TOWARDS A REGIONAL ENSEMBLE REANALYIS

Lilo Bach[1]

J.Keller[2,3], A.Hense[1] and C.Ohlwein[1,3]

Thanks to C.Schraff[2] & C.Bollmeyer[5]

and P.Unden[4], A.Kaiser-Weiss[2], F.Kaspar[2], R.Potthast[2], S.Wahl[1,3], C.Figura[1,3], M.Masbou[2,3],

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3rd UERRA GM Toulouse

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UERRA Uncertainties in Ensembles of Regional ReAnalyses

REGIONAL REANALYSES AT THE UNIVERSITY OF BONN

- Regional reanalyses in the Hans-Ertel Centre for Weather Research
  - COSMO-REA6
    - Europe, 6km
    - COSMO+nudging
    - 20 years

    Bollmeyer et. al, 2015
  - COSMO-REA2
    - Germany, 2km
    - COSMO+nudging+lhn
    - 8 years
  - Produced by C.Bollmeyer (PhD student)
  - Current contact clarissa.figura@uni-bonn.de (PhD student)

STATUS OF THE

EN-LETKF

Contact: jkeller@uni-bonn.de

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- Motivation is more spread in „background" ensemble
- Technical issues cleared, system at a too early stage of development

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- LETKF (*see Schraff et. al 2016, accepted*)
  - Requires high number of ensemble members & inflation techniques
  - Requires ensemble of lateral boundary conditions O(40)
  - Tuning of localization etc. to mesoscale
  - Assimilation of modern observations in development
- Distribution of observations between components
- Double-correction not precluded

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- Produce reanalysis based on ensemble nudging
- Potentially further experiments with EN-LETKF / just LETKF

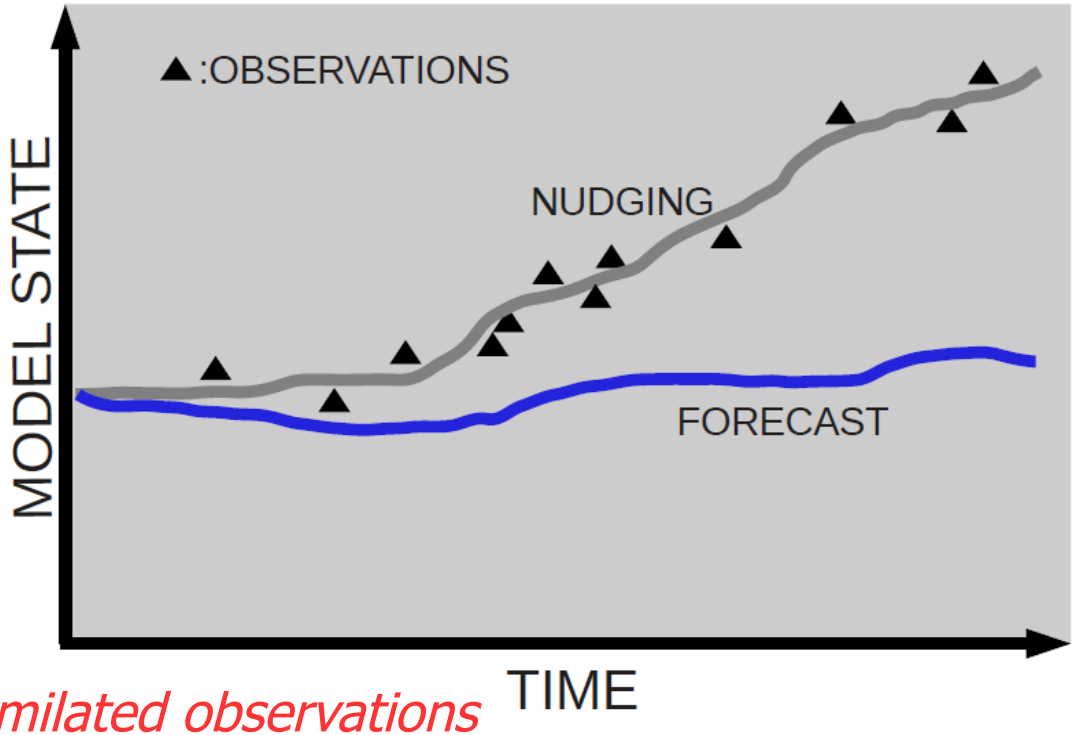
SET-UP

OF THE REANALYSIS SUITE

ENSEMBLE NUDGING

$$\frac{\partial}{\partial t}\psi(\mathbf{x},t) \;=\; F(\psi,\mathbf{x},t) \;+\; G_\psi \cdot \sum_{k_{(obs)}} W_k(\mathbf{x},t)\cdot[\psi_k^{obs} - \psi(\mathbf{x}_k,t)]$$

- Perturb the observations assuming
  - normally distributed
  - stationary
  - spatio-temporally uncorrelated
  - unbiased *obs errors*

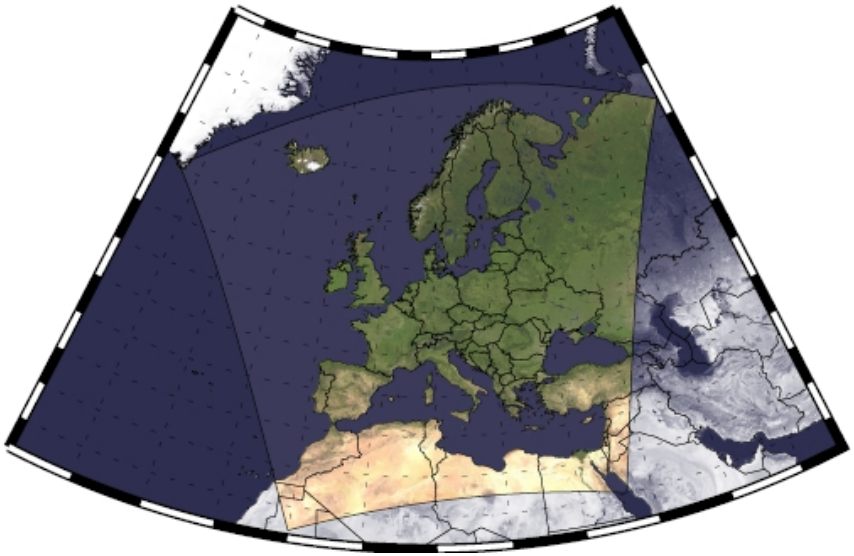


Uncertainty arising from errors in the assimilated observations

~ Measurement error + representativity error + observation operator error

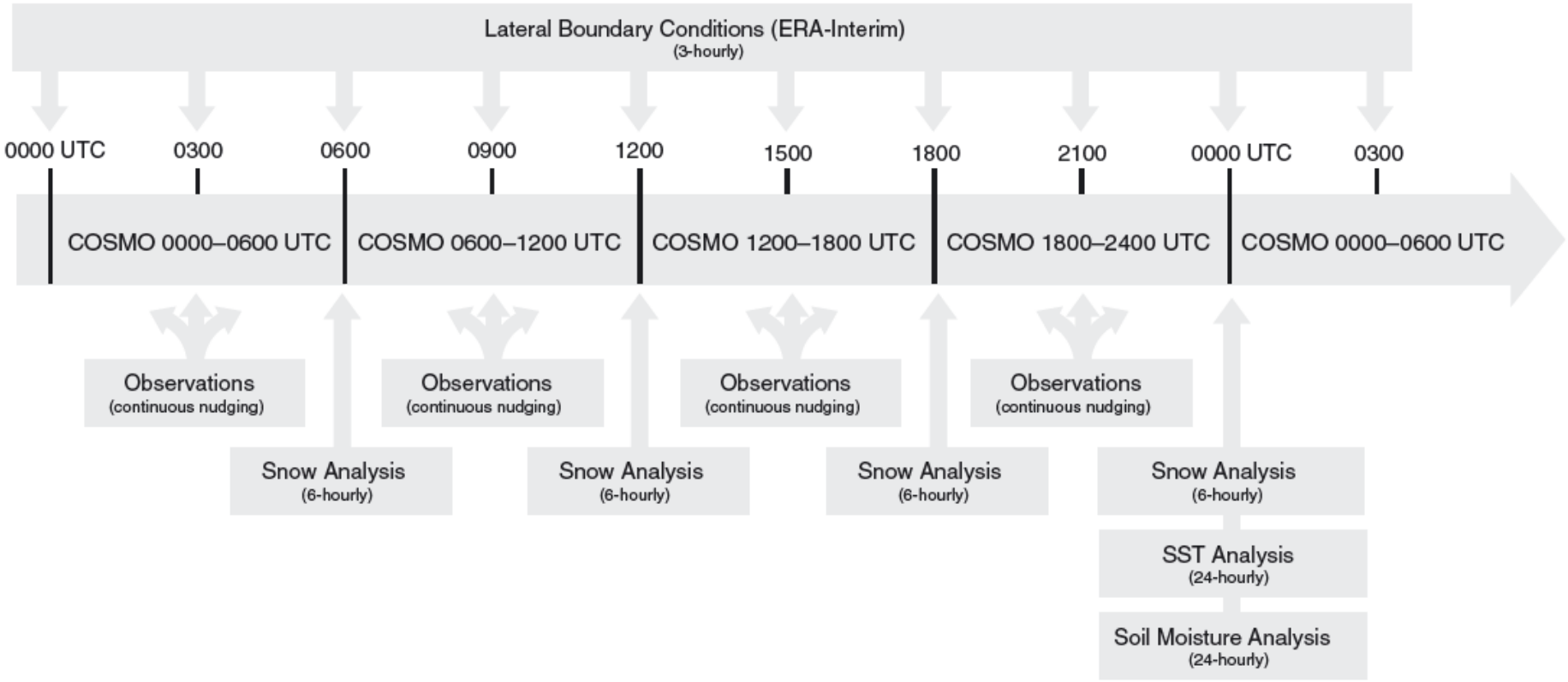
REANALYSIS SET-UP

- COSMO-EU set-up of model version 5.0 (extended)
- Conventional observations
- 3-hourly LBCs from ERA-INTERIM
- Reanalysis + reforecasts



Observing system	Report type	Observed variable
Radiosondes	PILOT	Upper-air wind
	TEMP	Upper-air wind, temperature, humidity
		Surface-level wind temperature, humidity, geopotential
Aircraft	AIREP	Wind, temperature
	AMDAR	Wind, temperature
	ACARS	Wind, temperature
Wind profiler		Upper-air wind
Surface systems	SYNOP	Screen level pressure, wind, humidity
	SHIP	Screen level pressure, wind, humidity
	DRIBU	Screen level pressure, wind, humidity

PRODUCTION CYCLE



PRODUCTION

- Implemented to ecflow at ECWMF
- Computation at CCA
- Implementation nearly finished
  - Archiving to ECFS
  - Small bug in SMA
- Start of production planned for late February 2016
- 5 test years 2006 to 2010

ESTIMATED COSTS

1.) Computational time

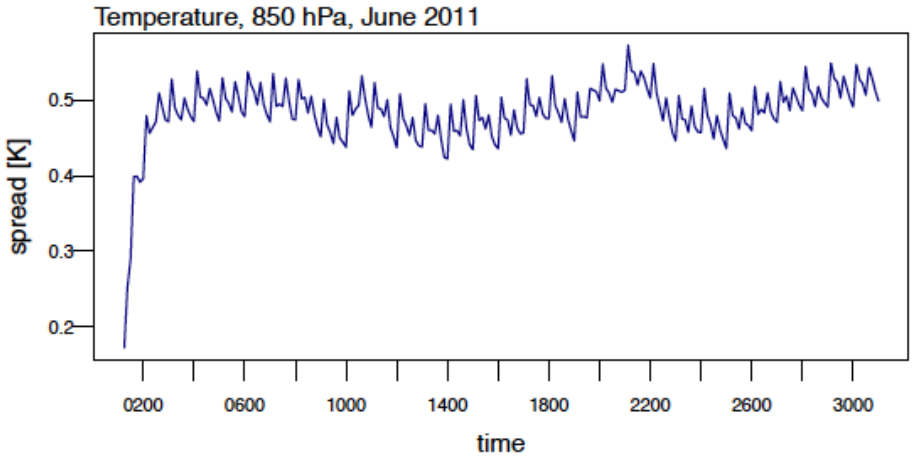
- 5 years à 21 members at 12 km grid spacing
- Speed about 0.5 days/hour
- 5 months pure computing time + archiving
- Should be completed by the end of 2016

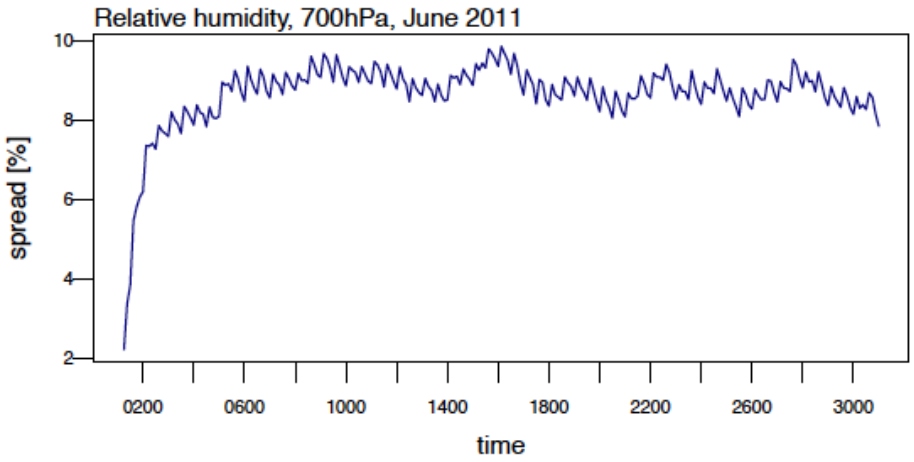
2.) Disk storage

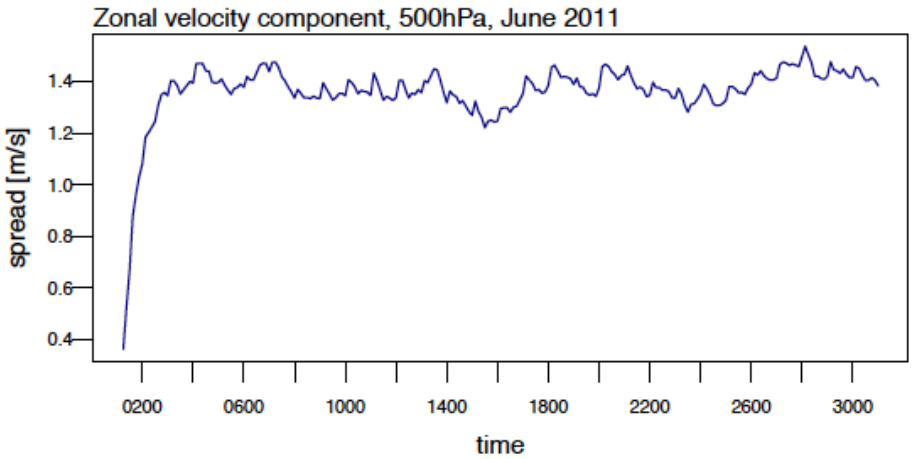
- 1 day of 12km version costs 9G/Member (as tar.gz)
- 5 years à 21 members ~350 T

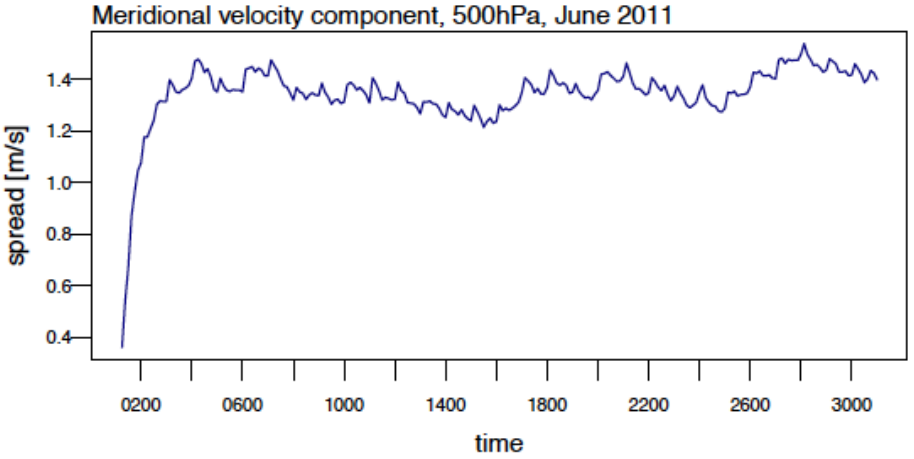
SOME RESULTS

SPREAD


Temperature, 850 hPa, June 2011
spread [K]
0.2
0.3
0.4
0.5
0200
0600
1000
1400
1800
2200
2600
3000
time


Relative humidity, 700hPa, June 2011
spread [%]
2
4
6
8
10
0200
0600
1000
1400
1800
2200
2600
3000
time


Zonal velocity component, 500hPa, June 2011
spread [m/s]
0.4
0.6
0.8
1.0
1.2
1.4
0200
0600
1000
1400
1800
2200
2600
3000
time

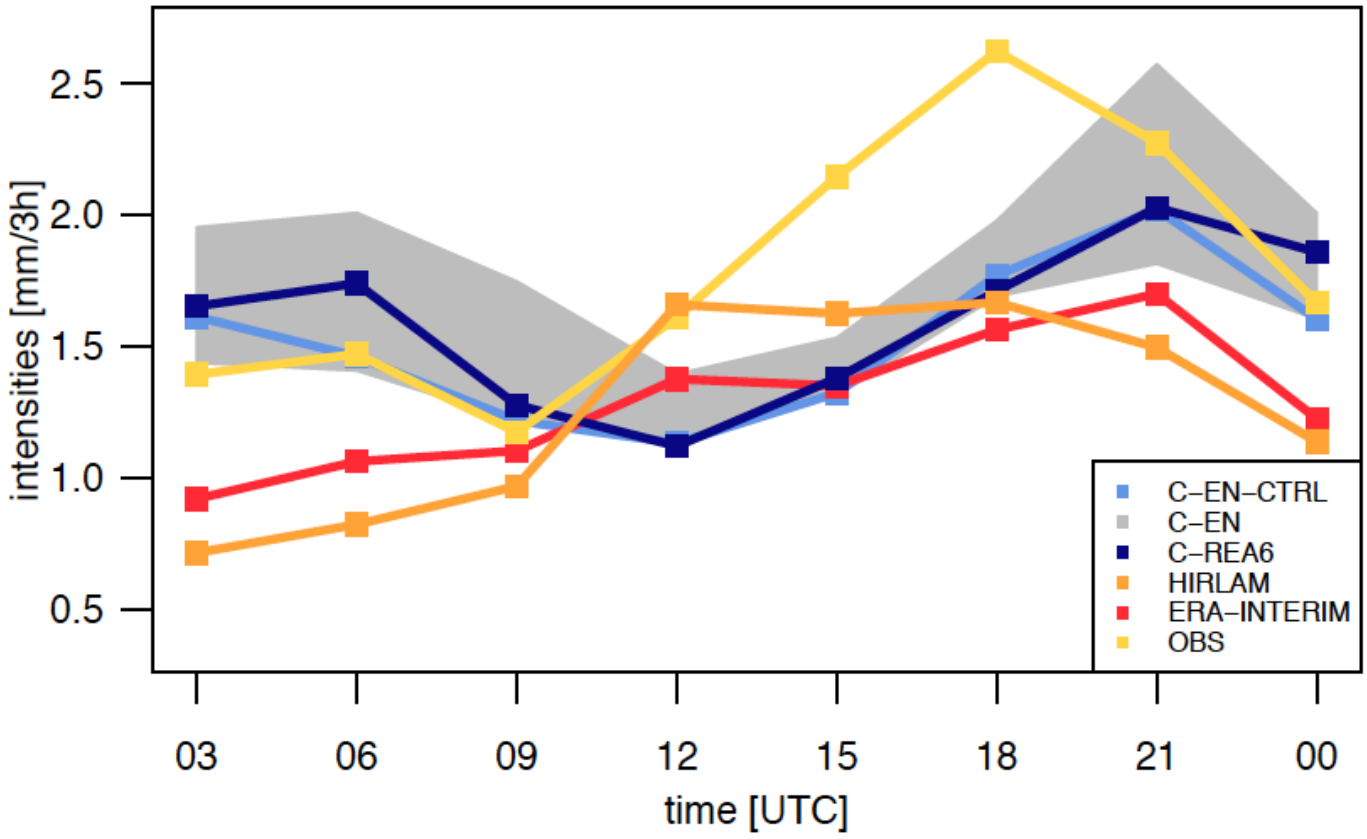

Meridional velocity component, 500hPa, June 2011
spread [m/s]
0.4
0.6
0.8
1.0
1.2
1.4
0200
0600
1000
1400
1800
2200
2600
3000
time

VERIFICATION OF PRECIPITATION

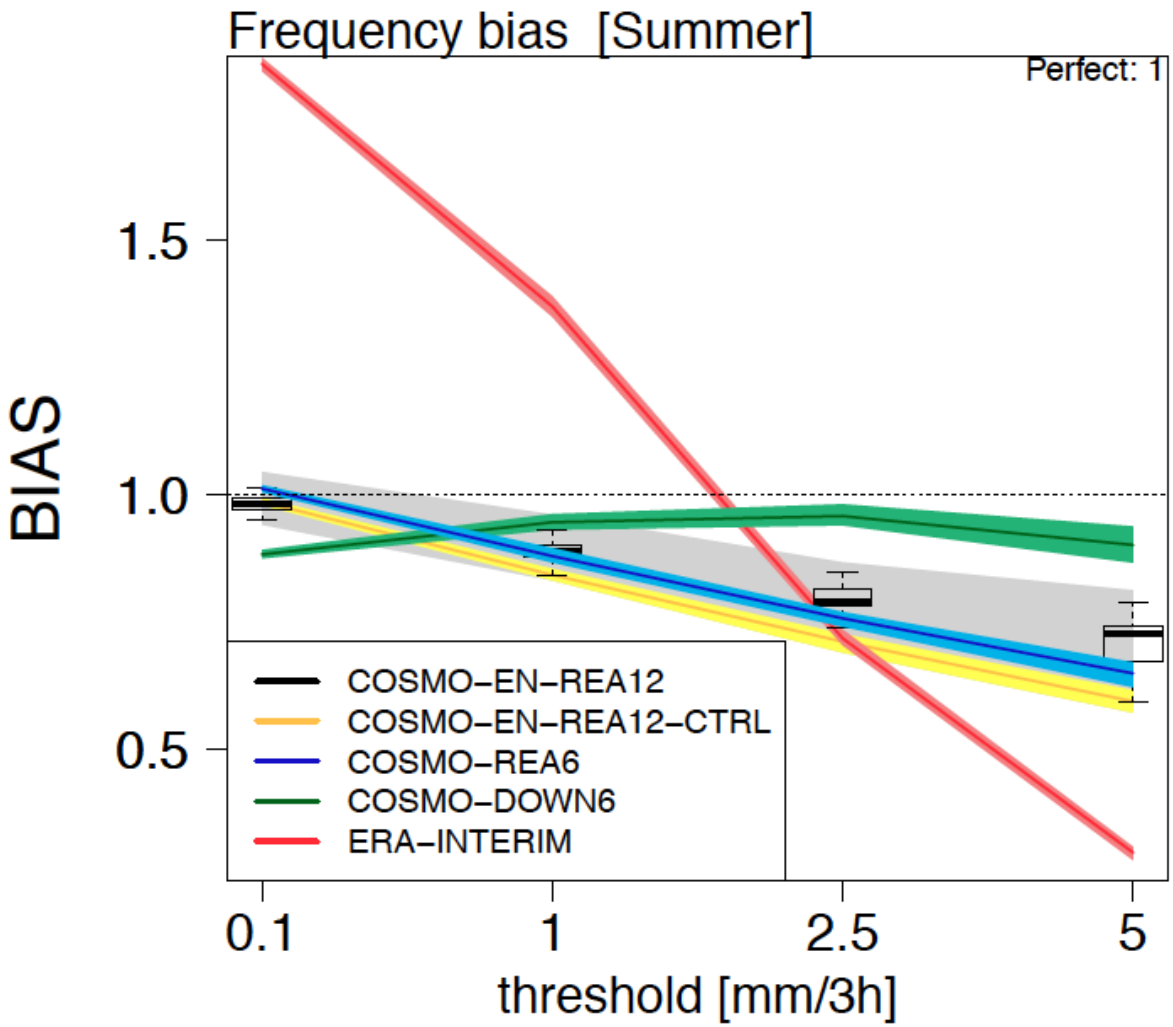
- Representation of precipitation should have an added value compared to ERA-INTERIM
- 2 longer experiments, June / December 2011
- Verification in German subdomain

- Probabilistic verification: 6-hourly precipitation sums
  - Comparison to +06 forecasts of ECMWF-EPS

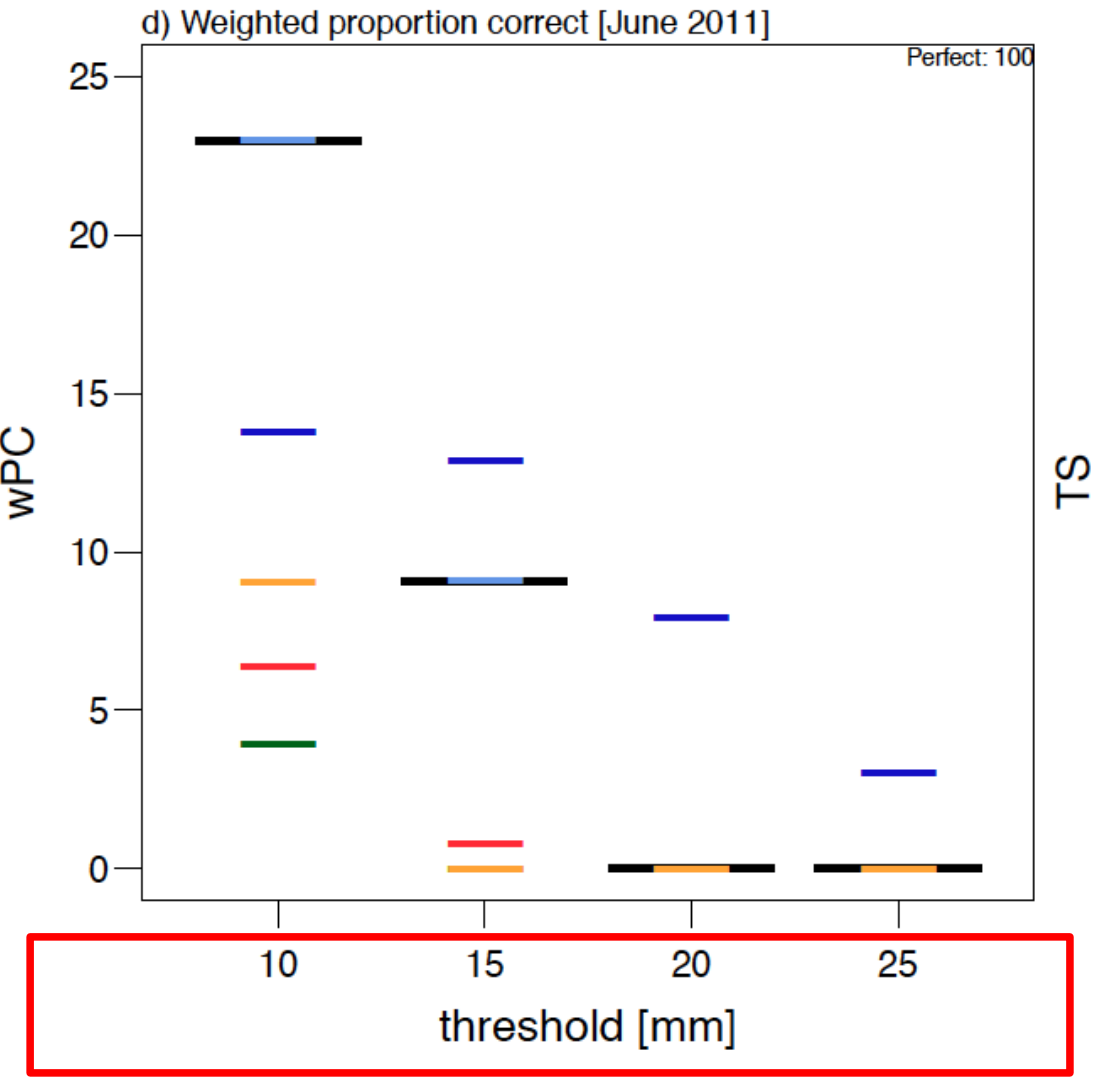
DIURNAL CYCLE OF PRECIPITATION INTENSITIES

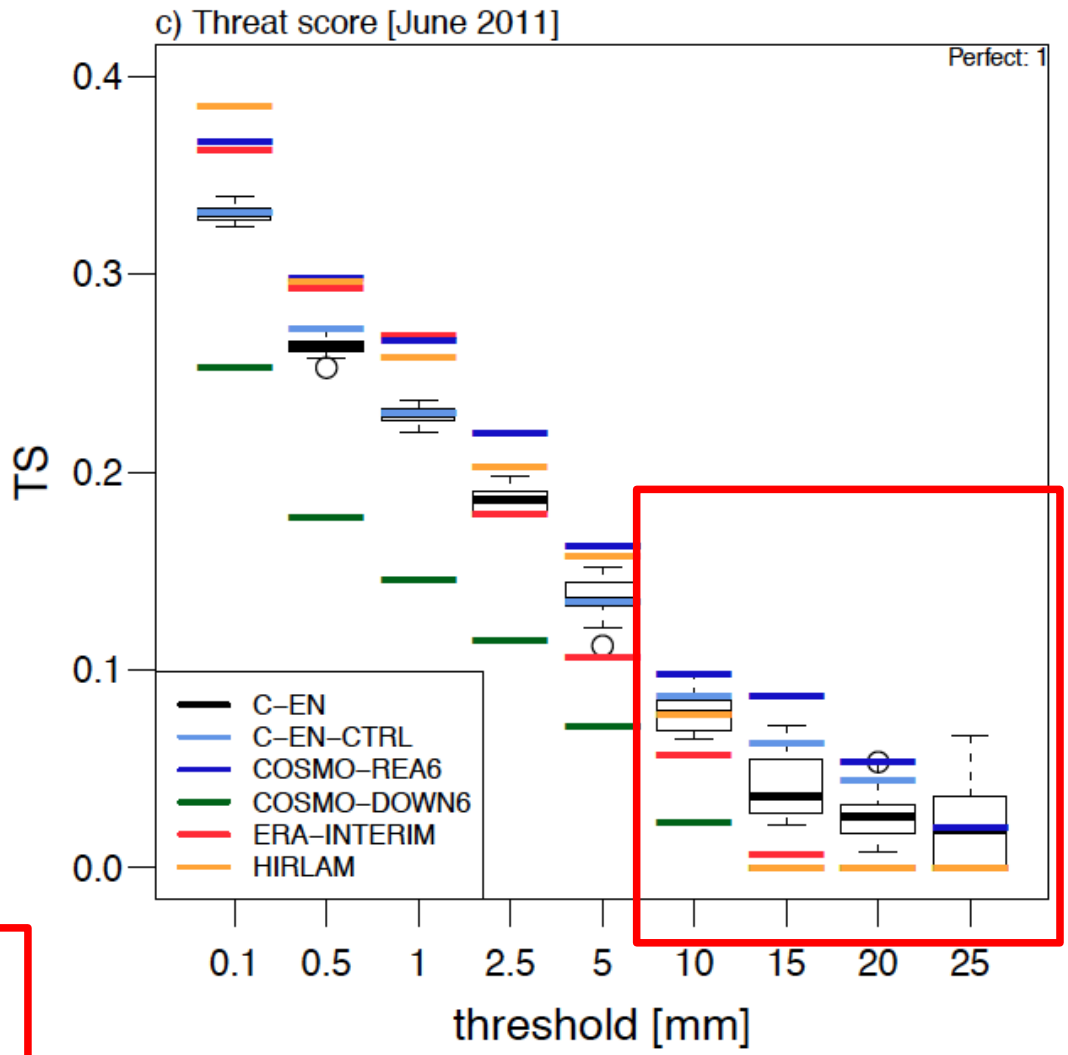


AGREEMENT OF MARGINAL DISTRIBUTIONS

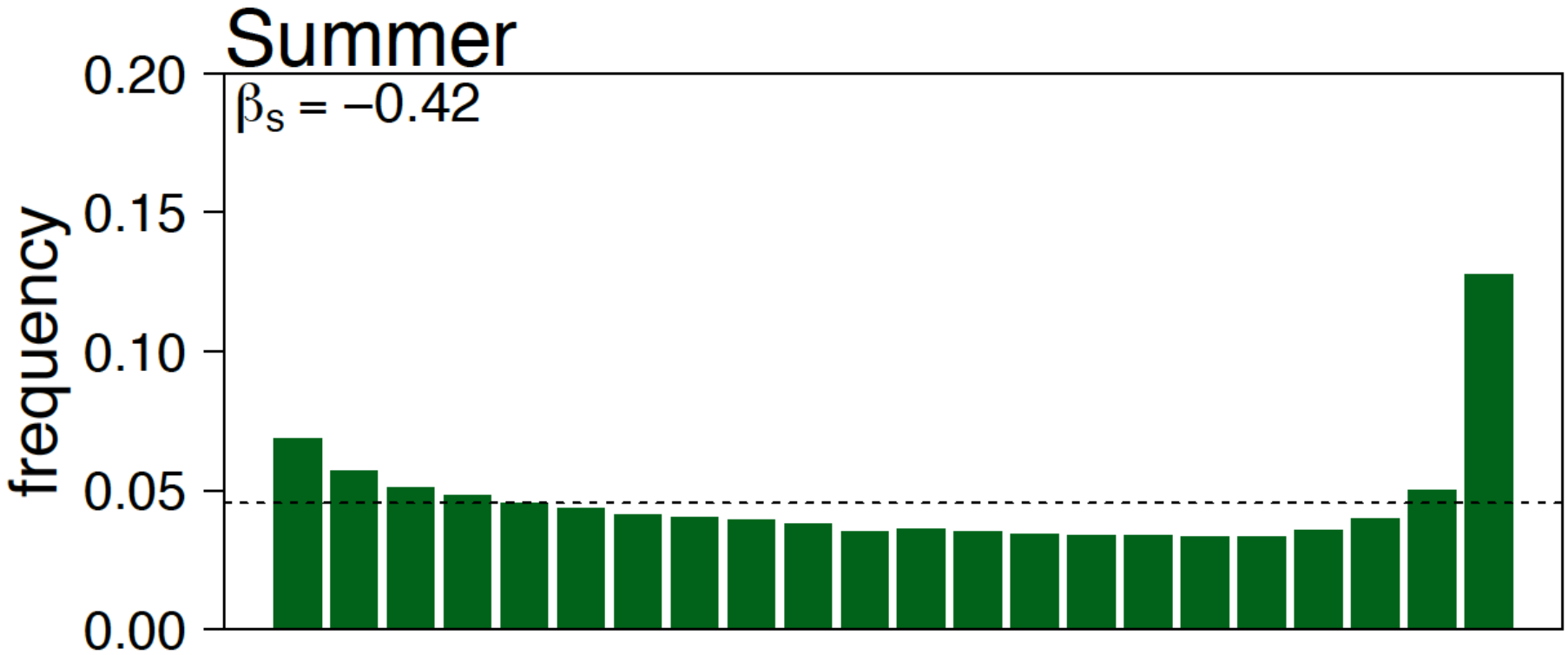


AGREEMENT OF CONDITIONAL DISTRIBUTIONS



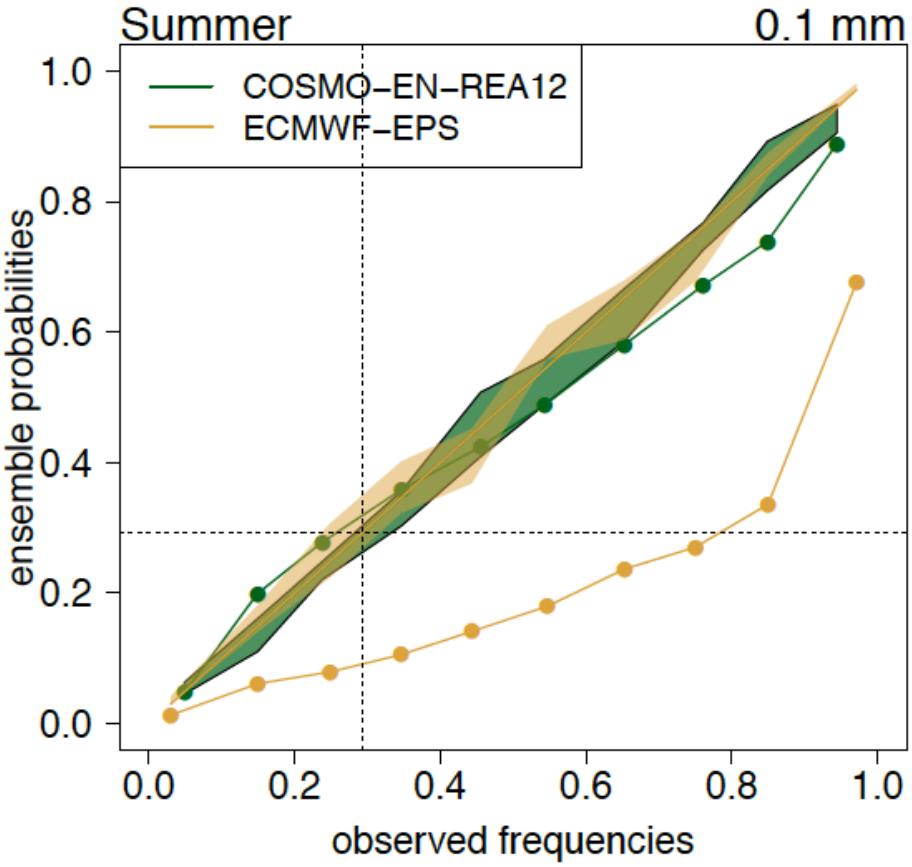


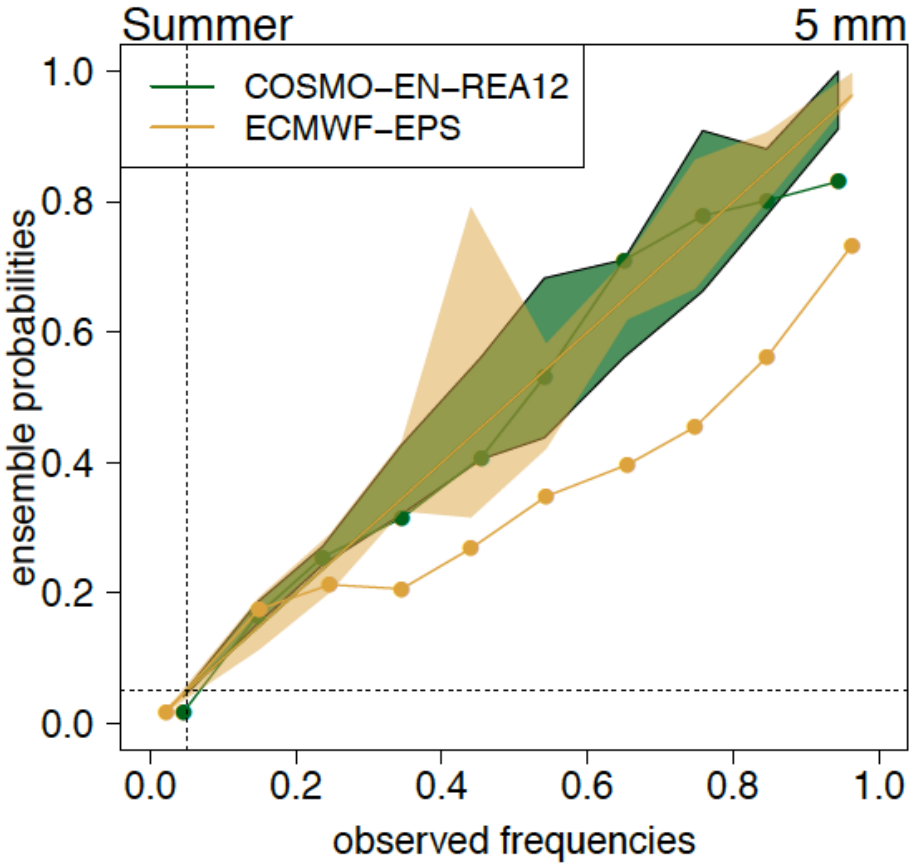
EQUAL-LIKELIHOOD



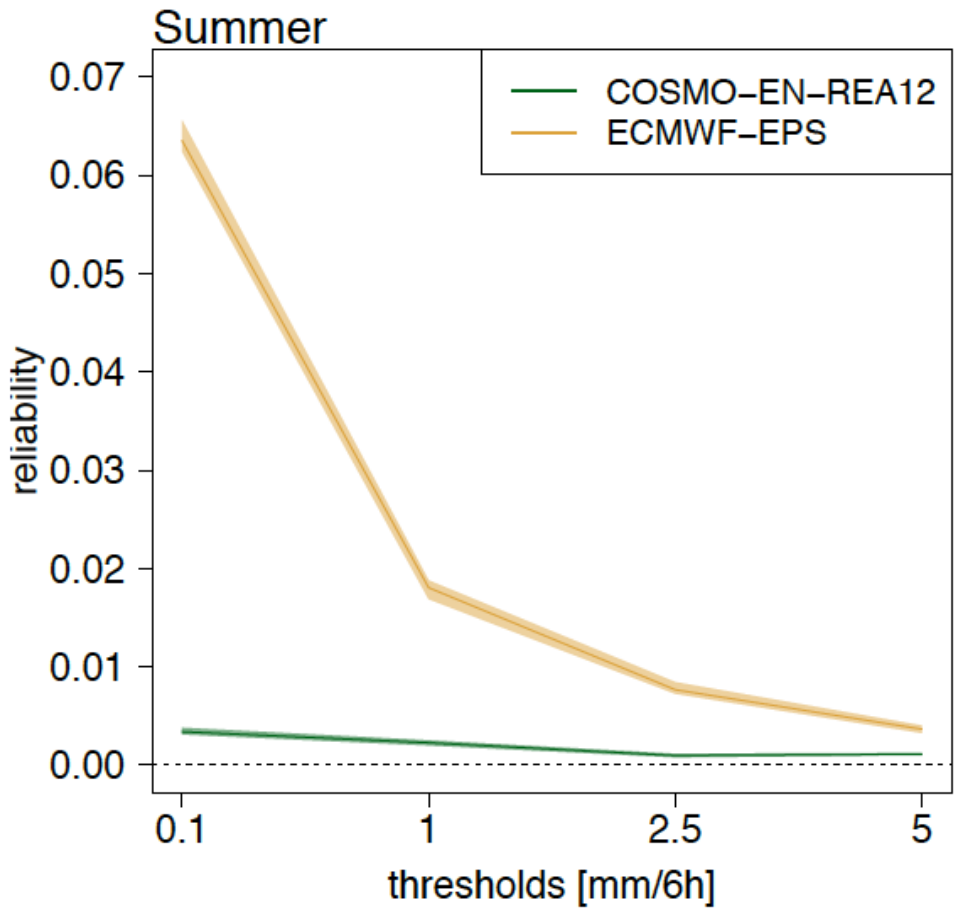
$$SSR \in [0.784, 0.794, 0.805]$$

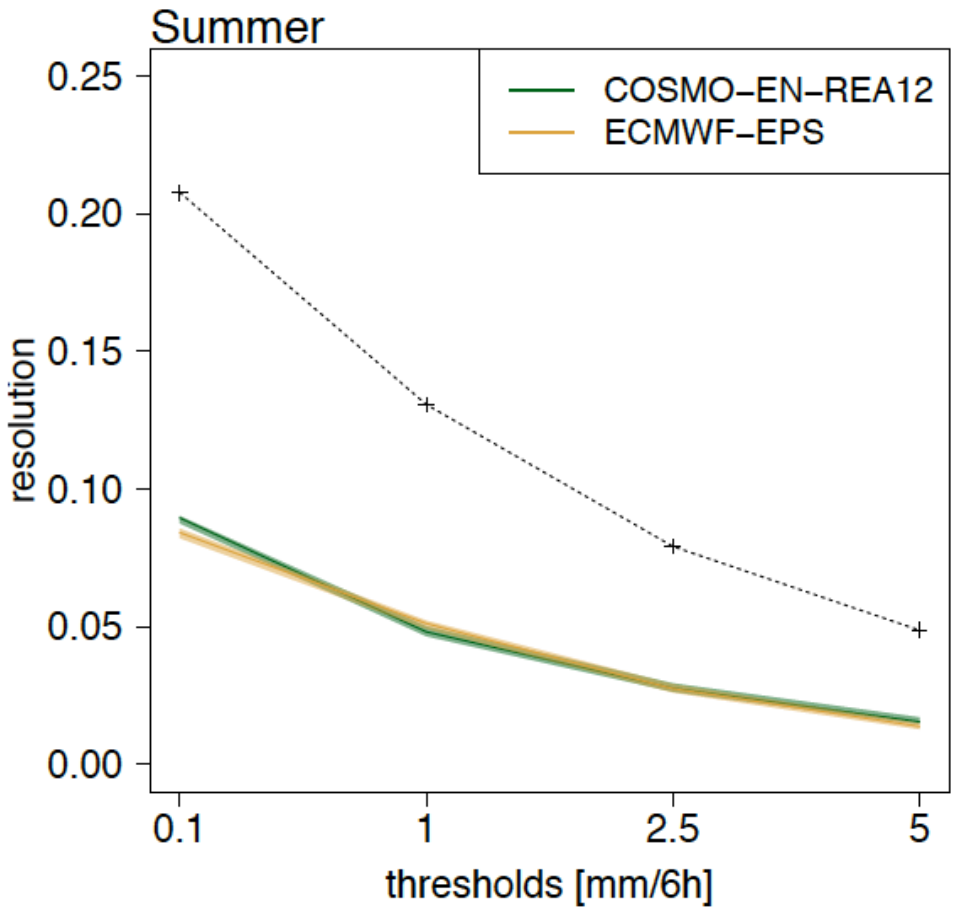
RELIABILITY





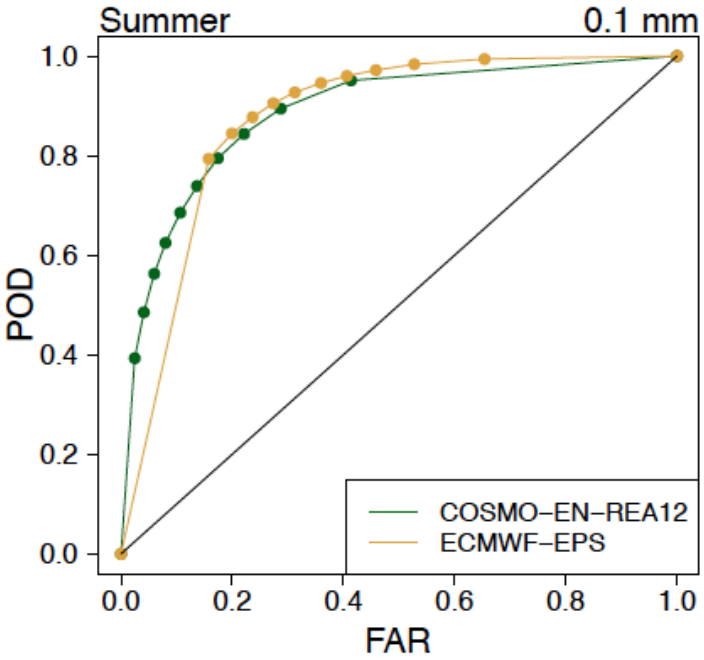
RELIABILITY & RESOLUTION

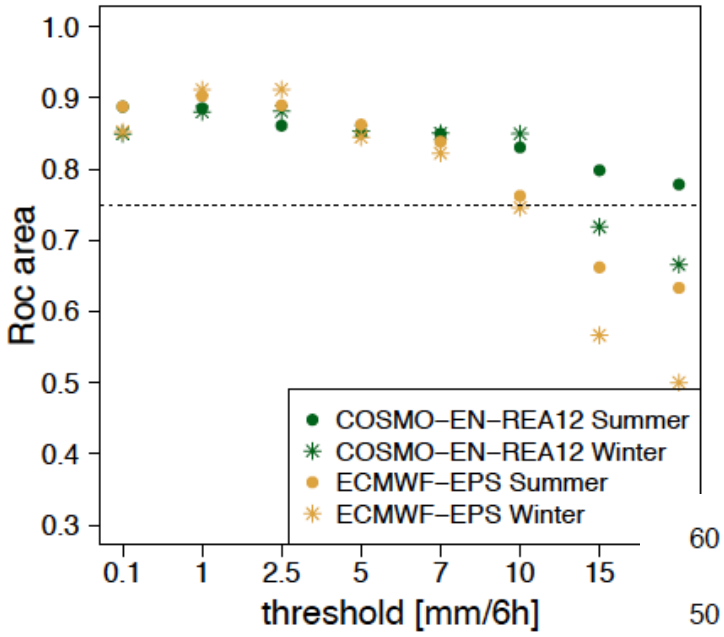


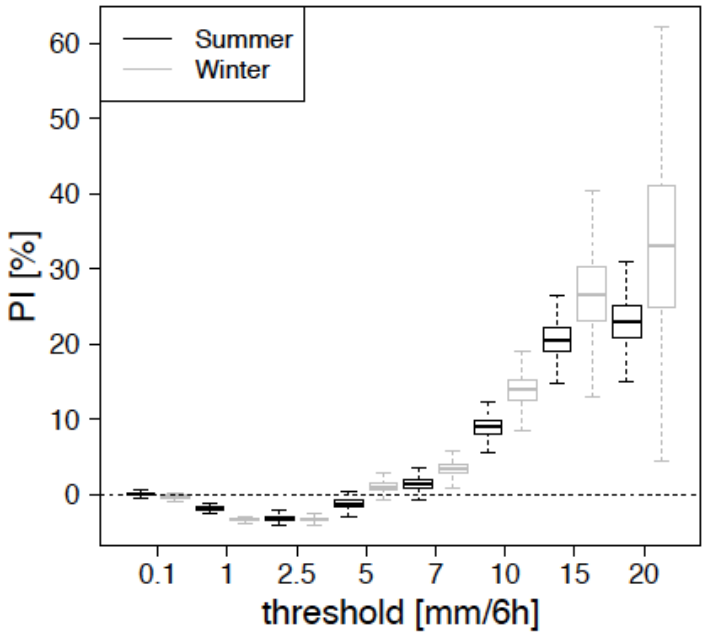


$$BS = \underbrace{\frac{1}{n}\sum_{i=1}^{N} N_i(y_i - \overline{o}_i)^2}_{Reliability} - \underbrace{\frac{1}{n}\sum_{i=1}^{N} N_i(\overline{o}_i - \overline{o})^2}_{Resolution} + \underbrace{\overline{o}(1-\overline{o})}_{Uncertainty},$$

DISCRIMINATION

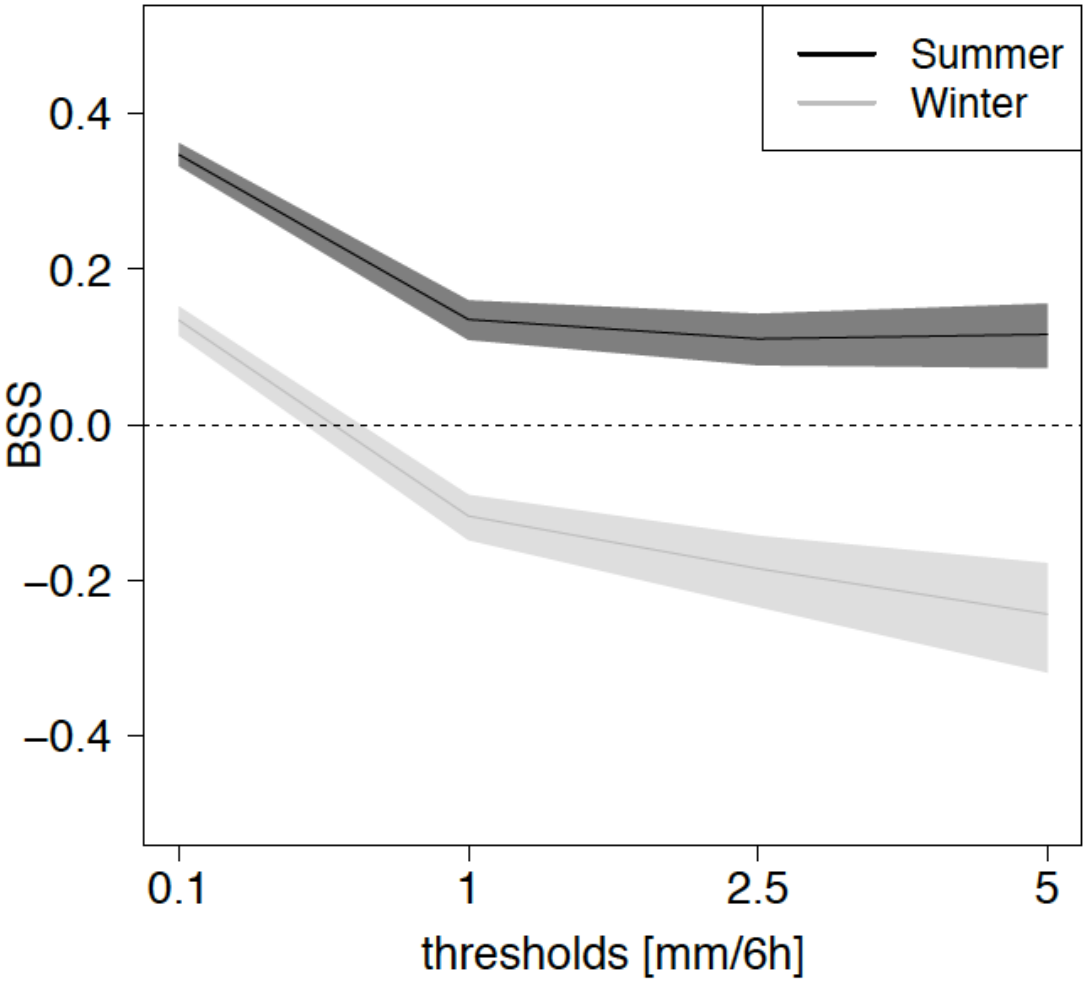






difference of conditional probabilities from the climatic average

SKILL



Summer

$CRPSS \in [-0.01, 0.00, 0.012]$

$CRPSS \in [-0.02, 0.00, 0.016]$

Winter

BENEFITS BY THE ENSEMBLE

- Added value in frequency bias
- Added value at high precipitation thresholds
- Uncertainty estimation for 12 km model set up given observation uncertainties (70 to 80 %)
- Quite well-calibrated ensemble (analysis rank histogram)
- Reliability win compared to ECMWF-EPS (reliability diagrams, BS)
- Resolution/discrimination (roc curve, BS)
- Probabilistic accuracy comparable to ECMWF-EPS (CRPSS)

RESEARCH

PLANS

RESEARCH PLANS

- *What are the uncertainties in regional reanalyses?*
- Experiments with
  - Lateral boundary conditions
    - ICON-Ensemble
    - ERA-5
  - Model physics
    - Perturbed physics ensemble
    - SPPT
- What combination of uncertainty sources will lead to the best spread skill ratio? What is the most important source of uncertainty?
- Experiments with LETKF + ICON-ENS at 12 km

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TEMPERATURE T2M

Only German stations with +-50 height difference to model grid point

	RMSE [K]	BIAS [K]
Control	1.69	0.09
Ensemble Mean	1.64	0.06