CERES Clouds Working Group Report

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AMA, Hampton, VA

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ADNET, Hampton, VA

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P. Yang (ice models), Texas A&M University

Thanks to Dave Doelling and the TISA/calibration teams!

Topics

Ed5 cloud algorithm: initial assessments

- GEO 3ch algo (most GEO's)
- MODIS and VIIRS (version alpha-1)

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Ed5 Cloud Algorithm Updates

1. Input data
   - Radiances (latest MODIS collection (C7), GEO calibrations)
   - Atmospheric state (GEOS-IT)
   - Surface characterizations (IGBP, snow/ice maps, Tskin, Rclr)

2. Cloud Properties
   - Atmospheric corrections (much improved)
   - Cloud mask (improved logic and new tuning - ongoing)
   - Optical & microphysical properties (THM for ice clouds)
   - Use of machine leaning for nighttime thick COP, polar night mask, cloud heights, phase in overlapping clouds (mostly developed with initial training datasets but not yet final and mostly not yet implemented)

Common 3ch Algorithm for GEO's

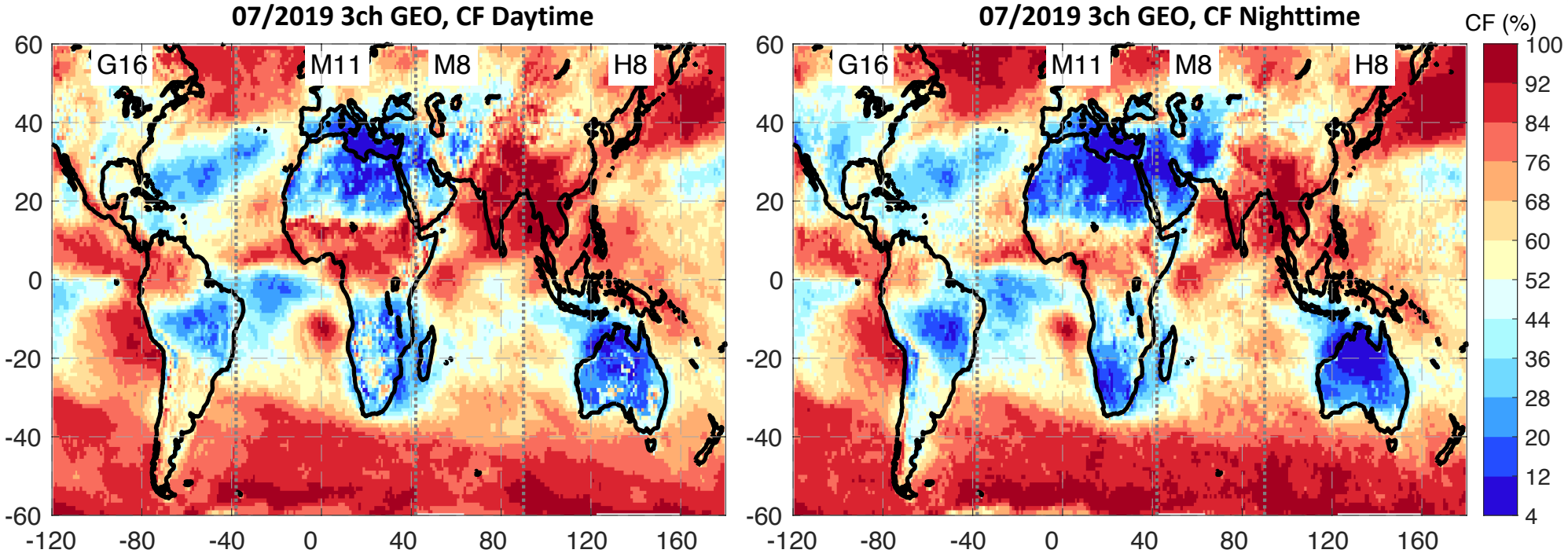
Preliminary inter-satellite consistency check

Objectives: Evaluate the consistency of cloud fraction and daytime cloud optical properties to help identify remaining problems in the new system (e.g. calibration, solar constants, atmos. correction) before tuning cloud mask for accuracy

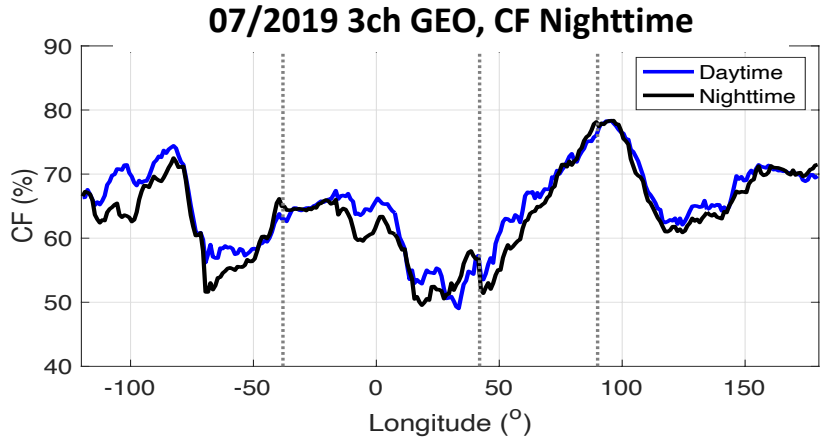
Three time periods:

July 2019:	G16, Met-11, Met-8, Him-8
July 2012:	G13, G15, M9
Dec 2017:	G13 and G16 over same domain

Total Cloud Fraction



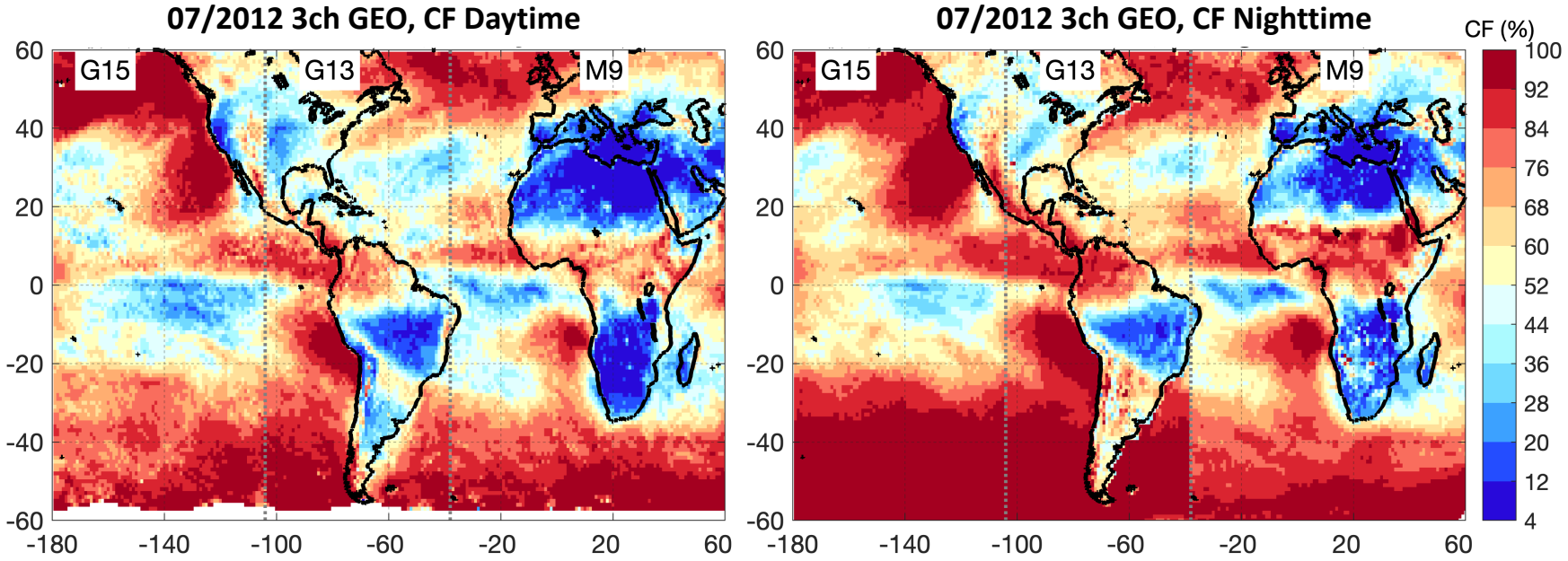
Zonal view:



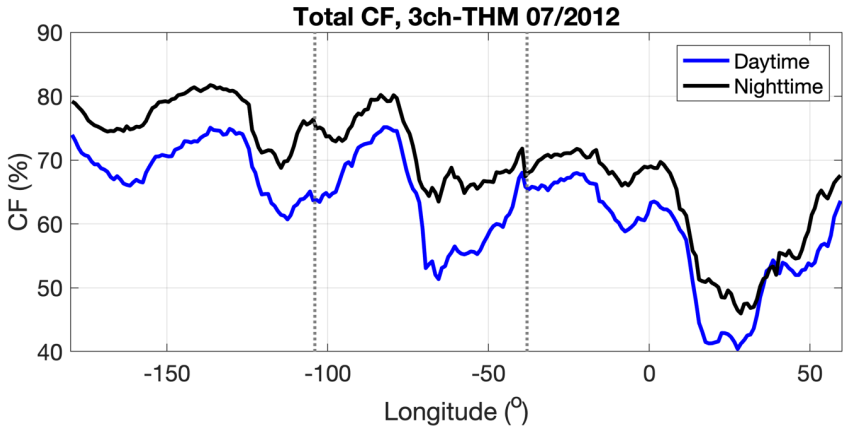
Very consistent across the modern satellites

Total Cloud Fraction

Daytime, SZA<75˚
Nighttime, SZA>90˚

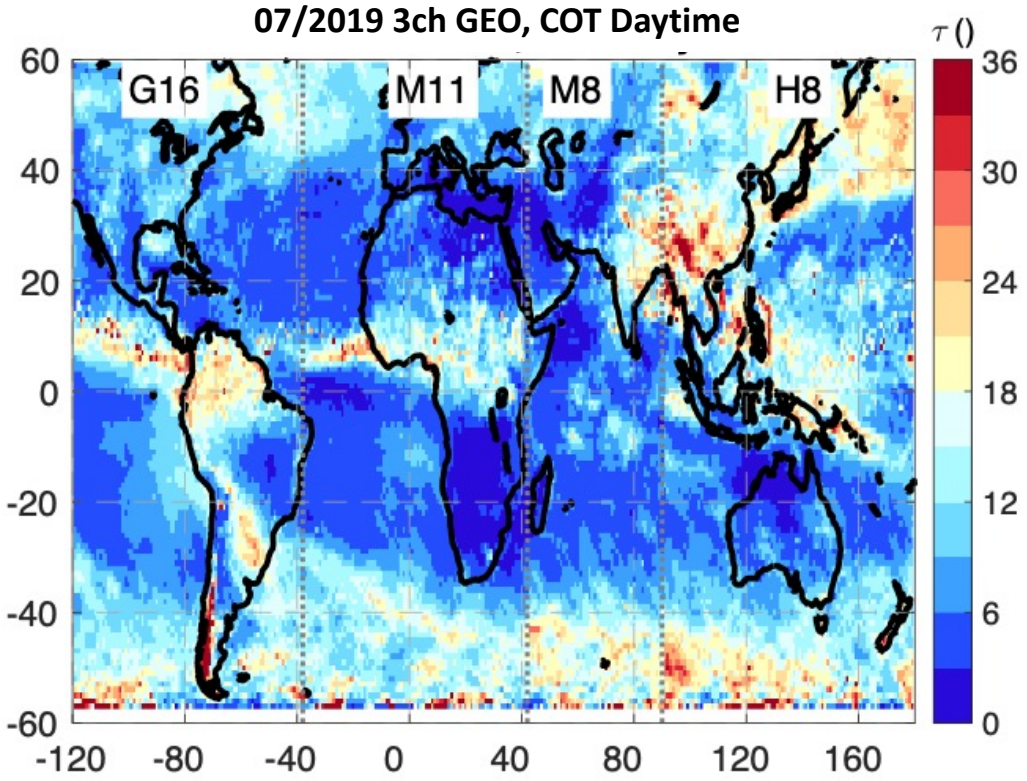


Latitudinal averages by longitude

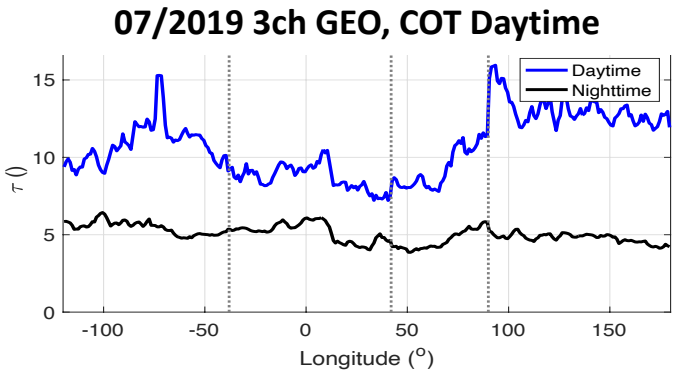


- Consistency across satellites very good except at night over the southern ocean – GOES looks too cloudy
- No tuning yet over land

Total cloud optical depth



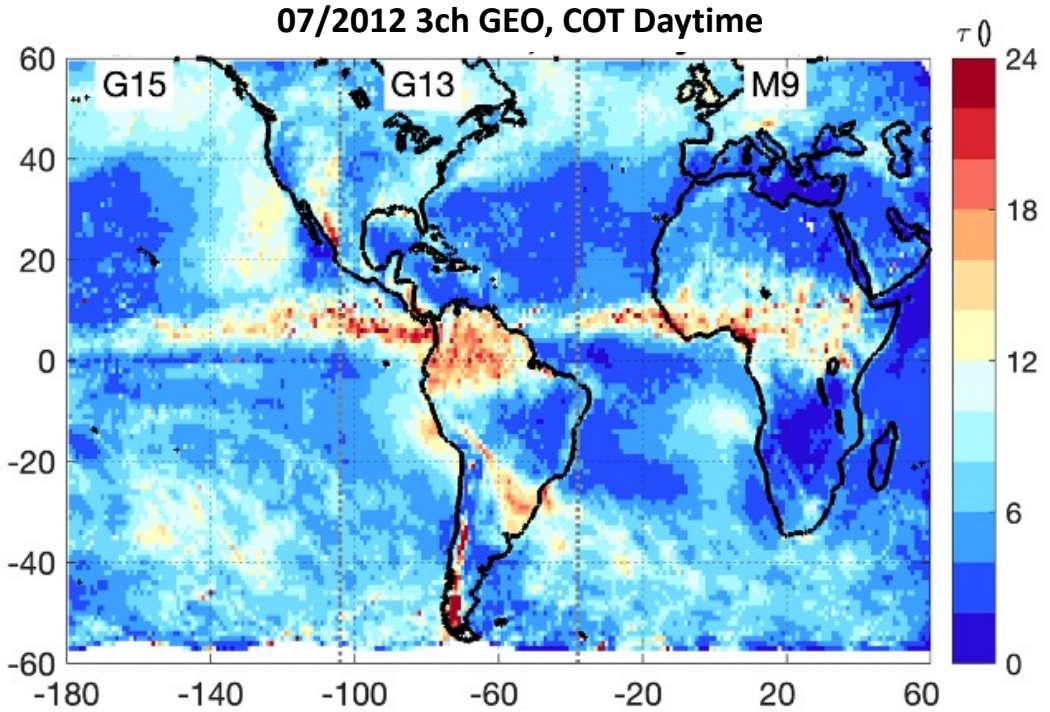
Zonal view:

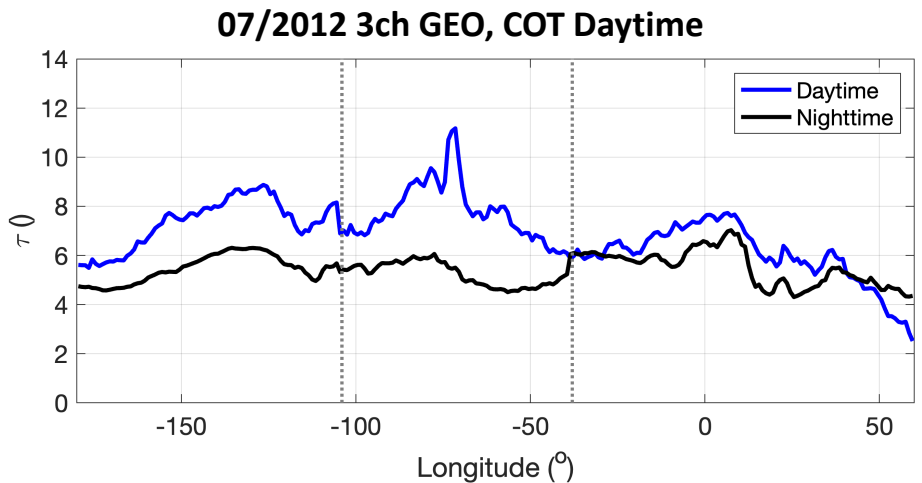


- Him-8 disagrees?

Ignore nighttime
Algo updates not yet implemented

Total cloud optical depth

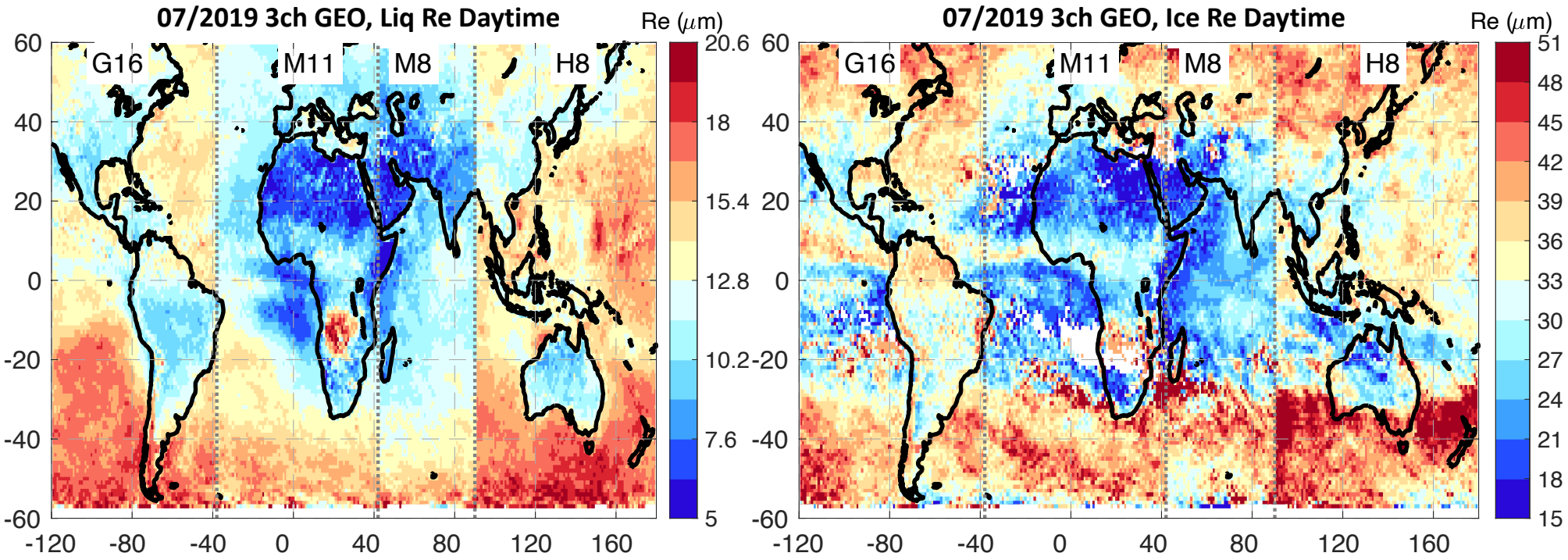




- Good inter-satellite consistency between the older GOES and Met-9

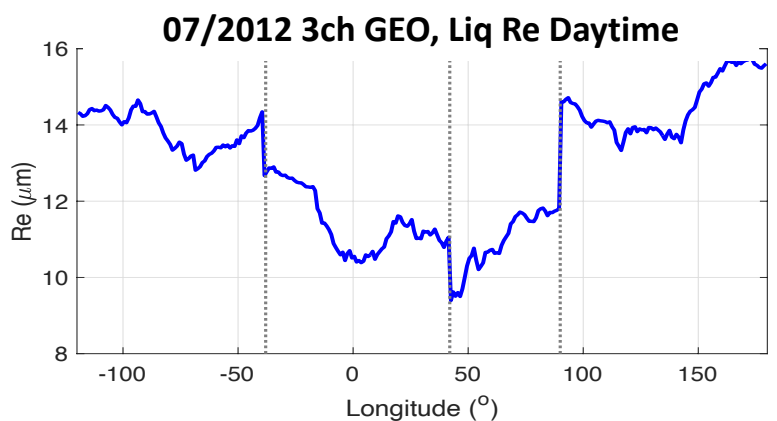
Ignore nighttime curve
Algo updates not yet implemented

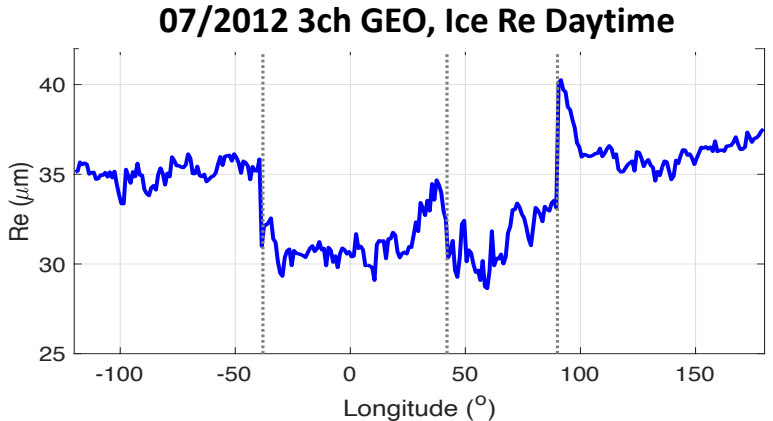
Daytime particle size (Liquid and ice)



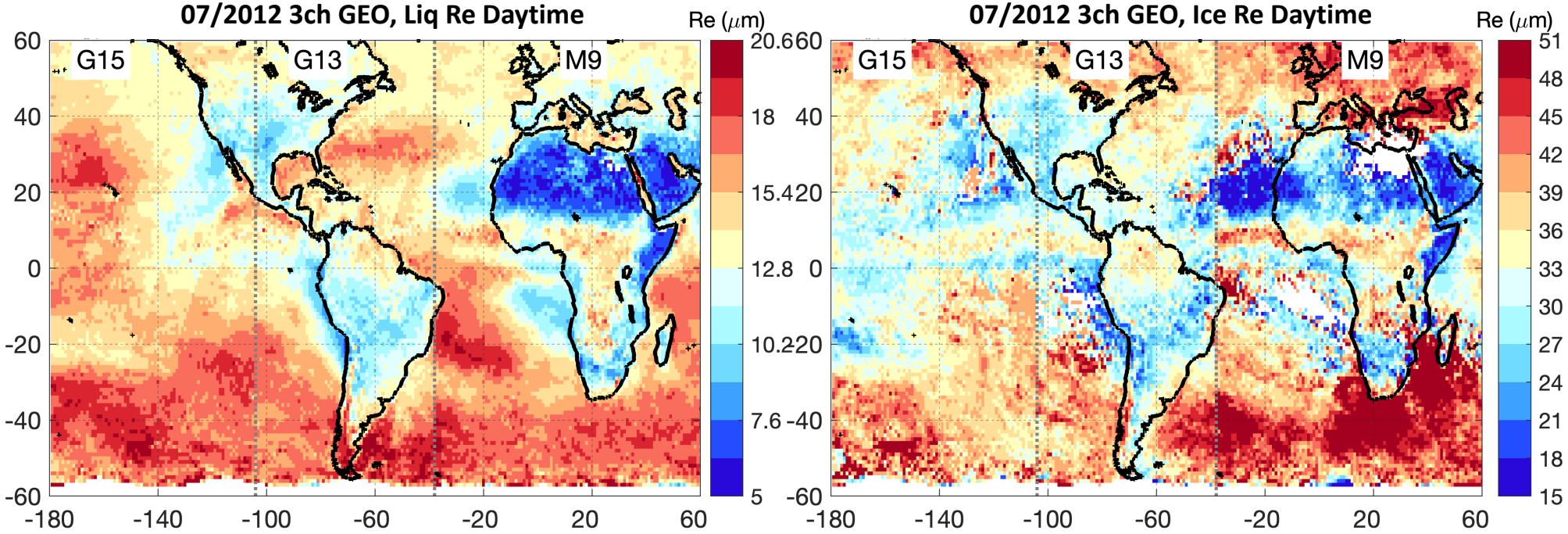
ABI/AHI disagree with SEVIRI on Met-8/Met-11

Zonal view:





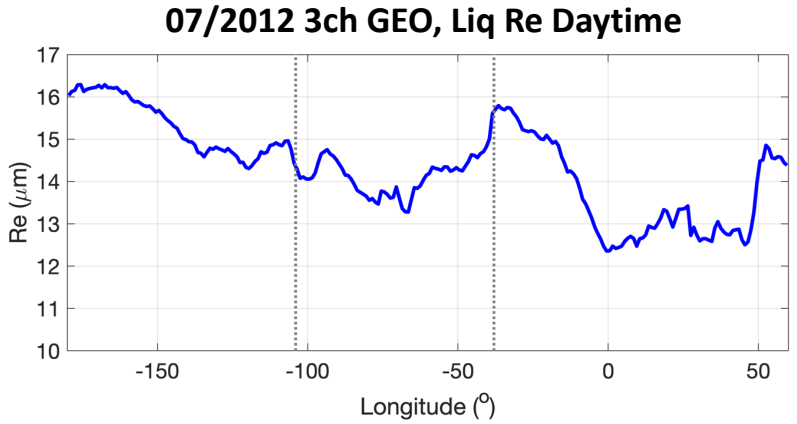
Daytime particle size (Liquid and ice)

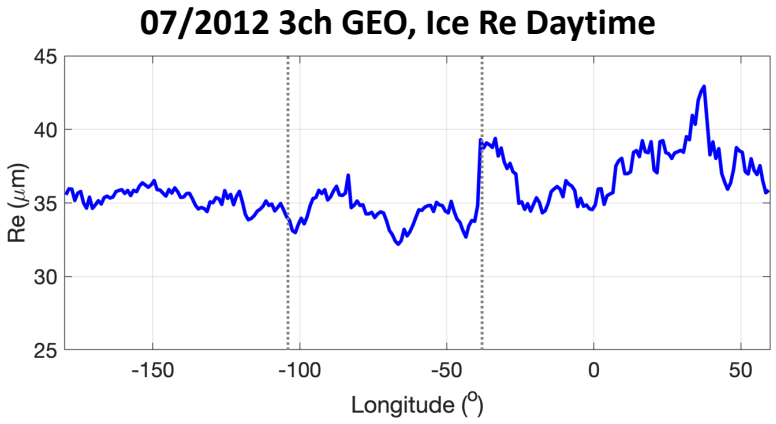


GOES-13/15 Liq Re consistent with Met-9 SEVIRI

Met-9 Ice Re disagrees with the two GOES

Zonal view:

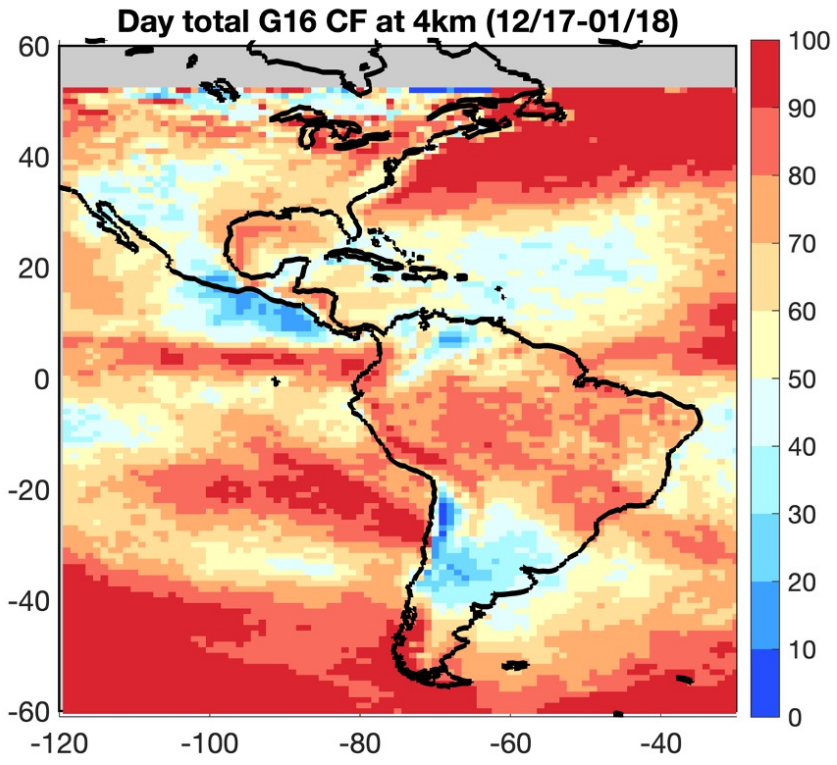




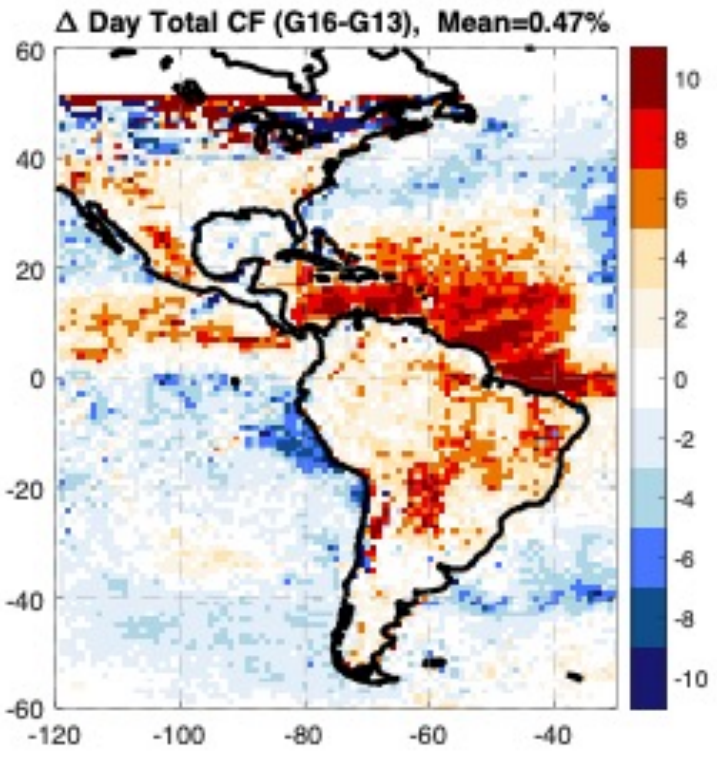
G13/G16 overlap period at 75 W

DAY

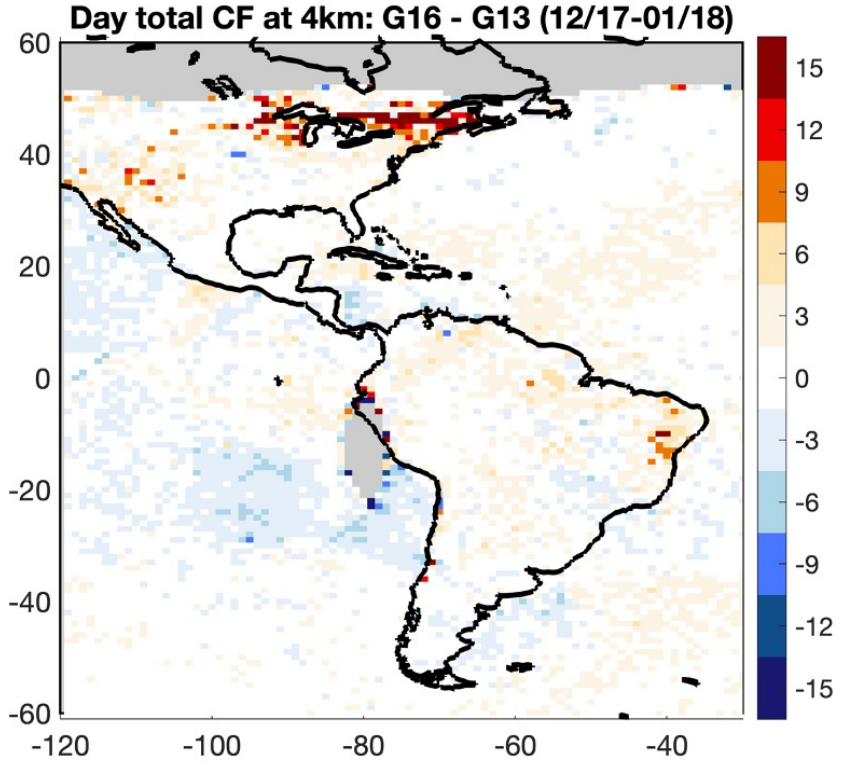
Total Cloud Fraction



Ed4 CF Difference



Ed5-test CF Difference

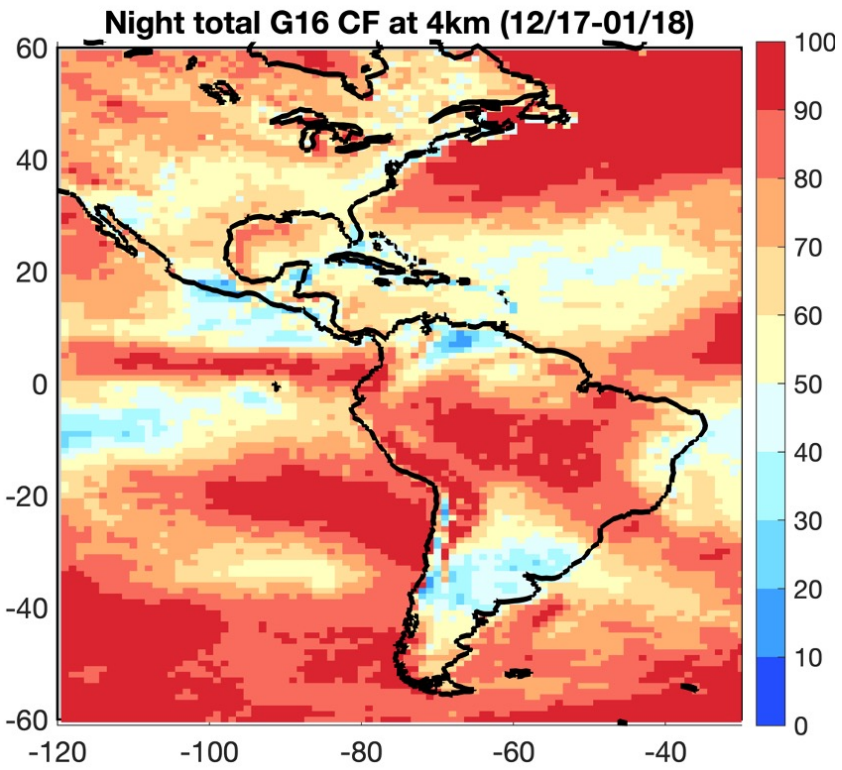


Ed5 3-ch algorithm considerably more consistent than Ed4 for all daytime cloud properties

G13/G16 overlap period at 75 W

Night

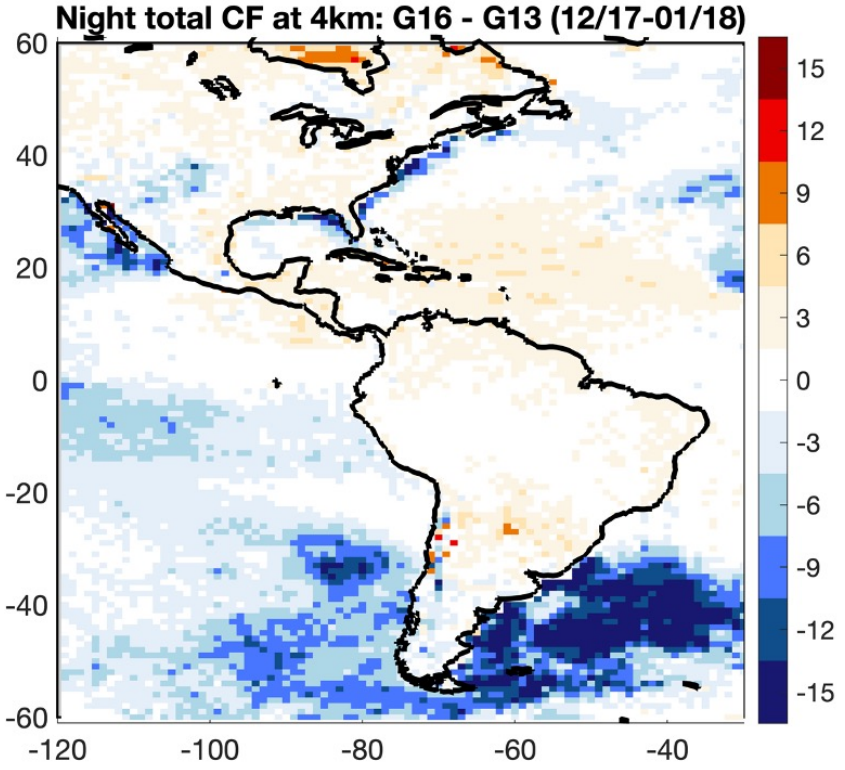
Total Cloud Fraction



Ed4 CF Difference

???

Ed5-test CF Difference



- Midnight effect caused by solar heating of 3-axis stabilized instruments can alter IR band calibrations
- Uneven effects for G13 and G16 possible cause for inconsistency
- More evaluation is in the works; potential for mitigation (Scarino et al. 2017 and subsequent work)

Next steps for GEO 3ch

- We have a decent test plan but the results are mixed (and confusing) across the various datasets being tested (e.g. 2019 vs 2012).
- Need to make sure that the algorithm implementations are consistent.
- Need more focused and consistent attention to the Ed5 GEO development moving forward.
- Calibration/Solar constant inconsistencies between the Meteosats with SEVIRI and the GOES series may also need more work.

Ed5 MODIS and VIIRS Algorithm Testing

Alpha versions are being processed to evaluate the accuracy and consistency of the cloud properties and fluxes as various algorithm updates are implemented

1. Alpha-0 (initial Ed5 framework for MODIS and VIIRS tested using 2019 data)
   - Used for evaluating and improving MODIS/VIIRS consistency using a common algorithm approach Uses C6.1 radiances for MODIS
   - Employs GEOS-IT but not all ancillary inputs were updated
   - New atmospheric corrections
2. Alpha-1 (clouds code delivered ~ 6-months ago to produce SSF's)
   - 2008 test data (MODIS only), need A-Train data for machine learning methods
   - Uses C7 radiances for MODIS
   - Also uses GEOS-IT and same cloud mask as Alpha-0
   - Most ancillary data updates implemented, e.g. IGBP, Snow/ice maps
3. Alpha-2 (clouds to be delivered ~ June 1)
   - cloud mask updates based on alpha-1 assessments (alpha 1.1, internal to CWG)

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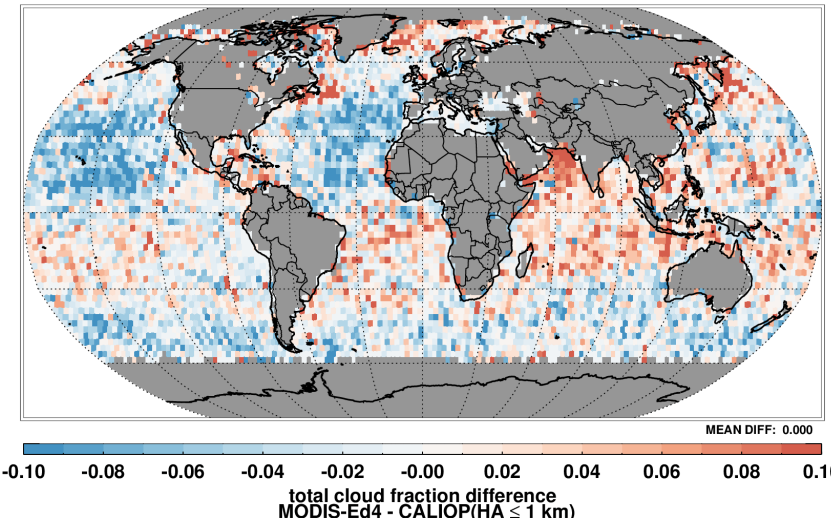
➢ Edition 5

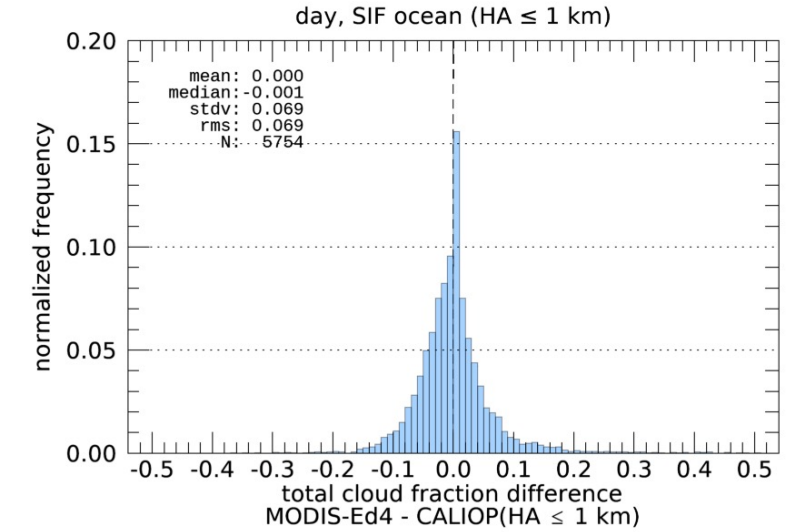
Aqua-MODIS **total cloud fraction** validation with CALIOP
July 2008 (A-Train era)
Day, snow/ice-free (SIF) ocean/water surfaces

A-Train: good spatial sampling but limited view angle sampling

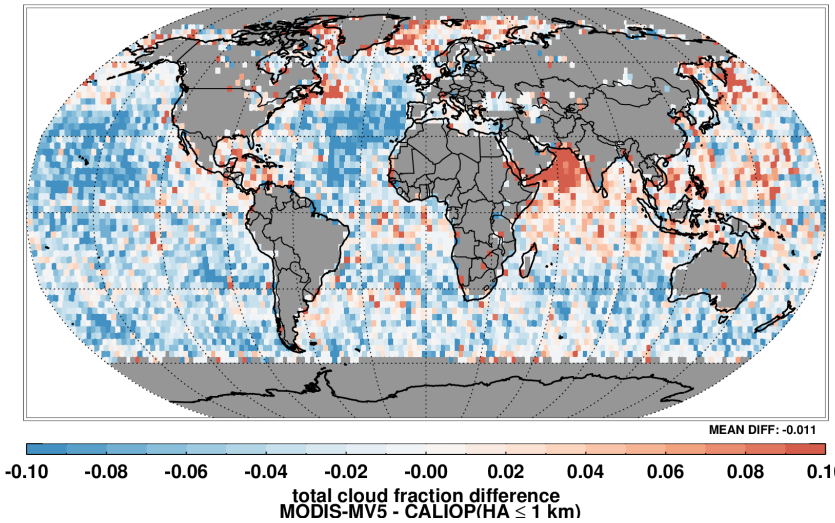
Progress towards Edition 5, Alpha 2

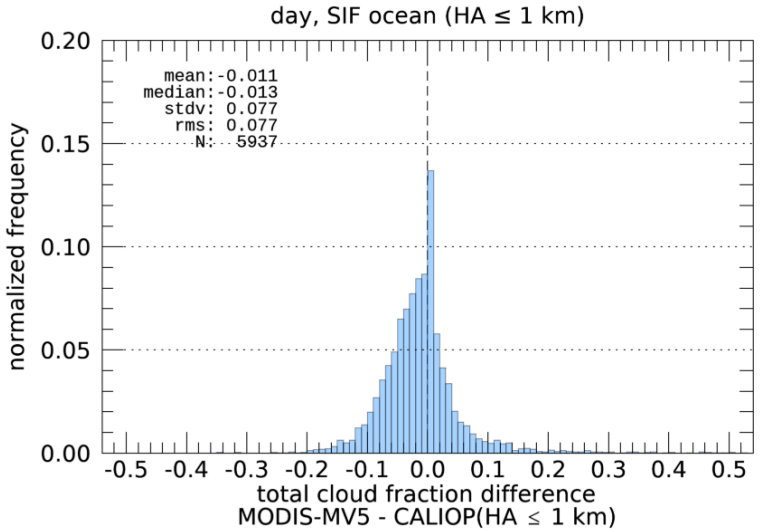
Edition 4



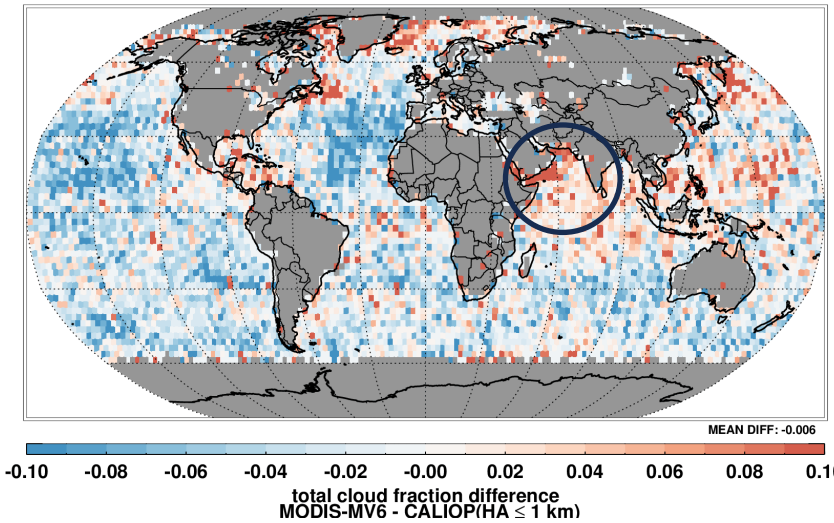


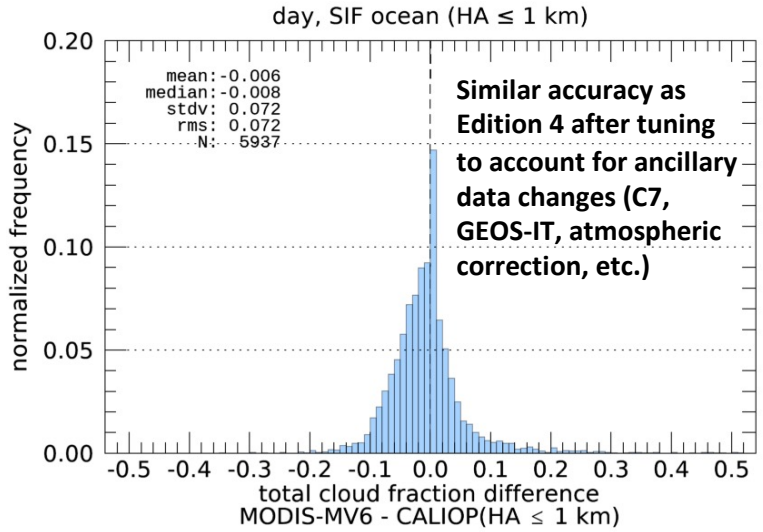
Alpha-1





Alpha-1.1





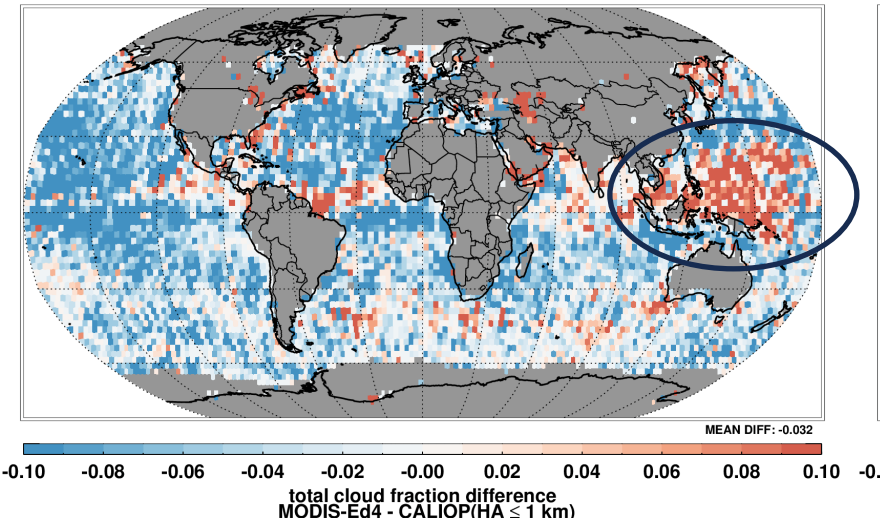
Similar accuracy as Edition 4 after tuning to account for ancillary data changes (C7, GEOS-IT, atmospheric correction, etc.)

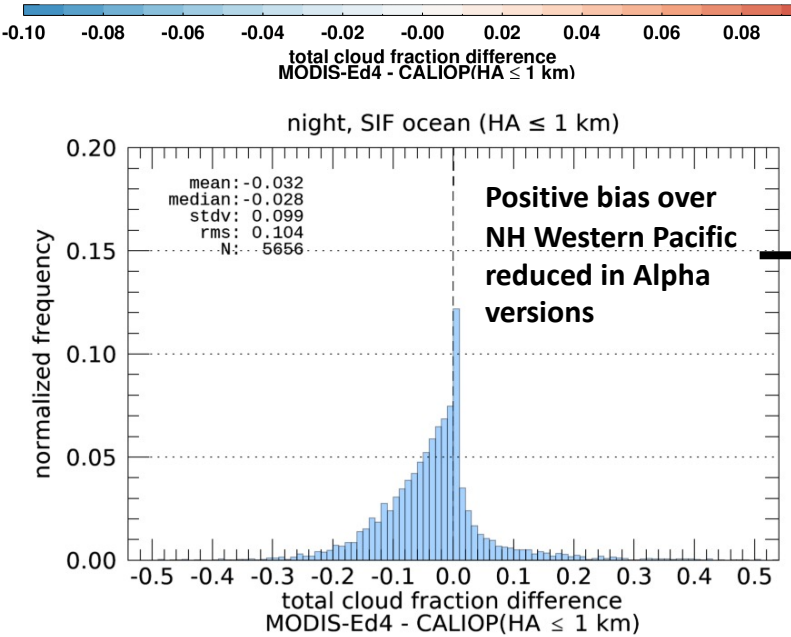
Aqua-MODIS **total cloud fraction** validation with CALIOP
July 2008 (A-Train era)
Night, snow/ice-free (SIF) ocean/water surfaces

A-Train: good spatial sampling but limited view angle sampling

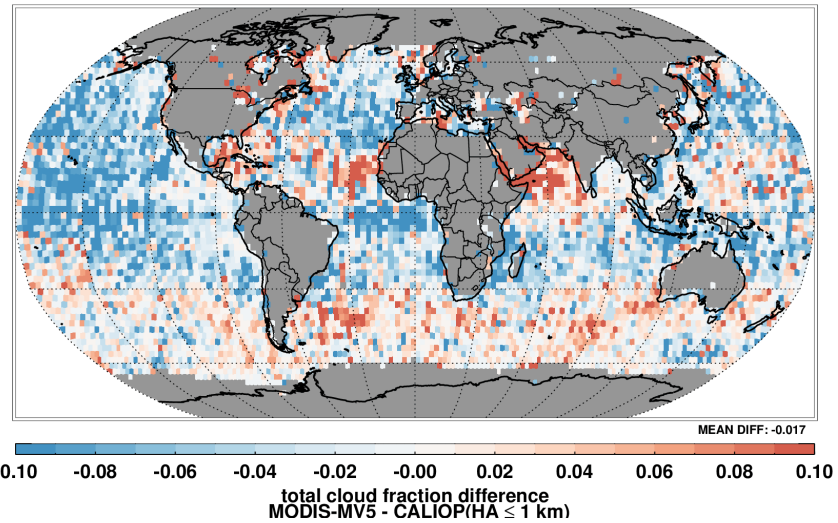
Progress towards Edition 5, Alpha 2

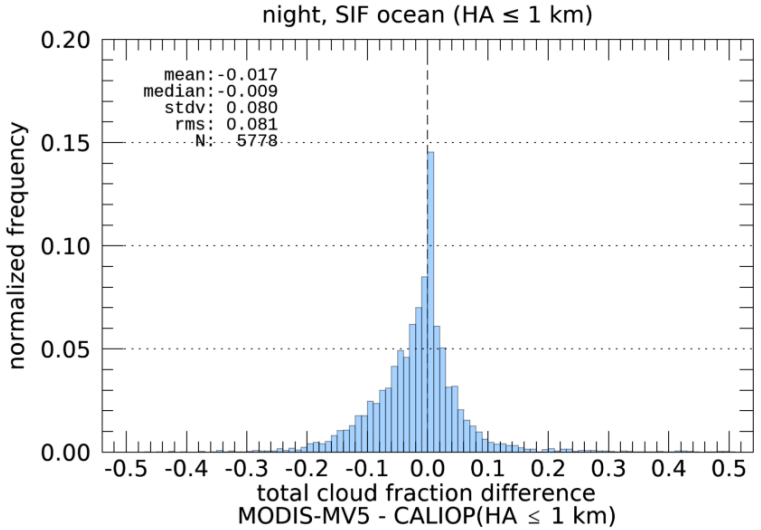
Edition 4



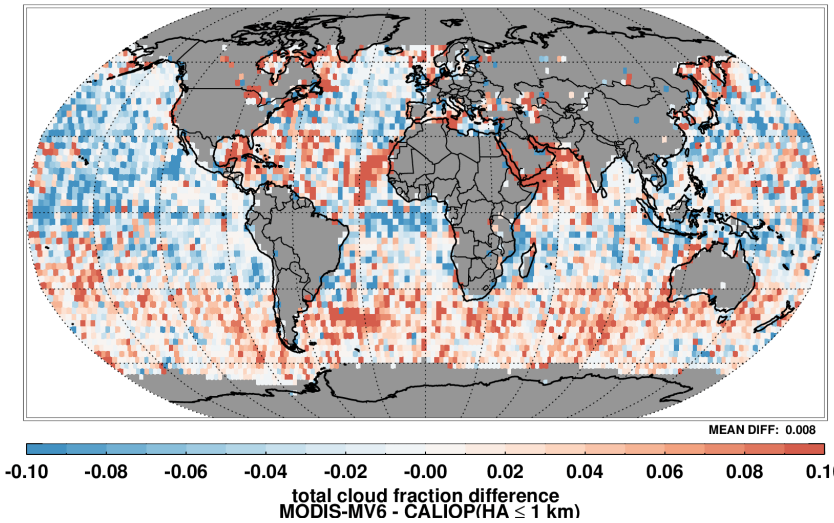


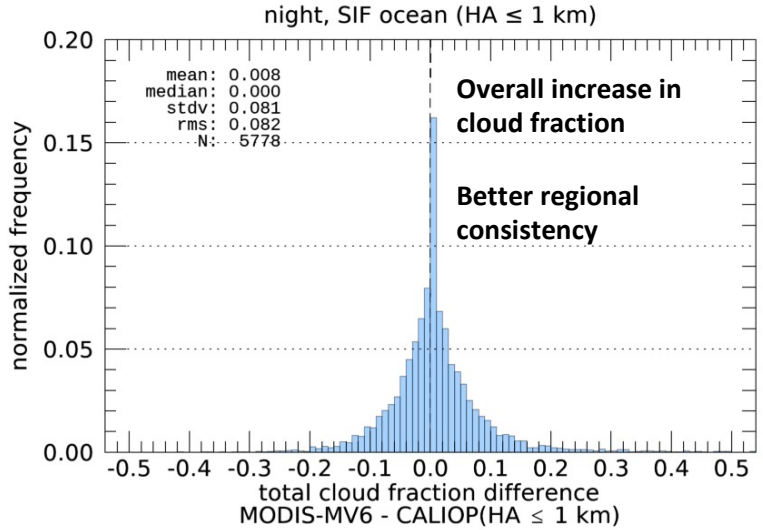
Alpha-1





Alpha-1.1



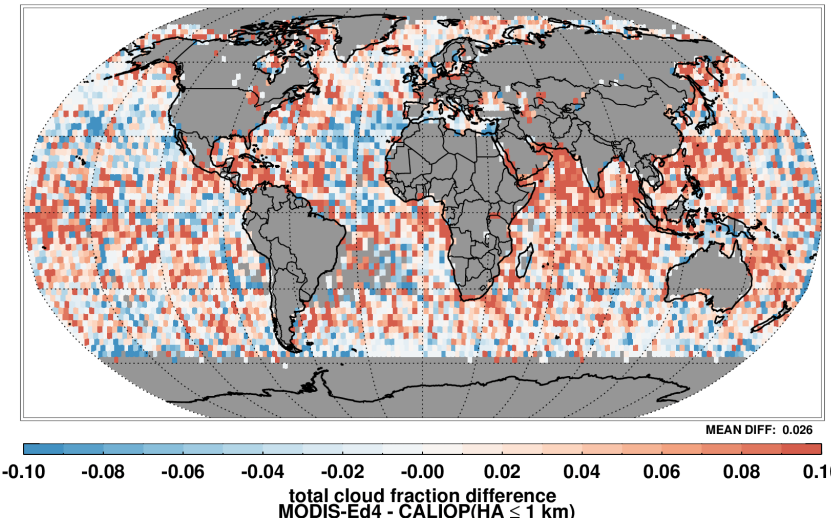


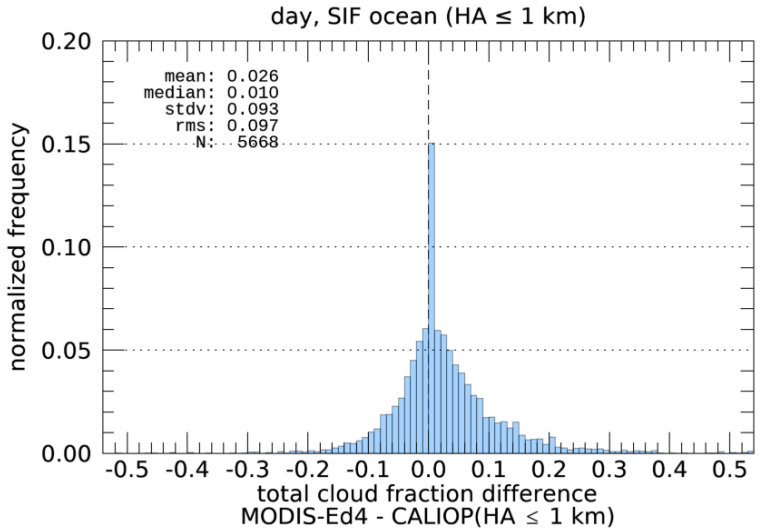
Aqua-MODIS **total cloud fraction** validation with CALIOP
July 2019 (C-Train era)
Day, snow/ice-free (SIF) ocean/water surfaces

C-Train: sparse spatial sampling but better view angle sampling

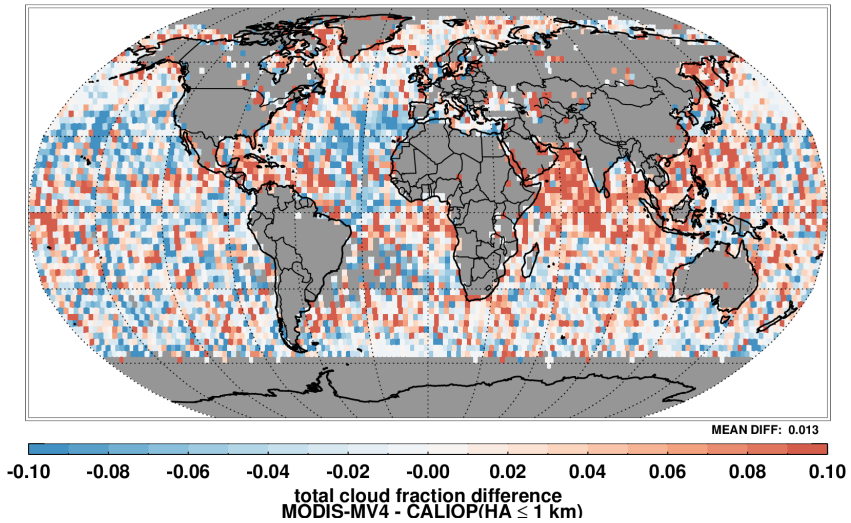
Progress towards Edition 5, Alpha 2

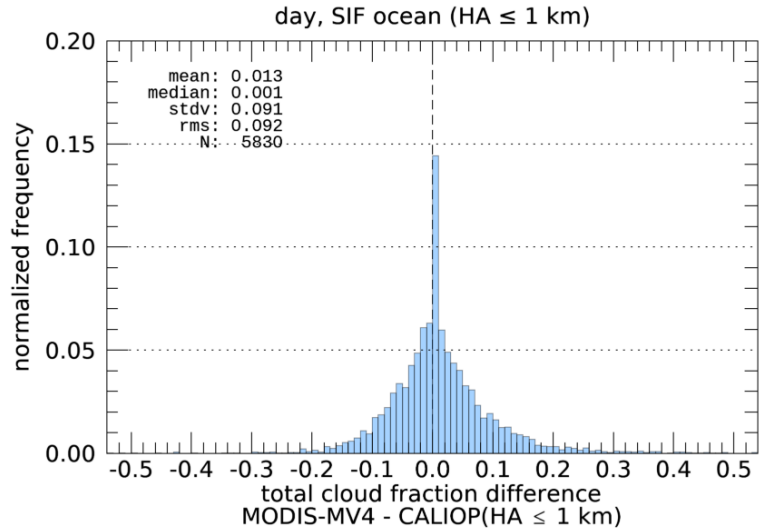
Edition 4





Alpha-0 (C6.1 radiances)





Edition 4 was tuned to A-Train era CALIOP observations when MODIS had only near-nadir views of CALIOP ground track.

In C-Train era (post-Sep 2018), MODIS has near-nadir and off-nadir views of CALIOP track.

Larger positive bias for Edition 4 likely due in part to shift towards larger MODIS view angles.

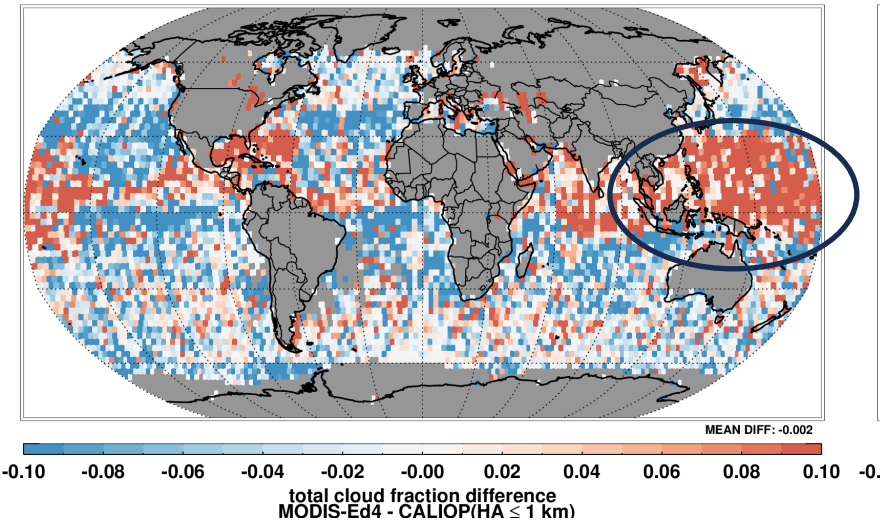
Positive bias was reduced somewhat with recent Alpha version.

Aqua-MODIS **total cloud fraction** validation with CALIOP
July 2019 (C-Train era)
Night, snow/ice-free (SIF) ocean/water surfaces

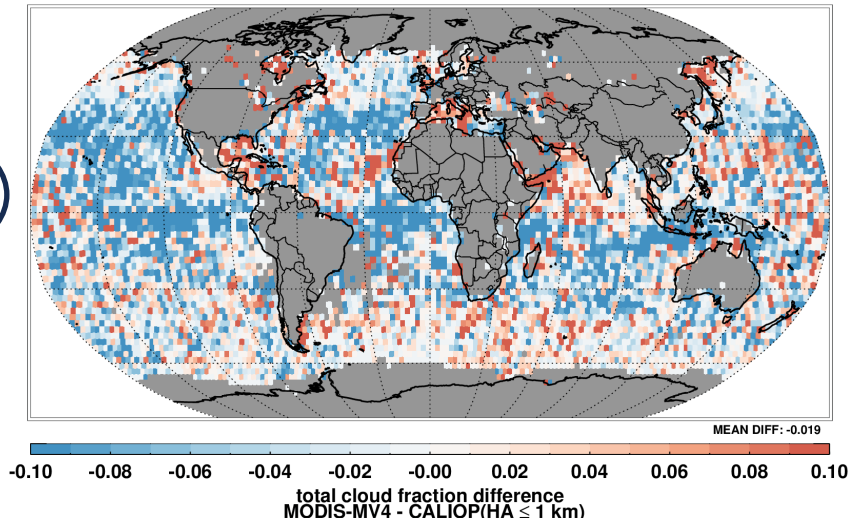
C-Train: sparse spatial sampling but better view angle sampling

Progress towards Edition 5, Alpha 2

Edition 4

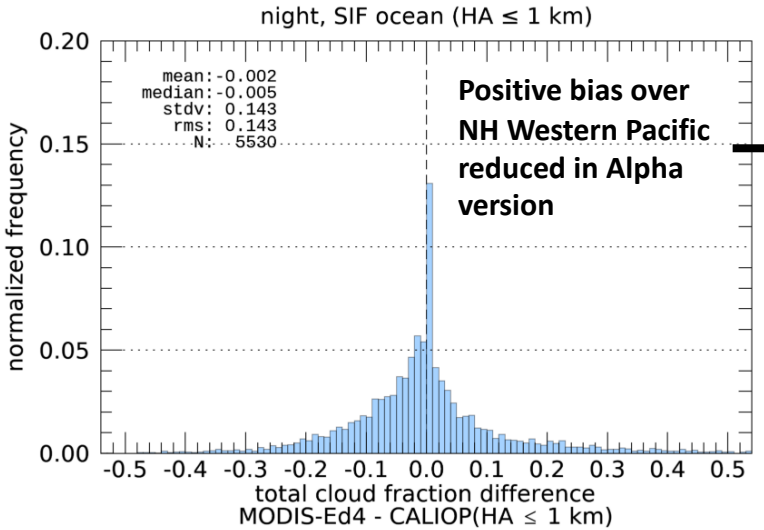


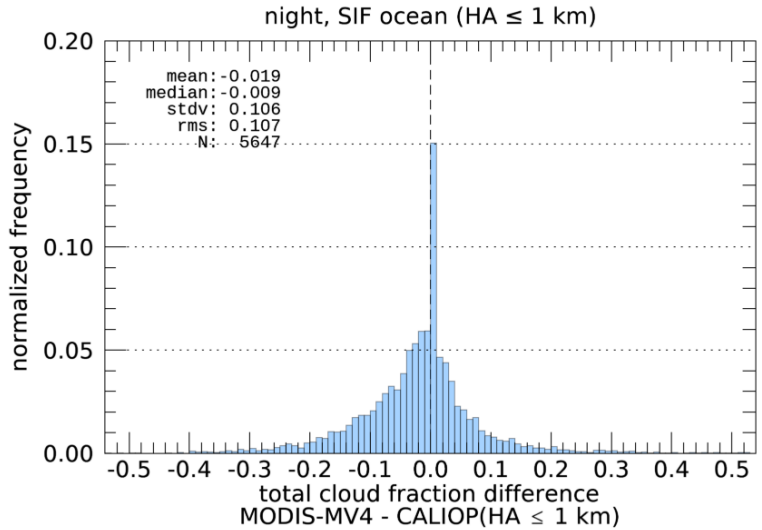
Alpha-0 (C6.1 radiances)



Nighttime data also show increased MODIS cloud fraction from A-Train to C-Train era comparisons.

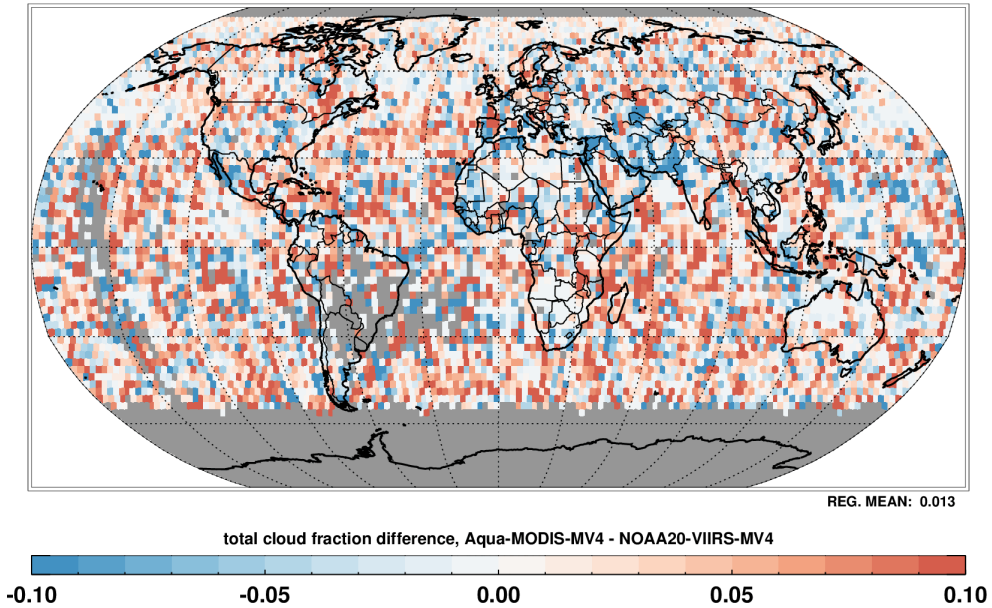
Large positive regional biases in tropical oceans reduced in Alpha version.

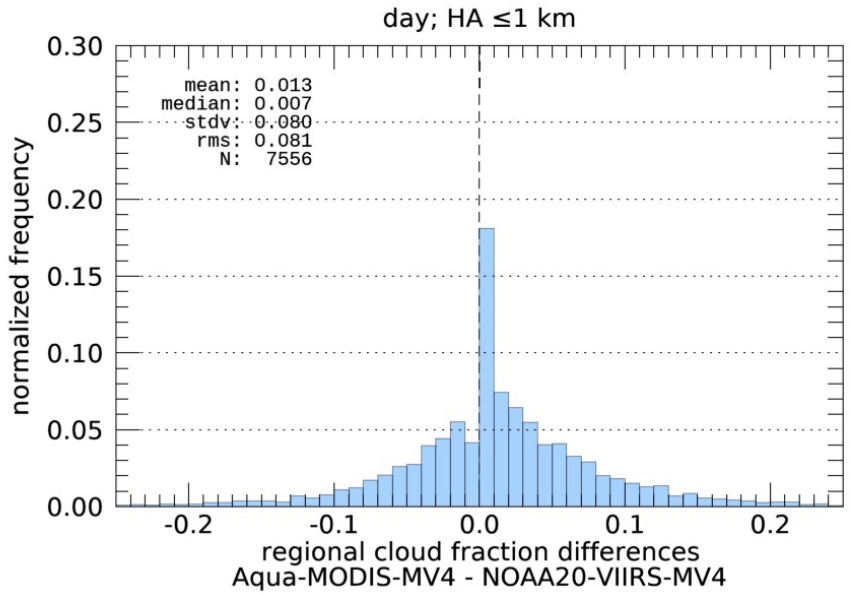




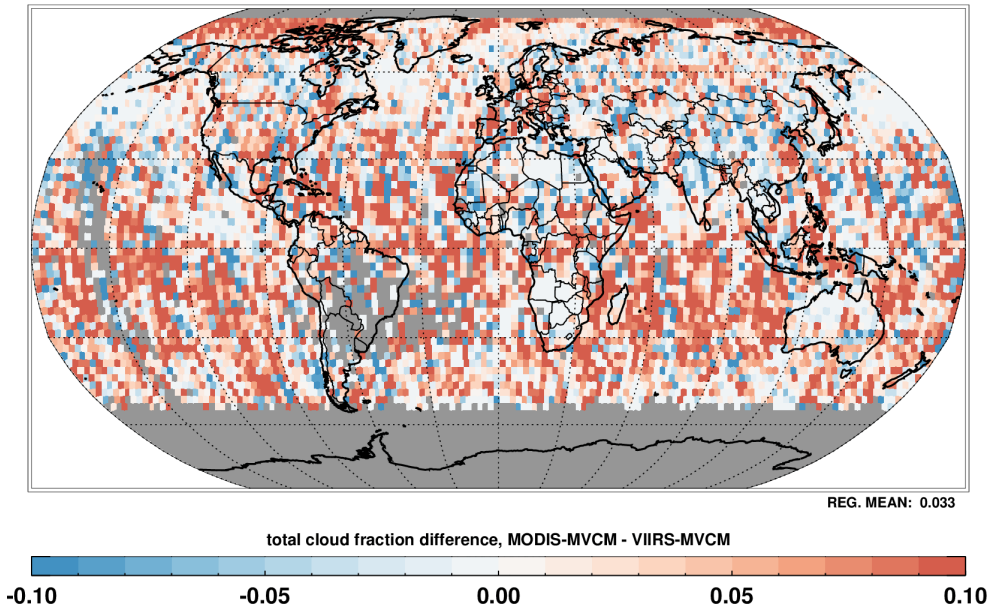
MODIS – VIIRS cross-platform continuity assessments
July 2019, **day**, all surface types

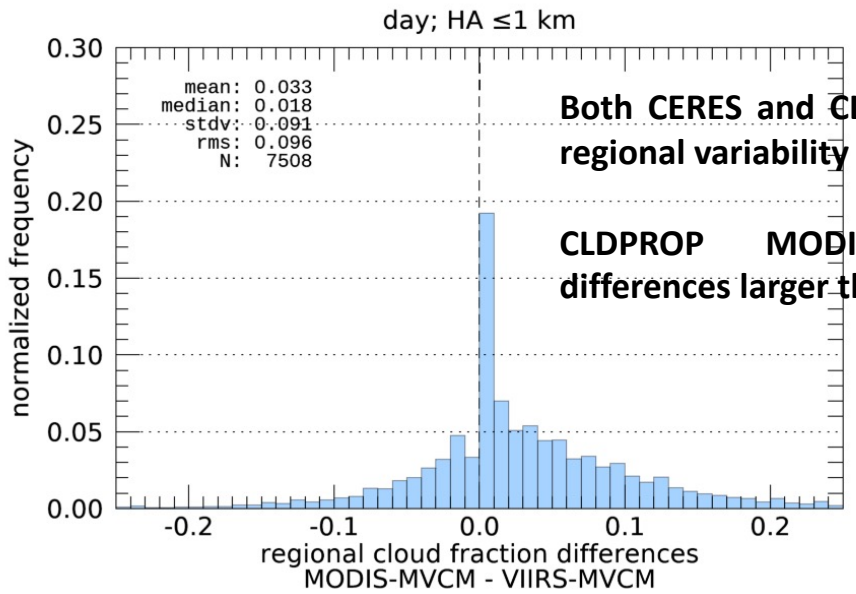
CERES Alpha-0
MODIS-VIIRS





MAST
CLDPROP
MODIS-VIIRS



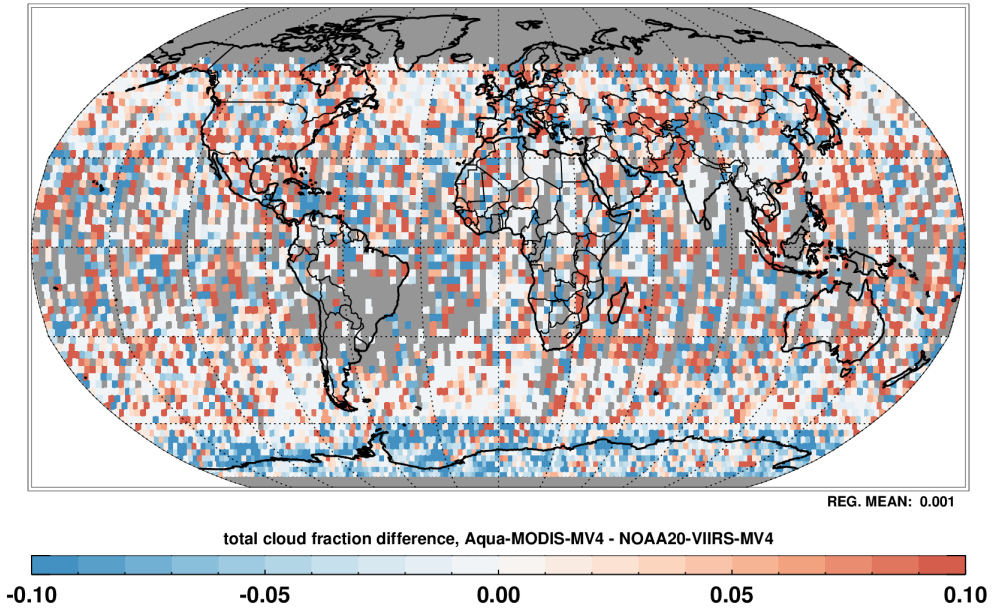


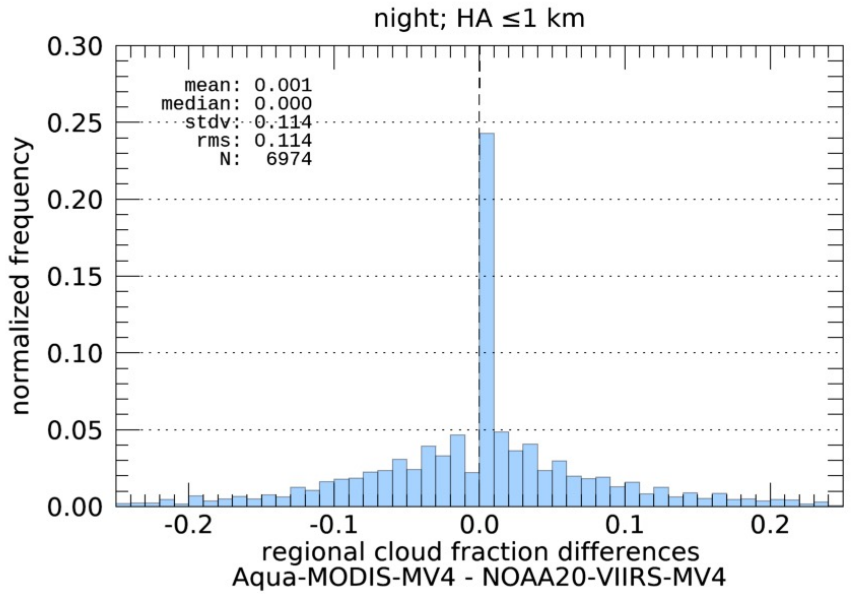
Both CERES and CLDPROP exhibit regional variability

CLDPROP MODIS – VIIRS differences larger than CERES

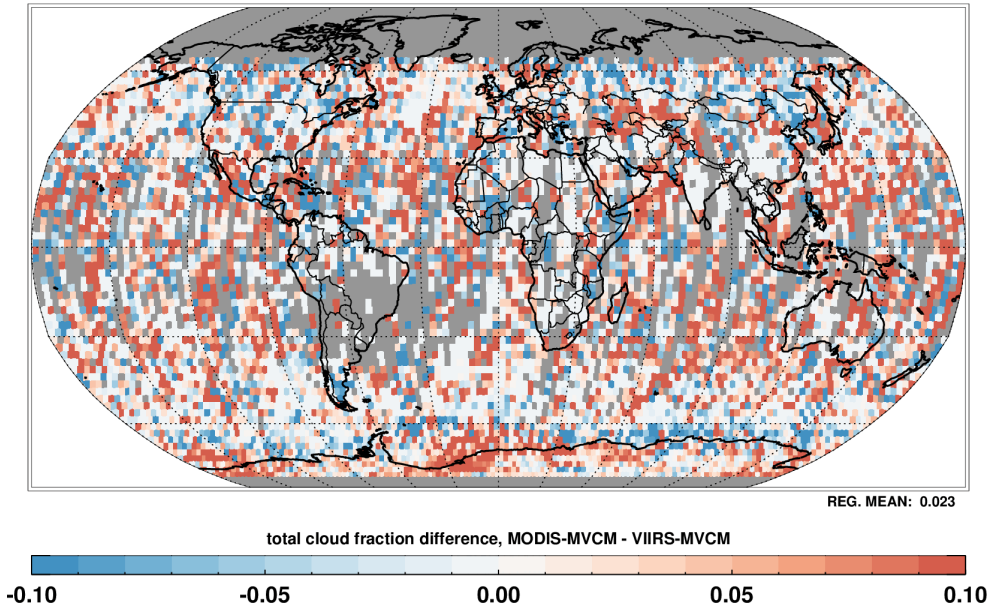
MODIS – VIIRS cross-platform continuity assessments
July 2019, **night**, all surface types

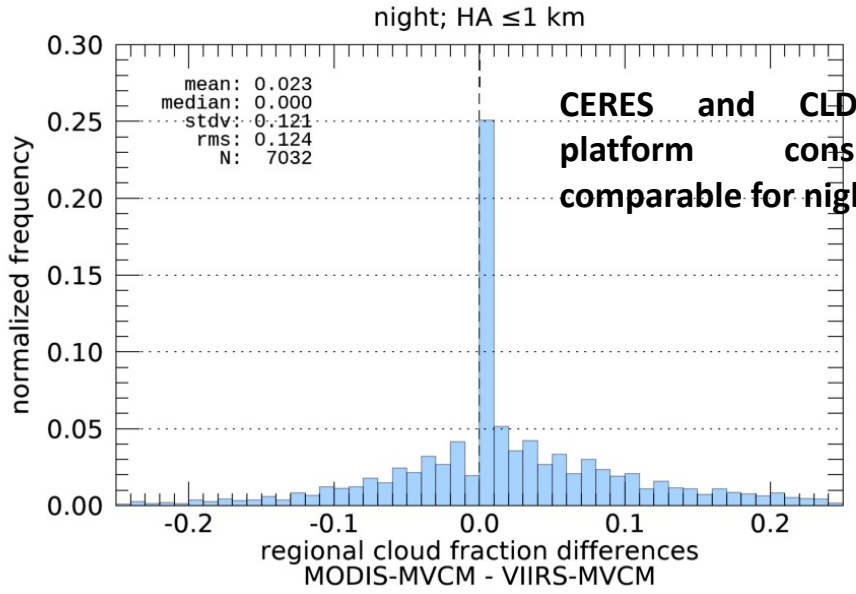
CERES Alpha-0
MODIS-VIIRS





MAST
CLDPROP
MODIS-VIIRS

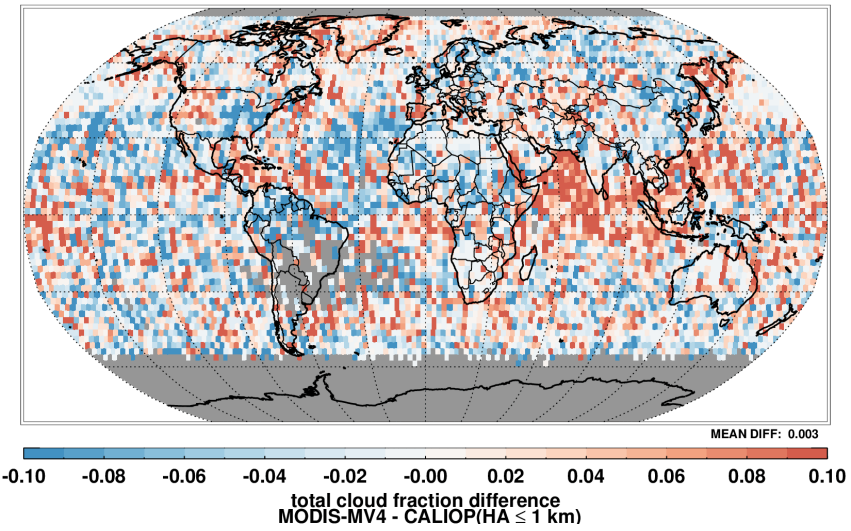




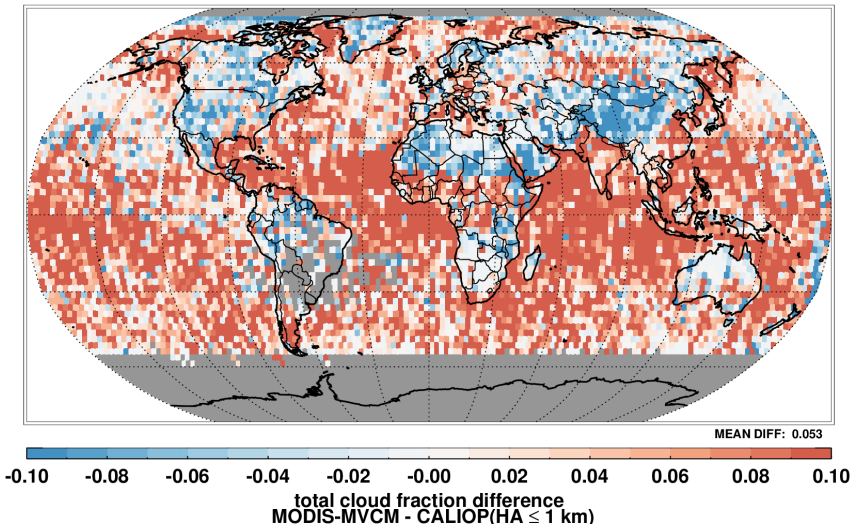
CERES and CLDPROP cross-platform consistency is comparable for night data.

MODIS Alpha & CLDPROP
July 2019, daytime, all surface types

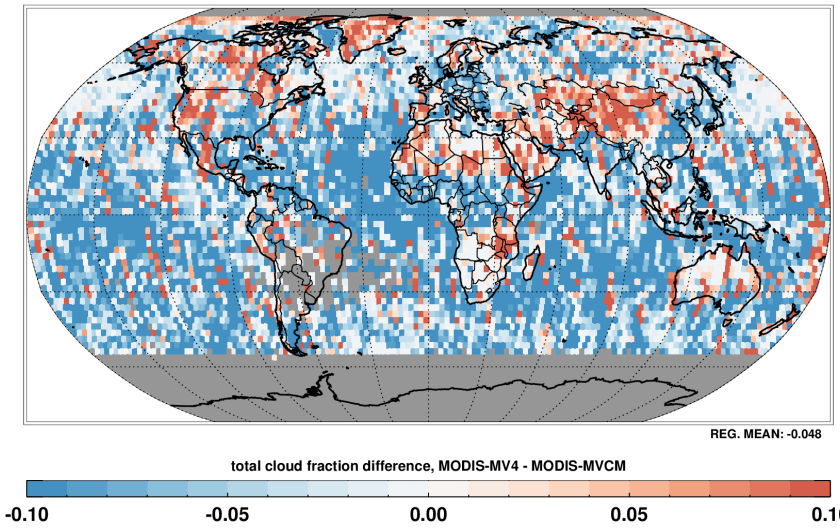
Alpha - CALIOP

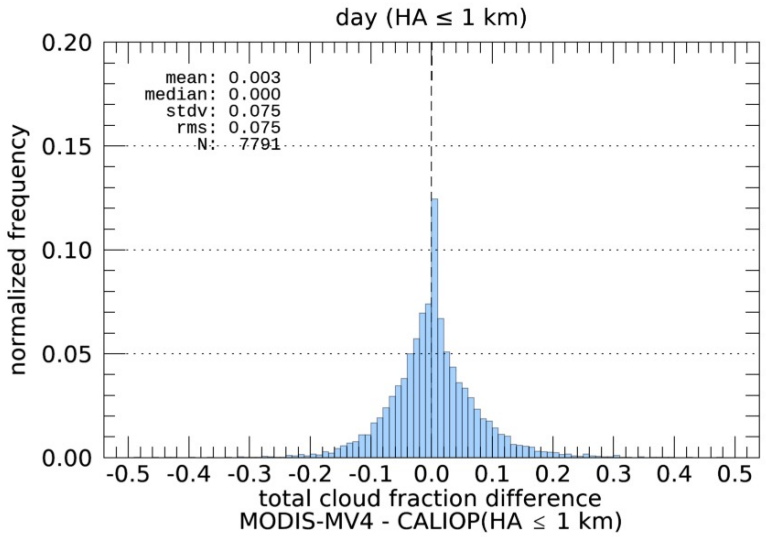


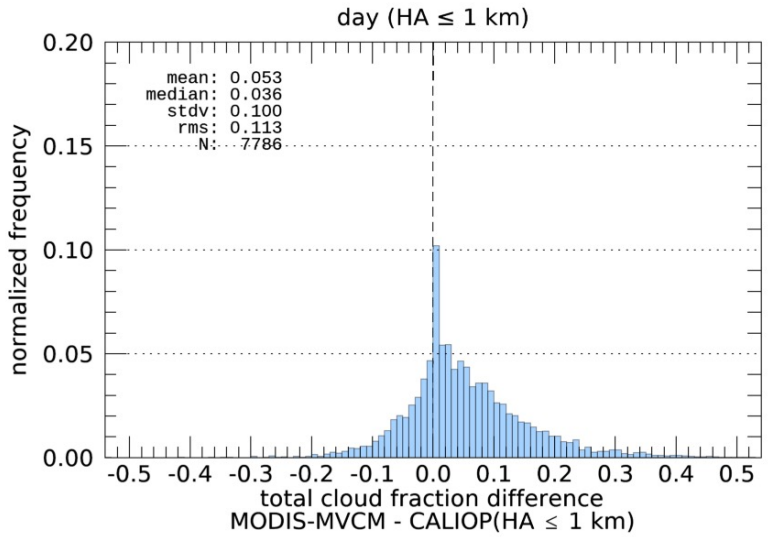
CLDPROP - CALIOP

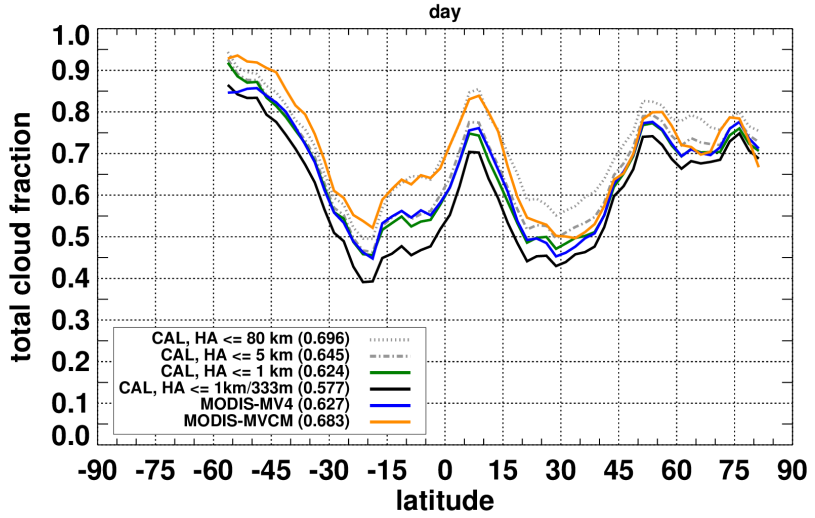


Alpha - CLDPROP



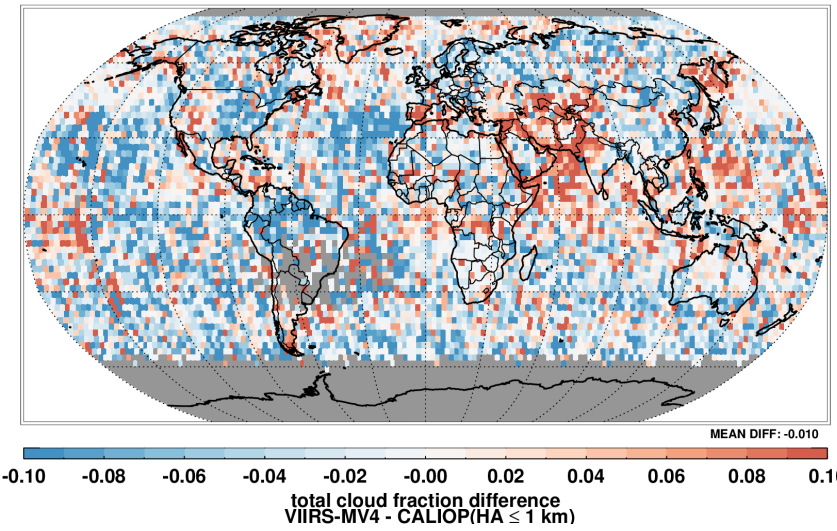




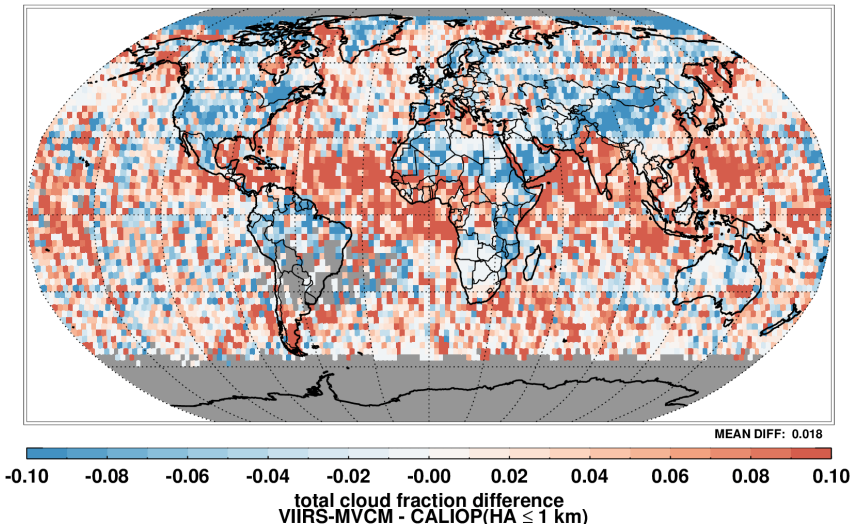


VIIRS Alpha & CLDPROP
July 2019, daytime, all surface types

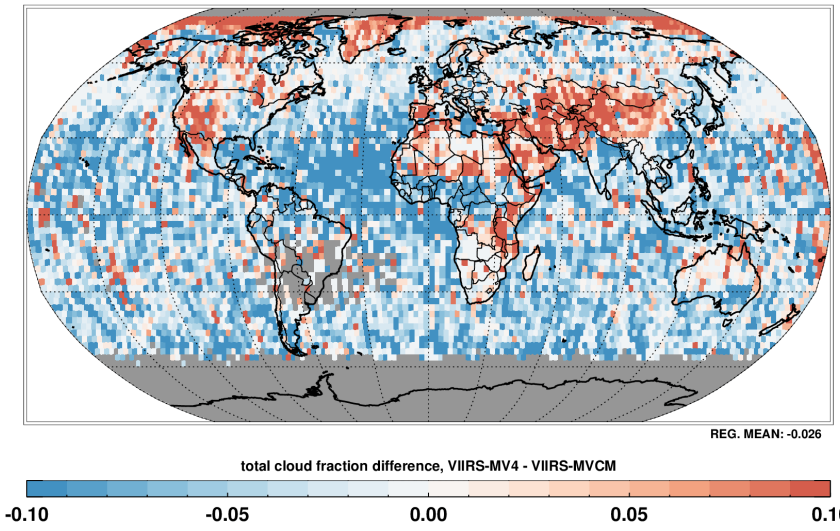
Alpha - CALIOP

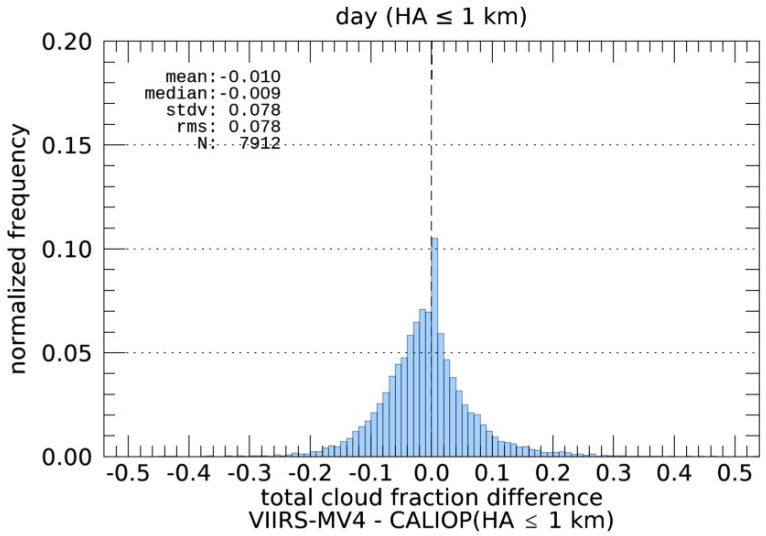


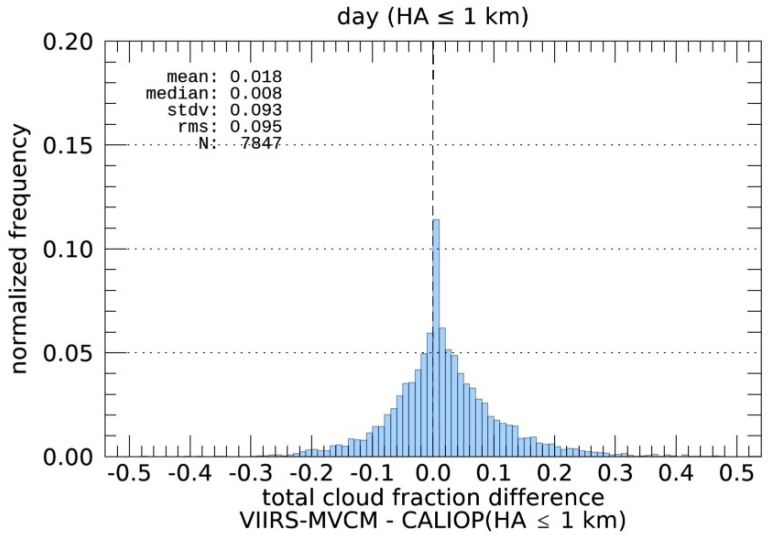
CLDPROP - CALIOP

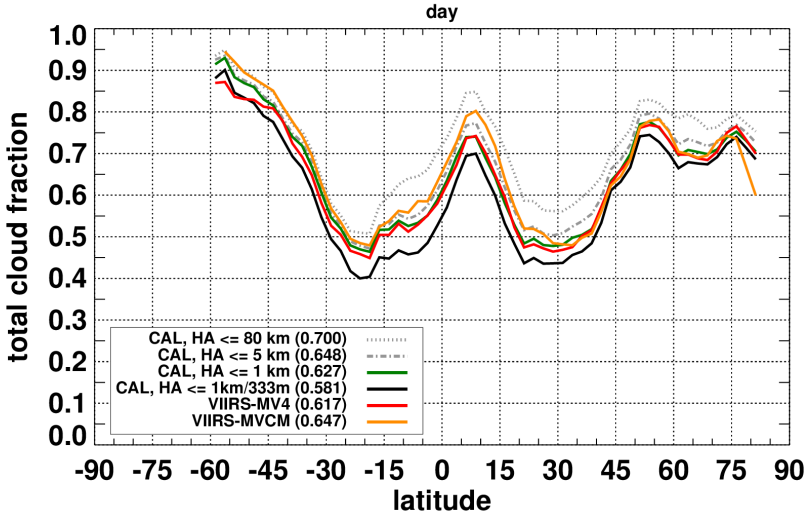


Alpha - CLDPROP



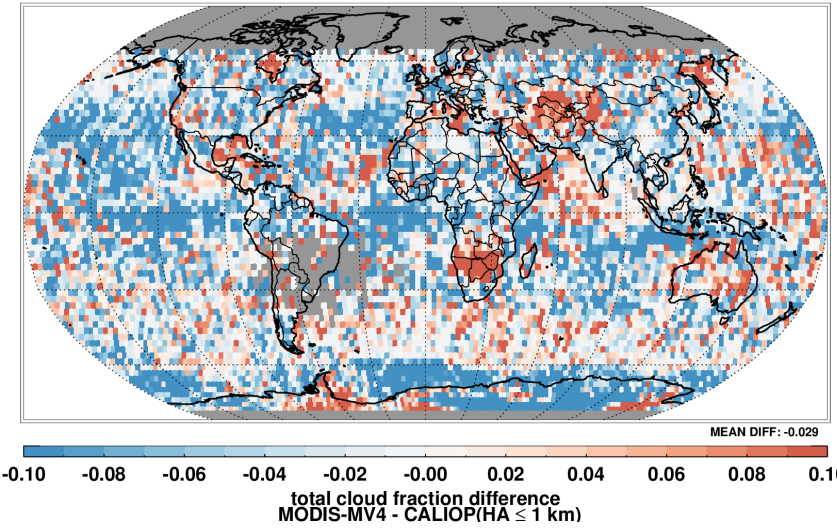




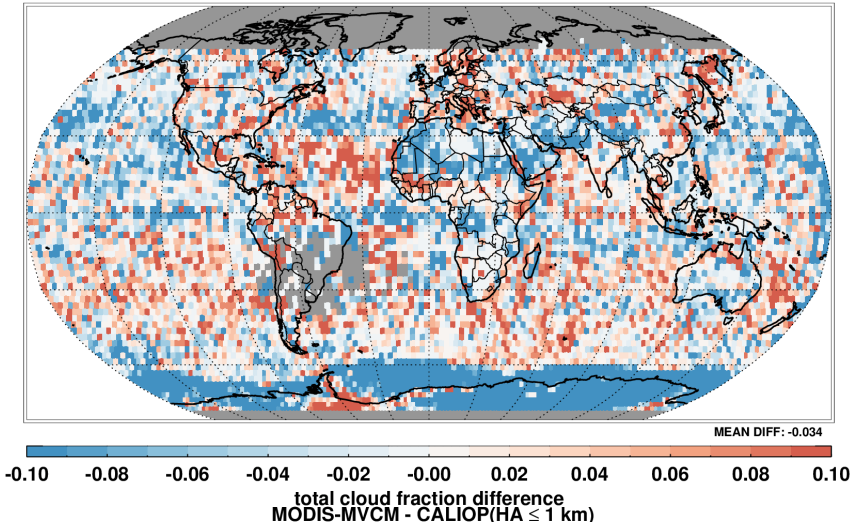


MODIS Alpha & CLDPROP
July 2019, nighttime, all surface types

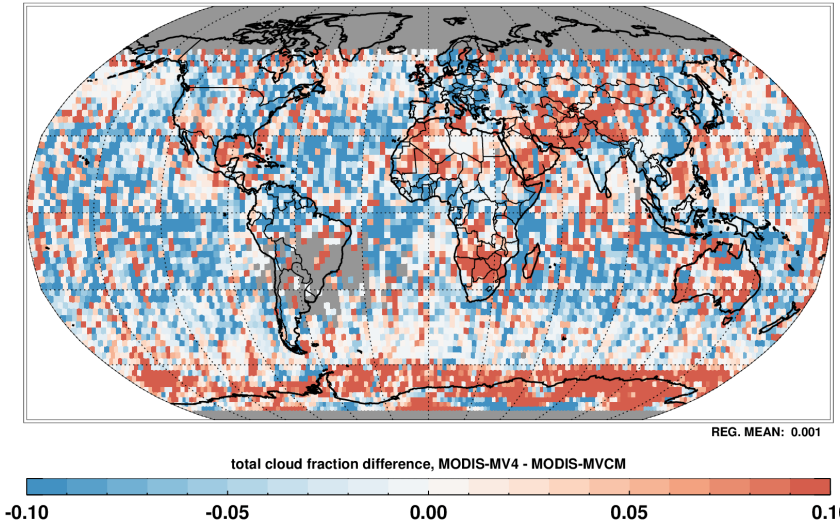
Alpha - CALIOP

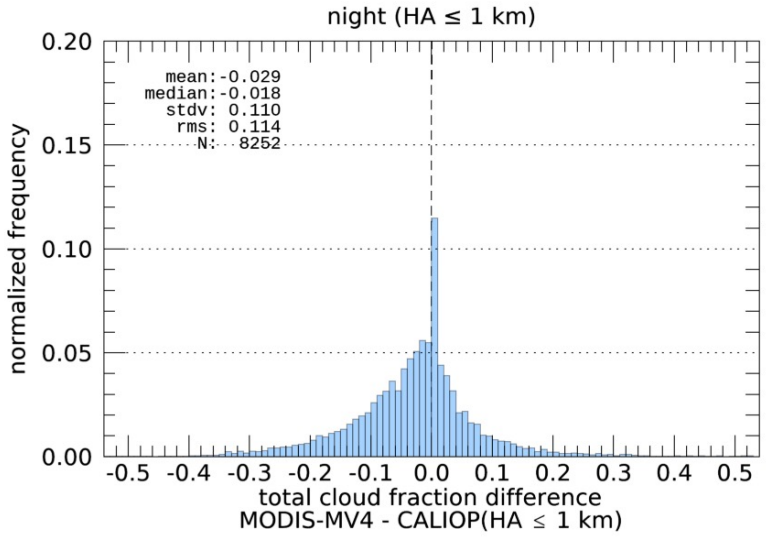


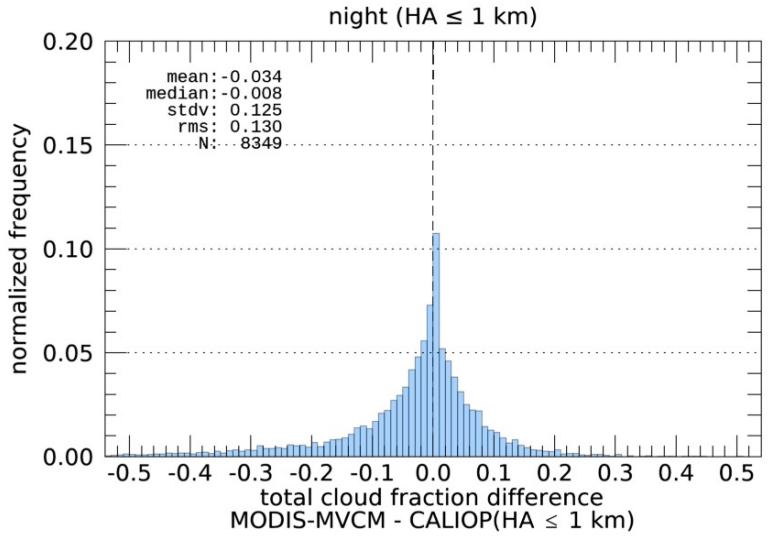
CLDPROP - CALIOP

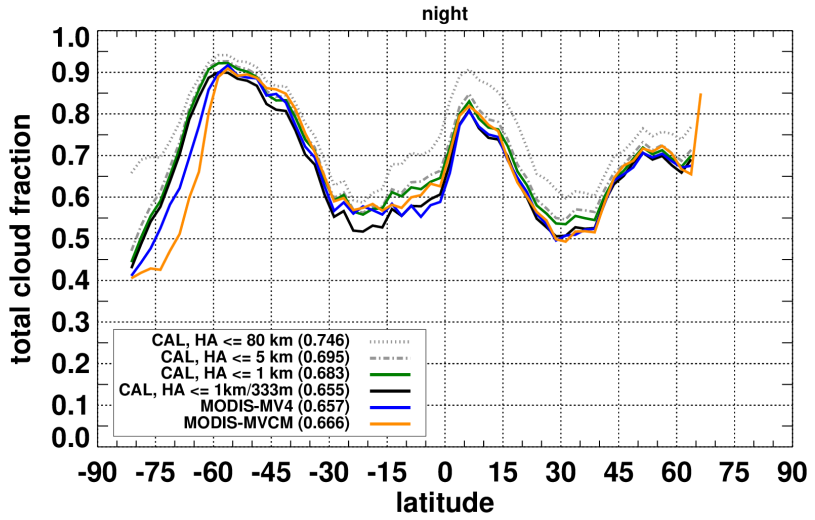


Alpha - CLDPROP



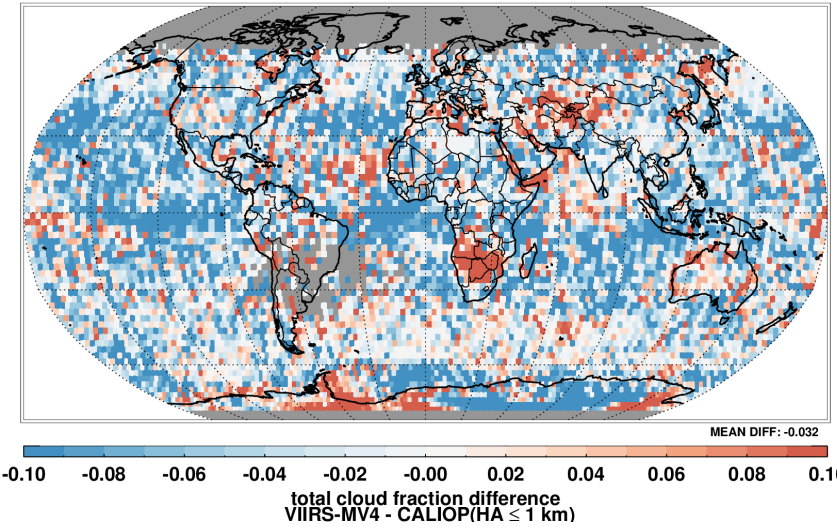




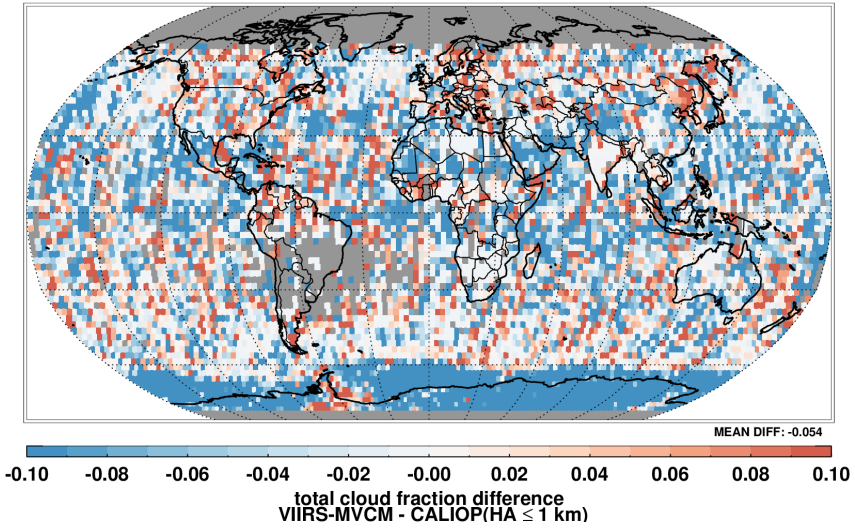


VIIRS Alpha & CLDPROP
July 2019, nighttime, all surface types

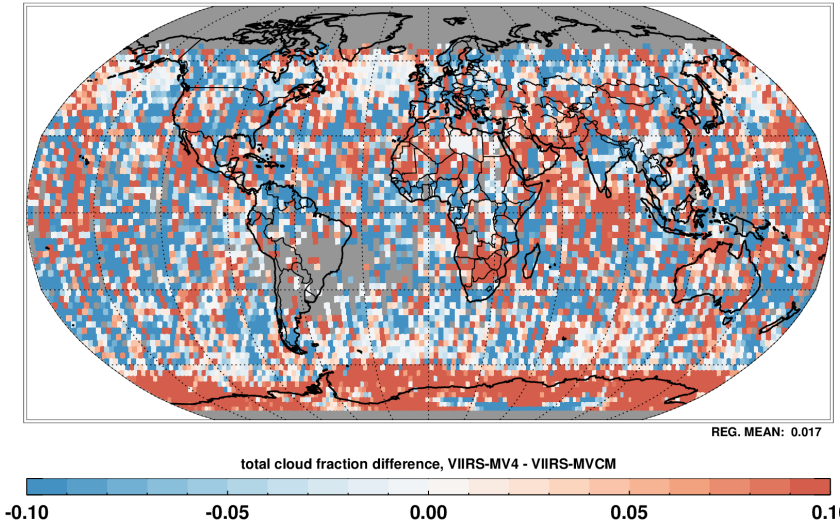
Alpha - CALIOP

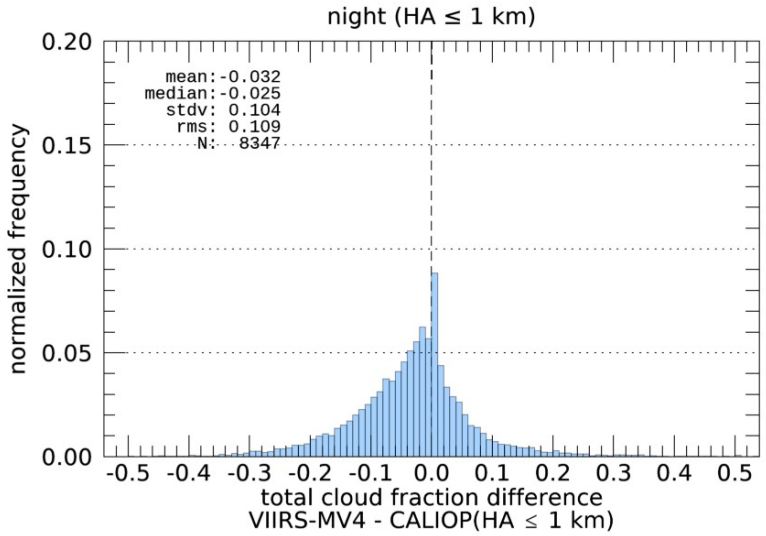


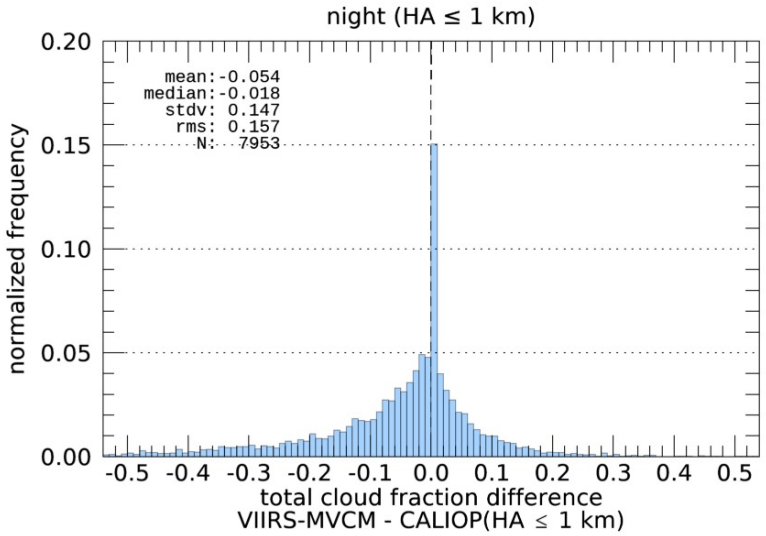
CLDPROP - CALIOP

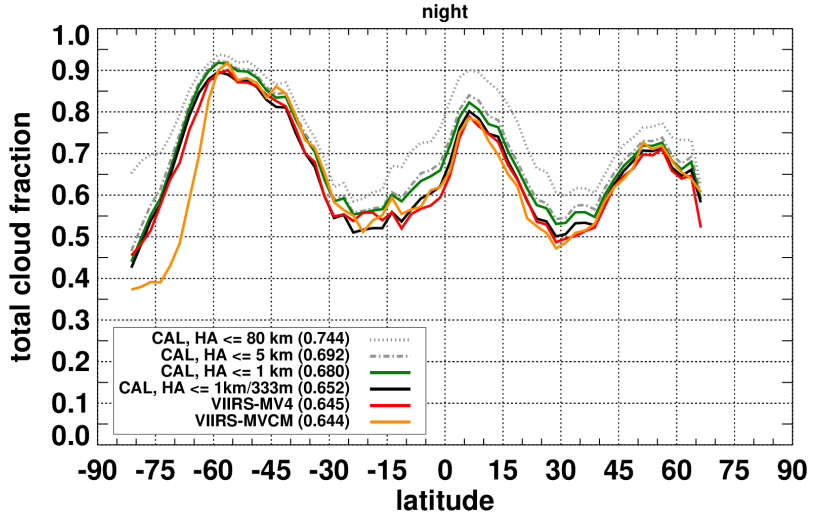


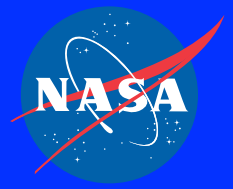
Alpha - CLDPROP










NASA


CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM
CERES
NASA

QUESTIONS ?

Input Data Status

Key
- ❑ Alpha 1
- ❑ Alpha 2
- ❑ Ed5

Radiances

- MODIS Collection-7 for Aqua and Terra
  - initial version for July 2008
  - resurrected Aqua 1.6 µm band use in CERES
- Fixed a calibration problem for the 3.9 µm bands

Atmospheric State

- GEOS-IT 0.5 deg MOA
- Atmospheric correction (corr-k's)
  - Updated gases, adjust continuum absorption & validated

Input Data

Key
- ❑ Alpha 1
- ❑ Alpha 2
- ❑ Ed5

Surface Characterization

- IGBP map
- Snow & ice map
- Water percent map
- Elevation map
- Ocean reflectance model (updated Jin)
- Surface emissivity
  - Zhou IASI climatology
  - May incorporate a CWG approach
- Land Skin temperature
  - Clear sky Neural Net for cloud mask
  - New logic for what to use below clouds

Common Cloud Mask (MODIS/VIIRS)

Key
- ❑ Alpha 1
- ❑ Alpha 2
- ❑ Ed5

- Removed cloud tests with 6.7 and 13.3 µm and replaced with other logic.
- Reduced nighttime tropical ice cloud over-detection (relative to CALIPSO)
- Modified BTD tests to include comparisons to clear sky calculations (better accounts for the impact of regional water vapor absorption variability and improves MODIS/VIIRS consistency.
- Improved nighttime desert.
- Tune non-polar land and ocean cloud masks to account for new ancillary data inputs (e.g. IGBP, atmos. corrections, ocean reflectance model, Tskin Nnet, CWG 3.7 µm land emissivity)
- Develop and implement Neural Net cloud mask for Antarctica and ice shelf, Greenland and Arctic sea-ice
- Tune polar daytime and nighttime mask for application to land regions not covered by permanent snow/ice

Cloud Properties

Key
- ❑ Alpha 1
- ❑ Alpha 2
- ❑ Ed5

Optical and Microphysical Properties

- THM (latest version from Ping)
- Hybrid daytime optical depth over snow/ice
- Nighttime optical depth Neural Net for thick cloud
- Note that CO2 channel phase (& height) logic remains in Alpha1
- Replace CO2 channel logic with split window logic
- Cloud phase
  - add cirrus flag for overlapping clouds that are interpreted with water cloud model