Satellite Cloud and Radiation Retrievals for ARM and ASR

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Motivation: ARM needs satellite data to complement surface measurements

- Outgoing radiation not measured at the surface
  - Satellite can provide TOA outgoing longwave radiation, shortwave albedo, and some spectral radiances
- Surface measurements characterize clouds only over small areas => 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 cloud & radiation retrievals as consistent as possible with ARM sfc measurements for all domains
  - Calibrate satellite 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)
  - Retrieval algorithms applied to GOES, MSG, MTSAT, AVHRR, MODIS, Suomi NPP data
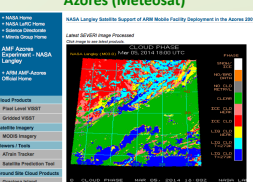
NASA Langley ASR Support webpage

- Accessed from http://cloudsgate2.larc.nasa.gov
- New design has all ARM-related satellite information in one place
- Satellite imagery and cloud products available for ARM ground sites (fixed and mobile) and aerial campaigns

Support for new ARM sites

Oliktok Point, AK (GOES-West)
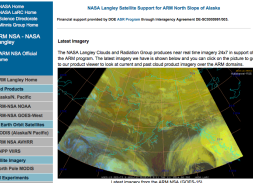
Azores (Meteosat)

Links to core ARM fixed sites

Links to AMF and AAF deployments

Links to viewers and useful tools

Quick links to A-Train tracking tool

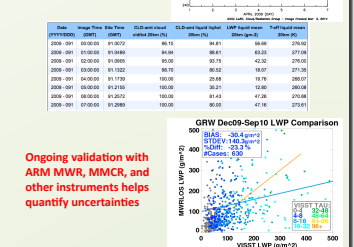## Available Satellite Imagery and Products

- Near real-time imagery and cloud and radiation products provided for each ARM domain
- Mean values within a 10- and 20-km radius of ARM fixed and mobile sites available as ASCII output
- Data are reprocessed when new calibrations and improved algorithms become available

Example cloud product imagery from Azores domain

0.65-μm reflectance | cloud temperature

multi-layer identification | broadband albedo
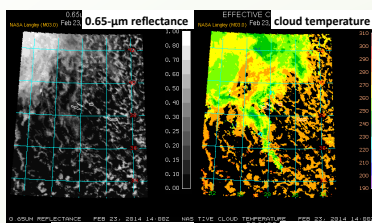
Sample Meteosat-9 cloud products matched to ARM Graciosa Island, Azores site within a 20-km radius

10- and 20-km means available as GIF images (right) or ASCII output (below)

Ongoing validation with ARM MWR, MMCR, and other instruments helps quantify uncertainties

Imagery available in GIF format. Pixel-level and gridded products available in NetCDF or ASCII format.

ASCII files with 10-km and 20-km mean properties ("radii files") available for these IOPs

Oliktok Point and Barrow data also available as part of NSA domain

Products available from multiple satellite instruments for many domains

Multi-layer cloud products limited to satellites with 13.3-μm channel

Experiment	Location	Dates Available	Satellite(s)
AMIE	Manus, Gan	Nov '11 – Jun '12	MTSAT-1R, MTSAT-2, FY-2E
MACPEX	SGP	Mar '11 – Apr '11	GOES-11, 12 Aqua, Terra
STORMVEX	Storm Peak Lab	Nov '10 – Apr '11	GOES-11
SPartICus	SGP	Jan '10 – Jun '10	GOES-11, 12 Aqua, Terra
Azores	Graciosa Island	Mar '09 – Mar '11, Jan '14 – Present	Meteosat-9, 10
AMF China	Taihu, Shouxian, Xianghe, Yuzhong	May '08 – Jan '09	MTSAT-2
COPS	Black Forest	Mar '07 – Dec '07	Meteosat-8, 9
TWP-ICE	Darwin	Jan '06 – Feb '06	MTSAT-2
MASRAD Pt. Reyes	Monterey	Mar '05 – Sep '05	GOES-10
AMF Niamey	Niamey, Niger	Apr '06 – Oct '07	Meteosat-8
MIDCIX	SGP	Apr' 04 – May '04	GOES-10

ARM Aerial Facility Campaigns

- Imagery and A-Train tracking tool useful for mission planning
- Aircraft flight tracks available on satellite imagery for all supported AAF campaigns
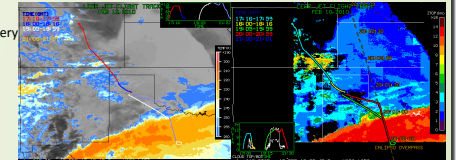- Mean cloud properties extracted along flight track and available as ASCII output

Sample flight track imagery from SPartICus

Supported AAF campaigns		
MACPEX	TWP-ICE	
CalWater	MIDCIX	
SPartICus	CRYSTAL-FACE	

Summary

- NASA LaRC ASR Support web site provides easy access to satellite imagery and cloud property retrievals
  - feedback and suggestions welcome for further improvements
- Cloud products are provided in various formats (netCDF, ASCII) in addition to real-time imagery for fixed sites and aerial campaigns
- Flight tracks and mean retrievals are also provided for requested AAF campaigns
- Validation studies with ARM products are ongoing work

Acknowledgement