Cloud & Surface Properties Derived from Satellite Data Over ARM Sites

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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** (Chang et al. 2010)
    - *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, data, & improvements under development**
  - Improved terminator cloud detection See Yost poster
  - Split-window retrieval for snow-covered scenes, for GOES, AVHRR, MTSAT-2
    - *aid retrievals over SGP, NSA; used for thin clouds over bright snow*
  - Nighttime ice cloud optical depth for thick clouds
  - Surface skin temperature for clear areas
  - **New Langley ARM Website**

http://cloudsgate2.larc.nasa.gov/cgi-bin/site/showdoc?docid=4&cmd=field-experiment-homepage&exp=ARM

- New web page puts all Langley ARM-related satellite information in one place
  - *links to main site, AMF, & IOP domains*
- Old and new datasets are all available as old links are restored
- New data from AVHRR, MODIS, Suomi NPP, and CERES Ed 4 later this year
- Data also available at DOE ORNL Archive

References

Chang, F.-L., P. Minnis, et al., 2010: A modified method for inferring cloud top height using GOES-12 imager 10.7- and 13.3-μm data. *J. Geophys. Res.*, **115**, D06208, doi:10.1029/2009JD012304.

Hong, G., P. Minnis, et al., 2012: Non-opaque and opaque ice cloud properties from infrared radiances at 3.7, 6.7, 11.0, and 12.0 μm. *Intl. Rad. Symp. 2012*, Berlin, Germany, Aug. 6-10.

Minnis, P., S. Sun-Mack, et al., 2011: CERES Edition-2 cloud property retrievals using TRMM VIRS and Terra and Aqua MODIS data, Part I: Algorithms. *IEEE Trans. Geosci. Remote Sens.*, **49**, *11*, 4374-4400.

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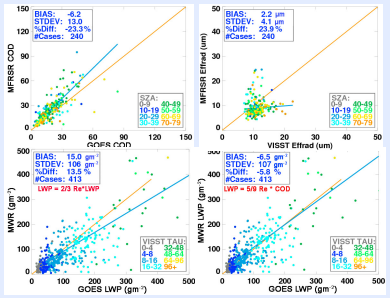
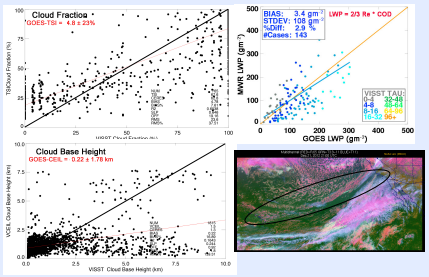
Validation

Liquid Cloud Properties, SGP, 2010
15-min SFC avg vs GOES 10-km radius



- Optical depth (Re) from GOES under (over) estimated relative to MFRSR, possibly due to GOES calibration, atmos absorption errors, MRSR uncertainties?
- Adiabatic LWP estimate (*lower right*) yields more unbiased value relative to MWR retrieval over SGP than std method (*lower left*)

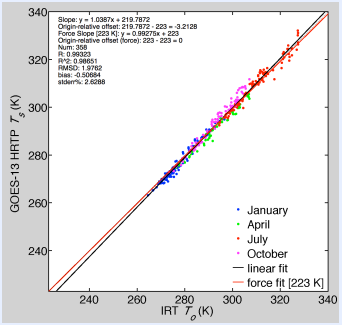
Cloud Properties, MAGIC, Sep – Dec 2012
15-min Ship avg vs GOES 10-km radius



- GOES cloud fraction 7% high relative to TSI on ship, yet *TSI is never clear.*
  - *Ceilometer cloud lower also due to missing cirrus*
- Cloud base heights from GOES tend to be too high compared to ceilometer measurements. Celiometer misses clouds above 7.5 km.
- GOES LWP matches MWR well, but uses standard definition. Adiabatic value would be 15% too small. Calibrations?

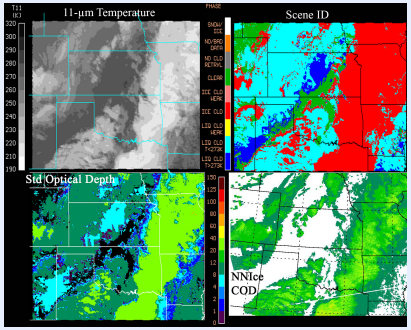
New Products

Clear-sky Surface Skin Temperature
SGP 10-m IRT vs GOES
T_s derived as in *Scarino et al.* (2013), Oct 2011 – July 2012



Matched IRT & GOES-derived skin temperatures for 100% clear sky 0.25° x 0.3125° region centered on ARM SGP Central Facility. RMS difference of 2.0 K. GOES T_s biased low by 0.5 K. This new parameter becomes part of Langley satellite products in 2013.

Thick Ice Cloud Optical Depth (COD) at Night
SGP Domain: GOES & MODIS
Ice cloud COD derived as in *Hong et al.* (2012), 4:15 UTC, 10 Mar 2013



Current nocturnal retrievals (GOES-E, *bottom left*) assume default COD, when COD > 8. Neural net (NN) COD retrieval (*MODIS*, bottom right), trained using CloudSat IWP/COD with Aqua MODIS 11, 3.7, and 6.7 μm temperatures, yields variable ice COD at ±63% uncertainty, unbiased. Will be merged with water cloud COD. Coming online for GOES in 2013.

Summary

- New ARM satellite web site should be more user friendly with data a click away
  - suggestions welcome for further improvements
- New parameters and improvements should expand applicability of satellite data in ARM studies
  - more information at night, surface temperature 24/7, fewer false clouds in twilight
- Comparisons with ARM data provide measure of consistency with surface data and help improve retrievals
  - explanations of LWP, COD differences lay in calibration, retrieval modeling
  - is adiabatic assumption for LWP calculation optimal?

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