CERES GEO Clouds Working Group Report

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F-L. Chang (CO2, corrk), D. Spangenberg (everything), Cecilia Wang (machine learning), B. Shan (GEO), A. DiNorscia (sounding)
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Thanks to Dave Doelling and the TISA/calibration teams!

Fall 2024 CERES Science Team Meeting,
Lawrence Livermore National Laboratory, 1-3 October 2024

Ed5 Cloud Algorithm Updates

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

2. Cloud Properties
   - Algorithm components were fully revised to improve algorithm consistency across all the GEO sensors
   - Atmospheric corrections (much improved)
   - Cloud mask (improved logic and new tuning - ongoing)
   - Optical & microphysical properties (THM for ice clouds)
   - Use of machine learning for nighttime thick COP, polar night mask, cloud heights, phase in overlapping clouds
     - Preliminary implementation reported in this presentation
   - For the 3.9-um channel: solar constant based on Kurucz and Fontenla et al. (2006, Astrophys. J).

Common 3-channel Algorithm for GEO's

(day: 0.65, 3.9, 11 µm night: 3.9, 6.7, 11 µm)

Inter-satellite consistency check

Objectives:

(1) Evaluate the consistency of cloud fraction and daytime cloud optical properties to help identify remaining problems in the new system before tuning cloud mask for accuracy.

(2) Assess cloud fraction against CALIPSO

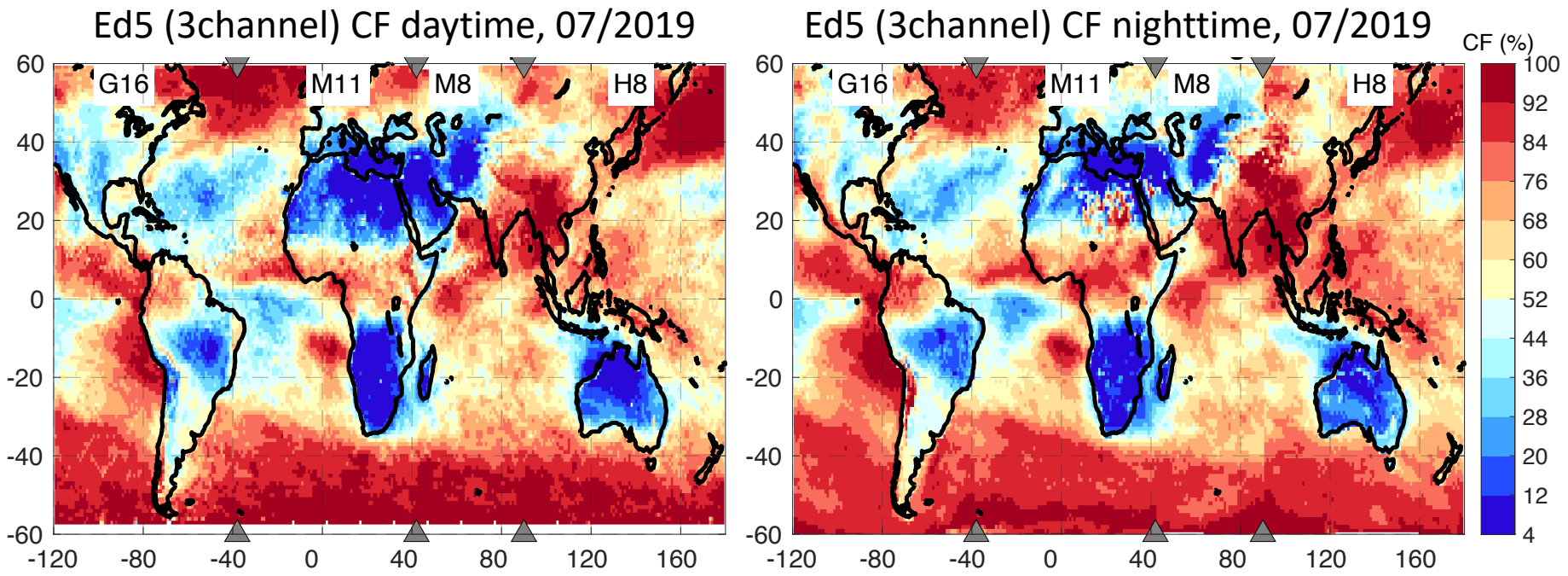
(3) Document changes relative to Edition 4.

Two time periods:

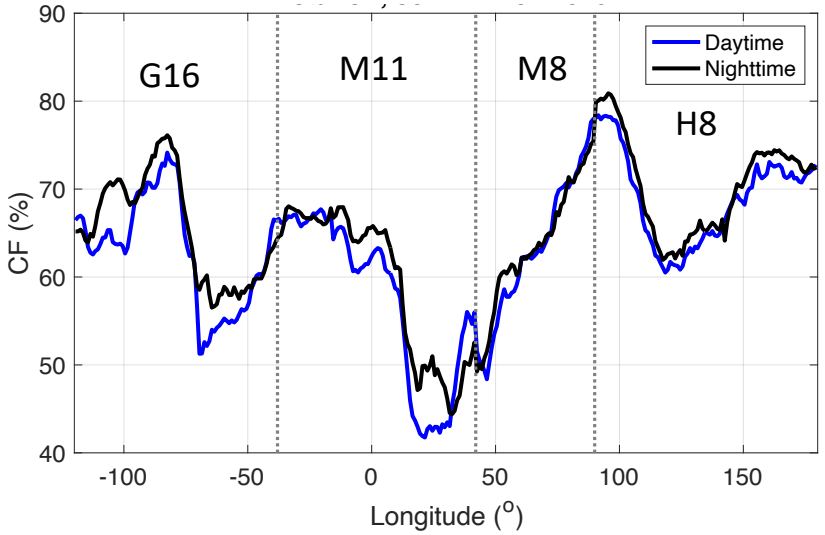
July 2019: GOES-16 (G16), Meteosat-11 (M11), Meteosat-8 (M8), Himawari-8 (H8).

July 2012: GOES-13 (G13), GOES-15 (G15), and Meteosat-9 (M9)

Total Cloud Fraction



Meridionally averaged

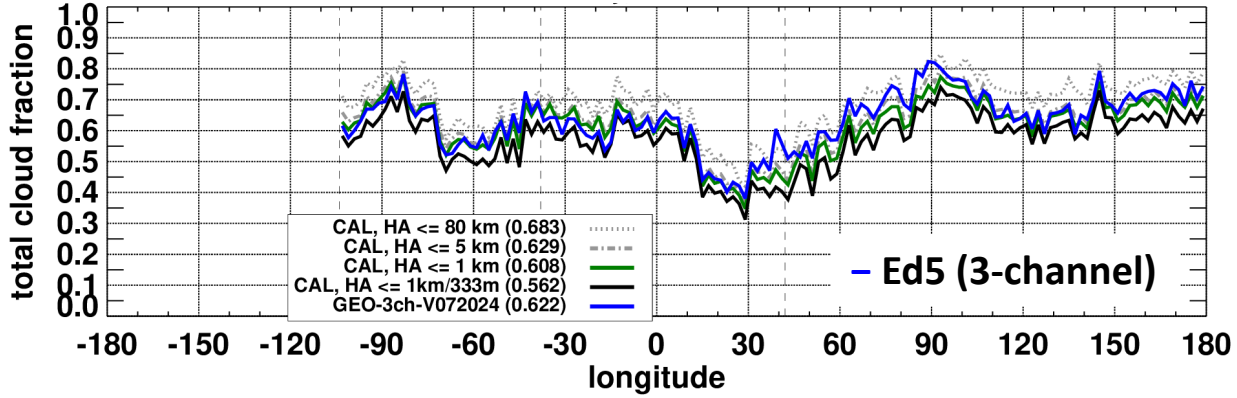


- Very consistent across the modern satellites

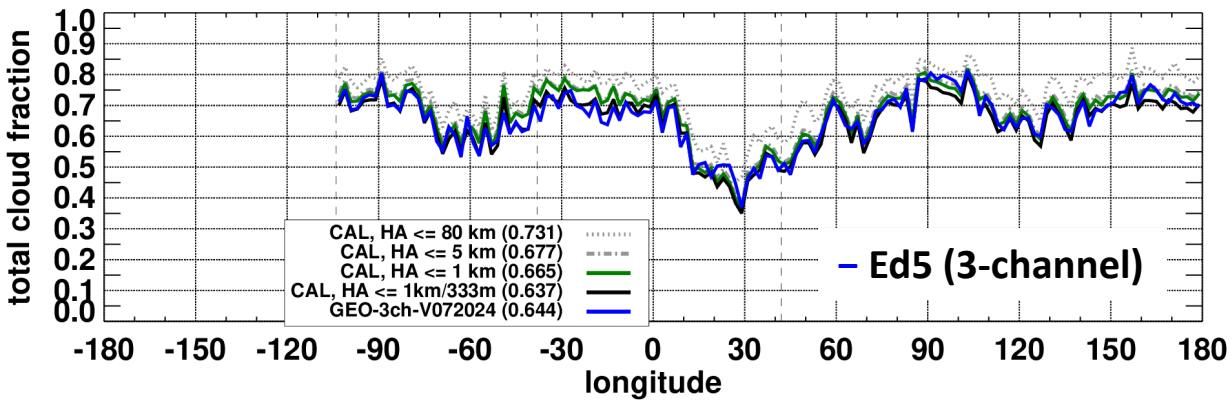
Comparison between GEOs and CALIPSO

3-channel CF

DAY

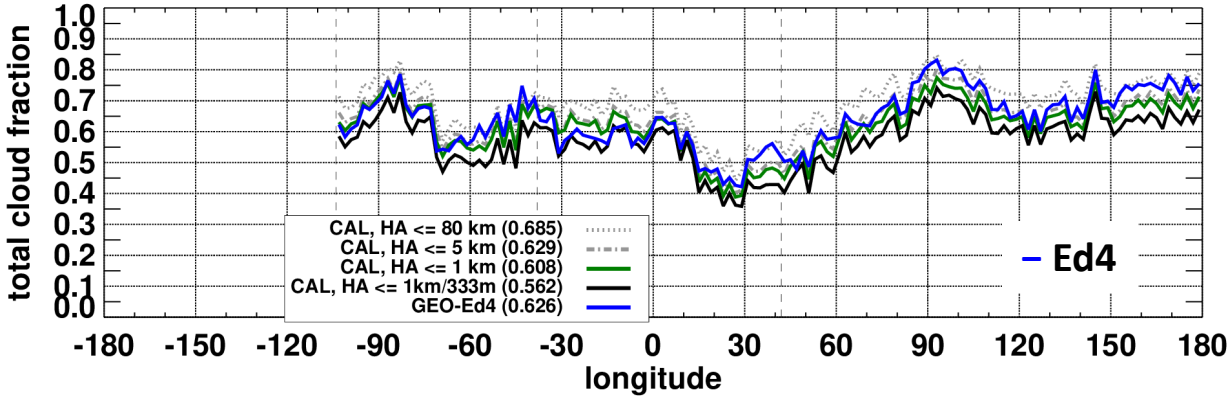


Night

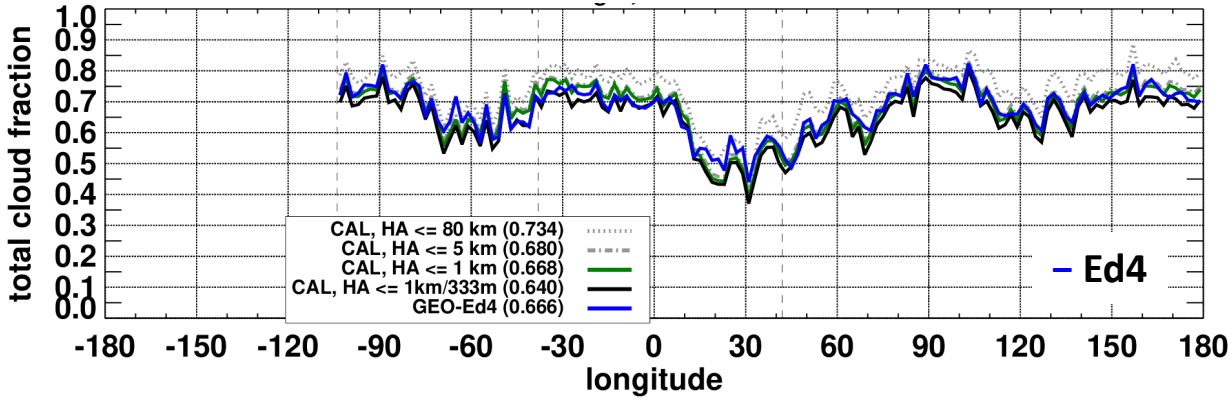


Ed4 CF

DAY



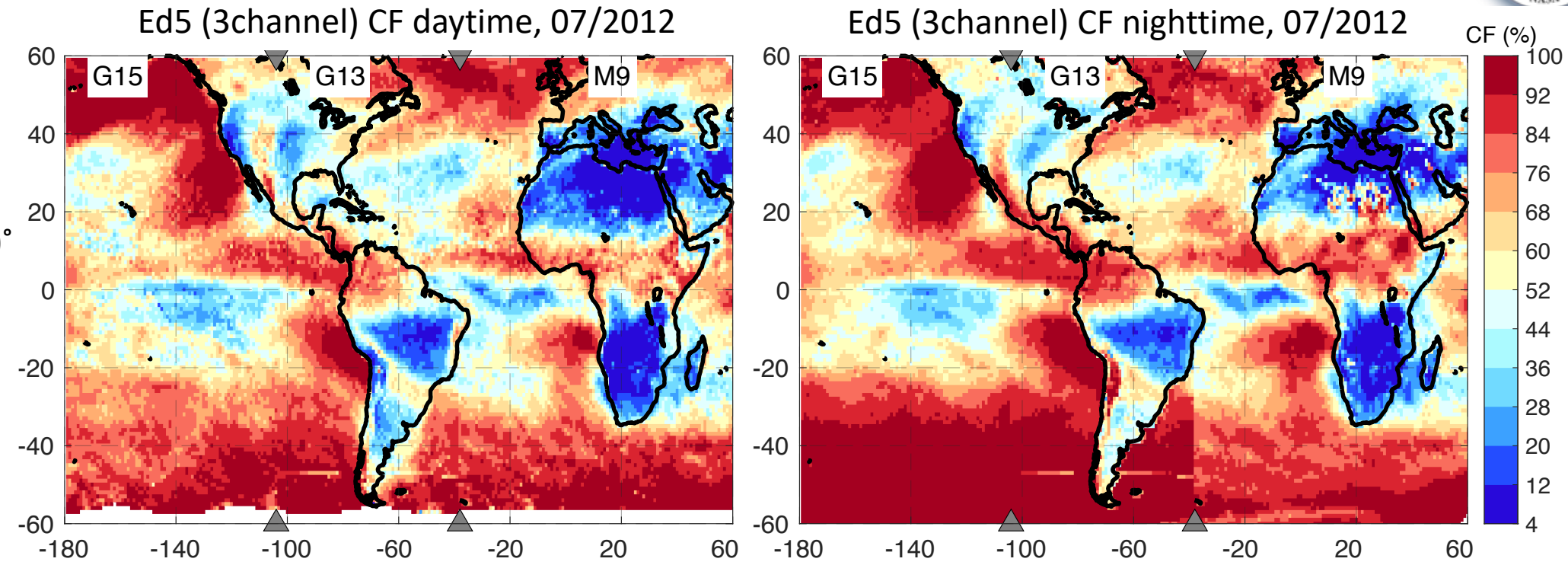
DAY



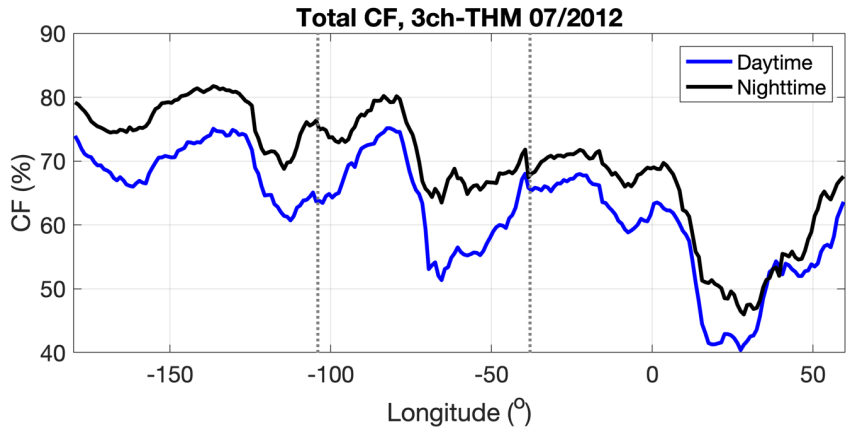
- The assessment is not easy (sampling issues, different products, etc.).
- Both Ed4 and 3-channel (Ed5) are generally consistent with CALIPSO.

Total Cloud Fraction

Daytime, SZA<75˚
Nighttime, SZA>90˚



Latitudinal average by longitude

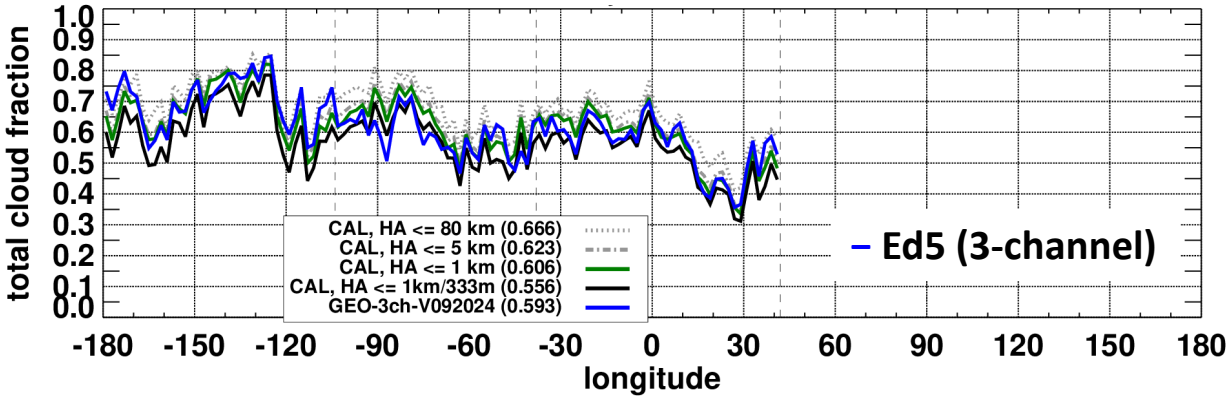


- Consistency across satellites very good except at night over the southern ocean – GOES look too cloudy
- No tuning yet over land

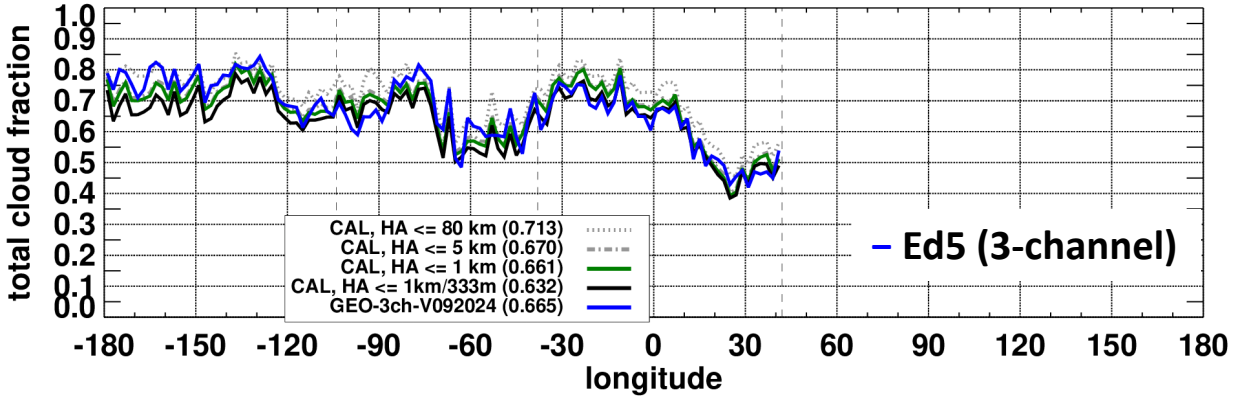
Comparison between GEOs and CALIPSO

3-channel CF

DAY

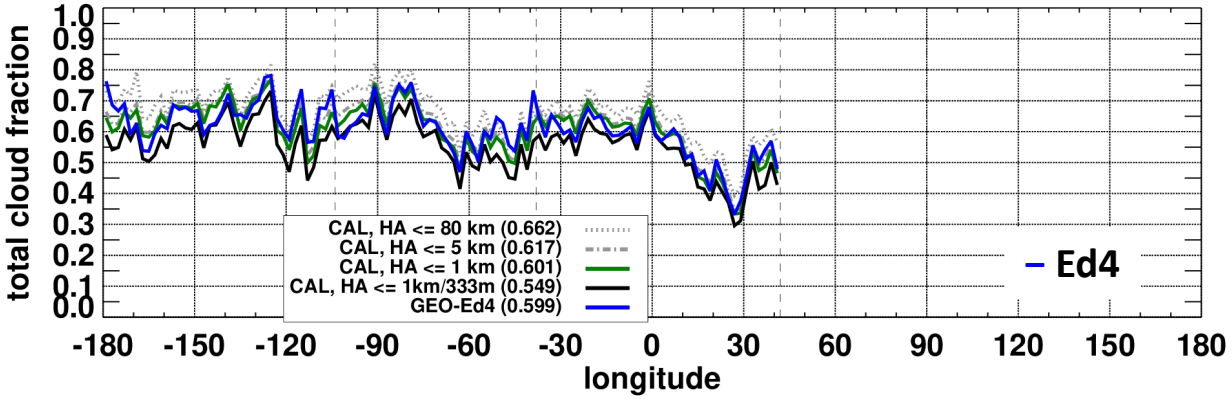


Night

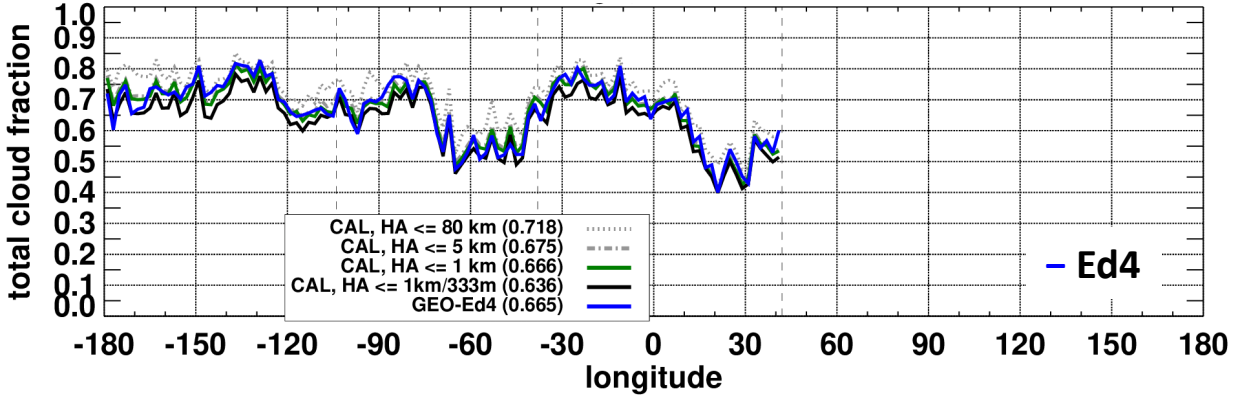


Ed4 CF

DAY

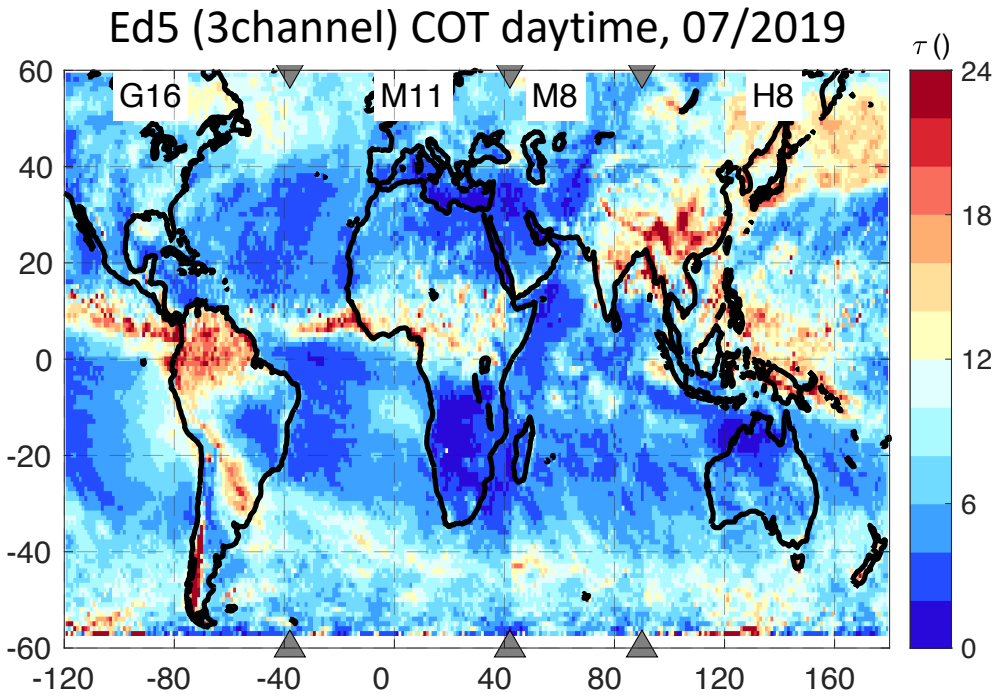


Night



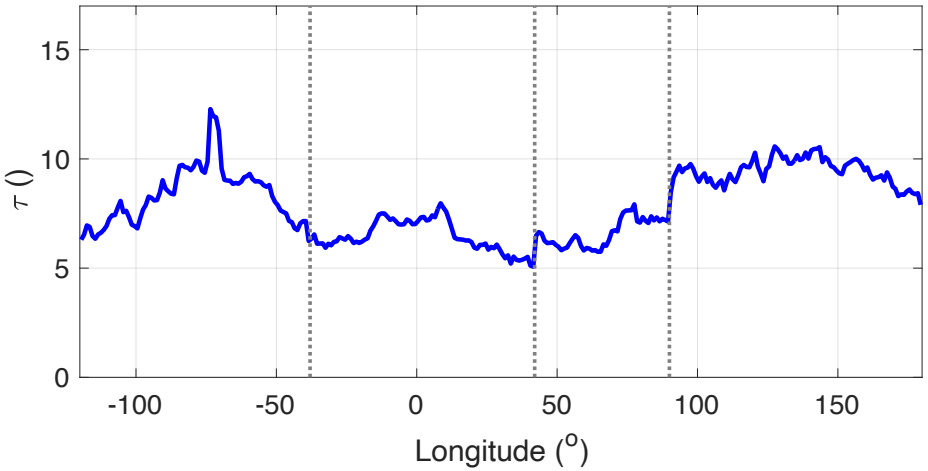
- Both Ed4 and 3-channel (Ed5) are generally consistent with CALIPSO.

Total cloud optical thickness (COT)

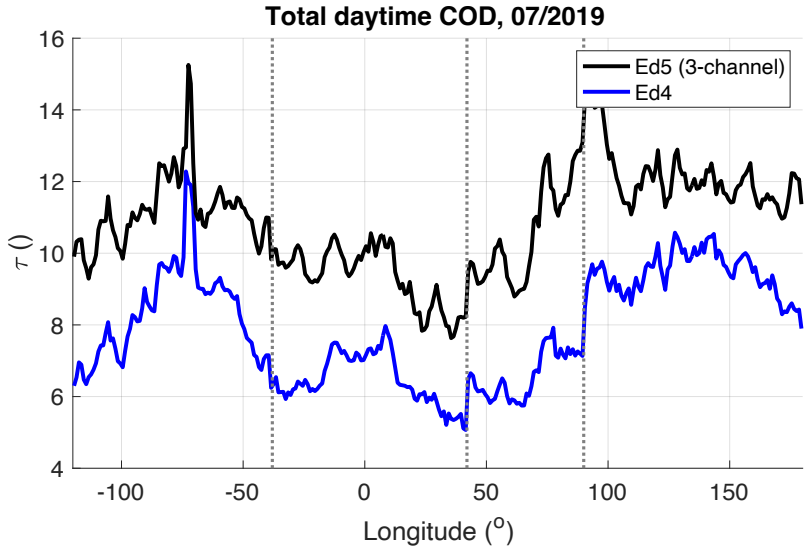


- Good inter-satellite consistency.
- Ed5 COT<Ed4 COT

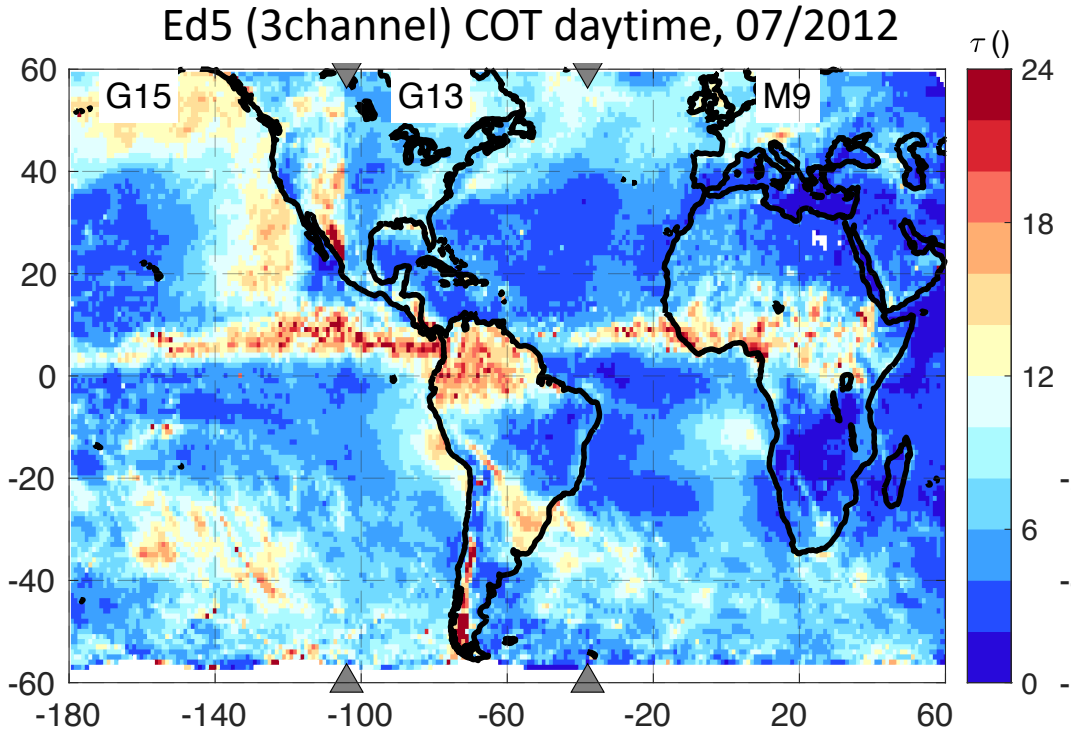
Latitudinal averages by longitude



3-channel vs Ed4

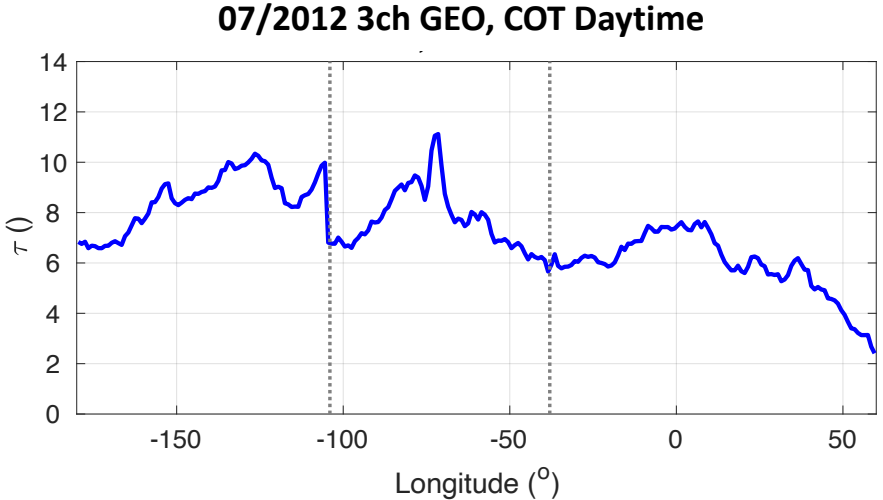


Total cloud optical depth

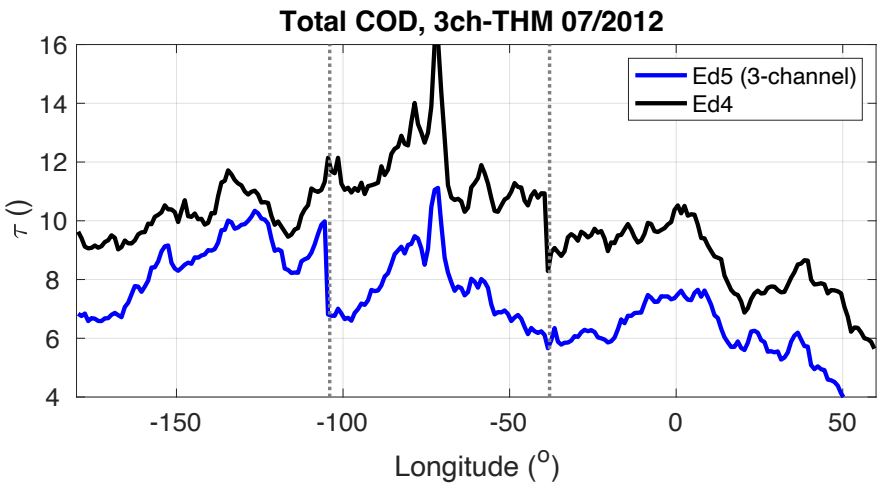


- Good inter-satellite consistency between the older GOES and Met-9
- Differences in North America need to be investigated.
- Ed5 COT<Ed4 COT

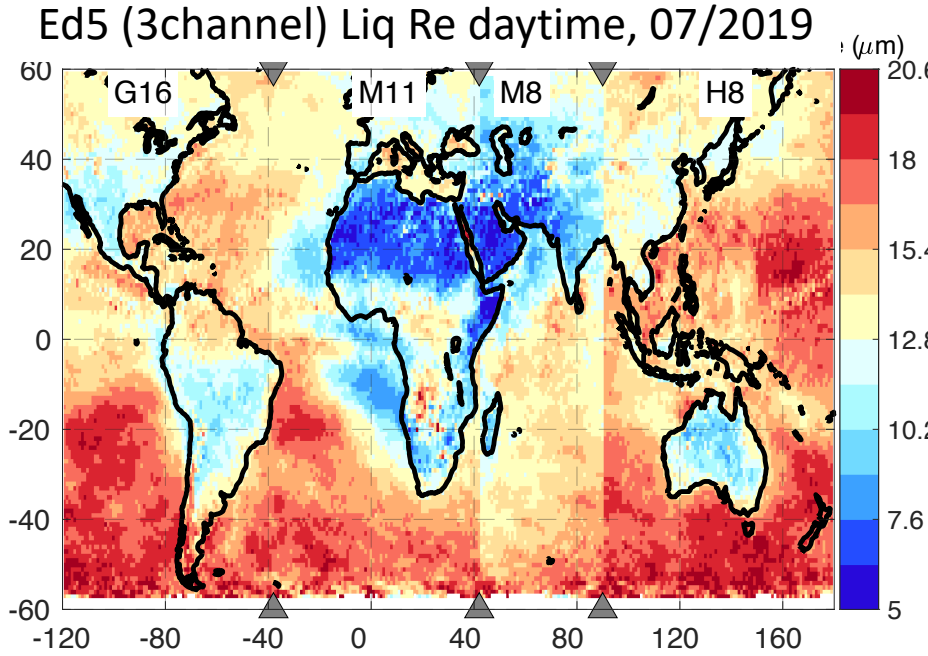
Latitudinal averages by longitude

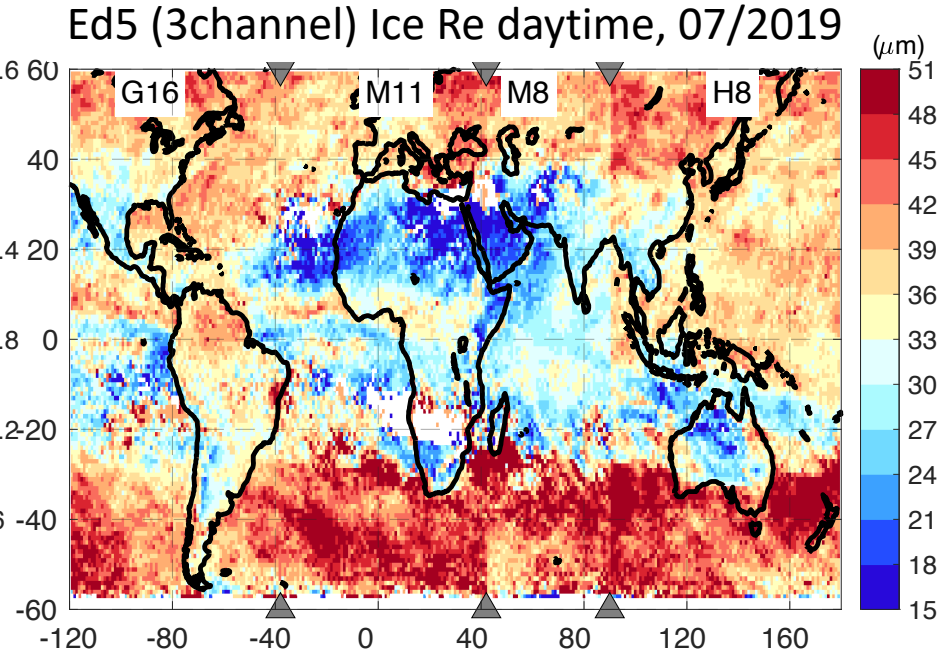


3-channel vs Ed4



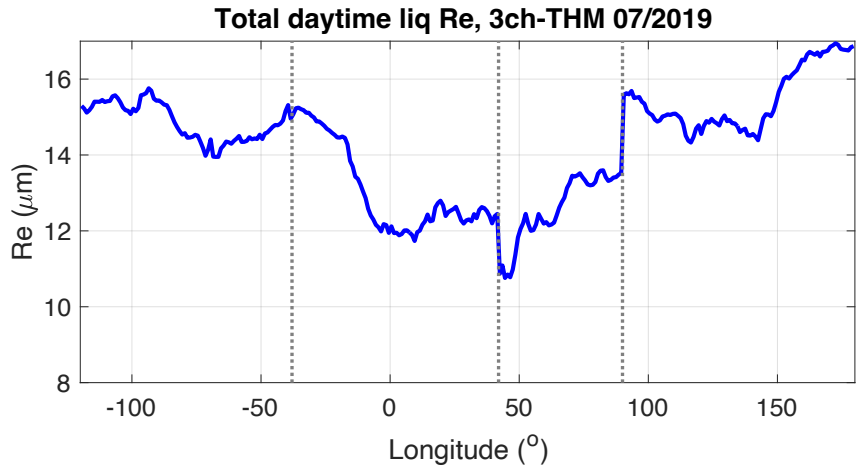
Daytime particle size (Liquid and ice)

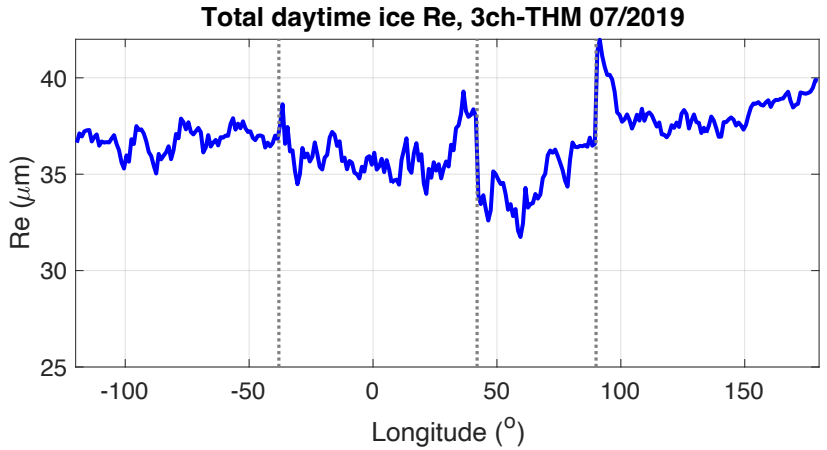




SEVIRI on Met-8 partially disagrees with M11 and H8

Zonal view:

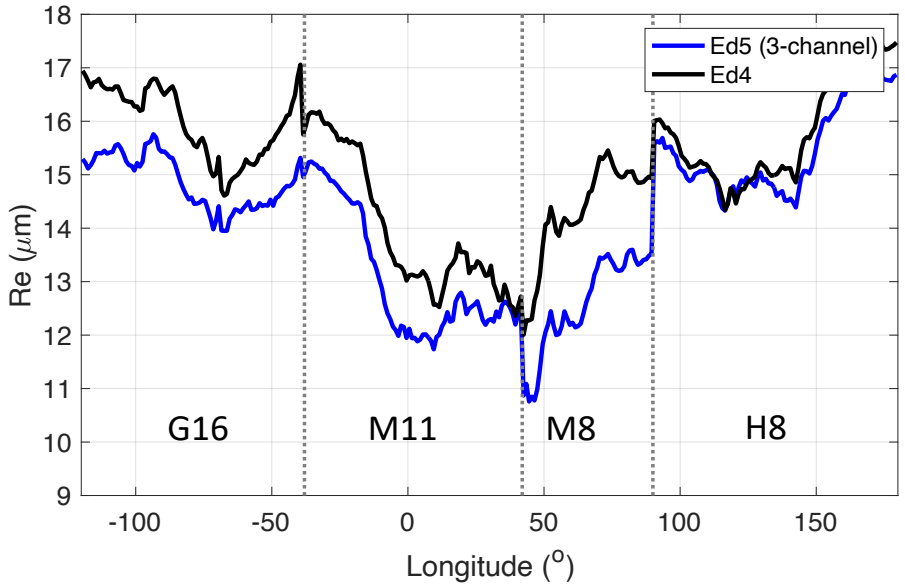




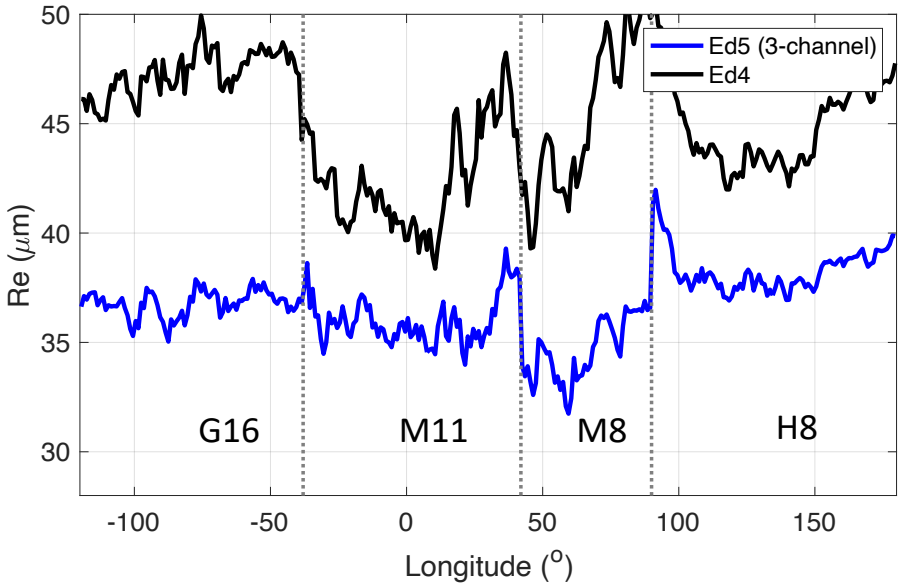
Cloud particle size: 3-channel (Ed5) vs Ed4

Ed5 (3channel) Liq Re daytime

Liq Re: 3-channel vs Ed4, 07/2019

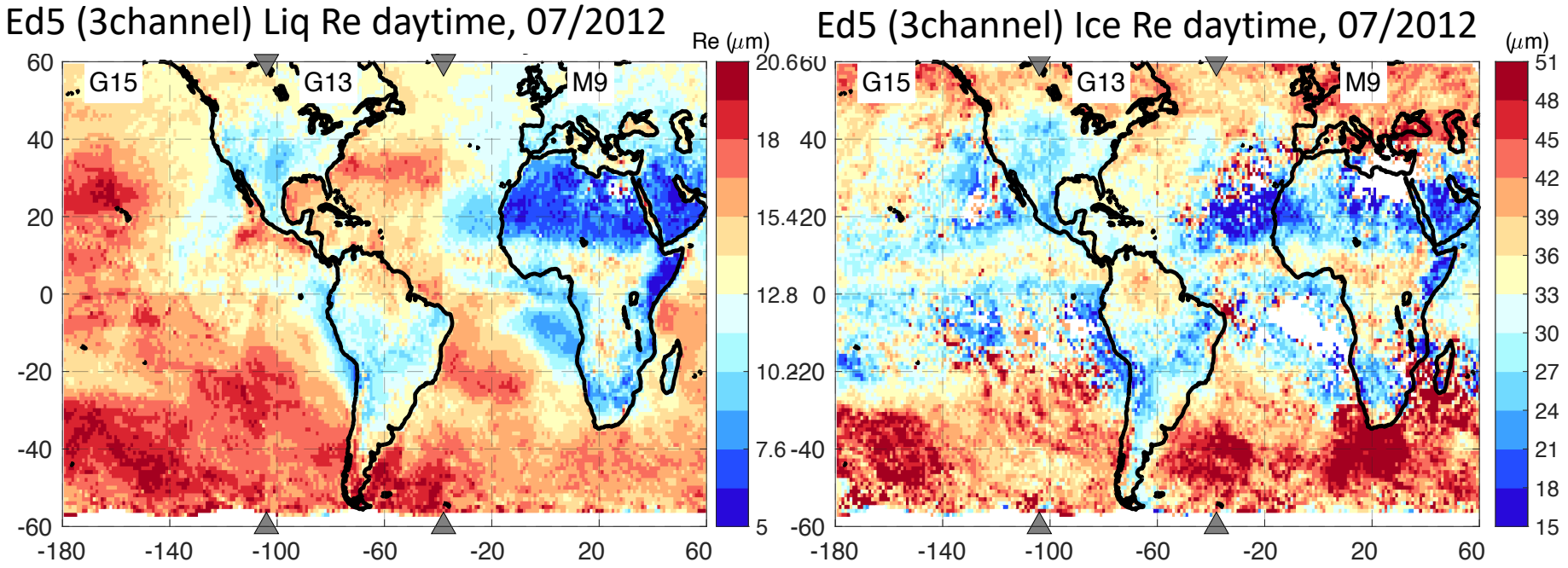


Ice Re: 3-channel vs Ed4, 07/2019



- Ed5 particle size decreases by ~ 2-3 um (liquid), 6 um (ice).

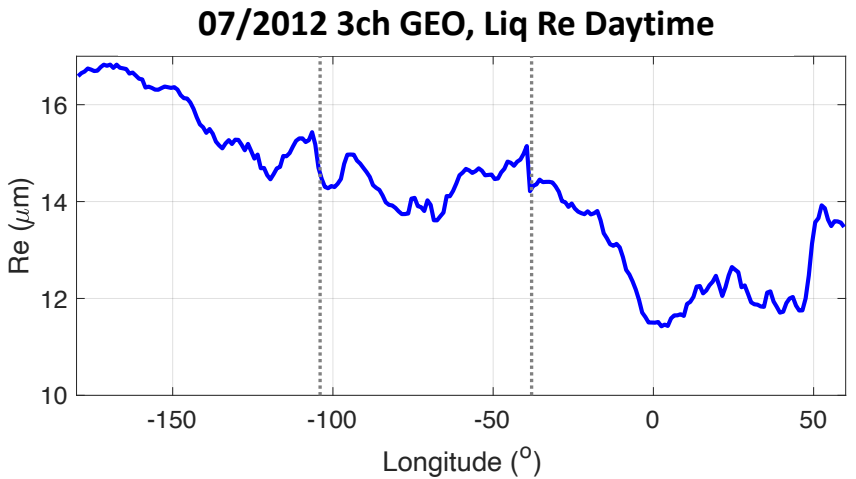
Daytime particle size (Liquid and ice)

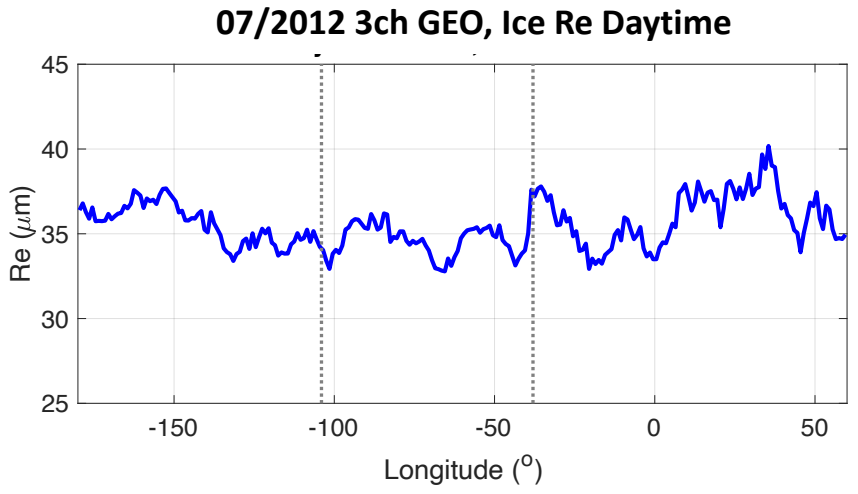


Met-9 liquid Re partially disagrees with the two GOES

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

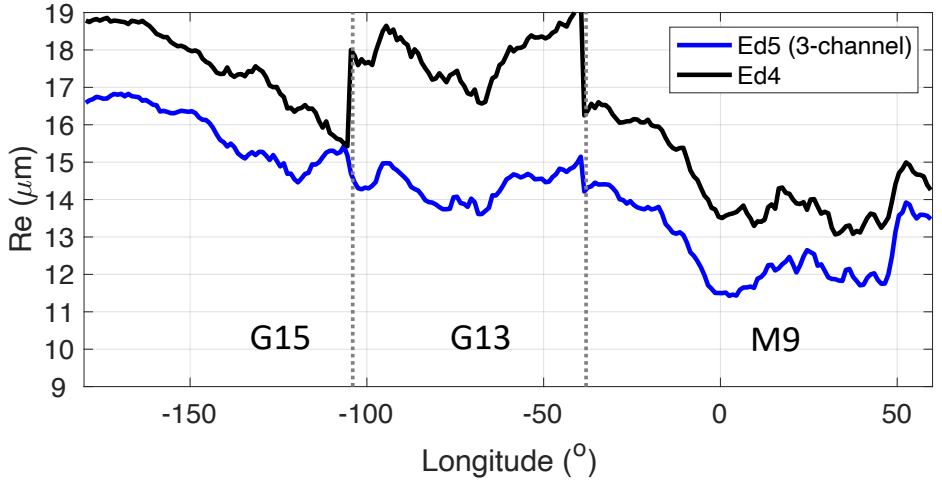
Meridional average:



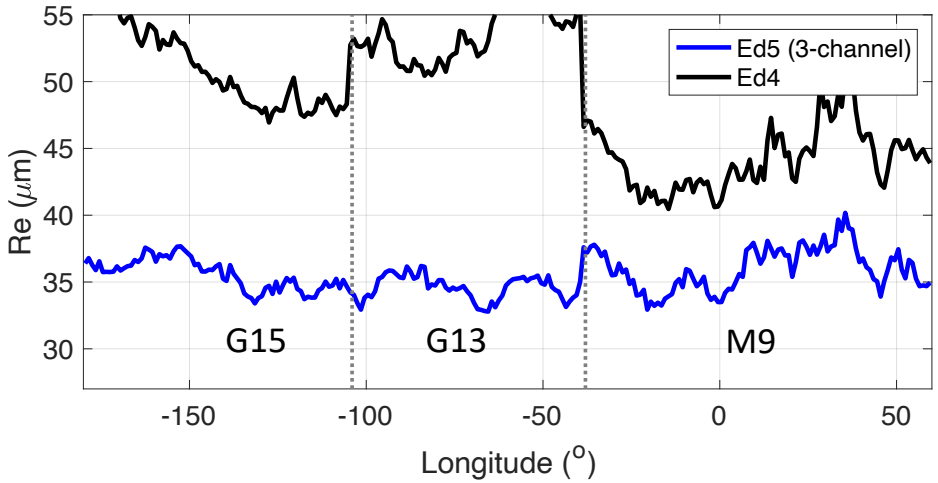


Particle size: 3-channel vs Ed4

Liq Re: 3-channel vs Ed4, July 2012



Ice Re: 3-channel vs Ed4, July 2012



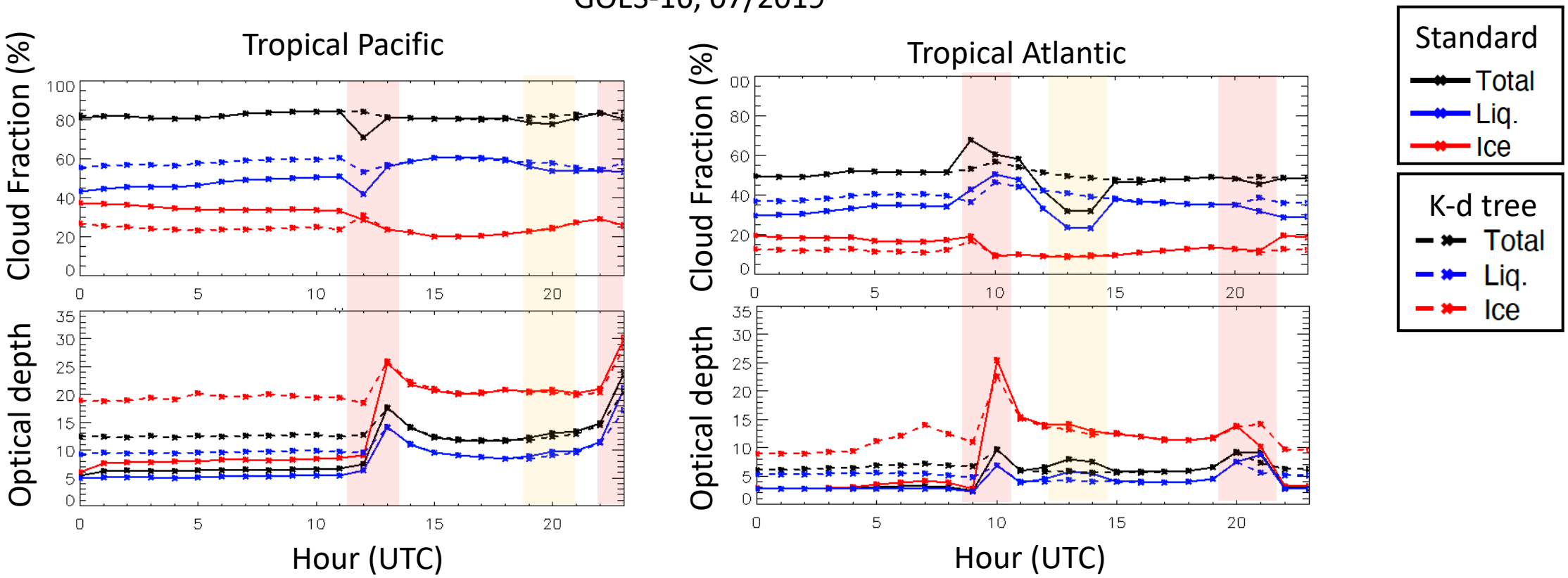
- Large discontinuities across different satellites are removed in Ed5 (3-channel).
- Ed5 particle size decreases by ~ 2-3 um (liquid), 6 um (ice).

Cloud mask refinements using K-d tree

- K-d tree methodology addresses 2 key issues :
  - cloud mask detection in sunglint conditions and twilight (day-to-night transition).
  - Computation of nighttime cloud optical depth
- Evaluation for GOES-16 in July 2019

Cloud mask refinements using K-d tree

GOES-16, 07/2019



- K-d tree substantially improves cloud fraction (mask) during sunglint/twilight.
- Nighttime k-d tree optical depth is more consistent with its daytime counterpart.

Next steps for GEO 3ch

- Other GEO sensors (GOES-17, GOES-18) will be tested during the following months.
- k-d tree algorithm will be refined and implemented in more satellites.
- Cloud mask tunning will continue, informed by comparisons against CALIOP.
- The algorithm development for the 2-channel satellites (GMS-5,Met-5, and Met-7) is ongoing.

List of publications

- Painemal, D., Smith, W., Gupta S., Moore, R., Cairns, B., McFarquhar, G., O'Brien J., (2024). Can we rely on satellite visible/infrared cloud retrievals in partially cloudy scenes: A SEVIRI assessment during ORACLES field campaign, *Geophys. Res. Lett.*, under review.

- Zhou, X., Painemal, D., Gettelman, A., and Feingold, G. (2024). Exploring causal relationships and adjustment timescales of cloud-aerosol interactions in geostationary satellite observations and CAM6 using wavelet phase coherence analysis, *Geophys. Res. Lett.*, under review.

- Chang I., et al. (2024). Low cloud diurnal cycle drives regional aerosol radiative warming, *Nature Geosc.*, under review.

- Park M., A. McComiskey, D. Painemal, and W. Smith Jr. (2024). Long-Term Trends in Aerosols, Low Clouds, and Large-scale Meteorology over the Western North Atlantic from 2003 to 2020, *J. Geophys. Res.*, 129, e2023JD039592. https://doi.org/10.1029/2023JD039592

QUESTIONS ?