GOES and CloudSat: Geo/Leo Synergy

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Launched on April 28, 2006, CloudSat is a NASA earth observation satellite that uses radar to measure the altitude and properties of clouds. CloudSat is part of the "A Train Constellation", flying in formation with several other satellites (Aqua, Aura, CALIPSO, and the French PARASOL) whose orbits occur in the same path, one behind the other. This configuration allows measurements to complement each other. CloudSat's main sensor is the Cloud Profiling Radar (CPR), a 94-GHz nadir-looking instrument that measures both the returned backscattered energy by clouds as well as cloud location and altitude. Thus, it is possible to derive accurate cloud heights and vertical profiles. CloudSat is not an operational instrument, but the Naval Research Laboratory in Monterey, CA (NRL-MRY) has placed CloudSat products on its NexSat website in near real-time to demonstrate potential forecaster applications.

The A Train Constellation (Fig. 1) has several other instruments that are potentially useful to operations, especially hindcasting. The Aqua satellite has the Advanced Microwave Scanning Radiometer-EOS (AMSR-E) instrument which can provide 2-D images of precipitation rate. While CloudSat cannot measure precipitation rate in all situations, it can be used to examine cloud processes that underlie AMSR-E retrievals. Aqua also contains the MODIS instrument which has become famous for spectacular high resolution true color images. The A-Train Calipso instrument is a cloud lidar which can give important information about cloud height, cloud phase and aerosol characteristics. The remarkable thing about the constellation concept is that although the satellite instruments are orbiting separately, together they comprise a “virtual satellite” for which observations coincide in time and space.

CloudSat can be used along with visible and infrared products to give us insight into frontal systems, especially over the large radar oceanic data void basins. While CloudSat's radar is designed to sense clouds rather than precipitation, it can still characterize precipitation in terms of stability and structure. For example, in Fig. 2, CloudSat has passed over two major cloud systems within a Pacific frontal system (orbit represented by the red line). Below the image, these two cloud systems are profiled. The northern cloud system shows a broad area of stable precipitation indicated by a melting layer. This feature is a horizontal reddish feature just below the 0° C level (black horizontal line bolded for emphasis). This suggests steady rain at the surface. The southern cloud system has a much different precipitation regime, characterized by numerous convective elements with no clearly defined melting layer. Notice that high reflectivities extend much higher into this cloud system, suggesting pronounced vertical motion and heavy convective showers at the surface. To analysts viewing model output and satellite images in a normal forecasting environment, such radical differences in precipitation structure might not be apparent.

The precipitation profiles shown in the two cloud regimes are consistent with the Norwegian Cyclone Model (Bjerknes and Solberg, 1922) in Fig. 3. In the northern hemisphere the north and east quadrants of mid-latitude cyclones are marked by the overrunning of warm air streaming northward and producing stable precipitation regimes. In the south and west quadrants cold air advection destabilizes the atmosphere, bringing convective precipitation. While this pattern is well known, CloudSat shows it more vividly and directly than any other observing system. For this reason CloudSat profiles are now being included in meteorological textbooks and other training materials. Even if the CloudSat concept has few strictly operational applications due to its low temporal/spatial refresh, it should have a unique place in case studies to enable forecasters to understand cloud and precipitation processes.

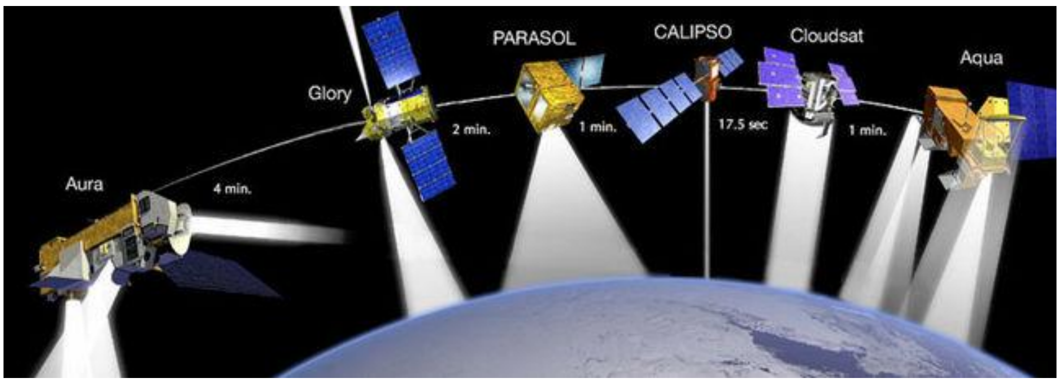

Figure 1. A Train Constellation. Credit: NASA

To view NRL CloudSat products go to http://www.nrlmry.navy.mil/NEXSAT.html and choose “CloudSat > radar_prof” from the Products frame on the left.

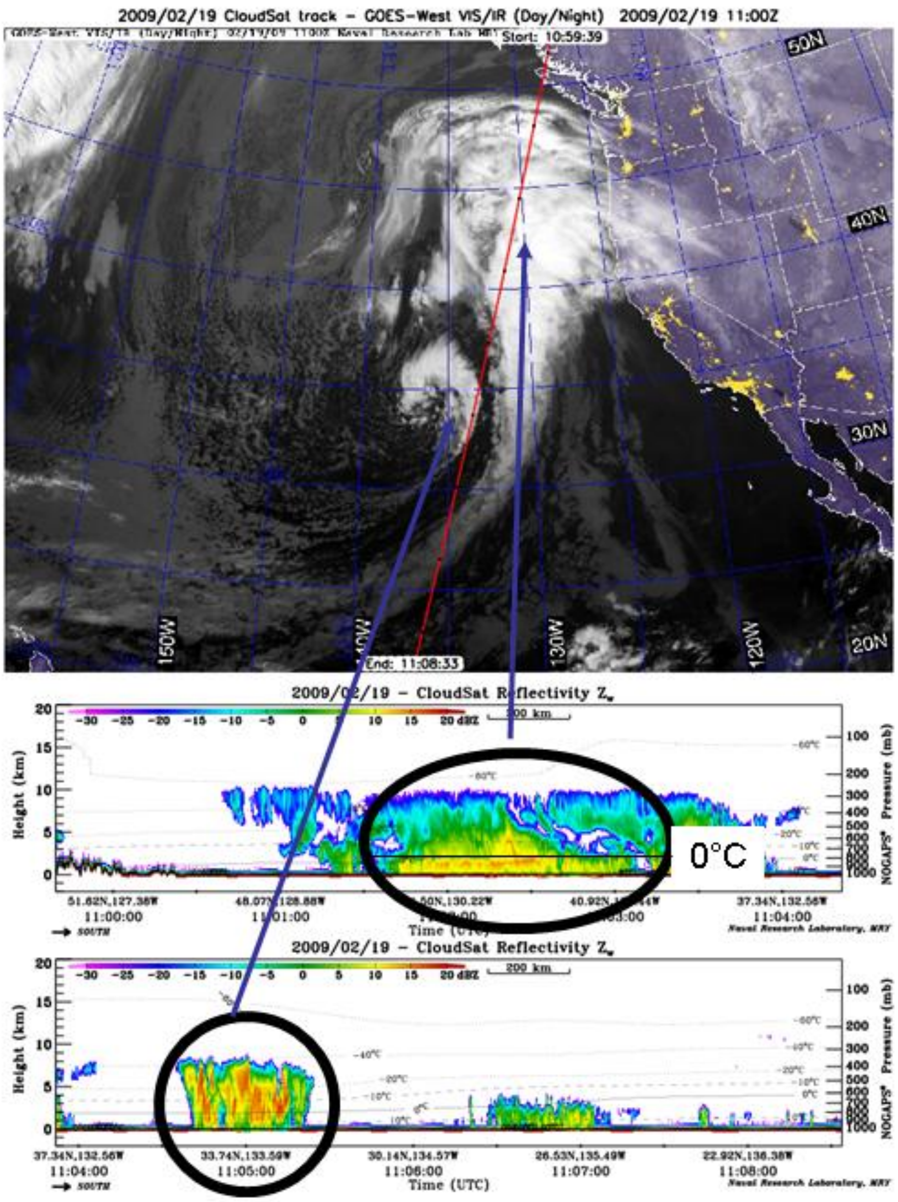

Figure 2. Top Panel: GOES infrared “GeoColor” image of the East Pacific. Middle Panel: CloudSat profile along northern segment of red trace (top panel). Isotherms are black dashed lines except for the O°C level, annotated in solid black for legibility. Bottom Panel: CloudSat profile along southern portion of red trace.

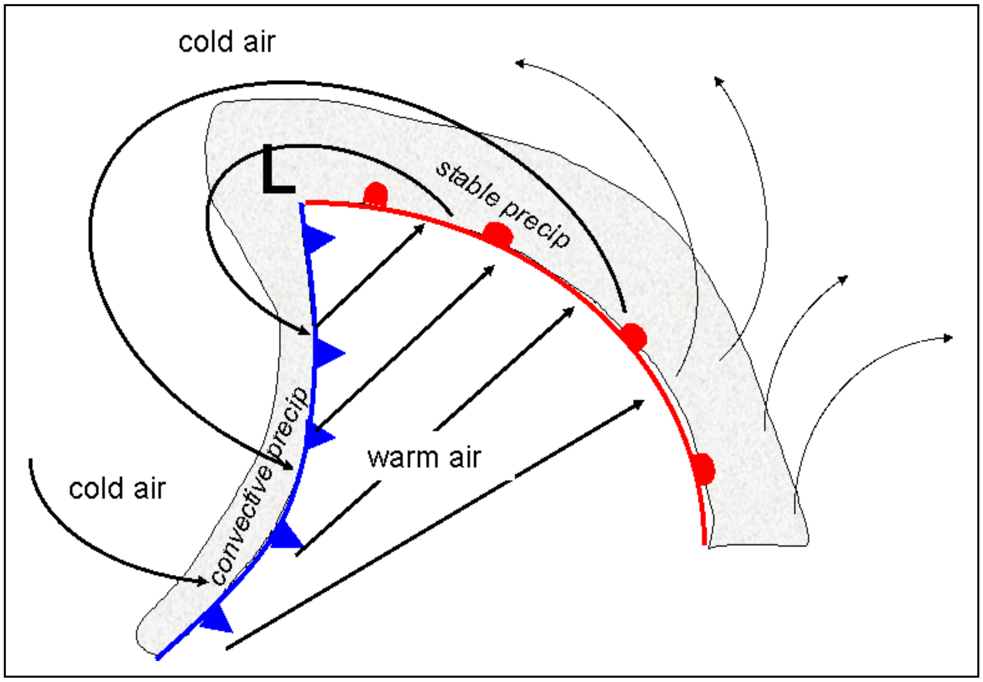

Figure 3. Authors' rendition of the Norwegian Cyclone Model**.**

Reference

Bjerknes, J. and H. Solberg 1922. Life cycle of cyclones and the polar front theory of atmospheric circulation. Geofys. Publ. 3, 1-18.

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