Seventh Framework Programme

Theme 6 [SPACE]

Project: 607193 UERRA

Full project title:

Uncertainties in **E**nsembles of **R**egional **R**e-**A**nalyses

Deliverable D 4.2

Data Plan: INSPIRE compliant data dissemination plan and hand over to CLIPC

WP no:	4
WP leader:	KNMI
Lead beneficiary for deliverable :	KNMI
Name of authors:	Wim Som de Cerff, Maarten Plieger (KNMI), Manuel Fuentes, Richard Mladek (ECMWF)
Nature:	Report
Dissemination level:	PU
Deliverable month:	12
Submission date: March 14, 2016	Version nr: 2

Contents

Introduction

This document describes the data dissemination plan, as one of the deliverables for WP4 Facilitating downstream services (data, derived products and outreach).

The aim of this document is to describe how the UERRA data products can be provided to a large number of users and link in an optimal way to existing data and visualization portals or portals that are being developed in parallel projects, for scientific and policy use.

There is a wide range of different climate portals and inventories/analysis have been made [R6]. These inventories can be used to analyze what is the best portal to publish the UERRA results in the existing portals.

Besides the already existing portals, a close connection to the emerging Copernicus Climate Change Service (C3S) is an important publication channel to be considered.

The mentioned INSPIRE compliant data dissemination and hand over to CLIPC is also discussed in this document.

Note that the document shows the plan for data dissemination, not the technical details on how it should be done.

Reference documents

#	Name	link
R1	INSPIRE Directive	http://inspire.jrc.ec.europa.eu/index.cfm/pageid/48
R2	INSPIRE legislation and Data specifications	http://inspire.jrc.ec.europa.eu/index.cfm/pageid/2
R3	INSPIRE Implementing Rules	http://inspire.jrc.ec.europa.eu/index.cfm/pageid/47
R4	INSPIRE Metadata Implementing Rules Technical Guidelines	http://inspire.jrc.ec.europa.eu/index.cfm/pageid/101
R5	ADAGUC geographic information system for NetCDF	http://adaguc.knmi.nl/
R6	D44.1 EUPORIAS inventory of existing climate data portals and their requirements	http://euporias.eu/node/383
R7	D3.5 Data storage and dissemination document describing the INSPIRE-compliant infrastructure	http://www.euro4m.eu/downloads/D3.5_Data%20Storage%20and%20dissemination%20document%20describing%20the%20INSPIRE-compliant%20infrastructure.pdf
R8	CLIPC project	http://www.clipc.eu/
R9	Climate Adapt portal	http://climate-adapt.eea.europa.eu/
R10	Climate4impact.eu portal	http://climate4impact.eu/
R11	UERRA Progress status	http://software.ecmwf.int/wiki/display/UER/Progress+status
R12	UERRA Parameters at ECMWF	http://software.ecmwf.int/wiki/display/UER/Parameters
R13	TIGGE data portal	http://apps.ecmwf.int/datasets/data/tigge
R14	ECMWF WebAPI	http://software.ecmwf.int/wiki/display/WEBAPI/ECMWF+Web+API+Home
R15	INSPIRE Geoportal	http://inspire-geoportal.ec.europa.eu/discovery/
R16	CAMS metadata Catalogue	http://macc.copernicus-atmosphere.eu/catalogue/
R17	ECMWF ecCharts	http://apps.ecmwf.int/forecaster/
R18	EarthServer2 project	http://www.earthserver.eu/
R19	UERRA Parameters (live document)	https://drive.google.com/folderview?id=0B0R5-gz4Xjz4MzJJaFBEbGhLUGM&usp=sharing_eid&invite=CI7L_tUC

Datasets generated in UERRA

According the statements in the Description of Work of UERRA the project will deliver:

The project will provide long-term datasets of Essential Climate Variables (ECVs) on the European regional scale in order to support adaptation action and policy development. The datasets will contribute to Climate services for Copernicus, climate monitoring and research.

According to the work packages deliverables the following data products are to be delivered by the project:

- D1.8 DARE data archives (in ECA&D and MARS archive)
- D1.13 E-OBS updates
- D2.3/D2.4 Ensemble Variational DA diagnostics data and documentation

- D2.5 : Report of results and datasets of two physics HARMONIE runs for spread estimation
- D2.7 : HARMONIE reanalysis report of results and dataset
- D2.8 : MESCAN reanalysis dataset and report 1961-present
- D2.10 : UERRA-MESA-CL 30-year European cloud fraction dataset and report
- D2.13 Kalman Filter Ensemble DA diagnostics data and documentation
- D4.5 : Indices based on reanalysis data, including uncertainty information

These datasets can be roughly grouped in the following categories:

1. Observation dataset (DARE)
2. Regridded observations (E-OBS)
3. Reanalysis datasets (HARMONIE, MESCAN, UERRA-MESA-CL, Ensemble Variational DA, Kalman Filter Ensemble DA)
4. Climate indices (based on reanalysis data)

The distinction in these four categories helps us determine which technology is best suited for data dissemination. Each category varies in e.g., purpose for which it was made, target user group, data size, and data format. Especially the data format (database, GRIB, NetCDF) and data content (point data, gridded data) is important to determine the type of services needed.

UERRA dataset in the MARS archive

There are eight reanalysis datasets identified which would be archived in ECMWF MARS archive:

- COSMO (MIUB)
- COSMO/En (MIUB)
- HARMONIE/V1 (SMHI)
- HARMONIE/V2 (SMHI)
- MESAN (SMHI)
- MESCAN (MF)
- UM/4DVAR (MO)
- UM/En4DVAR (MO)

(MIUB..Meteorologisches Institut der Universität Bonn)

These datasets will contain gridded data in GRIB2 format. Only selected parameters will be archived. The final list of the agreed parameters contains 8 parameters on 3 types of vertical levels (model,

pressure and height) and 43 surface parameters including 3 static fields [R19]. The archiving should start during 2016. As the ReAnalysis get produced, it is expected that each partner extracts the agreed selected parameters, convert them to the UERRA-convention in GRIB edition 2 and archive in the MARS system. This archiving step should be done as the ReAnalysis are produced. Until now as a test bed similar reanalysis data from EURO4M, project precursor of UERRA, was archived. The actual progress reports related to each UERRA dataset could be found at R11.

The up-to-date list of agreed upon UERRA parameters including all technical details and exact descriptions is available at R12.

The data will be available for users via dedicated web data portal which is under development. Similar data portal is for example one used for TIGGE global numerical weather forecasts from 10 world leading meteorological centres R13.

The users could also use all other standard ways how to get the data e.g. via recommended ECMWF WebAPI which is the best suited for large data volume retrievals R14.

The gridded reanalysis data described above will represent vast majority of data which will enter the MARS archive. Apart from them another type of data – rescued observations and observation feedbacks will be archived (in ODB format). Some additional information about the progress of ODB archiving can be found atR11.

INSPIRE

What is the INSPIRE Directive?

For explaining the INSPIRE directive we directly quote from the official JRC INSPIRE website [R3].

"The INSPIRE directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2019.

The INSPIRE directive aims to create a European Union (EU) spatial data infrastructure. This will enable the sharing of environmental spatial information among public sector organisations and better facilitate public access to spatial information across Europe.

A European Spatial Data Infrastructure will assist in policy-making across boundaries. Therefore the spatial information considered under the directive is extensive and includes a great variety of topical and technical themes."

The INSPIRE directive is adopted by all EU member states and implemented into national law. Main goal of INSPIRE is to provide EU wide easy access to harmonized spatial datasets (geographic information). Harmonization is needed because of the diversity of formats, schema's etc. in use, which makes it extremely difficult to create cross-border datasets. Easy access is needed in order to use the available data on a European scale. Below the core principles of INSPIRE are quoted to provide a background to the later mentioned infrastructure components specified by INSPIRE.

"INSPIRE is based on a number of common principles:

- *Data should be collected only once and kept where it can be maintained most effectively.*

- *It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.*
- *It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.*
- *Geographic information needed for good governance at all levels should be readily and transparently available.*
- *Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used."*

In order to establish the envisioned infrastructure, INSPIRE provides 'Implementing Rules' for the technical infrastructure to be established. These regulations are needed in order to enforce standardization and interoperability of the implemented services.

Also, a set of Annexes to the directive describing which data should be provided by each member state. There are three Annexes defined in INSPIRE, each with a different timeline for implementation. Each Annex contains a set of themes, e.g. "Annex III theme 14: Atmospheric Conditions and Meteorological Geographical Features". For each theme a 'Technical Guideline' [R4] is made available specifying which datasets should be provided by each member state.

Within a member state the implementation strategy can be different. In the Netherlands the Ministry of Infrastructure and the Environment is responsible and the implementation is coordinated by Geonovum. In the Netherlands for each dataset from every theme a responsible party has been appointed. E.g., KNMI is responsible for implementation of the services and providing the data in the "Annex III theme 14: Atmospheric Conditions and Meteorological Geographical Features"

Conformance and progress is monitored by JRC and reported yearly to the EC. More information on INSPIRE can be found on the JRC INSPIRE website [R1].

INSPIRE services

In Figure 1 a simplified overview of the envisioned INSPIRE service Architecture is provided. The gray arrow in the middle is called the Service Bus, connection layer between the provided services and the different applications and Geoportals.

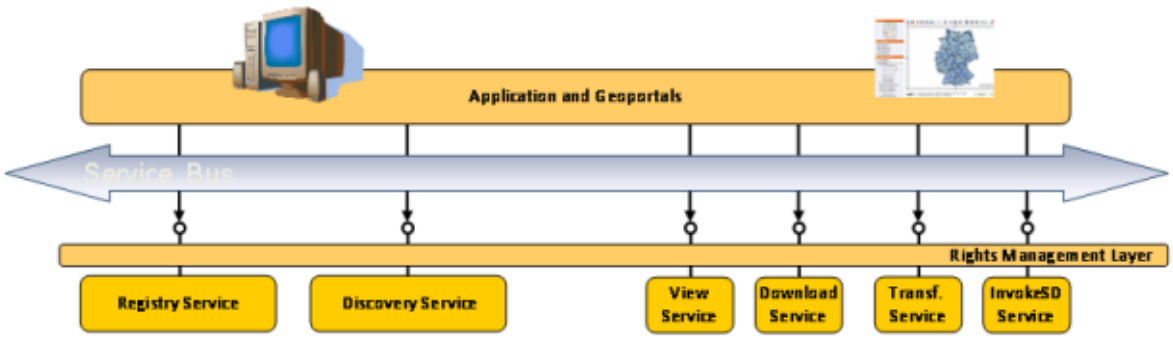

Figure 1 INSPIRE Service Architecture

We will not describe all services in detail. Focus will be on the services to be provided by UERRA in order to be able to connect to the INSPIRE infrastructure. For an extensive description of all services and their interaction we refer to the official INSPIRE website [R9]. Important to notice is that for the services INSPIRE uses specifications from the Open Geospatial Consortium (OGC). These specifications are open and reference implementations are available. INPSIRE does tailor the standards to better fit to the INSPIRE objectives. This is done in 'Technical Guidance' document. Using Open Standards enables both Industry and Open Source communities to implement OGC services.

For connecting the UERRA datasets to the INSPIRE framework the following services need to be provided:

- Discovery Service
- View Service
- Download Service

In the chapter below the services are discussed as well as the implementation done and needed to comply.

Discovery Service

This service provides the possibility to search (*discover*) datasets. The service is specified in detail by INSPIRE in the Technical Guidance for the implementation of the INSPIRE Discovery Service [R3].

In short, it is an OGC Catalogue Service for Web (CSW). This CSW provides metadata search services. In the INSPIRE infrastructure, CSWs are harvested for metadata by the central JRC catalogue service.

The CSW contains metadata. This metadata describes the available datasets according to a INSPIRE profile on the ISO 19115 metadata standard [R4].

For UERRA this implies: for all datasets metadata must be provided compliant with the INSPIRE ISO 19115 profile. This metadata must be stored in an OGC CSW and connected to the INSPIRE infrastructure. For the CSW server many Open Source implementation are available (e.g., Geonetwork).

ECMWF plans to create metadata records for the UERRA dataset stored in MARS and insert them in INSPIRE compatible catalogues, like the INSPIRE Geoportal (R15). In the context of Copernicus, in particular the Copernicus Atmosphere Monitoring Service (CAMS), INSPIRE-compliant metadata records have been created to help users discover some of the datasets available (R16).

Besides the dataset metadata, also the metadata describing the View and Download services need to be provided. This is also described using ISO 19115 metadata (again compliant with the INSPIRE profile for describing these services).

View Service

The View Service provides a graphical image of the data. The OGC Web Mapping Service (WMS) specification is used for this. For the specific INSPIRE WMS, the Technical Guidance for the implementation of the INSPIRE View Service is provided [R3].

For UERRA datasets a view service needs to be provided for each dataset. ADAGUC provides an INSPIRE compliant WMS, but this works for NetCDF CF compliant data only. ADAGUC also supports HDF5. For GRIB datasets and ASCII datasets additional effort is needed. It is possible to expand ADAGUC with support for Grib/ASCII datasets.

ECMWF has developed an OGC Web Mapping Service for real-time data called ecCharts, mainly targeted at forecasters (R17, note authorization is required). A limited set of fields in GRIB format are pushed daily to dedicated machines that provide the service. There are plans to extend this service to other MARS data, like ReAnalysis, in which subsets of these datasets would be made available for visualization and analysis. A subset of the UERRA dataset could be made available as a proof-of-concept.

Download Service

For the download services INSPIRE provides the Technical Guidance for the implementation of the INSPIRE Download Service. Unfortunately, for gridded datasets the most suitable OGC service Web Coverage Service (WCS) is not specified yet. Also, the most suitable OGC service for point data, the Sensor Observation Service (SOS) is not specified yet. For now, an Atom feed combined with an OpenSearch interface need to be implemented as download service.

For UERRA datasets a WCS service for each dataset seems the best option, but for the GRIB and ASCII datasets alternative solutions need to be investigated

As part of the EU project EarthServer2 (R18), ECMWF is exploring the possibility to provide OGC WCS services out of the MARS Archive. UERRA will be a clear example of dataset to make available via WCS, which will enhance its dissemination to users.

Connection with CLIPC

The CLIPC project has a connection with the UERRA project and will enable data dissemination of the UERRA products. The CLIPC project aims to provide the INSPIRE compliant services, as mentioned in the previous section.

For connecting the datasets there are two possible routes foreseen, both aiming at automation of the deployment of data services:

1) Using the UERRA ESGF data node. CLIPC will be able to provide services on top of an ESGF data node by harvesting metadata from specific datasets. UERRA and CLIPC have to discuss how to best enable this as there are several ways to solve this, e.g. by providing the specific dataset names to CLIPC, or to place the UERRA projects in a specific ESGF project. Placing data in an ESGF data node takes some effort and is best suited for the Regridded observations and Reanalysis datasets.
   CLIPC contacts: Victoria Bennet: victoria.bennett@stfc.ac.uk, Martin Juckes: martin.juckes@stfc.ac.uk

2) FTP upload data to climate4impact.eu, this is probably best for Indicator Datasets. This route is implemented for the CLIPC indicator datasets. Here also agreements have to be made (e.g., specific IP addresses for data upload need to be specified, metadata has to be complete and contained within the dataset data).
CLIPC contacts: Maarten Plieger: plieger@knmi.nl , Wim Som de Cerff, sdecerff@knmi.nl

To enable automated harvesting of metadata, the metadata contained in the dataset files should be standardized beyond the specifications of CF. To discuss this metadata and its standardization, a workshop is planned in Toulouse (10-14 February, 2016).

The handover of the UERRA data to CLIPC should be discussed in the overarching WP, but also directly with the people involved.

The DARE dataset is stored in MARS and ECA&D. The two earlier mentioned methods depend on the datasets being available as data files. A solution could be to extract the data from the database and provide the DARE dataset as NetCDF4 data file(s). In this way route 2 (FTP upload) is a feasible solution for data dissemination. If not, another solution has to be investigated.

Connection with Copernicus Climate Change Service (C3S)

The Copernicus Climate Change Service (C3S) will combine observations of the climate system with the latest science to develop authoritative, quality-assured information about the past, current and future states of the climate in Europe and worldwide.

ECMWF operates the Copernicus Climate Change Service on behalf of the European Union and will bring together expertise from across Europe to deliver the service.

C3S will provide key indicators on climate change drivers such as carbon dioxide and impacts, for example, reducing glaciers. The aim of these indicators will be to support European adaptation and mitigation policies in a number of sectors. [source: http://climate.copernicus.eu/about-c3s].

The C3S is in development UERRA should contact ECMWF on how we could provide the UERRA products to the C3S system. The outcome of this discussion could be that the UERRA partners should respond to the official C3S tenders.

Currently there are many tenders out for building the C3S and the services for data provisioning. Also for the dataset provisioning itself tenders are out or coming out. The UERRA consortium could try to coordinate efforts in responding to these tenders to ensure datasets created in the UERRA project can be sustained in the C3S context.

UERRA wider data dissemination

The EUPORIAS project decided not to build ‘yet another portal’, but to disseminate results to existing data portals in use by the target communities. To see what portals could be targeted an analysis was conducted and documented [R6]. We can use this document to see which existing data portals are also suited to disseminate the UERRA data products.

Possible candidates are the ClimateADAPT portal from EEA [R9] and the climate4impact portal [R10].

The connection with climate4impact is easy, as it is for base connection to CLIPC. Therefore not much extra effort would be required.

Connecting to the Climate-ADAPT portal will require more efforts. EEA has a strict data policy and quality check process. As the target of ClimateADAPT is the climate adaptation community, it is best suited to provide the climate indices datasets (not the reanalysis data).

Plan for data dissemination [Concluding remarks, recommendations]

UERRA should not built its own data portal, but connect to existing data portals. As can be concluded from the previous chapters, the following connections are foreseen:

- Data portal at ECMWF providing access to the raw reanalysis and feedback
- Connection with CLIPC through UERRA ESGF datanode
- Connection whit CLIPC through climate4impact data upload
- UERRA wider data dissemination through climate4impact and Climate-ADAPT

For connection with CLIPC it is useful to have contact persons (names, email addresses) for each dataset.

From CLIPC the main contacts for data dissemination are:

1) ESGF connection:
   Victoria Bennet: victoria.bennett@stfc.ac.uk, Martin Juckes: martin.juckes@stfc.ac.uk

2) FTP upload:
   Maarten Plieger: plieger@knmi.nl , Wim Som de Cerff, sdecerff@knmi.nl

The connection with C3S might be out of scope for the project duration of UERRA, as C3S will become operational after the project end. But as it will be the European operational portal for climate data it is very useful to investigate how C3S develops and how UERRA products can be provided. Since UERRA will become the state-of-the-art European Reanalysis by the end of the project, it would be reasonable to expect the C3S to make use of the UERRA dataset to exercise the capabilities of limited area reanalysis.

UERRA wider data dissemination through climate4impact and Climate-ADAPT is beyond the scope of what was promised in the DoW, but should be considered because of the wider impact.

Annex

Parameters to store from UERRA reanalyses

This document summarizes the agreement as of April 2015 of UERRA reanalysis producers on the output of the different products to be stored.

Below, the sections are divided according to the output levels: model levels, pressure levels, height levels, and the surface level including vertically integrated parameters. Each section is divided into subsections detailing the time steps, parameters, and specific levels where appropriate of the reanalysis output.

Parameters highlighted in blue are those planned to be used in WP3 verification.

We have reanalysis output from three models which cover the 3D atmosphere; each in deterministic mode and run with a set of ensembles:

- Unified Model by Met Office
- COSMO by University of Bonn/HErZ
- HARMONIE by SMHI

Characteristics of each model set-up are listed in the document: UERRA_comparison_table in this same google drive folder.

1 Model Levels

Output on model levels are stored up to a height of about 15km, for a specific set of parameters, and for the analyses every six hours only. The main users to address with this product may be regional climate modellers who like to initialize their model with our output.

1.1 Time step for model levels

Store analysis output every six hours at 00UTC, 06UTC, 12UTC, 18UTC for all models.

Don’t store any forecast fields.

1.2 Parameters on model levels

Here, the wind components are stored. In order to calculate wind speed and direction from them it is necessary to provide information of the grid on which the output is stored.

Parameter	UM/4DVar UM/En4DVar (MO)	COSMO COSMO/En (HErZ/UB)	Harmonie/V1 Harmonie/V2 (SMHI)
	Analysis	Analysis	Analysis
cloud cover	X	X	
cloud liquid water content (specific)	X	X	
cloud ice content (specific)	X	X	
pressure	X	X	X
specific humidity	X	X	X
temperature	X	X	X
U component of wind	X	X	X
V component of wind	X	X	X

1.3 Model levels to output (approximate height and pressure values)

Output on all model levels up to a height of about 15km above ground.

MetOffice:

- Model levels follow terrain and flatten towards the top of the model following Charney-Phillips staggering
- Model level values are interpolated in log(pressure) to provide fields on requested pressure surfaces

HErZ:

- Approximate heights and pressure are only valid for grid points above sea
- with orography these values can (dramatically) change due to the orography following coordinate

SMHI:

- relative to the model grid elevations / terrain following
- pressure relative to 1013.25 hPa surface pressure
- heights are approximate using a temperature of 273 K

2. Pressure levels

Output on pressure levels seems to be the main archive to be used, so the output is stored on a rather dense vertical grid, for a specific set of parameters, and for forecasts and analyses.

2.1 Time steps for pressure levels

Analysis:

- Store analysis output in six hourly intervals at 00 UTC, 06 UTC, 12 UTC, 18 UTC for the Unified Model and Harmonie
- Store analysis output in hourly intervals for COSMO

Forecasts for all models:

- T+1,2,3,4,5,6,9,12,15,18,21,24,27,30
  started at 00 UTC and 12 UTC
- T+1,2,3,4,5,6
  started at 06 UTC and 18 UTC

2.2 Parameters on pressure levels

Parameter	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	Analysis	Fore-cast	Analysis	Fore-cast	Analysis	Fore-cast
cloud cover	X	X	X	X		X
cloud liquid water content (specific)	X	X	X	X		X
cloud ice content (specific)	X	X	X	X		X
geopotential height	X	X	X	X	X	X
relative humidity	X	X	X	X	X	X
temperature	X	X	X	X	X	X
U component of wind	X	X	X	X	X	X
V component of wind	X	X	X	X	X	X

2.3 Pressure levels to output

Output on pressure levels on a rather dense vertical grid.

Pressure levels [hPa]
1000
975

950
925
900
875
850
825
800
750
700
600
500
400
300
250
200
150
100
70
50
30
20
10

3. Height levels

The agreement is to store lower tropospheric, near-ground, output on height levels in addition to model levels. Height levels are provided on fixed geometric height above model topography. It is a user friendly format, and the main user communities interested in this output may be the wind energy sector and forestry.

3.1 Time steps for height levels

Analysis:

- Store analysis output in six hourly intervals at 00 UTC, 06 UTC, 12 UTC, 18 UTC for the Unified Model and Harmonie
- Store analysis output in hourly intervals for COSMO

Forecasts for all models:

- T+1,2,3,4,5,6,9,12,15,18,21,24,27,30
  started at 00 UTC and 12 UTC
- T+1,2,3,4,5,6
  started at 06 UTC and 18 UTC

3.2 Parameters on height levels

It was decided that wind is provided as wind speed and wind direction on height levels because it is envisaged that the user community interested in height levels is more interested in these parameters instead of the separate components.

Parameter	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	Analysis	Fore-cast	Analysis	Fore-cast	Analysis	Fore-cast
Cloud cover	X	X	X	X		X
cloud liquid water content (specific)	X	X	X	X		X
cloud ice content (specific)	X	X	X	X		X
Pressure	X	X	X	X	X	X
Relative humidity	X	X	X	X	X	X
Temperature	X	X	X	X	X	X
wind speed	X	X	X	X	X	X
wind direction	X	X	X	X	X	X

3.3 Height levels to output

Output is stored on the following height levels. It needs to be taken care of that wind speed and wind direction at 10m height is also a 2D parameter. It should not be stored twice.

WP3 suggestion [m]
15
30
50
75
100
150
200
250
300
400
500

4 Surface level

We have reanalysis output for the surface level from six different models:

- Unified Model by Met Office
- COSMO by University of Bonn/HErZ
- HARMONIE by SMHI
- MESAN by SMHI which is a total cloud cover reanalysis only
- MESCAN by Météo France
- SURFEX by Météo France

Characteristics of each model set-up are listed in the document: UERRA_comparsion_table in this same google drive folder.

4.1 Time steps for 2D parameters

Analysis:

- Store analysis output in six hourly intervals at 00 UTC, 06 UTC, 12 UTC, 18 UTC for the Unified Model, Harmonie, MESCAN
- Store hourly analysis output for COSMO, MESAN, SURFEX

Forecast:

- Store forecast output at T+1,2,3,4,5,6,9,12,15,18,21,24,27,30 started at 00 UTC and 12 UTC for the Unified Model, COSMO, Harmonie
- Store forecast output at T+1,2,3,4,5,6 started at 06 UTC and 18 UTC for the Unified Model, COSMO, Harmonie

4.2 Parameters for the surface level

4.2.1 Precipitation and humidity

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Ana	For	Ana	For	Analysis	For
Accumulated total precipitation	X	X		X	X	X	X		X
2m relative humidity	X	X		X	X	X	X		X
Total column water vapour				X	X	X	X	X	X
runoff			X						
drainage			X						

4.2.2 Accumulated Radiation Fluxes

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
Albedo			X	X	X	X	X	X	X
Clear-sky short-wave downward flux at the surface				X	X				X
Clear-sky short-wave upward flux at the surface				X	X				X
Clear-sky long-wave downward flux at the surface				X	X				
Direct short-wave radiation flux at the surface	X		X	X	X	X	X		X
Evaporation			X	X	X	X	X		X
Long-wave downward flux at the surface	X		X	X	X	X	X		X
Net long-wave radiation flux at the surface	X		X	X	X	X	X		X
Net short-wave radiation flux at the surface	X		X	X	X	X	X		X

Surface latent heat flux			X	X	X	X	X		X
Surface sensible heat flux			X	X	X	X	X		X
Total short-wave radiation flux at the surface	X		X	X	X	diffuse as separate file not total	dito		X

4.2.3 Temperature and wind speed

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
10m wind speed	X	X		X	X	X	X	X	X
10 m wind direction	X	X		X	X	X	X	X	X
10 m wind gust [in the last 24 hrs | since previous post-processing]				X	X				
Maximum [1.5 m | 2 m] temperature since previous post-processing				X	X	X	X	X	X
Minimum [1.5 m | 2 m] temperature since previous post-processing				X	X	X	X	X	X
[1.5 | 2] m	X	X		X	X	X	X	X	X

temperature									
Surface temperature			X	X	X	X	X	X	X

4.2.4 Pressure/Height

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
Mean sea level pressure				X	X	X	X	X	X
Surface pressure	X			X	X	X	X	X	X

4.2.5 Cloud properties

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
High cloud cover				X	X	X	X	X	X
Medium cloud cover				X	X	X	X	X	X
Low cloud cover				X	X	X	X	X	X
Total cloud cover				X	X	X	X	X	X

4.2.6 Snow

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2	

				(MO)				(SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
Water equivalent of accumulated snow depth			X	X	X	X	X	X	X
Accumulated total snowfall				X	X				X
Snow density			X			X	X	X	X
Snow depth			X			X	X	X	X

4.2.7 Soil

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
Soil temperature level 1			X (10 cm)	X	X	X	X	X	X
Soil temperature level 2			X (20 cm)	X	X	X	X	X	X
Soil temperature level 3			X (50 cm)	X	X	X	X	X	X
Soil temperature level 4				X	X	X	X		
Volumetric soil water layer 1				X	X	X	X	X	X
Volumetric soil water layer 2				X	X	X	X	X	X
Volumetric soil water layer 3				X	X	X	X	X	X

Volumetric soil water layer 4				X	X	X	X		
Soil water index in the root zone (total and liquid)			X						
Soil water index for the first cm (total and liquid)			X						
Soil water index for 5cm (total and liquid)			X						
Soil heat flux			X						

4.2.8 Static fields

Parameter	MF	MESCAN (MF)	SURFEX (MF)	UM/4DVar UM/En4DVar (MO)		COSMO COSMO/En (HErZ/UB)		Harmonie/V1 Harmonie/V2 (SMHI)	
	For or Bg	Ana	For	Analysis	For	Analysis	For	Analysis	For
Land cover (1=land, 0=sea)	X		X	X	X	X	X	X	X
Orography (surface geopot height)	X		X	X	X	X	X	X	X
(Forecast) surface roughness	X		X	X	X	X	X		X

5. List of ECVs available from UERRA

The following table lists the variables which have been identified as ECVs by GCOS and are provided by the UERRA reanalyses. The list of ECVs conforms to the C3S indicative road map stage II. Only those ECVs are listed which are output by at least one partner of UERRA (this leaves out most of the oceanic parameters, for instance).

		Parameter	Met Office	SMHI	HErZ	Météo France	User Interest [%]
Atmospheric (over land, sea, and ice)	Surface:	air temperature	X	X	X	X	72
		wind speed and direction	X	X	X	X	70
		water vapour	specific humidity; total column water vapour	specific humidity; total column water vapour	specific humidity; total column water vapour	specific humidity	41
		precipitation	X	X	X	X	52
		pressure	X	X	X	X	68
		surface radiation budget	Surface net solar radiation; net short-wave radiation flux	Surface net solar radiation; net short-wave radiation flux	Surface net solar radiation; net short-wave radiation flux	Surface net solar radiation; net short-wave radiation flux	32
	Upper air:	temperature	X	X	X		50
		wind speed and direction	X	X	X		49
		water vapour	specific	specific	specific		34

			humidity	humidity	humidity		
		cloud properties	cloud cover; cloud liquid water content; cloud ice content	cloud cover; cloud liquid water content; cloud ice content	cloud cover; cloud liquid water content; cloud ice content		22
Terrestrial		Snow cover	accumulated total snowfall; water equivalent of accumulated snow depth	accumulated total snowfall; water equivalent of accumulated snowfall; snow depth; snow density	water equivalent of accumulated snowfall; snow depth; snow density	water equivalent of accumulated snowfall; snow depth; snow density	15
		Soil moisture	Volumetric soil water layer 1-4	Volumetric soil water layer 1-4	Volumetric soil water layer 1-4	Volumetric soil water layer 1-3	14
		Albedo	albedo	albedo	albedo	albedo	11