Norwegian Meteorological Institute

METinfo

No. 22/2021
ISSN 1894-759X
Meteorology

Verification of Operational Weather Prediction Models June to August 2021

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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

This verification report indicates the quality of the main operational weather forecasting models used at the Norwegian Meteorological Institute for the period indicated. Another purpose of the verification report series is to provide a stable source of information suitable for monitoring longer trends in forecasting quality for interested readers. The report complements the verification and monitoring performed on individual models. Each model is monitored and developed according to the scientific method, where changes are only introduced when they can document a better likely prediction skill. Such documentation is available as research papers, consortium news, and presentations at team-, syndicate- and consortium-meetings. The skill of the forecasting service in severe weather situations is also documented with special emphasis on forecast failures, in order to learn from them and improve the system.

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.

10 m wind speed is post-processed by downscaling to 1 km resolution to better represent local topography, and called YrPP.

YrPP is plotted with the color below.

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	$\left(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i - \mathrm{ME})^2\right)^{1/2}$	0 to ∞	0
Root Mean Square Error	RMSE	$\left(\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i)^2\right)^{1/2}$	0 to ∞	0
Correlation	COR	$\frac{\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})(o_i - \bar{o})}{\mathrm{SD}(f)\mathrm{SD}(o)}$	-1 to 1	1

In the formula for COR the following definitions are used

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

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

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

For wind direction the probability density function (PDF) is used to show the distribution of observed and forecast wind directions. The PDF used here is a kernel density estimate, which is a smoothed version of the histogram.

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.
- 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. Still, the errors are small, indicating that the timing of the temperature changes is generally good. 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 mean error of 00+12 T2m forecasts for stations, presented on maps, show that the underestimation of daytime temperatures is reduced as compared to the previous summer. The mean error plotted as a function of lead time shows that the temperature forecasts still are a little bit too cold during the day, but the underestimation is significantly reduced as compared to previous summer. 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.

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 over land, and particularly in the mountains, where ECMWF underestimates the speed considerably 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. 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. The post processing of wind speed was changed on 1 June 2021 by downscaling to 1km resolution to better represent local topography. The change implies that the post processed wind speed represents the mean wind speed rather than the maximum mean wind speed as before this change was introduced. The mean error indicates a somewhat larger underestimation of wind speed after post processing, while the other scores show almost identical results for MEPSctrl and YrPP.

Precipitation also shows varying results, depending on the amount and location. ECMWF has on average more precipitation than MEPS which this summer had mean errors very close to (and above) 0. Evaluated by skill scores, ECMWF performs a little bit better, but both have more errors for both very small amounts and very high amounts, than precipitation in the mid range. MEPSctrl performs better than ECMWF for small amounts and no precipitation.

The models generally perform better during summer months than during winter. 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. Precipitation is an exception from this trend, as summer often comes with convective cases that are challenging to predict. 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. Low clouds in Southern Norway 28 June 2021

There were several reports on missing low Stratus clouds also this summer. One example is from Southern Norway on 28 June. ECMWF was in this case better than MEPS, and had higher moisture content at cloud levels.

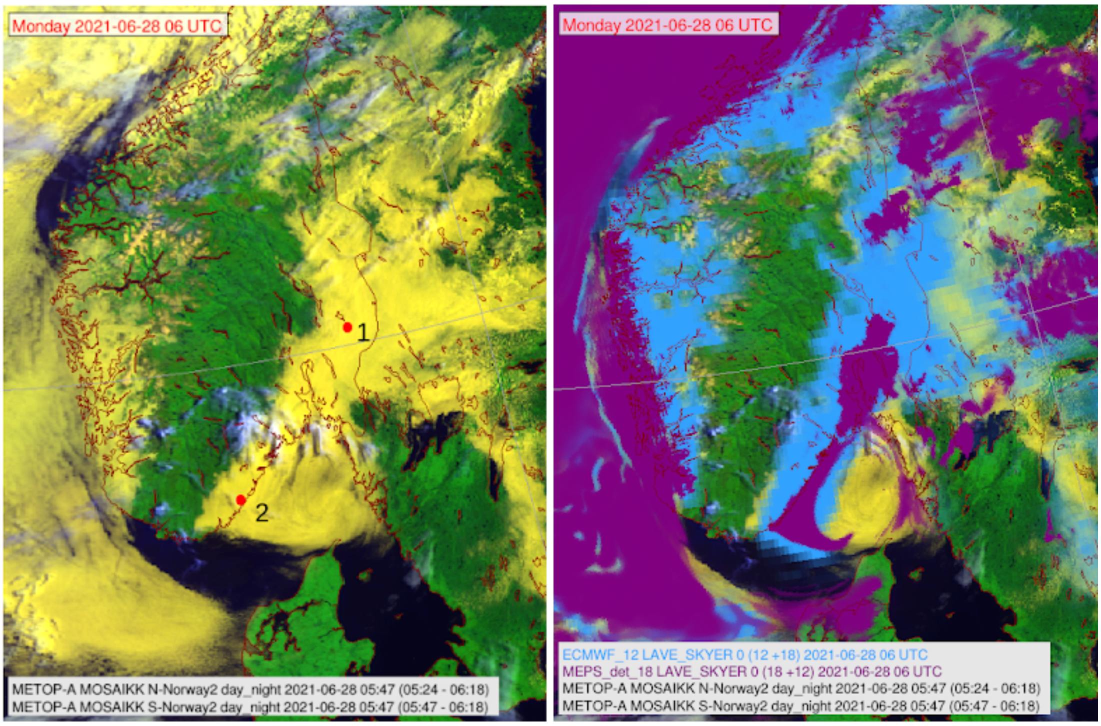


Figure 1: Left: The satellite image from the morning of 28 June. Yellowish areas are low clouds. Right: MEPS (purple) had generally less extent than ECMWF (blue) of low clouds.

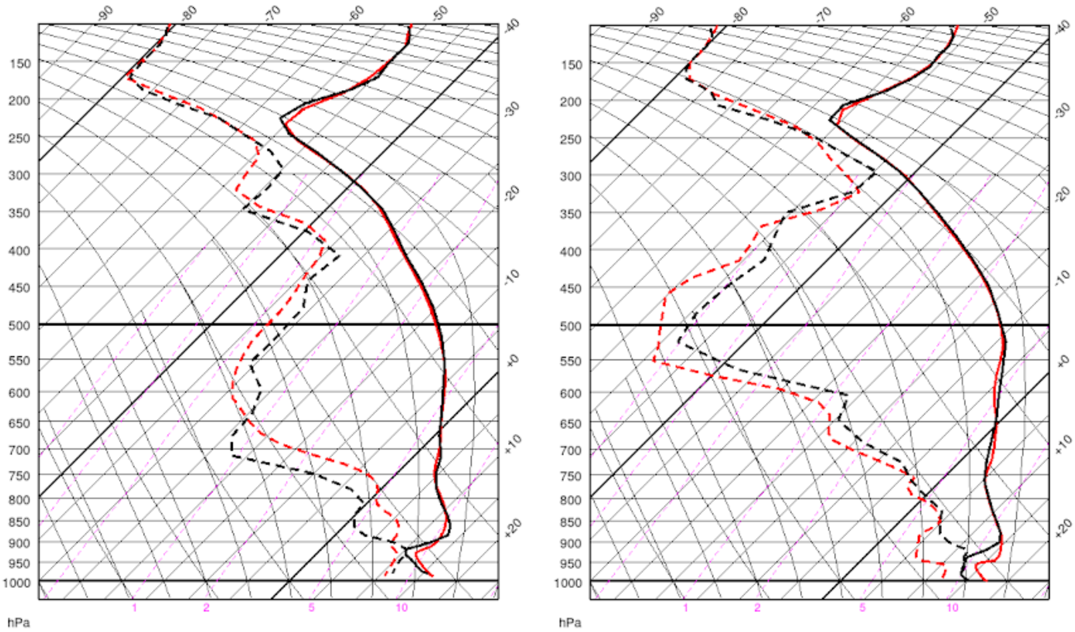


Figure 2: Left: The sounding from Kongsvinger with ECMWF, 00+7hrs in black and MEPS 03+4hrs in red. The T2m (18+13) was about 15°C for both models. Right: The sounding from Arendal with ECMWF, 00+7hrs in black and MEPS 03+4hrs in red. The prognostic (18+13) T2m from MEPS was 16.5°C and 15°C from ECMWF.

Soundings from two representative locations where MEPS were lacking low clouds are shown for Kongsvinger (figure 2, left) and Arendal (figure 2, right). The prognosed T2m was slightly higher in MEPS, probably as a response to more sun insolation. The soundings indicate that one reason may be excessive mixing at the lowest layers below the inversion at 925 hPa during the night.

Case 2. Fog in June and July 2021

There were several reports on erratic fog, either too much, misplaced, or with too little extent. Generally the last upgrade of MEPS was a slight improvement, in that it had slightly less extent in cases of misplaced or false fog. Some experiments have been run with the new HARMONIE-AROME Cy43h2.2 release candidate at MET. A first impression based on a few cases from June and July is that the new version has slightly less horizontal extent of the fog and that it is in slightly better agreement with observations than the current operational Cy43h2.1. The tendency for the fog to quickly dissolve after formation also seems to be less present in the Cy43h2.2 new candidate, in that it seems to extend further in from the leading edge of the fog area.

Fog in Northern Norway 2-3 June

On 2 June a band of fog was seen outside the Finnmark coast. The smooth appearance and sharp edge of the cloud area is a good indication that this is in fact fog, and not low stratus. An improved fit is seen with the new release candidate over the current operational.

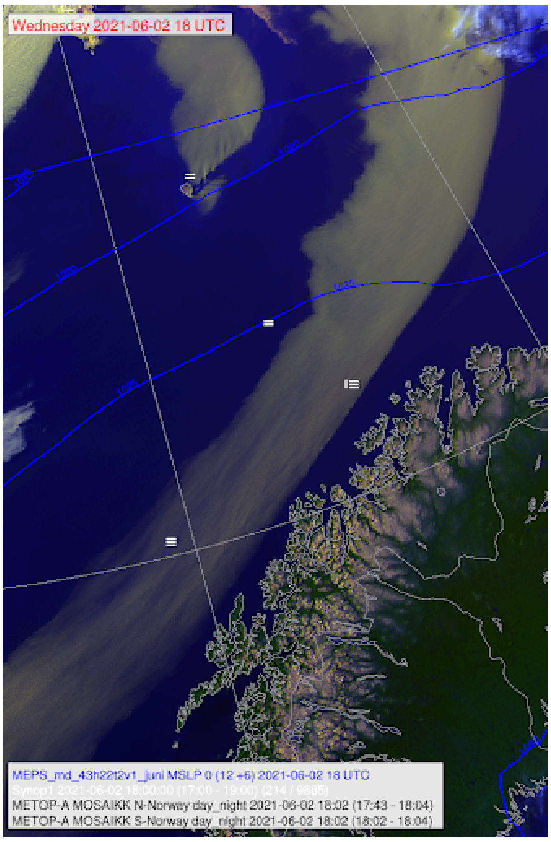


Figure 3: Satellite image showing band of fog outside the Finnmark coast.

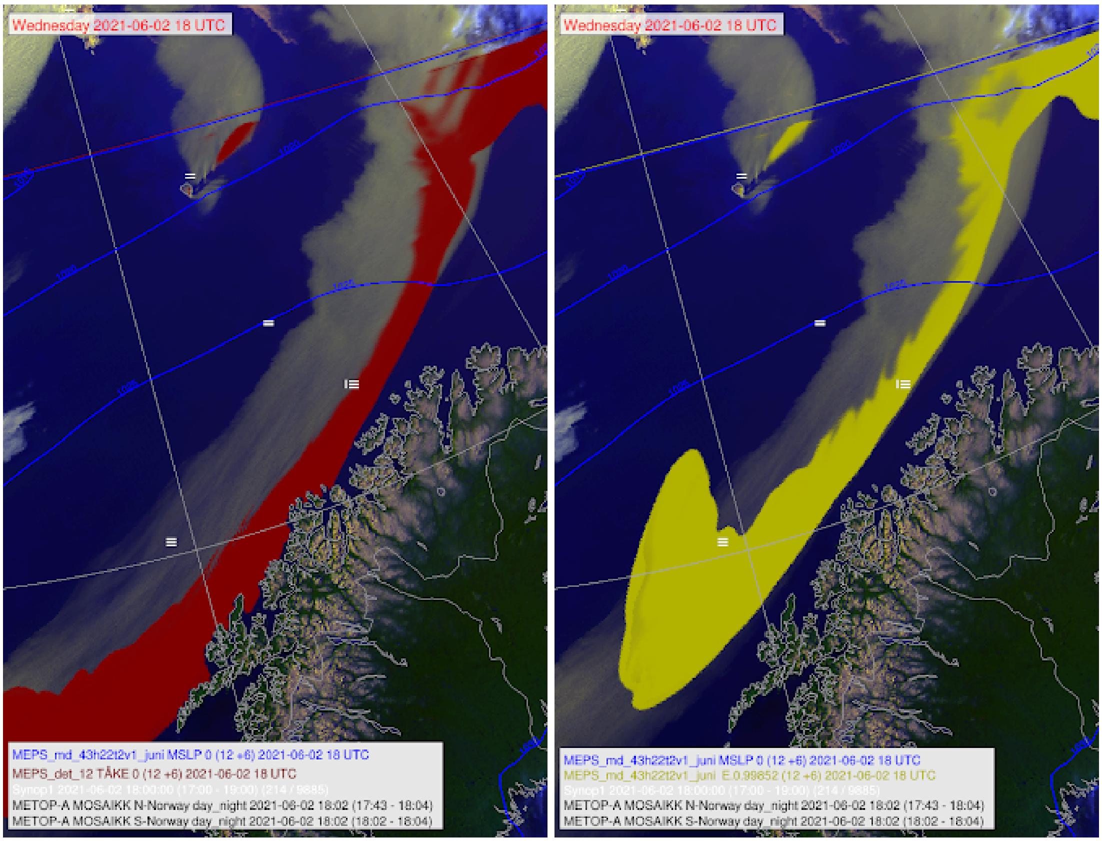


Figure 4: Left: MEPS prod showing excessive fog in the coastal areas of Northern Norway on the 2 June. Right: MEPS Cy43h2.2 new release candidate with a much better fit with observations and the satellite image.

On 3 June a case of misplaced fog was seen in Northern Norway. This is interesting since there are some observations of T2m from the actual sea fog here, which makes it possible to assess this aspect of the model.

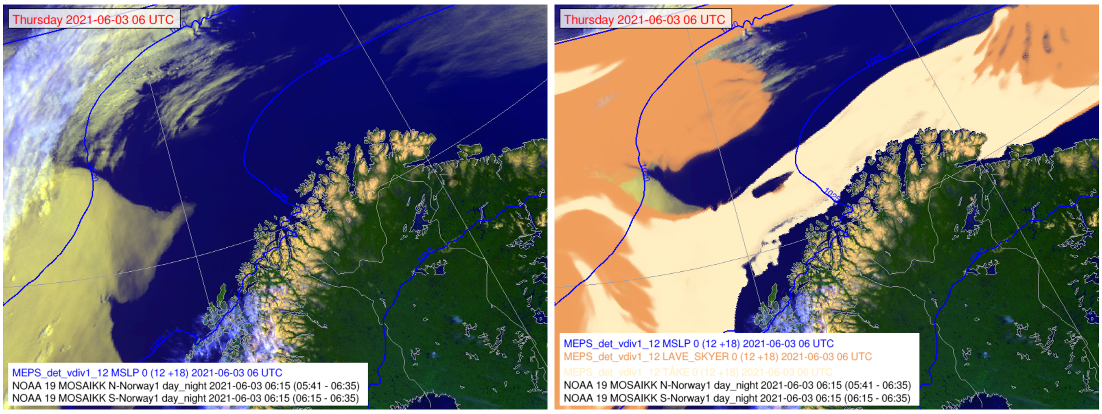


Figure 5: Left: Clear skies from the 3rd at 06z over Troms and Finnmark in northern Norway. A fog layer is seen as a yellow area in the left part of the picture. Right: Corresponding low clouds (light brown) and fog (beige) from HARMONIE-Arome from the 2nd, 12-run +18hrs.

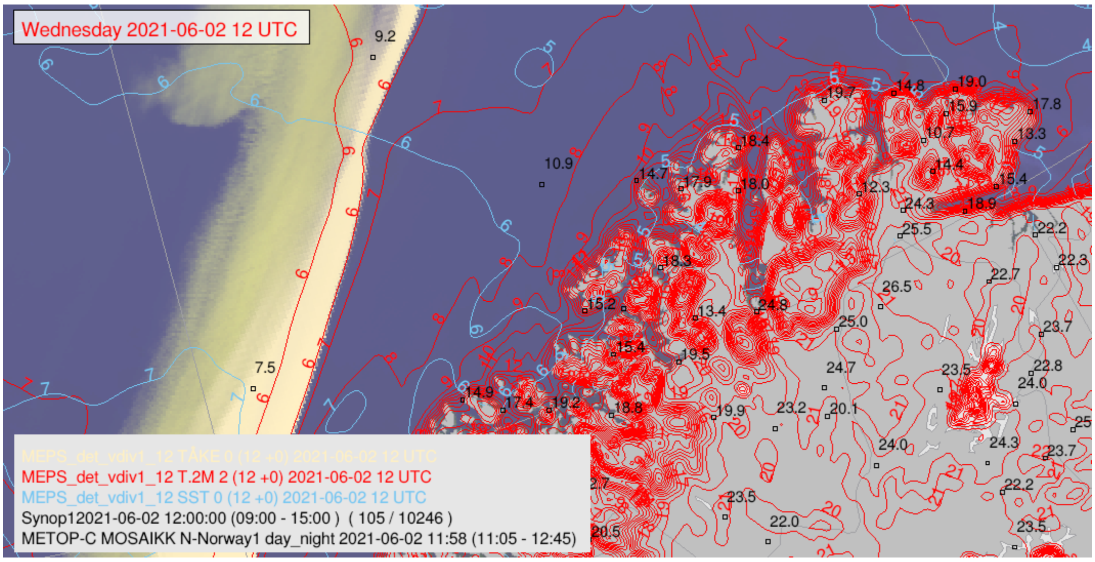


Figure 6: The analysis at 12z on the 2 of June. The sea surface temperature (blue) was from 6 to 7°C and the observed T2m was between 9 and 11°C. The model was generally too cold, indicating that it may have been too affected by the surface.

The model T2m within the fog drops gradually during the first 18 hours to 2 to 3°C, which is slightly below what was observed. This may support the assumption that the model IR radiation is reacting slighly too strongly to liquid water droplets, with the effect of cooling the cloud layer too much.

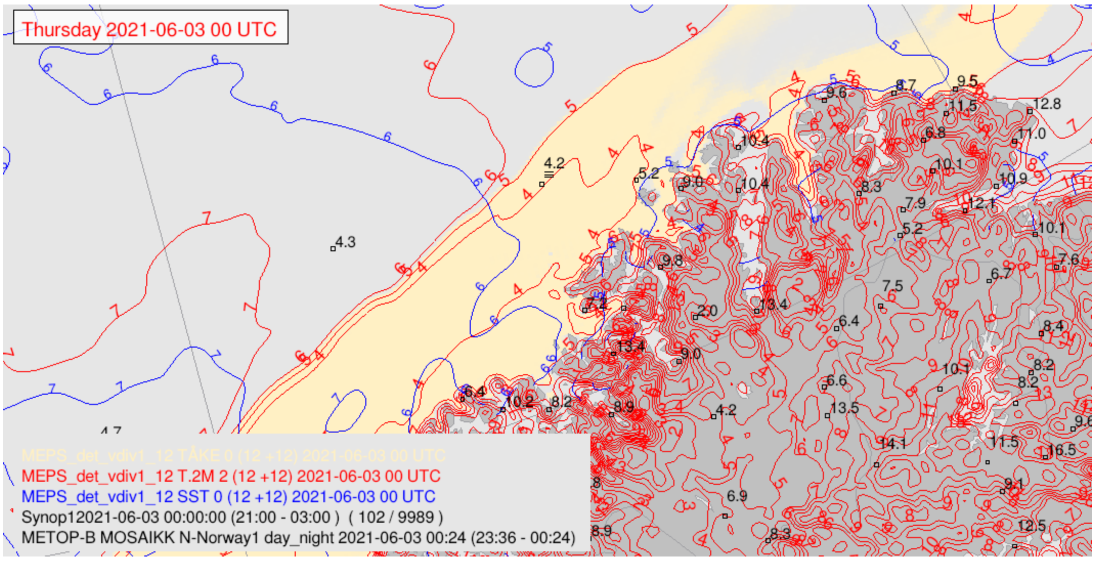


Figure 7: HARMONIE-Arome T2m (red) plotted against observed T2m (black) at 00z on 3 June, 12 hrs prognosis. The prognostic fog (yellow) was too far southeast towards the coast, while it in reality was covering the three observations in the upper left part of the picture. The minimum observed temperature within the fog layer was 3.7°C at 03z, (not shown). This shows that the model temperatures within the fog are quite realistic.

Fog in the Norwegian Sea 5-6 July

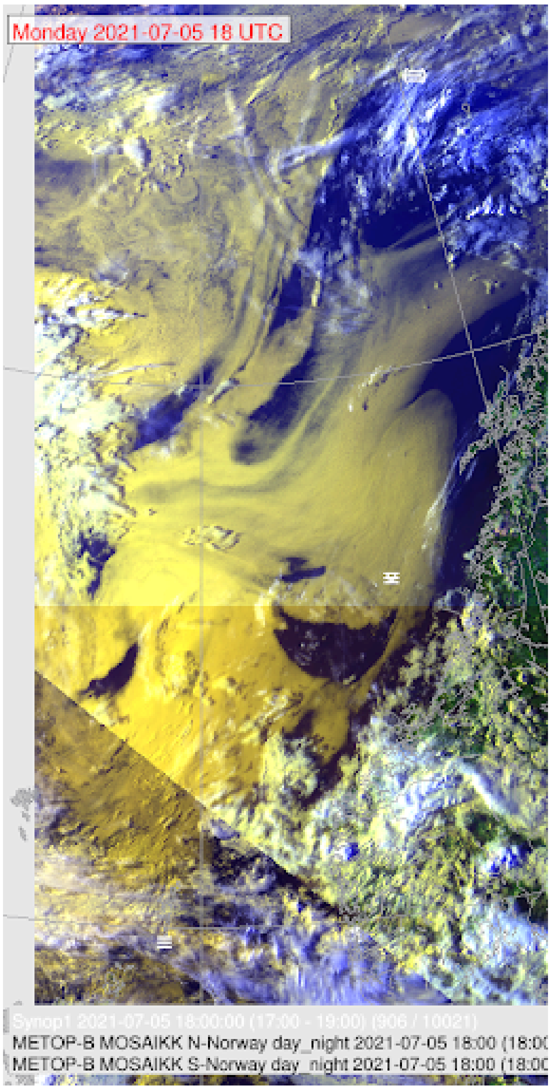


Figure 8: Satellite and observations of fog from 18z on 5 July. Large areas of low stratus and fog in the Norwegian Sea. The fog appears as yellowish areas with sharp edges, whereas the stratus tends to have fussy edges, but otherwise with the same colour. A few observations support the assessment of the nature of the cloud layer.

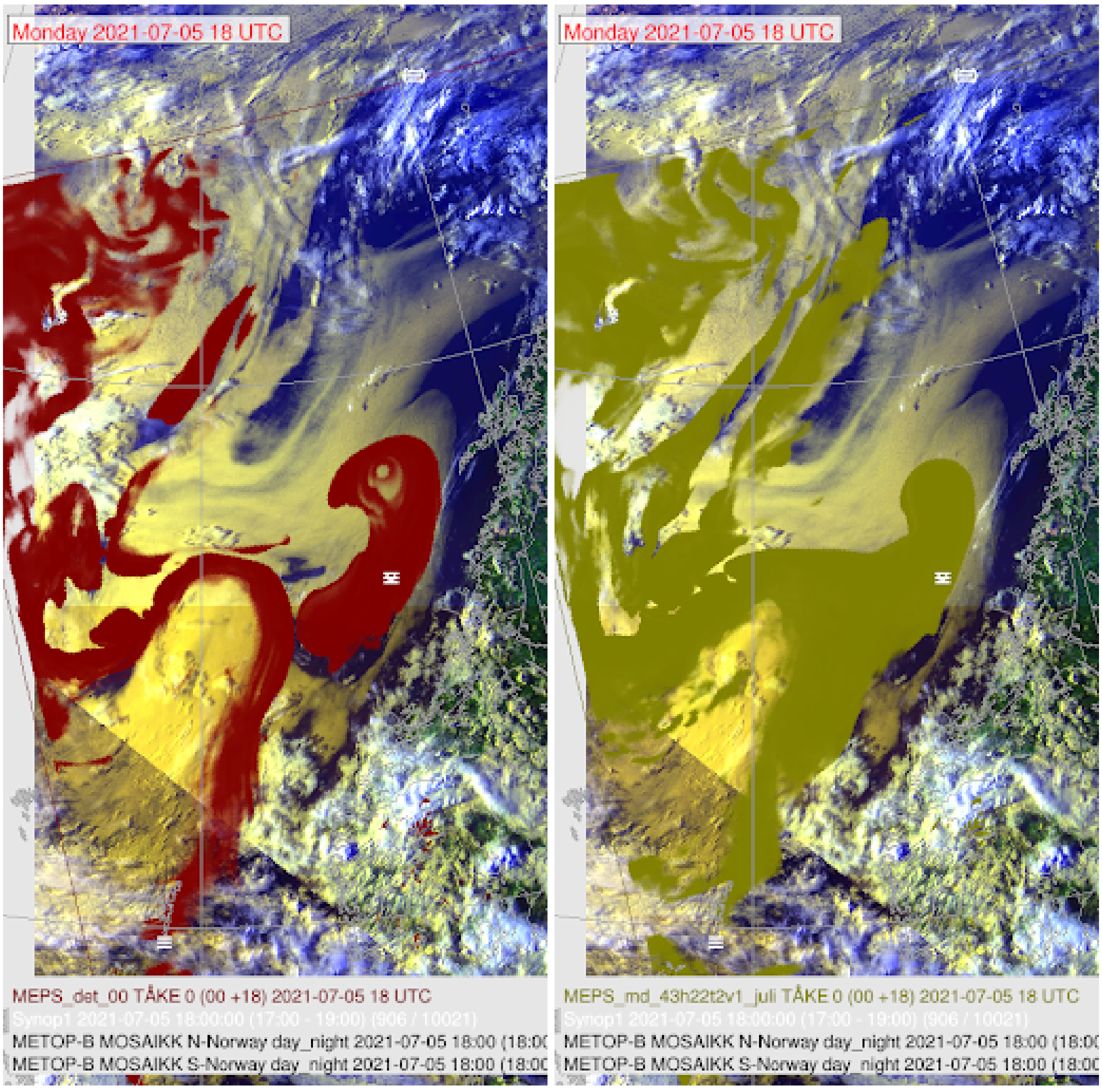


Figure 9: Left: MEPS Cy43h2.1 fog at 00+18hrs from 5 July. The fog in the current operational model is often confined to the edges of the cloudy area. Right: MEPS Cy43h2.2 new release candidate fog at 00+18hrs prognosis from 5 July. The new version seems to take longer to dissolve the fog after it has formed.

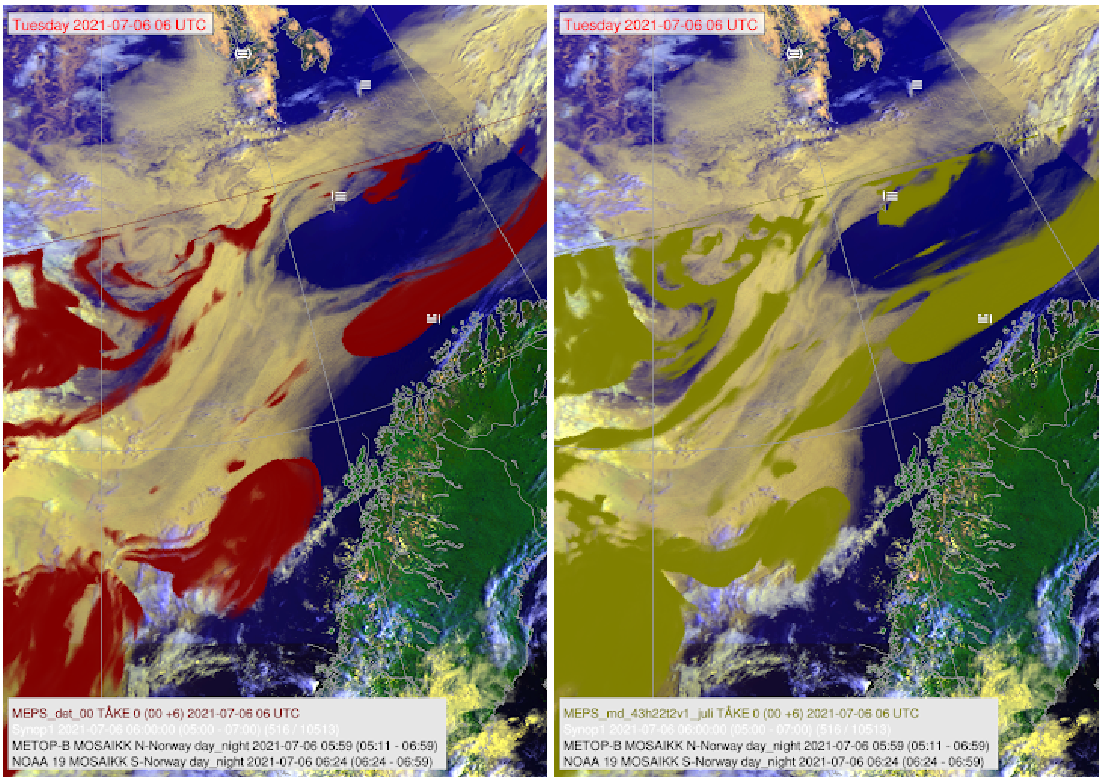
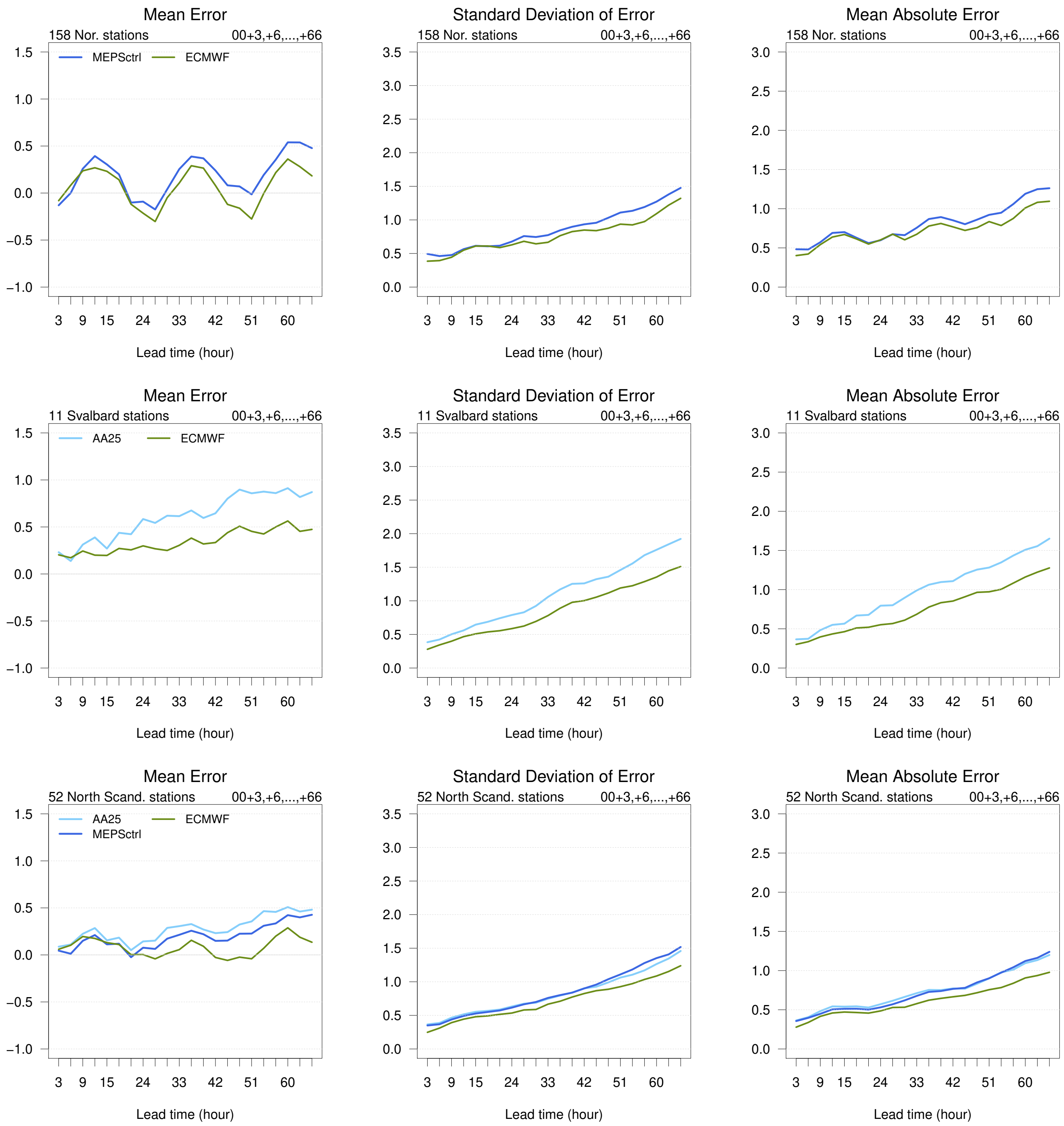
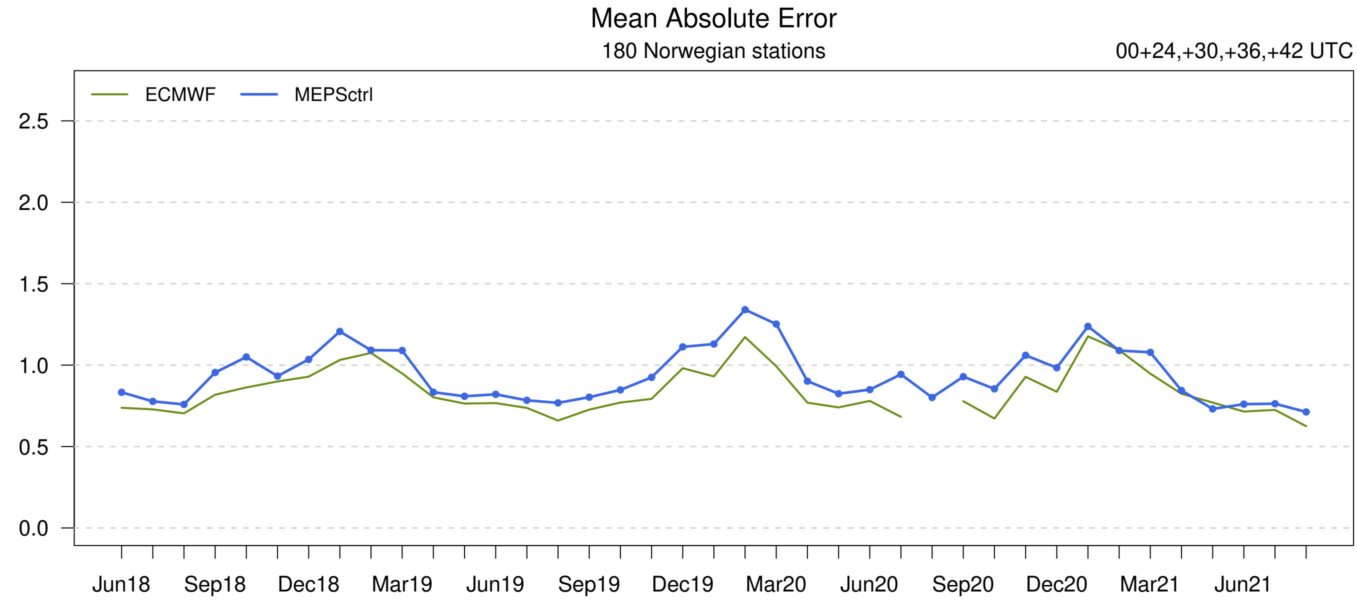
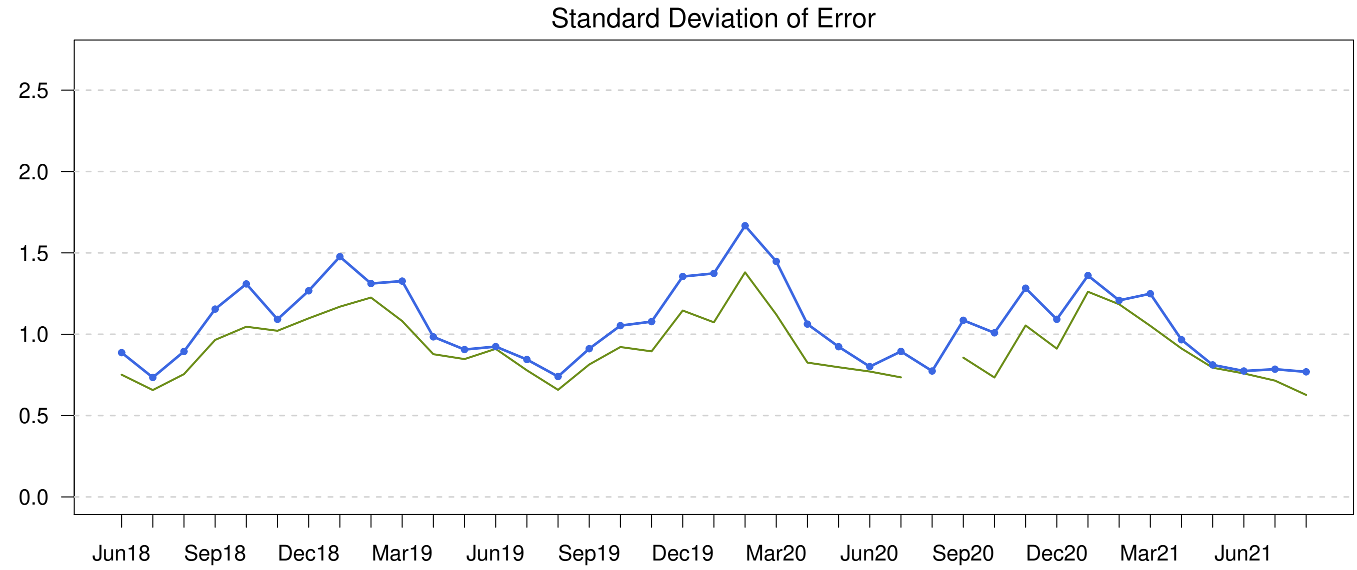


Figure 10: Left: The fog from the 6 July, 00+6hrs in the current Cy43h2.2. This has a slightly larger extent than the new experimental version. Right: Same field in the new release candidate shows slightly less outer extent of the fog patches, but somewhat better fit to observations, e.g. at Bear Island in the northern edge of the domain.

Summarized statistics


Mean Error
158 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
158 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
158 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
52 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
Lead time (hour)
Standard Deviation of Error
52 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
52 North Scand. stations
00+3,+6,...,+66
Lead time (hour)


Mean Absolute Error
180 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2.5
2.0
1.5
1.0
0.5
0.0
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21


Standard Deviation of Error
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2.0
1.5
1.0
0.5
0.0
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Sep18
Dec18
Mar19
Jun19
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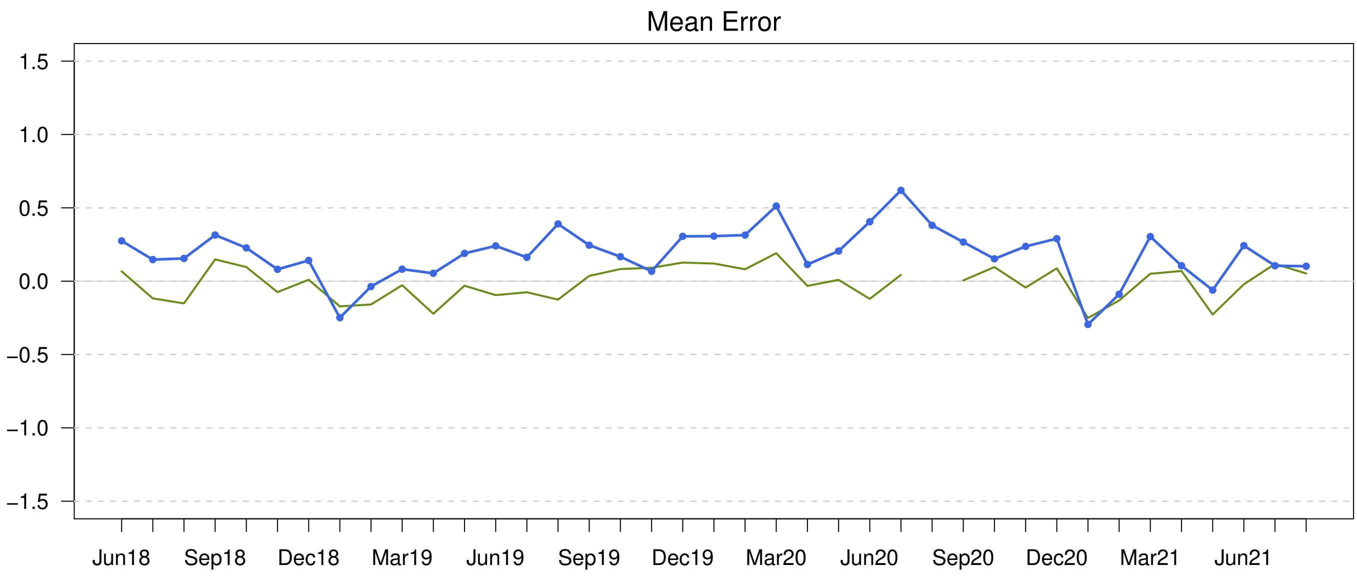
Sep20
Dec20
Mar21
Jun21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1.0
0.5
0.0
−0.5
−1.0
−1.5
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Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
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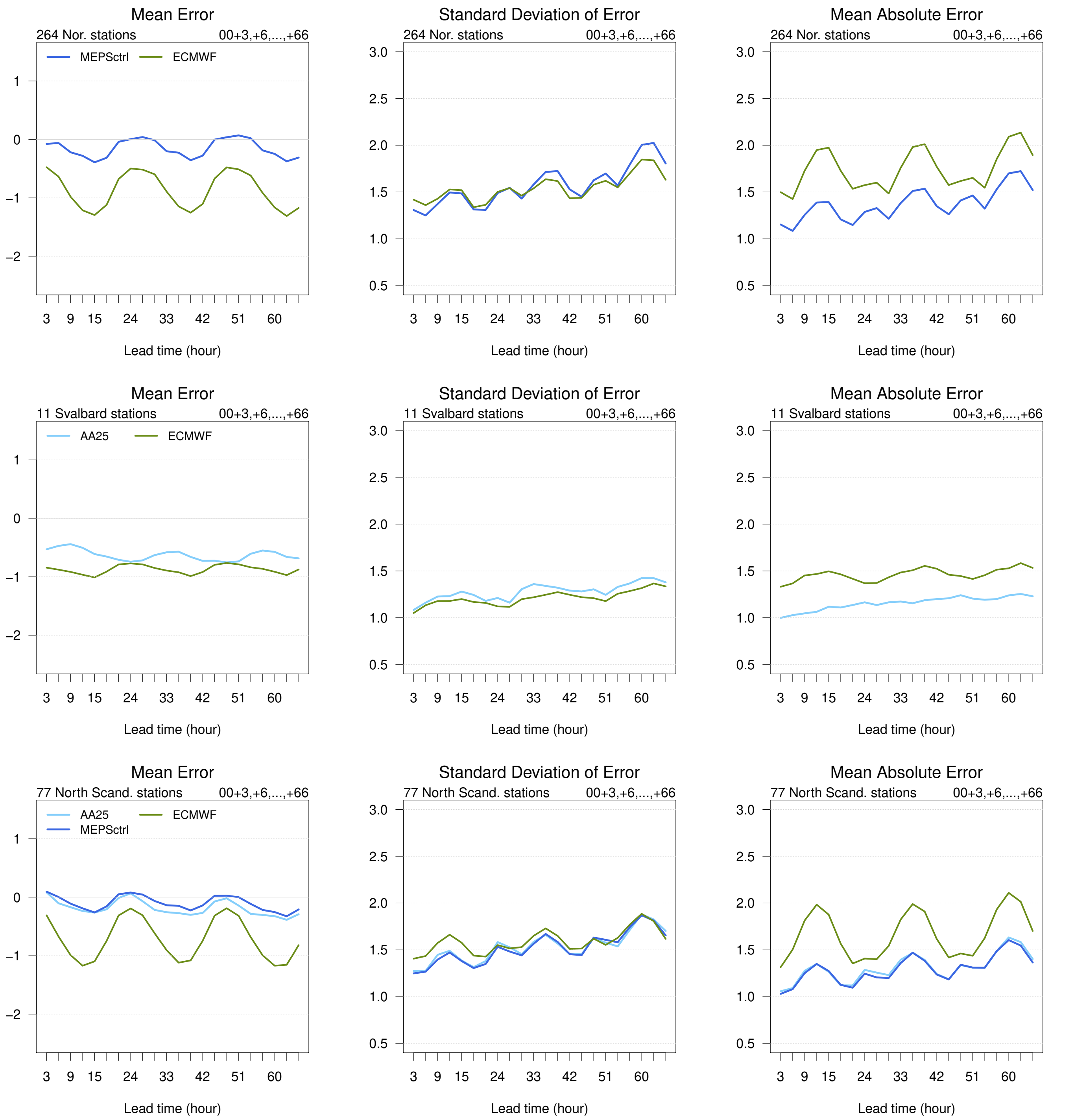
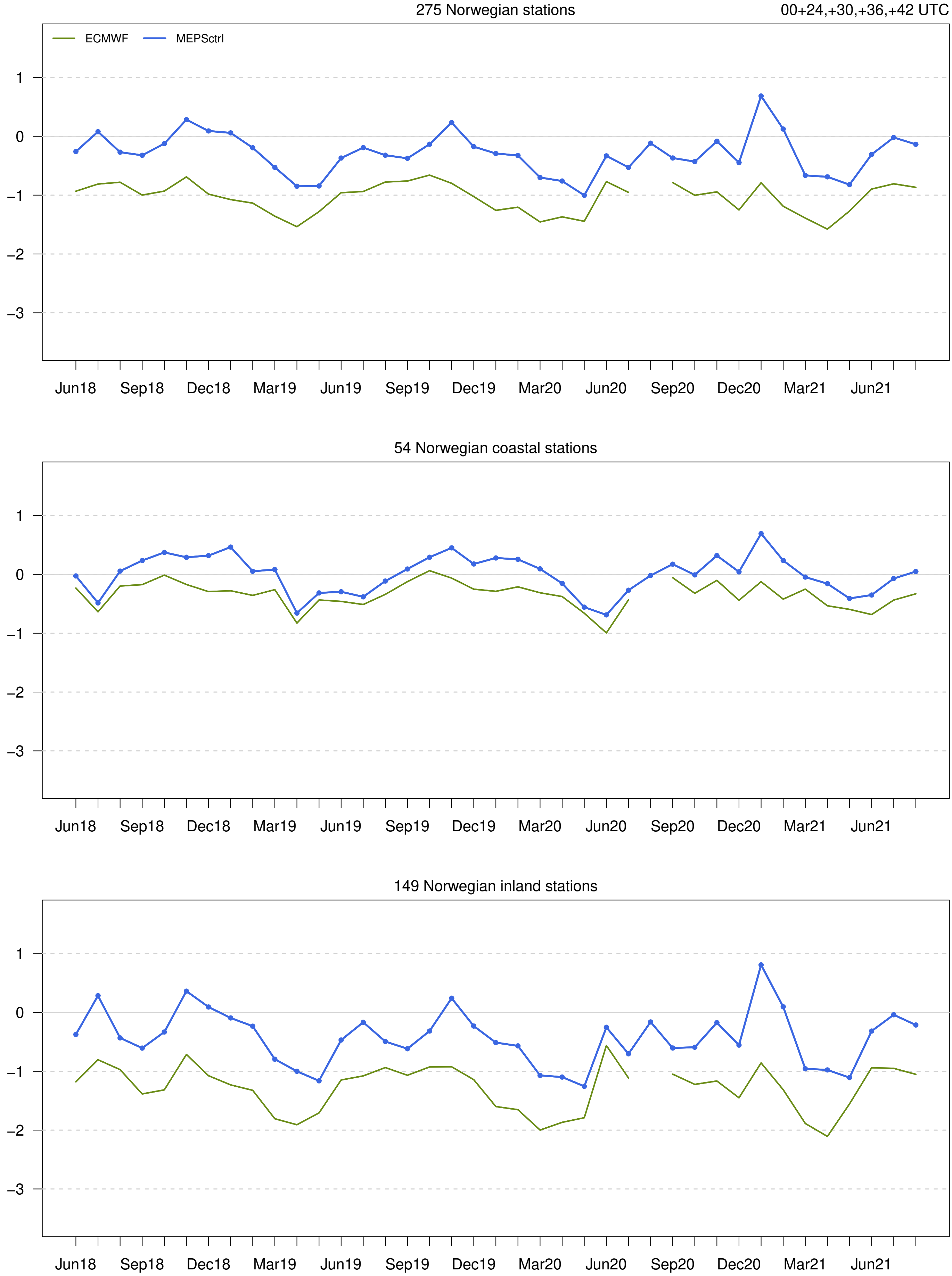
Jun20
Sep20
Dec20
Mar21
Jun21


Mean Error
264 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
264 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
264 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Error
77 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
Lead time (hour)
Standard Deviation of Error
77 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
77 North Scand. stations
00+3,+6,...,+66
Lead time (hour)

Mean Error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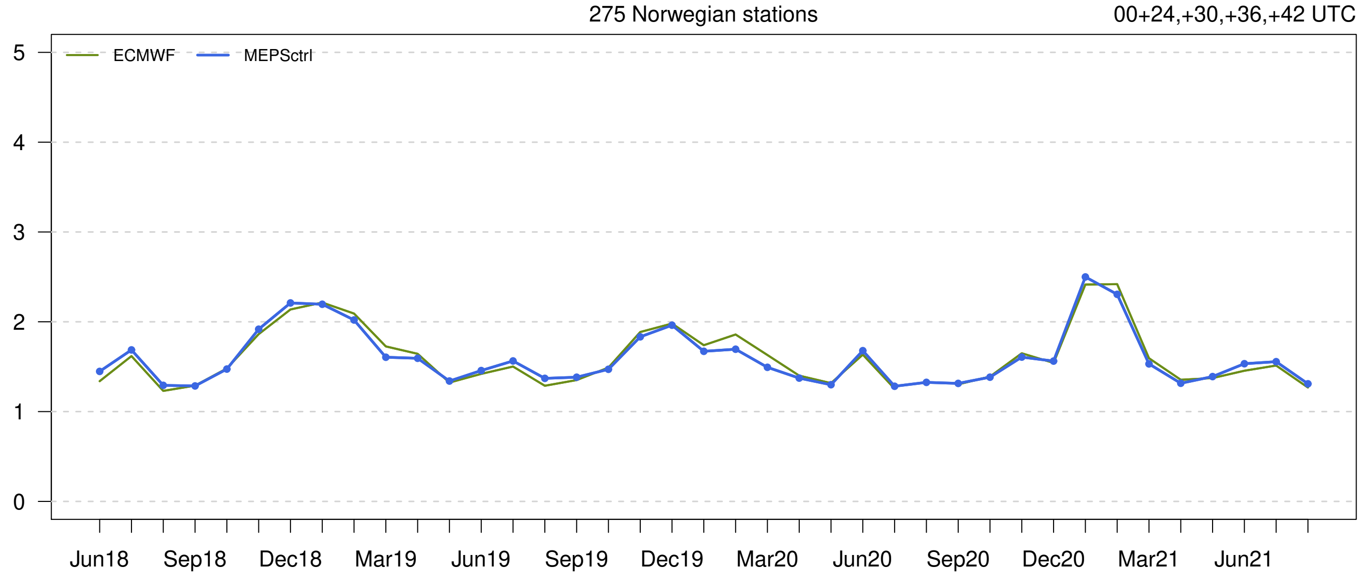
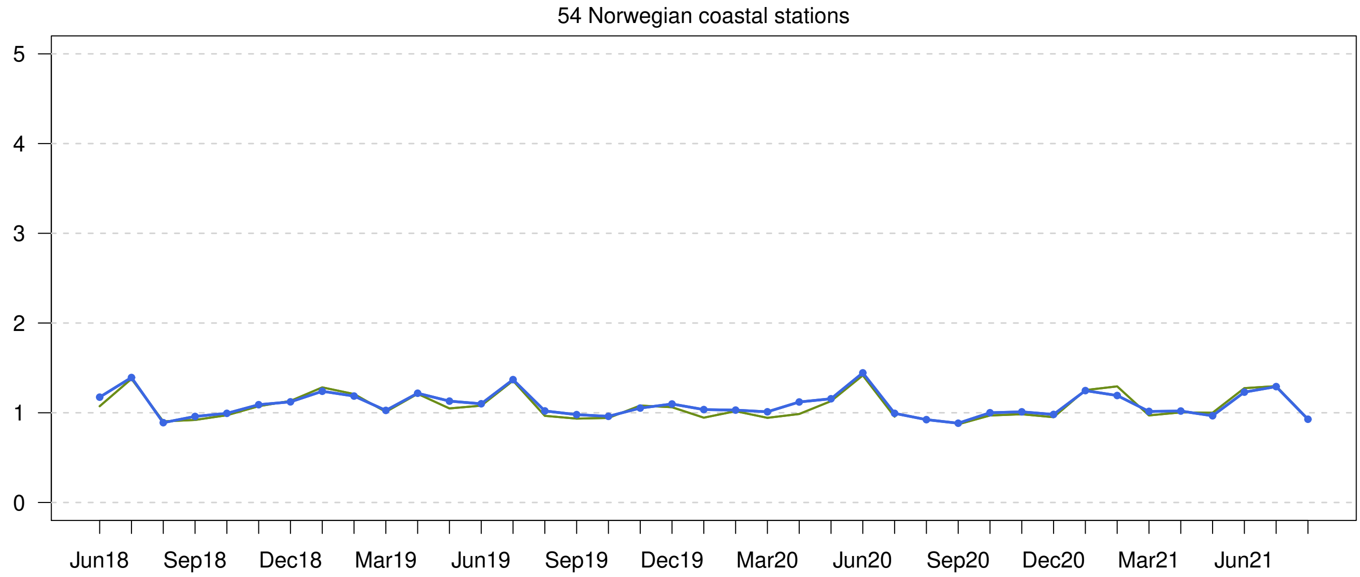
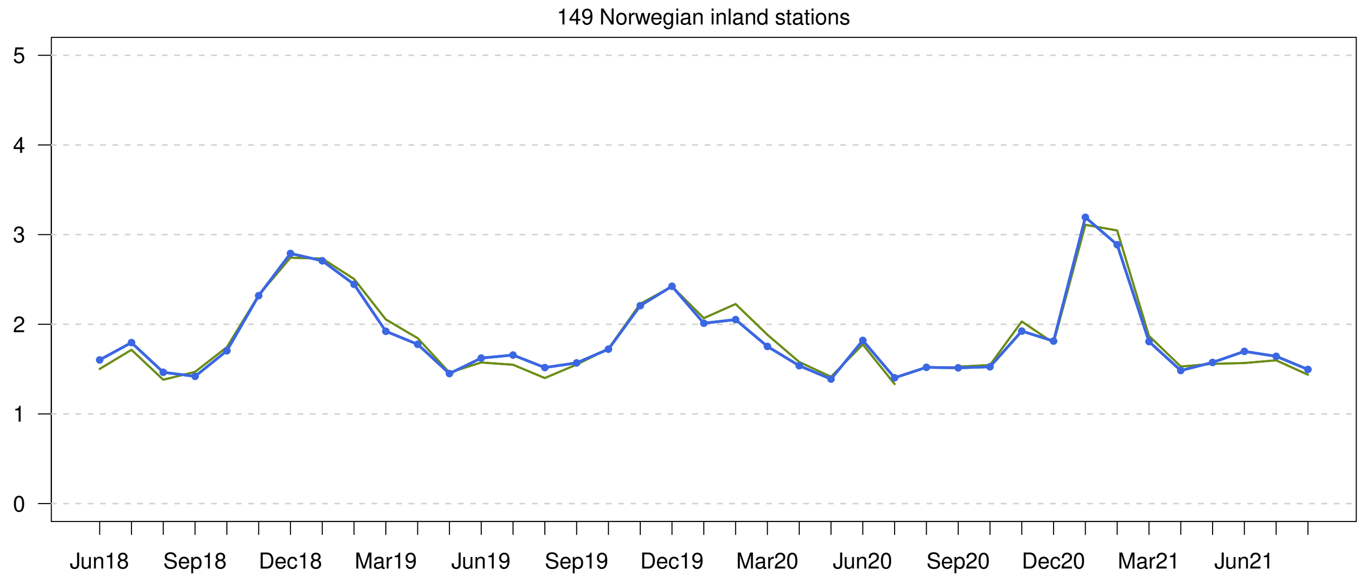
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
1
0
−1
−2
−3
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
54 Norwegian coastal stations
149 Norwegian inland stations

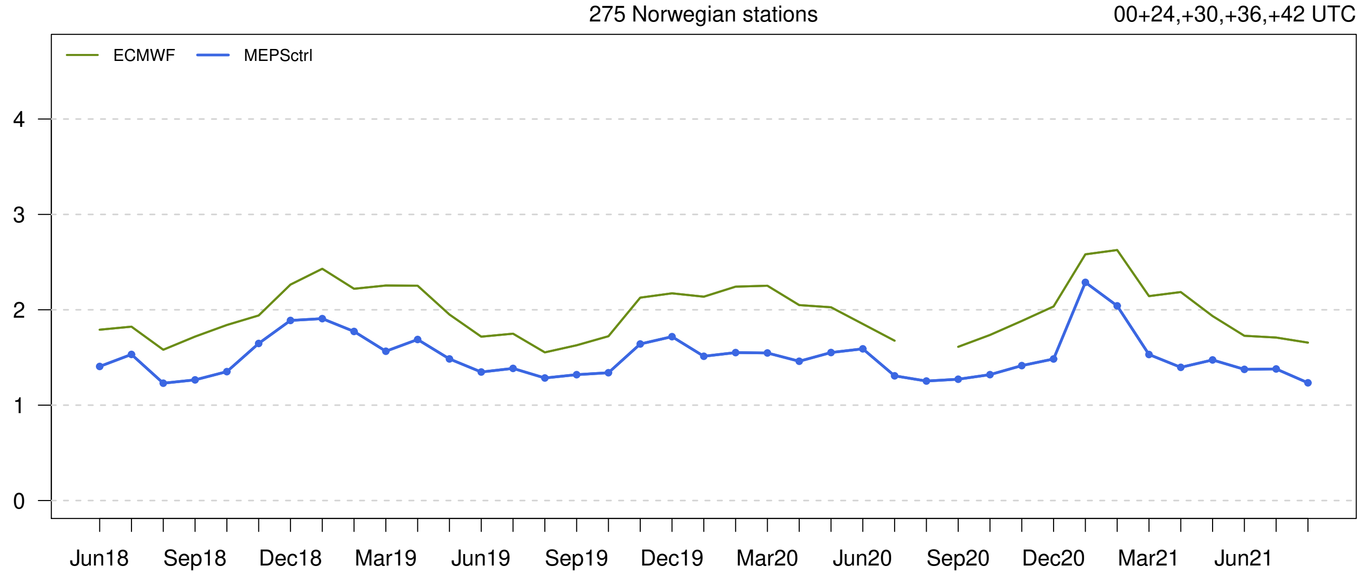
Standard Deviation of Error

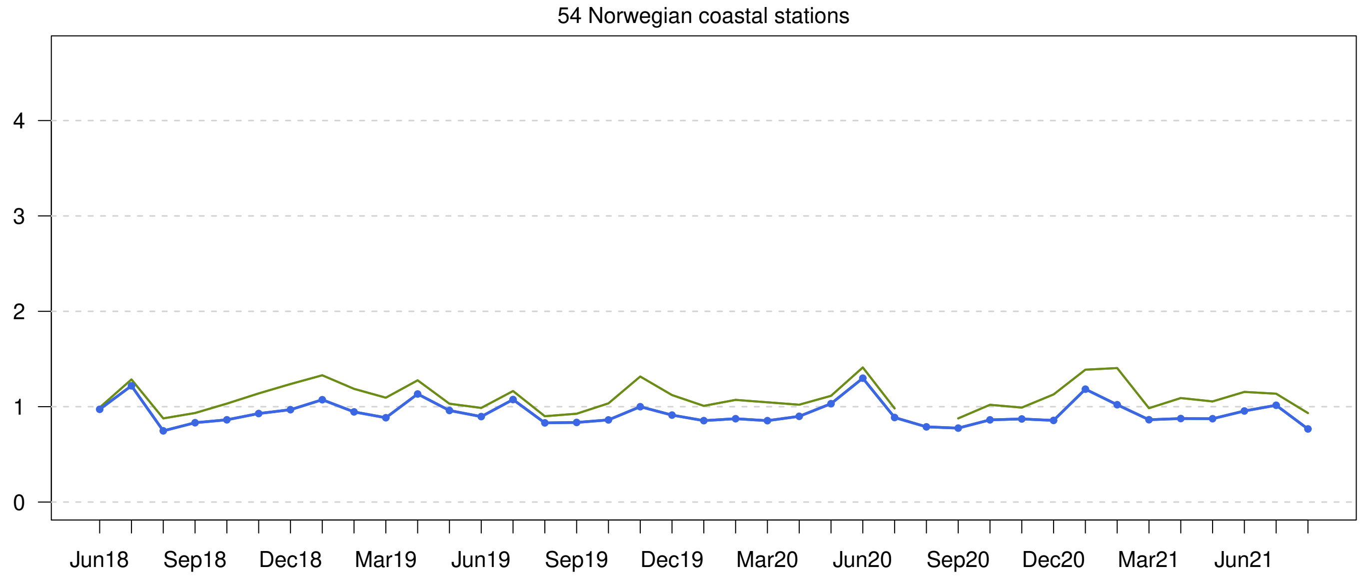


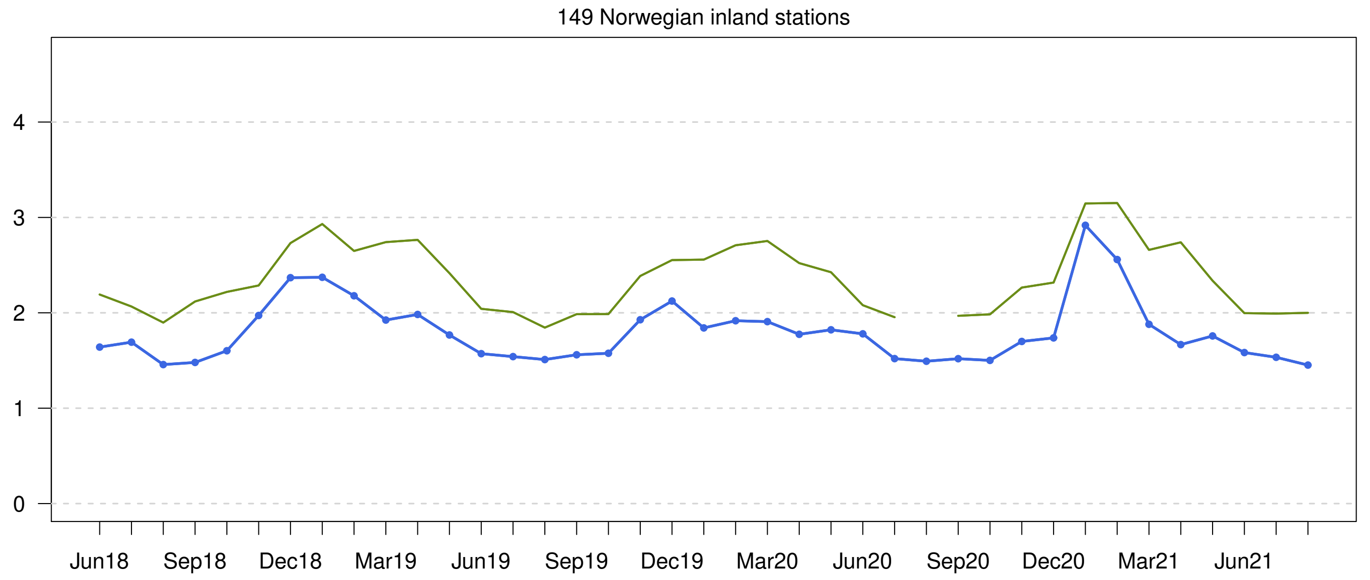


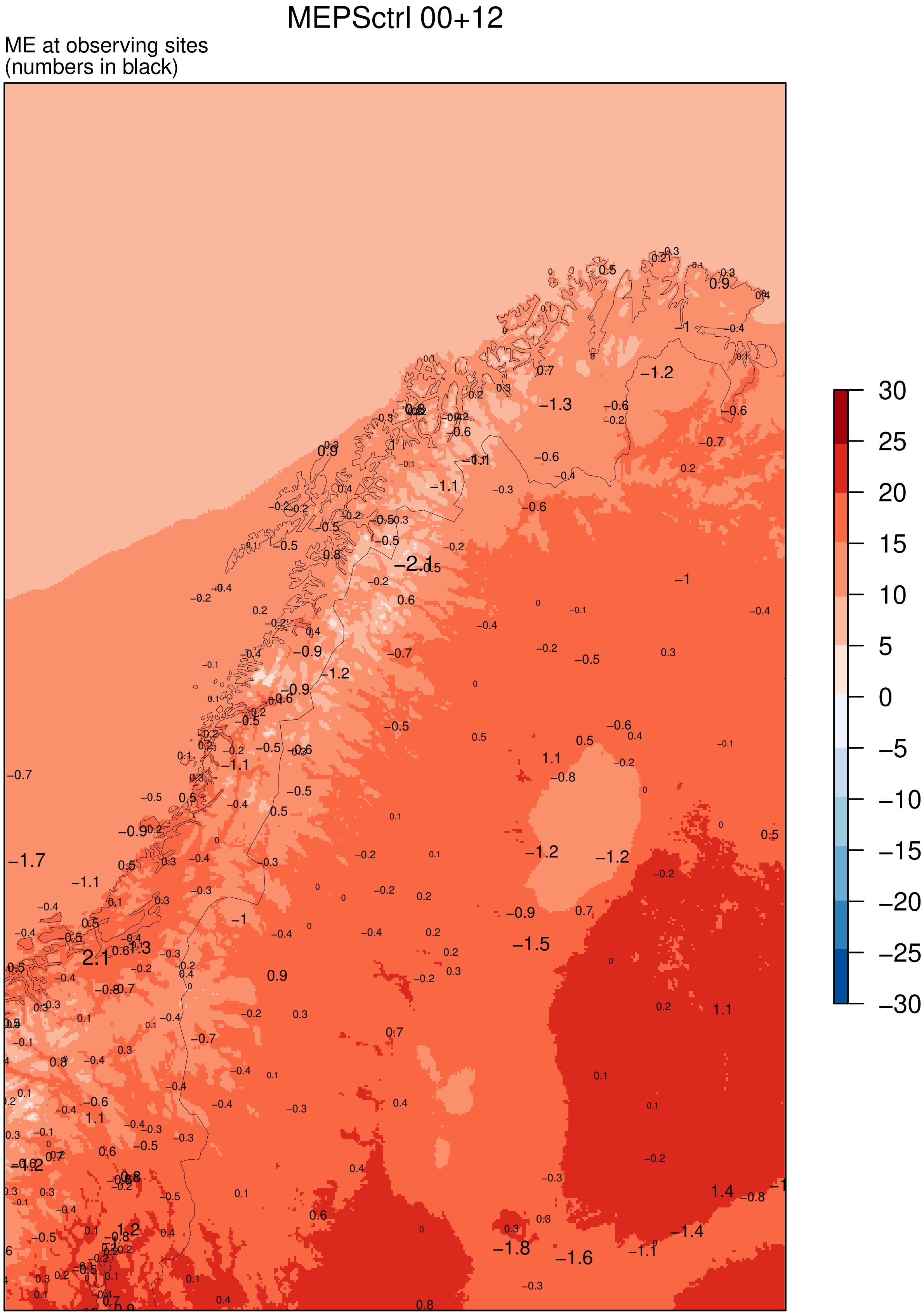


Mean Absolute Error

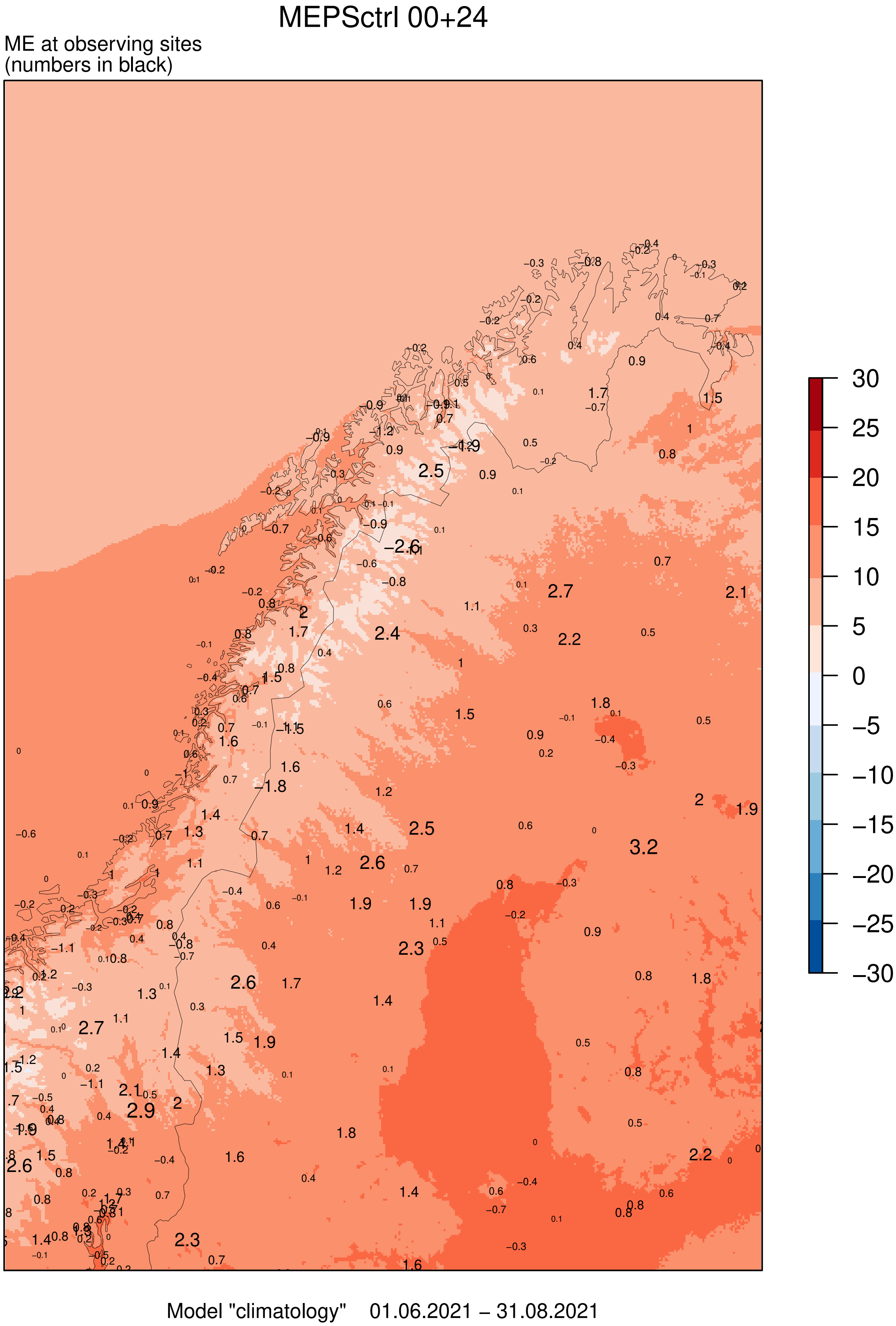


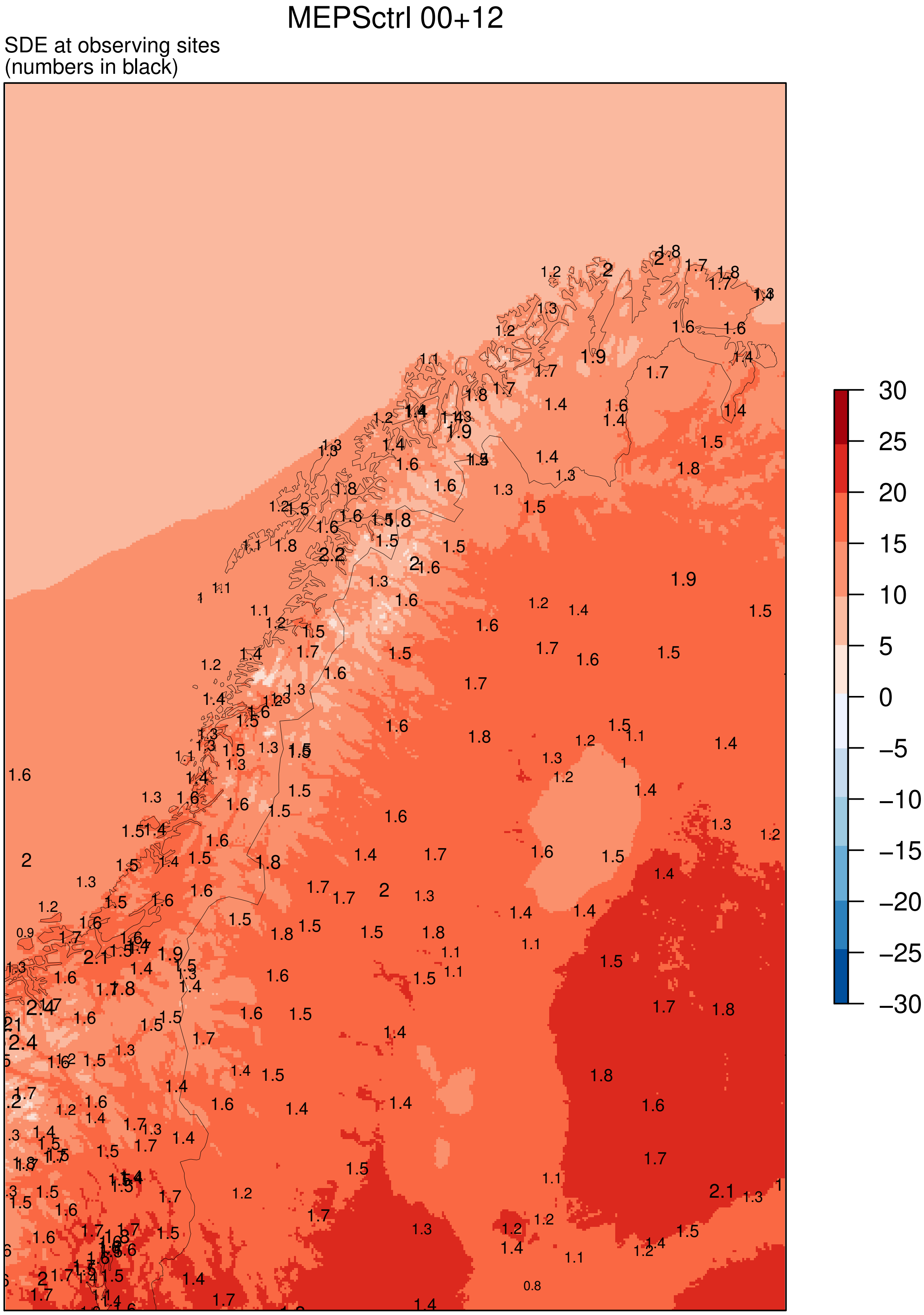




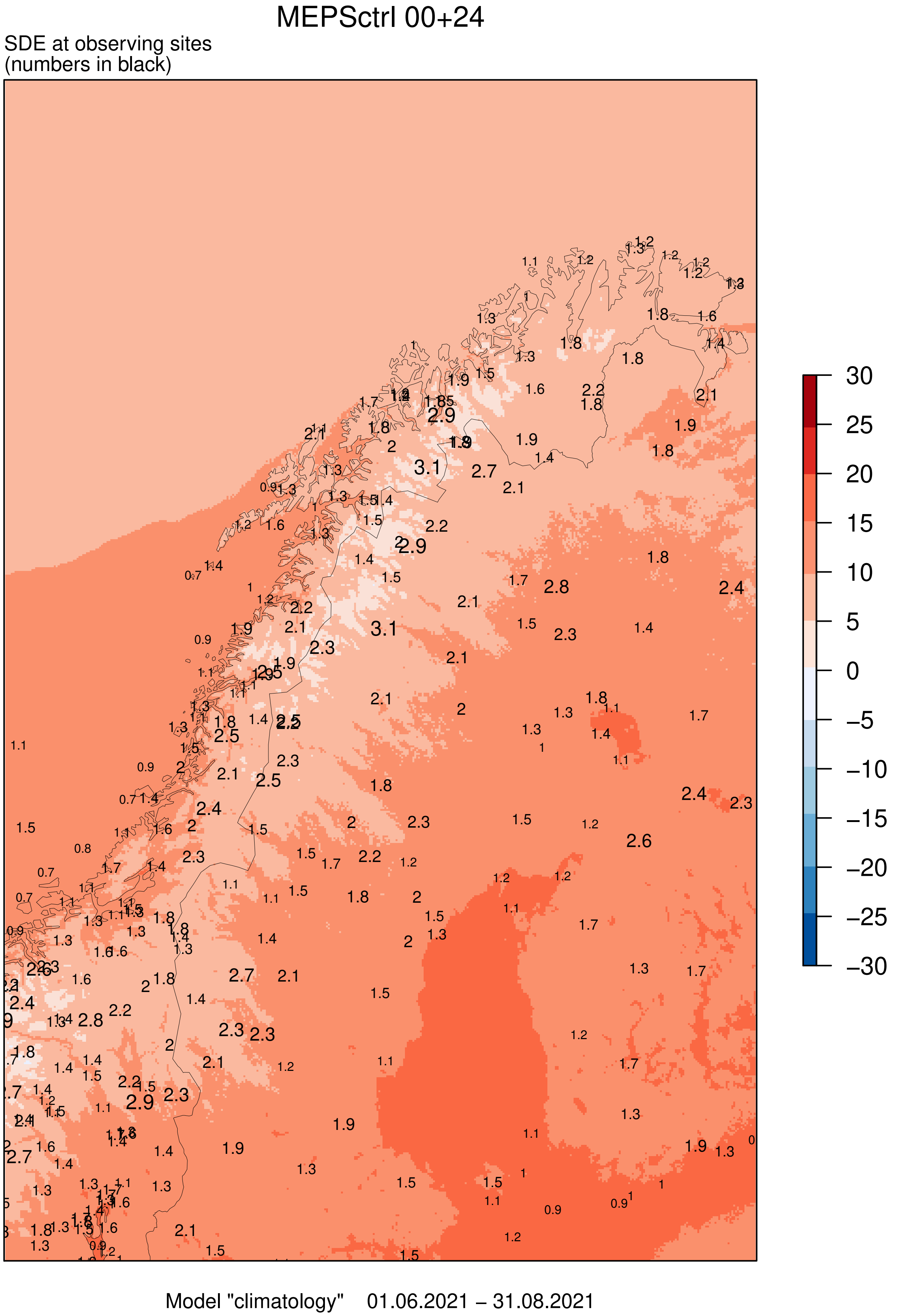


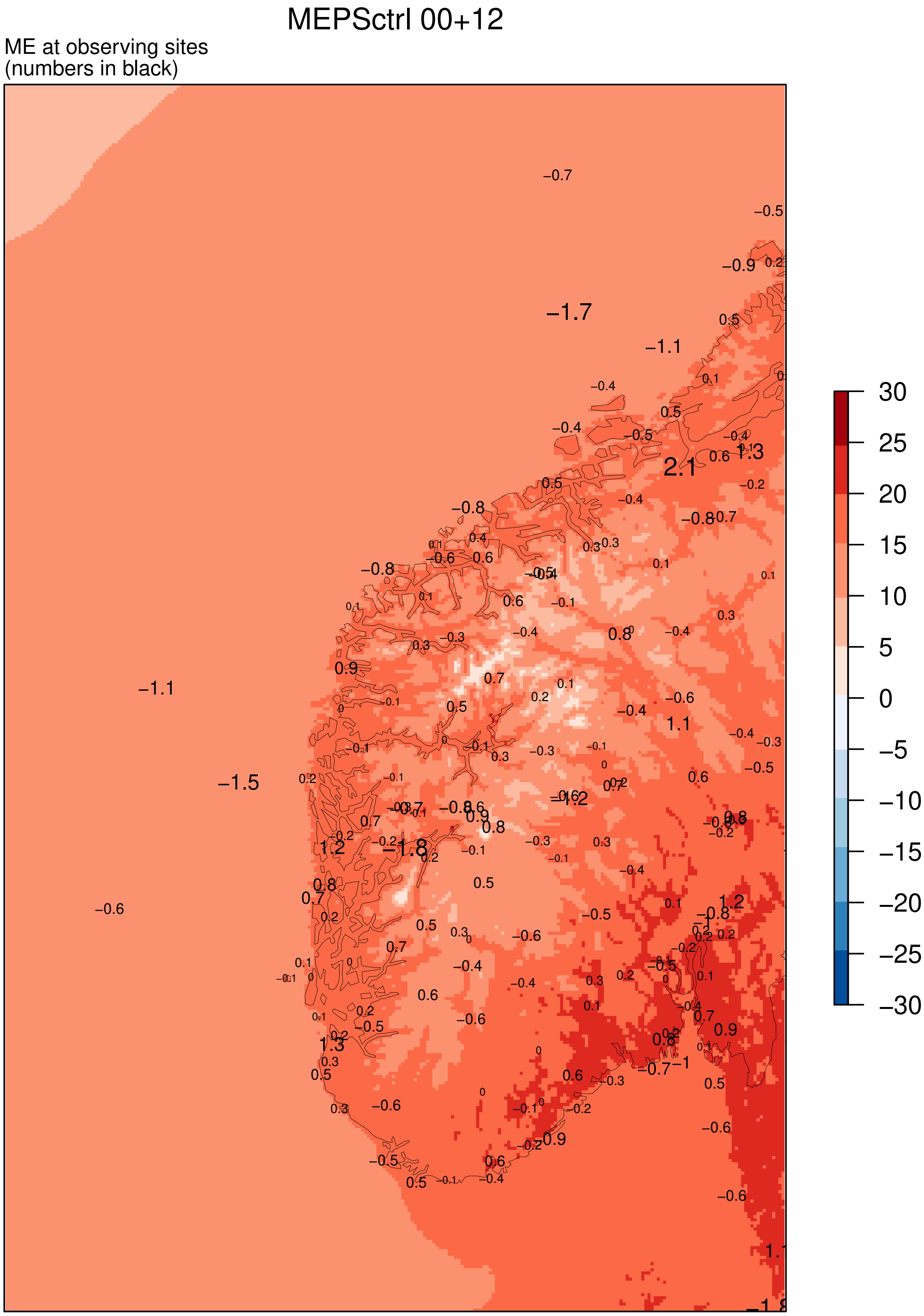
Model "climatology" 01.06.2021 – 31.08.2021


MEPSctrl 00+24
ME at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.06.2021 – 31.08.2021

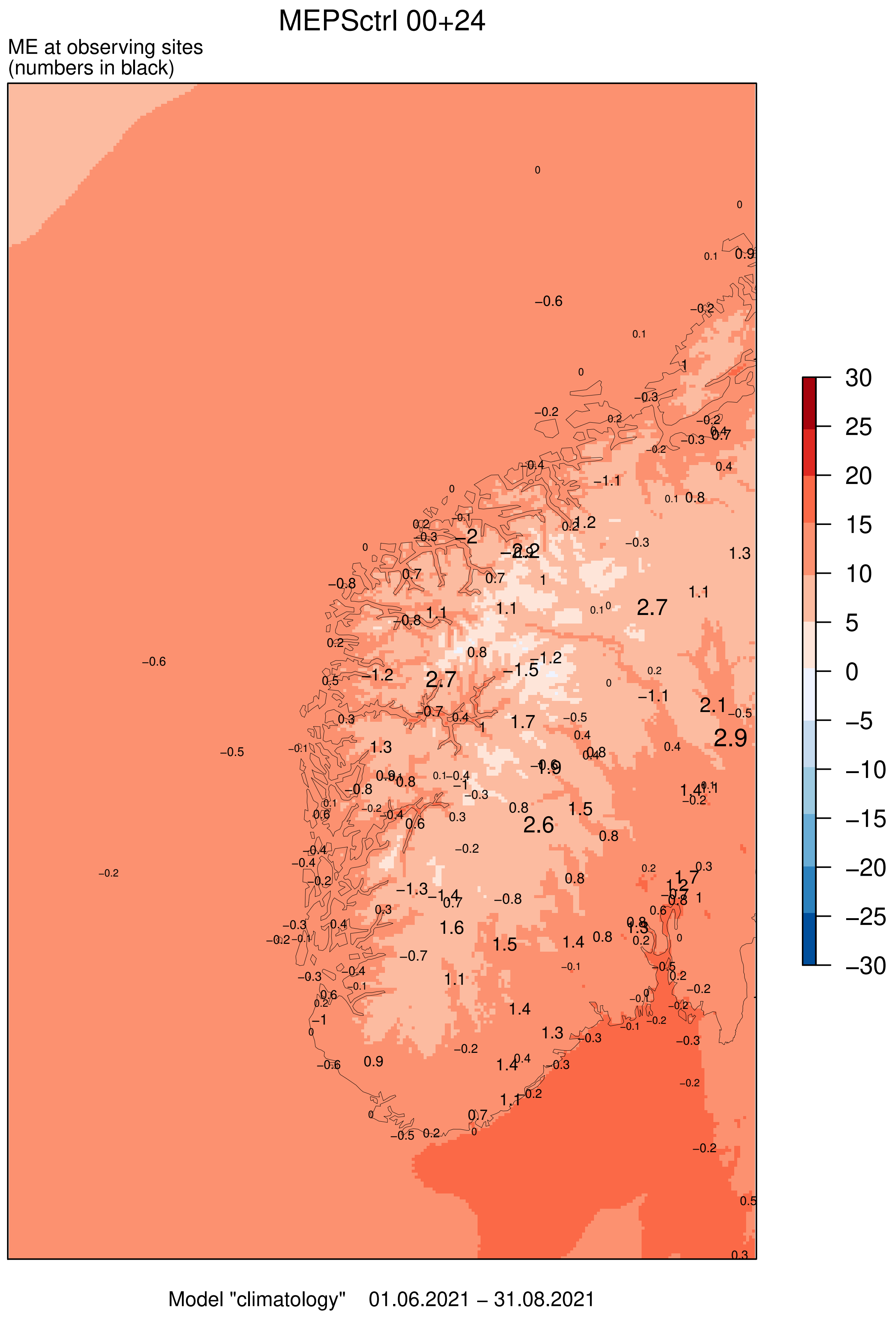


Model "climatology"   01.06.2021 – 31.08.2021


MEPSctrl 00+24
SDE at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.06.2021 – 31.08.2021

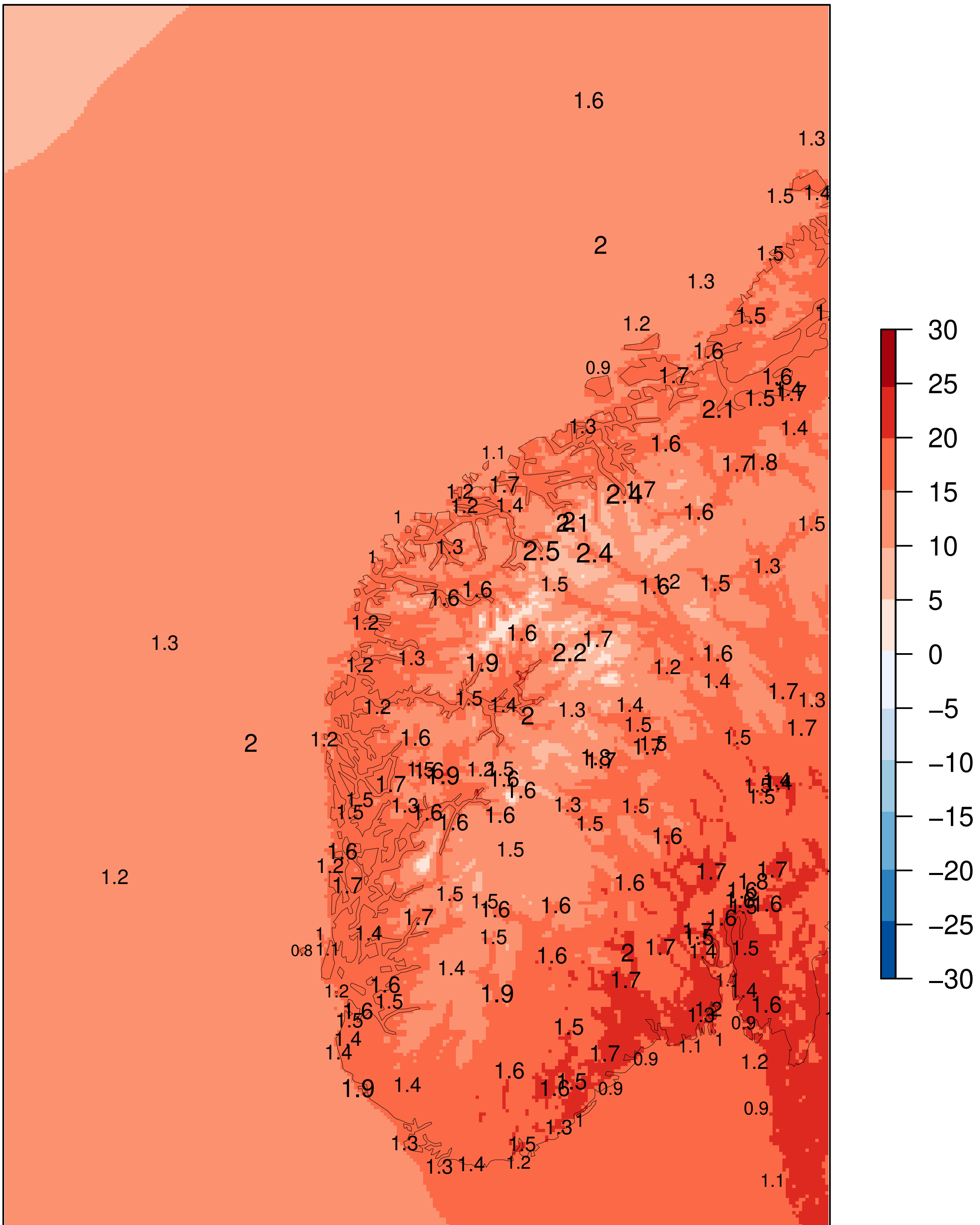


Model "climatology"   01.06.2021 – 31.08.2021

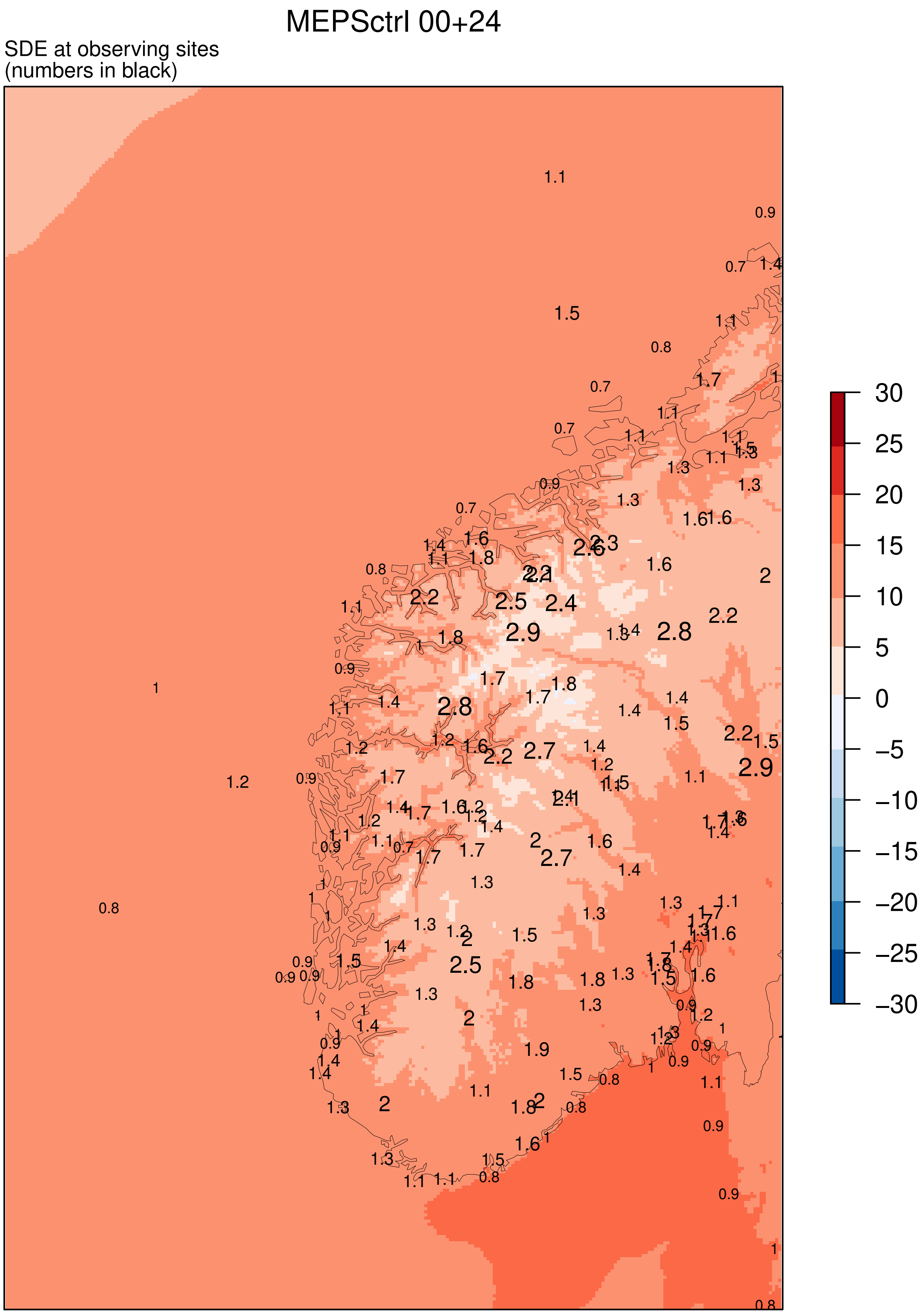

MEPSctrl 00+24
ME at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+12

SDE at observing sites
(numbers in black)



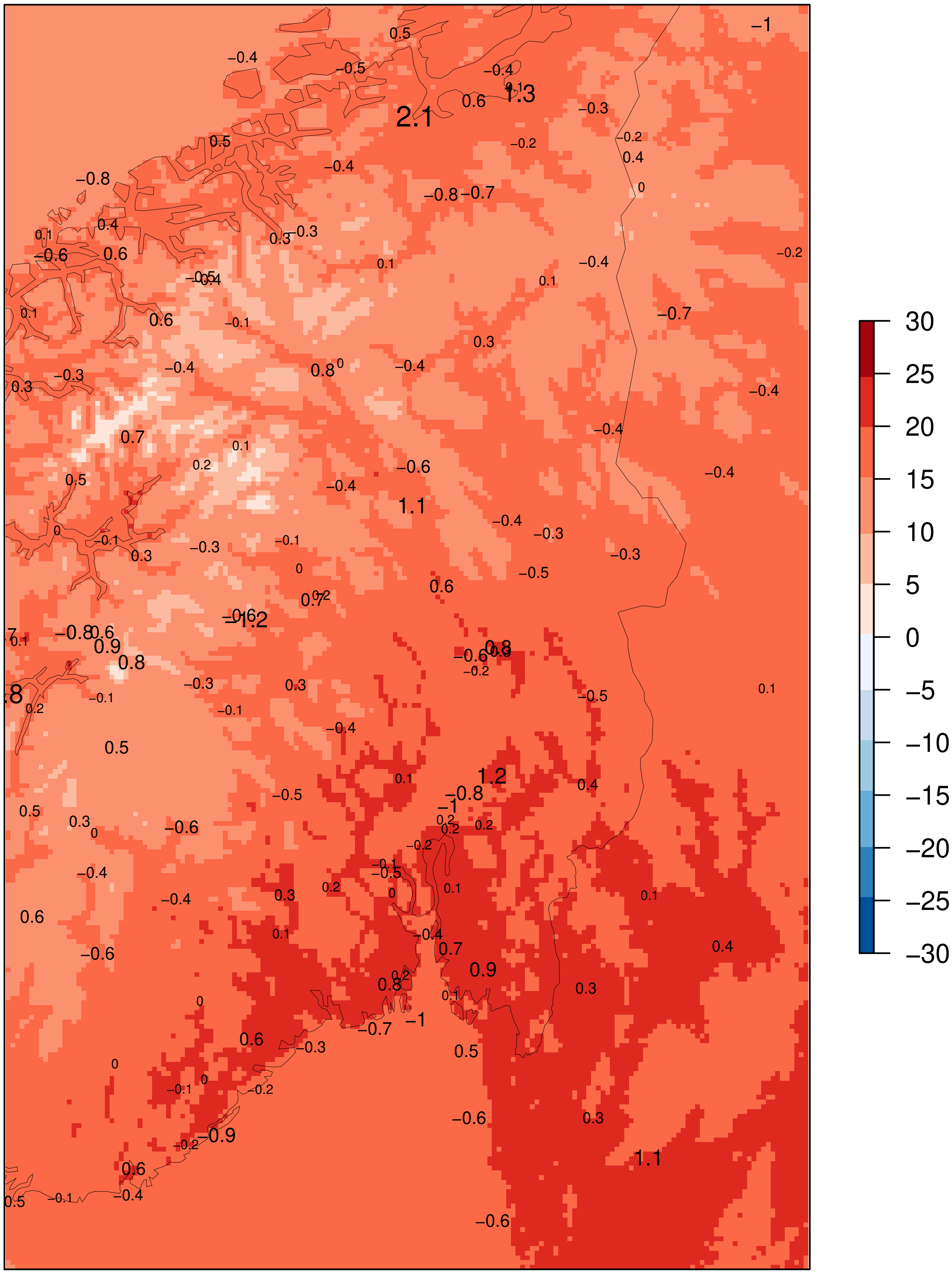
Model "climatology" 01.06.2021 – 31.08.2021



Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+12

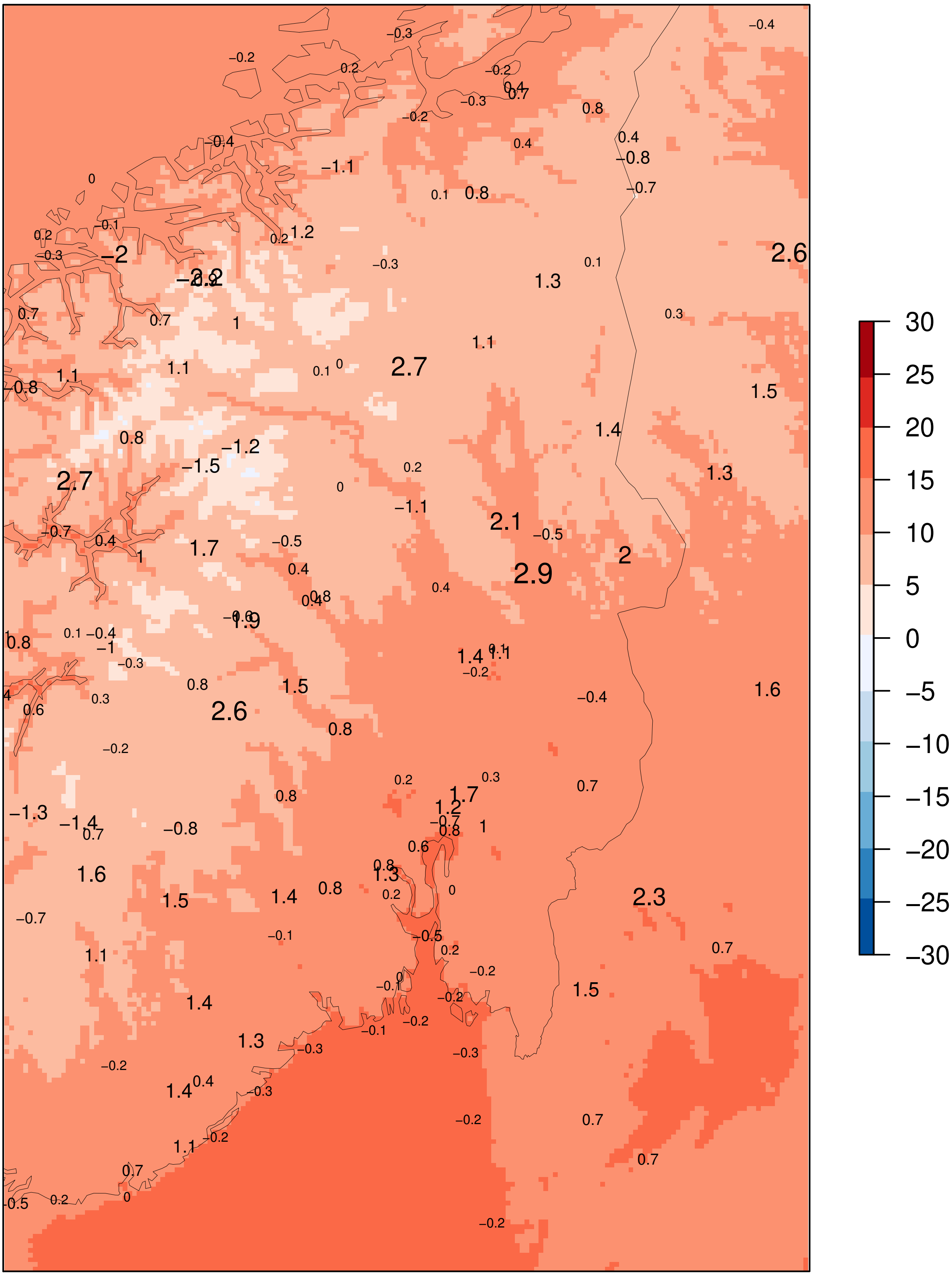
ME at observing sites
(numbers in black)



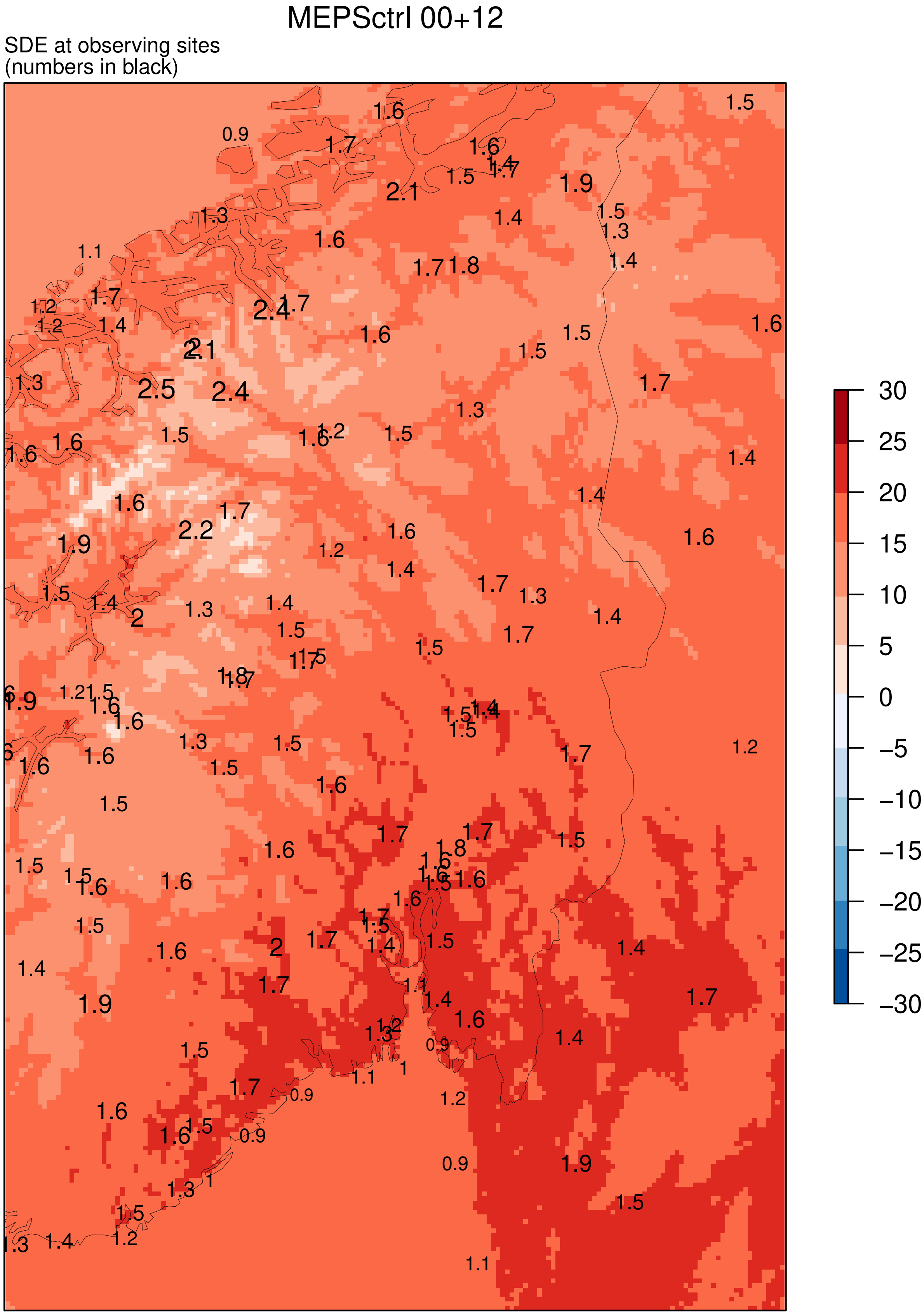
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+24

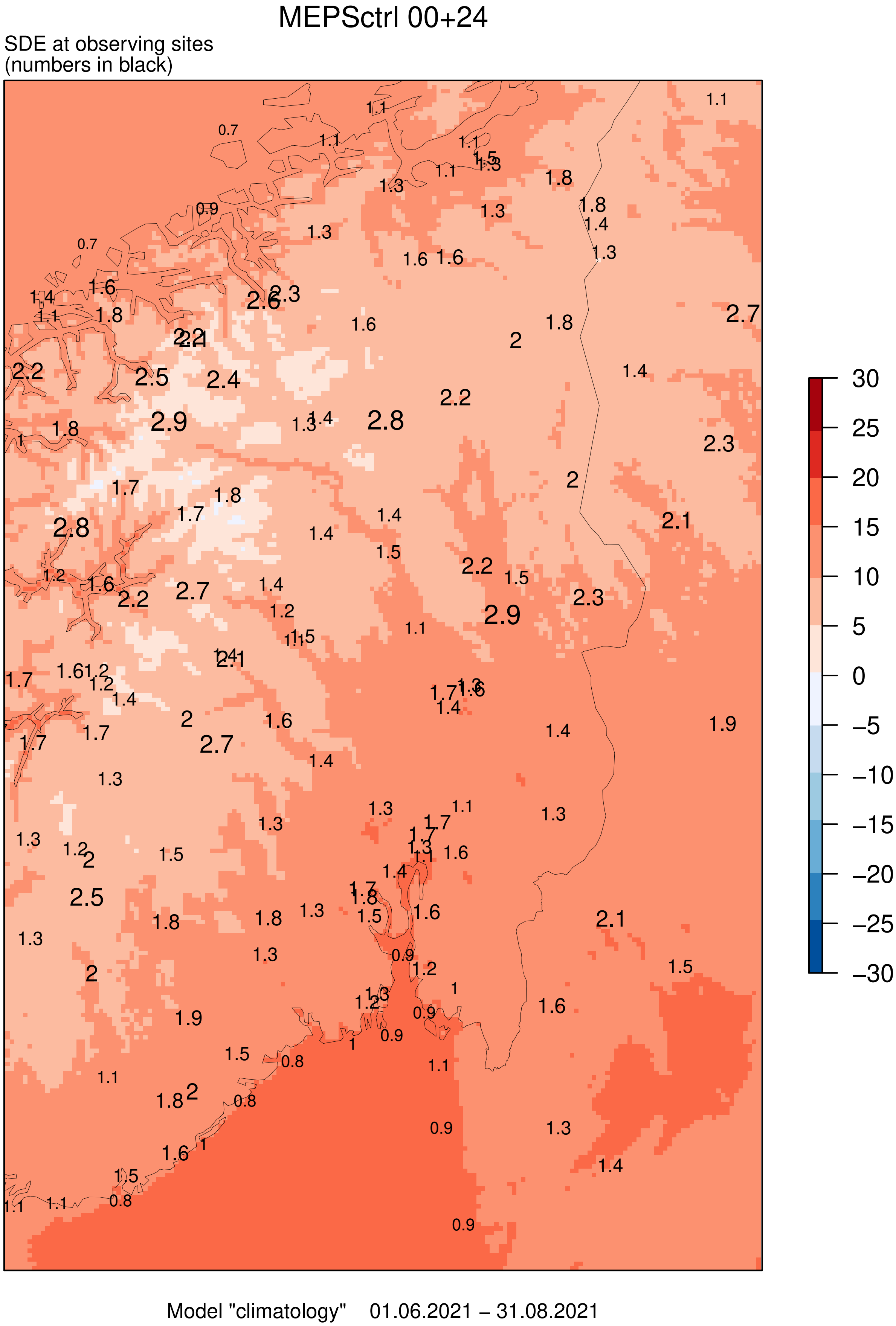
ME at observing sites
(numbers in black)

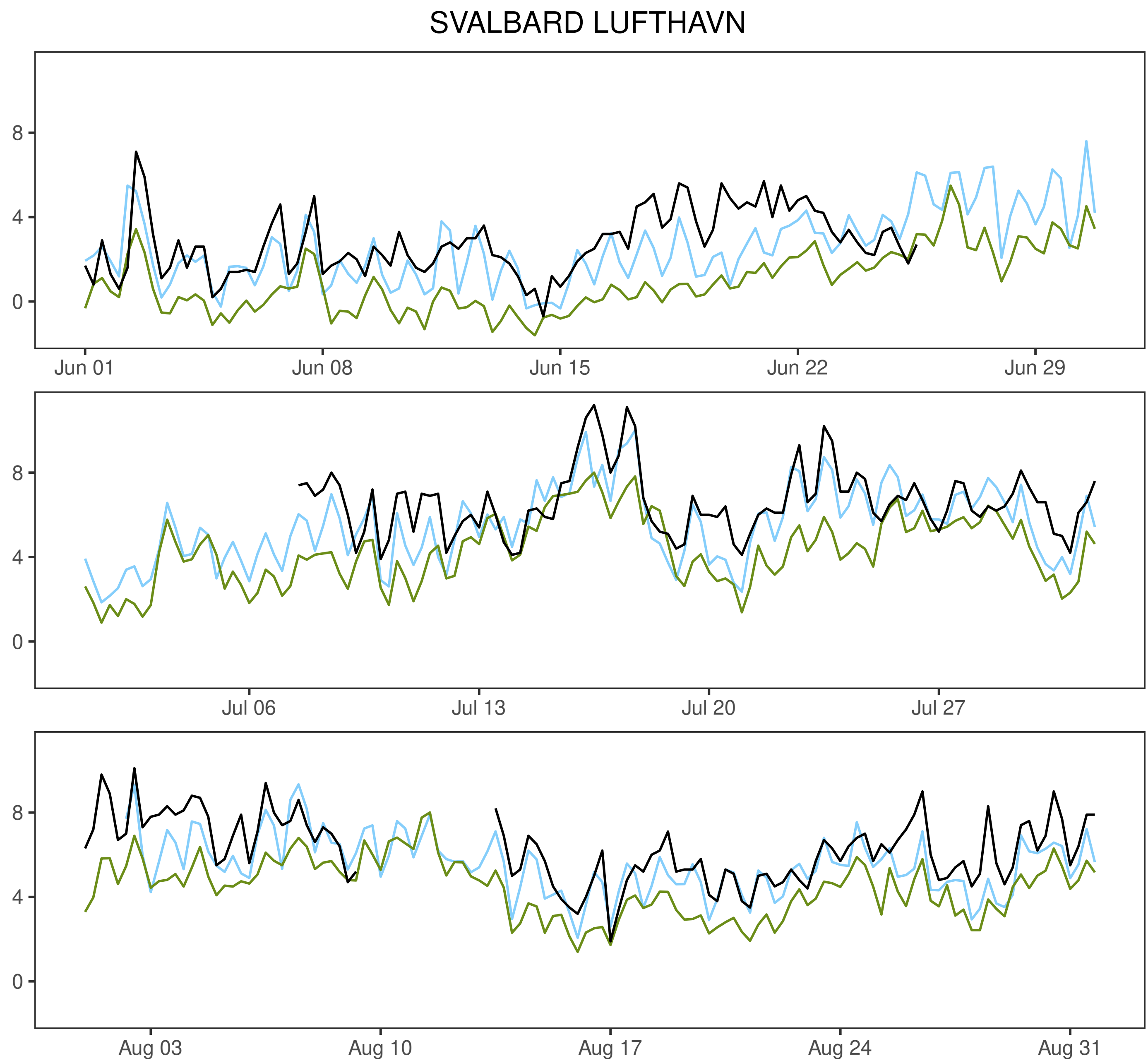


Model "climatology" 01.06.2021 – 31.08.2021



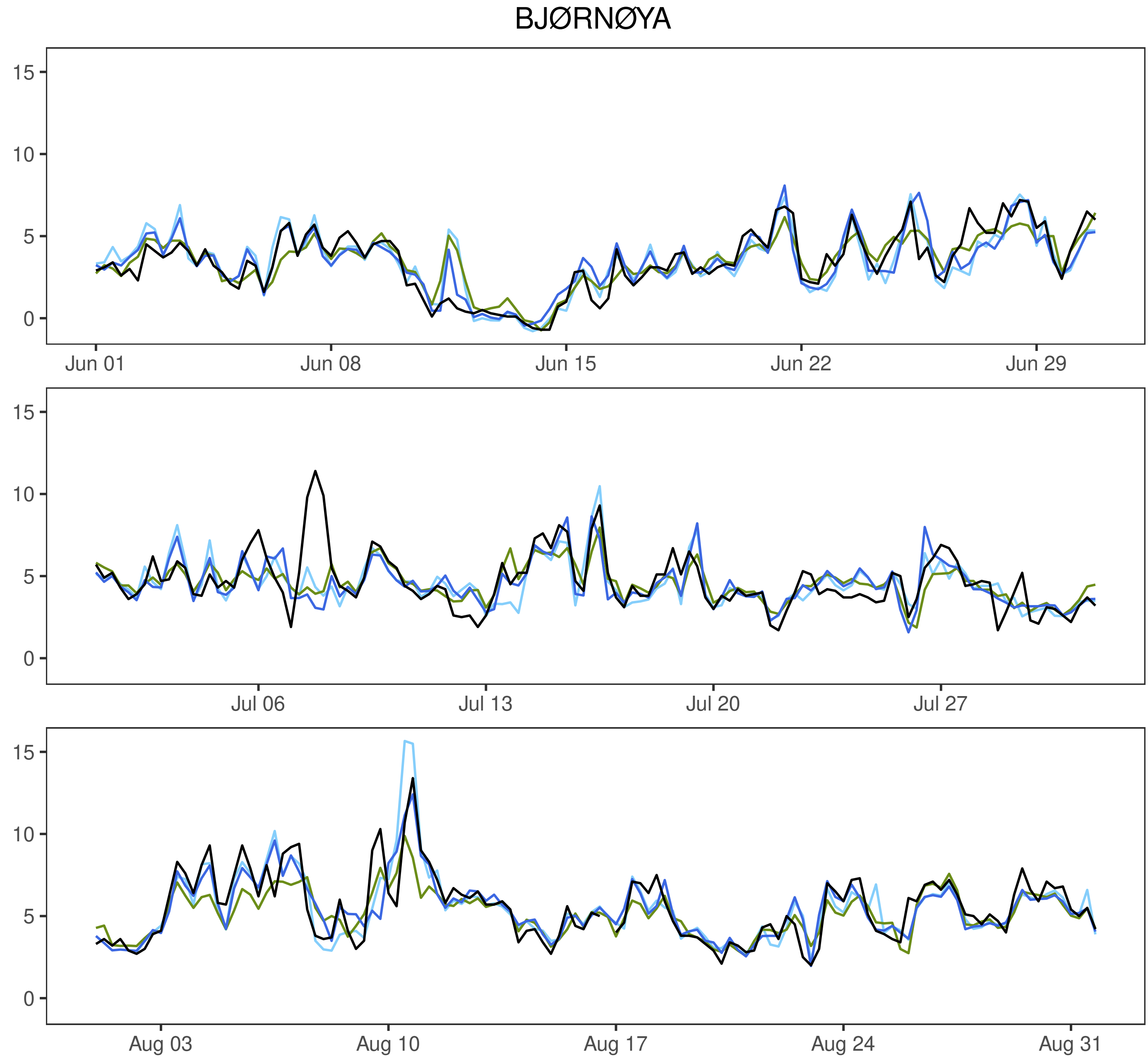
Model "climatology" 01.06.2021 – 31.08.2021


MEPSctrl 00+24
SDE at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.06.2021 – 31.08.2021



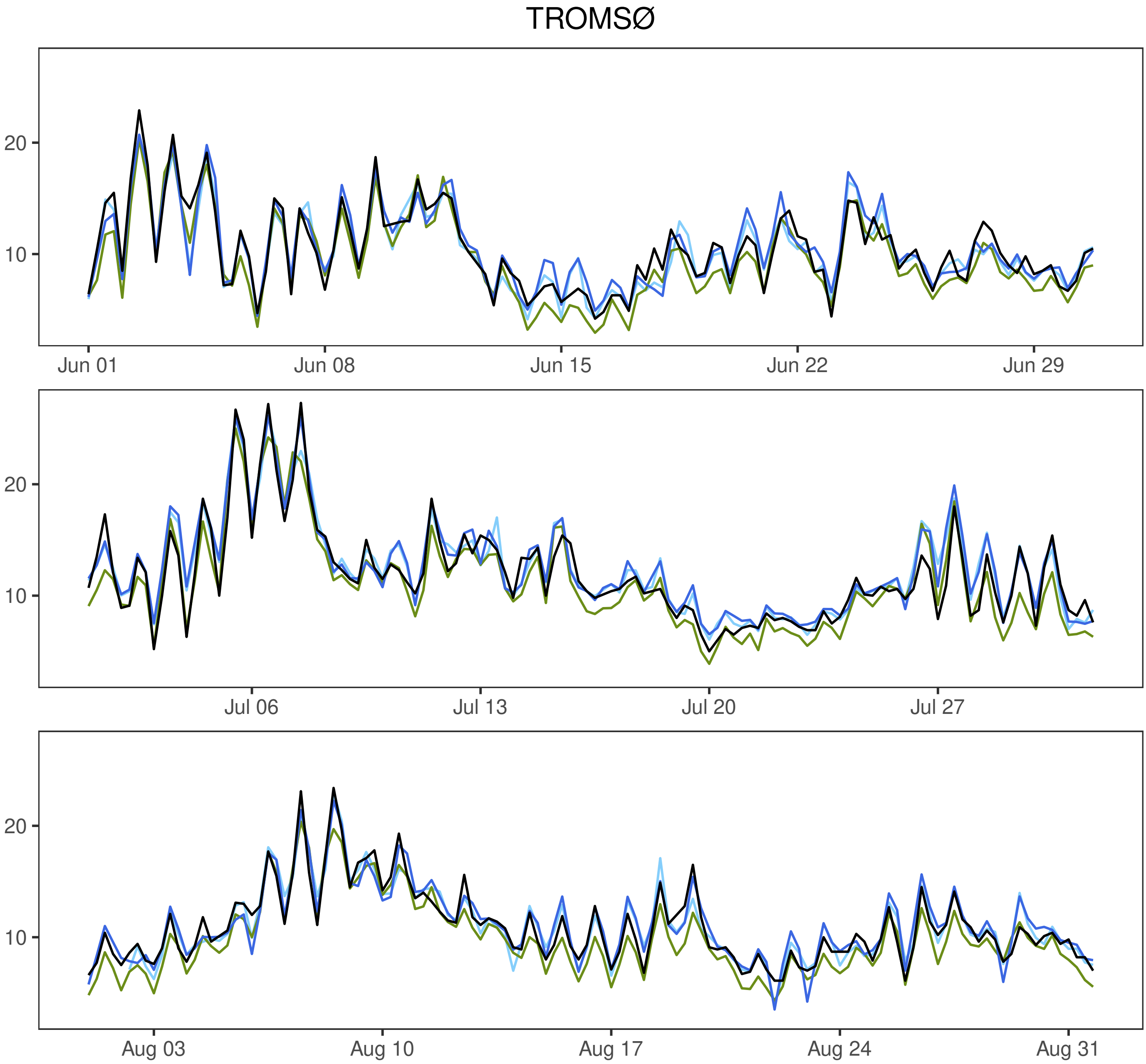
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−0.7	5.2	11.2	2.3	309
AA25: 12+18,+24,+30,+36	−0.3	4.6	10.0	2.1	364
ECMWF: 12+18,+24,+30,+36	−1.6	3.2	8.0	2.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	−0.7	1.1	1.3	1.1	4.1	305
ECMWF−synop	−2.1	1.2	2.4	2.1	4.8	305



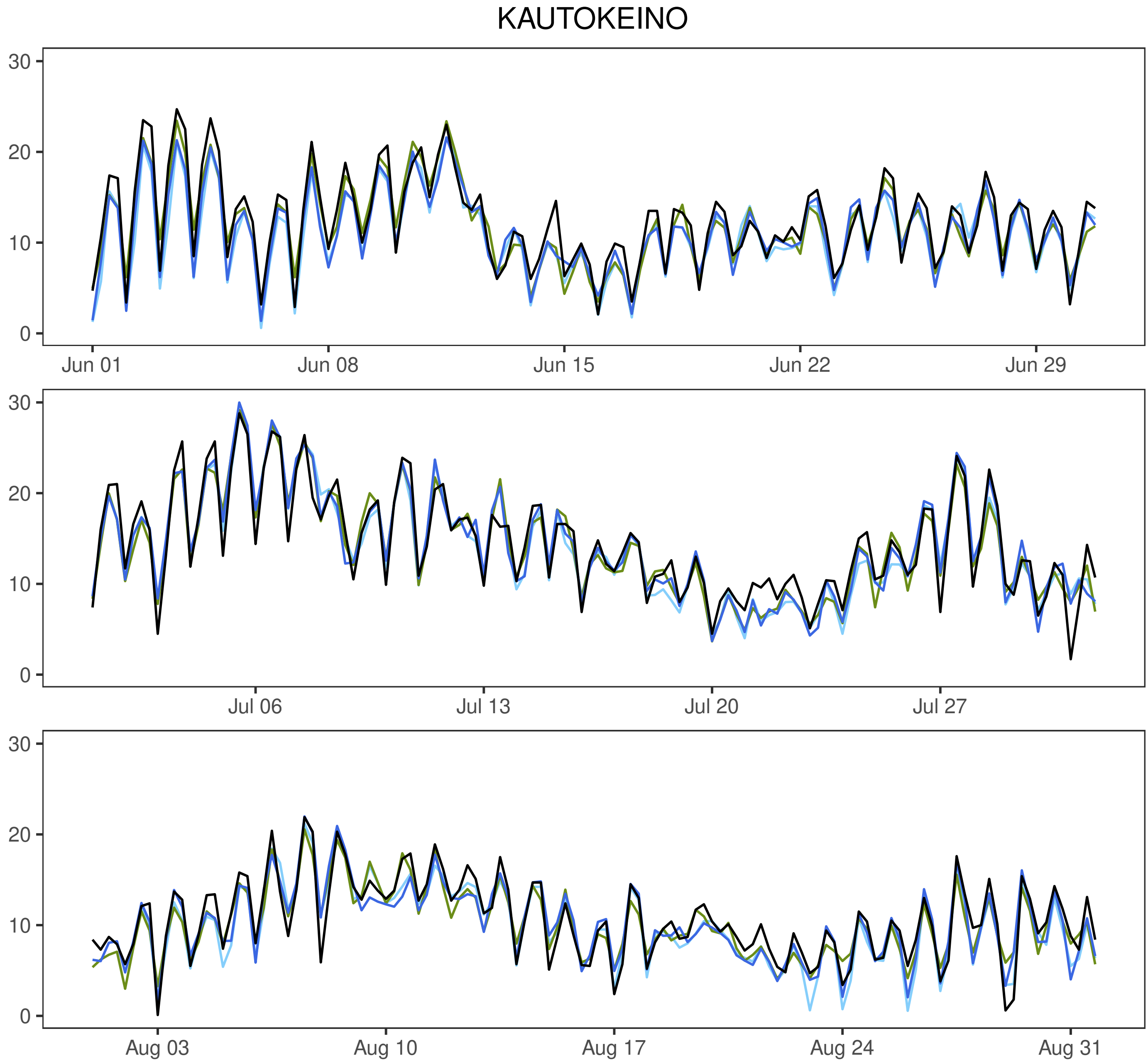
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−0.7	4.5	13.4	2.1	367
MEPSctrl: 12+18,+24,+30,+36	−0.5	4.5	12.4	1.8	368
AA25: 12+18,+24,+30,+36	−0.8	4.5	15.7	2.0	364
ECMWF: 12+18,+24,+30,+36	−0.7	4.4	9.9	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.1	1.2	1.2	0.8	8.3	363
AA25−synop	−0.1	1.2	1.2	0.8	7.1	363
ECMWF−synop	−0.1	1.2	1.2	0.8	7.5	363



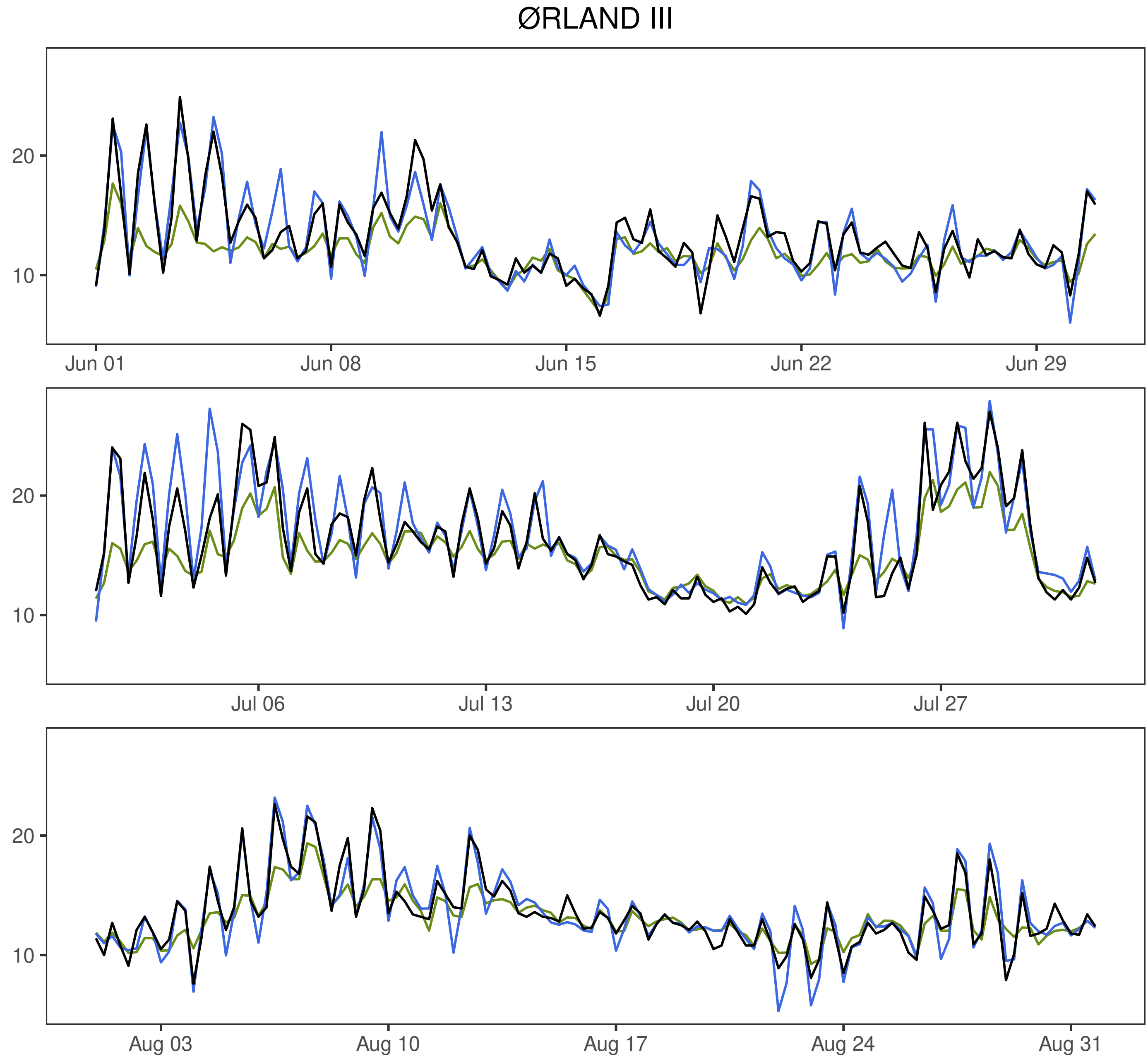
	Min	Mean	Max	Std	N
synop: 00,06,12,18	4.2	11.1	27.3	3.8	368
MEPSctrl: 12+18,+24,+30,+36	3.5	11.5	26.1	3.8	368
AA25: 12+18,+24,+30,+36	4.0	11.3	26.2	3.8	364
ECMWF: 12+18,+24,+30,+36	2.9	10.2	25.0	3.9	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	1.3	1.4	1.0	6.0	364
AA25−synop	0.2	1.4	1.4	1.0	5.4	364
ECMWF−synop	−0.9	1.2	1.5	1.3	5.2	364



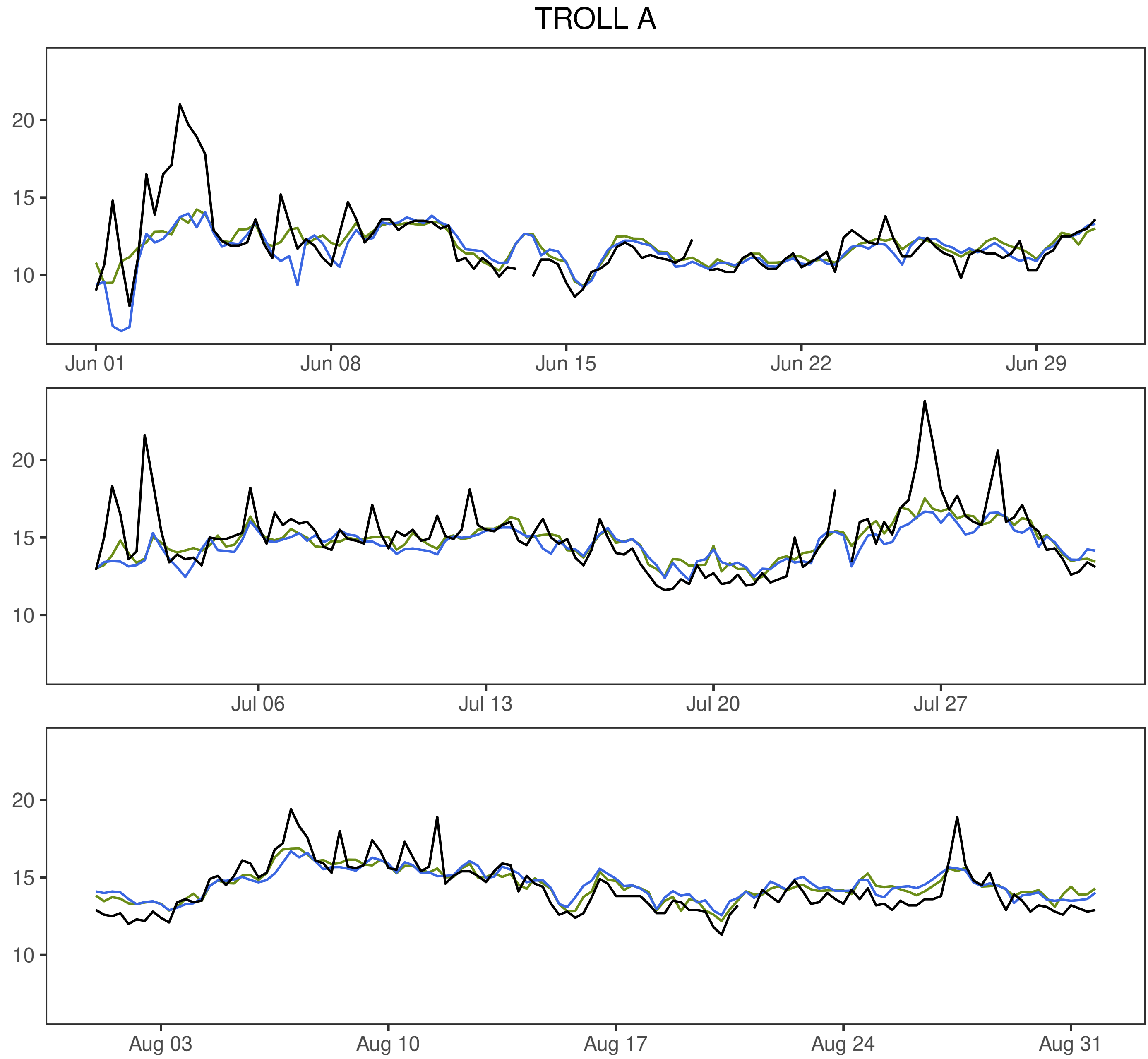
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	12.5	28.8	5.2	368
MEPSctrl: 12+18,+24,+30,+36	1.4	11.9	30.0	5.1	368
AA25: 12+18,+24,+30,+36	0.6	11.7	28.8	5.2	364
ECMWF: 12+18,+24,+30,+36	2.2	12.0	29.2	5.0	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.6	1.8	1.9	1.5	6.1	364
AA25–synop	–0.9	1.8	2.0	1.6	7.2	364
ECMWF–synop	–0.5	1.7	1.8	1.4	6.3	364



	Min	Mean	Max	Std	N
synop: 00,06,12,18	6.6	14.3	27.0	3.8	368
MEPSctrl: 12+18,+24,+30,+36	5.3	14.5	27.9	4.1	368
ECMWF: 12+18,+24,+30,+36	6.9	13.3	22.0	2.4	368

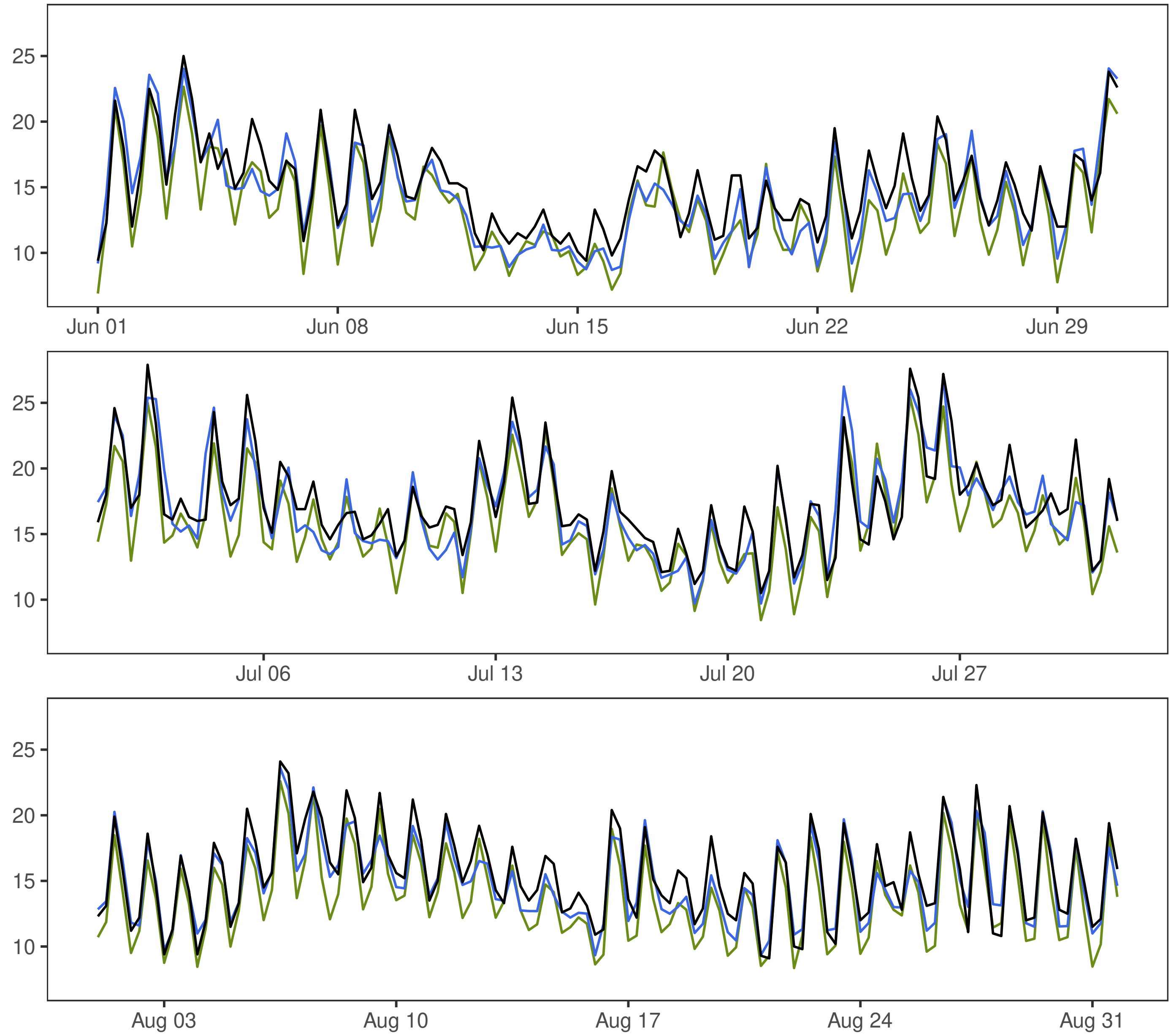
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	1.5	1.5	1.0	9.2	368
ECMWF–synop	–1.0	2.0	2.3	1.5	10.2	368



	Min	Mean	Max	Std	N
synop: 00,06,12,18	8.0	13.8	23.8	2.3	364
MEPSctrl: 12+18,+24,+30,+36	6.4	13.6	16.7	1.8	368
ECMWF: 12+18,+24,+30,+36	9.3	13.7	17.5	1.6	368

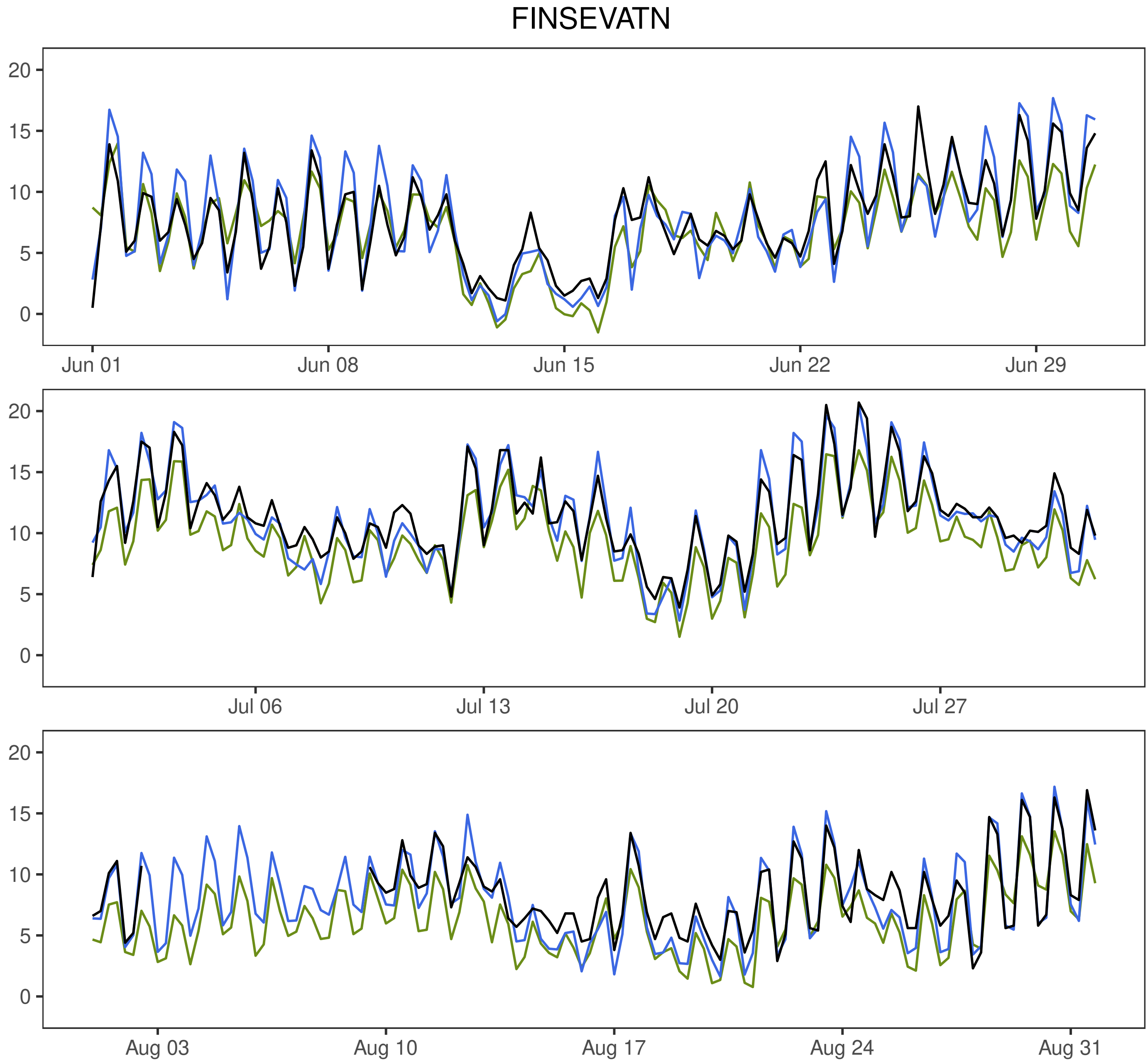
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	−0.2	1.5	1.5	1.0	8.1	364
ECMWF–synop	−0.1	1.4	1.4	0.9	8.0	364

BERGEN – FLORIDA



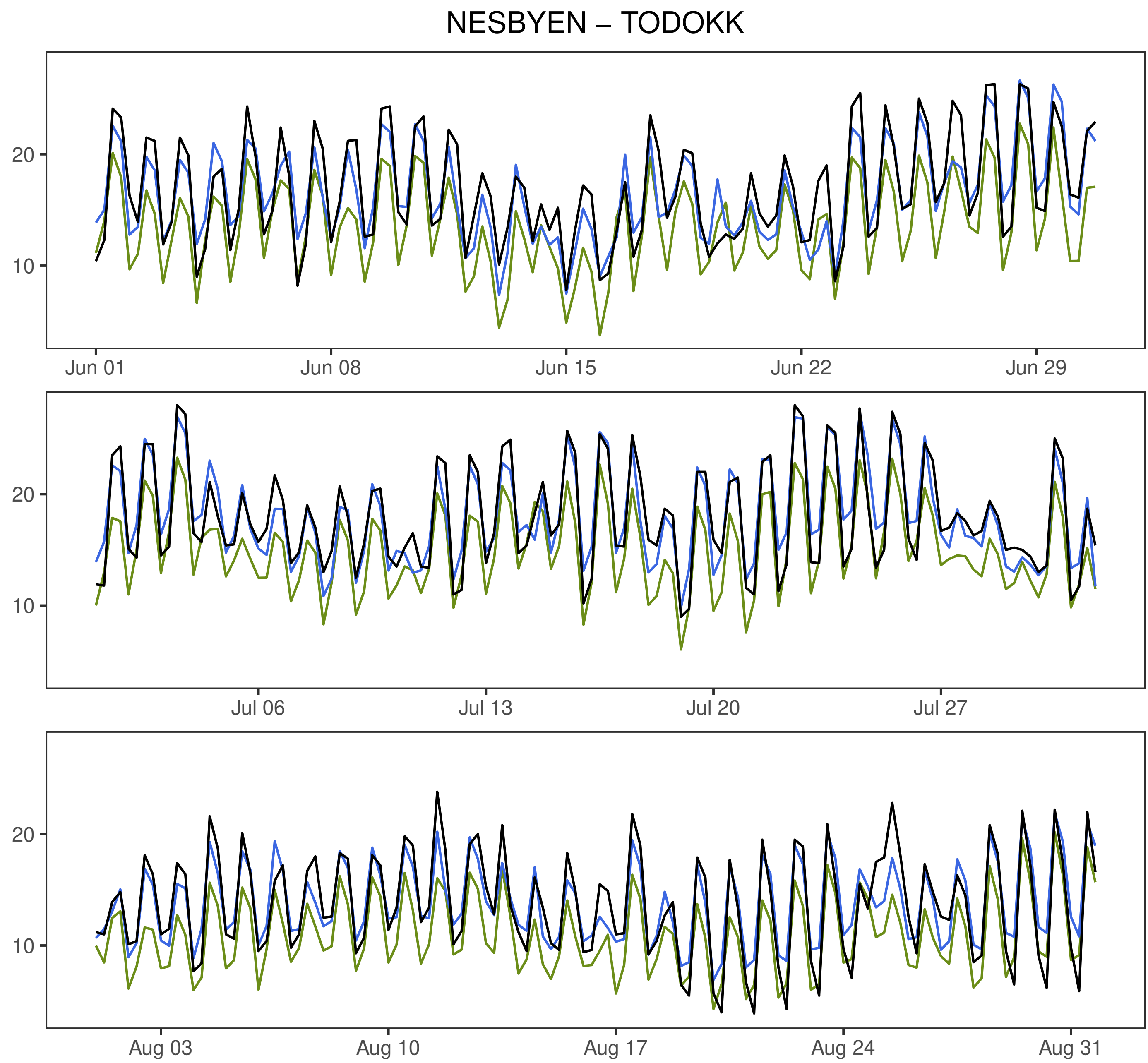
	Min	Mean	Max	Std	N
synop: 00,06,12,18	9.1	15.9	27.9	3.6	368
MEPSctrl: 12+18,+24,+30,+36	8.7	15.4	27.0	3.7	368
ECMWF: 12+18,+24,+30,+36	6.9	14.3	25.4	3.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.6	1.4	1.5	1.2	5.0	368
ECMWF–synop	–1.6	1.2	2.0	1.7	4.8	368



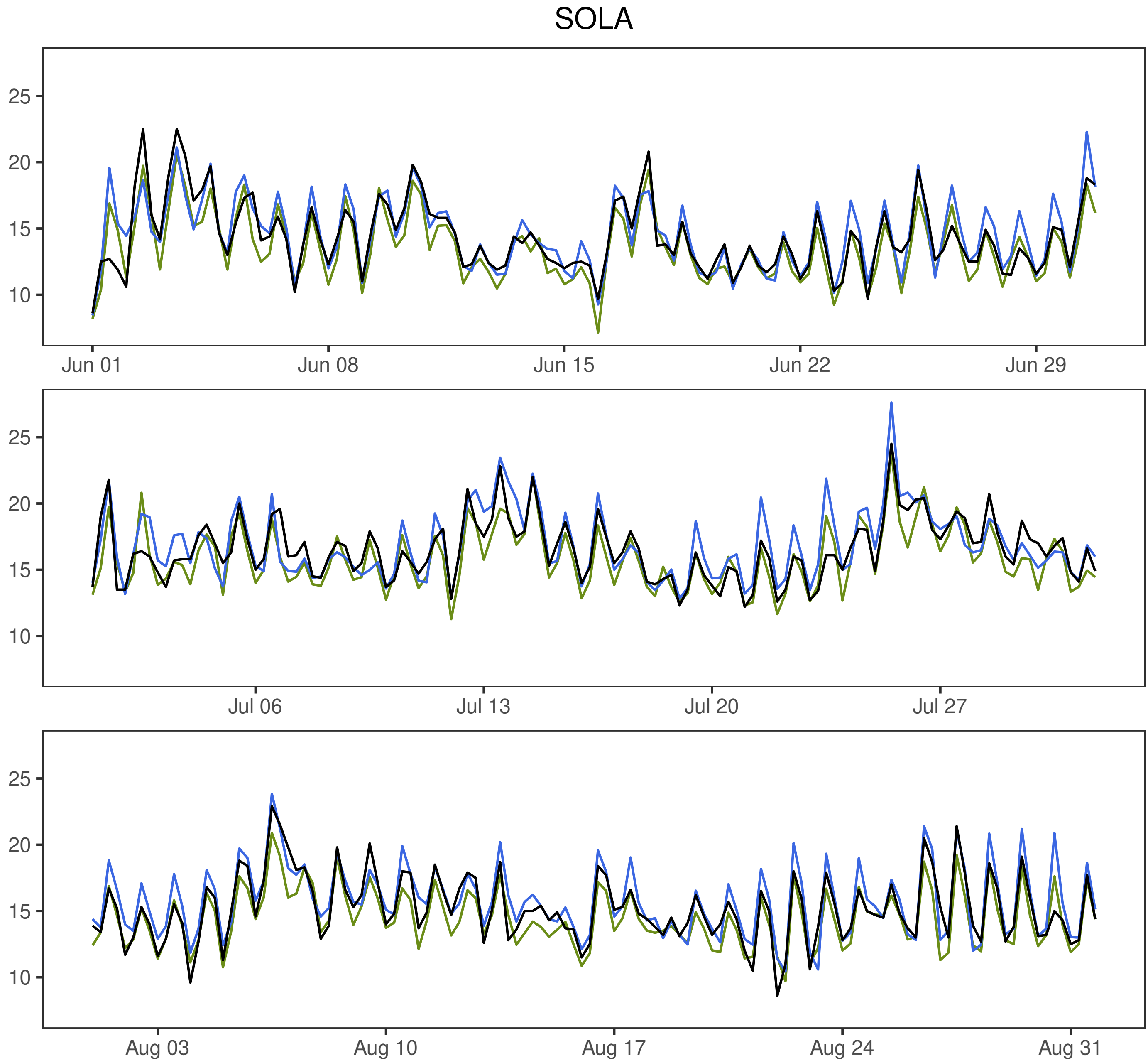
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	9.2	20.7	3.8	341
MEPSctrl: 12+18,+24,+30,+36	−0.6	9.0	20.4	4.3	368
ECMWF: 12+18,+24,+30,+36	−1.5	7.5	16.8	3.4	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.5	1.5	1.1	5.7	341
ECMWF−synop	−1.6	1.7	2.3	2.0	8.2	341



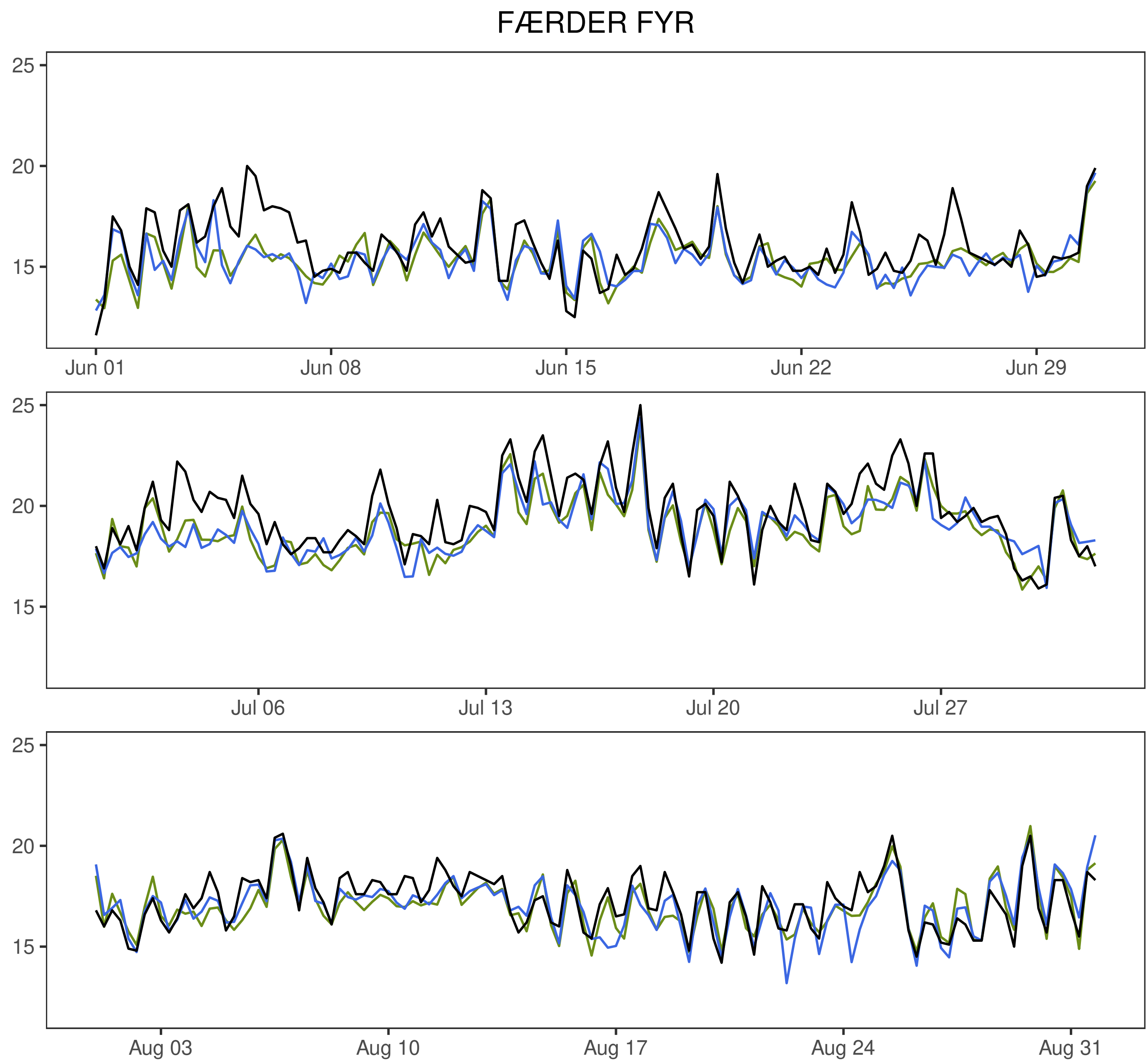
	Min	Mean	Max	Std	N
synop: 00,06,12,18	3.9	16.2	28.0	5.1	368
MEPSctrl: 12+18,+24,+30,+36	6.9	16.1	27.3	4.4	368
ECMWF: 12+18,+24,+30,+36	3.7	13.2	23.3	4.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	2.1	2.1	1.7	6.2	368
ECMWF–synop	–3.0	2.1	3.7	3.2	8.2	368



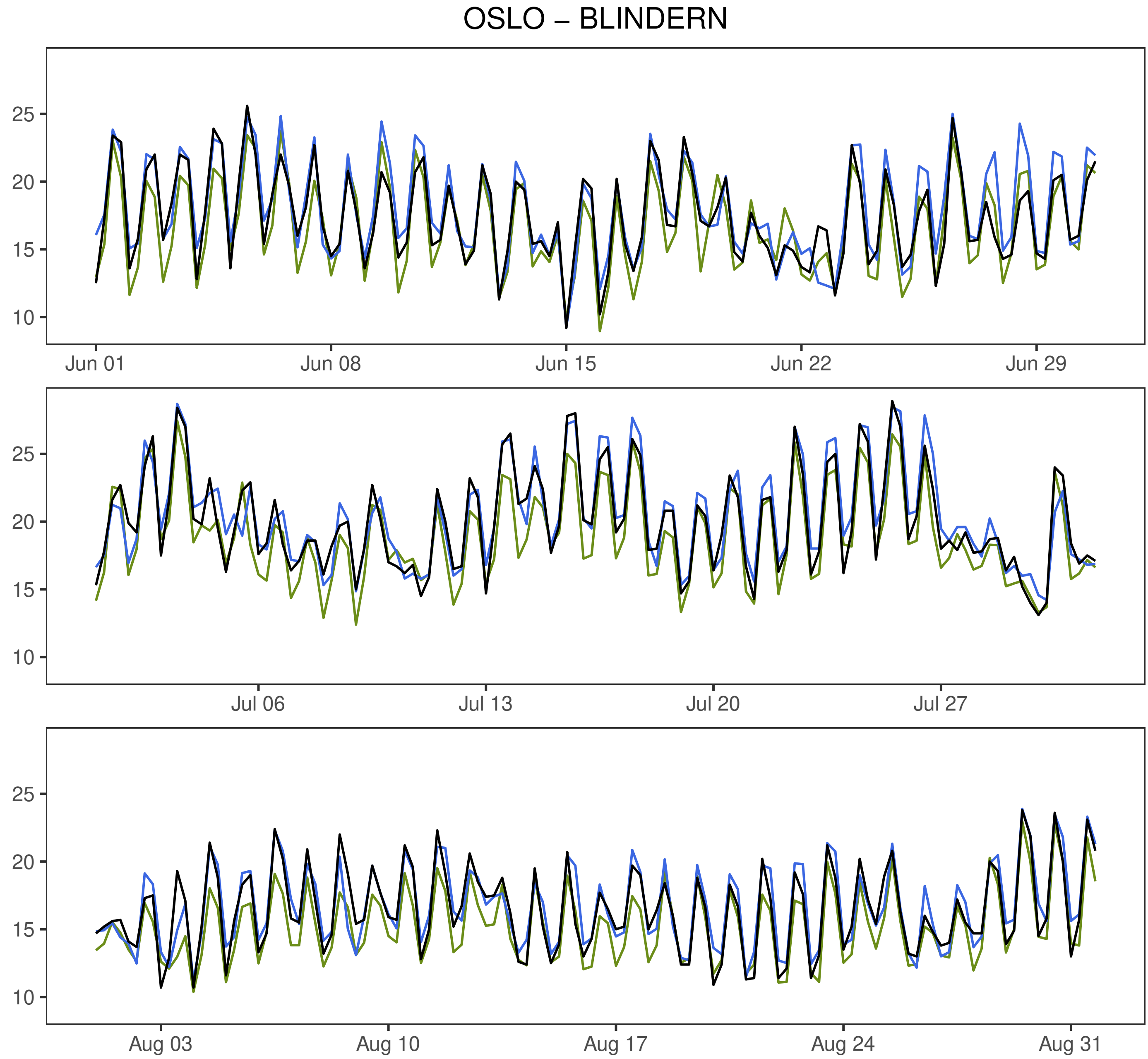
	Min	Mean	Max	Std	N
synop: 00,06,12,18	8.6	15.4	24.5	2.7	368
MEPSctrl: 12+18,+24,+30,+36	8.4	15.8	27.6	2.8	368
ECMWF: 12+18,+24,+30,+36	7.2	14.6	23.8	2.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	1.3	1.4	1.0	6.9	368
ECMWF−synop	−0.7	1.1	1.3	1.0	4.4	368



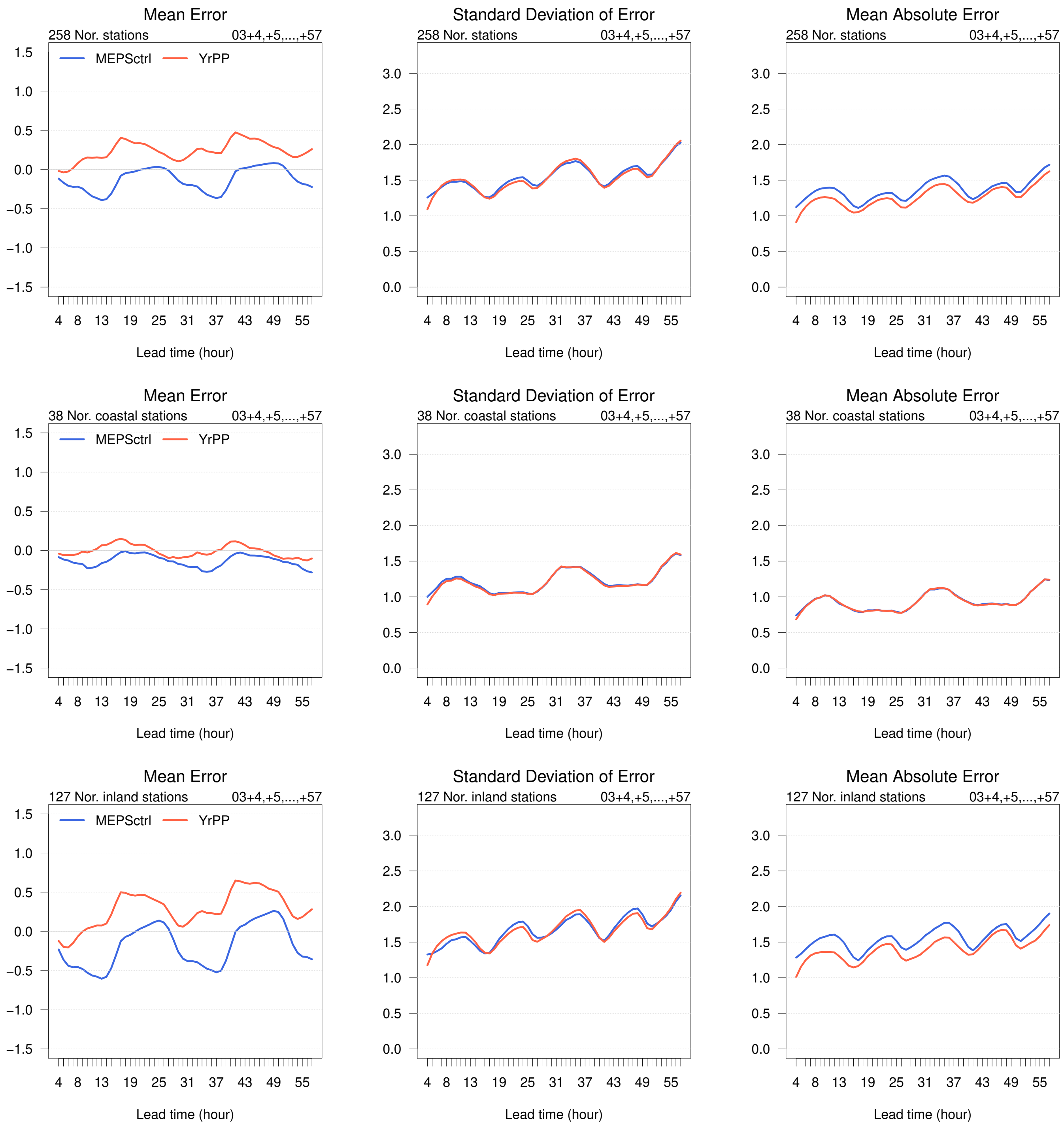
	Min	Mean	Max	Std	N
synop: 00,06,12,18	11.6	17.7	25.0	2.2	368
MEPSctrl: 12+18,+24,+30,+36	12.8	17.2	24.4	2.0	368
ECMWF: 12+18,+24,+30,+36	12.9	17.1	24.0	1.9	368

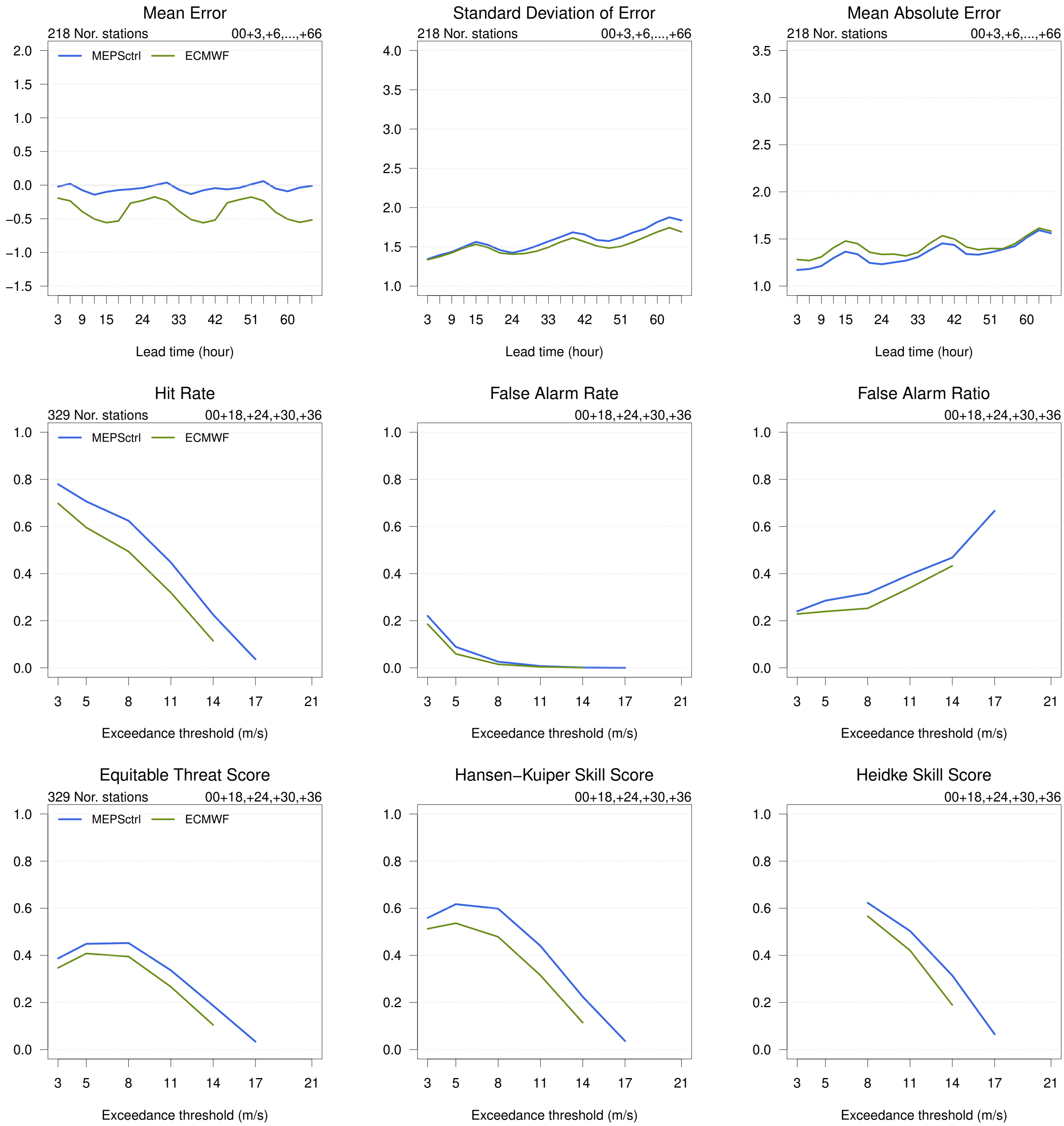
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.5	1.0	1.2	0.9	4.0	368
ECMWF−synop	−0.6	0.9	1.1	0.9	4.0	368

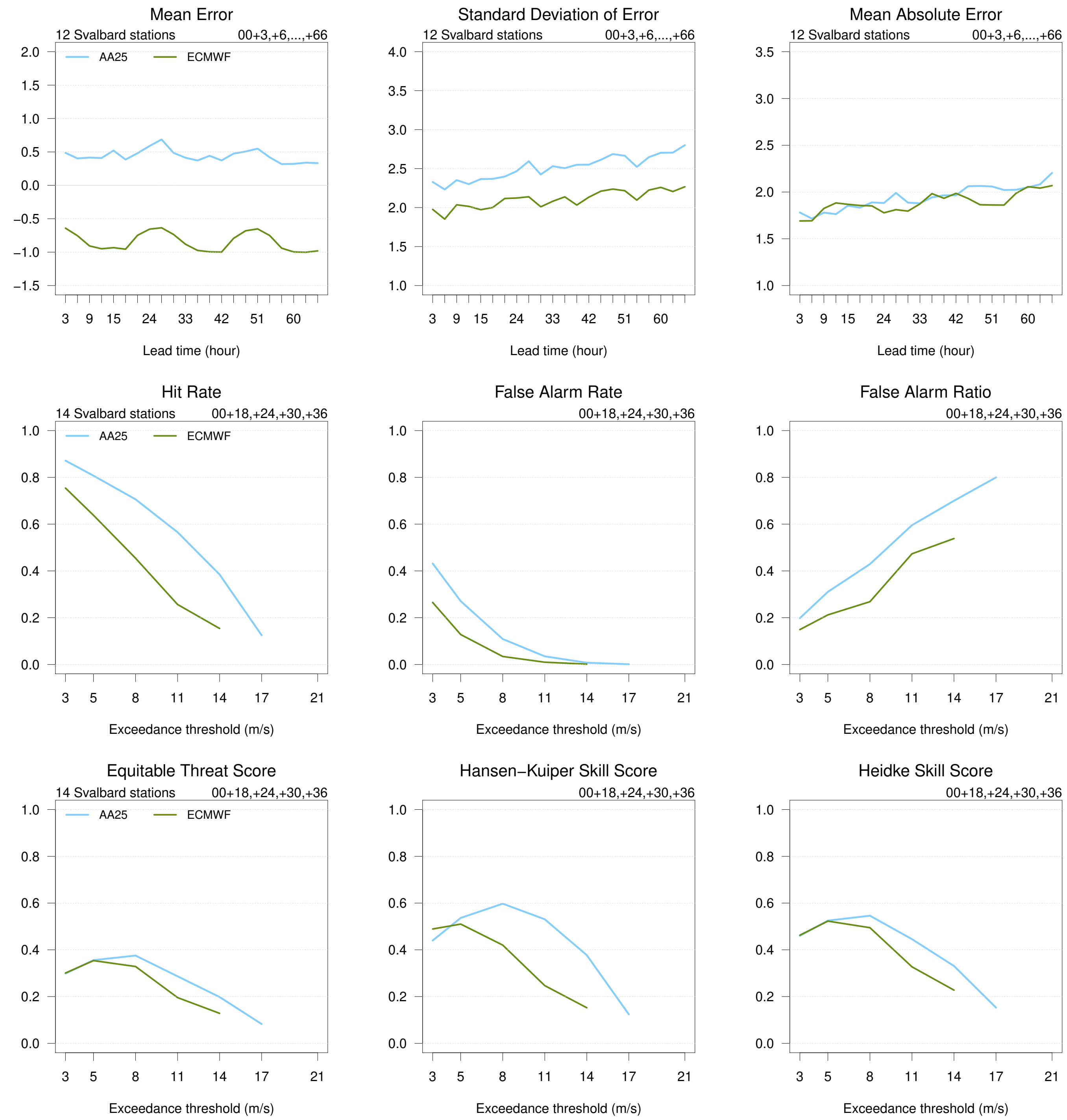


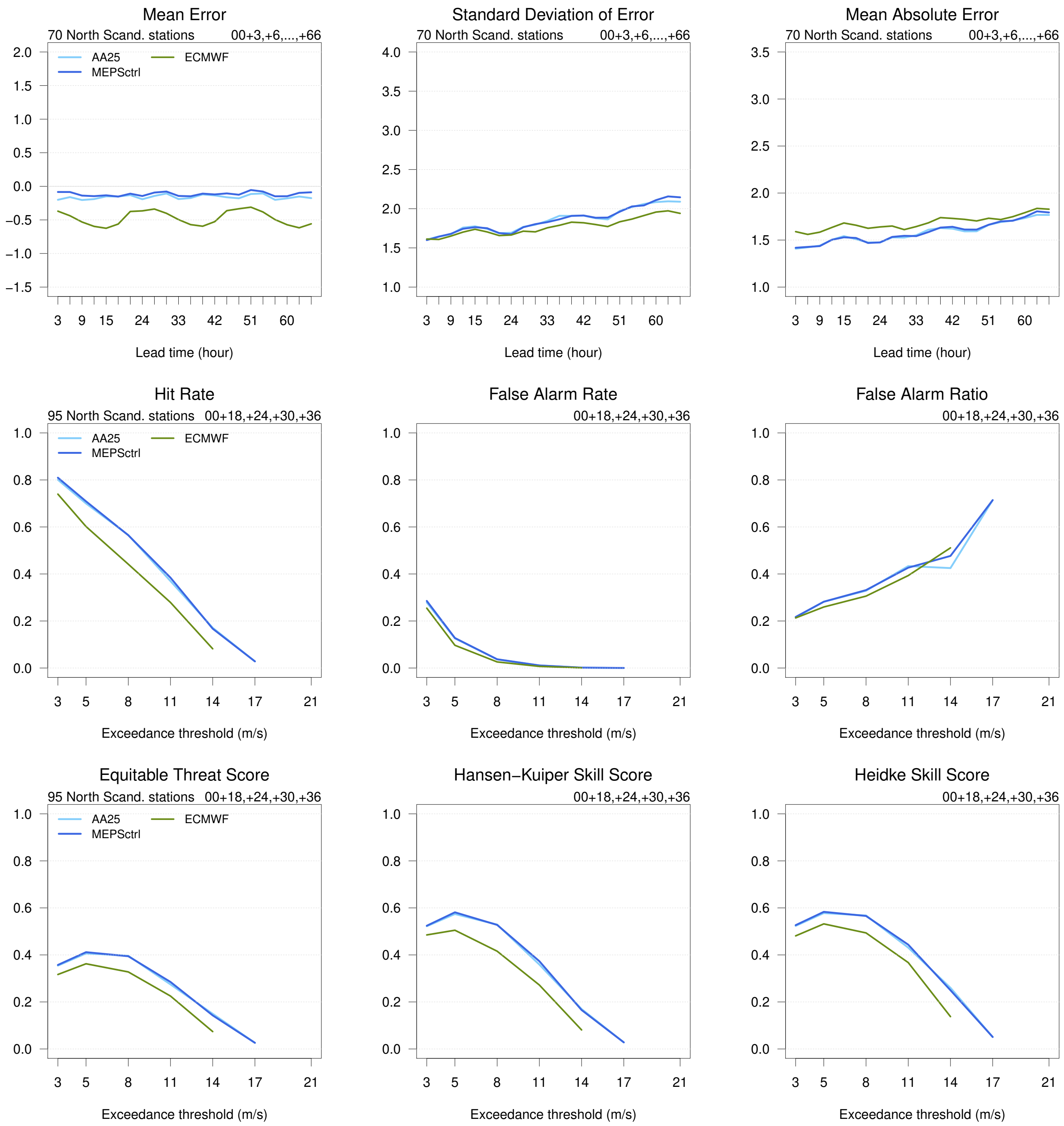
	Min	Mean	Max	Std	N
synop: 00,06,12,18	9.2	18.0	28.9	3.7	368
MEPSctrl: 12+18,+24,+30,+36	9.3	18.4	28.7	3.8	368
ECMWF: 12+18,+24,+30,+36	9.0	16.9	27.4	3.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.4	1.3	1.4	1.0	6.3	368
ECMWF–synop	−1.0	1.3	1.7	1.4	6.3	368

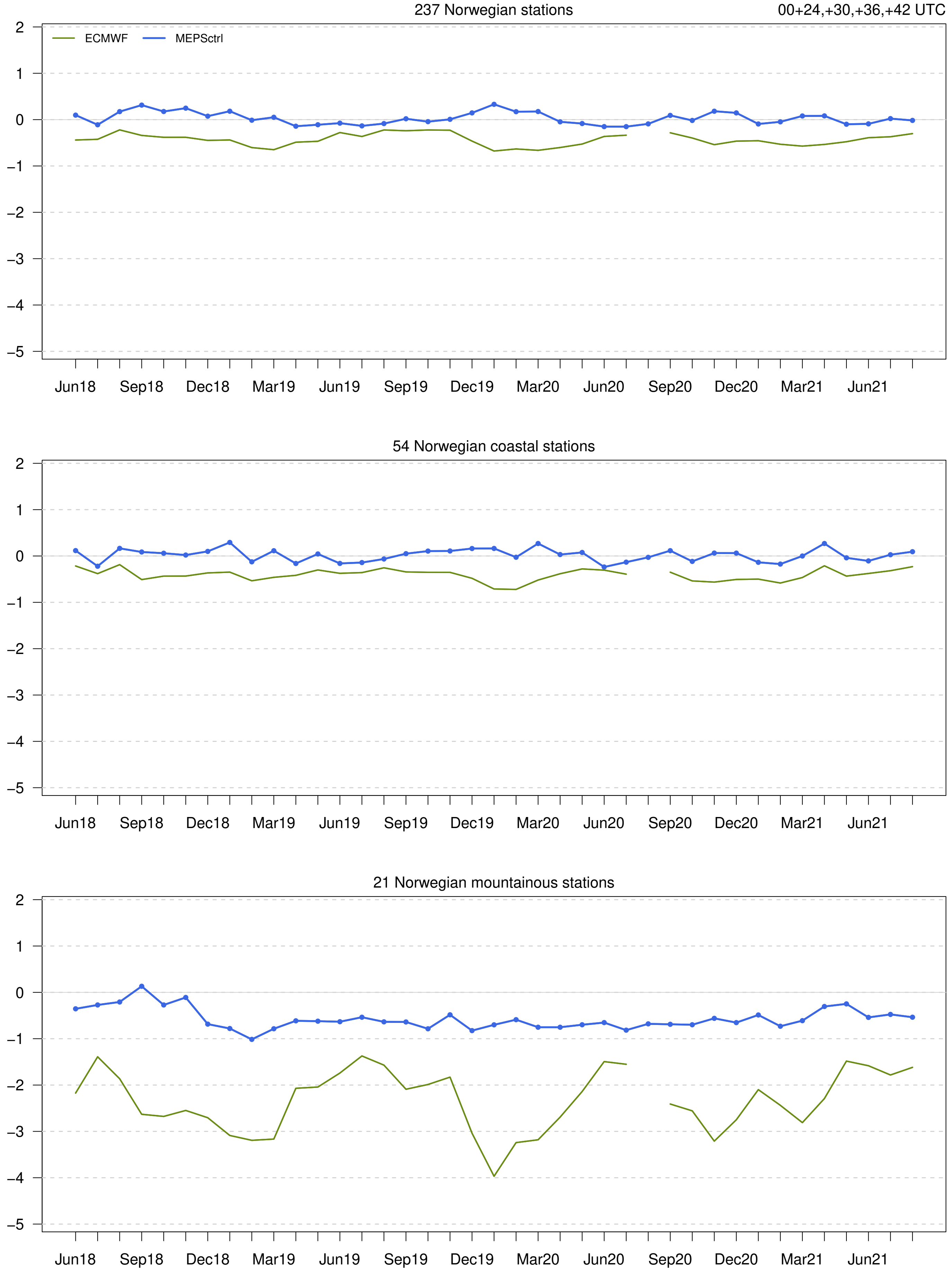

Mean Error
258 Nor. stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
258 Nor. stations
03+4,+5,...,+57
Lead time (hour)
Mean Absolute Error
258 Nor. stations
03+4,+5,...,+57
Lead time (hour)
Mean Error
38 Nor. coastal stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
38 Nor. coastal stations
03+4,+5,...,+57
Lead time (hour)
Mean Absolute Error
38 Nor. coastal stations
03+4,+5,...,+57
Lead time (hour)
Mean Error
127 Nor. inland stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
127 Nor. inland stations
03+4,+5,...,+57
Lead time (hour)
Mean Absolute Error
127 Nor. inland stations
03+4,+5,...,+57
Lead time (hour)


Mean Error
218 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
218 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
218 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (m/s)
False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)


Mean Error
12 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
12 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)
False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

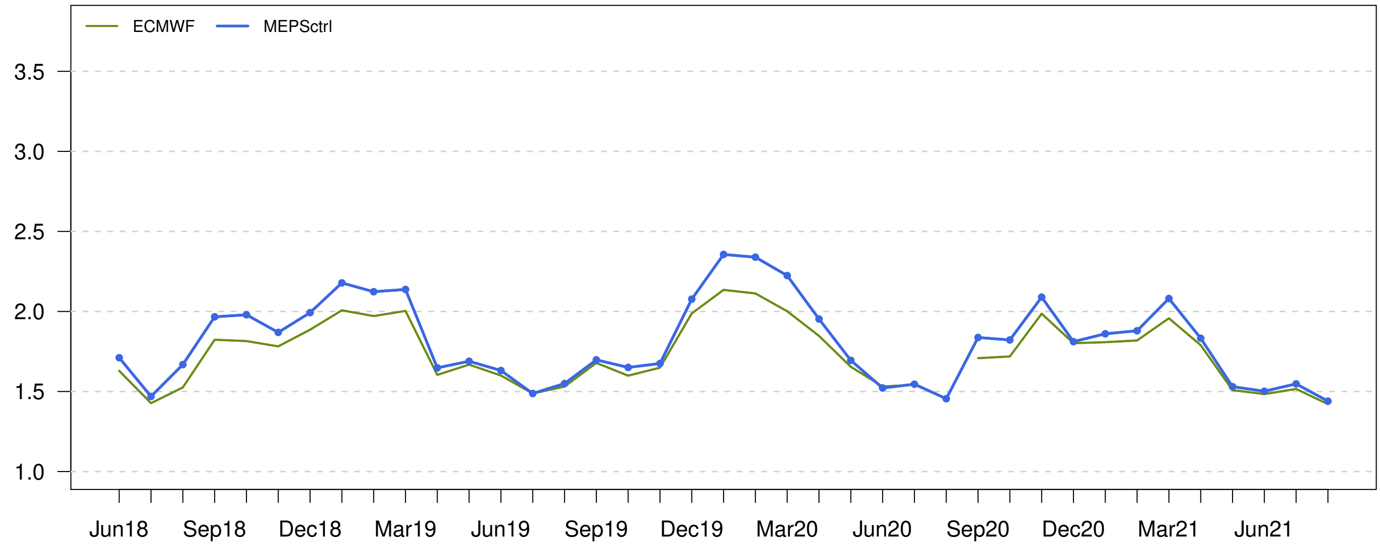

Mean Error
70 North Scand. stations
00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
70 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
70 North Scand. stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
95 North Scand. stations
00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
Exceedance threshold (m/s)
False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
95 North Scand. stations
00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

Mean Error

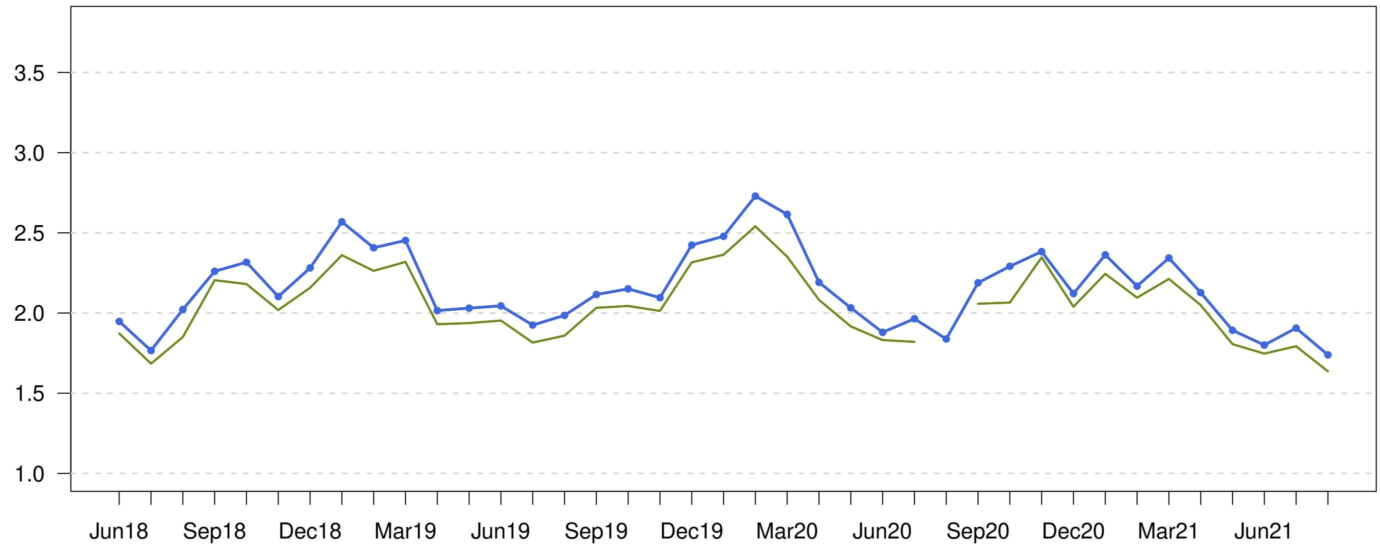

237 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Jun18
Sep18
Dec18
Mar19
Jun19
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
54 Norwegian coastal stations
21 Norwegian mountainous stations

Standard Deviation of Error

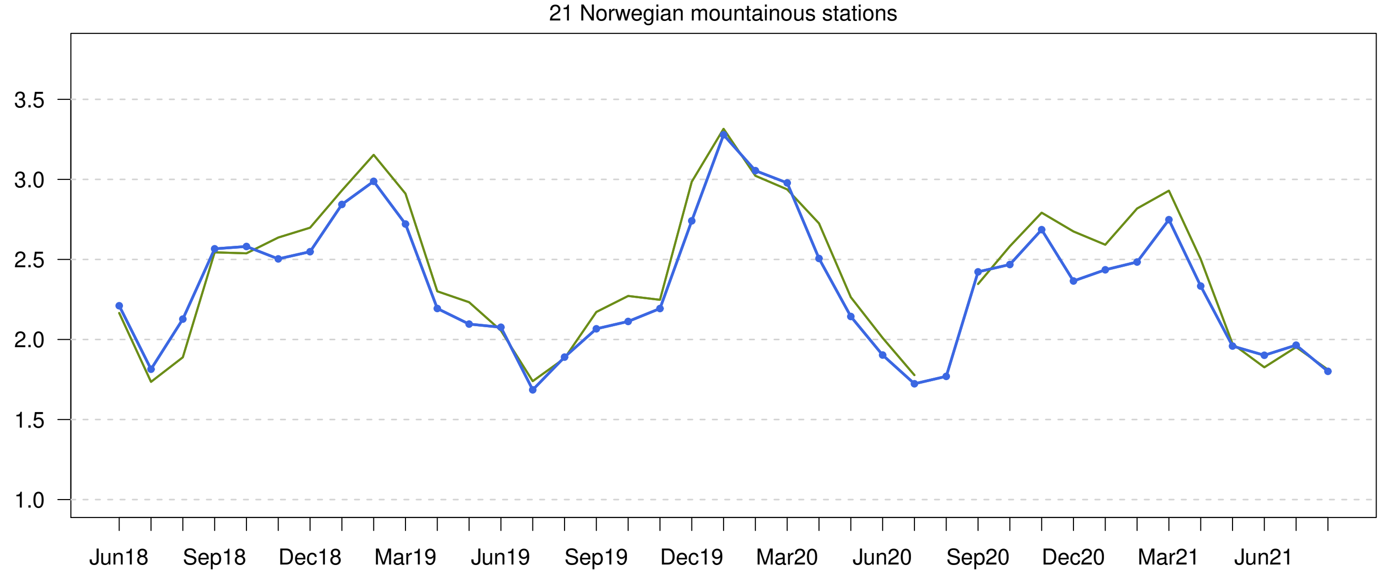
237 Norwegian stations   00+24,+30,+36,+42 UTC



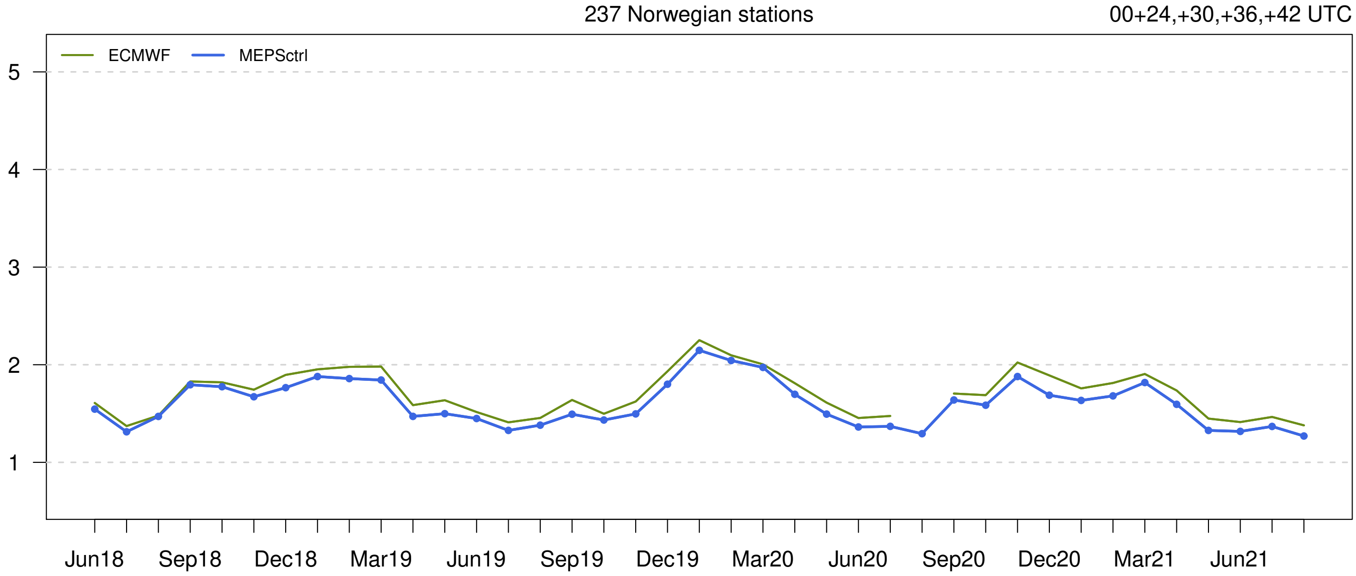
54 Norwegian coastal stations

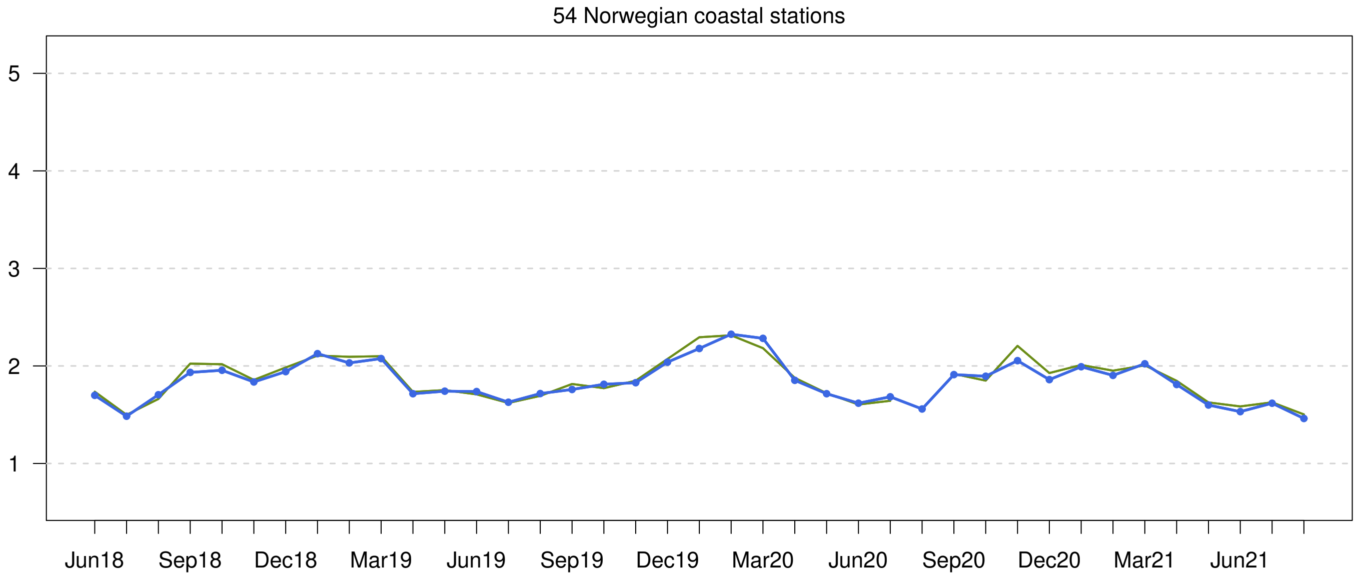


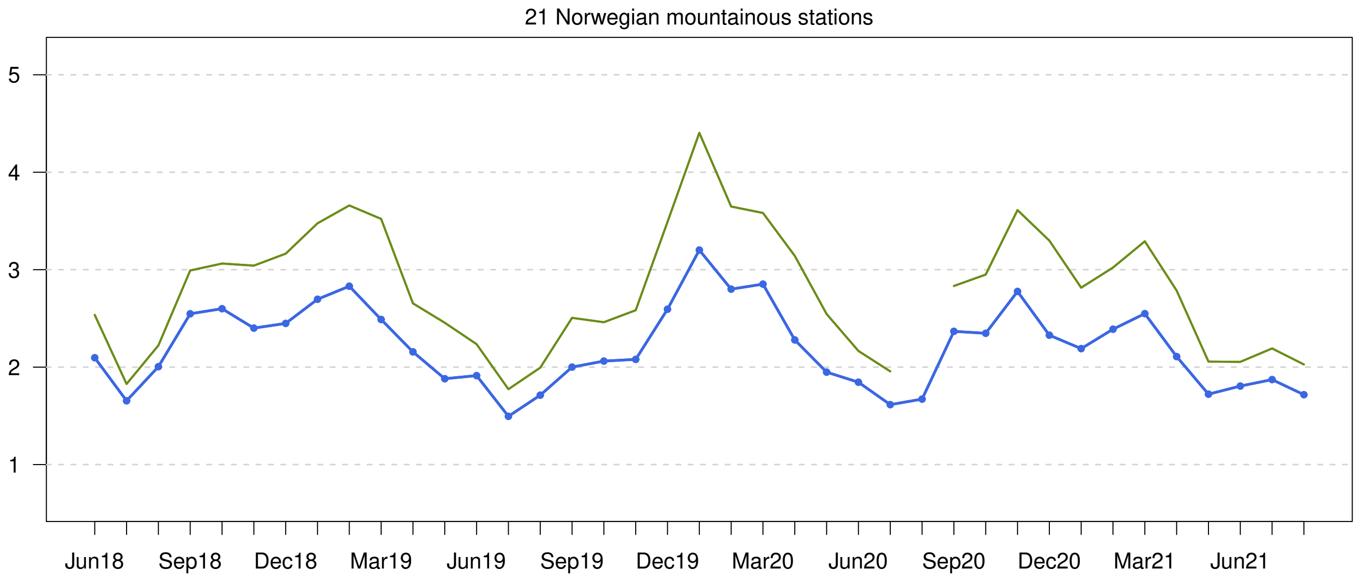
21 Norwegian mountainous stations



Mean Absolute Error

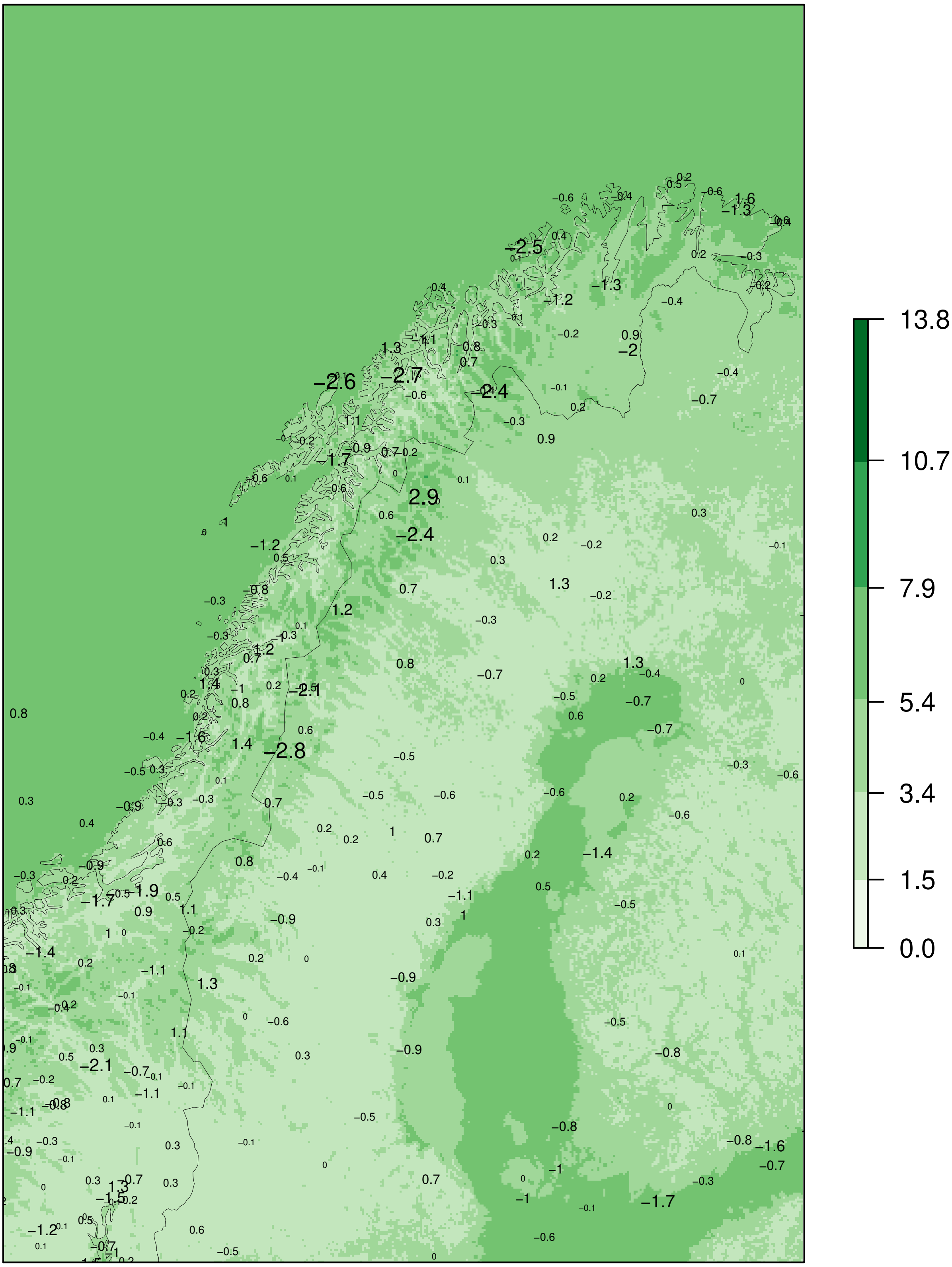






MEPSctrl 00+12

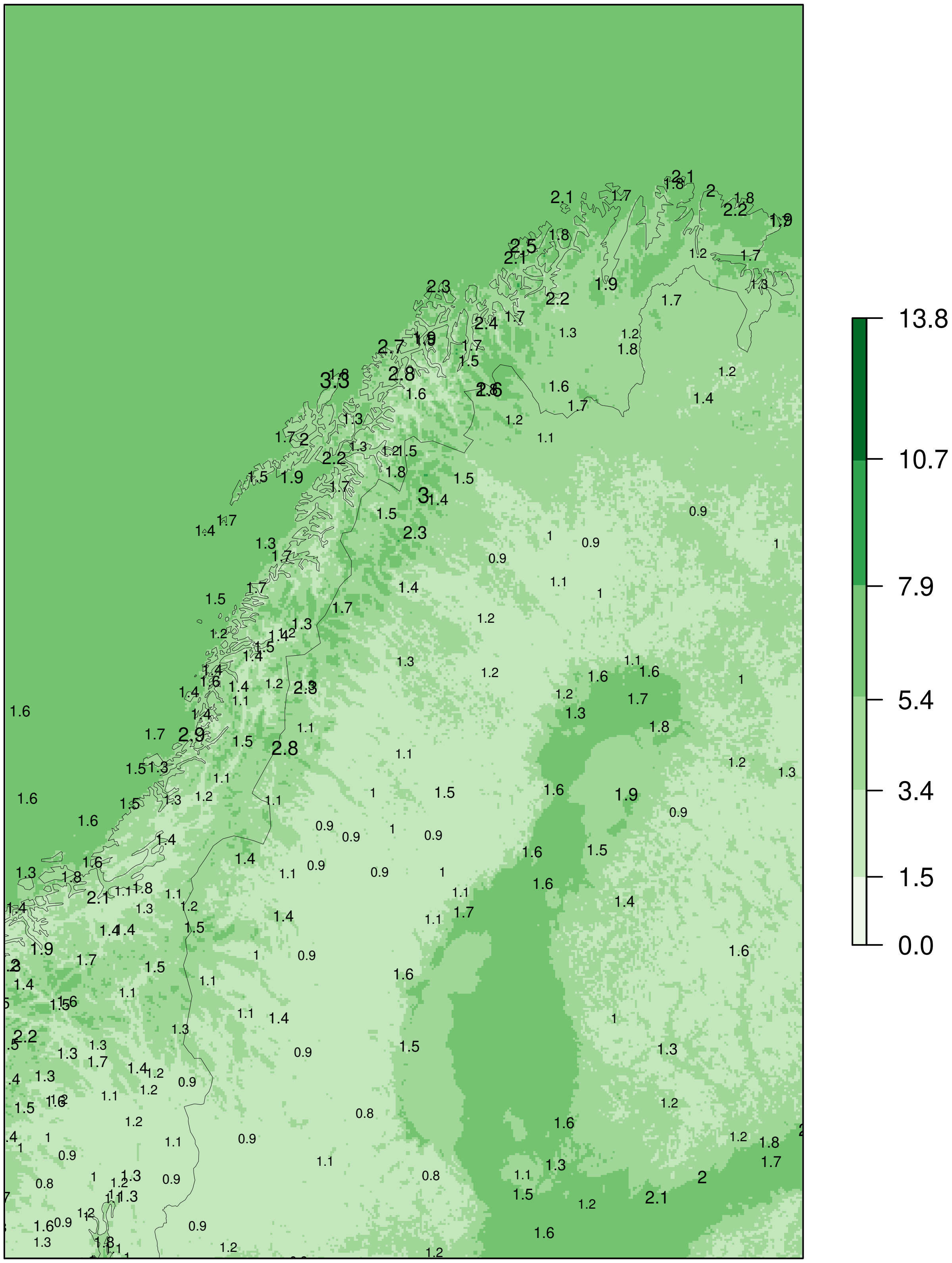
ME at observing sites
(numbers in black)



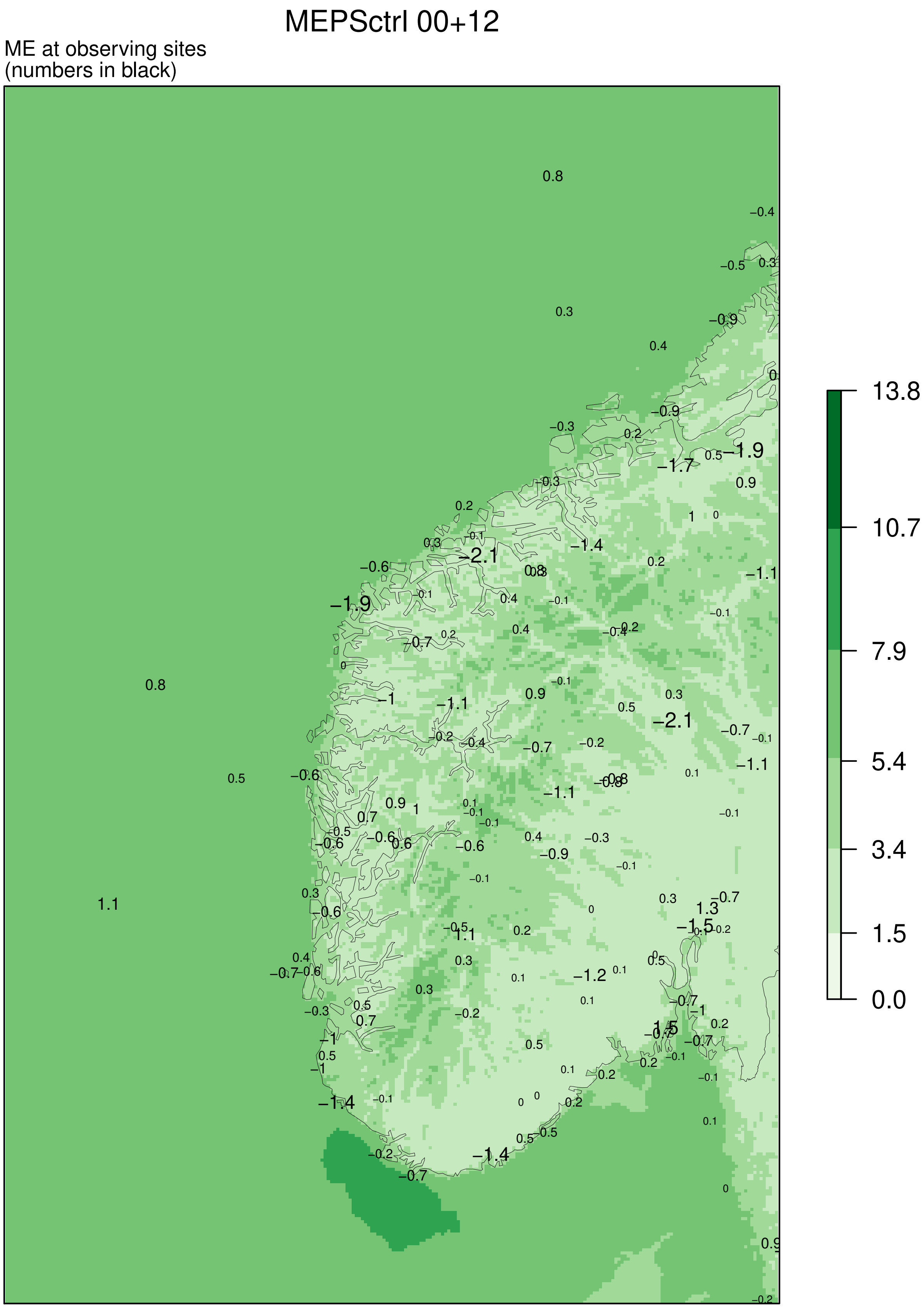
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+12

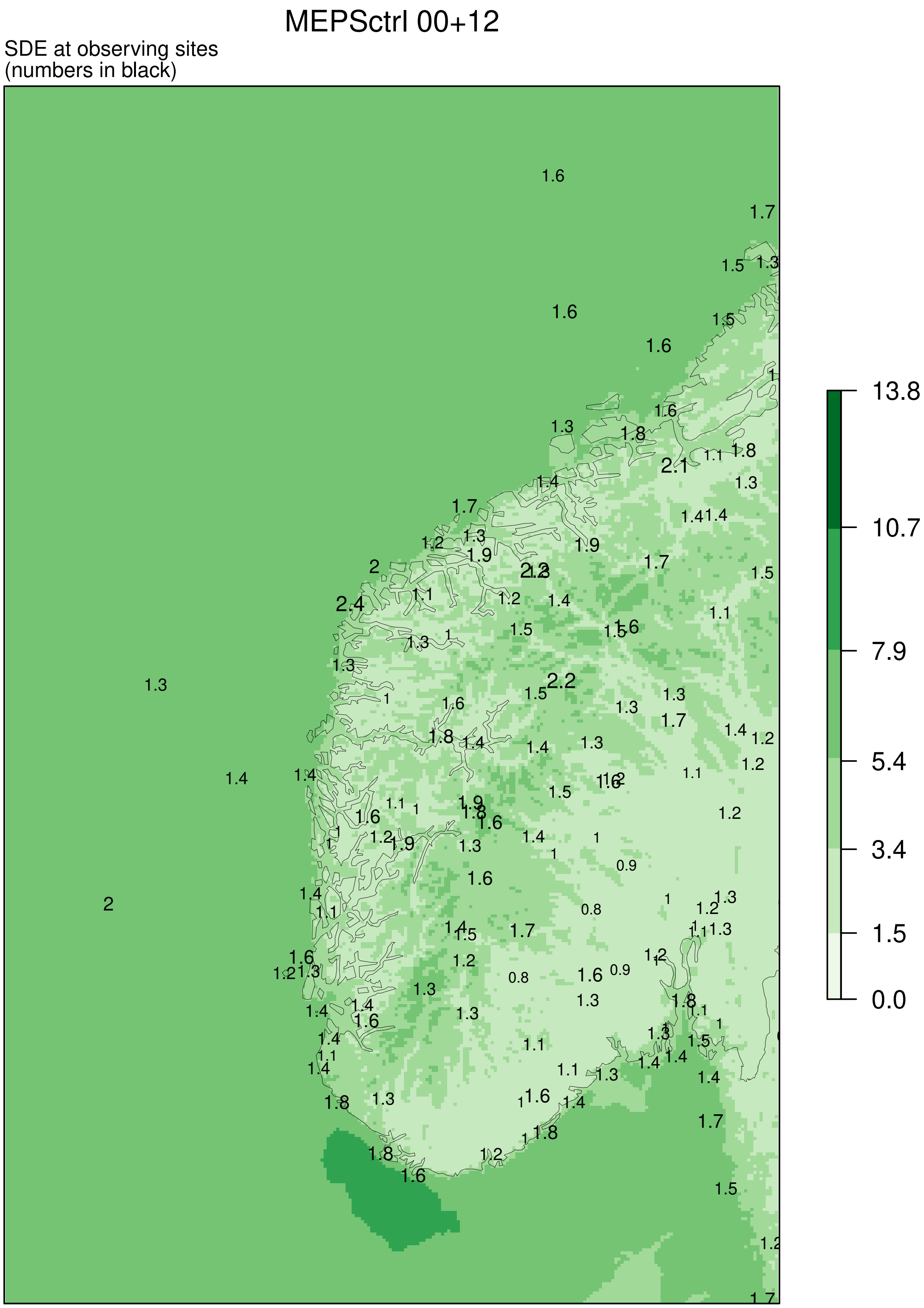
SDE at observing sites
(numbers in black)



Model "climatology" 01.06.2021 – 31.08.2021



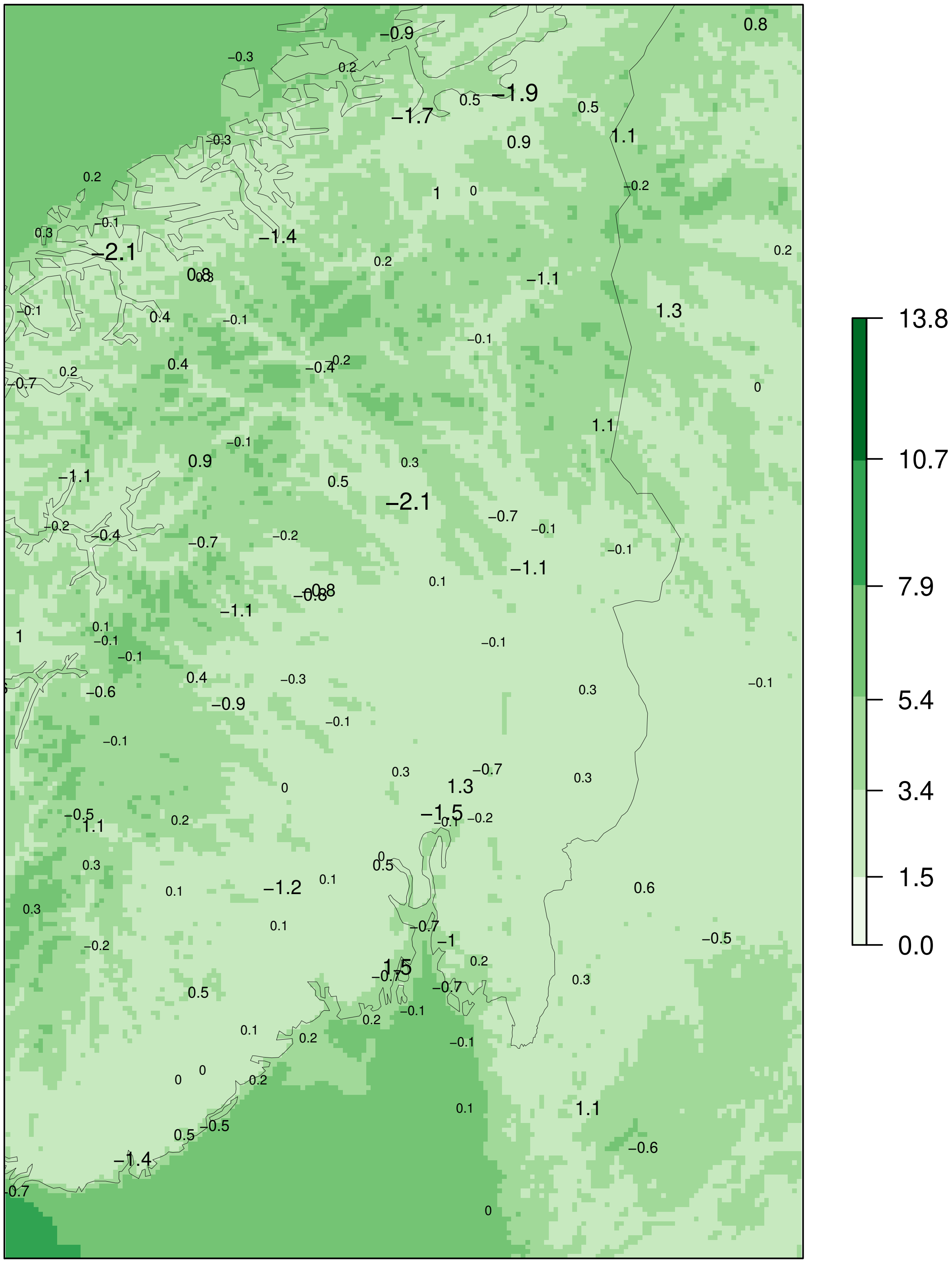
Model "climatology" 01.06.2021 – 31.08.2021



Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+12

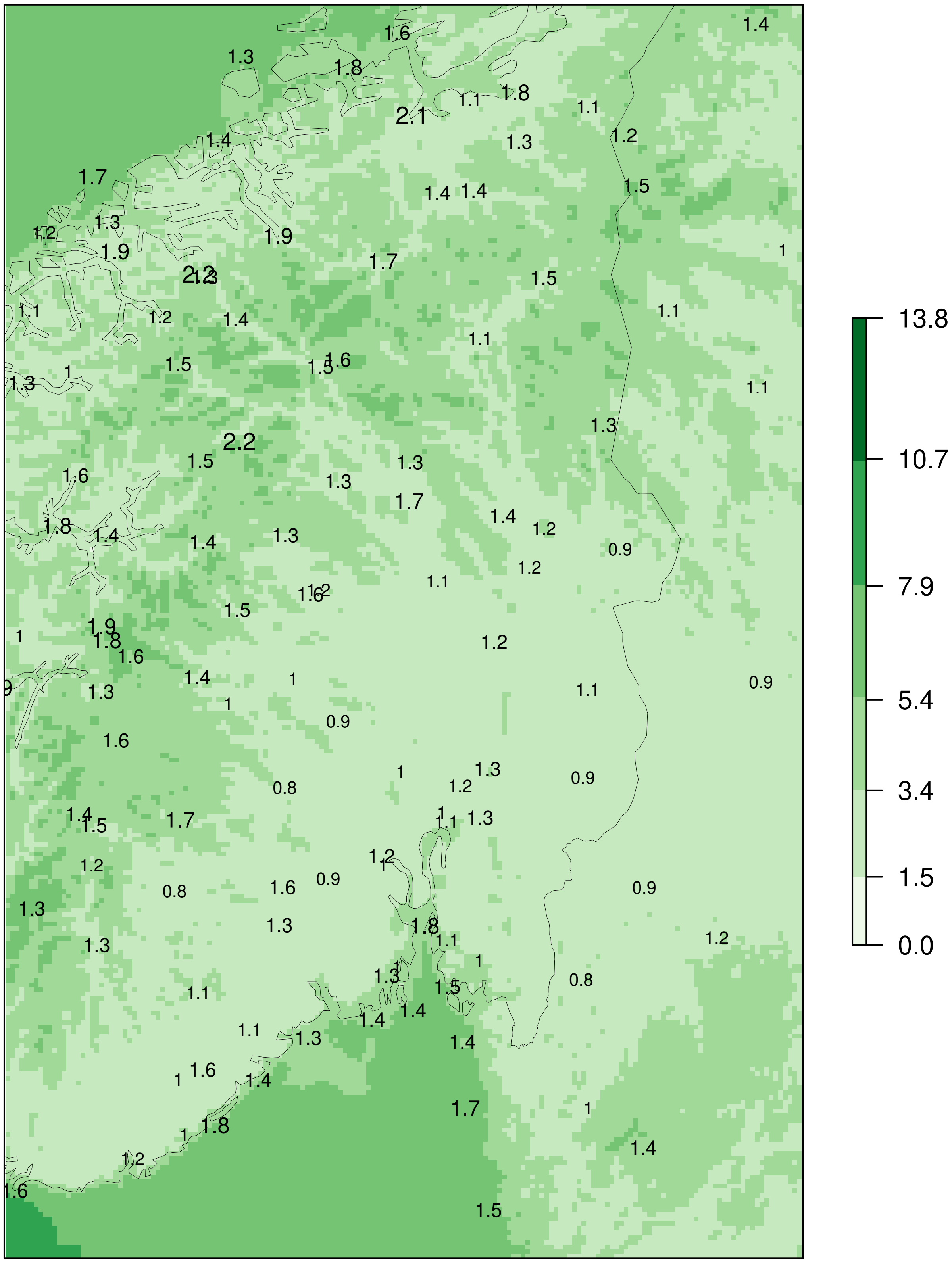
ME at observing sites
(numbers in black)



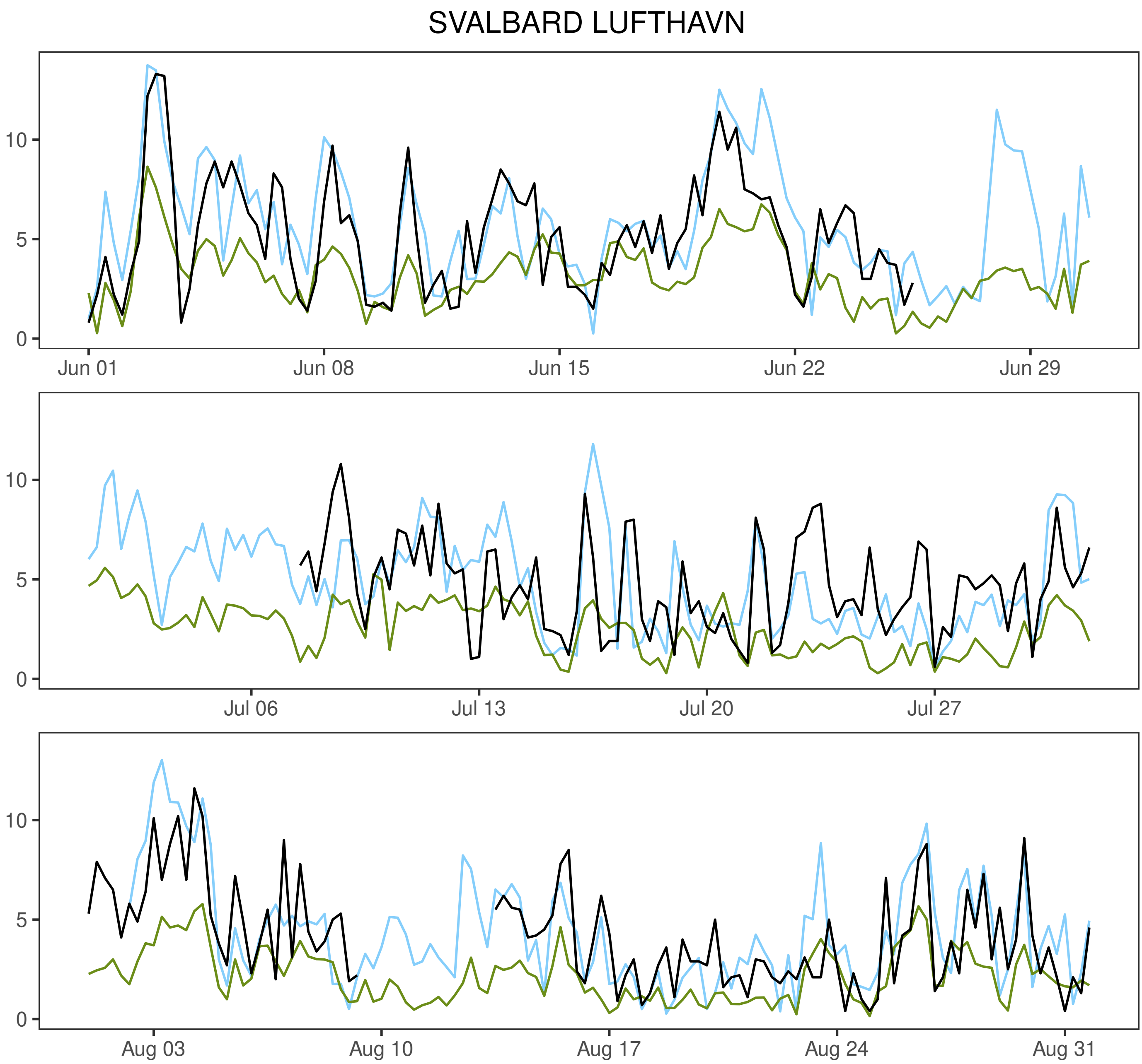
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+12

SDE at observing sites
(numbers in black)

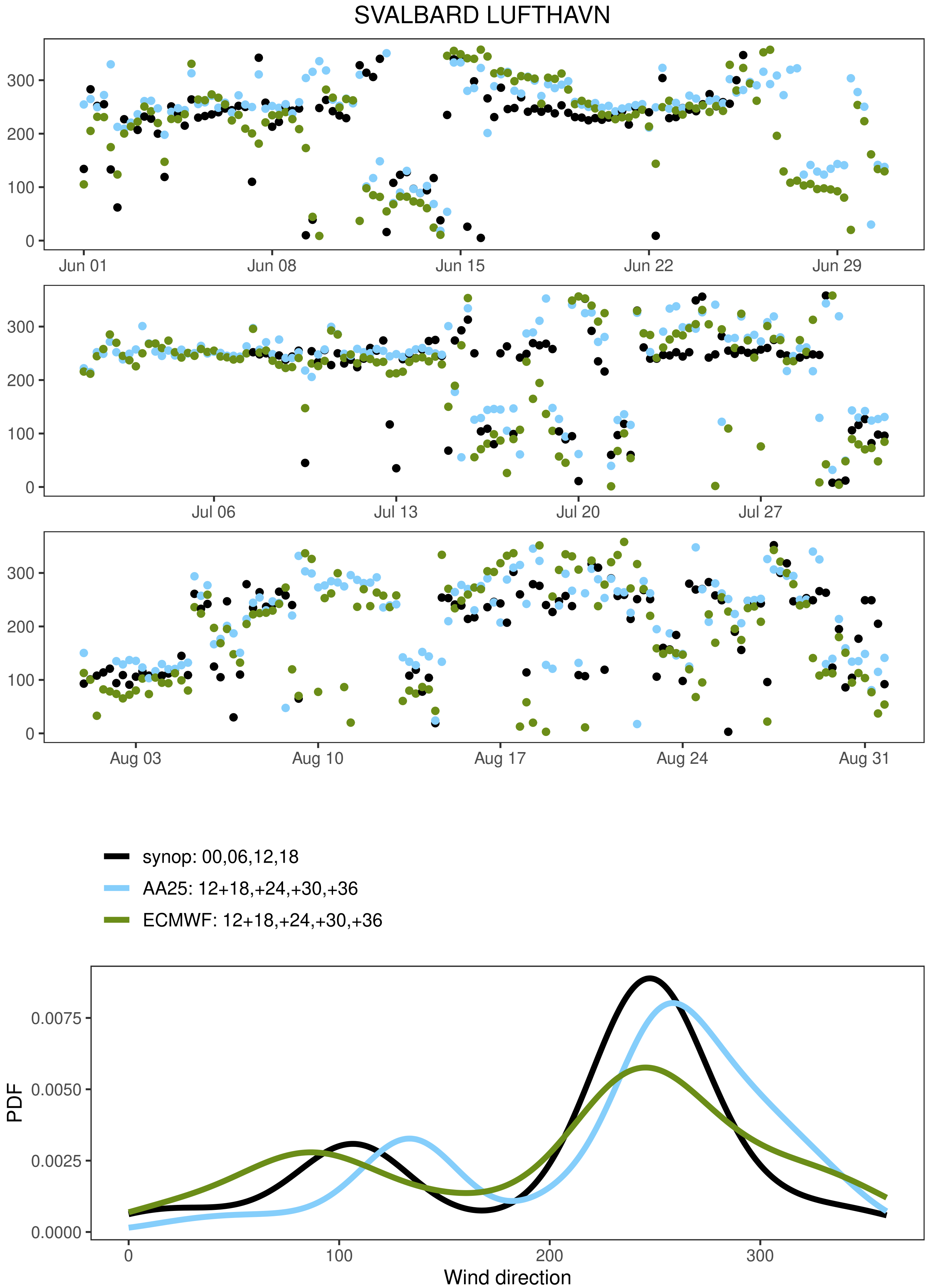


Model "climatology" 01.06.2021 – 31.08.2021

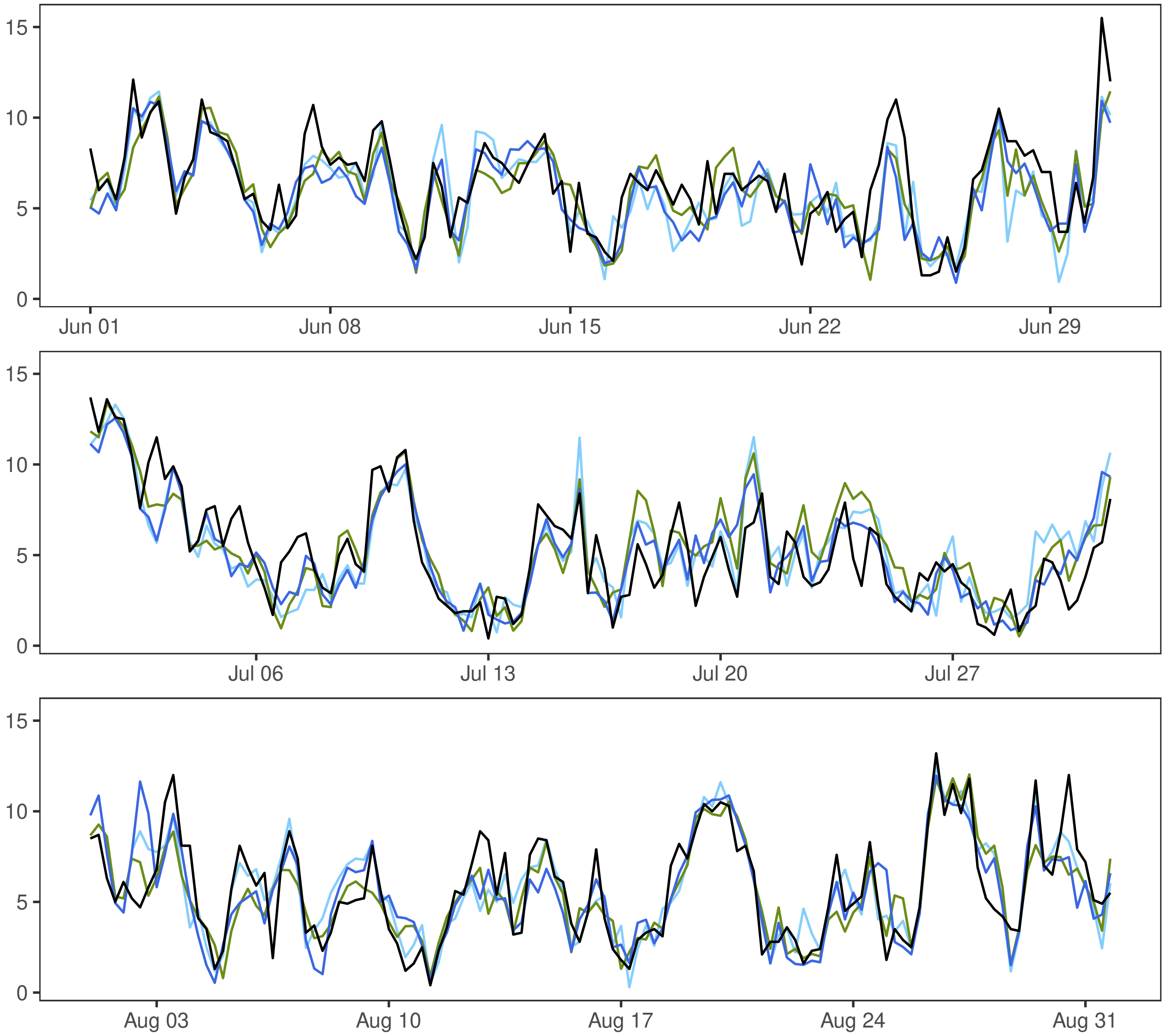


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.4	4.7	13.3	2.6	305
AA25: 12+18,+24,+30,+36	0.3	5.0	13.7	2.8	364
ECMWF: 12+18,+24,+30,+36	0.1	2.6	8.6	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.3	2.3	2.3	1.7	8.3	301
ECMWF−synop	−2.0	2.0	2.9	2.3	7.3	301

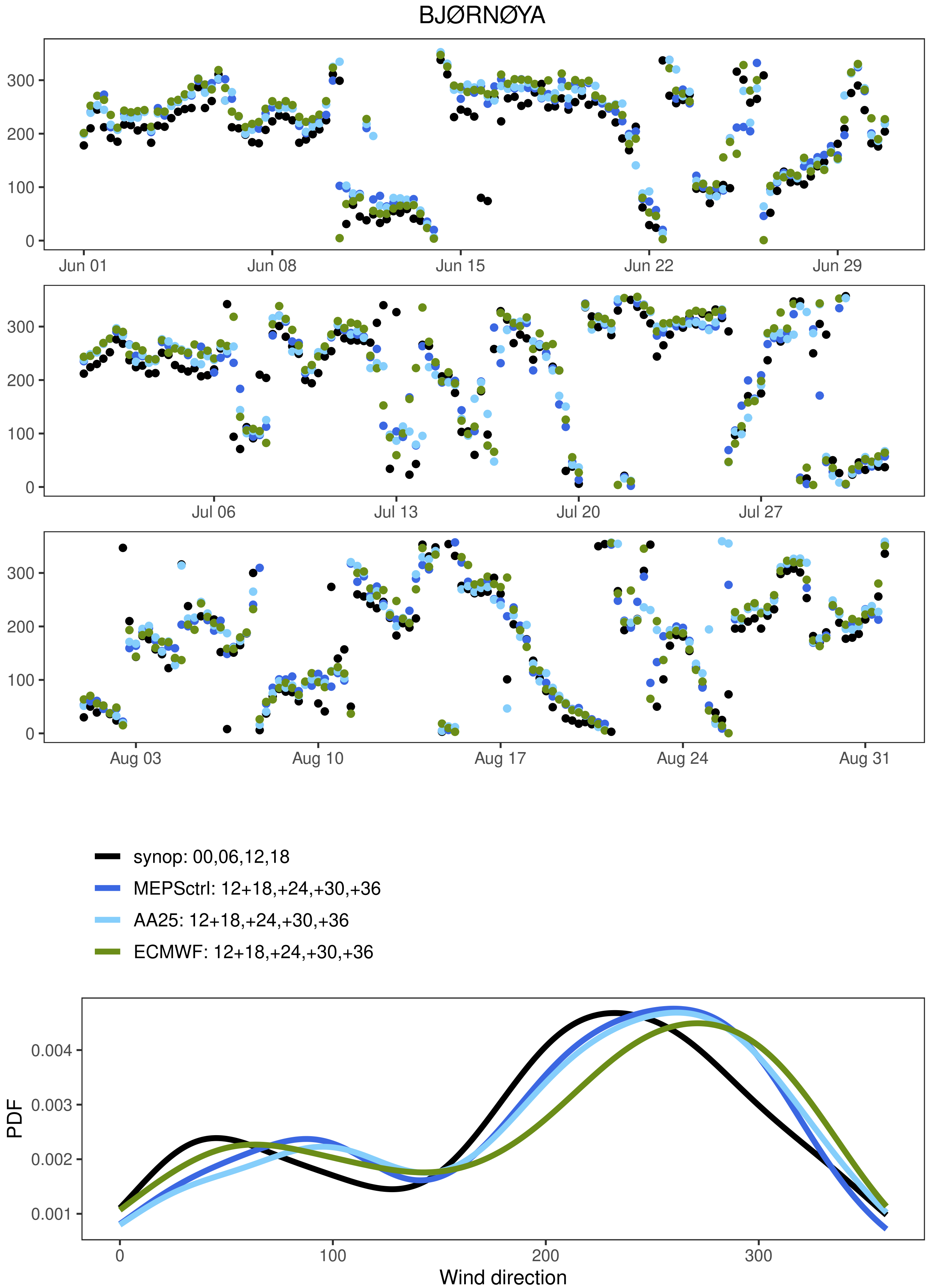

SVALBARD LUFTHAVN
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0075
0.0050
0.0025
0.0000
0
100
200
300
Wind direction

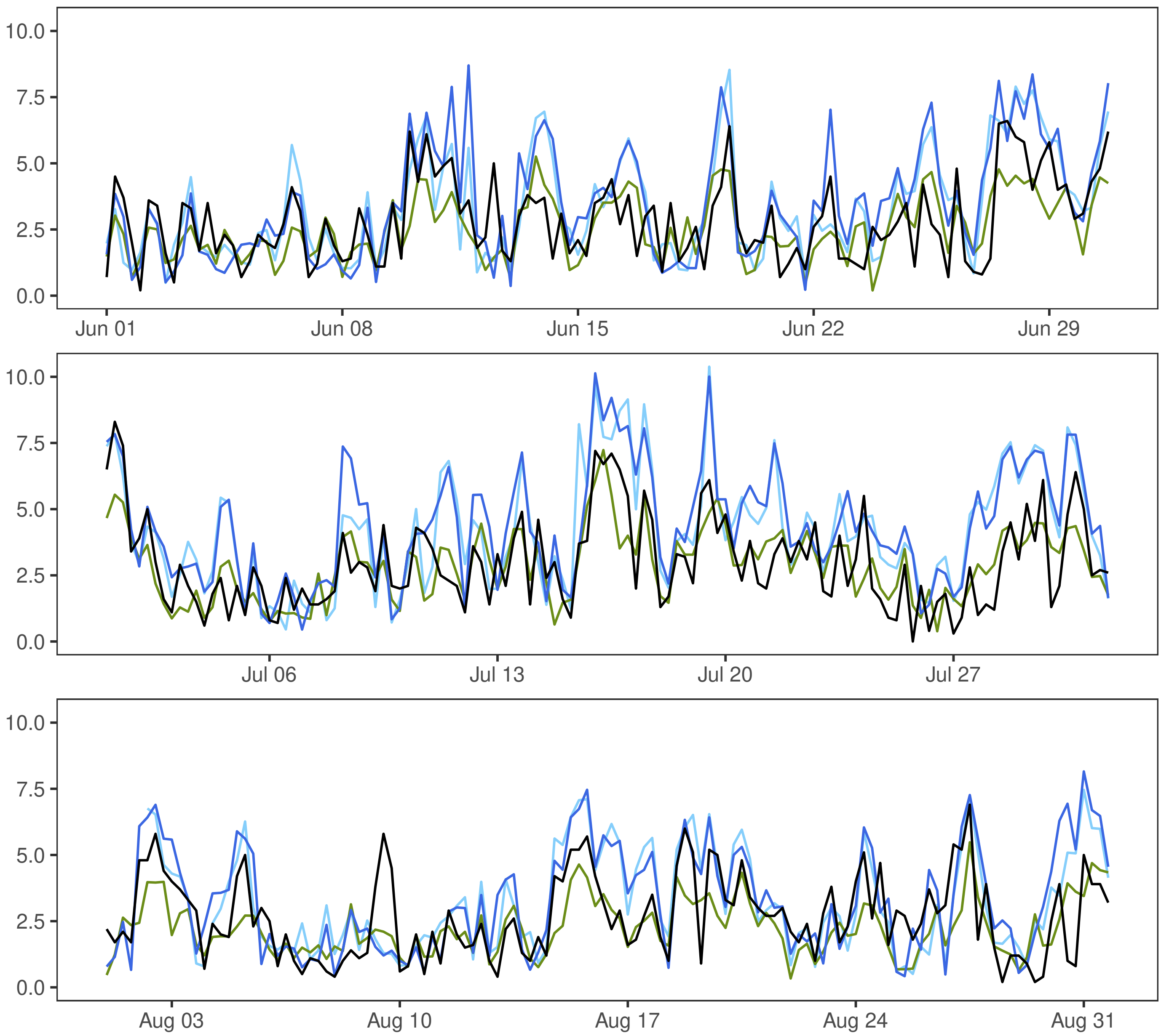
BJØRNØYA



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.4	5.8	15.5	2.8	368
MEPSctrl: 12+18,+24,+30,+36	0.5	5.5	12.5	2.6	368
AA25: 12+18,+24,+30,+36	0.3	5.6	13.3	2.6	364
ECMWF: 12+18,+24,+30,+36	0.5	5.6	13.4	2.5	368

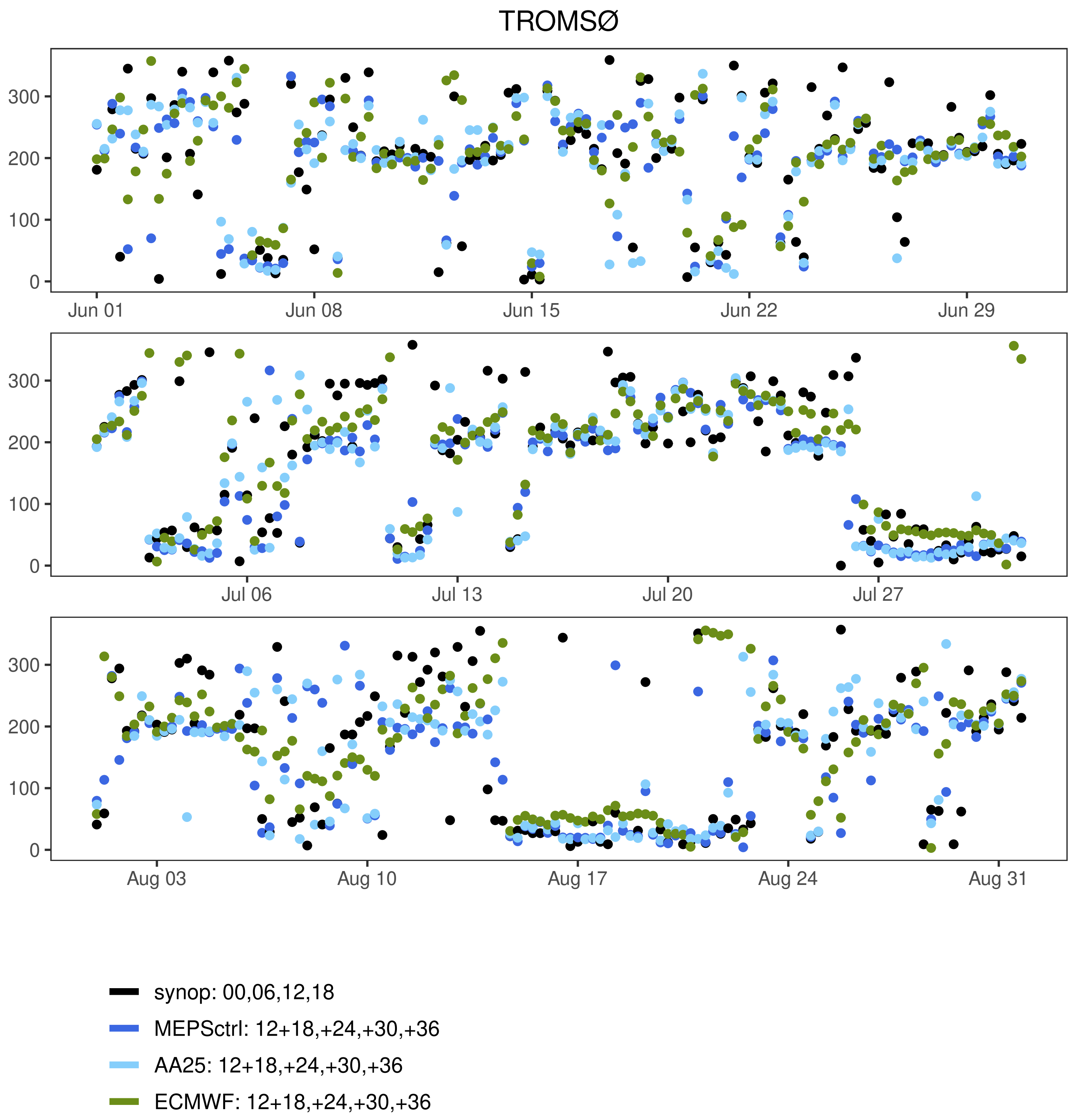
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.3	1.6	1.7	1.3	6.9	364
AA25–synop	–0.1	1.7	1.7	1.3	5.8	364
ECMWF–synop	–0.1	1.6	1.6	1.2	5.5	364

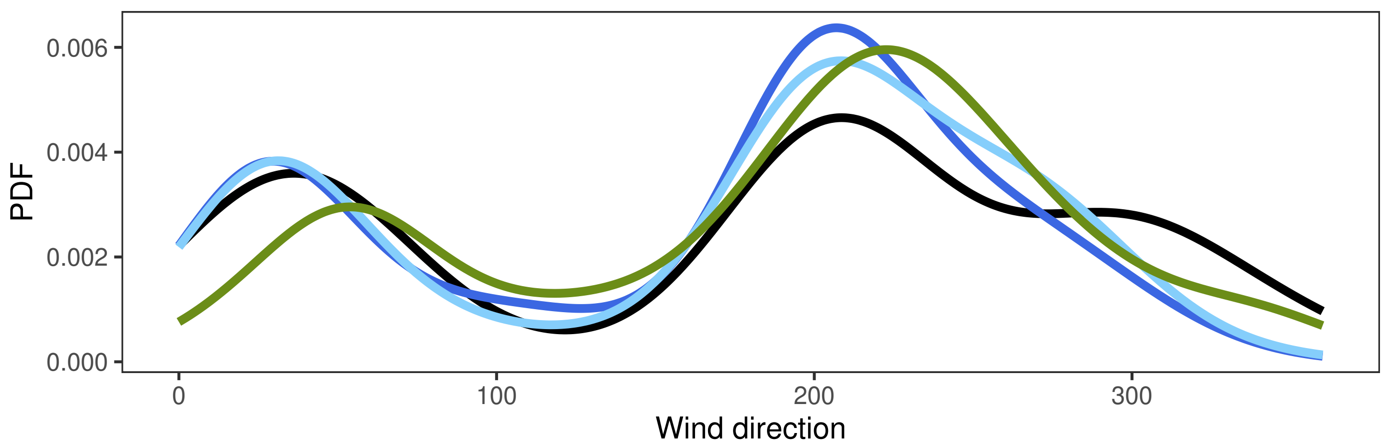

BJØRNØYA
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

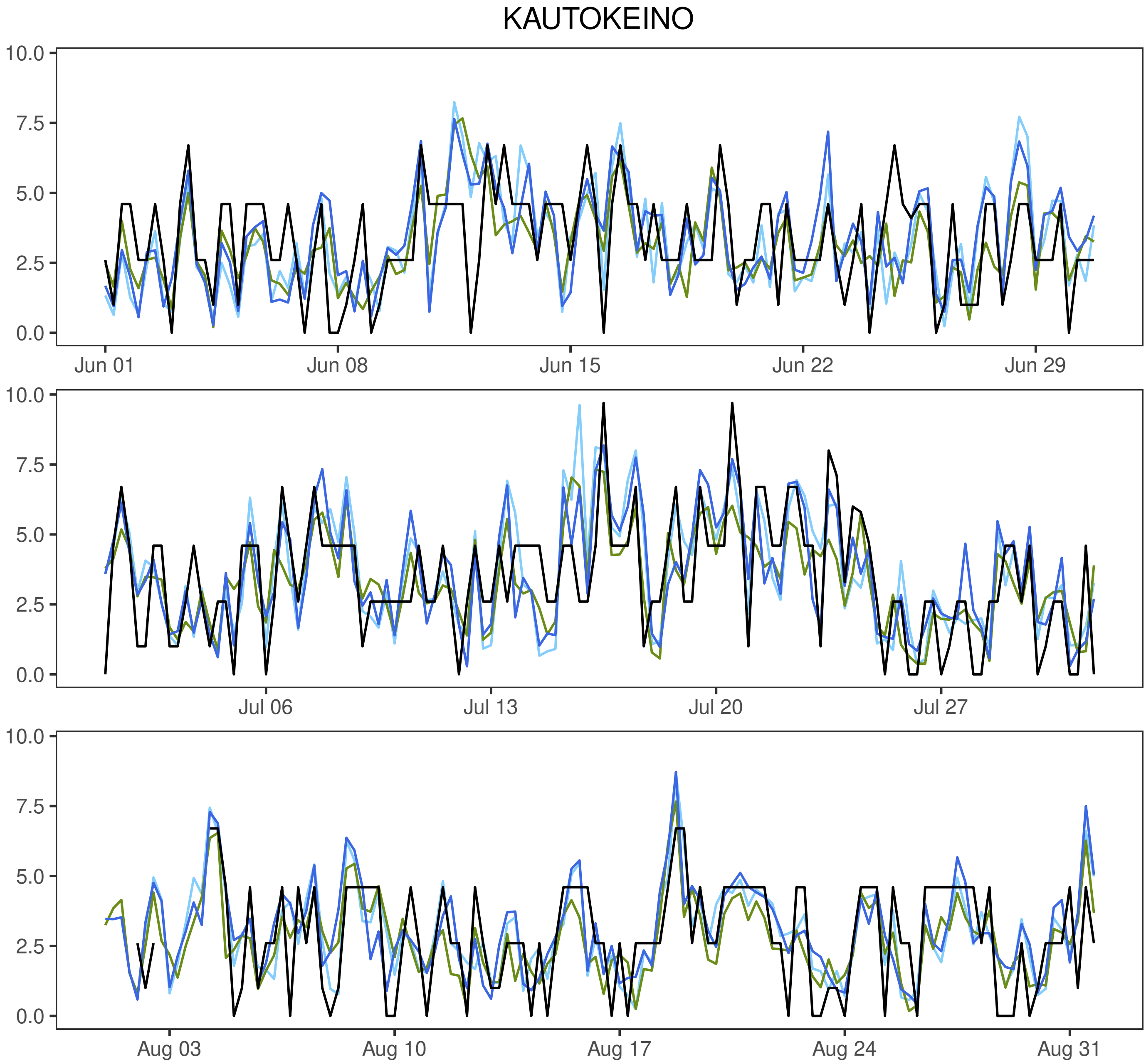


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	2.8	8.3	1.6	368
MEPSctrl: 12+18,+24,+30,+36	0.2	3.7	10.1	2.1	368
AA25: 12+18,+24,+30,+36	0.5	3.6	10.4	2.0	364
ECMWF: 12+18,+24,+30,+36	0.2	2.6	7.2	1.2	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.9	1.6	1.8	1.4	5.9	364
AA25–synop	0.8	1.5	1.7	1.3	5.4	364
ECMWF–synop	−0.3	1.2	1.2	1.0	3.7	364

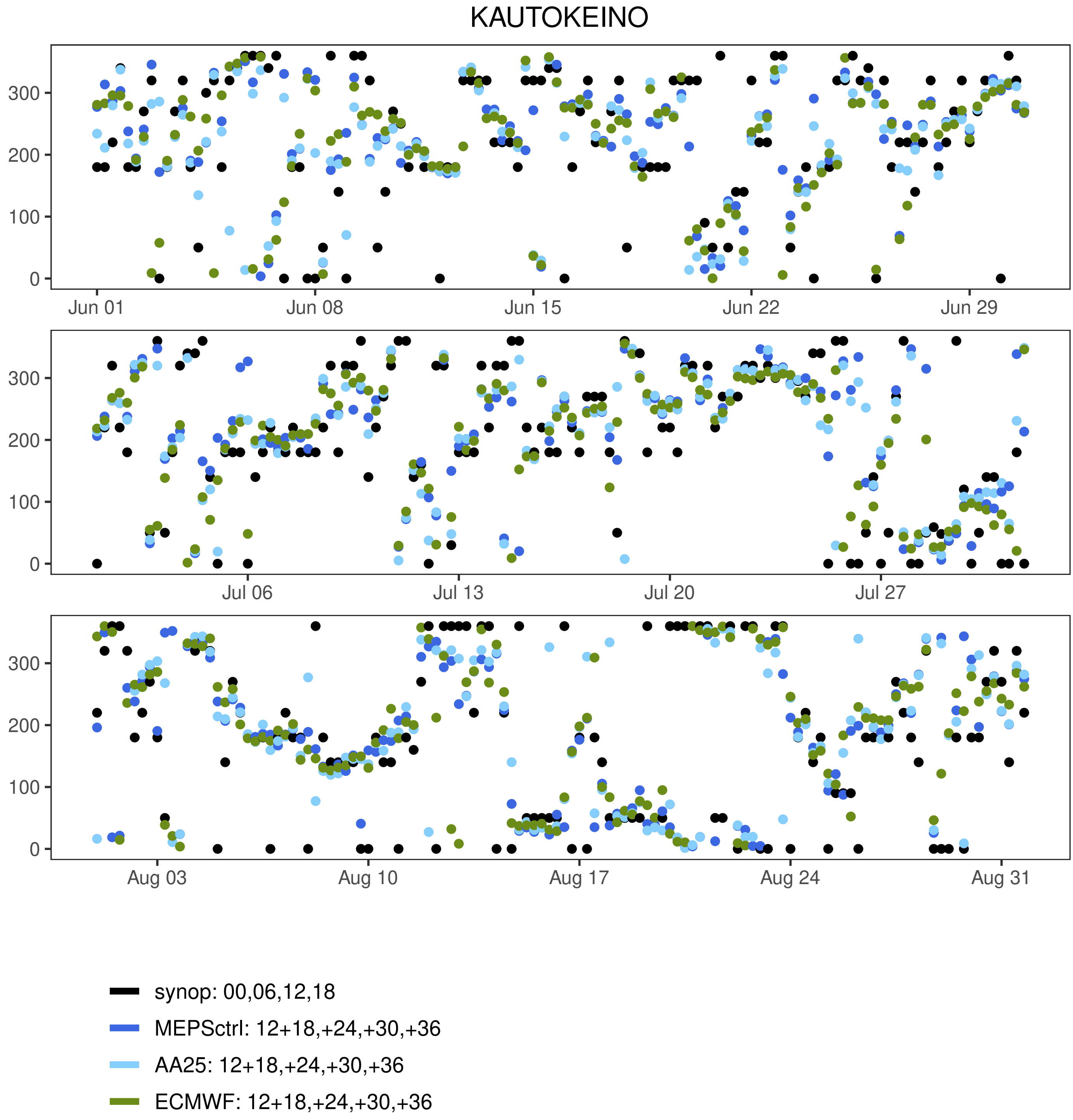

TROMSØ
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

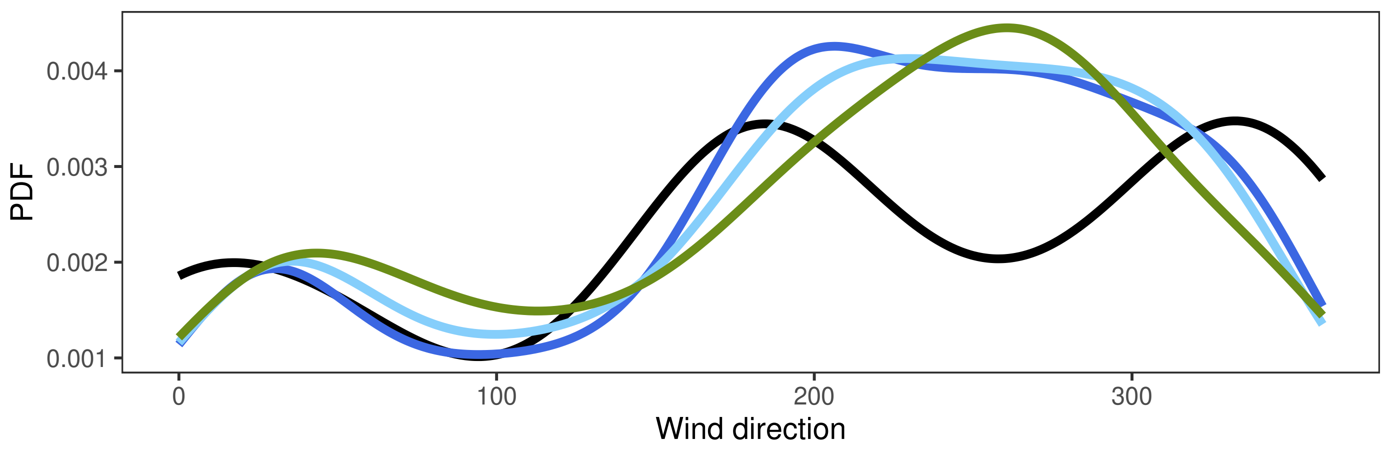

PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction

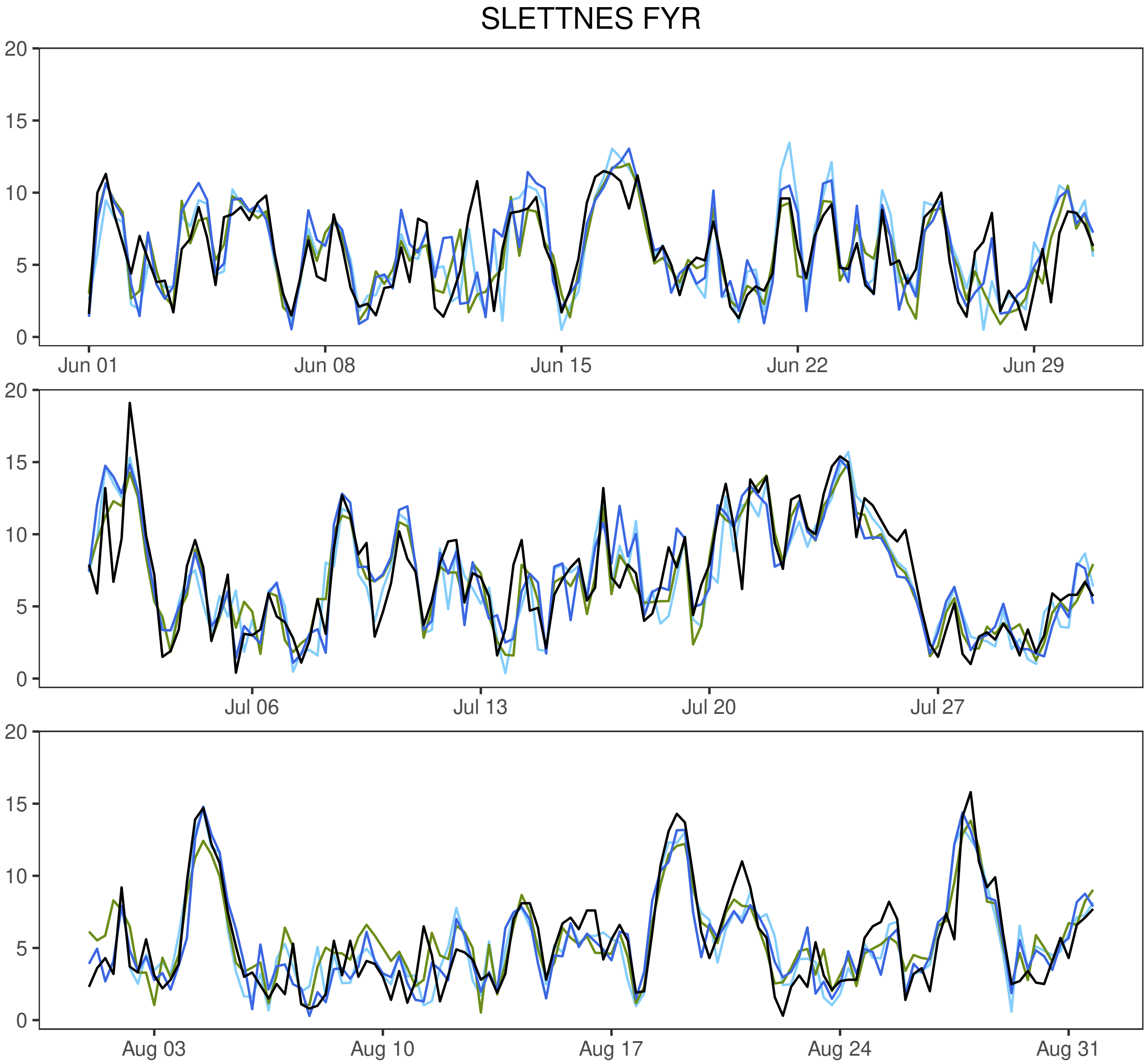


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.2	9.7	1.9	358
MEPSctrl: 12+18,+24,+30,+36	0.3	3.4	8.7	1.8	368
AA25: 12+18,+24,+30,+36	0.2	3.3	9.6	1.9	364
ECMWF: 12+18,+24,+30,+36	0.2	3.1	7.7	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	1.6	1.6	1.3	5.3	357
AA25–synop	0.1	1.6	1.6	1.3	7.0	357
ECMWF–synop	−0.1	1.6	1.6	1.3	6.4	357

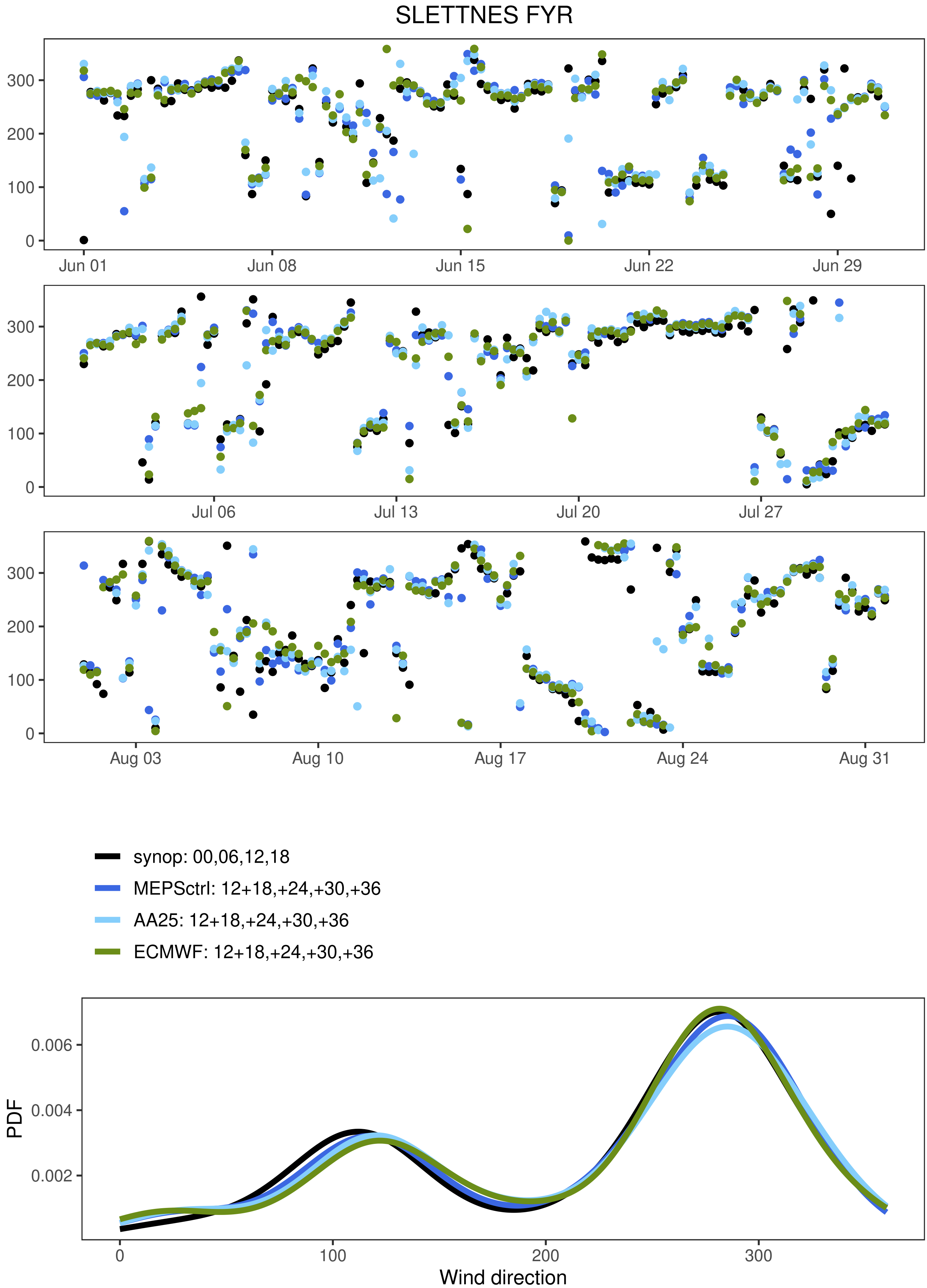

KAUTOKEINO
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

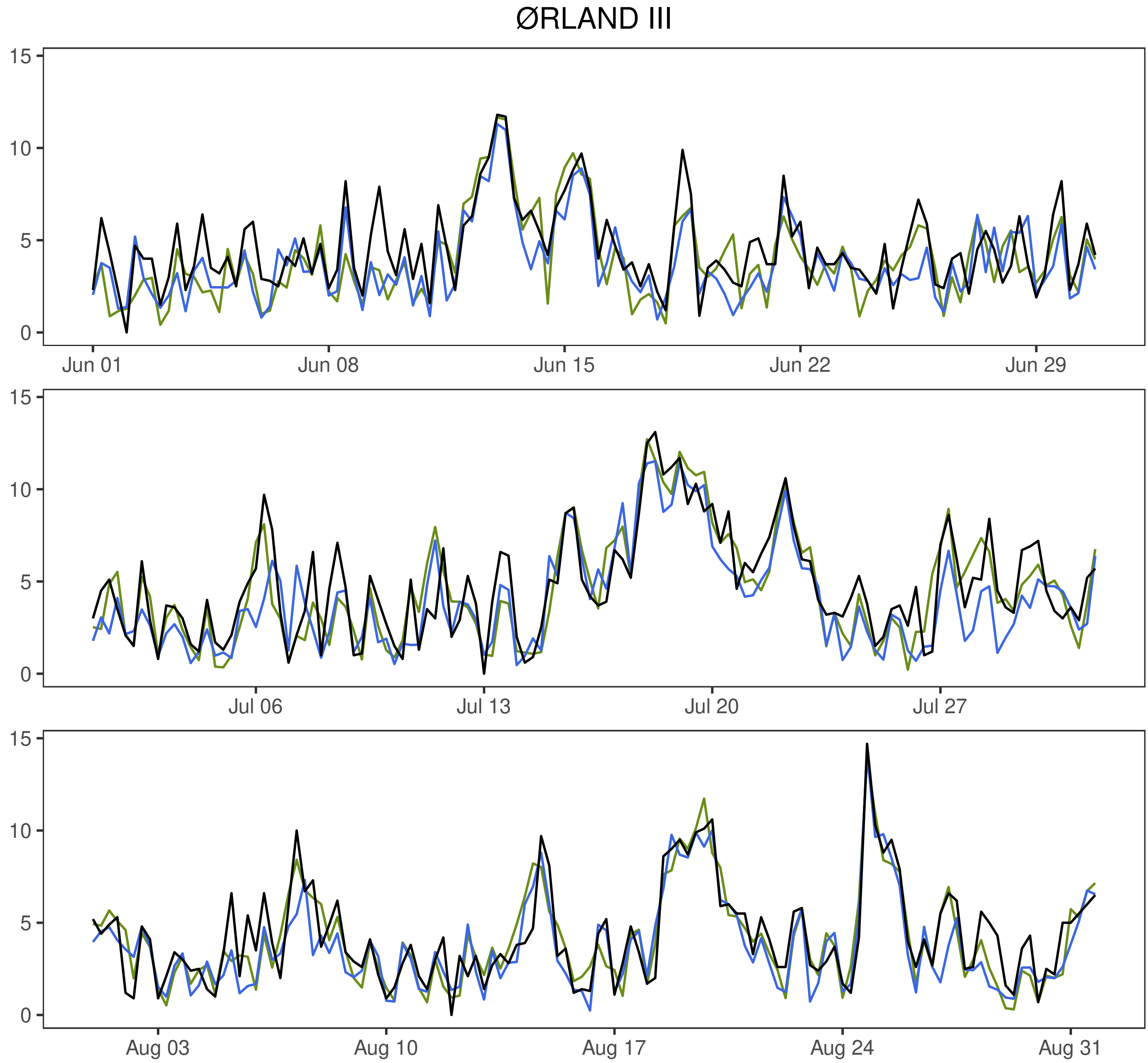

PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	6.1	19.1	3.4	368
MEPSctrl: 12+18,+24,+30,+36	0.3	6.2	15.2	3.4	368
AA25: 12+18,+24,+30,+36	0.4	6.1	15.7	3.4	364
ECMWF: 12+18,+24,+30,+36	0.5	6.1	14.9	3.0	368

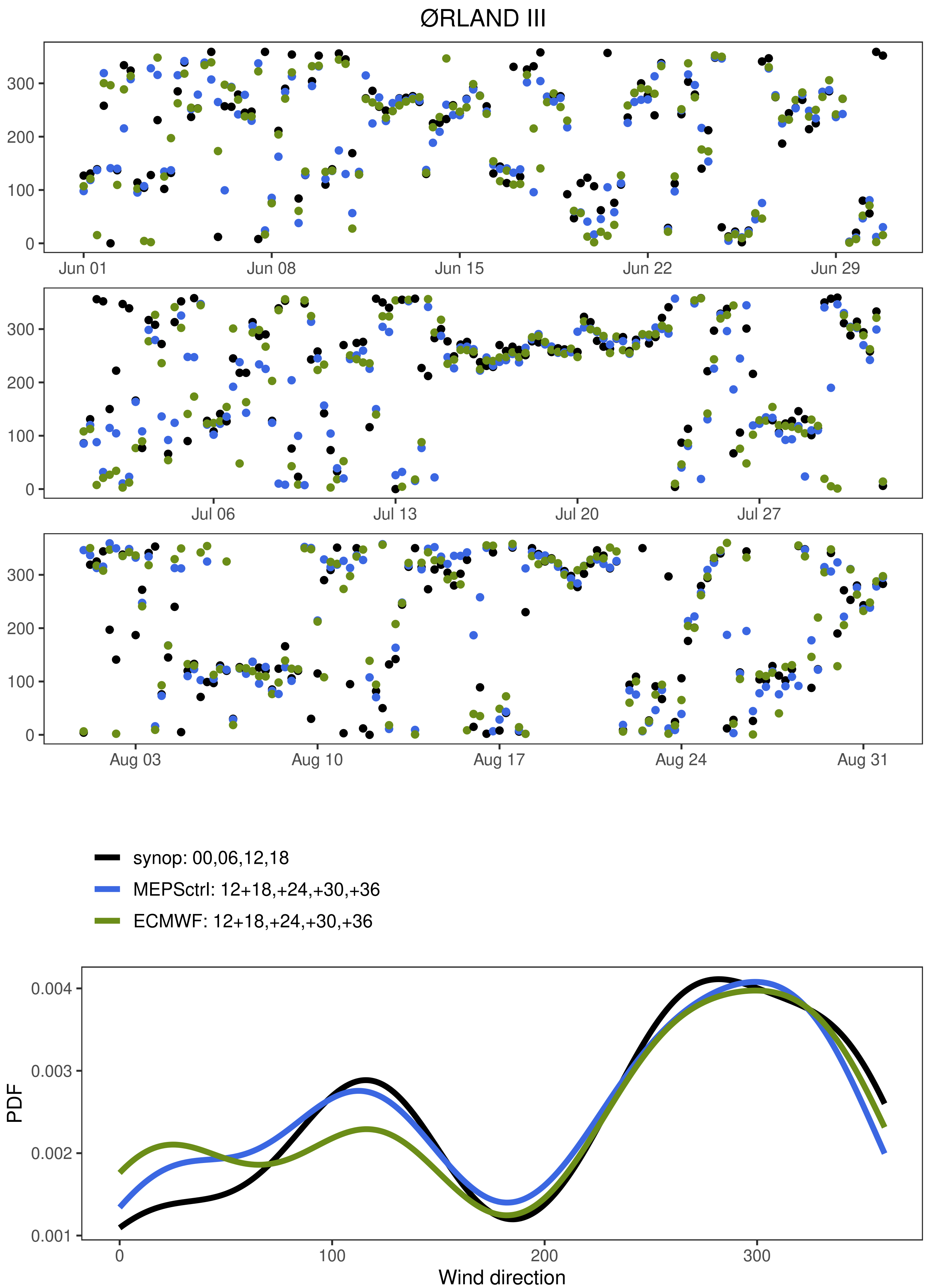
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.1	2.0	2.0	1.5	7.3	364
AA25–synop	0.0	2.0	2.0	1.5	7.6	364
ECMWF–synop	0.0	1.8	1.8	1.4	7.9	364

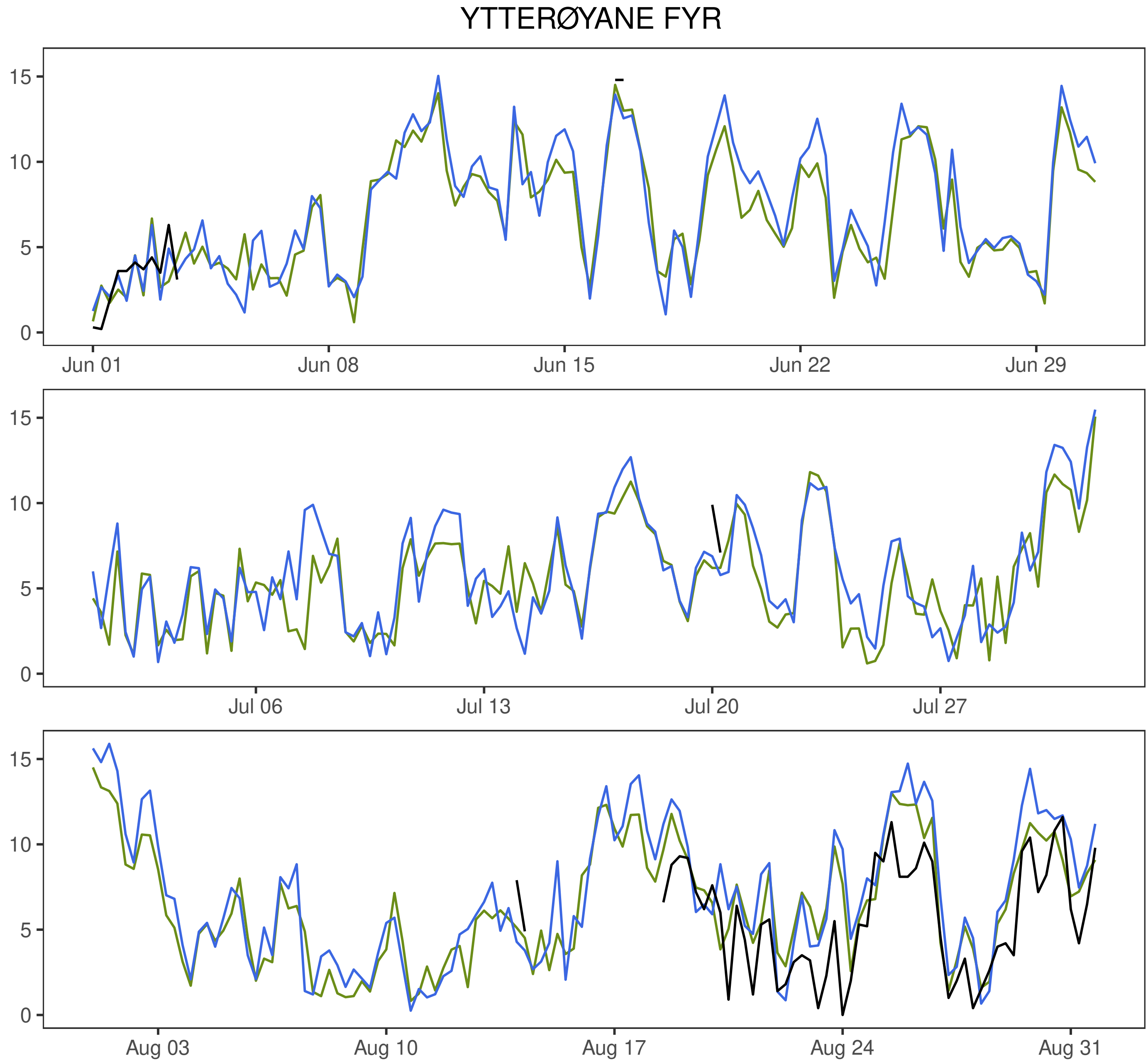

SLETTNES FYR
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.5	14.7	2.6	368
MEPSctrl: 12+18,+24,+30,+36	0.2	3.8	14.3	2.5	368
ECMWF: 12+18,+24,+30,+36	0.2	4.2	13.9	2.6	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.7	1.4	1.6	1.2	5.9	368
ECMWF−synop	−0.3	1.4	1.5	1.2	5.0	368

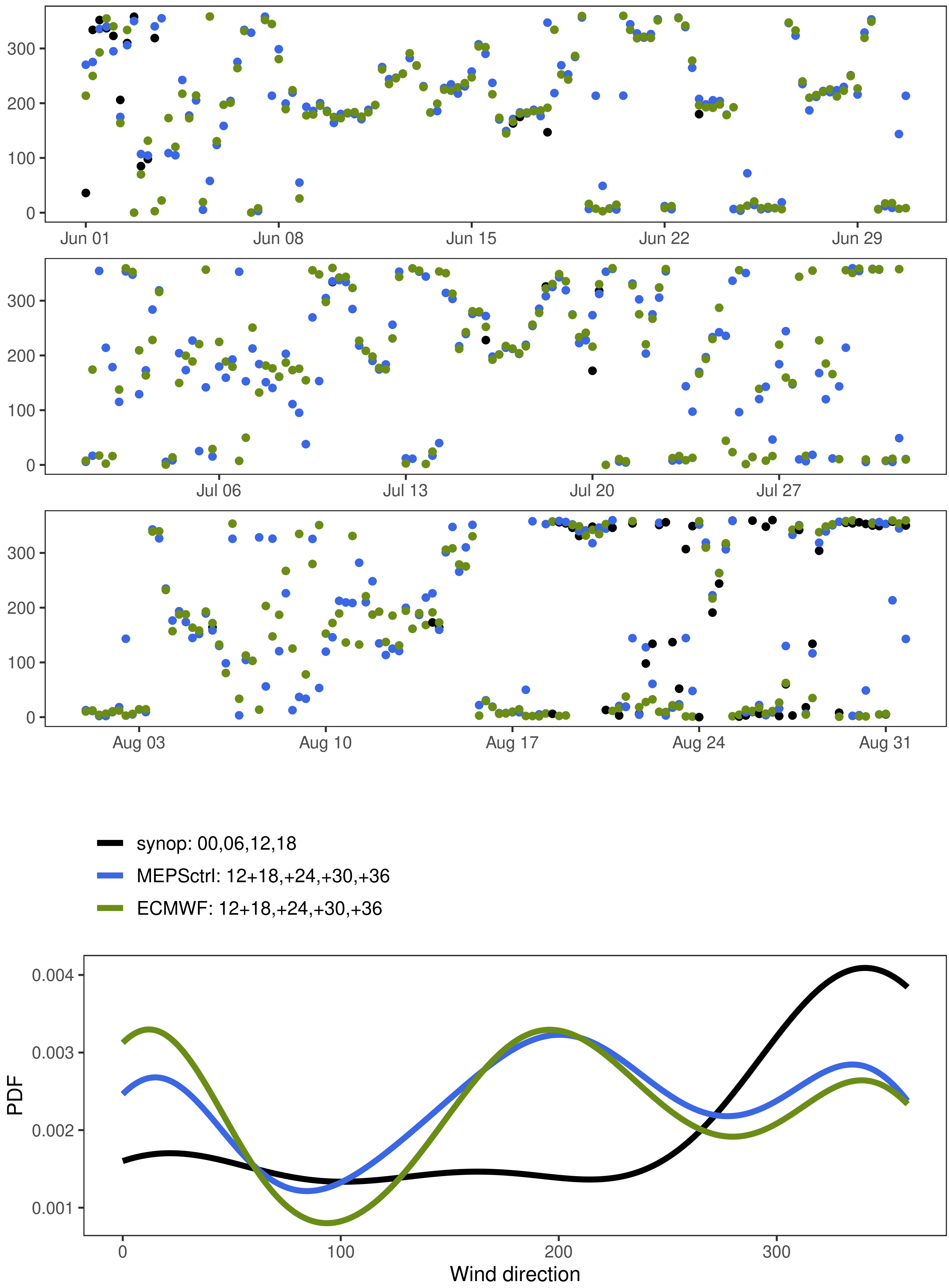

ØRLAND III
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction



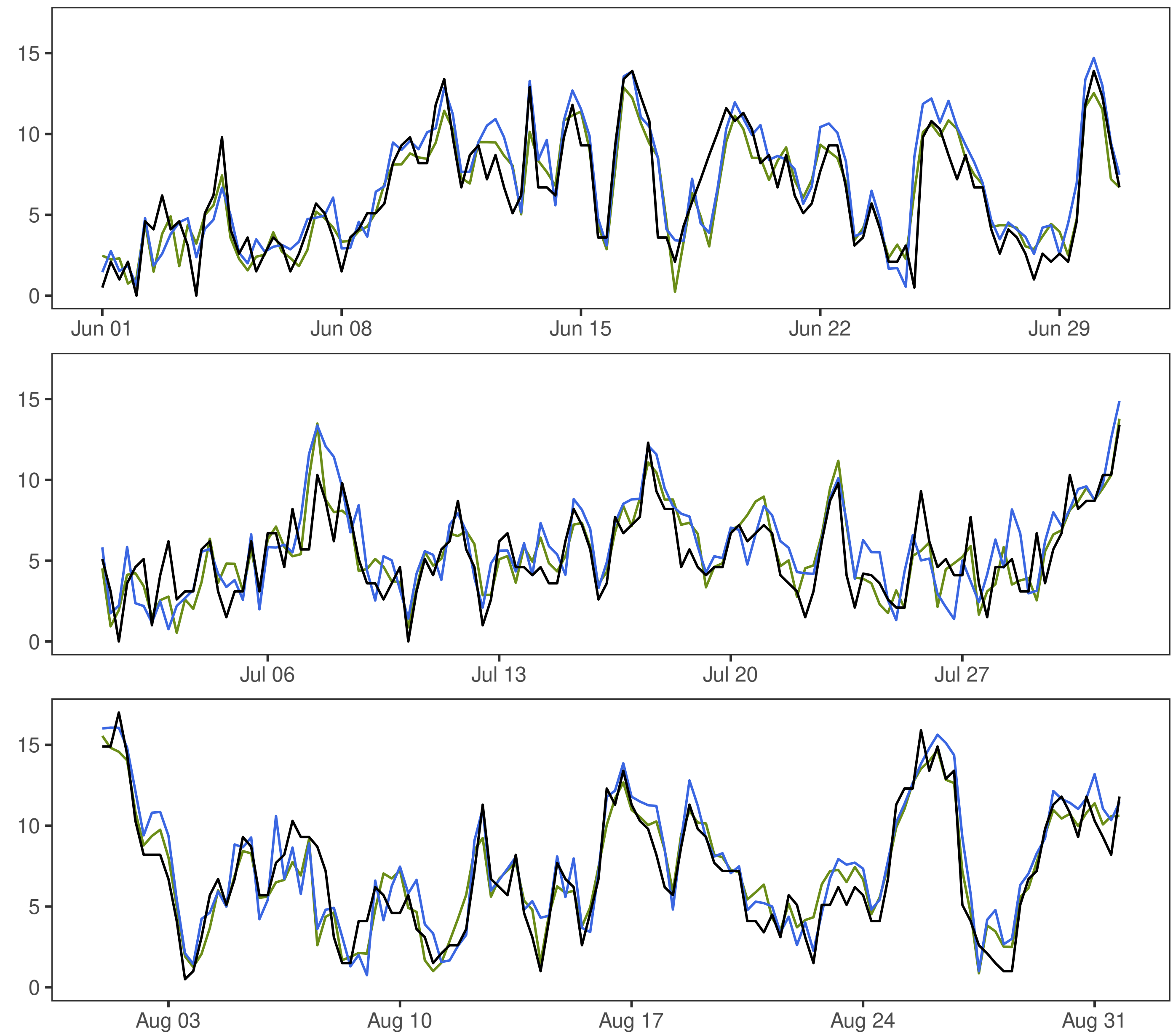
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.5	14.8	3.4	80
MEPSctrl: 12+18,+24,+30,+36	0.3	6.7	15.9	3.7	368
ECMWF: 12+18,+24,+30,+36	0.6	6.2	15.1	3.3	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	1.6	2.4	2.9	2.3	9.7	80
ECMWF−synop	1.0	2.1	2.4	1.8	7.7	80

YTTERØYANE FYR

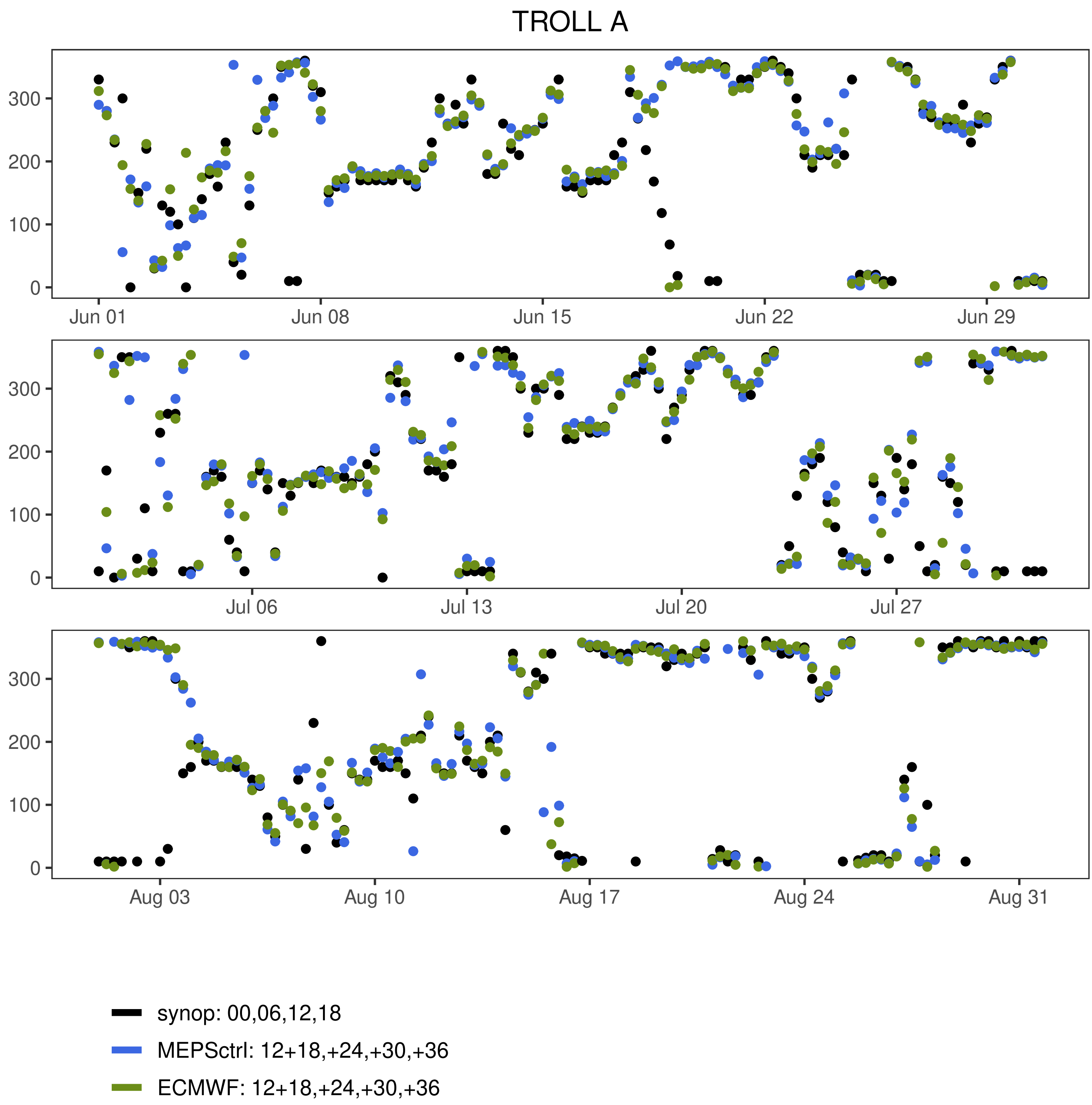


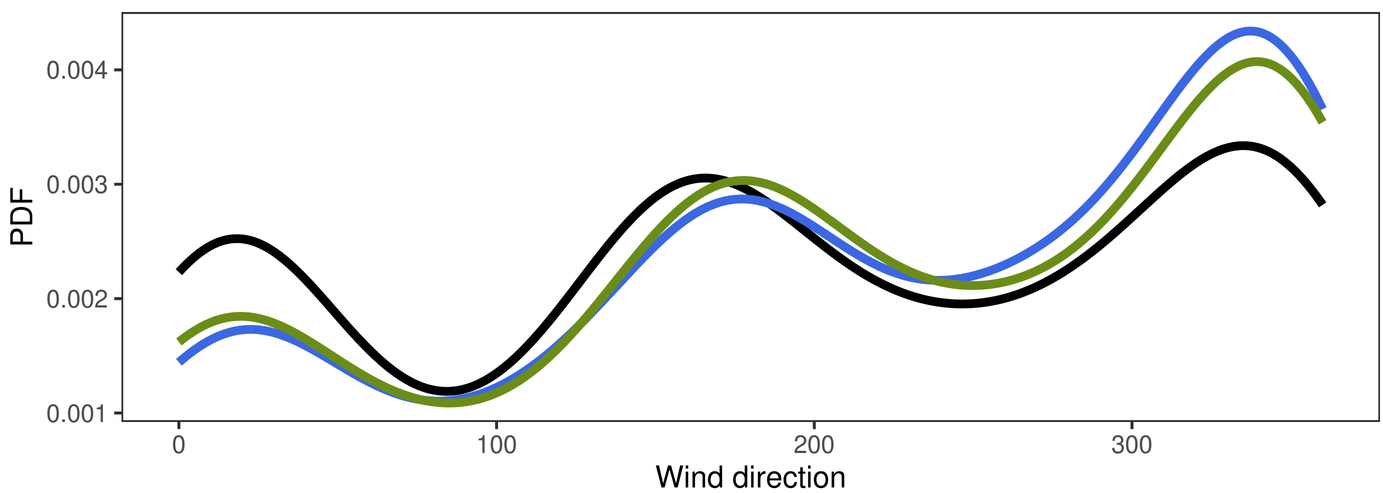
TROLL A



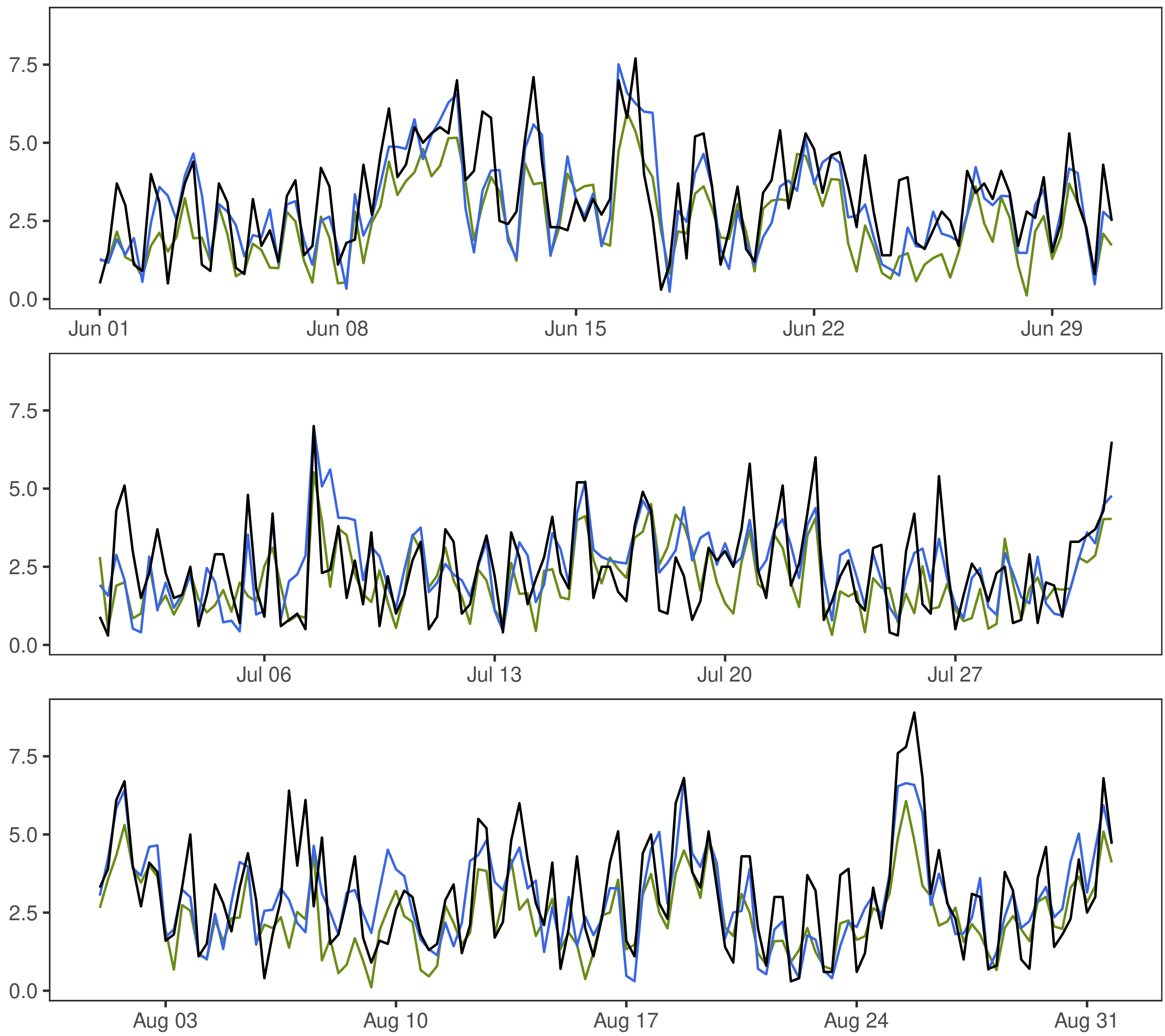
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	6.2	17.0	3.3	368
MEPSctrl: 12+18,+24,+30,+36	0.6	6.8	16.1	3.5	368
ECMWF: 12+18,+24,+30,+36	0.2	6.3	15.6	3.1	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.6	1.7	1.8	1.4	8.1	368
ECMWF−synop	0.1	1.5	1.5	1.1	6.1	368


TROLL A
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

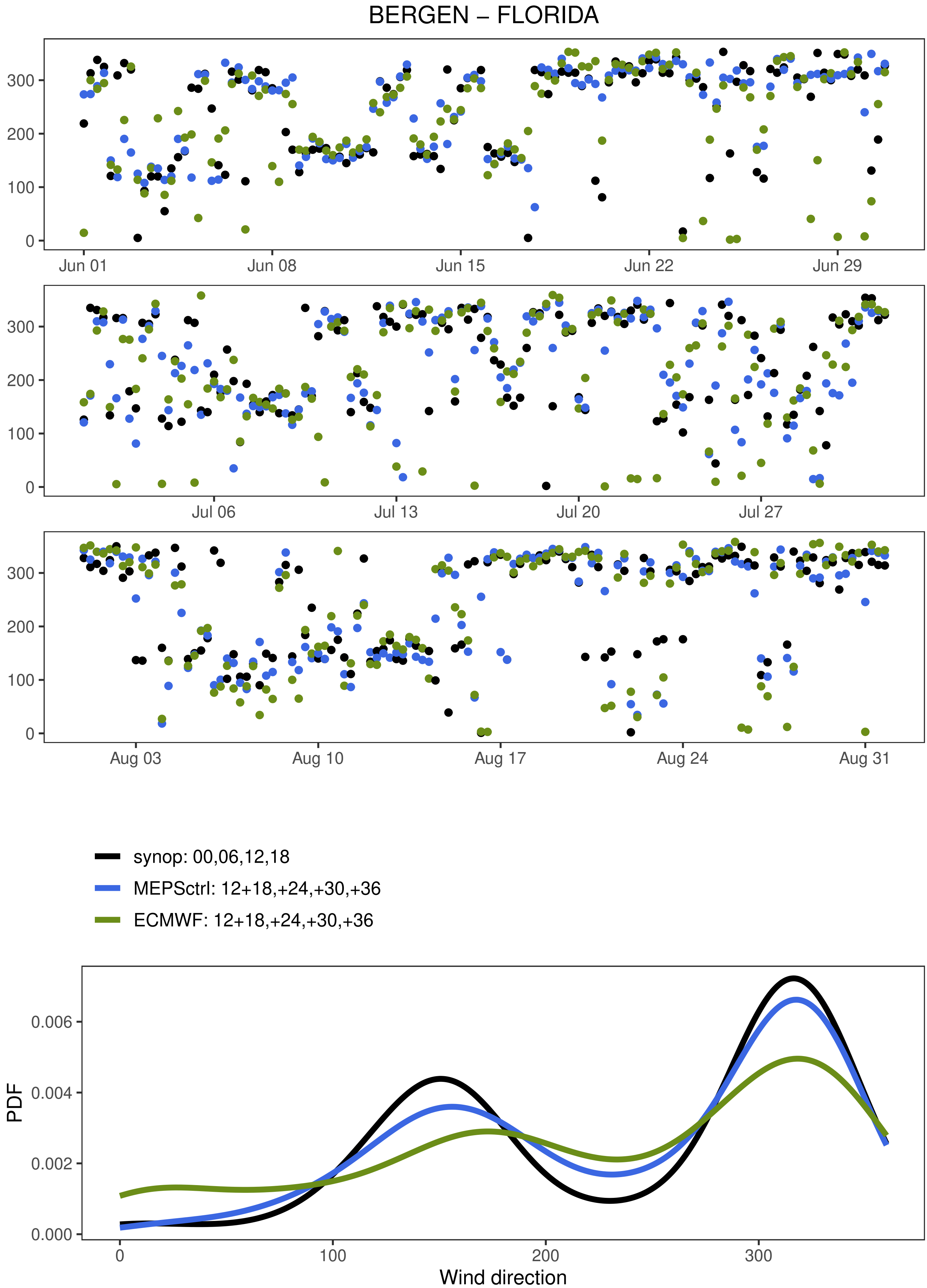

PDF
0.004
0.003
0.002
0.001
0
100
200
300
Wind direction

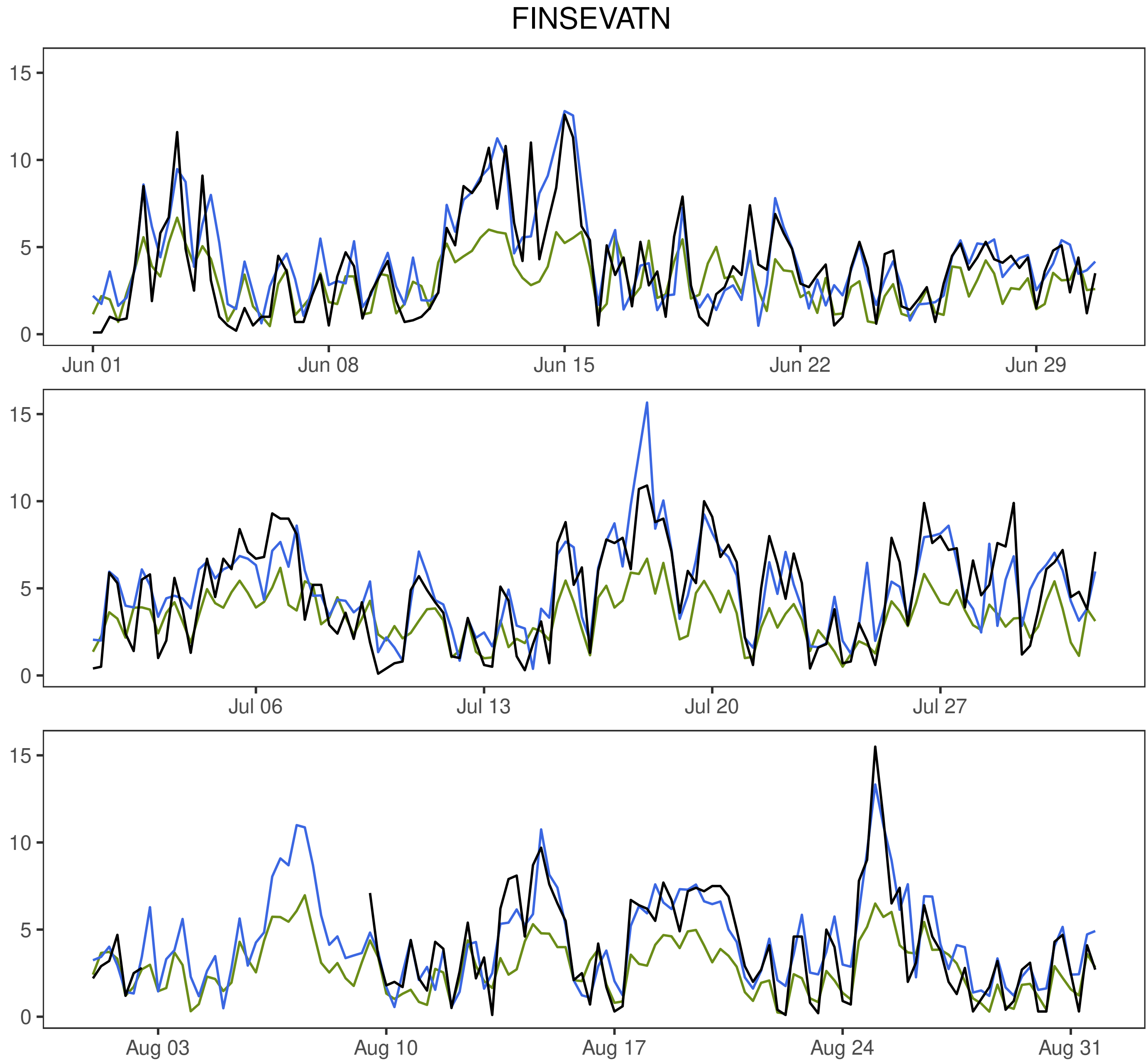
BERGEN – FLORIDA



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.3	2.9	8.9	1.6	368
MEPSctrl: 12+18,+24,+30,+36	0.2	2.8	7.5	1.4	368
ECMWF: 12+18,+24,+30,+36	0.1	2.3	6.1	1.2	368

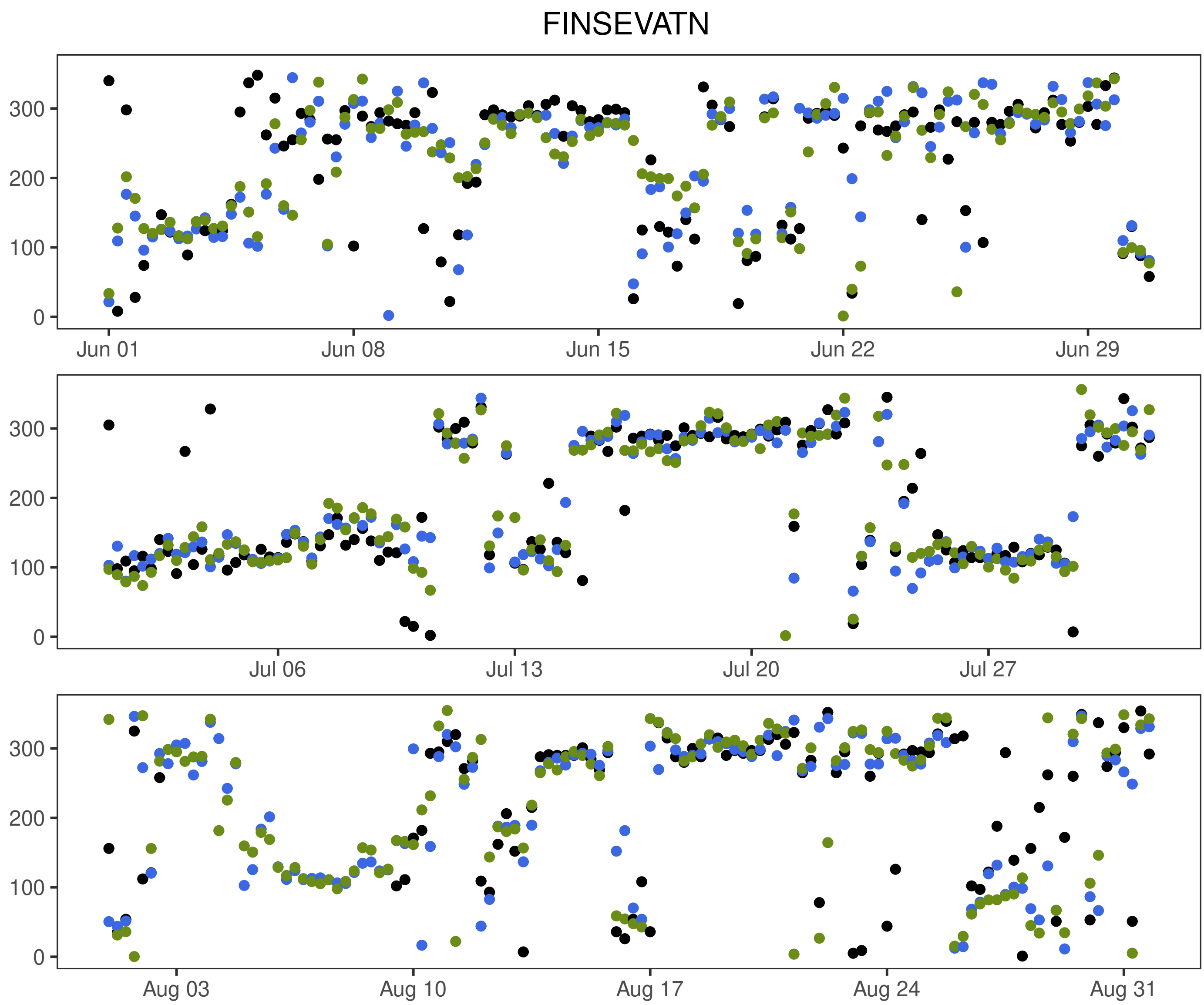
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	1.2	1.2	0.9	4.2	368
ECMWF–synop	–0.6	1.2	1.3	1.0	5.0	368

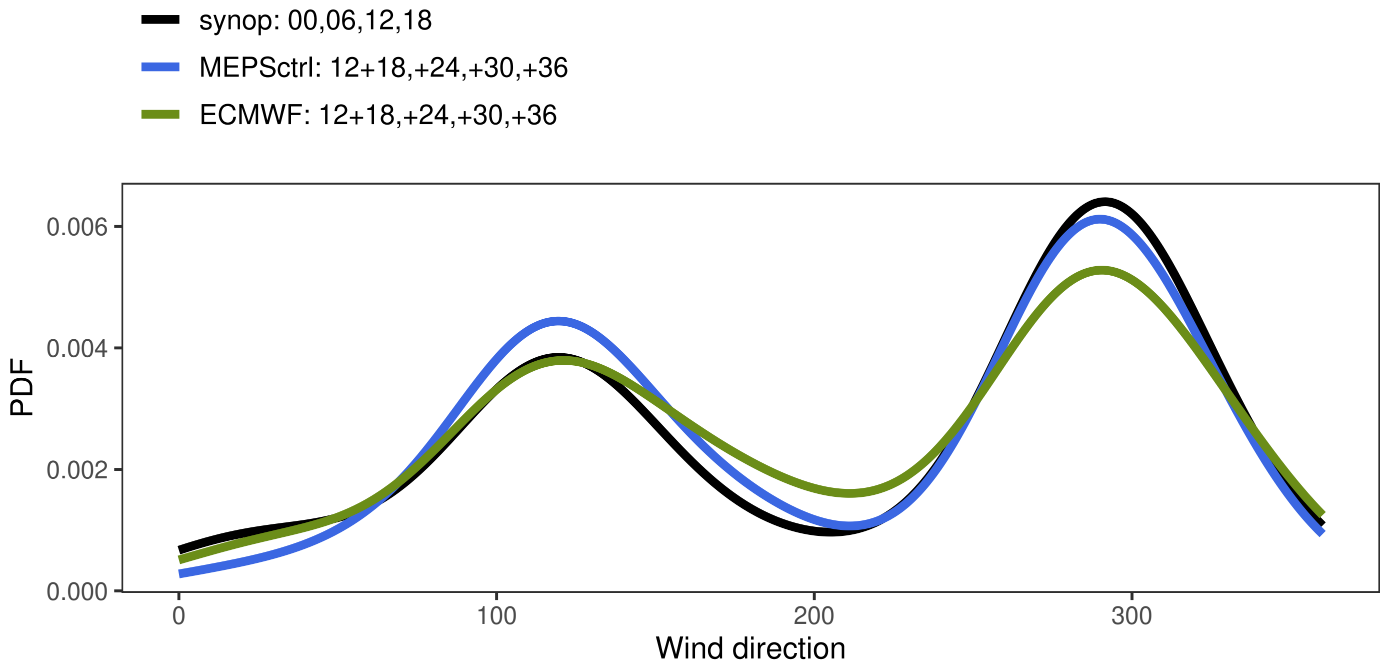

BERGEN – FLORIDA
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.000
0.002
0.004
0.006
0
100
200
300
Wind direction

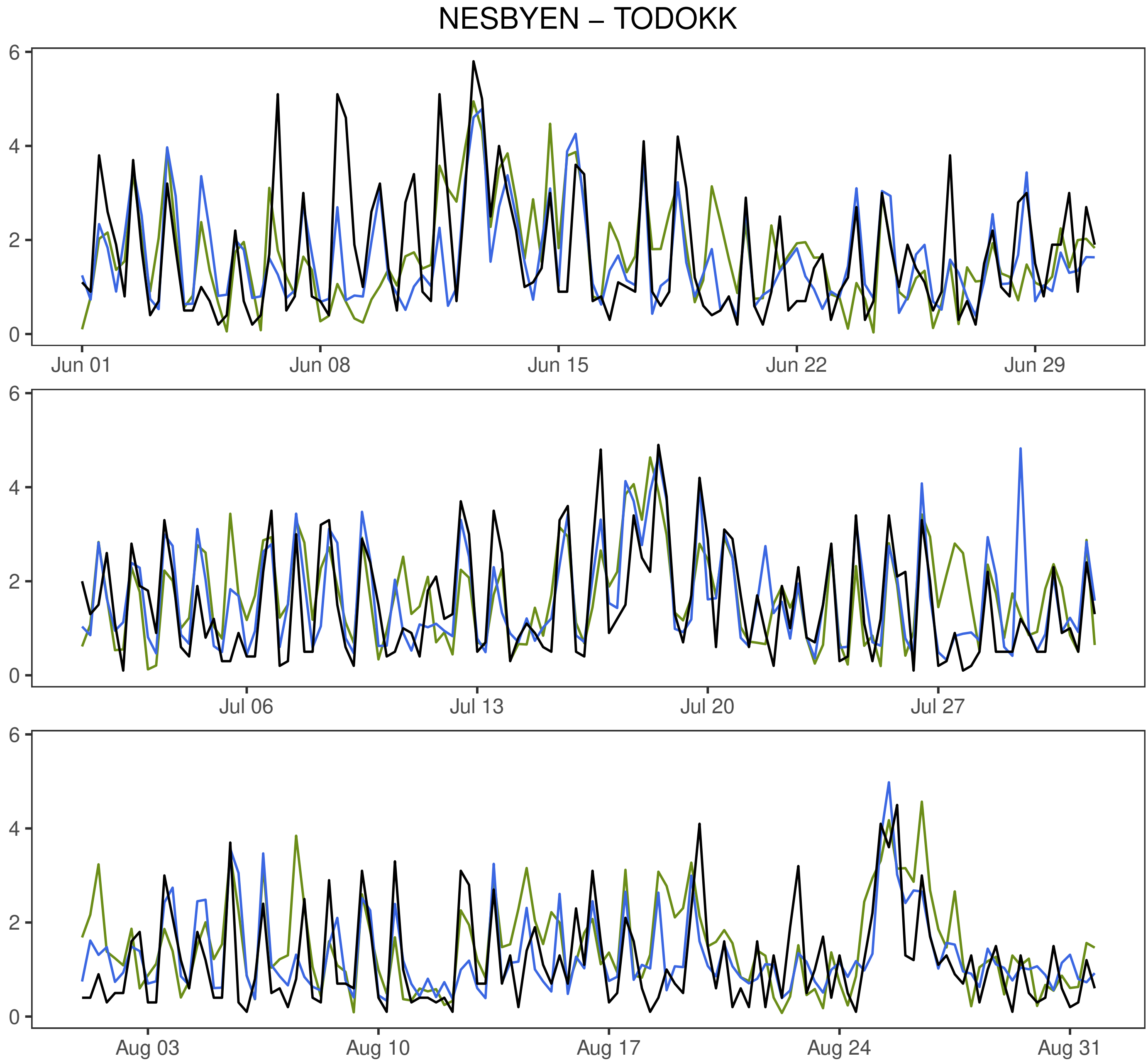


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	4.2	15.5	2.9	341
MEPSctrl: 12+18,+24,+30,+36	0.4	4.5	15.7	2.6	368
ECMWF: 12+18,+24,+30,+36	0.2	3.1	7.0	1.5	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.3	1.6	1.6	1.3	5.6	341
ECMWF–synop	−1.2	2.0	2.3	1.7	9.0	341

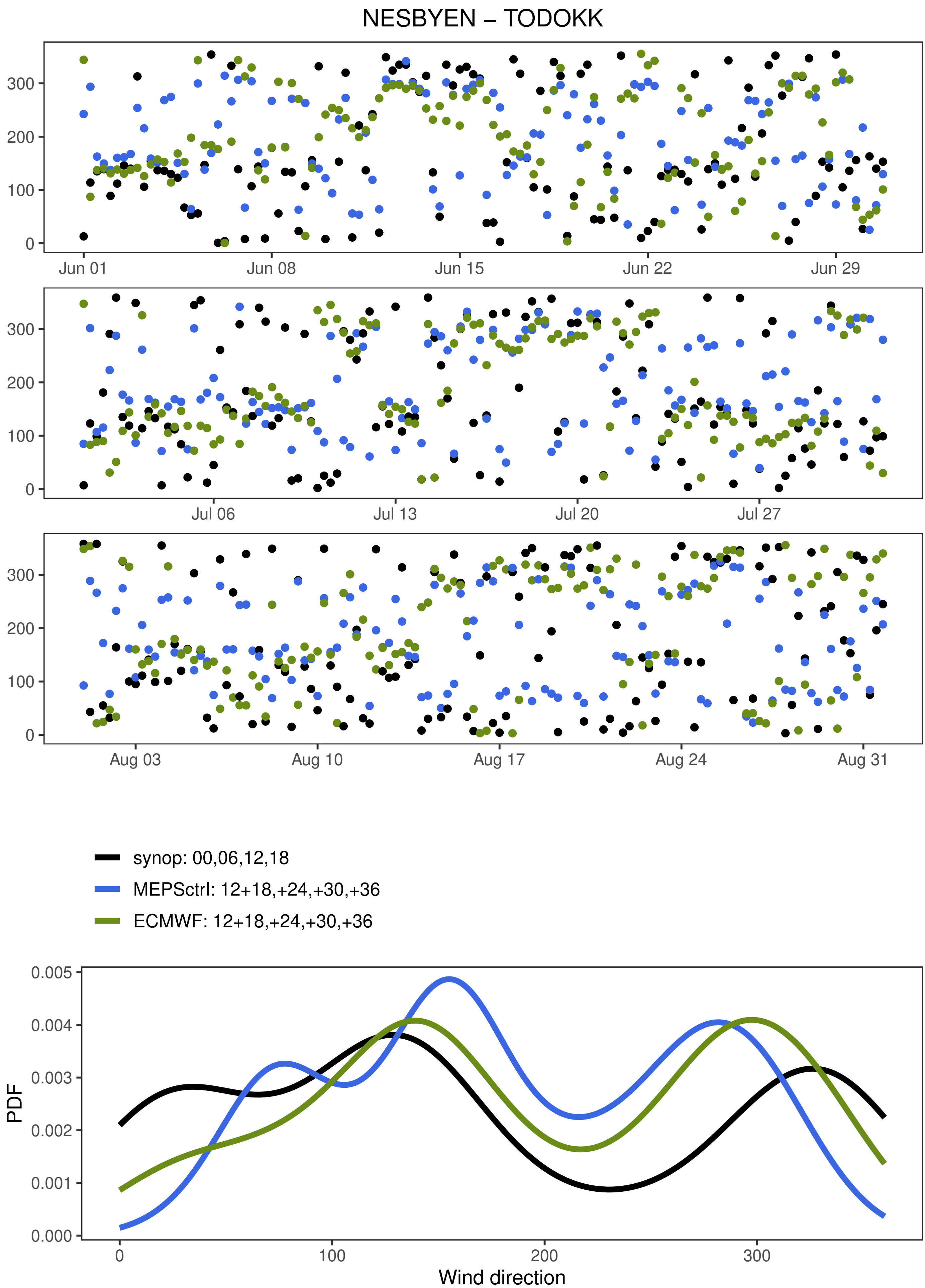

FINSEVATN
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31

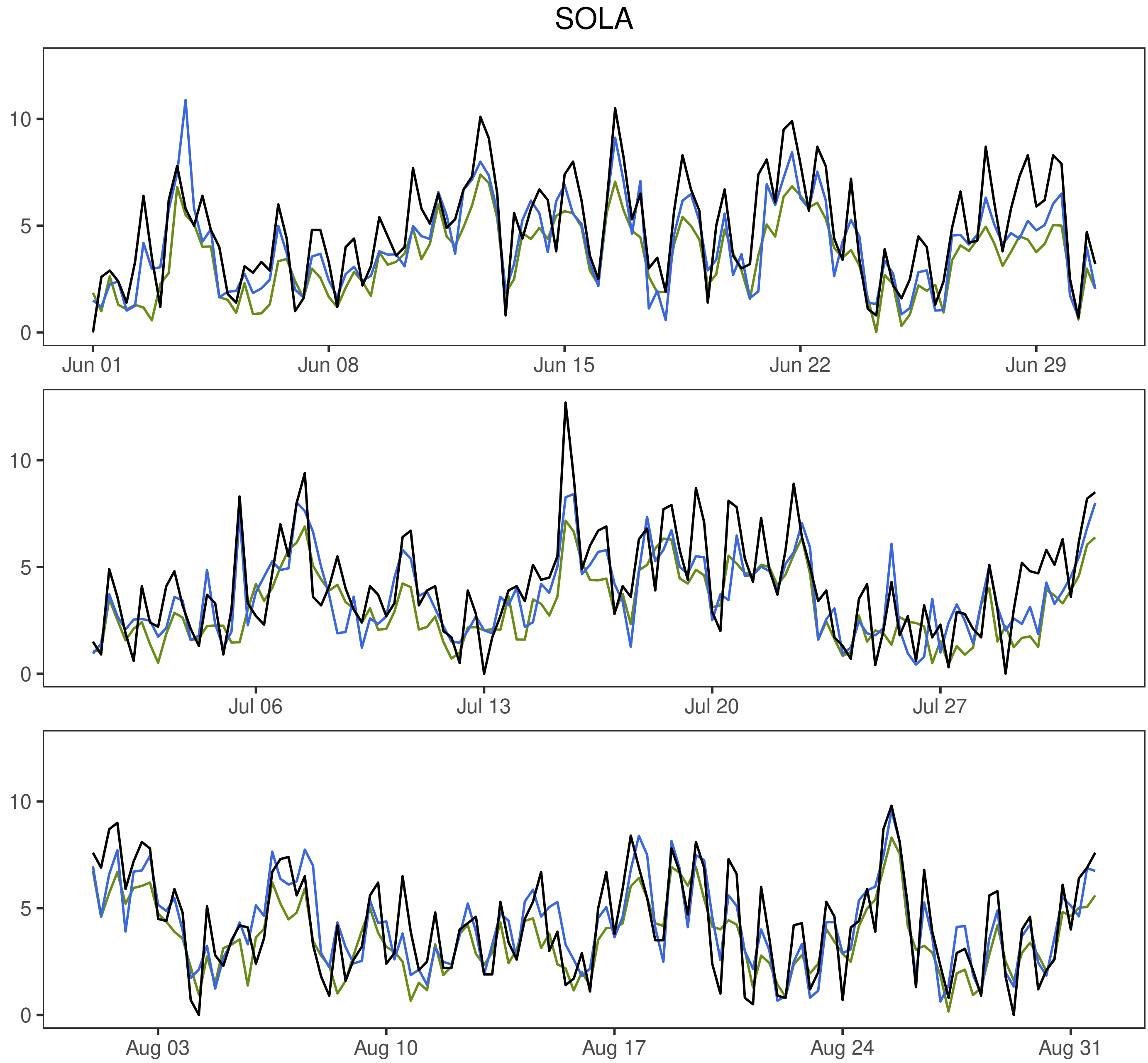

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	1.5	5.8	1.2	368
MEPSctrl: 12+18,+24,+30,+36	0.3	1.5	5.0	1.0	368
ECMWF: 12+18,+24,+30,+36	0.0	1.6	4.9	1.0	368

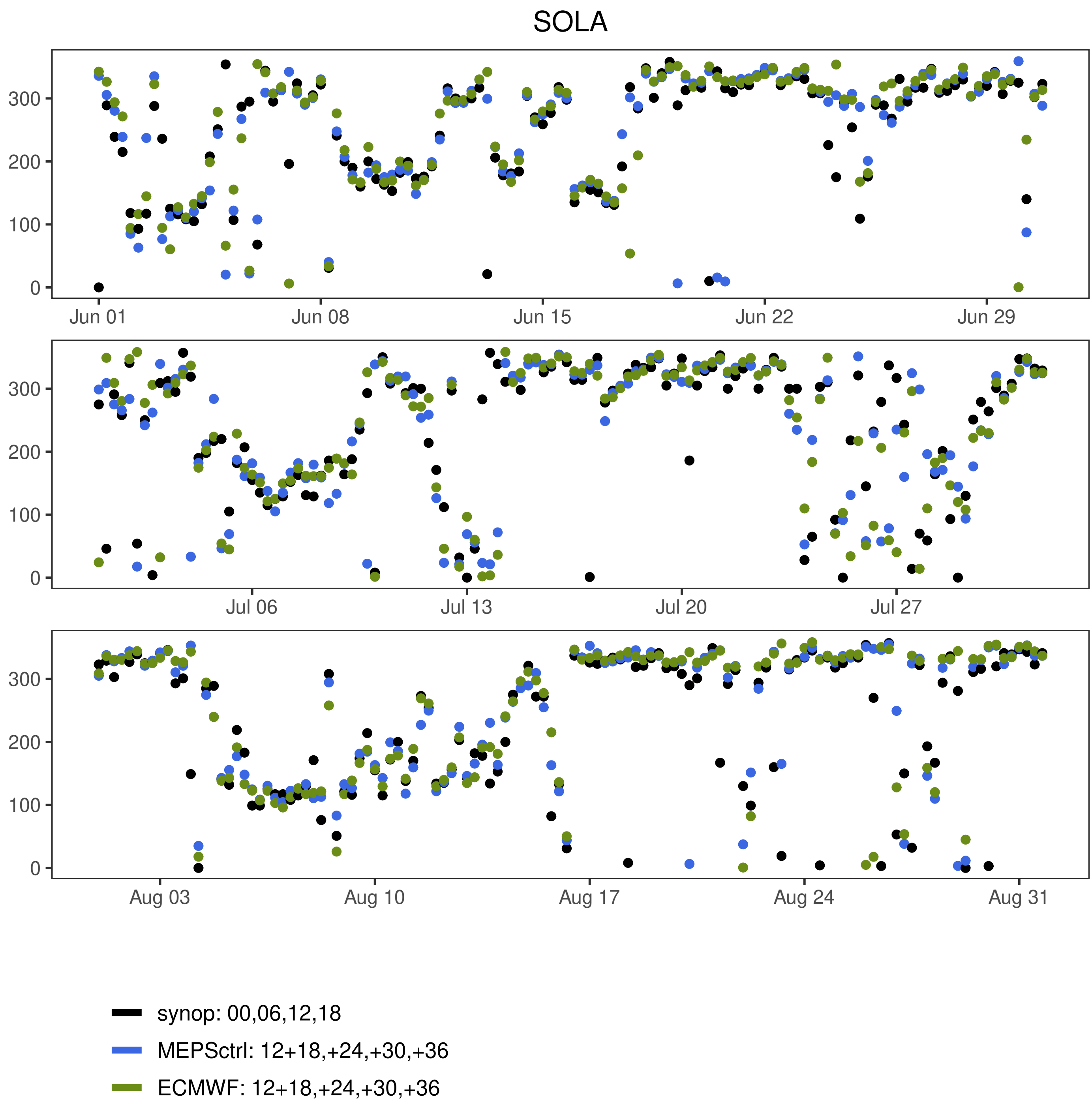
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	0.9	0.9	0.6	3.9	368
ECMWF−synop	0.2	1.0	1.1	0.8	4.0	368

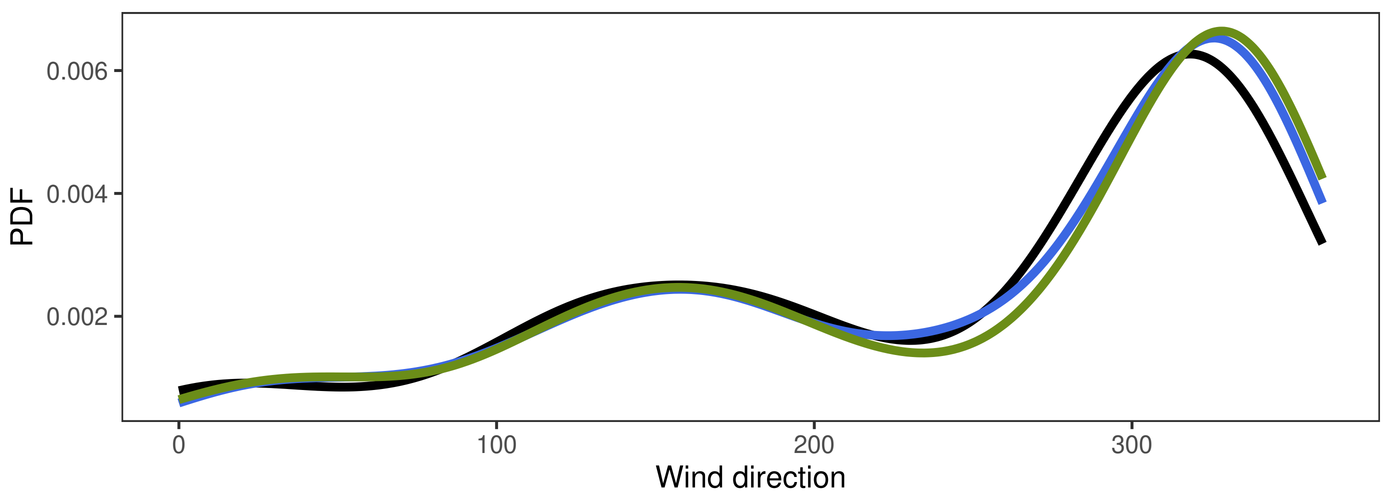

NESBYEN – TODOKK
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
0.005
0.004
0.003
0.002
0.001
0.000
PDF
0
100
200
300
Wind direction

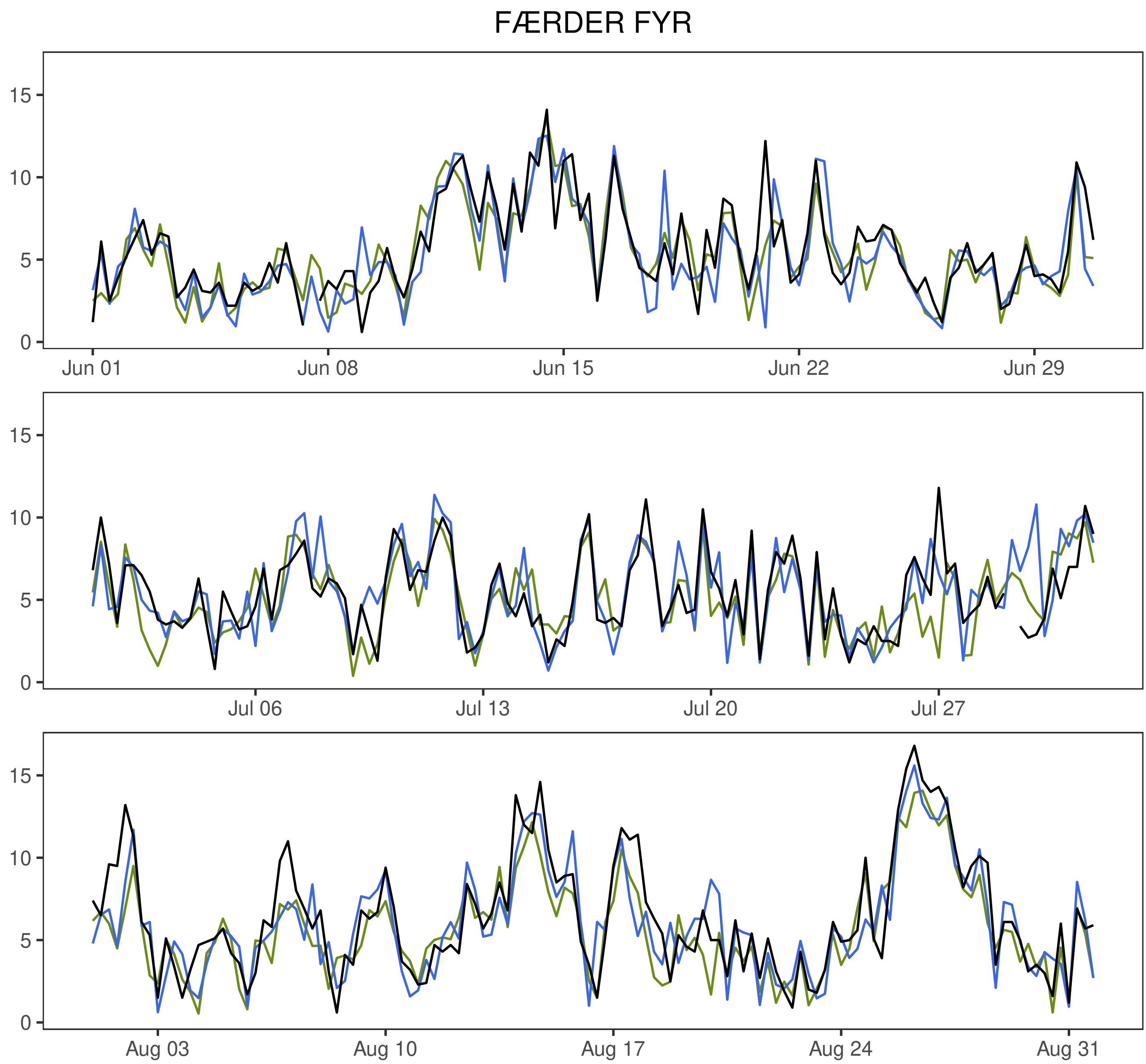


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.4	12.7	2.4	368
MEPSctrl: 12+18,+24,+30,+36	0.4	4.0	10.9	2.0	368
ECMWF: 12+18,+24,+30,+36	0.0	3.4	8.3	1.7	368

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.4	1.3	1.4	1.1	5.5	368
ECMWF−synop	−1.0	1.4	1.7	1.4	6.8	368

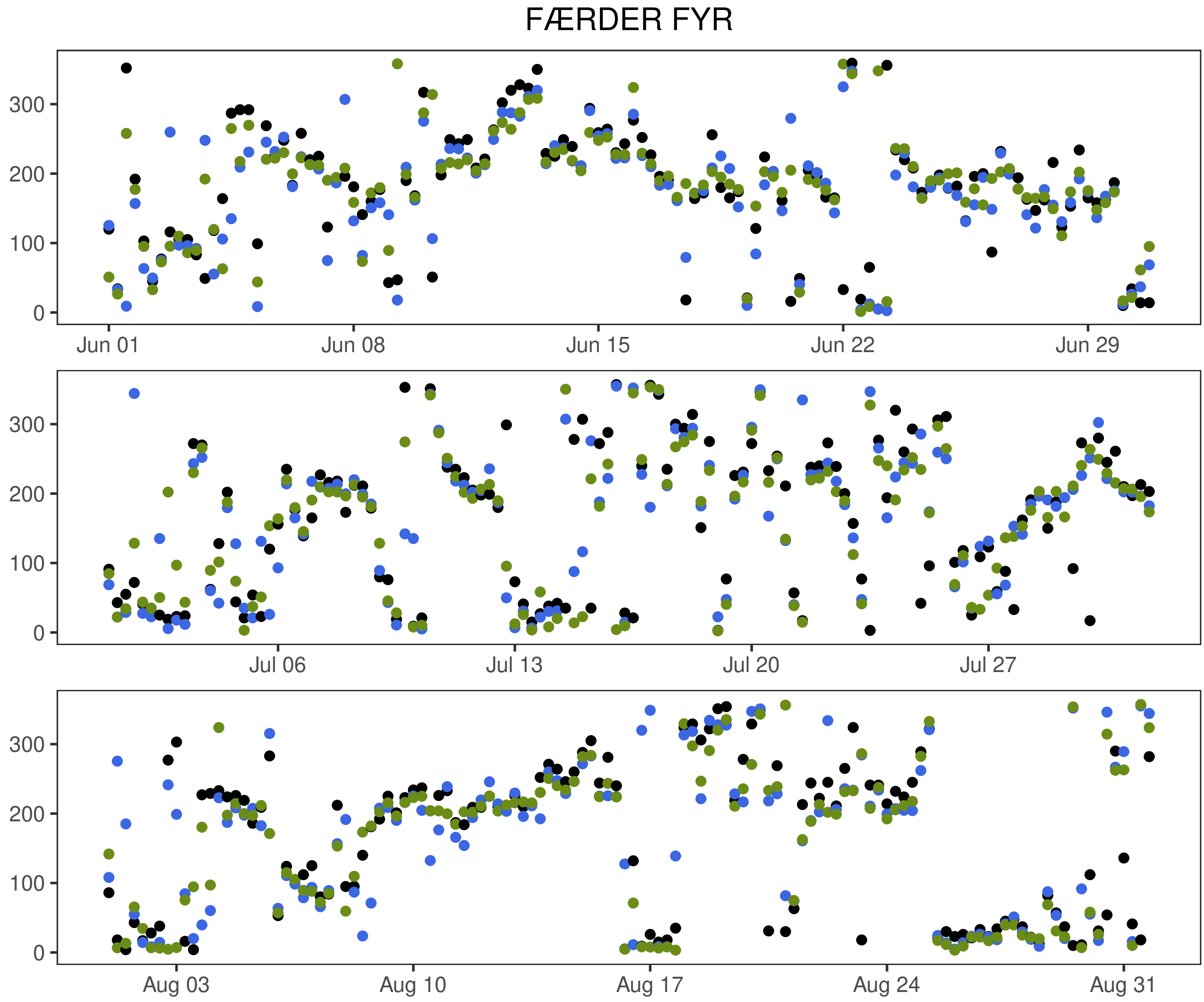

SOLA
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

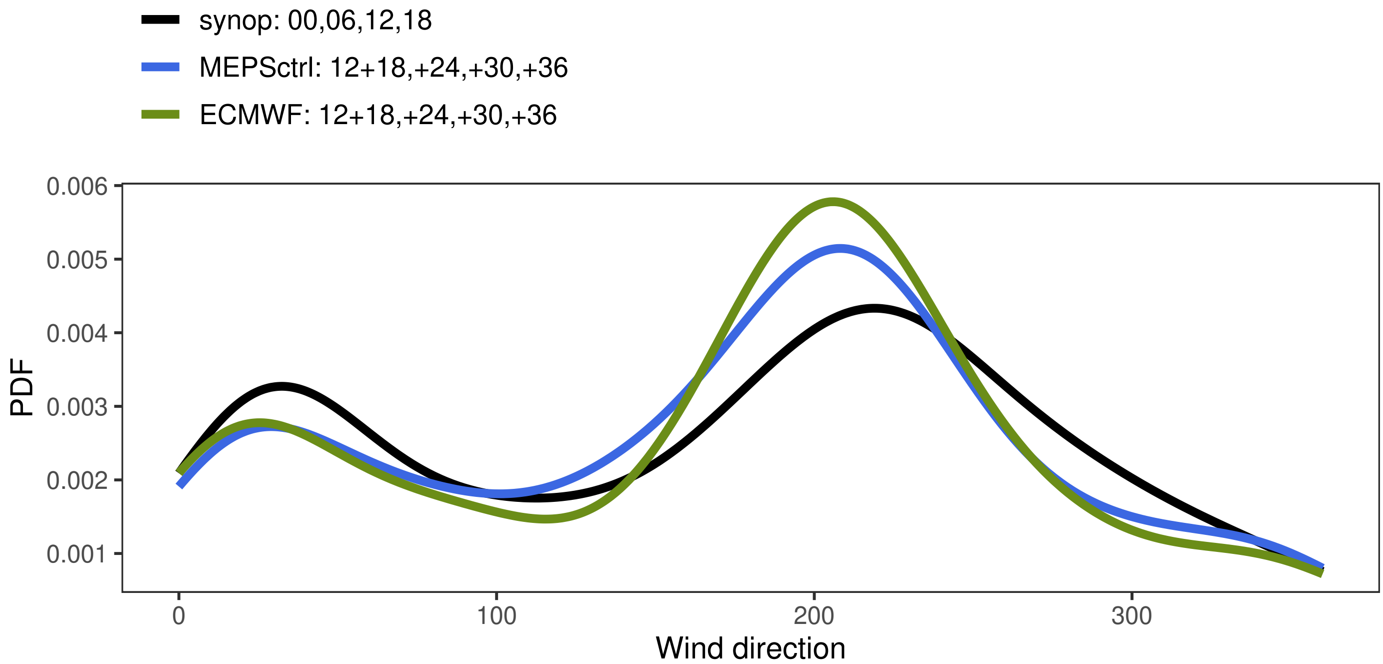

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

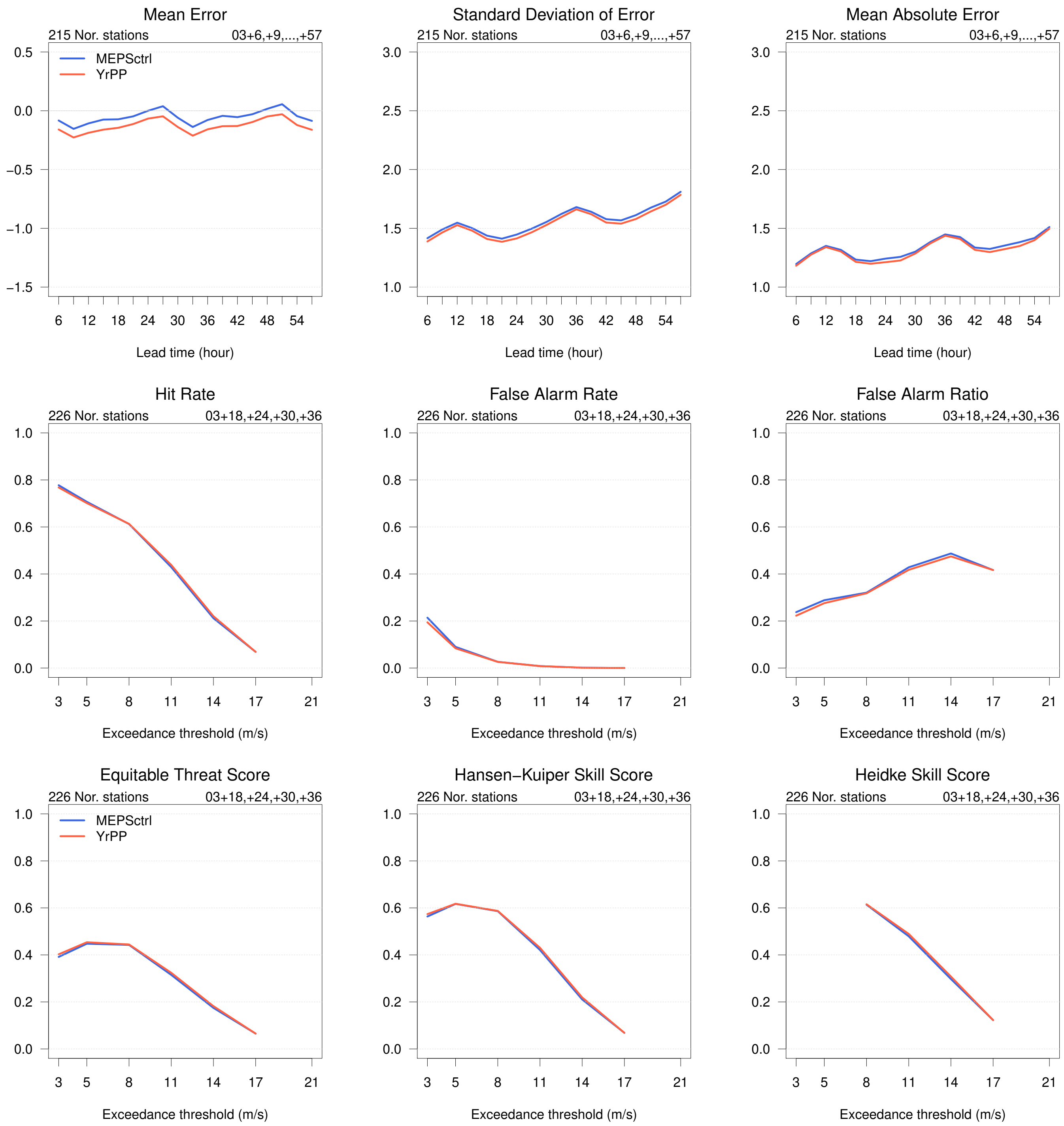


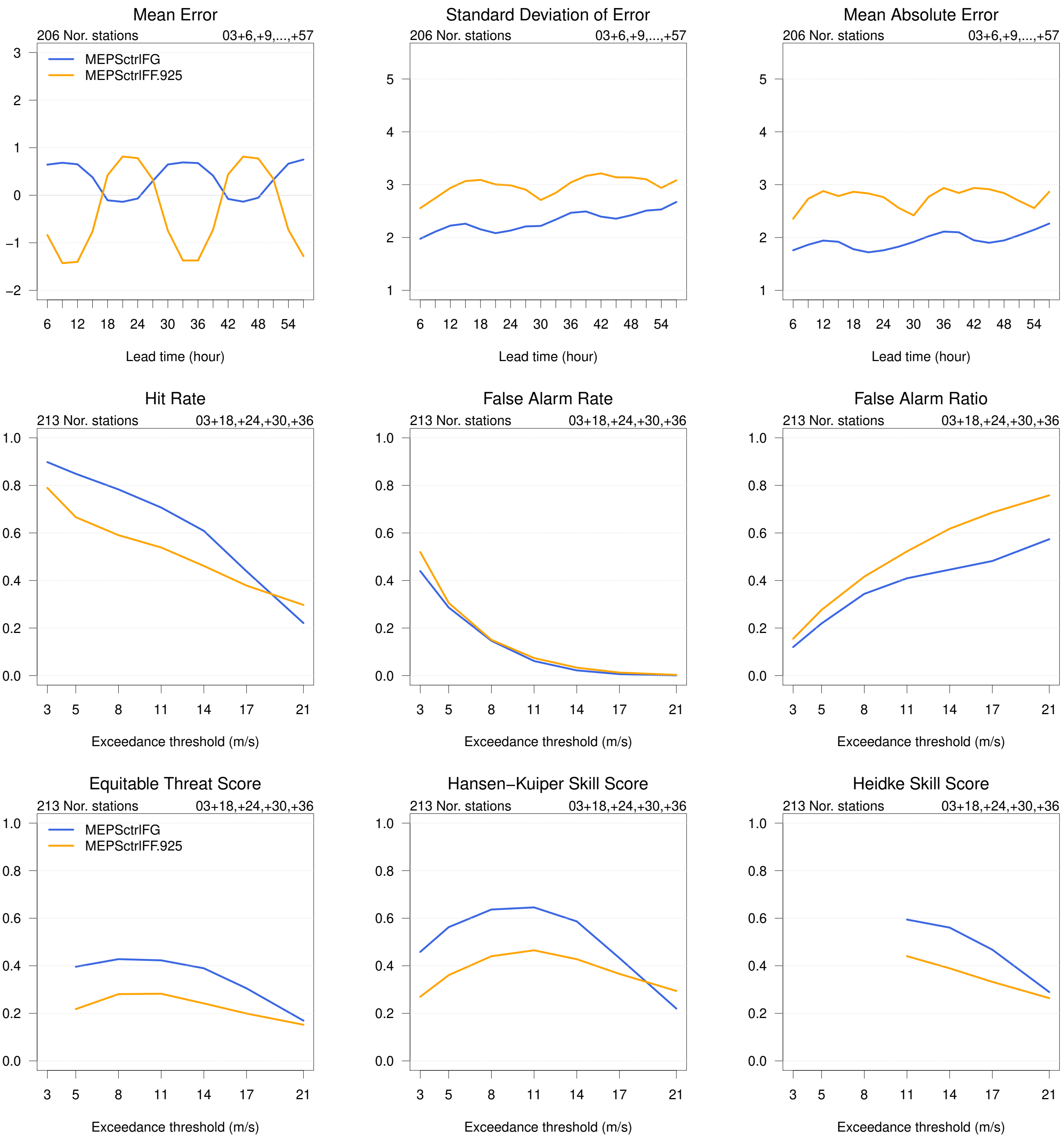
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.6	5.8	16.8	3.0	366
MEPSctrl: 12+18,+24,+30,+36	0.6	5.6	15.6	2.9	368
ECMWF: 12+18,+24,+30,+36	0.4	5.3	14.1	2.7	368

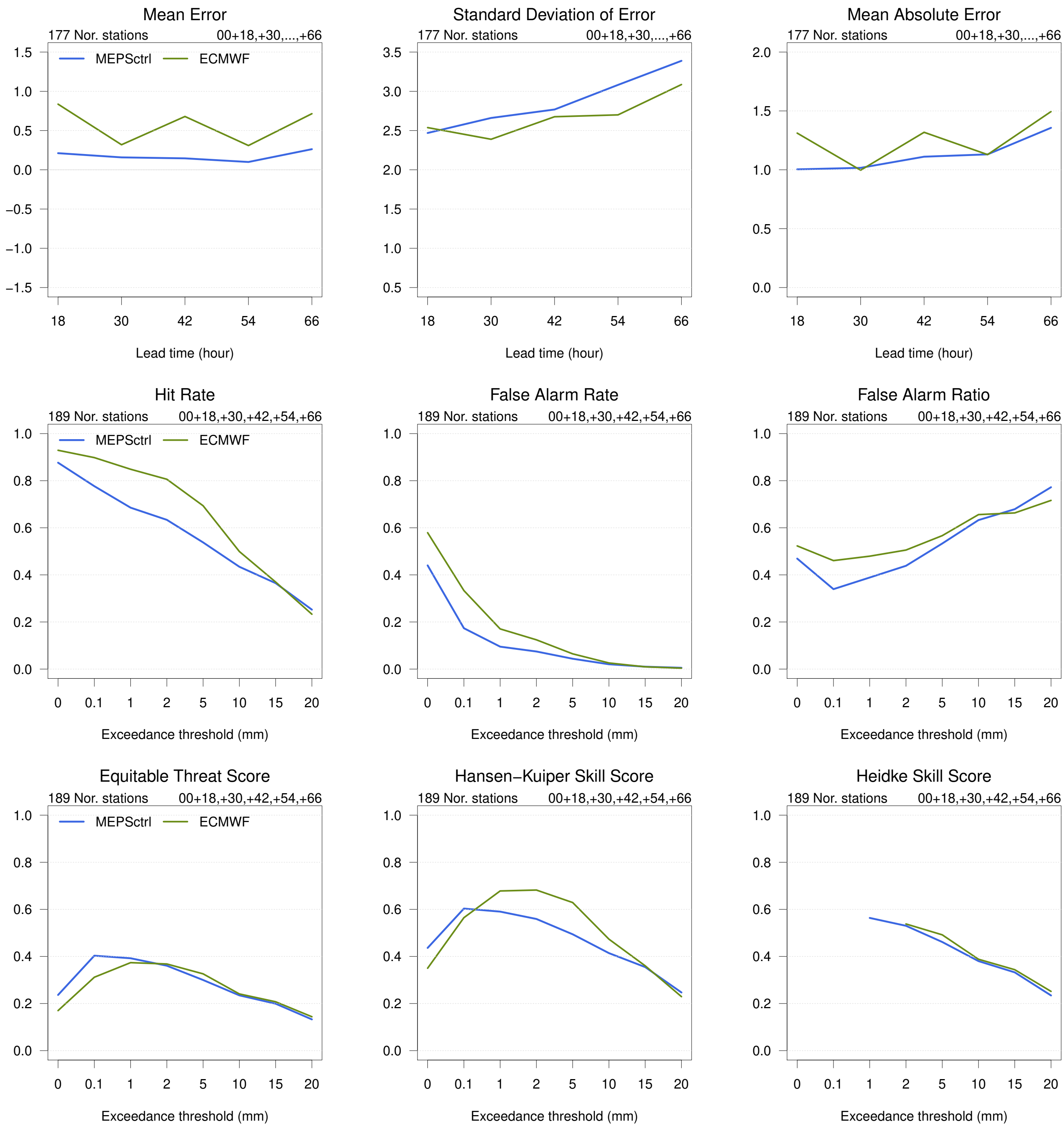
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.9	1.9	1.4	11.3	366
ECMWF−synop	−0.5	1.6	1.7	1.3	10.3	366

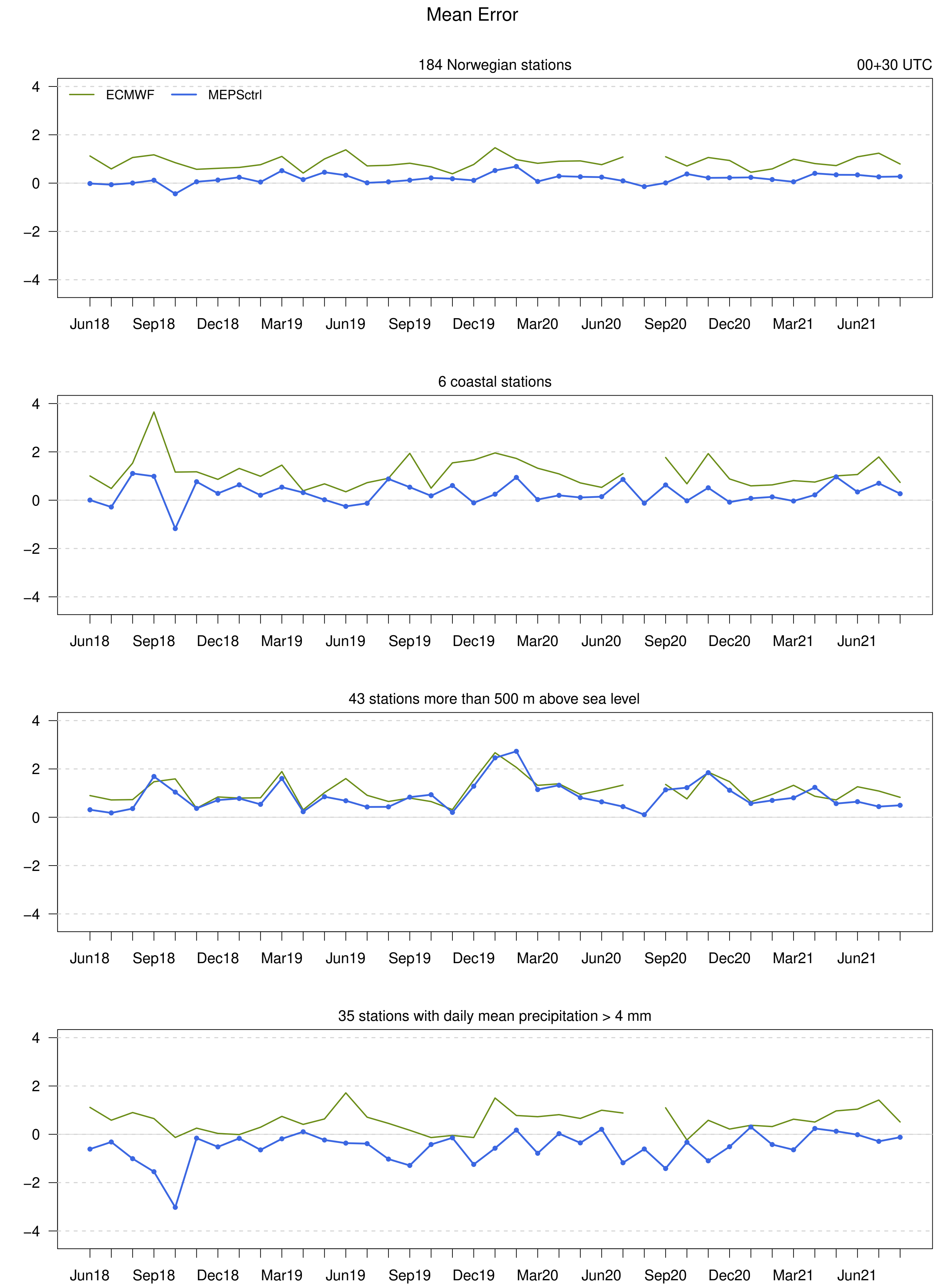

FÆRDER FYR
300
200
100
0
Jun 01
Jun 08
Jun 15
Jun 22
Jun 29
Jul 06
Jul 13
Jul 20
Jul 27
Aug 03
Aug 10
Aug 17
Aug 24
Aug 31


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


Mean Error
215 Nor. stations
03+6,+9,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
215 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
215 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
226 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Rate
226 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
226 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
226 Nor. stations
03+18,+24,+30,+36
MEPSctrl
YrPP
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
226 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
226 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)

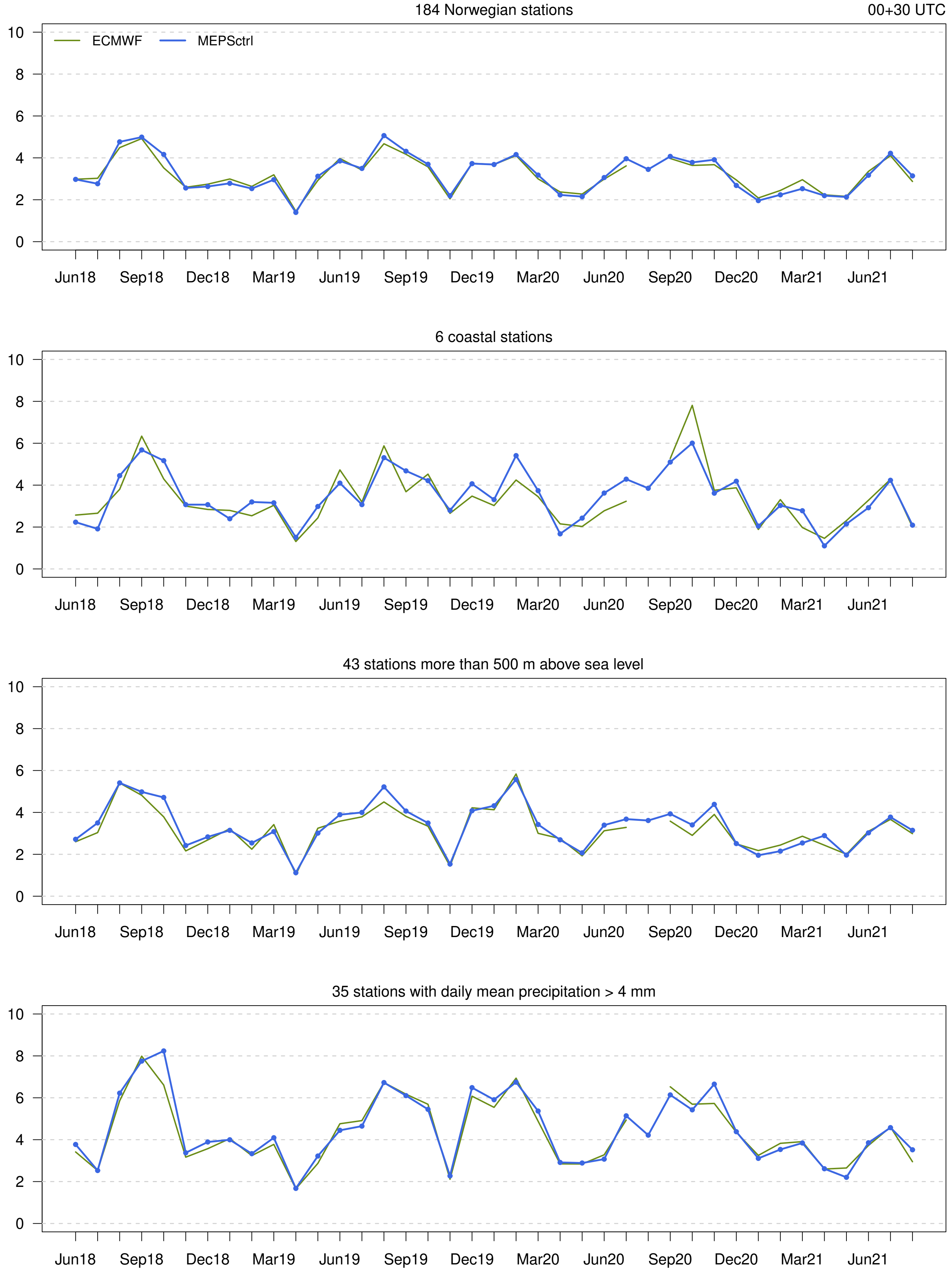

Mean Error
206 Nor. stations
03+6,+9,...,+57
MEPSctrlFG
MEPSctrlFF.925
Lead time (hour)
Standard Deviation of Error
206 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
206 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Rate
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False Alarm Ratio
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Equitable Threat Score
213 Nor. stations
03+18,+24,+30,+36
MEPSctrlFG
MEPSctrlFF.925
Exceedance threshold (m/s)
Hansen−Kuiper Skill Score
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
Heidke Skill Score
213 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)


Mean Error
177 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
177 Nor. stations
00+18,+30,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Lead time (hour)
Mean Absolute Error
177 Nor. stations
00+18,+30,...,+66
2.0
1.5
1.0
0.5
0.0
Lead time (hour)
Hit Rate
189 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
189 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
False Alarm Ratio
189 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
Equitable Threat Score
189 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance threshold (mm)
Hansen−Kuiper Skill Score
189 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
Heidke Skill Score
189 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)

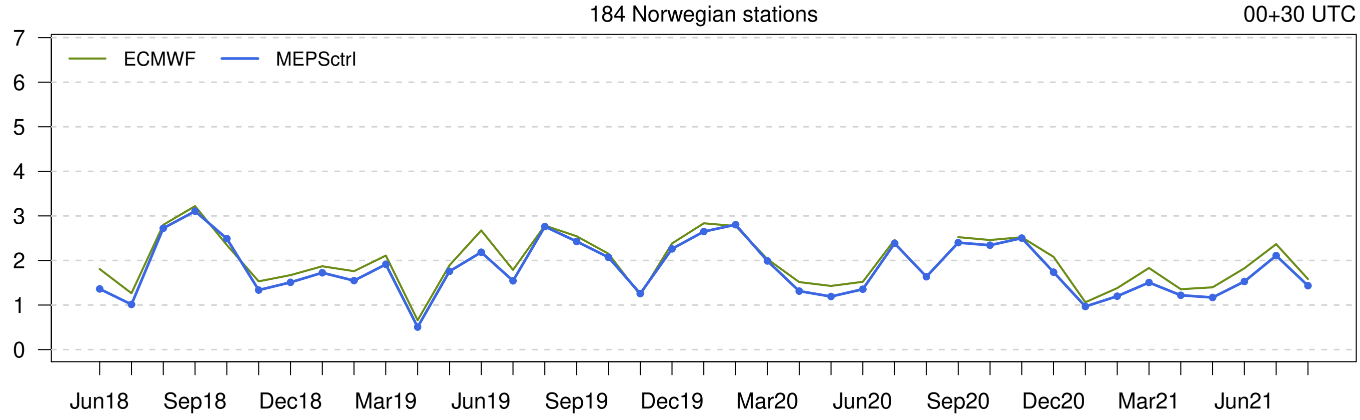


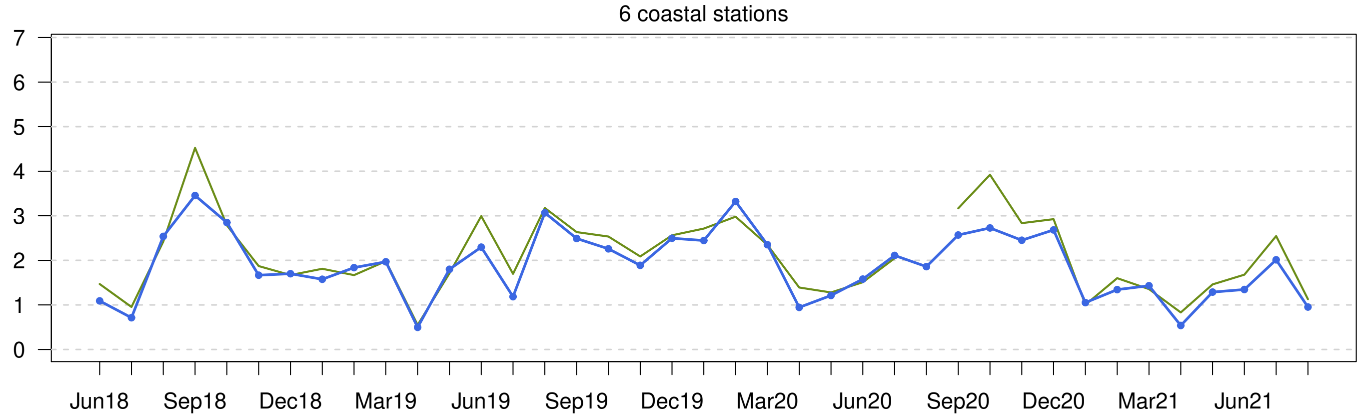
Mean Error
184 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
6 coastal stations
43 stations more than 500 m above sea level
35 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Jun18 Sep18 Dec18 Mar19 Jun19 Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21

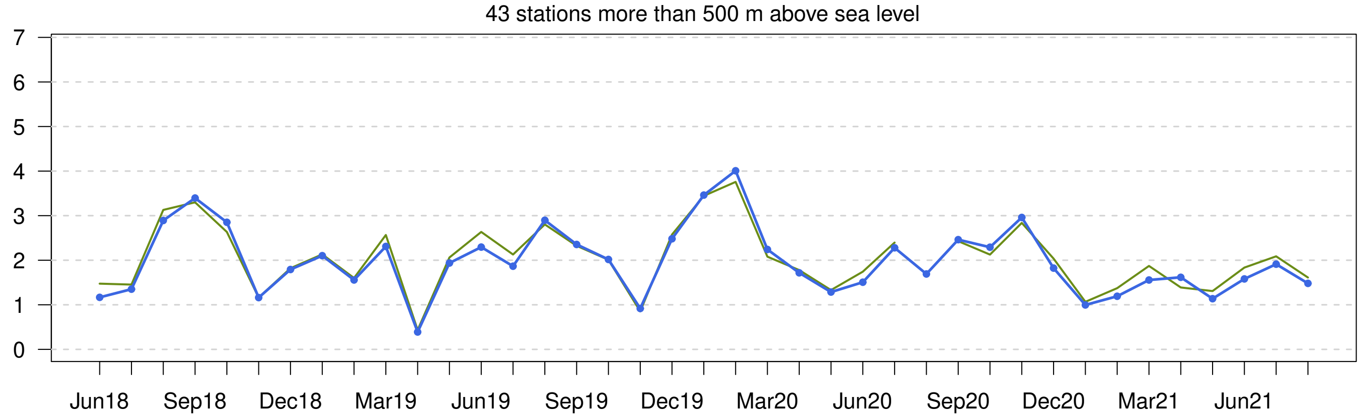
Standard Deviation of Error

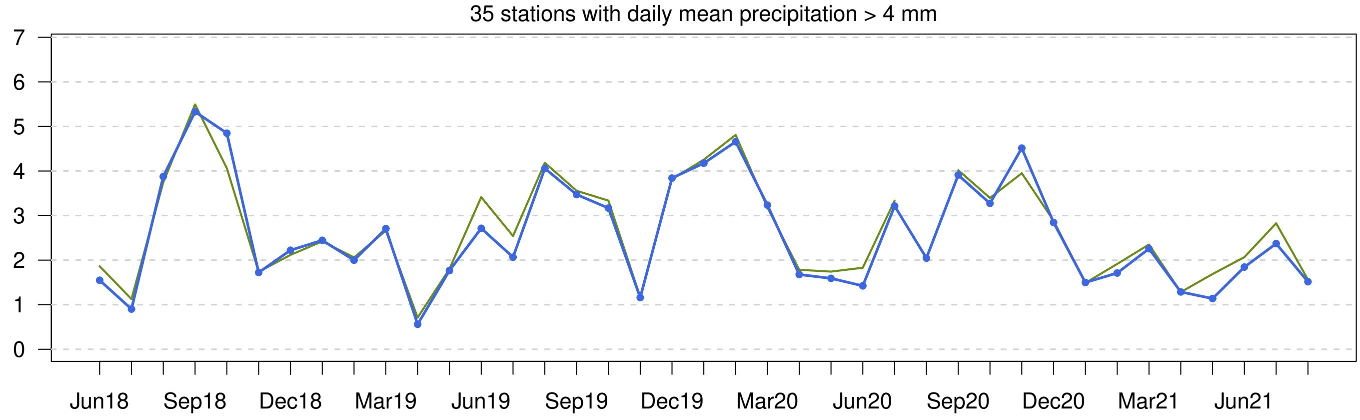


Mean Absolute Error



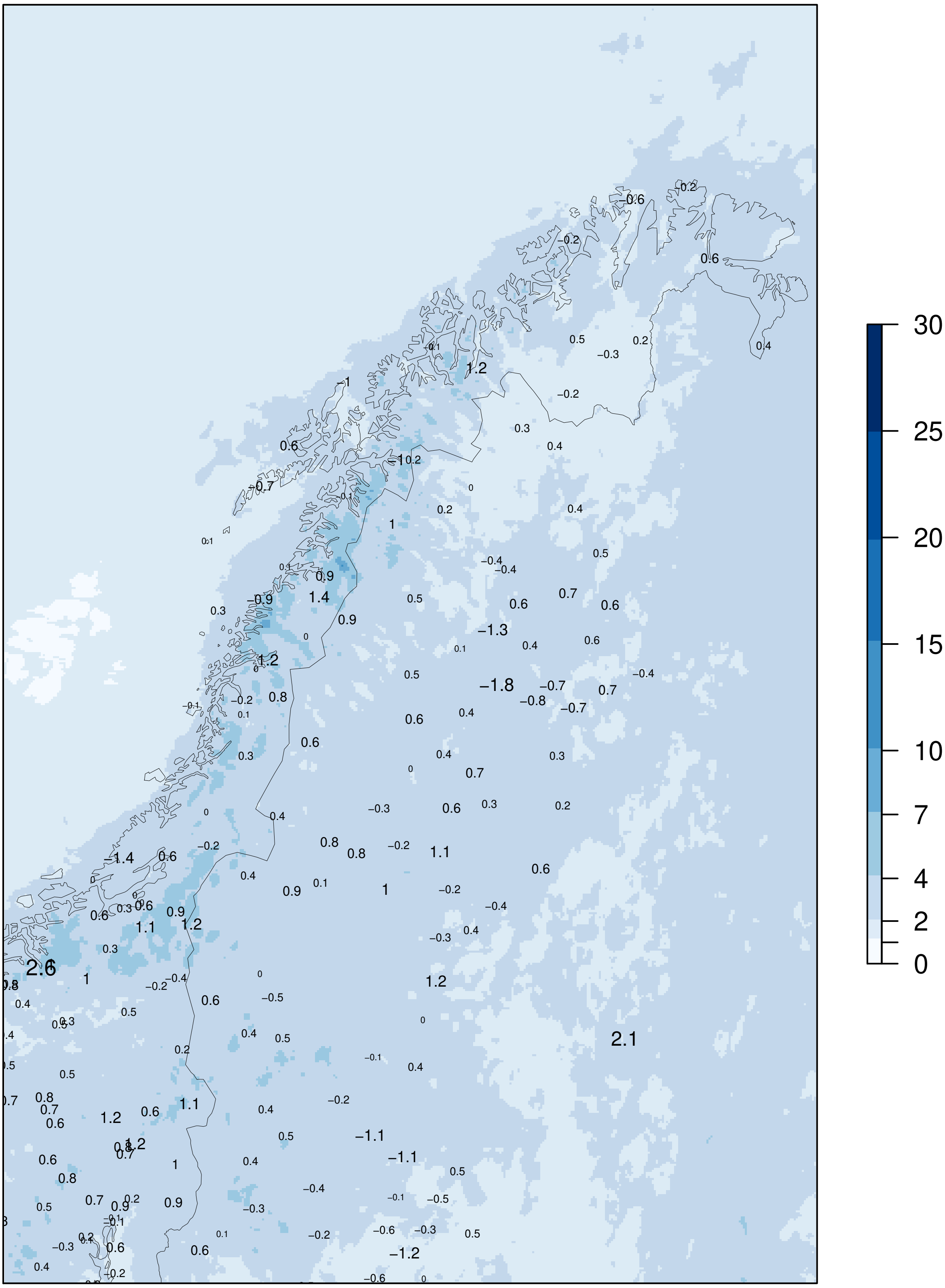






MEPSctrl 00+30

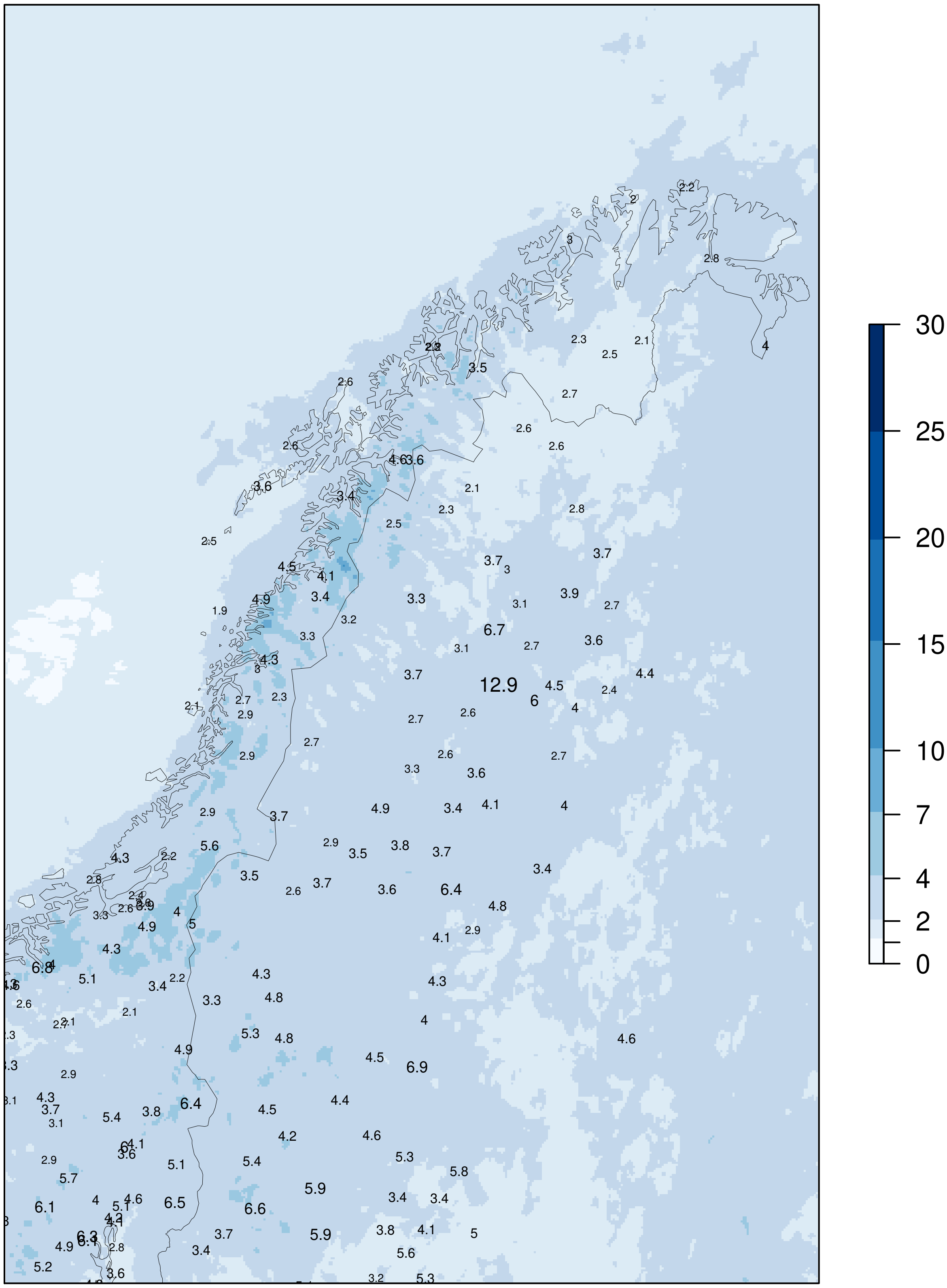
ME at observing sites
(numbers in black)



Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+30

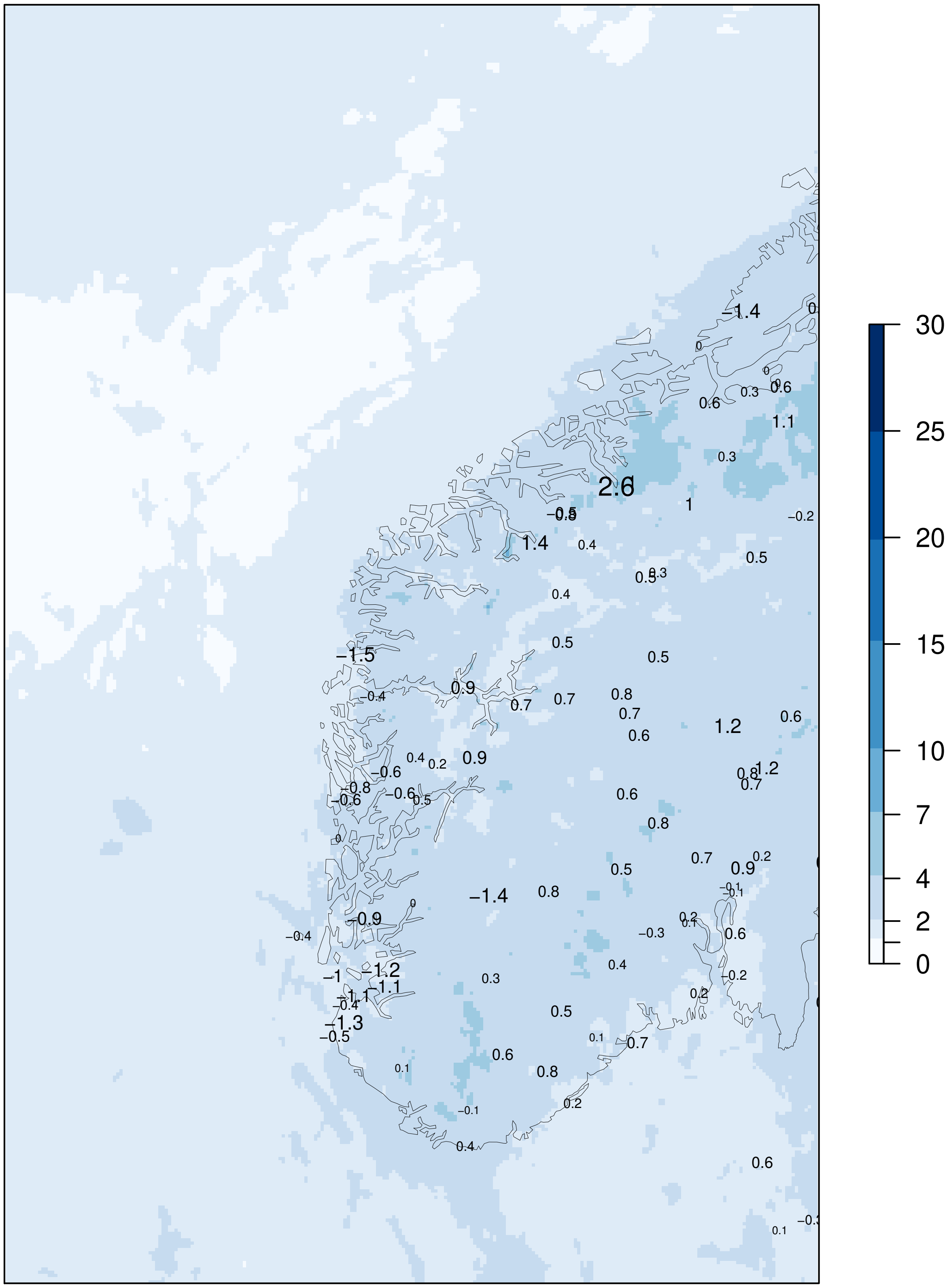
SDE at observing sites
(numbers in black)



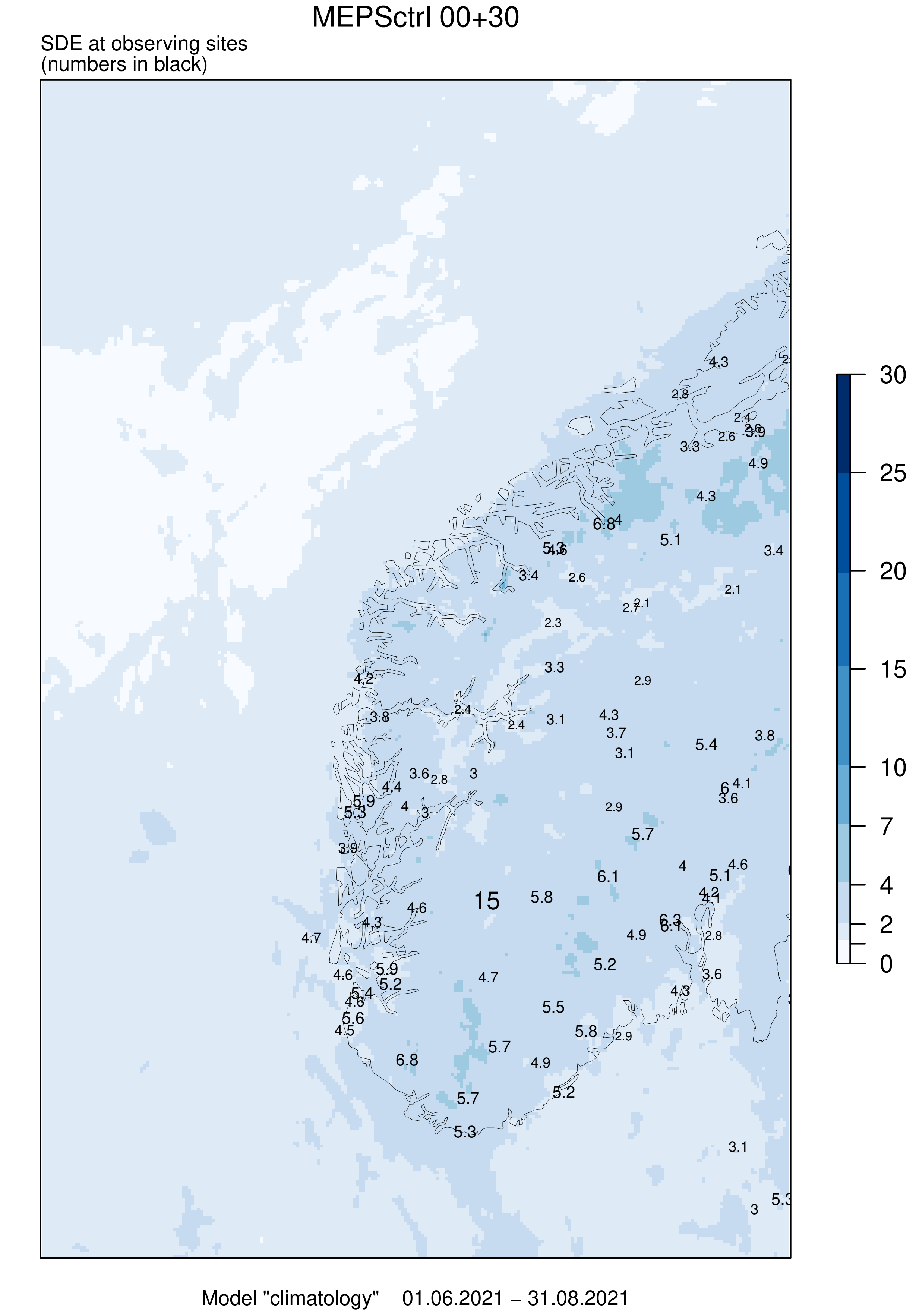
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+30

ME at observing sites
(numbers in black)

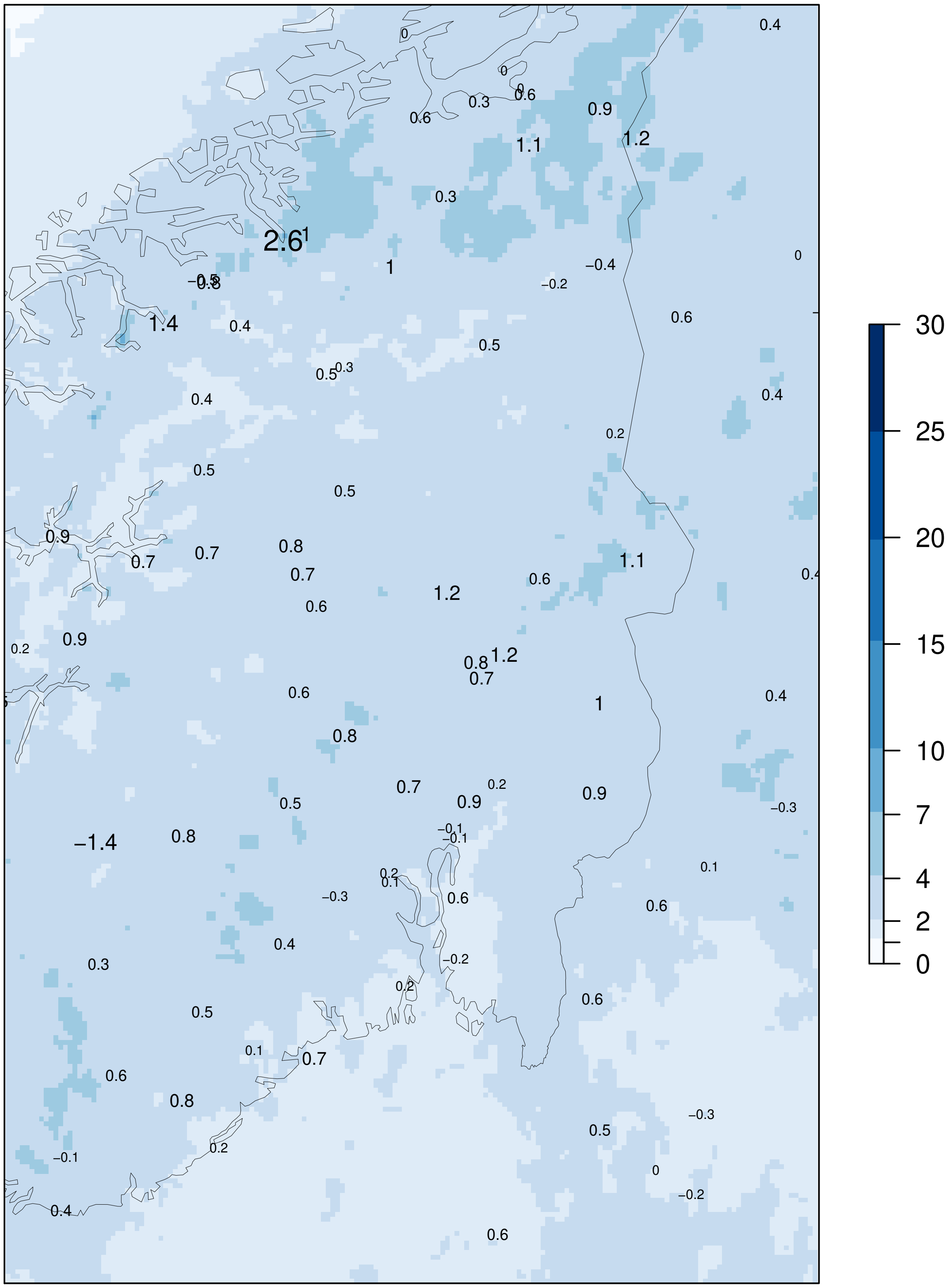


Model "climatology"   01.06.2021 – 31.08.2021


MEPSctrl 00+30
SDE at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+30

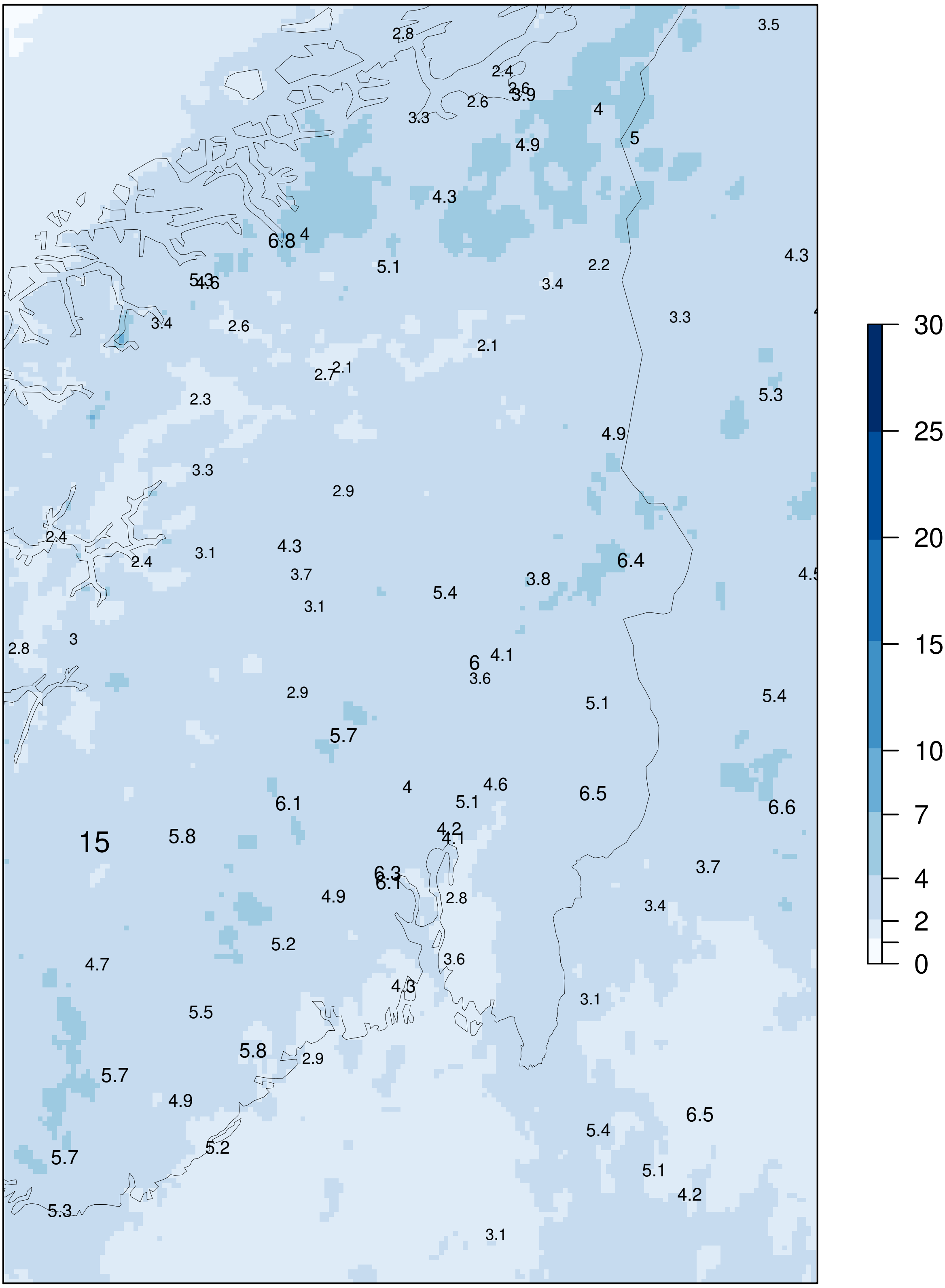
ME at observing sites
(numbers in black)



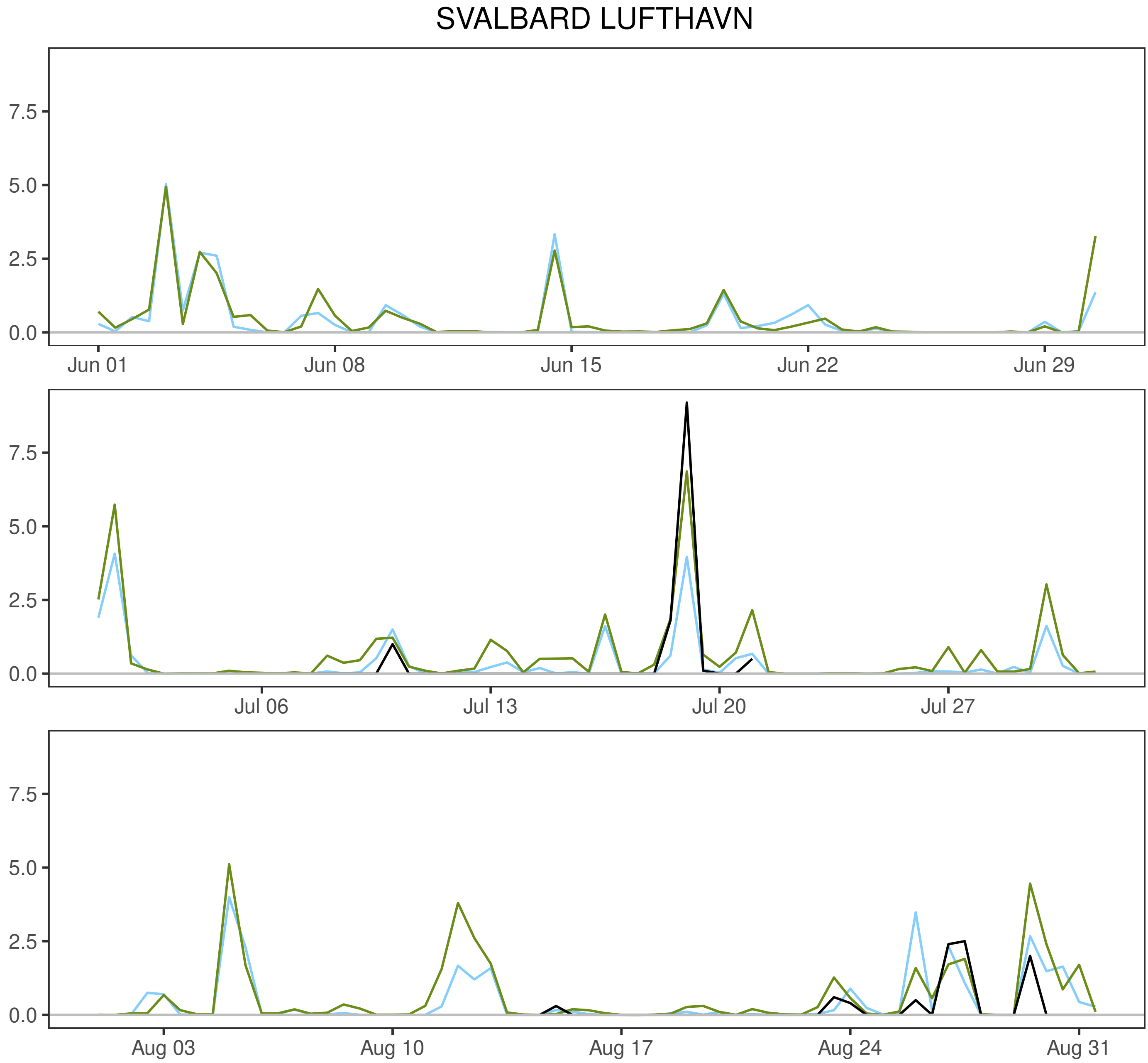
Model "climatology" 01.06.2021 – 31.08.2021

MEPSctrl 00+30

SDE at observing sites
(numbers in black)

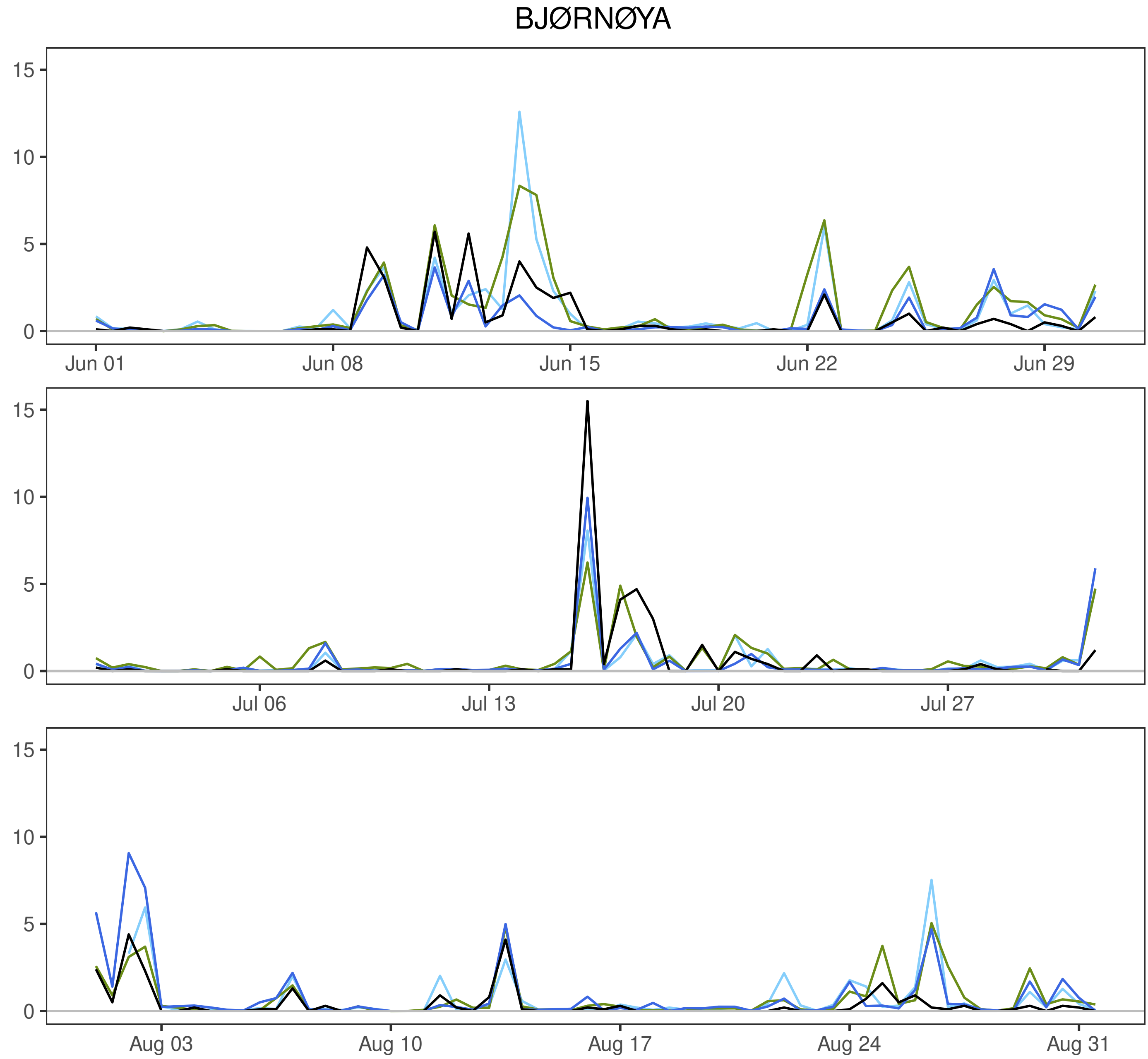


Model "climatology" 01.06.2021 – 31.08.2021



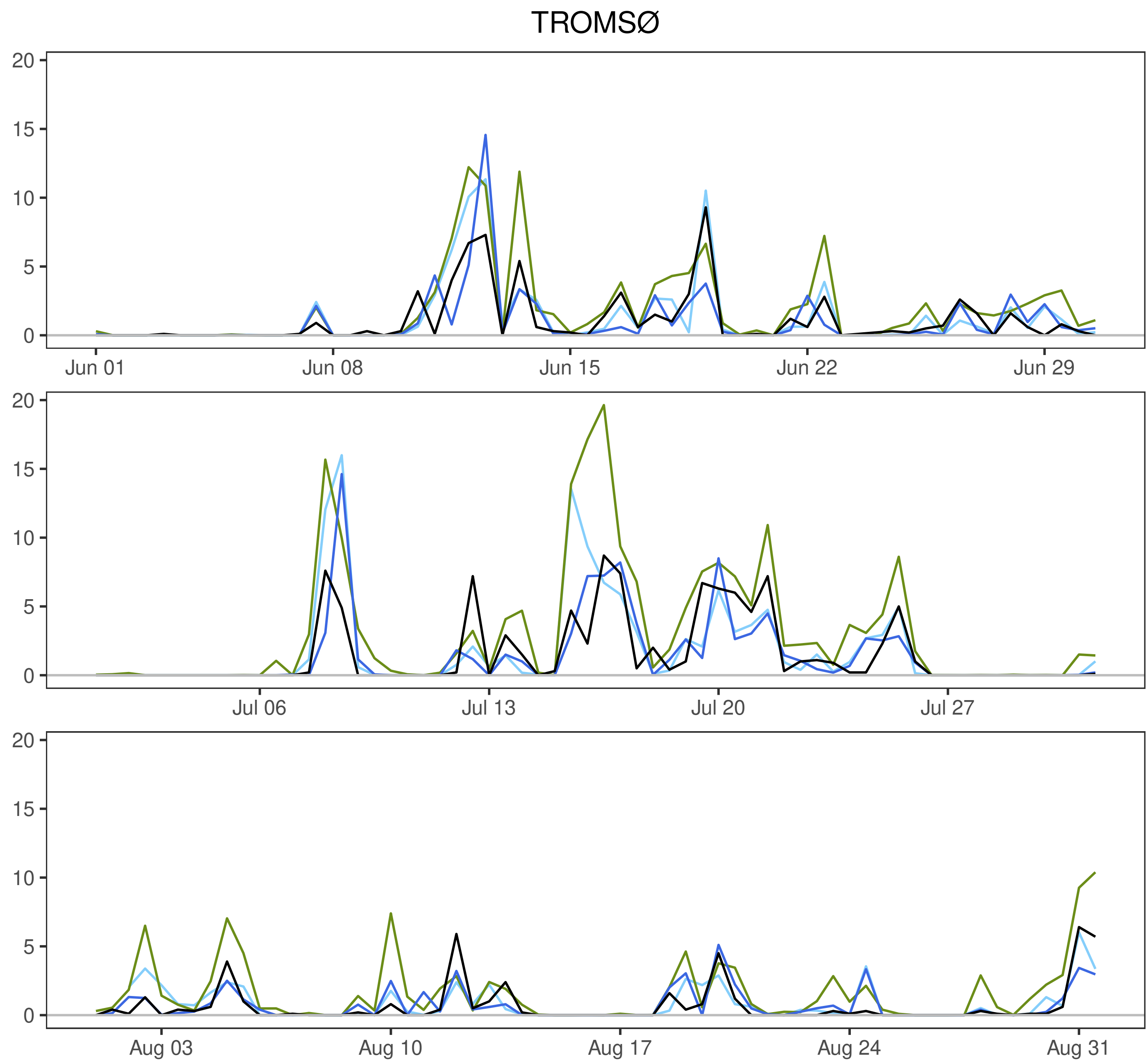
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.3	9.2	1.2	65
AA25: 12+18,+30	0.0	0.4	5.0	0.9	182
ECMWF: 12+18,+30	0.0	0.6	6.9	1.1	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.1	0.9	0.9	0.3	5.2	65
ECMWF−synop	0.3	0.7	0.8	0.4	2.5	65



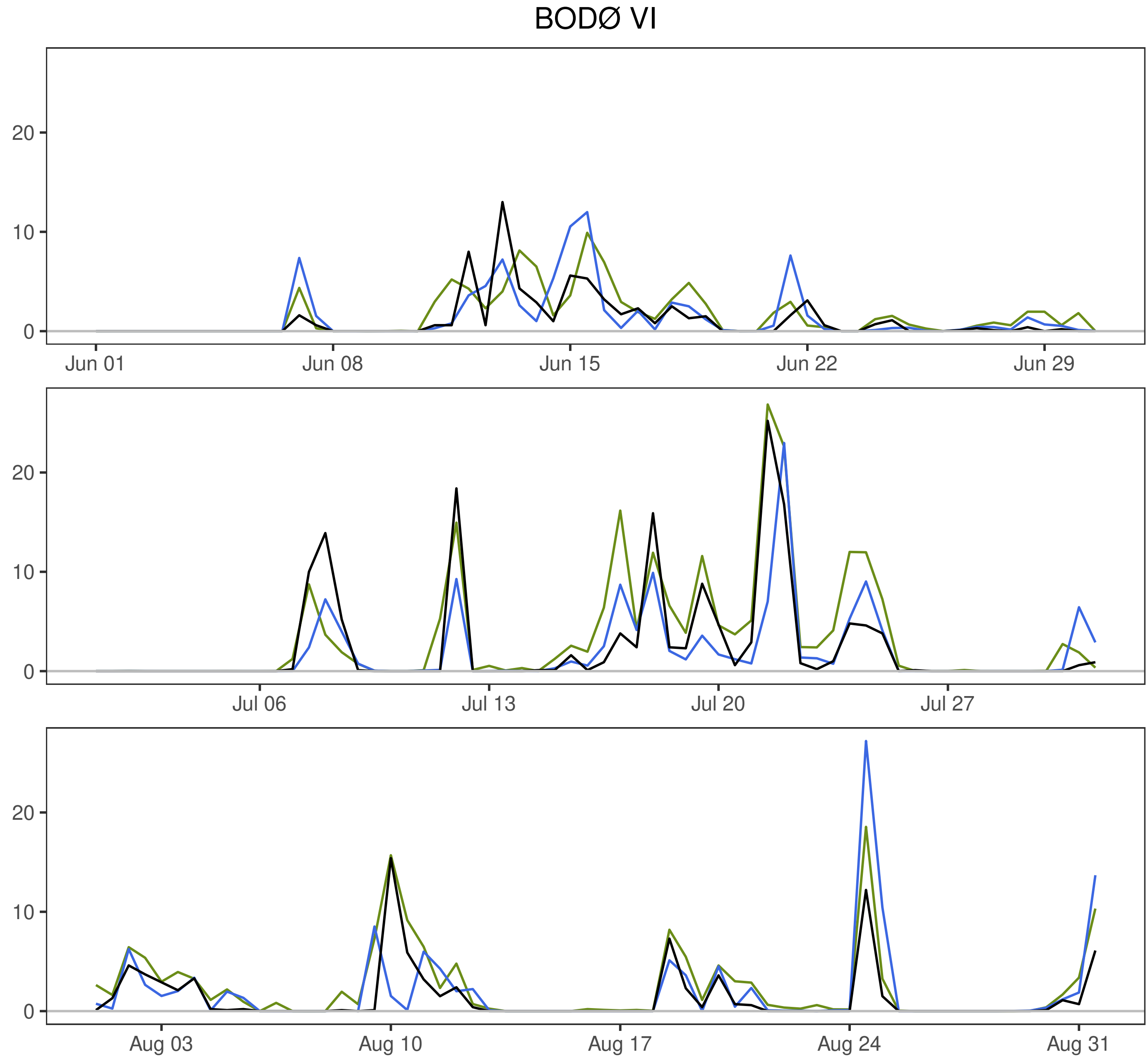
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.5	15.5	1.5	183
MEPSctrl: 12+18,+30	0.0	0.6	9.9	1.4	184
AA25: 12+18,+30	0.0	0.7	12.6	1.6	182
ECMWF: 12+18,+30	0.0	0.8	8.3	1.5	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	1.1	1.1	0.5	5.6	181
AA25−synop	0.2	1.3	1.3	0.6	8.6	181
ECMWF−synop	0.3	1.3	1.3	0.6	9.3	181



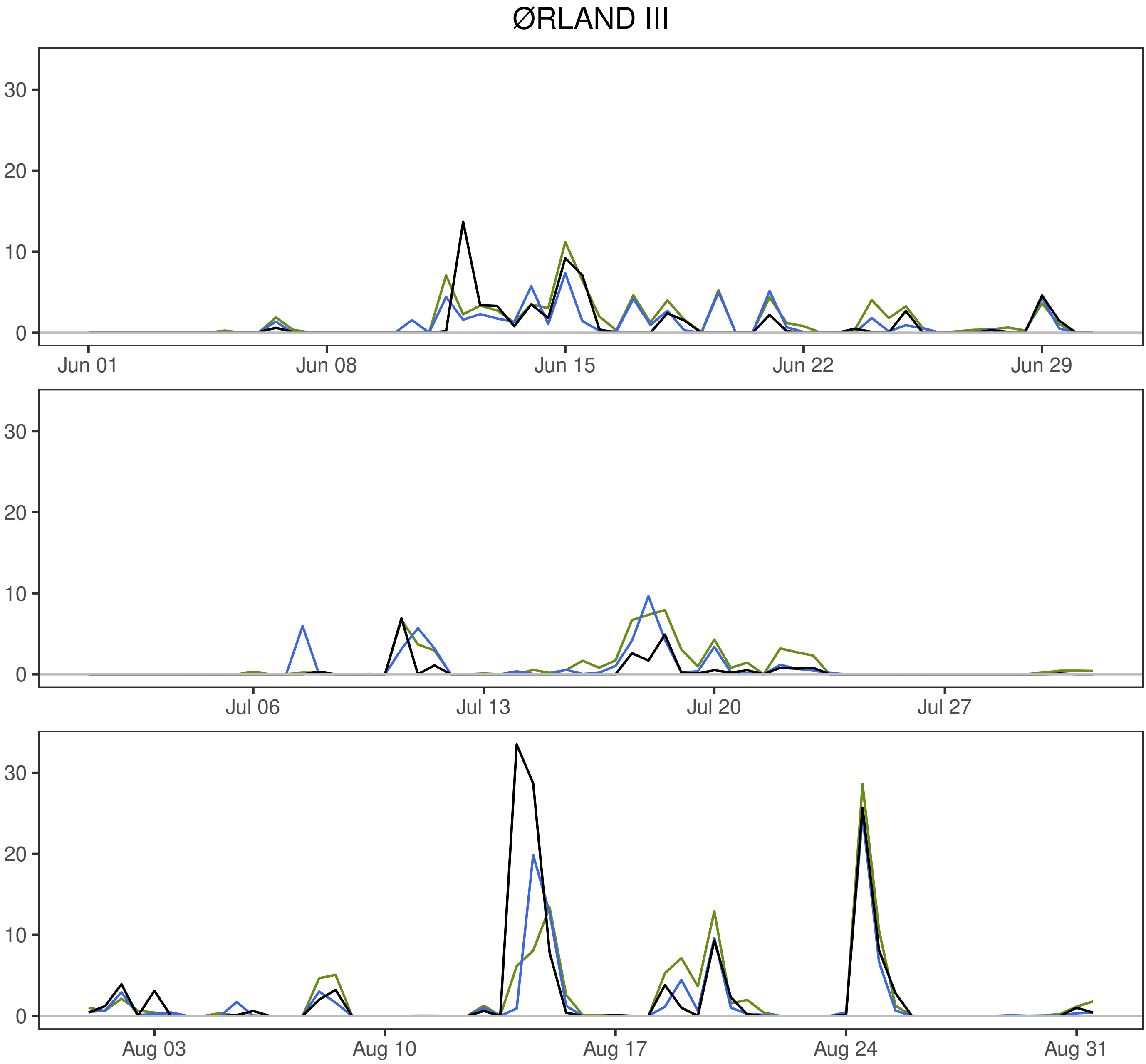
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.1	9.3	2.0	184
MEPSctrl: 12+18,+30	0.0	1.1	14.6	2.1	184
AA25: 12+18,+30	0.0	1.3	16.0	2.6	182
ECMWF: 12+18,+30	0.0	2.2	19.6	3.5	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.0	1.6	1.6	0.8	9.7	182
AA25−synop	0.2	1.7	1.7	0.8	11.1	182
ECMWF−synop	1.1	2.2	2.4	1.3	14.8	182



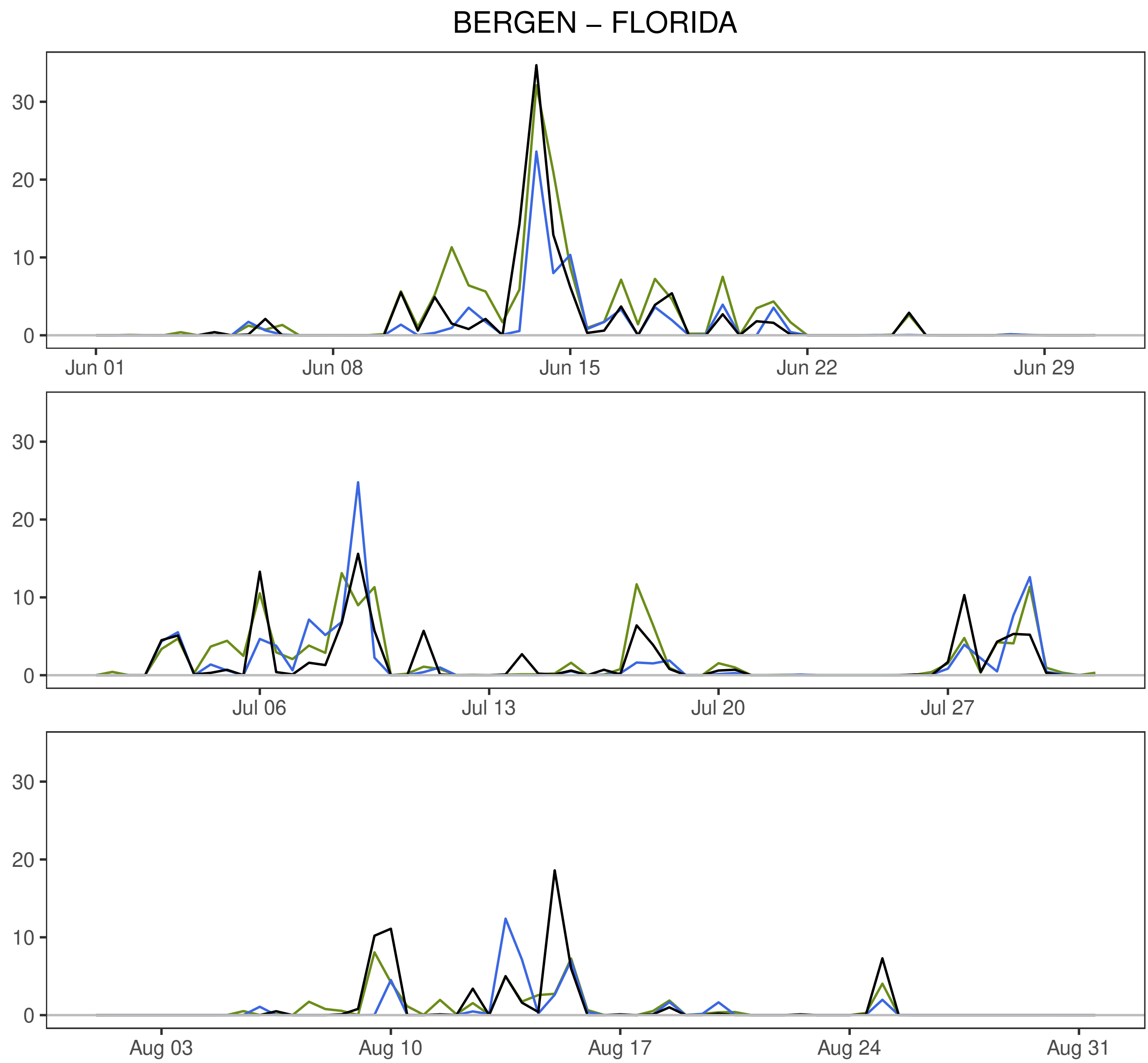
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.6	25.2	3.7	184
MEPSctrl: 12+18,+30	0.0	1.7	27.2	3.6	184
ECMWF: 12+18,+30	0.0	2.5	26.8	4.2	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.1	3.0	3.0	1.3	18.2	184
ECMWF−synop	0.8	2.2	2.4	1.3	12.4	184



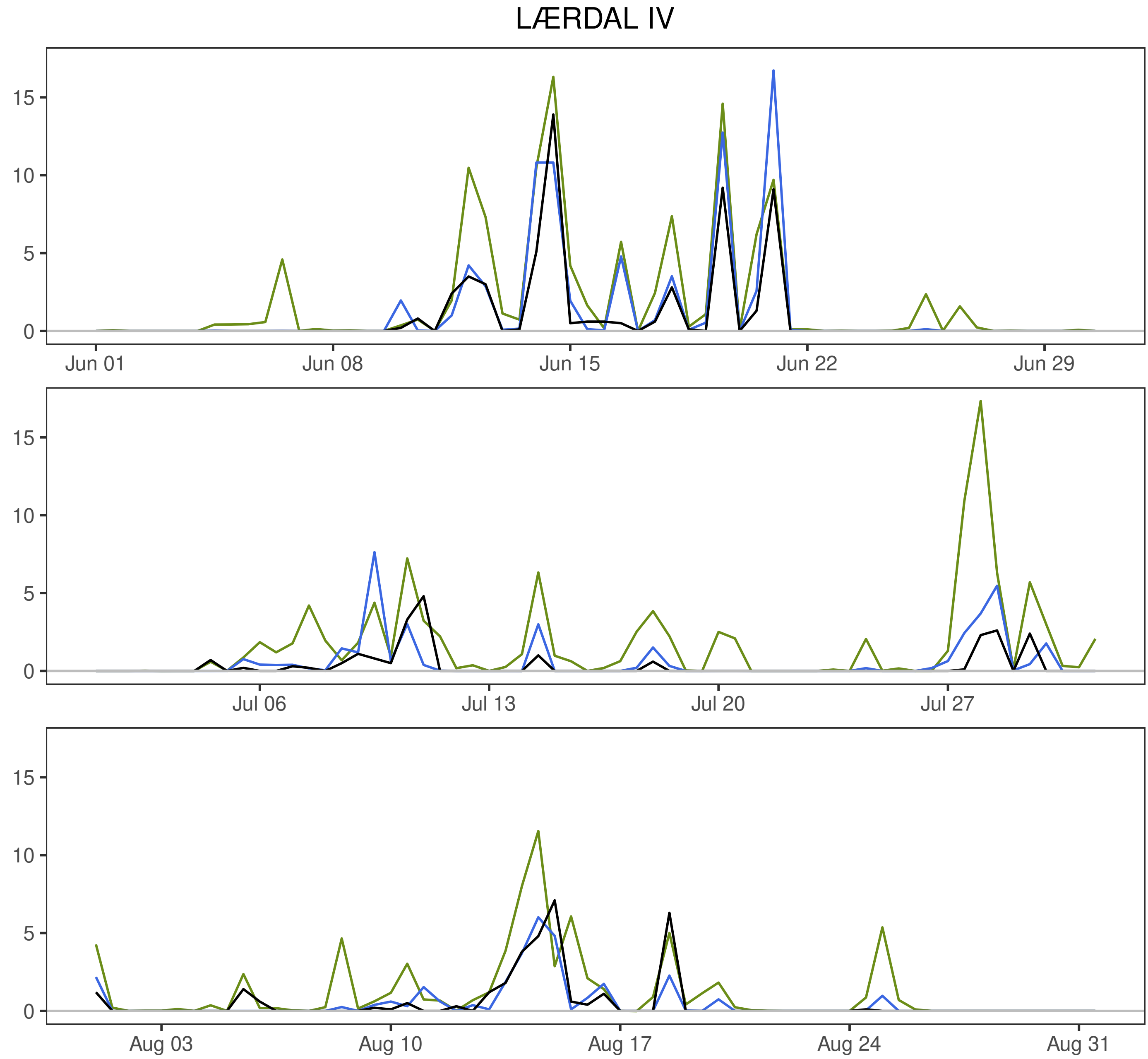
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.2	33.5	4.1	184
MEPSctrl: 12+18,+30	0.0	1.1	24.7	3.0	184
ECMWF: 12+18,+30	0.0	1.5	28.6	3.2	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	3.0	3.0	0.9	32.6	184
ECMWF–synop	0.3	3.0	3.0	1.0	27.3	184



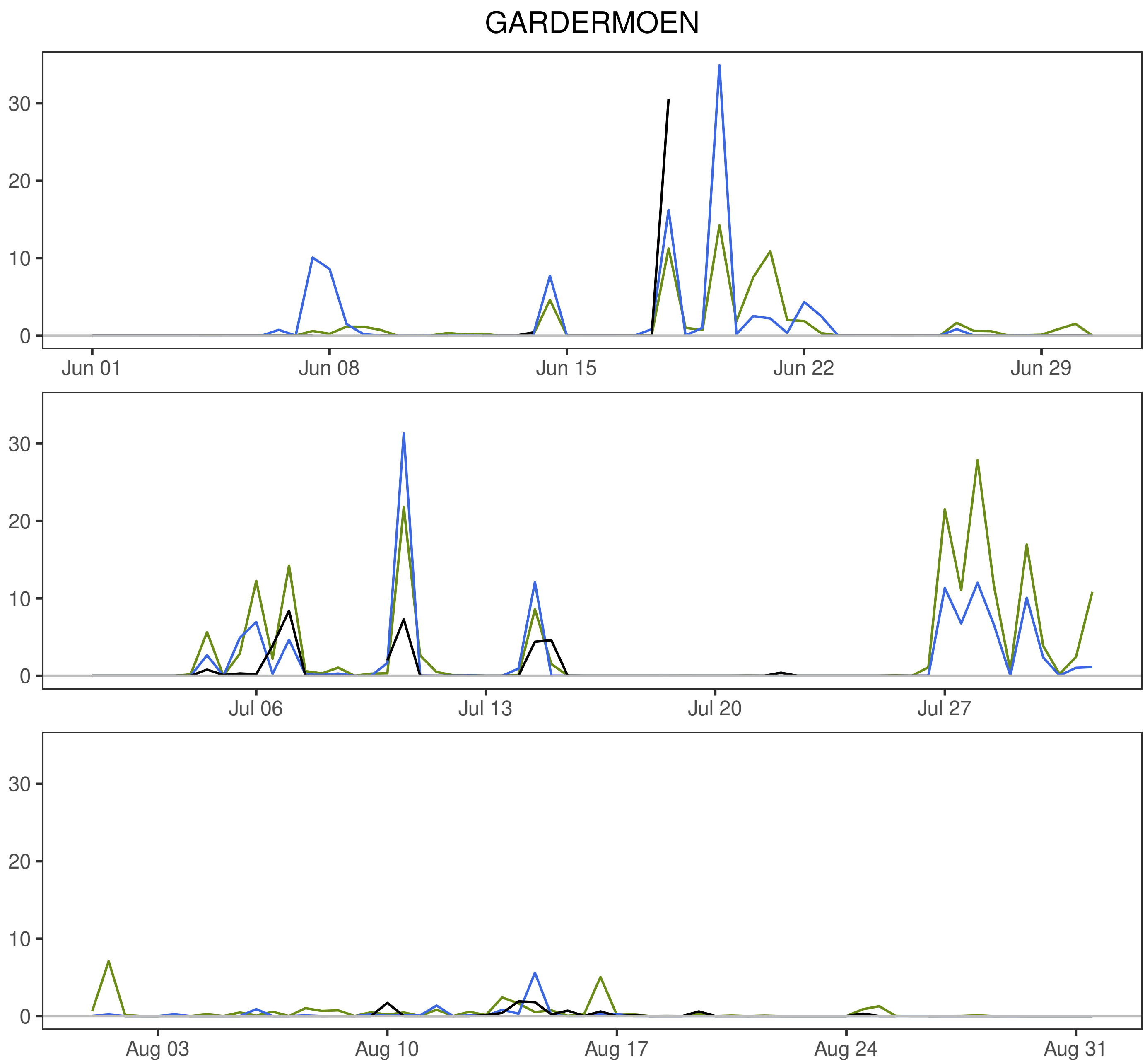
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.5	34.7	4.0	184
MEPSctrl: 12+18,+30	0.0	1.2	24.8	3.2	184
ECMWF: 12+18,+30	0.0	1.8	32.1	3.8	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.3	2.7	2.7	1.1	16.0	184
ECMWF–synop	0.3	2.3	2.3	1.0	15.9	184



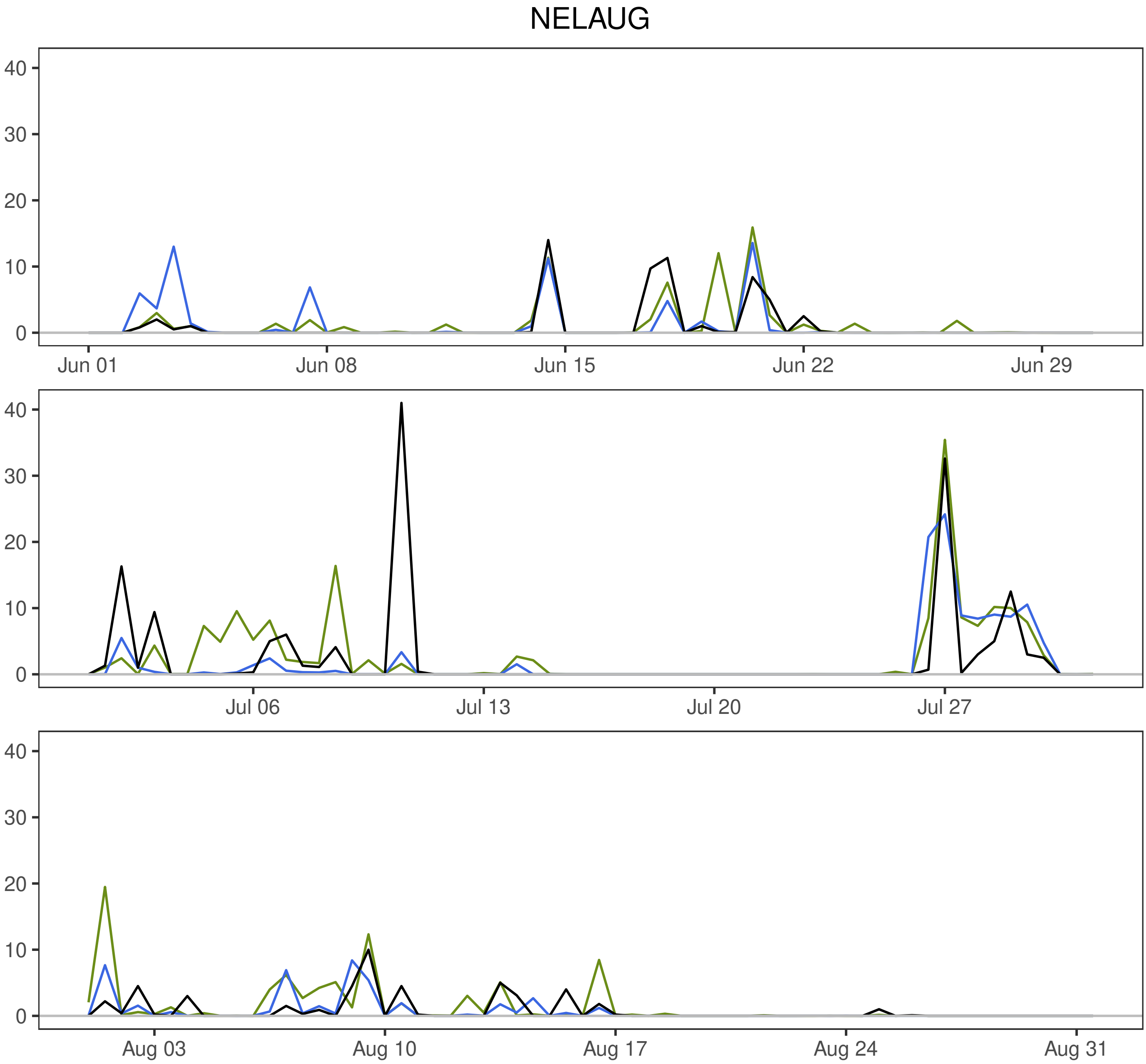
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.6	13.9	1.7	184
MEPSctrl: 12+18,+30	0.0	0.8	16.7	2.2	184
ECMWF: 12+18,+30	0.0	1.6	17.3	3.0	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.2	1.2	0.5	7.6	184
ECMWF−synop	1.0	2.1	2.3	1.1	15.0	184



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.5	30.6	2.6	158
MEPSctrl: 12+18,+30	0.0	1.2	34.9	4.2	184
ECMWF: 12+18,+30	0.0	1.5	27.9	4.1	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	2.6	2.6	0.7	24.0	158
ECMWF−synop	0.3	2.4	2.4	0.7	19.4	158



	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.4	41.0	4.6	184
MEPSctrl: 12+18,+30	0.0	1.2	24.2	3.4	184
ECMWF: 12+18,+30	0.0	1.7	35.4	4.2	184

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	−0.2	4.0	4.0	1.3	37.7	184
ECMWF–synop	0.3	4.2	4.2	1.5	39.4	184