 Sweden

Application and verification of ECMWF products 2018

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1. Summary of major highlights

2.

The ECMWF forecasts play an important role for SMHI, both for direct use and as provider of lateral boundary conditions for limited area (atmospheric) models and as upper boundary conditions for oceanographical models. The forecast quality of especially ‘early’ medium range forecasts (4-7 days) is regarded to be somewhat higher than previous years.

3. Use and application of products

2.1 Post-processing of ECMWF model output

2.1.1 Statistical adaptation

A Kalman filter is used for adjusting 2m- temperature and 10m-wind. The ensemble mean (computed locally at the institute) is used for products such forecast chart etc.

2.1.2 Physical adaptation

Similar to previous years, visibility is calculated by using an algorithm based on relative humidity, precipitation and latitude. The corresponding DMO from ECMWF is regularly verified with encouraging result and may replace the current visibility calculation.

ECMWF provides model data for lateral conditions and other input data such as 'large scale mixing', (LSM) and blending. Thus, the larger scale structures of the analysis or short forecasts are used as input for the first guess field, but the finer ones are retrieved from the first guess of the high resolution limited area models. This technique is used for AROME.

ECMWF is also used for longer (up to ten days) oceanographical forecasts. (the NEMO model). Here, ECMWF meteorological input is used as upper boundary condition.

MEPS is an ensemble system based on ten members with AROME physics at 2.5 km resolution. It is a collaboration between Sweden, Norway and Finland. The perturbations are based on the difference between older and newer lateral boundaries from ECMWF. (Often refereed to as SLAF, Scaled Lagged Average Forecasting.) The model domain covers north-western Europe. All three countries use the MEPS forecasts. There are plans to replace this method with lateral boundaries based on the ensembles produced by ECMWF.

2.1.3 Derived fields

A smoothing technique is still used for all meteorological model outputs of cloud cover and precipitation, including ECMWF deterministic forecasts. The grid-point information from an area of 20 km radius is used to provide a mean value, a median value, a 90% percentile value and a 10% percentile value. Those values are calculated for all grid-points in an area covering north west Europe, basically that same area as AROME, but with a slightly different grid. It is a rotated lat-lon grid of 0.025 degrees (2.75 km). This technique is not used for ECMWF ensemble mean.

2.2 ECMWF products

2.2.1 Use of Products

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2.2.2 Product requests

Although not being high priority, it could be of interest (especially for verification) to have low-,medium-, and high clouds derived closer to the WHO standard: Low clouds : based on model level cloud up to 2500 m (exclude lowest level), medium level clouds: 2500-5000m and high clouds: above 5000m. Another cloud parameter that is interesting for verification is a cloud cover calculated as the total cloud cover but using model level clouds (exclude lowest level) up to 7500m. This resembles what our automatic stations can detect. All heights refers to the height above ground. (not to sea level)

4. Verification of products

Include medium-range HRES and ENS, monthly, seasonal forecasts. ECMWF does extensive verification of its products in the free atmosphere. However, verification of surface parameters is in general limited to using synoptic observations. More detailed verification of weather parameters by national Services is particularly valuable.

At this point in time (2018) ECMWF would particularly welcome:

- Evaluation of systematic errors in near-surface parameters
- Evaluations related to visibility, humidity and clouds
- Conditional verification results (e.g. 2m temperature bias stratified by cloud cover)
- Comparisons between ECMWF ENS and external LAM-EPS systems (for probabilistic forecasts)

3.1 Objective verification

Describe verification activities and show related scores.

3.1.1 Direct ECMWF model output (both HRES and ENS)

Focus on local weather parameters verified for locations that are of interest to your service

3.1.2 ECMWF model output compared to other NWP models

The general performance of the models mostly used by the institute is illustrated by the verification result for some near surface parameters, table 1:

Table 1:

Verification results for different models and seasons: AROME is the control run in the MEPS ensemble system. '10M wind' is 10 metre wind speed, 't2m' is 2 metre temperature and 'td2m' is 2 metre dew point temperature. The area for verification is north-western Europe and the forecast length ranges from 3 hours up to 48 hours.

Summer (June – August 2017)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.19	0.00	1.36	1.24
t2m	-0.41	-0.26	1.31	1.22
td2m	-0.30	-0.14	1.18	1.26

Autumn (September – November 2017)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.37	0.29	1.50	1.34
t2m	-0.11	-0.12	1.23	1.08
td2m		-0.47		1.03

	-0.28		1.10	

winter (December 2017– February 2018)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.32	0.37	1.55	1.55
t2m	-0.02	-0.02	1.69	1.50
td2m	-0.29	0.12	1.70	1.51

spring(March – May 2018)

parameter	Systematic error or bias		Mean absolute error	
model	ECMWF	AROME	ECMWF	AROME
10m wind	0.12	0.08	1.35	1.25
t2m	-0.58	-0.60	1.72	1.59
td2m	0.07	0.50	1.55	1.70

AROME has generally a lower absolute error due to higher horizontal resolution. ECMWF is still a little too cold during spring and summer. AROME is a little too dry (negative 2m- dew point bias) in autumn, but the opposite is seen in early spring. ECMWF forecasts of 2m dew point have less of those systematic errors and have been a valuable guidance for 2m moisture forecast variables. (This means also 2m relative humidity etc.)

The ECMWF forecasts of low clouds are generally somewhat better than those from AROME during spring and autumn. During autumn, AROME has too little of low low clouds, but in early spring there is too much low clouds instead and also too much fog. Also here, ECMWF preforms a valuable guidance, since the model has less- or no such systematic errors.

24 hour precipitation is regularly verified against a dense network of climate stations, mainly over Sweden and some parts of northern Norway. Only the short time forecasts (the 24 hour period starting at six- and ending at 30 hour forecast length) are verified. Fractions skill score (FBSS) is used with 'sample climate' as reference forecast. The period for verification is July 2017 to May 2018. The result is seen in in figure 1.

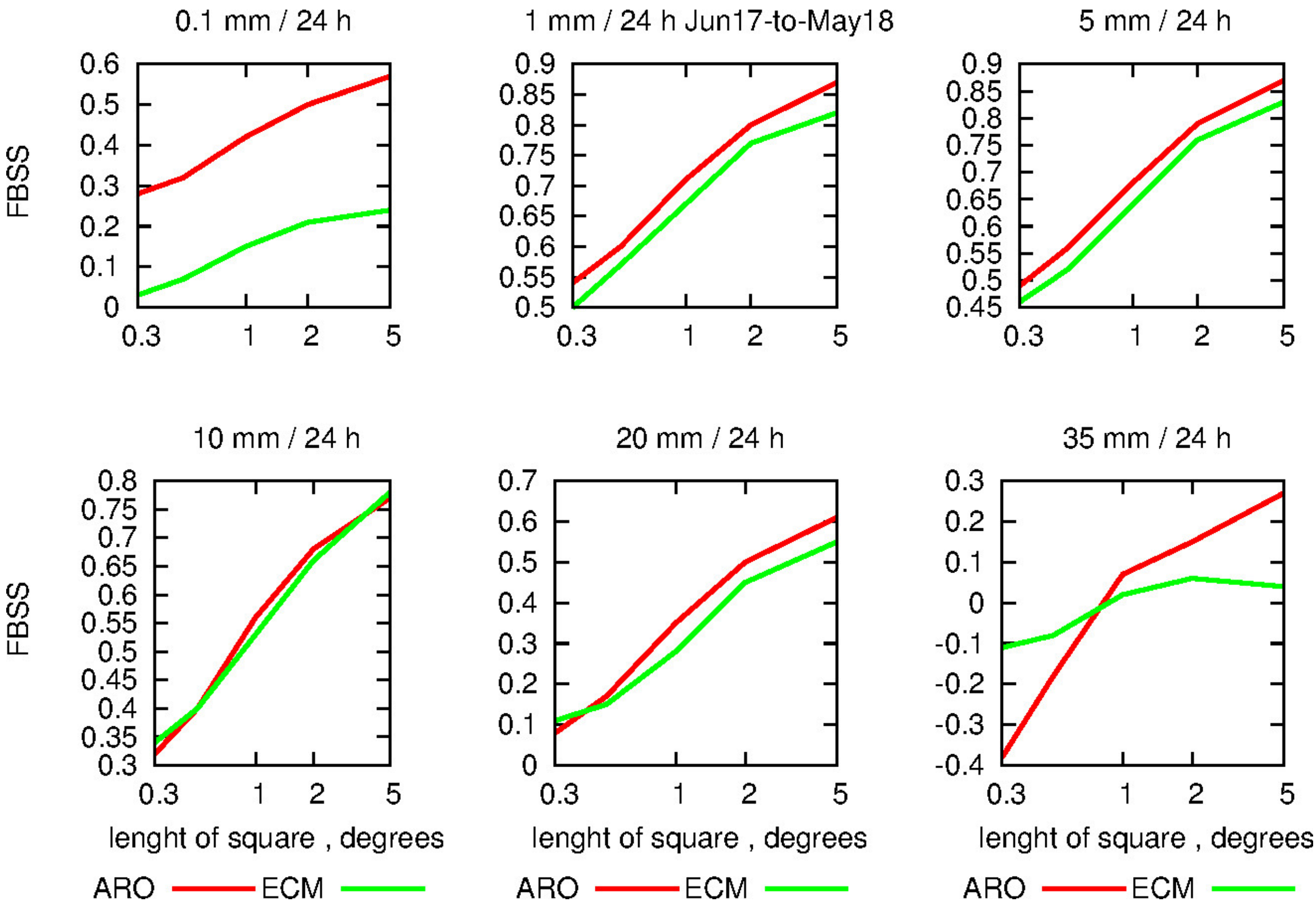

Figure 1: FBSS for different thresholds of precipitation. FBSS at the vertical axis and the size of different squares in degrees. There should be at least three observations in a square for being used in the verification. One degree is about 111 km. ECM (green) is ECMWF forecasts and ARO (red) is AROME with 2.5 km grid.

AROME has the highest score for all scales for precipitation thresholds up to 5 mm. For higher thresholds, the results are mixed, but a tendency is that ECMWF has somewhat better result for the smaller sizes than AROME, but the opposite is seen for larger scales. The low skill for ECMWF for 0.1mm threshold may partly be caused by that interpolated ECMWF fields are used.

The diurnal cycle of **low clouds, clouds up to 7500 m** and **3 hourly precipitation** for June and a major part of July 2018 is seen in figures 2,3 and 4.

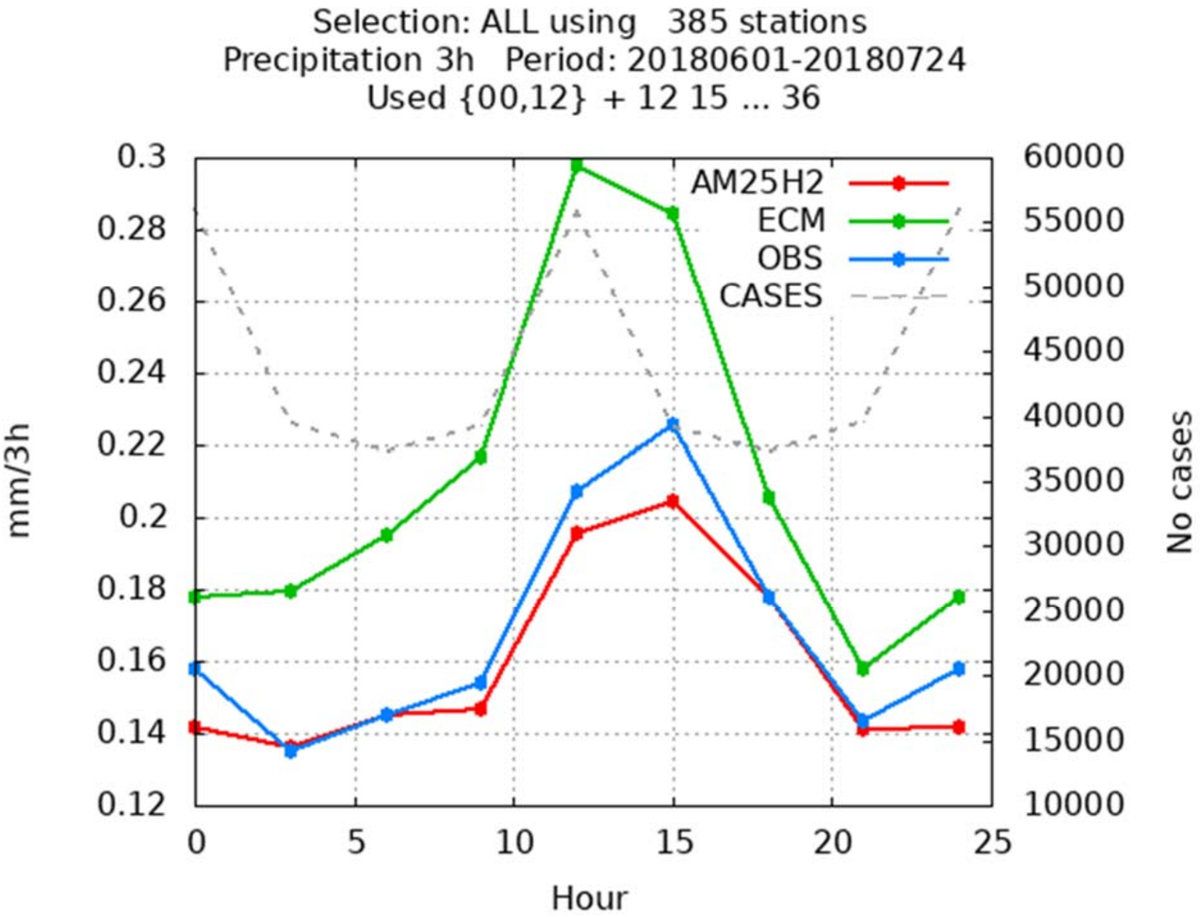

Figure 2: Diurnal cycle for 3h precipitation over Scandinavia during 20180601 – 20810724. Red is the MEPS control run (AROME), green is ECMWF and blue is observed precipitation. Hour of the day at horizontal axis and mean 3 hour precipitation at vertical axis.

There is a slightly too early onset of daytime precipitation for ECMWF forecasts, and the amplitude is too large. For AROME it is almost correct, but the amplitude is a little too small. Be ware of the possibility that rain gauges measurement may underestimate precipitation amount somewhat.

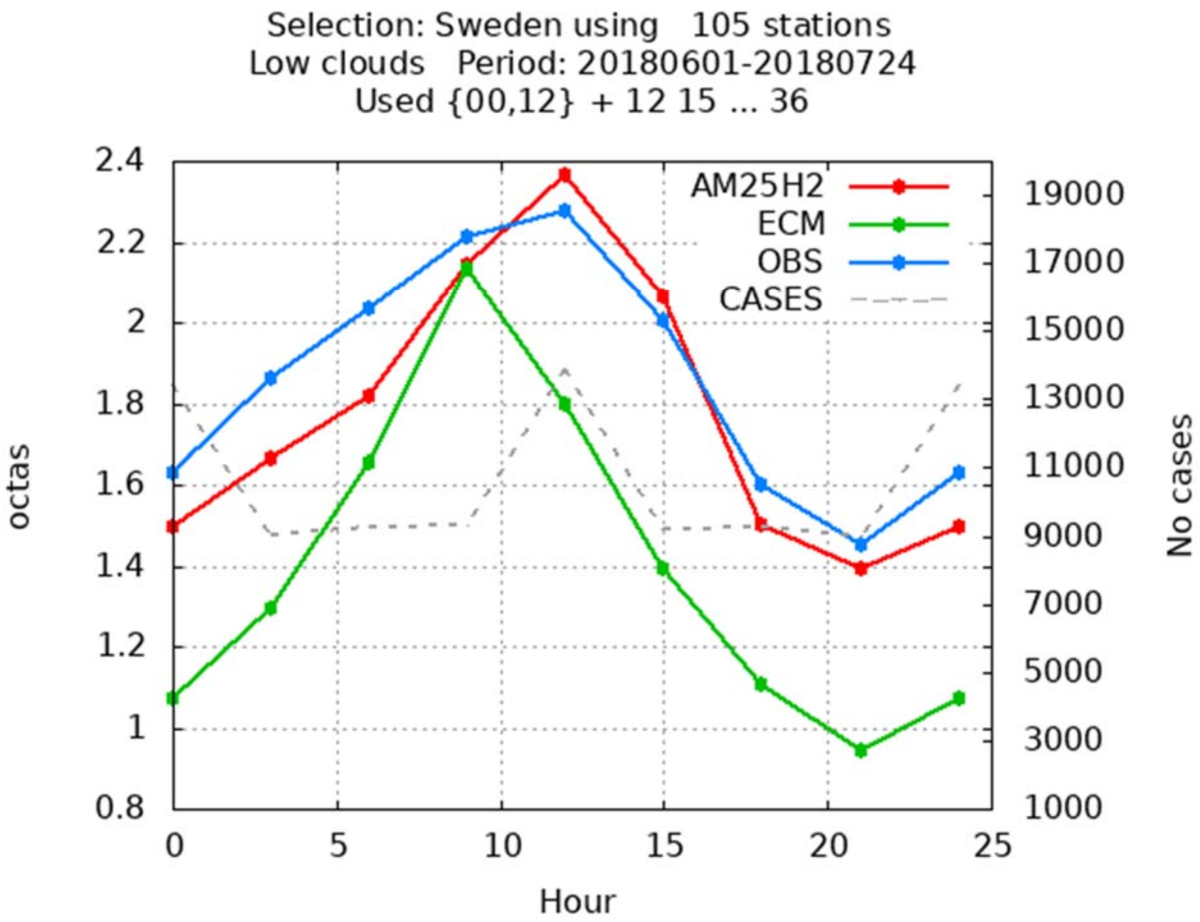
Selection: Sweden using 105 stations
Low clouds Period: 20180601-20180724
Used {00,12} + 12 15 ... 36
AM25H2
ECM
OBS
CASES
octas
No cases
Hour
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
19000
17000
15000
13000
11000
9000
7000
5000
3000
1000
0
5
10
15
20
25

Figure 3: Diurnal cycle for low clouds over Sweden during 20180601 – 20810724. Red is the MEPS control run (AROME), green is ECMWF and blue is observed low clouds. Blue is observed cloudiness from automatic stations. In other respects as figure 2.

ECMWF forecasts generally underestimate low cloud amount a little, especially in the evening. The amplitude of the diurnal cycle is too high and the daytime maximum is about three hours too early. Also AROME has a little too large amplitude, but the phase error is smaller and opposite to that of the ECMWF forecasts. Note that automatic stations only detects clouds near zenith so the perspective effect near the horizon, present in manual observations is not present for automatic stations. This leads to somewhat lower amounts of clouds observed from automatic stations compared to manual observations.

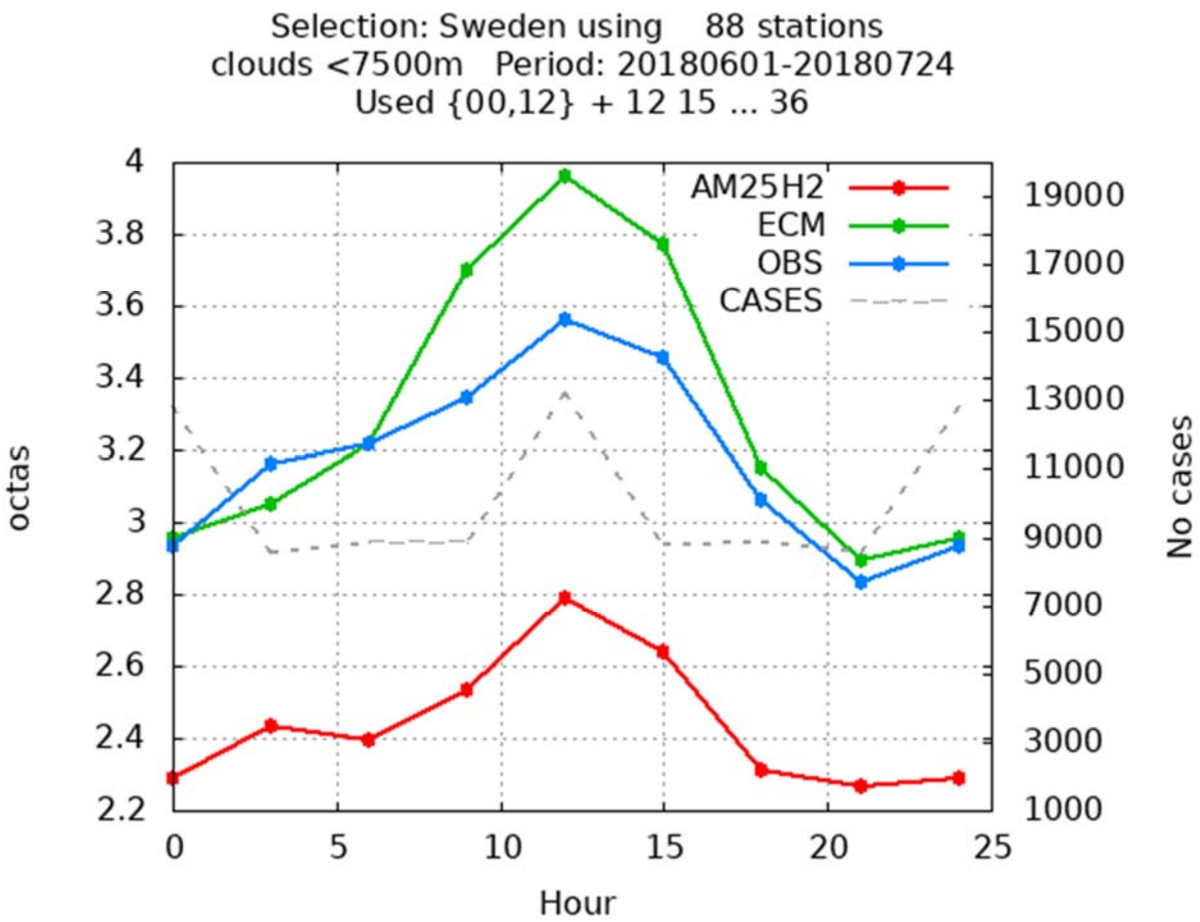
Selection: Sweden using 88 stations
clouds <7500m Period: 20180601-20180724
Used {00,12} + 12 15 ... 36
AM25H2
ECM
OBS
CASES
octas
No cases
Hour
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
19000
17000
15000
13000
11000
9000
7000
5000
3000
1000
0
5
10
15
20
25

Figure 4: Diurnal cycle for low clouds up to 7500 m over Sweden during 20180601 – 20810724. Red is the MEPS control run (AROME), green is ECMWF and blue is observed cloudiness from automatic stations only. In other respects as figure 2.

The cloudiness from ECMWF forecasts up to 7500m is calculated from the ECMWF model level clouds. The daily amplitude of ECMWF forecasts is a little too large, whereas some general underestimation of clouds up to 7500m is seen for AROME. Both models forecast the diurnal phase in a correct manner.

A daily verification of **maximum wind gusts** has recently started at SMHI. The reason for not doing this earlier is some issues regarding the time period for verification. Both observations and forecasts had different time periods. (instantaneous, one hour, three hours etc.) The verification showed below is based on the maximum wind gust during one hour. The result for May, June and July (except the very last days) this year is seen in figures 5,6 and 7.

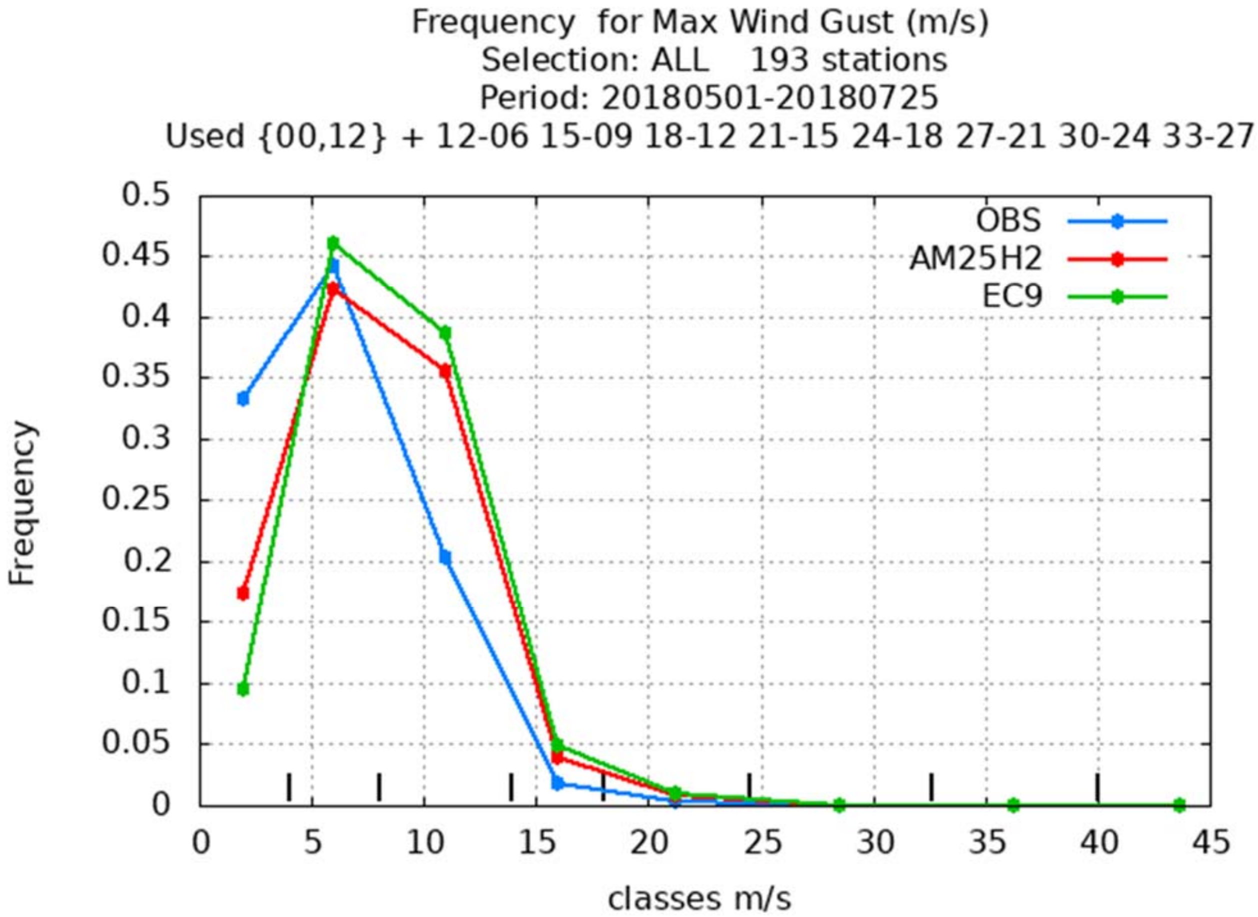
Frequency for Max Wind Gust (m/s)
Selection: ALL 193 stations
Period: 20180501-20180725
Used {00,12} + 12-06 15-09 18-12 21-15 24-18 27-21 30-24 33-27
OBS
AM25H2
EC9
Frequency
classes m/s
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
35
40
45

Figure 5: Relative frequency (vertical axis) of one hourly maximum of wind gust during 20180501 – 2080725 for different intervals. The intervals are marked with vertical bars at the bottom of the figure. Red is the MEPS control run (AROME), green is ECMWF and blue is observations. Most stations are situated in Sweden.

Both models suffer from an over prediction of wind gusts. The largest over prediction is seen for ECMWF. However, for coastal stations this error is smaller, figure 5.

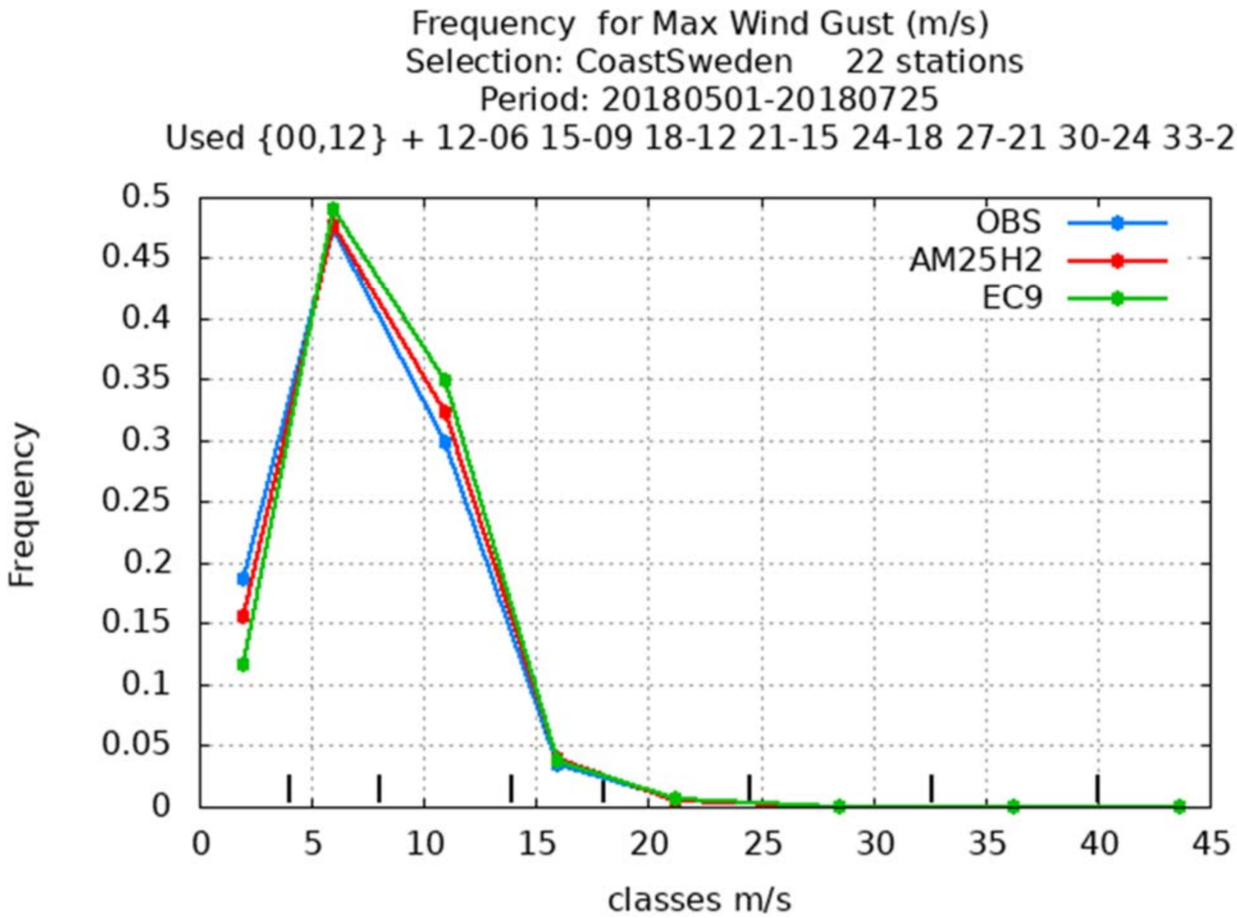

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Figure 6: The same as in figure 5, but for Swedish coastal stations only.

The equitable treat score for the wind gust forecast is seen in figure 7.

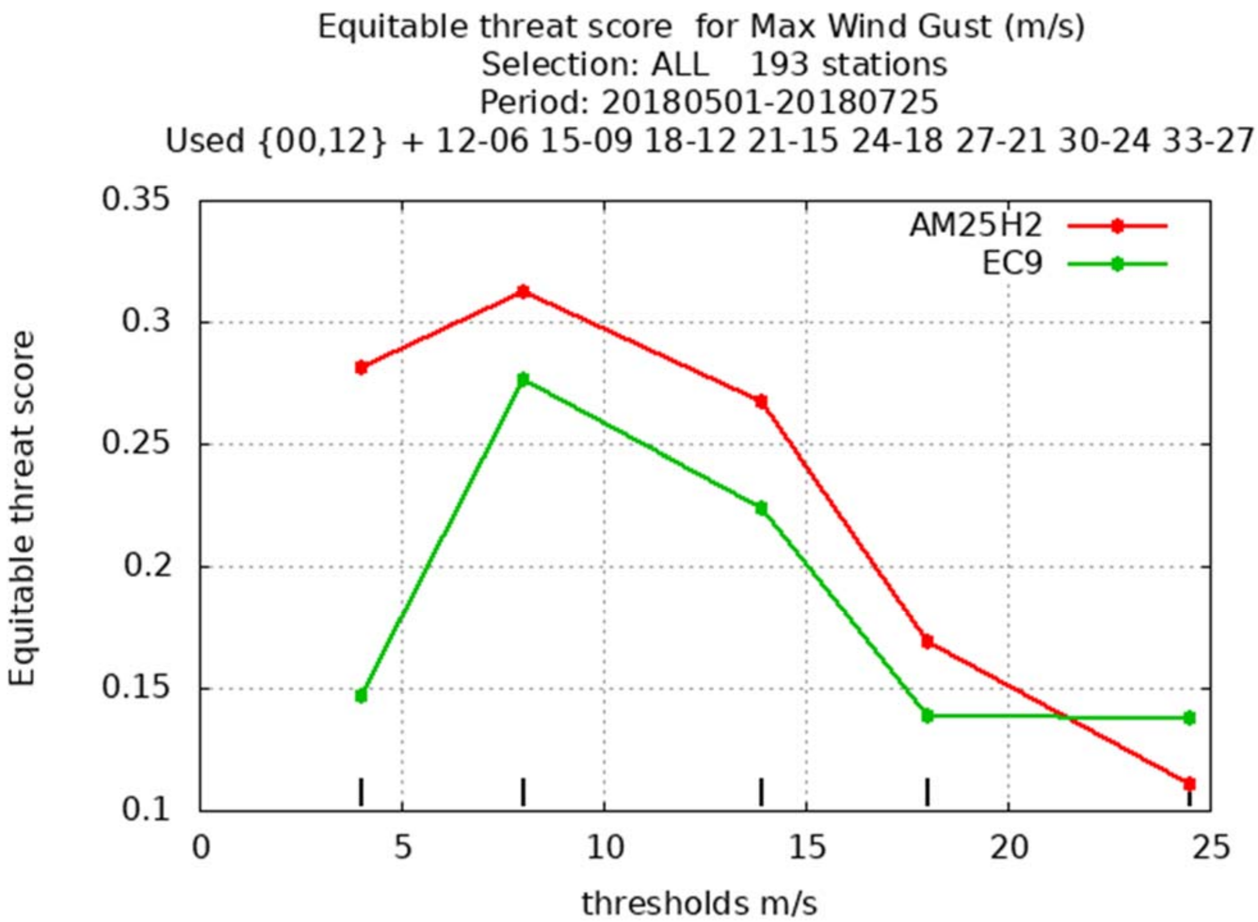
Equitable threat score for Max Wind Gust (m/s)
Selection: ALL 193 stations
Period: 20180501-20180725
Used {00,12} + 12-06 15-09 18-12 21-15 24-18 27-21 30-24 33-27
Equitable threat score
thresholds m/s
AM25H2
EC9
0.35
0.3
0.25
0.2
0.15
0.1
0
5
10
15
20
25

Figure 7: ETS for one hourly maximum of wind gust during 20180501 – 2080725 for different thresholds. Red is the MEPS control run (AROME), green is ECMWF and blue is observations. Most stations are situated in Sweden. ETS at vertical axis, the thresholds (marked as vertical bars) at the horizontal axis.

ECMWF has the highest ETS for wind gusts above 25 m/s, which is the most important threshold if high impact weather is regarded as the most important. But there are only a few cases (22) above 25m/s, which makes the result uncertain. AROME has the highest scores for the other thresholds, one important reason for this is less over prediction.

3.1.4 End products delivered to users

3.2 Subjective verification

Duty forecasters are satisfied with the forecasts in most respects. But there seems to be an over-prediction of middle level clouds in daytime during the warm season. It is possible that this is partly related to the definition of low- and middle level clouds (see point 2.2.2).

3.2.2 Case studies

Severe weather events/non-events are of particular interest. Include an evaluation of the behaviour of the model(s). Reference to major forecast errors, even if they are not in a "severe weather" category, are also very welcome.

5. Feedback on ECMWF "forecast user" initiatives

We invite comments on how useful you find the information provided on ECMWF's "Forecast User Portal", see: (https://software.ecmwf.int/wiki/display/FCST/Forecast+User+Home), and on any changes you would like to see. A new web-based "Forecast User Guide" will be added soon (due May 2018) and we would particularly welcome initial comments on that.

5. References to relevant publications