Copernicus Regional Reanalysis for Europe

Climate Change

MÉRA workshop, 02/05/2019

Semjon Schimanke et al.

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What's the service about?

- Operational production of a regional reanalysis (RRA) for Europe in near real-time

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- Long series of freely available RRA
  - Starting 1961 with a horizontal resolution of 11km/5.5km
  - From the early 1980 with a horizontal resolution of 5.5km (under development)

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  - From the early 1980 with a horizontal resolution of 5.5km (under development)
- User support and guidance

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Overview

1. Introduction to the service
2. The RRA system and available data
3. Data quality
4. Homogeneity
5. Summary

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1. Introduction/Background

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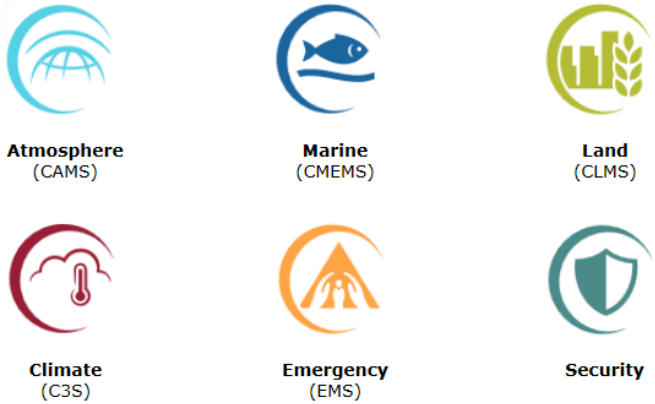
Copernicus / C3S

- Copernicus is the European Union's earth observation program (http://www.copernicus.eu/)



- Our service is part of Copernicus Climate Change Services (C3S) (http://climate.copernicus.eu/)

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Service facts

- The service lifetime is 4 years.
- Onset was on 1/9/2017.
- The service is operated together with two subcontractors

METEO FRANCE

Norwegian Meteorological Institute

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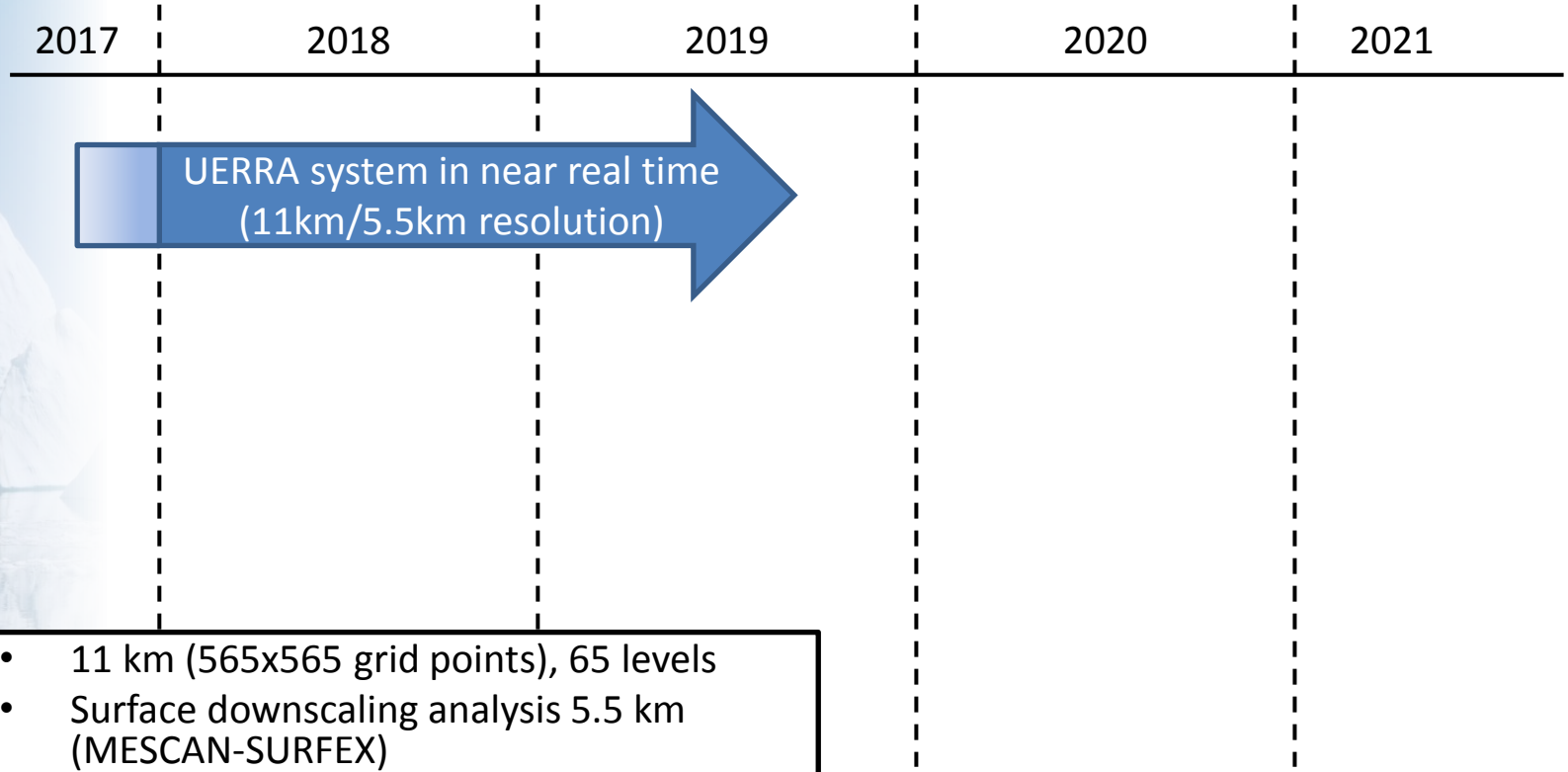
Time line of service and system details



- 11 km (565x565 grid points), 65 levels
- Surface downscaling analysis 5.5 km (MESCAN-SURFEX)
- Start in 1961 and operational since 2/2018

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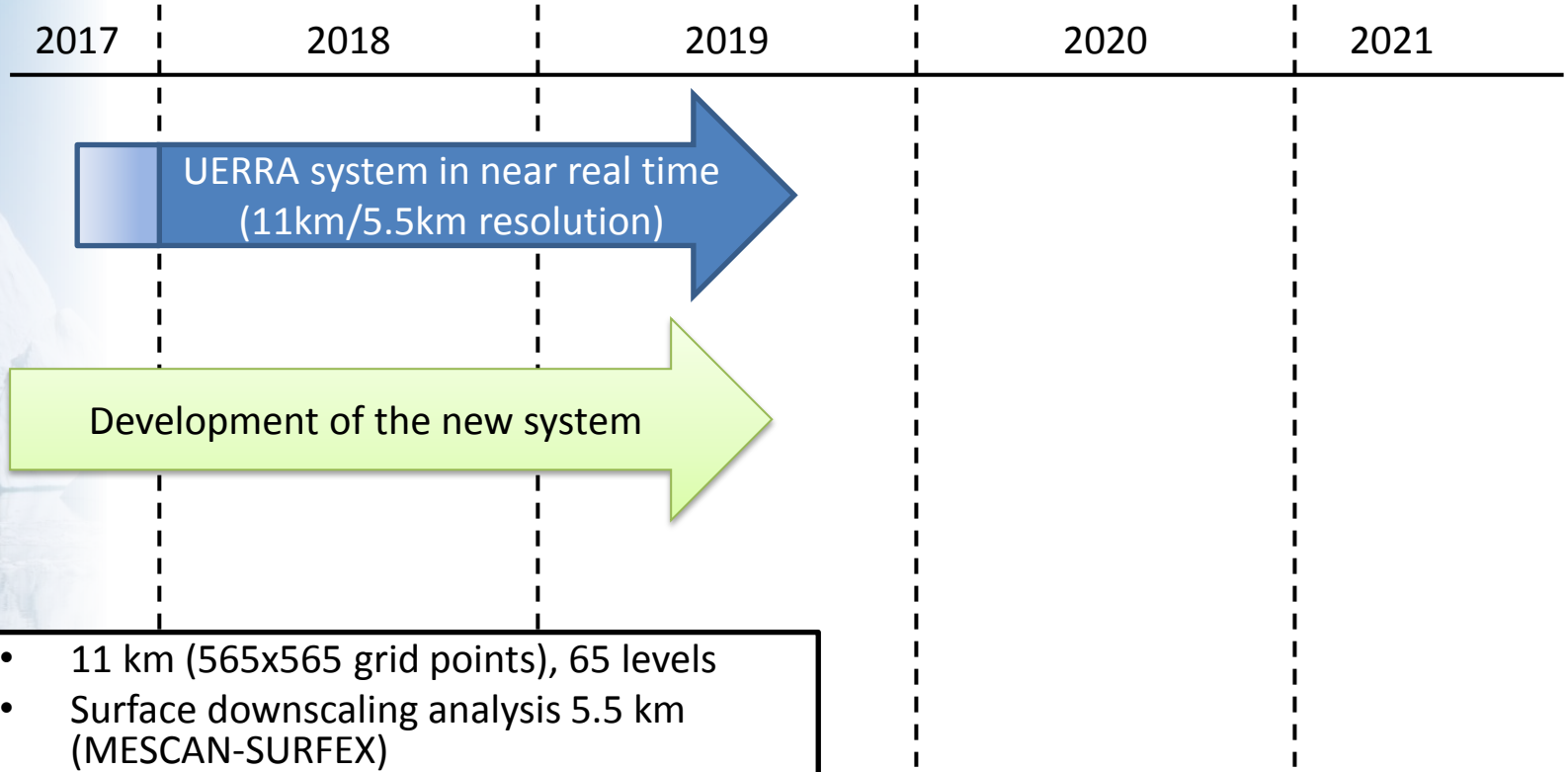
Time line of service and system details



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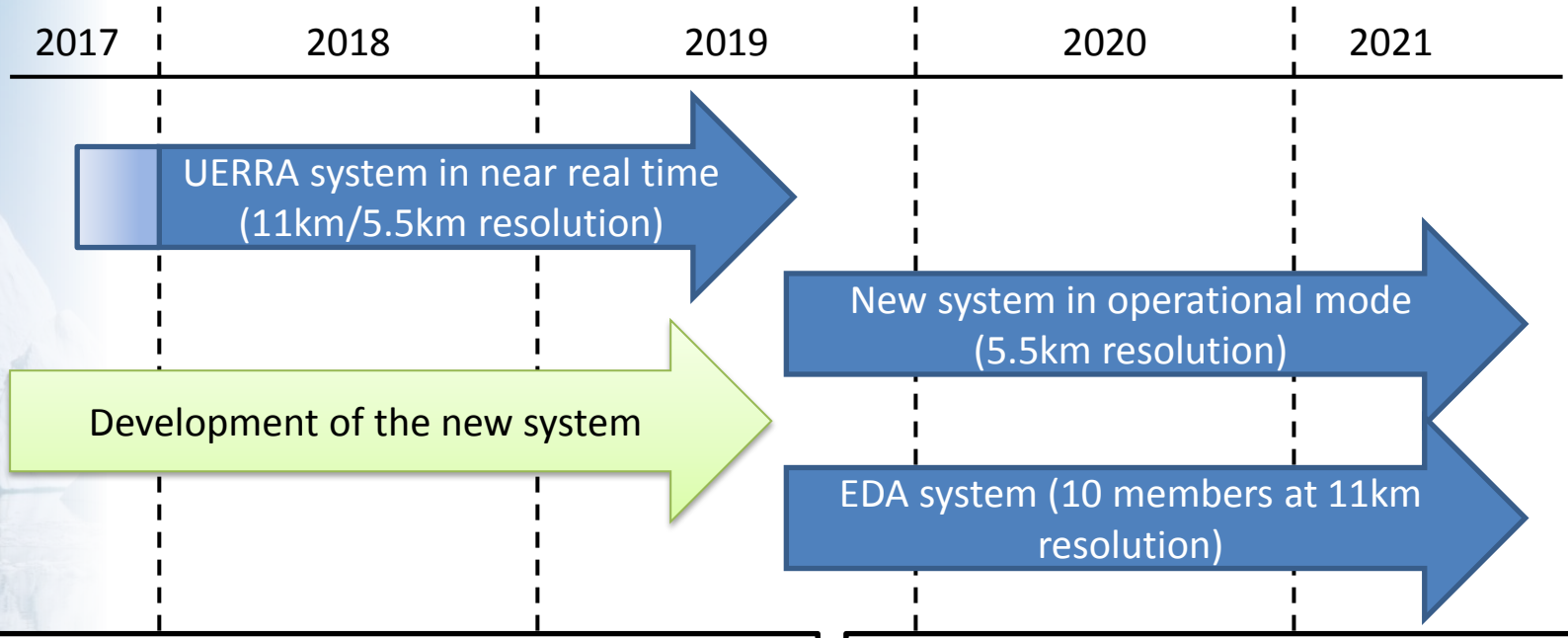

- 11 km (565x565 grid points), 65 levels
- Surface downscaling analysis 5.5 km (MESCAN-SURFEX)
- Start in 1961 and operational since 2/2018

- 5.5 km (1069x1069 grid points), 106 levels
- Surface analysis at 5.5 km
- Plus 10 ensemble members at 11km
- Will start in the early 1980s

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Objectives of the service

- Operational production of the RRA for Europe in near real-time
- Develop an enhanced system which should provide data from the early 80's
  In addition, an ensemble at lower resolution
- A comprehensive set of output parameters, ECVs, upper air, surface and soil
- Collaboration and coordination with other reanalysis activities (e.g. Arctic regional reanalysis and ERA5)
- User guidance and support

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2. The RRA systems and available data

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The pre-operational FP7 project

- UERRA: Uncertainties in Ensembles of Regional ReAnalysis
- 12 European partners
- Three different RRA plus ensembles

- SMHI's UERRA data is produced for 1961-2015 and it is available through this Copernicus service.

www.uerra.eu

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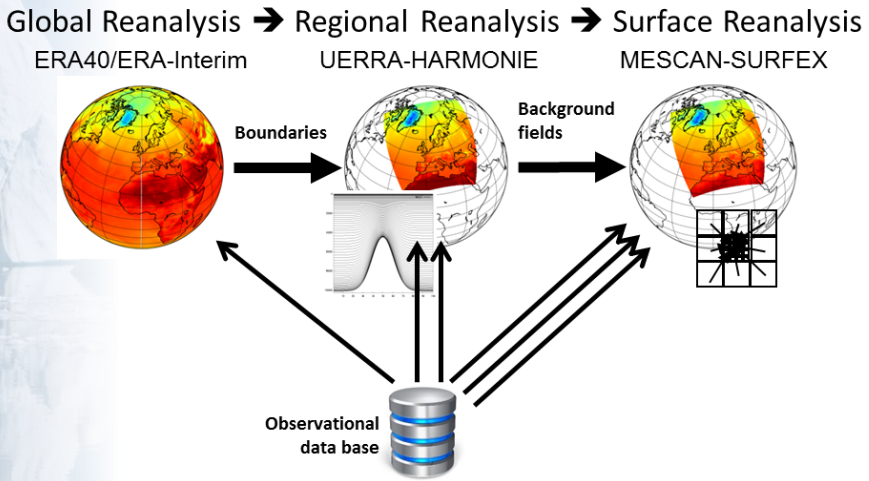
The system



- UERRA system
  - HARMONIE cycle 38h1, ALADIN physics
  - ERA40/ERA-interim as lateral boundary
  - Assimilation of conventional observations
  - 4 cycles per day, forecast lengths 6h and 30h
  - 11km resolution (565x565) and 65 vertical levels
- MESCAN-SURFEX
  - Optimal interpolation (OI)
  - 5.5km resolution

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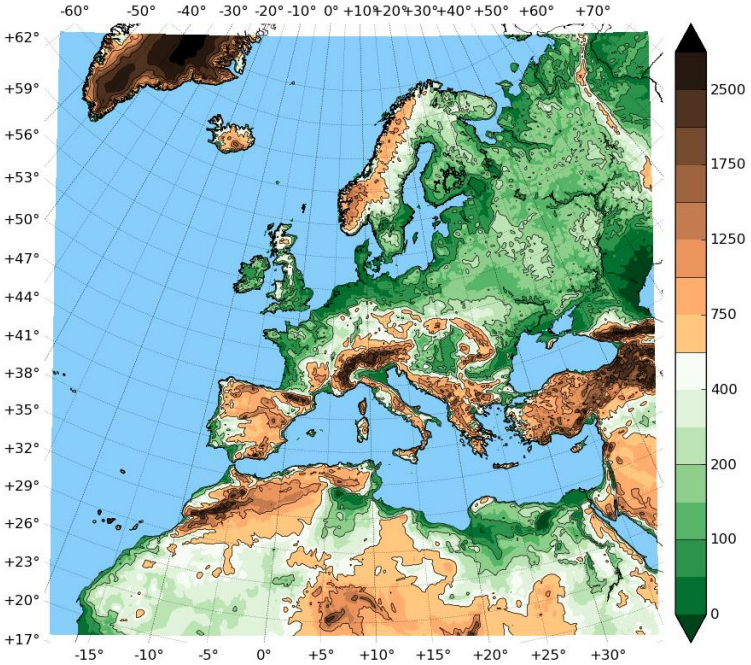
Available data

- Modell domain covers entire Europe
- Period 1961-December 2018 with monthly updates
- 31 surface parameters,
  9 parameters on pressure levels,
  7 parameters on height levels,
  4 parameters on model levels
  2 parameters on soil levels

- Additional output from MESCAN-SURFEX (surface and soil)



Model domain illustrated with model topography and land-sea mask

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Available time steps

		1978-12-02							1978-12-03																								
Forecast starting at		17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0	1	2	3
1978-12-02	0 UTC																																			
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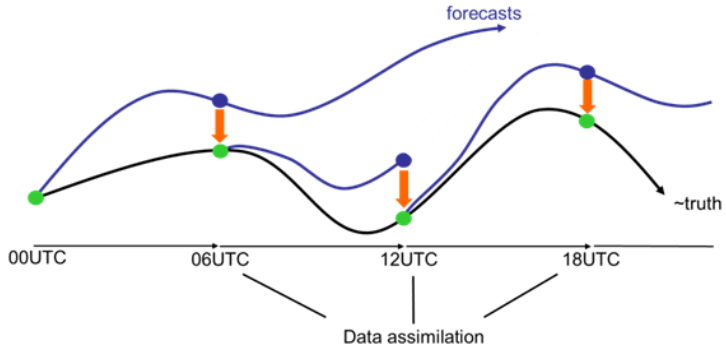
1978-12-03	18 UTC																																			
1978-12-04	0 UTC																																			
Number of available time steps									4	1	1	2	1	1	4	1	1	3	1	1	4	1	1	2	1	1	4	1	1	3	1	1				

- 4 analysis per day
- Hourly resolution from the forecast model
- Maximum forecast lengths is 30 hours



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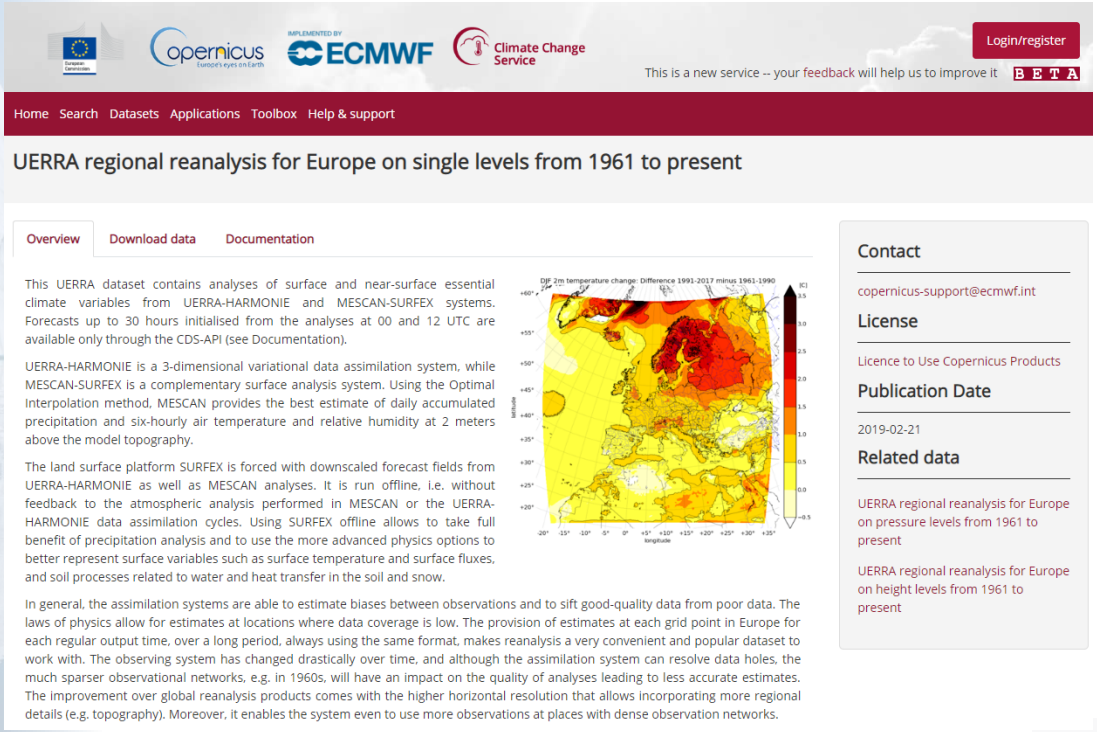
Data access via CDS

https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-uerra-europe-single-levels?tab=overview



- All data is freely available! (1961 – 2018)
- Monthly updates ca. four months behind real time
- All you need is to register!
- Almost 500 TB of data

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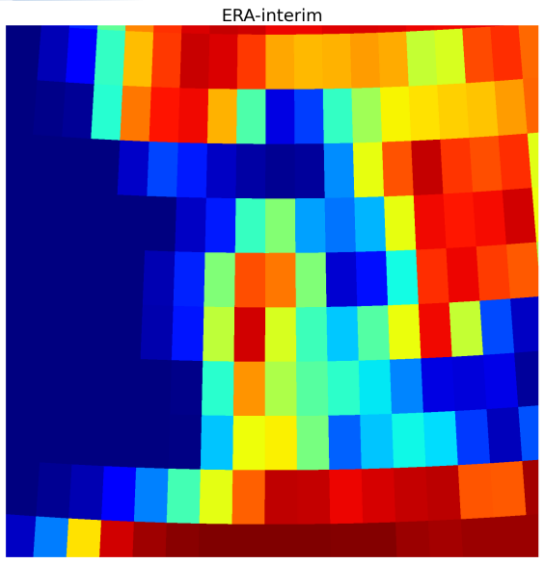
3. Data quality

Added value compared to global RA

Land-sea masks



~80km

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Added value compared to global RA

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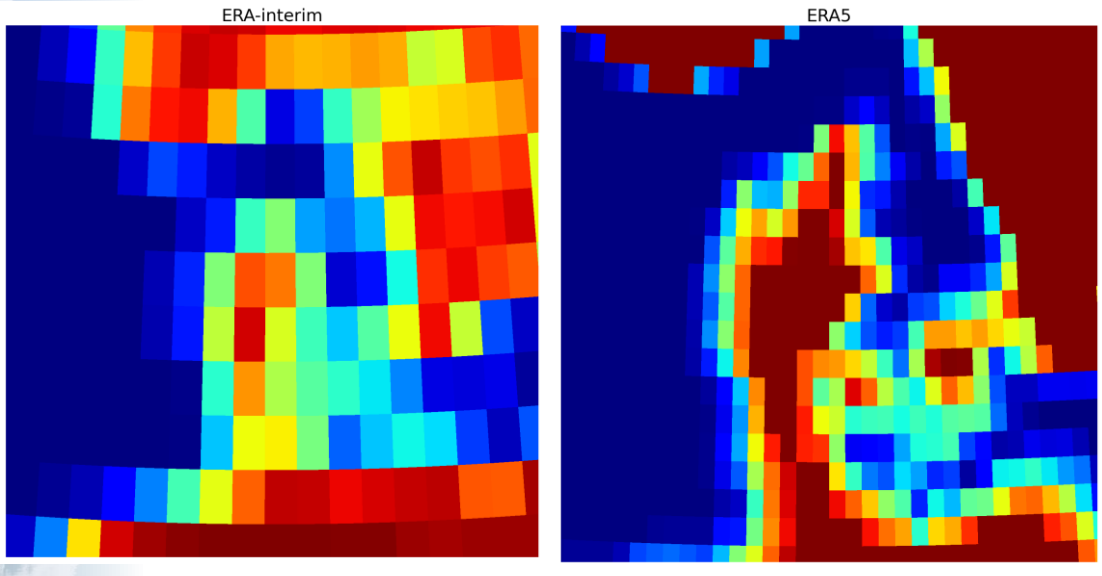

~80km

~31km

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Added value compared to global RA

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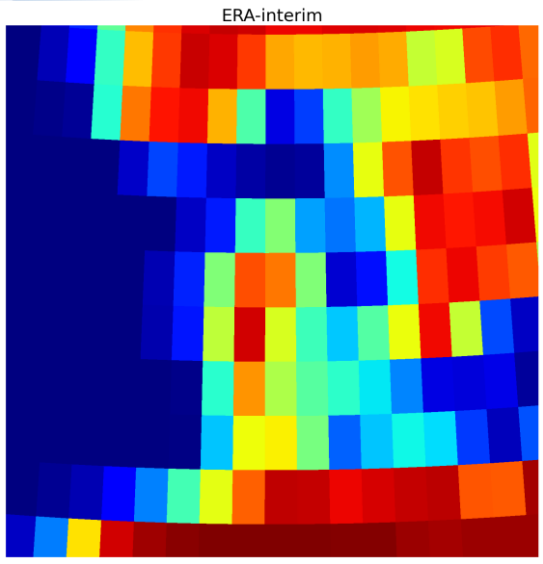

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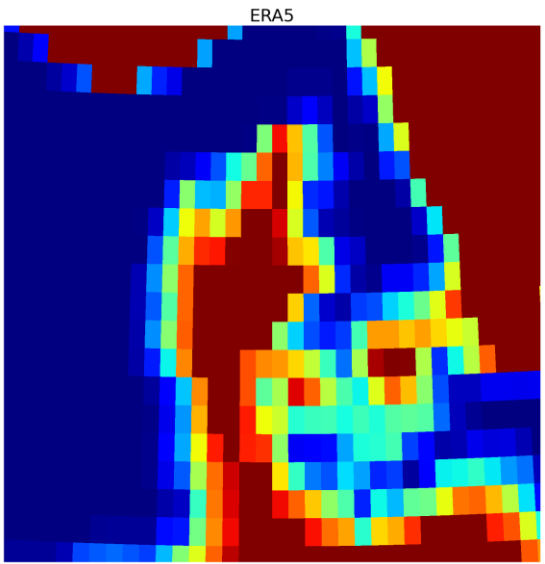

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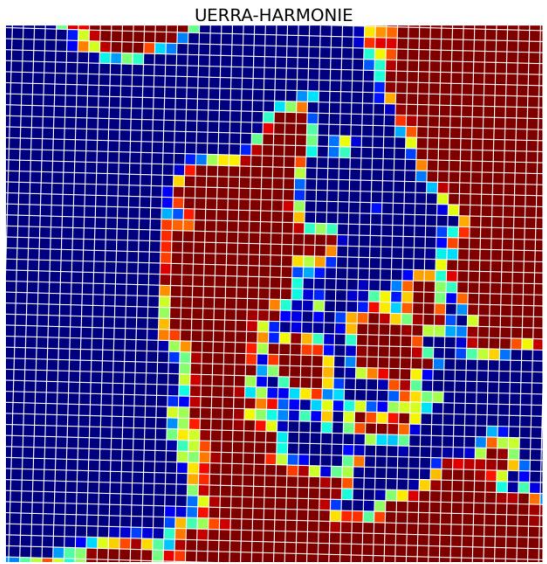

11km

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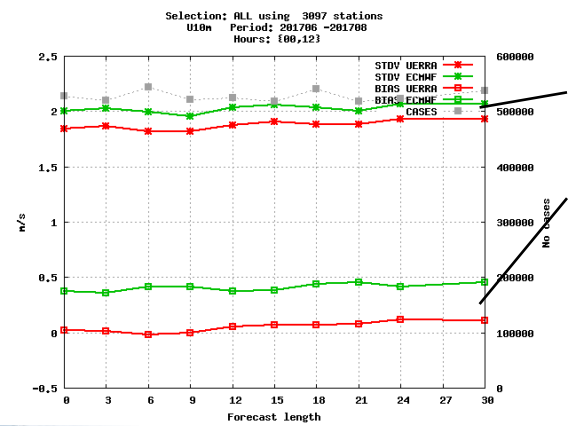
Verification



Standard deviation

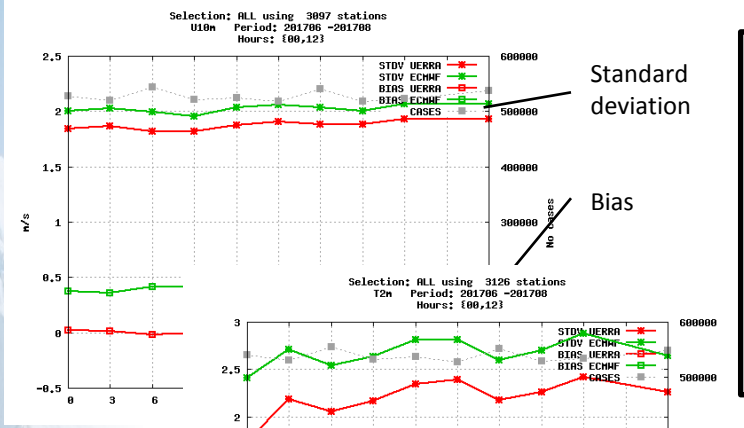
Bias

- Verification tools are part of the quality control during the production
- Smaller bias and std than ERA-interim, e.g. T2m, wind speed, precipitation

UERRA

ERA-interim

Verification



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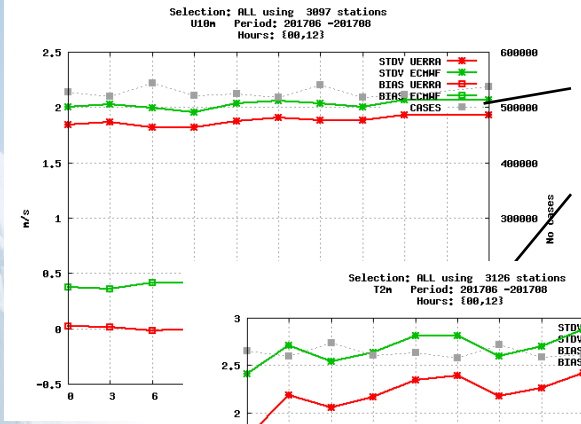

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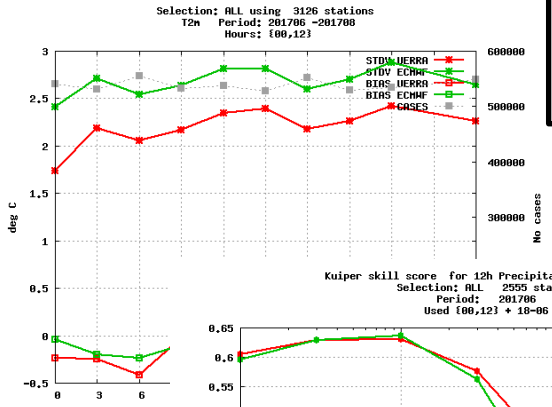

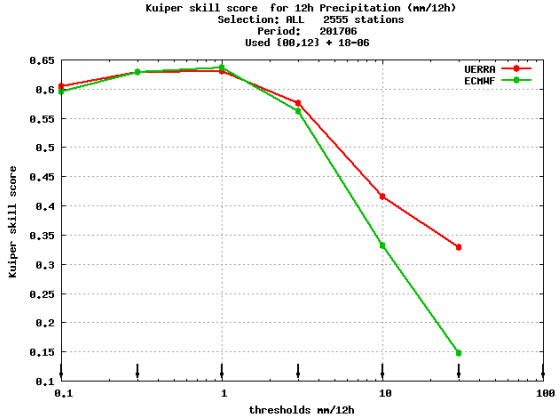

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ERA-interim

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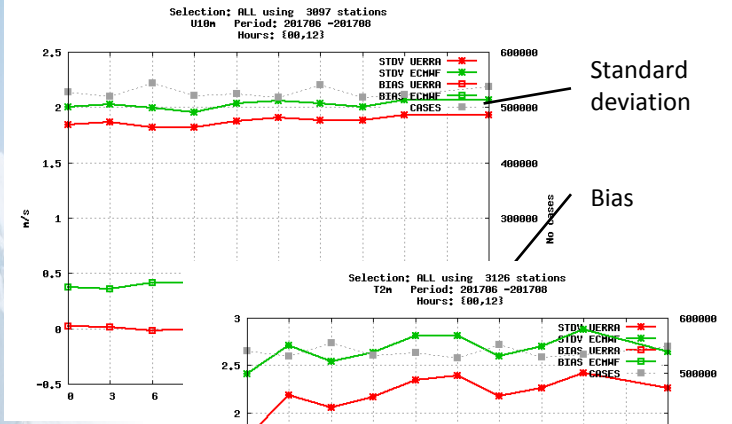
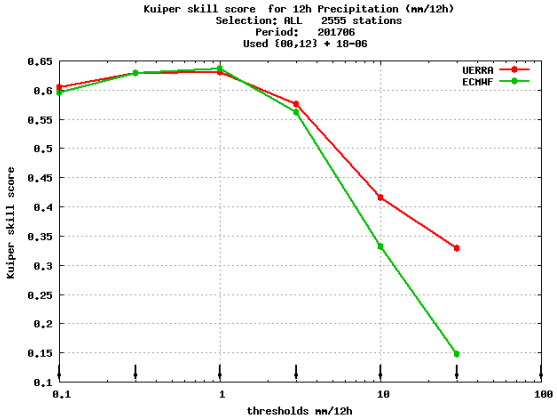
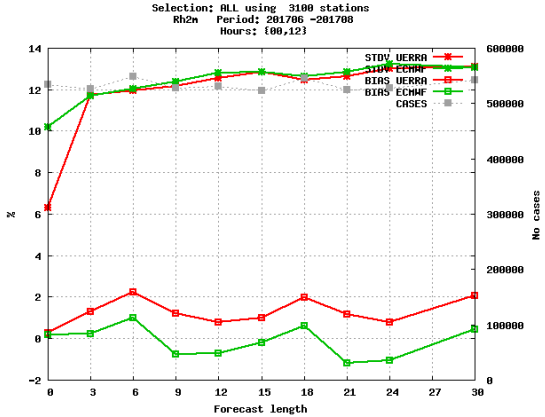


- Verification tools are part of the quality control during the production
- Smaller bias and std than ERA-interim, e.g. T2m, wind speed, precipitation
- Some parameters not better than ERA-interim, e.g. RH2m





UERRA
ERA-interim

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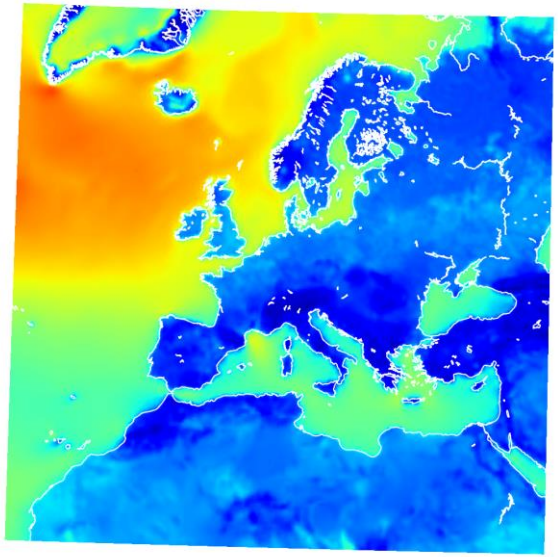
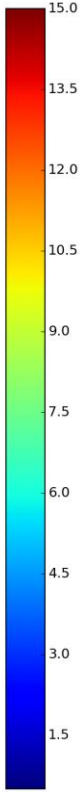
DJF wind speed in ERA5 and UERRA

ERA5

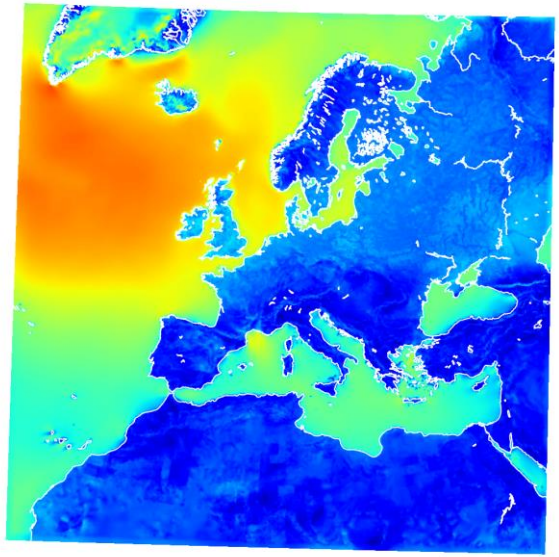
ERA5 DJF windspeed, 2000-2015

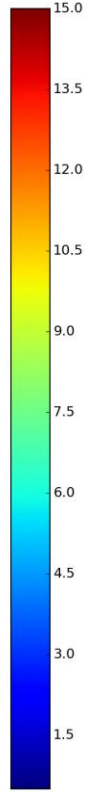




UERRA-HARMONIE

UERRA DJF windspeed, 2000-2015





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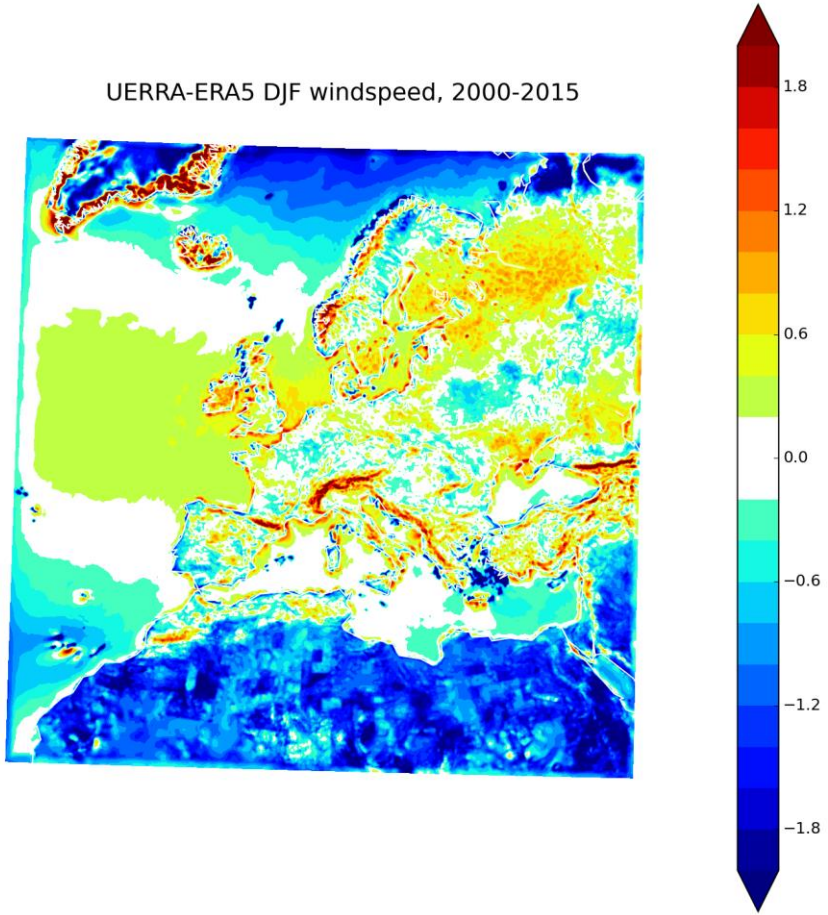
DJF windspeed in ERA5 and UERRA



- Differences mainly smaller than 1m/s
- Differences related to topography/coastline
- General weaker winds over northern Africa and the Norwegian/Barents Sea

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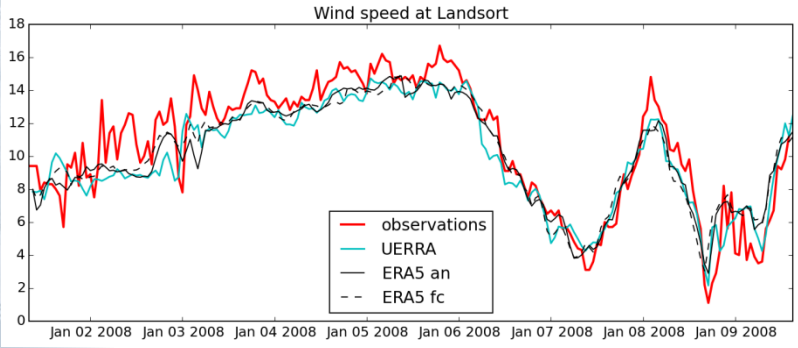
Quality of wind speed

Comparison of wind speed at 24 Swedish coastal stations

	UERRA	ERA5	ERA-int
Mean bias	-0.02	0.01	Not checked
Correlation	0.85	0.85	0.79
RMSE	1.83	1.97	2.36

Based on the period 2000-2015. Hourly data for UERRA and ERA5, 6hourly for ERA-interim



Series of a random sample for visual check.

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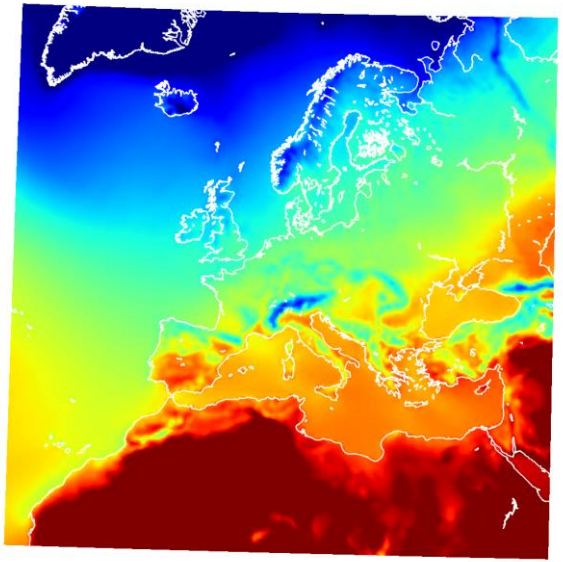
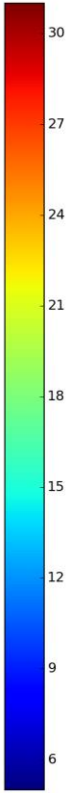
JJA 2m-temperature in ERA5 and UERRA

ERA5

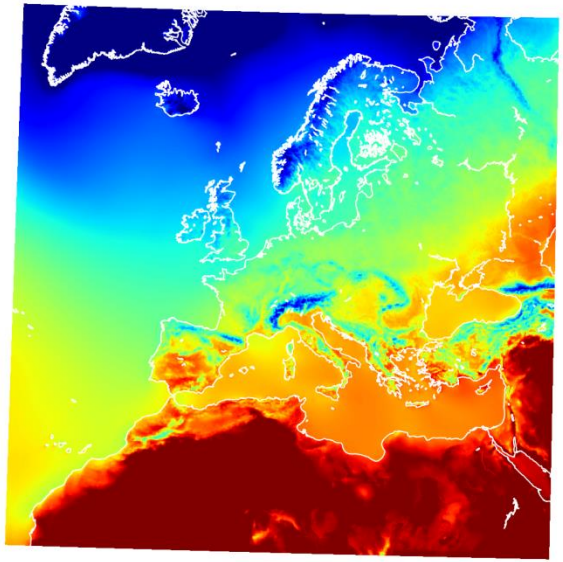
ERA5 JJA T2m, 2000-2015

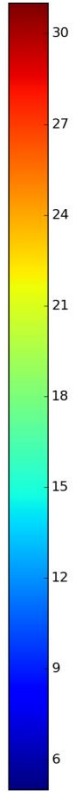




UERRA-HARMONIE

UERRA JJA T2m, 2000-2015





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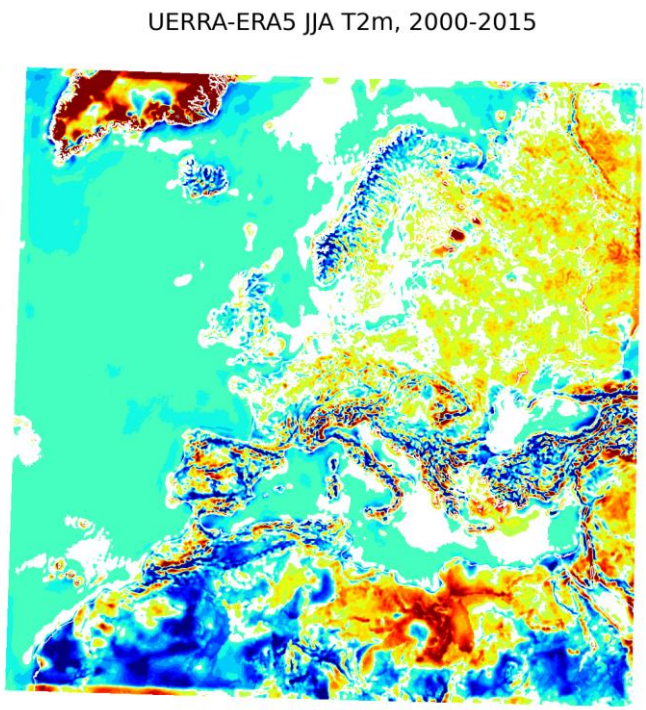
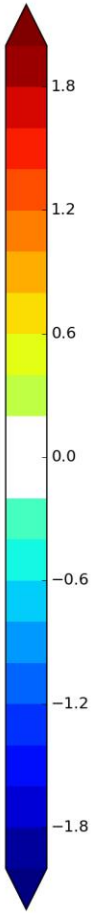
JJA 2m-temperature in ERA5 and UERRA





- Small differences over the ocean and flat areas
- Strong effect of topography
- Uncertainty in northern Africa is large

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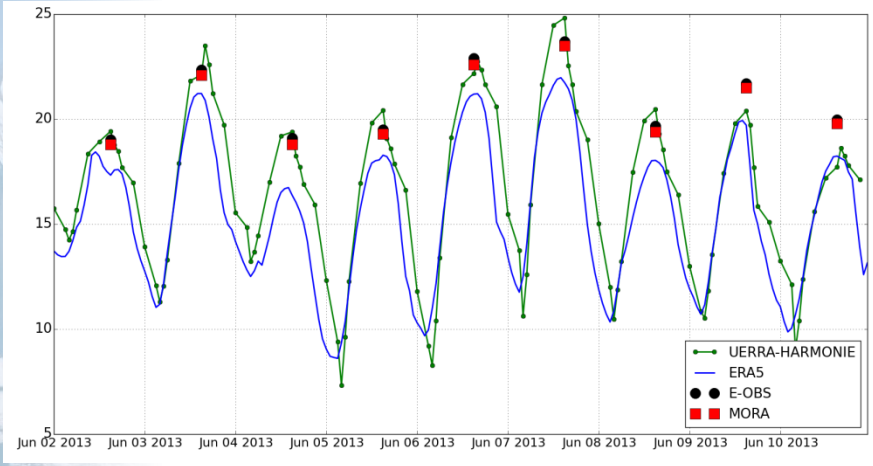
T2m: Daily cycle and maximum

Växjö (Sweden)



- Random sample, nine days in June 2013
- Växjö region is quite flat and homogenous
- UERRA-HARMONIE has general higher daily maximum temperatures than ERA5

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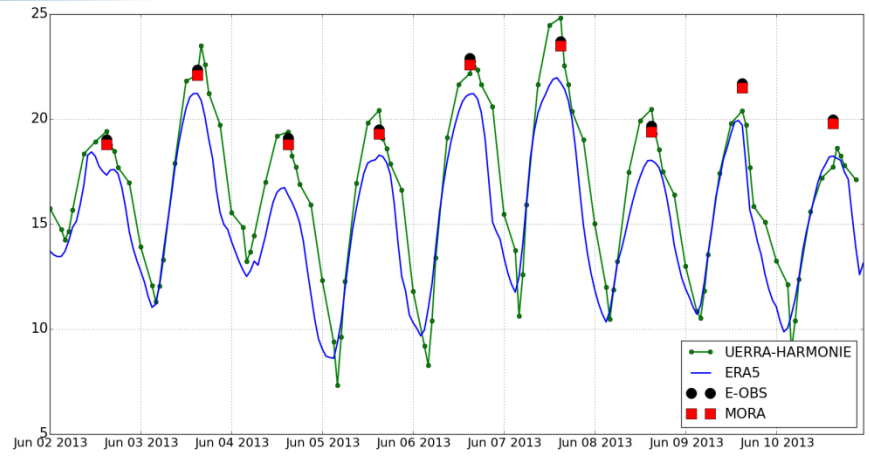
T2m: Daily cycle and maximum

Växjö (Sweden)



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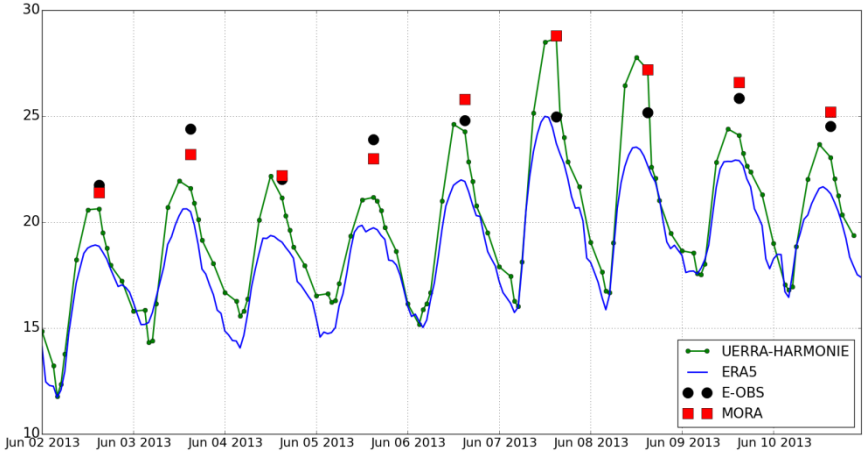
Grazzanise (Italy)



- Grazzanise has a more complex terrain
- UERRA-HARMONIE has general higher daily maximum temperatures than ERA5
- Clear difference between gridded (E-OBS) data and direct measurements

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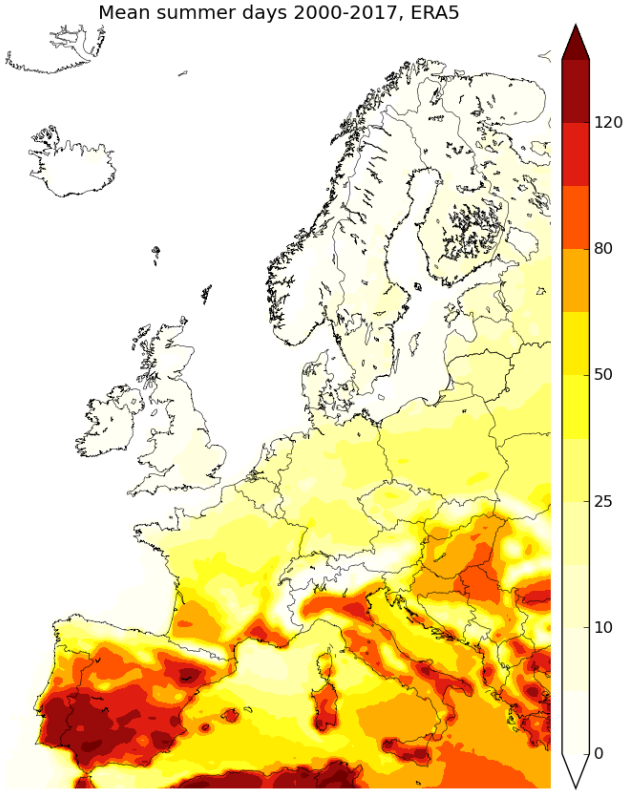
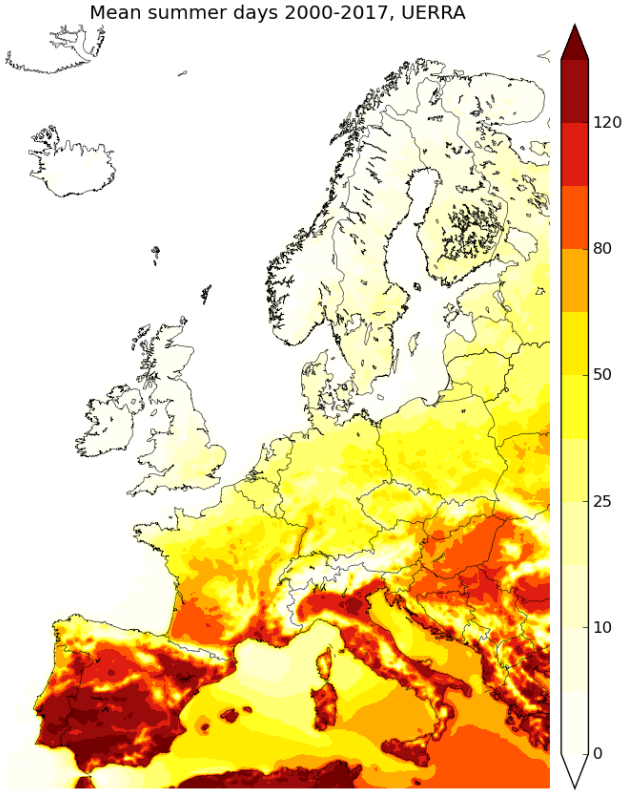
Summer days = Tmax > 25C





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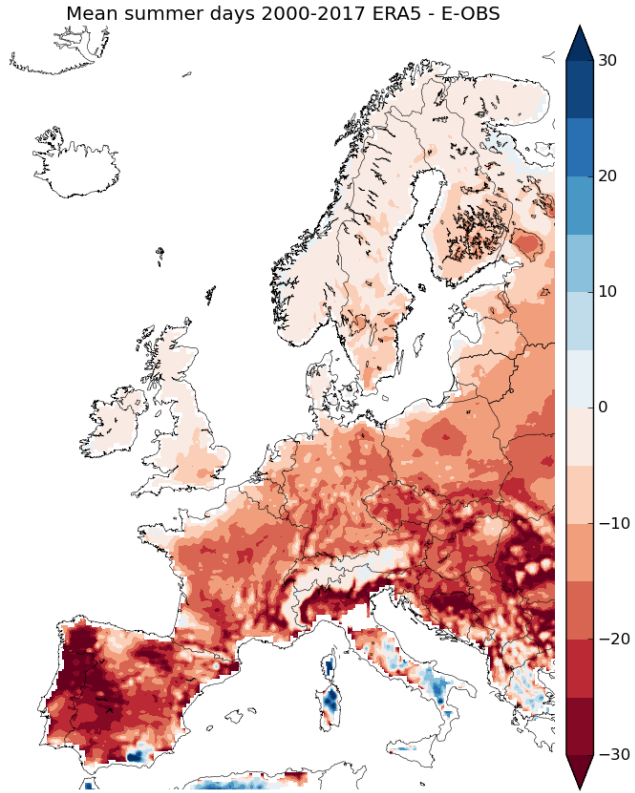

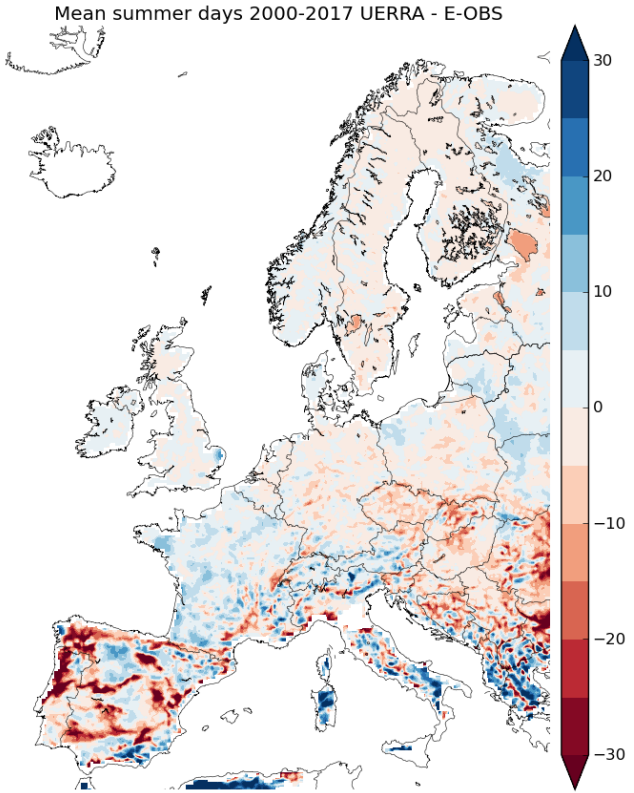

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4. Homogeneity

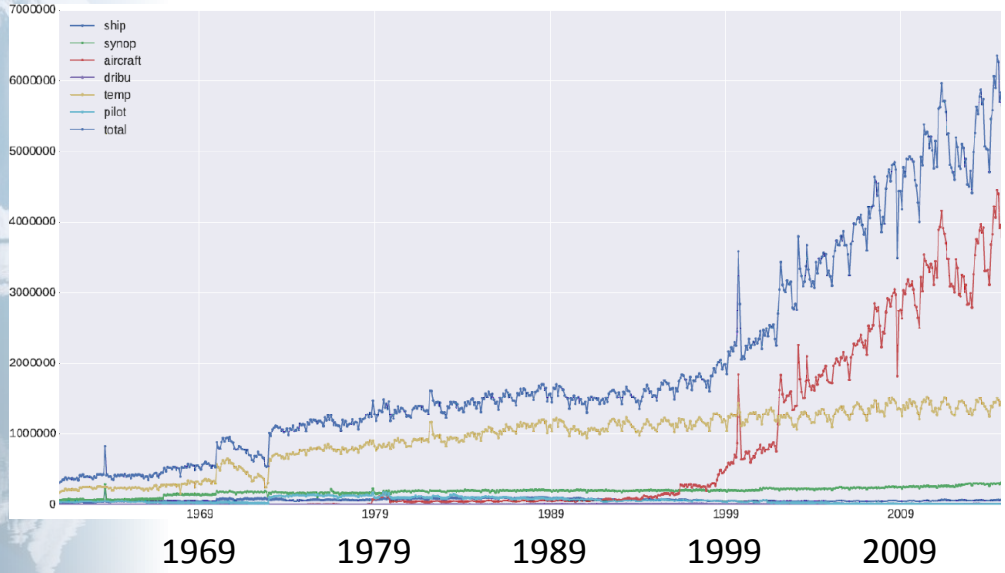
Homogeneity

Risks for inhomogeneity

- Switch of lateral boundary data
  - 1961-1978 ERA40
  - 1979- ERA-interim

Homogeneity

Number of observations



Risks for inhomogeneity

- Switch of lateral boundary data
  - 1961-1978 ERA40
  - 1979- ERA-interim
- Increasing numbers of observations in time, especially aircraft data

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Homogeneity

Investigations of the forecast skill (differences between fc30 and fc6):

- Forecast skill effects accuracy of the first guess and has herewith consequences on the data quality

Homogeneity

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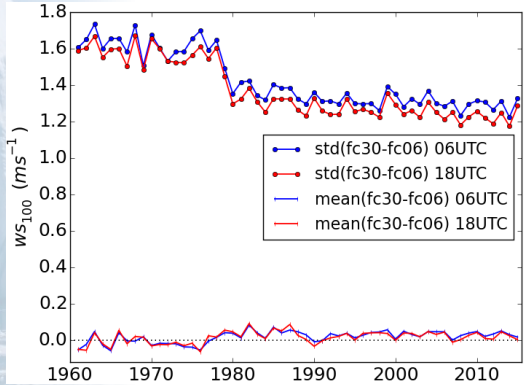
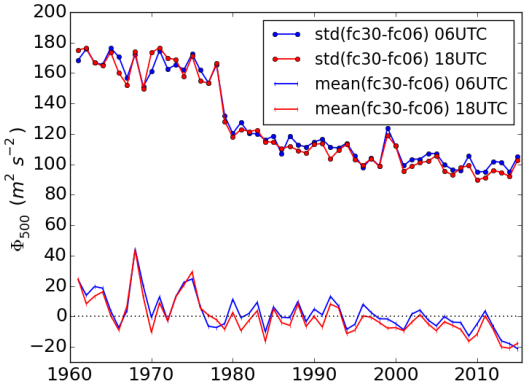
100m wind speed



500 hPa geopotential



Yearly averages of the standard deviation and mean of the forecast difference fc30-fc06 during winter (DJF).
Left: 100m wind speed. Right: 500 hPa geopotential. Curtesy Adam von Kraemer.

Investigations of the forecast skill (differences between fc30 and fc6):

- Forecast skill effects accuracy of the first guess and has herewith consequences on the data quality
- Increase of quality with the switch to ERA-interim and increasing numbers of observations (upper air)

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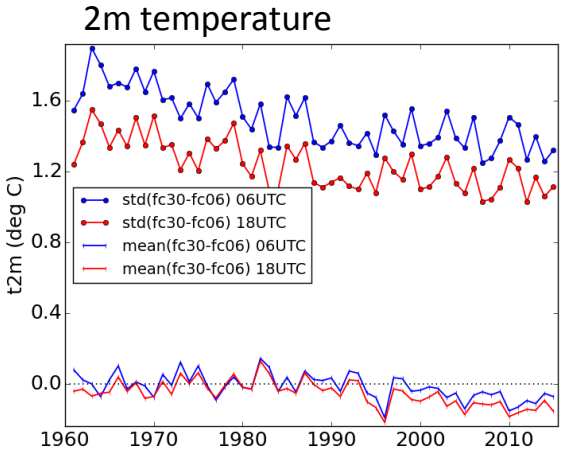
Homogeneity



Yearly averages of the standard deviation and mean of the forecast difference fc30-fc06 during winter (DJF).
Curtesy Adam von Kraemer.

Investigations of the forecast skill (differences between fc30 and fc6):

- Less change of quality for surface parameters
- Surface parameters are less affected due to a more constant number of surface observations throughout time

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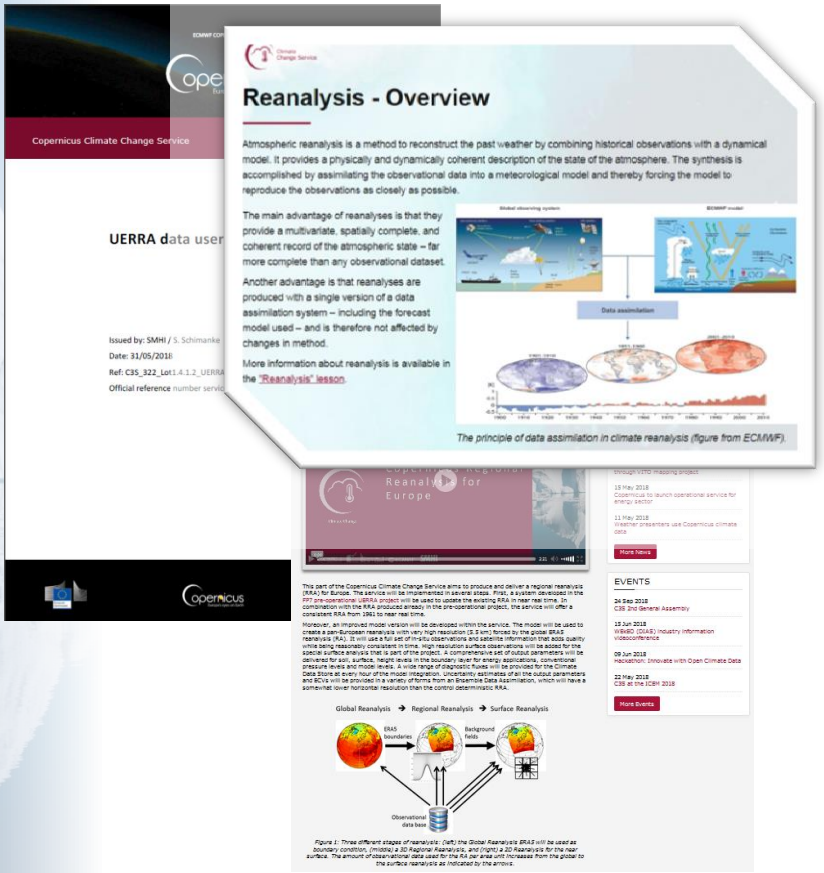
User support



- User guide
- Homepage https://climate.copernicus.eu/regional-reanalysis-europe
- Git server with example scripts https://git.smhi.se/C3S_322_Lot1/C3S_322_Lot1_user_examples
- Training material https://climate.copernicus.eu/user-learning-services

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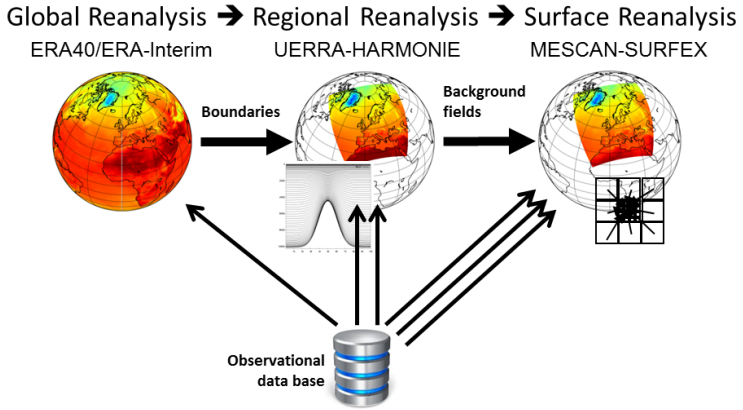
Summary

- The service offers:
  - Based on the RRA from the FP7 UERRA project, hourly data at 11km resolution from 1961 to near real time for Europe
  - A comprehensive set of output parameters for the surface, the upper air, and the soil
  - User guidance and support
- Data quality improves compared to global products
- Some inhomogeneity due to the change from ERA40 to ERA-interim



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Back-up slides…

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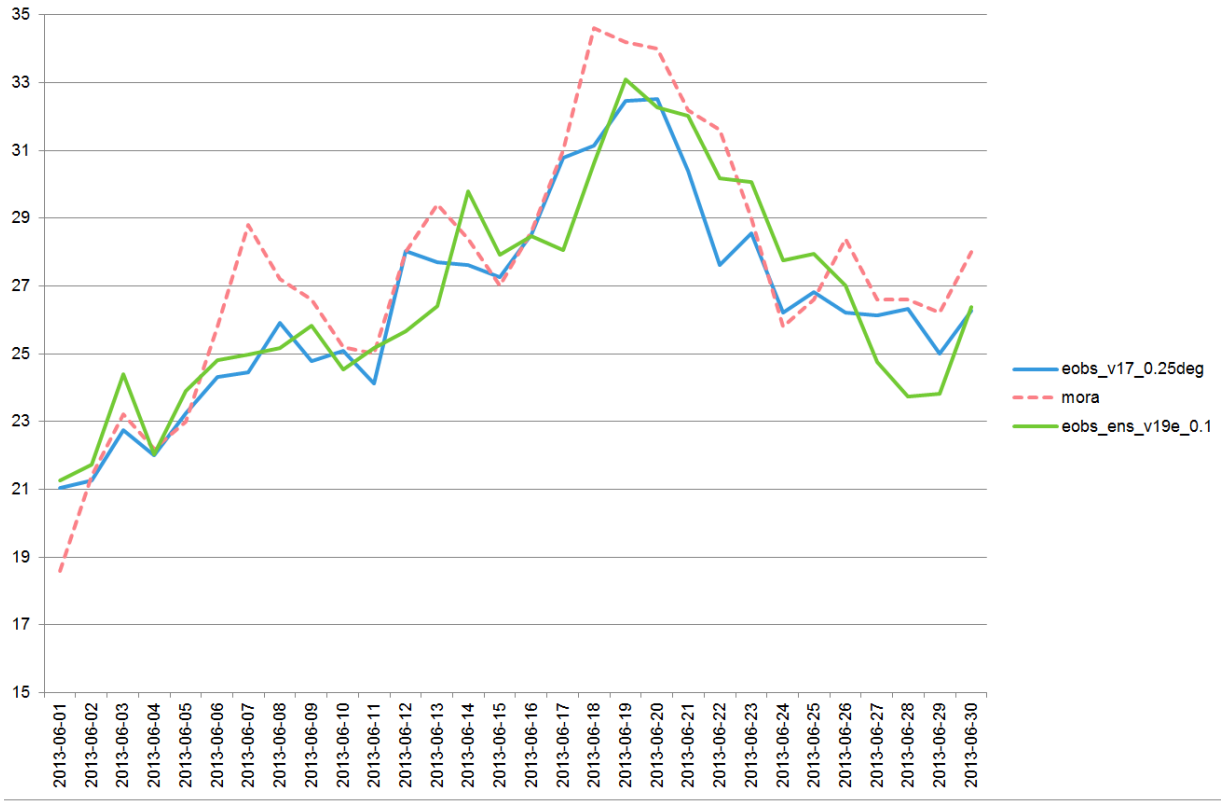

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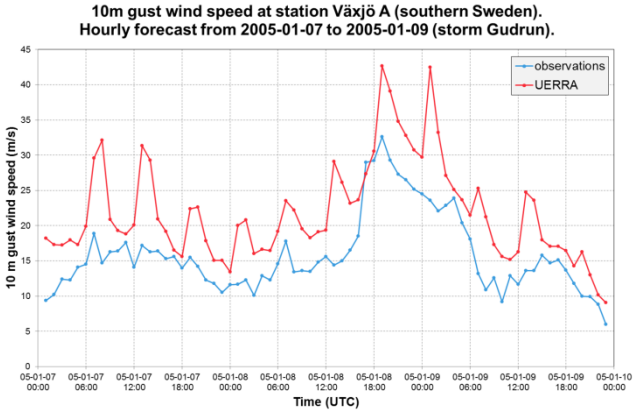
Model systems: differences

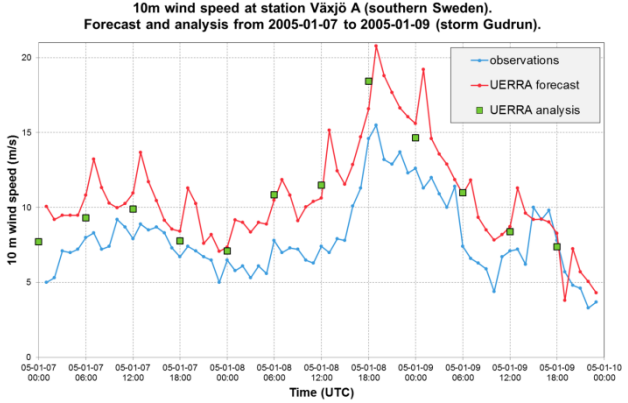
UERRA system	New system
HARMONIE cycle 38h1 (ALADIN physics)	HARMONIE cycle 40.1h/42 (ALADIN physics)
SURFEX 7.3	SURFEX 7.3 with updates from SURFEX 8.0
ERA40 and ERA-interim as LBC	ERA5 as LBC
4 cycles per day	8 cycles per day
No satellite data	Satellite radiances, e.g. IASI, MSU, AMSU
---	Usage of ERA5 ODB files, e.g. blacklisting information
---	More obs-data, e.g. GBGNSS

Known short comings

Gust wind speed



10m wind speed



Windspeed during Gudrun

- Wind at a station in southern Sweden during a major storm
- Shown are fc1-6 (and fc0)

➔ Clearly unrealistic jumps

➔ Affected are forecasts lengths 1h and 2h