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Verification of Operational Weather Prediction Models March to May 2021

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Photo: Jan Erik Haugen

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Verification results are also available on internal web pages

- https://metcoop-comm.smhi.se/ and https://metcoop.smhi.se/ - MetCoOp Web Tools - including verification and observation monitoring
- https://harp.smhi.se/ - MetCoOp verification visualized with harp
- http://verif/vmap/ - timeseries and windroses - on Google map
- https://hirlam.org/trac/wiki/CommunicationWithUsers - HARMONIE quarterly reports

About this report

The report includes verification results for 3 Numerical Weather Prediction (NWP) models; MetCoOp ensemble system (MEPS) covering Norway, Sweden, Finland, Denmark and the Baltic states, AROME-Arctic covering Svalbard, Novaja Semlja, Frans Josefs land and the Northern part of Scandinavia and the global ECMWF. The models are further described in the Models section. The variables verified are mean sea level pressure, temperature, wind speed and precipitation. The results are grouped by variable. A short summary of the results and cases studies by forecasters are also included.

Verification results are shown for different groups of stations: Norwegian, Svalbard and North Scandinavian. For temperature there are additional groups with Norwegian coastal and Norwegian inland stations, for wind speed Norwegian coastal and Norwegian mountainous stations, and for precipitation coastal stations, stations more than 500 m above sea level, and stations with daily mean precipitation $>$ 4 mm. For MEPSctrl statistics at the observing sites are also visualized on maps with model climatology. The text size of the statistics increases with the value. Time series with observations and available models are included for selected stations. Post processed variables are compared with MEPSctrl.

Models

The following Numerical Weather Prediction (NWP) models are verified in this report. The verification measures are plotted for each model with the colors indicated in the table below.

ECMWF	Global model (IFS) at the European Centre for Medium-Range Weather Forecasts. From 26 January 2010 horizontal resolution approximately 16×16 km^2. From 8 March 2016 cycle 41r2 with horizontal resolution about 9 km. ECMWF is available about 5 hours later than models run at MET.
MetCoOp ensemble system (MEPSctrl)	MEPS has 30 lagged ensemble members, constructed from 5 members updated hourly and run up to 66 hours. Only member 0, the control, is verified in this report. MEPS is based on HARMONIE with AROME physics and non-hydrostatic dynamics, horizontal resolution defined by a 2.5×2.5 km^2 grid. Experimental with cycle 37h1.1 from November 2012, on Yr since 1 October 2013, operational since March 2014, cycle 38h1.2 from December 2014, cycle 40h1.1 since November 2016 and cycle 43h2.1 from 23 March 2021. MEPS is run in cooperation with Swedish Meteorological and Hydrological Institute (SMHI), Finnish Meteorological Institue (FMI) and Estonian Environment Agency (ESTEA).
AROME-Arctic (AA25)	HARMONIE with AROME physics, horizontal resolution defined by a 2.5×2.5 km^2 grid. Experimental with cycle 38h1.2 from 15 October 2015, on Yr from 14 December 2016, cycle 40h1.1 since June 2017, cycle 43h2.1 since 5 May 2021.

Analysis and lead times of forecasts are denoted by e.g. 00+30 UTC which indicates forecast generated at 00 UTC and valid 30 hours later.

A change log for HARMONIE AROME is available on internal webpages
https://metcoop.smhi.se/dokuwiki/nwp/metcoop/changelog/start.

Post processed forecasts

Most of the raw NWP model data are post processed before being published on Yr.

The met nordic temperature forecasts, YrPP in the plots, are post-processed forecasts based on the latest MEPS control run. The MEPS temperature forecasts are first downscaled to 1 km resolution using the model lapse rate in a neighbourhood. The forecasts are then bias corrected using a fine scale 1 km temperature analysis as reference. The temperature analysis is based on multiple data sources using both conventional and citizen observations. YrPP is plotted with the color below.

10 m wind speed is statistically post processed to represent maximum wind speed 10m last hour, and called YrPP.

The HARMONIE system

HARMONIE is the acronym for HIRLAM's meso-scale forecast system (Hirlam Aladin Regional/Meso-scale Operational NWP In Europe). For documentation see
- *The HARMONIE-AROME Model Configuration in the ALADIN-HIRLAM NWP System* by Bengtsson et al. 2017, available at https://doi.org/10.1175/MWR-D-16-0417.1
- *AROME-MetCoOp: A Nordic Convective-Scale Operational Weather Prediction Model* by Müller et al. 2017, available at https://doi.org/10.1175/WAF-D-16-0099.1

More documentation is also available on http://www.cnrm.meteo.fr/gmapdoc/ and http://hirlam.org/.

This section presents some of the main components and setups that are used at MET.

AROME physics

AROME (Applications of Research to Operations at MEsoscale) is targeted for horizontal resolution 2.5 km or finer. It uses physical parameterizations based on the French academia model Meso-NH and the external surface model SURFEX. AROME has been operational at Météo-France since 18 December 2008 with a horizontal resolution of 2.5 km and 65 vertical layers, and from April 2015 1.3 km and 90 vertical layers.

SURFEX as surface model

SURFEX (Surface externalisée) is developed at Météo-France and academia for offline experiments and introduced in NWP models to ensure consistent treatment of processes related to surface. Météo-France uses SURFEX in all their configurations. Surface modelling and assimilation benefit from the possibility of running offline experiments. SURFEX is also used for offline applications in e.g. hydrology, vegetation monitoring and snow avalanche forecasts.

SURFEX includes routines to simulate the exchange of energy and water between the atmosphere and 4 surface types (tiles); land, sea (ocean), lake (inland water) and town. The land or nature tile can be divided further into 12 vegetation types (patches). ISBA (Interaction between Soil Biosphere and Atmosphere) is used for modelling the land surface processes. There are 3 ISBA options; 2- and 3-layer force restore and a diffusive approach, where the first one is used in HIRLAM. Towns may be treated by a separate TEB (Town Energy Balance) module. Seas and lakes are also treated separately. The lake model, FLAKE (Freshwater LAKE), has recently been introduced in SURFEX. A global ECOCLIMAP database which combines land cover maps and satellite information gives information about surface properties. The orography is taken from gtopo30.

SURFEX Scientific Documentation and *User's Guide* are available on http://www.cnrm.meteo.fr/surfex/

Data assimilation

NWP models are updated regularly using observations received in real-time from the global observing system. MEPS is updated each third hour; at 00, 03, 06, 09, 12, 15, 18 and 21 UTC.

Surface analysis

Surface analysis is performed by CANARI (Code d'Analyse Nécessaire à ARPEGE pour ses Rejets et son Initialisation) (Taillefer, 2002). The analysis method is Optimal Interpolation and only conventional synoptic observations are used. 2 meter temperature and relative humidity observations are used to update the surface and soil temperature and moisture.

The snow analysis is also performed with CANARI in analogy with the HIRLAM snow analysis. Snow depth observations are used to update Snow Water Equivalent. The snow fields are analysed only at 06 UTC as there are very few snow depth observations at 00, 03, 09, 12, 15, 18 and 21.

The Sea Surface Temperature (SST) and Sea Ice Concentration (SIC) is not analysed, but taken from the boundaries. ECMWF uses the OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis) product, including SST from UK Met Office and SIC from MET. SST and SIC for the Baltic Sea have since 26 November 2015 been taken from ocean models run at SMHI; first HIROMB and since 26 April 2017 NEMO.

The surface temperature over sea ice was taken from the boundary model and remained unchanged through the forecast. A simple thermodynamical sea ice scheme (SICE) giving prognostic sea ice temperatures in 4 fixed layers was introduced 26 November 2015.

Upper air analysis

MEPS runs three dimensional variational (3D VAR) data assimilation using conventional observations from synop stations, ships, radiosondes and aircrafts and AMSU-A and AMSU-B/MHS data from polar orbiting NOAA and METOP satellites. GNSS were introduced 17 February 2015, radar reflectivities 16 June 2015, IASI 26 November 2015 and ASCAT 17 March 2016.

Boundary fields

MEPS gets its boundary values (1-hourly) from the ECMWF model at approximately 16 km resolution, and has currently 65 vertical levels. None of the HARMONIE configurations at MET have applied digital filter initialization (DFI).

Verification measures

All model forecasts in this report are verified against observations by interpolating (linear) the grid based forecasts to the observational sites. As a consequence, it should be noted that it is the models' abilities to forecast the observations that is being quantifed and assessed. Thus, there is no attempt in this report to verify area averaged precipitation for example.

Verification is carried out both for raw and categorized forecasts. In the following, let $f_1, ..., f_n$ denote the forecasts and $o_1, ..., o_n$ the corresponding observations.

Forecasts of continuous variables

The verification statistics applied to continuous variables are defined in the table below

Statistic	Acronym	Formula	Range	Optimal score
Mean Error	ME	$\frac{1}{n}\ \sum_{i=1}^{n}(f_i - o_i)$	$-\infty$ to ∞	0
Mean Absolute Error	MAE	$\frac{1}{n}\ \sum_{i=1}^{n} \mid f_i - o_i \mid$	0 to ∞	0
Standard Deviation of Error	SDE	$\Big(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i - \mathsf{ME})^2\Big)^{1/2}$	0 to ∞	0
Root Mean Square Error	RMSE	$\Big(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i)^2\Big)^{1/2}$	0 to ∞	0
Correlation	COR	$\frac{\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})(o_i - \bar{o})}{\mathsf{SD}(f)\mathsf{SD}(o)}$	-1 to 1	1

In the formula for COR the following definitions are used

$$\bar{f}\ =\ \frac{1}{n}\sum_{i=1}^{n} f_i, \qquad \bar{o}\ =\ \frac{1}{n}\sum_{i=1}^{n} o_i$$

$$\mathsf{SD}(f)\ =\ \big(\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})^2\big)^{1/2}, \qquad \mathsf{SD}(o)\ =\ \big(\frac{1}{n}\sum_{i=1}^{n}(o_i - \bar{o})^2\big)^{1/2}$$

for the means and standard deviations of the forecasts and observations.

Forecasts of categorical variables

All variables in this report are continuous in raw form, but it is possible to categorize them and verify these. For example, wind speed above a given threshold could be of interest which would result in two possible outcomes (yes and no). The verification is then completely summarized by a contingency table as the one shown below

		event observed	
		yes	no
event forecasted	yes	a	b
	no	c	d

Verification statistics for such forecasts are listed in the following table

Statistic	Acronym	Formula	Range	Optimal score
Hit rate	HR	$\frac{a}{a+c}$	0 to 1	1
False alarm rate	F	$\frac{b}{b+d}$	0 to 1	0
False alarm ratio	FAR	$\frac{b}{a+b}$	0 to 1	0
Equitable threat score	ETS	$\frac{a-ar}{a+b+c-ar}$	$-1/3$ to 1	1 (0 = no skill)
Hanssen-Kuipers skill score	KSS	HR - F	-1 to 1	1 (0 = no skill)
Heidke skill score	HSS	$\frac{(a+d)/n-ssf}{1-ssf}$	$-\infty$ to 1	1 (0 = no skill)

In the formula for ETS $ar = (a+b)(a+c)/n$.
In the formula for HSS the score for the standard forecast $ssf = [(a+b)(a+c)+(b+d)(c+d)]/n^2$.

Observations

All observations come from Klimadatavarehuset at MET. Only synop stations are used. From June 1 2021, both the model wind speed and the post-processed wind speed are verified against mean wind observations, FF. The model wind gust is verified against the observed wind gust, FG. FF and FG are defined as follows:

- FF: Wind speed (10 meters above ground) - defined as the mean value for the last 10 minutes before the time of the observation.
- FX: Maximum mean wind speed (10 m above ground) - defined as the highest 10 minutes mean wind speed since the previous observation time.
- FG: Gust wind speed (10 m above ground) - defined as highest gust wind speed (3 second mean) the last 10 minutes before the time of the observation.

Summary of the results

Summarized statistics show that ECMWF in general forecast sea level pressure better than MEPSctrl/AA25, but the errors are small for both.

Temperature is on average better forecast by MEPSctrl/AA25 than ECMWF. All models tend to underestimate the temperature for the different groups of stations, but more so for ECMWF. However, the standard deviation of the error is about the same for MEPSctrl and ECMWF, although somewhat larger for AA25 for Svalbard stations. Still, the errors are small, indicating that the timing of the temperature changes is generally good. The temperature forecast is further improved by post processing, particularly for the shortest lead times. The improvement is larger for inland stations than coastal stations, which have less variation in temperature and smaller errors than inland stations for both MEPSctrl and post processed forecasts. The upgrade of MEPS from cycle 40 to cycle 43 on 23 March 2021 had some effect on near surface temperatures. The new physiography data set - ECOCLIMAP Second Generation - has a new albedo data set leading to a slight increase in daytime temperatures in the summer season. Comparison of ME of 00+12 T2m forecasts for stations, presented on maps, show that the underestimation of daytime temperatures is reduced as compared to the previous spring. The changes introduced to improve the performance in stable situations works as intended in the coldest situations, but also leads to reduction of the temperatures in some situations and at some locations that already are too cold. Typical examples of degradation in the mountains are shown in the time series in Case studies by forecasters, Case 2, and also reflected in increased negative ME of 00+24 T2m forecasts from stations presented on the map. A change in the radiation physics that takes the effect of thin ice clouds better into account counteracts the degradation. The change was introduced 1 June 2021.

For wind speed and precipitation, a larger number of verification scores is used to assess model quality, including threshold statistics. Wind speed is challenging to evaluate. MEPSctrl clearly performs better than ECMWF for mountainous stations, although both underestimate the speed here as seen in the monthly mean error and mean absolute error. The maps show that underestimation also applies to coastal stations in strong wind events. The threshold scores indicate that wind speed is better forecast for lower than for higher wind speeds for all models. Otherwise, the results are ambiguous. Post processing yields in general smaller errors, but also has somewhat more false alarms. The near surface wind speeds are effected by the upgrade to cycle 43 both by modifications in the turbulence scheme and by the physiography upgrade. ECOCLIMAP Second Generation has new tree heights and a more ”binary” separation between patch 1 (low vegetation) and 2 (trees). The largest effect of the change is seen at coastal stations with increased diurnal cycle in wind speed and less underestimation during day.

Precipitation also shows varying results, depending on the amount and location. On average, MEPSctrl performs a little better than ECMWF, but both have more errors for both very small amounts and very high amounts than precipitation in the mid range.

The models generally perform better during summer months than during winter for all variables. A possible cause is that storm activity is challenging to predict accurately, and there are often more storms during fall and winter than during summer. AA25 and MEPSctrl show very similar results, which is expected since both are HARMONIE with AROME physics, horizontal resolution defined by a 2.5×2.5 km^2 grid.

Case studies by forecasters

Case 1. Precipitation in coastal regions March and April 2021

There are several reports of missing precipitation in coastal regions. Figure 1 shows an event from the 2 March which illustrates the model's tendency to delay the precipitation downstream. This makes it too dry at the coast, and leads to too much precipitation on the lee side of the mountains. In this case the wind was westerly. There is a certain amount of collection deficit of snow at the coast in windy situations, but still the observations indicate significantly more snow than the forecast. Typical wintry showers are shown for Tromsø on 12 April in figure 2.

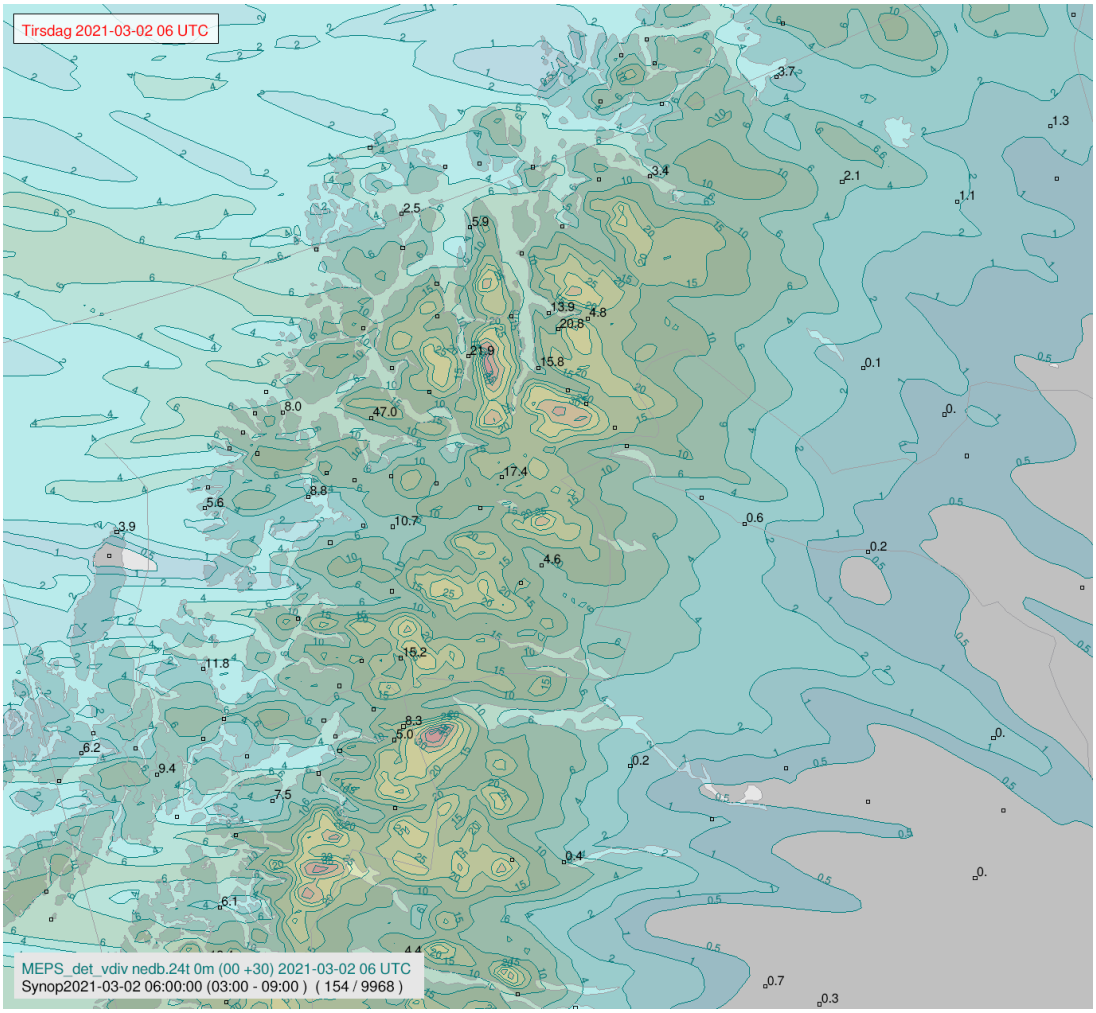
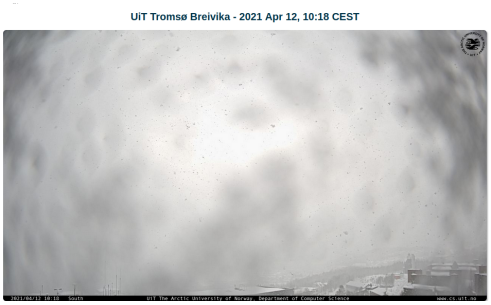


Figure 1: Precipitation event on 2 March 2021 in Troms. MEPS deterministic 24h precipitation plotted against observed 24hr precipitation.



I dag 12. apr.

Tid	Vær	Temp.	Nedbør mm
10		1°	0 – 0,2
11		1°	
12		1°	
13		1°	
14		1°	

Figure 2: Typical wintry showers in Tromsø here from 12 April. The forecasts on YR are often quite different from the perceived weather in such situations, with showery weather and wind towards the coast.

Case 2. Temperature T2m in Northern Norway 7 May 2021

Temperatures tended to have an excessive diurnal variation in this period, with too much cooling at night in the melting season in the mountains in southern Norway, and along the coast in northern Norway. This is shown for 4 stations in the figures 3 and 4 on 7 May. Reasons for that might be the smoothing of the terrain, uncertainty about presence of snow, the effect of snow on the near surface temperatures in the melting season, and also modifications to the Richardson number from an attempt to improve overall performance in T2m in stable conditions.

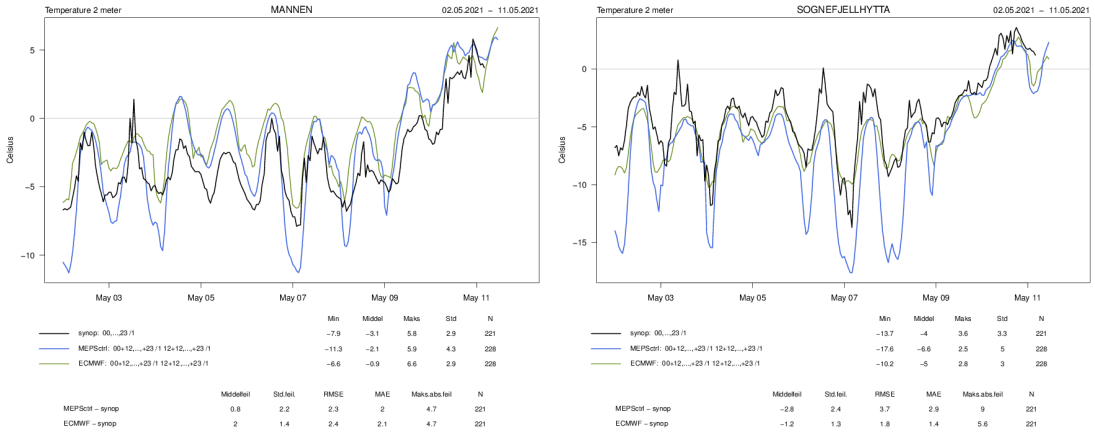


Figure 3: Two mountain stations in southern Norway: Mannen at 1294 masl (left), and Sognefjellshytta at 1410 masl (right) with too low night time temperatures. MEPSctrl in blue, ECMWF in green and observations in black.

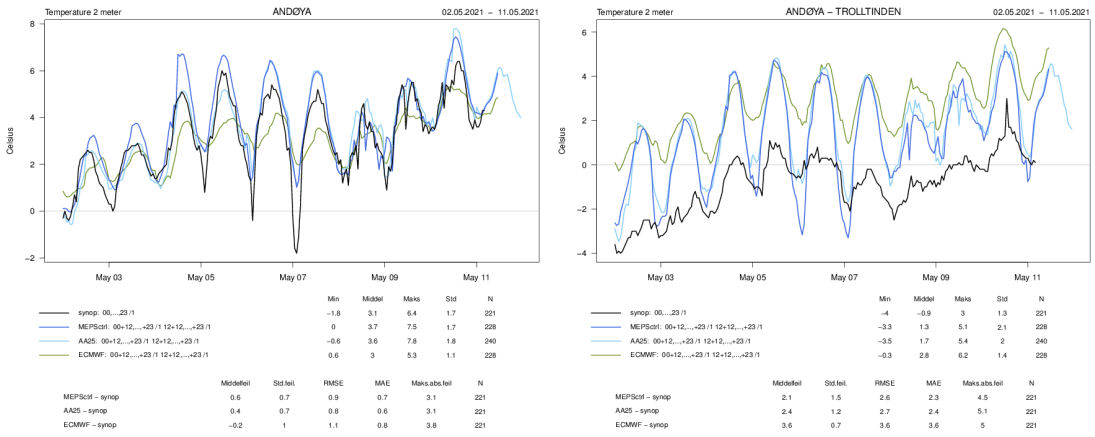


Figure 4: The airport at Andenes at 5 masl (left) has a positive bias in daytime, and a negative bias on some cloud free nights, but otherwise realistic diurnal variation. The nearby mountain station Trolltinden at (436 masl right) is at about 150 masl in the model and snow free, and had an exaggerated diurnal variation in this period.

Case 3. Fog and low clouds May 2021

The general impression from fog cases from May 2021 is that the fog, or cloudiness in the lowest model layer, tends to be rather uncertain in the positioning (figure 5, left). Using probabilities for fog only improves the situation slightly (figure 5, right). The prognosis for low clouds on the other hand shows quite good performance (figure 6).

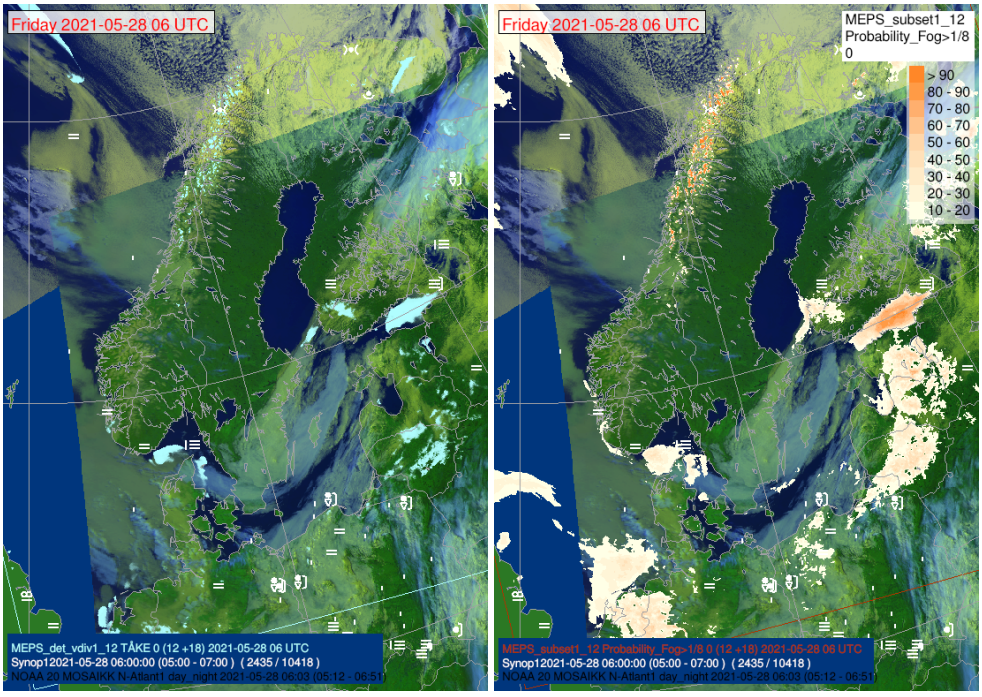


Figure 5: Satellite image (NOAA19) and synoptic observations of weather type (ww) from the 28th of May 06 UTC, with an 18hr forecast for fog (left, light blue) and probabilities for fog $>$ 1 octa (right, brown). In the satellite image fog or low stratus appear as yellowish smooth areas.

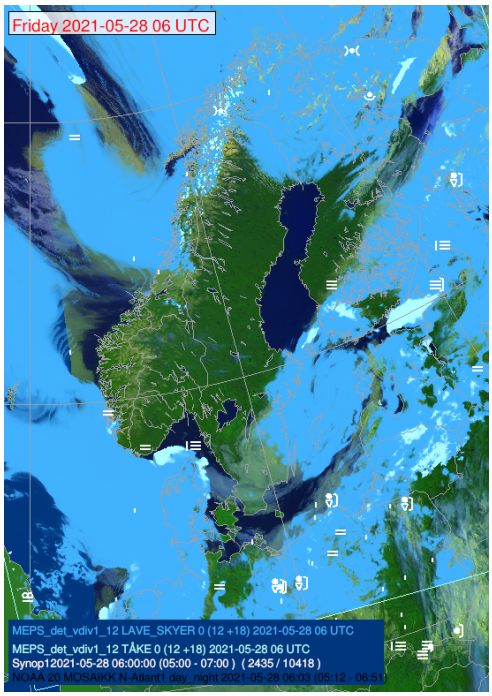
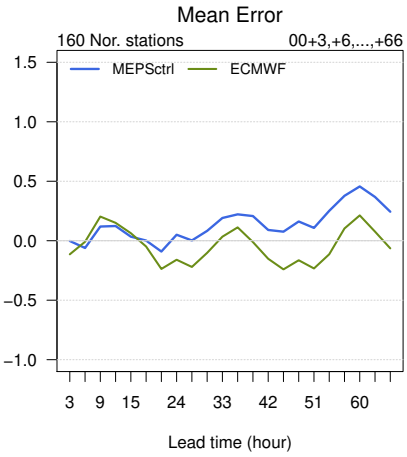
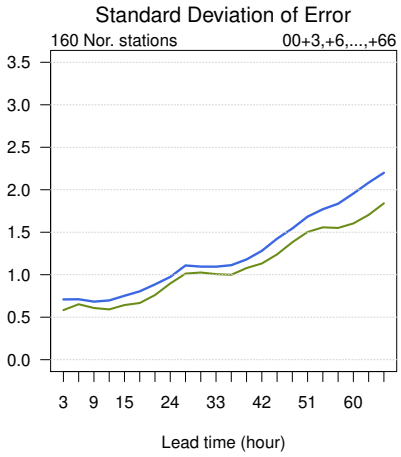
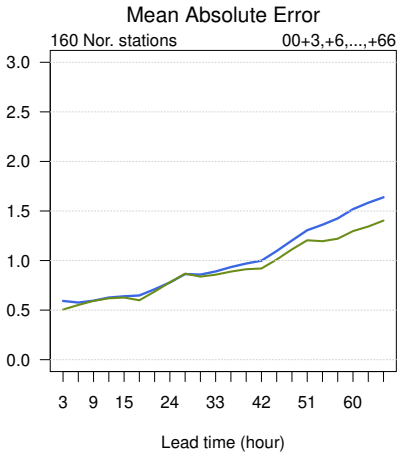


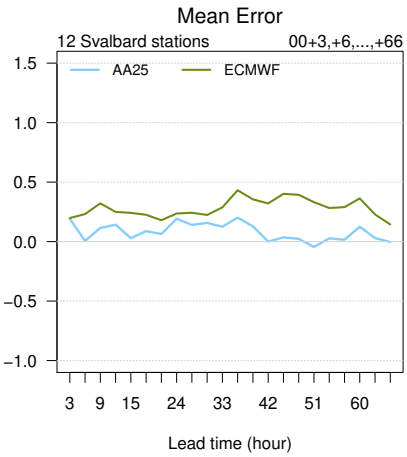
Figure 6: Satellite image (NOAA19) and synoptic observations of weather type (ww) from the 28th of May 06 UTC, with an 18 hr prognosis for fog (light blue) and low clouds (blue).

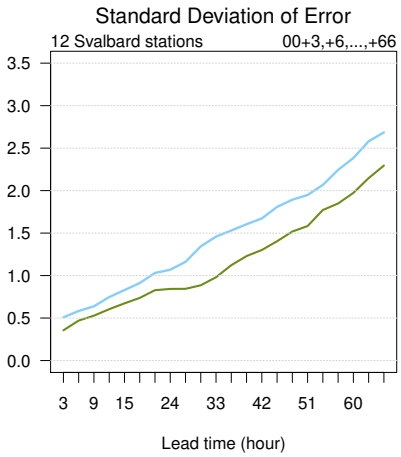
Summarized statistics

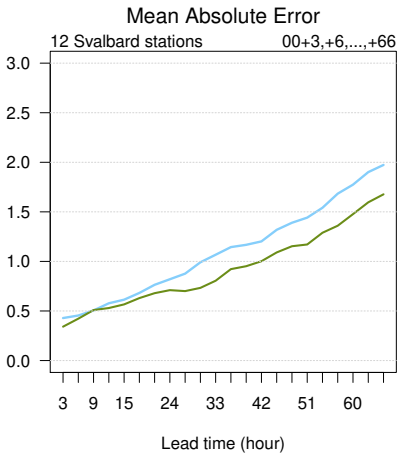

Mean Error
160 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

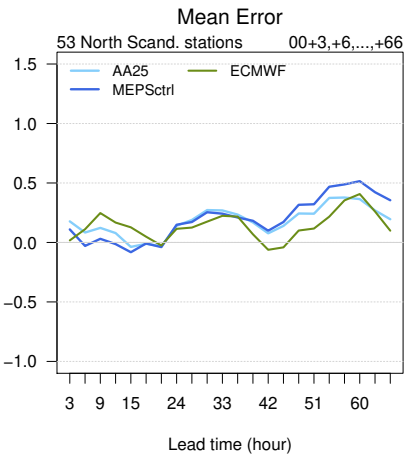

Standard Deviation of Error
160 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

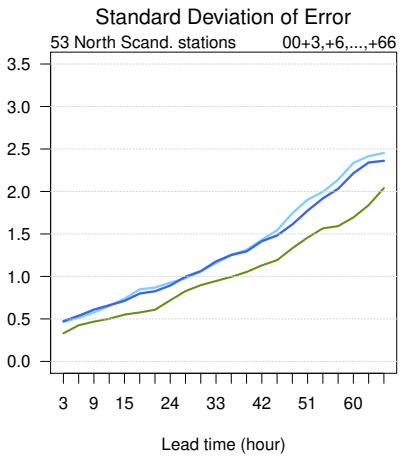

Mean Absolute Error
160 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

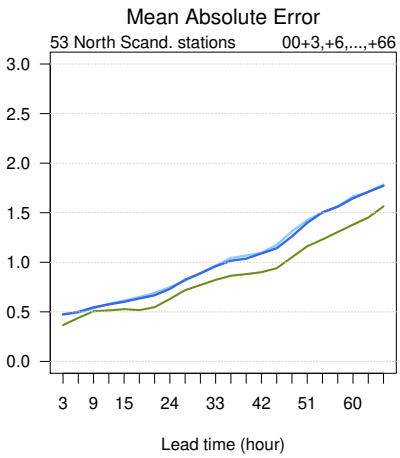

Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

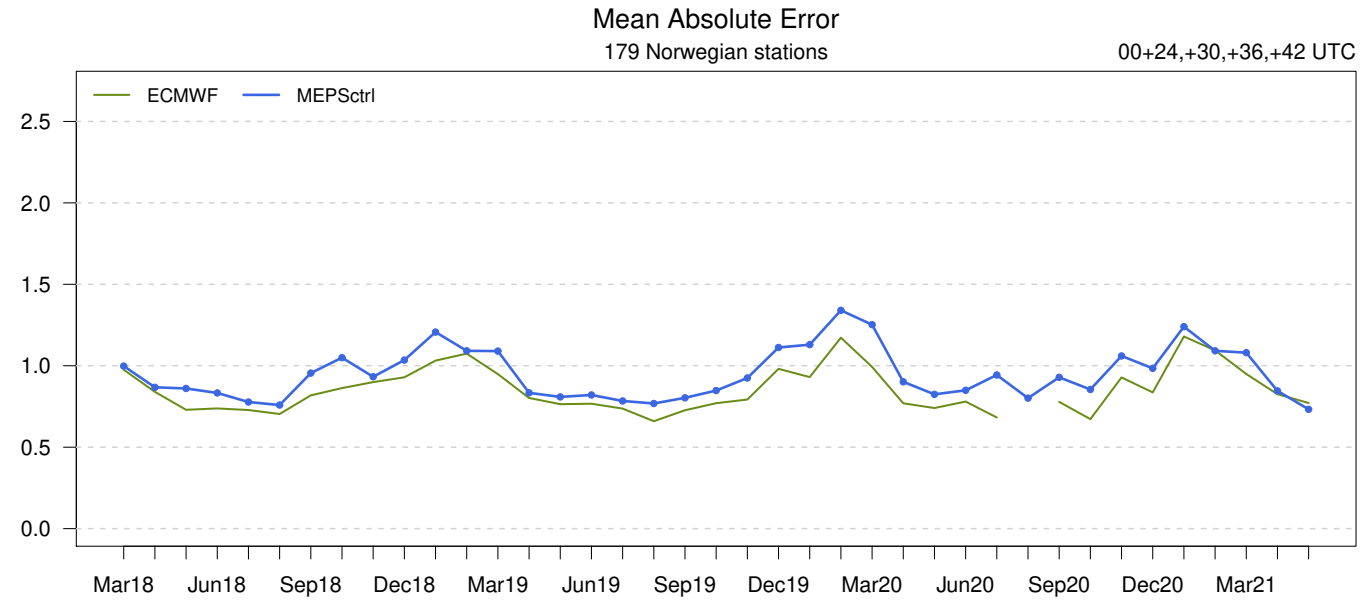

Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

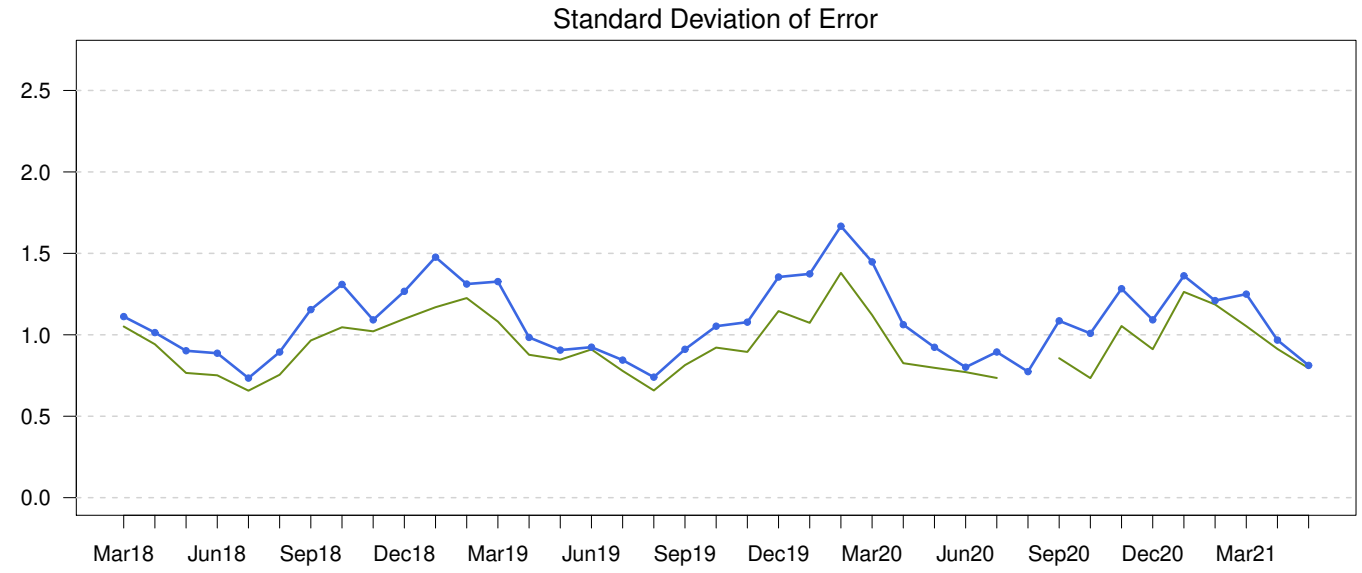

Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

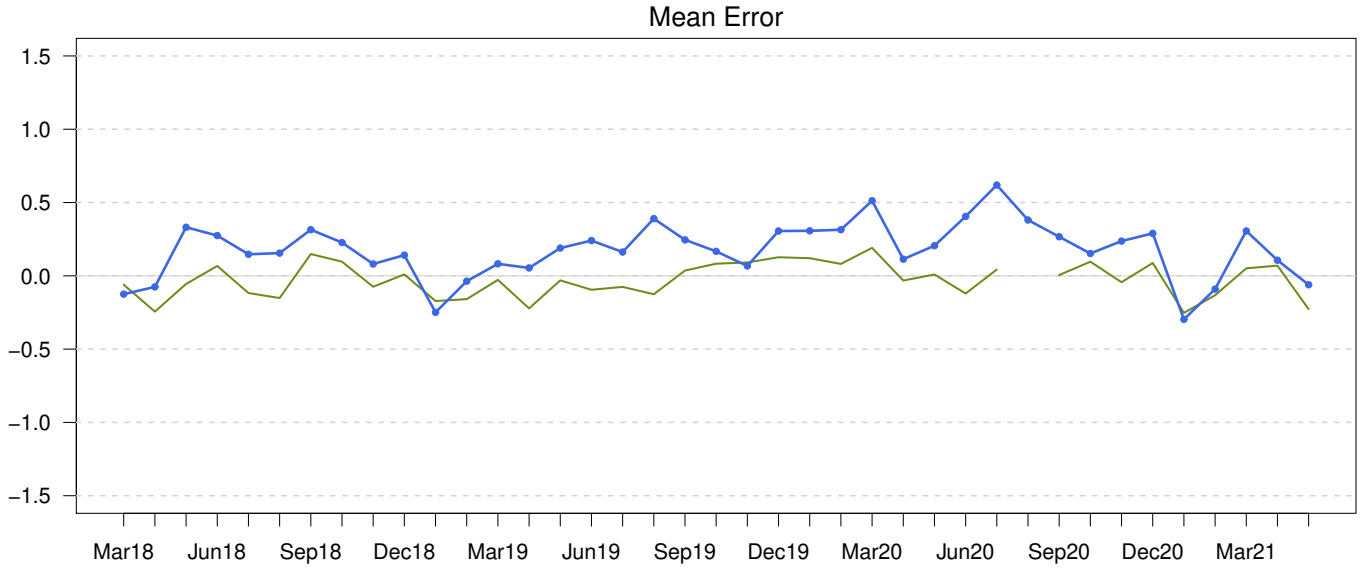

Mean Error
53 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

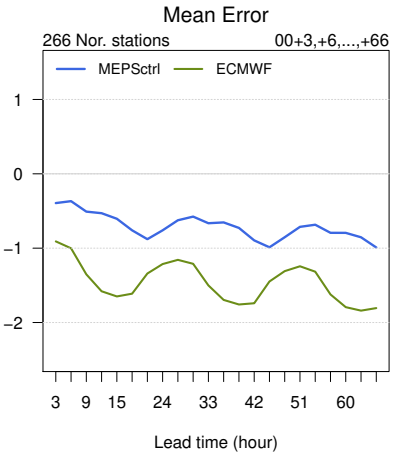

Standard Deviation of Error
53 North Scand. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

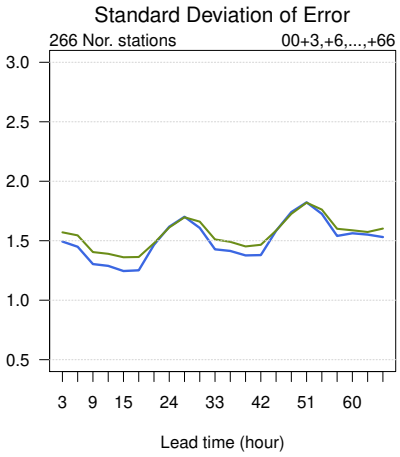

Mean Absolute Error
53 North Scand. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

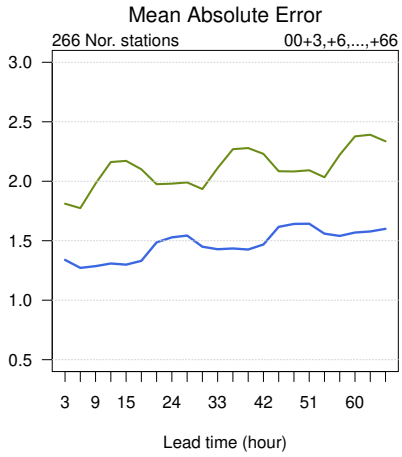

Mean Absolute Error
179 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2.5
2.0
1.5
1.0
0.5
0.0
Mar18
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21

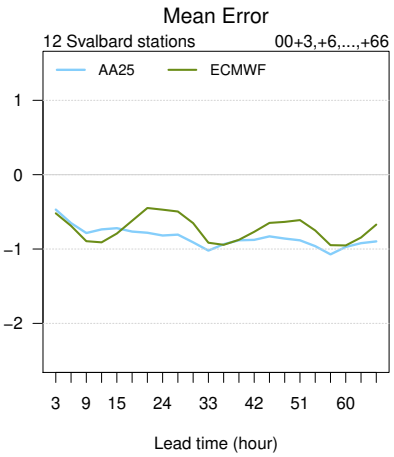

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Mar18
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21

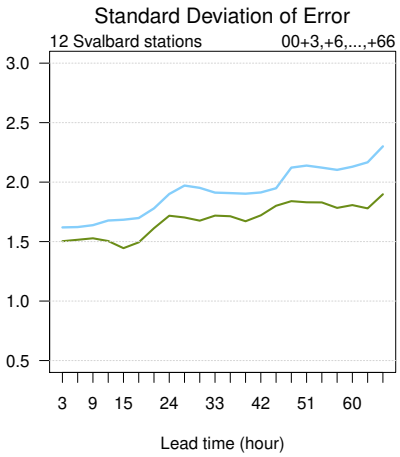

Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Mar18
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21

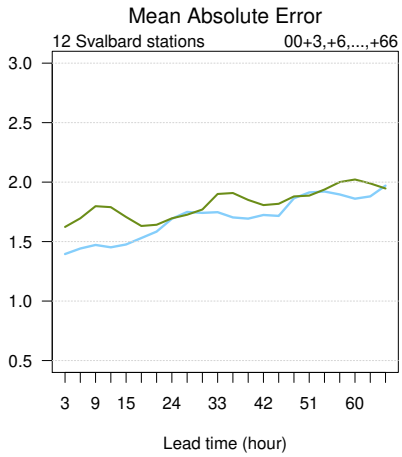

Mean Error
266 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
1
0
−1
−2
3 9 15 24 33 42 51 60
Lead time (hour)

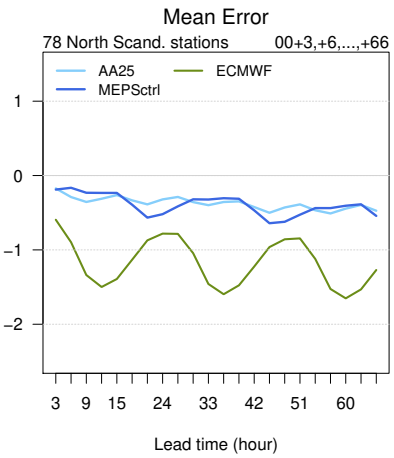

Standard Deviation of Error
266 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

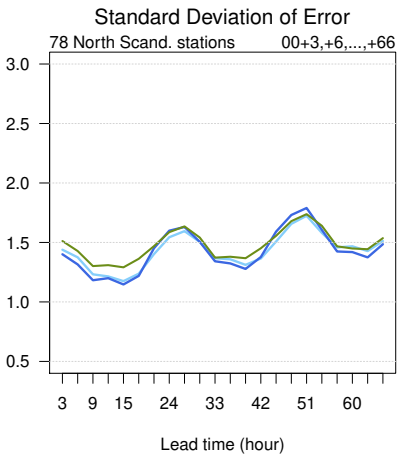

Mean Absolute Error
266 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

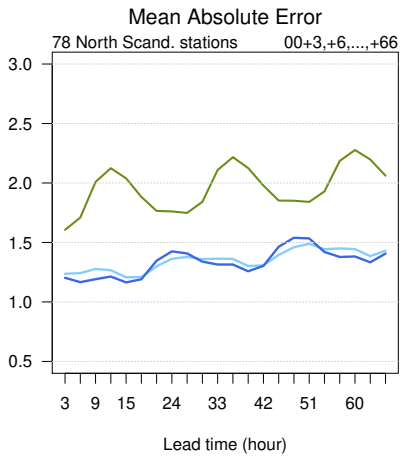

Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
1
0
−1
−2
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)


Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

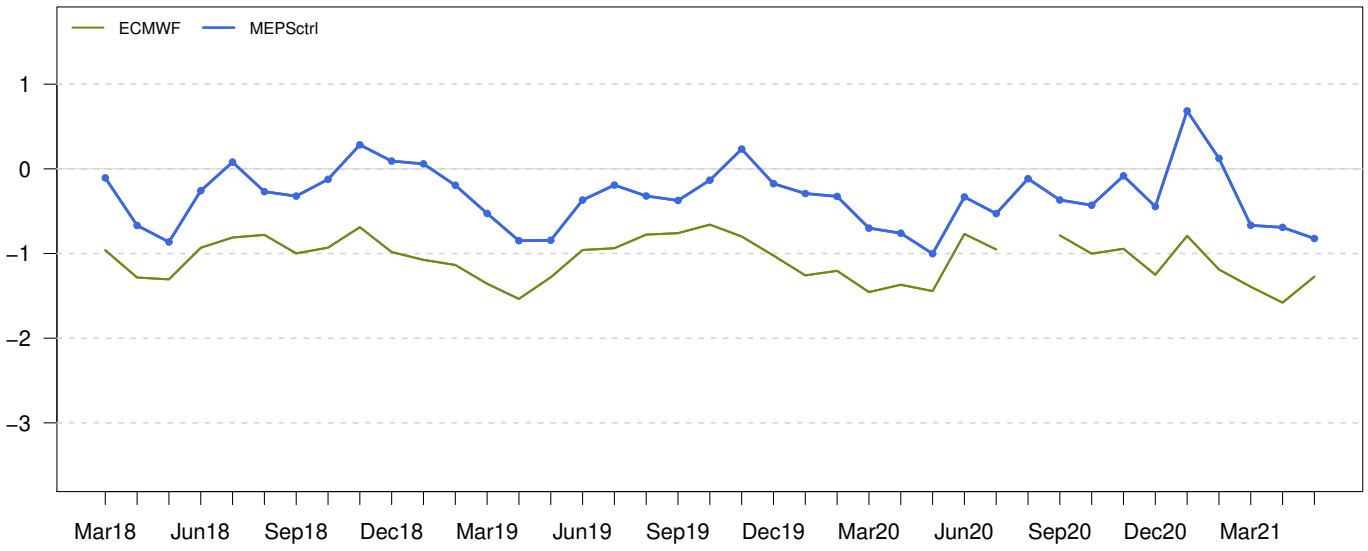

Mean Error
78 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
1
0
−1
−2
3 9 15 24 33 42 51 60
Lead time (hour)


Standard Deviation of Error
78 North Scand. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

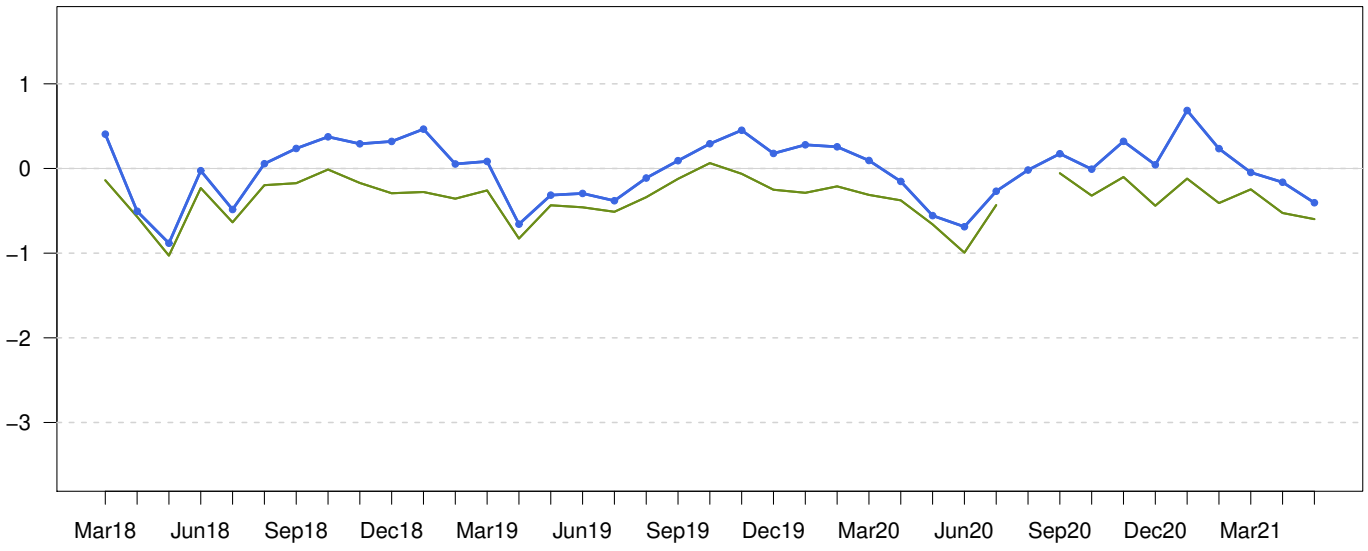

Mean Absolute Error
78 North Scand. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
3 9 15 24 33 42 51 60
Lead time (hour)

Mean Error

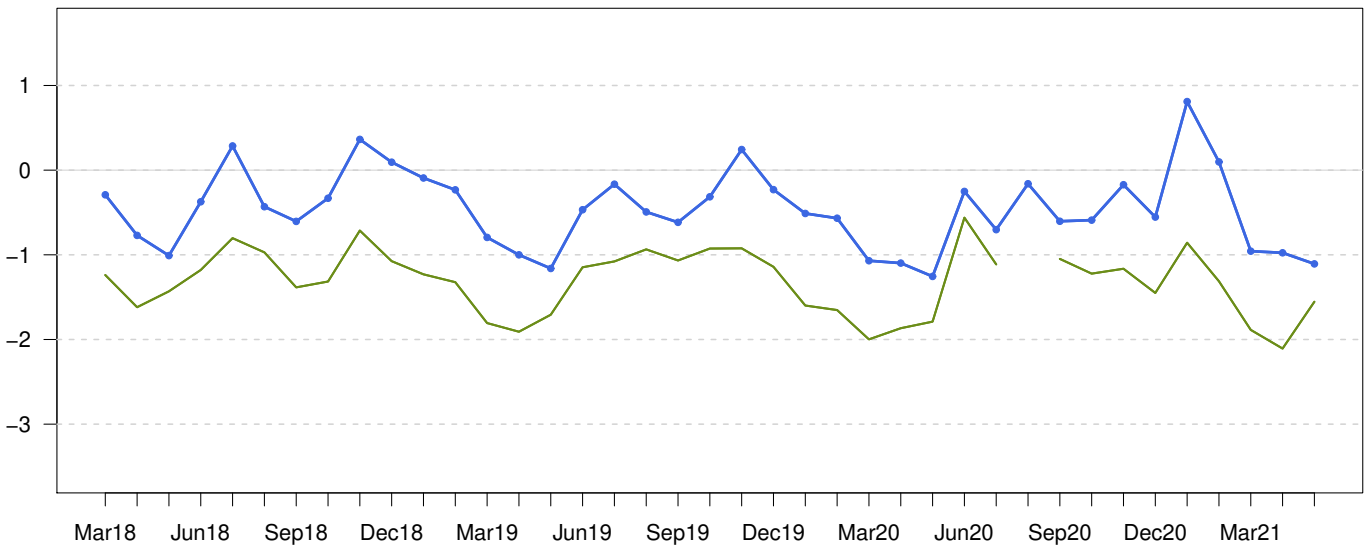
275 Norwegian stations 00+24,+30,+36,+42 UTC



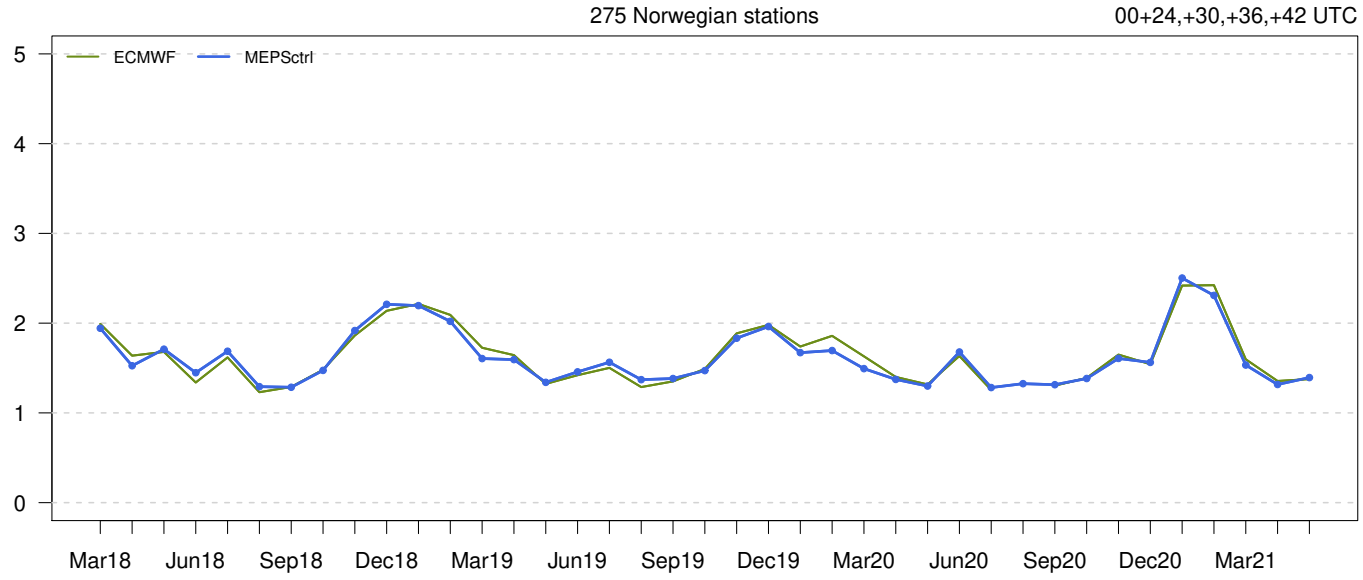
54 Norwegian coastal stations

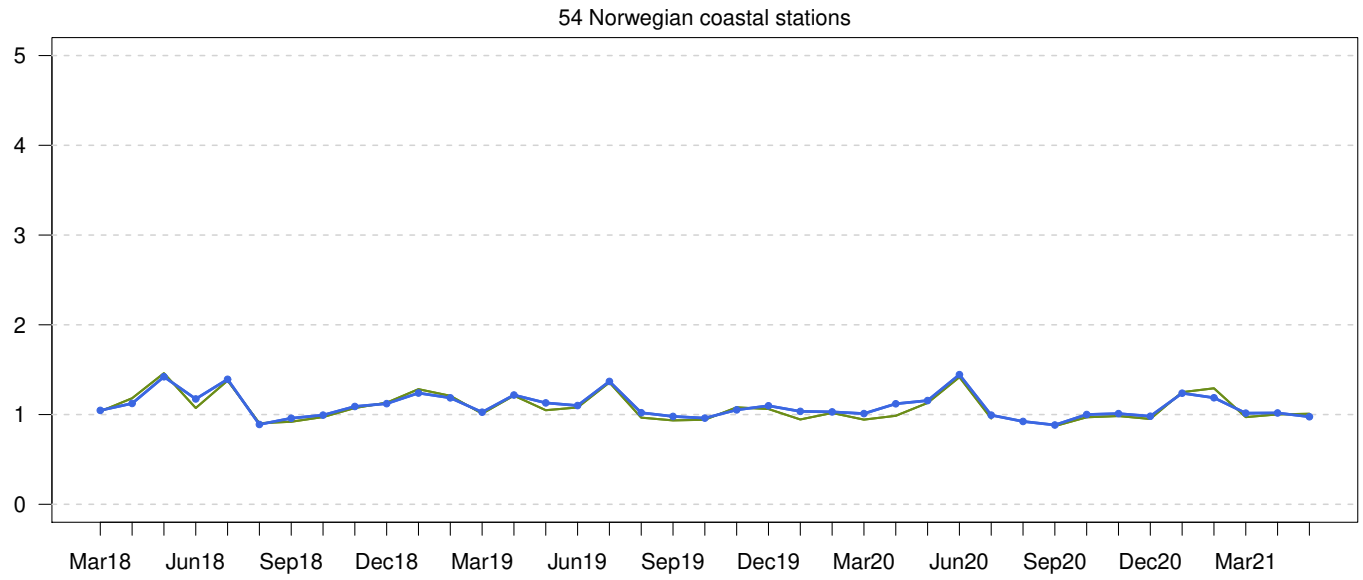


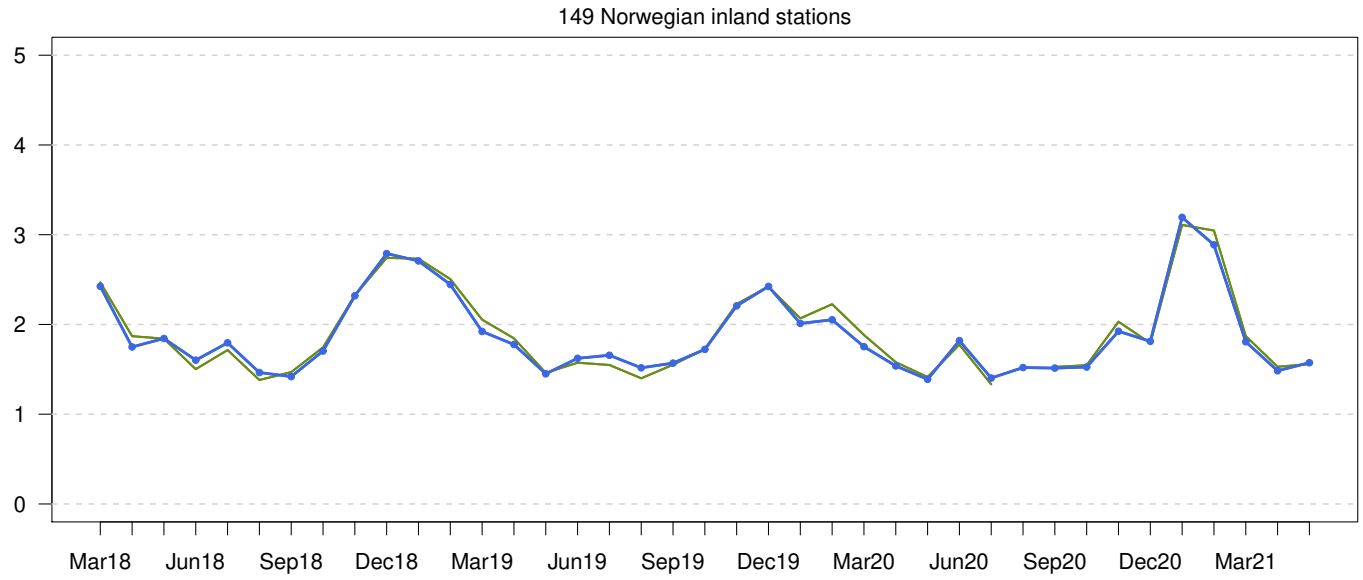
149 Norwegian inland stations



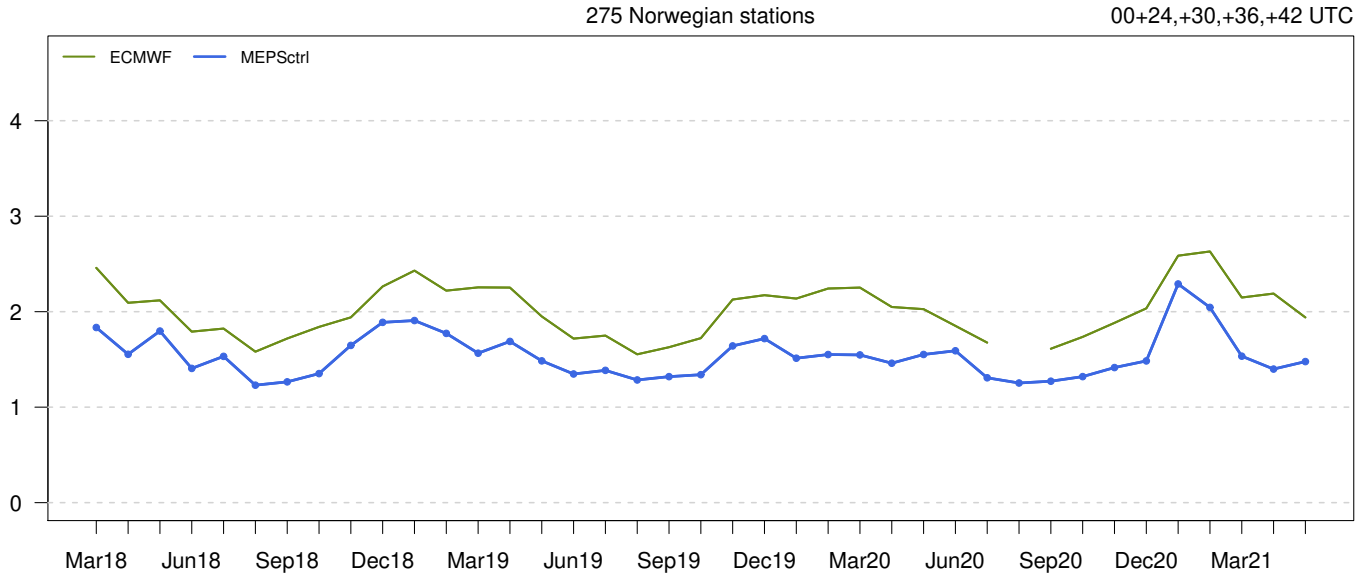
Standard Deviation of Error

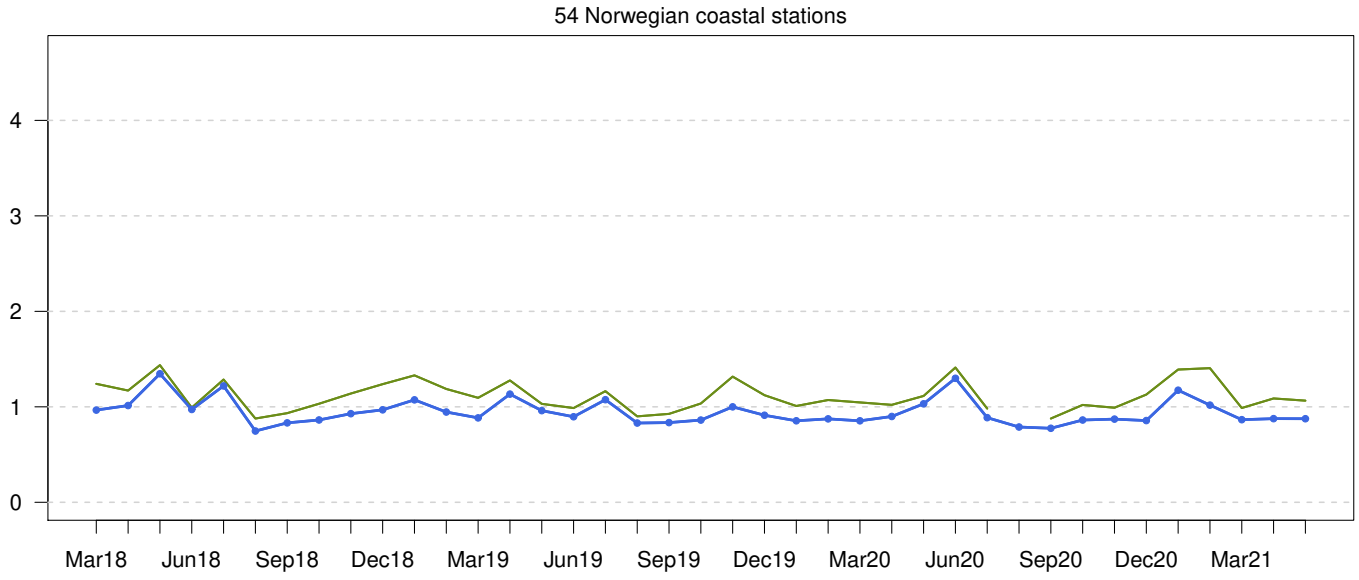


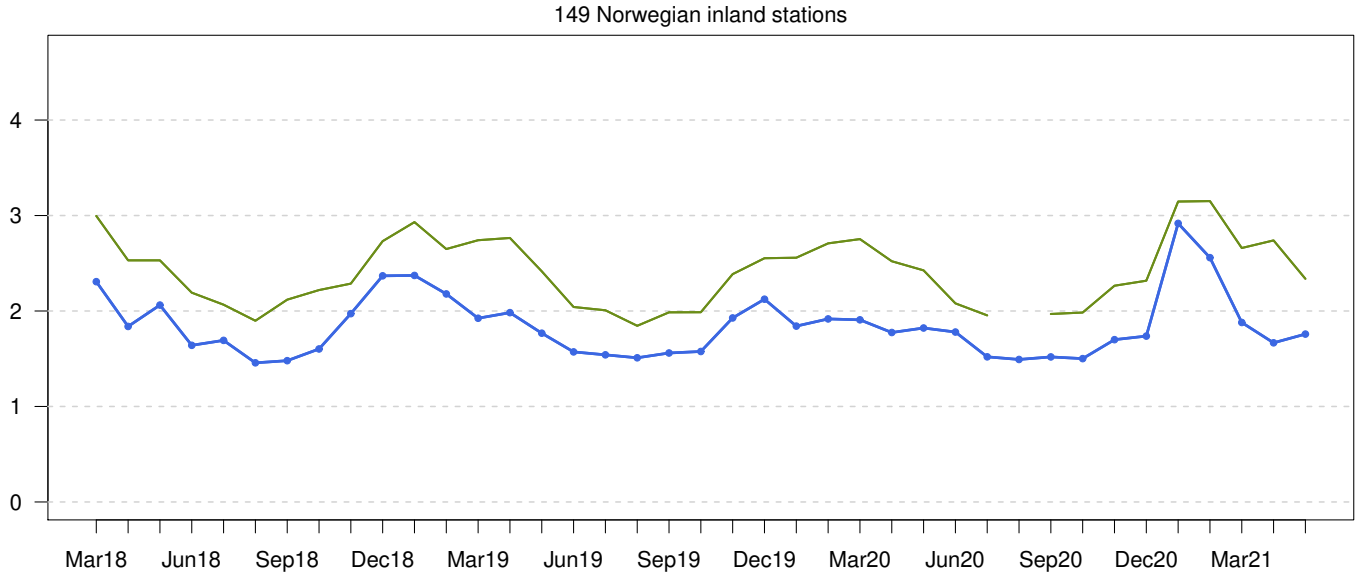




Mean Absolute Error

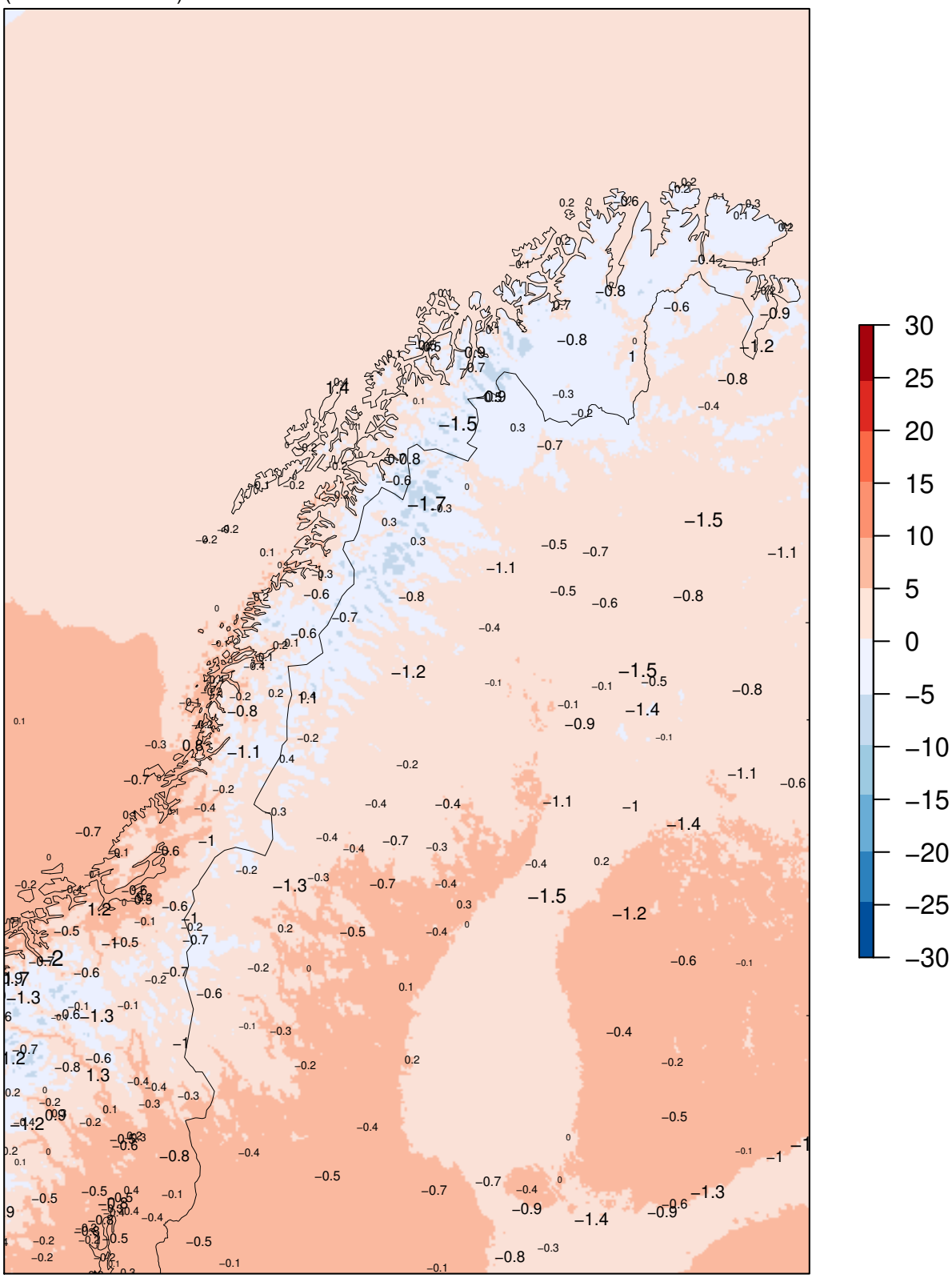






MEPSctrl 00+12

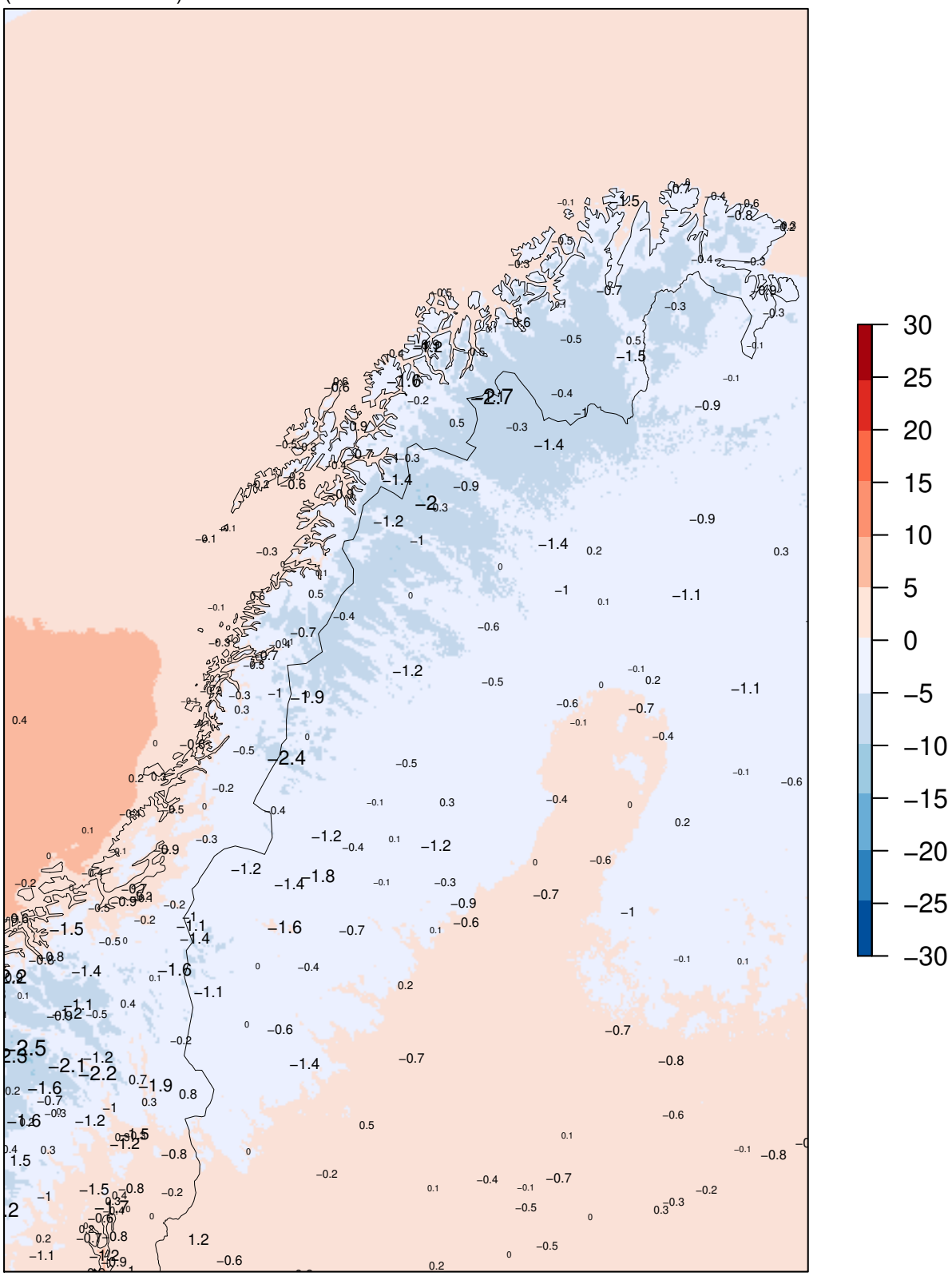
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+24

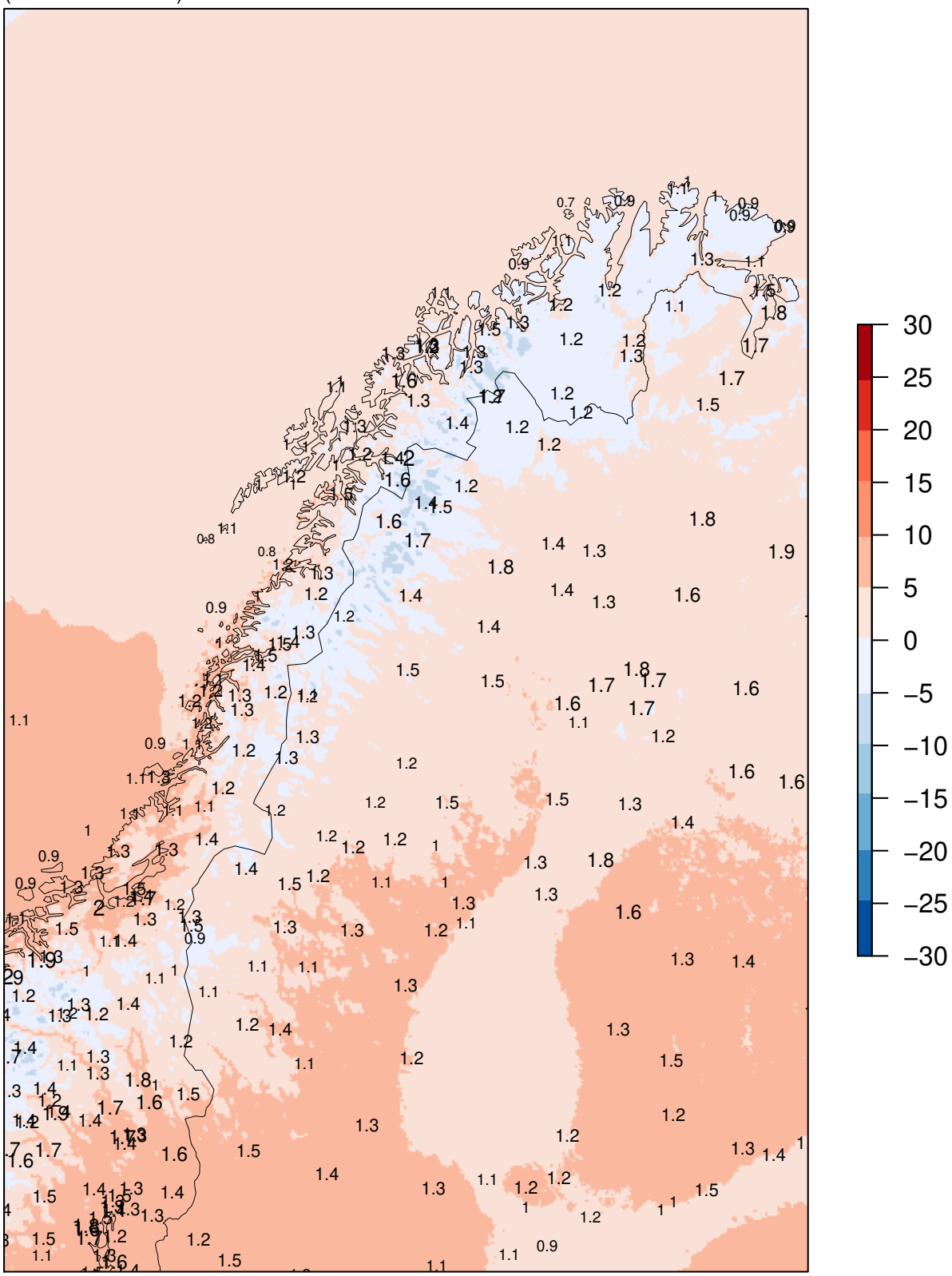
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

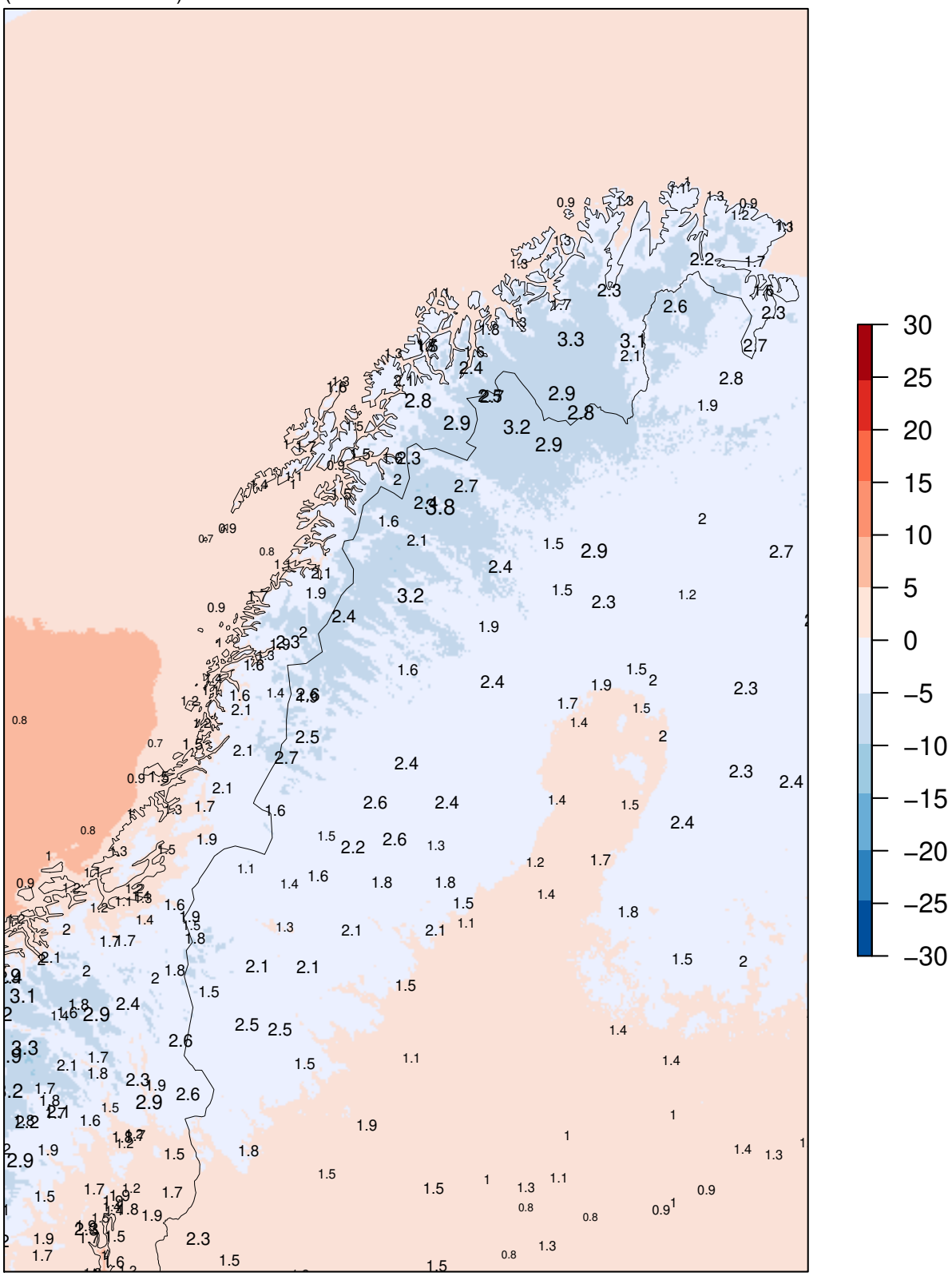
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+24

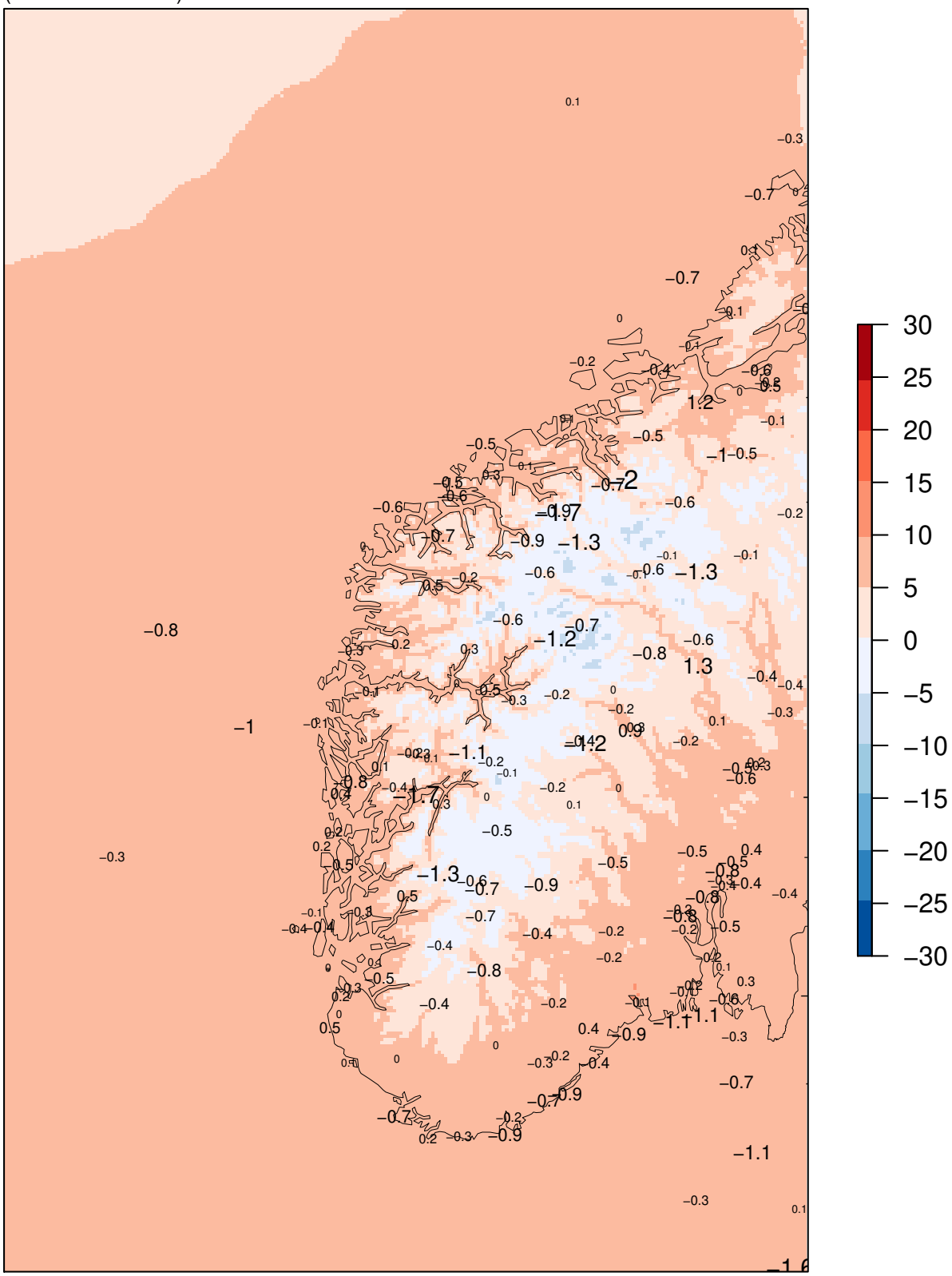
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

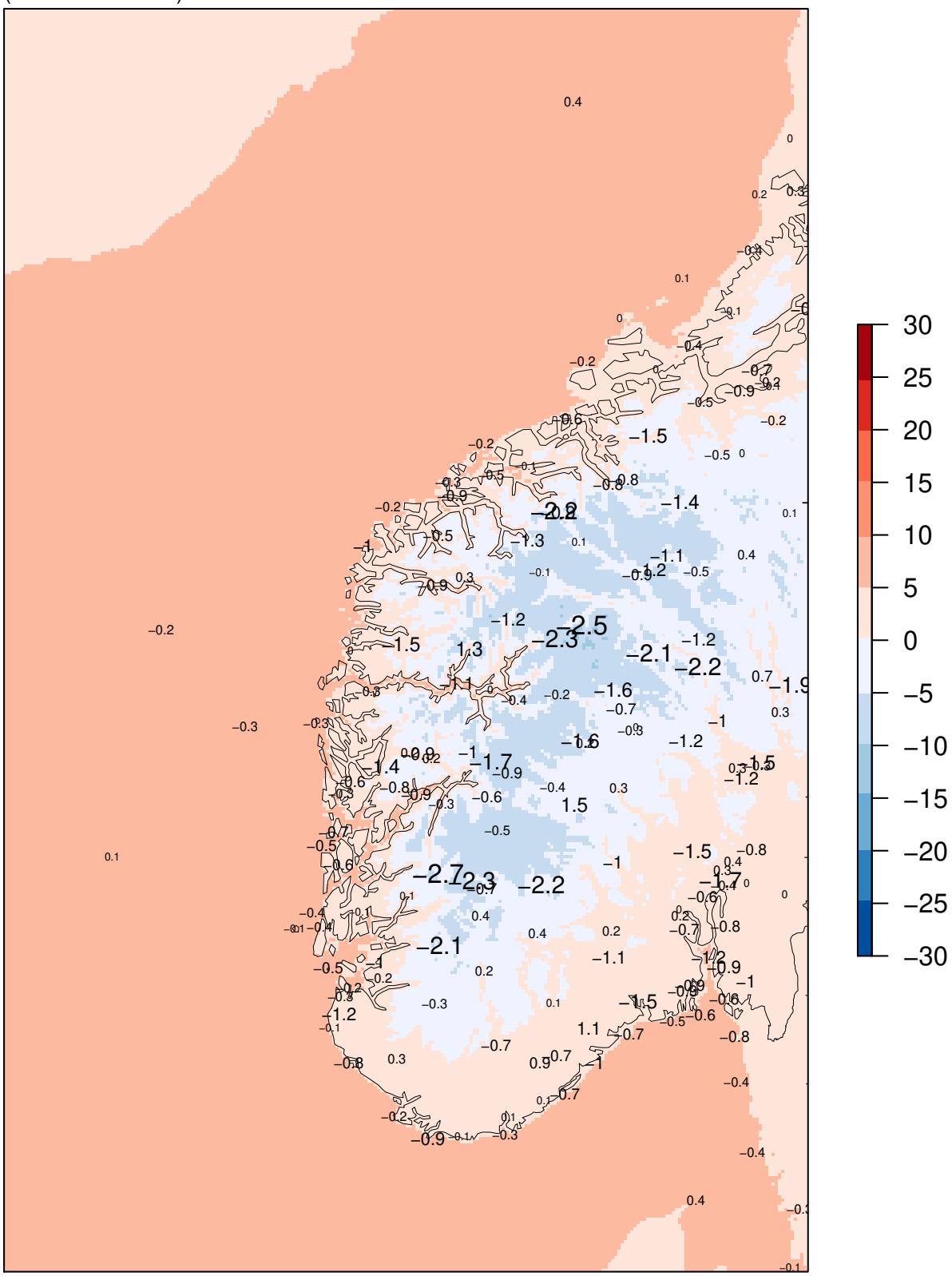
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+24

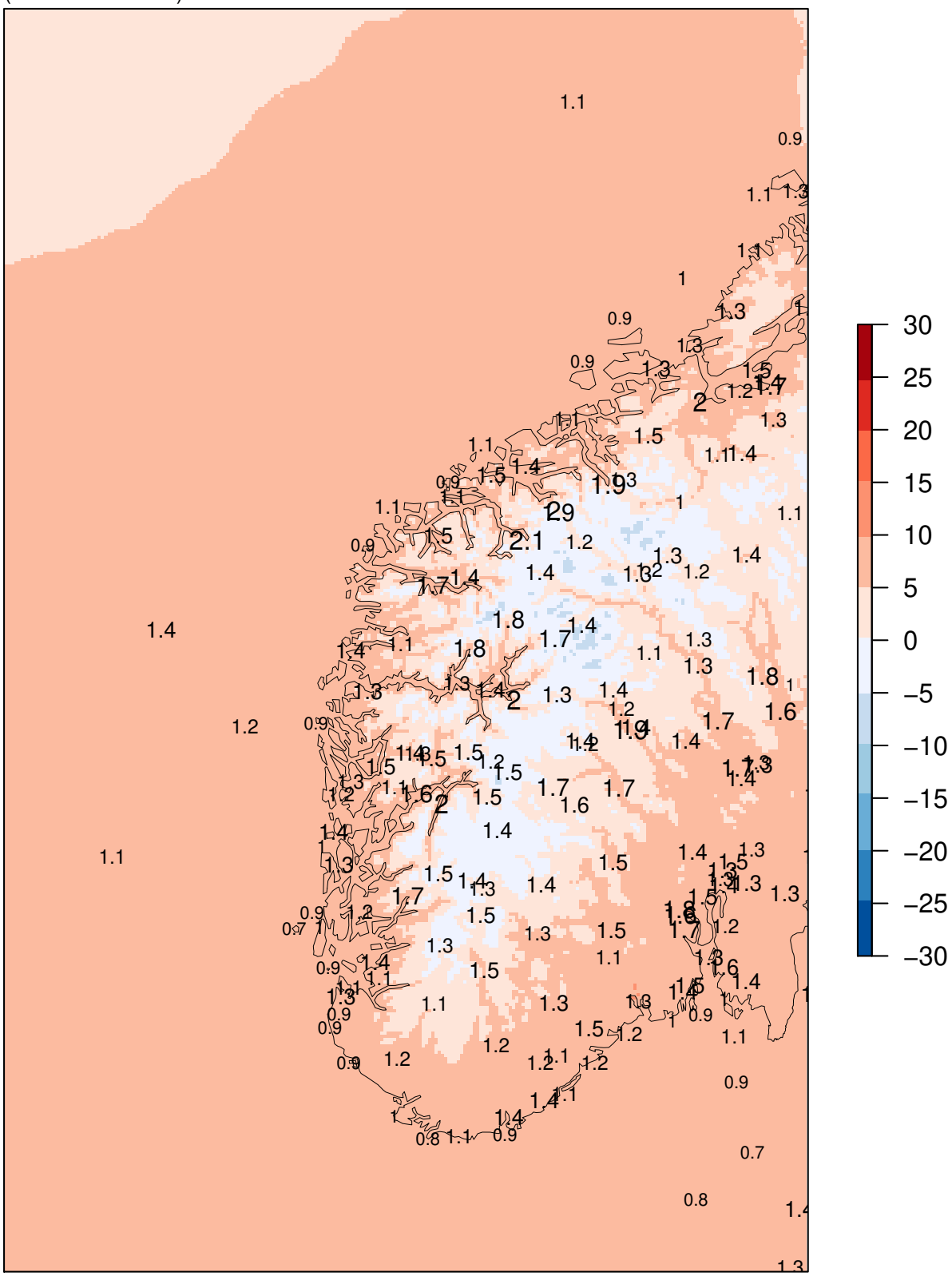
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

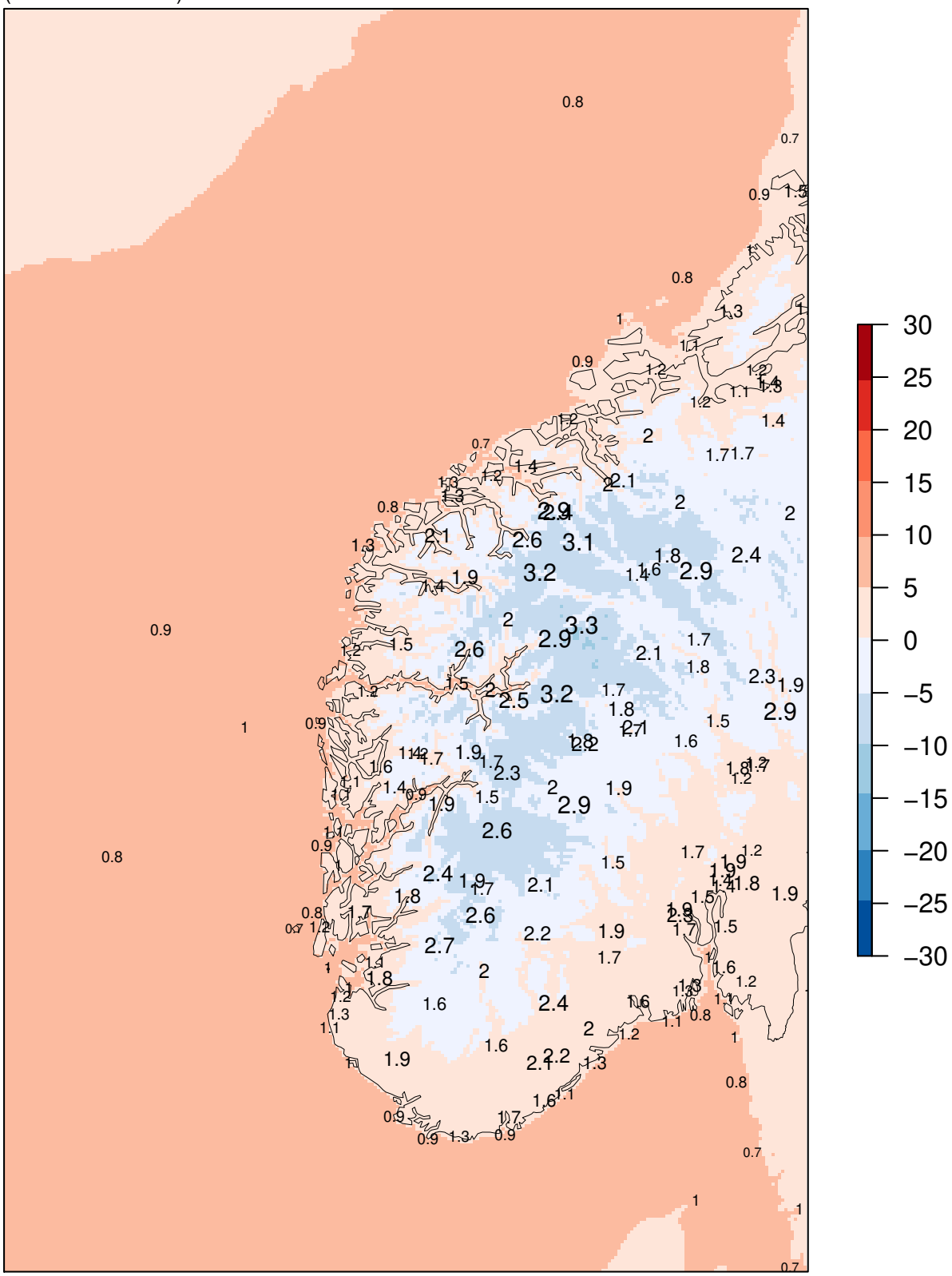
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+24

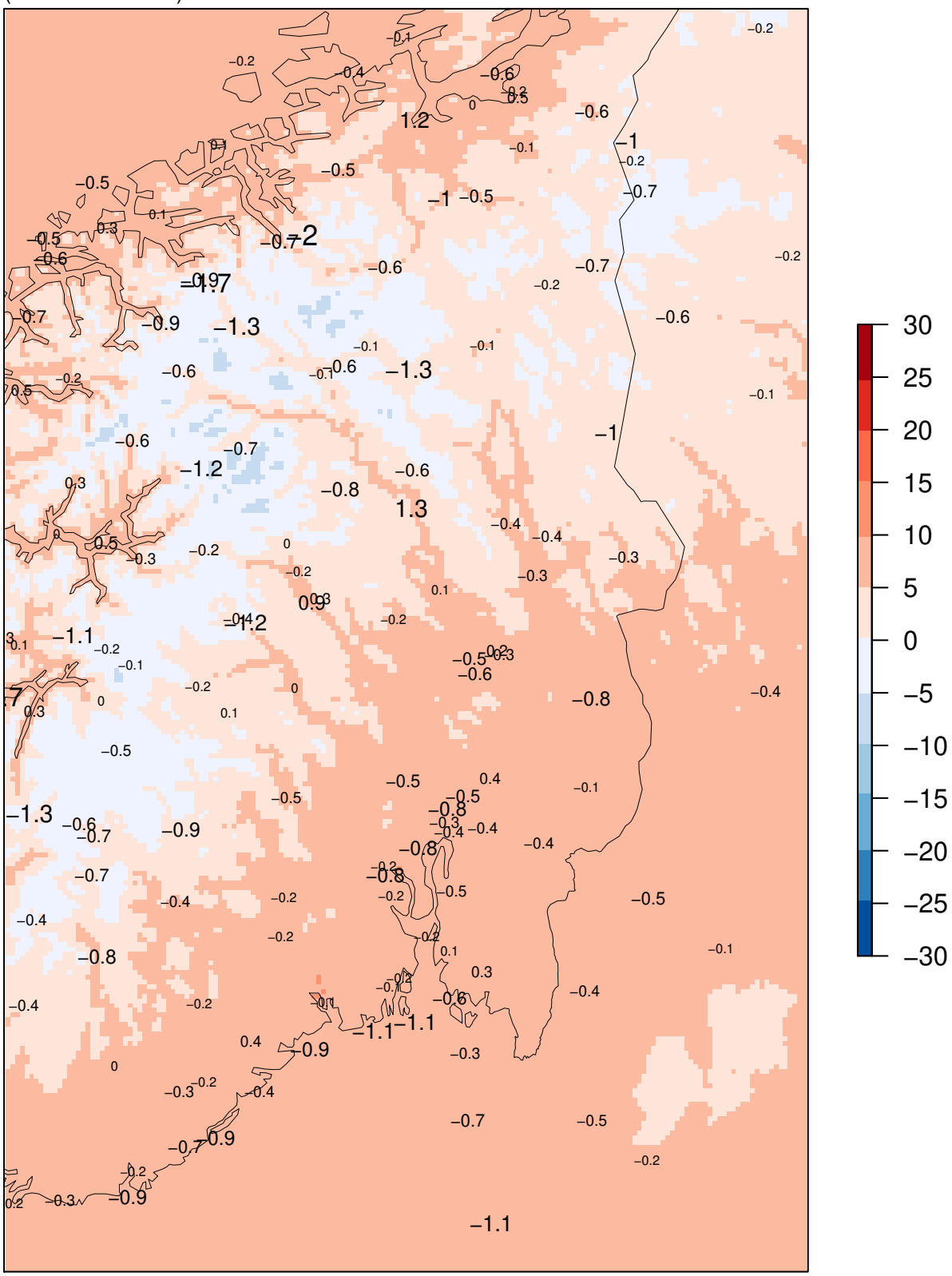
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

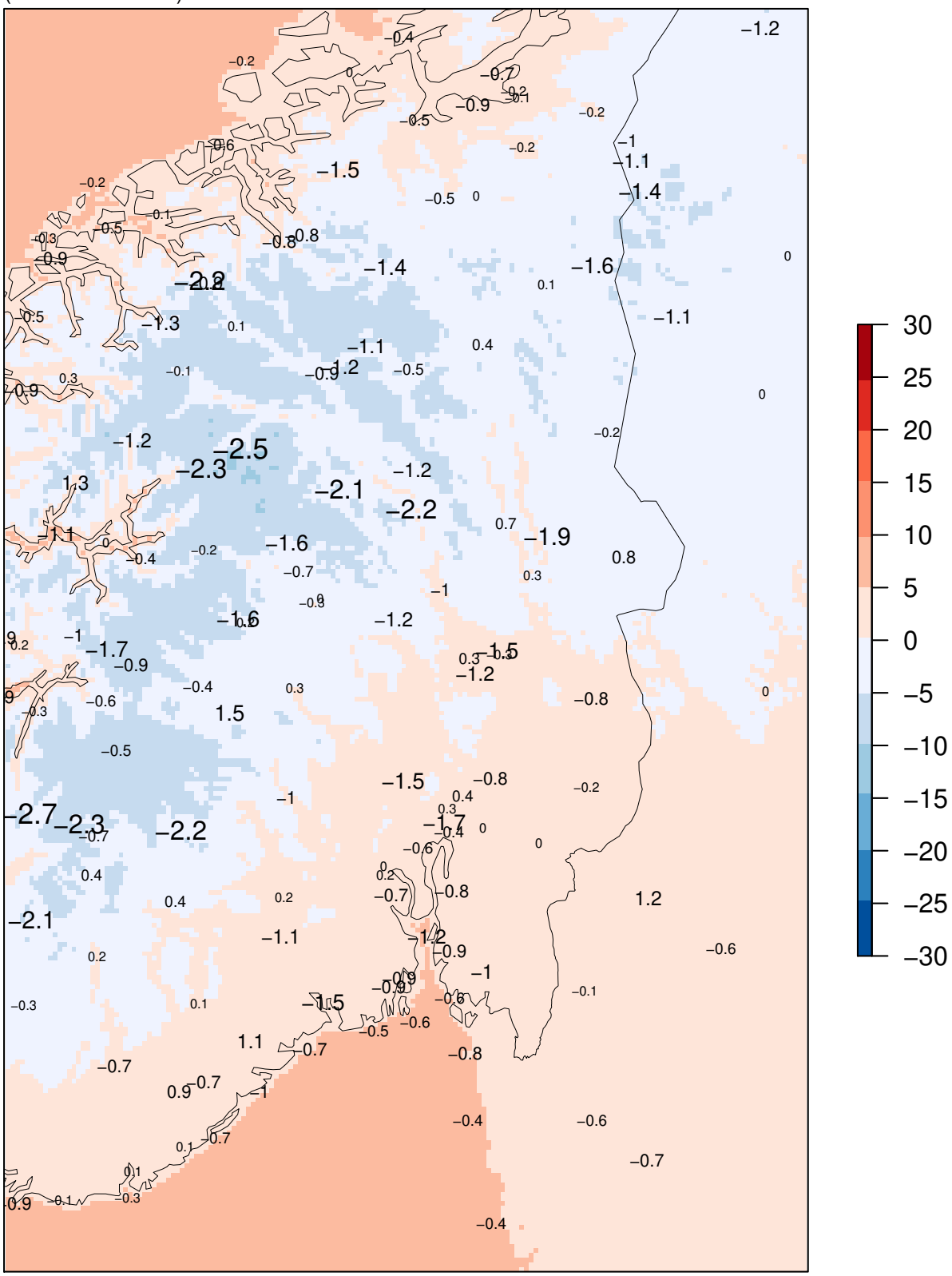
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+24

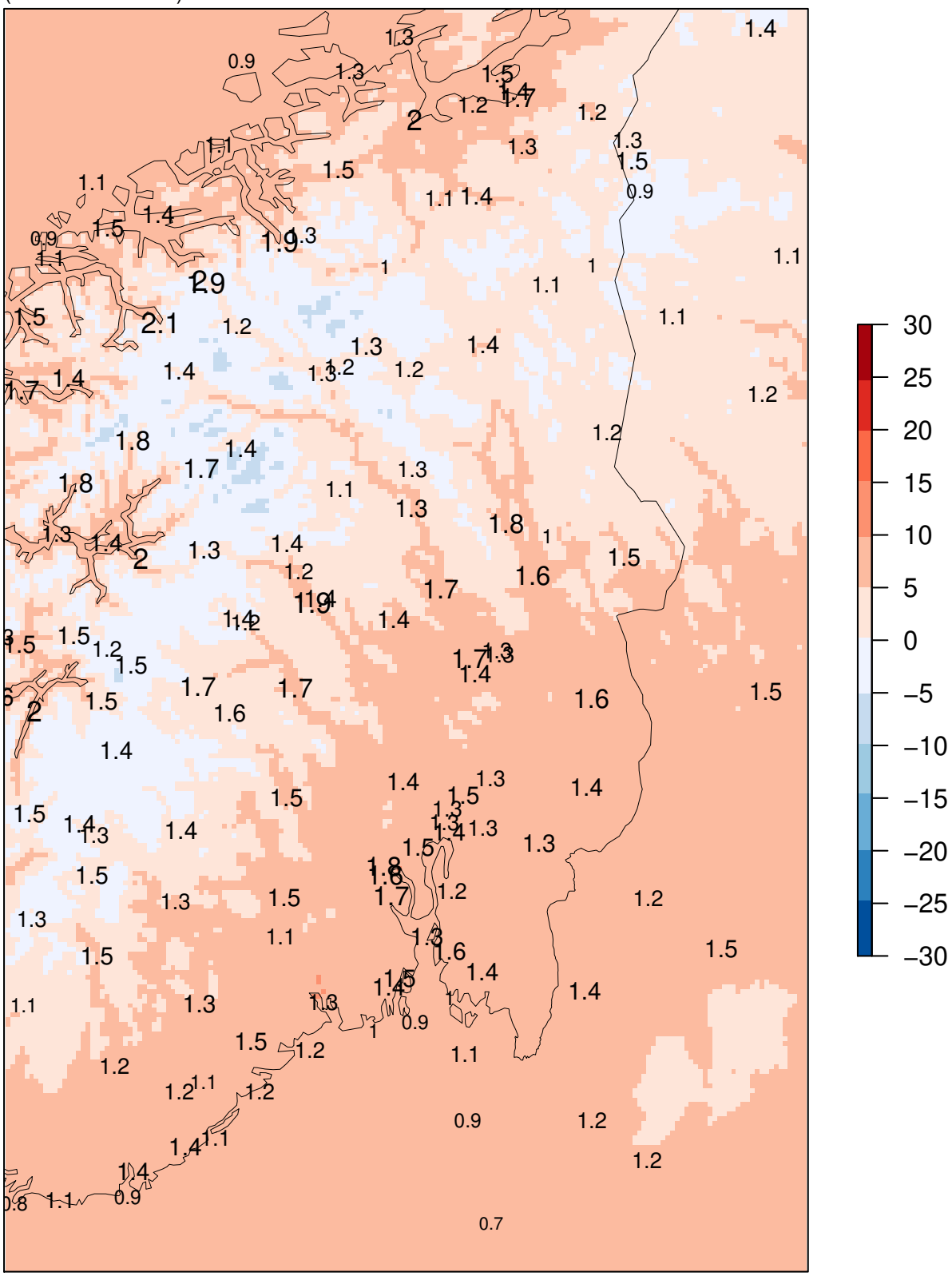
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

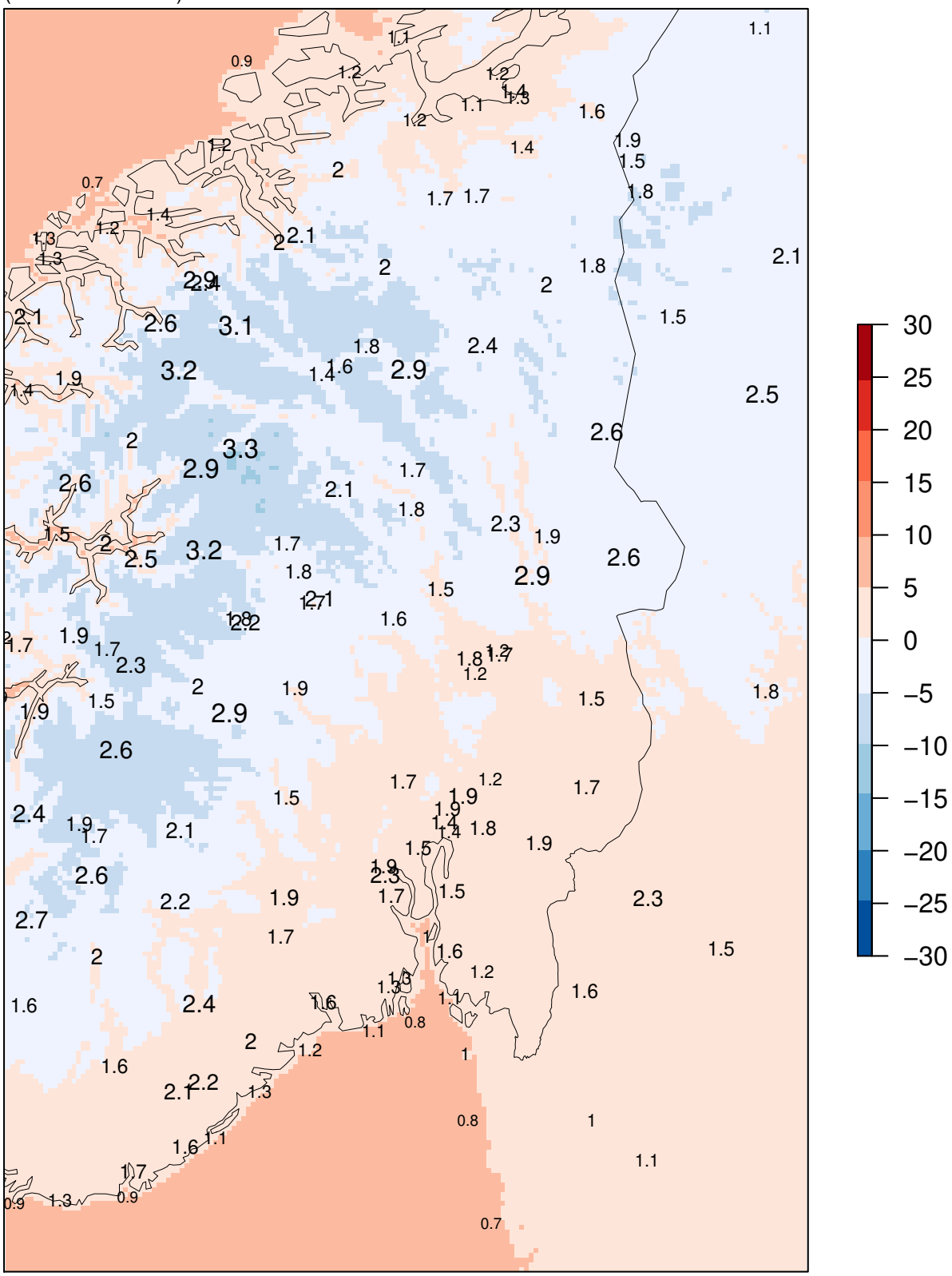
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

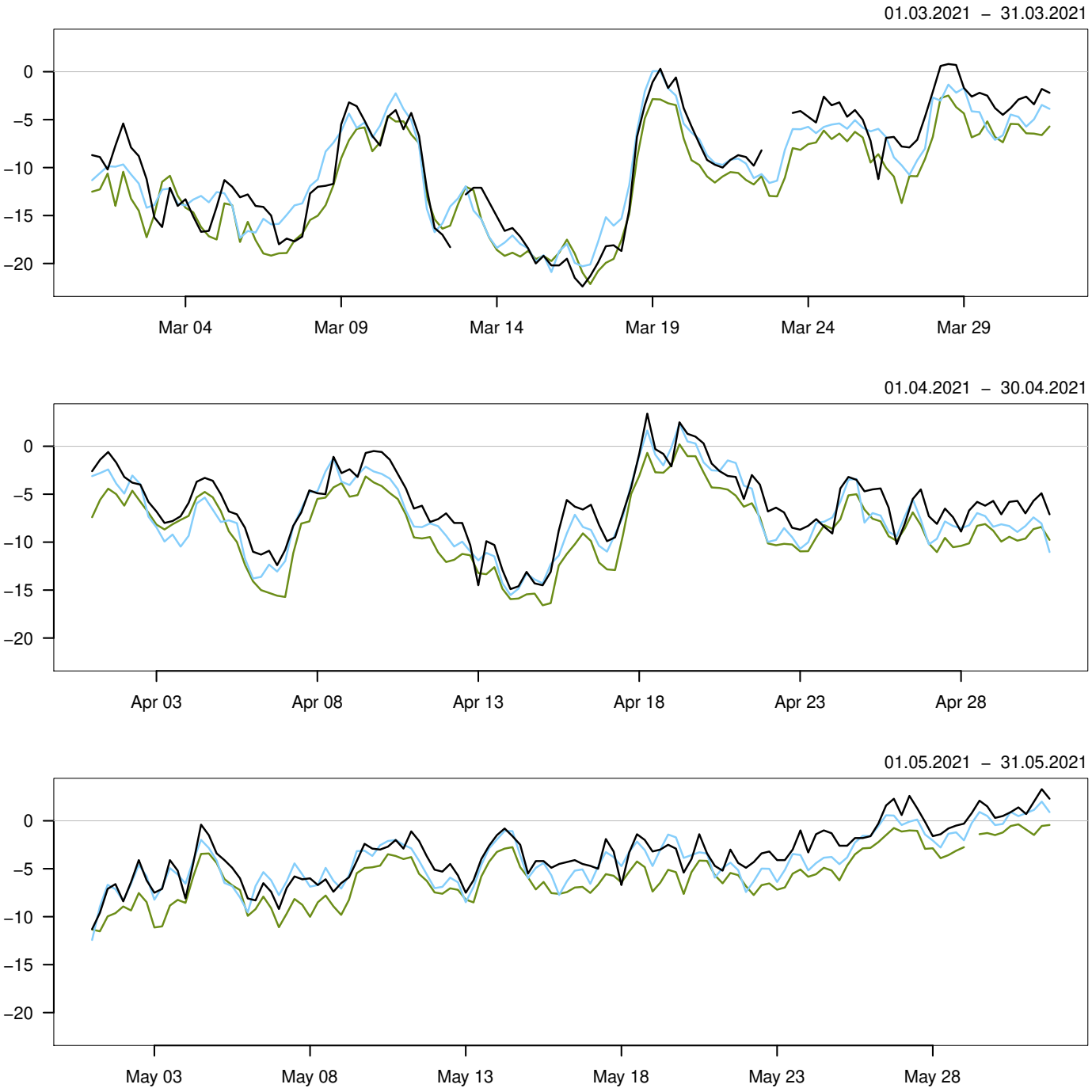
MEPSctrl 00+24

SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

SVALBARD LUFTHAVN

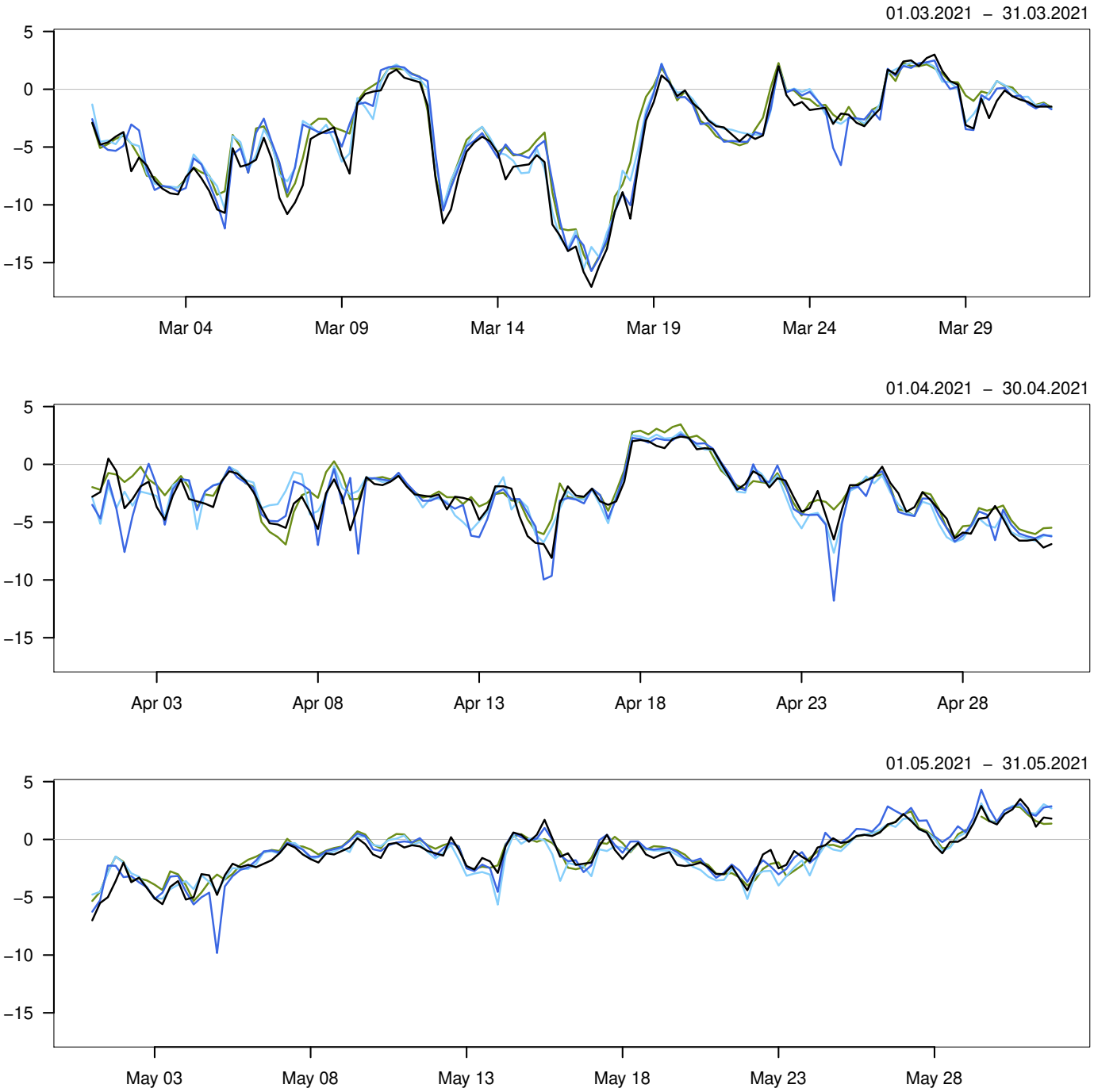


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−22.4	−6.2	3.4	5.2	368
AA25: 12+18,+24,+30,+36	−20.9	−7	2.6	4.8	372
ECMWF: 12+18,+24,+30,+36	−22.2	−8.6	1.1	4.8	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25 – synop	−0.7	1.6	1.8	1.4	5.2	368
ECMWF – synop	−2.2	1.5	2.7	2.4	6.3	367

BJØRNØYA

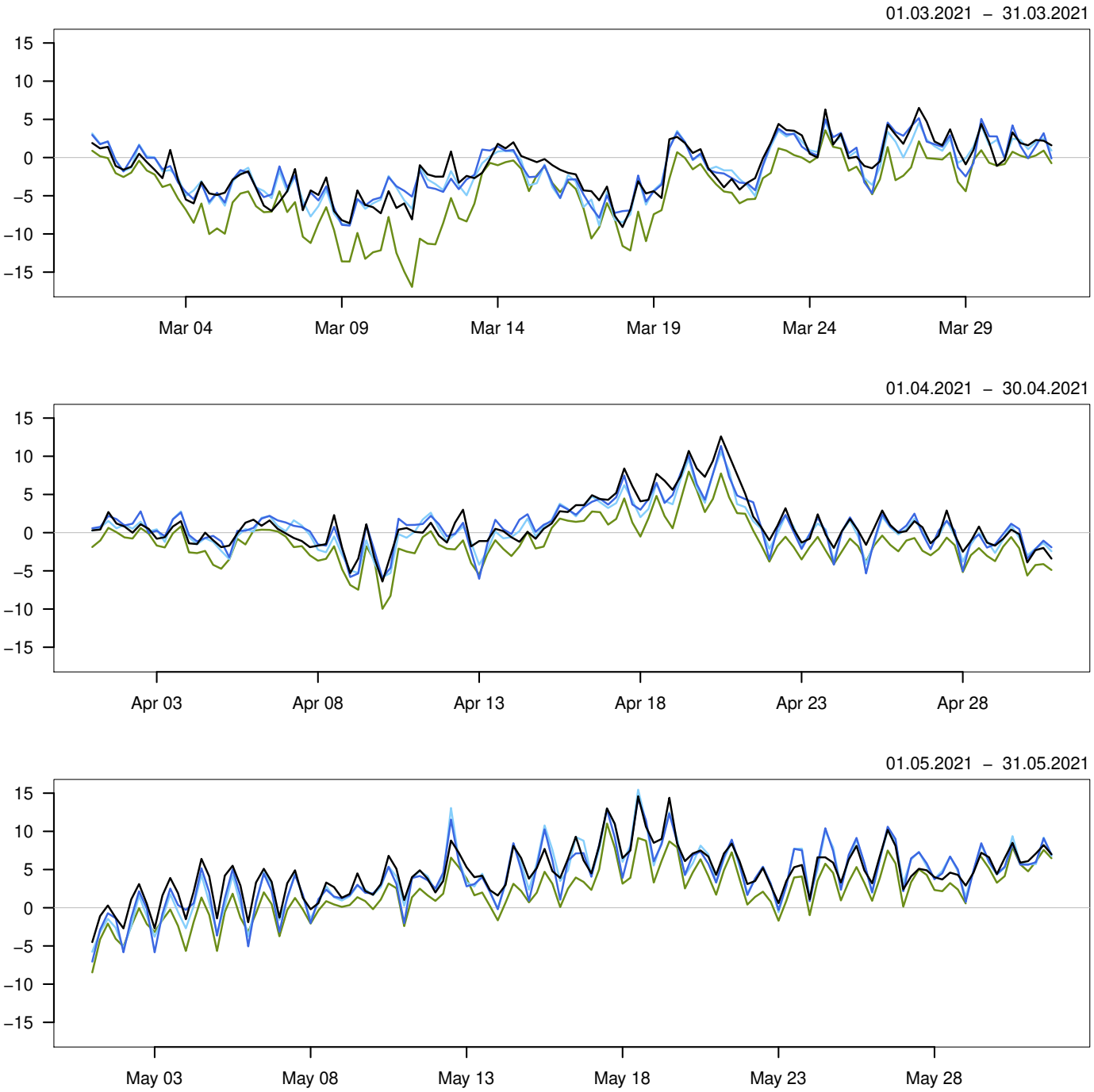


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−17.1	−2.7	3.5	3.4	372
MEPSctrl: 12+18,+24,+30,+36	−15.7	−2.6	4.3	3.4	372
AA25: 12+18,+24,+30,+36	−15.6	−2.5	4.3	3.2	372
ECMWF: 12+18,+24,+30,+36	−15.7	−2.3	3.5	3.1	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.2	1.2	1.2	0.8	5.3	372
AA25 – synop	0.2	1	1.1	0.7	5.6	372
ECMWF – synop	0.4	0.9	1	0.8	4.9	371

TROMSØ

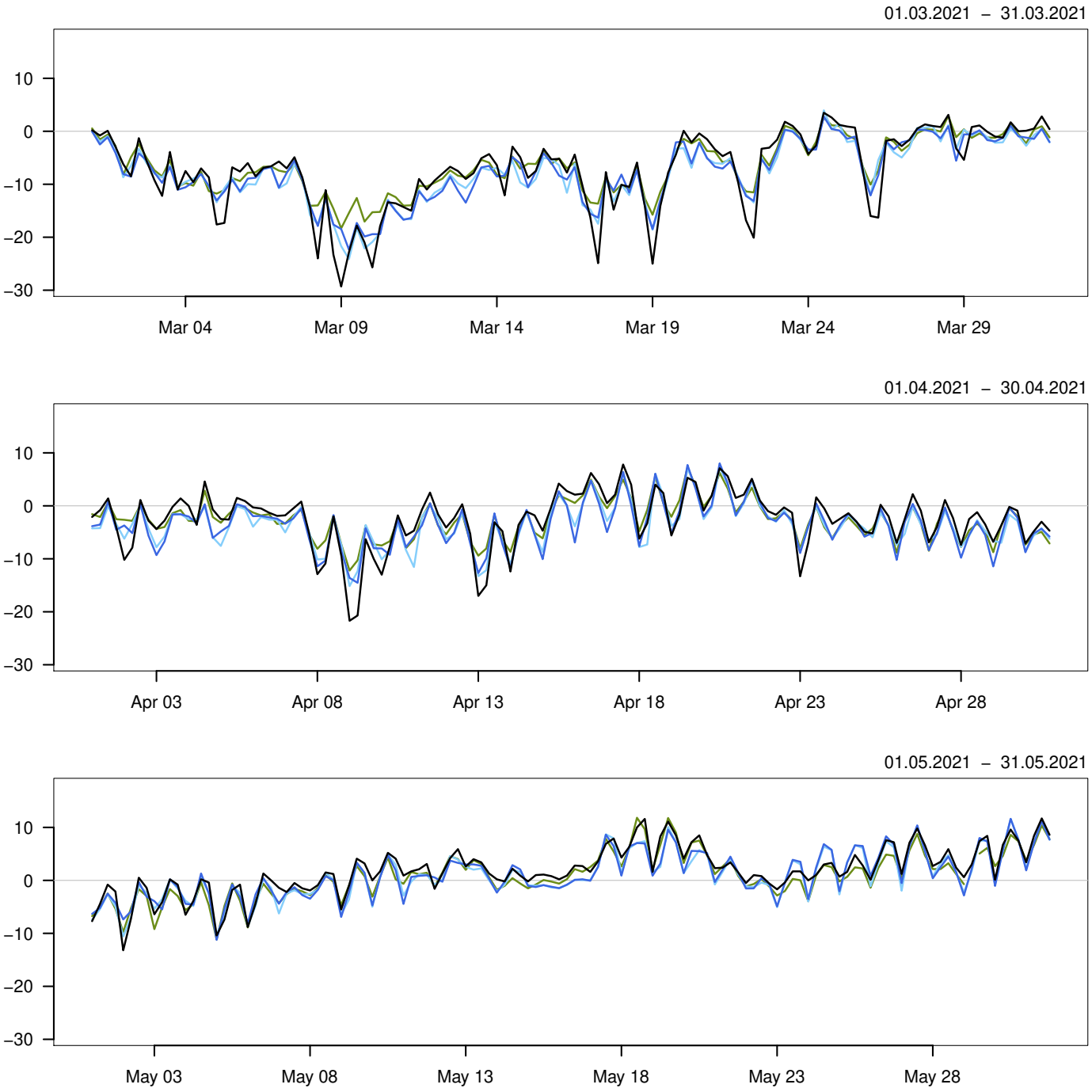


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−9.1	1.5	15.5	4.3	372
MEPSctrl: 12+18,+24,+30,+36	−8.9	1.2	14.3	4.3	372
AA25: 12+18,+24,+30,+36	−8.9	1.1	15.5	4.4	372
ECMWF: 12+18,+24,+30,+36	−16.9	−1.1	12.1	4.6	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.3	1.4	1.4	1.1	4.9	372
AA25 – synop	−0.4	1.3	1.4	1.1	4.3	372
ECMWF – synop	−2.6	1.6	3.1	2.6	9.6	371

KAUTOKEINO



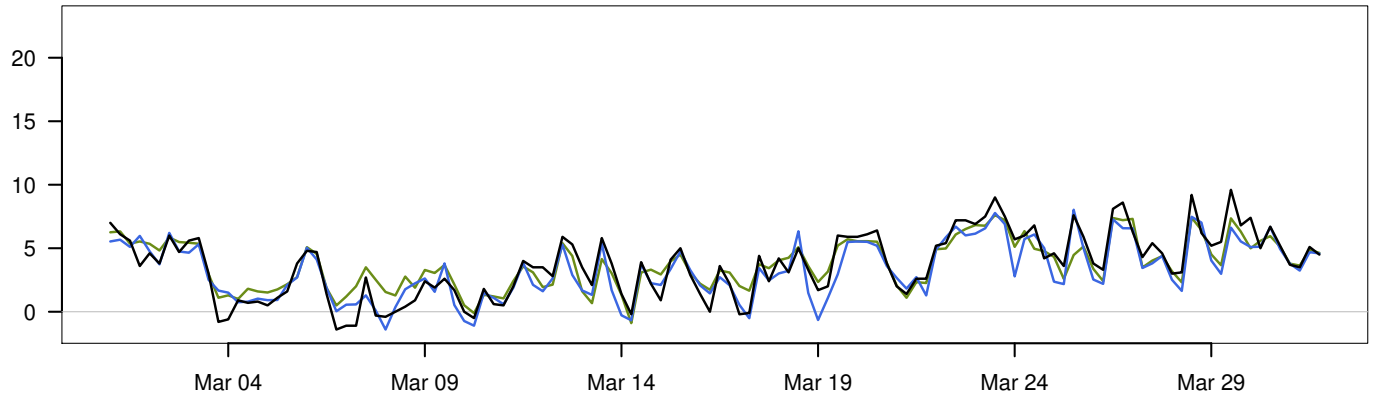
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−29.3	−2.4	17.4	7	372
MEPSctrl: 12+18,+24,+30,+36	−22.4	−3.2	15.2	6.1	372
AA25: 12+18,+24,+30,+36	−24.1	−3.3	15.6	6.2	372
ECMWF: 12+18,+24,+30,+36	−18.3	−2.6	15.2	5.5	371

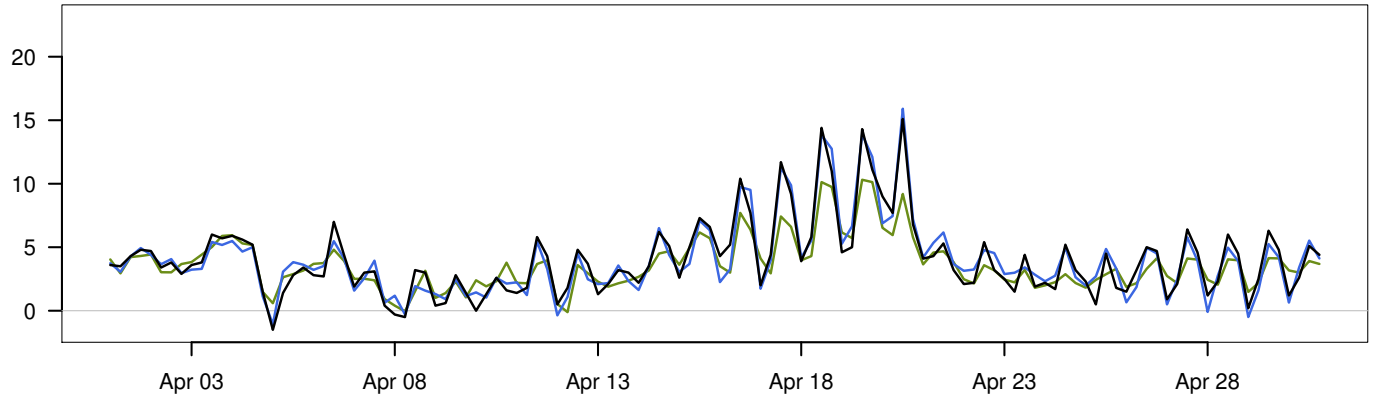
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.8	2.4	2.5	1.9	10.8	372
AA25 – synop	−0.9	2.3	2.5	1.9	10.9	372
ECMWF – synop	−0.1	2.5	2.5	1.7	11.2	371

ØRLAND III

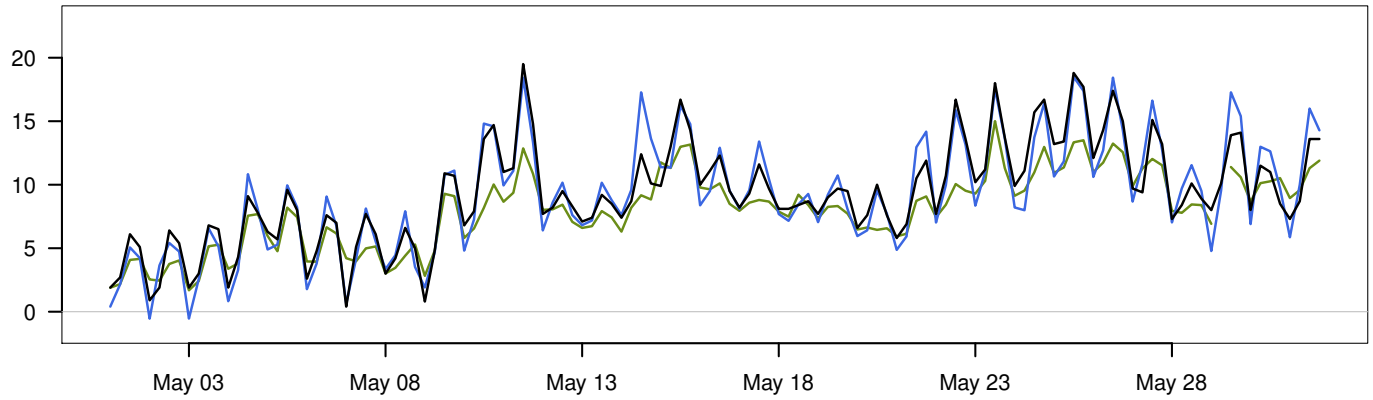
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



01.05.2021 – 31.05.2021

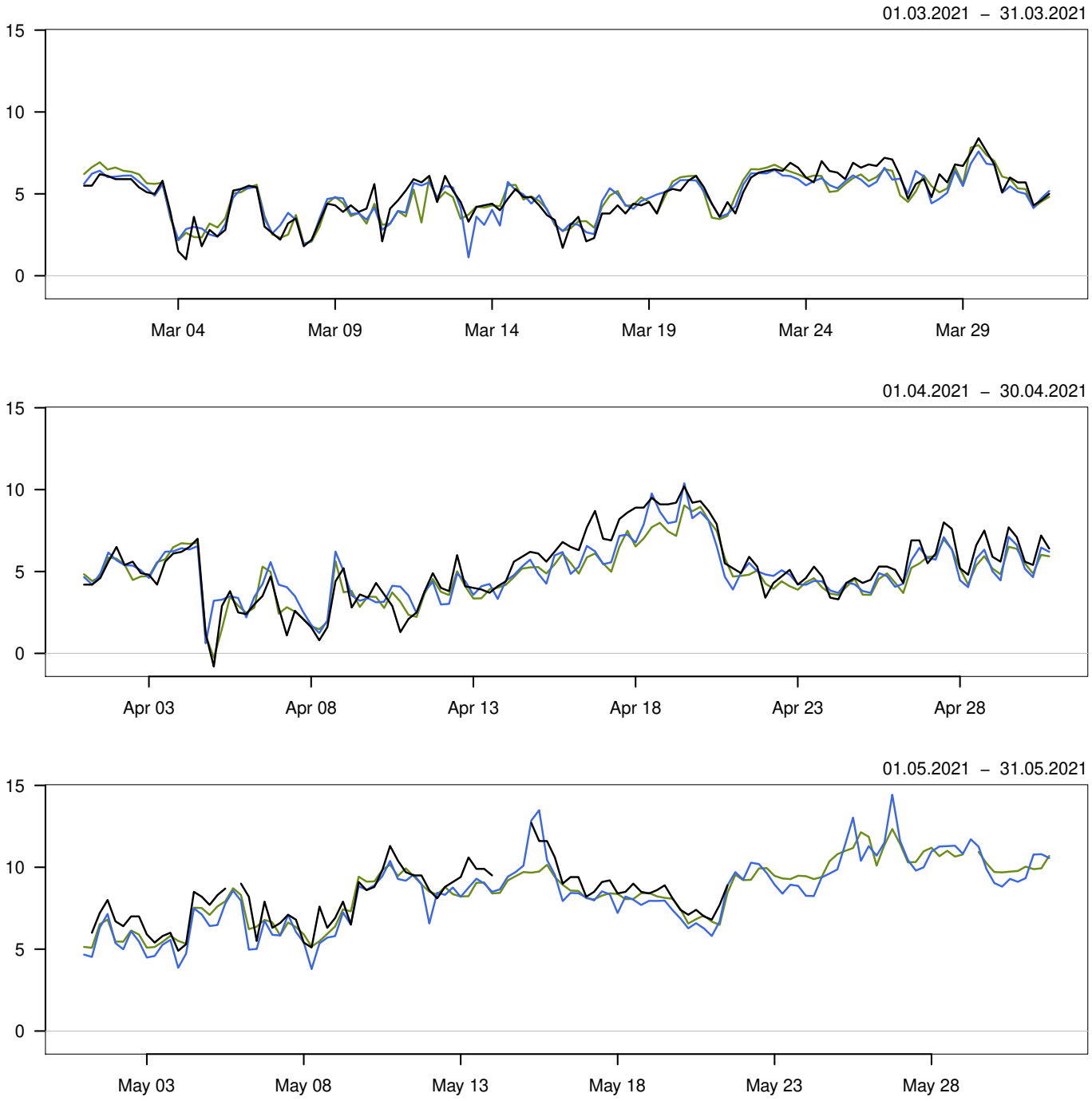


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−1.5	5.8	23.1	4.3	372
MEPSctrl: 12+18,+24,+30,+36	−1.4	5.6	22.6	4.4	372
ECMWF: 12+18,+24,+30,+36	−0.9	5.2	17.7	3.2	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.2	1.1	1.1	0.9	4.9	372
ECMWF – synop	−0.6	1.5	1.6	1.2	6.6	371

YTTERØYANE FYR

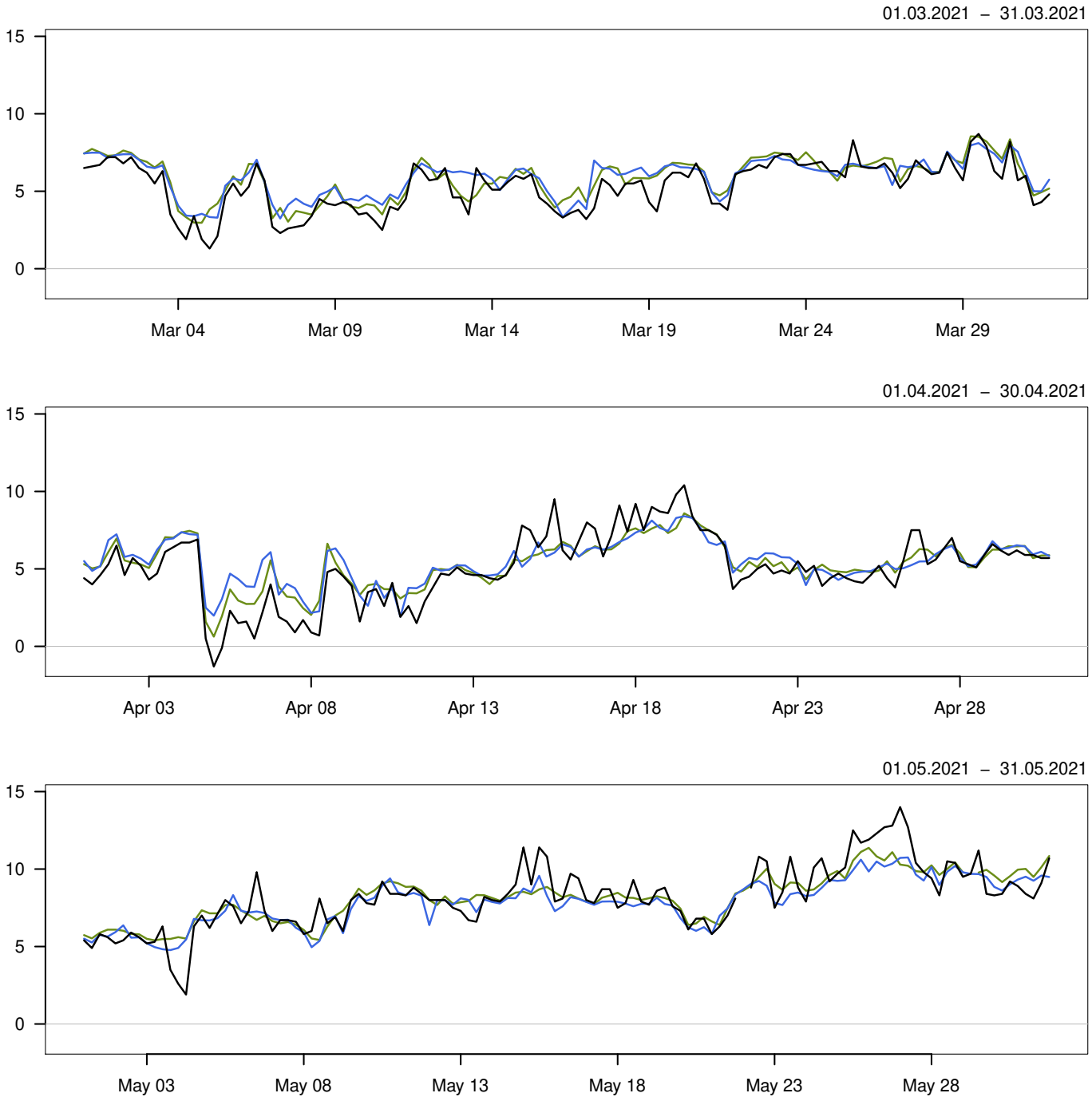


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−0.8	5.8	12.7	2.2	321
MEPSctrl: 12+18,+24,+30,+36	0.6	6.1	14.4	2.4	372
ECMWF: 12+18,+24,+30,+36	−0.3	6.1	12.3	2.4	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.3	0.8	0.9	0.7	4	321
ECMWF – synop	−0.3	0.8	0.8	0.6	3	321

TROLL A

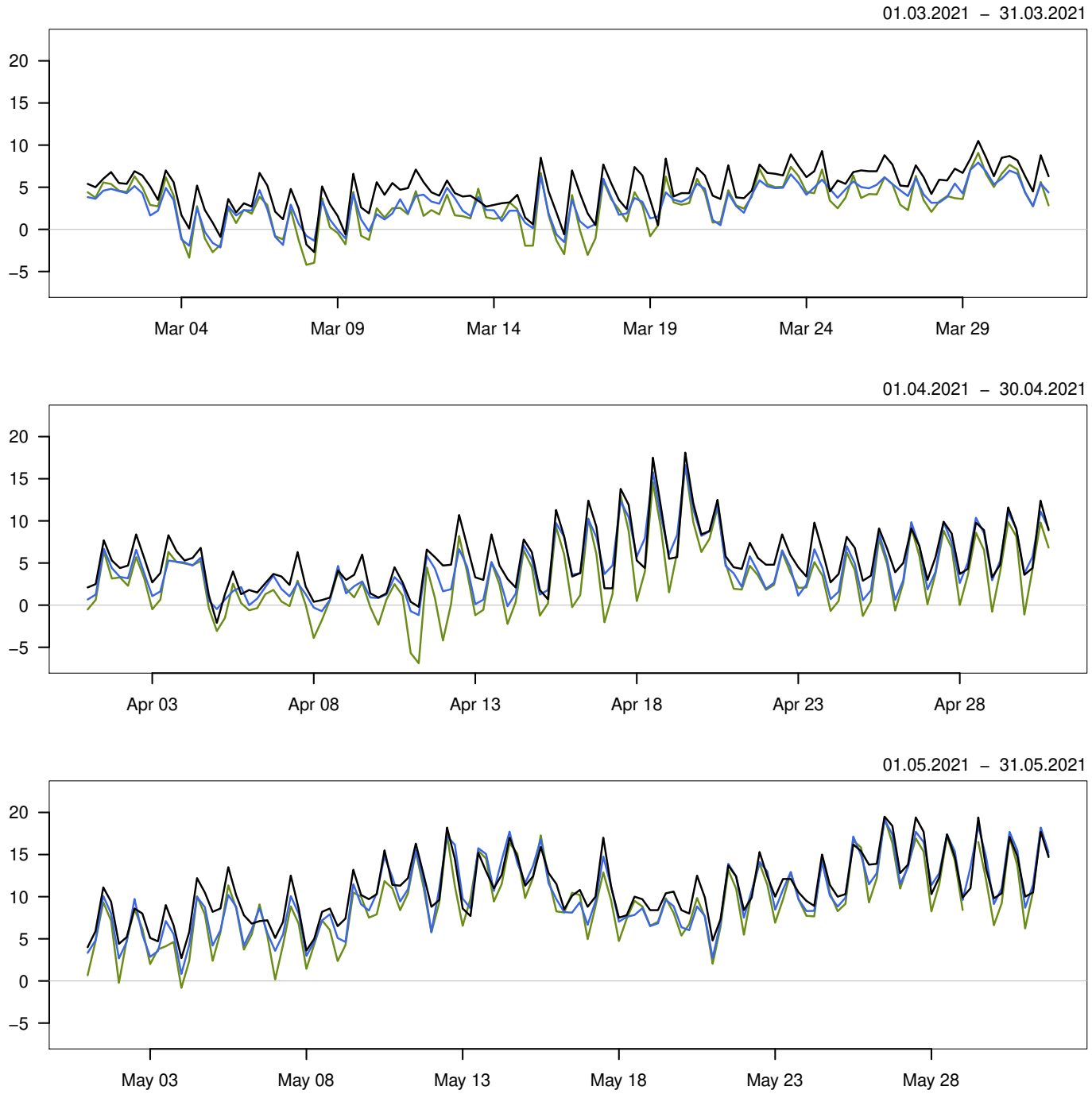


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−1.3	6.3	14.8	2.5	371
MEPSctrl: 12+18,+24,+30,+36	1.9	6.4	10.7	1.7	372
ECMWF: 12+18,+24,+30,+36	0.6	6.5	11.4	1.9	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.2	1.2	1.2	0.9	8.1	371
ECMWF – synop	0.2	1	1	0.8	5.3	370

BERGEN – FLORIDA

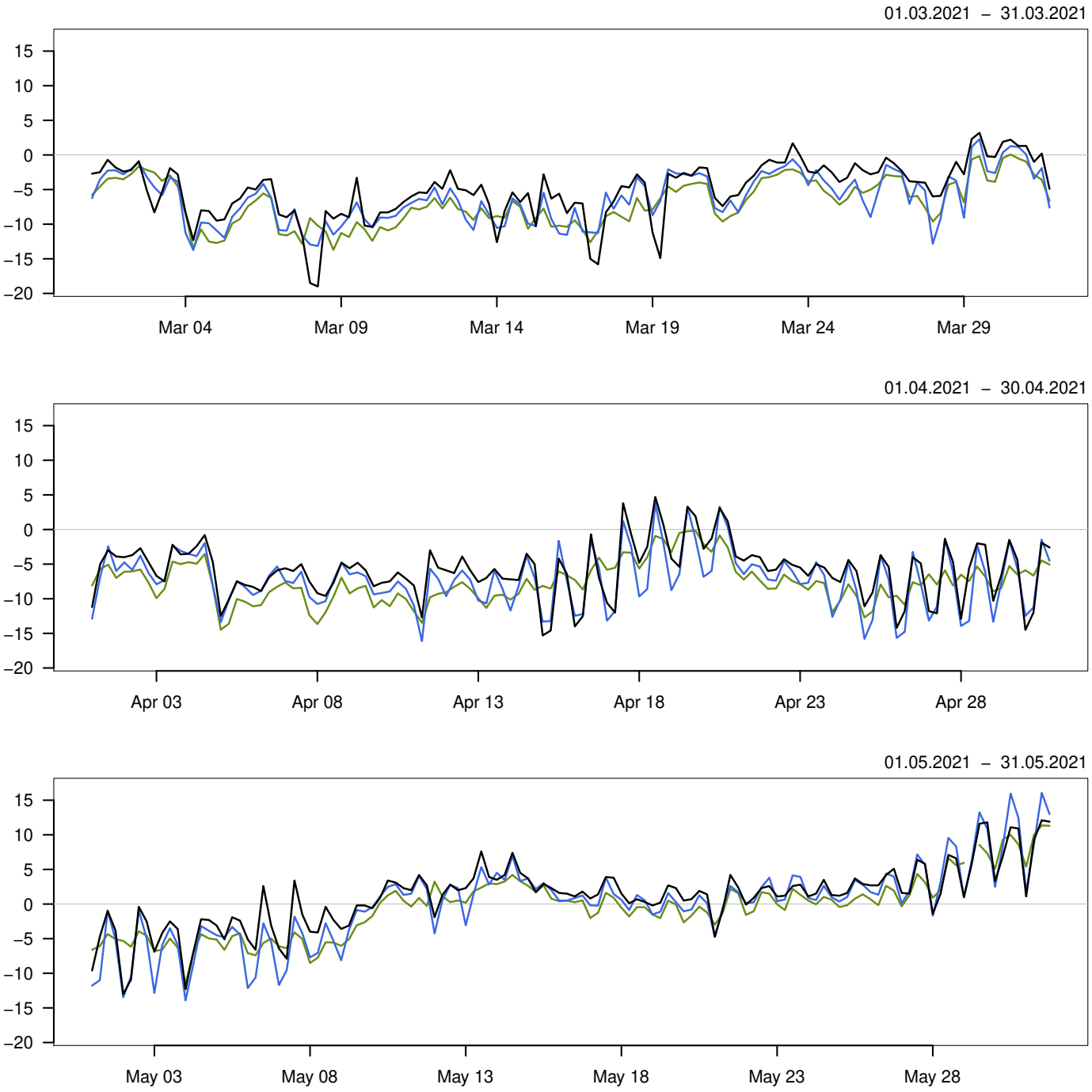


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.7	7.2	21.6	4.4	372
MEPSctrl: 12+18,+24,+30,+36	−2.1	6	22.6	4.7	372
ECMWF: 12+18,+24,+30,+36	−6.9	5.2	21.1	4.9	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−1.2	1.3	1.7	1.5	4.1	372
ECMWF – synop	−2	1.4	2.4	2.1	8.9	371

FINSEVATN

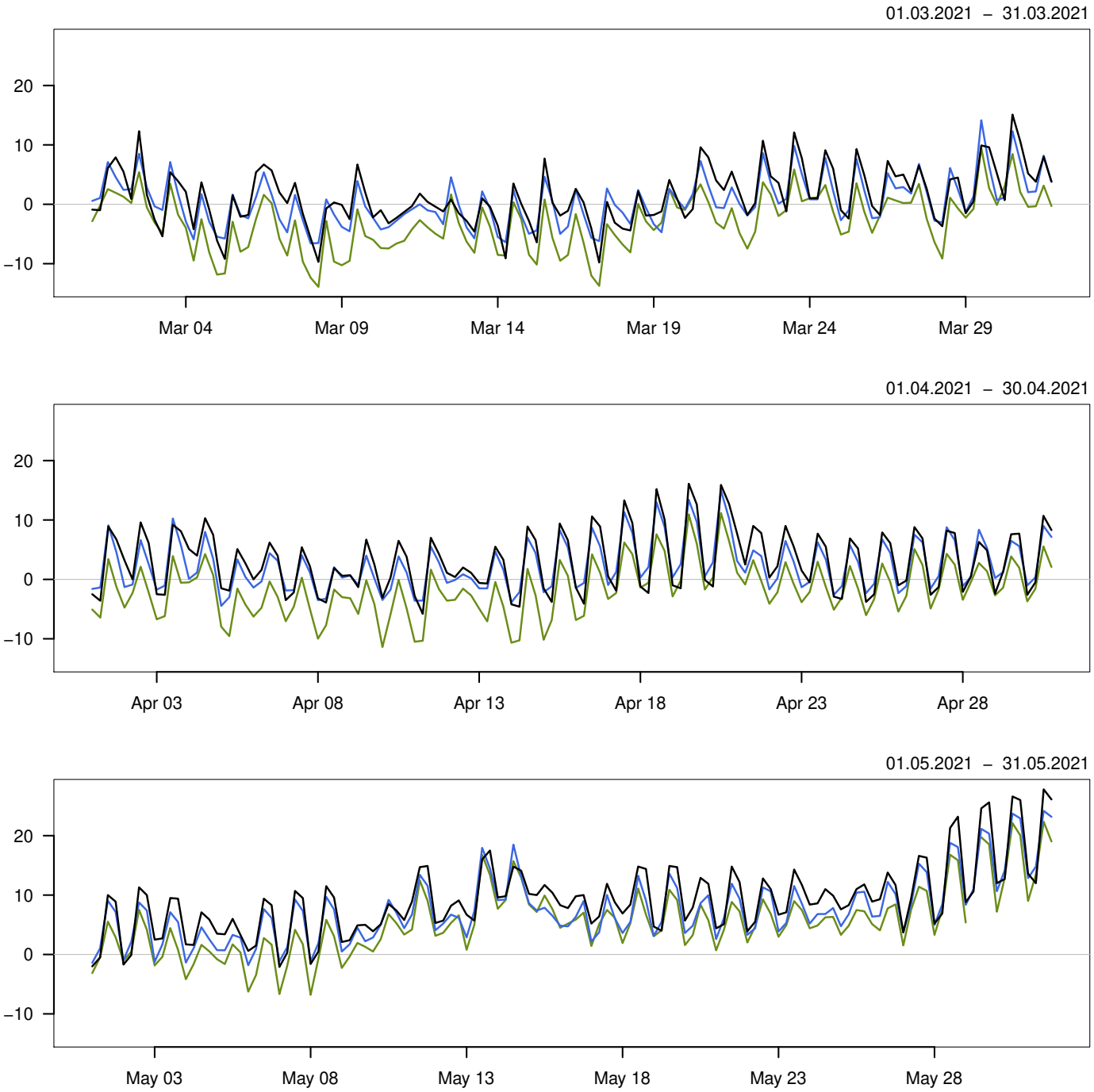


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−19	−3.1	13.9	5.3	372
MEPSctrl: 12+18,+24,+30,+36	−16.1	−4.2	16.7	5.8	372
ECMWF: 12+18,+24,+30,+36	−14.5	−4.8	14	5.1	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−1.1	1.9	2.2	1.7	8.3	372
ECMWF – synop	−1.6	2.6	3.1	2.7	9.4	371

NESBYEN – TODOKK

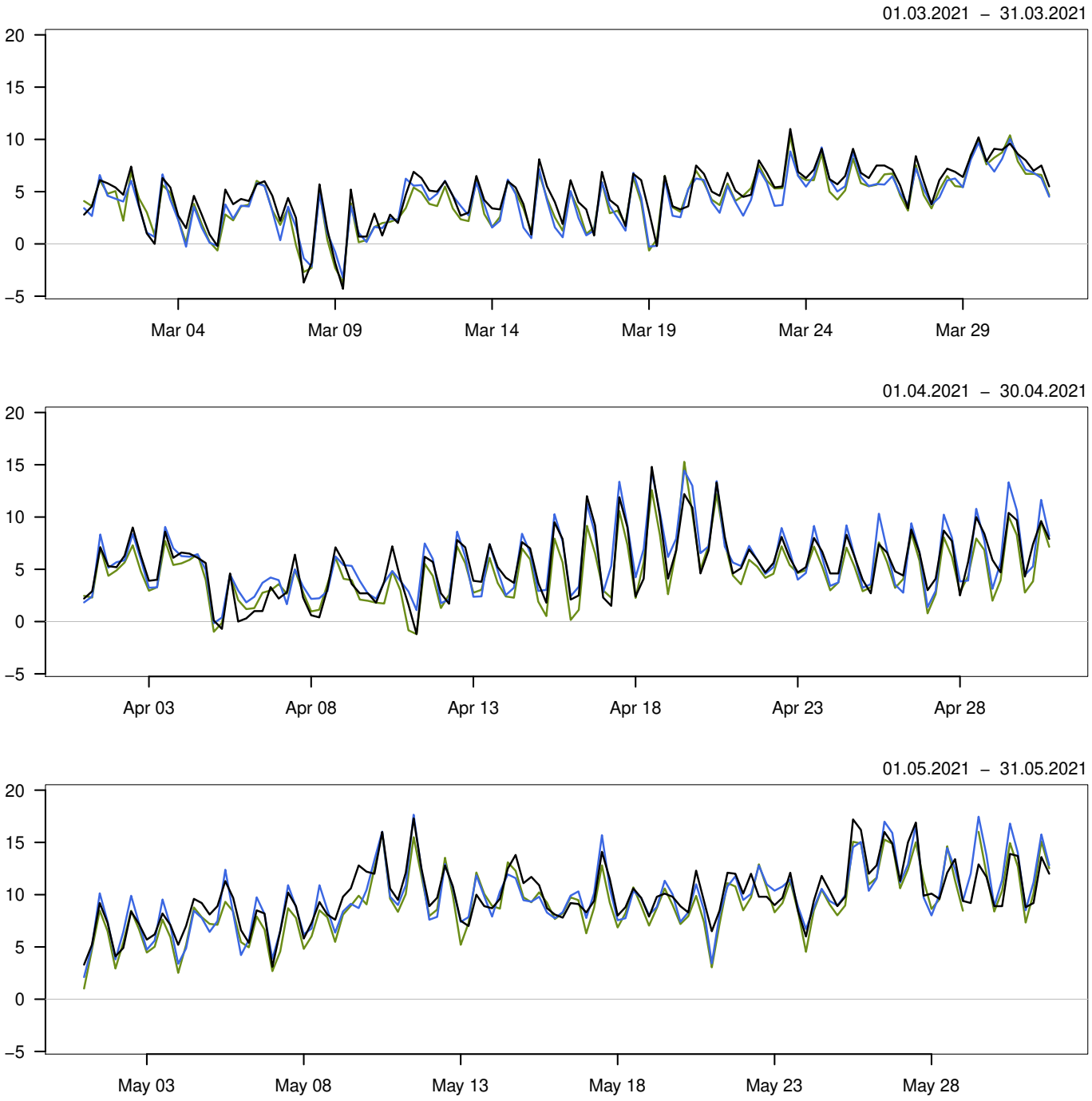


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−9.8	4.7	27.8	6.5	372
MEPSctrl: 12+18,+24,+30,+36	−6.6	3.7	24.2	5.8	372
ECMWF: 12+18,+24,+30,+36	−13.9	0.5	22.3	6.4	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−1.1	2	2.3	1.9	5.3	372
ECMWF – synop	−4.2	2.4	4.9	4.4	10.2	371

SOLA



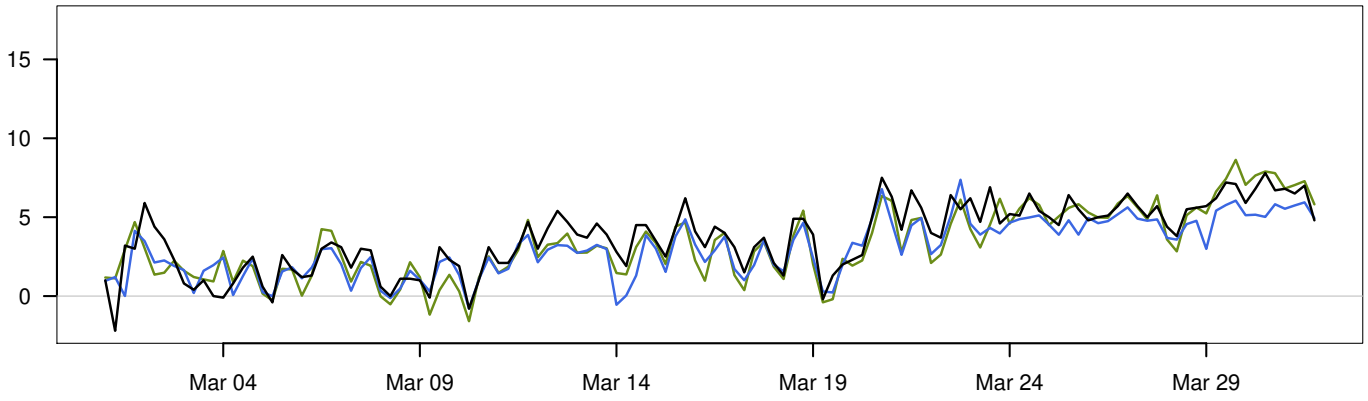
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.3	6.8	17.3	3.7	372
MEPSctrl: 12+18,+24,+30,+36	−3.2	6.6	19.6	3.9	372
ECMWF: 12+18,+24,+30,+36	−3.7	6.1	16.9	3.7	371

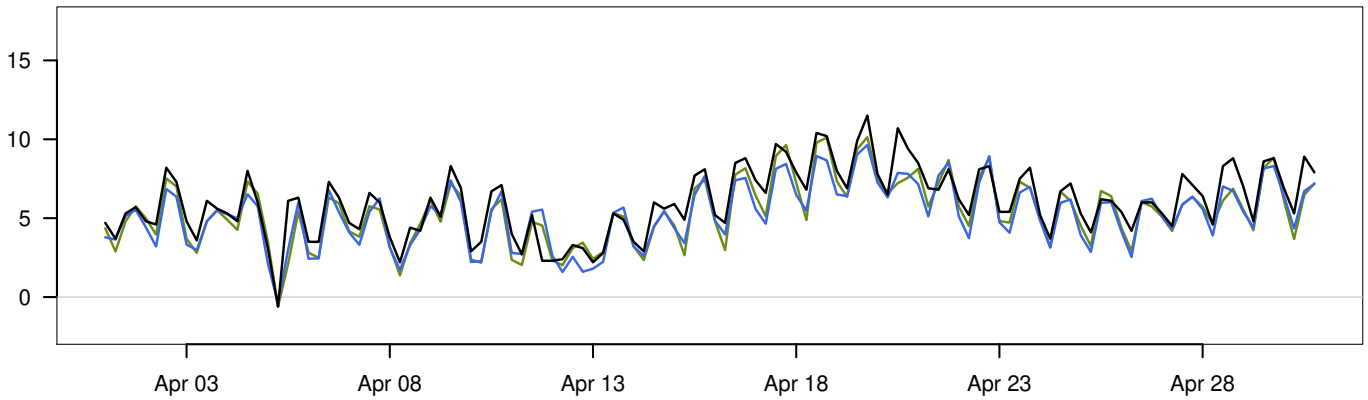
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.2	1.3	1.3	1	6.9	372
ECMWF – synop	−0.7	1.1	1.3	1.1	4.2	371

FÆRDER FYR

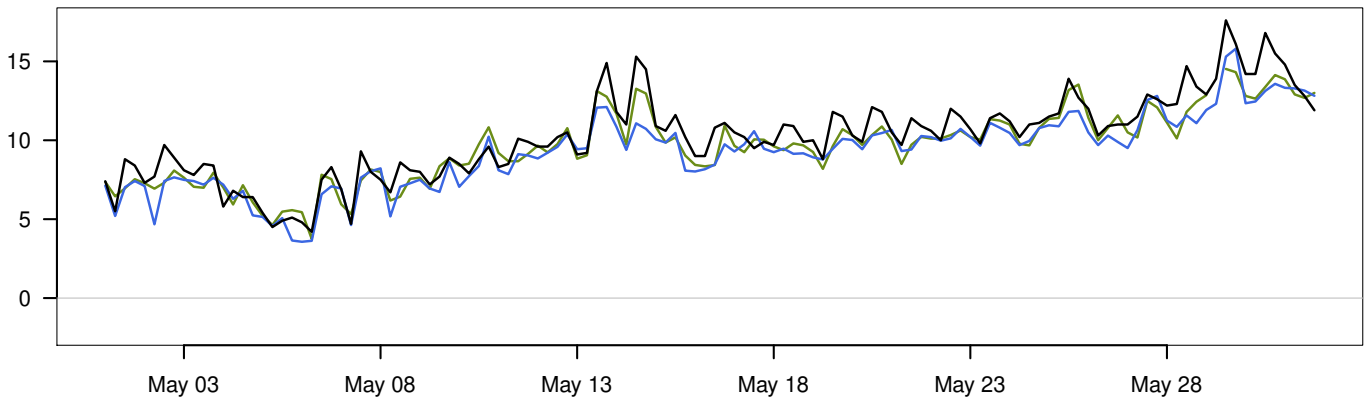
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



01.05.2021 – 31.05.2021

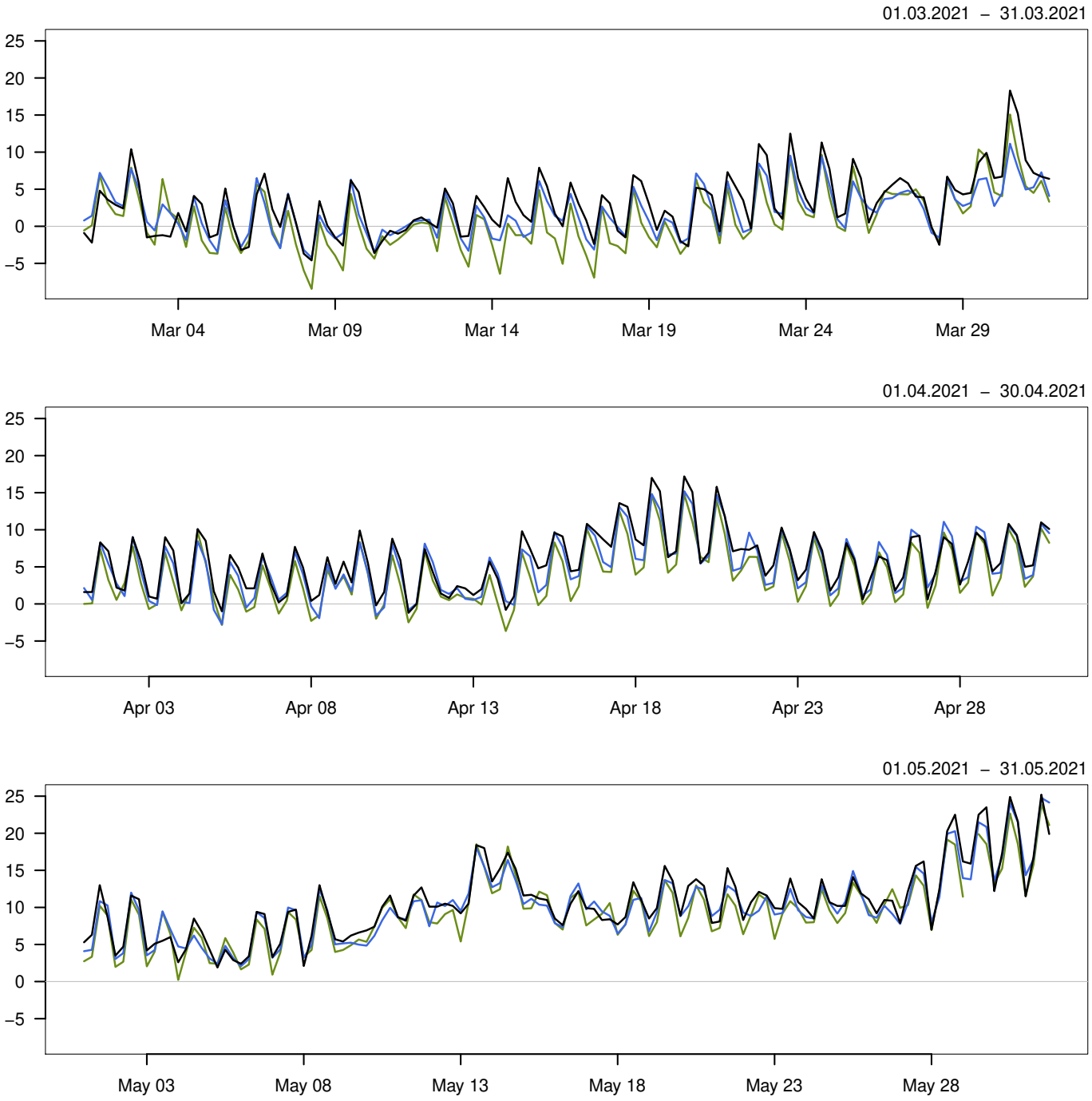


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	–2.2	6.7	17.6	3.7	372
MEPSctrl: 12+18,+24,+30,+36	–0.8	5.9	16.9	3.4	372
ECMWF: 12+18,+24,+30,+36	–1.6	6.2	15.6	3.5	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	–0.8	0.9	1.2	1	4.2	372
ECMWF – synop	–0.5	0.9	1.1	0.8	4	371

OSLO – BLINDERN

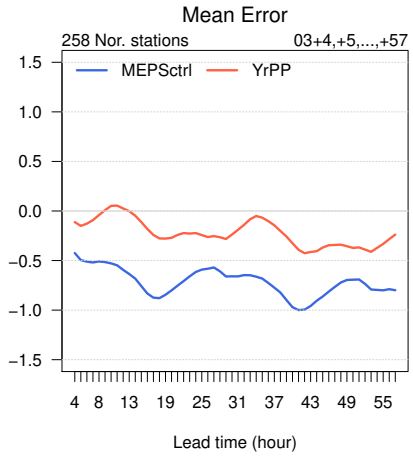


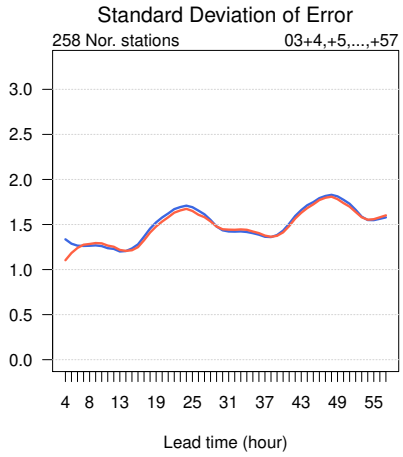
01.03.2021 – 31.05.2021

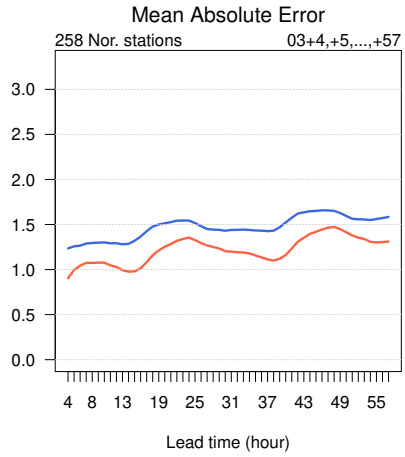
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.6	6.6	25.2	5.5	372
MEPSctrl: 12+18,+24,+30,+36	−4.2	5.9	24.8	5.4	372
ECMWF: 12+18,+24,+30,+36	−8.4	4.9	23.9	5.7	371

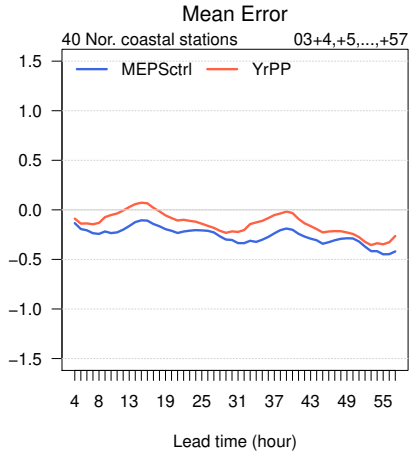
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.7	1.5	1.7	1.3	7.3	372
ECMWF – synop	−1.7	1.6	2.3	1.9	7.6	371

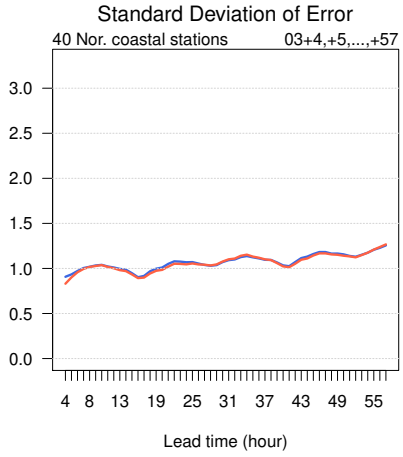
Post processed temperature 2m (YrPP)

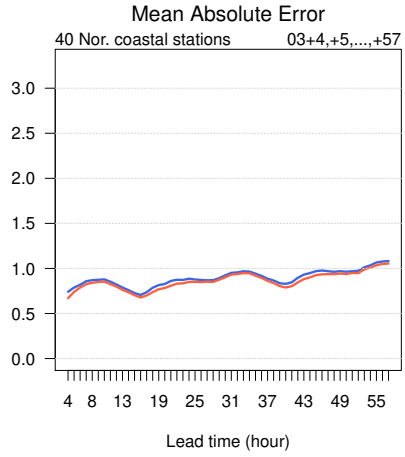


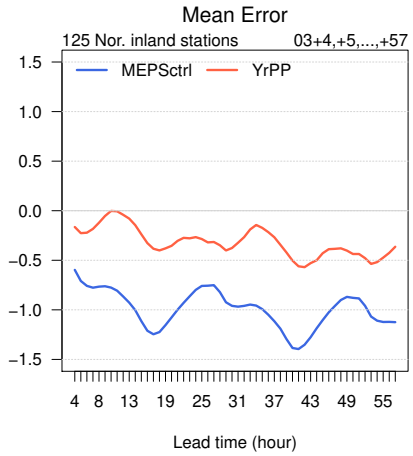


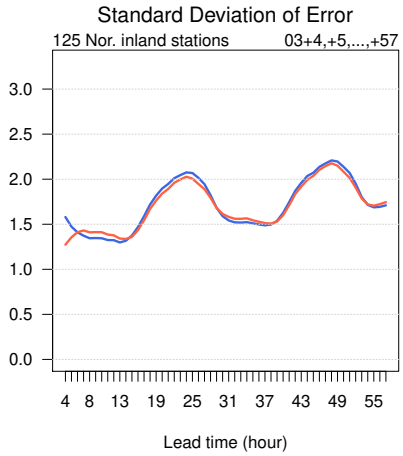


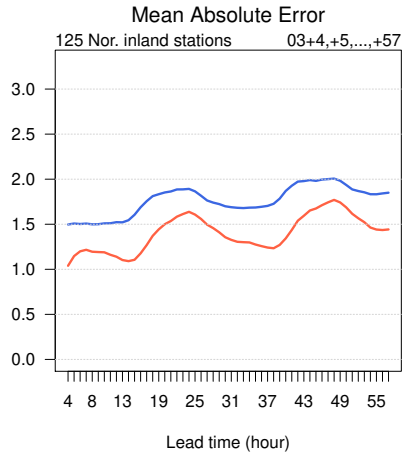


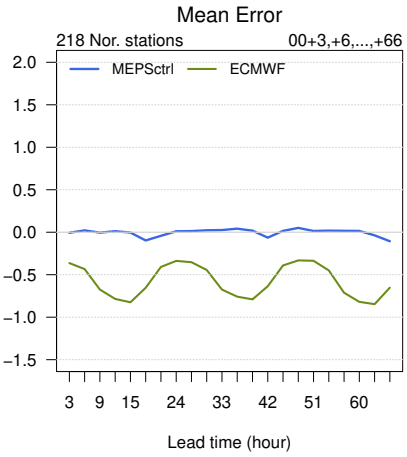


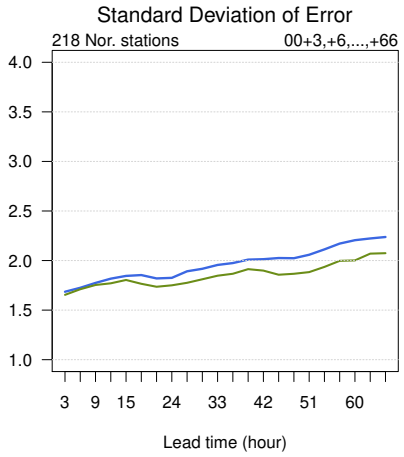


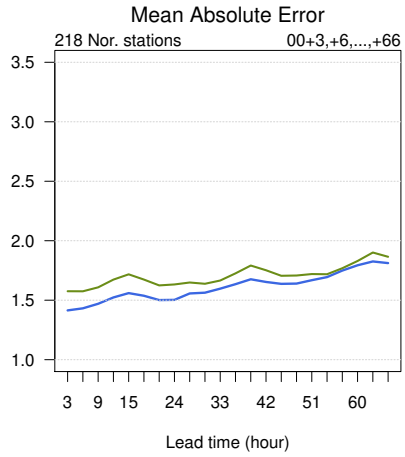


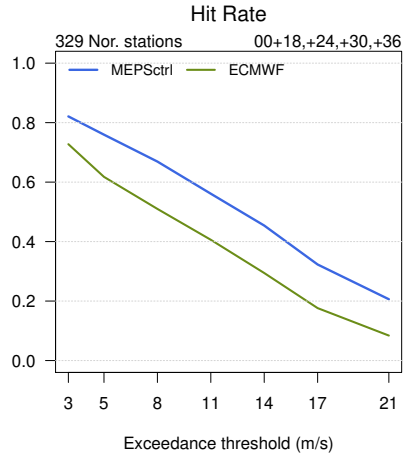


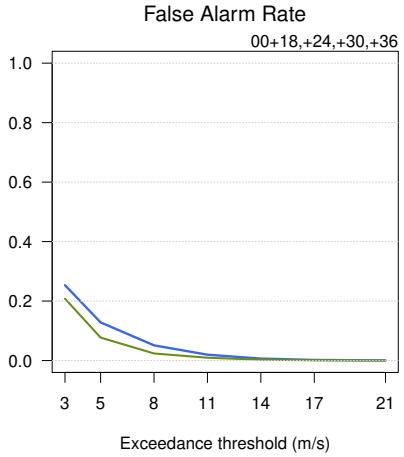


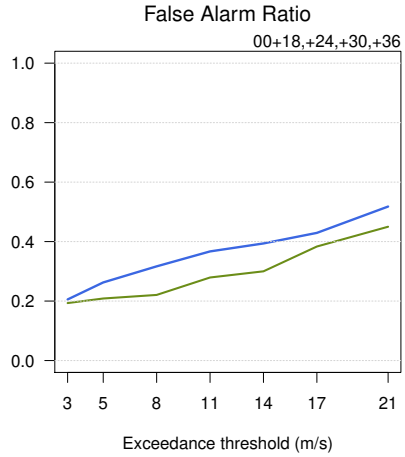

Mean Error
218 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)

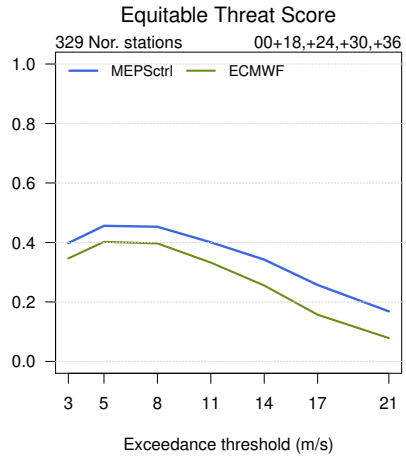

Standard Deviation of Error
218 Nor. stations
00+3,+6,...,+66
4.0
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

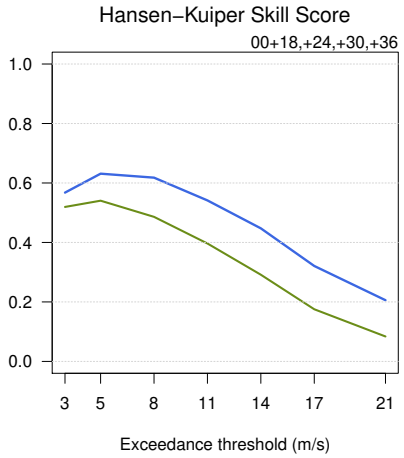

Mean Absolute Error
218 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

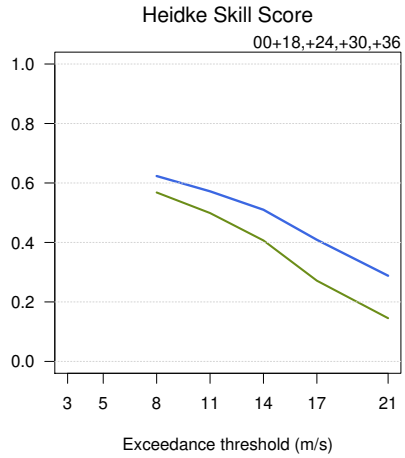

Hit Rate
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

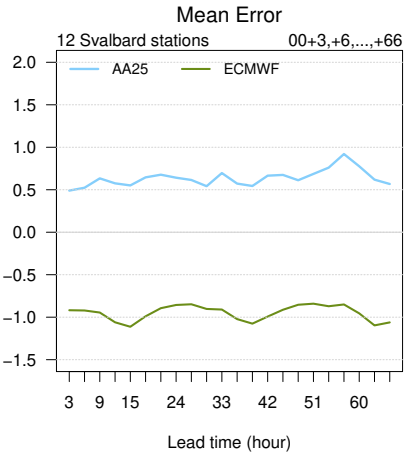

False Alarm Rate
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

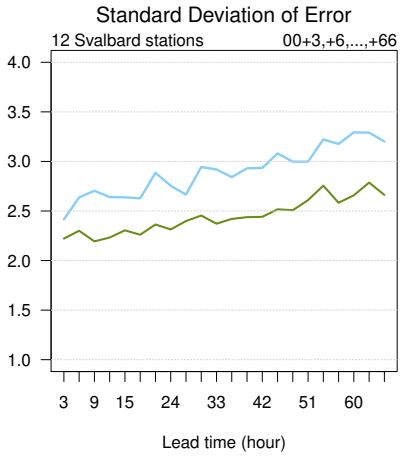

False Alarm Ratio
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

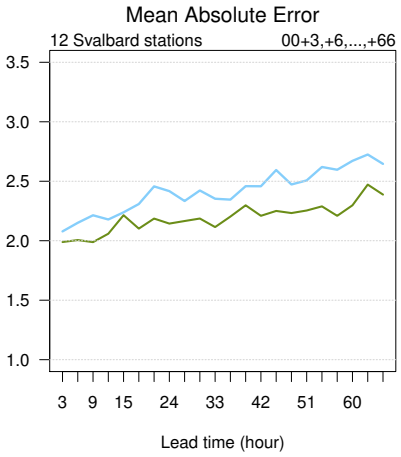

Equitable Threat Score
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

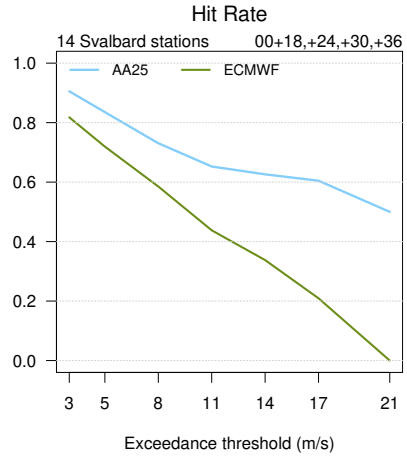

Hansen−Kuiper Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

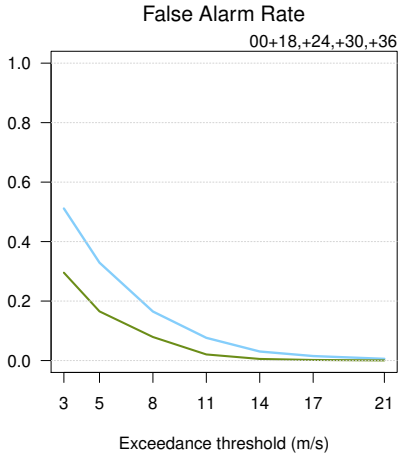

Heidke Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

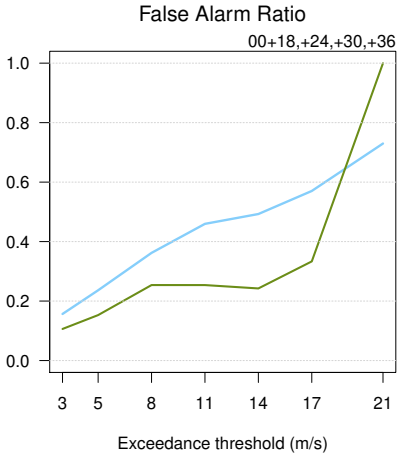

Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)

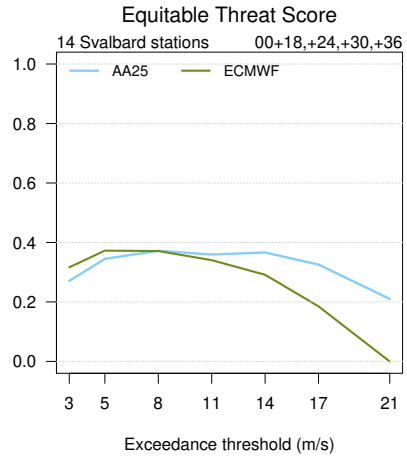

Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
4.0
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

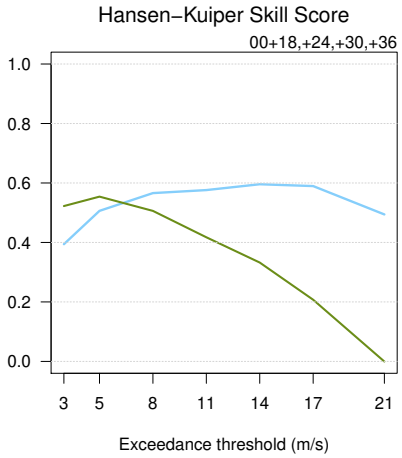

Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

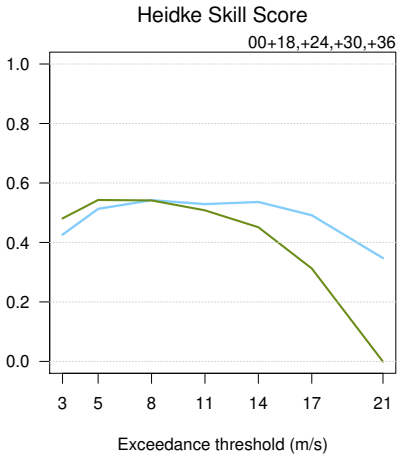

Hit Rate
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

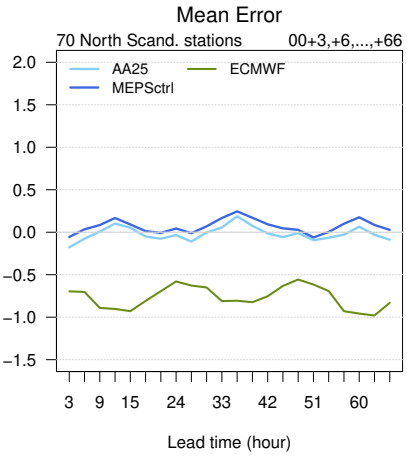

False Alarm Rate
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

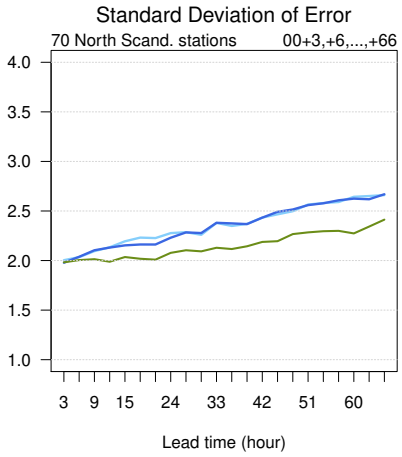

False Alarm Ratio
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

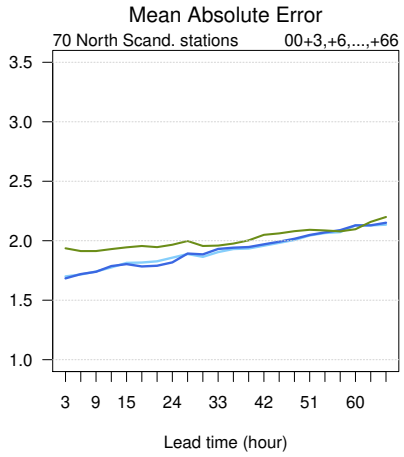

Equitable Threat Score
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

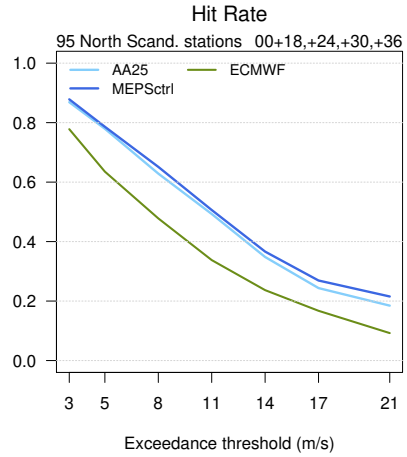

Hansen−Kuiper Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

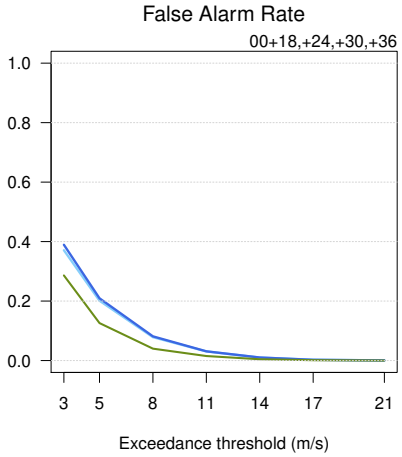

Heidke Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

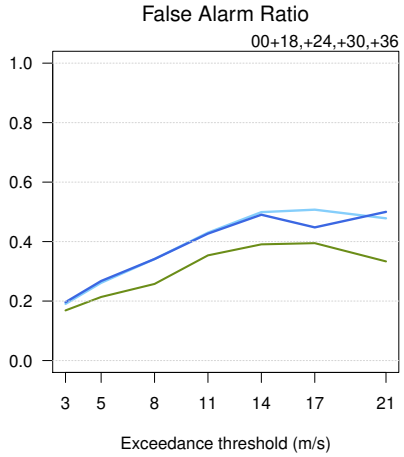

Mean Error
70 North Scand. stations 00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
3 9 15 24 33 42 51 60
Lead time (hour)

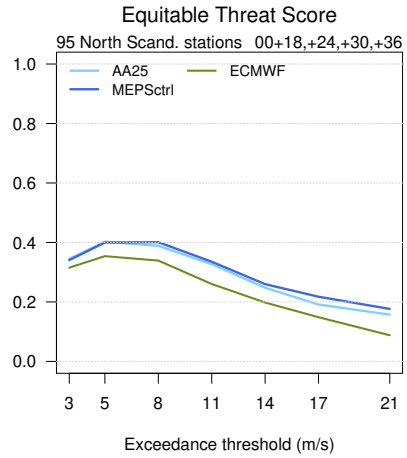

Standard Deviation of Error
70 North Scand. stations 00+3,+6,...,+66
4.0
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

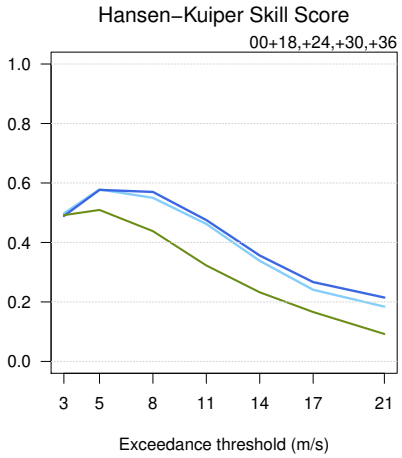

Mean Absolute Error
70 North Scand. stations 00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
3 9 15 24 33 42 51 60
Lead time (hour)

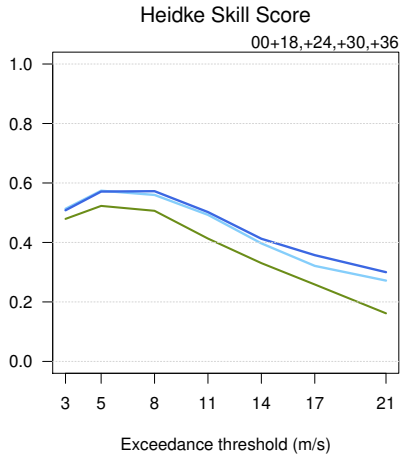

Hit Rate
95 North Scand. stations 00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)


False Alarm Rate
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

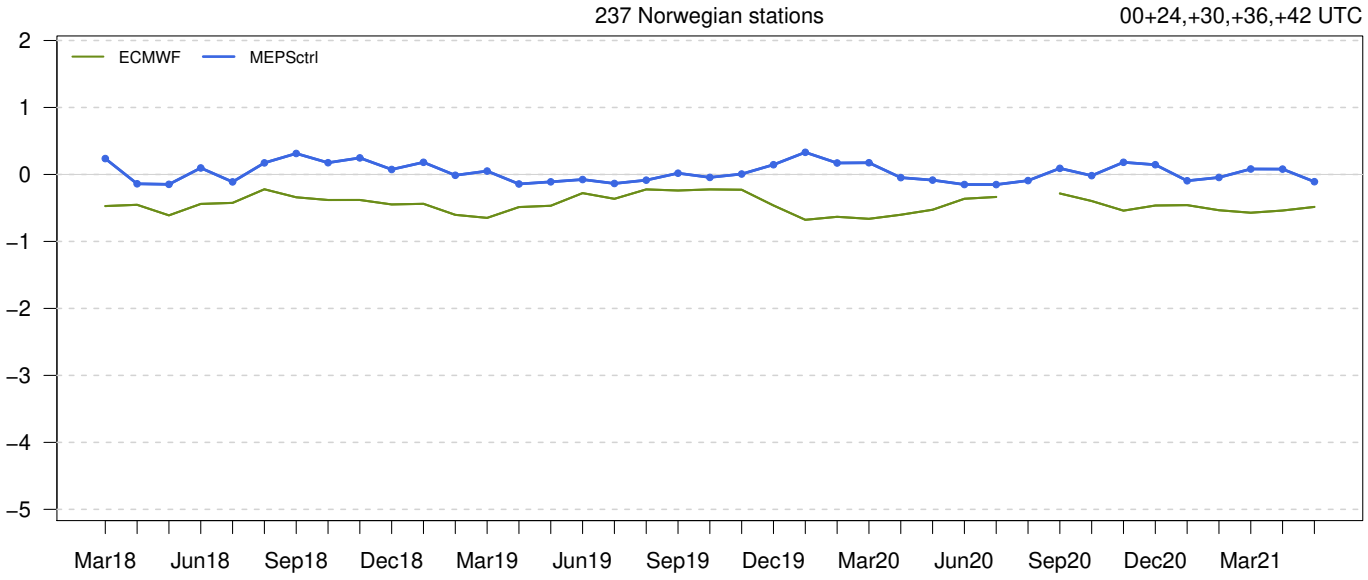

False Alarm Ratio
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

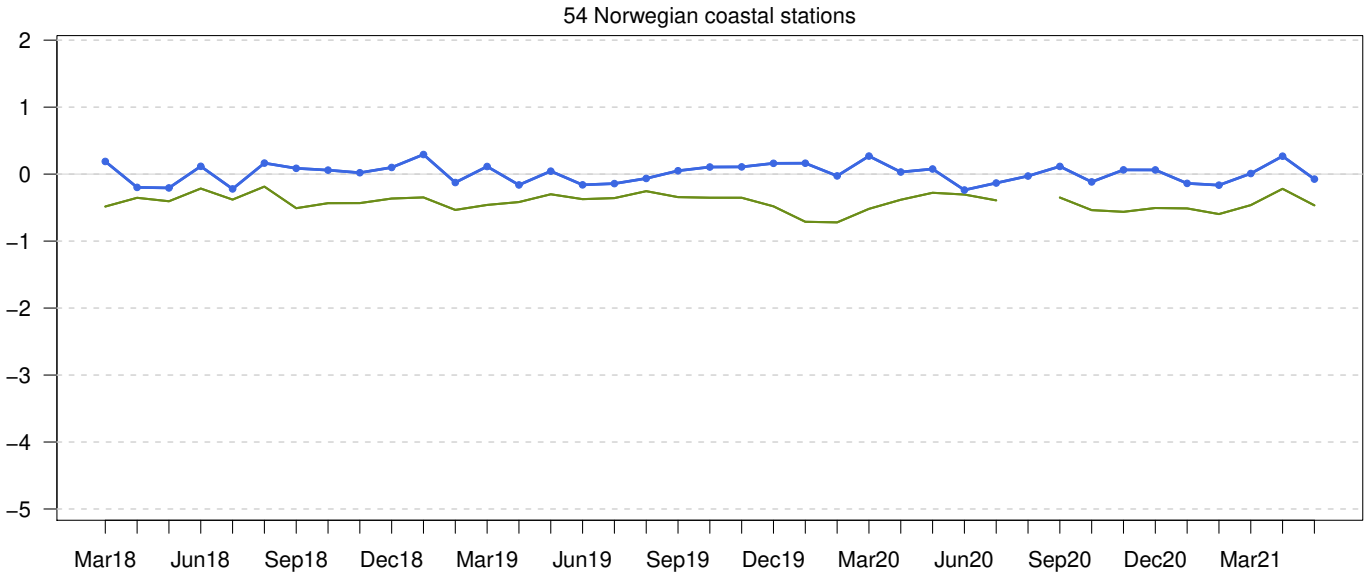

Equitable Threat Score
95 North Scand. stations 00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

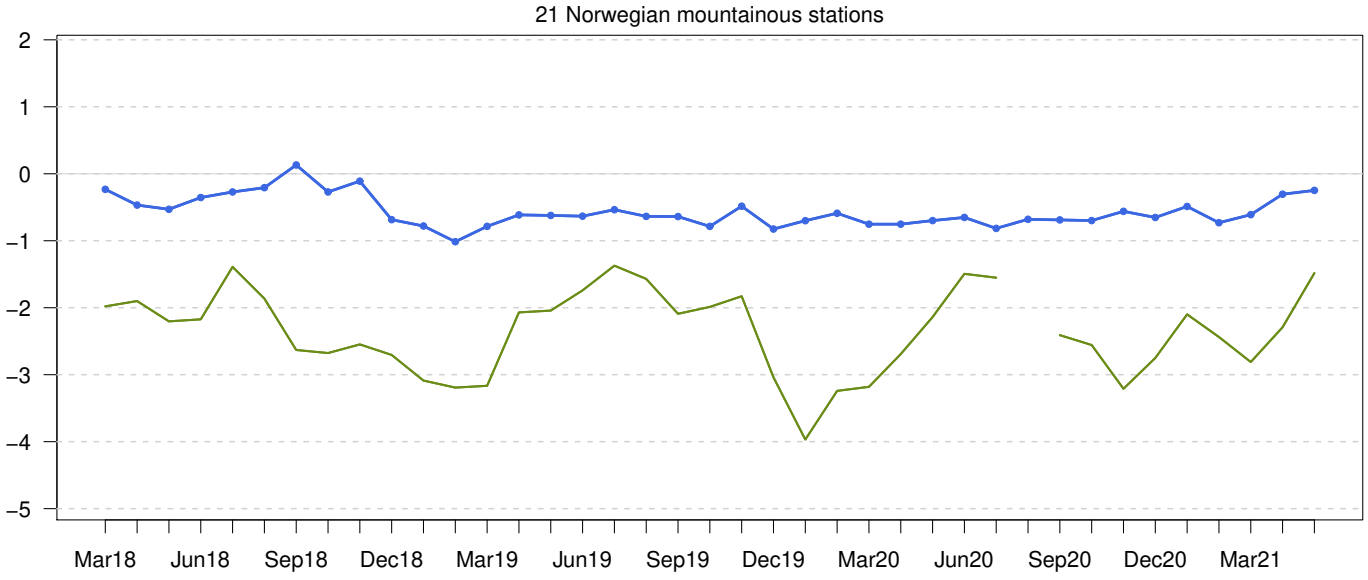

Hansen−Kuiper Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)


Heidke Skill Score
00+18,+24,+30,+36
1.0
0.8
0.6
0.4
0.2
0.0
3 5 8 11 14 17 21
Exceedance threshold (m/s)

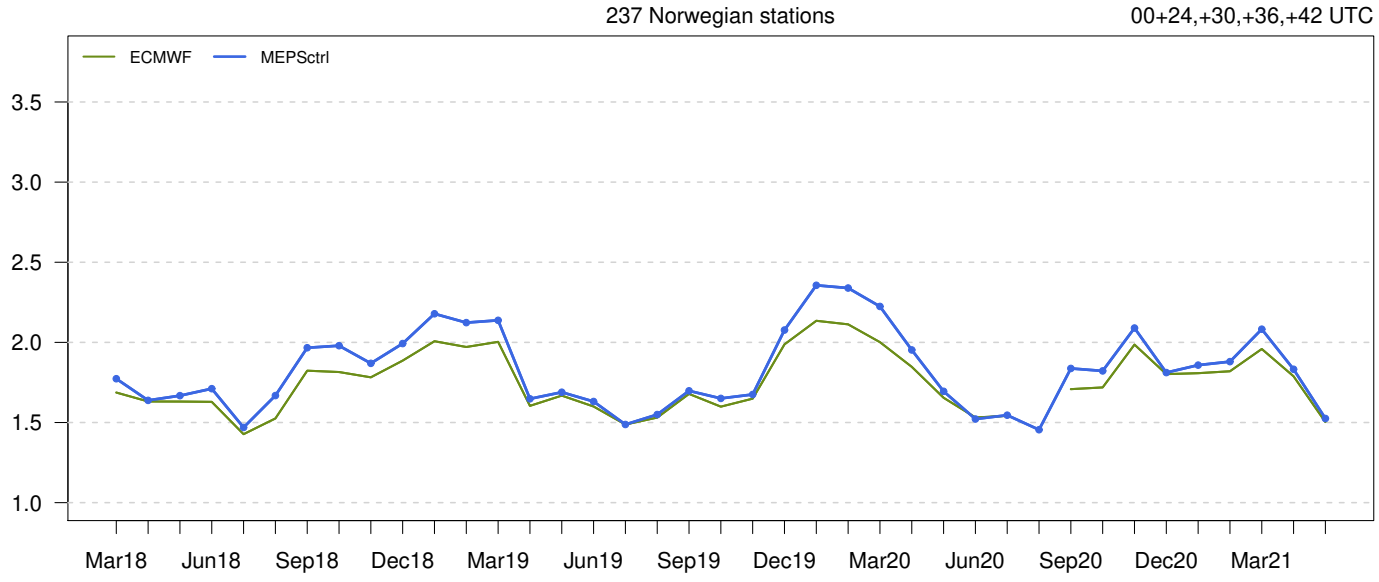
Mean Error

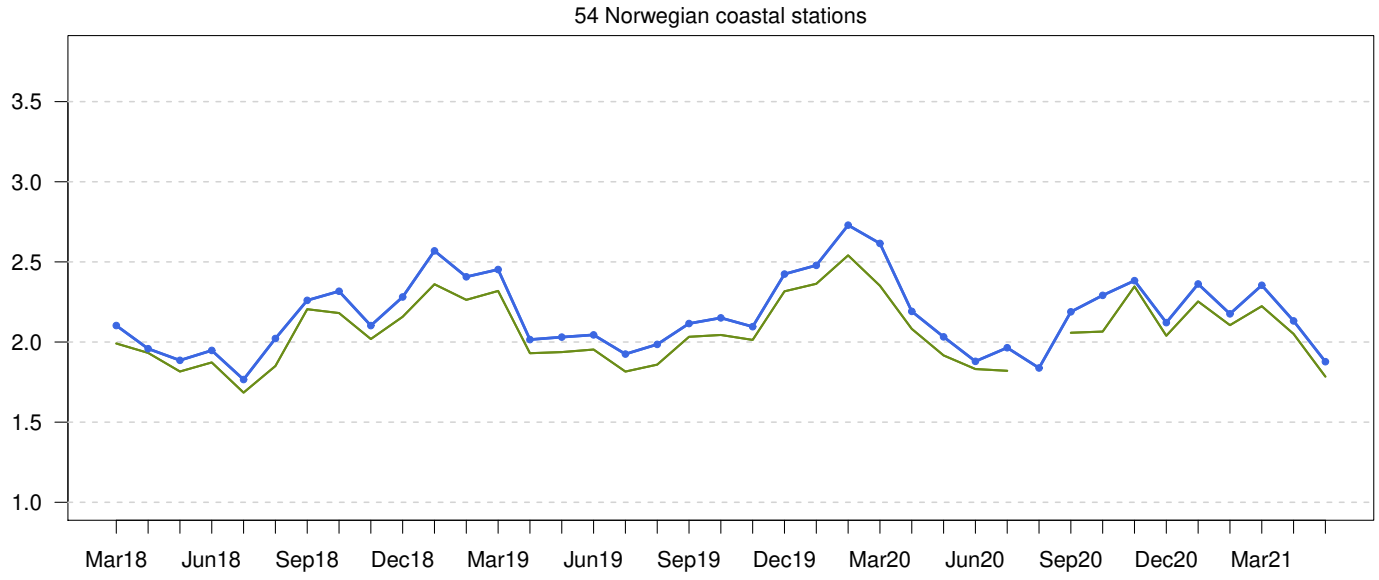

237 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Mar18
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21

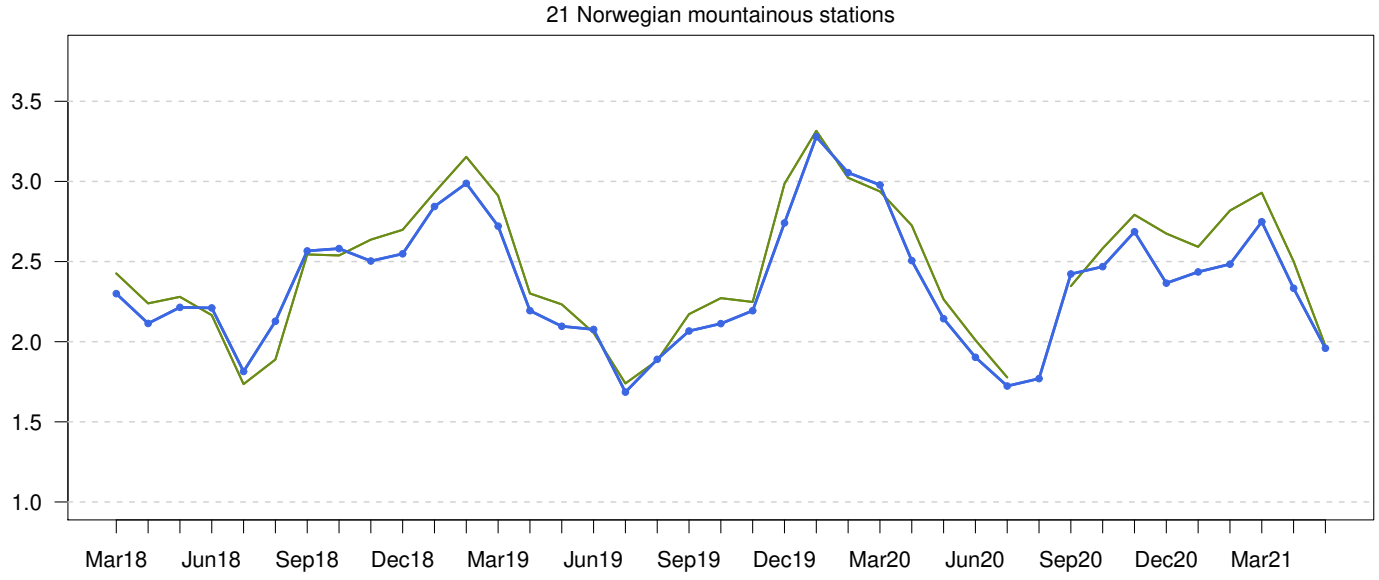

54 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Mar18
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21


21 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Mar18
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21

Standard Deviation of Error

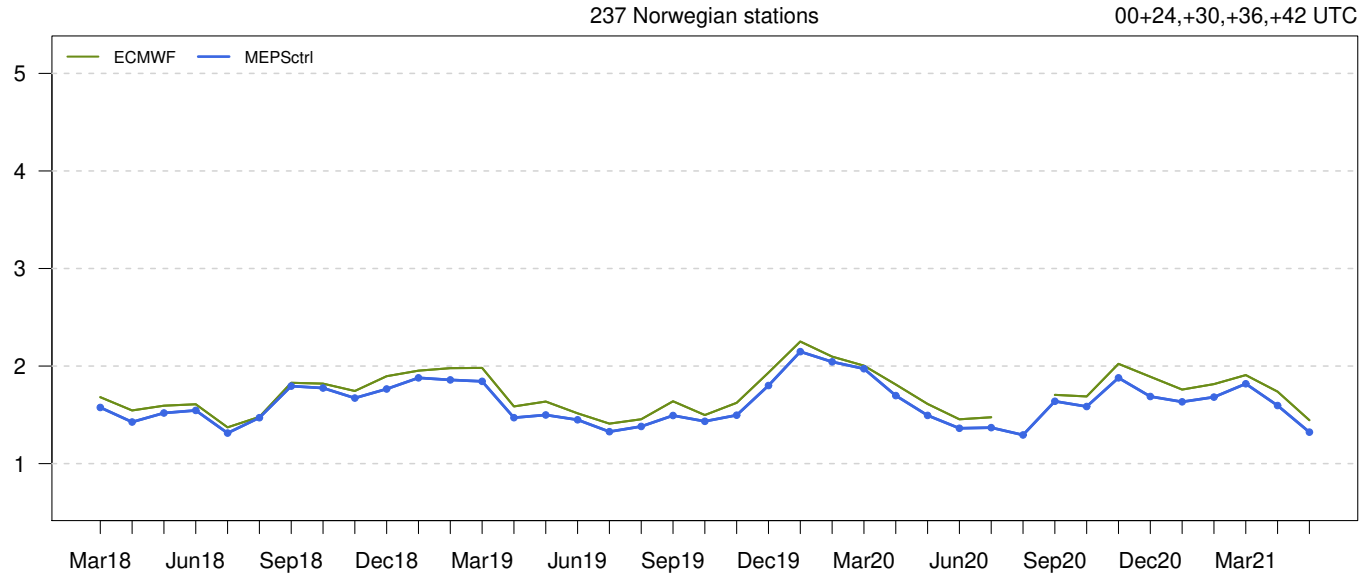




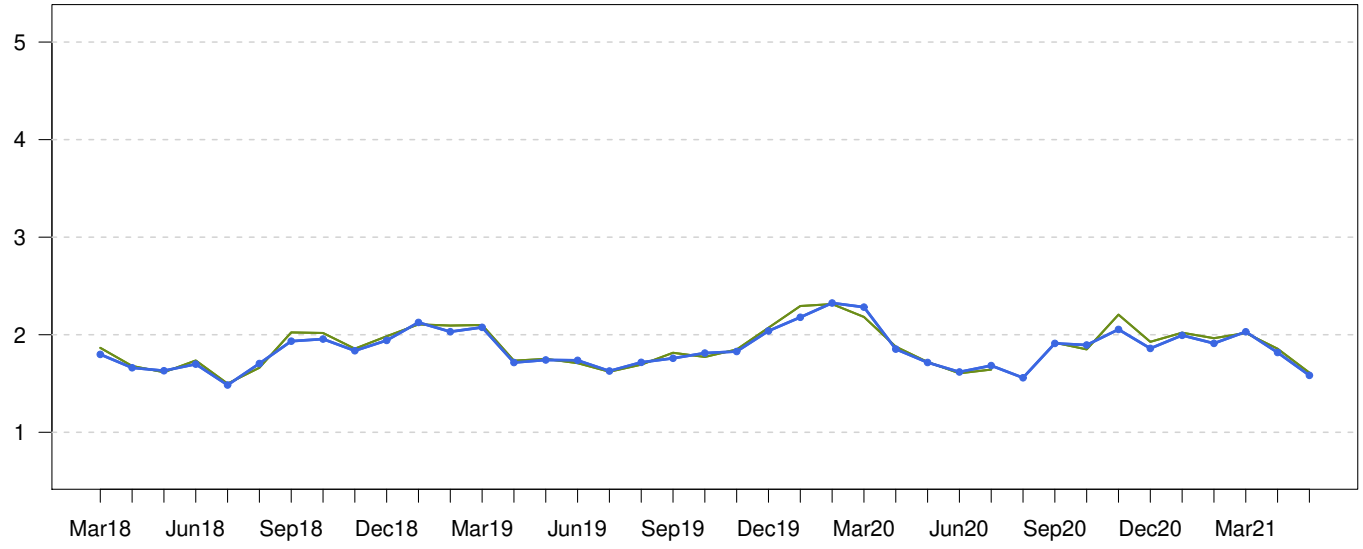


Mean Absolute Error

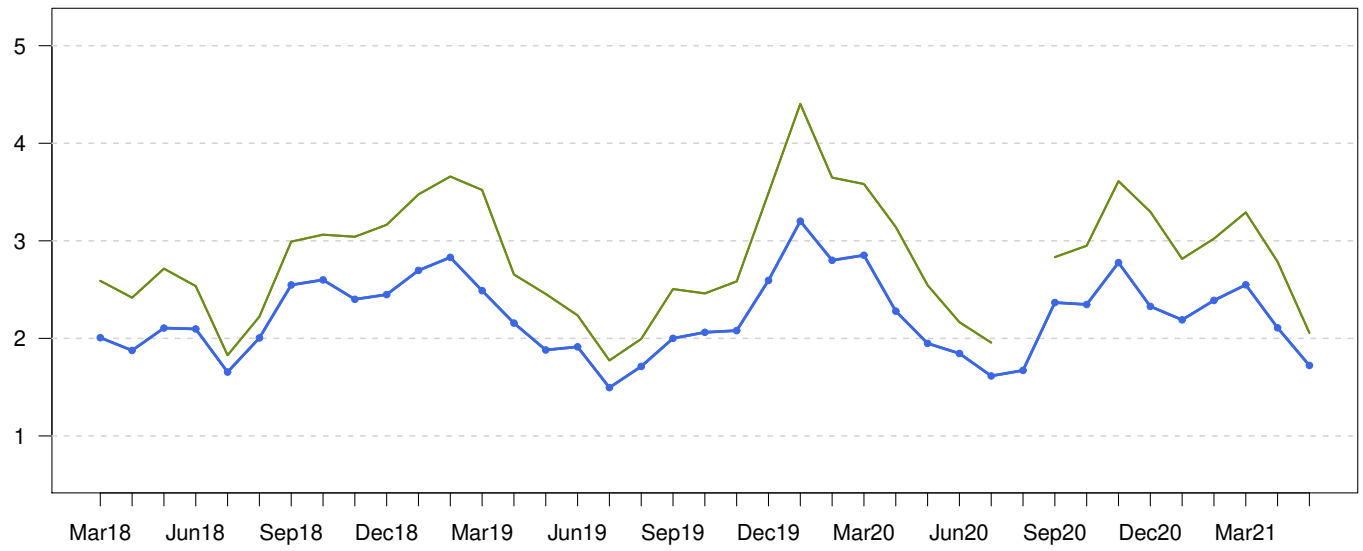
237 Norwegian stations 00+24,+30,+36,+42 UTC



54 Norwegian coastal stations

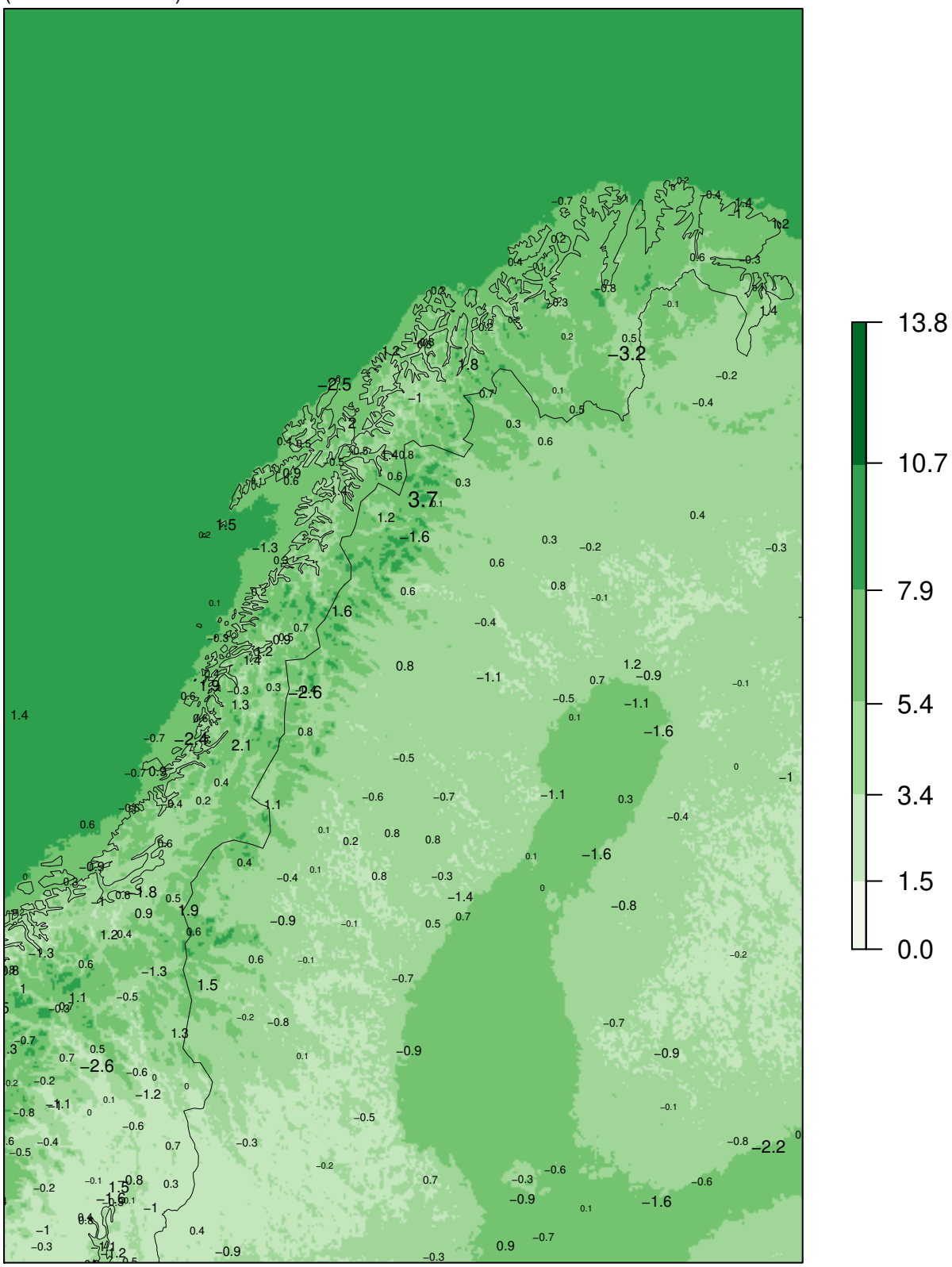


21 Norwegian mountainous stations



MEPSctrl 00+12

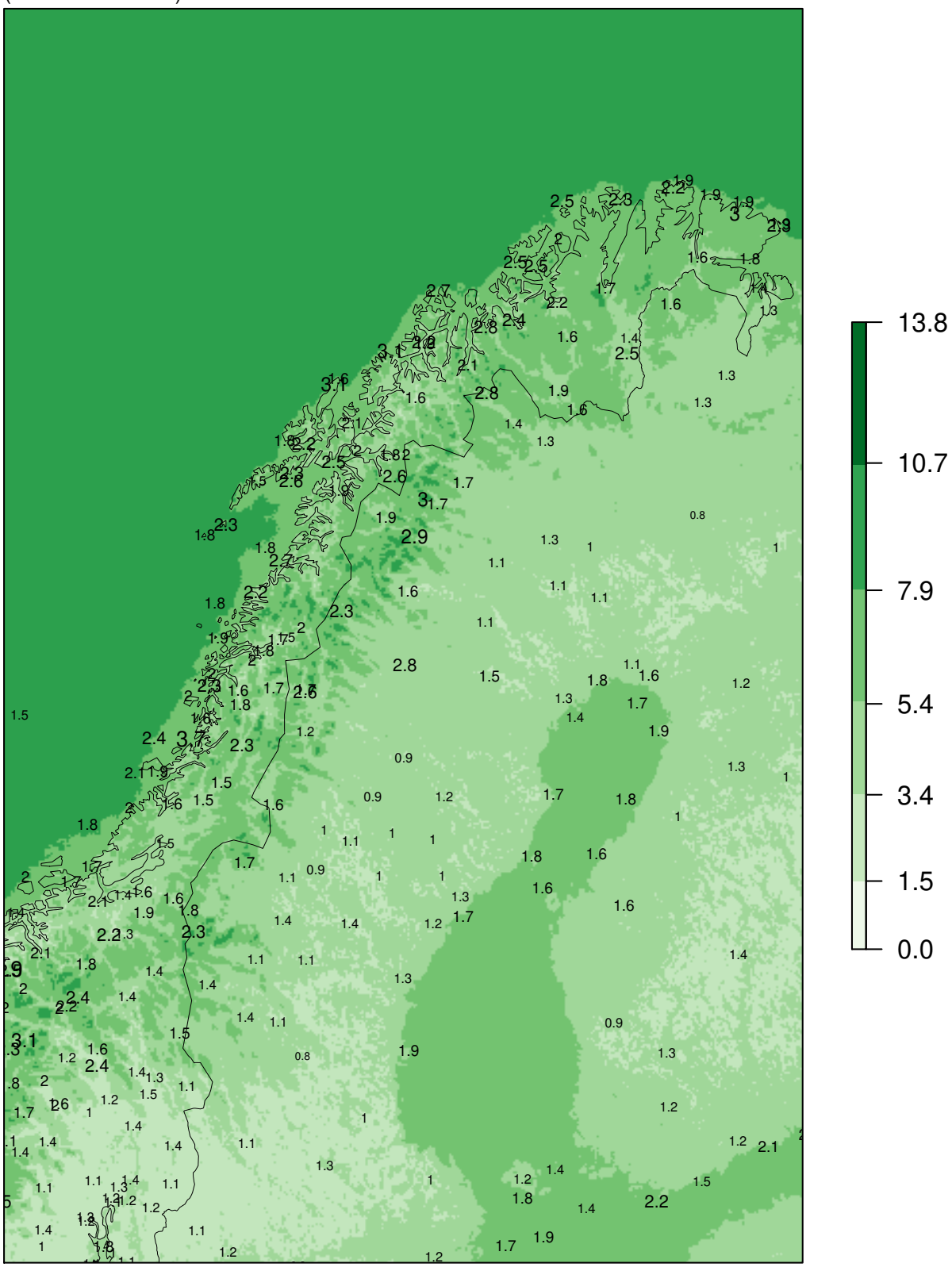
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

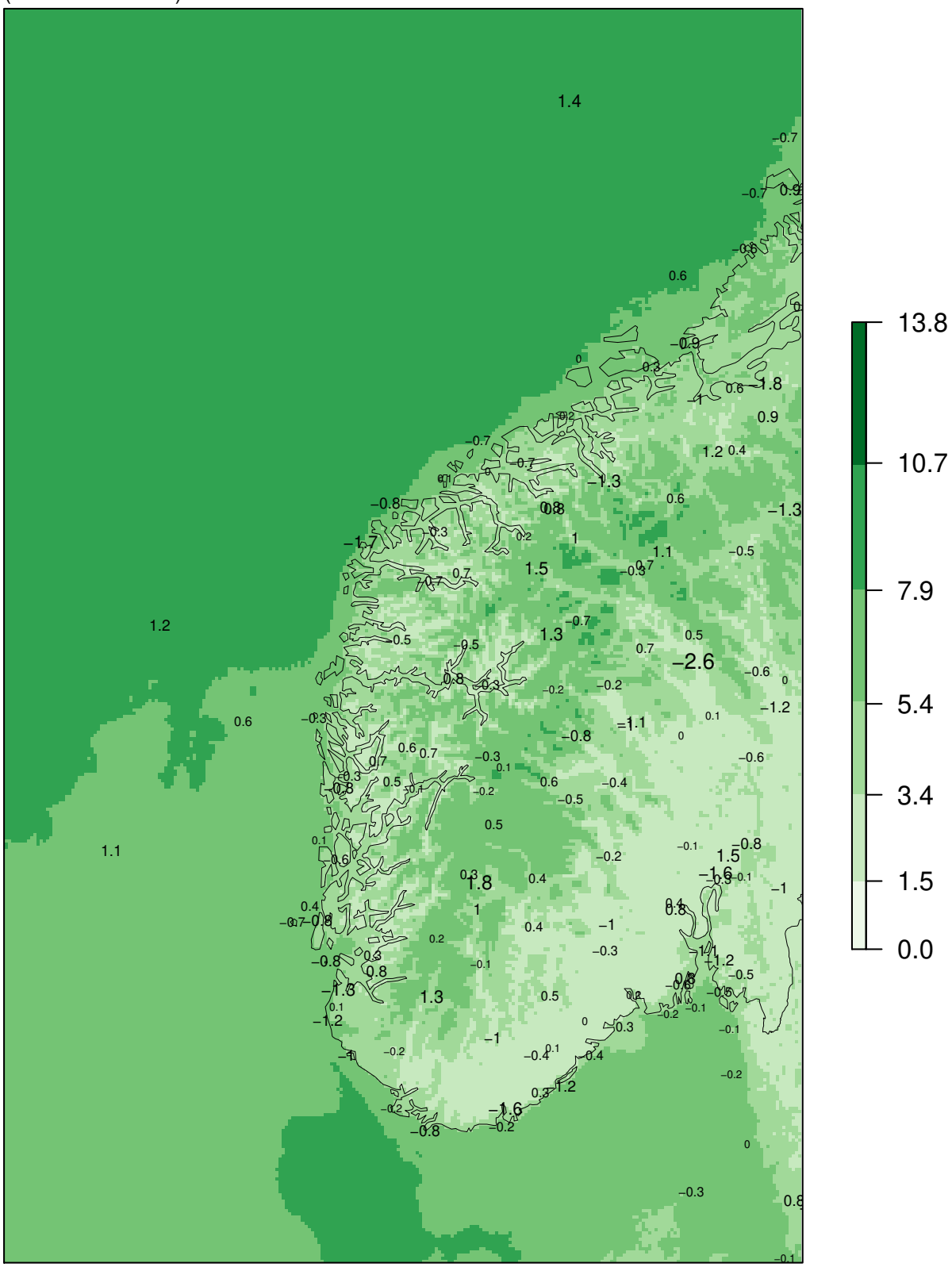
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

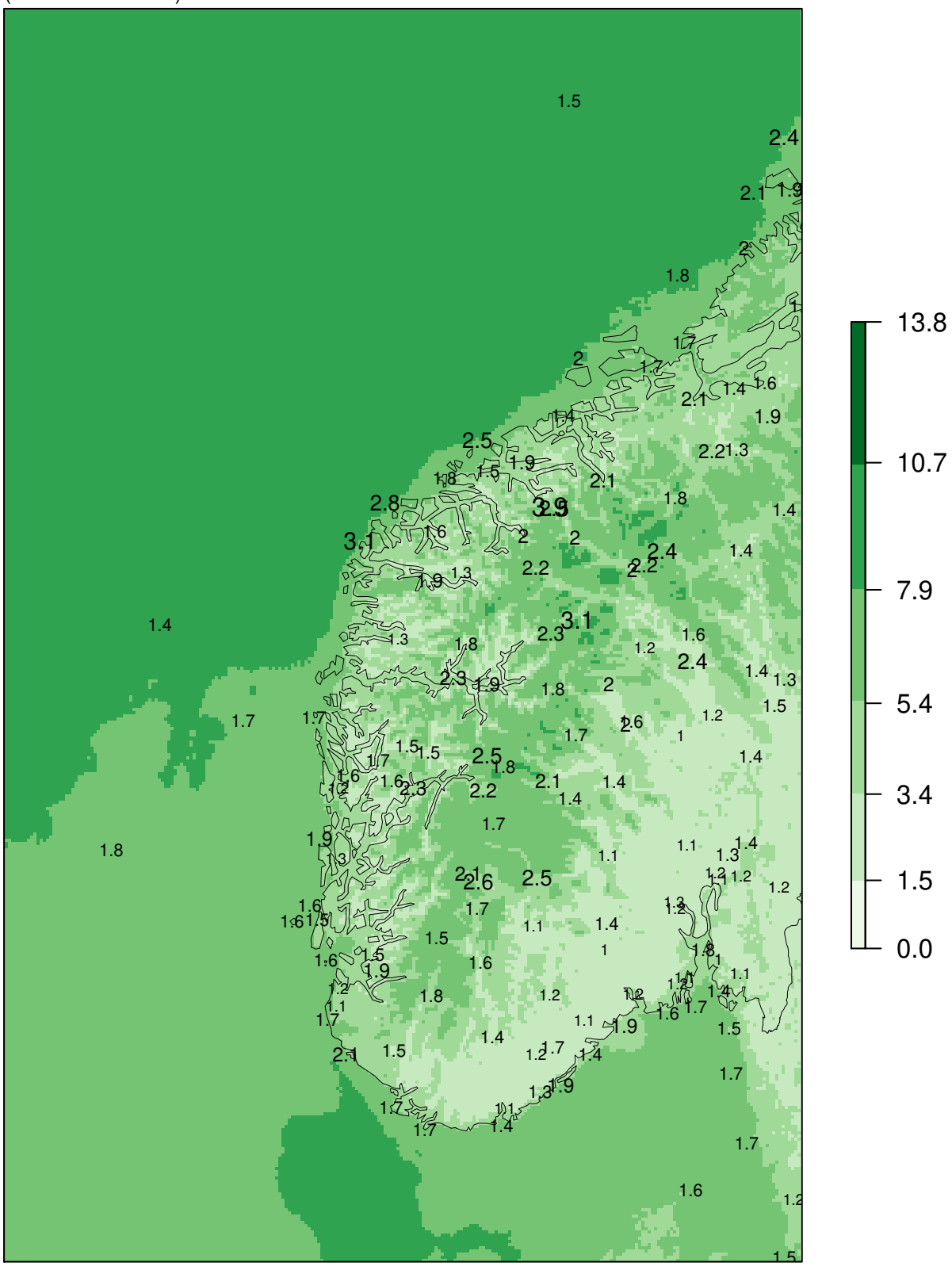
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

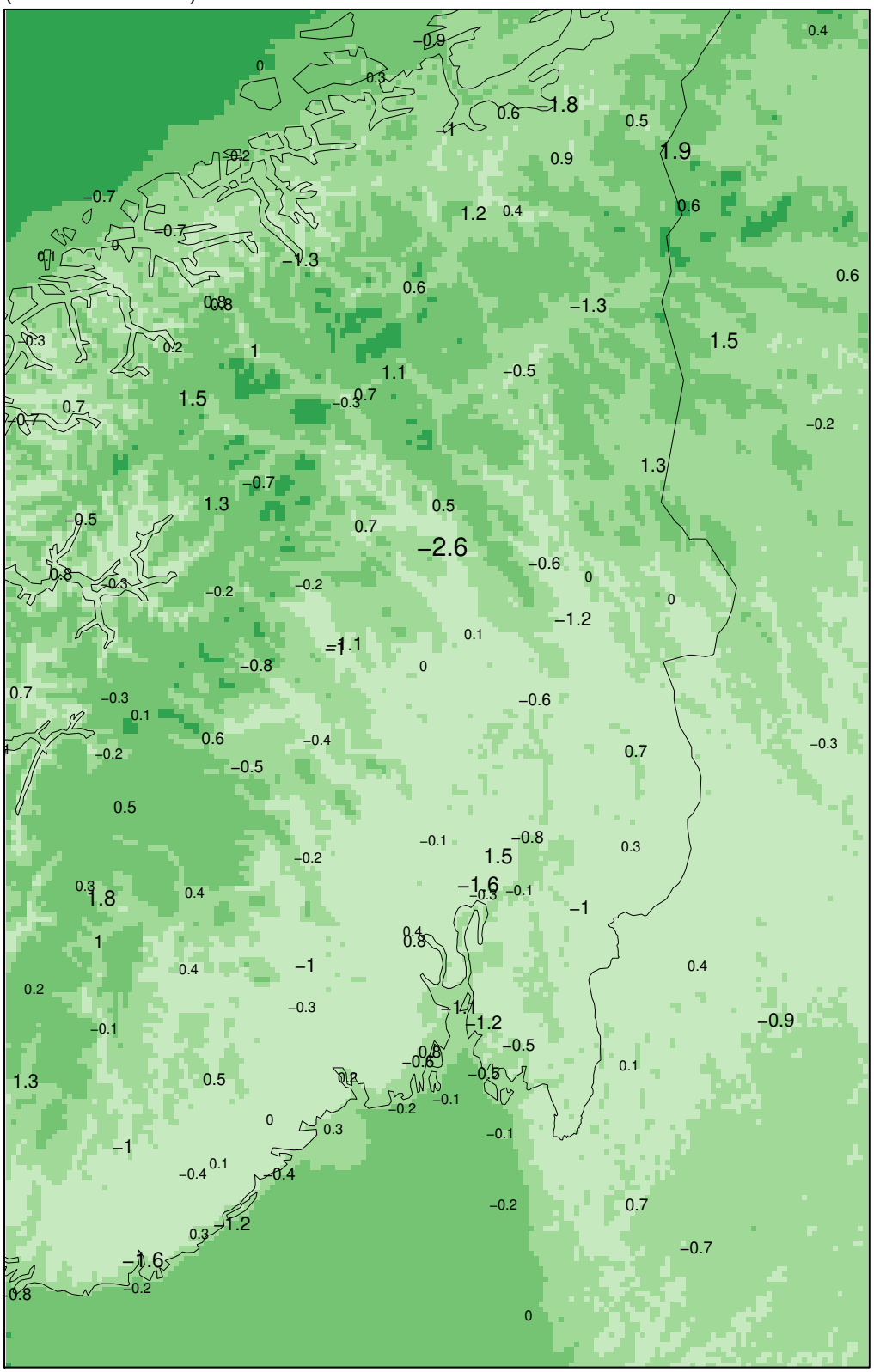
SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+12

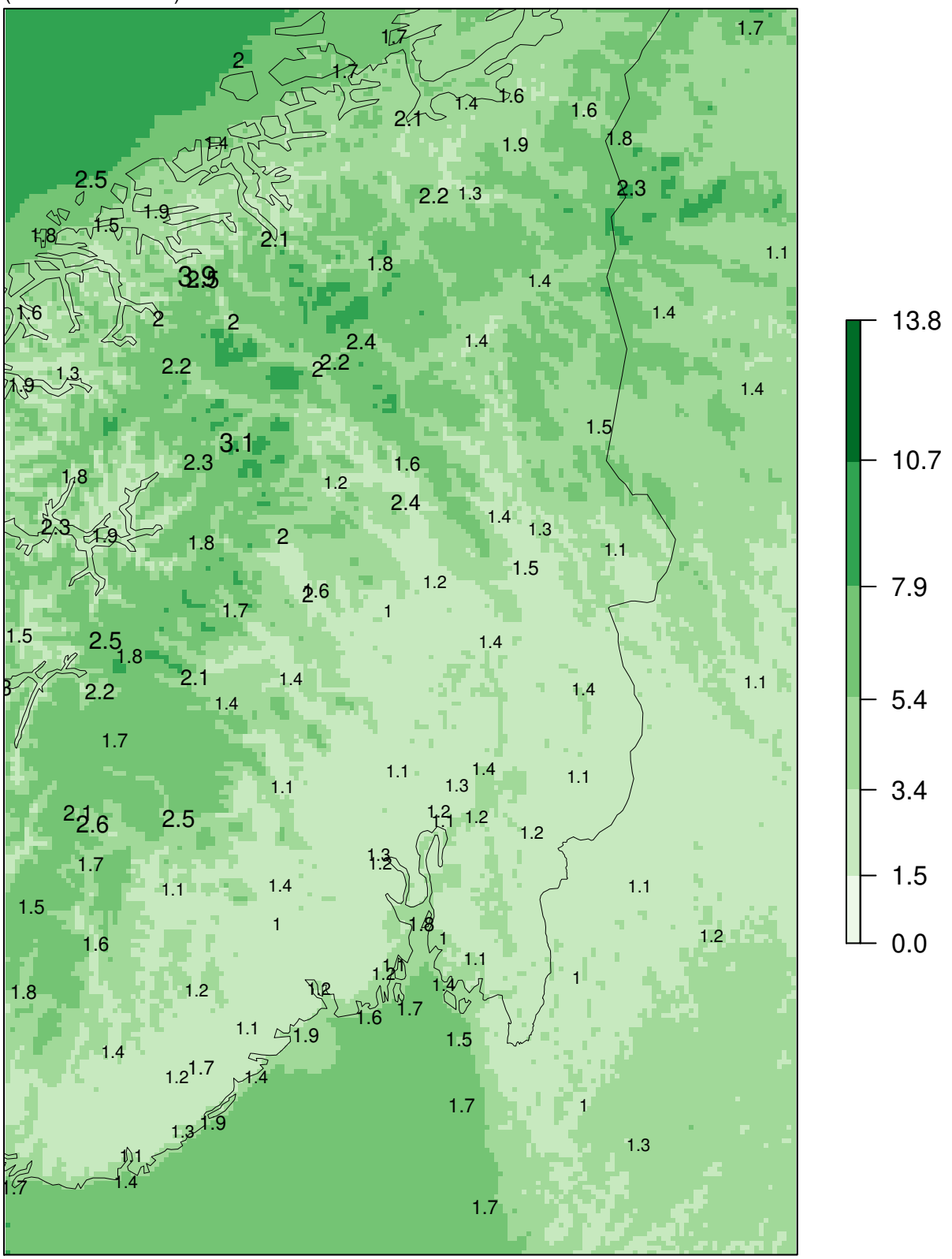
ME at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

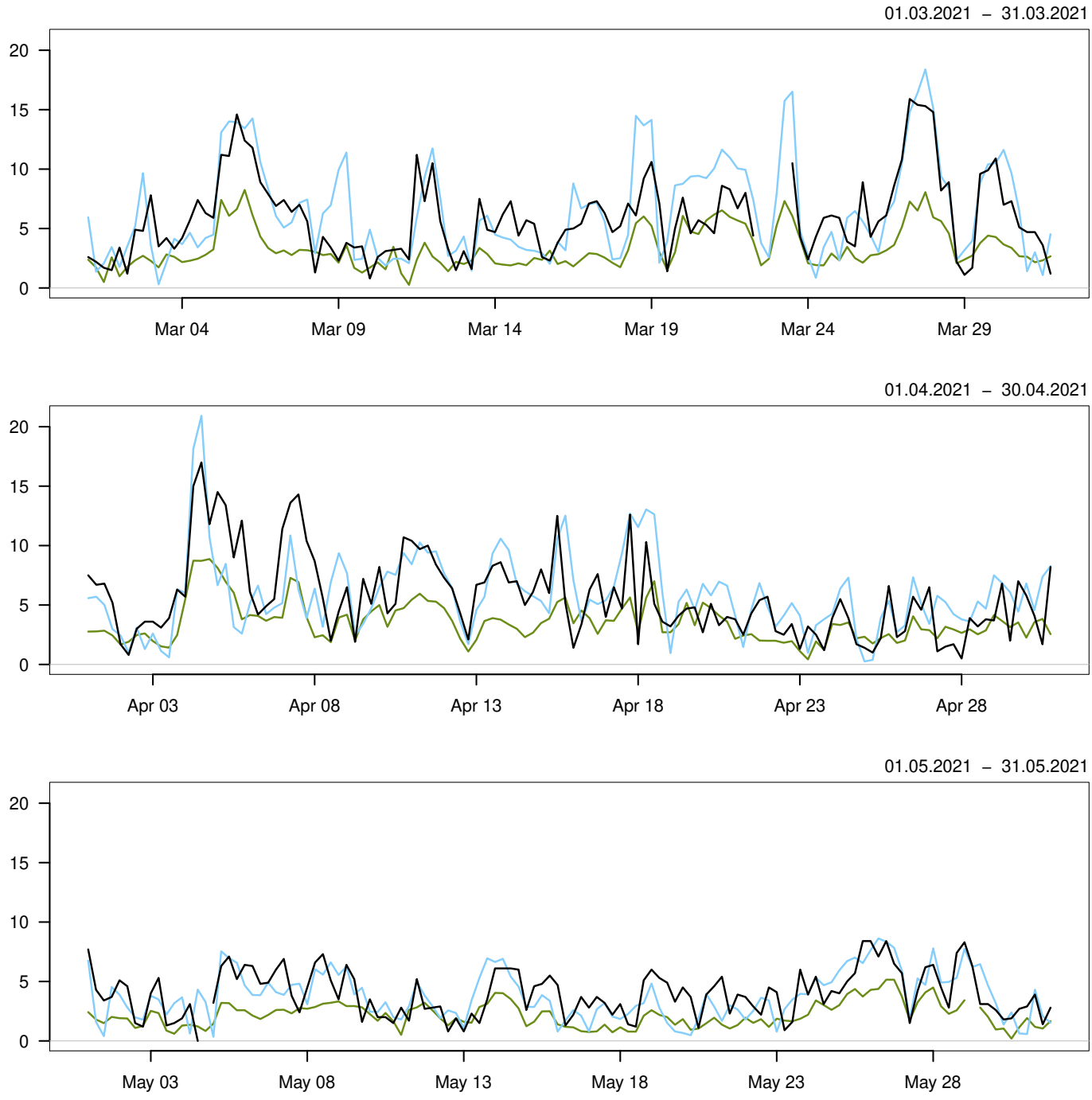
MEPSctrl 00+12

SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

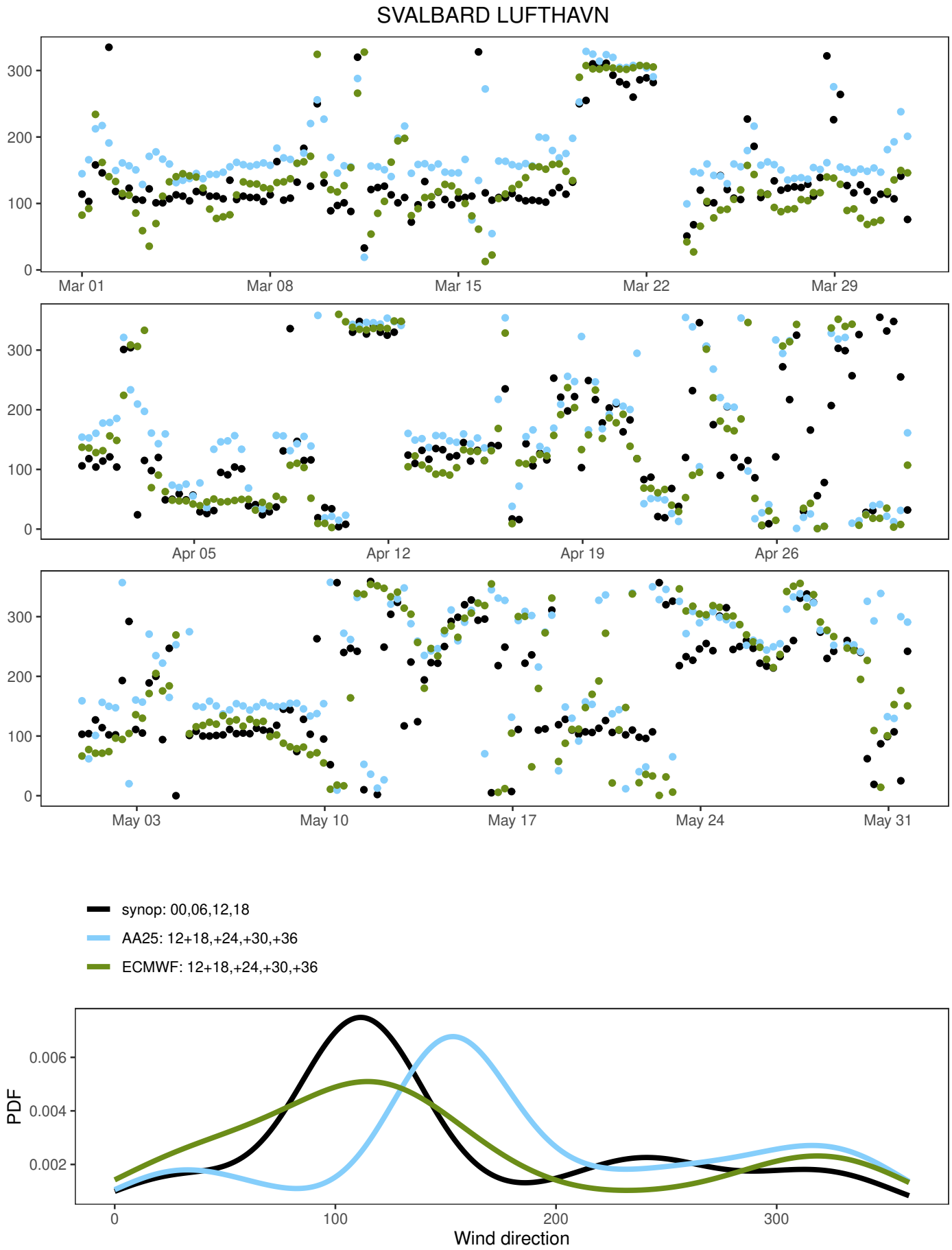
SVALBARD LUFTHAVN



01.03.2021 – 31.05.2021

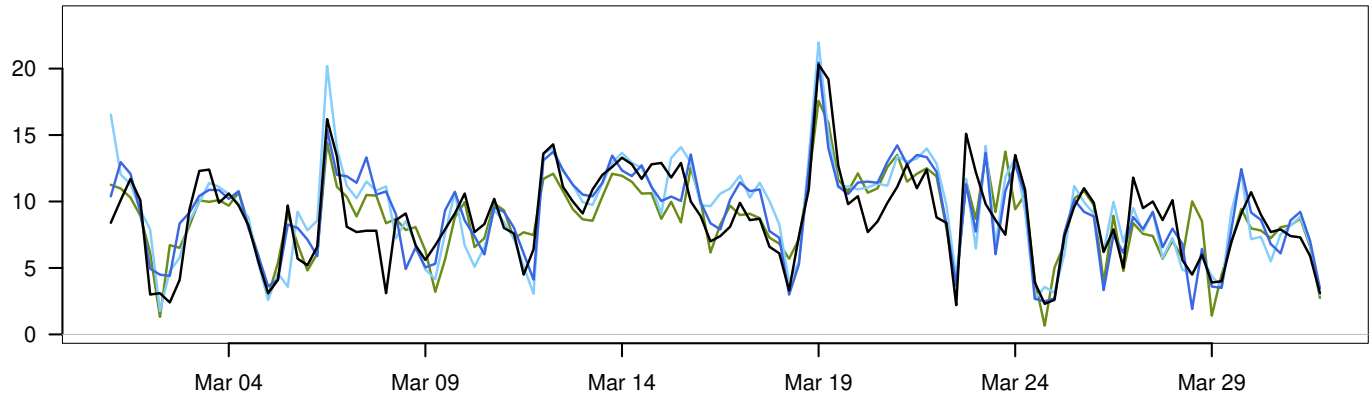
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	5.2	17	3.1	367
AA25: 12+18,+24,+30,+36	0.3	5.4	20.9	3.5	372
ECMWF: 12+18,+24,+30,+36	0.2	3	8.9	1.6	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25 – synop	0.2	2.5	2.5	1.9	9.9	367
ECMWF – synop	–2.2	2.2	3.1	2.4	8.9	366

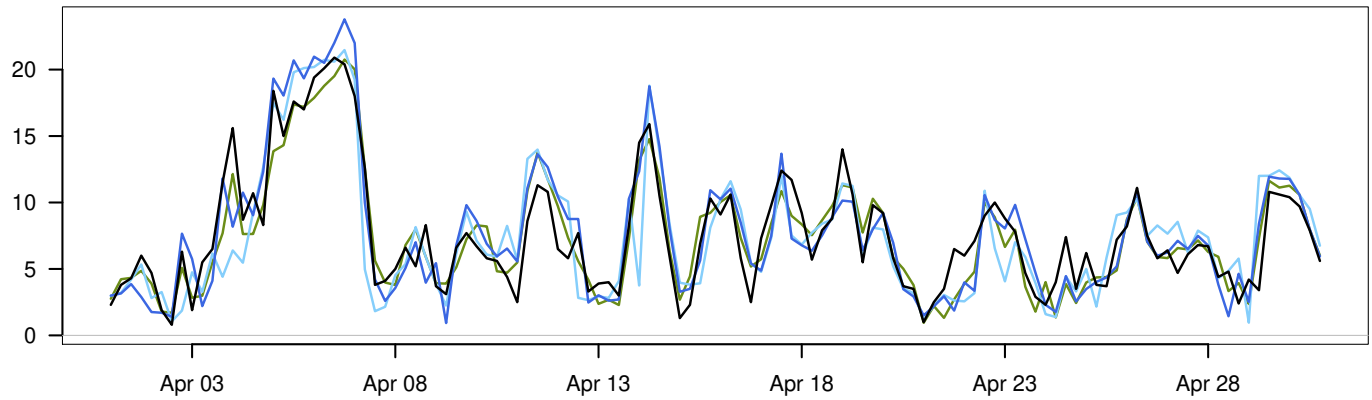

SVALBARD LUFTHAVN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
Wind direction

BJØRNØYA

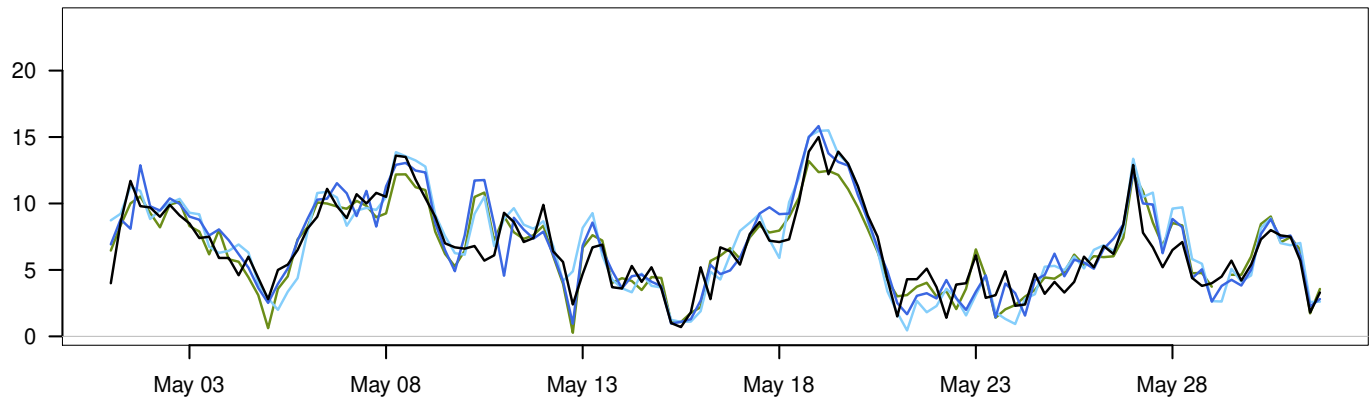
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



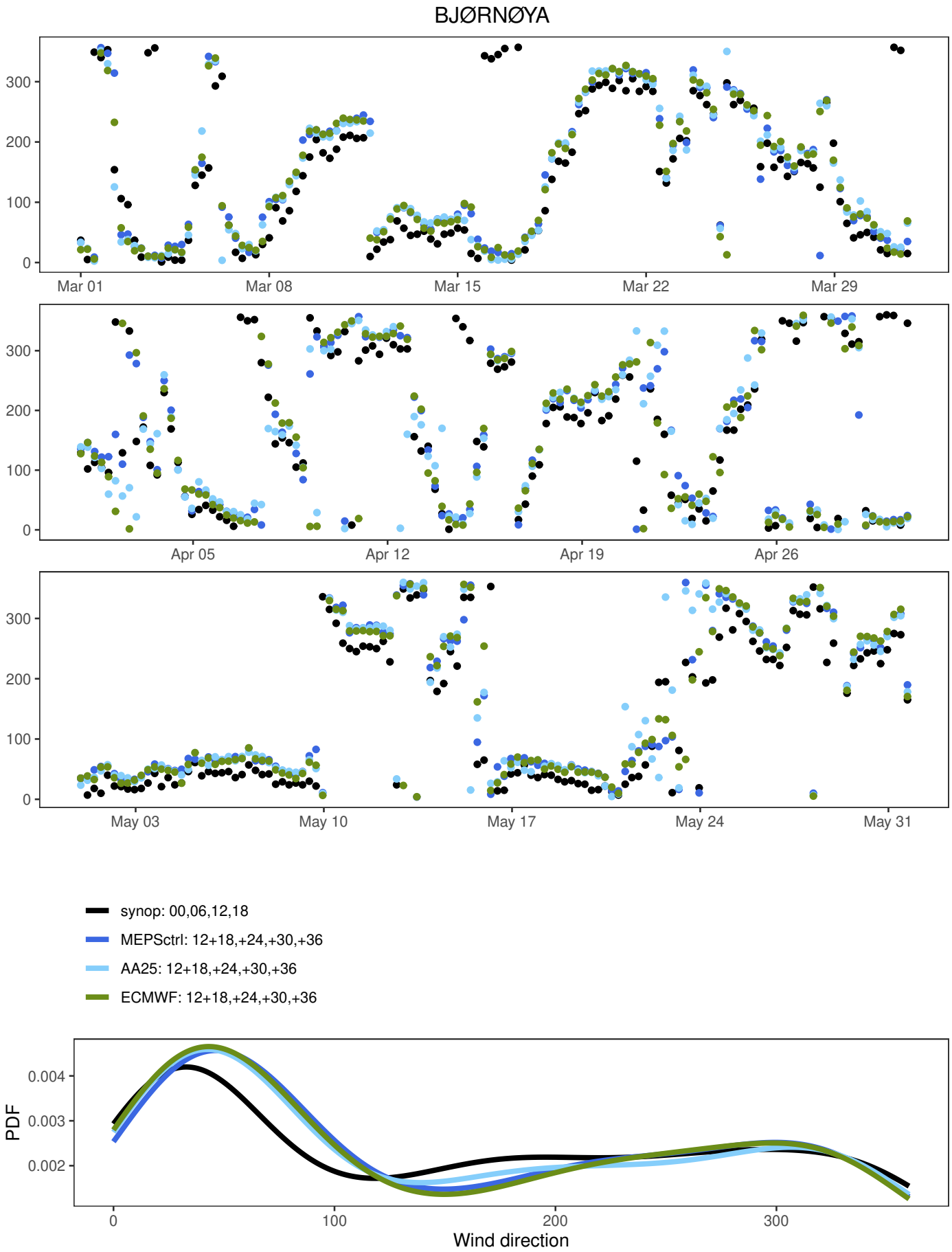
01.05.2021 – 31.05.2021



01.03.2021 – 31.05.2021

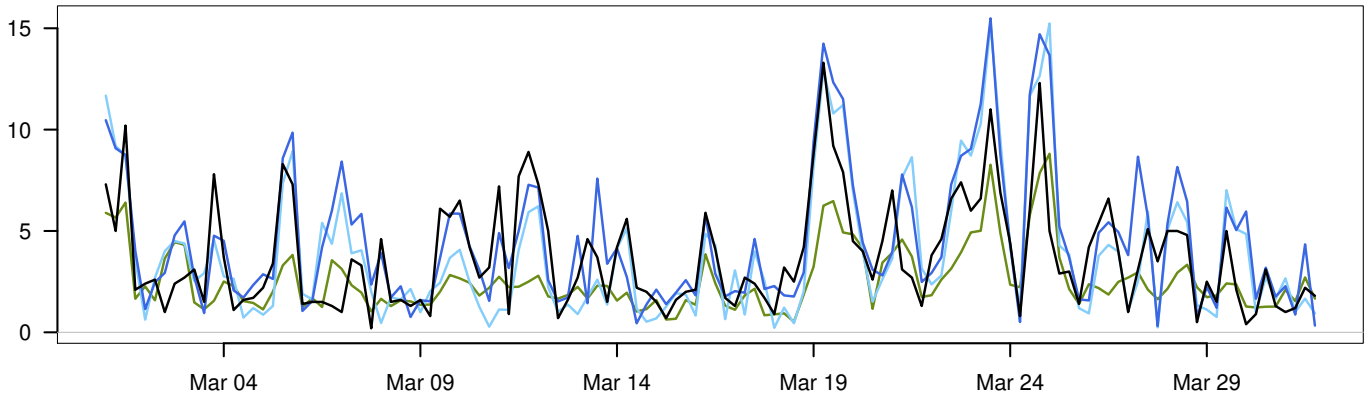
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.7	7.7	20.9	3.7	372
MEPSctrl: 12+18,+24,+30,+36	0.9	7.9	23.8	4.1	372
AA25: 12+18,+24,+30,+36	0.4	7.9	22	4.1	372
ECMWF: 12+18,+24,+30,+36	0.3	7.6	20.8	3.5	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.2	1.9	2	1.5	7.7	372
AA25 – synop	0.2	2.3	2.3	1.7	10.7	372
ECMWF – synop	–0.1	1.7	1.7	1.3	6.3	371

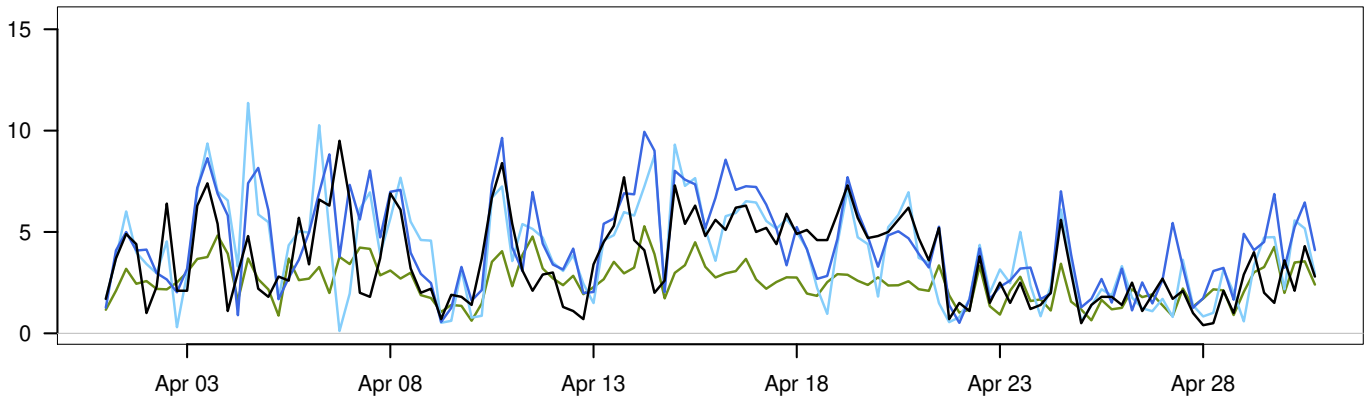

BJØRNØYA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0
100
200
300
Wind direction

TROMSØ

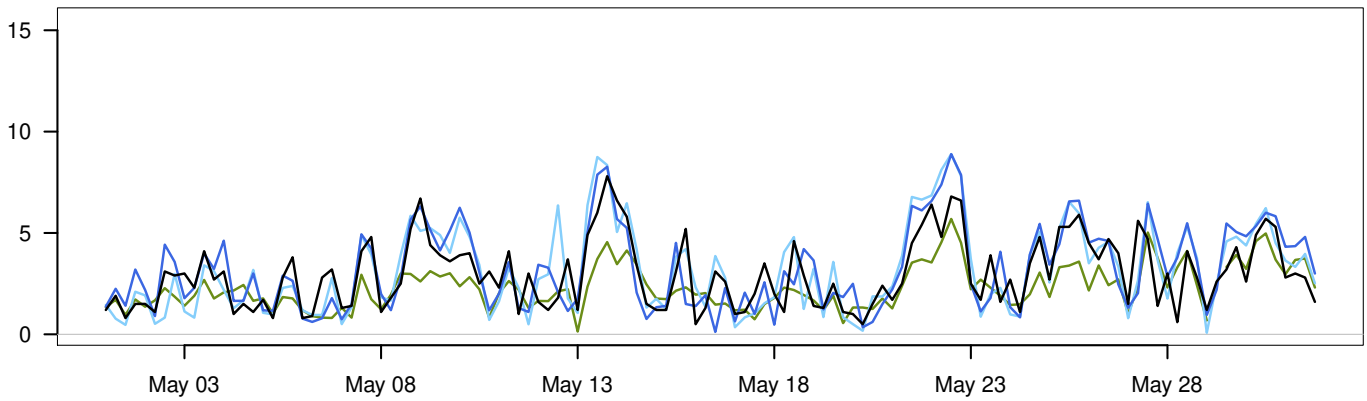
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



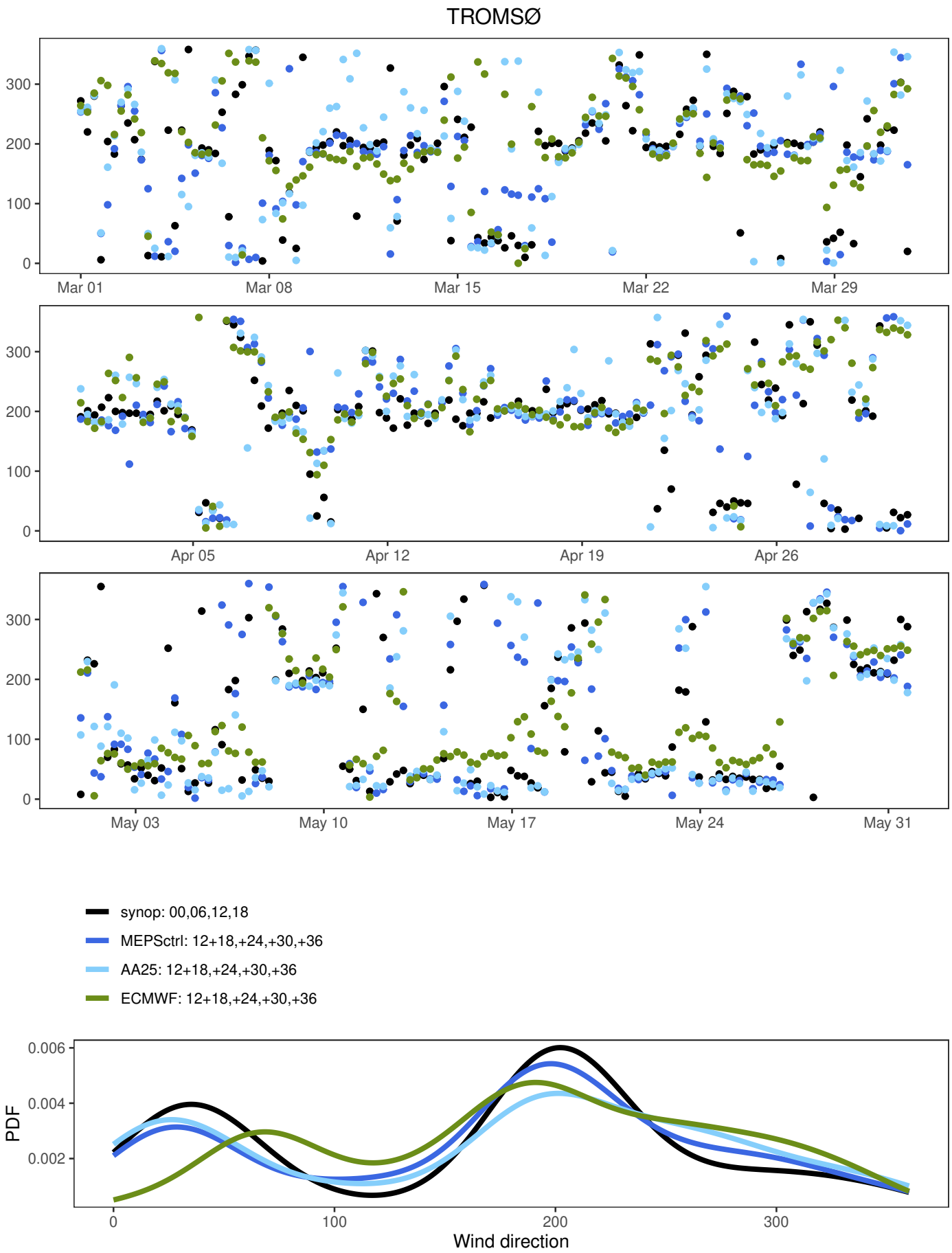
01.05.2021 – 31.05.2021



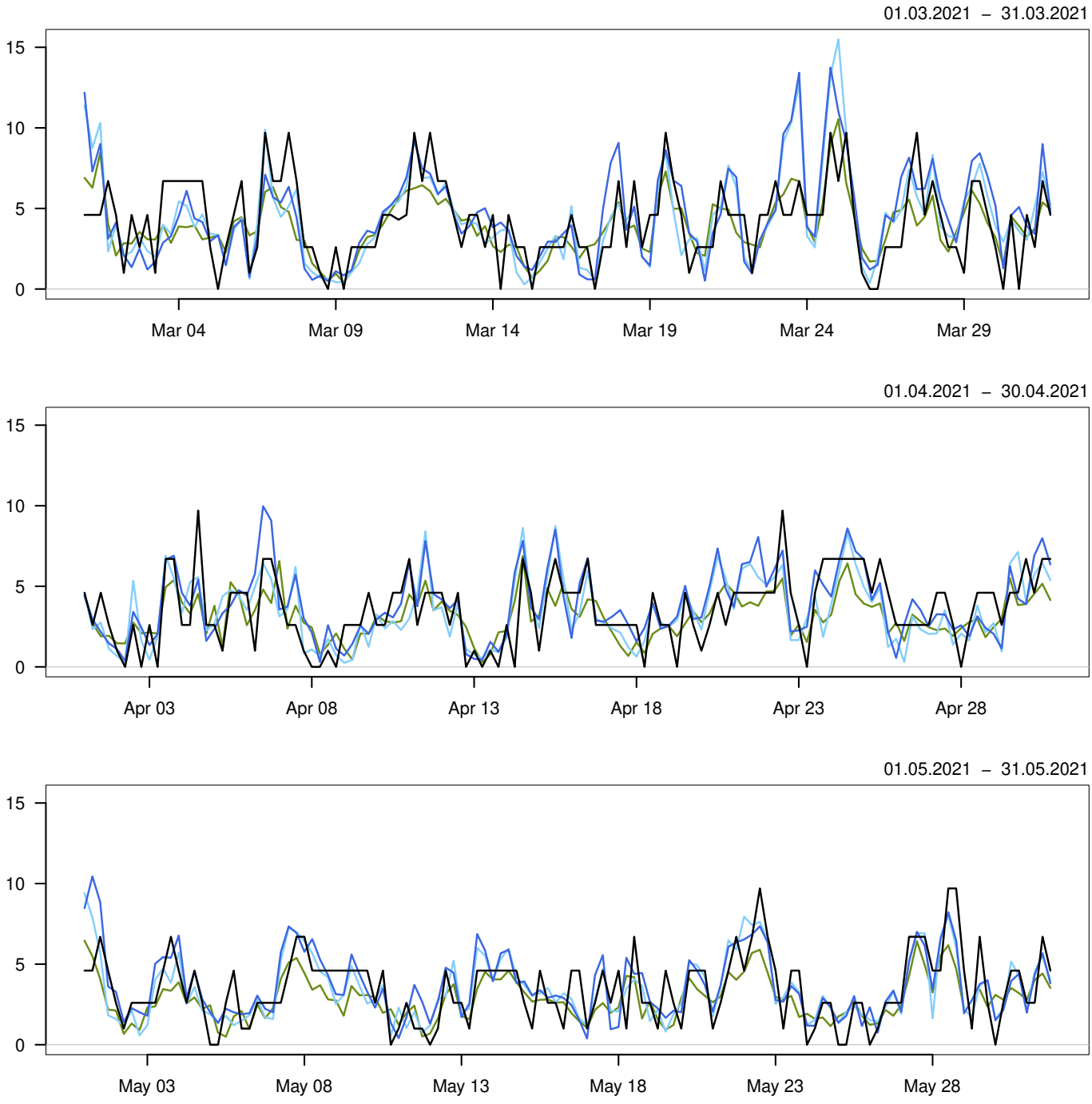
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	3.4	13.3	2.2	372
MEPSctrl: 12+18,+24,+30,+36	0.1	4	15.5	2.7	372
AA25: 12+18,+24,+30,+36	0.1	3.7	15.3	2.7	372
ECMWF: 12+18,+24,+30,+36	0.1	2.5	8.8	1.2	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.6	1.8	1.9	1.4	8.7	372
AA25 – synop	0.2	2	2	1.4	10.2	372
ECMWF – synop	−1	1.7	2	1.5	7.1	371


TROMSØ
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

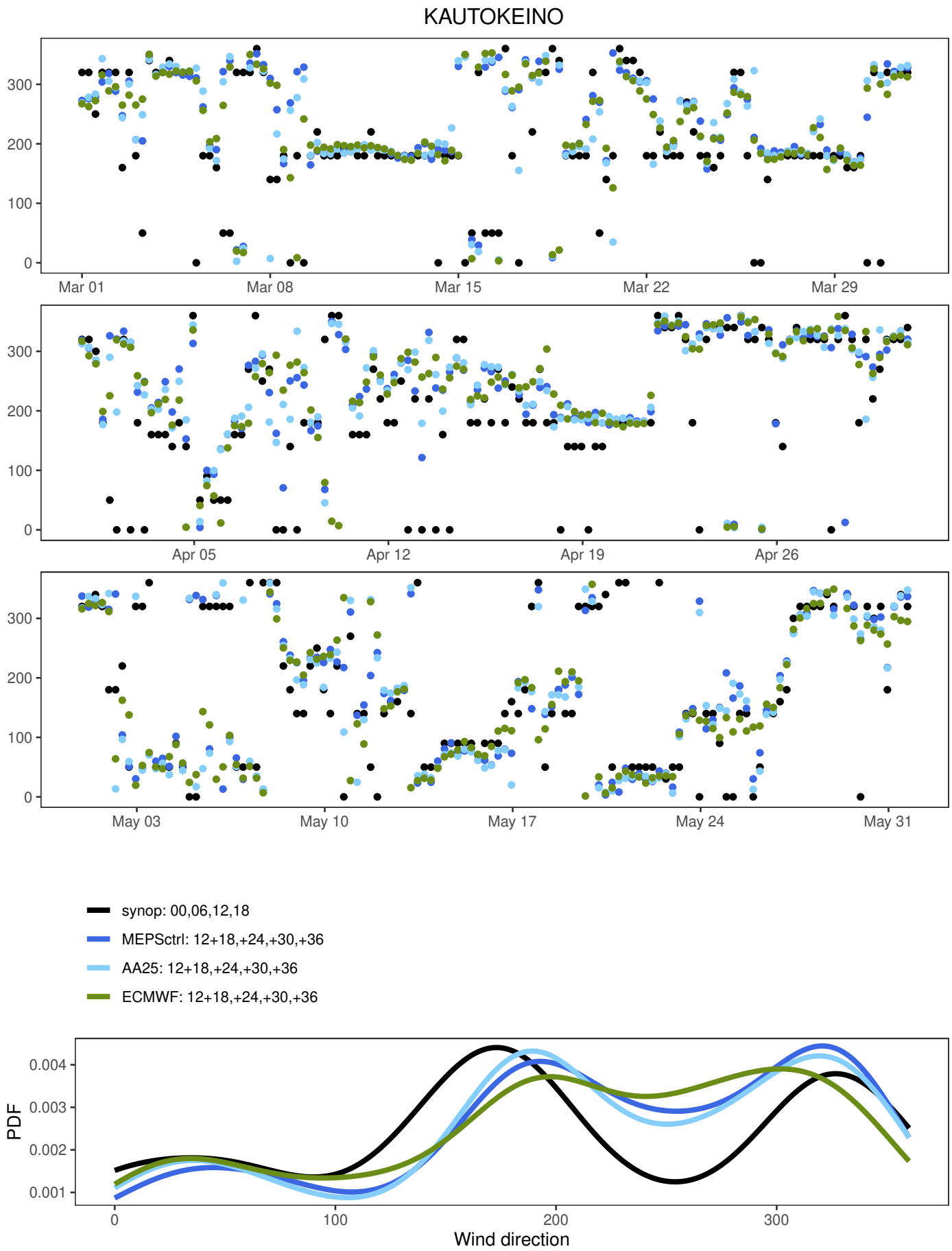
KAUTOKEINO



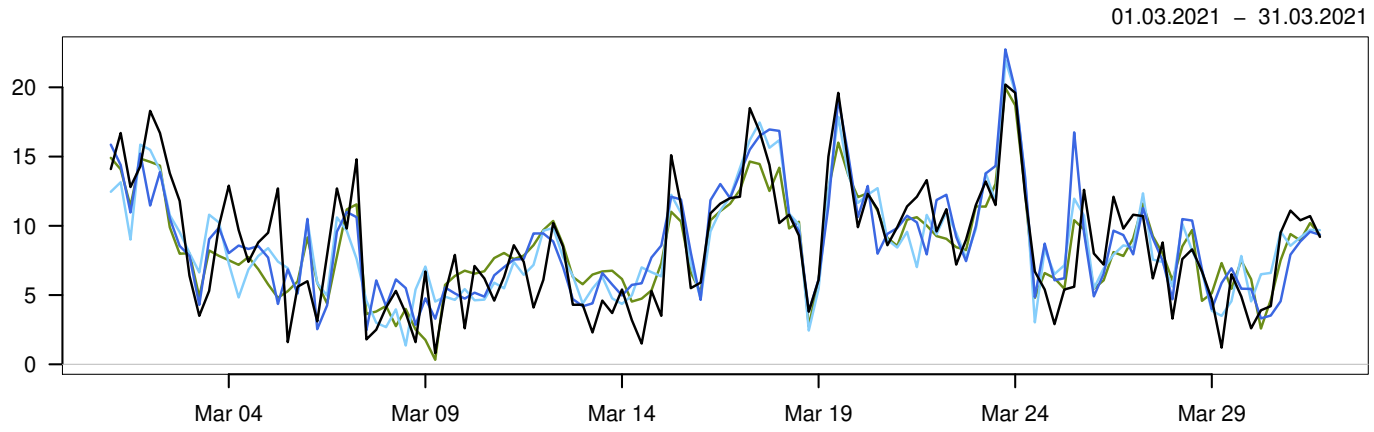
01.03.2021 – 31.05.2021

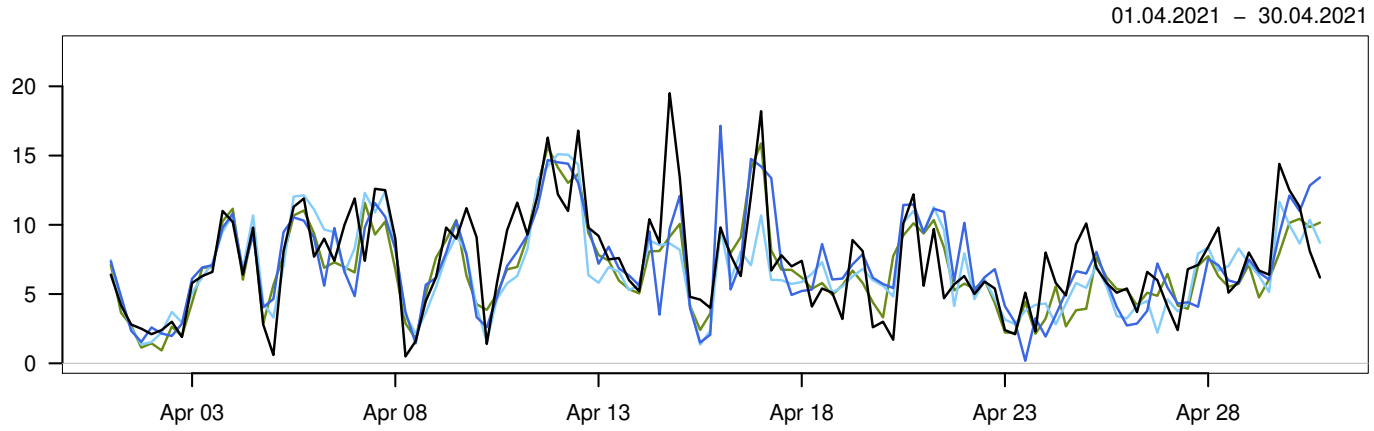
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	3.7	9.7	2.3	372
MEPSctrl: 12+18,+24,+30,+36	0.3	4.1	13.7	2.4	372
AA25: 12+18,+24,+30,+36	0.3	3.8	15.5	2.4	372
ECMWF: 12+18,+24,+30,+36	0.3	3.3	10.5	1.6	371

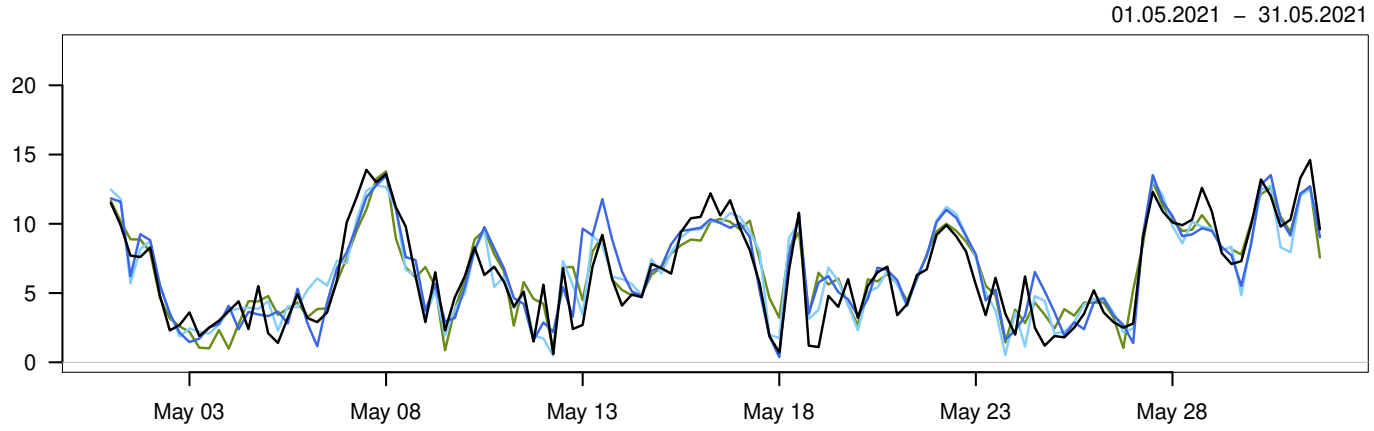
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.3	1.9	1.9	1.5	7.6	372
AA25 – synop	0	1.9	1.9	1.5	8.8	372
ECMWF – synop	–0.4	1.7	1.8	1.4	5.8	371


KAUTOKEINO
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

SLETTNES FYR



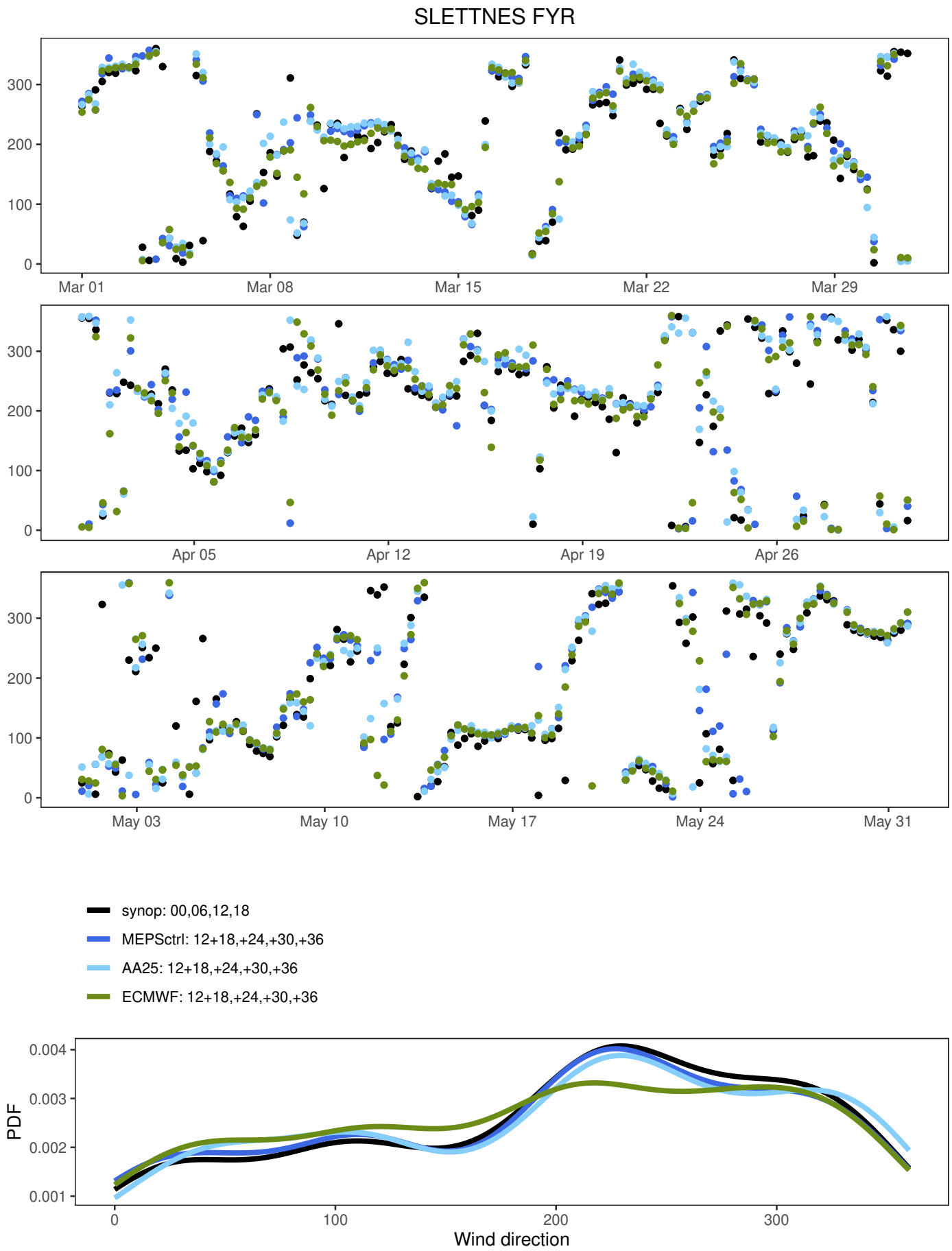




01.03.2021 – 31.05.2021

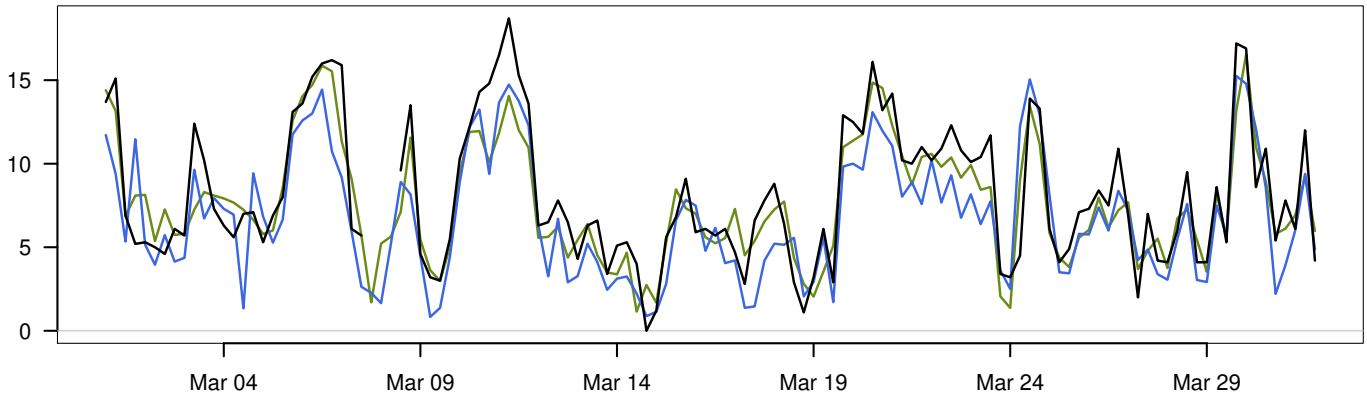
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	7.5	20.2	4	372
MEPSctrl: 12+18,+24,+30,+36	0.2	7.5	22.7	3.7	372
AA25: 12+18,+24,+30,+36	0.5	7.3	22	3.5	372
ECMWF: 12+18,+24,+30,+36	0.3	7.3	20	3.3	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.1	2.4	2.4	1.7	11.1	372
AA25 – synop	−0.2	2.2	2.2	1.7	10.8	372
ECMWF – synop	−0.2	2.2	2.2	1.6	10.4	371

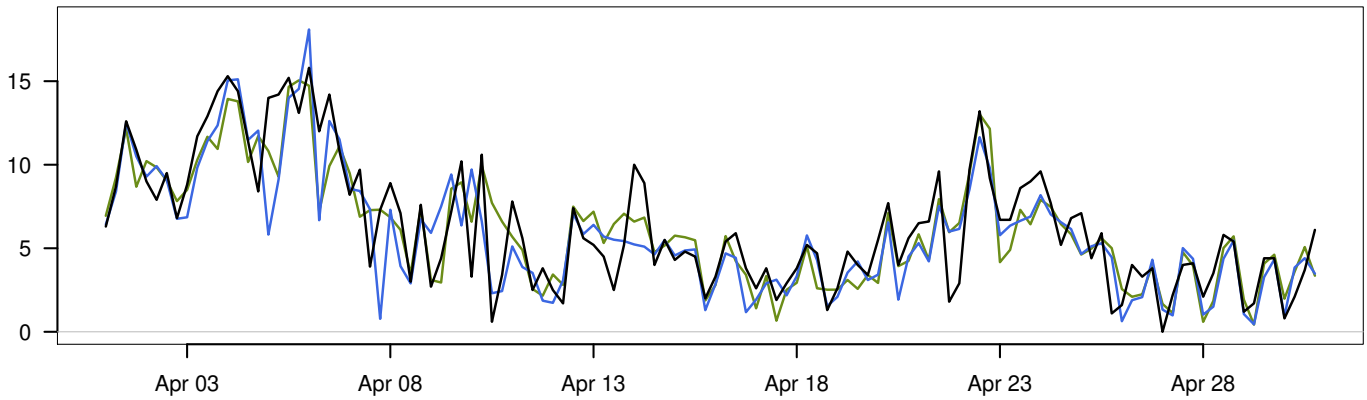

SLETTNES FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

ØRLAND III

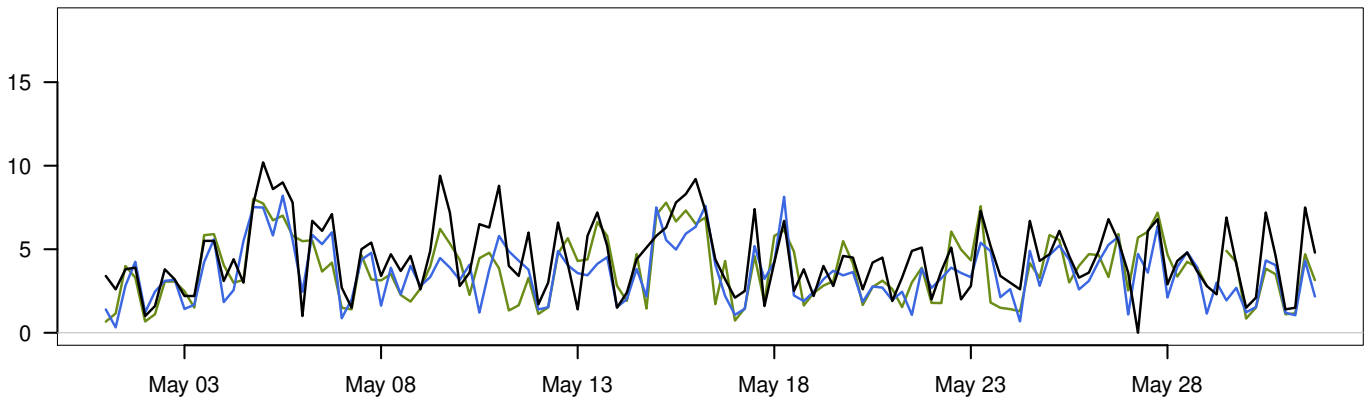
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



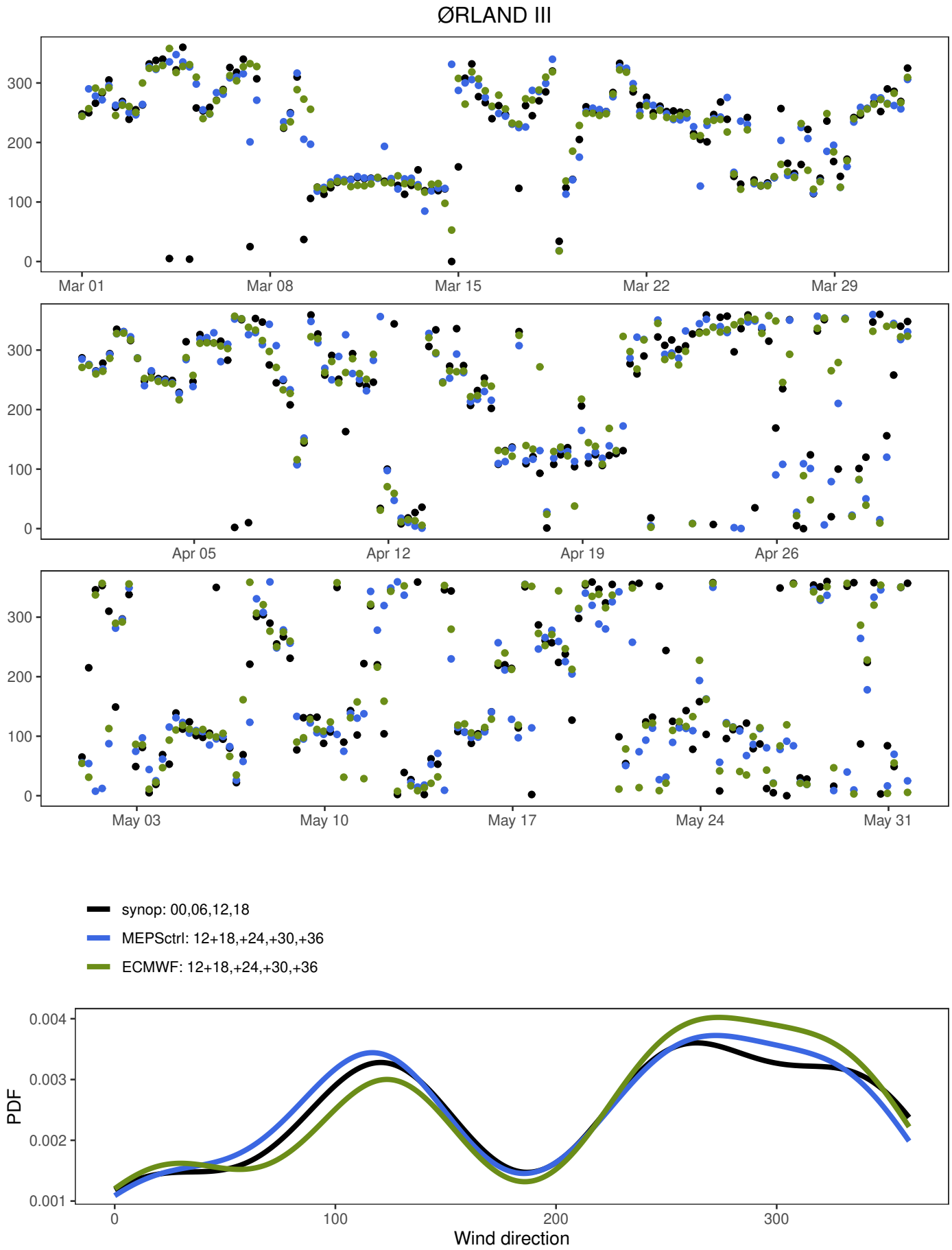
01.05.2021 – 31.05.2021



01.03.2021 – 31.05.2021

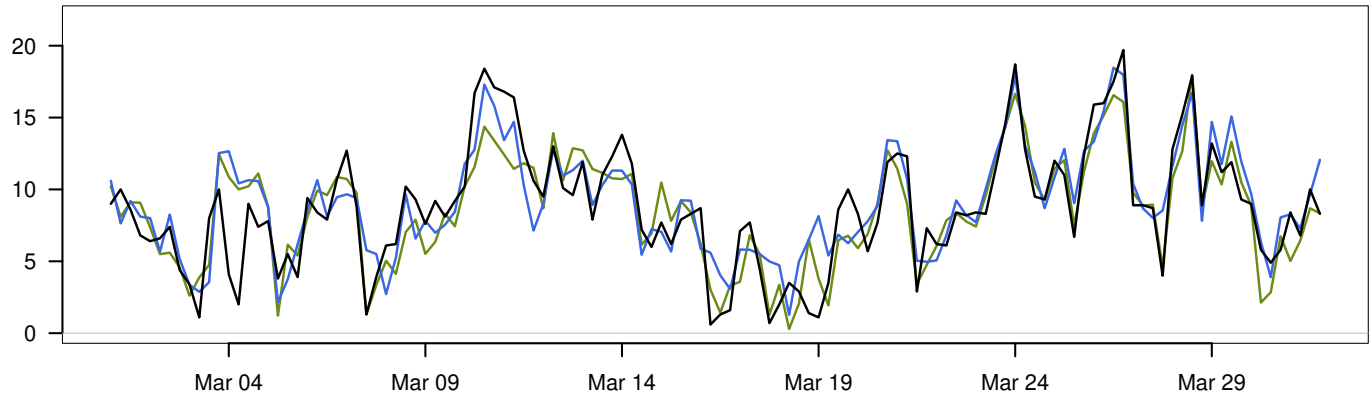
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	6.3	18.7	3.8	369
MEPSctrl: 12+18,+24,+30,+36	0.3	5.4	18.1	3.4	372
ECMWF: 12+18,+24,+30,+36	0.4	5.8	16.5	3.4	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.9	1.9	2.1	1.6	8.2	369
ECMWF – synop	−0.5	1.8	1.8	1.4	7.1	368

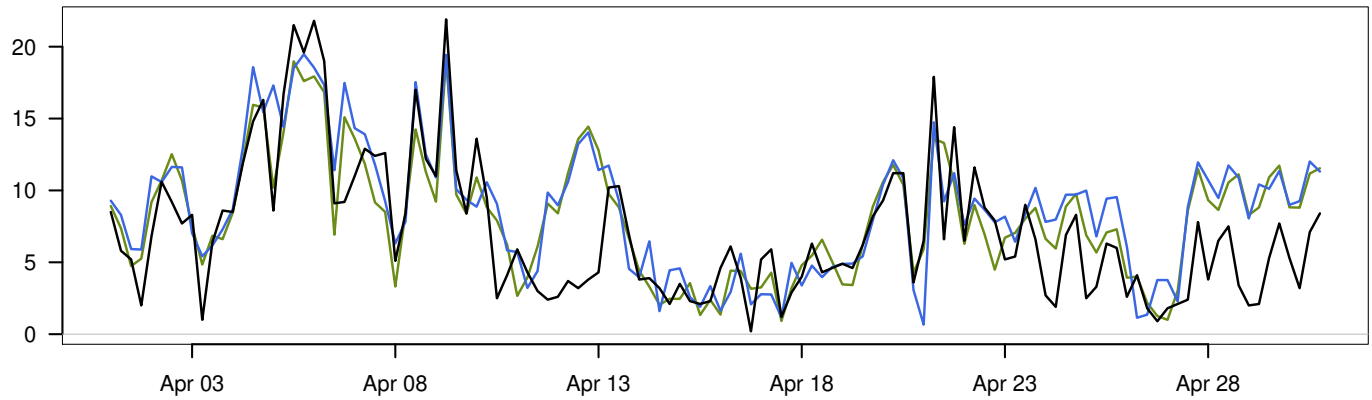

ØRLAND III
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

YTTERØYANE FYR

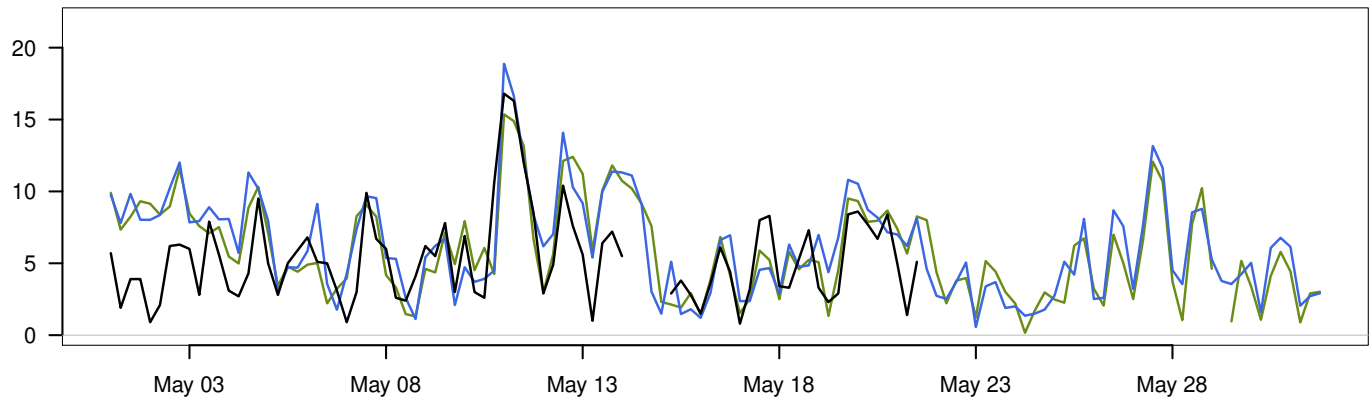
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



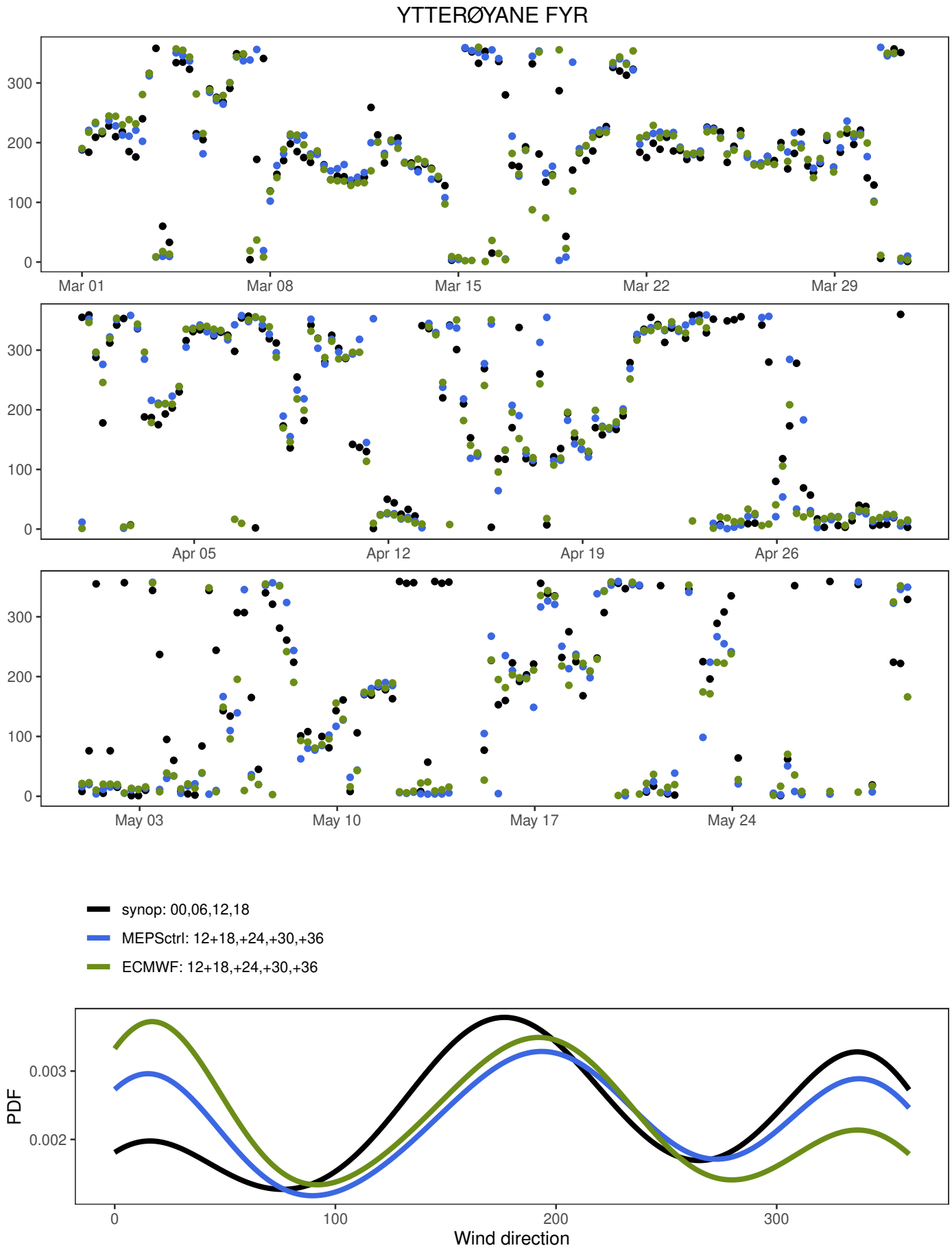
01.05.2021 – 31.05.2021



01.03.2021 – 31.05.2021

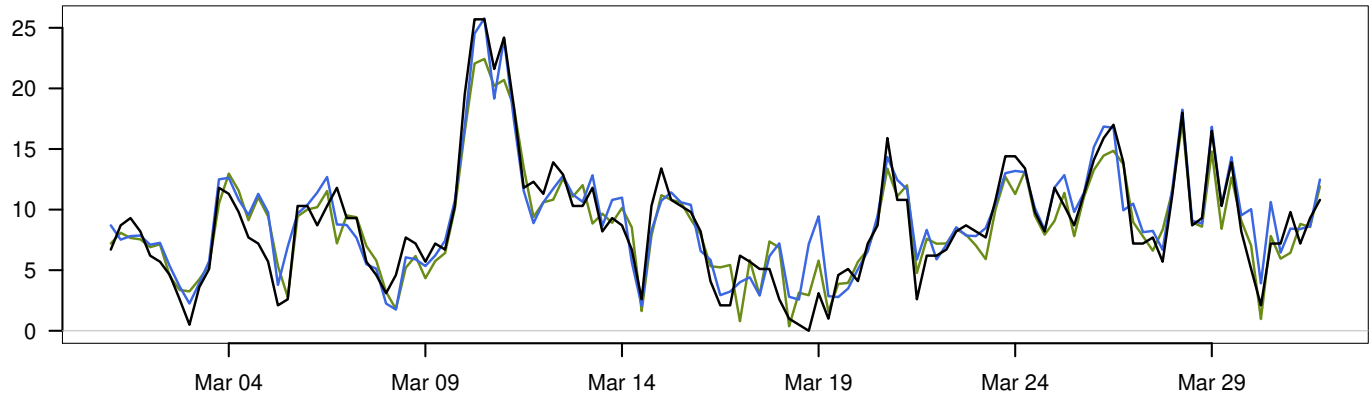
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	7.3	21.9	4.4	323
MEPSctrl: 12+18,+24,+30,+36	0.6	7.9	19.5	4.1	372
ECMWF: 12+18,+24,+30,+36	0.2	7.4	19.1	3.9	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	1.1	2.8	3.1	2.3	10.2	323
ECMWF – synop	0.6	2.7	2.8	2.1	10.6	323

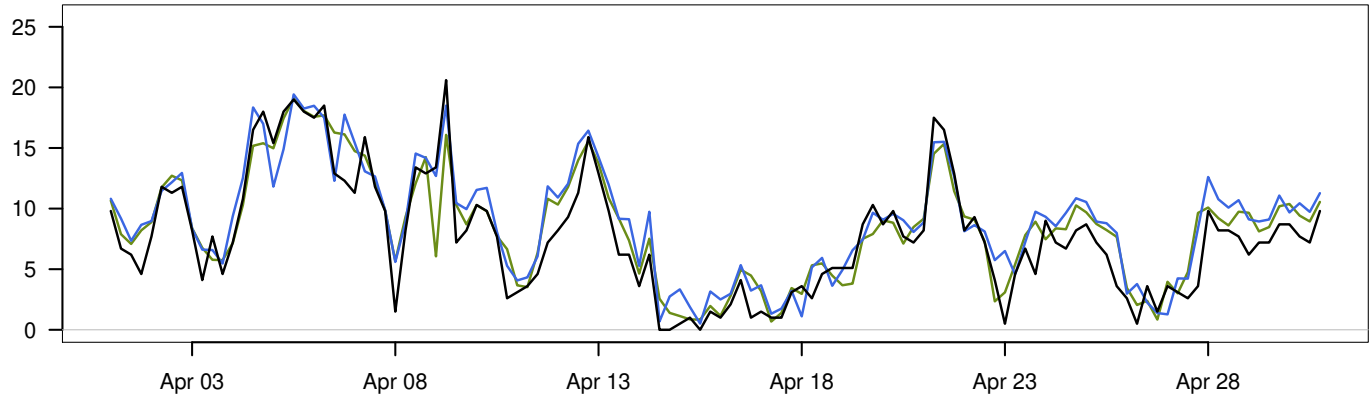

YTTERØYANE FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.003
0.002
0
100
200
300
Wind direction

TROLL A

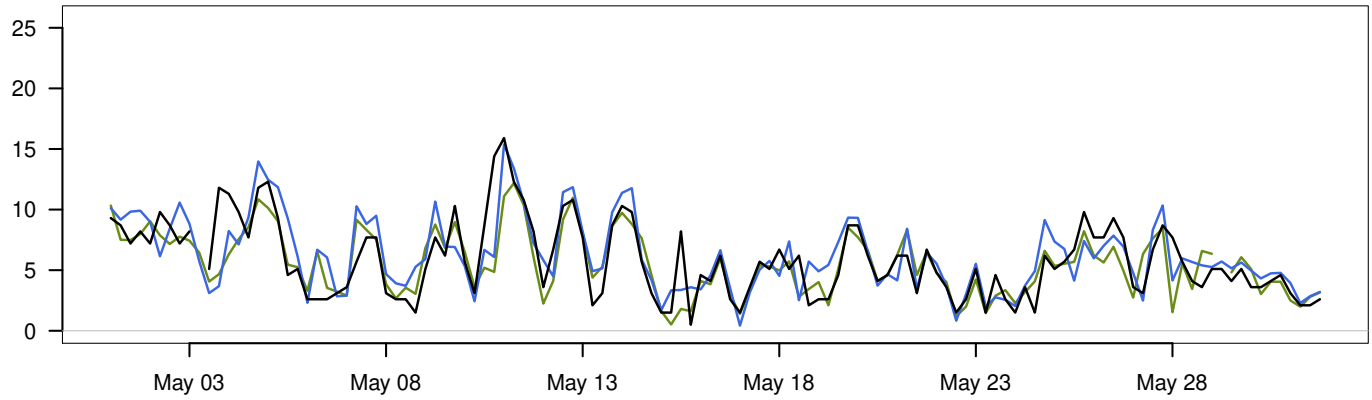
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



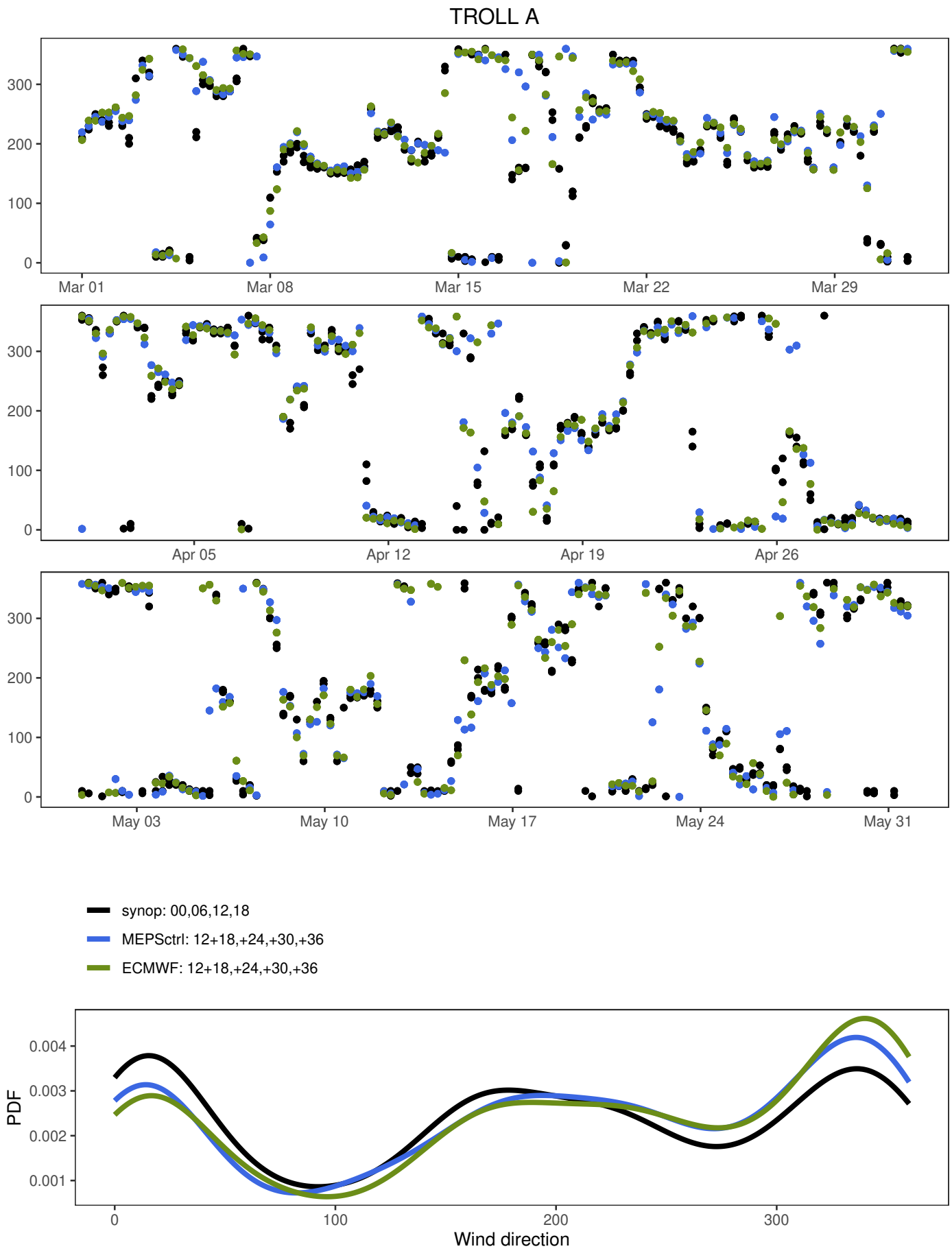
01.05.2021 – 31.05.2021



01.03.2021 – 31.05.2021

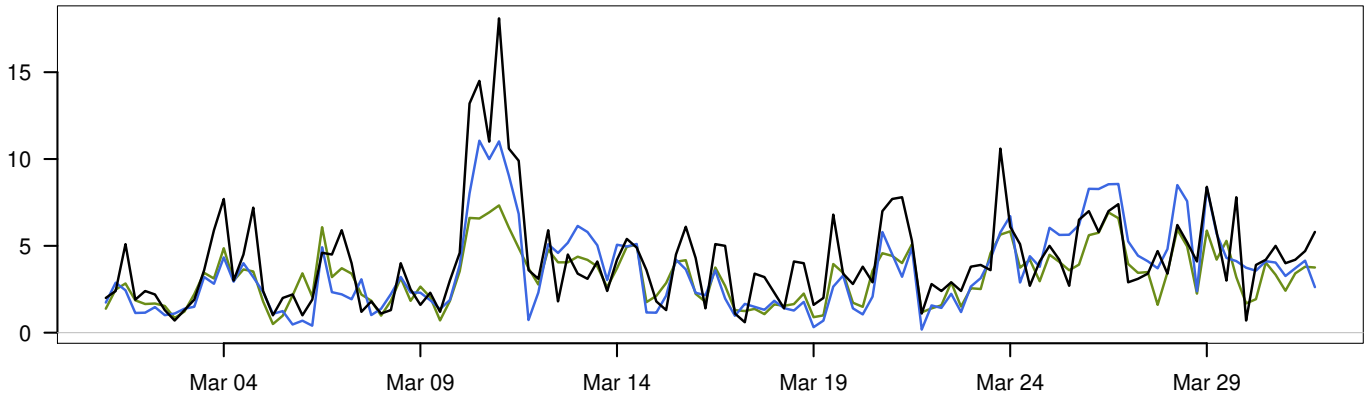
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	7.4	25.7	4.5	371
MEPSctrl: 12+18,+24,+30,+36	0.4	8.1	25.8	4.3	372
ECMWF: 12+18,+24,+30,+36	0.4	7.5	22.4	4.1	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.7	1.9	2.1	1.6	8.3	371
ECMWF – synop	0.1	1.9	1.9	1.4	9.5	370

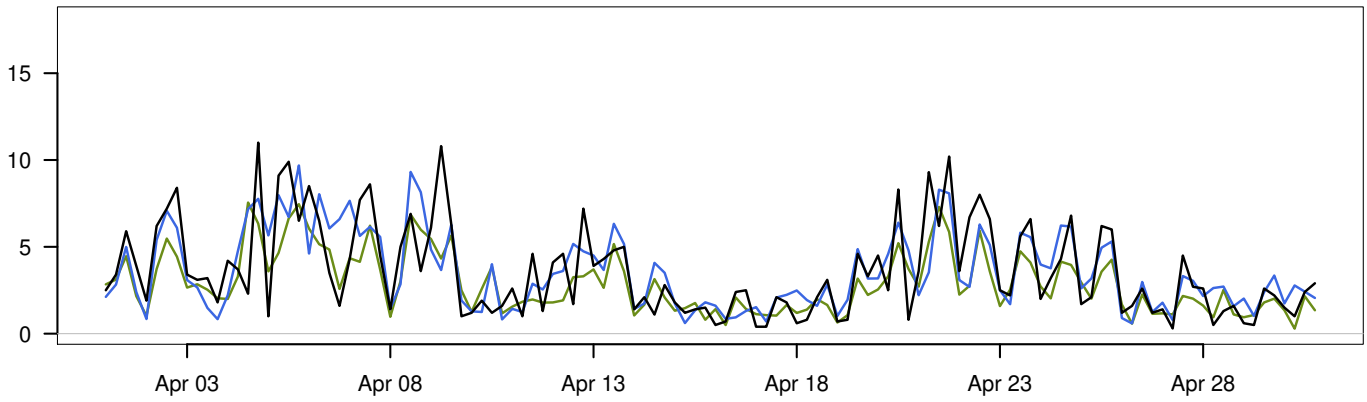

TROLL A
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

BERGEN – FLORIDA

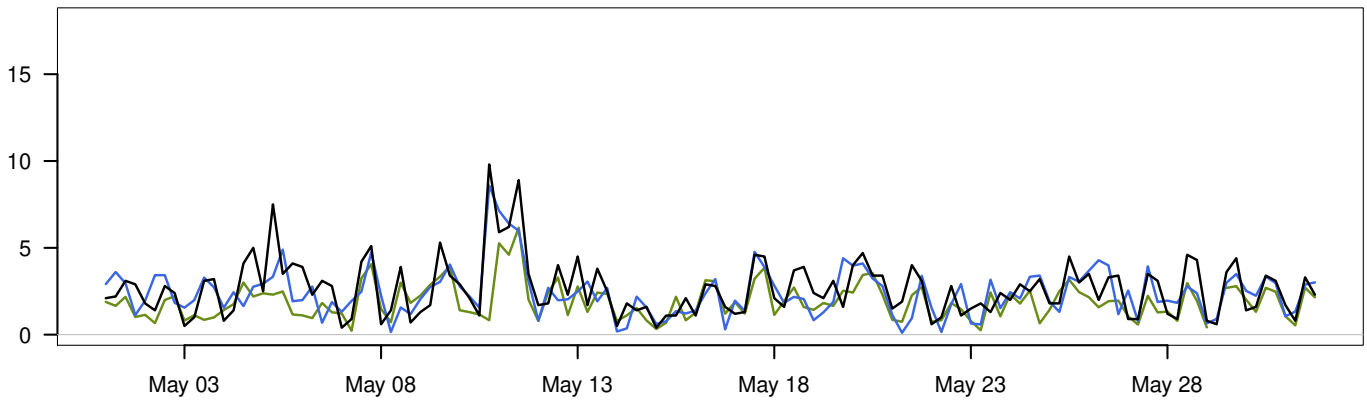
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



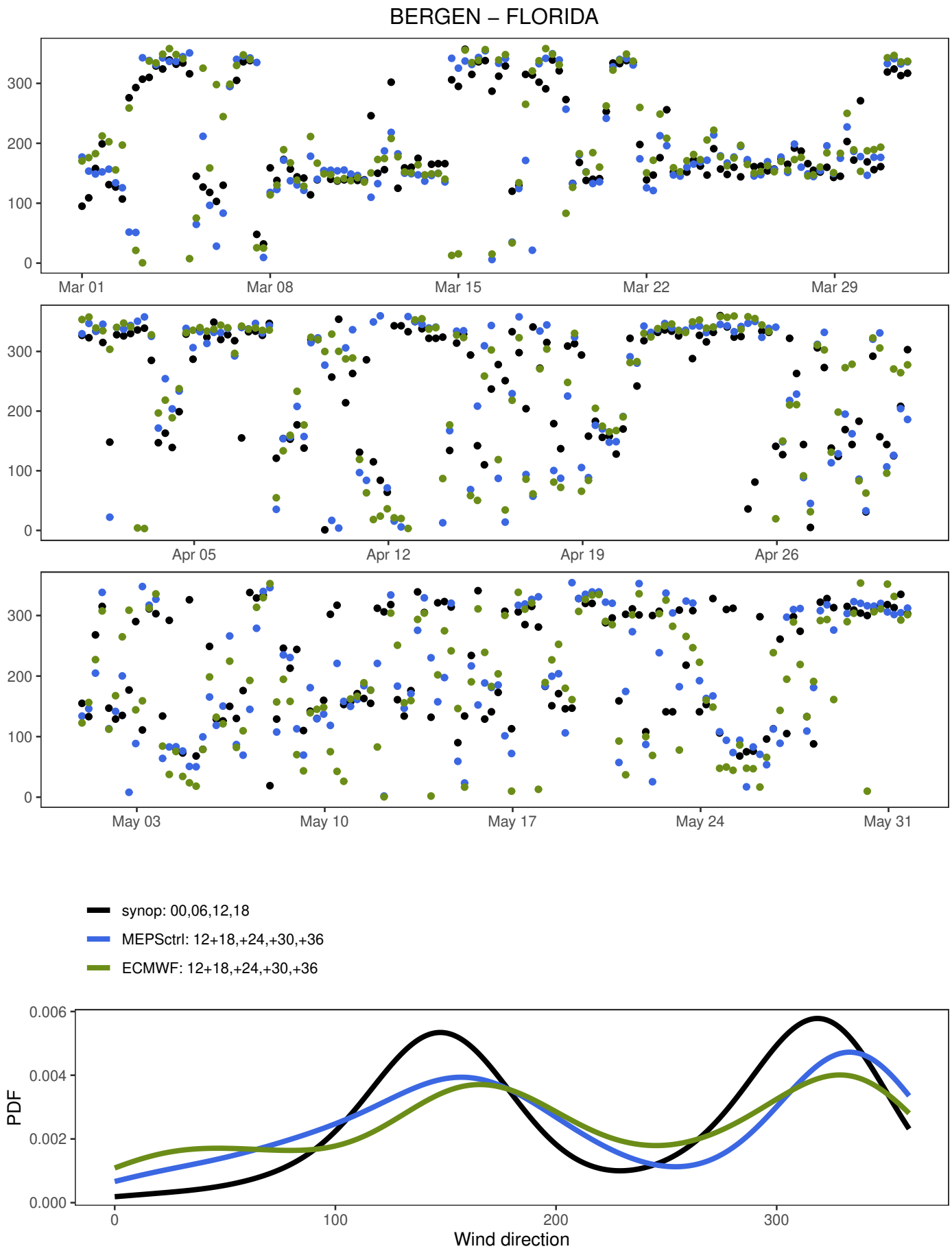
01.05.2021 – 31.05.2021



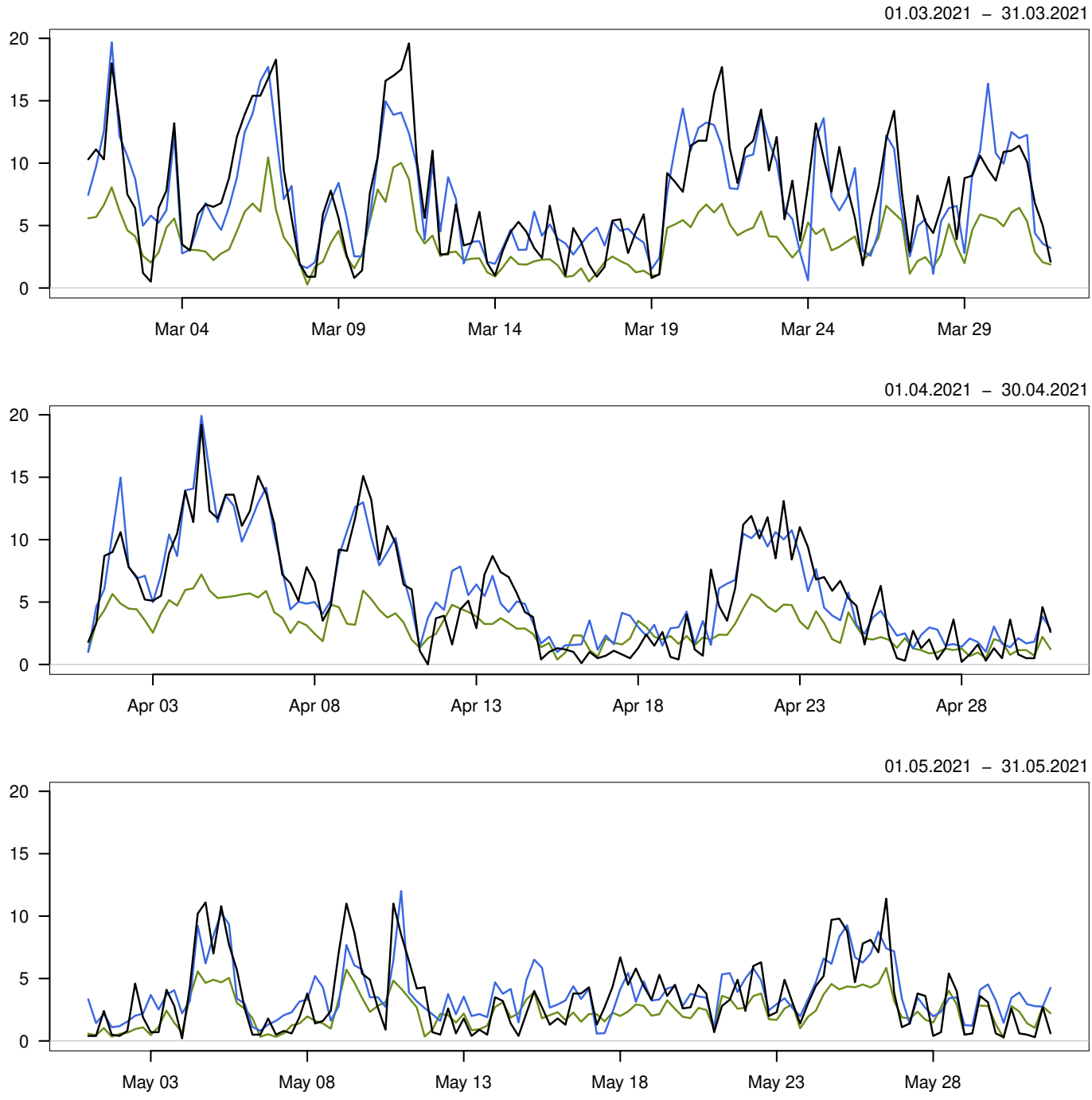
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	3.5	18.1	2.5	372
MEPSctrl: 12+18,+24,+30,+36	0.1	3.2	11.1	2.1	372
ECMWF: 12+18,+24,+30,+36	0.2	2.7	7.6	1.6	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	–0.3	1.7	1.7	1.3	7.1	372
ECMWF – synop	–0.8	1.6	1.8	1.3	10.8	371


BERGEN – FLORIDA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
0.006
0.004
0.002
0.000
PDF
0
100
200
300
Wind direction

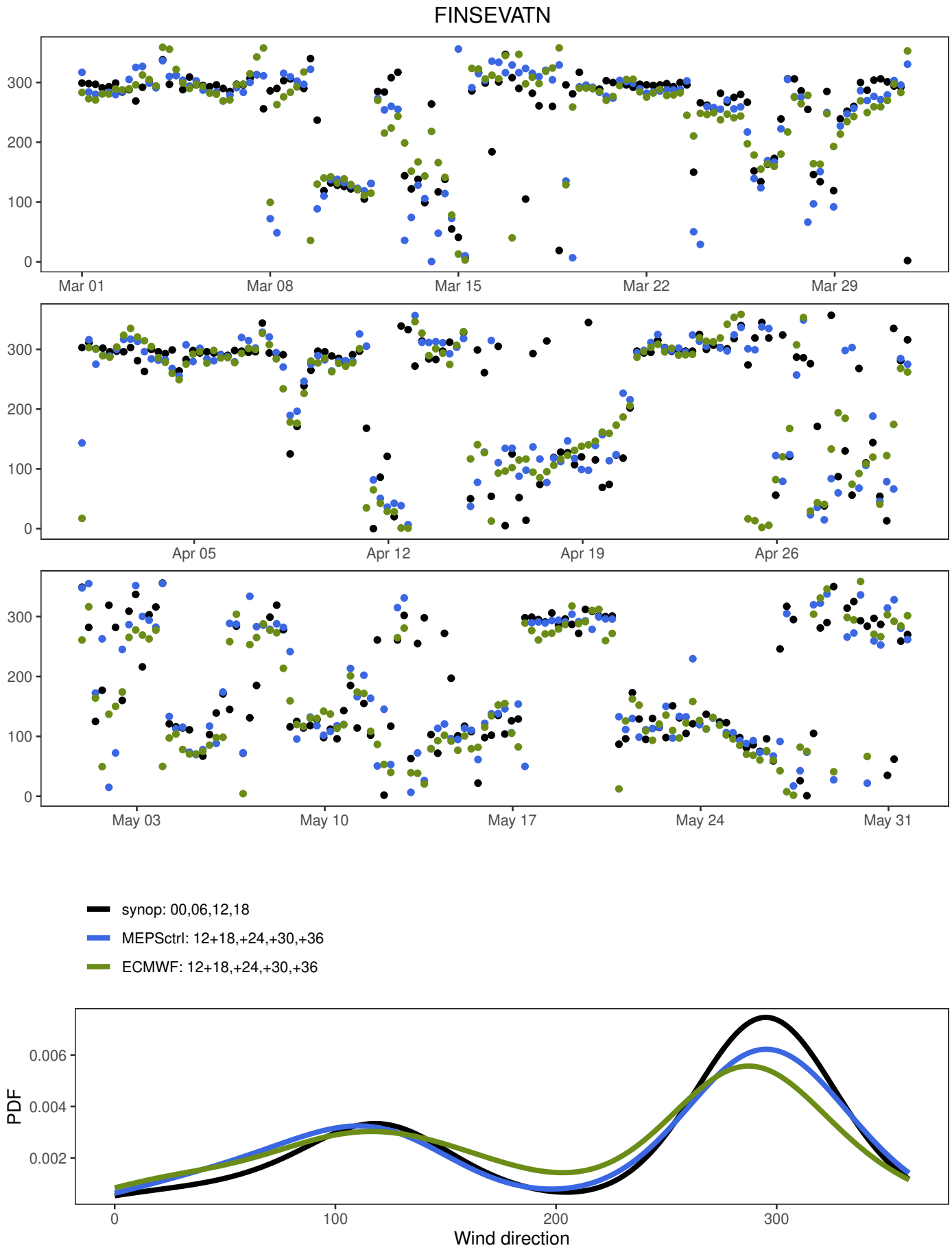
FINSEVATN



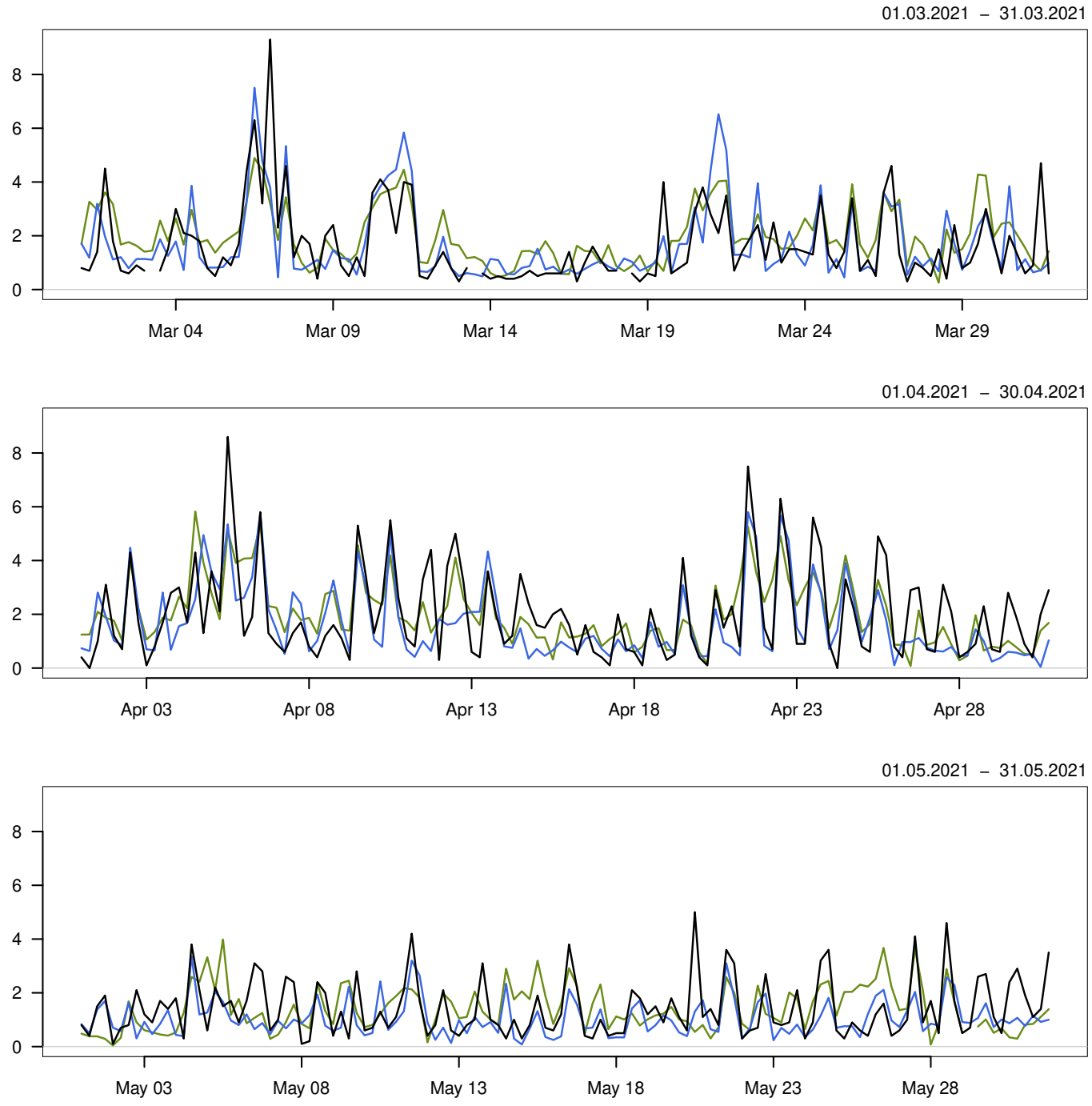
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	5.5	19.6	4.4	372
MEPSctrl: 12+18,+24,+30,+36	0.6	5.6	19.9	3.9	372
ECMWF: 12+18,+24,+30,+36	0.2	3.1	10.5	1.8	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.1	2.1	2.1	1.7	7.6	372
ECMWF – synop	–2.4	3	3.8	2.8	12	371


FINSEVATN
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

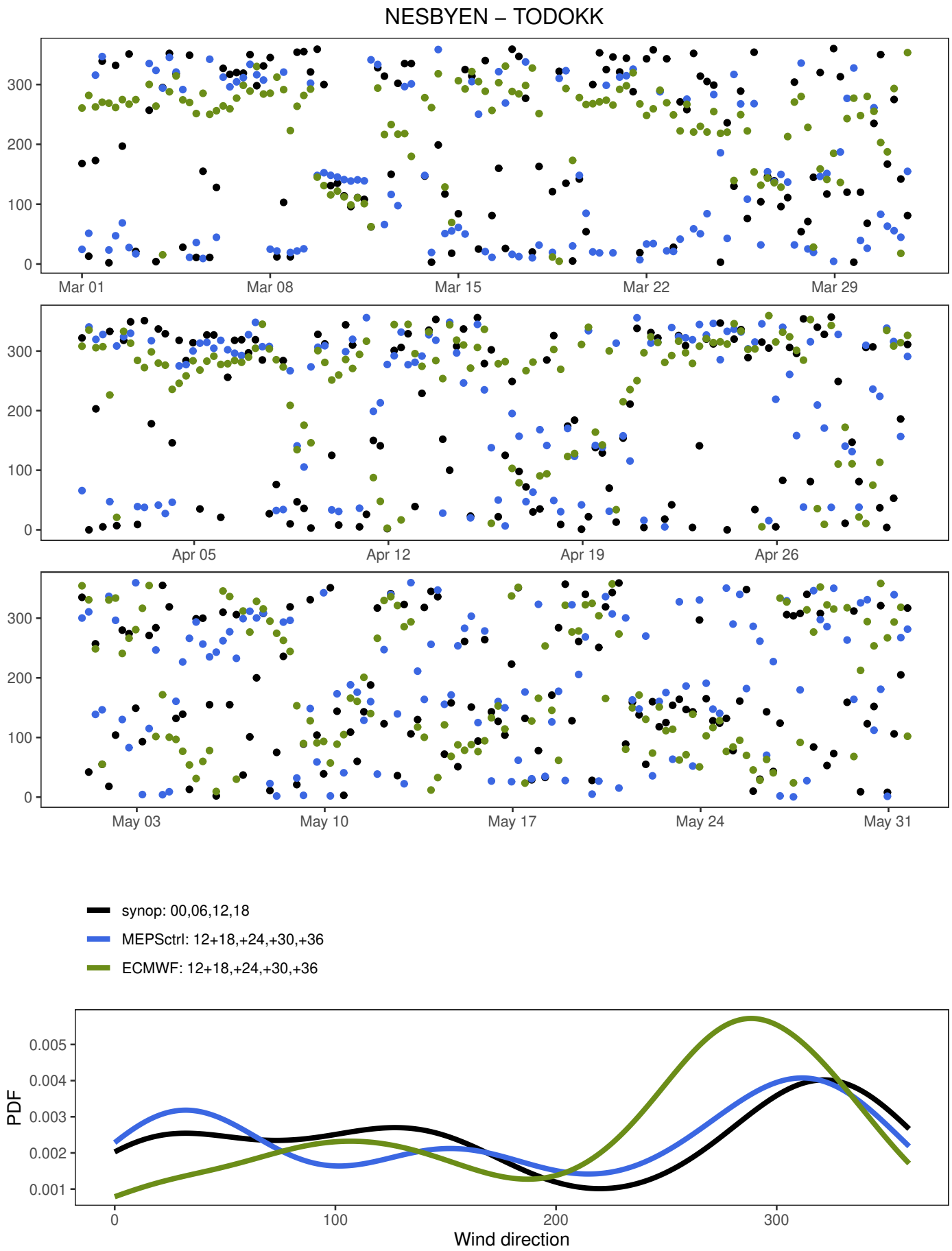
NESBYEN – TODOKK



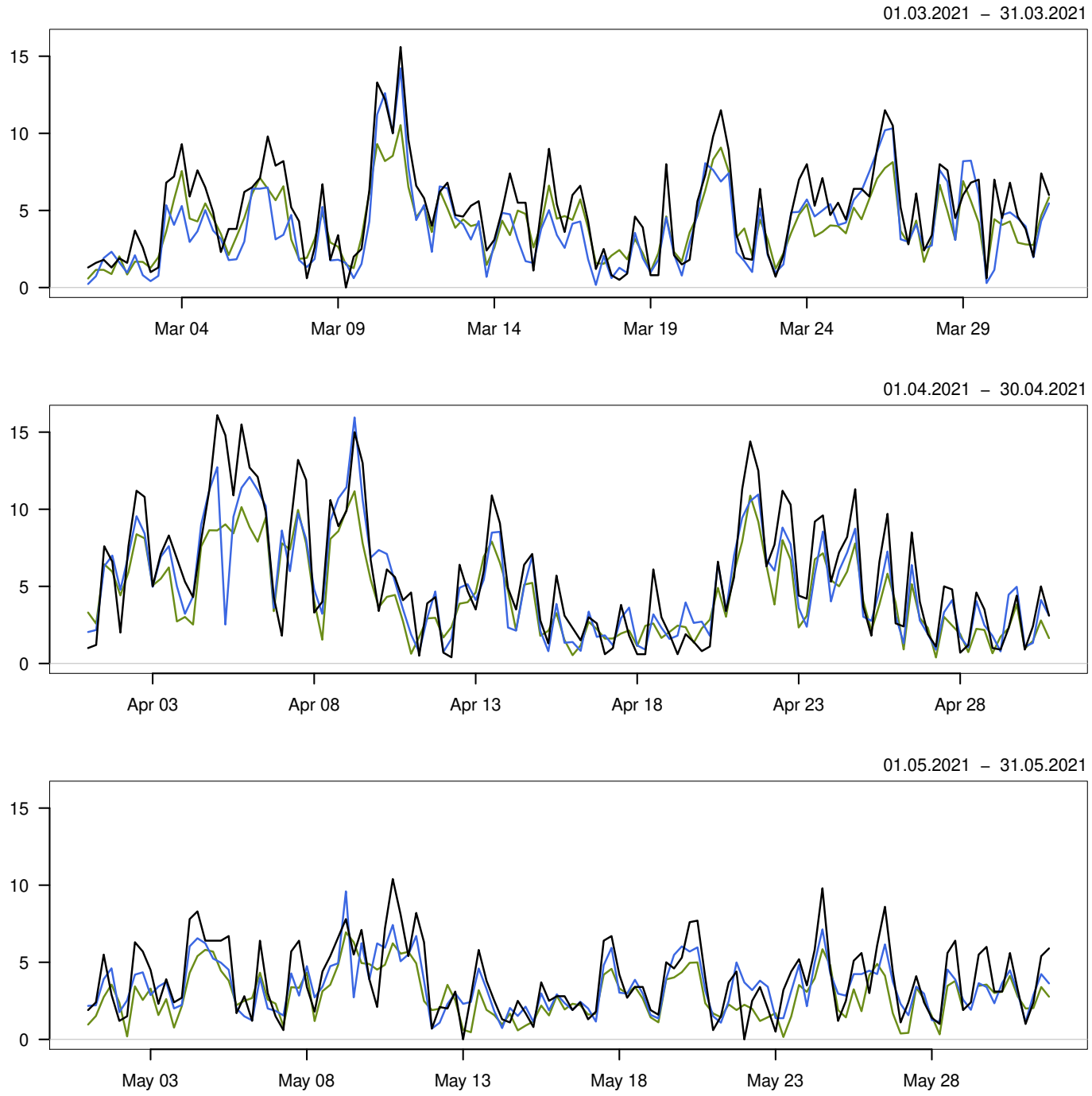
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	1.7	9.3	1.4	369
MEPSctrl: 12+18,+24,+30,+36	0	1.5	7.5	1.2	372
ECMWF: 12+18,+24,+30,+36	0	1.8	5.8	1.1	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.2	1.1	1.1	0.8	5.5	369
ECMWF – synop	0.1	1.2	1.2	0.9	6.1	368


NESBYEN – TODOKK
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

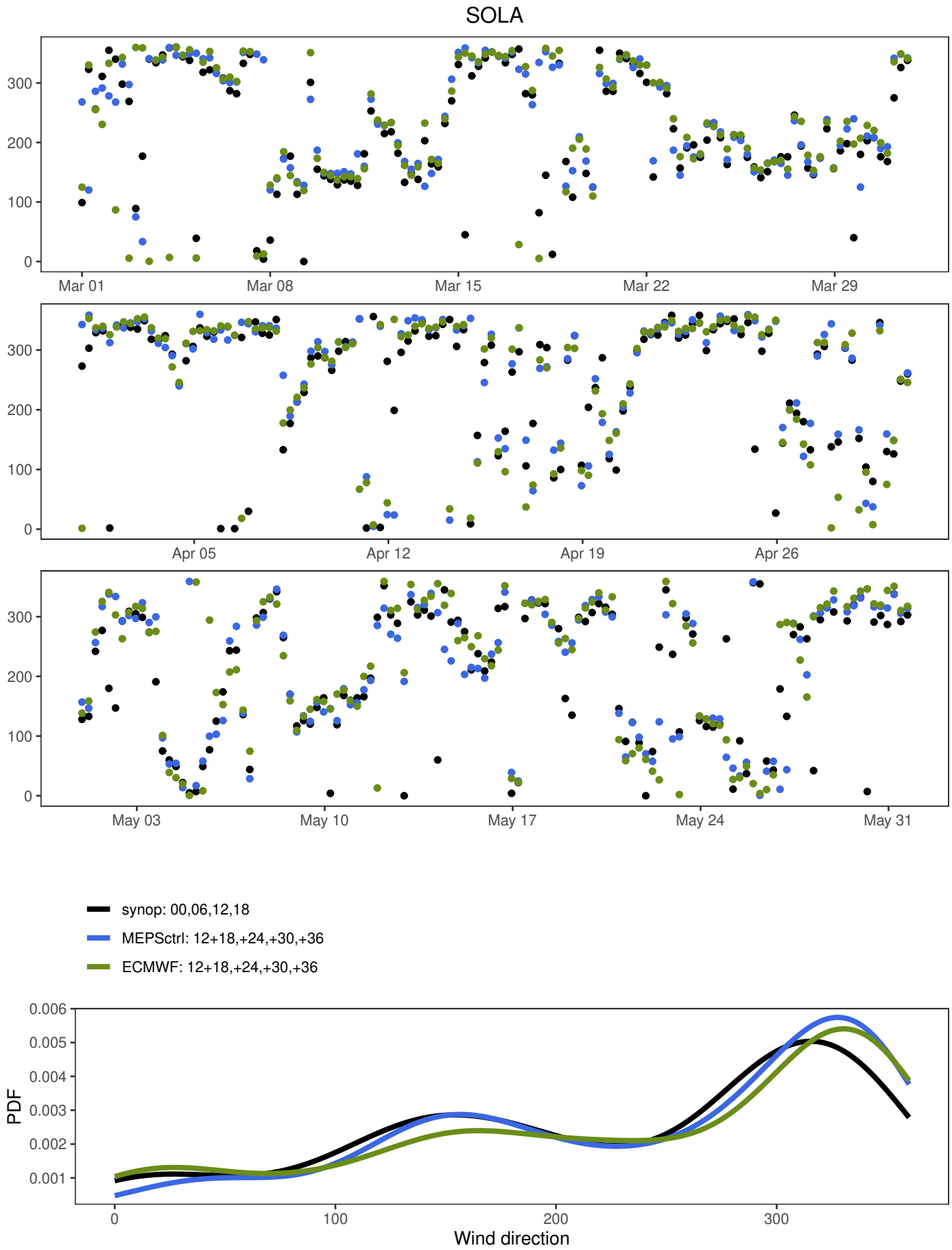
SOLA



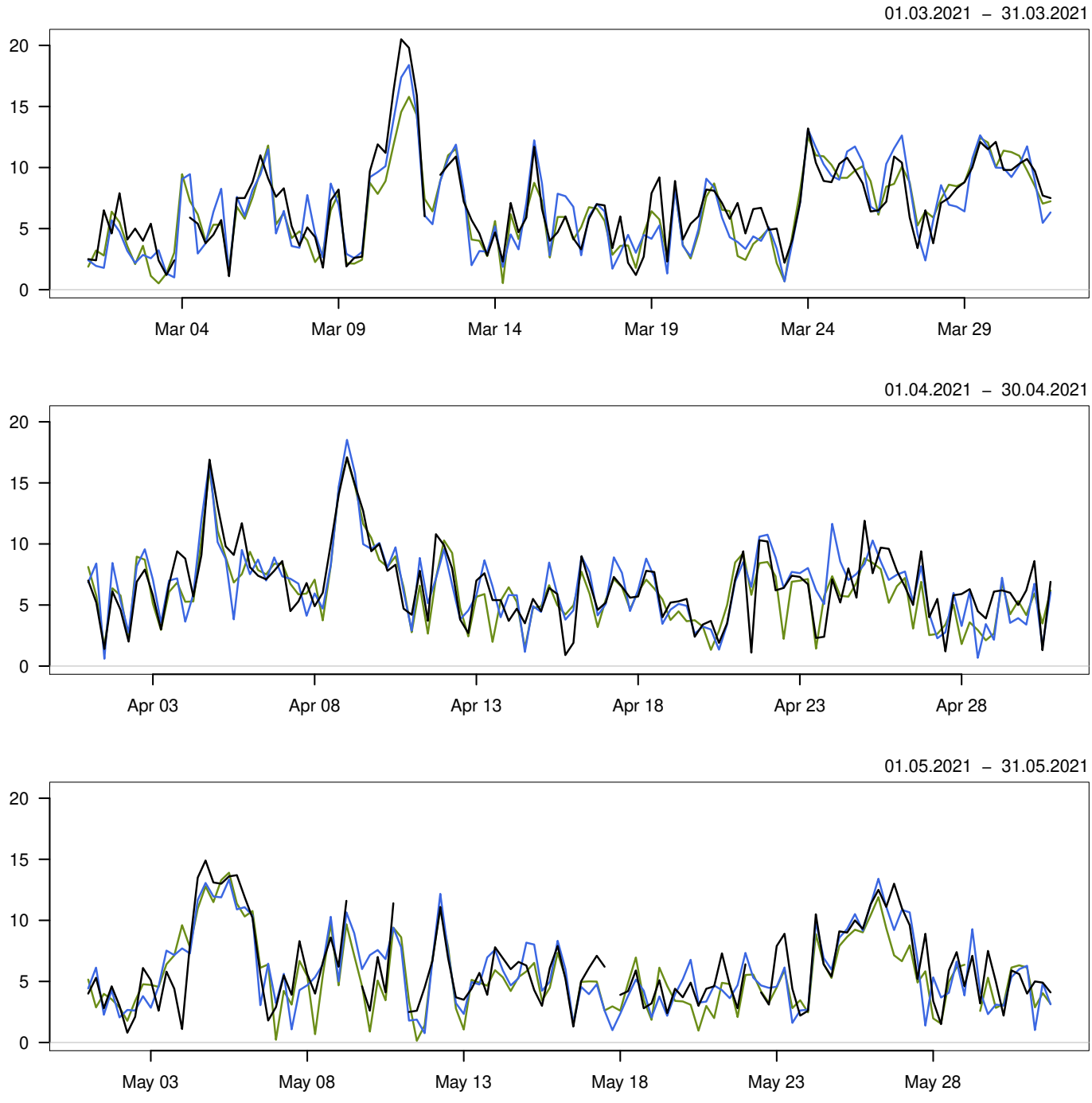
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 00,06,12,18	0	4.8	16.1	3.3	372
MEPSctrl: 12+18,+24,+30,+36	0.2	4.1	16	2.7	372
ECMWF: 12+18,+24,+30,+36	0.2	3.8	11.2	2.3	371

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.7	1.6	1.7	1.3	12.3	372
ECMWF – synop	−1.1	1.6	1.9	1.5	7.5	371


SOLA
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.005
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

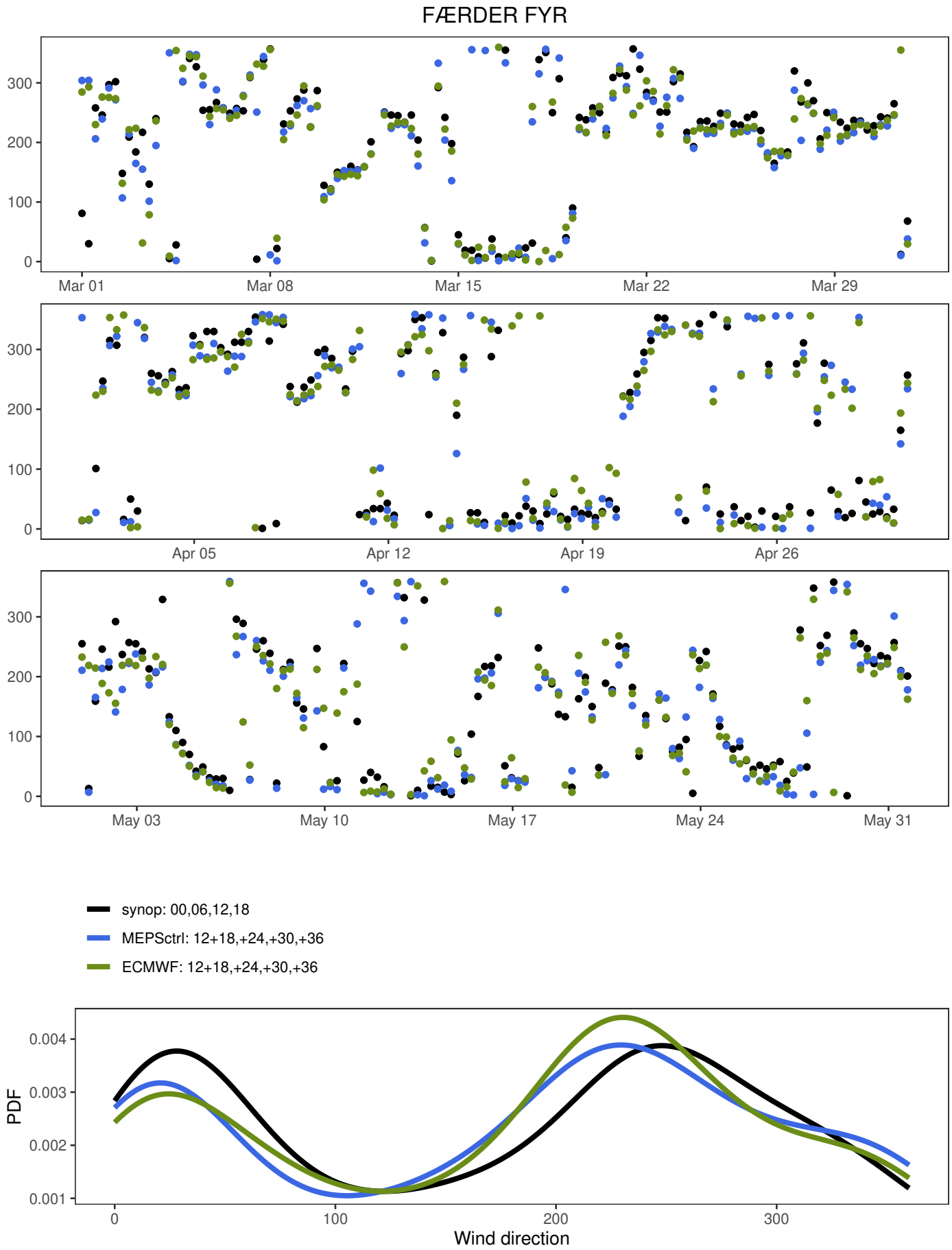
FÆRDER FYR



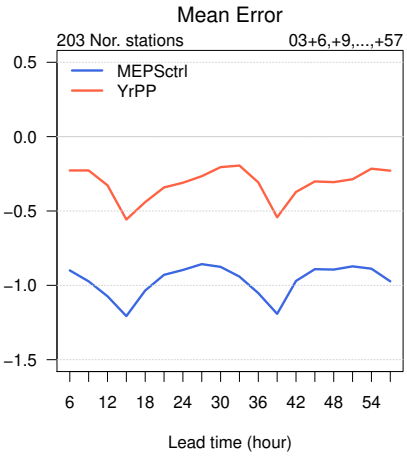
01.03.2021 – 31.05.2021

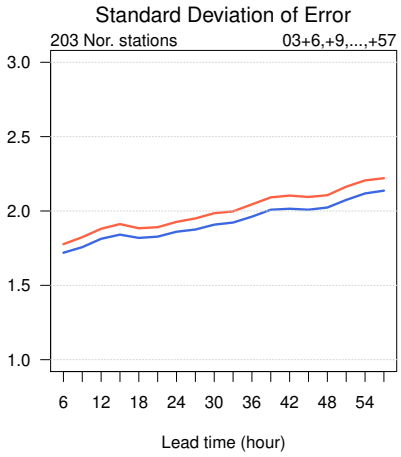
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.8	6.5	20.5	3.3	366
MEPSctrl: 12+18,+24,+30,+36	0.6	6.3	18.5	3.3	372
ECMWF: 12+18,+24,+30,+36	0.1	6	17	3.1	371

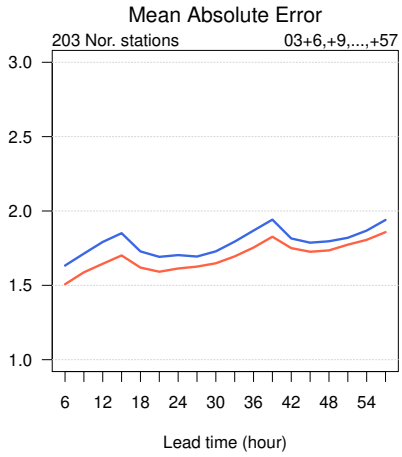
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	–0.2	1.9	1.9	1.4	7.5	366
ECMWF – synop	–0.5	1.7	1.8	1.4	8.5	365

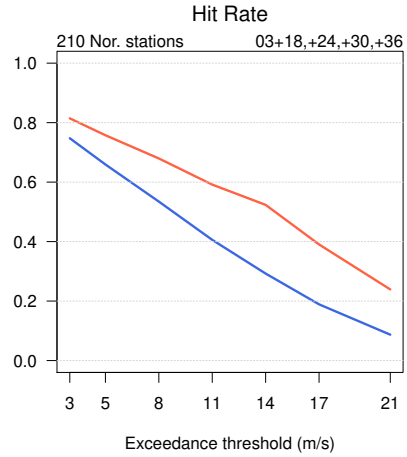

FÆRDER FYR
300
200
100
0
Mar 01
Mar 08
Mar 15
Mar 22
Mar 29
Apr 05
Apr 12
Apr 19
Apr 26
May 03
May 10
May 17
May 24
May 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

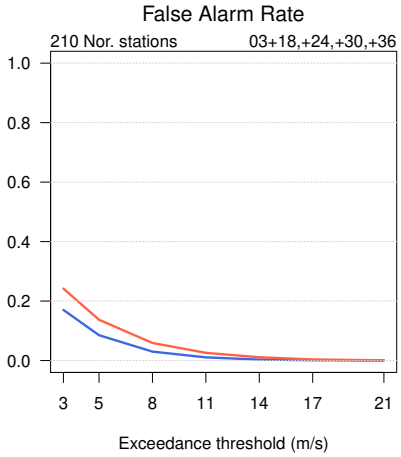
Post processed maximum mean wind speed 10m (YrPP)

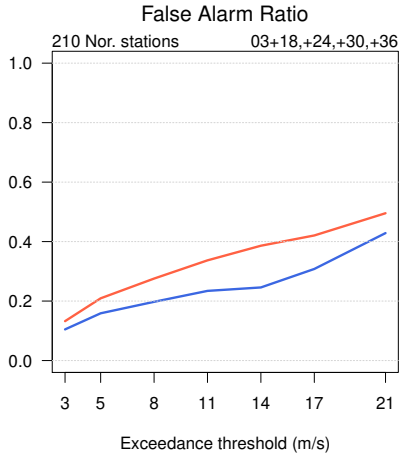


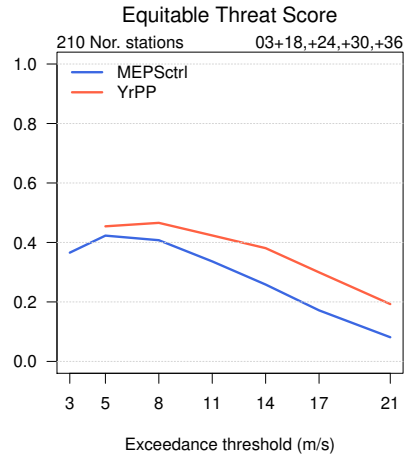


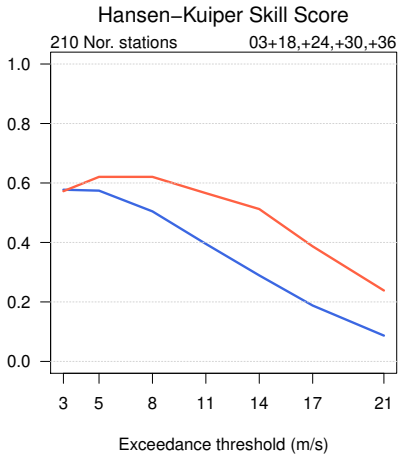


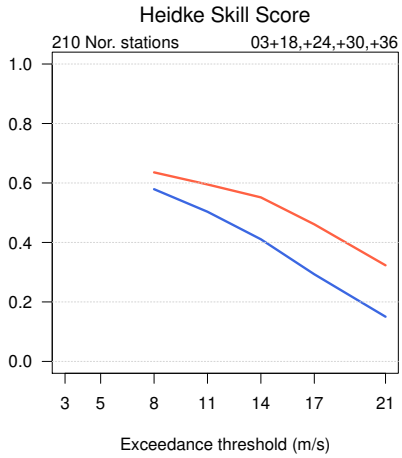




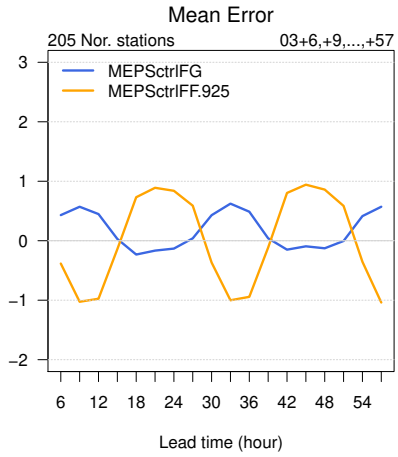


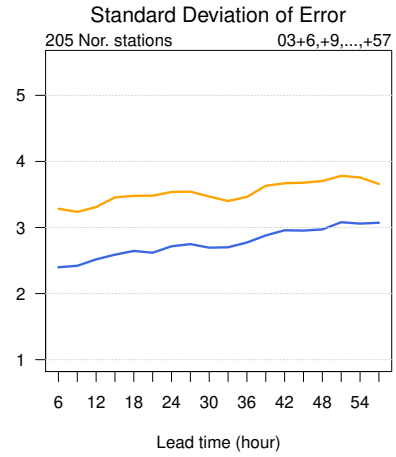


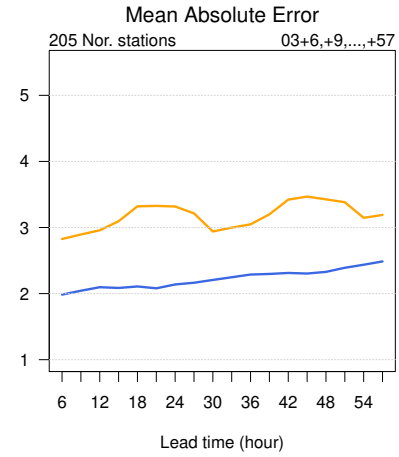


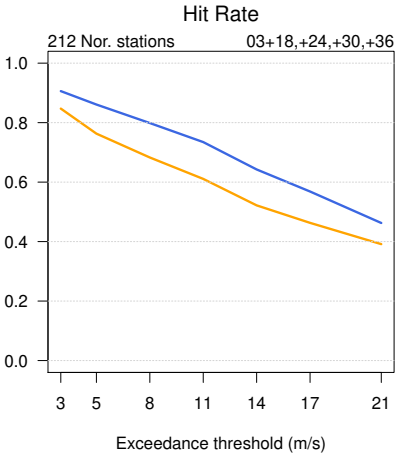


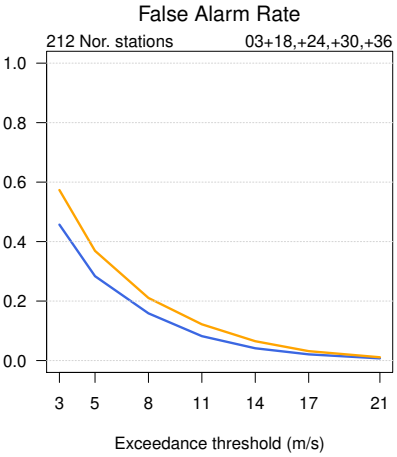
Wind gust (FG) and wind speed in 925 hpa (FF.925)

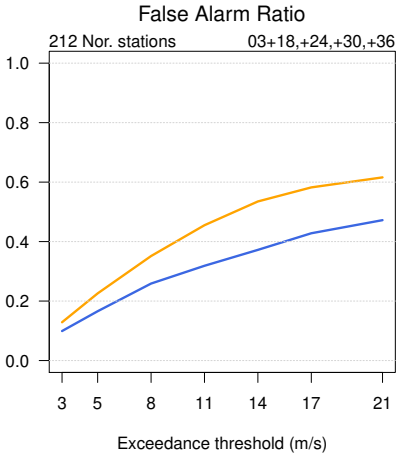


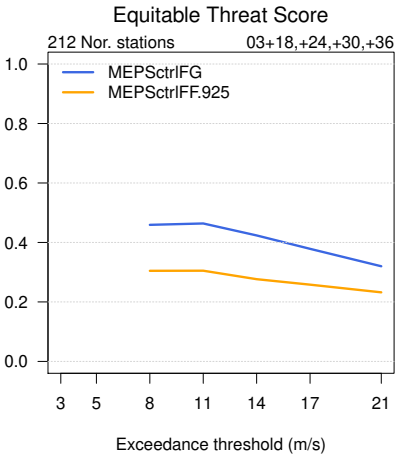


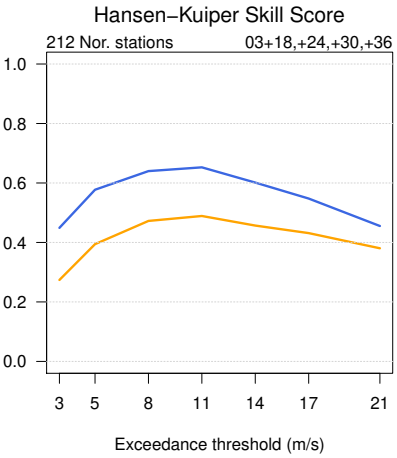


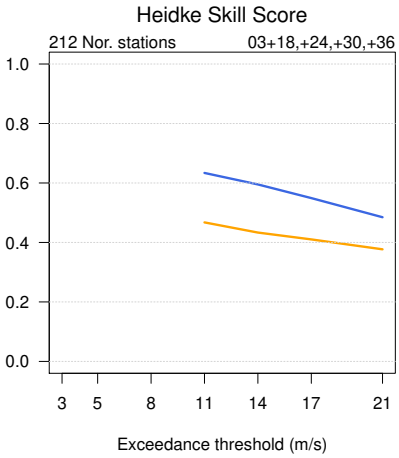


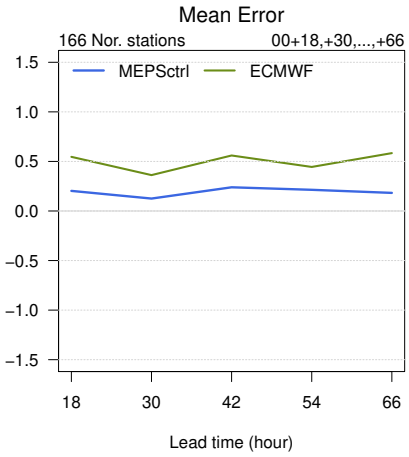


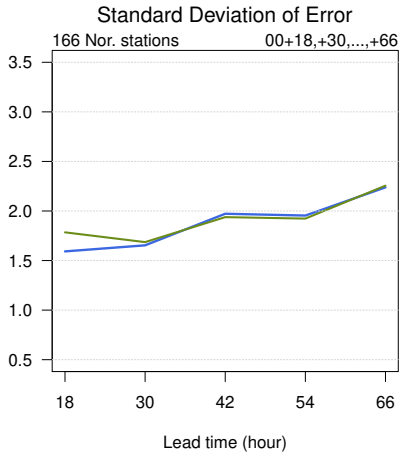


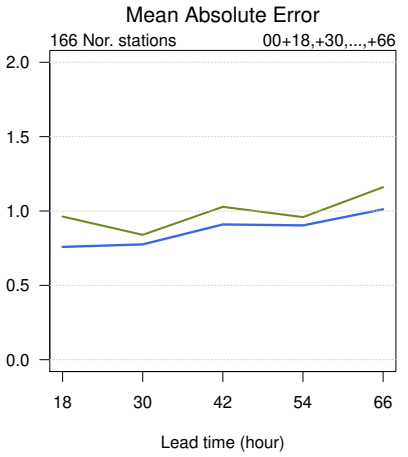


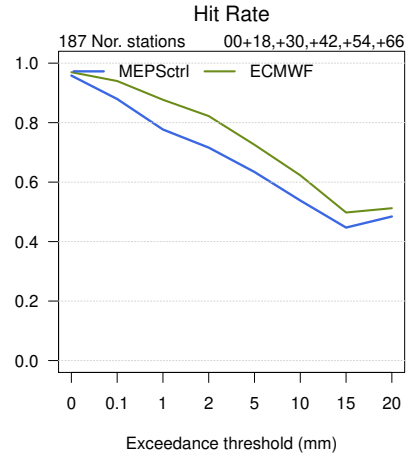


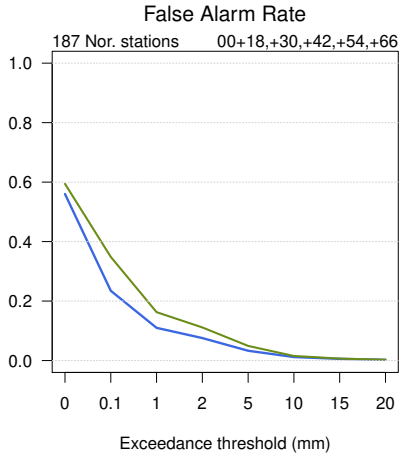


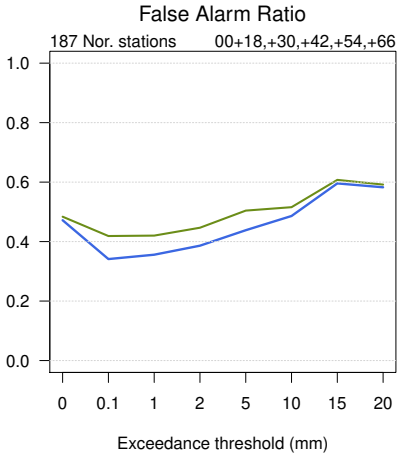

Mean Error
166 Nor. stations
00+18,+30,...,+66
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
18
30
42
54
66
Lead time (hour)

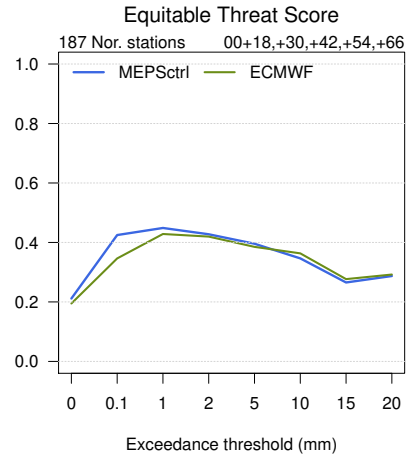

Standard Deviation of Error
166 Nor. stations
00+18,+30,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
18
30
42
54
66
Lead time (hour)

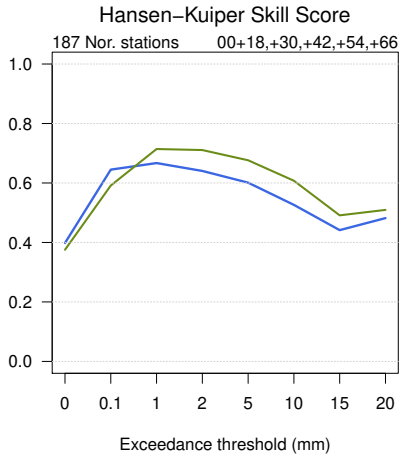

Mean Absolute Error
166 Nor. stations
00+18,+30,...,+66
2.0
1.5
1.0
0.5
0.0
18
30
42
54
66
Lead time (hour)

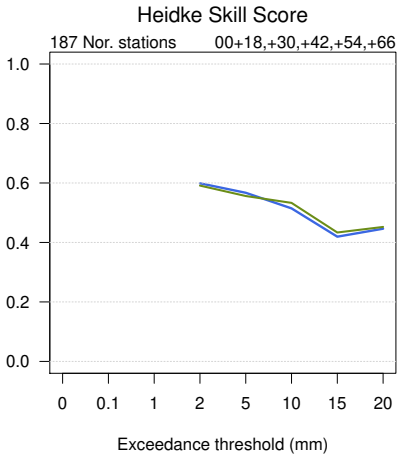

Hit Rate
187 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)


False Alarm Rate
187 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)


False Alarm Ratio
187 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)

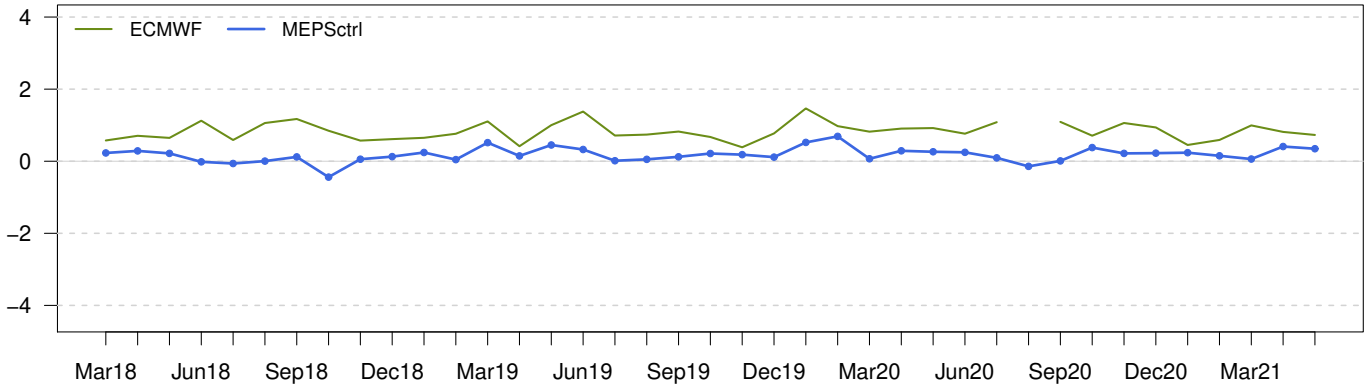

Equitable Threat Score
187 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)


Hansen−Kuiper Skill Score
187 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)

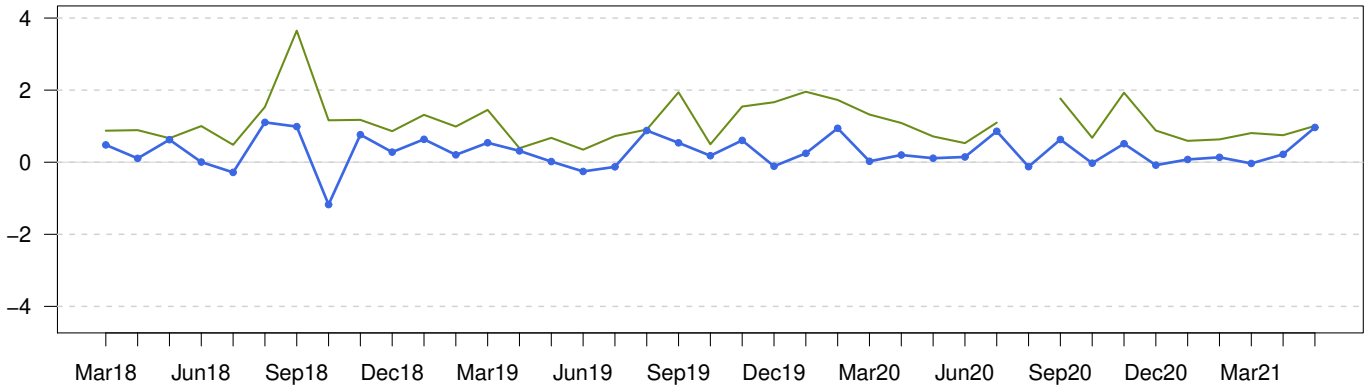

Heidke Skill Score
187 Nor. stations
00+18,+30,+42,+54,+66
1.0
0.8
0.6
0.4
0.2
0.0
0
0.1
1
2
5
10
15
20
Exceedance threshold (mm)

Mean Error

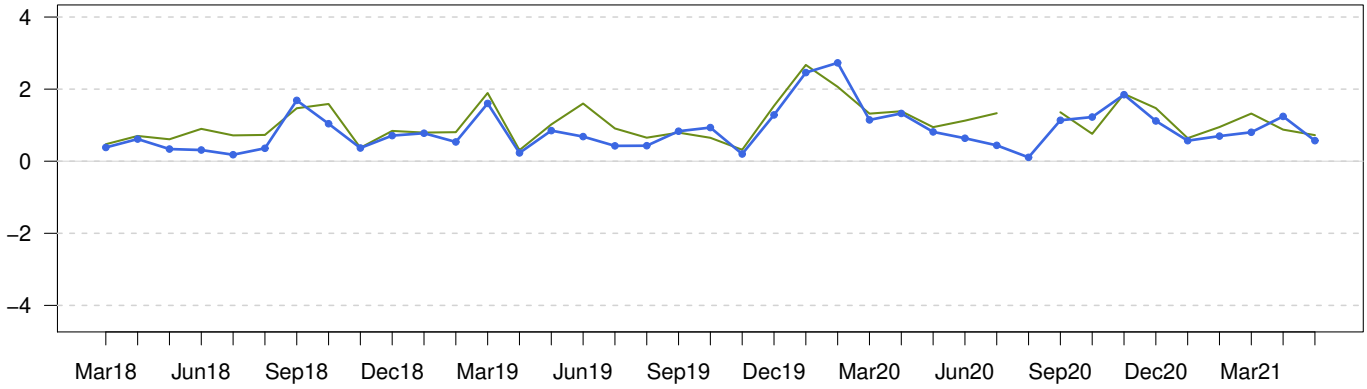
184 Norwegian stations 00+30 UTC



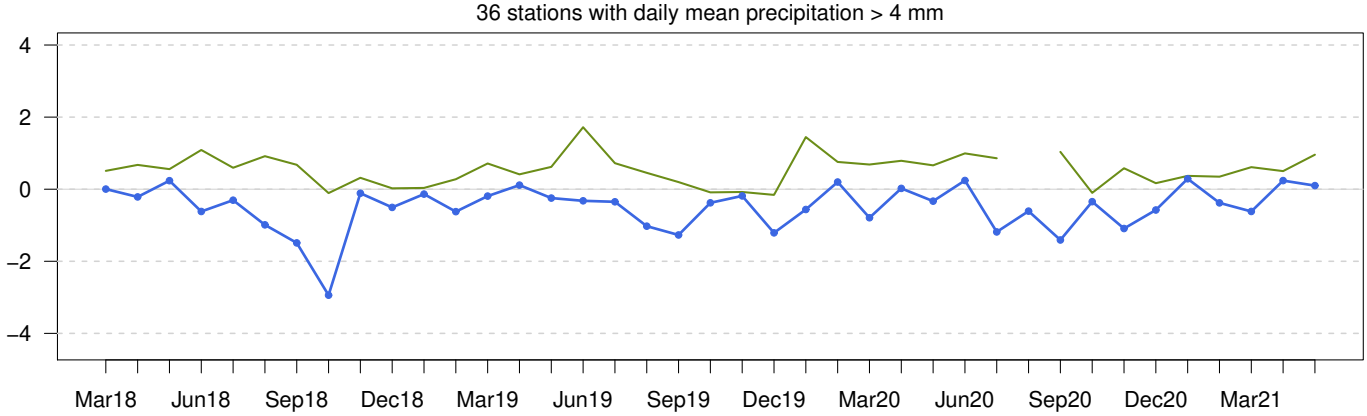
6 coastal stations



43 stations more than 500 m above sea level

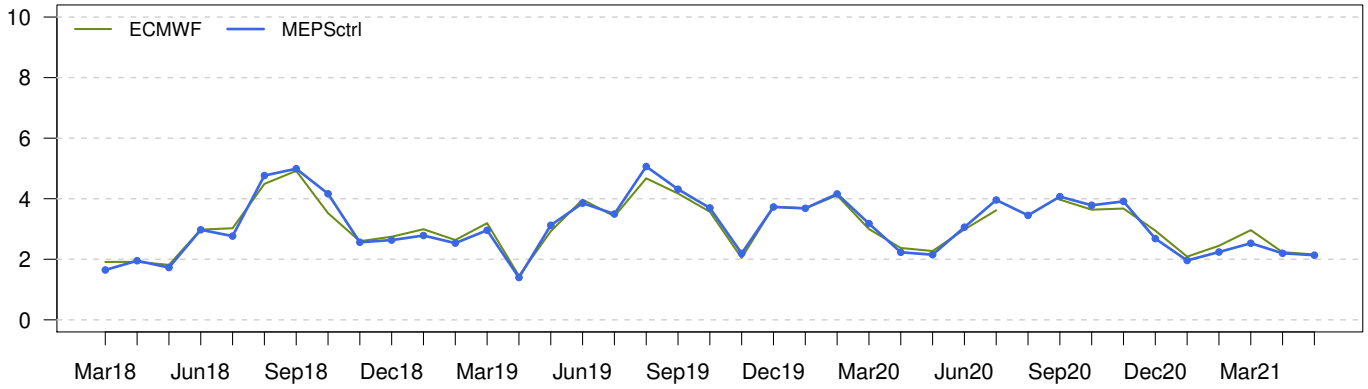


36 stations with daily mean precipitation > 4 mm

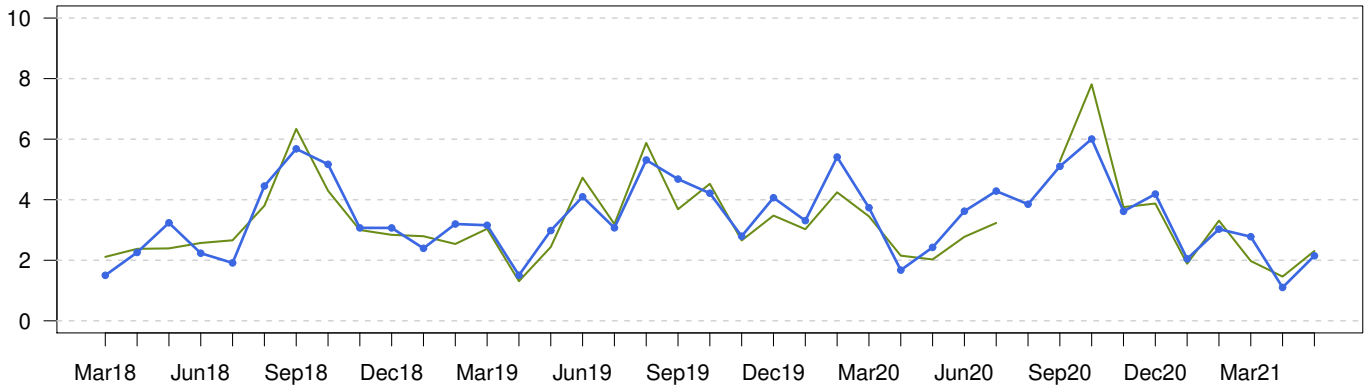


Standard Deviation of Error

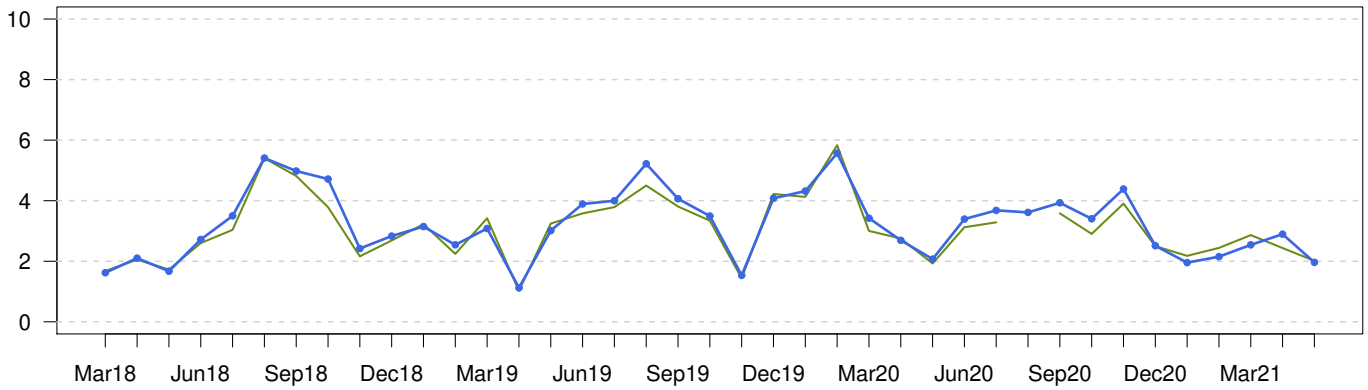
184 Norwegian stations 00+30 UTC



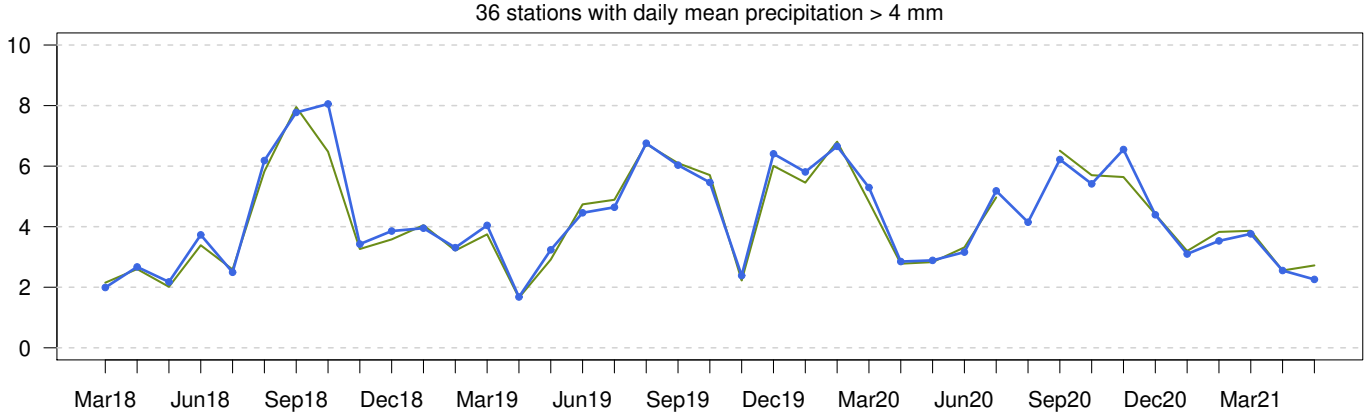
6 coastal stations



43 stations more than 500 m above sea level

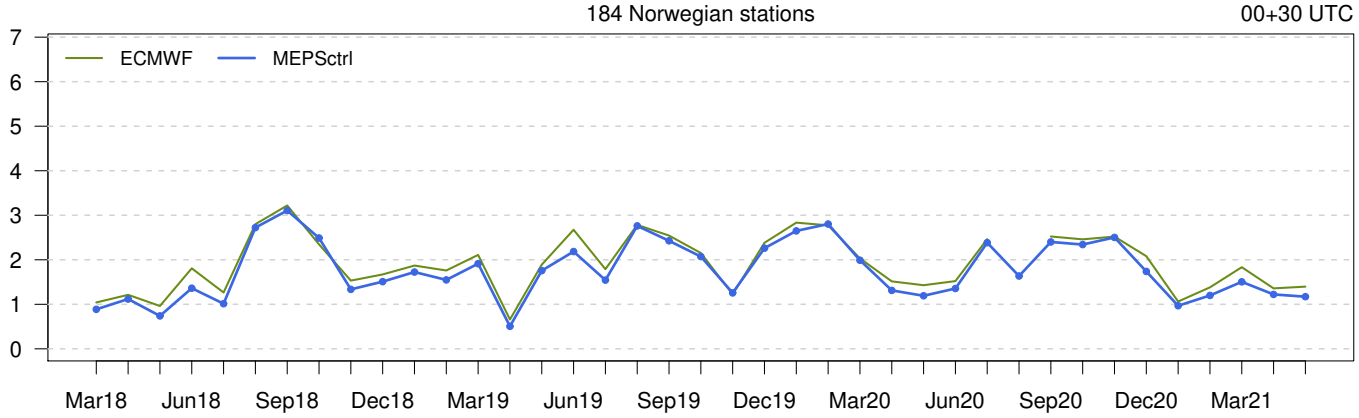


36 stations with daily mean precipitation > 4 mm

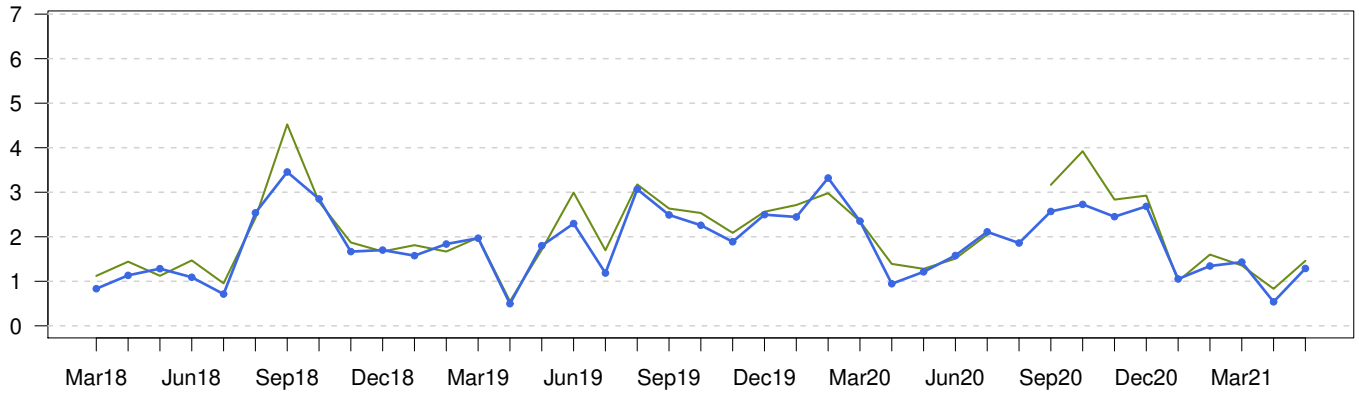


Mean Absolute Error

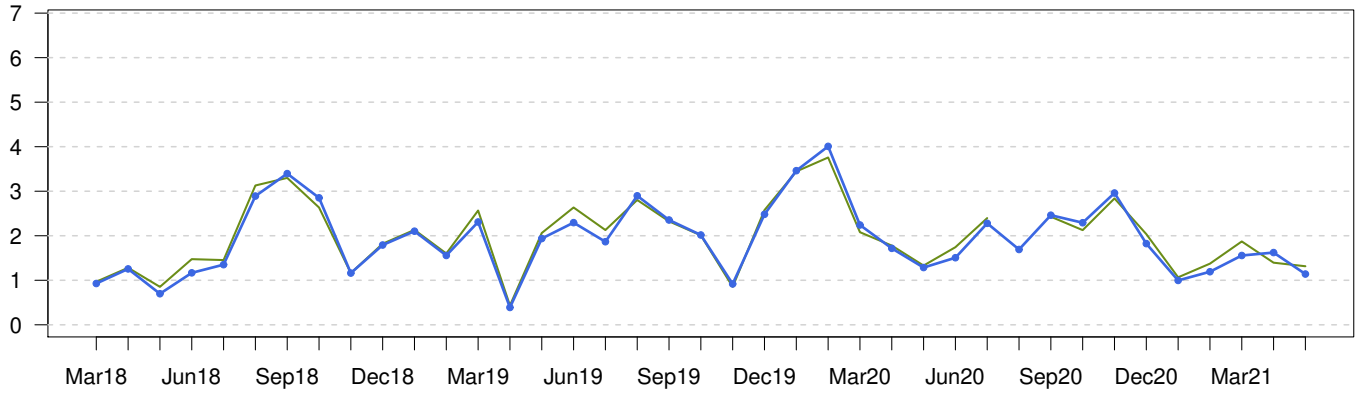
184 Norwegian stations 00+30 UTC



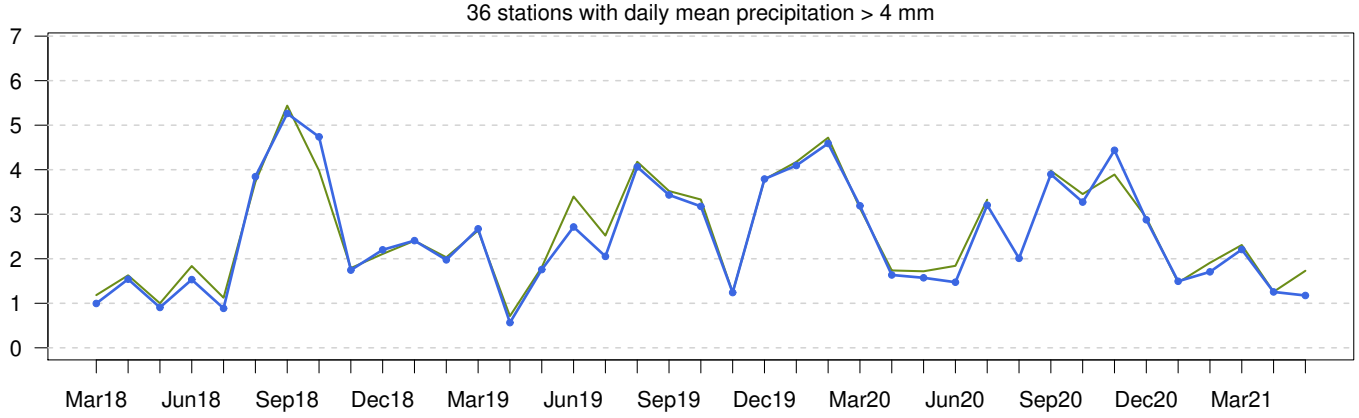
6 coastal stations



43 stations more than 500 m above sea level

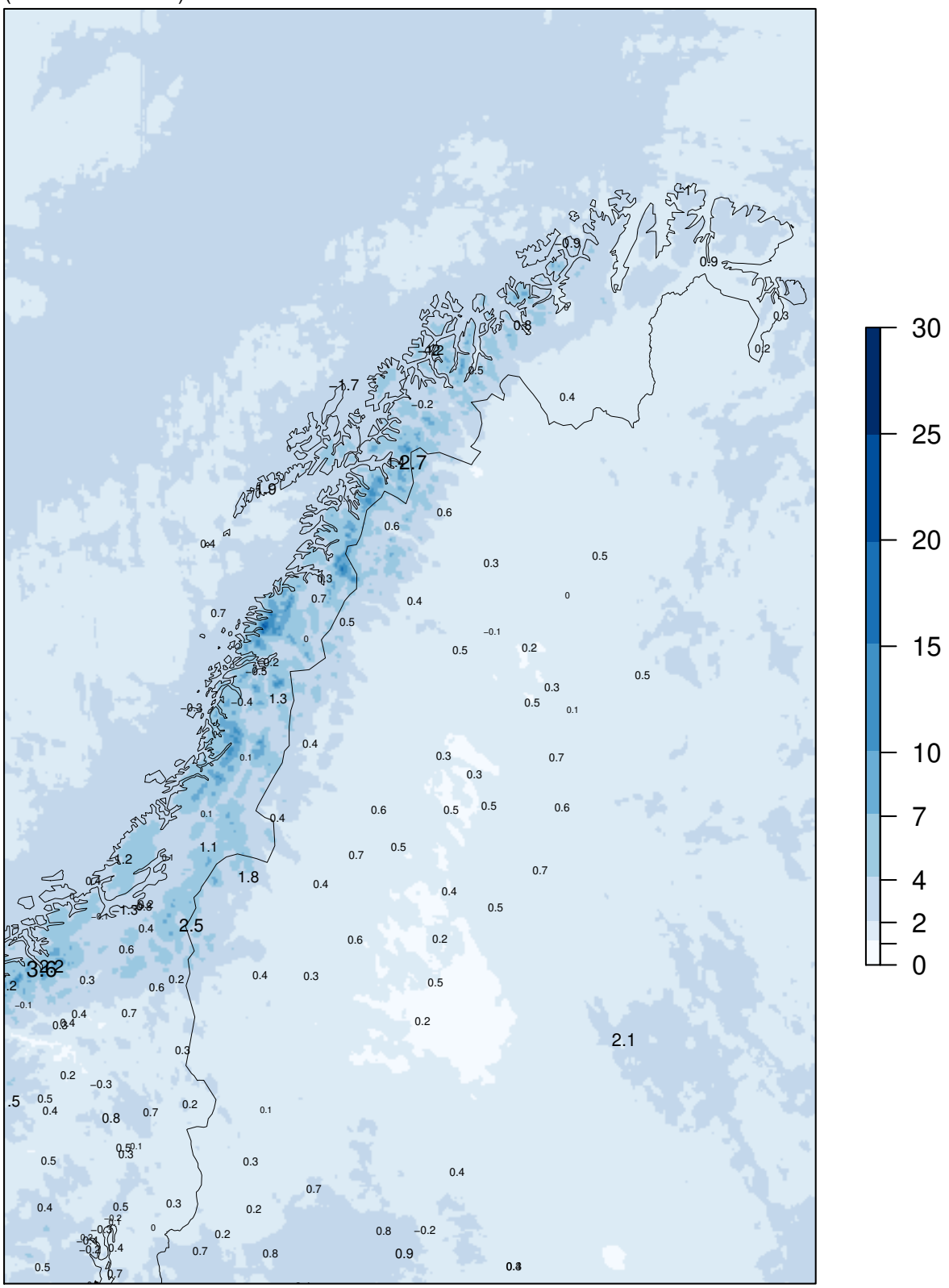


36 stations with daily mean precipitation > 4 mm



MEPSctrl 00+30

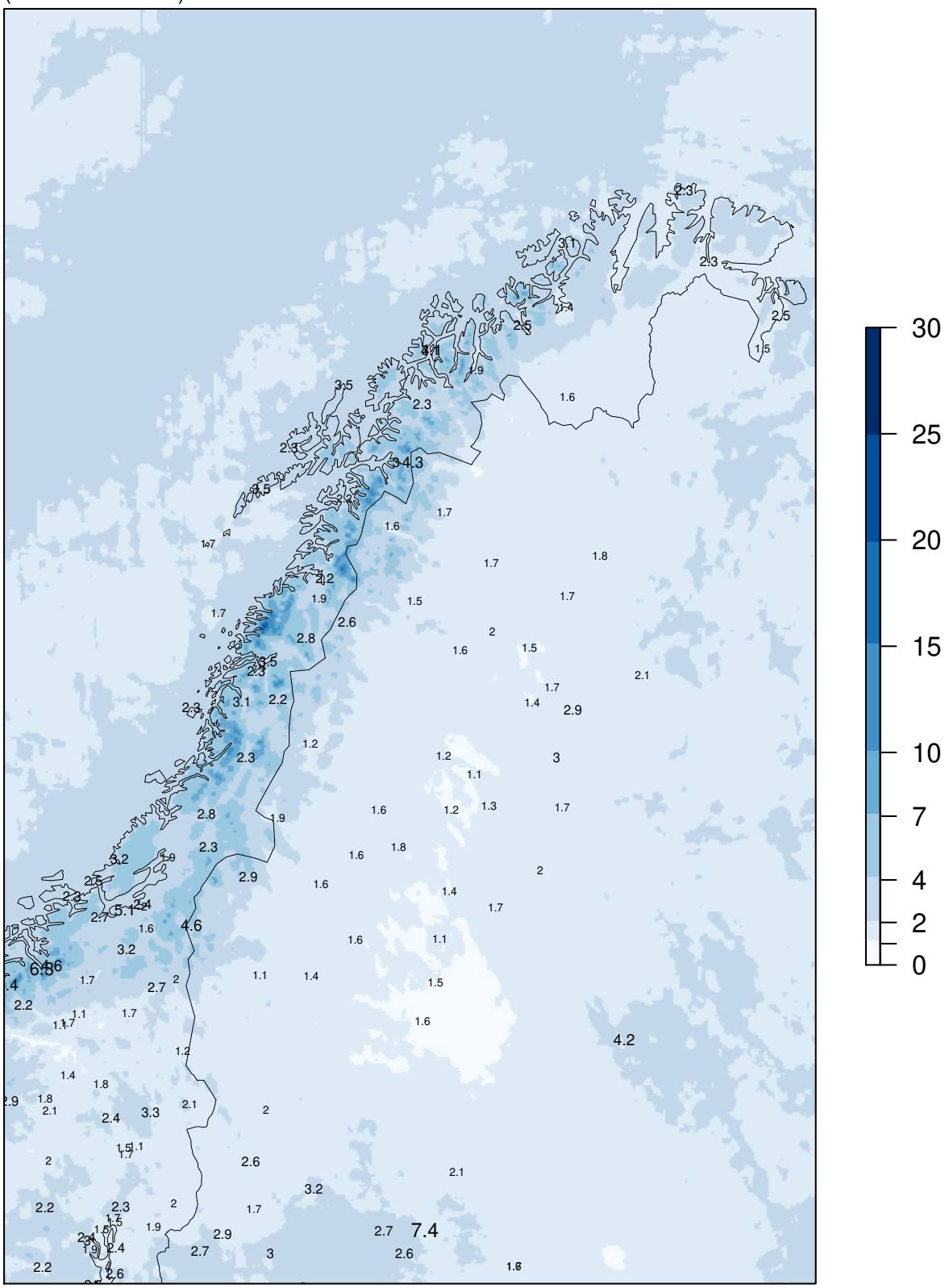
ME at observing sites
(numbers in black)



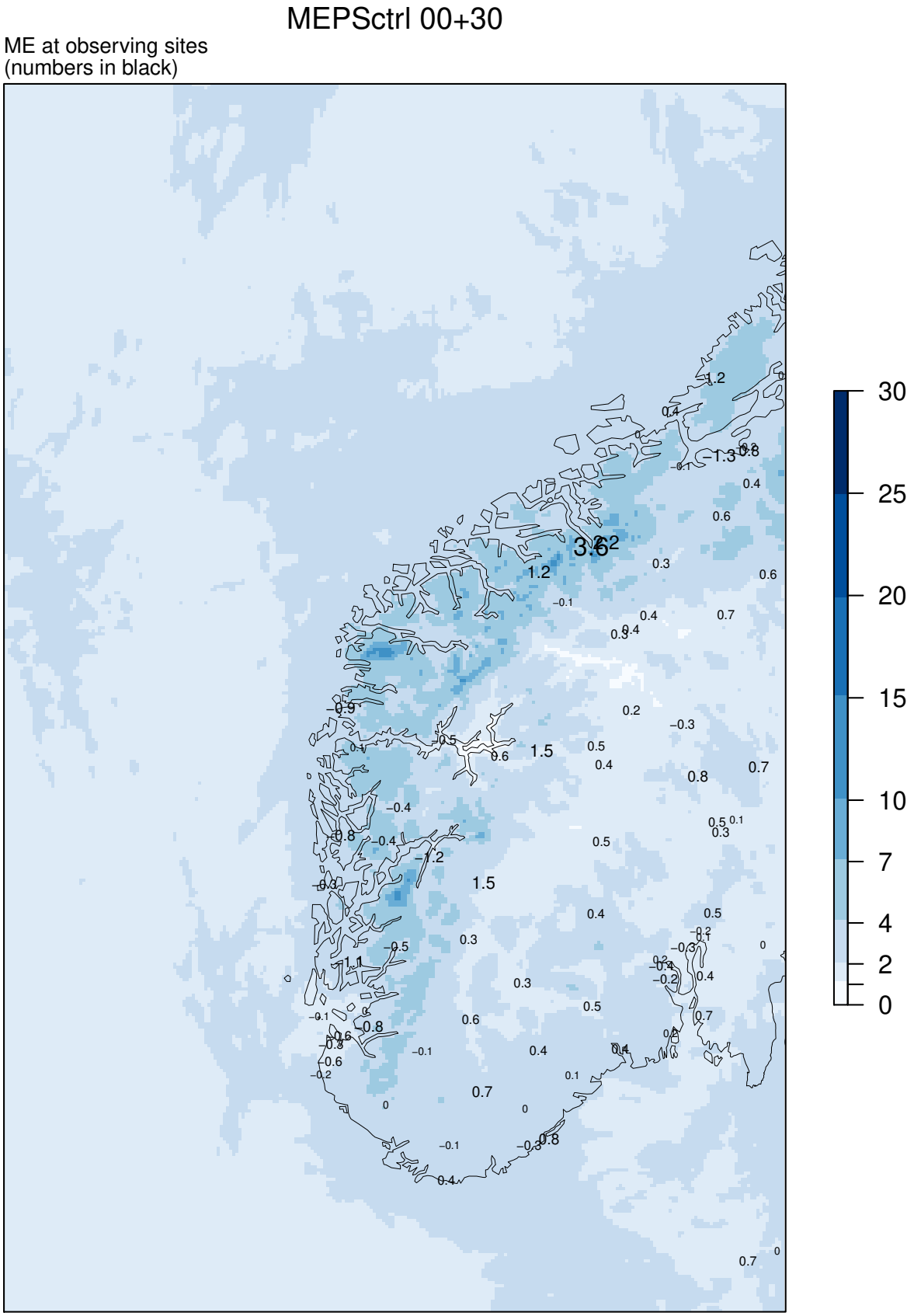
Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+30

SDE at observing sites
(numbers in black)



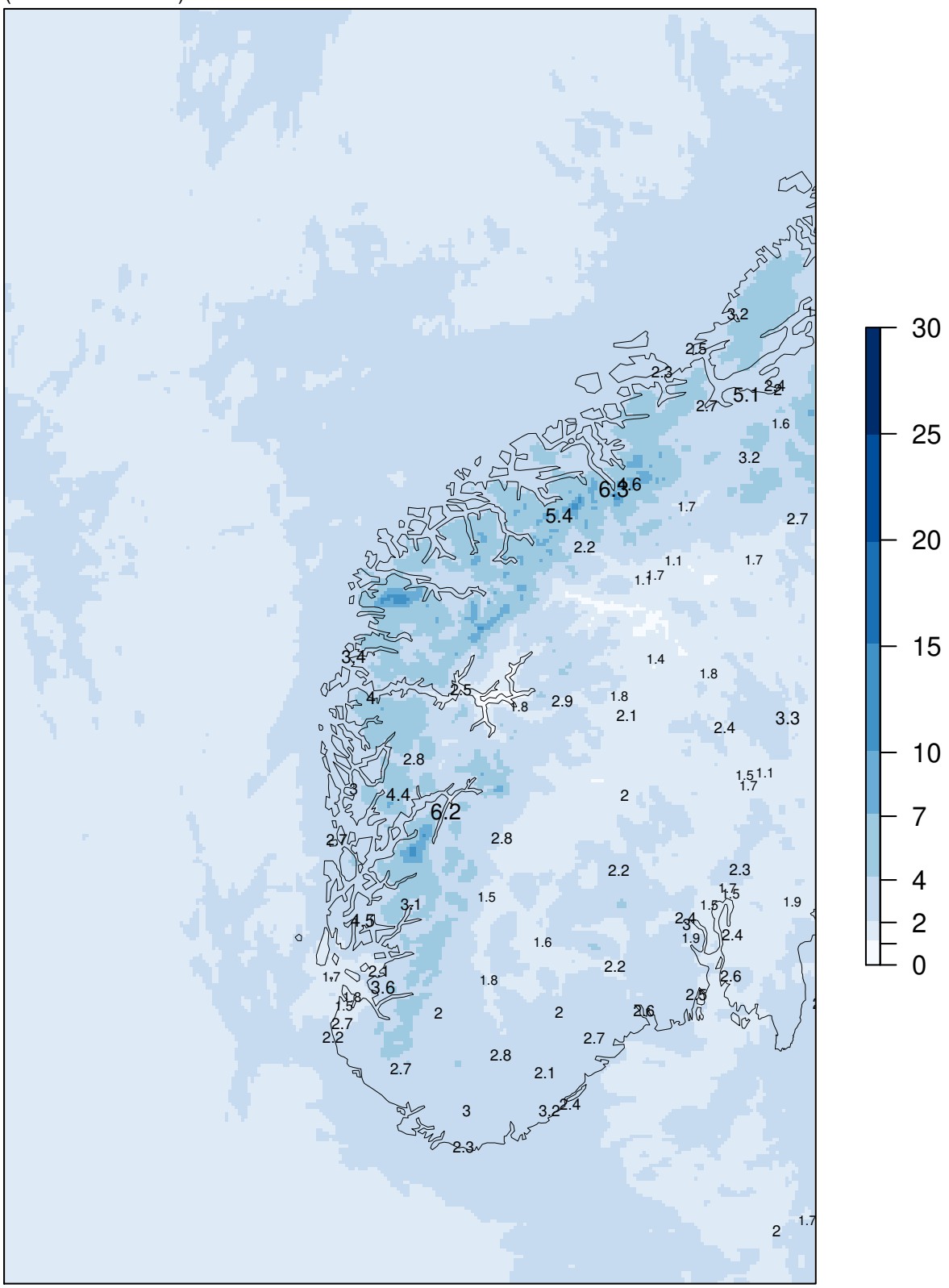
Model "climatology" 01.03.2021 – 31.05.2021



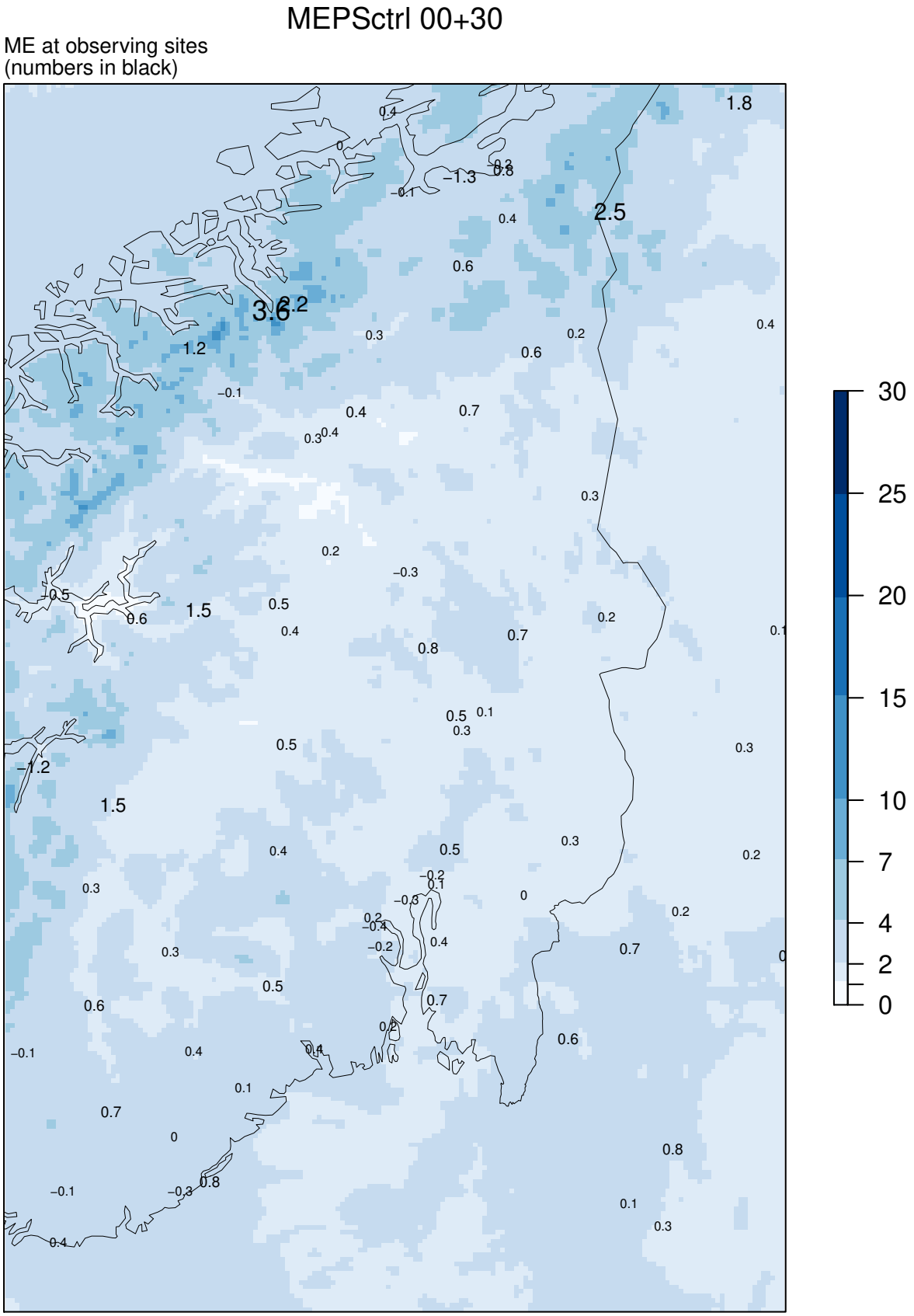
Model "climatology" 01.03.2021 – 31.05.2021

MEPSctrl 00+30

SDE at observing sites
(numbers in black)



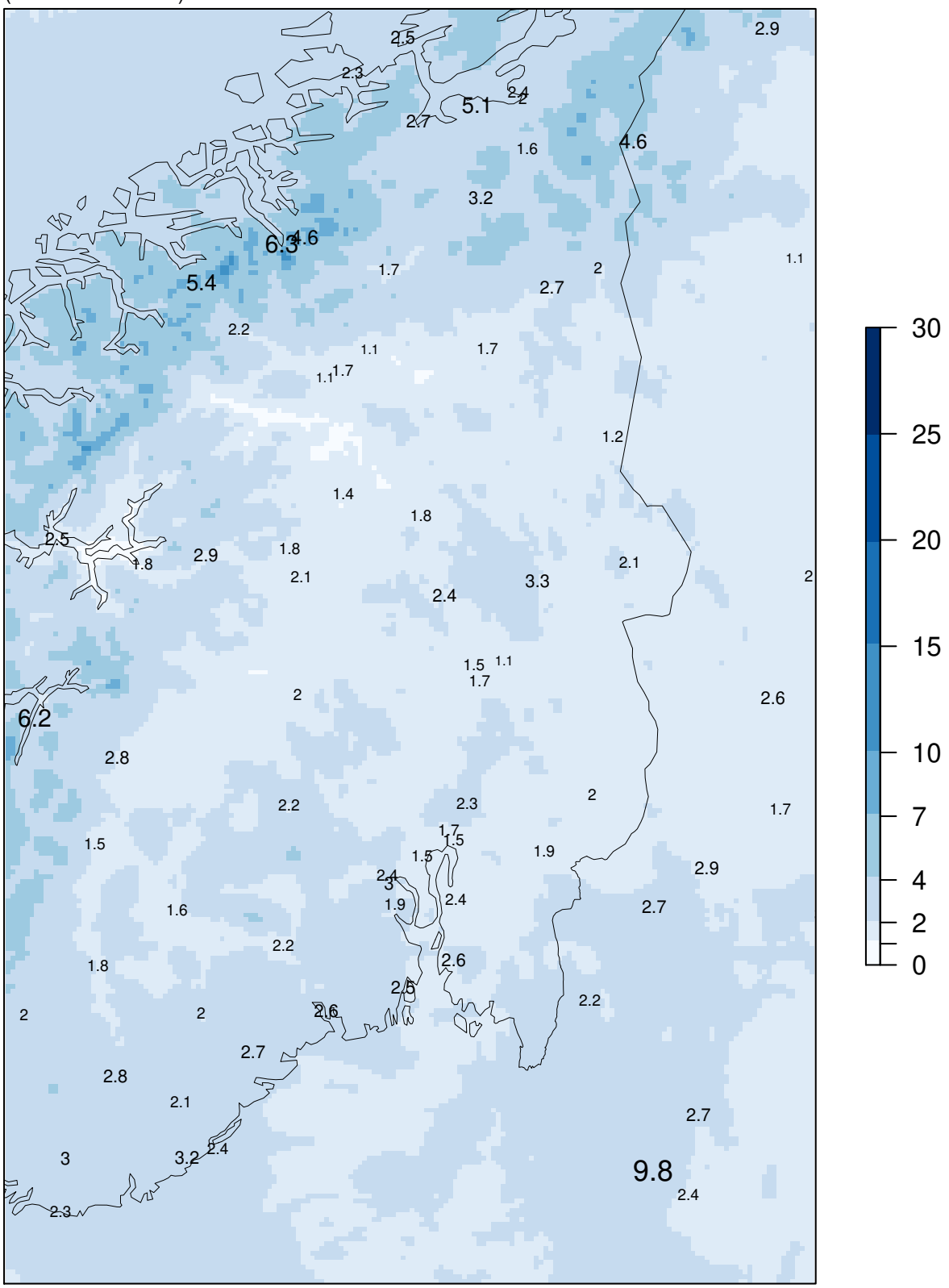
Model "climatology" 01.03.2021 – 31.05.2021



Model "climatology" 01.03.2021 – 31.05.2021

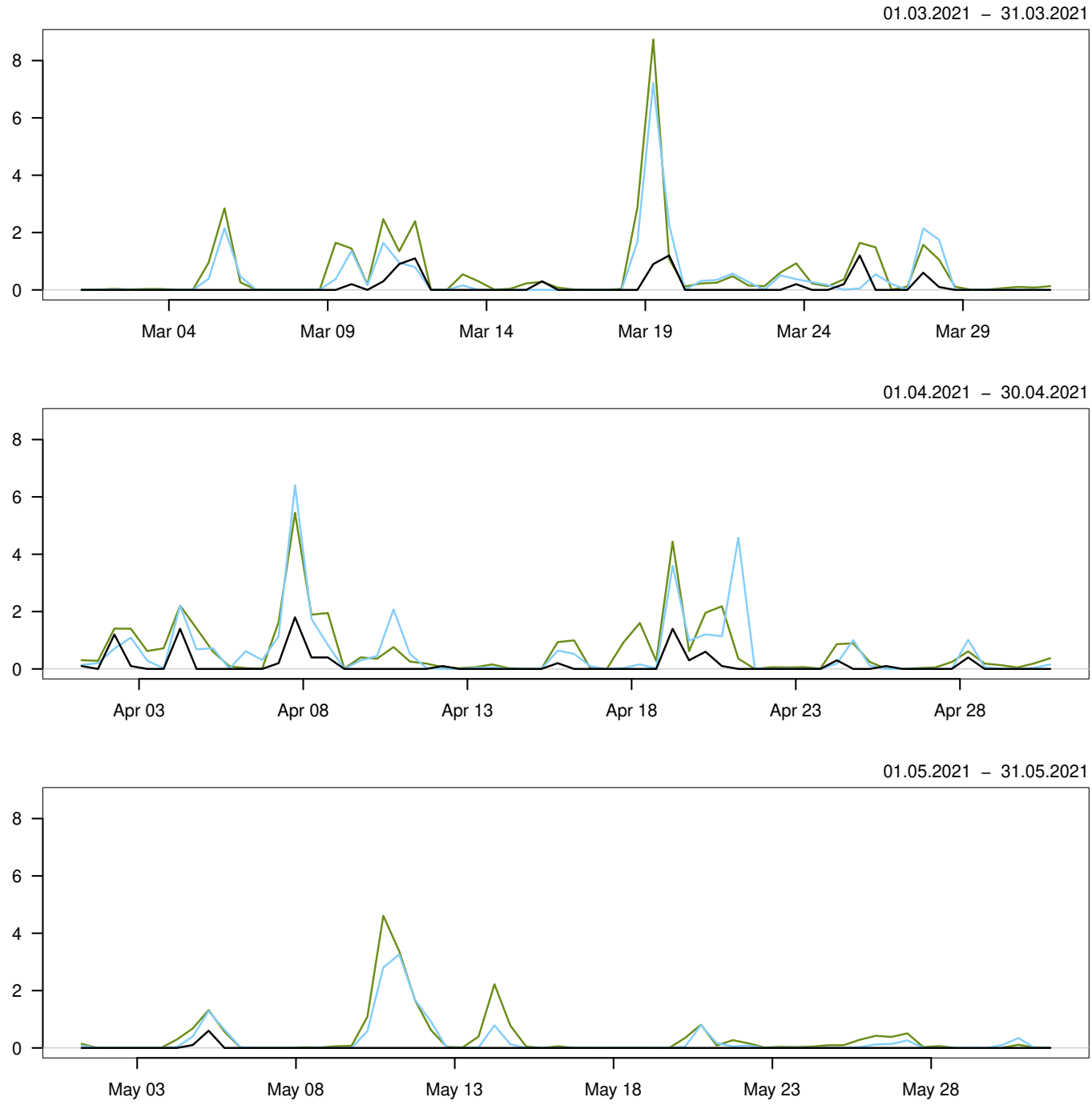
MEPSctrl 00+30

SDE at observing sites
(numbers in black)



Model "climatology" 01.03.2021 – 31.05.2021

SVALBARD LUFTHAVN



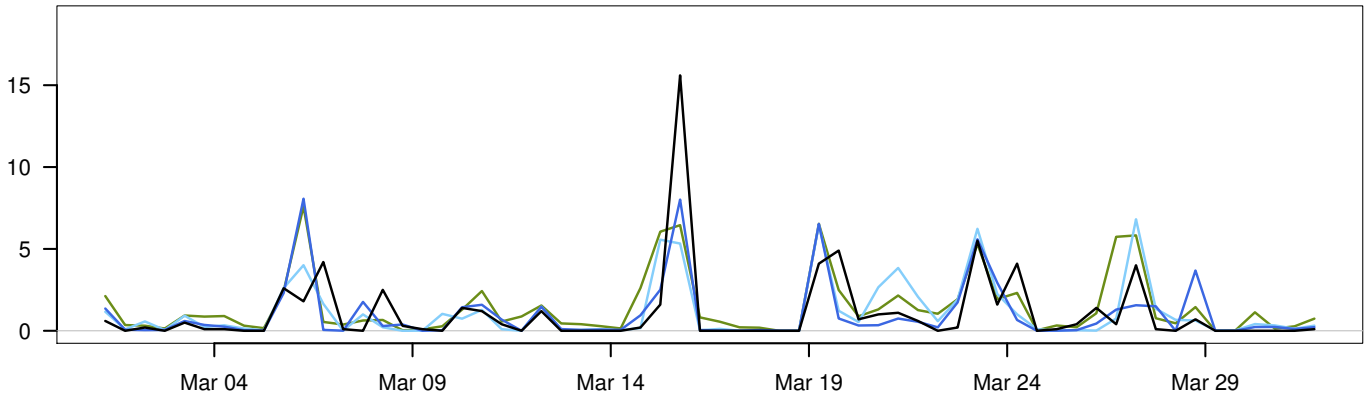
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	0.1	1.8	0.3	186
AA25: 12+18,+30	0	0.4	7.2	1	186
ECMWF: 12+18,+30	0	0.6	8.7	1.1	184

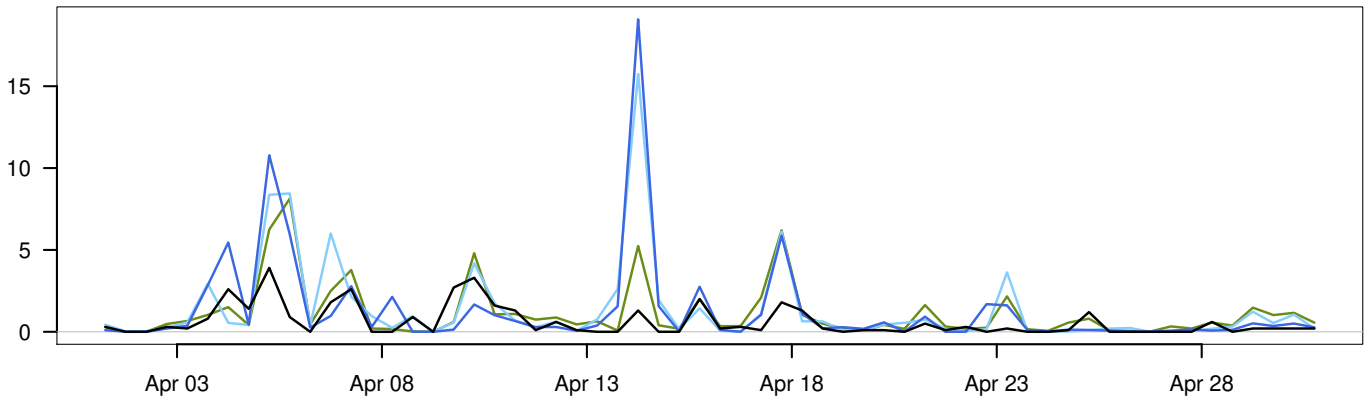
	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25 – synop	0.3	0.8	0.9	0.4	6.3	186
ECMWF – synop	0.5	0.9	1	0.5	7.8	184

BJØRNØYA

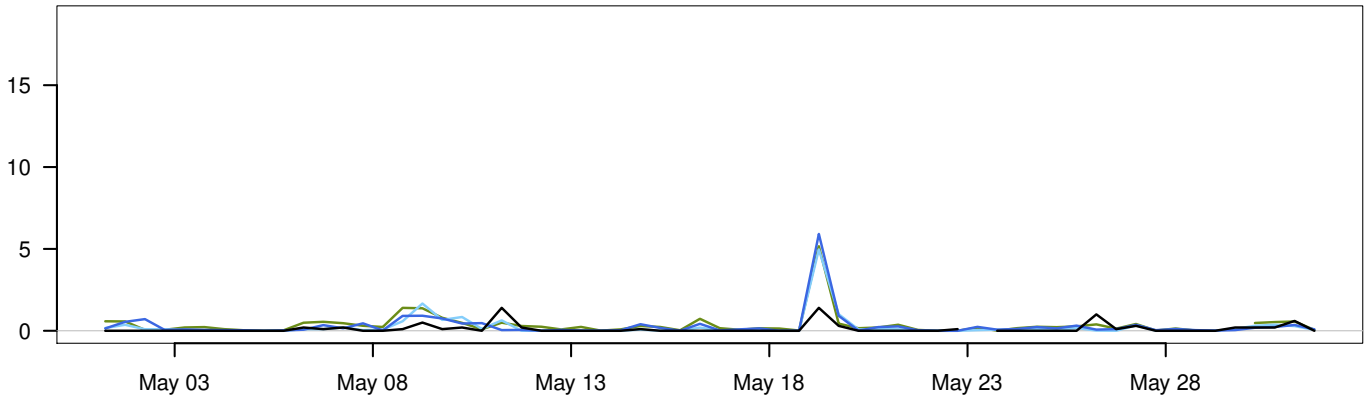
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



01.05.2021 – 31.05.2021



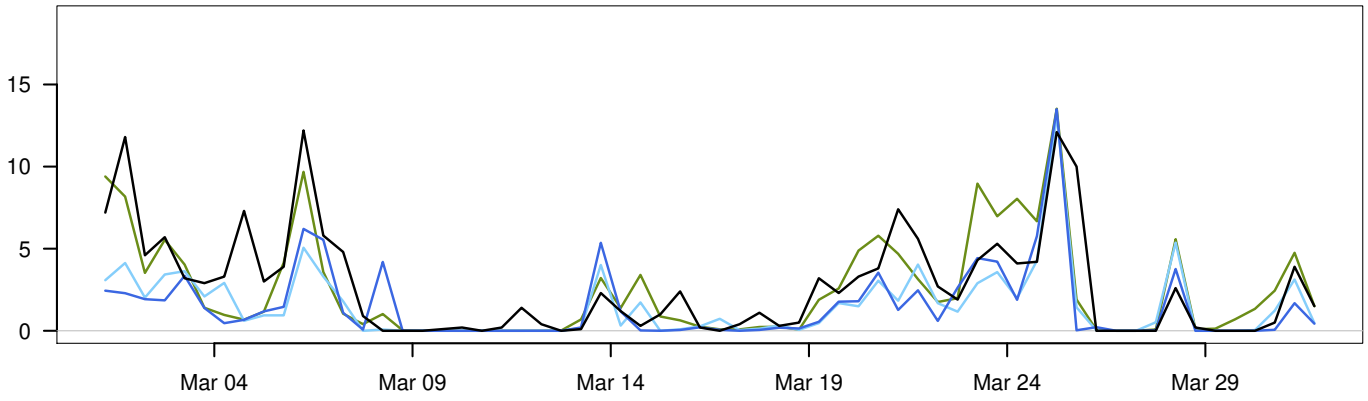
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	0.6	15.6	1.5	185
MEPSctrl: 12+18,+30	0	0.9	19.1	2.1	186
AA25: 12+18,+30	0	0.9	15.7	1.9	186
ECMWF: 12+18,+30	0	1	8.1	1.6	184

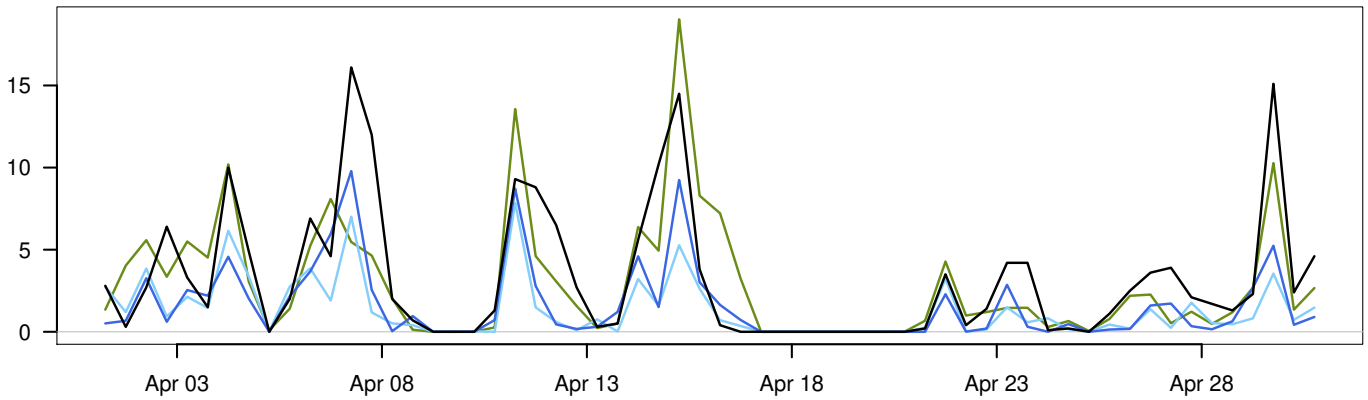
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.3	1.9	1.9	0.7	17.8	185
AA25 – synop	0.3	1.8	1.8	0.7	14.4	185
ECMWF – synop	0.4	1.4	1.4	0.7	9.1	183

TROMSØ

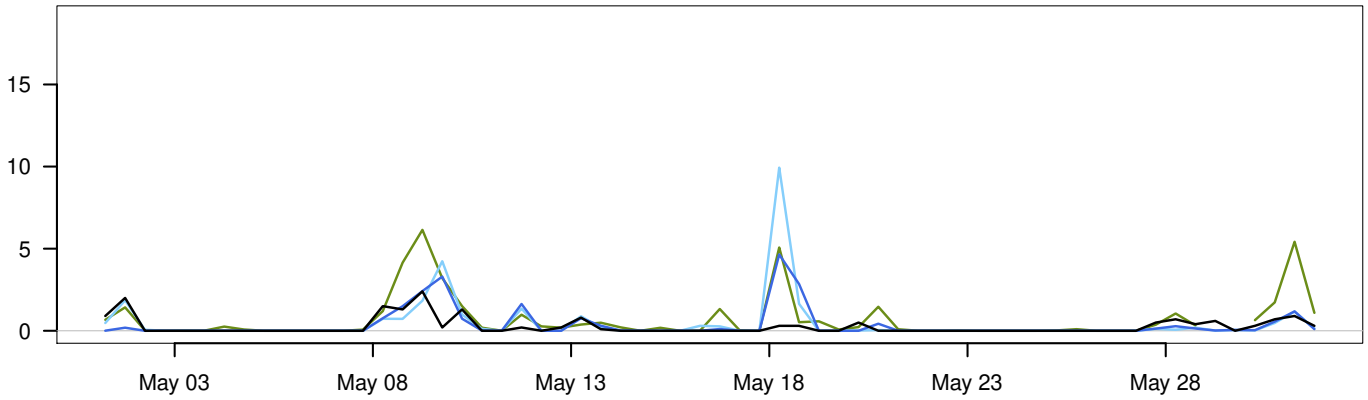
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



01.05.2021 – 31.05.2021



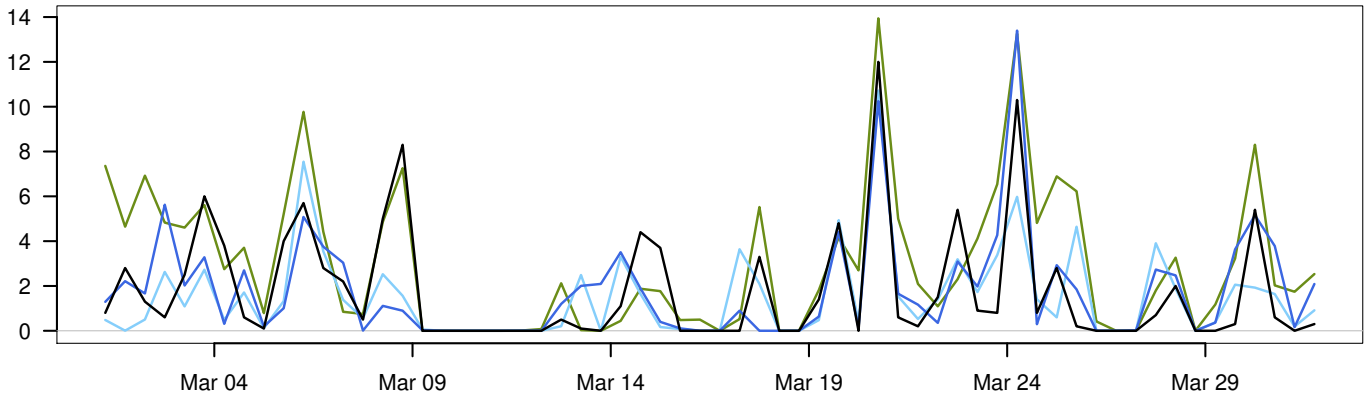
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	2	16.1	3.2	186
MEPSctrl: 12+18,+30	0	1.1	13.5	2	186
AA25: 12+18,+30	0	1.1	13.1	1.9	186
ECMWF: 12+18,+30	0	2	19	3	184

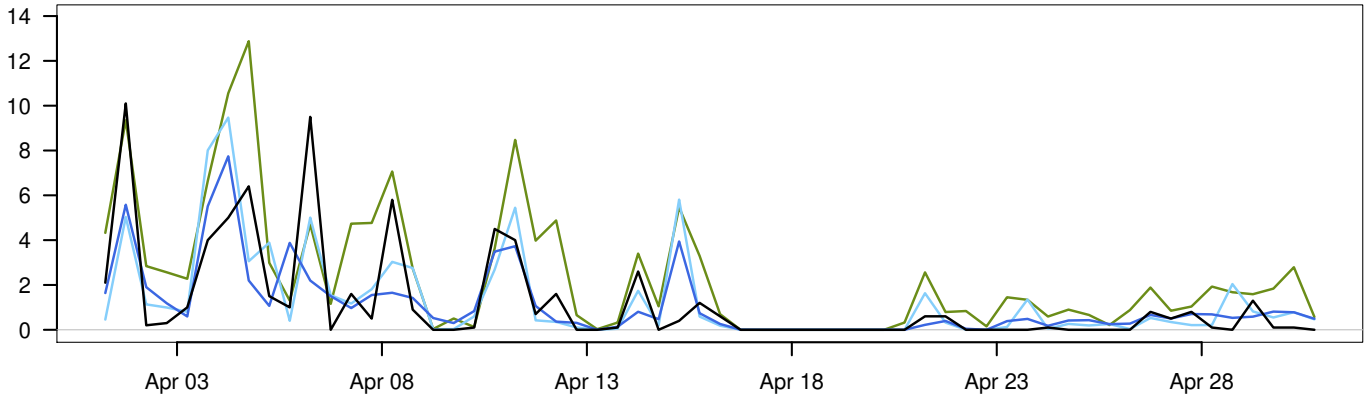
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.9	2.2	2.4	1.2	10	186
AA25 – synop	−0.9	2.4	2.6	1.3	11.6	186
ECMWF – synop	0	2.1	2.1	1.2	10.6	184

BODØ VI

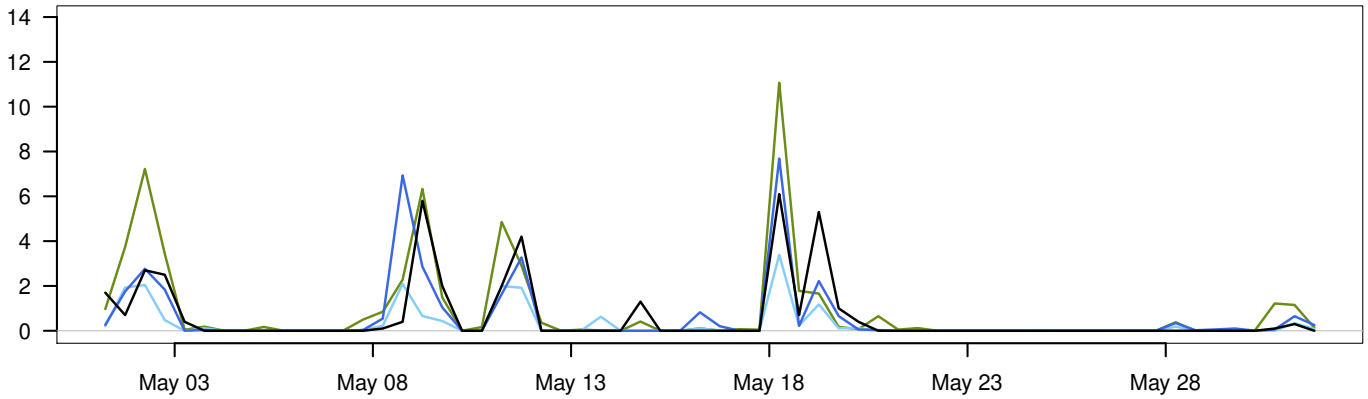
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



01.05.2021 – 31.05.2021



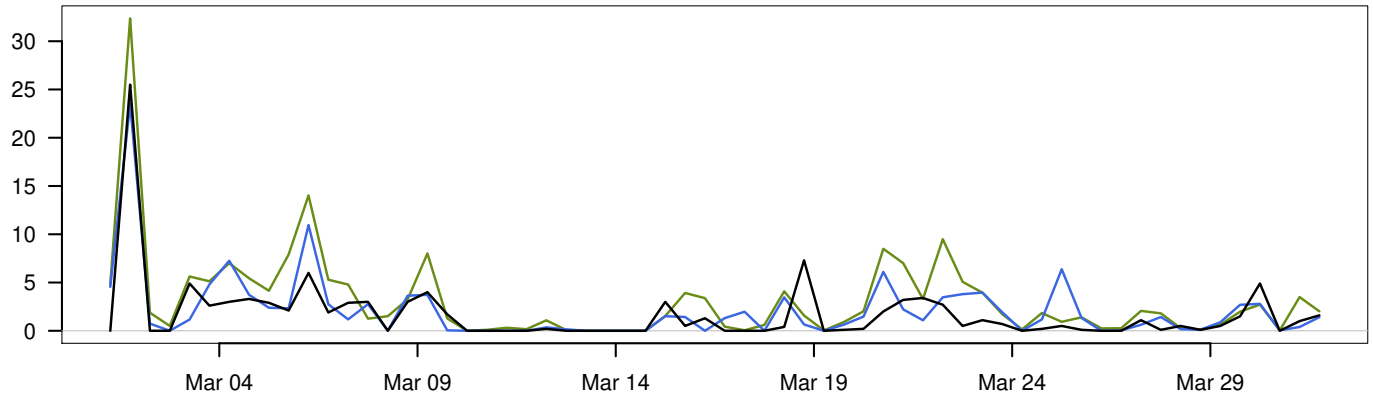
01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	1.2	12	2.2	186
MEPSctrl: 12+18,+30	0	1.2	13.4	1.9	186
AA25: 12+18,+30	0	1	10.7	1.8	186
ECMWF: 12+18,+30	0	2.1	13.9	2.9	184

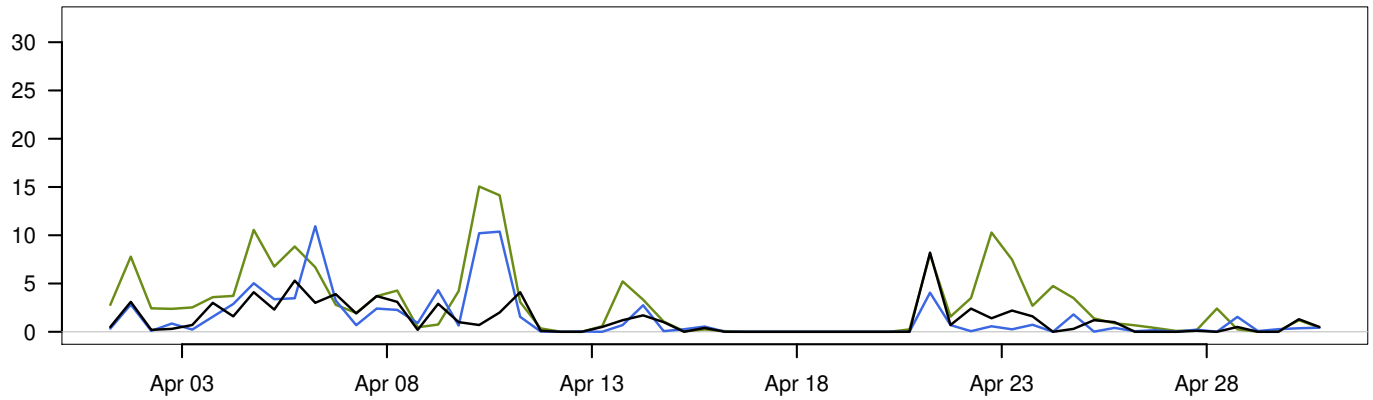
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0	1.6	1.6	0.9	7.4	186
AA25 – synop	−0.2	1.6	1.6	0.9	6.7	186
ECMWF – synop	0.9	1.7	2	1.2	6.6	184

ØRLAND III

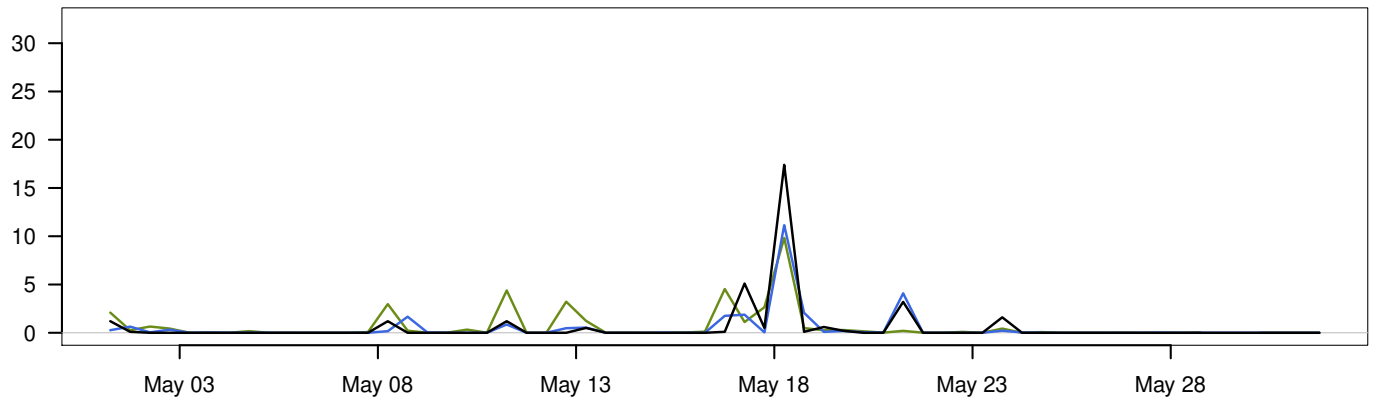
01.03.2021 – 31.03.2021



01.04.2021 – 30.04.2021



01.05.2021 – 31.05.2021

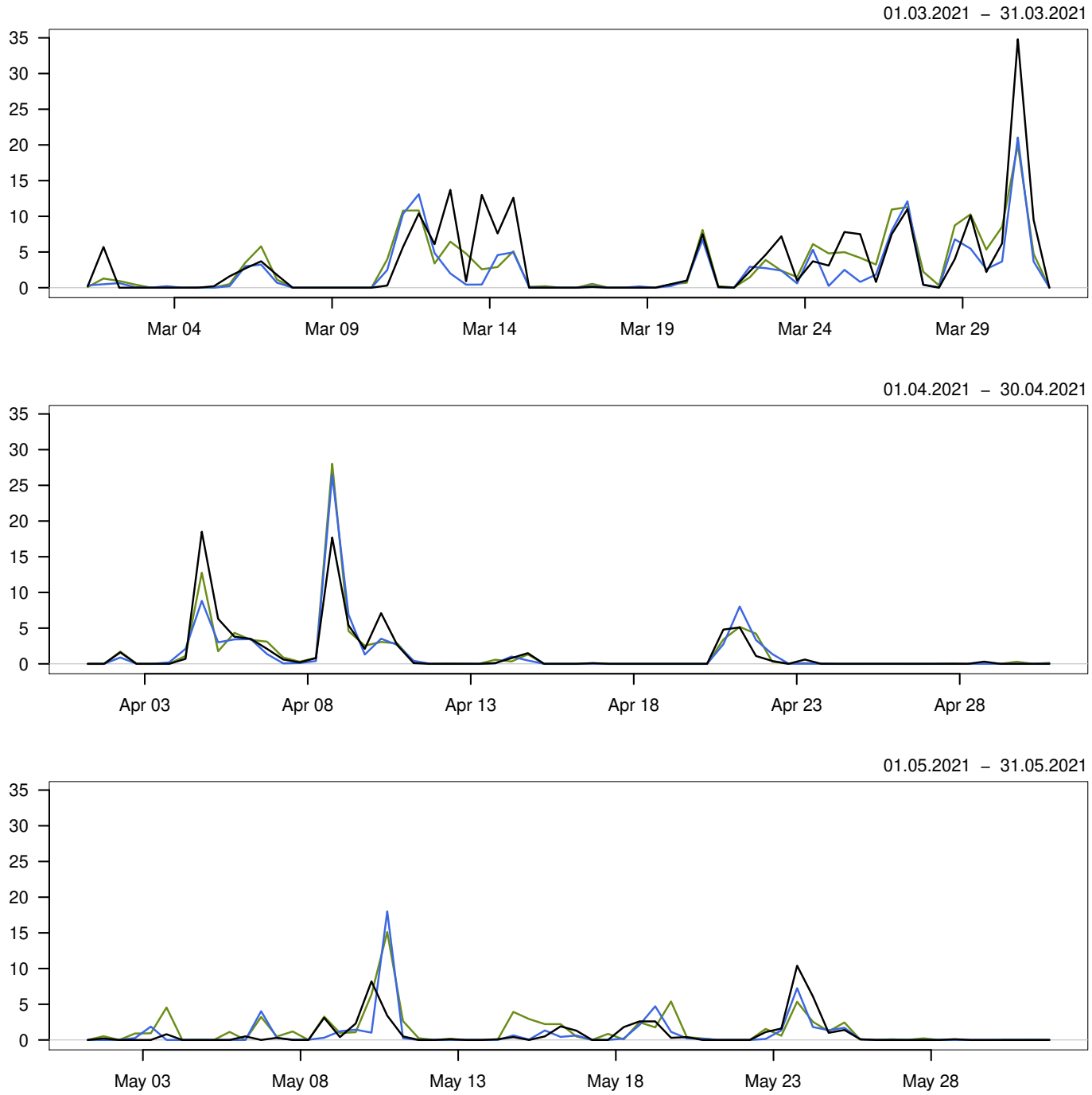


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	1.1	25.5	2.6	186
MEPSctrl: 12+18,+30	0	1.3	23.5	2.7	186
ECMWF: 12+18,+30	0	2.2	32.4	3.7	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.2	1.8	1.8	0.9	9.5	186
ECMWF – synop	1	2.4	2.6	1.4	14.4	184

BERGEN – FLORIDA

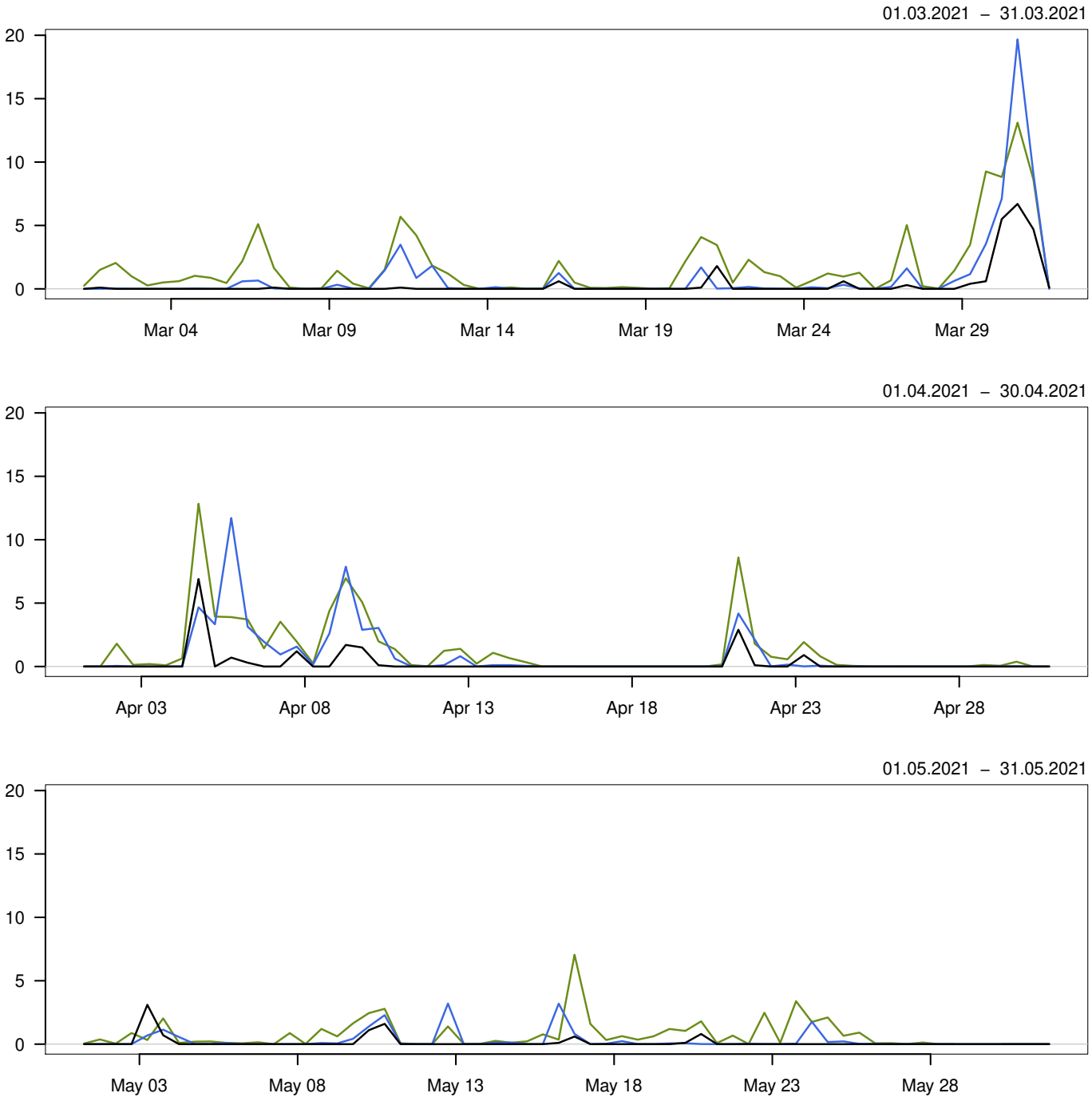


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	1.9	34.8	4.1	186
MEPSctrl: 12+18,+30	0	1.5	26.5	3.5	186
ECMWF: 12+18,+30	0	1.9	28	3.6	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.4	2.7	2.7	1.1	14.6	186
ECMWF – synop	0	2.5	2.5	1.1	14.8	184

LÆRDAL IV

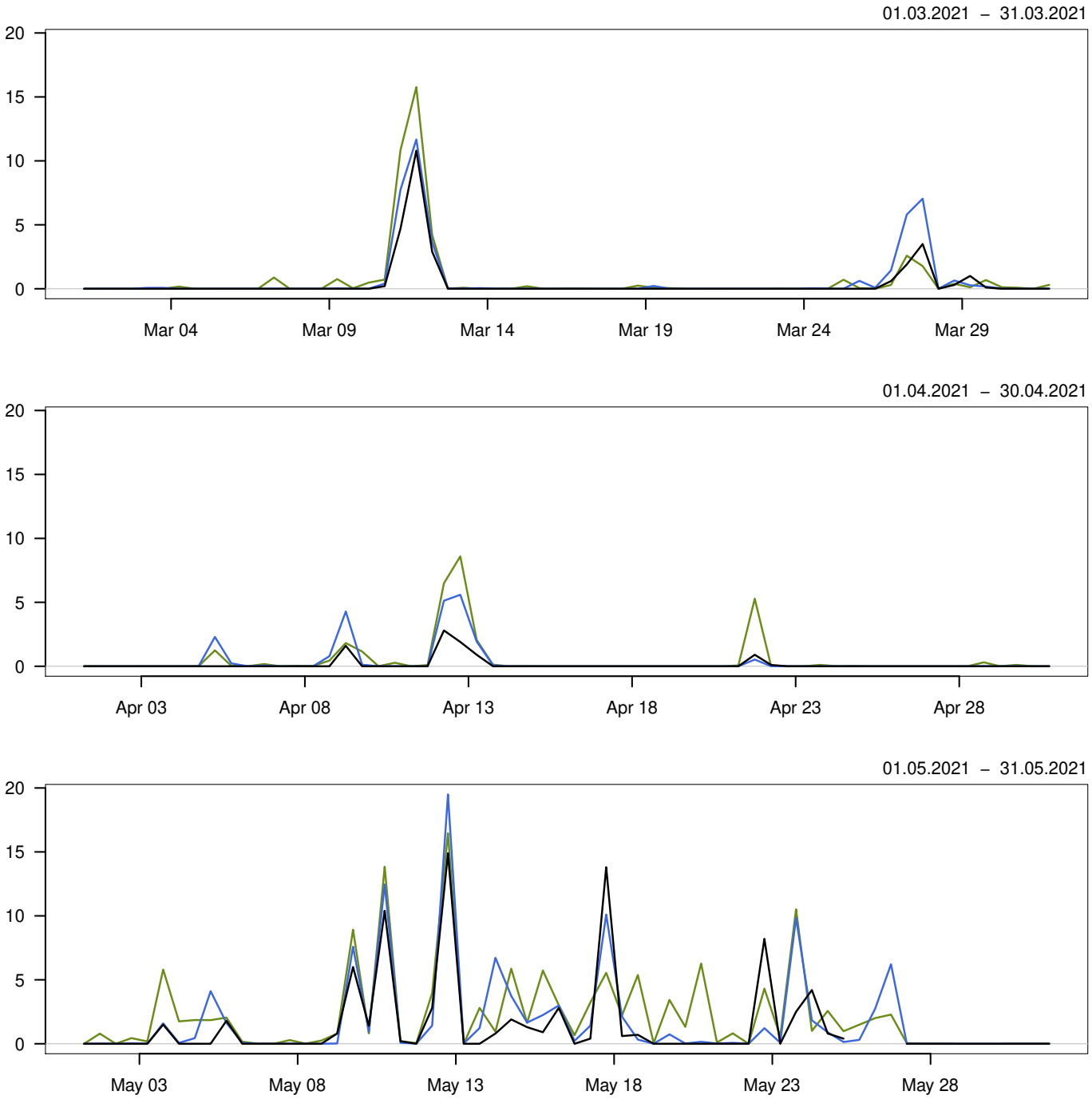


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	0.2	6.9	1	186
MEPSctrl: 12+18,+30	0	0.7	19.7	2.1	186
ECMWF: 12+18,+30	0	1.2	13.1	2.2	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.4	1.5	1.6	0.5	13	186
ECMWF – synop	1	1.5	1.8	1	8.7	184

GARDERMOEN

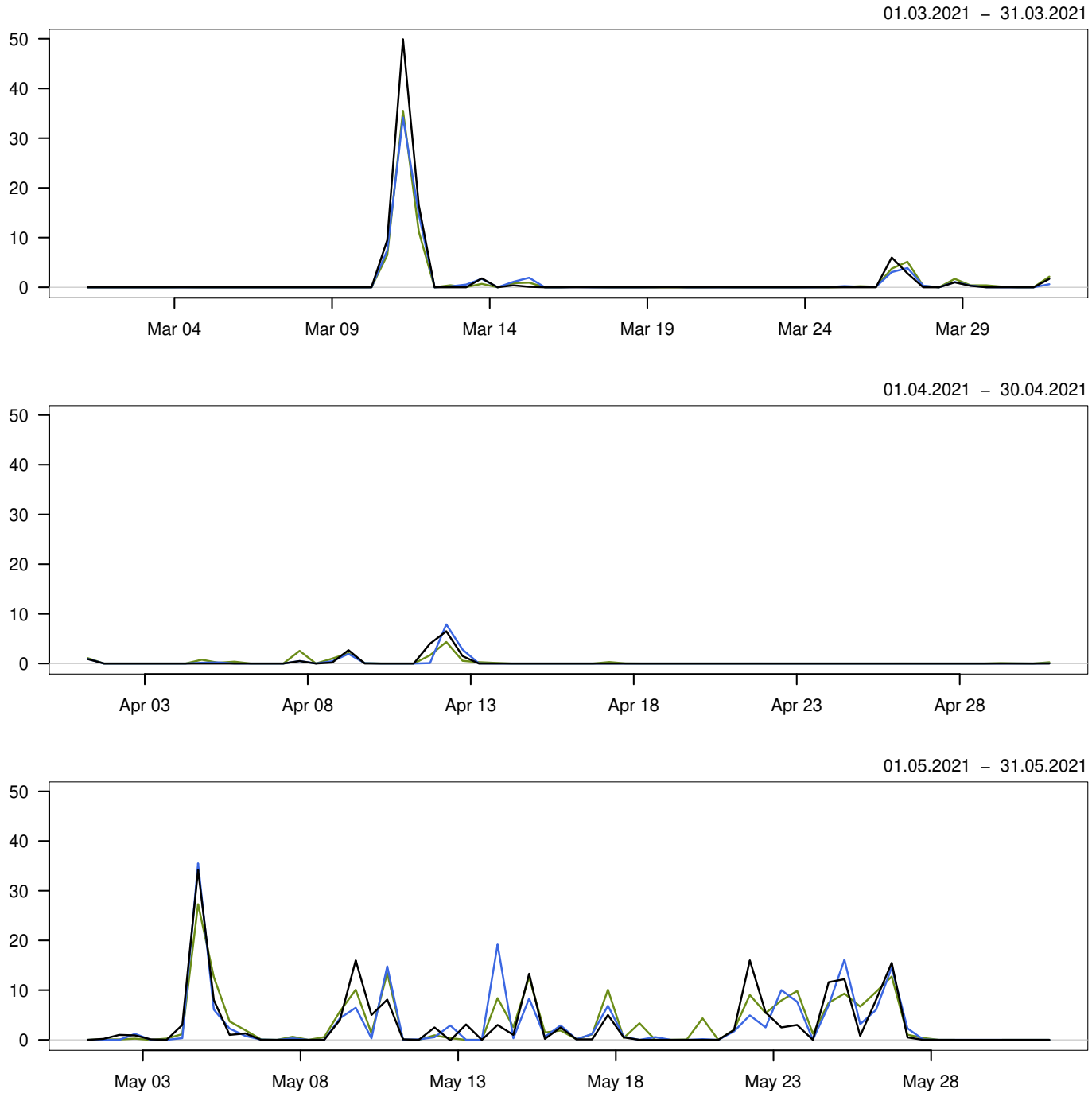


01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	0	0.6	14.9	2.1	183
MEPSctrl: 12+18,+30	0	0.9	19.5	2.5	186
ECMWF: 12+18,+30	0	1.1	16.5	2.7	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	0.2	1.2	1.3	0.4	7.3	183
ECMWF – synop	0.5	1.6	1.7	0.7	8.3	181

NELAUG



01.03.2021 – 31.05.2021

	Min	Mean	Max	Std	N
synop: 06,18	−0.1	1.6	49.9	5.3	186
MEPSctrl: 12+18,+30	0	1.5	35.5	4.6	186
ECMWF: 12+18,+30	0	1.6	35.5	4.3	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl – synop	−0.1	2.4	2.4	0.8	16.2	186
ECMWF – synop	0	2	2	0.8	14.4	184