Combining the perspective of vertical resolved ground observations and geostationary satellite observations by use of a forward model approach

Anja Hünerbein, Hartwig Deneke, Andreas Macke

Leibniz Institute for Tropospheric Research (TROPOS)

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Motivation: Cloud frontal systems

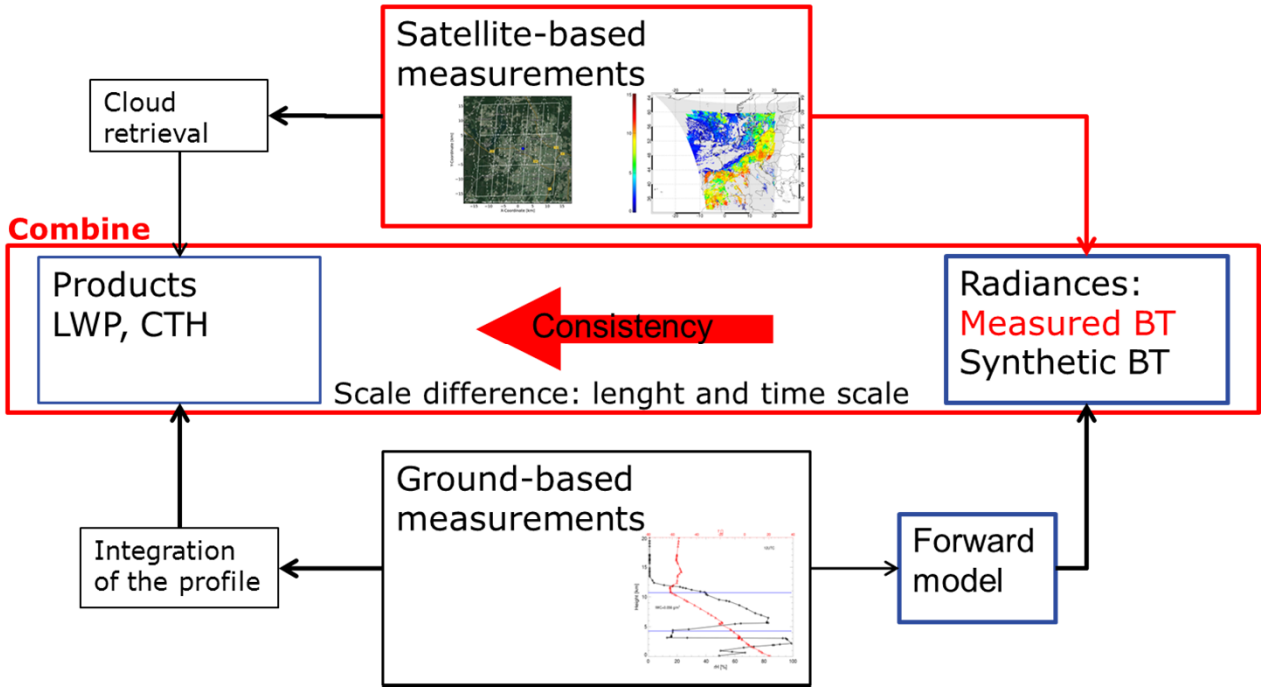
Still, a need of observation to improve the understanding of the cloud processes

Characterization of *three*-dimensional cloud distribution and the vertical distribution of cloud microphysics to verify the physical parameterization that control cloud as well as the models

- ➔ By combining the two perspectives of the vertical profiles of the cloud properties (ground-based) and the spatial variance (satellite)
- ➔ To study different state of cold and warm front systems passing European super sites (so far Germany)

Approach

1. Characterization of the cloud structure and air mass classification using synoptic satellite meteorology (Satrep-Eumetrain)
2. Combination of the two perspectives of the satellite- and ground-based measurement by utilizing a forward model to provide synthetic satellite data



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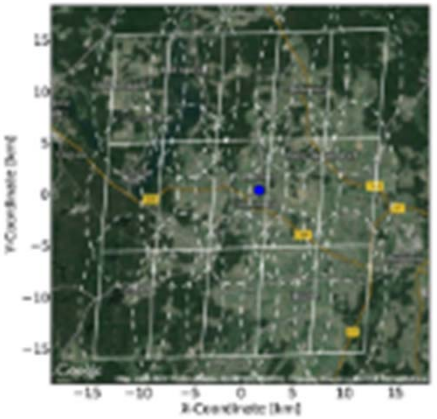
Approach: 2. Combination of the two perspectives

Difference time and length scale:

- Parallax correction and standard deviation of surrounding 3 x 5 pixels
- Averaging in time (synthetic, 15min)



Different metric to combine:

1. BT at the thermal IR channels (water vapour, window channels)
2. Split window and tri-spectral technique (cirrus, cloud type)
3. Outgoing longwave radiation (Eumetsat regression scheme)

Radiances:
Measured BT
Synthetic BT

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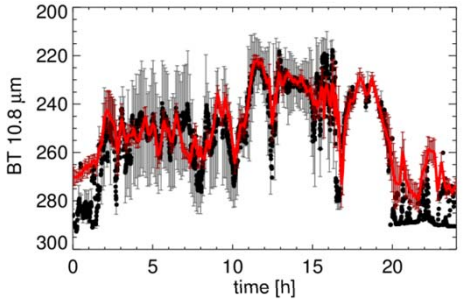

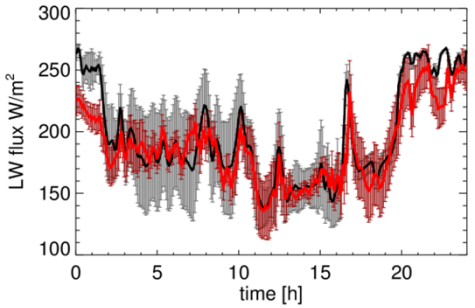

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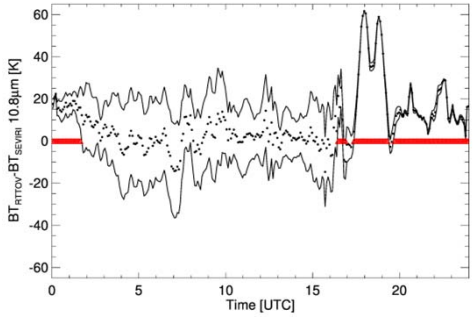
Different metric to combine

➢ **Consistency check**



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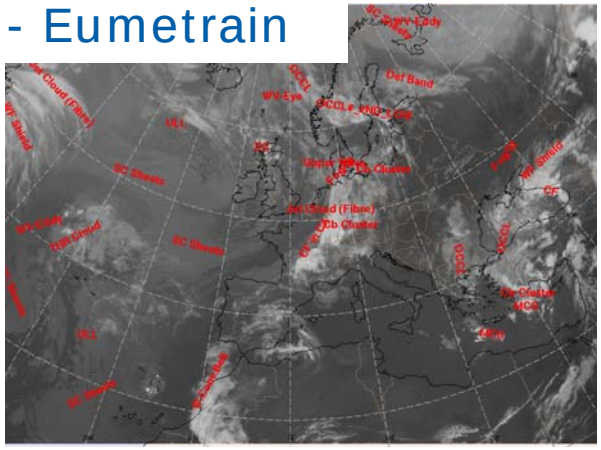
1. Characterization of the cloud frontal system with the air mass classification using synoptic satellite meteorology (Satrep-Eumetrain)
2. Combination of the two perspectives of the satellite- and ground-based measurement by utilizing a forward model to provide synthetic satellite data
   - We consider different metrics to quantify and interpret the consistency of the synthetic and the observed satellite data

3. Characterization of the development of the passing cloud frontal system passing

Dataset

Satrep - Eumetrain



August 2011- August 2012 data of synoptic satellite meteorologie thanks Paul de Valk

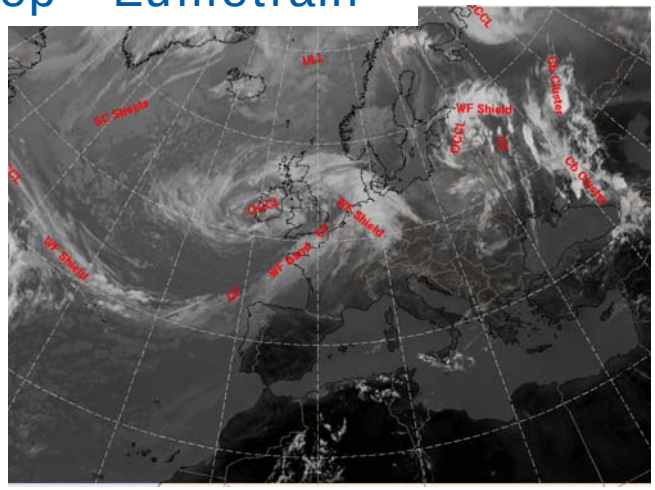
Sorted by cold front or warm front passing Europe -> Germany

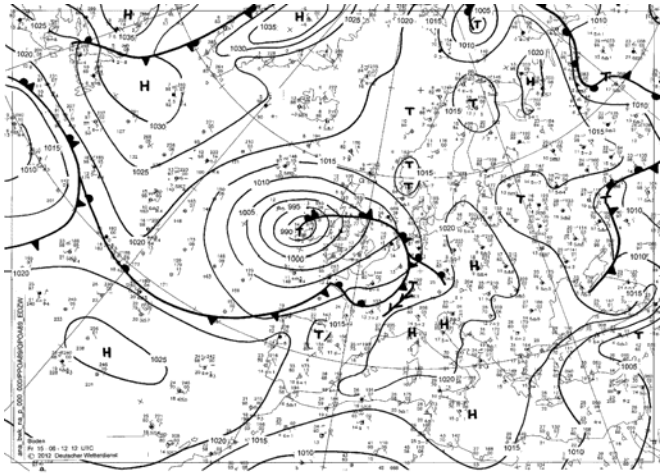
Number of days:

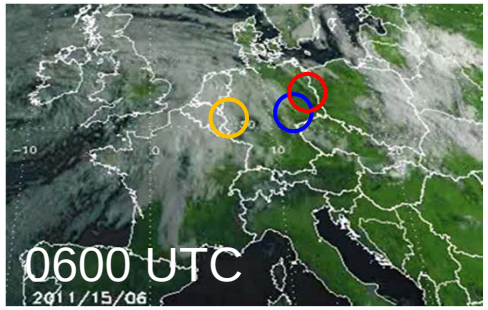
	Cold front	Warm front
Jülich (JOYCE)	17	17
Leipzig (LACROS)	21	21
Lindenberg (MOL)	15	14
One Station	7	4
Two stations	11	15
All stations	8	6

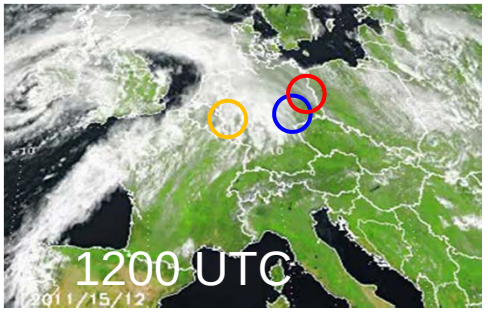
Characterization of the cloud frontal system e.g. 15 June 2012 Warm Front

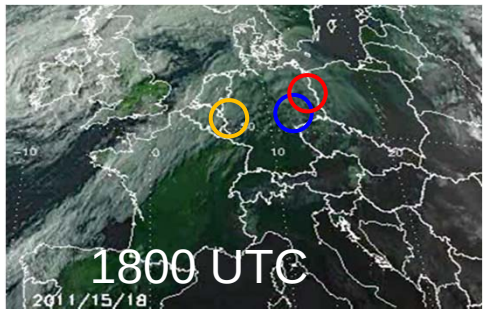
Satrep - Eumetrain











Jülich
Leipzig
Lindenberg

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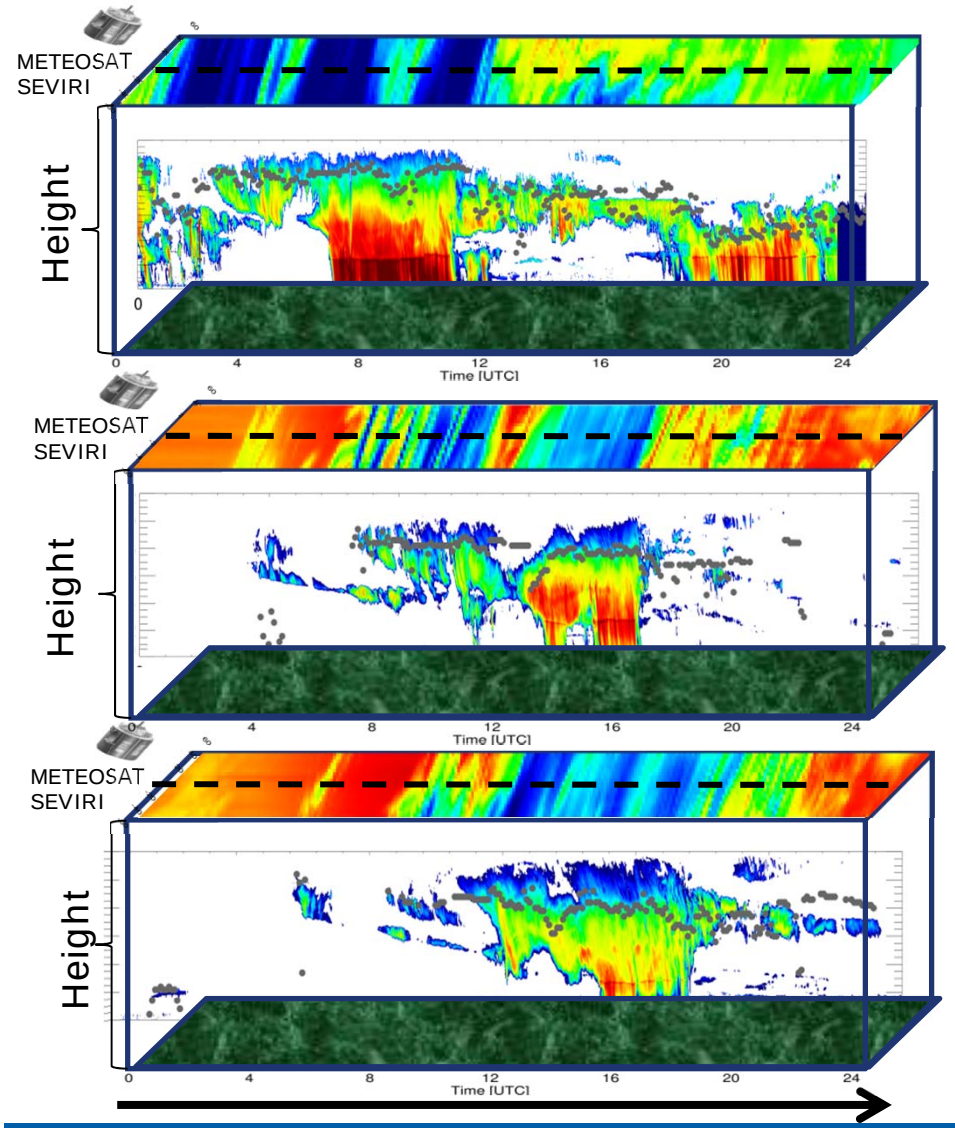
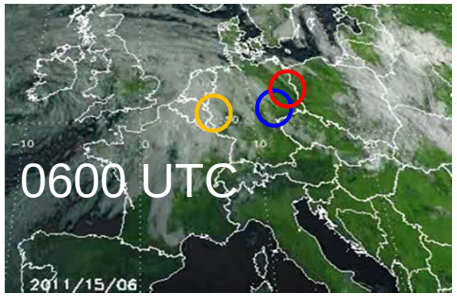
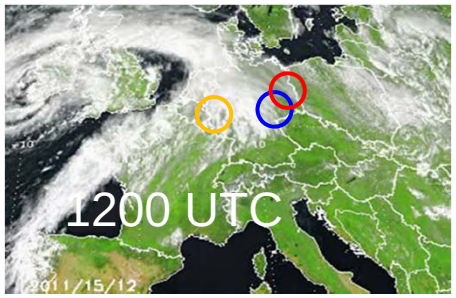
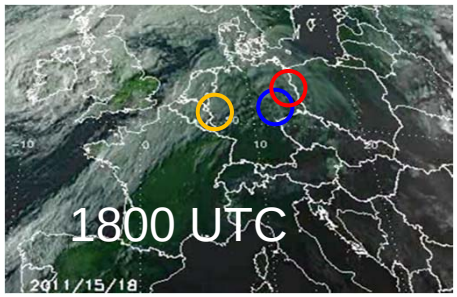
Combination of the two perspectives e.g.
15 June 2012 Warm Front





Jülich
Leipzig
Lindenberg





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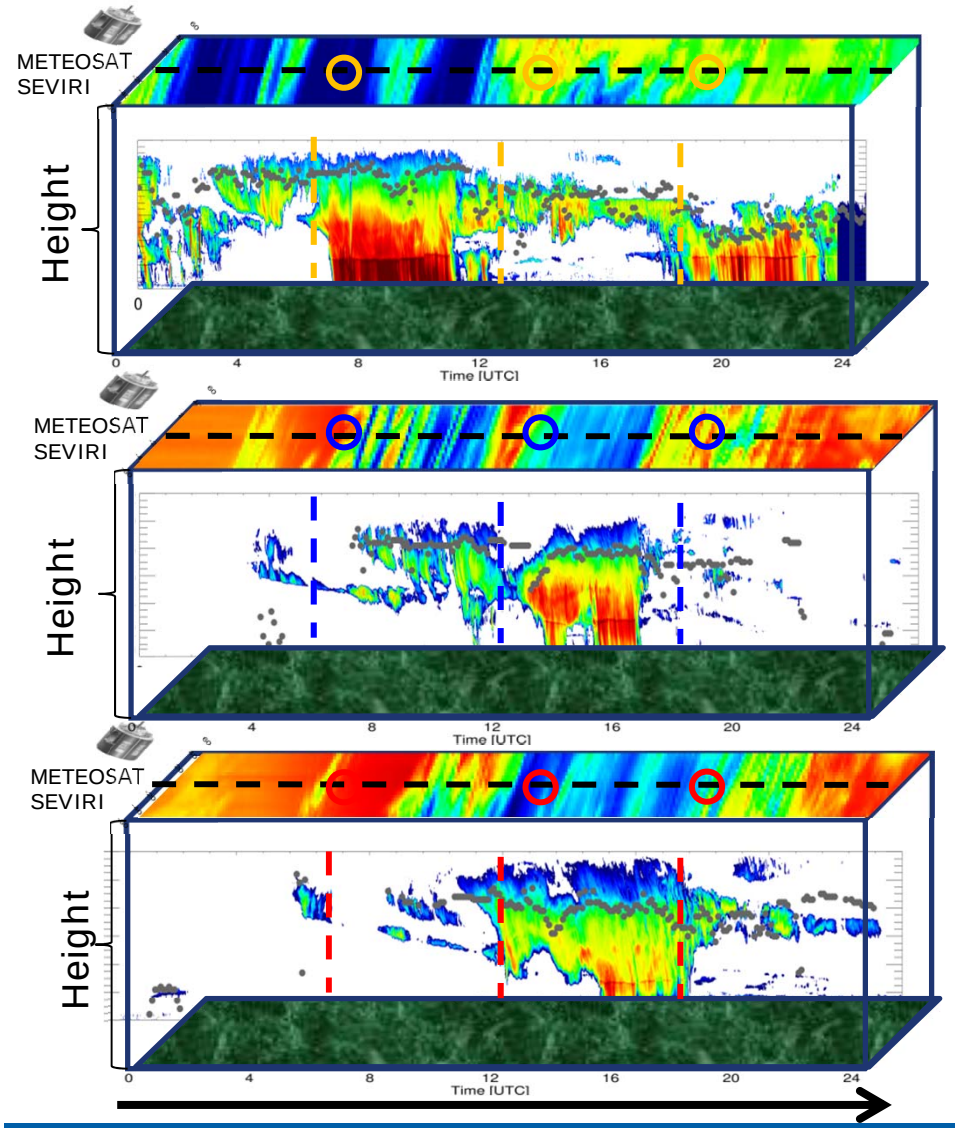
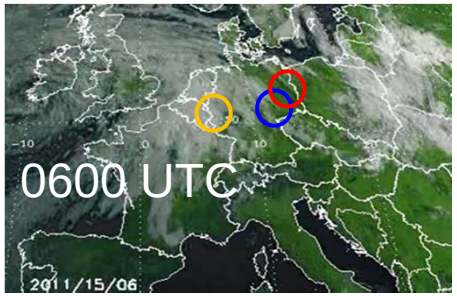
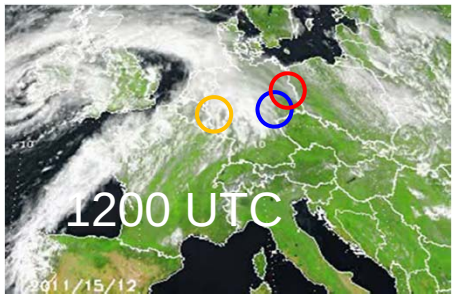
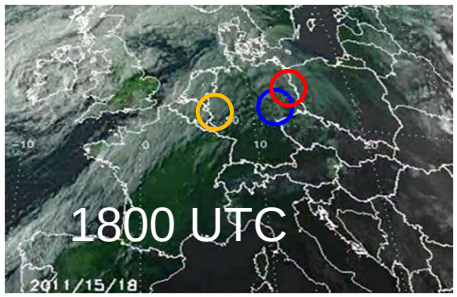




Jülich
Leipzig
Lindenberg





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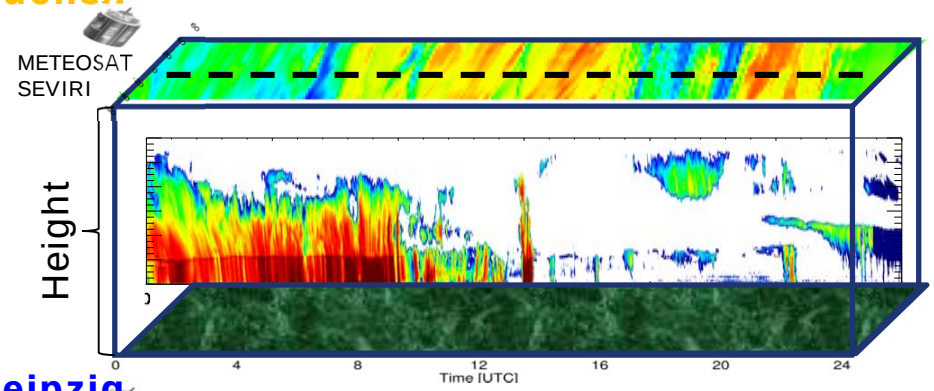
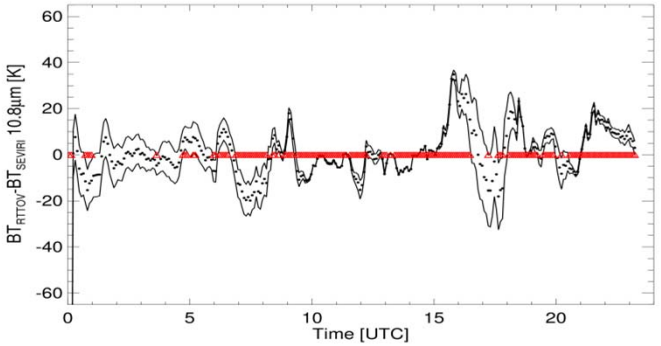
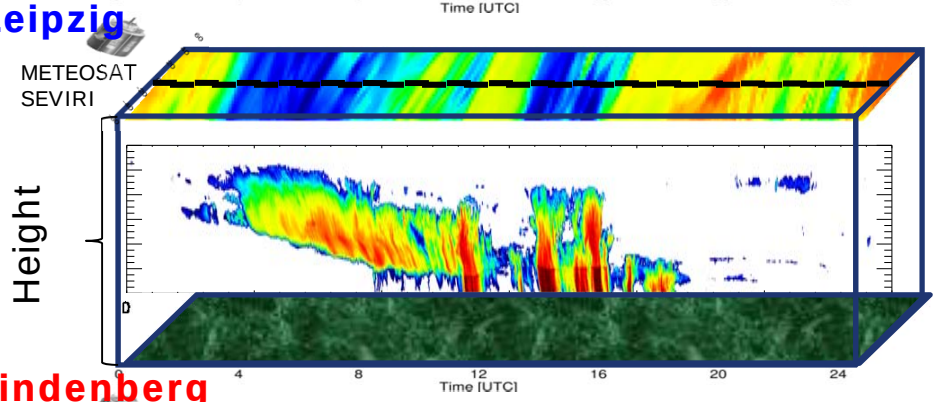
Selection of data - Consistency check -
e.g. 06 June 2012 Warm Front

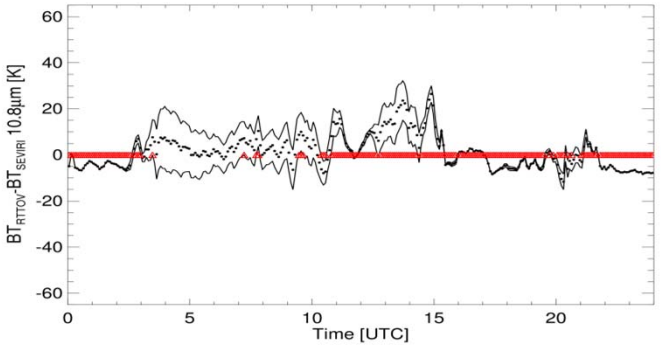
Juelich



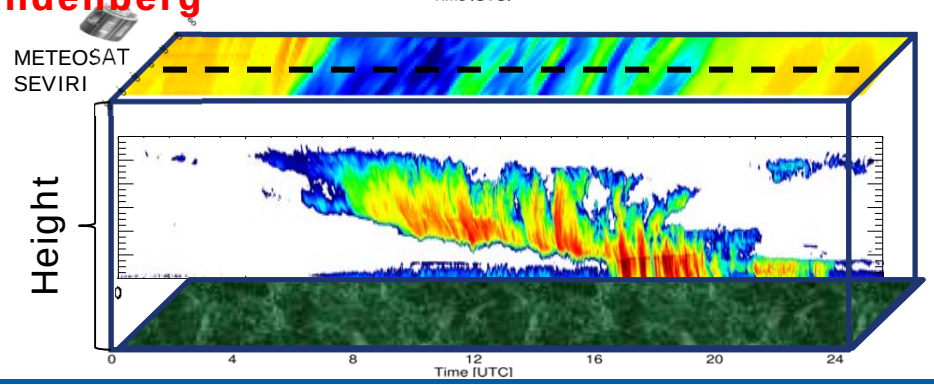


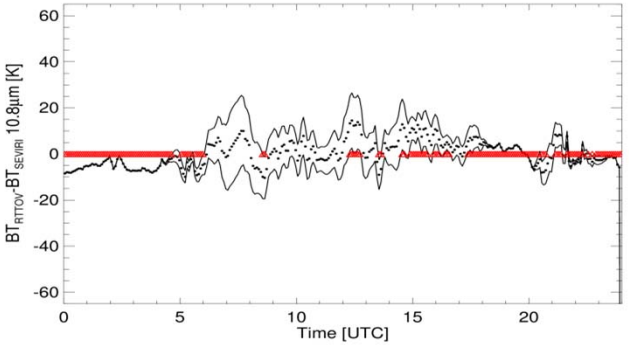
Leipzig





Lindenberg





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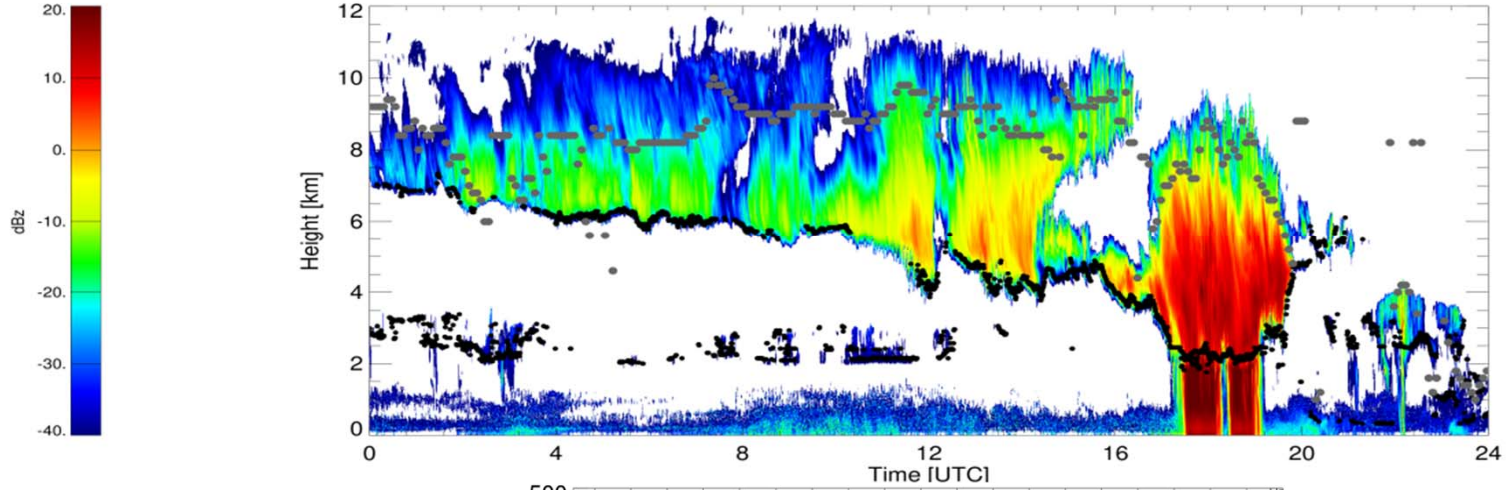
Characterization of the cloud frontal system which passed the consistency check

➔ Only those data used, which has passed the consistency to give us confidence to combine the cloud products as CTH, CWP



Example: May 12 2011 over Lindenberg

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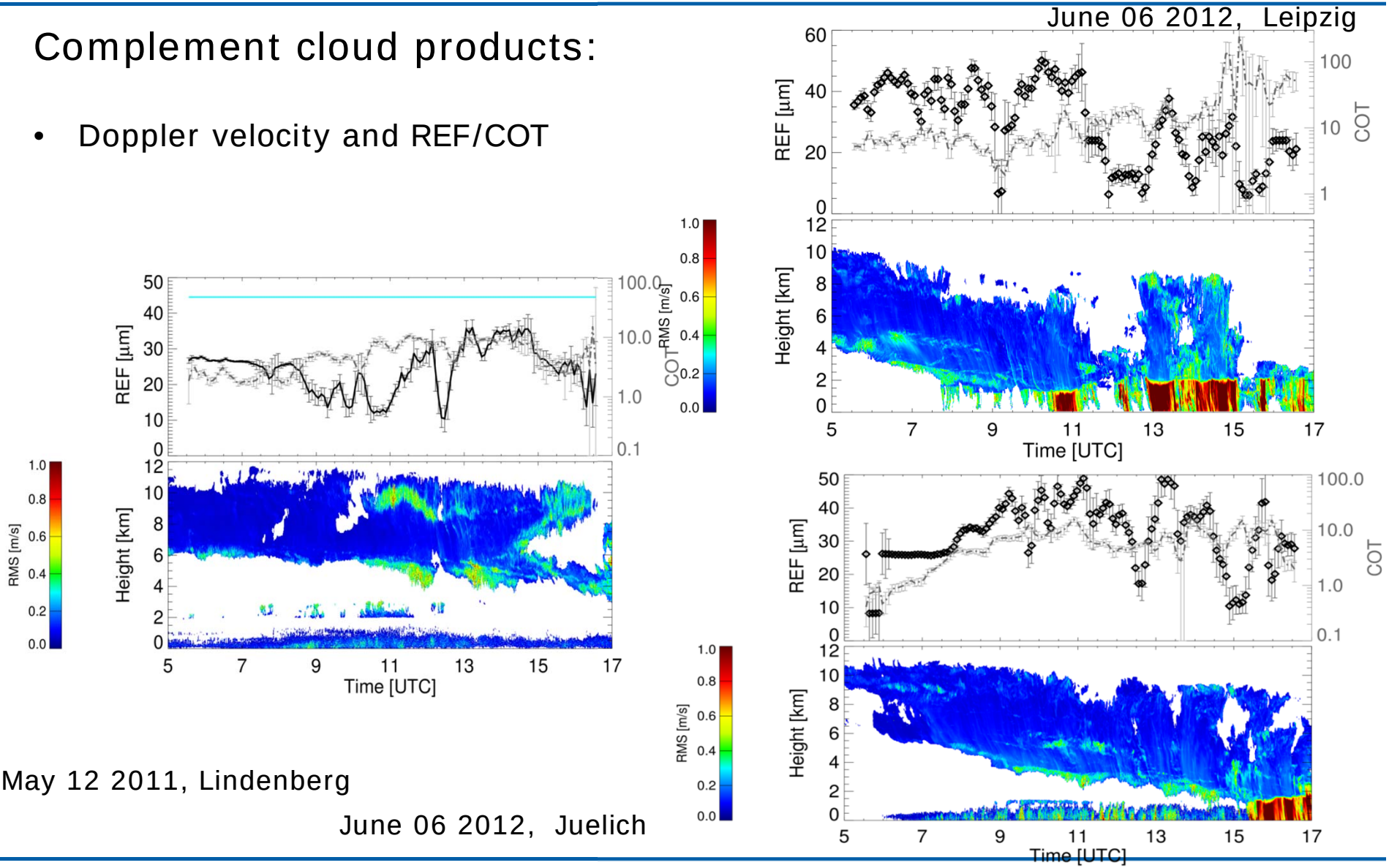
Characterization of the cloud frontal system which passed the consistency check

Complement cloud products:

- Doppler velocity and REF/COT



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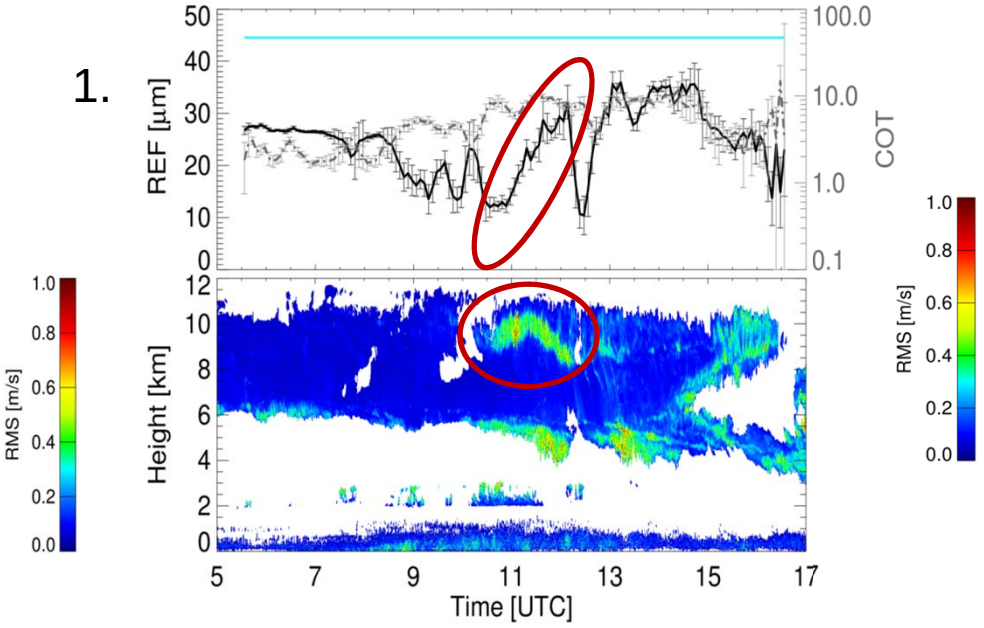
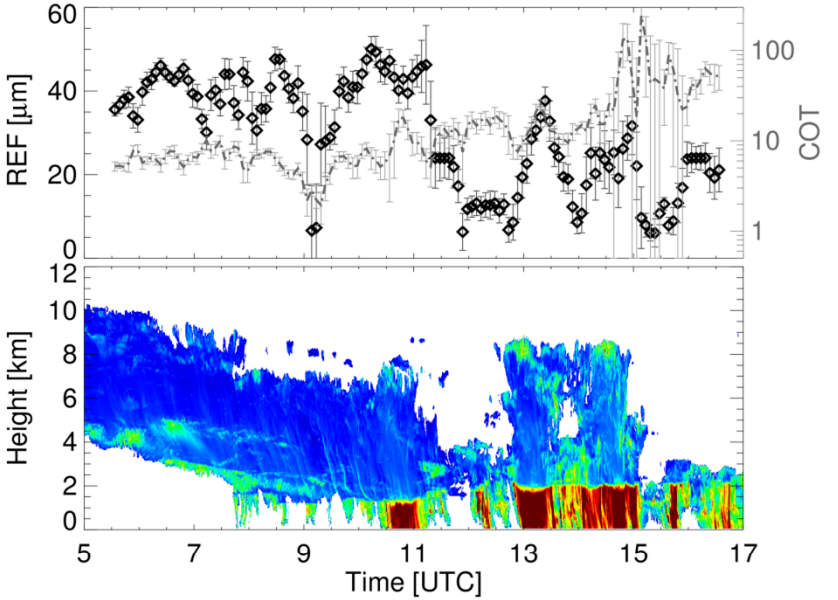
Characterization of the cloud frontal system which passed the consistency check

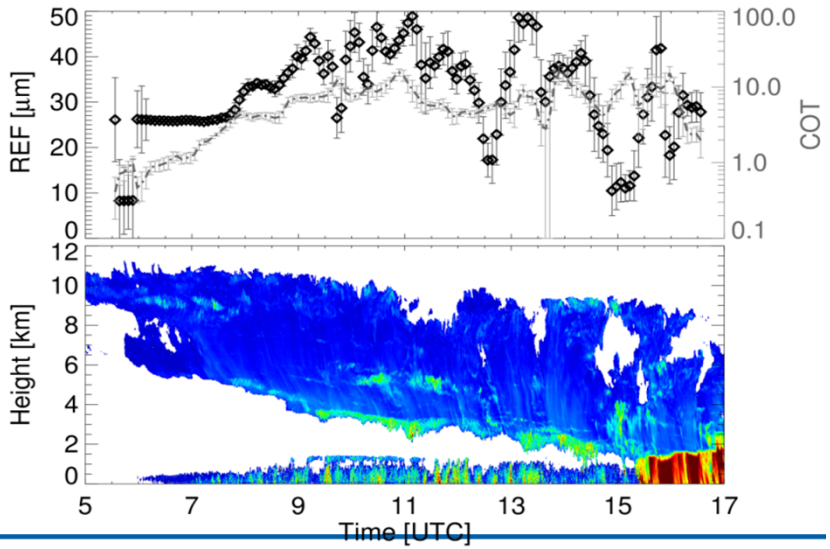
Complement cloud products

1.





1. Increase of Doppler velocity indicate higher lability and extended turbulent flux, which could explain the growing ice particle



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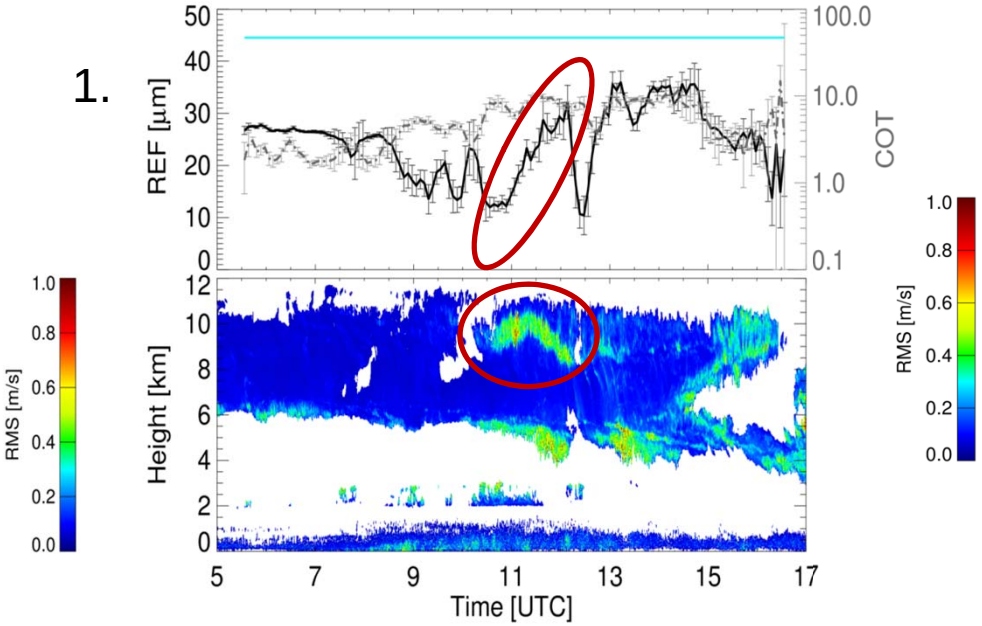

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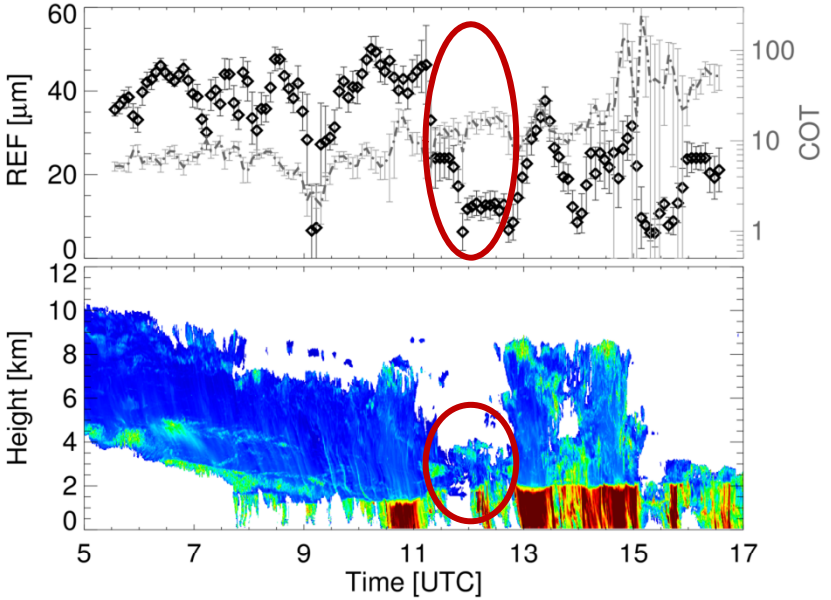

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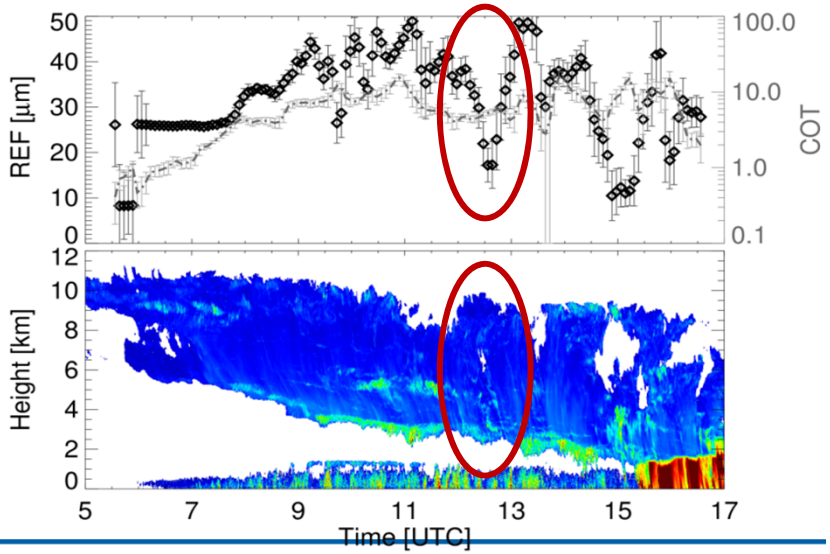

1. Increase of Doppler velocity indicate higher lability and extended turbulent flux, which could explain the growing ice particle
2. The water cloud below has been detected

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Summary

- ➔ Satellite- and ground-based measurement has been combined by utilizing a forward model to provide synthetic satellite data.
- ➔ Different metrics to quantify and interpret the consistency of the synthetic and the observed satellite data are considered.
- ➔ One year dataset: cloud frontal systems passing JOYCE, LACROS and MOL

Further:

- Can provide guidance for the revision of the retrievals understanding and problems
- Backward trajectory adopted also allow to link observations between different stations
- Radiative impact study