Effects of Clouds on the Radiation Balance as Derived from the New CloudSat Fluxes Product

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CERES Science Team Meeting, Ft. Collins, CO

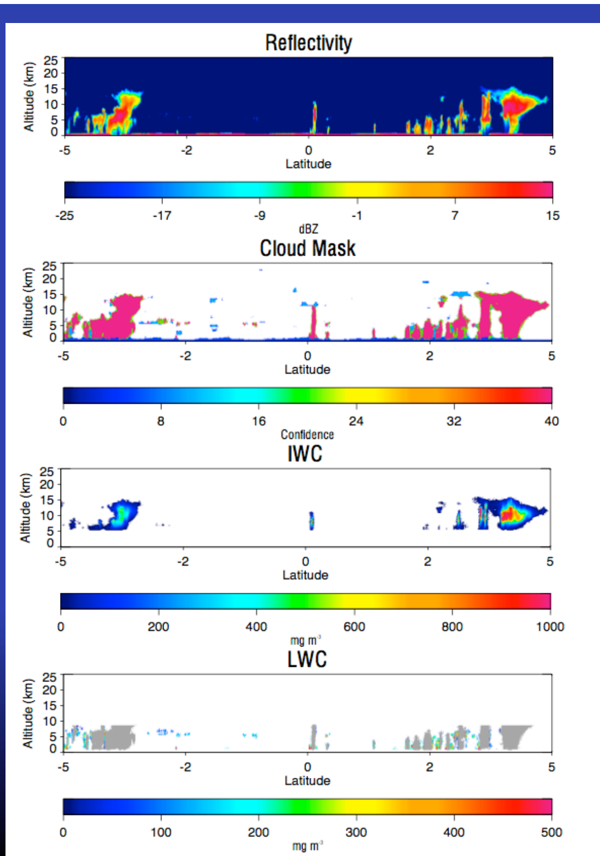
Overview

•Brief discussion of current FLXHR product

•Detecting and finding properties of new clouds, not seen by CloudSat, to input into FLXHR-LIDAR

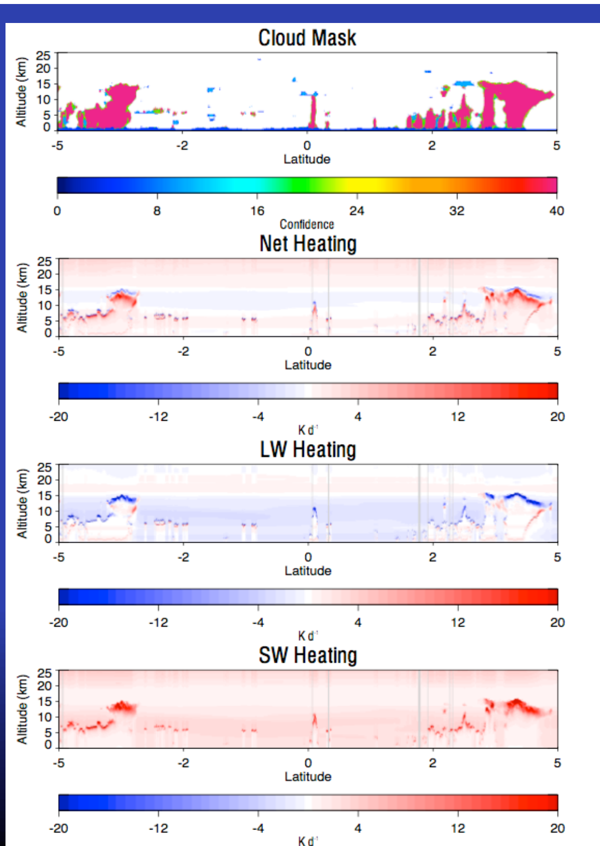
•Effects of new clouds on Radiation Balance
  - •Average Heating Rate Profiles
  - •Top of Atmosphere Cloud Radiative Effect (TOACRE)
  - •Bottom of Atmosphere Cloud Radiative Effect (BOACRE)
  - •Globally Averaged Cloud Impacts

•Future work on FLXHR-LIDAR product



Current FLXHR Algorithm

- •Vertical distributions of LWC, IWC, and liquid and ice effective radii, are inputted from CloudSat's 2B-CWC Product
- •Temperature and relative humidity profiles from ECMWF
- •Surface albedo and emissivity from the International Geosphere-Biosphere Programme (IGBP)
- •Inputted into the Radiative transfer model
- •Outputs contain:
  - Vertical profiles of upwelling and downwelling LW and SW fluxes
  - Vertical profiles of radiative heating



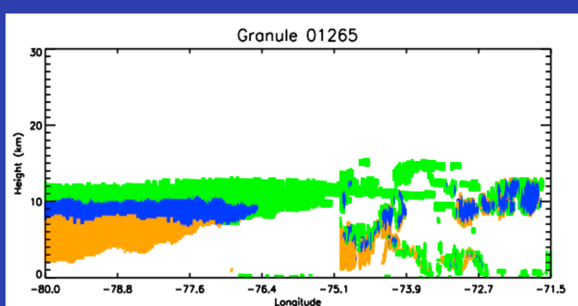
Current FLXHR Algorithm (Cont)

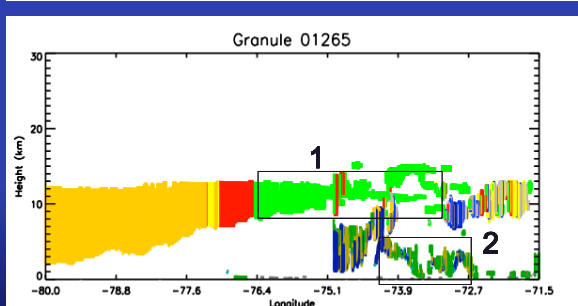
- •Example of heating profile from the FLHXR product.
- •The FLXHR product can find fluxes and heat rates for most clouds, but can not obtain results for undetected clouds

Detection problems with current FLXHR product

- Thin subvisible cirrus clouds are not detected by the CloudSat CPR because their reflectivities are below the minimal detectable signal of -30 dBz
- Low clouds are either below the minimal detectable signal or considered clutter clouds (below 1 km), because of contamination from surface reflectivity.
- Look at fixing high and low cloud detection and find their properties.

Finding and Classifying new clouds

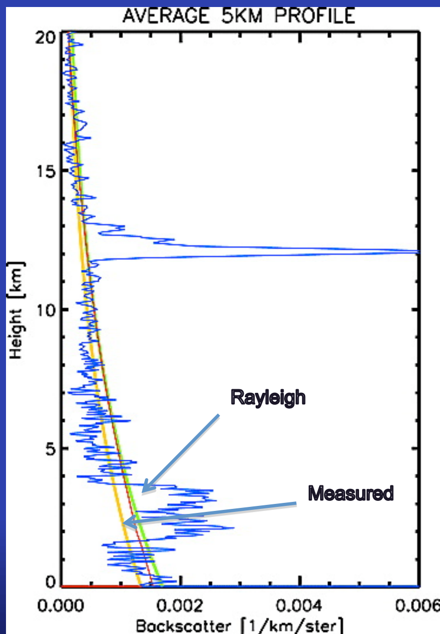




•Using the Geoprof-Lidar product, clouds detected by CloudSat, both CALIPSO and CloudSat, and CALIPSO only are found

•Clouds are then classified by temperature, and by how much of the cloud CALIPSO detects

•We are looking at undetected thin high clouds (1) and undetected low clouds (2)



Properties of Thin Cirrus and Low Clouds

- Low level clouds given R_e=18µm $LWC_{<1km}$=120mgm^{-3} or $LWC_{>1km}$=50mgm^{-3}
- Thin Cirrus clouds given R_e=30µm and IWC calculated from cloud optical depth
- Exponential fits for Rayleigh and Measured taken from CALIPSO backscatter

$$\beta = A\, e^{-z/H}$$

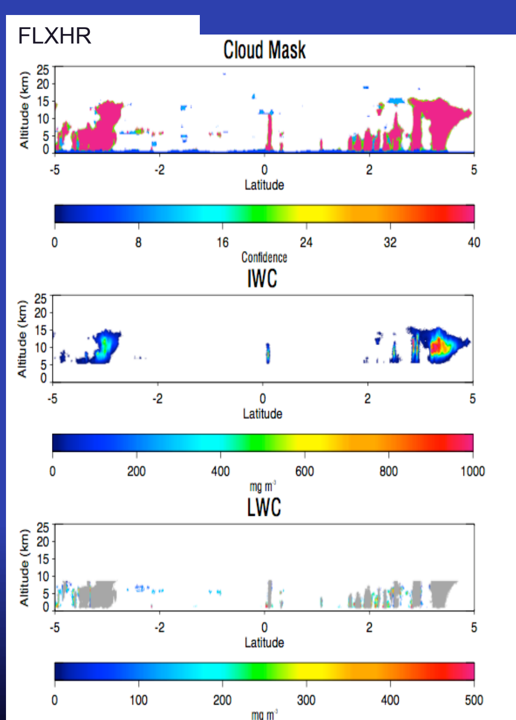
- Ratio of coefficients yields estimate of OD

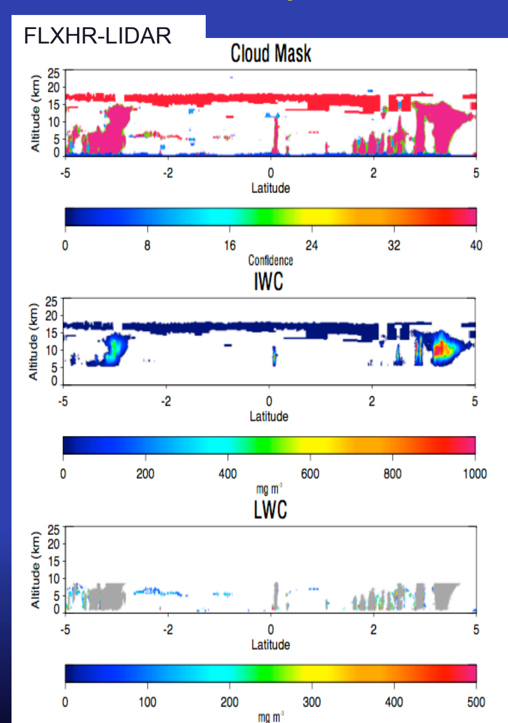
$$\frac{A_M}{A_R} = e^{-2\tau_{cld}}$$

- Optical depth used to calculate IWC

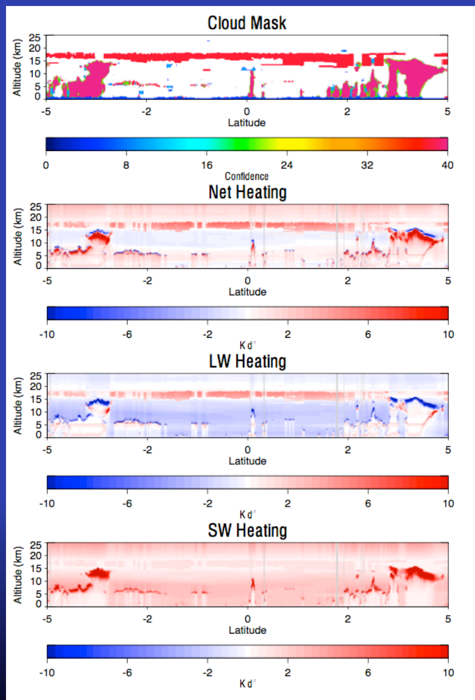
$$\tau_{cld} = \frac{3}{2}\frac{IWC}{\rho_i R_e}\Delta z$$

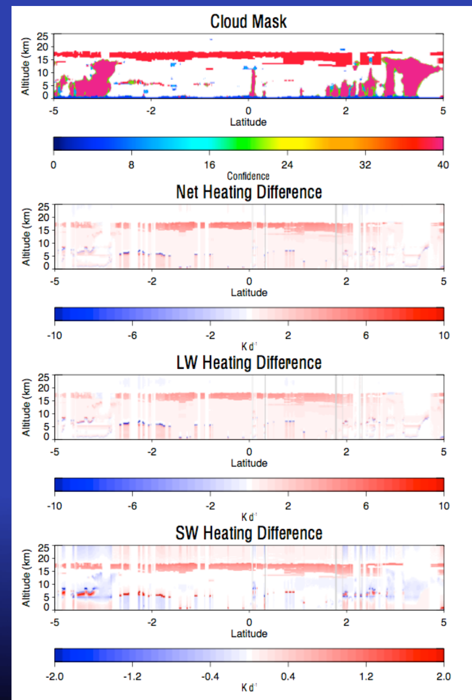
FLXHR and FLXHR-LIDAR Cloud Properties





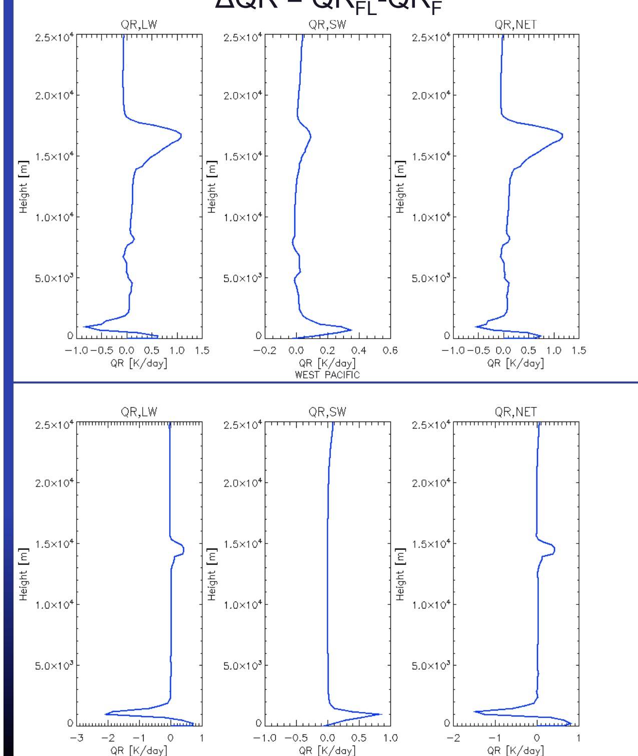
FLXHR-LIDAR Heating Rates





Average Vertical Profiles of Heating Rates, January 2007

$\Delta QR = QR_{FL} - QR_{F}$



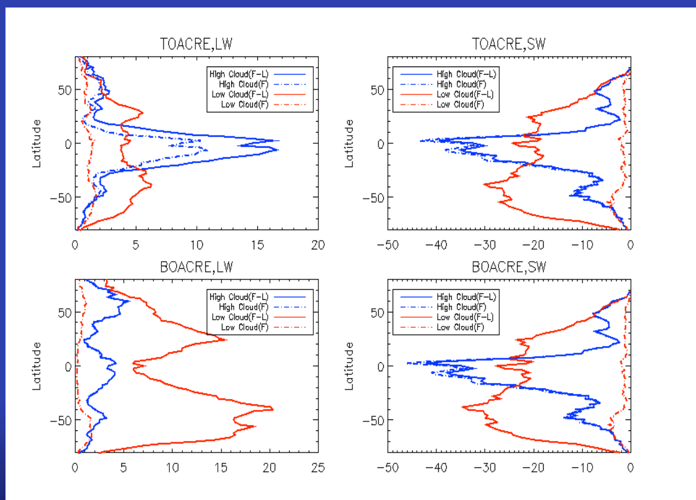
- Vertically averaged profile of Heating Rate Differences from West and East Pacific

- West: Lat: -10 to 10
  Lon: -170 to -140
  - In tropics near ITCZ where there are higher amounts of subvisible cirrus
- East: Lat: -40 to -20
  Lon: -110 to -80
  - Off the western coast of South America where low level stratus are common

- More heating near 16 km due to more LW heat trapped by new high cirrus clouds.

- Increased SW heating and LW cooling in the lower levels due to new low clouds

Latitudinal averaged TOACRE and BOACRE January 2007



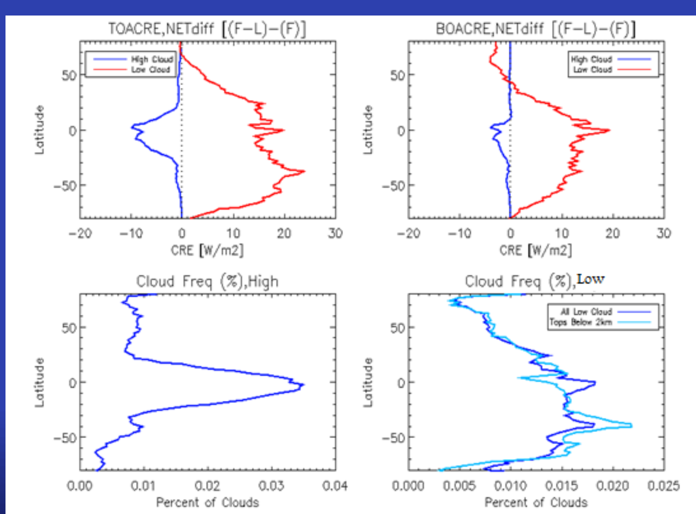
•Values are where only a new high cloud is present or where only a new low cloud is present

•Increase in SW and LW CRE where new low clouds are present with SW values increased as much as 25 Wm^{-2}

•Large increase in TOACRE LW where new high clouds are present especially in the tropics with values increased by 6 Wm^{-2}

•Overall, there is a decrease in CRE where new high clouds are present due to the increased trapping of LW radiation and changes in CRE where new low clouds are present due to a higher amount of SW reflected

TOACRE and BOACRE Net Differences and Cloud Frequency January 2007



•Impact of high clouds largest in tropics

•Low clouds have have largest impact in Southern Hemisphere summer where SW dominates. Higher latitudes in Northern Hemisphere impacted more by LW effects due to less sunlight.

•Largest amount of low clouds below 2km located from 30-40 S. .

Globally Averaged Impacts of High and Low Clouds January 2007

Cloud Type	$\Delta F_{up,SW,TOA}$	$\Delta F_{dn,SW,SFC}$	$\Delta F_{up,LW,TOA}$	$\Delta F_{dn,LW,SFC}$
Cirrus	-0.5	0.4	-1.4	0.04
Low	12.9	-13.7	-2.4	7.4
Cirrus (Both)	2.5	-2.6	-2.5	1.4
Low (Both)	15.4	-16.1	-3.5	8.4

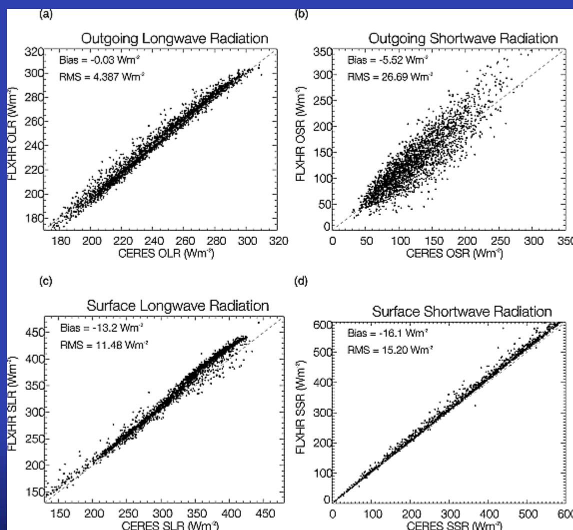
- ΔF = FLXHR-LIDAR – FLXHR, with all values in Wm^{-2}
- New high clouds have the largest impact on upwelling LW
- New low clouds have largest impact in upwelling and downwelling SW

Future Algorithm Development for Release 5*

- Implement an optimal "blend" of thin cirrus optical depth based on current approach, CALIPSO cloud product, and MODIS cloud properties where available.
- Add vertically-resolved aerosol information from CALIPSO layer aerosol optical depth and type product.
- Refine effective radii and optical depth of detected clouds using MODIS-based 2B-Tau product.
- Improve representation of raining pixels:
    - Add explicit precipitation mode in LWC and IWC size distributions.
    - Replace "arbitrary" LWC and IWC thresholds with explicit retrievals from CloudSat's precipitation algorithms.
    - Refine vertical distribution of liquid above the freezing level based on a new convective/stratiform classification.
- Add explicit representation of sea ice extent based on AMSR-E sea ice product.

*Release 5 to be complete around March 2010

Future Algorithm Development for Release 5 (cont)



L'Ecuyer et al, 2008

- Validation with CERES FLASHFlux Products
- Example of validation of FLXHR product with CERES
- Need to repeat this process to validate the new FLXHR-LIDAR product