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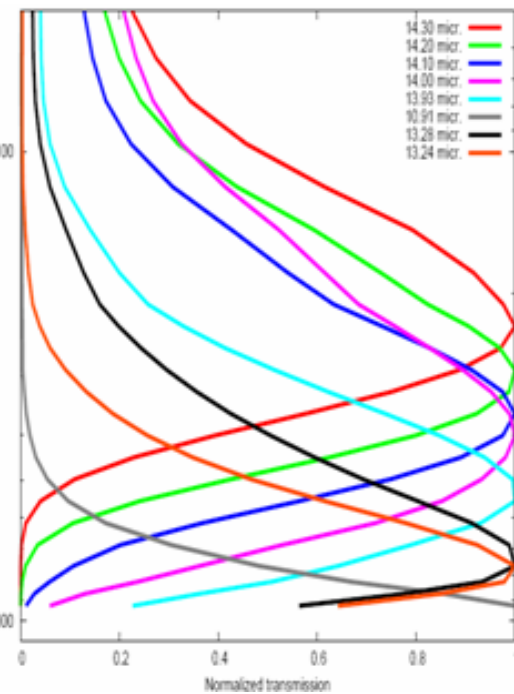
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## Climate monitoring with IR Sounders

TOVS, ATOVS, AIRS, CrIS, IASI (1,2,3), IASI-NG

>1979 / ≥ 1995 NOAA ≥2002 / ≥ 2012 NASA ≥2006 / ≥ 2012 / ≥ 2020 CNES-EUMETSAT  
onboard polar orbiting satellites, with local observation time at:  
7:30 AM/PM, 1:30 AM/PM, 9:30 AM/PM

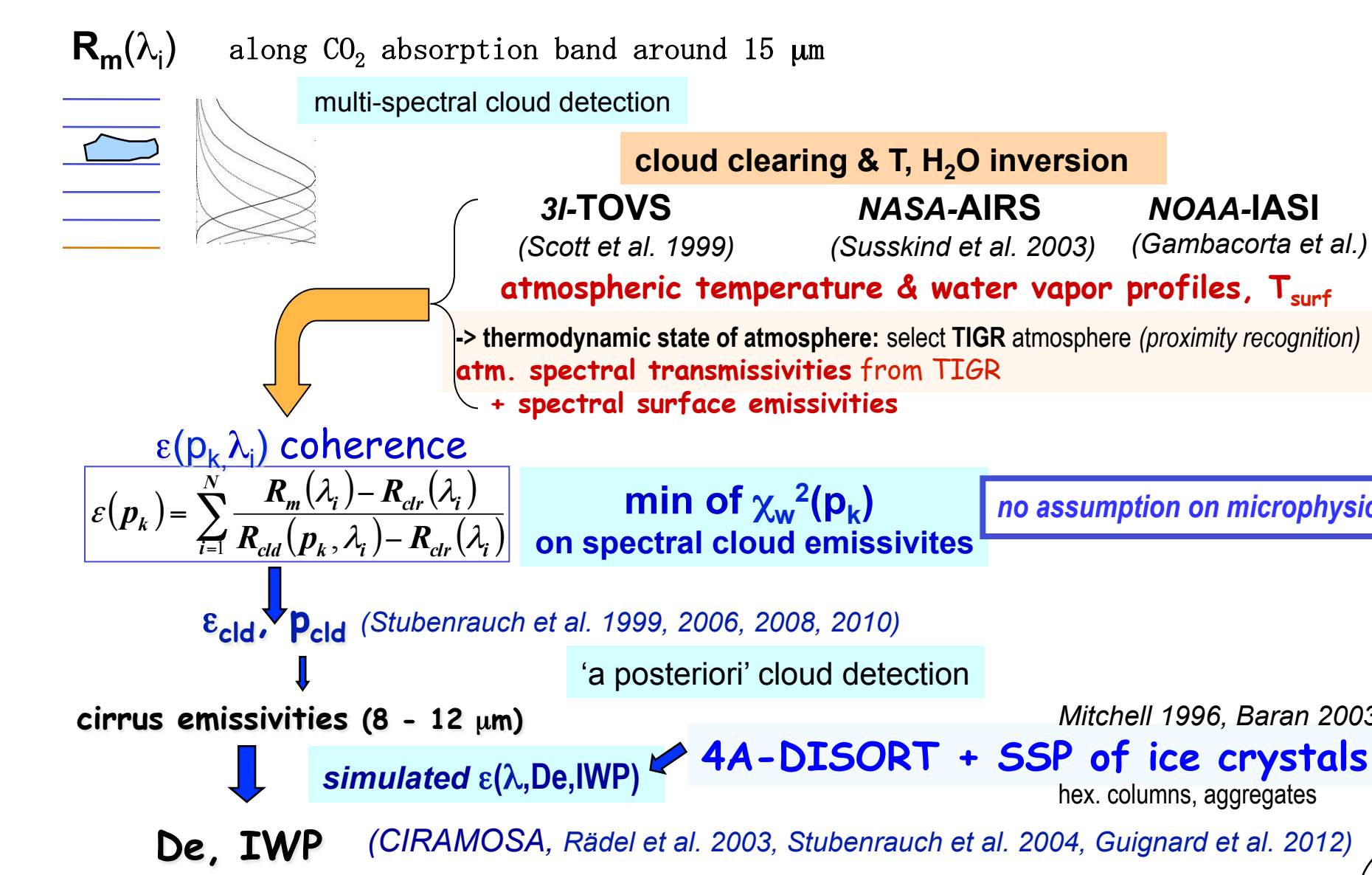


- satellite observations: good spatial coverage
- long time series -> climate studies
- channels along the CO<sub>2</sub> / H<sub>2</sub>O absorption bands (with different vertical contribution functions) allow sounding the atmosphere
- Both day- and nighttime retrieval of: T, H<sub>2</sub>O profiles; surface, cloud and aerosol properties
- high spectral resolution: esp. reliable Cirrus properties
- increasing spectral resolution -> increasing vertical resolution of the upper tropospheric humidity

TOVS: TIROS Operational Vertical Sounder: High resolution InfraRed Sounder (HIRS) / Microwave Sounding Unit (MSU)  
ATOVS: Advanced TIROS Operational Vertical Sounder: HIRS / Advanced Microwave Sounding Unit (AMSU)  
AIRS: Atmospheric InfraRed Sounder + AMSU  
CrIS: Cross-track Infrared Sounder + Advanced Technology Microwave Sounder (ATMS)  
IASI: Infrared Atmospheric Sounding Interferometer

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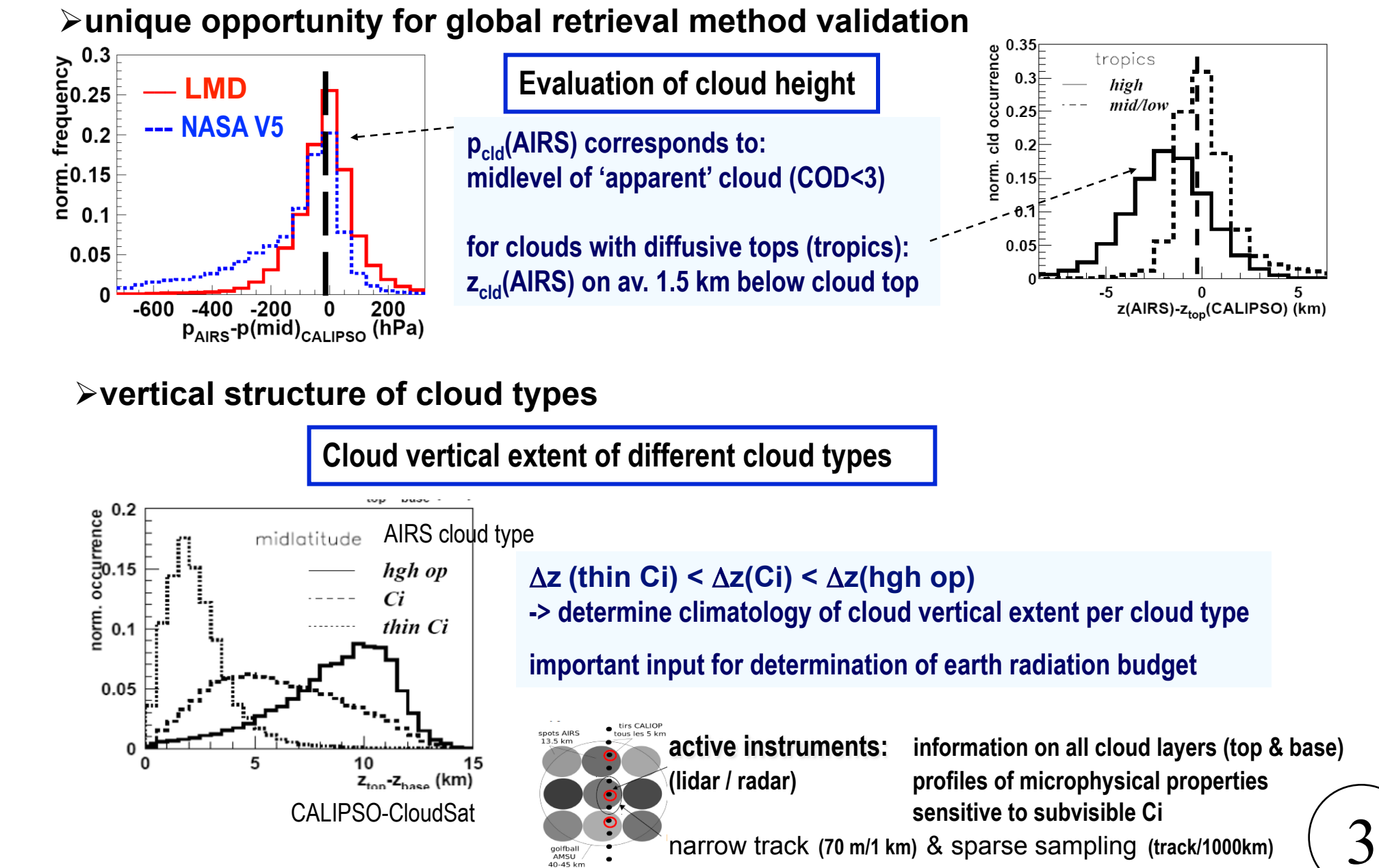
## Cloud property retrieval : TOVS, AIRS, IASI



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## A-Train Synergy: evaluation & vertical cloud structure

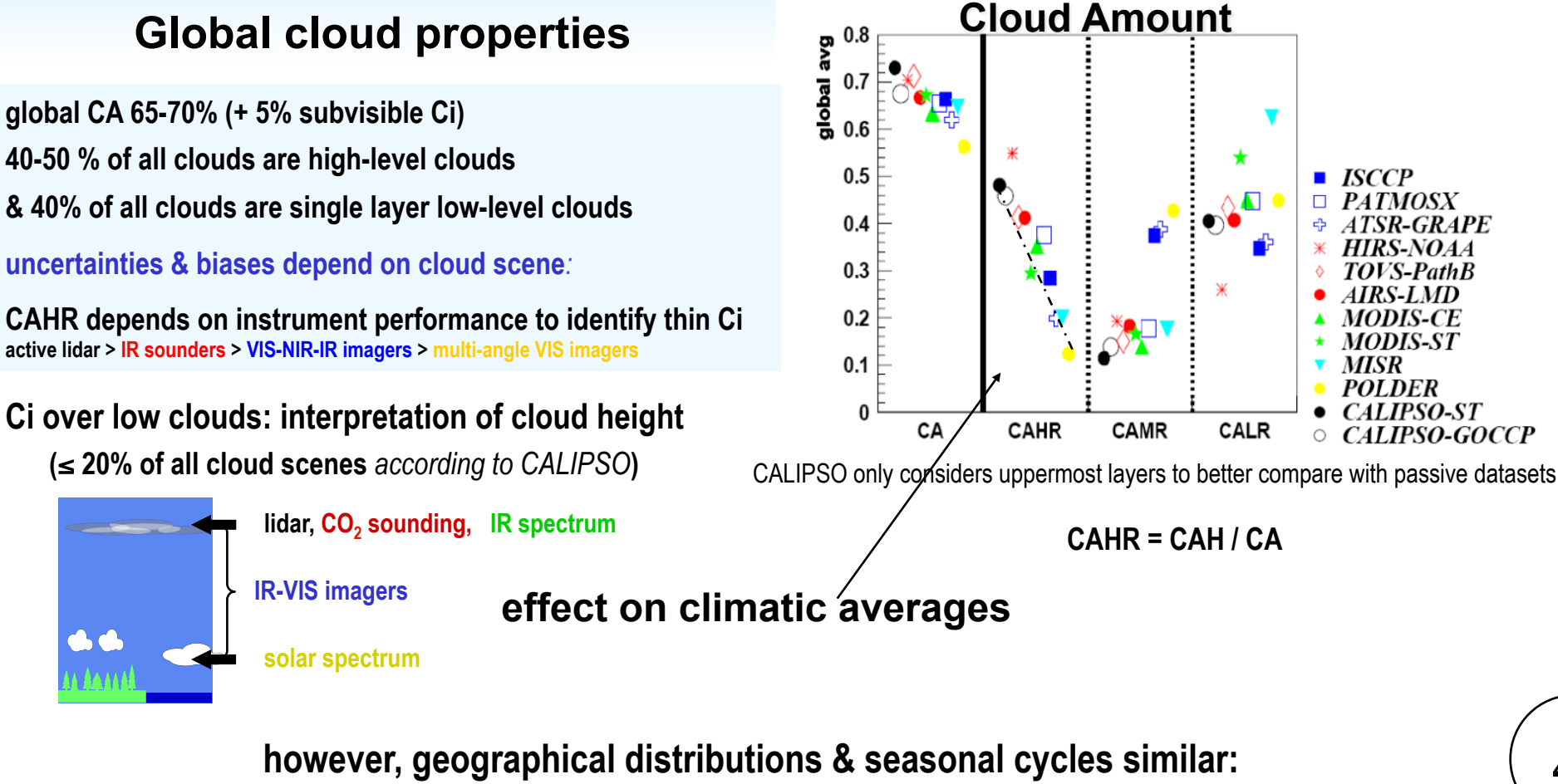
(AIRS-CALIPSO-CloudSat) Stubenrauch et al. ACP 2008, 2010



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## Participation in GEWEX Cloud Assessment (2005-2012)

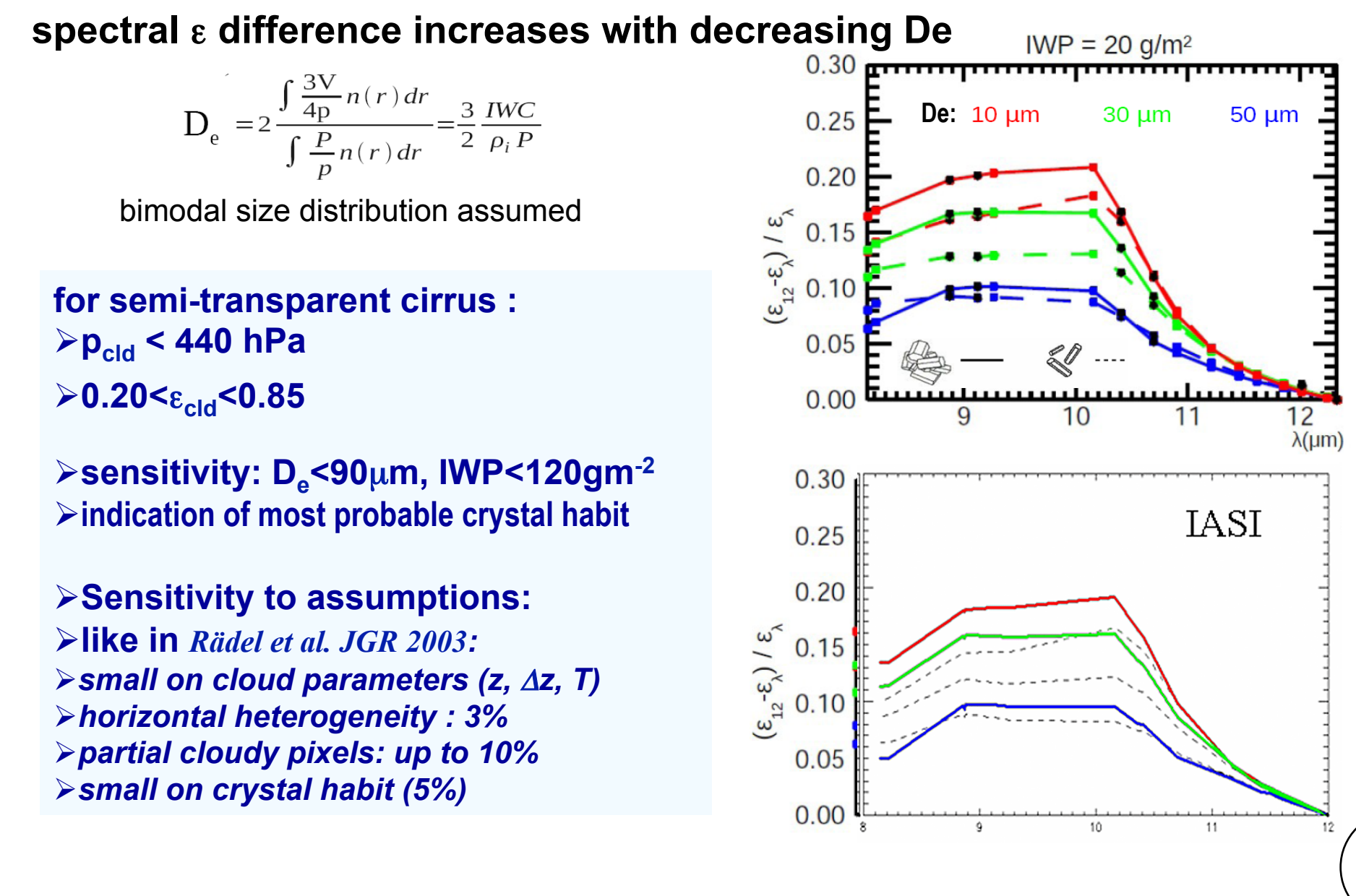
assessments essential for climate studies & model evaluation:  
1st coordinated intercomparison of 12 'state of the art' global cloud datasets  
Database: global gridded L3 data (1° x 1°): monthly averages, variability, Probability Density Functions  
available at: <http://climserv.ipsl.polytechnique.fr/gewexca>



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## Microphysical properties of semi-transparent cirrus

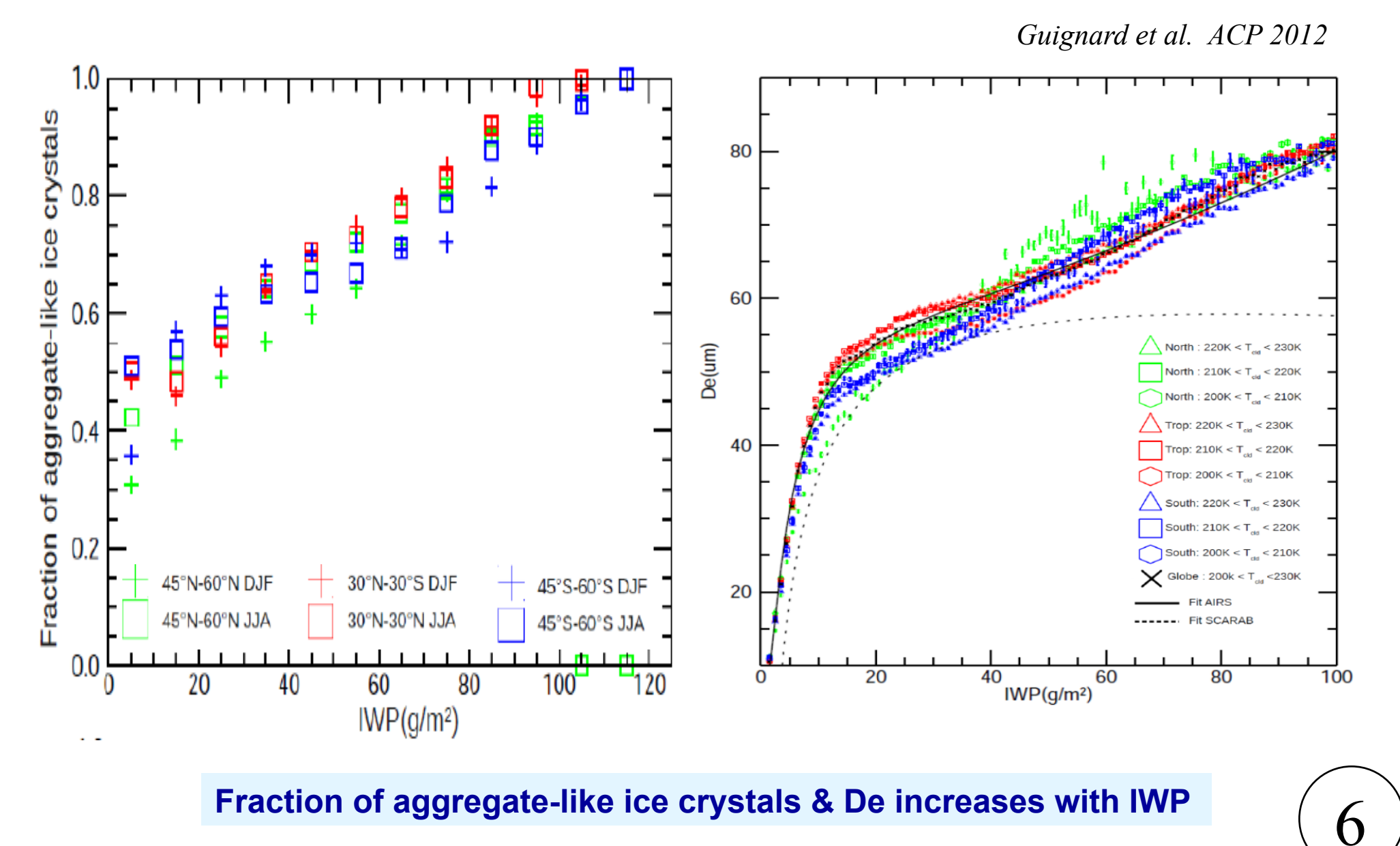
PhD thesis Guignard 2012; Guignard et al. ACP 2012



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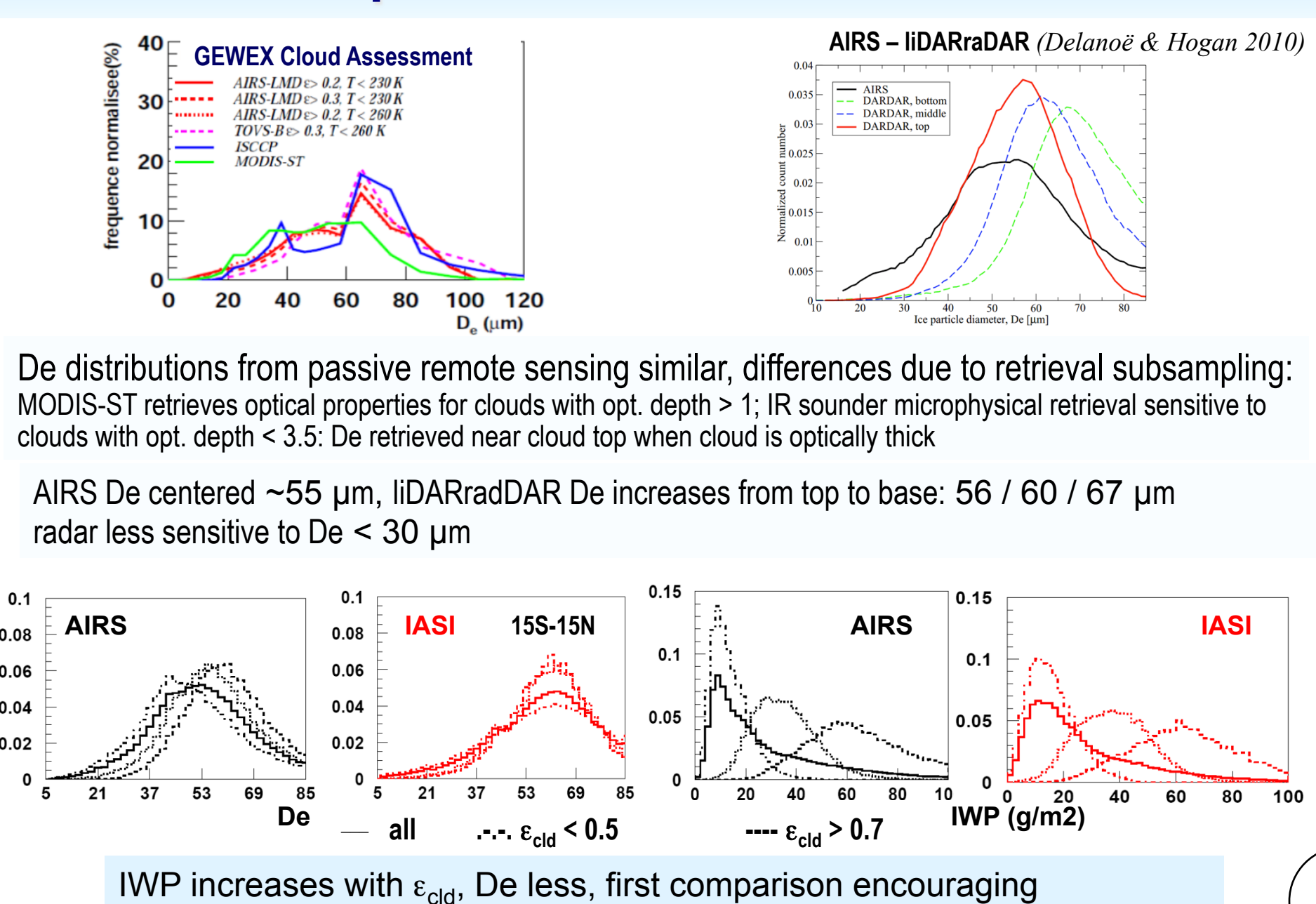
## Relationship between ice crystals and IWP

Guignard et al. ACP 2012



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## Comparison with other datasets



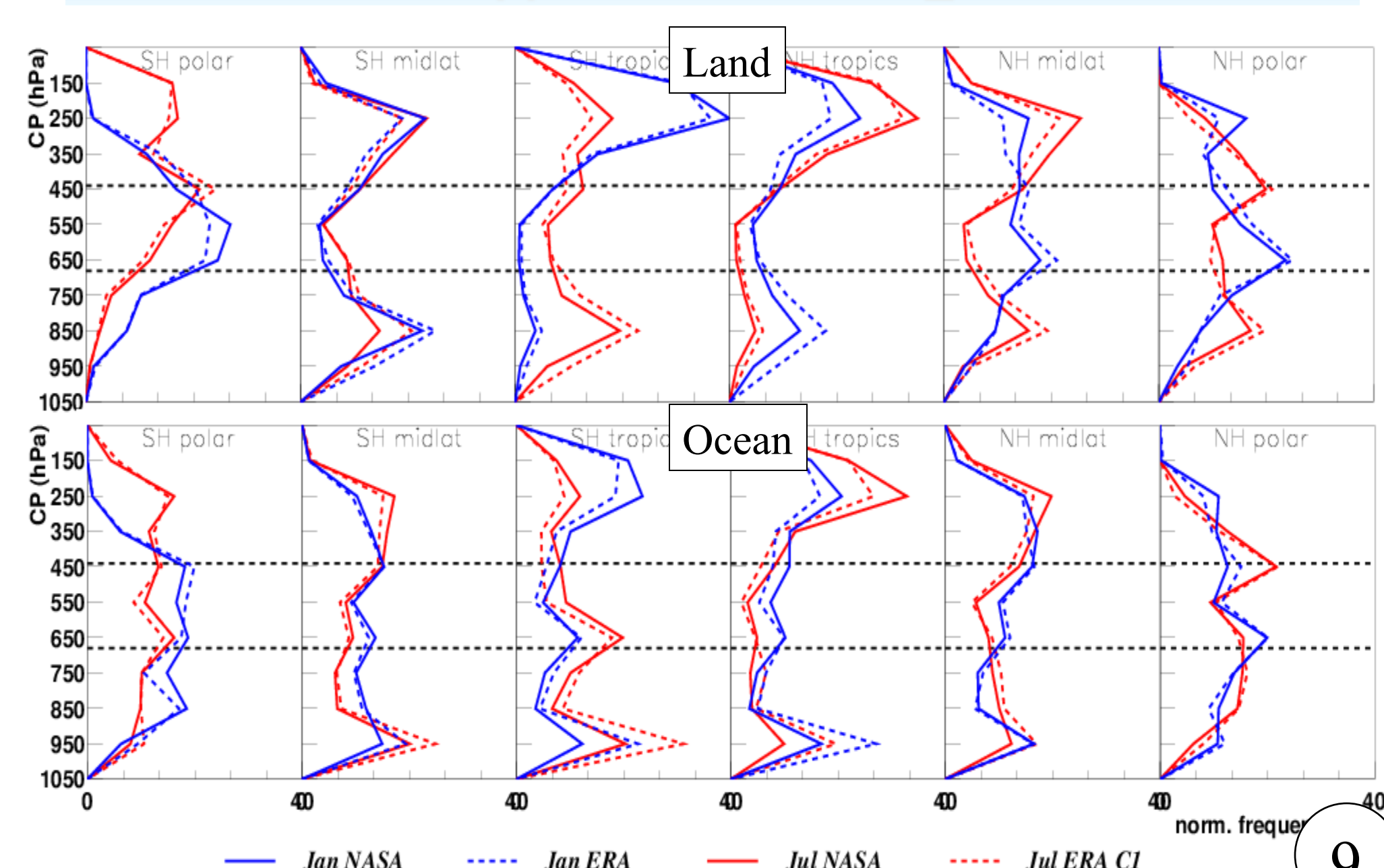
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## New code for Pcid/Tcid/epsilon\_cld retrieval from IR observations

- Main features**
  - chi-squared minimization approach
  - flexibility allows using various instruments, spectral channels, auxiliary data
  - improved calculation of the transmissivities for layers close to the ground
  - improved calculation of clear sky radiances
- Spectral channel selection**
  - CO<sub>2</sub> channels closest to the AIRS in T<sub>e</sub>
- Using auxiliary data:**
  - atmospheric T/H<sub>2</sub>O profiles, T<sub>surf</sub>, T<sub>surface</sub>, P<sub>surf</sub> ice/snow: L2 instantaneous for good quality profiles; averages for other cases
  - tropopause determined from L2 atmospheric profiles (Reichler et al. 2003)
  - spectral weights, spectral transmissivities pre-computed for TIGR profiles and used for radiative transfer
  - spectral surface emissivities (monthly climatologies): 30N-30S AIRS, IASI, 90S-30S, 30N-90N MODIS. Another option: 90S-90N LERMA\_IASI

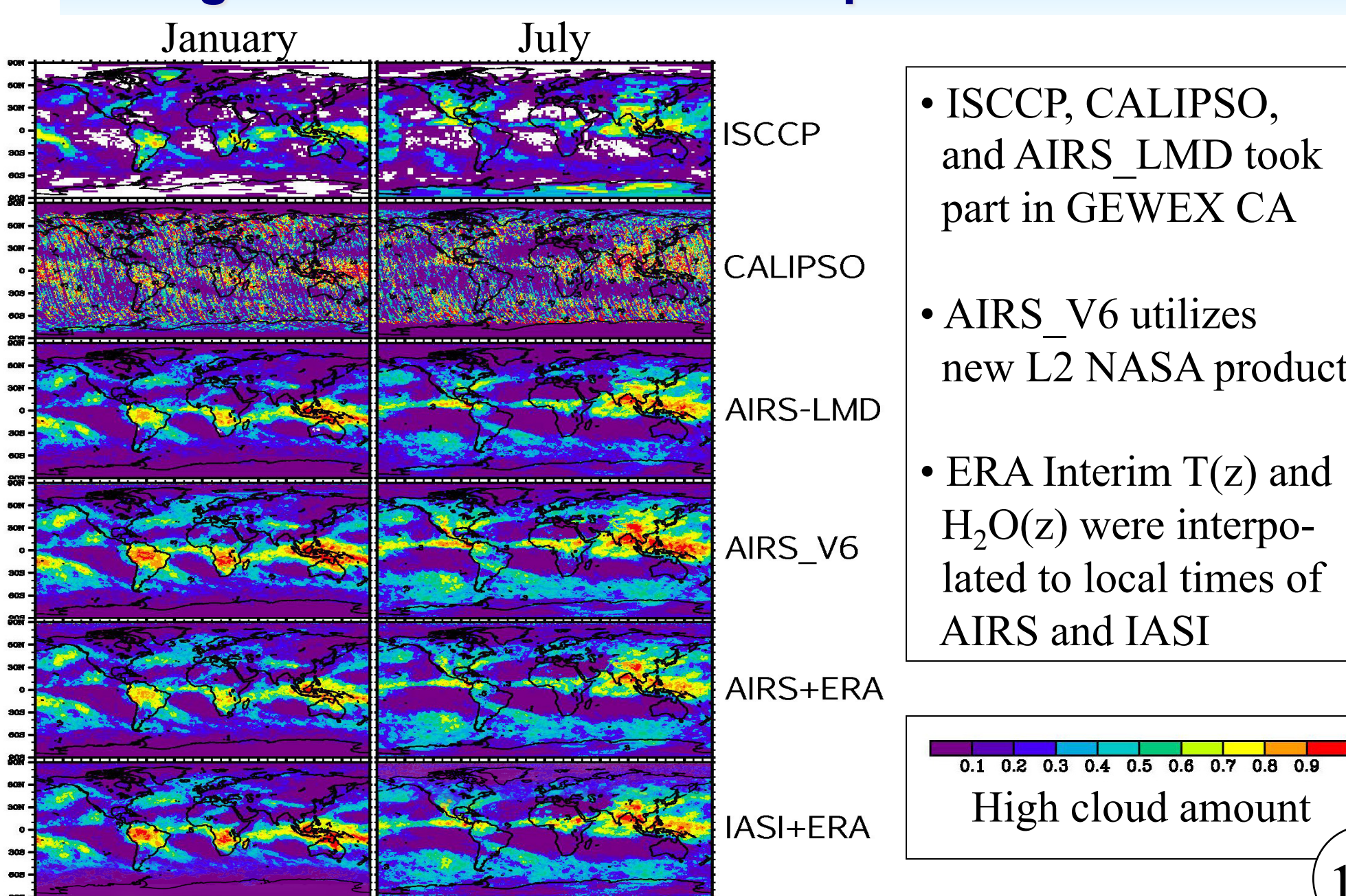
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## New code: application to AIRS\_V6 and IASI



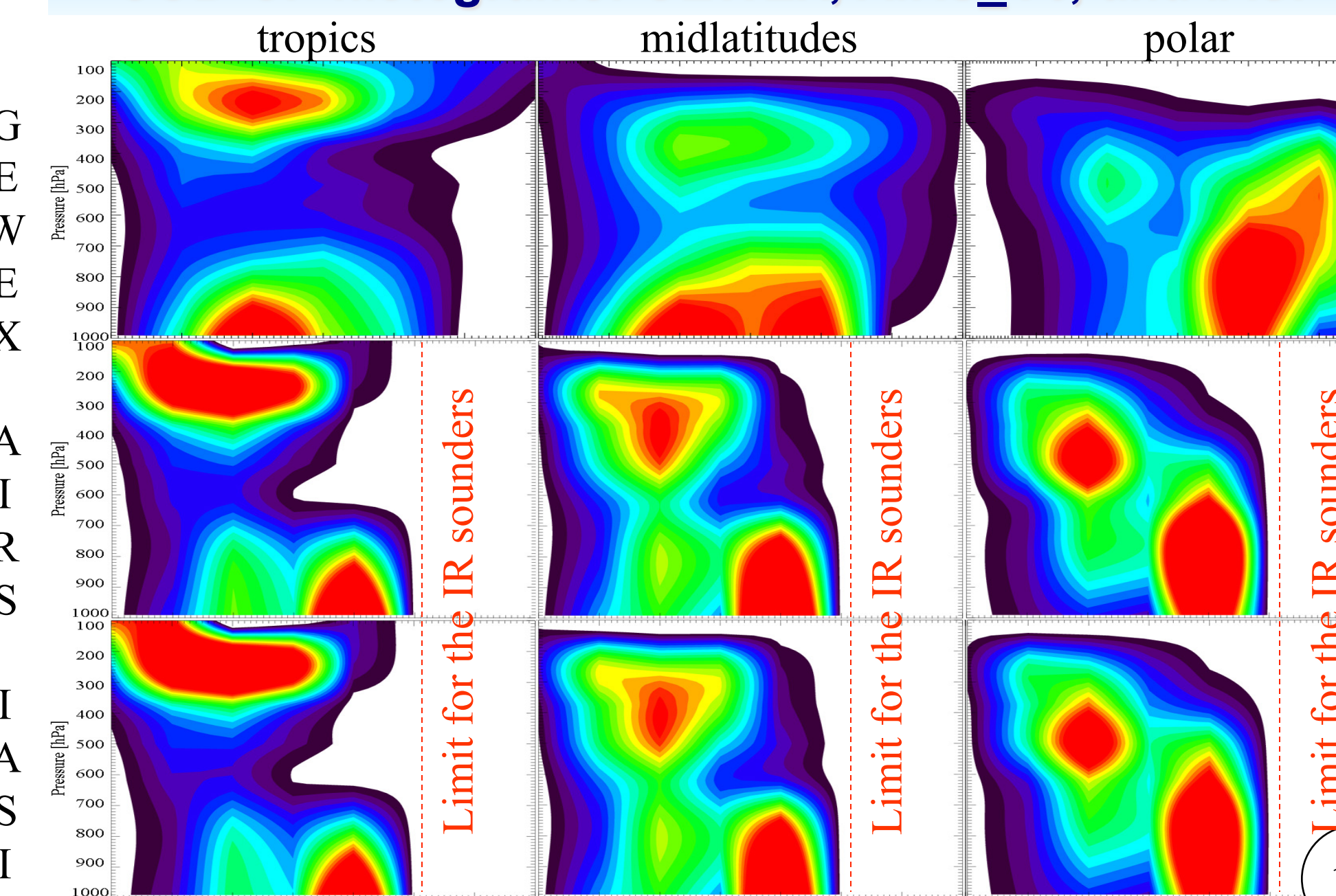
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## High clouds retrieved from space observations



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## COD-CP histograms: GEWEX, AIRS\_V6, and IASI



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## Conclusions and Outlook

- 40% of all clouds are high-level clouds, 70% of them are semi-transparent, and 50% pure ice (more aggregates at larger IWP)
- IR sounders are sensitive to cirrus (for multi-layered cloud systems, day/night)
- P<sub>cid</sub> corresponds to midlevel of apparent cloud depth (COD<3)
- Retrieval of De, IWP, ice crystal shape seems to be coherent: De increases logarithmically with IWP -> parameterization for GCM's
- A new retrieval code has been developed, based on weighted chi-squared minimization approach. The code is capable to retrieve cloud properties from any multi-channel infrared sounder.
- Cloud properties from IASI are in a good agreement with AIRS and with the GEWEX reference subset (ISCCP, AIRS-LMD, MODIS-CE, MODIS-ST, and PATMOSx)

Last but not least: this work was supported by CNRS and CNES. Thanks to all Science teams as well as the engineers and space agencies for their efforts and cooperation in providing the data! Data processing possible thanks to Ether, Icare and ClimServ centers.

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