Vertical Structure of Radiative Fluxes and Heating in Cloudy Atmospheres From A-Train Observations

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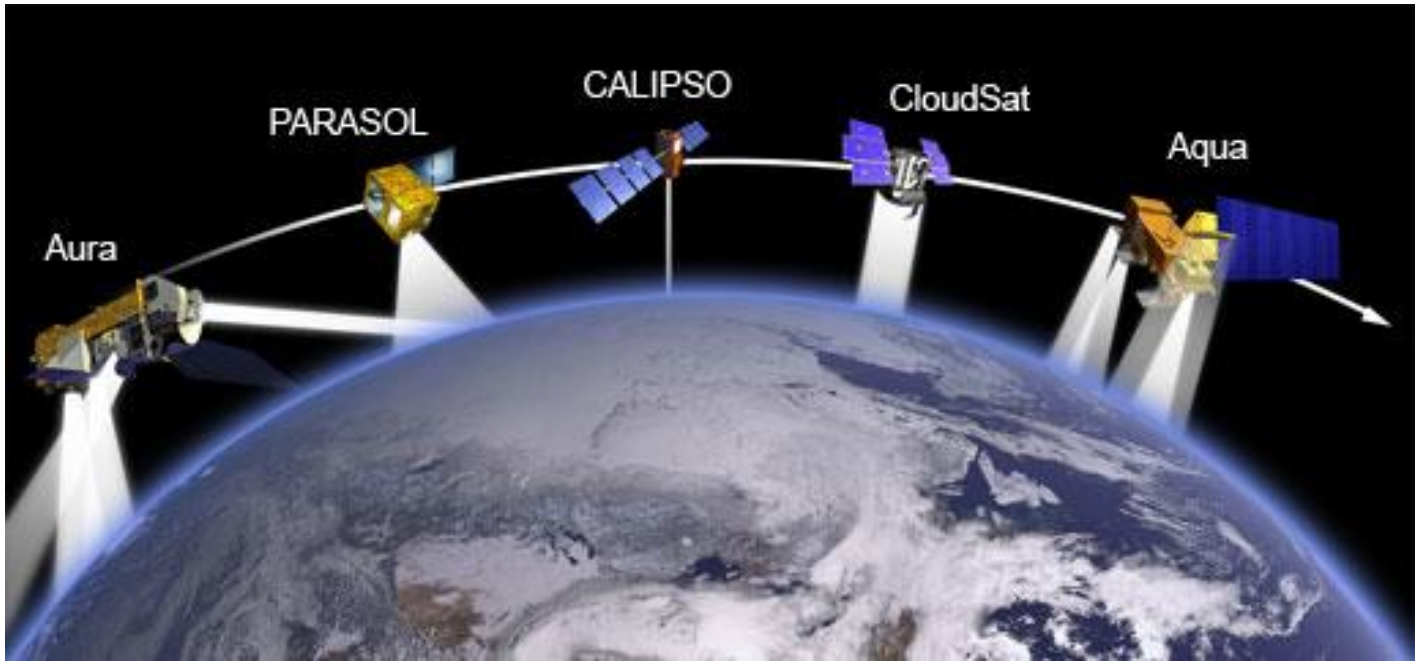
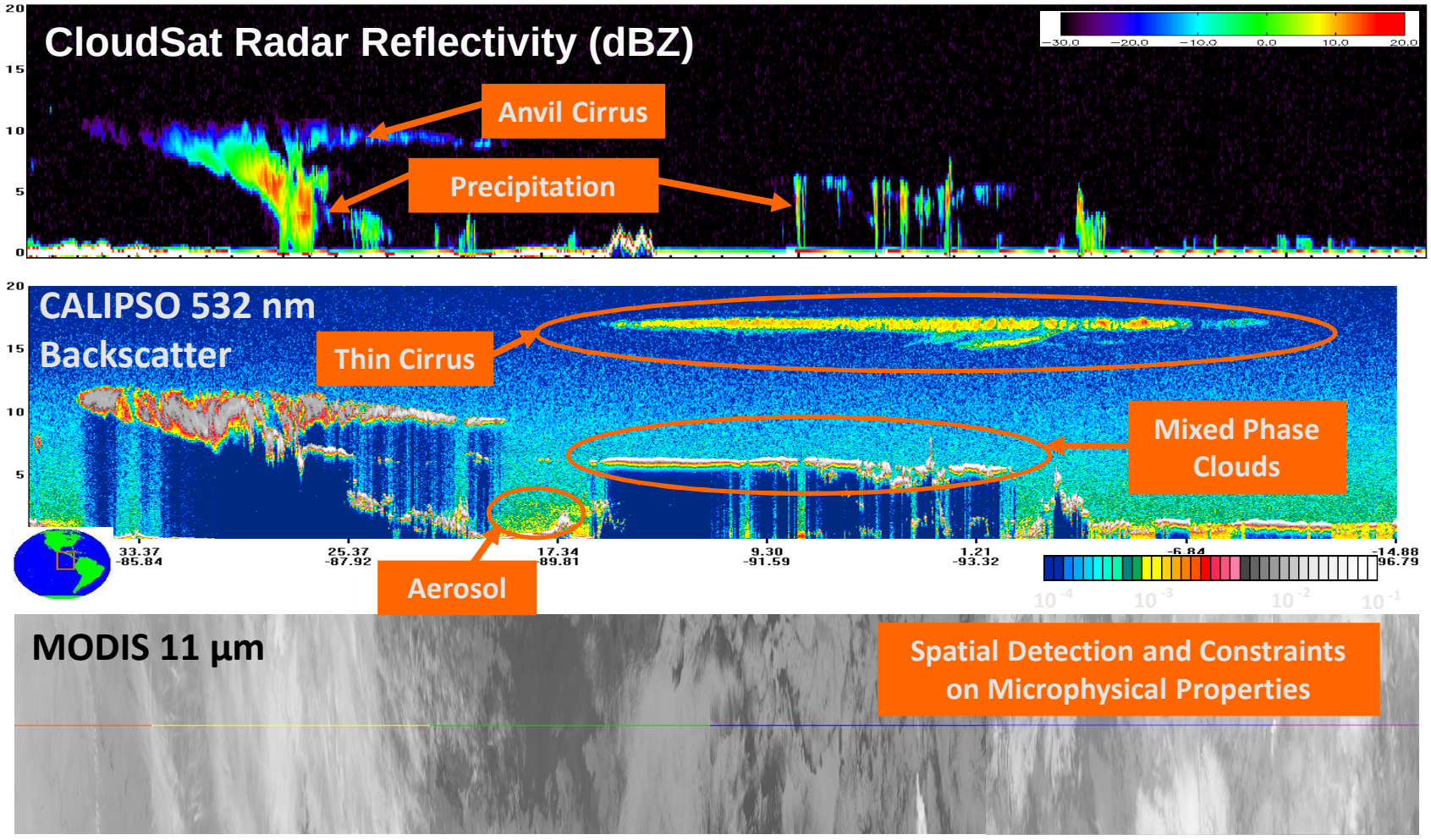
A-Train Fluxes and Heating Rates

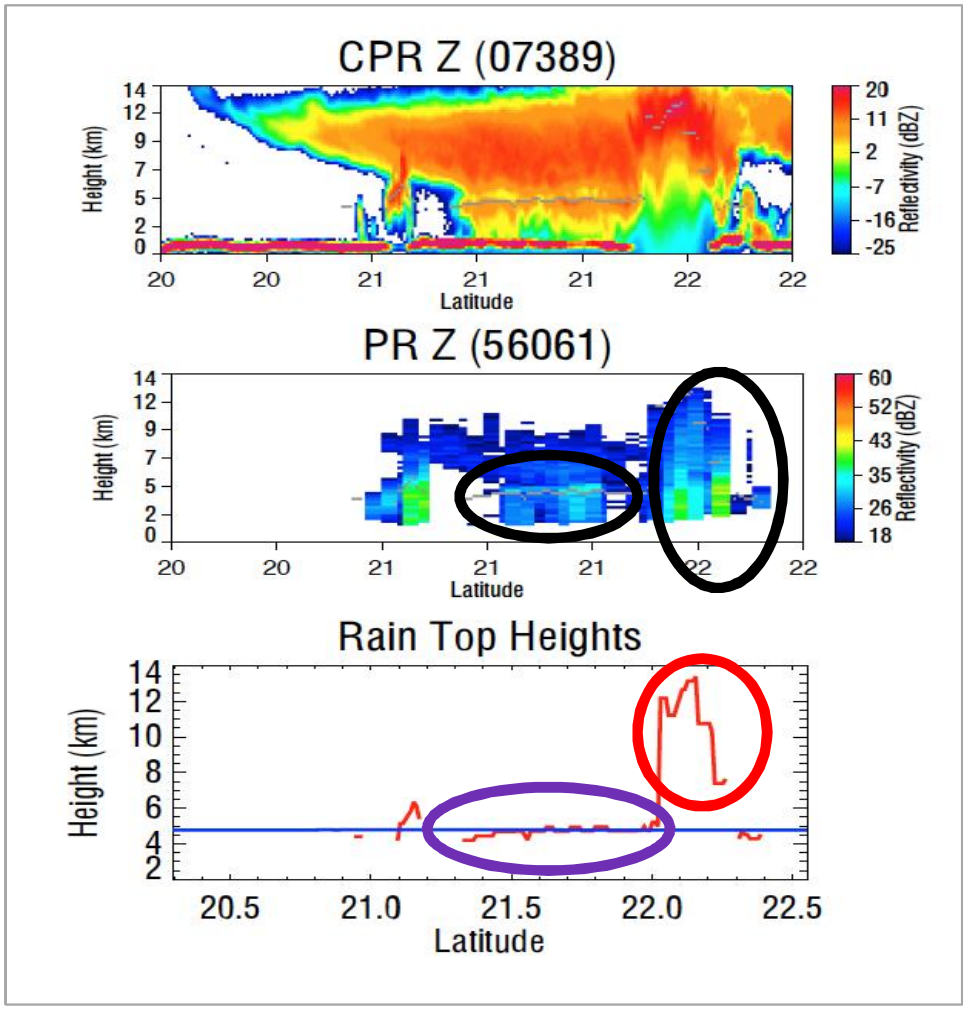


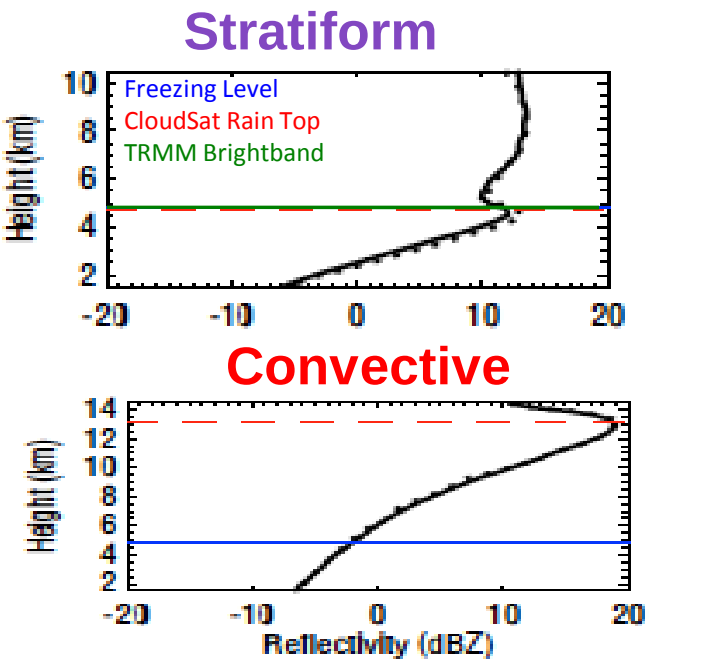
- Radiative Fluxes Consistent with CloudSat, CALIPSO, MODIS, and AMSR-E Inputs and CERES TOA Fluxes
- Vertical profiles of LW and SW heating rates at 240 m vertical and 1.4×1.7 km horizontal resolution

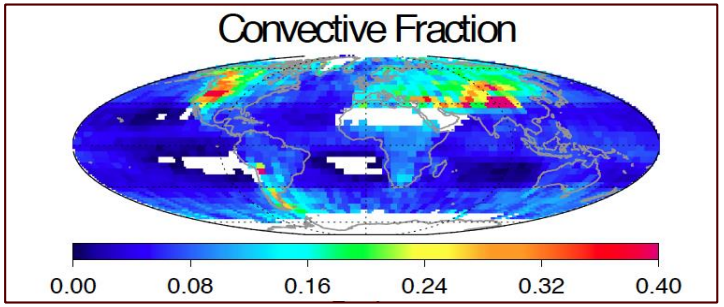
Cloudy-Sky Inputs



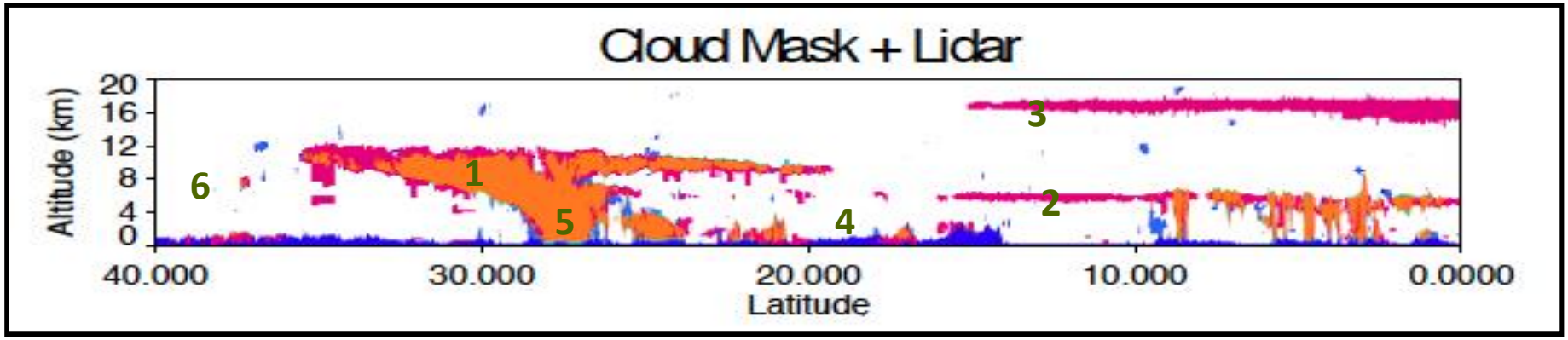
Locating Convective Cores





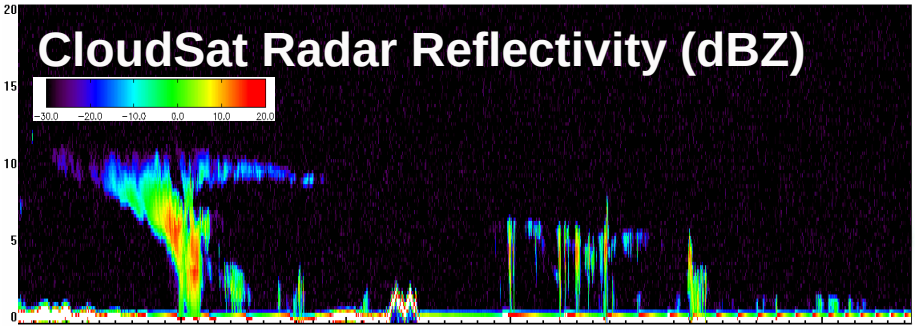


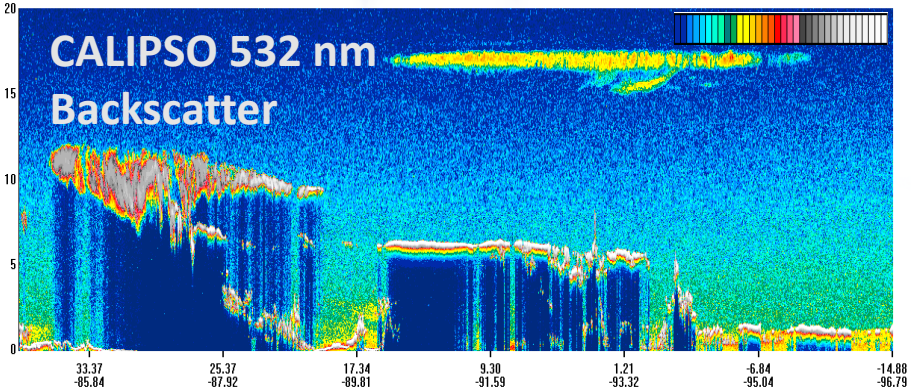
CloudSat's 2B-FLXHR-lidar Algorithm

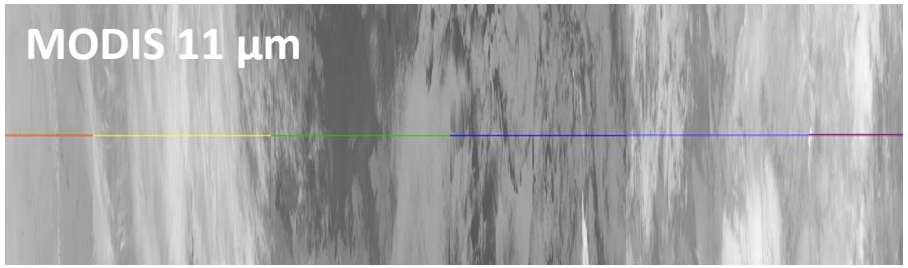


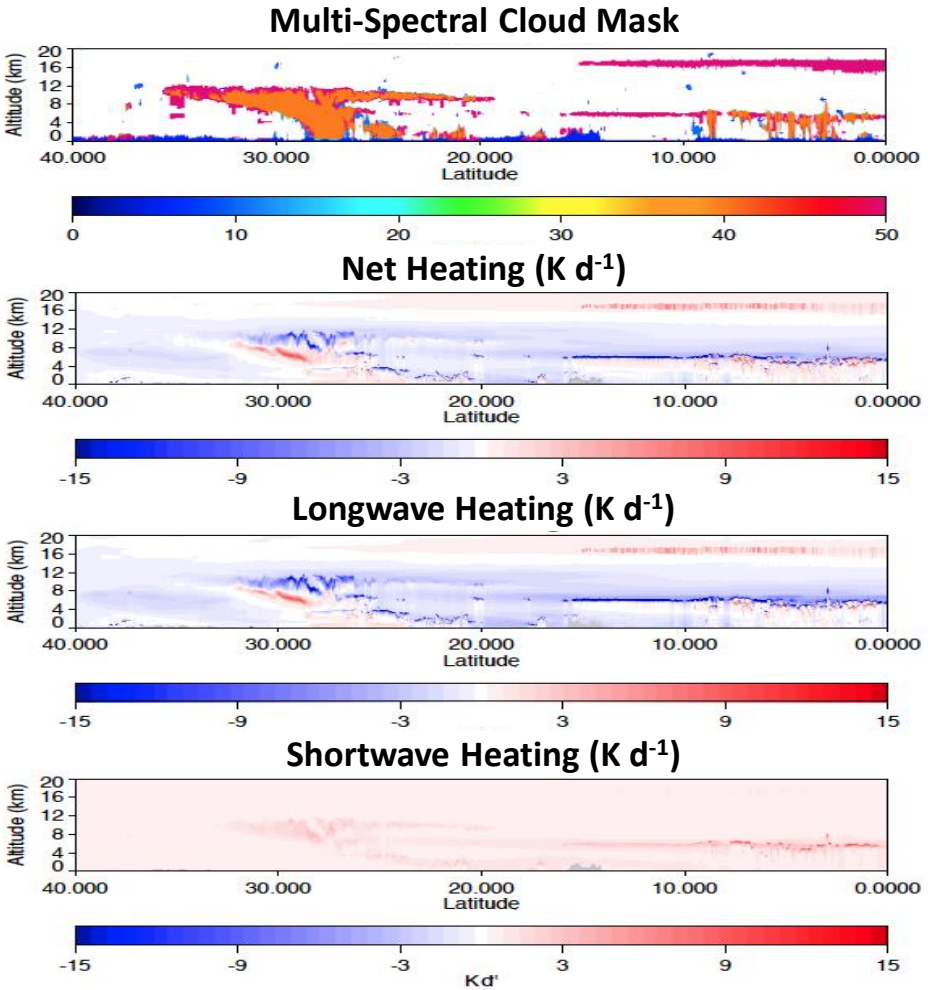
1. Clouds ï CloudSat CPR + MODIS optical depth
2. Sub-visual Cirrus ï CALIPSO (5 km Cloud Layer Product)
3. Stratus/mixed-phase ï CALIPSO (identification) + MODIS (microphysical properties)
4. Aerosol ï CALIPSO (5 km Aerosol Layer Product)
5. Precipitation ï explicit rain DSD and CloudSat 2C-PRECIP-COLUMN (identification/LWP)
6. Temperature & Humidity ï ECMWF/AIRS (in progress)

Sample Heating Rates



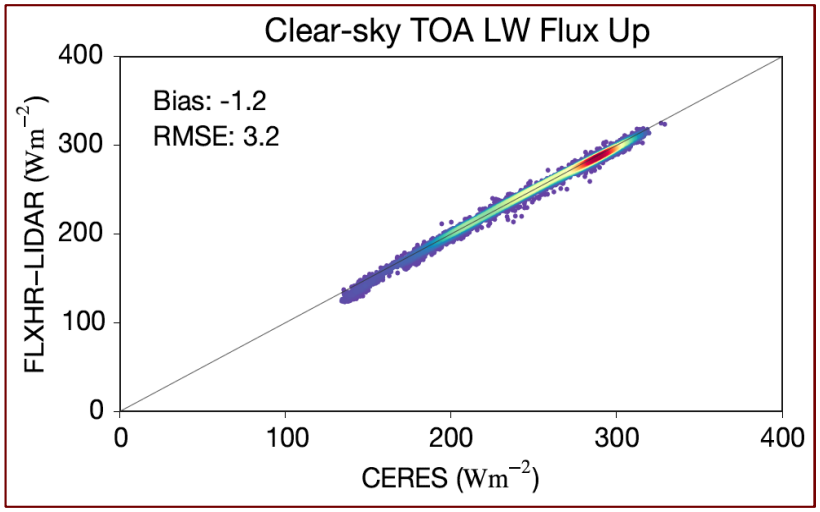


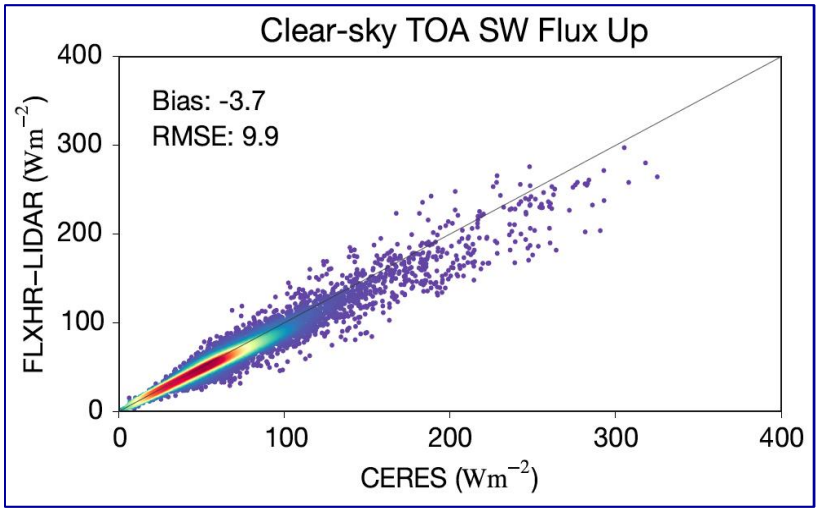


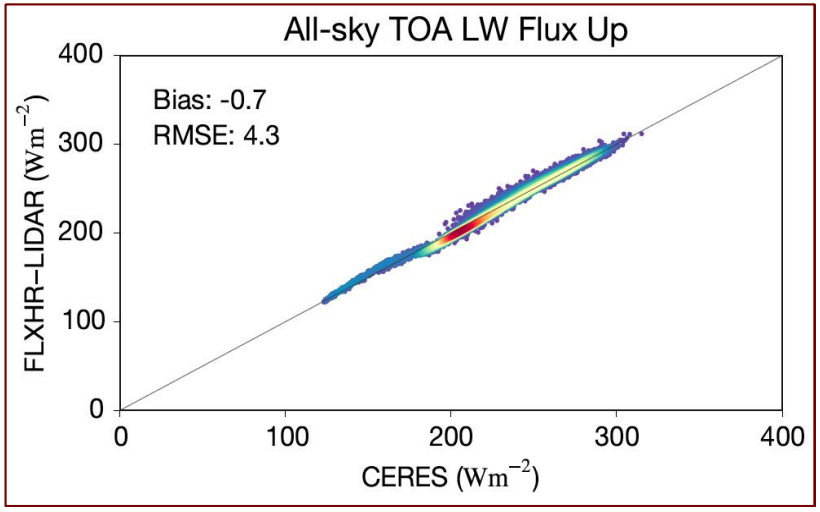


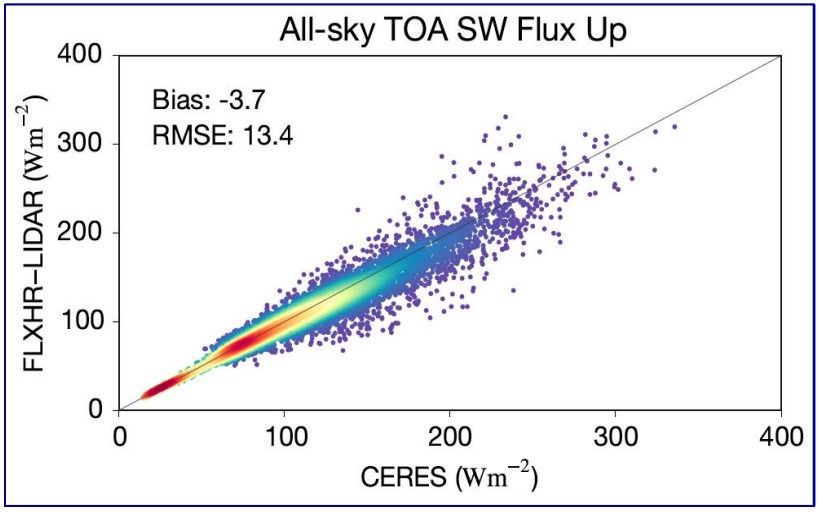
L'Ecuyer et al., *J. Geophys. Res.* (2009)

Evaluation of TOA Fluxes

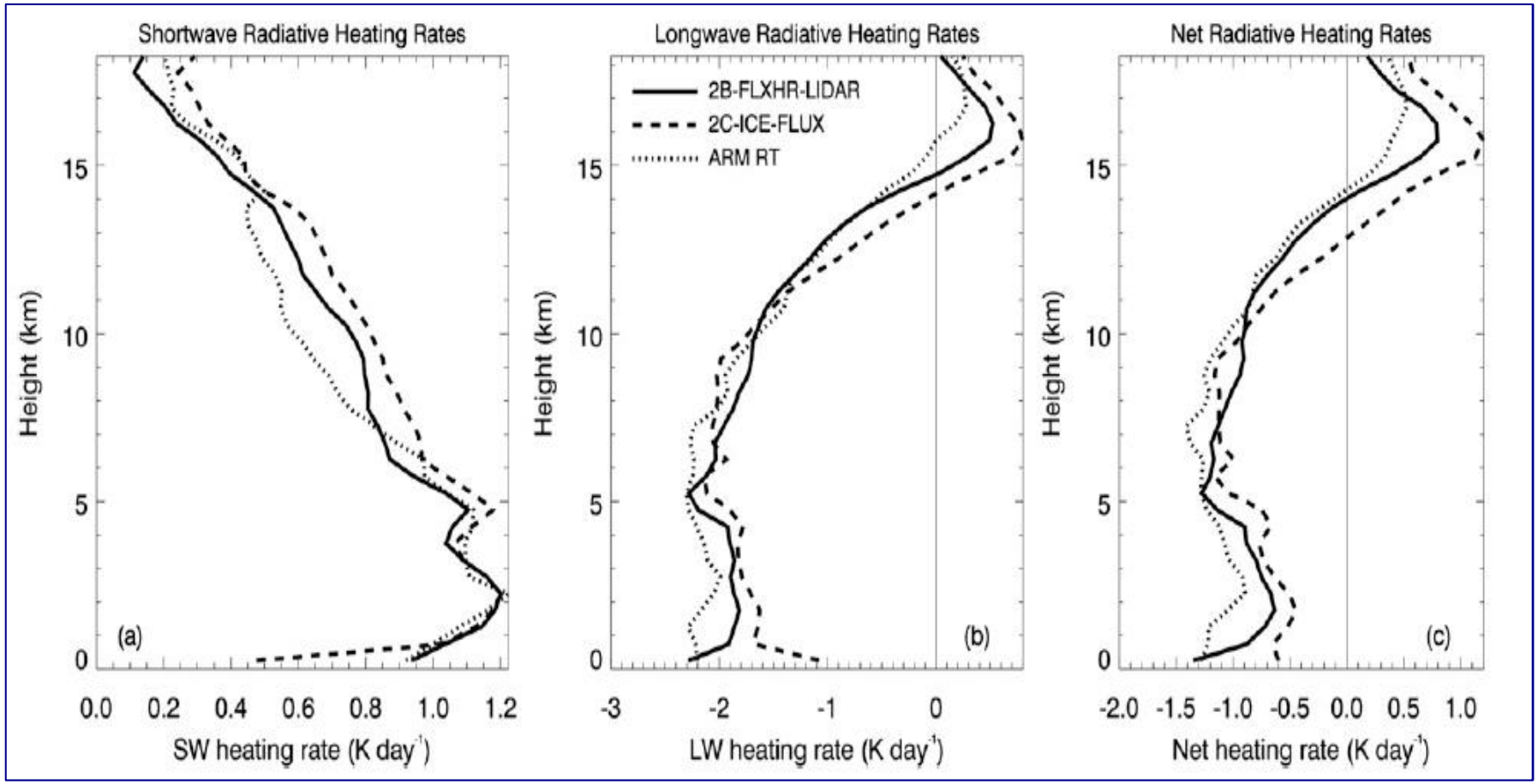






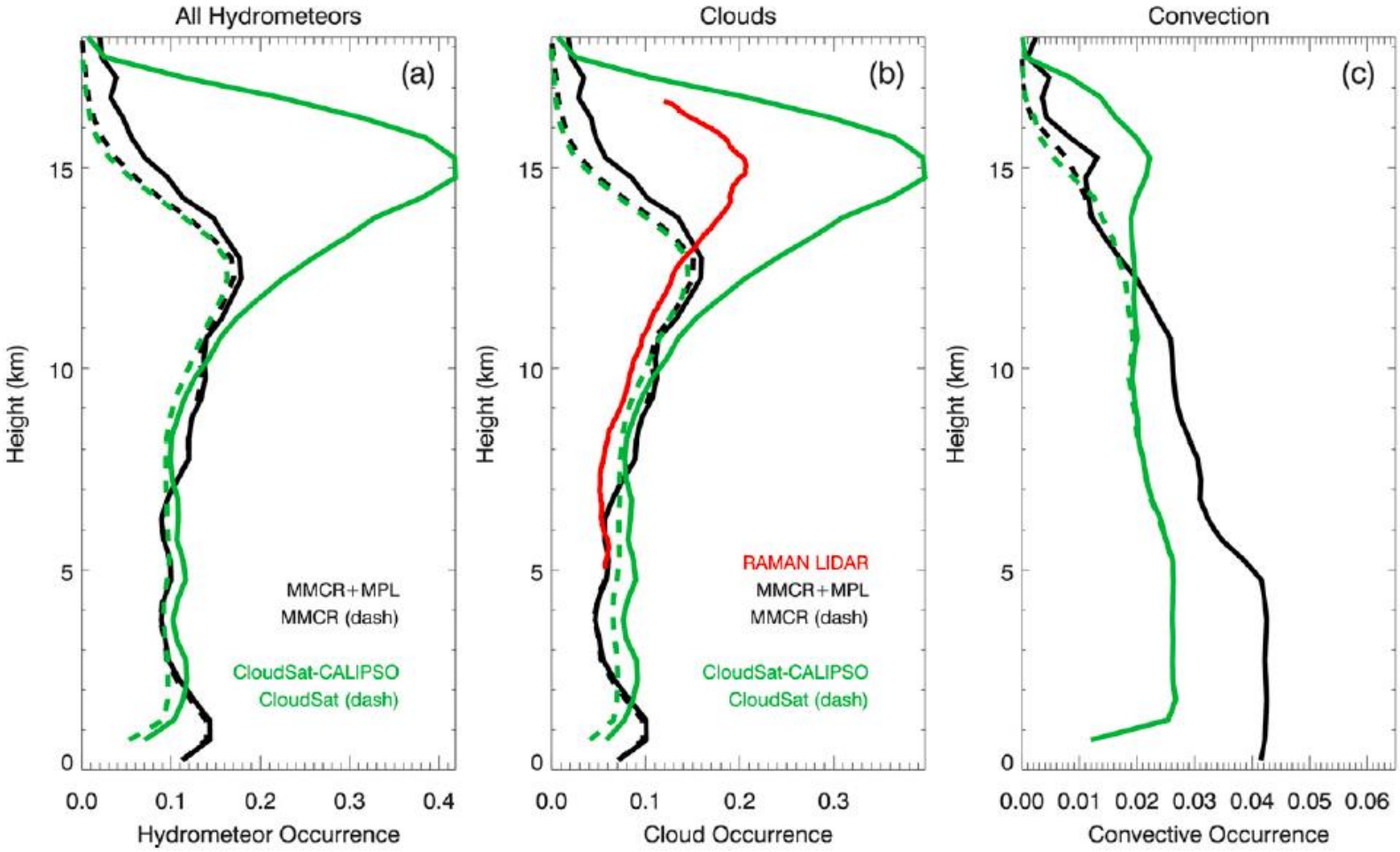


Evaluating Vertical Structures



Protat et al, JGR (2014)

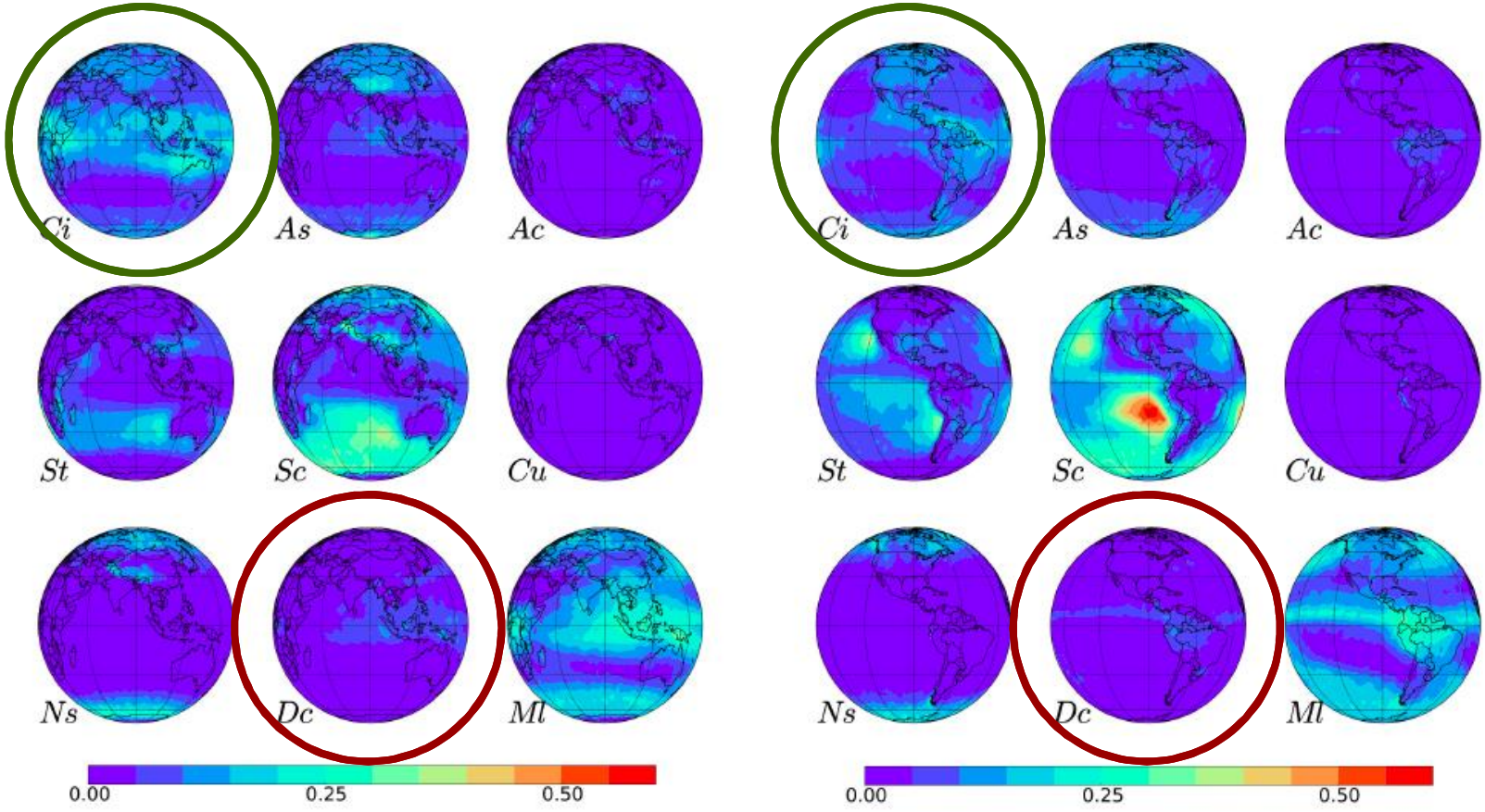
Cloud Detection Differences



Protat et al, JGR (2014)

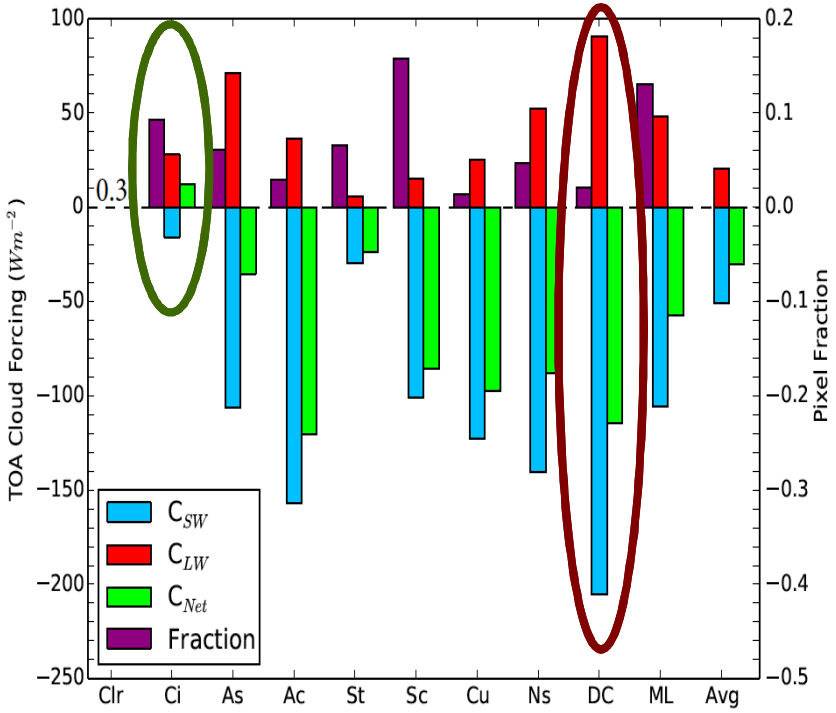
Distributions of Cirrus and Deep Convection

CloudSat + CALIPSO Annual Mean Cloud Fractions

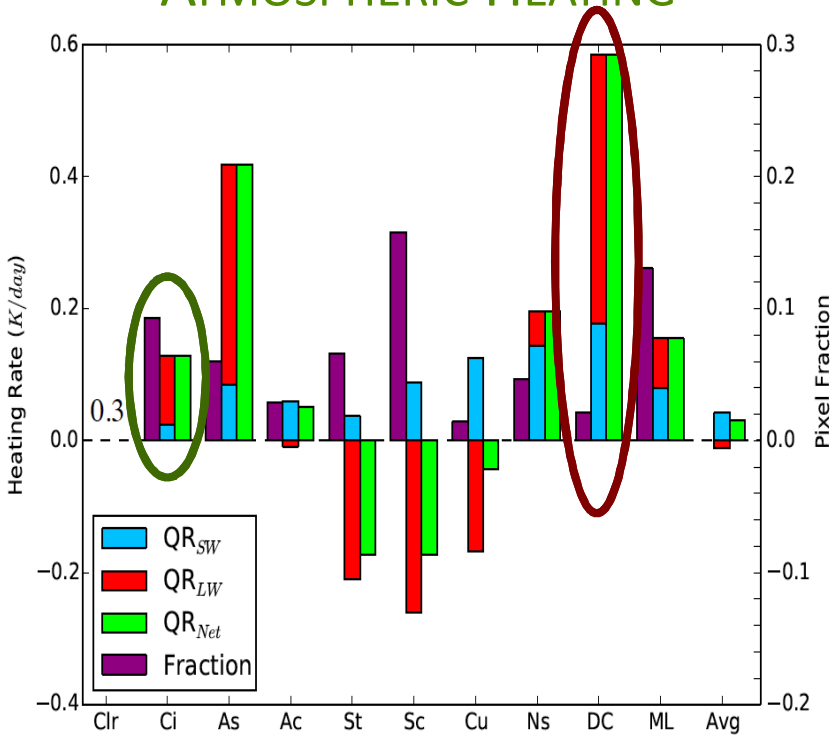


Radiative Effects

TOA Cloud Radiative Effect

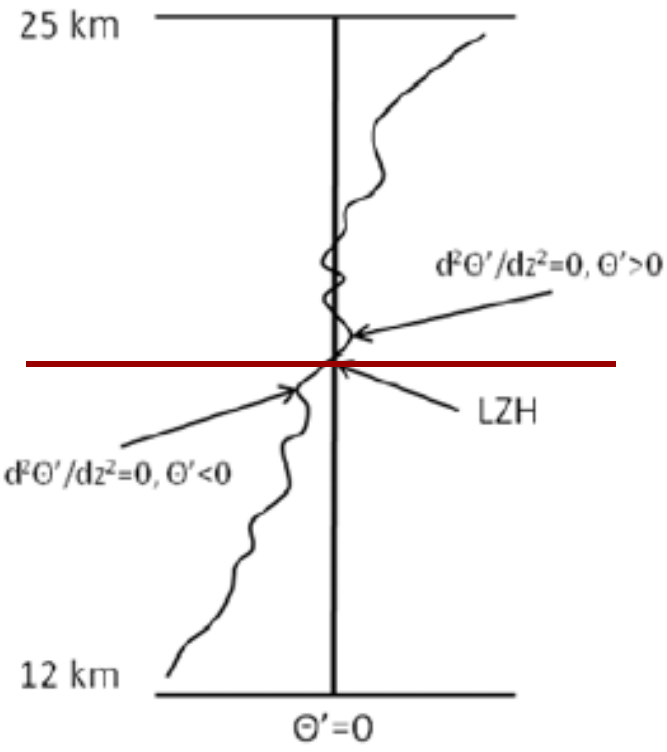


Atmospheric Heating

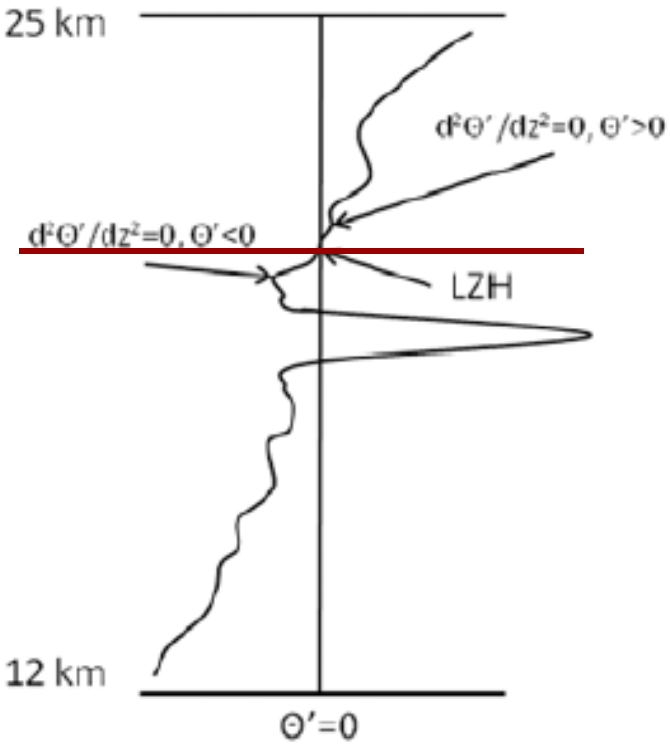


Impacts of Cirrus on the TTL

CLEAR SKY

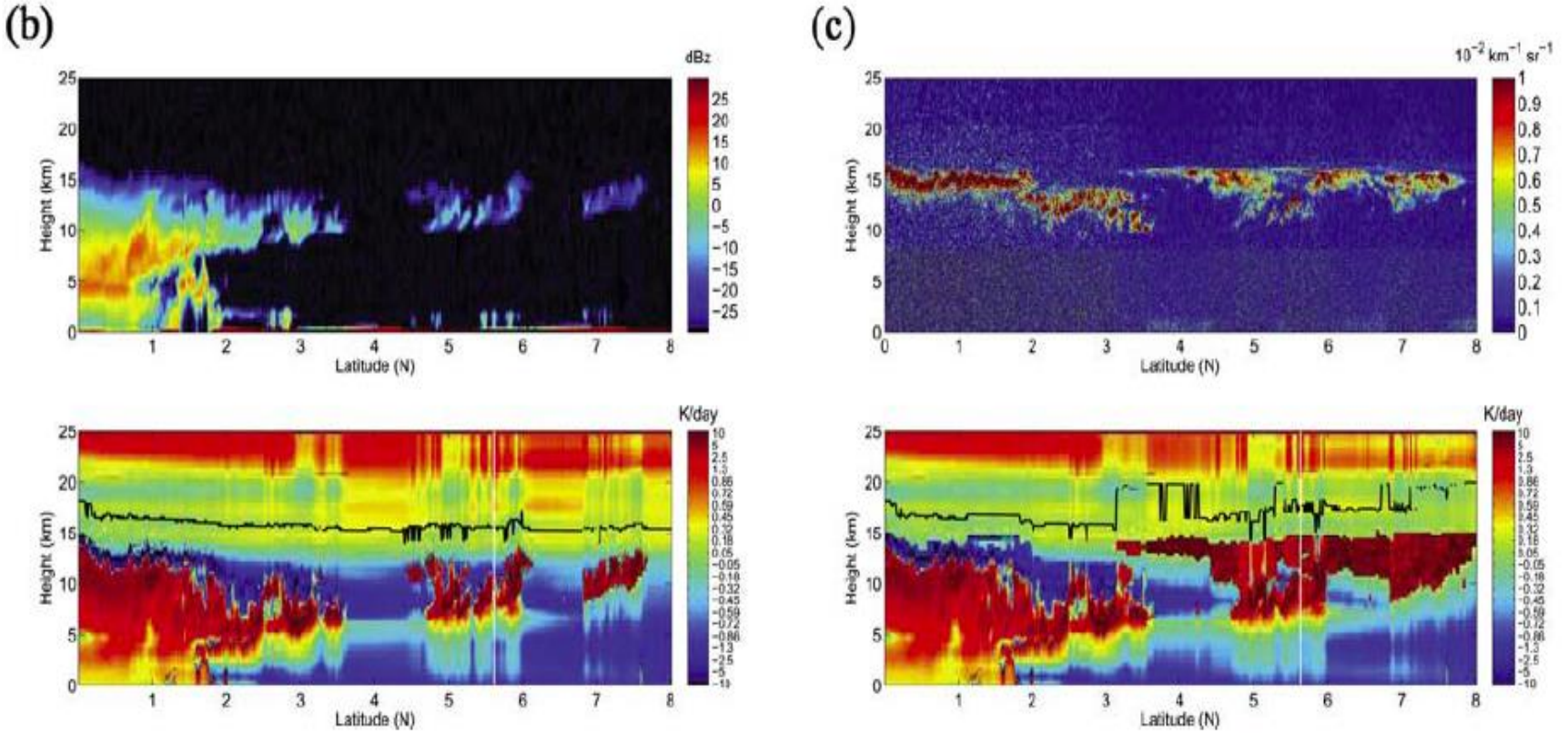


CIRRUS



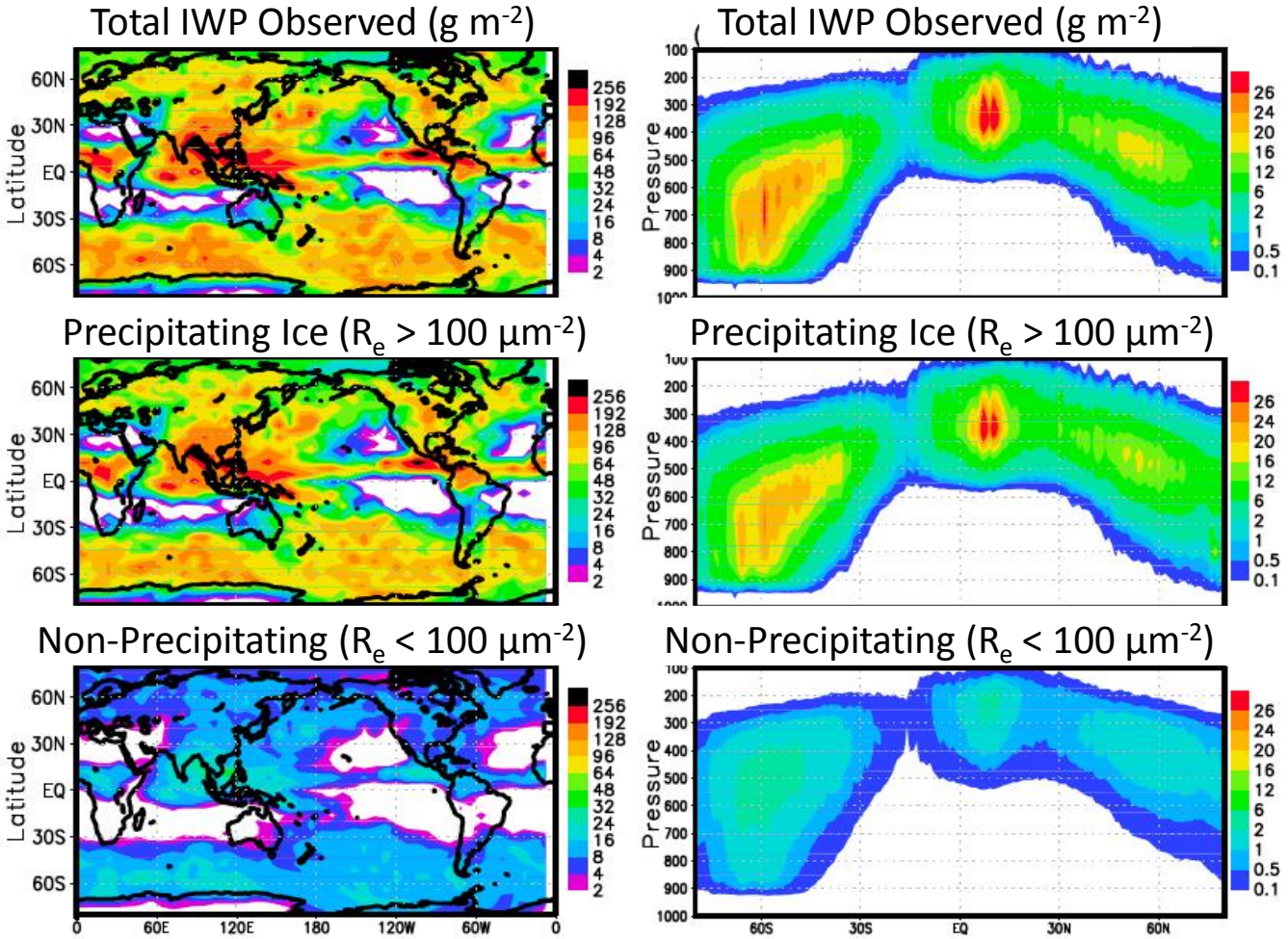
Feldman et al, JGR (2008)

Impacts of Cirrus on the TTL



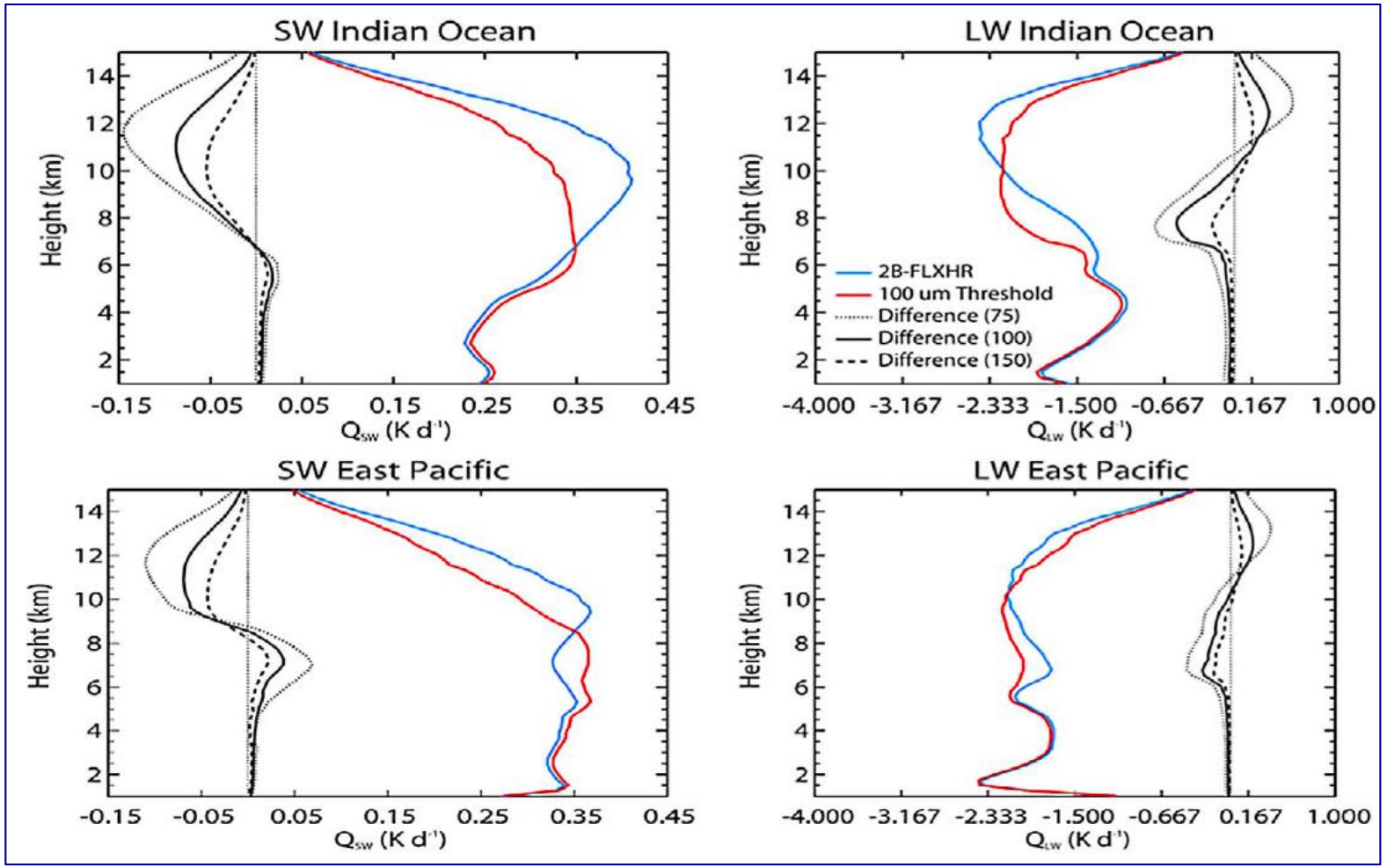
Feldman et al, JGR (2008)

Radiative Impacts of Precipitating Ice



Waliser et al, GRL (2011)

Radiative Impacts of Precipitating Ice



Waliser et al, GRL (2011)

Summary

- The A-Train-based 2B-FLXHR-LIDAR dataset yields high resolution radiative flux and heating rate profiles consistent with CloudSat, CALIPSO, MODIS, and AMSR-E observations.
- These data add a new vertical dimension for assessing the impacts of convection and upper tropospheric clouds.
- Top of atmosphere fluxes are consistent with CERES and uncertainties in heating rates are estimated through sensitivity studies based perturbations to inputs.
- The dataset has been applied to a range of problems including documenting the global radiative impacts of convection and cirrus, illustrating the influence of cirrus on heating structure within the TTL, and quantifying the impact of precipitating ice on atmospheric radiative heating rates.

References

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- Waliser, D., J.-L. F. Li, **T. L'Ecuyer**, W.-T. Chen, and W.-L. Lee, 2011. Estimating the Radiative Impact of Ice Mass in Convective Clouds and Precipitation, *Geophys. Res. Letters* **38**, doi:10.1029/2010GL046478.