Recent development of cloud microphysics (ICE3) within MetCoOp

ASM meeting April 2017 Helsinki, Karl-Ivar Ivarsson

Outline :

- Improved forecasts of supercooled rain
- Better Interaction/consistency with radiation
- Remove unnecessary differences between OCND2= TRUE/FALSE
- Short summary
- (Tuning parameters microphysisc cy40h1.2)

Improved forecasts of supercooled rain (operational since 2017-01-25)

Problem: Several events with supercooled rain are not forecast properly.

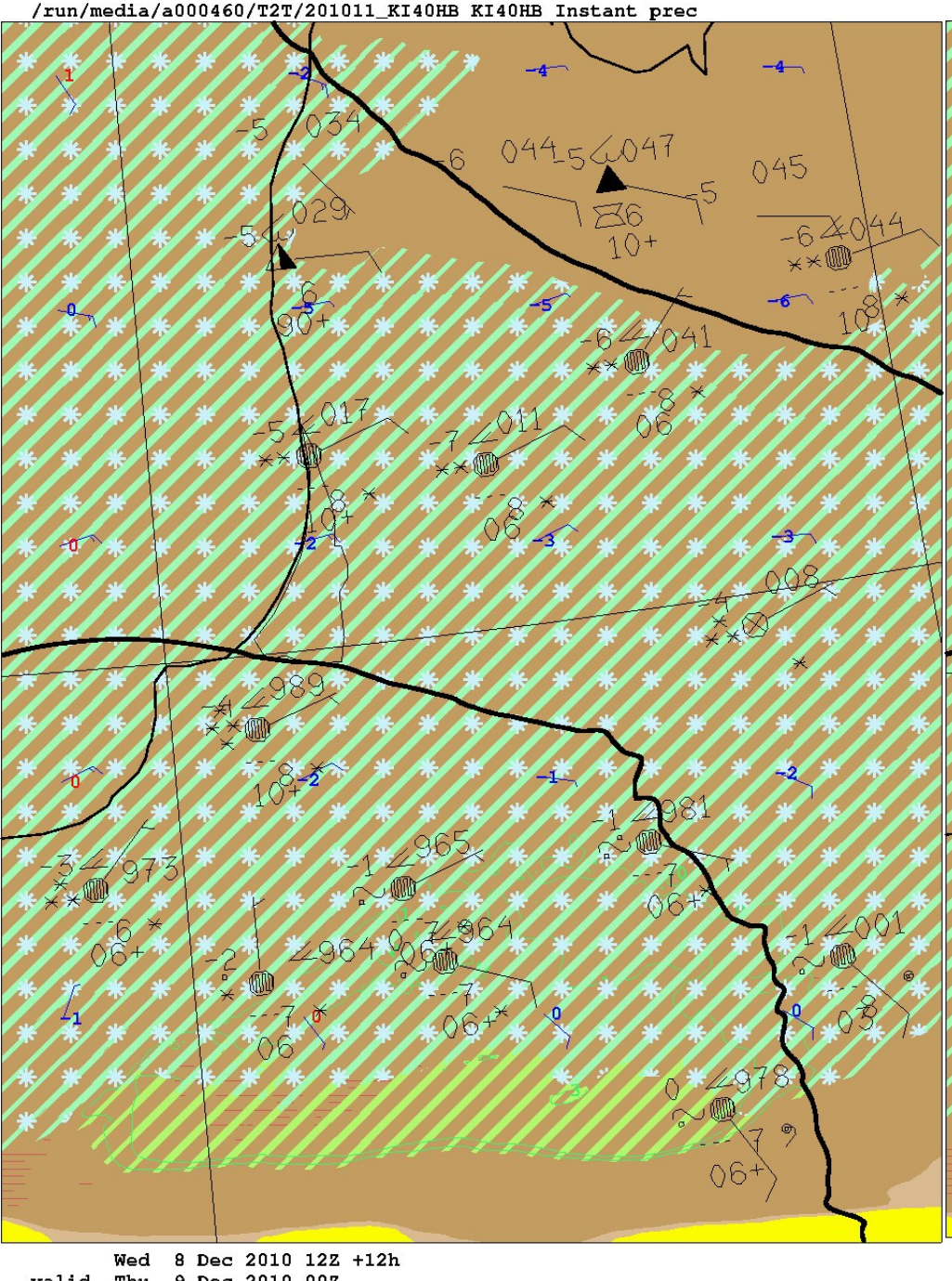
- Reason 1: Missing warm layer in AROME (NOT solved)
- Reason 2: Too fast refreezing of supercooled rain. (Solved)

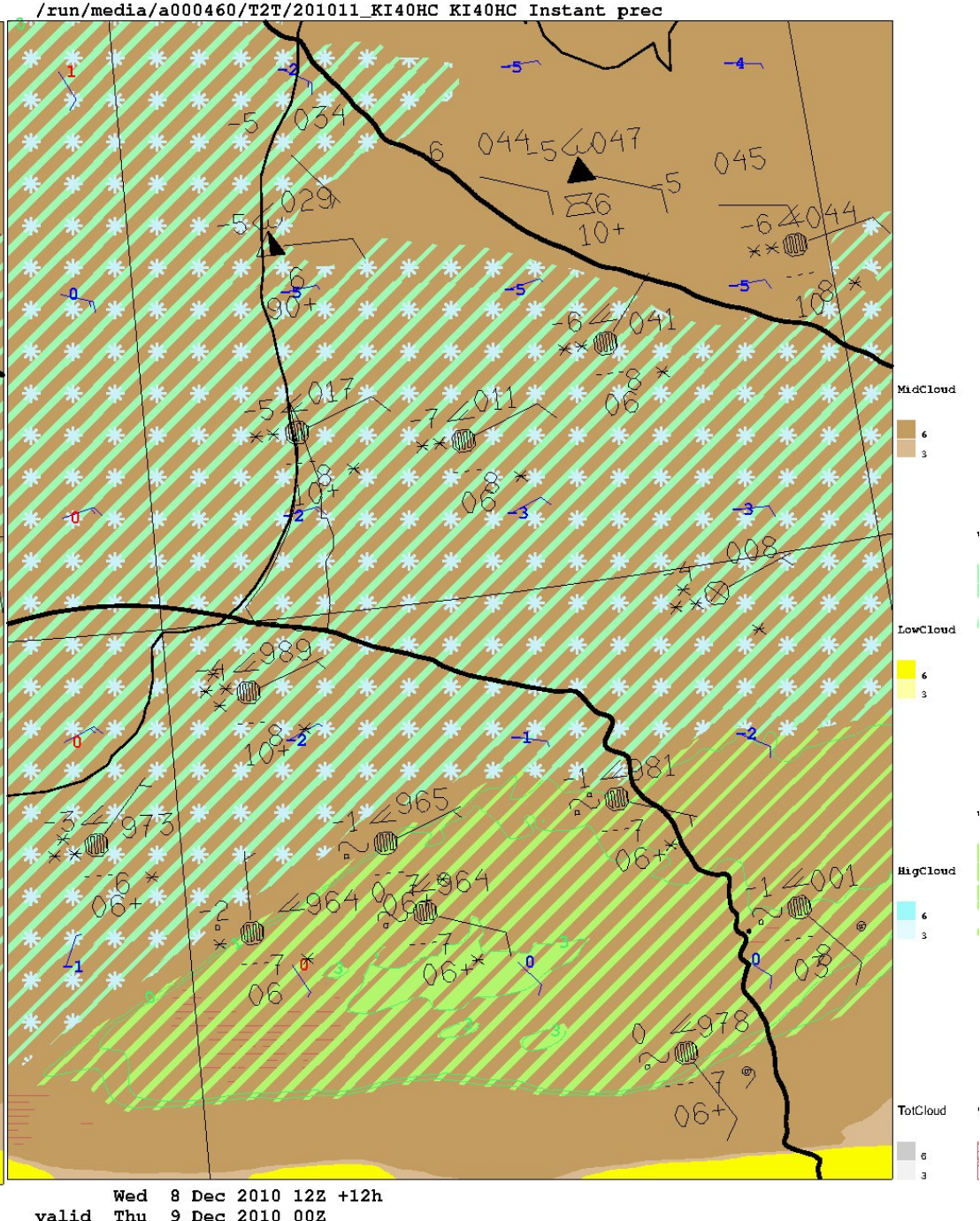
Slower refreezing by: (see rain_ice.F90 for details)

- 5.2.4: No “raindrop accretion on the small sized aggregates” (supercooled rain → snow)

  5.2.6: Only “raindrop accretion-conversion of the large sized aggregates into graupels” if mixing ratio of snow > 1.0E-5
- 6.1: Only “rain contact freezing” for ice number concentration > 1.0E-8
- 6.3: Only compute the wet or dry growth case when mixing ratio of graupel > 3.0E-7

Example of improved supercooled rain forecasts (SE Baltic 2010120812 UTC +12 h) original to the left mod to the right





Better interaction/consistency with radiation

- Use same CCN in radiation as in microphysics
  Currently (land,sea): (300,100) in microphysics, but (900,50) in radiation
- Radiation uses output cloud cover to determine subgrid-scale distribution of water and ice – but it may be dependent on the mixing-ratio and temperature as well – Use the calculated subgrid fractions in microphysics instead
- … ...

Remove unnecessary differences between OCND2= TRUE/FALSE

Main (technical) differences OCND2 (FALSE/TRUE)

- Only liquid determined from statistical cloud scheme
- Modified output cloud cover
- Reduced deposition/evaporation of snow and graupel by a factor.
- Turn large ice crystals to snow
- Replace Bergeron-Findeisen with deposition/evaporation of ice

Reduced deposition/evaporation of snow and graupel by a factor

Present OCND2 (pragmatic):

- Reduce deposition/evaporation of snow with 90 % (factor 0.1)
- Reduce deposition/evaporation of graupel with 75 % (factor 0.25)

Tentative alternative : Use a different size distribution/number concentration for snow:

- Use XCCS = 1.0E3,XCXS = 0.1 (or near those) in ini_rain_ice.F90 for snow instead of original values 5, 1. Gives reduced deposition/evaporation for low mixing ratios of snow, but the same or higher- for high mixing ratios **Preliminary results: Little better precipitation, little worse clouds**

Bergeron-Findeisen vs deposition/evaporation of ice

OCND2=F:

- Use ice crystal size distribution based on general gamma function.
- Assume plates
- Large effect of ventilation factor for crystal growth/decay, especially for temperatures just below freezing
- No subgrid-scale parametrization

Bergeron-Findeisen vs deposition/evaporation of ice

OCND2=T: (Present version)

- Ventilation factor for crystal growth/decay ignored since the fall speed of tiny ice crystal is assumed to be low.
- Use one mean size of ice crystals.
- Subgrid-scale parameterization with one ice super saturated part and one sub saturated part
- Spherical crystals, but account for non-spherical effects by a simple function

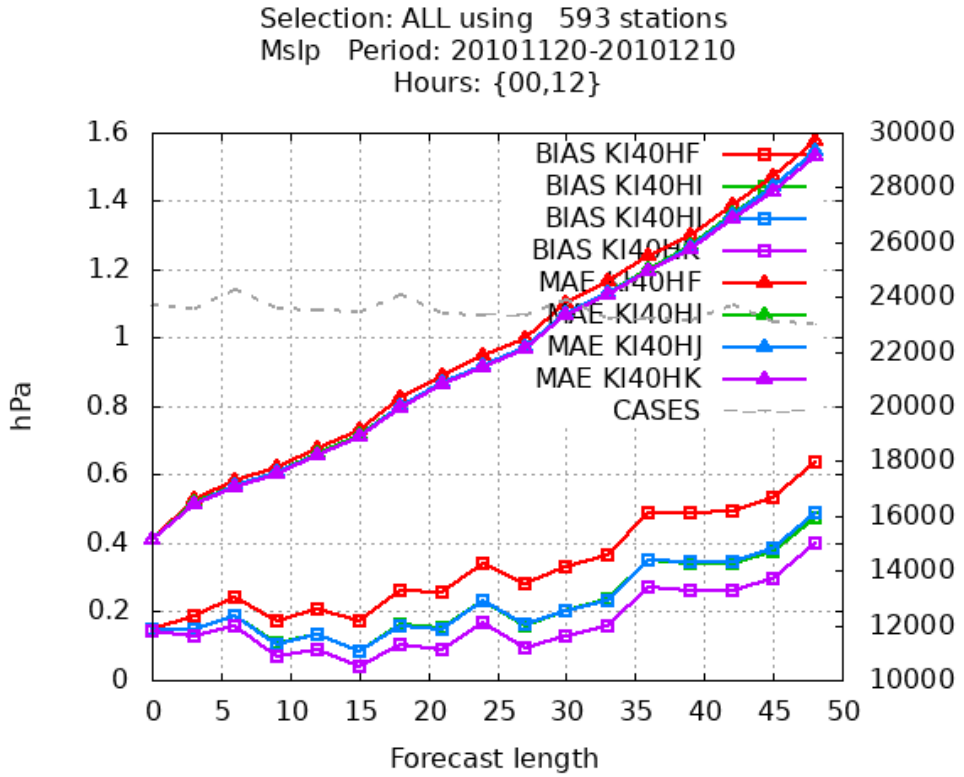
Bergeron-Findeisen vs deposition/evaporation of ice

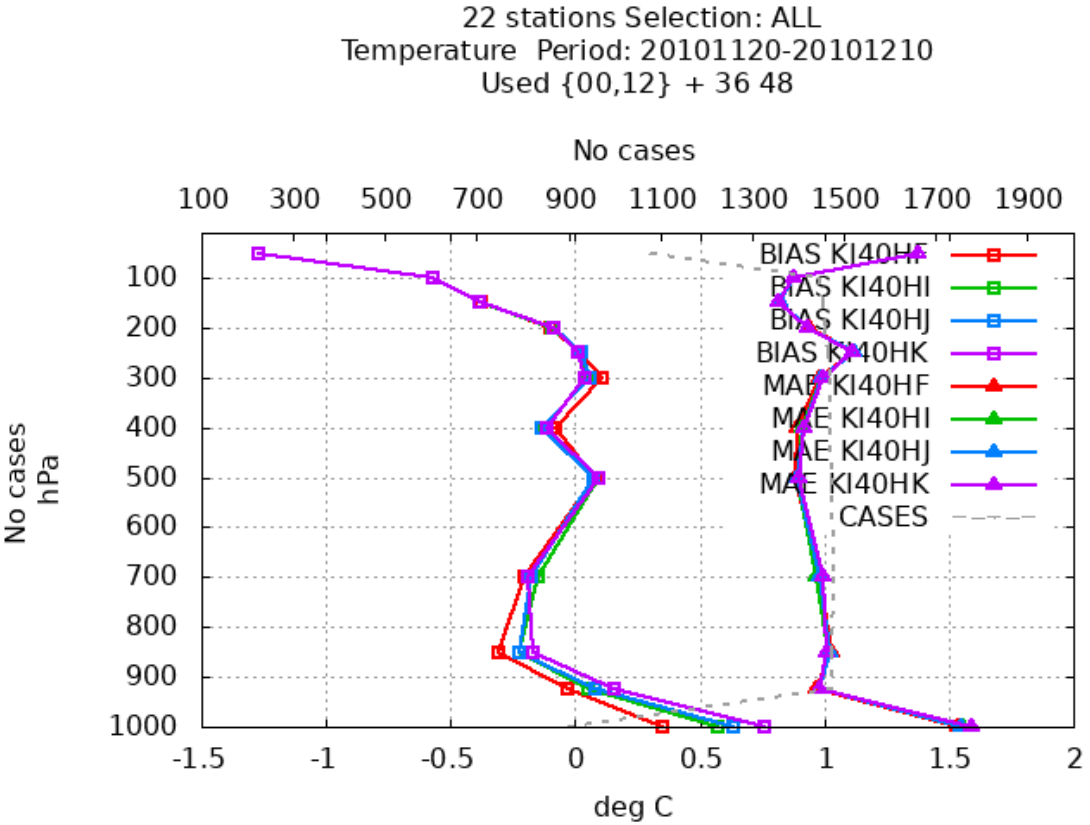
OCND2=T: (Test version, KI40HK, LMODICEDEP=T in cy40h1.2)

- Ventilation factor for crystal growth/decay still ignored
- Use (same) ice crystal size distribution based on general gamma function as with OCND2=F.
- Subgrid scale parameterization with one ice super saturated part and one sub saturated part
- Assume plates. (as OCND2=F)

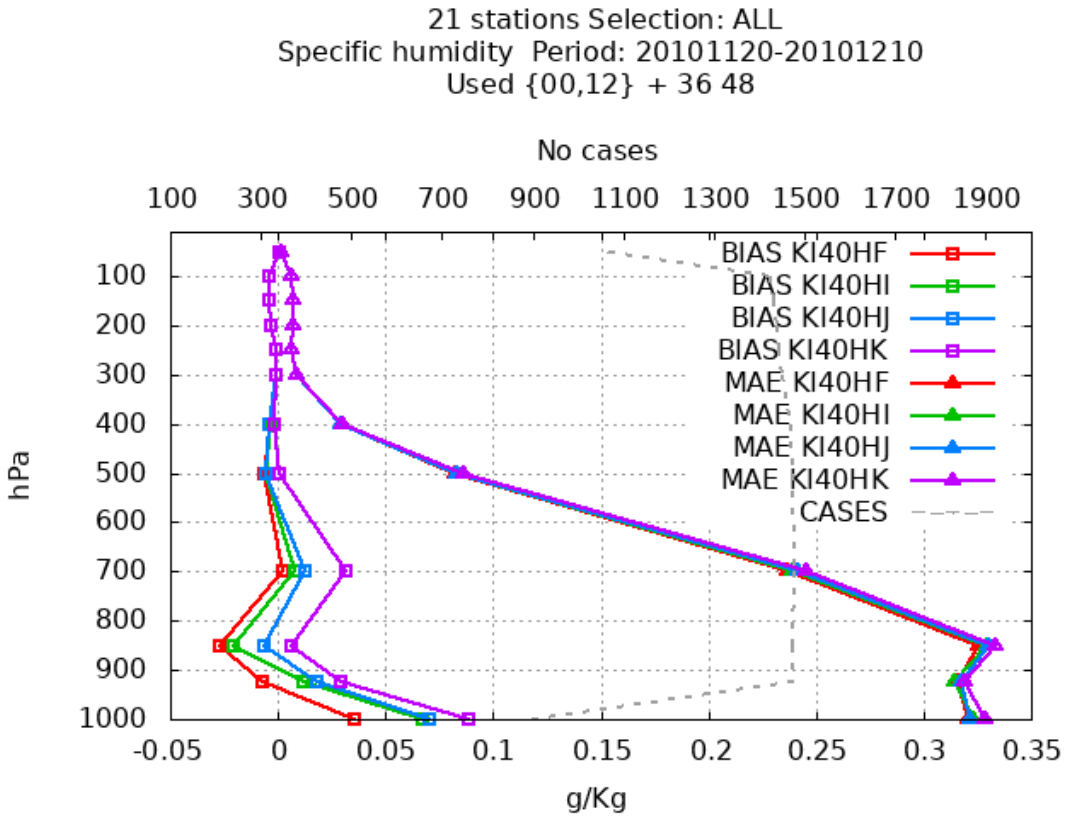
Comparison winter MSLP, T(pressure levels) KI40HC = orig OCND2, KI40HI : with more consistent subgrid scale handling of ice and liquid in microphysics and radiation.KI40HJ: KI40HI with LGRSN. KI40HK: as KI40HJ but also LMODICEDEP=T

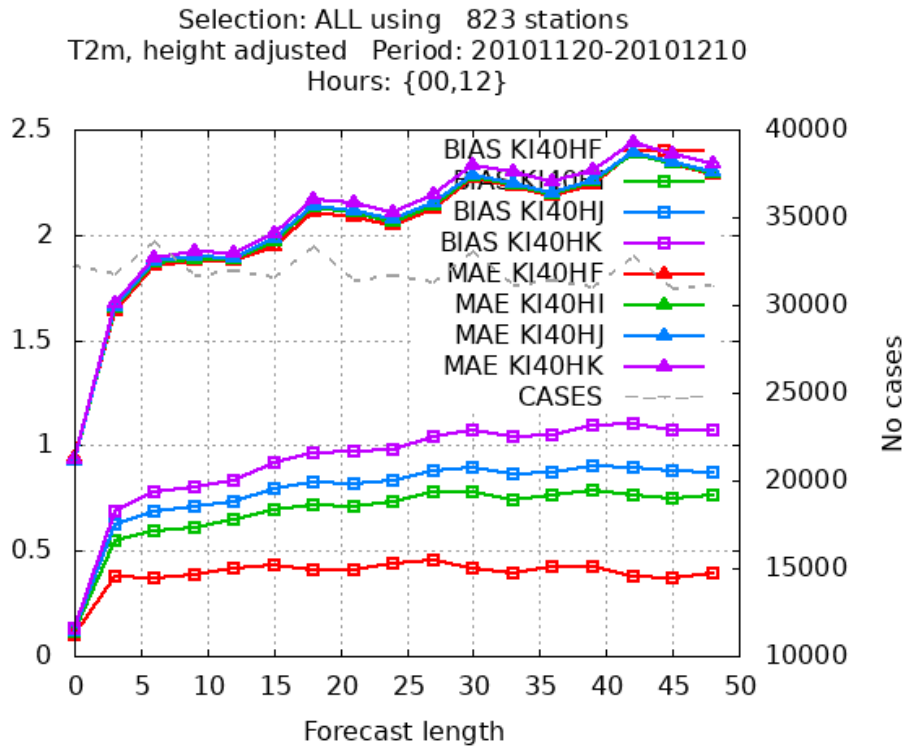
(Note that VSIGQSAT = 0.02 in all experiments)





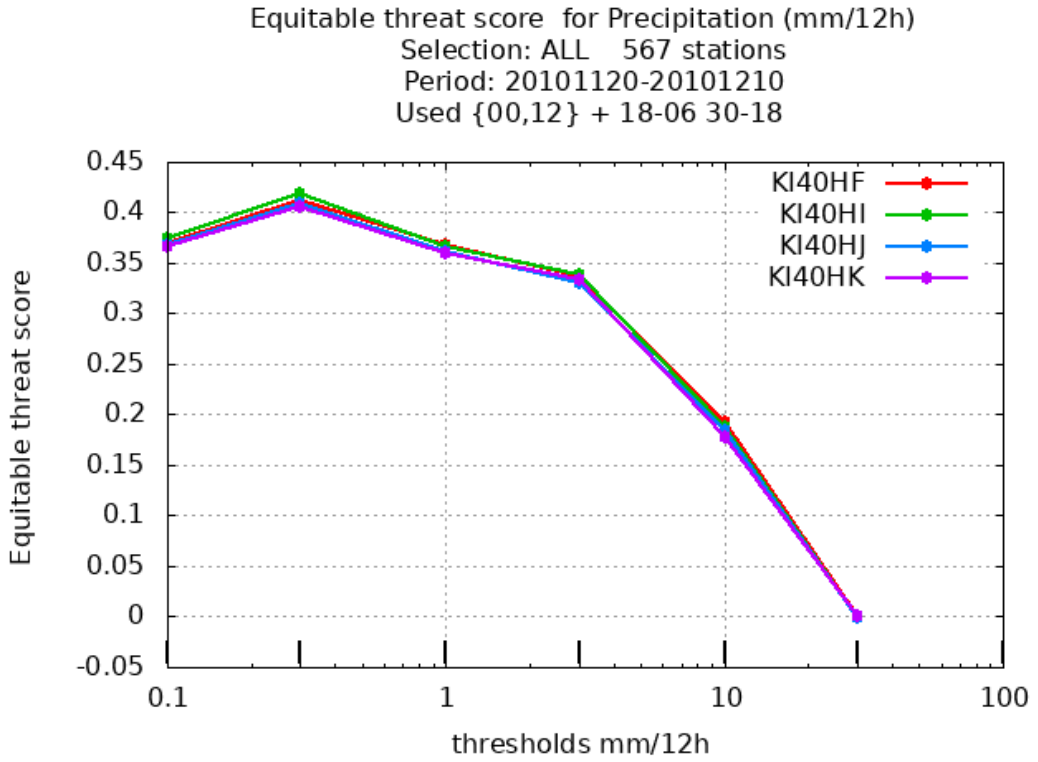
Comparison winter q (pressure levels) T2m,KI40HC = orig OCND2, KI40HI : with more consistent subgrid scale handling of ice and liquid in microphysics and radiation.KI40HJ: KI40HI with LGRSN. KI40HK: as KI40HJ but LMODICEDEP=T

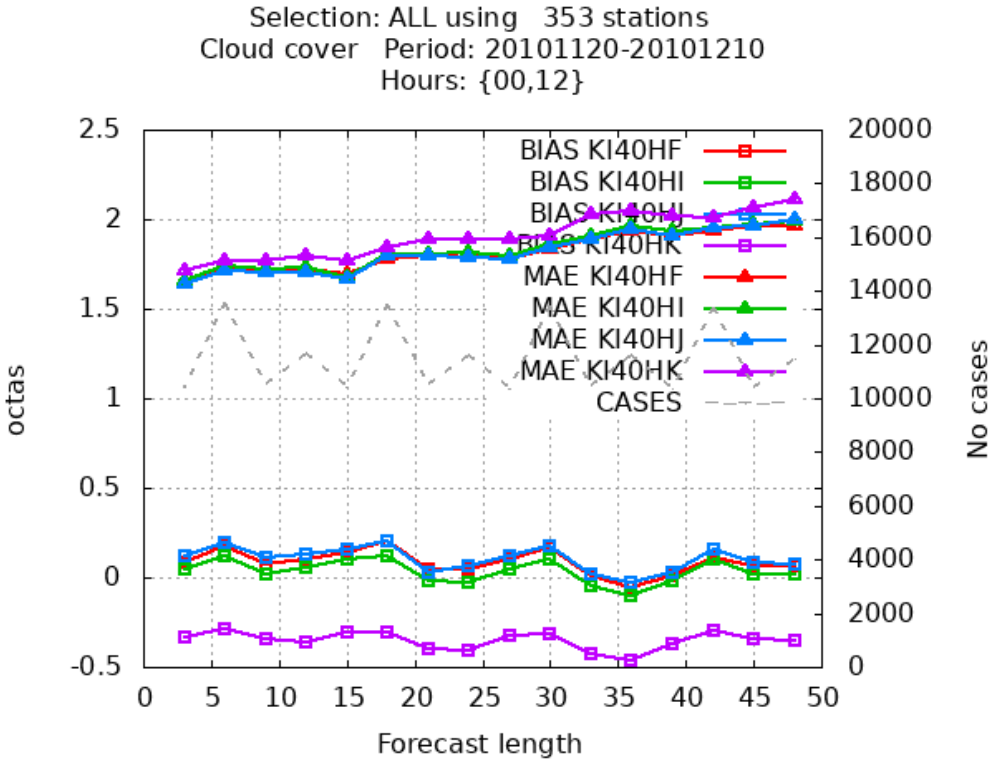




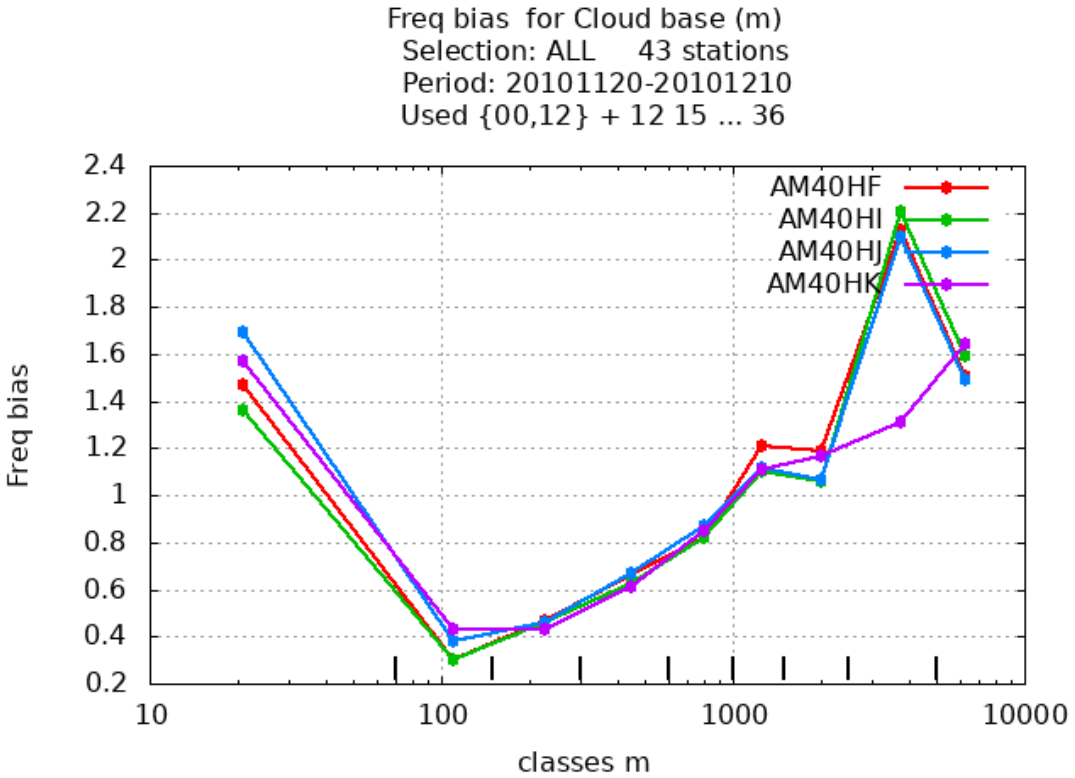
Comparison winter 12h precipitation and total cloudsiness

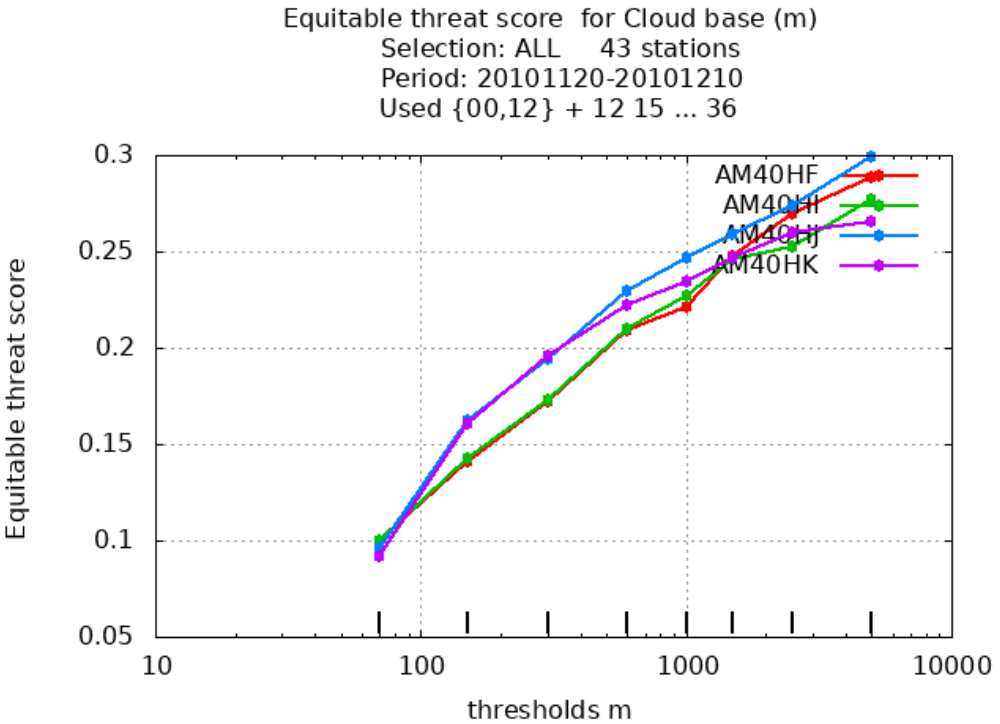
KI40HC = orig OCND2, KI40HI : with more consistent subgrid scale handling of ice and liquid in microphysics and radiation. KI40HJ: KI40HI with LGRSN. KI40HK: as KI40HJ but also LMODICEDEP=T





Comparison winter q (pressure levels) T2m, AM40HC = orig OCND2, AM40HI : with more consistent subgrid scale handling of ice and liquid in microphysics and radiation. AM40HJ: AM40HI with LGRSN. AM40HK: as AM40HJ but also alternative deposition/evaporation of ice.





Summary:

- Improve forecasts of supercooled rain: works well, but missing warm layers unsolved
- Interaction/consistency with radiation: Works satisfactory (less MSLP bias), but a lot of job remains (regarding effective radius etc). More complicated relation cloudiness -T2M
- Consistency OCND2 TRUE/FALSE in ICE3 (where it is possible): Progressing …

Appendix: Tuning parameters available for cy40h1.2

Default: (Does not change anything)

- LMODICEDEP=FALSE (TRUE: Use new deposition/evaporation of ice within OCND2)
- RFRMIN(1:6)=0.
- RFRMIN(7:9,11)=1.
- RFRMIN(10) =10.

Supercooled rain mod:

- RFRMIN(1)=1.0E-5 (higher value means more supercooled rain and somewhat less graupel)
- RFRMIN(2)=1.0E-8 " "
- RFRMIN(3)=3.0E-7 " "
- RFRMIN(4)=3.0E-7 " "
- RFRMIN(7)=0. (higher value means less supercooled rain and somewhat more snow)

Reduce graupel:

- RFRMIN(5)=1.0E-7 (Higher value means less graupel and more snow)
- RFRMIN(6)=0.15 (Higher value means more graupel and less snow)
- RFRMIN(8)= 1. (> 1. Increase melt of graupel, < 1 decrease it. 0.5 recommended by Sander Tijm)
- RFRMIN(9) =1. (> 1 means increase IN-concentration and <1 decrease)
- RFRMIN(10)=10 (>10 means faster Kogan autoconversion <10 slower, only active for LKOGAN=T)
- RFRMIN(11)=1. (Setting e.g. 0.01 means that subgrid-scale fraction of cloud water is used. Minimum cloud fraction=0.01. Only active for LKOGAN=T)