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Verification of Operational Weather Prediction Models September to November 2022

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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.

The MEPS 10 m wind speed forecast 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	$\left(\frac{1}{n} \sum_{i=1}^{n} (f_i - o_i - \mathrm{M}E)^2 \right)^{1/2}$	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

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

$$\mathrm{S}D(f) = \left(\frac{1}{n}\sum_{i=1}^{n}(f_i - \bar{f})^2\right)^{1/2}, \qquad \mathrm{S}D(o) = \left(\frac{1}{n}\sum_{i=1}^{n}(o_i - \bar{o})^2\right)^{1/2}$$

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 Norwegian and Svalbard stations, but more so for ECMWF. For the North Scandinavian stations AA25 tend to be a bit warm, while the mean error for MEPSctrl is close to zero. ECMWF is too cold for these stations as well. The difference between MEPSctrl and AA25 temperature forecasts is expected. The setting XRIMAX>0 in MEPS is an attempt to improve stable situations and lower the temperatures. Unfortunately this setting also leads to too low temperatures in some situations. For AA25, XRIMAX was set to 0 on 25 April 2022.

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. The threshold scores indicate that wind speed is better forecast for lower than for higher wind speeds for all models. 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, but slightly smaller mean absolute error, 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 fall had mean errors very close to (and above) 0. Evaluated by skill scores, ECMWF shows a higher hit rate, but also have more false alarms than MEPSctrl. Both models have more errors for both very small amounts and very high amounts, than precipitation in the mid range. Since the upgrade from cycle 40 to 43 in March 2021, there have been some minor updates aiming to improve precipitation, fog and low clouds. Such improvements are difficult to demonstrate by summary scores, but might be revealed in cases, like the ones presented in the next section.

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

The cases are a selection of situations of interest reported by various forecasters. Figures and text for the case on low clouds from 3 October was contributed by Tor-Ivar Mathiesen, MET Norway.

Case 1. Fog and low clouds

On 29 September large areas of fog were not forecast in MEPSctrl in Ofoten, Troms and West-Finnmark (figure 1). This is an example of too much outgoing radiation off the top of the fog layer at sea, making for the false areas of fog seen at around 70°N and 0 to 10°E. The red arrow indicates the location of the Andenes sounding station. The sounding from Andenes is shown in figure 2. The moist layer at 800 to 850 hPa is not resolved in the model. The problem of stratus in association with weak subsidence inversions has been recurring for some years now and is currently seen as one of the main weaknesses of the fine scale model at MET Norway.

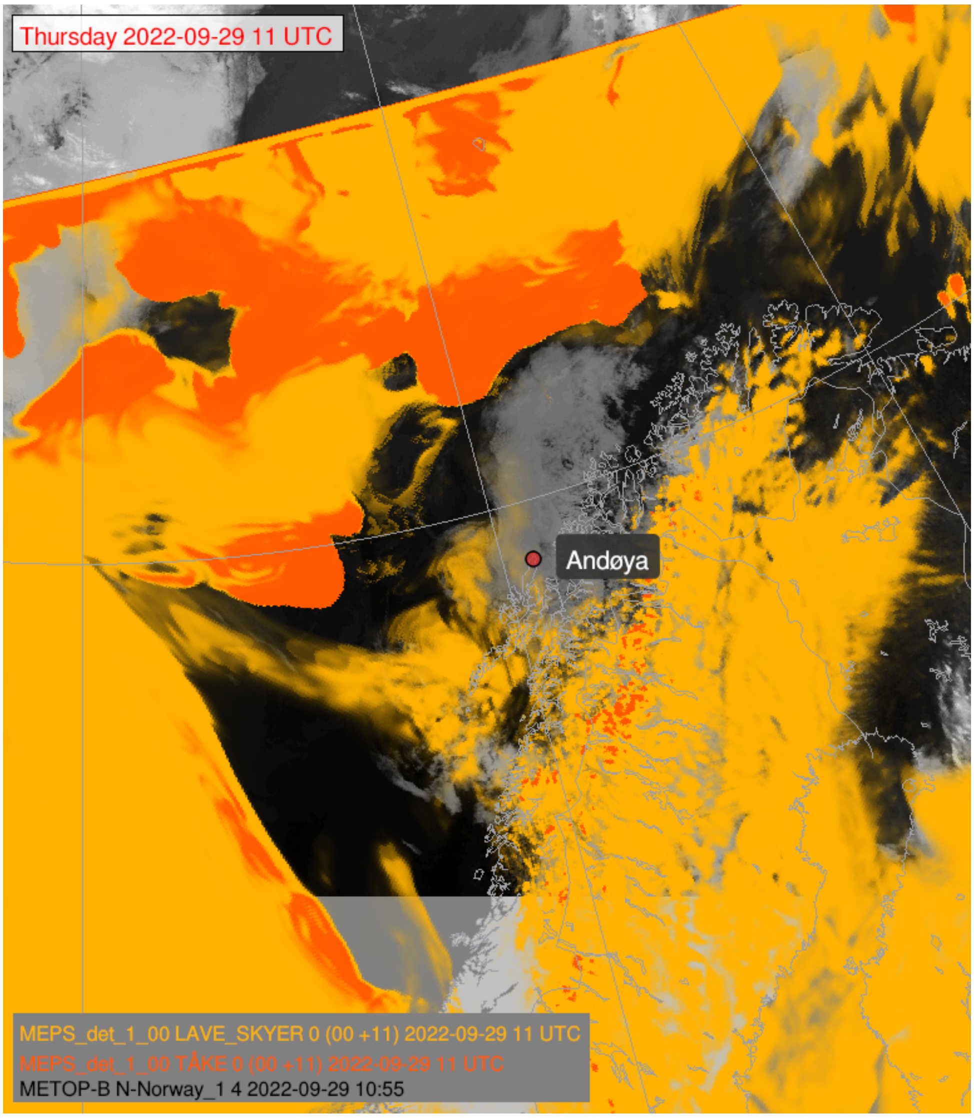


Figure 1: Satellite image from 29 September with low clouds from MEPS shown as yellow areas, and fog as orange areas. The red dot indicates the location of Andenes sounding station at Andøya.

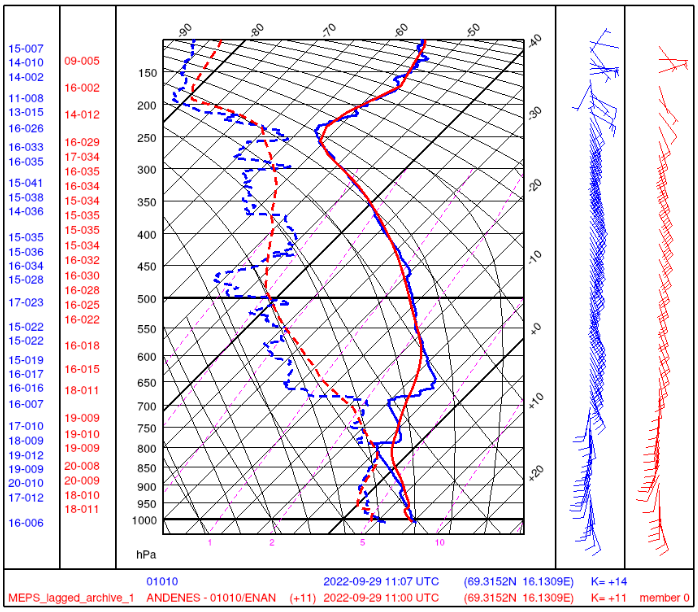


Figure 2: The sounding from Andenes (Observation in blue, MEPSctrl in red) shows that the moist layer at 800 to 850 hPa is not resolved in the model.

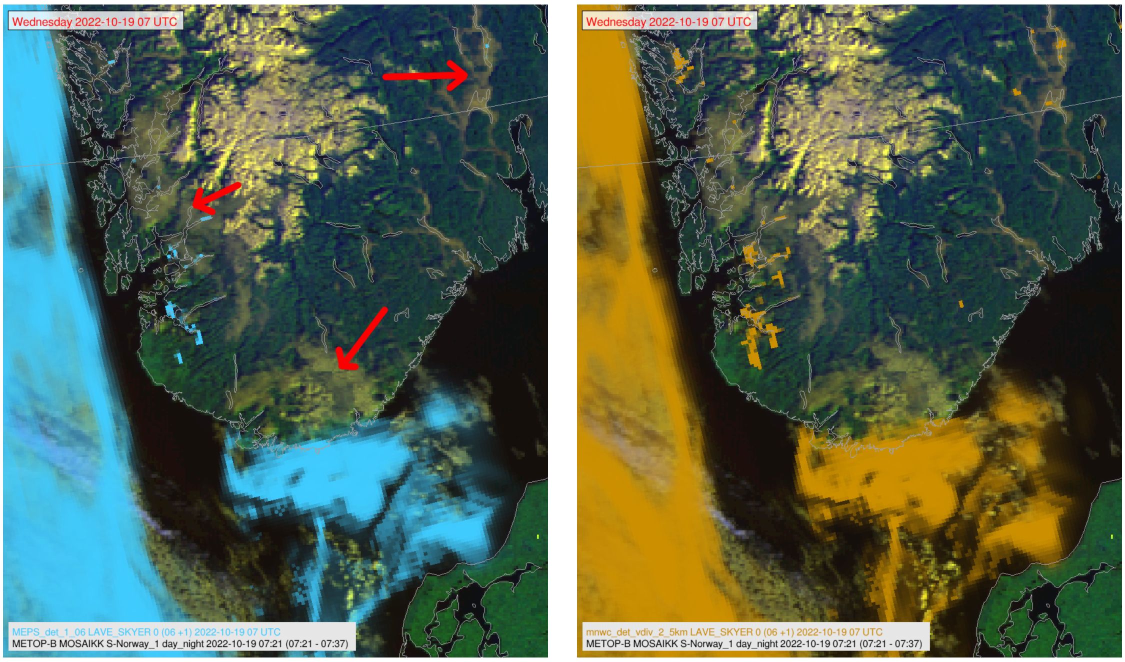


Figure 3: A case of missing inland radiation fog in southern Norway from the 19 October, as indicated by red arrows, for MEPSctrl (left) and MNWC (right).

Figure 3 shows a case of missing inland radiation fog in southern Norway from the 19 October for MEPSctrl and the nowcasting model MNWC. MEPSctrl is generally not able to reproduce this fog, even at just 1hr lead time. The nowcast model MNWC was made operational on 4 October 2022. It is based on MEPS, but has a shorter cutoff and moisture adjustment based on observed cloudiness. It is supposed to give better forecasts within the first few hours, but shows only very small improvements in this case.

A similar case from 3 October (figure 4) shows a clear improvement in MNWC over the MEPSctrl in forecasting low clouds over southeastern Norway.

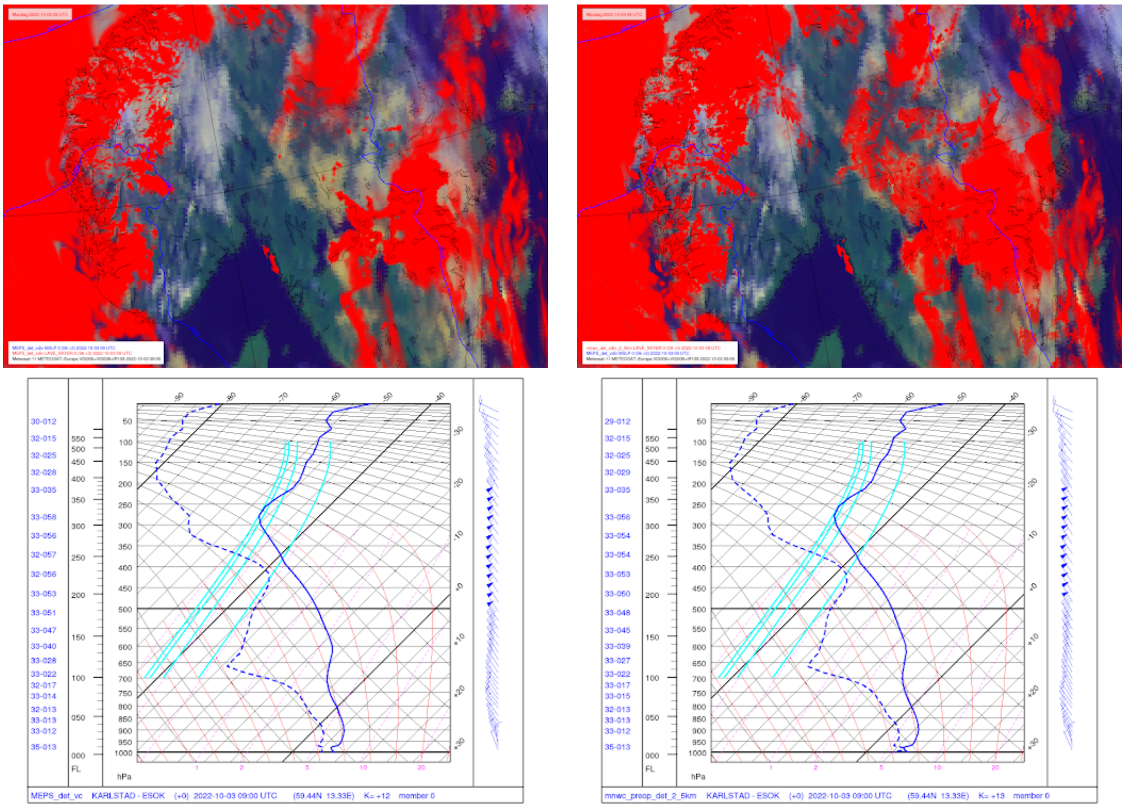


Figure 4: Analysis from MEPSctrl (left) and the sounding from Karlstad, Sweden shows a dry area and moist but not saturated between 850 and 1000 hPa. The MNWC (right) has better coverage in southeastern Norway and manages to achieve saturation between 850 and 1000 hPa.

Case 2. Precipitation

There are generally fewer reports on missing precipitation in 2022 than in previous years, but this may be due to the fact that this has been a known problem for some time now.

On 8 November 2022, an updated tuning of the hydrometeor advection scheme was introduced in MEPS, expecting to improve the forecasts of clouds and precipitation. The change was introduced already 31 October in the pre-operatonal MEPS2_preop, which does four dimensional variational (4D VAR) data assimilation. There are several examples of this new version performing better than the current MEPSctrl in forecasting precipitation, as shown in figures 5 and 6. In these cases MEPS and MEPS2_preop differ both in 3D/4D VAR assimilation and the update related to the hydrometeor advection.

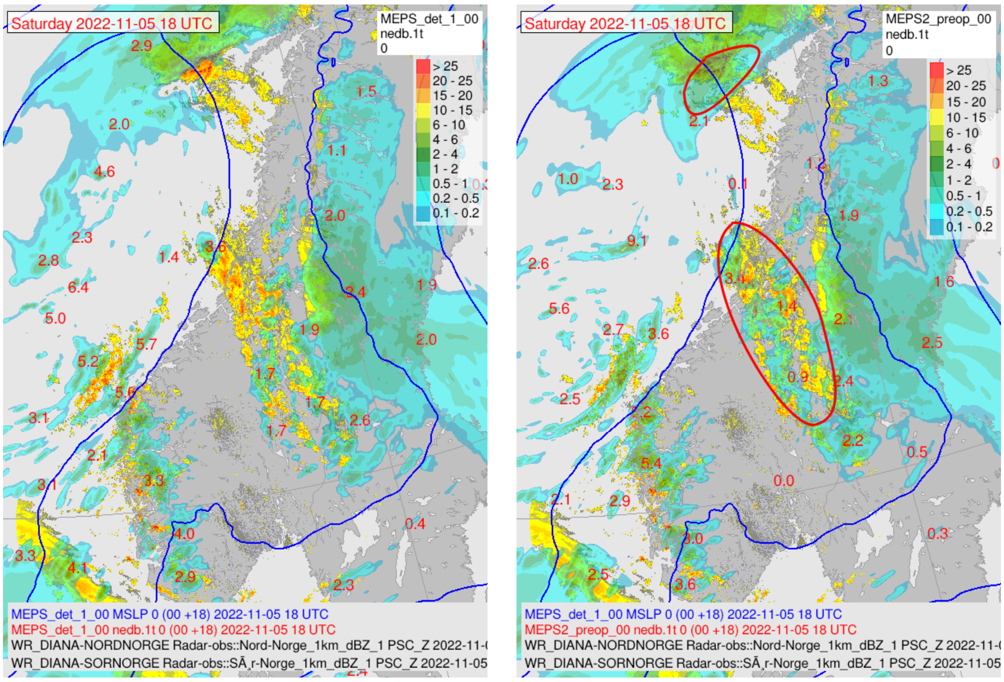


Figure 5: 5 November 2022: MEPSctrl (left) is lacking in precipitation (green shading) when compared to radar (yellow/orange) on 18 hrs lead time. MEPS2_preop (right) has a better coverage over Trøndelag and central Norway in this case. Blue lines are MSLP. Red numbers are maximum values for 1 hr precipitation from the model.

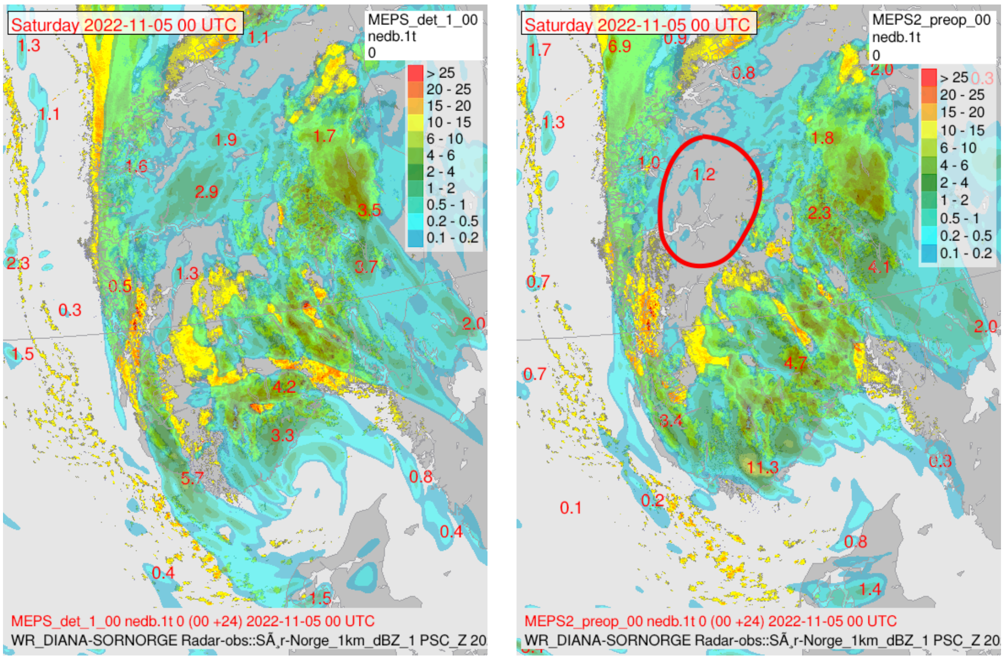


Figure 6: From earlier in the same November event we see an example of better fit in the MEPS2_preop in areas without precipitation, e.g. in the central mountain areas of southern Norway.

A severe weather event with heavy precipitation from 7 November (figures 7-9) shows an example where MEPSctrl is generally too dry in the coastal areas before orographic lifting takes place, but has otherwise realistic maximum values, although the placement in this case was slightly off. The prevailing wind in this case was from the southwest.

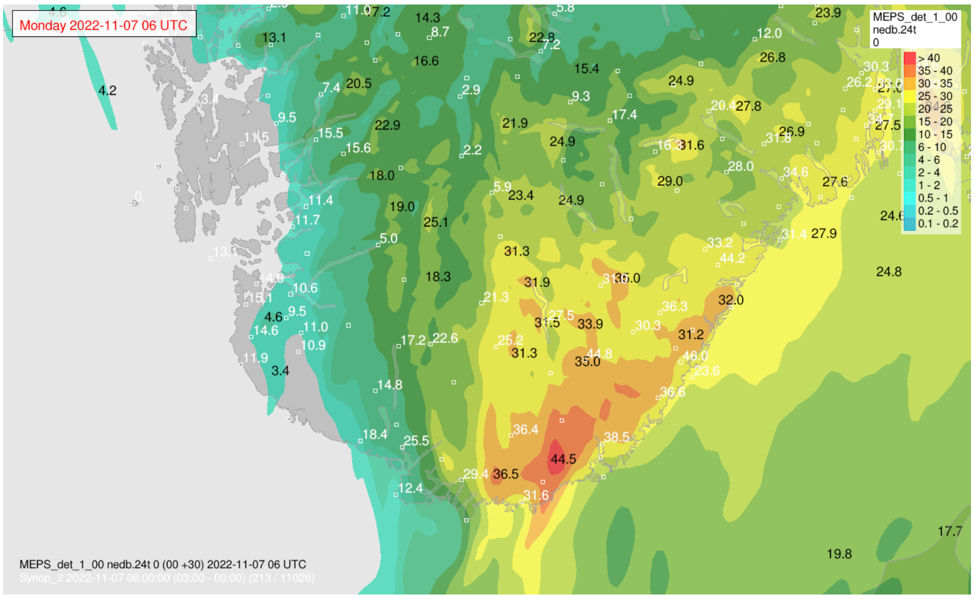


Figure 7: MEPSctrl from 7 November 2022. Black numbers are model maxima for 24 hour precipitation. White numbers are observed 24 hour precipitation.

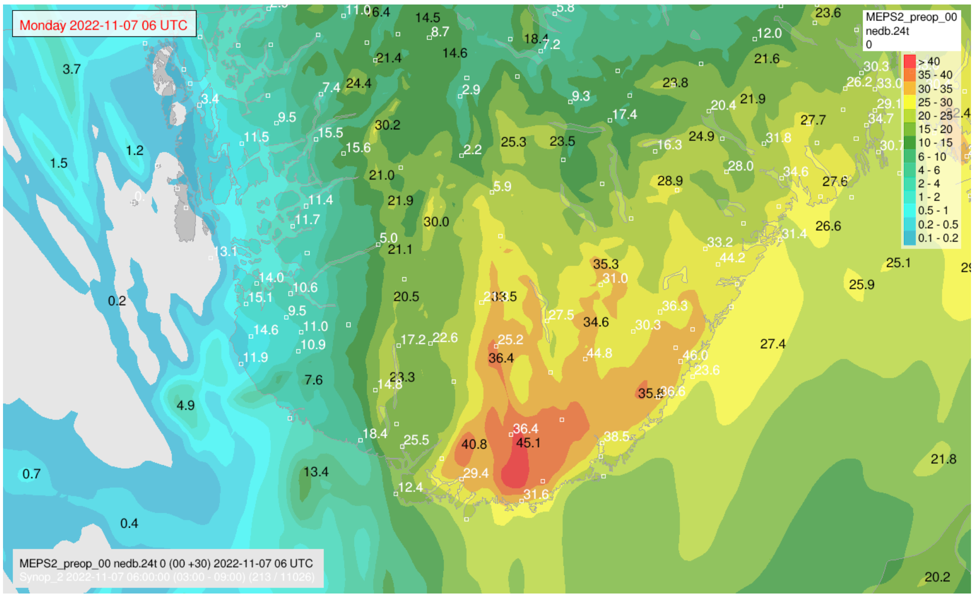


Figure 8: MEPS2_preop from 7 November shows similar maximum values, but more precipitation upstream in the coastal regions in southwestern Norway.

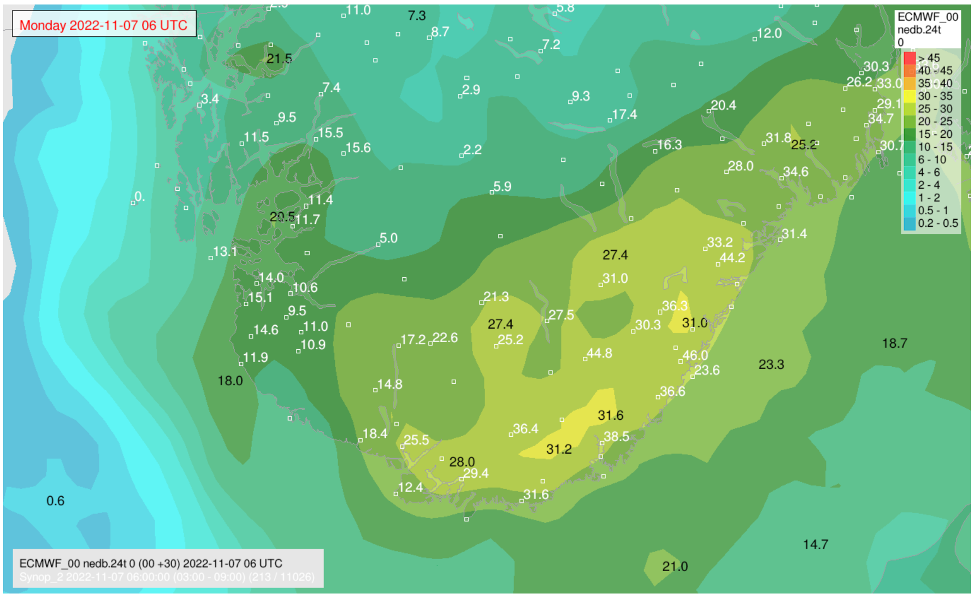
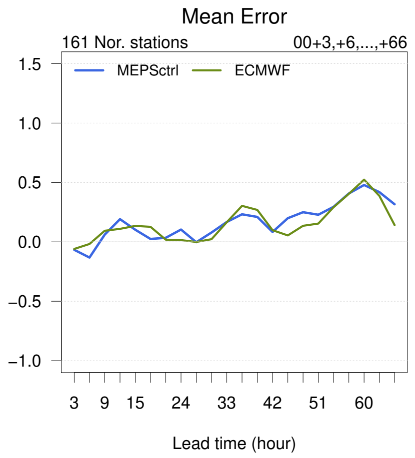
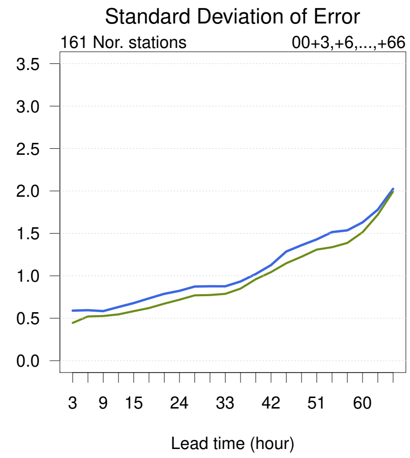
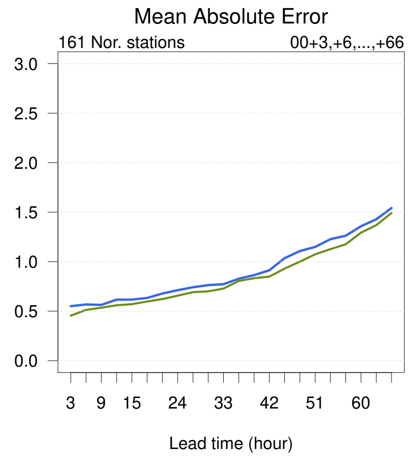


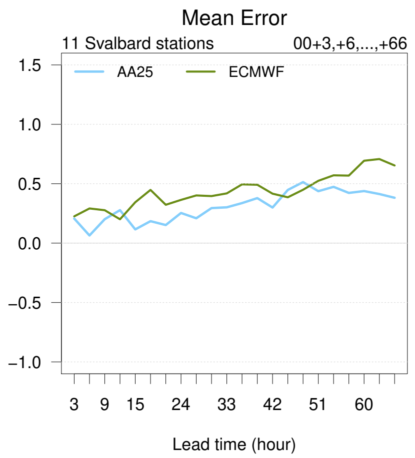
Figure 9: Typical performance from the ECMWF HRES, with precipitation covering a wider area, but with less definition and generally a tendency to underforecast precipitation in the maxima areas.

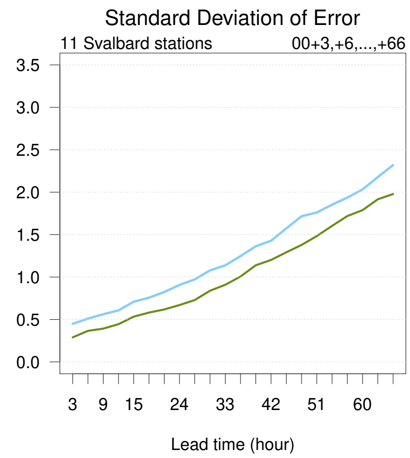
Summarized statistics

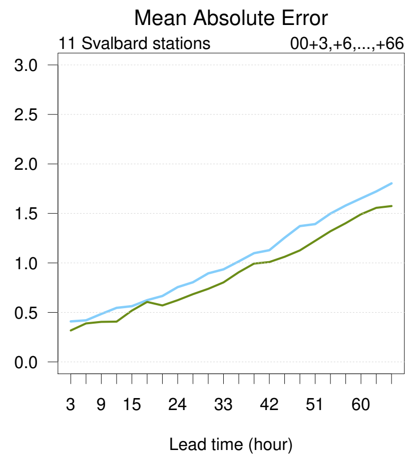

Mean Error
161 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

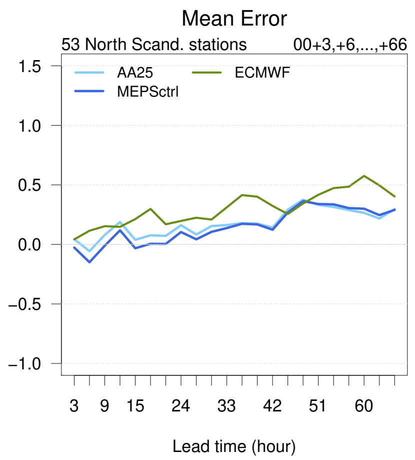

Standard Deviation of Error
161 Nor. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

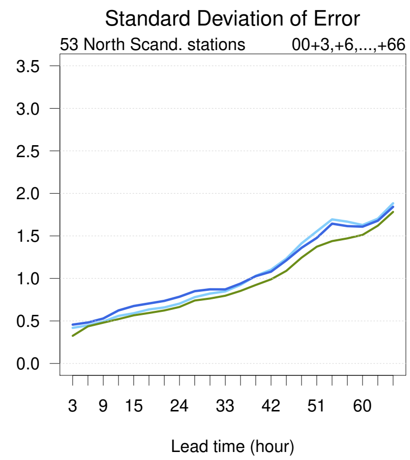

Mean Absolute Error
161 Nor. stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

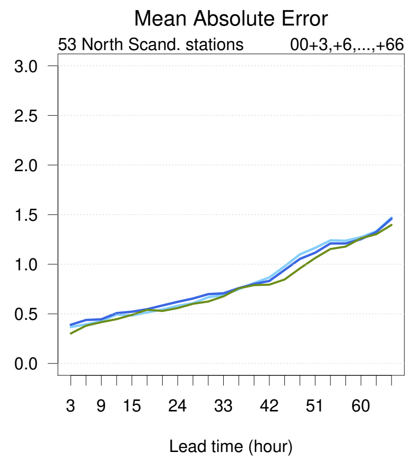

Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

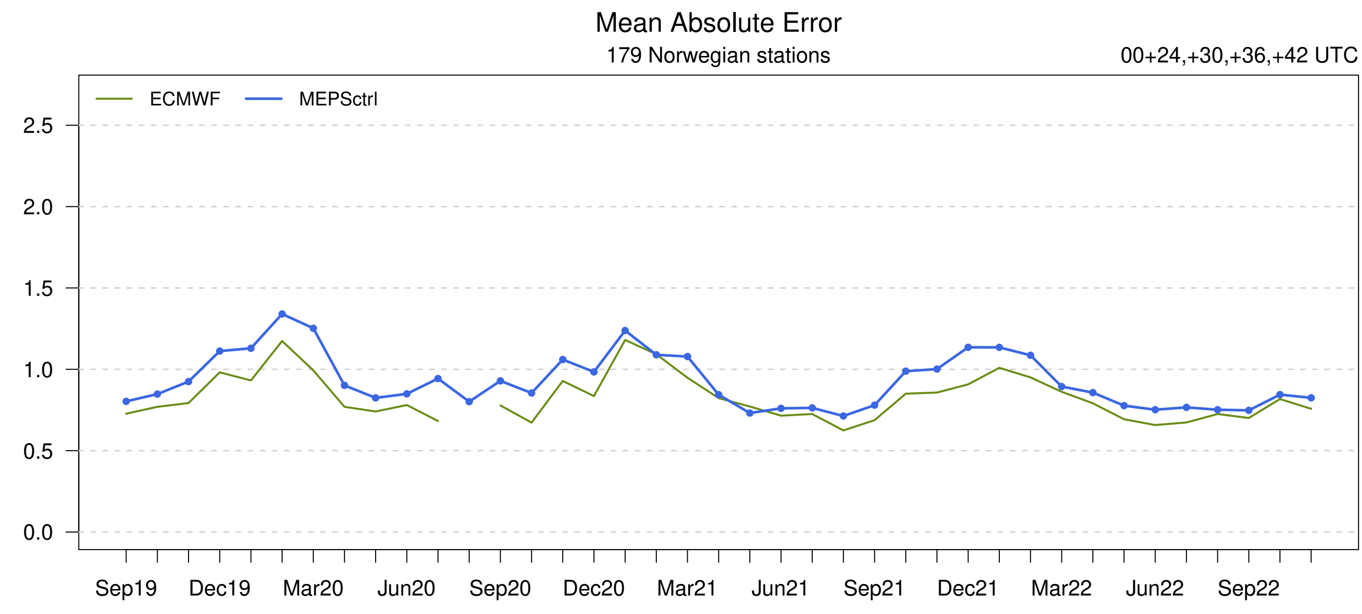

Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

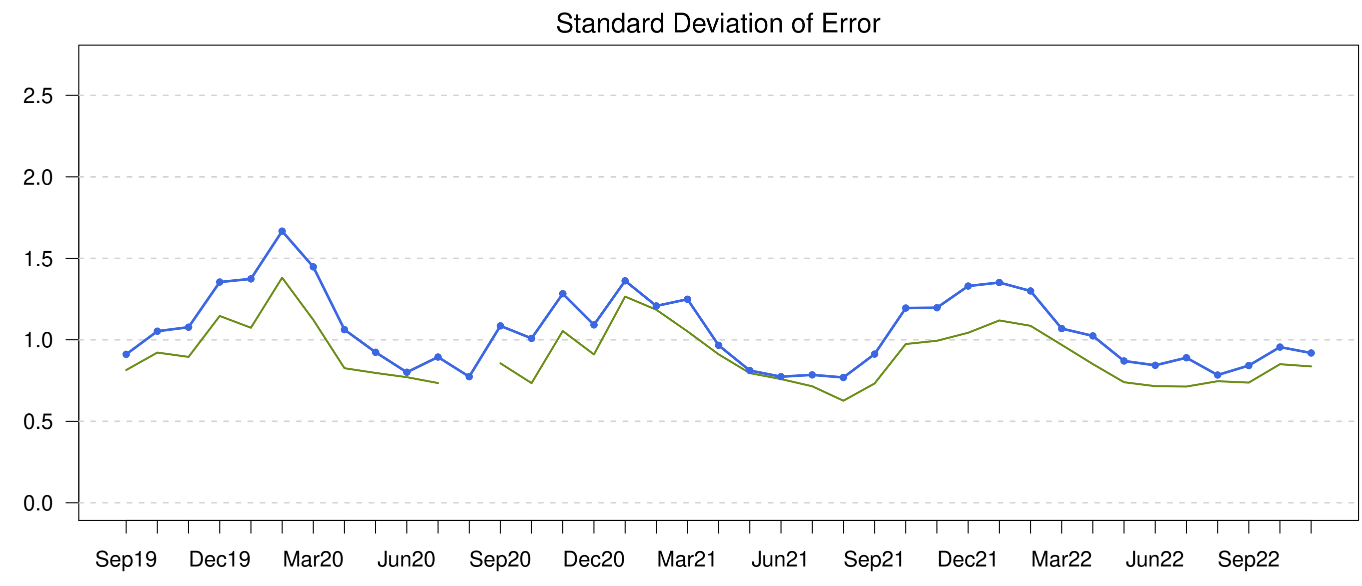

Mean Absolute Error
11 Svalbard stations
00+3,+6,...,+66
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)

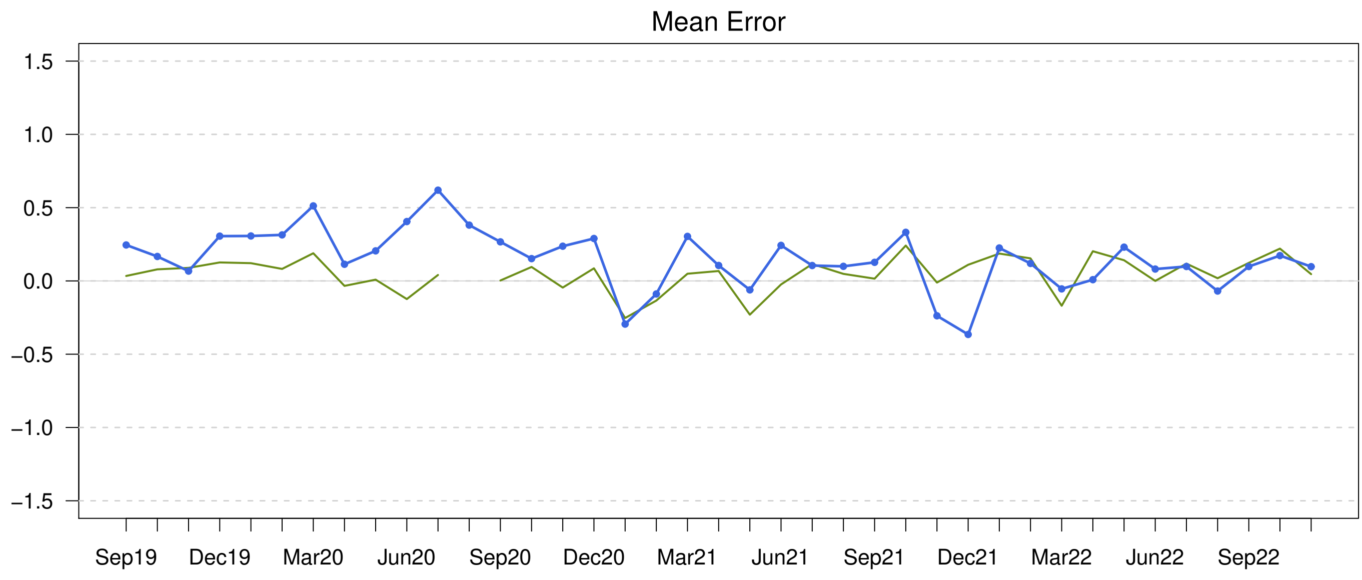

Mean Error
53 North Scand. stations
00+3,+6,...,+66
AA25
ECMWF
MEPSctrl
1.5
1.0
0.5
0.0
−0.5
−1.0
3 9 15 24 33 42 51 60
Lead time (hour)

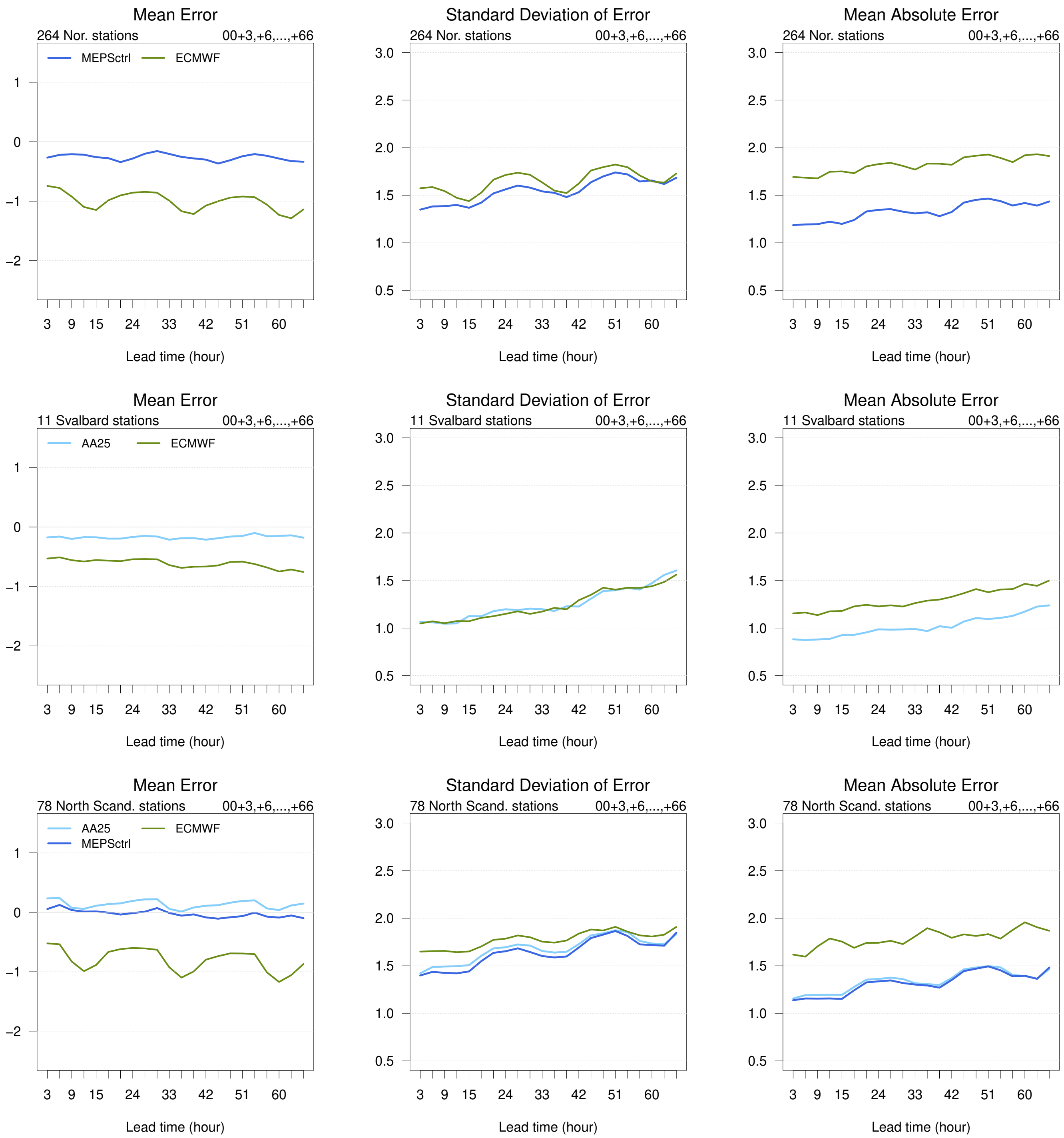

Standard Deviation of Error
53 North Scand. stations
00+3,+6,...,+66
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3 9 15 24 33 42 51 60
Lead time (hour)


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
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22

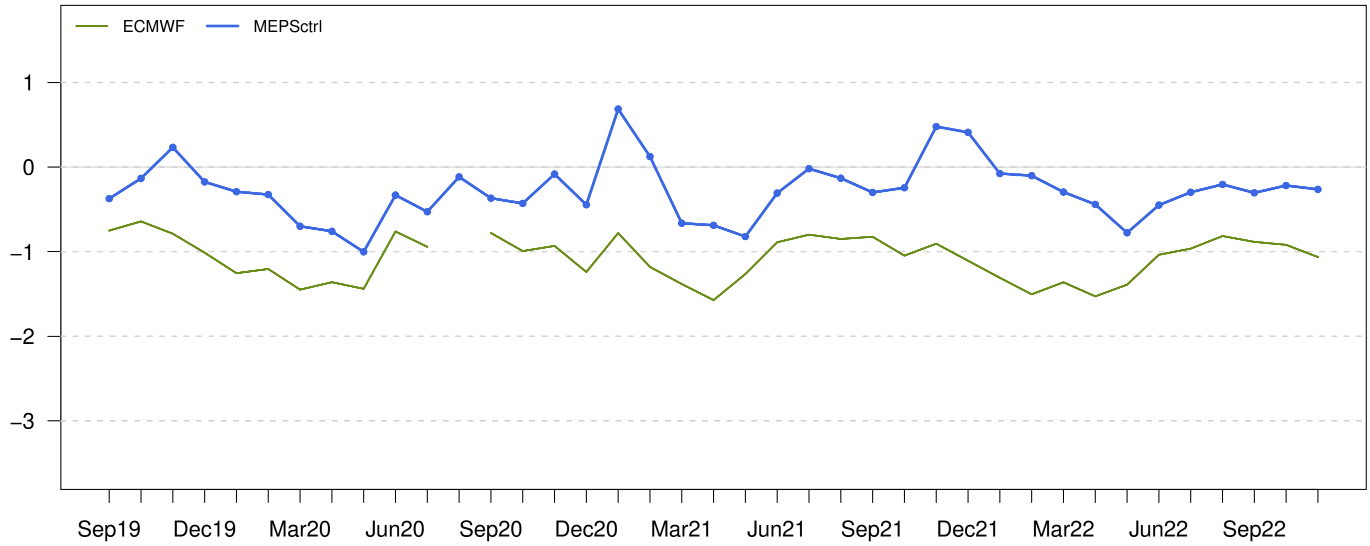

Standard Deviation of Error
2.5
2.0
1.5
1.0
0.5
0.0
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22


Mean Error
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22

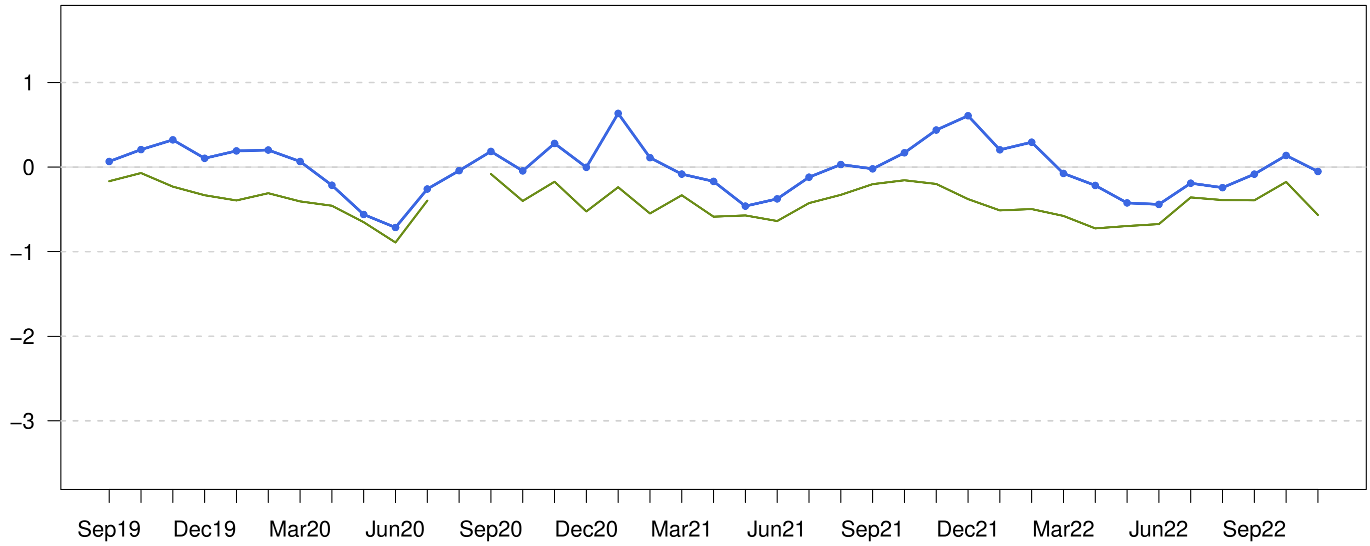

Mean Error
264 Nor. stations 00+3,+6,...,+66
MEPSctrl ECMWF
Standard Deviation of Error
264 Nor. stations 00+3,+6,...,+66
Mean Absolute Error
264 Nor. stations 00+3,+6,...,+66
Mean Error
11 Svalbard stations 00+3,+6,...,+66
AA25 ECMWF
Standard Deviation of Error
11 Svalbard stations 00+3,+6,...,+66
Mean Absolute Error
11 Svalbard stations 00+3,+6,...,+66
Mean Error
78 North Scand. stations 00+3,+6,...,+66
AA25 ECMWF
MEPSctrl
Standard Deviation of Error
78 North Scand. stations 00+3,+6,...,+66
Mean Absolute Error
78 North Scand. stations 00+3,+6,...,+66
Lead time (hour)
3 9 15 24 33 42 51 60

Mean Error

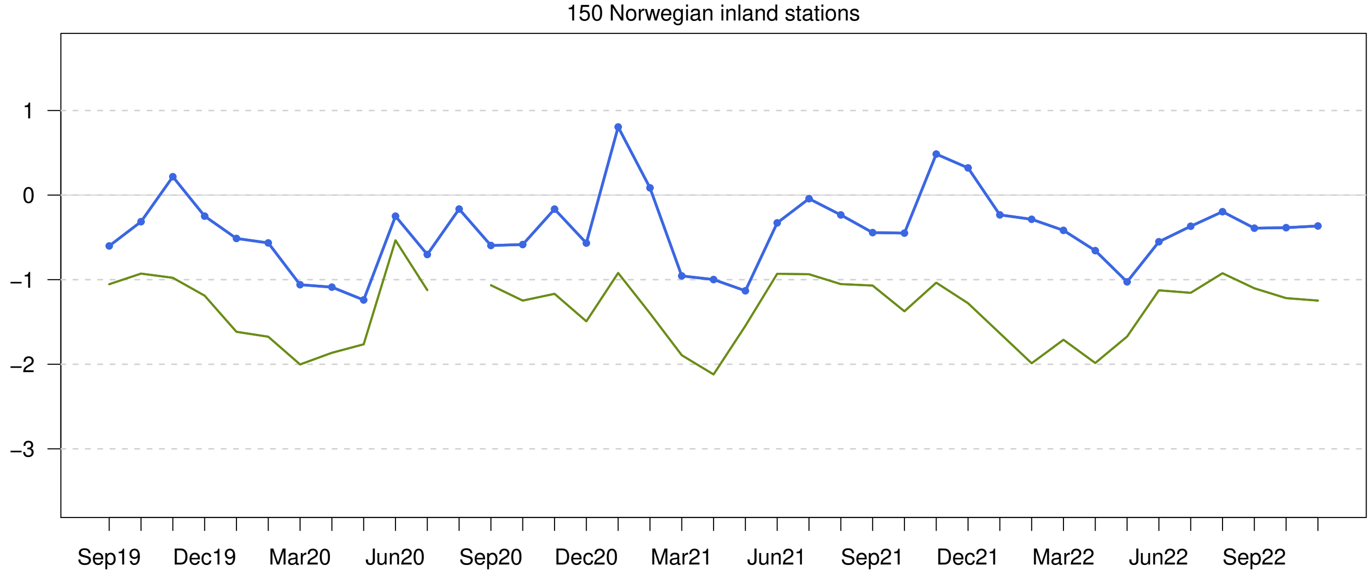
274 Norwegian stations 00+24,+30,+36,+42 UTC

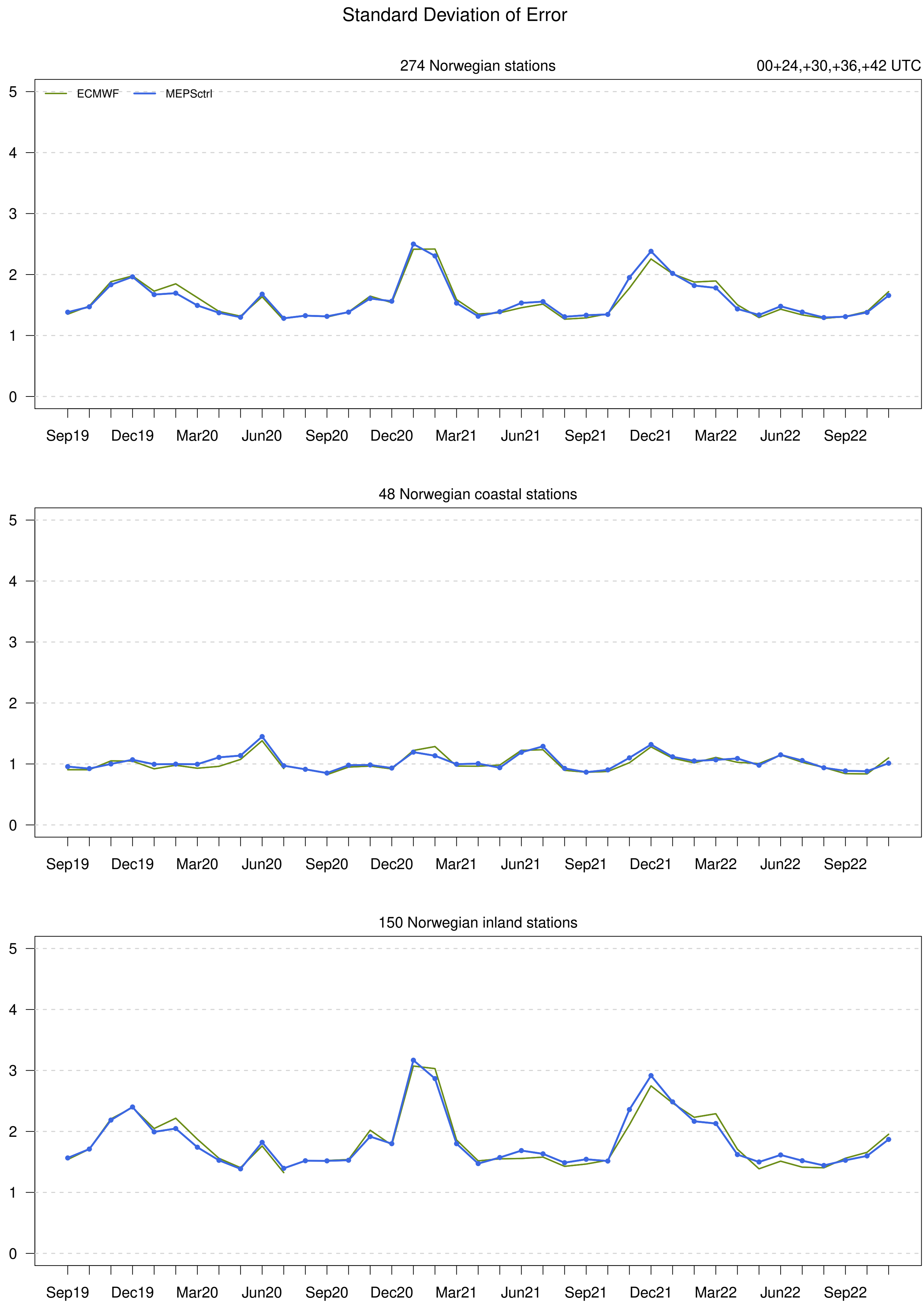


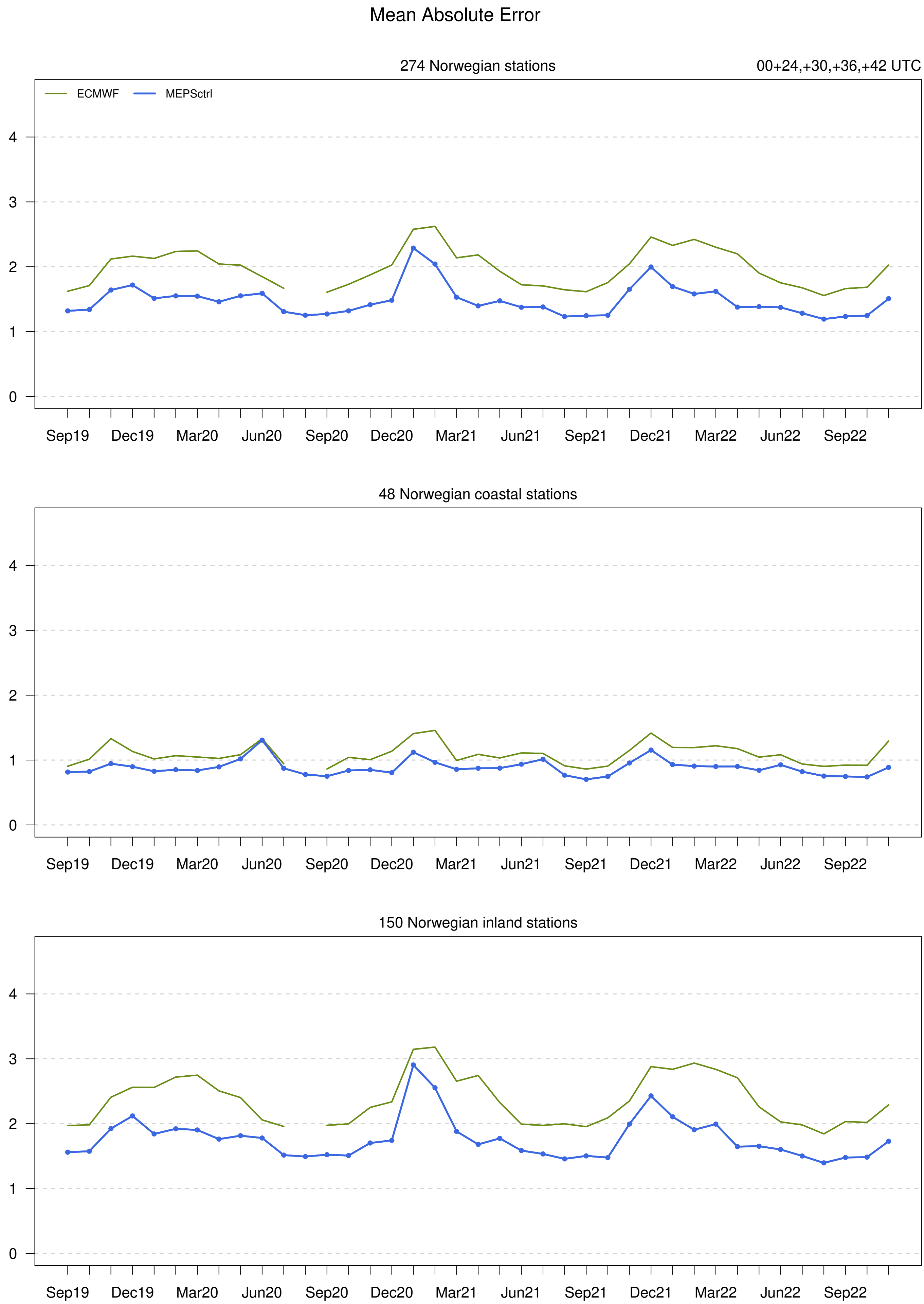
48 Norwegian coastal stations



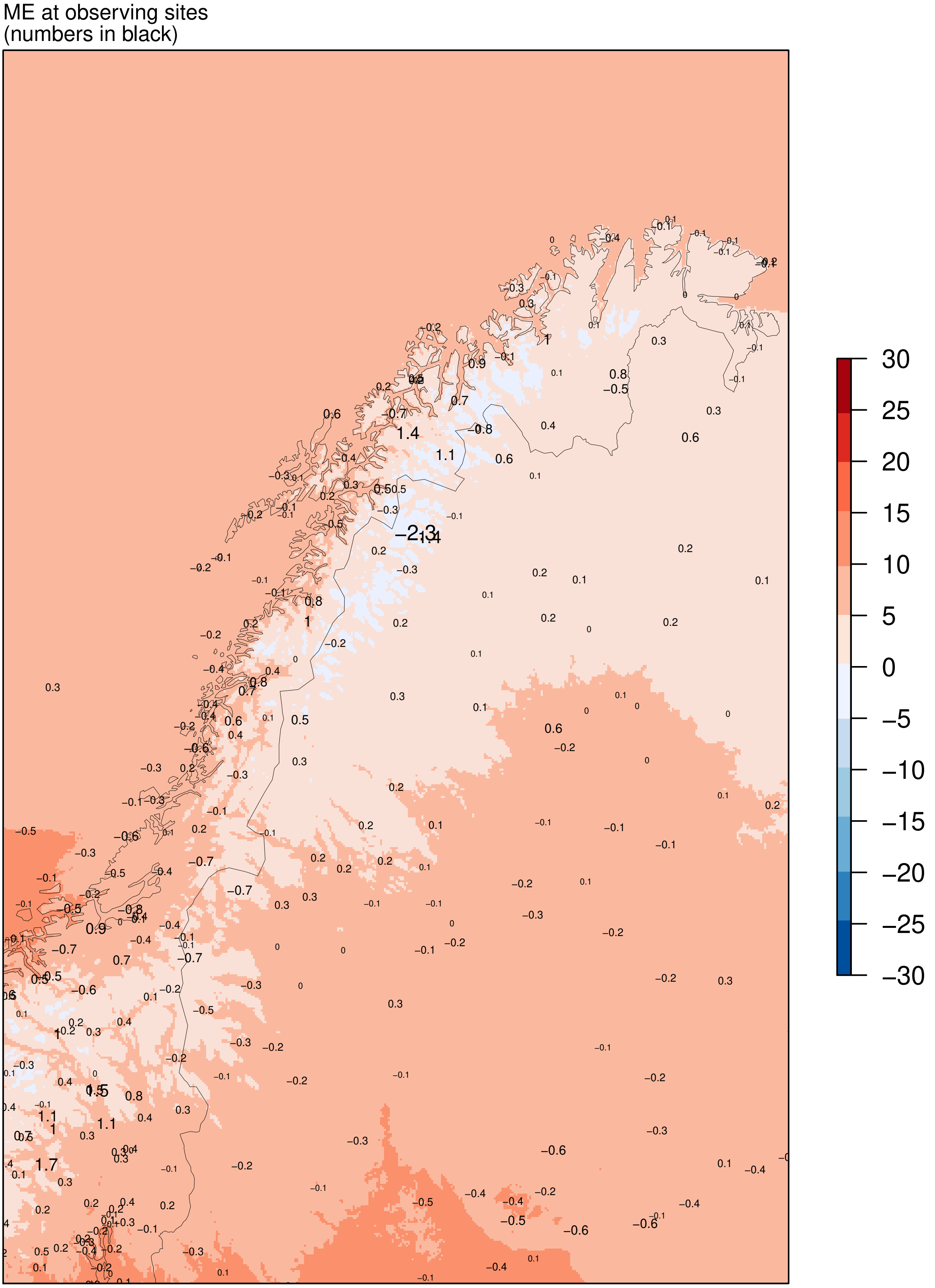
150 Norwegian inland stations




Standard Deviation of Error
274 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
0
1
2
3
4
5
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
48 Norwegian coastal stations
150 Norwegian inland stations


Mean Absolute Error
274 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
0
1
2
3
4
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
48 Norwegian coastal stations
150 Norwegian inland stations

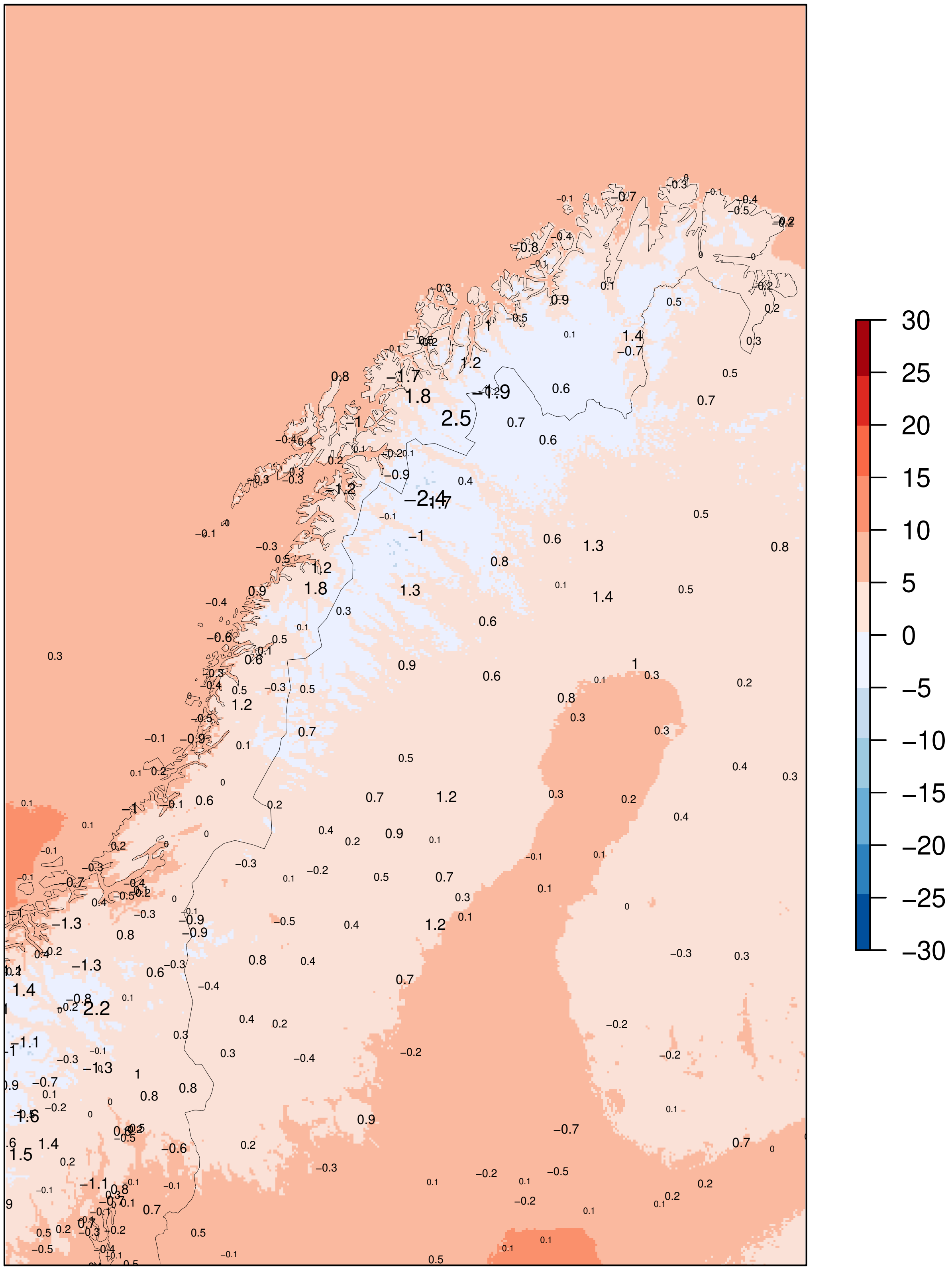
MEPSctrl 00+12



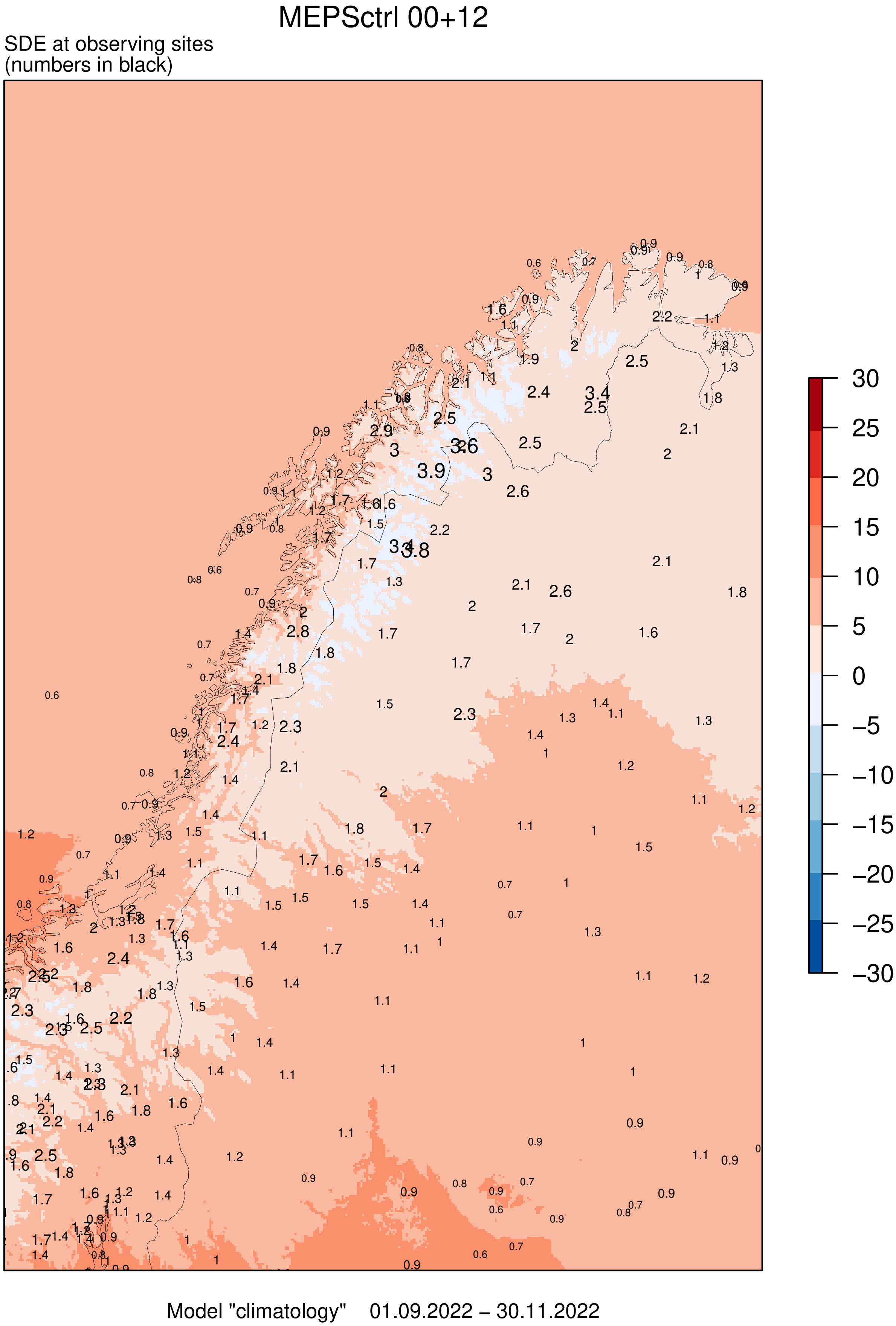
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+24

ME at observing sites
(numbers in black)

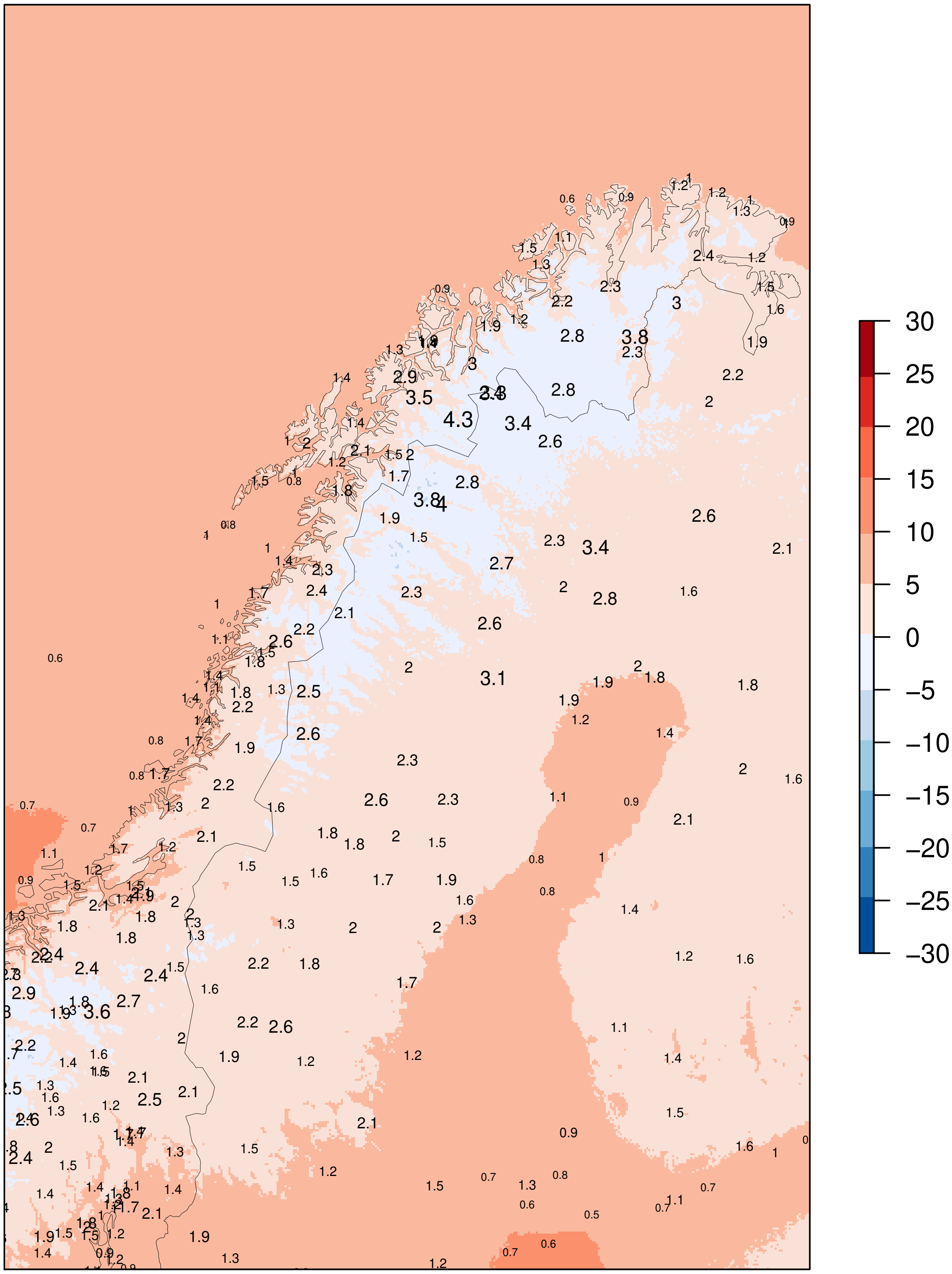


Model "climatology" 01.09.2022 – 30.11.2022


MEPSctrl 00+12
SDE at observing sites
(numbers in black)
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+24

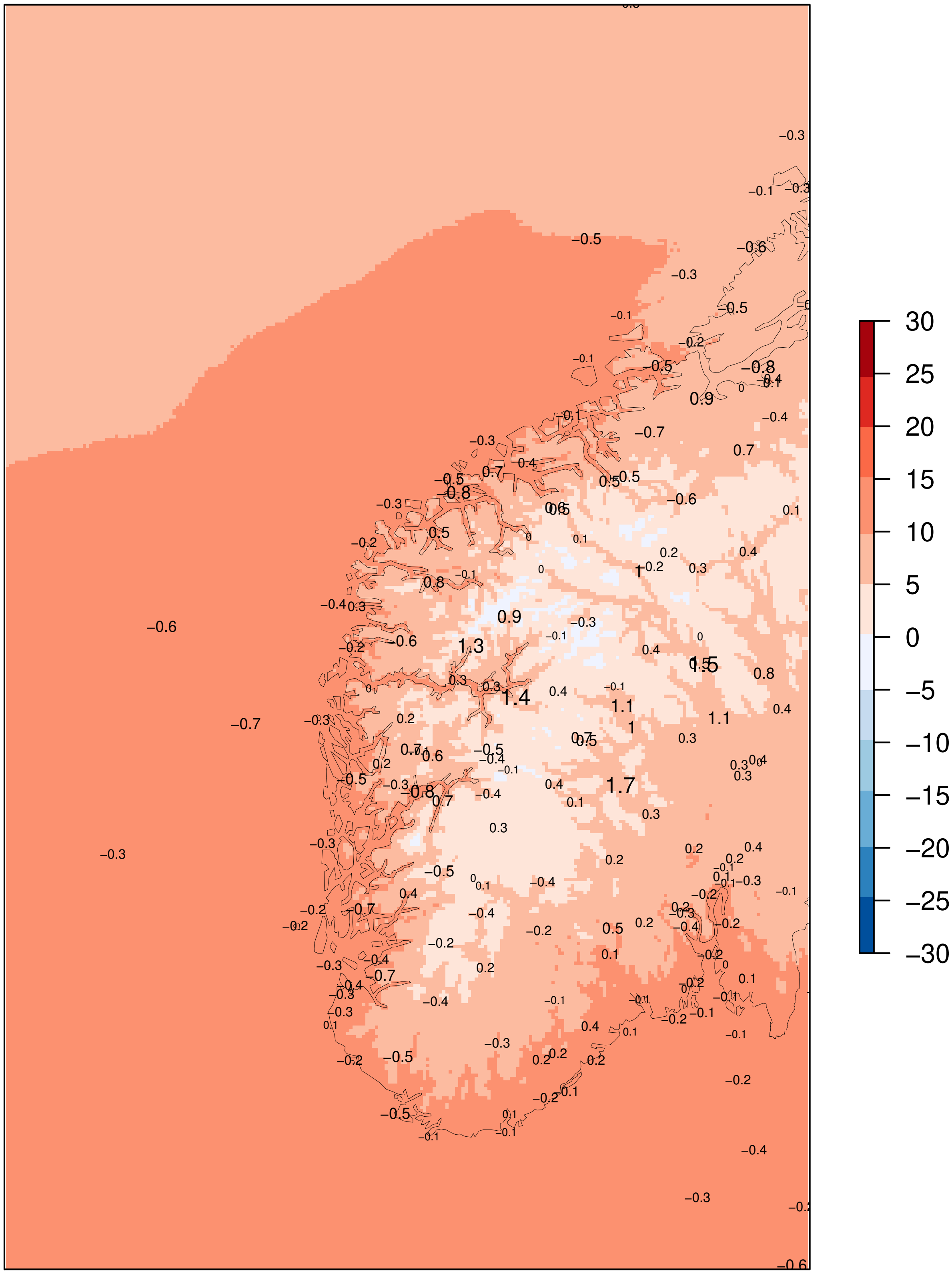
SDE at observing sites
(numbers in black)



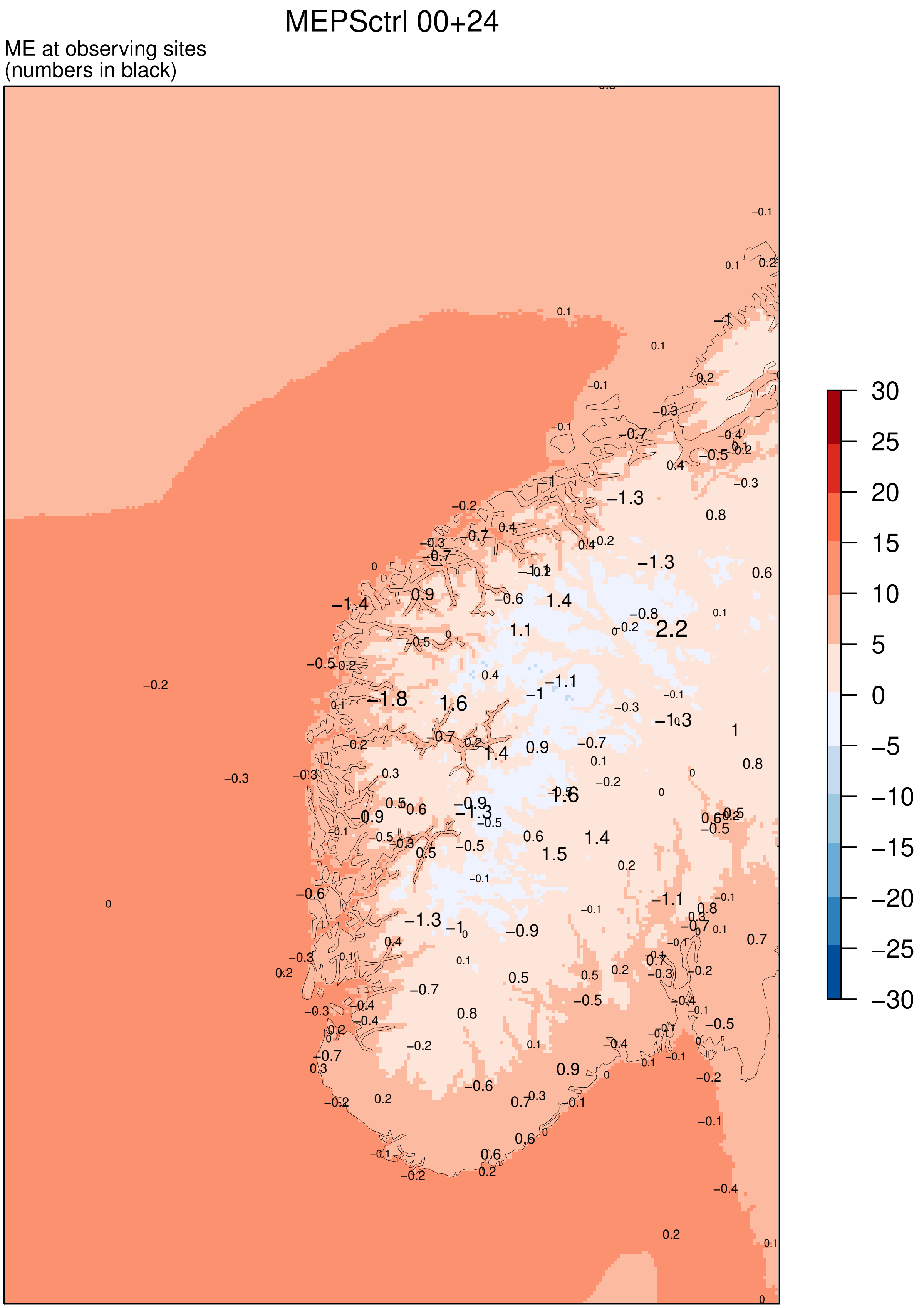
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+12

ME at observing sites
(numbers in black)



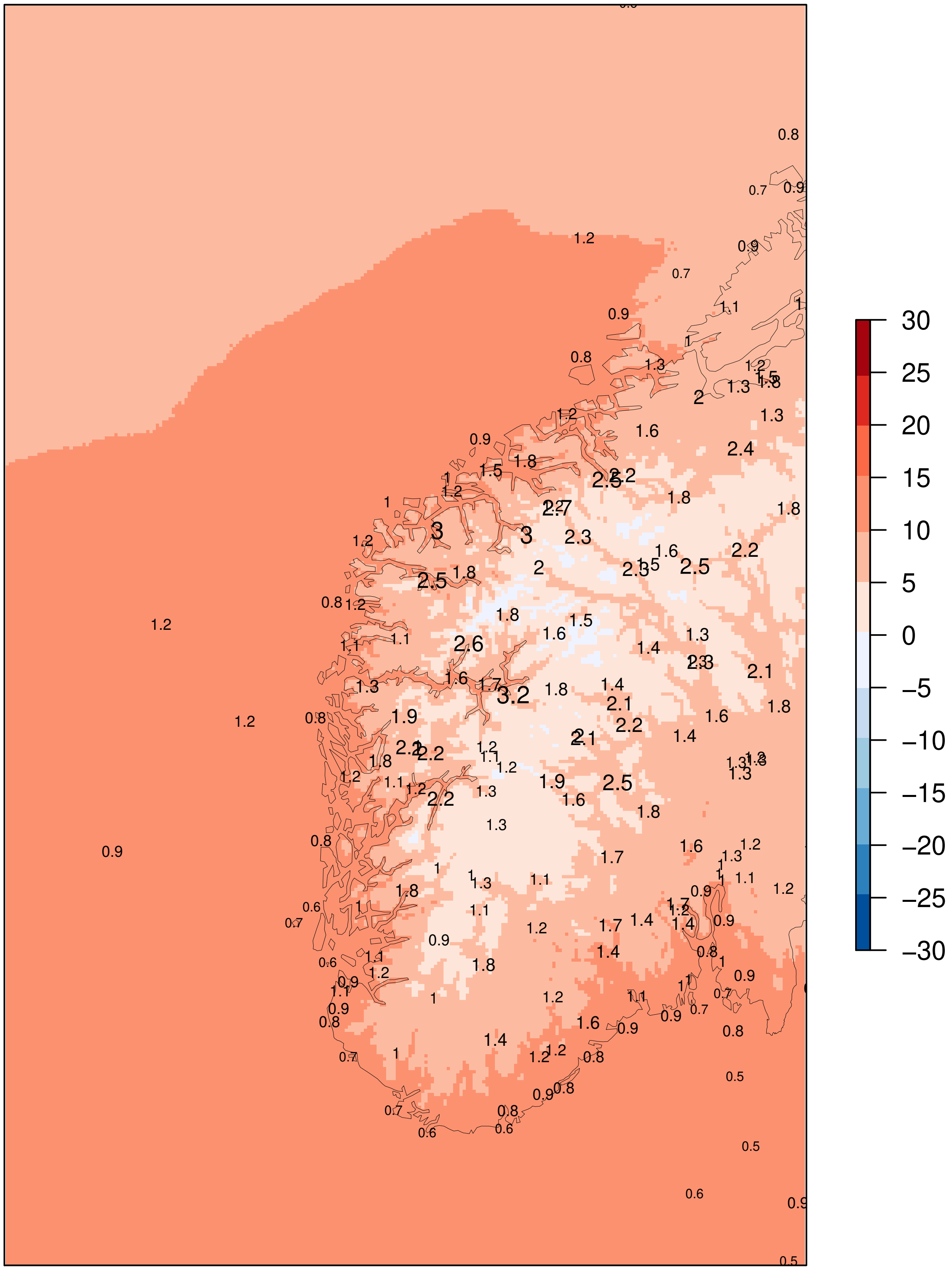
Model "climatology" 01.09.2022 – 30.11.2022



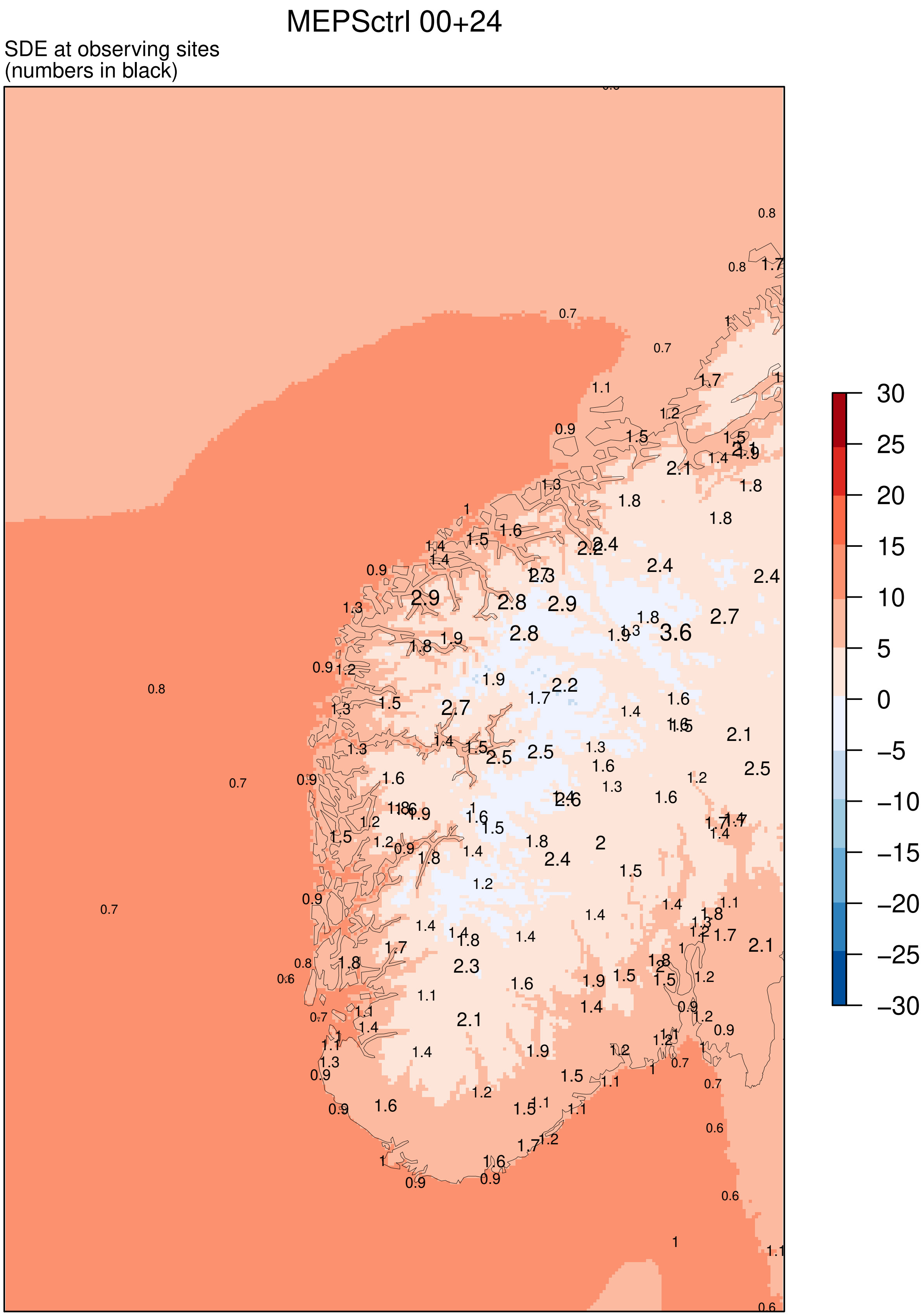
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+12

SDE at observing sites
(numbers in black)



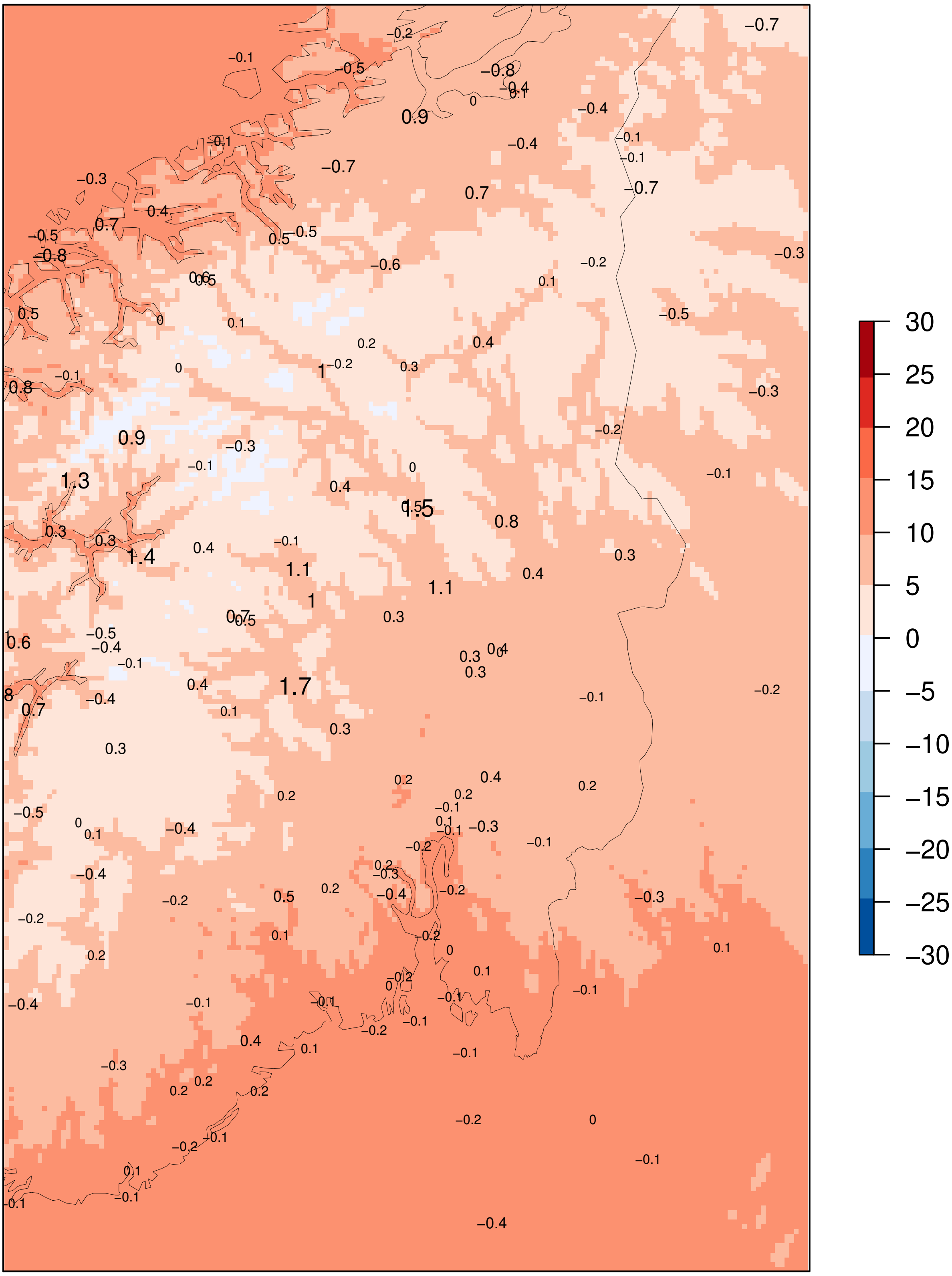
Model "climatology" 01.09.2022 – 30.11.2022



Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+12

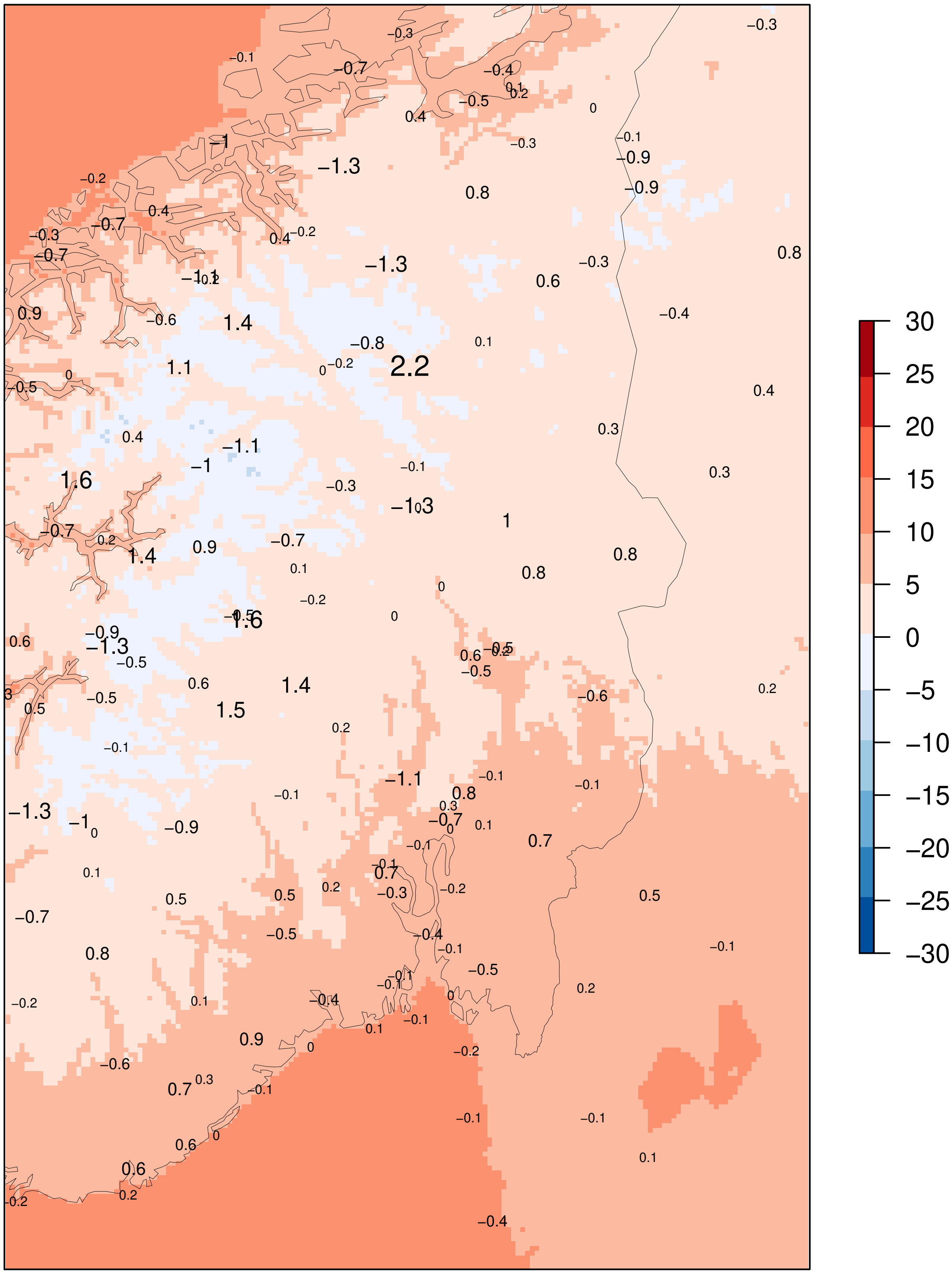
ME at observing sites
(numbers in black)



Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+24

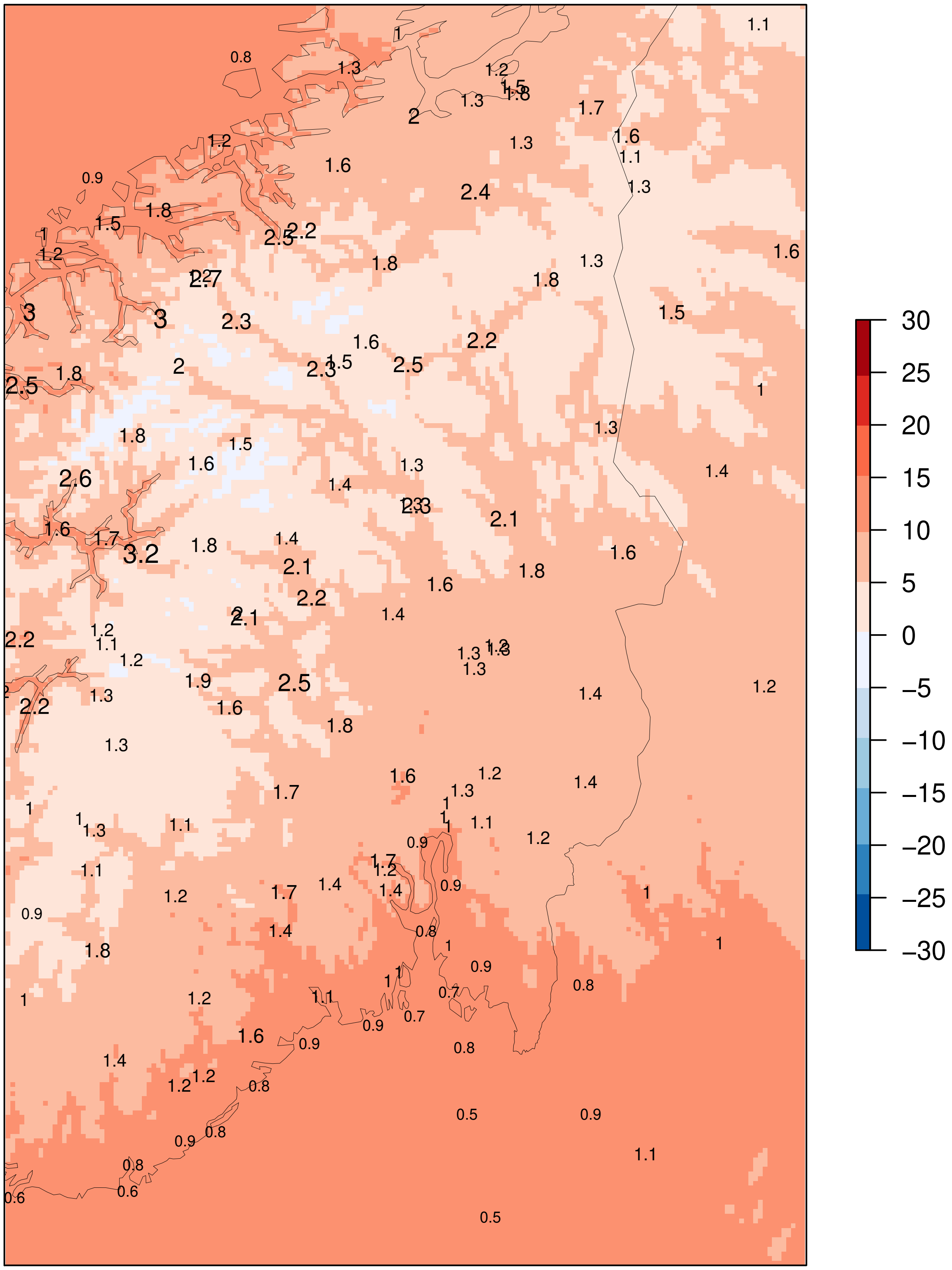
ME at observing sites
(numbers in black)



Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+12

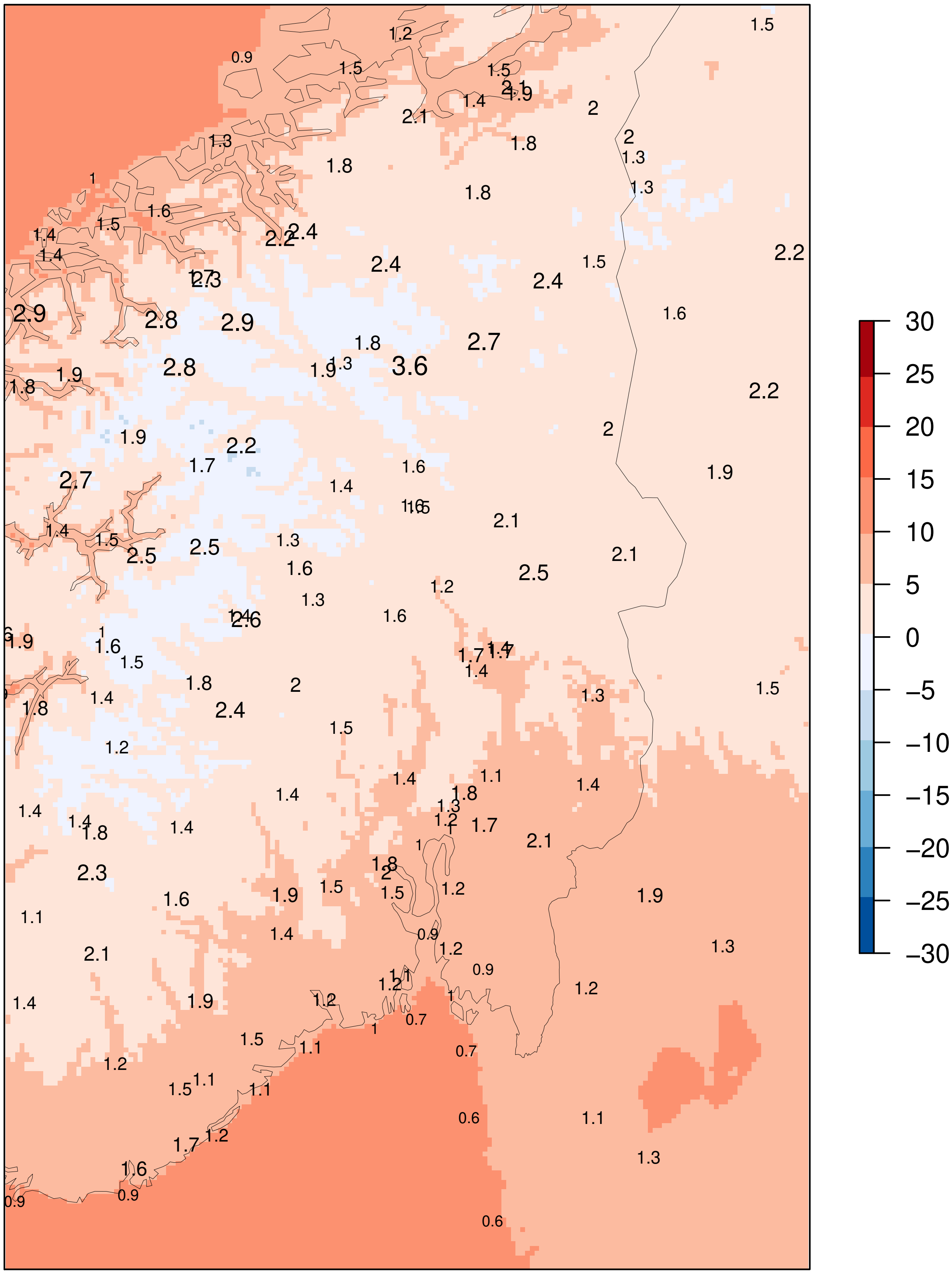
SDE at observing sites
(numbers in black)



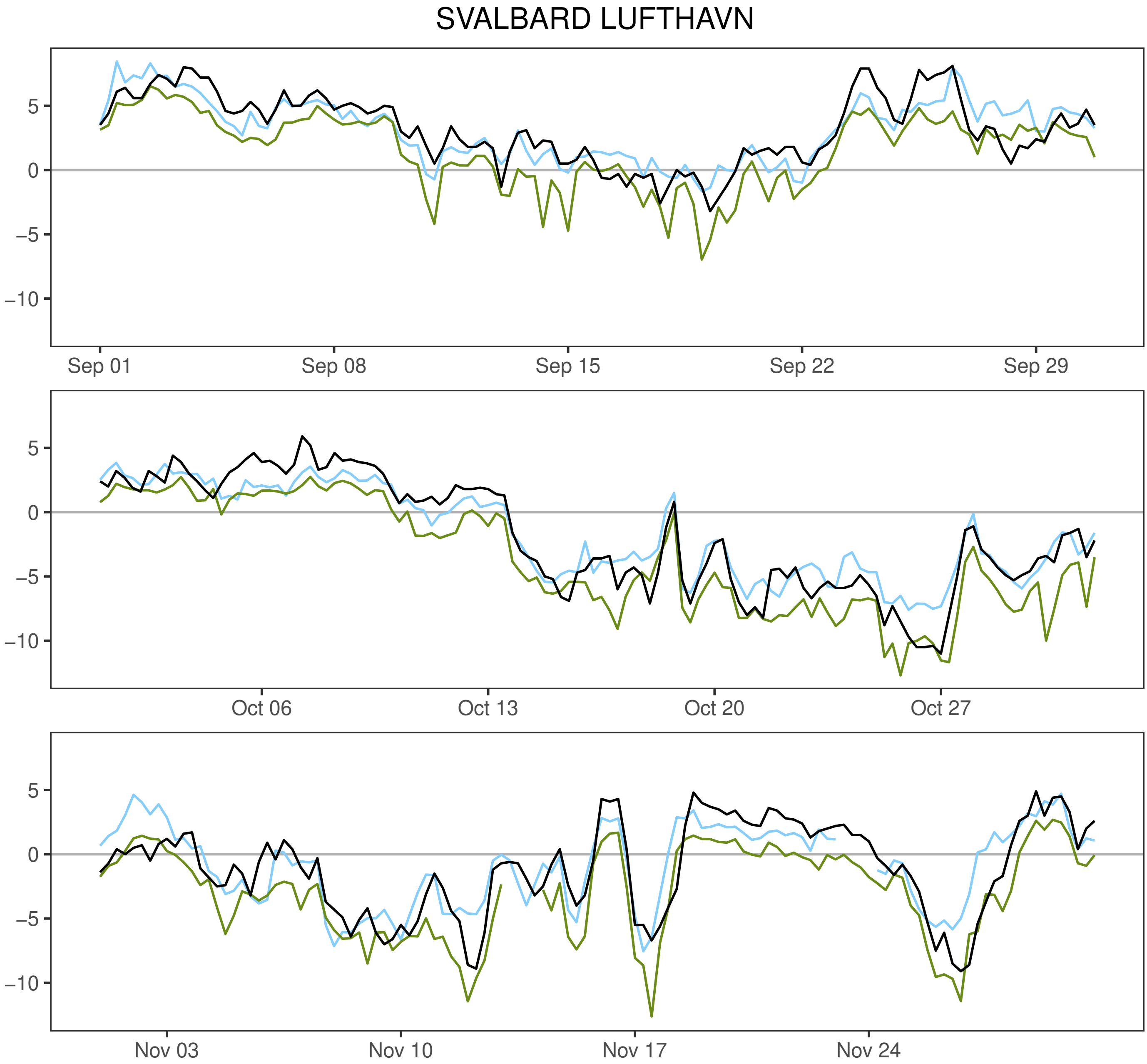
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+24

SDE at observing sites
(numbers in black)

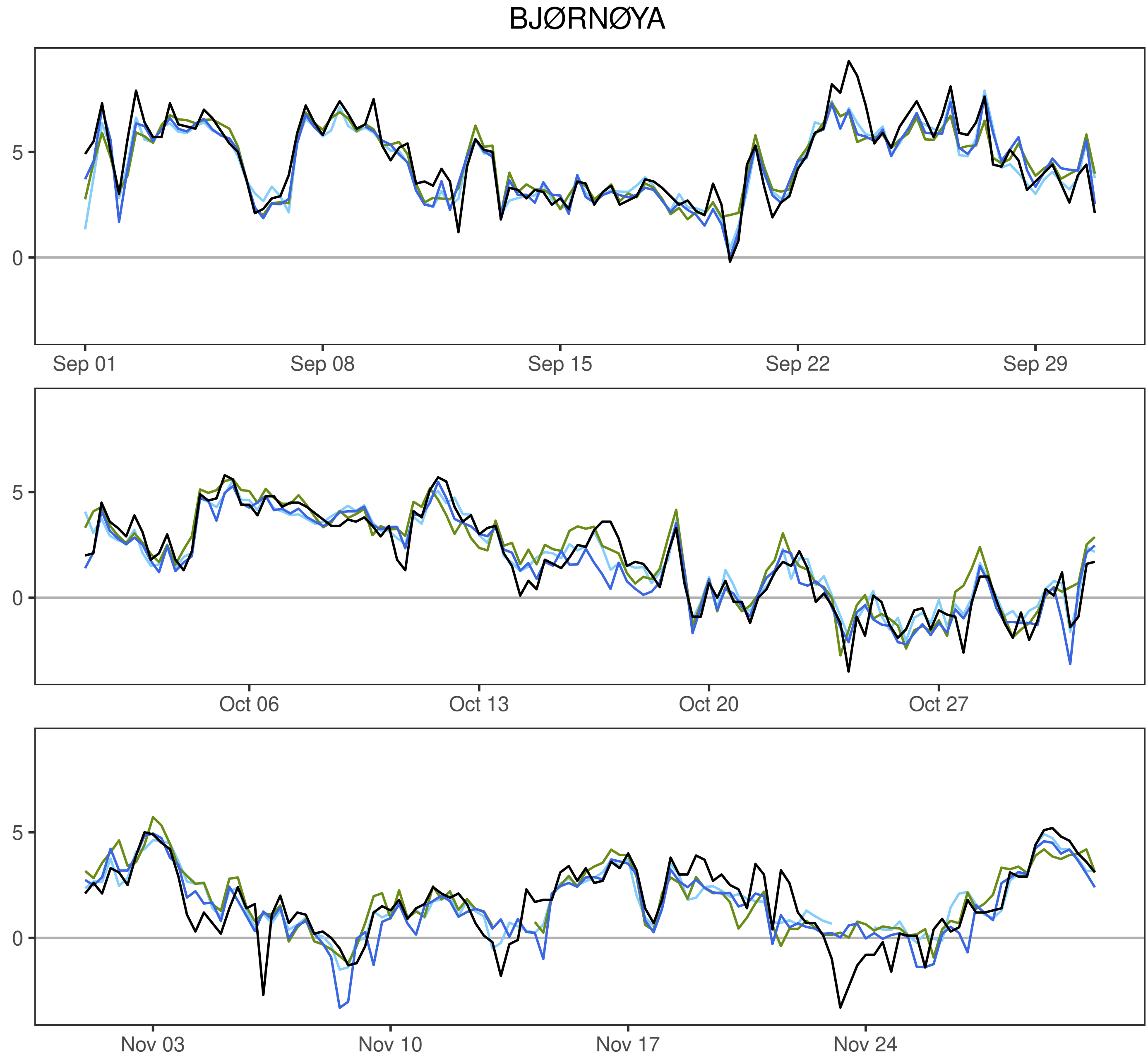


Model "climatology" 01.09.2022 – 30.11.2022



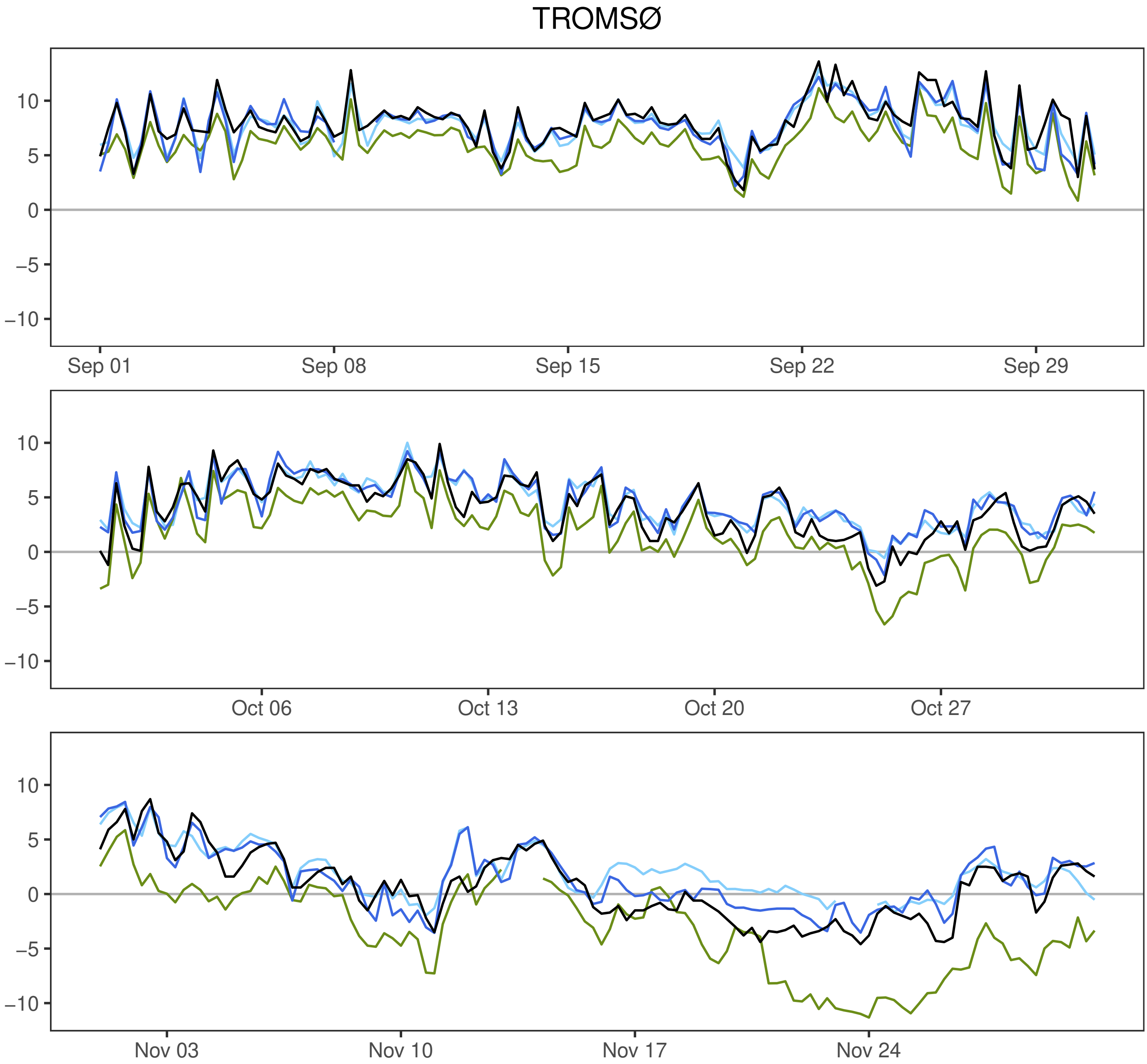
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−11.0	0.1	8.1	4.2	364
AA25: 12+18,+24,+30,+36	−7.6	0.2	8.4	3.7	360
ECMWF: 12+18,+24,+30,+36	−12.7	−1.7	6.5	4.3	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.1	1.6	1.6	1.3	5.6	356
ECMWF−synop	−1.8	1.4	2.3	1.9	6.7	356



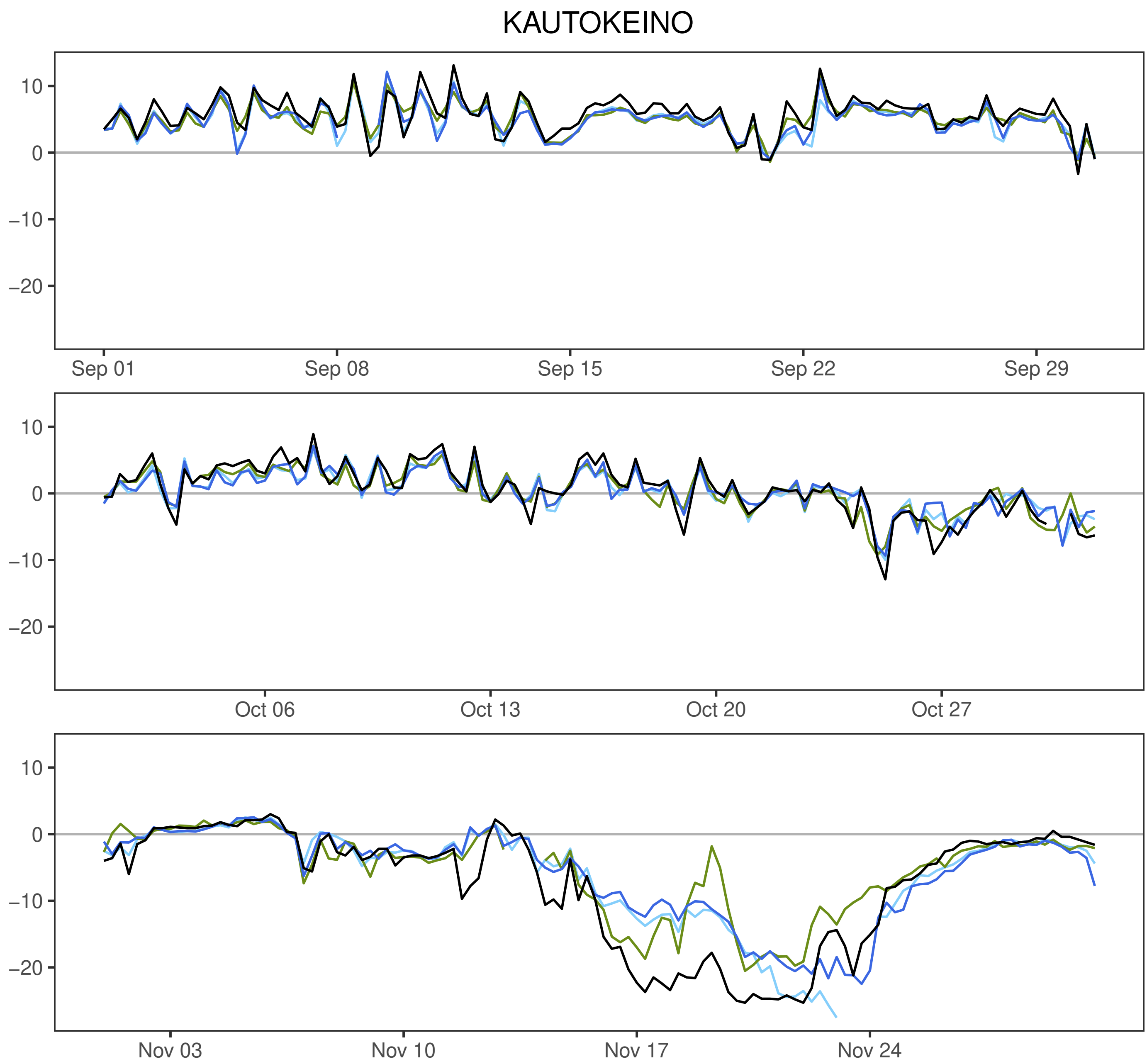
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−3.5	2.7	9.3	2.4	364
MEPSctrl: 12+18,+24,+30,+36	−3.3	2.4	7.7	2.2	360
AA25: 12+18,+24,+30,+36	−2.0	2.7	7.9	2.1	360
ECMWF: 12+18,+24,+30,+36	−2.7	2.8	7.3	2.1	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	0.8	0.8	0.6	3.9	352
AA25−synop	−0.1	0.8	0.8	0.6	3.8	352
ECMWF−synop	0.1	0.9	0.9	0.7	3.9	352



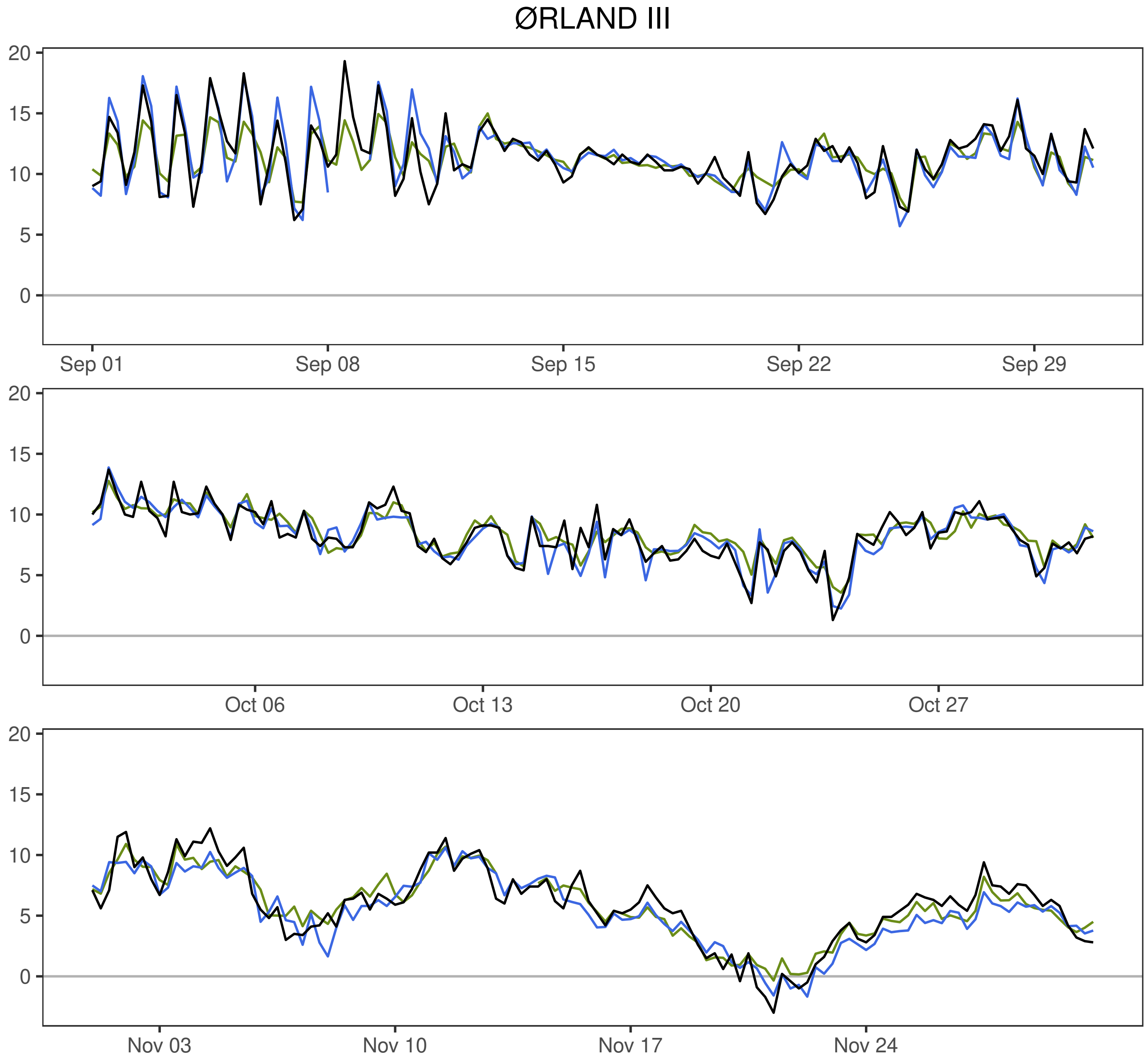
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−4.6	4.2	13.6	4.0	364
MEPSctrl: 12+18,+24,+30,+36	−3.6	4.5	12.2	3.6	360
AA25: 12+18,+24,+30,+36	−2.0	4.8	12.9	3.2	360
ECMWF: 12+18,+24,+30,+36	−11.3	1.5	11.2	4.9	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.3	1.3	1.3	1.0	5.9	352
AA25−synop	0.6	1.5	1.6	1.2	5.9	352
ECMWF−synop	−2.6	1.9	3.2	2.6	8.6	352



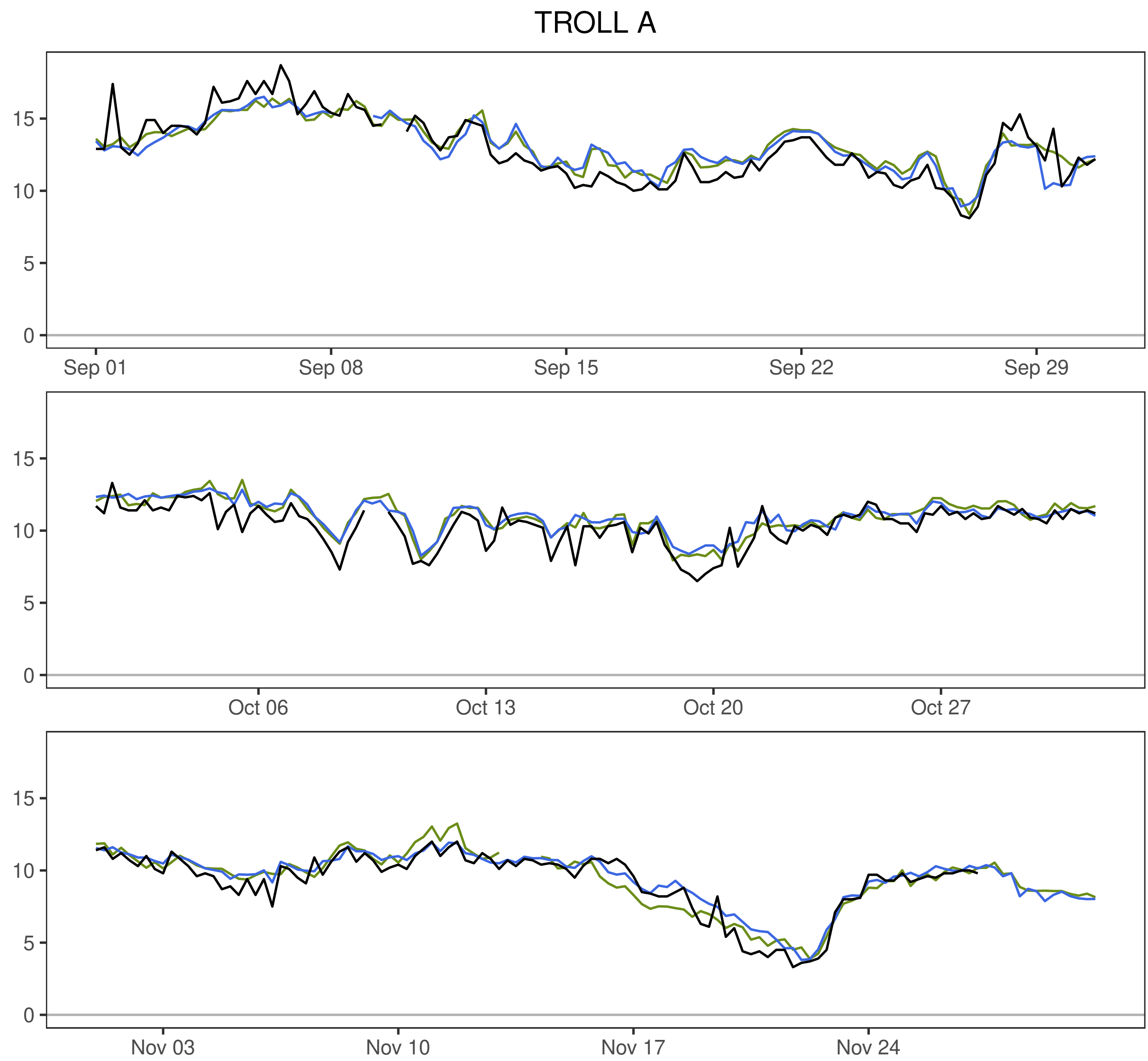
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−25.3	−0.5	13.1	8.0	362
MEPSctrl: 12+18,+24,+30,+36	−22.5	−0.3	12.1	6.3	360
AA25: 12+18,+24,+30,+36	−27.5	−0.2	12.2	6.4	360
ECMWF: 12+18,+24,+30,+36	−20.5	0.0	11.7	6.0	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.3	3.0	3.0	1.9	12.8	350
AA25−synop	0.1	2.8	2.8	1.8	13.1	350
ECMWF−synop	0.4	2.8	2.9	1.7	16.0	350



	Min	Mean	Max	Std	N
synop: 00,06,12,18	−3.0	8.5	19.3	3.5	364
MEPSctrl: 12+18,+24,+30,+36	−1.7	8.3	18.1	3.5	360
ECMWF: 12+18,+24,+30,+36	−0.3	8.5	15.0	3.0	360

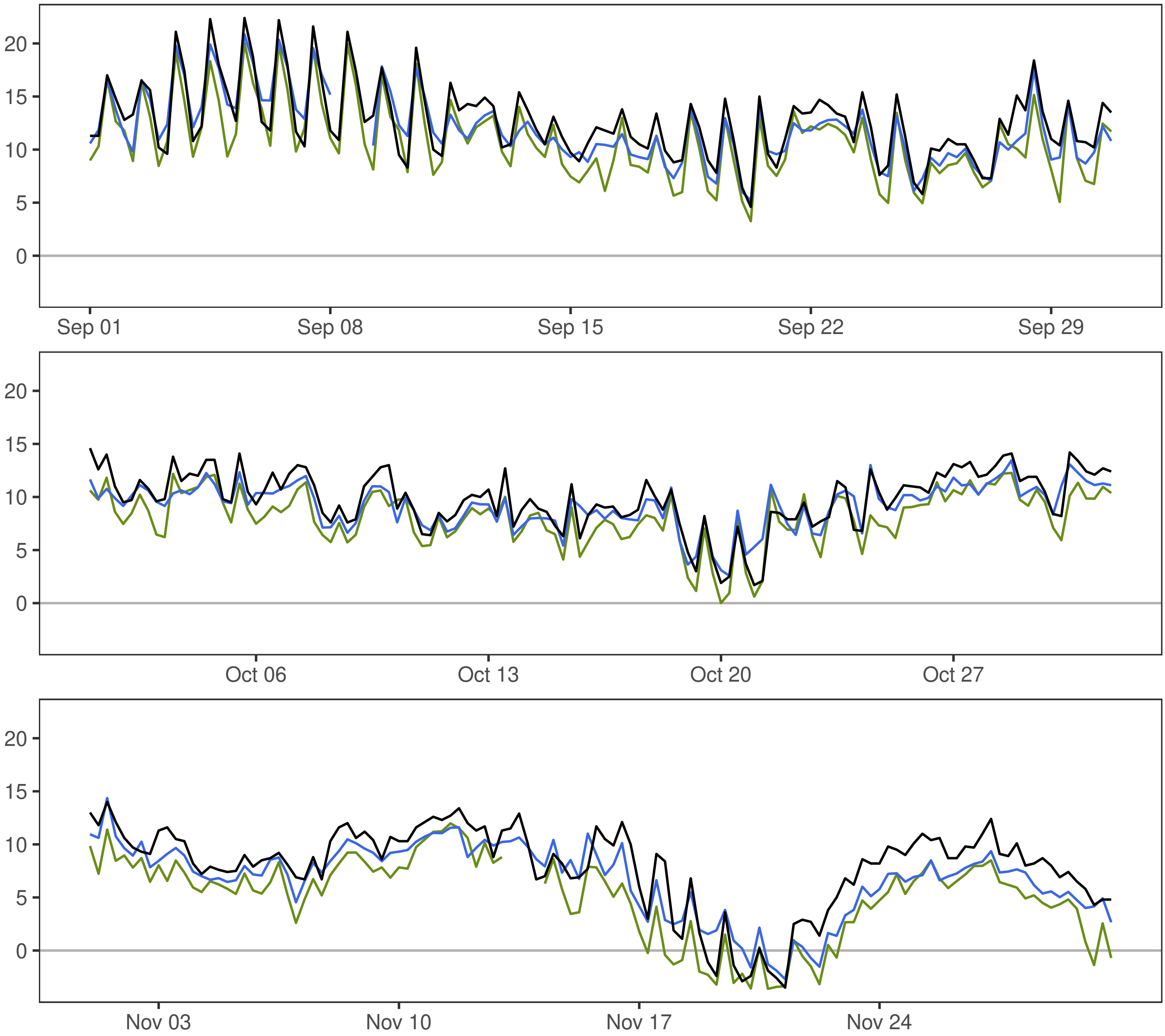
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.1	1.1	0.9	4.6	356
ECMWF−synop	0.0	1.2	1.2	0.9	4.3	356



	Min	Mean	Max	Std	N
synop: 00,06,12,18	3.3	10.9	18.7	2.5	346
MEPSctrl: 12+18,+24,+30,+36	3.8	11.1	16.5	2.1	360
ECMWF: 12+18,+24,+30,+36	3.9	11.2	16.4	2.3	360

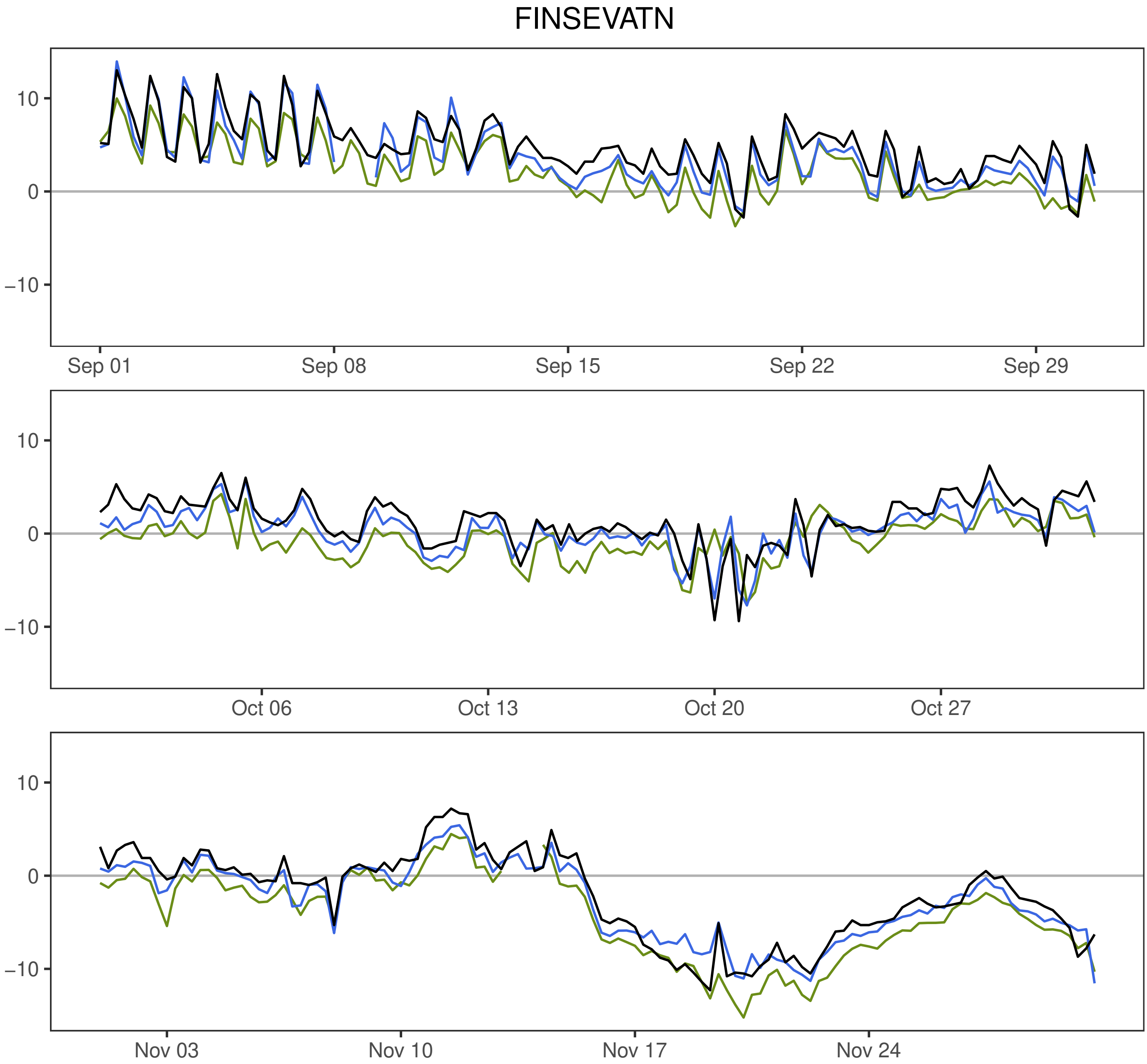
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	0.9	1.0	0.7	4.3	338
ECMWF−synop	0.4	0.9	0.9	0.7	4.2	338

BERGEN – FLORIDA



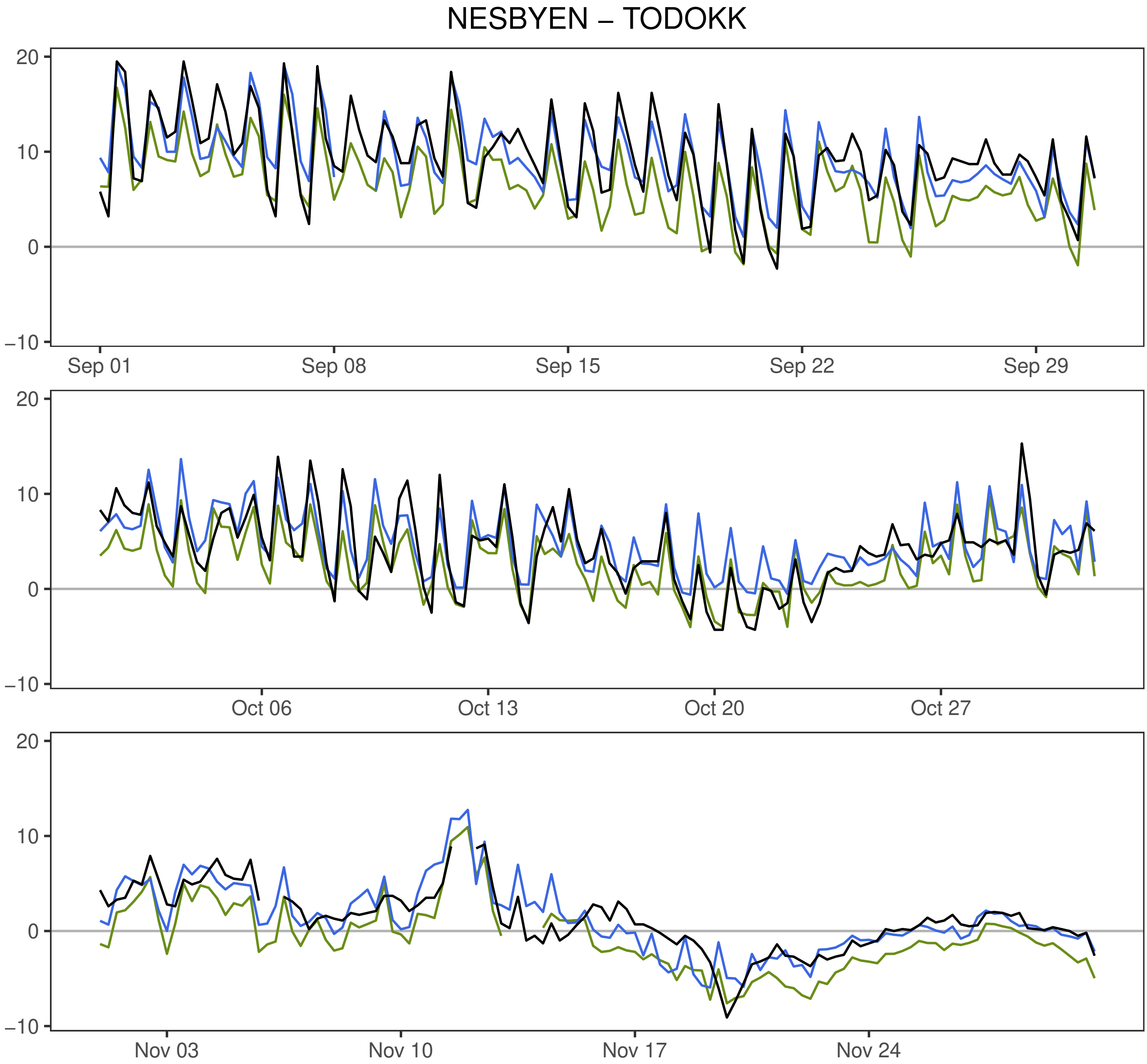
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−3.5	10.1	22.4	4.0	364
MEPSctrl: 12+18,+24,+30,+36	−2.7	9.2	20.9	3.6	360
ECMWF: 12+18,+24,+30,+36	−3.6	8.0	20.0	4.1	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.8	1.5	1.7	1.4	5.5	356
ECMWF−synop	−2.1	1.4	2.5	2.2	8.8	356



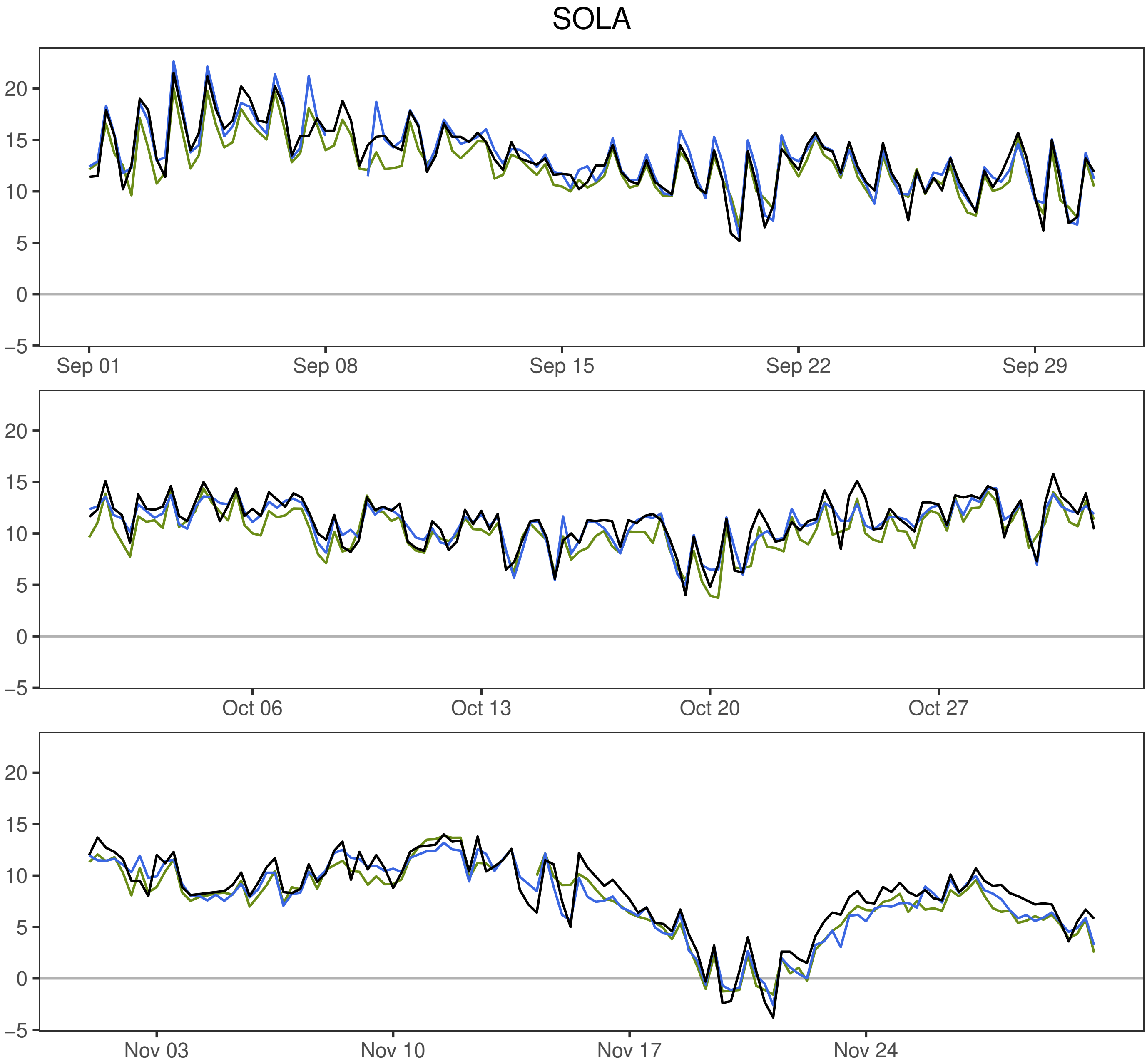
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−12.3	1.3	13.0	4.6	364
MEPSctrl: 12+18,+24,+30,+36	−11.6	0.4	14.0	4.3	360
ECMWF: 12+18,+24,+30,+36	−15.2	−0.8	10.0	4.4	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.8	1.3	1.5	1.2	5.4	356
ECMWF−synop	−2.1	1.6	2.7	2.4	9.7	356



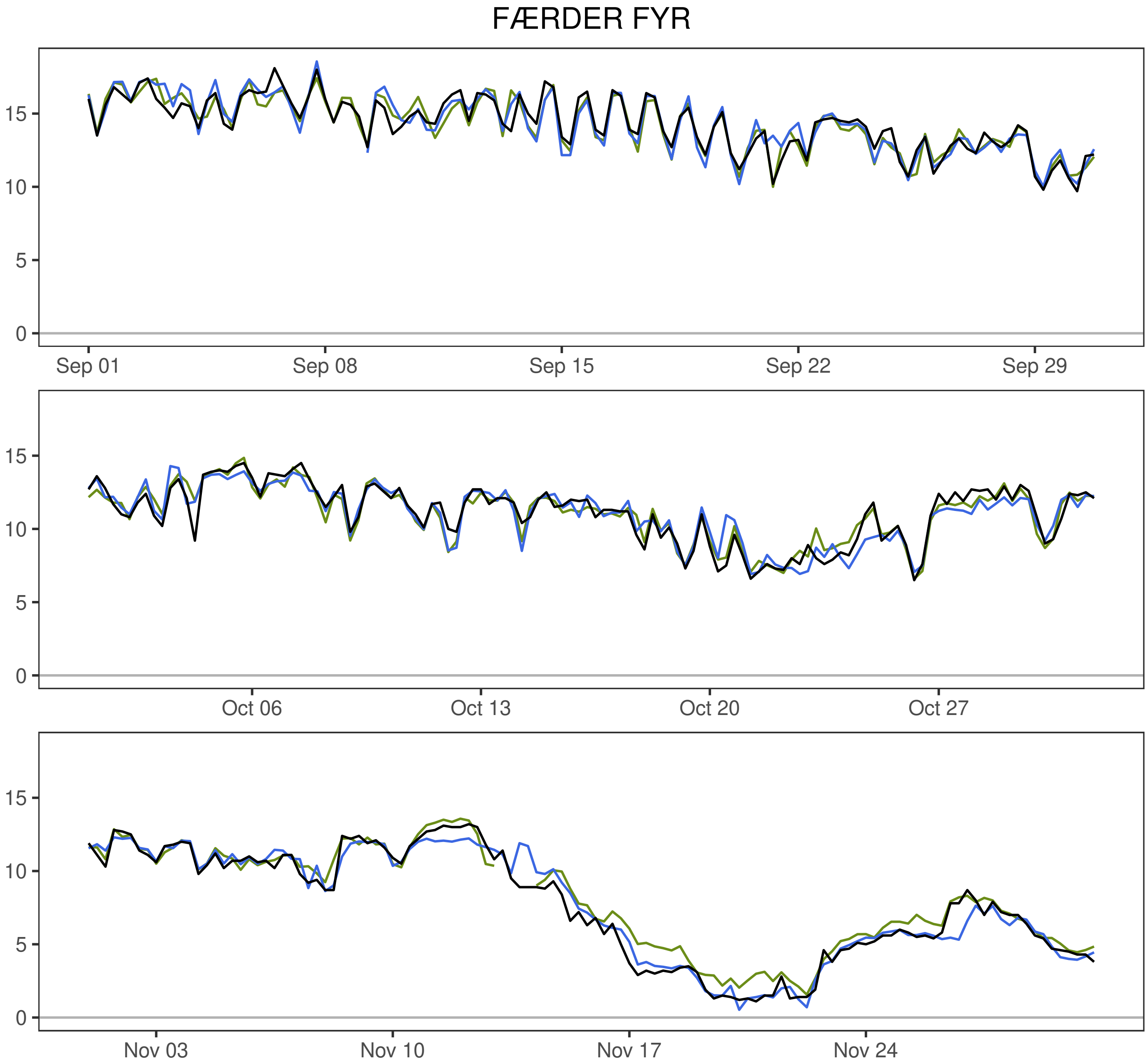
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−9.1	4.9	19.5	5.3	360
MEPSctrl: 12+18,+24,+30,+36	−5.9	5.1	19.2	4.9	360
ECMWF: 12+18,+24,+30,+36	−7.6	2.8	16.7	4.6	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	2.3	2.3	1.8	6.0	352
ECMWF−synop	−2.2	2.1	3.0	2.6	7.7	352



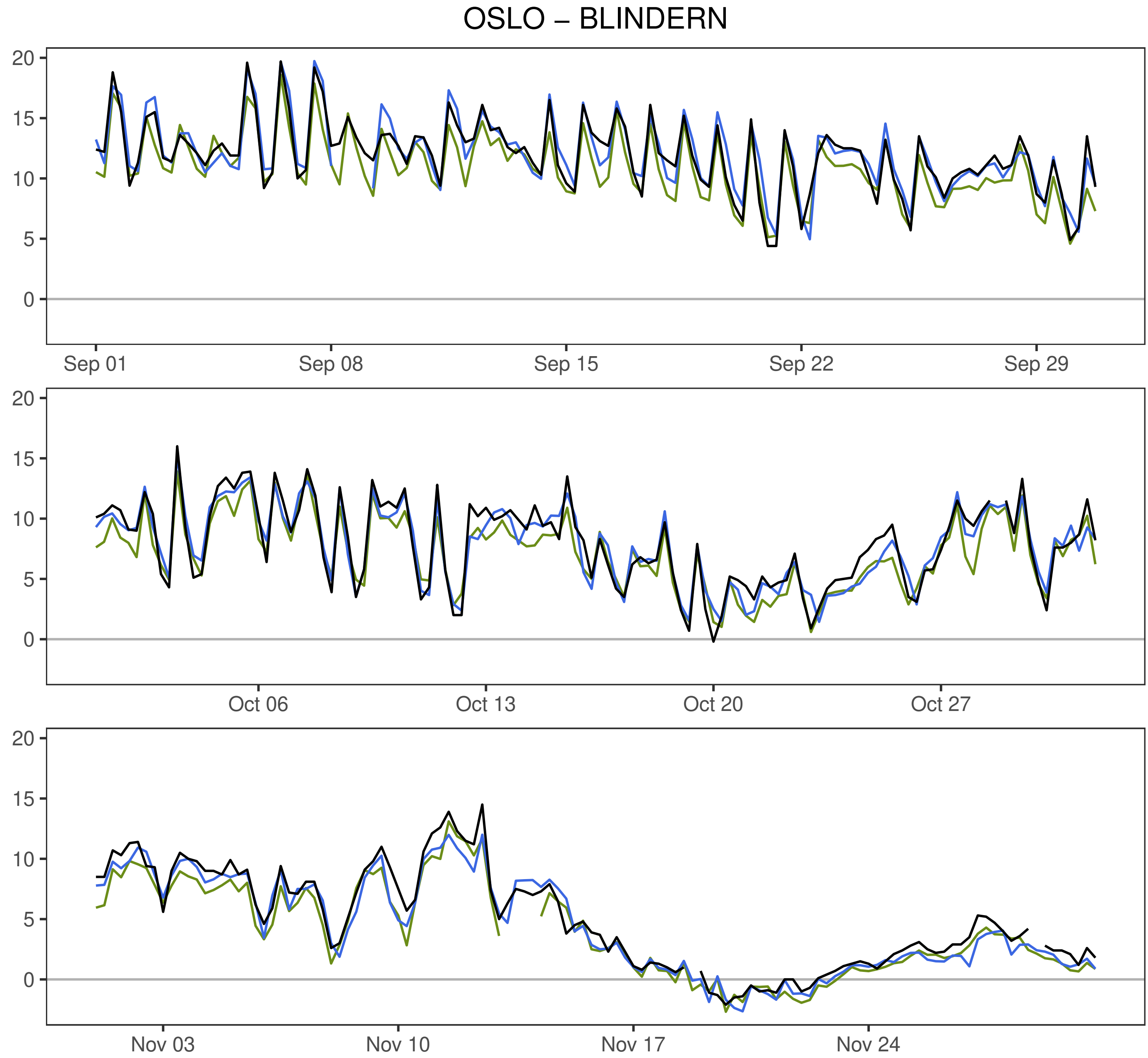
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−3.8	10.9	21.5	3.7	364
MEPSctrl: 12+18,+24,+30,+36	−2.6	10.6	22.6	3.8	360
ECMWF: 12+18,+24,+30,+36	−1.6	10.1	20.0	3.6	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.1	1.1	0.9	5.8	356
ECMWF−synop	−0.8	1.1	1.4	1.2	4.1	356



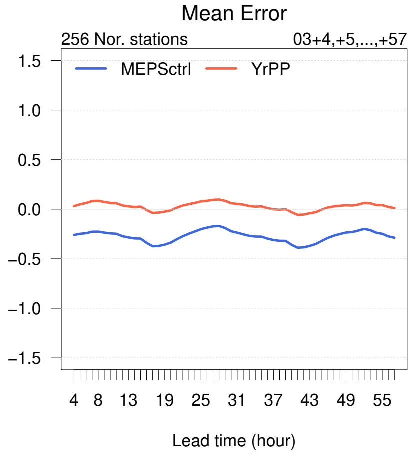
	Min	Mean	Max	Std	N
synop: 00,06,12,18	1.1	11.0	18.1	3.8	364
MEPSctrl: 12+18,+24,+30,+36	0.5	11.0	18.6	3.8	360
ECMWF: 12+18,+24,+30,+36	1.6	11.2	17.4	3.5	360

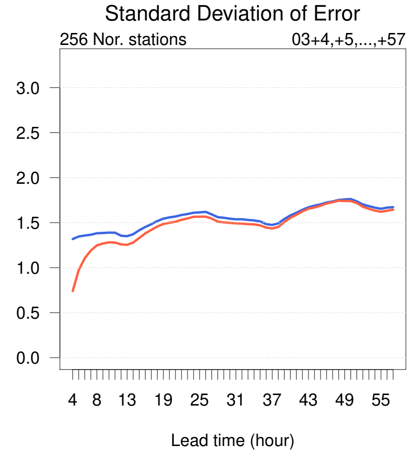
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.0	0.7	0.7	0.5	3.4	356
ECMWF−synop	0.1	0.7	0.7	0.5	2.8	356

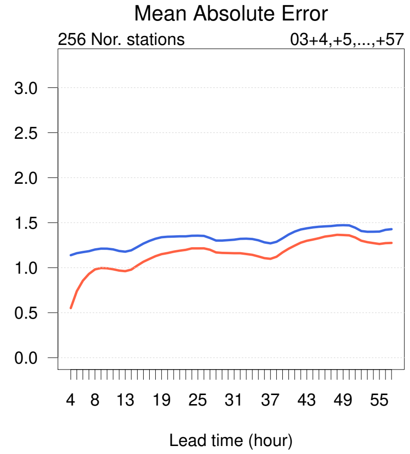


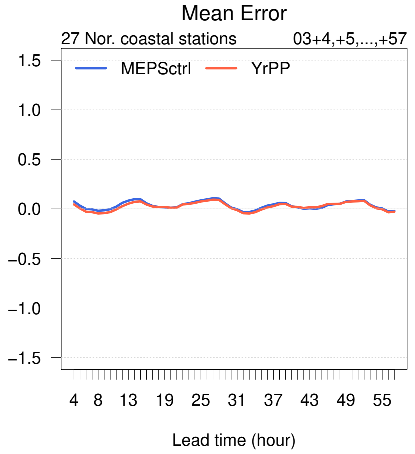
	Min	Mean	Max	Std	N
synop: 00,06,12,18	−2.1	8.3	19.7	4.5	361
MEPSctrl: 12+18,+24,+30,+36	−2.6	8.0	19.7	4.6	360
ECMWF: 12+18,+24,+30,+36	−2.7	7.3	18.6	4.3	360

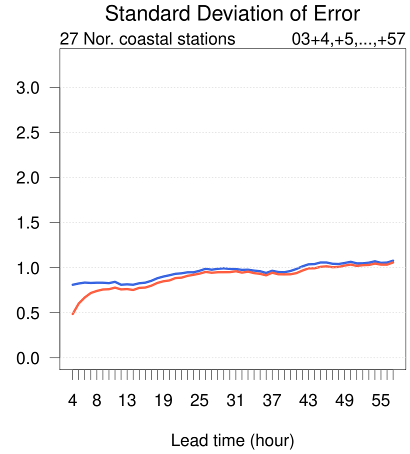
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.1	1.1	0.8	3.7	353
ECMWF−synop	−0.9	1.1	1.4	1.2	4.4	353

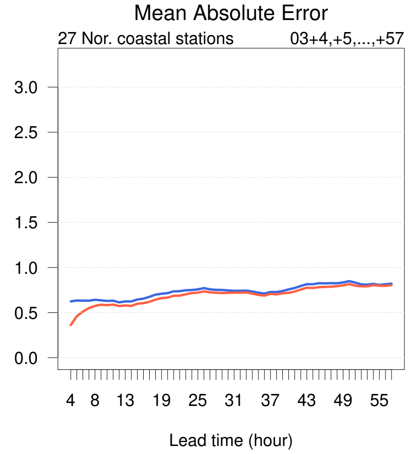

Mean Error
256 Nor. stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)

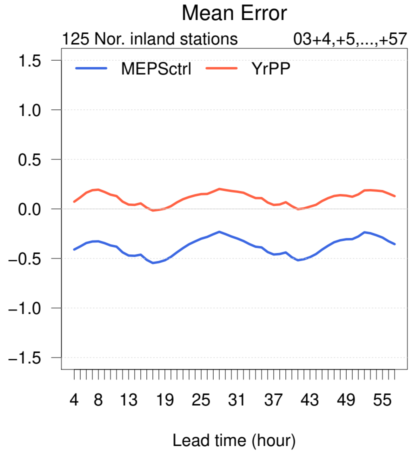

Standard Deviation of Error
256 Nor. stations
03+4,+5,...,+57
Lead time (hour)

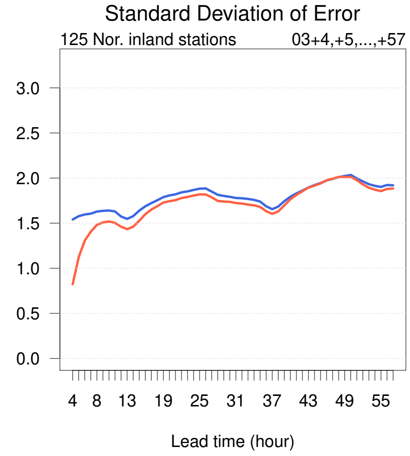

Mean Absolute Error
256 Nor. stations
03+4,+5,...,+57
Lead time (hour)

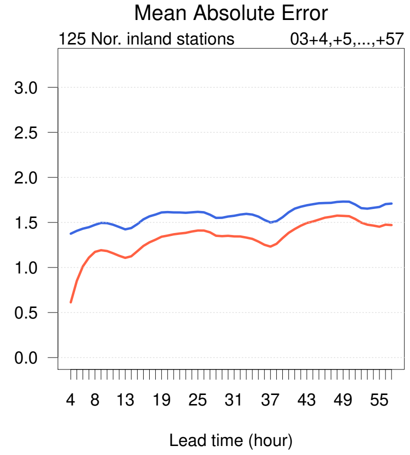

Mean Error
27 Nor. coastal stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)

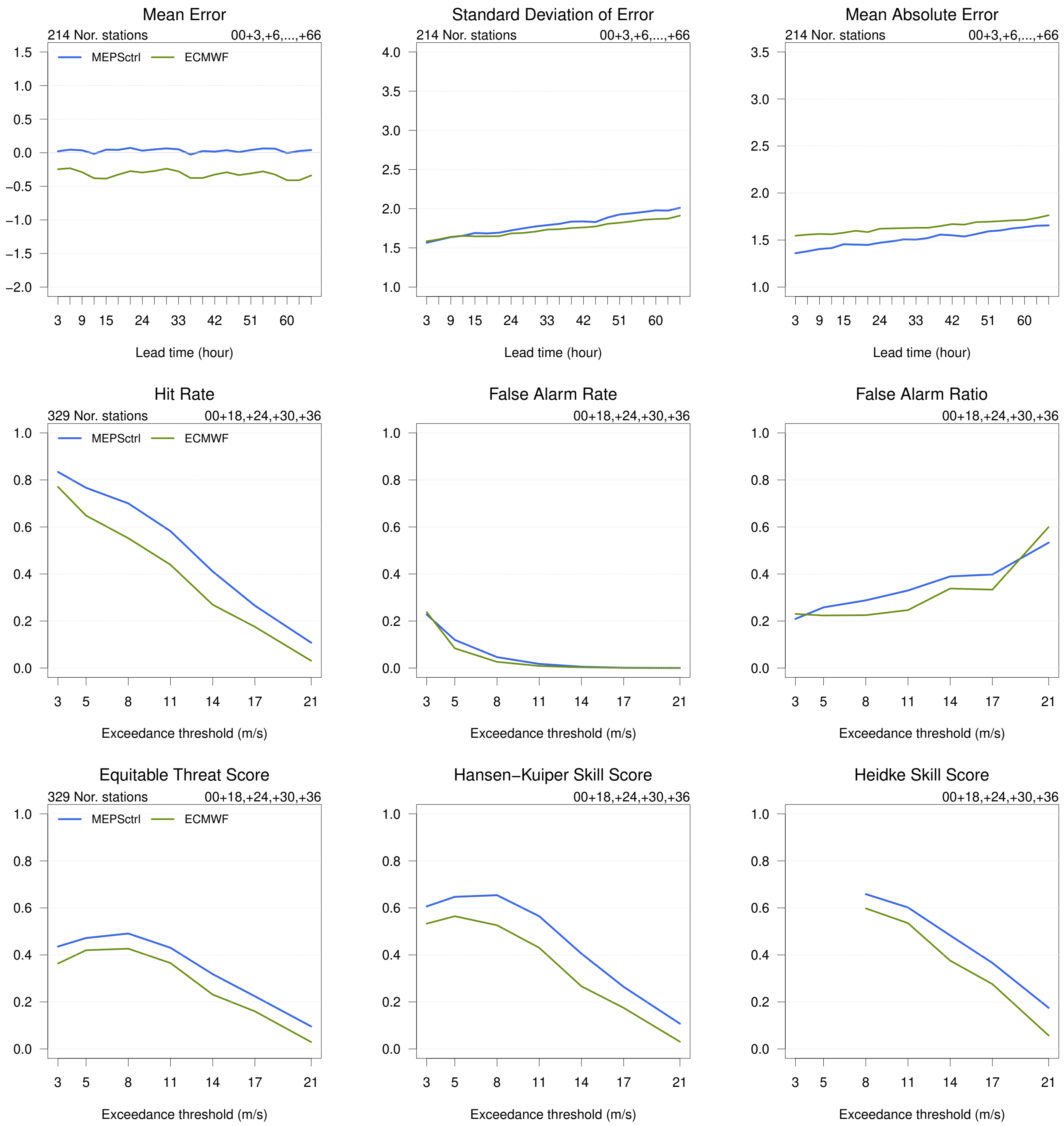

Standard Deviation of Error
27 Nor. coastal stations
03+4,+5,...,+57
Lead time (hour)

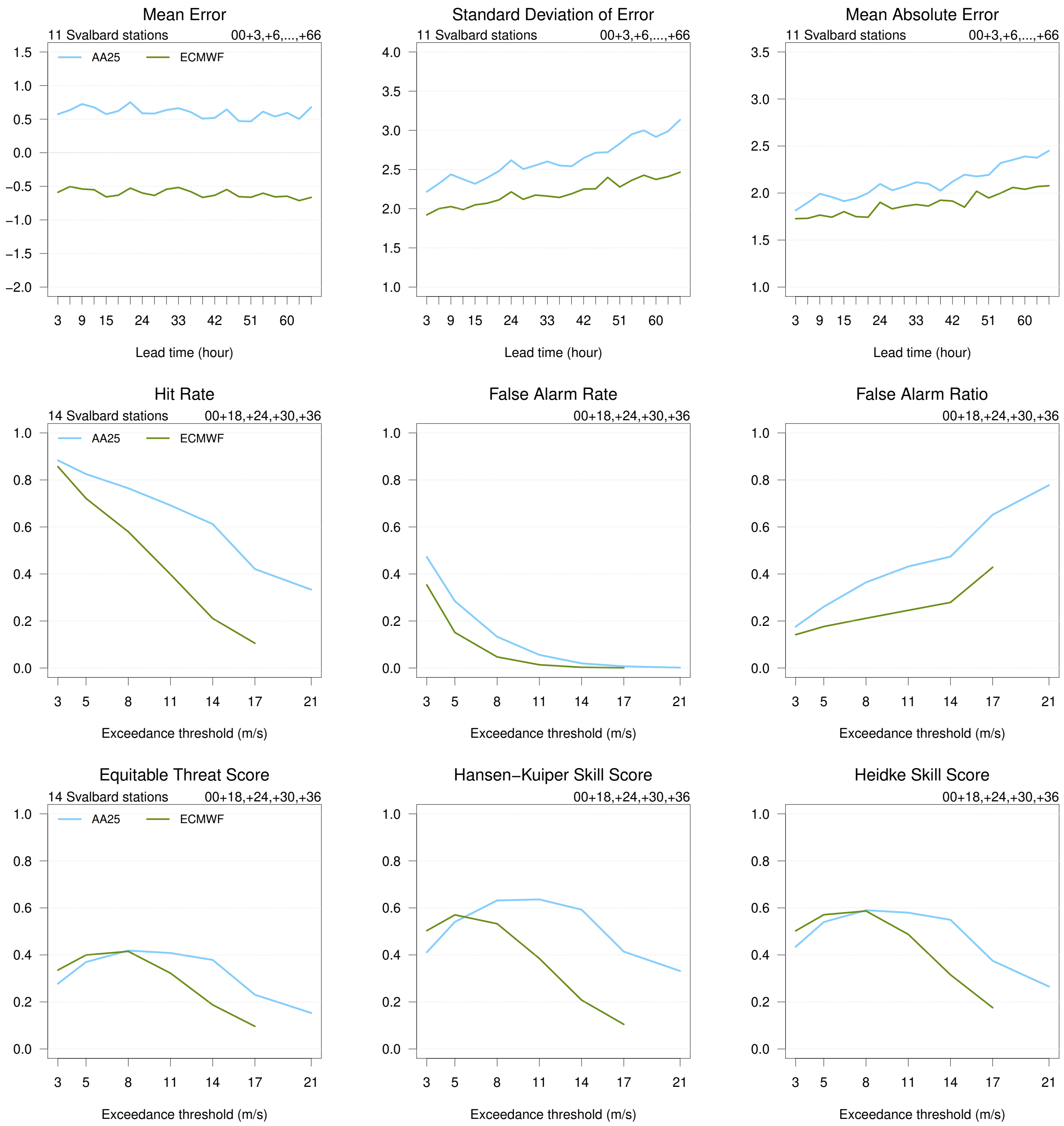

Mean Absolute Error
27 Nor. coastal stations
03+4,+5,...,+57
Lead time (hour)

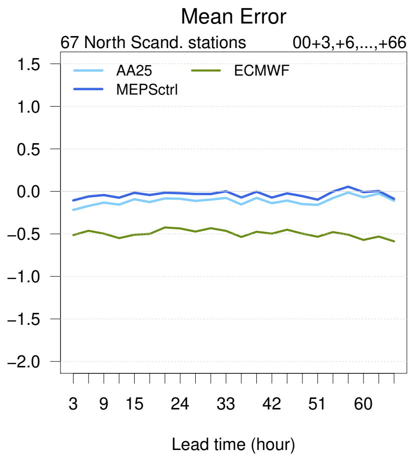

Mean Error
125 Nor. inland stations
03+4,+5,...,+57
MEPSctrl
YrPP
Lead time (hour)

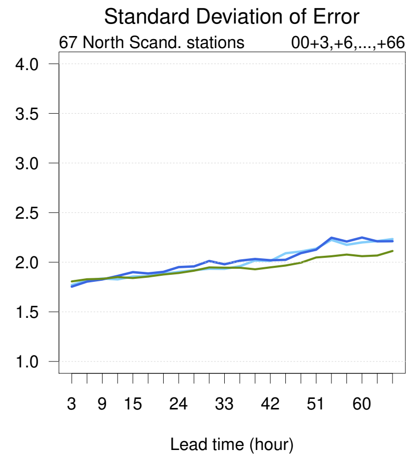

Standard Deviation of Error
125 Nor. inland stations
03+4,+5,...,+57
Lead time (hour)

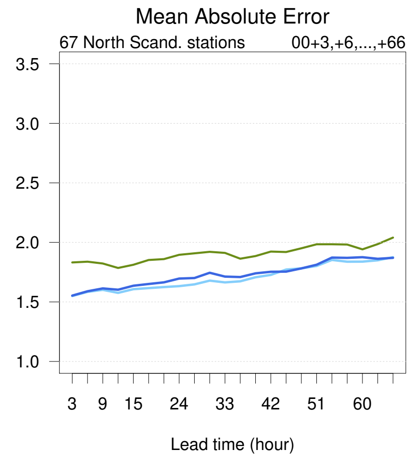

Mean Absolute Error
125 Nor. inland stations
03+4,+5,...,+57
Lead time (hour)

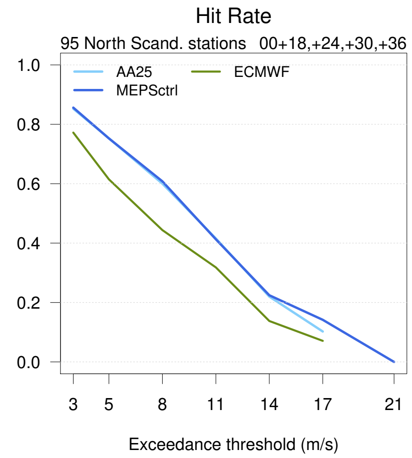

Mean Error
214 Nor. stations
00+3,+6,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
214 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
214 Nor. stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
329 Nor. stations
00+18,+24,+30,+36
MEPSctrl
ECMWF
Exceedance threshold (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)

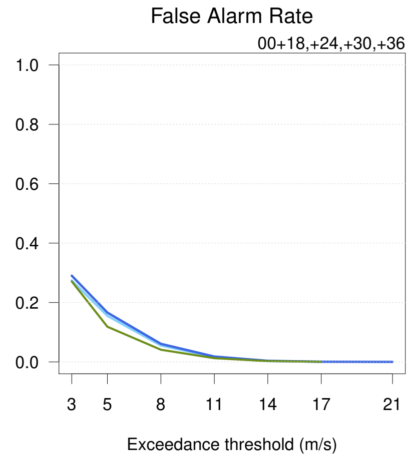

Mean Error
11 Svalbard stations
00+3,+6,...,+66
AA25
ECMWF
Lead time (hour)
Standard Deviation of Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Mean Absolute Error
11 Svalbard stations
00+3,+6,...,+66
Lead time (hour)
Hit Rate
14 Svalbard stations
00+18,+24,+30,+36
AA25
ECMWF
Exceedance 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)

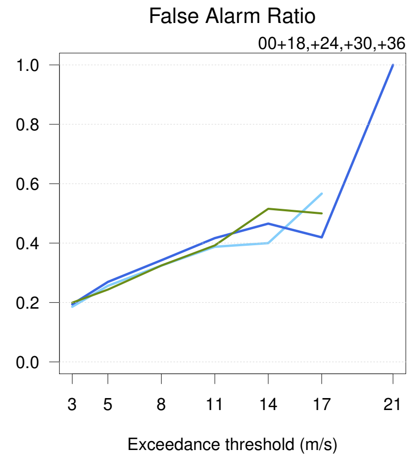

Mean Error
67 North Scand. stations
00+3,+6,...,+66
AA25
MEPSctrl
ECMWF
Lead time (hour)

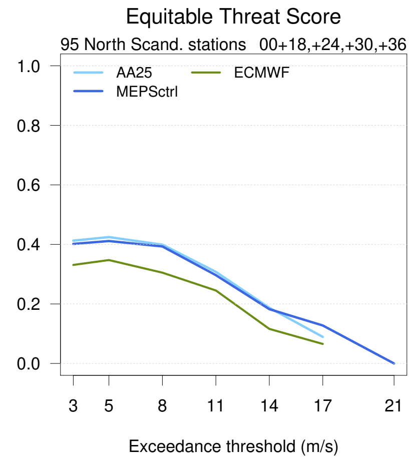

Standard Deviation of Error
67 North Scand. stations
00+3,+6,...,+66
Lead time (hour)

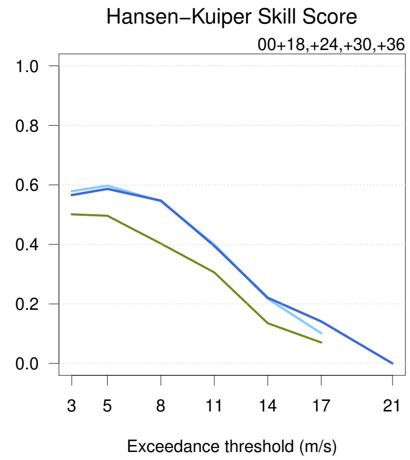

Mean Absolute Error
67 North Scand. stations
00+3,+6,...,+66
Lead time (hour)

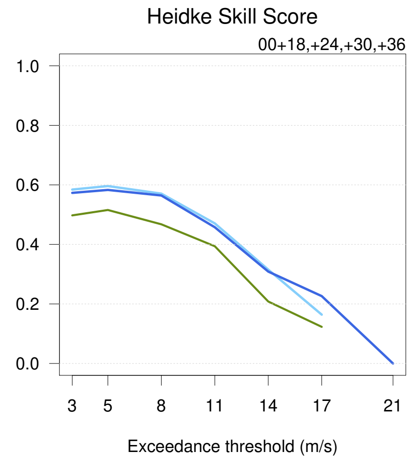

Hit Rate
95 North Scand. stations
00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
Exceedance threshold (m/s)

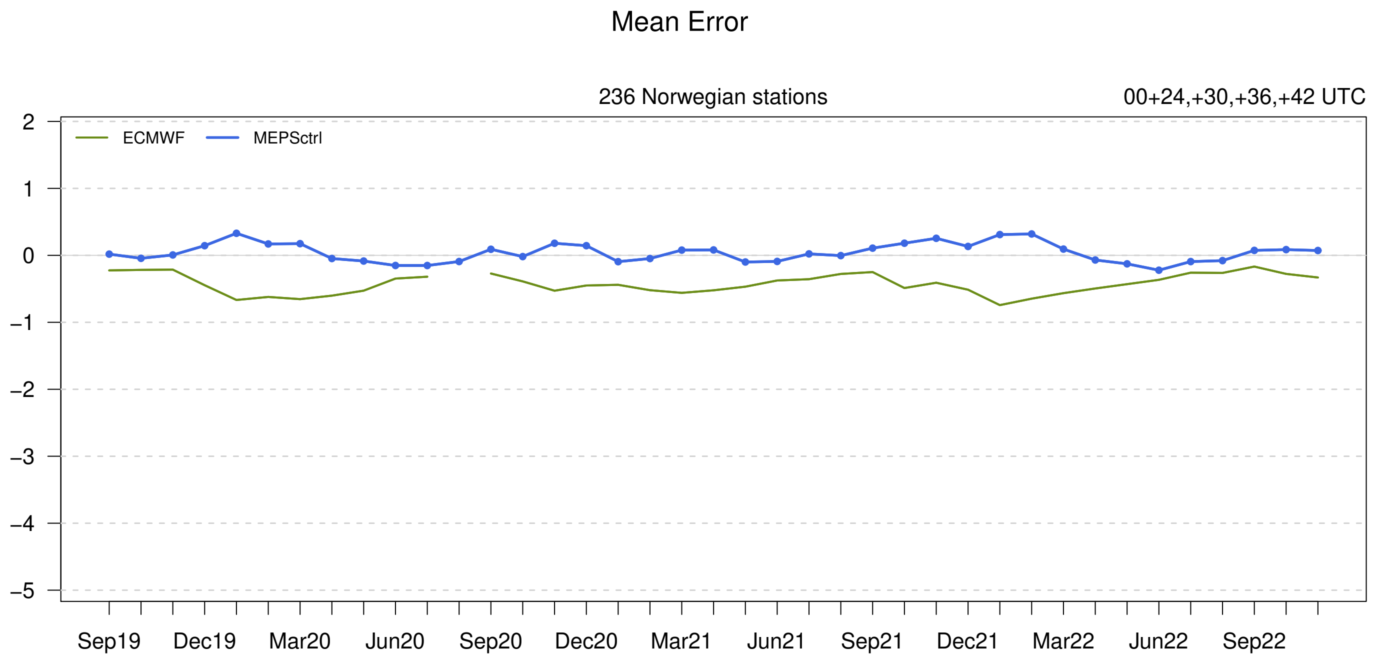

False Alarm Rate
00+18,+24,+30,+36
Exceedance threshold (m/s)

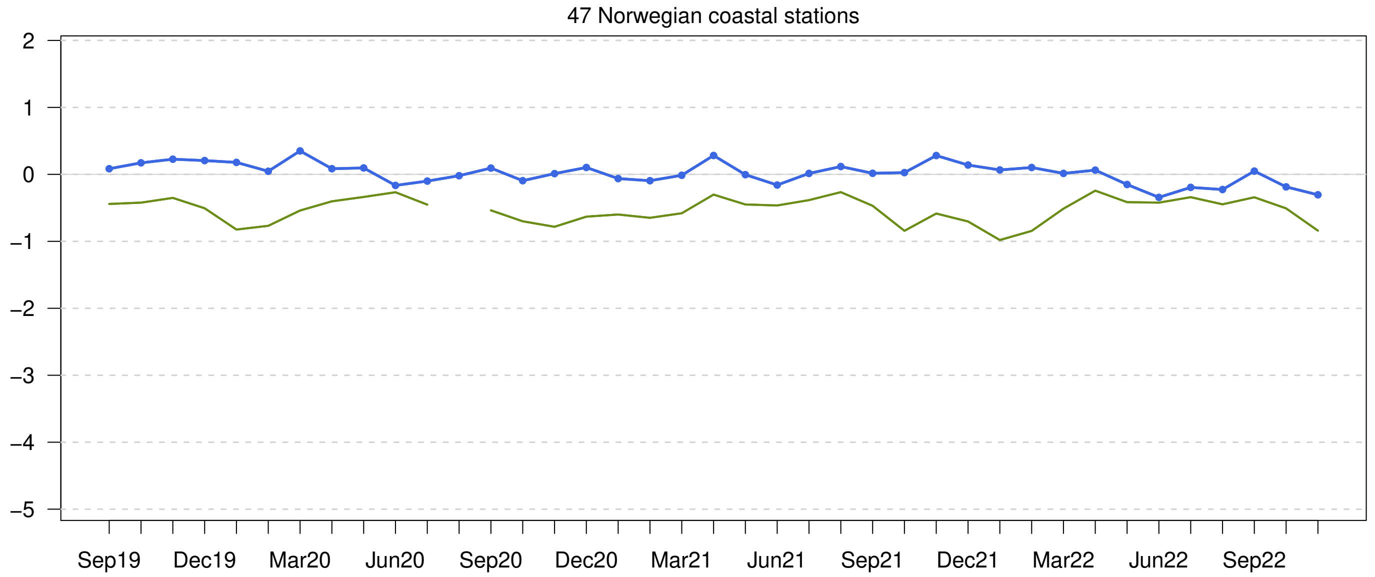

False Alarm Ratio
00+18,+24,+30,+36
Exceedance threshold (m/s)

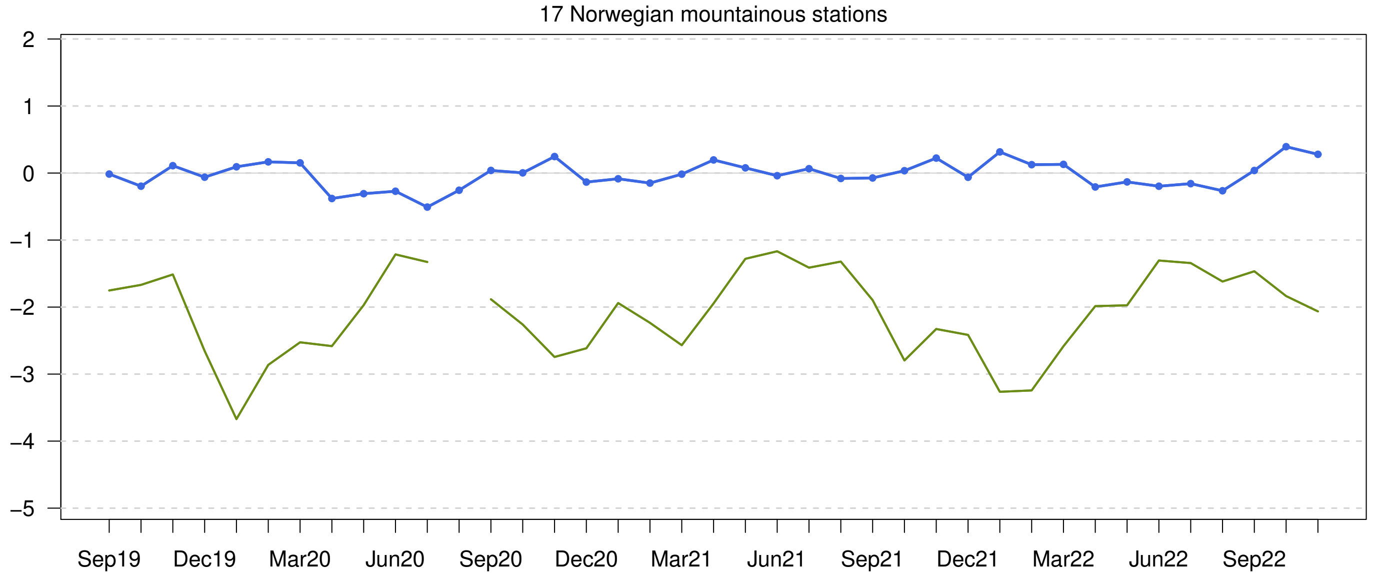

Equitable Threat Score
95 North Scand. stations
00+18,+24,+30,+36
AA25
MEPSctrl
ECMWF
Exceedance threshold (m/s)


Hansen−Kuiper Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

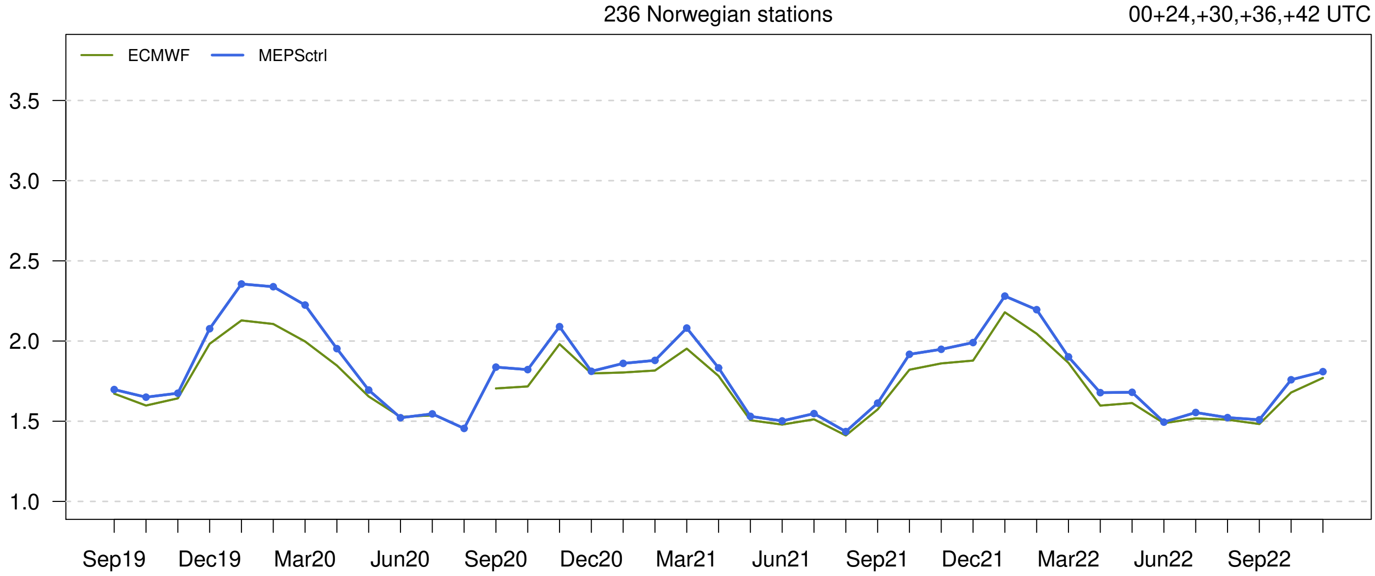

Heidke Skill Score
00+18,+24,+30,+36
Exceedance threshold (m/s)

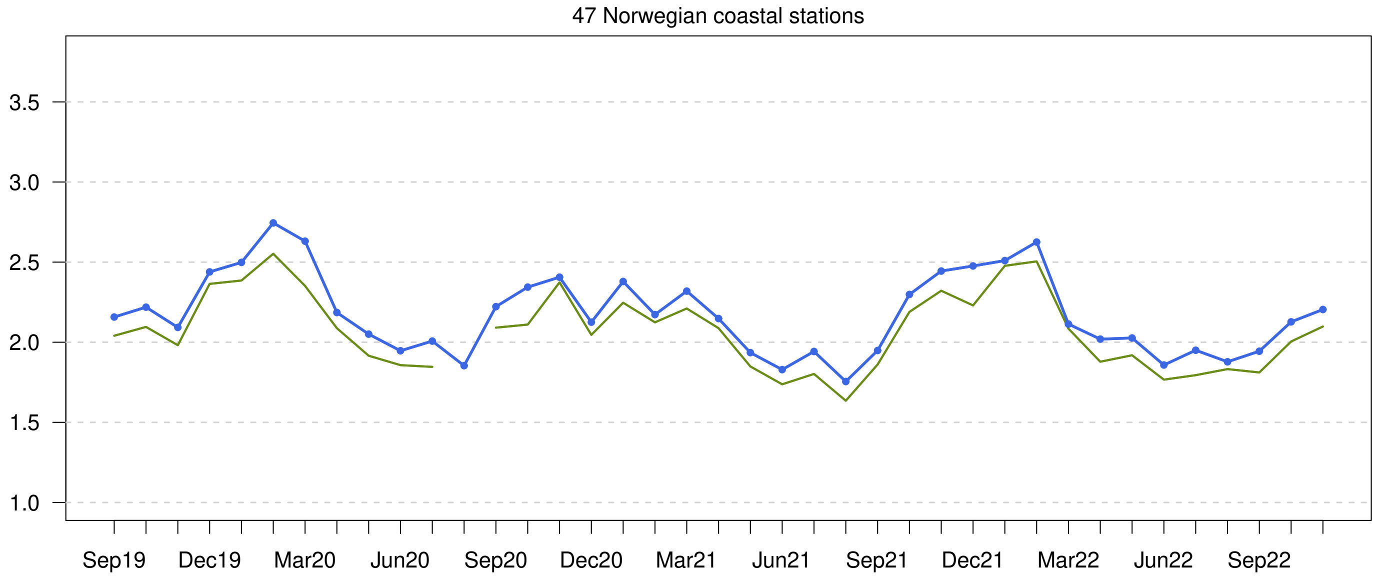

Mean Error
236 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
2
1
0
−1
−2
−3
−4
−5
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22

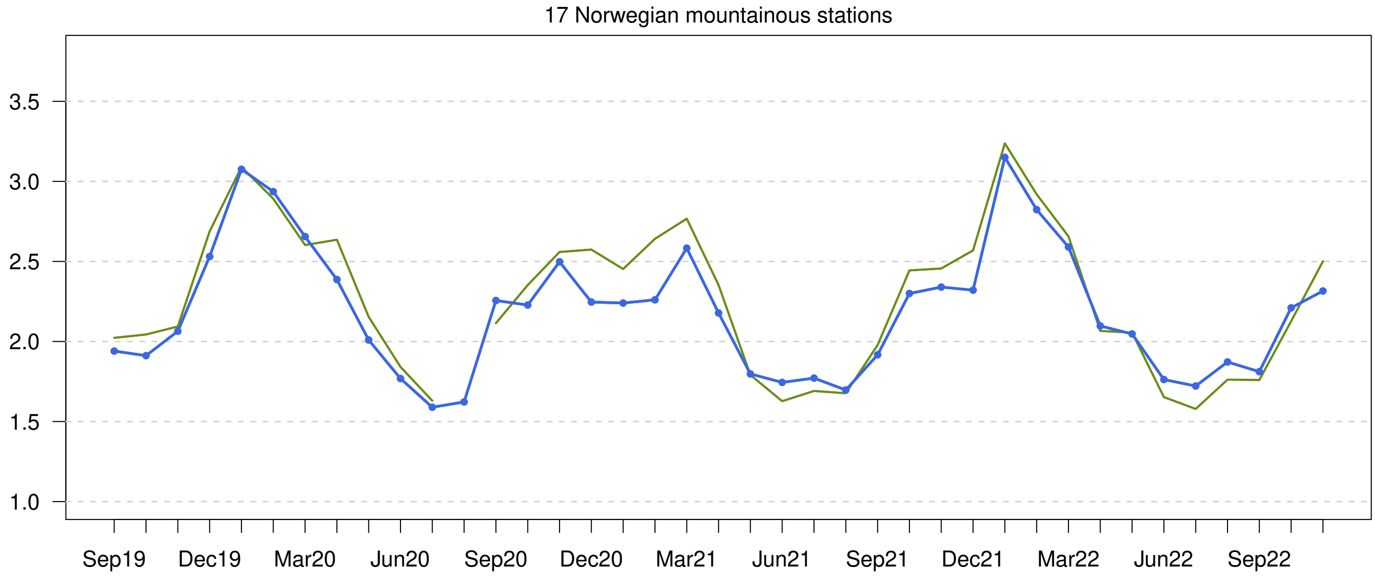

47 Norwegian coastal stations
2
1
0
−1
−2
−3
−4
−5
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22

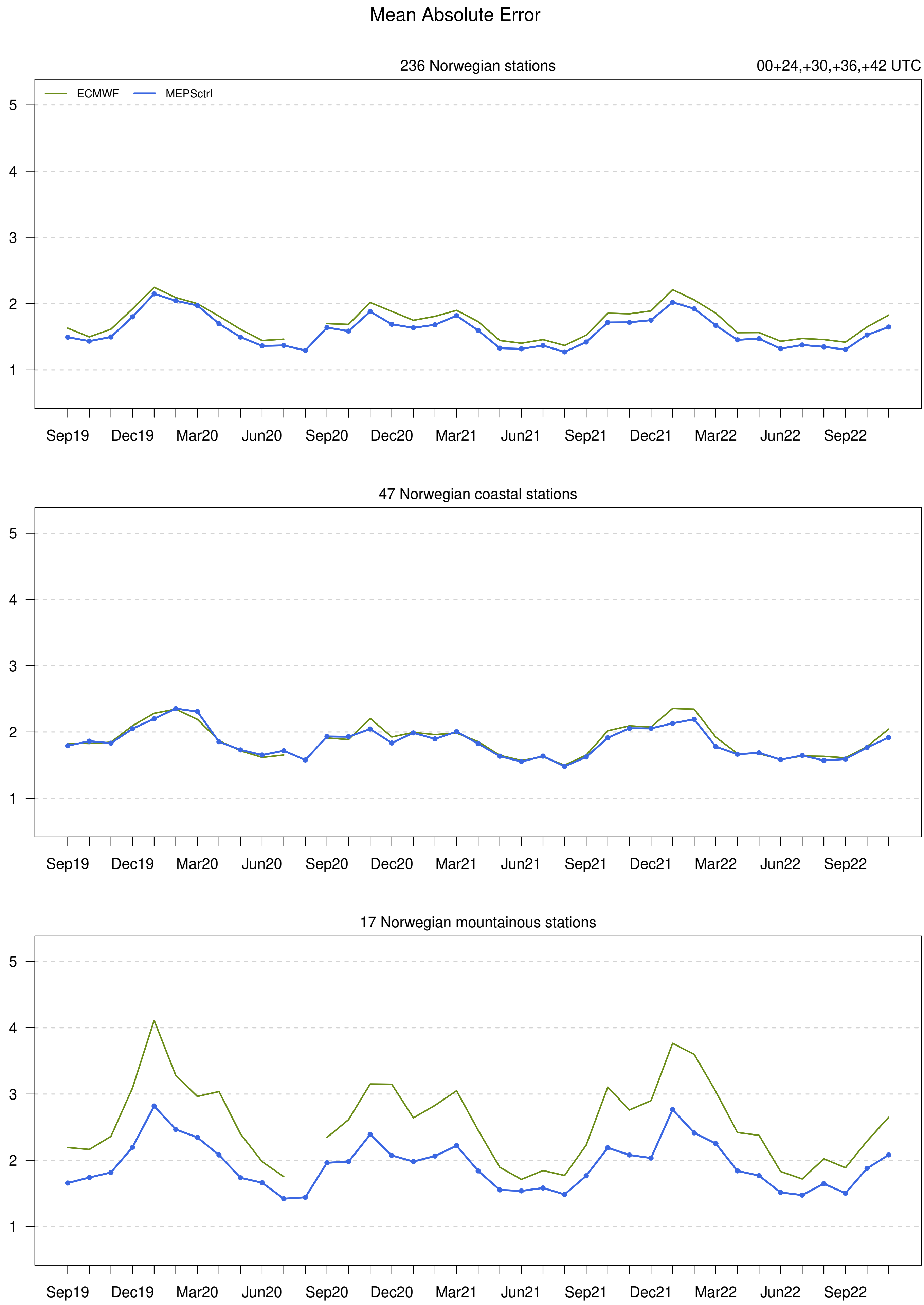

17 Norwegian mountainous stations
2
1
0
−1
−2
−3
−4
−5
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22

Standard Deviation of Error



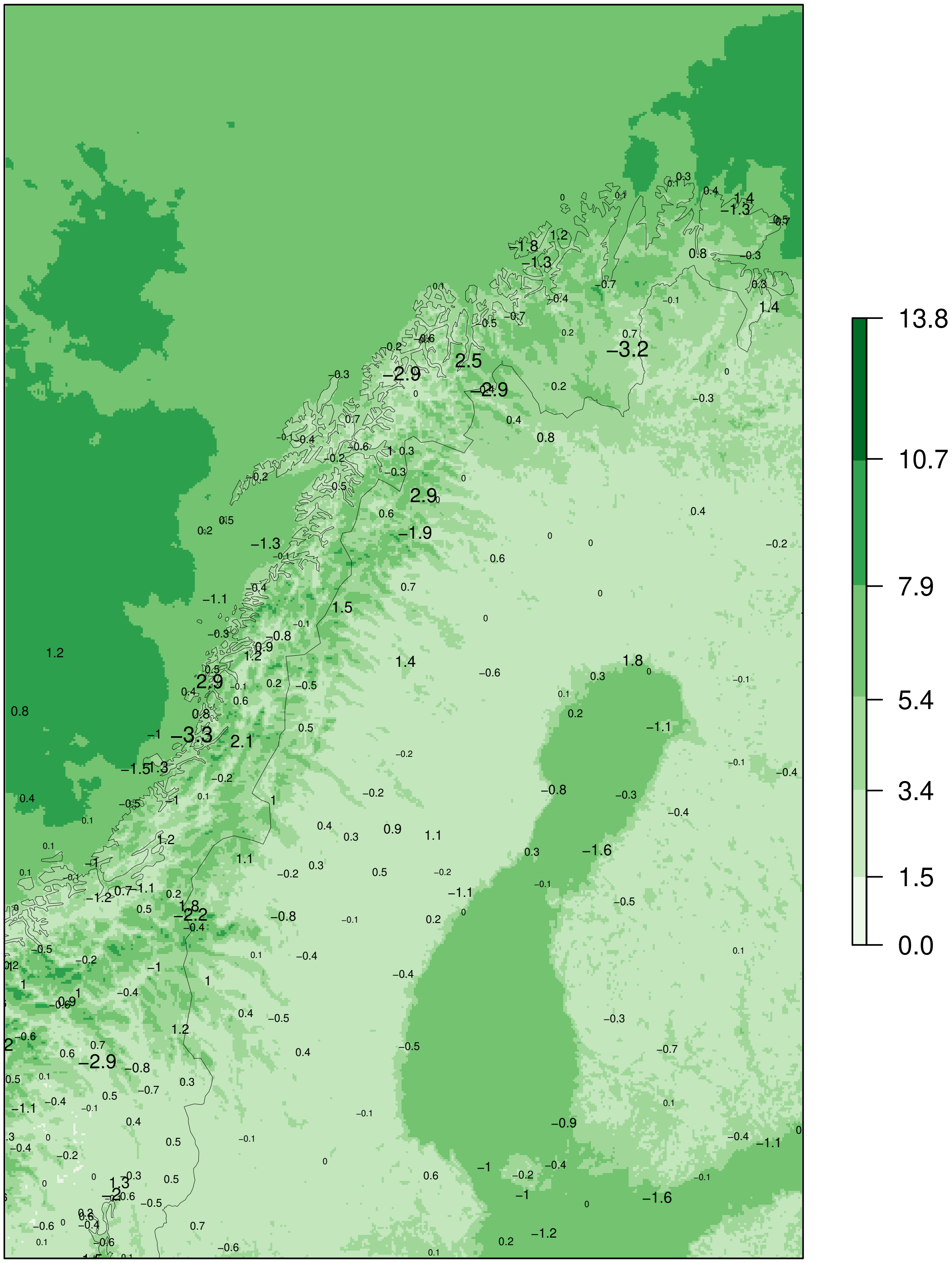





Mean Absolute Error
236 Norwegian stations
00+24,+30,+36,+42 UTC
ECMWF
MEPSctrl
5
4
3
2
1
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22
47 Norwegian coastal stations
17 Norwegian mountainous stations

MEPSctrl 00+12

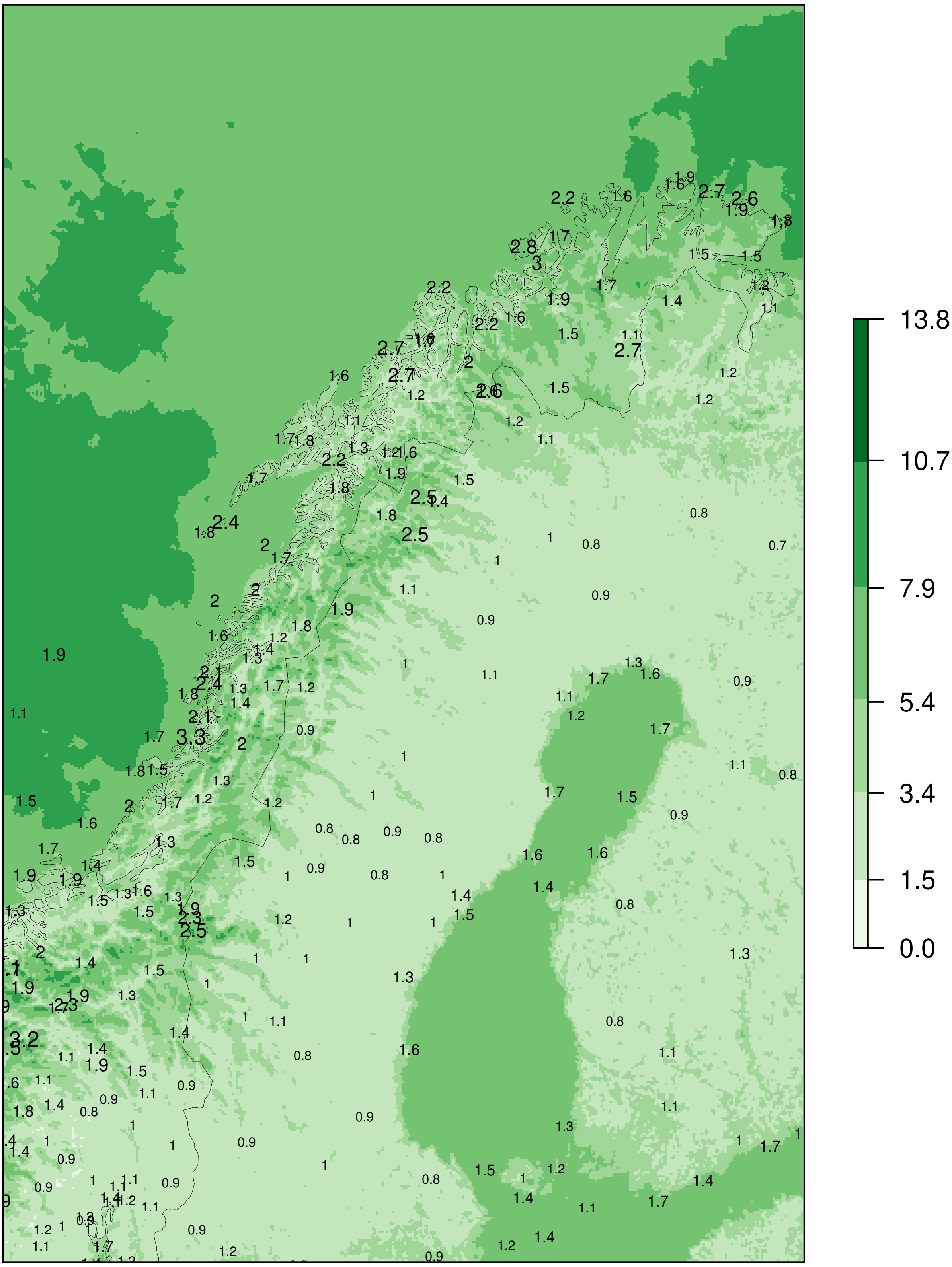
ME at observing sites
(numbers in black)



Model "climatology"   01.09.2022 – 30.11.2022

MEPSctrl 00+12

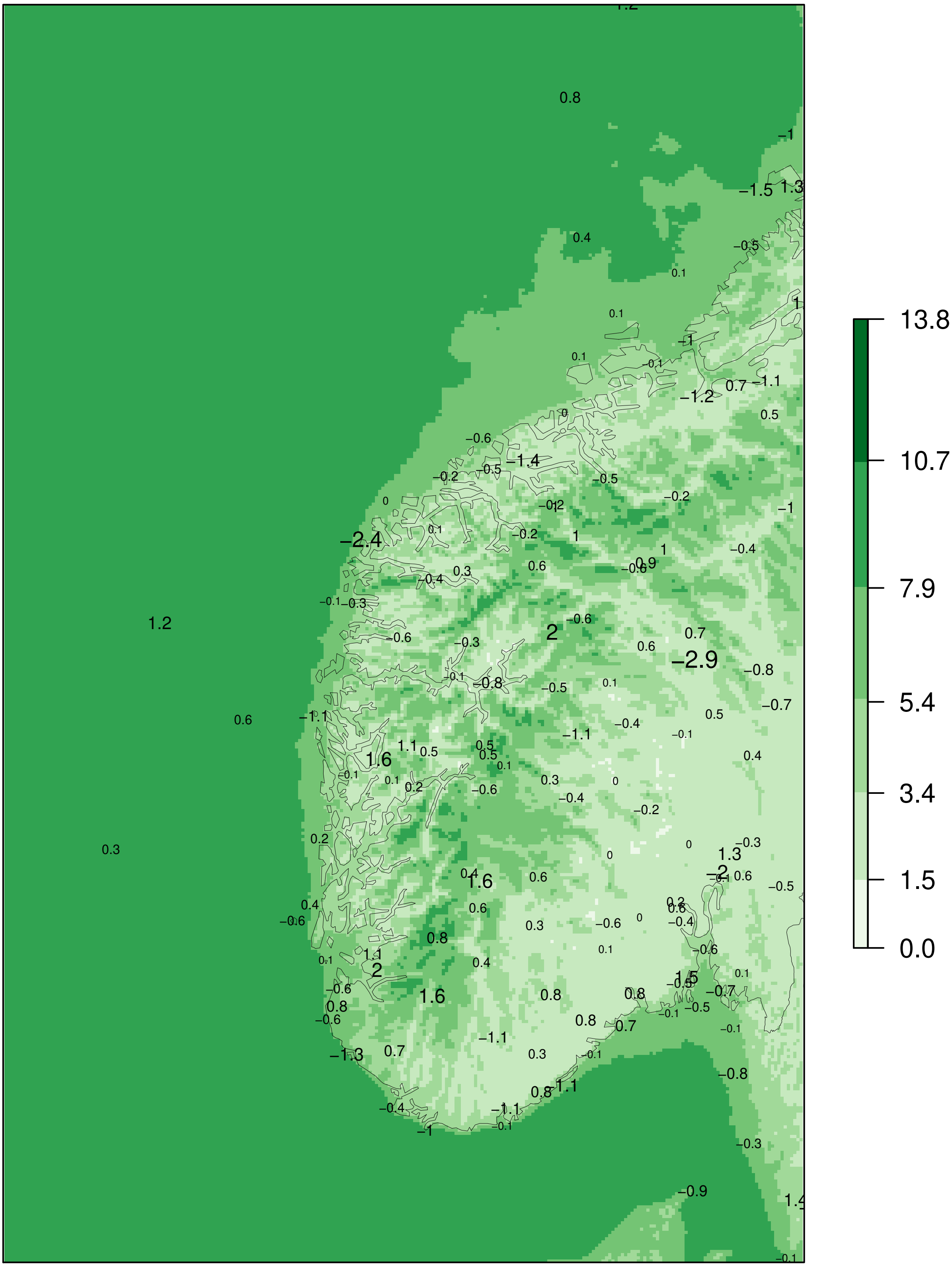
SDE at observing sites
(numbers in black)



Model "climatology" 01.09.2022 – 30.11.2022

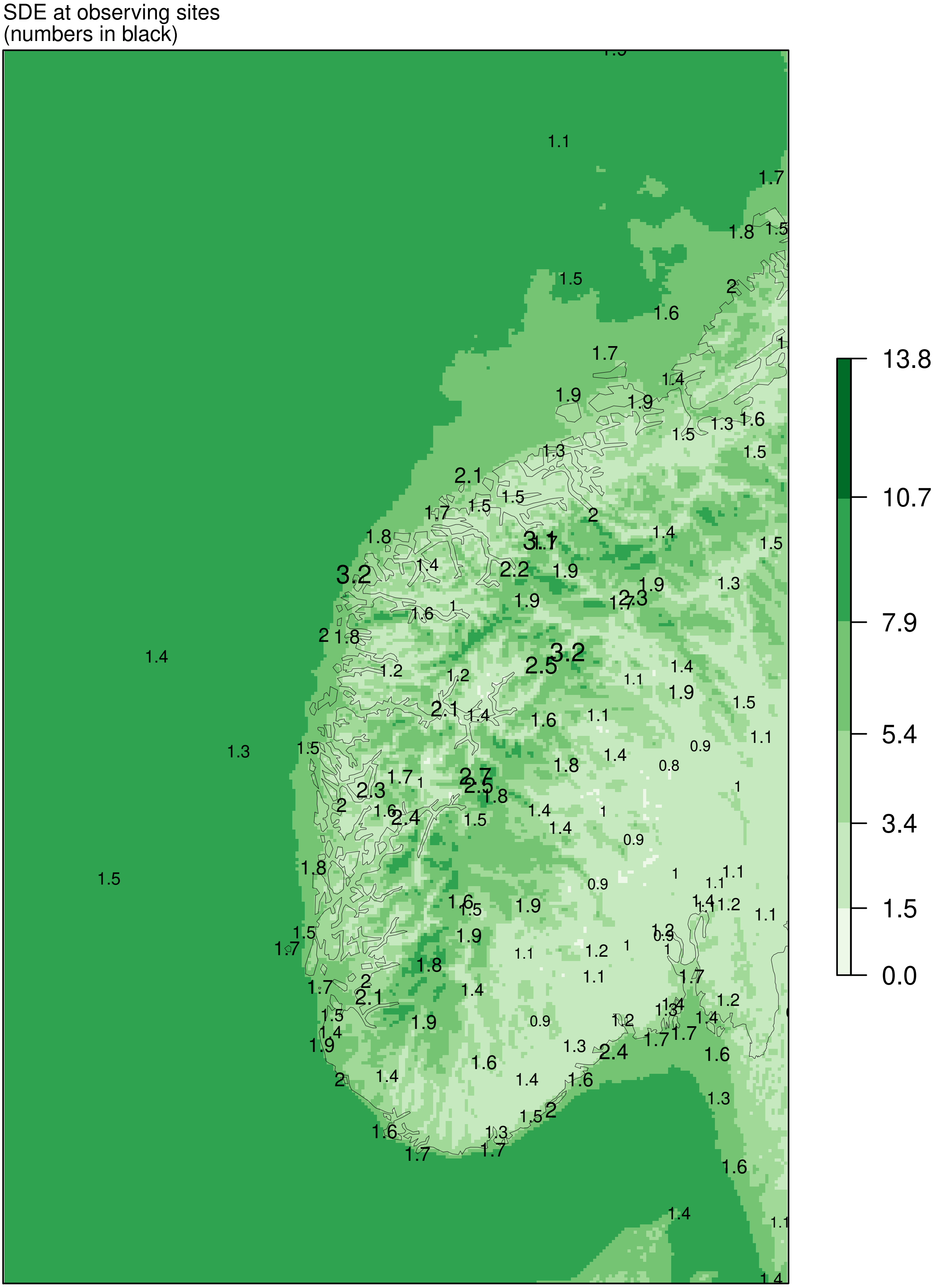
MEPSctrl 00+12

ME at observing sites
(numbers in black)

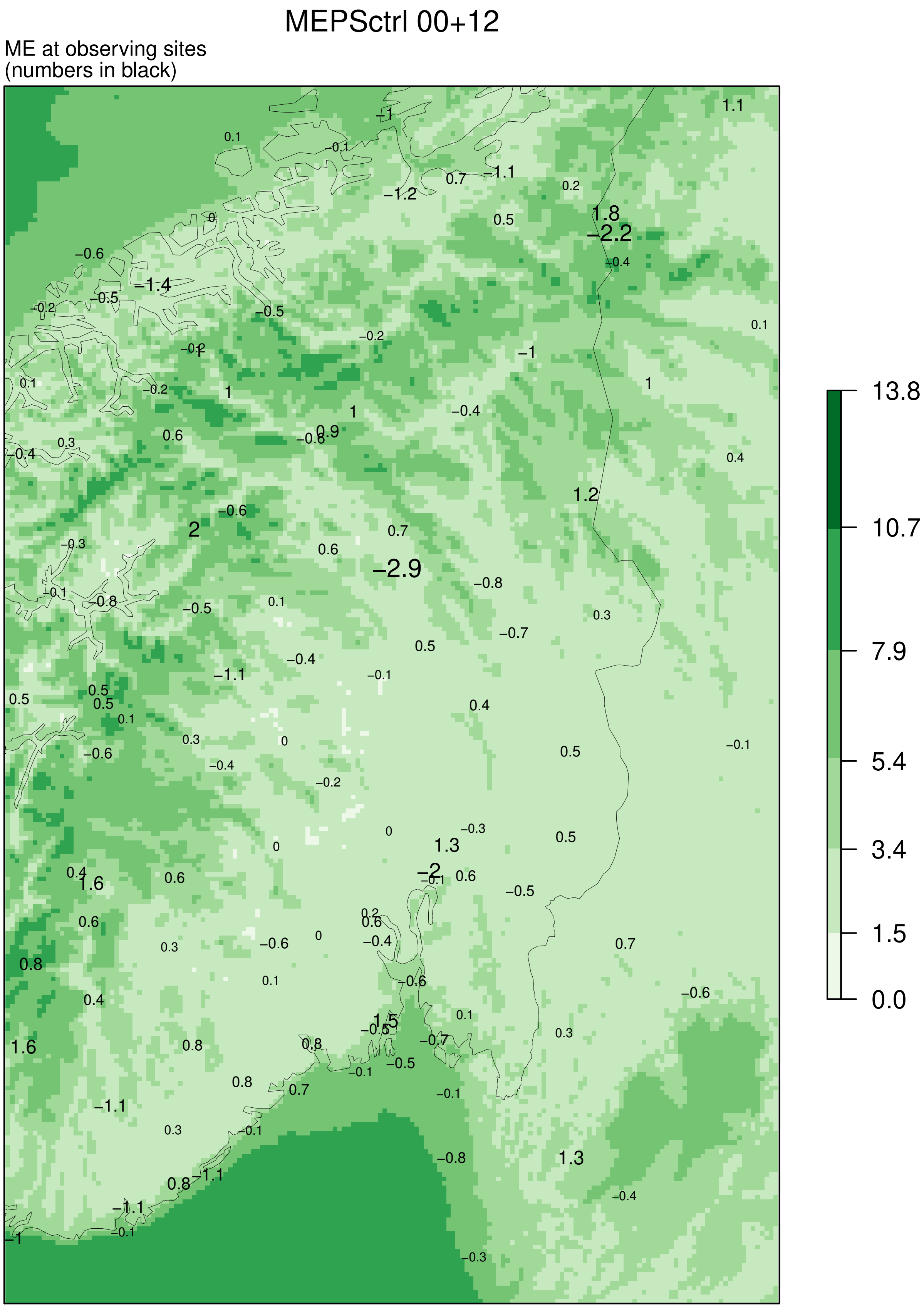


Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+12



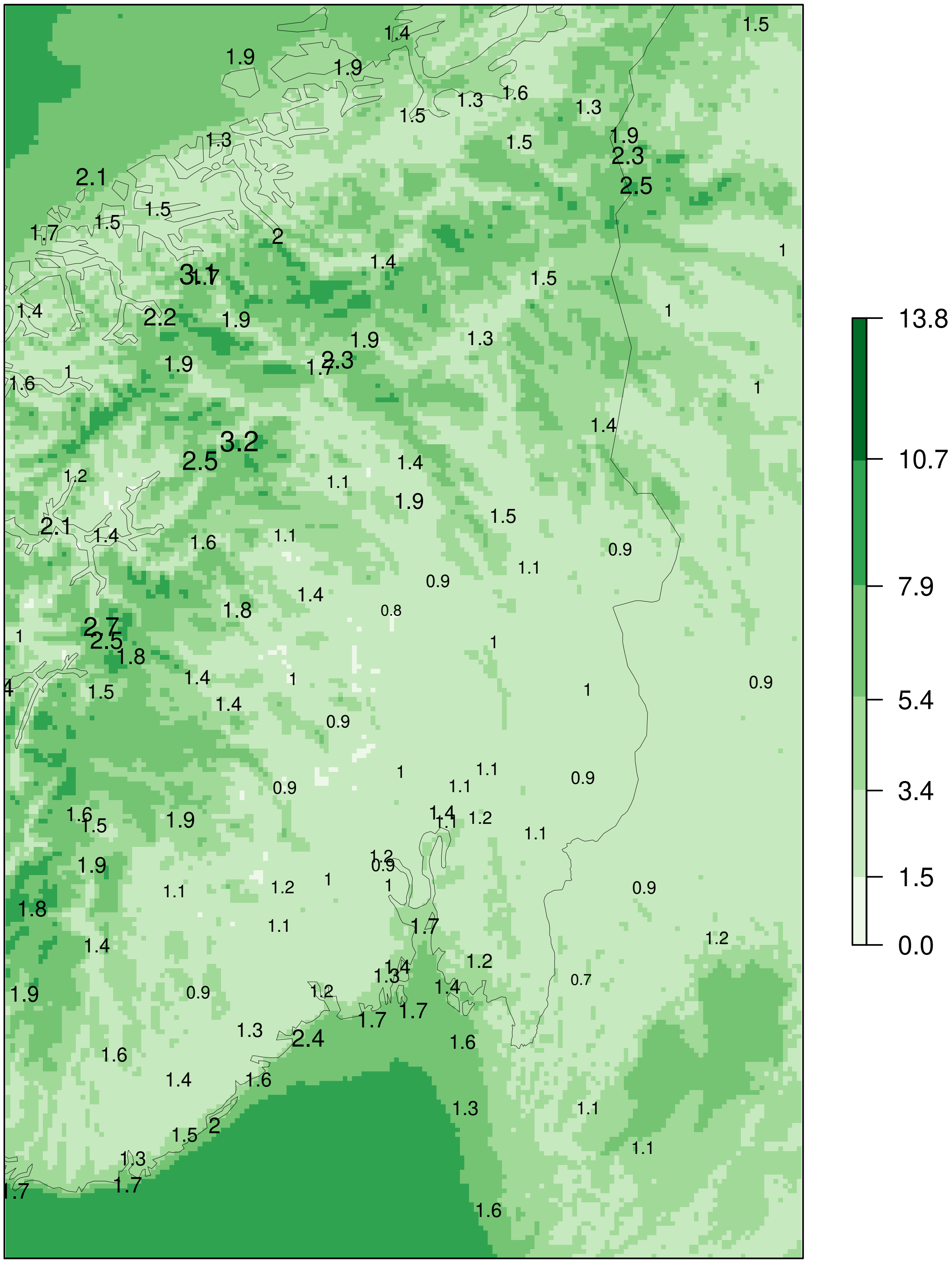
Model "climatology" 01.09.2022 – 30.11.2022



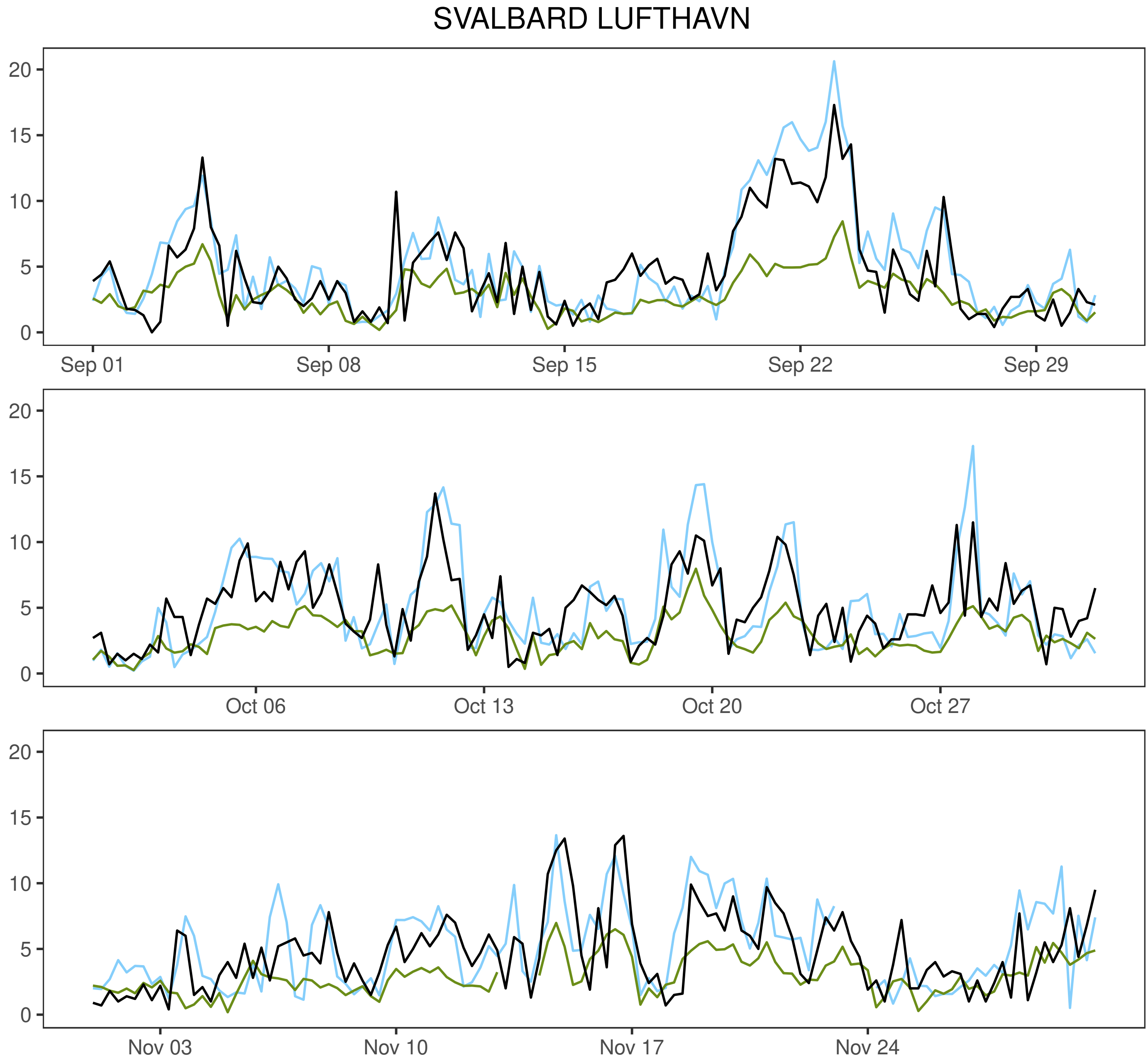
Model "climatology"   01.09.2022 – 30.11.2022

MEPSctrl 00+12

SDE at observing sites
(numbers in black)

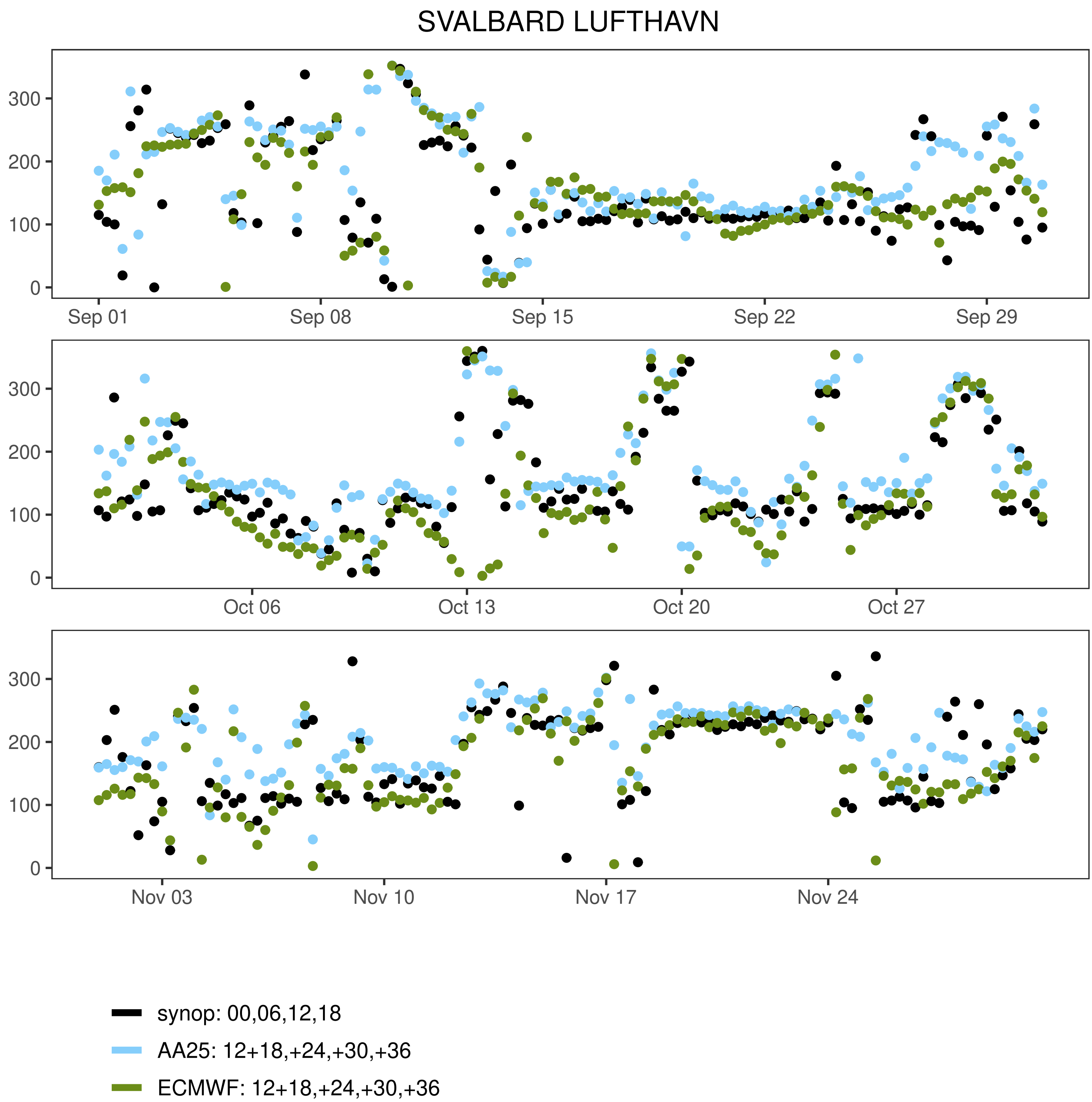


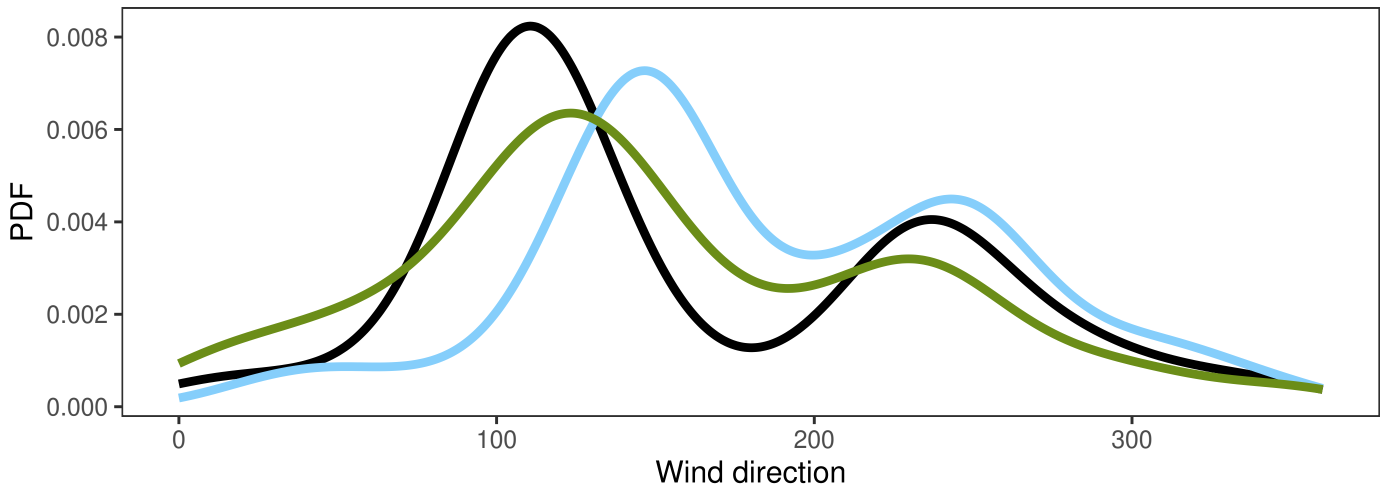
Model "climatology" 01.09.2022 – 30.11.2022

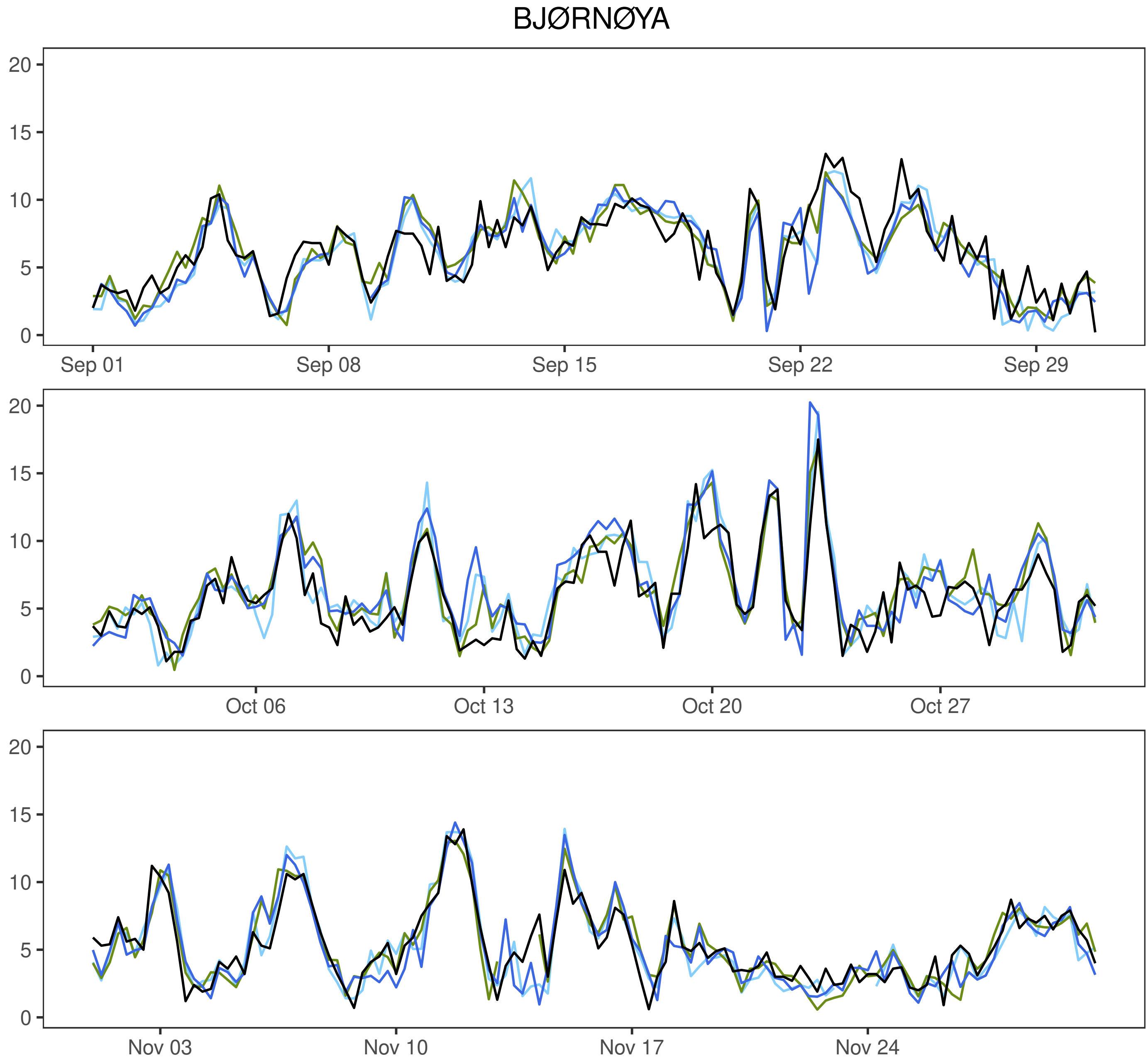


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	4.8	17.3	3.1	364
AA25: 12+18,+24,+30,+36	0.2	5.2	20.6	3.6	360
ECMWF: 12+18,+24,+30,+36	0.2	2.9	8.4	1.5	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25−synop	0.4	2.5	2.5	2.0	8.3	356
ECMWF−synop	−1.9	2.3	3.0	2.3	10.0	356

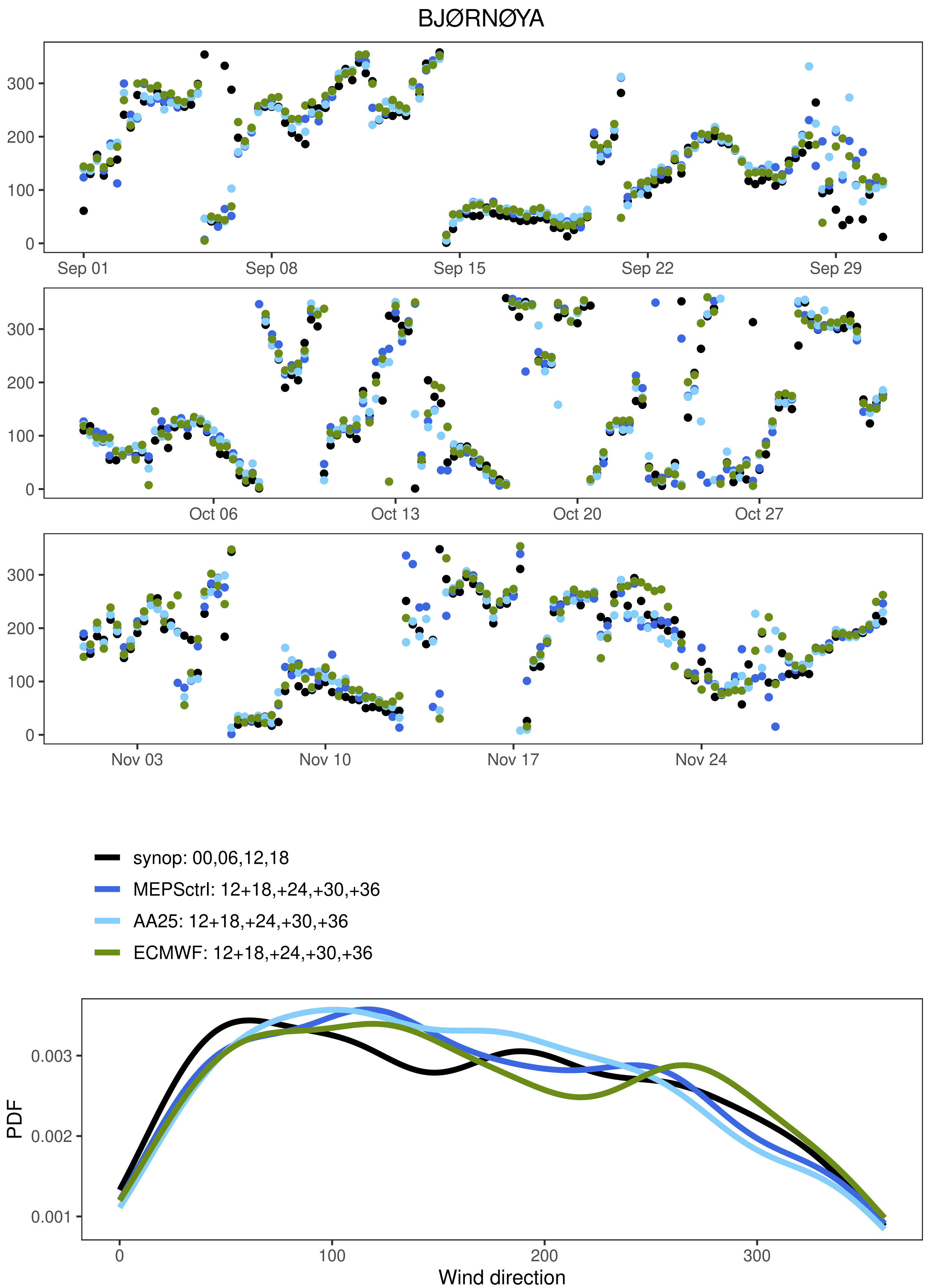

SVALBARD LUFTHAVN
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
synop: 00,06,12,18
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

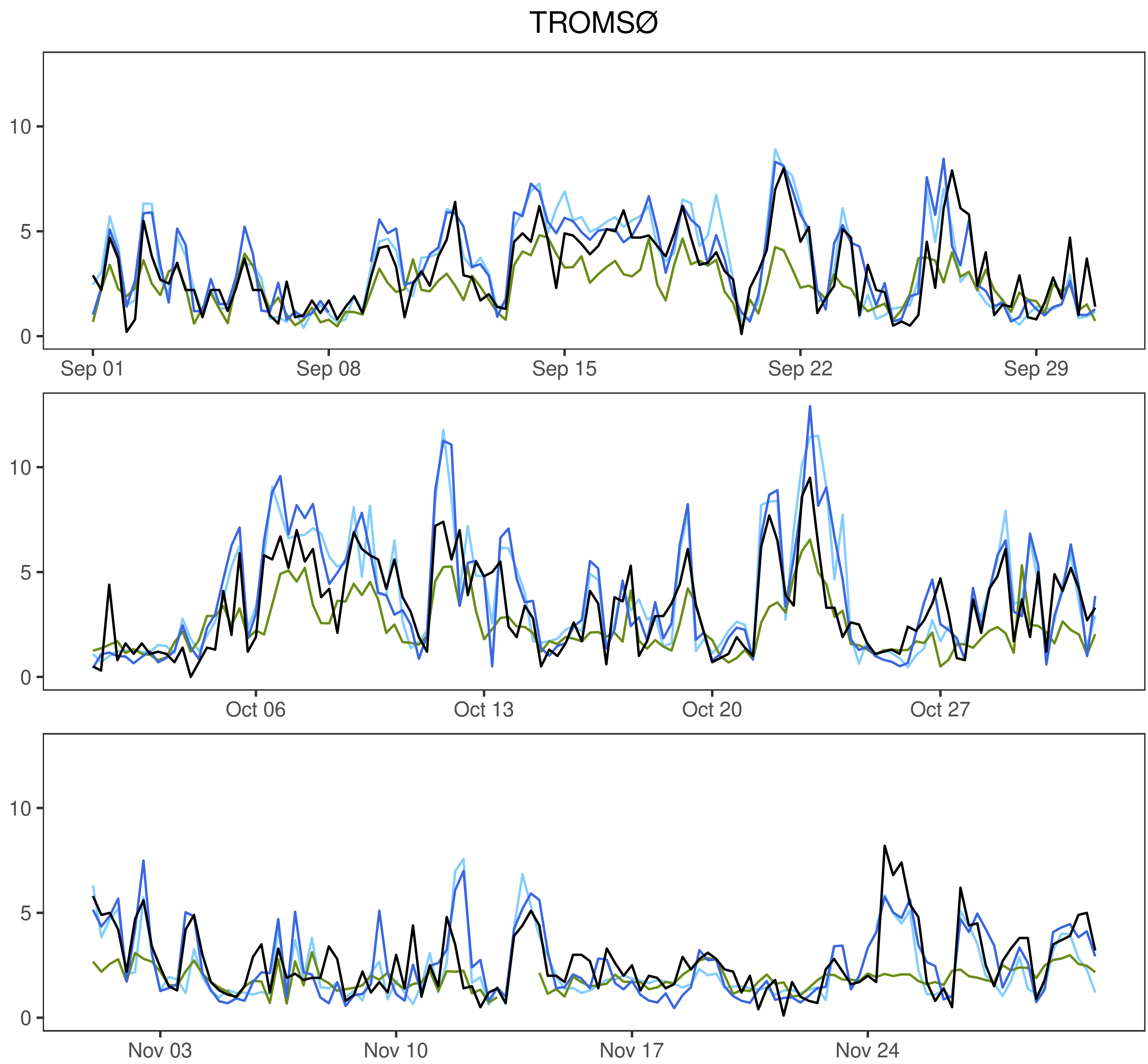

PDF
0.008
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.2	5.9	17.5	2.9	364
MEPSctrl: 12+18,+24,+30,+36	0.3	6.0	20.2	3.2	360
AA25: 12+18,+24,+30,+36	0.3	5.9	19.5	3.2	360
ECMWF: 12+18,+24,+30,+36	0.5	6.1	16.9	2.9	360

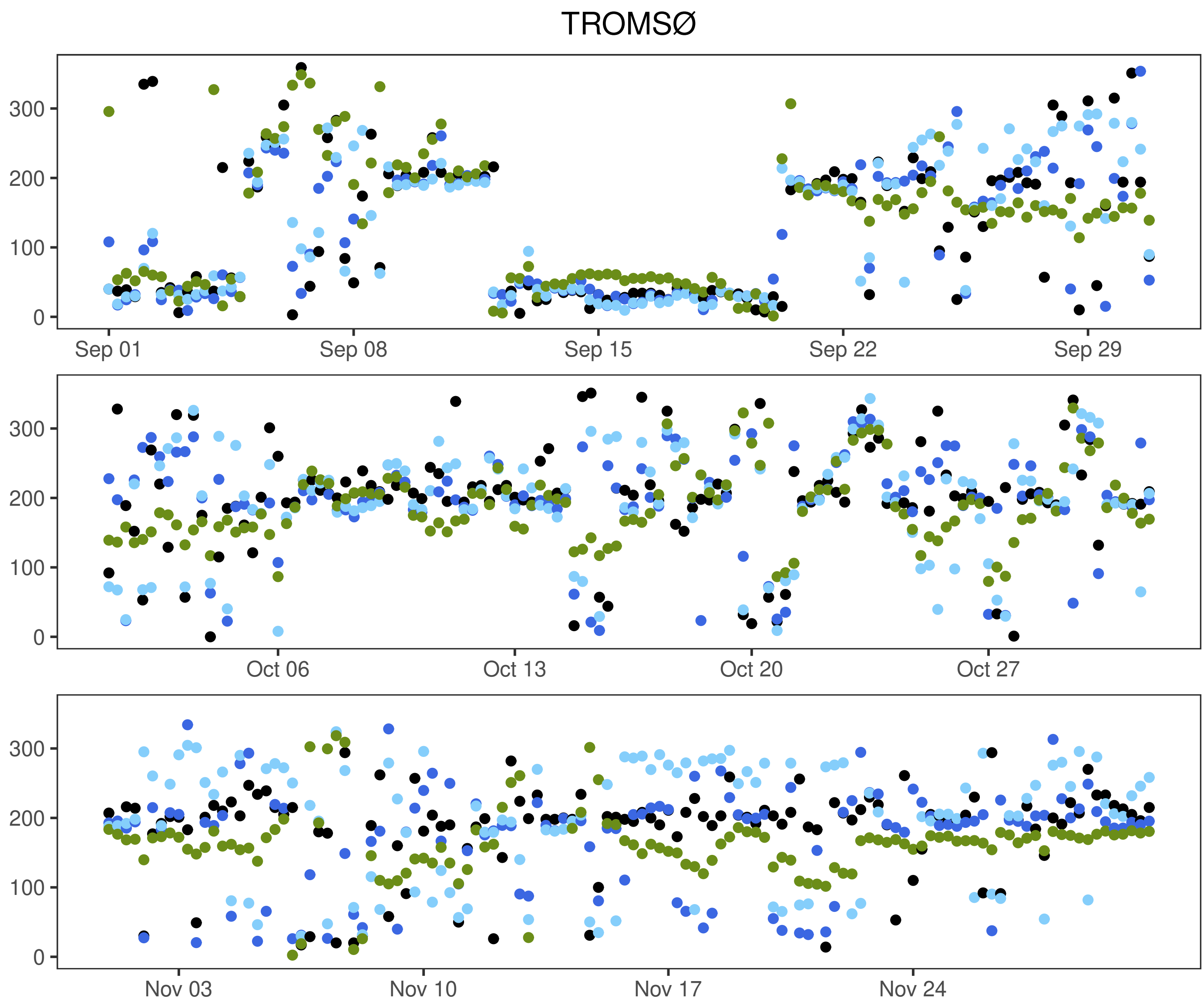
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.1	1.8	1.8	1.3	9.1	352
AA25–synop	0.1	1.6	1.6	1.3	5.5	352
ECMWF–synop	0.2	1.5	1.5	1.2	4.7	352

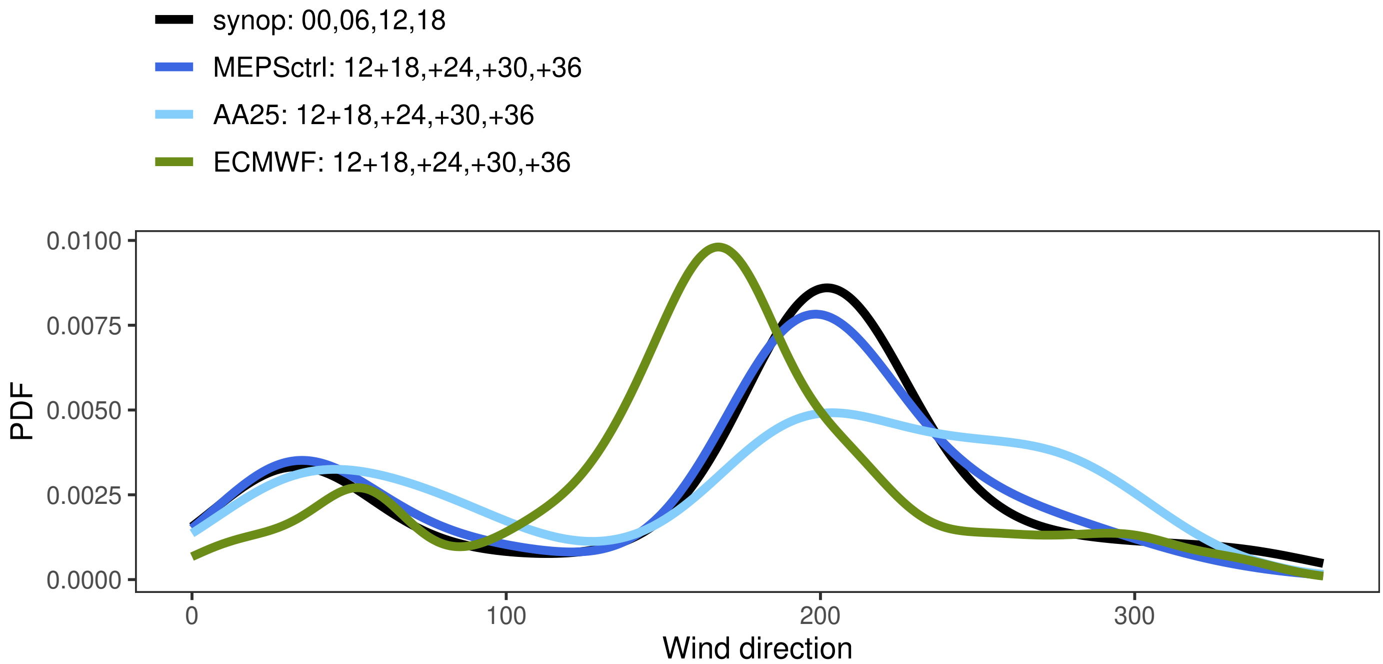

BJØRNØYA
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.003
0.002
0.001
Wind direction

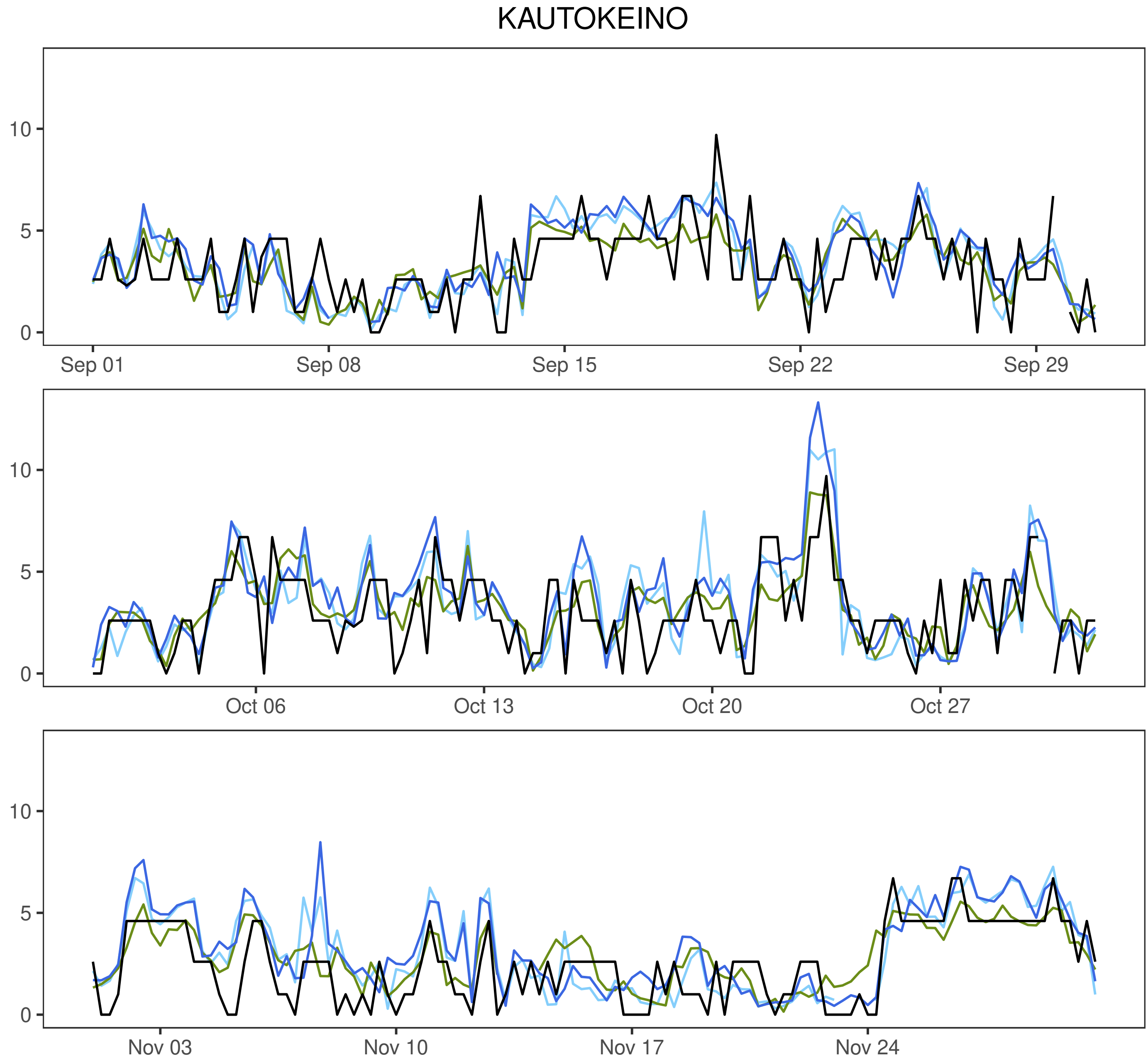


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	3.0	9.5	1.9	364
MEPSctrl: 12+18,+24,+30,+36	0.4	3.3	12.9	2.3	360
AA25: 12+18,+24,+30,+36	0.4	3.2	11.8	2.3	360
ECMWF: 12+18,+24,+30,+36	0.4	2.2	6.5	1.1	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.3	1.4	1.5	1.1	5.7	352
AA25–synop	0.2	1.5	1.5	1.1	6.2	352
ECMWF–synop	−0.8	1.4	1.6	1.2	6.1	352

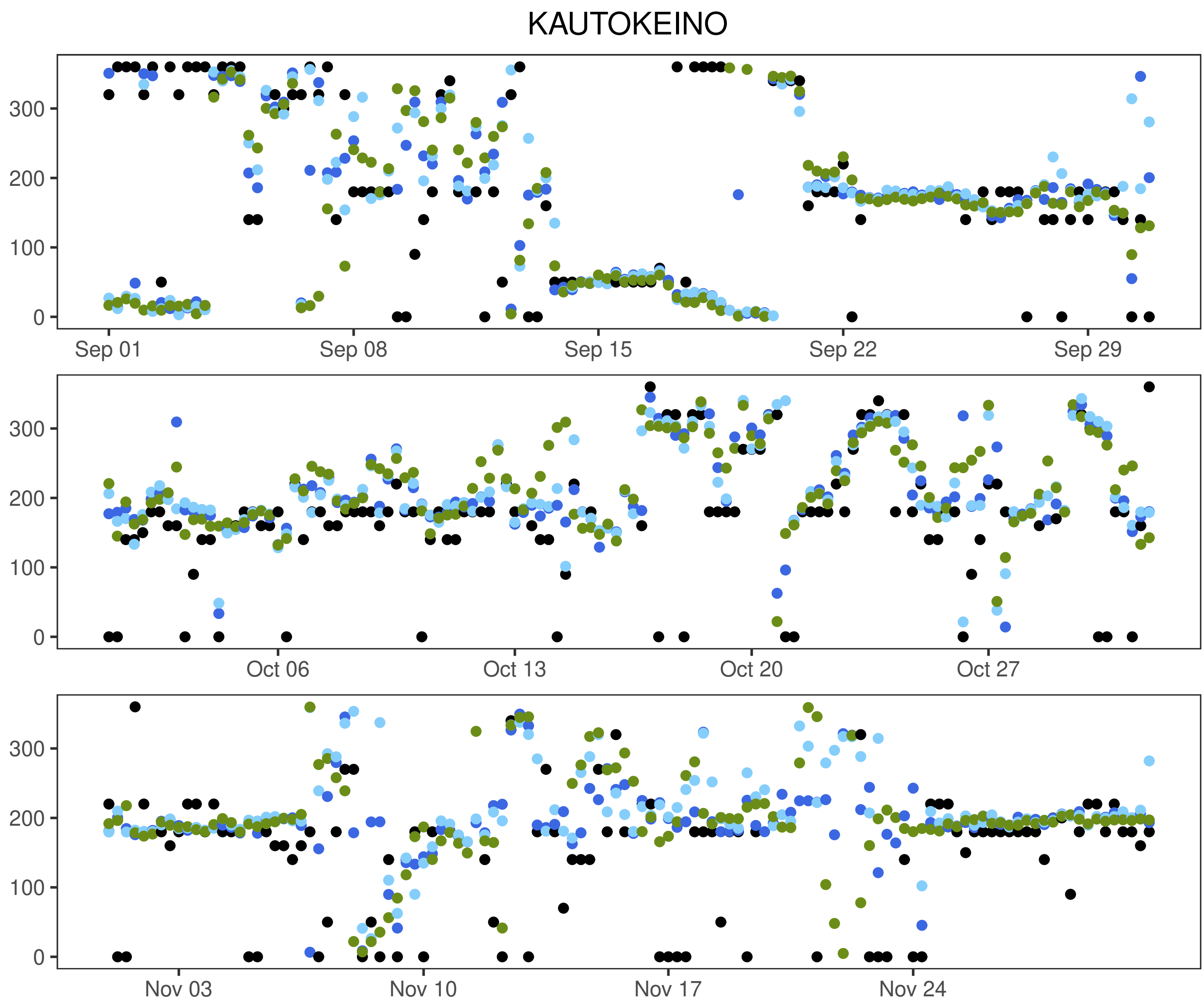

TROMSØ
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24

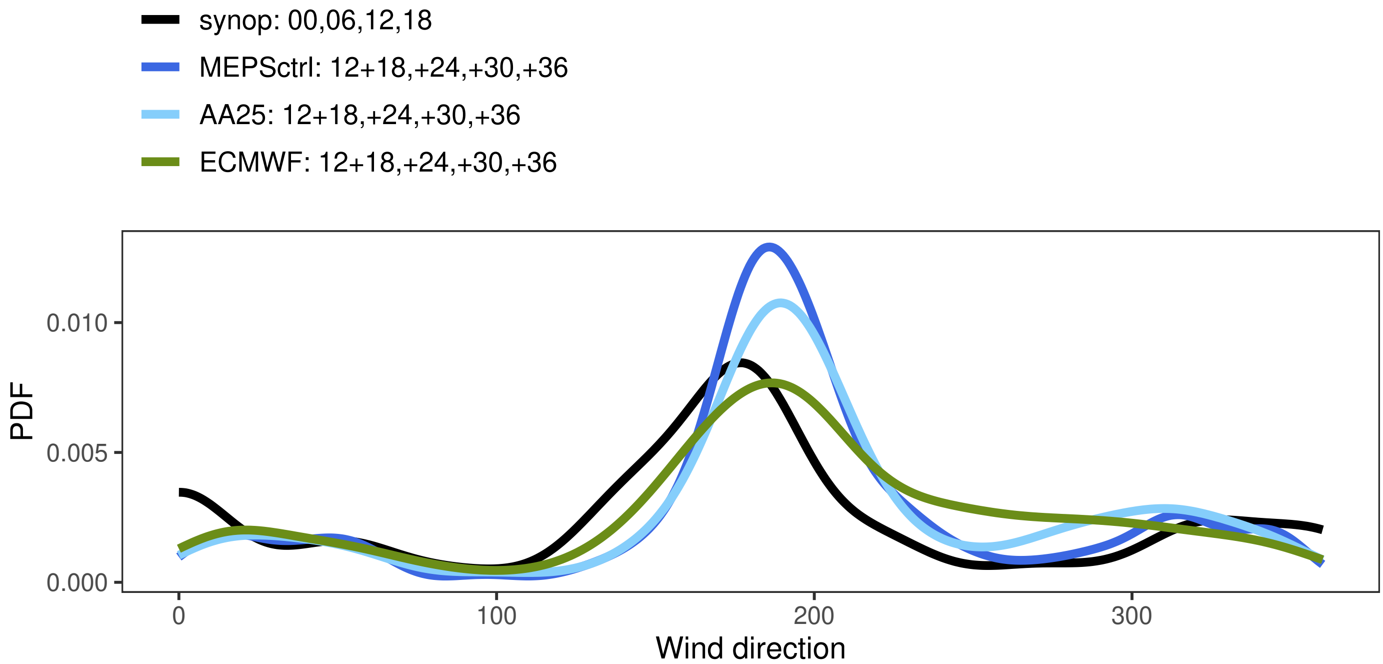

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0100
0.0075
0.0050
0.0025
0.0000
0
100
200
300
Wind direction

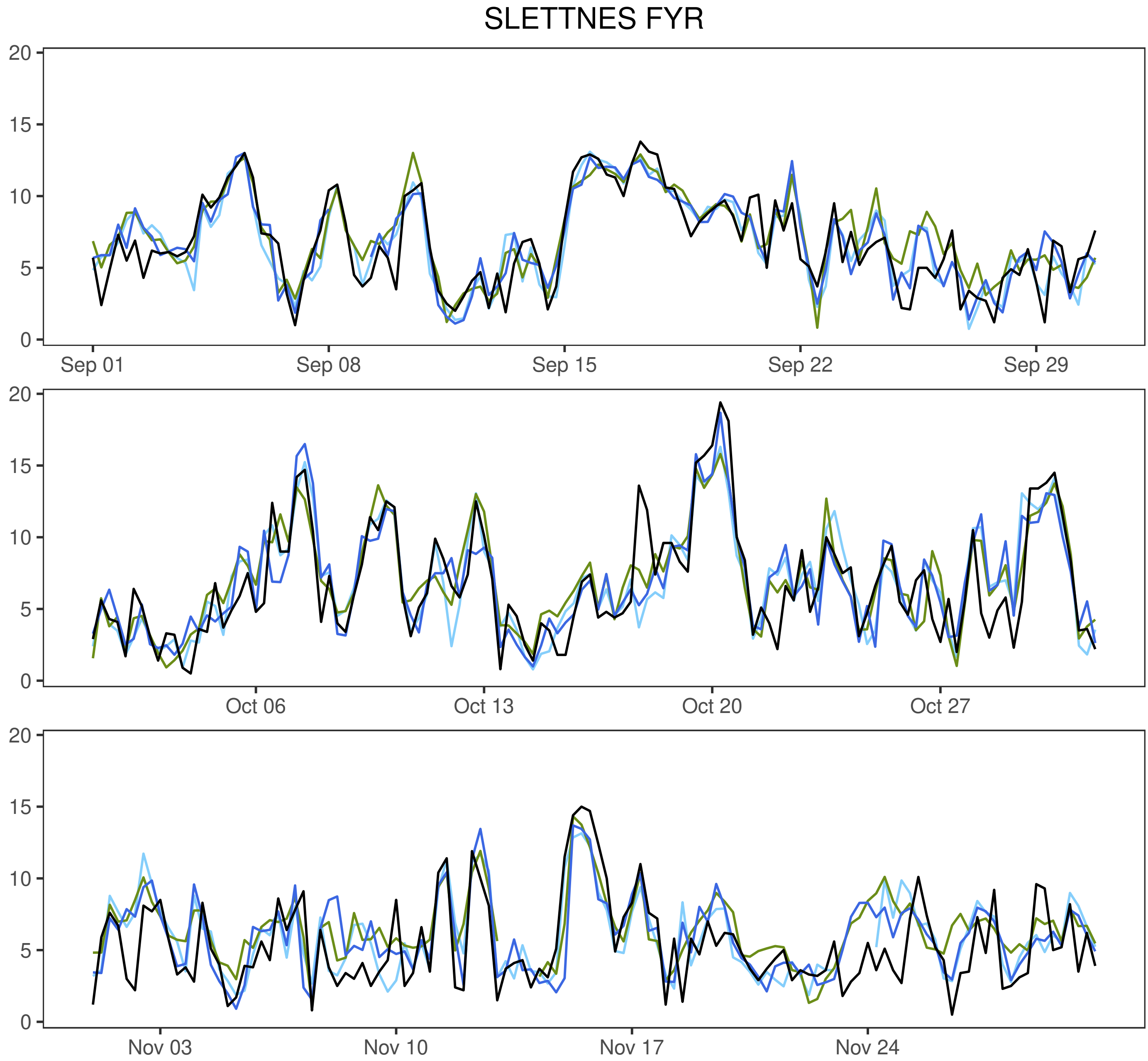


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	2.9	9.7	1.9	362
MEPSctrl: 12+18,+24,+30,+36	0.3	3.5	13.3	2.0	360
AA25: 12+18,+24,+30,+36	0.1	3.4	11.0	2.1	360
ECMWF: 12+18,+24,+30,+36	0.1	3.1	8.9	1.5	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.6	1.7	1.8	1.4	6.6	350
AA25–synop	0.5	1.7	1.8	1.4	6.4	350
ECMWF–synop	0.2	1.5	1.5	1.2	4.1	350

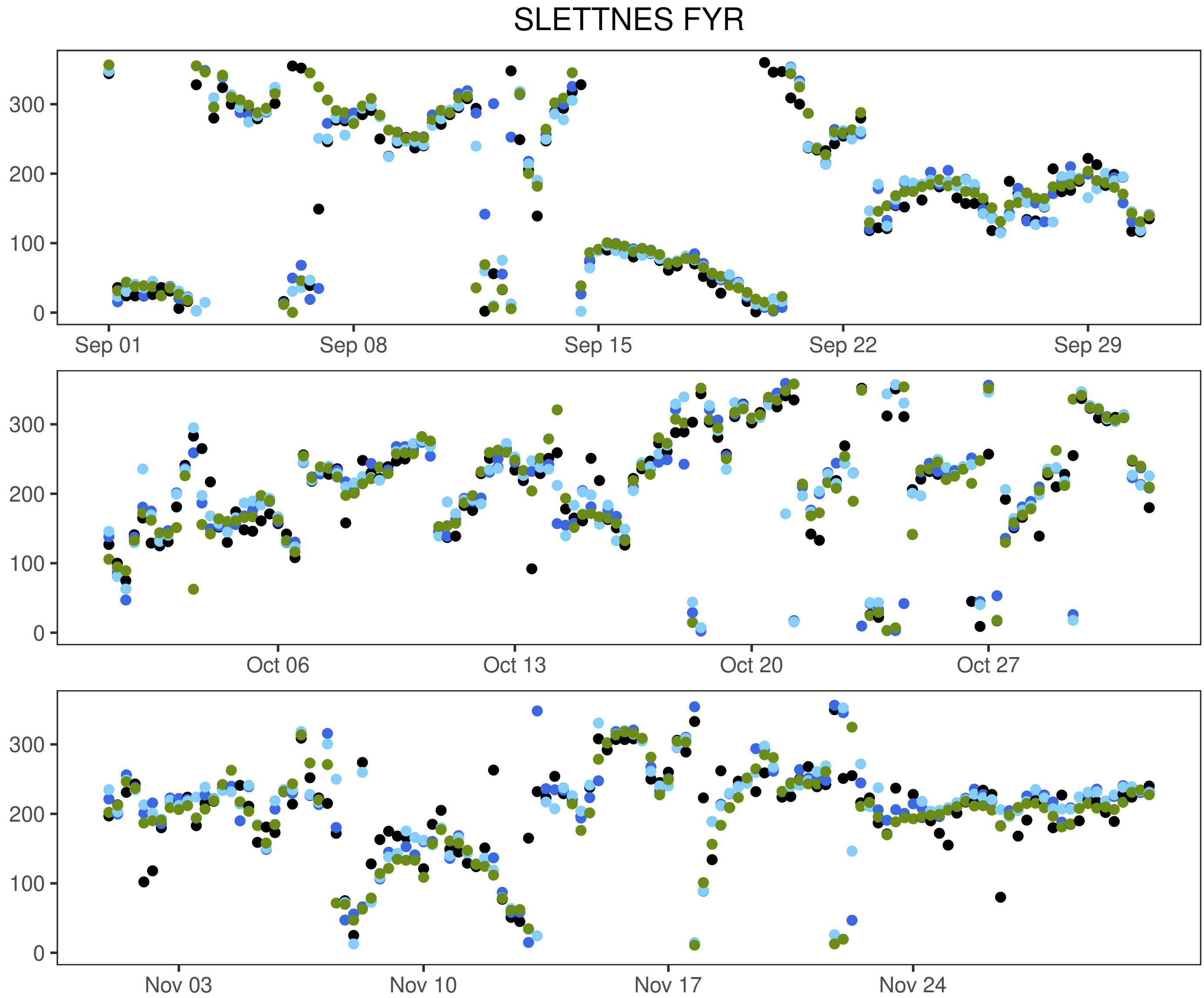

KAUTOKEINO
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24

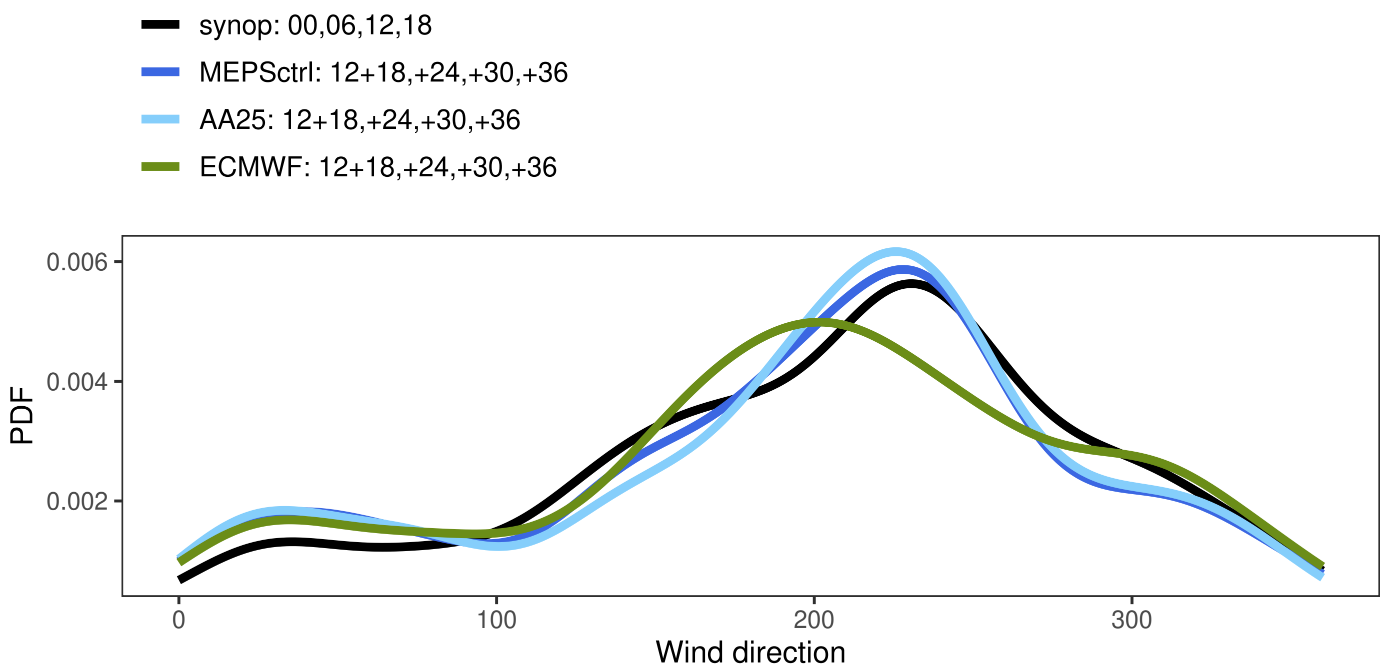

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.010
0.005
0.000
0
100
200
300
Wind direction



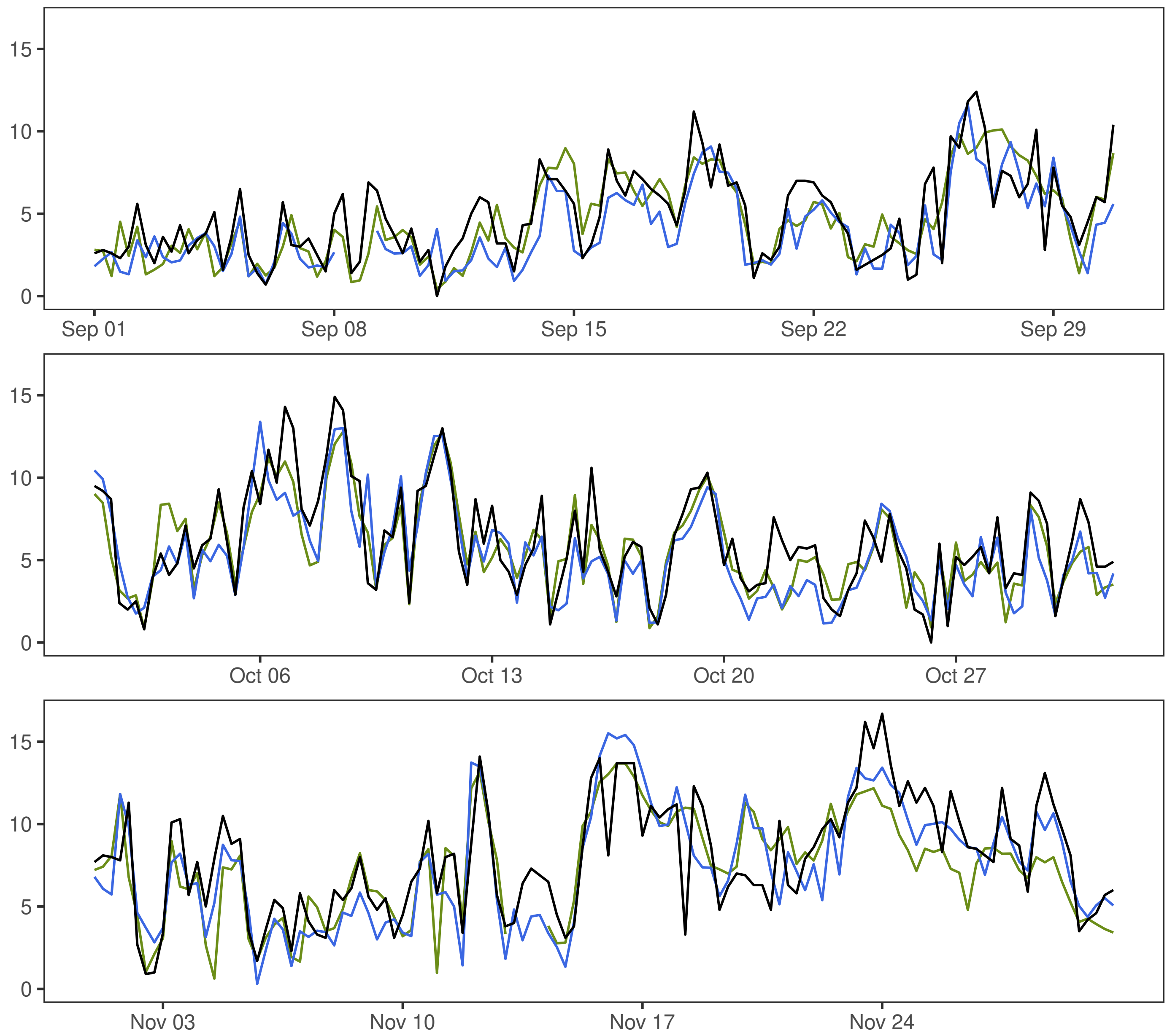
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	6.3	19.4	3.5	364
MEPSctrl: 12+18,+24,+30,+36	0.9	6.6	18.7	3.1	360
AA25: 12+18,+24,+30,+36	0.7	6.5	16.3	3.2	360
ECMWF: 12+18,+24,+30,+36	0.8	6.9	15.8	2.9	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	2.1	2.2	1.6	8.5	352
AA25–synop	0.2	2.1	2.1	1.6	9.9	352
ECMWF–synop	0.6	2.0	2.1	1.6	6.3	352


SLETTNES FYR
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24

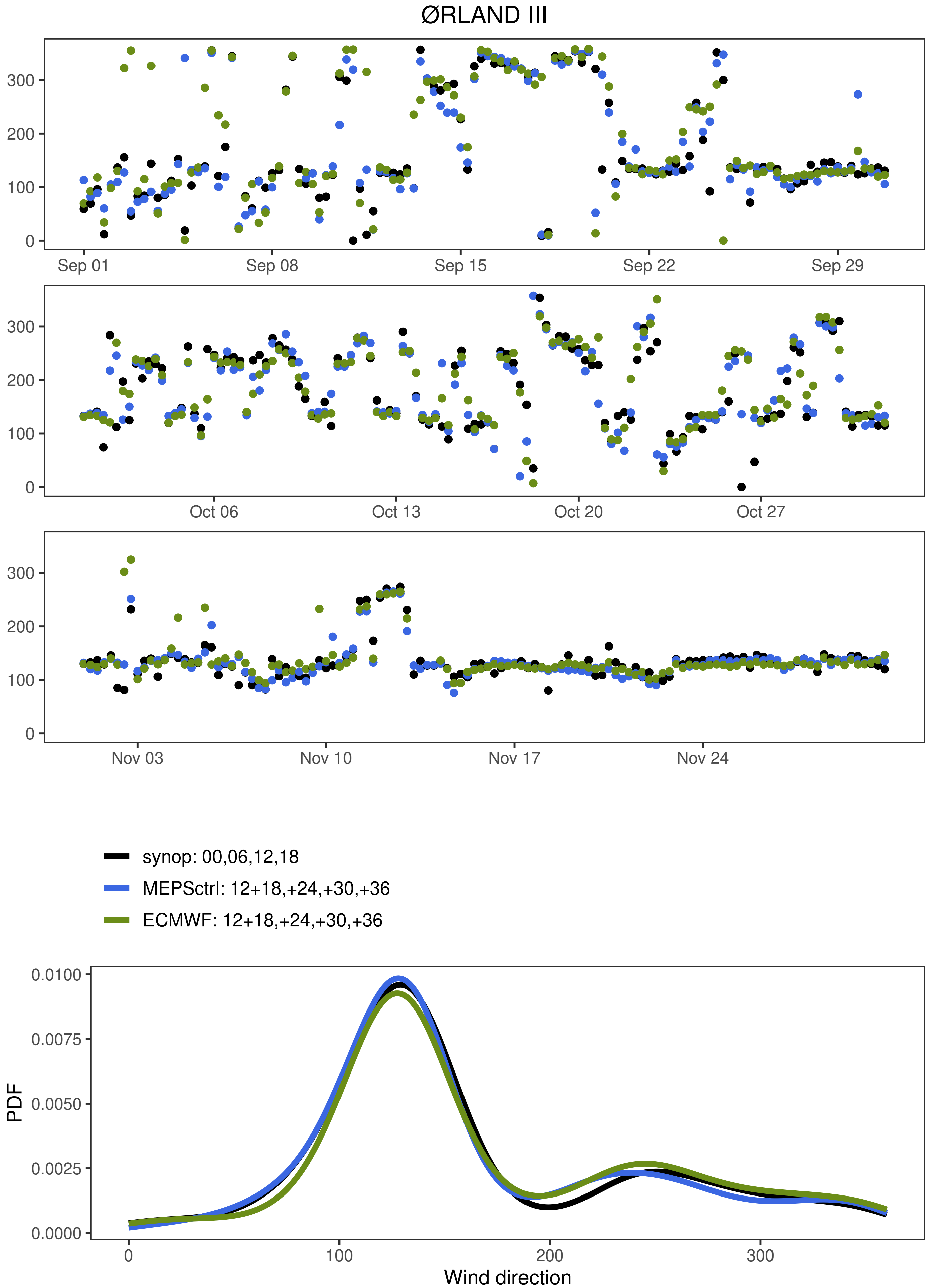

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
AA25: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

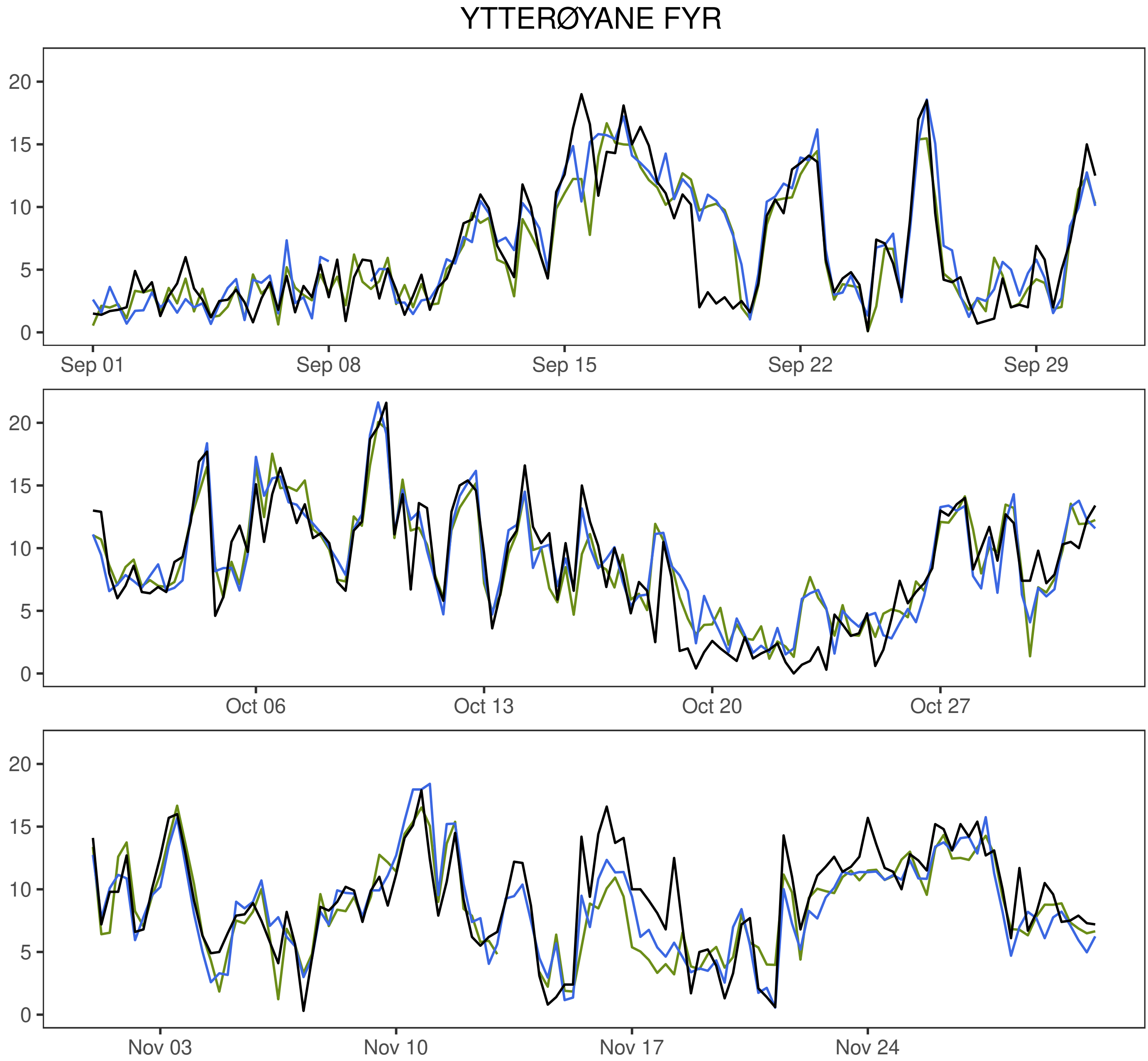
ØRLAND III



	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	6.3	16.7	3.3	364
MEPSctrl: 12+18,+24,+30,+36	0.3	5.6	15.5	3.3	360
ECMWF: 12+18,+24,+30,+36	0.4	5.9	13.7	3.0	360

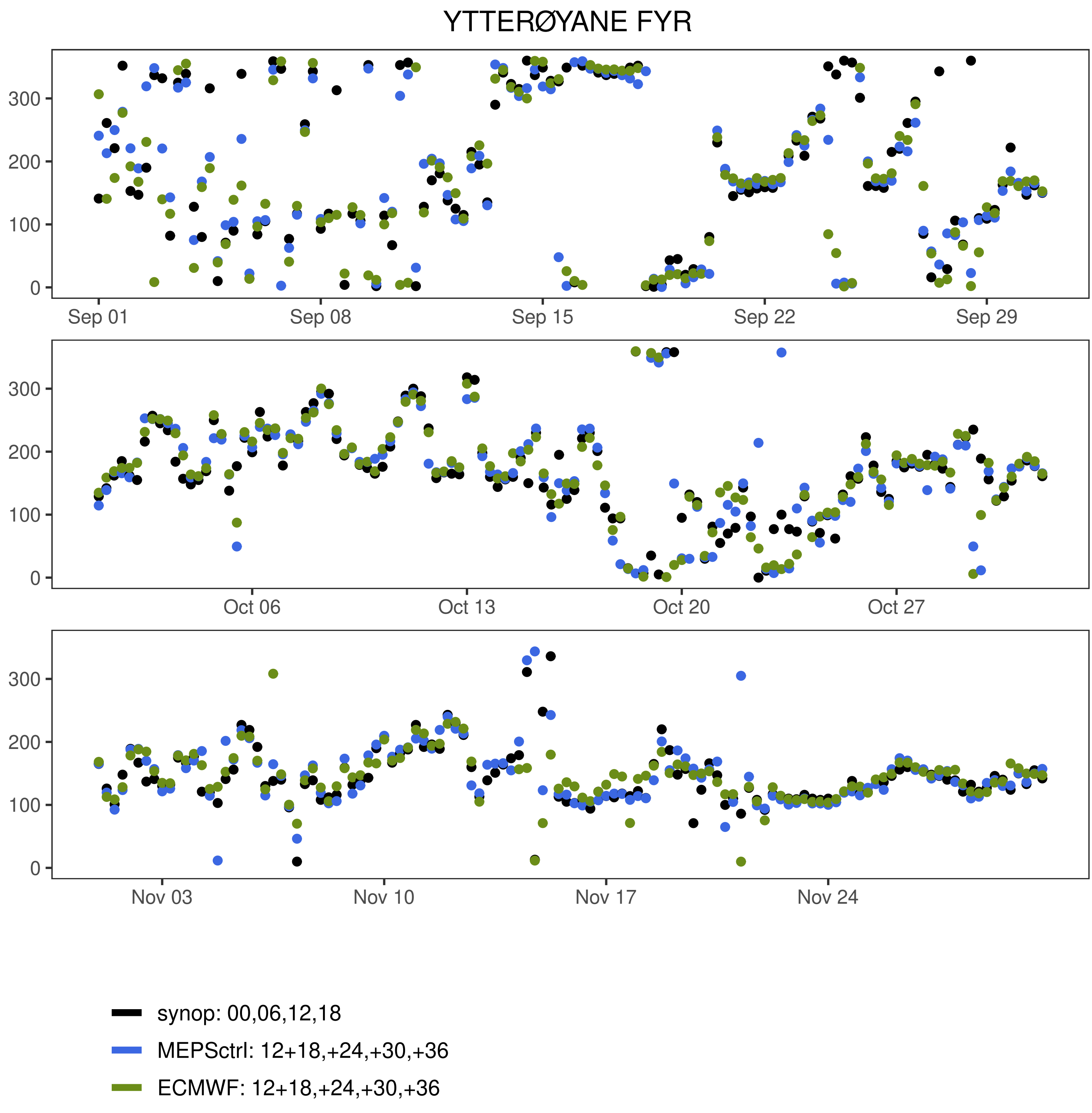
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.7	1.9	2.0	1.5	7.4	356
ECMWF–synop	–0.4	1.9	1.9	1.5	7.7	356

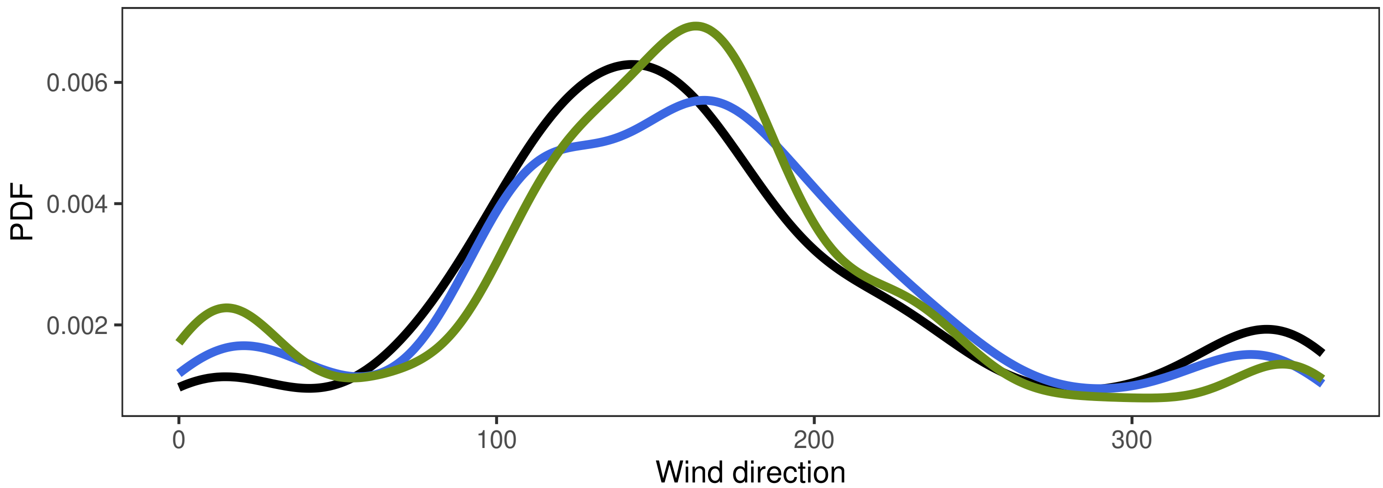

ØRLAND III
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.0100
0.0075
0.0050
0.0025
0.0000
Wind direction

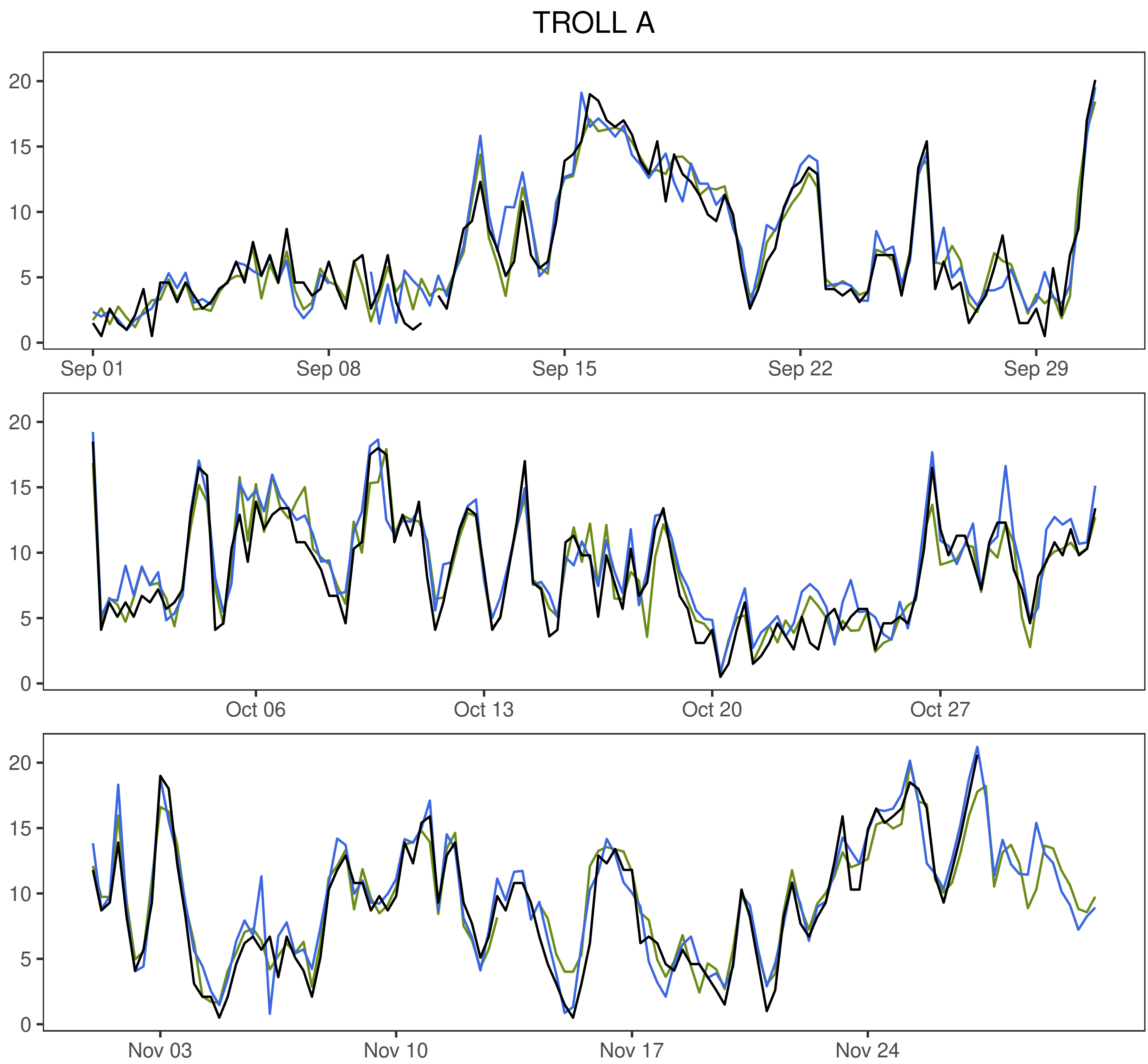


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	8.1	21.6	4.7	364
MEPSctrl: 12+18,+24,+30,+36	0.6	8.1	21.6	4.3	360
ECMWF: 12+18,+24,+30,+36	0.1	7.8	20.1	4.2	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.0	2.3	2.3	1.7	8.6	356
ECMWF−synop	−0.2	2.3	2.4	1.7	9.4	356

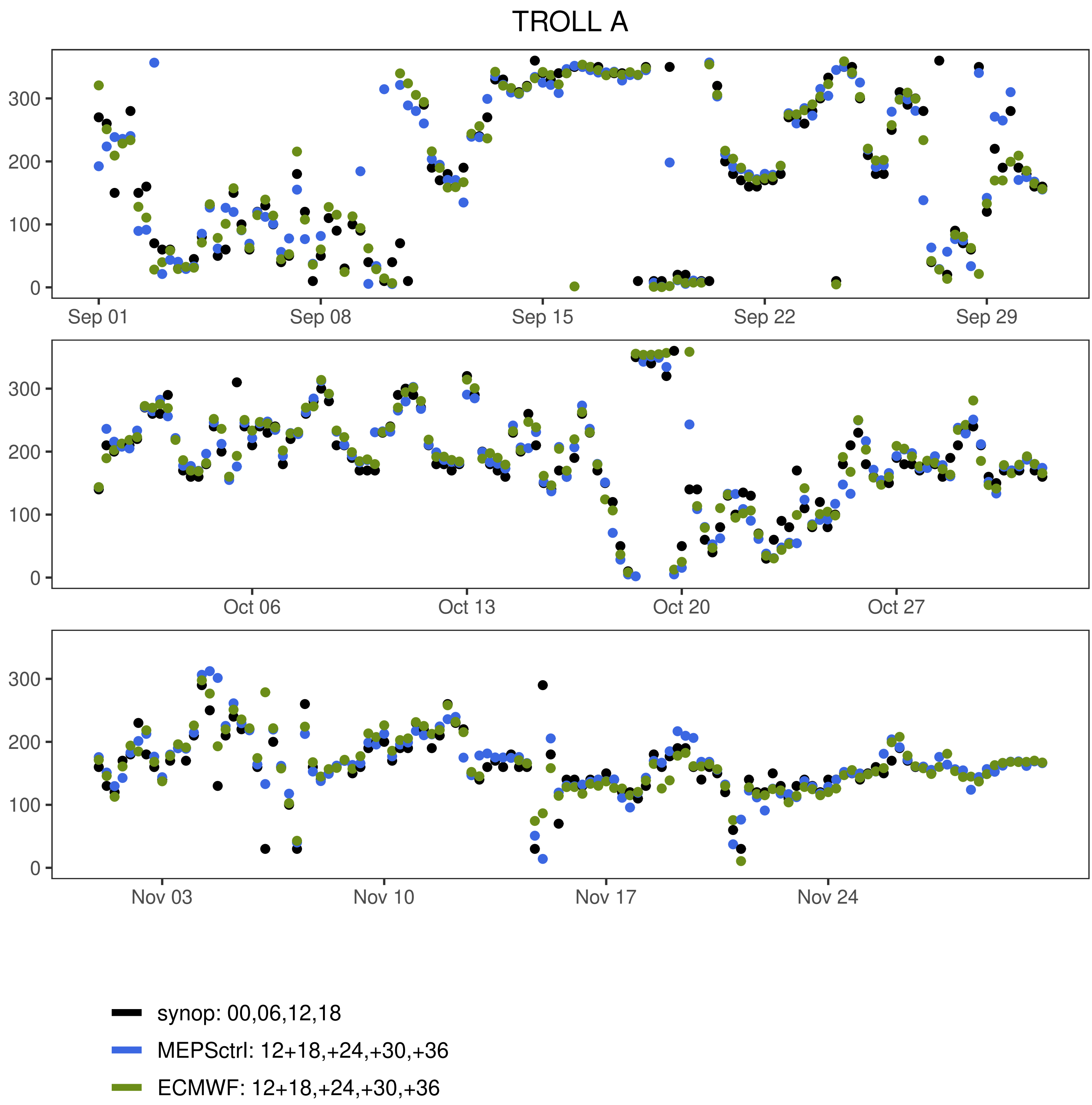

YTTERØYANE FYR
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

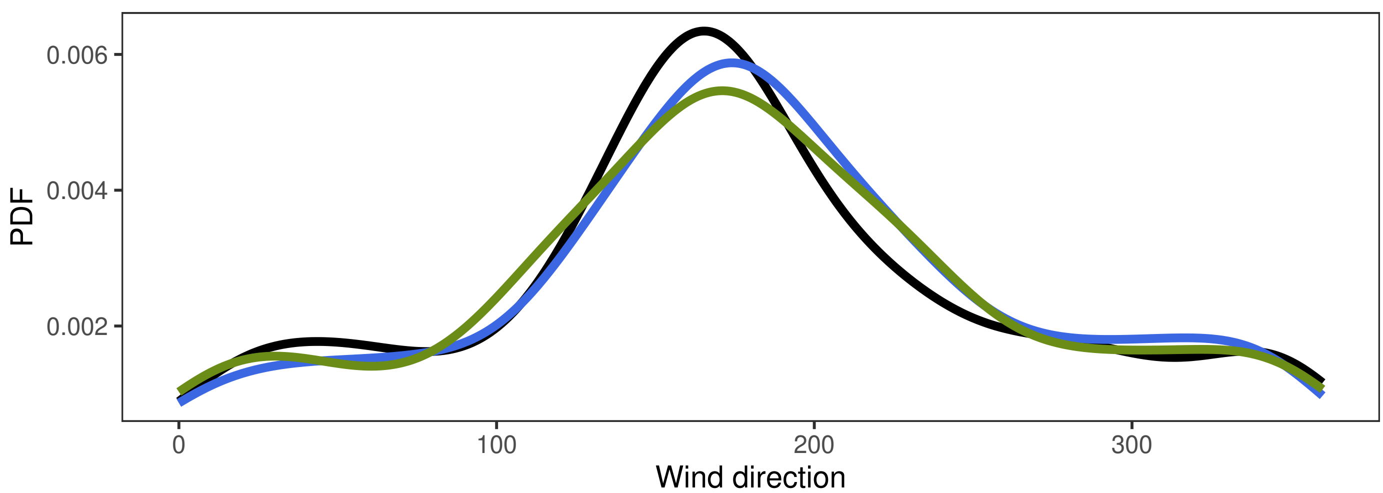

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

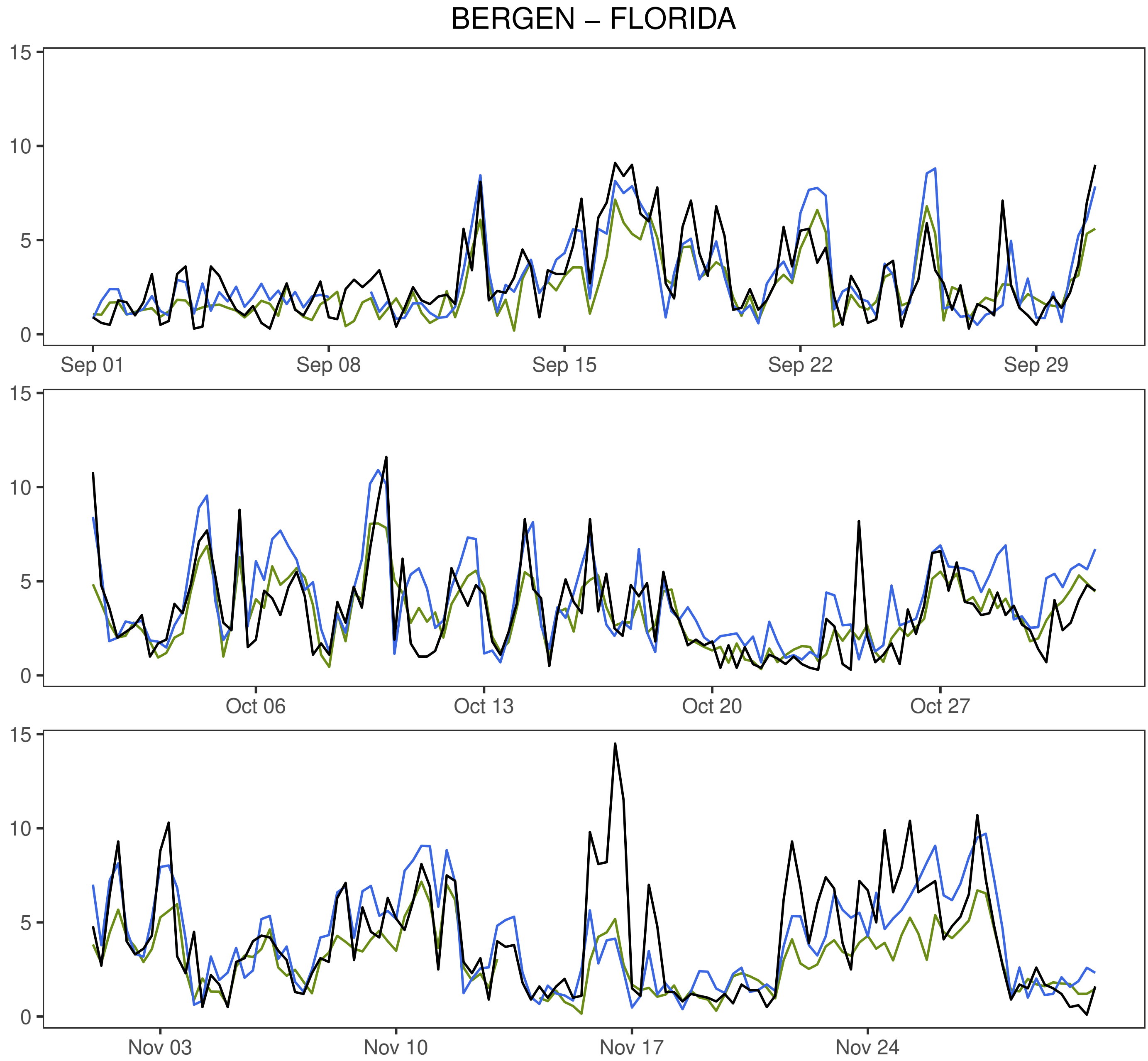


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.5	8.1	20.6	4.6	349
MEPSctrl: 12+18,+24,+30,+36	0.8	8.8	21.2	4.5	360
ECMWF: 12+18,+24,+30,+36	0.8	8.4	20.0	4.3	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.6	1.7	1.8	1.4	5.9	341
ECMWF−synop	0.2	1.5	1.5	1.2	5.9	341

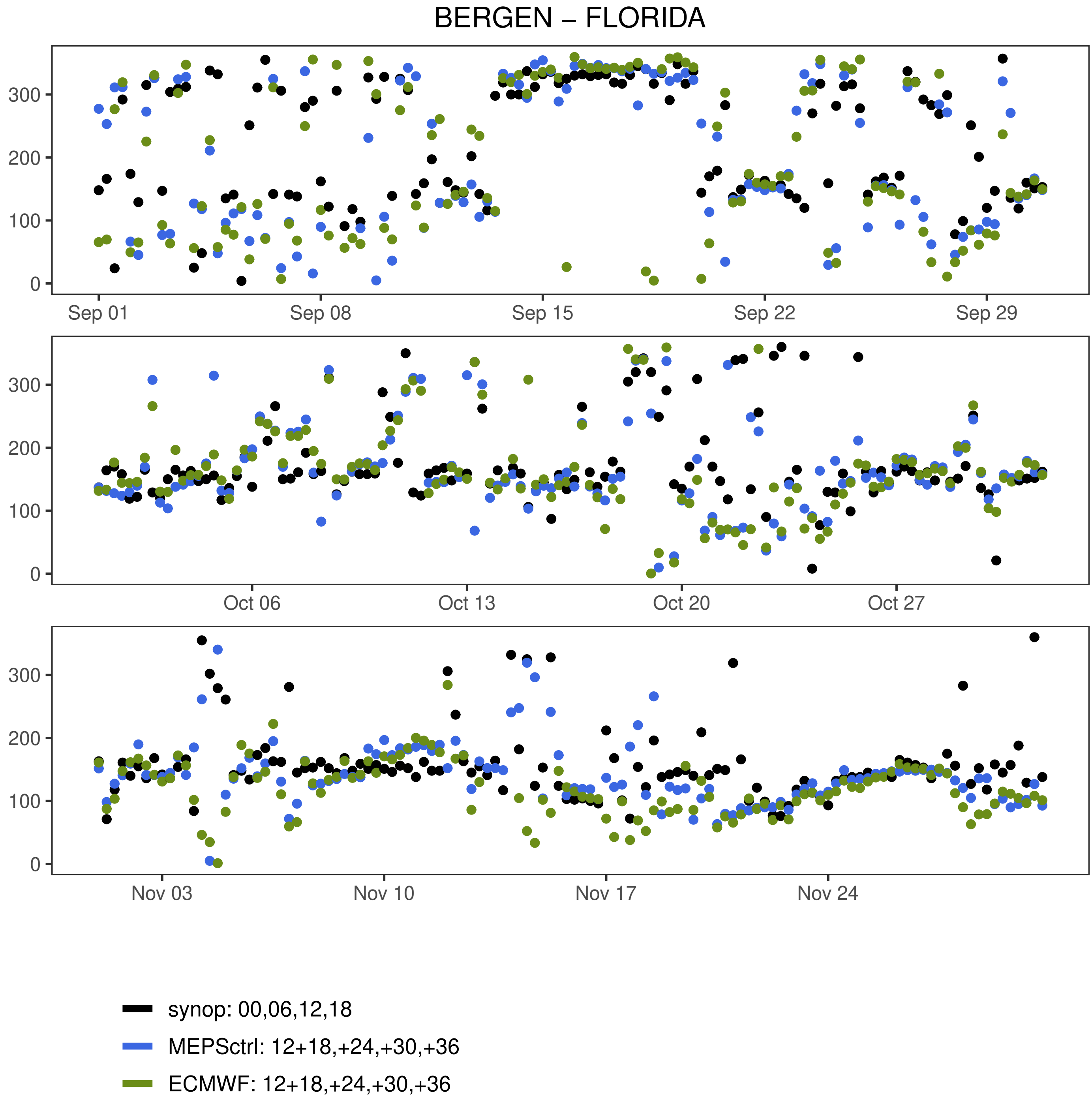

TROLL A
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

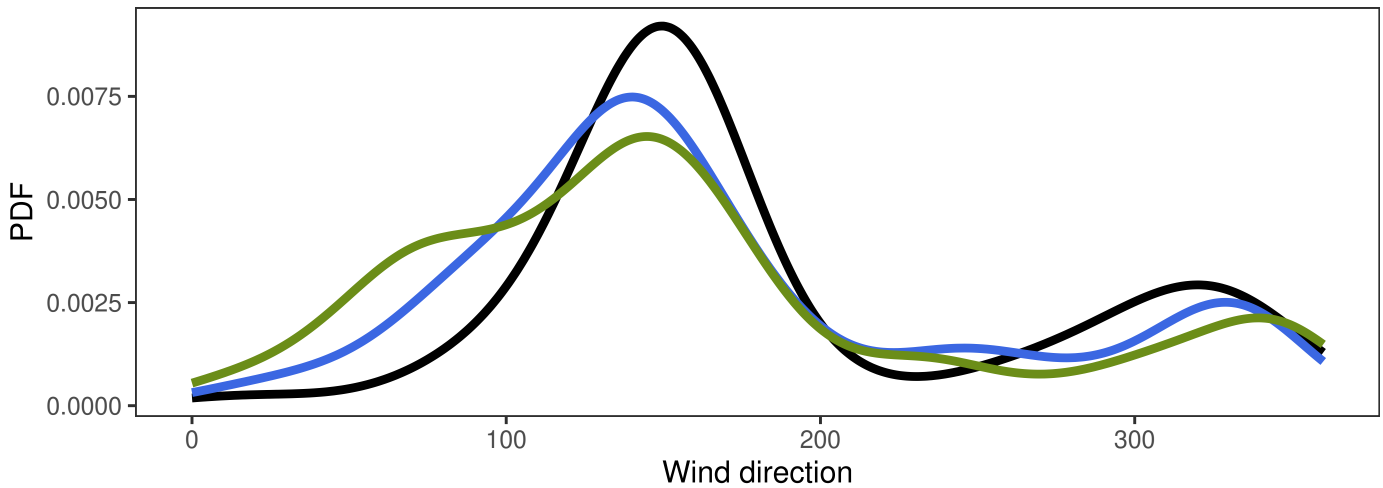

PDF
0.006
0.004
0.002
0
100
200
300
Wind direction

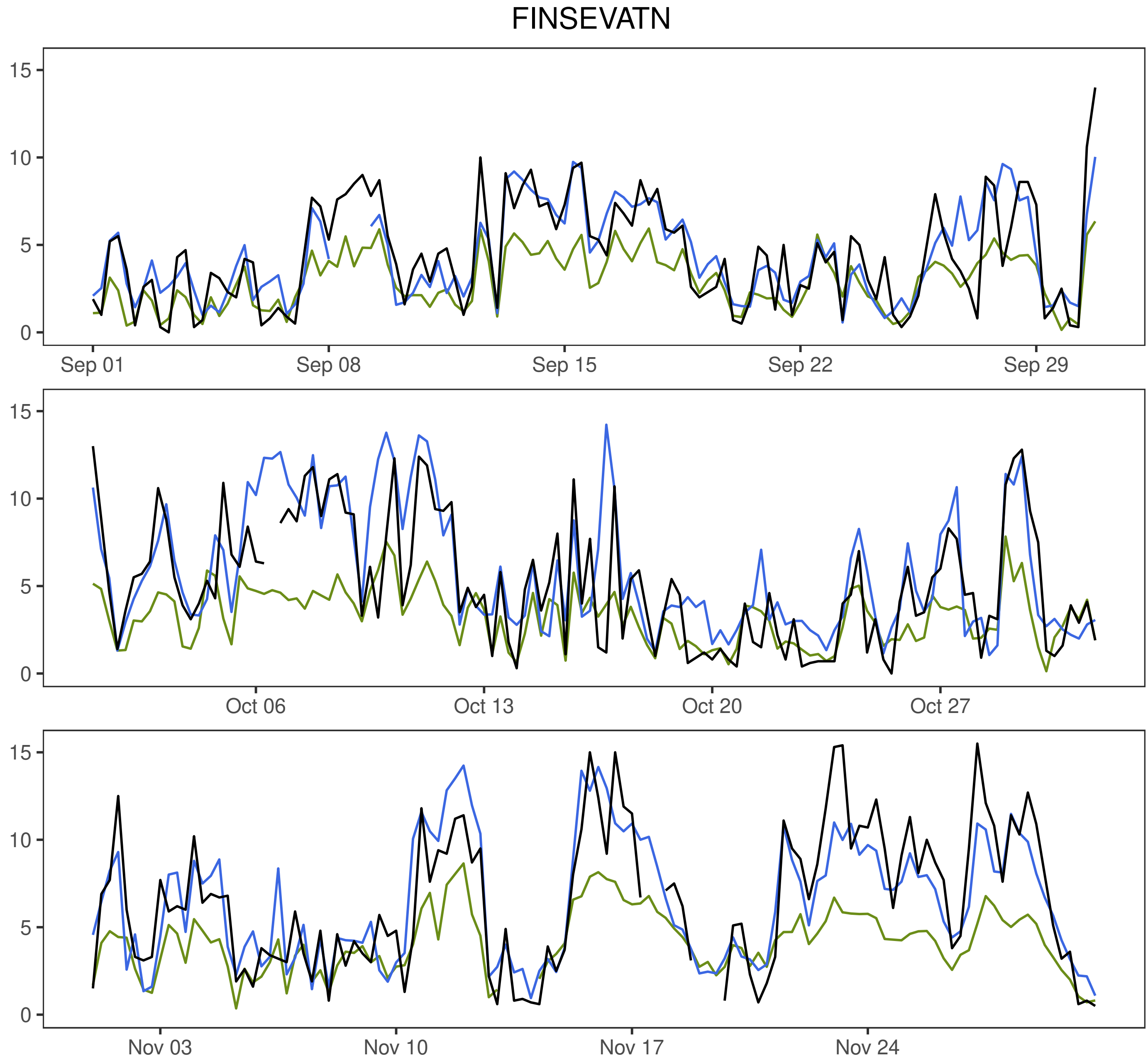


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.1	3.5	14.5	2.5	364
MEPSctrl: 12+18,+24,+30,+36	0.4	3.7	10.9	2.4	360
ECMWF: 12+18,+24,+30,+36	0.2	2.9	8.1	1.7	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	1.9	1.9	1.4	10.4	356
ECMWF–synop	−0.6	1.7	1.8	1.2	9.3	356

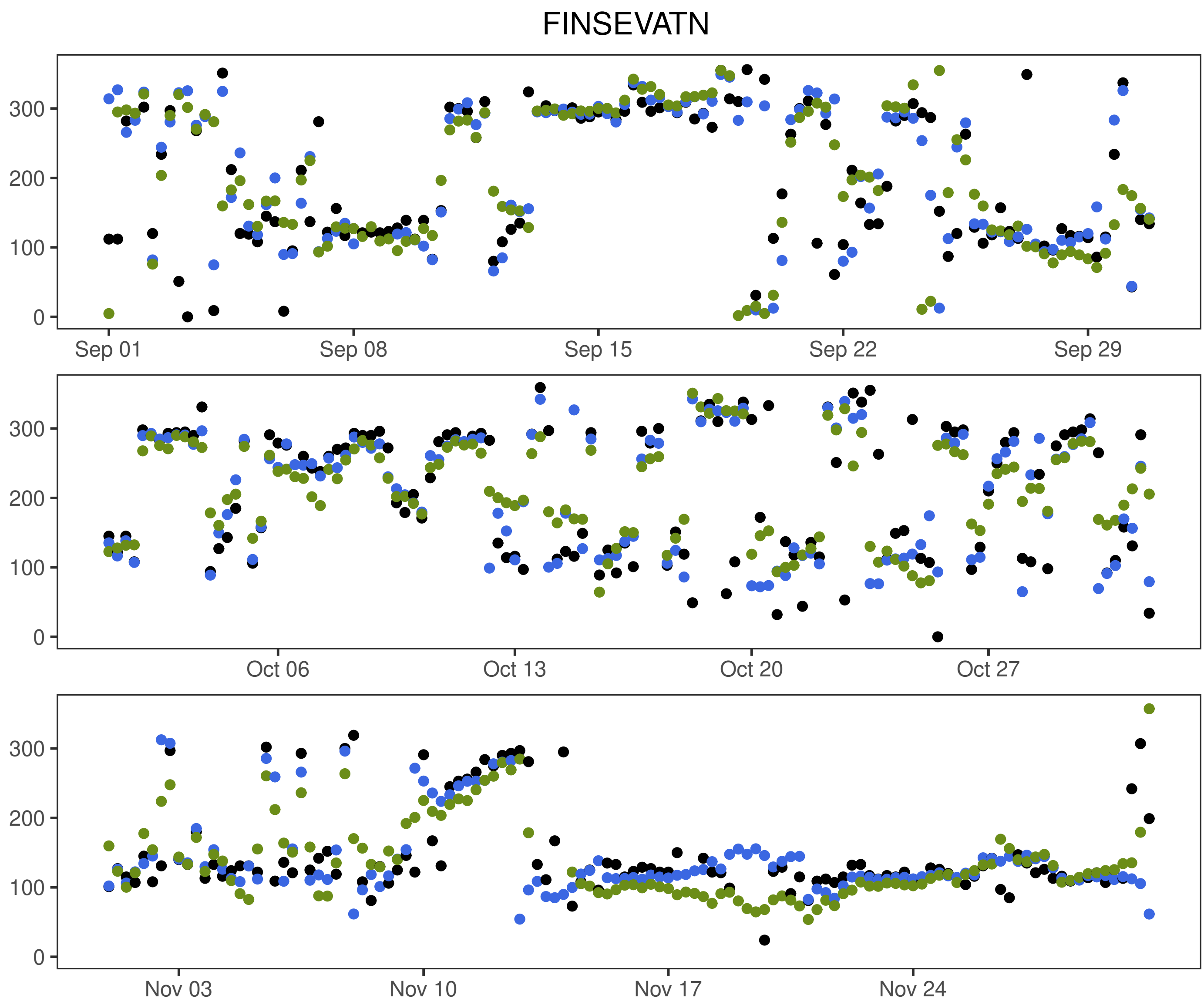

BERGEN – FLORIDA
0
100
200
300
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36

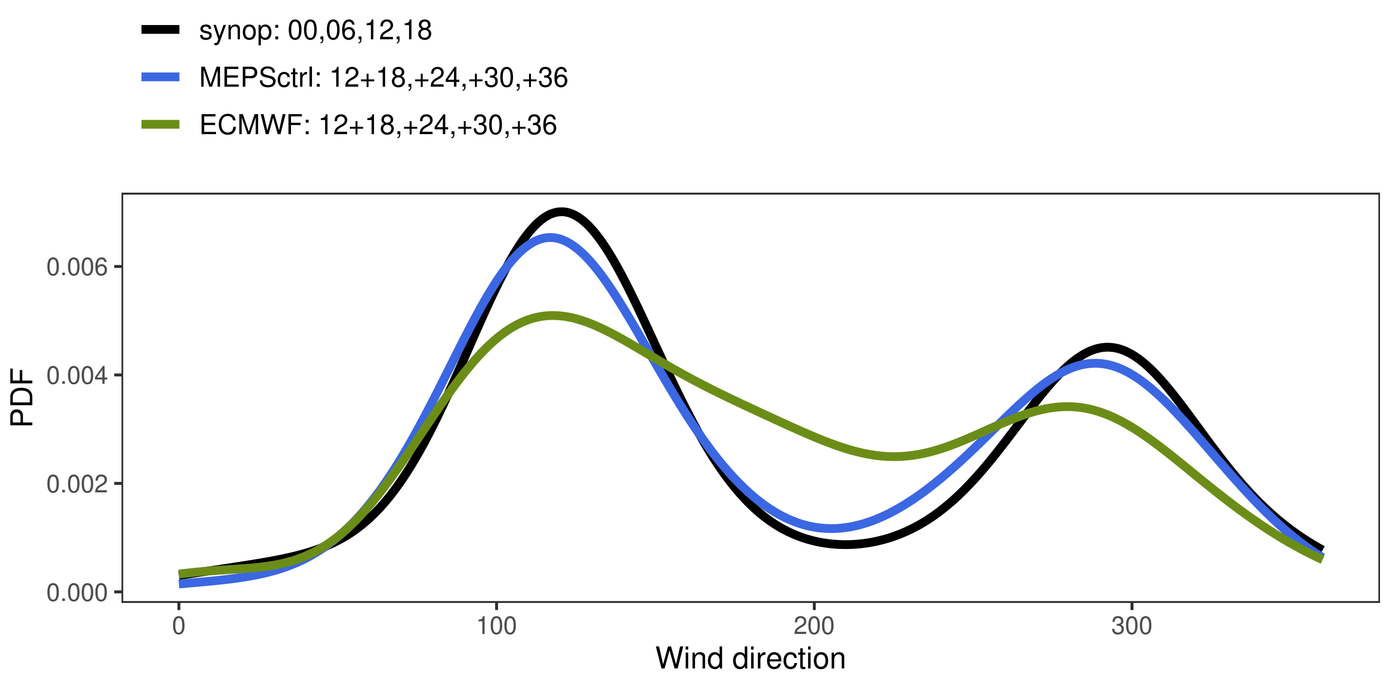

PDF
0.0000
0.0025
0.0050
0.0075
0
100
200
300
Wind direction



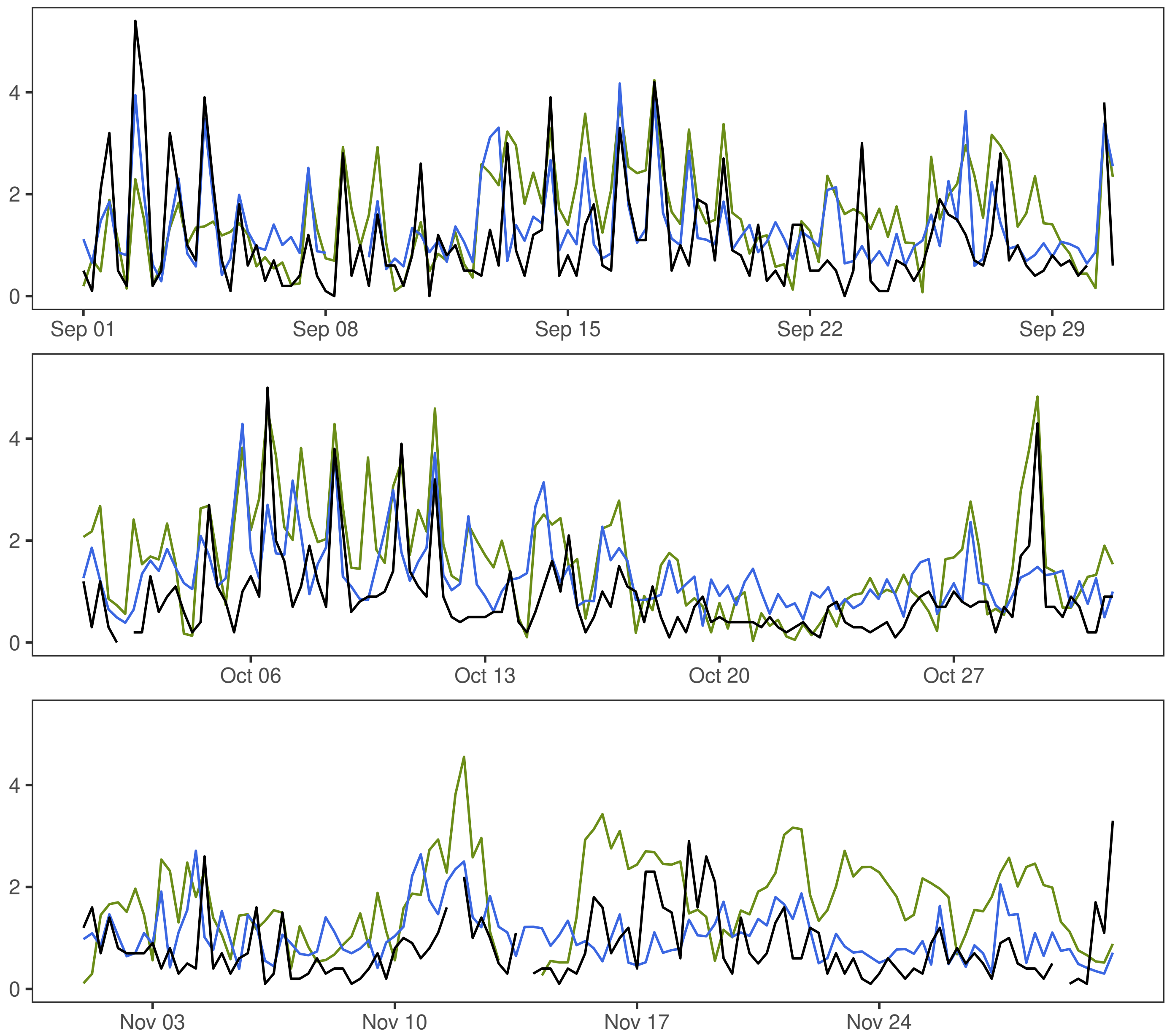
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.4	15.5	3.6	358
MEPSctrl: 12+18,+24,+30,+36	0.6	5.6	14.2	3.4	360
ECMWF: 12+18,+24,+30,+36	0.1	3.5	8.6	1.8	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.2	2.2	2.2	1.6	13.0	350
ECMWF–synop	−1.9	2.4	3.1	2.3	10.3	350


FINSEVATN
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24

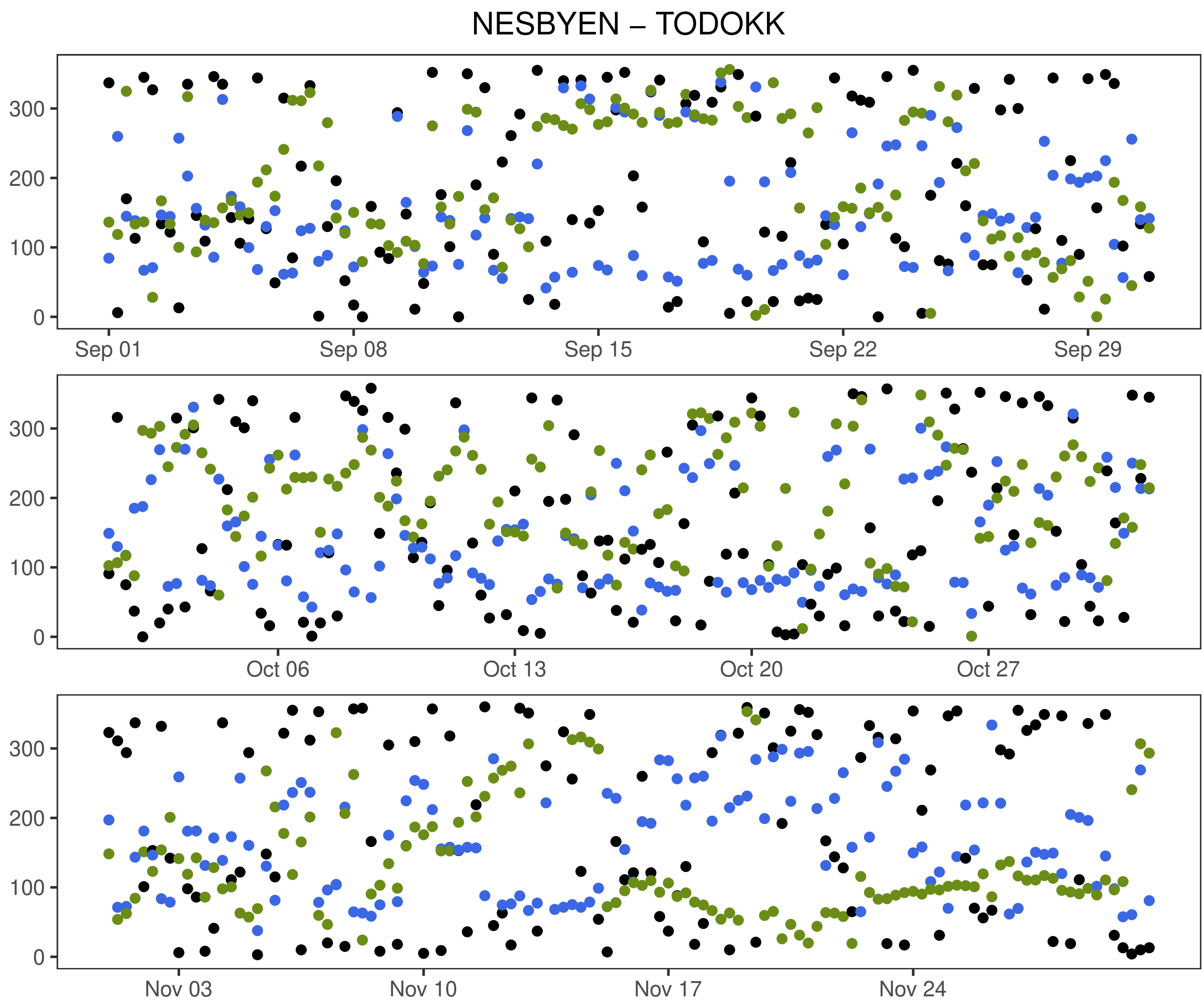

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction

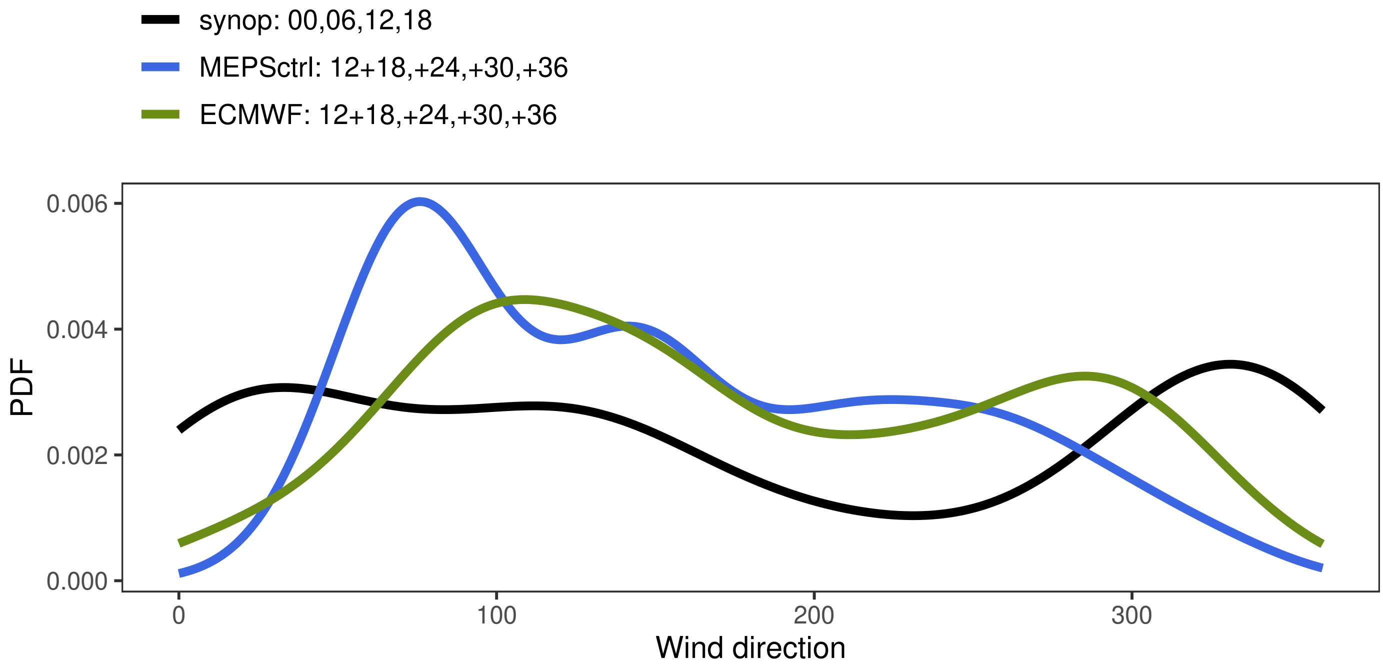
NESBYEN – TODOKK

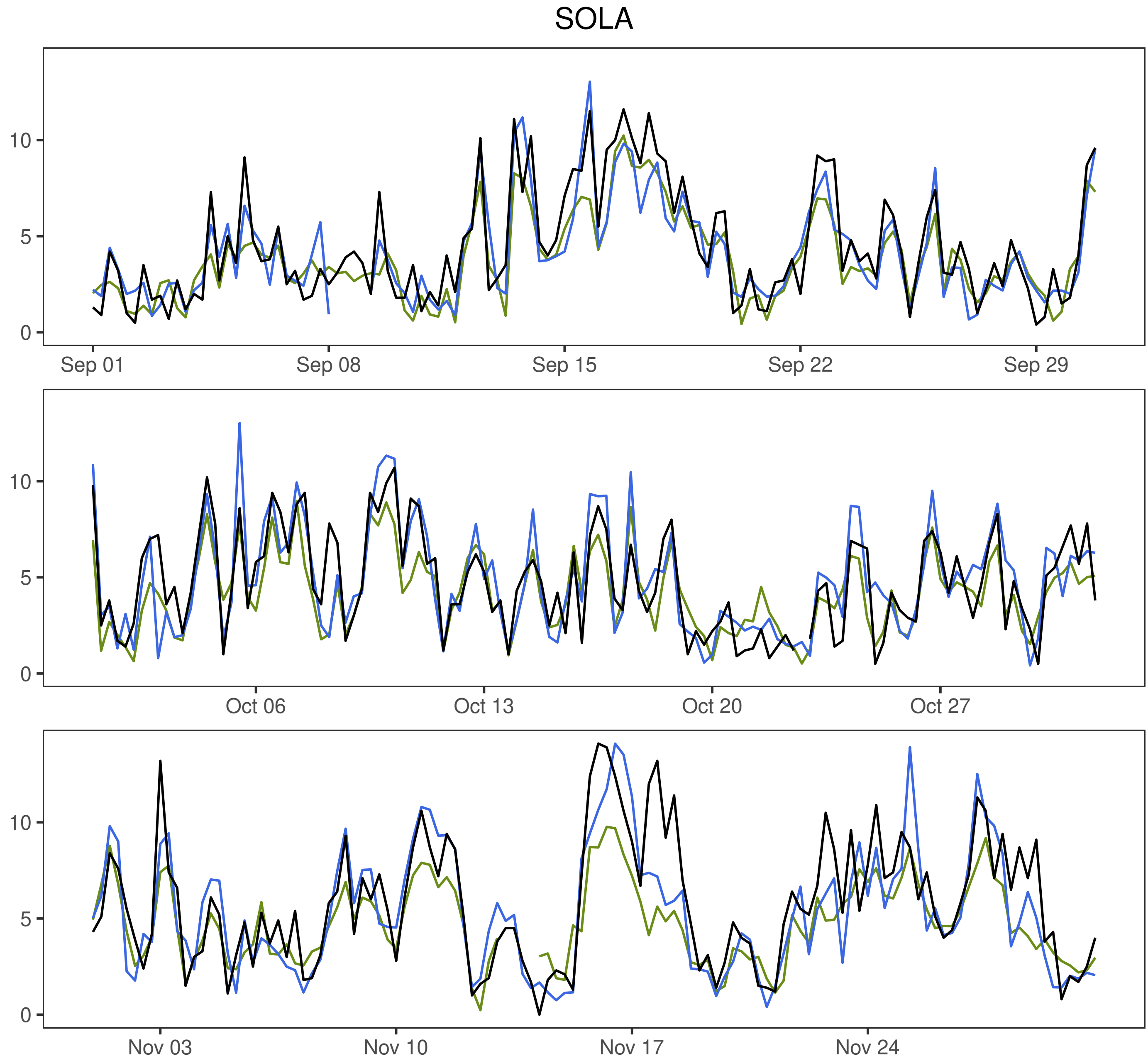


	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	0.9	5.4	0.9	359
MEPSctrl: 12+18,+24,+30,+36	0.3	1.2	4.3	0.7	360
ECMWF: 12+18,+24,+30,+36	0.0	1.6	4.8	0.9	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	0.3	0.8	0.9	0.7	3.3	352
ECMWF–synop	0.7	0.9	1.1	0.9	3.1	352

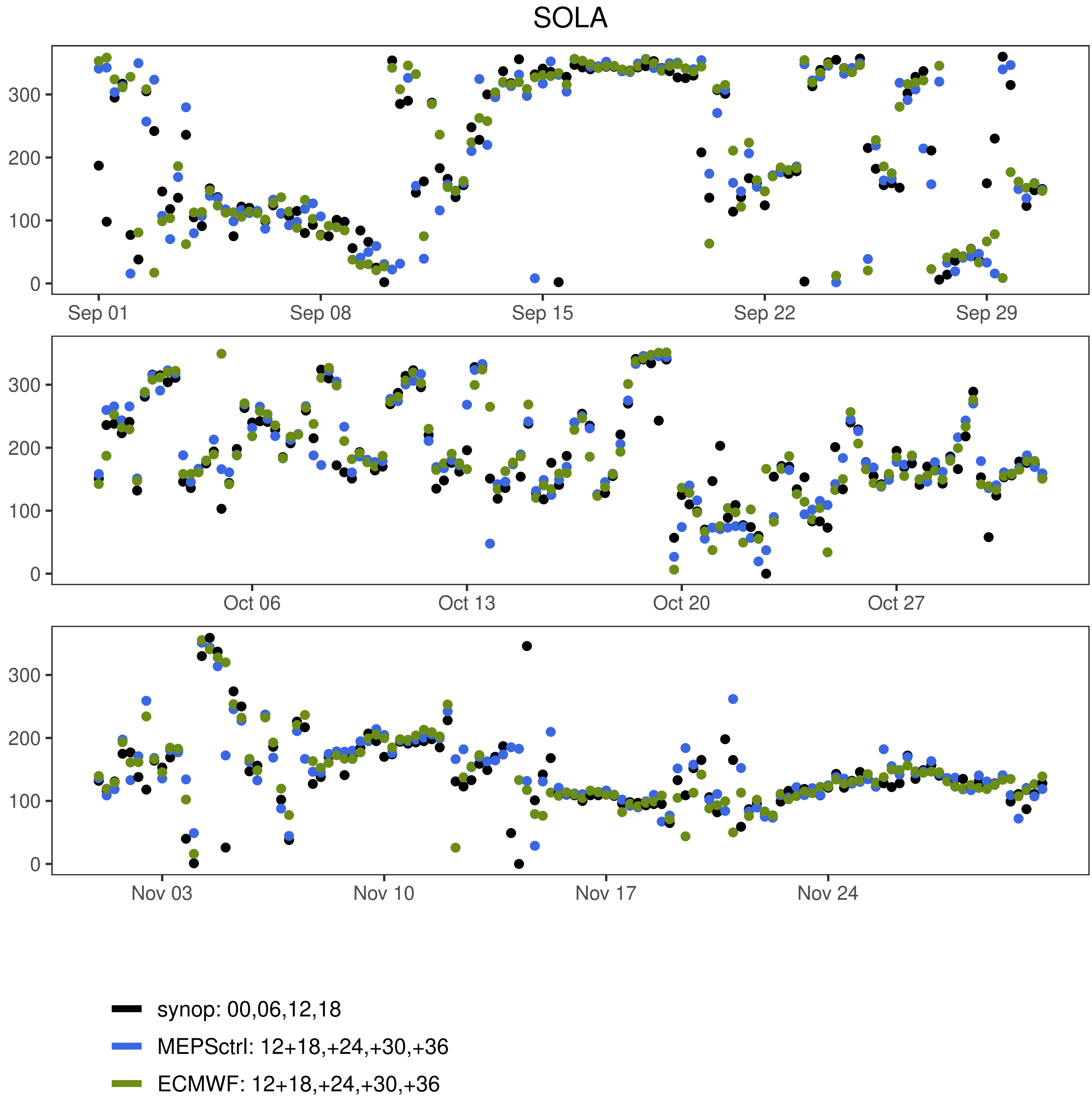

NESBYEN – TODOKK
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24

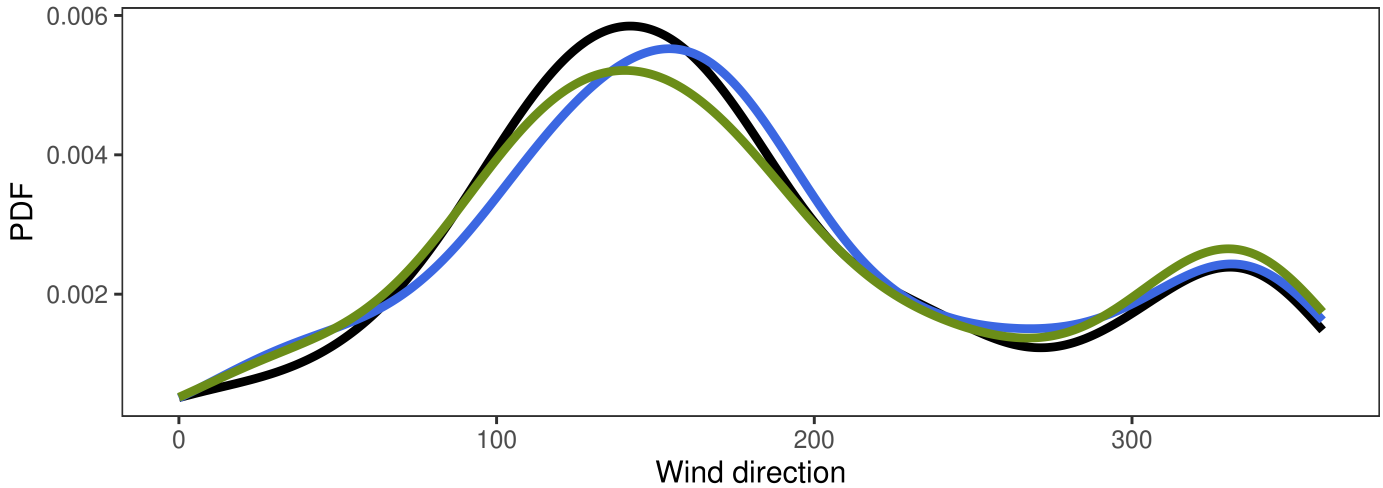

synop: 00,06,12,18
MEPSctrl: 12+18,+24,+30,+36
ECMWF: 12+18,+24,+30,+36
PDF
0.006
0.004
0.002
0.000
0
100
200
300
Wind direction



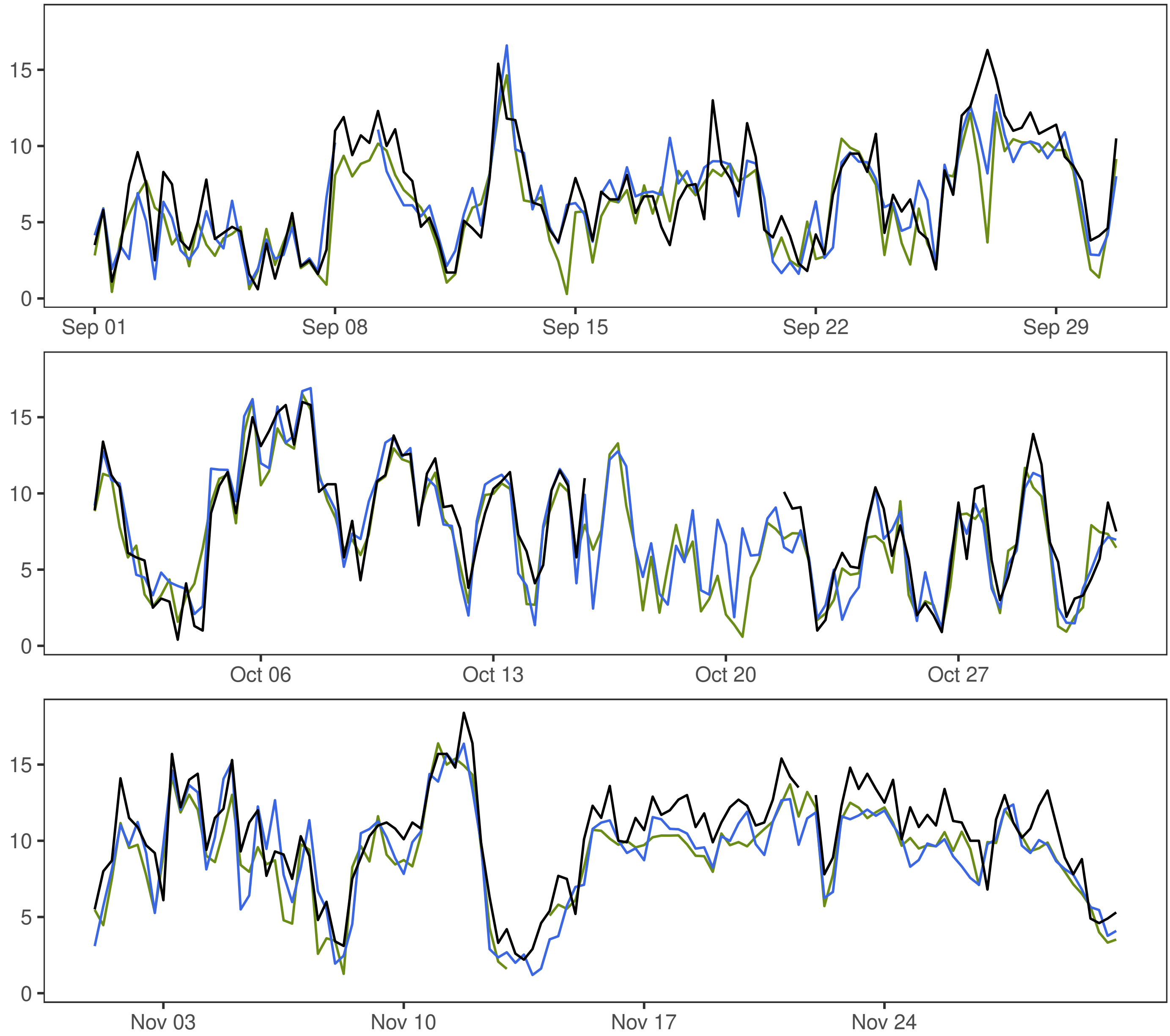
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.0	5.0	14.1	3.0	363
MEPSctrl: 12+18,+24,+30,+36	0.4	4.8	14.1	2.9	360
ECMWF: 12+18,+24,+30,+36	0.2	4.2	10.2	2.1	360

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.2	1.7	1.7	1.3	6.4	355
ECMWF−synop	−0.7	1.7	1.8	1.4	7.9	355


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

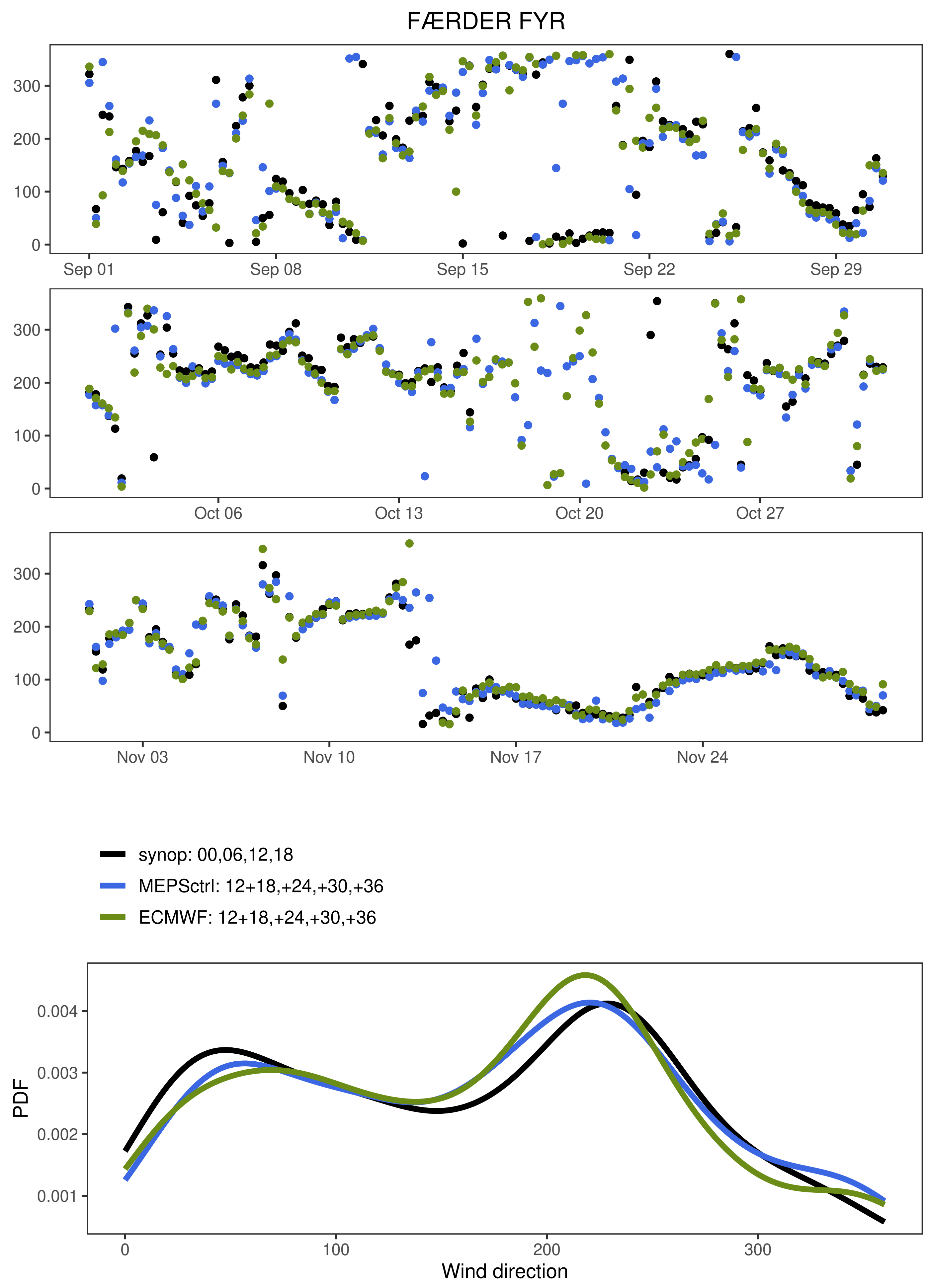

0.006
0.004
0.002
PDF
0
100
200
300
Wind direction

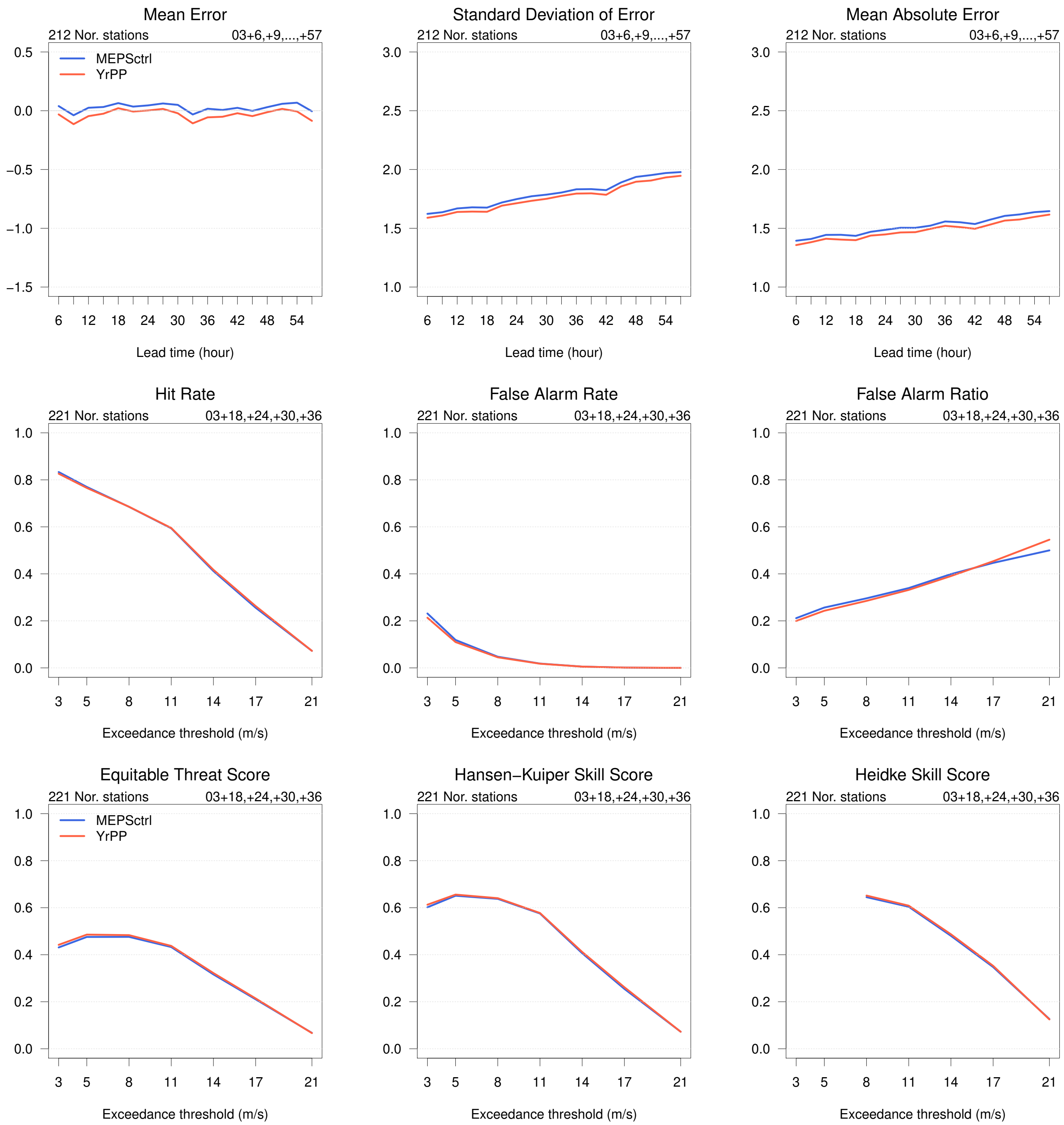
FÆRDER FYR



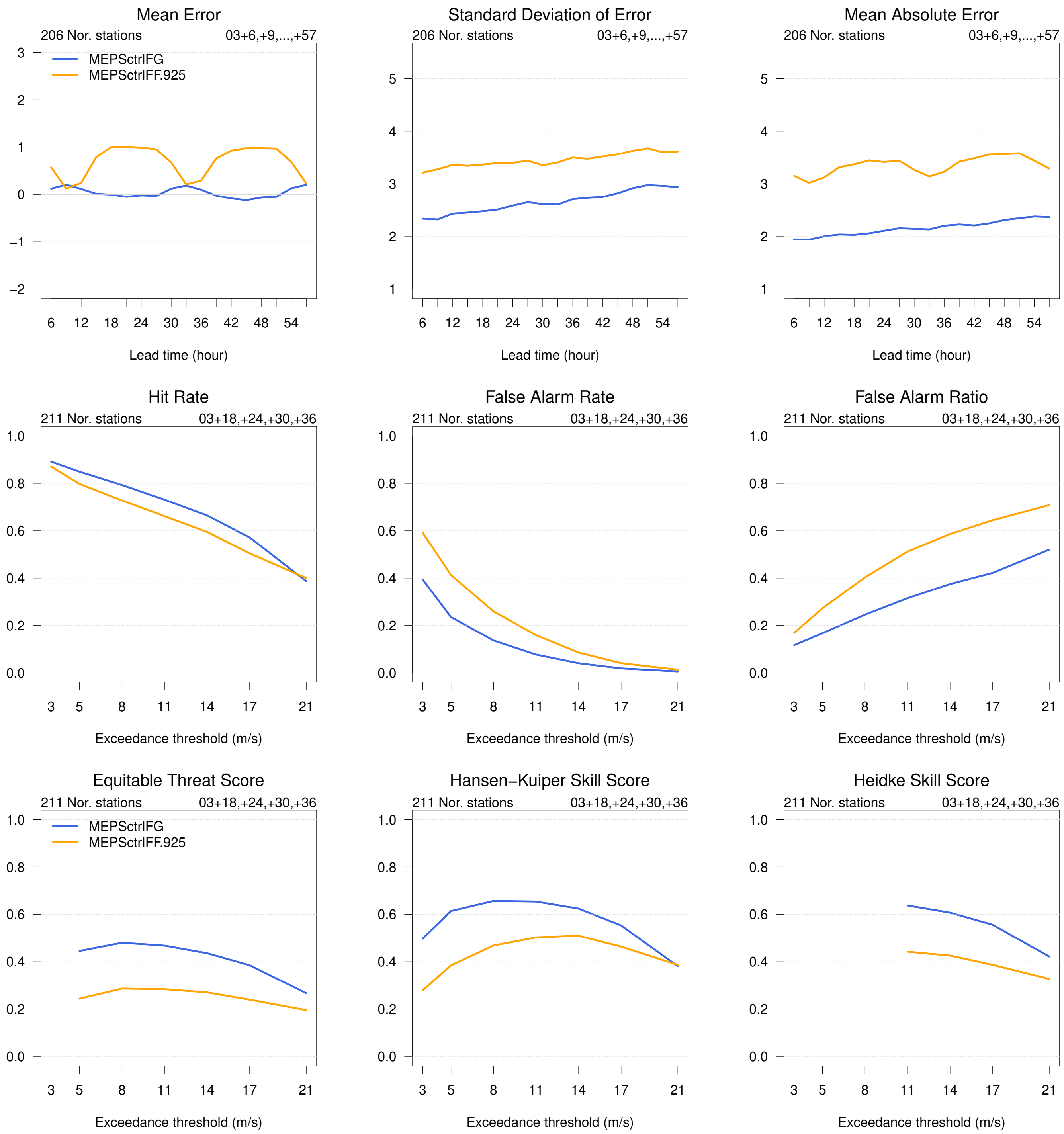
	Min	Mean	Max	Std	N
synop: 00,06,12,18	0.4	8.4	18.4	3.9	340
MEPSctrl: 12+18,+24,+30,+36	0.9	7.7	16.9	3.6	360
ECMWF: 12+18,+24,+30,+36	0.3	7.4	16.5	3.5	360

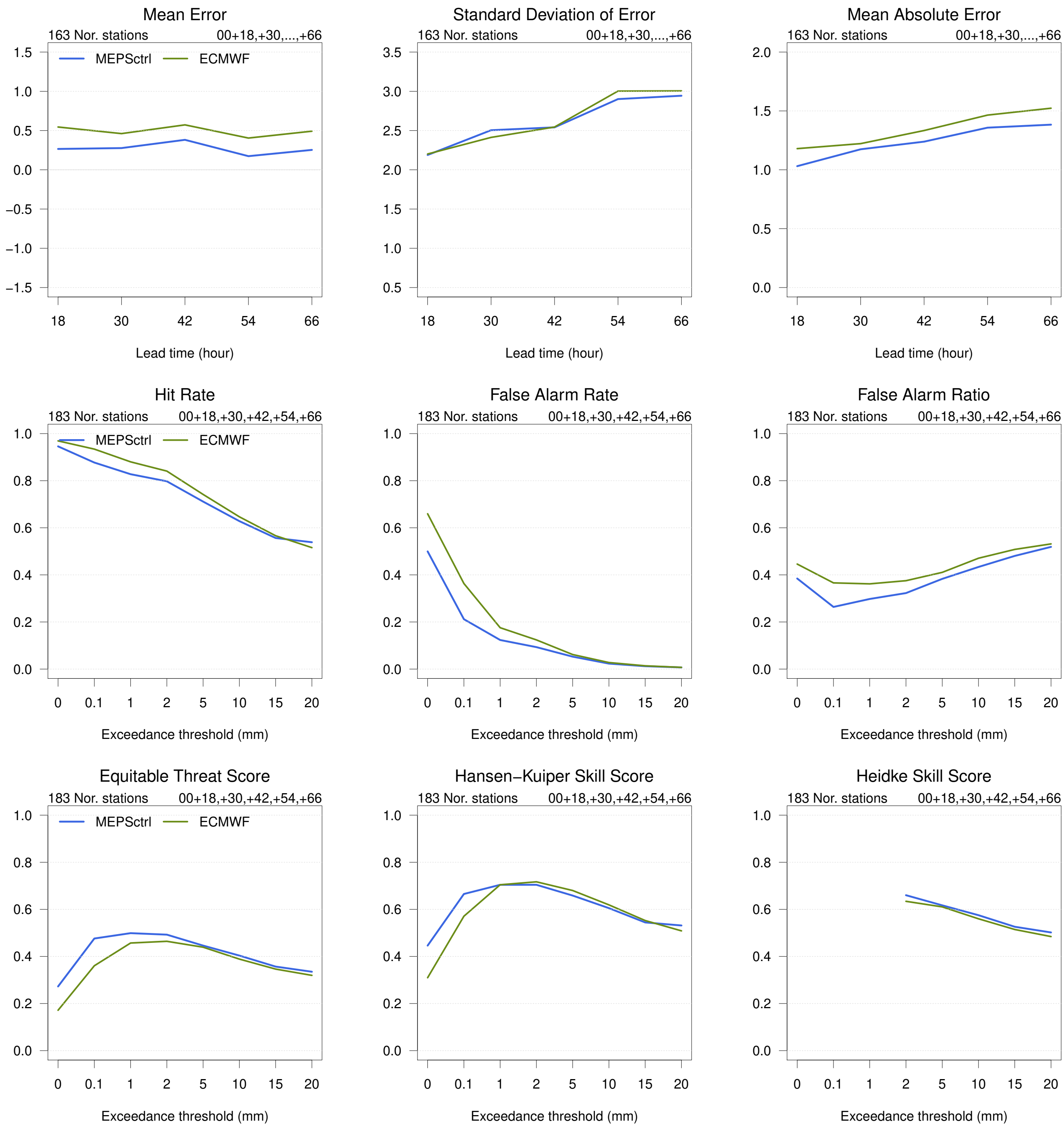
	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.6	1.8	1.9	1.5	8.1	332
ECMWF–synop	–0.9	1.7	1.9	1.5	12.6	332


FÆRDER FYR
300
200
100
0
Sep 01
Sep 08
Sep 15
Sep 22
Sep 29
Oct 06
Oct 13
Oct 20
Oct 27
Nov 03
Nov 10
Nov 17
Nov 24
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
Wind direction

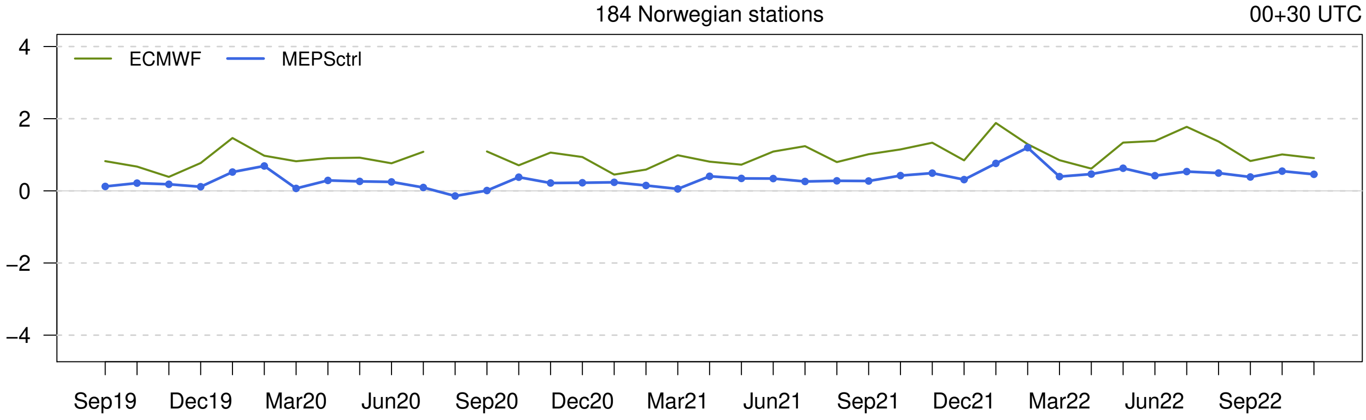

Mean Error
212 Nor. stations
03+6,+9,...,+57
MEPSctrl
YrPP
Lead time (hour)
Standard Deviation of Error
212 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Mean Absolute Error
212 Nor. stations
03+6,+9,...,+57
Lead time (hour)
Hit Rate
221 Nor. stations
03+18,+24,+30,+36
Exceedance threshold (m/s)
False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

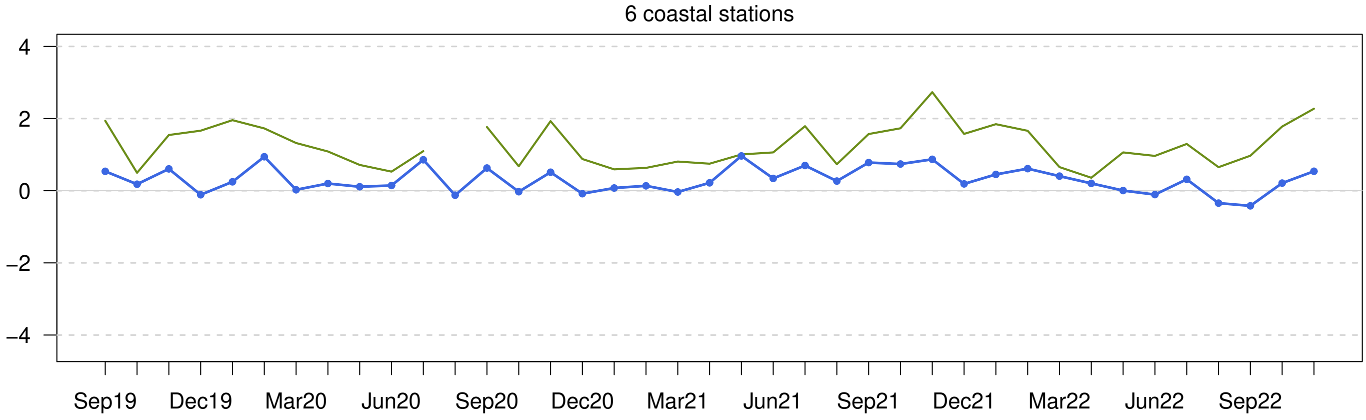
Wind gust (FG) and wind speed in 925 hpa (FF.925)

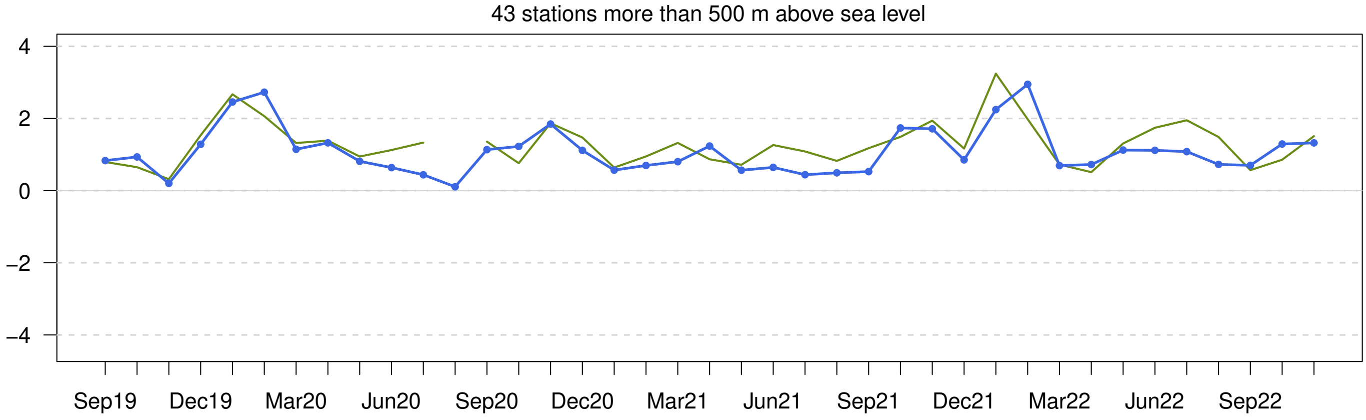


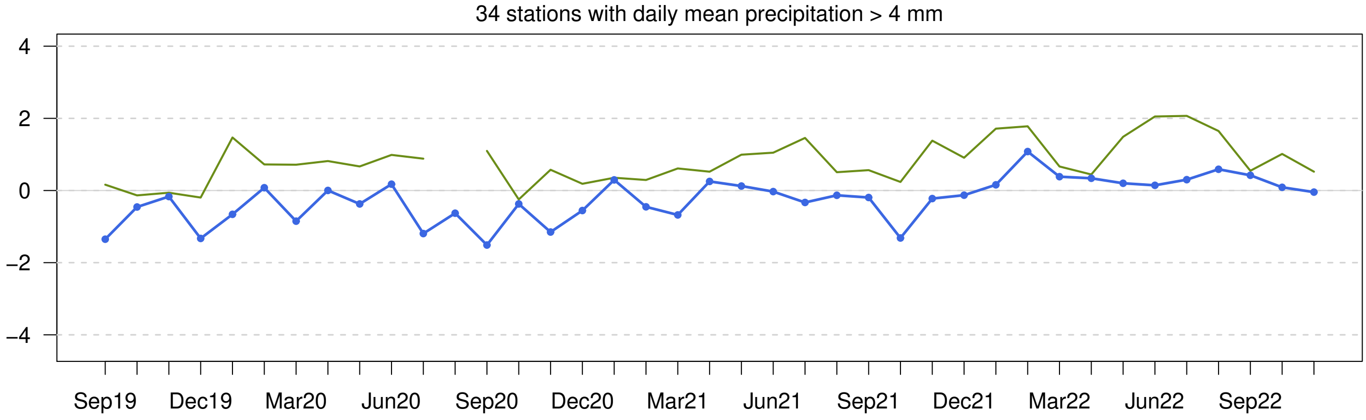

Mean Error
163 Nor. stations
00+18,+30,...,+66
MEPSctrl
ECMWF
Lead time (hour)
Standard Deviation of Error
163 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Mean Absolute Error
163 Nor. stations
00+18,+30,...,+66
Lead time (hour)
Hit Rate
183 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance threshold (mm)
False Alarm Rate
183 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
False Alarm Ratio
183 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
Equitable Threat Score
183 Nor. stations
00+18,+30,+42,+54,+66
MEPSctrl
ECMWF
Exceedance threshold (mm)
Hansen−Kuiper Skill Score
183 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)
Heidke Skill Score
183 Nor. stations
00+18,+30,+42,+54,+66
Exceedance threshold (mm)

Mean Error

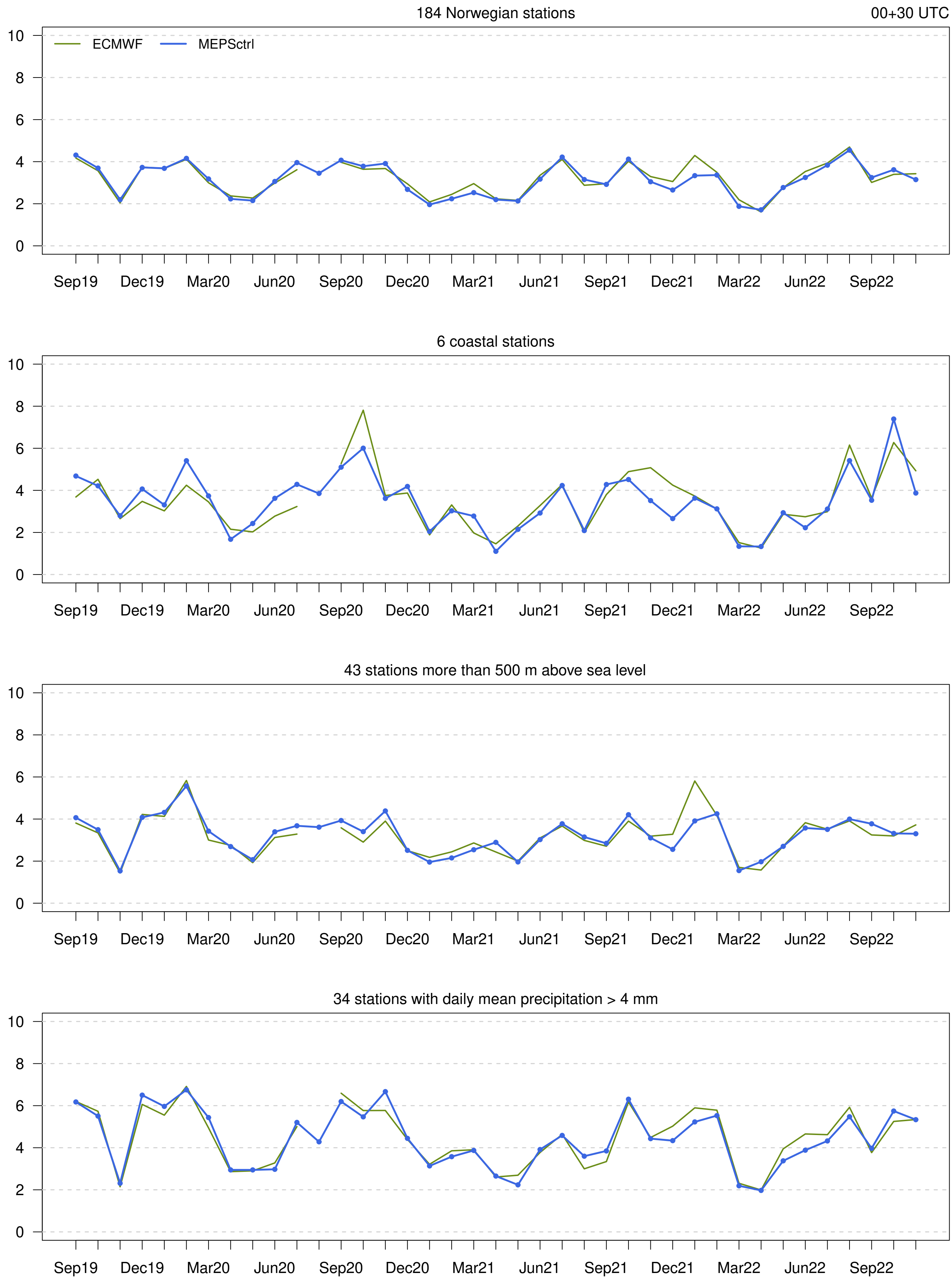

184 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
4
2
0
−2
−4
Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22

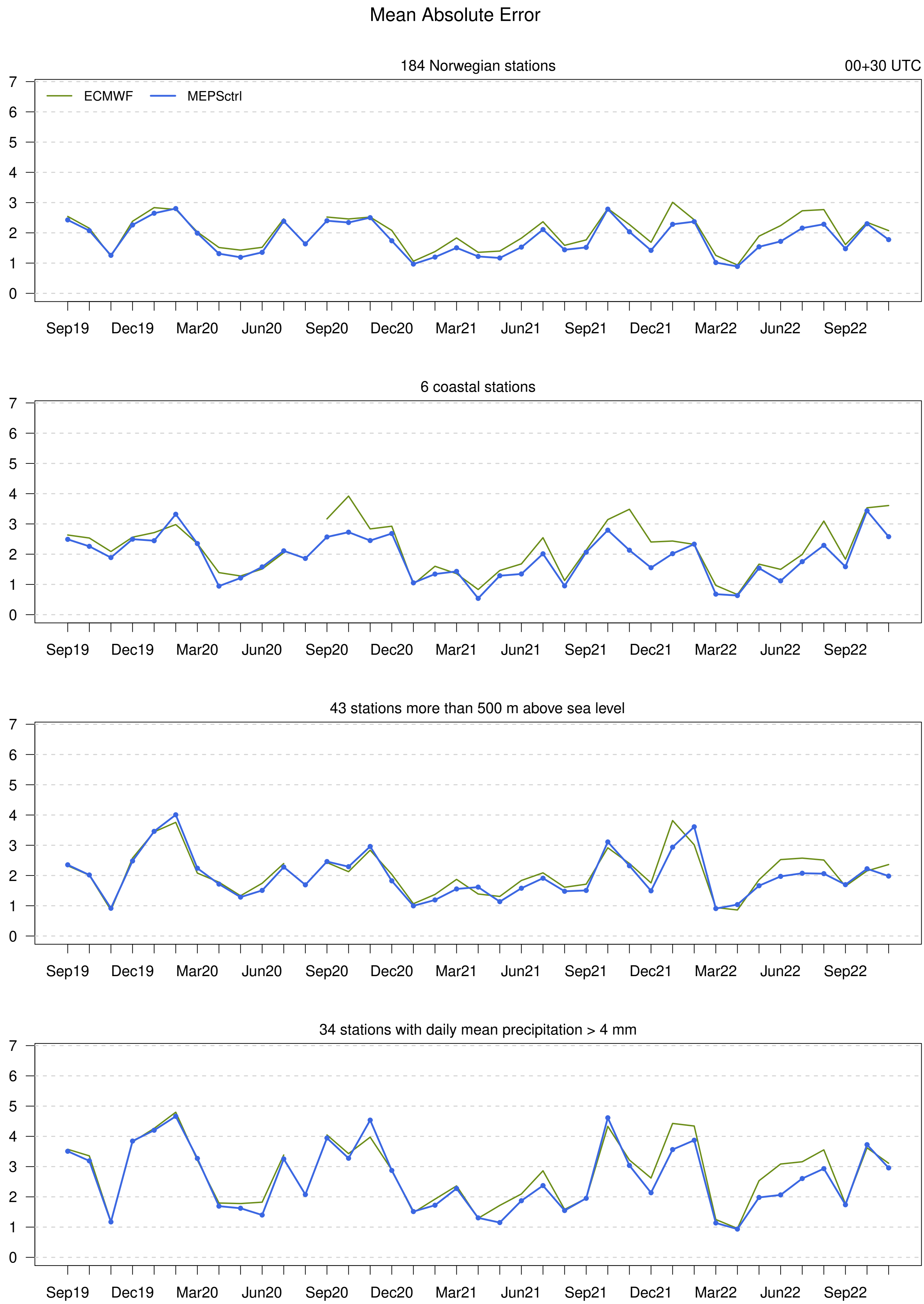

6 coastal stations
4
2
0
−2
−4
Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22


43 stations more than 500 m above sea level
4
2
0
−2
−4
Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22


34 stations with daily mean precipitation > 4 mm
4
2
0
−2
−4
Sep19 Dec19 Mar20 Jun20 Sep20 Dec20 Mar21 Jun21 Sep21 Dec21 Mar22 Jun22 Sep22

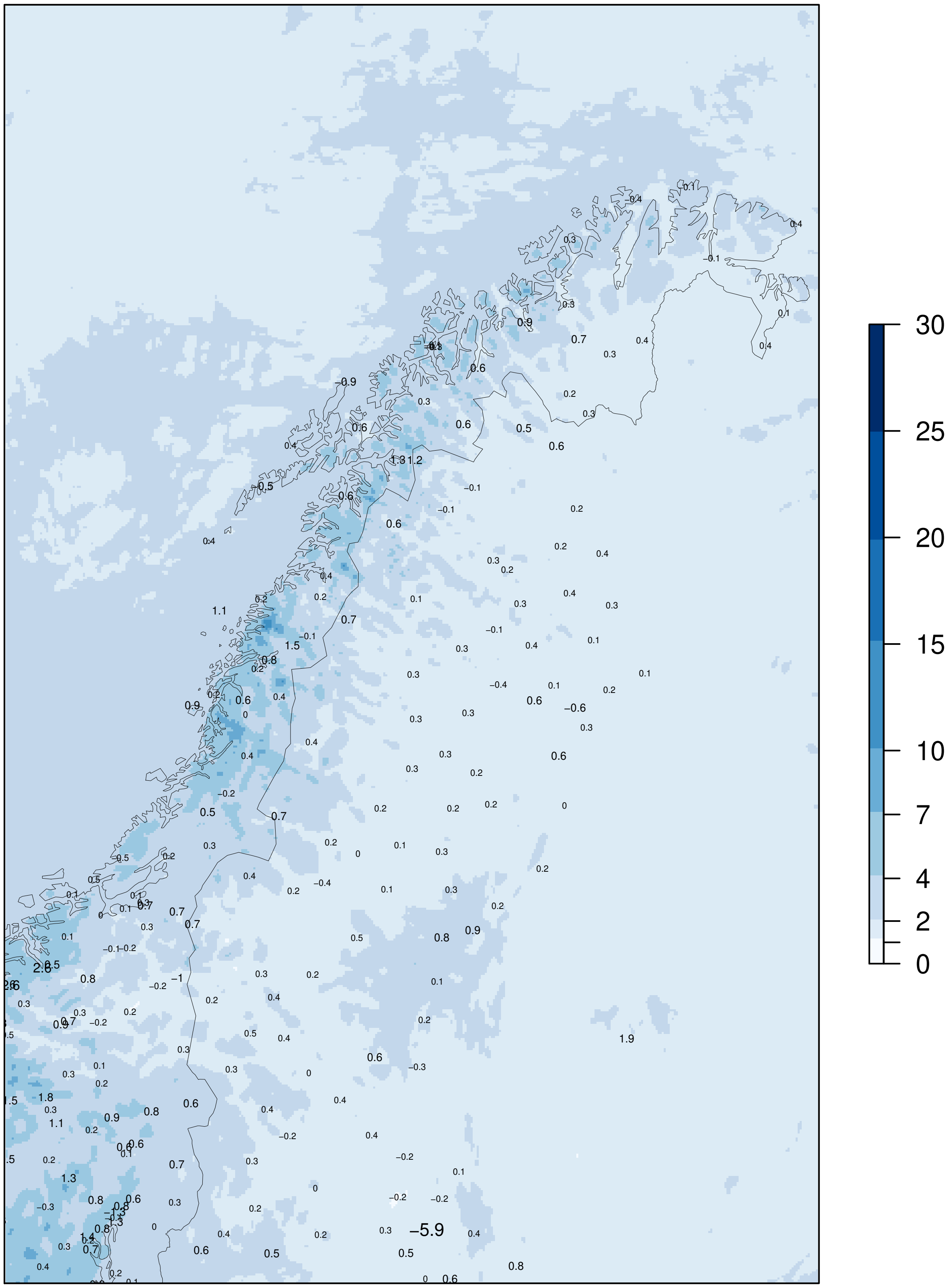
Standard Deviation of Error



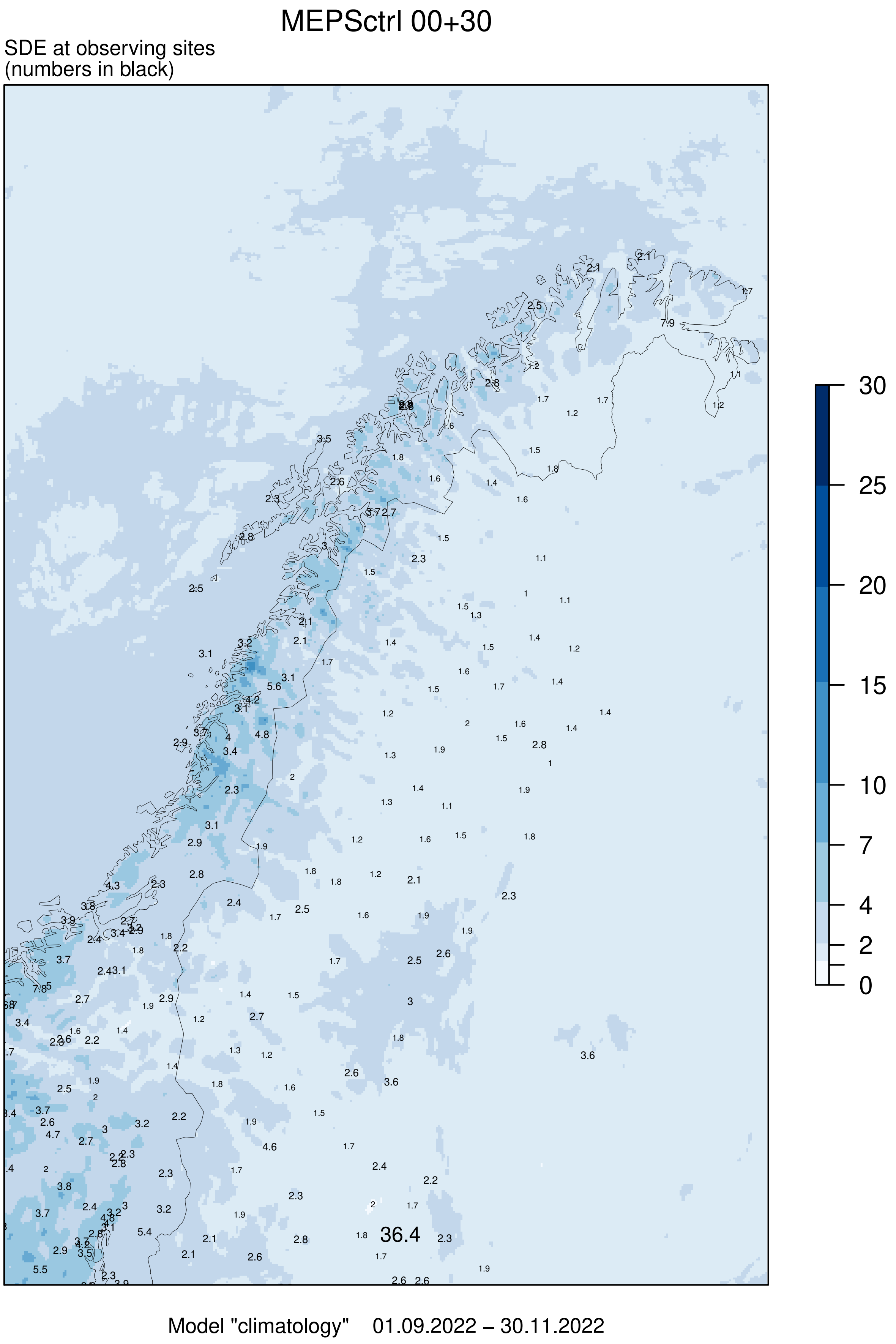

Mean Absolute Error
184 Norwegian stations
00+30 UTC
ECMWF
MEPSctrl
6 coastal stations
43 stations more than 500 m above sea level
34 stations with daily mean precipitation > 4 mm
0
1
2
3
4
5
6
7
Sep19
Dec19
Mar20
Jun20
Sep20
Dec20
Mar21
Jun21
Sep21
Dec21
Mar22
Jun22
Sep22

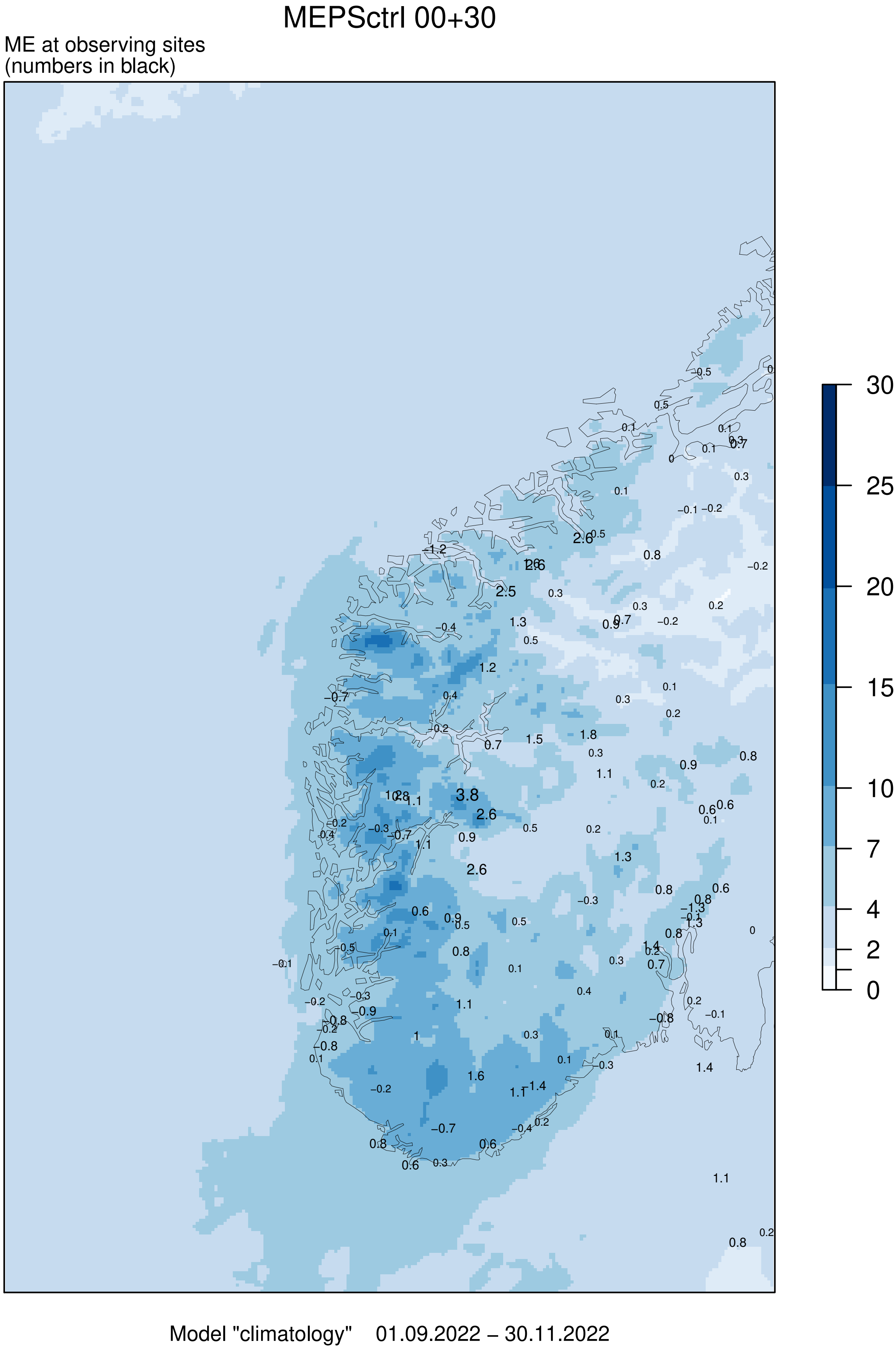
MEPSctrl 00+30

ME at observing sites
(numbers in black)



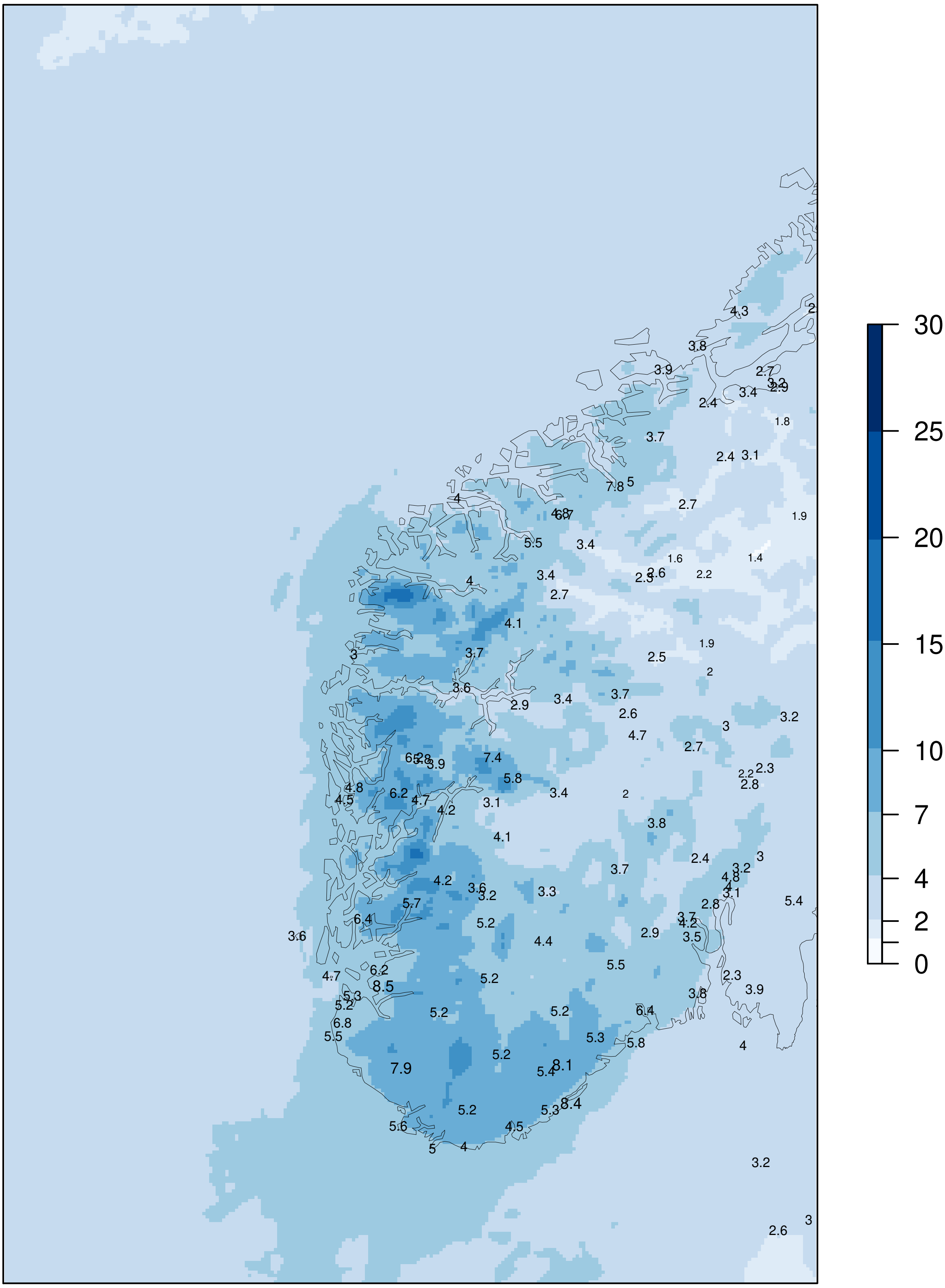
Model "climatology"   01.09.2022 – 30.11.2022


MEPSctrl 00+30
SDE at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.09.2022 – 30.11.2022


MEPSctrl 00+30
ME at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+30

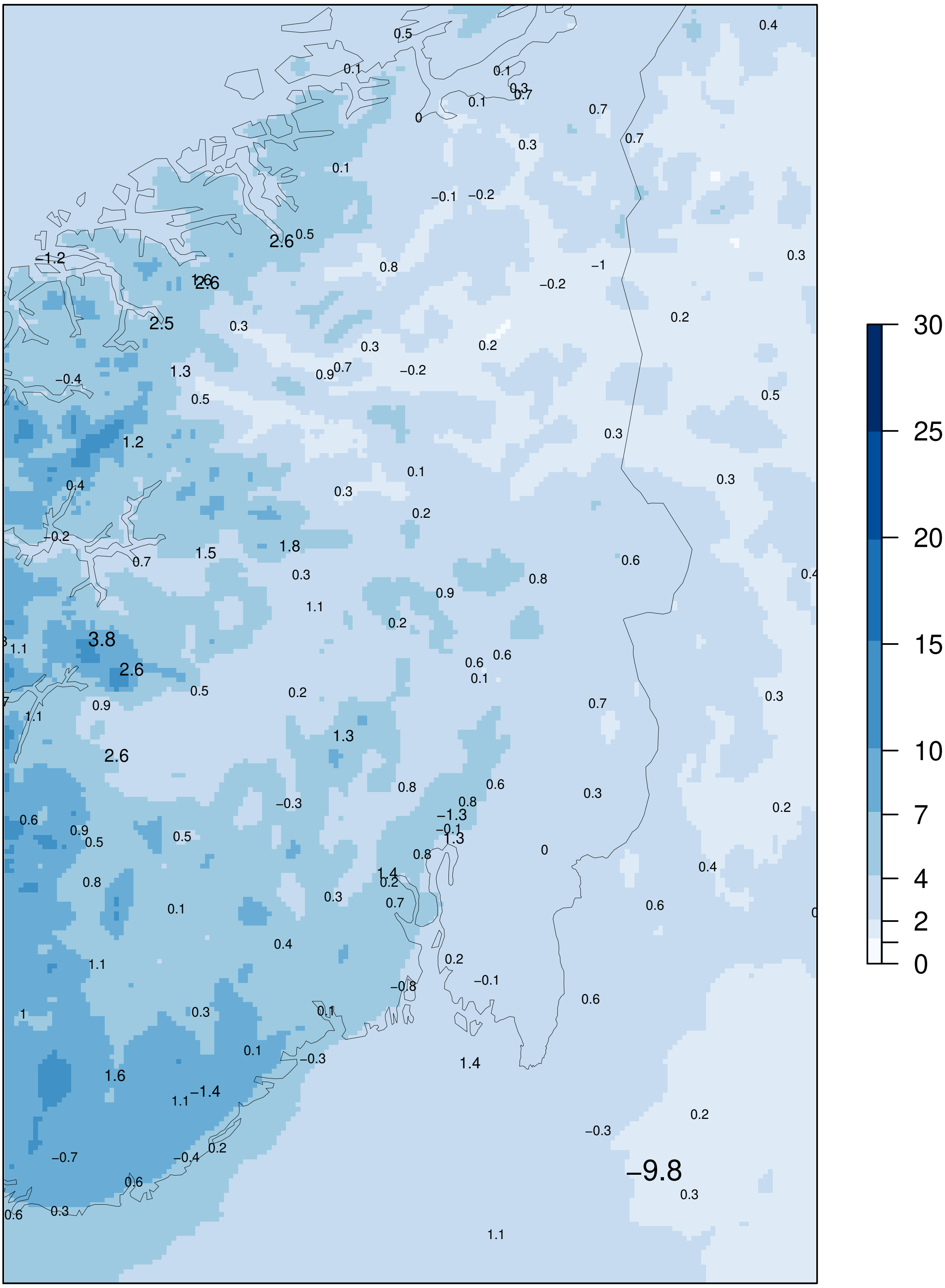
SDE at observing sites
(numbers in black)



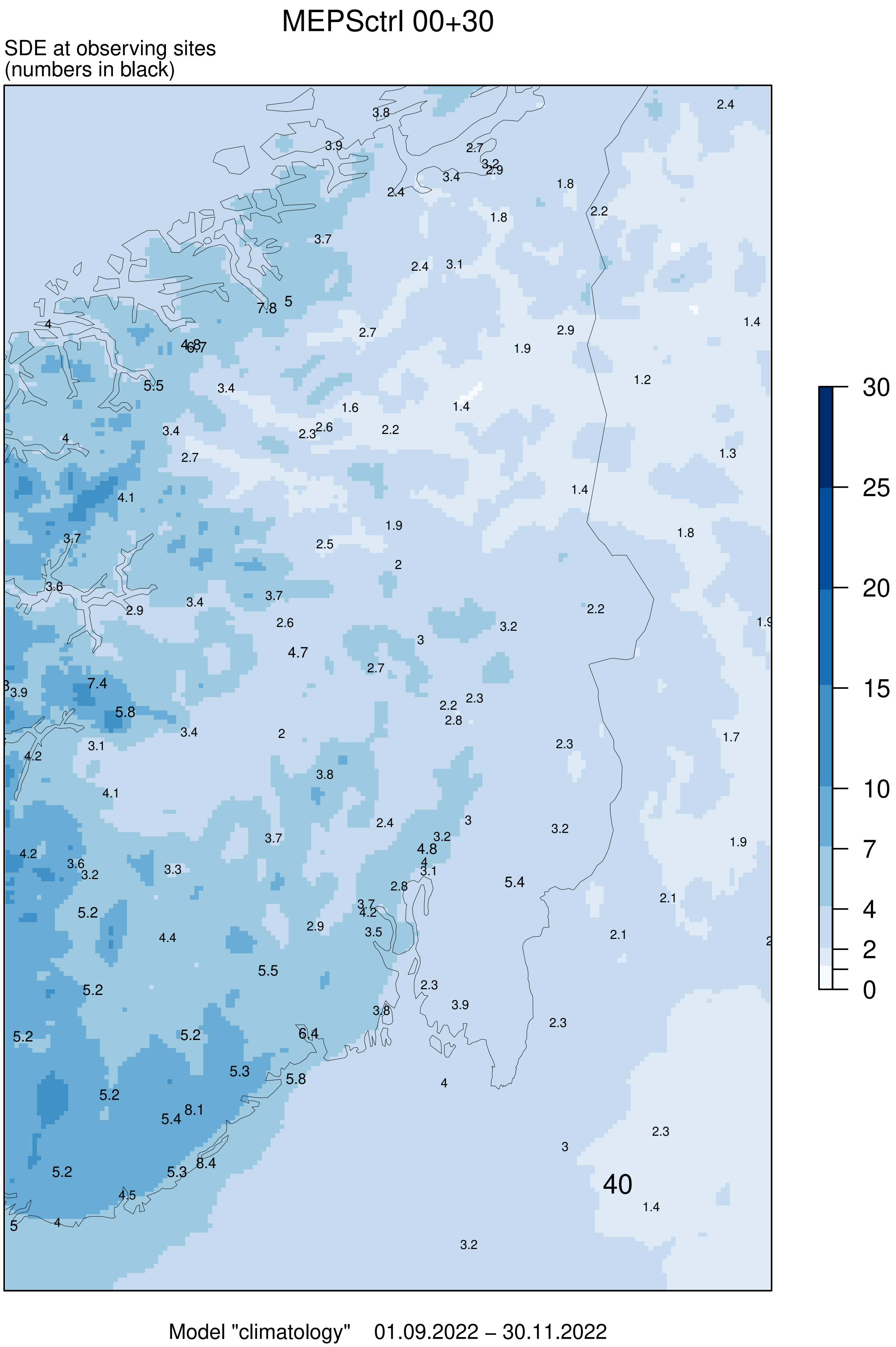
Model "climatology" 01.09.2022 – 30.11.2022

MEPSctrl 00+30

ME at observing sites
(numbers in black)



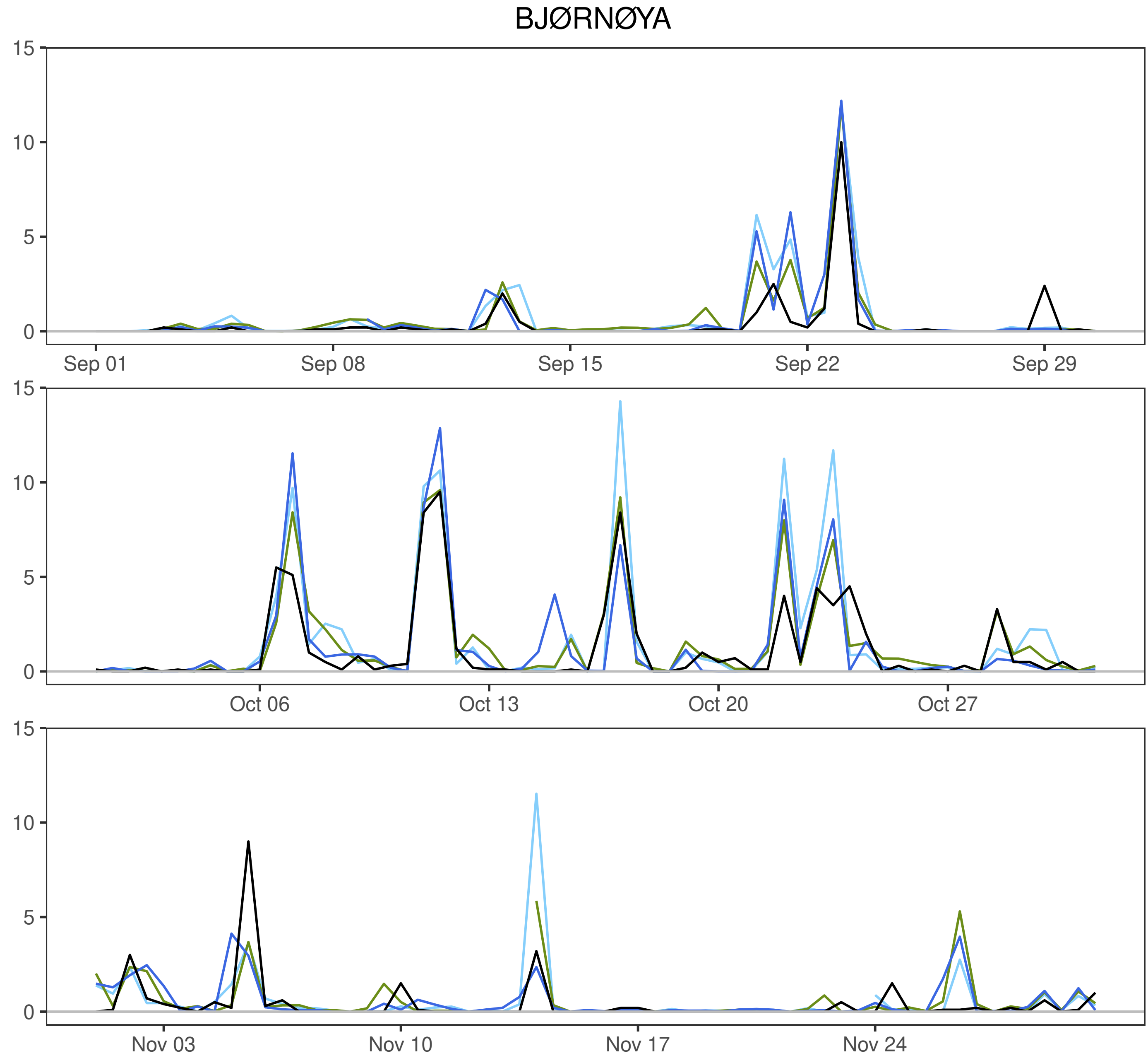
Model "climatology" 01.09.2022 – 30.11.2022


MEPSctrl 00+30
SDE at observing sites
(numbers in black)
30
25
20
15
10
7
4
2
0
Model "climatology" 01.09.2022 – 30.11.2022

SVALBARD LUFTHAVN

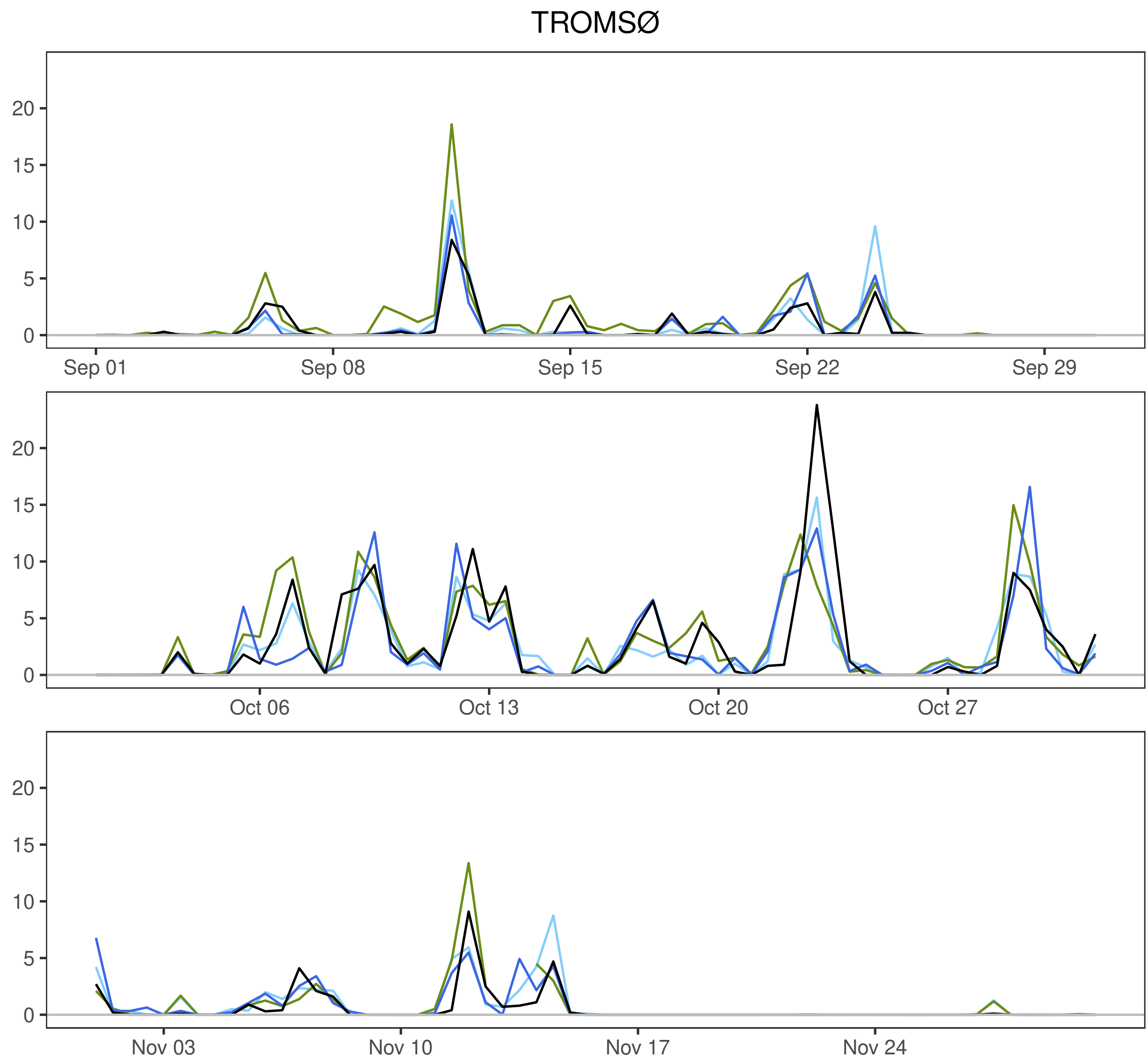
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.4	9.7	1.2	182
AA25: 12+18,+30	0.0	0.7	12.4	1.7	180
ECMWF: 12+18,+30	0.0	0.8	10.1	1.4	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
AA25–synop	0.3	1.3	1.4	0.5	12.0	178
ECMWF–synop	0.4	1.0	1.1	0.5	5.9	178



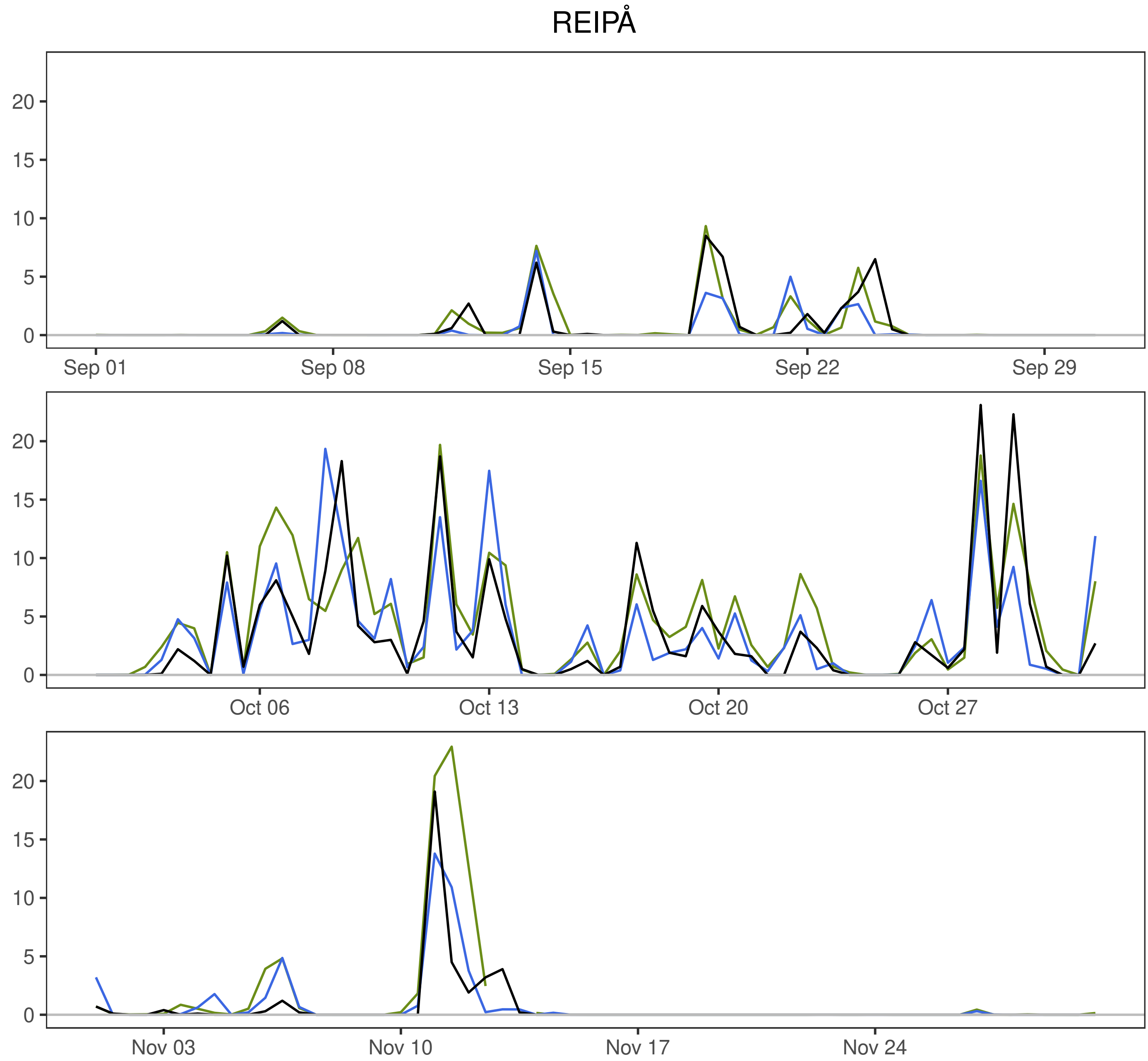
	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.7	10.0	1.7	182
MEPSctrl: 12+18,+30	0.0	0.9	12.9	2.1	180
AA25: 12+18,+30	0.0	1.0	14.3	2.5	180
ECMWF: 12+18,+30	0.0	0.9	12.0	1.9	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.4	1.4	0.6	6.4	176
AA25−synop	0.3	1.5	1.6	0.7	8.3	176
ECMWF−synop	0.2	1.0	1.1	0.5	5.3	176



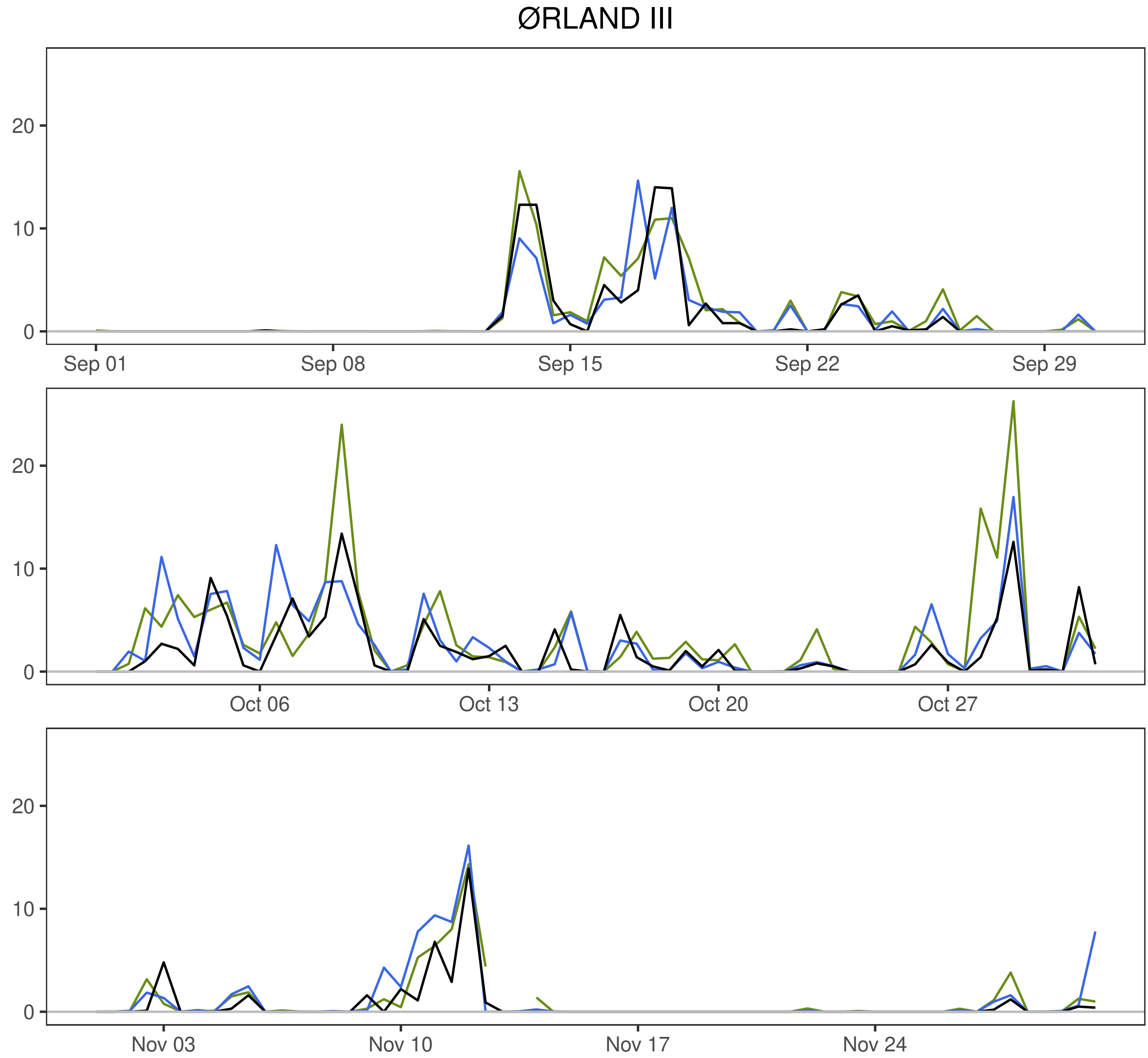
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.4	23.8	3.0	182
MEPSctrl: 12+18,+30	0.0	1.3	16.6	2.7	180
AA25: 12+18,+30	0.0	1.4	15.6	2.6	180
ECMWF: 12+18,+30	0.0	1.7	18.6	3.0	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	−0.1	1.9	1.9	0.8	10.9	176
AA25−synop	0.0	1.7	1.7	0.8	9.7	176
ECMWF−synop	0.4	2.1	2.1	1.0	15.9	176



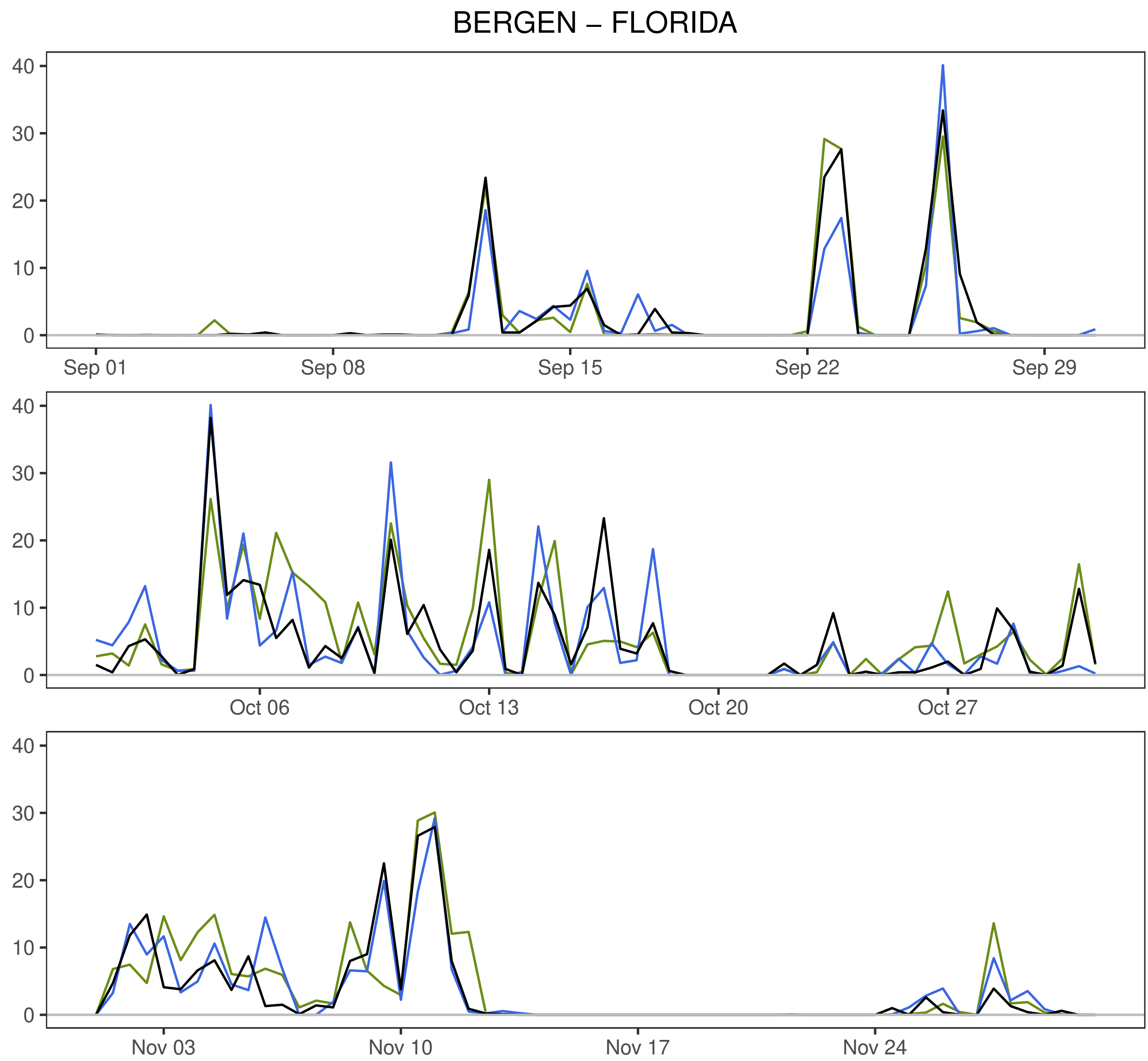
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.7	23.1	3.9	182
MEPSctrl: 12+18,+30	0.0	1.6	19.3	3.4	180
ECMWF: 12+18,+30	0.0	2.2	22.9	4.2	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.0	2.3	2.3	1.0	13.1	178
ECMWF−synop	0.6	2.5	2.5	1.2	18.4	178



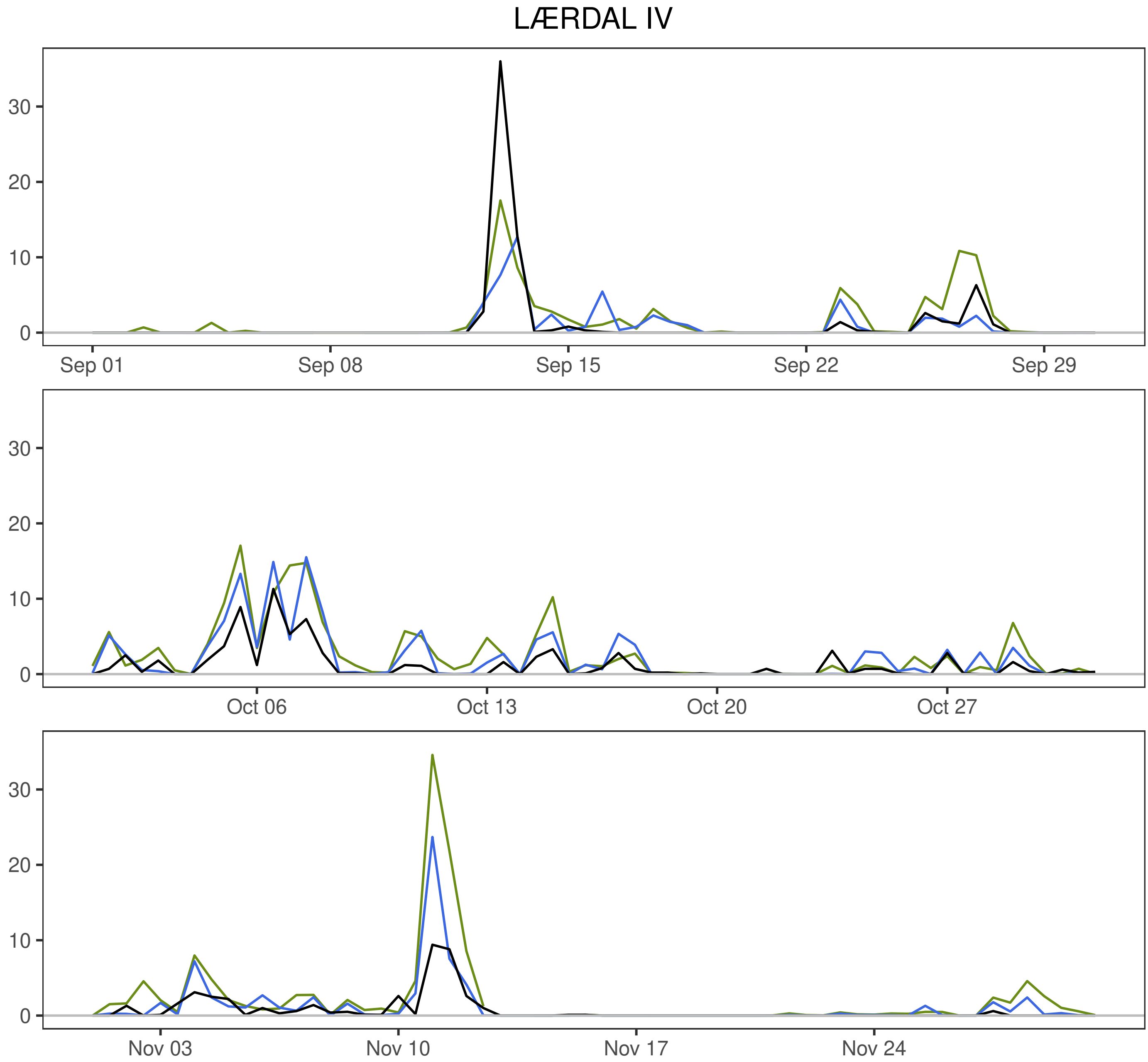
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.4	14.0	2.9	182
MEPSctrl: 12+18,+30	0.0	1.8	17.0	3.2	180
ECMWF: 12+18,+30	0.0	2.1	26.3	3.9	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	2.1	2.1	1.0	10.7	178
ECMWF−synop	0.7	2.3	2.4	1.1	14.4	178



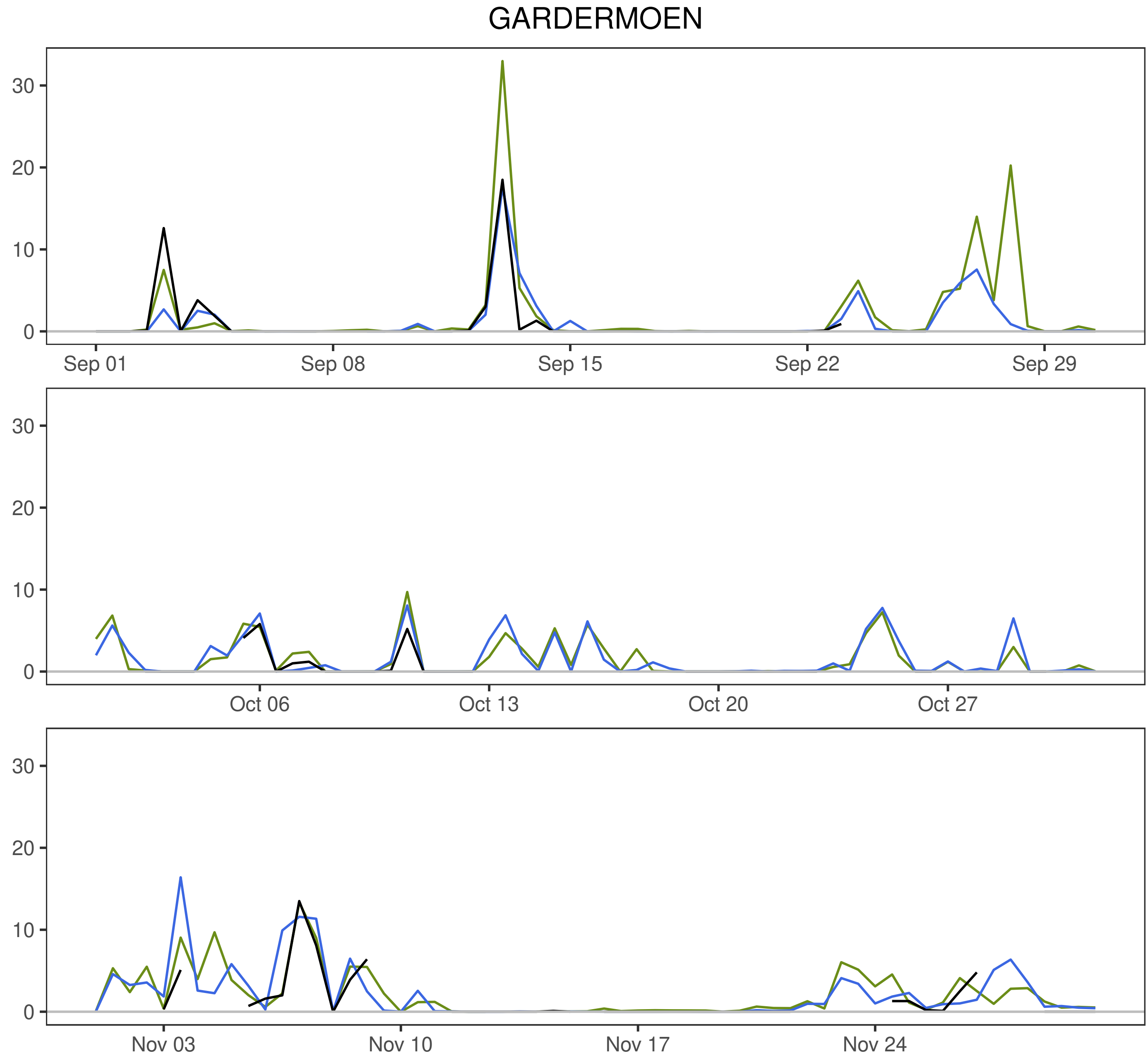
	Min	Mean	Max	Std	N
synop: 06,18	0.0	3.6	38.2	6.8	182
MEPSctrl: 12+18,+30	0.0	3.6	40.1	6.8	180
ECMWF: 12+18,+30	0.0	4.1	30.1	7.0	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.1	3.4	3.4	1.8	13.2	178
ECMWF–synop	0.5	4.0	4.0	2.1	18.2	178



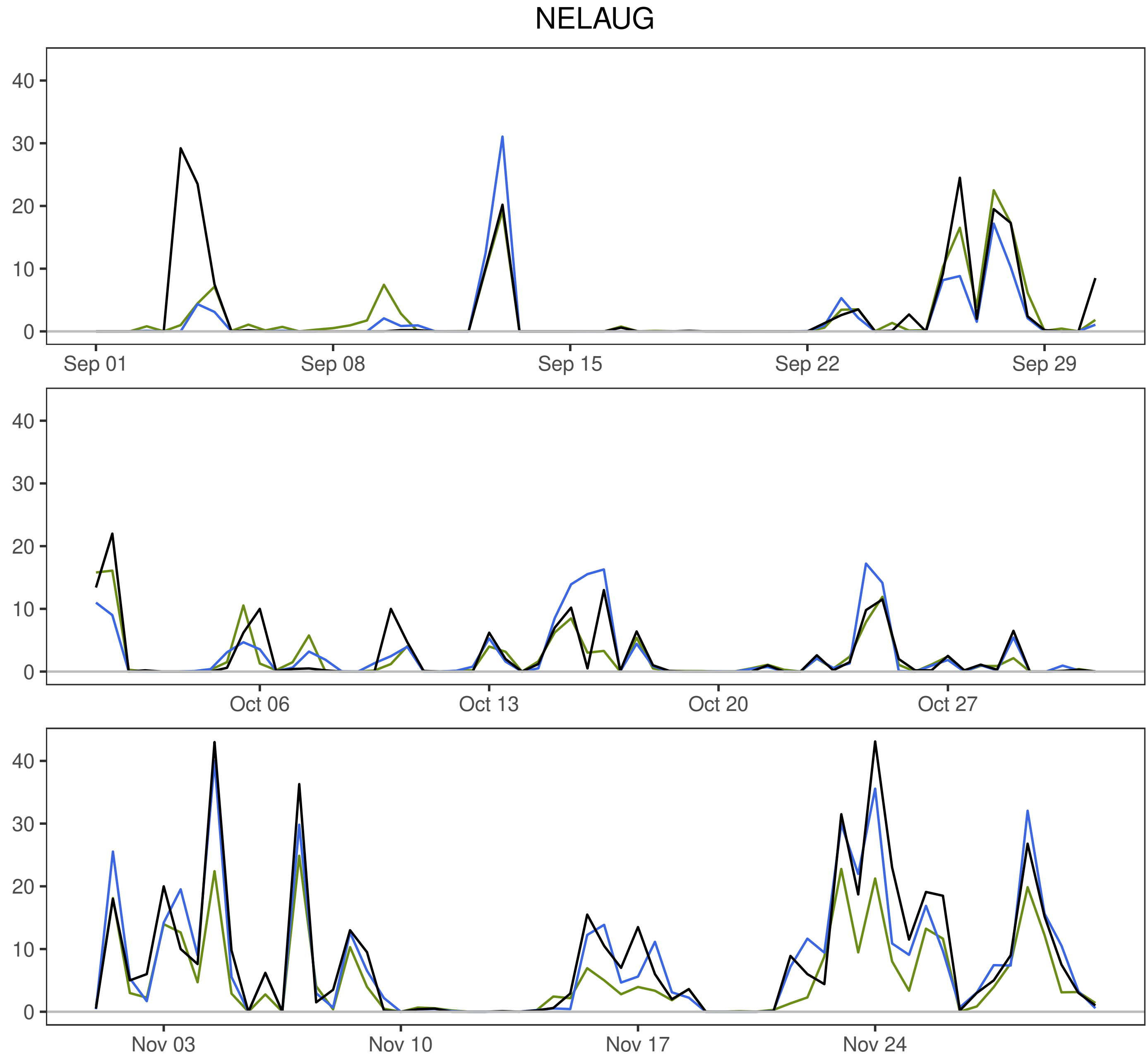
	Min	Mean	Max	Std	N
synop: 06,18	0.0	1.0	36.0	3.3	182
MEPSctrl: 12+18,+30	0.0	1.4	23.7	3.1	180
ECMWF: 12+18,+30	0.0	2.1	34.6	4.3	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.4	2.8	2.8	1.0	28.4	178
ECMWF−synop	1.1	3.2	3.3	1.5	25.2	178



	Min	Mean	Max	Std	N
synop: 06,18	0.0	0.9	18.5	2.6	132
MEPSctrl: 12+18,+30	0.0	1.6	17.6	2.9	180
ECMWF: 12+18,+30	0.0	1.8	33.0	3.7	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl−synop	0.2	1.8	1.8	0.7	11.3	128
ECMWF−synop	0.4	1.8	1.9	0.7	14.5	128



	Min	Mean	Max	Std	N
synop: 06,18	0.0	4.7	43.1	8.2	182
MEPSctrl: 12+18,+30	0.0	4.2	40.0	7.4	180
ECMWF: 12+18,+30	0.0	3.3	24.9	5.4	180

	ME	SDE	RMSE	MAE	Max.abs.err.	N
MEPSctrl–synop	–0.5	4.2	4.2	1.9	29.2	178
ECMWF–synop	–1.4	4.5	4.7	2.2	28.2	178