"Using A-Train satellite data to investigate the relationship between cloud ice water path and cloud radiative effects"

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Gordon Research Seminar on Radiation and Climate, 2013

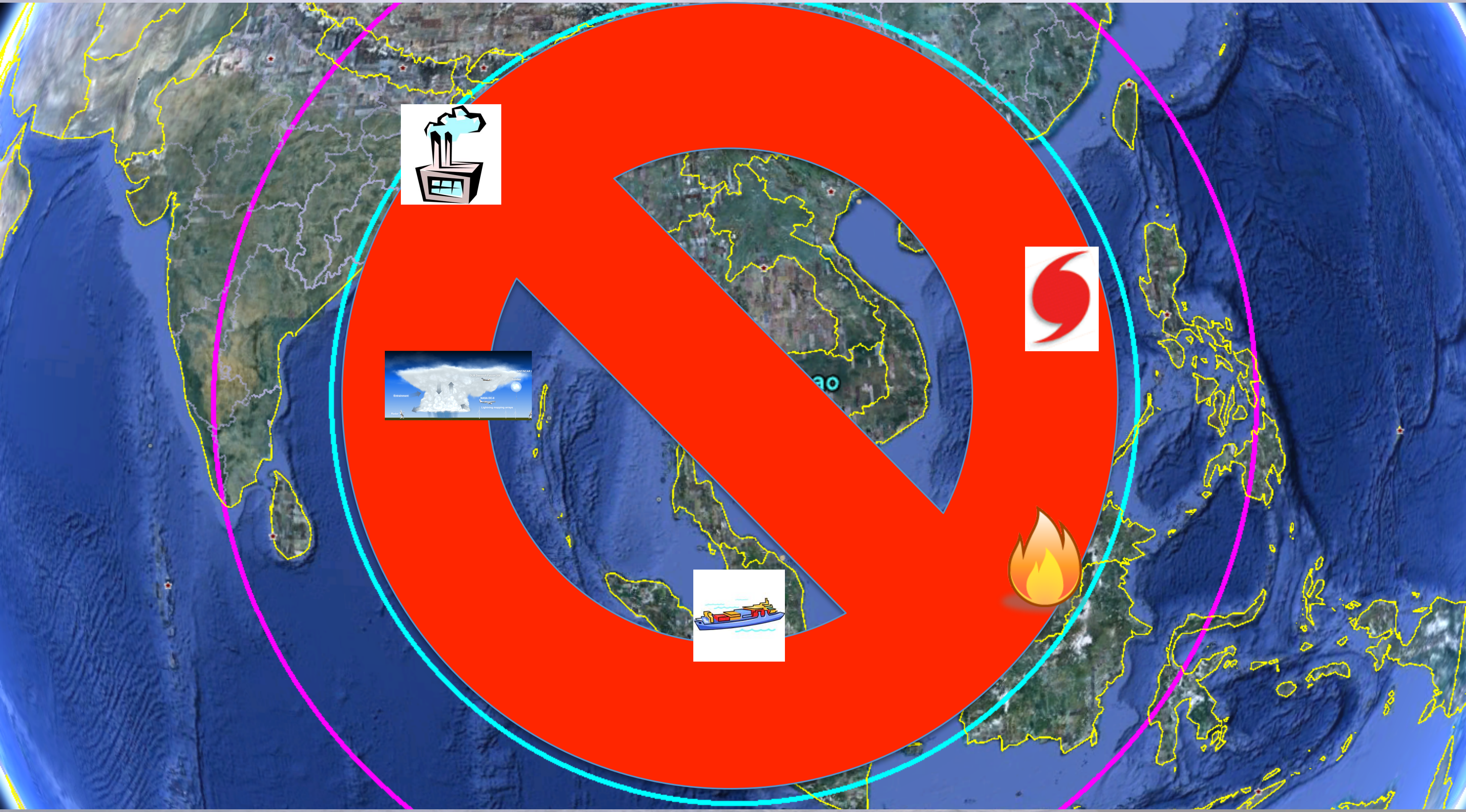
Outline

- Background on region that was the focus of this study
- Cloud climatology
- Ice water path climatology
- Cloud radiative effects
- Relationship between IWP and CRE

August and September 2007 and 2008 Monsoon season

Peak in convection
Over land ~ 1630
Over ocean~ 0230
(Liu and Zipser, 2008)

Why Southeast Asia? SEAC^{4}RS Experiment

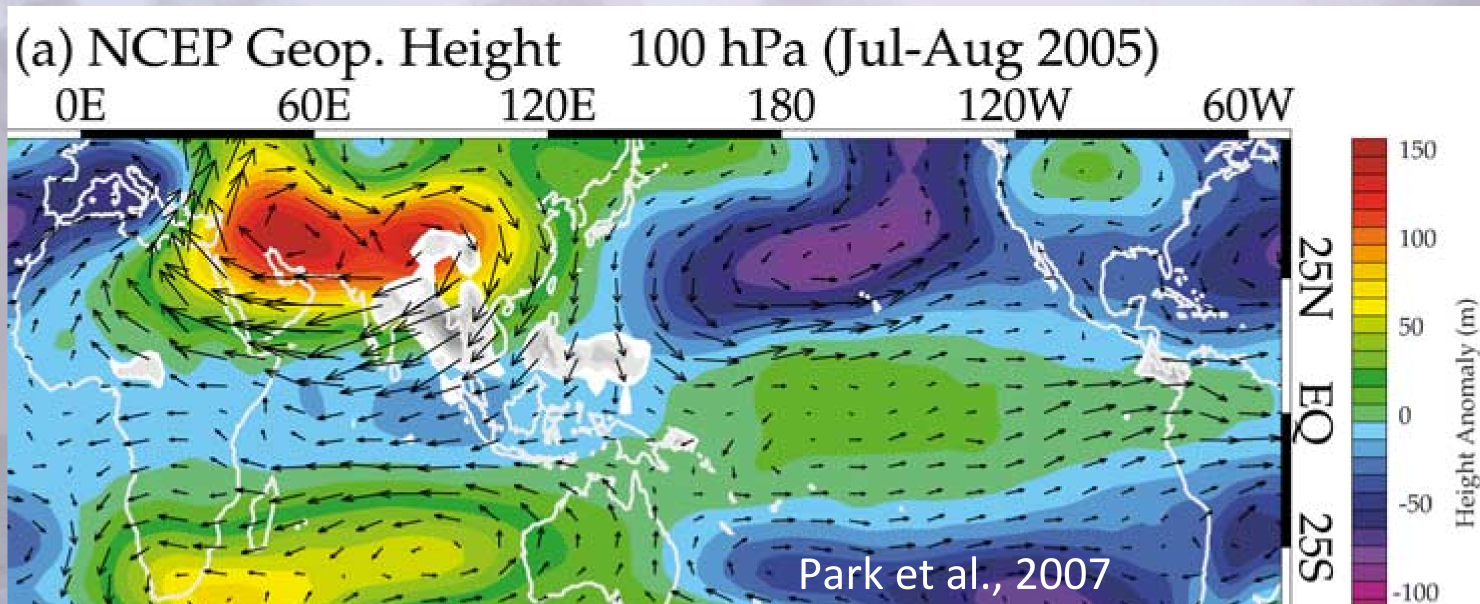


SouthEast Asia Composition, Cloud, Climate Coupling Study Summer 2012

Aircraft: ER-2, GV, DC-8

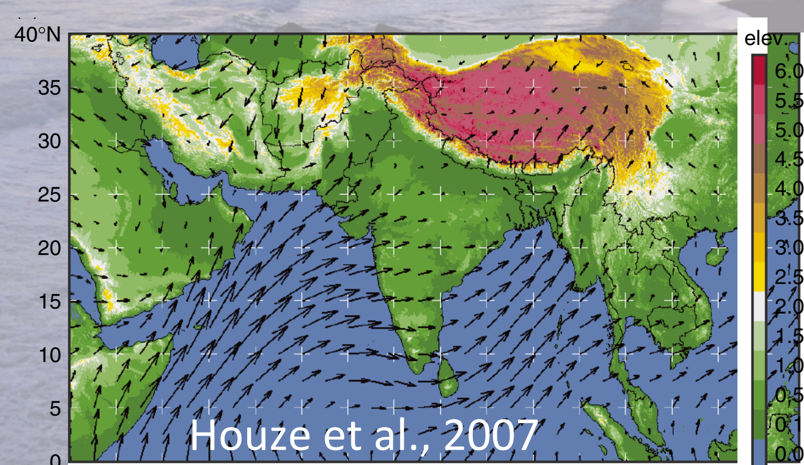
Climatology of the region

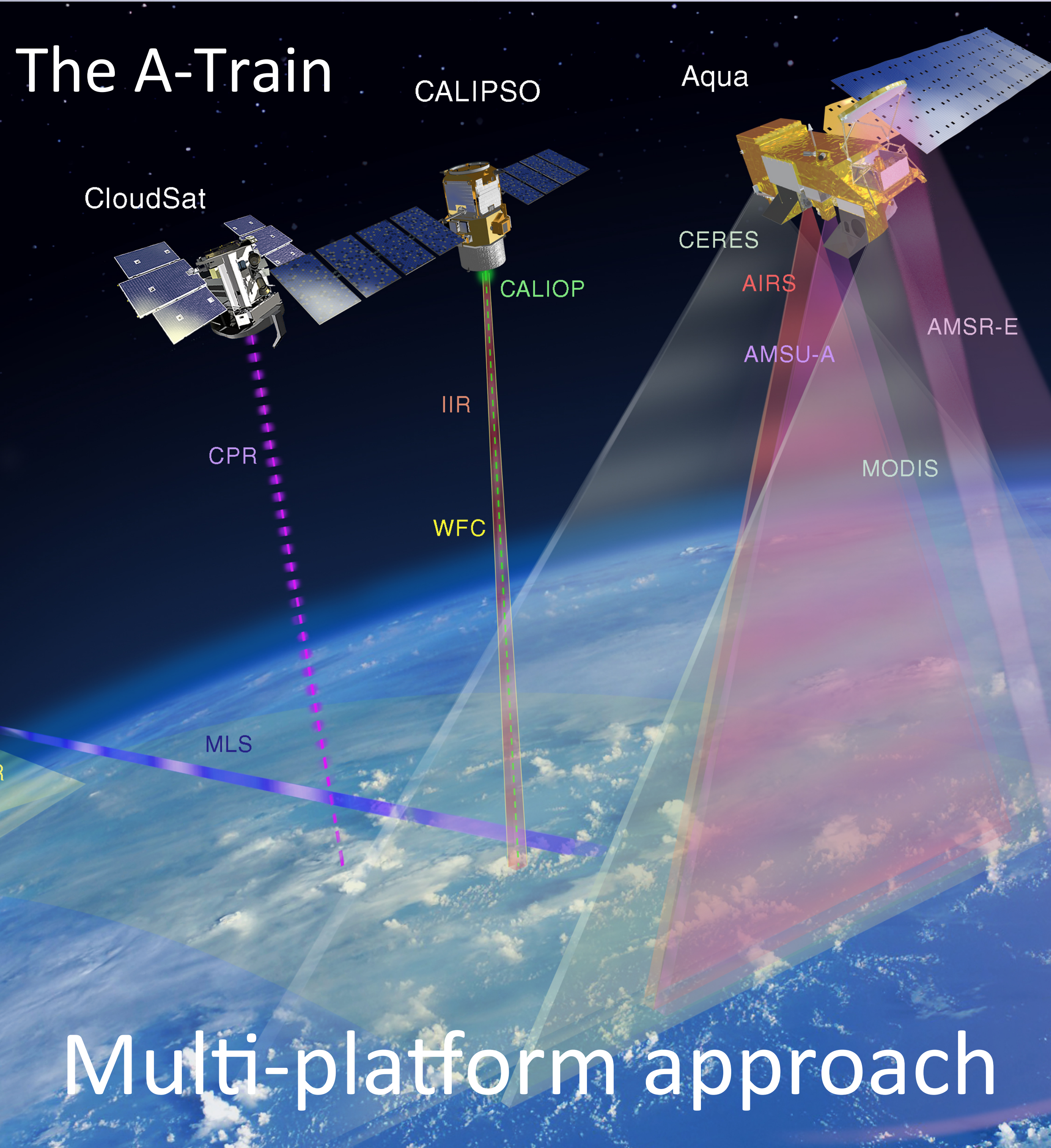
Upper Troposphere



Lower Troposphere

1000mb (Jun-Sep 2002-2003)

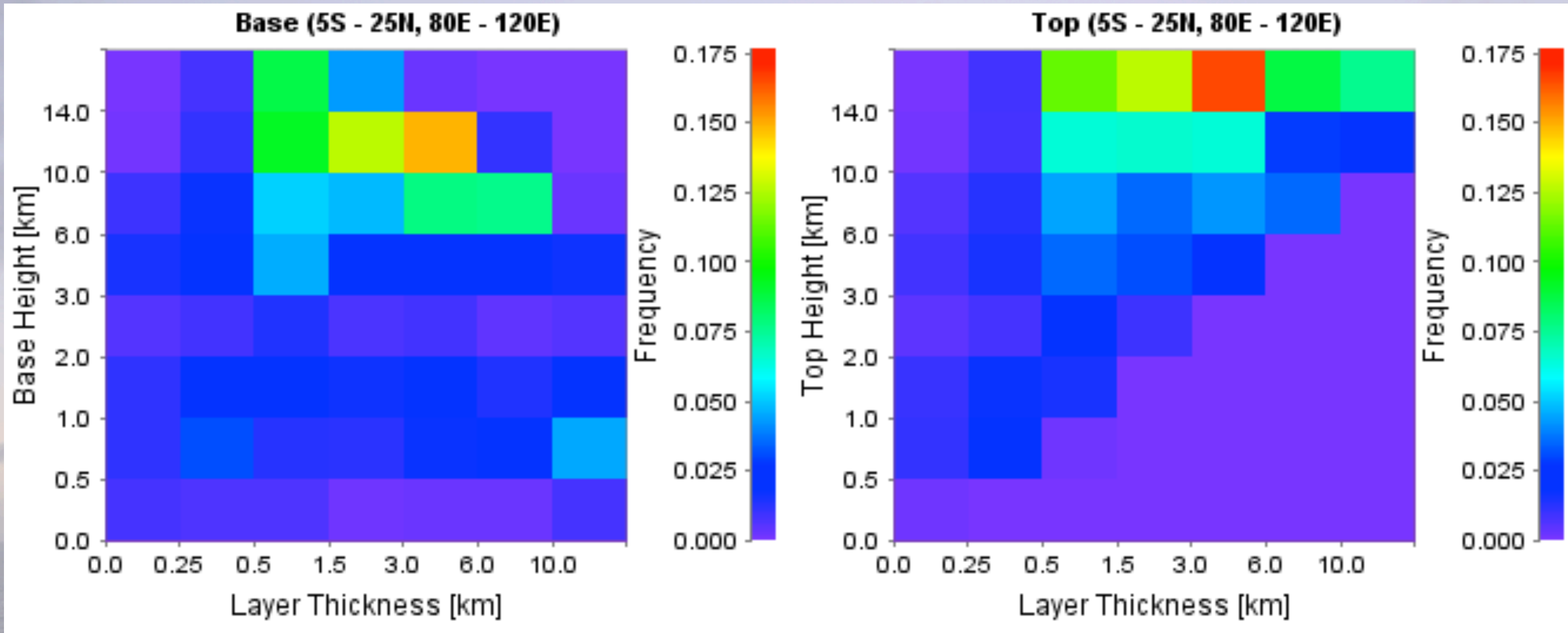


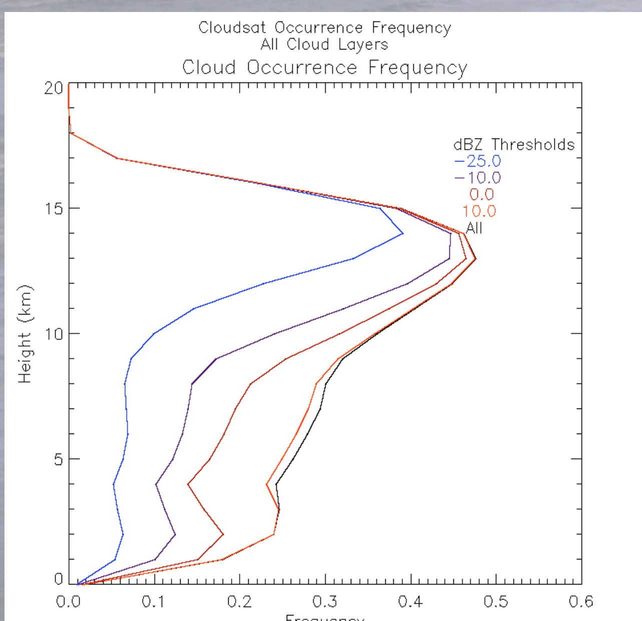


Multi-platform approach

Data

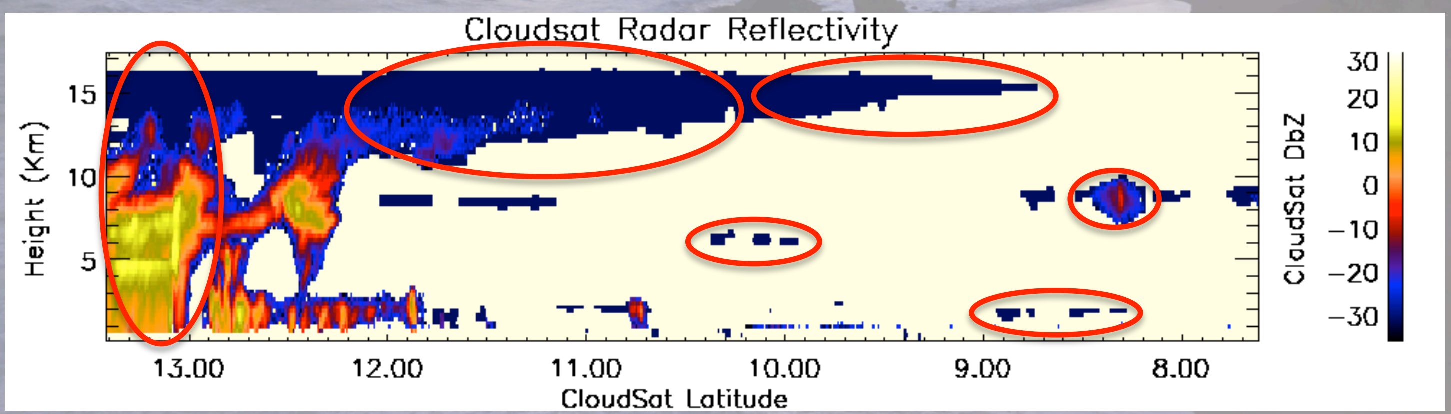
- CloudSat: radar reflectivity
- CALIPSO: lidar backscatter
- CERES: SW and LW irradiances
- MODIS: visible optical depth
- AMSRE-E: LWP





Cloud coverage= 85%

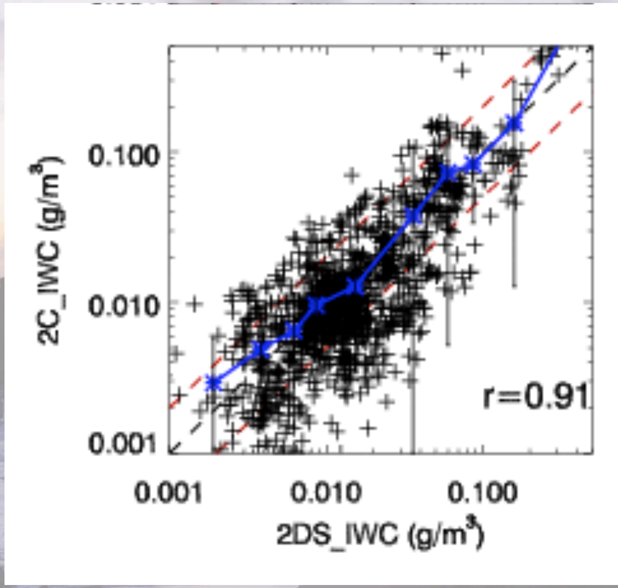
Cloud types	Top ht.	Thickness	RFO%
Thin cirrus	>10km	<3km	27%
Thick cirrus	>10km	3-6km	23%
Deep layers	>6km	>6km	33%
Thin mid	3-10km	<3km	9%
Thick mid&low	<10km	3-6km	4%
Thin low	<3km	<3km	4%



CloudSat Data Browser in Google Maps: created by Chris Galli, maintained by Quiqing Zhang

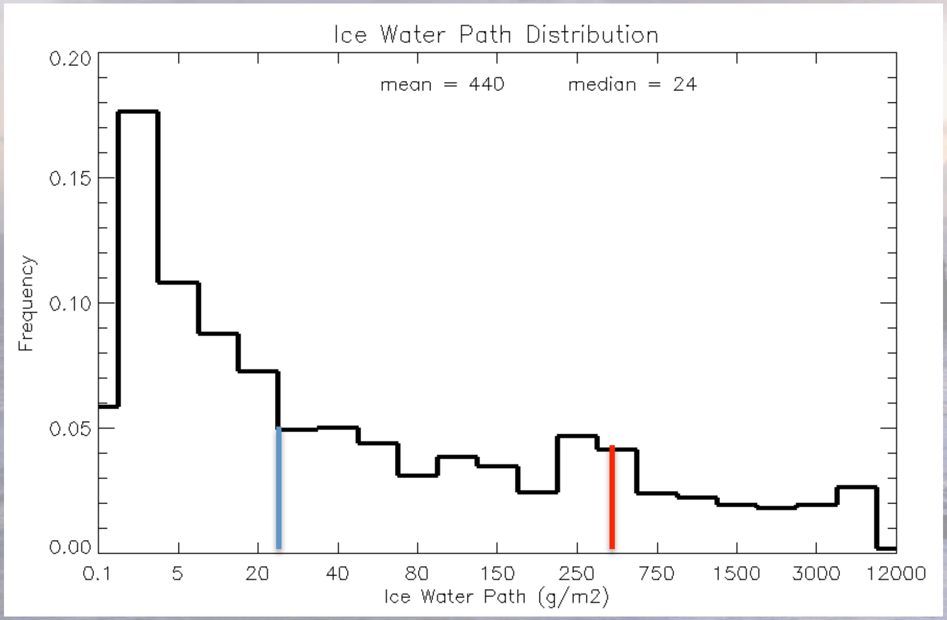
Cloud Properties

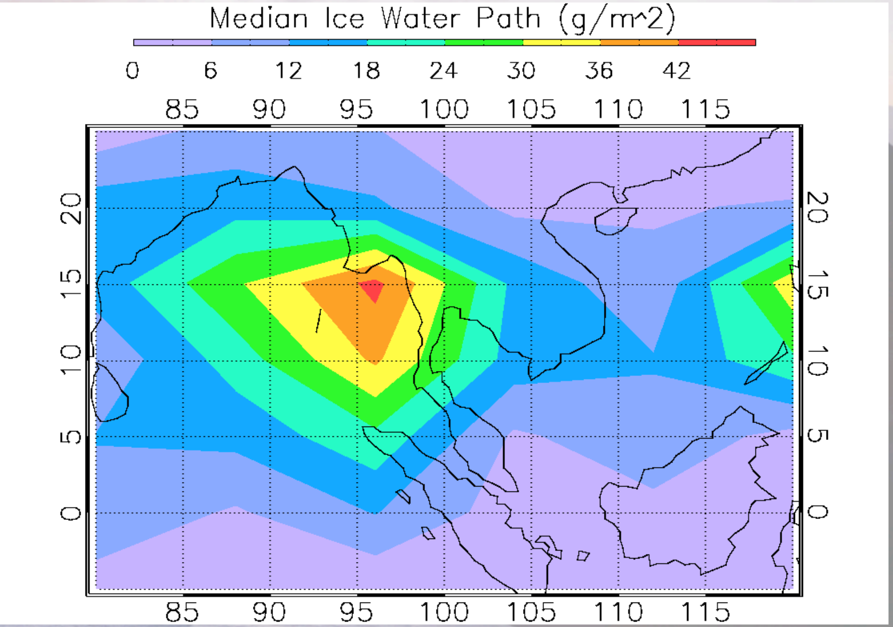
- Ice water content and ice effective radius from 2C-ICE CloudSat data product (Deng et al. 2010)
- Liquid water content and liquid effective radius derived from Z-tau algorithm during day and Z-LWP algorithm at night (Mace, 2006)



Deng et al., 2013

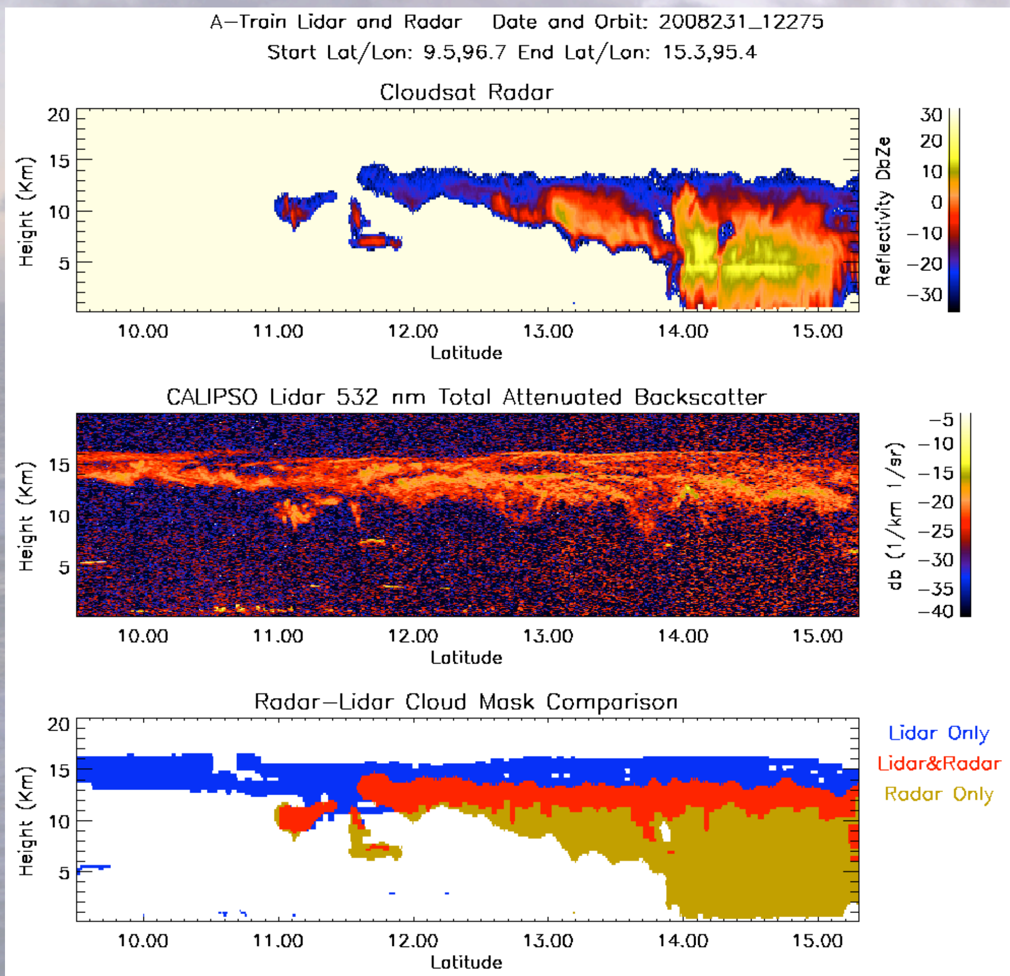
Ice Water Path Climatology

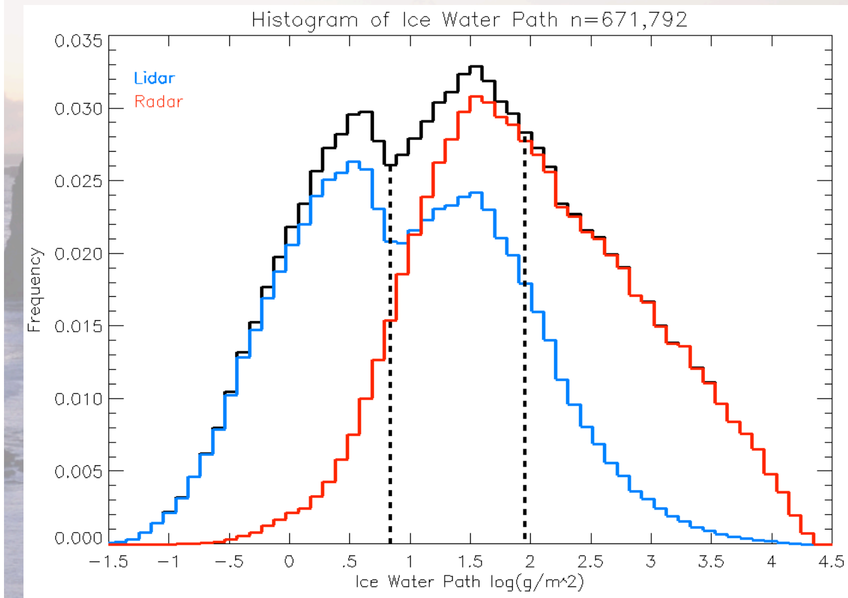




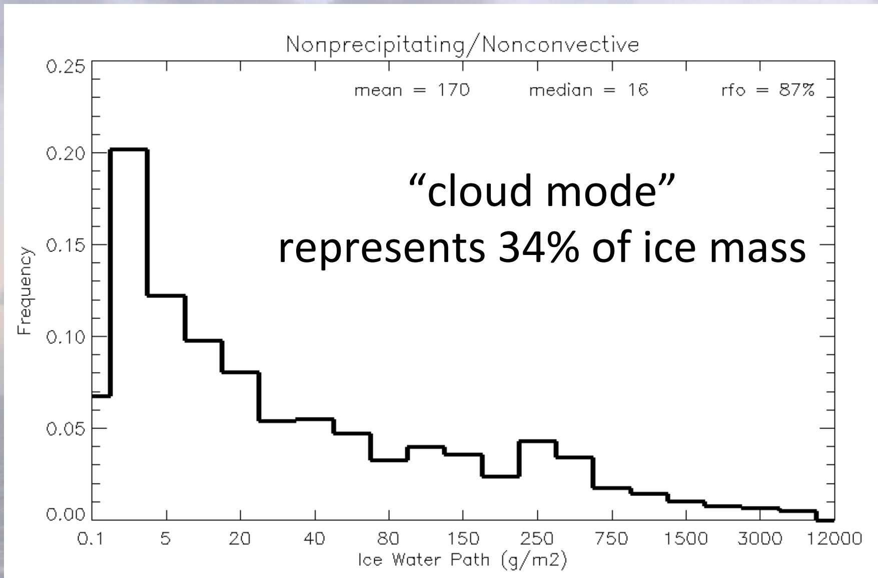
Mean
median

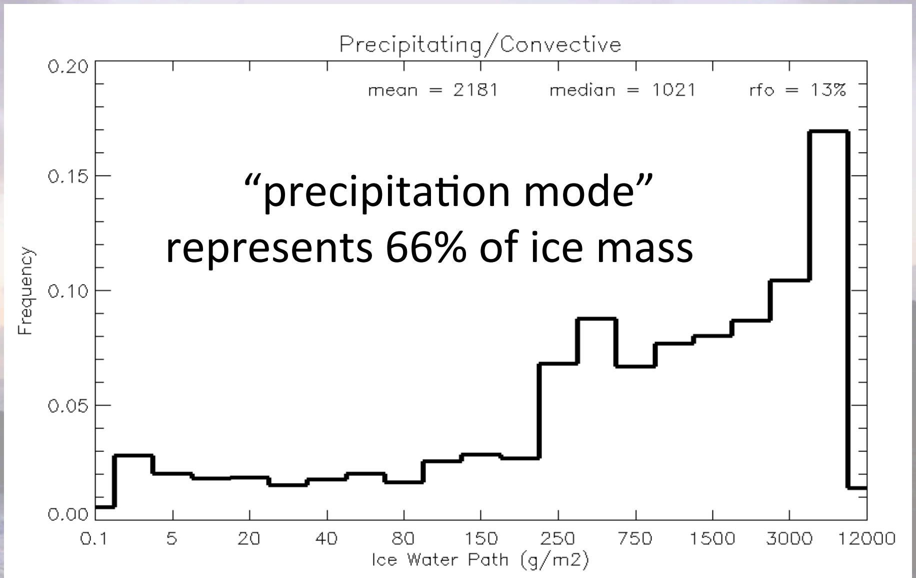
Remote Sensing of Ice Hydrometeors





Ice Water Path Distribution





Separate cloud and precipitating IWP following Waliser et al., 2009

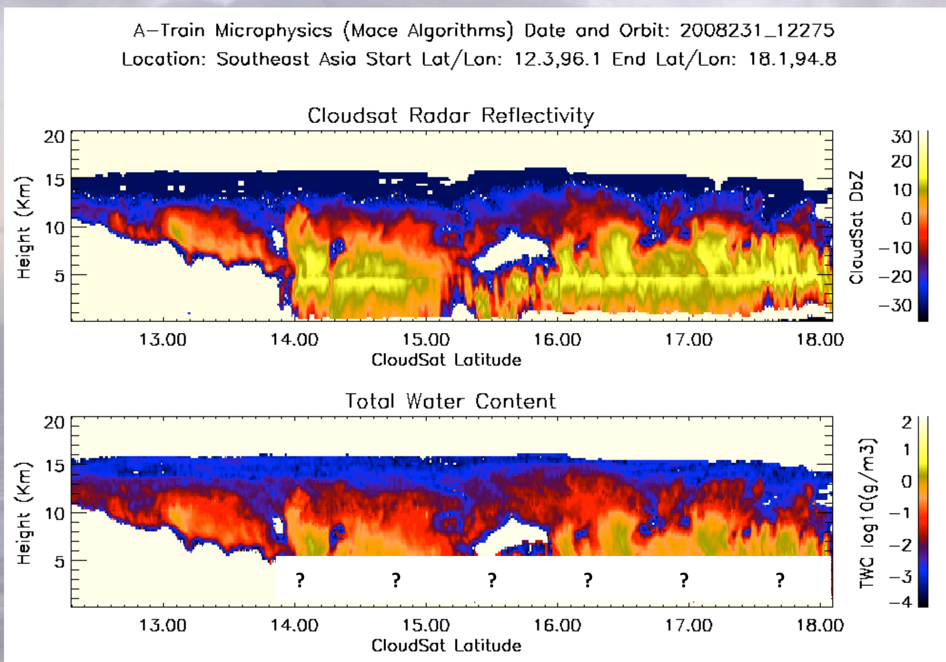
- Precipitating/Convective profiles identified using the 2B-CLDCLASS-LIDAR dataset
- 22% of profiles are ice-free

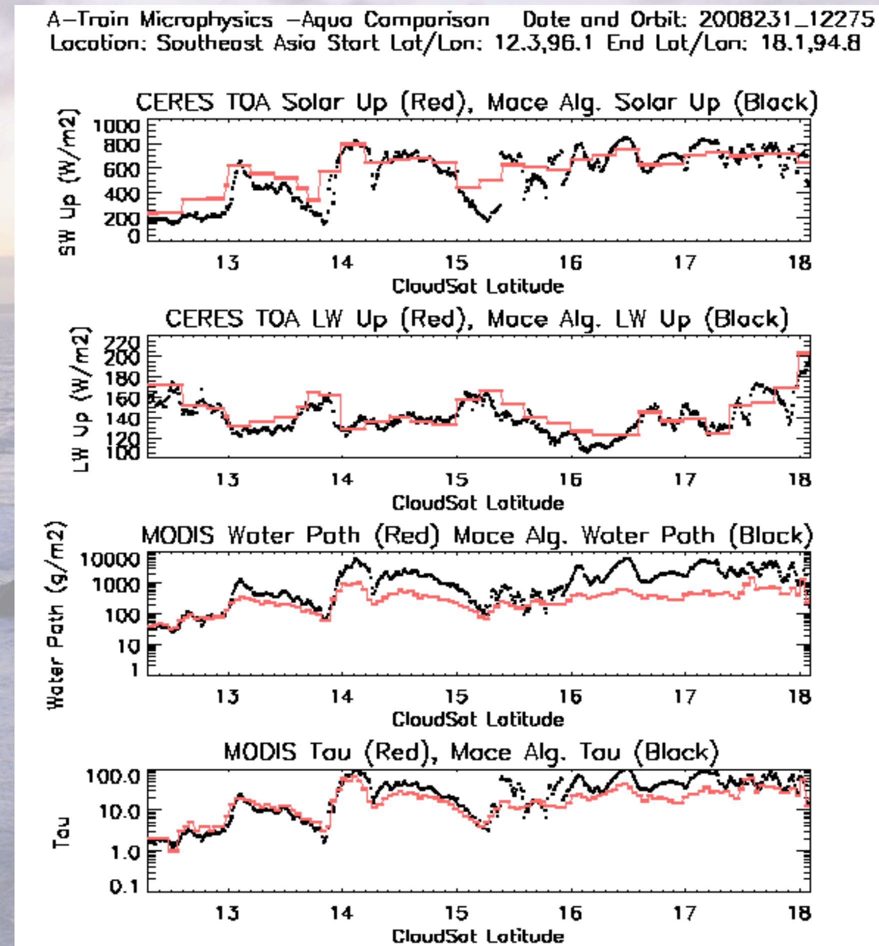
Methods adopted from Mace, 2010

- Use microphysical properties (water content and effective radius) to calculate radiative properties
- Radiative transfer model (Toon et al., 1989)
- Inputs: single-scattering albedo, extinction coefficient, asymmetry parameter
- Outputs: SW and LW radiative fluxes

Deep Layer Example

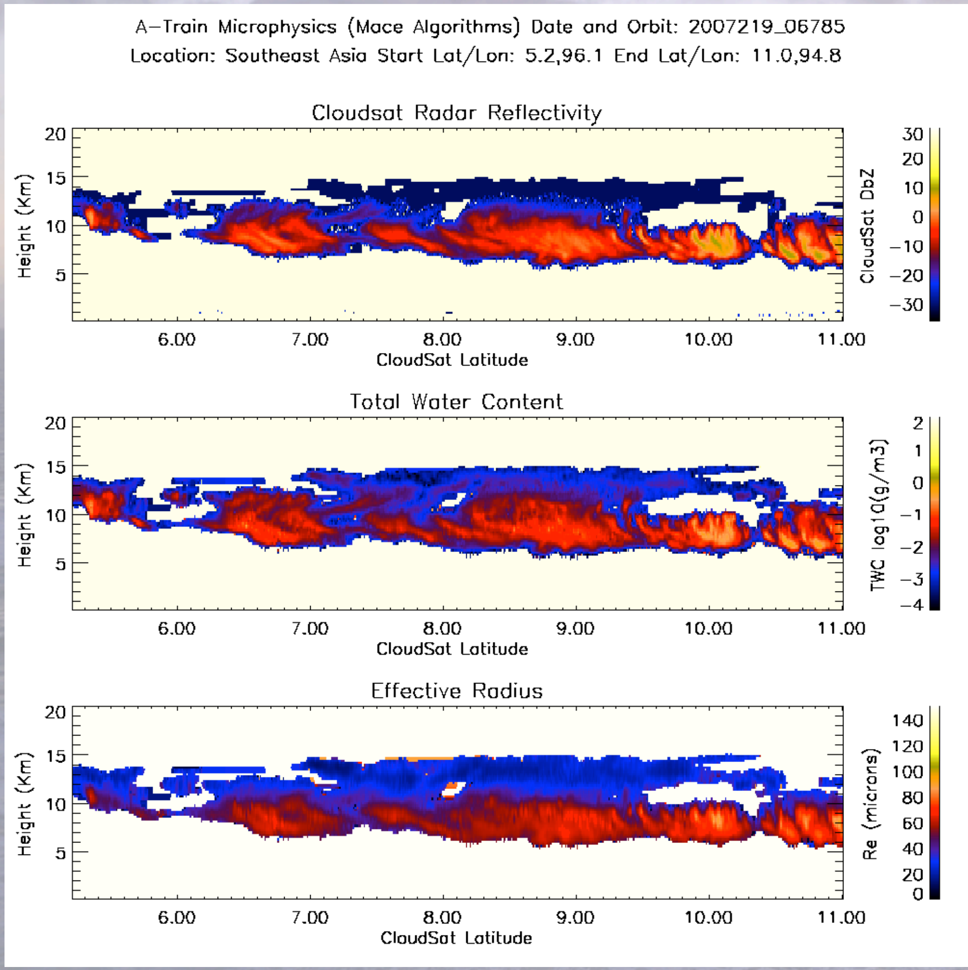
Retrieved Quantities

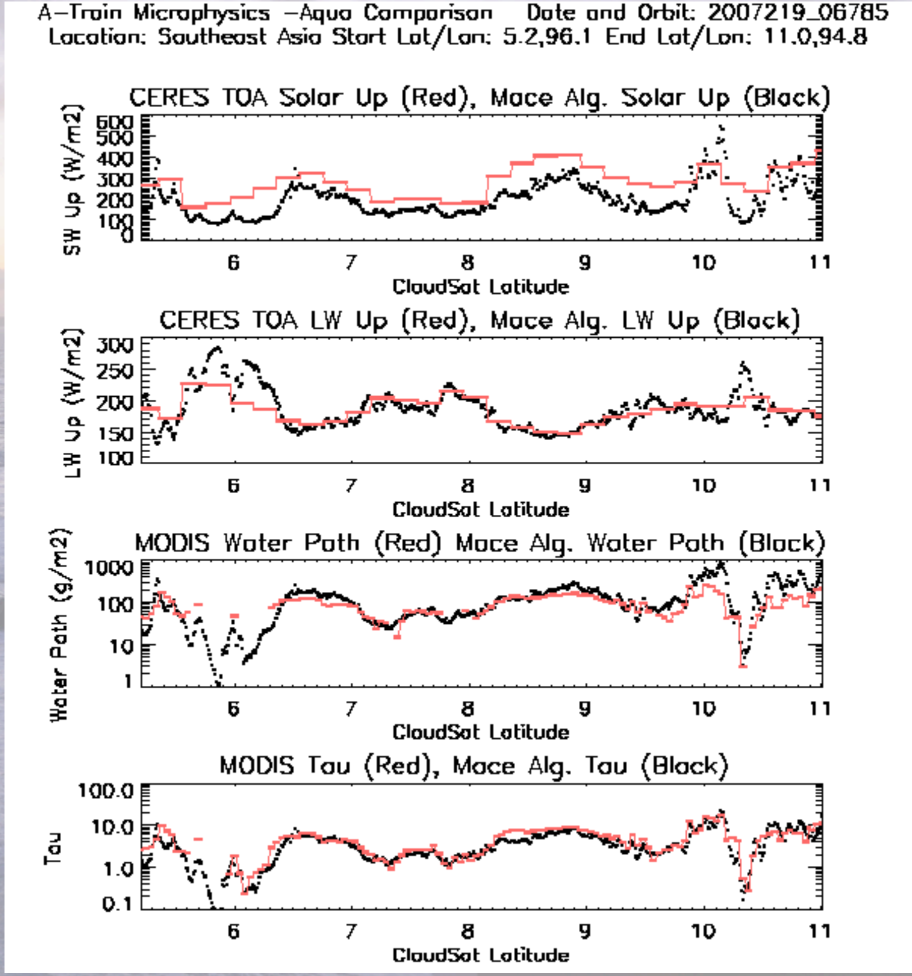




Thick Cirrus Example

Retrieved Quantities

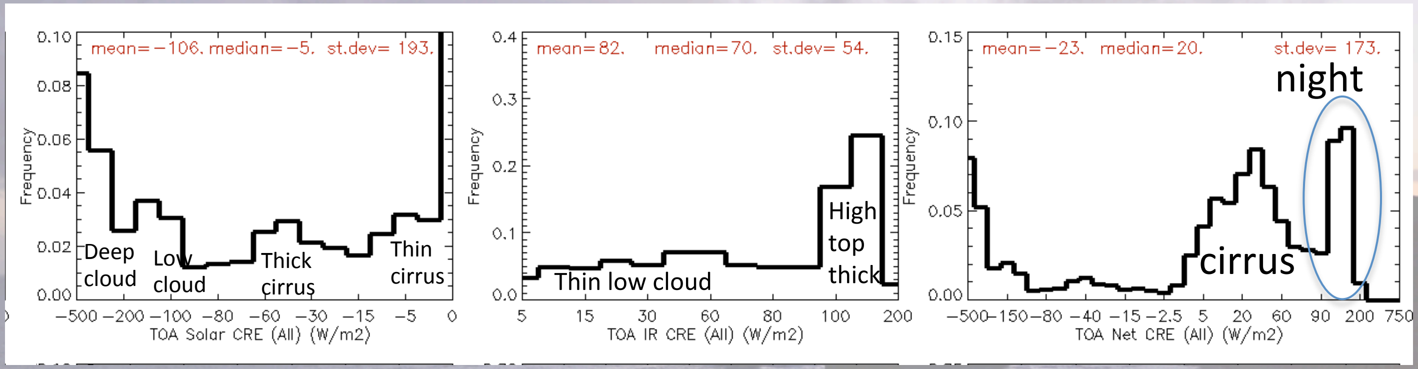




Cloud Radiative Effects

Solar IR Net

TOA



CRE = $(F\downarrow - F\uparrow)_{All} - (F\downarrow - F\uparrow)_{Clear}$

Cirrus effects on energy budget

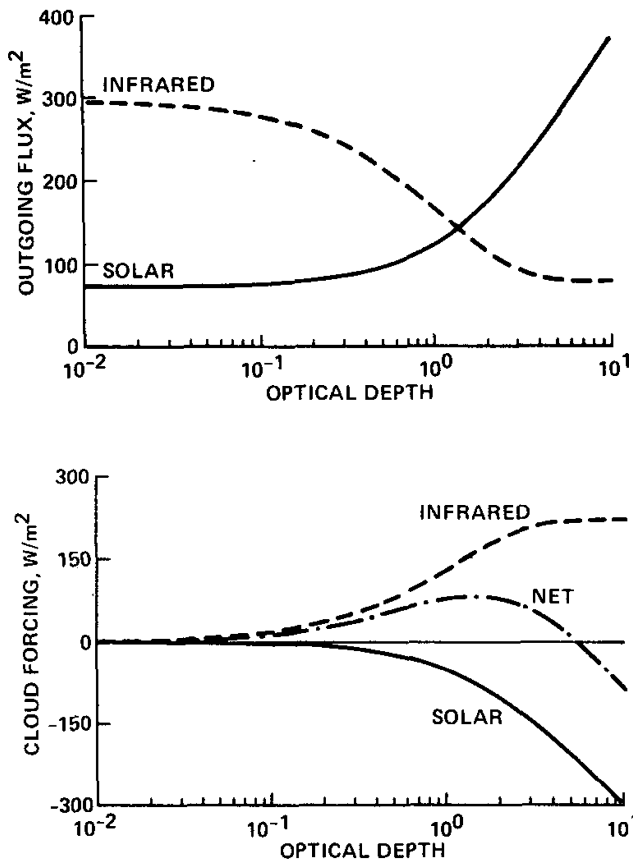


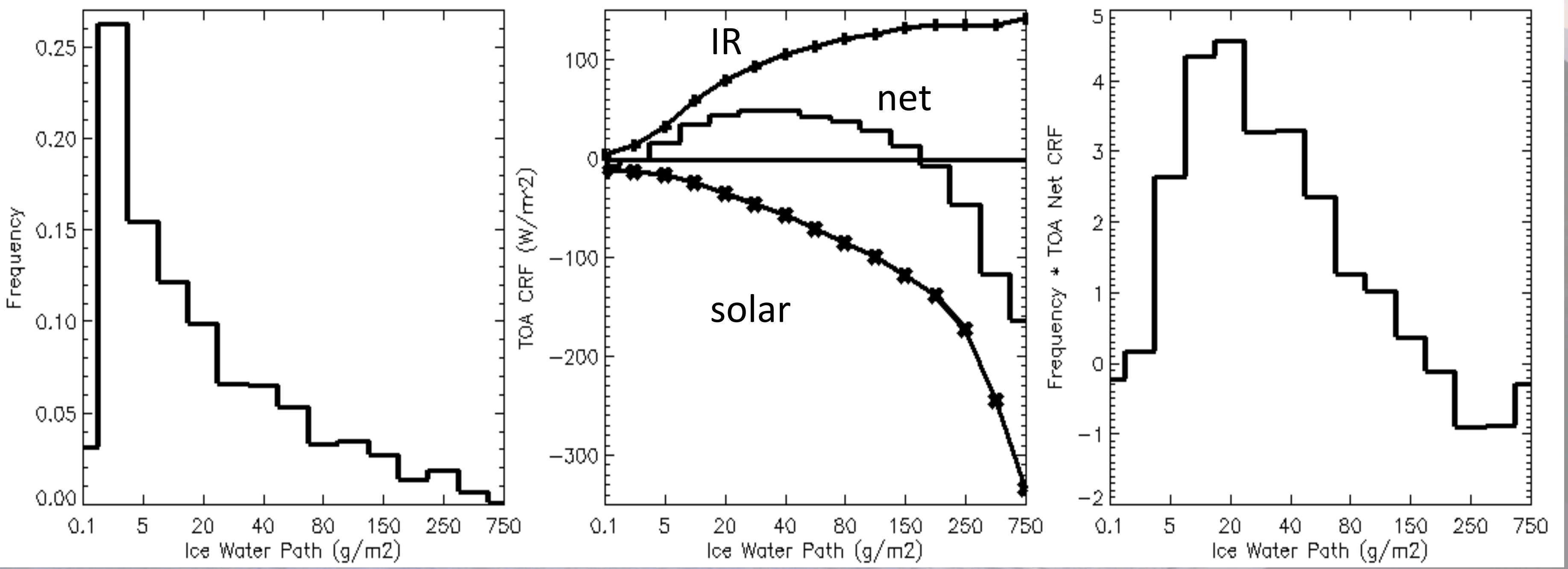
FIG. 13. (a) Emitted infrared and reflected solar flux and (b) infrared, net, and solar cloud forcing in W m^{-2} as a function of cirrus 0.55 μm optical depth. The cloud is assumed to be plane-parallel and located between 15 and 17 km altitude. The solar zenith angle is 53°.

How would this vary as a function of IWP for observed clouds?

Ackerman et al., 1988

Which cirrus contribute most to heating?

Cirrus: Top Height > 10km Thickness 0-6km



Mean net CRF at TOA for Cirrus= 21Wm^{-2}

Conclusions

- Cirrus and deep layers dominate
- Mean value alone is not representative for IWP
- Radar and lidar needed to describe IWP
- Net zero Cloud Radiative Effect at TOA
- Cirrus layers with IWP ~ 20g/m^2 contribute most to heating