LEGMC

# Some developments and tests regarding cloud physics etc in MetCoOp (overview)

Karl-Ivar Ivarsson ASW-ACCORD April 2024
Thanks to Patrick, Jenny, Emily, Panu, Meto and many others.

**OUTLINE:**

1: Tuning the visibility parametrization (in gl)

2: Testing new surface schemes with/without some updates of microphysics (winter cases)

# Tuning the visibility parametrization (in gl)

**Problem: Often too low visibility, especially in case of high relative humidity.**

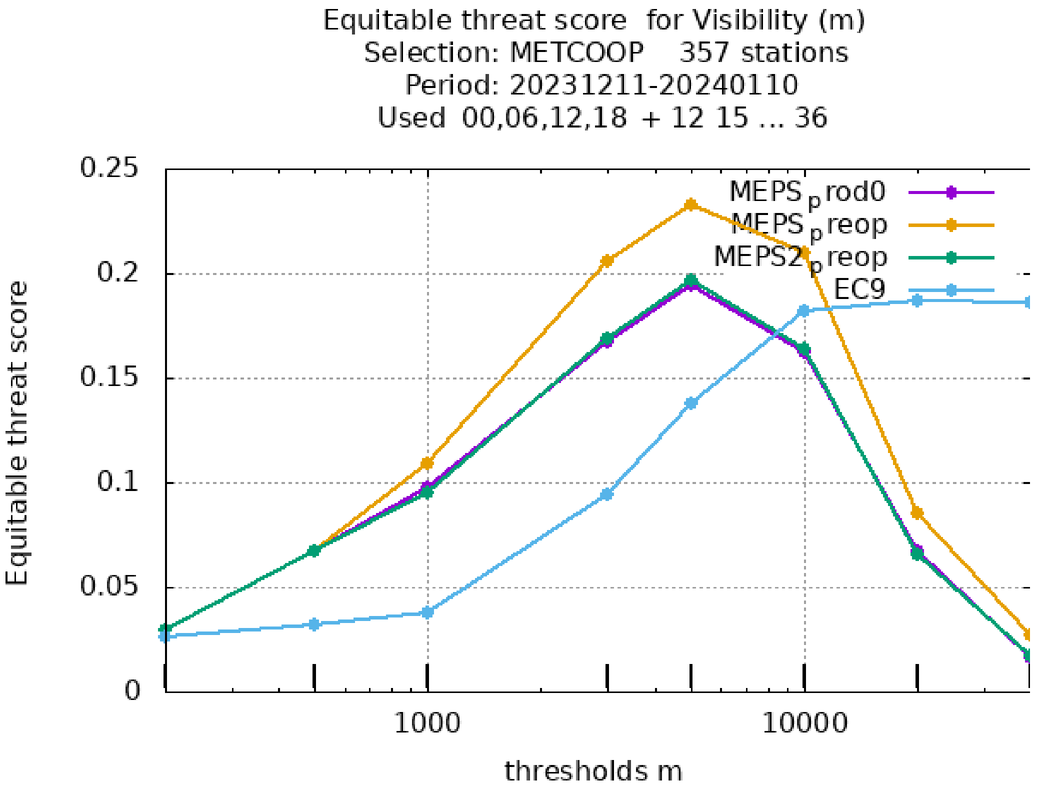
----------- TUNING: ---------

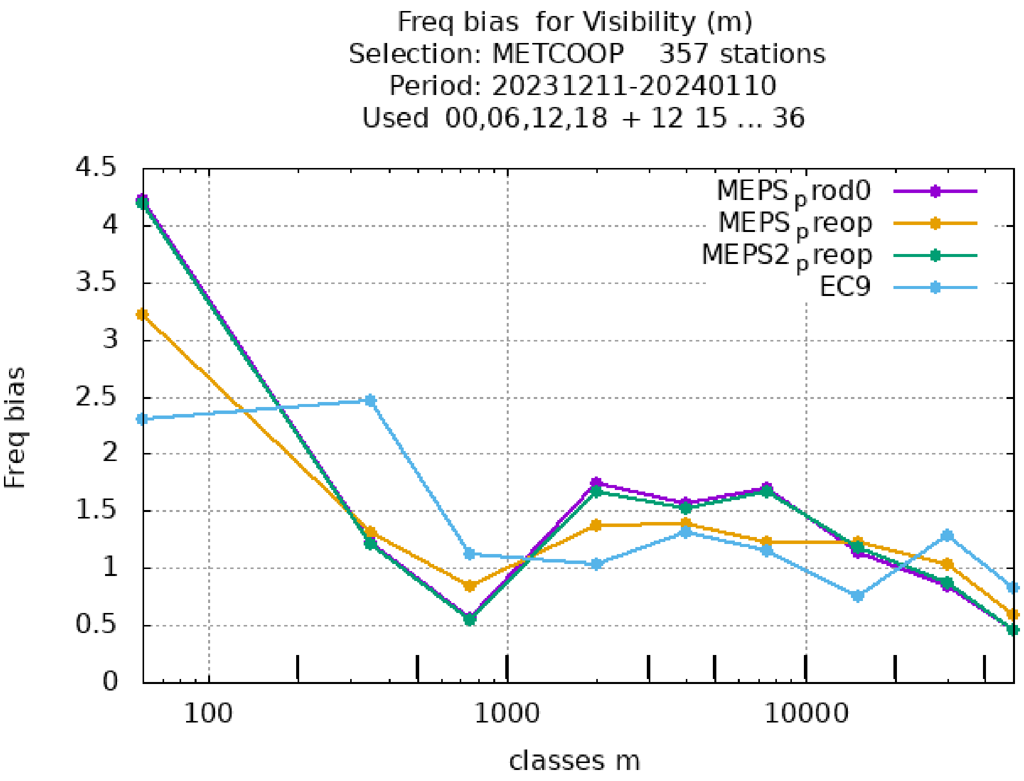
1: Suppressing the effect of ’moist haze’ when high relative humidity

2: Some increase of the effect of precipitation, especially the effect of snow, since the proportion of graupel/snow seems somewhat too large. Graupel has a lower effect on visibility reduction than snow.

3: A general increase of visibility (by a factor of 1.25)

RESULTS:
(See yellow lines, purple is reference, light blue is ECMWF, disregard green lines)
Left: ETS improves for the thresholds from 1km(=fog or not) up to  to 20 km.
Right: Frequency bias, somewhat reduced. (perhaps reduce the effect of cloud liquid also?)



# Testing new surface schemes with/without some updates of microphysics (winter cases, cy46)

***Typical winter- problems addressed here:***

1: Missing low clouds in cold high pressure situations

2: Difficult catching the lowest temperatures ( below ~ -35 C)

3: Over-forecasting of precipitation over mountains. (to some extent this is also seen in the warm half of the year)

4: T2m reacts too slowly, when the weather is changing quickly

# New things in this test (MetCoOp domain, 1-15 December 2021)

NEW SURFACE:

1: ‘DIF’  (instead of 3-L,force-restore)

2: 12-layer snow scheme.

3: New surface analysis

NEW CLOUD MICROPHYSICS:

1: ICET (Extension/Flavour of OCND2)

2: LMODICEDEP (Extension/Flavour of OCND2)

**TESTS:**

REF: Old surface

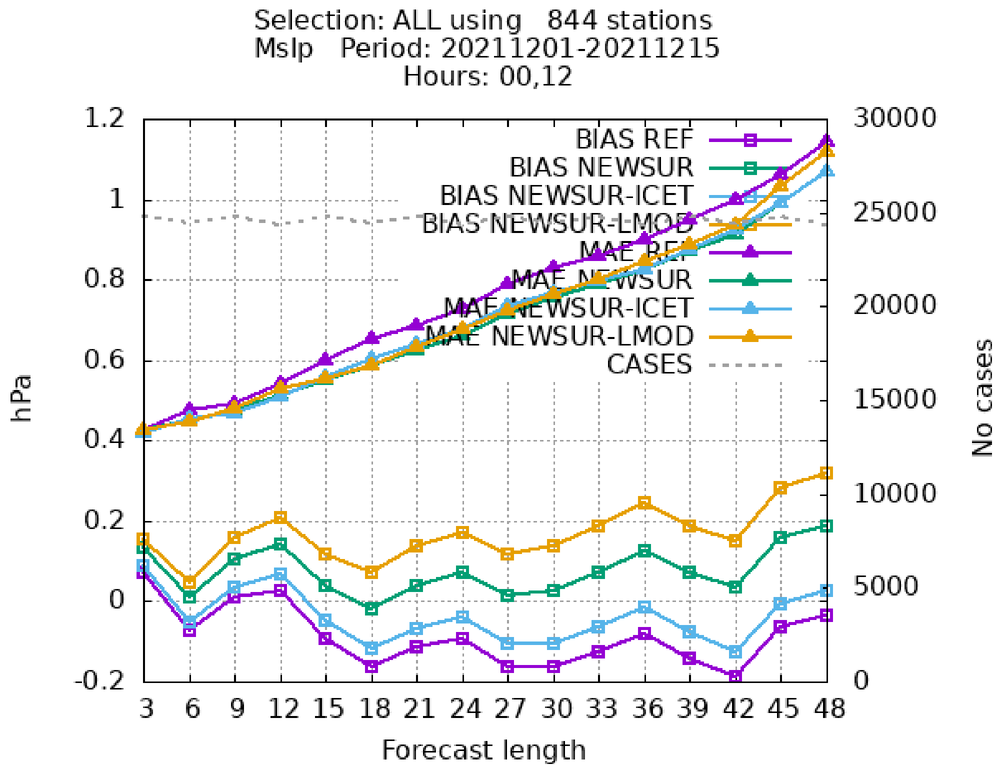
NEWSUR: New surface

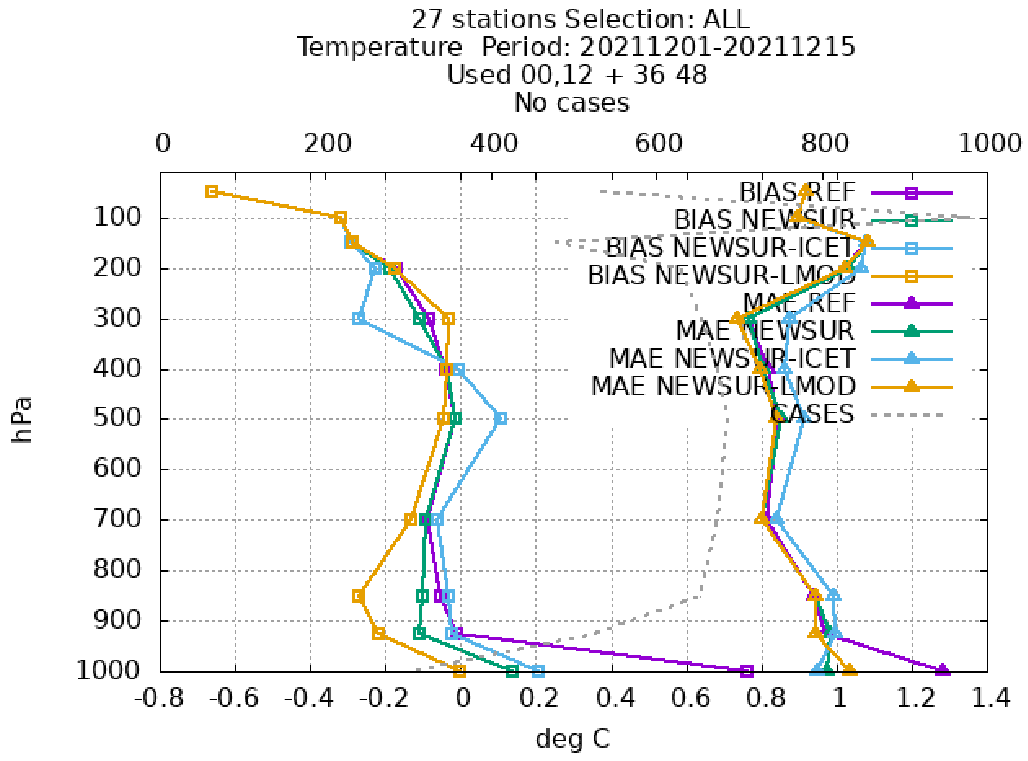
NEWSUR-ICET: New surface+ ICE-T

NEWSUR-LMOD: New surface+ MODICEDEP

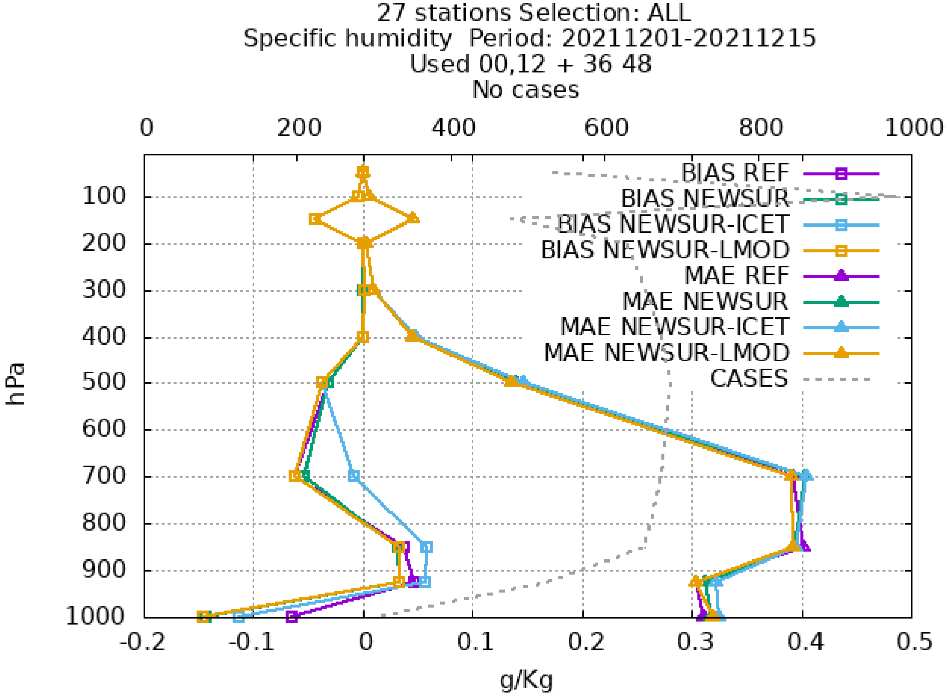
# MSLP, Temperature in troposphere

MSLP improved for all NEWSUR(new surface) runs, but only NEWSUR-ICET improvement is statistical significant. Some positive bias for NEWSUR-LMOD, probably related to negative temperature bias lower troposphere (see right plot)

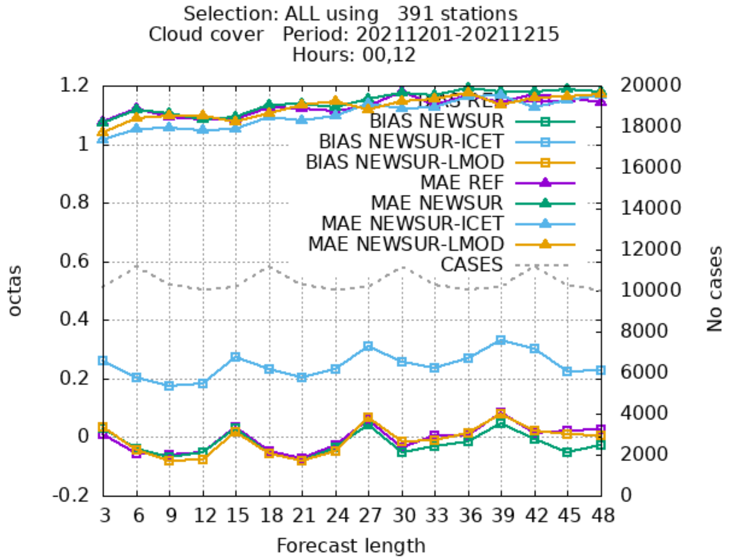


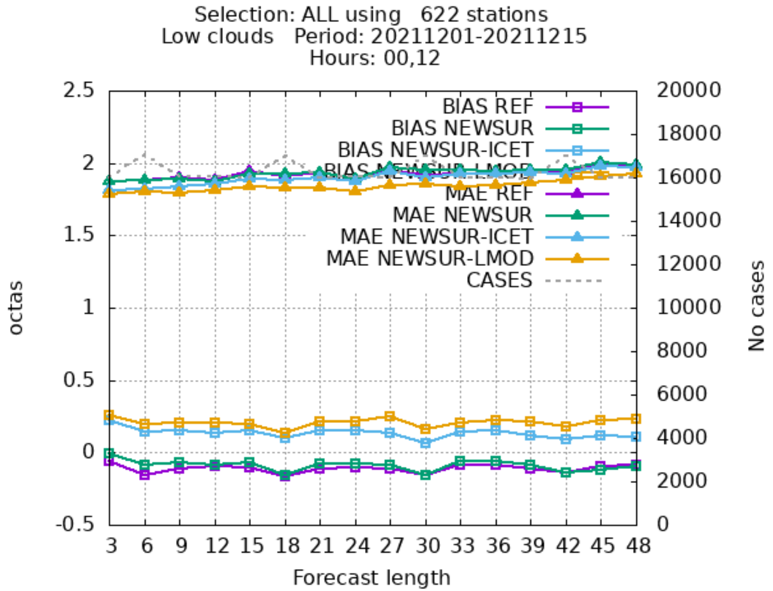



# Humidity in troposphere, cloudiness

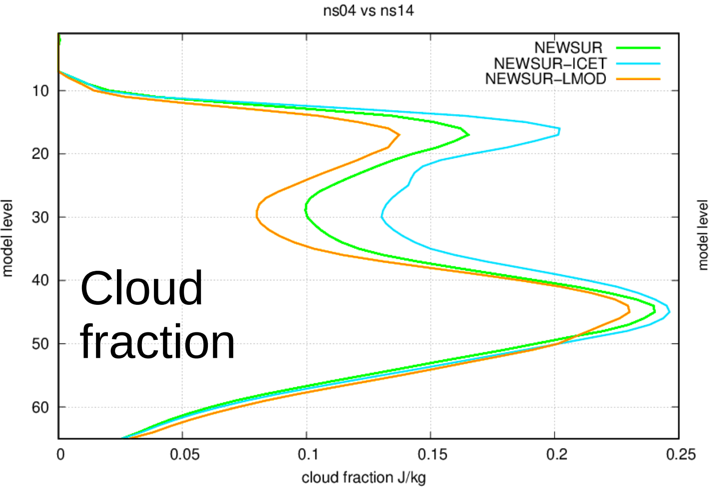


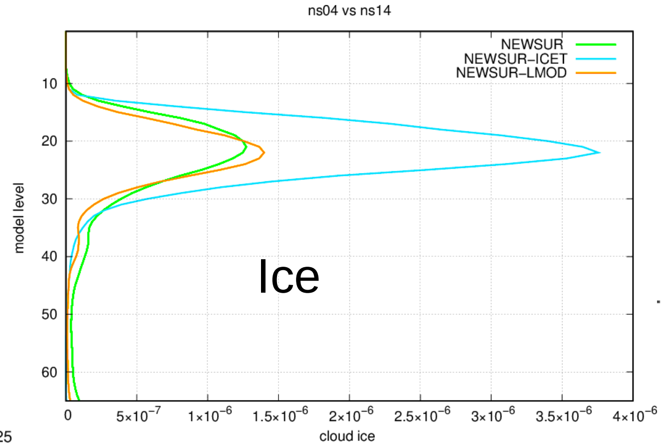

New surface schemes make it a little drier at lowest level (1000hPa)
Somewhat more humidity with ICET for middle troposphere and also(thus) some more cloudiness.
Also a small increase of low clouds.

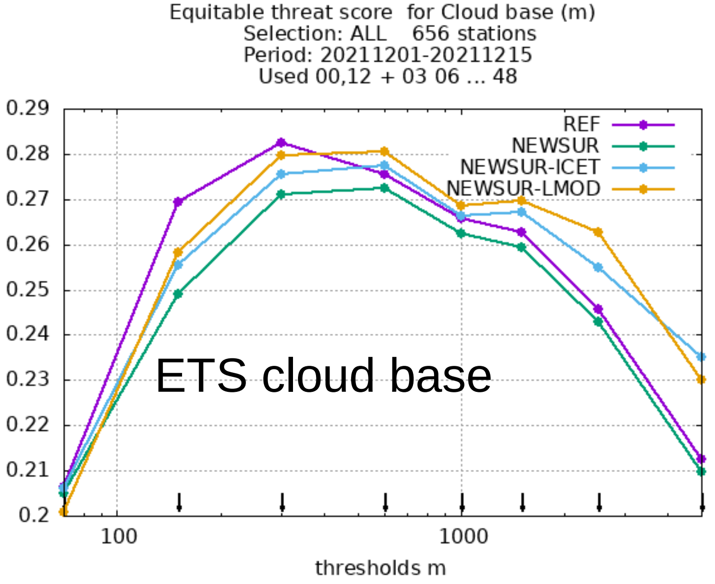


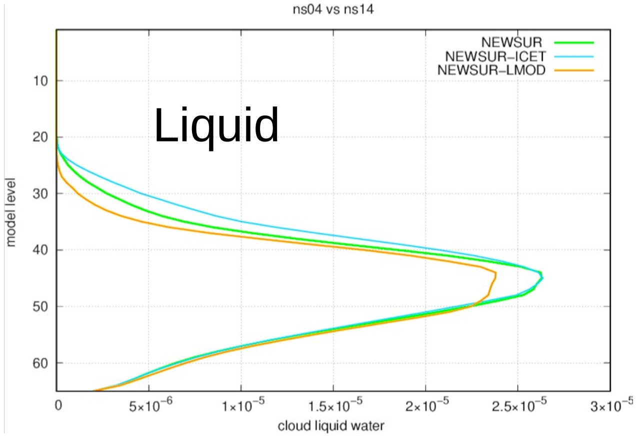
# Mean cloudiness/ice/liquid different levels

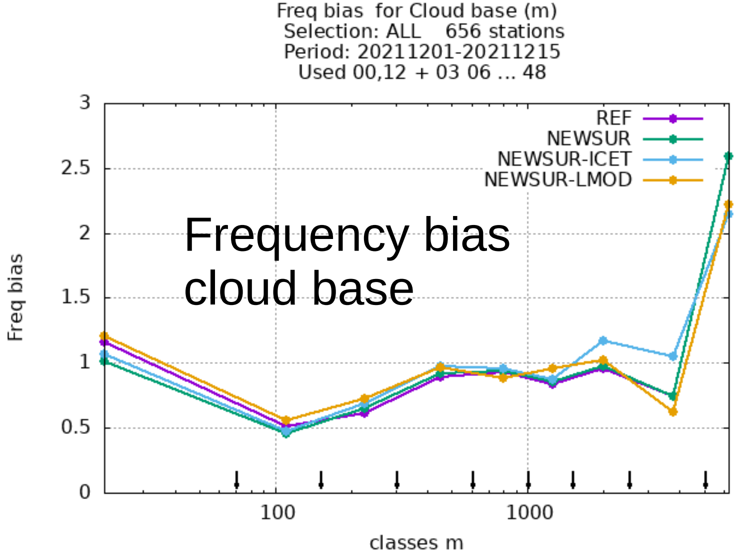


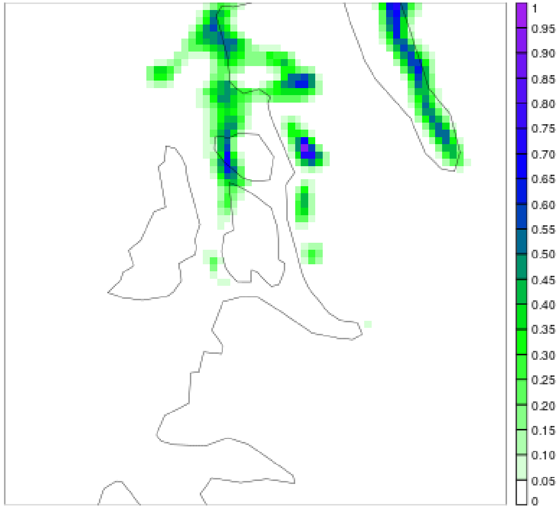

Somewhat lower ETS for cloud base with new surface parametrization, counteracts when applying ICET or MODICEDEP. More ice and clouds with ICET in upper troposphere



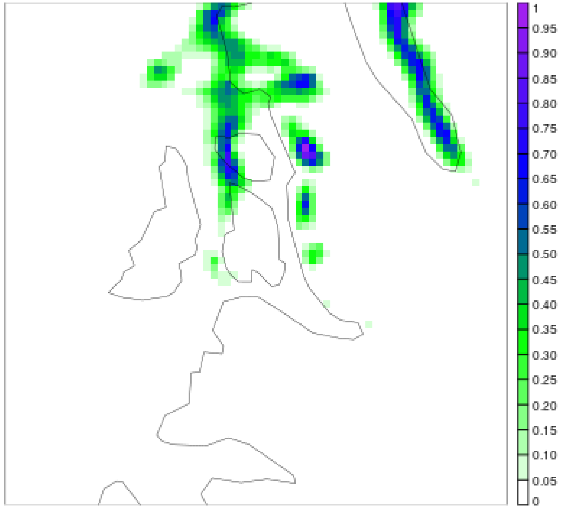



# Example of different liquid water path’s with ICET (middle) or without (left) when activating ICET scheme (from Jenny)

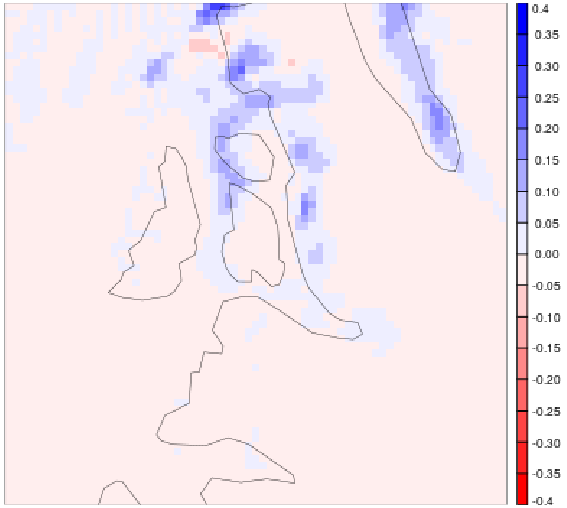
CLW in model level 41 (~830hPa) [g/m³], DEF
April 19 2023 1400UTC




CLW in model level 41 (~830hPa) [g/m³], ICE-T
April 19 2023 1400UTC

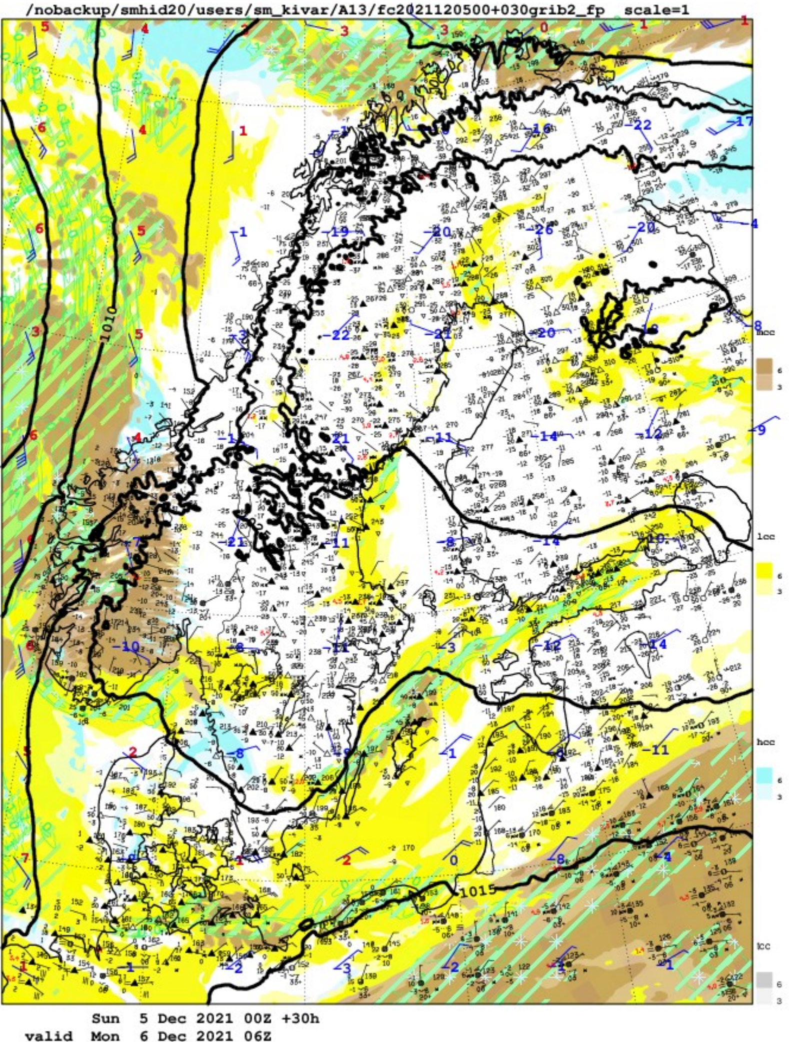


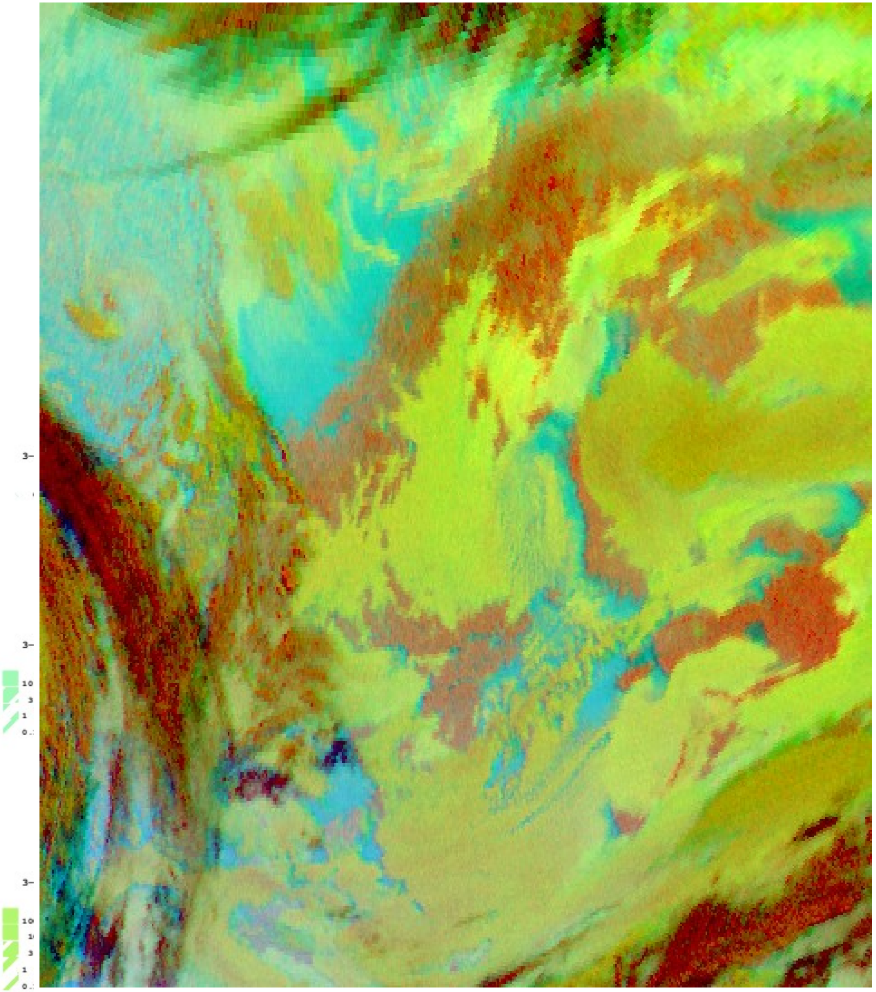

Diff CLW model level 41 (~830hPa) [g/m³], ICE-T-DEF
April 19 UTC 2023




More liquid with ICET, see difference plot to the right.

# ‘Epic’ missing of low clouds: 6th December 06UTC 2021 (18h forecast) REF

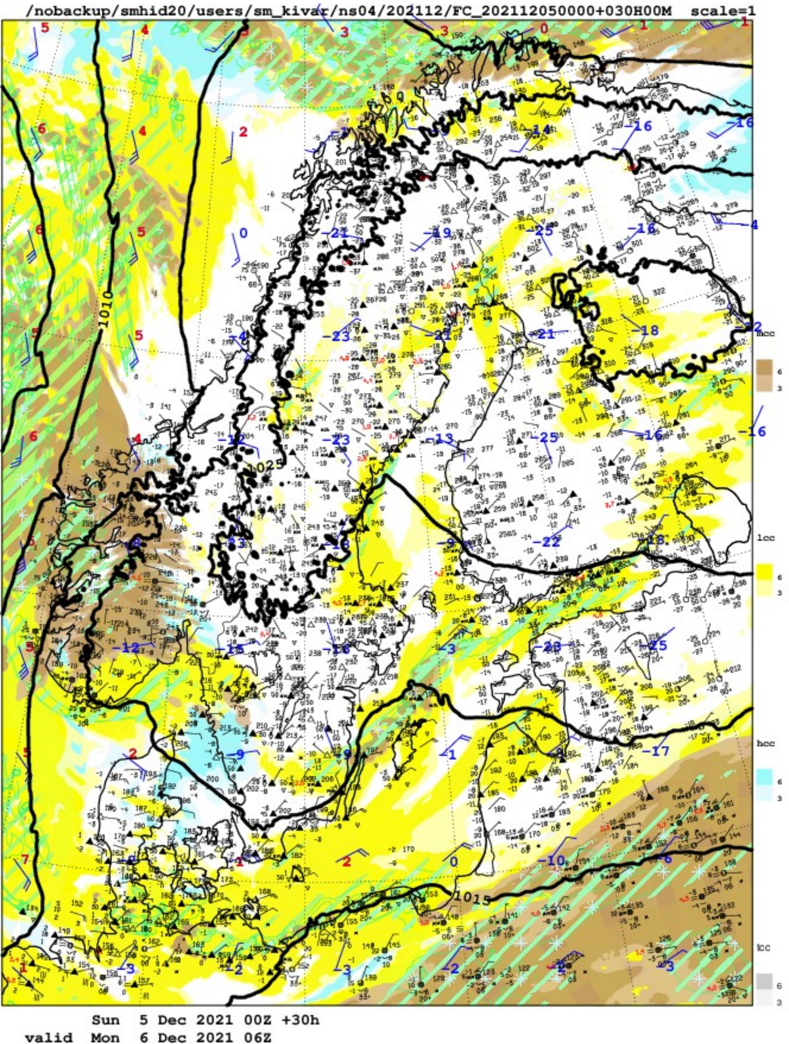


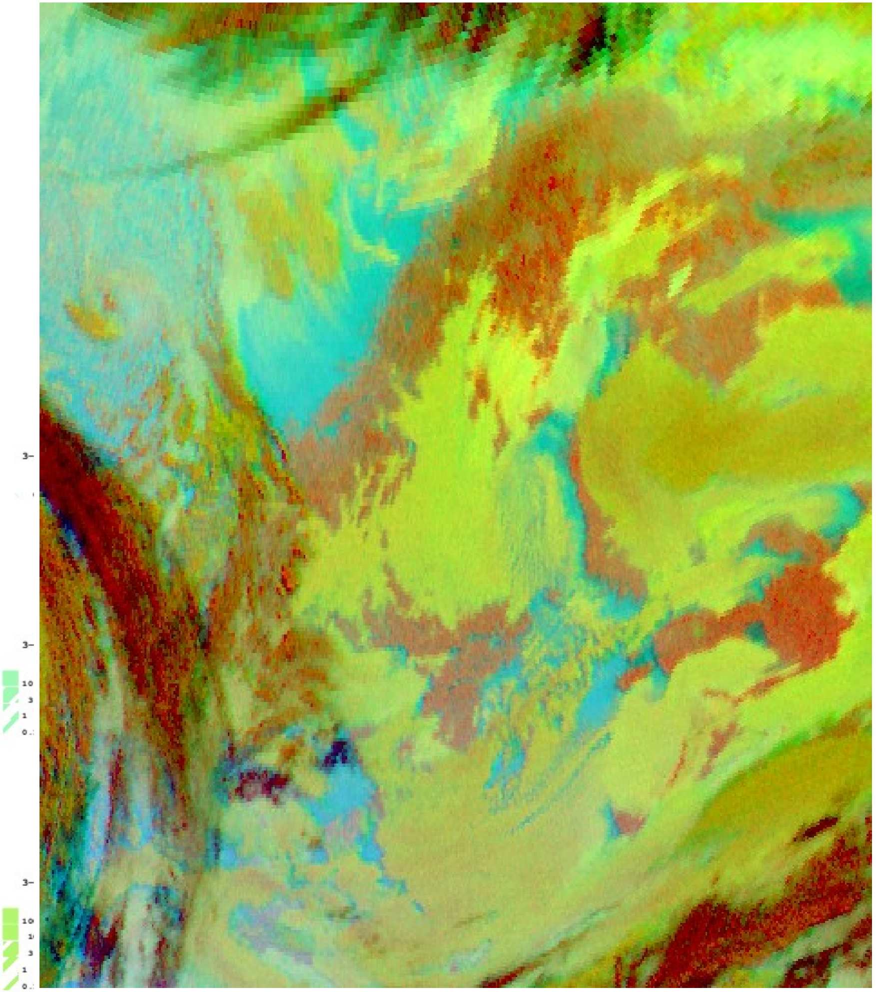



Missing a lot of low clouds, especially over Finland and Sweden.

Low clouds are yellow in both forecast maps(left) and satellite pictures(right).

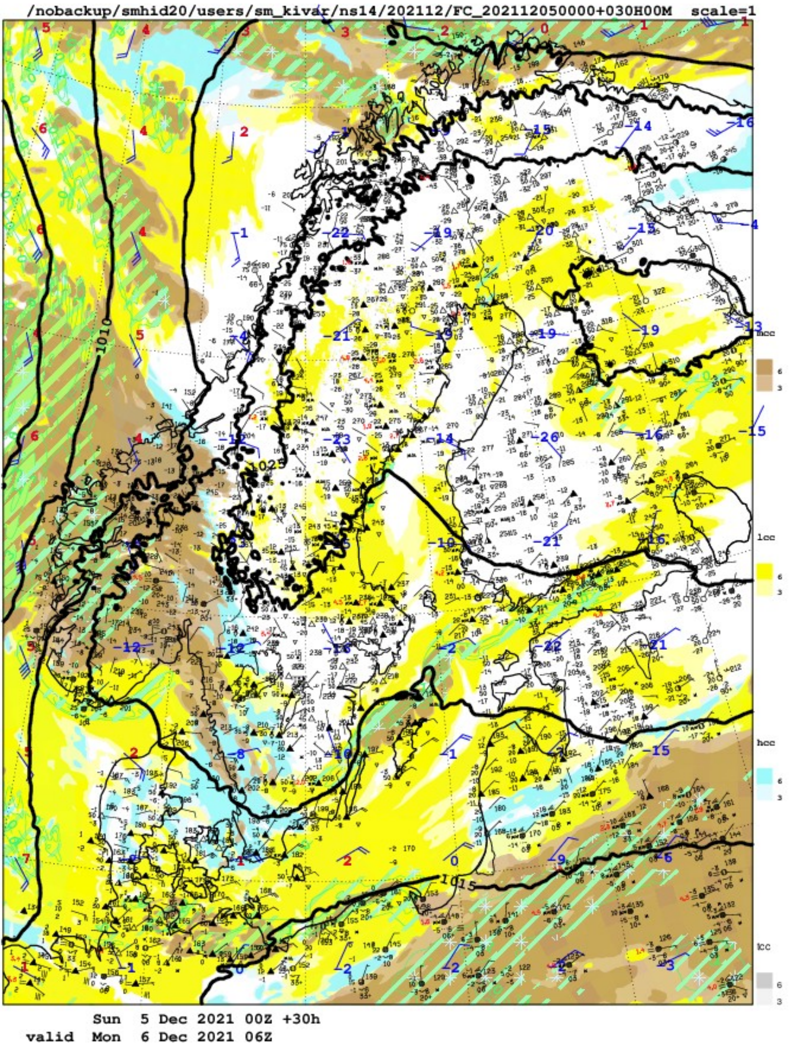
# 6th December 06UTC (18h forecast) NEWSUR

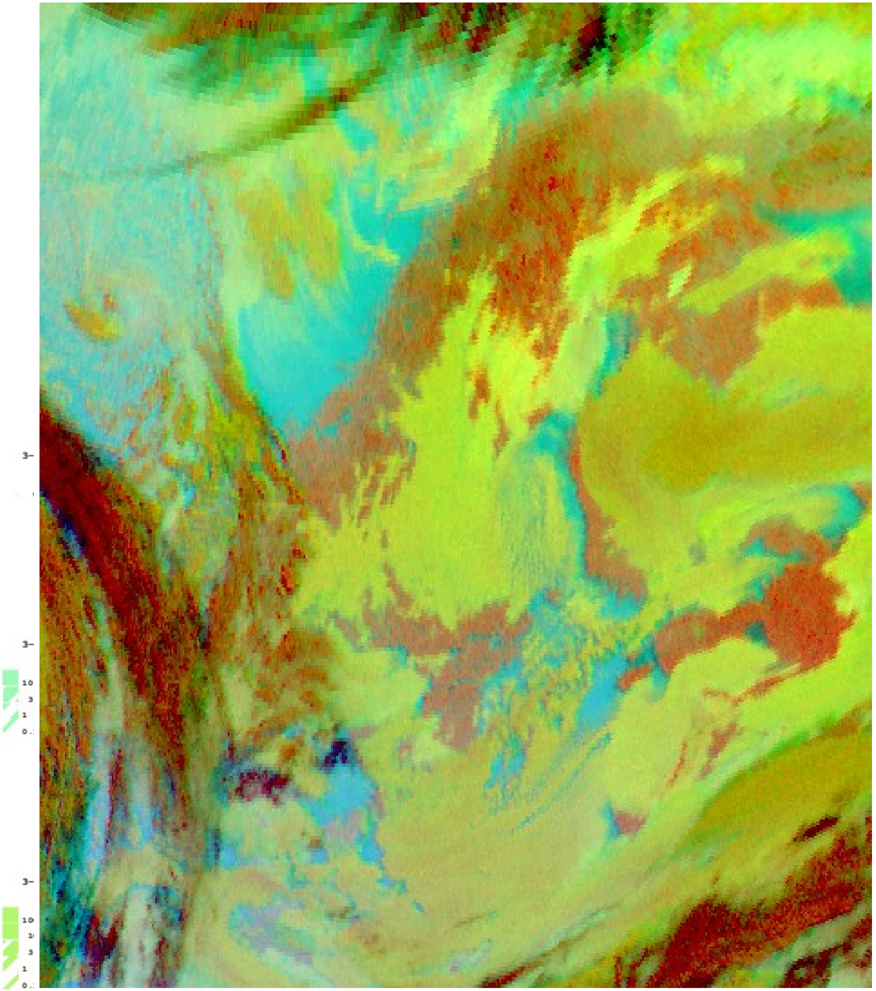


Still missing a lot of low clouds, but a little less bad.

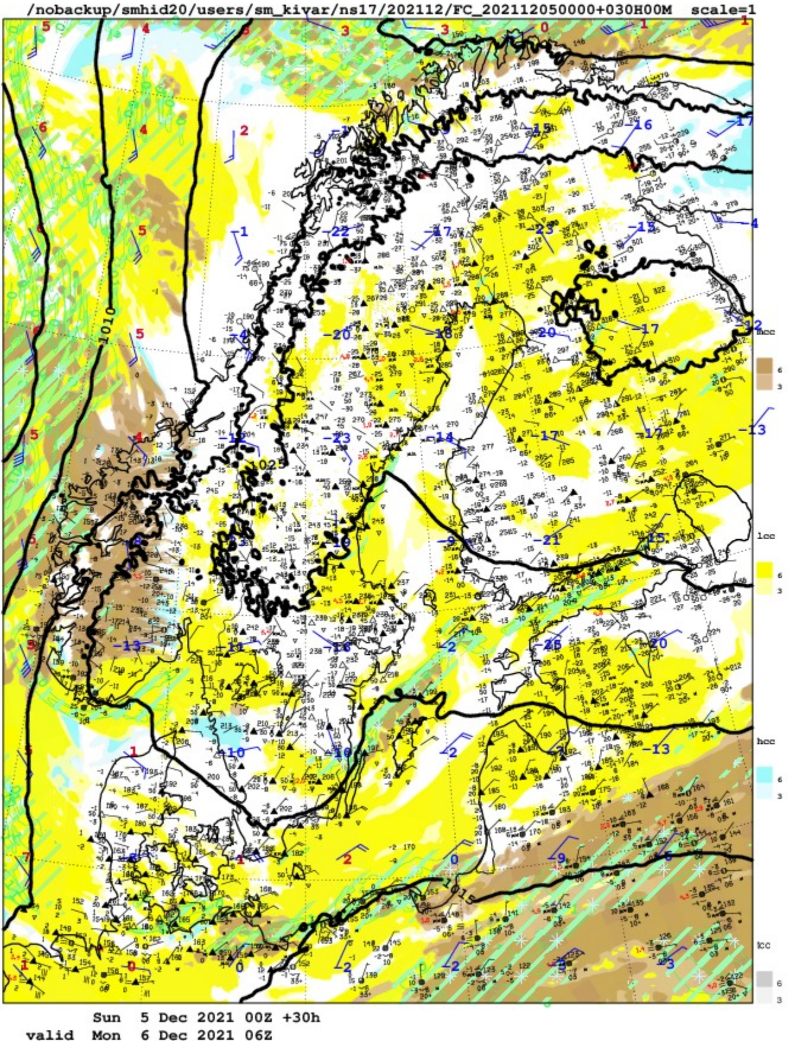
# 6th December 06UTC (18h forecast) NEWSUR-ICET

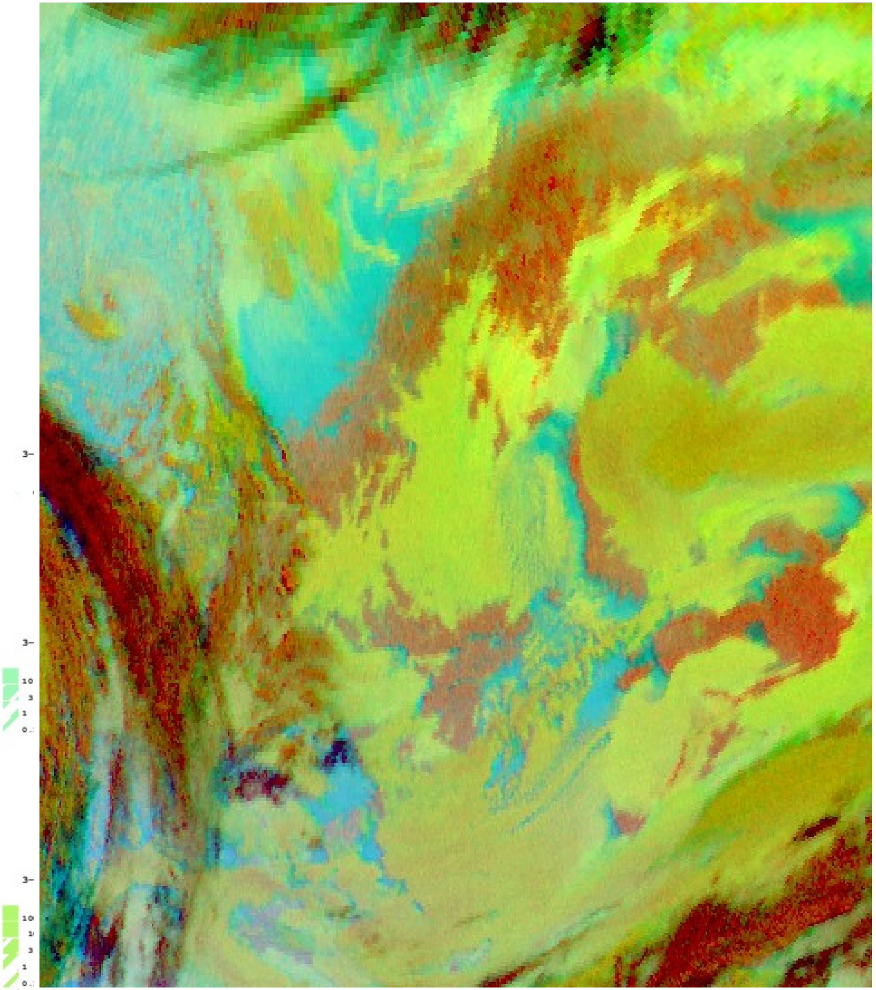


Missing low clouds, but better than without ICET

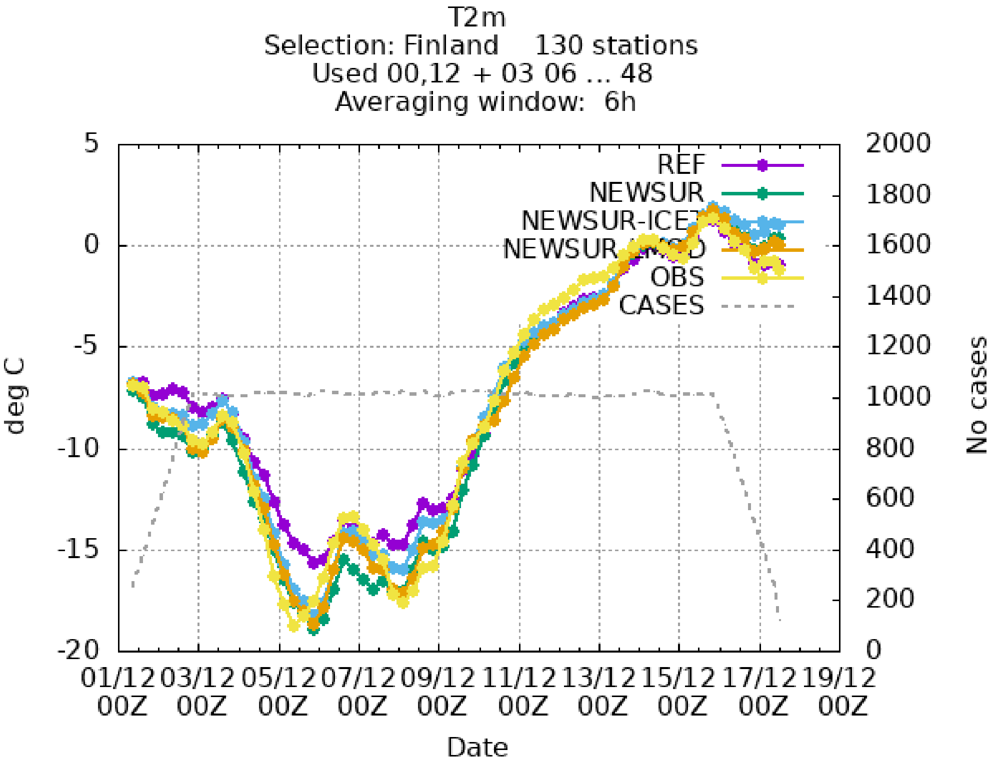
# 6th December 06UTC (18h forecast) NEWSUR-LMOD

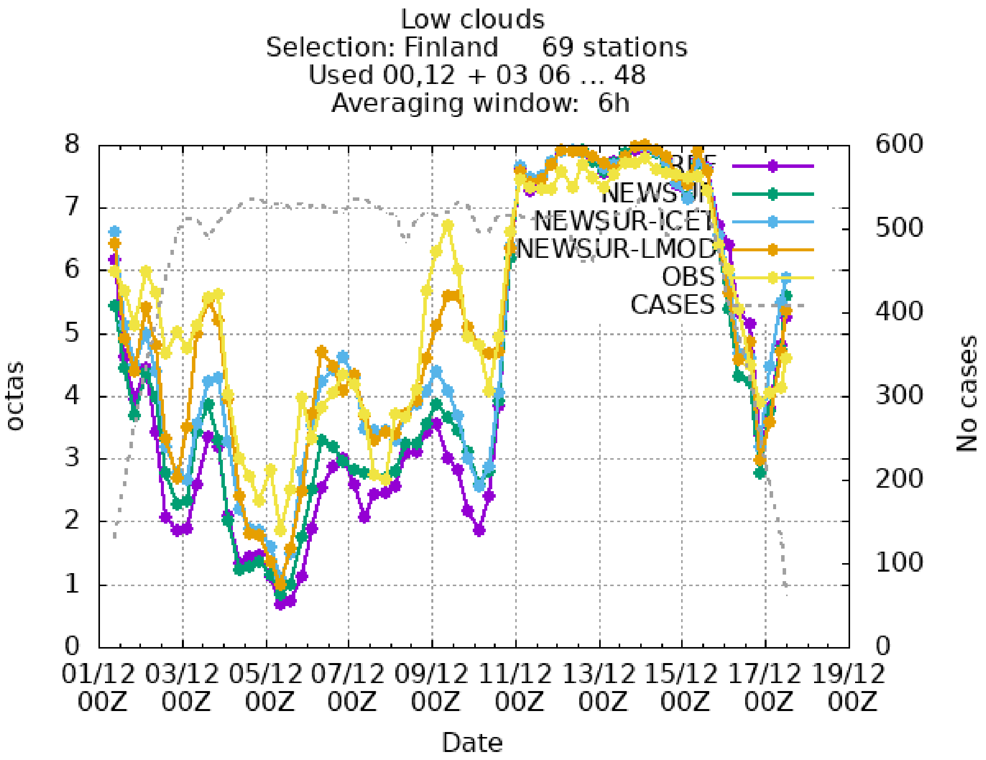


Missing low clouds but better than without MODICEDEP. Some over prediction over northern Finland.

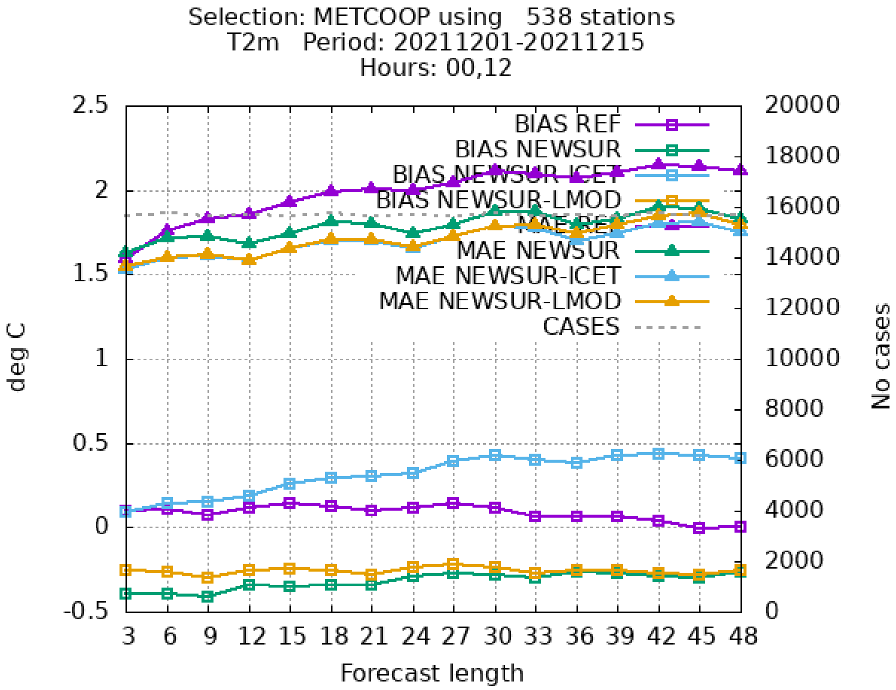
# Evolution of low clouds and temperature, Finland

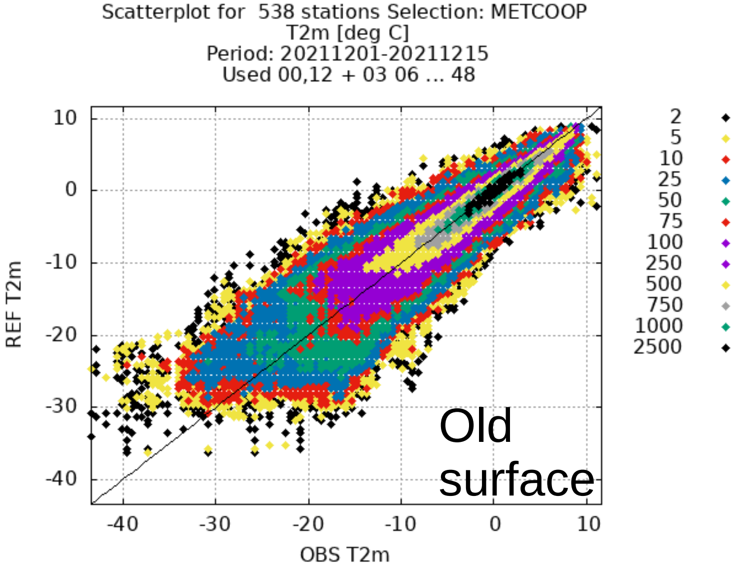


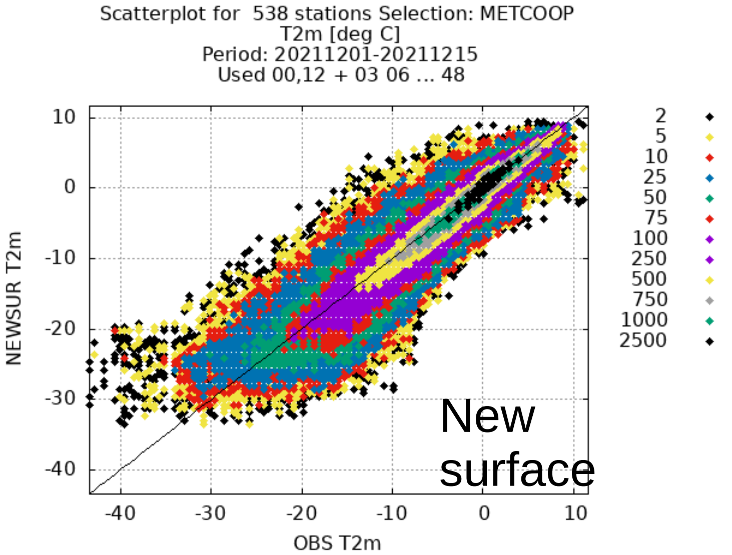




Better agreement with new surface, with observed T2m, especially faster cooling, but still some tendency of changing too slowly. Too strong heat transport trough snow layer? Something XRIMAX related? Better fit with observed low clouds with ICET and MODICEDEP

# T2m temperature.

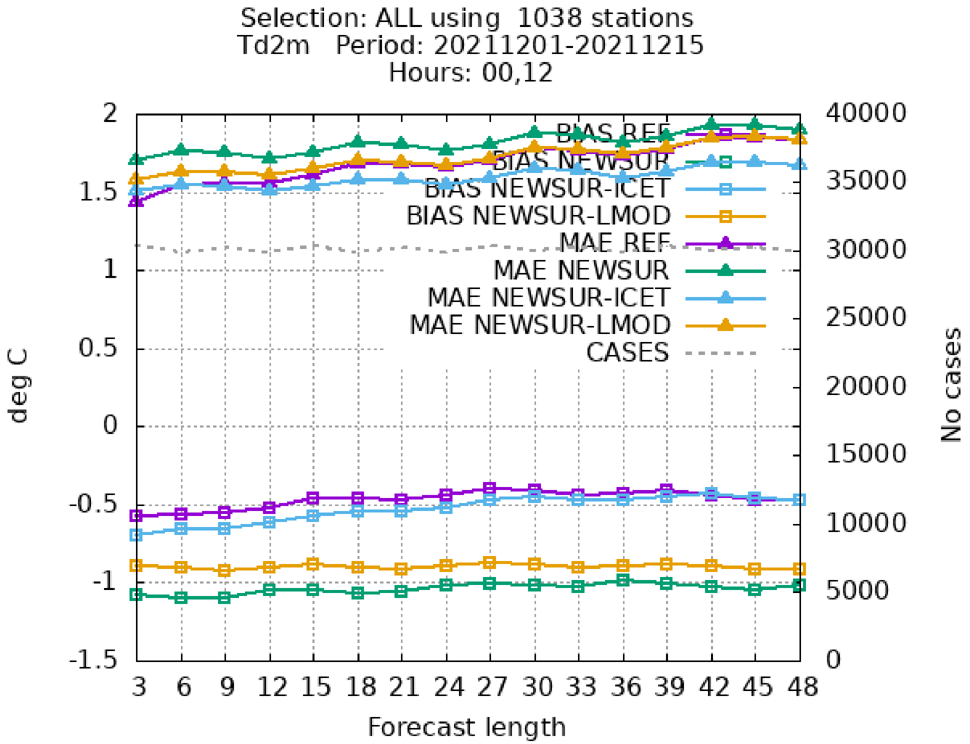


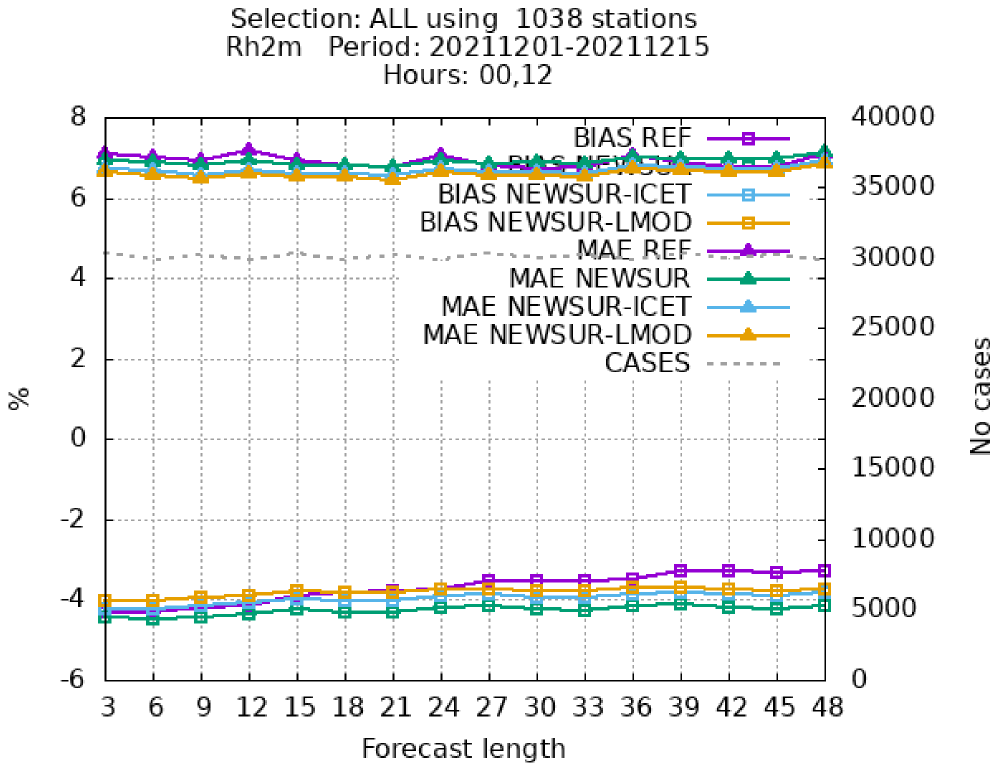



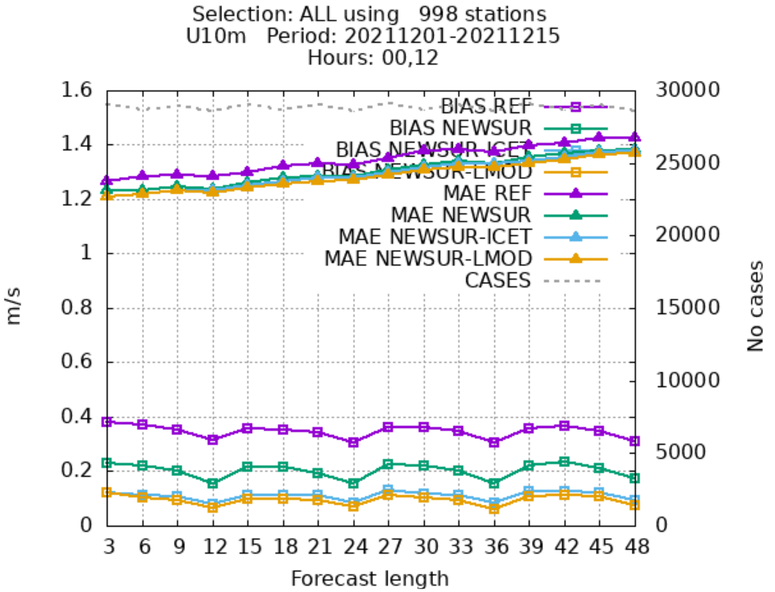

Better T2m forecast with new surface, especially combined with ICET or MODICEDEP, (Only stat. sign. for ICET) but still hard catching the lowest temperatures. (Scatter plots for ICET and MODICEDEP not shown since they are similar to that of new surface only.)

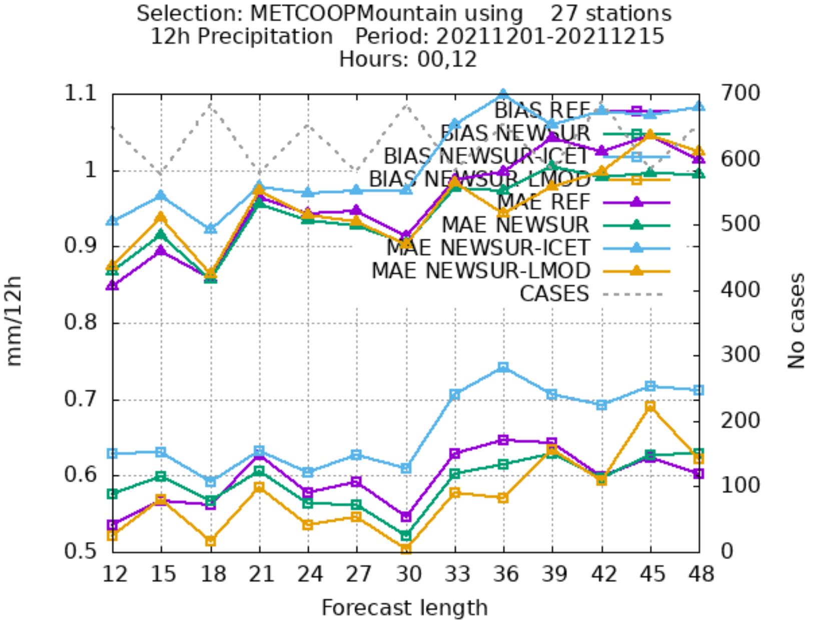
# 2m - dew point and relative humidity

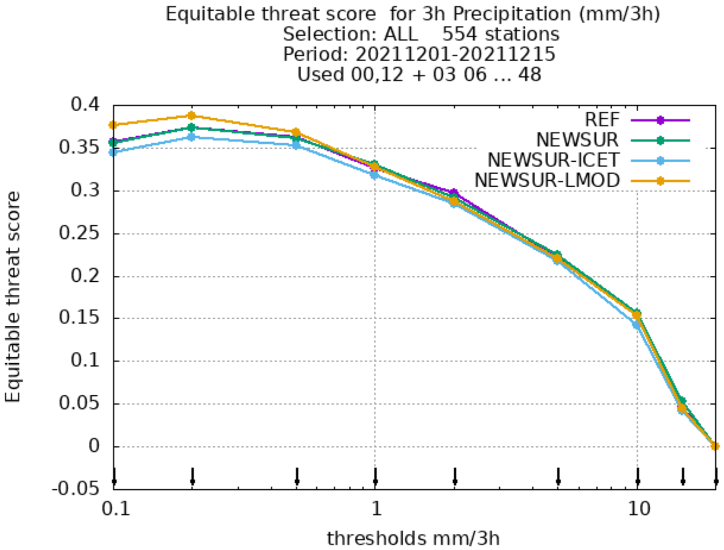


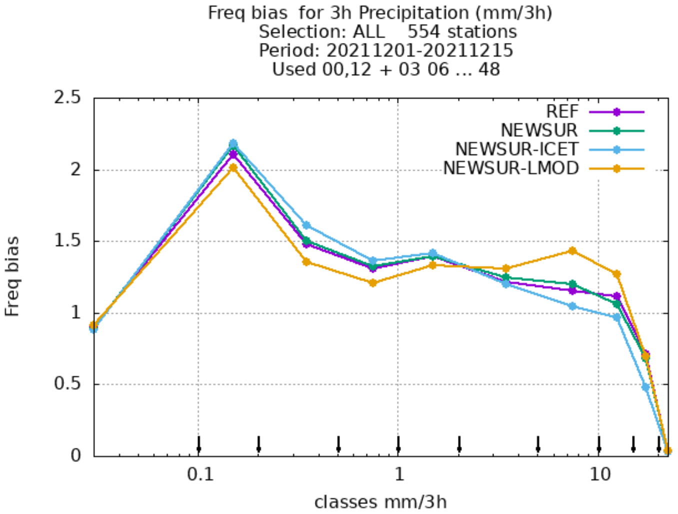




Lower dew point with new surface but this counteracts with ICET, probably due to warmer surface conditions (differences in absolute errors not statistical significant)
RH2m quite similar



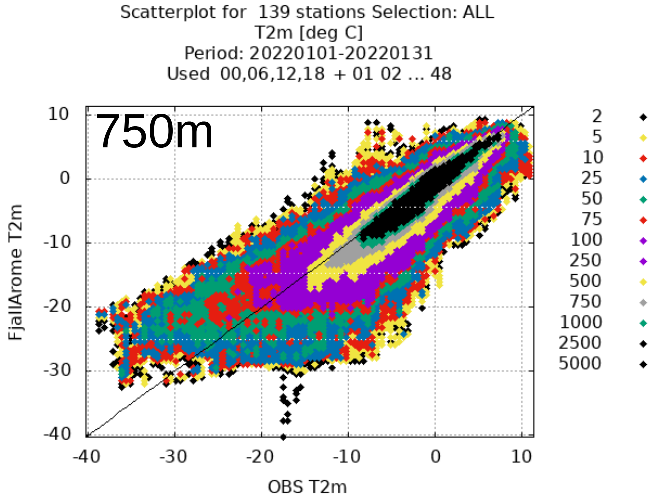

**10 m wind speed:** Less bias and stat. sign. better with all three with new surface.

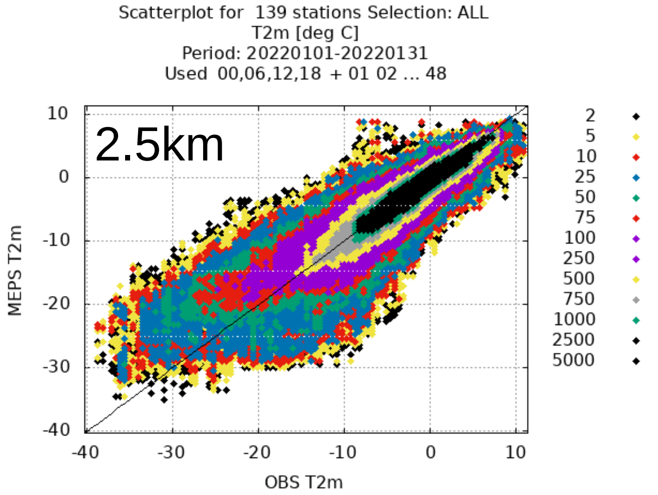
**12h precipitation:** ETS and frequency bias quite similar for all runs.

**12h precipitation over mountains:** All have some over- forecasting. Smallest systematic error with MODICEDEP.

# Summary and remarks

- Tuning of visibility improves a bit.
- New surface routines improves MSLP, T2m and 10m wind speed and to some extent low clouds. In other respects neutral or mixed result.
- New surface with ICET or MODICEDEP further improves low clouds in cold winter situations. This also improves T2m temperature and to some extent 10m wind speed.
- A drawback with MODICEDEP is some positive MSLP bias and with ICET an over prediction of precipitation over mountains. (Testing combination of the two is ongoing, but so far without progress)
- Still hard to catch the lowest winter temperatures. Going from 2.5km grid to 750m seems not to help much either, see right plot for Scandinavian mountain range. Notice! Both graphs are cy43 and old surface.



# *Extra slides follows ….*

# The most important differences between LMODICDEP T/F in this test:

## TRUE: LMODICEDEP

$$c_{vdo} = (4N_i/\rho_i)\frac{(U_i - 1)}{(A_2 + B_2)}(f_0 M_1 + \cancel{f_2 c_i^2 M_2})$$

Original formulation for ice deposition (OCND2=F), this term gives too fast deposition/evaporation, especially just below freezing, removed with LMODICEDEP

Conversion ice → snow based on size distribution

Size distribution for snow: C = 8E6, x=-1 (set by RFRMIN(16:17) )

Reduction of deposition/evaporation speed for snow and graupel: Factor 0.75 and 1 respectively (set by RFRMIN(39:40)

## FALSE: (PRESENT OCND2)

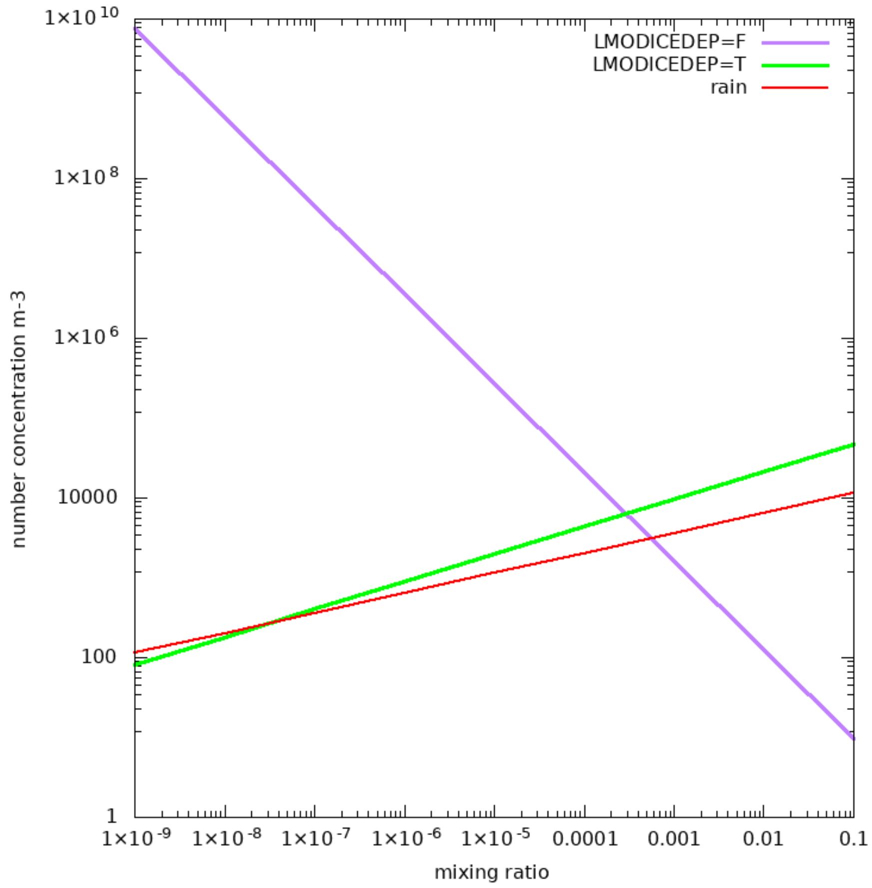
$$c_{vd} = (48\pi^2/\rho_i)^{\frac{1}{3}}\frac{(N_i/\rho)^{\frac{2}{3}}(U_i - 1)}{(A_2 + B_2)}S(T, U_i)$$

Conversion ice → snow based on mean size.

Size distribution for snow: C = 5, x=1

Reduction of deposition/evaporation speed for snow and graupel: Factor 0.15 and 0.25 respectively

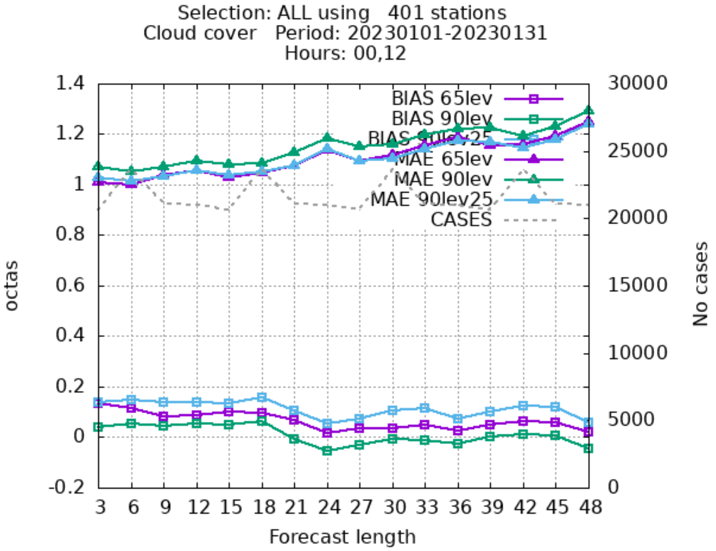
The different size distributions for snow in this test (and comparison with rain, with the same C and x) :

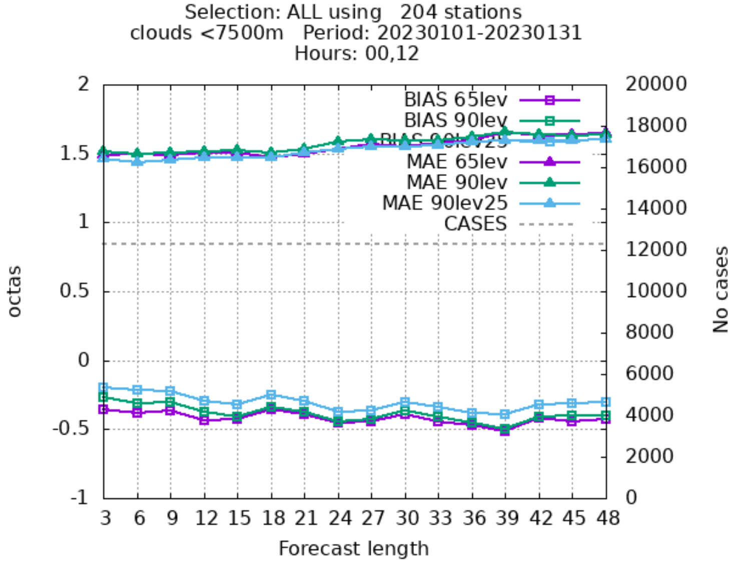


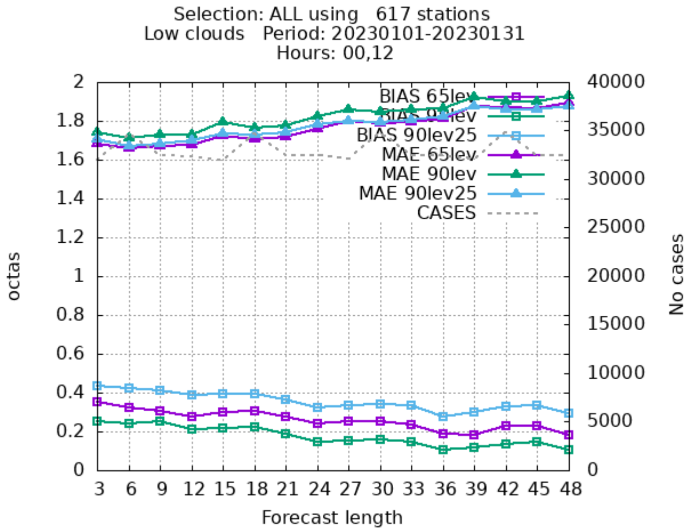
# A 90-level test:

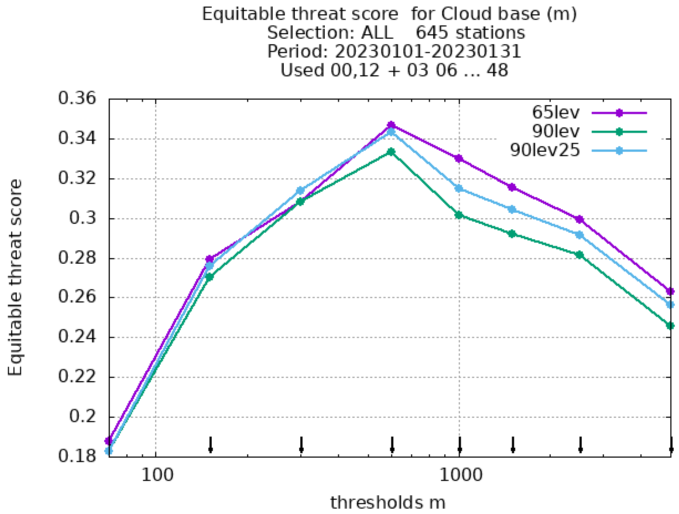
- Let it be easier to get condensation for thinner model levels.
- The limit for VSIGQSAT to increase with increasing model level thickness is changed from 30m thickness to 25m thickness (RFRMIN(25) =25)

# Cloud parameters




Total clouds and clouds up to 7.5 km for 90 level test significant worse than the 65 level test, but not so for the 90lev-25 test.

Both 90lev tests sign worse regarding low clouds.

BUT, rms error perhaps not the best measure, since it favors forecasts near 4 octas

ETS quite similar for the most important low thresholds.

# Testing 90 levels (Oles suggestion) vs present 65 levels

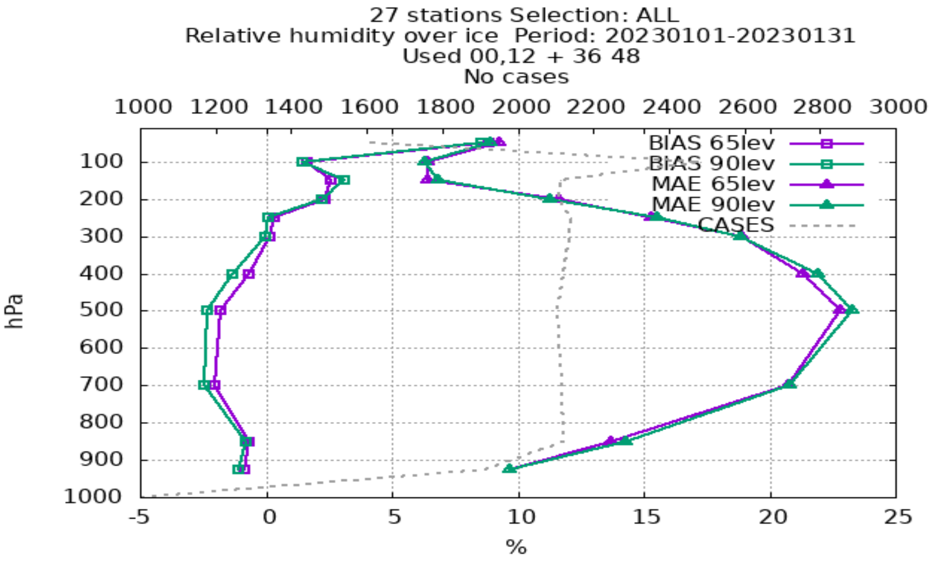
MF-90 levels:  Lowest at 5m. Good for describing details of the lowest boundary level, but currently MetCoOp cannot afford the short time step needed.

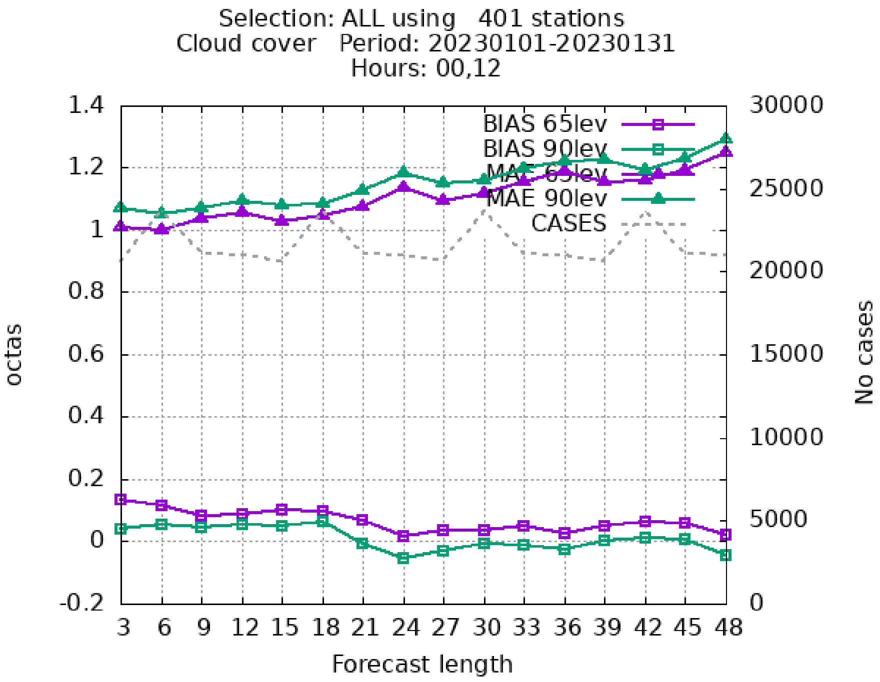
Oles-90 levels:  Lowest at 10m. Still better than existing 65 levels with lowest at 12m, and no reduction of time-step needed. More levels for middle troposphere gives better description there.

# Results (January 2023, MetCoOp domain)

- Mainly neutral
- Marginally reduction of 10m wind speed bias and also of T2m bias → better, but not statistical significant.
- Marginally better precipitation forecasts (ETS)
- A little worse cloudiness parameters (total clouds, low clouds , cloud base, statistical significant)

# The somewhat worse cloud forecasts seems to be related to lower relative humidity in the troposphere.




A little drier with 90 levels. Seems to related to a little lower specific humidity combined with a little warmer at some levels. (Increased RH-error not stat significant.)