NWP model evaluation using ACTRIS cloud profiling

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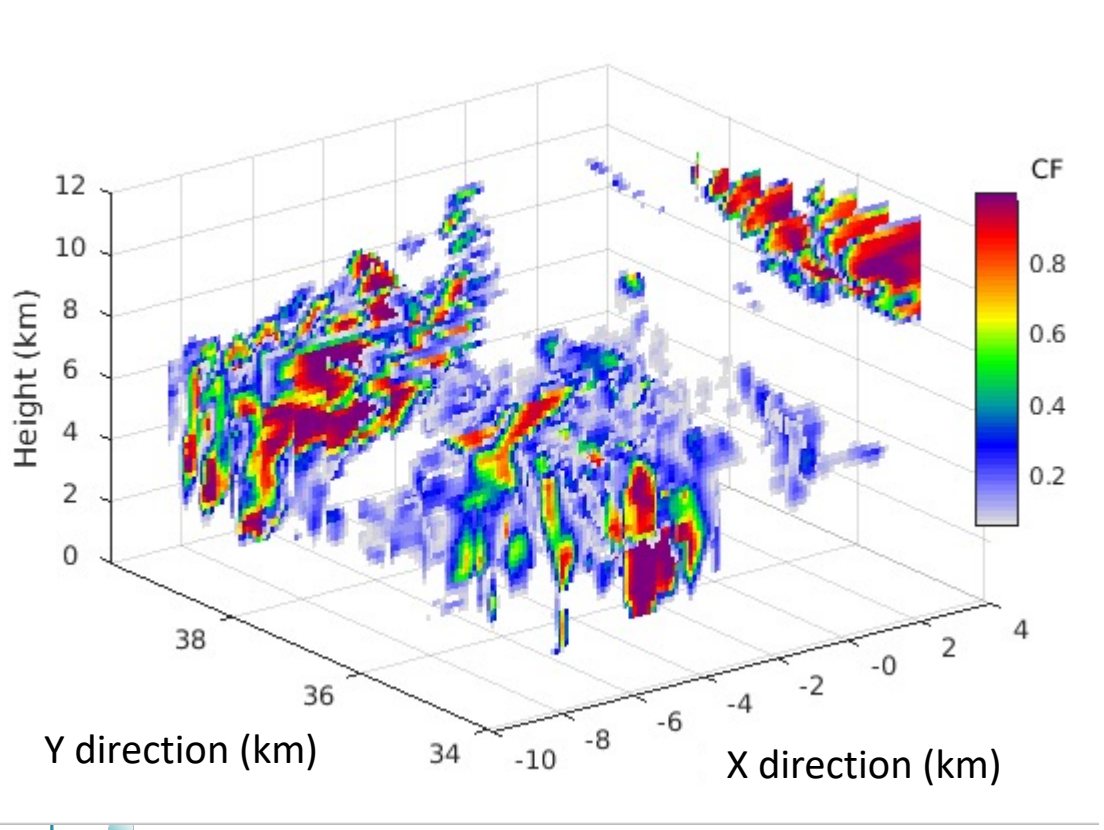
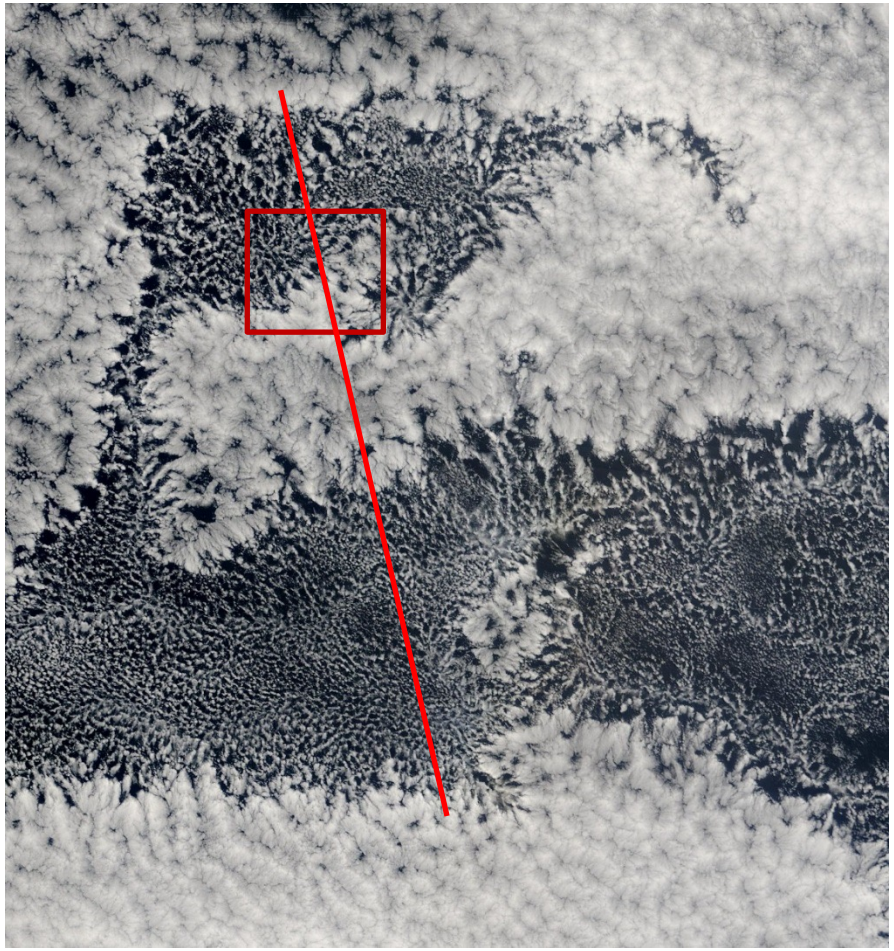
online

25-28 May 2021

Climate and NWP Model Evaluation

- Challenge: Compare 3D volume to 2D slice
  - Satellite
    - 2D slice in space





Climate and NWP Model Evaluation

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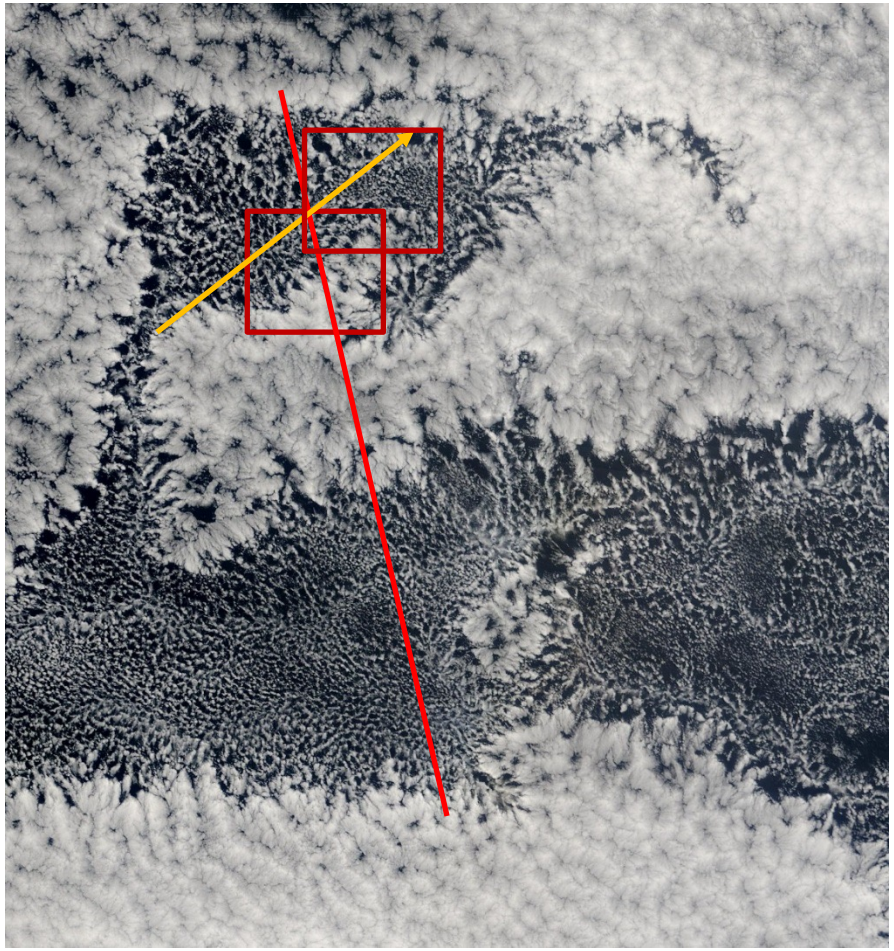
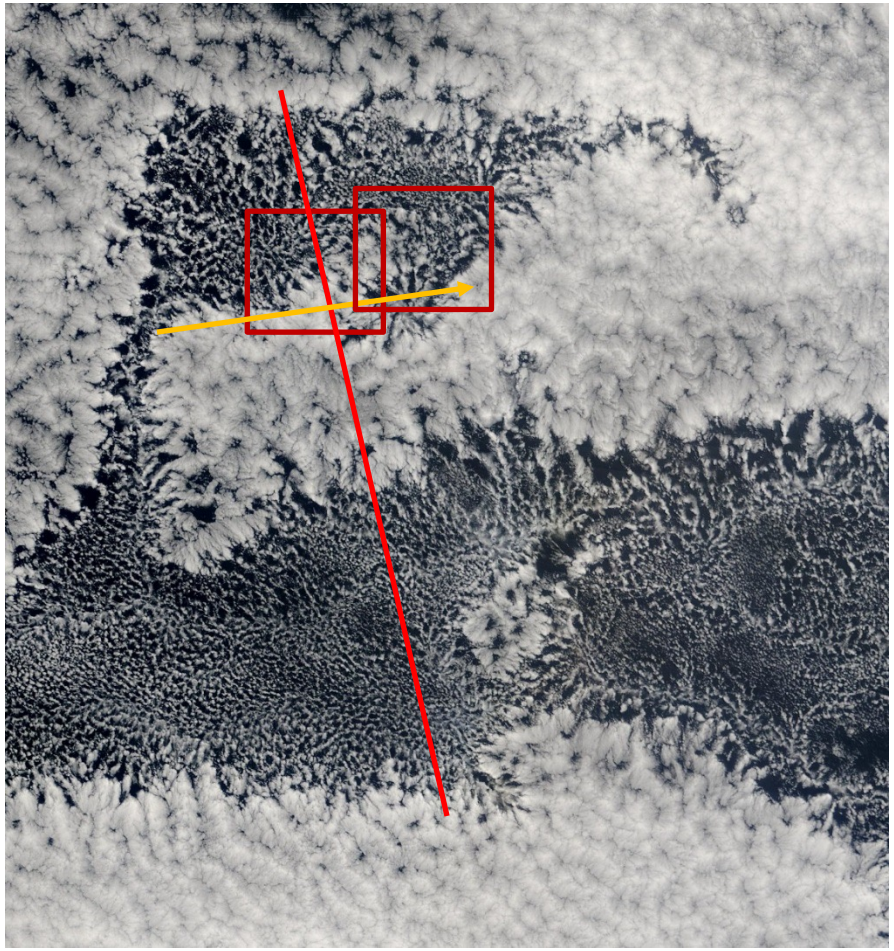
  - Ground-based
    - 1D – use winds to advect -> 2D



Climate and NWP Model Evaluation

- Challenge: Compare 3D volume to 2D slice
  - Satellite
    - 2D slice in space
  - Ground-based
    - 1D – use winds to advect -> 2D
    - Re-bin to model grid
    - Always along-wind



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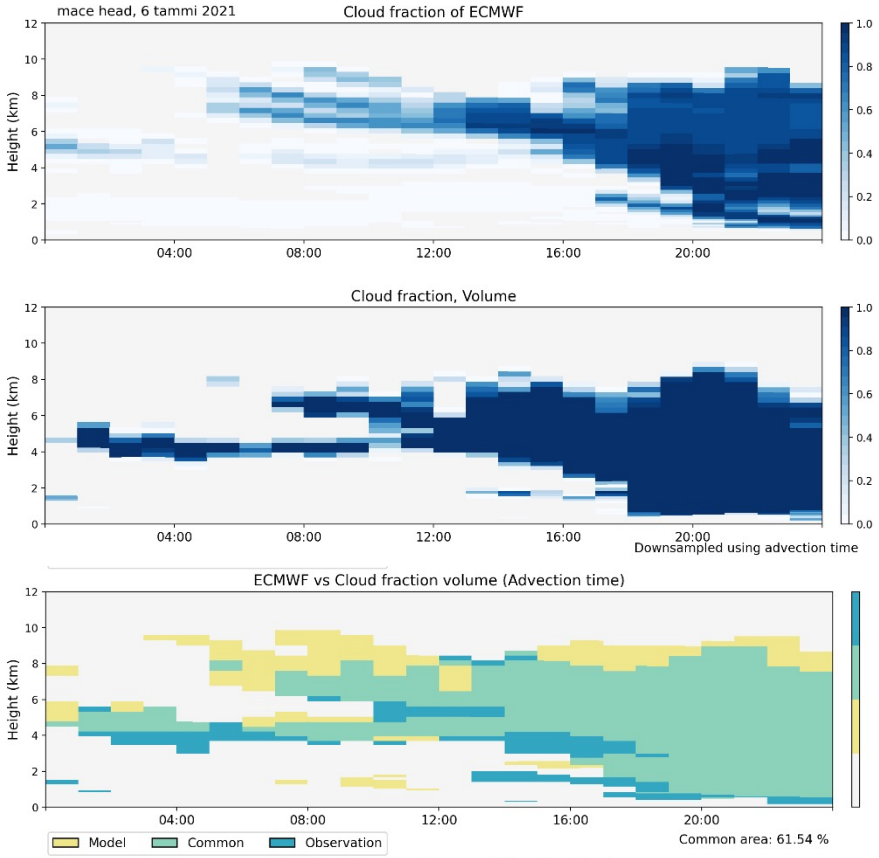
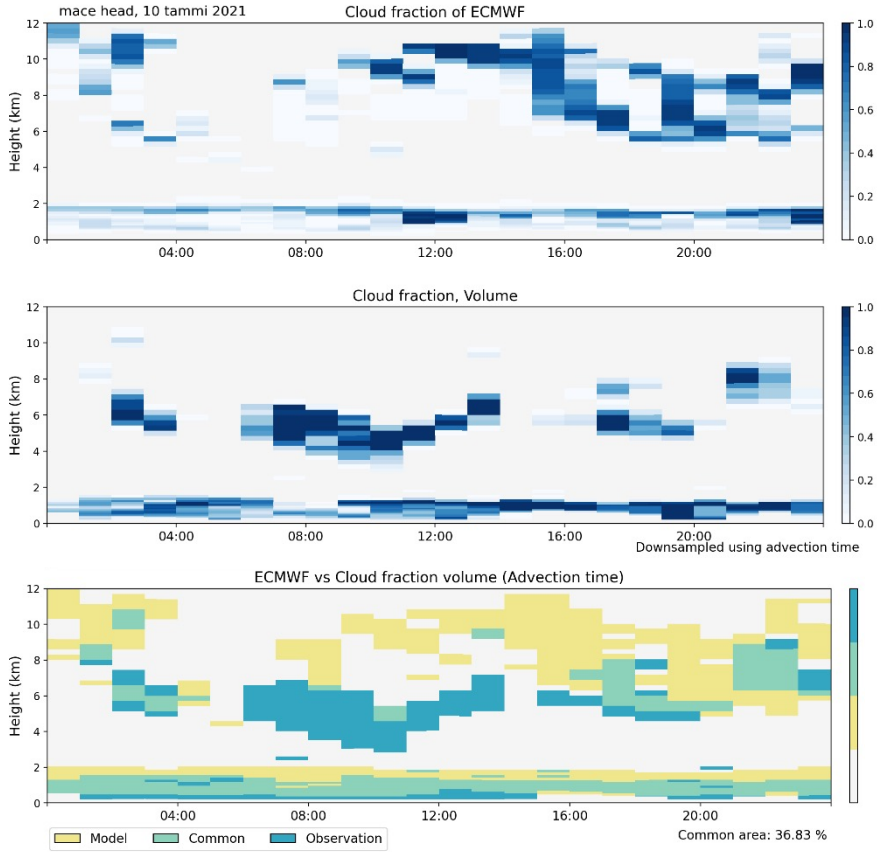


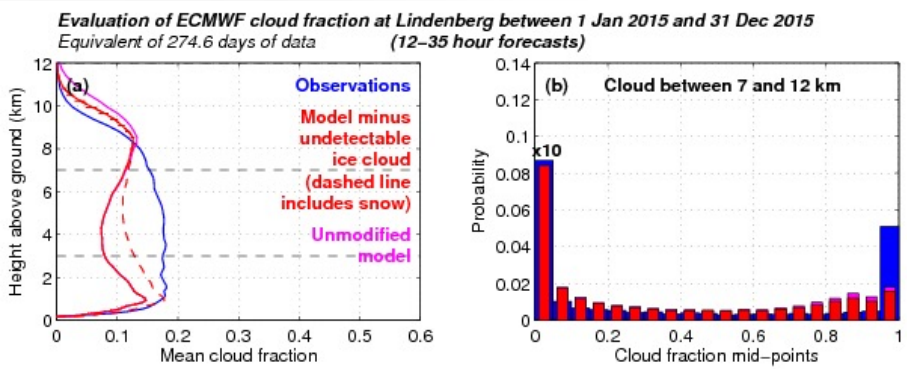
Model

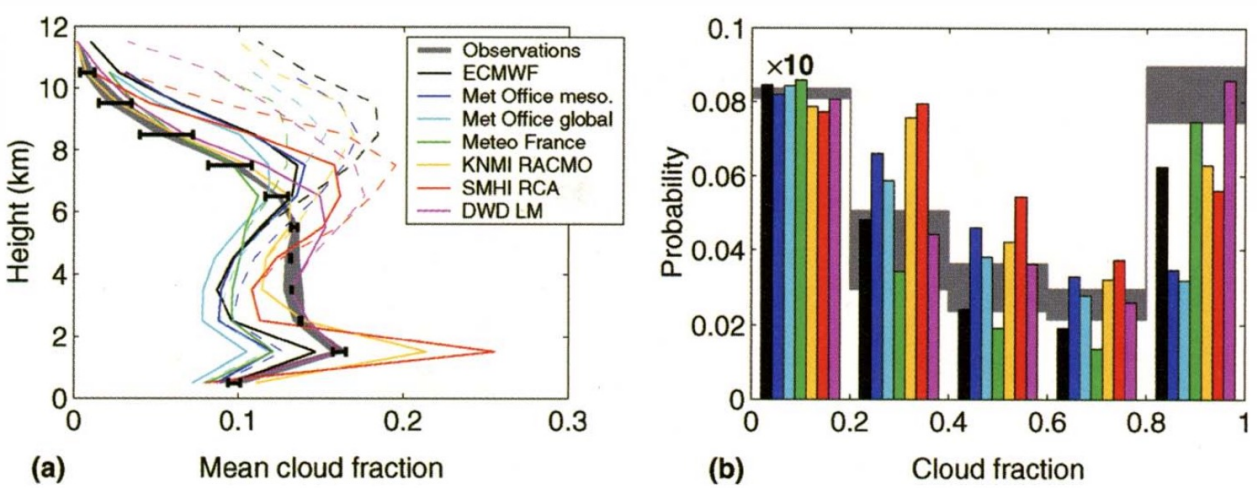
Obs



Climate and NWP Model Evaluation

- Challenge: Compare 3D volume to 2D slice
  - Options are:
    - Statistical
    - Probabilistic
  - Climatologies
    - Mean profiles, distributions





CLOUDNET

Continuous Evaluation of Cloud Profiles in Seven Operational Models Using Ground-Based Observations

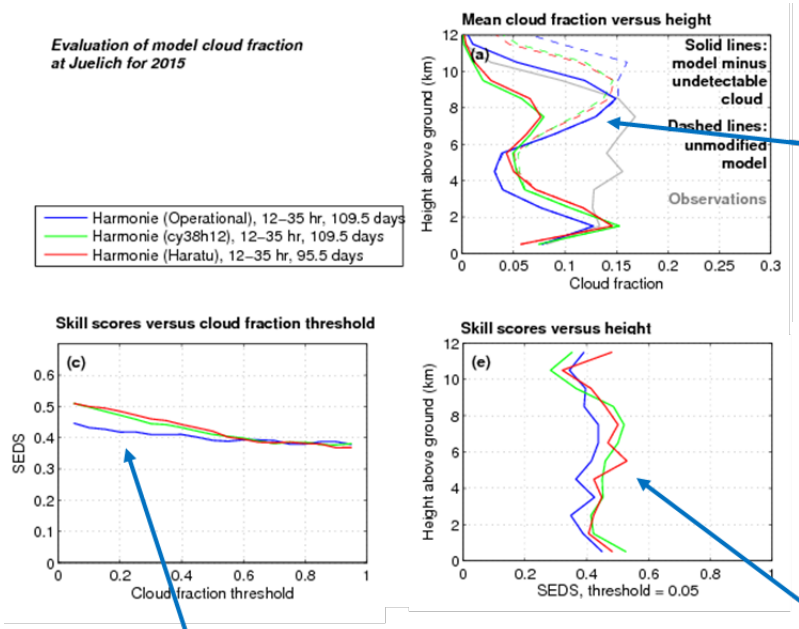
BY A. J. ILLINGWORTH, R. J. HOGAN, E. J. O'CONNOR, D. BOUNIOL, M. E. BROOKS, J. DELANOÉ, D. P. DONOVAN, J. D. EASTMENT, N. GAUSSIAT, J. W. F. GODDARD, M. HAEFFELIN, H. KLEIN BALTINK, O. A. KRASNOV, J. PELON, J.-M. PIRIOU, A. PROTAT, H. W. J. RUSSCHENBERG, A. SEIFERT, A. M. TOMPKINS, G.-J. VAN ZADELHOFF, F. VINIT, U. WILLÉN, D. R. WILSON, AND C. L. WRENCH

Cloud fraction, liquid and ice water contents derived from long-term radar, lidar, and microwave radiometer data are systematically compared to models to quantify and improve their performance.

https://doi.org/10.1175/BAMS-88-6-883

New NWP models

- **HARMONIE NWP model data from KNMI and SMHI**
  - **Multiple versions to test different parametrizations**



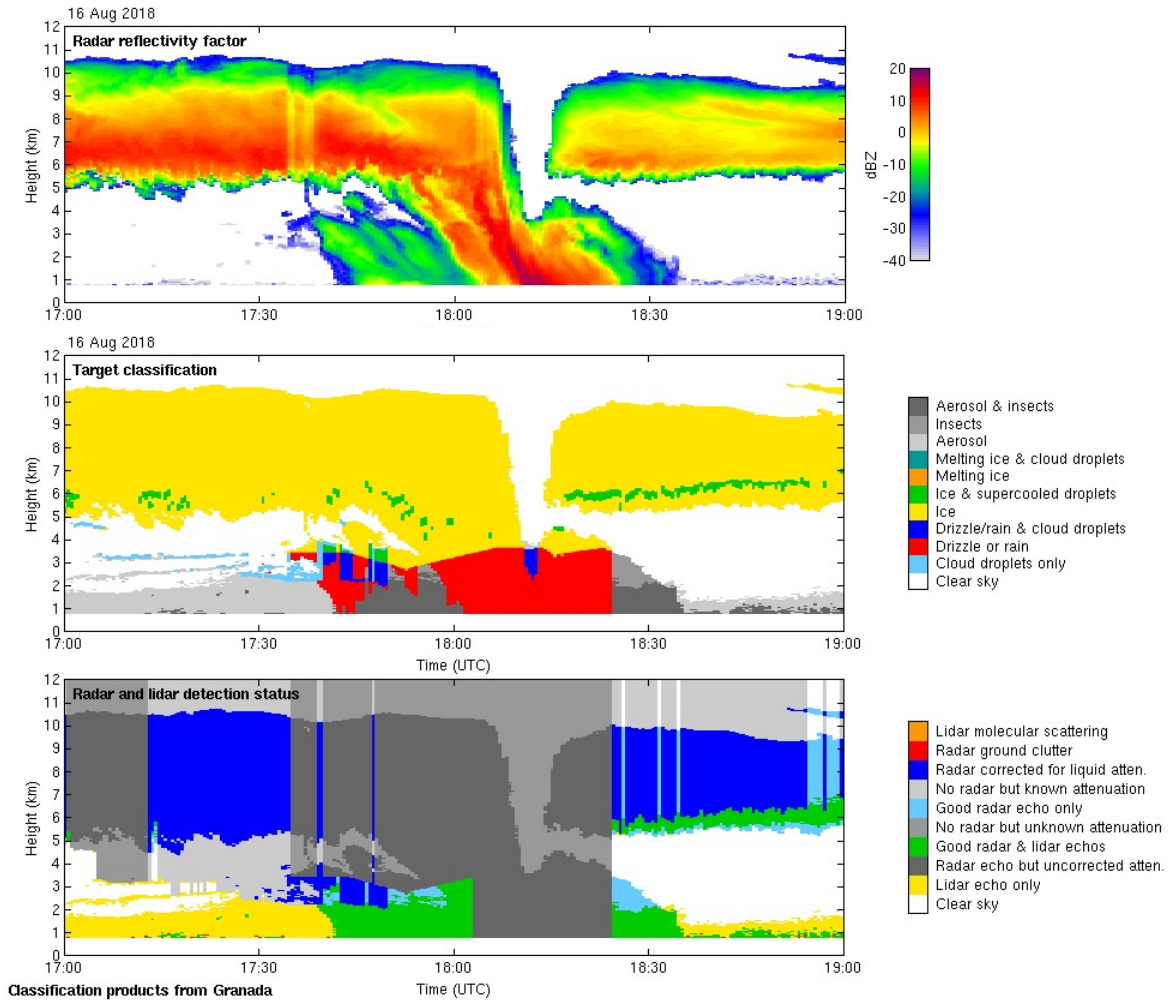
Change in transfer of ice to snow is obvious in mean cloud fraction! (snow not included)

Improvement in skill is for lower cloud fraction amounts

New versions show overall improvement in skill

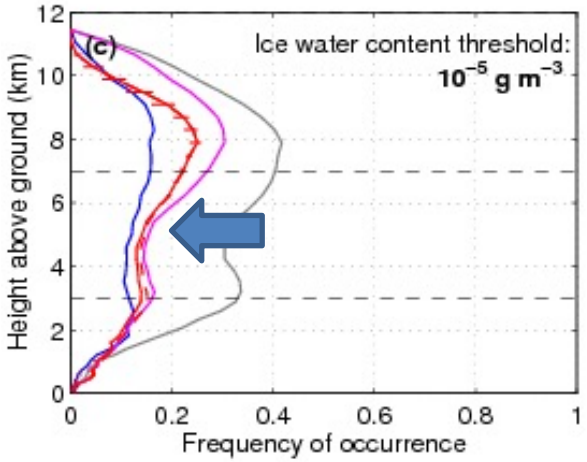
Conditional sampling

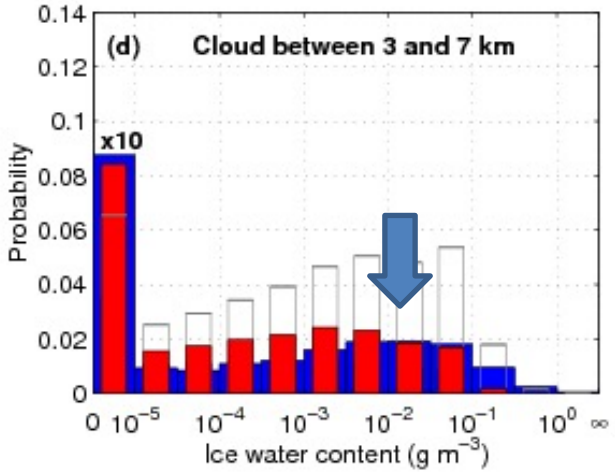
- Challenge: Compare 3D volume to 2D slice
  - Options are:
    - Statistical
    - Probabilistic
  - Climatologies
    - Mean profiles, distributions
  - Issues:
    - Conditional sampling
      - Varies with parameter of interest

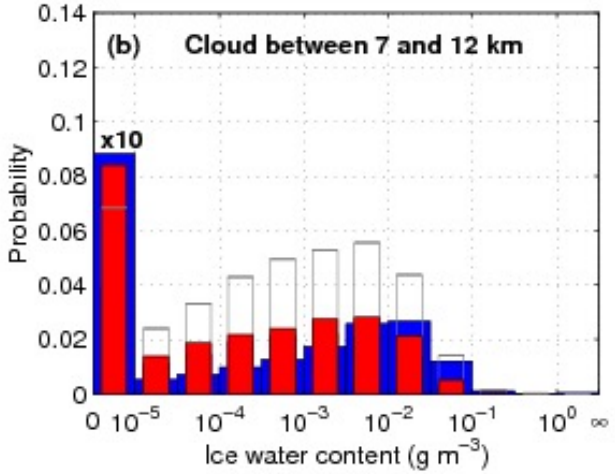


Conditional sampling

- Challenge: Compare 3D volume to 2D slice
  - Options are:
    - Statistical
    - Probabilistic
  - Climatologies
    - Mean profiles, distributions
  - Issues:
    - Conditional sampling
      - Varies with parameter of interest
  - Treat model in a similar manner

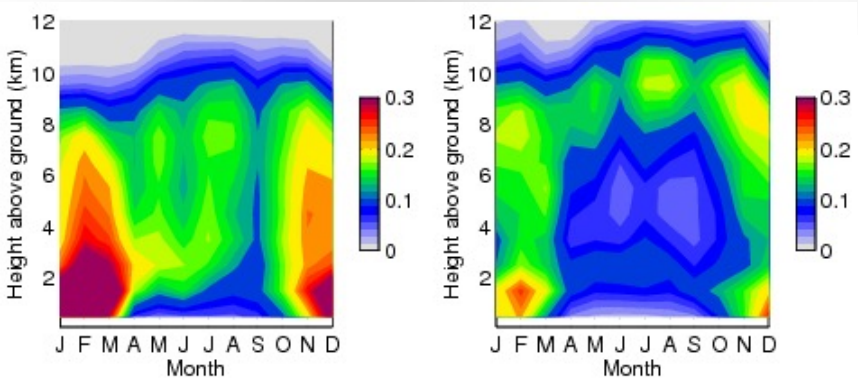






Composites: ECMWF, Lindenberg

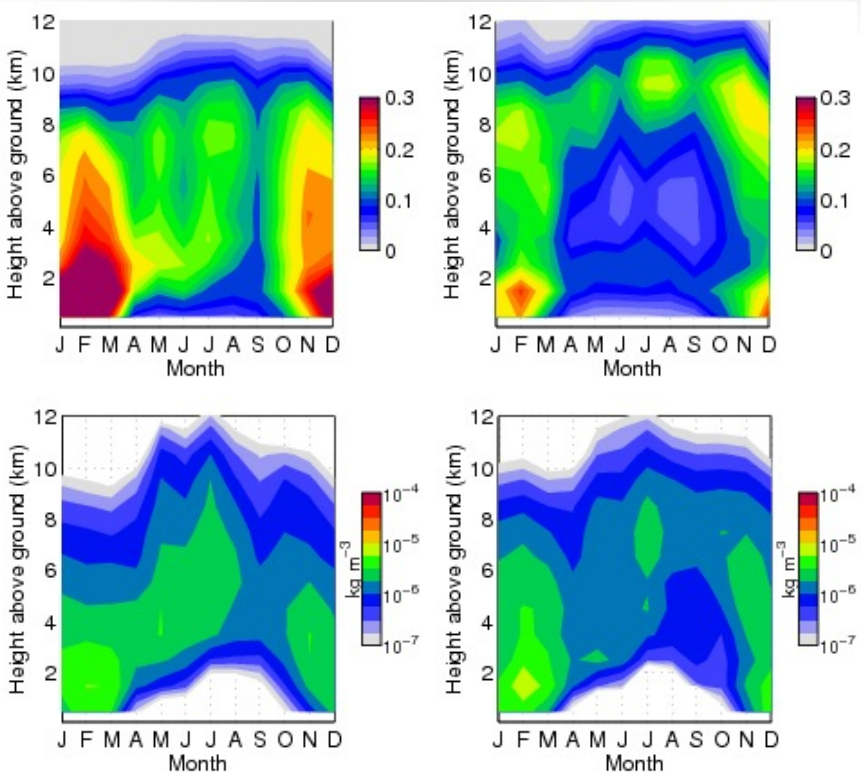
Observation Model



Cloud fraction

Composites: ECMWF, Lindenberg

Observation Model

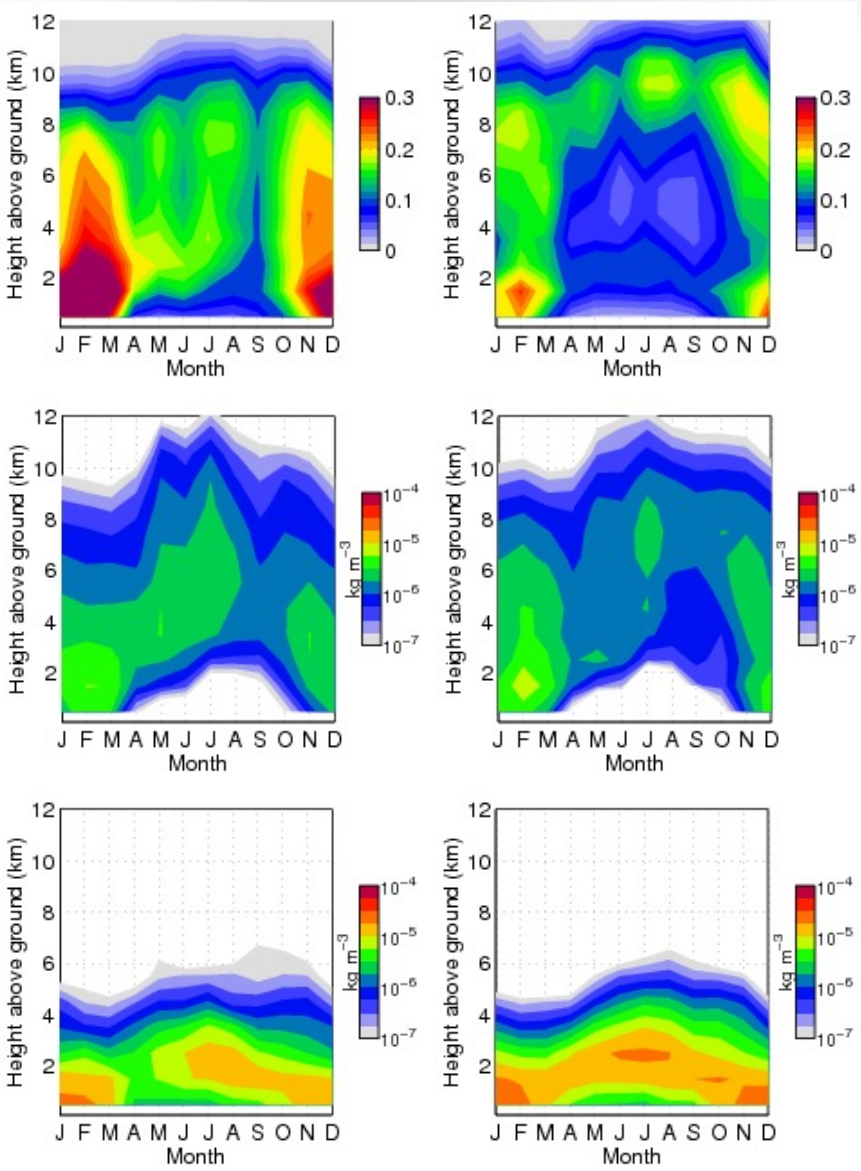


Cloud fraction

Ice water content

Composites: ECMWF, Lindenberg

Observation Model



Cloud fraction

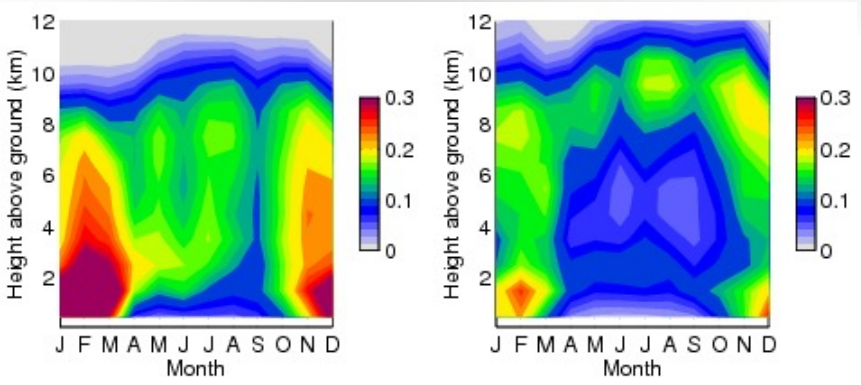
Ice water content

Liquid water content

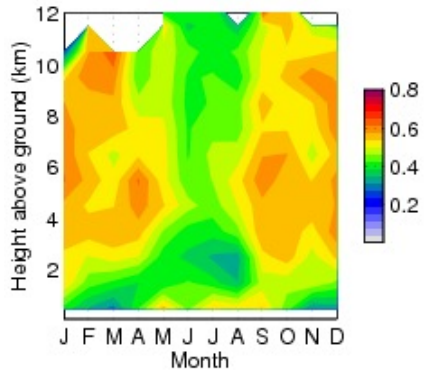
Composites: ECMWF, Lindenberg

Observation

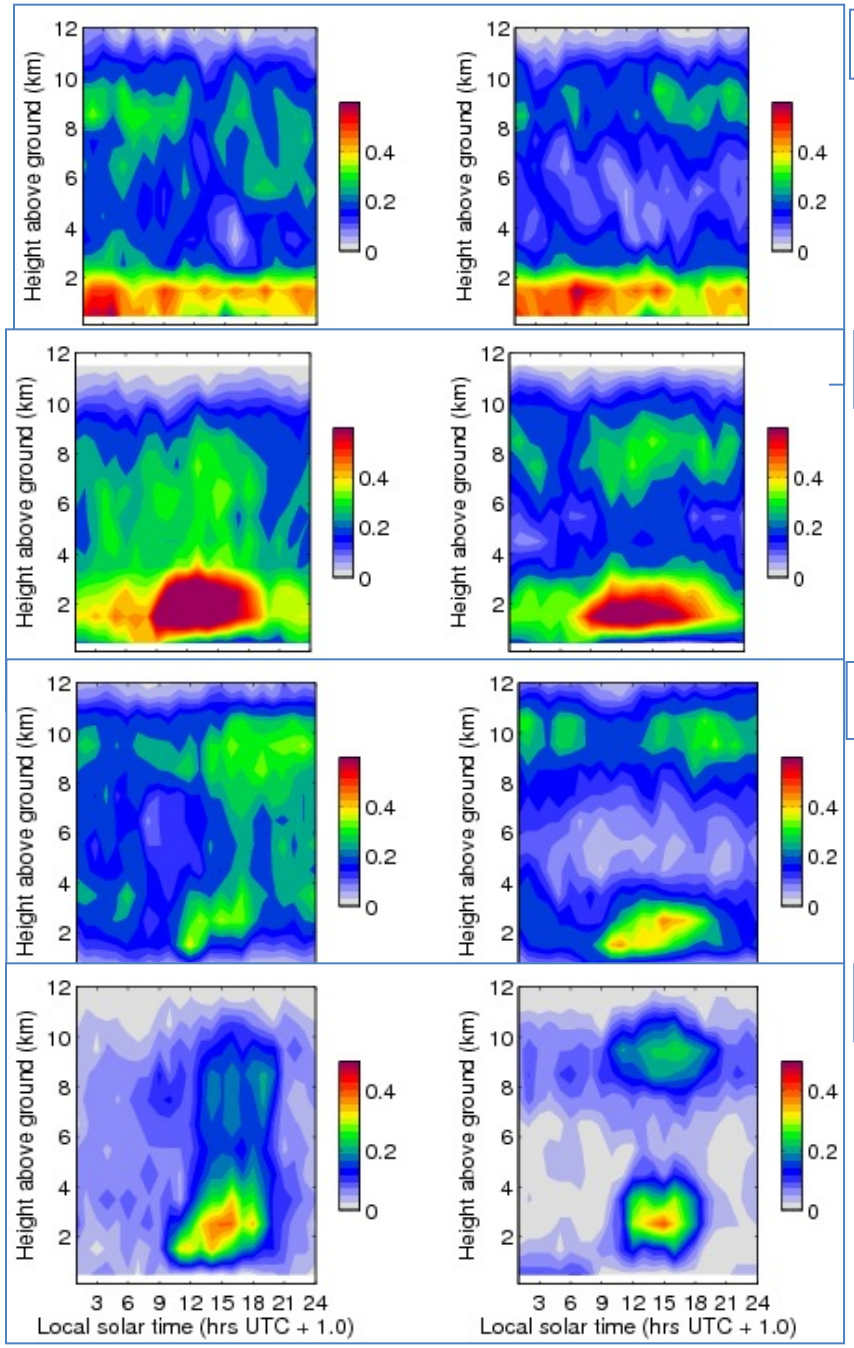
Model



Cloud fraction



Skill score SEDI



Mace Head

Chilbolton

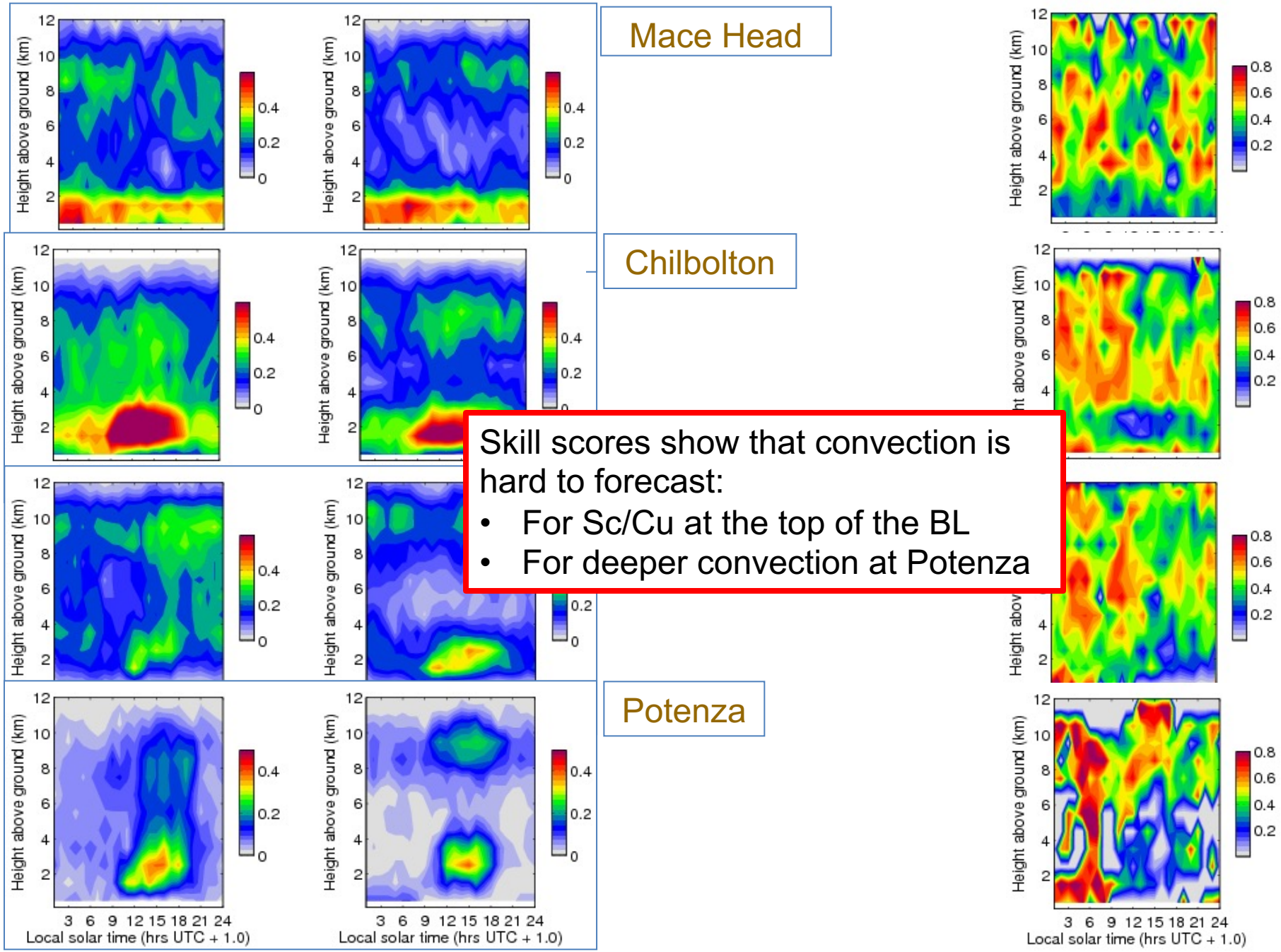
Lindenberg

Potenza

Diurnal composite of cloud fraction in summer

ECMWF model (on the right) now has a good representation of the diurnal cycle.

Still not enough mid-level cloud


Mace Head
Chilbolton
Potenza
Height above ground (km)
Local solar time (hrs UTC + 1.0)
3 6 9 12 15 18 21 24
Skill scores show that convection is hard to forecast:
• For Sc/Cu at the top of the BL
• For deeper convection at Potenza

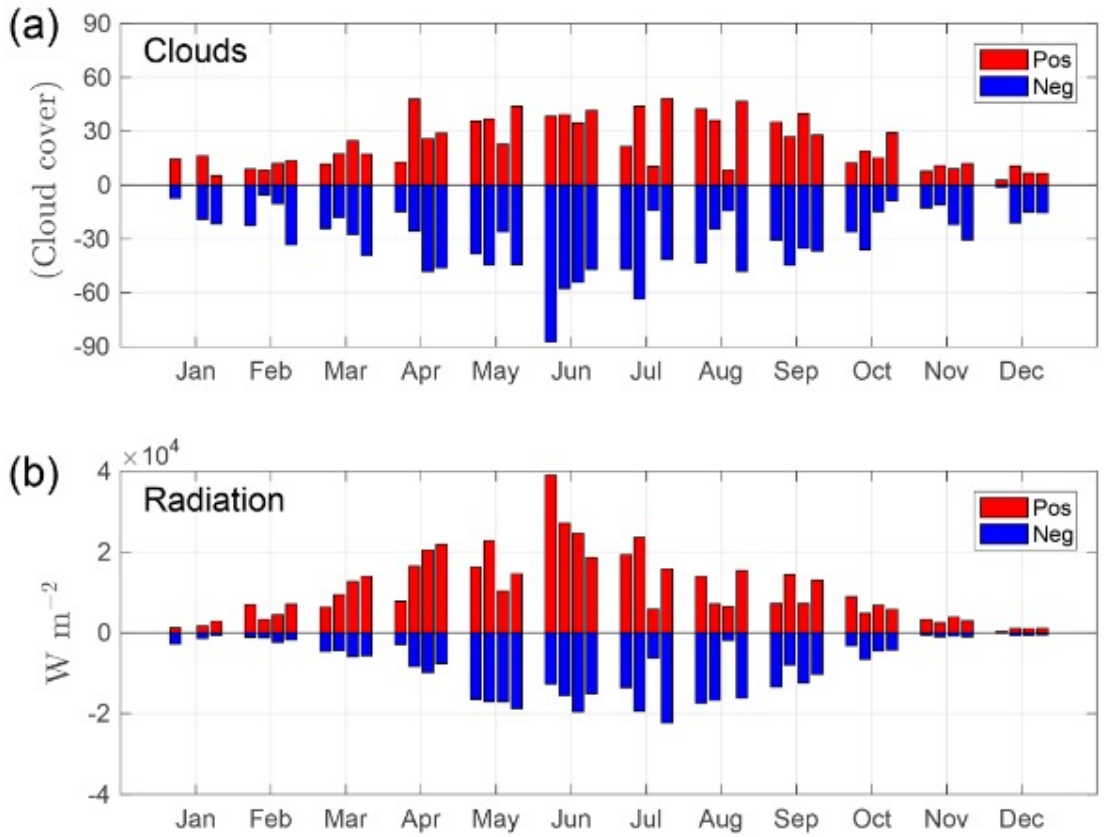
Climate and NWP Model Evaluation

- Routine metrics for evaluating clouds in Climate and NWP models
  - Climatologies
    - Mean profiles, distributions
  - Evaluate NWP forecast skill
    - Forecast the correct cloud at the right time

- Progress during ACTRIS
  - Annual composites
    - Can be on height or temperature grid
  - Diurnal composites
    - Can be on height or temperature grid
    - Seasonal comparisons (Define your season or regime)
  - Extend skill score comparison
    - Long-term (interannual variability)
    - Forecast lead time
    - Model version

Solar forecast uncertainty

Impact of ECMWF cloud forecast on solar radiation forecast

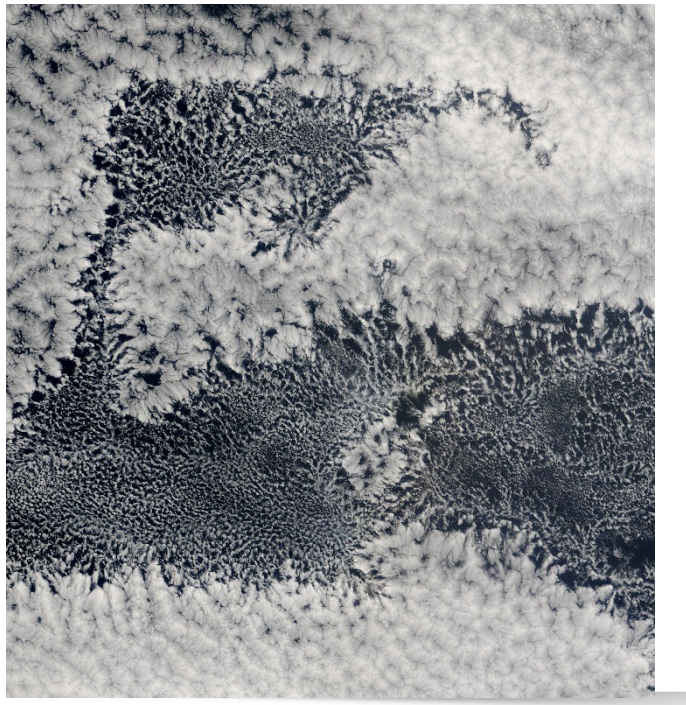


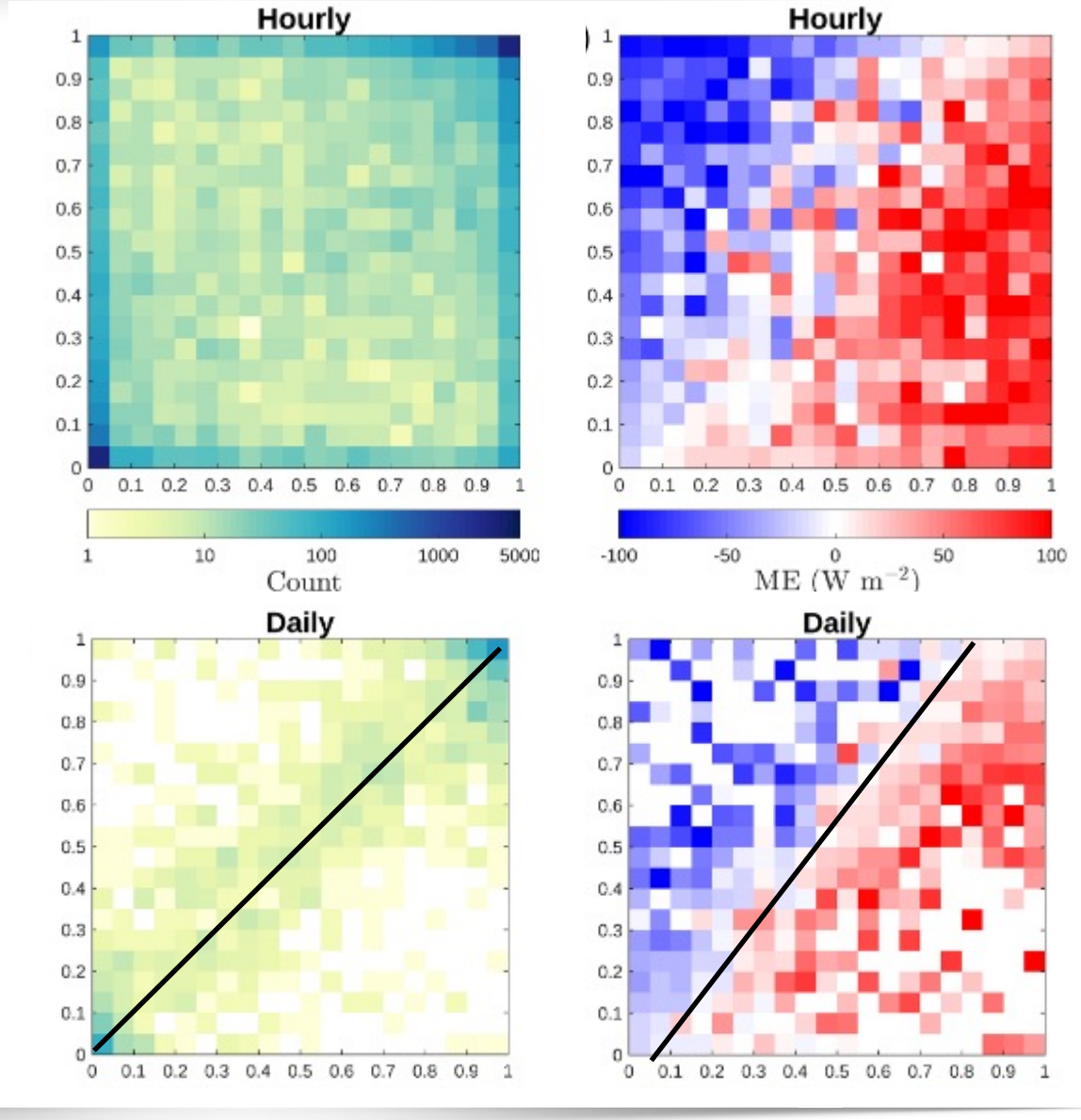
Tuononen, M., O'Connor, E. J., and Sinclair, V. A. (2019): Evaluating solar radiation forecast uncertainty, Atmos. Chem. Phys., 19, 1985-2000, doi.org/10.5194/acp-19-1985-2019, 2019

Solar forecast uncertainty

Impact of ECMWF cloud forecast on solar radiation forecast

Expected to be noisy – low clouds are inhomogeneous





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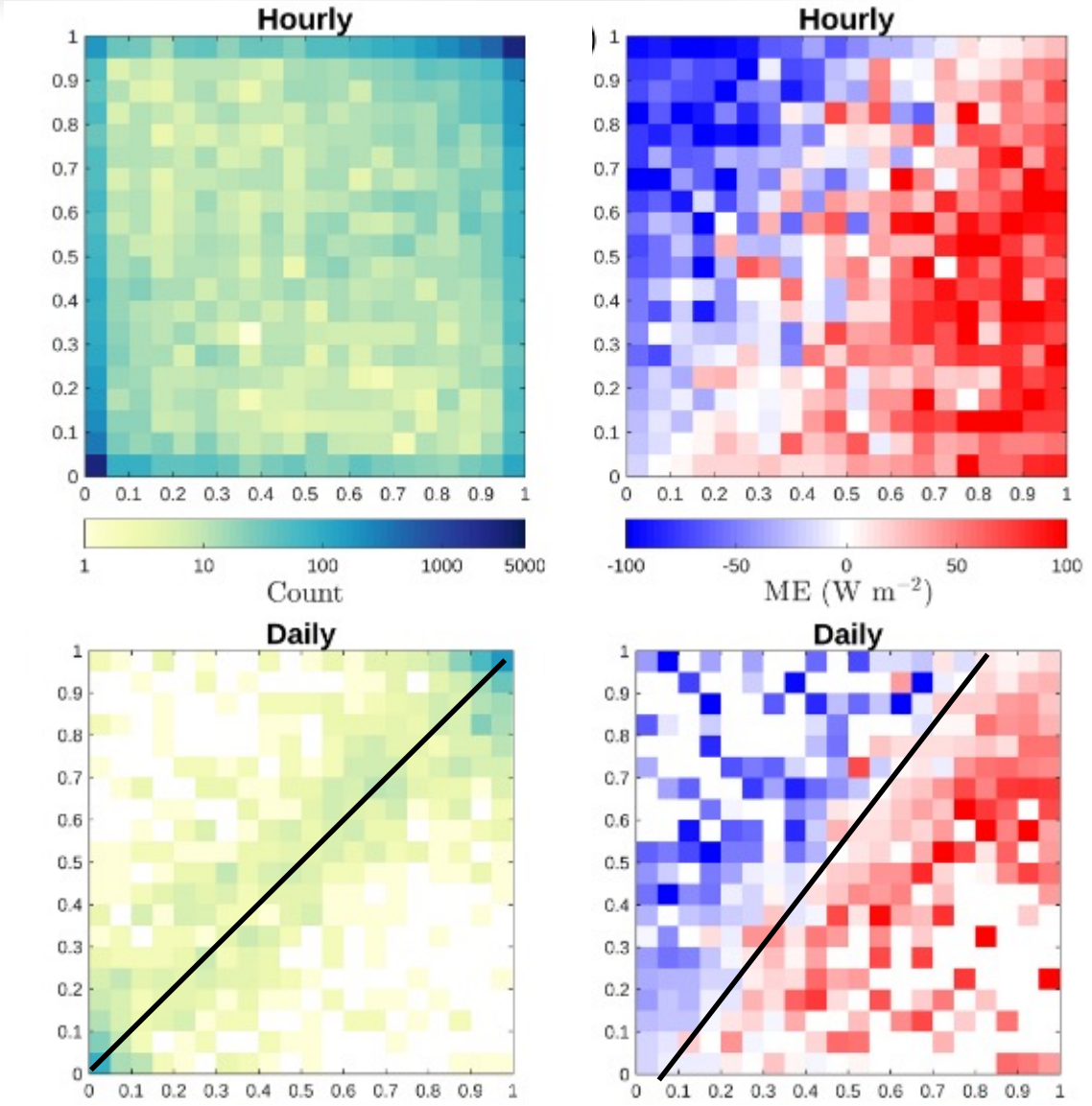

Solar forecast uncertainty

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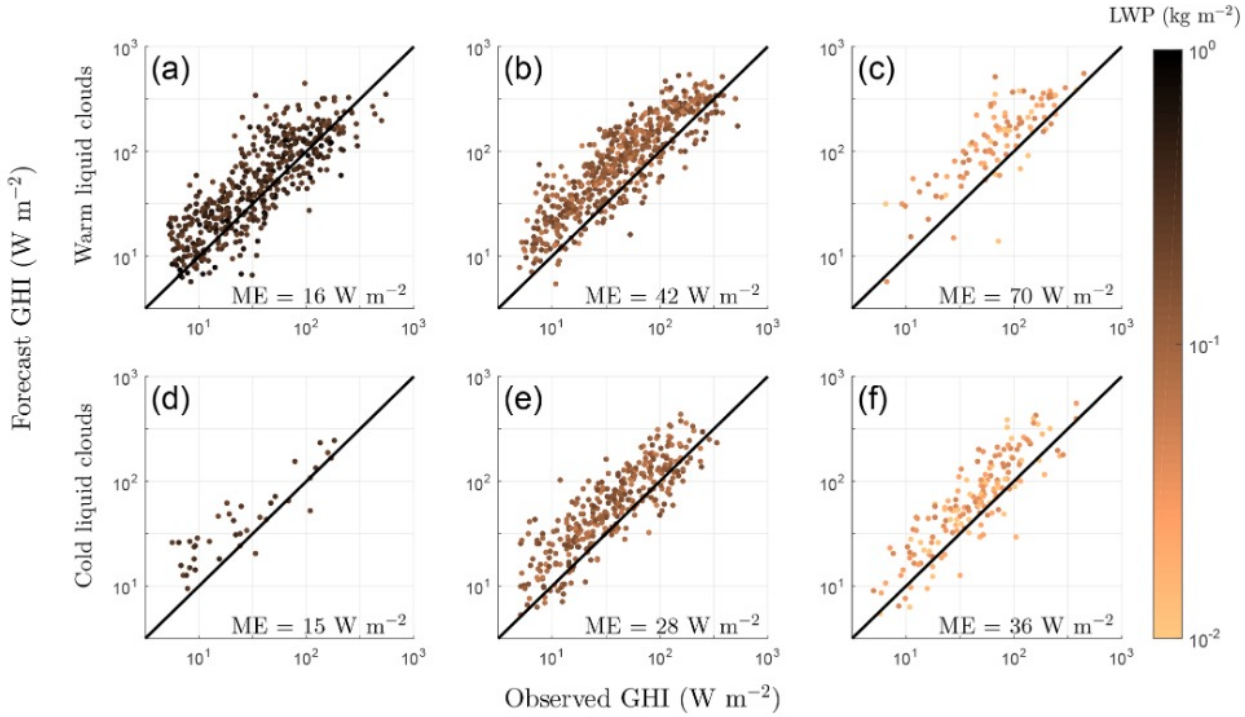
Expected to be noisy – low clouds are inhomogeneous

However bias in clear sky and in fully overcast. Why?

Clear sky -> aerosol climatology

Overcast -> thin clouds have wrong LWP



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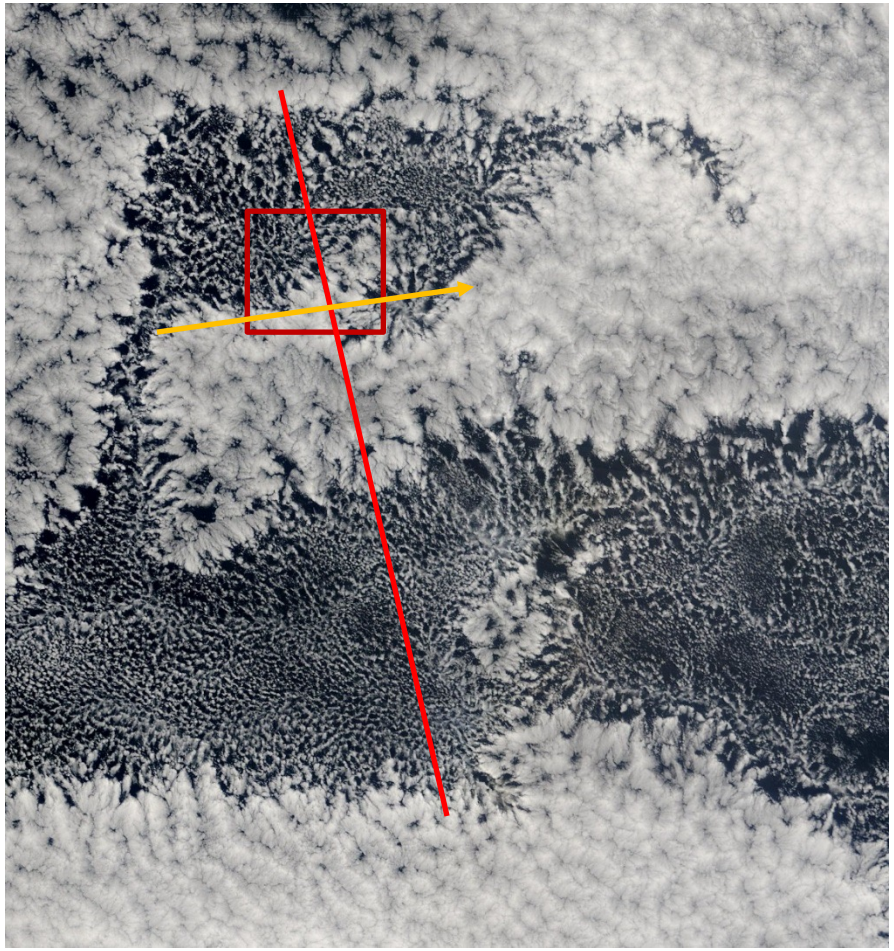
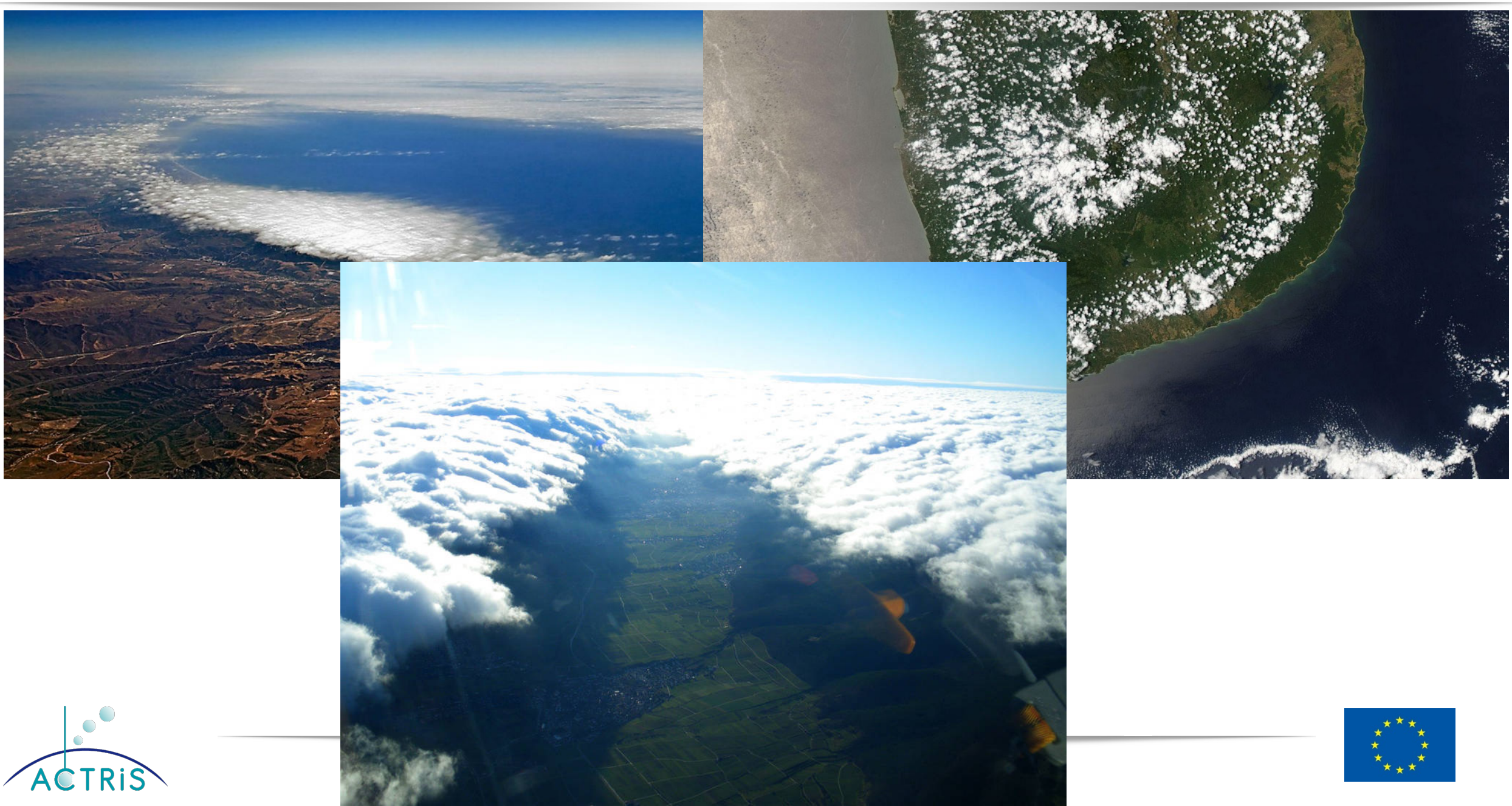


Persistent cloud features



EARTHCARE Validation

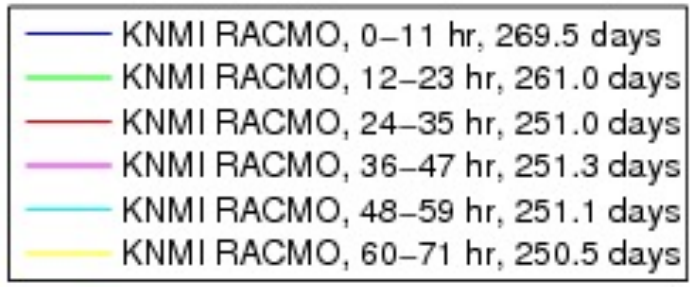
- Challenge: Compare 1D profile to 1D profile
  - Colocation issue

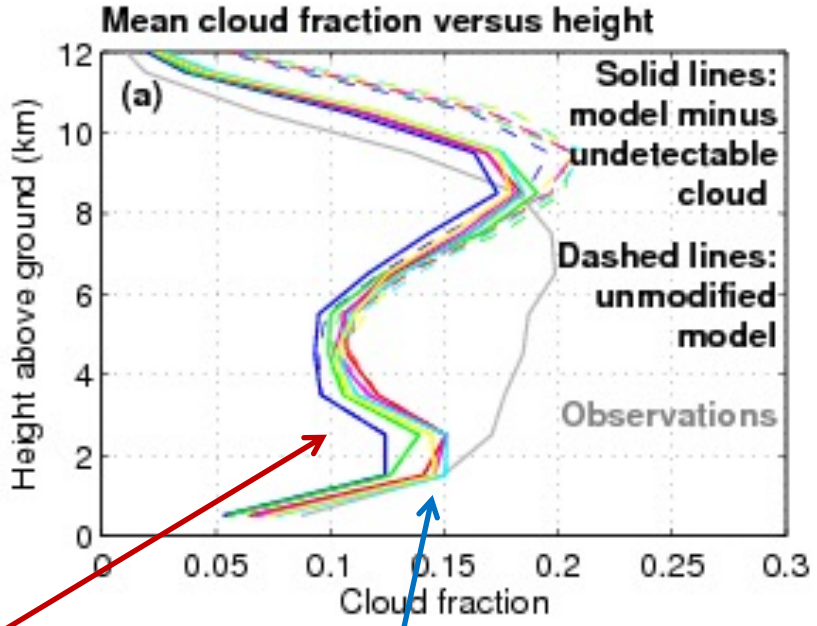
- Evaluation:
  - Options are:
    - Statistical (CFADs etc)
    - Probabilistic
  - Issues:
    - Conditional sampling different
    - Spatial vs temporal sampling
      - aircraft

- Check meteorological input data

Forecast lead-time

Evaluation of model cloud fraction at Lindenberg for 2014





Model spin up

Assimilation preferred state

Model preferred state