Norwegian Meteorological Institute

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Description of the OCND2-option in the IC3 cloud- and stratiform condensation scheme in AROME

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Outline:

- Short background
- Brief description of the changes of the ICE3 physics
- Results with the modified ICE3-physics
- Summary

Short background (1)

Although the cloud physics in AROME is advanced and generally work well, there are two weaknesses that are addressed here:

- Low clouds disappear too quickly in 'moderate' cold conditions (around 0 to -10 C)
- To much low clouds when it is 'very' cold, below ~ -25 C. There also seems to be a moderate over prediction of cirrus clouds.

Short background (2)

The two weaknesses are assumed to be related to:

- The first one is because there is too little of mixed-phase clouds. The reason is that there is a too active generation of cloud ice and solid precipitation, which too quickly removes moisture.
- The second one is because there is too much of ice clouds. (such as cirrus, ice clouds or fog near ground in winter in case of low temperatures) Clouds appears as soon as the relative humidity with respect to ice is close to 100%. The different physical properties of ice clouds compared to water clouds are not fully included in the model physics.

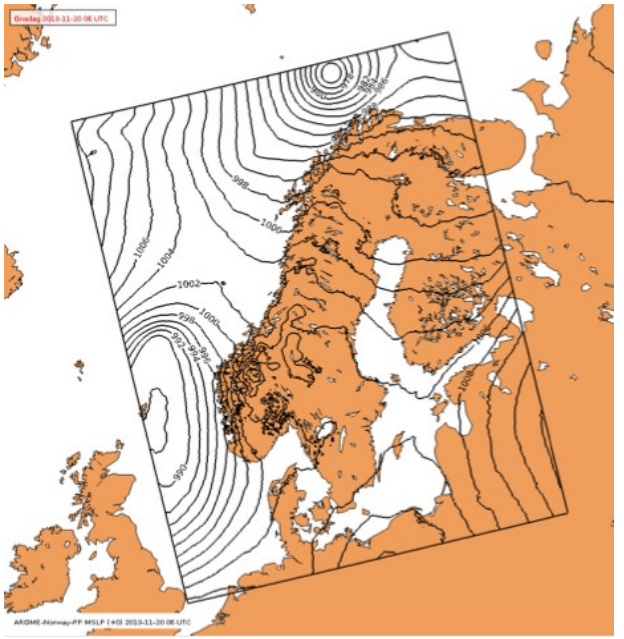
Brief description of the changes of the ICE3 physics

More rigorous separation of fast cloud liquid water related processes from slow ice water processes. This means that :

- The statistical cloud-scheme only handles water- and mixed phase cloud cover. Only the amount of cloud-liquid is calculated from this scheme.
- The Bergeron-Findeisen process is derived as a conversion from vapor to ice.
- Tuning of the conversion ice –>vapor and vapor --> ice
- A separate ice cloud fraction is derived. It is related to the content of cloud ice water and to the relative humidity with respect to ice. Also the content of solid precipitation contributes, since the optical properties of solid precipitation are 'cloud-like' and not too different from that of cloud ice.
- Total cloud cover is the sum of the liquid fraction and ice fraction

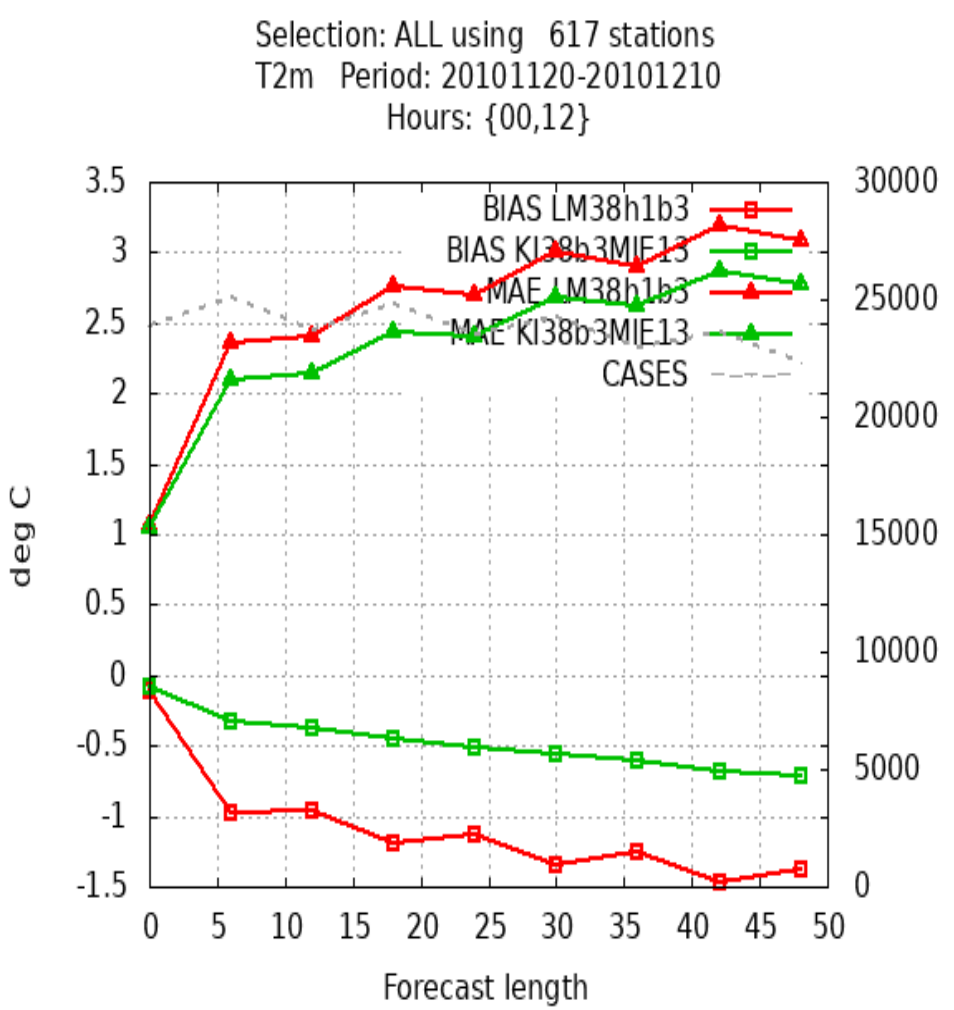
The ice cloud fraction is dependent of model thickness, since ice clouds are generally considerable optical thinner than water clouds

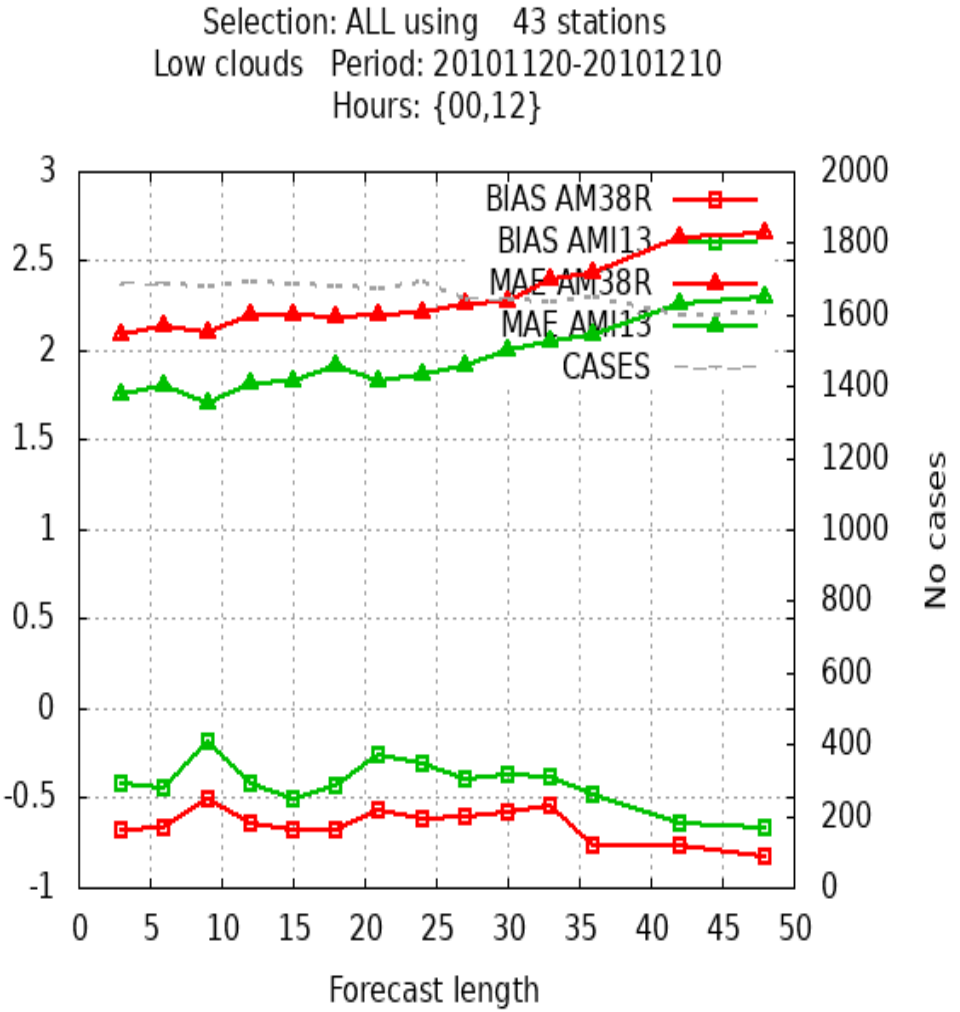
Results with the modified ICE3-physics



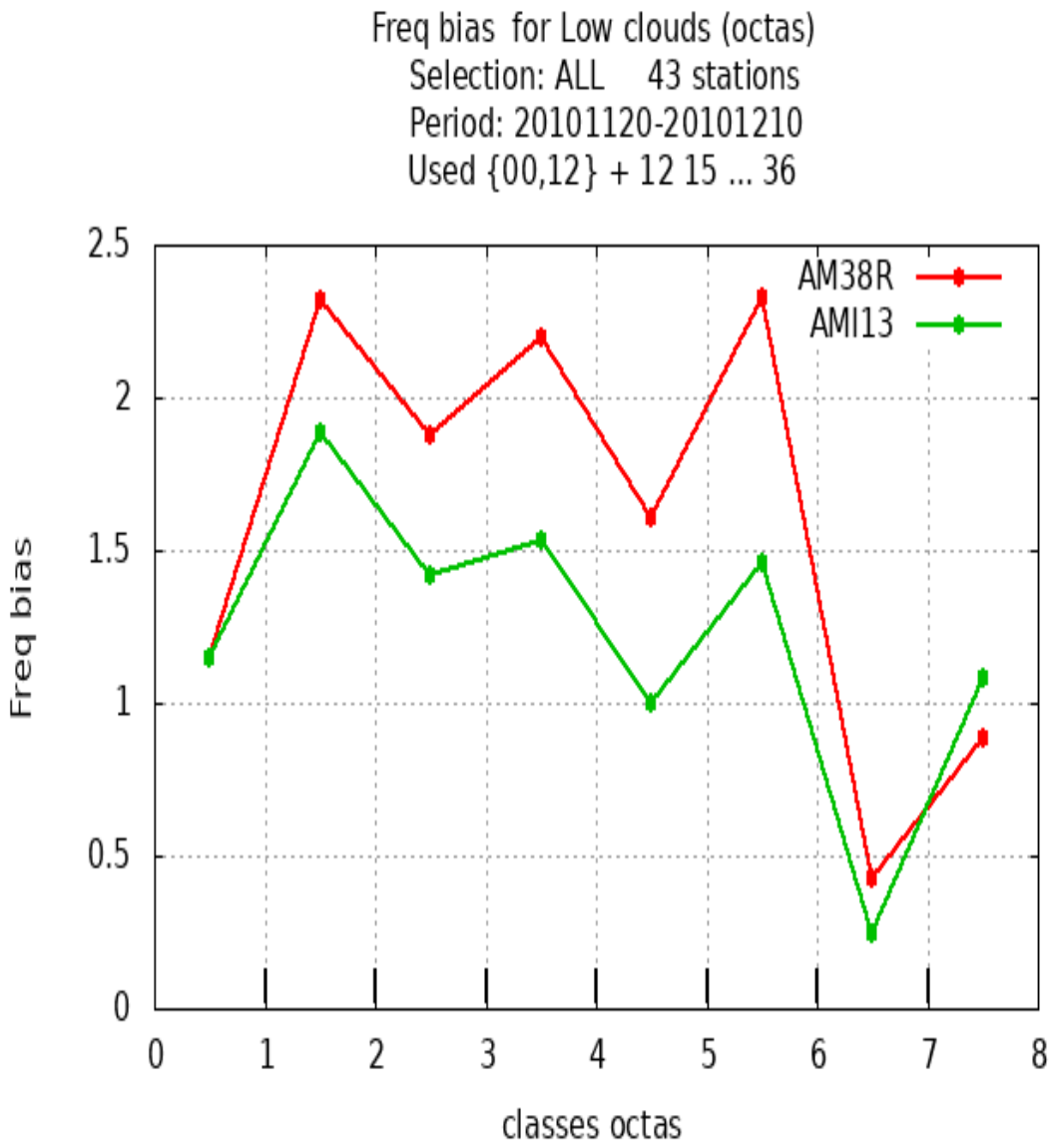
- Metcoop domain (northwestern Europe)
- 960x750 gridpoints, 2.5 km grid. 65 levels
- 3DVAR analysis every 3 hour
- 00 UTC and 12 UTC have been verified.
- Version 38 h1b3
- One cold winter period 20 November 2010 – 10 December
- One wet late summer period: 12 -23 August 2011.
- Red: original, green: OCND2=T

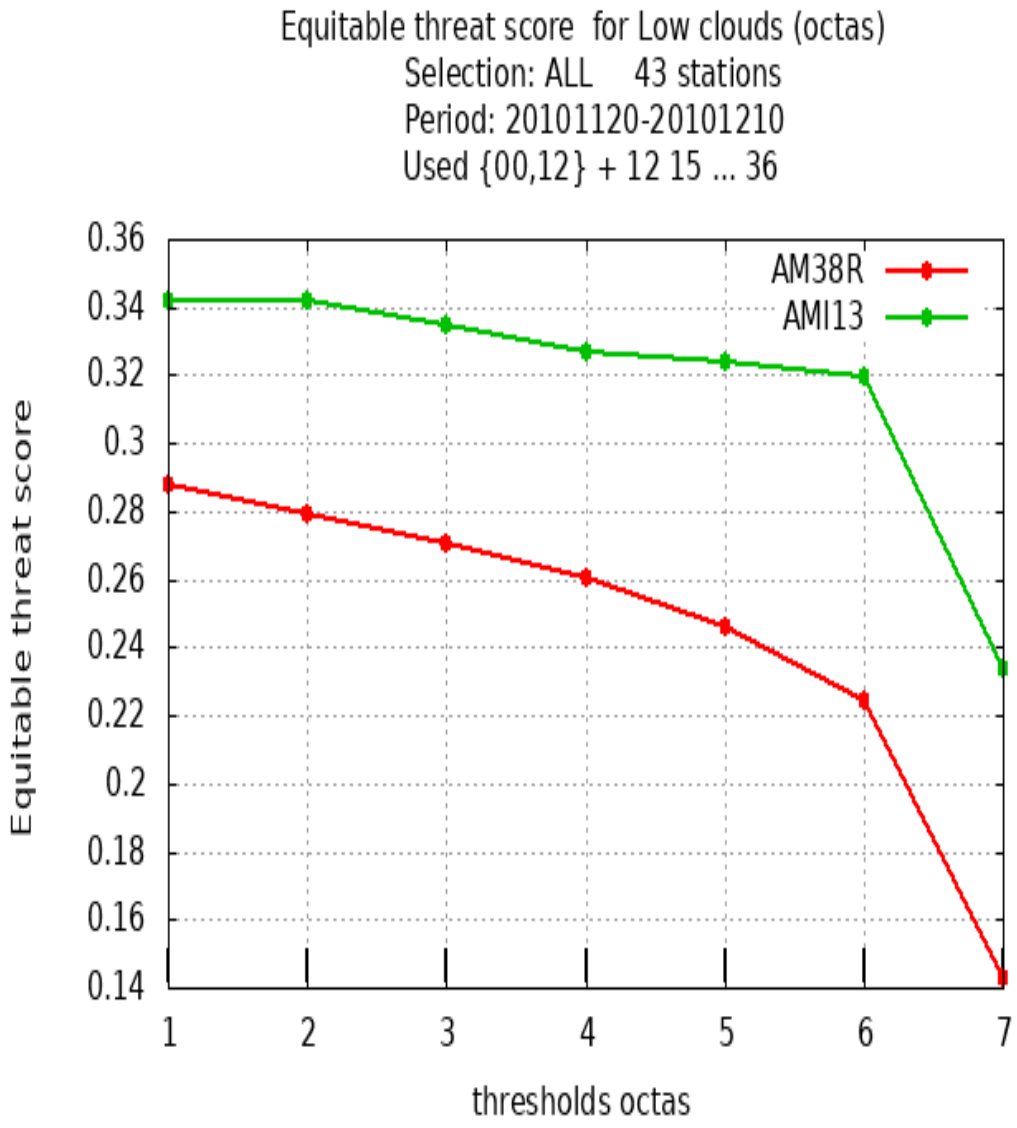
2m- temperature and low clouds. Winter (20 November -10 December 2010)



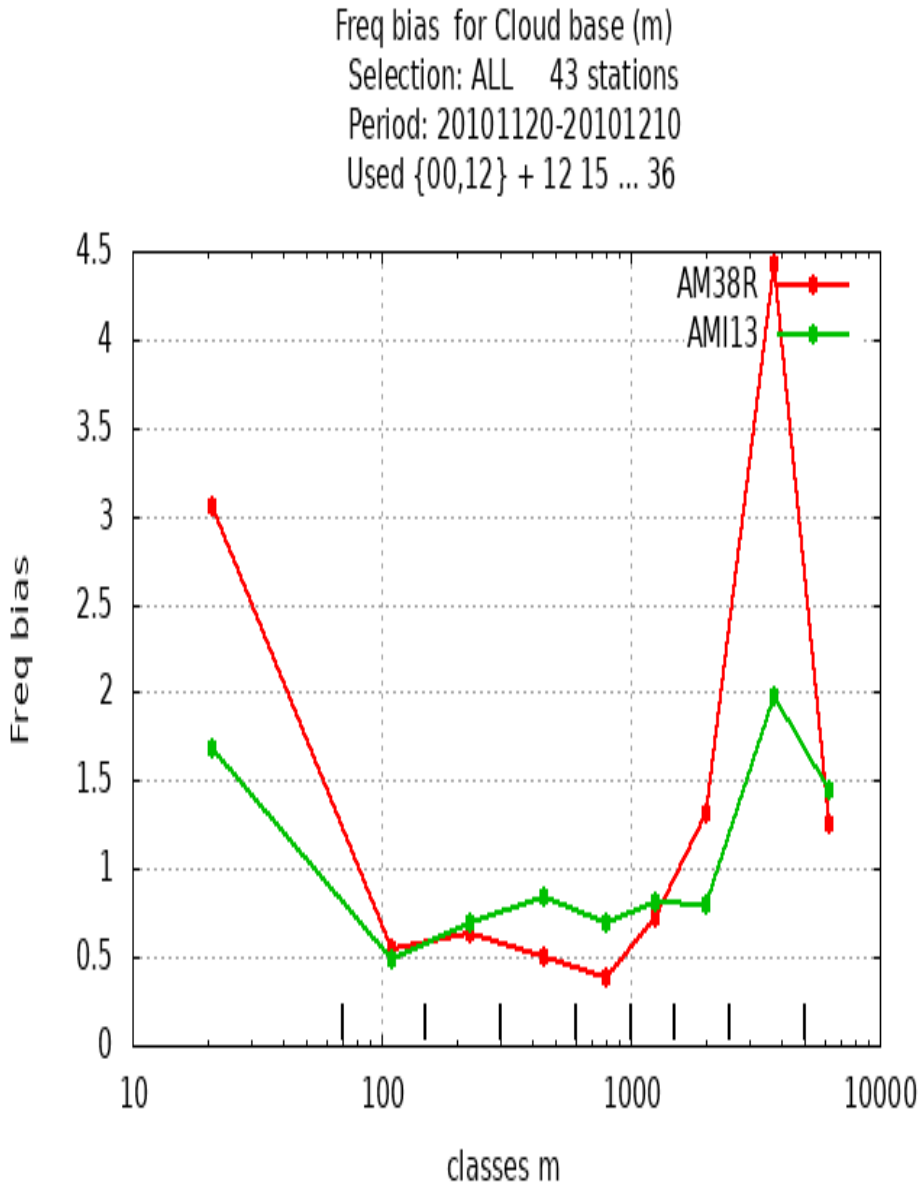


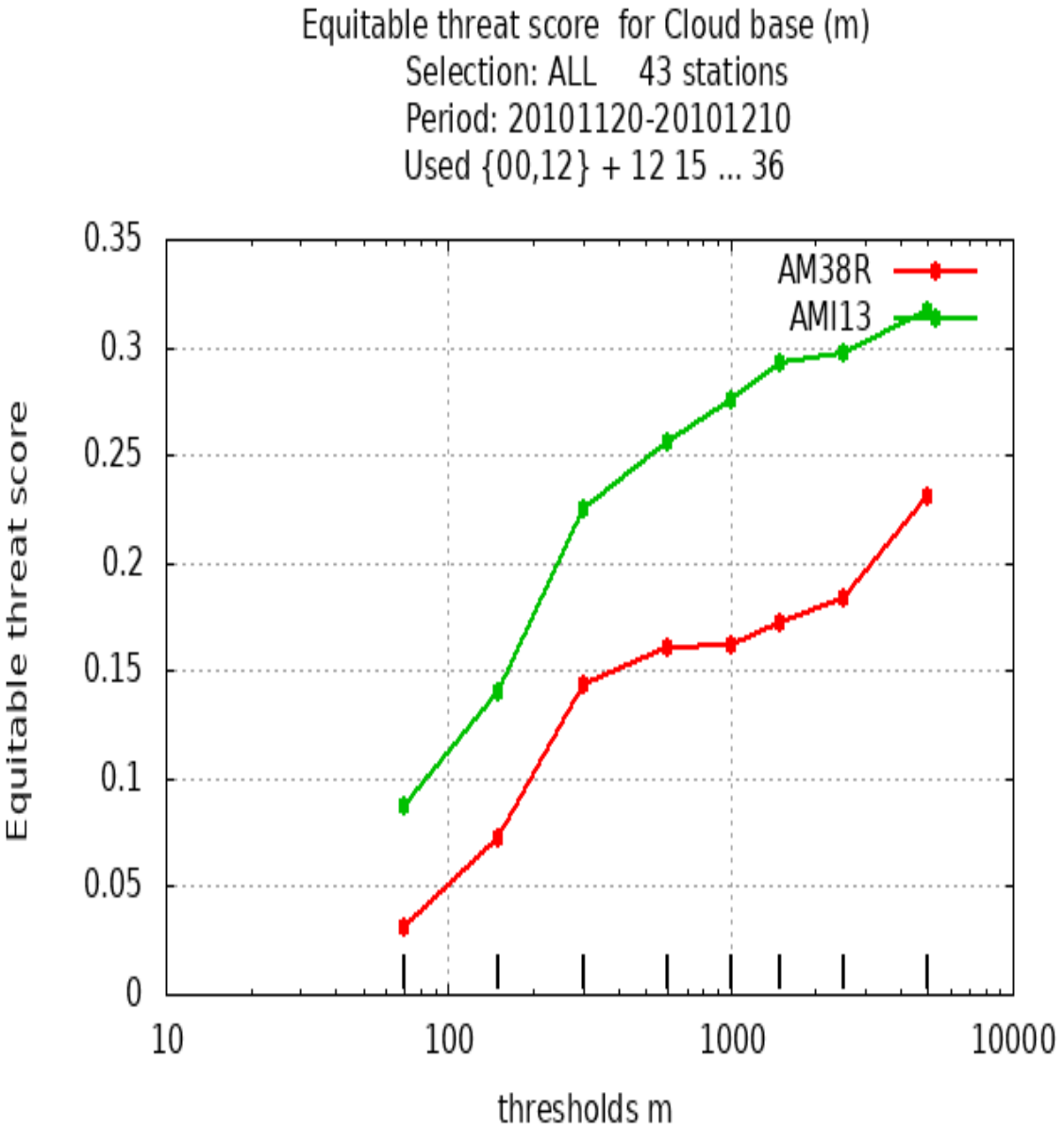
Frequency bias and ETS, low clouds, winter



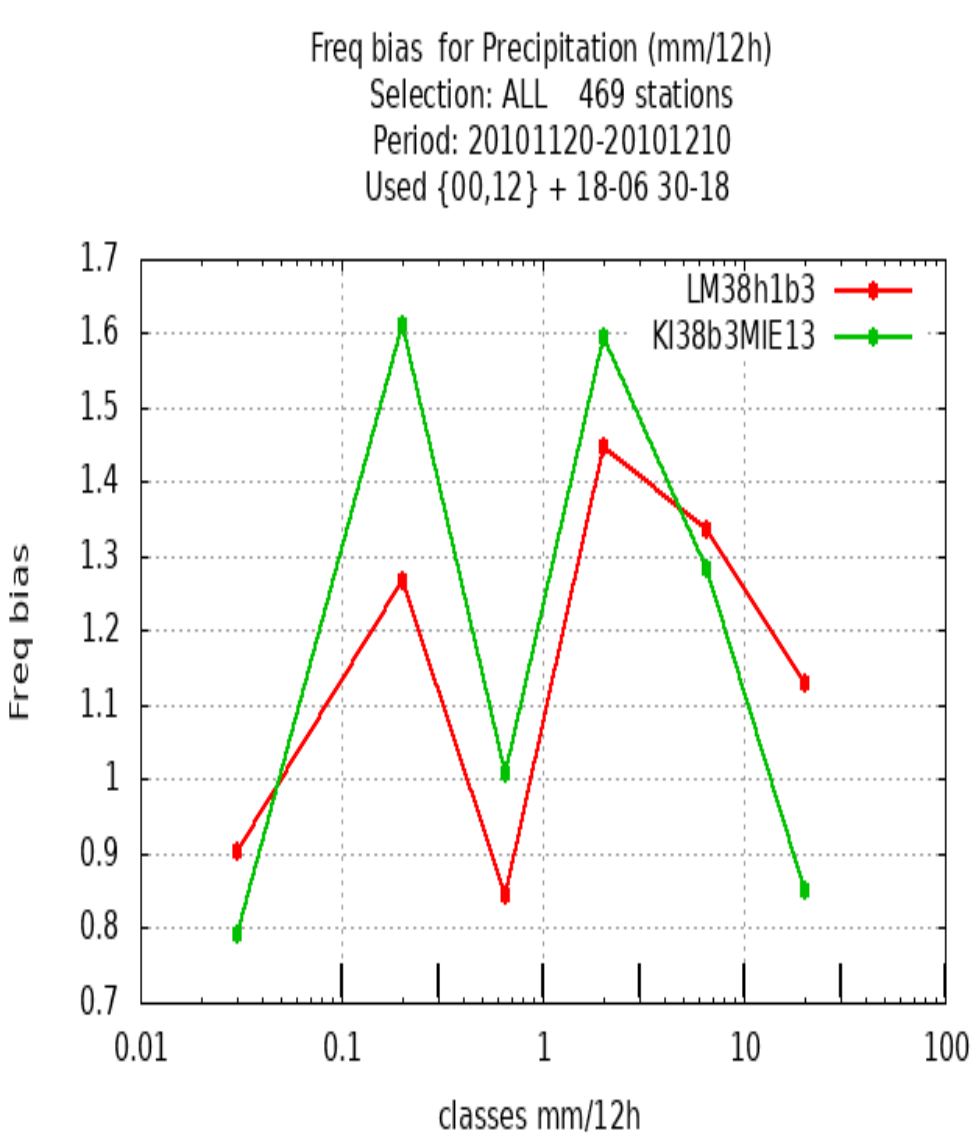


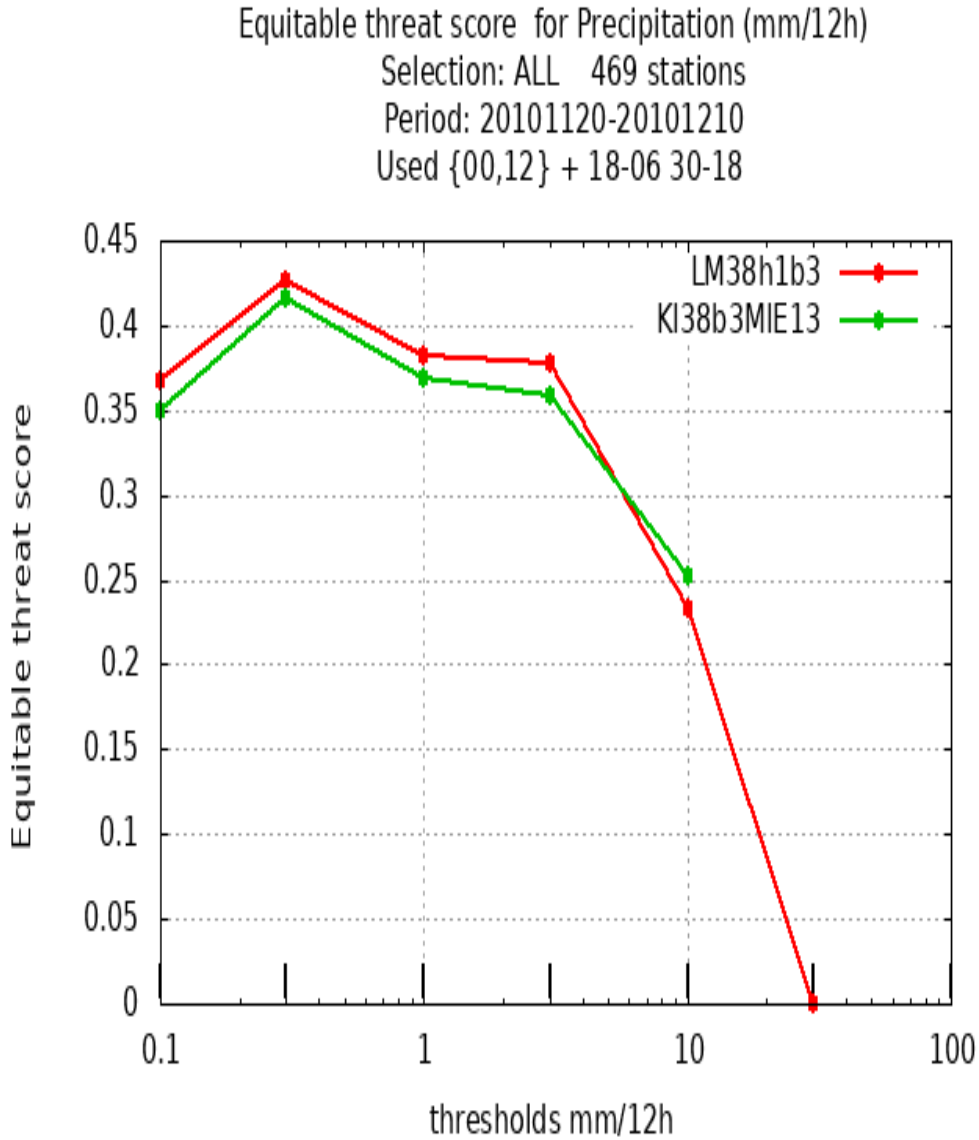
Frequency bias and ETS, cloud base, winter



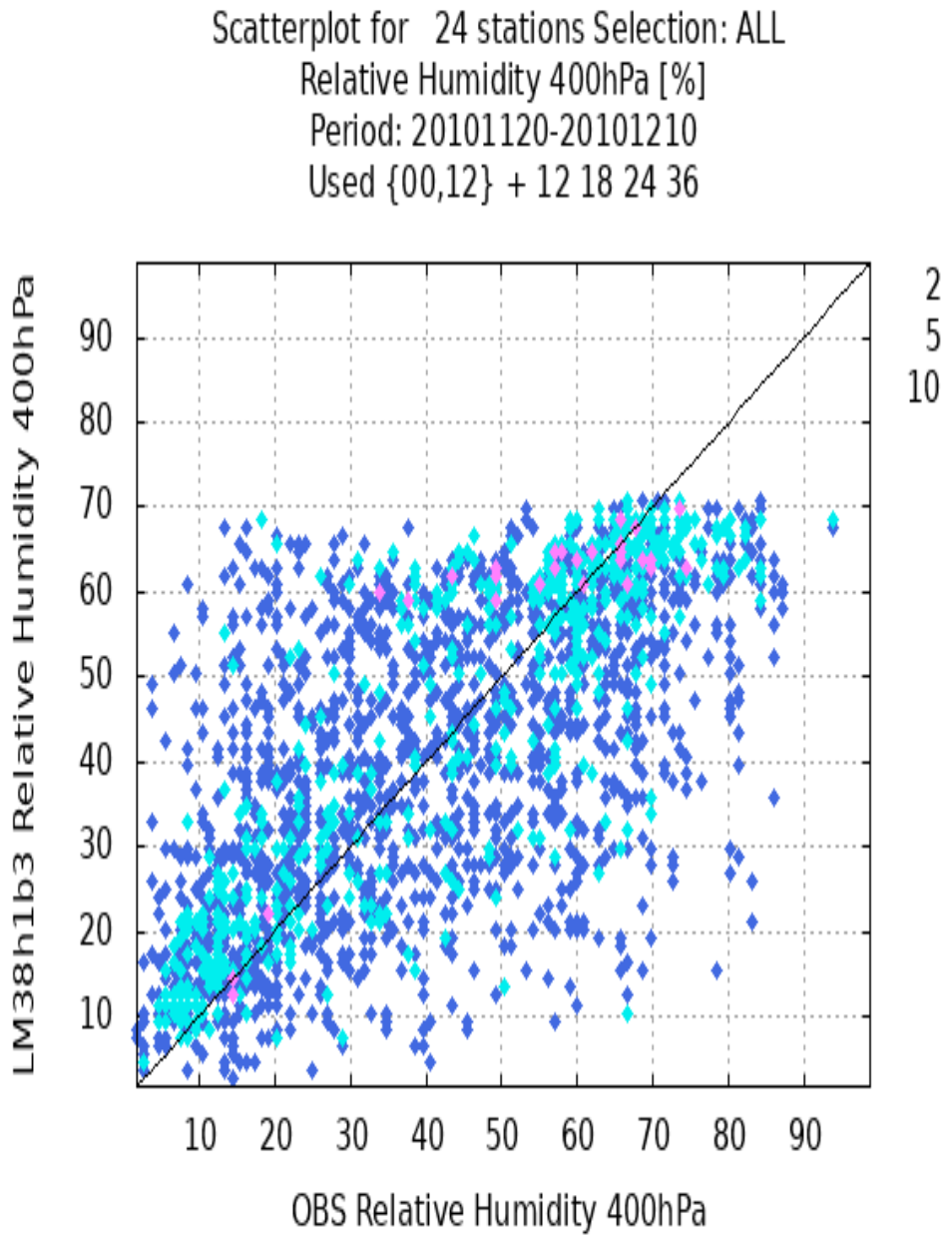


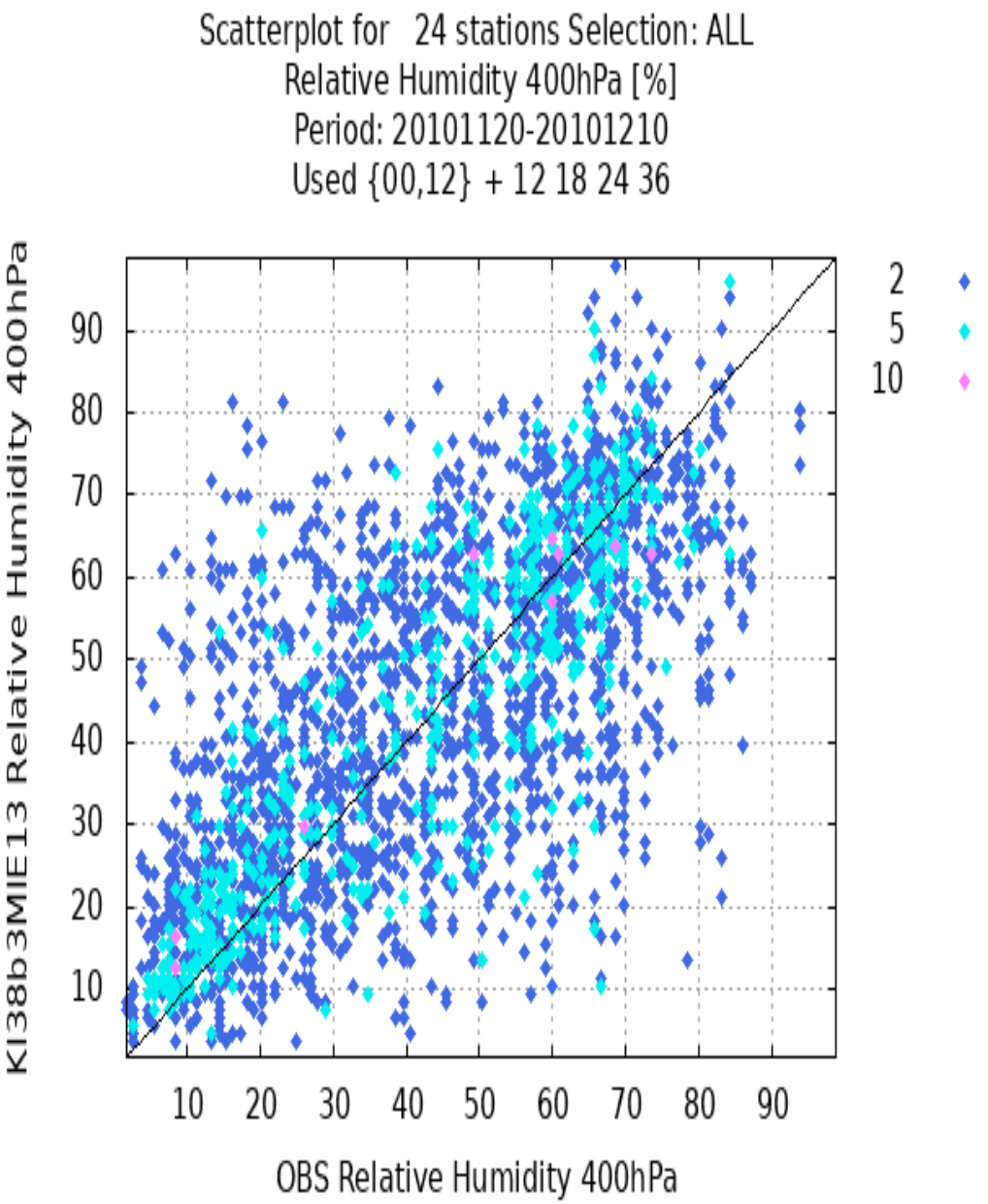
Frequency bias and ETS, 12 hours precipitation, winter





Relative humidity 400 hPa (winter) left reference, right with OCND2





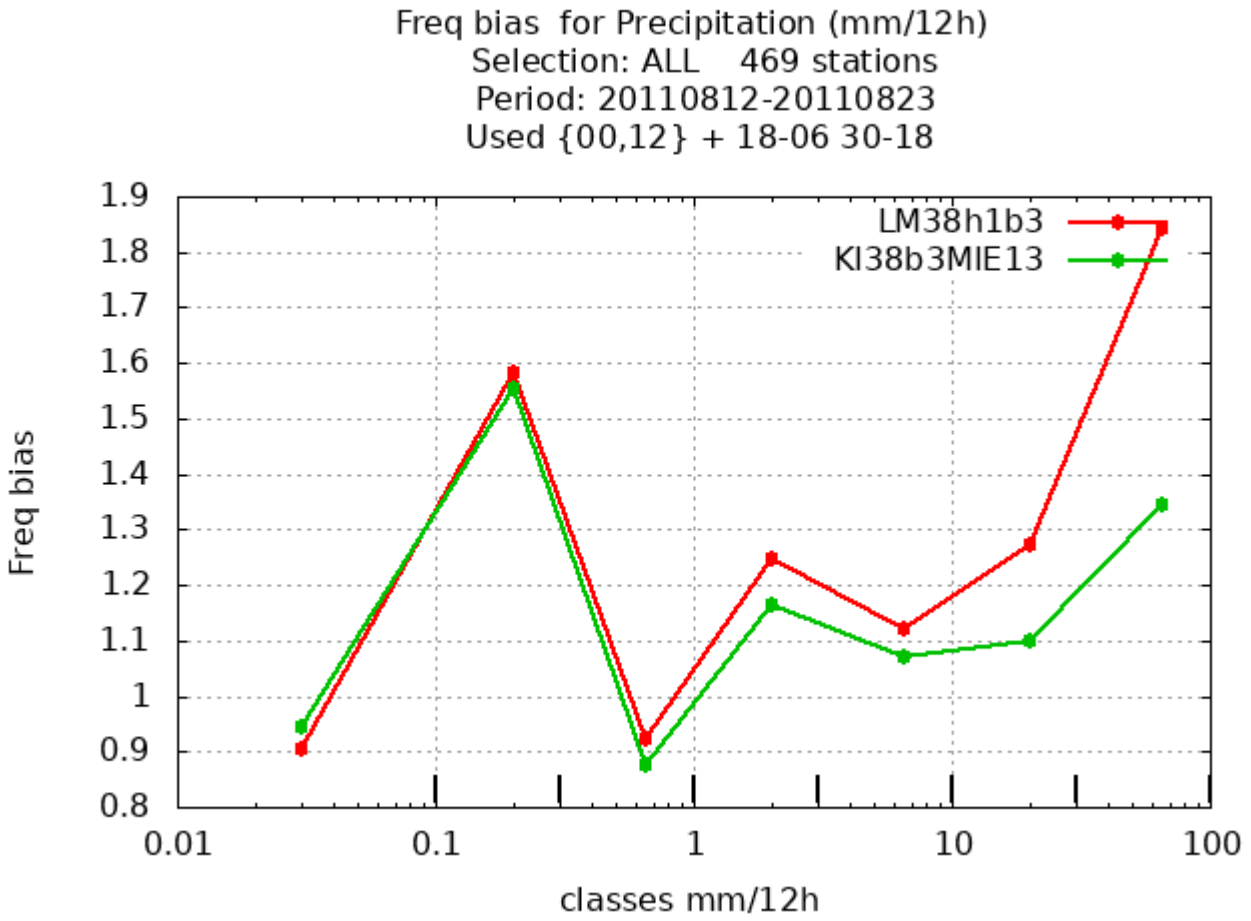
Other results (winter)

Red=worse,green=better

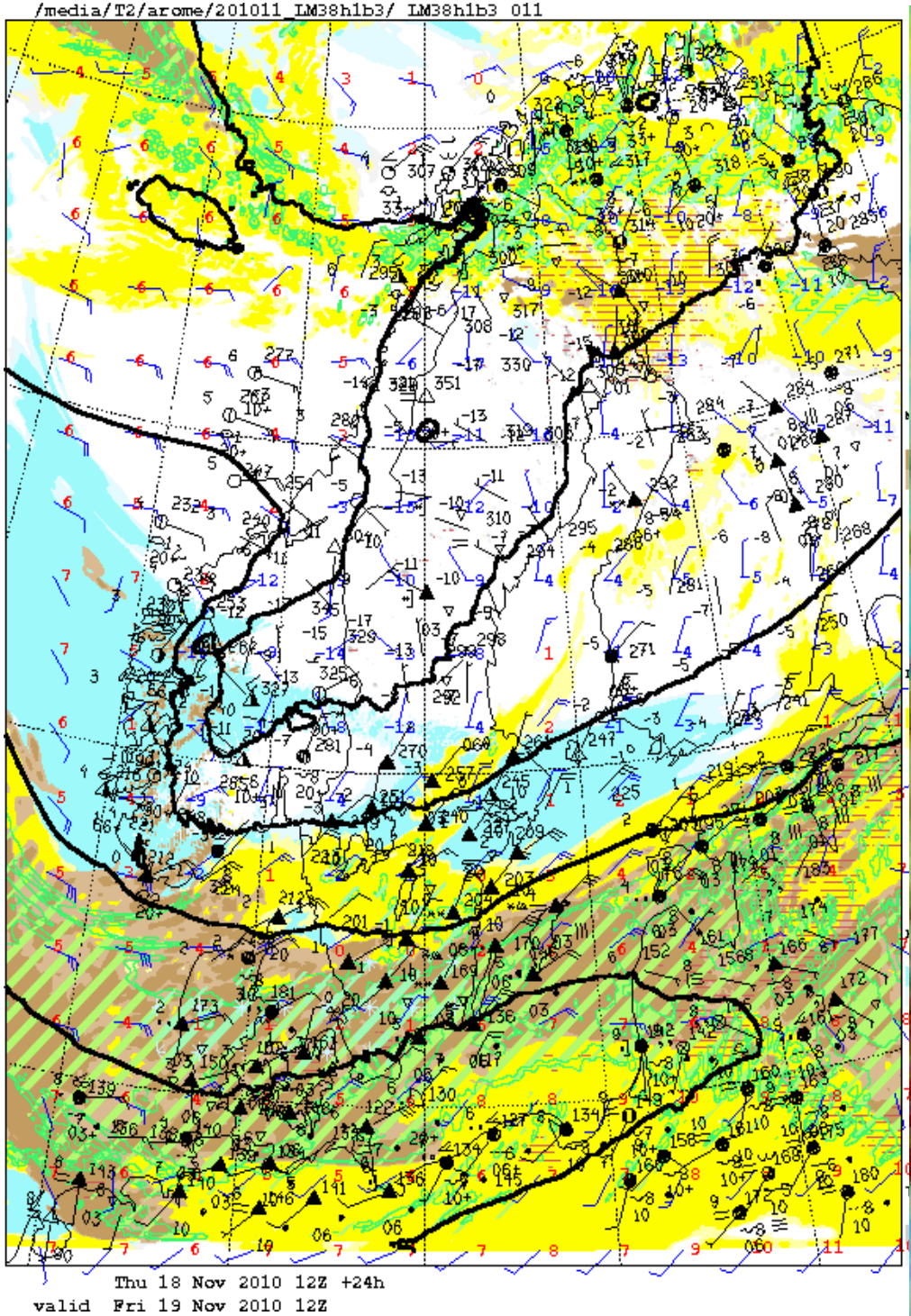
- Some increase of MSLP bias in winter. Seems related to a cooling of lower troposphere.
- 10 m wind speed bias a little increased with OCND2
- Total cloudiness and 2m- dewpoint temperature are improved with OCND2

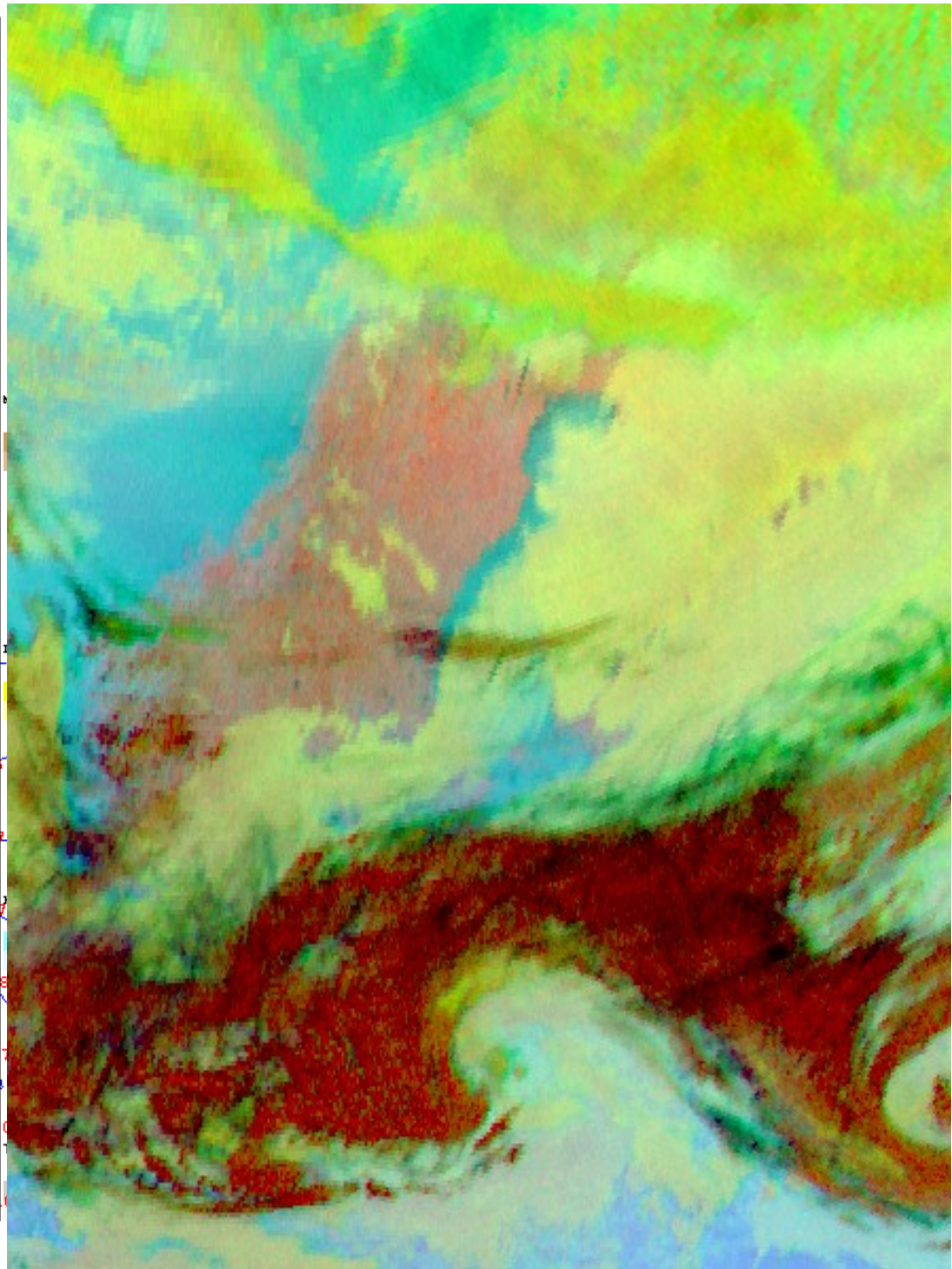
Results for the summer period:

Mainly neutral impact, but there is less over-prediction of large precipitation amount. (30-100 mm/12h)

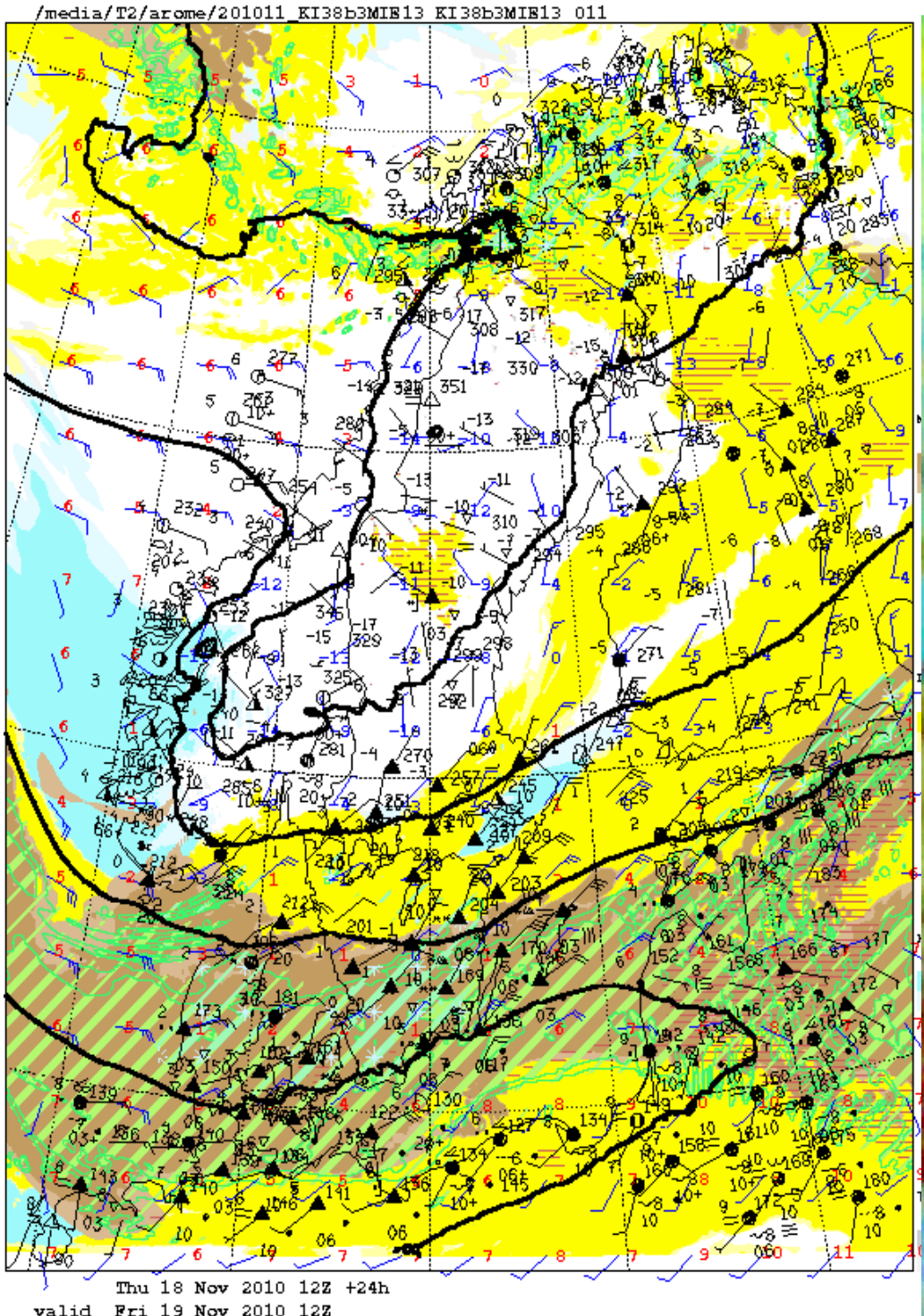


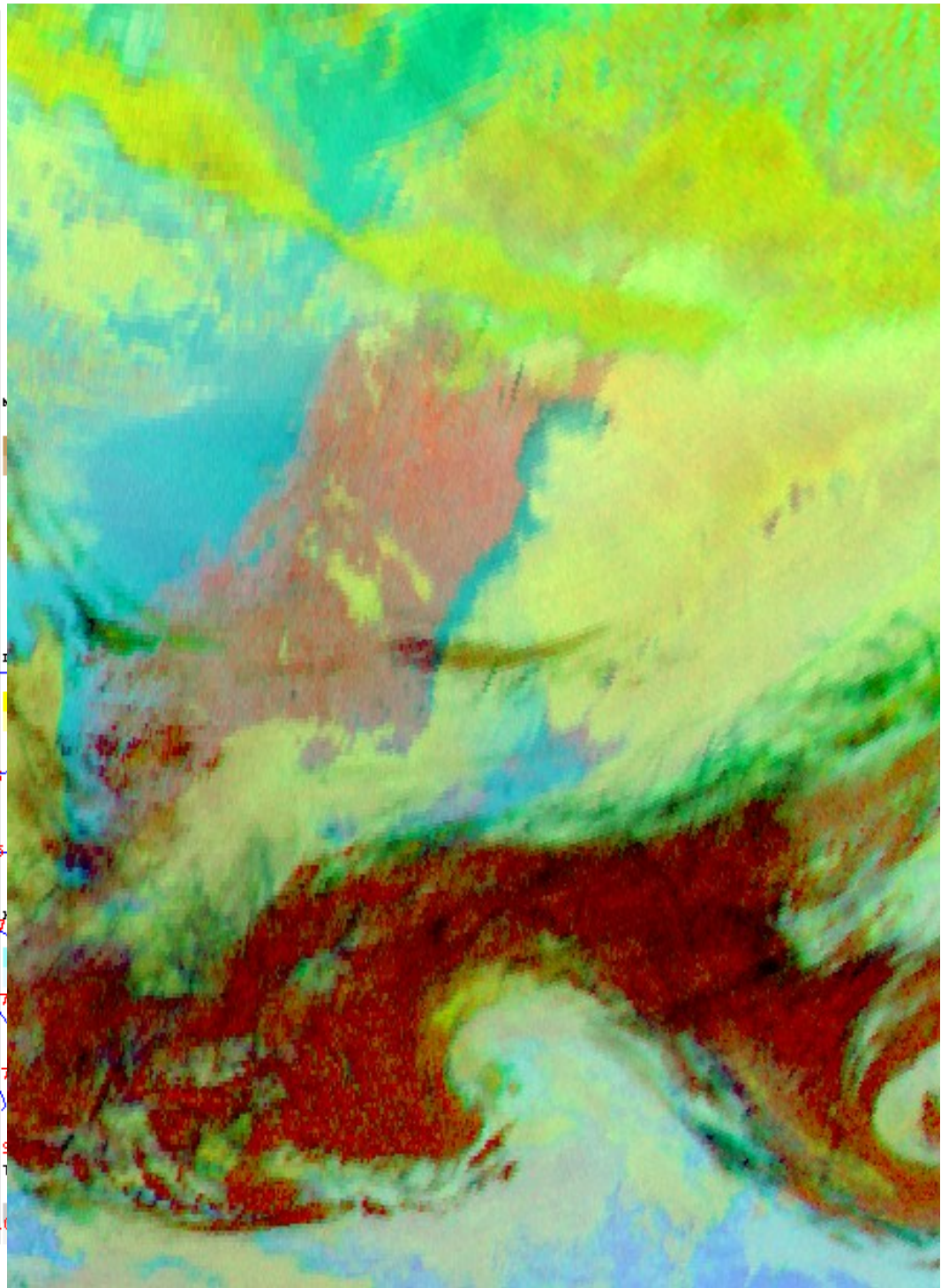
Moderate cold case. Low clouds =yellow left ref ,right satellite



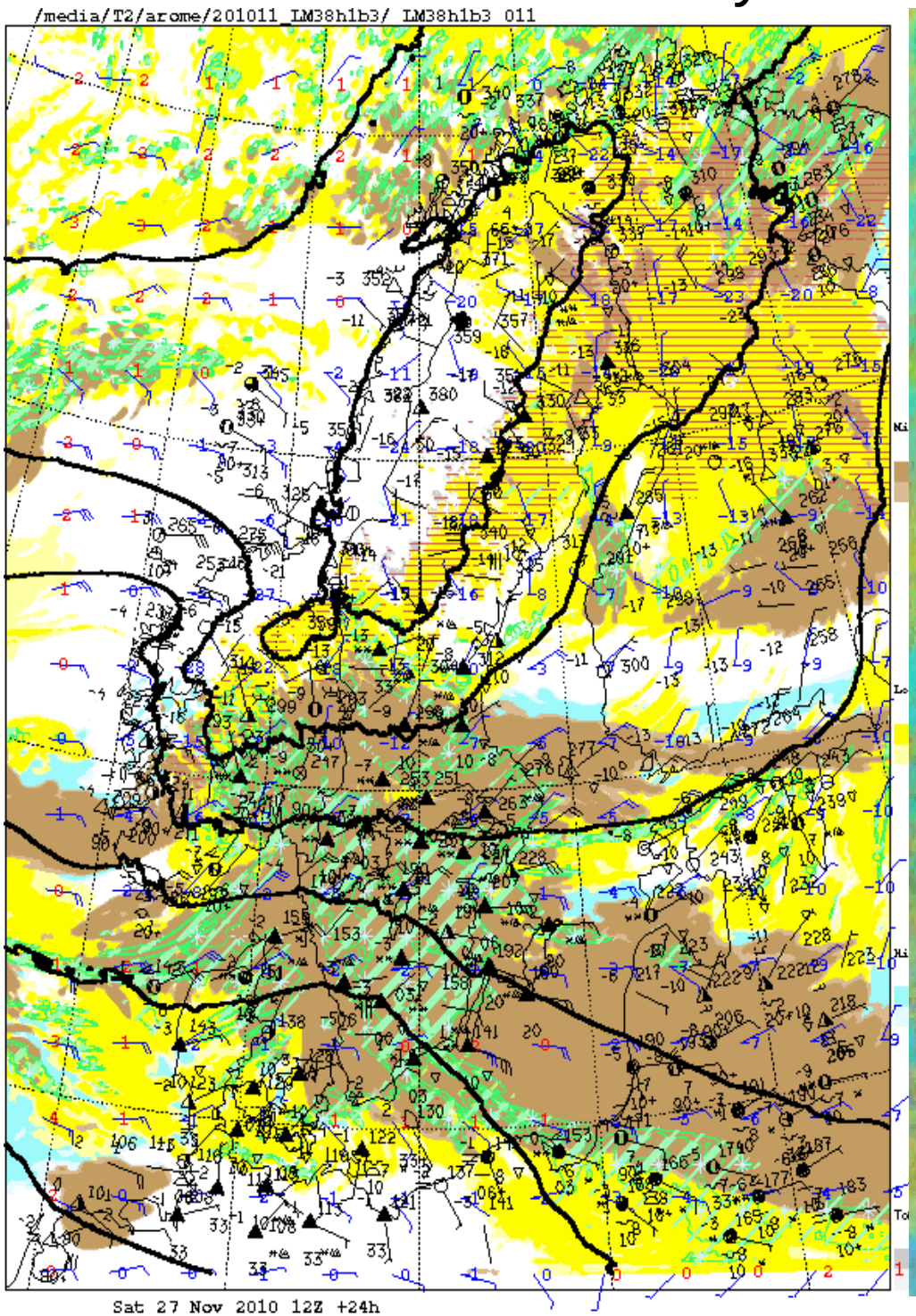


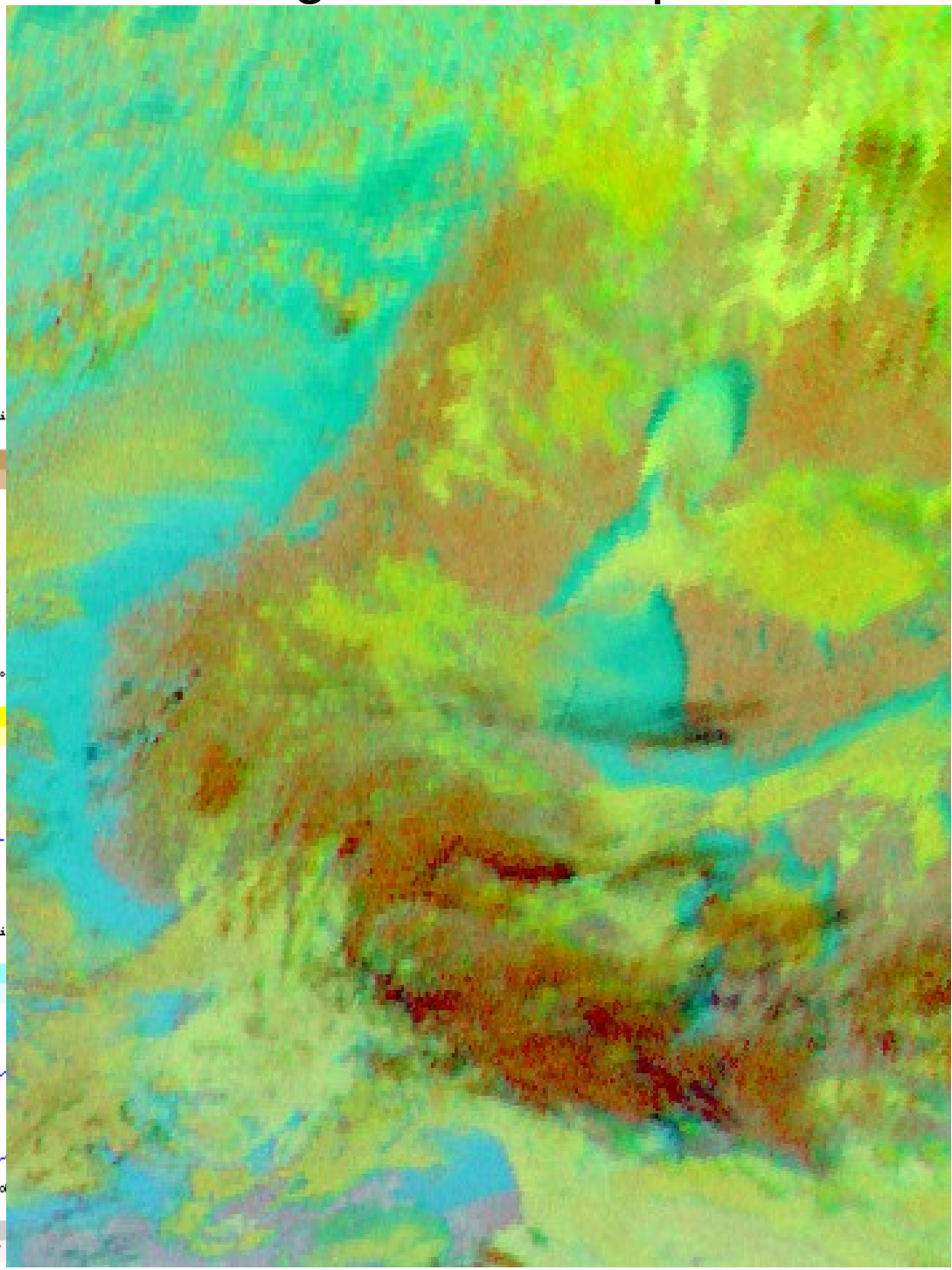
Left mod , right Satellite picture



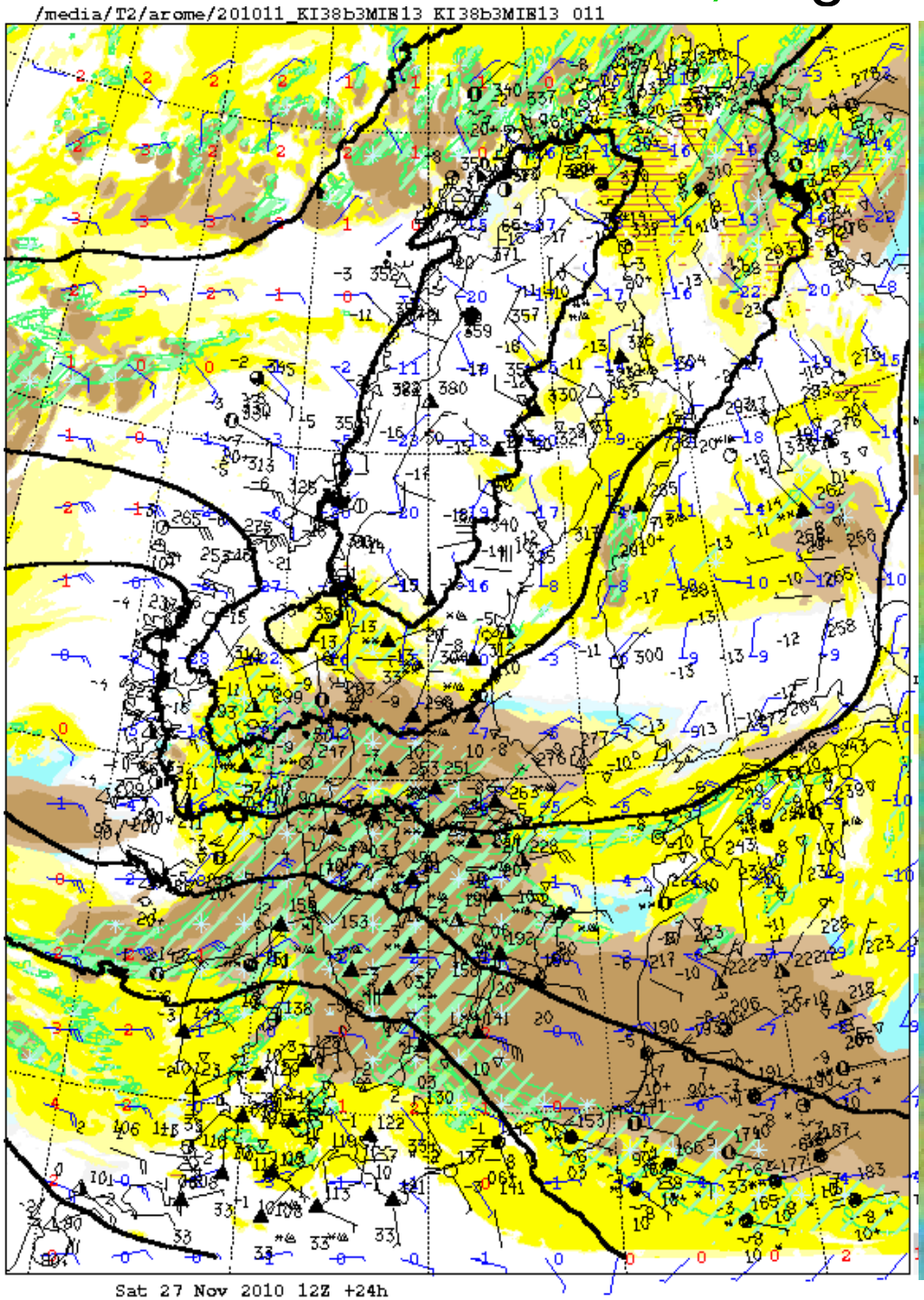


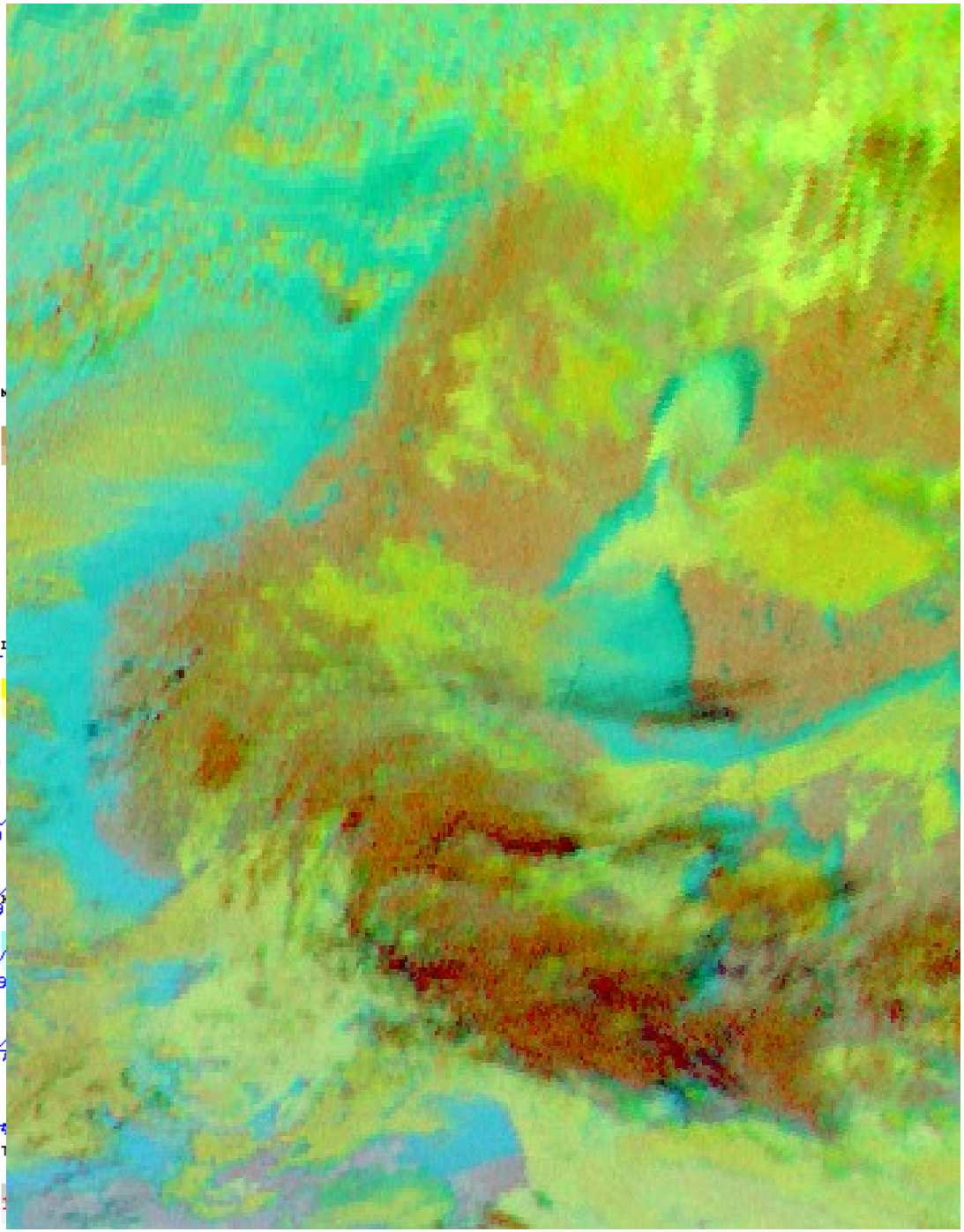
Colder case with heavy snow. Left ref right : satellite picture



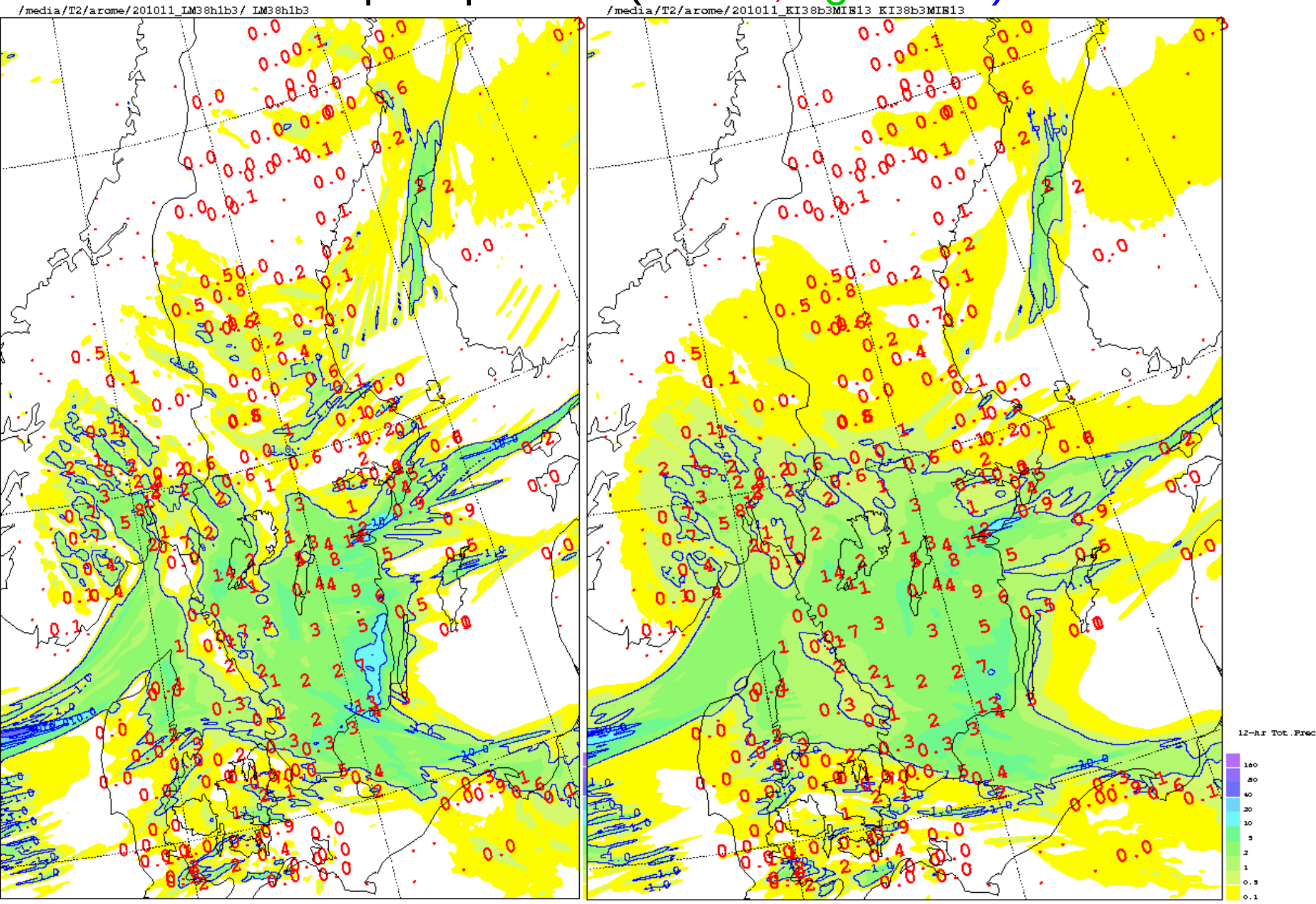


Left mod, Right , Satellite picture





12h precipitation (left ref, right mod)



Summary

- Winter : With OCND2: Better T2m, clouds , cloud base, more realistic upper air relative humidity, (but not lower MAE,RMSE etc). Somewhat worse precipitation, except for large amounts. Somewhat increased positive bias of MSLP. (This bias is reduced with RACMO turbulence.)
- Summer: Mainly neutral impact, but better frequency bias for precipitation

Remaining problems:

- Too cool lower lower troposphere in winter. Probably a reason for slightly worse MSLP.
- Too much of light precipitation (=snow, graupel) in winter (seems to be better with RACMO turbulence, so it seems partly to be a cloud top entrainment problem)

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Thank you for listening !

Extra things, not have time to mention etc ...

Plans rest of 2015

- Continued studies of the microphysical processes, tunings (Such as constants used for gamma functions, etc)
- Can optimization's introduced in OCND2 be used also elsewhere in the physics, such as turbulence.

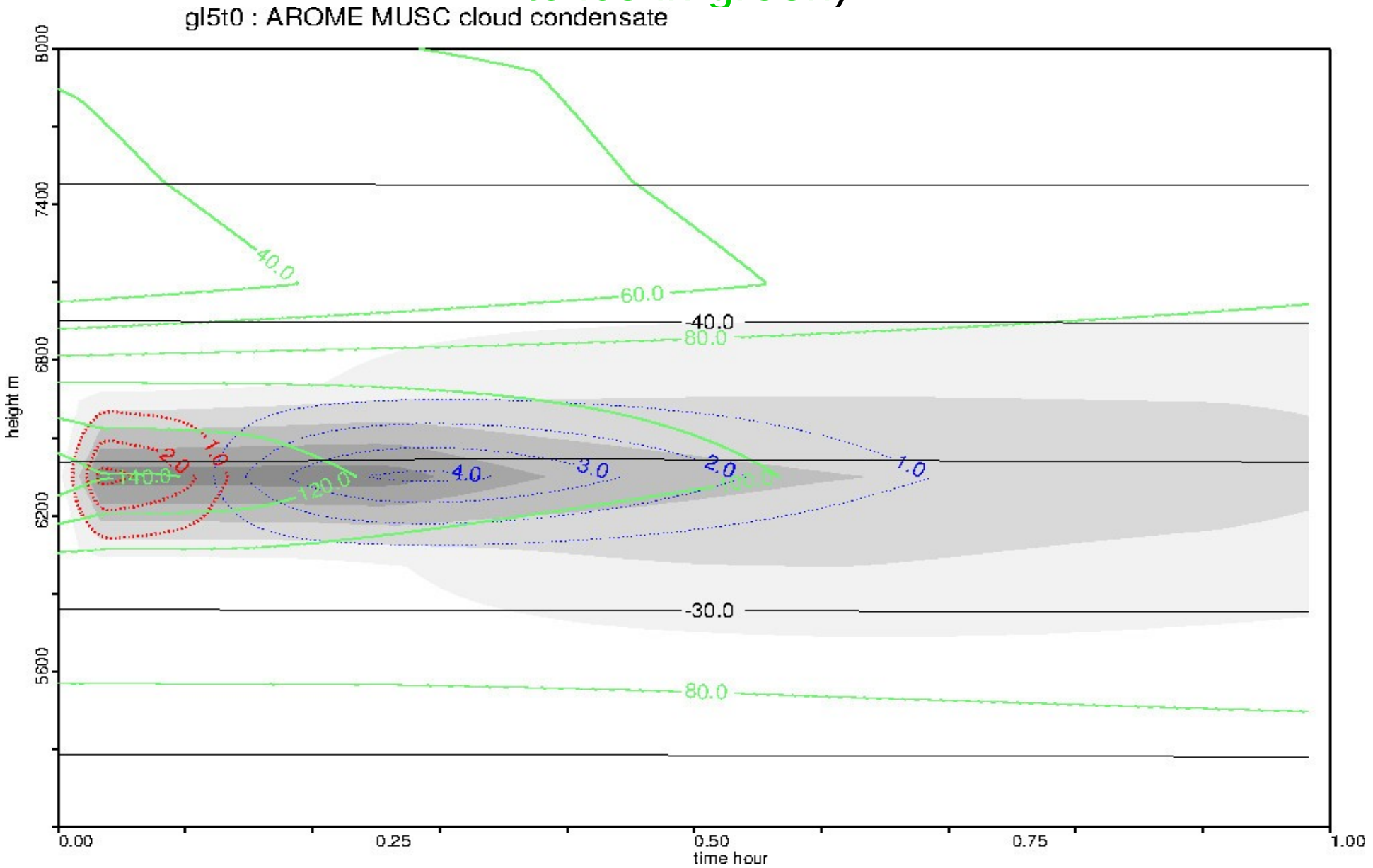
1D tests (MUSC)

- Test of supercooled altocumulus case, Heymsfield et al (1991): Ideally, it should give a mainly supercooled liquid cloud of about -30 C. Mixed result. Probably the vertical resolution is too coarse.
- Test of orographic wave cloud around -35 C , Heymsfield and Miloshevich (1993). Ideally it should start as a water cloud, but rather quickly glaciate. See next slide.
- References :

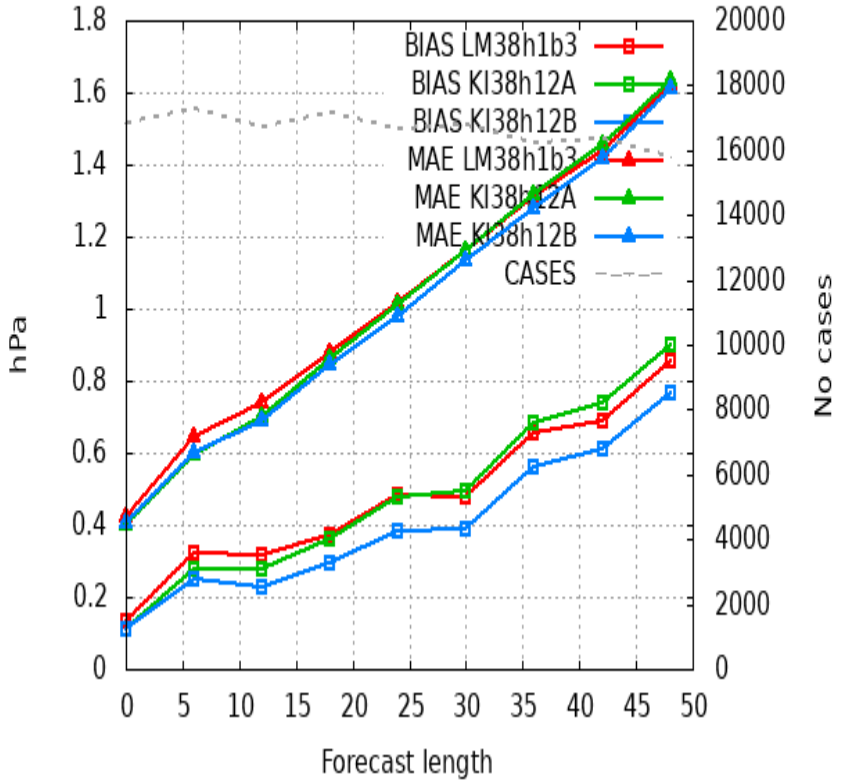
Heymsfield et al, 1991 : An observational and theoretical study of highly supercooled altocumulus. JAS VOL 48.

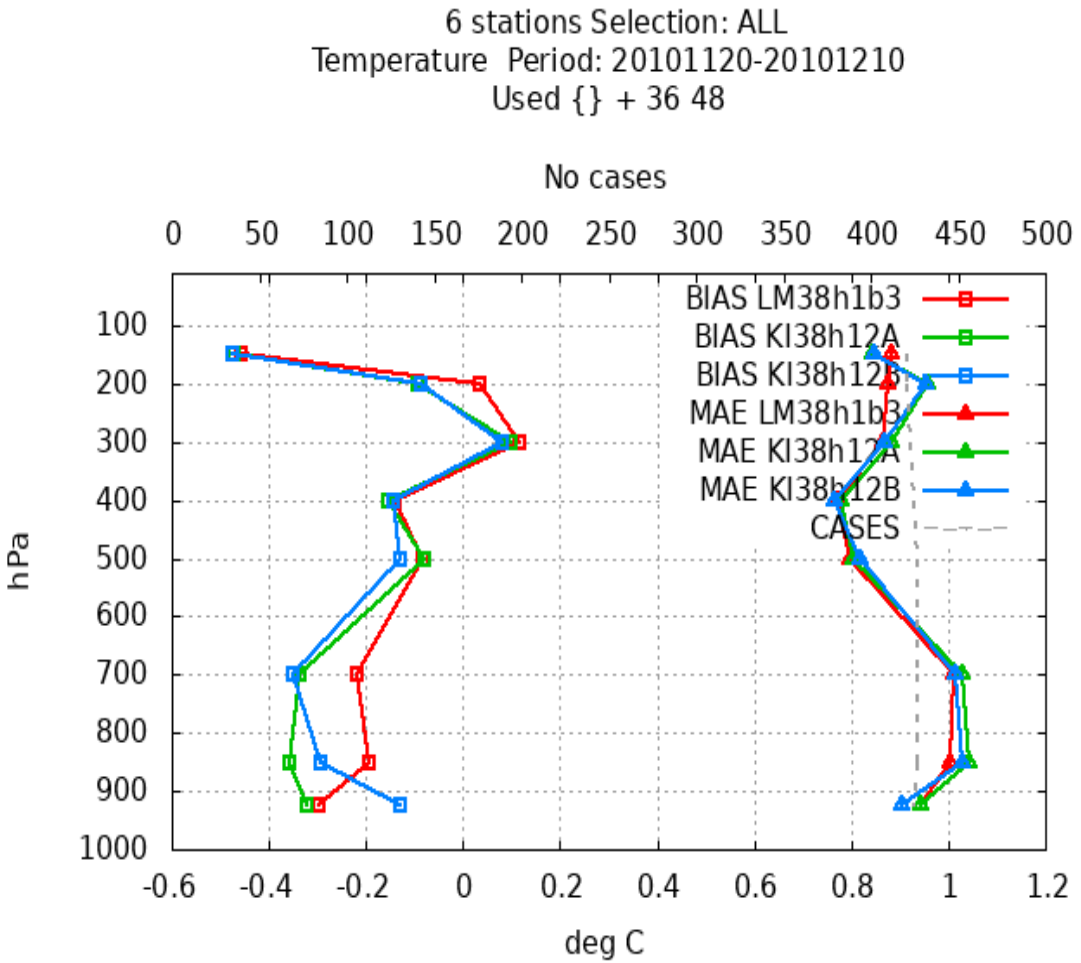
Heymsfield and Miloshevich 1993: Homogenous ice nucleation and supercooled liquid water in orographic wave clouds. JAS VOL 50

Result with OCND2 (with OCND2=F ,ice from start, not shown, Red= liquid, blue=ice. Forecast length: 1 hour. Model clouds are shaded. Temperature: black lines. RH with respect to ice in green)

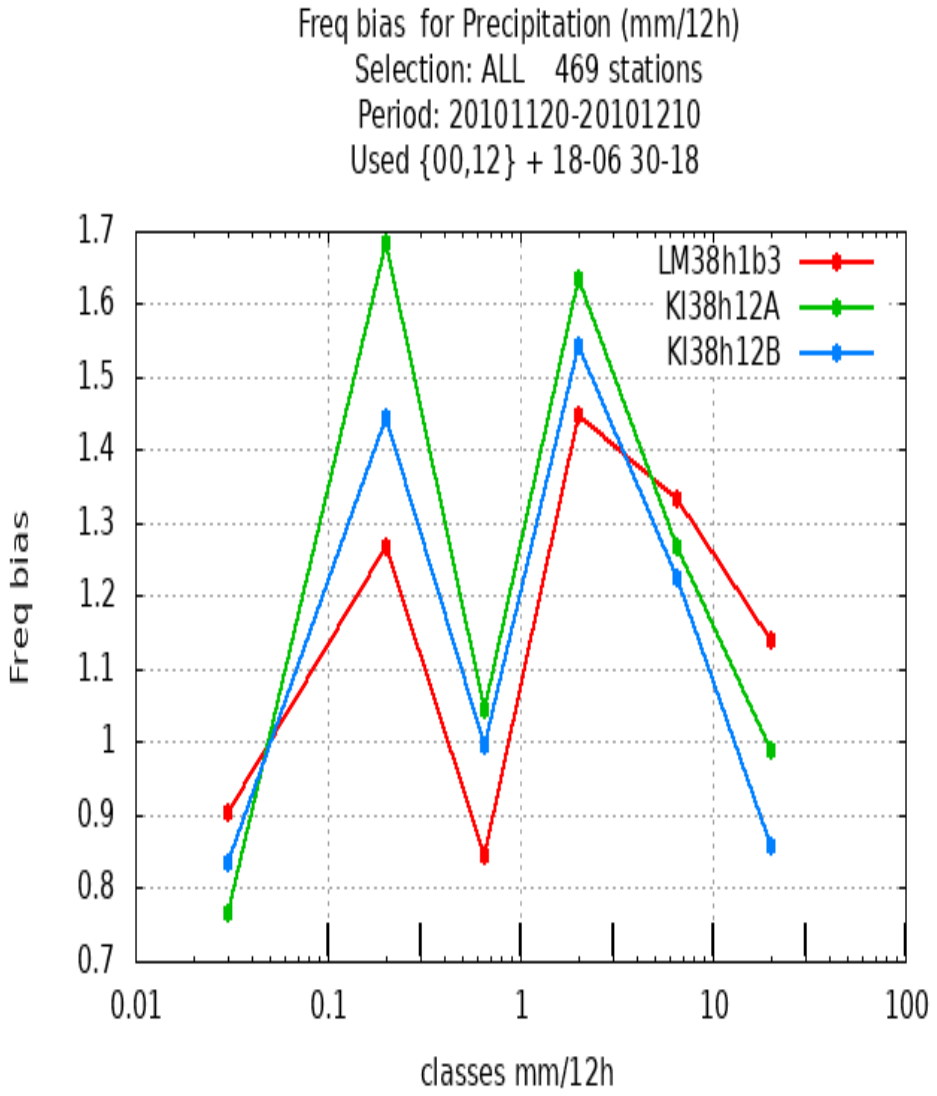


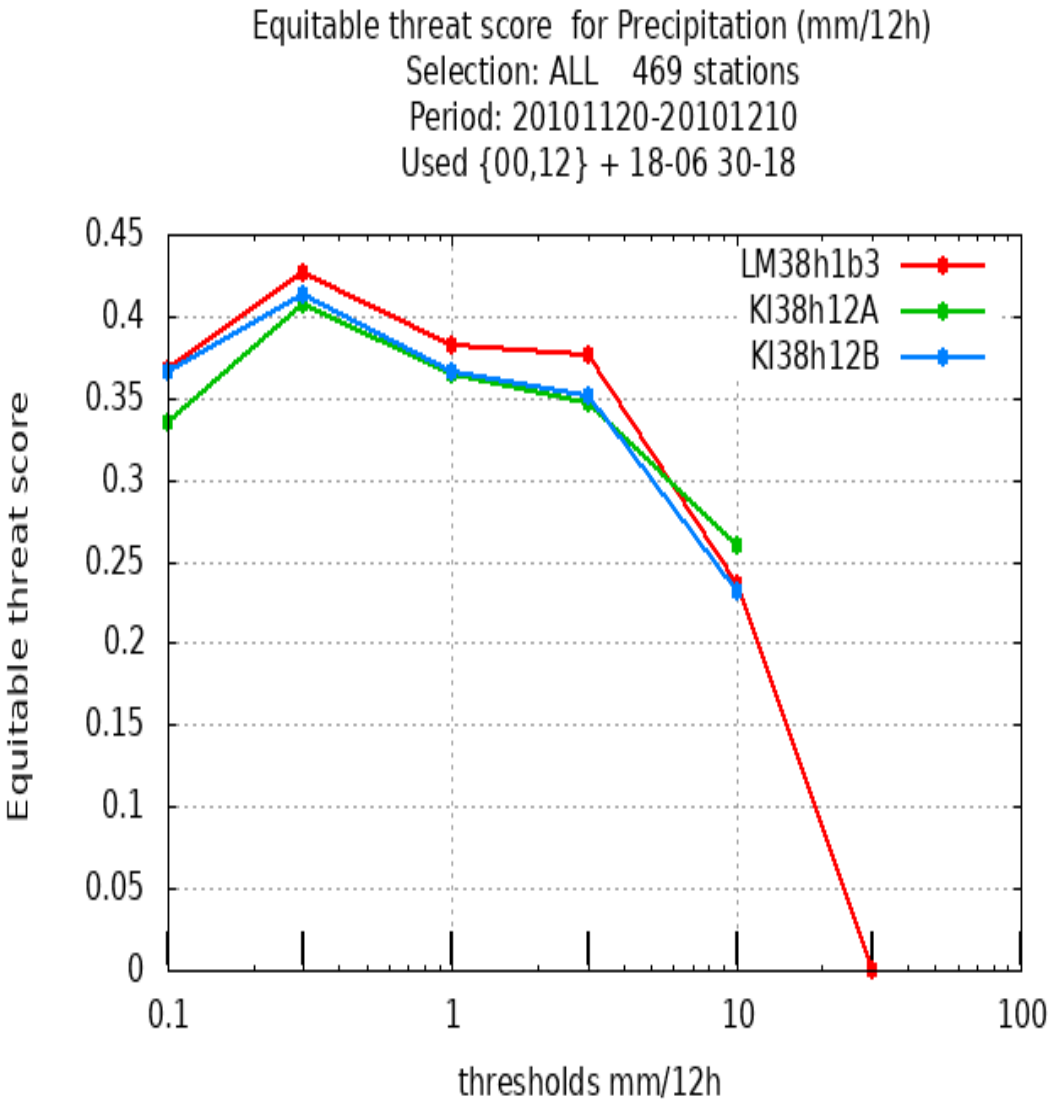
Racmo test result of special interest (1)





Racmo test result of special interest (2)





Extra verification stuff (winter)

Parameter	len	BIAS	MAE	RMSE	STDE	N	BIAS	MAE	RMSE	STDE	N
PS	48	0.846	1.615	2.146	1.972	15793	0.963	1.657	2.193	1.970	15793
TT	48	-1.371	3.089	4.357	4.135	22333	-0.708	2.780	3.951	3.887	22333
NN	48	0.505	1.999	3.213	3.173	8498	0.337	1.772	2.999	2.980	8498