Towards assimilating IASI satellite observations over cold surfaces - the cloud detection aspect

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Outline

- IASI instrument and handling observations in NWP system
- Why is it important to detect clouds before assimilation?
- What's the difficulty with cold surfaces?
- Cloud detection and CO2-slicing methods
- Comparison with observations: CONCORDIASI field measuring campaign in Antarctica

IASI (*Infrared Atmospheric Sounding Interferometer*)

- Satellite sounder onboard polar-orbiting Metop satellite
- Measures inrared radiances in high spectral resolution (8461 channels)
- Main input for NWP model are temperature and humidity profiles (extracted inside the NWP system from radiances)
- Assimilated operationally in all the biggest NWP centres and also in many smaller ones.

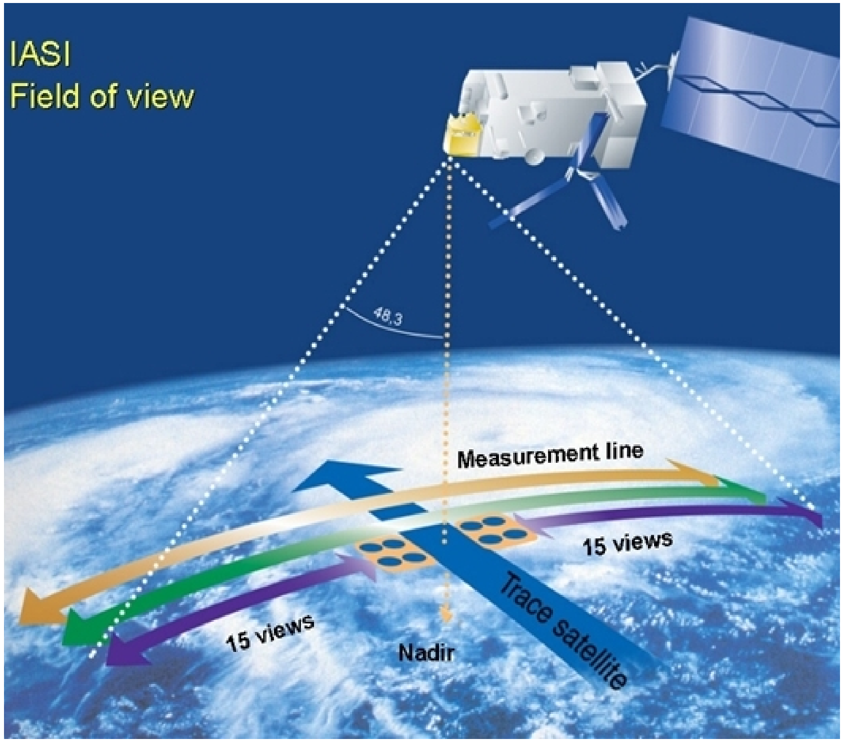

Fig: EUMETSAT

Handling IASI observations in NWP, part 1

- **Blacklisting:**
  - Careful channel selection has to be made before assimilation: only max. ~ 400 channels out of the 8461 assimilated, often much less
  - Channel selection depends on surface: normally more channels used over sea areas than over land areas because of more homogeneous surface
- **Thinning:** only 1/2 or 1/4 pixels used to avoid inter-correlation of observation errors

Handling IASI observations in NWP, part 2

- **Cloud detection:** only use channels not affected by clouds
- **Bias correction:** satellite observations are biased, variational bias correction used to handle this
- **Minimization:** Radiative transfer model RTTOV is used as a link between the observed parameters (radiances) and the model parameters (temperature and humidity)

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IASI and clouds

- In infrared spectral region the radiation is almost completely attenuated by clouds
- Since IASI is an infrared sounder we cannot see through clouds with it
- Cloudy pixels have to be omitted either completely or use only the channels not affected by clouds.

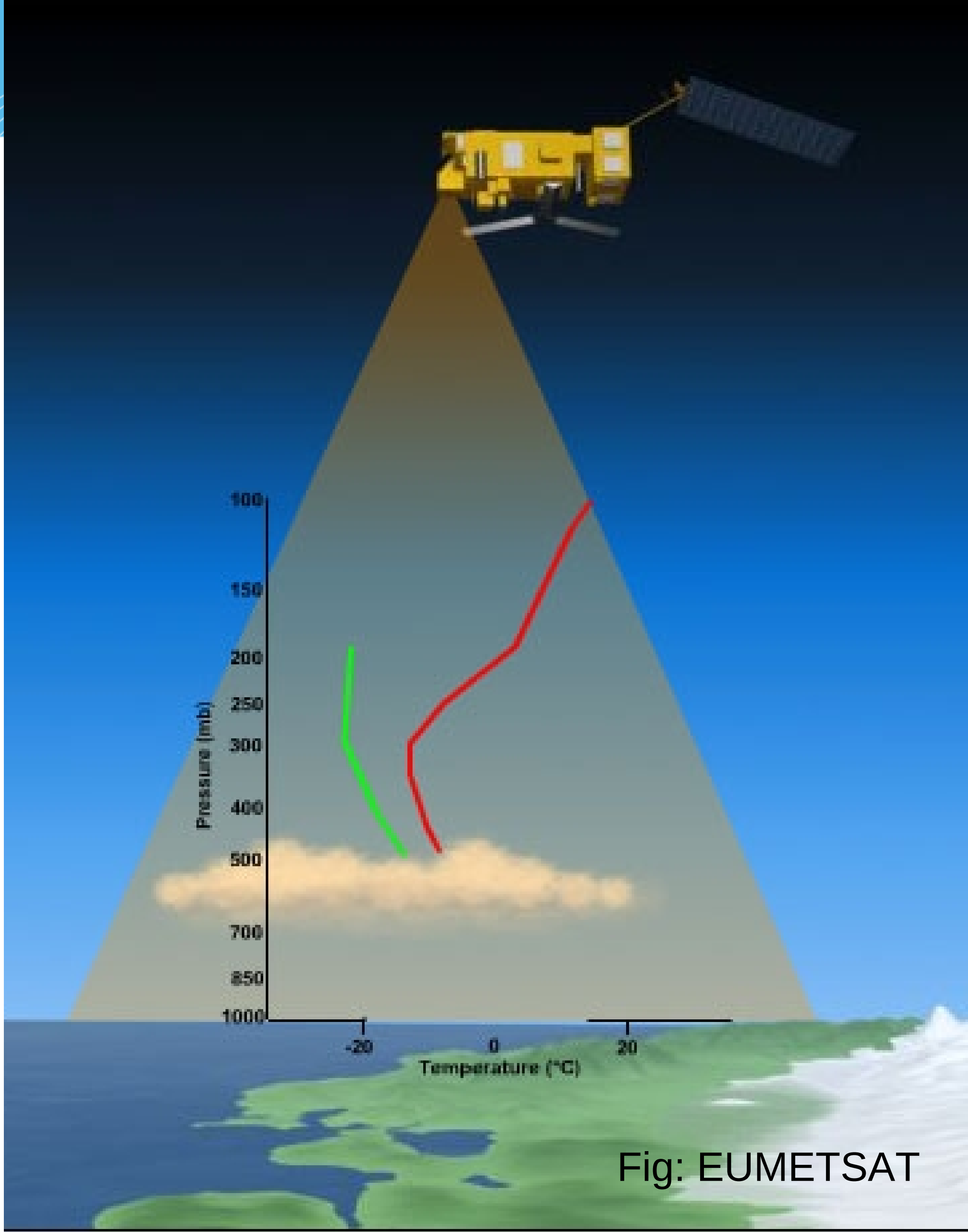


Fig: EUMETSAT

The challenges with cold surfaces

- Normally a cloud shows in the IASI spectrum as a colder signal because the measured radiance depends a lot on the emitting surface (clouds are generally colder than the Earth surface).
- If the surface temperature is really low or the surface really elevated the clear sky radiance and cloudy sky radiance come closer to each other.

  → Harder to detect clouds.
- Also, NWP models sometimes have difficulties to forecast correctly really cold surface temperatures and inversions. Since model fields are used as a first guess in cloud detection schemes this might be problematic as well.

Two cloud detection and cloud parameter retrieval schemes

1) ECMWF cloud detection scheme by McNally and Watts

2) CO_2-slicing method for determining cloud top pressure and cloud fraction

ECMWF cloud detection scheme by McNally and Watts

1) IASI channels are arranged by height from highest to lowest peaking channel.

2) Simulated radiance spectrum is compared with observed radiances.

3) The top-most channel where we can still see the cloud signal is chosen.

4) The channels upwards from the chosen channel are flagged clear and the channels downwards cloudy.

CO_2-slicing method

1) Determination of cloud top pressure:

- The observed IASI radiances are compared with both simulated clear radiances and simulated cloudy sky radiances. In cloudy sky simulations a black body cloud layer is simulated on all the possibly cloudy RTTOV layers (layers in troposphere and lower stratosphere) one layer at a time.
- The best match from simulations vs. observations is determined as the cloud top pressure.

2) Determination of cloud fraction:

- Cloud fraction is calculated by comparing a surface channel observation with simulated clear sky surface channel radiance and a simulated cloudy sky (using the obtained cloud top pressure) radiance.

Comparison with observations: The CONCORDIASI field measuring campaign in Antarctica

- Used observations co-located with IASI:
  - CALIOP (cloud lidar onboard CALIPSO satellite)
  - CPR (cloud radar onboard CloudSat satellite)
  - AVHRR MAIA cloudmask (onboard Metop satellite with IASI)
  - Dropsondes
- The model used was MF global model ARPEGE but with a resolution of 2,5 km over the study region of Antarctica
- Study period 3 Oct – 11 Nov 2010 (Austral spring)

Cloud detect compared with MAIA cloud mask

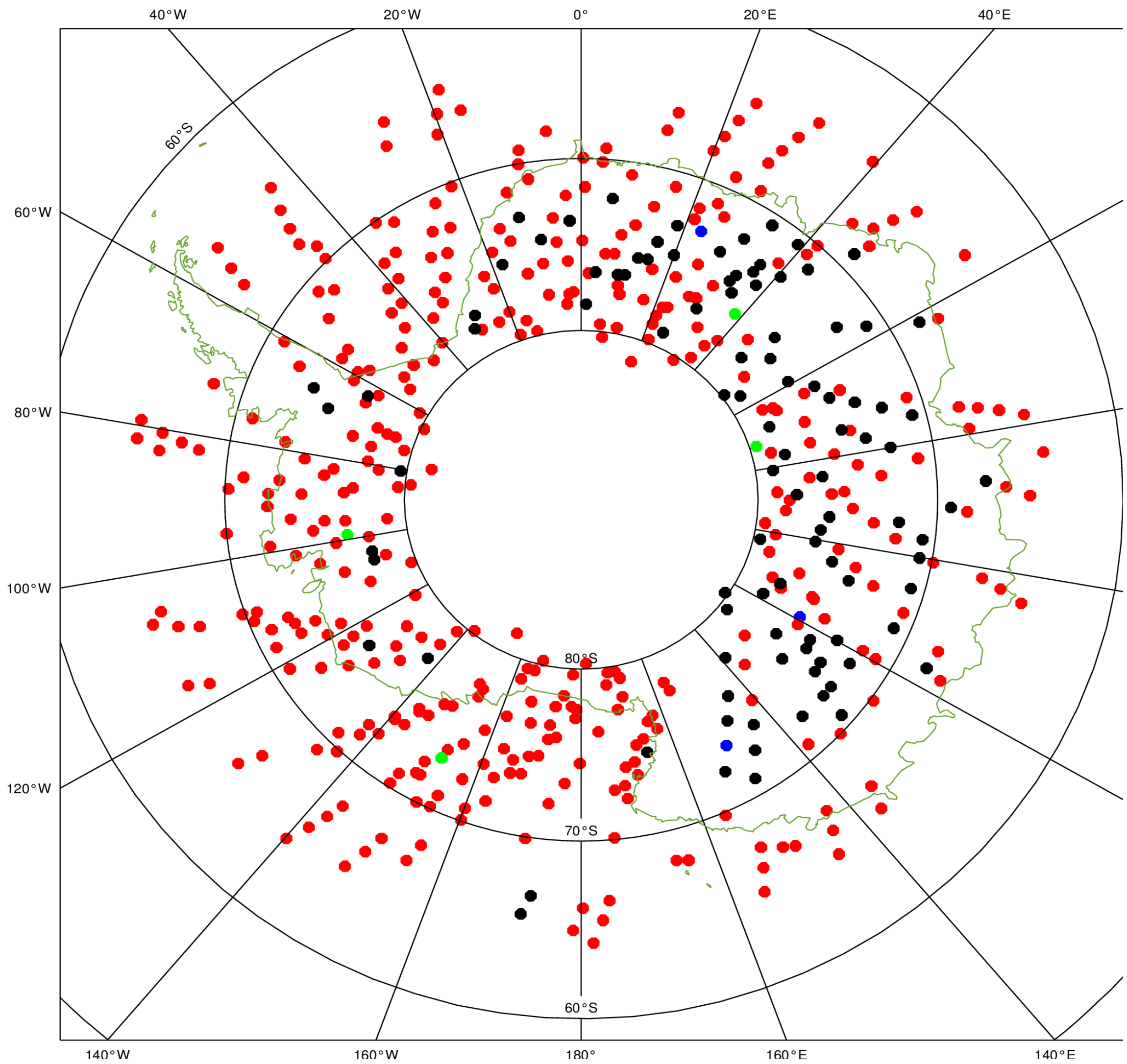
Blue = both MAIA and cloud detect clear

Red = both MAIA and cloud detect cloudy

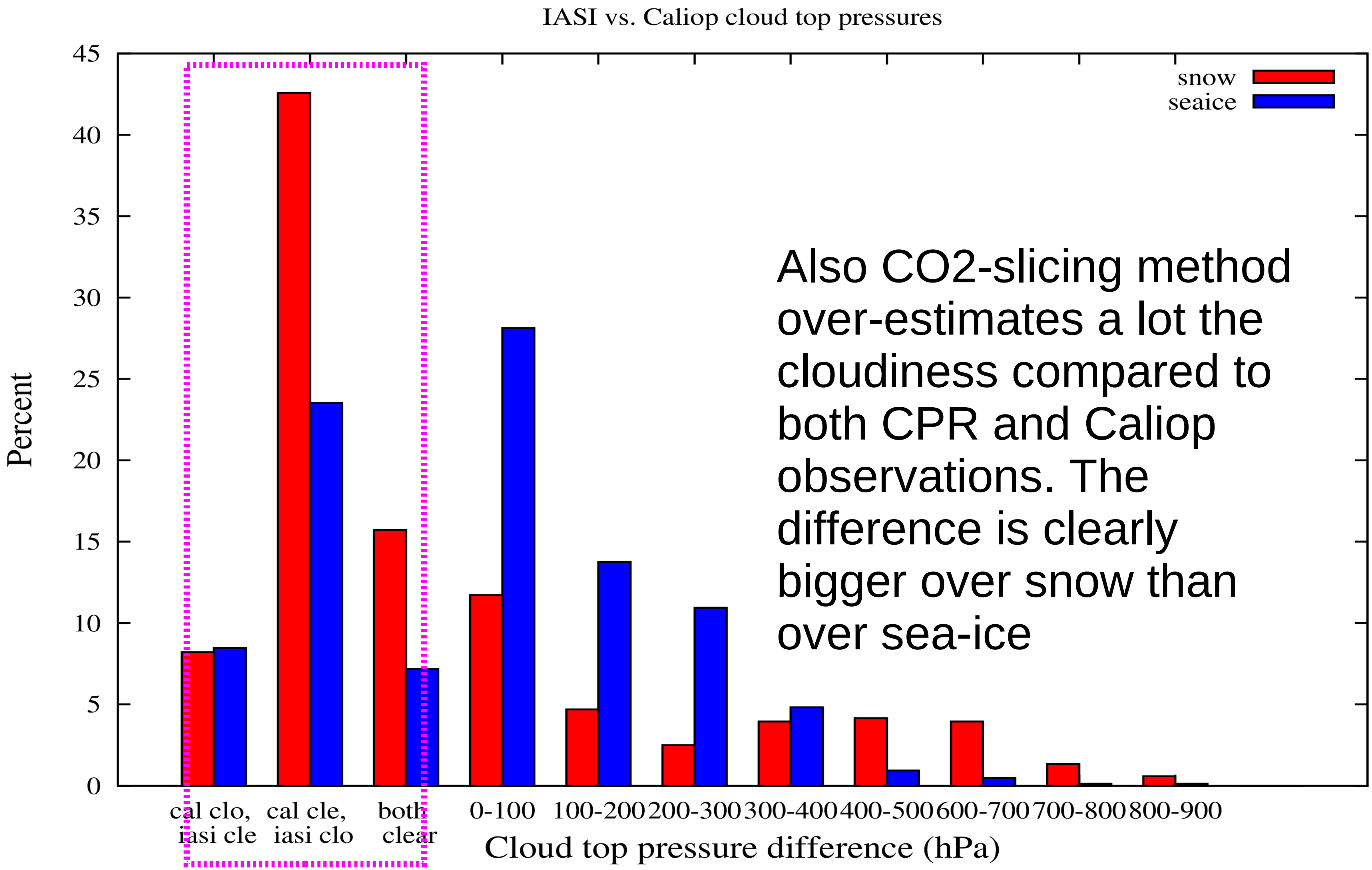
Green = MAIA cloudy, cloud detect clear

Black = MAIA clear, cloud detect cloudy

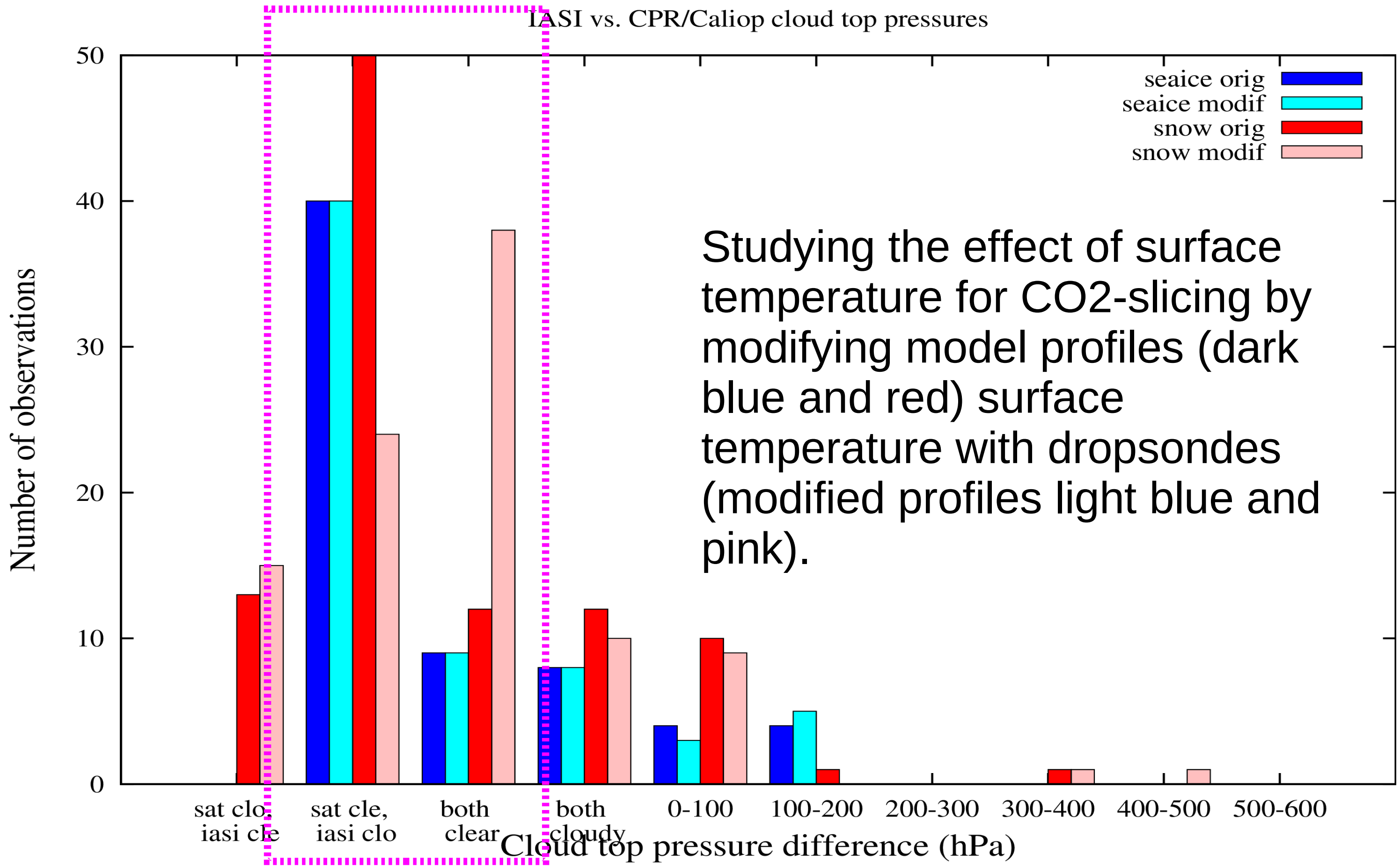
→ Compared to MAIA cloud mask IASI cloud detection over-estimates the amount of clouds, especially over snow-covered land and high elevations



CO2-slicing vs. Caliop



Also CO2-slicing method over-estimates a lot the cloudiness compared to both CPR and Caliop observations. The difference is clearly bigger over snow than over sea-ice



Studying the effect of surface temperature for CO2-slicing by modifying model profiles (dark blue and red) surface temperature with dropsondes (modified profiles light blue and pink).

The modification has bigger effect on snow covered land than on seaice (more variation on surface temperature) and bigger effect on cloud fraction than on cloud top pressure. On snow covered plateau the amount of falsely cloudy pixels is diminished.

Conclusions

- When compared with CPR and Caliop the IASI cloud top pressures retrieved by CO2-slicing method seem to correspond alright.
- The ECMWF cloud detection tool, CO2-slicing cloud fraction product and MAIA cloud mask all over-estimate the cloudiness especially over snow-covered land.
- The modification of model profiles by dropsonde profiles showed that there is a clear impact of surface temperature in deriving the cloud top properties by CO2-slicing.
- One of the possibilities could be to derive surface temperature from IASI measurements itself (in clear pixels) and use that as a first guess of surface temperature for cloud detection in nearby pixels.


Thanks for listening!
Any questions?
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