Contribution ID: 52c88874-71ff-4067-9cea-1cb0ce3d5109
Date: 16/05/2024 12:01:52

Green Book 2024 - aka Use and verification of ECMWF products in the Member and Co-operating States

Fields marked with * are mandatory.

Introduction

Welcome to ECMWF new "Green Book" online submission system (aka "Use and verification of ECMWF products in the Member and Co-operating States")

This time we have two options for completion:

- Filling out the online questionnaire below (new for this year based on feedback from the Meteorological Representatives meeting in November 2023)
- Producing a single report offline (as done in previous years), and emailing the report as detailed in Section 1.

Both methods ask the same questions, however the questionnaire method requires no formatting and aims to make analysis of all responses easier. The questionnaire option also allows you to part-complete, and save your entries to come back to later (using the "Save as Draft" button in the top right corner of this page). Note that the EUSurvey page will timeout after 60 minutes of no activity, responses are usually saved however to be sure please "Save as Draft" to avoid losing responses.

The deadline for all submissions is 23:59UTC on Wednesday 15th May 2024

A summary of responses will be presented at UEF2024 with a summary report available in the ECMWF Publications library in due course.

Section 1: Background - please fully complete

* **1.1 Which Country is your submission for?**

EE - Estonia

* **1.2 Please provide your name(s)**

Alina Lerner-Vilu, Ivar Ansper

* **1.3 Please provide your organisation**

ESTEA

* **1.4 Please select your preferred submission method:**

- ( ) Producing a single report offline
- (•) Online questionnaire

Online questionnaire

Please answer the following questions, and illustrate your answers, where appropriate, by also uploading clearly annotated images with image/figure numbers (max 1MB per file). More questions or options may appear, depending on answers to particular questions. Mandatory questions are marked with a '*'. Free text boxes appear to have a 5000 character limit (if your answers are longer than this please email them to Becky and they will manually added), answers don't need to fit the box size given, the boxes expand.

Responses to the questionnaire can be saved and returned to at a later date before submitting. To do this click the 'Save as Draft' button on the left, this will provide you with a link which you can return to to continue /complete your submission.

Section 2: Summary of major highlights

* **Please detail major highlights since January 2022**

You may wish to complete this section at the end, after completing all others**.**

1) The new supercomputer ATOS went live.
2) New cycle 48r1 has given higher-resolution ensemble products and, consequently, the size of the output files became larger.
3) The sea model NEMO_Est and wave model SWAN were developed and adapted to Estonian conditions, then set up operationally as the time-critical task at TC2 on ATOS.
4) Various ECMWF model (HRES, ENS, ENS Extended, SEA5) parameters and products have found wider usage in ESTEA.
5) Wider usage of ECMWF tools and applications: eccodes, ecFlow, and Metview.
6) Wider usage of the MARS archive and ERA5 + Copernicus (ERA5, ERA5_Land, etc) for own and clients' purposes.
7) Participation in ECMWF seminars and trainings.
8) Pre-schedule delivery for operational data dissemination has allowed us to get data 30-45 minutes before the usual time, which is highly beneficial for operational forecasts.

Section 3: Forecast products

3.1. Please outline what direct use you make of standard ECMWF model products (on ecCharts / OpenCharts / own workstation), for operational duties, in the following 4 categories (noting that new AI model output should be dealt with separately, via question 3.4).

* **a) Medium Range (e.g. for high impact weather forecasting)**

In ESTEA, ECMWF model output is in the widest and the most popular use compared to other models (MetCoOp-HARMONIE (MEPS), GFS, ICON etc.). IFS-HRES runs are used on an everyday basis for operational weather prediction. IFS-ENS runs are in rarer use. They are utilised to obtain affirmation for the ready forecast, provide weather forecasts for specific locations, predict critical weather situations (e.g. storm tracks), and for longer predictions (e.g. sea ice formation).

* **b) Extended Range (monthly)**

Monthly and seasonal forecasts cannot be highly trusted in Estonia, as weather processes here are highly variable and change rapidly. Mostly these forecasts are analysed to make announcements in the press and for public presentations.

* **c) Long Range (seasonal)**

See text above.

* **d) CAMS and Fire-related output (ecCharts mainly)**

The direct data from ecCharts are used to get additional information for the forecasts, as these contain the parameters and tools not available in ESTEA products, such as snow depth, thunder-related products and other hazardous events probabilities.
So far ESTEA has used the Nesterov ignition index (Nesterov, 1949; Chandler et. al, 1983; Chowdhurry & Hassan, 2015), which is based on temperature, dew point and cumulative precipitation. The calculations have been done in the weather stations coordinates and interpolated to the whole Estonian territory. Lately we have been developing new fire-related output based on Canadian Fire Weather Index (Fire Weather Index, http://cwfis.cfs.nrcan.gc.ca/background; Wagner, 1987; Wang, Anderson, Suddaby, 2015).
CAMS is not used on a daily basis, but for the special situations or to prepare special products for the clients.

3.2. ECMWF cycle 48r1 went live at the end of June 2023. Changes included a much higher resolution medium range ensemble, and much more frequent monthly forecasts.

* **a) Please describe any positive impacts of model cycle 48r1 for your service**

Impacts are mainly positive and the quality of forecasts haven't suffered significantly.

If you have any annotated graph/diagram/plot that would help clarify your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

* **b) Please describe any negative impacts of model cycle 48r1 for your service**

Significant negative impacts have not discovered so far.

If you have any annotated graph/diagram/plot that would help clarify your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

* **c) Have you noticed any systematic changes in forecast output since model cycle 48r1 was implemented?**

- ○ Yes
- ◉ No

* **3.3: Do you modify ECMWF model output to create 'derived fields' (e.g. post-processed output, regimes, probabilities).**

- ◉ Yes
- ○ No

Please describe what you modify and how

There are several products based on the data derived from ECMWF forecasts, which were developed by ESTEA for the internal use by the agency's weather forecasters. These products include a large variety of parameters and probabilities derived from ECMWF forecasts expressed in maps and graphs.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

* **3.4: Do you currently use Artificial Intelligence (AI) and/or Machine Learning (ML) techniques in your service, in conjunction with standard ECMWF model output?**

- ○ Yes
- ◉ No

* **3.5: Does your NMHS use ECMWF data for modelling purposes - e.g. by providing initial/boundary conditions for limited area model runs, or for hydrological models, or for dispersion models, etc...**

- ◉ Yes
- ○

No

Please describe these activities

ECMWF forecast output is provided as boundary conditions for limited-area models like sea model NEMO_Est and wave model SWAN. Also, hydrological department of the agency uses the data in hydrological model SWAT.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

* **3.6: In the last year or so ECMWF has made available, on ecCharts and OpenCharts, selected fields from AI models (e.g. Pangu Weather, AIFS). Were you aware of this?**

- (●) Yes
- ( ) No

* **a) What are your views on this initiative?**

It is interesting way for forecasting and if it is cost-effective than traditional methods and also give a potential to do forecast better then worth to experiment and when succesful to use in operationally as well.

* **b) Do you currently use AI forecasts for operational purposes?**

- ( ) Yes
- (●) No

What would you need in order to use AI models in your forecast activities?

More trainings and seminars are needed to get good knowledge how to use and evaluate these products.

Section 4: Verification

ECMWF does extensive verification of its products in the free atmosphere. However, our verification of surface parameters is more limited and can be constrained to only using synoptic observations. More detailed verification of these surface weather parameters by National Services is always valuable to us. We are most interested in results for the last 1 or 2 years. Also, any evidence you have of performance changes since the introduction of cycle 48r1 would be very valuable.

* **4.1 Do you routinely verify raw model output from ECMWF model(s) and/or other operational models /ensembles?**

- (●) Yes

- [ ] No

Please describe your verification activities and show and discuss related scores in the the two lead-time categories shown below, including, where possible, comparisons with your own models /ensembles, and other models/ensembles.
Ideally focus on surface weather parameters in your own territory. Inclusion of conditional verification results is also strongly encouraged - e.g. stratification by a weather type - as these can provide very useful insights into model weaker points.

a) Short Range and Medium Range

Verification of IFS-HRES output is produced monthly for a time period of maximum 90 hours. Mean sea level pressure, 2m temperature, 2m dew point temperature, 2m relative humidity, 10 m wind speed, lprecipitation accumulated for 1 and 3 hours are analysed for Estonian domain against ground-based weather stations observations. Methodology used for that includes the calculation of minimum, maximum and mean error (bias), absolute mean error as well as root squared mean error. Also the comparison of model-based forecasts used in ESTEA (ECMWF IFS-HRES and MetCoOp MEPS) to each other is completed every month.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

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523403f4-68bb-4393-8be2-49fb2c740a03/ws10.PNG

b) Extended Range (Monthly) and Long Range (Seasonal)

No, we do not verify Extended range and long range forecasts.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

* **4.2 Do you routinely verify post-processed products and/or tailored products delivered to users?**
- [ ] Yes
- [x] No

* **4.3 Do you perform any subjective verification of forecasts?**
- [x] Yes
- [ ] No

Please describe and illustrate any activities and results in this area

The results and conclusions from the survey conducted by ESTEA's forecasters in May 2024 are presented in the following section. Forecasters had a chance to evaluate ECMWF parameters on a 5-point scale where 1 indicates "very bad," 2 "bad," 3 "average," 4 "good," and 5 "very good." Responses and comments were received from all 17 forecasters, representing 100% of the forecasters working at ESTEA.

As shown in Figure 1, the lowest ratings were given to the ice depth and visibility categories. The highest ratings were given to parameters measured at different pressure height levels. Among surface parameters, mean sea level pressure and 2-meter temperature received the highest ratings.

Some conclusions and comments from the survey include:

Visibility (especially fog) and low cloudiness are not well predicted, which is troublesome for aviation forecasters who need accurate forecasts. ECMWF tends to underestimate the real conditions, although it still performs better compared to MetCoOp MEPS.
Temperature extremes (minimum at night and maximum at noon) are not well predicted. Depending on the location, temperature differences might exceed 10 degrees (see case study). This discrepancy is mostly due to the forecasted cloudiness (clear or cloudy), which affects temperatures.
The timing and location of convective precipitation do not align well with actual conditions, but the forecasts do provide a useful indication of areas with a higher probability of convective processes. Generally, predictions are reliable for about 24 hours.
Average 10m wind speeds are usually overestimated by 2-3 m/s, but storm predictions are mostly accurate.
Long-term predictions (90 hours and beyond) tend to change frequently as the cyclone trajectory changes.
Forecasting ice formation and melting in lakes (e.g., Lake Peipus, Lake Võrtsjärv) and the Baltic Sea remains problematic and often does not match the real situation. Incorrect predictions affect local conditions and result in inaccurate temperature and wind forecasts for those areas.
Additionally, forecasters provided their evaluations of forecast length (Figure 2) and warnings (Figure 3).

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

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3ca8b486-b362-4d60-a7f6-1e2ebef707ee/Figure2.png
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4.4: Case Studies. Please describe and illustrate any case study verification you have undertaken. Examples of both good and bad model performance are welcome. Severe weather events (and non-events) are of particular interest to us.

a) Case Study 1 - Please describe the forecast(s) and what happened

On 7 January 2024 the cloudiness above Estonia, especially the low clouds, got highly overestimated by IFS-HRES forecast. As the result, in the northern part of Estonia, where low clouds have been overestimated, the surface temperature was predicted to be about 10 degrees warmer than observed. The more precise description of the situation is in the attached PDF.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

240dd764-5de5-48d3-95e1-a6b43d54da68
/Overestimated_cloudiness_case_study_in_Estonia_on_07_January_2024.pdf

Case Study 1 is an example of:

- ○ Good model performance
- ◉ Bad model performance
- ○ Mixed (good and bad) model performance
- ○ Other (please describe above)

Add another Case Study?

- ○ Yes
- ◉ No

Section 5: Output Requests

5. Please describe, and illustrate if necessary, any particular requests you may have for new or modified ECMWF products.

a) Product request 1 - title / summary

Product request 1 - description of request

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

Add another Product Request?

- ○ Yes
- ○ No

Section 6: References

6. Are there any recent internal or external publications that relate to the questions in this survey? Please list them including the respective link/s. For any publications that cannot be readily downloaded via a link please attach a copy below (or email Becky Hemingway (becky.hemingway@ecmwf.int) and Tim Hewson (timothy.hewson@ecmwf.int) if too large to upload here).

No, there are no publications.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

Section 7: Additional comments and Feedback

7.1. Please use the box below if you have additional comments on topics that have not been covered in any of the questions above

No more comments.

If you have any annotated graph/diagram/plot that would help support your answer to the previous question, please upload here.
File types: most accepted, File Size: max 1MB per file.

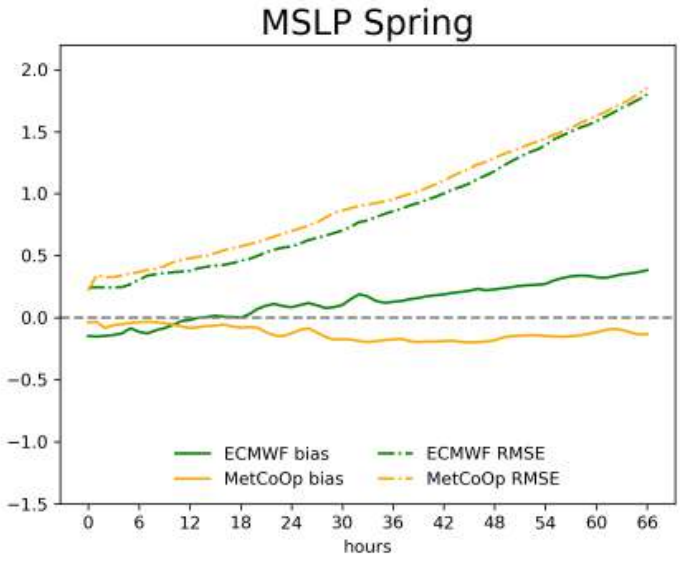
7.2. This is the first time we have used a survey style structure for Green Book submissions. You thoughts and feedback on this process are very welcome

It was convenient to fill the survey, this structure could be used in the future, too.

Thank you for taking the time to complete your Green Book report. Your feedback and comments are very valuable to us!

Contact

Contact Form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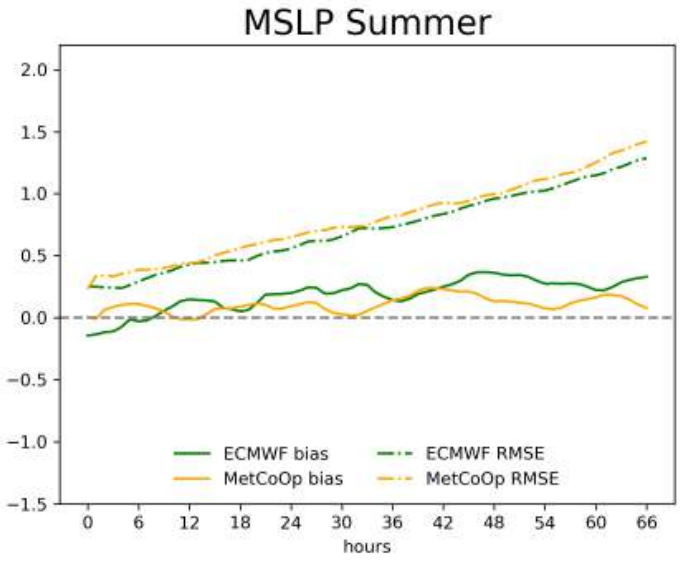
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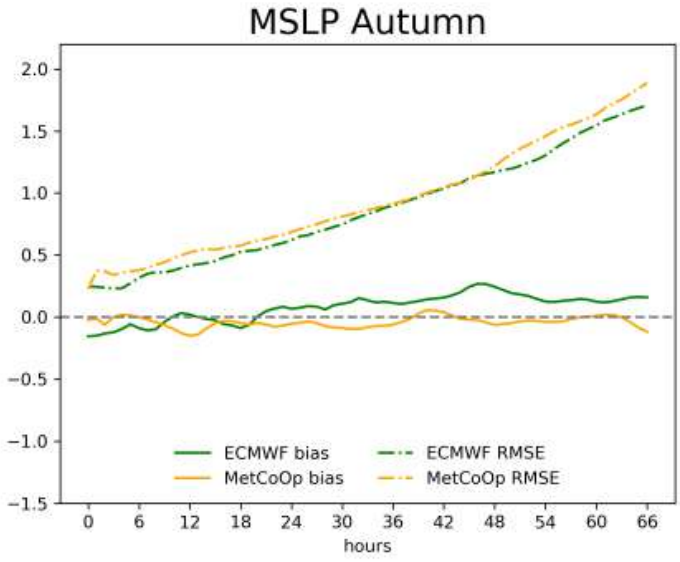
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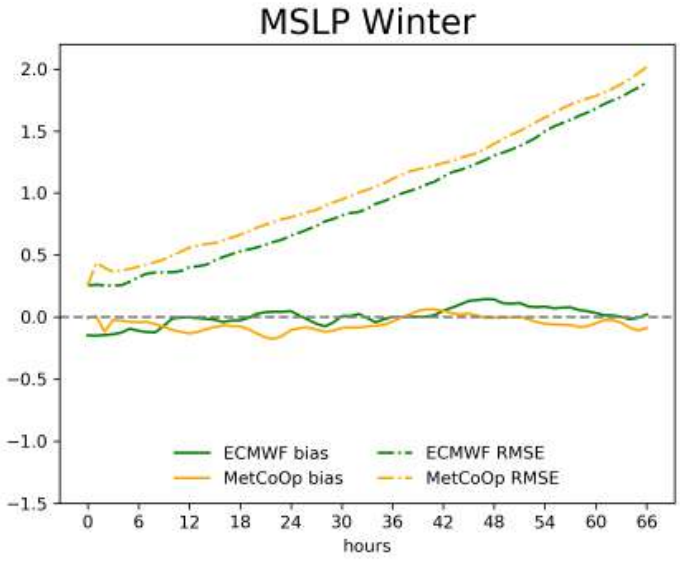
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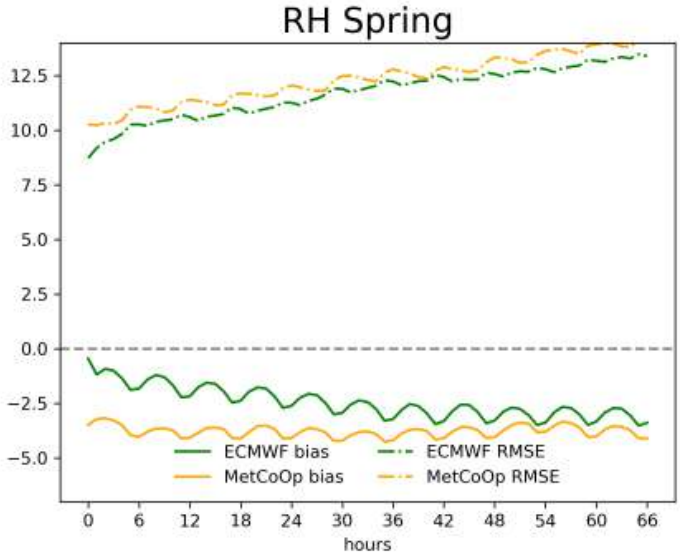
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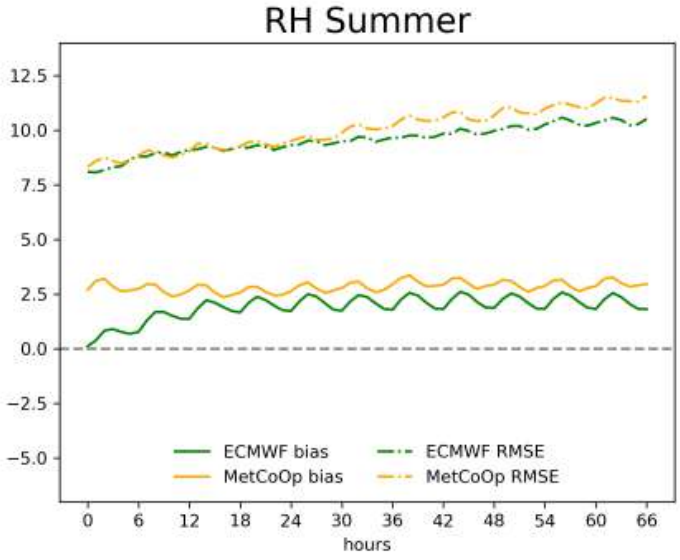
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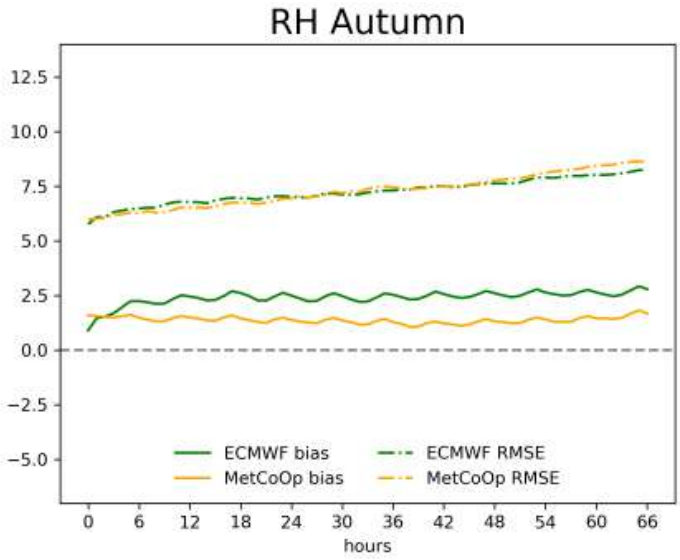
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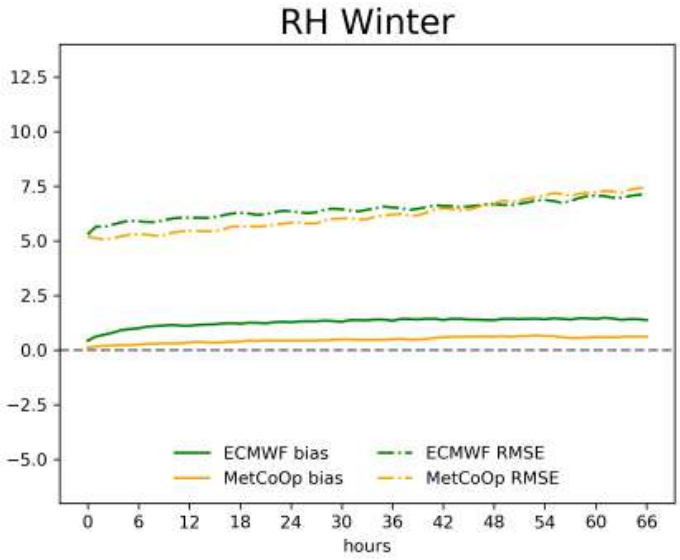
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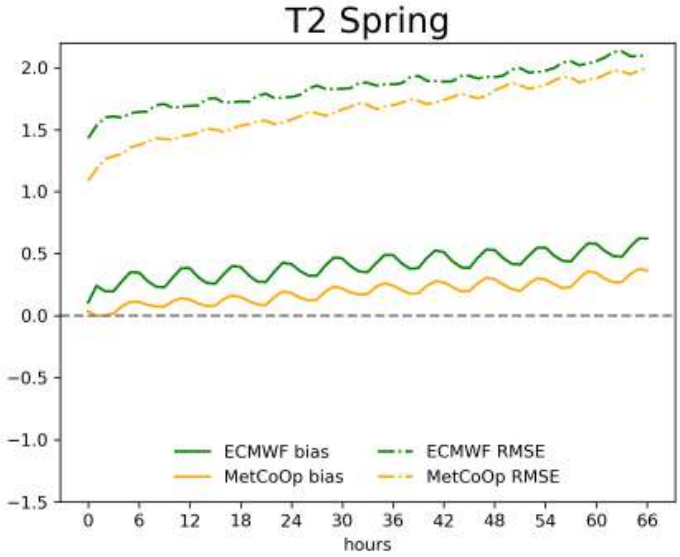
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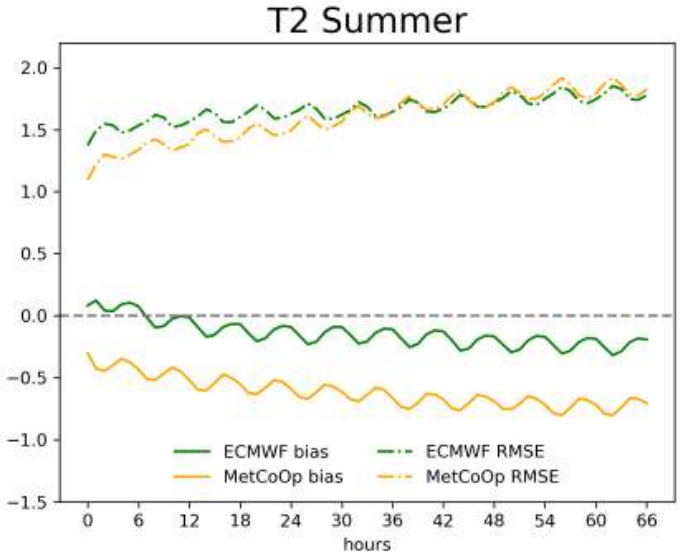
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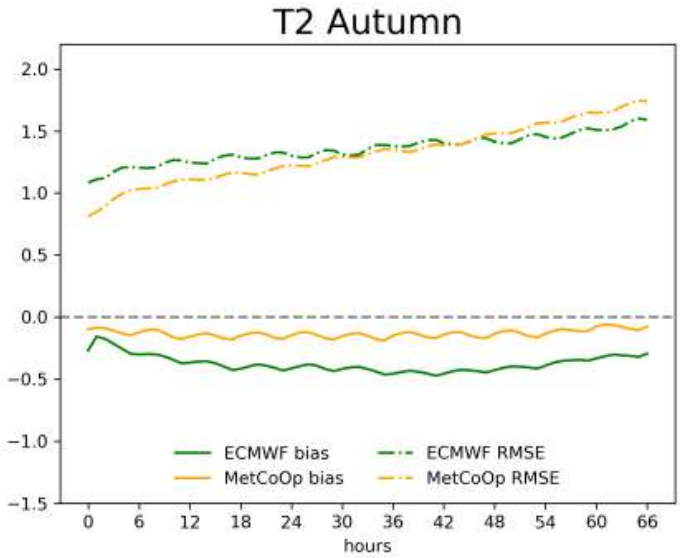
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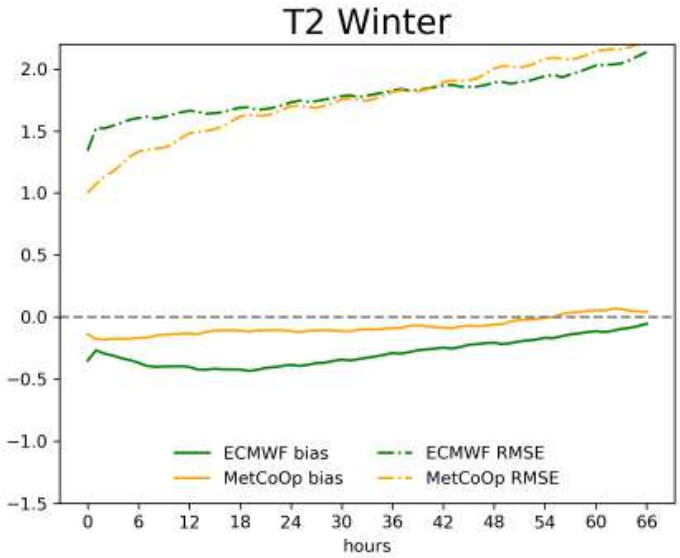
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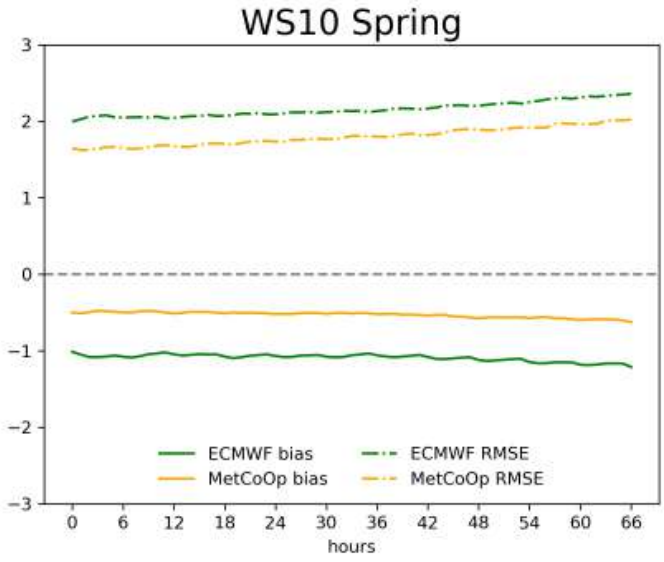
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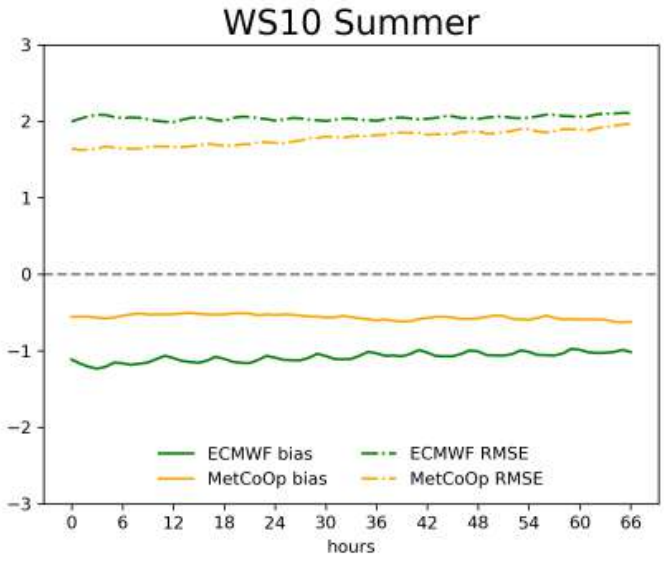
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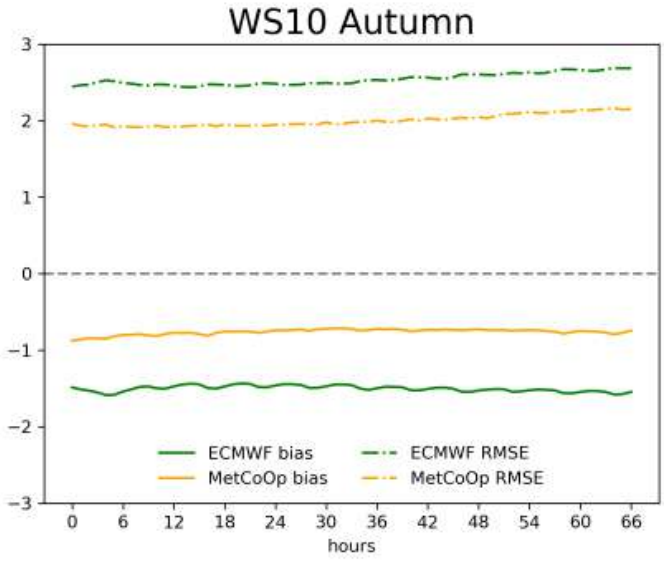
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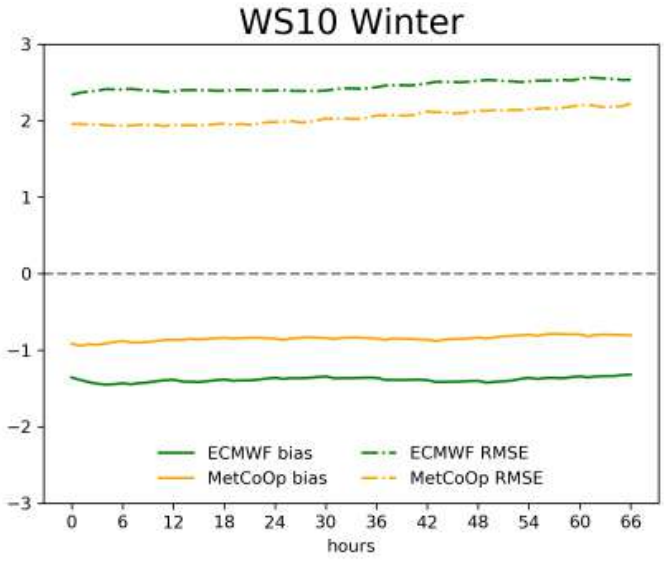
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Figure 1

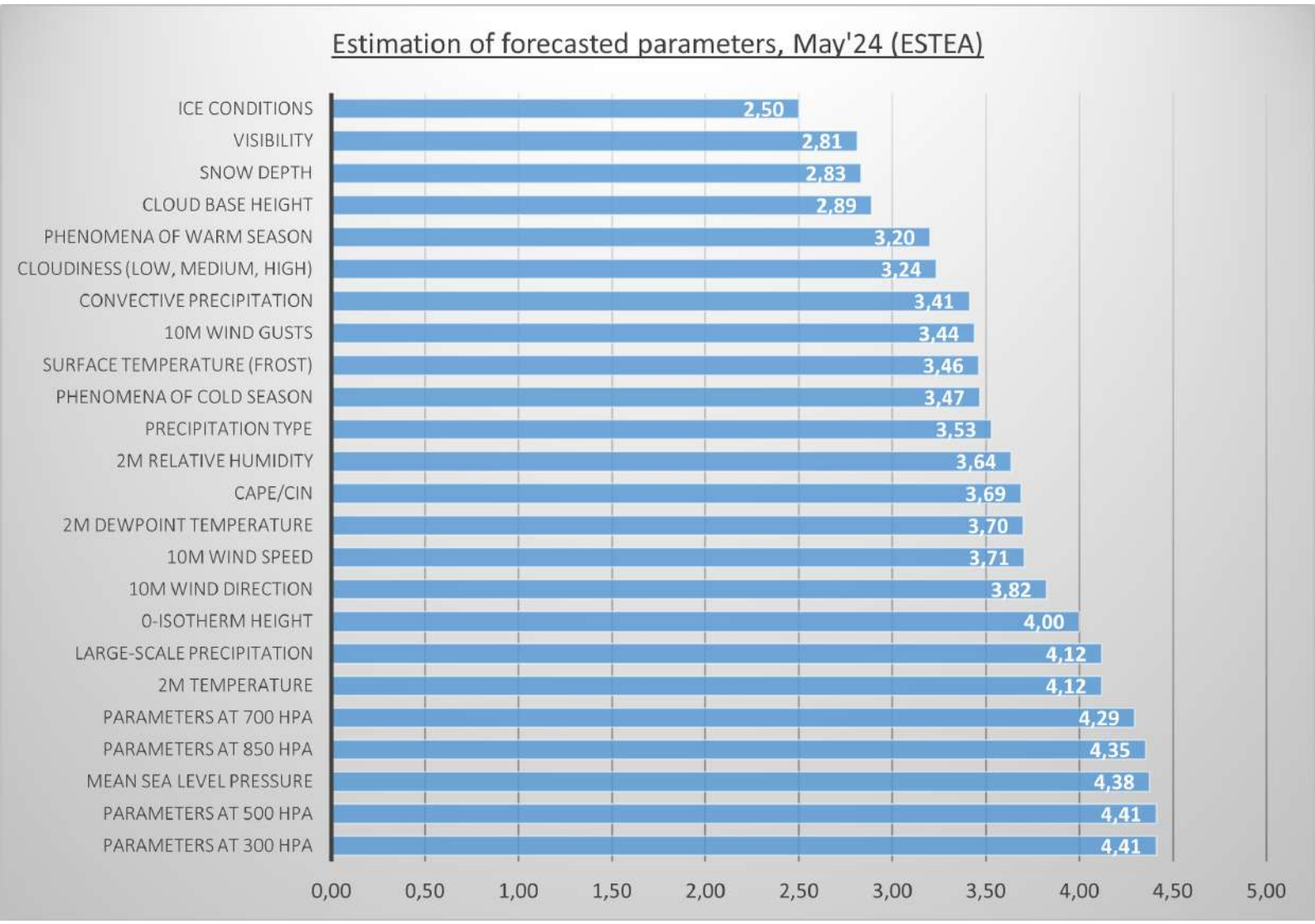
Estimation of forecasted parameters, May'24 (ESTEA)
ICE CONDITIONS 2,50
VISIBILITY 2,81
SNOW DEPTH 2,83
CLOUD BASE HEIGHT 2,89
PHENOMENA OF WARM SEASON 3,20
CLOUDINESS (LOW, MEDIUM, HIGH) 3,24
CONVECTIVE PRECIPITATION 3,41
10M WIND GUSTS 3,44
SURFACE TEMPERATURE (FROST) 3,46
PHENOMENA OF COLD SEASON 3,47
PRECIPITATION TYPE 3,53
2M RELATIVE HUMIDITY 3,64
CAPE/CIN 3,69
2M DEWPOINT TEMPERATURE 3,70
10M WIND SPEED 3,71
10M WIND DIRECTION 3,82
0-ISOTHERM HEIGHT 4,00
LARGE-SCALE PRECIPITATION 4,12
2M TEMPERATURE 4,12
PARAMETERS AT 700 HPA 4,29
PARAMETERS AT 850 HPA 4,35
MEAN SEA LEVEL PRESSURE 4,38
PARAMETERS AT 500 HPA 4,41
PARAMETERS AT 300 HPA 4,41
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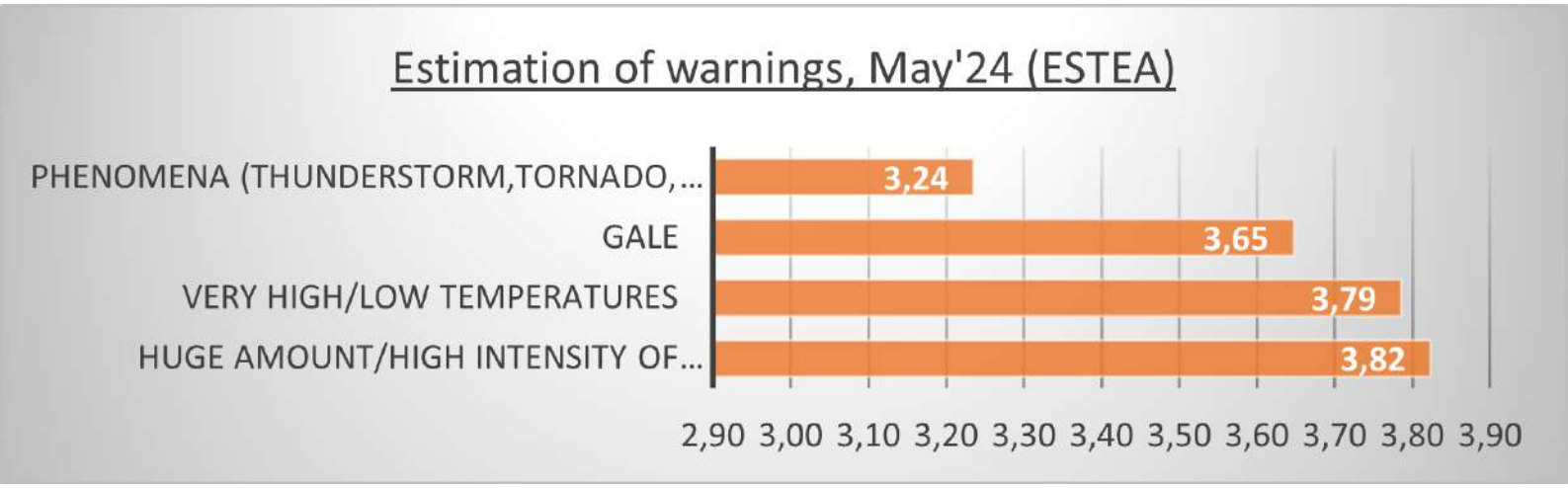
Figure 2


Estimation of warnings, May'24 (ESTEA)
PHENOMENA (THUNDERSTORM,TORNADO,...
GALE
VERY HIGH/LOW TEMPERATURES
HUGE AMOUNT/HIGH INTENSITY OF...
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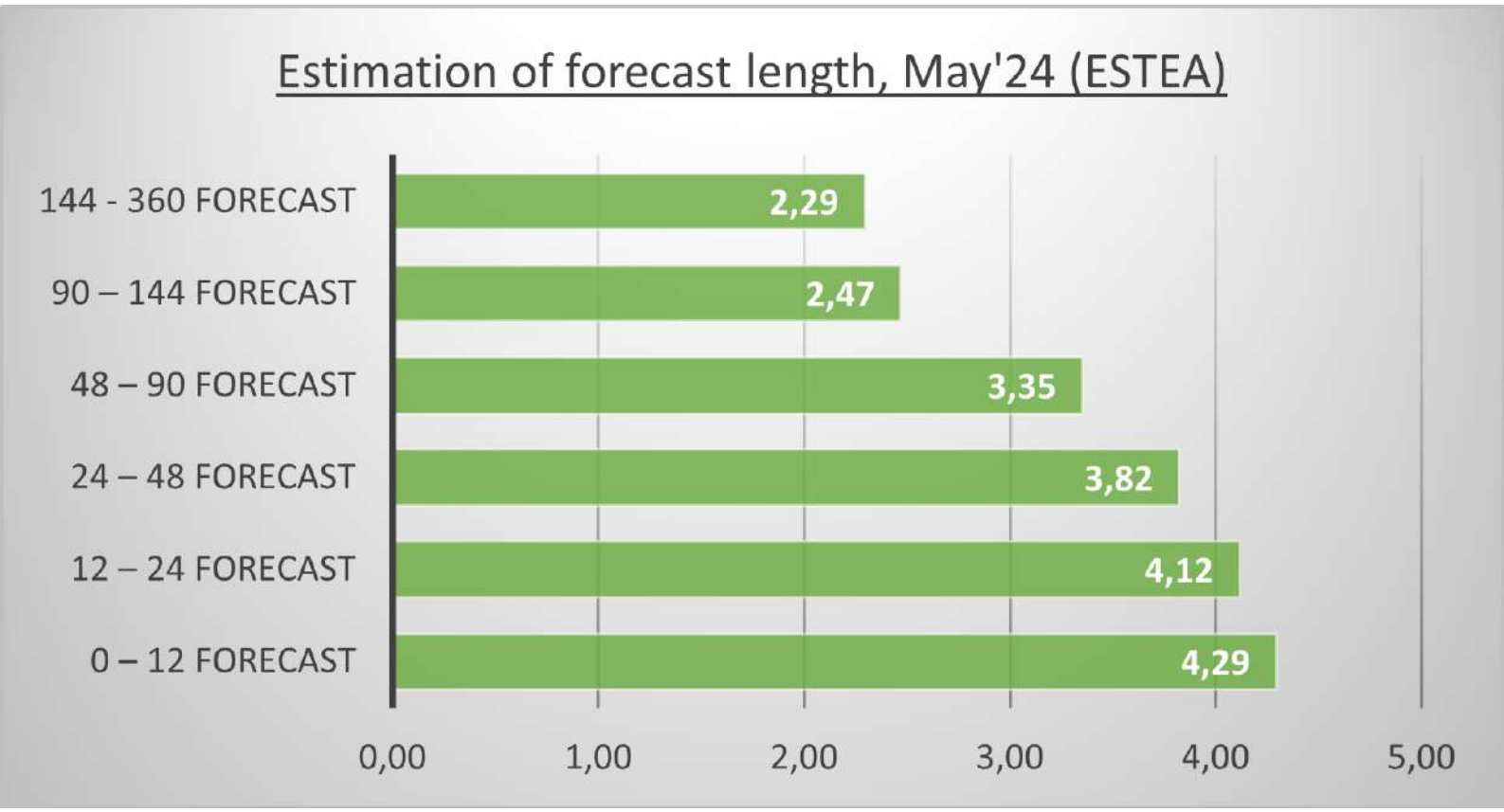
3,79
3,82
2,90 3,00 3,10 3,20 3,30 3,40 3,50 3,60 3,70 3,80 3,90

Figure 3


Estimation of forecast length, May'24 (ESTEA)
144 - 360 FORECAST
2,29
90 – 144 FORECAST
2,47
48 – 90 FORECAST
3,35
24 – 48 FORECAST
3,82
12 – 24 FORECAST
4,12
0 – 12 FORECAST
4,29
0,00
1,00
2,00
3,00
4,00
5,00

Overestimated cloudiness case study in Estonia on 07 January 2024

On 7 January 2024 the cloudiness above Estonia, especially the low clouds, got overestimated by IFS-HRES forecast. The Figure 1 shows the ceilometer measurements of cloud cover and cloud base height over Estonia on 07/01/2024 at 01 UTC. At 01 UTC the north-eastern part of Estonia is cloud-free, the western part is covered by the middle clouds, and some low clouds are located in the south-eastern part of the country.

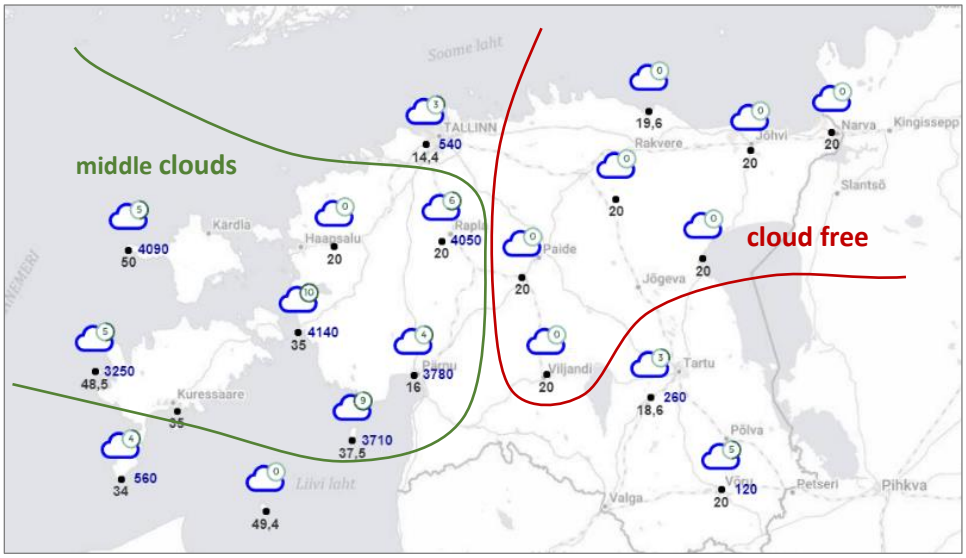


Figure 1. Ground-based observations of cloud cover and cloud base height over Estonia on 7 January 2024 at 01 UTC (03 by local time)

The Figure 2 demonstrates two examples of IFS-HRES low cloud cover forecasts valid at 07/01/2024 01 UTC: the 25-hour forecast based on 06/01/2024 00 UTC analysis time (2a) and 13-hour forecast based on 06/01/2024 12 UTC analysis time (2b). The low cloud cover is highly overestimated in the northern part of Estonia.

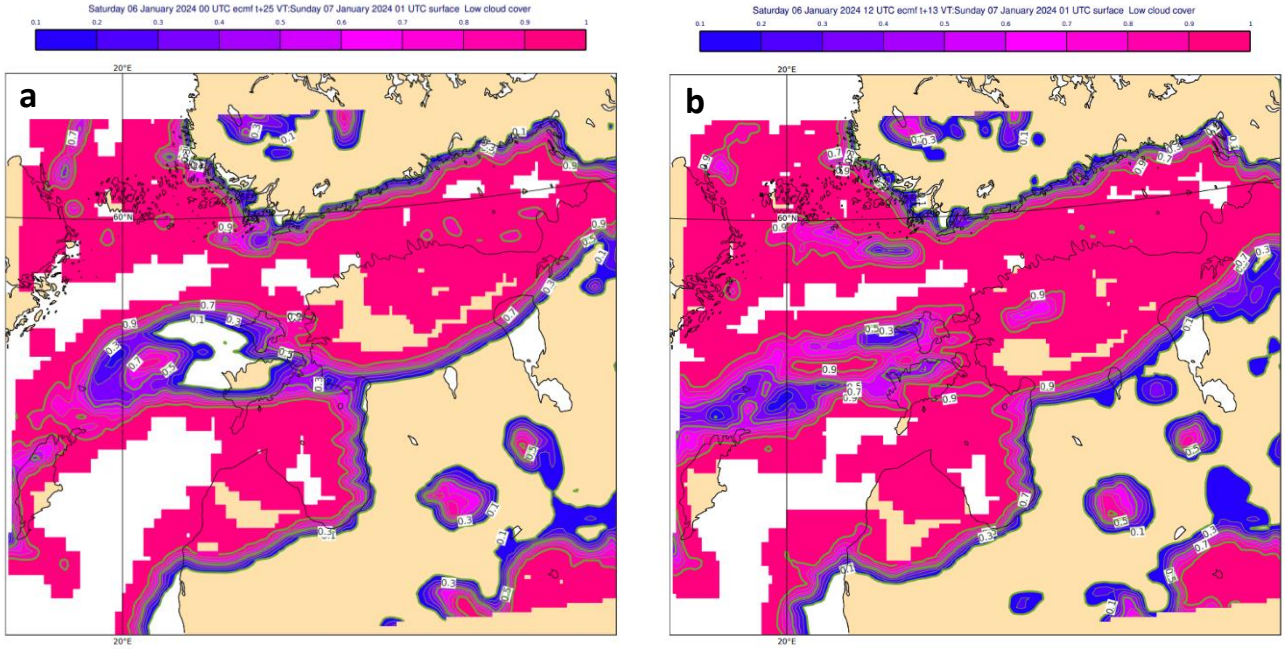


Figure 2. Low cloud cover forecast over Estonia at 07/01/2024 01 UTC (03 local time) a) based on 06/01/2024 00 UTC analysis + 25 h forecast, and b) based on 06/01/2024 12 UTC analysis + 13 h forecast.

The low clouds can absorb and re-radiate infrared radiation emitted by the Earth's surface, trapping some of the heat within the lower atmosphere. This trapped heat keeps the surface temperature higher than it would be in the case of clear sky. This effect can be seen in the present case study. The Figure 3 shows ground-based 2-meter temperature observations. Surface temperature was varying between -18 to -27 °C in the northern part of the country with some warmer exceptions in the stations located very close to the ice free sea.

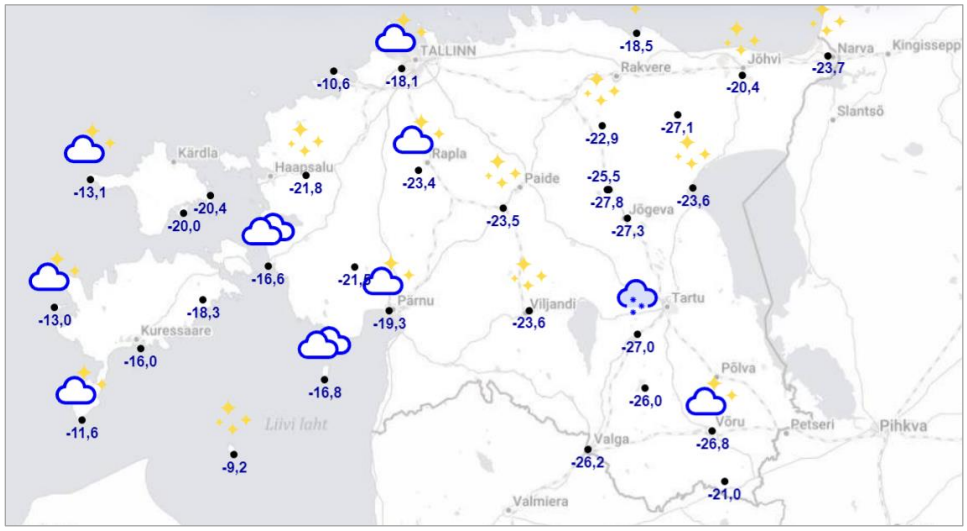


Figure 3. 2-meter temperature ground-based observations on 7 January 2024 at 01 UTC in Estonia.

Figure 4 shows IFS-HRES 2-meter temperature forecasts valid at 07/01/2024 01 UTC based on 06/01/2024 00 UTC (4a) and 12 UTC (4b) analyses times. In the northern part of Estonia, where low clouds have been overestimated, the surface temperature was predicted to vary between -6 to -15 °C, which is substantially warmer than observed.

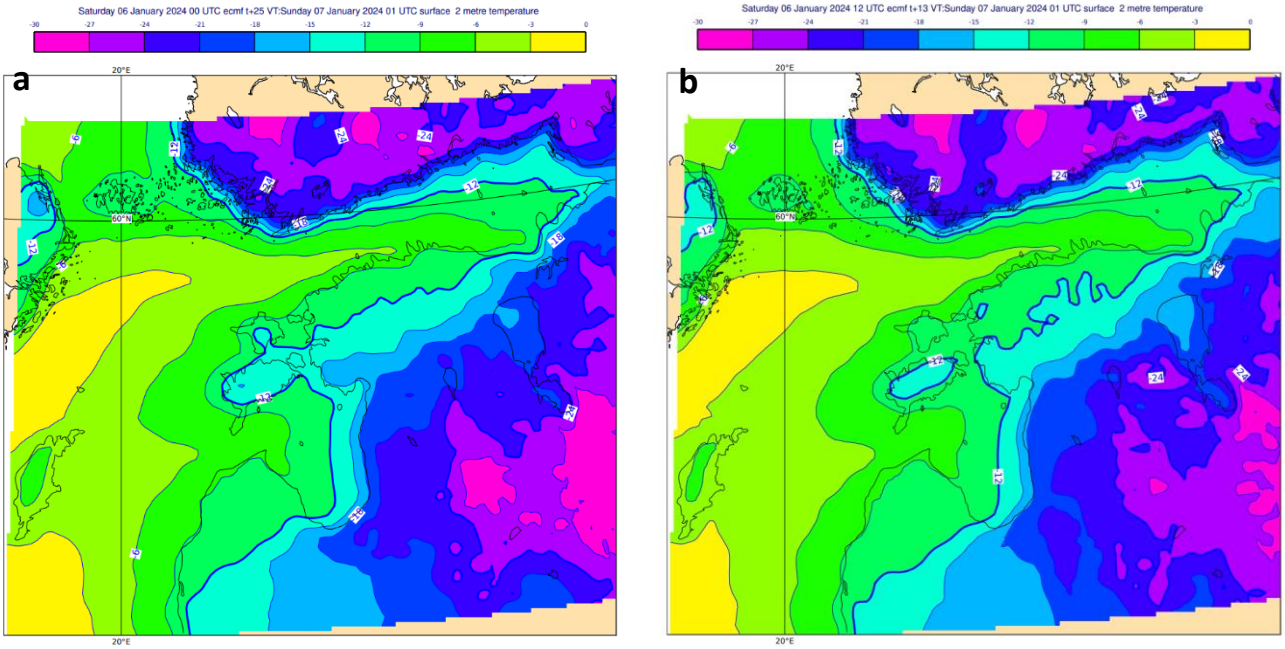
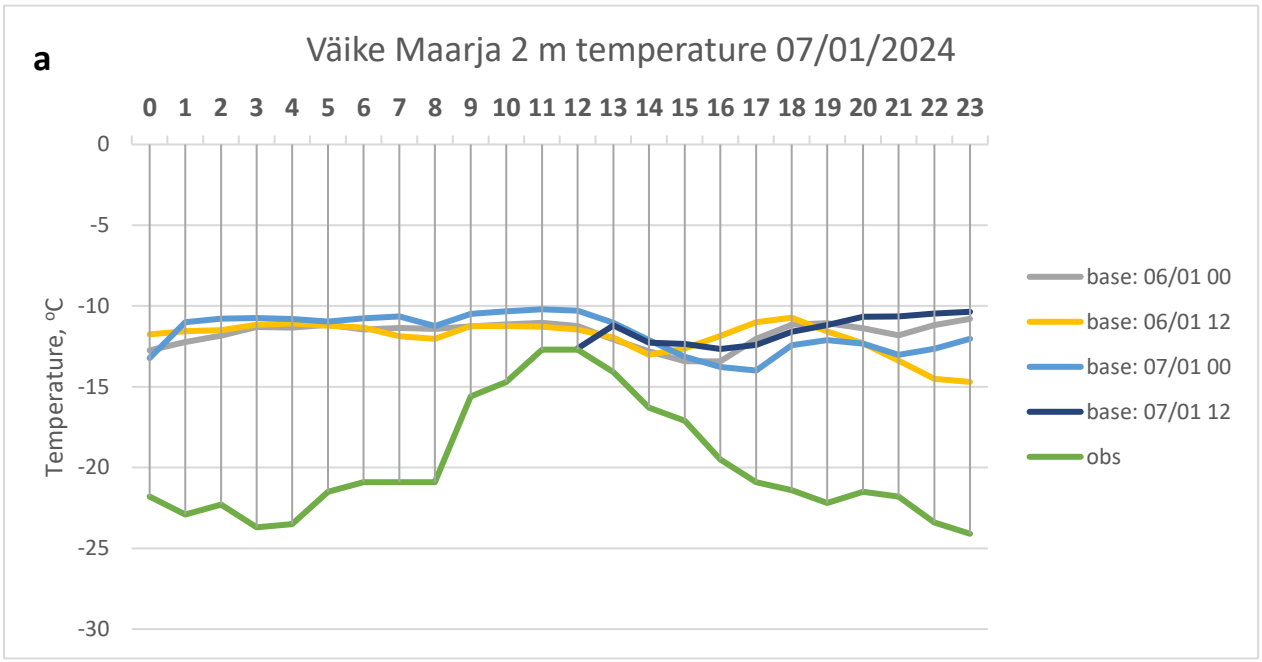


Figure 4. 2-meter temperature forecast in Estonia at 07/01/2024 01 UTC a) based on 06/01/2024 00 UTC analysis, and b) based on 06/01/2024 12 UTC analysis.

The situation with the overpredicted clouds was present throughout the night and some hours during the daytime. In the morning, at the time people go to work or do skiing, the meteorological service of Estonian Environment Agency received plenty complaints from the public about too warm model forecast.

Figure 5 demonstrates the 2-meter temperature (5a) and total cloud cover (5b) forecasts and observed values on 07/01/2024 in Väike Maarja weather station located in the northern part of Estonia. During the day there were no clouds detected by ground-based cloud cover measurements. However, different leading time forecasts predicted overcast sky, and consequently too warm temperature, smoothing the diurnal temperature cycle.

Despite the cloudiness in Estonia is often overpredicted by IFS, the temperature forecasts are ususally accurate. The case presented in this study shows outstansing situation, when the overpredicted low clouds in the cold winter day induced substantial surface temperature overprediction.



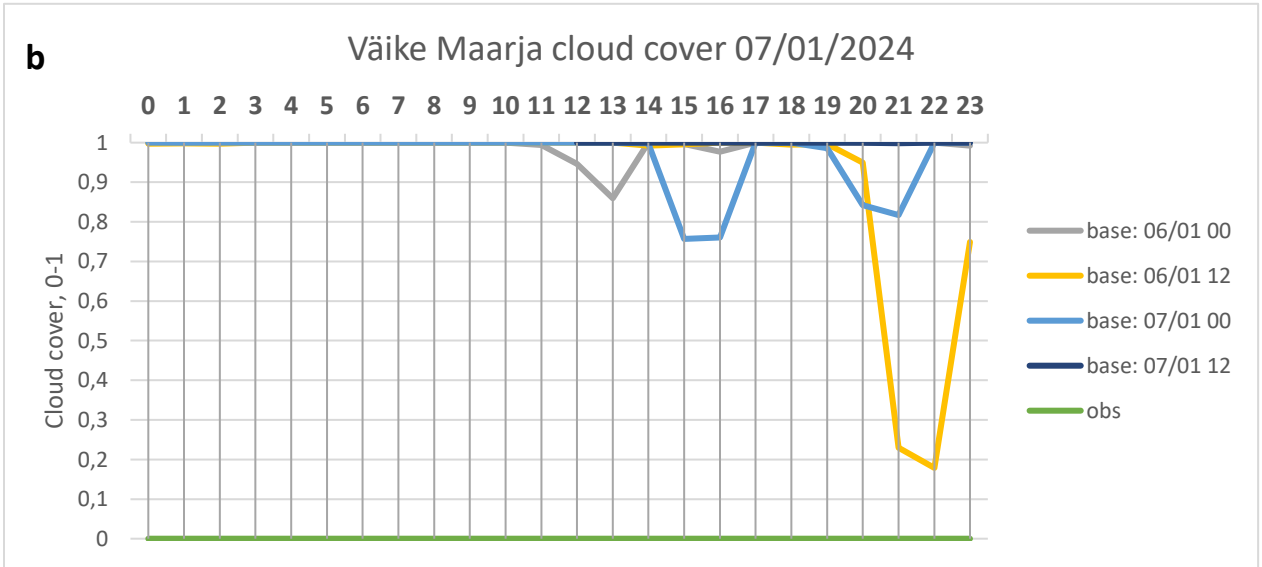


Figure 5. Timeseries of 07/01/2024 (times in UTC) forecasts and ground-based observations of a) 2-meter temperature, and b) cloud cover.