



Climate Change

# Copernicus Regional Reanalysis for Europe

Available UERRA-HARMONIE data, 20/11/2018  
Semjon Schimanke, Ludvig Isaksson and Lisette  
Edvinsson





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# Overview

1. Available data
2. Data quality
3. Data treatment: number of summer days



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# 1. Available data



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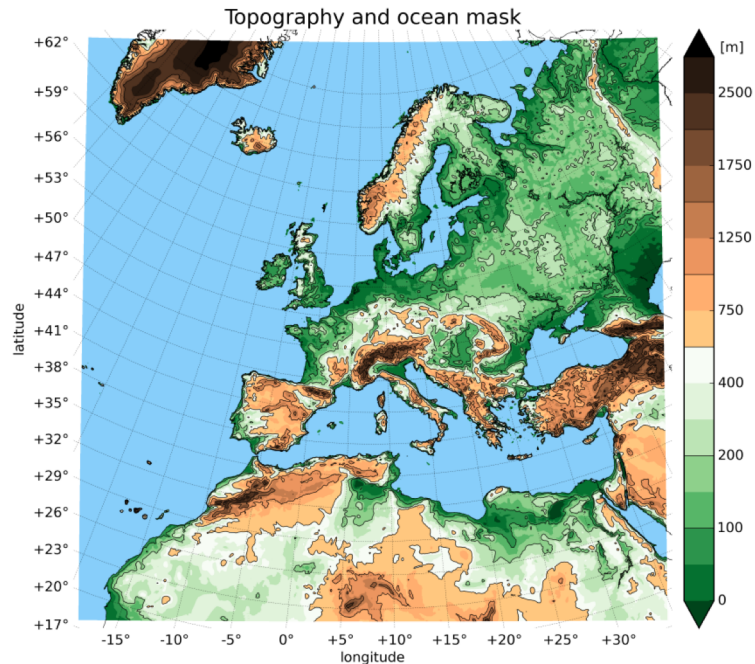
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## Available data

- 11km horizontal resolution including entire Europe
- Period 1961-July 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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# Surface parameters

- Levels: at the surface, at 2m, at 10m, vertically integrated above the surface
- 18 parameters in the analysis step, 29 for the forecasts
- Values are instantaneous or accumulated

	Parameter	Analysis	Forecast	Height
1.	<a href="#">Surface air relative humidity</a>	yes	yes	2m
2.	<a href="#">Total column water vapour</a>	yes	yes	vertically integrated above the surface
3.	<a href="#">Total precipitation</a>	-	yes	surface
4.	<a href="#">10 metre wind speed</a>	yes	yes	10m
5.	<a href="#">10 metre wind direction</a>	yes	yes	10m
6.	<a href="#">10 metre wind gust speed</a>	-	yes	10m
7.	<a href="#">Surface air maximum temperature</a>	-	yes	2m
8.	<a href="#">Surface air minimum temperature</a>	-	yes	2m
9.	<a href="#">Surface air temperature</a>	yes	yes	2m
10.	<a href="#">Skin temperature</a>	yes	yes	surface
11.	<a href="#">Albedo</a>	yes	only six hours	surface
12.	<a href="#">Evaporation</a>	-	yes	surface
13.	<a href="#">Time-integrated surface latent heat flux</a>	-	only six hours	surface
14.	<a href="#">Time-integrated surface sensible heat flux</a>	-	only six hours	surface
15.	<a href="#">Time-integrated surface direct solar radiation</a>	-	yes	surface
16.	<a href="#">Time-integrated surface net solar radiation</a>	-	yes	surface

	Parameter	Analysis	Forecast	Height
19.	<a href="#">Time-integrated surface thermal radiation downwards</a>	-	yes	surface
20.	<a href="#">Mean sea level pressure</a>	yes	yes	surface
21.	<a href="#">Surface pressure</a>	yes	yes	surface
22.	<a href="#">High cloud cover</a>	yes	yes	above 5000m
23.	<a href="#">Low cloud cover</a>	yes	yes	surface-2500m
24.	<a href="#">Medium cloud cover</a>	yes	yes	2500m-5000m
25.	<a href="#">Total cloud cover</a>	yes	yes	above ground
26.	<a href="#">Snow density</a>	yes	only six hours	surface
27.	<a href="#">Snow depth water equivalent</a>	yes	only six hours	surface
28.	<a href="#">Snow fall water equivalent</a>	-	yes	surface
29.	<a href="#">Land-sea mask</a>	yes	-	surface
30.	<a href="#">Orography</a>	yes	-	surface
31.	<a href="#">Surface roughness</a>	yes	only six hours	surface



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# Parameters on height levels

	Parameter	Analysis	Forecast
1.	<a href="#">Wind speed</a>	yes	yes
2.	<a href="#">Wind direction</a>	yes	yes
3.	<a href="#">Pressure</a>	yes	yes
4.	<a href="#">Specific cloud liquid water content</a>	-	yes
5.	<a href="#">Specific cloud ice water content</a>	-	yes
6.	<a href="#">Relative humidity</a>	yes	yes
7.	<a href="#">Temperature</a>	yes	yes

Available levels [m]
15
30
50
75
100
150
200
250
300
400
500

- Levels:  
11 levels between 15-500m
- 5 parameters for the analysis, 7 for the forecasts
- Values are instantaneous for these parameters
- Height levels were introduced with special focus on applications in the wind energy sector.



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# Parameters on pressure levels

Available 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

- Levels:  
24 levels between 1000-10hPa
- 6 parameters for the analysis, 9 for the forecasts
- Values are instantaneous for these parameters
- Pressure levels are the common levels for investigations in the atmosphere

	Parameter	Analysis	Forecast
1.	<a href="#">Cloud cover</a>	-	yes
2.	<a href="#">Specific cloud liquid water content</a>	-	yes
3.	<a href="#">Specific cloud ice water content</a>	-	yes
4.	<a href="#">Relative humidity</a>	yes	yes
5.	<a href="#">Temperature</a>	yes	yes
6.	<a href="#">U-velocity</a>	yes	yes
7.	<a href="#">V-velocity</a>	yes	yes
8.	<a href="#">Geopotential</a>	yes	yes
9.	<a href="#">Geopotential height</a>	yes	yes



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# Parameters on model and soil levels

- 65 model levels from the surface to the model top (10hPa)
- 4 parameters, only for the analysis
- Values are instantaneous
- Hybrid-sigma coordinates, which makes it more complex to use these parameters.

	Parameter	Analysis	Forecast
1.	<a href="#">Specific humidity</a>	Yes	-
2.	<a href="#">Temperature</a>	Yes	-
3.	<a href="#">U-velocity</a>	Yes	-
4.	<a href="#">V-velocity</a>	Yes	-

- 3 soil levels
- 2 parameters, available for the analysis and forecasts up to six hours
- Values are instantaneous  
(Check the MESCAN-SURFEX output if you need soil parameters.)

	Parameter	Analysis	Forecast
1.	Volumetric soil water	yes	yes
2.	<a href="#">Soil temperature</a>	yes	yes



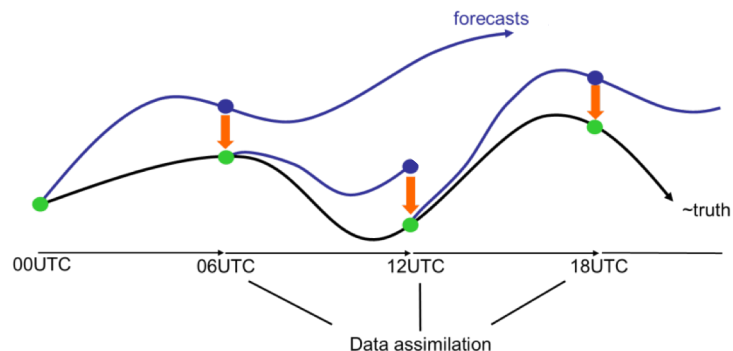


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## Available time steps

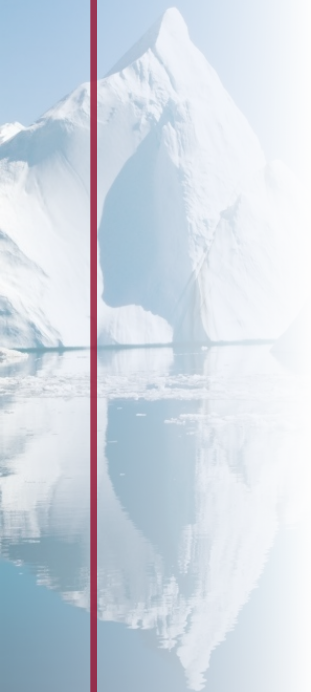
Forecast starting at	1978-12-02												1978-12-03																											
	12	13	14	15	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23				
1978-12-02 12 UTC	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█	█
1978-12-02 18 UTC	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

- 4 analysis per day
- Hourly resolution from the forecast model
- Maximum forecast lengths is 30 hours
- Up to four valid time steps at a certain time





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## 2. Data quality



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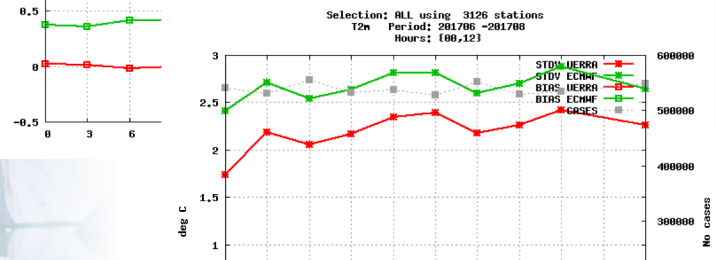
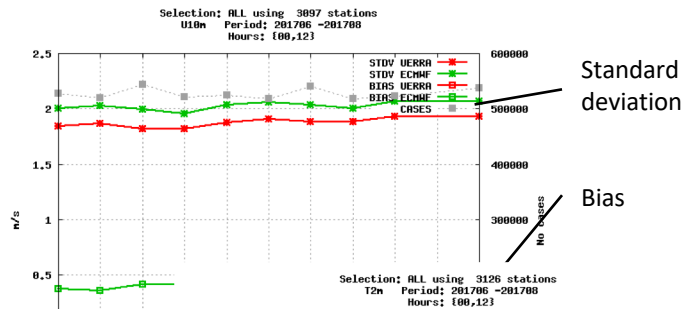
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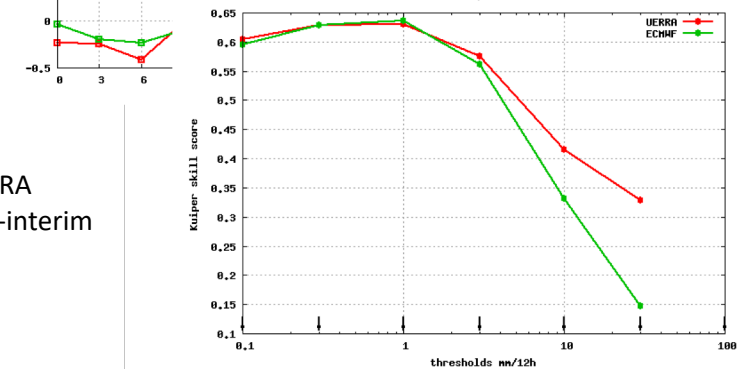
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# Verification

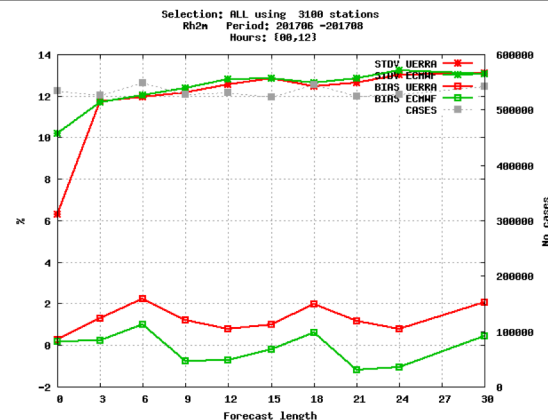
- Verification tools are part of the quality control during the production
- Smaller bias and std than ERA-interim, e.g. T2m, wind speed, precipitation
- Some parameters not better than ERA-interim, e.g. RH2m



Kuiper skill score for 12h Precipitation (mm/12h)  
Selection: ALL 2555 stations  
Period: 201706  
Used {00,12} \* 10-dg



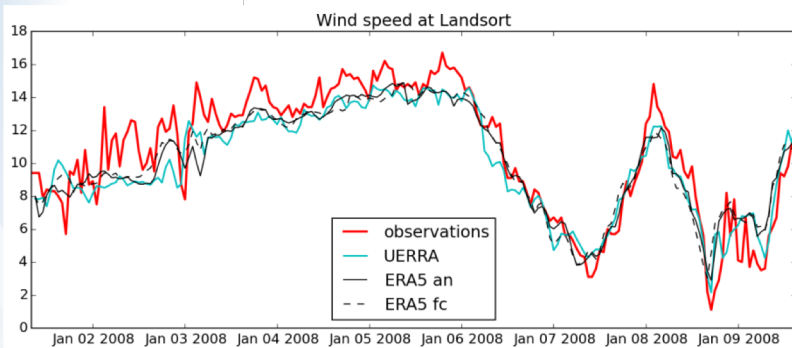
— UERRA  
— ERA-interim





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# Quality of wind speed



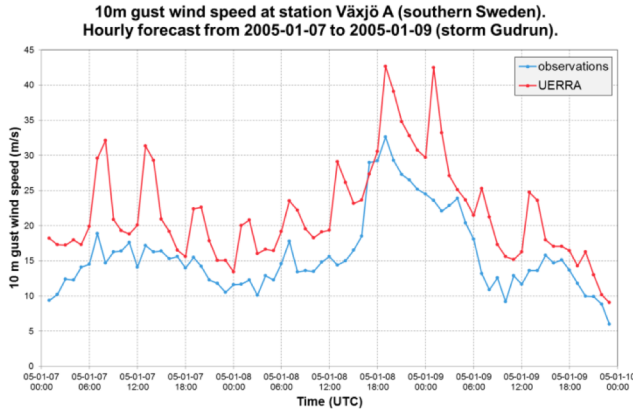
Comparison of hourly wind speed with ERA5 products. Based on observations along the Swedish coastline.

	UERRA- HARMONIE	ERA5 an	ERA5 fc
RMSE	1.89	2.49	2.54
Correlation	0.84	0.81	0.81

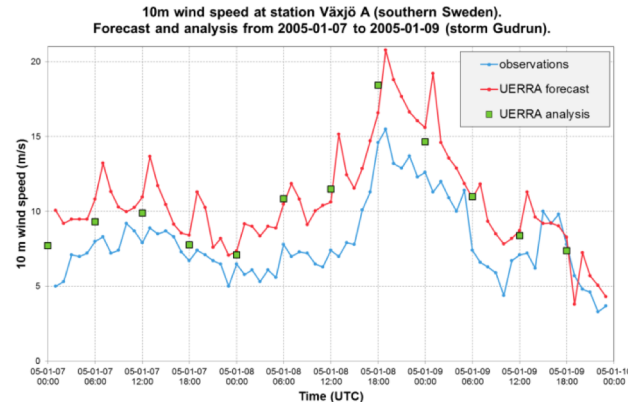
Based on hourly data for the period 2008-2015.



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



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## 3. Data treatment



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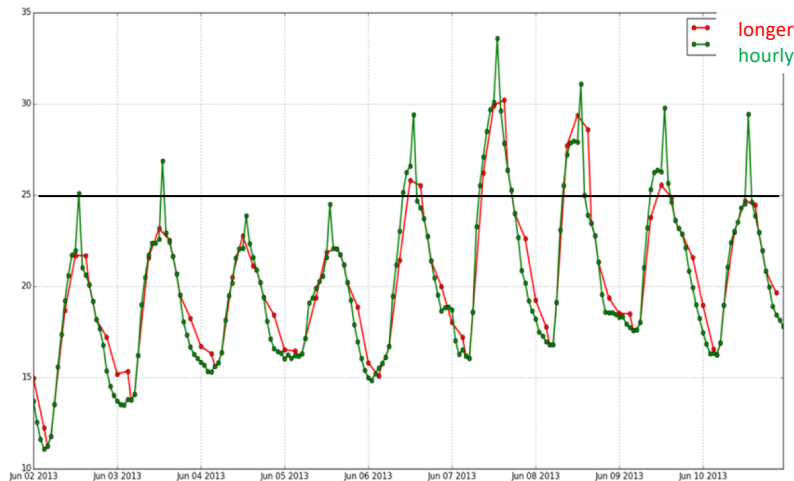
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# Data treatment

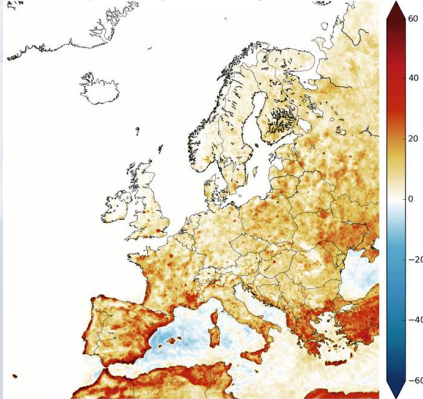
## Example: number of summer days

- Overestimation of summer days if hourly data is considered
- ➔ Affected are forecasts lengths 1h and 2h
- Possible workaround with maximum temperature from longer forecasts

2m maximum temperature, grid point in Italy



Summer days SMHI(Hourly data) - SMHI(Longer forecasts) 2005



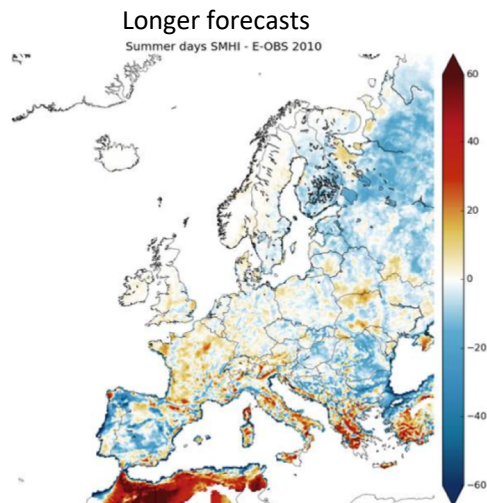
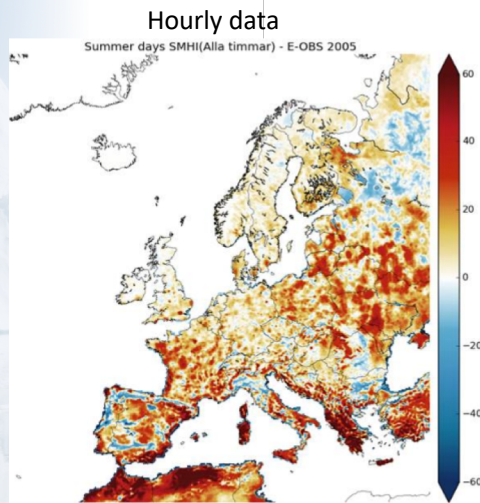
	1978-12-02												1978-12-03																									
Forecast starting at	12	13	14	15	16	17	18	19	20	21	22	23	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
1978-12-02 12 UTC	Red	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue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





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# Summer days compared to E-OBS



Better results compared to  
E-OBS with a clever data  
selection.





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## Conclusions

- Users need to check if the quality is fit for their purpose
- Spend some extra time on testing different options, e.g. selection of time steps
- Check our user guide for
  - Data availability
  - Known issues
- Copernicus/C3S and hence this service is a user driven service.  
What do you need/wish in the future?  
We are working on the extension of output fields in the moment.



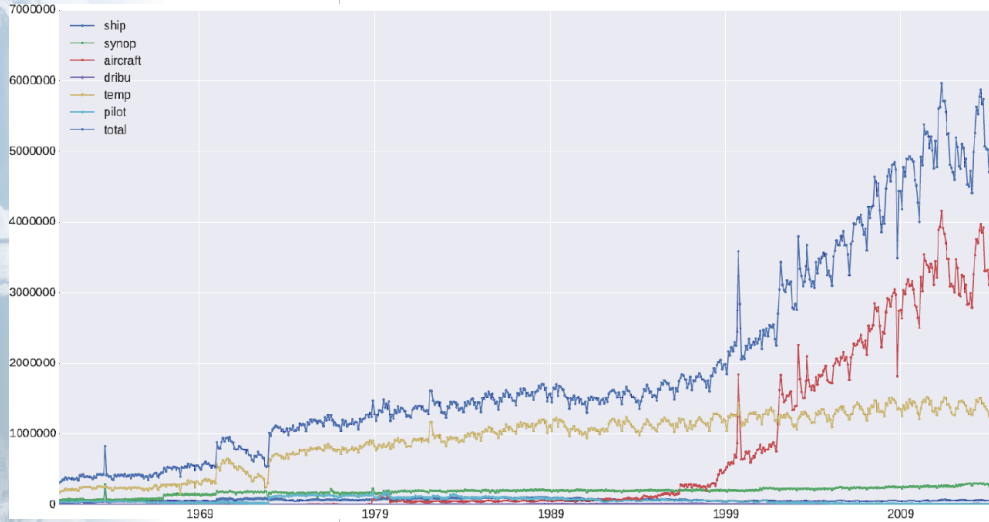




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# Homogeneity

## Number of observations



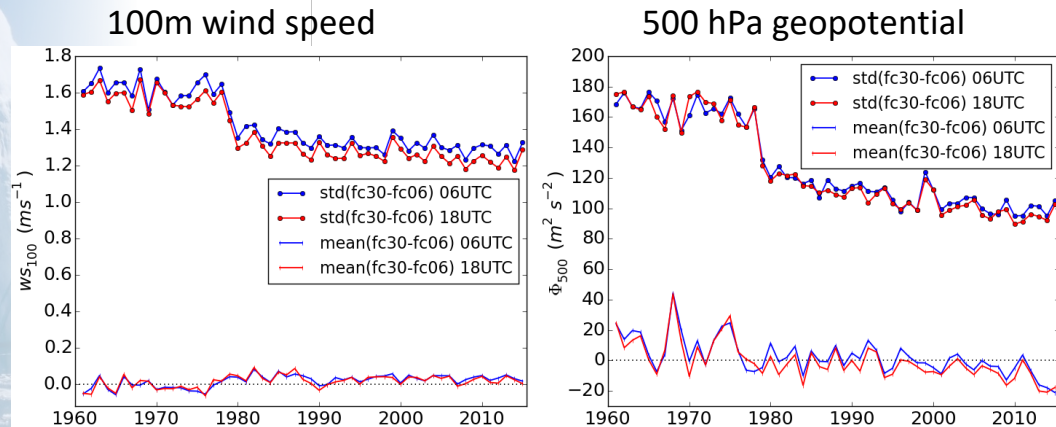
## Risks for inhomogeneity

- 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



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.

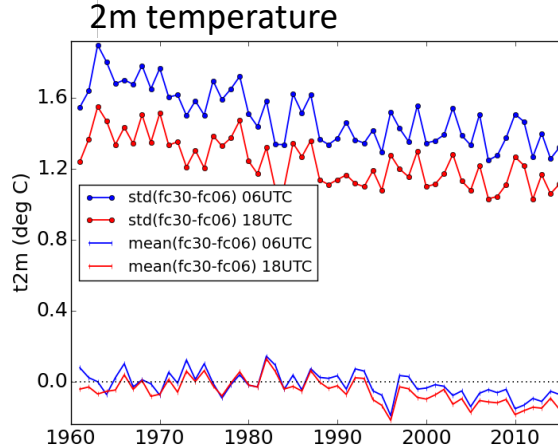
Investigations of the forecast skill (differences between fc30 and fc6):

- 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).

Courtesy Adam von Kraemer.

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

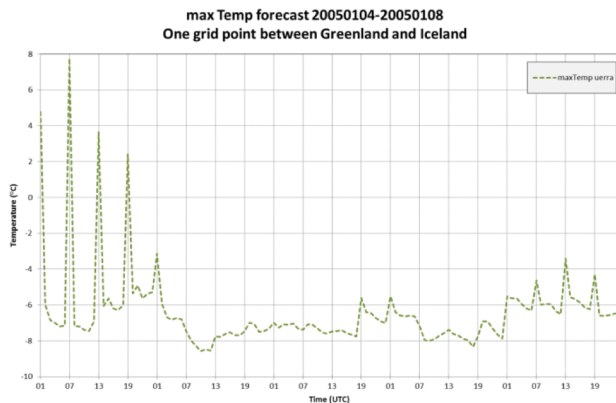
- Less change of quality for surface parameters
- Surface parameters are less affected due to a more constant number of surface observations throughout time



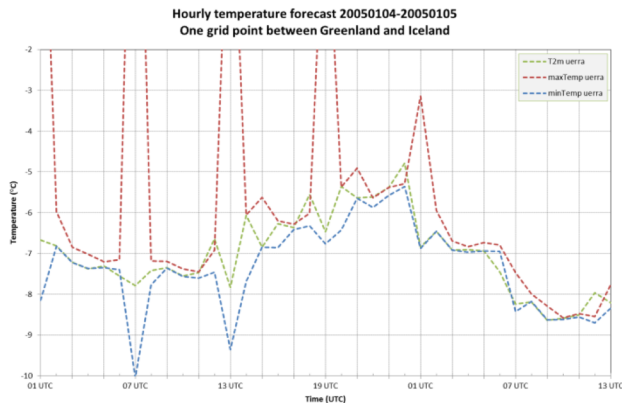
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# Known shortcomings

2m max temperature



2m temp, max  
and min



## Temperature (max and min)

- Hourly resolution at a grid point between Greenland and Iceland
  - Shown are fc1-6
- ➔ Clearly unrealistic jumps
- ➔ Deviations in both directions (max and min) at the same time
- ➔ At least fc1 is affected.

Note that...

- These are extreme cases.
- In most cases even hourly data seems OK.



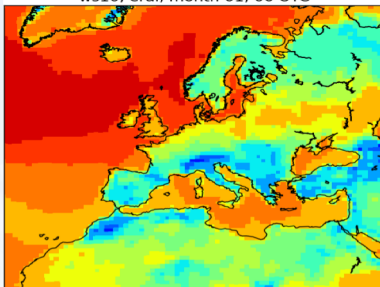
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# Spatial pattern: wind speed

Mean

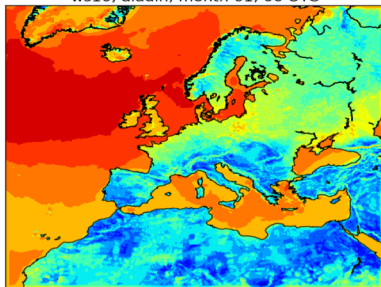
ERA-interim

ws10, erai, month 01, 00 UTC



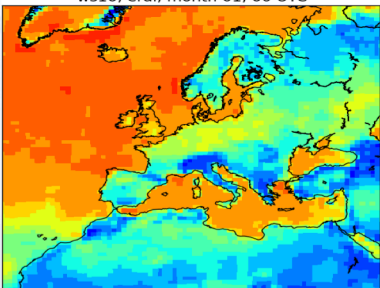
UERRA

ws10, aladin, month 01, 00 UTC

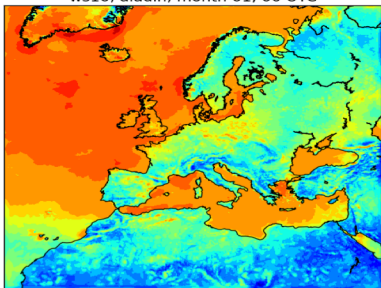


STD

ws10, erai, month 01, 00 UTC



ws10, aladin, month 01, 00 UTC

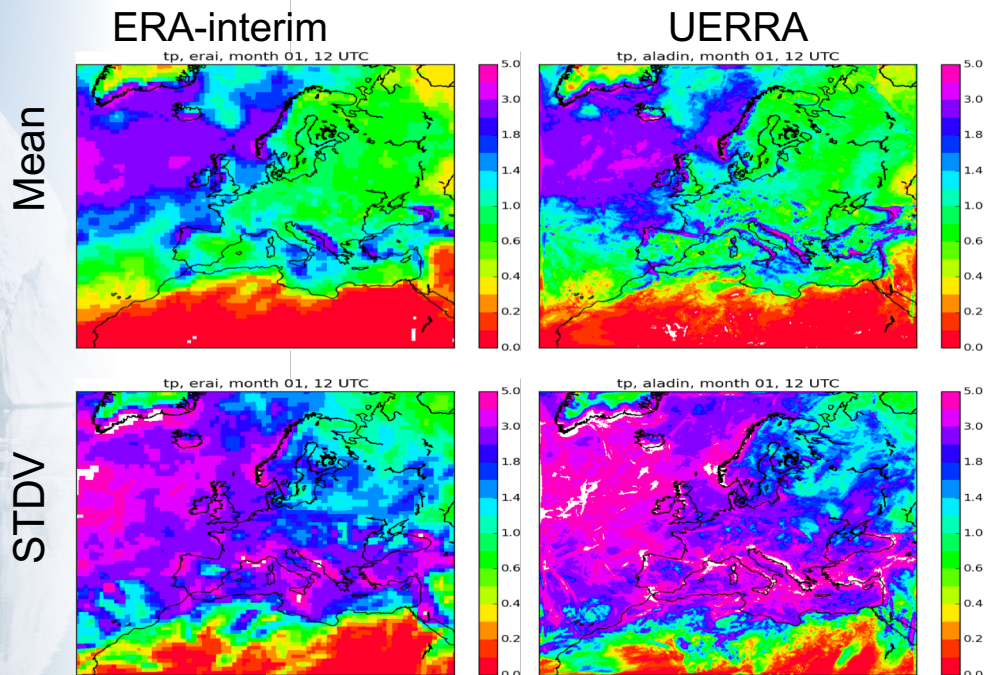


- Monthly mean and standard deviation at 0 UTC
- Finer spatial scales connected to topography and coastline
- Weaker winds over land, especially over Africa
- Stronger variance in mountain ranges



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# Spatial pattern: precipitation



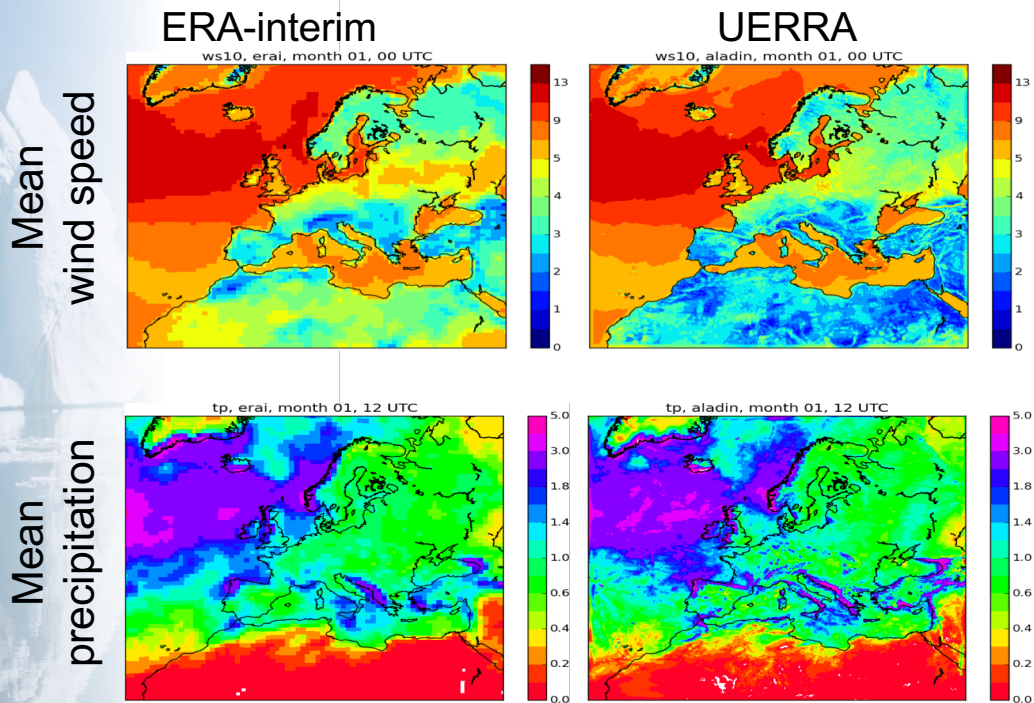
- 12h accumulated precipitation (spin-up period avoided)
- Climatological features similar to ERA-interim
- Finer details than in ERA-interim for the coastline and mountain regions





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# Spatial pattern

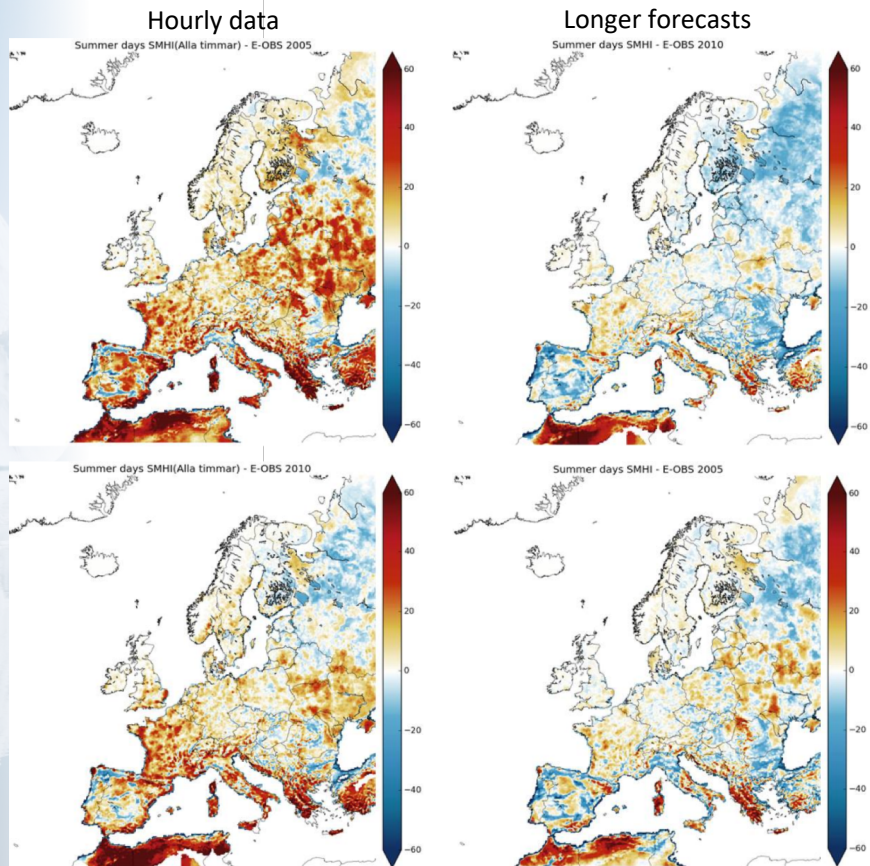


- Monthly means of wind speed and precipitation in January
- Finer spatial scales connected to topography and coastline



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# Summer days compared to E-OBS



Better results compared to E-OBS with a clever data selection.



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## Quality of wind speed: part I

	ERA-interim	Downscaling with RCA	EURO4M	UERRA
RMSE	2.36	2.36	1.88	1.80
Correlation	0.79	0.75	0.83	0.85

Quality of wind speed at Swedish coastal stations based on 6 hourly data for a 10year period (1996-2005)

	Horizontal resolution	Resolution in time
ERA-interim	80 km	3 hourly
Dynamical downscaled with RCA	11 km	hourly
EURO4M	22 km	3 hourly
UERRA	11 km	hourly



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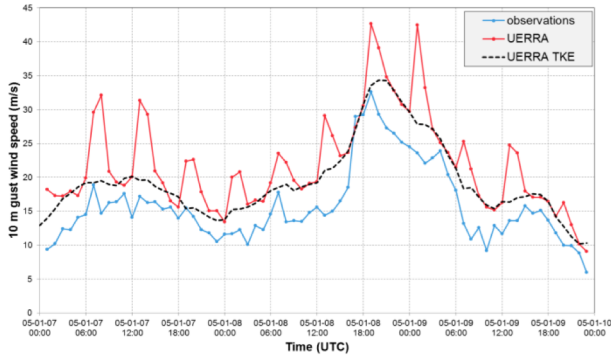
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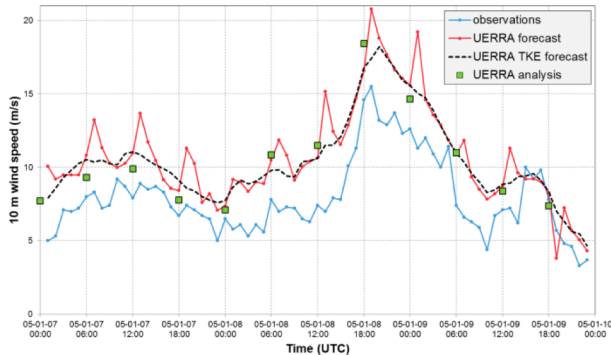
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# Known solutions

10m gust wind speed at station Växjö A (southern Sweden).  
Hourly forecast from 2005-01-07 to 2005-01-09 (storm Gudrun).



10m wind speed at station Växjö A (southern Sweden).  
Forecast and analysis from 2005-01-07 to 2005-01-09 (storm Gudrun).



Just some changes in the  
namelist settings...

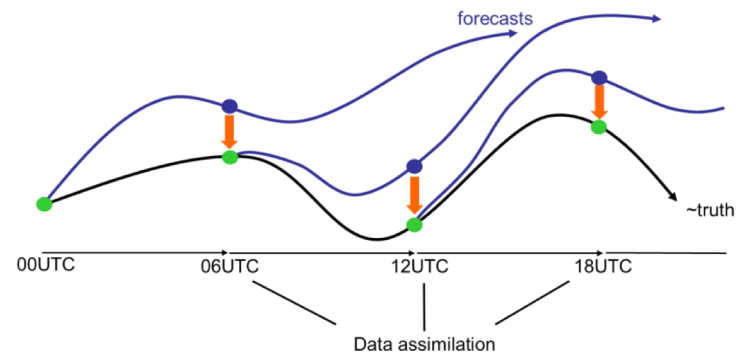


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# Available time steps

		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		■			■			■					■							■															
1978-12-02	6 UTC		■						■						■						■															
1978-12-02	12 UTC	■				■			■						■						■															
1978-12-02	18 UTC	■	■			■			■						■						■															
1978-12-03	0 UTC								■						■						■														■	
1978-12-03	6 UTC								■						■						■														■	
1978-12-03	12 UTC								■						■						■														■	
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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