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B 1 Scientific and technical quality relevant to the topics addressed by the call

A setup of a pre-operational Climate Service was recommended at the GMES conference organised by the European Commission in Helsinki 2011. Based on in-situ and space-based observations as coordinated in the WMO GCOS (Global Climate Observing System) and the GEO (Group on Earth Observations), there is a requirement for evolving reanalysis (RA hereafter) activities, both on global and regional scales. The reanalyses integrate and synthesize the data into consistent and coherent high- resolution gridded datasets and they will give vital support for the monitoring of the climate system.

The climate trends that are evident from observations and gridded datasets show a clear long-term global temperature increase for most of the decades over the last century. The largest increases are over the most recent 50 years. The extremes have also changed in that the occurrence of very cold days has decreased and the number of warm days increased (IPCC AR4, WG1 report, IPCC 2012). EURO4M results show that these changes are also seen in Europe. Climate projections indicate that this trend will also continue in the future.

The importance of extremes for defining the impact-relevant aspects of climate cannot be overestimated and requires accurate high-resolution datasets both in time and space. For example, sub-daily values enable a better understanding of the temperature and precipitation climate than just daily averages. The climate projections show north-south gradients with quite complex local features especially for precipitation.

B 1.1 Concept and objectives

B 1.1.1 Some existing datasets

Several national institutes in Europe have their own gridded datasets for various purposes and lengths (Met Office, DWD, MF, MI, SMHI MESAN, FMI etc.). There are different data polices and many are not in the public domain. As an important attempt to create a pan-European data capability, EUMETNET instigated the EUMETGRID project for which the main idea was to access and merge national datasets through a portal. It ended at the demonstration level but the Final Report by Tveito (2012) provides a full background of the needs and lists available datasets. Those that can be accessed will be very useful in assessing the quality of the datasets described later, in section 1.2.

Global reanalysis datasets exist from ECMWF (ERA-40, ERA-Interim and ERA-CLIM being produced). ERA-40 has been used extensively, even if at low-resolution (125 km) but is now mainly replaced by ERA-Interim at 78 km (from 1979). Also NCEP and JMA have good quality global RA. NCEP pioneered reanalysis for the whole of the 20th Century using surface based observations only (20CR). Comparisons within UERRA with these global RA datasets will be essential.

In EURO4M NWP based RA are carried out at moderately high-resolution but for quite a long time period, to reach 20 years. Also in the project, there is a higher resolution with a more advanced assimilation system and with additional information (rain rates). The more advanced reanalysis can for cost reasons only be carried out for a few years. A lot of experience has been gained and knowledge and tools been built up, but the resulting datasets will be limited in time or resolution. Even so the resulting datasets are substantial and e.g. require of the order of 100 TB archiving space.

B 1.1.2 Regional reanalyses extending from EURO4M

The statistical analyses in Numerical Weather Prediction (NWP) systems are designed to cope with many different observation types and variable data density in space and time. The model-based background makes up for paucity of observations in certain areas from forcing the forecast model evolution with observations in other areas. The NWP model will provide a background value for the quality control and analysis of observations. It provides model- based values in areas or of variables that are not observed. The analyses of the individual variables, including many ECVs, are coupled in an internally consistent way (multi-variately, i.e. the different variables are coupled following physical and statistical relationships).

RA means, as for the global systems, that a fixed state-of-the-art Data Assimilation system (analysis and NWP models and data processing) is run for the full time period under consideration. Regional systems are forced by global RA (or model) boundaries and the global system also needs to be fixed (such as ERA-Interim or ERA-SAT). The observations that go into the global, as well as the regional RA, have generally improved a lot over the last century. Radiosondes, satellite and aircraft data have become established, with improving quality. Surface data over land and importantly, over sea, have expanded considerably. However, there remain regions or countries where observations have been taken, but their data have not yet been made available in digital archives. An important basis for all RA is to assemble as much input data as possible from historic times and this has been part of the work in ERA-40 and in EURO4M, which in its turn feeds in to the data collection efforts in the FP7 ERA-CLIM project.

Data rescue (DARE) is the all encompassing term used within climate science to include determining the location of likely sources, organising plans for developing inventories and preserving (producing images of the material) the data they contain and digitizing these data into usable forms. Brunet and Jones (2011) have shown that only a part of the total of the surface weather and climate observations data taken across the world are available for use in climate science and by climate and weather services, principally for low-resolution time scales (e.g. monthly). Although some data taken in the past will have been lost, a considerable fraction of that not currently available is sitting in archives around the world and many of these archives are in Europe or kept in hard-copies at the National Meteorological and Hydrological Services (NMHSs) pending digitisation and potentially at risk of being lost forever.

The global RA datasets (ERA-40 and ERA-Interim foremost) have become established datasets for climate monitoring, observation studies, model validation and many other research and customer applications. Their value lies in the relatively long periods of uniform datasets, but this comes at the expense of a relative low spatial resolution. There is also a clear need for long climate time-scale high-resolution *regional* RA data for European and many national applications. The RA need to properly resolve local climate features and need to well represent important features at least at the scales that are represented in the networks of national climate stations. This implies in the case of NWP (Numerical Weather Prediction) based RA resolutions of around 10 km or better which means that high-resolution RA need to be run on the *regional* scale for many years to come.

The needs for high-resolution datasets are common to all nations and in Europe there have been a series of efforts to create gridded datasets through EUMETNET (EUMETGRID, Tveito 2012, Showcase EUROGRID before that and ERAMESAN (Jansson et al., 2007)). These efforts have been either limited to coarse resolution or fragmented into national datasets. European NMHSs, institutions and users do not have any such high-resolution coherent RA dataset today. In EURO4M, a significant part of the effort is going into answering these needs and RA products are created for a some decades and at an intermediately high-resolution (22 km but also with a downscaling to higher resolution).

UERRA will enable a pan-European approach to achieve this, rather than many fragmented national attempts, and provide all European users with reliable and easily accessible data and information. In Europe, for regional modeling the experience has shown that quite a large regional area is needed to resolve meteorological features (such as pressure systems and waves in the flow pattern). Regional models include the whole continent and the even higher resolution models (a few km scale) need to include a good fraction of Europe.

UERRA brings together the main regional RA groups in Europe (and some also with global competence) with a long experience and development capacity. Reanalyses have been performed by some of the partners within the EURO4M and other projects and a lot of experience has been gained. The limitations of what was possible to do in EURO4M will be addressed in UERRA, but on top of that there are several new scientific and technical tasks in UERRA that will bring much more user benefits than anything provided hitherto:

- There is a focus on reanalyses and their uncertainties.
- The time period will be much longer than in EURO4M to suite climate monitoring applications.
- The resolution will be higher than in EURO4M for selected components of UERRA.
- Advanced Ensemble Data Assimilation will be used for a long time period to assess uncertainties in the RA themselves.
- Different high-resolution deterministic RA and other gridded datasets will be included in the evaluation of the uncertainties.
- Data services and user driven dissemination systems will be built from the RA datasets.
- Observational data rescue will be specifically targeted towards sub-daily and synoptic time-scale data that can be used in the RA.
- A major and cross-project aspect of UERRA is that evaluation and quality assurance activity estimating uncertainties estimated in several ways from the different datasets that will be available.
- Users will be involved in the evaluation in an interactive way and access the data and products and the use of uncertainty information.

Ensemble data assimilation to estimate uncertainty
The techniques for providing gridded datasets include, in the case of gridding, assumptions about the interpolation method. In the case of RA there are also assumptions in the statistical interpolation and about the NWP model used.. There are thus different uncertainties in the datasets, depending on variable and location. For applications and in particular for analysing climate and trends, an estimate of the uncertainty is an obvious requirement. The analysis methods are designed to give the most likely value at each point, but there is also an implied probability distribution function around these values. The statistical methods may also give an estimated error variance. (The explicit minimum variance methods do, see e.g. Haylock et al. (2008) where this is discussed for the E-OBS dataset). The values are not very realistic due the assumption of perfect statistical specifications. Only part of the true uncertainty is represented. The value is only a function of the specific statistics and the number of observations and just adding more observation will reduce the value to an infinitely small one.

The observations themselves are also affected by usually small instrumental errors being complicated by often larger errors due to location (representativeness) effects. Gross errors in various parts of the processing are usually detected and flagged in quality control and can be assumed taken care of.

Ensemble techniques have become fully established for NWP, where spread between forecast members, resulting from perturbing the initial state and model parameters, is used to estimate forecast uncertainty. Perturbations are introduced in the assimilation system commensurate with the uncertainties of data or model processes. Different physics parameterisation may be used as well as different boundaries for regional modeling.

Variations of the technique have also been applied for estimating the error variance for the data assimilation and used as a horizontally varying field in the assimilation ("error of the day") (Bonavita et al., 2011 and 2012, Berre et al. 2006). Ensemble Data Assimilation (EDA) systems are growing in popularity and ECMWF has such a system for providing parts of the background errors and part of the perturbations for the Ensemble Prediction System (EPS). Météo-France has also such a system in operations for use in their data assimilation. The Met Office employs a hybrid ensemble-variational assimilation technique in operational NWP that employs fully three-dimensional flow-dependent covariances (Clayton et al. 2012) – this technique will be applied to regional reanalysis in the UERRA project for the first time.

Multi-model ensembles for uncertainties

The advantage of a complete and contained ensemble assimilation system discussed in 1.2.8 is that the perturbations are controlled, in balance and in some sense optimal and reflecting the uncertainties in the data assimilation system itself. A multi-model or multi-centre ensemble has differences that are not given by design but are more incidental. Still all the NWP systems are similar so the differences lie within the uncertainties of the models and the assimilation. A multi-centre ensemble, if consisting of just a few members, can be run at much higher resolution than a full ensemble system at any one centre and may provide some more insight into the uncertainties. When different models are employed, then larger or other types of differences are likely than for the internal spread in EDA systems. Multi-model ensembles are also employed for a number of NWP applications including seasonal predictions. In climate modeling the ensemble and multi-model techniques have become necessary tools for climate projections. The results from the FP6 project ENSEMBLES is a well-known example, which is still much used.

Thus, another way of estimating uncertainties is by comparing a number of different RA, using different NWP models and Data assimilation systems and even different resolutions. These individual RA are often (but not always) single integrations supposed to represent the most likely state of the atmosphere. Since these individual states by themselves do not include any uncertainty information, they are often referred to as deterministic later on in the text.

Detailed near surface downscaling reanalyses

The 3D (and 4D) upper air (UA) analyses (which are the biggest part of the NWP based RA) use multi-variate state-of the art statistical methods optimised and employed for the atmosphere from near surface upwards (to at least 30 km). They are optimised for the complete 3D atmosphere, not just near the surface. Although their higher resolution allows them to do a better job than global reanalyses e.g. ERA, most NWP based regional RAs cannot make optimal use of all surface based observations due to the conflict of resolving many details of the surface compared with the large-scale flow in the free atmosphere. The 3D and 4D UA systems also include 2D analyses of soil and other surface conditions, but the 2 m temperatures and 10 m wind and other near surface ECVs in the UA systems are in balance with the atmospheric conditions which in turn are forced from the surface.

Local 2 m temperature and 10 m inland wind observations cannot readily be used due to strong representativity errors (i.e. that the model topography and other physiographic fields do not fit the local conditions). Both due to the small space scales, but also due to the time variations, accumulated precipitation is difficult to use in an UA analysis. 24 hour precipitation is even more difficult to use in such a system where shorter-period (1-6 hr) accumulations would be more ideal.

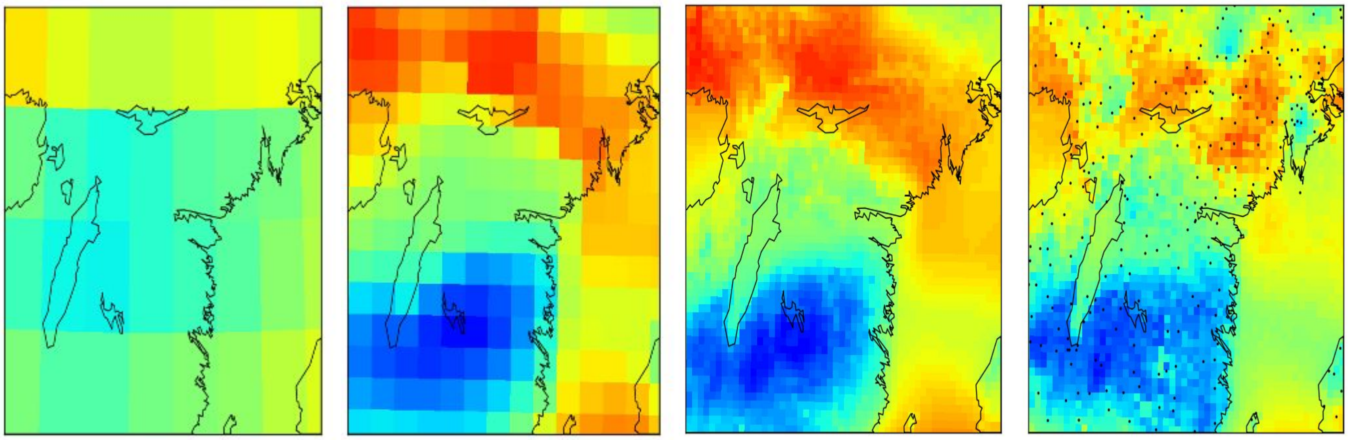


Figure 1: 2 m temperature for the date 20091001:1200 UTC in a 300 x 300 km area centred around the city of Norrköping in Sweden. From left: ERA-Interim, HIRLAM using ERA on the borders and as large scale constraint. Downscaled HIRLAM, MESAN 2D analysis (obs locations as black dots) using downscaled HIRLAM as a first guess. It shows the benefits of resolution 78 km - 22 km - 5 km and then using observations for 5 km analysis.

In order to analyse these surface, or near surface, ECVs, other statistical 2D analysis systems have been devised for the purpose. They use the NWP model background but usually downscaled to higher resolution in different ways. The most common method is to use advanced interpolation and statistical relationships related to the high-resolution physiography (like topography). Another more demanding method is dynamical downscaling with a NWP model. After the adaptation to high resolution physiography a first guess is provided to the analysis step. The analysis is designed to take rather small scales and local features into account.

Many NHMSs develop and run high-resolution 2D analyses of the most demanded near surface ECVs and the resulting features are rather faithful to observations and close to what e.g. a hand analysis be an experienced forecaster would produce.

B 1.1.3 Objectives

- The overriding objective is to produce long-term high-resolution climate quality datasets over Europe complete with estimations of their quality and uncertainty
- To produce these through 3 and 4-dimensional reanalyses (RA) and 2-dimensional downscaling RA and extended observation gridded datasets
- To estimate the uncertainty of the individual RA through ensemble data assimilation for Europe and produce a high-resolution ensemble RA for as long multi-decadal time period
- To provide additional observations to be used for these RAs, other projects and for the community at large
- To make the RA data available to a large number of users
- To provide data services and visualisation portals for a large number of RA fields (in WP4)

- To quantify uncertainties and establish knowledge of the quality of the different RA in many different ways, between datasets and with respect to observation gridded sets and satellite-based datasets and river discharge data
- To get a consistent knowledge for Europe with a common evaluation procedure for ECVs, climate indicators, extremes and scales of variability in space and time and distributions
- To document how well extremes and special climate features are reproduced in the RA
- To show how the data can be exploited for user-oriented products
- To provide a unique and useful datasets for a wide range of downstream applications
- To support Climate change services and climate adaptation
- To support and aid policy development and monitoring of climate for European wide and European national applications
- To establish good user contacts and get early feedback on the user products
- To have a long lasting impact also after the end of the project

B 1.1.4 Scientific questions

Where are the most important data gaps for the time period of most interest for the regional RA and which variables are the most important for the RA?

Ensemble systems are used for estimating the uncertainty of a single deterministic RA compared with observations. Can we measure the real uncertainty by using the spread between ensemble members?

Do individual deterministic RAs (i.e. without uncertainty estimations) differ much, and if so, in which ways for the relevant ECVs? It is expected that different model formulations cause differences in data sparse areas. Do these differences between different RA systems reflect real uncertainties, as measured between any one of the RA and observations?

The spread between ensemble members is generated in a theoretically optimal way whereas the differences between the different models and RA systems are more incidental, i.e. not designed for the purpose of uncertainty estimation. Still model differences may provide useful measures that for some, particularly near surface ECVs. How do these differences compare? Are they more useful or are they dominated by systematic errors in the different models?

What is the quality and uncertainties of the different constituent RA and do they vary with different validation datasets? There are also uncertainties in the validation datasets. Are the results different when other datasets are used and do they depend on the resolution of the RA or the validation dataset?

How do the perceived errors in the RA vary in time over years and decades?

Do we see differences in uncertainties in the pre-satellite era in the regional RA and should we use the earlier decades differently?

Which measures of uncertainty do the users want and how can it be translated into variables that impact the users or the society at large?

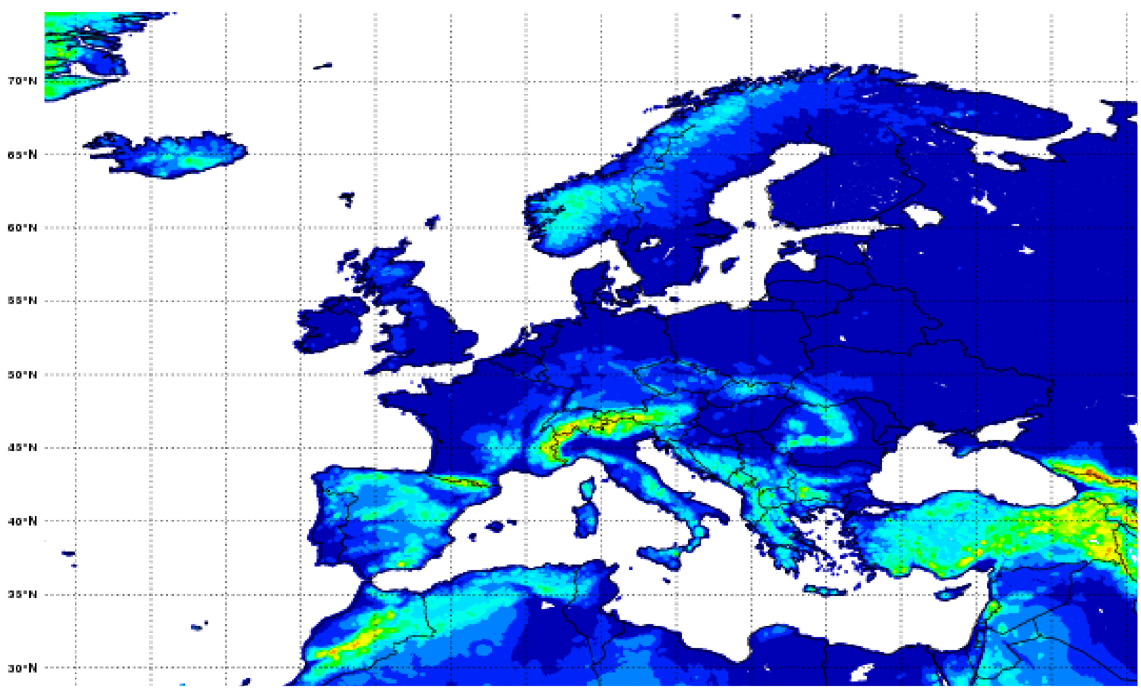
UERRA shall explore these areas the research will be directed to give answers to these questions and it will be carried out in WP3 mainly.

B 1.1.5 Scope of the project

In UERRA there will be work to gather and complete existing observational datasets, mainly to be used as input for the reanalyses. The basic observations for the regional RA will be based on ECMWF and ERA-CLIM observation archives.

Additional regional data will be recovered and received as far as possible for the purpose of high-resolution analyses (10 km roughly) and at synoptic hours. The new data will be archived at ECMWF, either completely, or a common subset of all ECVs; those that are to be used in the project, dissemination or user products, will reside at ECMWF, transferred to ECMWF archives to be used by all RA. As in EURO4M, this additional data will be made available to the UERRA NWP based reanalyses. The work will be done in close co-operation with ERA-CLIM2. The availability of the new data is envisaged to be successive and some will benefit directly the UERRA RA whereas some other may be too late and benefit future RA efforts.

The *ensemble system of regional reanalyses* will actually be composed from a few different components: Ensemble Data Assimilation (EDA) will be further developed and used for RA by the Met Office and University of Bonn (Hans Ertel Centre, HErZ, in Germany funded by DWD). Another way of obtaining an ensemble is from a number of different high-resolution deterministic RA. One will come from SMHI and the other ones from deterministic control member of the two ensemble systems. The horizontal domain covers most of the European land area (see Fig. 2)



From the 3-dimensional reanalyses, there will also be even higher resolution downscaling of near surface ECVs but only 2-dimensional (2D) for the surface conditions only. These high-resolution 2D analyses use additional data and will differ from the 3D reanalyses and thus add a component to the understanding of uncertainties reflected in the different types of RA.

Then, as a fourth member of the composite, there are the observation-only gridded datasets which give yet another estimate of near surface ECVs. These are based on independent daily values (rather than 6 hourly for most RA) and are important for validation the climate quality of the RA.

A fifth pillar that is included in UERRA consists of already (or at the start of the project) available *other reanalyses or datasets.* RA coming from EURO4M are of particular interest, as is the well-established ECMWF global RA. Satellite data from the CM-SAF data base as well as ESA's CCI (Climate Change Initiative) data will be employed for extensive validations. They are of especially important to UERRA since they are available at the start of the project and will be used to develop the concepts in the evaluation work, despite the datasets being limited in time or resolution.

The sets of ensemble RA and individual RA and datasets will be exploited in a number of ways to determine the quality of the individual components but following a pre-determined methodology applied across the project in a coordinated manner. All components, from observations to analysis methods and models have their own uncertainties. The information content of each dataset in terms not only of error bars but also in terms of scales represented, will be considered in the evaluation. From the many validations against datasets, *estimates of uncertainties of ECVs during the RA period* will be produced and measured in different ways. A number of important *climate indicators and users* will be considered in order to derive recommendations on use and uncertainties to take into account. Together with a number of key users, ways of *translating the uncertainties* of the RA into i*mpact indicators* will be explored.

For the regional RA the proposed length of RA will be from 1961 onwards in order to have the qualities of high enough resolution and ensemble members for uncertainty information. The last 50 year period is also the most commonly demanded for climate monitoring and modeling. The satellite era just starts after this, although with limited data in the first decade. To gauge the impact of satellite data or not, two ensemble RA will be run by the Met Office to compare conventional observations only with conventional plus satellite. Uncertainty measures as given by the ensemble method will come out of these experiments and how *to account for sparse observations in the pre-satellite era* will be studied using also observation datasets.

The data archiving, *data services and dissemination* of data and provision of data services is a serious issue. The project will build on developments already undertaken and on other ongoing projects. Data dissemination will be coordinated with the other Copernicus projects of this call. ECMWF has developed MARS also for other's models and Web Map Services based on MARS, SMHI also works with MARS and KNMI has developed such services for climate models and other datasets. UERRA will make maximum use of the experience of these partners and expand facilities to also cover other partner's datasets. Particular user driven fields and products will receive special attention for common archiving and easily accessible user data.

There is a strong and natural dependence on ERA-CLIM2, focusing on Global 20th century reanalysis, for the global boundaries including ensembles, but also for observation data and data services where two-way relations are likely. WP1 will contribute to the observational data base benefitting also the Global RA. CLIPC, focusing on provision of access to simulated and observed climate datasets and climate indicator toolbox, will use RA data and derived quantities and that project is envisaged to use the data services of UERRA. UERRA has a co-ordination WP with corresponding WPs in the other 4 FP7 Projects in this Space call.

B 1.2 Progress beyond state-of-the-art

B 1.2.1 Observational data bases

Large volumes of station climate data have been digitized and are available from a number of sources (e.g. data centres such as NCDC, GPCC, UEA/CRU, ECA&D and some European NMHSs). The emphasis in collecting these data over the years has changed. In the 1960s to 1980s when the first digitization efforts began emphasis was placed on monthly averages and totals, time-scales for which the majority of the data (about the 80%) are already available in digital format. This gradually extended to daily values, for which data availability is more restricted (less than 40% of daily observations are available and digitized for mainly temperature and precipitation, while for other variables the digitised fraction is much lower). Generally, daily data series are not as long as the series of monthly ones, but the original daily data ought to exist in many hard-copy archives. What is additionally required now for RA are data at sub-daily time steps, data that would have had to be taken to calculate the daily and monthly averages. So, we are not searching for needles in haystacks: we know for which locations and sites sub-daily data ought to exist and where it should be located.
Within UERRA, the emphasis is twofold: to infill gaps over data-sparse European regions and the post-1950 period and to recover, digitize and develop longer time-series since the beginning of the 20th century. The latter will also contribute to the quality of Global RA and there are gridded observational data sets (like the CRU datasets) that go back to the beginning of the 20th century and earlier. UERRA focuses on the second half of last century, but it is likely that also future regional RA will go back to the beginning of the century. A number of resources for exploring availability of relevant digital data exist and can be assessed using the information provided by WIS/GISC, EUMETNET, ECA&D or MEDARE metadata portals. Complementary searches of the MARS archive to be undertaken by UEA within EURO4M will provide UERRA with a comprehensive overview of what is needed for additional historical hourly observations. Additionally, the UERRA partners will liaise with NMHSs and other sub-regional initiatives (e.g. MEDARE, DRR/SEE) to gain access to more of their sub-daily weather data. It is known, for example, that Météo-France is undertaking plans for digitising a vast collection of historical data for France and its former and current overseas territories. SMHI is carrying out this work to fill the gaps in the Swedish records, currently for the 1950s and as fast as resources permit. The Israeli NMHS is providing free access to their digital climate series. The MEDARE initiative (co-ordinated from URV), linked to the effort made under EURO4M, is working to extend digitized data sources across the Mediterranean and parts of the Middle East and North Africa and build climate datasets for this region. In UERRA these efforts will continue, but the principal aim in Work Package 1 will be the location, the digitization and the reformatting of known data sources not yet in the MARS archive with the main focus on the recovery and digitization of about 4M of not-currently available at the MARS archive of sub-daily observations over poorly represented European regions and periods. In UERRA, we propose to add the new data to the MARS archive, using protocols developed by UEA during EURO4M.
We clearly do not have the resources (monetary and personnel) to digitize all the relevant data recorded in the past for RA, so the key aspect in any data rescue activity is to determine both what is most needed (e.g. what will have the greatest effect in any new Reanalysis simulation) and what is possible given the many NMHS constraints on accessing both the archives and more importantly their digital holdings. UERRA will work in close connection with relevant data holders in Europe and make use of the different DARE initiatives and projects in Europe to gain access to their holdings and to promote the culture of data and knowledge sharing. Special attention will be paid to and respect for data exchange policies in place at some data holders, while at the same time of ensuring an enhanced accessibility.
WP1 will build on the already accessed climate data sources and digital data gathered and developed under EURO4M to extend the effort to other synoptic-scale data-sparse European regions and periods in current European RA inputs. **URV** will work with other ongoing DARE initiatives to provide access to more data and instigate a new culture for sharing of knowledge and data. The particularly data sparse regions of Europe and time periods will be identified together with relevant stakeholders, including the regional RA actors in UERRA.

It is planned to digitize some 3.7M hourly observations at URV. All partners will assist with contacts in NHMSs across Europe. **NMA-RO** will take part in rescuing synoptic observation over Romania and the Balkans. Some 300K additional hourly values will be provided to MARS. They will liaise with other NHMSs in the Balkan region to gain access to their archives and coordinate with URV and DRR/SEE project for the Balkans. This is also in order to avoid duplication of efforts.

To recover and digitize synoptic time scale data is the first step to improve the inputs for enhanced European regional RA. To ensure time-series quality and homogeneity is the next important task. Present and particularly past climate data contain both non-systematic and systematic errors that have to be identified and accounted for in order to develop high-quality time-series, since a number of individual errors and systematic biases can remain in any time-series compromising their integrity and reliability (e.g. Domonkos 2011, Venema et al. 2012). Although nowadays a number of quality controls (QC) are regularly undertaken on the data transferred in near-real time into databanks by data managers, this practise was not common in the past. These tests also do not ensure the temporal coherency of the records. Therefore, time-series quality insurance requires subjecting them to more complete QC. While a variety of QC will take place at the monthly and daily scales using well defined and available procedures, it is important to assess for some ECVs additional tests to identify individual errors in time-series at the sub-daily scale. Another previous requirement is ensuring time-series homogeneity through homogeneity assessments aimed at detecting systematic biases in time-series and apply homogenization methods if the series require adjustments accounting for the validated inhomogeneities. Again, a wide range of homogenisation methods exist for adjusting time-series at the monthly scale but to a much lesser extent at the daily scale. The application of adjustments at the sub-daily time-steps remains poorly explored.

Under UERRA a new battery of QC tests will be defined and the digitized synoptic-scale data will be assessed to identify non-systematic errors at the sub-daily time scale. We will also explore the applicability of currently available state-of-the-art in homogenisation methods to adjust time-series at the hourly scale, such as those recommended by the COST Action HOME. In this case, UERRA will build upon the experience gained by the participants after its leadership in HOME and will work together with other new homogenisation initiatives (e.g. HOME Community, the EU-EMRP/MeteoMet project and the O-REG on minimising the impact in time-series of the changeover to AWS) to enhance homogenisation techniques and their applicability for adjusting time-series at the sub-daily scale.

URV and **UEA** will lead this task and work together to implement new QC and homogenisation strategies to adjust time-series at the sub-daily scale following a double strategy. While URV will be in charge of the testing of the individual recovered/digitized synoptic time-series with the new QC and homogenisation strategies implemented under UERRA, the UEA will ensure network consistency and data encoding.

Data polices of individual countries will be respected while the expectation is for a loosening of restrictions. MI has released all its data and SMHI will make all its data publicly available in 2014. (Although there may also be some moves in the other direction, to withhold some data, as has happened at AEMET in Spain). Such actions will be disappointing but they will not jeopardize the project since there are is far more data out there waiting to be recovered and much more than UERRA has resources for. (See also section 1.3.4). The European Directive on the Re-use of Public Sector Information (PSI) is a driver for opening up national archives. Some data may have to be used with restrictions for the reanalysis only, but this will only be a limitation for subsequent independent validation efforts. This is in contrast to the policy in ERA-CLIM and ECMWF where all constituent data must be available together with the reanalyses.

B 1.2.2 Gridded observational datasets

Global RA (e.g. NCEP/NCAR, ERA and JARE) all make use of input surface data in what ECMWF term the MARS archive. This is the operational weather archive of sub-daily data taken for the principal purpose of deriving operational weather forecasts. A number of projects funded with Europe, North America and elsewhere (e.g. EURO4M, ERA-CLIM, ACRE, MEDARE and many national European NMHS initiatives) have sought to digitize additional data, so the archive is a growing resource. EURO4M had an additional component where it sought to determine what was in the archive and to compare this with other similar large datasets that have been developed for purposes other than Reanalysis and weather forecasting (e.g., the ISHD and ISPD datasets). Long-term datasets exist at fairly low resolution from gridding observations for temperature and precipitation. The main ones are the CRU at 0.5 ˚ resolution covering the globe (but at monthly timescale since 1901) and the ECA&D E-OBS daily dataset at 25 km for Europe for the period from 1951. These continue to be updated in near real time and they have many existing users among researchers, institutions and policymakers, not least the EEA. They are considered as a reference and will need to continue to be updated. There is an important role for the gridded long-term observational datasets for validation purposes.

The E-OBS dataset is being expanded across a number of regions where NMHSs are supplying KNMI with more extensive versions of their daily station data (principally for Tx, Tn, precipitation, but datasets of MSLP and snow cover are available for some parts of the continent). The differences in station availability are now quite marked across some parts of Europe (e.g. coverage maps indicate the station network is almost an order of magnitude greater across Germany than it is for Poland or the Balkan countries). UERRA will investigate whether this dramatic difference in data density is adequately being catered for by the operational software. Specifically KNMI and UEA will investigate different approaches to the gridding, such as transformations of precipitation data to improve the interpolation of extreme values and to assess whether the resolution of the whole dataset could be improved in some parts of the continent. This will involve developing a gridding tool as a specific deliverable. Another issue in WP1 is how susceptible the gridding and particularly the gridding of extremes might be susceptible to changes in station density. Comparisons within WP3 will emphasize extreme periods and will require potentially more comprehensive error estimates than currently available. UERRA will investigate whether the development of multiple realizations of the dataset (see Morice et al., 2012) will assist users in better understanding the components that form the uncertainty estimates in any gridded dataset. This work will also draw heavily on comparisons with the national grids. The results will be compared with independent uncertainty estimates derived by EDI using their much more highly resolved station dataset for the Alpine region.

B 1.2.3 NWP based regional reanalyses

In EURO4M it has been demonstrated that the higher resolution possible in regional reanalysis provides significantly more detail mainly due to better resolved topographic and land-sea-lake features and contrasts. One can see this when going from T255 (~78 km) to 22 km in HIRLAM 3D-VAR and 12 km in Met Office 4D-VAR. Further downscaling provides even more detail in various meso-scale (a few km scale) surface analysis systems: MESAN, SAFRAN and CANARI. Local features due to topography or land-sea contrasts as well as the extreme values (wind and temperatures) show a higher fidelity as a function of the resolution of the model and analysis. The physics of the model that is responsible for clouds and precipitation and land processes is run at a much higher resolution than globally. In combination with high-resolution physiography, these processes create much more detail in the related ECVs.

Regional data assimilation and RA use state-of-the-art variational (3D and 4D) or ensemble Kalman filter methods, similar in sophistication to those used in current operational global NWP and global reanalyses applications.

WP2 is responsible for the development of regional ensemble reanalysis capabilities based on state-of-the-art data assimilation (DA) and Numerical Weather Prediction (NWP) techniques, and the production of multi-decadal, gridded, multivariate reanalysis datasets, complete with consistent uncertainty estimates based on the spread between the members of the ensemble.

ERA-CLIM will produce a global deterministic RA to replace the ERA-Interim with a resolution aiming for 40 km (ERA-SAT). It is planned for mid 2014. In ERA-CLIM2 a longer period (a century) is expected to be covered at a spectral resolution of T159 (in wavenumbers, approximately 125 km). The satellite period from 1979 is planned to be at least at 40 km resolution (CERA-SAT). In contrast, the regional reanalyses will be at about 12 km grid resolution. This means that there is about the same ratio between the global deterministic RA and the regional RA (about 4:1) as in EURO4M.The UERRA regional RA at 10-12 km resolution will add significant value for the users since small scale features due to coast lines or mountains are better resolved with the high resolution.

The ensemble assimilations will be coupled to the global ensembles through a common core observation datasets as well as through the lateral boundaries of the regional domain. The regional ensembles will also cover a significant part of last century. This will enable high resolution both for the deterministic control and also enough ensemble members, both of higher resolution than the global by a factor of 3-4.

B 1.2.4 Downscaling analyses

The upper air HARMONIE RA will be further enhanced through down-scaling and higher (5.5 km) resolution 2D analysis of ECVs. In UERRA this will build on the work in EURO4M and the common tool MF-SMHI, MESCAN. The added value compared to the 10 km UERRA will be gained from both high-resolution observation datasets and from high-resolution physiographic fields as well as adapted structure functions for the spatial scales. Météo-France will set up and carry out a pan-European RA with MESCAN, which is developed during the EURO4M project with SMHI. It will provide a near surface analysis for temperature, relative humidity, precipitation and wind. Météo-France will downscale the 3D-VAR HARMONIE analysis as an input field or background for the 2D–analysis system MESCAN at 5.5 km. If possible additional surface datasets from WP1 will be used.

A coherent 5 km dataset of near-surface ECVs extending back to 1961 will be a unique asset for all the European NHMSs and all other users of climatological data. This RA will be a single deterministic one for most of the period, but for a period of 5 years there will be two downscaling RA driven by the two different physics parameterisations in HARMONIE (mentioned later on). These will introduce differences in the down-scaling from the model backgrounds used and the basic observations are the same in the two runs. Additional perturbations may be introduced by also perturbing the observations. This spread between the two datasets will give a unique and novel measure of uncertainties at very high resolution.

Then the evaluation of these uncertainties in WP3 will make the data even more useful for applications.

B 1.2.5 New cloud fraction analysis from new satellite data

Also other 2D (horizontal) ECVs may be analysed. One important variable for the climate is satellite derived cloudiness and new such data exist, from EUMETSAT SAFs. Good quality data CM-SAF datasets exist for both polar NOAA/METOP satellites and geostationary METEOSAT satellites. (Note: The ESA CCI data are quite different and advanced datasets that have already used optimal analyses, from all available sources. For cloud cover they will still be in production phase until 2016).

The monitoring of the evolution of cloudiness through the years is very important for the local climates and in itself an important climate indicator. Space based observations are really necessary and satellite retrieved cloud products have revolutionised this research. Surface stations are sparse and with varying density and practices over time. Especially with the number of channels and resolution being available on AVHRR (1978-) and SEVIRI (2004-) instruments the potential for reliable cloud products is great. Products from earlier geostationary instruments, like MVIRI from EUMETSAT, make it possible to extend the geostationary record back to 1982. Data from polar and geostationary sources complement each other over the European area but an optimally gridded cloud fraction dataset is needed for climate studies, validation of models and solar energy potential. The SMHI MESAN system (Häggmark et al., 2000) will be adapted to cover the area and a common grid. It is a specially designed OI 2D-analysis which will provide a pan-European gridded dataset for evaluation in WP3 and many applications and validations.

A MESAN cloud fraction analysis will be performed over Europe in the project and add further information to a wide range of users. It will also be of value for the validation in the project itself. Geostationary data will be used for much of the continent while polar orbiters give a high resolution in time and space in the northern areas.

B 1.2.6 Downstream hydrological applications for validation

Hydrological modeling can be done with a routing scheme that directs the model grid precipitation onto river catchments. The HYPE model (Lindström et al. 2010) is a semi-distributed, process based hydrological model and nutrient model which simulates hydrological fluxes on a daily time-step in coupled sub-basins. The major hydrological processes simulated by the model are snowmelt, evapotranspiration, surface runoff, macropore flow, tile drainage, groundwater outflow from the individual soil layers and routing in rivers and lakes. Calculations are made for unique soil and land-cover classes (SLC classes) at the sub-basin scale. A common input to nearly all large-scale hydrological models is gridded precipitation data over the model domain. Precipitation is the most important input to hydrological models. Reanalyses are often used to drive European hydrological models because databases of historical gauge data are limited. Observed discharge data is considered to be the most reliable of the main hydrometeorological variables (Di Baldasarre and Montanari 2009). Discharge data can therefore be used to consider the accuracy of the accumulated catchment precipitation where discharge measurements are available.

In this project, we will test whether forcing data from higher resolution reanalyses can improve pan-European discharge simulations in the E-HYPE model. The pan-European application of the HYPE model, E-HYPE (Donnelly et al. 2010) with a median sub-basin resolution of 215 km^2 has been set up to calculate hydrological variables (e.g. runoff, discharge, snow depth, groundwater level) and nutrient variables (e.g. concentrations and loads) for over 35 000 sub-basins across all of Europe. We will also provide feedback as to the quality of the simulated precipitation fields using a 2 step process:

1. The long-term accumulated catchment precipitation from the reanalysis will be compared with the long-term discharge volume for that catchment (e.g. 30-year volumes)
2. The reanalysis precipitation and temperature fields are then used to simulate discharge across all of Europe. Errors in long-term means of simulated discharge as compared to long-term mean of observed discharge are plotted to determine regions where there is a systematic error in simulated discharge.

In a second and conceptually different approach, the MESCAN RA will be used to drive the surface module (SURFEX) which computes soil variables such as surface and deep soil temperature, soil moisture and snow characteristics (density, albedo). The drainage and run-off computed by SURFEX will be used to force the hydrological model TRIP (Total Runoff Integrating Pathway) at 25 km over Europe to compute river discharge. The work is part of WP4.

B 1.2.7 Multi-model ensembles

The new regional reanalyses will aim for much longer periods and higher resolution than anything done hitherto. One deterministic highresolution RA will be made for 50 years or more. Individual reanalyses will be made or be available from different centres: SMHI, DWD and from the Met Office (the deterministic control in the ensemble DA). Multi-model statistics will be derived from such a multi-model ensemble, admittedly with only few members, but at high-resolution and over a very long time period.

HARMONIE

SMHI with involvement from Météo-France will set up and run a 3D-VAR regional RA with the HARMONIE modeling system. The HARMONIE system has been developed within the ALADIN consortium and it has during recent years been adapted and used also within the HIRLAM NWP consortium. It will be implemented and optimised for the entire European area with surrounding sea areas at as high resolution as is possible (11 km and at least 65 levels). It will be run from 1961, and serve as one member of a multi-model reanalysis. The data will be archived in MARS at SMHI and at ECMWF.

The data assimilation will be driven by the global ECMWF ERA-SAT reanalysis (with earlier ERA RA as backup) and also use a large scale J_k constraint (Dahlgren, 2011) to add large Atlantic scale information from ECMWF satellite assimilation into the 3D-VAR minimisation.

The coupling between the global and regional reanalyses can further be enhanced through a constraint in the variational cost function, J_k. It is designed to include a measure of the distance to the external global analysis for the large scales only. This has been developed in HIRLAM by Dahlgren (2012) and before that in somewhat different way by Guidard et al. (2008) in ALADIN. The methods are being further developed in the current HARMONIE 3D-VAR system used in this project. This can be seen as a way of imposing signals from the satellite data used in the global ECMWF system into HARMONIE 3D-VAR.

Coupling and the earth system part of the models

A very important scientific area that affects the *interaction between the upper air* part of the NWP model and the *thermal and hydrological processed in the soil* is the data assimilation of the soil from near surface observations. This together with the evolution of the vegetation properties during the ~50 years will be an issue that needs attention during the long period of deterministic high-resolution RA that SMHI and Météo-France will run. From the FP7 project GEOLAND2 (GMES-land) it is possible to apply a consistent Leaf Area Index (LAI) since the 1980's. It is based on a mixture of SPOT satellite data at 1 km resolution and AVHRR data at 5 km. The surface model module of HARMONIE, SURFEX, will use this LAI in the RA runs from the 1980's as will the SURFEX in the hydrological application in WP4. (The surface models in NWP handle soil water and ice, but only the hydrological models in WP4 handle and route run-off water correctly). This will be a novel and scientifically interesting application of these data. Before this time period other estimations will be used following what is used by the Climate Modelling Community who use data available from University of Maryland, http://luh.umd.edu/ .

In the RA, both the modeling of the surface interaction with the atmosphere as well as the *analysis* updating of the surface and soil properties is crucial for the quality of the ECVs. A new Extended Kalman Filter soil analysis will be introduced and adapted for the production reanalysis.

Oceanographic models will not be included in these regional RA, but will benefit from the global forcing and part of the period may become available from ERA-CLIM2 where oceanographic coupling is applied and sea surface data are used.

Multi-physics mini-ensemble

HARMONIE is available with different modeling of the sub-grid (scales not resolved) of physical processes like turbulence, convection, condensation, clouds, precipitation and radiation. The existing parameterisation schemes, such as those at Météo-France (ALADIN) and the more recent ALARO designed for multi-scales, will be employed. Both will be run and evaluated for at least a 5 year period on the 11 km European grid.

COSMO European domain RA

In an intermediate nesting step from ECMWF ERA-Interim, a European domain is used by UB and DWD at a resolution of 6 km (configured as EURO-CORDEX). This intermediate step will be provided as a valuable contribution to a multi-model ensemble reanalysis for Europe. The data for Europe are therefore produced anyway, but currently the focus of verification is on the German domain. The data will be provided to the UERRA partners and is available for evaluation. As a contribution to the European ensemble, but extensive validation for the European domain is needed.

B 1.2.8 Ensemble Data Assimilation (EDA) and uncertainty estimations

Unified Model (UM) ensemble RA

The EURO4M project (2010-2014) has provided the core 'deterministic' European regional reanalysis system, assimilating conventional, satellite and hydrological cycle (humidity, cloud, precipitation) observations into the Met Office Unified Model (UM)'s advanced four-dimensional variational (4D-Var) data assimilation (Rawlins et al 2007). An ensemble European regional reanalysis requires in addition both an ensemble data assimilation capability to estimate analysis uncertainty (Ensemble-Variational DA - EVDA), and a regional ensemble prediction system to propagate uncertainty information forward in time (Met Office Global Regional Ensemble Prediction System for the EU – MOGREPS-EU). The respective regional EVDA and MOGREPS-EU capabilities do not yet exist as Met Office NWP efforts are focused on global versions, and so they must be developed and maintained as part of the UERRA project. MOGREPS-EU will provide consistent ensemble uncertainty estimates using a regional configuration of the operational MOGREPS-G system currently implemented at the Met Office for global operational probabilistic NWP. Lateral boundary condition will be provided by CERA-20C T159 (125 km) global ensemble reanalysis if available, alternatively by perturbing deterministic T255/T511 (78/40 km) ERA-Interim (or ERA-SAT pilot atmospheric reanalysis if available from ERA-CLIM project).

Because of computing constraints the long-term ensemble assimilations will be at lower resolution than the limited number of single reanalysis that will be run in the project. The relatively large (20-50) number of ensemble members will be decisive in defining the detailed flow-dependent uncertainty estimates required for EVDA for this.

The regional EVDA ensemble will contain much more detail due to its significantly higher resolution than the global products. Although driven by global boundary conditions, the details of the EVDA RA itself will differ from the global RA (which utilizes a much smaller ensemble, with less flow-dependence) and will be tailored for European application. In the EVDA approach, the ensemble is coupled with the deterministic 4D-Var RA, which serves as the central member around which perturbations based on ensemble data assimilation techniques are added. The target UM resolution is 12km model with 12-24km 4D-Var analysis increments and ~40km ensemble uncertainty. Two production runs are planned (in 3-4 approximately decadal parallel streams) – all observations, and reduced (conventional observations only) dataset to assess impact of satellite data on accuracy/uncertainty reduction. These extensive datasets will be archived in MARS at ECMWF.

COSMO Ensemble RA

Since 2011, DWD has funded several research groups in the framework of the Hans Ertel Centre for Weather Research /HErZ) The climate monitoring branch of HErZ (a cooperation with the universities of Bonn and Cologne; www.herz-tb4.uni-bonn.de) is focused on high-resolution regional model-based reanalysis for Germany (at 2.8 km resolution, based on DWD's limited area NWP model COSMO). DWD considers this as a future concept for regional climate monitoring (with continuous updates similar to ERA-Interim). Currently, this is considered as basic research task, but the first production run started in 2012.

The University of Bonn (UB) will develop a hybrid local ensemble transform Kalman filter/ensemble nudging based in the COSMO RA system used for the deterministic runs. This is a new development and, even though the Met Office EVDA system is also based on ensemble data assimilation, the approach and particularly implementation, is different here. Comparison of the two different ensemble data assimilation RA for a limited period of 5 years (at least) will be performed to provide a multi-model/technique estimate of reanalysis uncertainty. The system will be comprised of a local ensemble transform Kalman filter component currently developed at the DWD (following Hunt et al., 2007) and an ensemble nudging component for continuous data assimilation between two Kalman Filter initializations based on the current nudging implementation in the COSMO model (Baldauf et al., 2011 and references therein). The principle of a hybrid Ensemble Kalman Filter/nudging approach is described and applied in Lei et al. (2012) and references therein. With ensemble nudging UB will investigate how to make use of covariance structure given by the ensemble realizations to enhance nudging weights. In addition, there will also be perturbed observations and looking into particle filter approaches (e.g. van Leeuwen, 2009) for resampling to ensure that the ensemble spread does not become too small. Preliminary testing will be done on reanalysis uncertainty estimation capabilities. To ensure the progress of the depending project parts in the case that the implementation of the ensemble nudging scheme are not successful, the system can also be set up as a standalone LETKF (Local Ensemble Transform Kalman Filter) version.

In order to increase the number of observations available for data assimilation in the pre-satellite era and in data-sparse regions, statistical transfer functions will be used to derive probability distributions of free-atmosphere quantities from surface observations (e.g., 850hPa temperature probability distribution from surface temperature). Virtual observations drawn as random samples from this distribution allow for assimilation in the ensemble nudging scheme. This might also serve as a tool to gauge the pre-satellite era uncertainties (as given by this ensemble system).

Building on the experience from the joint deterministic reanalysis project at HErZ (UB/DWD), the feasibility of an ensemble regional reanalyses using the hybrid data assimilation system developed in UERRA (KENDA, Kalman filter Ensemble DA) will be demonstrated. Therefore an ensemble reanalysis dataset will be produced spanning at least 5 years using a reduced observational dataset comparable to that in the pre-satellite era, but including the virtual observations produced in the same task in WP2. The KENDA will be used with a 6-hour Kalman filter interval (or 1-hour interval if ensemble nudging implementation in KENDA was not successful) and continuous ensemble nudging between two Kalman filter initializations. The target resolution for the ensemble is 12 km ensuring high resolution uncertainty estimates for the European CORDEX domain (covering whole Europe). A possible further increase of the resolution to 6 km will be investigated with respect to the availability of computing time and storage. Perturbed boundary conditions will be provided by the ERA-20C or NOAA 20CR reanalysis.

Observational input

Basic observation database will be from ECMWF as archived in MARS within the ERA-CLIM project, supplemented by high-resolution conventional observations made available for regional reanalysis by partners within UERRA WP1. All of the RA, the HARMONIE deterministic, the EVDA and the KFENDA at UB will aim to use as much extra new observations archived in MARS from WP1. We can phase the different parallel streams of RA so certain periods with data gaps that can wait for WP1.

Assimilation of cloud/precipitation observations will be pioneered in this project to provide uncertainty information for hydrological variables. This sub-task will retrieve additional hydrological cycle observations suitable for high-resolution reanalysis, namely disaggregated precipitation accumulations and surface/satellite cloud observations for the period of the reanalysis. The EVDA reanalysis will additionally assimilate satellite-based estimates of soil moisture via an Extended Kalman filter (EKF) land-surface data assimilation algorithm.

Extensive validation across the RA runs

The EVDA-derived ensemble regional reanalysis will be evaluated deterministically through a) Comparison of ensemble mean against independent, unassimilated observations, and b) Sanity check on quality of forecast run from ensemble control analysis. Additional evaluation of the EVDA output will be performed within WP3 against gridded observation datasets (e.g. E-OBS), global (ERA-CLIM), and regional reanalysis datasets,

Diagnostics and uncertainties of the ensembles

Probabilistic evaluation will contain standard matches for ensemble reliability and/or resolution, e.g. spread-skill relation, rank histograms, Brier/CRPS scores. Ensemble reanalysis uncertainties will be evaluated by comparing EVDA, HARM, and KFEN datasets against each other and against global RA (from ERA-CLIM).

Additional comparisons will be made against the high resolution deterministic regional reanalyses. Extensive evaluation of the reanalysis ensemble against independent observations, e.g. satellite and in-situ observations, will be performed within UERRA WP3.

B 1.2.9 Estimation of uncertainties

One of the main purposes of the project, once the long-term high-resolution RA datasets have been produced, is to evaluate the uncertainties for a wide range of variables in the datasets.

The ensemble method provides a spread of all the variables that are modeled; mass, wind, temperature, precipitation, moisture and cloud species as well as surface variables, coupled (mainly balanced) in a consistent way through the NWP/DA schemes. This is an advantage, but the spread in one ensemble system will be from this single reanalysis system, so it will measure a dynamic but internal uncertainty in that system.

The second way is to compare different NWP and analysis systems against each other. As different methods are used for deterministic reanalysis within different systems, their comparison can uncover parts of the uncertainty component which are method or system dependent. However, the high resolution deterministic multi-system ensemble will be restricted in number of members by the producing costs.

On the other hand, all the systems share certain systematic errors compared with nature, due to similar assumptions and limits of resolution. These are addressed with the third way, by comparing the ensemble reanalyses, the high resolution or the 2D-downscaled reanalyses with observations.

The third way is to compare ensemble reanalyses, high resolution or 2D-downscaled reanalyses with observations. Even though some studies can be made against some high quality stations, for the most part it will be against gridded datasets that are more convenient for general validations since they are presented on a regular grid and without gaps. It will only be for those variables for which observations were used and at the resolution of the gridding. Over Europe it means 25-50 km for daily temperatures and precipitation (and pressure) but 1-2 km for limited areas for precipitation, snow and temperature. The interpolation methods do of course introduce other errors and especially where and when there are gaps in the observations. An important strength is that the underlying observation dataset in many regions is better than what is available to the reanalyses due to data policies.

Independent validations from other data, such as those space based data that were not included in the reanalysis, or other downstream post-processing applications, will be valuable to understand uncertainties in *some of the* ECVs. Synergies with QA4ECV will be considered within UERRA.

Satellite based ECV datasets, such as the ones produced in EURO4M (by MO, DWD and KNMI), will be included in validations, as well as in-situ data. There are currently over 600 users for the former, several thousands for the latter. Many of these users would be interested in using regional reanalysis products for filling gaps.

Satellite derived cloud and solar radiation data are widely applied, e.g. ECWMF is using the data for uncertainty analysis, AEMET and RMIB used CM-SAF Radiance data to generate their national solar radiation atlas. JRC is using the data within their PVGIS (Phote Voltaic Geographical Information System) to mention a few. The CM-SAF data sets and the ESA CCI (Climate Change Initiative) data sets span several years to decades by now and will be included for validation of the reanalyses.

Pan-European gridded datasets (such as E-OBS) provide a primary reference for the evaluation of precipitation and surface temperature in UERRA. The density of the underlying station data available for these continental datasets is subject to considerable variations due to constraints from national data policies. As a consequence uncertainties in these reference datasets must be expected to vary considerably, with larger uncertainties expected in areas of coarse data coverage, and, due to higher variability, in areas of complex topography and coastal shape. This will restrict the range of spatial scales that can meaningfully be assessed in the evaluation of WP3. Of particular concern are systematic effects of station density on ECV PDFs and on climate indices of extremes.

Many NMHSs have developed gridded surface ECV datasets over national territories and European sub-regions exploiting more comprehensive station data and adopting methods of spatial analysis adapted to the climate of the region (see also Tveito 2012). Two such datasets are part of the evaluation suite in UERRA: The high-resolution daily precipitation dataset for the whole of the Alpine region integrates measurements from several thousand rain gauges and is currently being updated and improved in EURO4M (see also Frei and Schär 1998). A high-resolution dataset of surface temperature, precipitation and snow-water equivalent may become available for Scandinavia using gridding procedures developed at MI (Jansson et al. 2007).

The incorporation of denser station data and the regional design of these reference datasets allows for a more comprehensive evaluation (including the scale-dependence of uncertainty), and the evaluation of snow-water equivalent, thus a more comprehensive - yet regionally constrained - insight into the structure of reanalysis uncertainty.

Downstream products, such as the hydrological modeling from the reanalyses in WP4, will serve as another source of measuring uncertainties (foremost biases but they may have variations over time).
Statistical methods will be employed in order to gauge how far the uncertainties are described in the ensembles. This will lead to probabilistic applications on the ensemble data. Links and extrapolations will be made to the results of the high-resolution deterministic RA. The basis for these estimations will be gridded observational data from EURO4M and WP1, GPCC precipitation (by DWD) and national/subregional gridded datasets for Alps (by MeteoSwiss (EDI)) and Scandinavia (by MI). Drought indices will be derived from the reanalysis products (from WP2) and compared to the drought indices derived from the gridded observation data (by NMA-RO).

UERRA will now include periods with and without satellite observations. The evaluation of these RA should provide a basis for assessing quality and uncertainties in the reanalysis data prior to the satellite era.

The strength of a coordinated evaluation in WP3 is that a common procedure can be applied to the different reanalysis products (deterministic, ensemble and downscaled). This procedure will be applied similarly with reference datasets at the European-scale (in-situ grids and satellite-derived datasets), for special climate features at high resolution in sub-regions and for third-party national evaluation activities, ensuring comparability of results and targeted to user needs. Identification of a set of ECVs, derived indices and time and space scales of primary interest, agreement on a minimum subset of regional reanalyses products for which a distributed evaluation (including external participants) is practically feasible, and definition of a minimum set of evaluation scores, considering spatial-temporal, probabilistic and multi-variate measures, e.g., systematic and random errors, frequency distributions, extreme values, inter-decadal variability and trends, correlations in time and space, cross-correlation between ECVs (UEA, KNMI, DWD) and concepts of probabilistic forecast verification (EDI, MO, DWD). The group in WP3 will also address technical and scientific issues regarding the proper comparison of datasets, such as the consistency in spatial resolution and the conversion between different grids, reference heights, and land-sea masks.

There will be links with user-oriented partners from WP8 (DWD, indicators of primary interest, downstream use of uncertainties), with partners from WP1 (UEA and KNMI). Estimates of uncertainty for some of the reference datasets are derived in WP1 and these will be included in the evaluation process. Measures of uncertainties within the ensemble RA will result from WP2 and basic verification measures from the deterministic RA will also be available and shall be compared with the essentially independent evaluation in WP3.

The estimation of uncertainties includes the following elements:

a) Evaluation of frequency distribution and its change over time (i.e., inter-decadal variations and trends): The possible application of regional reanalyses as climate monitoring products requires that they are carefully evaluated for their reproduction of regional inter-annual to inter-decadal climate variations. For instance, observed in-situ surface temperatures show clear trends in the last century over Switzerland and Germany. Whether the regional reanalysis can capture such (regional) trends shall show whether climate consistency is achieved, especially comparing the satellite area to pre-satellite area.

b) Evaluation of **Ensemble** ReAnalysis (RA): Is the measure of uncertainty provided by reanalysis-ensembles

reliable? This would require adopting concepts of probabilistic forecast evaluation. This subject is not covered in EURO4M. The results would enhance the interpretation of RA ensembles as uncertainty measures.
c) Quantification of uncertainty: The evaluation above can be used for quantifying uncertainties at various space and time scales. This would involve a (geo)statistical modeling of the RA error (taking account of its spatial/temporal auto-covariance structure). Space-/time- scale dependent uncertainty measures are crucial for hydrological applications.
WP3 will compile a synthesis of knowledge on the uncertainties of regional reanalyses, including production related evaluation activities (WP1 and WP2) and including third party evaluation in the light of applications (WP8), and translate into a language that is understood by users. Thus WP3 will give considerable assistance to users wishing to utilize the regional reanalyses products on the European to local scale.

B 1.2.10 Data services, tools and portals

A comprehensive data portal (or portals) and provision of user interfaces are crucial for the work in this project, as well as the accompanying projects, for creating products and interact with users.

ECMWF has valuable experience in these areas, having been a partner in projects like TIGGE (THORPEX Interactive Grand Global Ensemble, http://tigge.ecmwf.int), where ensemble forecast data from nine operational centres is exchanged on a daily basis, archived and served using ECMWF systems. ECMWF led the discussions to encode the data using a common format in order to enable homogeneous access by users. TIGGE data is currently available to users via a data portal (http://tigge-portal.ecmwf.int). ECMWF is partner in another project GEOWOW (http://www.geowow.eu/) where the Centre is going to archive TIGGE-like data from several European Limited Area Models. Again, the common encoding will have to be found so data from different originating centres and models can be accessed and used in a seamless way. This experience will help in the shaping of the data format and encodings to be used for the data produced in UERRA.

“Efficient web-based data services, as well as versatile visualization services” are crucial for optimal dissemination of the large amounts of gridded data resulting from the reanalysis archives (WP2) of this project. Rather than developing yet another portal for access to and visualisation of the ensemble reanalysis raw dataset, the synergies with existing systems and systems under development will be exploited to the full. This will guarantee that “the large amount of gridded data” are “easily accessible by a large number of users, for scientific and policy use”.

This development will be done taking into account existing services (MARS archival/retrieval infrastructure and existing data portals), with a view to extend the datasets available to users to include the output of WP2.
The current data portal offers the possibility to download raw data from the MARS archive with a user friendly point-and-click interface. For large datasets, users can greatly reduce the amount of data to download by using some of the facilities provided, for instance:
- dataset slicing and subsetting: the granularity of retrieval is one field. This avoids having to download un-necessary data volumes and it greatly helps in data discovery (users can inspect few sample fields without having to download complete sets)
- area cropping, by providing coordinates, the system will crop the desired area of interest, delivering only the points of interest
- re-gridding, by providing the desired resolution (for example, in latitude/longitude increments) the system can interpolate into a coarser resolution, which again can greatly reduce the data volumes.
- batch access, the data portals support batch access, which provides users with the ability to script their extractions. This is particularly useful when extracting few variables of long-time datasets, like reanalysis.
- REST api, we are in the process of deploying a RESTful API to the Archive, which allow users to write the extraction scripts in their preferred language, from python, to perl, C language, javascript, etc... This is fully web-based, using standard HTTP protocol.
All these features will be available to UERRA datasets archived in MARS by extending the existing data portals.

INSPIRE view services to display, navigate, zoom, pan and overlay spatial data sets will be employed and demonstrated at least in a prototype and for some of the UERRA data stored in MARS. All the data services and visualisation will be web-based and versatile in that the are INSPIRE-compliant and follow QGC WMS standards.

Facilities are being built to generate WMS services automatically from ESFG nodes automatically with the help of their metada using the OpenDAP protocol. The number of those data sets are is large and growing all the time. For INSPIRE data a viewer has to be configured manually unless the metadata are supplied.

When data from MARS and ESGF is availabile as a WMS service, users can combine and overlay visualisations of the datasets in an online viewer. This will be a very powerful tool for data exploration. This tool is very versatile and combinations of data can be done almost beyond imagination. It is also very efficient since the datasets stay in their existing locations and only subsets are transmitted on Internet for the viewer in a web browser.

The user Workshop in UERRA will help to establish the user requirements in terms of data requirements and access patterns. The adaptation to user needs will be done in close connection with the adjoining CLIPC project.

Demonstrations of the data services and visualisation will be provided in both User Workshops in WP8.

Building on the data dissemination and visualisation work performed in EURO4M, a strong link will be established with the community of developers of web portals and tools elsewhere to be able to disseminate RA and observational data through these existing channels. These “efforts to liaise with other projects, in particular in the context of data access and formatting, avoids duplications” and assures optimal use of resources.

Using the network to which EURO4M contributed, the data sharing activities within the project will follow a service-oriented approach adopting common standards on metadata, data models, and network services as described by the Global Earth Observation System of Systems (GEOSS) Architecture and Data Committee, and in accordance with existing legislation such as the INfrastructure for SPatial InfoRmation in Europe (INSPIRE) Directive. Following these rules will ensure global connectivity and interoperability, also providing appropriate links to the WMO Information System (WIS). The INSPIRE-compliant infrastructure will enable considerable data-sharing efficiencies between this project and the various Copernicus services requiring access to climate-related data.
Over the years, ECMWF has developed a service oriented infrastructure to provide access to its archived data. Users can retrieve, transform, manipulate and visualize data on-demand using OGC (Open Geospatial Consortium) Web Map Services according to international standards. This infrastructure will be further developed and scaled up to meet the UERRA requirements in terms of access to the data.

Starting from the work in the TIGGE-LAM project, **ECMWF** will make (part of) the reanalysis data developed in WP2 available to the meteorological community, focussing on but not limited to the datasets relevant for the evaluation in WP3) through the MARS archive at ECWMF. This archive will hold subsets of every reanalysis dataset produced in WP2, stored in a common format (but still using the original grid and resolution).

The MARS archive at ECMWF is popular among the meteorological community, but users in the climate change research community and users from other communities usually employ different archiving systems, in particular through the ESFG. For this outside world, **KNMI** will assess the requirements for connectivity to existing data portals, capitalising on the benefits associated with an adherence to standards, interoperability and consolidation. The goal is to facilitate that the data produced in the project are made available through an ESGF (Earth System Grid Federation) node; see http://www.esgf.org/ . This requires that the dataset developers within WP1 and WP2 meet particular criteria for data format and metadata to facilitate dissemination as OPeNDAP, NetCDF, and WMS. **KNMI** will investigate what needs to be done and together with **SMHI, MF and MO.** (the dataset developers in WP1 and WP2) will seek to implement these requirements. We will benefit from the examples of similar work for the dissemination of large volumes of model based climate projections in ongoing projects such as IS-ENES, METAFOR, CHARMe, and EUPORIAS (in which SMHI, MF, MO, DWD and KNMI are participants). For each dataset the work required will be slightly different because the native archive for nearly each dataset is different.

The work will be done in close coordination with CLIPC because this consortium will provide access to simulated and observed climate datasets by developing an internet based one-stop-shop that provides access to model generated as well as satellite and in-situ based INSPIRE-compliant climate relevant datasets. SMHI and KNMI participate in CLIPC which intends to develop a ESGF backend to provide INSPIRE compliant services. Data from UERRA will be available to this consortium and the community at large without delays. The CLIPC project can be expected to extend the dissemination of UERRA products to a an even wider range of users.

B 1.2.11 User-oriented products

Building on the Climate Indicator Bulletins (CIBs) developed in EURO4M, **KNMI** will develop a core set of 26 climate change indices on the basis of the reanalysis data. These indices will follow the definitions recommended by the CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices (ETCCDI). They are calculated in a similar way for other regions of the world and for other data sources. An additional set of indices will highlight particular characteristics of climate change in Europe. Each index describes a particular characteristic of climate change (both changes in the mean and the extremes). Using the uncertainty information developed for the reanalysis and observational data products in WP3, the uncertainties associated with the derived indicators will be assessed and quantified too. All indicator information will be updated every month using newly available reanalysis and observational data. This information is most relevant to the development and assessment of policies. The trends in the indicators will be assessed in order to help understanding past climates and climate change in Europe.

B 1.2.12 Overview of the different models used

MODEL	MO control	MO Ensemble	HARMONIE 2 versions	COSMO Ensemble
Assimilation system	Hybrid 4D-VAR/ Ensemble Transform Kalman Filter	Ensemble 4D-VAR	3D-VAR	Localised Ensemble Transform Kalman Filter, Ensemble nudg
Forecast model in the data assimilation	3D Non-hydrostatic with subgrid physical parameterisation	3D Non-hydrostatic with subgrid physical parameterisation	3D Non-hydrostatic with subgrid physical parameterisation	3D Non-hydrostatic with subgrid physical parameterisation
Resolution	12 km ~70 levels	about 36 km ~70 levels	11 km ~65 levels	6 km (or 12 km)~40 levels
Ensemble	Control only	20 members	2 members for part of the period, otherwise only one	10-20 members
Period	1978 - 2013	1978-2013	1961-2013	5 years test period
Forcing model	ERA-INTERIM/CLIM	ERA-INTERIM/CLIM	ERA-INTERIM/CLIM	ERA-INTERIM/CLIM
Observations	Conventional and satellites	Conventional and satellites	Conventional plus large scale forcing from ERA	Conventional plus satellites

Table 2.1. Overview of the 3D RA models used.

Model	MESAN	MESCAN	HYPE	SURFEX/TRIP
Type of model	2D sophisticated statistical interpolation analysis	2D sophisticated statistical interpolation analysis	Hydrological physical model	Surface flux model / hydrological physical model
Background	Downscaled HIRLAM or climatologically adapted	Interpolated HARMONIE model values	HARMONIE or ERA precipitation and temperature	MESCAN atmospheric variables incl. precipitation
Observations	Surface and climate networks, cloud or radar precipitation	Surface and climate networks	Discharge fo validation	no
Resolution	5 km	5 km	Catchment areas median 215 km^2	25 km -> river discharge

Time period	1982-2011 for clouds	1961-2013	30 years	~30 years

Table 2.2. Overview of the 2D near surface/soil and hydrological models used

B 1.3 S/T methodology and associated work plan

B 1.3.1 Overall strategy of the work plan

The most time-critical work will begin in two parallel strands, one focusing on the observations and datasets based on observations WP1). The other one is the big WP2, which will develop and run the actual reanalyses and ensemble assimilation RA. There are developments of the ensemble methods for RA in the beginning of the project. Components of the RA system will be enhanced, like the coupling to the surface and its assimilation. Also the variational analysis will be adapted and optimised for the domain chosen. Apart from soil related fields, the handling of sea surface temperatures and ice cover and boundaries will be implemented in the optimal way for the project.

These initial activities will mainly be carried out over the first year and there will already be some RA results after the first year. During the first year the results will be evluated and the best configuration of the RA system will be employed for the continuation of the project. The initial year in WP2 will mainly only impact on its own tasks.

The data rescue and data development (quality improvement) will take place through most of the project and some of the resulting data, when entering into MARS at ECMWF, will be used for the RA in UERRA itself. This is particularly the case later in the project there are possibilities to use more data since the RA will be run in different streams, e.g. from 1989 first and only later doing from 1961.

Towards the end of the first year of UERRA the heavy production runs will start. They will need a lot of computer resources and data to run and also the manual work on supervision of runs and basic diagnostics and checking will be demanding. There are dependencies from the high-resolution HARMONIE RA for the MESCAN 2D downscaling which also is very demanding in resources for the whole of Europe.

WP1 will continue to deliver recovered observations from the areas and types of most importance to the project. The observations will be added to the archives, foremost the one at ECMWF, and they will thus also benefit later RA efforts that can be foreseen. Observations of the daily values will also enter the E-OBS and CRU datasets and gridded data will hence be extended intermittently. These datasets will be used for WP3 in the evaluation and, even though the datasets from the beginning of UERRA will suffice for most purposes, the enhanced datasets will be more complete and more up to date.

The evaluation and uncertainty estimation part may not seem as time-critical as the first two WPs but there is important work in the first task to agree on common basic evaluation methods. This can have an impact on how the data from the RA is delivered and on internal validation in WP2. Furthermore the agreed methodology will be tested in the beginning using EURO4M RA. The products from WP2 will be available for a part of the RA period, for a couple of decades in most cases, and the evaluation proper will start using the available time series during year 2. Particularly the uncertainties from the ensemble RA will be very important to compare with the ones with respect to individual RA or gridded datasets. There is an interaction between the developers and executors of the RA in WP2 and the evaluation in WP 3 since all that common work is done together within WP3.

The user interaction and requirements of data will be established early in WP8 and the data archiving of the user-defined data will start early in WP4. Data services and dissemination will build on developed tools as far as possible and in two complementary ways. They are targeted to different user communities with particular standards. Throughout the project archiving and data dissemination to early users, not at least to the consortium in CLIPC, will take place. Interaction with ongoing projects, policy makers and users also outside of Europe will take place.

B 1.3.2 Timing of the Work Packages and their components

Table 2.3.2 GANTT diagram of timing of WPs and tasks

	Year 1												**Year 2**												**Year 3**												**Year 4**											
	Q1			**Q2**			**Q3**			**Q4**			**Q1**			**Q2**			**Q3**			**Q4**			**Q1**			**Q2**			**Q3**			**Q4**			**Q1**			**Q2**			**Q3**			**Q4**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
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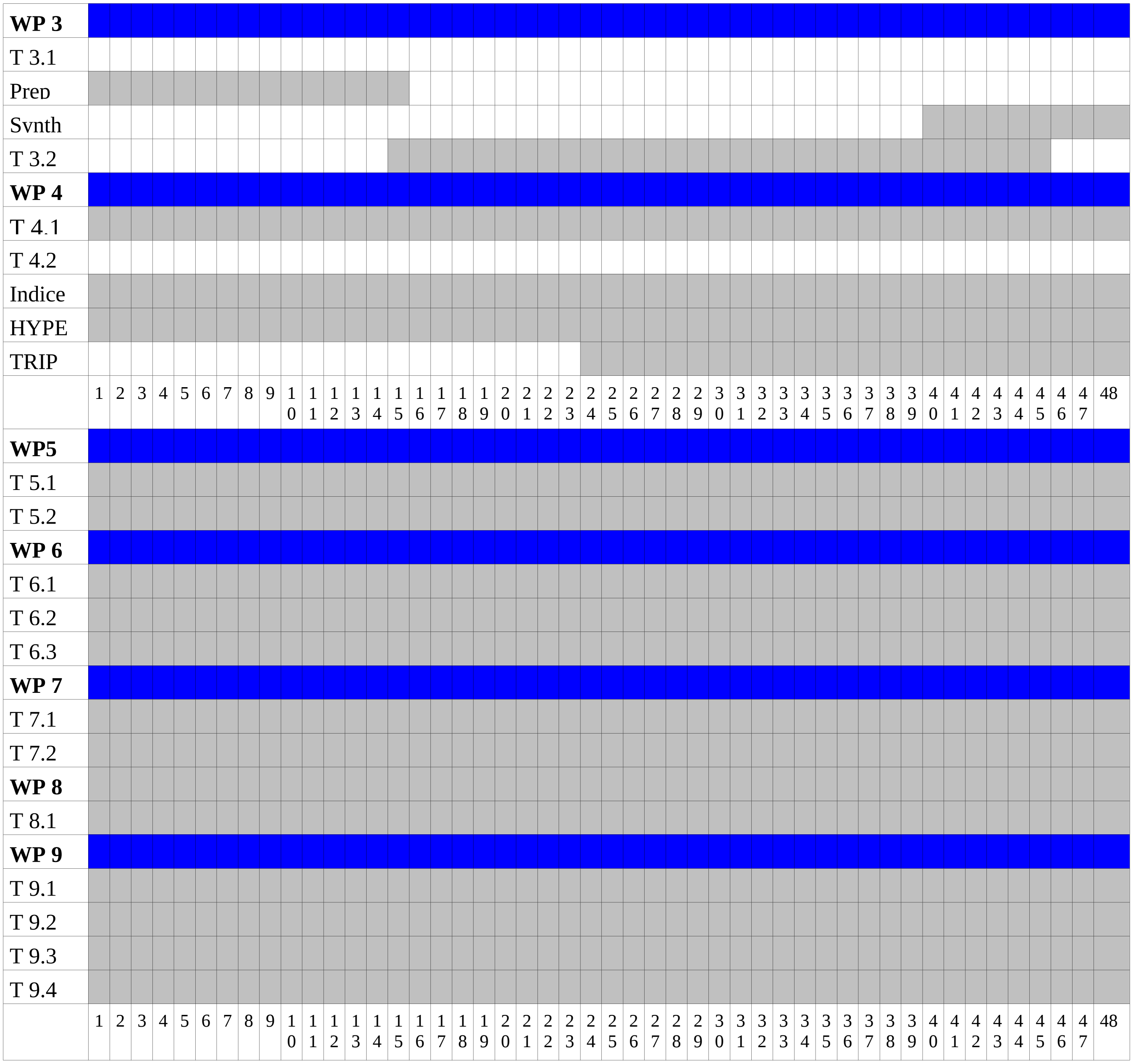
WP 3
T 3.1
Prep
Synth
T 3.2
WP 4
T 4.1
T 4.2
Indice
HYPE
TRIP
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
WP5
T 5.1
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WP 6
T 6.1
T 6.2
T 6.3
WP 7
T 7.1
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WP 8
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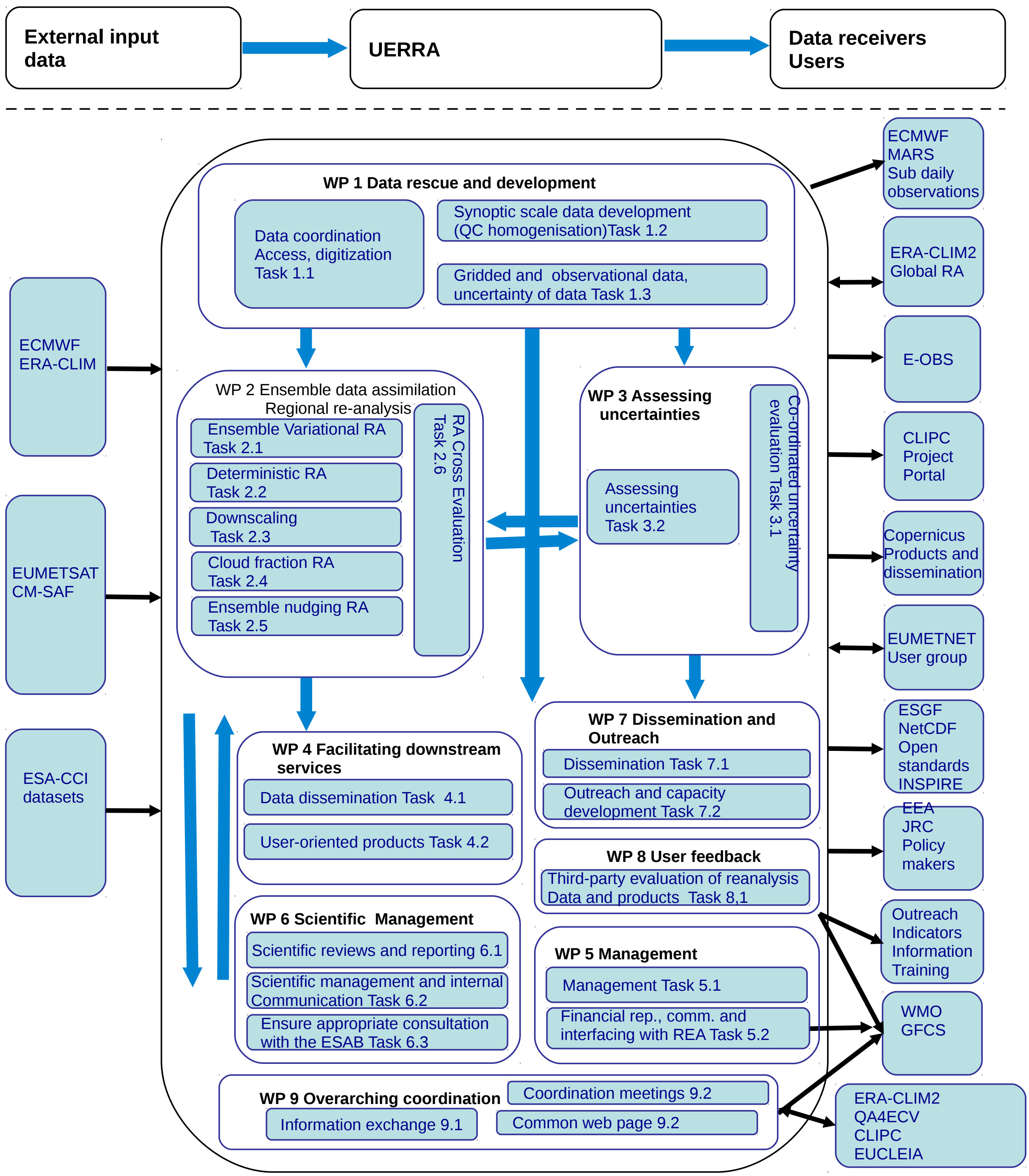
WP 9
T 9.1
T 9.2
T 9.3
T 9.4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48

B 1.3.3 Interdependence of the work packages



B 1.3.4 Risks and contingency plans

UERRA has ambitious goals in all of its four areas and with both important scientific and technical developments, and in particular with a very demanding large-scale computing and data handling component.

There are dependencies on EURO4M data deliveries for the evaluation WP3 to start their developments. EURO4M has also a lot of RA computational work left to do and it has already been advertised that there are delays, but they are not insurmountable. It is still planned to finish the 20 years of RA before the end of the project. If there are unforeseen problems during the remaining time of EURO4M, it might result in that the full 20 year period is not ready. Still, based on the number of years archived 2012, most of the period will be there. For the developments of data services and methodology, a shorter period is e.g. 15 instead of 20 years will be used.

There is a strong coupling to the driving global RA from ECMWF and UERRA hopes to be able to use the ERA-SAT planned to be ready for mid 2014. Before that, a significant part of the satellite era data will be available anyway, and such a period can be chosen in WP2. During the first year of UERRA there is more of development than production, so the full period is not at all needed then. There is also ERA-Interim available albeit at lower resolution, but fully usable for deterministic RA. The ensemble global RA from 20th century will take a few years more. To summarize, in UERRA one can chose the period to run to be one for which the latest global ECMWF exists, but there is a backup in the ensemble RA that has been run in ERA-CLIM.

For observation rescue data policies may be an issue, but EU and the User community drive NHMSs towards open policies and UERRA and other funded efforts require data to be publicly available in MARS at EVMWF. A perhaps more worrying aspect is that the economic crisis in Europe starves many institutes of public funding and technical facilities, or staff for data services, may be withdrawn. There has been one such recent example in Spain. A non-availability of parts of the intended observations is not crucial since a reduced choice had to be made in UERRA due to budgetary constraints in the project. If one data source poses difficulties, then there will be others to choose from anyway. Rescued observations will only in part enter into WP2 RA through the archives at ECMWF and the rescue efforts should be seen as a long term issue which will benefit also future regional as well as global RA

There is no other need of EO data than what is available at ECMWF through MARS or what is already available from ESA at DWD.

The funding situation in many NHMSs is difficult and new staff may not be recruited. For the UERRA, the partners are recruiting scientists for the project or assign internal resources. The staffing situation will be monitored by the Coordinator through direct contacts and in the regular MST meetings and every effort will be made to make sure partners can deliver their work on time.

There are some scientific risks in the novel developments for regional ensemble RA. The concept has been demonstrated at the Met Office and builds on their global capacity. The Met Office has a large DA group and with internal support, any unforeseen difficulties will be remedied. For UB there is a more of new methods to be developed and this is the aim for UB in this project. There is not a strong dependence on a long production period; it is more important to show and compare with the other partners which is only possible if UERRA goes ahead. The multitude of models and assimilation methods is desirable, but a relatively short period of several years is still valuable to show the expected spread in the uncertainties. If the UB RA unexpectedly is deficient, it is mainly a matter for the one Deliverable, but UERRA can base its uncertainty estimations on the other RA and the ensemble RA from the MO.

The computational risks are mainly in terms of possible delays in production of RA. The partner's memberstate allocations on the ECMWF computer systems are going to be used for much of the RA work (except Météo-France). The upgrades of ECMWF computer facilities are planned and approved, so there is very small risk of serious delays. The situation will be monitored in the MST and GA meetings and if there is possibility for serious delays, alternative computer resources will be sought (e.g. at home rather than at ECMWF). The products and uncertainty information will in the meantime, in case of delays, be based on a shorter period than otherwise.

Data services and dissemination build on developed concepts and many of the facilities and further more there is synergy with the project CLIPC in this call.

The Coordinator has long and good experience of running distributed large projects and of participating in other projects, as well as management experience. There is a strong administrative support through SMHI's EU "bureau". There is a group of experts available which provides backup, should it be necessary. The WP leaders are experienced and are supported by strong home institutions.

B 2 Implementation

B 2.1 Management structures and procedures

UERRA is a large and strategically very important project for the consortium. The partners consider competent and efficient project management as a key task to achieve the project objectives in the most effective way. The project management task is therefore adequately resourced, a dedicated work package (WP5) is devoted to the project management. WP7 includes the tasks necessary to adequately disseminate interim and final results of the project. The project is coordinated by Per Undén from the Swedish Meteorological and Hydrological Institute (SMHI).

The management structure of UERRA is designed to allow fast flow of information between partners, project administration, the REA and thus the European Commission and the outside world (e.g. User Community, Advisory Board and adjoining projects). It is kept as simple as possible to minimize frictional energy losses along these paths. It addresses the specific challenges related to the complexity of the task, the size of the consortium and the duration of the project. Central will be the project administration at the Swedish Meteorological and Hydrological Institute (SMHI). All practical administration of FP7 instruments, financial, reporting and contractual matters will be handled by experienced project administrators, where the UERRA project administration will be located. The scientific management of the project will be integrated within a hierarchical but flexible decision-making structure involving the coordinator, a dedicated WP6 and the Management Support Team. Principle ways of communication are the internet (e-mail and web), teleconferences and project workshops, including general assemblies and task-specific workshops. Figure 2.1 shows the general management structure of UERRA

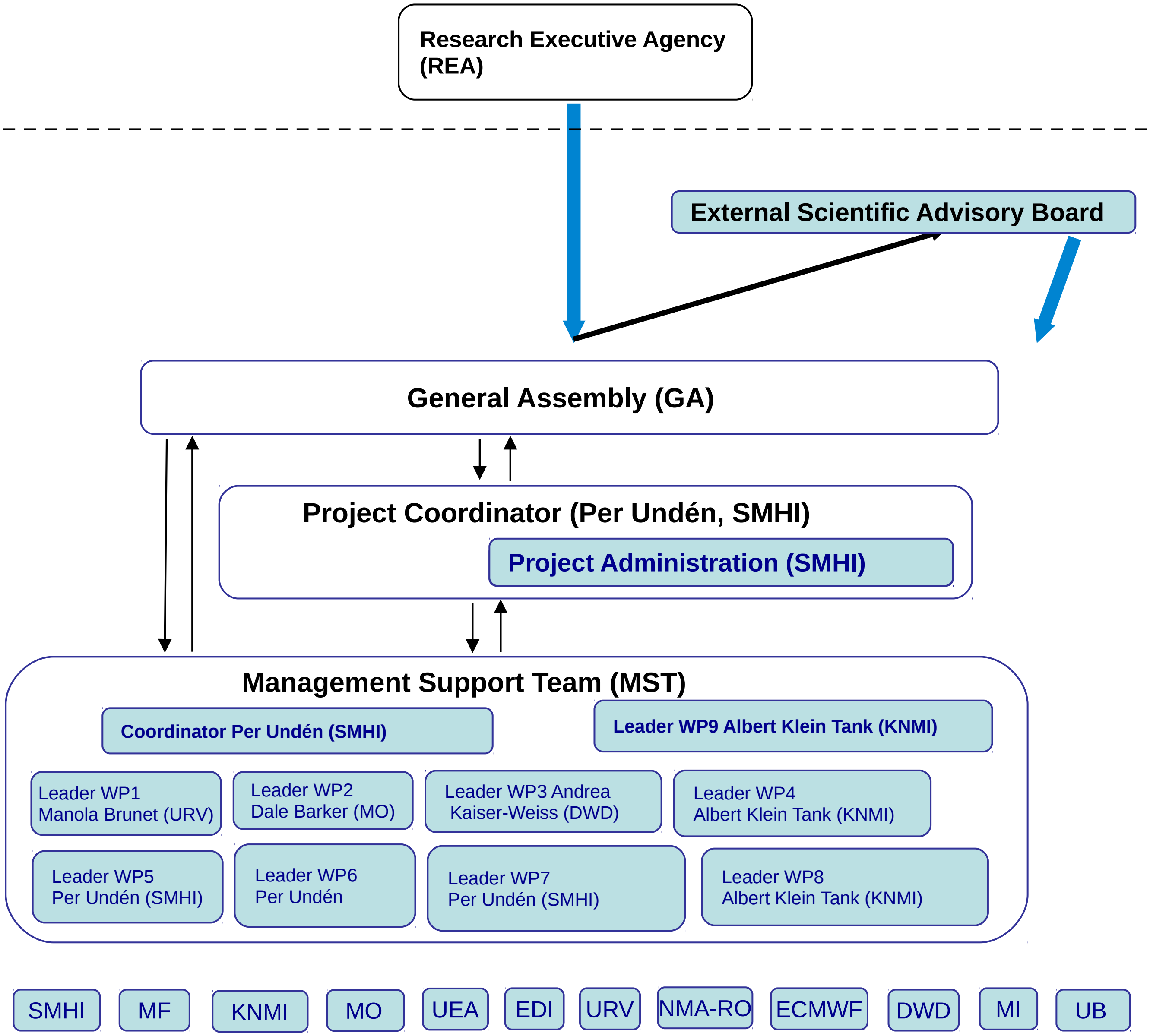


Figure 2.1: Project management structure of UERRA

B 2.1.1 Decision making and executive bodies

The General Assembly (GA)

The General Assembly is the overall decisive body of the consortium and constitutes representatives from all institutions presented in section “3.2 Beneficiaries”. It is this board which validates the major decisions concerning the project. The General Assembly is the arbitration body for all decisions proposed by the Coordinator or the Management Support Team (MST). Thus, any Beneficiary may submit for arbitration by the General Assembly any decision by the Coordinator or proposals by the Management Support Team it deems to be contrary to its interests. The General Assembly is also the decision-making body for any issue concerning the proper operation of the Consortium. In principle, approval by the General Assembly shall be given by mail vote, upon proposition by the Management Support Team. Formal meetings of the General Assembly will be held at least three times during the project, in connection with the reporting periods. Members of the External Scientific Advisory Board and selected members of the user Community will be invited to join the meeting of the General Assembly. The matters to be acted upon by the GA include:

- Political and strategic orientation of the project;
- The Consortium’s work plan and plan for using and disseminating the knowledge and their regular updates;
- The Consortium’s budget and the financial allocation of the EU’s contribution between the various research and dissemination activities on the one hand, and between the Beneficiaries on the other;
- Validation of the realised expenditure in accordance with the budget;
- Changes in the Consortium membership;
- Any major change in scientific plans relative to the initial agreed implementation plan;
- Any major reallocation of budget between partners;
- Any alterations of the Consortium Agreement;
- The acceptance of new Beneficiaries as well as any exclusion of Beneficiaries;
- Any premature completion or termination of the project;

Rules for decision making and problem resolving process will be defined in detail in a Consortium Agreement. The General Assembly will be chaired by the project coordinator.

B 2.1.2 The Project Coordinator

The project will be coordinated in all financial, administrative and managerial aspects by SMHI which assumes responsibility for the project management in all aspects as stated by the European Commission contracting rules. Per Undén will act as the project manager. Per Undén has a long track record of project coordination. Between has held the position as HIRLAM Project Leader (now called Programme Manager) for two 3 year terms, 2000-2006. HIRLAM is a modeling consortium of 8 countries NHMSs plus one associated member, at that time. (High Resolution Limited Area Modeling). It is a coordination of modeling development on a common large system of code and scripts for research and operational NWP forecasting. There is management of equivalent of about 22 person-years of scientists in the member institutes with extensive planning and reporting and a management structure, and limited financial management. Before this period, and after, Per has held middle-level management positions in research both at ECMWF and then SMHI. . The Coordinator will be responsible for the management of UERRA and liaison with the REA on behalf of the consortium. He will also be the principle contact to the financial administration at SMHI. If and when necessary he can propose to convene full General Assembly meetings.
The Coordinator, assisted in the day-to day work by the members of the project office has the responsibility of overall co-ordination and management of the project, including:

- Communication of all information in connection with the UERRA project to the REA.

- Preparation of the project deliverables and address them to the REA, after validation by the Management Support Team;
- Make progress reports on the state of advancement of the project;
- Establish the Project Deliverables for the REA;
- Propose changes of the Project budget to the General Assembly as well as the re-allocation of funding between the Beneficiaries;
- Propose and implement the competitive selection procedure for new Beneficiaries;
- Make proposals to the General Assembly for changes in consortium membership;
- More generally propose any and all decisions required for the proper conduct of the project.
- Day to day co-ordination of the project; monitors project planning and progress, deadlines, bottlenecks, deliverables;
- Communication within the project, to users, and to the general public;
- Organisation of meetings and internal reviews;
- Preparation of the quality control and documentation plan;
- Taking part and contributing to the overarching coordination (WP9)
- Co-ordination with other EU – funded or other international projects;
- Overall administrative and financial management,
- Management of consortium-level legal and ethical issues

B 2.1.3 The Management Support Team (MST)

The main role of the Management Support Team is to provide assistance to the Coordinator in terms of following up the progress in UERRA, making propositions to the General Assembly on the project work plan, budgets, and other matters necessary for the project advancement and success and to implement the project decisions approved by the General Assembly.
The composition of the Management Support Team is proposed by the Coordinator and confirmed by the GA. It will include the Work Package leaders and the Coordinator, who chairs the MST. The Management Board will meet at least every 6 months. This may be in form of a telephone conference but they will all meet at the GAs.

WP leaders have been appointed for each of the project WPs. WP leaders are specifically responsible for ensuring the implementation of the WP is consistent with the overall workplan and with the other project components. This entails in particular: a) the continuous monitoring of the implementation of the Tasks within the WP, b) keeping the coordinator and the other members of the MST regularly informed of any problem arising therein and c) ensuring that the interactions between the WP and other project WPs and Tasks are consistent with the specifications of the workplan. For both planning and monitoring the WP leader will be assisted by designated task leaders within the respective WP. The WP leaders shall ensure that partners deliver in time and with good quality input to the WP deliverables and, furthermore, prepares for technical audits by sending all relevant information on technical progress and results.

The Coordinator will take advice from the MST at regular intervals and keep communication or convene extra meetings with the MST when deemed necessary by the Coordinator or when called by a member of the MST.

Implementation of the plans under knowledge and innovation-related activities, intellectual property issues and Gender Action Plan will be under the responsibility of the coordinator.

B 2.1.4 The Coordinator and Project Administration (PA)

The Project administration (PA) at SMHI will comprise the coordinator and administrative support, with comprehensive financial and administrative work carried out by staff in the SMHI financial department. The PA maintains the project communication instruments: web site with public and restricted areas, mailing lists and newsletter. The PA will assist the Coordinator in the preparation of the reporting including finances and in the financial actions between the REA and the project partners. The Coordinator will be responsible for organizing the consortium general assemblies.
The responsibilities of the financial administration of UERRA include:

- receiving the entire financial contribution from the REA. With advice from the Project Coordinator it will manage this contribution by allocating it to the Beneficiaries pursuant to the “Work Plan” and the decisions taken by the appropriate bodies.
- preparing accounts, if requested by the REA or by the Beneficiaries, to inform them of the distribution of funds among the Beneficiaries;
- the overall financial management of the coordination,
- keeping track of budgets
- coordination of the financial reporting in line with the financial rules of FP7
- clarifying any problem pertaining to the budgets that might be raised, both from the partnership and from the REA

B 2.1.5 External Scientific Advisory Board (ESAB)

UERRA will establish an External Scientific Advisory Board (ESAB) with distinguished scientists to ensure external evaluation of the project progress, commenting on the progress in achieving the plans, provide recommendations for new actions and activities in the area by liaison with the Management Support Team (MST), increase the project visibility and strengthen its links to international programmes and other activities outside Europe. The ESAB will receive an executive report in connection with the Periodic Reports detailing the status of the project together with specific requests for advice. The ESAB will meet at at least three times during the project, either in person or by teleconference, if necessary extraordinary meetings will be scheduled.
The regular consultation of the ESAB will help that the UERRA products support the aims of the EC policies and the wider international climate services community ensuring that the project remains directly relevant to the Copernicus and GEO polices and implementation plans.
The functions of the ESAB will be:

- to advice on the project's scientific approach and monitor the progress. It will interact with the Coordinator, MST and the Partners during the GAs.
- to advice on how the project's outreach in Europe and beyond.
- provide a link with RA, observational activities and derived products for climate monitoring from in-situ and space based instrument, outside Europe.

- make recommendations for new actions in this area as to gain maximum benefits also after the project.

The UERRA collaborating institutes and name of the members intended to invite to the ESAB are:

- ECMWF (even though a Partner, but the ESAB member would be from a different area)
- EEA
- EC, DG CLIMA

The exact composition of the ESAB will be decided at the start of the project in consultation with the REA. UERRA has reserved within WP6 funds to support the participation of the ESAB in personal meetings.

B 2.1.6 The Overarching Coordination activities

The five projects ERA-CLIM2, UERRA, QA4ECV, CLIPC and EUCLEIA from the 2013 FP7 Space call have the common obejctive of preparing for a future Coopernicus Climate Change service. The coordination between these projects and coordination of exchanges with potential users and stakeholders is organised through a common WP (9) in all five projects. Dr Albert Klein Tank and KNMI leads this WP but the Coordinators or the five projects particicipate and share the work. Dr Klein Tank's work for the overarching coordination is funded from the UERRA budget.

B 2.1.7 Other management issues

Project meetings
The project kick-off meeting marks the effective launch of the project. It reinforces the common purpose of all partners, and identifies the responsibilities of each in the endeavour. Unresolved technical issues will be identified and debated; science and co-operation between Work Packages initiated. The coordinator and WP leaders will outline the project aims and what is expected of each group in terms of results, performance and reporting. Other project meetings are timed with the preparation of the reports for the periods of month 1-12, 13-30, and 31- 48. They will involve all the participants, and take place at months 12, 30 and 48 or very soon thereafter. They will be complemented and prepared by MST meetings to be held in the shorter time frame. Additional MST meetings may be convened as required. Topical working meetings will be organised by the Work Package leaders as needed for the progress of their specific tasks.

Internal Communication
The communication strategy adopted in the project aims at keeping all the partners fully informed about the status of the different activities underway. The target is maximum transparency for all involved parties and hence increased synergy. All reports produced (like meeting and project reports, publications etc) will be communicated to the project office and channeled to other partners when appropriate. The project administration will likewise distribute to the partners relevant information obtained from sources outside the project. All documents will be properly indexed and available to all partners on a project web-site. The web site will consist of a public area and a restricted access area.

Management of outreach activities

Science to Science communication:
The Coordinator will represent the UERRA at some European or international conferences about Climate services and reanalysis (like EMS/ECAM annual meetings, one or two reanalysis conferences. Also, or alternatively, the appropriate WP leaders may attend such conferences.
Science to Policy communication: EU policy briefs will be given, normally in written form, but also some EU meeting may be attended by the Coordinator or one of the WP leaders. National Climate Policy meetings will be natural for the individual partners to attend but they can often take place outside the scope or funding from UERRA, as they are part of the normal duties of partner institutes.

Science to Society communication:
The User Workshops in WP8 will be the most important vehicle for interacting with stakeholders and different sectors of society. The scientists working in WP8 will obviously be active in the workshops as will the Coordinator and other WP leaders and also scientists from other partners.

The meetings in the Climate change and adaptation areas both nationally and internationally will be attended by several UERRA researchers and results from the project conveyed. A selection of such meetings will be attended by the Coordinator or WP leaders and the MST will see that the most important of these have UERRA representation and two way communication take place. The MST will prioritise the meetings in terms of using UERRA funding and the Coordinator will in addition have dialogues with individual partners to promote participation. The travel budget includes a number of external meetings, so the priories are important to deal with in the MST meetings.

The UERRA website will be promoted as a source for information about the regional reanalyses and development of uncertainty information. The Coordinator with support from the MST will regularly review the information contents and adapt to societal needs throughout the project.

The WP leader for Overarching coordination (WP9) will make sure that UERRA and the other GMES projects are represented and take active part in in additional meetings where stakeholders are present.

B 2.2 Individual Participants

Beneficiary no 1: SVERIGES METEOROLOGISKA OCH HYDROLOGISKA INSTITUT (SMHI)
Expertise and experience of the organization
SMHI is a government institute under the Swedish Ministry of Environment. With expertise in all the environmental fields of meteorology, hydrology, oceanography and climate, it provides forecasting services, monitoring and consulting services in all of these fields to society to suppor decision-making and to save life and property. SMHI has a large R&D activity and a well developed IT infrastructure with super computing resources with partners in Sweden (National Supercomputing Centre) as well as its national share of the ECMWF (European Centre for Medium Range Weather Forecasts). ECMWF is most important for its use in weather (and oceanographic) forecasting but SMHI has also cooperation on model and archiving codes. Meteorological models are developed within the HIRLAM and ALADIN model consortia in Europe. SMHI has particular experience in Data Assimilation and reanalysis related to those models. There is an important and wide activity in regional climate modelling at SMHI with both meteorological and oceanographic modelling and coupling. On the global scale SMHI is part of the EC-EARTH consortium and runs global climate projections as well. SMHI is also active outside of Europe in modelling of climate, hydrology and air-pollution (S America, Africa and Asia).

Role and contribution
SMHI acts as coordinator of UERRA. SMHI's activity is in this WP(2) but also with hydrological evaluation in WP4.

Principal personnel involved:
Per Undén is senior scientist in the meteorological modelling section and has until just recently managed this section including the SMHI part of several of its external projects in Wind Energy and satellite radiance assimilation (Swedish Energy Agency and Swedish Space Board) and EU (FP6 DAMOCLES, Marie Curie SEAMOCS, PREVIEW Windstorm and FP7 EURO4M). He has a long experience in Data Assimilation at

ECMWF and after that managed the HIRLAM international modelling consortium (http://www.hirlam.org/) for two terms.

Dr Chantal Donnelly is senior scientist in the hydrological research section and has a wide experience in water resource engineering, spatial analysis and is responsible for continental scale hydrological and nutrient transport modelling. She is managing SMHI's part of the FP7 projects GEOLAND2, SUDPLAN, OPERR and has done so for ECOSUPPORT (Bonus) and FP6 MYOCEAN. Her research is in large-scale discharge and water quality modelling with application to climate.

Dr Tomas Landelius is a senior scientist in the Atmospheric remote sensing group. He is experienced in mesoscale data assimilation and analysis and has been heavily involved in the SMHI part of the EURO4M project, especially concerning the development and use of the surface analysis systems MESAN and MESCAN. In UERRA he will work in WP2 with the 2D cloud fraction reanalysis and surface related issues for the HARMONIE 3D-VAR re-analysis.

Dr Magnus Lindskog has a long experience Data Assimilation R&D with the HIRLAM and ALADIN systems (now called HARMONIE). One of the main goals for HARMONIE is to develop a km scale operational NWP system. Magnus has extensive knowledge of observation handling including use of satellites and 3 and 4-dimensional variational assimilation (4-D VAR). He is implementing 4D-VAR within the HARMONIE system including use and quality control of observations.

Per Dahlgren is also senior scientist within the modelling research section and has extensive knowledge of observation coding, quality control and handling. Another extensive area is all the aspects of satellite radiance assimilation including bias correction, He has developed the large-scale constraint J_k in HIRLAM and is working with the actual reanalysis and observation diagnostics in EURO4M.

Beneficiary no 2: METEO-FRANCE (MF)

Expertise and experience of the organization

Météo France (MF) is the national research and information centre for weather and climate. The meteorological research is a major part of the activity of MF. With 250 researchers, MF plays a leading role in the international community, especially in the fields of climate research and atmospheric modelling. The NWP models, developed jointly with ECMWF for the global model ARPEGE-IFS and the ALADIN Group for a small scale numerical limited area model ALADIN and recently for the NH-model AROME. MF owns and maintains a climatological database which archives data acquired by more than 1300 automatic stations and over 3200 weather stations, some of which go back to 1850. This dense observation network allows statistical studies for research purposes and the elaboration of decision support tools for various sectors of the economy.

MF participates actively in several European collaborations, including EURO4M, EUCLIPSE, HIRLAM, EUMETNET, Copernicus, and ENSEMBLES.

Role and contribution

Météo France is mainly active with RA in WP2 and then with a surface and river discharge application in WP4.

Principal personnel involved:

Eric Bazile is senior scientist at the research center of MF (CNRM-GAME) since 1991. He has several years of experience in the fields of surface data assimilation, surface and boundary layer parameterization for NWP (GEWEX/GABLS, EUCLIPSE). He has been involved and collaborates with both the HIRLAM and ALADIN consortia since 1993, in particular during the development and the operational implementation of the soil moisture assimilation and the ISBA scheme. He is member of the coordinating group in the NetFAM project (Nordic Network on Fine-scale Atmospheric Modelling) and the Meteo-France coordinator for the EURO4M project.

CNRM (Centre National de Recherches Météorologiques) is the research organisation funding much of the MF research and GAME (Groupe d'etudes de lÁtmosphère Météorologique) is an eqivalent name for CNRM used for external evaluation. CNRM-GAME constitutes a group within MF as well as some external research institutes. All the personnel mentioned here are staff employed and managed by MF.

Dr Jean-Francois Mahfouf is head of the "Observation" Team from the CNRM-GAME numerical weather prediction research branch since 2011. He worked at CNRM-GAME from 1988 to 1994 with main activities on land surface processes for NWP and climate modelling. From 1995 to 2002, he performed research at ECMWF on global variational data assimilation and on land surface analysis. He worked at Environment Canada from 2002 to 2006 on mesoscale data assimilation of soil and precipitation. In 2006, he moved back to CNRM-GAME with main activities on meso-scale data assimilation of soil and boundary layer observations. He is a Member of the Royal Meteorological Society since 2000.

Eric Martin is head of the CNRM-GAME team involved in atmosphere-surface-hydrology interactions research. This team has used and validated the SAFRAN analysis system at the scale of France and is involved in the EURO4M project for the validation of surface variables produced by a land surface model forces by the 2D analysis developed in the project. Eric Martin has a long experience in surface processes modelling, including snow cover modelling. He will be involved in the the validation of the new analysis system by comparison to existing analyses and datasets.

Jean-Michel Soubeyroux is head of the « Hydro-Climatological Analysis and Watch » Department at Direction de la Climatologie, Météo-France. He has a good experience in hydro-meteorological applications (climate monitoring, extrem events analysis, impact of climate change) and in the coordination of scientific projects (see ClimSec project). His department is in charge of the operationnal run of the hydrometeorological system Safran/Isba/Modcou and of regular climatic publications over France.

François Besson is engineer in the Climate Data Management team at MF. Since 2010, he is in charge of the operational hydrometeorological model system called SAFRAN-ISBA-MODCOU and will be in charge of the validation of the new system based on MESCAN (developed during the EURO4M project) and SURFEX.

Beneficiary no 3: KONINKLIJK NEDERLANDS METEOROLOGISCH INSTITUUT-KNMI (KNMI)

Expertise and experience of the organization
The Royal Netherlands Meteorological Institute (KNMI) is the national research and information centre for weather, climate and climate change in the Netherlands. KNMI has a long tradition in operational and scientific activities. Climate research at KNMI aims at observing, understanding and predicting changes in the climate system.

Role and contribution
KNMI will contribute to UERRA by developing and updating gridded datasets (E-OBS), and by evaluating the uncertainties in the regional reanalysis products. KNMI will also be involved in the data dissemination and outreach activities.

Principal personnel involved:
Dr. Albert Klein Tank has been working as a scientist for KNMI for almost 20 years. He is actively involved in observational research embedded in international projects and programmes. Albert Klein Tank co-ordinates the FP7 EURO4M project, and leads the ECA&D project (eca.knmi.nl) that joins over 40 meteorological services in Europe and the Mediterranean. The latter project has proved to deliver high quality observational datasets and derived information on indices for studying extremes. He has been involved in the production of the IPCC-WGI-AR4 and AR5 as a (coordinating) lead author of the chapter on observations. He is currently co-leading the CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices. In the Netherlands, he is responsible for the national climate change scenario activities at KNMI.
Dr. Gerard van der Schrier also is a scientist at KNMI. Following a post-doctoral at the Climatic Research Unit, UEA, where Gerard van der Schrier worked on estimating thermohaline ocean-circulation influences on European climate and on quantification and analysis of European droughts for the 1900-2002 period with Prof. Phil Jones, he returned to KNMI. Working first on climate change from a modelling perspective, by applying a newly developed data assimilation method to model past climate changes, he now focuses on changes in climate extremes from the viewpoint of observations. Gerard van der Schrier’s research is largely based on the station data from the ECA&D project for which he also maintains the database and website.
Dr. Gé Verver: A senior researcher in the Climate Services department of KNMI. He is involved in the FP7 EURO4M which develops regional reanalyses of past weather and user-oriented data products for monitoring climate variability and change in Europe. He is programme manager of the EUMETNET Climate Capability in which 25 European Meteorological Services collaborate to better serve the European user community with climate products and services for the benefit of environment, safety, economy and health. In the past he participated in several national and European projects and coordinated the FP6 STAR project on tropical atmospheric research. He did his Ph.D. at Utrecht University on the interaction of atmospheric chemistry and boundary layer mixing.

Beneficiary no 4: MET OFFICE (MO)

Expertise and experience of the organization
The Met Office is the UK's National Weather Service. The Met Office has a long history of weather forecasting and has worked in the area of climate change for more than two decades. The Met Office is a Trading Fund within the Department for Business Innovation and Skills, operating on a commercial basis under set targets. As a world leader in providing weather and climate services, we employ more than 1,800 at 60 locations throughout the world. We are recognized as one of the world's most accurate forecasters, using more than 10 million weather observations a day, an advanced atmospheric model and a high performance supercomputer to create 3,000 tailored forecasts and briefings a day. These are delivered to a huge range of customers from the Government, to businesses, the general public, armed forces, and other organizations.

Role and contribution
The Met Office’s role in the UERRA project is to lead WP2 which will develop/create the data assimilation regional reanalysis datasets, and in particular the ensemble-variational (EVDA) technique, which for the first time applies techniques successfully implemented in global NWP to regional reanalysis.

Principal personnel involved:
Prof. Dale Barker is Head of the Data Assimilation and Ensembles (DAE) section within the Weather Science component of the Met Office's Science Programme. He is a visiting professor at the University of Reading, UK and also an Affiliate Scientist at the US National Center for Atmospheric Research (NCAR) in Boulder, Colorado. Prof. Barker is responsible for research and development for NWP data assimilation and ensemble forecasting. His experience in regional reanalysis started as PI on NCAR's Arctic System Reanalysis project. More recently, he has led WP2 of the current EU-funded EURO4M European regional reanalysis project, and is a current member of the EURO4M management board. He will lead UERRA WP2.
Mr. Richard Renshaw is an expert on regional data assimilation within DAE. Recently he has been developing and running a European-area reanalysis as part of the EURO4M project. He has earlier experience in satellite sounding for NWP, having coded assimilation of radiances in the Met Office variational analysis system.
Dr. Peter Jermey is a scientist within DAE section. His work focuses on developing hybrid data assimilation techniques, as used operational in global NWP since July 2011 and proposed for the UERRA-EVDA ensemble reanalysis. He is a member of the core Met Office WP2 project team of the current EU-funded EURO4M European regional reanalysis project, and is responsible for scientific diagnostics and evaluation of reanalysis output.
There will be additional staff members recruited for UERRA, at the start of the Project.

Beneficiary no 5: UNIVERSITY OF EAST ANGLIA (UEA)

Expertise and experience of the organization

The Climatic Research Unit (CRU) at the University of East Anglia (UEA) has over 35 years of extensive experience in the analysis of climate data. CRU jointly produces the well-known datasets of global surface temperatures (HadCRUT4 and CRUTEM4 - see www.cru.uea.ac.uk/cru/data/temperature), as well as many other climatic variables (www.cru.uea.ac.uk/data). CRU has been involved in a number of studies on the analysis of long instrumental records with particular emphasis on extremes, as well as the development of long homogeneous series not only within Britain, but also in other parts of Europe. UEA were actively involved in FP5 projects ALP-IMP and EMULATE projects and were involved in the FP6 projects ENSEMBLES, CIRCE and are involved in FP7 projects ATOPICA, TOPDAD, CLARIS-LPB, CLIM-RUN and EURO4M.

Role and contribution

UEA is active with the data development in WP1 and also in assessing uncertainties to the gridded data sets. It is also taking part in the evaluation of uncertainties of the RA in WP3.

Principal personnel involved:

Prof. Phil Jones is Director of the Climatic Research Unit at UEA. He is also a member of the Atmospheric Observations Panel (AOPC) for GCOS and was one of the two coordinating lead authors on the Chapter on Atmospheric Observations of the 2007 IPCC report. Within the AOPC, he chairs the Advisory Group for the GCOS Upper Air and Surface Networks (the GUAN and GSN). This group assesses the performance of these two key networks and suggests improvements and changes to NMHSs as well as approving or not suggestions for network improvements made by NMHSs. He co-ordinated the EMULATE project and has been involved in numerous other EU projects including (IMPROVE, STARDEX, ALP-IMP) and was involved in ENSEMBLES, ECOCHANGE and CLARIS-LPB and is involved in EURO4M. He has over 30 yr of experience in the climate change field. He was awarded the Hans Oeschger medal from the European Geophysical Society in 2002 for work in paleoclimatology. Also in that year he was awarded the International Journal of Climatology prize of the Royal Meteorological Society for papers published in the past five years in the International Journal of Climatology. He is recognised as one of the top 0.5% of highly-cited researchers in the Geosciences field by the ISI (the institute in the US that maintains the Web of Science, where publications and citations are monitored). In 2007 he was awarded a fellowship by the American Meteorological Society and in 2009 was awarded a similar fellowship from the American Geophysical Union. He has worked with most of the partners within the present project.

David Lister has been in CRU since the mid-1990s. He has worked on a number of EU-supported projects (including EMULATE, ENSEMBLES and CLARIS-LPB), as well as several for the Environment Agency in the UK and a number of consultancy type projects. He is currently working on the EURO4M Project. He is adept at data handling, particularly when comparing observations with climate model output. In addition, he has a wide experience of work towards the extension (with associated QC), general maintenance and other facets of the management of climate-data archives. Extensive work with a range of climate datasets includes a variety of analyses associated with a number of investigations that have been reported, jointly with colleagues, in several peer-reviewed journal articles. David will work on WP1 issues analysing the digitized datasets and enabling their use for WP2 and also in the comparisons envisaged in WP3.

Dr. Richard Cornes has been at the CRU since 2006. After gaining his PhD in 2010, for his work on the recovery and homogenization of 300-year-long data series, he has worked on research projects (including the EU-funded projects CIRCE, EUCAARI and CLIM-RUN) concerned with the processing and analysis of observed and model-simulated climate data. Richard will work on WP1 to improve the gridding procedures and error estimates used within E-OBS, and complementary work for WP3 which will account for uncertainties in reference datasets.

Beneficiary no 6: EIDGENOESSISCHES DEPARTEMENT DES INNERN (EDI)

Expertise and experience of the organization

MeteoSwiss is the governmental office (under EDI) for information on weather and climate in Switzerland. It operates the national observation networks, issues weather forecasts, warns the authorities and the general public of dangerous weather conditions, and monitors the Swiss climate. Its legal duties include the provision of climate information and climatological services for the benefit of the general public. MeteoSwiss provides generic and tailor-made datasets for customers, and conducts applied research on themes from now-casting to climate prediction. Weather and climate in the Alpine region is one of its core competences.

MeteoSwiss hosts the national GCOS office and is the official representative of Switzerland in various international organisations (WMO, ECMWF, EUMETSAT, EUMETNET, etc.). MeteoSwiss has participated in several previous/ongoing EU FP projects (ENSEMBLES, EURO4M, EUPORIAS), in the EUMETSAT CM SAF CDOP 1 and 2, and in several COST actions. In its research MeteoSwiss collaborates with academia (e.g. ETH Zurich, C2SM), with other governmental offices (e.g. hydrology), and the private sector (e.g. reinsurance).

Role and contribution

Tasks/Role in UERRA: In WP3 MeteoSwiss will evaluate and quantify uncertainties of regional reanalyses using the gridded high-resolution precipitation dataset for the Alpine region that was developed in EURO4M. In WP1 MeteoSwiss will contribute to methods for quantifying uncertainty in European grid datasets.

Principal personnel involved:

PD Dr. Christoph Frei, is senior scientist in the Climate Analysis Group of MeteoSwiss and a lecturer at ETH Zurich. He has long-standing research experience in statistical climatology, notably spatial climate analysis, evaluation, and extreme value analysis. He was active in evaluation efforts of several EU research projects (MERCURE, PRUDENCE, STARDEX, EURO4M, COST733) where he contributed to the validation of global/regional climate models, climate-change downscaling methods and weather type classifications. He compiled a pan-Alpine rain-gauge dataset and developed gridding methods tailor-made for complex topography. Several grid datasets established with these methods will be used for evaluation in UERRA. Recently, he worked on uncertainties in gridded precipitation datasets and this experience will be relevant in the project.

Dr. Mark A. Liniger: Head of the Climate Analysis Group (10 collaborators) and is responsible for several ongoing climate projects. He has research experience in climate change in observations and future climate scenarios, statistical methods in climate science, extreme climatological events in Europe and Alpine region, and dynamic meteorology. In the past 10 years, his work has focused on the verification and application of probabilistic dynamical monthly, seasonal and decadal forecasts, climate risk management and statistical data analysis based on observations and reanalysis data. He is Co-Principle Investigator (Co-PI) of the MeteoSwiss contribution to the Swiss NCCR-Climate, leads the MeteoSwiss contribution to EU FP7 EUPORIAS, and is member of the management committee of the COST Action ES1102 VALUE, of the steering group of EUMETSAT CM SAF and of the C2SM.

Prof Dr. Christof Appenzeller, is head of the division Climate at MeteoSwiss (~25 collaborators) and Professor at ETH Zürich. He has long-standing research experience in the analysis and prediction of the atmosphere-ocean-cryosphere system and was PI of several research projects on climate variability and climate risk management. He is author of numerous papers including Science and Nature and is governmental representative in various commissions (ECSN, WMO and IPCC).

Beneficiary no 7: UNIVERSITAT ROVIRA I VIRGILI (URV)

Expertise and experience of the organization

The Centre for Climate Change (C3), set up in late 2008 by University Rovira i Virgili (Tarragona, Spain), is focused on researching, outreaching and knowledge transfer in the fields of climate reconstruction and analysis. The specific activities include high-quality climate datasets development (comprising data rescue procedures and research on data quality control and homogenization methods) and climate variability and change assessments at different spatial (from local to global) and temporal (from sub-daily to annual) scales, including analysis of the factors forcing climate variability. C3 is leading and/or involved in several international, European and nationally funded projects.

Role and contribution

URV is leading WP1 and is the main responsible for the data rescue work. It works closely together with UEA in particular with the data developments on the rescued data.

Principal personnel involved:

Dr. Manola Brunet is the C3's director and Reader at URV, where she has been working since almost the last 30 years. She will lead under UERRA the WP1. She is intensively involved in a number of international activities, projects and initiatives related to her expertise in instrumental climate reconstruction and analysis. Besides of being co-chair of the WMO/Commission for Climatology (CCl) Open Panel of CCl Experts on Climate Monitoring and Analysis, she is leading the WMO/MEDARE Initiative (http://www.omm.urv.cat/MEDARE/index.html) that joins 23 Mediterranean NMHS and 10 research centers. These responsibilities have provided her either the insights or skills and contacts to ensure the WP1's success under UERRA.

Enric Aguilar is a PhD in Physical Geography (2010) and is currently employed as an Assistant Professor at the Geography Department and as a Senior Researcher at C3. He has intensively worked in the analysis of climate change indices worlwide. Currently, his research is focused on climate data quality control and homogenization, developing different state-of-the art software on these topics. He has also been involved in projects/networks devoted to the comparison of homogenization methods.

Constanța Boroneanț is a PhD in Physics (University of Bucharest) and currently is a Senior Researcher at C3. Her expertise is on climate variability and change analysis using both observation and modeled data (GCMs and RegCMs). She has been involved as participant or PI in both national and European research projects on these topics (STARDEX, ENSEMBLES and CECILIA - EU projects). Her research has been mainly focused on multivariate analysis, extreme events and their link with large scale circulation.

Peter Domonkos graduated as meteorologist (MsC) in 1984 and was awarded as PhD in 1999. After 1984, he was an observer in surface and upper air observing stations and was weather forecaster for 3 years in the international airport of Budapest. Since 1993 he is a climate researcher, he has 43 reviewed publications. Between 1993 and 2003 he dealt with the statistical analysis and synoptic climatology of climatic extremes. Since 2003 his main research field is the climate data homogenization. Since 2009 he works in C3.

Dr. Javier Sigró is Lecturer at the Department of Geography and senior scientist at C3. He has a wide experience in the fields of climate variability and climate change reconstruction studies. He has also focused his research interest on the development of high-quality instrumental surface climate variables at different temporal and spatial scales. This include data rescue activities, quality control, homogenization and spatial and temporal multivariate analysis.

Beneficiary no 8: ADMINISTRATIA NATIONALA DE METEOROLOGIE R.A. (NMA-RO)

Expertise and experience of the organization

The National Meteorological Administration (NMA-RO) represents the national authority in the field of meteorology in Romania acting within the Ministry of Environment and Sustainable Development. NMA-RO is the owner and unique administrator of the meteorological, climatological and aerological Romanian databases. NMA-RO coordinates the National Meteorological Observation Network, which consist of: 162 meteorological stations, 2 aerological stations, 8 radar centers, 60 agrometeorological stations and 35 actinometrical stations. Our research activity is focused on climate variability and change at the regional scale and climate predictability. The main research topics are: analysis of the main characteristics of climate variability using long-term observations (trends, shifts, extreme events), connection between regional climate and large-scale phenomena (e.g. the North Atlantic Oscillation, Atlantic Multidecadal Oscillation), projection of global climate change on local scale using statistical and dynamical downscaling models, validation of global/regional climate models on large-scale and regional scale.

Role and contribution

NMA-RO is active with data rescue to complement the work by URV, for the area of south-eastern Europe. It is also involved in the evaluation work in WP3, particularly for drought conditions.

Principal personnel involved:

Dr. Roxana Bojariu is leading the Climatological Department at the NMA-RO. Her expertise is in the field of climate variability and change and associated impacts. She has been involved in European projects such as EuroGLOBEC (European global ocean ecosystem dynamics), FP6 DYNAMITE (Understanding the Dynamics of the Coupled System), FP6 IPY-CARE (Climate of the Arctic and its role for Europe – an European component of the International Polar Year), FP6 CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment), FP7 METAFOR (Common Metadata for Climate Modelling Digital Repositories), FP7 EURO4M (European Reanalysis and Observation for Monitoring) and in international ones (e.g. Small Pelagic Fishes and Climate Change). She was lead author of the chapter on observations in the IPCC-WGI AR4 and Review Editor of the AR4 Synthesis Report. She is lead author of the chapter on near term projection and predictability in the IPCC-WGI AR5.

Alexandru Dumitrescu is deputy head of Climatological Department, NMA-RO. His expertise is in spatio-temporal interpolation of meteorological data using geostatistical techniques. He has been involved in European projects such as: The South East Europe Transnational Cooperation Program - CC Waters, FP 6 HYDRATE (Hydrometeorological data resources and technologies for effective flash flood forecasting), FP6 CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment), LIFE AIR AWARE (Ari pollution impact surveillance and warning system for urban environment).

Dr. Marius-Victor Birsan is senior researcher within the same department. He is an environmental physicist with expertise in statistics, hydroclimatic variability, rainfall-runoff modelling, wind modelling, data management and homogenization. He has been involved in three European projects: LIFE-MOSYM (Modernisation of the system of measurement, storage, transmission and dissemination of hydrological data to decision makers at various levels); EU-FP7 MUSIC (Multi-sensor precipitation measurements integration, calibration and flood forecasting), HYDRATE (Hydrometeorological data resources and technologies for effective flash flood forecasting).

Beneficiary no 9: EUROPEAN CENTRE FOR MEDIUM-RANGE WEATHER FORECASTS (ECMWF)

Expertise and experience of the organization

The European Centre for Medium-Range Weather Forecasts (ECMWF) is an international organisation supported by 34 States: 19 Members (Belgium, Denmark, Germany, Greece, Iceland, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Norway, Austria, Portugal, Switzerland, Finland, Sweden, Turkey, United Kingdom) and 15 Co-operating Members (Bulgaria, Croatia, Czech Republic, Estonia, the former Yugoslav Republic of Macedonia, Hungary, Israel, Latvia, Lithuania, Montenegro, Morocco, Romania, Serbia, Slovakia and Slovenia).

ECMWF's principal objectives are the development of numerical methods for medium-range weather forecasting; the preparation, on a regular basis of medium-range and long-range weather forecasts for distribution to the meteorological services of the Member States; scientific and technical research directed to the improvement of these forecasts; the collection and storage of appropriate meteorological data. ECMWF's computer facility includes supercomputers, archiving systems and networks. A detailed description is available at http://www.ecmwf.int/services/computing/overview

ECMWF, through its partnerships with EUMETSAT, ESA, the EU and the European Science base, has established a leading position for Europe in the exploitation of satellite data for operational numerical weather prediction, for operational seasonal forecasting with coupled atmosphere-ocean-land models, and for climate reanalysis.

Role and contribution

ECMWF is providing the expertise for archiving in MARS and working with the data services in WP4. It works closely with the RA producers in WP2 and with KNMI for the data and web map services in WP4.

Principal personnel involved:

Mr Manuel Fuentes has been working at ECMWF for almost 18 years. He is currently Principal Analyst in the Meteorogical Data section. He is responsible for the Meteorological Archival and Retrieval System (MARS) archive, a unique multi-petabyte repository of meteorological data. He is responsible for the design of the data that is to be stored in the MARS system, from meteorological observations to output of NWP models. He was involved in the data design of all reanalysis produced by ECMWF (ERA-15, ERA-40, ERA-Interim and ERA-CLIM). He is member of the WMO Expert Team on Metadata and Interoperability and he is currently leading the technical developments to archive TIGGE-LAM output in MARS.

Beneficiary no 10: DEUTSCHER WETTERDIENST (DWD)

Expertise and experience of the organization

The Deutscher Wetterdienst (DWD, founded 1952) is the National Meteorological Service of Germany. Besides its main task to warn against weather related dangers, DWD offers weather services for the general public as well as specific services for e.g. nautical, aviational or agricultural purposes. DWD's spectrum of activity comprises weather observation and forecasting, climate monitoring, as well as research and development. DWD is responsible for climate consultancy and information provision for users in governmental authorities and various thematic sectors, e.g. agriculture, hydro-meteorology, urban planning and the health sector. A major task of DWD is monitoring of climate (from local to global scale) and atmospheric composition (ozone, radioactive trace elements). DWD leads the WMO Global Precipitation Climatology Centre (GPCC) and the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF), which provides regional and global satellite derived climate data records. DWD was recently Principal Investigator for the ESA DUE GlobVapour project, is leading the ESA CCI Clouds project, and is partner in the EU FP7 Copernicus projects EURO4M, CORE-CLIMAX and CHARMe. DWD has the lead for the Regional Climate Center (RCC) node on climate monitoring for WMO region RA VI (Europe and Middle East). In 2011, DWD initiated the Hans-Ertel-Centre for Weather Research (HErZ) to enhance and better coordinate research in different fields of weather forecasting and climate monitoring between universities and the DWD. One of the five funded topical research groups is working on a high-resolution regional reanalysis for Europe and Germany based on the numerical weather prediction model COSMO (Consortium for Small-scale Modelling). This group (located at the University of Bonn) is also partner of UERRA.

Role and contribution

DWD is leading WP3 and coordinating the evaluation of RA and the common methodology. It will be active mainly with the satellite based data sets and precipitation evalution in WP3. Together with KNMI DWD will develop products and be active in outreach in WP4. It is also involved in evaluation for COSMO in WP2.

Principal personnel involved:

Dr. Andrea Kaiser-Weiss is member of the division "National Climate Monitoring" and coordinates the public dissemination of climate data. Until July 2012 she was project coordinator of the GHRSST (Group on High Resolution Sea Surface Temperature) at the University of Reading, liaising with users and space agencies. She is specialized in data assimilation (DA) theory concerning the optimal use of satellite data, and has experience with DA experiments, trend analysis, homogenisation of time series of ground-based and satellite measurements, and COSMO based modelling for source attribution of trace gases. She will lead WP3.

Dr. Frank Kaspar, Head of the National Climate Data Centre and the division "National Climate Monitoring" which is responsible for quality control and archiving of measurements from Germany's station network, data rescue of historic data, provision of gridded products and general information on the state of national climate. He was member of the CM SAF team from 2007 to 2011 and has a decade of research experience in climate impact research (focus on hydrology) and climate modelling (with global and regional models: ECHAM4 and COSMO). He contributes to the coordination of a research programme on decadal climate prediction (MiKlip). His section is partner in CORE-CLIMAX.

Dr. Jan Keller is the DWD coordinator of research activities on high-resolution regional reanalysis that are performed within the Climate Monitoring Branch of HErZ. While he is situated at the University of Bonn, he supervises and supports the setup, production and evaluation of the deterministic reanalysis with his strong background in data assimilation and ensemble forecasting methods as well as probabilistic verification techniques.

Dr. Jörg Trentmann is member of the surface radiation team of the CM SAF and responsible for the satellite-based surface radiation datasets and is leading the CM SAF Training Activities, which include classroom workshops as well as online resources. He has a long-term research experience in the validation of NWP-model simulations, including the validation of reanalysis data sets with satellite-derived data. Starting 2013 he will be responsible for the DWD activities within EURO4M.

Beneficiary no 11: METEOROLOGISK INSTITUTT (MI)

Expertise and experience of the organization

The Norwegian Meteorological Institute (MI) was founded in 1866 and is a public agency. MI has 420 employees and is responsible for the public weather service in Norway, covering both civilian and military purposes. The institute provides information that supports public authorities, businesses and the general public to secure life and property and in support of societal planning and environmental protection. R&D at MI is supported directly by the government by research councils, EU, ESA, EUMETSAT and others. MI only undertakes externally funded project work that supports the core mission of the institute which is to safeguard life and property.

MI R&D is related to operational numerical models of the atmospheric; oceanographic and sea-ice forecasting are continuously being improved, and environmental models are developed and operated. Numerical modeling techniques, in situ and remote sensing observations and data assimilation techniques are used in the work. Climate research ranges from modeling the global and regional climate and Earth System including scenario calculations as well as downscaling to finer resolution over Norway and adjacent seas. The institute also develops climate services including observation based gridded datasets. Time series analyses of climate variables are carried out, as well as remote sensing research and development of IT-tools and applications.

MI is representing Norway in many international conventions (WMO, ECMWF, EUMETSAT) and is involved in a multitude of partnerships both within the operational parts as well as in R&D. The institute educates PhD's and hosts postdocs on a regular basis thanks to its close collaboration with (and proximity to) the University of Oslo through CIENS (Oslo Centre for Interdisciplinary Environmental and Social Research). MI has an open data policy.

Role and contribution

MI will work on the evaluation methodology in WP3 and will in particular focus on precipitation and snow in mountaneous regions.

Principal personnel involved:

Ole Einar Tveito will coordinate MI contributions to UERRA. He has been affiliated to MI as a researcher since 1995. He became senior scientist in 1998 and was appointed as head of the “Climate data and spatial analysis” in 2011. Tveito is an experienced expert on spatiotemporal analysis of climatic variables, snow modeling, atmospheric circulation classifications, extreme value analysis and homogeneity testing. He has developed the Norwegian high resolution observation grid data set that is heavily utilized for climate assessment studies. He has a broad experience in working with scientists from other disciplines, in particular hydrology, ecology and forestry.

He has been participating in and had leading roles in several national and international projects. In 2010-2012 he was manager for the EUMETNET programme EUMETGRID. He was also leading COST Action 733 on harmonization of weather type classification (2005-2010) and was leader of the spatial interpolation working group in COST Action 719 on the application of GIS in meteorology and climatology (2001-2006). He has also been task manager for Climate applications within NORDic METeorological institutes (NORDMET)/NORDKLIM, and was joint leader of NORDKLIM project NORDGRID. Currently he is national expert in meteorology in the COST ESSEM domain committee, and are used as lecturer at Universities in Norway and Sweden.

Beneficiary no 12: RHEINISCHE FRIEDRICH-WILHELMS-UNIVERSITAET BONN (UB)

Expertise and experience of the organization

The Meteorological Institute at the University of Bonn is committed to education and research in the field of atmospheric science, with expertise in climate dynamics, cloud physics, remote sensing, and meso-scale modelling. It hosts the Climate Monitoring Branch of the Hans Ertel Centre for Weather Research (HErZ), which focuses on the retrospective analysis of regional climate. The HErZ programme was initiated by the Deutscher Wetterdienst (DWD) to advance research in the field of weather forecasting and climate monitoring at German universities and non-university institutions and within the DWD. It aims on a better coordination of the wide variety of atmospheric research activities in Germany and directs the focus onto fundamental, highly topical problems in the field of atmosphere and climate research at an internationally recognised level. The Climate Monitoring Branch currently produces a high-resolution regional reanalysis for Europe (CORDEX-Europe, 6.1 km) and Germany (2.8 km) based on the COSMO NWP model.

Role and contribution

UB will develop its Ensemble RA in WP2 and work closely with the Met Office and the other partners with the RA diagnostics in WP2.

Principal personnel involved:

Dr. Christian Ohlwein is head of the Climate Monitoring Branch and member of the Programme Management Group of the Hans-Ertel-Centre for Weather Research where he coordinates the production and verification of the aforementioned high-resolution regional reanalysis for Europe and Germany. During the past decade his research interests focused on model-based reanalysis systems, regional climate modelling, ensemble methods, extreme events, as well as palaeo-environmental transfer functions. Christian Ohlwein also coordinates a DFG-project on regional climate simulations with COSMO in the CORDEX-EastAsia domain. Earlier works include the probabilistic assessment of regional climate change by ensemble dressing as well as a postdoctoral position at the Laboratoire des Sciences du Climat et l'Environnement in Gif-sur-Yvette, France, where his special interest was on the probabilistic assessment of climate extremes from GCM simulations.

Prof. Dr. Andreas Hense is head of the working group on Climate Dynamics at the Meteorological Institute (UB) and has more than 20 years experience in the joint analysis of large-scale climate models and observations. His working group has more than fifteen years experience with climate model ensembles including climate change detection and attribution studies using the IPCC-AR4 multi model ensemble as well as about 10 years experience with the generation and analysis of global and regional ensemble weather forecasts. He was coordinator of various climate-research related BMBF projects and coordinator of the DFG-funded priority programme SPP1167 “Quantitative Precipitation Forecast”. Publication are in topics such as climate change detection and attribution, statistics of extremes, techniques in stochastic weather forecasting, and data assimilation using simplified models. He is member of the Scientific Steering Committee of the German Climate Computing Center DKRZ.

PD Dr. Petra Friederichs is senior lecturer at the Meteorological Institute (UB). She leads the working group on Stochastic Dynamics in Weather and Climate and has a strong experience in statistical methods, extremes and statistical-dynamical modelling of precipitation. One major focus of her research lies on the prediction of meso-scale high-impact weather and the understanding of the dynamics involved in the generation of extreme events. This is the goal of the research unit funded by the Volkswagen Foundation (WEX-MOP), and involves the investigation of conserved quantities, scale interactions and turbulence characteristics on the atmospheric meso-scale. She is principal investigator in the Transregional Research Centre 32 “Patterns in Soil-Vegetation-Atmosphere Systems - Monitoring, Modelling and Data Assimilation” and the BMBF funded initiative on “High Definition Clouds and Precipitation for Climate Prediction”, $HD(CP)^2$.

The activities are jointly supervised by Dr. Christian Ohlwein and Dr. Jan Keller from DWD.

B 2.3 Consortium as a whole

B 2.3.1 Quality of the consortium

The UERRA consortium brings together partners that have already been demonstrated their ability to work as a team in international projects. The partners have a wide range of expertise in the field of climate research and each partner brings in the specific expertise relevant to the call. Together, they cover the range from station- and satellite-based climate data, including rescue of historical data, to state-of-the-art numerical modeling and data assimilation. The consortium includes the expertise from universities and meteorological agencies, esp. some of the leading NWP centers. Partners come from 7 EU countries, Switzerland. Norway and an international organisation (ECMWF) participates. The organizational structure of UERRA builds on the expertise of the different partners and their complementary activities. It is well balanced in relation to data rescue and observational datasets, ensemble-based regional reanalysis, evaluation and outreach. Due to the broad activities of the meteorological services, close (partly internal) contact to activities like CM-SAF or ESA-CCI, but also to potential relevant national users is assured. They have established contacts to various international activities.
The UERRA consortium has a strong expertise in climate research and NWP based Data Assimilation. The most important groups in the area are involved in the UERRA project. URV and UEA are at the forefront in climate research and, together with KNMI, EDI and MI, they provide a strong and rather complete scientific basis for the the climate quality of the UERRA deliverables. UEA is recognised worldwide for its research and long period data sets. These groups have a long standing working relationship. They are used to work together in science developments and in data activities. They are also contributing to the IPCC AR5 writing (as was the case for AR4). In addition, EDI and MI have particular experience with small scale features in complex terrain and high resolution data analysis. KNMI combines data collection and data production with many outreach activities.
The RA efforts include all the main Data Assimilation groups in Europe, where Met Office, Météo-France, DWD and SMHI have a long track record of forefront Data Assimilation developments. They are dedicated both for NWP forecast applications but also, and increasingly so for RA. SMHI and Météo-France have a close working relationship through the HIRLAM and ALADIN model consortia in Europe and also in EURO4M. Met Office has a large research group in the area and this ensures a strong support. DWD is putting a concerted effort into Data Assimilation, modelling and RA through the HErZ and UB in this case. Météo-France has also a wide and strong research activity and with well developed national research networks.
ECMWF is world leader in NWP forecasting and leading in global RA with very extensive expertise. The ECMWF is well known to the partners in the RA area and is a focal point for Meteorological Infrastructure in Europe. It is in this capacity that ECMWF participates in UERRA and this will assure that the best possible data services can be provided together with the partners. Furthermore, the ECMWF computer facilities will be used for much of the RA work and involvement of ECMWF in the project is essential for the common developments in UERRA.
Most of the partners are also working together in EURO4M so UERRA can build on a working relationship already from the start.

B 2.3.2 Subcontracting

No core tasks within UERRA will be subcontracted.
The subcontractors selected for UERRA have been selected according to the rules for subcontracting laid down in FP7 Financial Guidelines of 11/03/2013 and Article II.7 of the FP7 Grant Agreement – Annex II General Conditions. Therefore, the subcontracts will be awarded according to the principles of best value for money, transparency and equal treatment. The work to be subcontracted is as follows:
Partner 1, Subcontractor 1: SMHI will subcontract the services related to development, setting-up, hosting and maintenance of a website with a public and non-public project section. The latter will be used for internal project communications and document exchange. Budget 25,000€. Deliverable D7.6.
Apart from audit costs for Certificates of Financial Statements (Partner 1SMHI 6,000€, Partner 3 KNMI 2,000€, Partner 4 MO 3,000€) there will also be some minor tasks subcontracted by Partner 1 SMHI. These minor tasks are services related to external meeting facilities for workshops and the Show Case Event. Two WP3 workshops and two WP8 workshops are planned for the project à 5,000€ each, for renting of a room and catering, approx. 30

persons per workshop. There will also be a Show Case Event at a budgeted cost of 12,000€ for renting a room, conference facilities and catering, approx. 75 persons. The total costs for audit costs and subcontracts is 68,000€.

Table 2.3.1 Subcontracting & audit

Partner	Cost Item	Cost	Type
1 SMHI	Project website	25,000 €	OTH
1 SMHI	Subcontracts minor tasks, meetings	32,000 €	OTH
1 SMHI	Audit	6,000 €	MGT
3 KNMI	Audit	2,000 €	MGT
4 MO	Audit	3,000 €	MGT
	Totals	**68,000 €**	

B 2.3.3 Third parties

Not applicable in this project.

B 2.4 Resources to be committed

The project will rely on the proven competencies of the organisations and researchers involved in UERRA This competencies are backed by the high quality of participants and their long-term involvement in climate research and reanalysis as described in the previous section. The work to be performed builds on the state-of-the art and takes into account of on-going research and developments in the area of climate change and reanalysis. This approach avoids unnecessary duplication of work and ensures that the resources are committed in the most efficient way.

B 2.4.1 Financial planning approach

The financial plan for the project relates directly to the human resources as pointed out in the previous section. The calculation of the budget thus depends on a proper estimation of efforts associated with fulfilling the project's objective by executing the planned tasks. The key factors for the budget calculations were.

- Resource estimation procedure was conducted in several iterative steps involving the WP leaders and the other participants. The resource estimation went hand-in-hand with specifying the work packages, tasks and deliverables. This approach ensures a good estimation of the overall resource consumption
- Based on existing and on-going research and technologies in climate change and reanalysis as well as related areas building upon the experience of the UERRA consortium
- Calculation of travel and other costs in a way that avoid unnecessary cost (e.g. for travel) by making use of teleconferences.
- Limiting subcontracting to the absolute minimum by avoiding outsourcing core tasks and respecting the financial rules of FP7 as they are laid in the last version dated from 16th January 2012.

B 2.4.2 Resource distribution

As usual for a project of this size and ambition, human resources (including indirect cost) are the major cost factor representing 95% of the total project budget. UERRA will deploy 644 PMs at a total cost of 7,072,124 € with a funding of 4,999,727 €. The budget has been adequately distributed across the nine work packages and among the 12 partners according to their role in the project. The relationship of other cost categories versus personnel cost is not excessive as demonstrated in the following.

Total cost per Work Package

Table 2.4.2.-1 shows the distribution of PM and total cost across the different work packages.

Table 2.4.2-1 Total cost per workpackage

	Efforts		Total Labour budget	
WP	**PM**	**%**	**€**	**%**
WP1	97.0	15.1	487,400 €	13.1
WP2	348.0	54.0	1,860,065 €	50.0
WP3	85.0	13.2	556,180 €	15.0
WP4	64.0	9.9	483,490 €	13.0
WP5	8.0	1.2	52,000 €	1.4
WP6	9.0	1.4	58,500 €	1.6
WP7	13.0	2.0	86,465 €	2.3
WP8	12.0	1.9	80,340 €	2.2
WP9	8.0	1.2	52,500 €	1.4
Totals	**644.0**	**100.0**	**3,716,940 €**	**100.0**

Table 2.4.2-1: Total cost per WP

Due to the nature of the project the scientific work packages WP1 – WP4 are equipped with 91,1 % of the total project budget. The project management is lean and efficient and will consume 3.0 % of the total budget only. The funds allocated to the scientific work packages range from 13.0 – 50.0 % and are adequate to the importance they have in the project. It is evident that WP2 that works on regional reanalyses gets the largest share. In the following we justify the budget distribution across the scientific work packages.

To carry out production runs of the ensemble and deterministic RA there is a heavy demand on the High Performance Computers (HPC) that the partners make use at no cost to UERRA. Once the systems have been developed there is a very manpower demanding period of pursuing the runs in several parallel streams continuously. Researchers will both monitor the quality and the scheduling of computer runs over a few years of the project. The manpower demand plus the fact that UERRA wants to cover a long multi-decadal time period and it involves multiple RA, involving 4 partners in the NWP based RA work, requires that WP2 is much larger than the other WPs. It is a priority of the project to provide as much RA and uncertainty for such a long time period and high resolution that it becomes interesting for a large user community.

These heavy demands in WP2 on computing and manpower make it necessary for UERRA to extend out to 4 years, in order to produce long enough time periods of the data. Furthermore, the development of methods for evaluation of the uncertainties in the RA take time before they can be applied. Still, after or around 3 years into the project, results will be available for about half of the intended period and initial validations can be made.

Also the evaluation tasks for estimating the uncertainties is central to the project and concerted efforts are put into WP3 and it is focused on the European wide evaluation and validation data sets. The RA produced in UERRA are all European wide and this is a choice made in the project in order not to dilute the resources over different sub-regions and cut back on the length of the RA periods. Data services is then another essential component of UERRA and it will be optimized by concentrating this effort to a few partners. Dissemination and outreach (in WP7) have been strengthened as much as possible, with the other constraints of the project in mind. The Data recovery and data set developments in WP1 are central to the community for climate research and contributes to the quality of the RA themselves. the diagnostic work and the products in WP4. UERRA wants to contribute as much as possible, but again it is constrained by the demanding work in WP2.

Total cost per Partner

The Project Effort listed in WT8 in Part A (and A3) shows the detailed breakdown of cost per partner and the requested EU contribution. As mentioned above the cost categories that are not related to labour (including indirect cost) are minor. A budget of 329,400 € is allocated to cover Travel, audit & Subcontracting and other cost. This represents a share of 4.7 % of total project budget. Further details on these costs are given in WT8.

As described in section 3.4.1 the budget allocation per partner was strictly based on their specific expertise and there role in the project. This is reflected by the different PM each partner is contributing. Differences in total budgets are motivated by different direct labour cost and variations in indirect cost of the partners. Nevertheless, it is obvious that two partners have an outstanding high budget.

There is first SMHI as the coordinator. Beyond the resources for project management SMHI has also to cover considerable efforts for the scientific management of the project ensuring the high quality of results and deliverables. In addition, SMHI holds the Other Cost foreseen to fund dissemination activities and workshops, page charges for publications, the expenses for the coordination body and expenses for the expenses for the External Scientific Advisory Board.

Second, there is MO who receives a high number of person months, but do so at a 50 % requested funding rate from the EU, hence providing excellent value for money. MO has long been established as one of the leading international centres for Global Climate and Earth System Modeling and reanalyses and they make highly important contributions to UERRA particularly in WP 2.

Thirdly, DWD has decided to only request 50% funding instead of their normal co-funding rate of 75%, on exceptional grounds, in order to release funds for UB to participate significantly to WP2. This is important for DWD due to the relation with the HErZ and it increases the strength of WP2 and the consortium.

Table 2.4.2-2 Breakdown of other direct costs and subcontracting costs per beneficiary

Explanation of the tables and the abbreviations:
1. Costs for travels & meeting are estimated based on WP involvements in PMs, and maybe subject to rearrangements by beneficiaries and according to the needs of the project.
2. "Other" means either review meetings at REA or external conferences
3. Where the number of persons is not mentioned , it means 1 person only

Beneficiary 1 - SMHI			
Cost Category	**Activity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	24,000	Travels WP2,WP4: 4 GA 3 persons, 2 WSs WP4 2-3 persons, 2 WSs WP3 1 person, 2 WP meetings, 2-3 other
Other dir costs	RTD	9,000	Travels WP6: 4 ESAB meetings 1 person, MSB meetings and other relevant meetings 1person
Other dir costs	MGT	5,000	Travels: 3 consortium specific meetings, 2 persons
Other dir costs	OTH	6,000	Travels: 4 EU-briefs 1 person, WP9 meeting 1 person, Show case Event 2 persons
Other dir costs	OTH	4,000	Workshop 1 WP3, travel costs for 4 invited persons
Other dir costs	OTH	4,000	Workshop 2 WP3, travel costs for 4 invited persons
Other dir costs	OTH	3,000	Workshop 1 WP4, travel costs for 3 invited persons
Other dir costs	OTH	3,000	Workshop 1 WP4, travel costs for 3 invited persons
Other dir costs	OTH	5,000	Show case Event WP7, travel costs for 5 invited persons
Other dir costs	OTH	12,000	Advisory Group year 1-4, travel costs for 3 invited persons
Other dir costs	OTH	15,000	Publication costs
Other dir costs	OTH	5,000	Dissemination material, print eg
Total oth direct costs		**95,000**	
Subcontracting	MGT	6,000	Certificate of Financial Statement (audit certificate)
Subcontracting	OTH	25,000	Project web page incl maintenance (SMHI)
Subcontracting (minor task)	OTH	5,000	Workshop 1 WP3, renting of a room and catering, approx 30 persons
Subcontracting (minor task)	OTH	5,000	Workshop 2 WP3, renting of a room and catering, approx 30 persons
Subcontracting (minor task)	OTH	5,000	Workshop 1 WP4, renting of a room and catering, approx 30 persons
Subcontracting (minor Task)	OTH	5,000	Workshop 2 WP4, renting of a room and catering, approx 30 persons
Subcontracting (minor task)	OTH	12,000	Show case Event WP7, renting a room, conference facilities and catering, approx 75 persons
Total subcontracting		**63,000**	
TOTAL		**158,000**	

Beneficiary 2 - MF			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	21,000	Travels: 4 GA 3 persons, 4 WP meetings 1 person, 3 WSs WP4, WP3 2 persons
TOTAL		**21,000**	

Beneficiary 3 - KNMI			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	18,000	Travels: 4 GA 2-3 persons, 2 WSs WP3 2 persons, 2 WP meetings, 4 other
Other dir costs	OTH	8,000	Travels: Educational activities 2-3 WSs WP7 1 person, 2 WSs WP8 1 -2 persons, 2 WSs WP9 1 person
Subcontracting	MGT	2,000	Certificate of Financial Statement (audit certificate)
TOTAL		**28,000**	

Beneficiary 4 - MO			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	24,000	Travels: 4 GA 2-3 persons, 2 WSs WP3 2 persons, 2 WSs WP4 1 person, 2 WP meetings, 4 other
Subcontracting	MGT	3,000	Certificate of Financial Statement (audit certificate)
TOTAL		**27,000**	

Beneficiary 5 - UEA			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	9,000	Travels: 4 GA 1 person, 2 WSs WP3 1-2 persons, 2 WSs WP4 1 person
TOTAL		**9,000**	

Beneficiary 6 - EDI			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	9,400	Travels: 4 GA 1 person, 2 WSs WP3 2 persons, 1 other
TOTAL		**9,400**	

Beneficiary 7 - URV			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	12,000	Travels: 4 GA 1-2 persons, 1 WP meeting, 4 other
TOTAL		**12,000**	

Beneficiary 8 - NMA-RO			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	9,000	Travels: 4 GA 1 person, 2 WSs WP3, 2 WSs WP4
TOTAL		**9,000**	

Beneficiary 8 - NMA-RO			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	9,000	Travels: 4 GA 1 person, 2 WSs WP3, 2 WSs WP4
TOTAL		**9,000**	

Beneficiary 9 - ECMWF			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	9,000	Travels: 4 GA 1 person, 2 WSs WP4 2 persons, 1 WP meeting
TOTAL		**9,000**	

Beneficiary 10 - DWD			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	26,000	Travels: 4 GA 2-3 persons, 2 WSs WP3 2 persons, 2 WSs WP4 2 persons, 2 WP meetings, 4 other
TOTAL		**26,000**	

Beneficiary 11 - MI			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	9,000	Travels: 4 GA 1 person, 2 WSs WP3 1 person, 1 WS WP4, 2 WP meetings
TOTAL		**9,000**	

Beneficiary 12 - UB			
Cost Category	**Acitivity Type**	**Cost (€)**	**Description**
Other dir costs	RTD	12,000	Travels: 4 GA 2 persons, 2 WSs WP3, 2 WP meetings
TOTAL		**12,000**	

B 2.4.3 Contributions from beneficiaries

The in-kind contributions to UERRA are only in the form of internal resources being used in the project, for which no costs are charged. They consist of:

- HPC computing costs: Met Office, DWD (including UB) and SMHI will use a large part of their national allocations at ECMWF, paid for by their Membership contributions to ECMWF. Météo-France will use significant own HPC resources. UB and DWD will additionally use national HPC resources.
- The long time periods with relatively high resolution or many ensemble members will require large amount of data storage and there are continuous costs for every year that the data are maintained. It applies for SMHI national MARS archives as well as for Météo-France and partly for the other partners as well.

B 3 Impact

B 3.1 Expected impacts listed in the work programme

B 3.1.1 Long-term high resolution climate datasets

There is a strong demand for coherent long-term and high resolution gridded datasets of near surface ECVs. This demand exists in all NHMSs, universities, consultancy firms and companies in the environmental area, and in governmental departments at the national as well as the European level. Long-term and reliable climate datasets are vital for detecting, understanding, predicting and responding to climate change and variability. The datasets are needed for research as well as climate change monitoring and assessment. Many applications in hydrology, environmental pollution and renewable energy need reliable climate data for Europe as an input. There are plenty examples where there have been limitations of the data. Existing datasets are either too coarse (such as the global reanalysis ERA-40) or only covering land areas at national or local scale. Many datasets are not extending over very long time periods (multi-decadal) or not coherent over time due to changes in observation practice or changes in reanalysis system (e.g. in Sweden the MESAN system and driving NWP model have changed both in version and resolution).

In addition, datasets are not easily available even within the producing institutes and user interfaces for outside users are even rarer. Where data exist, there are significant manual efforts required to make them available to users in the required format. The aforementioned EUMETGRID (See Sect. 1.1.1) project was an attempt by the meteorological community aimed to bridge this gap and combine national datasets of NMHSs, but this project has not yet been realised in practice. The underlying data services at each of the institutions are just not there. And even if successful there would not be a consistency between countries with such a system. The exceptions are the datasets where the EU has contributed with funding, such as the ERA-40 dataset (Uppala et al., 2005) and the E-OBS dataset (Haylock et al., 2008) which cover all of Europe and which are readily available from the respective websites. But either the resolution in space and time (ERA-40) or the number of ECVs (E-OBS) is limited in those datasets.

UERRA will improve this situation considerably. It will produce long-term datasets of climate relevant parameters at high resolution for the European region which will easily surpass any other alternative available or under development today. There will not be only one RA dataset, but in fact a large number of different datasets. The most important ones in terms of user impacts are expected to be the HARMONIE and MESCAN deterministic but high or very high-resolution RA. The resolutions at 10 km and 5 km for MESCAN over as long a time period (in excess of 50 years) will be a major asset for the European Community and beyond what is just possible to imagine today. The two sorts of RA have different properties, as explained in Sect. 1.2, and the 10 km RA has a more general use whereas the 5 km near surface RA has a great potential for climate monitoring and comparing and checking national observational data. Climate indicators can be built from both, but it is expected that the 5 km MESCAN will have the best *Climate quality* for those most often used near surface ECVs. It is in the design of the system and it will likely be rather close to observations but more faithful local features (like coasts and mountains) reflected in the RA.

B 3.1.2 Multitude of RA flavours

The multitude of RA datasets at high resolution will be a reason for extensive use of the datasets in climate change research. One important user group is the climate modeling community. The development of increasingly sophisticated climate models has reinforced the need for basic observations. Reference data for the present and recent past climate (including climate trends) during the last 30-50 years is an established requirement for all climate model evaluation exercises. The UERRA reanalyses also form the necessary baseline for future projections of climate change.

In theory, the analysis state at a particular time in any of the RAs is really only one realization of all possible atmospheric states in a probability distribution an ensemble of multiple analyses should be used. Moreover, this one realization might be affected by NWP model bias to some extent. Reducing Regional Climate Model (RCM) bias against one dataset is sub-optimal (see the ongoing FP7 EMBRACE project). Therefore, regional climate modellers want to compare their present-day climate simulations against as many different observational datasets as possible.

At present, most of these are from satellites or gridded station observations at relatively coarse resolution. If UERRA is approved, there will be a multitude of new datasets at the end of the project that fit the needs of the RCM community much better than anything else available today.
For the full 50 years there are two different datasets (MESCAN and HARMONIE). For the satellite era from 1978 there will be two similar high resolution datasets produced with quite different modelling and analysis systems (HARMONIE and Unified Model). Additionally, there is a third alternative, the 5 km downscaling RA with MESCAN, again different to the first two, and even more different due to the different methods and observations (as explained in 1.2).
A 4th additional dataset will be provided by DWD and HErZ to the project to aid in the uncertainty estimation, and when the quality of the COSMO RA is evaluated in WP3, the RCM community will be recommended to also use this RA.
The additional RAs developed in the project (with different physics, satellites or not, and the KFENDA from UB) are probably too short to be of major interest for this community. However, the UB ensemble RA is developed with the proposed support from UERRA and is expected and planned by the HErZ and UB to continue this work to a multi-decadal RA as well, providing an additional deterministic control (central member in the ensemble).

B 3.1.3 Comprehensive uncertainty estimates

A novel expected impact will come from the delivered uncertainties. Since we usually do not have uncertainty measures associated with most of today's observational datasets, it is somewhat speculative to predict how much the user community will make use of them. In general though, the notion of uncertainties and probabilities has won a lot of ground in hydrological and meteorological forecasting through ensemble techniques. The probabilistic approach requires some years to become accepted by users. For use in applications the probabilistic approach requires that ECV probabilities are translated to used impact parameters. For research users in the RCM community, this process will be easier than for the downstream users of RAs. The ensemble spread based RA uncertainties are expected to be quite widely used for model evaluation. They provide an indication for the relationship between model errors and the errors of the verifying RA dataset. In fact all model validation against any gridded data will become more stringent when the probability distribution function (PDF) of the gridded dataset is taken into account (in addition to the PDF of the model data). Since uncertainties from the ensemble RA will be produced for all modeled variables (both surface and upper air) and at all model time steps (as often as archived, for RA usually every 6 hours) the error bars are complete for all the model variables of the RCM undergoing the test. Uncertainty estimates are a definite advantage to the modelling scientist. However, also most downstream user products will benefit from uncertainty information, e.g. a customer or a journalist may want to know the reliability of analyzed trends in temperature, cirrus clouds, or in the occurrence of condensation trace from aircraft.

For a selected set of ECVs of particular user interest, to be established early in WP3, the most qualified uncertainty estimation will be made against several quite different datasets in WP3. The verifying observation datasets are state-of-the-art (including E-OBS and CRU which are enhanced with their error bars in WP1) and used to validate the climate quality of the RA datasets. Also the satellite derived datasets of e.g. cloudiness selected for RA evaluation are the best available for EUROPE (developed as part of CM-SAF). The uncertainties for climate time scales and a number of space scales will add credential to the Climate Indicators that will be derived from the RA and provided to downstream users and policy makers. The uncertainties will be as comprehensive as is possible for anyone to derive for a long time to come. To be able to answer the questions from policy makers about the reliability of the RA and the derived indicators this information is extremely important and will widen the use of the RA data.

B 3.1.4 User friendly data services for assessments and policy support

UERRA must interface directly with the full range of intermediate- and end-user requirements, including disaster prevention, health, energy, water resources, ecosystems, forestry agriculture, transport, tourism and biodiversity. Developing user friendly data services is the most important step to making the long-term high resolution climate datasets and derived products available to the different user communities. Building on existing expertise, UERRA will develop these services by implementing existing techniques and extending these for RA data and products. We will start from the services built for the MARS archives in the TIGGE/LAM project at ECMWF and extend these to include the EURO4M data and link to the services for the THREDDS archives of climate model data developed at

KNMI. The concepts are proven but there will be still significant work to apply them and enhance the services further to include RA data. These data services will for a start be used between the UERRA partners; WP2 will archive the data and WP4 will provide the data services for the evaluation of uncertainties in WP3. Subsequently, the RA data will be made available to outside users. It is anticipated that the consortium in CLIPC will develop data services for observational data coming out of UERRA (and its predecessor EURO4M) too. Therefore, the synergy effects of the two projects will be exploited. Data services for EURO4M data will facilitate the developments in UERRA WP3, since they are likely to be available before the main UERRA RA have been produced.

The observational datasets will substantially support (in combination with climate model predictions) climate change impact and adaptation action assessments, policy development and policy monitoring for European and national users. UERRA will complement the national gridded datasets, where they exist, in terms of being European wide and based on beyond state-of-the-art RA systems. For non-experts in geophysics and for policy makers the ECVs will be translated into climate indicator information adapted to user needs. As an important source of reliable information about the state of the climate in Europe, the suggested collaborative project is an important building block for Copernicus. The RAs will provide basic information for climate services that deliver consistent products and support downstream applications. We will assess whether the ensemble of reanalyses developed in this project is fit for generating climate change products that meet the user needs. The goal is to explore how the reanalysis data (and associated uncertainty information) are best exploited to develop user oriented products such as derived climate indicators and how best to utilize this additional information for “understanding past climates and climate change in Europe”. This activity will assure that the RA datasets and products are useful for policy-makers, planners and the citizens and their organizations. It will provide scientific input for policy implementation.

National decision makers and local authorities will be able to utilise the state–of–the–art UERRA data products and services for their country or region as input to climate change assessments, and the formulation of adaptation and mitigation strategies. It is the longer multi-decadal time scale addressed in UERRA that is needed for governments to minimize and adapt to the societal and environmental impacts of climate variability and change. European countries can directly use the results of the proposed project for their “national communications on climate change policies” which are a written requirement for the Conference of the Parties of the UNFCCC and include national GCOS implementation activities.

The processing systems set up in UERRA for reanalysis, post-processing of ensembles, data services and for products will be built up to a much higher level than available now. The demands for efficient production of the heavy computational runs, archiving of large amounts of data and user friendly and efficient data dissemination are high. It will be necessary to enhance the existing infrastructure for particular aspects of RA and data dissemination. This means that the Consortium will be in a good position to continue in real time the RA after UERRA finishes, provided that subsequent funding can be organized. Most likely there will be a need for re-doing the RA once NWP models and RA systems have developed further and/or additional input data have become available. Also, more computer power will enable higher resolution and/or longer time periods in future. As such, UERRA has the potential to evolve into a future Copernicus service on climate change monitoring that is fully complimentary and supporting the existing operational services.

B 3.1.5 Need for Cooperation at the European level

UERRA will build up the capacity as a pre-operational Copernicus climate change service, employing variations of the operational tools in the partner's institutes. The European scale ensures that sufficient resources are mobilized to address the goal and objectives of the work program and maintain pre-eminence within the international community. Through the expected support from the Commission these “pre-operational” services used in the RA production and dissemination will reach a high level of readiness for a future operational Copernicus climate change service. It involves all the partners in the Consortium with the heavy production facilities employed by the Met Office, SMHI, DWD, UB and Météo-France. The Data Services and dissemination rely on ECMWF (which computer resources as allocated to member states will also be used for many of the RA) as well as KNMI. The other institutes provide unique expertise on observations and datasets and methods of validation that is a continuous activity in RA work. Thus the core of the regional pre-operational Copernicus services are using most of the specialized expertise available in Europe for the regional RA, as far as the FP7 project permits, in a pan-European approach.

The capabilities of the data assimilation systems developed in UERRA will go far beyond the functions that they would have otherwise. The Met Office regional EVDA would not be built otherwise, if not for UERRA (but of course it build on the developments of the global system). RA would not be done by Météo-France nor SMHI either, unless funded externally. This is in spite of the large value of high-resolution datasets for the institutes themselves. But resources in manpower to maintain the runs and in High Performance Computing (HPC) are very large.

The RA work is very demanding even for the biggest NHMSs in Europe and necessitates cooperation at the European level. E.g. Météo-France cannot do its 5 km MESCAN RA without the SMHI HARMONIE datasets.

Extensive validation and the data services requires expertise and manpower from the other partners in UERRA. The archeology and rescue of historical observational data at the European level (DARE) has only a few experts in Europe, most of them working at the partner organizatoins of UERRA. Often the NHMSs are only equipped to do data rescue for their own nations with relatively little coordination and slow progress due to the extensive manual work.

Data assimilation and ensemble assimilation are part of the core NWP tools in the NMHSs which are employed in reanalysis mode within different projects (FP6 DAMOCLES and EURO4M are recent examples). But the NMHSs are able to keep the growing data archives only for a number of years after the project. It is therefore important for the institutes involved to ensure funding for long term archives and for continuing reanalysis services.

B 3.1.6 Links with other EU projects and international initiatives

Since UERRA intends to become an important building block for a future Copernicus climate change service, coordination of activities with other projects will be crucial. UERRA will link very strongly to the wider international community. The high costs and joint responsibilities of climate monitoring have always favoured international co-operation, which helps to avoid duplication and promotes sharing of information. As described in Section 1.1, the project fully benefits from ongoing national and international work on observational datasets and data assimilation. Current Data Assimilation and NWP model systems which will be used in UERRA are shared, developed and maintained with other partners in Europe and beyond. SMHI, MI and KNMI are members of the HIRLAM regional modelling consortium. Météo-France is working with the ALADIN consortium which in turn is closely cooperating with HIRLAM. DWD and MeteoSwiss (EDI) are members of the COSMO consortium and NMA -RO is member of both ALADIN and COSMO. Met Office cooperates with MI on modelling and has several overseas cooperating NHMSs using the UM and contributing to its development.

The project will establish a very tight interaction with other NMHSs in Europe, in particular through the EIG EUMETNET (European Meteorological Network). EUMETNET is a grouping of 29 European National Meteorological Services that provides a framework to organise co-operative programmes between its Members in the various fields of basic meteorological activities. The project will give NMHSs which collaborate in the EUMETNET Climate Programme early access to the UERRA data in order to evaluate the use of regional reanalysis data and derived products and their uncertainties. These third-party partners are data providers and climate service developers themselves making use of their national observation networks. Together with other European climate service providers they will serve as a ‘test-panel’ for the project results (see Task 8.1).

The UERRA results will also feed into the impact indicator toolbox to be developed as part of the CLIPC project. To avoid overlap of activities, Task 4.2 will deliberately not engage in (application specific) impact indicators. The products will be meteorological/climatological products at the appropriate level of aggregation and processing for the main user applications. These products close to the original ECVs will form a key source for the impact indicator toolbox in CLIPC. Although scientific, these products will be easy to understand – in relation to a question/decision/activity.

A connection to the climate change community (including ESA-CCI) and the Copernicus-related projects (GEOLAND2, CRYOLAND, MYOCEAN2) will be established to inform them on the developed reanalyses and observation products, and to get relevant feedback for the project. To coordinate links with other ongoing FP7 projects (such as EURO4M, ERA-CLIM, MACC II, CARBONES, MONARCH-A, ECLISE, CLIMRUN, EUPORIAS, SPECS, etc.) a targeted activity is foreseen working with the CORE-CLIMAX coordination project. Remaining coordination gaps will be closed by bilateral contacts and by generating/evaluating specific news items and surveys. Actors in the relevant downstream Copernicus services and in related national and international programmes will be actively involved in this process.

UERRA participants include members of the GEO Committees, GCOS Steering Committee, its Atmospheric Observation Panel for Climate (AOPC) and Oceanic Observation Panel for Climate (OOPC) specialist groups, WMO Open Programme Area Groups (OPAGs) and Expert Teams (some of them also lead by UERRA participants), International research programme on Climate Variability and Predictability (CLIVAR) Expert Teams, the WCRP Observations and Assimilation Panel and the WCRP WG on Observational Data Sets for Reanalyses. UERRA participants are also intimately involved in IPCC activities. UERRA will link via ACRE to the 20th Century Reanalysis Project and other longer historical reanalyses. With these reanalysis products, there are also the full linkages and “end-to-end” infrastructure which ACRE integrates in working with climate applications users. UERRA has already linked with the EUMETSAT-SAFs, in particular to assess user community needs and to contribute to the development of integrated products. The coordinator (at DWD) of the CM-SAF is participating in UERRA. UERRA also links to MEDARE activities on data rescue and surface climate reconstruction for the Mediterranean (under the umbrella of WMO; see Brunet and Kuglitsch, 2008).

UERRA’s deliverables will represent an important element of the Copernicus climate service. As such they will need to be integrated in the Global Earth Observation System of System GEOSS, to which Copernicus is the explicit European contribution. In line with the Copernicus data policy and the GEOSS data sharing principles, UERRA products and services will be fully and openly accessible to a wide user community. UERRA will also deliver substantial European contributions to the GEOSS Data Collection of Open Resources for Everyone (DataCORE). Technically, this will be achieved through the use of established and open mechanisms for the exchange and harvesting of metadata, e.g. standards such as OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting) or OGC-CSW (OGC catalogue services).

B 3.1.7 Benefit for future RA development and observation network design

The experience gained from the evaluation of a new RA set up at an institute usually turns out to be manifold. The Data assimilation and NWP model's ability to represent important climate features are put to a hard test. Evaluation against other RA or independent datasets often highlights some features that need to be rectified and that may not have been known before. Thus the RA activities have a feedback on improving the underlying modelling components. This is of course necessary for the RA production but the improvements of model components and model input data also provides a positive feedback on the future operational weather forecasting and related user products.

The uncertainties in the RA datasets and differences between the individual RA will provide valuable input for those responsible for operational observation network design at the national and European level (EUMETNET). It is vital to optimize the networks when budgets for NHMSs are tight and gradually shrinking. The money has to be spent on areas where the observing stations are sparse in relation to the local climate variability. Statistics from UERRA in the form of uncertainties will aid decision makers in network design, and point to parameters or areas in Europe that need their attention. Contacts with EUMETNET program managers will be established to communicate these outcomes. The results of the RA will also provide feedback for the evolution of the GCOS, in particular their concept of Essential Climate Variables (ECVs).

B 3.2 Dissemination and/or exploitation of project results, and management of intellectual property

B 3.2.1 Dissemination and/or exploitation plans

Outreach and publication activities will be carried out both at the start of the project and at regular steps during the project. These activities will peak when certain datasets will become available, and when new results and articles are published.

Data sets from the RA will be publicly available and can be downloaded via the website. The data can be used for any purpose but not to be passed on to third parties. Making information available and easily accessible is important for any EU funded project. In UERRA proper visibility will be ensured by creating appropriate visual and editorial support elements for all documents issued as well as by ensuring a regular information flow about progress. The information will be prepared in such a way that it is understandable also for readers not having the same technical level of expertise as the project partners. The concrete dissemination activities include: project logo, leaflet and poster, and website. UERRA results will be published in peer reviewed international journals or scientific reports. Presentations will be made at international conferences during the course of the project by many of the scientists working in the project.

Science-Society

UERRA will disseminate data, adapted information translated into user's language and downstream products to community at large. It will serve as ambassador of the Copernicus program and demonstrate the use of FP7 funds. UERRA provides a unique opportunity to bring together meteorological services, universities and research institutions in order to provide a seamless integration of ECV data. The effective dissemination strategy of the RA datasets includes the identification of early adopters of these data. Some European NHMSs or responsible institutes started providing climate data services to national users and authorities already, but many others are only in their infancy or not yet active. Bringing these stakeholders together in a “test-panel” (see WP8) will be a useful vehicle to demonstrate the project results to a wider audience. The workshops will provide guidance and feedback on the use of the ensembles of reanalyses including the associated uncertainties.
To populate this “test-panel” we will start from the review of existing user consultation reports performed in EURO4M and the associated meta user-requirement document produced. The review shows that the stakeholder community is diverse and stakeholder needs in terms of climate data and products cover a wide range of raw or derived variables, indicators, spatial and temporal scales, and uncertainty assessment at various levels of complexity. The meta user document from EURO4M will be updated incorporating information from the soon to start project GMES-PURE. GMES-PURE is a FP7 support action led by EUMETSAT with the aim of gathering user needs and translating those to requirements and service specifications in the atmosphere and marine domain.

Science-Policy

Policy makers and stakeholders at both national and European levels will be involved in the user workshops and their requirements on the quality and reliability of the RA data and derived products will be incorporated and matched with the outputs of UERRA and the adjoining projects in the SPACE call. Since there are strong links between the projects producing RA and the ones involved with climate indicators and tools, it is important to join or coordinate workshops or other events in order to maximise the outreach to as wide and appropriate audience as possible.

UERRA will take into account the input from early adaptors and policy makers as established in an early workshop and, together with the other projects, accommodate the requirements in the work in WP3 and WP4 as much as possible. In the second workshop there will be hard tests of the suitability of the RA products and indicators from the user and policy maker communities. Verdicts on the usability of products as well as guidelines on the use of both recently produced, as well as future data, will be established.

Close contacts will be maintained with the climate change community of the EU, EEA, WCRP and IPCC and other WMO programs, both for regular updating of the progress in the project and as a way of getting user and/or societal feedback into the project.

Work with EEA and JRC started in EURO4M will be continued. This will assure that the derived indices products which are based on the RA are actually also included in the EEA and JRC reports and websites, such as their periodic indicator report (which has EURO4M information included up to now), the websites Eye On Earth (eyeonearth.org) and Climate Adapt (climate-adapt.eea.europa.eu). In addition, two policy briefs about the RA datasets and in particular the derived products describing climate change in Europe will be organized for policymakers in Brussels (see WP7).

Finally, all project activities, related documents and results, published materials (including training materials and reports) and event announcements will be regularly posted on the project website. In addition, UERRA information will be actively offered to other websites, including the reanalysis website (www.reanalysis.org) ECOWEB project info site (ecoweb-project.eu) which brings companies close to relevant eco-innovation from EU-funded results through an interactive platform and existing eco-innovation networks. The results and availability of data from UERRA will also be communicated to the GEO Portal (www.geoportal.org)-

Exploitation plan

It is expected that reanalysis services will continue and be updated in near-real time in a future operational Copernicus Climate Change service. All the tools, software and systems developed in UERRA will continue to be available at the respective partner institutes. When significant evolution in NWP modeling systems (after several years) one need to consider to re-do the RA for the whole period.

Data archives will be retained at the individual institutes normally for several years, as they are used internally, and until a new generation of data exists. It is with the reservation that if costs turn out to be high due e.g. to change of hardware, this might limit the lifetime. Future funding also for the data archives is essential to guarantee a certain lifetime. The subsets of most requested data in MARS at ECMWF may stay somewhat longer, depending on ECMWF policies and future funding.

B 3.2.2 Educational links and capacity development

UERRA will foster better integration of research laboratories and operational meteorological agencies in education programs (WP1, 2 and 3). The project will catalyse a program of visiting scientists and postdoctoral positions through existing institutions. Emphasis will focus on fostering interactions between existing, new, Accession and Candidate EU States and neighbouring countries.

Specific communication activities, targeted at the general public, schools and the press, will be developed in order to stimulate interest in youth audiences, to attract future scientists in the broad fields of geo-sciences, and to increase public awareness about climate change. In addition, communication activities will also address educational outreach to the public with respect to basic knowledge about climate change.

The knowledge and expertise developed in the project will be passed on to the young scientists and engineers in training through university professors involved who teach at their institutions and supervise PhD and graduate students (in particular at URV and UEA in WP1 and UB in WP2). Chances will be provided for young scientists to be integrated into, and gain experience in, high level European research and international collaboration. The involvement of universities in the consortium means that the UERRA approach and data products will be incorporated in existing earth system education programs. In particular this is the case for WP1 (in which Universities and Met Services closely cooperate on data rescue) and in WP2 (in which Universities and Met Services closely cooperate on RA). UERRA funding will support Masters, PhD and post-doctoral fellowships at some of the participant institutions.

The consortium will also contribute explicitly to the Global Framework on Climate Services. WMO launched the GFCS in 2011 and it calls for comprehensive observational data, reanalyses and climate models available for all nations in the World. The implementation plan for the GFCS (WMO report No. 1102, p. 59) includes initial priority project no. 8 which makes reference to outreach of the in situ data work performed in EURO4M for Europe to other regions of the world. Together with WMO the EURO4M partners have already started these outreach activities in Indonesia (for South East Asia), Equador (for Latin America) and Niger (for West Africa). These activities will continue and be extended to reanalysis data as part of UERRA. We will work with developing countries, which will be amongst the largest potential beneficiaries of international co-operation in earth observation by liaising with and providing input to the series of worldwide workshops (Peterson and Manton, 2008; see also Klein Tank et al., 2006) organised by the joint Expert Team on Climate Change Detection and Indices (ETCCDI) of the CCL, CLIVAR and JCOMM (Peterson et al., 2001). Two UERRA partners are member of this Expert Team. The intention is to explore the potential for reanalysis in data sparse regions, in particular Africa, together with local service providers and ongoing initiatives (like SASSCAL and CMSAF training activities). This will complement the Copernicus activities in the field of capacity development and contributes to the Nairobi work programme on impacts, vulnerability and adaptation to climate change of the UNFCCC. In addition, outreach activities on data rescue, preservation, digitization and homogenization techniques and procedures programmed jointly with the WMO MEDARE Initiative will also contribute to capacity development on these subjects in developing countries and Least Developed Countries (see WP7 for details).

B 3.2.3 Management of knowledge and intellectual property

The overall management, storage and internal dissemination of knowledge will be the responsibility of the Project Coordinator, while work package leaders will be responsible for communicating knowledge produced for the work packages or specific tasks undertaken. A central knowledge repository will be created and operated by the Project Coordinator, in which all knowledge products as well as critical supportive knowledge material will be stored in an organized and easily accessible manner. Moreover, the Project Coordinator will be responsible for maintaining the necessary communication channels (project site, mailing list, etc.) for the internal dissemination of knowledge among consortium members.

Data generated in the project will be publically available and particularly through the data services described in the WP4 and through the data portal of the adjoining Copernicus CLIPC project. Management of intellectual property will be according to the Grant Agreement with the European Commission and in particular in compliamce with its Annex II. The details will be ruled within the Consortium Agreement (CA). There are extensive pre-existing volumes of software and knowledge going into the project mainly in the form of models and data assimilation systems (background). Also some developments in the project may be mainly done from national research programs. The background needed for the purpose of the project is defined by the concerned beneficiaries in a written agreement, and where appropriate, excludes specific background (Art.II.31 to the GA). Both the background going into the project and that part of the foreground that is subject to access rights will be declared in the CA. Other software and methods developed entirely in UERRA will follow the rules for the foreground in the GA. There are model and data assimilation codes that are jointly owned background but this is not a problem since the partners involved have already the access rights and use the software. The Consortium Agreement will address: ownership and transfer of ownership of knowledge, protection of knowledge, use and dissemination of knowledge and access rights to knowledge. Any patents applied that are related to knowledge developed in the project will be communicated to all partners and to the Commission-funded IPR support.

There are no confidentiality issues within the project.

B 4 Ethical issues

The project does not address ethical issues.

	Research on Human Embryo/ Foetus	YES	Page
*	Does the proposed research involve human Embryos?	No	
*	Does the proposed research involve human Foetal Tissues/ Cells?	No	
*	Does the proposed research involve human Embryonic Stem Cells (hESCs)?	No	
*	Does the proposed research on human Embryonic Stem Cells involve cells in culture?	No	
*	Does the proposed research on Human Embryonic Stem Cells involve the derivation of cells from Embryos?	No	
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROJECT	Yes	

	Research on Humans	YES	Page
*	Does the proposed research involve children?	No	
*	Does the proposed research involve patients?	No	
*	Does the proposed research involve persons not able to give consent?	No	
*	Does the proposed research involve adult healthy volunteers?	No	
	Does the proposed research involve Human genetic material?	No	
	Does the proposed research involve Human biological samples?	No	
	Does the proposed research involve Human data collection?	No	
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROJECT	Yes	

	Privacy	YES	Page
	Does the proposed research involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No	
	Does the proposed research involve tracking the location or observation of people?	No	
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROJECT	Yes	

	Research on Animals	YES	Page
	Does the proposed research involve research on animals?	No	
	Are those animals transgenic small laboratory animals?	No	
	Are those animals transgenic farm animals?	No	
*	Are those animals non-human primates?	No	
	Are those animals cloned farm animals?	No	
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROJECT	Yes	

	Research Involving ICP Countries	YES	Page
	Is the proposed research (or parts of it) going to take place in one or more of the ICP Countries?	No	
	Is any material used in the research (e.g. personal data, animal and/or human tissue samples, genetic material, live animals, etc): a) Collected in any of the ICP countries? b) Exported to any other country (including ICPC and EU Member States)?	No	
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROJECT	YEs	

	Dual Use	YES	Page
	Research having direct military use	No	
	Research having the potential for terrorist abuse	No	
	I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROJECT	Yes	

B 5 Consideration of gender aspects

Approximately 15% of the scientists working in UERRA are female, with 2 of 5 persons who are WP leaders are female. While this is far from an even distribution, it does indicate that females are beginning to move towards greater parity with their male colleagues compared to earlier years. In fact, in UERRA, while only a small portion of the researchers are female, the majority of these are quite senior scientists, with established international reputations and have extremely important roles in UERRA. Nevertheless, the consortium is aware of the importance of attracting more female talent to RA and climate science and will actively encourage the hiring of young female scientists, to the degree allowed through European and National rules on open and fair competition.

UERRA will contribute to the EU recommendation to promote the basic principle of equality between women and men. Gender issues will be considered and promoted in every WP by means of:

- Encourage the recruitment of women at equal scientific or technical merit. All job announcements will encourage women to apply by including a statement that demonstrates an “equal opportunities policy”.
- Help the participation of women by developing e-conference tools to limit travel, which is more difficult for staff with young children, encouraging a family-friendly organisation of the work; organize child care at meetings, in particular the general assemblies, and conferences as a standard.
- Create a good working environment by encouraging working-time flexibility.
- Raise awareness in the Consortium due to the involvement of women in the leadership team, through workshops and training.
- Communicate within the Consortium and the stakeholder communities the current EU gender legislation.

List of abbreviations

AEMET - Agencia Estatal de Meteorología (Spanish Meteorological Office)
ALADIN - Aire Limitée Adaption dynamique Developpment INternationall - Limited area modeling consortium and model
AWS - Automatic Weather Station(s)
CANARI - MF surface analysis system
CCI - ESA's Climate Change Initiative)
CLIPC - Climate Information for Copernicus (ptoject)
COSMO - Consortium for Small-scale Modeling
COST - European Cooperation in Science and Technology
CRPS - Continuous Ranked Probility Score
DA - Data Assimilation
DARE - Data Rescue
DWD - Deutscher Wetterdienst
E-OBS - European gridded Observations
EC - European Commission
ECA&D - European Climate Assessments and Datasets
ECMWF - European Centre for Medium-Range Weather Forecasts
EDA - Ensemble Data Assimilation
ECV - Essential Climate Variables
EMRP - European Metrological Research Programme
ERA-20C - ERA 20th Century reanalysis ensemble usein surface observations only
ERA-CLIM - Current EU project
ERA-Interim - ECMWF re-analyis
ERA-SAT - ERA satellite era new reanalysis
ERA - European Reanalysis
ERRA - European Regional Reanalysis
ESA - Euroepan Space Agency
EU - European Union
EUMENET-ECSN - European Meteorological Network-European Climate Surface Network
EURO4M - European Reanalysis and Observations for Monitoring
GCOS - Glocal Climate Observing System
GEOSS - GLobal Earth Observation System of Systems
GPCC - Global Precipitation Climatology Centre
HARMONIE - Hirlam and Aladin Research for Mesoscale Operations In Europe
HErZ - Hans-Ertel-Centre for Weather Research
HIRLAM - High Resolution Limited Area Model(ing)
HOME - Advances in Homogenization Methods of Climate Series: An Integrated Approach
HYPE - Hydrological Prediction System for the Environment
ISHD - International Surface Hourly Dataset
ISPD - International Surface Pressure Databank
JAR-25 - Japanese Reanalyses 25 years
KENDA - Kilometer-scale Ensemble Data Assimilation
KF - Kalman Filter
KNMI - Koninklijk Nederlands Meteorologisch Instituut
MARS: Meteorological Archives Retrieval System at ECMWF
MEDARE: MEditerraean DAta REscue Initiative

MESAN - MESAN and CANARI combined mesoscale 2D analysis system
MESCAN - MESan CANari 2D analysis system as developed in EURO4M
MeteoMet - Metrology for Meteorology project
MSLP - Mean Sea Level Pressure
NCDC - National Climate Data Center
NCEP/NCAR- National Centers of Environmental Prediction/National Center for Atmospheric Research
NMHS - National Meteorological and Hydrological Service
O-REG - Organization-Researcher Excellence Grant
PA - Project Administration
QC/QA- Quality Control/Quality Assurance
QGC - Open Geospatial Consortium
RA - reanalysis or reanalyses
REA - Research Executive Agency for the EC
RRA: Regional Reanalysis
SURFEX - EXternailsed SURF system
Tn - miNimum temperature
Tx - maXimum temperature
UEA/CRU - University of East Anglia/Climatic Research Unit
UM - Unified Model of the Met Office and its partners
URV - Universitad Rovira i Virgili
WIS/GISC - WMO Information System/Global Information System Centre
WMO DRR/SEE - Regional Cooperation in South-Eastern Europe (SEE) for meteorological, hydrological and climate data management and exchange to support disaster risk reduction (DRR)
WMO - World Meteorological Organization
WMS - Web Map Service

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