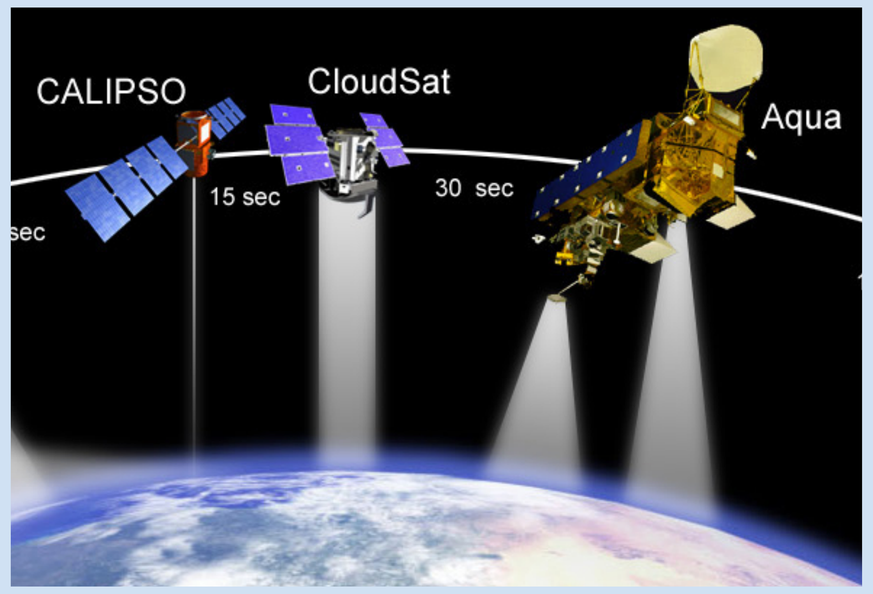


# Cloud Properties and Radiative Forcing in Southeast Asia

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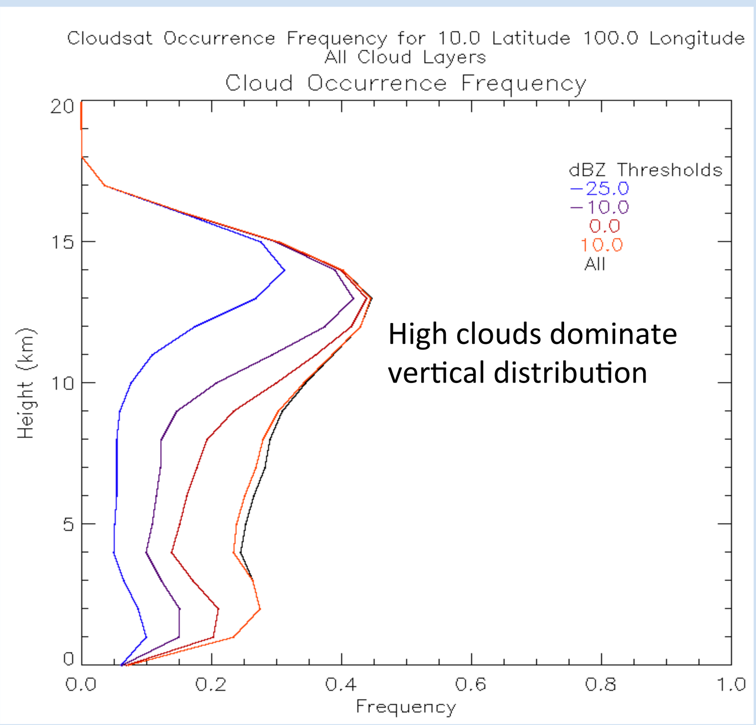
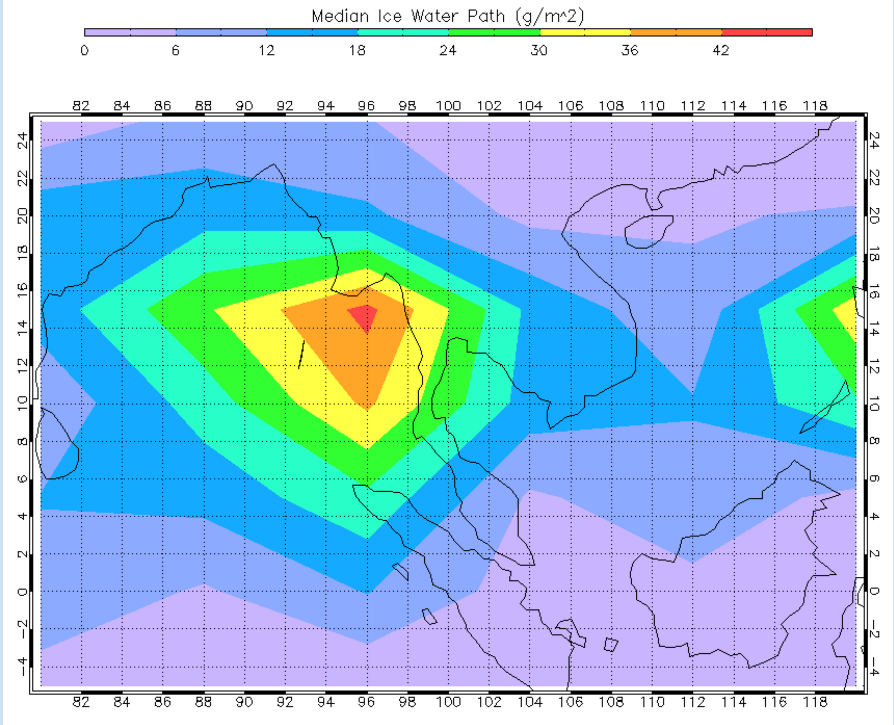
## Goals:

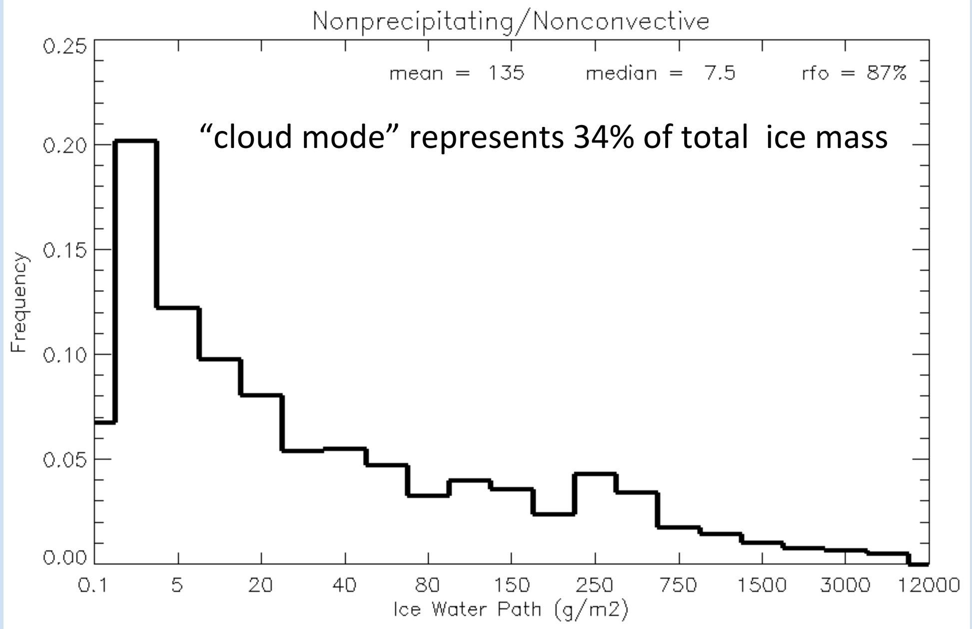
- •Use A-Train data to document cloud properties in Southeast Asia [5S-25N, 80-120E] during the monsoon season (Aug-Sep 2007-2008), with a particular focus on cirrus.
- •Investigate how these clouds impact the radiation budget.
- •Compare findings with other observations and models

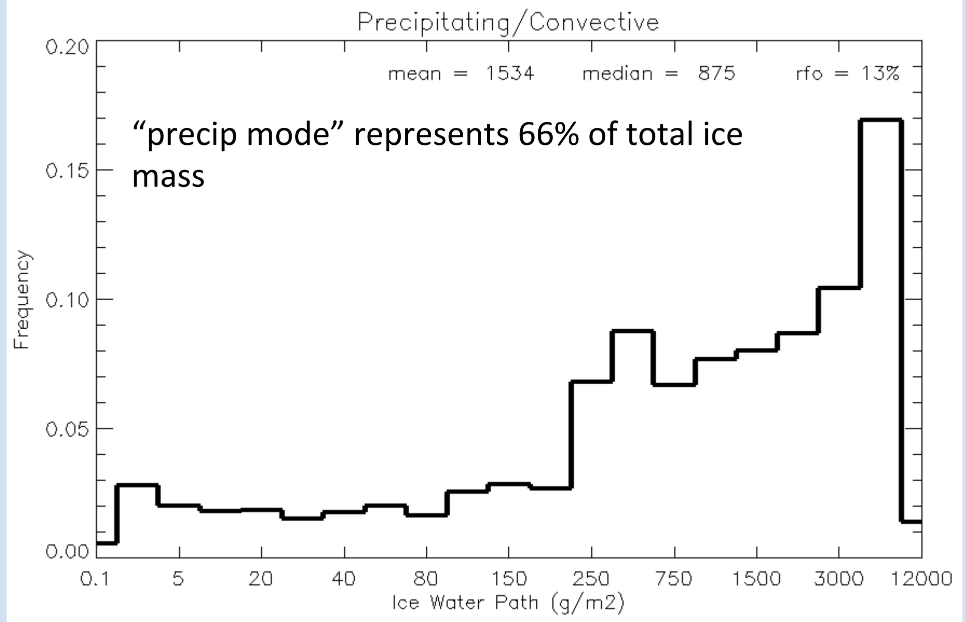
## Methodology:

- •Use a multiplatform algorithm suite (CloudSat radar, CALIPSO lidar, MODIS optical depth) to derive the cloud microphysical and radiative properties (Mace, 2010)
- •A two-steam radiative transfer model is used to obtain the radiative fluxes (Toon et al., 1989)




- Ice microphysical properties from the CloudSat/CALIPSO 2C-ICE dataset (Deng et al., 2010)
- Precipitating/Convective profiles identified using the 2B-CLDCLASS-LIDAR dataset
- 22% of profiles are ice-free
- mean IWP is skewed by large values

## Cloud Radiative Effects

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

~ 50% nighttime observations

ATM: LW effects dominate the net CRE

SFC: SW effects dominate the net CRE

TOA: large range of values for net CRE

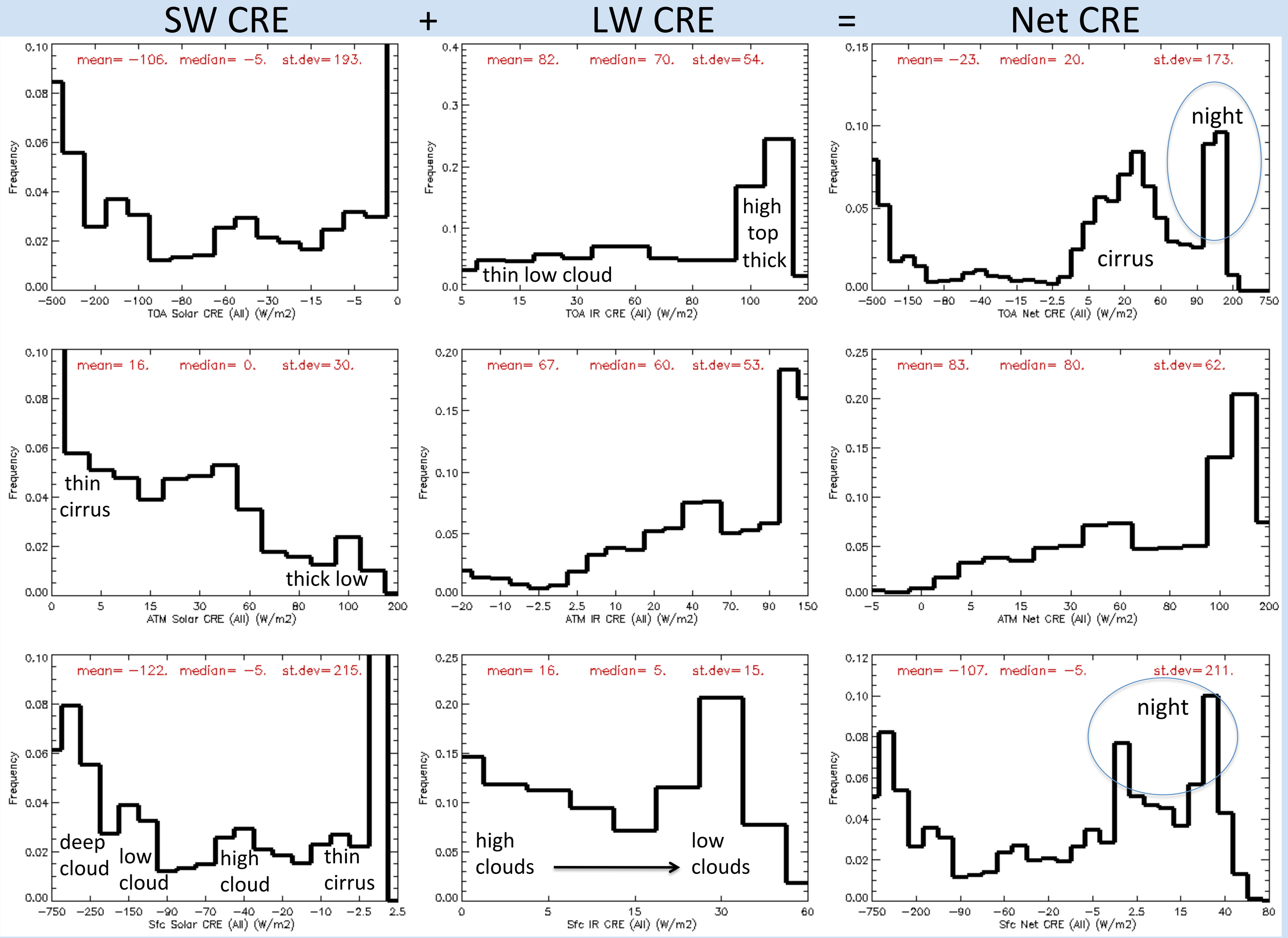
The mean (-23W/m$^2$) and median (20W/m$^2$) values for the net CRE indicate an overall balance between the SW CRE and LW CRE

SW CRE + LW CRE = Net CRE

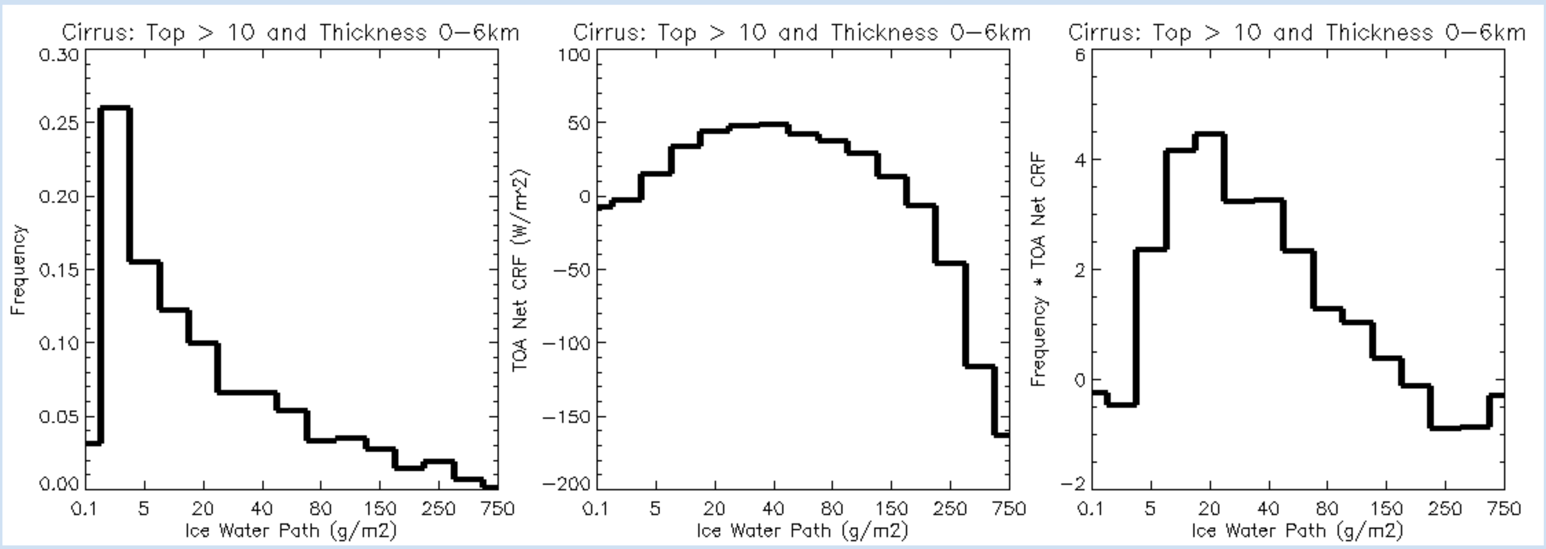
TOA

ATM

SFC




### Which cirrus contribute most to heating the upper troposphere?



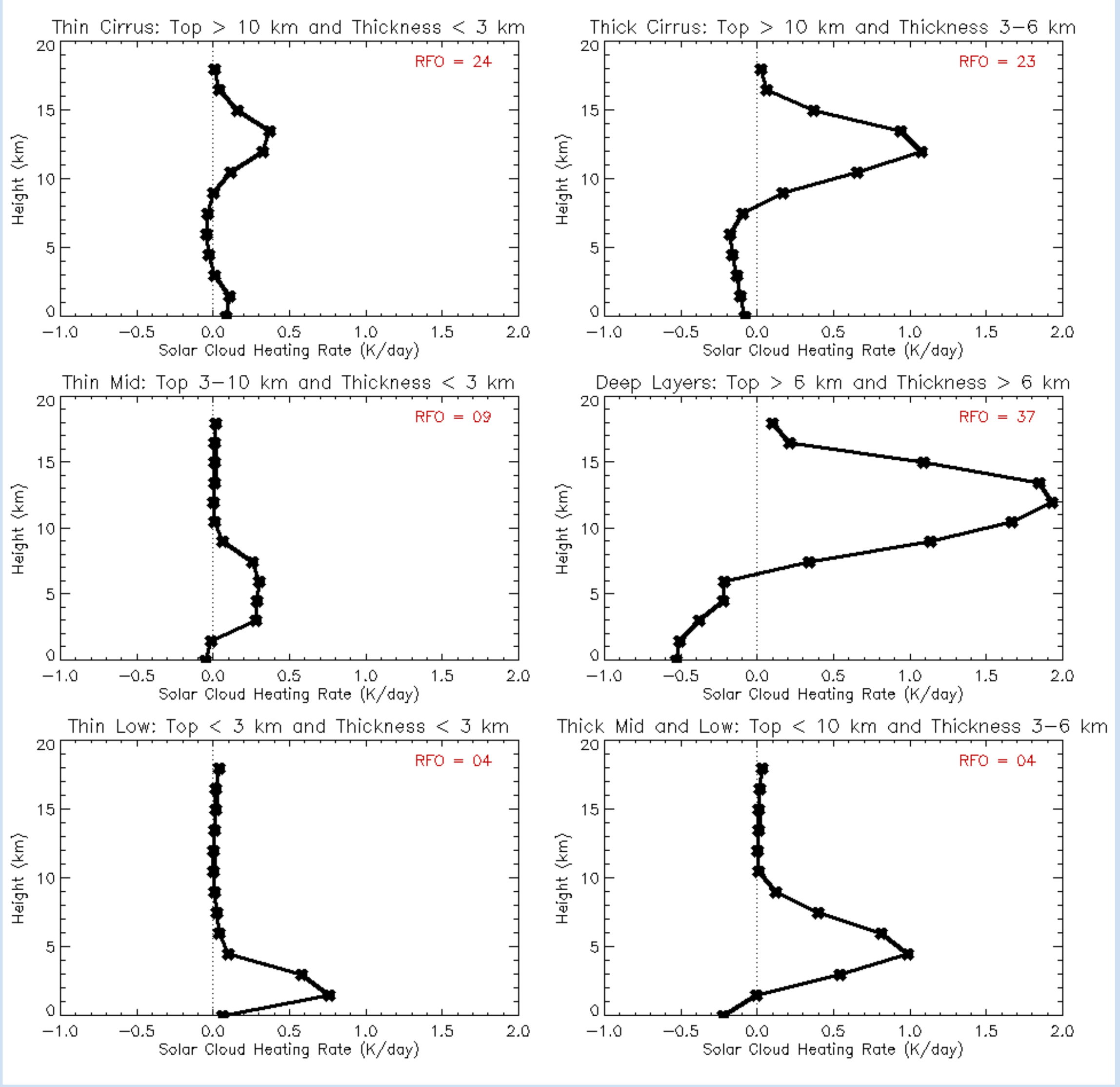

For IWP >200g/m$^2$, solar effects dominate and cirrus produce TOA net cooling

Given their frequency of occurrence and mean net CRE at the TOA, cirrus with IWP=20g/m$^2$ contribute most to upper level heating

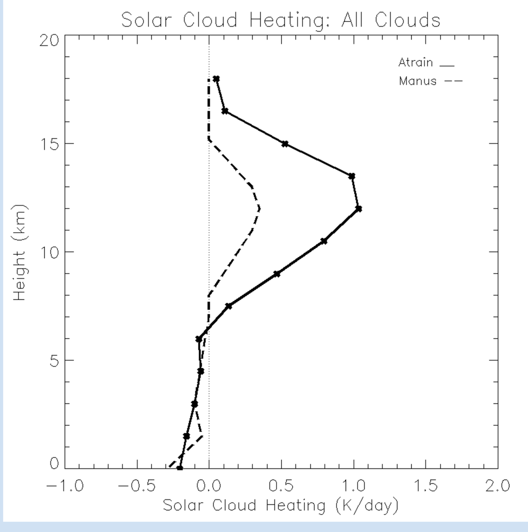
Do models show the same relationship between IWP and CRE?

## Cloud Radiative Heating Rates

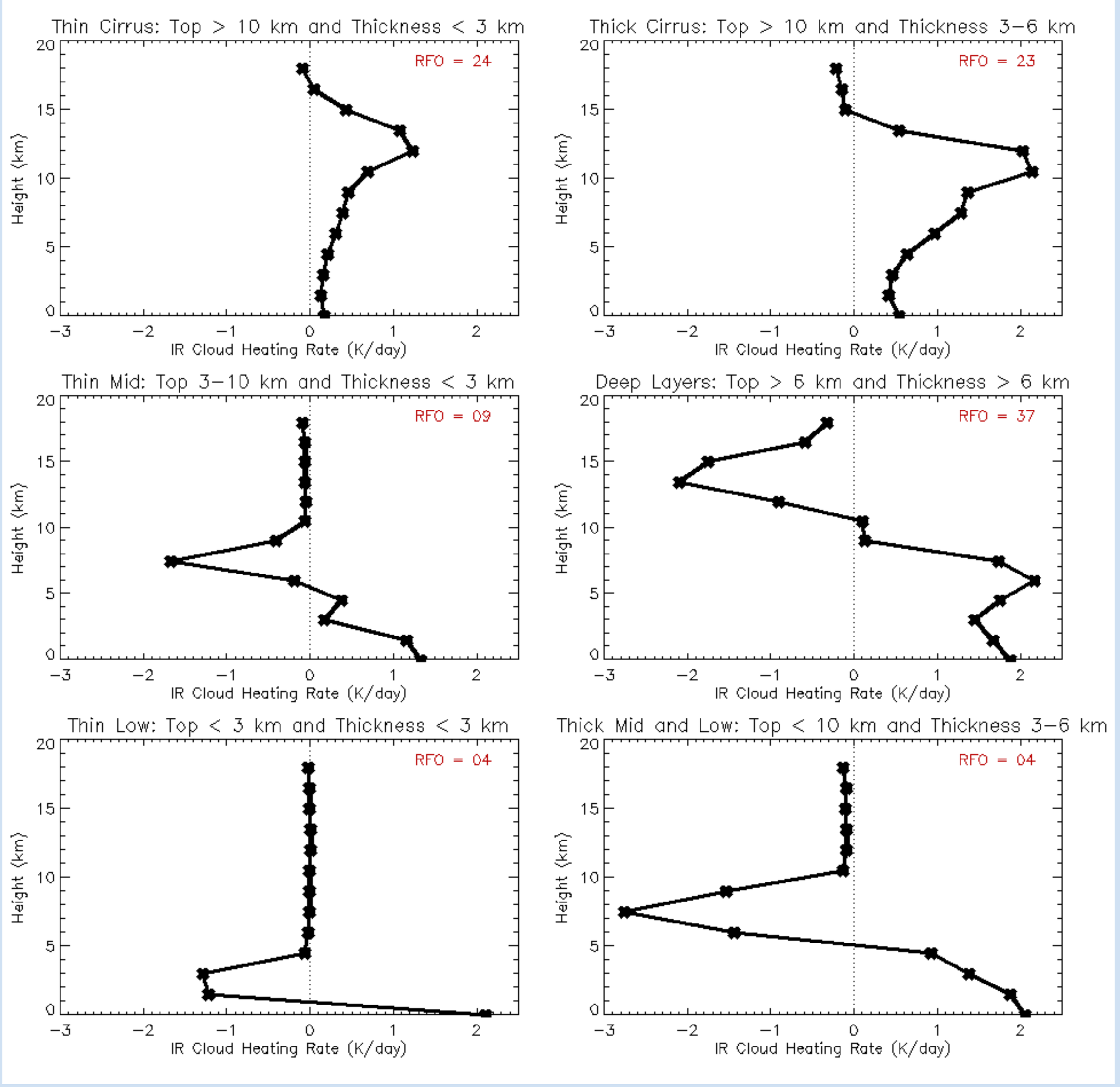
### SW heating rates by cloud type



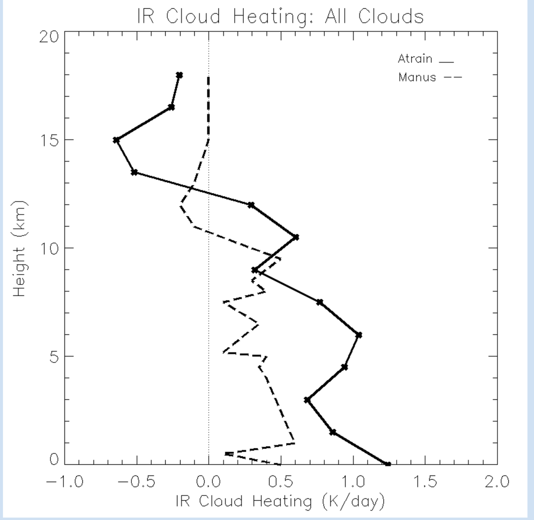

Thick cloud contributes most to the overall solar cloud heating




### LW heating rates by cloud type

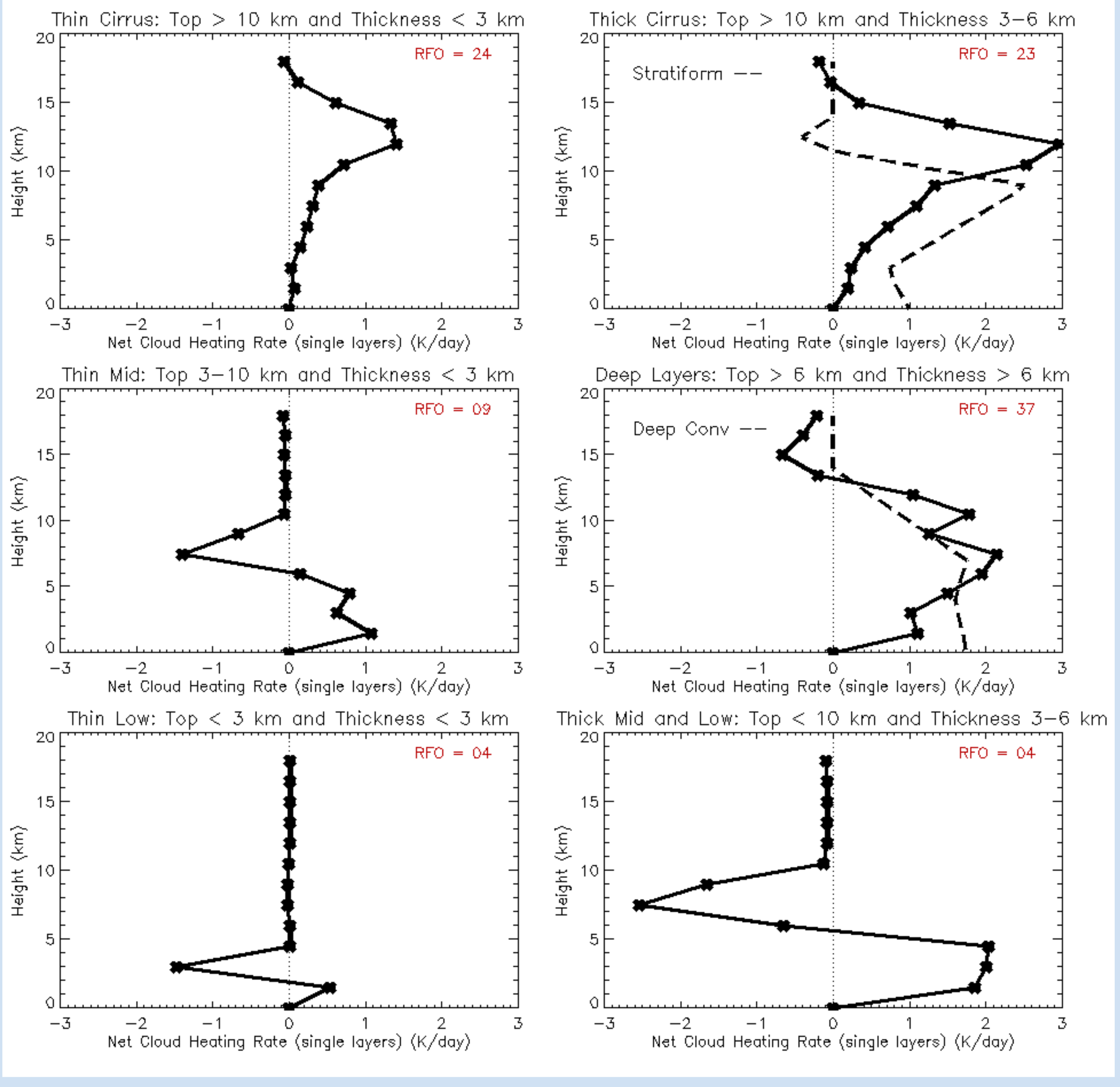



Strong cloud top cooling for deep layers cancels out cirrus LW heating above 10.5km

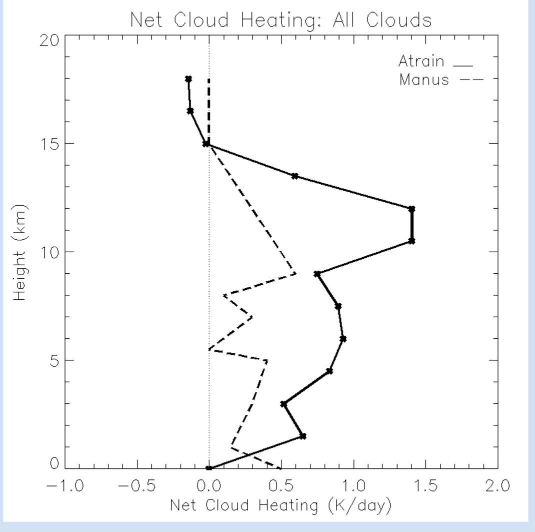



For comparison to another tropical location, we show the heating rates derived From the Manus ARM site (Mather et al., 2007) on the overall heating rate plots.

### Net heating rates by cloud type




- •The overall net heating rate shows that clouds in this region produce heating throughout the atmosphere.
- • Peak heating above 9km is due to SW heating from thick clouds with high tops.
- • The heating below 9km is due to LW heating from thick clouds with high tops.




For comparison, we show the idealized tropical deep convection and stratiform heating rates derived from TRMM (Schumacher et al., 2004)