Investigation of Hurricane Precipitation Coverage and the Absorption of Solar NIR Radiation with CloudSat

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Hurricane passes from CLOUDSAT

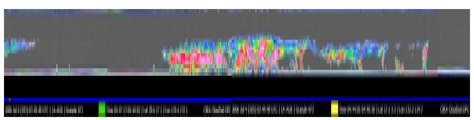
- Overall, CloudSat gives an unparalleled view of a slice through the eye of a hurricane and a cross section of precipitation through the hurricane .
- Although there are only 32 overpasses of the earth each day, CloudSat has made seven eye hits of hurricanes and seven eye wall grazes. A statistical analysis predicts that one would expect 9 eye hits for a 29 hurricane season. The common features of the eye such as the spiral rainbands and the stadium structure of the eye wall boundary help identify a pass near the eye. There is very heavy rain in the eyewall, so much so that the radar return is completely absorbed several km above the ocean surface at a rainfall rate of 30 mm/hr. This also helps to identify an eye wall graze.

Precipitation areas of NH hurricanes

- Hurricanes cover large areas which are profiled by a latitude slice with CloudSat. The CloudSat slices through the hurricanes were used to estimate the area covered by rainfall and drizzle in each hurricane. These slices were used to calculate the average area covered by precipitation in each of the eight events. This was then used as the mean area for the 29 hurricanes in 2006. The season covered 24 weeks and each storm lasted typically a week. A mean duration of one week was used, so there was on average, one storm active in the NH belt from 0 to 20 degrees N continuously during the season.

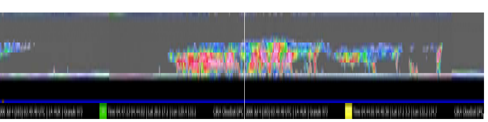
Typical CloudSat cross section through a hurricane in 2006

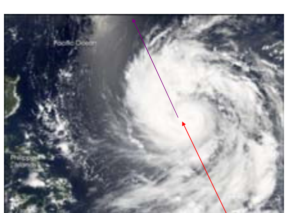
1100 km



2500 km

Size of precipitation diameter about 1000 km





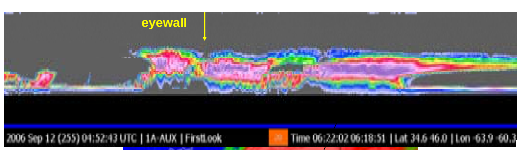
Day 185 July 4
20,130

CloudSat pass through the Eye of **Typhoon Eweniar**

Hurricane	Diameter from CloudSat
Ewiniar	1000 km
Prapiroon	1100 km
Lane	950 km
Ileana	950 km
Helen	850 km
Daniel	650 km
Carlotta	750 km
Florence	850 km
Average	890 km

Strong absorption of solar NIR by precipitating clouds

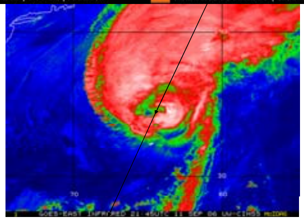
- Our previous work on the strong absorption of solar NIR by precipitating clouds showed that precipitation in clouds can typically cause 50 W/m^2 of absorption of solar NIR radiation thus preventing it from reaching the ocean surface (The Figure shows an example where 78 W/m^2 was absorbed).
- This number can then used to calculate the total power absorbed by each hurricane.



Hurricane Florence

Close graze of eyewall

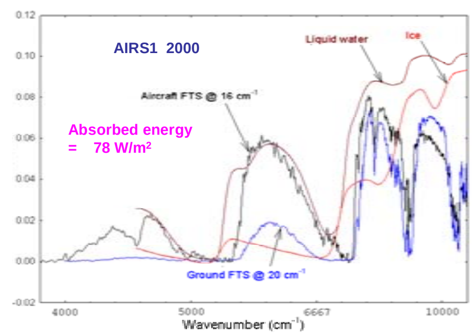
Sept 12,2006



Potential error in the surface energy budget of climate models

- The total average power absorbed can be used to estimate the potential error in the surface energy budget of climate models due to missing hurricanes.
- Area of a hurricane = πR_h^2
- = 3.14 x 450 km x 450 km = 0.64 x 10^6 km^2
- NH Belt ocean area = 2 πR_e x 2000 km x 2/3 = 40,000 x 2000 x 2/3 = 53 x 10^6 km^2
- area of a hurricane/area of tropics = 1/83
- 50 W/m^2/83 = 0.6 W/m^2 cooling in NH belt
- Temperature drop in NH belt =0.6 x .25 = 0.15 K

Comparison of Aircraft with Ground Spectra Showing Ice and Liquid Water Absorption



References

1. W.F.J. Evans and E. Puckrin, Near-Infrared Spectral Measurements of Liquid Water Absorption by Clouds, Geophys. Res. Lett., **23**, pp 1,941-1,944 (1996).

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FUTURE WORK

- In the future it is planned to extend this type of analysis to evaluate the cooling effect of other large storm systems by using the CloudSat data and ARM data.

SUMMARY

- Below hurricanes there is an average cooling of 12 C. This could be significant in the energy balance under the hurricane.
- In the NH hurricane belt this represents a cooling of 0.15 C
- If climate models do not have hurricanes, this would only be a 0.15 C error which is not significant to the global energy budget
- Regional effects would be in between these extremes

Total average power absorbed by NH hurricanes in 2006

- Thus, our previous work on the absorption of solar NIR by precipitating clouds of 50 W/m^2 was used to calculate the total average power absorbed by hurricanes in 2006 in the tropics.
- The average power absorbed by a hurricane was scaled by the average area to give an estimate of the average NIR power absorbed by a hurricane of 32 TW.
- The resulting estimate was that hurricanes in the NH hurricane belt absorbed 32 x 29 = 928 TW during the 2006 season.

Typical Hurricane cooling

- Precipitating area = πR_h^2
- R_h = 450 km
- 3.14 x (450 km) ^{2} = 0.64 x 10^6 km^2
- Total cooling below hurricane = 32 TW
- Average cooling below hurricane = 50 W/m^2
- Temp drop = 50 W/m^2 x .25 K / W/m^2 = 12 K