MetCoOp FINNISH METEOROLOGICAL INSTITUTE EMHI SMHI Meteorologisk institutt

Progress in turbulence, shallow convection and cloud microphysics in MetCoOp

ASM meeting April 1-4, 2019 Madrid, Karl-Ivar Ivarsson , SMHI

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Outline :

- Update of turbulence and shallow convection (HARATU and EDMF scheme)
- Update of fluxes over sea (ECUME6)
- Model levels thickness dependent threshold for condensation (VSIGQSAT)
- Other tests/updates

Update of turbulence and shallow convection (HARATU and EDMF scheme)

Thanks to Wim de Rooy – Netherlands

One issue with current forecasts: Often too moist near the surface and missing low- and medium level clouds (under forecasting)

The tests on next slides are with cy40h.1.1.1 and three periods:

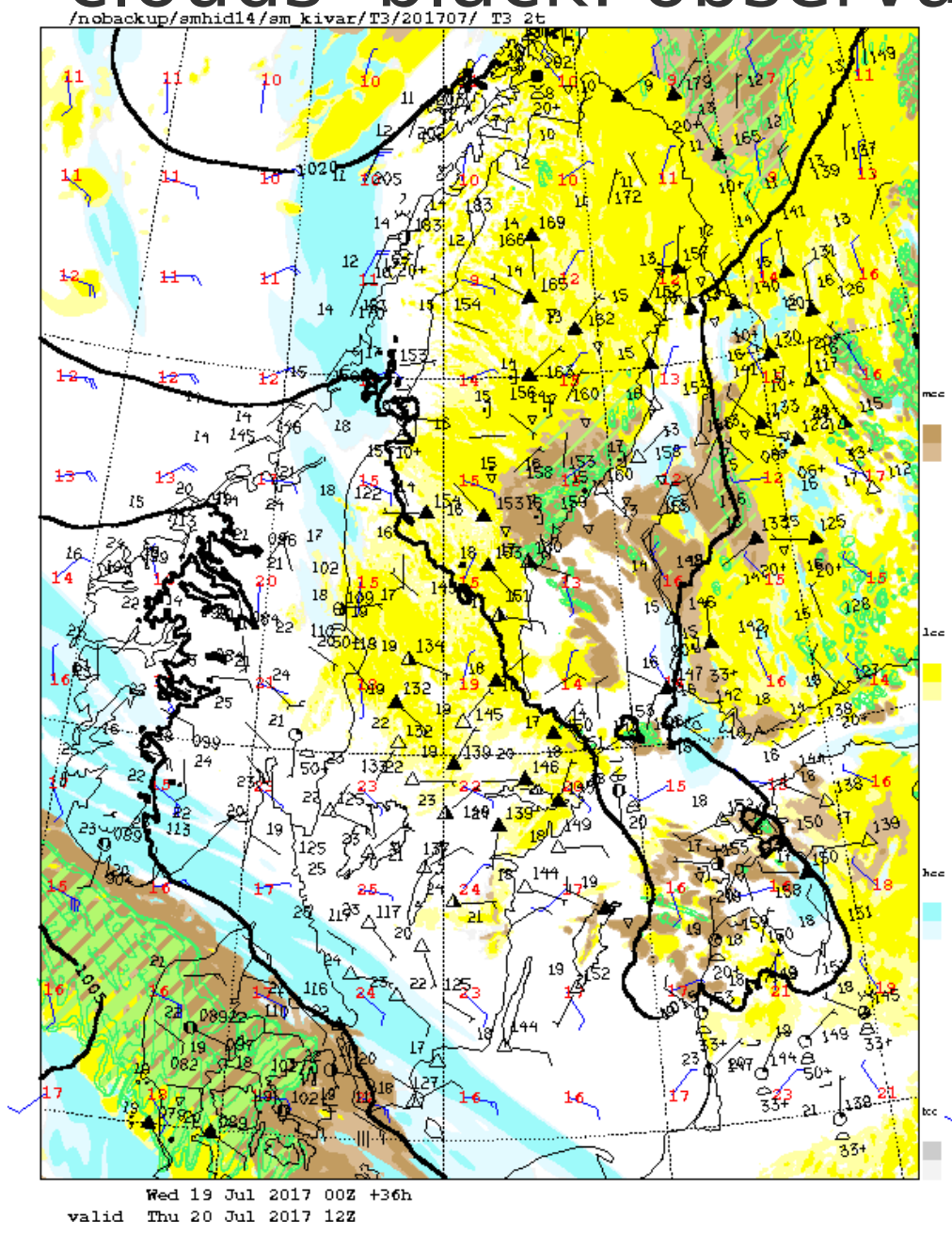
July 2017, September 2017 and February 2018.

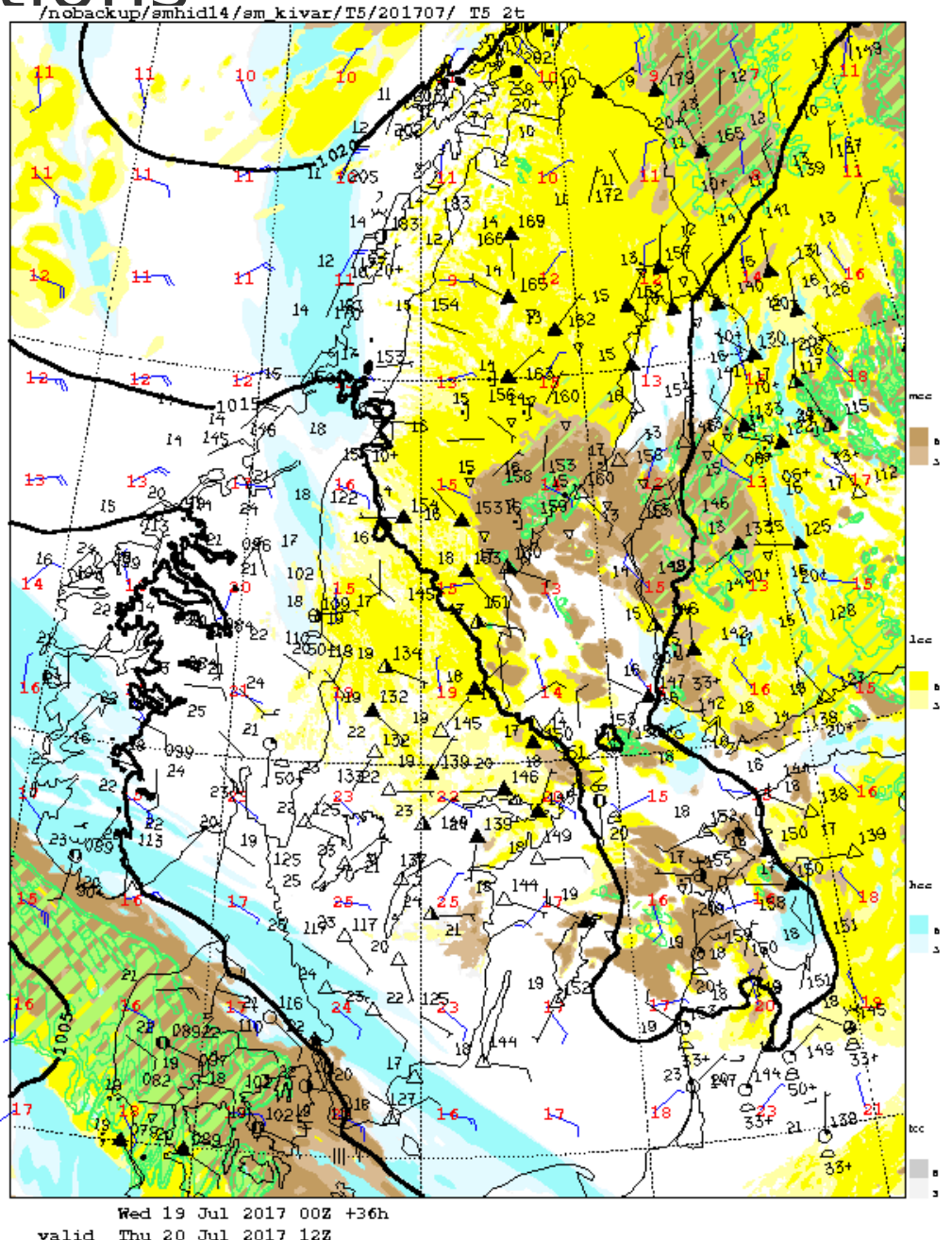
The current MetCoOp domain is used.

The maximum forecast length is 36 hours. Red= REF, green = modified.

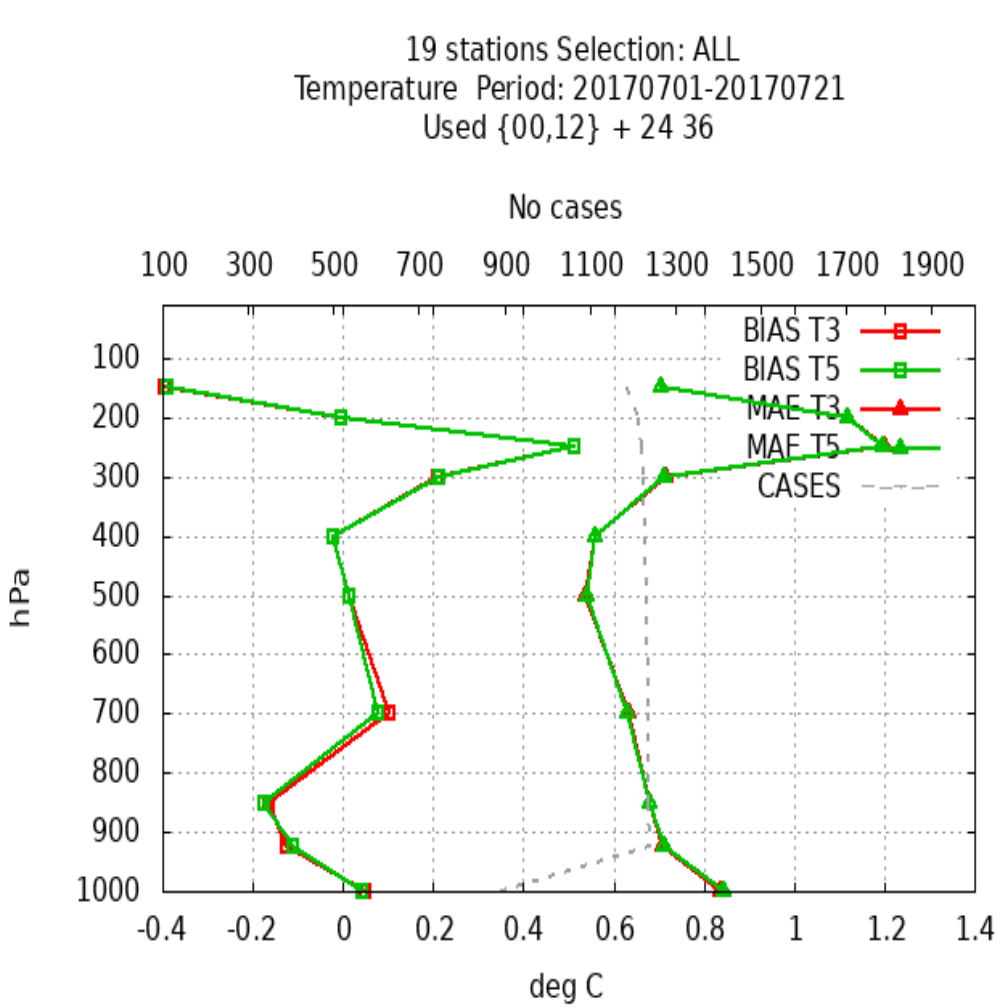
Since small differences dominate (neutral impact) only the differences large enough to be of interest, e.g. statistical significant are presented here.

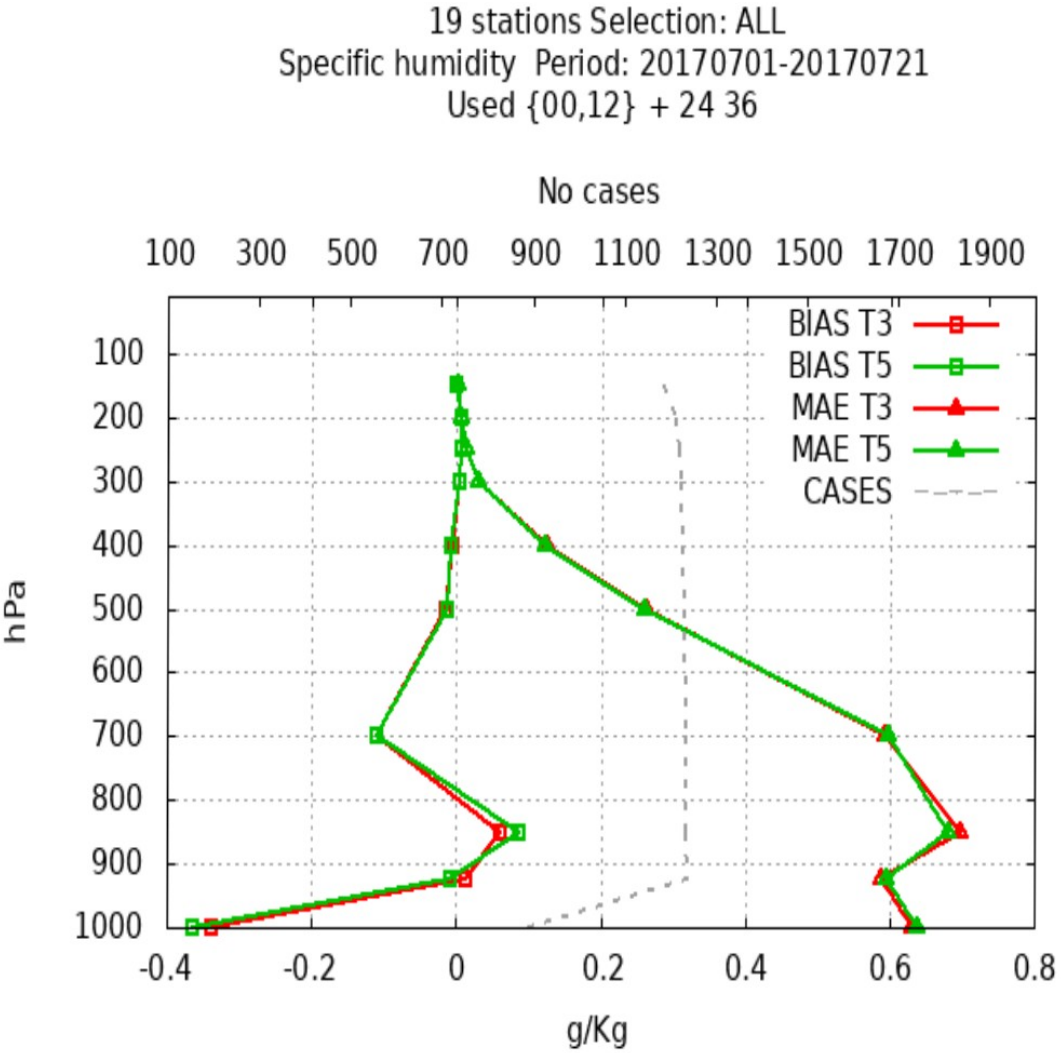
Example: July 20 : Left : Reference. Right: with new EDMF/HARATU. low/medium/high clouds black: observations





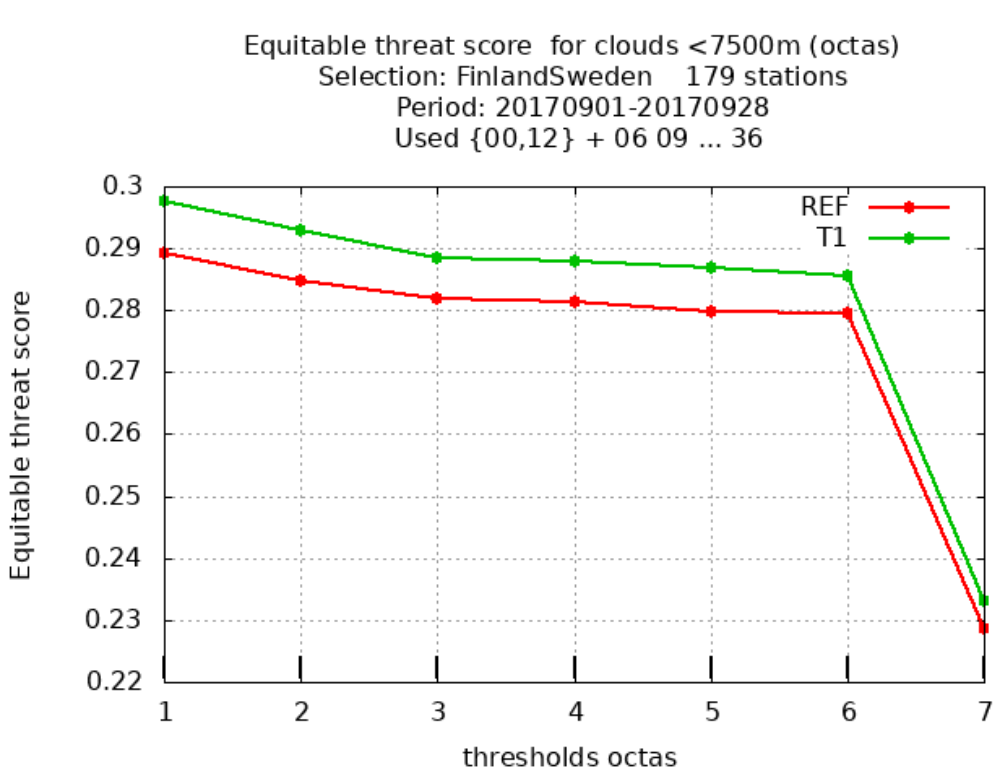
July 2017 (1-22)

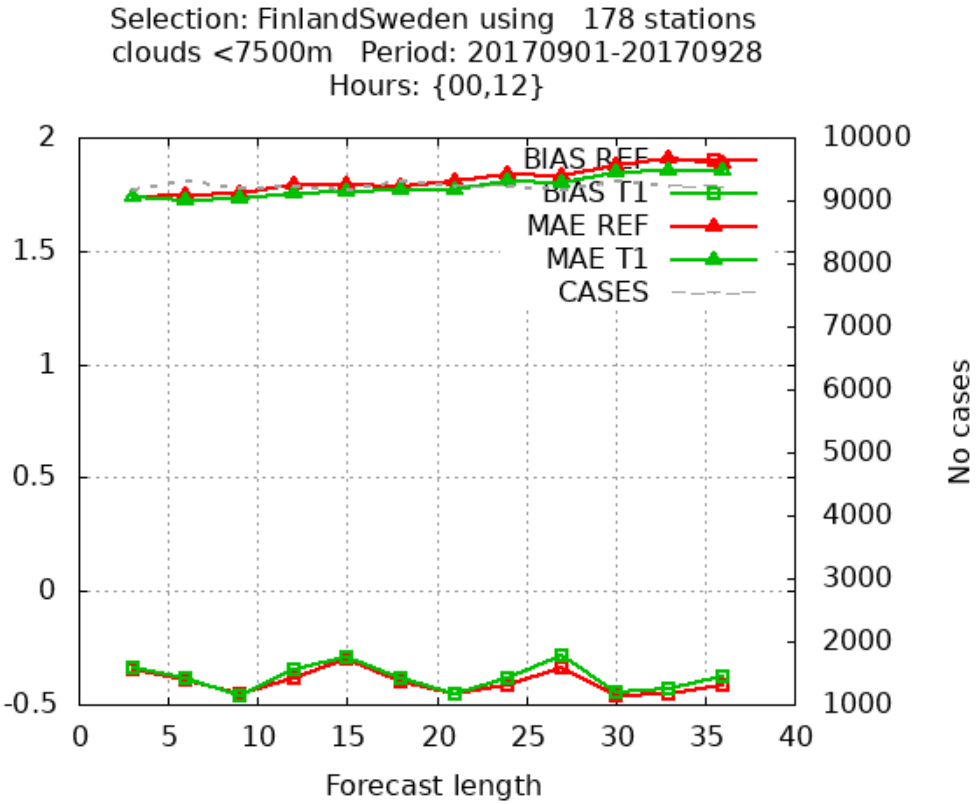




Comment: New version seems to move more heat and moisture upwards in lower troposphere. Total error mainly the same. Similar findings for autumn (September 2017) and winter (February 2018), not shown.

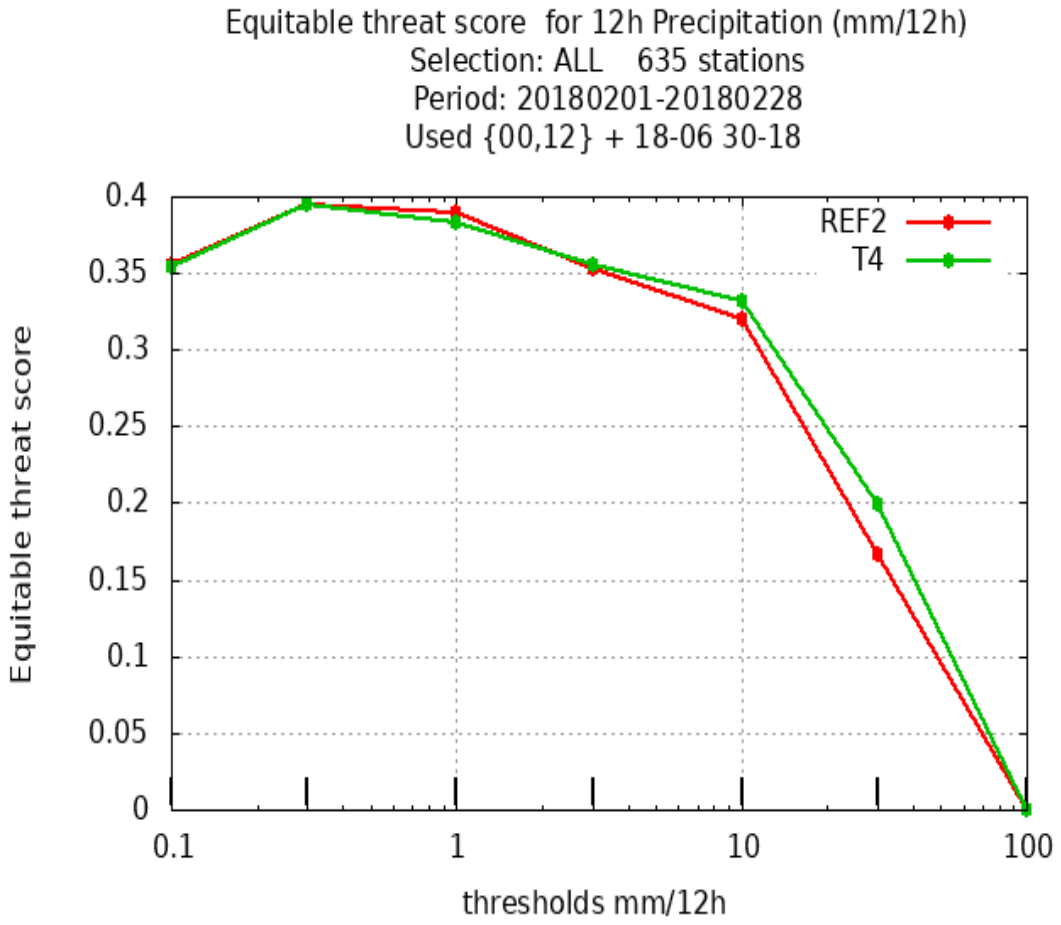
September 2017 (1-28), clouds <7.5 km (as seen by automatic stations) red= REF, green = modified.

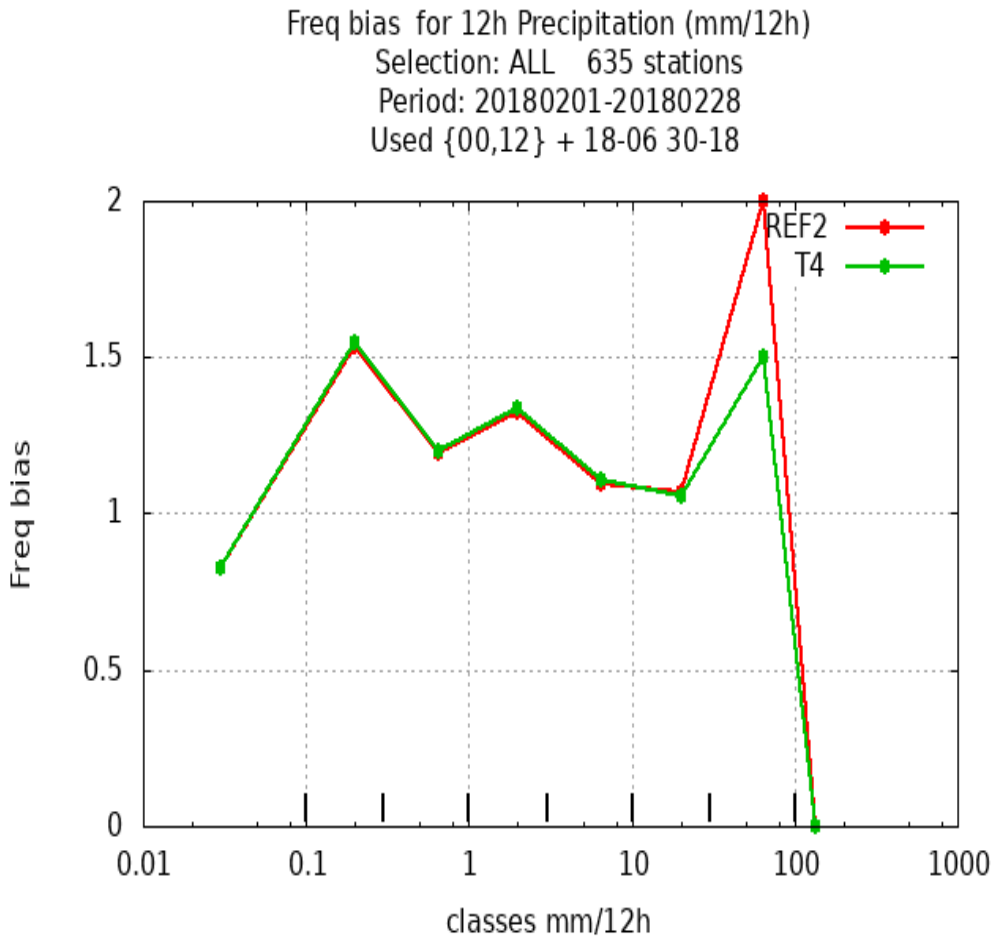




Comment: A small improvement with the modified scheme (ETS)
Verification against automatic stations only.

February 2018, 12h precipitation red= REF, green = modified.

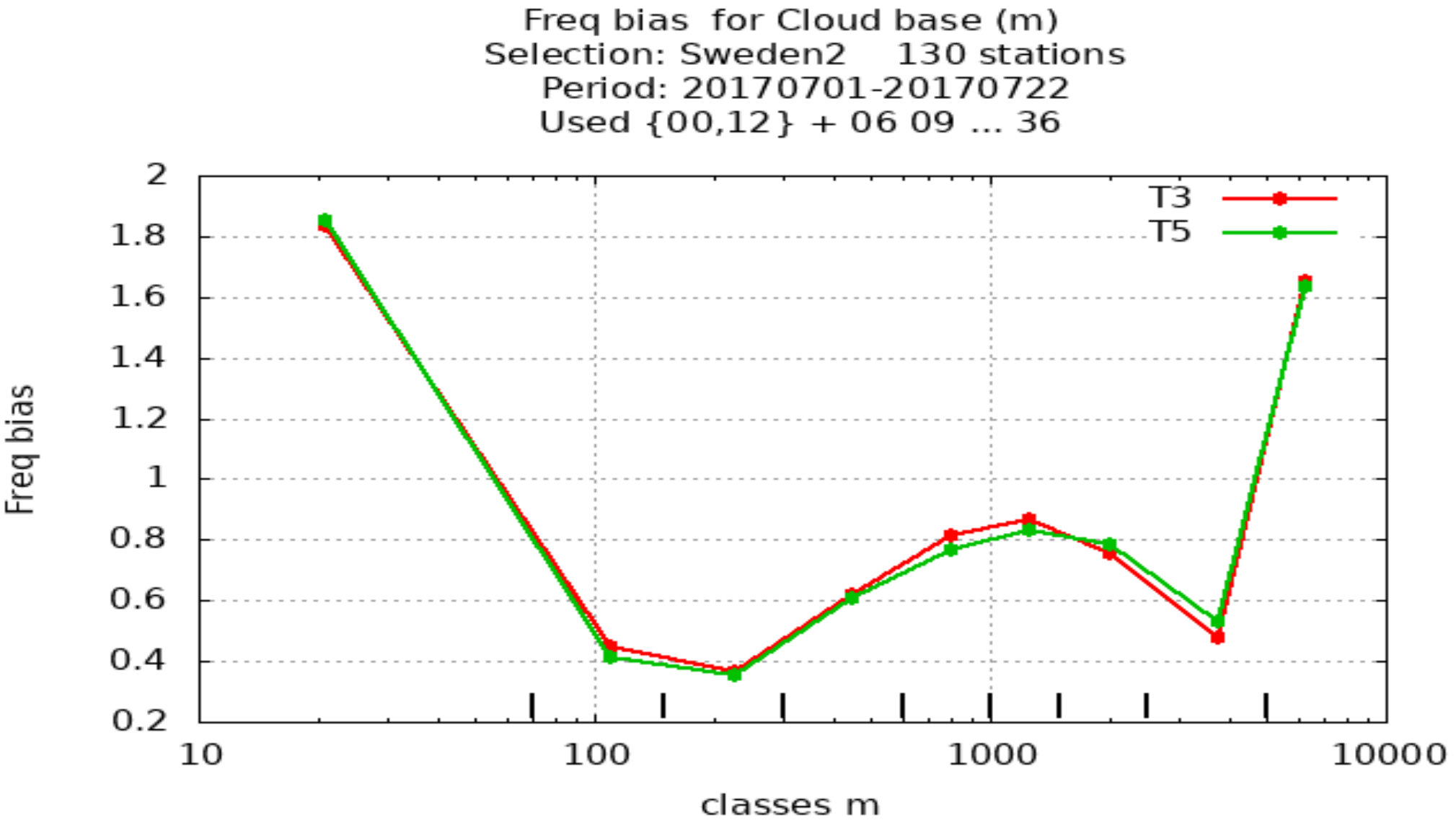




Comment: Neutral result for 3h precipitation in winter, but the 12 hour precipitation is a little better with somewhat higher ETS and the FB is reduced for the higher thresholds, but that might be a coincidence due to few cases.

Does the new version improve cloudbase forecasts ?
Answer: no, neutral impact for all three months, ETS and other skills scores fairly the same and so is the frequency bias

Example from February 2018, red= REF, green = modified.

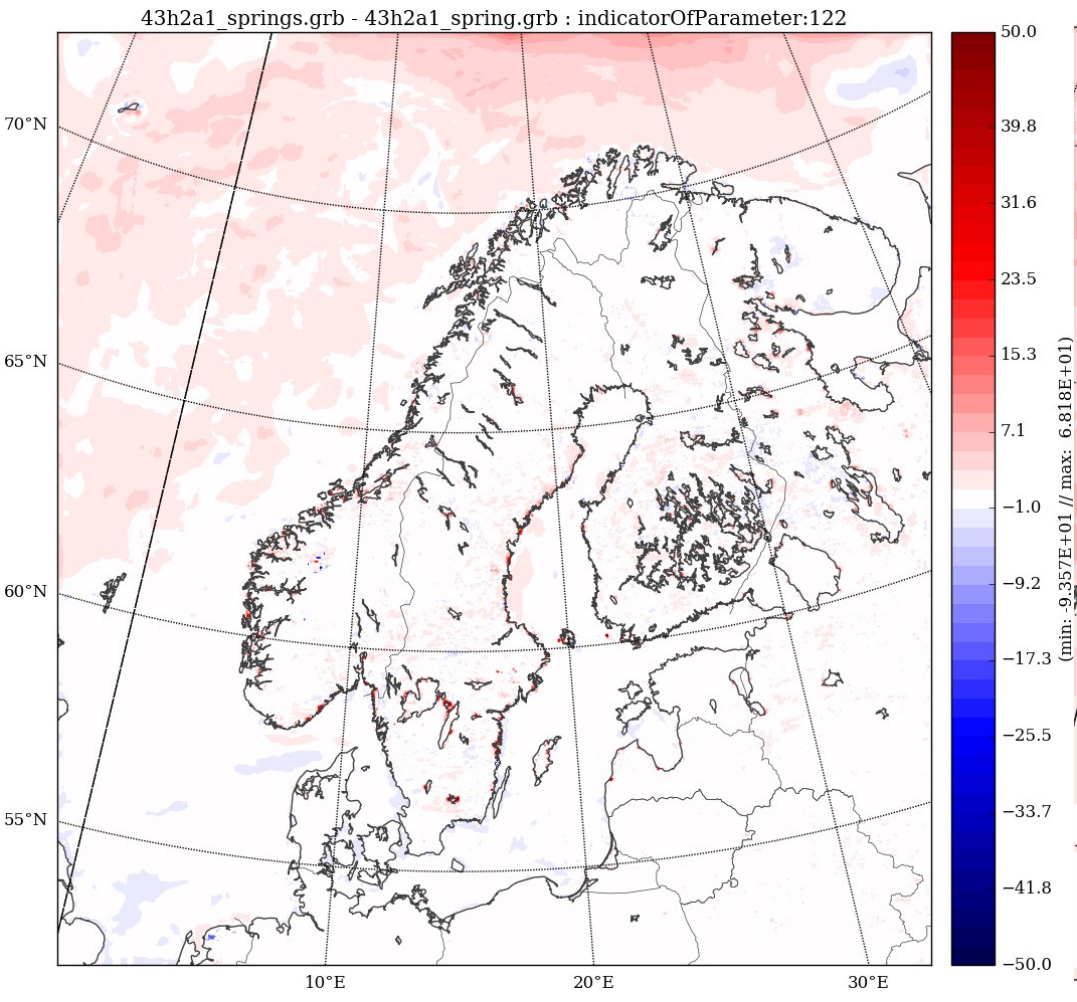


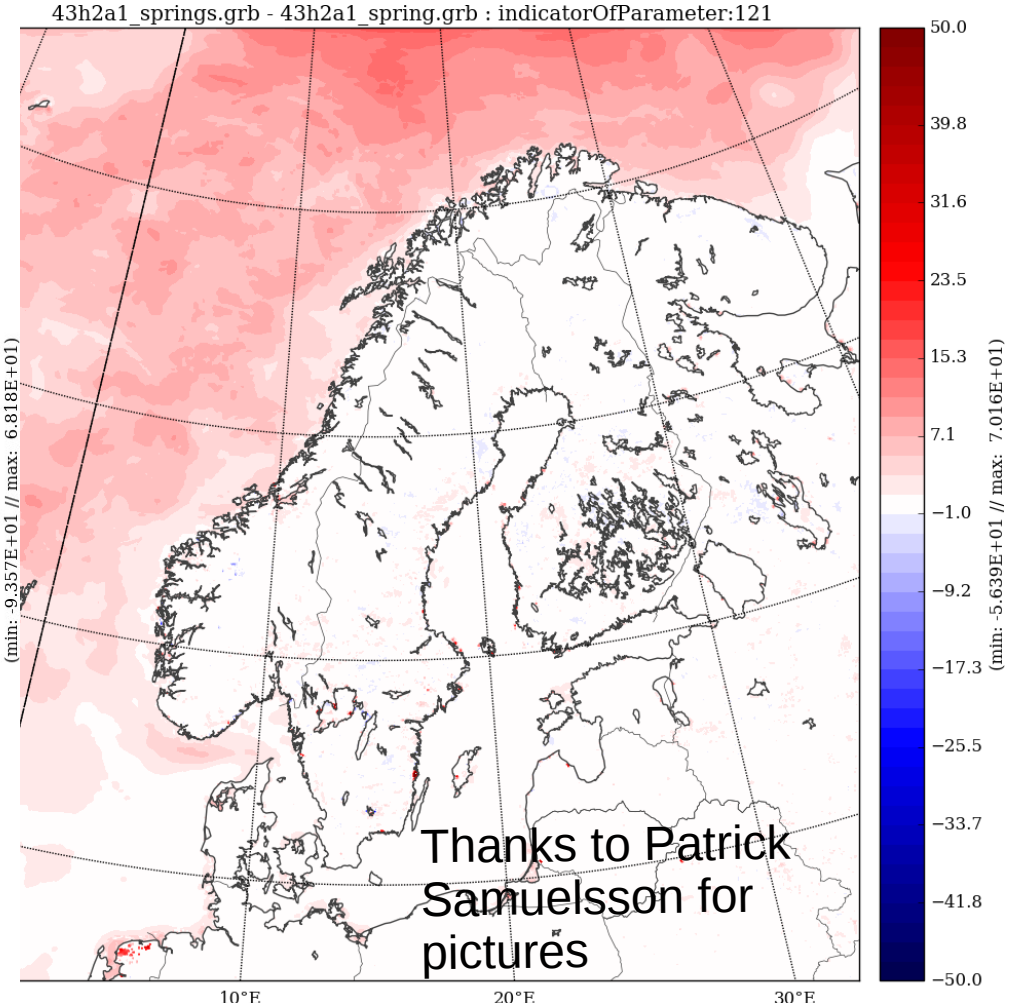
Summary EDMF/HARATU updates

- PBL becomes a little thicker with the modified EDMF
- A little better moisture forecasts for lowest troposphere and a tiny improvement of cloudiness
- In other respects ~ neutral impact

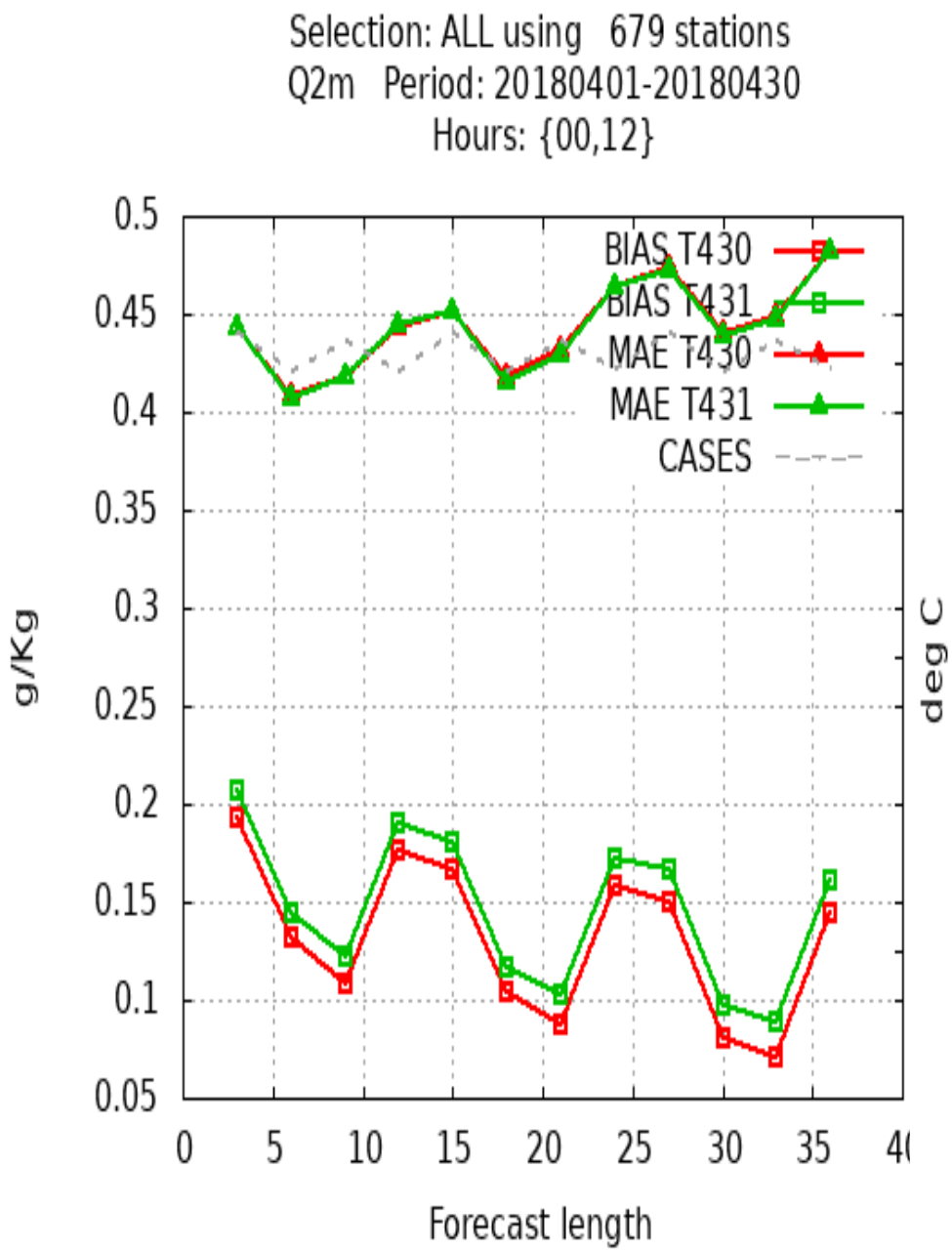
Update of fluxes over sea (ECUME6)

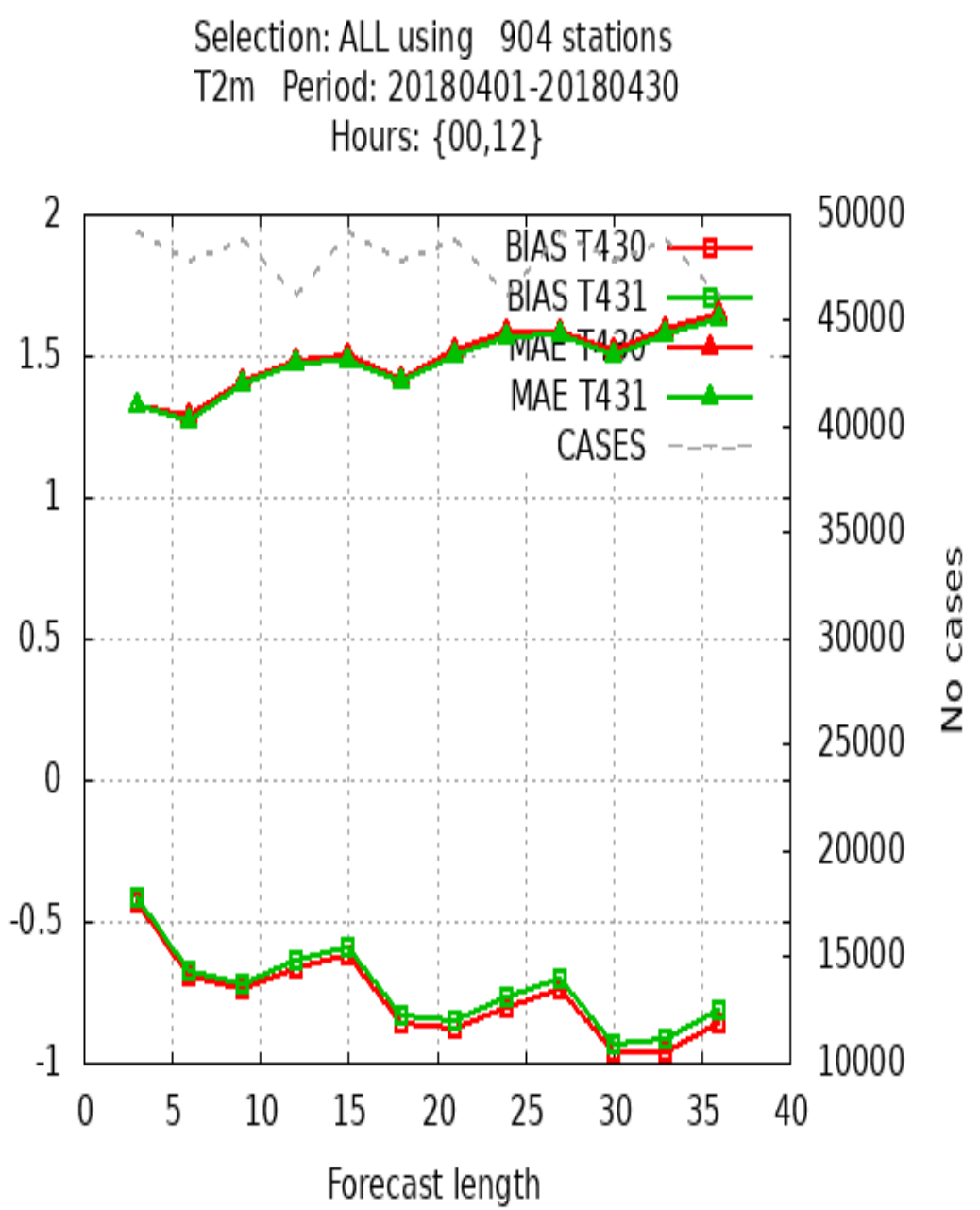
Based on cy43. Test over MetCoOp domain- April 2018
Below left: Difference in sensible heat flux ECUME6-REF (=ECUME)
Below right: Difference in latent heat flux ECUME6-REF. Both are 12 UTC + 06 during April, so it is April mean 12-18 UTC. Larger increase of latent heat flux with ECUME6 than for sensible heat flux.



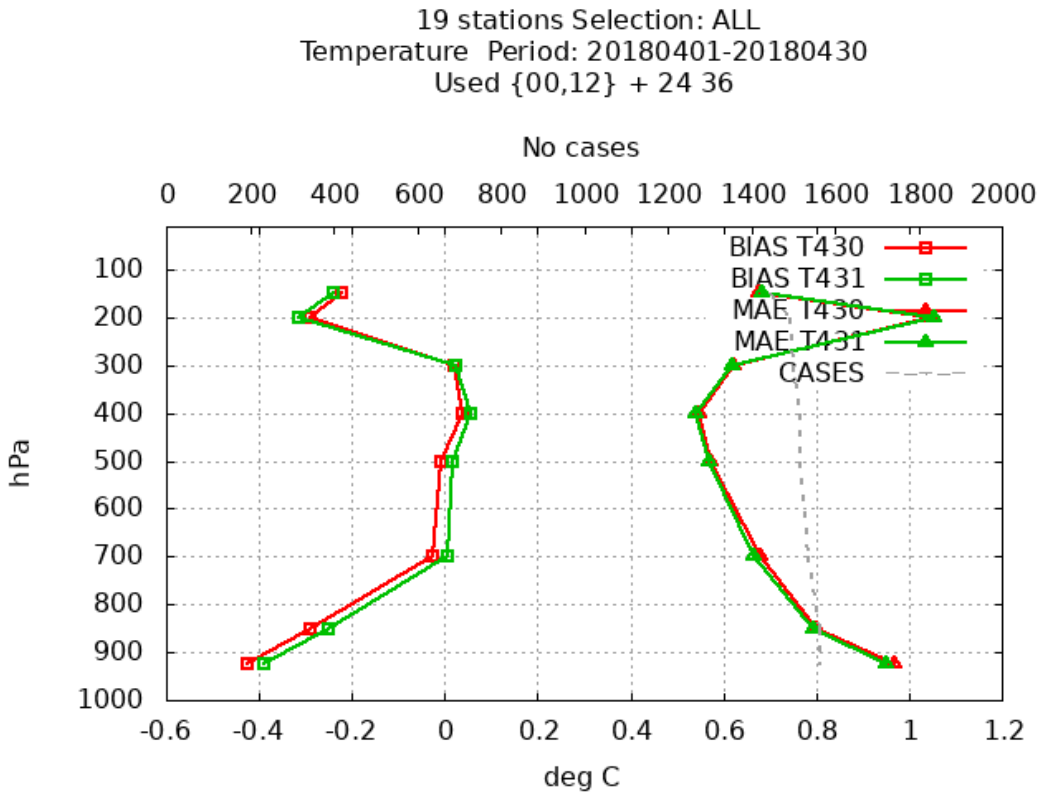


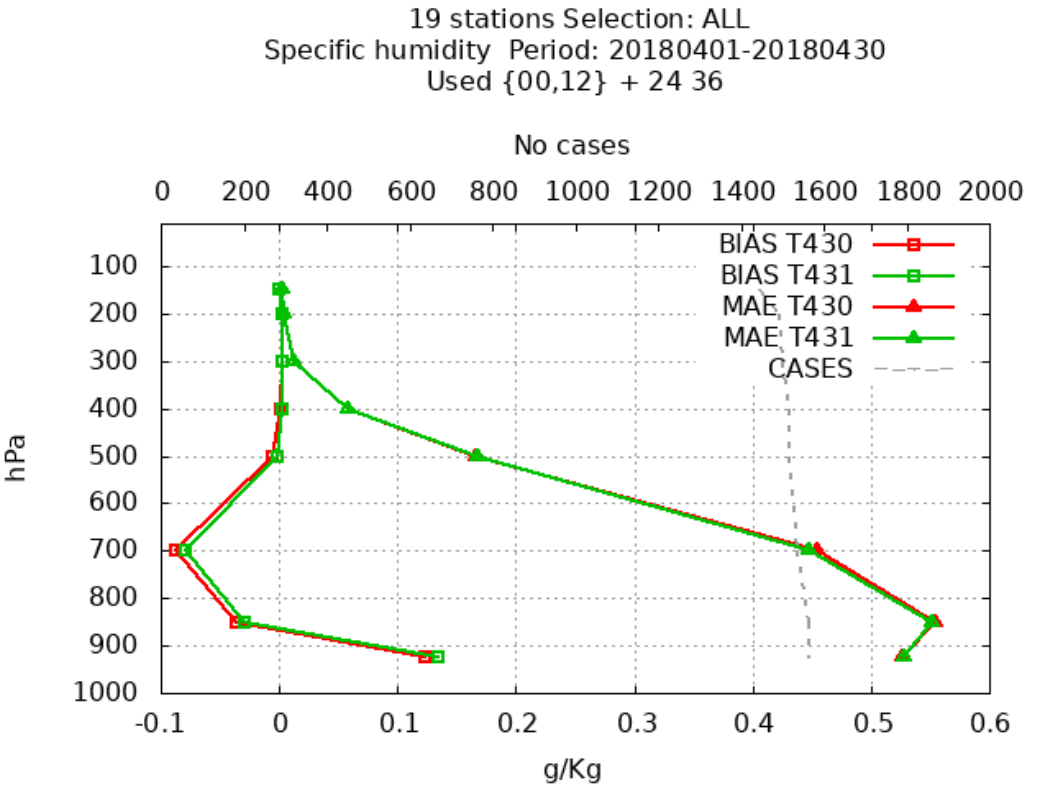
Mainly neutral impact for most parameters, but a little warmer and more moist with EUME6 vs REF.





Little warmer and more moist with EUME6 vs REF also for soundings.





Comment: Spring too moist with ref forecasts, but e.g. winter too dry. Better test another season?

Summary

- A little warmer and more moist with ECUME6, so far mainly neutral impact on scores.
- Need for testing other seasons

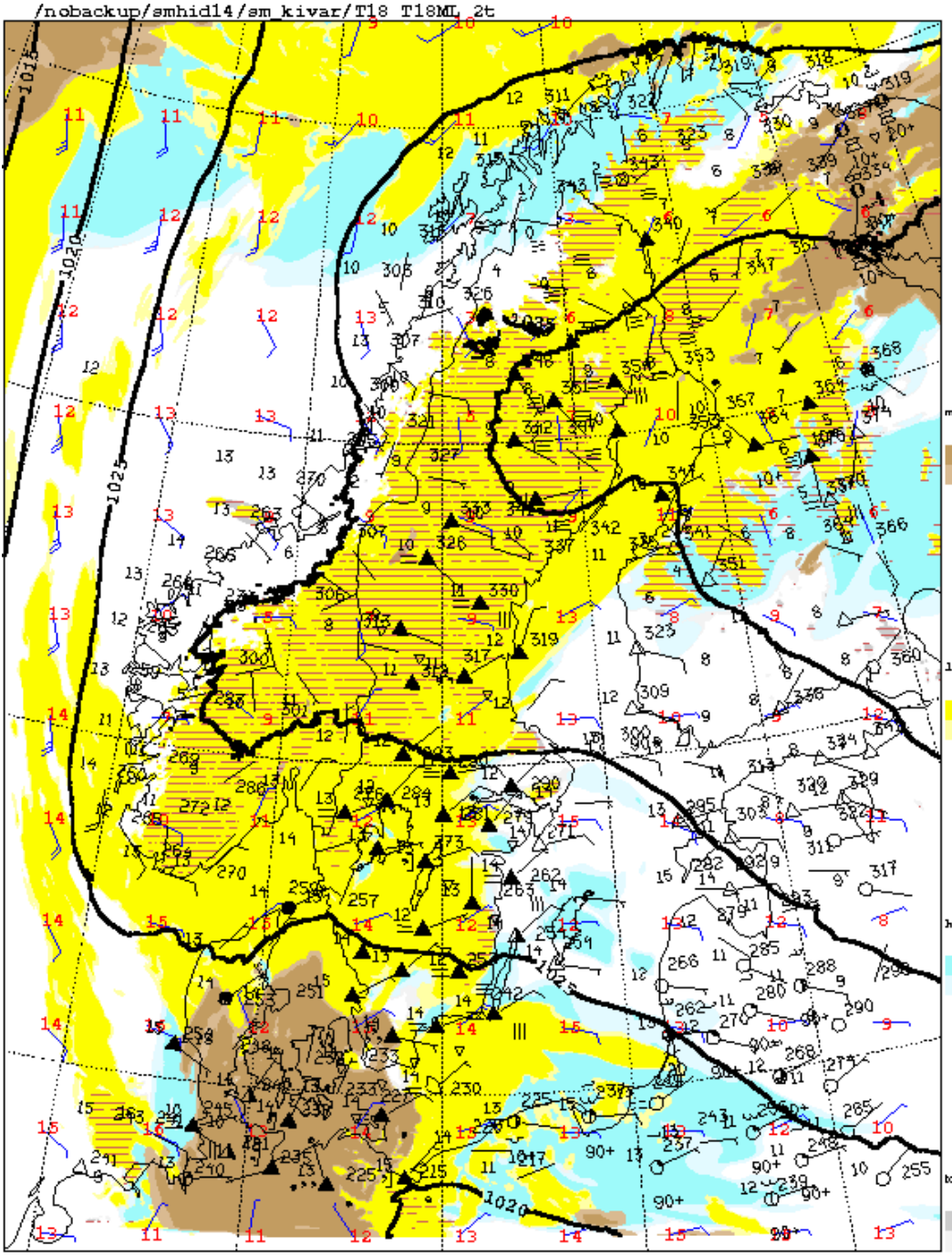
Model levels thickness dependent threshold for condensation (VSIGQSAT)

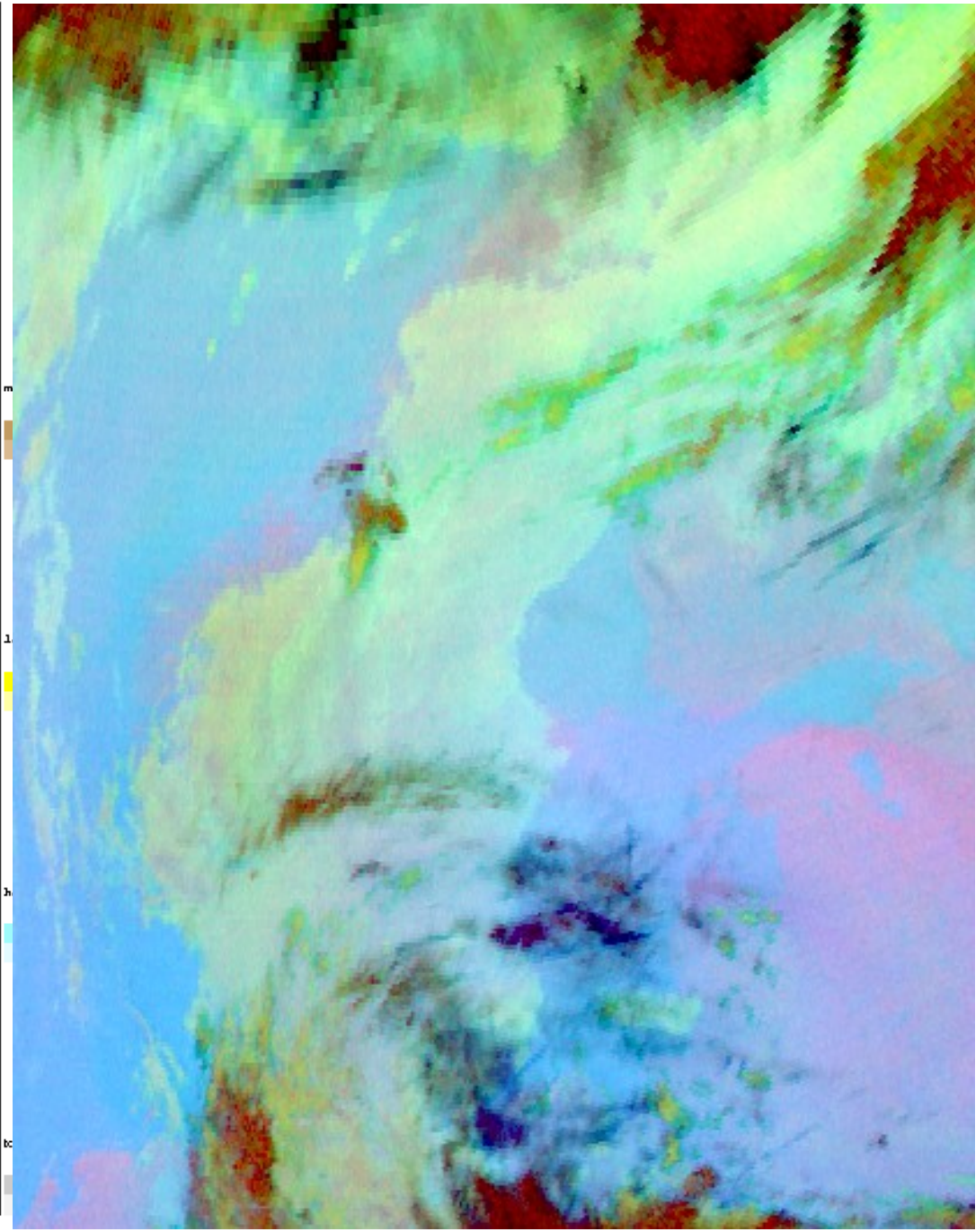
The problem: Often too much fog but too little low- and middle level clouds. (similar reason as testing new EDMF scheme)

One may account for a higher grid box variability of relative humidity for a thick model level than for a thin layer.

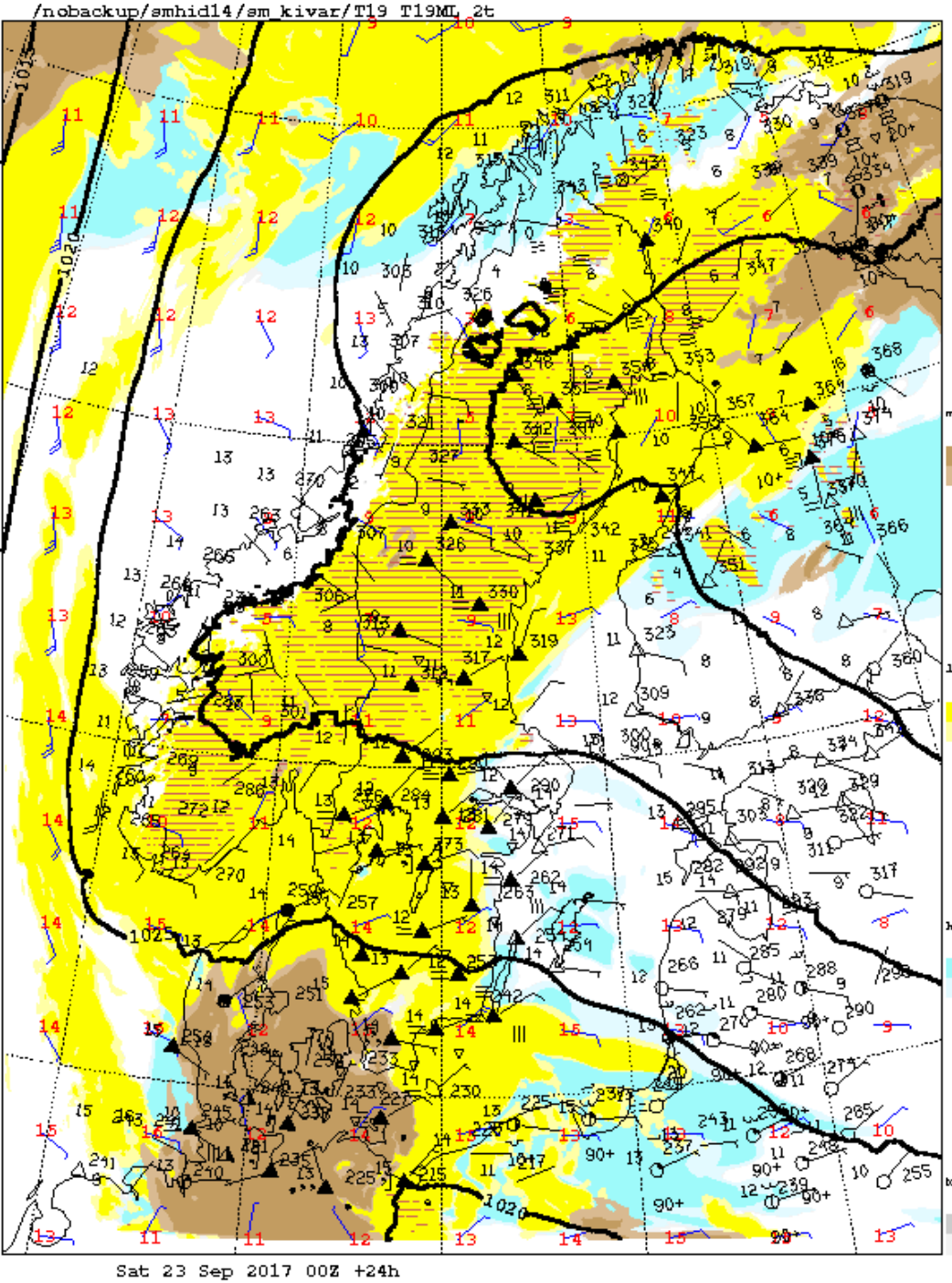
The test: Let VSIGQSAT be valid for a fixed level thickness only (here: 30m) For other level thicknesses (DZ) use VSIGQSAT* DZ/30 , but limit it to the range of DZ/30 to [0.5:1.5]. With current 65 levels setup and VSIGQSAT=0.03 this leads to VSIGQSAT ~ 0.015 at lowest level, unchanged around 200m and 0.045 above 400 m.

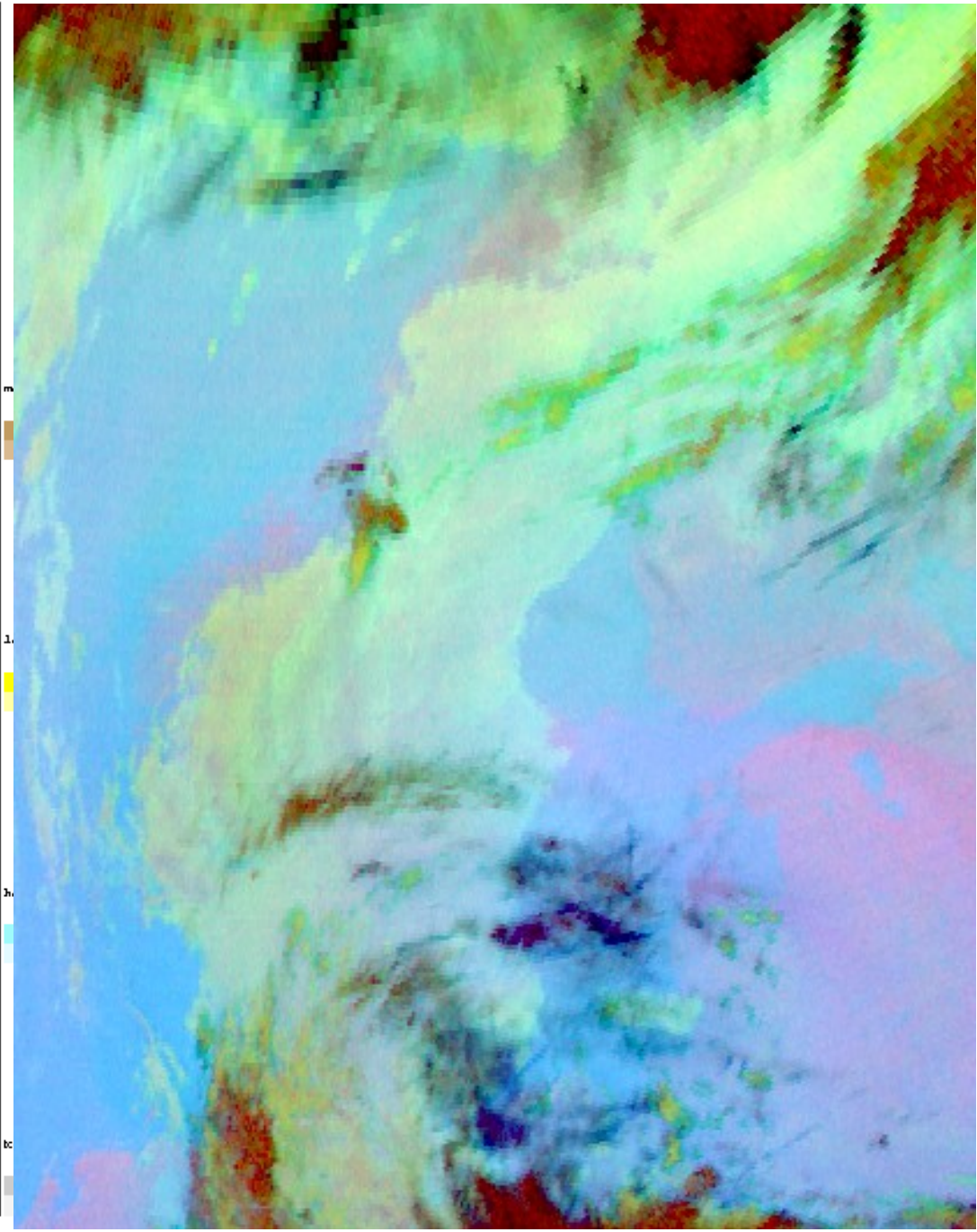
Test 2017-09-23-00 +24 h (ref) low/medium/high clouds Fog: = =



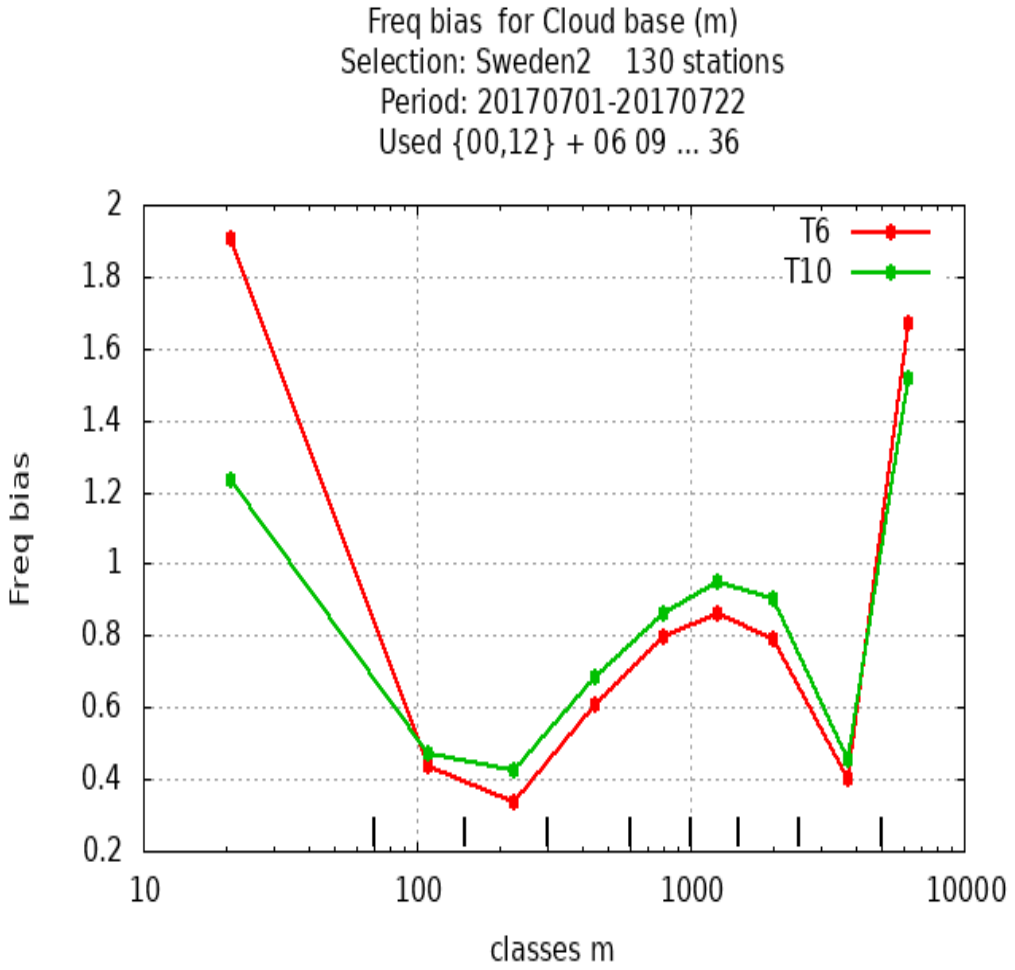


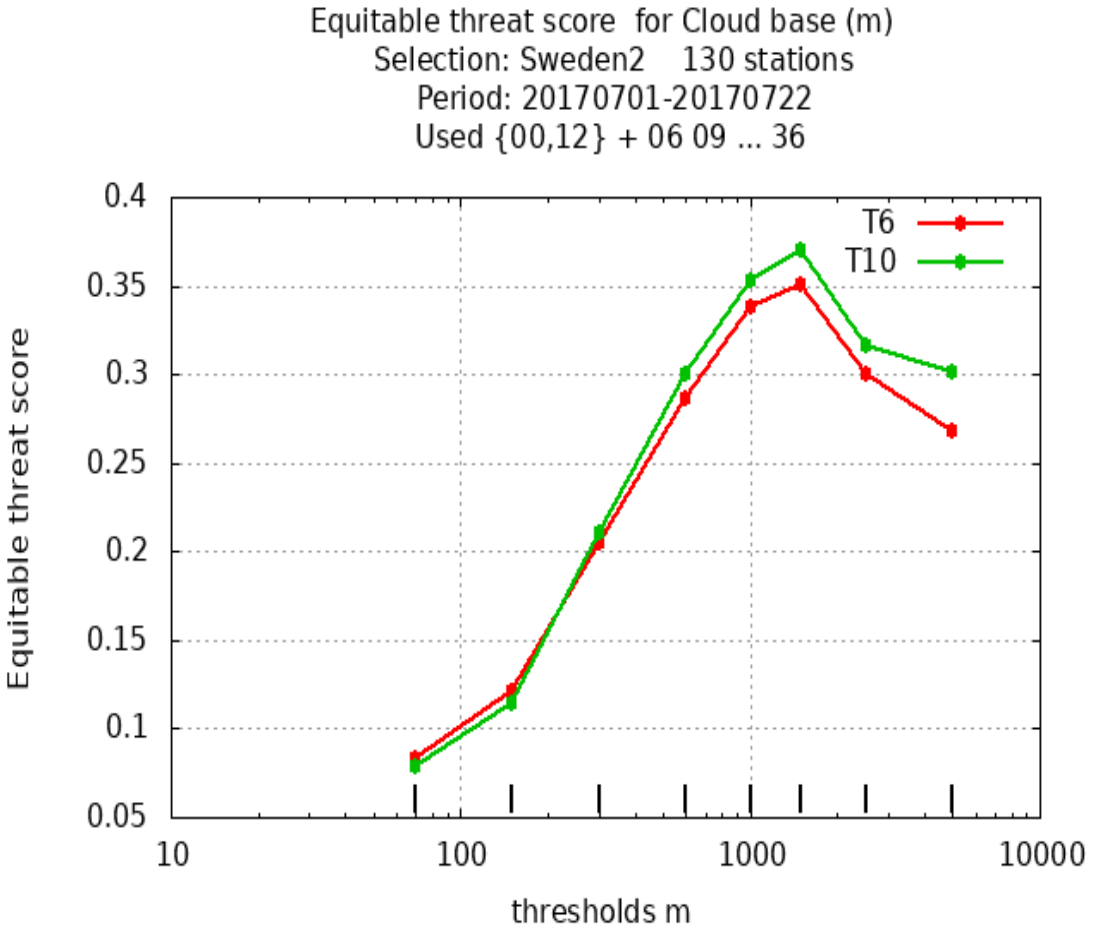
Test 2017-09-23-00 +24 h (variable VSIGQSAT) low/medium/high clouds Fog: = =





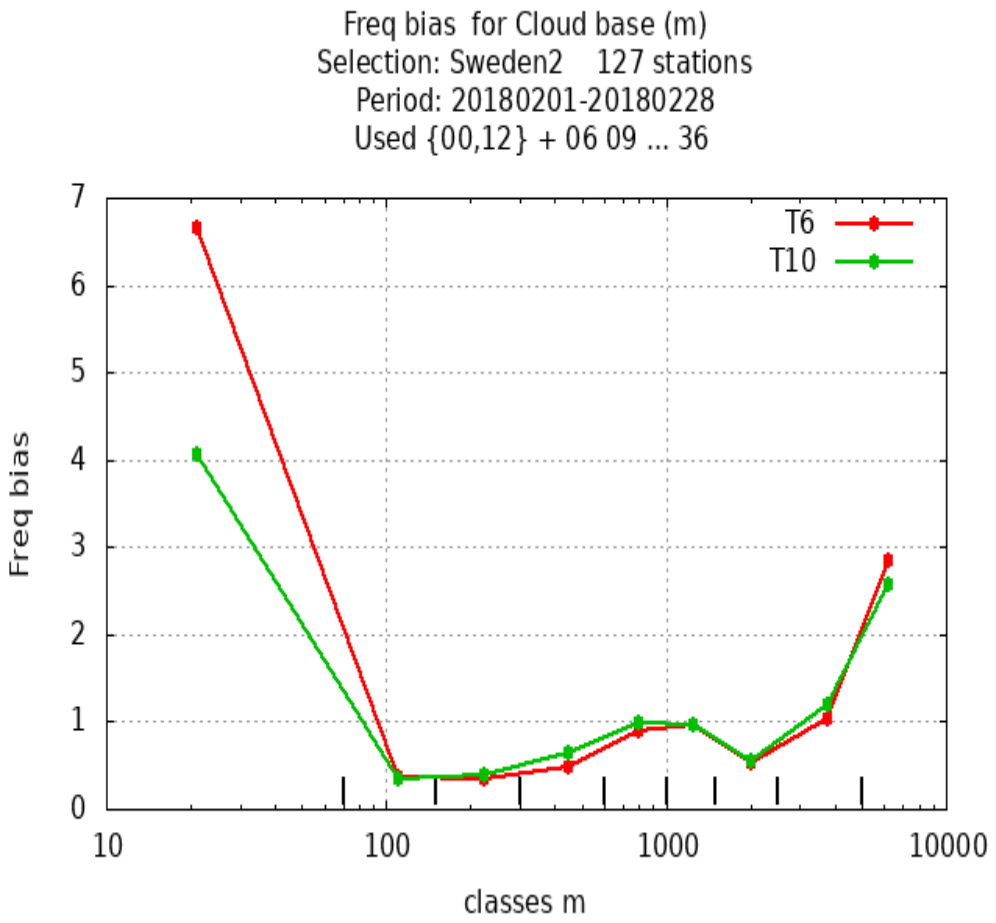
July 2017 (Sweden) Red = constant VSIGQSAT, green = variable (unfortunately also with some change of overlap)

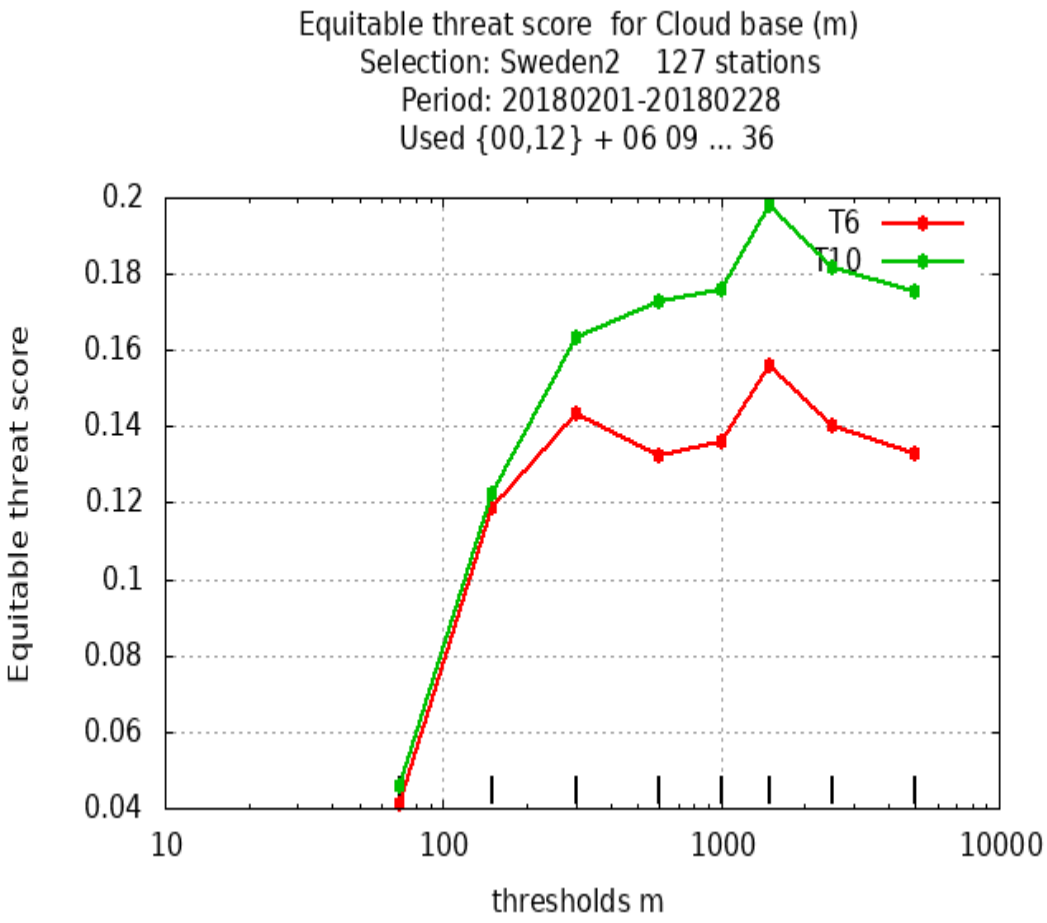




Comment: Better FB , a little better ETC for higher cloud bases

February 2018 (Sweden) Red = constant VSIGQSAT, green = variable (unfortunately also with some change of overlap)





Comment: Less over-prediction of lowest cloud bases, inclusive fog , a little better ETS from 400m thresholds and above

Summary

- Less fog and clouds below 200m but a little more at higher levels
- Somewhat better cloud base forecasts
- Need for “clean” tests

Other tests/updates

1) Testing the Kain-Fritsch (KF) scheme in AROME

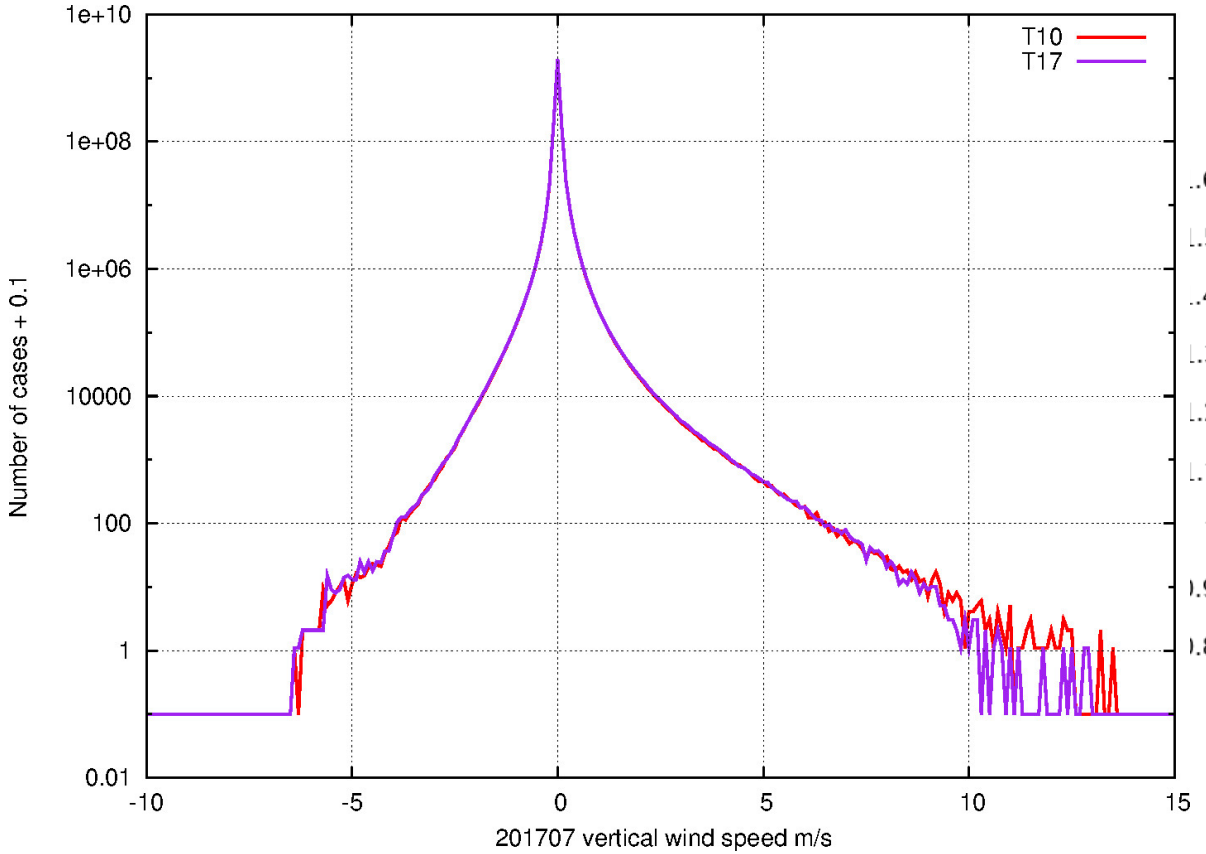
Background: There are often complaints about missing precipitation from “shallow” showers at all seasons

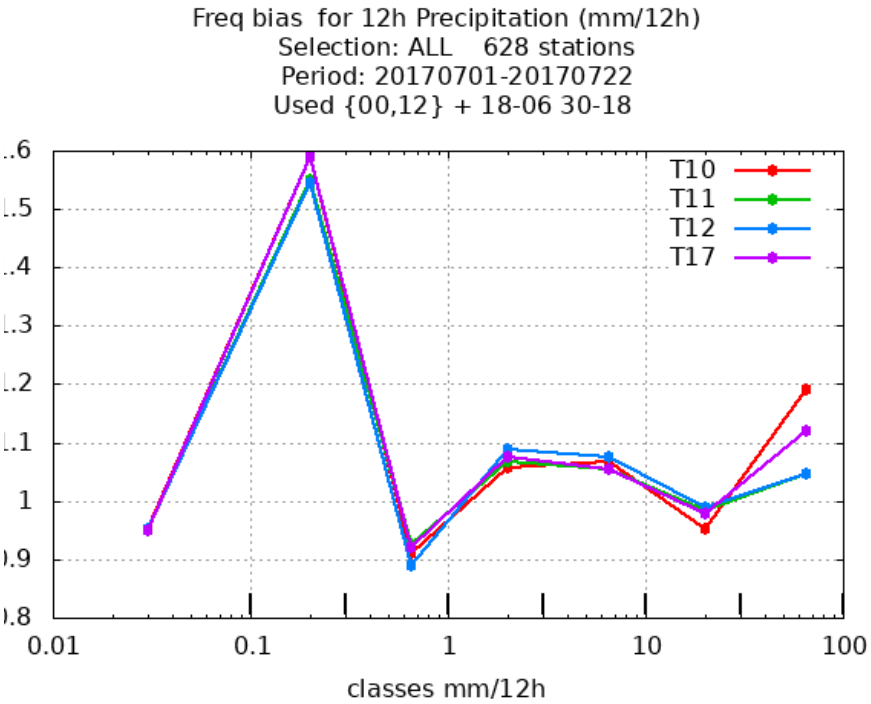
Could the KF scheme be a help here ?

Updates needed:

- Bug fixes. (.e.g inverting levels)
- Quit the scheme if the number of iterations is too long.
- Adjust the time scale for convection. (longer timescale for a high resolution model)
- The precipitation from the scheme enters the microphysics instead of immediately go to the ground.
- Correction of the heat and moisture budget.
- Avoid overshooting tendencies. (Not result in negative amount of water species)

Very preliminary result, July 2017: Red = no KF, green = KF timescale ~10 hours, Blue: KF. timescale ~5.5 hours, EDMF maximum cloud dept adjusted to fit KF scheme minimum cloud dept: 2500m instead of 4000m. Purple: KF. EDMF maximum cloud dept default 4000m KF minimum 4000m. KF timescale 5.5 hours



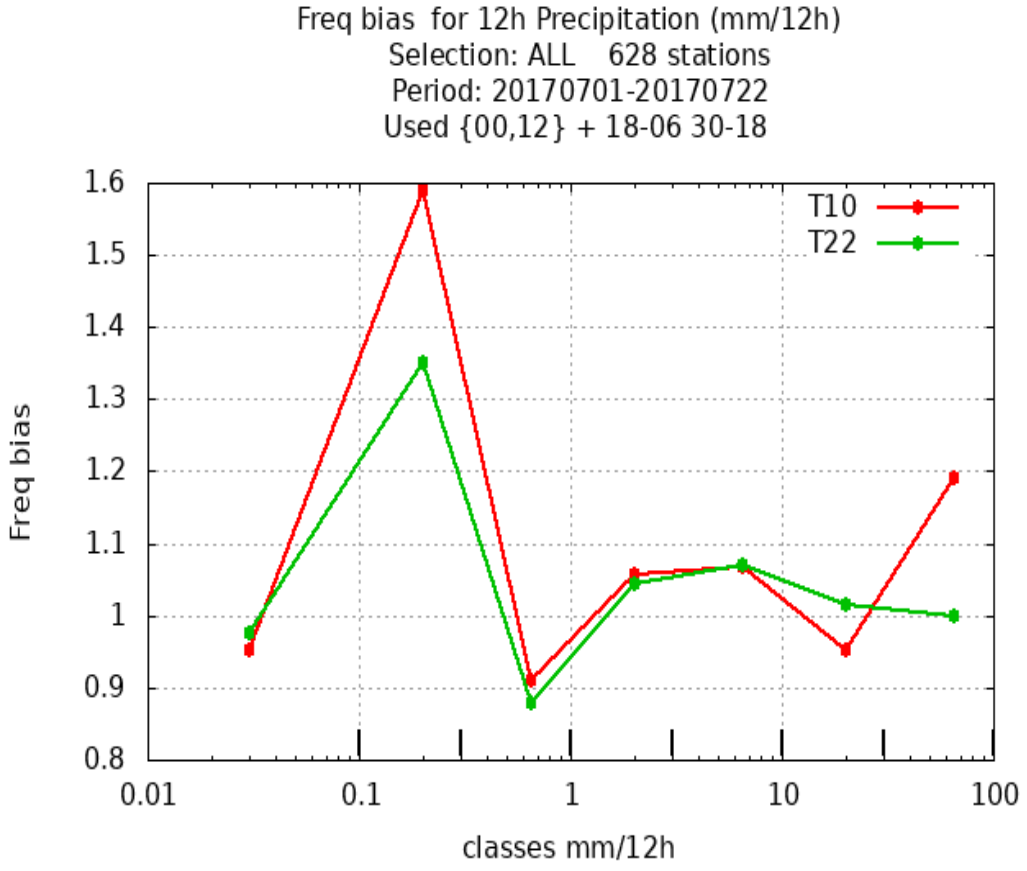


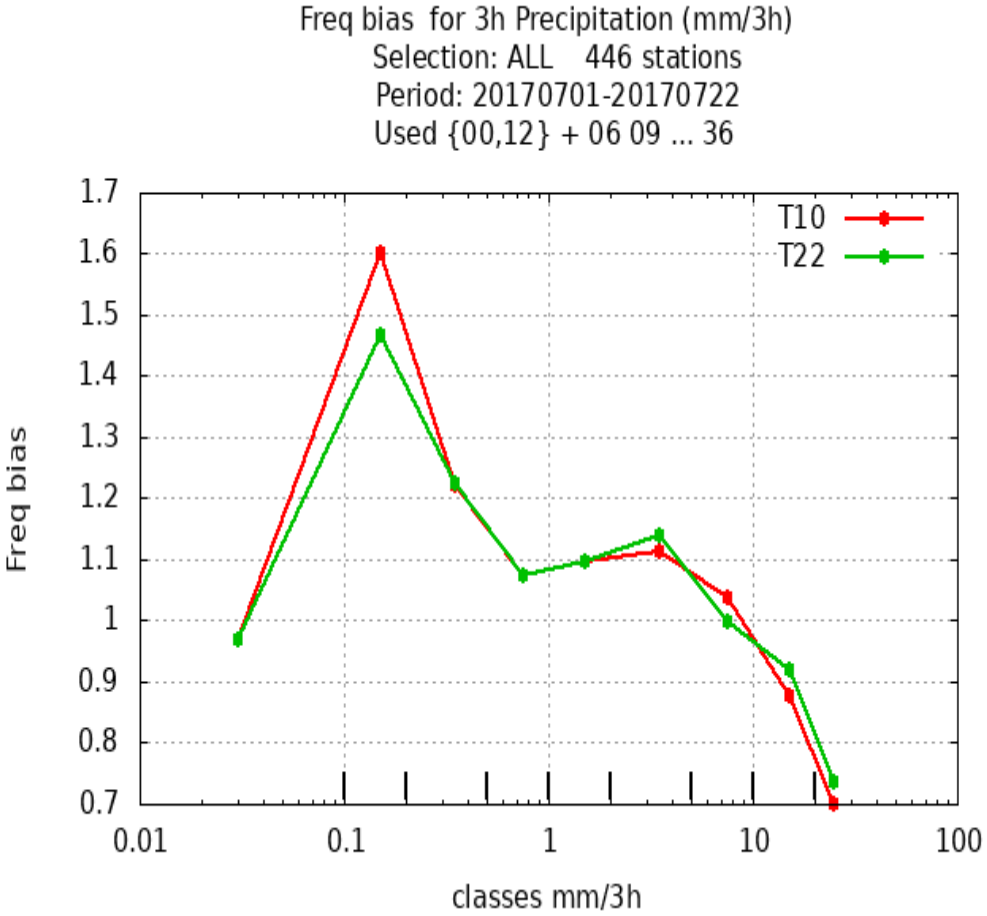
Comment: Very small differences for e.g. MSLP, T2M etc and for upper air parameters. A little less violent updrafts with KF. Small effect of KF scheme with the long convective time scales. Need to test shorter ones. Somewhat less over prediction of high precipitation amounts A little less active resolved convection. Not obviously better of forecasting light showers (so far)

2) Test LTOTPREC option but use original updraft fraction ‘ZFRACB’ :

Only difference with LTOTPREC=F left is then that precipitation goes to microphysics instead of instantaneously to the ground.

Test three weeks in July (2017) shows mainly neutral impact but better FB for 12h and 3h precipitation: (green is mod. LTOTPREC)

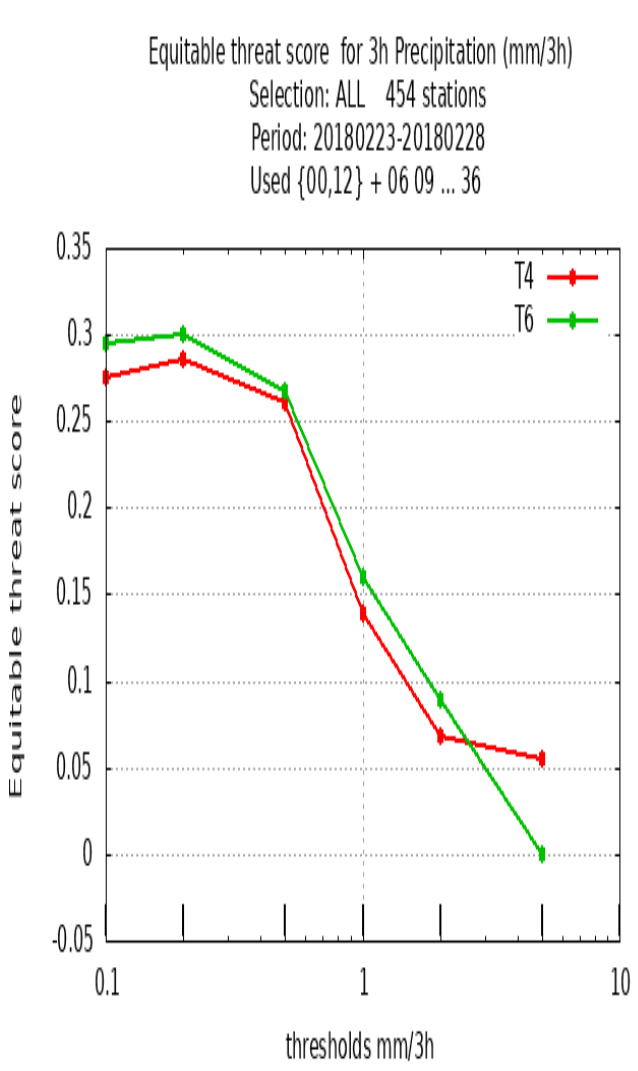


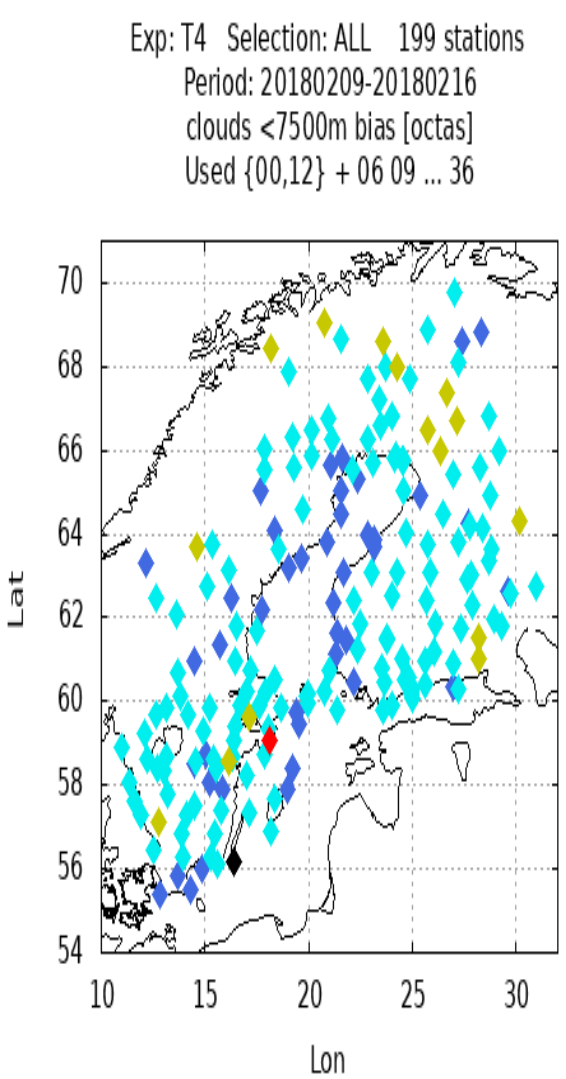


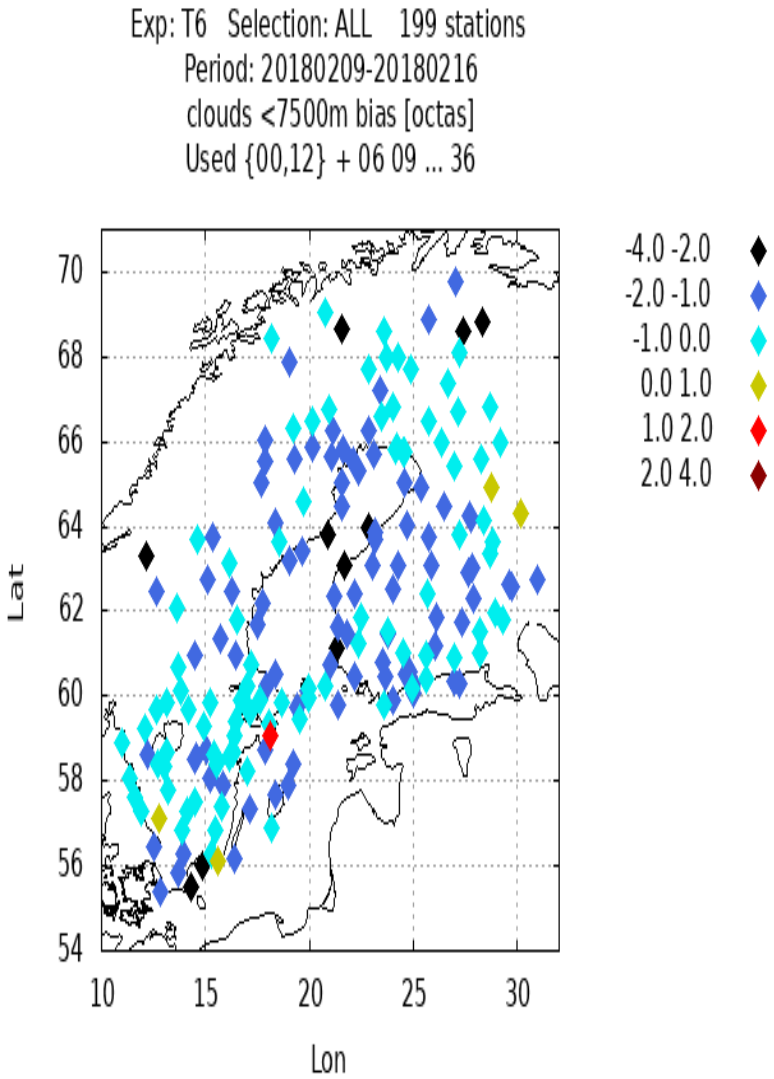
3) Update of OCND2 called LMODICEDEP

Makes it possible to reduce the amount of graupel, without any side effects seen so far. Better for microphysics perturbations of snow size distribution.

Roughly neutral impact all seasons except winter, where precipitation forecasts are improved in cold weather situations. Unfortunately, for winter season and mild weather some problems with cloud cover and thus also t2m. (T4=REF, T6=LMODICEDEP)







4) Better forecasts of supercooled rain

Supercooled rain mod (since late 2016):

- RFRMIN(1)=1.0E-5

  Action: No rain interacting with snow if mixing ratio of snow is lower than RFRMIN(1)

- RFRMIN(2)=1.0E-8

  Action: No rain interacting with ice nucleus (=IN) to form graupel if IN concentration is lower than RFRMIN(2)

- RFRMIN(3)=3.0E-7

  Action: cloud water, cloud ice and snow should not form graupel if mixing ratio of graupel is lower than RFRMIN(3)

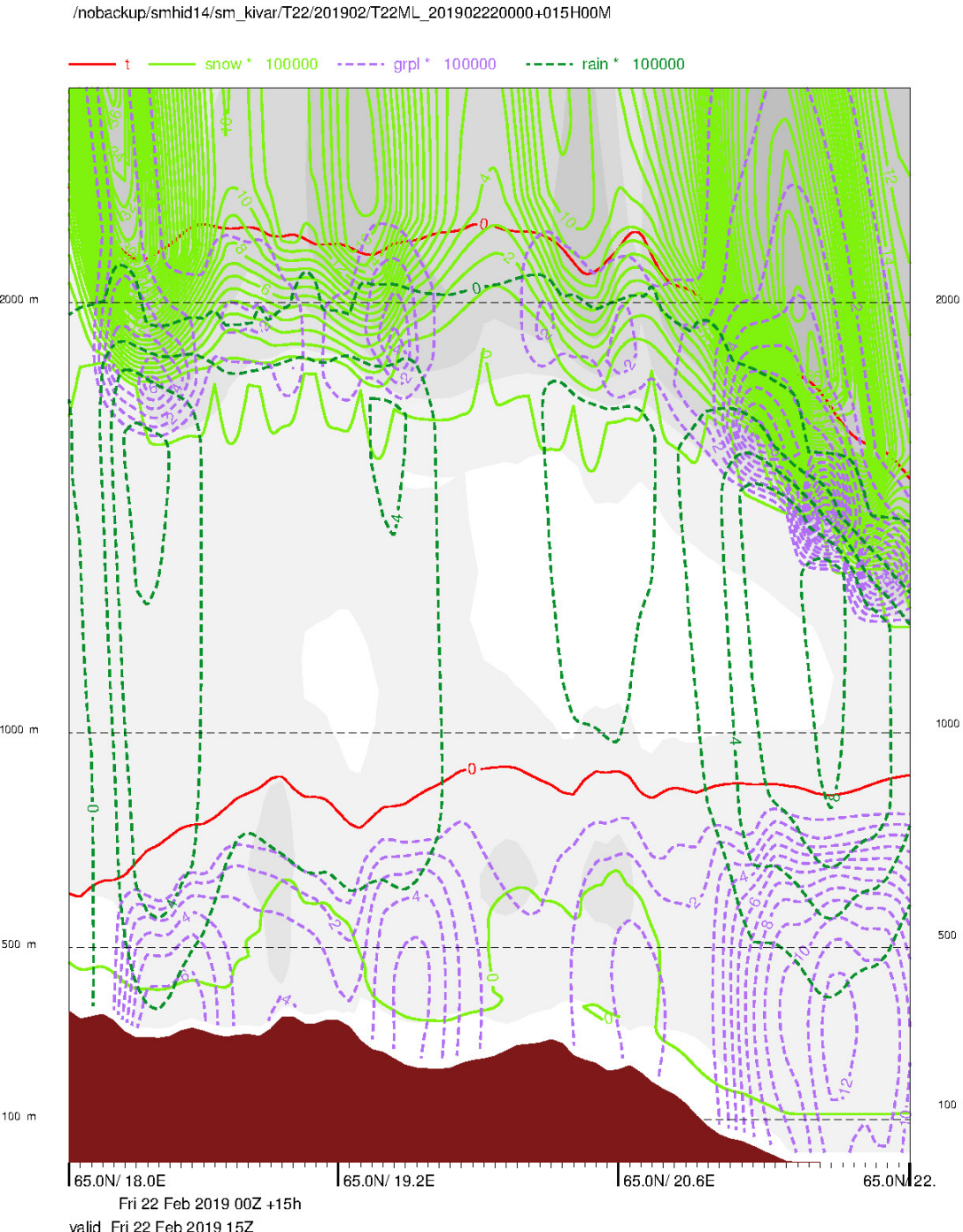
- RFRMIN(4)=3.0E-7

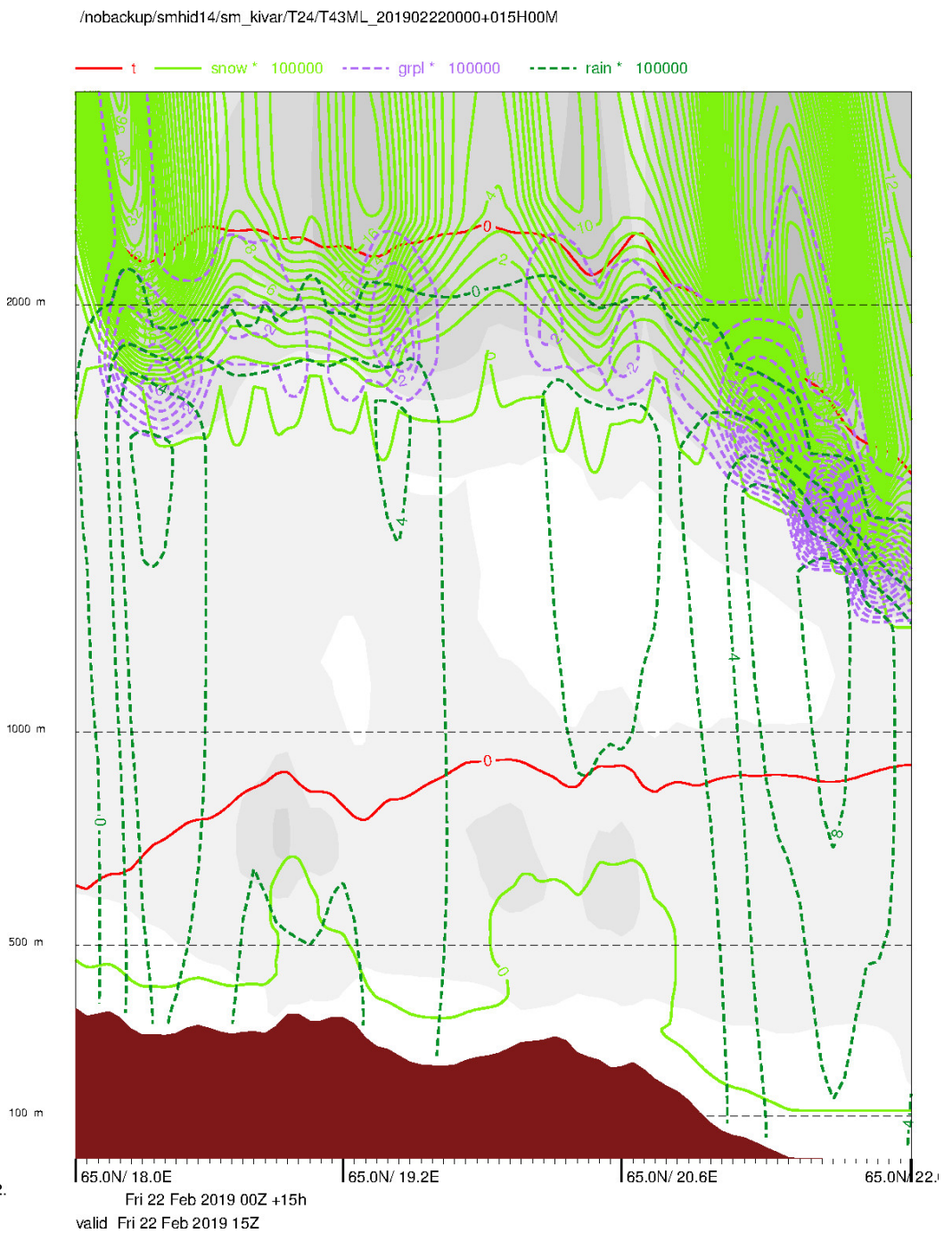
  Action: cloud water, rain, cloud ice and snow should not form graupel if mixing ratio of graupel is lower than RFRMIN(4)

- RFRMIN(7)=0. Action: Rain should not be converted to snow if RFRMIN(7)=0.

  Problem : Those settings are not always enough: Example: February 22 in the afternoon the north-eastern part of Sweden got supercooled rain which was poorly forecast. Increasing RFRMIN(3) and RFRMIN(4) with a factor of 10 helps a bit, but the reason for failure seems to be the presence of small amounts of cloud ice. Solution: RFRMIN(3) and RFRMIN(4) unchanged, but are used as limits also for cloud ice amounts

Cross section 2019022200+15h : 65N, 18-22 E Left : Original Right: RFRMIN(3) and RFRMIN(4) unchanged, but are used as limits also for cloud ice amounts. Rain Graupel Snow





Summary all tests:

- HARATU/EDMF update: more physical, small improvement
- Update of fluxes over sea (ECUME6) : Test other seasons.
- Model levels thickness dependent threshold for condensation (VSIGQSAT) Encouraging results, but ‘clean’ tests needed.
- KF-scheme: Works technically well, but more tests and work, e.g. optimization of the code.
- Modified LTOTPREC: Test other seasons.
- LMODICEDEP: More work …
- Supercooled rain: New tuning works, but possible side effects must be checked.

EXTRA SLIDES: clouds almost unchanged, with EUME6 vs REF. Somewhat unexpected a little higher MSLP with EUME6