The Impact of cloud condensation nuclei (CCN) concentration and ice- nucleus (IN) concentration on clouds and precipitation in Hirlam

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Utrecht, the Netherlands

In this presentation:

- Recent developments of the Rasch-Kristjansson (RK) condensation scheme and Kain-Fritsch (KF) convection scheme.
- Impact of CCN concentration in the current parametrization of clouds, condensation and radiation.
- Results of CCN sensitivity tests
- Impact of IN concentration in the current prognostic cloud ice formulation.
- Results of ice nuclei concentration sensitivity tests

Recent developments of the Rasch-Kristjansson (RK) condensations scheme and Kain-Fritsch (KF) convection scheme.

- Some tuning, code cleaning.
- Possibility to use Bectold KF
- New max-random cloud overlap formulation (also in our local versions of Alaro,Arome)
- IFS – coding (Both RK and KF)

Impact of CCN concentration in the current parametrization of clouds,condensation and radiation.

- Clouds – not directly.
- Condensation : the expression for the Kogan autoconversion of cloudwater
- Radiation : Effective radius :

$$r_e = \left(\frac{3q_l}{4\pi\rho_l k C_{cn}}\right)^{1/3}$$

- Not included : Haze, affecting radiation, hygroscopic effects on the effective relative humidity for condensation ... ...

Experiments:

- 22km resolution 40 levels. January 2006 + July 2007. Newsnow scheme + “orosur” + QNSE + “Colin-2”-radiation + ifs-coded KFRK (old KF)
- Current CCN concentration in RK and radia (C3J) replaced by a change in boundary layer. (no change above)
- A max in central Europe (C3o) , min near the north pole.
- Reversed (C3p, unrealistic, but interesting for a sensitivity test)

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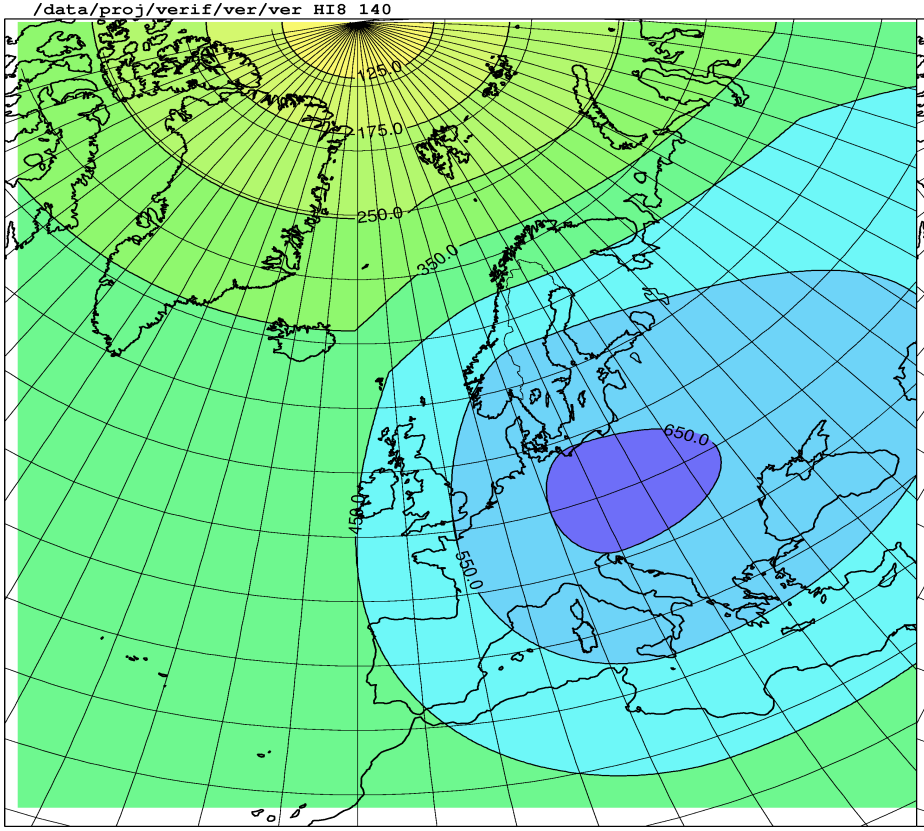

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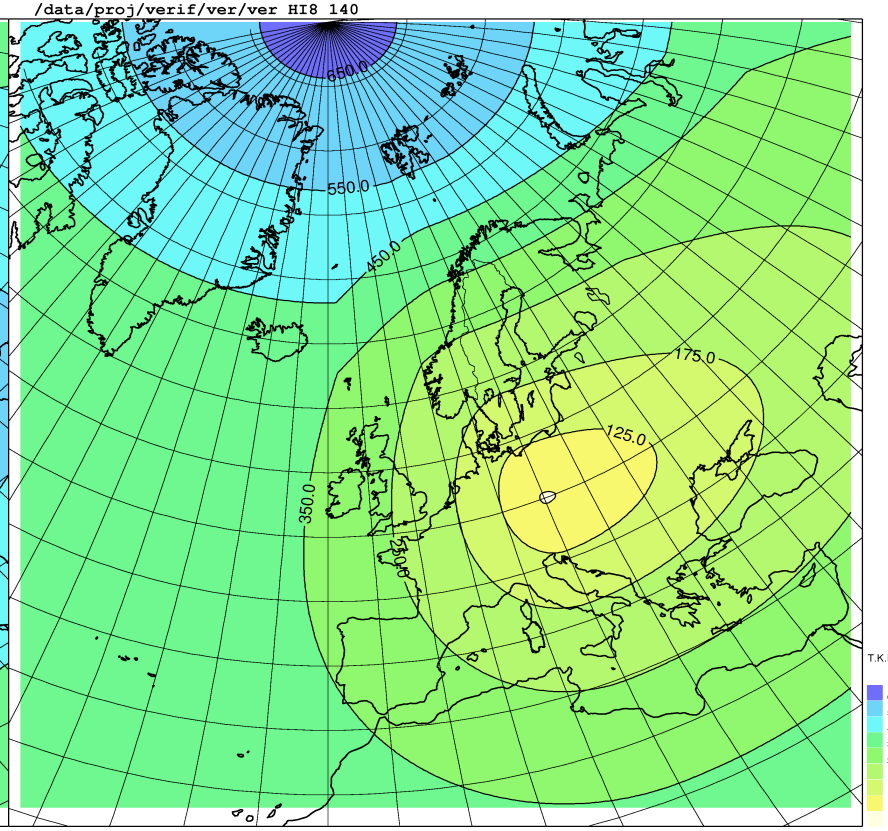

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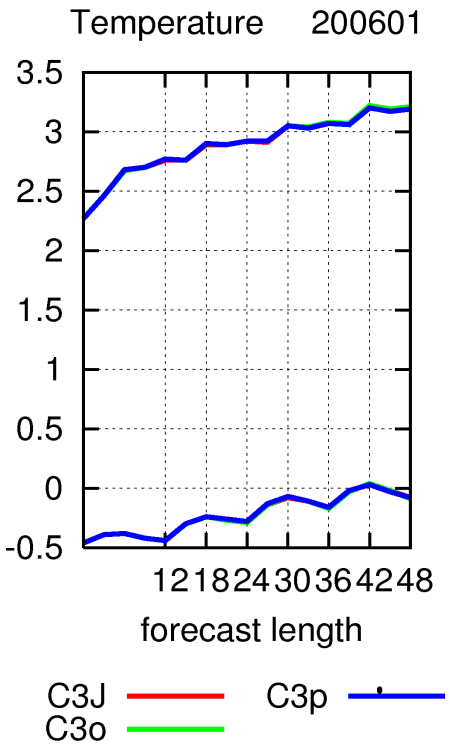
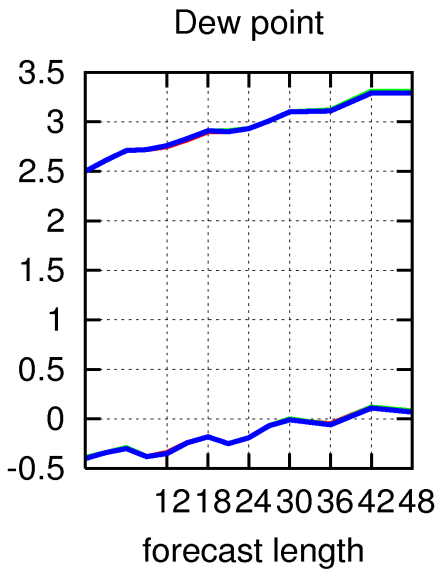
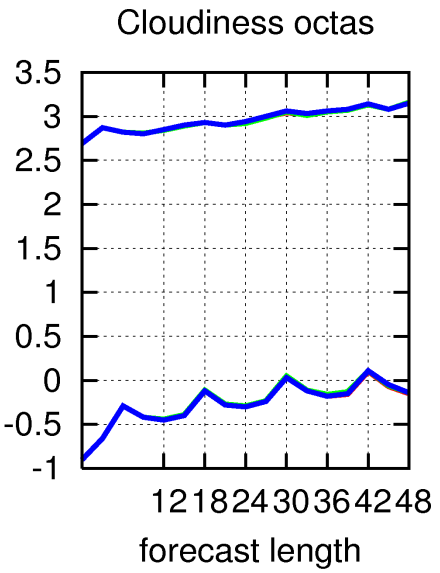
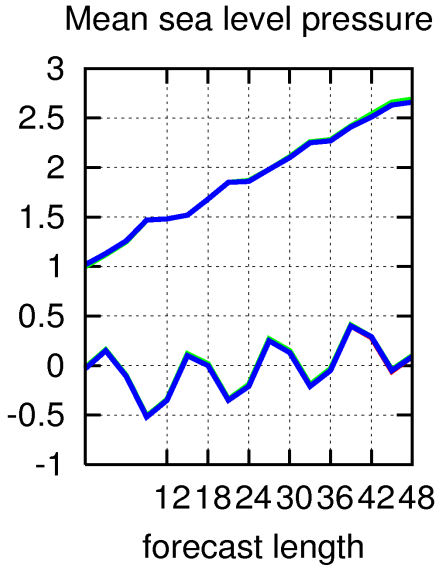
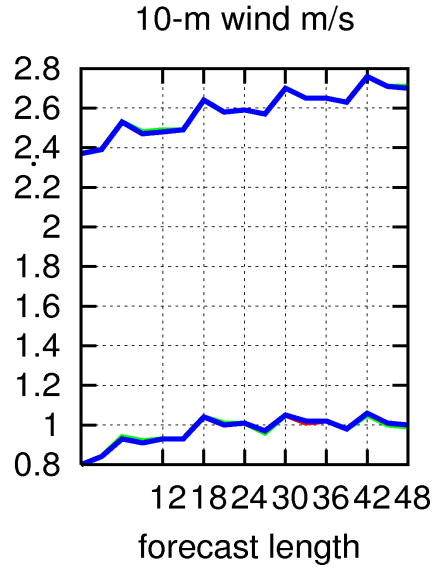
Verification winter: C3J: orig CCN concentration. C3o : most in central Europe
C3p: reversed



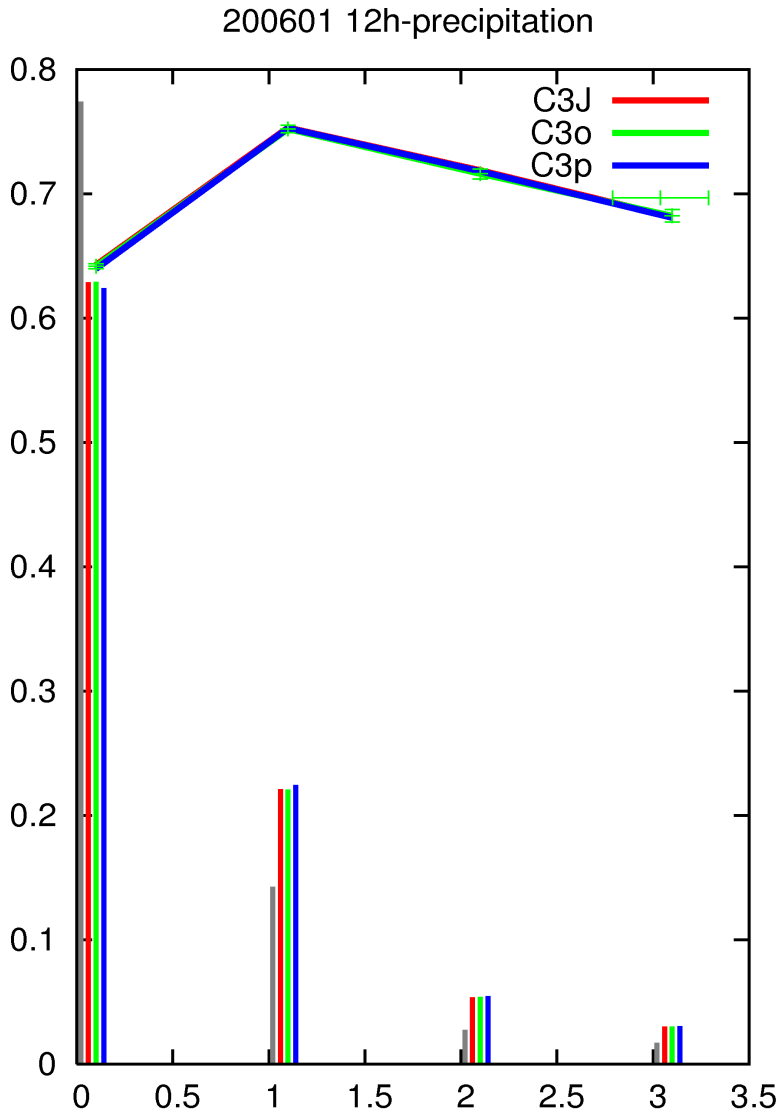


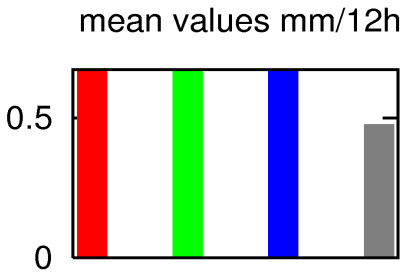


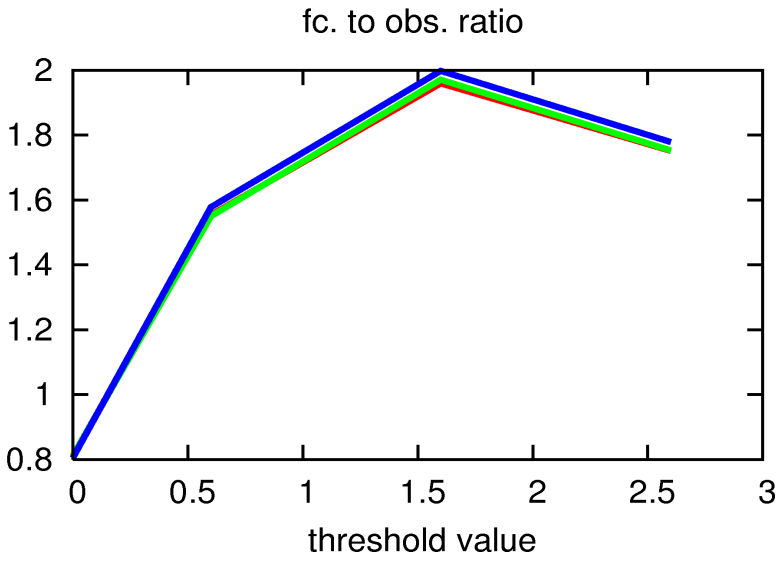




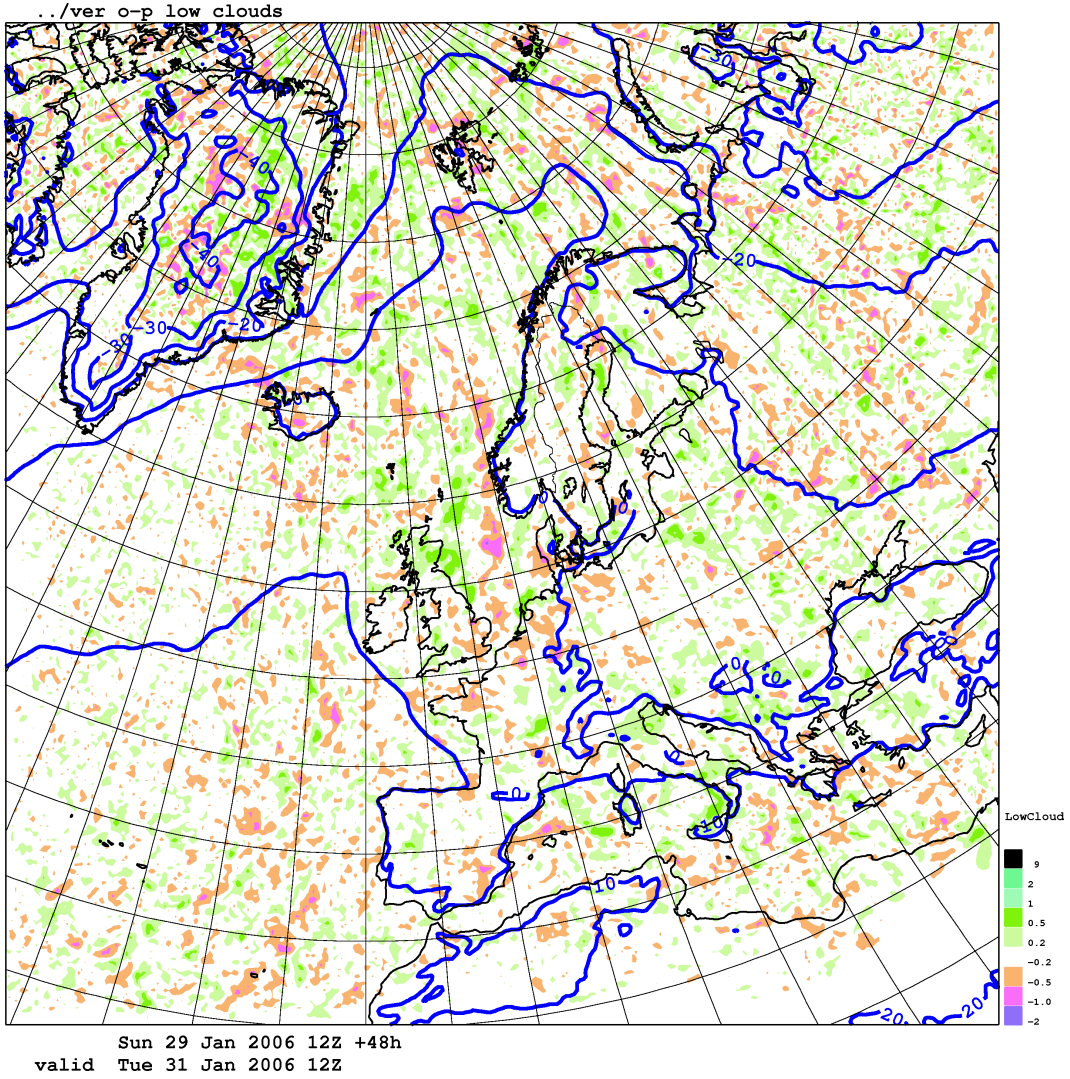
Prec:Verification winter: C3J: orig CCN C3o : most CCN in central Europe C3p: reversed



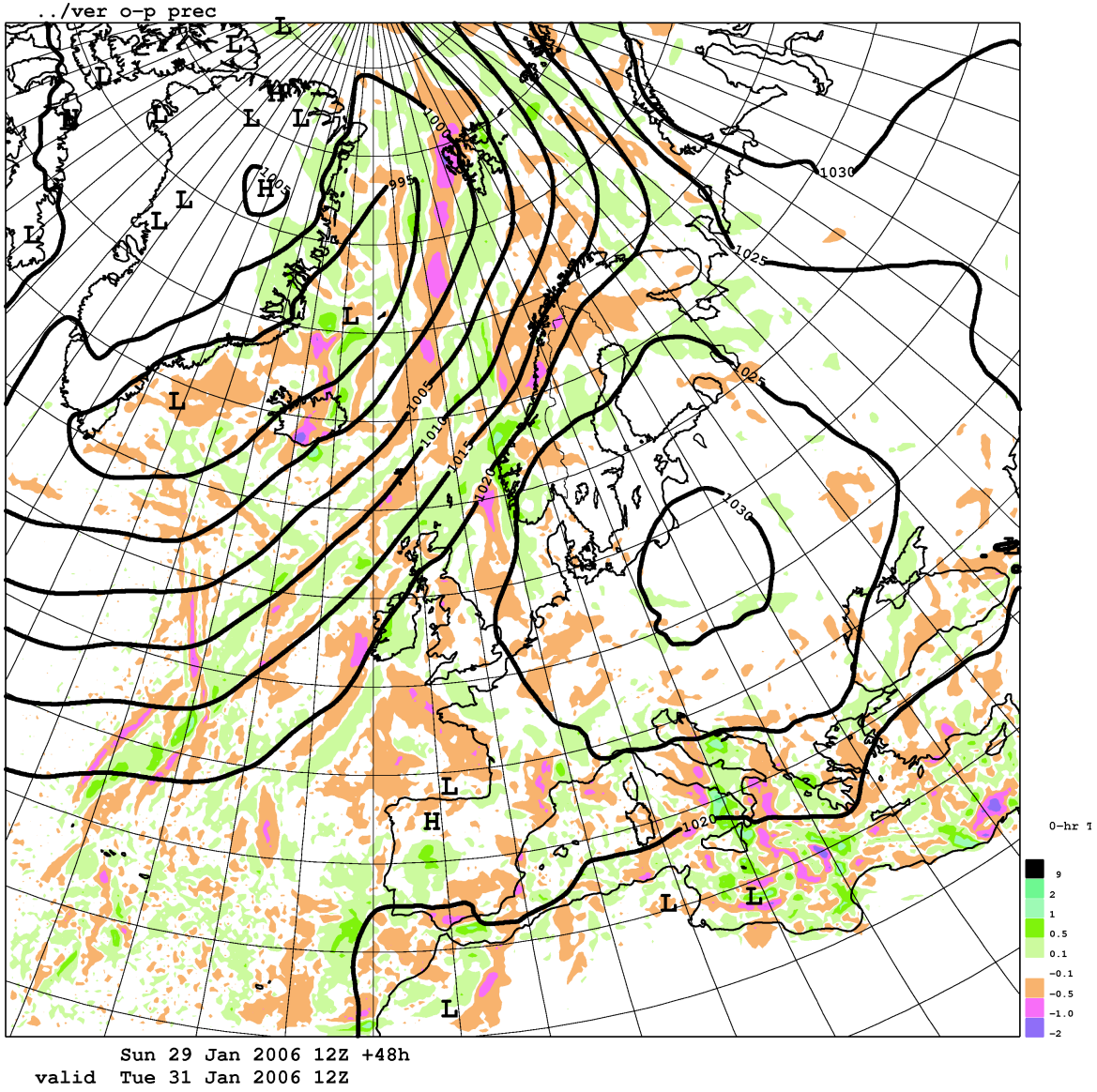




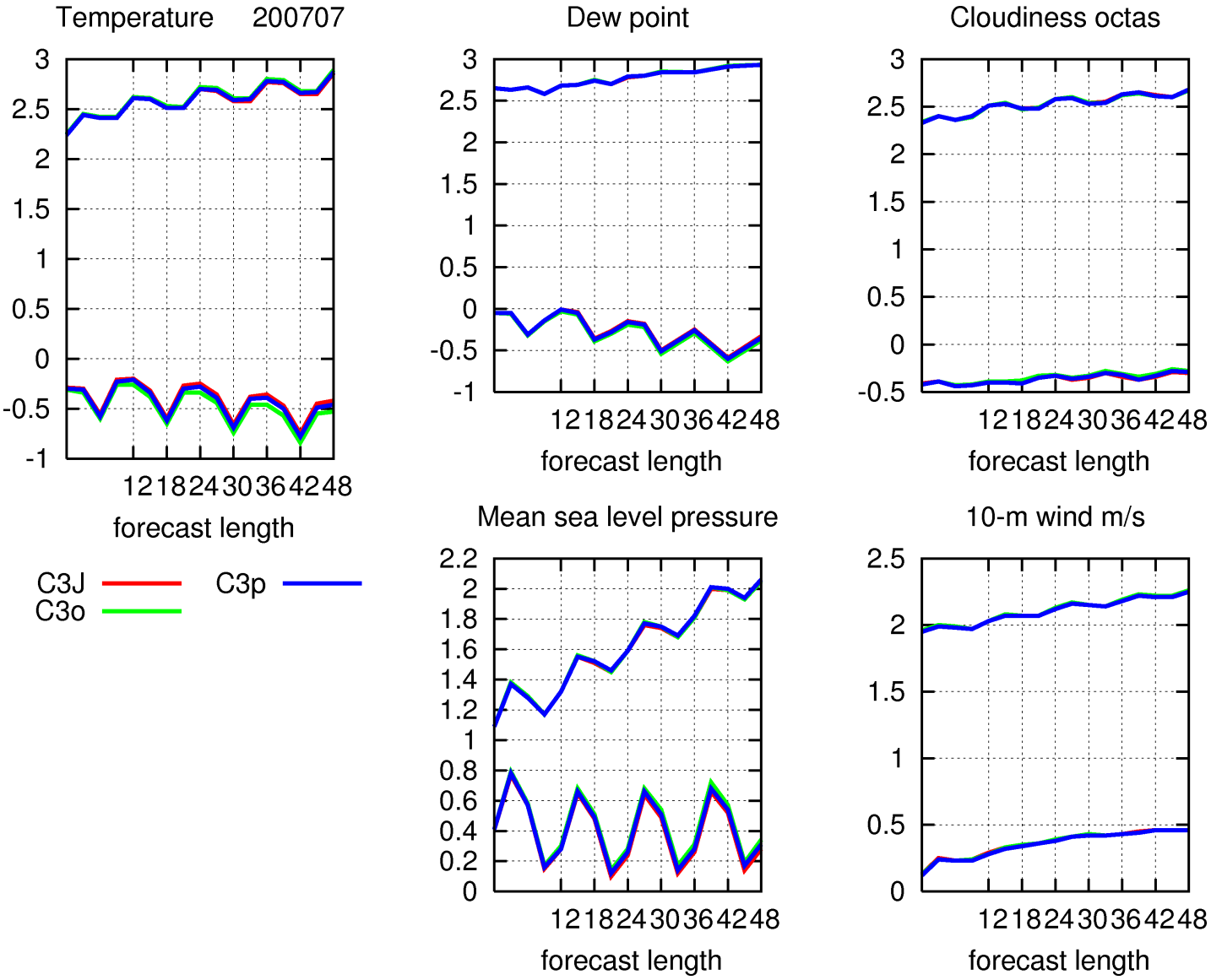
Difference map – low clouds (C3o – C3p) Note x 80! reddish : less low clouds 'normal' CCN distribution, greenish : more low clouds 'normal' CCN distribution



Difference map – precipitation (C3o – C3p) mm during 28 days reddish : less for 'normal' CCN distribution, greenish : more for clouds 'normal' CCN distribution



Verification summer: C3J: orig CCN C3o : most in central Europe C3p: reversed



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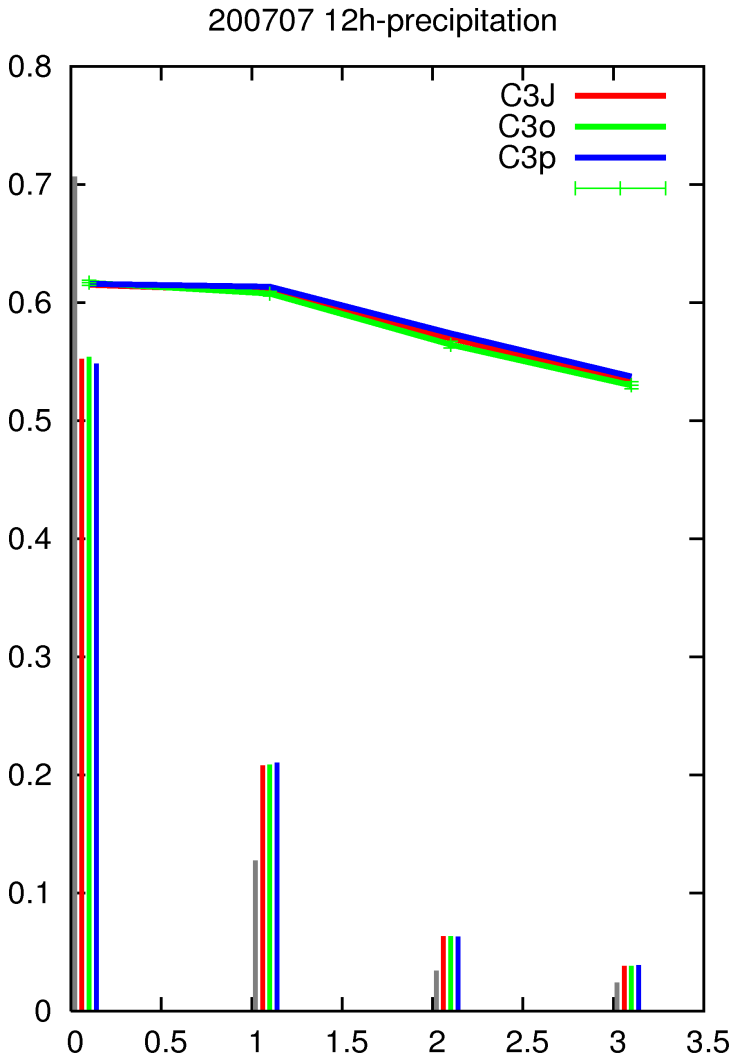
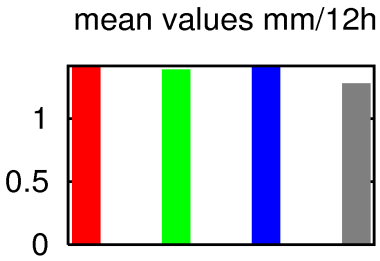
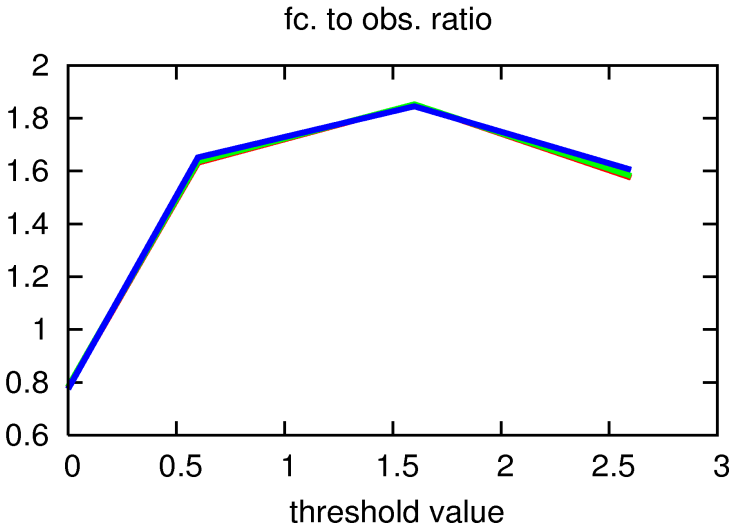
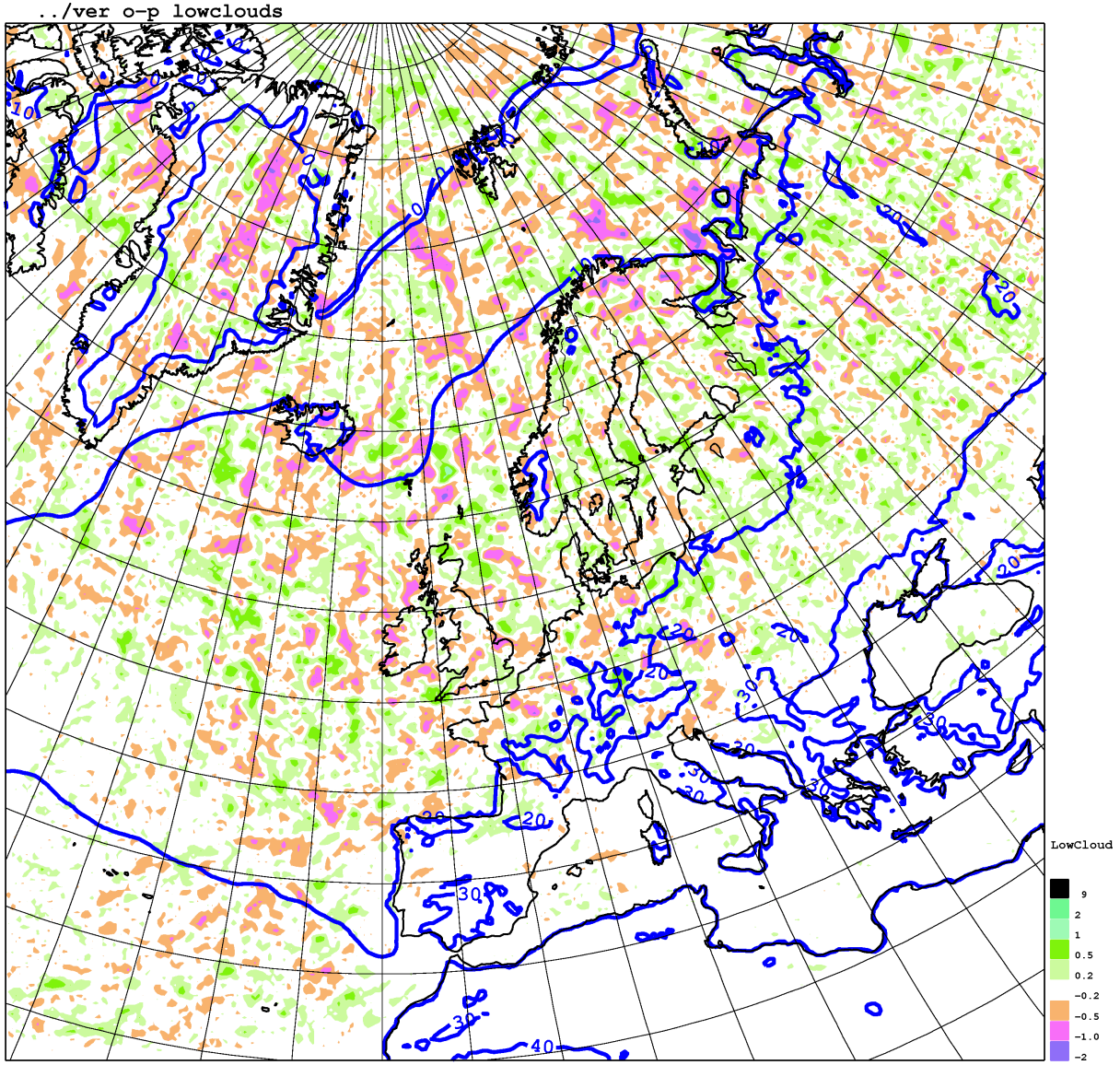


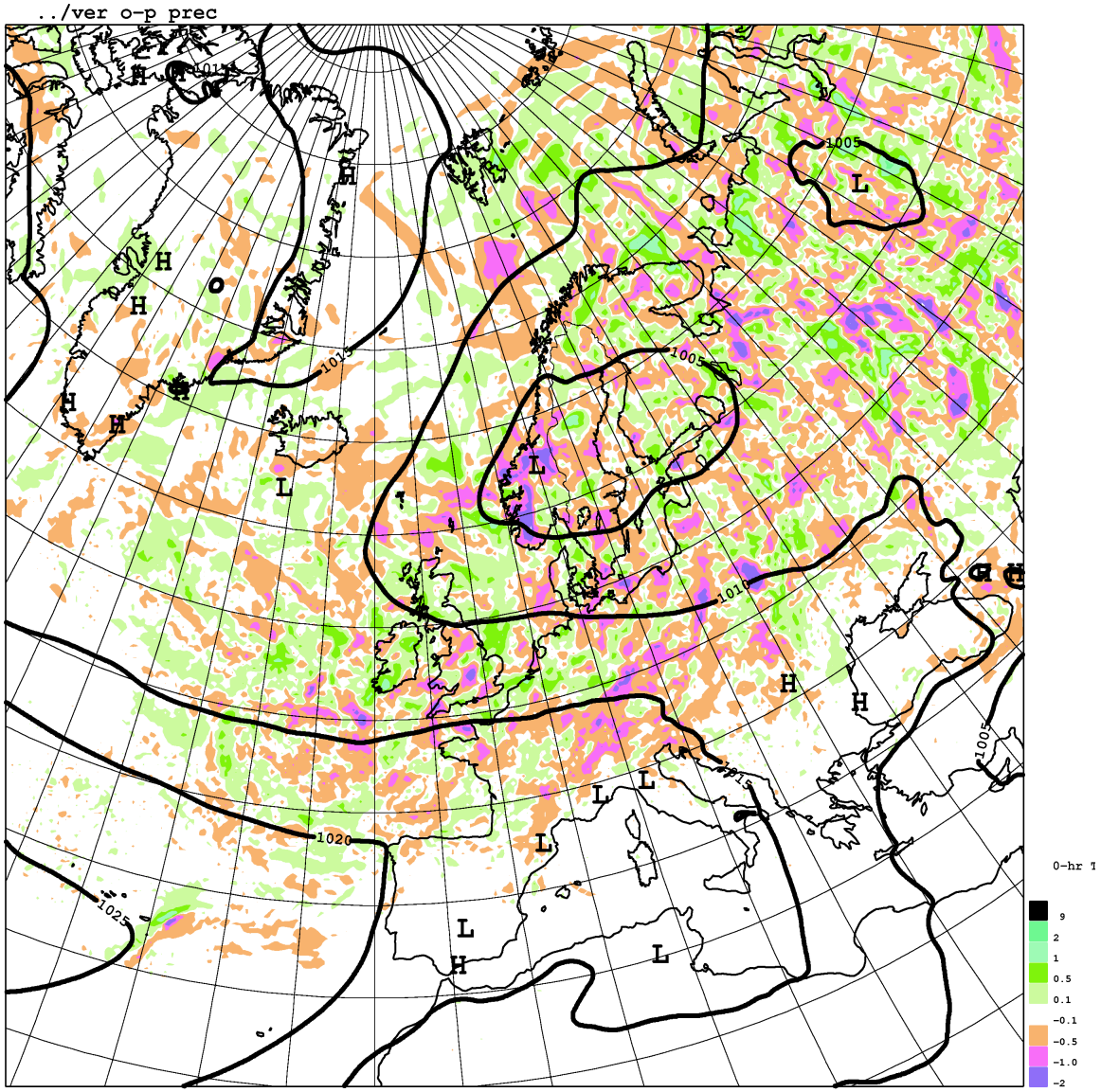




Difference map, summer:– low clouds (C3o – C3p) x80 reddish : less low clouds 'normal' CCN distribution, greenish : more low clouds 'normal' CCN distribution



Difference map, summer – precipitation (C3o – C3p) mm, 28 days reddish : less for 'normal' CCN distribution, greenish : more for clouds 'normal' CCN distribution



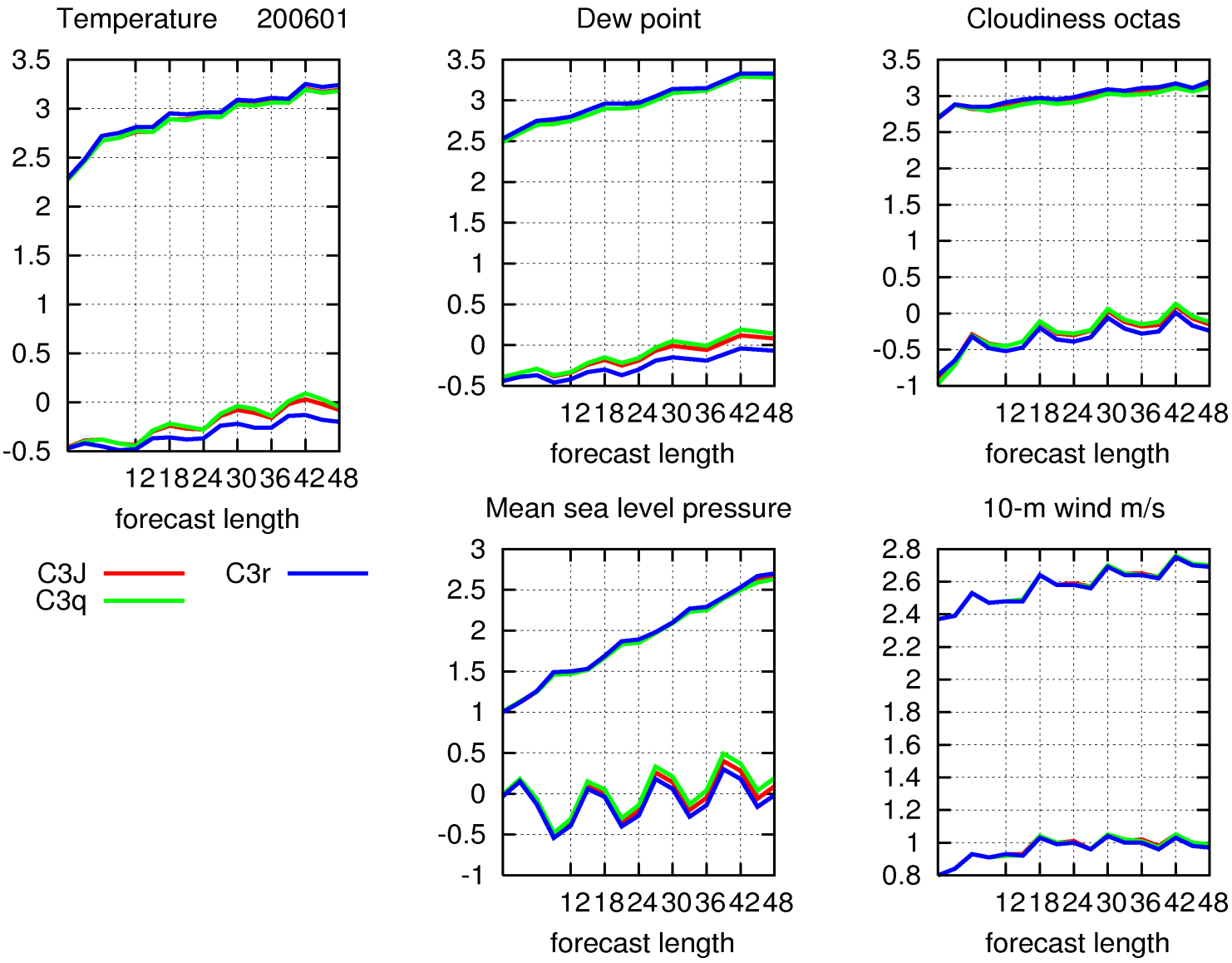
Results, discussion, questions (CCN)

- Very small differences between the runs.
- Some tendency of an increase of low clouds and a decrease of precipitation for high CCN amounts in the PBL. But very weak signal !
- Reasons for the small effect ? CCN change only in the PBL?, too little change? Bugs? Poor parametrizations, e.g. too fast glaciation of supercooled clouds? Or it should not be larger ?

Impact of ice nuclei concentration in the current prognostic cloud ice formulation

- Only just a function of temperature in current parameterization. (Mayers, 1992) The colder it is, the more particles are assumed to be active for triggering heterogeneous freezing.
- Formula: K exp(12.96(es(wat) -es(ice))/es(ice)-0.639)
- Here, testing only the change of the constant K. It will make the glaciation of supercooled clouds go faster or slower everywhere.
- C3J original ,K=500. C3q: K=125 C3r: K=2000.

Verification winter: C3J: orig IN concentration C3q : 25% C3r: 400%



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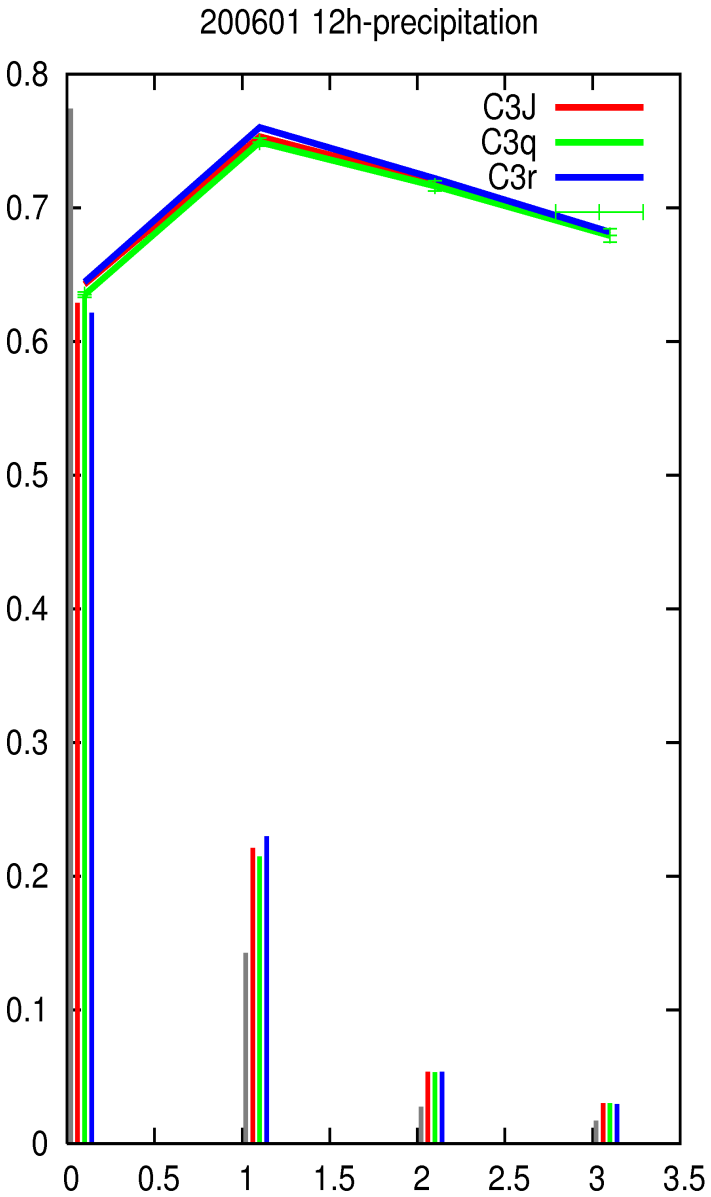
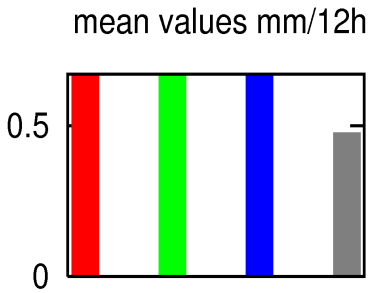
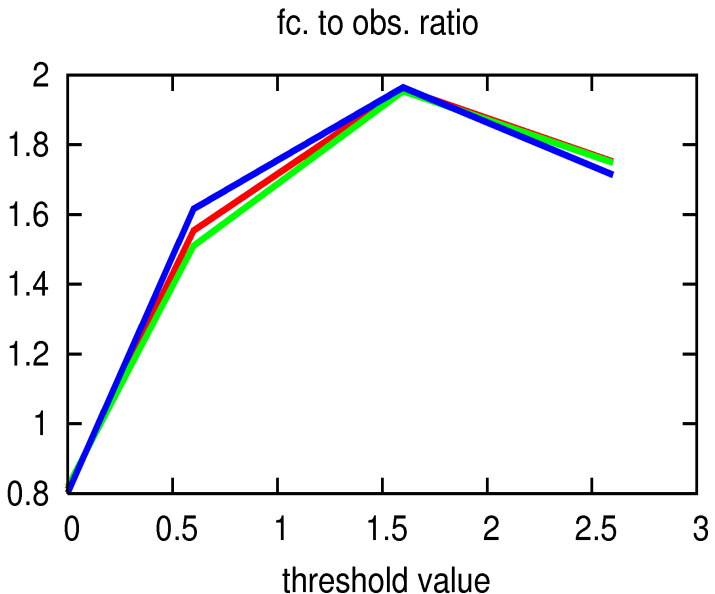
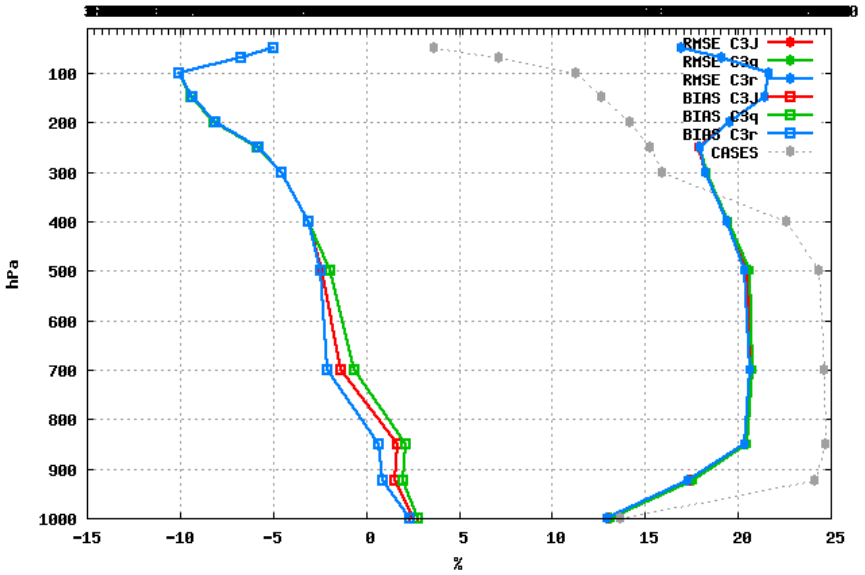






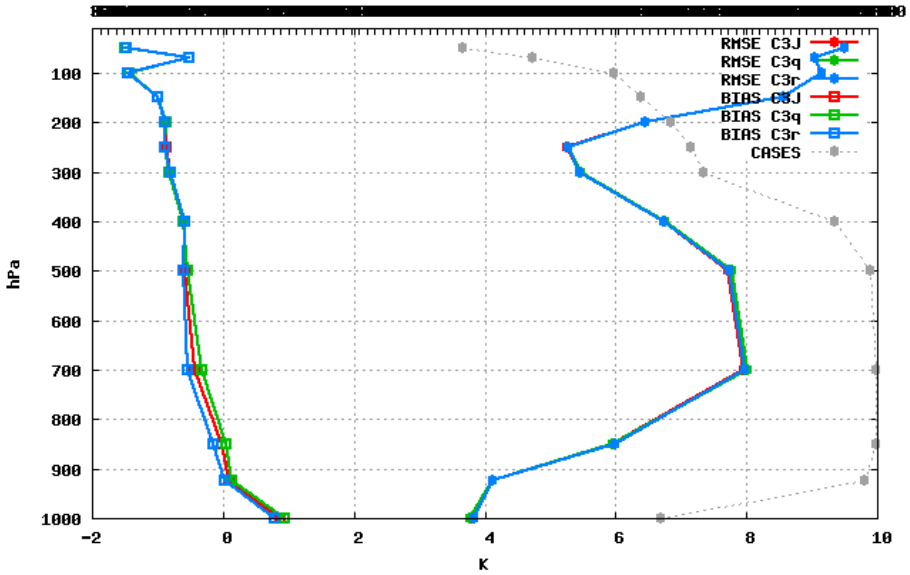
170 stations Area: ALL
Relative Humidity Period: 20060102-20060128
At {00,12} + 06 12 18 24 30 36 42 48

No cases



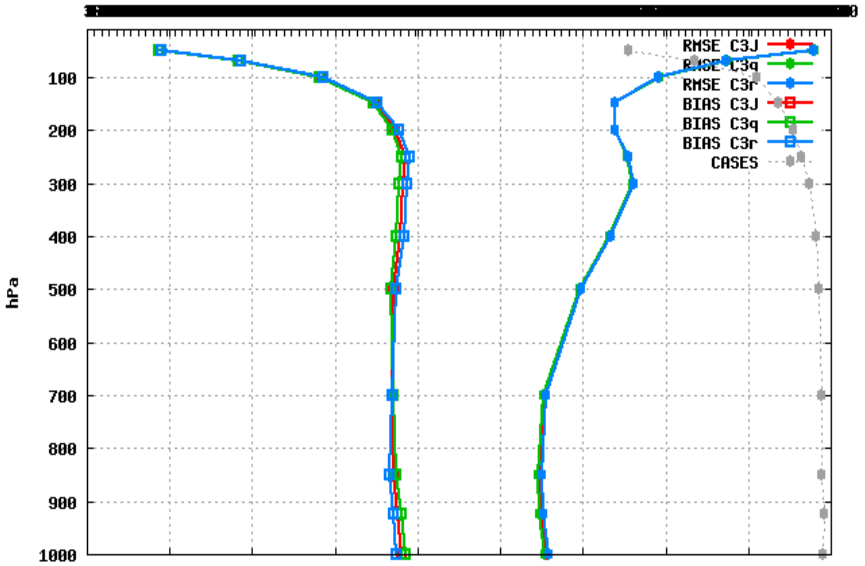
170 stations Area: ALL
Dew point temperature Period: 20060102-20060128
At {00,12} + 06 12 18 24 30 36 42 48

No cases



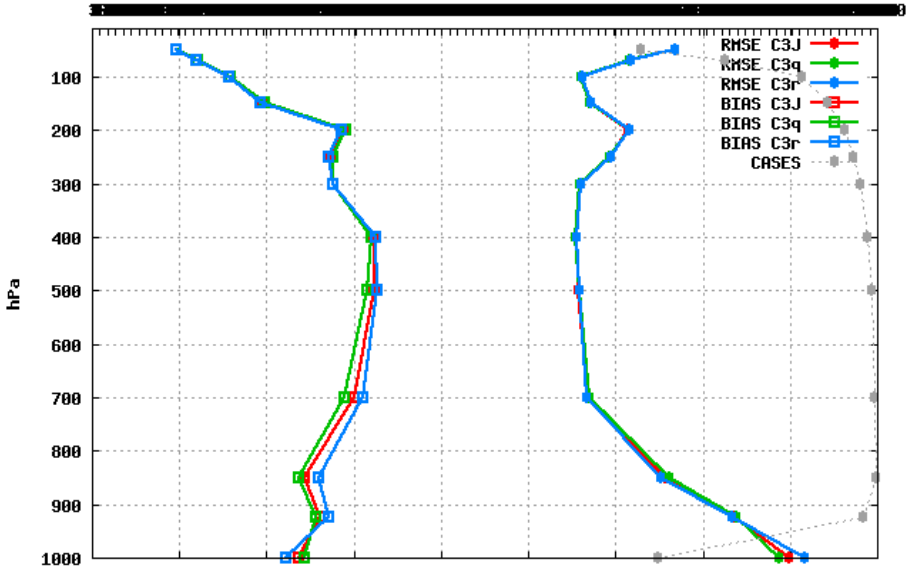
170 stations Area: ALL
Height Period: 20060102-20060128
At {00,12} + 06 12 18 24 30 36 42 48

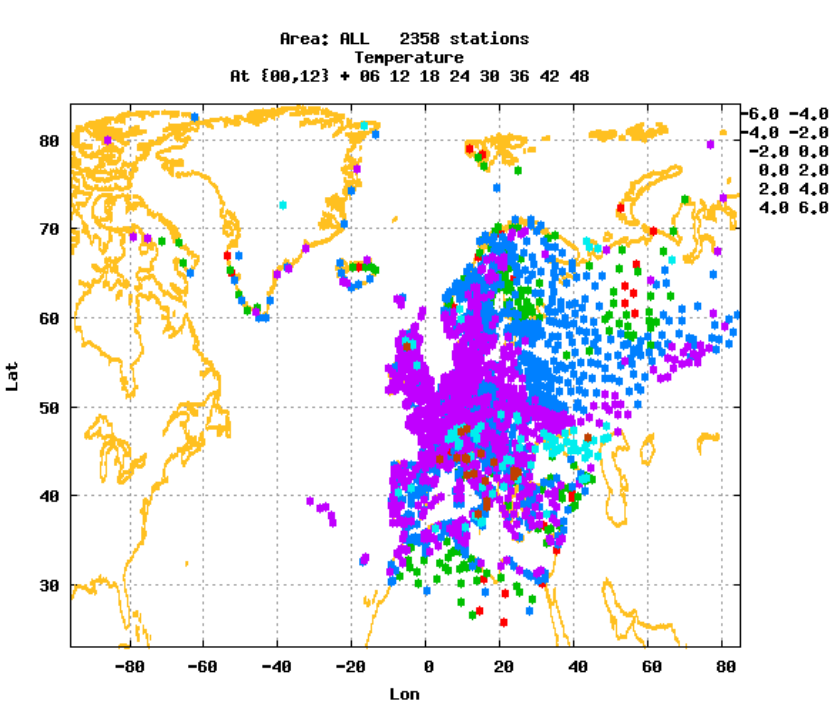
No cases



170 stations Area: ALL
Temperature Period: 20060102-20060128
At {00,12} + 06 12 18 24 30 36 42 48

No cases




Area: ALL 2358 stations
Temperature
At {00,12} + 06 12 18 24 30 36 42 48
-6.0 -4.0
-4.0 -2.0
-2.0 0.0
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2.0 4.0
4.0 6.0
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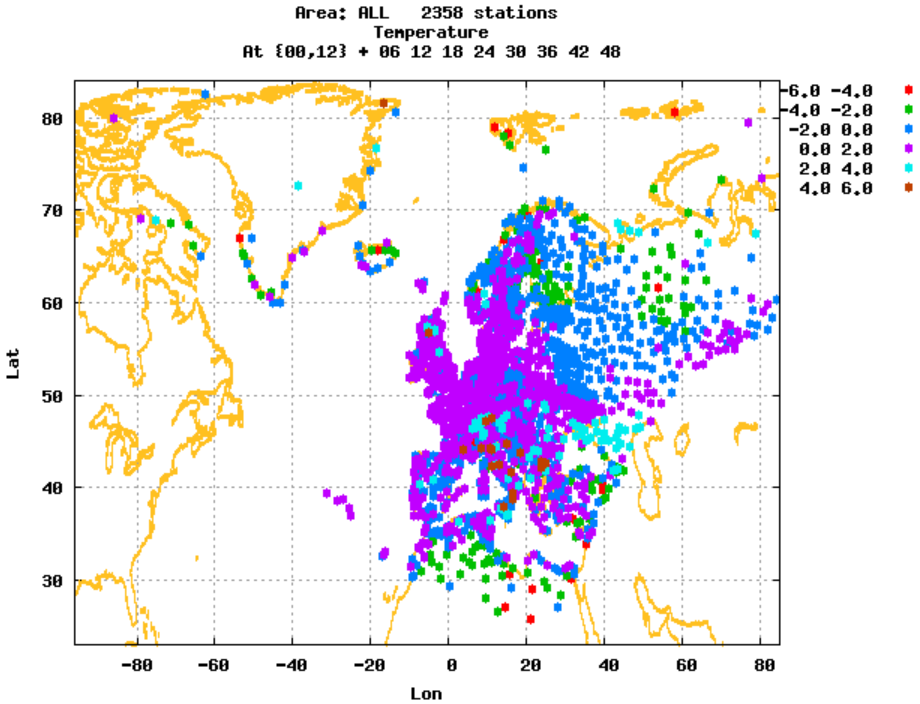
Area: ALL 2358 stations
Temperature
At {00,12} + 06 12 18 24 30 36 42 48
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-4.0 -2.0
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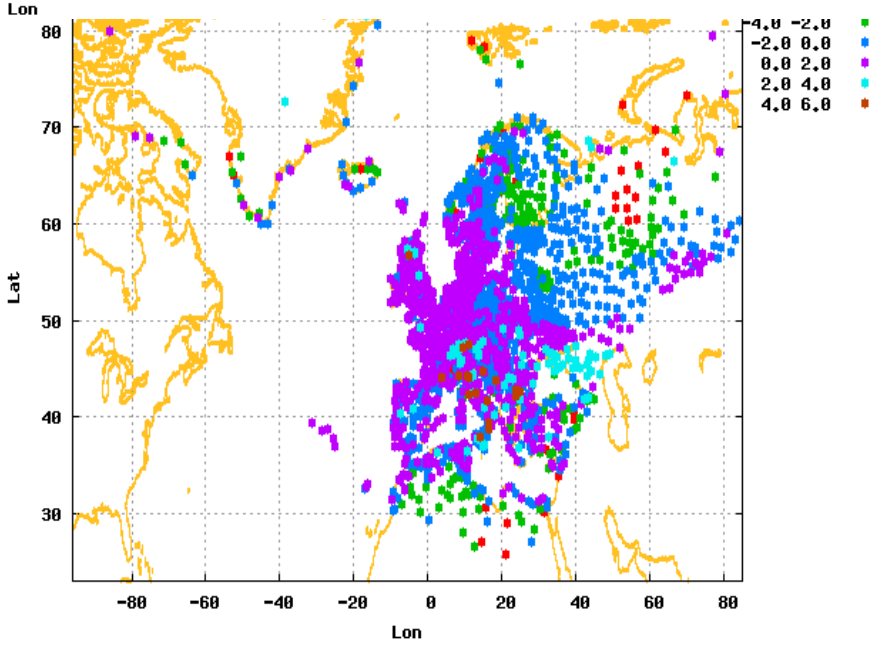
-4.0 -2.0
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Lat
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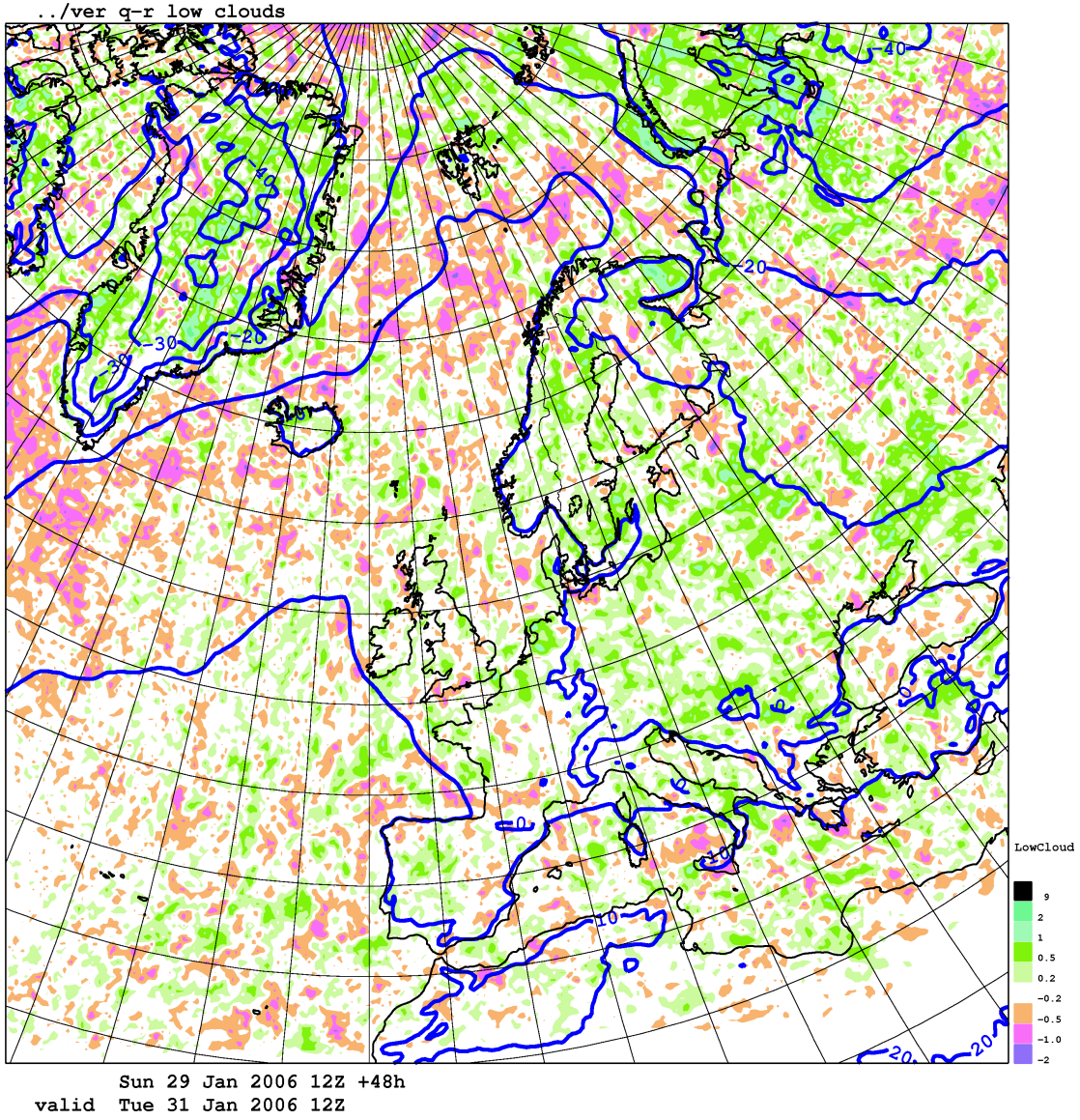
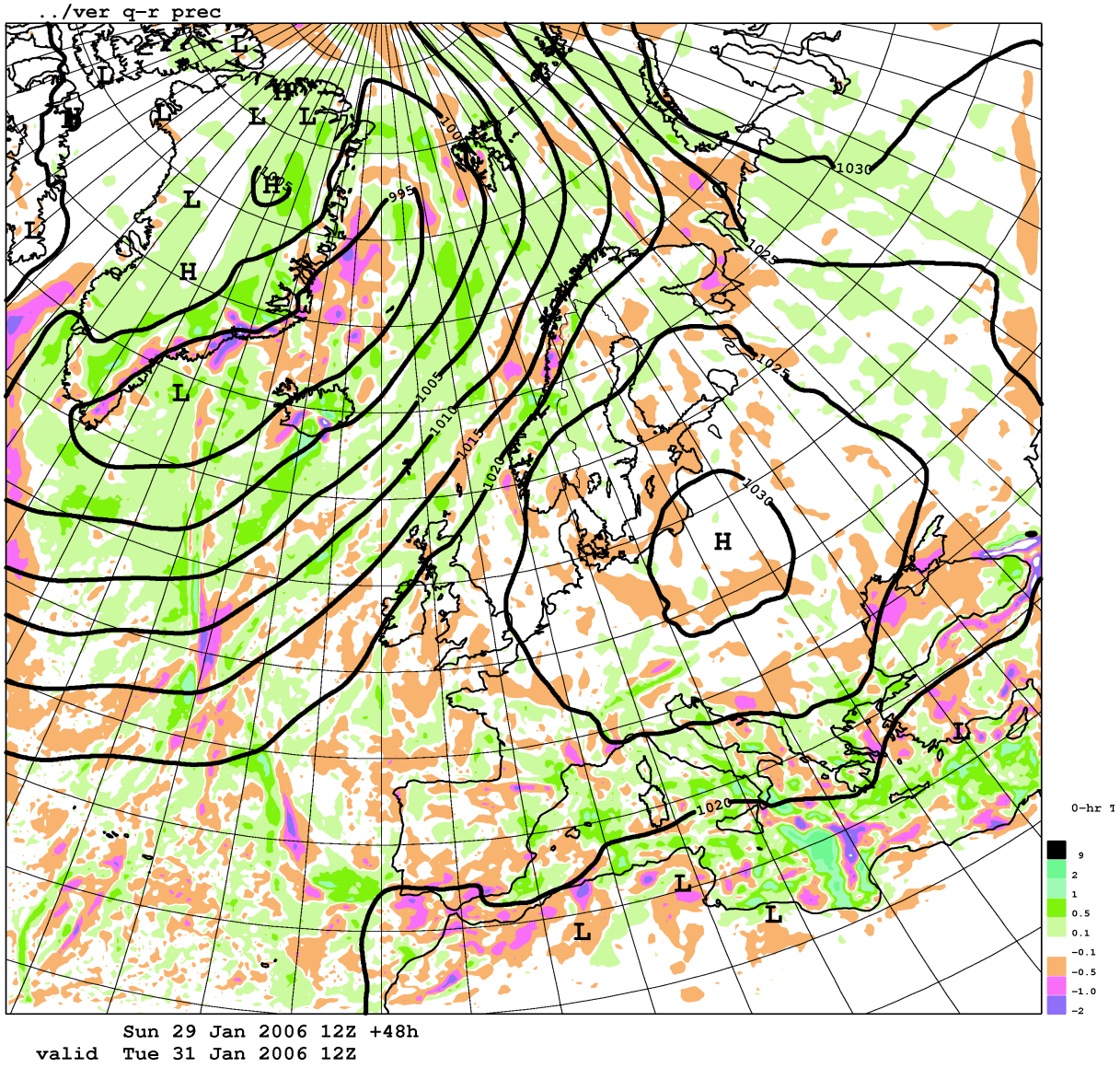
Difference map – low clouds (C3q – C3r) x 80 reddish : less low clouds low IN distribution, greenish : more low clouds for low IN distribution



Difference map – precipitation (C3q – C3r) mm 28 days reddish : less for low IN distribution, greenish : more for low IN distribution



Results, discussion, questions, IN-concentration.

- Somewhat stronger signal for changes in concentrations of IN than for CCN in winter but almost no signal in summer. (less supercooled clouds in summer)
- Stronger IN signal may be caused by experiment set up : larger differences affecting not only PBL.
- But other things as well (parametrizations , bugs ... ???)
- Lower IN gives less cloud ice --> relative humidity more related to water saturation --> less clouds.
- But less cloud ice also gives lower Bergeron-Findeisen effect --> less precipitation, so existing clouds stay longer --> more clouds
- The latter effect seems to dominate.
- Better temperature forecasts in winter with lower IN, in summer almost no effect.

References

- Meyers et al: New primary ice-nucleation parametrization in an explicit cloud model J. Appl. Metetor. 31, 708-721
- Kogan et al 2000: A new cloud physics parametrization in large-eddy simulation model of marine stratocumulus. Mon. wea. rev.,Vol 128 p 1070-1088.