Satellite Cloud Retrievals for ARM Sites and Field Experiments

P. Minnis[1], W. L. Smith, Jr.[1], R. Palikonda[2], P. Heck[3], C. R. Yost[2], M. L. Nordeen[2], F. L. Chang[2], T. Chee[2], D. A. Spangenberg[2], G. Hong[2], J. K. Ayers[2], K. T. Bedka[2], S. Bedka[2], M. M. Khaiyer[2], Q. Trepte[2], B. Scarino[2], B. Shan[2]

[1]NASA Langley Research Center, Hampton, VA [2]Science Systems and Applications, Inc., Hampton, VA [3]CIMSS, U. Wisconsin, Madison, WI

http://www-angler.larc.nasa.gov/satimage/products.html

Motivation: ARM needs satellite data to complement surface measurements

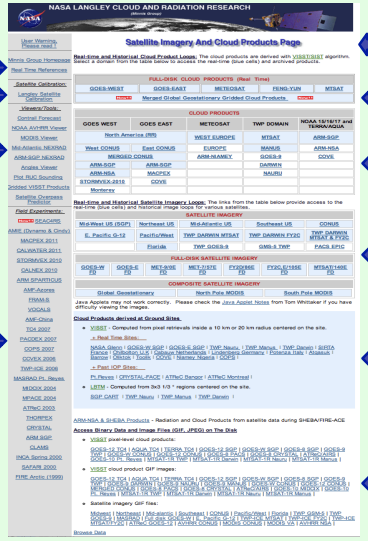
- Outgoing radiation not measured at the surface
  - *satellite can provide outgoing longwave radiation and shortwave albedo, & some spectral radiances*
- Surface measurements characterize clouds only over small area => *partial picture*
  - *satellite data can be used to estimate cloud fields over larger scales at lower resolution, less info content*
- Cloud modeling studies need larger scale validation data and boundary/initial conditions
  - *satellite data used both for validation and initialization of GCMs, SCMs, WRF, etc.*

Objective: Provide large scale cloud & radiation parameters for ARM

- Produce variables as consistent as possible with ARM sfc measurements, for all domains
  - *calibrate satellites against a common reference*
  - *validate results using ARM surface and aircraft measurements*

Data & Methods

- **Cloud & radiation parameters from geostationary (GEO) & low-earth orbiting (LEO) satellites**
  - Visible channel calibration standard: **Aqua MODIS** channel 1 (0.63 μm)
  - Shortwave & longwave flux standard: **CERES** broadband data — *See **Khaiyer** poster*
  - Main cloud retrieval algorithms: **VISST/SIST** — *(Minnis et al. 2011)*
  - Multilayer retrieval algorithm: **MCAT** — *See **Chang** poster*
    - *requires 13.3-μm channel, only on new GOES (12+), Meteosat, MODIS*
  - Special algorithms: **SINT**, applied to snow-covered regions — *(Minnis et al. 2011)*
    - *uses NIR in place of VIS channel to retrieve τ*
    - *requires 1.2, 1.6, or 2.1-μm channel, only on Meteosat & MODIS*
- **New methods & improvements under development, partial list**
  - Split-window retrieval for snow-covered scenes, for GOES, AVHRR, MTSAT-2
    - *aid retrievals over SGP, NSA; used for thin clouds over bright snow*
  - Other multilayer or thin cloud techniques for imagers lacking 13.3-μm channel
    - *Split-window approach*
    - *Water vapor – infrared technique (**WIT**) and WIT-VISST Multilayer System (**WIMS**)*
  - Clear-sky updating for snow and snow-free surfaces
    - *improves cloud detection & retrievals*
    - *provides data for monitoring surface albedos*
  - Overshooting Convective Tops
  - Surface skin temperature — *See **Scarino** poster*
  - Cloud water content profiling
    - *provides reasonable estimate of vertical structure of clouds*
    - *enables the development of 4-D cloud representation*
- **New & Variable Domains for AMF sites, Field Experiments**
  - *Data available at Langley site or ARM Data Center*



Langley Web Page
http://www-angler.larc.nasa.gov

Full disk & global cloud products

Ongoing and historical domains for ARM and other projects, many include ARM domains

Imagery for various domains

Includes various channels & combinations

Surface site averages
- e.g., up to 96 data points per day

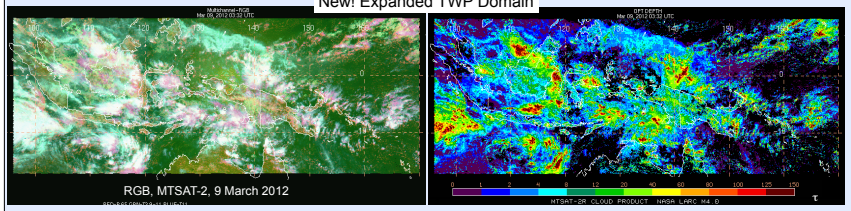
Provides ascii and/or gif plots

Links to obtain digital data and imagery directly from file list rather than menu

Digital downloads also available from menus above, some data available at ARM Data Center

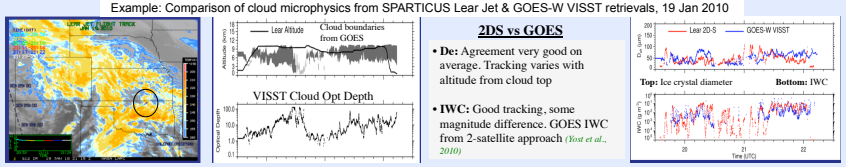
Domains: SGP, TWP, NSA, AMF (Azores, MASRAD, AMIE, COPS, STORMVEX, SPARTICUS, etc.)

New! Expanded TWP Domain



Validation: Comparisons to surface/in situ measurements from SGP, TWP, NSA, AMF, & AAF

Example: Comparison of cloud microphysics from SPARTICUS Lear Jet & GOES-W VISST retrievals, 19 Jan 2010

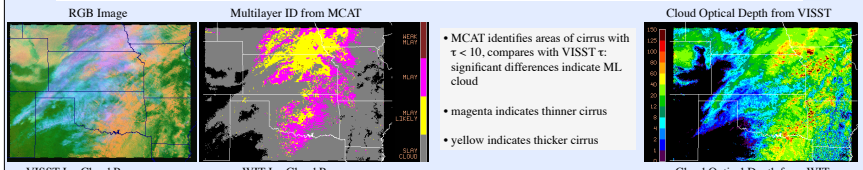


2DS vs GOES

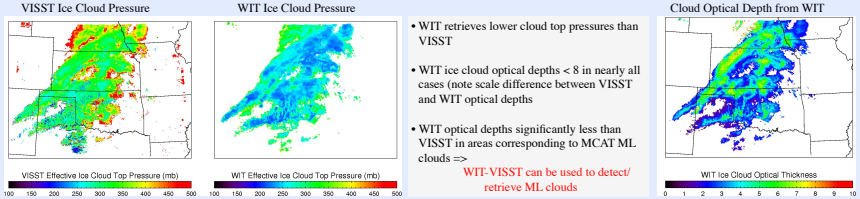
- **De:** Agreement very good on average. Tracking varies with altitude from cloud top
- **IWC:** Good tracking, some magnitude difference. GOES IWC from 2-satellite approach (*Yost et al., 2010*)

New Algorithms: Address shortcomings for snow & multilayer clouds

Example: Applying WIT to GOES to demonstrate capabilities for ML detection & retrieval: GOES-13 retrievals, 7 Mar 2012, SGP domain



- MCAT identifies areas of cirrus with τ < 10, compares with VISST τ: significant differences indicate ML cloud
- magenta indicates thinner cirrus
- yellow indicates thicker cirrus

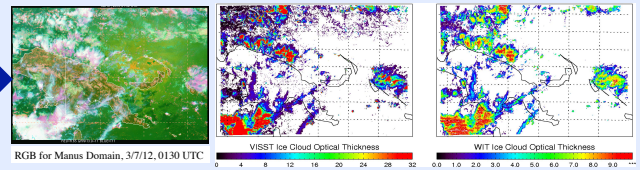


- WIT retrieves lower cloud top pressures than VISST
- WIT ice cloud optical depths < 8 in nearly all cases (note scale difference between VISST and WIT optical depths
- WIT optical depths significantly less than VISST in areas corresponding to MCAT ML clouds =>

WIT-VISST can be used to detect/ retrieve ML clouds

After proving its potential over the SGP, the WIT can be applied to the TWP domains to detect and retrieve multilayer clouds

- In some areas, WIT optical depths much smaller than VISST indicating multilayered clouds
- Work has just begun on this method



Summary

- Langley continues to provide a variety of satellite products to the ARM Science Team & community at large
  - Data are provided through two venues: ARM Data Center & Langley web site
  - Data are reprocessed on priority basis when new calibrations or improved algorithms become available
  - New domains added as when requested for AMF deployments or AAF or other field experiments
- Validation efforts ongoing using ARM & other measurements
- Algorithmic improvements made when possible and applied to real-time and archival data
  - improvements in the algorithm input also introduced periodically , e.g., clear-sky reflectance updating

Acknowledgment

This research supported by the ASR Program via Interagency Agreement, DE-SC0000991/003, with NASA LaRC through Batelle, PNNL.