Chasing Clouds? How satellite observations help pin down the most evasive climate constituents

Ralf Bennartz

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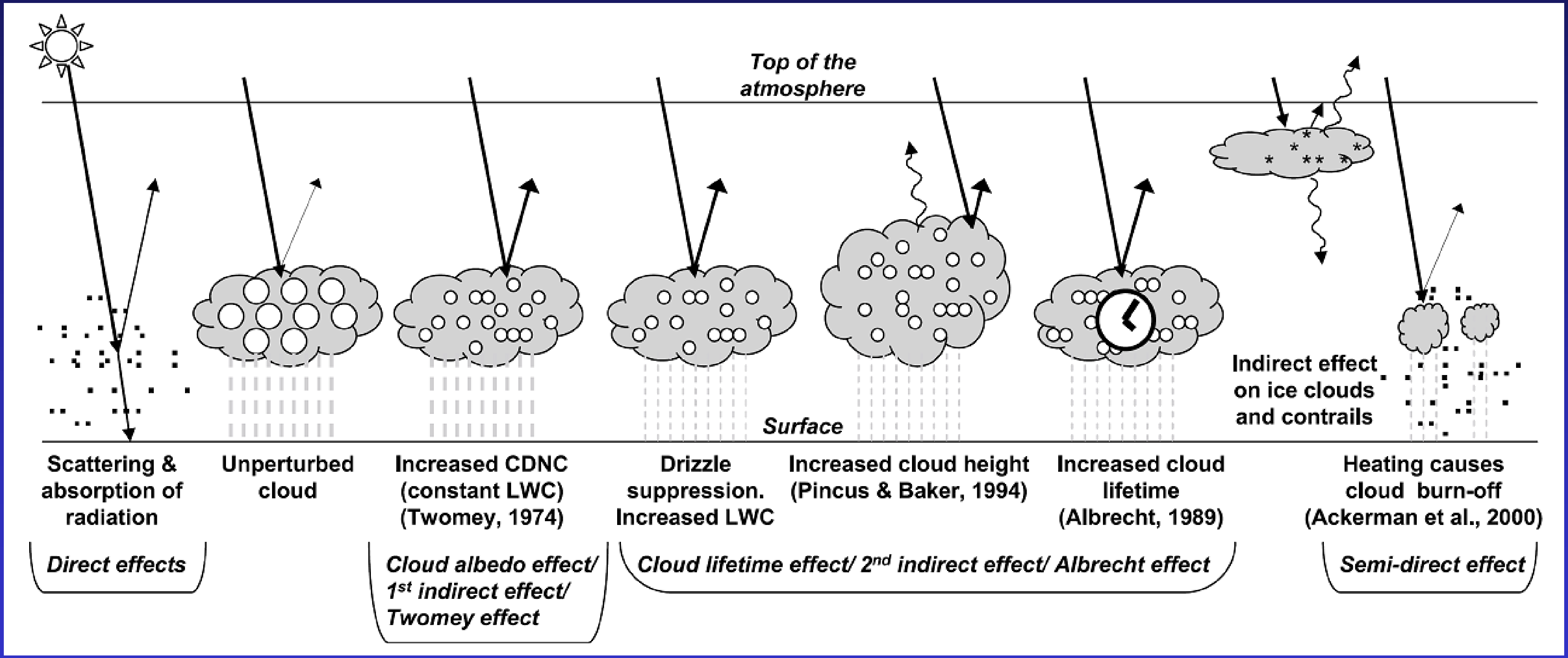
Outline

- Why are clouds important?
- What can satellite observations contribute?
  - Monitoring climate
  - Understanding climate processes
- Challenges

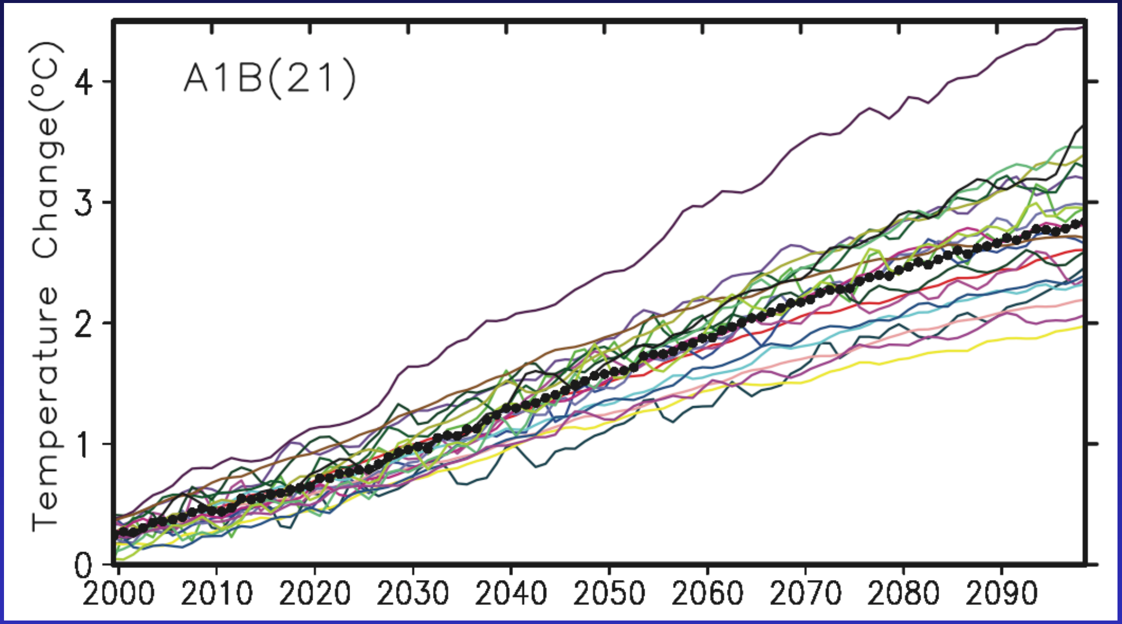
Clouds are the single-most important factor modulating climate sensitivity…..

… and we know very little about forcings and feedbacks



IPCC 2007

21 climate models- one scenario



IPCC 2007

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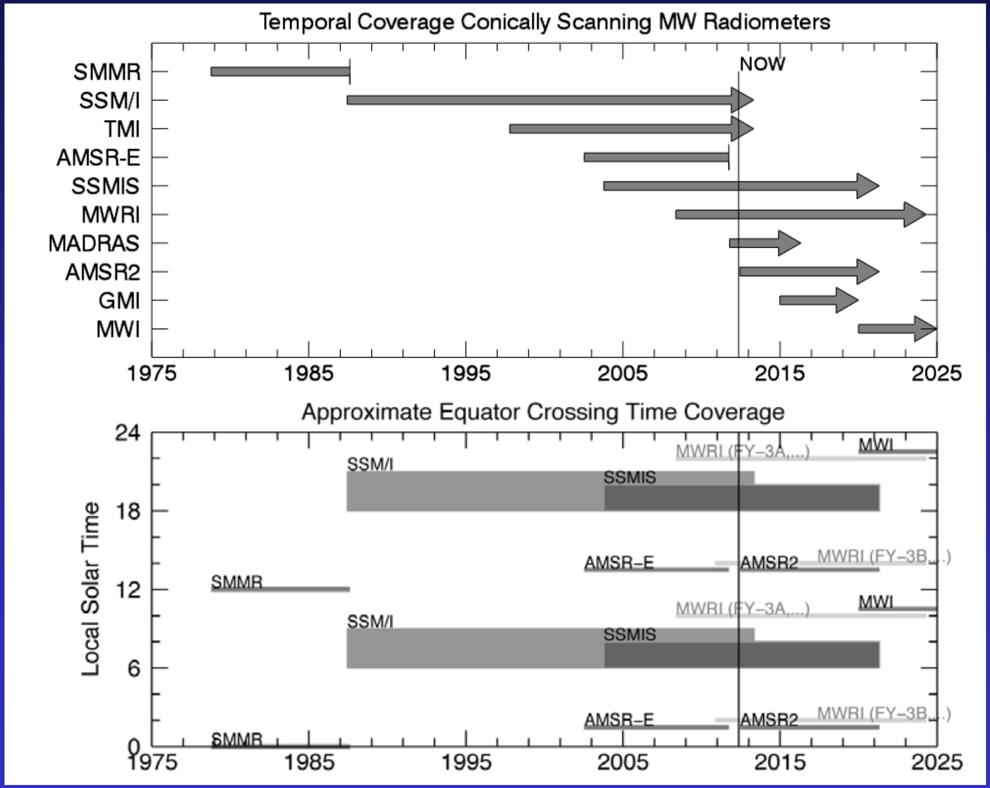
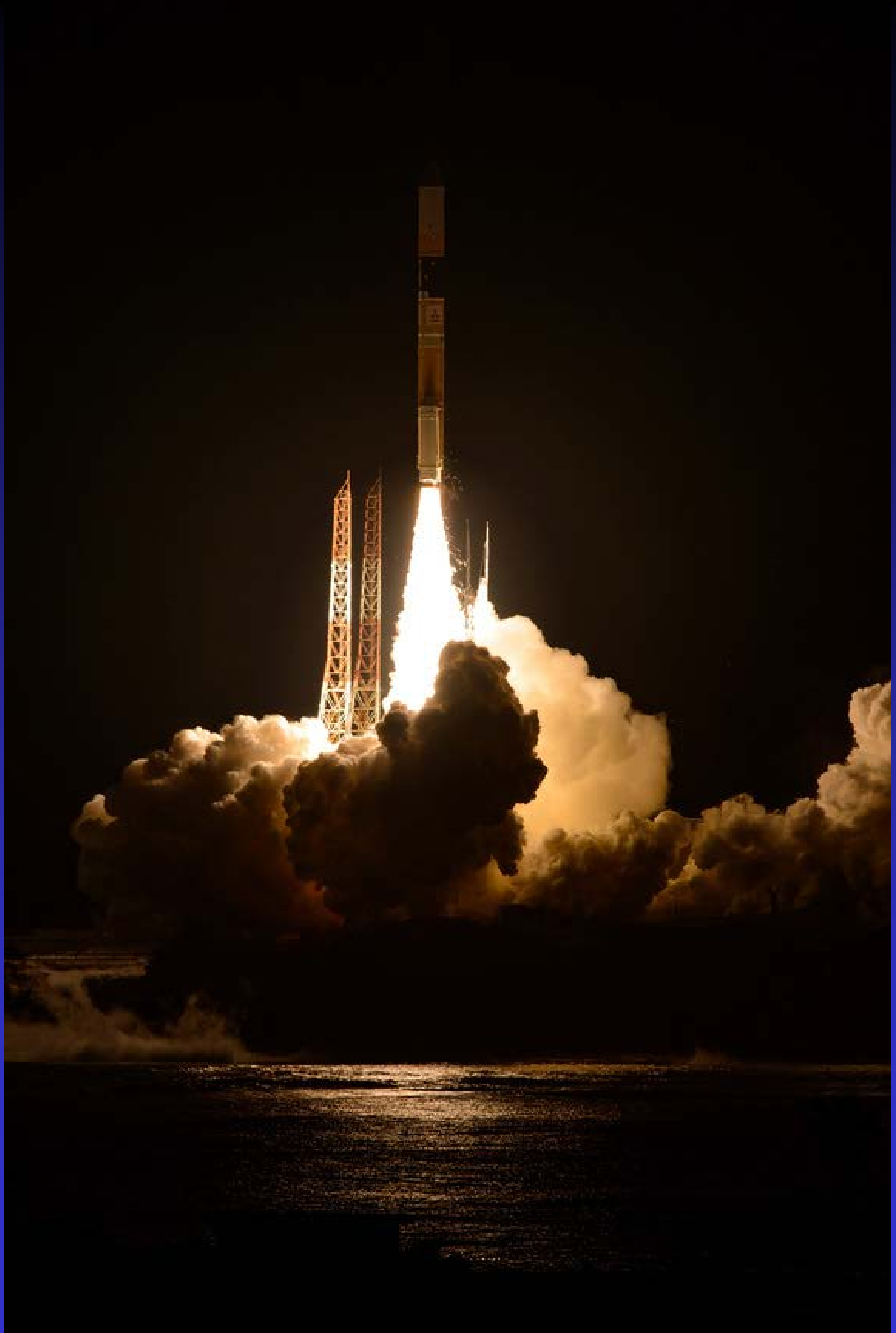
Data Record



- SSM/I, SSMIS Morning/Evening Coverage since 1987
- TRMM/GPM crisscrossing in LEXT since 1997 resp 2014
- AMSR-E/AMSR-2 13:30 LEXT
- MWI on EUMETSAT/ EPS-SG early afternoon orbit

GPM was launched successfully on:

Thu, 27 Feb 2014 18:38:33 UTC



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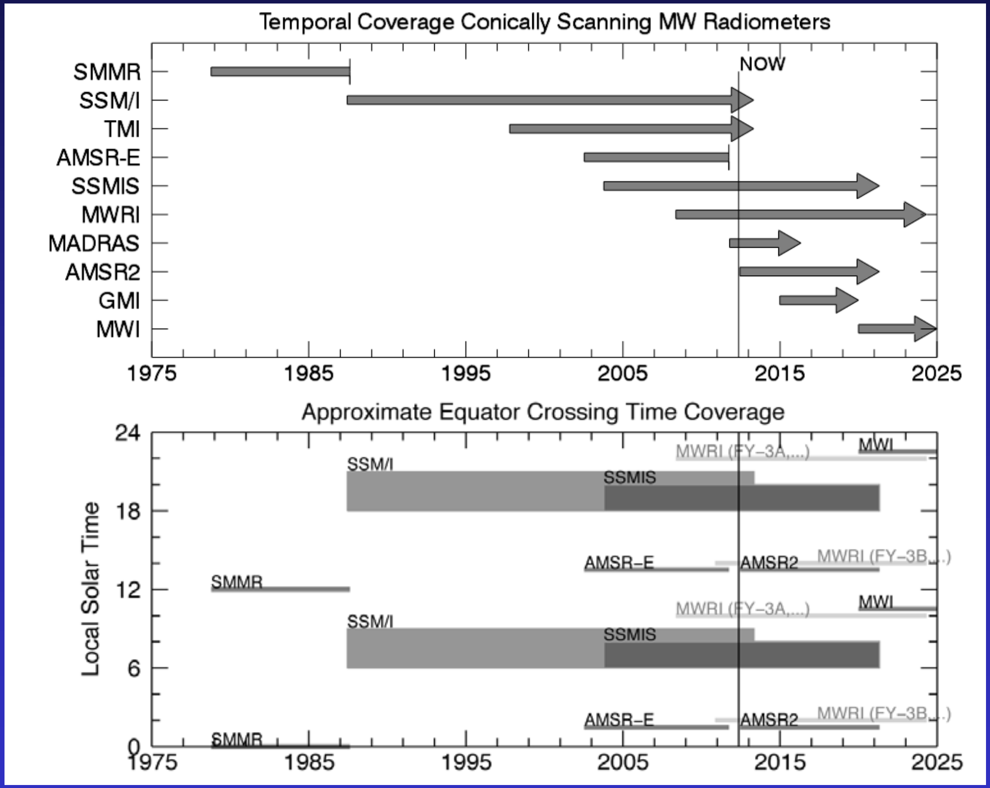

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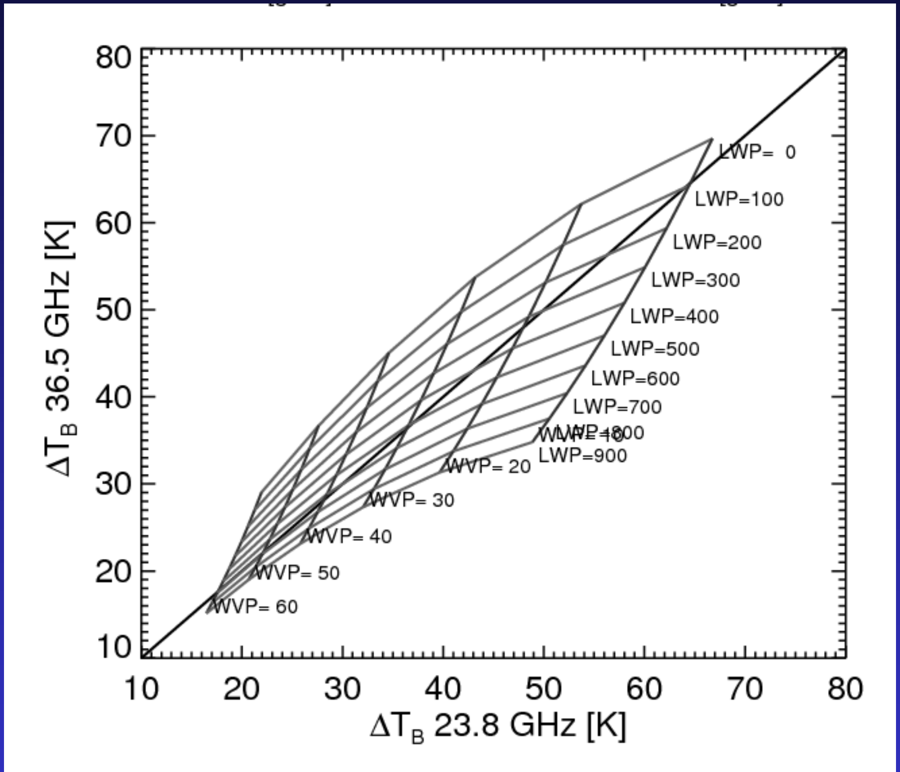
MW cloud liquid water path climatology

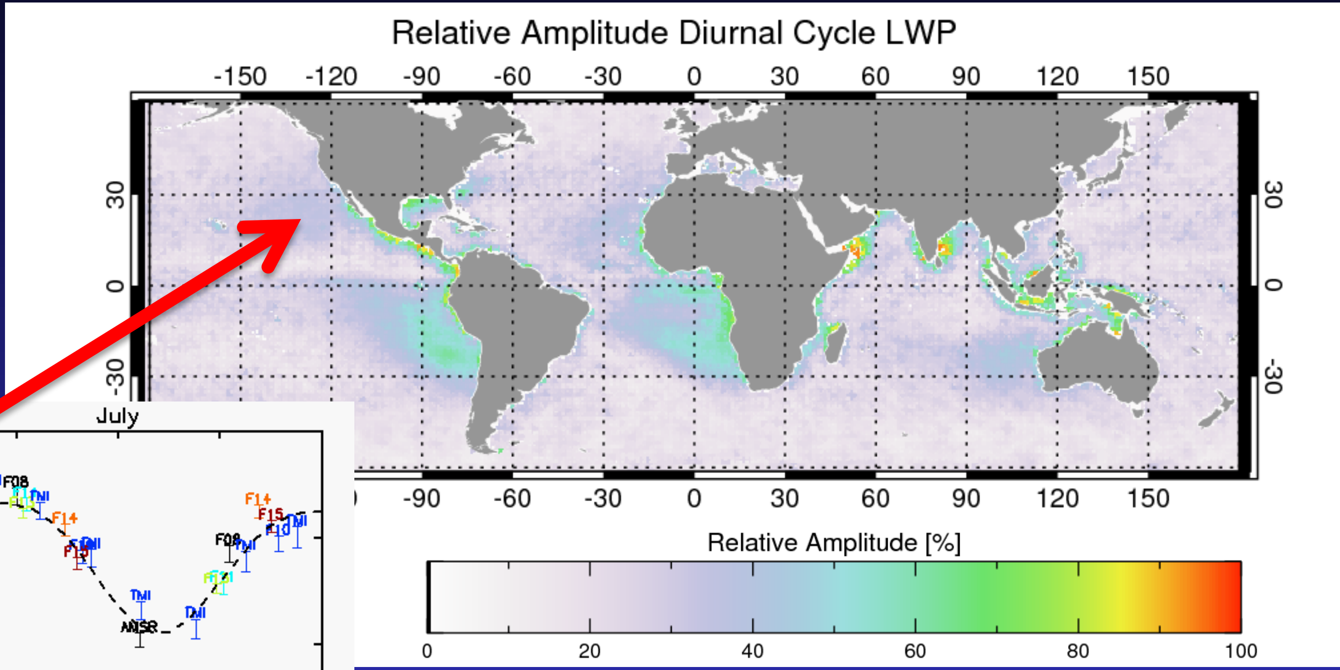
- Based on SSM/I since 1987, AMSR-E, and TMI
- Monthly diurnal mean liquid water path. Climatological diurnal cycle
- Various limitations for high LWP (due to presence of rain), slight biases for low LWP.
- Ongoing NASA Measures project (2013-2018)
- CM-SAF leading European efforts (HOAPS)
- Internationally coordinated via SCOPE-CM

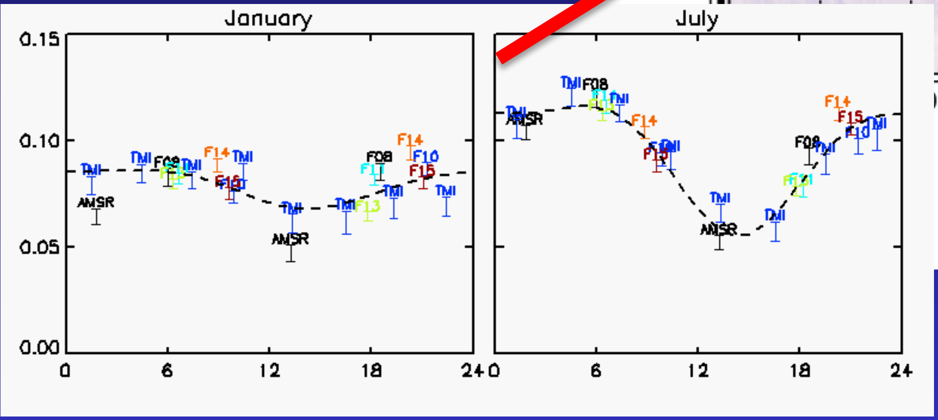
MW: Principle of retrieval



- Use 2 channels and polarization difference to estimate WVP, LWP
- Also affected by rain water
- Separation of RWP/LWP critical.

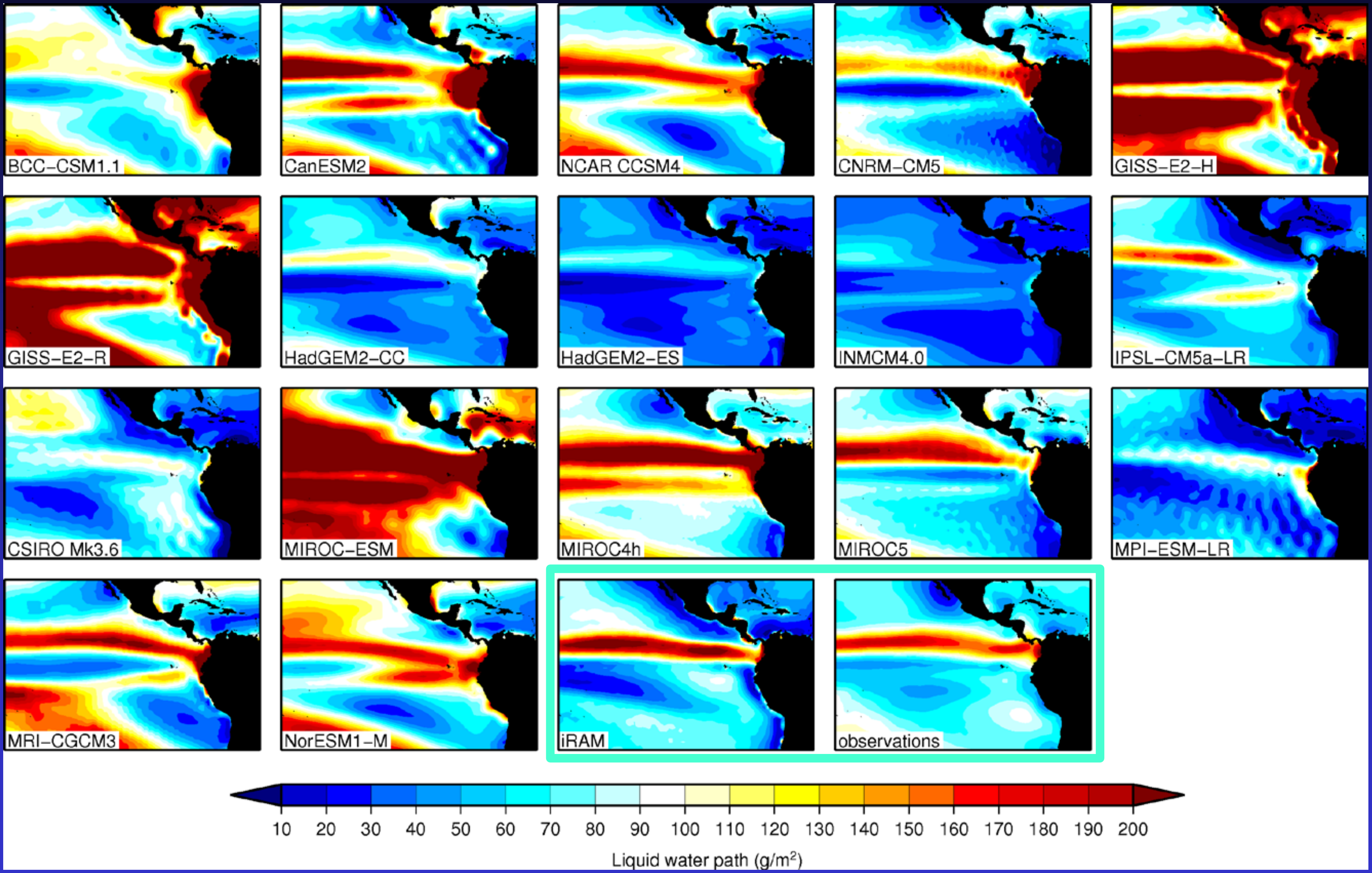
The diurnal cycle of LWP





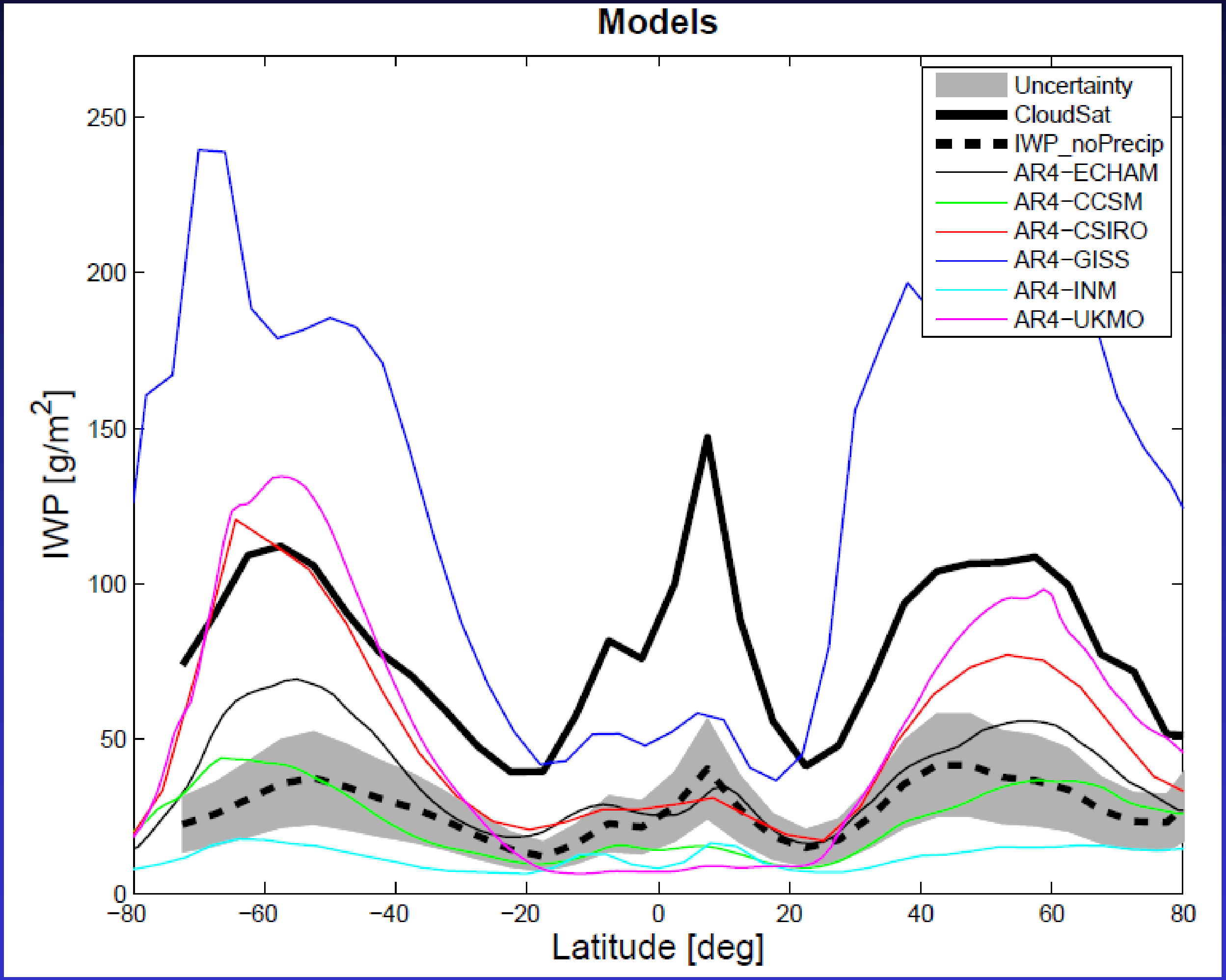
Long-term satellite studies of LWP must account for the diurnal cycle. Otherwise, satellite drifts will lead to an aliasing of the diurnal cycle onto trends of LWP.

Liquid water path, observations versus IPCC AR-5 (CMIP-5)



Lauer et al. (2012)

Ice water path



(Eliasson et al, 2011)

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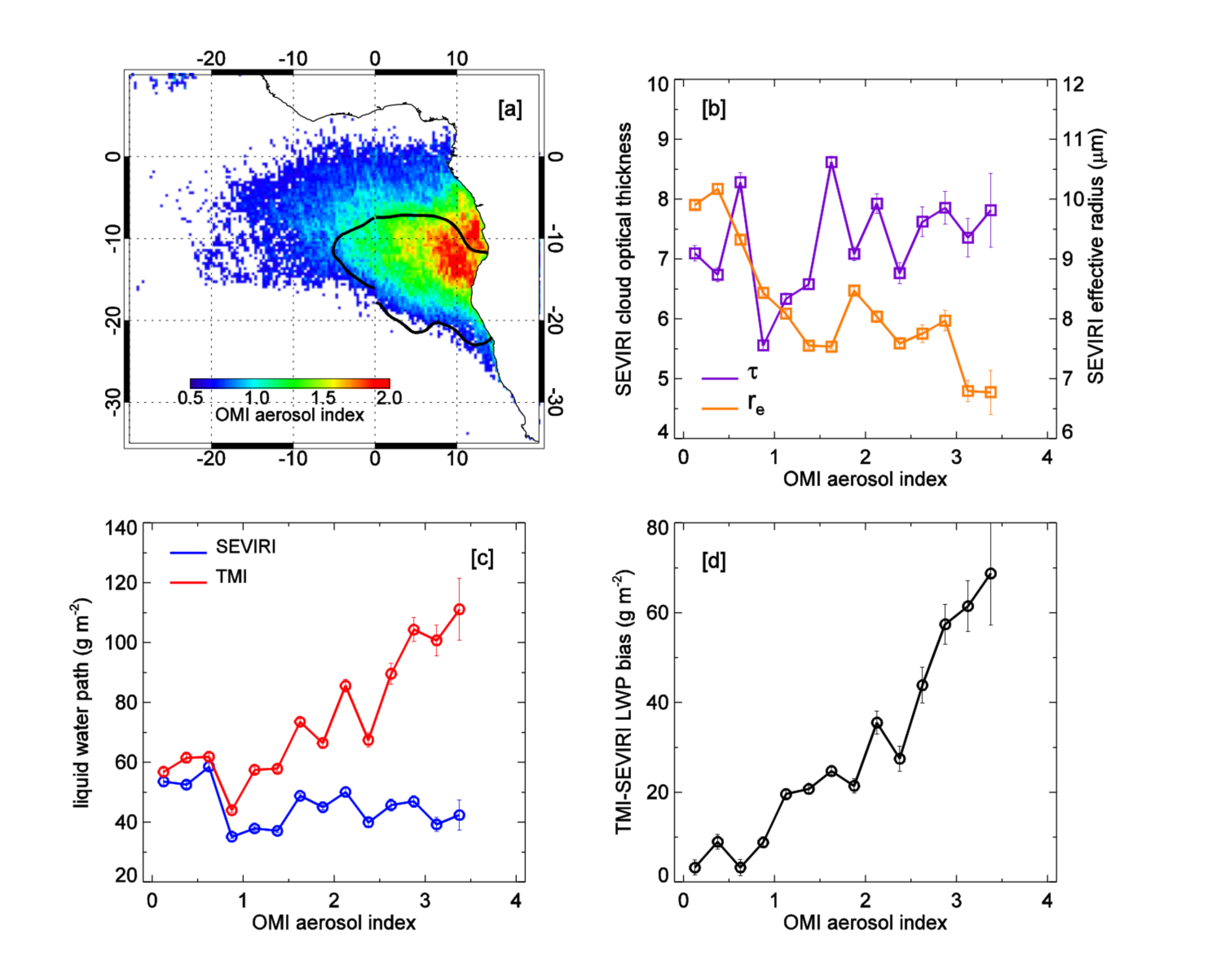
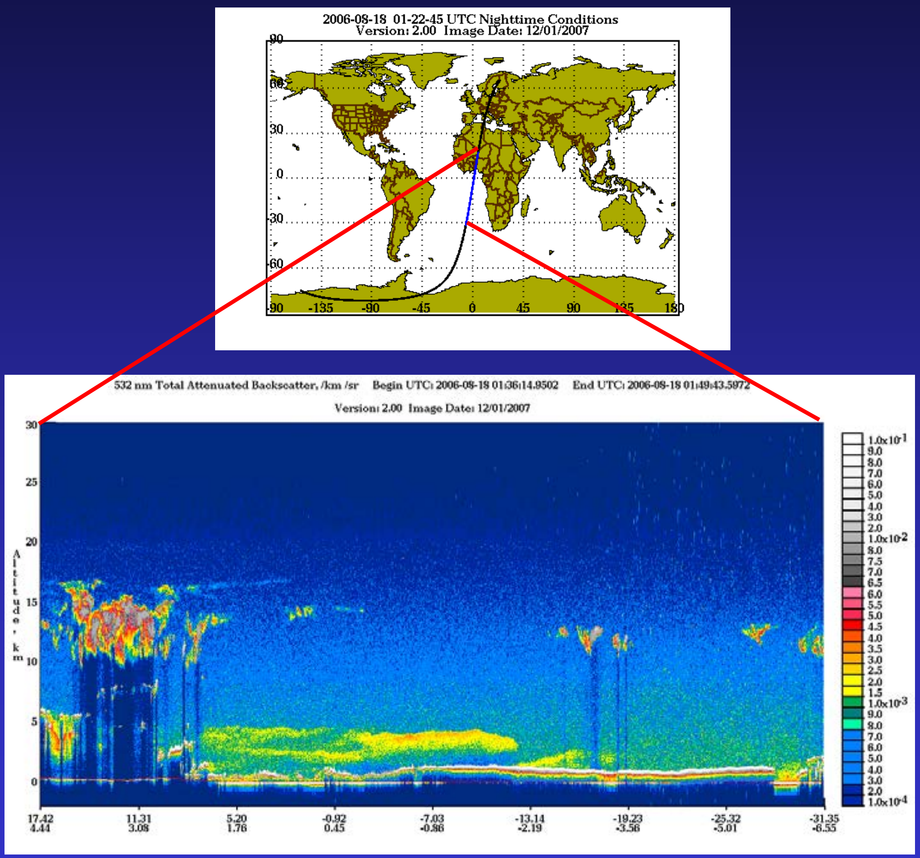
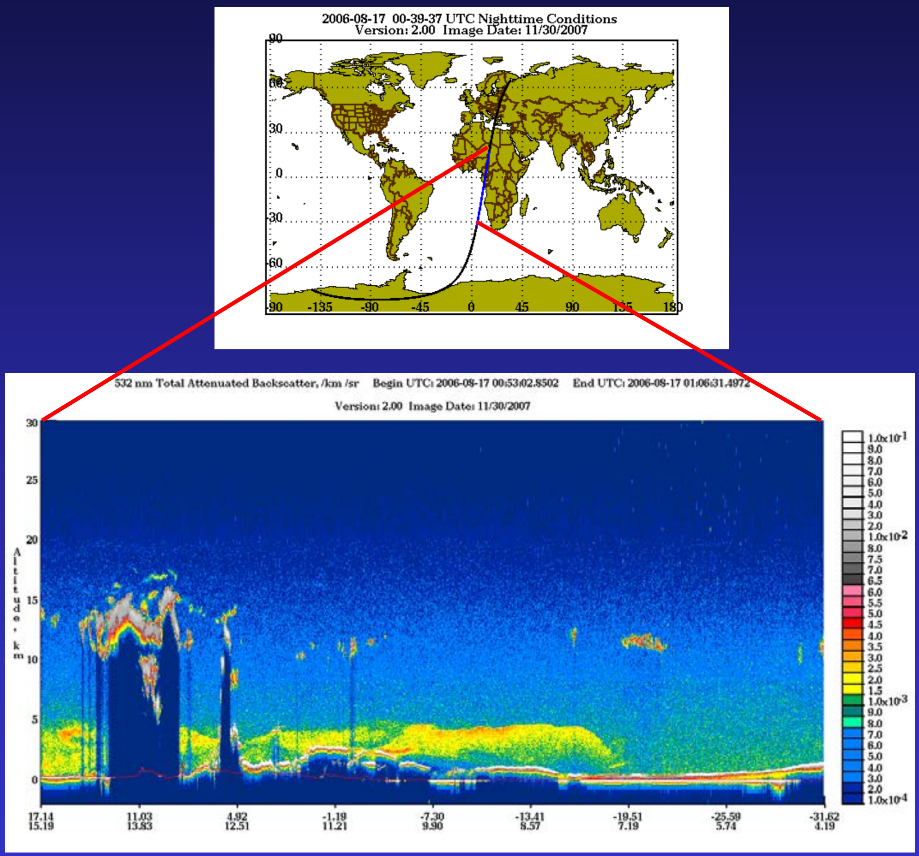
Biomass burning aerosol and 1st indirect aerosol effect



Seethala et al. (2014)

Lidar observations of aerosols over clouds





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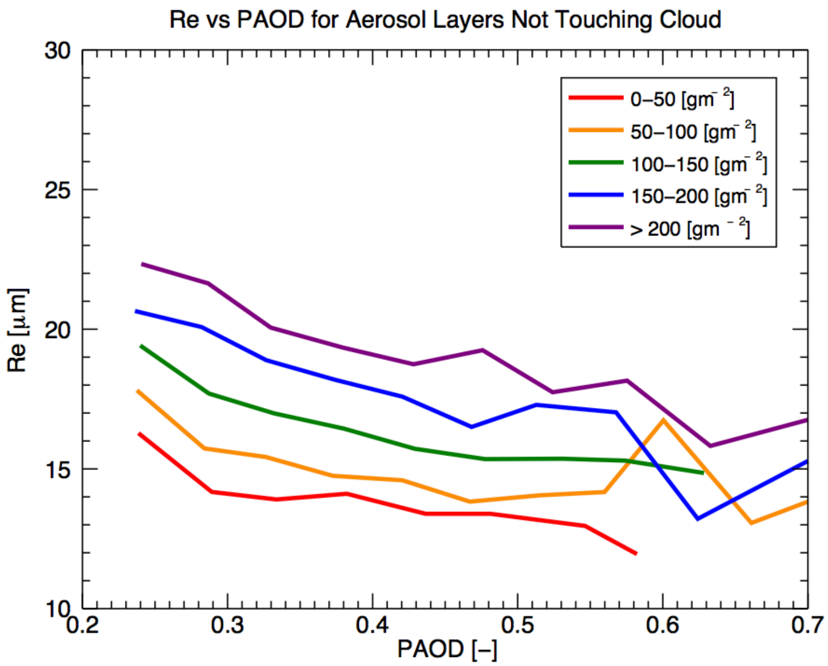
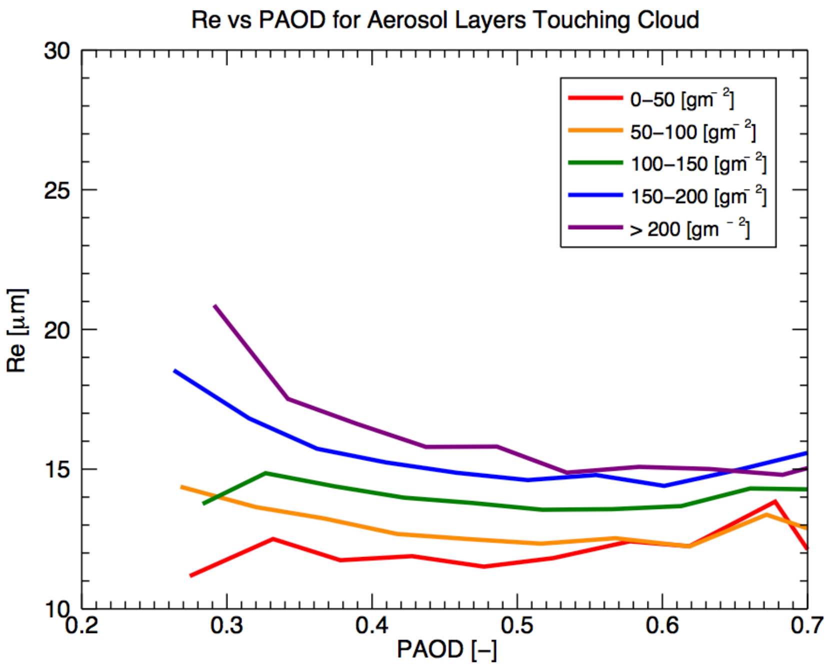
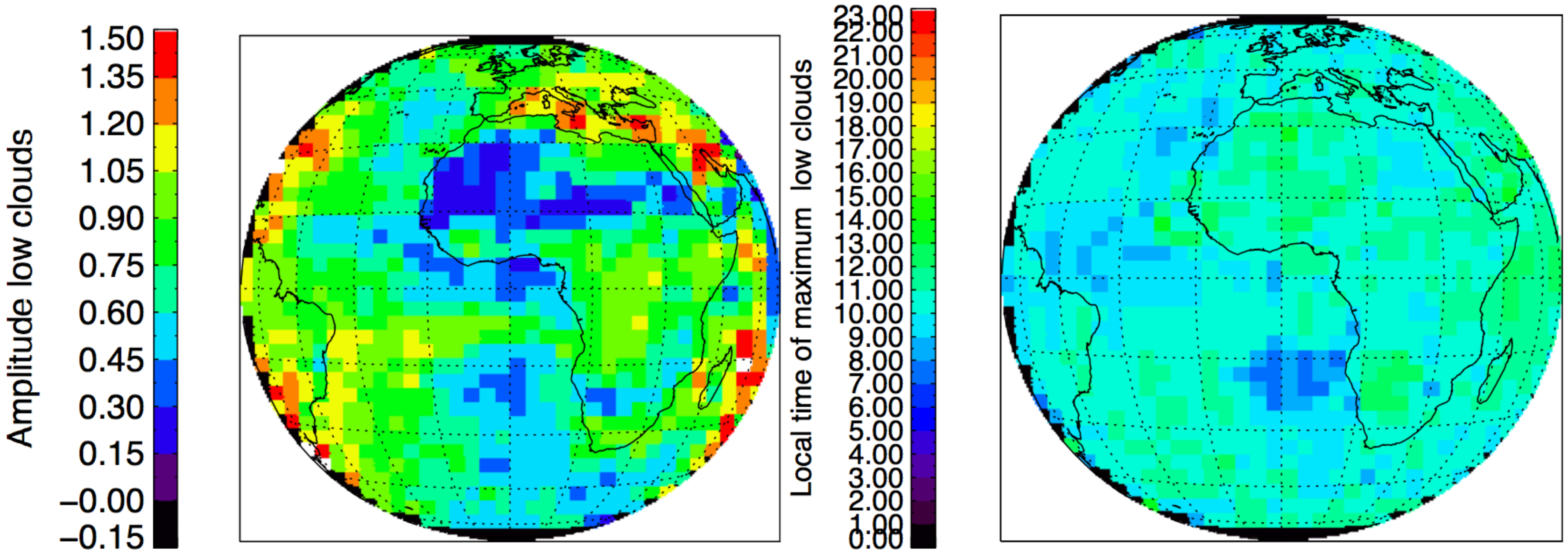


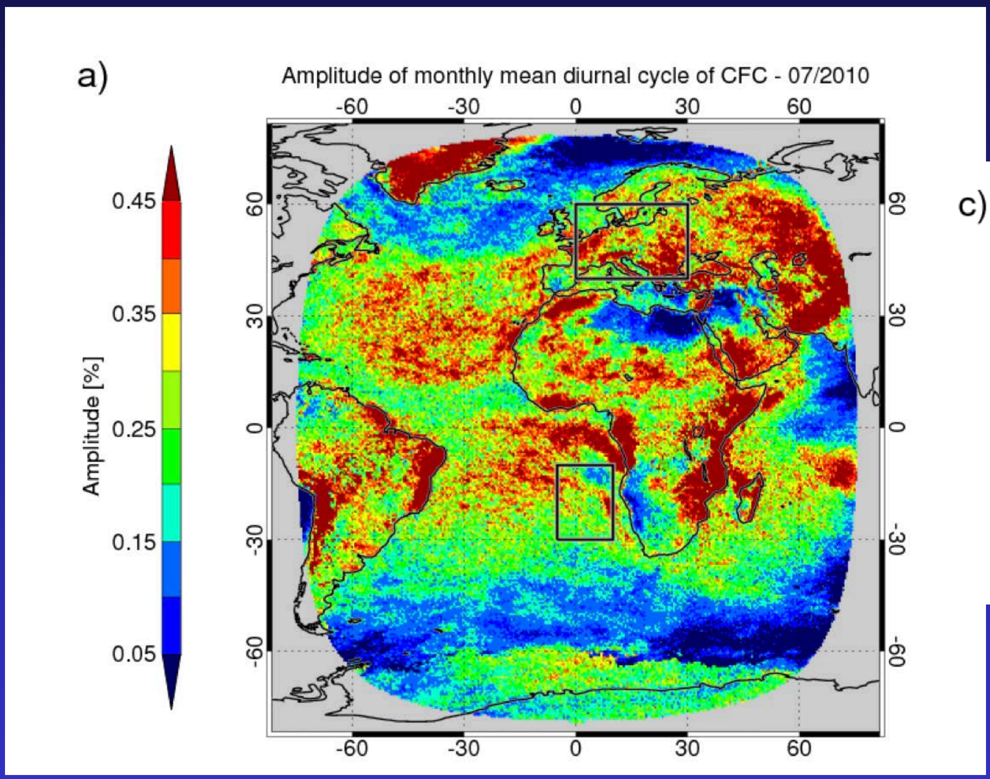


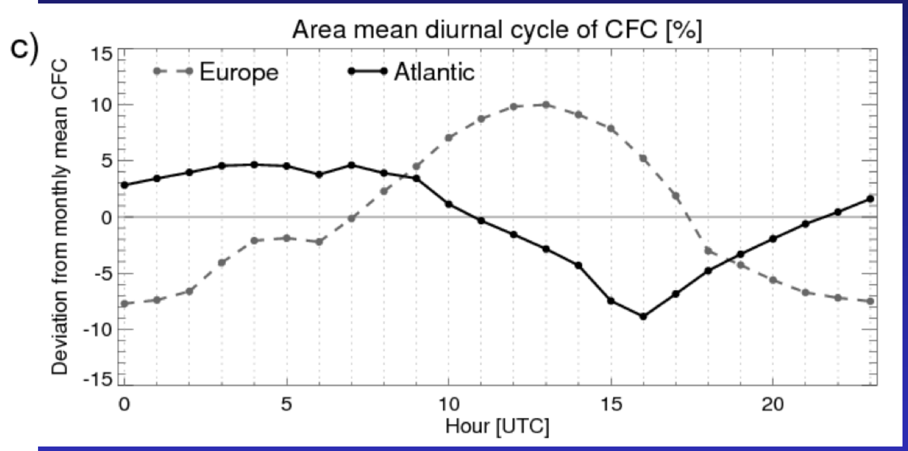
Diurnal cycle of clouds from SEVIRI



Kniffka et al. (2014)

Diurnal cycle of clouds from SEVIRI

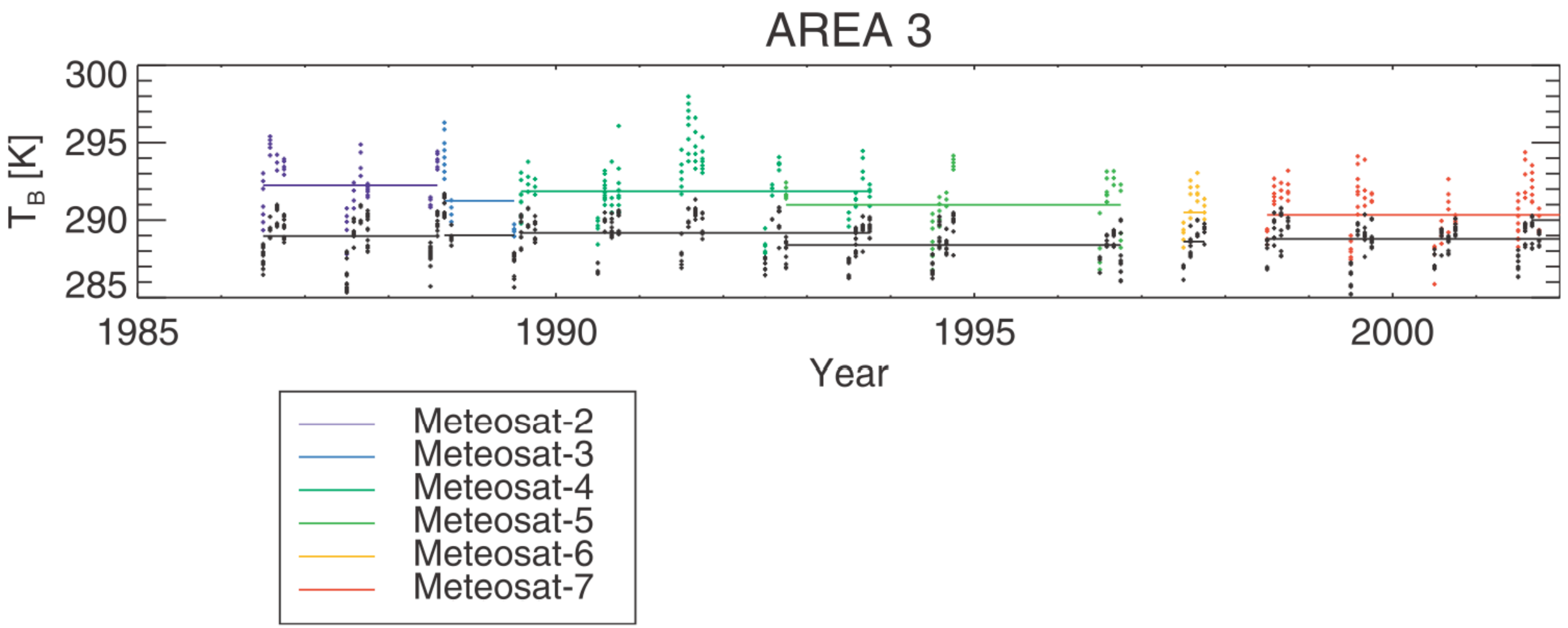




Stengel et al. (2014)

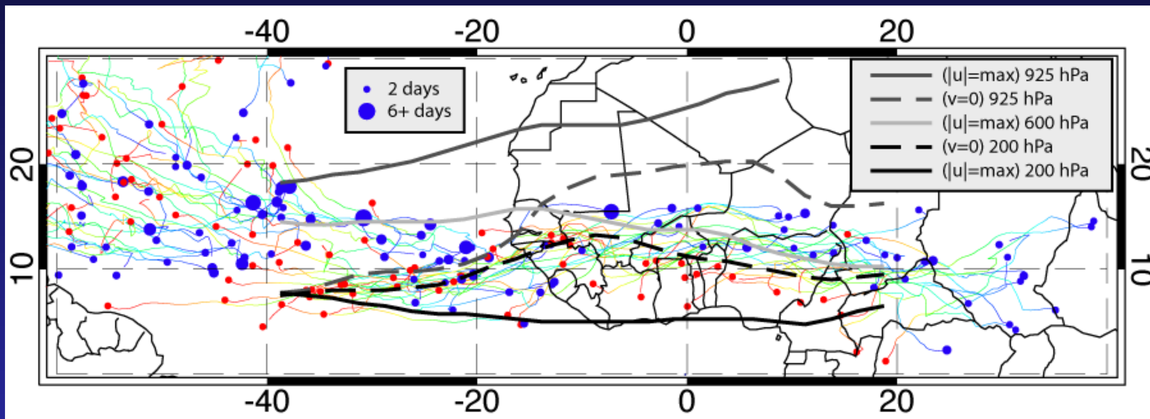
Convective activity over Africa and the tropical Atlantic inferred from 20 years of MVIRI satellite observations

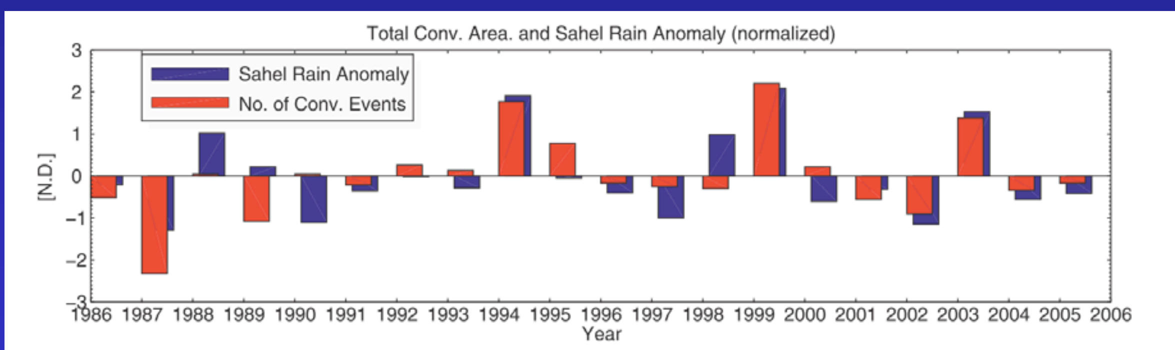
- 20 years, hourly 0º MVIRI observations 1986-2005



(Bennartz and Schroeder, J. Climate, 2011)

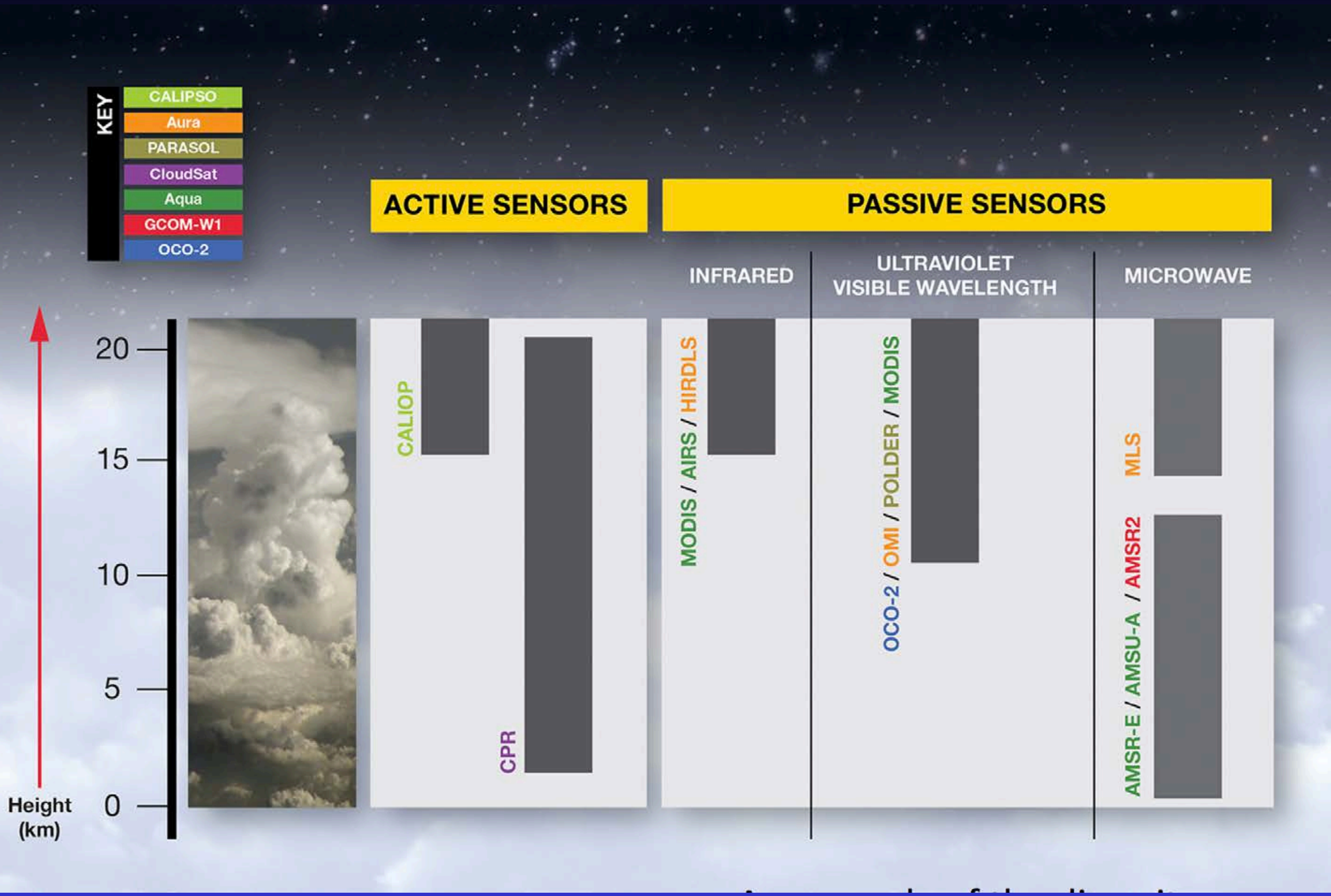
General patterns for long lived convection





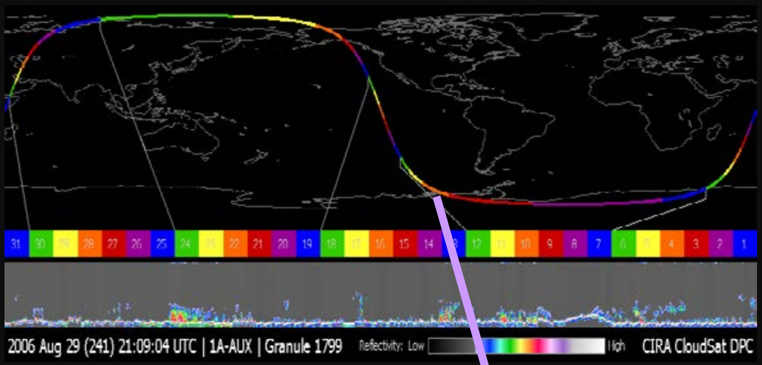
- Tracks for all events that lasted more than 2 days
- Clear separation between event triggered by AEJ (land) and surface convergence (ocean)
- Total convective areas strongly correlated with Sahel rainfall anomaly

(Bennartz and Schroeder, J. Climate, 2011)


KEY
CALIPSO
Aura
PARASOL
CloudSat
Aqua
GCOM-W1
OCO-2
ACTIVE SENSORS
PASSIVE SENSORS
INFRARED
ULTRAVIOLET
VISIBLE WAVELENGTH
MICROWAVE
20
15
10
5
0
Height
(km)
CALIOP
CPR
MODIS / AIRS / HIRDLS
OCO-2 / OMI / POLDER / MODIS
MLS
AMSR-E / AMSU-A / AMSR2

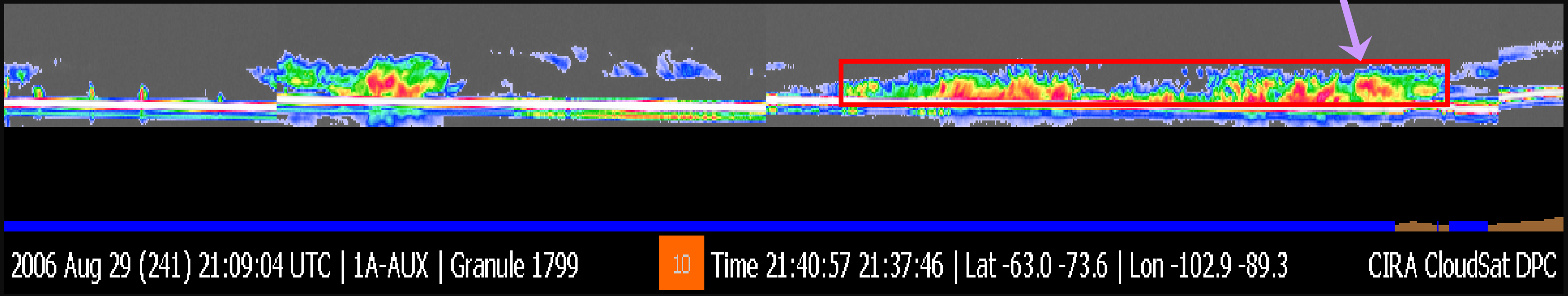
G. Stephens

CloudSat



Strengths of CloudSat:

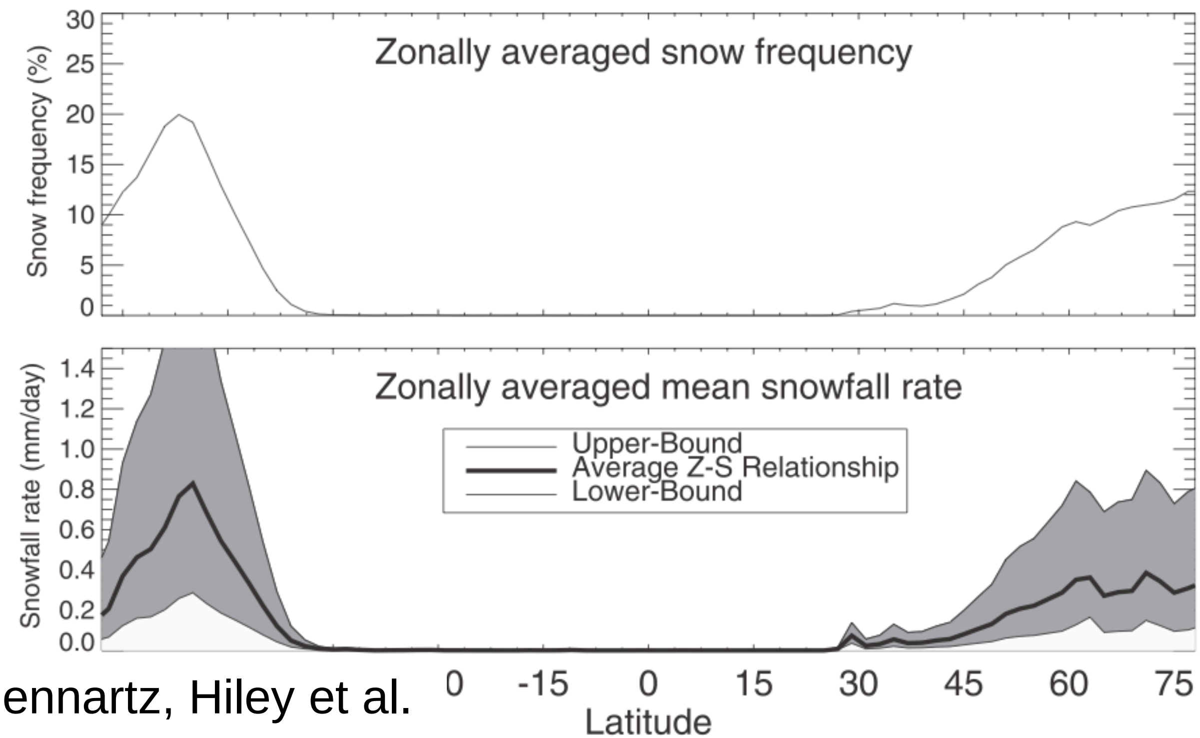
- Active sensor
- Excellent sensitivity
- Near-global coverage
- Coincident measurements from other A-Train sensors



Challenges:

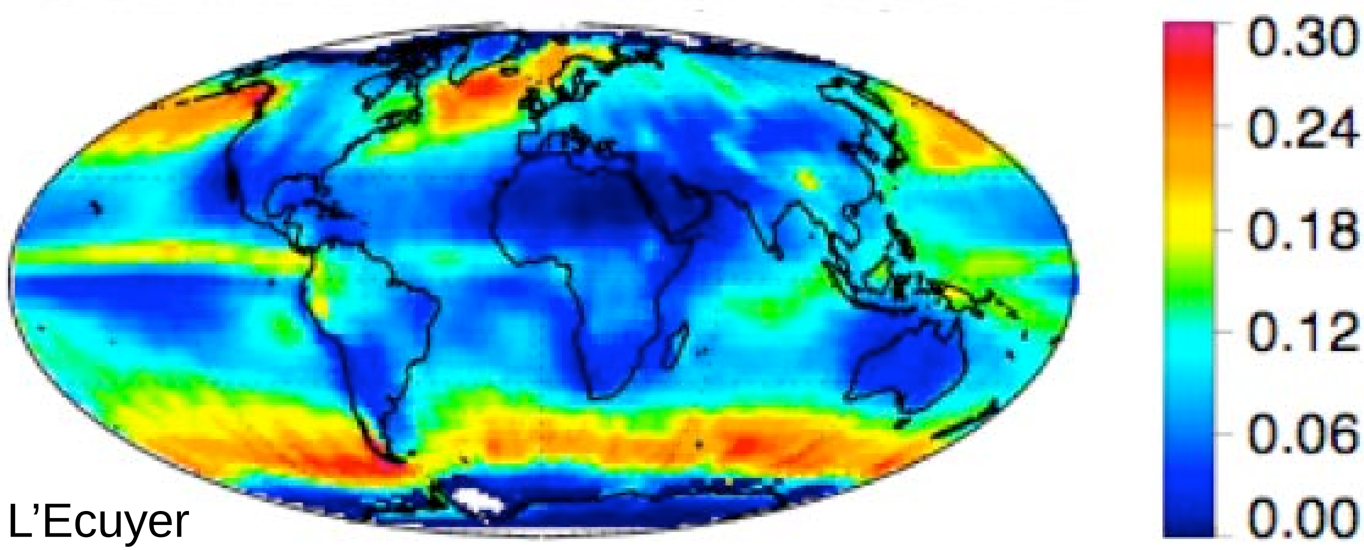
- Complex relationship between reflectivity and snowfall rate/IWC
- Rain/snow discrimination
- Sampling
- Ground Clutter

T. L'Ecuyer



Bennartz, Hiley et al.

CloudSat Rain Fraction



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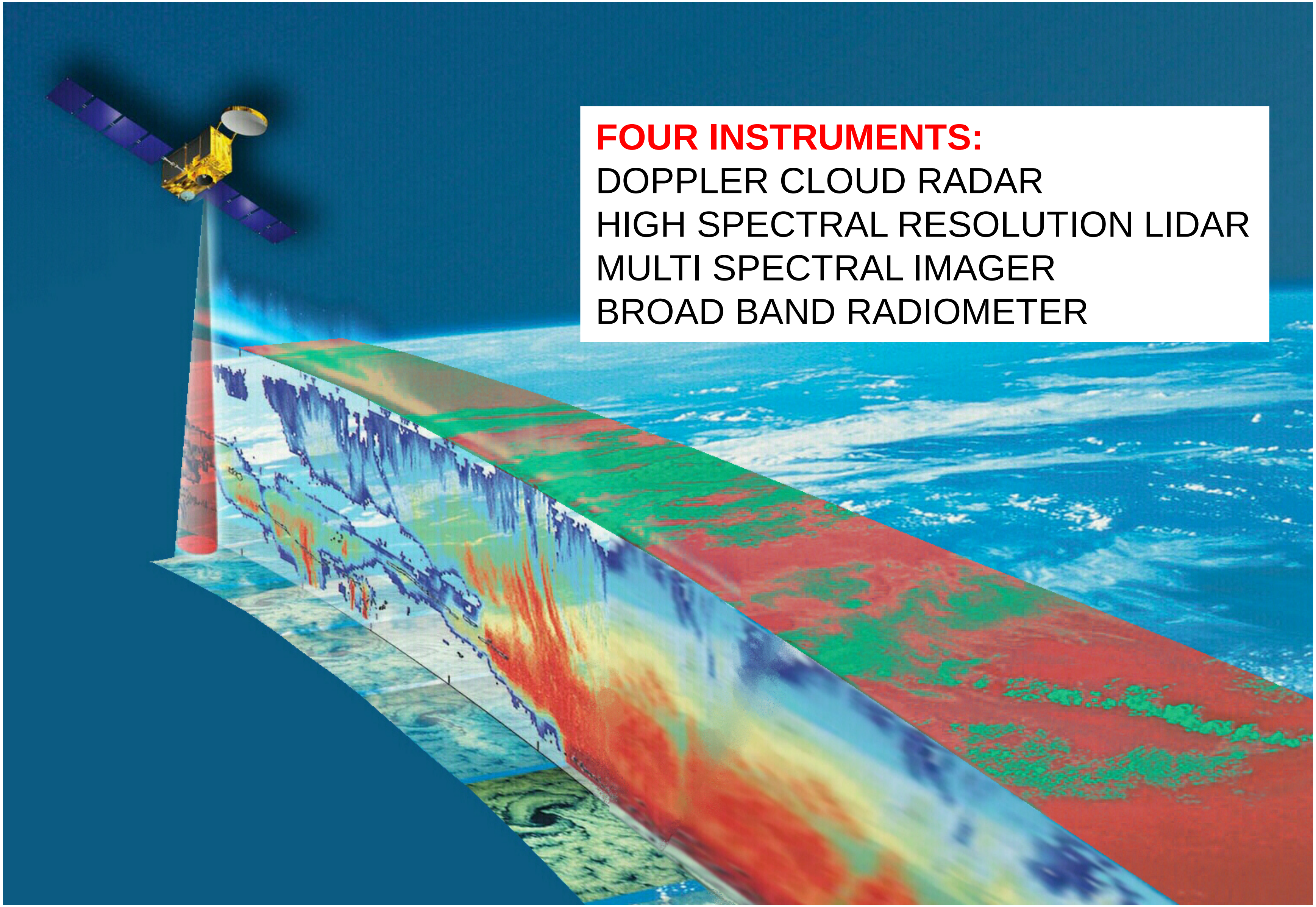
EarthCARE



A. Illingworth

Cloud Retrieval Evaluation Workshop-4
(CREW-4)

Image: Courtesy and Copyright by Alexander Riehn, Hotel am Badersee, Grainau

4-7 March 2014, Grainau, Germany, Europe

Organized by Deutscher Wetterdienst. Financially supported by EUMETSAT, the European Space Agency through the ESA Cloud CCI project and Deutscher Wetterdienst

Program Committee

Bryan Baum (co-chair), Rob Roebeling (co-chair), Ralf Bennartz, Ulrich Hamann, Andrew Heidinger, Jan Fokke Meirink, Martin Stengel, Andi Walther, Phill Watts, and Anke Thoss

Active Sensors

- CREW recognizes the value of space-borne active instruments (lidar/radar) for process studies and climate research.
- In addition, these instruments provide a validation reference for various passive instruments.
- There is concern about data continuity beyond EarthCare.

Challenges

- Legacy: If we want to observe climate, we need to have long-term data records.
- Transparency: We need to keep track of what is being done in each processing step. From calibration to level 3 gridding.
- Dynamics: Move away from static datasets. Need to be able to re-process entire time-series.
- Active sensors become increasingly important for climate research and process studies. Data continuity beyond EarthCare is critical.