Typhoon Nida; November 28, 2009

Typhoon Nida was the most intense tropical cyclone during 2009, with a minimum central pressure of 900 hPa. Nida formed late in the season from a monsoon trough, and became a Category 5 Typhoon. The A-Train had an overpass of the storm when it was at or near maximum intensity, with sustained winds of 135 knots and central pressure of 926 hPa. The storm was near the edge of the Typhoon eye, which was in this case covered at high altitude with cirrus clouds observed by the IIR and CALIPSO. The radar observed heavy rain near the ocean surface. The Nida overpass makes an ideal case study for understanding how the instruments perform while observing deep convection. The optical depth of the storm varies, so a comparison can be made of one big convection system that has many varied conditions associated with it. The core of Nida is opaque to the IIR, but the edges of the storm are transparent. The cloud tops reach to 18 km, not only above the eyewall and core, but also at the transparent edges of the storm where they remain almost as high. CALIPSO sees a very thin, wary layer of barely visible cirrus at 19 km above the eye. The IIR shows the variation in effective particle size and optical properties. This Typhoon suggests that a much more detailed case study of Typhoon Nida will be rewarding.

The View from the Top: CALIPSO Ice Water Content in the Uppermost Layer of Tropical Cyclones

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Introduction: NASA’s CALIPSO satellite carries both the Cloud and Aerosol Lidar with Orthogonal Polarization (CALIOP) and the Imaging Infrared Radiometer (IIR). The IIR is ideally suited to viewing the very top of tropical cyclones, and the IIR provides critical optical and microphysical information. The IIR and the CALIOP data work together to understand storm clouds since they are perfectly co-located, and big tropical cyclones provide an excellent complex target for comparing the observations. There is a lot of information from these case studies for understanding both the observations and the tropical cyclones, and we are just beginning to scratch the surface of what can be learned from tropical cyclone cloud particle measurements. Many tropical cyclone cloud particle measurements are focused on the mid and lower regions of storms, but characterization of cyclone interaction with the lower stratosphere may be important for determining the total momentum and moisture transport budget, and perhaps for predicting storm intensification as well. A surprising amount of cloud ice is to be found at the very top of these big storms.

CALIPSO measures 532 nm backscattered light, at both parallel and perpendicular polarizations. The backscattered signal, with 60 m vertical resolution, provides an accurate measurement of tropical cyclone cloud top heights. Ice water content is parameterized from optical extinction coefficients, using an empirical relationship derived from aircraft measurements (Heymsfield et al., 2003). Extinction coefficients are retrieved as the 532 nm beam penetrates the cloud deck, until attenuation occurs at an effective optical depth of approximately three, with some extinction profiles deeper than this due to multiple scattering effects. Depolarization by ice cloud particles provides some insight about particle phase and habit. CALIOP sensitivity to ice crystal content in the uppermost layer is 0.1 mg/m³ (Avery et al., 2012), a detection range that includes sub-visible cirrus and allows CALIPSO to accurately measure cloud top height in the storm core and also in the associated rain bands and extended cirrus shield. The IIR has 3 medium-resolution channels centered at 8.65 μm, 10.6 μm and 12.05 μm. The Level 1 IIR radiances are registered on a reference grid centered on the CALIPSO ground track, with 1 km horizontal resolution over a 498 km swath. Effective emissivities and optical depths are derived for suitable scenes selected according to the vertical information provided in the CALIOP Level 2 layer products (Garnier et al., 2012a). Ice crystal effective diameters are derived using a split-window technique and two effective microphysical indices defined as the 12.5 to 10.6 and 12.5+to 12.05 μm ratios of the natural logarithm of the co- emissivities (Part A et al., 1999; Garnier et al., 2012b). These three models have been selected in the works by Yang et al. (2007), as representative of the families of relationships between both microphysical indices and ice crystal effective diameter.

The CALIPSO and IIR operational products (Version 3) are available at: NASA LaRC ASDC (http://eosweb.larc.nasa.gov) and ICARE (http://www.icare.univ-lille1.fr) and references are provided.

References:


Hurricane Sandy: October 29, 2012

NOAA/NAO GOES-13 13.2 μm IR images from October 29, 2012, enhanced by the SSEC at the University of Wisconsin, CMDSS. The images show the substantial movement and merging with an extratropical system just before landfall. The CALIOP water content overpasses of Sandy on this day occurred at ~7:15 UTC (nighttime overpass, outshined in blue) and ~17:15 UTC (daytime overpass, outshined in red). During the night the VIIRS instrument also captured an image of Sandy in the 741-nm MODIS and CloudSat also provide data.

These images were made with the VIIRS day/night bands using levels from the VIIRS data and the CALIPSO data. The larger image has the CALIPSO satellite overpass ellipses plotted in red, with points A, B and C corresponding to these labeled points on the CALIPSO and IIR data plots. The smaller image shows the location of Hurricane Sandy on the previous NPP MODIS IR Swath images of Hurricane Sandy.

Optical and Microphysical Cloud Particle Properties derived from the IIR 8.65, 10.6 and 12.05 μm channels also show the difference between the main tropical and extratropical Circus associated with Sandy. The optical depth (D) and effective particle size (N) larger in the tropical C, as is the ice water path (IWP). A shape index also varies (H; 7 for aggregates-like, 8 for plates-like, and 9 for solid columns-like).

Cloud Temperature and Ice Water Path: Plot A is the cloud top temperature and average temperature of the SSM/I GEO 5.72° interpolated meteorological assimilation. The range of temperature is largest for the extratropical clouds. Plots B and C are the CALIOP ice water content in water paths, respectively.

Daytime overpass of Sandy, just before landfall: The A-Train passed over the western edge of Hurricane Sandy on October 29 at ~17 UTC, 3 am EDT. The images illustrate how well the CALIOP and CALIPSO are in providing a rapid assessment of the Hurricane. CloudSat (left) identifies the thick lower clouds and rain, while CALIPSO provides cloud top height and ice water content above 10 km.