Future Enhancements to GOES-R Retrievals of Nighttime Cloud Optical & Microphysical Properties

Patrick W. Heck
Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin-Madison, Madison, Wisconsin

Patrick Minnis
Science Directorate, Climate Science Branch
NASA Langley Research Center, Hampton, Virginia

Gang Hong **Fu-Lung Chang** **Sarah T. Bedka** **Christopher R. Yost** **J. Kirk Ayers**
<-------- *Science Systems and Applications, Inc.* ----->
Hampton, Virginia

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Introduction

Currently in the GOES-R framework, NASA Langley's Nighttime Cloud Optical and Microphysical Properties (NCOMP) algorithm, a thermal wavelength-only retrieval algorithm can be applied both day and night, but is used primarily at night due to the added advantages of using visible wavelengths during sunlit portions of the day. NCOMP is one of the suite of techniques being used to retrieve cloud properties from the GOES-R Advanced Baseline Imager (ABI) proxy data set, SEVIRI imagery.

NCOMP is a variation of NASA Langley's Solar-infrared Infrared Split-window Technique (SIST), which is being applied at LaRC to SEVIRI, GOES, MODIS, AVHRR, FY-2C and MTSAT data in near real-time in support of a variety of projects. SIST-derived nighttime cloud properties derived from MODIS data also form one of the underpinnings of Clouds and the Earth's Radiant Energy System (CERES) radiation budget products.

Using wavelengths in the window region (11.2 and 12.3 µm, as well as the emitted portion of 3.9 µm) NCOMP yields cloud macro-physical and microphysical properties that have been validated and meet the GOES-R F&PS requirements. NCOMP retrieves

- **Cloud Optical Depth (COD)**
- **Particle Size (CPS)**
- **Liquid Water Path (LWP)**
- **Ice Water Path (IWP)**

Due to the inherent limits of using the window region channels, NCOMP cloud optical depth (COD) accuracy is limited to optically thin clouds (about tau < 6), so usage of additional wavelengths outside the window region is being explored . An example of this new technique's application to MODIS, GOES and MTSAT data is presented.

Additionally, an application of a multi-layer detection and retrieval algorithm using CO_2 channels is presented. This technique has been used extensively during daylight hours and is now being extended to nighttime imagery when COD information was previously less robust.

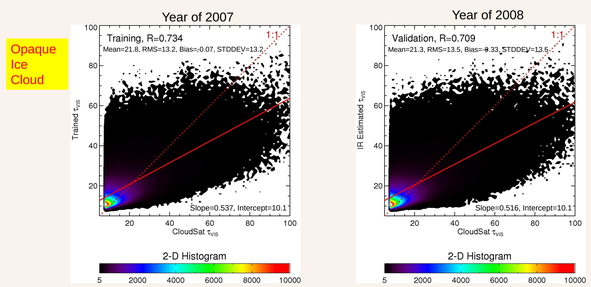
New Thermal Retrievals for Optically Thick Clouds at Night

The **W**ater vapor **I**nfrared **T**echnique (**WIT**) is based on work from Gang Hong.

Using 3.7-, 6.7-, 11.0- and 12.0-µm channels or their equivalents from GOES, MODIS or MTSAT, WIT has been developed and applied to a full year of imagery.

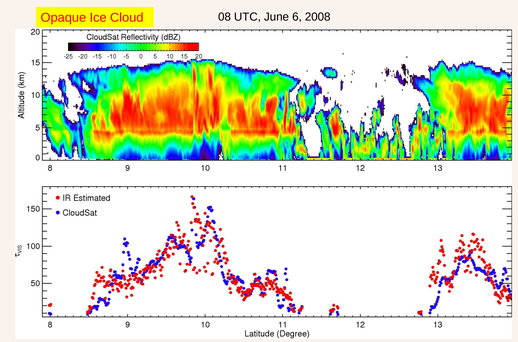
WIT uses a combination of a SIST-type approach and a neural network approach to derive COD, CPS and cloud top temperature/height for a much larger range of COD.

Neural Network Training for Opaque Ice COD at the Nighttime from MODIS 3.7, 6.7, 11.0, and 12.0-µm



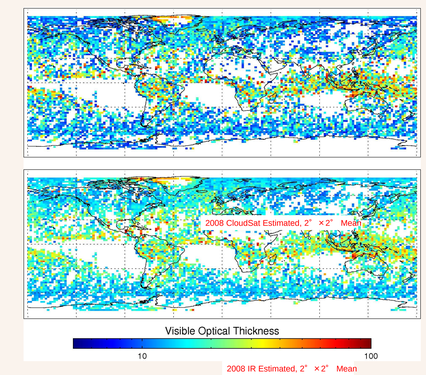
WIT shows promise for extending the range of nightime COD to as large as 75 or greater.

Opaque Ice Cloud CODat the Nighttime: An Example of Application



WIT COD compares very well with CloudSat fo an individual scene.

Geographical Distribution of Opaque Ice COD at Night from CloudSat and MODIS



WIT COD compares well with CloudSat COD both on a mean annual basis and regionally.

Note that the optically thin COD are retrieved with an NCOMP-type approach, whereas for thick clouds WIT is applied.

Conclusions & Future Plans

•The development and application of the Water vapor Infrared Technique (WIT) has been exhibited with promising results for the extension of COD to much greater values.

•WIT COD compared well to a validation set of CloudSat COD for optically thick ice clouds and for the thin clouds that were obtained by NCOMP-like methods.

•Work is ongoing to extend the neural network technique to CPS for ice clouds and to cloud temperature. Initial results for cloud temperature were excellent, but that is expected for optically thick clouds. Ice CPS work continues.

•Variations of WIT can be developed for different instruments should particular channels be unavailable.

•The MCAT multilayer system is producing a depiction of multilayer clouds that validates well with surface measurements, hence the apportionment of COD into upper and lower layers is promising.

•Consistency between day and night application of MCAT is excellent.

•A combination of WIT and MCAT can be used to infer a more sophisticated depiction of multilayer clouds that includes a separation of upper and lower cloud layers with accurate cloud optical depth and particle size, including larger COD than is currently retrieved

•NCOMP can easily be updated to include some of these features in the future.

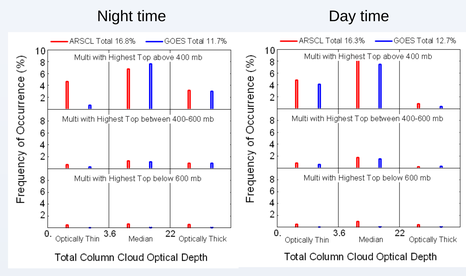
•VIIRS and other instruments could be included, but VIIRS' lack of a water vapor and 13.3-µm channel is a hindrence.

Nighttime Retrievals of Multi-Layer Cloud Properties

The MCAT, a new multilayer cloud property retrieval algorithm, is based on the work of Fu-Lung Chang.

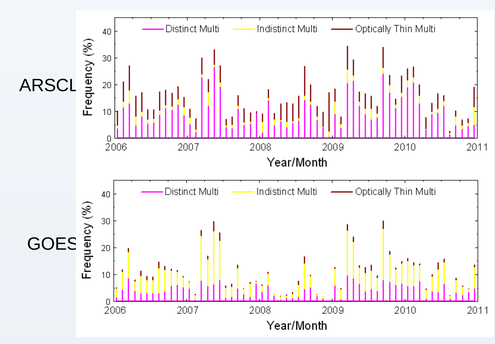
It is an extension of CO2-based methods.

Multilayer Cloud Amount for different Highest Top and COD



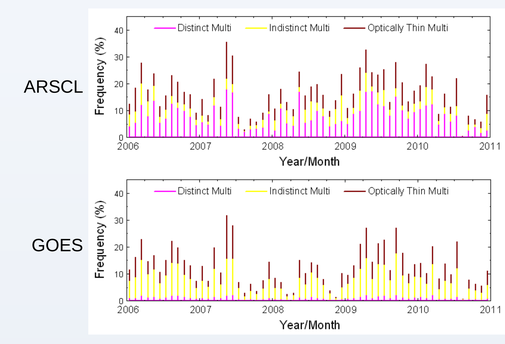
MCAT cloud amounts from GOES for multilayer clouds at the ARM SGP for 2006 to 2010 for are much like surface-based retrievals (ARSCL) for a large range of COD.

Daytime Monthly Multilayer Cloud Amount at ARM SGP Site



MCAT daytime multilayer cloud amounts from GOES at the ARM SGP for 2006 to 2010 for all 3 multilayer cloud types agree quite well .

Nighttime Monthly Multilayer Cloud Amount at ARM SGP Site



Similarly, MCAT nighttime multilayer cloud amounts from GOES agree quite well, exhibiting MCAT's promising performance at night when NCOMP and SIST COD was previously limited to thin clouds.