GEO Edition 4 cloud properties

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Introduction

- The CERES cloud retrieval algorithm from MODIS adapted for the geostationary satellite data processing

- Available geostationary satellites provide up to 1-hour global monitoring between 60°S and 60°N

- CERES MODIS and GEO imager cloud properties are retrieved with the emphasis on improving the CERES flux product

CERES GEO derived cloud properties

- CERES group is challenged to provide the best cloud properties keeping in mind the following priorities
  - Consistent cloud properties throughout the Edition record, both in time, and amongst imagers to avoid any artificial discontinuities in the flux record
    - Edition 4 will be at least a 14 year record
    - There are now 15 GEO imagers, and 3 LEO imagers
  - Minimizing the number of pixels with no retrievals to mitigate scene specific systematic flux biases

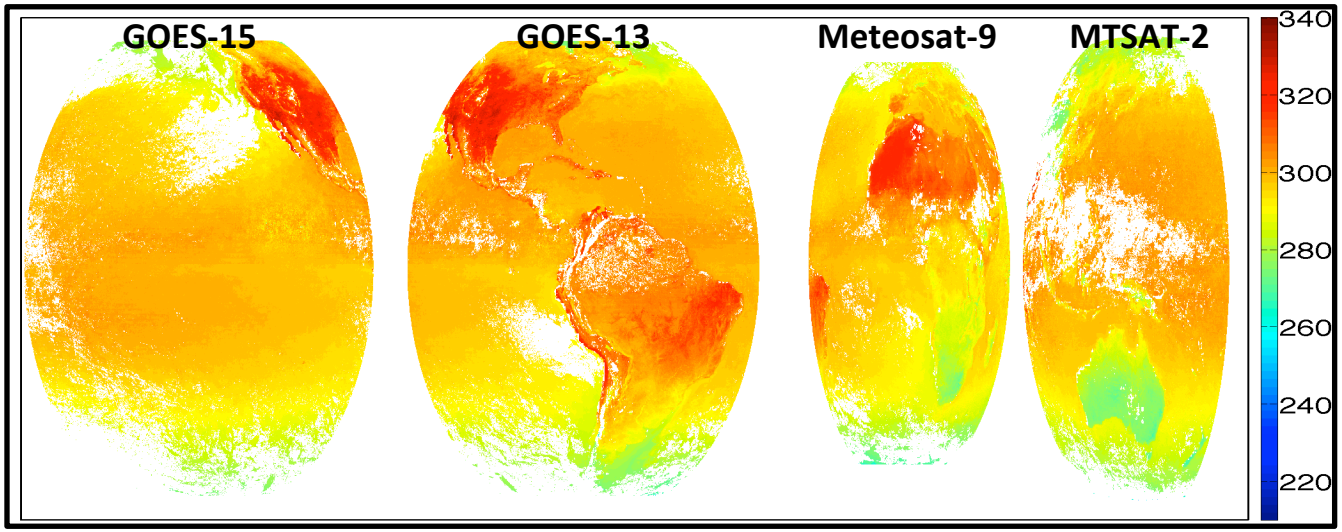
GEO Ed4 cloud retrieval improvements

	ED2	Ed4
channels	Visible and 11µm (LBTM)	Visible, 3.7µm, 11µm (VISST)
Temporal resolution	3-hourly	1-hourly
Particle size	Water = 10µm, Ice = 60µm	3.7µm retrieved. 7-water, 9-ice
Emissivity	Night = 1	Based on 3.7, 11 and 12µm at night
Clear-sky mask	GEOS-4/5 temperature threshold, MODIS monthly clear-sky albedo maps	GEOS-4/5 temperature threshold, MODIS monthly clear-sky albedo maps. Mask uses additional channels
Cloud top/base height	GEOS-4/5	GEOS-4/5 with MODIS code revised lapse rate. When 13.3µm present then co2 results used to correct Ttop.
Skin temperature	GEOS-4/5	retrieved

GEO-based Pixel-level Skin Temperature Algorithm

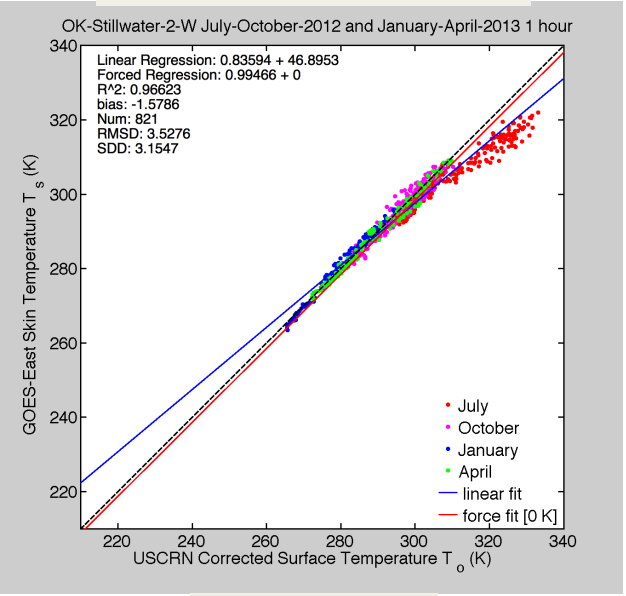
Scarino, B., P. Minnis et. al., 2013, Remote Sensing

- Start with modeled skin temperature T_s (MERRA at 1°x1° resolution)
- Bring T_s to TOA via correlated *k*-distribution and modeled sounding data
- Compare TOA value to observed 11-µm mean clear brightness temperature T_{toa} (from mask)
- Adjust modeled T_s and temperature/humidity profiles such that T_s consistent with observed T_{toa}
- Convert T_s and T_{toa} to radiance and find ratio for each 1°x1° grid box
- Apply ratio to pixel-level TOA radiance for all pixels within that 1°x1° grid box
- Yields a pixel-level surface radiance, which is converted back to T_s
- Only for designated-clear pixels not adjacent to designated-cloudy pixels



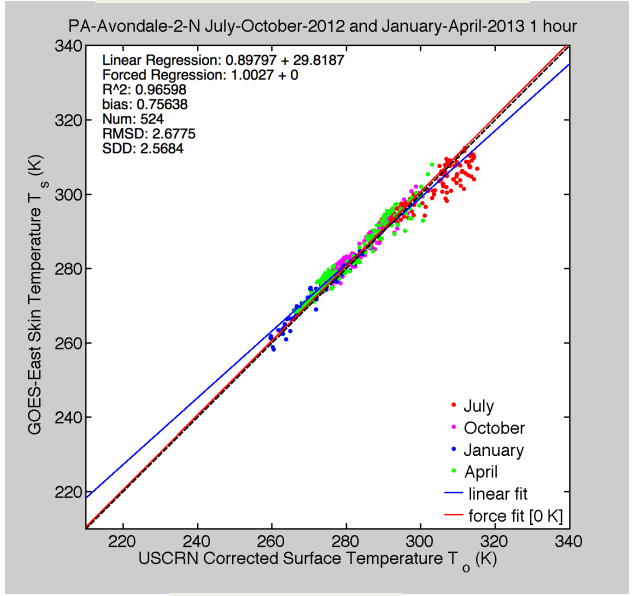
Land Skin Temperature Validation

NCDC USCRN IRTS-P
Stillwater, OK



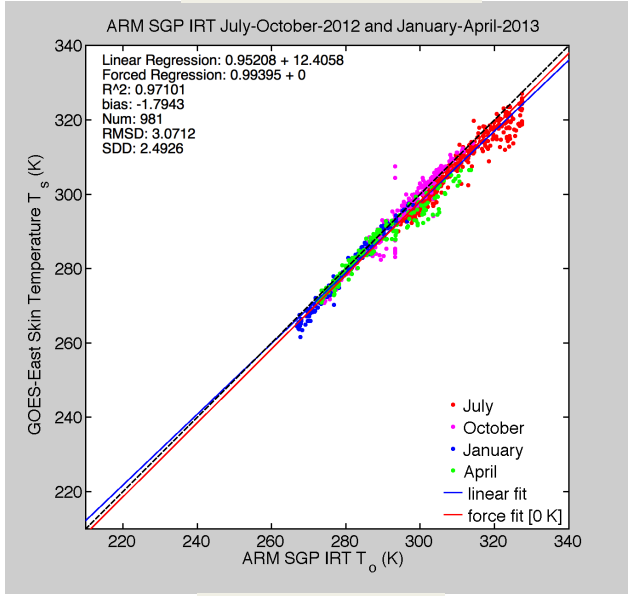
Bias -1.6°K

NCDC USCRN IRTS-P
Avondale, PA



Bias 0.8°K

ARM-SGP IRT

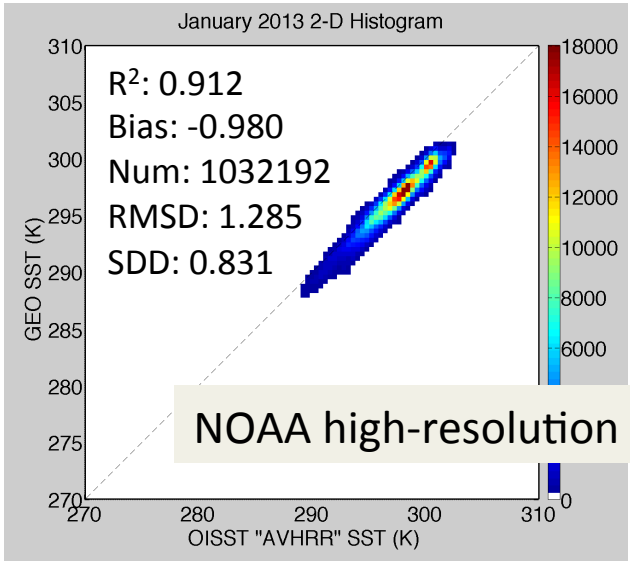


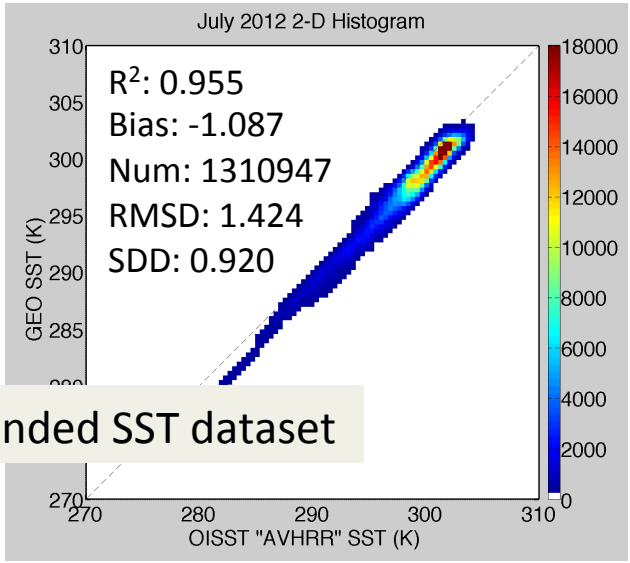
Bias -1.8°K

Compare GOES derived skin temperatures with ground observations

- IRTS-P is the Precision IR Ground Surface Temperature sensors
- ARM-SGP IR thermometer measurements (IRT)

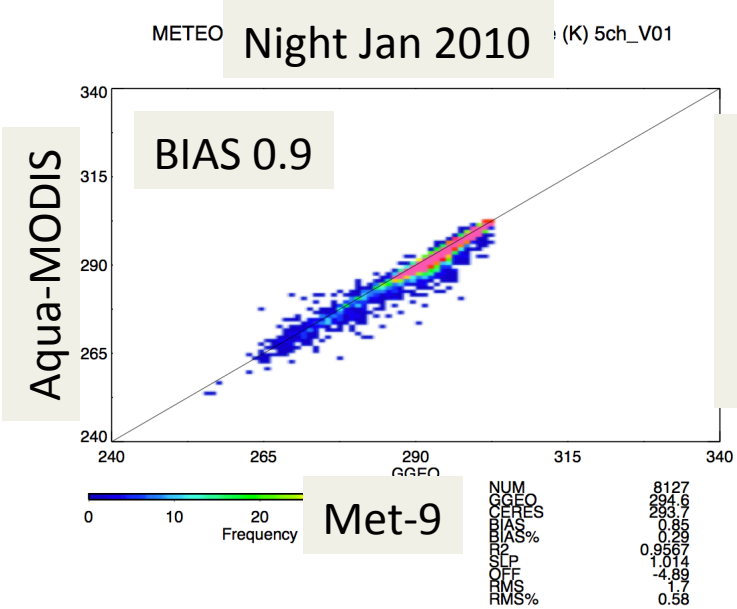
Skin Temperature Validation

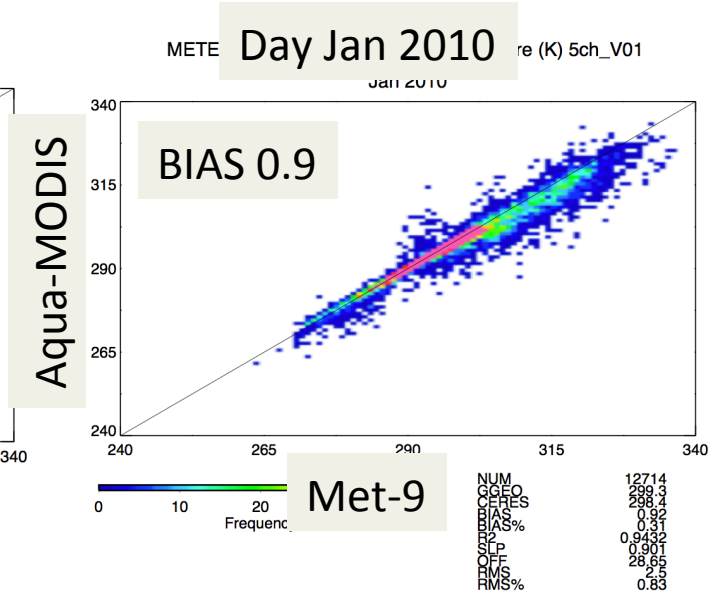




NOAA high-resolution blended SST dataset

- All skin temperature datasets within 2°K
- Investigating possible GEO view angle dependency

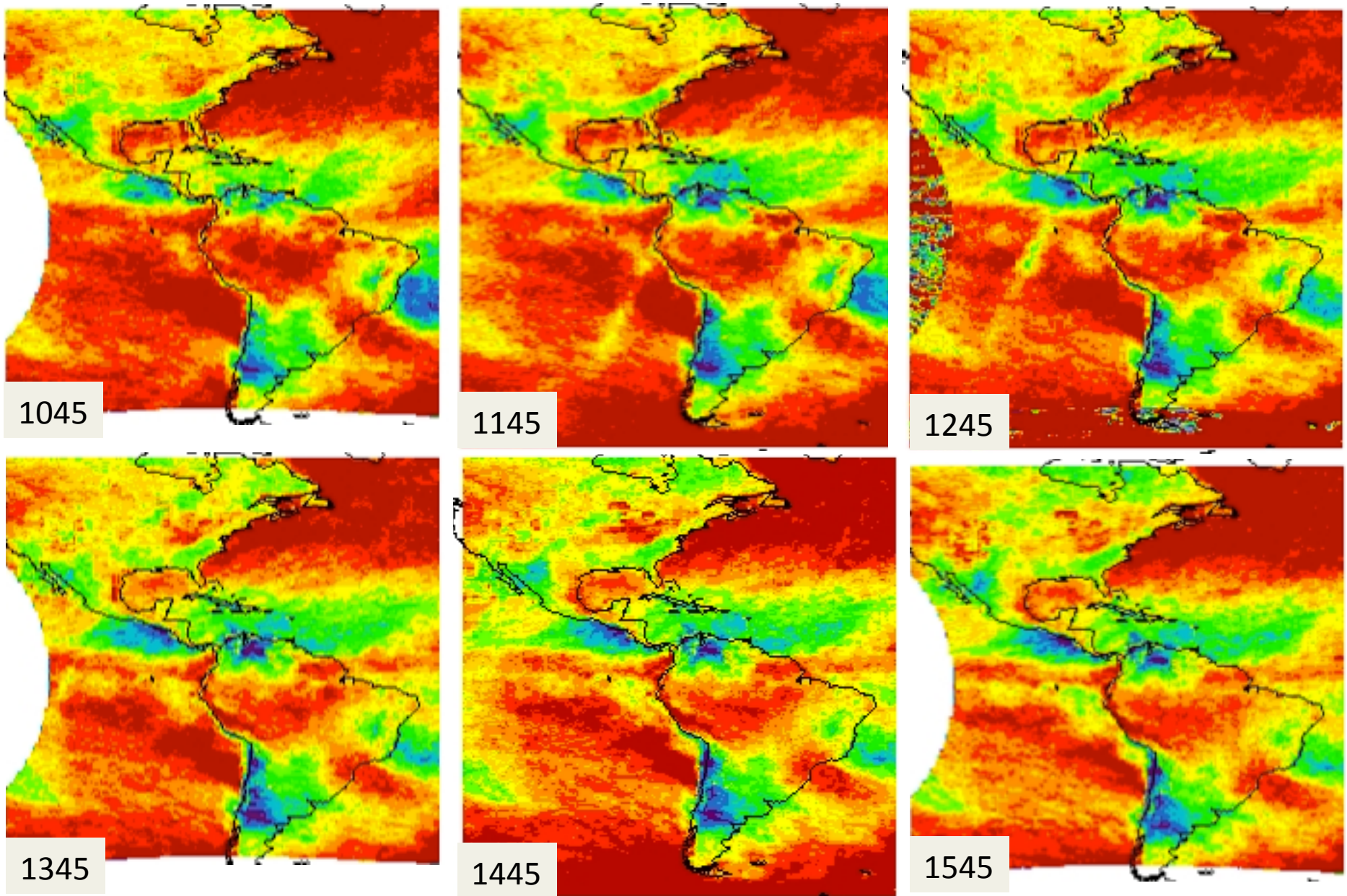




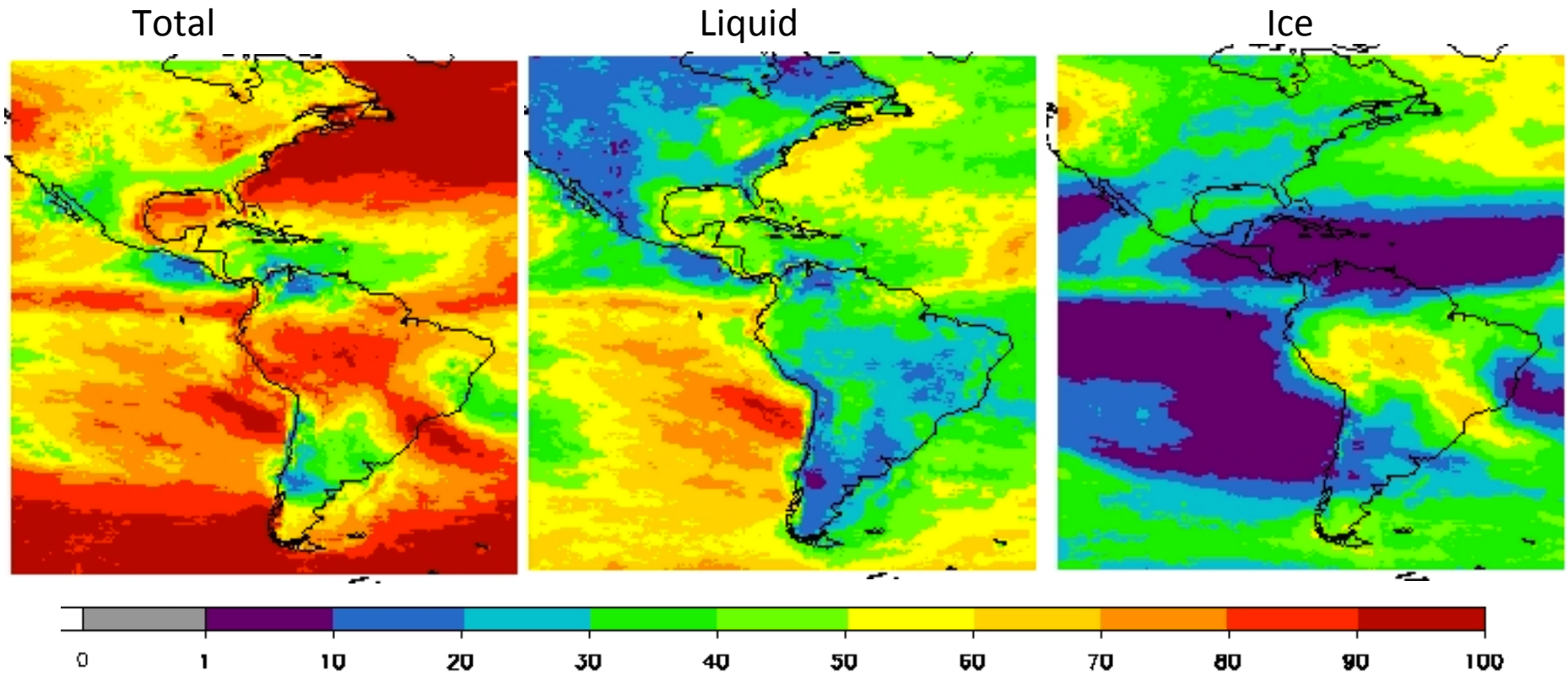
- MODIS team uses different surface emissivities

GOES-12 Total Cloud Amount, Jan, 2010, hourly means

- Hourly means show diurnal artifacts, e.g., terminator effects & sampling peculiarities



GEO cloud properties: monthly means



- Monthly hourly means used to compute monthly means
- Each parameter separated into liquid & water, day & night

GEO cloud properties QC

Monthly mean plot website to look for anomalies

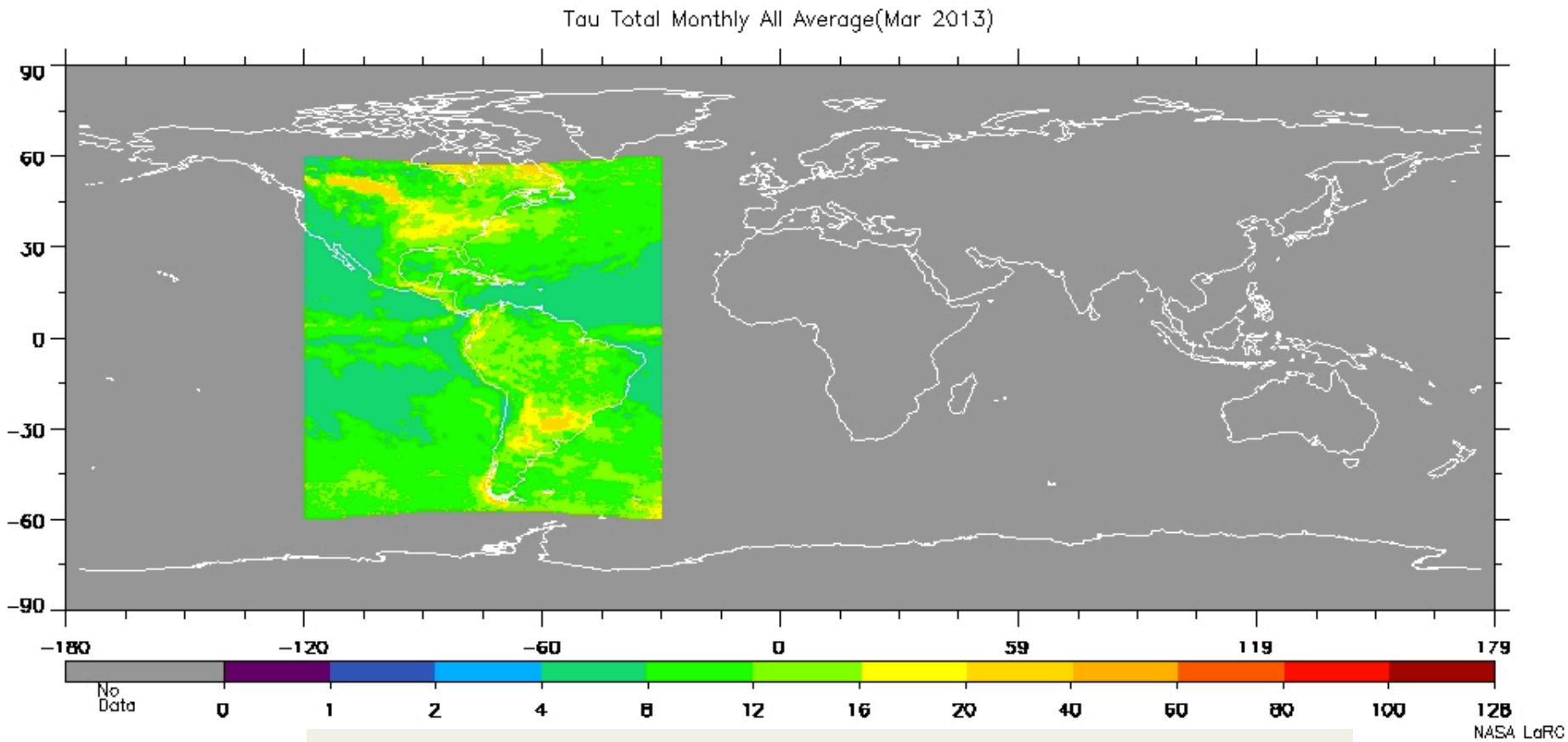
– Minnis Group Home | + Cloud Products | + Satellite Imagery | + Field Experiments | + Related References

VISST Monthly Averages for GOES-E

http://cloudsgate2.larc.nasa.gov/cgi-bin/site/showdoc?docid=220

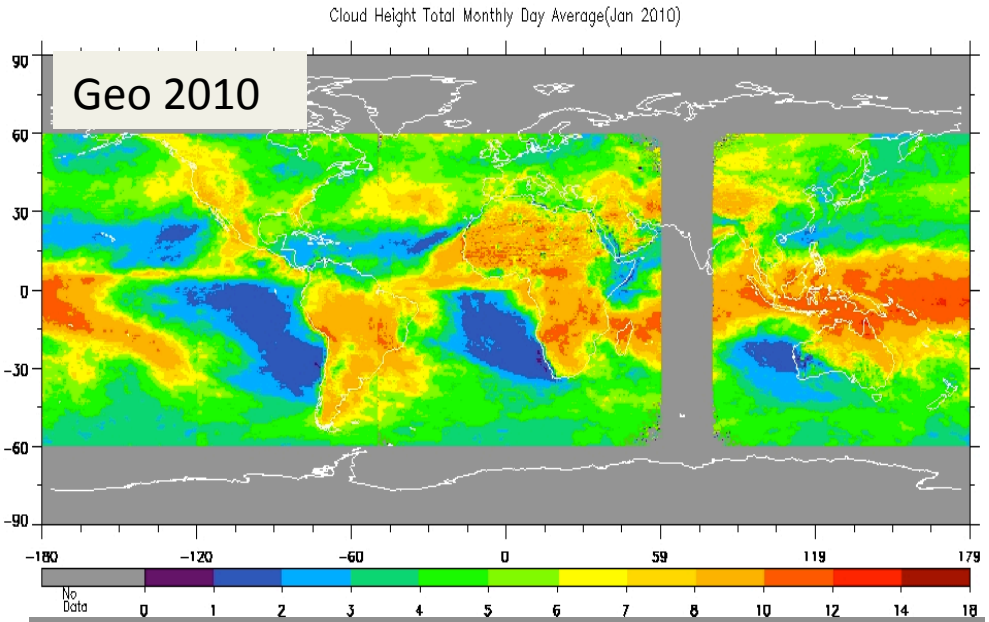
Enter the parameters you'd like to see and click submit:
Or, you can change domain.

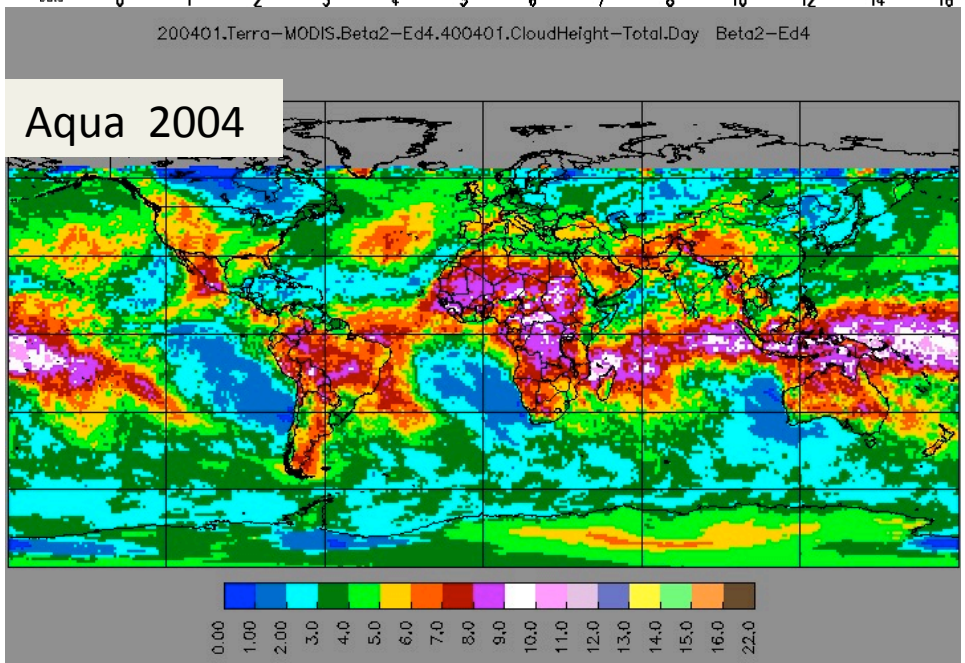
Monthly | 2013 | March | Optical Depth Linear Avg | Total | All | Submit



- Trend lines of averages and zonal means will included

GEO cloud properties: QC vs MODIS





Cloud Height, January day

- Despite differences in color bars and years, results are very similar
- Discontinuities evident but not huge
- Numerical comparisons will be performed when 2004 GEOSats analyzed

GEO cloud property validation procedure

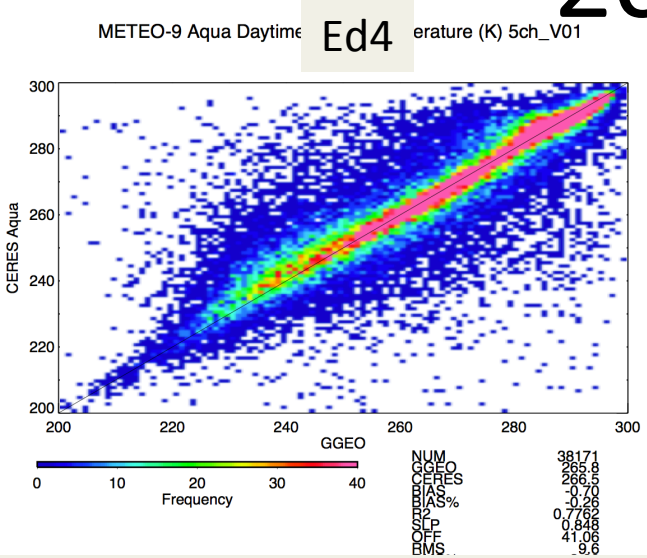
- Compare coincident (±15 min) MODIS/GEO monthly gridded cloud properties
  - Stratify by day and night
  - Compare GEO Ed4, GEO Ed2, and MODIS Ed2/4
  - The SYN product, which contains computed fluxes, is 80% GEO
- Compute no-retrieval rate for each satellite
  - scene specific systematic flux biases to be minimized
- Compare computed fluxes derived with GEO Ed4 cloud properties with GERB and surface fluxes
  - GEO derived flux validation is top priority, how do the GEO cloud retrievals impact the fluxes
  - Emphasis on the monthly hourly diurnal TOA and surface analysis

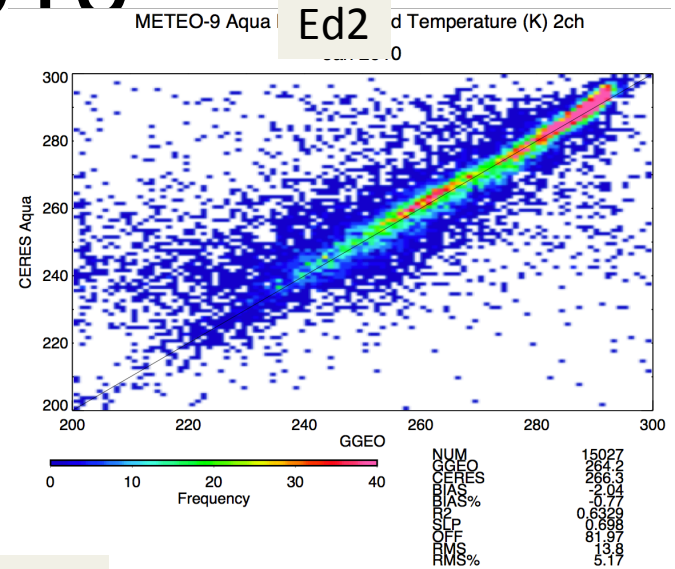
Met-9 cloud temperature, Jan 2010

Ed4

Ed2

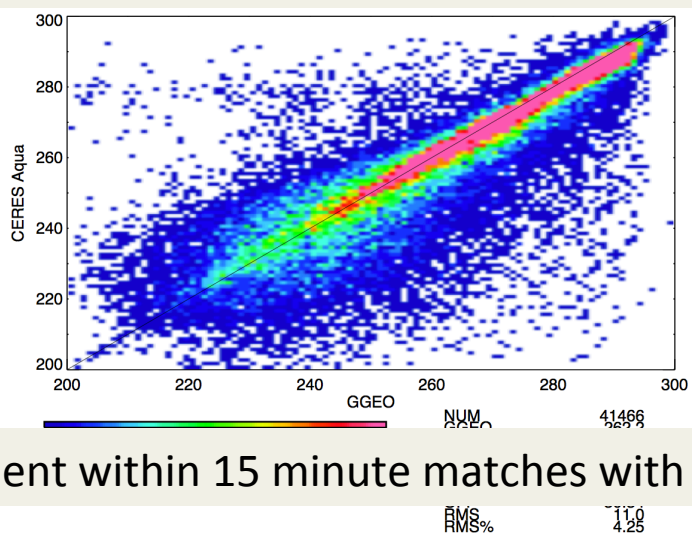
Day

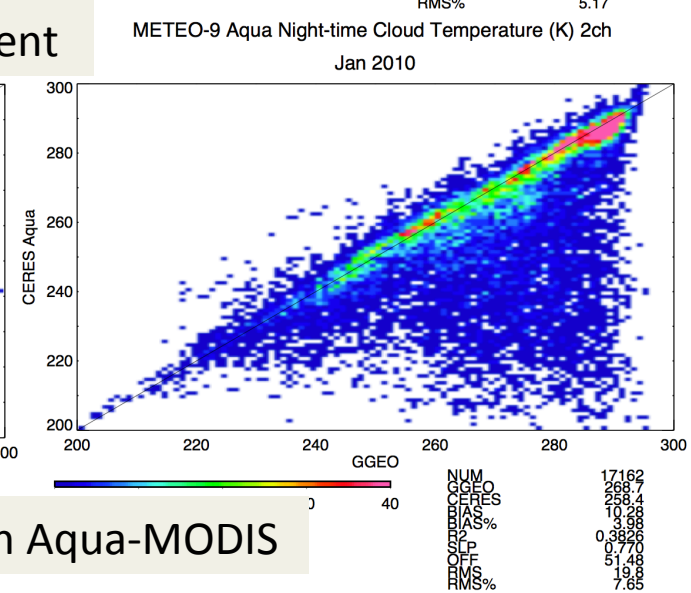




Ed4 night cloud temperature improvement

Night





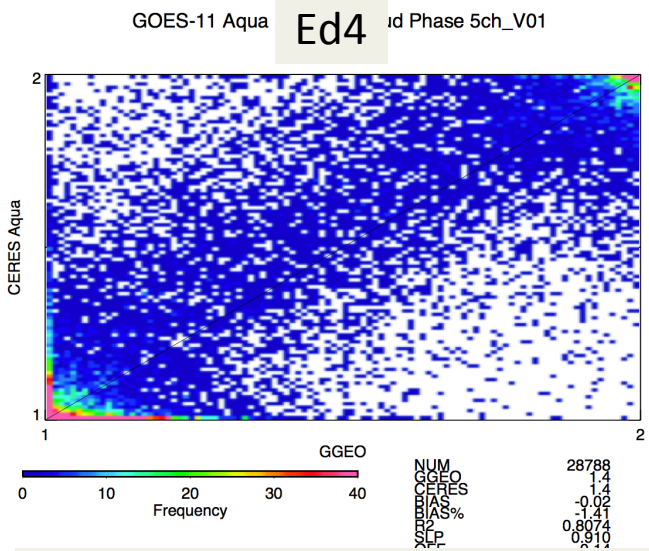
Coincident within 15 minute matches with Aqua-MODIS

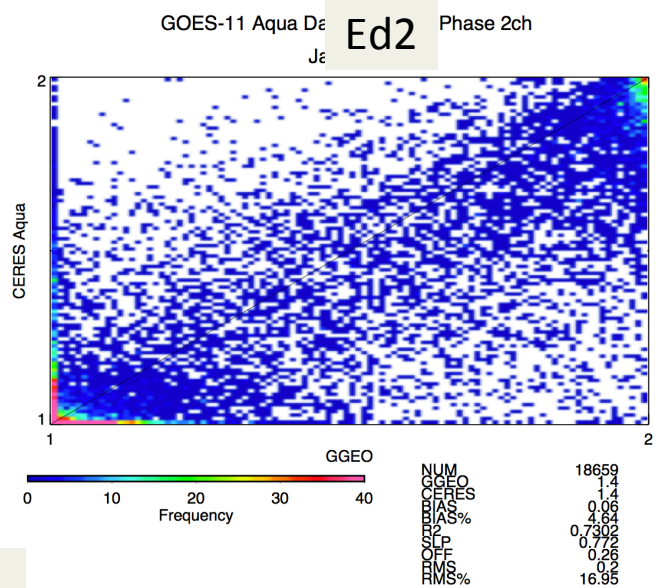
GOES-11 Cloud Phase, Jan 2010

Ed4

Ed2

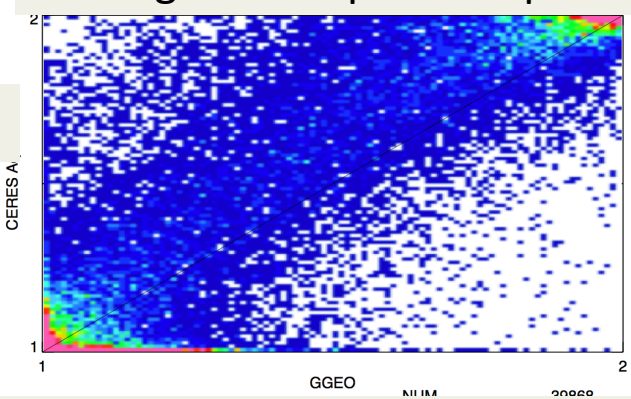
Day

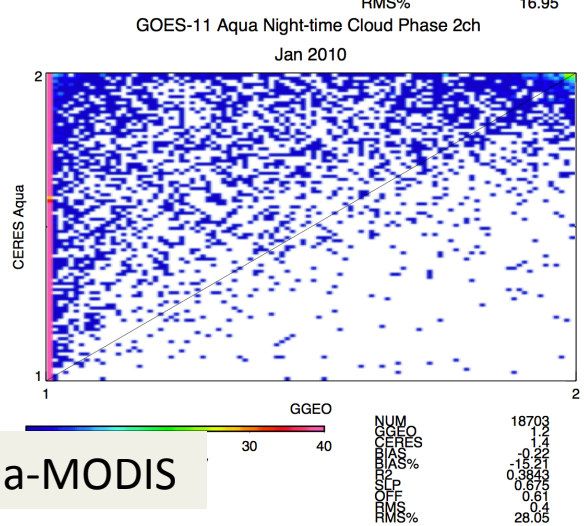




Ed4 night cloud phase improvement

Night





Matches coincident within 15 min of Aqua-MODIS

GEO Ed4, Jan 2010

Ed4 retrieves particle size, IWP/LWP, skin-temp, and top/base heights based on MODIS lapse rate

Ed4 retrieves IR emissivity at night for improved, phase, top and base temperatures

	Met-9		MTSAT-1		GOES-11		GOES-12	
	day	night	day	night	day	night	day	night
Fraction (%)	57	61	72	73	67	81	64	74
Top (hPa)	649	618	610	580	643	608	656	659
Eff (hPa)	663	636	631	610	659	627	670	686
Base (hPa)	766	711	736	701	766	705	780	783
Optical depth	1.1	------	0.9	------	0.9	------	1.3	------
Liq Rad (µm)	14	10	16	10	18	11	16	11
Ice Diam (µm)	46	46	48	50	47	50	44	54
LWP	3.4	3.4	3.5	3.4	3.7	3.0	4.0	4.1
IWP	3.5	3.3	3.4	3.2	3.6	3.0	3.6	3.6

Matches coincident within 15 min of Aqua-MODIS averaged over month
Mostly similar to MODIS results on the next page

- COD less by 0 – 0.3
- cloud fractions, especially night, are larger

MODIS (Ed2), Jan 2010

	Met-9		MTSAT-1		GOES-11		GOES-12	
	day	night	day	night	day	night	day	night
Fraction (%)	58	57	67	65	62	64	65	62
Top (hPa)	660	593	636	562	658	590	677	616
Eff (hPa)	674	613	651	586	672	609	691	640
Base (hPa)	744	669	721	649	737	662	758	698
Optical depth	1.2	------	1.2	------	1.1	------	1.3	------
Liq Rad (µm)	13	14	13	14	15	15	13	13
Ice Diam (µm)	48	56	46	56	50	57	46	51
LWP	3.7	3.7	3.8	3.7	3.6	3.6	3.8	3.8
IWP	4.0	3.8	3.7	3.8	3.9	3.7	3.8	3.8

Edition 4 Has ~0.05 more cloud fraction and Ed4 ln(COD) – ln(M_Ed2) = -0.25

- explains some of the discrepancies with GEO Ed4
- Re smaller than GEO Ed4

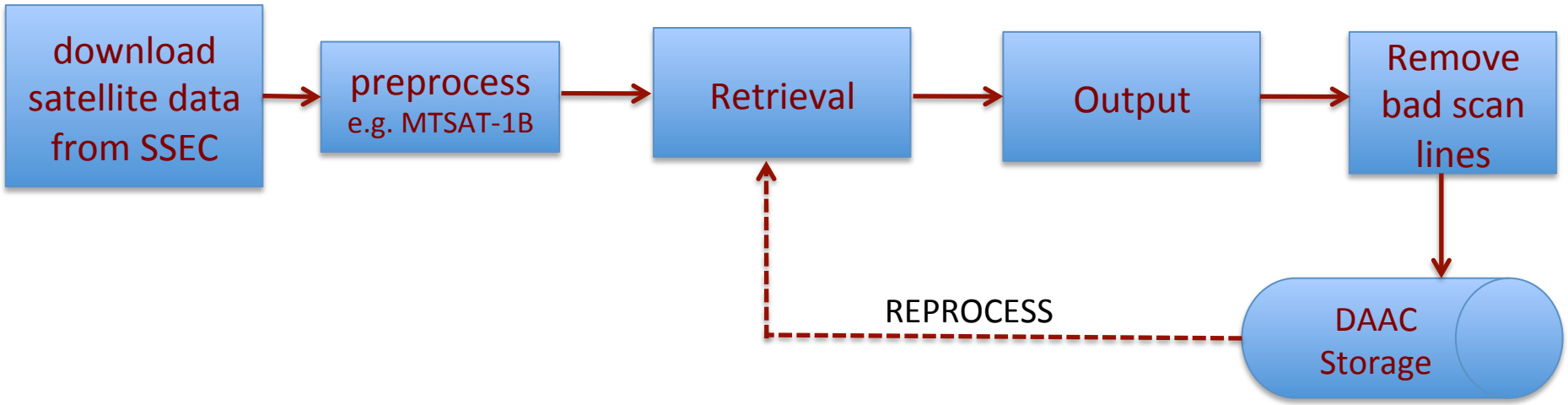
GEO Ed2, Jan 2010

	Met-9		MTSAT-1		GOES-11		GOES-12	
	day	night	day	night	day	night	day	night
Fraction (%)	58	57	62	62	67	60	69	58
Top (hPa)	629	-----	582	-----	678	-----	644	-----
Eff (hPa)	653	709	617	704	697	710	672	708
Base (hPa)	712	-----	650	-----	756	-----	732	-----
Optical depth	1.3	-----	1.0	-----	1.5	-----	1.7	-----
Liq Rad (µm)	-----	-----	-----	-----	-----	-----	-----	-----
Ice Diam (µm)	-----	-----	-----	-----	-----	-----	-----	-----
LWP	-----	-----	-----	-----	-----	-----	-----	-----
IWP	-----	-----	-----	-----	-----	-----	-----	-----

- Same spatial resolution as Ed4, except 3-hourly
- Mostly similar to the MODIS results on the previous page
  - avg COD larger
  - Eff pressures larger at night

Processing Schedule

- Cloud WG to process 12 years of 1-hourly GEO 5-channel 8-km retrievals and output netCDF files



- Bad scan lines can be removed using the GEO netCDF
- In case cloud properties need to be rerun, the current GEO output netCDF files can be used as input.
  - No need to clean or reorder McIDAS imager data or reapply MTSAT-1 PSF correction

Processing Schedule (cont.)

- Each Full-Disk image is split into NH & SH and processed separately
- 1440 total files processed per month per GEO. 5760 total files processed per month.
- Run 5-day chunk per process.

- 12 processes for one month per GEO. 48 processes for 4 GEO (global) per month

- Uncompressed 85 TB/10 years, Compressed 30TB

- Processing rate currently is 13 – 18 hours per month.
  - downloading McIDAS satellite images in parallel
  - Currently exploring opportunities to reduce the processing time
    - Analyzing the retrieval code for potential time sink
    - Design processes to maximize system resources

Processing Schedule (cont.)

- 534 total satellite/month records to process with the 4-channel algorithm.

MONTHS FOR EACH GEO 2000-2012

GOES-EAST	MONTHS
GOES-8	39
GOES-12	84
GOES-13	33

GOES-WEST	MONTHS
GOES-10	78
GOES-11	65
GOES-15	13

EURO-AFRICA	MONTHS
MET-8	37
MET-9	69

W.PACIFIC	MONTHS
GOES-9	26
MTSAT-1B	60
MTSAT-2B	30

immediate plans…..

- Process Jan 2010 (*GOES-11, GOES-12,MET-9, MTSAT-1*), July 2004 (*GOES-10, GOES-12, Met-8, GOES-9*) and Apr 2008 (*GOES-11, GOES-12, Met-9, MTSAT-1*)
  - Coordinate with TISA and SARB groups
  - With these runs GOES-9,10,11,12 and MTSAT-1, Met-8,9 will be analyzed and represent ~78% of the record.
  - GOES-13,15 and MTSAT-2 will be analyzed for month in 2012/2013

- Once a GEO satellite has been validated sequester code and process the entire record.

Outstanding issues

- Final tweaks to GEO masks, night especially
  - 4 vs 1 km requires IR threshold changes
- Calibrations of all channels, particularly 3.7/3.9 µm need final checks
  - GEO vs GEO
- Terminator hours (82.5 > SZA < 87.0) may need exclusion
  - continue effort to fix terminator masks
- Repeat process for all sets of satellites
  - every imager slightly different even on same series

EXTRA

Introduction

- CERES MODIS & GEO imager cloud properties are retrieved with emphasis on improving the CERES flux product & are used to
  - select the appropriate GEO NB to BB radiance coefficients, CERES and GEO radiance to flux ADM coefficients, and diurnal averaging of TOA observed fluxes
  - compute Fu-Liou radiative transfer model TOA, surface and in atmosphere fluxes

Processing Schedule

- Cloud WG to process 12 yrs of hourly GEO 5-channel 8-km retrievals and output netCDF files
  - Uncompressed 85 TB/10 years, Compressed 17TB
  - Processing rate?? Includes downloading McIDAS images
  - Can process 12 years in 3 months
- Bad scan lines removed using GEO netCDF files
- Any reruns will use current GEO netCDF files as input
  - No need to reclean or reorder McIDAS imager data or reapply MTSAT-1 PSF correction
- Process Jan 2010, July 2004, and Apr 2008
  - Coordinate with TISA and SARB groups
  - GOES-9,10,11,12 and MTSAT-1, Met-8,9 will be analyzed
  - GOES-13,15 and MTSAT-2 will be analyzed for month in 2012/2013
- Once a GEO is validated, code will be frozen & entire record processed