

CERES Clouds Working Group Report



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[P. Minnis](#) (multi-layer), [Y. Chen](#) (clrsky, QC plots), [R. Palikonda](#) (GEO sys), [S. Bedka](#) (retrievals, val),

[F-L. Chang](#) (corrk), [Cecilia Wang](#) (machine learning), [B. Shan](#) (geo), [A. DiNorscia](#) (satellite sounding)

AMA, Hampton, VA

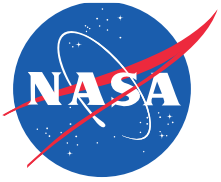
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ADNET, Hampton, VA

[L. Nguyen](#) (IT lead, GEO), *NASA Langley Research Center*

[P. Yang](#) (ice models), *Texas A&M University*

Thanks also to the TISA/calibration & SARB teams!



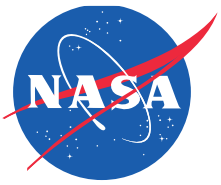
Ed5 Cloud Algorithm



- *Ed4 Aqua-MODIS cloud properties the most accurate and consistent record ever produced*
- *Ed4 Terra-MODIS clouds not as stable as Aqua - hampered by unmitigated calibration changes*
- *Ed4 GEO record also state-of-the-art for the 5 GEO-rings, but inconsistent across platforms*

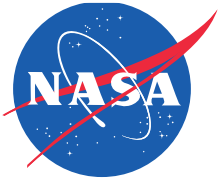
Ed5 Objectives

1. Improve cross-platform consistency between MODIS and VIIRS, and across 25+ GEO's
 - Develop and apply common algorithms: 11 channels for MODIS and VIIRS, 3 channels for GEO's
 - Better account for satellite SRF differences in atmospheric corrections, clear sky simulations, and cloud models
2. Apply updated/new ancillary data inputs
 - Radiances: MODIS collection (C7), latest VIIRS collection
 - Calibration normalizations to Aqua-MODIS C7 for all satellites
 - Atmospheric state (ERA5)
 - Updated surface characterizations (IGBP, snow/ice maps)
 - Improved clear sky radiances: more accurate methods for land surface skin temperature and reflectance
3. Improve accuracies based on extensive comparisons with CALIPSO/CloudSat
 - Cloud mask (adjust logic to enable common algo approach applied to instruments with different SRF's)
 - Optical & microphysical properties
 - Revised water droplet models to improve cross-platform consistency
 - New two-habit ice scattering model
 - Apply some machine learning
 - heights, optical properties at night, cloud detection over Antarctica (LEO night), GEO twilight and sun-glint



Edition 5 Final Software Delivery Schedule

Subsystem	Terra and Aqua	Suomi NPP and NOAA-20
Instrument (BDS)	June 2025	Gains (March 2026)
Clouds	May 2026	November 2026
Inversion (SSF)	February 2027	August 2027
TISA Gridding (SSF1deg-Hour)	April 2027	October 2027 (if needed)
TISA (SSF1deg-Day/Month)	June 2027	December 2027 (if needed)
FluxByCldTyp	June 2027	December 2027 (if needed)
GEO Clouds	March 2027	N/A
SARB (SYN1deg-Hour/MHour/Day/Month)	April 2028	N/A
CldTypHist	November 2027	January 2028 (if needed)
EBAF	September 2028	N/A



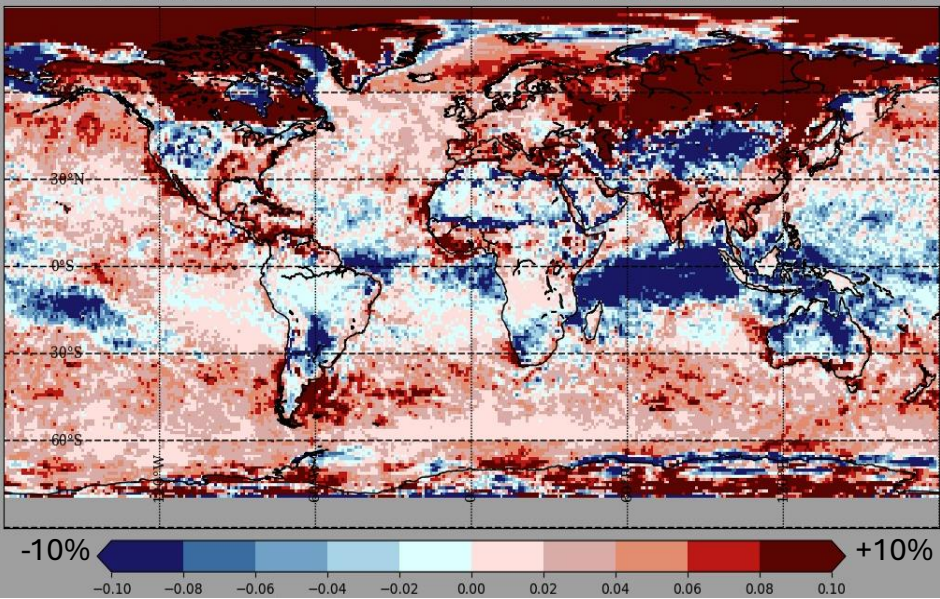
State of the Ed5 MODIS Clouds

Current Ed5 test version is Alpha-5

- Cloud parameter comparisons with Ed4 and CALIPSO
 - Cloud fraction, optical depth, height
- Clear sky radiance evaluations
- Summary and plans for remaining work before MODIS delivery
- GEO Update

Alpha-5 minus Ed4 MODIS Cloud Fraction

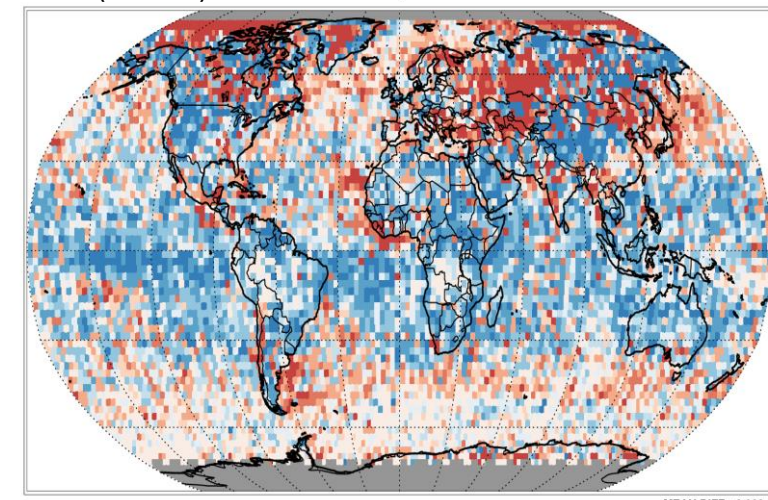
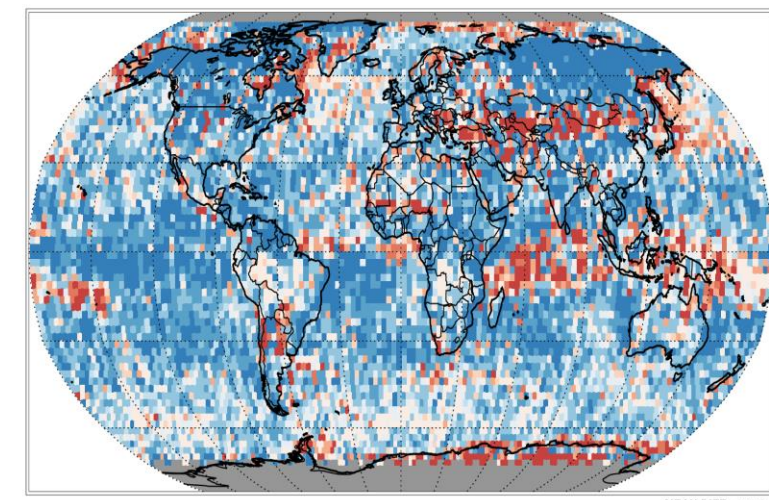
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Jan 2008 Aqua-MODIS Total Cloud Fraction Comparisons (NIGHT)

Nadir Comparisons (A-Train)

January 2008

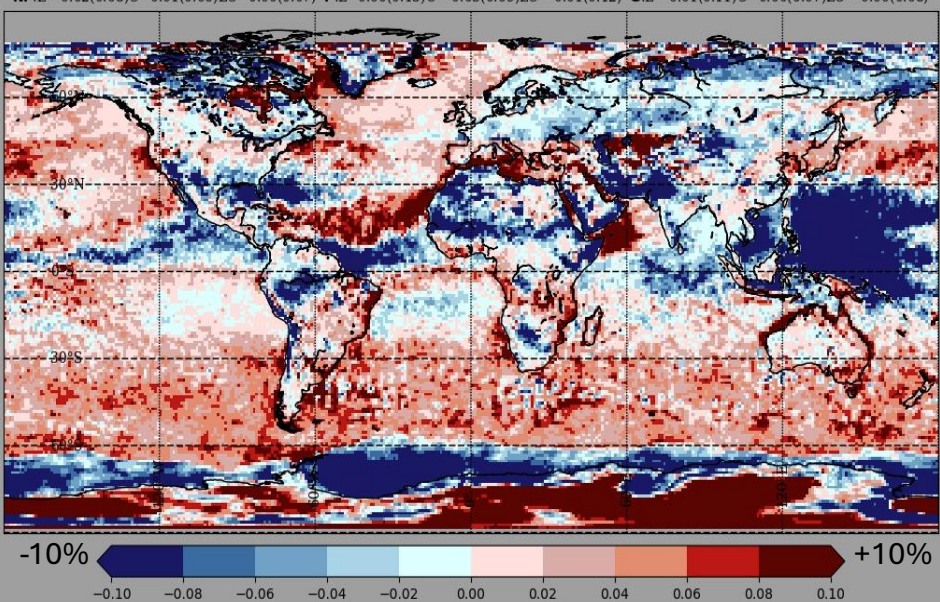


Ed4 - CALIOP (HA ≤ 1 km)

Alpha5 - CALIOP (HA ≤ 1 km)

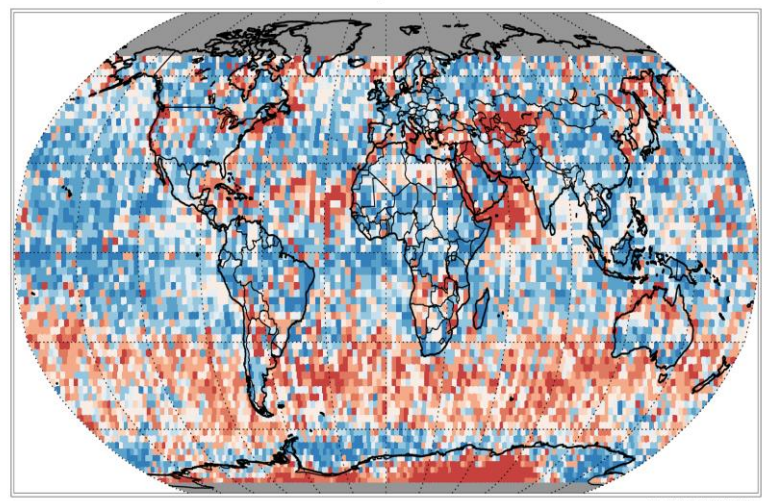
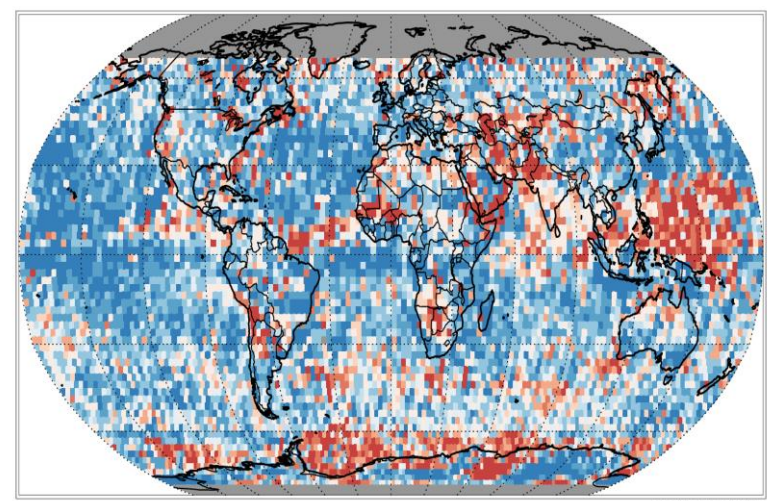
Alpha-5 minus Ed4 MODIS Cloud Fraction

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Jul 2008 Aqua-MODIS Total Cloud Fraction Comparisons (NIGHT)

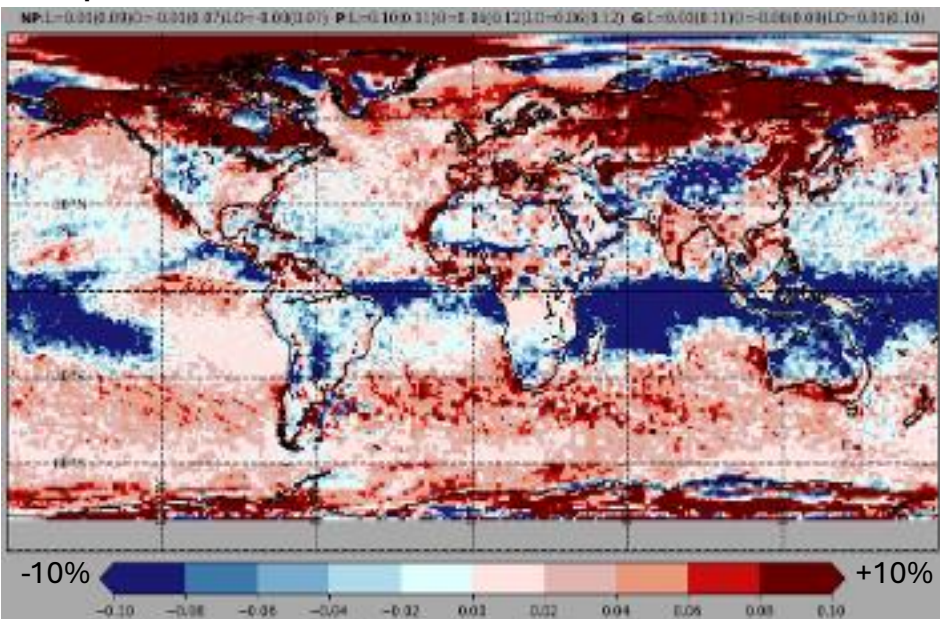
July 2008



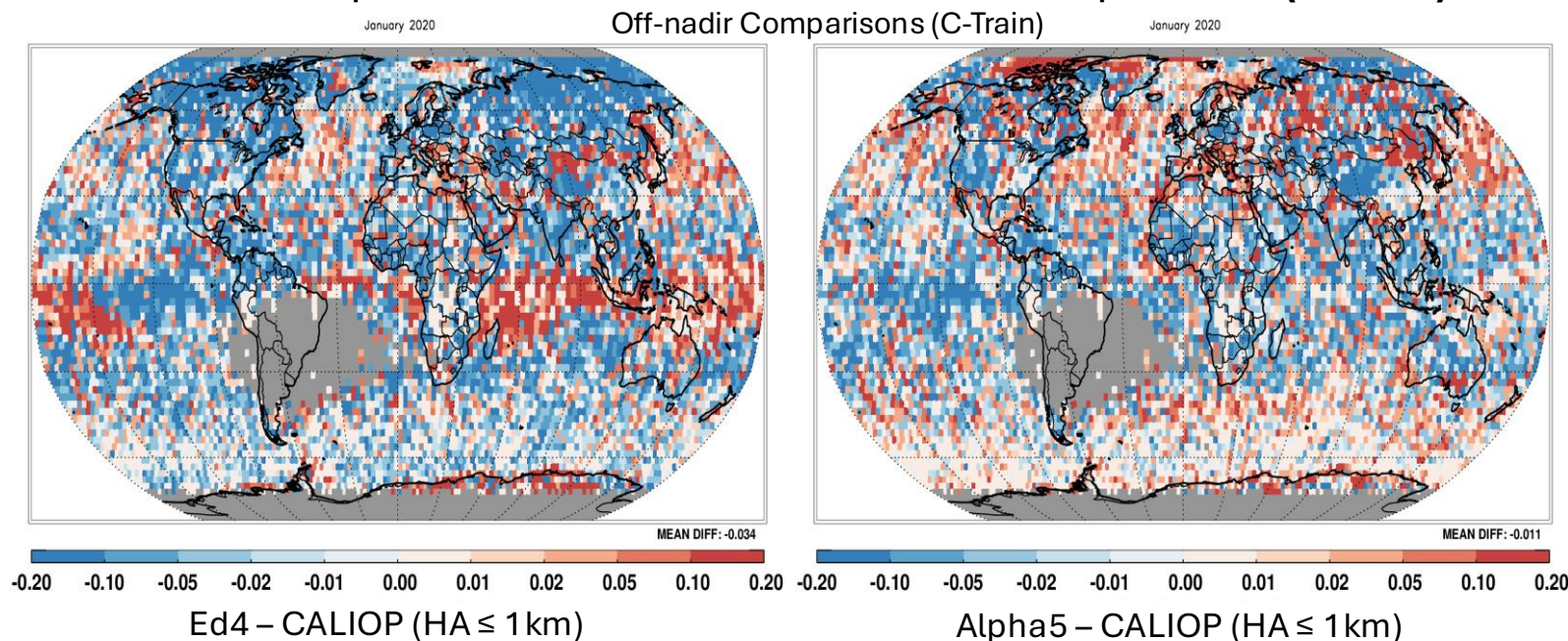
Ed4 - CALIOP (HA ≤ 1 km)

Alpha5 - CALIOP (HA ≤ 1 km)

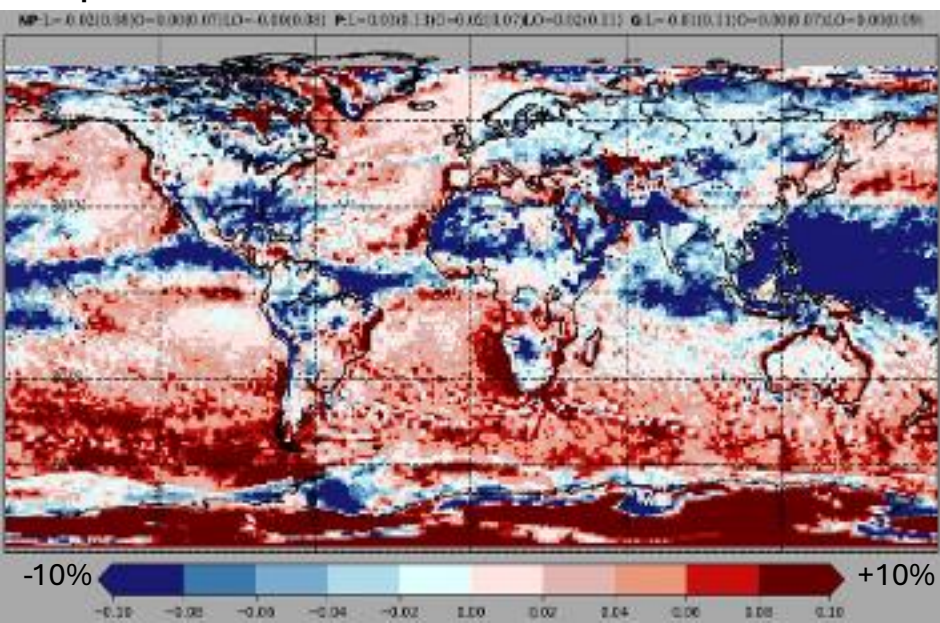
Alpha-5 minus Ed4 MODIS Cloud Fraction



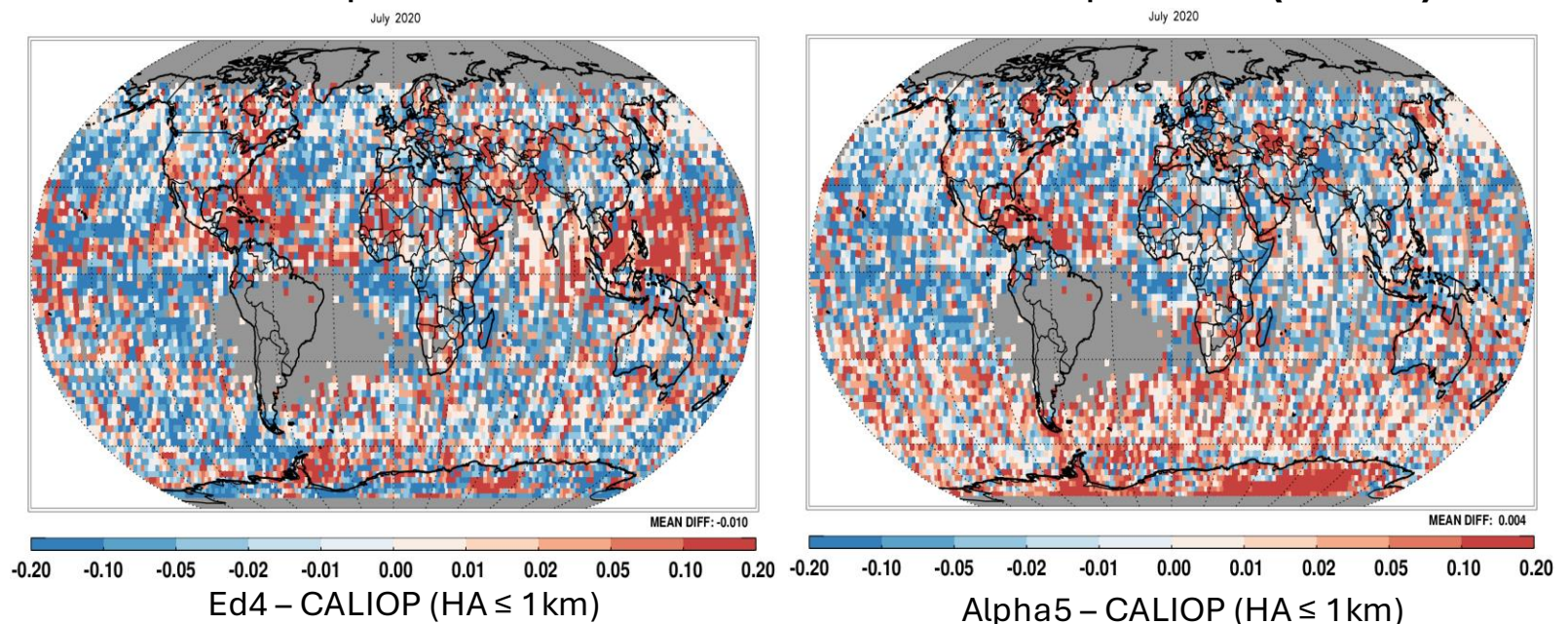
Jan 2020 Aqua-MODIS Total Cloud Fraction Comparisons (NIGHT)



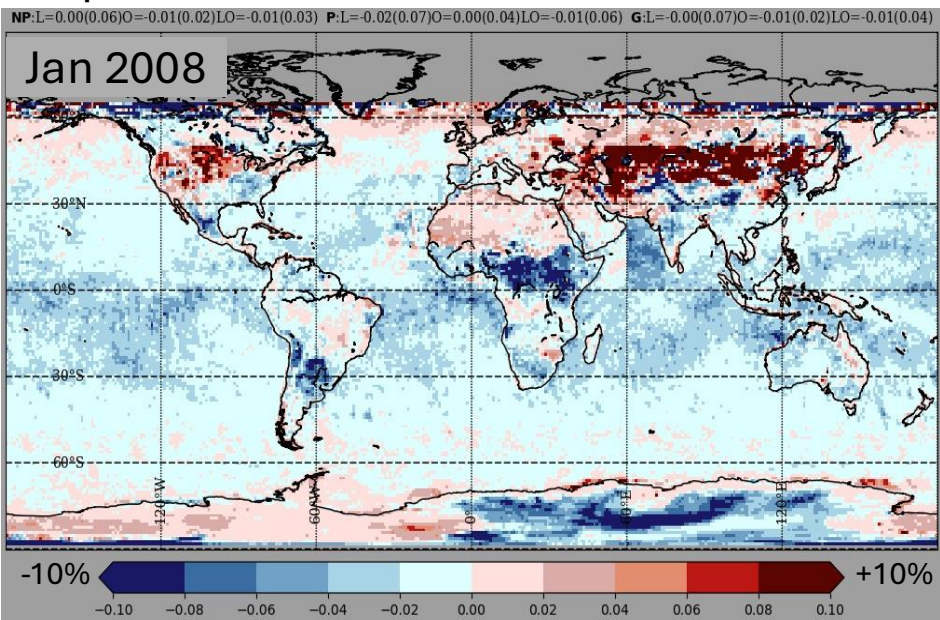
Alpha-5 minus Ed4 MODIS Cloud Fraction



Jul 2020 Aqua-MODIS Total Cloud Fraction Comparisons (NIGHT)

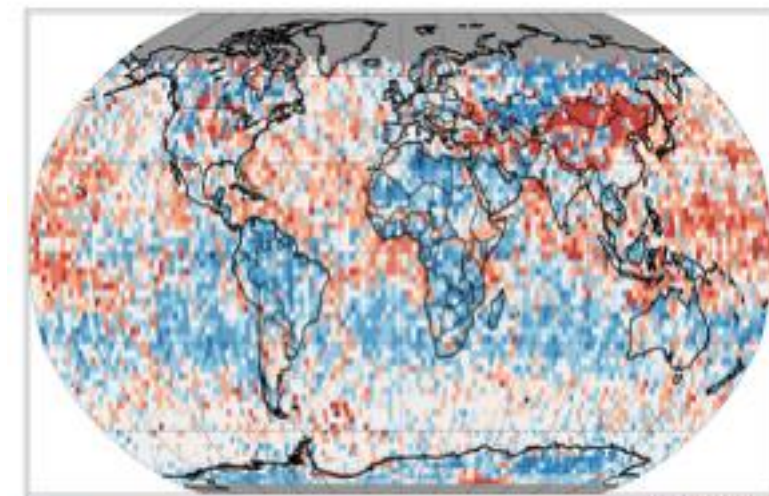


Alpha-5 minus Ed4 MODIS Cloud Fraction

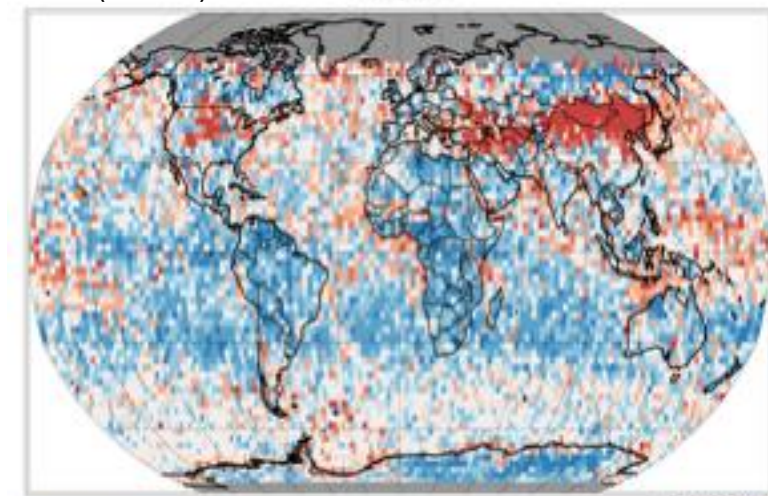


Jan 2008 Aqua-MODIS Total Cloud Fraction Comparisons (DAY)

Nadir Comparisons (A-Train)

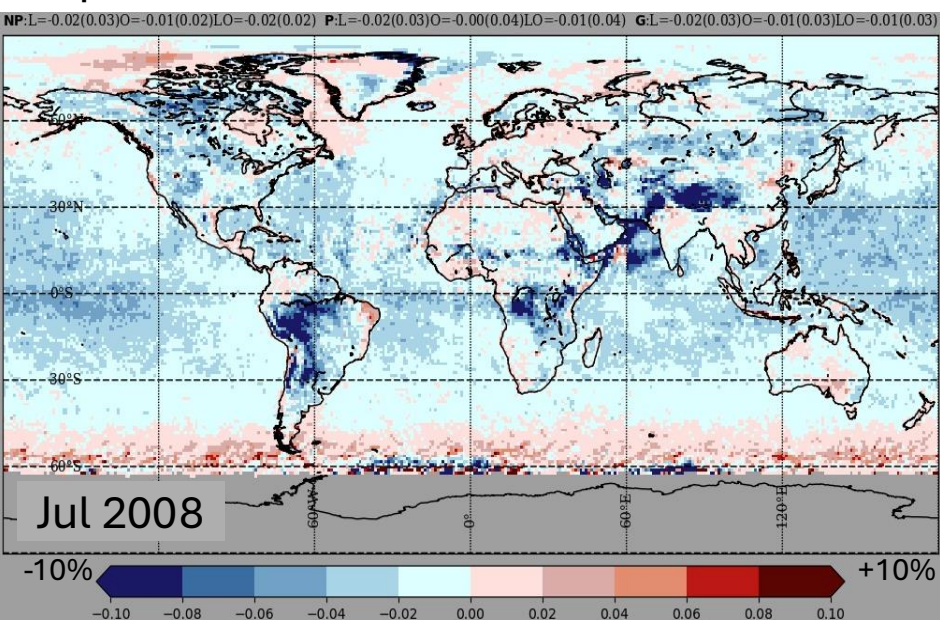


Ed4 - CALIOP (HA ≤ 1 km)

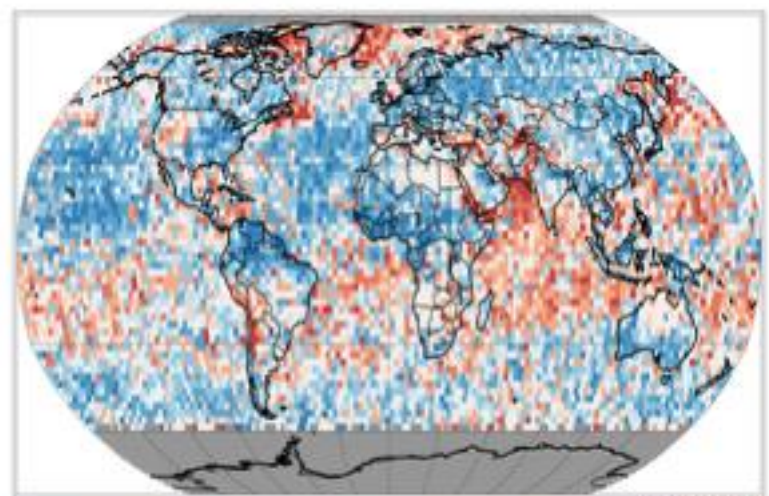


Alpha5 - CALIOP (HA ≤ 1 km)

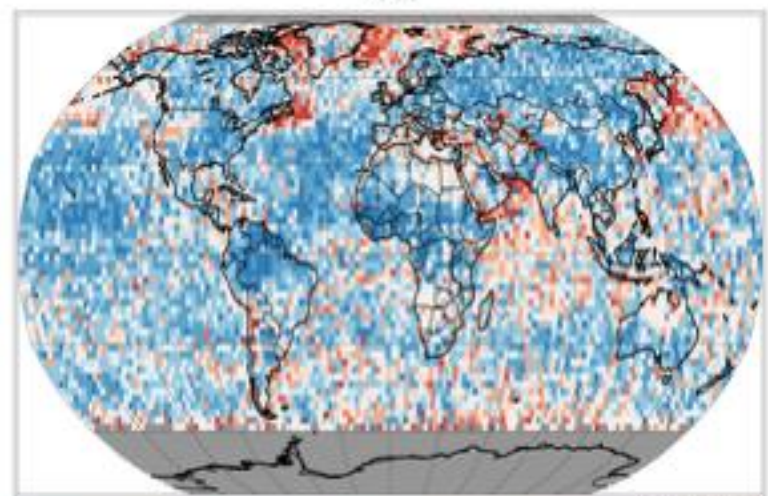
Alpha-5 minus Ed4 MODIS Cloud Fraction



Jul 2008 Aqua-MODIS Total Cloud Fraction Comparisons (DAY)



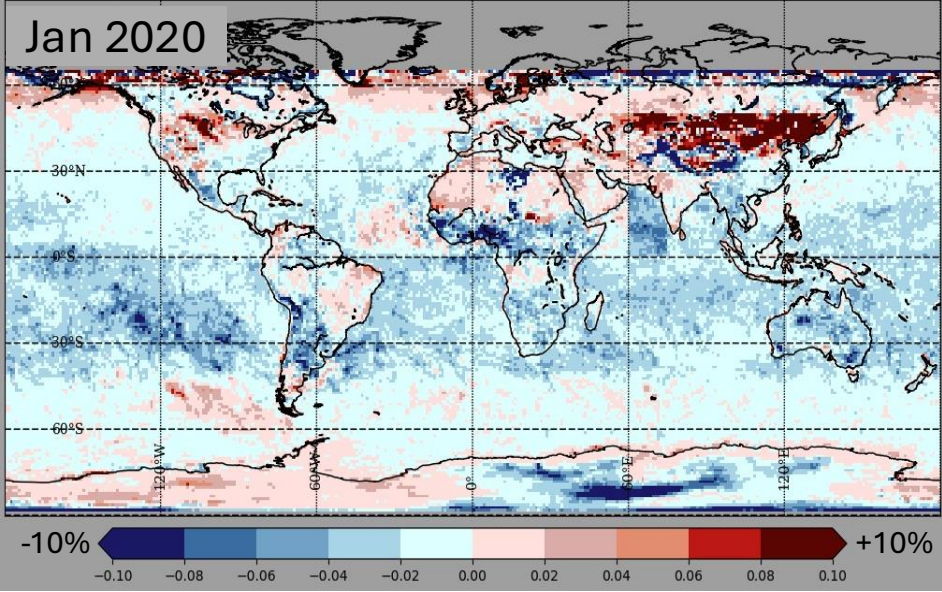
Ed4 - CALIOP (HA ≤ 1 km)



Alpha5 - CALIOP (HA ≤ 1 km)

Alpha-5 minus Ed4 MODIS Cloud Fraction

NP:L=-0.00(0.05)O=-0.02(0.02)LO=-0.01(0.03) P:L=-0.02(0.08)O=-0.00(0.04)LO=-0.01(0.06) G:L=-0.00(0.06)O=-0.02(0.02)LO=-0.01(0.04)

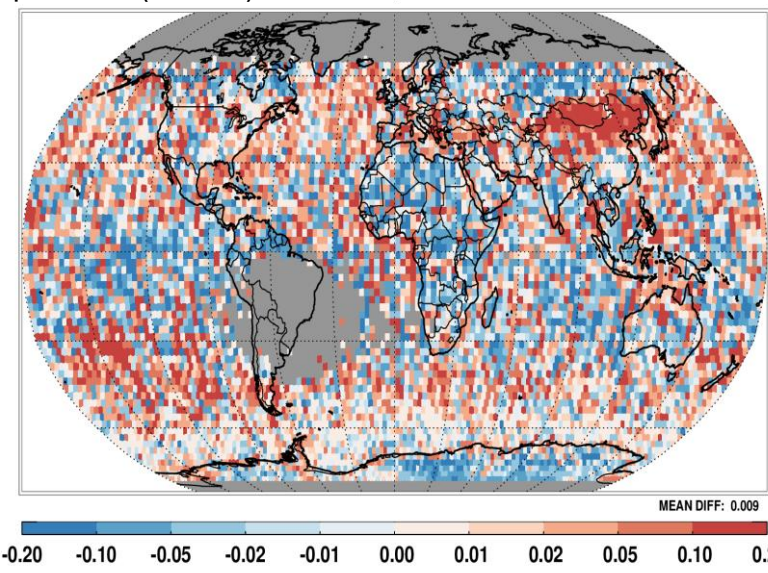
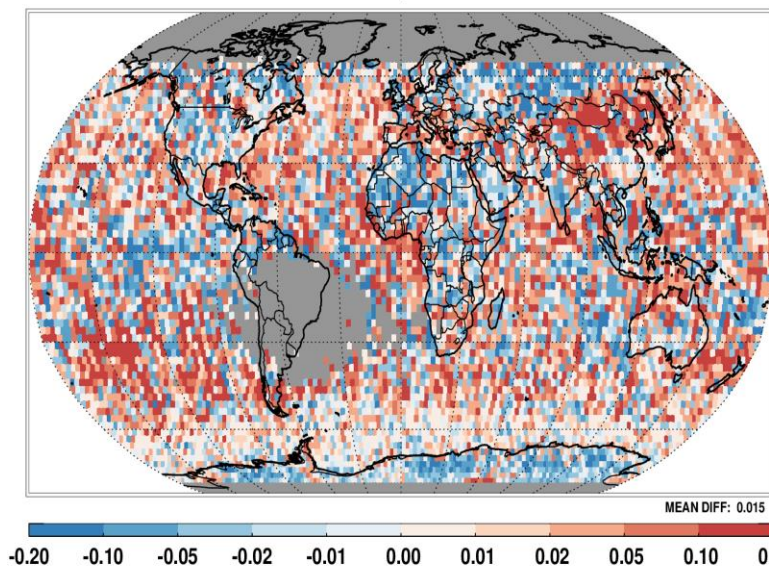


Jan 2020 Aqua-MODIS Total Cloud Fraction Comparisons (DAY)

January 2020

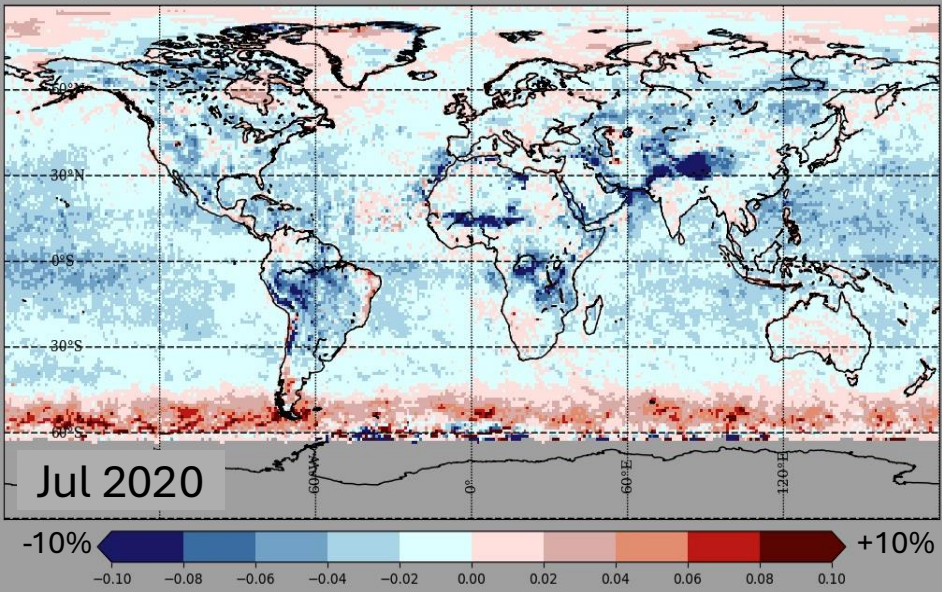
Off-nadir Comparisons (C-Train)

January 2020



Alpha-5 minus Ed4 MODIS Cloud Fraction

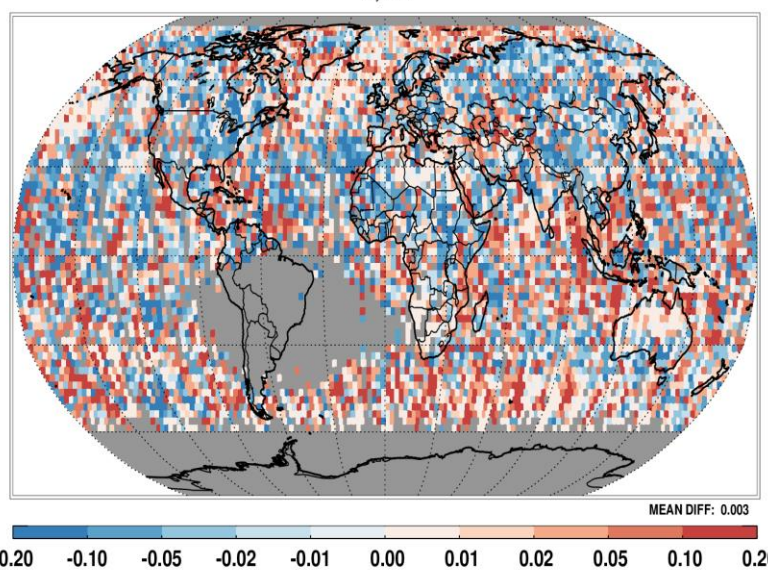
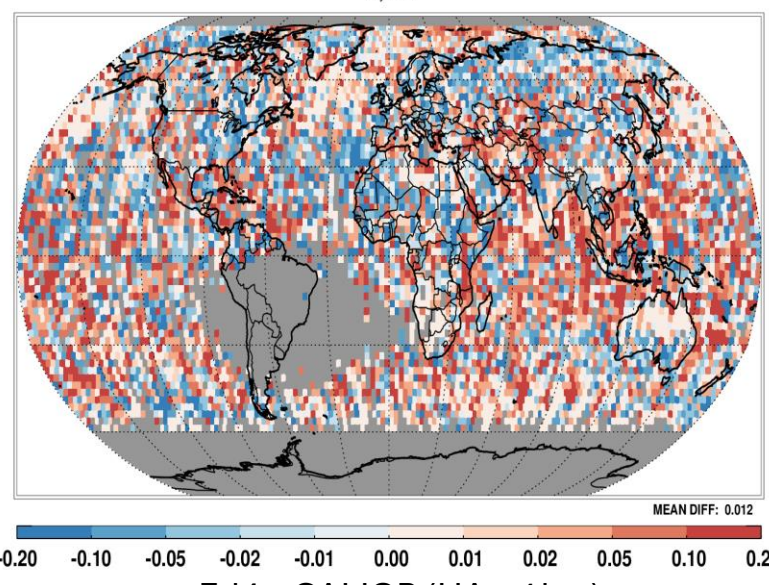
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Jul 2020 Aqua-MODIS Total Cloud Fraction Comparisons (DAY)

July 2020

July 2020



Aqua-MODIS total cloud fraction validation with CALIOP

July 2020 (C-Train era)

Night, snow/ice-free (SIF) ocean/water surfaces

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

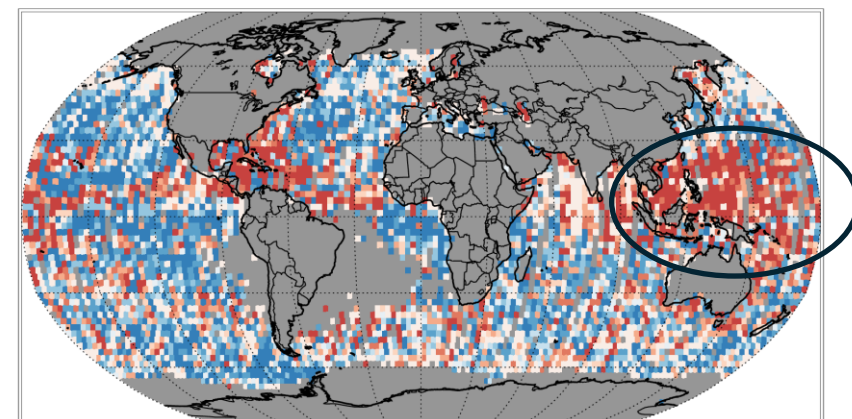
C-Train: sparse spatial sampling but better view angle sampling

Progress towards Edition 5, Alpha 5

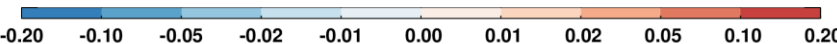


Edition 4

July 2020



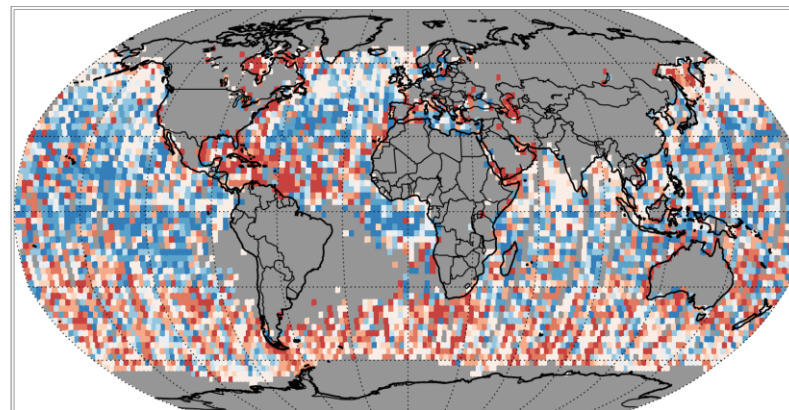
MEAN DIFF: -0.011



total cloud fraction difference
MODIS-Ed4 - CALIOP(HA ≤ 1 km)

Large positive regional biases in tropical

July 2020



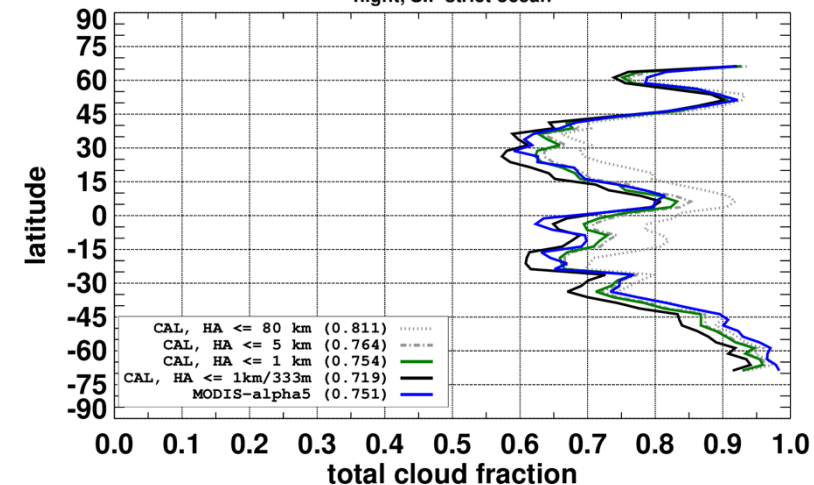
MEAN DIFF: 0.003



total cloud fraction difference
MODIS-alpha5 - CALIOP(HA ≤ 1 km)

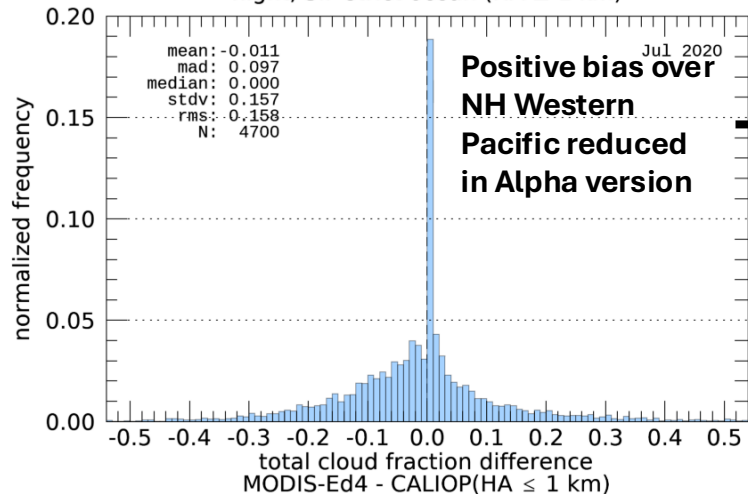
Alpha-5

night, SIF strict ocean

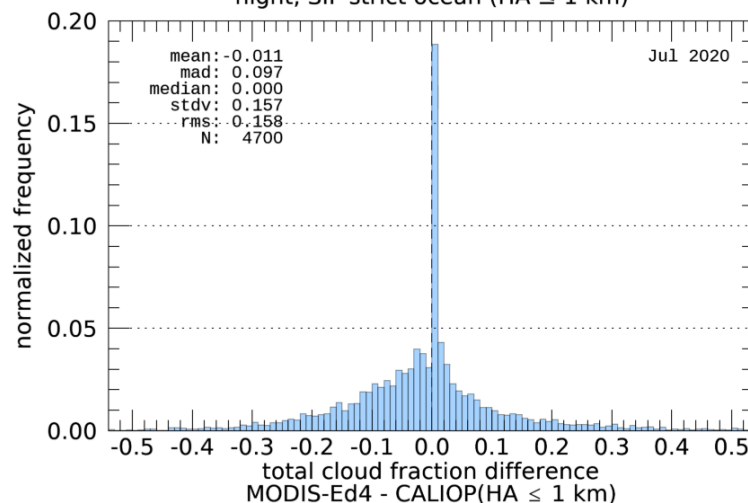


CAL, HA ≤ 80 km (0.811)
CAL, HA ≤ 5 km (0.764)
CAL, HA ≤ 1 km (0.754)
CAL, HA ≤ 1km/333m (0.719)
MODIS-alpha5 (0.751)

night, SIF strict ocean (HA ≤ 1 km)

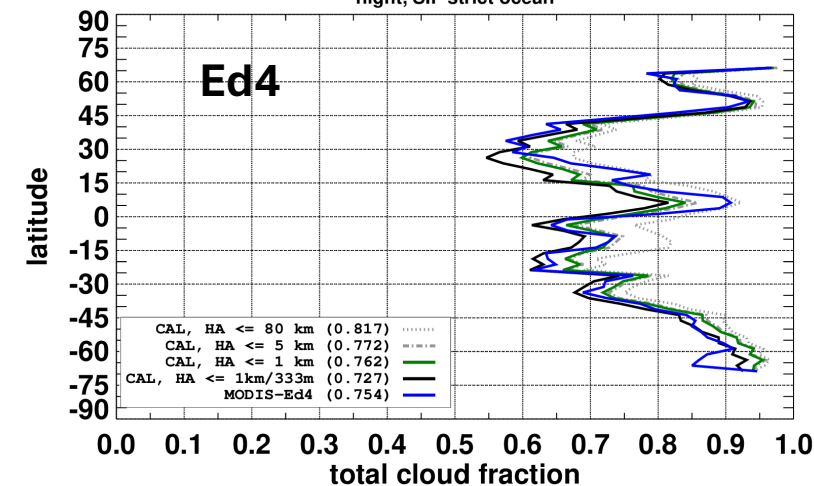


night, SIF strict ocean (HA ≤ 1 km)



Ed4

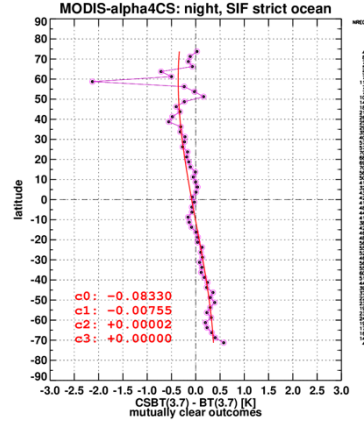
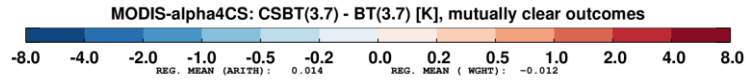
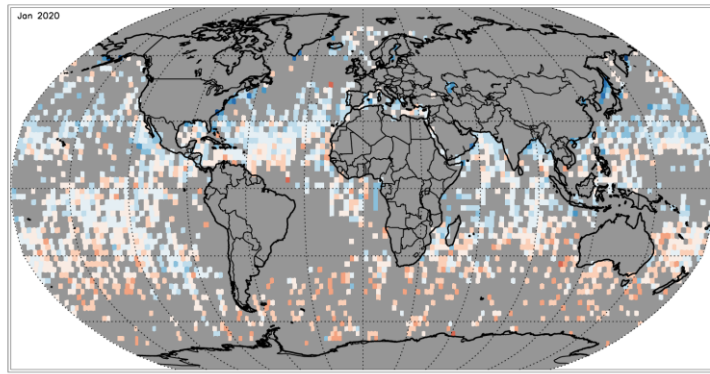
night, SIF strict ocean



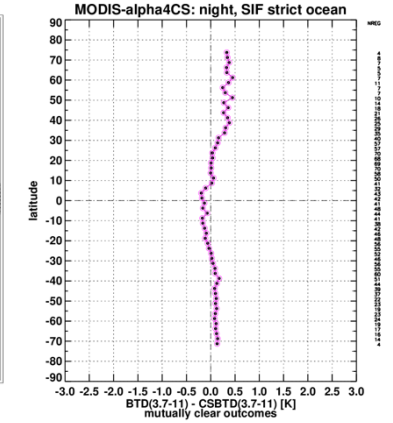
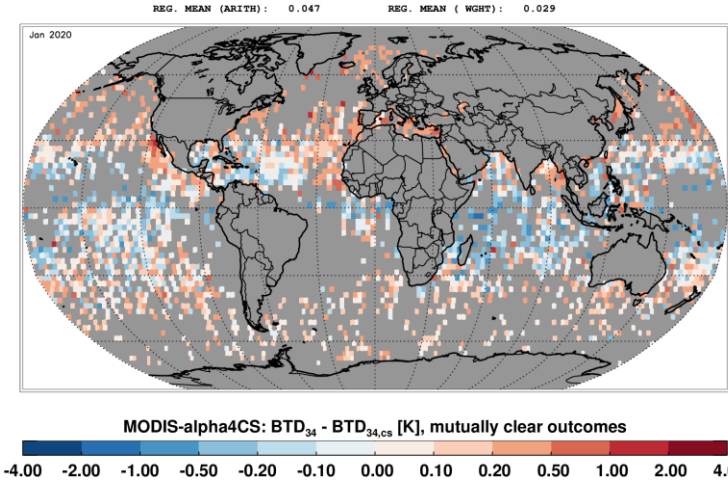
CAL, HA ≤ 80 km (0.817)
CAL, HA ≤ 5 km (0.772)
CAL, HA ≤ 1 km (0.762)
CAL, HA ≤ 1km/333m (0.727)
MODIS-Ed4 (0.754)

MODIS Clear-sky BT Assessments CALIPSO 'Clear' January 2020 Nighttime

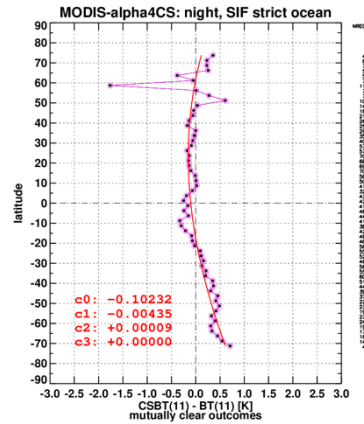
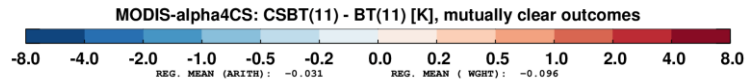
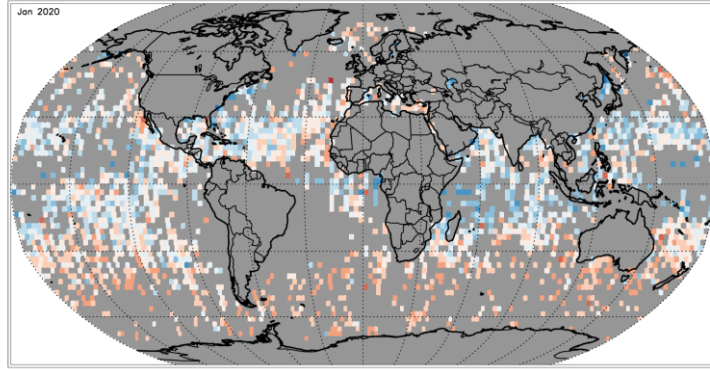
3.7 μm



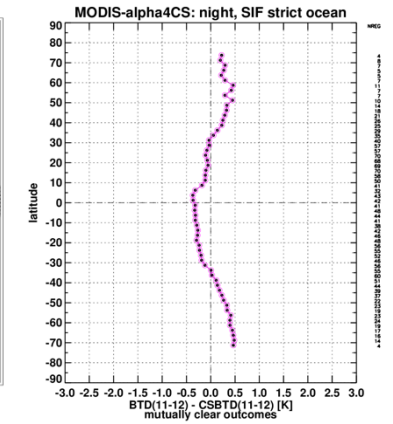
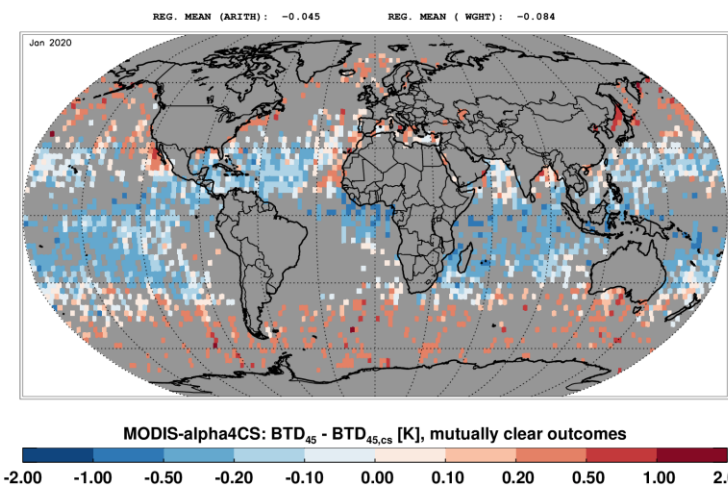
3.7 – 11 μm BTD



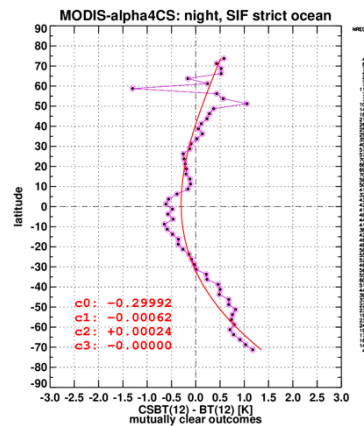
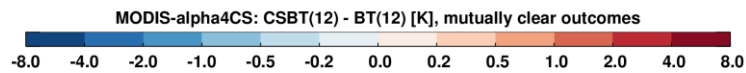
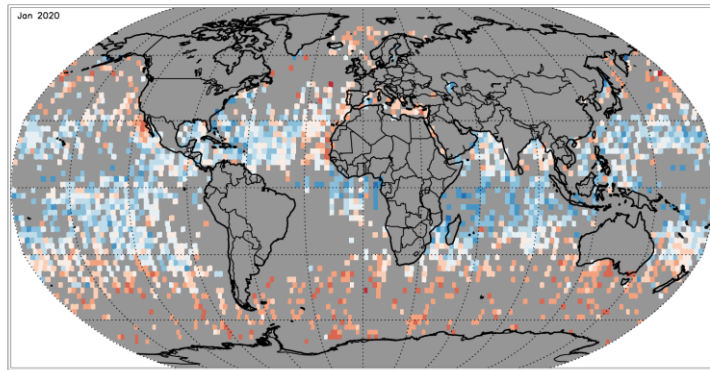
11 μm



11 – 12 μm BTD

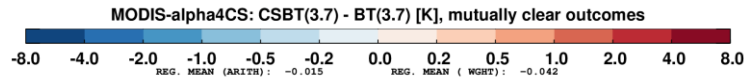
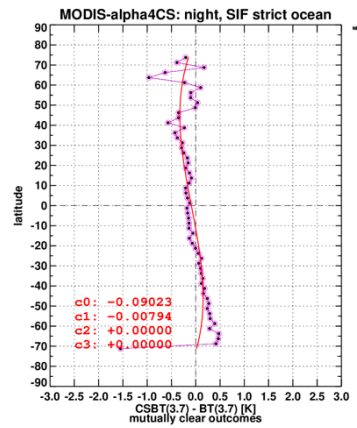
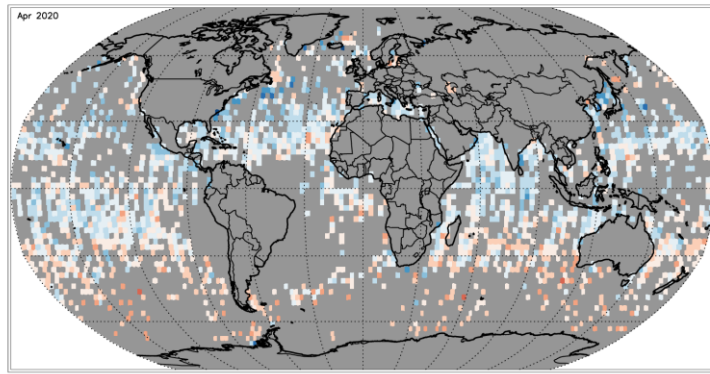


12 μm

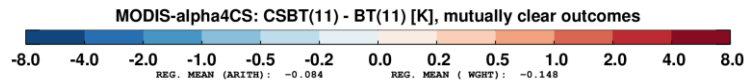
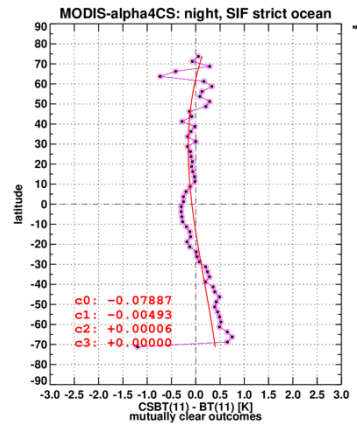
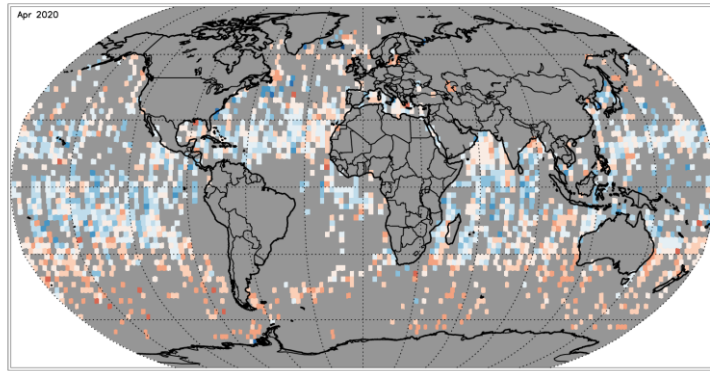


MODIS Clear-sky BT Assessments CALIPSO 'Clear' April 2020 Nighttime

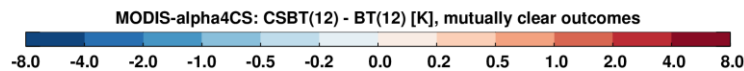
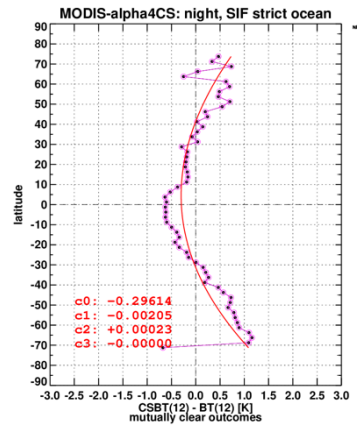
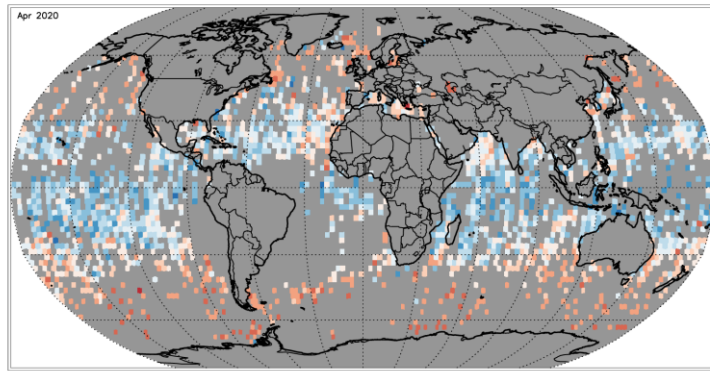
3.7 μm



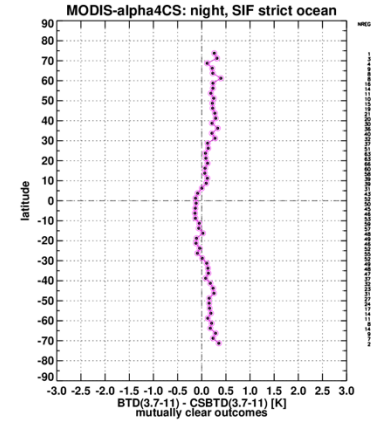
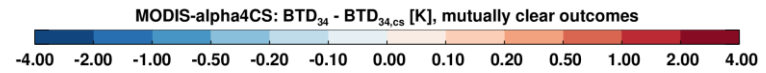
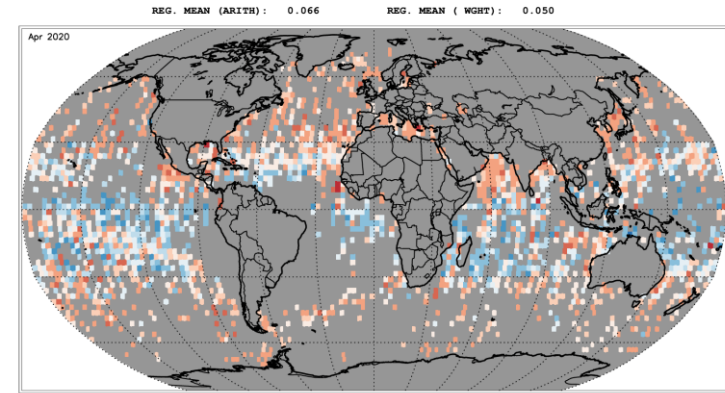
11 μm



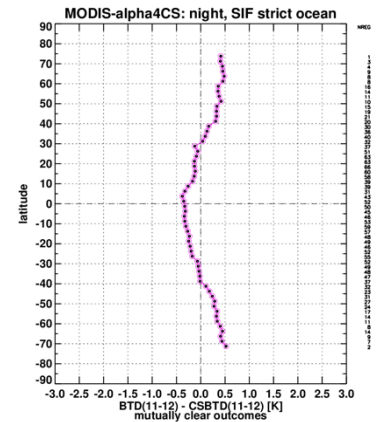
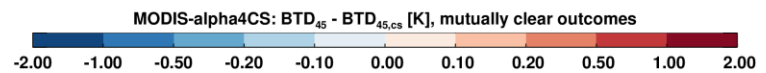
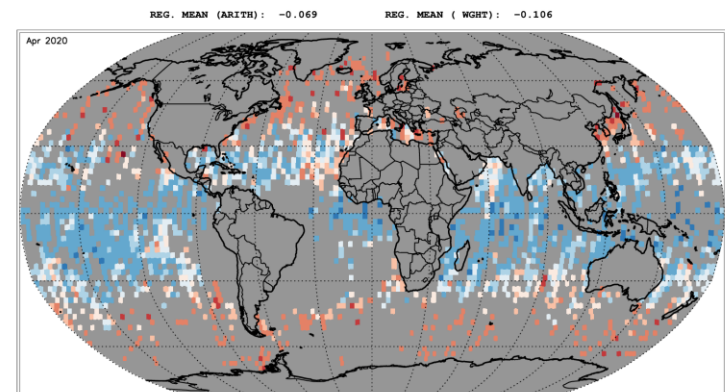
12 μm



3.7 – 11 μm BTD

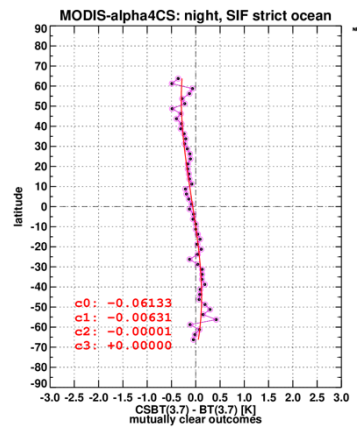
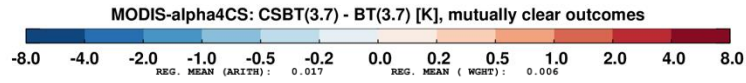
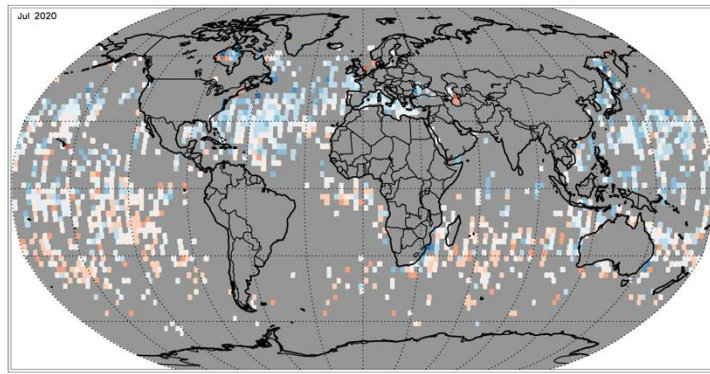


11 – 12 μm BTD

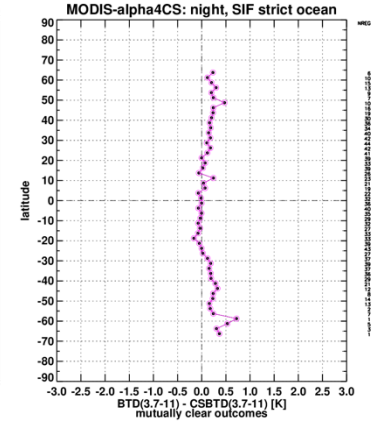
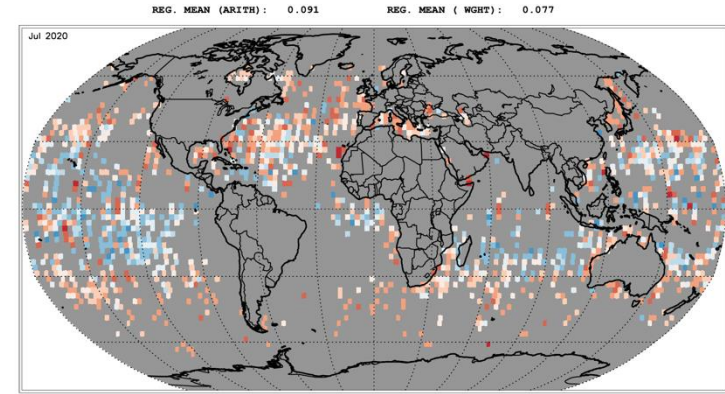


MODIS Clear-sky BT Assessments CALIPSO 'Clear' July 2020 Nighttime

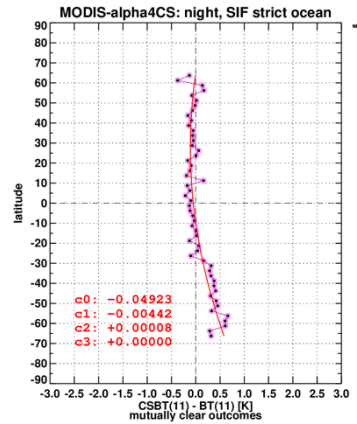
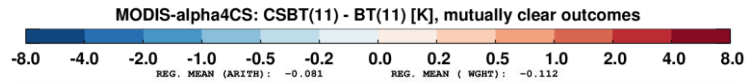
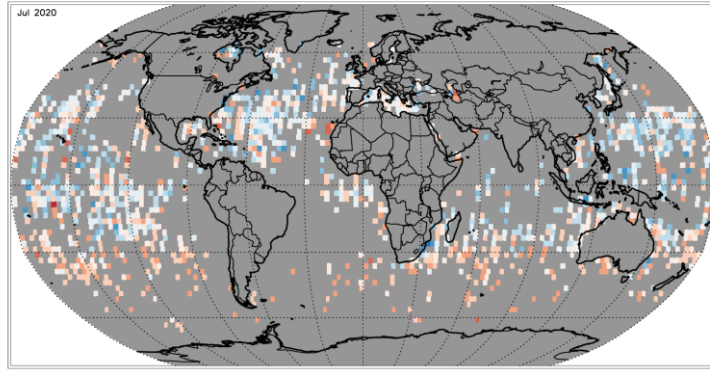
3.7 μm



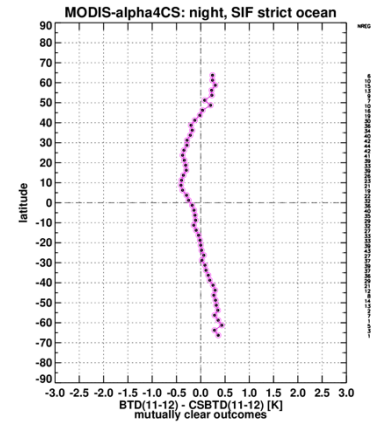
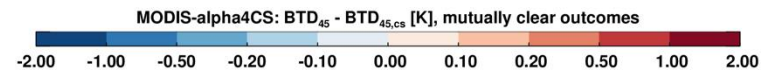
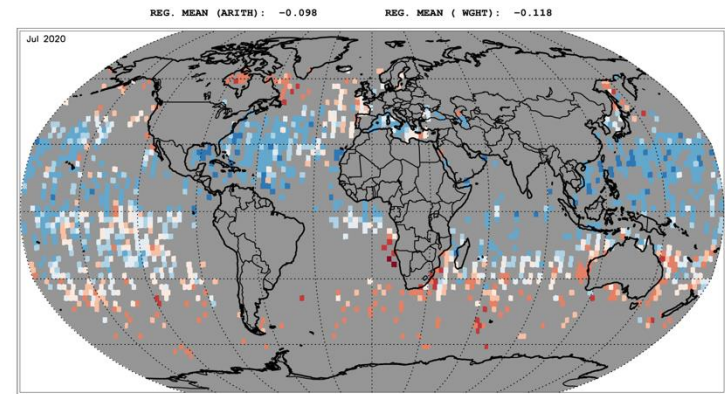
3.7 – 11 μm BTD



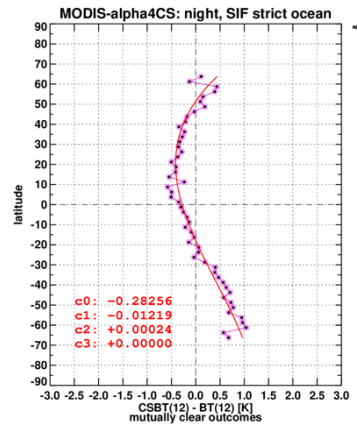
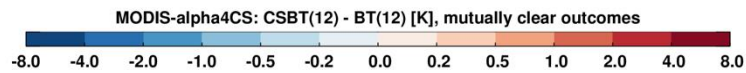
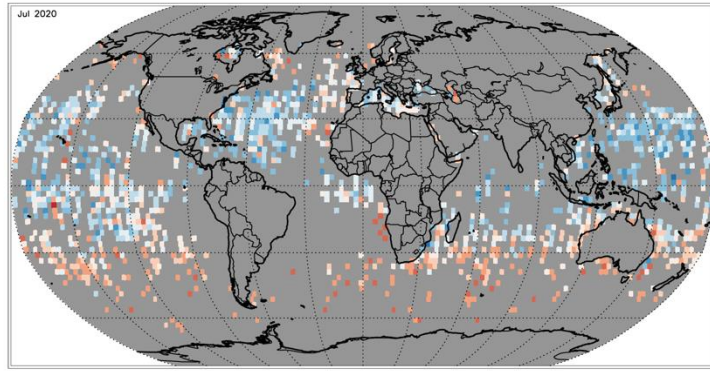
11 μm



11 – 12 μm BTD

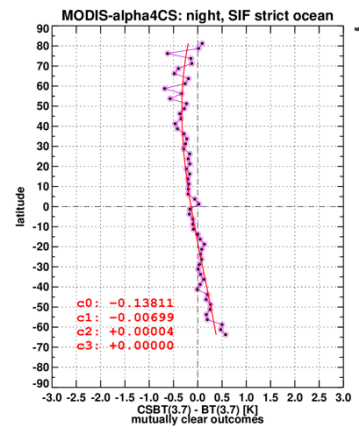
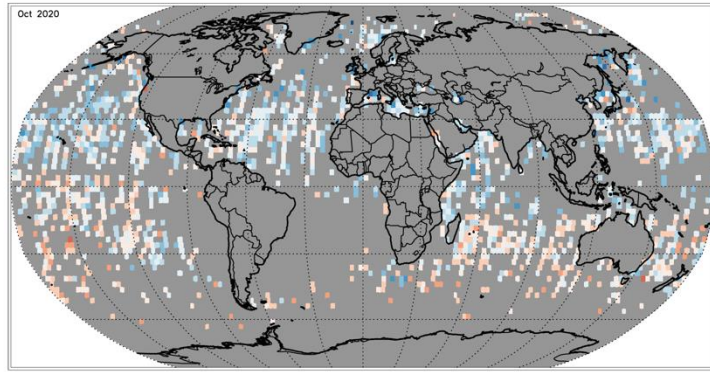


12 μm



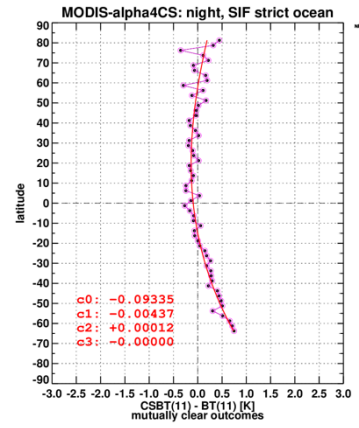
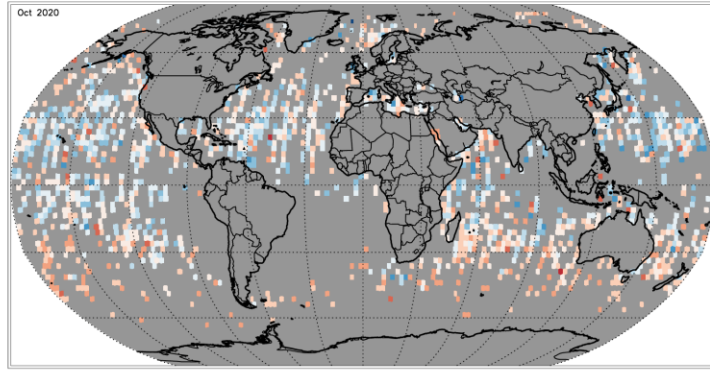
MODIS Clear-sky BT Assessments CALIPSO 'Clear' October 2020 Nighttime

3.7 μm



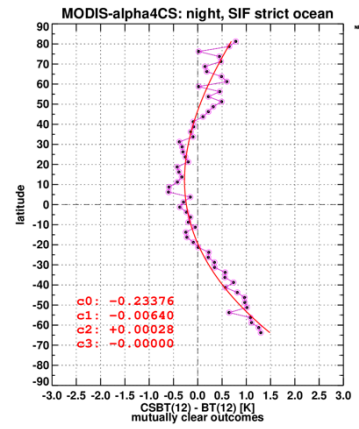
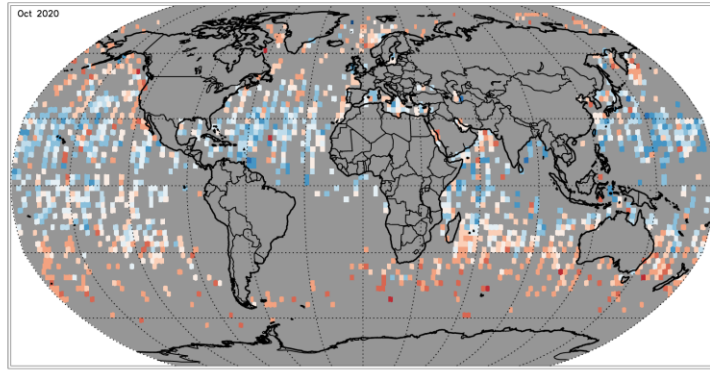
MODIS-alpha4CS: CSBT(3.7) - BT(3.7) [K], mutually clear outcomes
REG. MEAN (ARITH): 0.011, REG. MEAN (WGHT): -0.005

11 μm



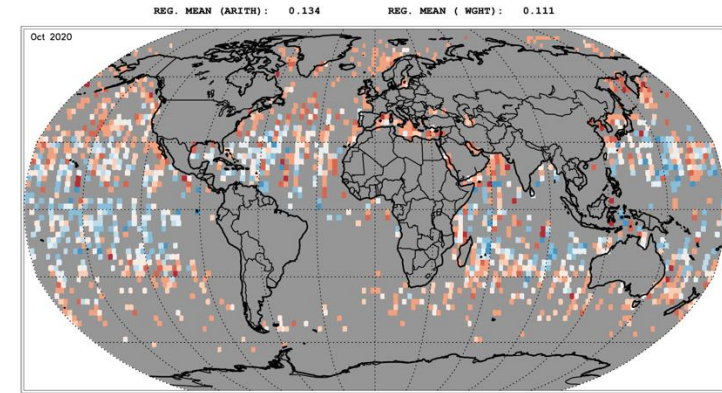
MODIS-alpha4CS: CSBT(11) - BT(11) [K], mutually clear outcomes
REG. MEAN (ARITH): 0.020, REG. MEAN (WGHT): -0.034

12 μm

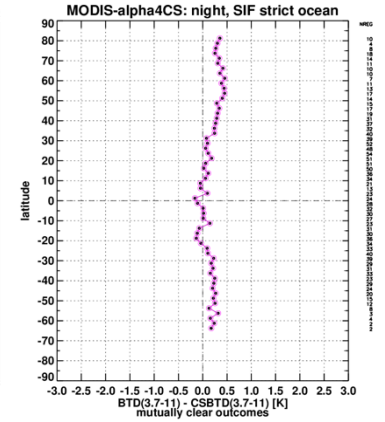


MODIS-alpha4CS: CSBT(12) - BT(12) [K], mutually clear outcomes
REG. MEAN (ARITH): 0.009, REG. MEAN (WGHT): -0.029

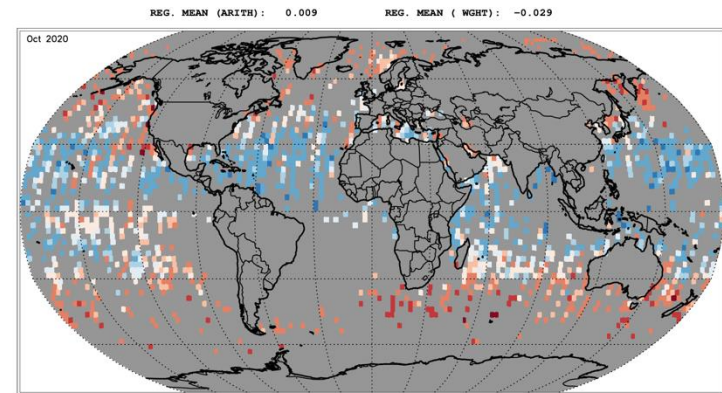
3.7 – 11 μm BTD



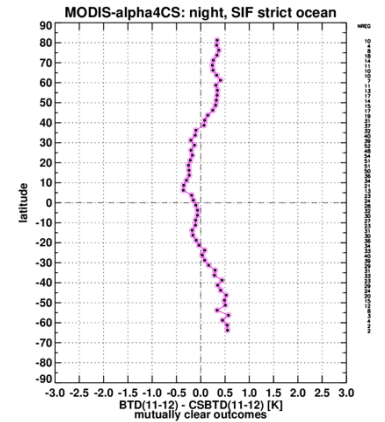
MODIS-alpha4CS: BTD₃₄ - BTD_{34,cs} [K], mutually clear outcomes
REG. MEAN (ARITH): 0.134, REG. MEAN (WGHT): 0.111

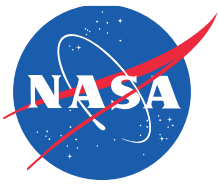


11 – 12 μm BTD



MODIS-alpha4CS: BTD₄₅ - BTD_{45,cs} [K], mutually clear outcomes
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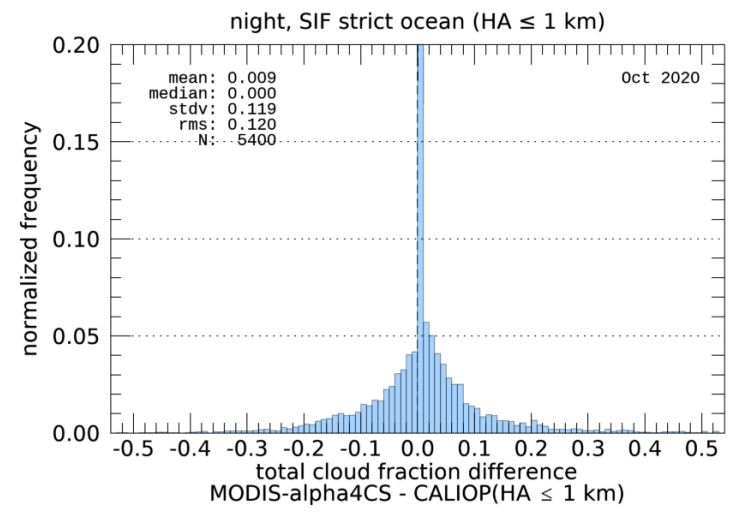
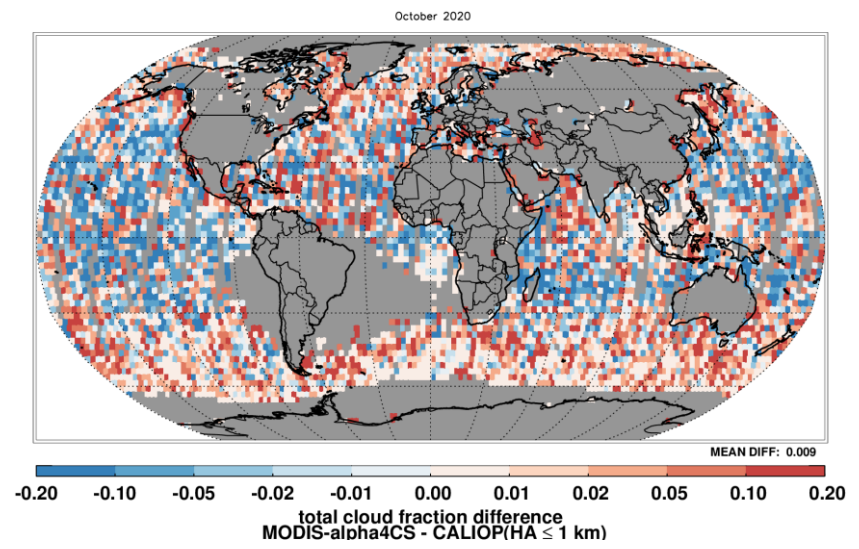
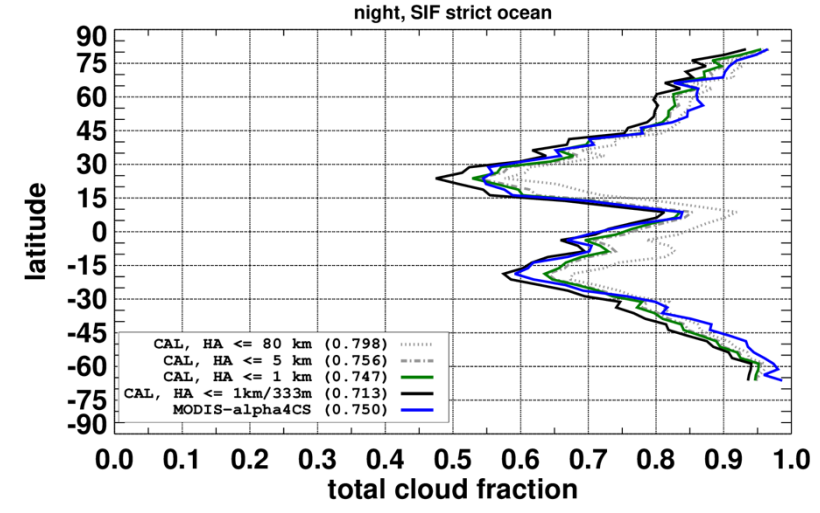
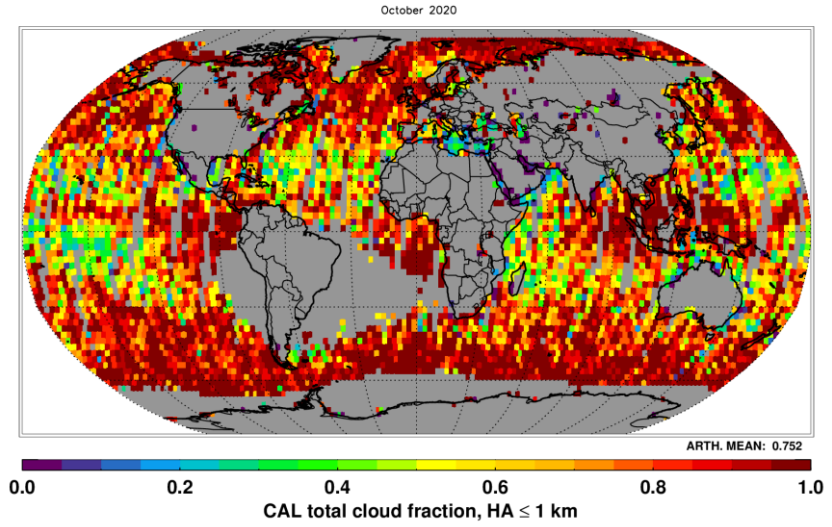
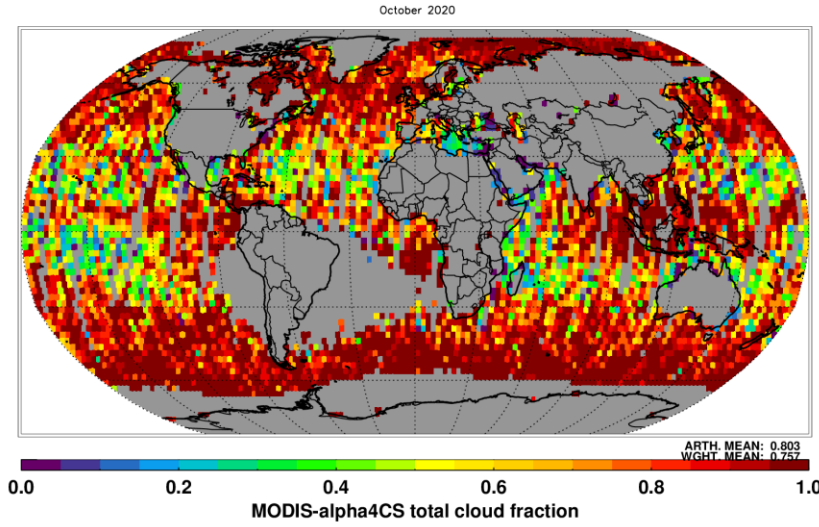


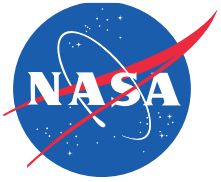


Application of Clear-Sky BT Correction Fits in Oct 2020 Cloud Mask



Baseline without Correction

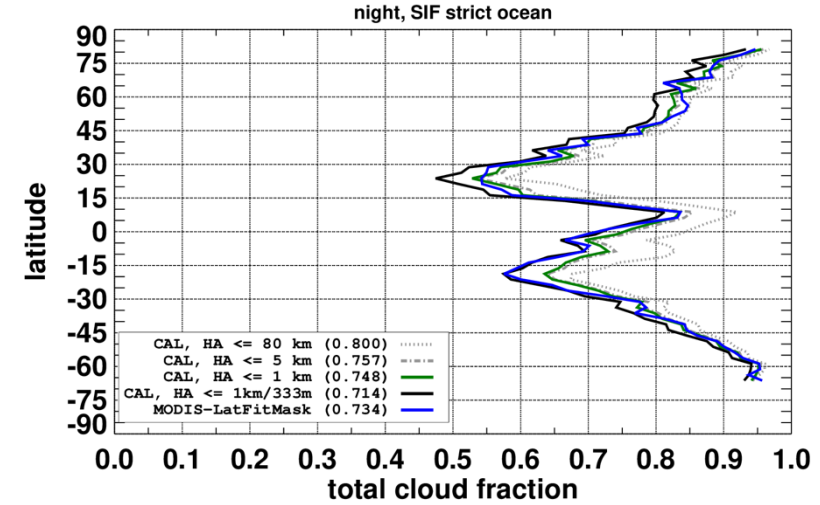
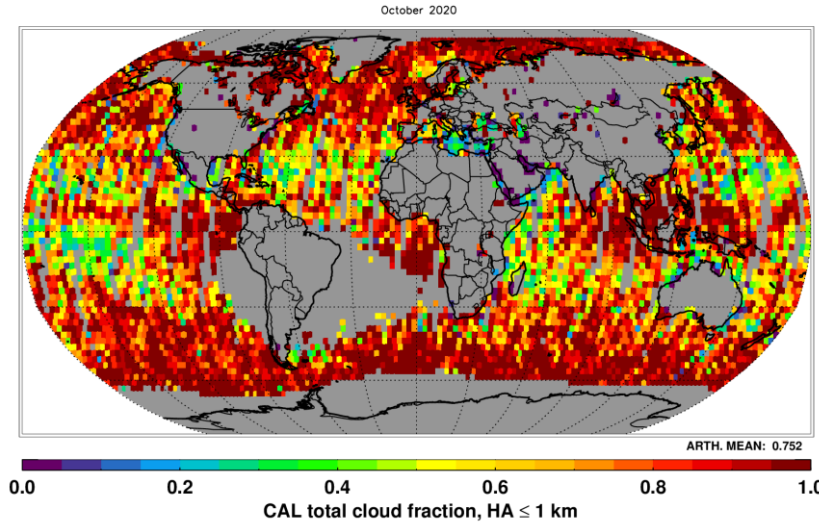
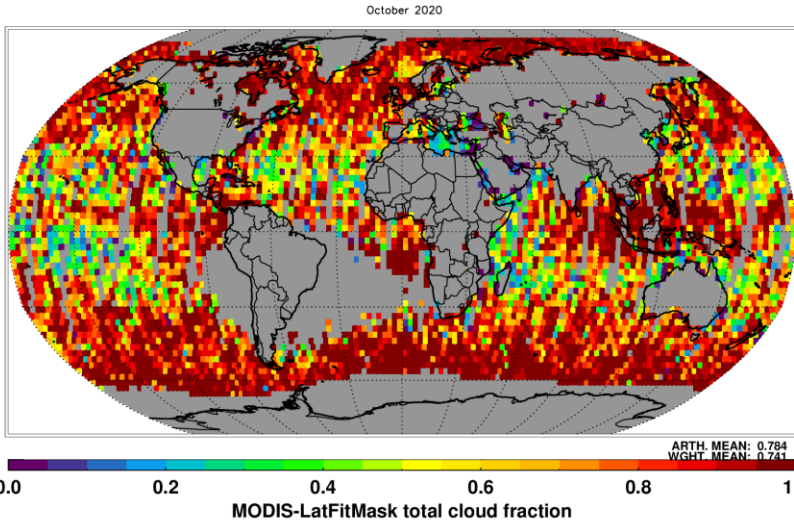




Application of Clear-Sky BT Correction Fits in Oct 2020 Cloud Mask

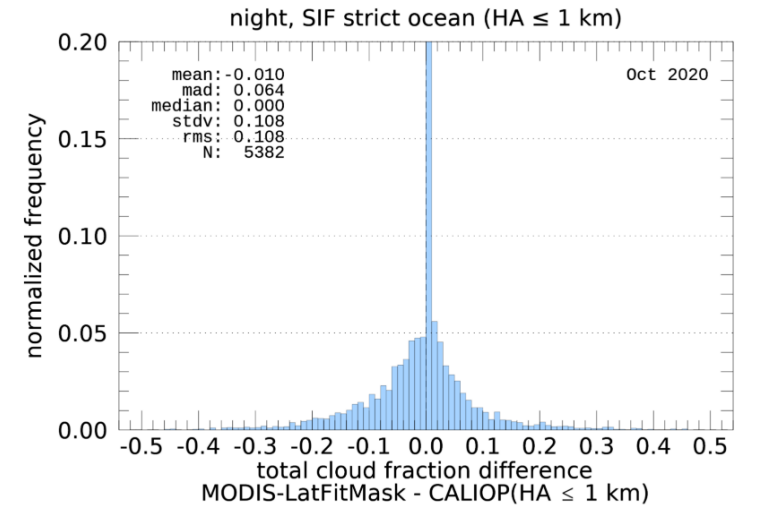
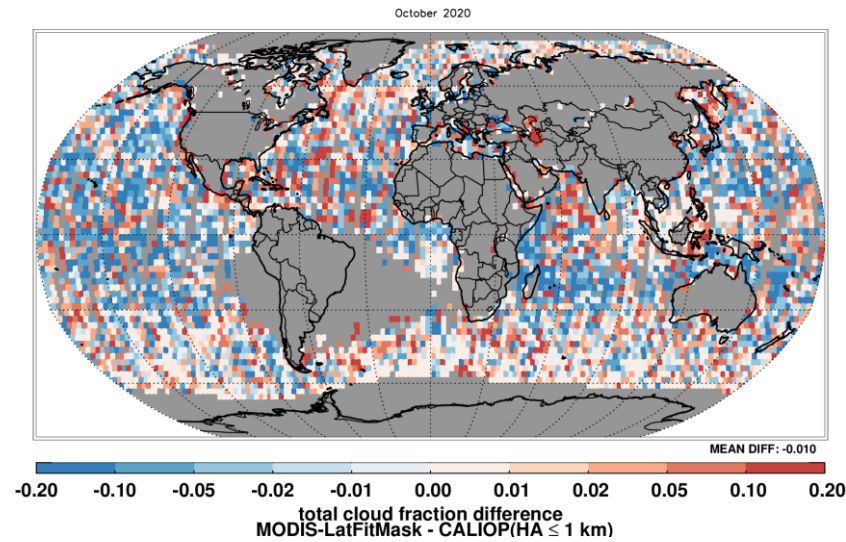


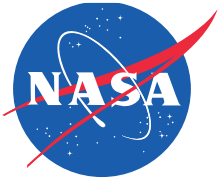
With Corrections



Nighttime

- Latitude based curve fits work well
- Zonal means compare much better with CALIPSO especially at higher latitudes
- Reduces latitude dependence of cloud detection errors

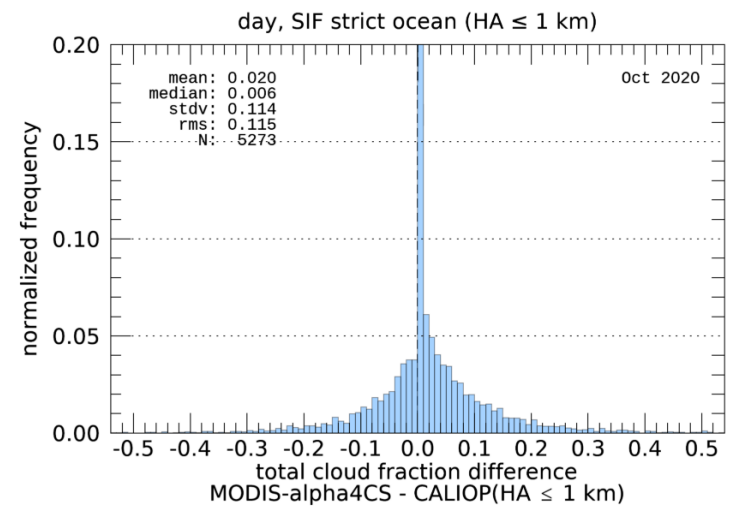
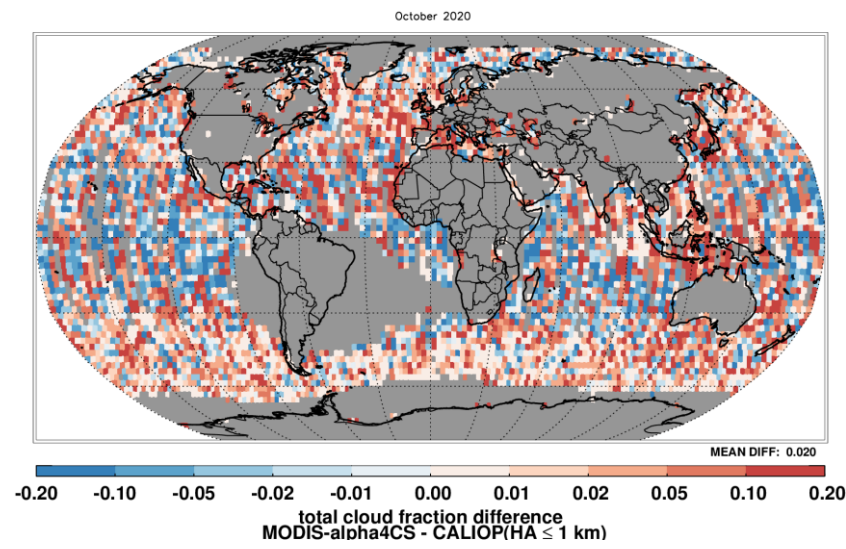
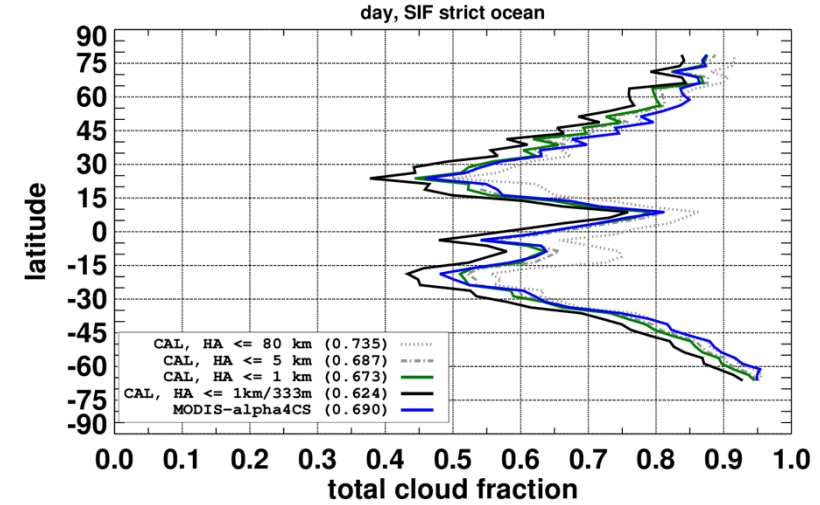
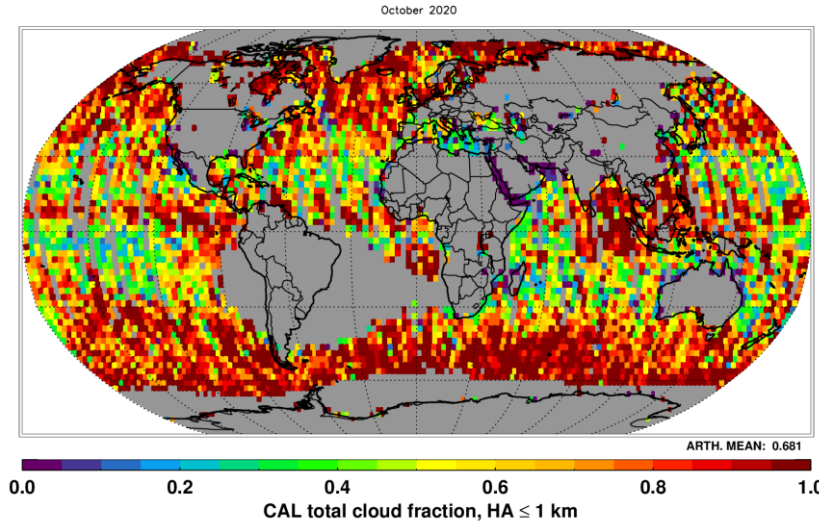
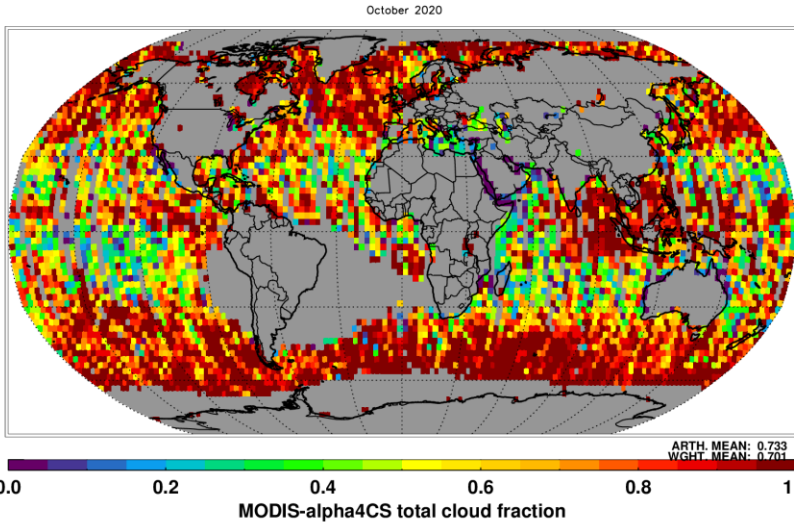


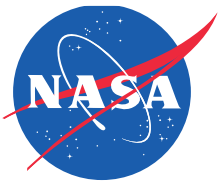


Application of Clear-Sky BT Correction Fits in Oct 2020 Cloud Mask



Baseline without Correction

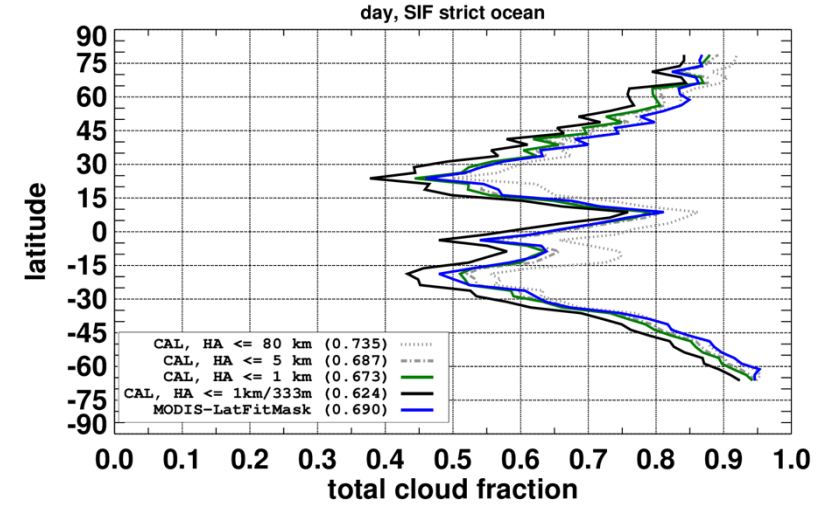
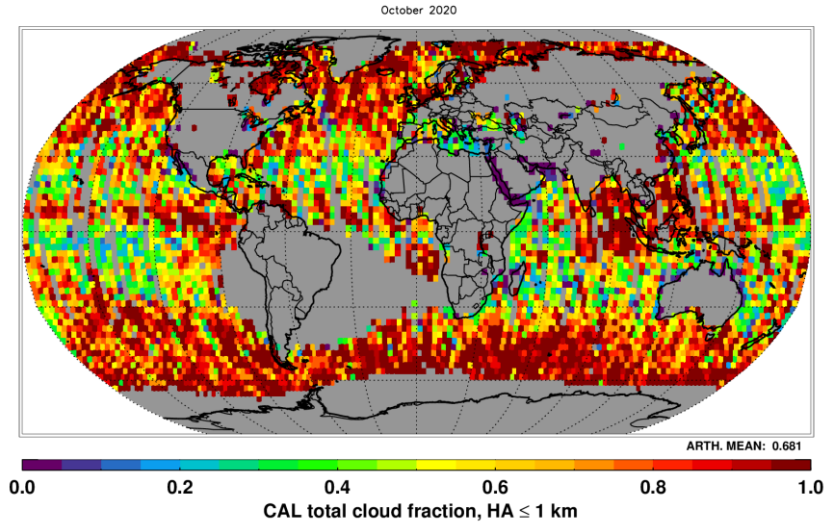
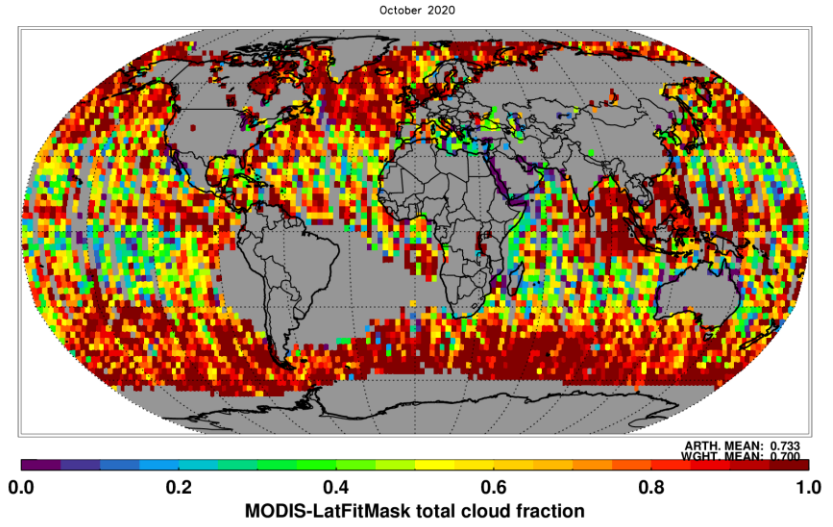




Application of Clear-Sky BT Correction Fits in Oct 2020 Cloud Mask

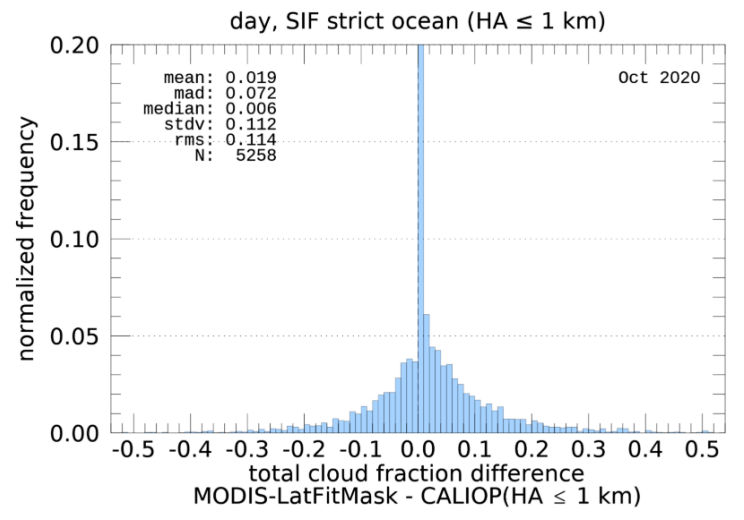
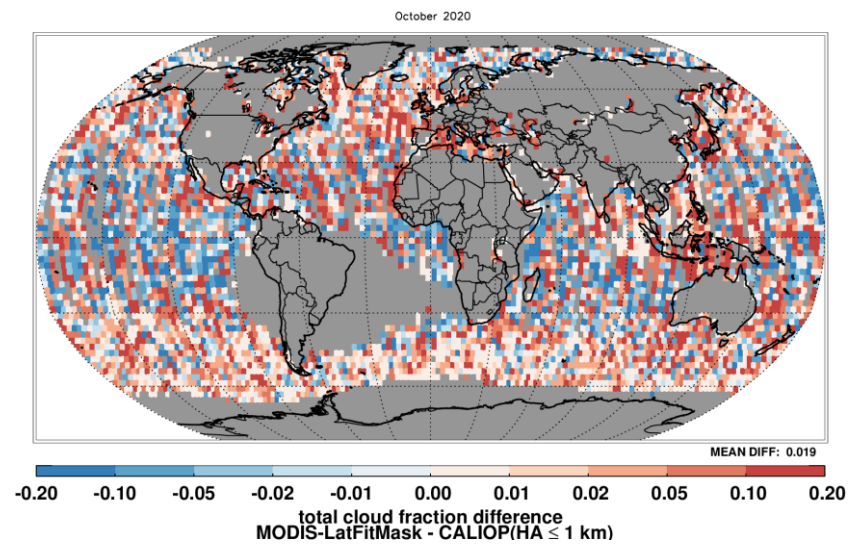


With Corrections



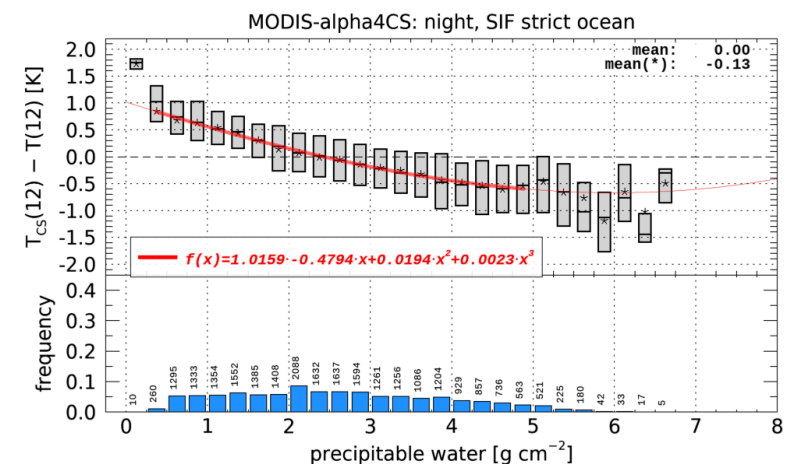
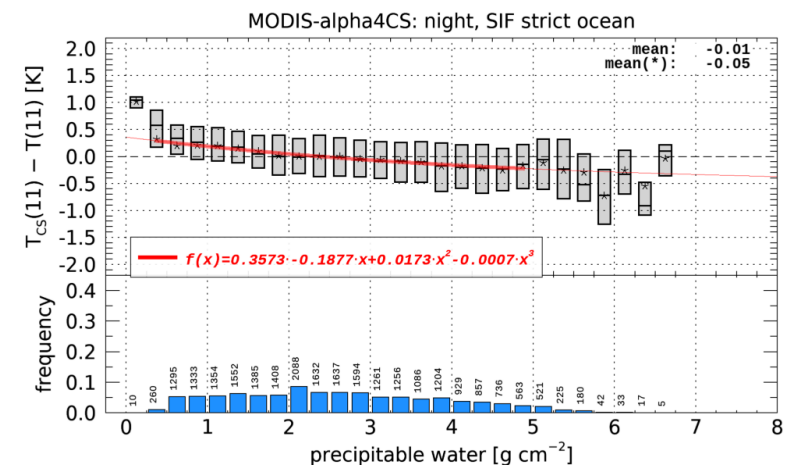
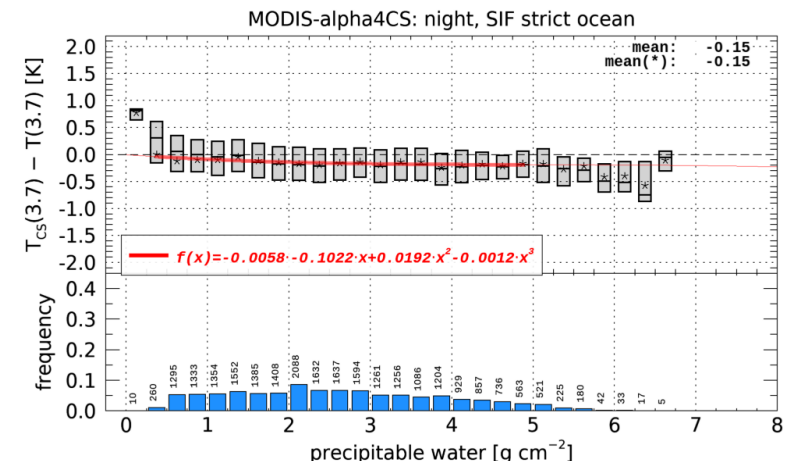
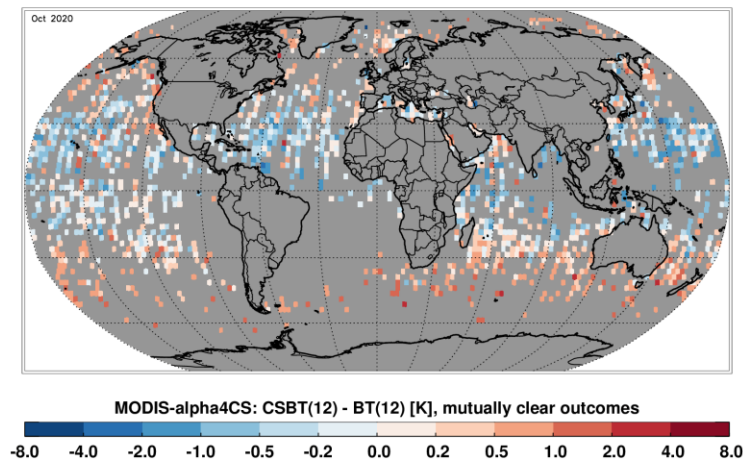
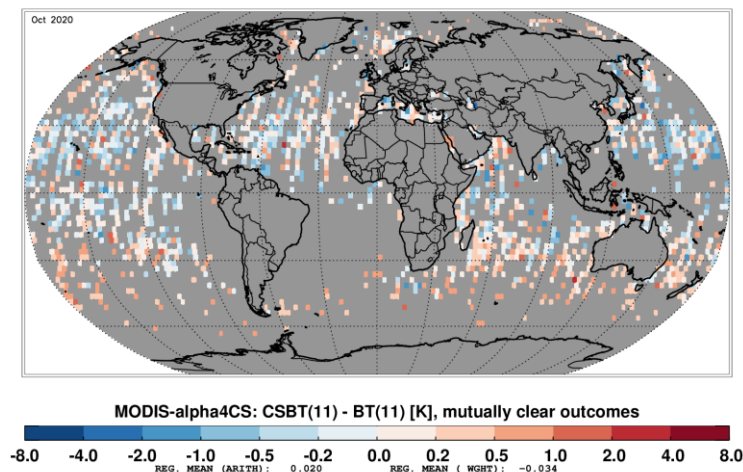
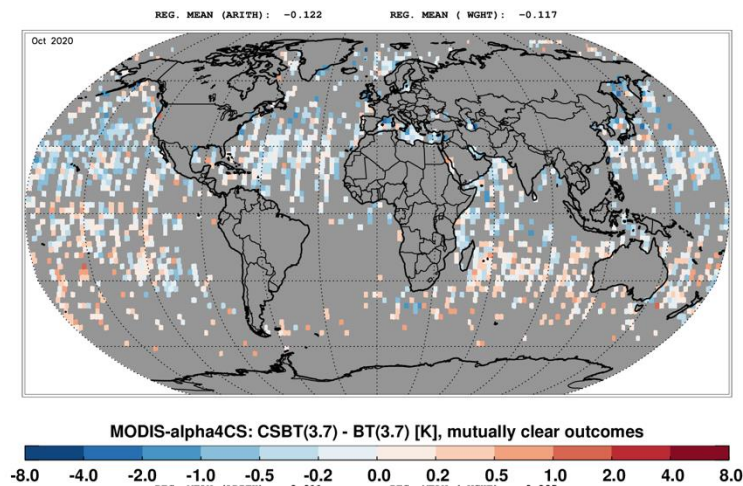
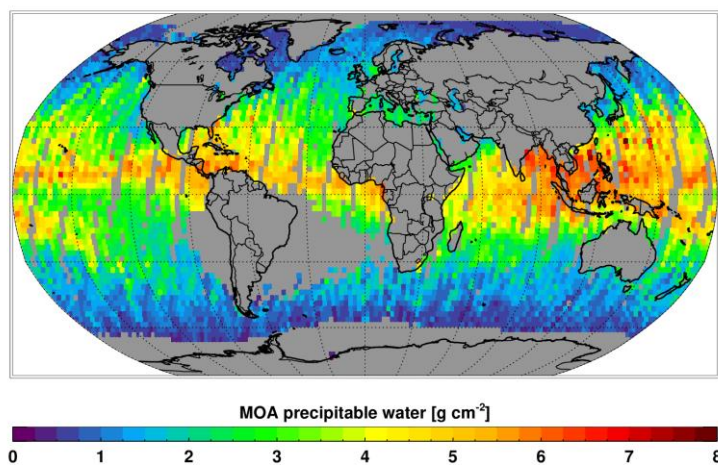
Daytime

- No impact during day (SW channels do most of the work)



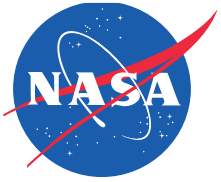
October 2020, night

Clear-sky BT errors also correlated with PW
 - fairly consistent from month to month



Next steps

- Test PW fits
- Compile seasonal fits into one set of corrections that could be applied across entire record



Ed5 Alpha5 Cloud Fraction Summary

Notable Improvements:

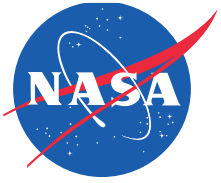
- Compared to Ed4, daytime ocean is more regionally consistent with CALIPSO (C-Train).
- Nighttime ocean much better than Ed4 (increased low clouds and eliminated tropical high cloud bias).
- Daytime land - reduced false clouds over high-elevated desert
- Polar daytime clouds similar to Ed4 despite dropping 6.7 and 13 μm bands (Tau much improved)
- NH Polar night tuned well to account for loss of 6.7 and 13 μm , but ERA-5 Tskin errors challenging
- SH Polar clouds identified with Nnet are much more spatially consistent, mitigate loss of 6.7/13 μm but still very challenging over the high plateau

Work still in progress:

- Final tuning to reduce daytime SIF non-glint oceanic low clouds
- Testing clear-sky BT bias corrections to reduce latitude dependent cloud detection errors
- Final tuning over land to better account for clear-sky errors

Unmitigated challenges:

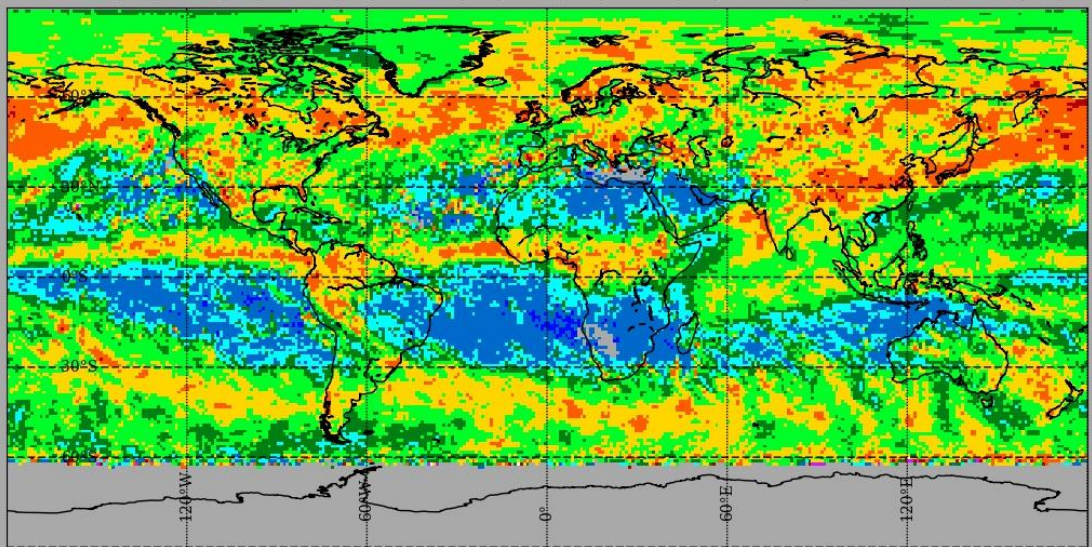
- Large ERA5 skin temperature errors over snow & ice



Neural Net for Nighttime Optical Depth

Alpha-5 Ice Cloud Optical Depth (Day)

Non-polar land = 4.3 ; Non-polar ocean = 3.1



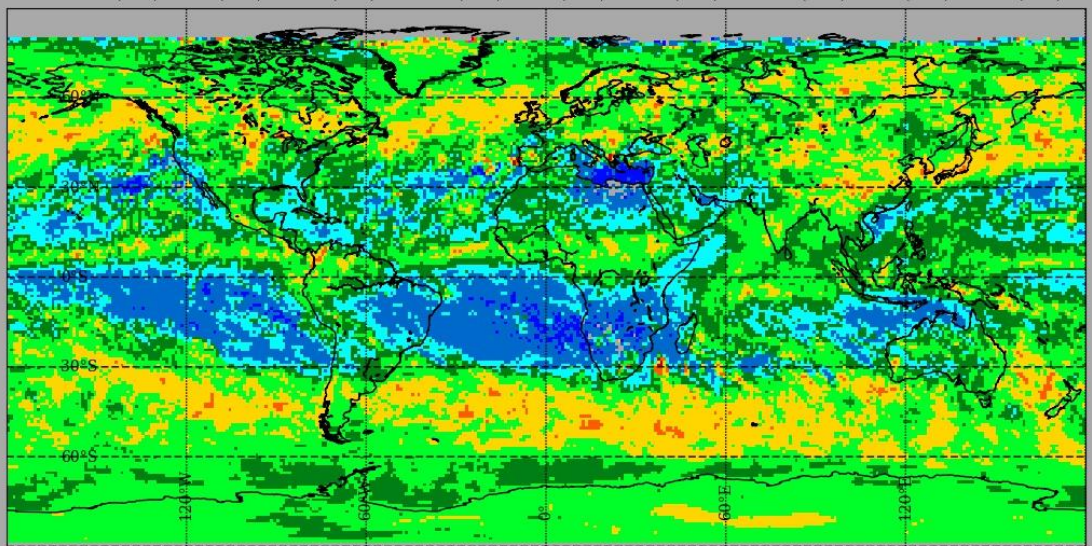
Ice Cloud Optical Depth Aqua-MODIS July 2020



- Alpha-5 applies a neural net to more accurately assign COD's at night for optically thick clouds (trained with IR BTs during day) – leads to more accurate cloud height assignment and computed fluxes
- Nighttime theoretical approach only works for optically thin clouds
- Neural net COD more realistic than Ed4 but still too low compared to daytime (too many false thin clouds from theoretical method)
- Solution to better partition Nnet and theoretical COD's ready to test

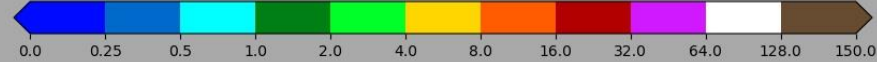
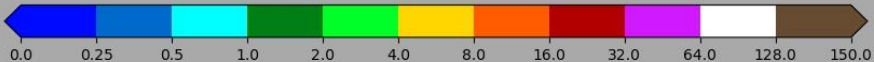
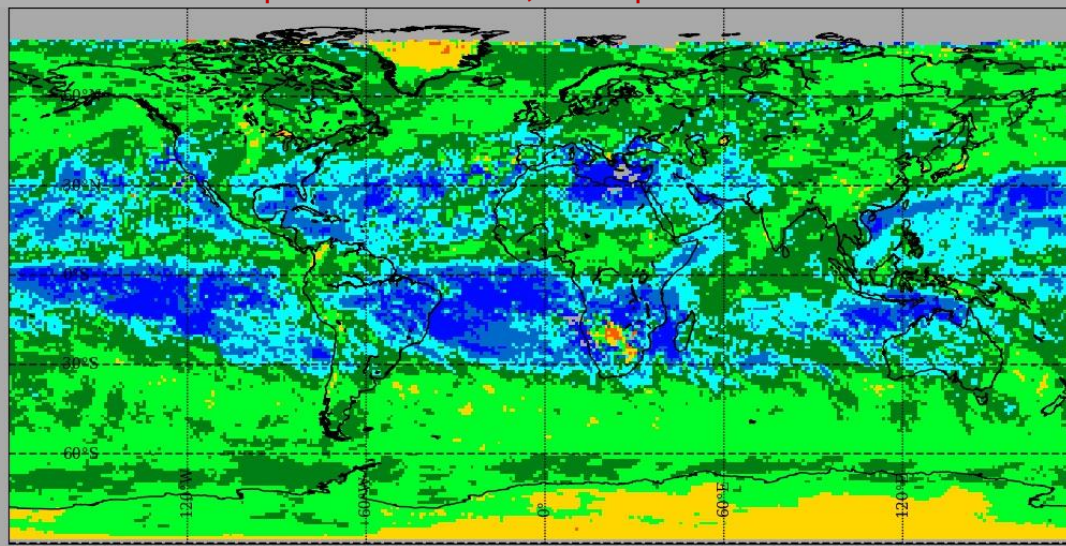
Alpha-5 Ice Cloud Optical Depth (Night)

Non-polar land = 2.4 ; Non-polar ocean = 2.4



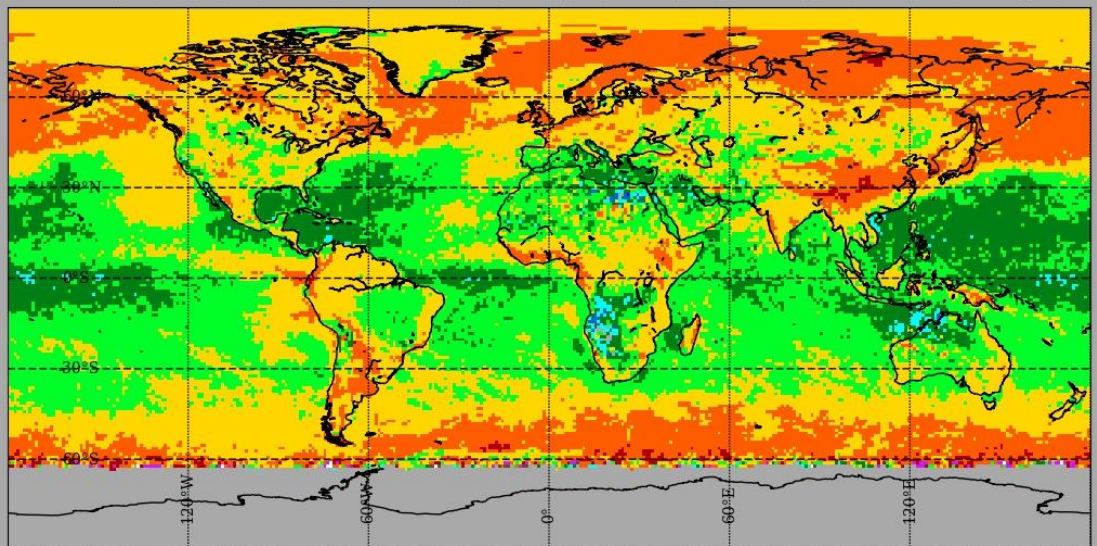
Ed4 Ice Cloud Optical Depth (Night)

Non-polar land = 1.5 ; Non-polar ocean = 1.4



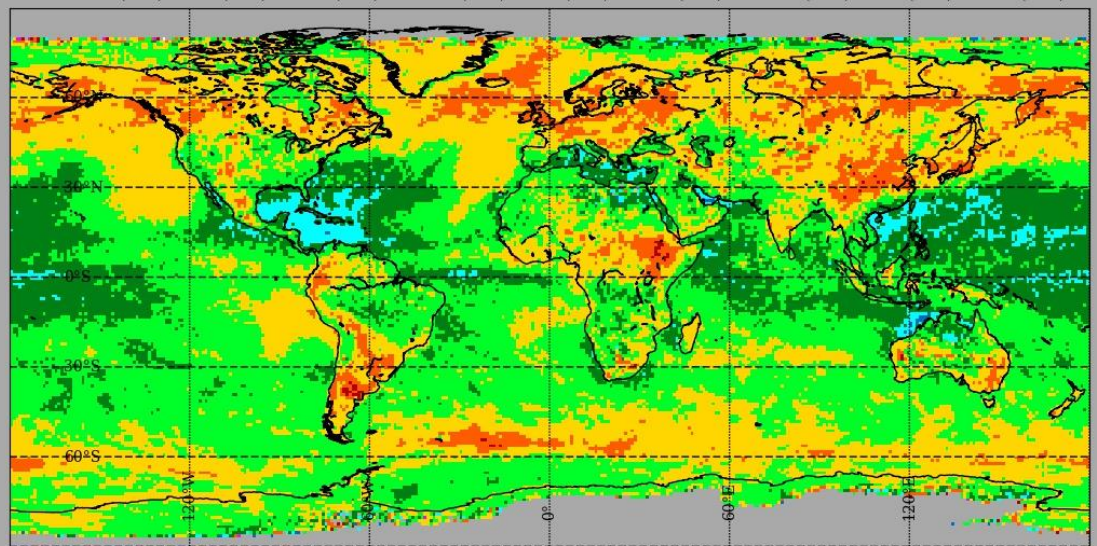
Alpha-5 Liquid Cloud Optical Depth (Day)

Non-polar land = 5.4 ; Non-polar ocean = 4.2



Alpha-5 Liquid Cloud Optical Depth (Night)

Non-polar land = 5.2 ; Non-polar ocean = 3.2



Liquid Cloud Optical Depth

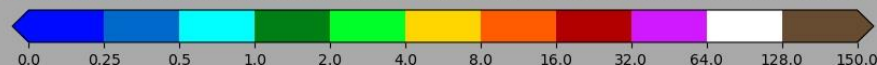
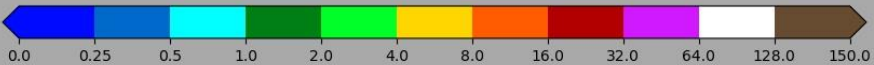
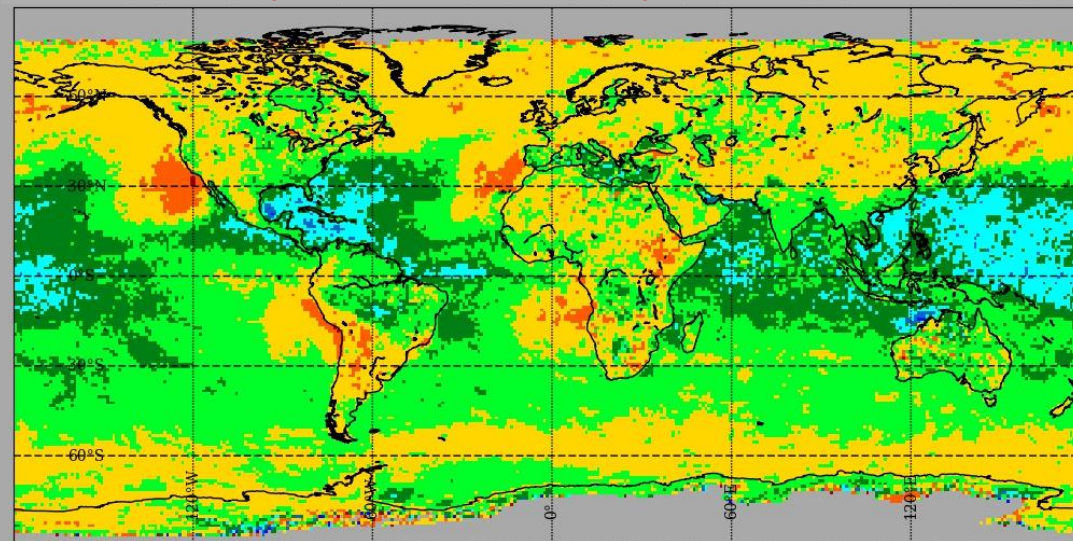
Aqua-MODIS July 2020

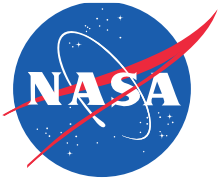


- Day/night differences not as large as ice in Ed4
- COD Nnet trained separately for ice and liquid clouds
- Overall, better nighttime COD for liquid clouds with Nnet but diurnal cycle can not be captured

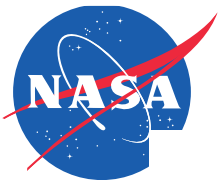
Ed4 Liquid Cloud Optical Depth (Night)

Non-polar land = 4.4 ; Non-polar ocean = 3.0





Cloud Top Height Neural Net For Optically Thick Ice Clouds

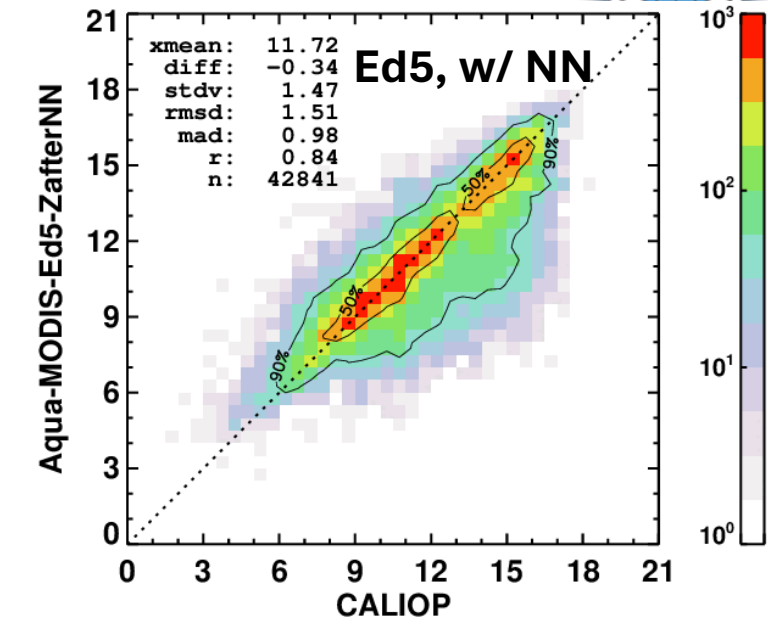
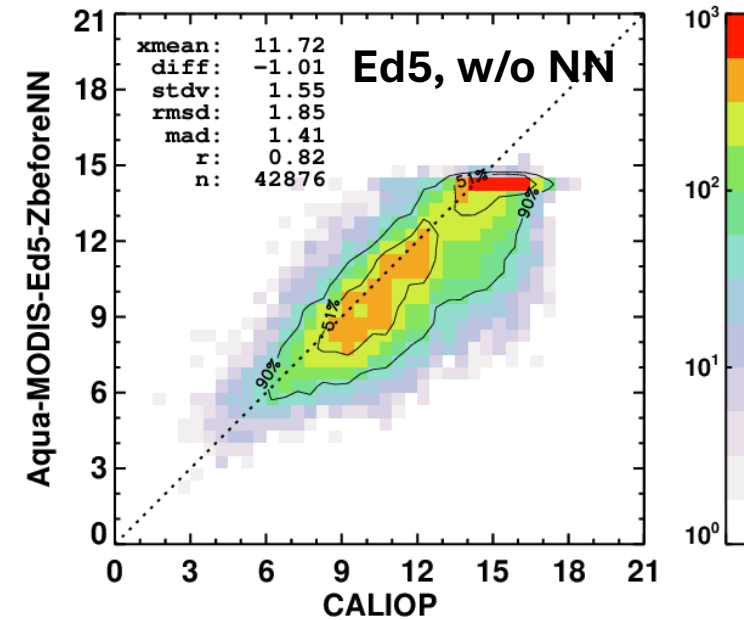
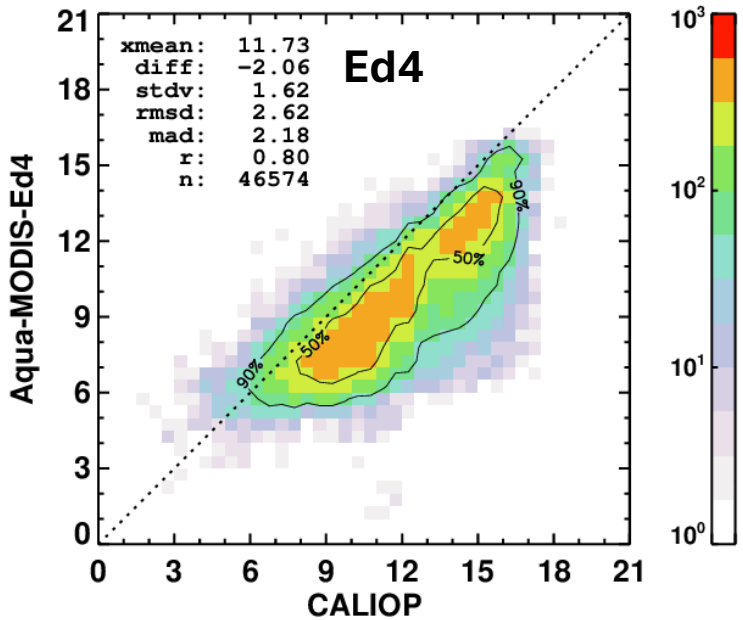


July 2020 Cloud Top Height Comparisons with CALIPSO MODIS Ice Clouds with optical depth > 6

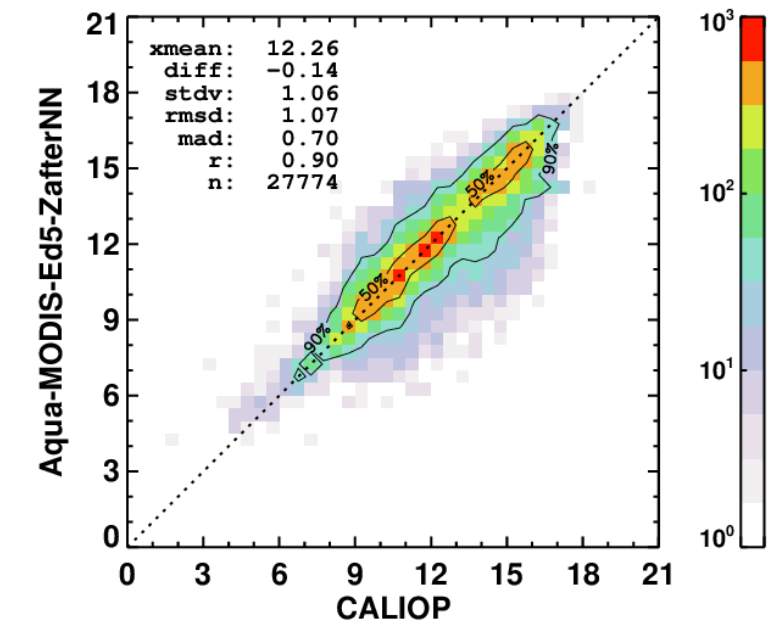
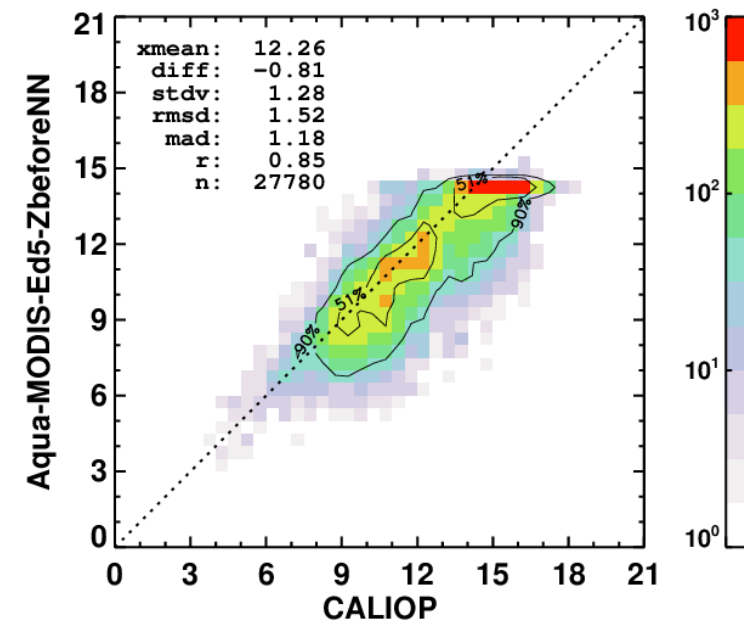
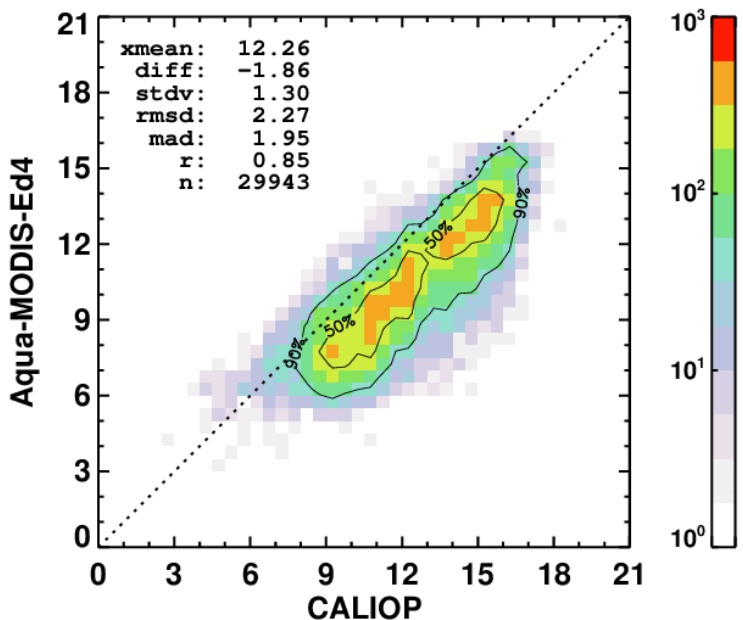
DAY

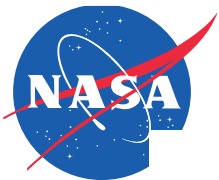


all clouds



single-layer clouds



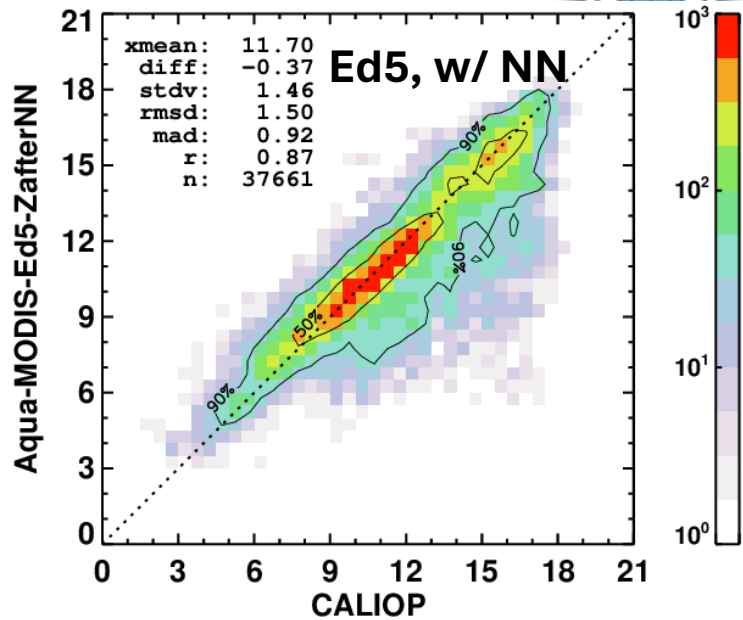
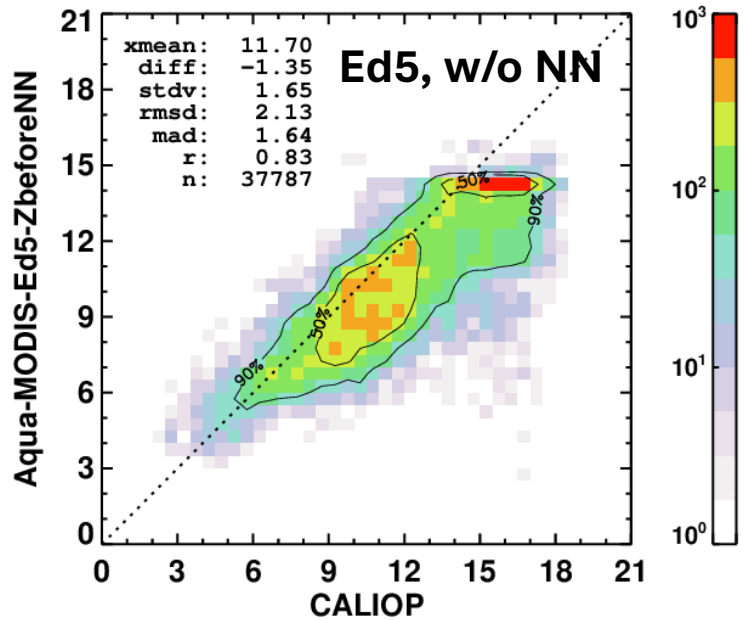
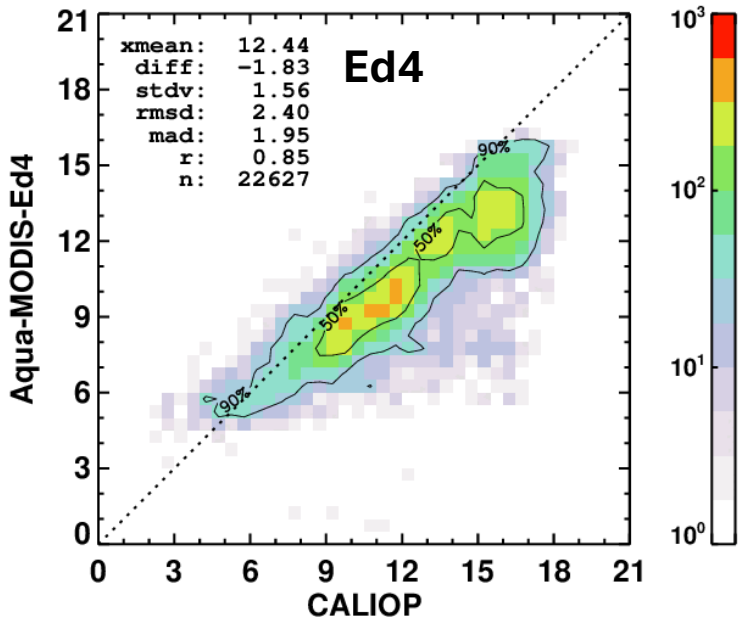


July 2020 Cloud Top Height Comparisons with CALIPSO MODIS Ice Clouds with optical depth > 6

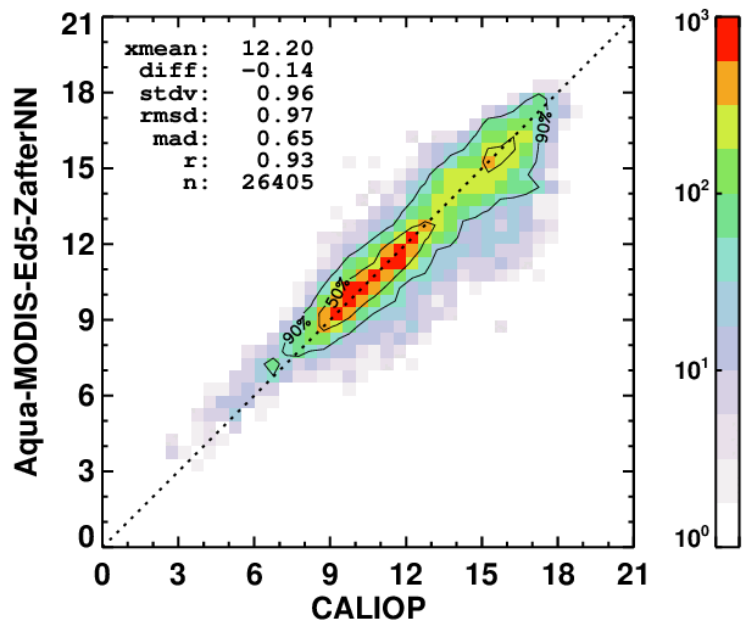
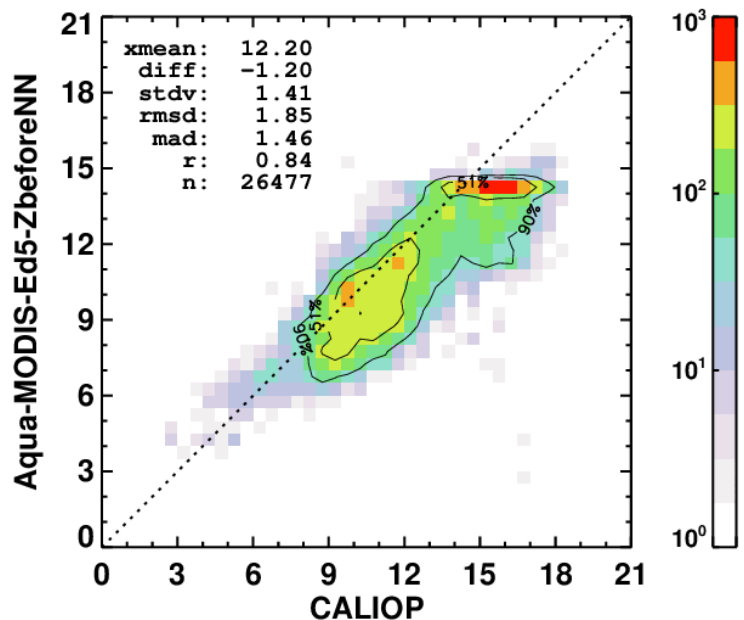
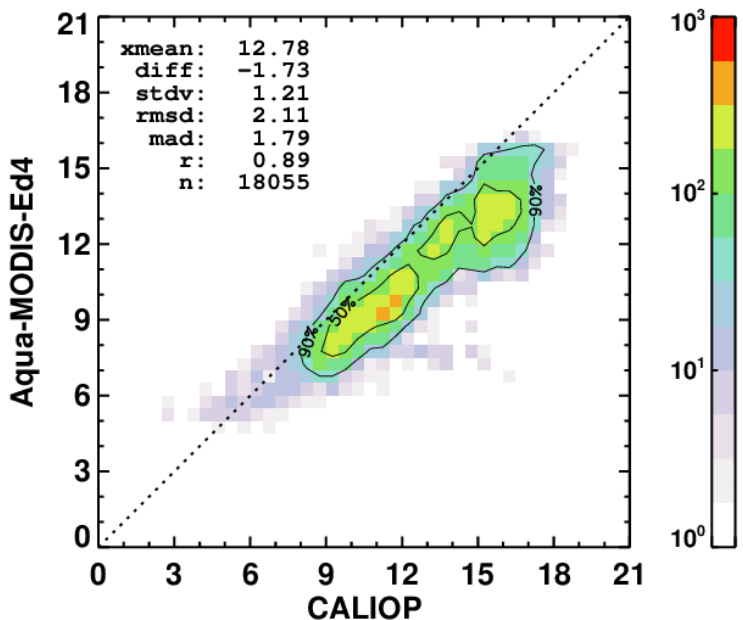
NIGHT

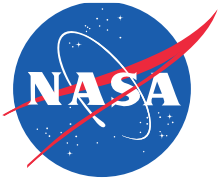


All clouds



single-layer clouds





Ed5 MODIS Delivery Status



Remaining work

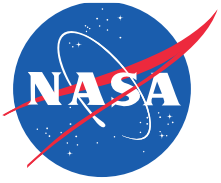
- Sunny and team working with DMT on delivery preparations
- Final tuning for cloud mask
 - complete clear sky updates and corrections
- Test new implementation procedure for Nighttime Tau neural net
 - current implementation still allows for too many theoretical (thin) cloud retri.
- Cloud height neural net and implementation need further vetting
- Evaluate new logic for daytime no retrievals
- Evaluate Terra-MODIS clouds

Risks

- To meet schedule, we may have to freeze code before remaining work is completed
- MODIS/VIIRS cloud retrieval consistency not yet well understood
 - C7 scalings for VIIRS still in progress
 - Need to ensure clear-sky end is well characterized in SW for cloud mask
 - Without radiance scalings, consistency is better than Ed4/ED1C but...
- Neural net impacts and consistency across platforms not yet known

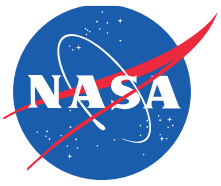
Publications

1. Chang I., et al. (2025). Low cloud diurnal cycle drives regional aerosol radiative warming, *Nature Geosc.*, 18, pages 702–708.
2. Tornow, F., et al.(2025). High accumulation mode aerosol concentration and moderate aerosol hygroscopicity limit impacts of recent particle formation on Northwest Atlantic post-frontal clouds. *Geophys. Res. Lett.*, 52, e2025GL116020. <https://doi.org/10.1029/2025GL116020>.
3. Ham, S., N. G. Loeb, S. Kato, T. J. Thorsen, A. Voigt, W. L. Smith, and D. M. Winker, 2025: Zonal Cloud Trends Observed by Passive MODIS and Active CALIOP and CPR Sensors. *J. Climate*, 38, 2605–2622, <https://doi.org/10.1175/JCLI-D-23-0722.1>.
4. Yuan, T., Song, H., Oreopoulos, L., Wood, R., Meyer, K., Crawford, A., et al. (2025). Analyses of virtual ship-tracks systematically underestimate aerosol-cloud interactions signals. *Geophysical Research Letters*, 52, e2024GL114356. <https://doi.org/10.1029/2024GL114356>
5. Chen, J., Wang, H., Zhang, B., Liu, H., Painemal, D., Sorooshian, A., Tai, S.-L., and Voigt, C.: Response of marine post-frontal clouds to Gulf Stream variability, *Atmos. Chem. Phys.*, 26, 2209–2224, <https://doi.org/10.5194/acp-26-2209-2026>, 2026.
6. Zheng, X., Feng, Y., Painemal, D., Zhang, M., Xie, S., Li, Z., Jacob, R., and Lusch, B.: Regime-based aerosol–cloud interactions from CALIPSO-MODIS and the Energy Exascale Earth System Model version 2 (E3SMv2) over the Eastern North Atlantic, *Atmos. Chem. Phys.*, 25, 17473–17499, <https://doi.org/10.5194/acp-25-17473-2025>, 2025.
7. Li, Z, Painemal, D., Feng, Y., and Zheng, X. (2026). Advancing the quantification of aerosol-cloud interactions using the CALIPSO-CloudSat-Aqua/MODIS record, *Atmos. Chem. Phys* (accepted).
8. Zhang, J., Painemal, D., Dror, T., Lim, J.-S., Sorooshian, A., and Feingold, G. (2026): Inferring processes governing cloud transition during mid-latitude marine cold-air outbreaks from satellite, *Atmos. Chem. Phys.*, 26, 6015–6034, <https://doi.org/10.5194/acp-26-6015-2026>.
9. Chellappan, S., Painemal, D., Thieman, M., Pelayo, C., Smith Jr., W. L., and Russell, L. M.: Atmospheric circulation and boundary layer processes modulating aerosol and cloud characteristics over the coastal Northeast Pacific during April to October of ARM EPCAPE field campaign (2026), *EGUsphere* [preprint], <https://doi.org/10.5194/egusphere-2026-933>, 2026.
10. Ren, T., P. Yang, N. G. Loeb, W. L. Smith, and P. Minnis, 2026: Precipitation on the Manus Island of Papua New Guinea and Ice Cloud Radiative Effects in the Surrounding Atmosphere in Boreal Winters. *J. Atmos. Sci.*, 83, 615–631, <https://doi.org/10.1175/JAS-D-25-0161.1>.



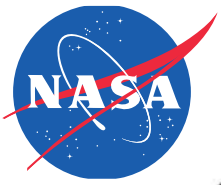
GEO UPDATE

Latest Ed5 Test Version is Alpha 4



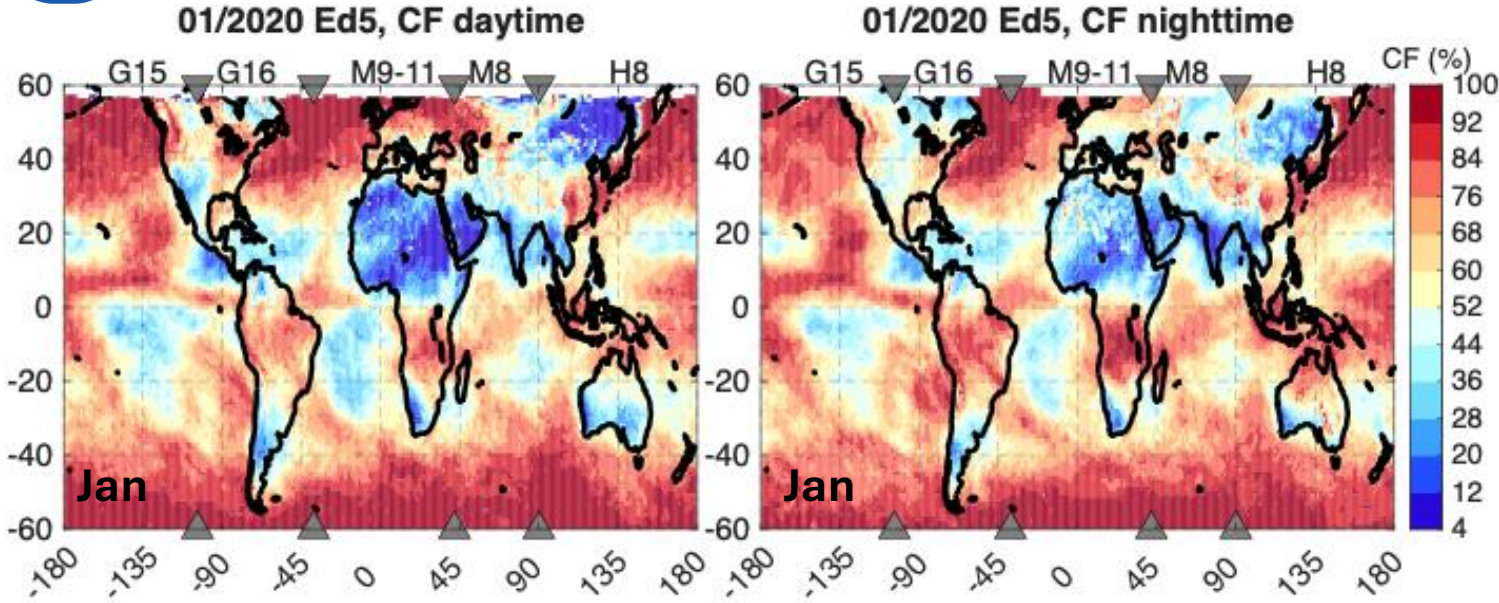
Updates

- Revised cloud reflectance lookup tables (LUT) that fix past methodological inconsistencies.
- New LUT reduces number of pixels with no physical solution.
- New logic for retrieving cloud optical thickness when no solution is found for cloud particle size.
- Development of tuning factors for reducing clear-sky biases between computed and observed T_b at $3.9 \mu\text{m}$.
- Bug fix: ozone profile truncation logic removed.

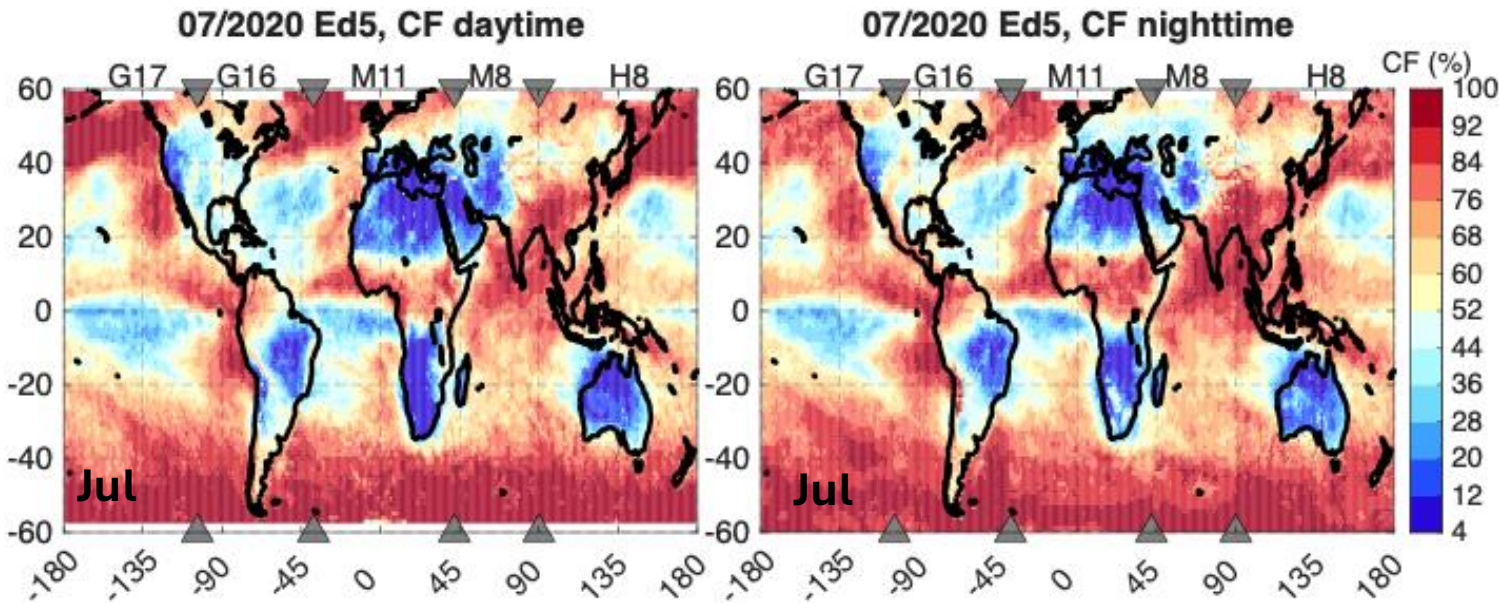


GEO Edition 5 Cloud Fraction

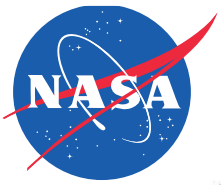
Alpha-4



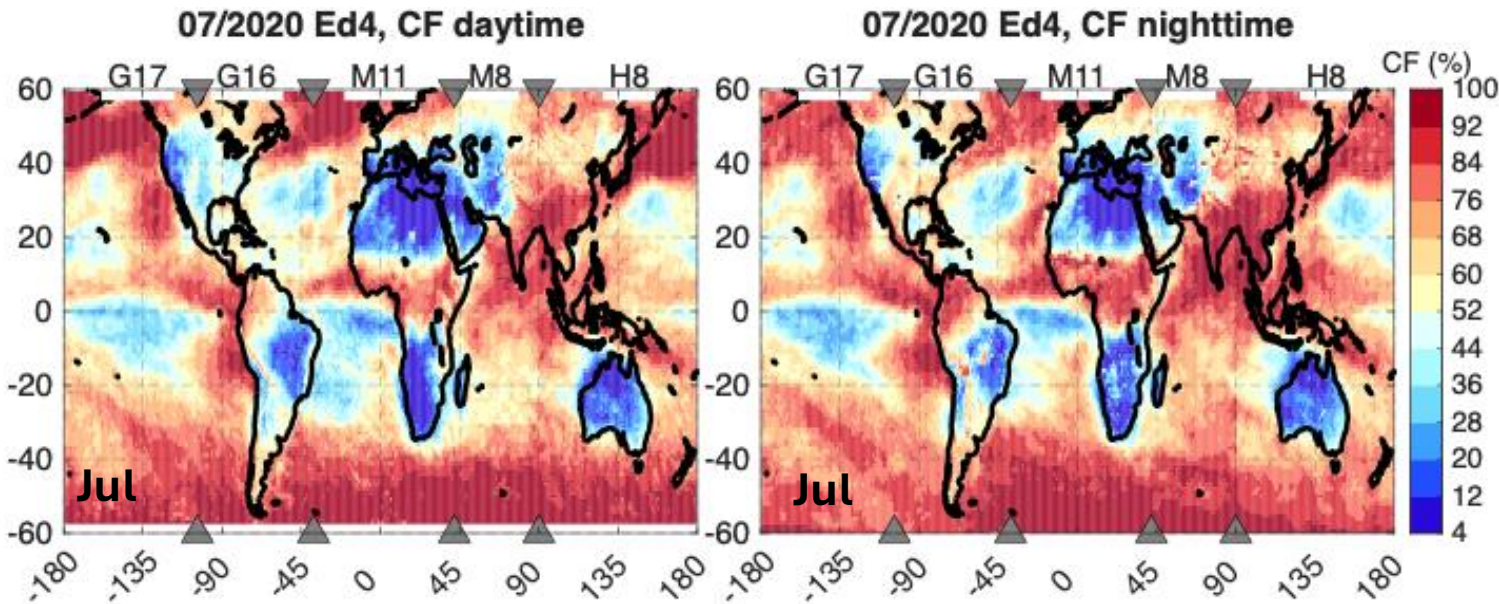
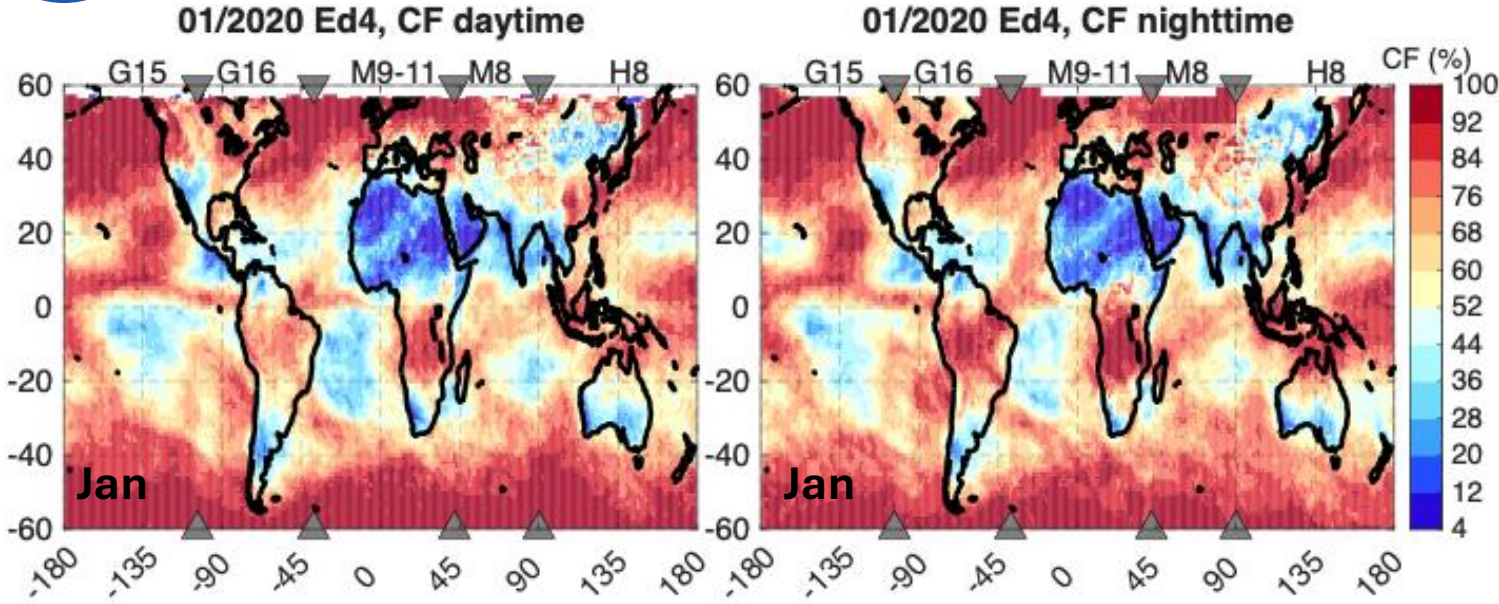
SZA < 75°



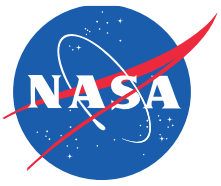
SZA > 90°



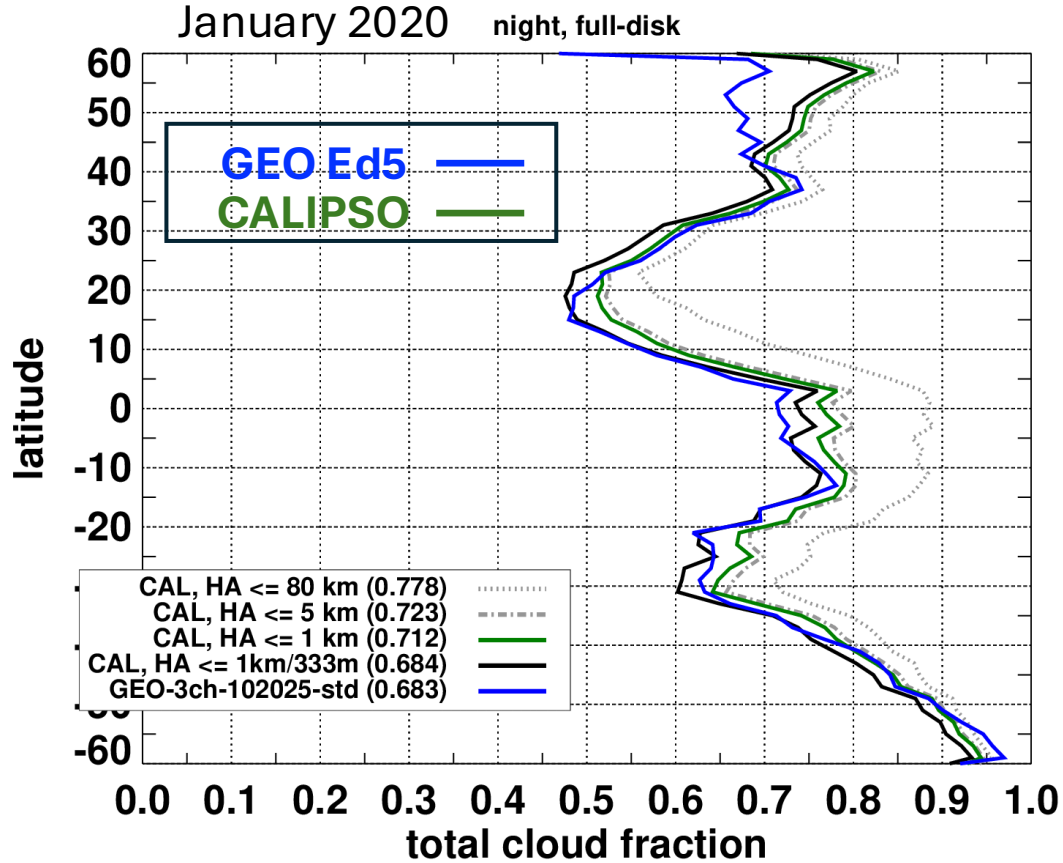
GEO Edition 4 Cloud Fraction



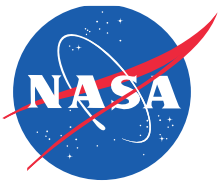
- CF is reduced in Ed5
- A CF decrease over the high latitude ocean helps mitigate biases observed in Ed4.



Cloud Fraction biases in Ed5 (nighttime) Alpha-4



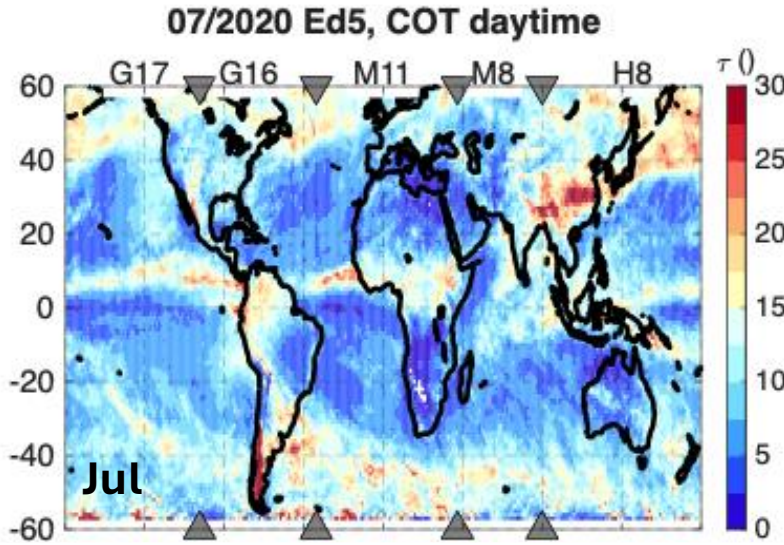
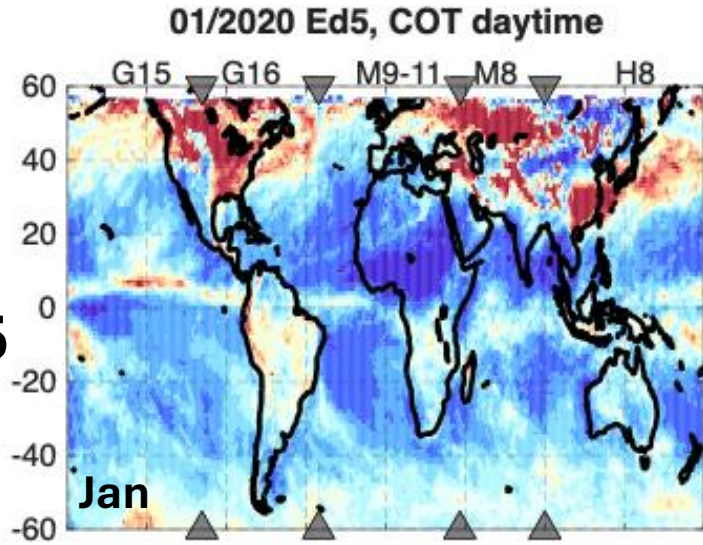
- Reasonable agreement with CALIPSO.
- Substantial underestimation north of 40° N, primarily over land.
- Cloud mask tuning will continue once the new skin temperature (neural net) is rederived during the following months.



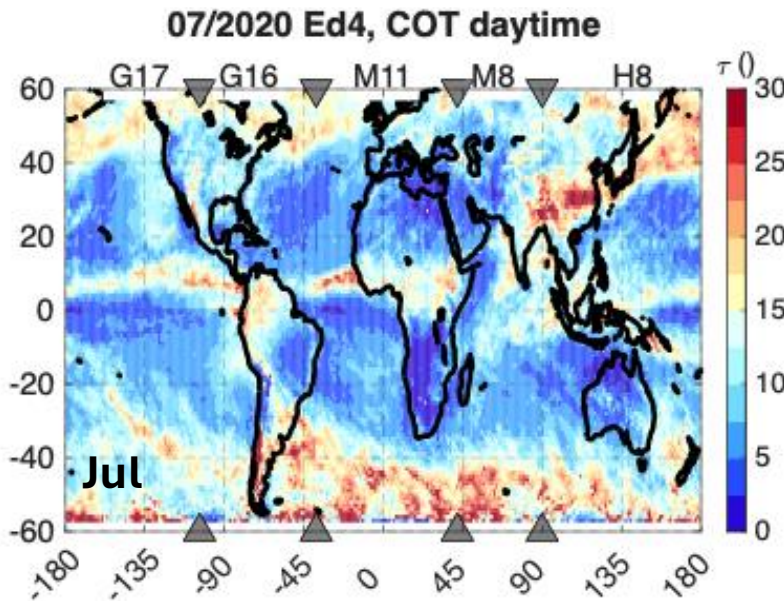
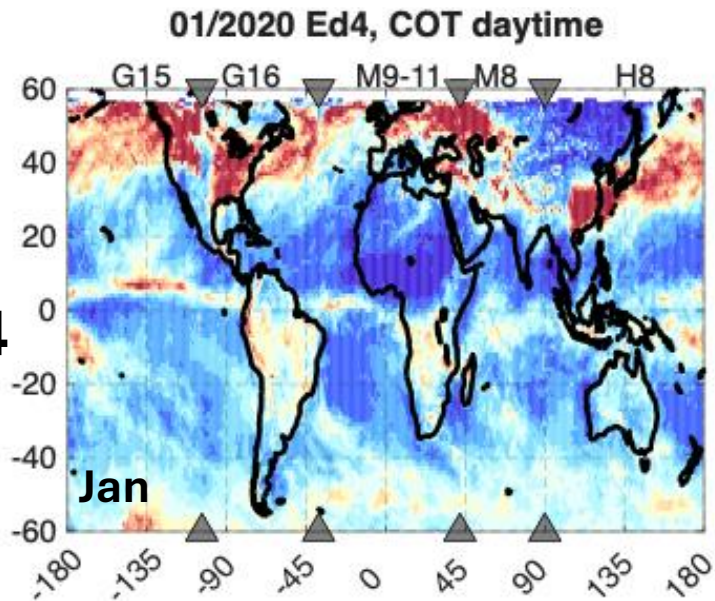
GEO Cloud optical thickness (COT)



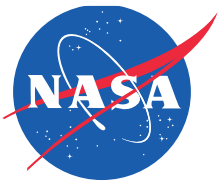
Ed 5



Ed 4



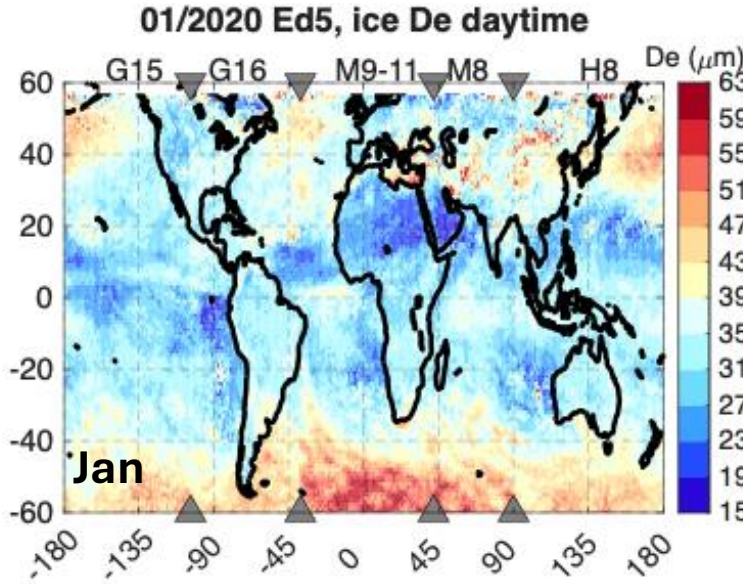
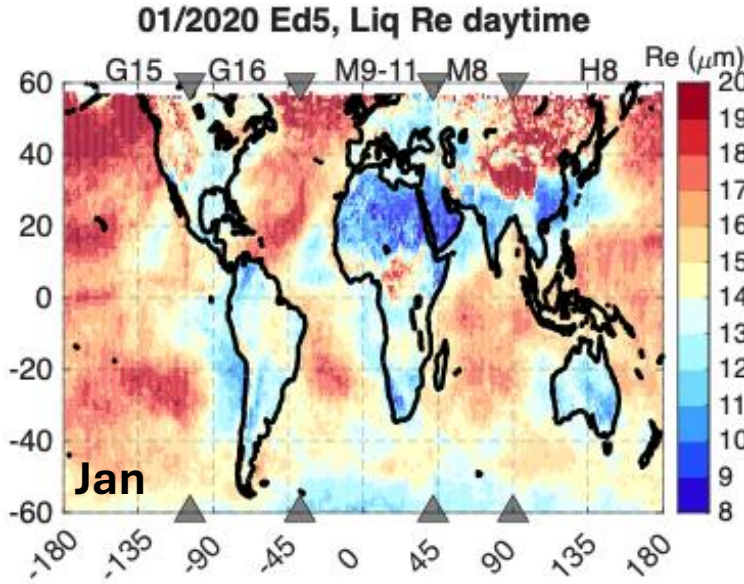
- Ed5 and Ed 4 COT are similar
- Discrepancies primarily attributed:
 - The reliance of Ed5 on the 0.64 um for clouds over snow/ice surface
 - Different ice cloud optical models



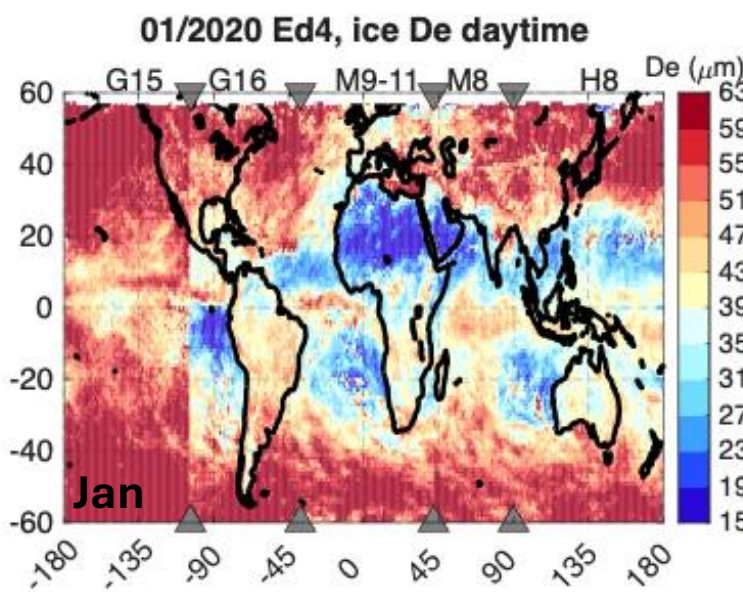
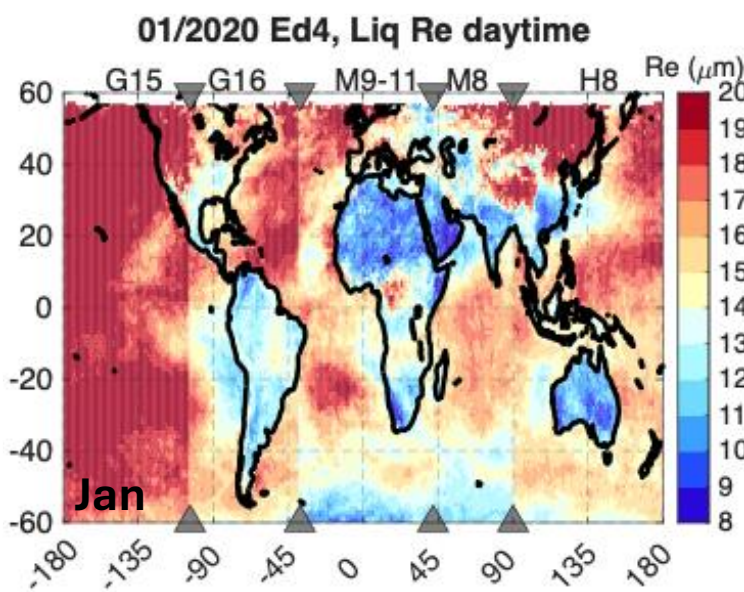
GEO cloud particle size (Re and De)



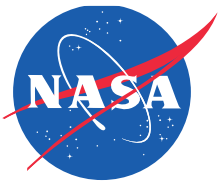
Ed 5



Ed 4



- Improved spatial consistency and reduced values for Re.
- Large De differences are attributed to the adoption of a Two-Habit model in Ed5



Nighttime Cloud Optical thickness (COT) reconstruction with KDT

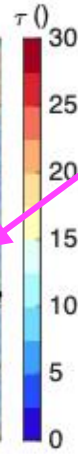
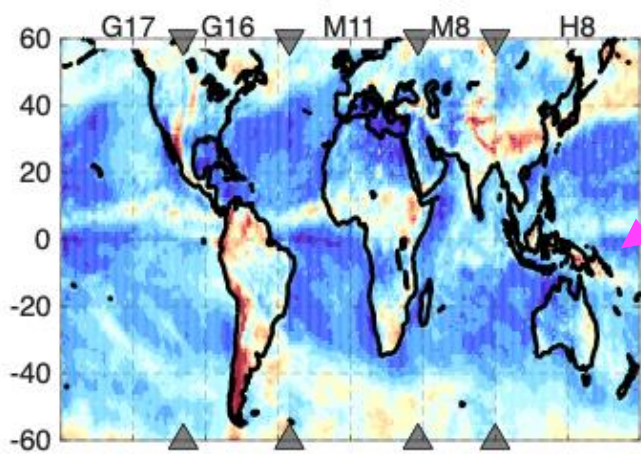
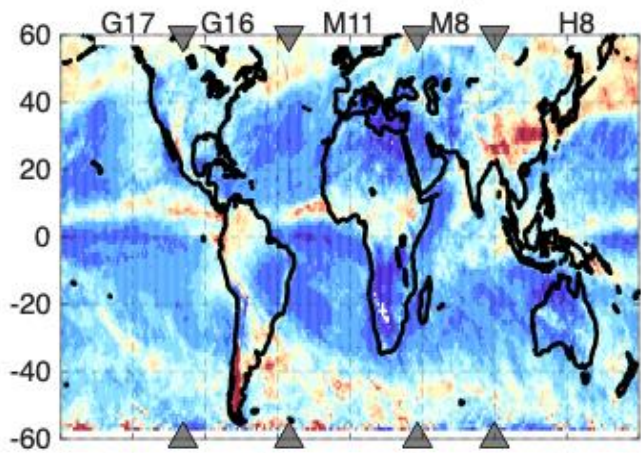


Day

Night

07/2020 Ed5, COT daytime

07/2020 Ed5, COT nighttime

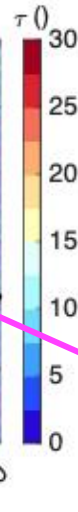
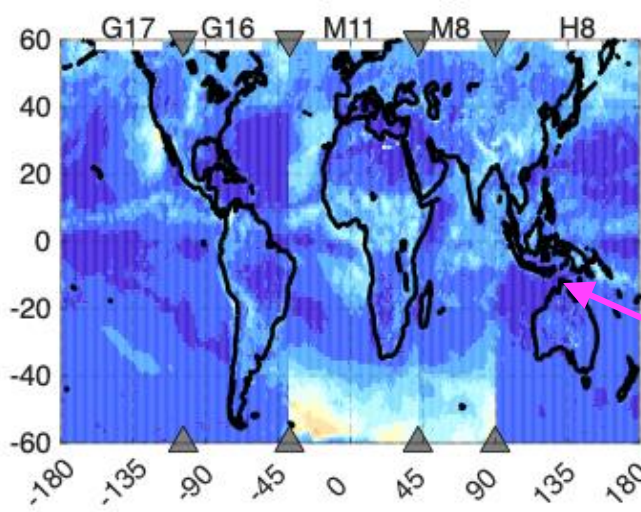
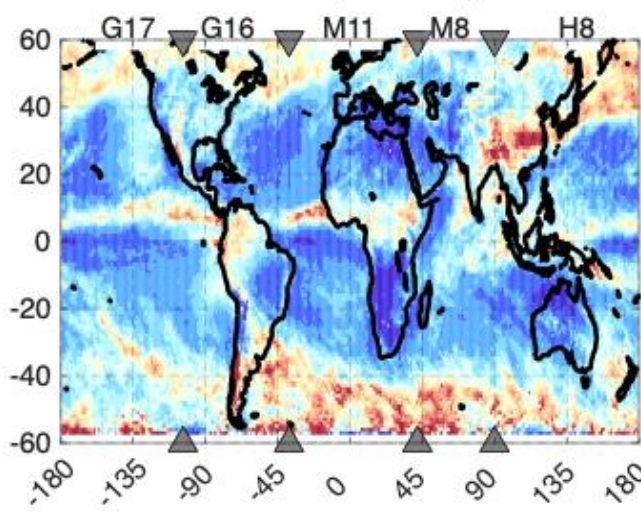


Ed5 KDT COT (nighttime)

Ed 5

07/2020 Ed4, COT daytime

07/2020 Ed4, COT nighttime

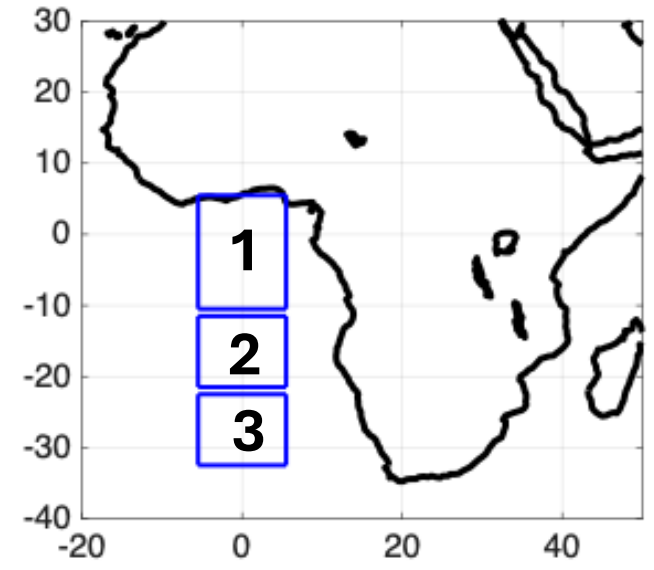
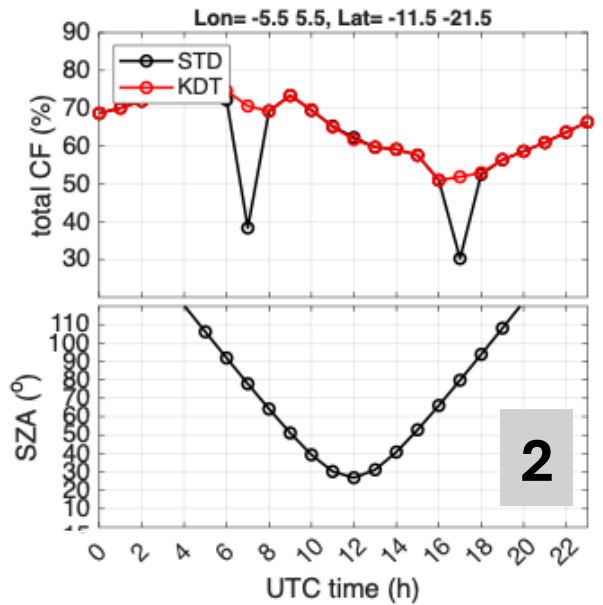
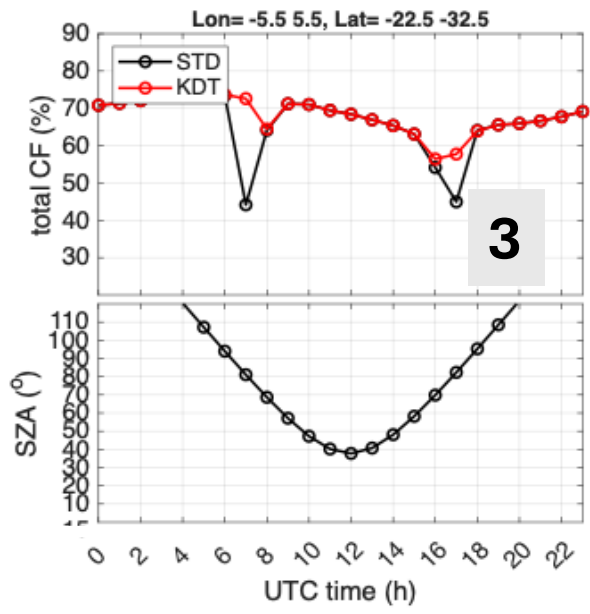
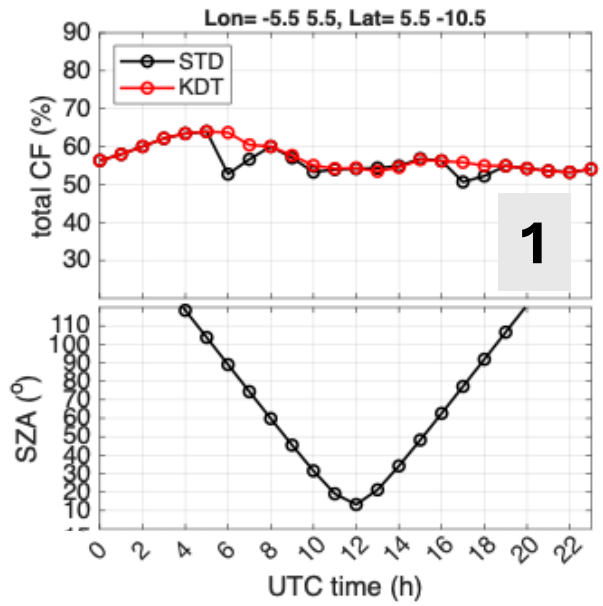


Ed4 solution for nighttime COT

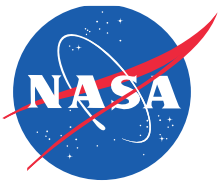
Ed 4

- New nighttime COT is more consistent with daytime COT.
 - Convective regions are better represented.
- Ongoing validation with ground-based observations and MW liquid water path.

Cloud reconstruction with KDT: Cloud Fraction (mask)

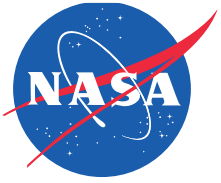


- KDT removes cloud fraction underestimation for $70^\circ < \text{SZA} \leq 90^\circ$
- KDT also mitigates artifacts over sunglint (not shown).

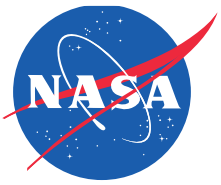


Future work

- Assess cloud products for 2nd generation GEO
- Explore ways to reduce biases in 3.9 μm clear-sky computations
- Ongoing work for improving the 2-channel algorithm
- Re-compute neural net Skin Temp and continue cloud mask tuning
- Assess clear-sky BT errors, similar to LEO



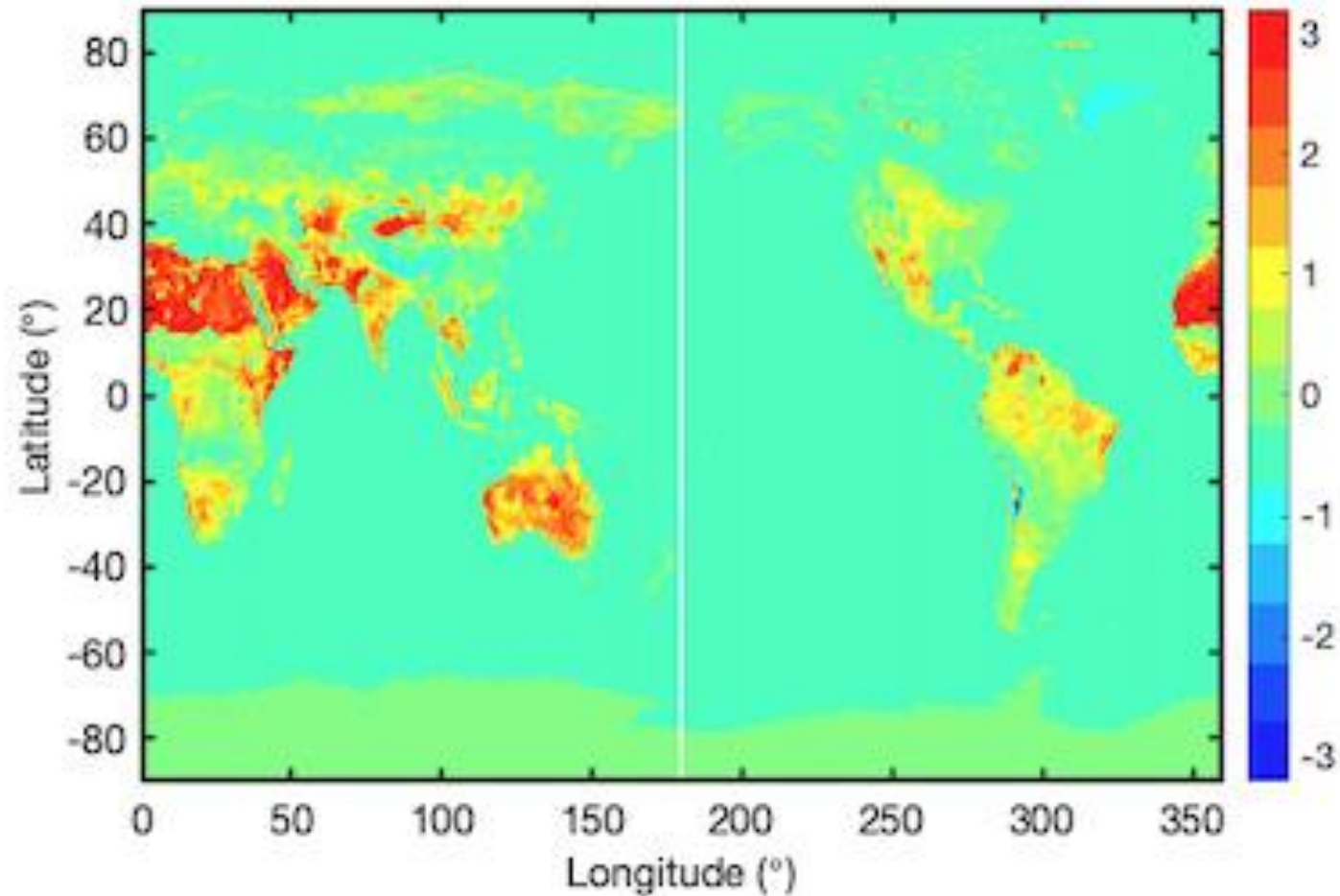
Extra Slides



Satellite-derived Tskin Difference Ed4 minus Ed5



April Monthly Mean, Nighttime



If Zhou atlas is assumed to be accurate, then CWG Tskin is overestimated by up to 3K.

Aqua-MODIS total cloud fraction validation with CALIOP

July 2008 (A-Train era)

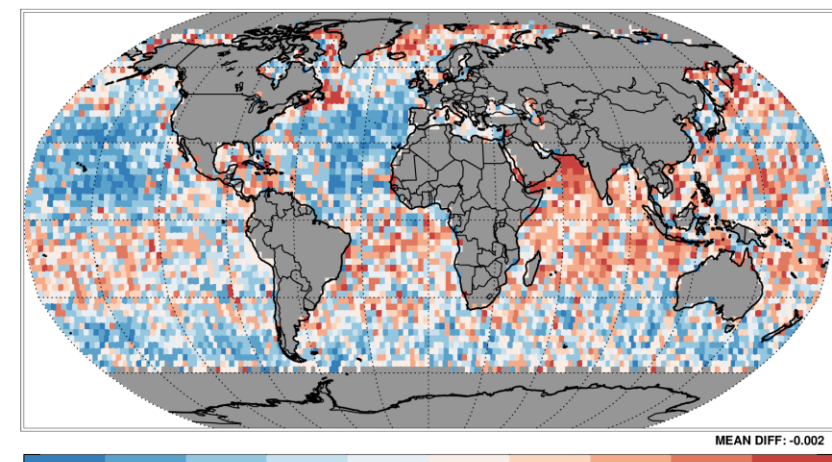
Day, snow/ice-free (SIF) ocean/water surfaces

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

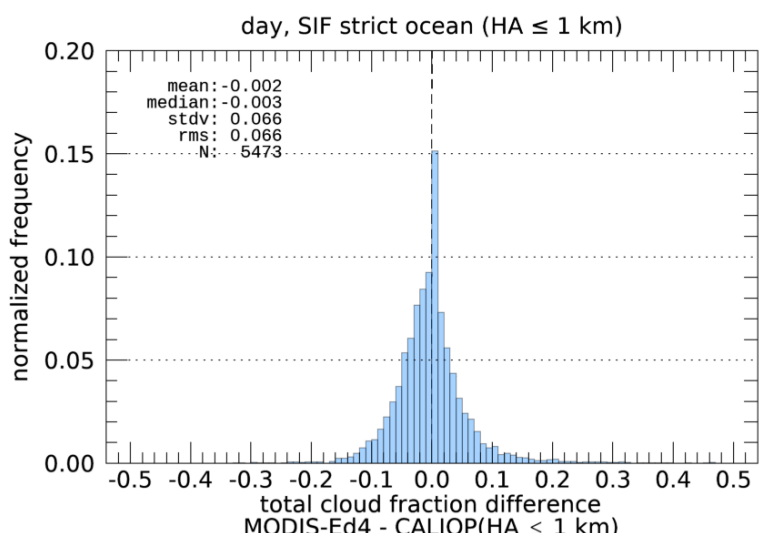
Progress towards Edition 5, Alpha 5



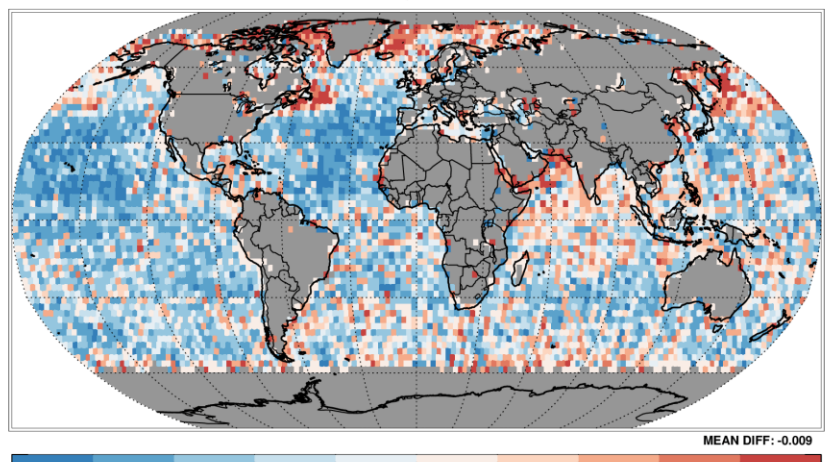
Edition-4



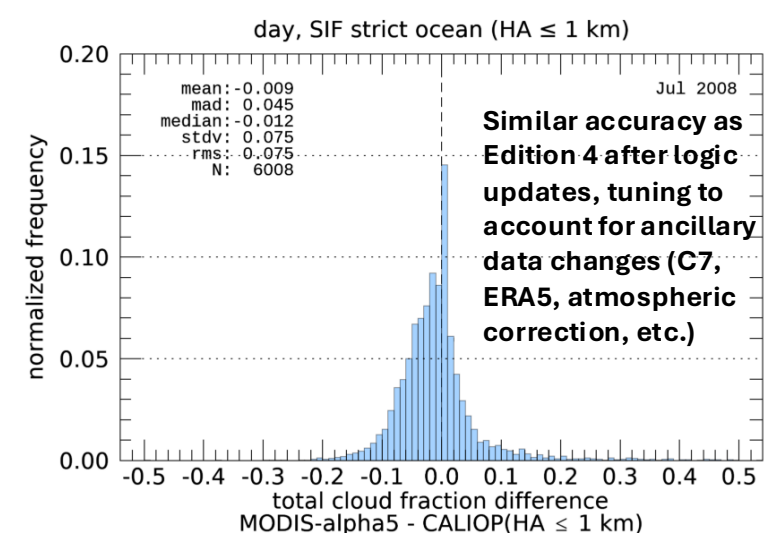
total cloud fraction difference
MODIS-Ed4 - CALIOP(HA ≤ 1 km)



Alpha-5

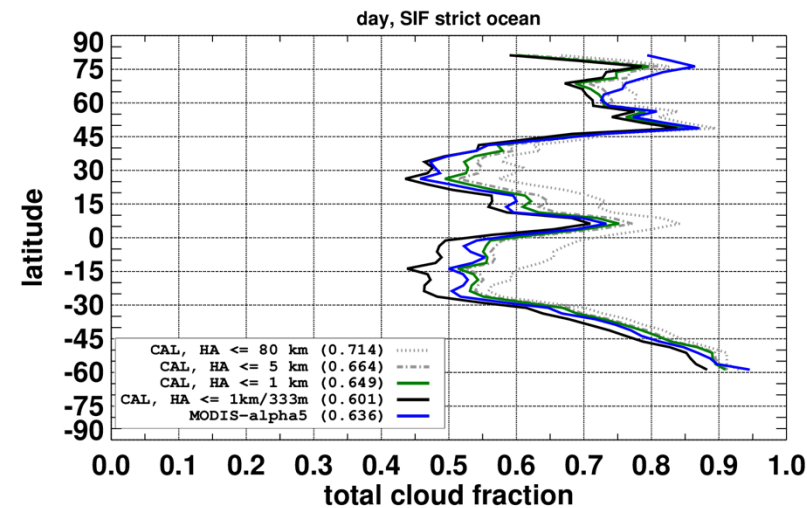


total cloud fraction difference
MODIS-alpha5 - CALIOP(HA ≤ 1 km)

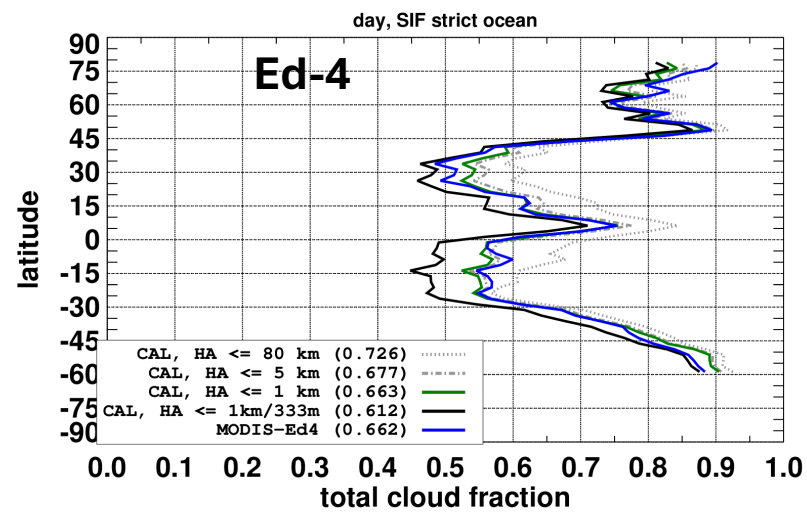


Similar accuracy as Edition 4 after logic updates, tuning to account for ancillary data changes (C7, ERA5, atmospheric correction, etc.)

Alpha-5



Ed-4



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

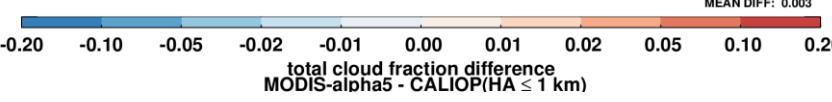
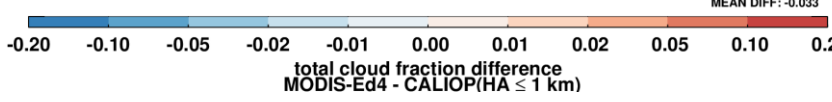
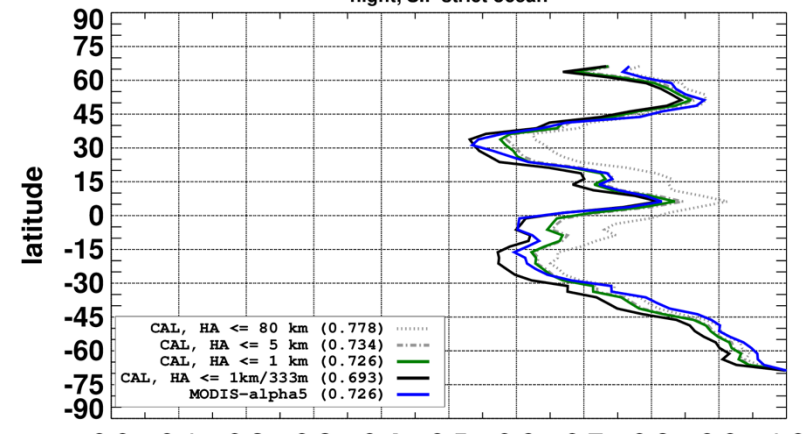
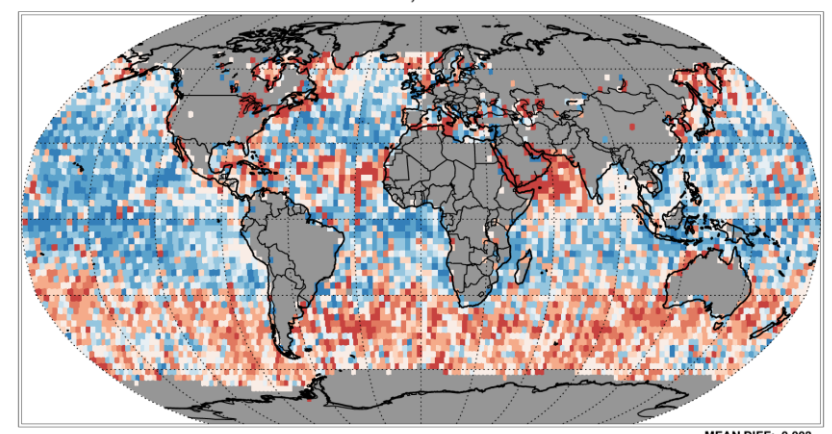
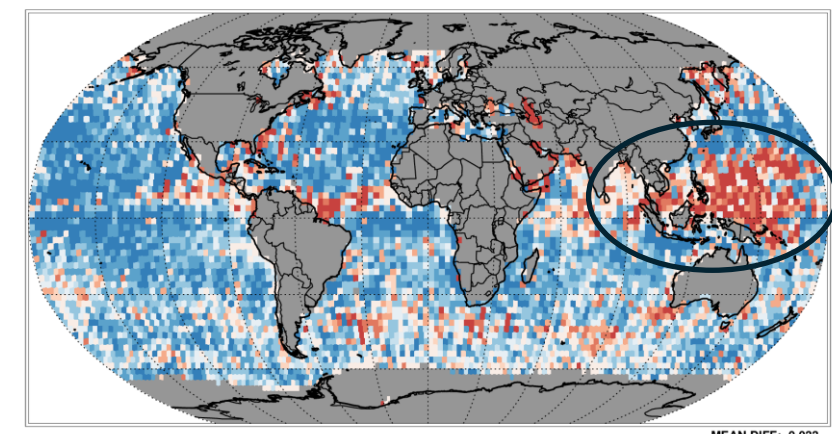
Progress towards Edition 5, Alpha 5



Edition-4

Alpha-5

Alpha-5



night, SIF strict ocean (HA ≤ 1 km)

night, SIF strict ocean (HA ≤ 1 km)

