

New statistical balance of moisture variable

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Humidity Analysis Formulation

- The assimilation of moisture is more difficult than assimilation of the dynamical model variables.
- The main reason is that assimilation builds on the assumption that involved variables have a Gaussian probability distribution
- This is not valid for humidity due to the condensation effects near saturation and the strict limit at zero humidity
- The reference HIRLAM humidity data assimilation uses specific humidity increments δq within the control variable

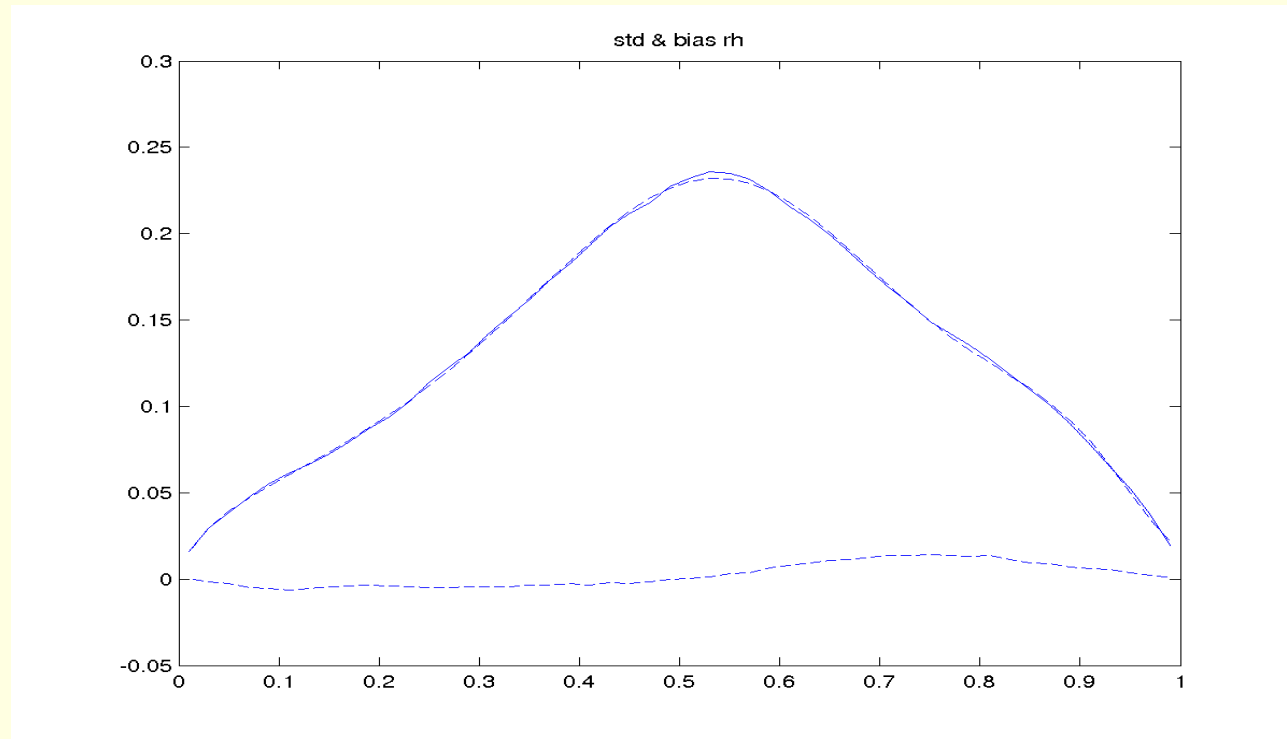
Humidity Analysis Formulation

- A new q-based assimilation variable, where the specific humidity assimilation increment normalized by the background saturation specific humidity is tried.
- In order to avoid the problems at saturation and at zero humidity, a transformation by normalization with a background error standard deviation that depends on the relative humidity.
- An improved balance constraint where we avoid double counting of balances of q and T will also be investigated.

$$\left(\frac{\delta q}{q_{sat}(T^b)} \right)^{total} = \frac{\left(\frac{\delta q}{q_{sat}(T^b)} \right)^{ub}}{\sigma(p, RH^b, \delta RH)} + \left(a\delta T^{ub} + b\delta D^{ub} + d\delta V \right)$$

Normalized Humidity

- The Fig. shows at 800 hPa standard deviation σ (solid), 7 order piecewise polynomial to σ (dashed) and bias (dashed) as a function of $RH^b + 0.5\delta RH$.



Generating background error statistics

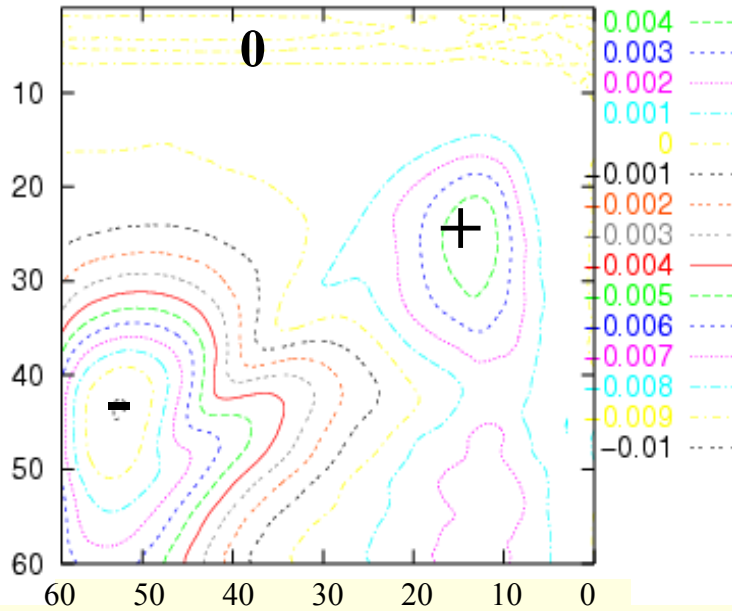
The NMC-method

- Error statistics estimated from differences of forecasts valid at the same time (48h-24h or 36h-12h).

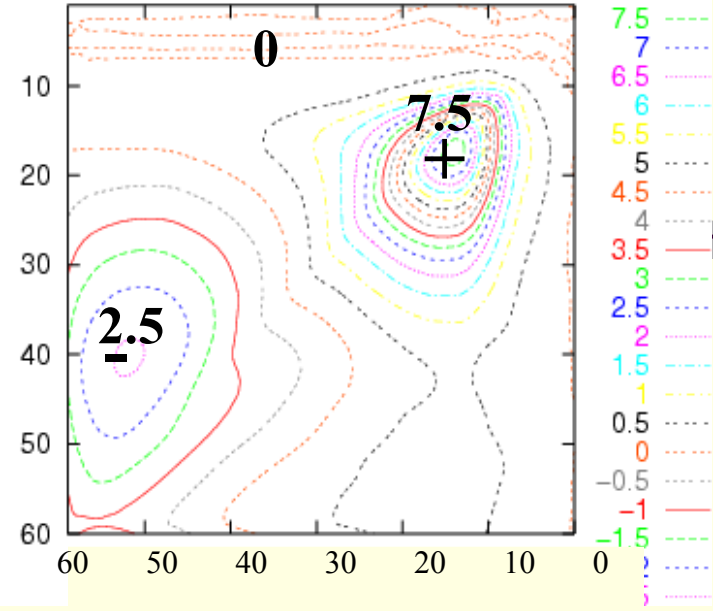
Ensemble assimilation

- Error estimated statistics from an ensemble of 6h forecast differences from an ensemble data assimilation experiment with perturbed observations, boundaries, model physics....

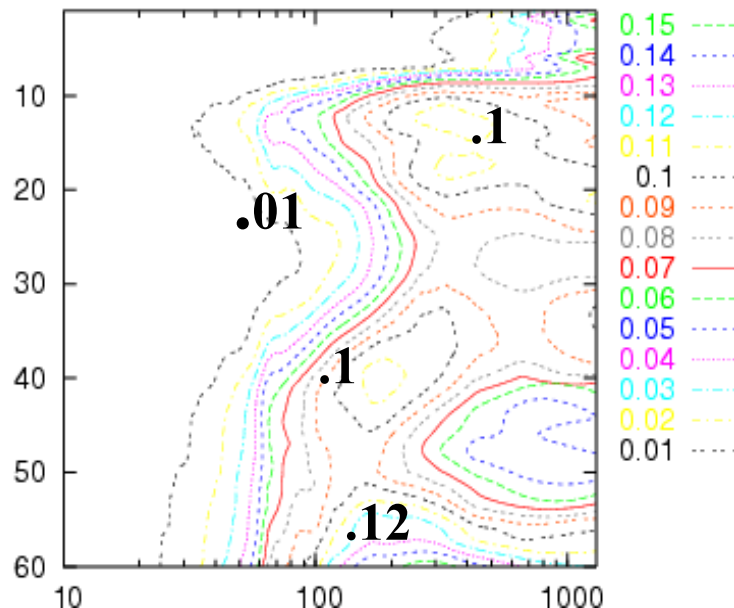
covqp.xy (oldmoist,+36h - +12h fc from 2007020212, 116 cases)



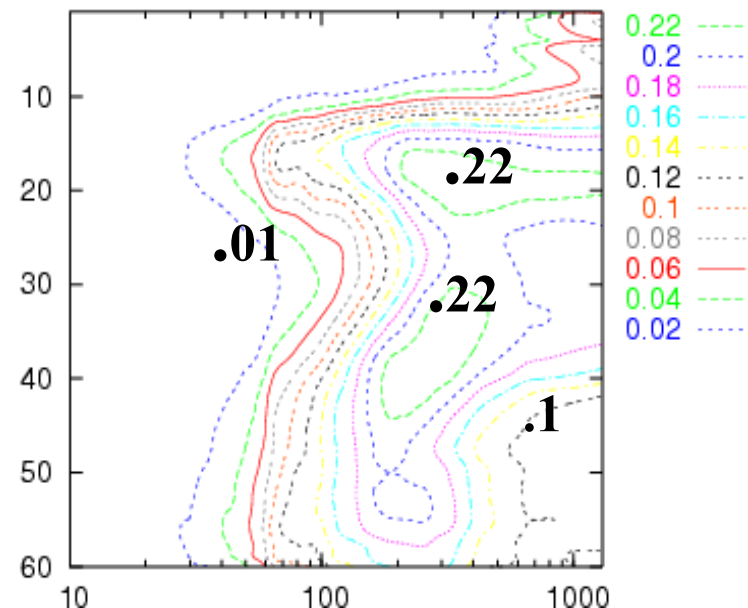
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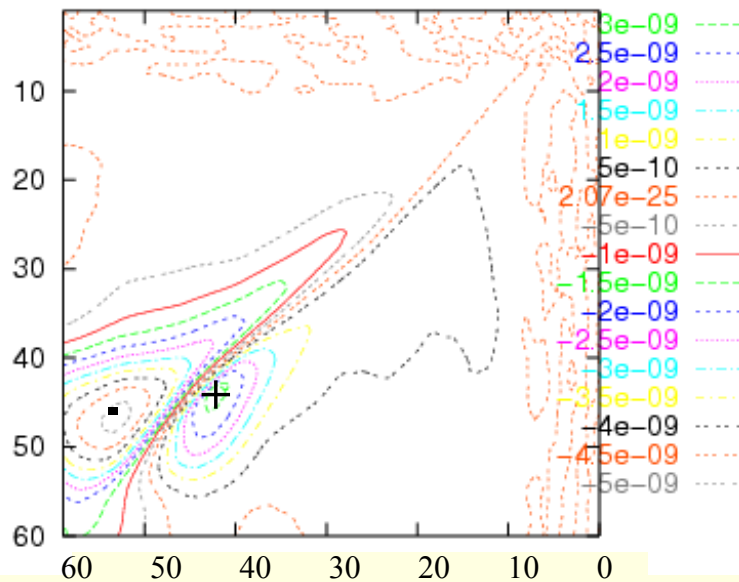
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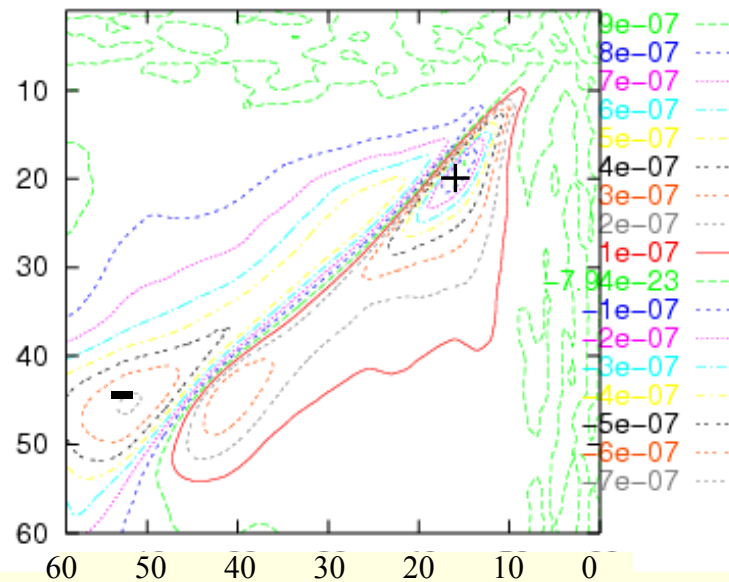
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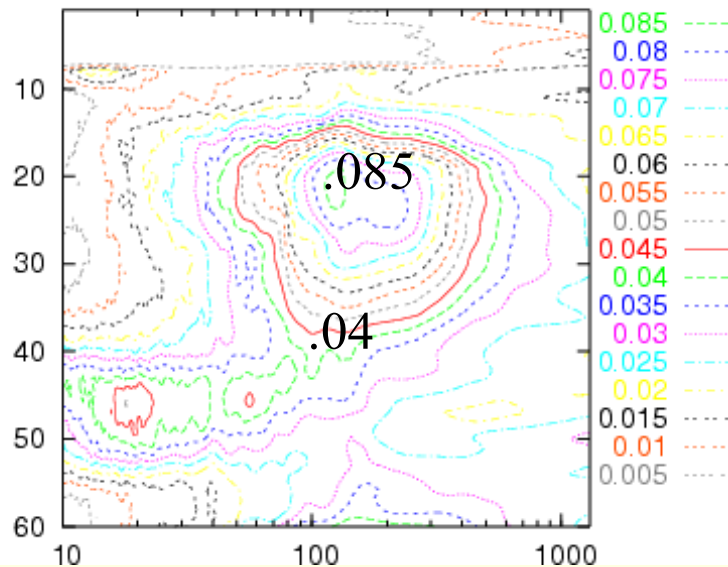
covqd.xy (oldmoist,+36h - +12h fc from 2007020212, 116 cases)



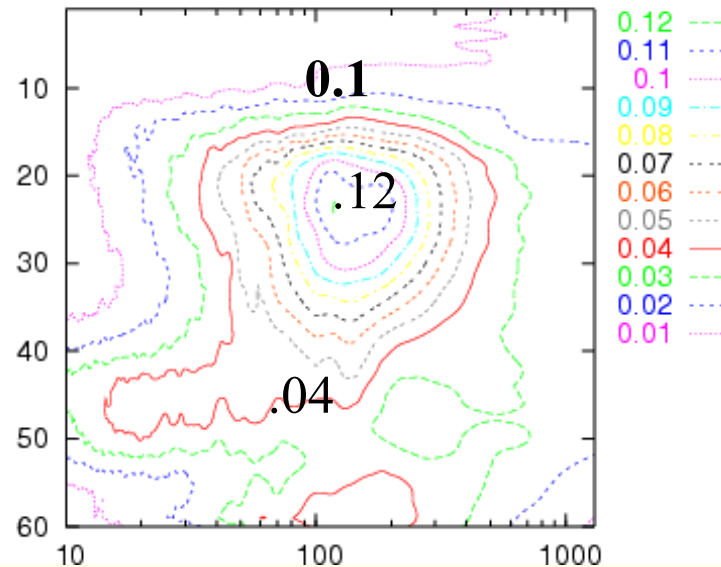
covqd.xy (nm balance,+36h - +12h fc from 2007020212, 116 cases)



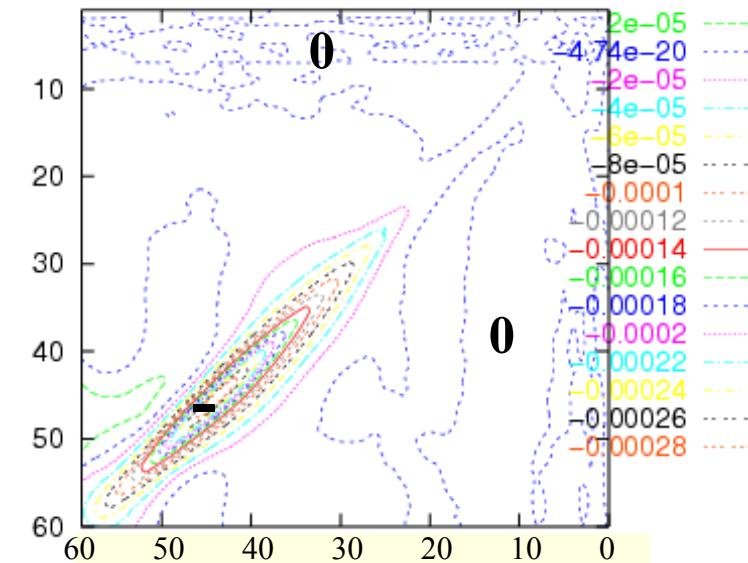
explq_divu.xy (oldmoist,+36h - +12h fc from 2007020212, 116 cases)



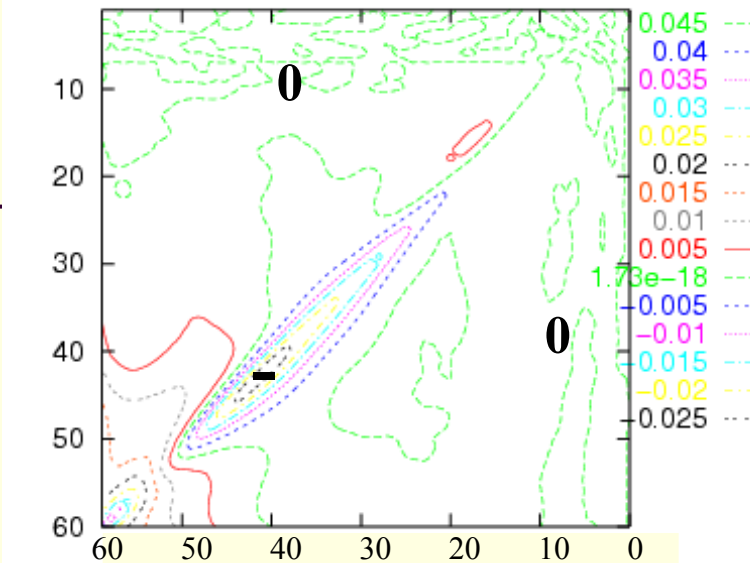
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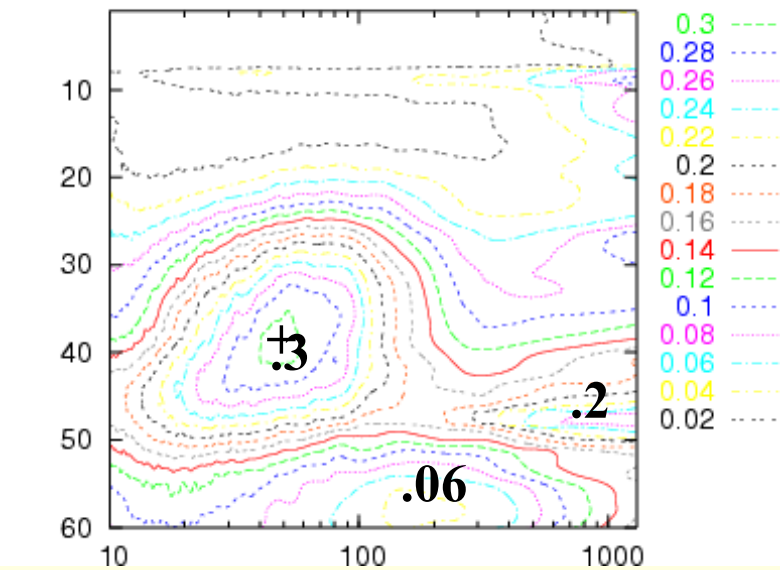
covqt.xy (oldmoist,+36h - +12h fc from 2007020212, 116 cases)



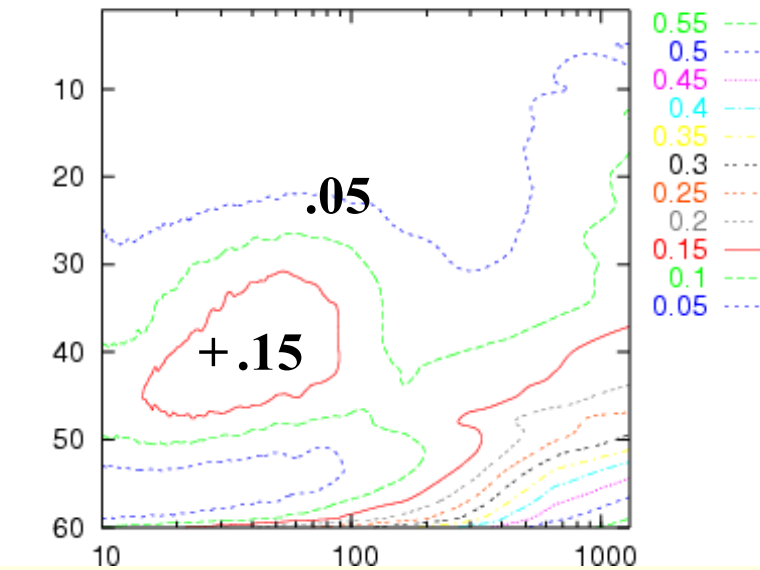
covqt.xy (nm balance,+36h - +12h fc from 2007020212, 116 cases)

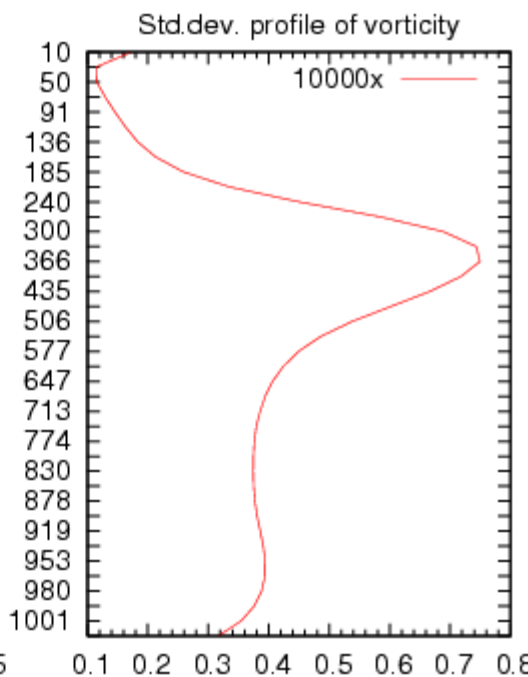
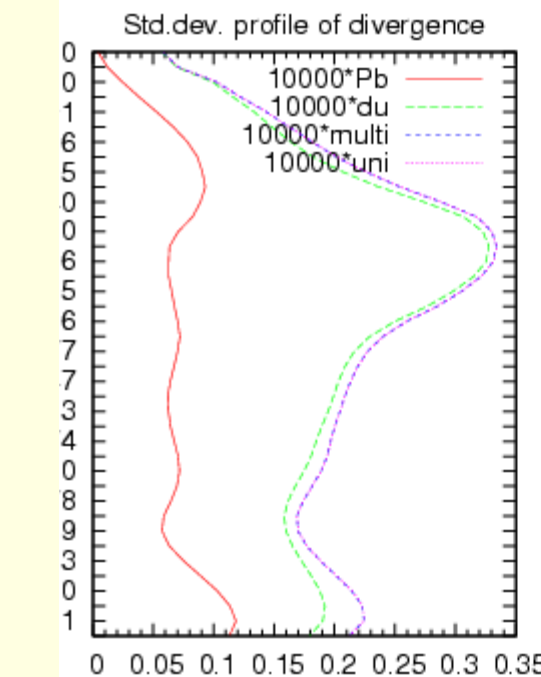
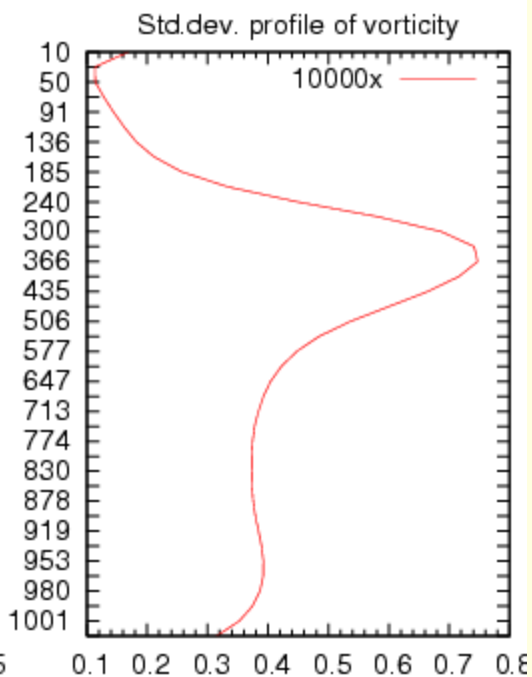
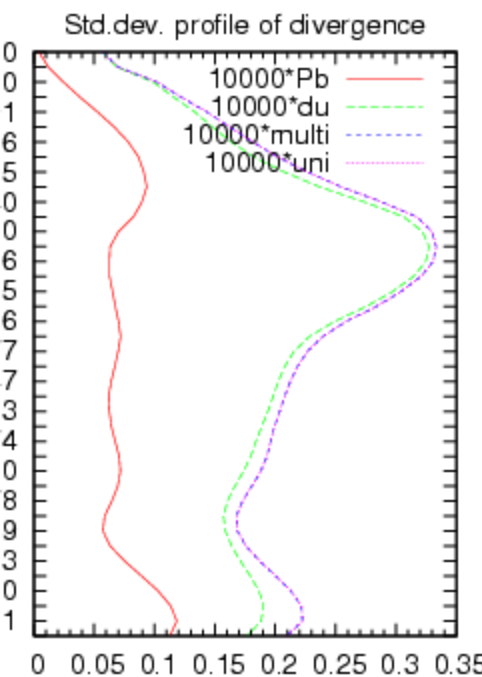
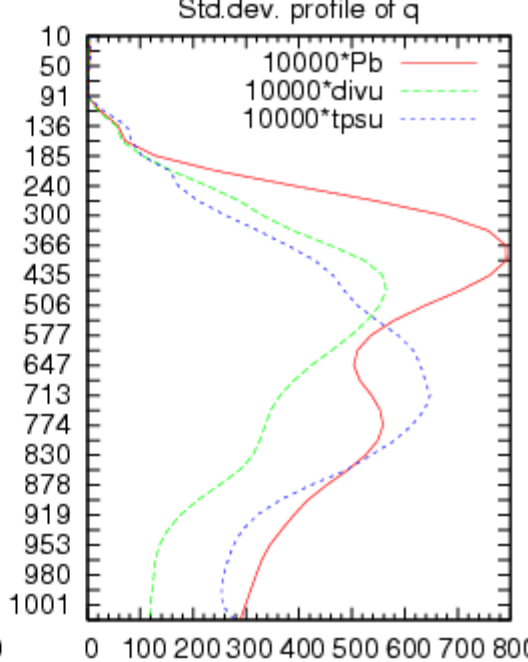
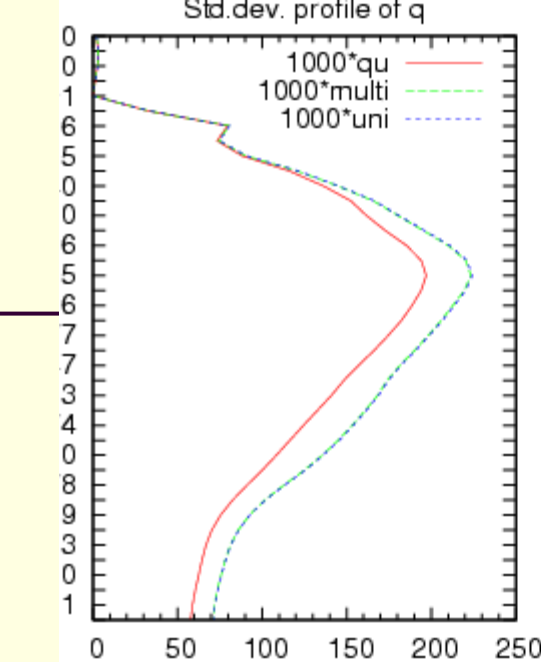
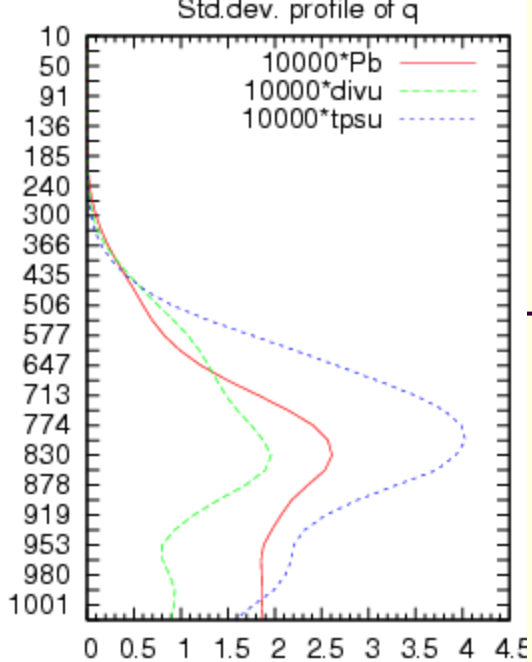
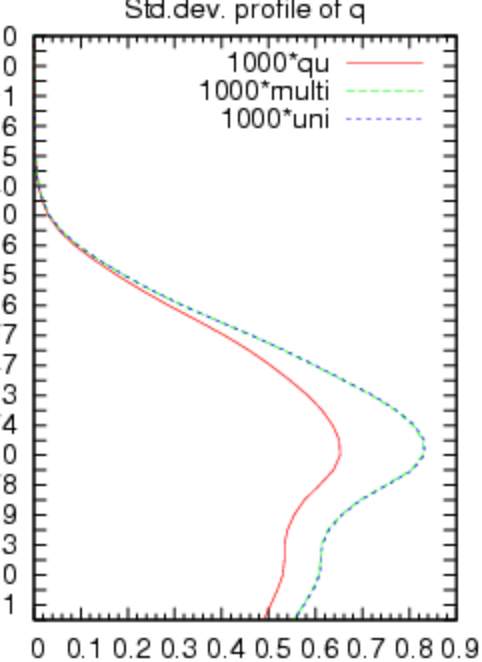


explq_tpsu.xy (oldmoist,+36h - +12h fc from 2007020212, 116 cases)



explq_tpsu.xy (nm balance,+36h - +12h fc from 2007020212, 116 cases)

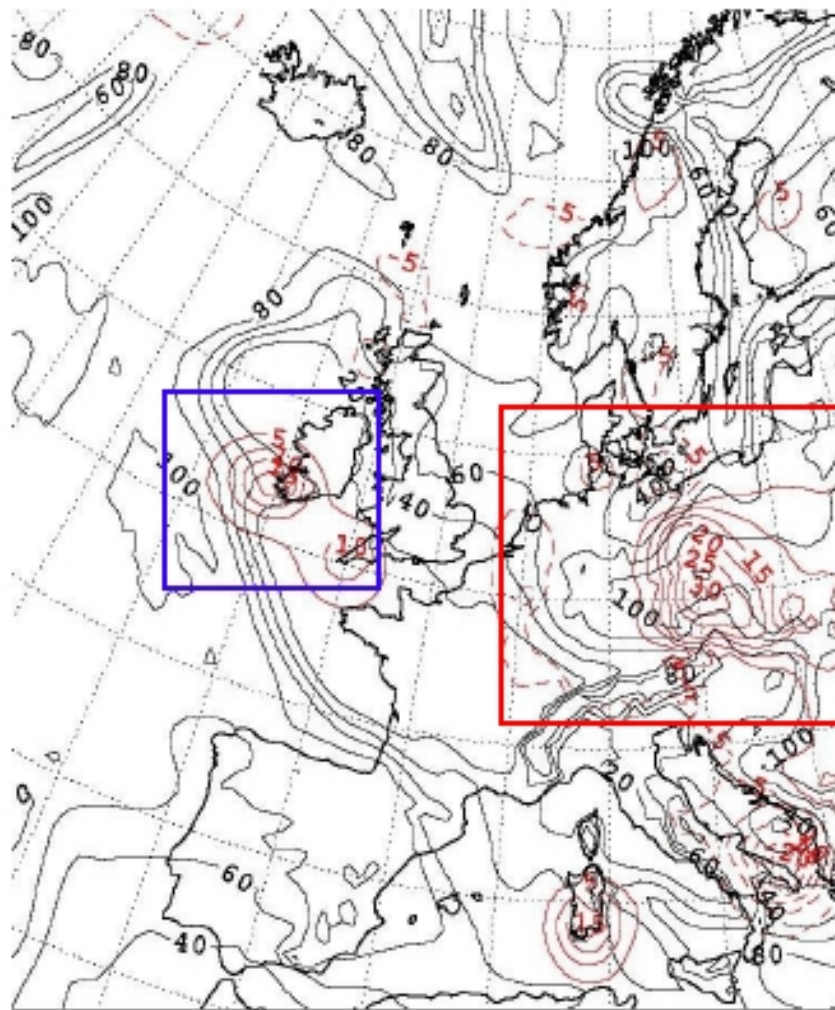




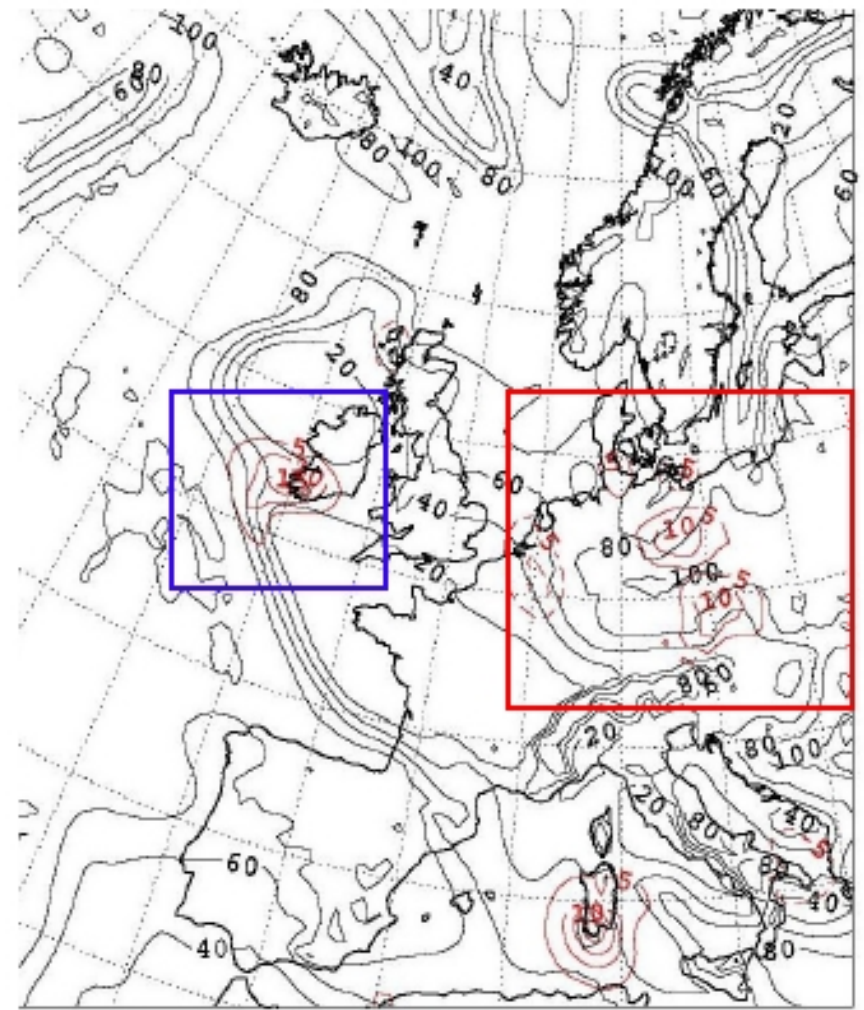
New assimilation control variable for humidity

Old formulation

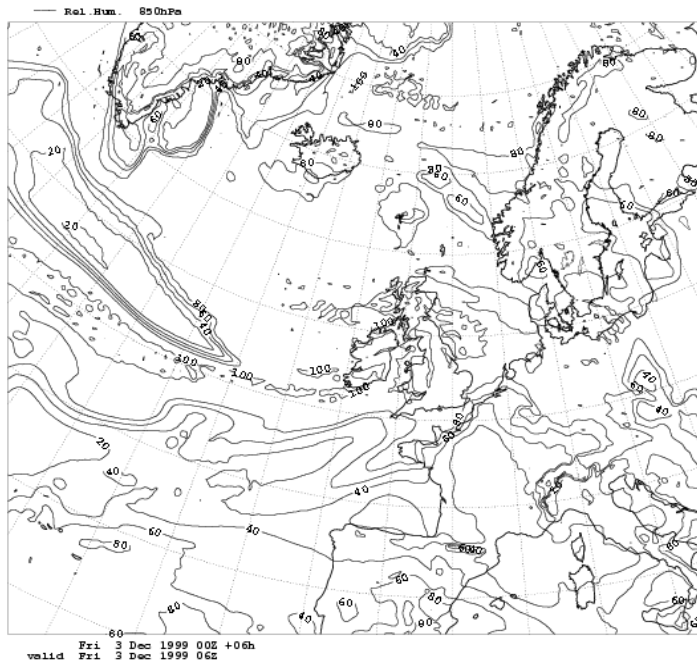
δq



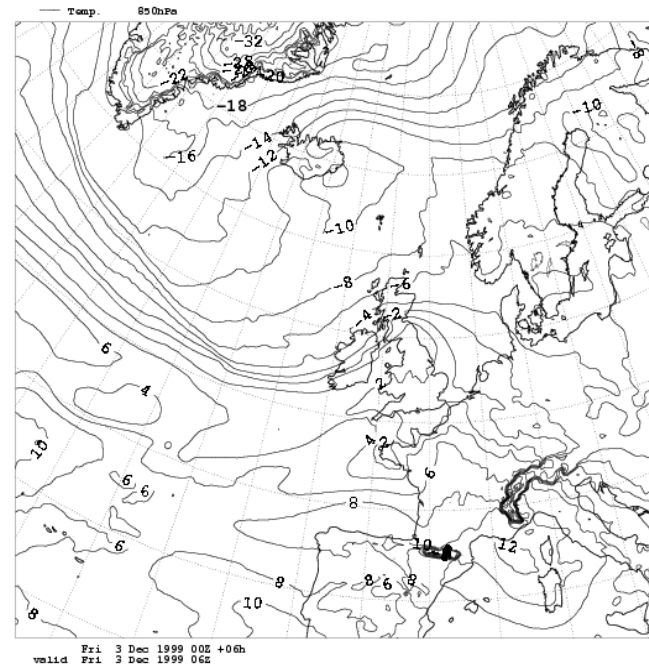
New formulation: $\delta RH^* = \delta RH / \sigma_b (RH_b + 0.5 \delta RH)$



Backgrounds fields at 3.12.99 at 0600

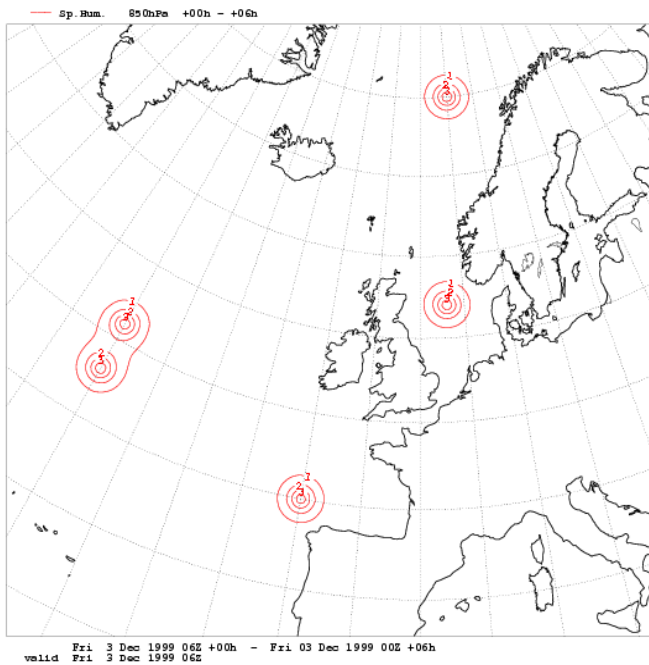


RH at 850 hPa

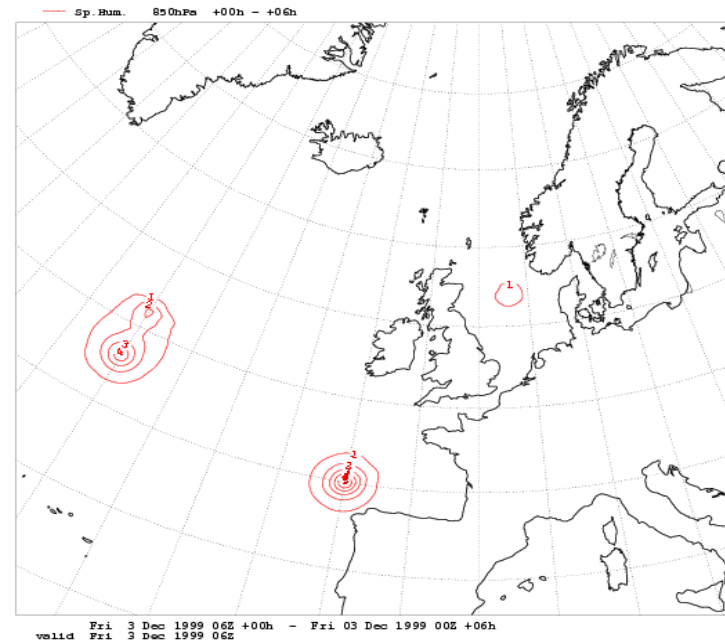


T at 850 hPa

Assimilation increments of q at 850 hPa due to 5 sim q obs. 10 g/kg

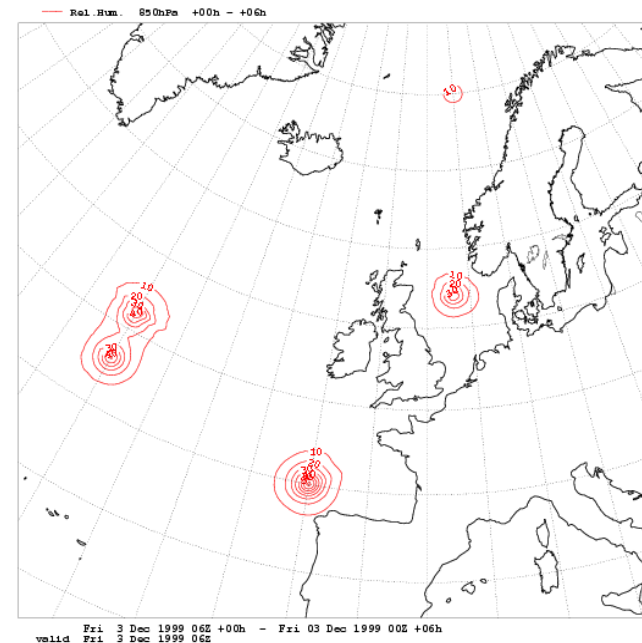


Ref. ass. ctr. var. q.



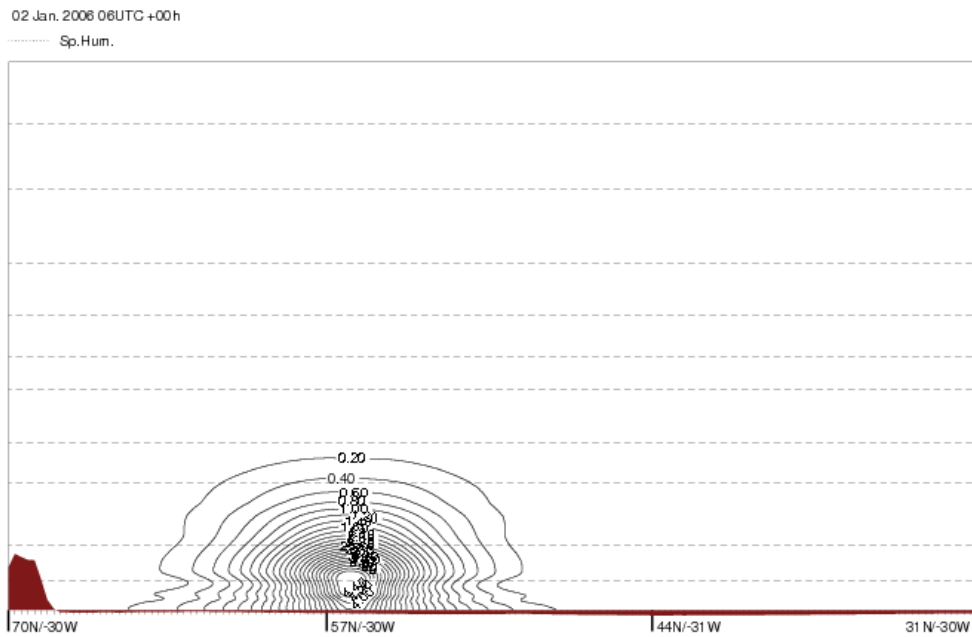
Normalized new bal Humidity

Assimilation increments of RH at 850 hPa due to 5 sim. q obs 10g/kg

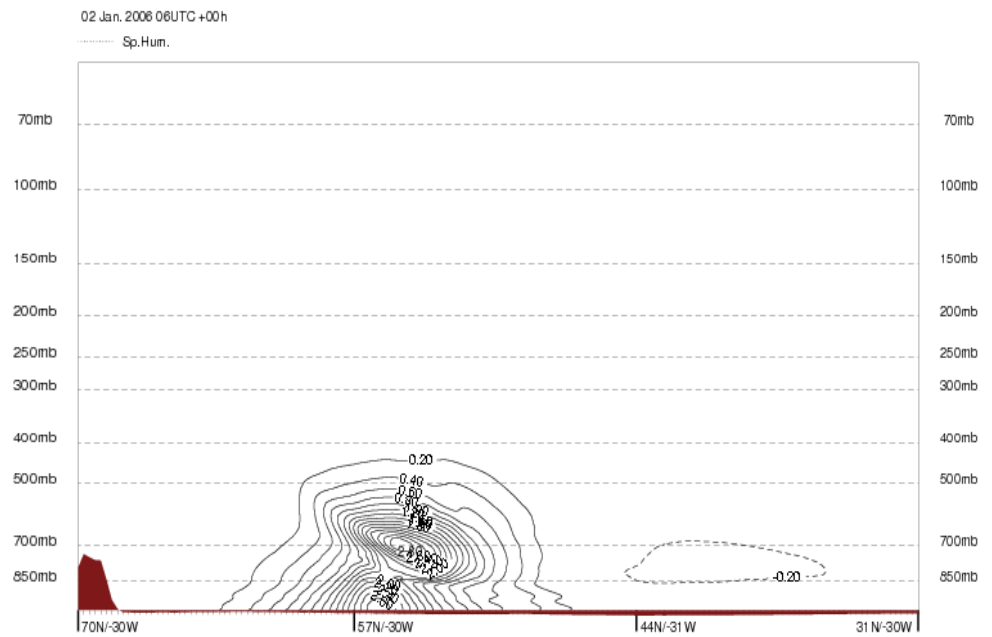


Normalized new bal Humidity

Vertical crosssection of q increments due to a simulated surface pressure obs

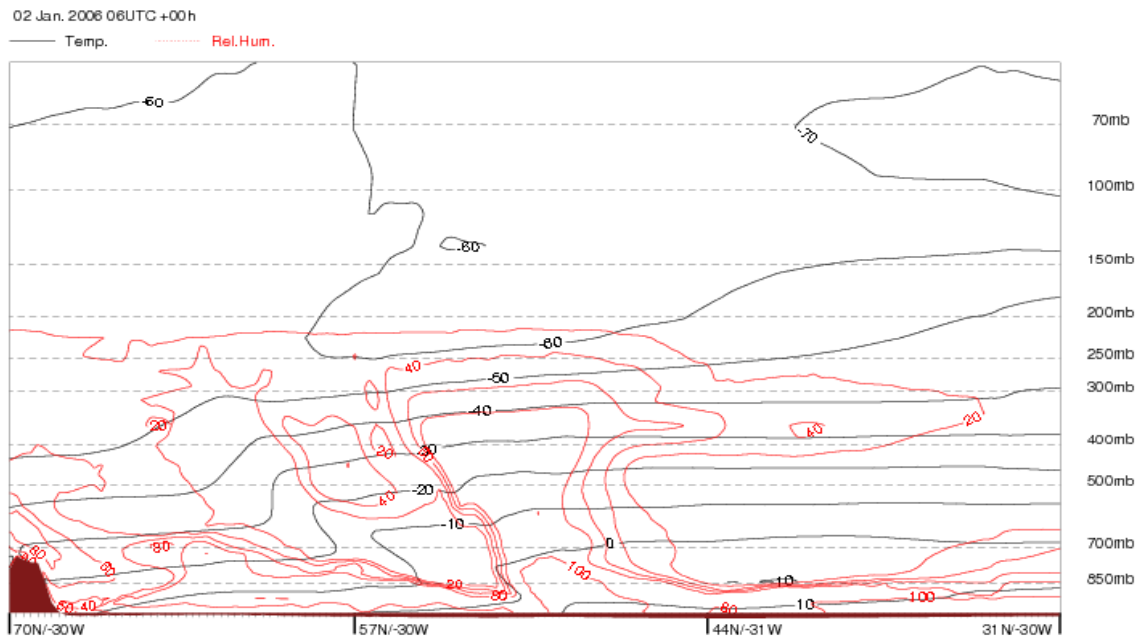


Specific Humidity

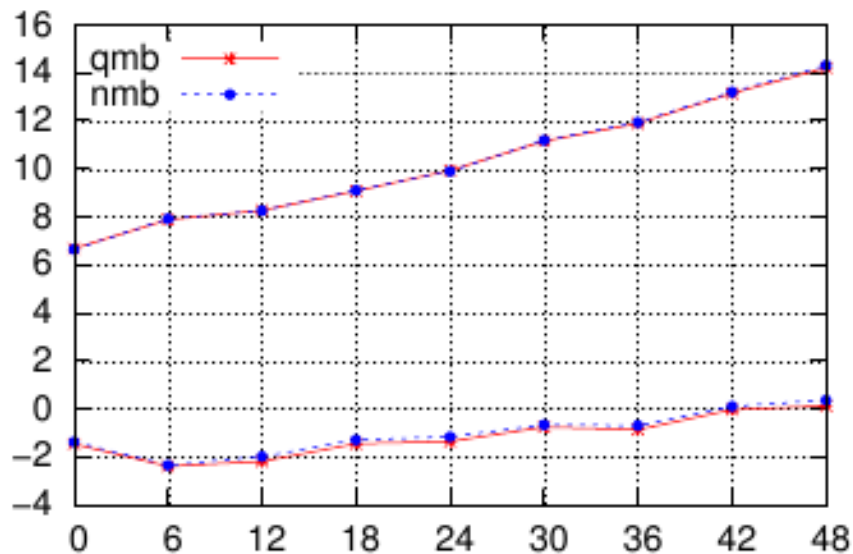


Normalized new bal Humidity

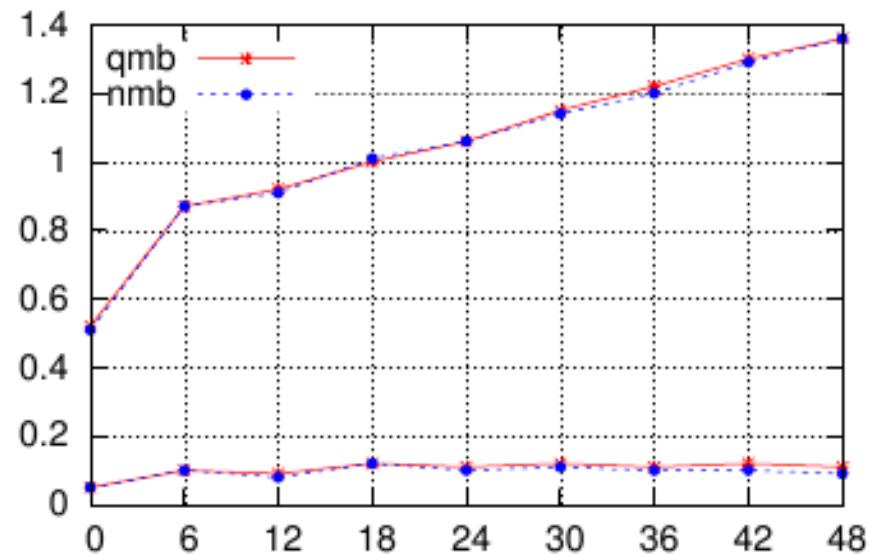
Same vertical crosssection with the background T and RH fields



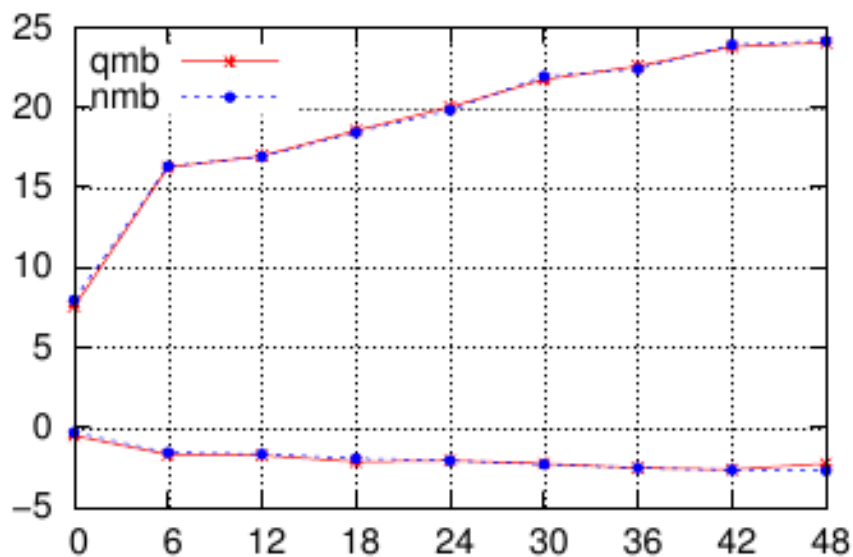
validating: 2004040200 – 2004043118
700.HPa Geopotential



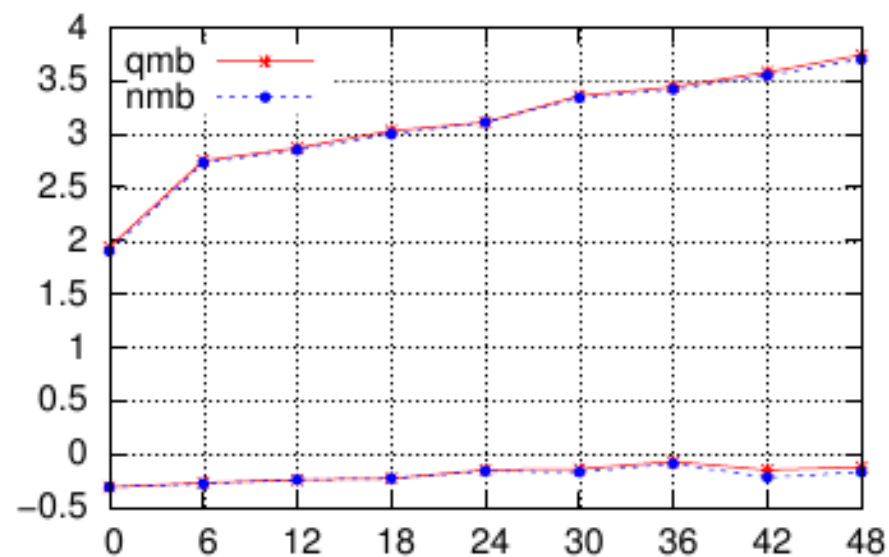
700.HPa Temperature



700.HPa Relative Humidity



700.HPa Wind Speed



Concluding Remarks

- The transformed humidity variable has been implemented in the background constraint of HIRLAM 3D and 4D-Var.
- Work to test this new humidity variable has started with SYNOP 2 m relative humidity, radiosonde humidity and AMSU-A temperature data.
- Further evaluation of the new moisture balanced control variable is presently undergoing.