The Assimilation of Cloudy Infrared Radiances in the HIRLAM Model: Initial Experiences

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(Per Dahlgren, Magnus Lindskog, Tomas Landelius, Nils Gustaffson, Per Unden, Anke Thoss)

SMHI, Swedish Meteorological and Hydrological Institute

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Outline

- **Short motivation**
- **Strategy for using cloudy IR radiances (Extending the observation operator)**
- **Observation operator**
- **Preliminary 1D-Var experiments**
  - Synthetic data
  - Case study
  - Real data set
- **Problematic issues**
- **Summary and Outlook**

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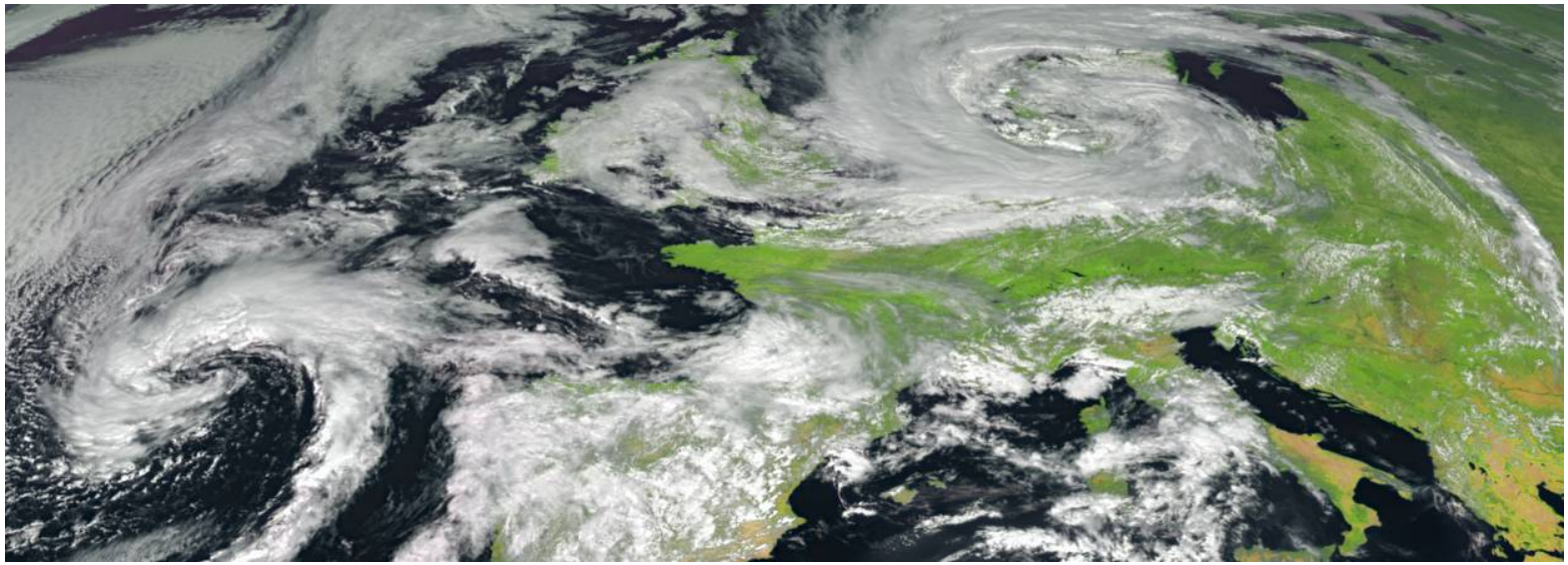
Motivation

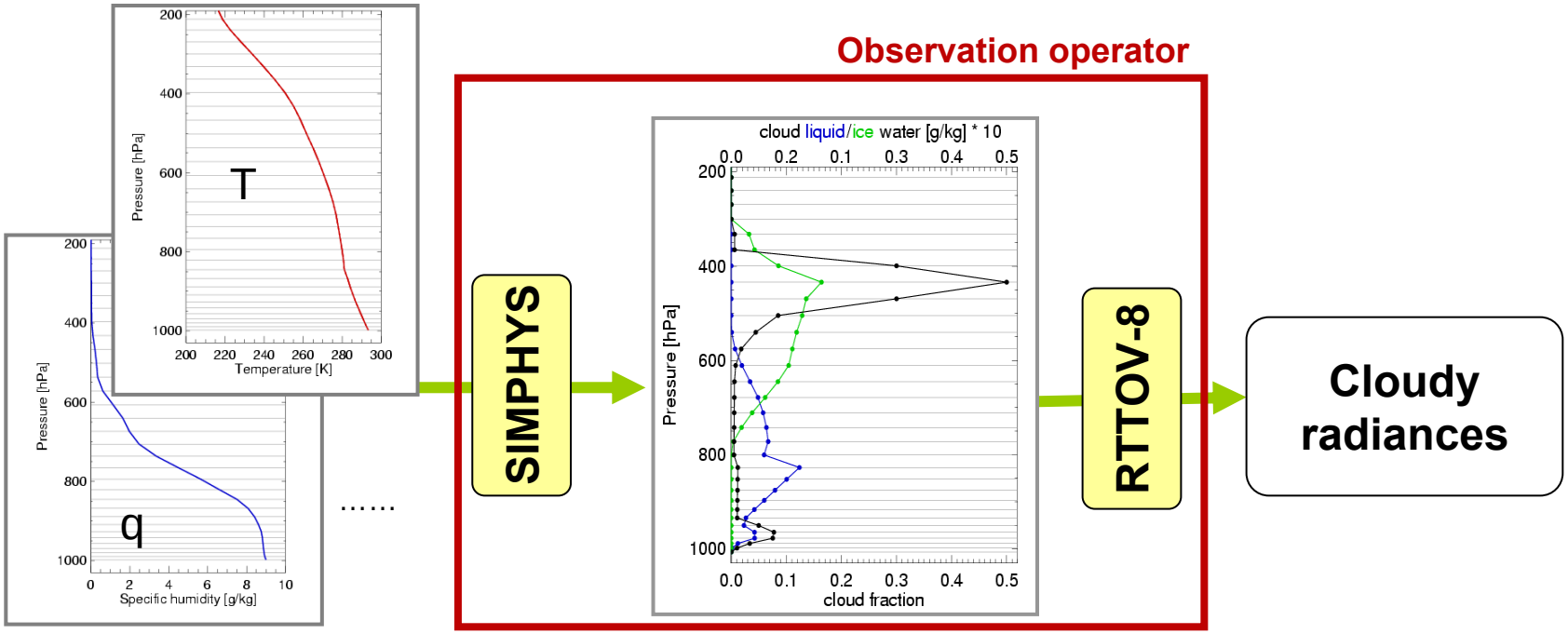


- Large number pixels are classified as cloudy
- Nearly all satellite obs. are rejected in those areas (where the weather is happening)
- Forecast results seem to be sensitive to cloudy regions

- IR radiation very sensitive to clouds – especially to cloud cover and vertical position of clouds => strong signal
- Should be possible to convert this information into something that is useable for NWP systems

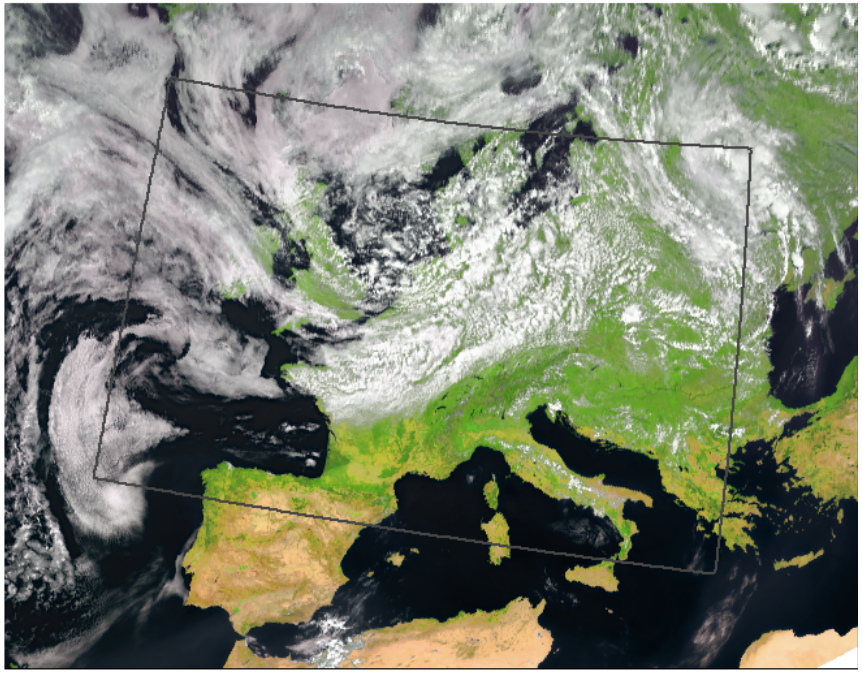
Strategy

- ECMWF's "Next-Generation" Simplified Moist Physics Package (SIMPHYS) in offline mode
- Simplified parameterizations for convection and large scale cloud and precipitation processes
- Using sensitivity of modelled cloud to model fields of T and q → sensitivity of modelled cloudy radiances to T and q
- Goal: Mapping cloudy BG-O via those sensitivities to T and q increments



Observation operator - SIMPHYS part

- **SIMPHYS applied to HIRLAM 6h forecast fields**



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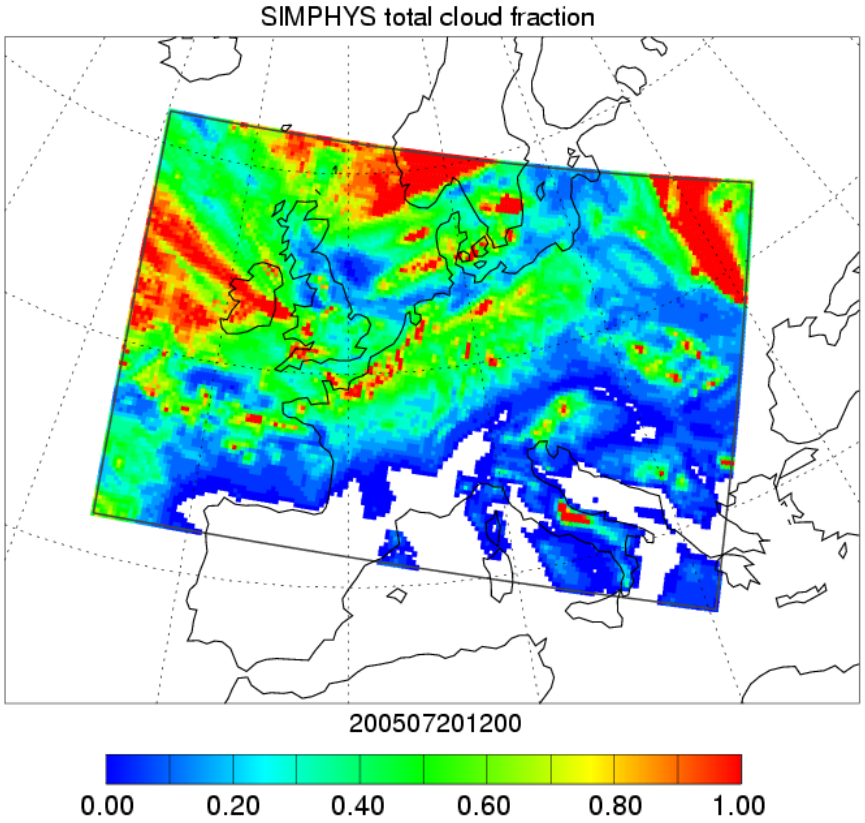
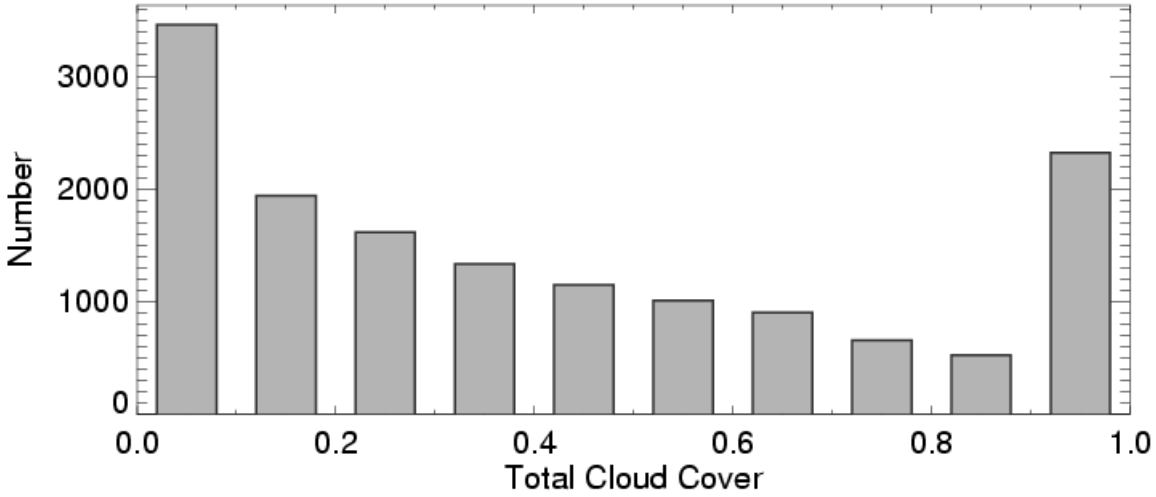
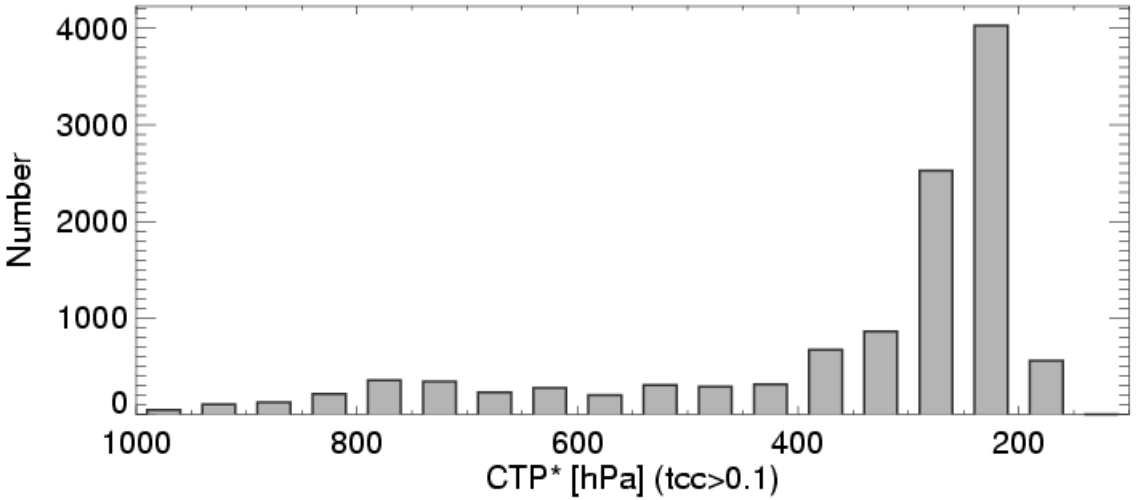


Observation operator - SIMPHYS part

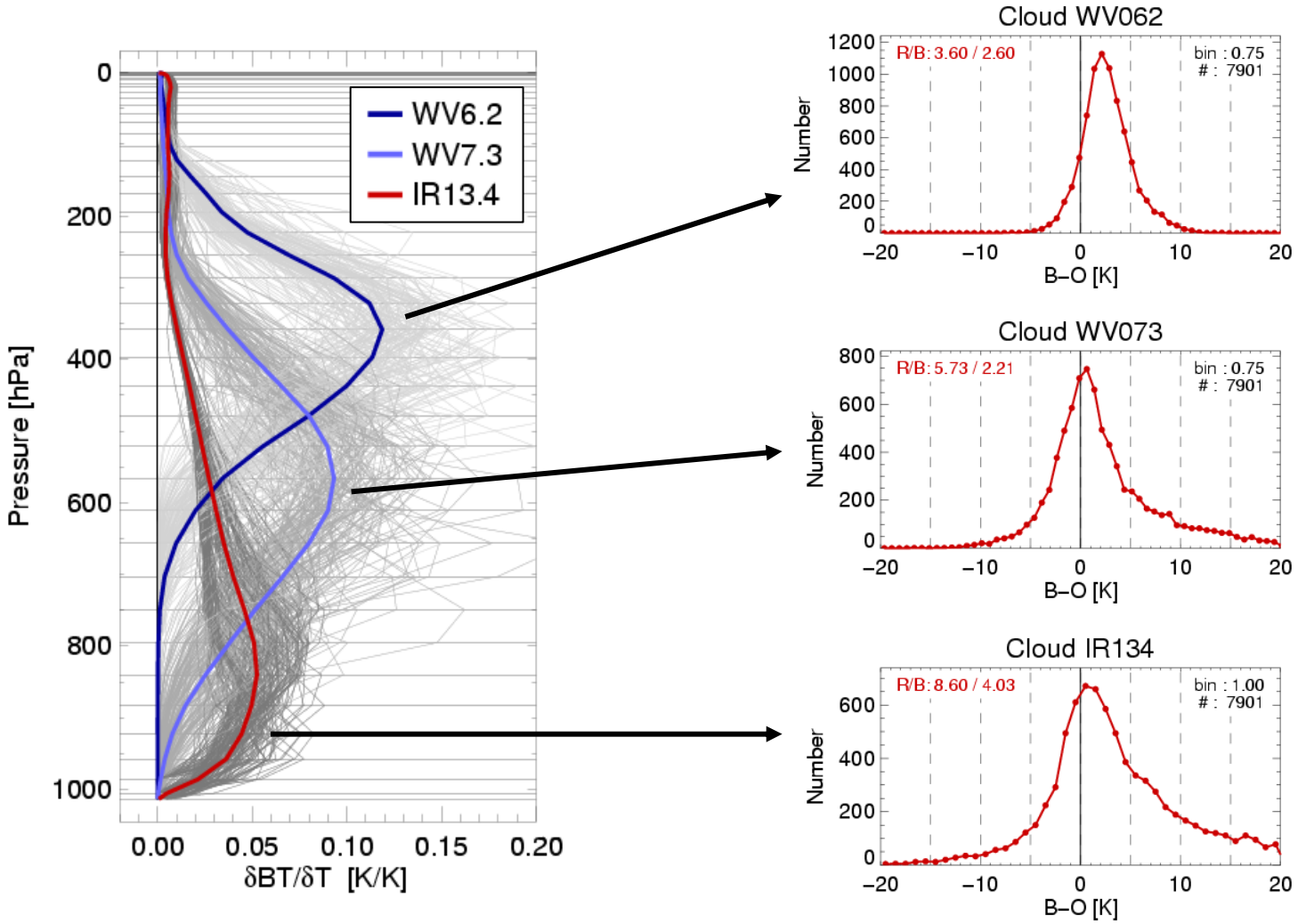
- **SIMPHYS cloud cover and cloud top pressure statistics over 15000 profiles**





Observation operator performance

- **O-B statistics for SEVIRI's "sounding channels" for cloudy cases. (HIRLAM 6h forecast vs SEVIRI 5x5 pixel mean)**



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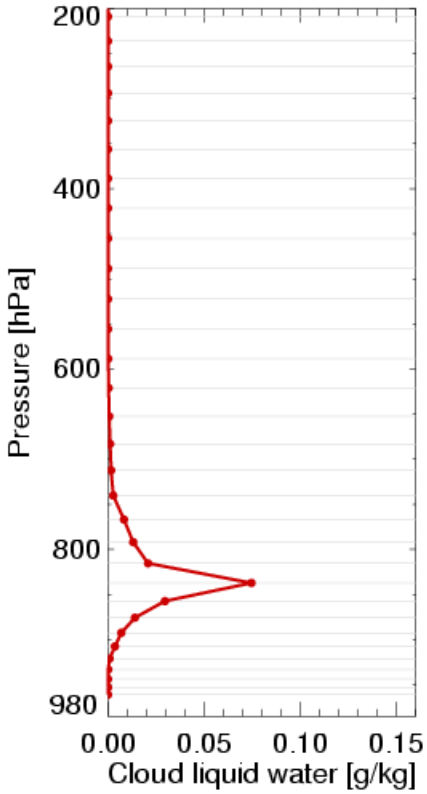
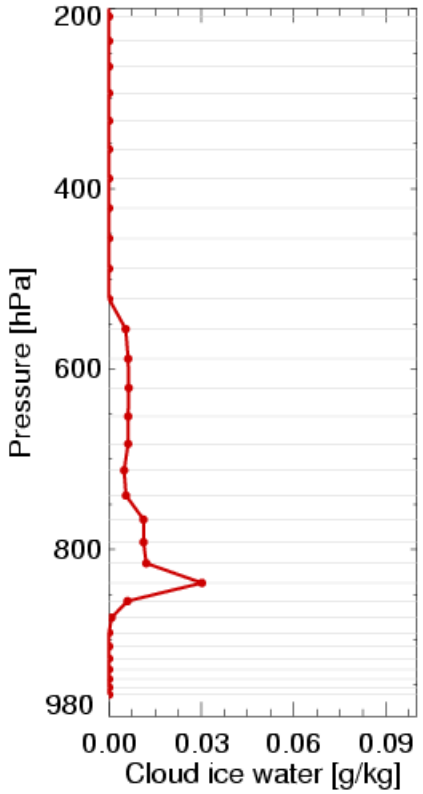
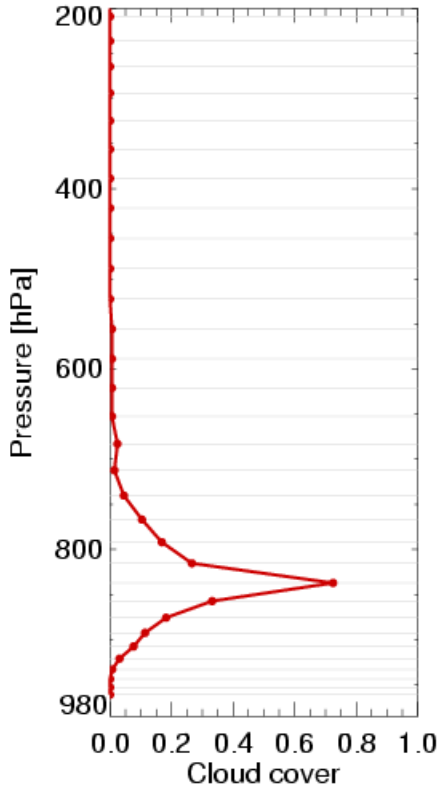
Sensitivity study

- **Sensitivity of cloud properties (lwc, iwc, cc, ctp) to perturbations in specific humidity at each level**







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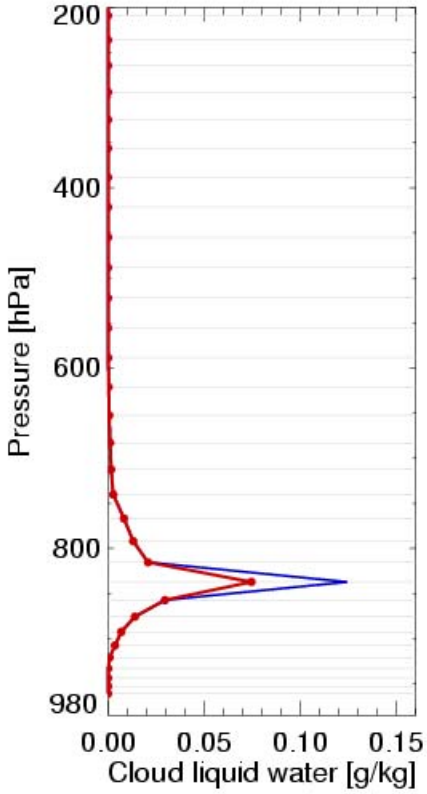
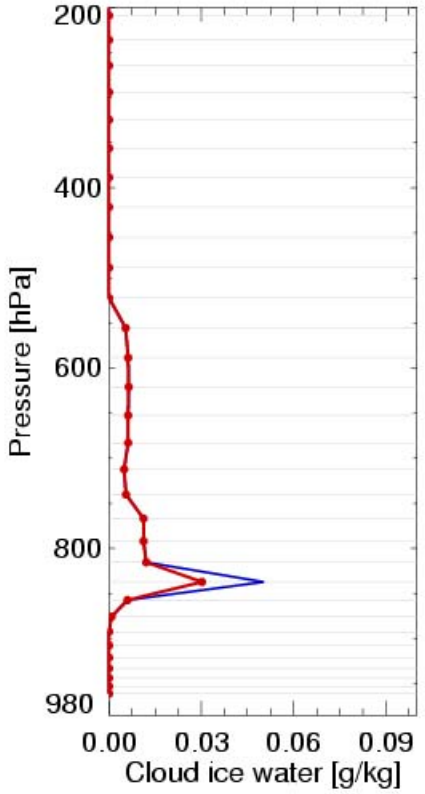
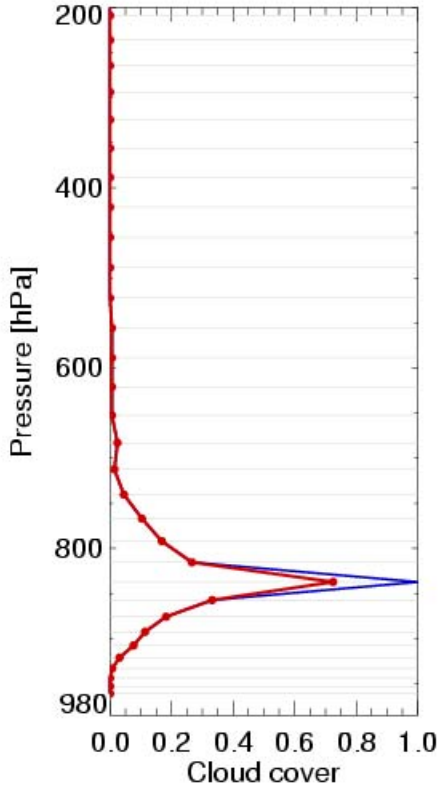
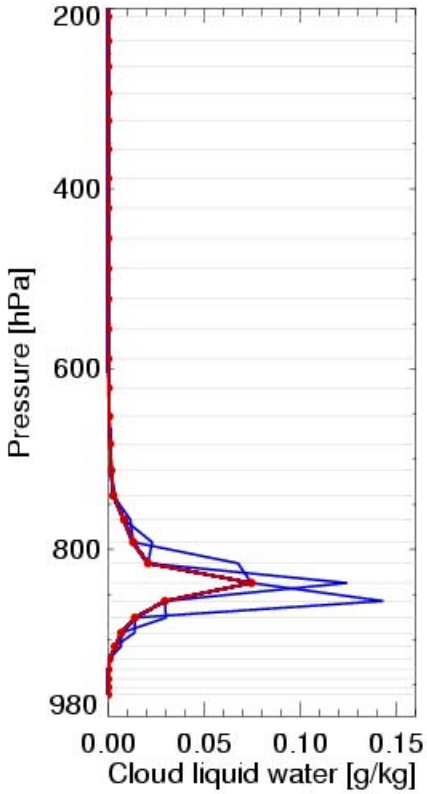


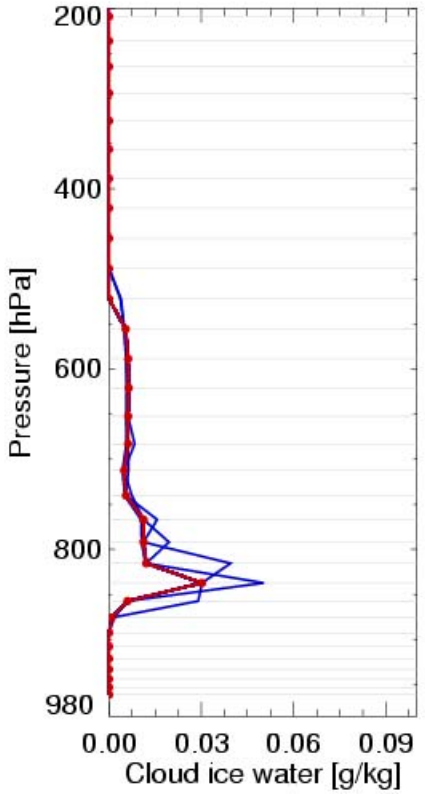


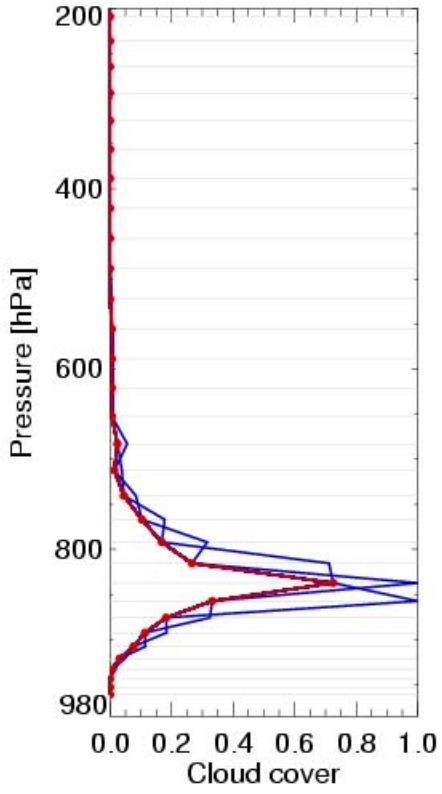


Sensitivity study

- **Sensitivity of cloud properties (lwc, iwc, cc, ctp) to perturbations in specific humidity at each level**

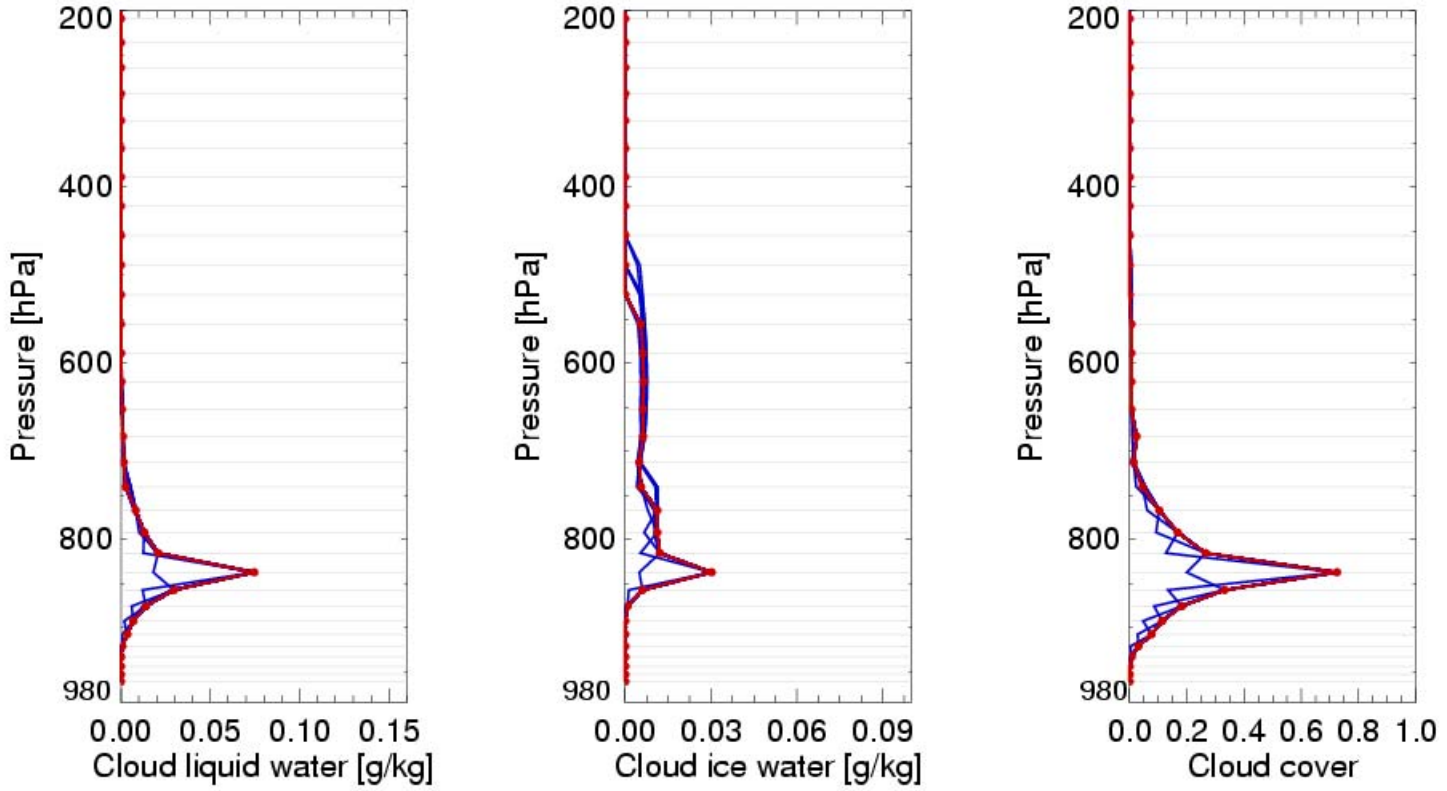






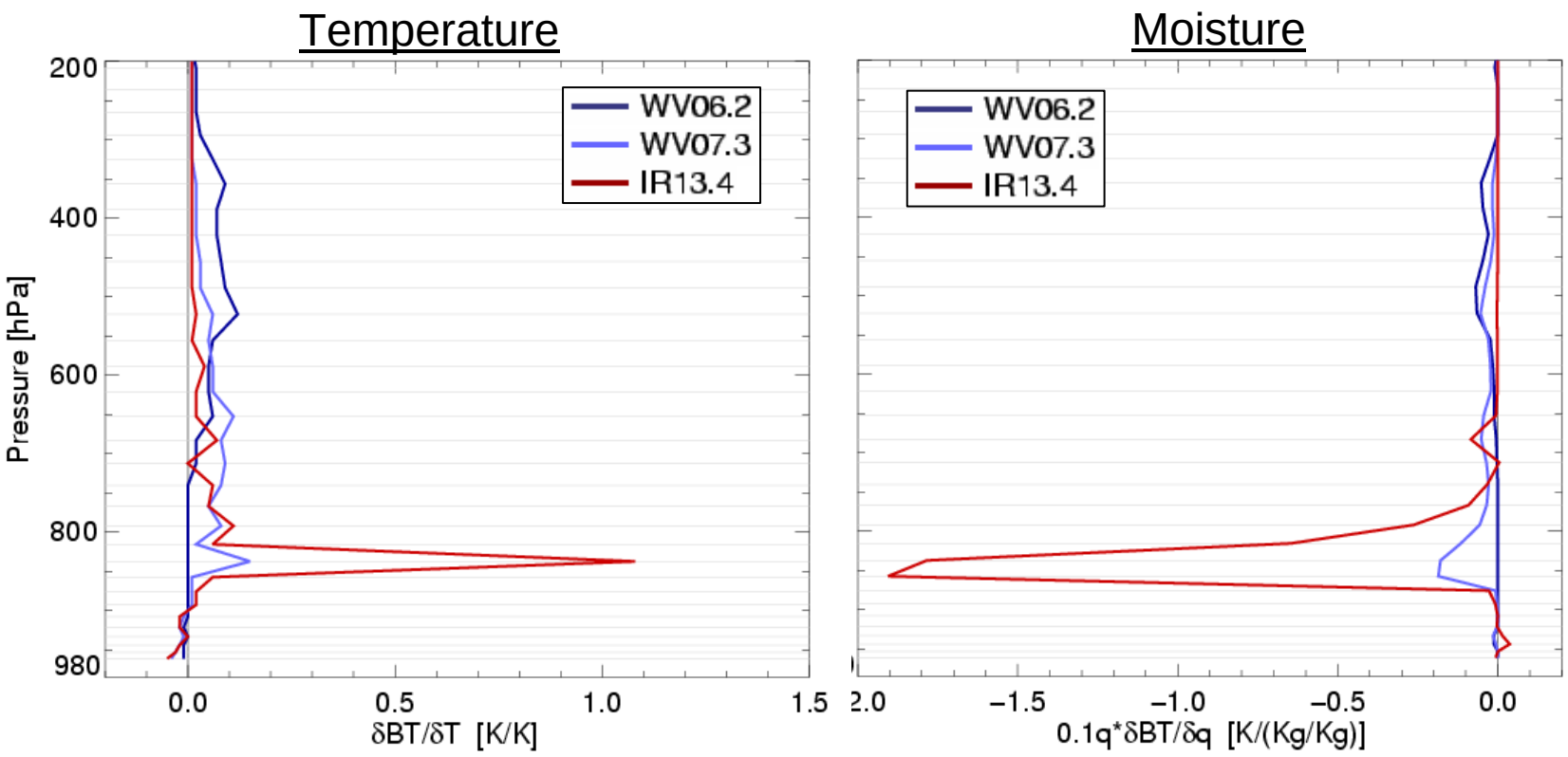
Sensitivity study

- **Sensitivity of cloud properties (lwc, iwc, cc, ctp) to perturbations in temperature at each level**



Sensitivity study

- **Jacobians (brute force):**
  - Depend on amplitude/direction of perturbation (here: perturbation = ¼ of background error stddev
  - Problematic near cc=0/1!



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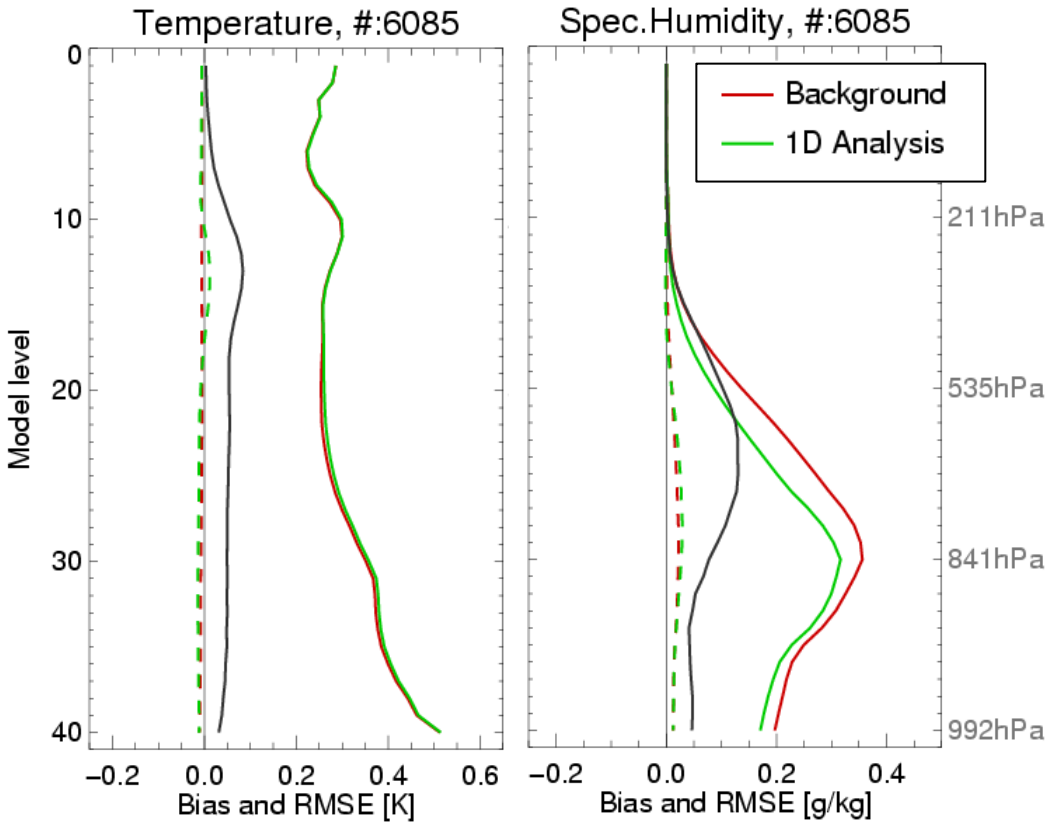
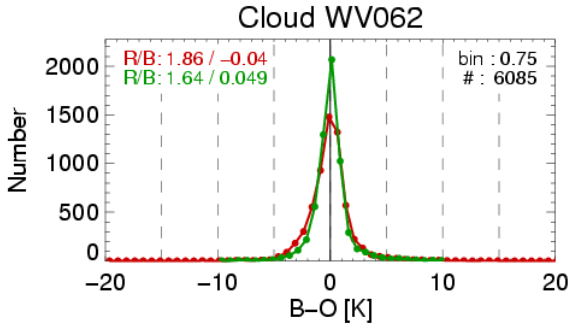
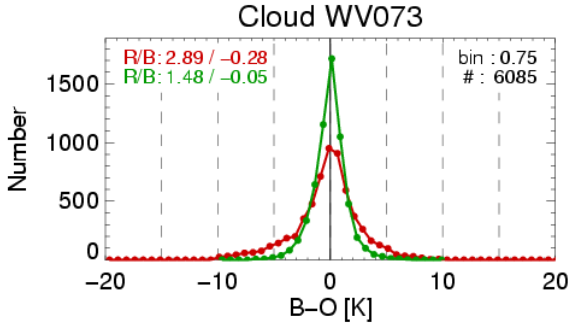
1D-Var experiments - synthetic data set

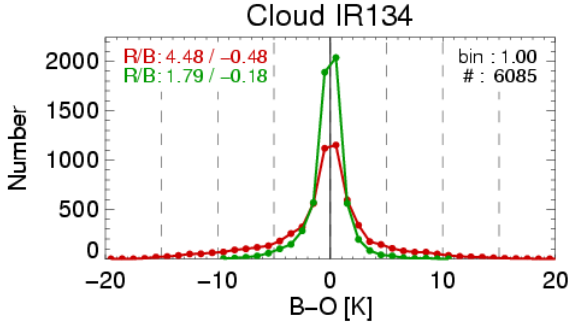
- **Control vector: [T,q,Psfc] ; HIRLAM: [T,q,u,v,Psfc]**
- **NWP profiles as truth, perturbed profiles as first guess (Stddev of perturbation: ½ background error)**

Impact only on moisture!









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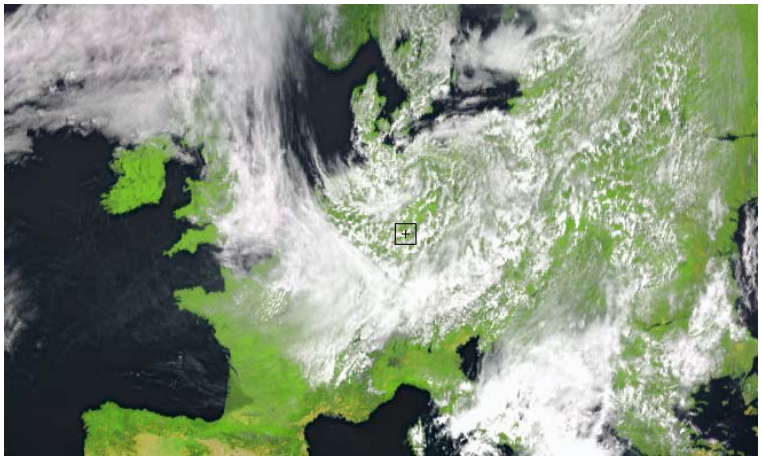
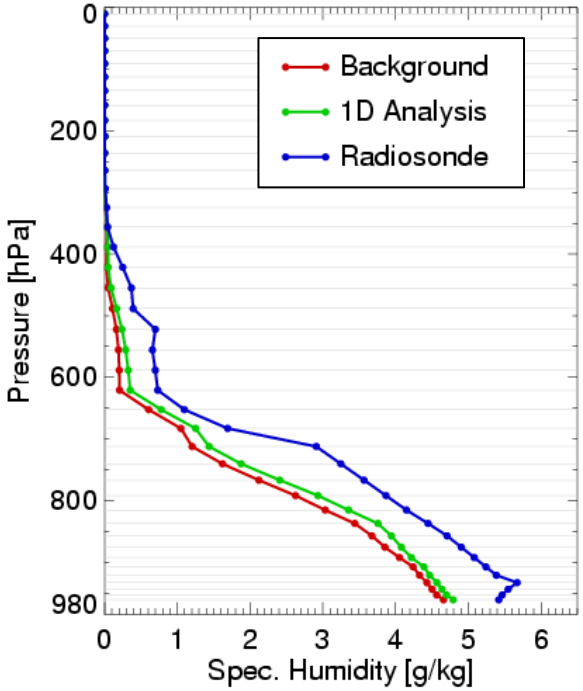
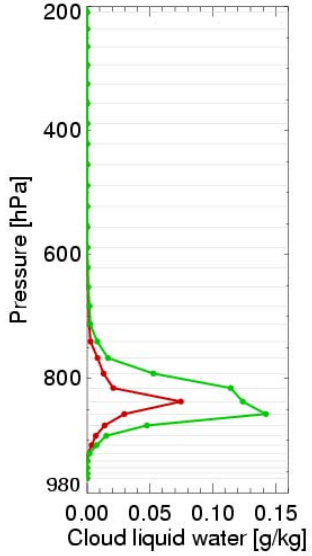
1D-Var experiments - Case study

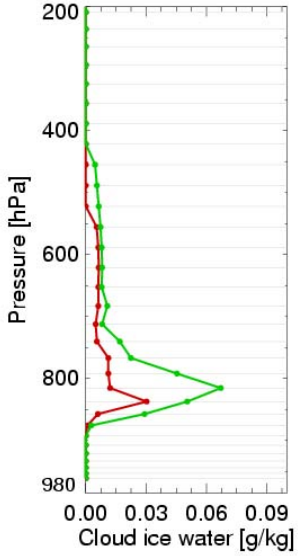
- Control vector: [T,q,Psfc] ; HIRLAM: [T,q,u,v,Psfc]
- Observations: 5x5 pixel box mean (approx. 25x25km)

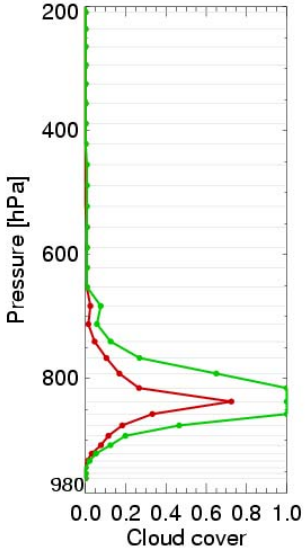
	WV06.2	WV7.3	IR13.4
SigmaO	2.5K	2.5K	3.5K
B-O [K]	0.7	4.4	5.8
A-O [K]	-1.1	2.5	3.5











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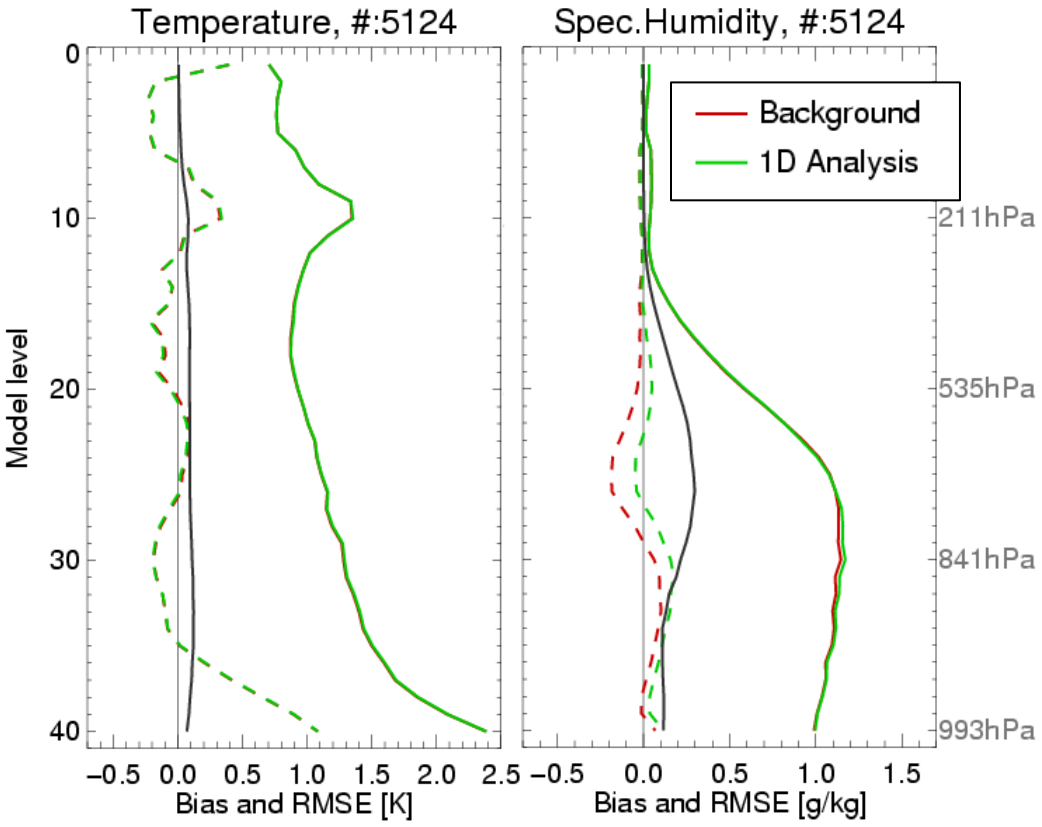
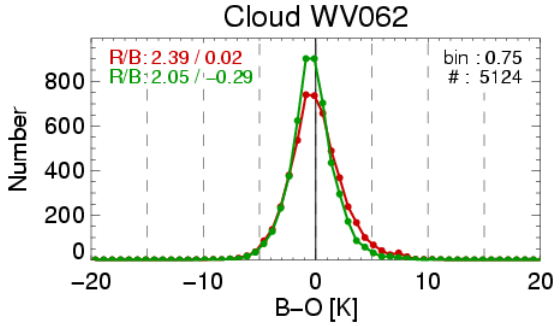
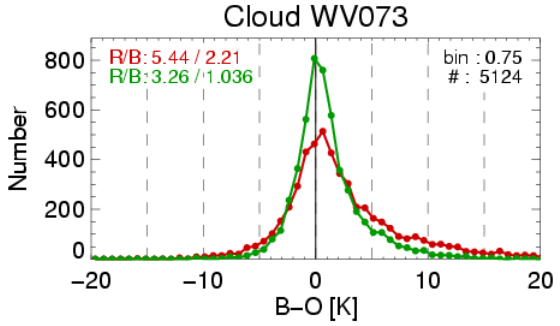
1D-Var experiments - real data set

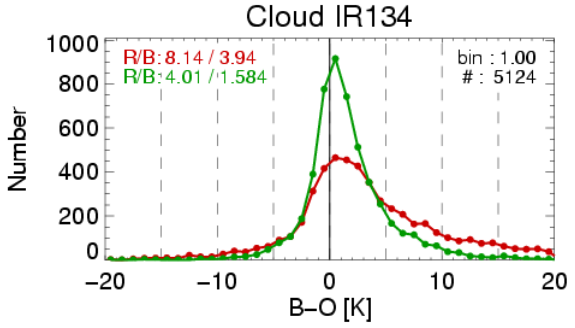
- **Control vector: [T,q,Psfc] ; HIRLAM: [T,q,u,v,Psfc]**
- **Collocation with radiosondes (.lt. 75° scanning angle)**
- **Observations: 5x5 pixel box mean (approx. 25x25km)**

Impact only on moisture!









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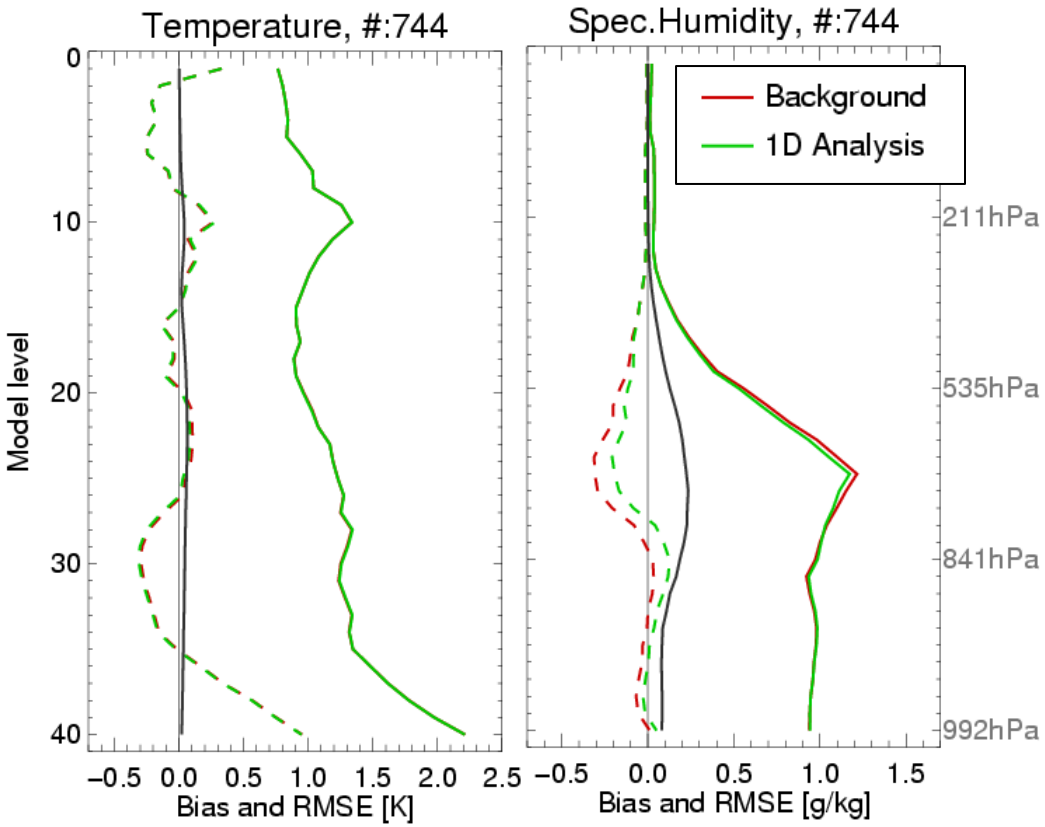
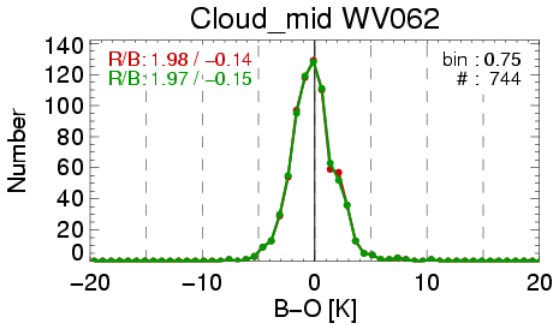
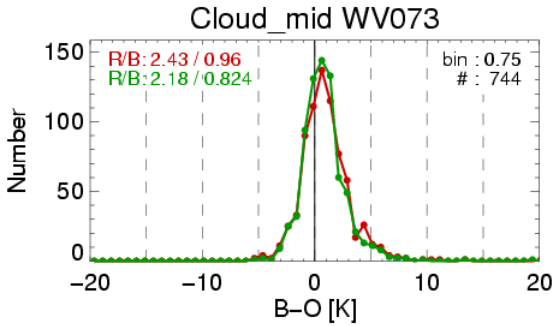
1D-Var experiments - real data set

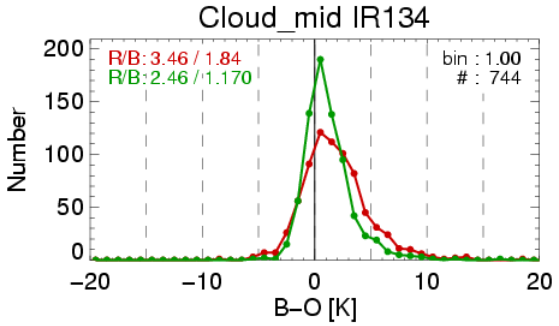
- Collocation with radiosondes (.lt. 75° scanning angle)
- Observations: 5x5 pixel box mean (approx. 25x25km)
- Only cases with 450hPa<CTP<850hPa

Impact only on moisture!









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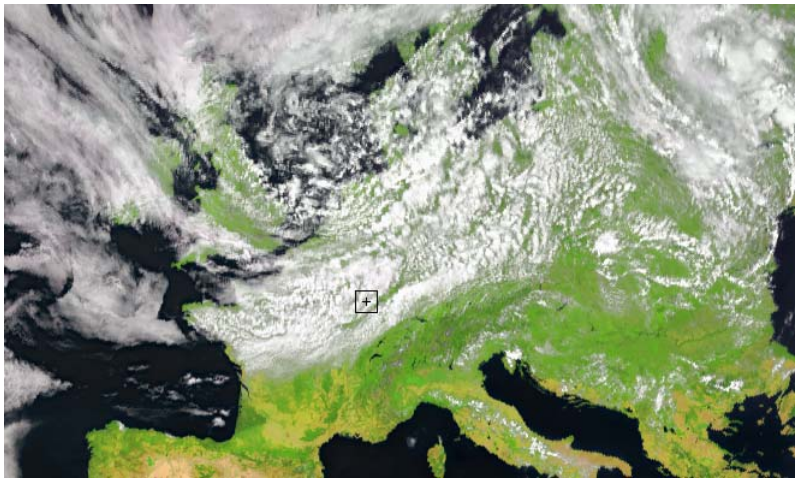
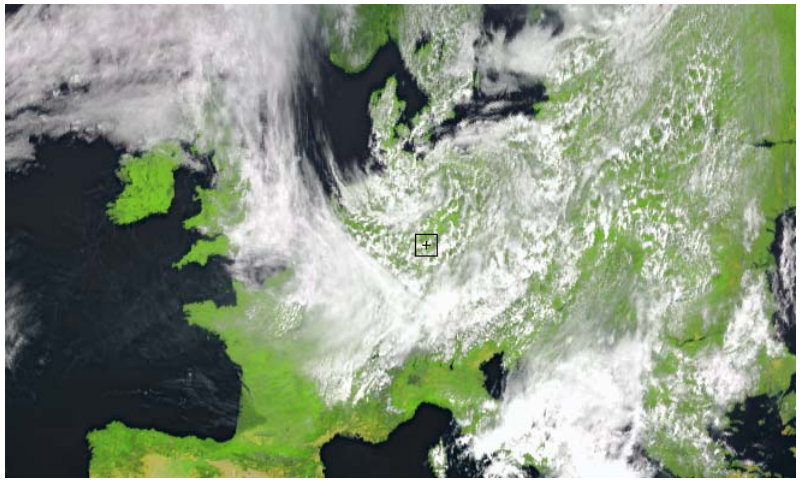
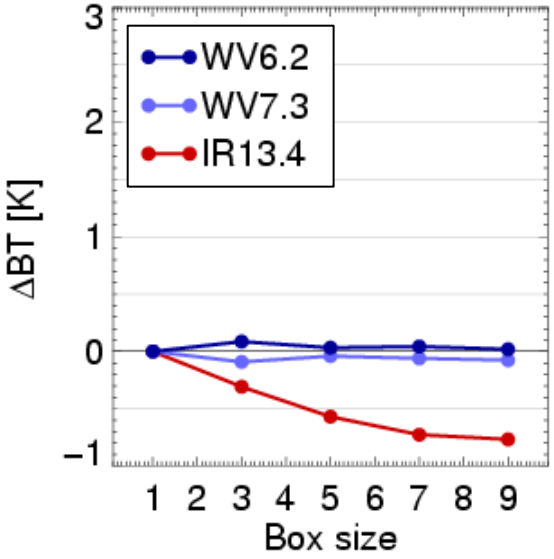
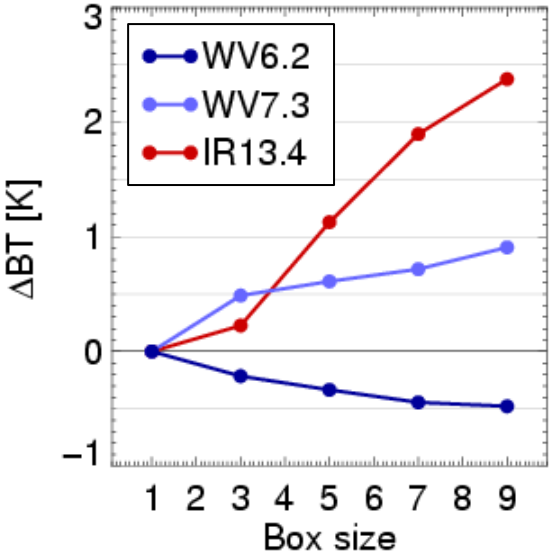
Problematic issues I

- **Spatial mapping of Sat to NWP in cloudy conditions**



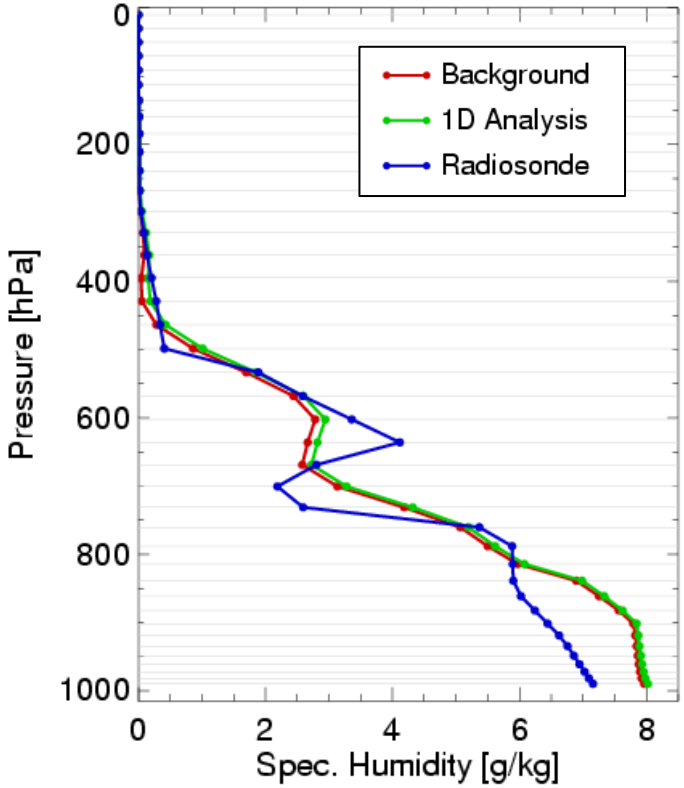


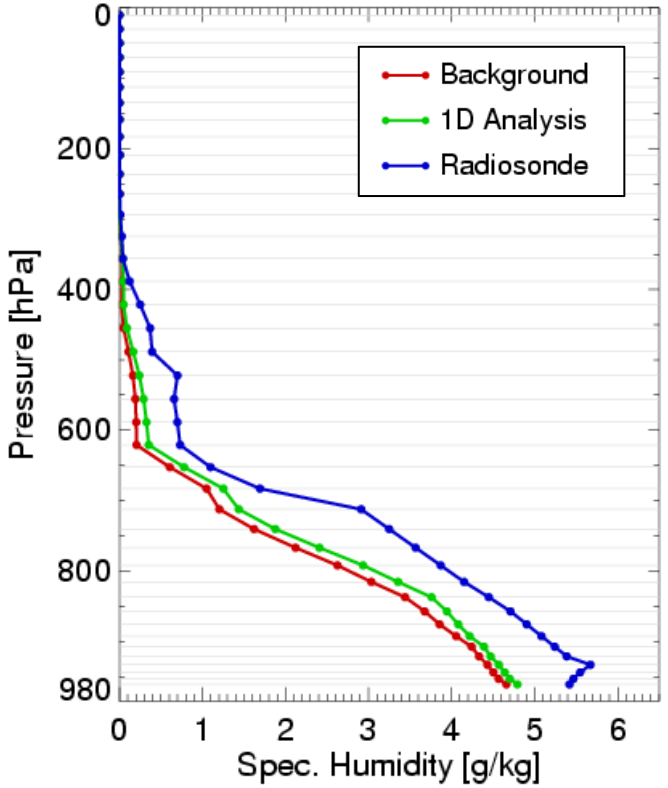




Problematic issues II

- **Structure functions (vertical correlations of background errors) smooth perhaps too much (40 levels here)**





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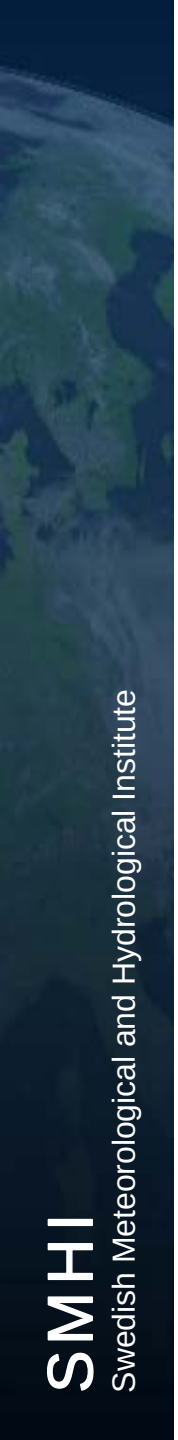
Summary

- Extended the observation operator
- Investigated the O-B statistics and sensitivities
- Preliminary 1D-Var experiments have been carried out
- Fist results look promising

Future work

- Tuning of SIMPHYS / Bias correction
- Jacobians to be calculated better?
- Surface temp. in NWP…? Over ocean only?
- Identifying ‘good’ cases (perhaps mid- and low-level water clouds with cloudcover < 1)
- Provide this to the full HIRLAM 3D-Var/4D-Var assimilation system (uses transpose of the Jacobians)



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Thank you

International TOVS Study Conference, 16th, ITSC-16, Angra dos Reis, Brazil, 7-13 May 2008. Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies, 2008.