CERES Cloud Working Group Report

CERES Science Team Mtg., Virtual#4, 12-14 Oct 2021

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Y. Chen (clr props, test runs), C. Yost (val), R. Smith (web, NPP), R. Brown (QC),
R. Palikonda (GEO lead), S. Bedka (retrievals, val), D. Spangenberg (everything), M. Nordeen (GEO),
B. Scarino (cal, Tskin, GEO), F-L. Chang (CO2, corrk), Cecilia Wang (machine learning)
E. Heckert (web), B. Shan (GEO), Churngwei Chu (web), Zhujun Li (val)

SSAI, Hampton, VA

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

P. Heck (retrieval code), *CIMSS, UW-Madison*

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

Thanks to Dave Doelling and his TISA/calibration teams!

Cloud Working Group Objectives

Produce pixel-level cloud properties from LEO & GEO imager radiances

- Include cloud mask, thermodynamic phase, optical depth, effective radius, temperature, height, etc.
- Must be inferred at high resolution within coarser CERES footprints even under the most difficult conditions (e.g. at night, over snow/ice, in the presence of thin cirrus and heavy aerosols)
- Used by other WG's to convert measured radiances to radiative fluxes, to compute surface fluxes, and to improve the time interpolation of radiative fluxes.
- Must be as spatially and temporally consistent as possible across platforms in order to minimize discontinuities in the CERES CDR

Topics

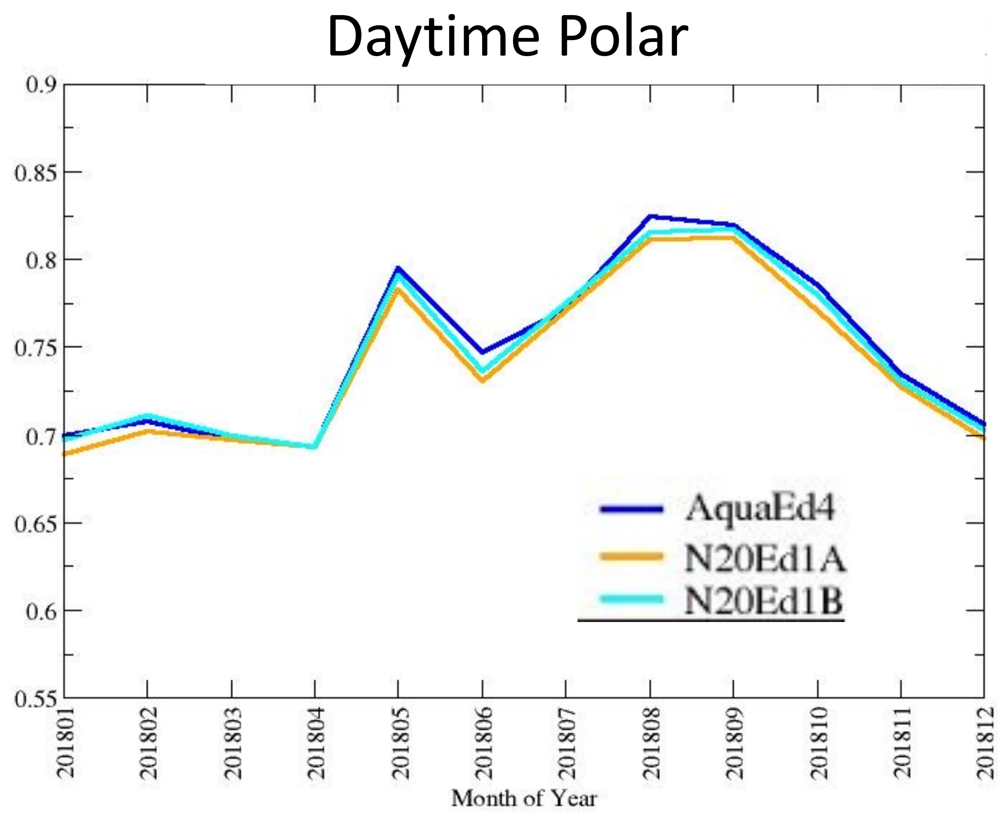
- Data processing status
- Ed4 GEO timeseries/discontinuities
  - Opportunity to update parts of record
- Ed5 progress
  - Clear sky radiance improvements
  - Optical depth over snow/ice
- Use of ancillary snow/ice data products
- Publication/documentation update

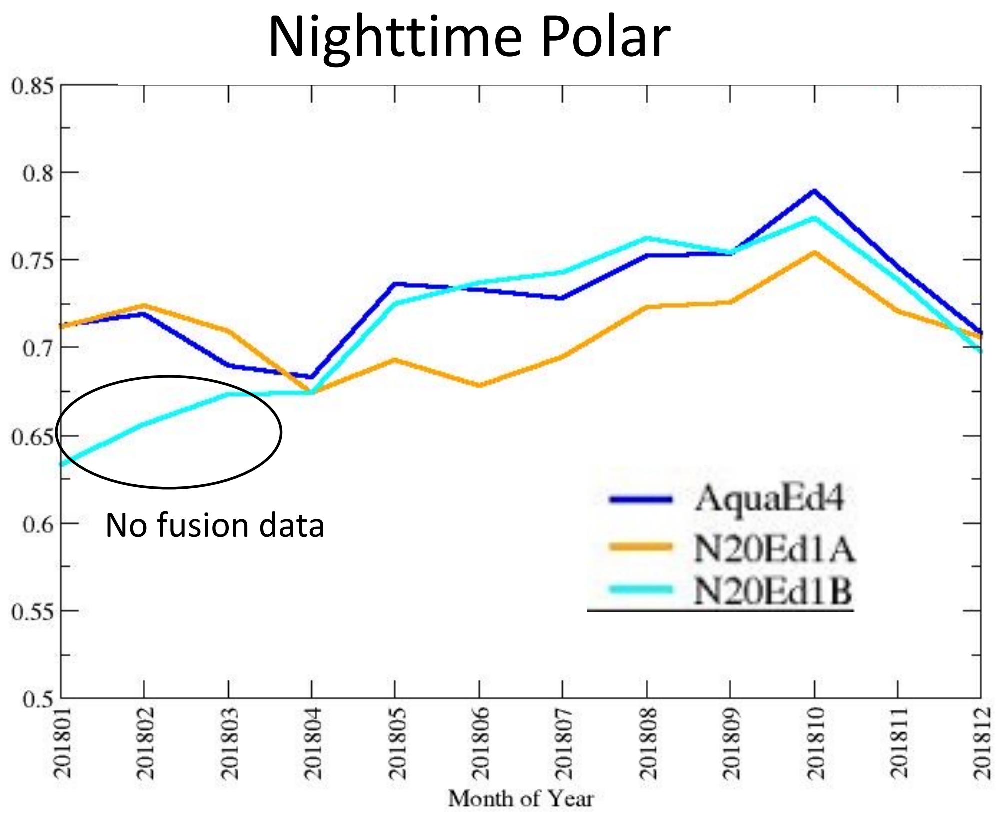
Clouds Processing Status (MODIS & VIIRS)

CERES-MODIS Edition 4 (*CDR)	*Aqua: Jul 2002 – July 2021 (~19 y)* *Terra: Feb 2000 – July 2021 (~21.5 y)*	• ***Uses frozen Ed4 cloud codes delivered in 2013*** • ***MODIS Collection 5 radiances thru Feb 2016,*** • ***MODIS Collection 6.1 March 2016 – present and scaled to C5 for consistency over entire record*** • ***Terra-MODIS normalized to Aqua-MODIS (Sun-Mack, et al. 2018)***
CERES-VIIRS Edition 1A	*SNPP: Jan 2012 – July 2021 (~9.5 y)* *NOAA-20: Jan 2018 – July 2021 (~3.5 y)*	• ***Uses VIIRS Ed1A cloud code*** • ***SNPP uses forward processing calibrations (C1 radiances), not scaled to MODIS; has discontinuity ~2016 due to a calibration update by SIPS*** • ***N20 uses C2 radiances and scaled to MODIS C5***
CERES-VIIRS Edition 2A	*SNPP: Jan 2012 – Sept 2016 (~4.5 y)*	• ***Uses VIIRS Ed1A cloud code*** • ***Uses C2 radiances and scaled to MODIS C5***
CERES-VIIRS Edition 1B (*CDR)	*NOAA-20: Jan 2018 – Dec 2018 (~1 y)* *May 2020 – Aug 2020 (~3 m)* **- Being reprocessed**	• ***Uses new version of VIIRS cloud code (temporary continuity version until Ed5 is released)*** • ***Fills Aqua-MODIS gap in Aug 2020***

Cloud Fraction Comparison

2018 Monthly Mean Timeseries





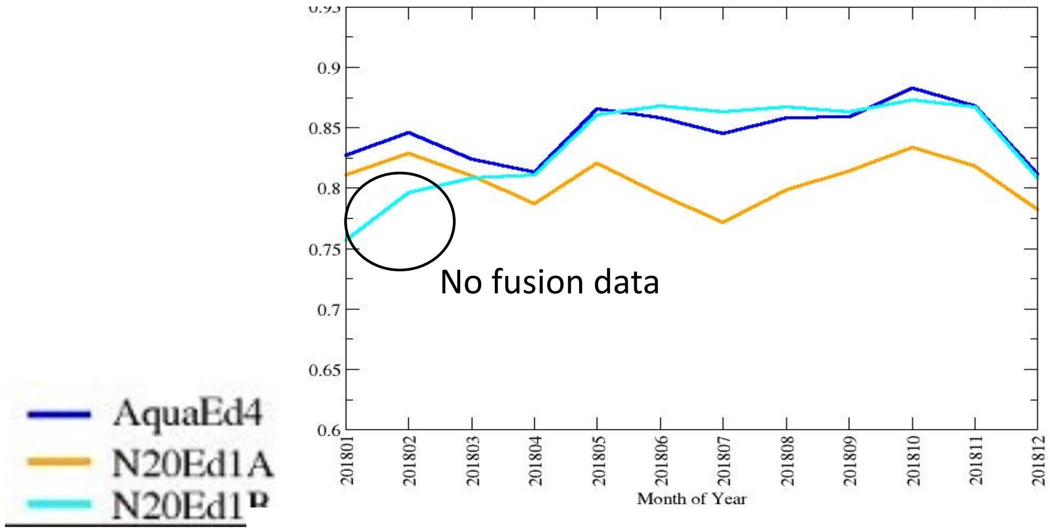
- All versions agree well overall
- Ed1B in slightly better agreement with MODIS
- Satellites track each other better in daytime

- Ed1B polar cloud fraction increased ~5%
- In better agreement with MODIS Ed4
- Poor Ed1B agreement when no fusion data

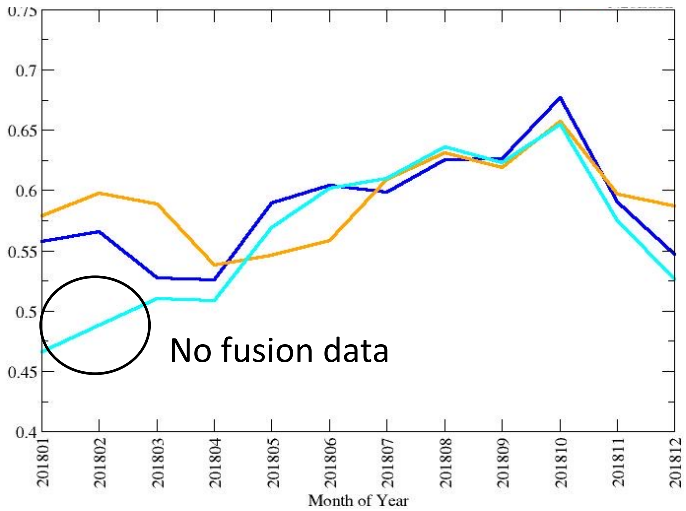
Nighttime Cloud Fraction Comparison

2018 Monthly Mean Timeseries

Nighttime Polar Ocean

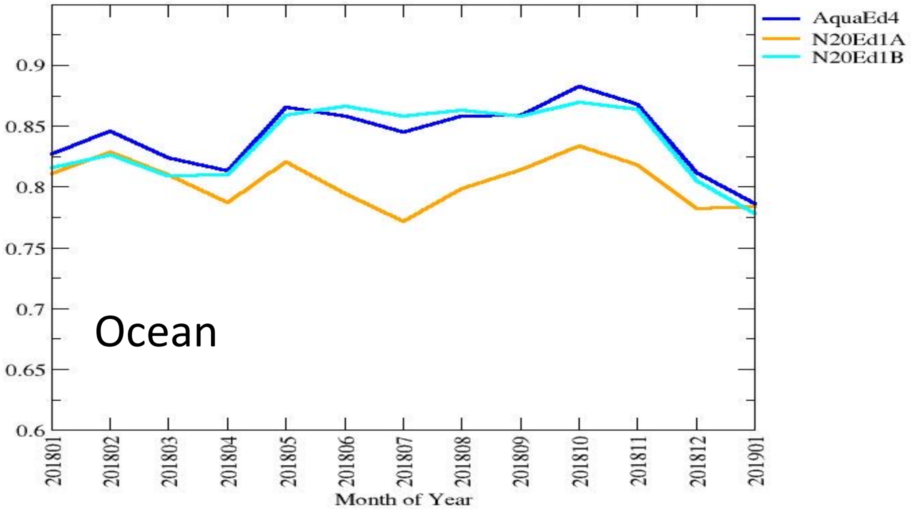


Nighttime Polar Land

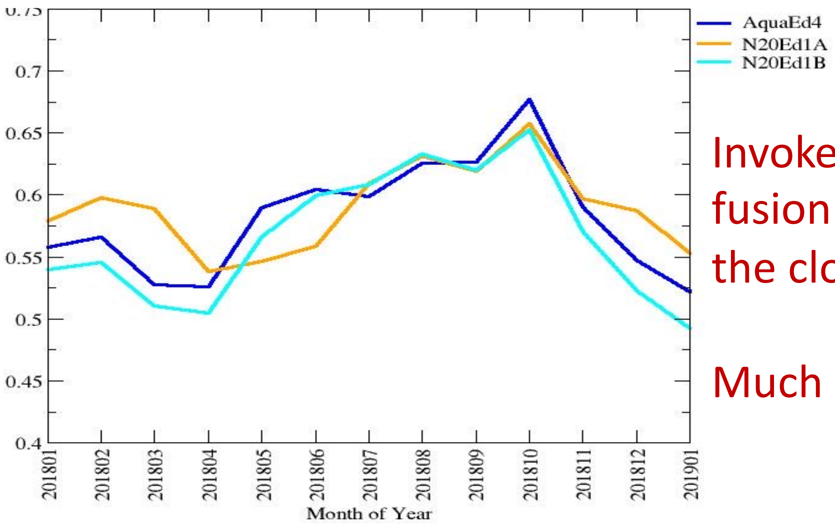


Last meeting: Ed1b polar night cloud problem early in record (no fusion data)

Nighttime Polar Ocean



Nighttime Polar Land



Invoked and tuned a ‘no fusion data’ branch in the cloud mask

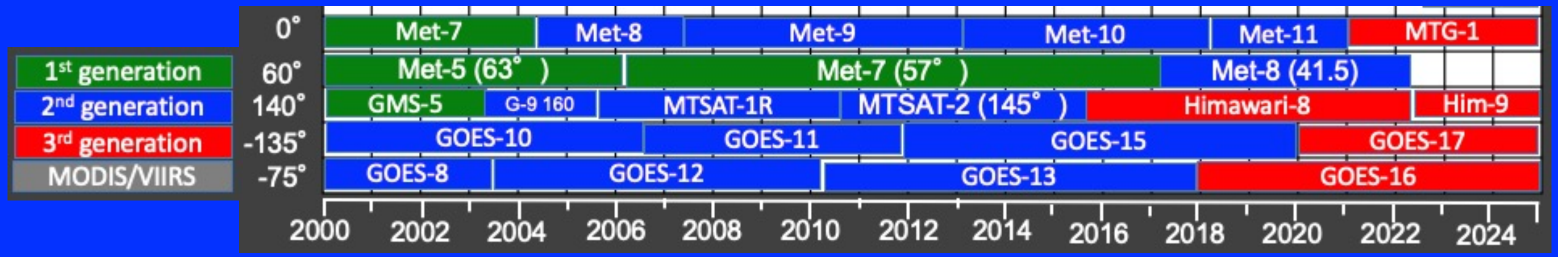
Much better agreement

CERES GEO CLOUDS UPDATE

- An update to EBAF is necessary (Loeb/Kato 2:20 pm today)
  1) **One reason: to account for artifacts and discontinuities in GEO cloud retrievals, which impact EBAF surface fluxes.**
- EBAF-Surface fluxes will be processed with MODIS/VIIRS imager cloud retrievals (no GEO).
- After EBAF reprocessing is complete, SYN1deg will also be reprocessed for the entire record and this will include GEO data.
  1) Cloud team has identified some parts of the GEO record that can be reprocessed relatively quickly with modest algorithm updates to reduce some of the discontinuities.
  2) These can be employed in the intermediate version SYN1deg if completed by next spring
  3) Development of a more comprehensive GEO processing strategy for Ed5 continues

Ed4 GEO Record

21 different GEO satellites processed thru March 2021



1st generation satellite

Satellite	Channels (µm)
MET-5	0.6, 11
MET-7	0.6, 11
GMS-5	0.6, 11

3rd generation satellite

Satellite	Available Channels (µm)
GOES-16	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
GOES-17	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
HIMAWARI-8	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3

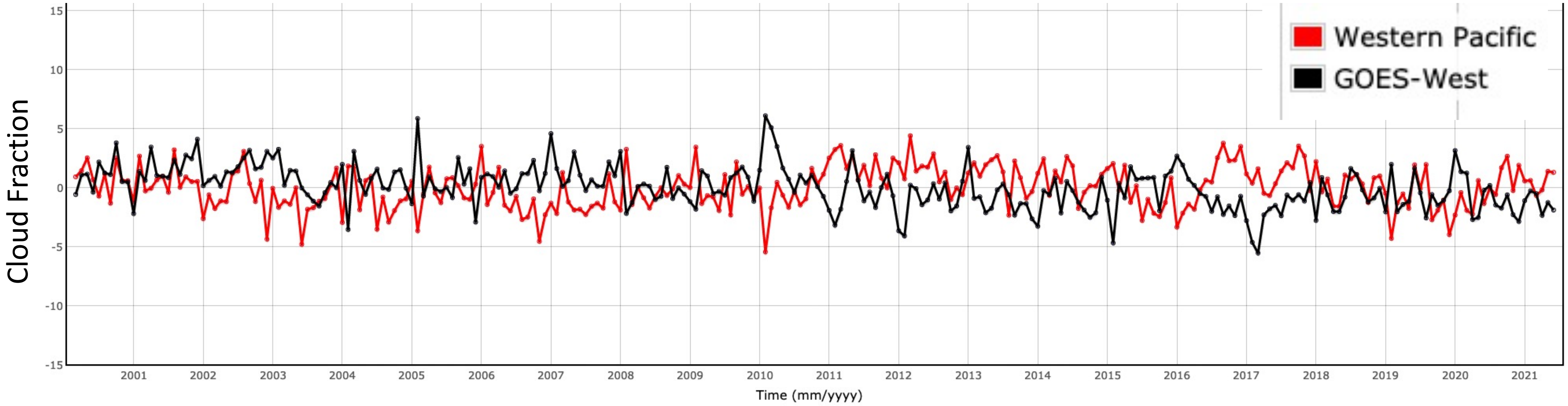
2nd generation satellite

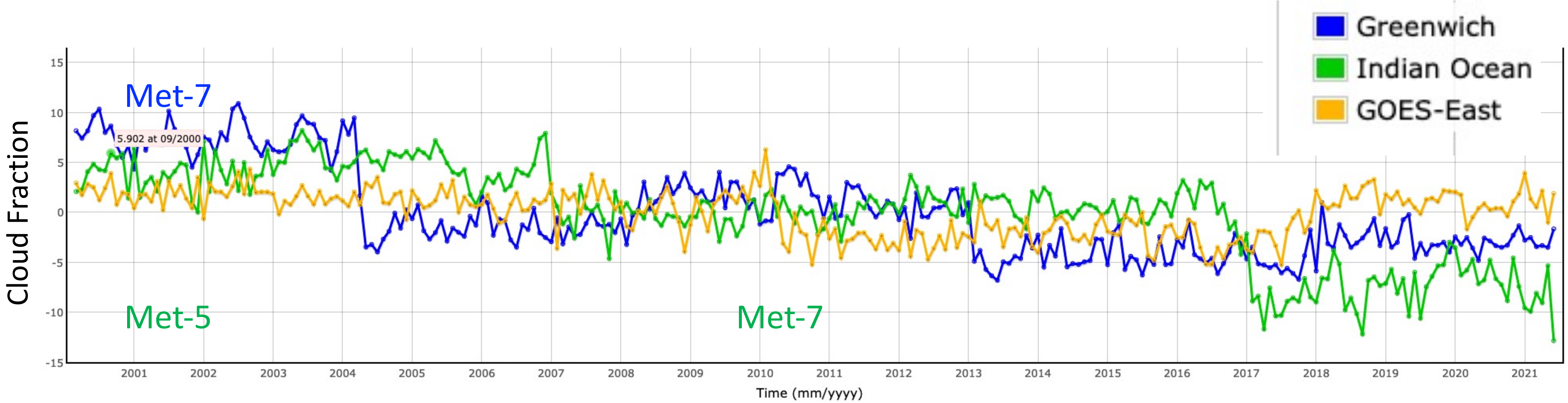
Satellite	Available Channels (µm)
GOES-8	0.6, 3.9, 6.7, 11, 12
GOES-9	0.6, 3.9, 6.7, 11, 12
GOES-10	0.6, 3.9, 6.7, 11, 12
GOES-11	0.6, 3.9, 6.7, 11, 12
MTSAT-1R	0.6, 3.7, 6.7, 11, 12
MTSAT-2R	0.6, 3.7, 6.7, 11, 12
GOES-12	0.6, 3.7, 6.7, 11, 13.3
GOES-13	0.6, 3.7, 6.7, 11, 13.3
GOES-14	0.6, 3.7, 6.7, 11, 13.3
GOES-15	0.6, 3.7, 6.7, 11, 13.3
MET-8	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
MET-9	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
MET-10	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
MET-11	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3

- CERES GEO approach in Ed4 utilizes as much available spectral information as possible to help improve accuracy and consistency with MODIS
- Results in some inconsistencies across GEO platforms (due to different algo's)
- Have been mitigated to some degree in CERES ERB data products but becoming more difficult
- Goal for Ed5 is to improve consistency across all GEO's

Ed4 GEO Timeseries

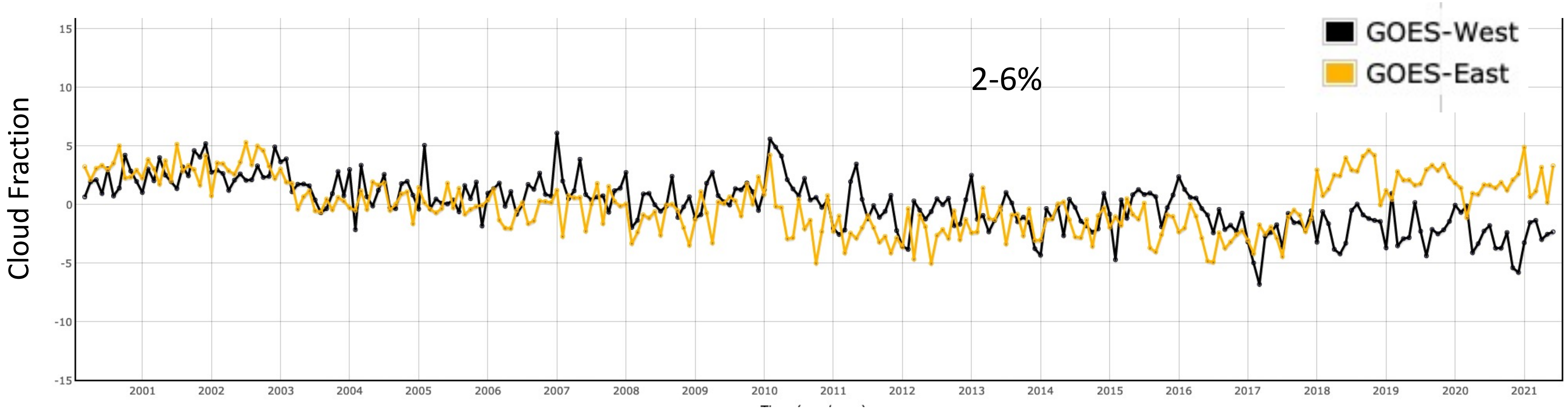
Daytime Cloud Fraction Anomalies

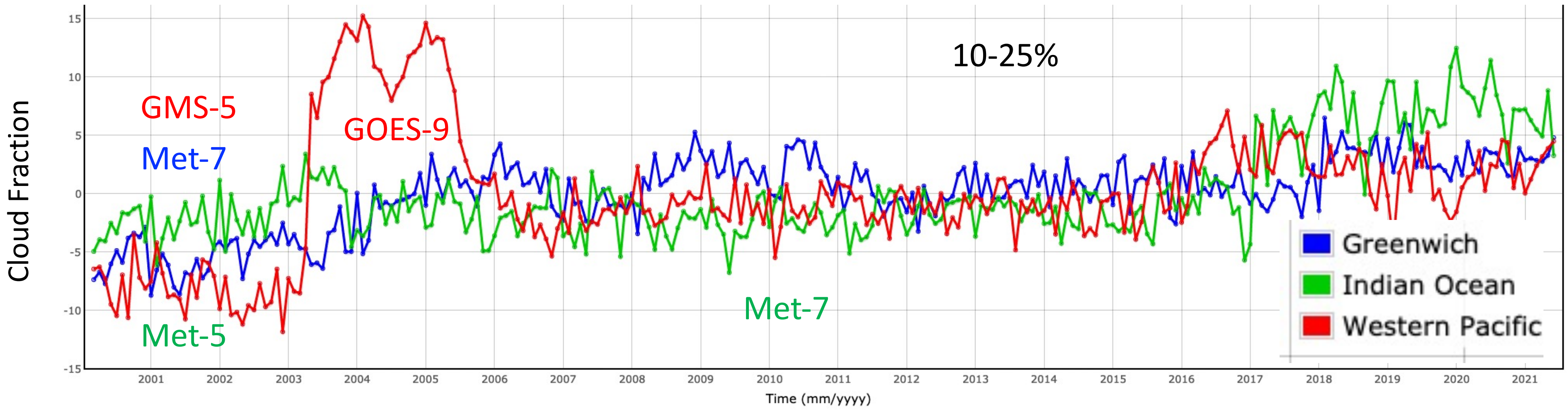




Ed4 GEO Timeseries

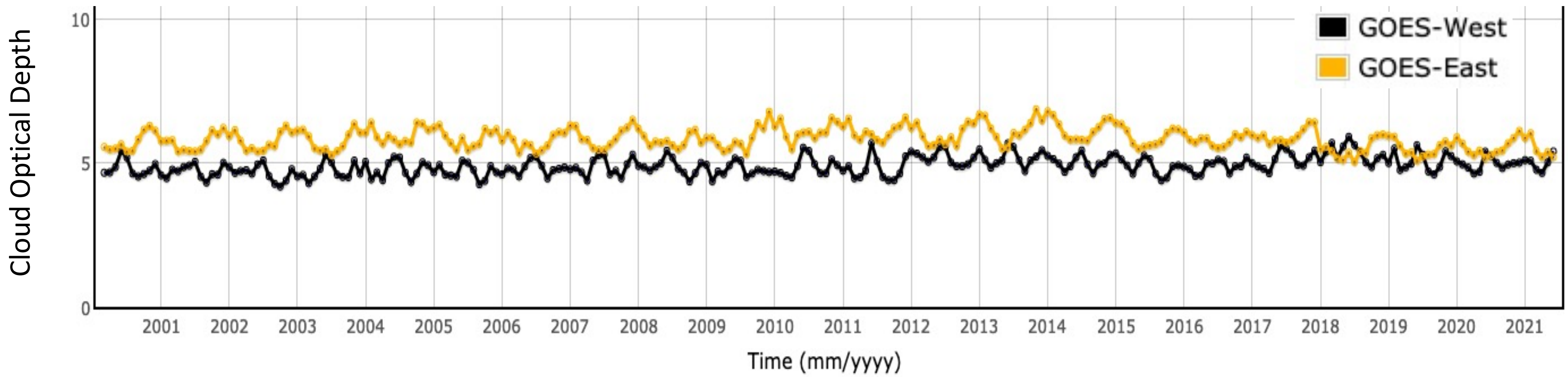
Nighttime Cloud Fraction Anomalies

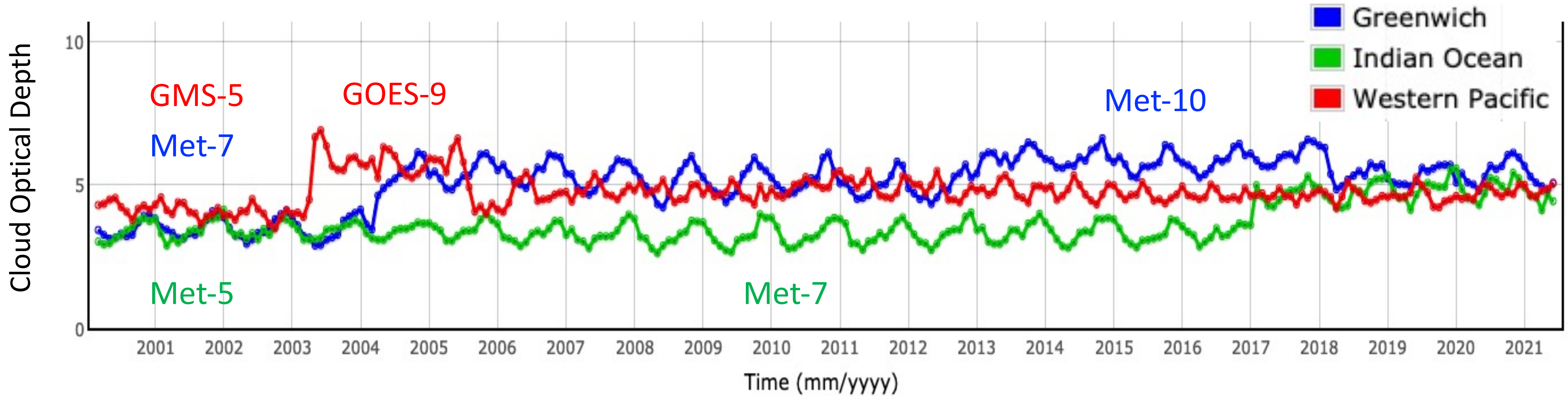




Ed4 GEO Timeseries

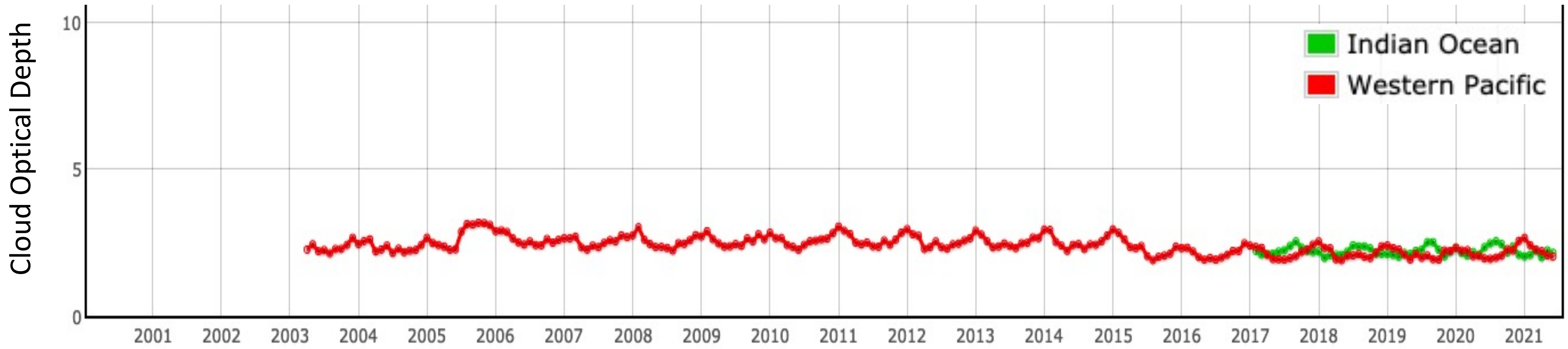
Daytime Cloud Optical Depth

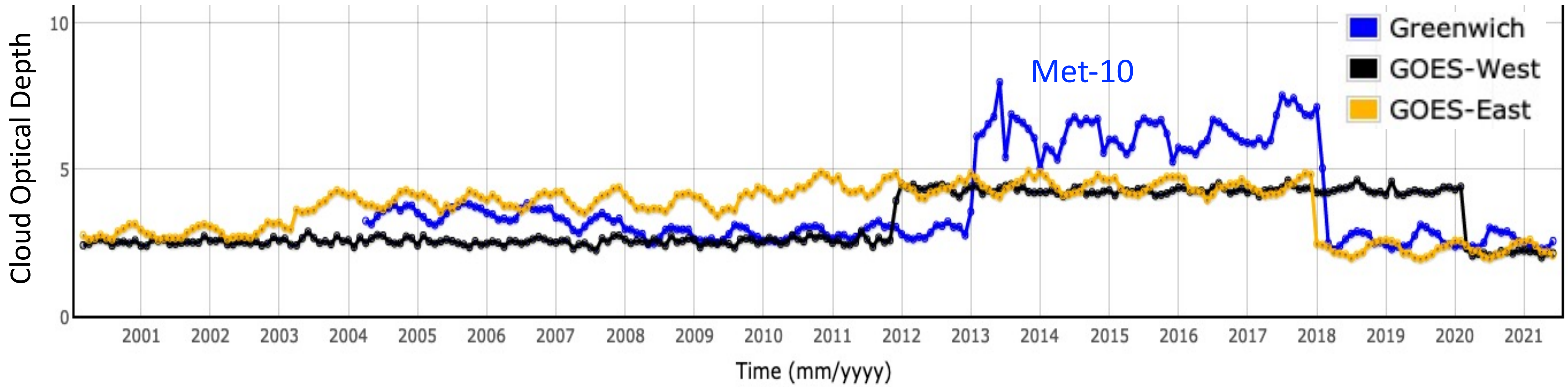




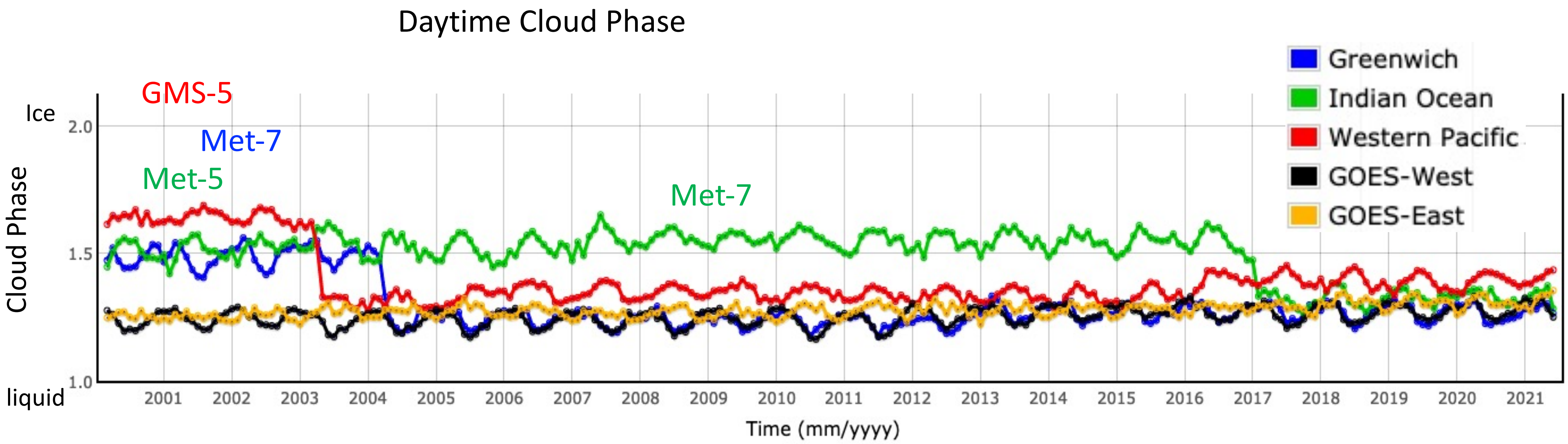
Ed4 GEO Timeseries

Nighttime Cloud Optical Depth





Ed4 GEO Timeseries



Ed4 GEO Timeseries

Main conclusion from time series

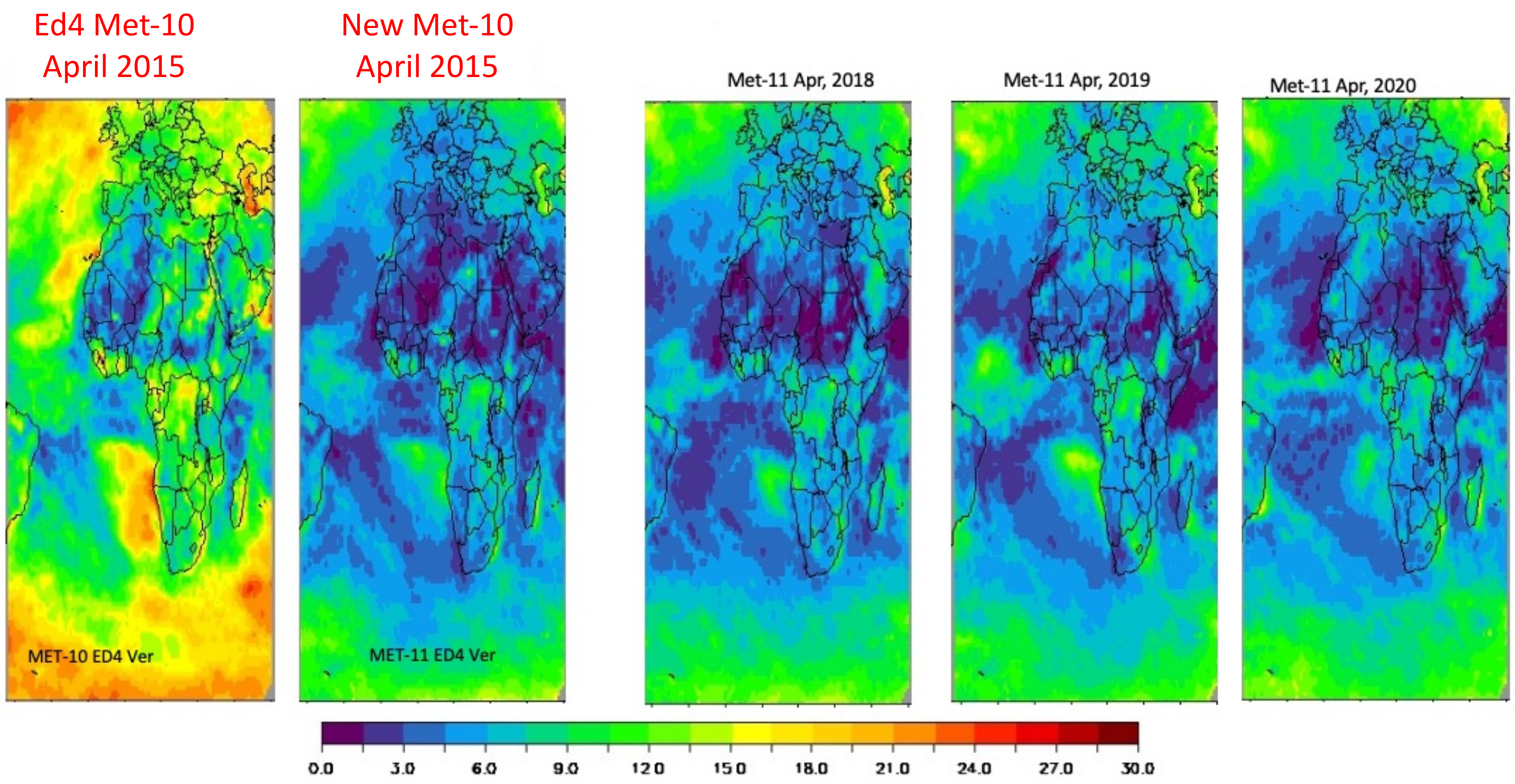
- The 2-channel satellites (GMS-4, Met-5 & Met-7) and Met-10 are most problematic

Possible solutions that can be addressed within ~ 6-months

- Re-run Met-10 record with Met-11 code (SEVIRI imager on both satellites) Completed!
    - *Met-10 code had lots of bugs that were fixed for Met-11*
- Tune the algorithms for the 2-channel satellites to produce cloud properties more consistent with the modern satellites (to the extent possible) Just Started
- Deliver these new versions for Syn1deg processing Next spring

Reprocessed MET-10 Evaluation
(uses Met-11 code)

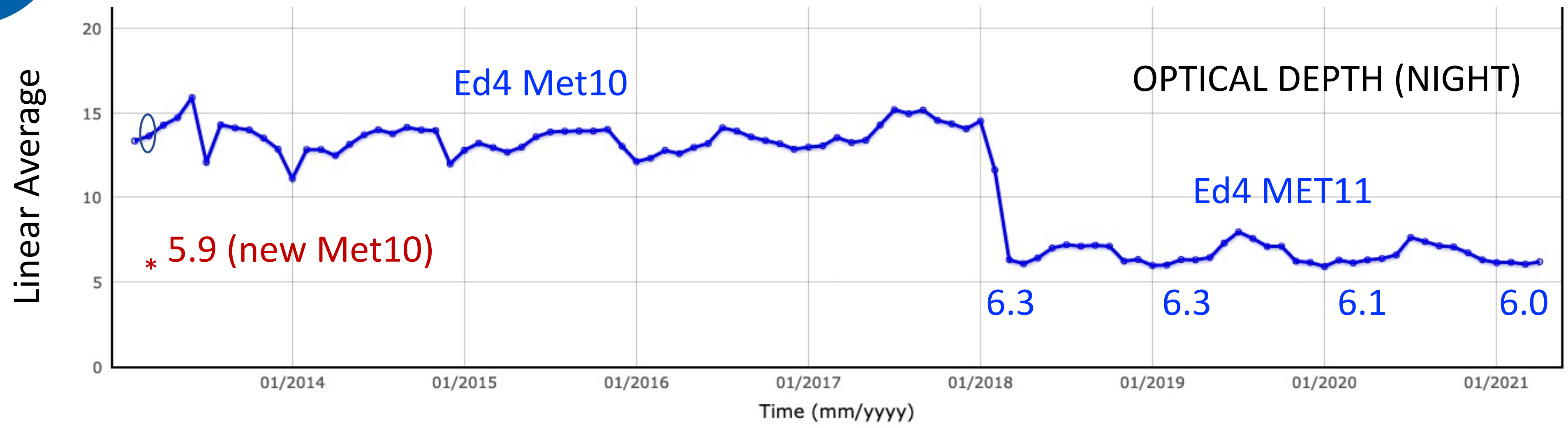
TOTAL OPTICAL DEPTH (NIGHT)

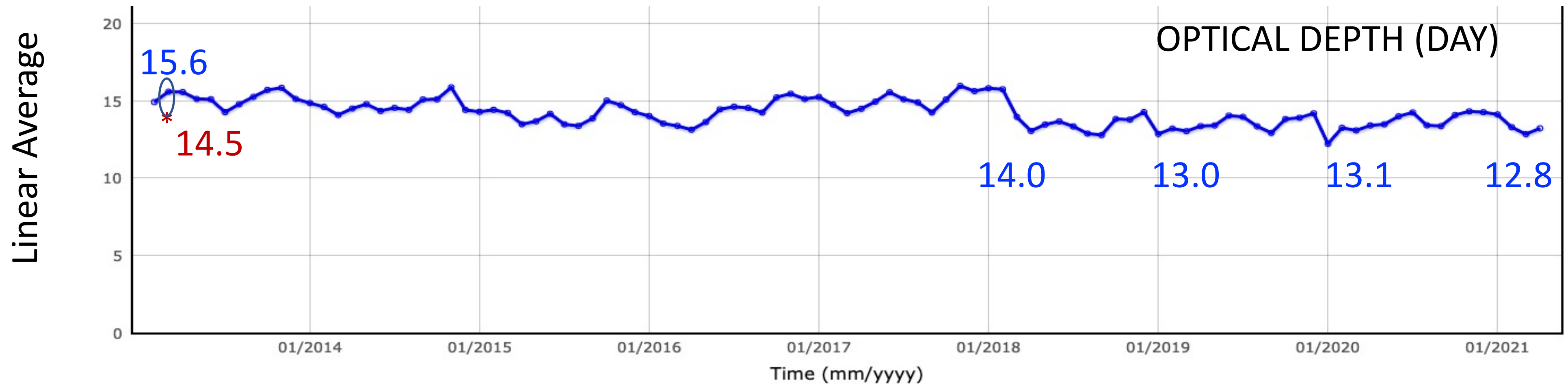


Nighttime cloud optical depth markedly more consistent

New Met-10 (March 2013)

Optical Depth Consistency Check in Timeseries

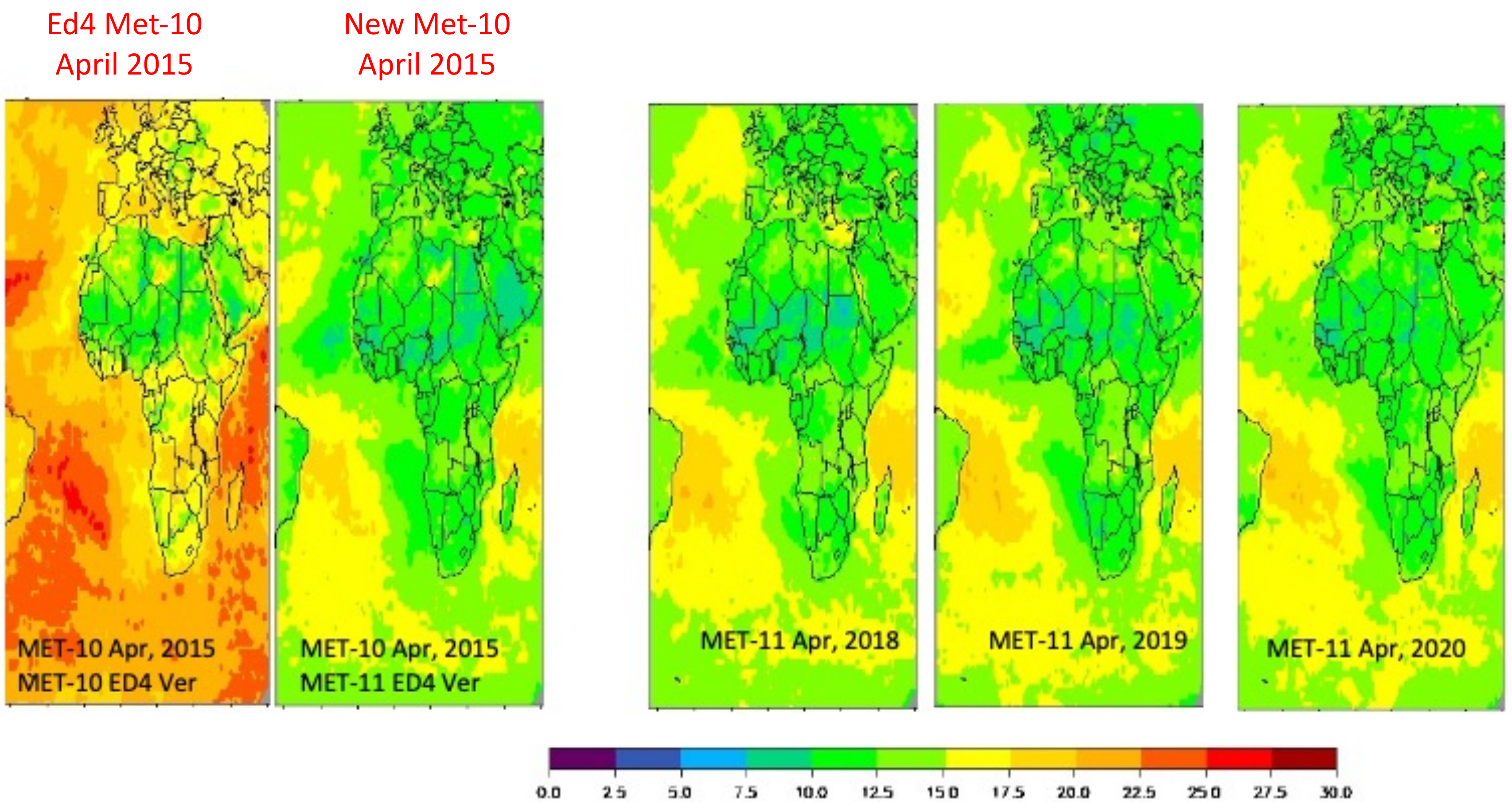




Reprocessed MET-10 Evaluation

(uses Met-11 code)

WATER CLOUD EFFECTIVE RADIUS (DAY)

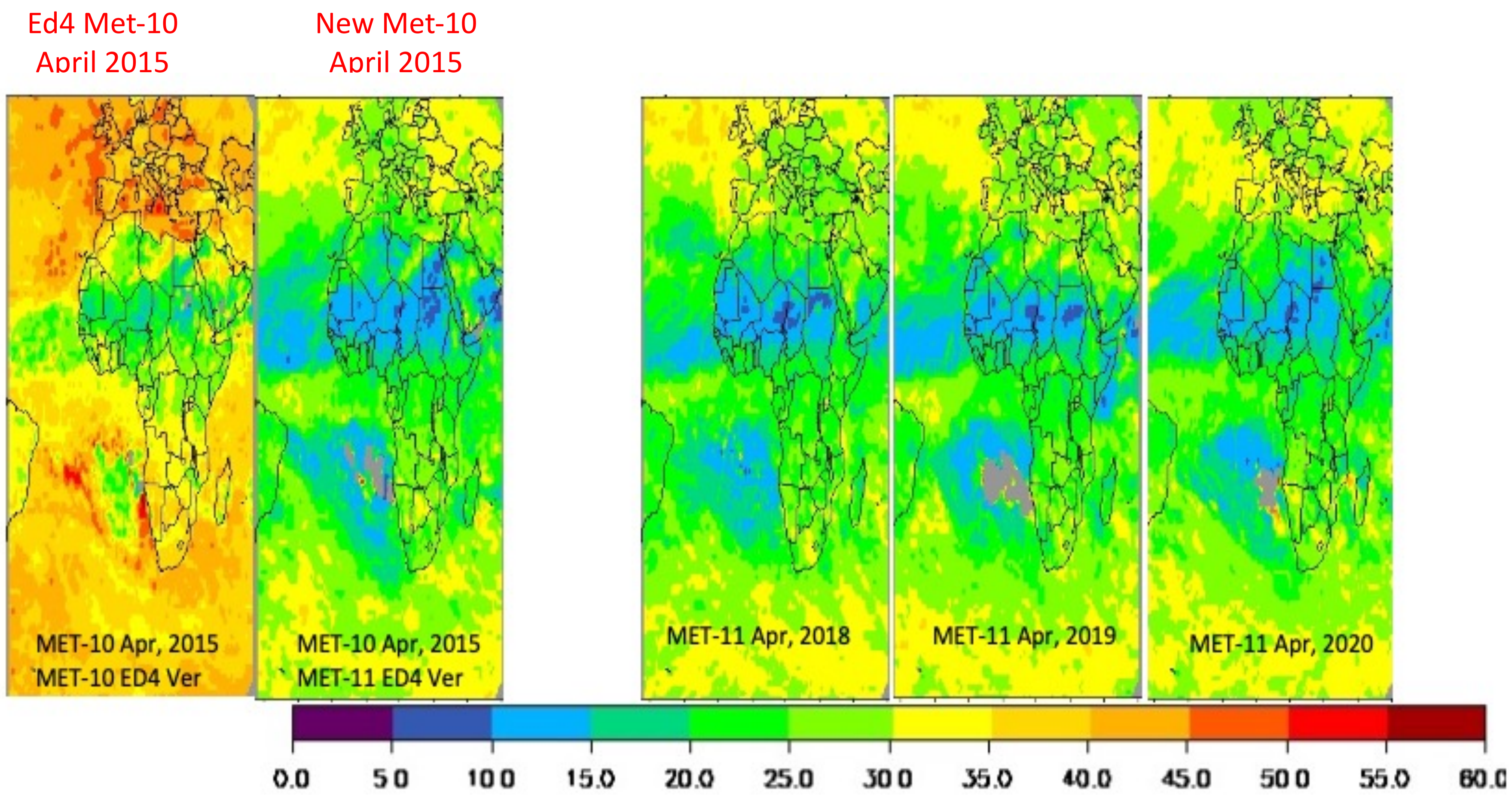


DAYTIME R_e markedly more consistent

Reprocessed MET-10 Evaluation

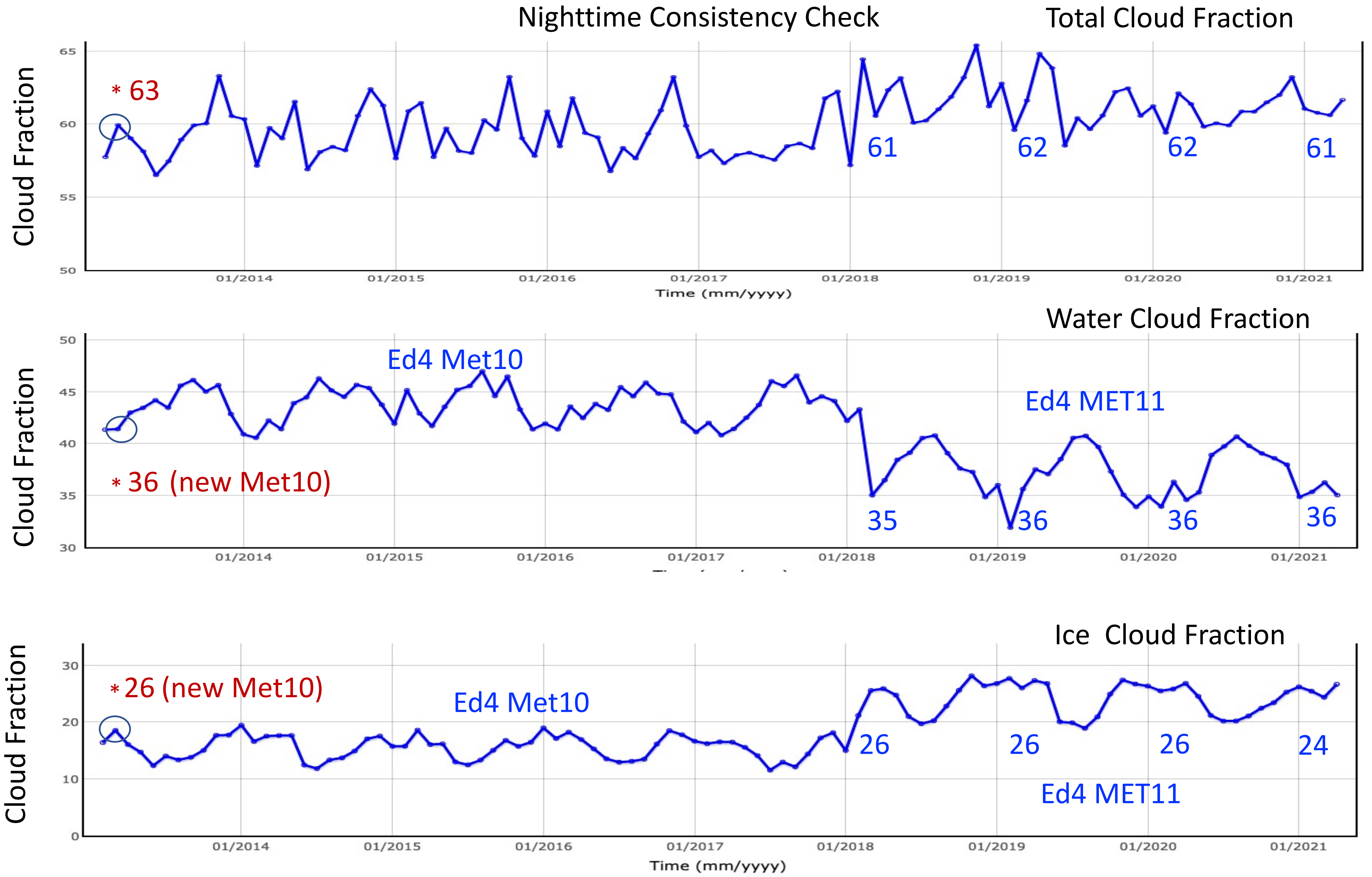
(uses Met-11 code)

ICE CLOUD EFFECTIVE RADIUS (DAY)



DAYTIME R_e markedly more consistent

New Met-10 (March 2013)



Updating Cloud Properties For GEOs With Two Channels

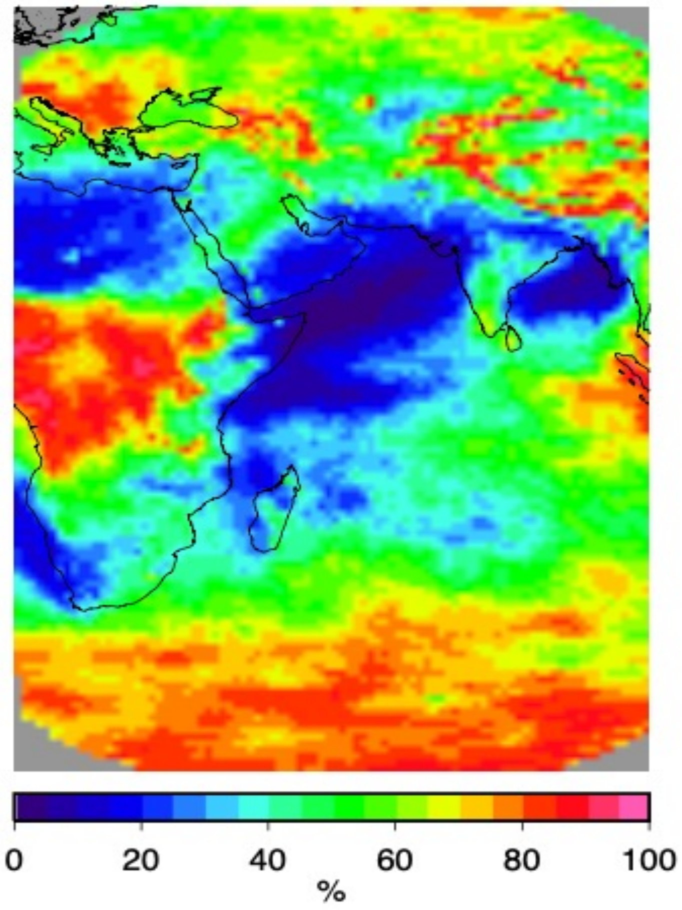
- Goal: Get closer to Multi-Channel Results (see time series)
    - Adjust 2-channel code for 2-channel instruments (ongoing)
        - Qualitative comparisons to multi-chan results since comparing different years
    - Apply 2-channel code to multi-channel instruments (coming soon)
        - Quantitative comparisons for same month/year/satellite
- Started with Nighttime IR-Only Cloud Algorithm, Met-7 → Met-8
    - Algorithm changes are simpler and easy to evaluate, start with cloud %
    - Fewer derived properties so fewer unintended consequences
- Just starting Daytime 2-Channel Cloud Algorithm , Met-7 → Met-8
    - Apply night changes first, then the more complex algorithm & more properties
- Complete Met-7 updates, apply to Met-5 & GMS-5, tune if necessary

MET-7 TEST (NIGHT)
Total Cloud Fraction

Revision 1
Clear/Cloud Threshold Adjustments

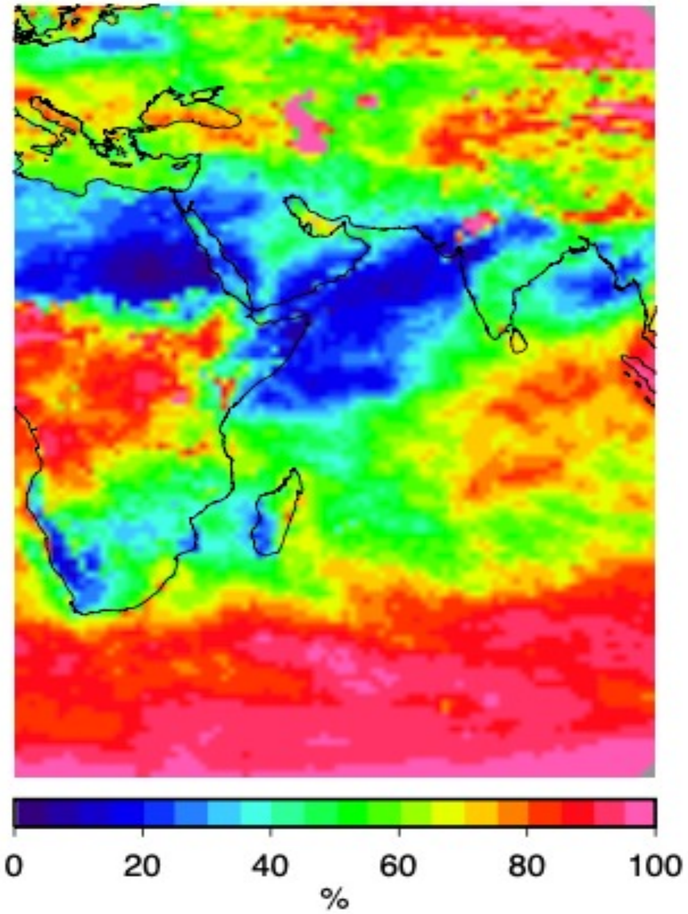
Land: 6K changed to 5K
Ocean: 3K changed to 1K

Ed4 (IR Only)
Met-7 (April 2014)



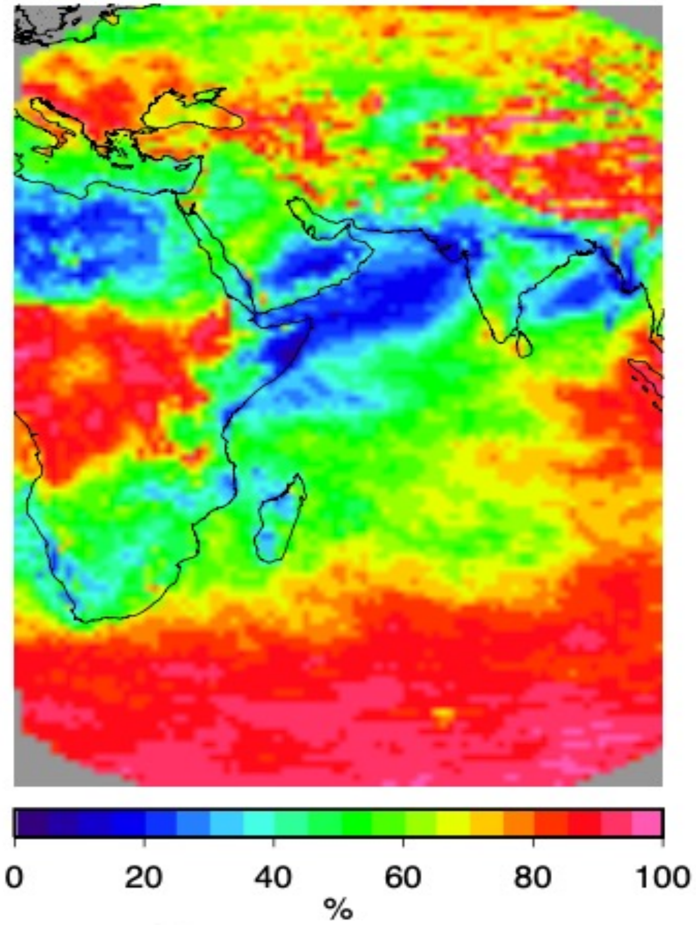
Ocean 53.57
Land 50.67

Ed4 Baseline (Multi-Channel)
Met-8 (April 2019)



Ocean 70.34
Land 55.86

Revision 1 (IR Only)
Met-7 (April 2014)



Ocean 70.62
Land 59.76

MET-7 TEST (NIGHT)
Total Cloud Fraction

Revision 1
Clear/Cloud Threshold Adjustments

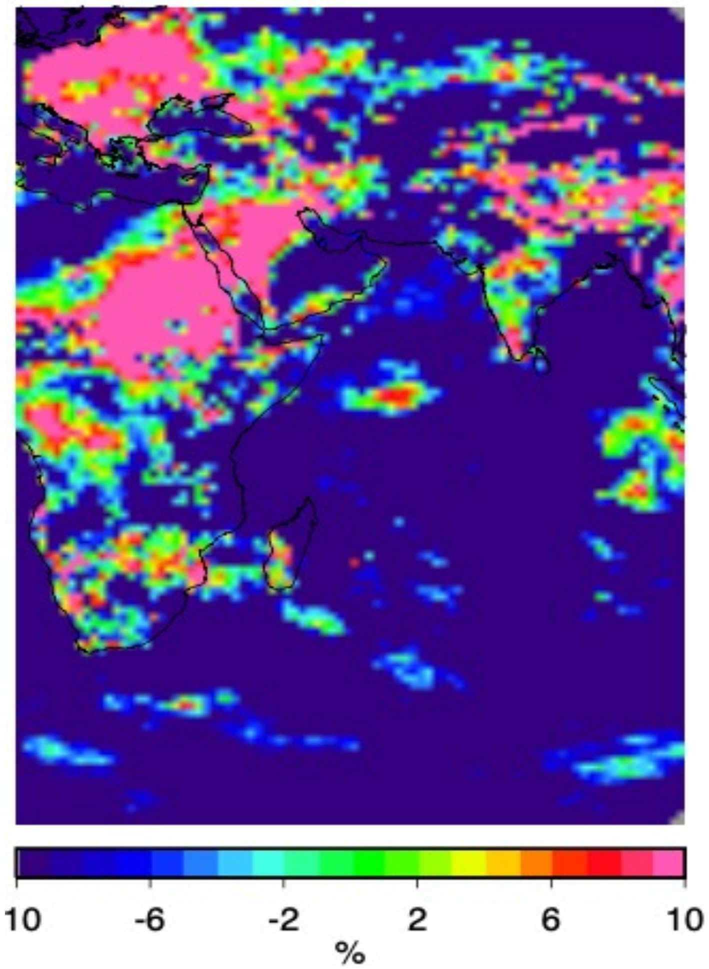
Land: 6K changed to 5K
Ocean: 3K changed to 1K

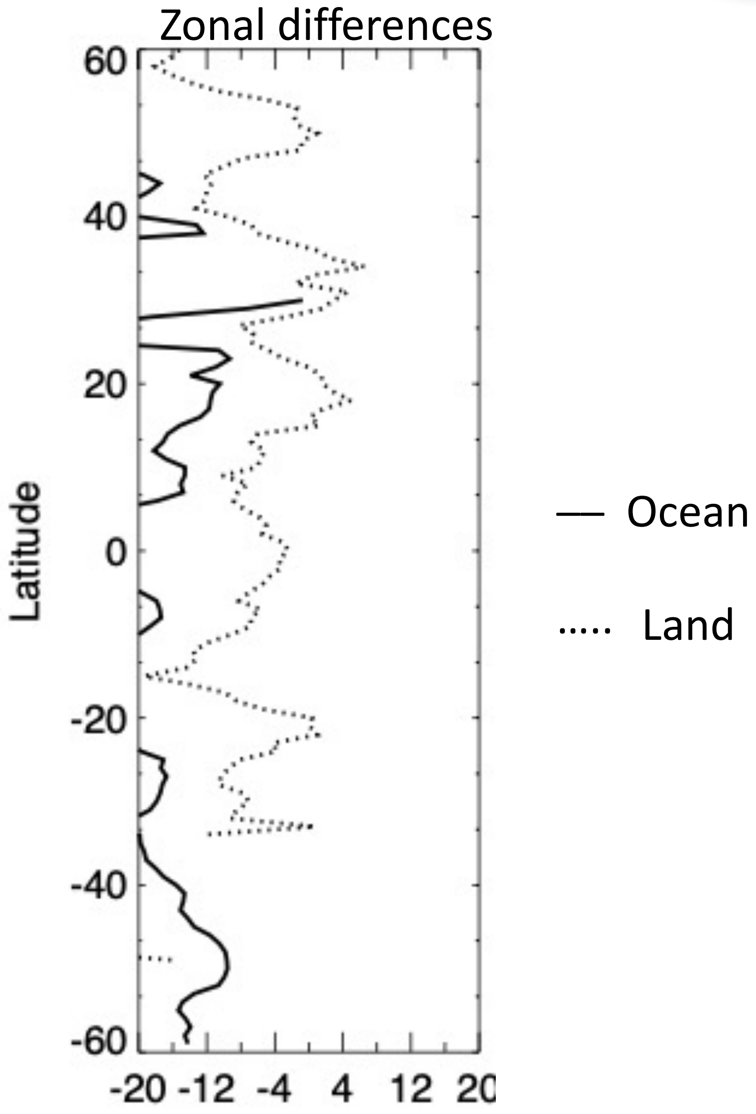
Ed4 Met-7 (IR Only) minus **Baseline Met-8** (Multi-Chan)
[April 2014 minus April 2019]

<u>Mean diff</u>

Ocean: - 16.8 %

Land: - 5.2 %





MET-7 TEST (NIGHT)
Total Cloud Fraction

Revision 1
Clear/Cloud Threshold Adjustments

Land: 6K changed to 5K
Ocean: 3K changed to 1K

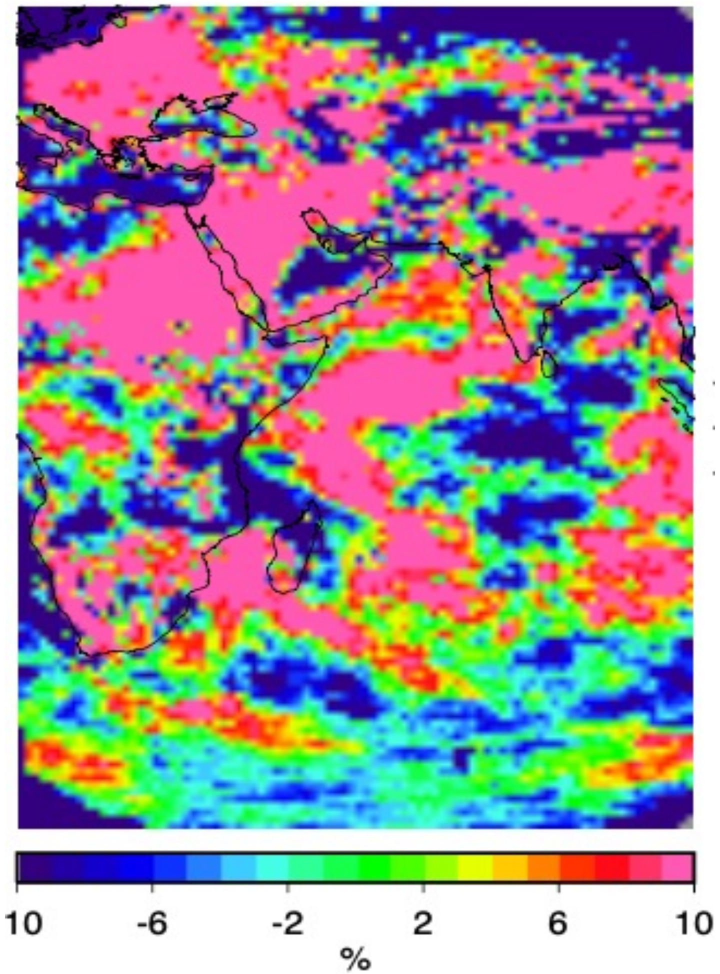
Revision 1 Met-7 (IR Only) minus **Baseline Met-8 (Multi-Chan)**

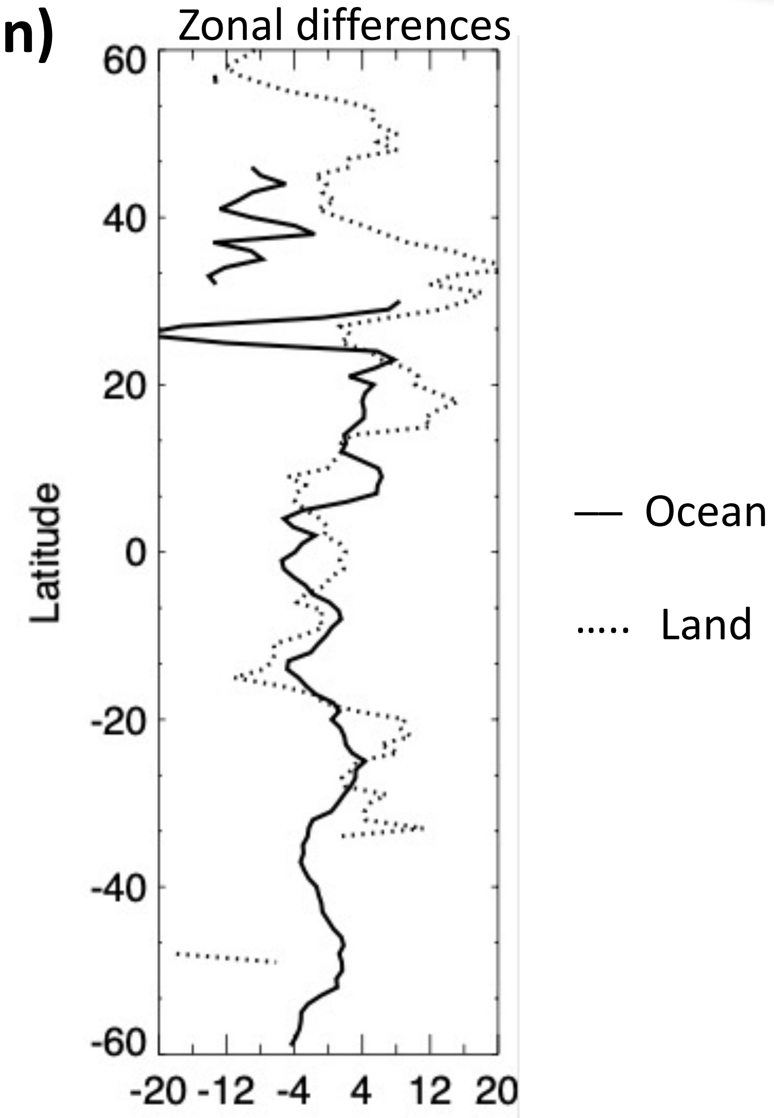
[April 2014 minus April 2019]

<u>Mean diff</u>

Ocean: + 0.3 %

Land: + 3.9 %





MET-7 TEST (NIGHT)
Cloud Fraction By Phase

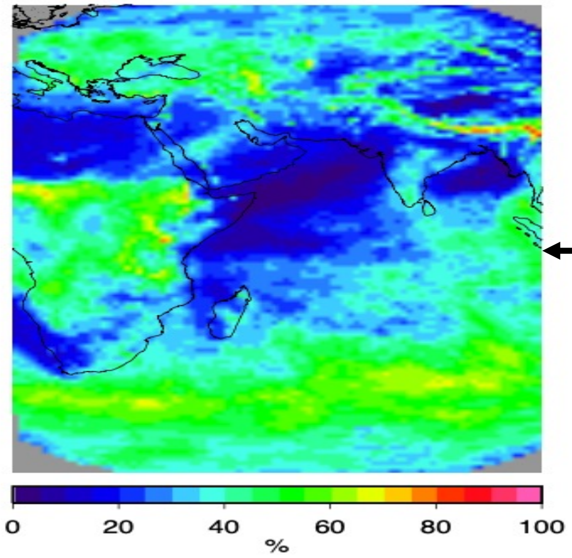
Revision 1
Clear/Cloud Threshold Adjustments

Land: 6K changed to 5K
Ocean: 3K changed to 1K

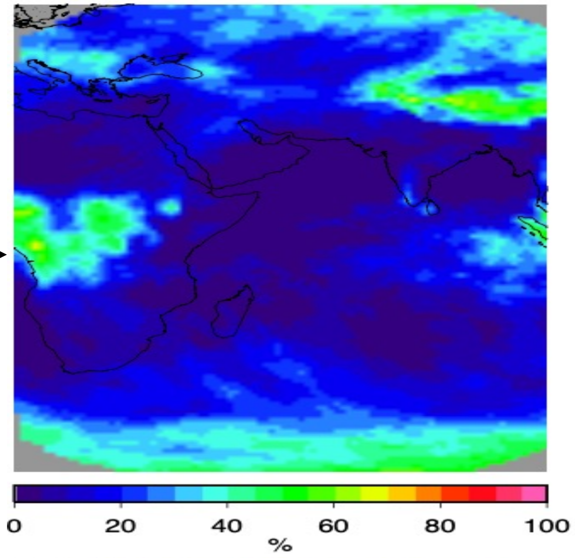
WATER CLOUDS

ICE CLOUDS

Ocean 37.81
Land 32.36



Ed4 Met-7
(IR Only)
April 2014

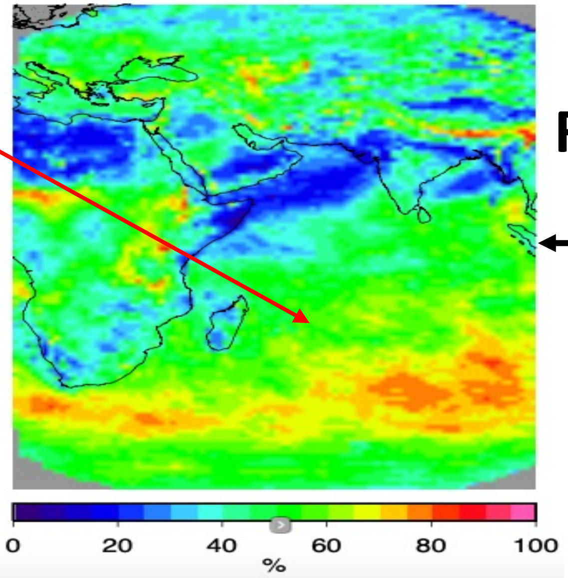


Ocean 15.75
Land 18.31

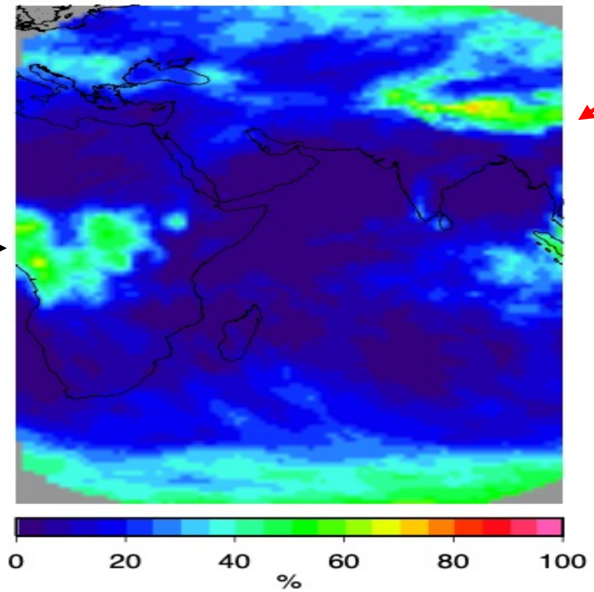
Clear/Cloud adjustments increase mostly water cloud amounts

Little change in ice cloud amounts

Ocean 54.86
Land 41.36



Revision 1 Met-7
(Multi-Chan)
April 2014



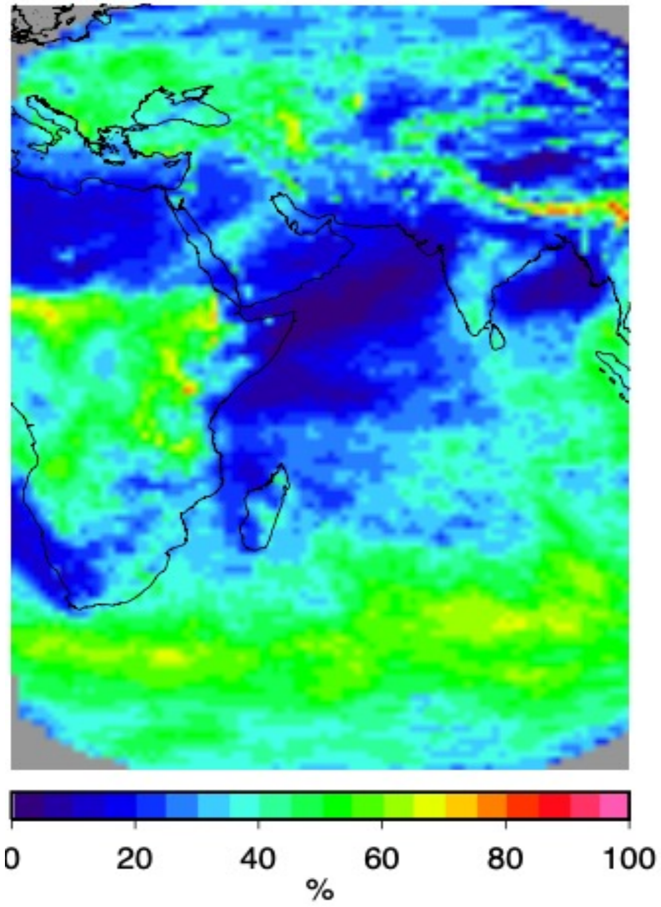
Ocean 15.76
Land 18.40

MET-7 TEST (NIGHT)
Water Cloud Fraction

Revision 1
Clear/Cloud Threshold Adjustments

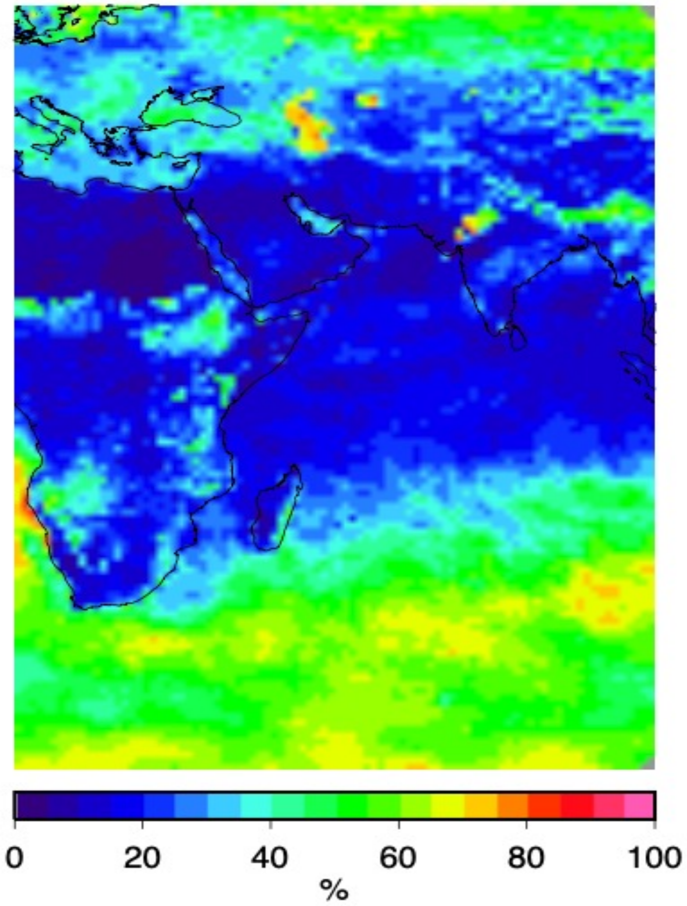
Land: 6K changed to 5K
Ocean: 3K changed to 1K

Ed4 (IR Only)
Met-7 [April 2014]



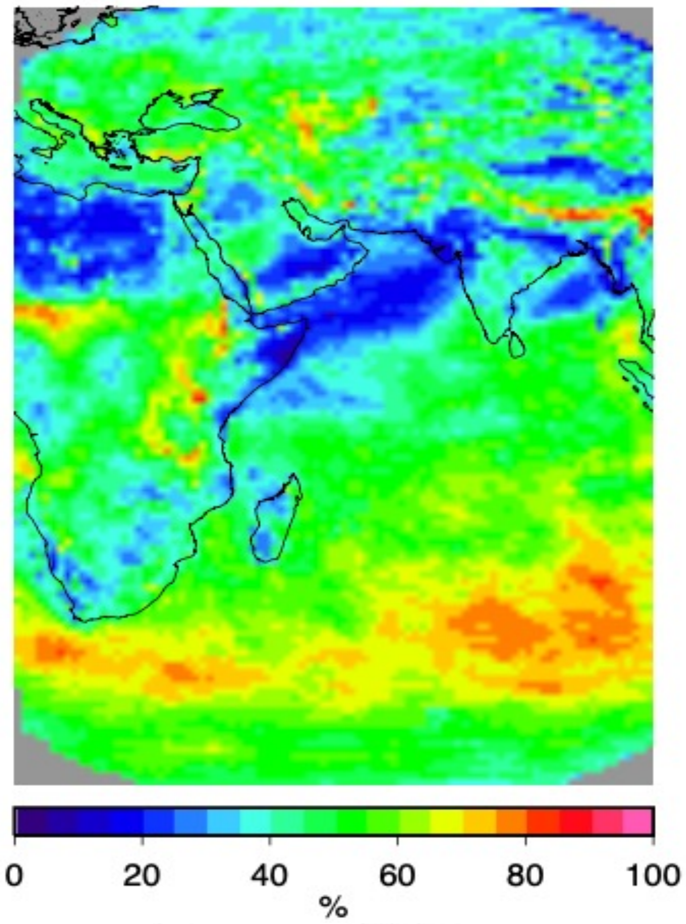
Ocean 37.81
Land 32.36

Ed4 Baseline (Multi-Chan)
Met-8 [April 2019]



Ocean 41.18
Land 25.30

Revision 1 (IR Only)
Met-7 [April 2014]



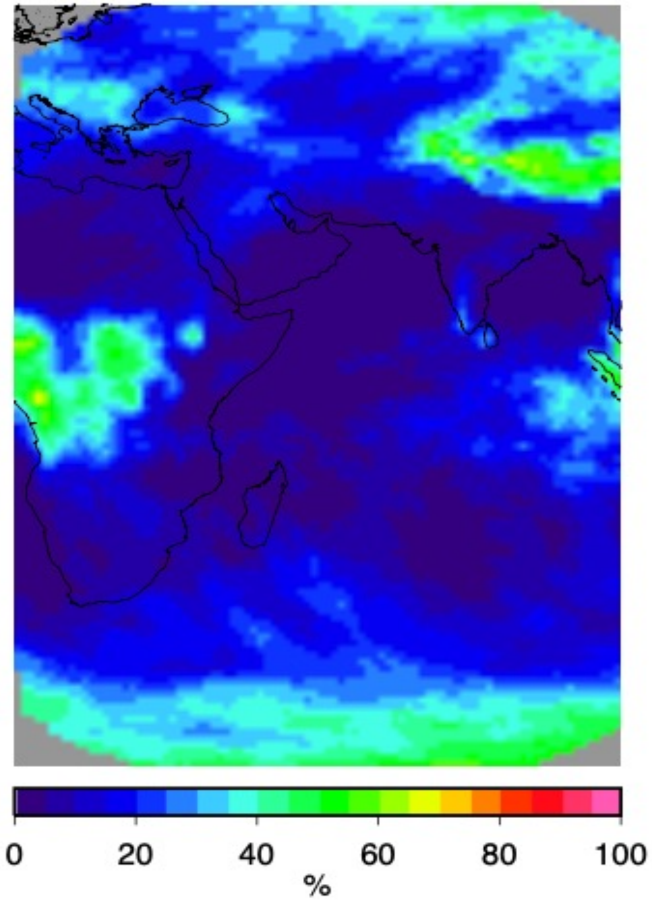
Ocean 54.86
Land 41.36

MET-7 TEST (NIGHT)
Ice Cloud Fraction

Revision 1
Clear/Cloud Threshold Adjustments

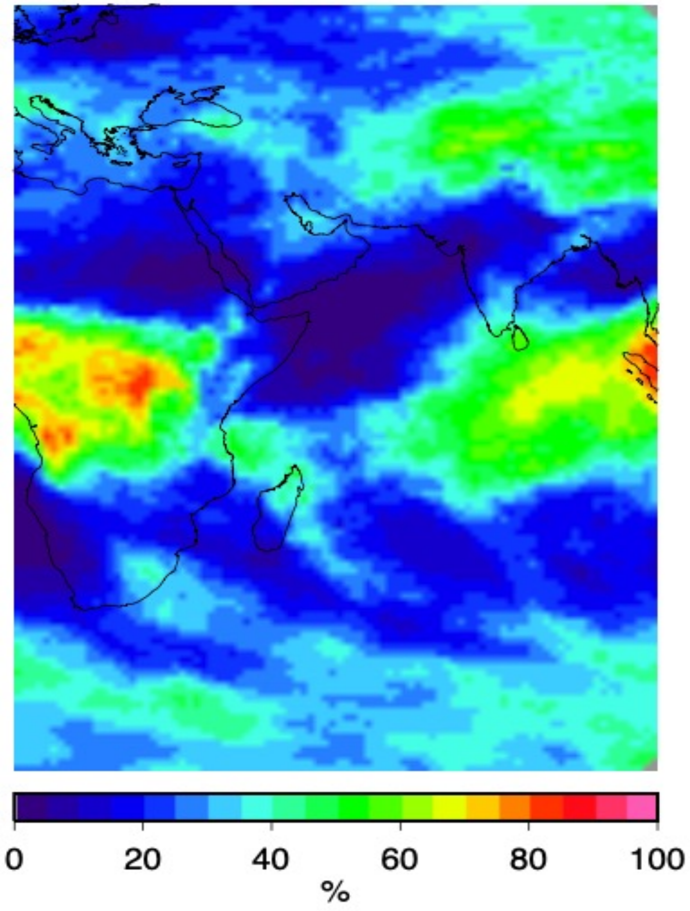
Land: 6K changed to 5K
Ocean: 3K changed to 1K

Ed4 (IR Only)
Met-7 [April 2014]



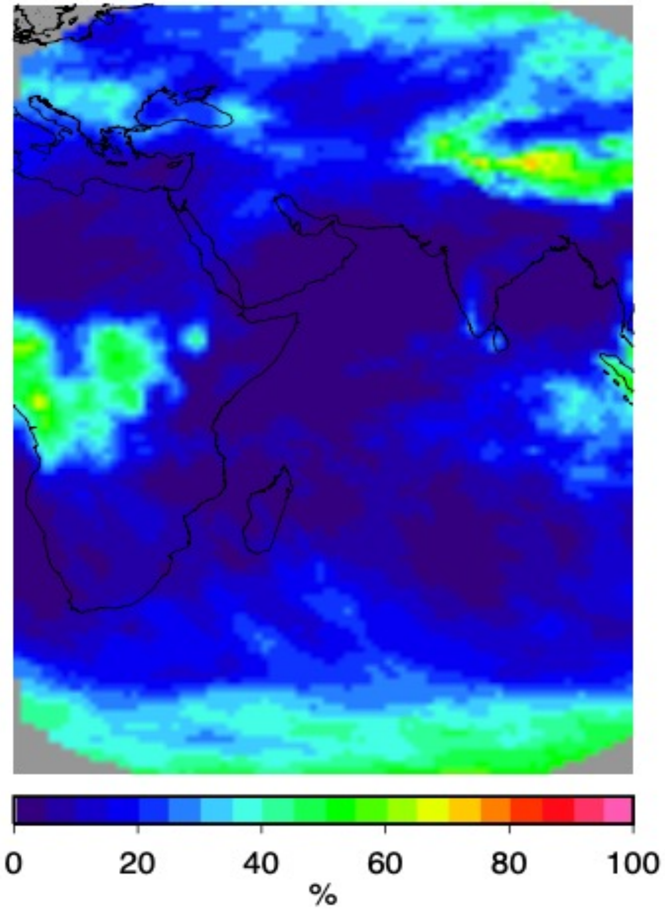
Ocean 15.75
Land 18.31

Ed4 Baseline (Multi-Chan)
Met-8 [April 2019]



Ocean 28.90
Land 29.99

Revision 1 (IR Only)
Met-7 [April 2014]



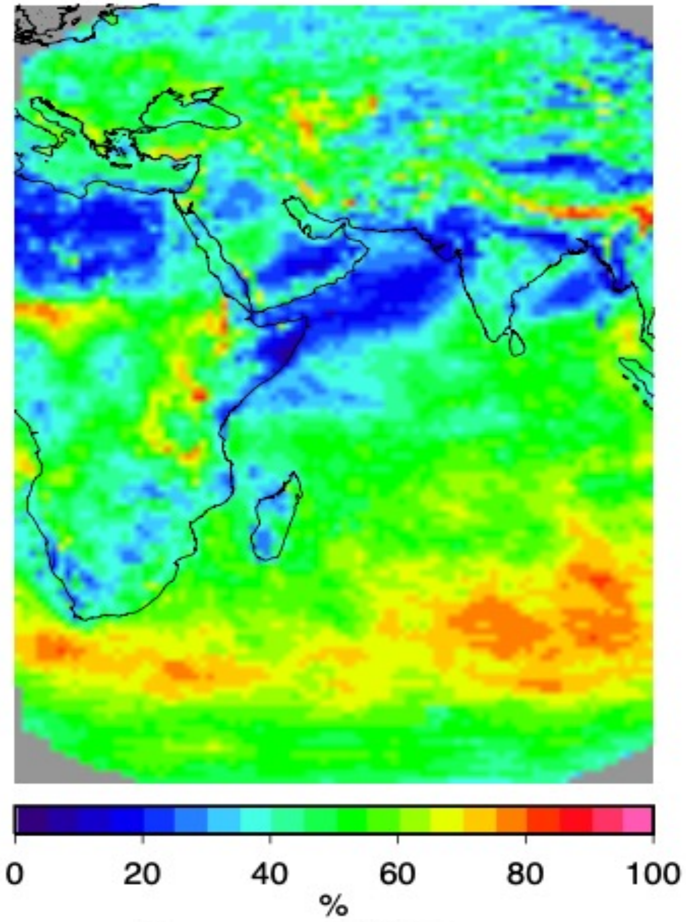
Ocean 15.76
Land 18.40

MET-7 TEST (NIGHT)
Water Cloud Fraction

Revision 2
Cloud Phase Threshold Adjustments

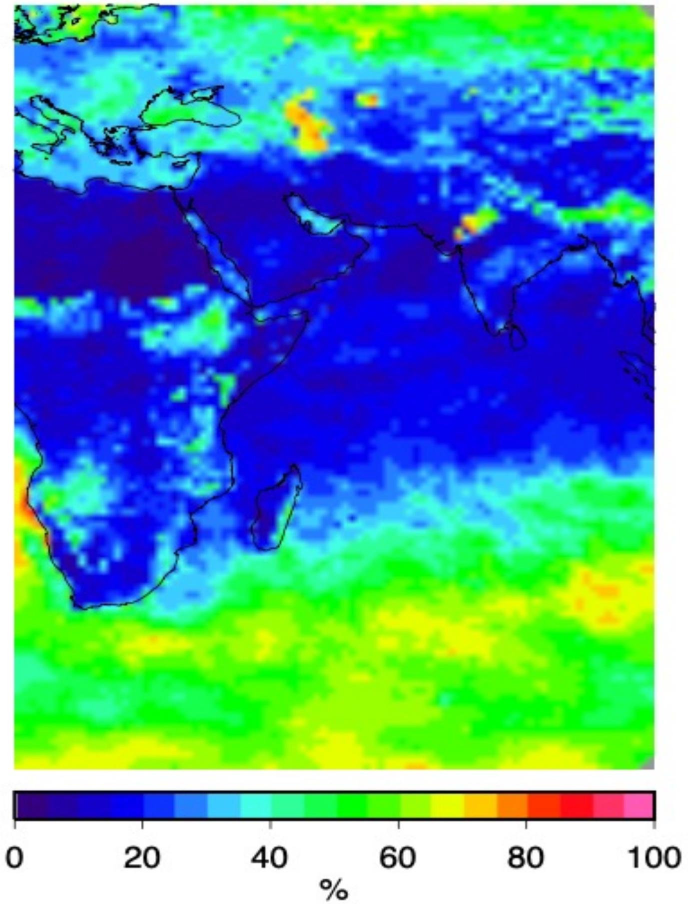
253K changed to 258K
(need less water cloud)

Revision 1 (IR Only)
Met-7 [April 2014]



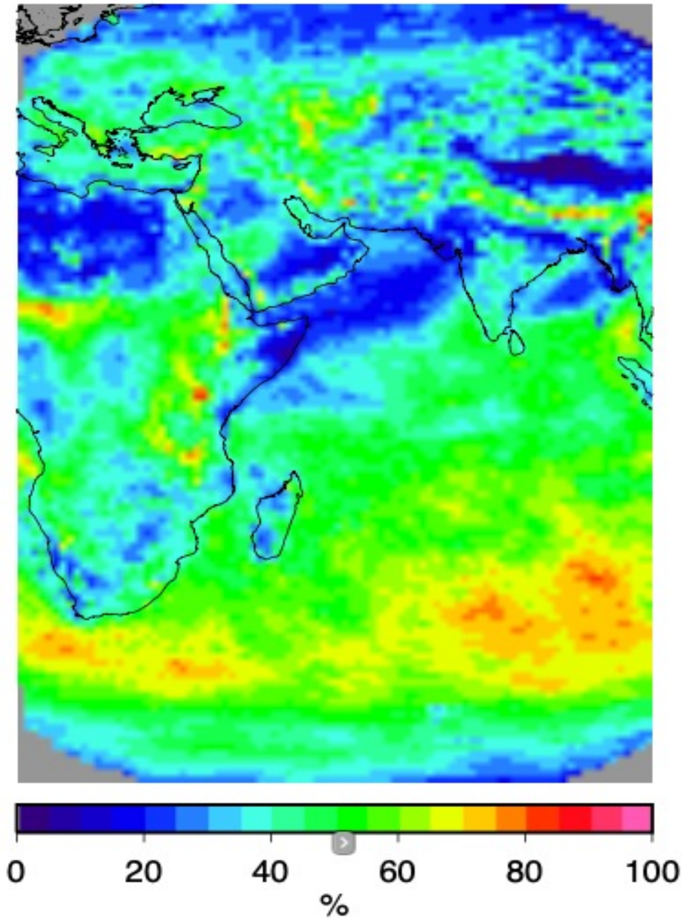
Ocean 54.86
Land 41.36

Ed4 Baseline (Multi-Chan)
Met-8 [April 2019]



Ocean 41.18
Land 25.30

Revisions 1 & 2 (IR Only)
Met-7 [April 2014]



Ocean 51.05
Land 36.02

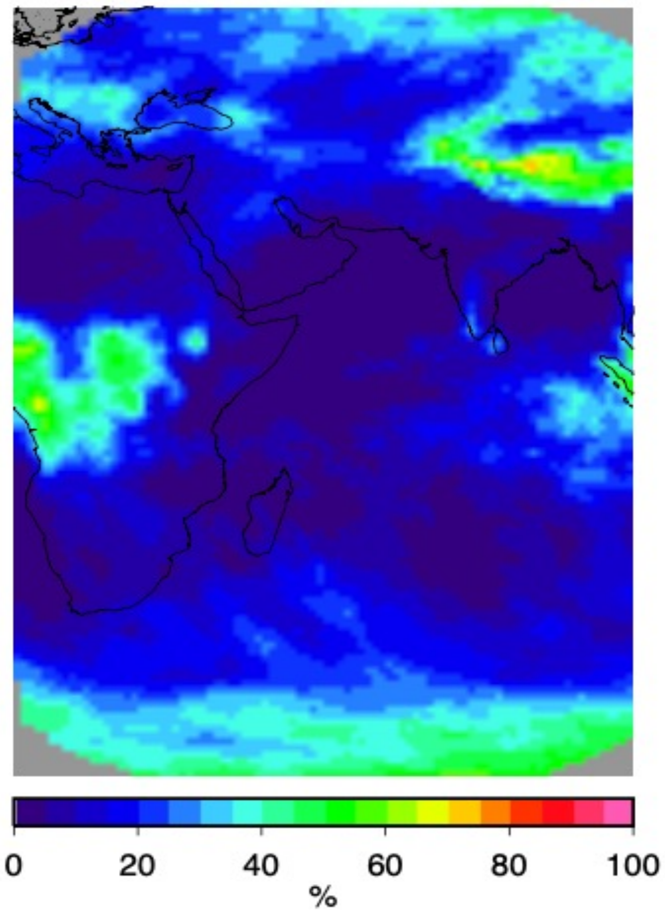
5K change
Not enough

MET-7 TEST (NIGHT)
Ice Cloud Fraction

Revision 2
Cloud Phase Threshold Adjustments

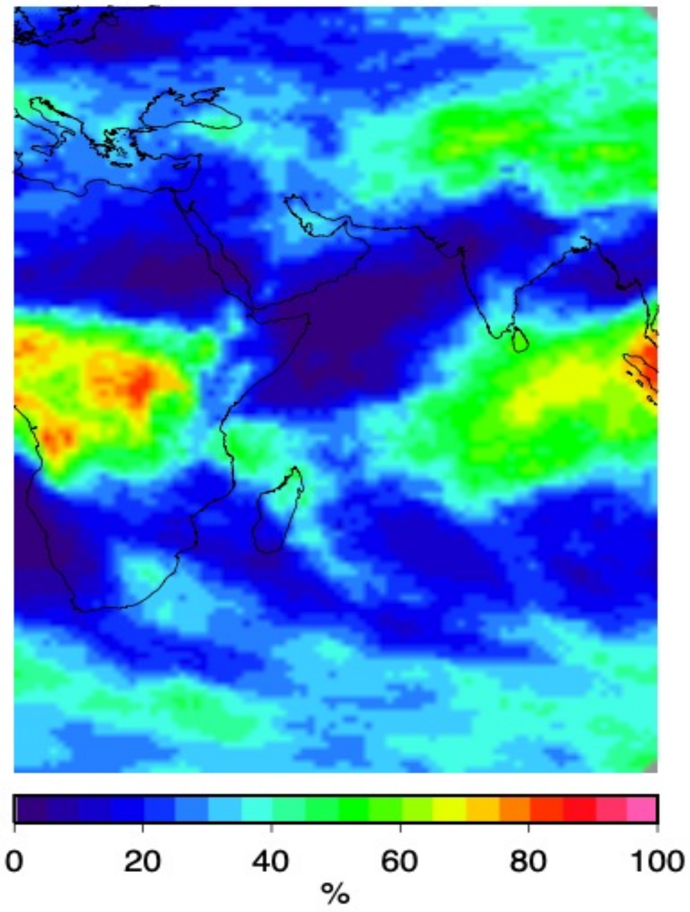
253K changed to 258K
(need more ice cloud)

Revision 1 (IR Only)
Met-7 [April 2014]



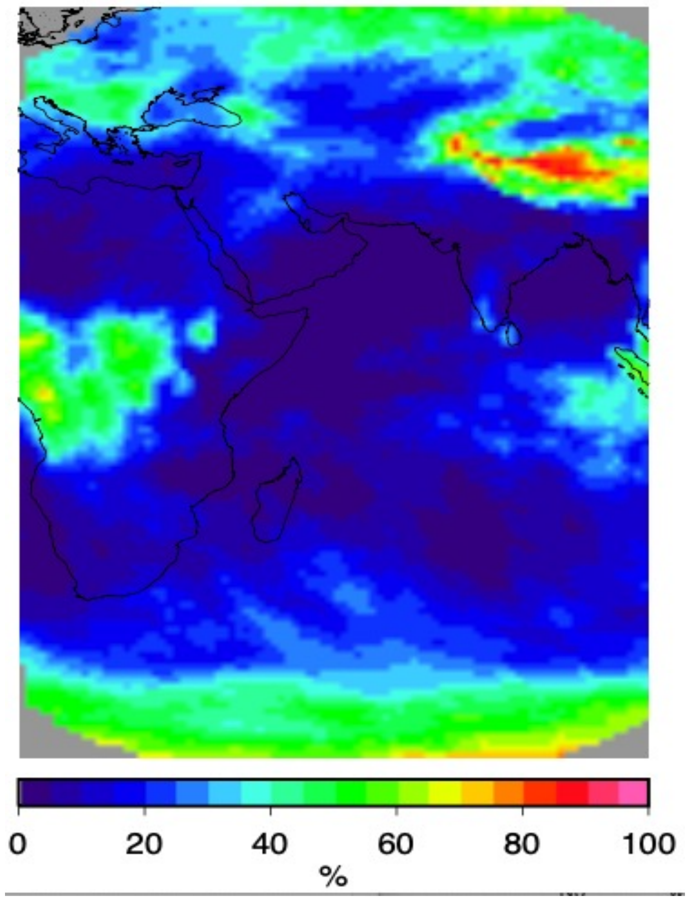
Ocean 15.76
Land 18.40

Ed4 Baseline (Multi-Chan)
Met-8 [April 2019]



Ocean 28.90
Land 29.99

Revisions 1 & 2 (IR Only)
Met-7 [April 2014]



Ocean 19.57
Land 23.73

5K change
Not enough

Progress Towards Edition 5 Clouds

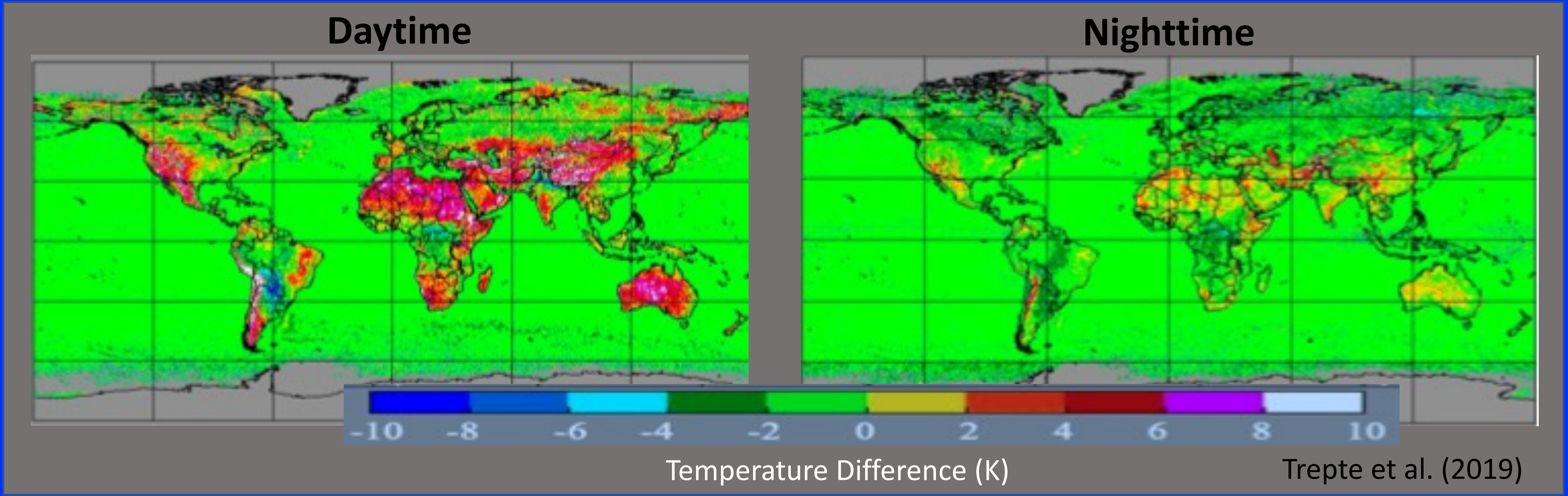
Clear Sky Radiances

The cloud mask and derived cloud properties rely on knowledge of the background or ‘clear sky’ radiances. Key inputs are:

- Skin temperature (Tskin) to compute the clear sky emission temperature at TOA for the IR channels (surface emissivity, atmospheric correction also required)
  - Tskin comes from reanalysis system (GEOS5.41 in Ed4)
- Spectral surface bidirectional reflectance for the solar channels

11 µm Clear Sky Radiance Differences

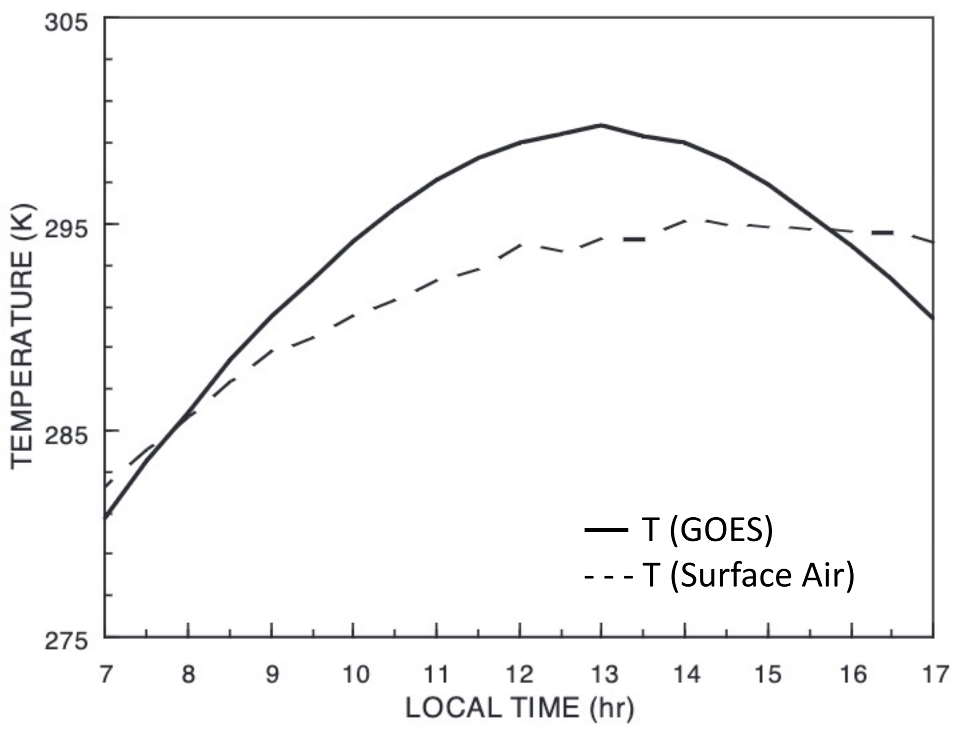
MODIS Ed4 Observations minus Calculations

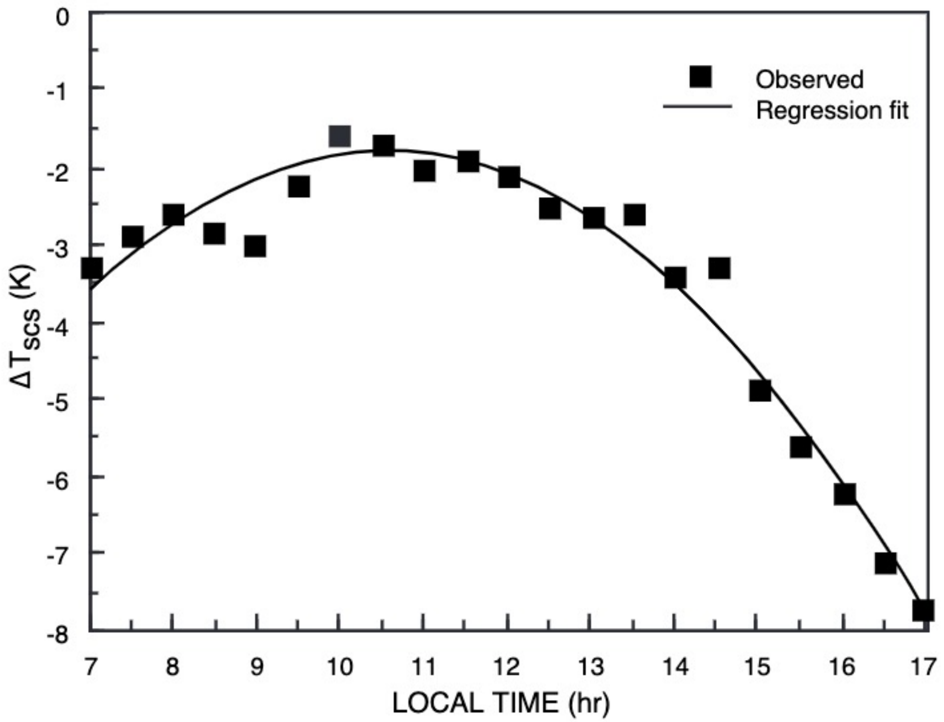


- Large differences (obs much warmer) over land especially in daytime
- Calculations use GEOS 5.41 Tskin but significant differences also found for other modeling systems
- Can impact cloud retrievals (especially thin cirrus)
- Cloud mask is tuned to some degree to account for these differences, but adjustments are needed anytime the reanalysis system is updated or changed

GOES-7 11 µm Clear Sky Temperature
- relationship to surface air temperature

Spring 1994 ARM IOP in the SGP





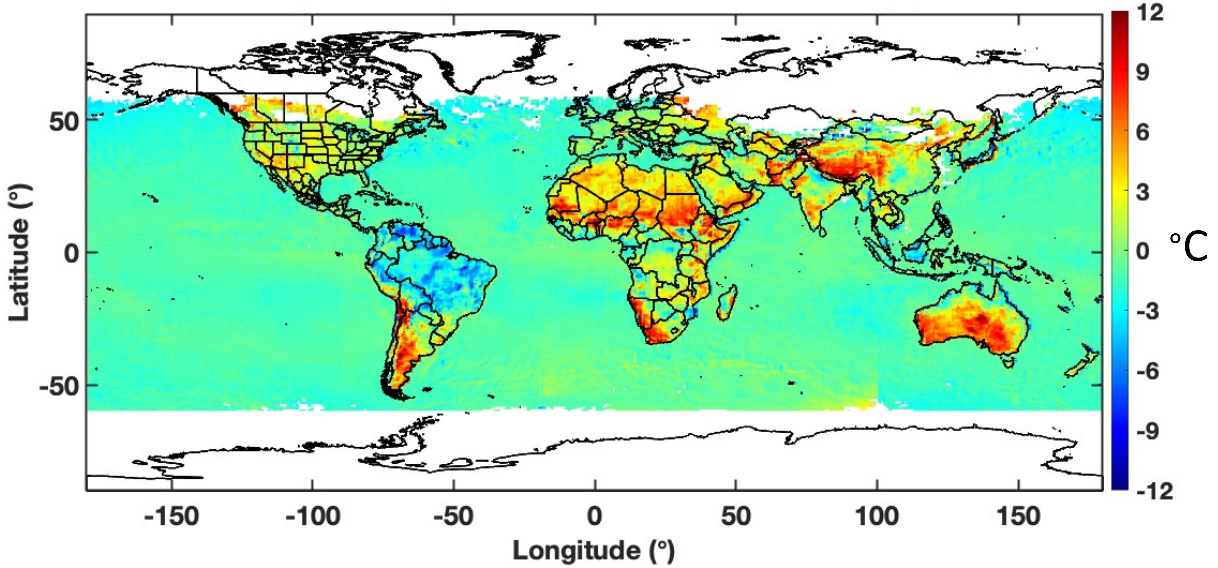
Minnis et al. 1994, NASA RP

Deep Neural Network for Predicting Skin Temperature as Observed from Satellites

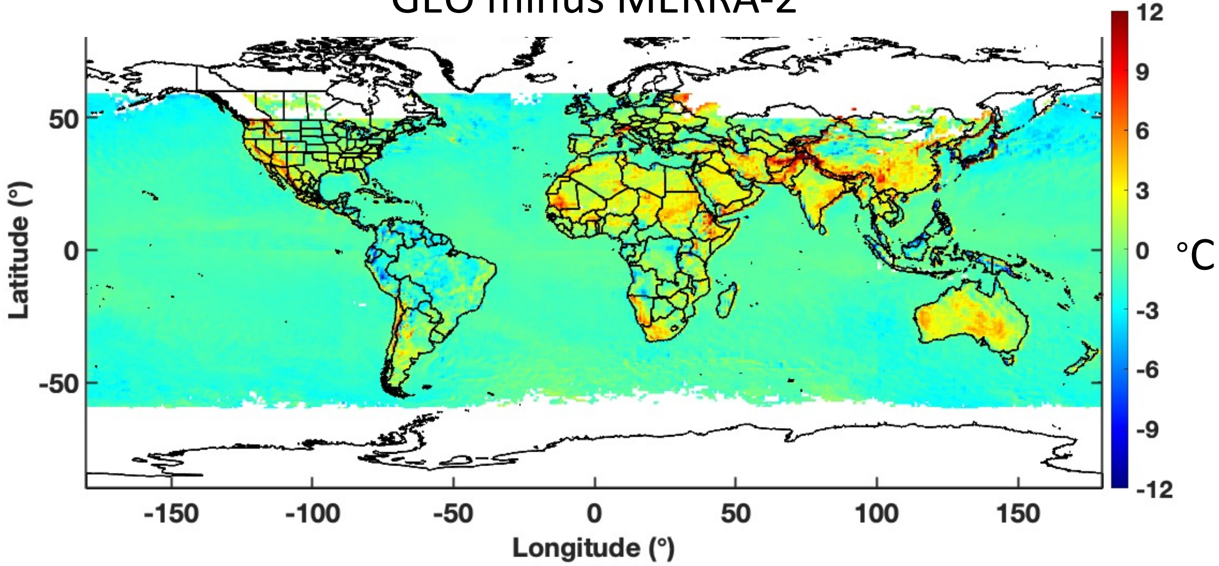
-work by Ben Scarino

- Input (X)
  - 2-meter Air Temperature (MERRA-2)
  - Latitude
  - Longitude
  - Local Time
  - SZA
  - IGBP (homogenous)
- Truth (Y)
  - December 2020 Global GEO Satellite Skin Temperature
  - 100% Clear Sky Regions Only
- Output ($\hat{Y}$)
  - Predicted Satellite Skin Temperature

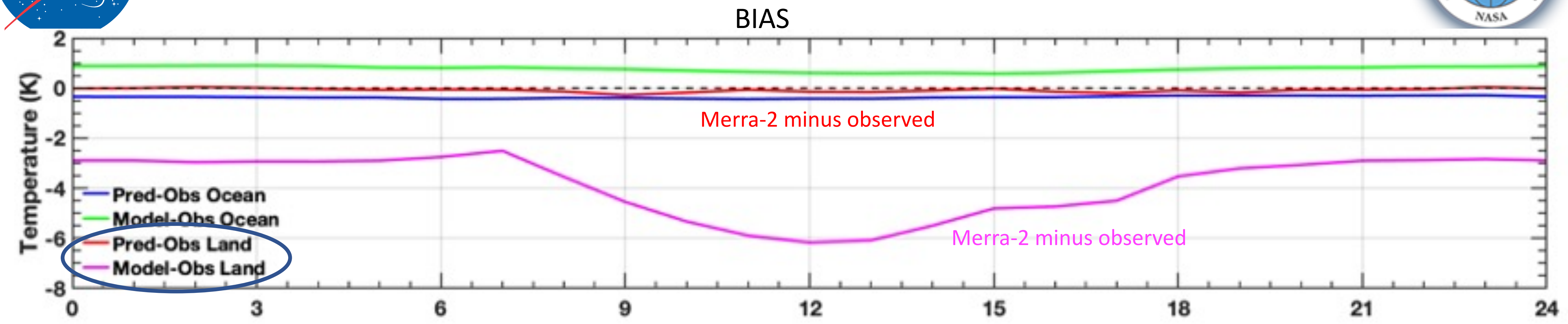
Daytime Skin Temperature Difference **(Dec 2020)**
GEO minus MERRA-2

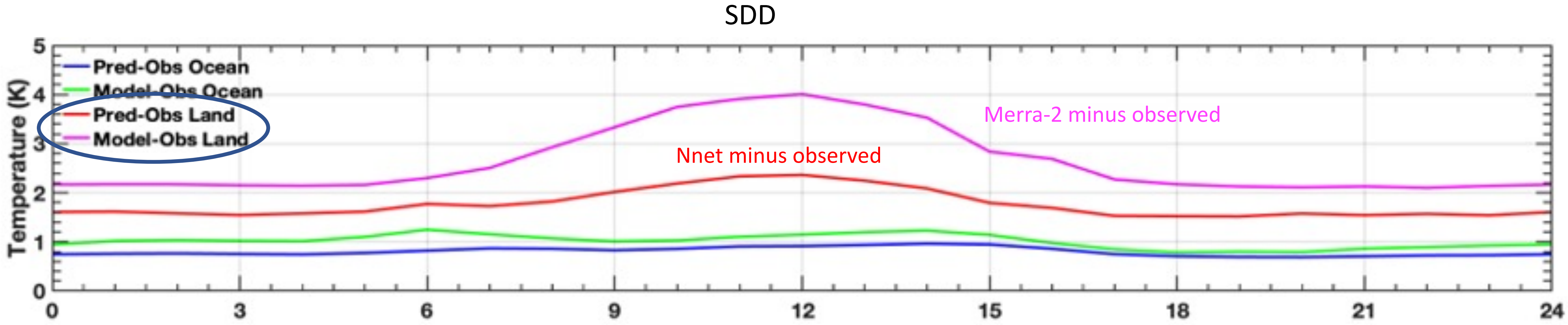


Nighttime Skin Temperature Difference **(Dec 2020)**
GEO minus MERRA-2

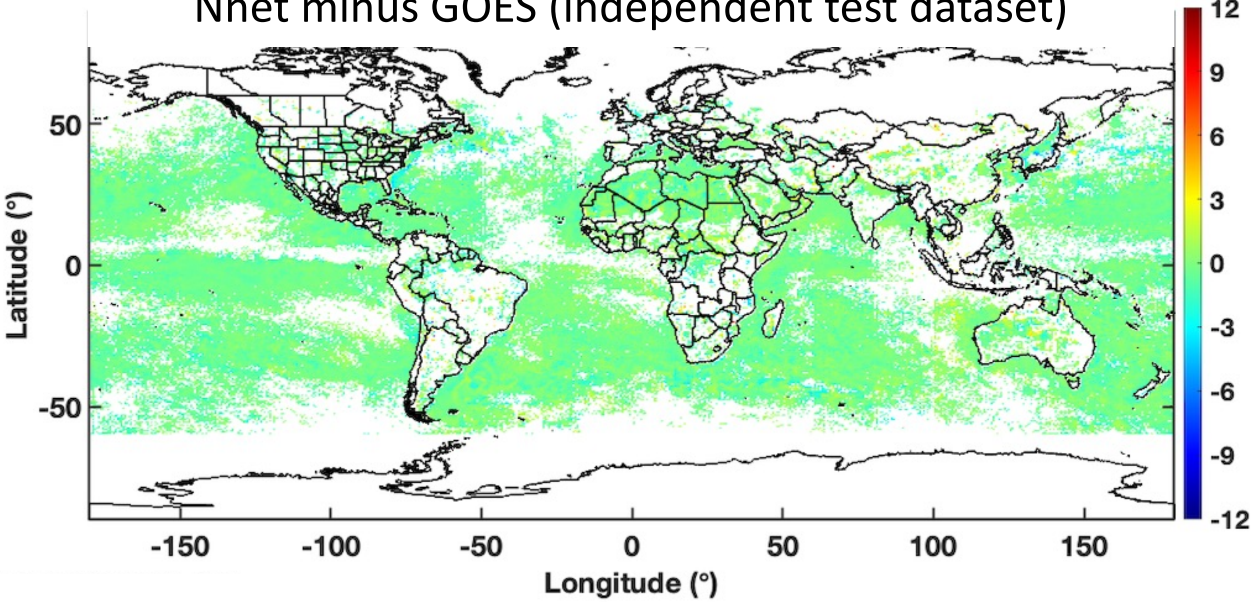


Tskin Validation

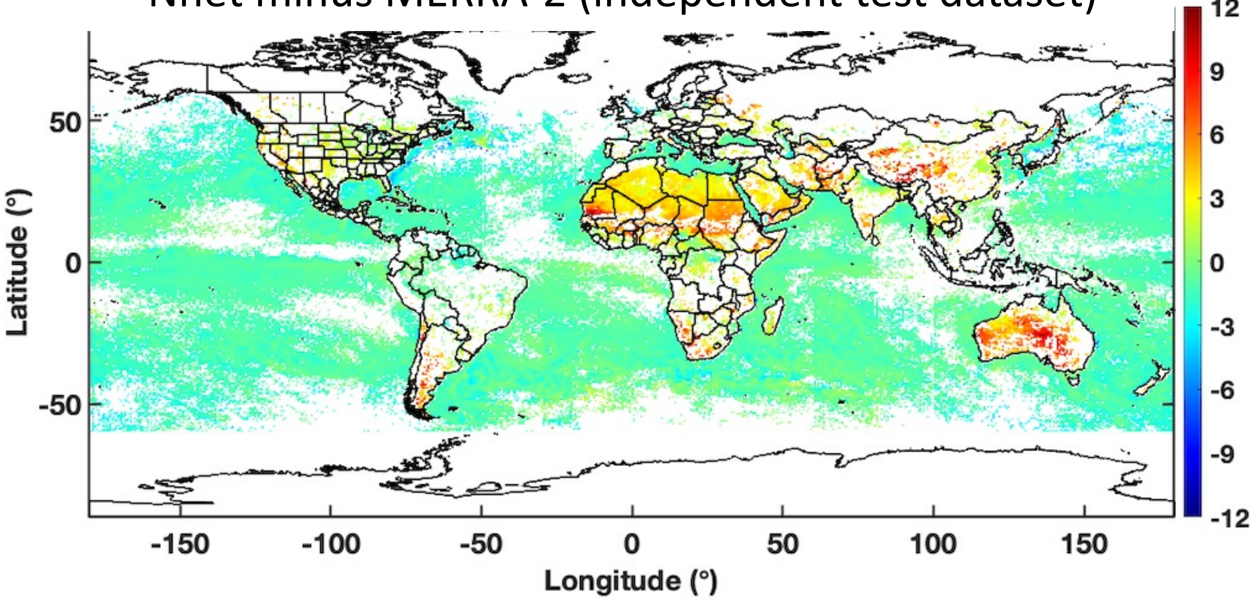




Skin Temperature Difference **(Dec 2020)**
Nnet minus GOES (independent test dataset)



Skin Temperature Difference **(Dec 2020)**
Nnet minus MERRA-2 (independent test dataset)



GEO Clear Sky Reflectance Update

- In CERES MODIS and VIIRS forward processing, a clear sky reflectance updating scheme is employed to update the snow/ice/land reflectances based on clear pixels discerned by the cloud mask. These provide input for the cloud algorithms the following day.

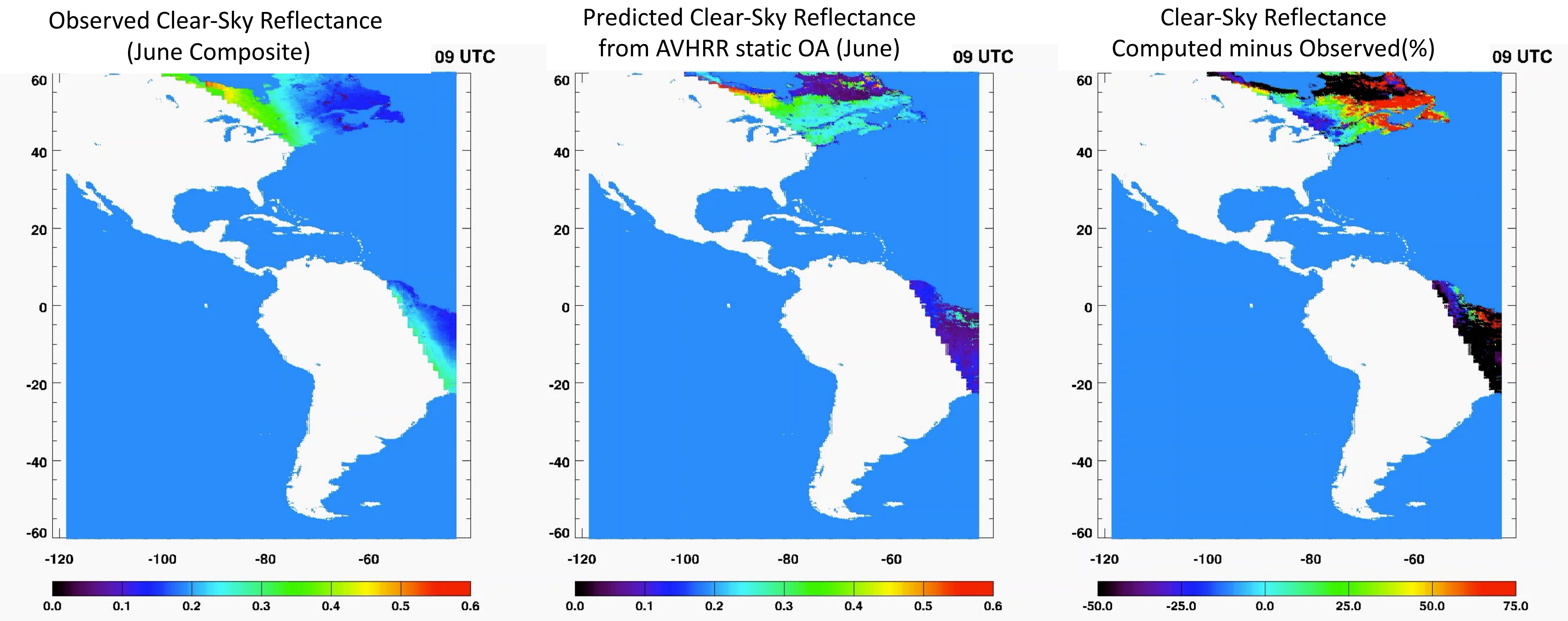
- In CERES GEO processing, there is no updating scheme. Instead static monthly mean clearsky overhead albedo maps (for the 0.65 µm band) created from an AVHRR climatology are employed to estimate the GEO land surface bi-directional reflectance by applying directional models developed from MODIS and bidirectional models developed from ERBE for desert and from aircraft data (Kriebel) for all other land types.

- Compared to GEO observations, the AVHRR based approach leads to large errors over some surface types at various times of day

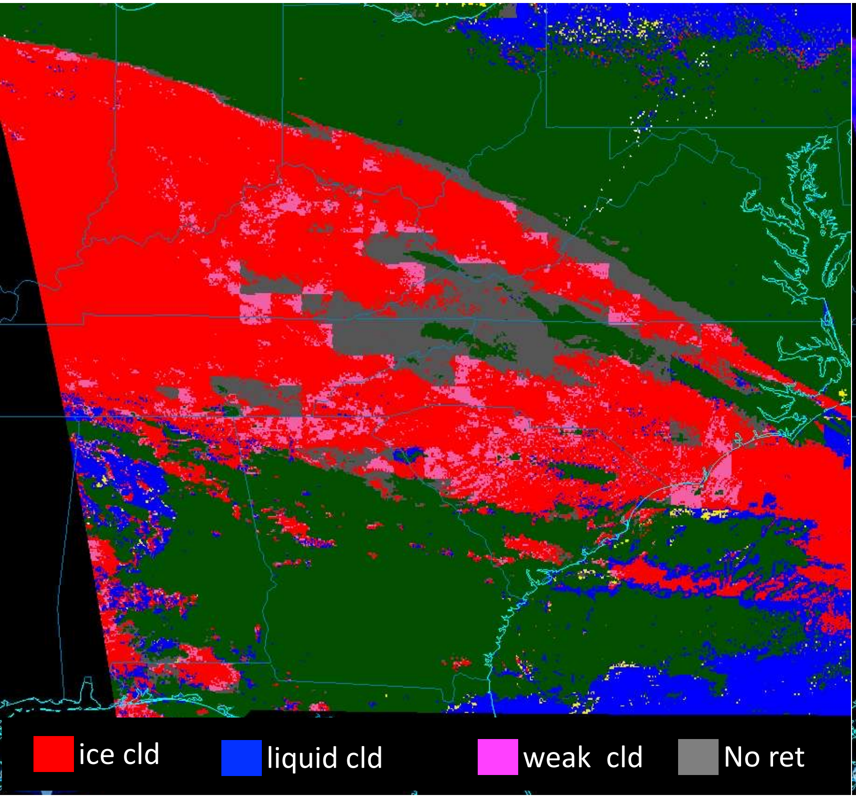
- For Edition 5, we plan to develop a more robust clear sky reflectance method based on global hourly GEO data (reduce impact of uncertainties in DRM and BRDF models)

GOES-16 Clear-Sky Reflectance Comparison

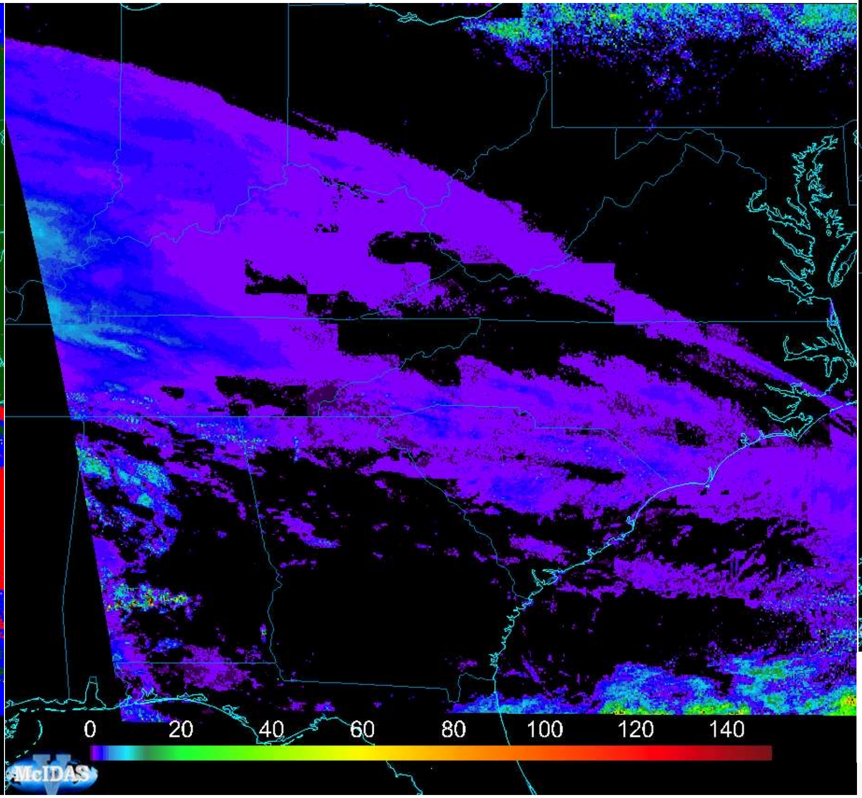
- monthly hourly composites created using two years of data, stored as OA and tested in the cloud retrieval system (S. Bedka)

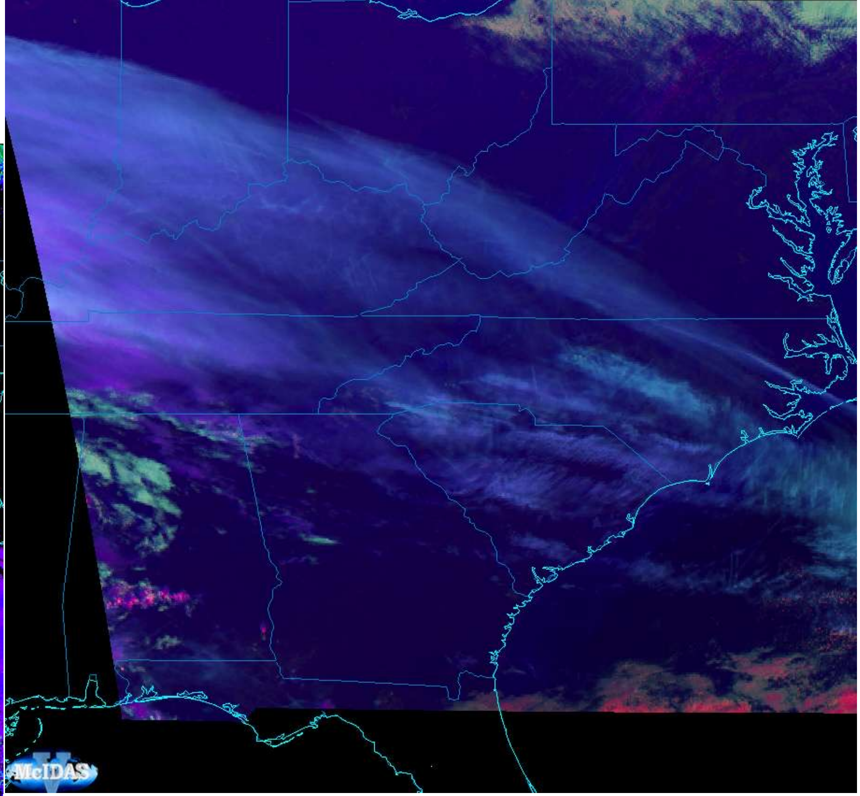


Cloud Phase using AVHRR OA Map

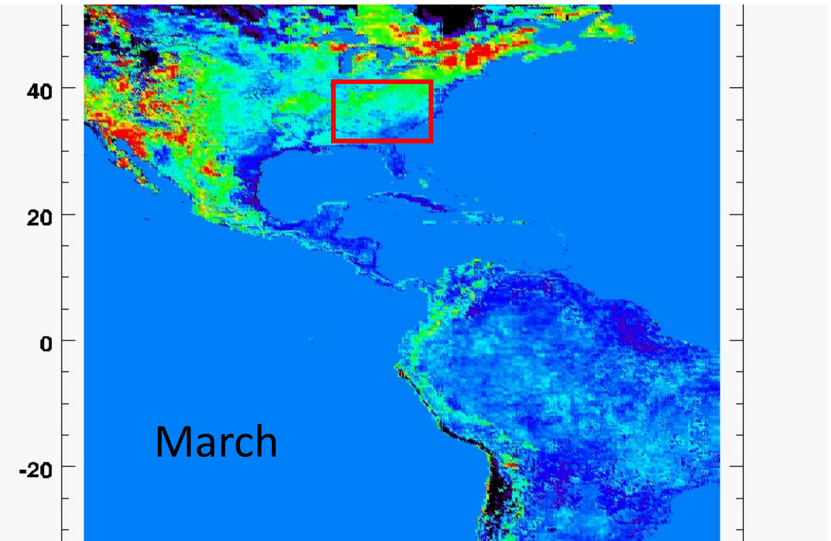


Cloud τ using AVHRR OA Map





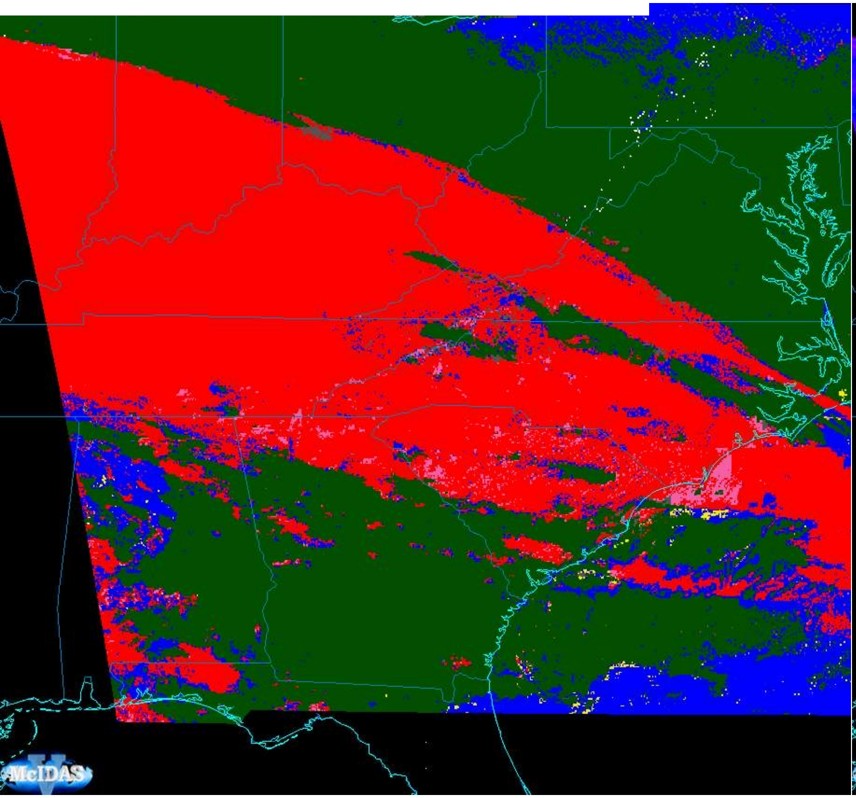
AVHRR minus GOES Observed Clear-Sky Reflectance Difference



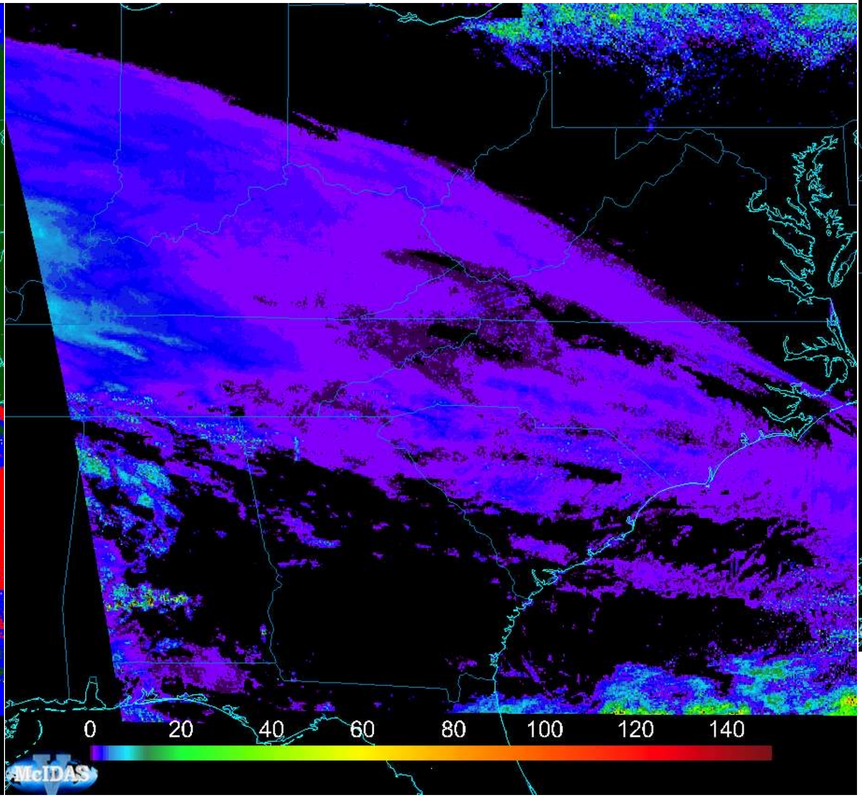
March 12, 2019

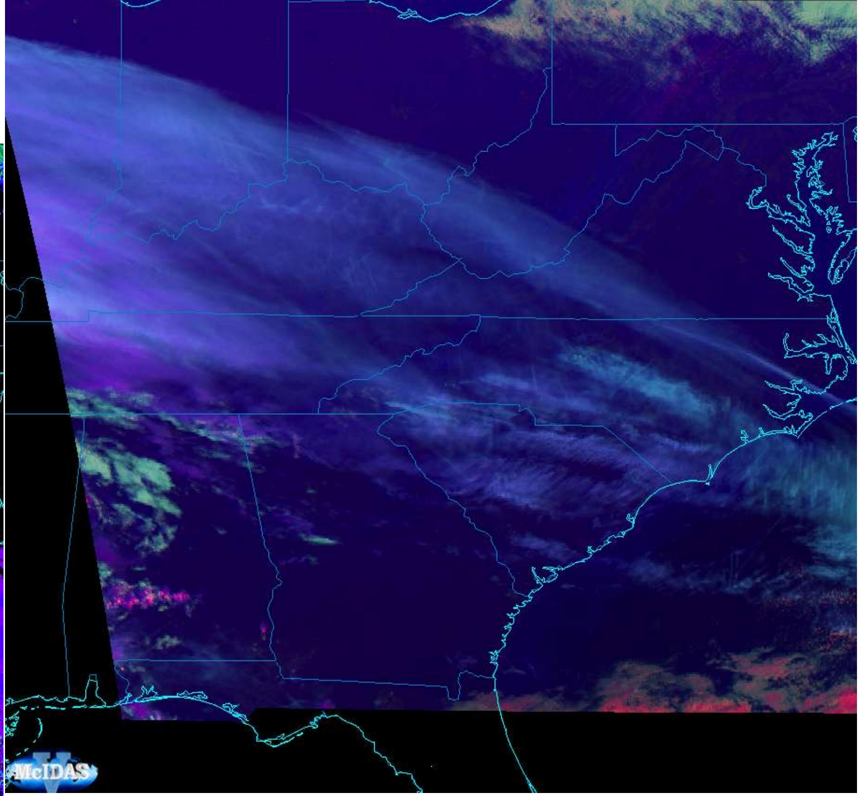
- Difference between AVHRR predicted and the Observed clear-sky reflectance in this region is between 0.06 and 0.13. Differences are largest over deciduous broadleaf forest IGBP type
- Note large areas of no retrievals (gray) and low confidence clouds in the cloud phase image

Cloud Phase using Observed OA Map



Cloud τ using Observed OA Map



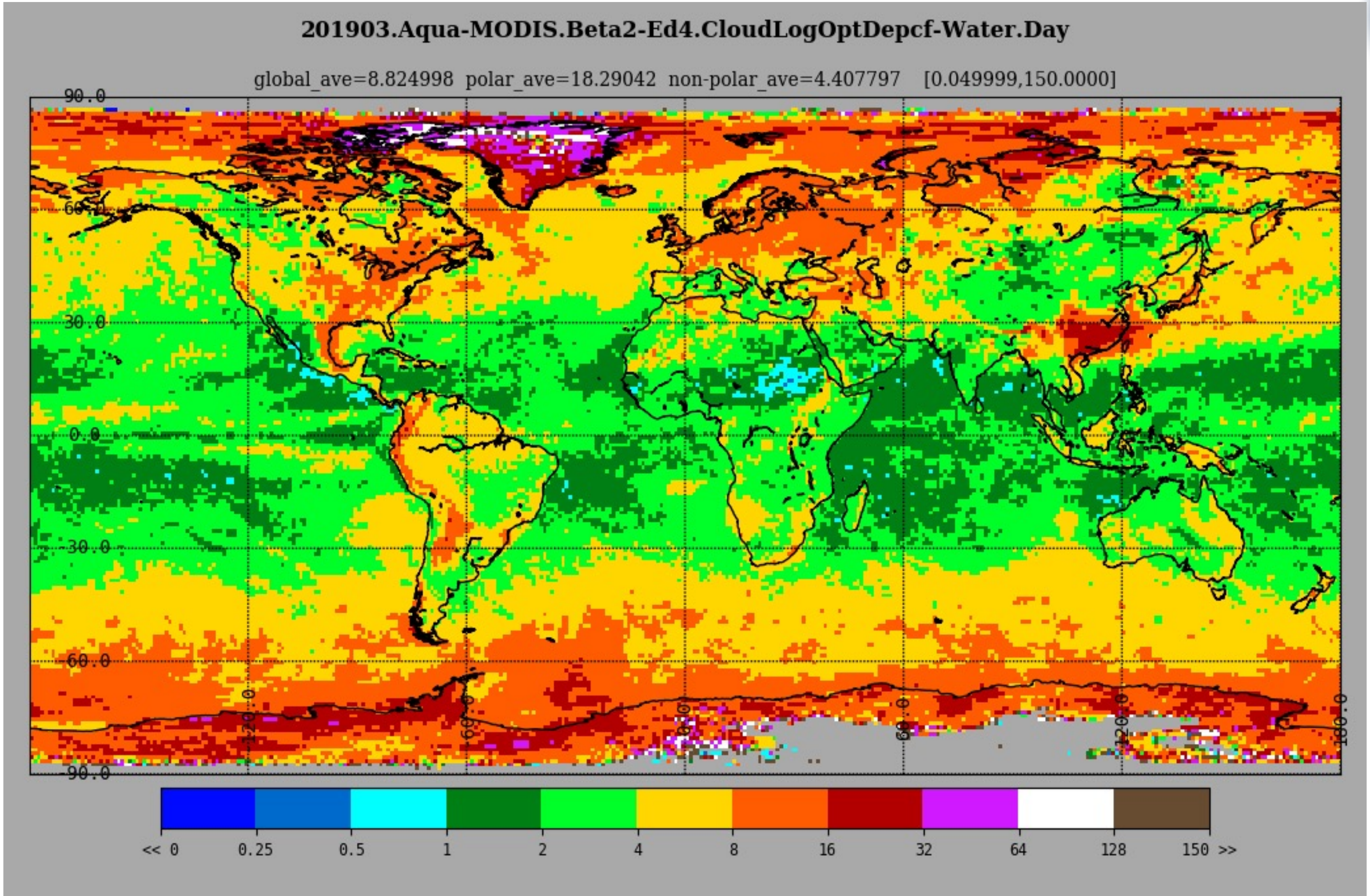


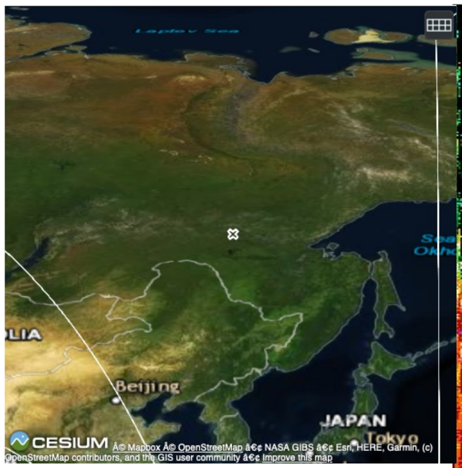
- Using the observed OA map results in significant improvement in cloud phase for cirrus (fewer weak clouds, fewer misclassifications) and a much lower occurrence of no retrievals
- There is a slight increase in cirrus cloud optical depth
- More work is needed to implement the GEO compositing approach in our retrieval system and assess the impact on the cloud mask and cloud properties

Multi-spectral Hybrid Approach for Estimating Cloud Optical Thickness over Snow/ICE for Ed5

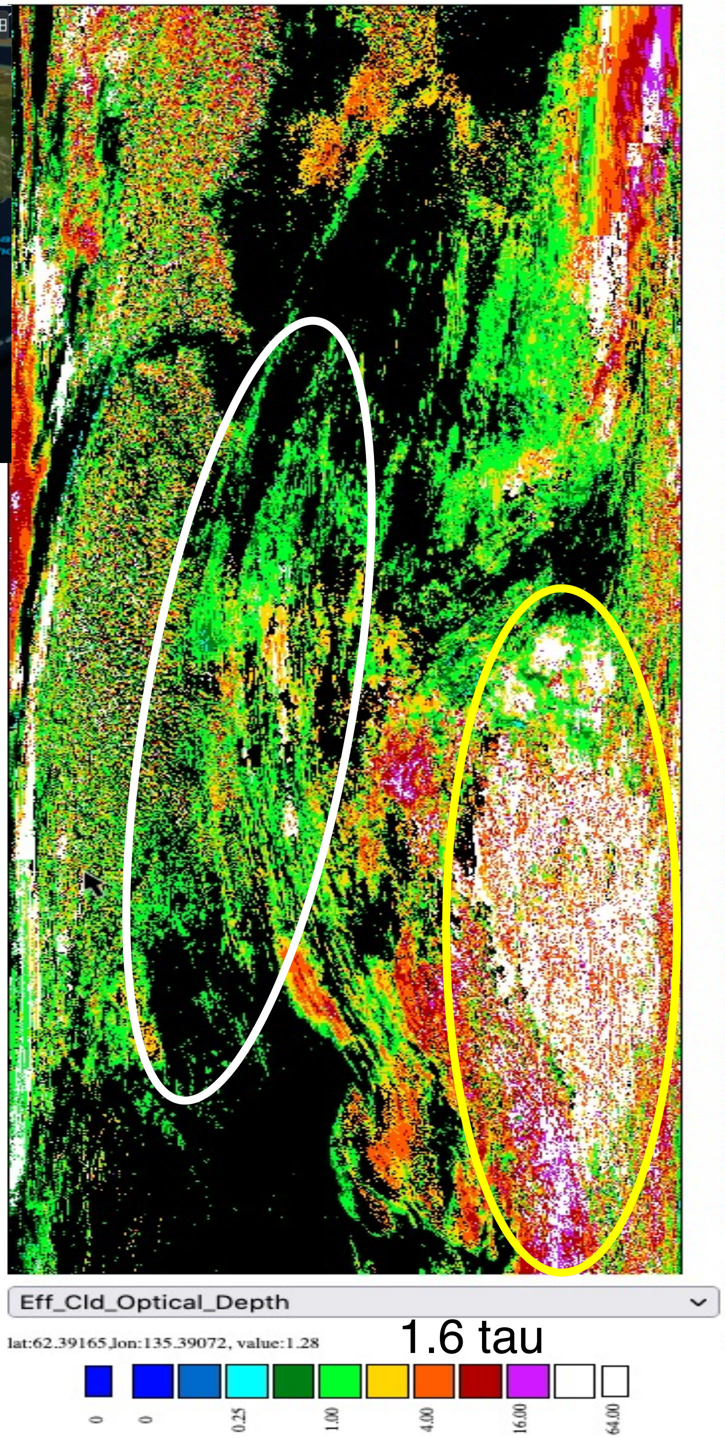
Water Clouds, Day Time, Aqua

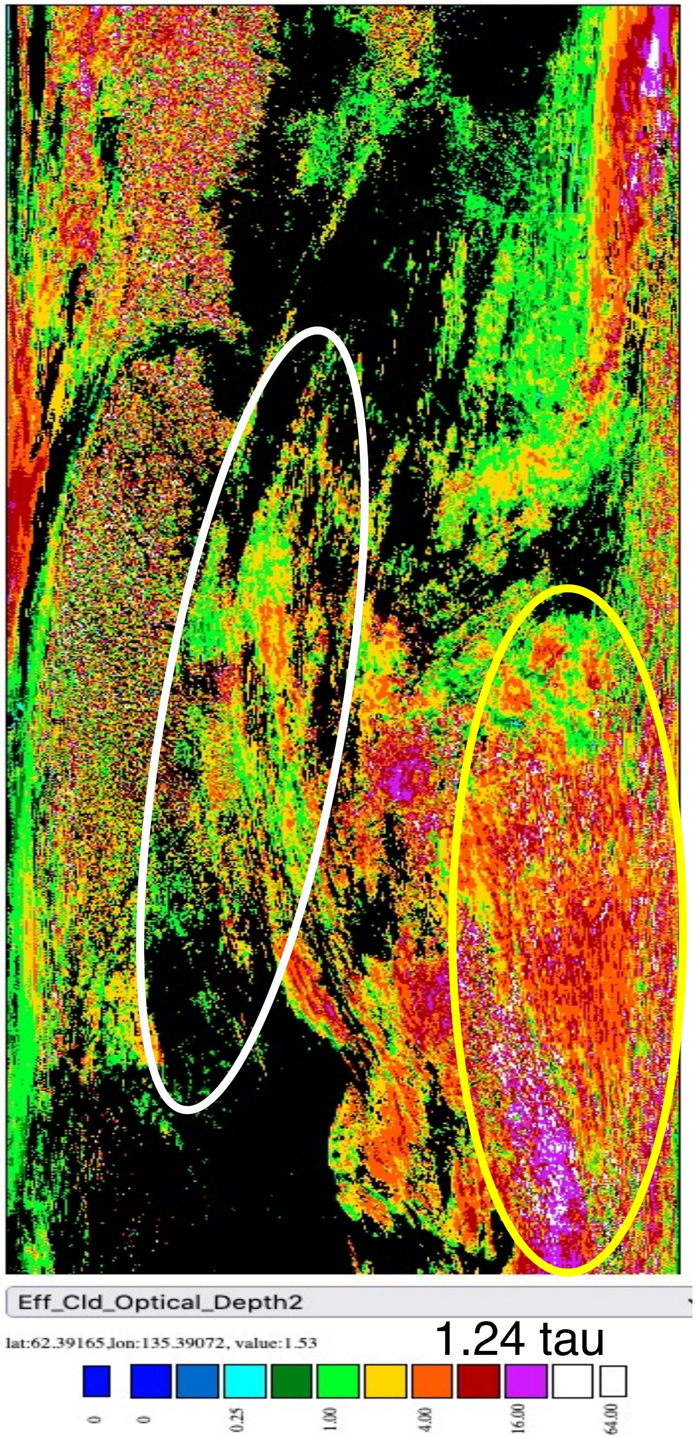
ED4 Optical Depth

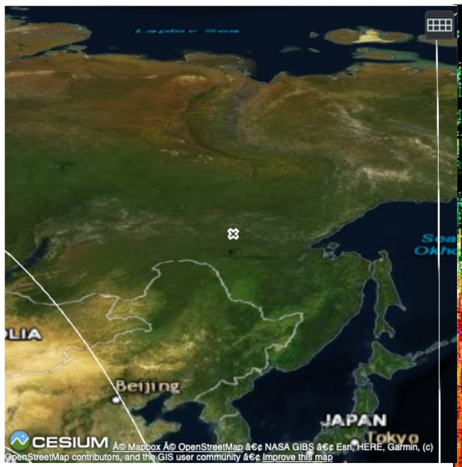




20190315 hr 4
Aqua







20190315 hr 4
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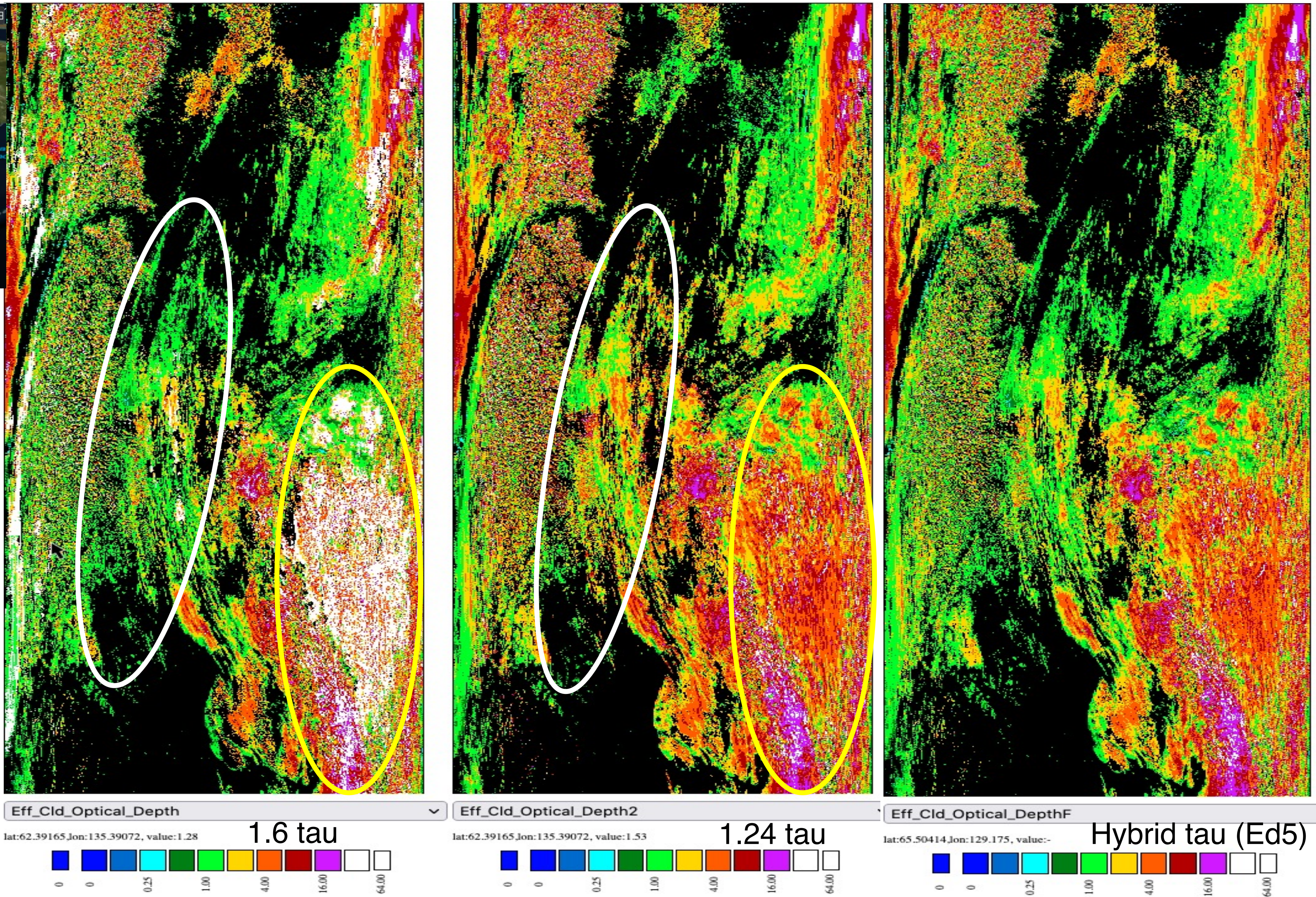

20190315 hr 19
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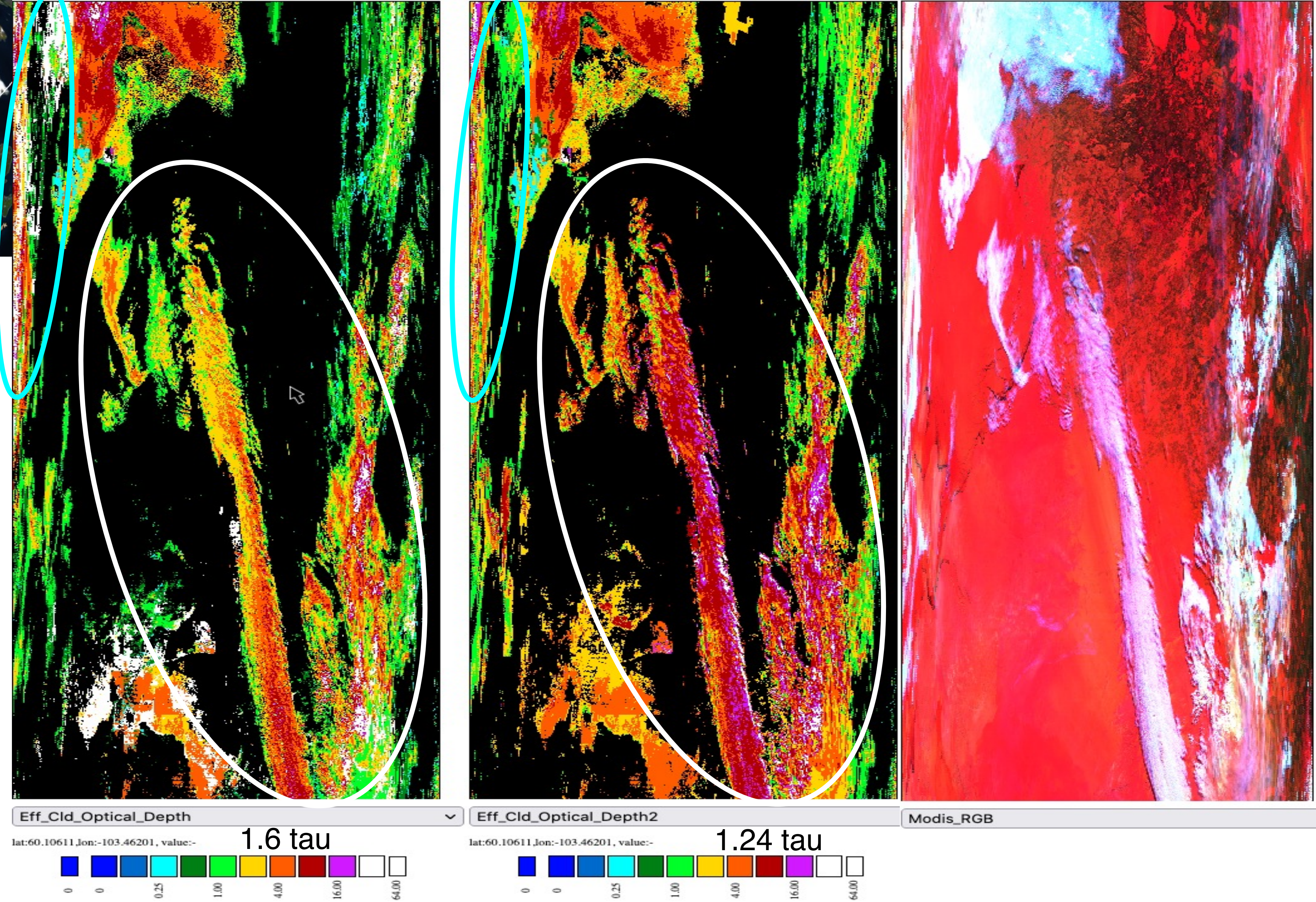
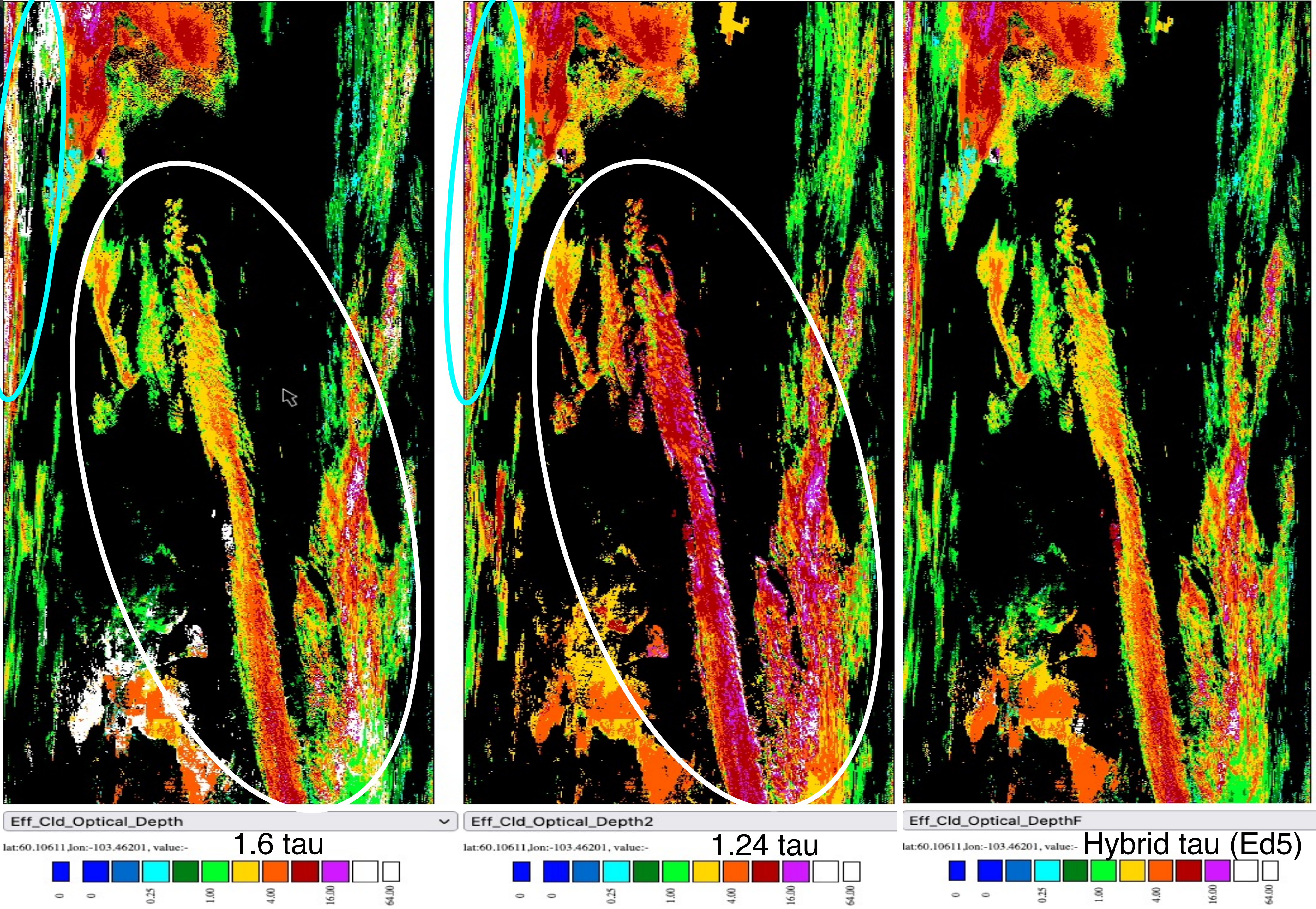


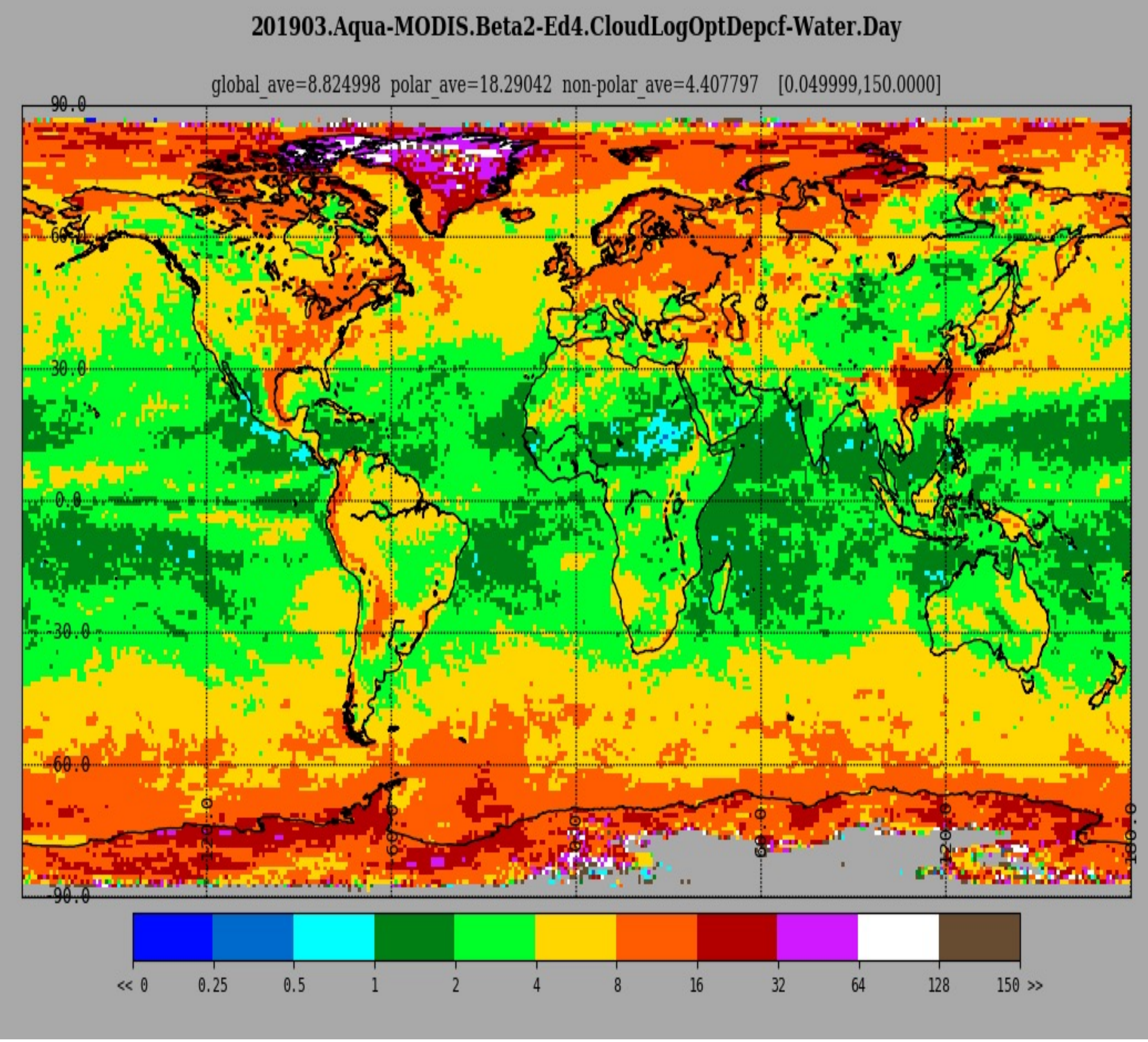
20190315 hr 19
Aqua

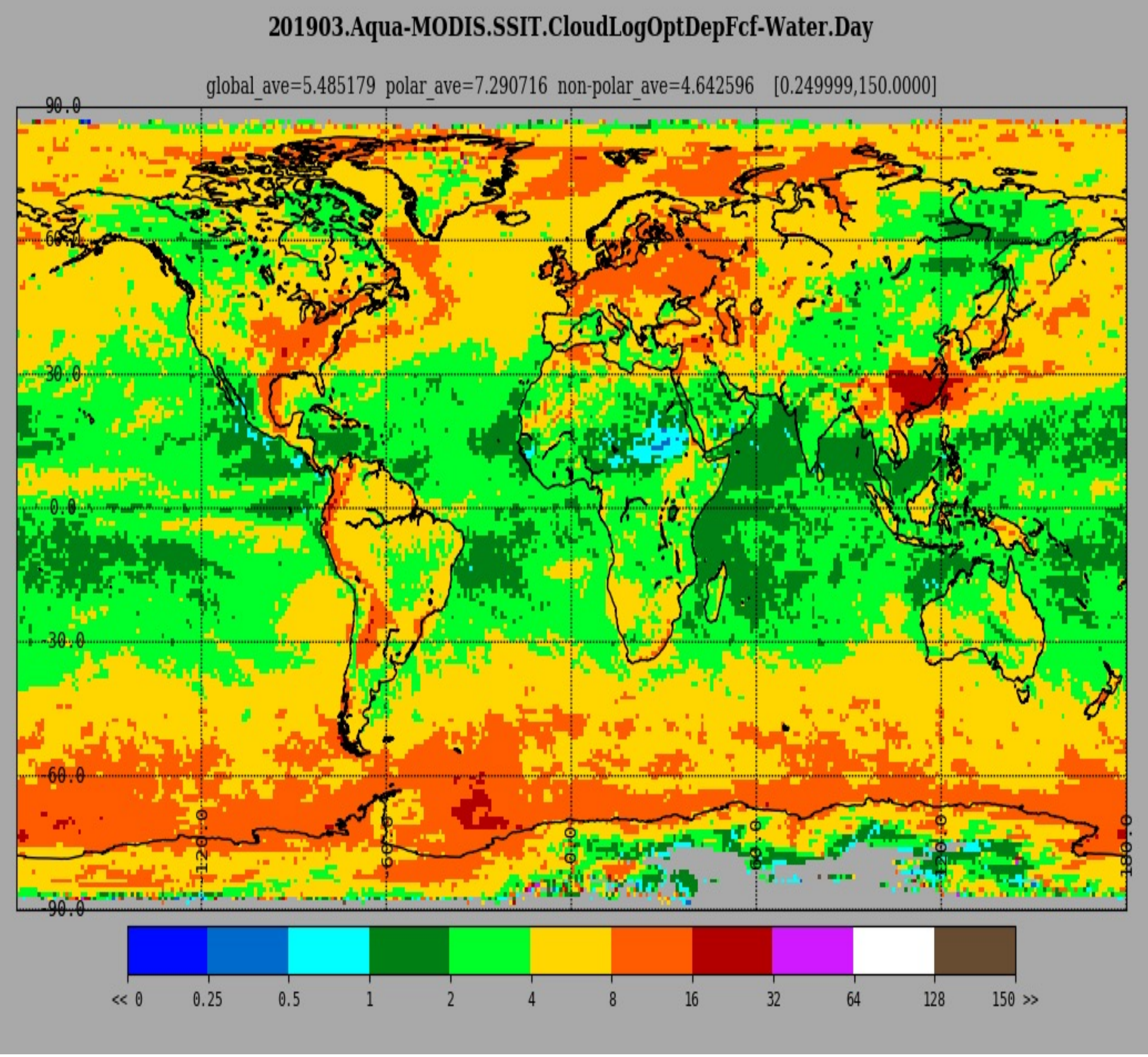


Water Clouds, Day Time

ED4 Optical Depth

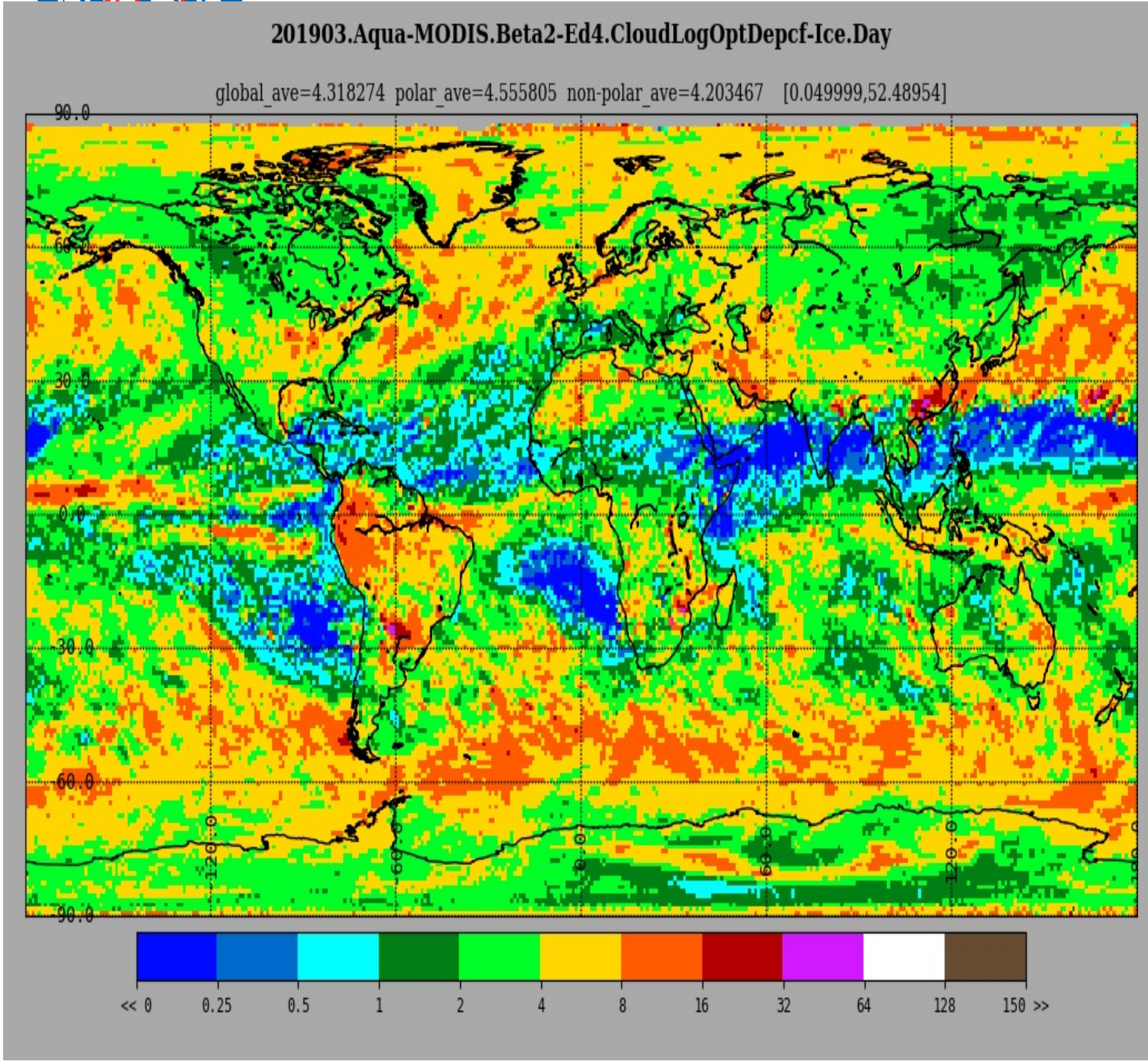
ED5 (Hybrid) Optical Depth



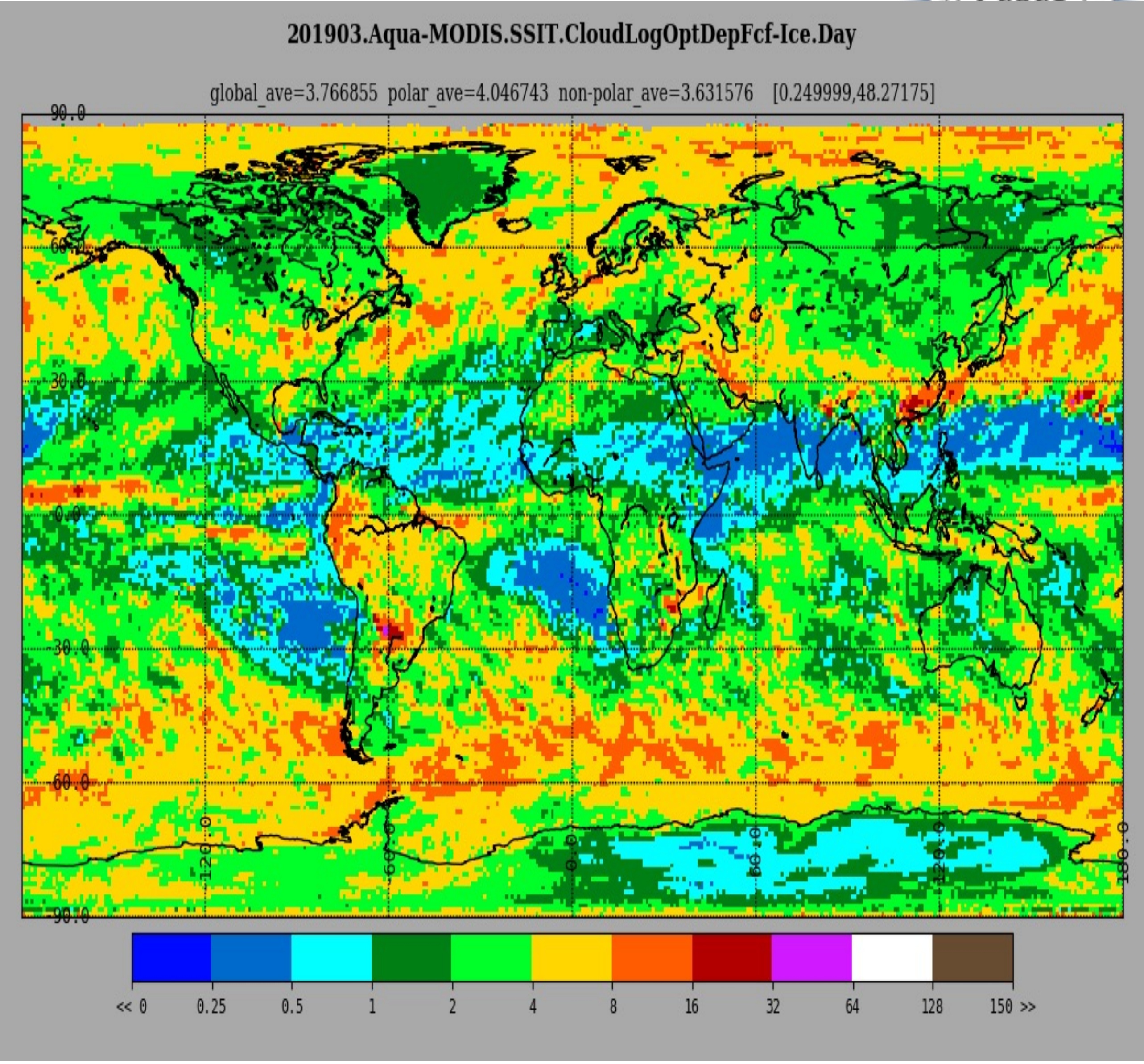


Ice Clouds, Day Time

ED4 Optical Depth



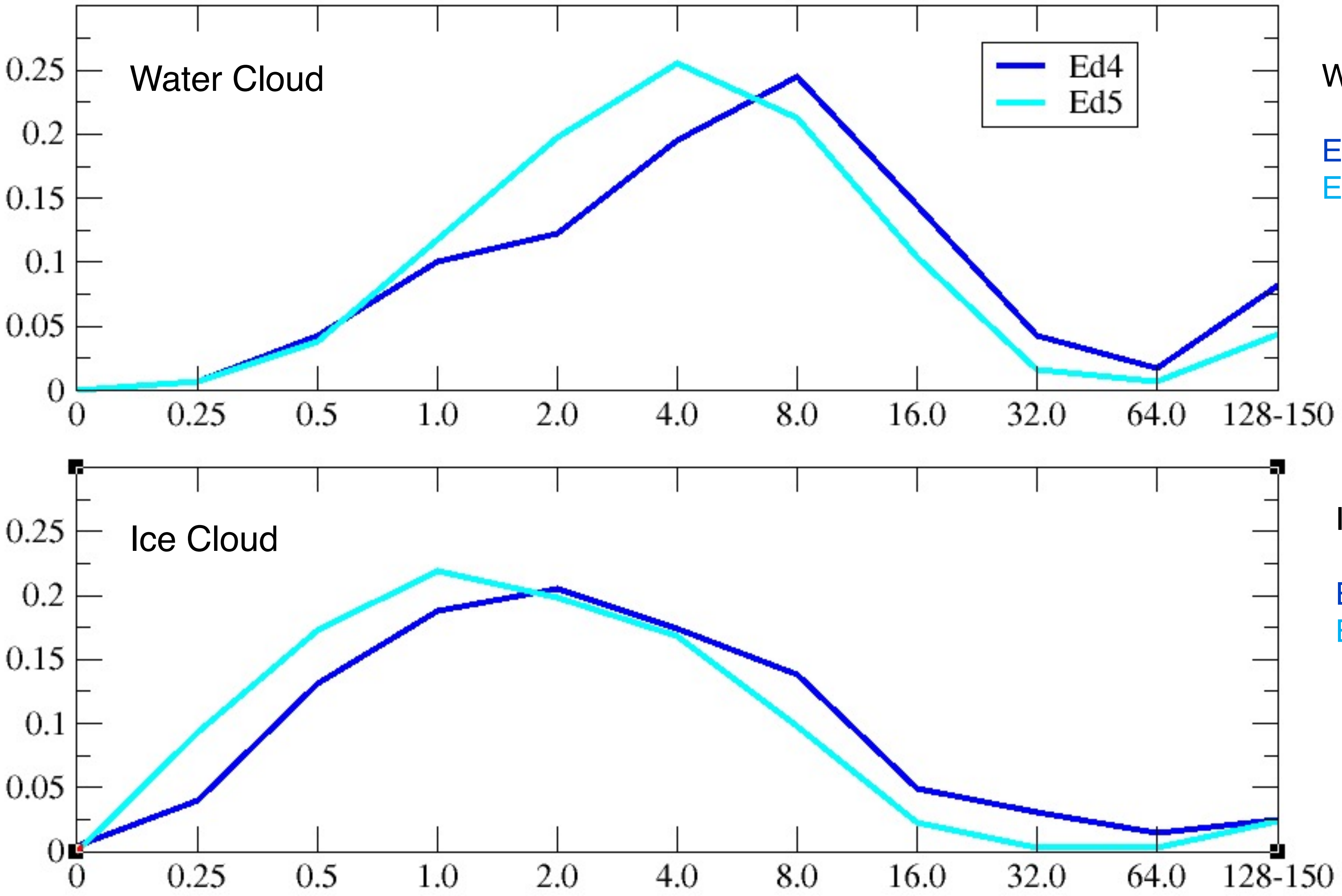
ED5 (Hybrid) Optical Depth



Day Time
Snow/Ice Covered
Aqua-MODIS

Histogram of Optical Depth

March 2019, Daytime Snow/Ice Cover



Water Cloud:

	Mean (Std)
Ed4:	23.4 (40.5)
Ed5:	14.9 (30.7)

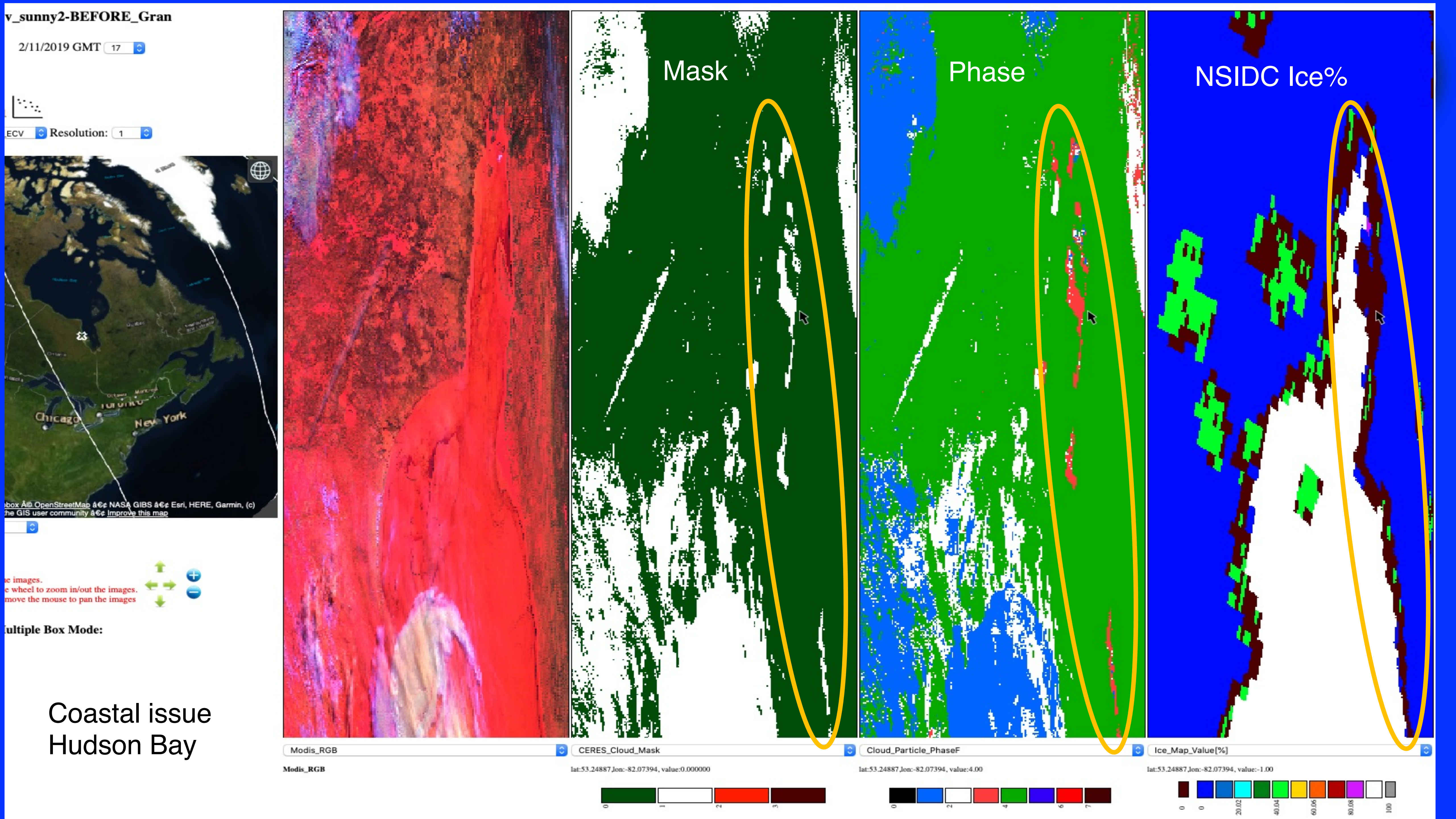
Ice Cloud:

	Mean (Std)
Ed4:	10.9 (25.7)
Ed5:	7.4 (23.1)

Use of Sea-Ice information in CERES Cloud Algorithms

- Cloud working group uses NSIDC/AFWA sea-ice concentration for cloud mask and cloud optical properties
- Current product being used does not provide data over lakes or along coastlines (~50 km near coastline is unknown)

Coastal Snow & Ice Unknown (~ 50 km) regions from NSIDC



v_sunny2-BEFORE_Gran
2/11/2019 GMT 17
ECV
Resolution: 1
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New York
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CERES_Cloud_Mask
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Ice_Map_Value[%]
Modis_RGB
lat:53.24887,lon:-82.07394, value:0.000000
lat:53.24887,lon:-82.07394, value:4.00
lat:53.24887,lon:-82.07394, value:-1.00
Multiple Box Mode:
Coastal issue
Hudson Bay

v_sunny2-BEFORE_Gran

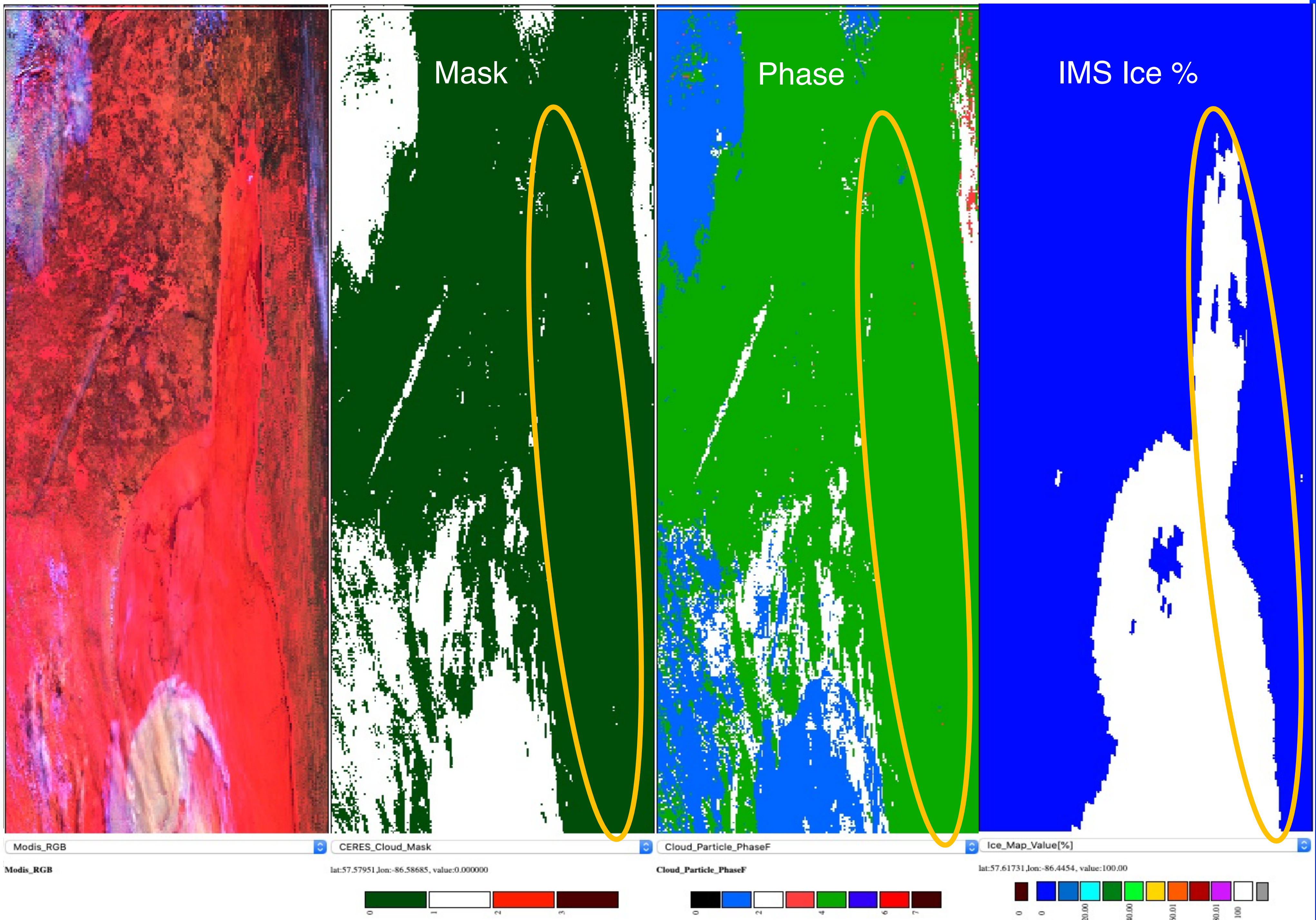
2/11/2019 GMT 17

ECV Resolution: 1

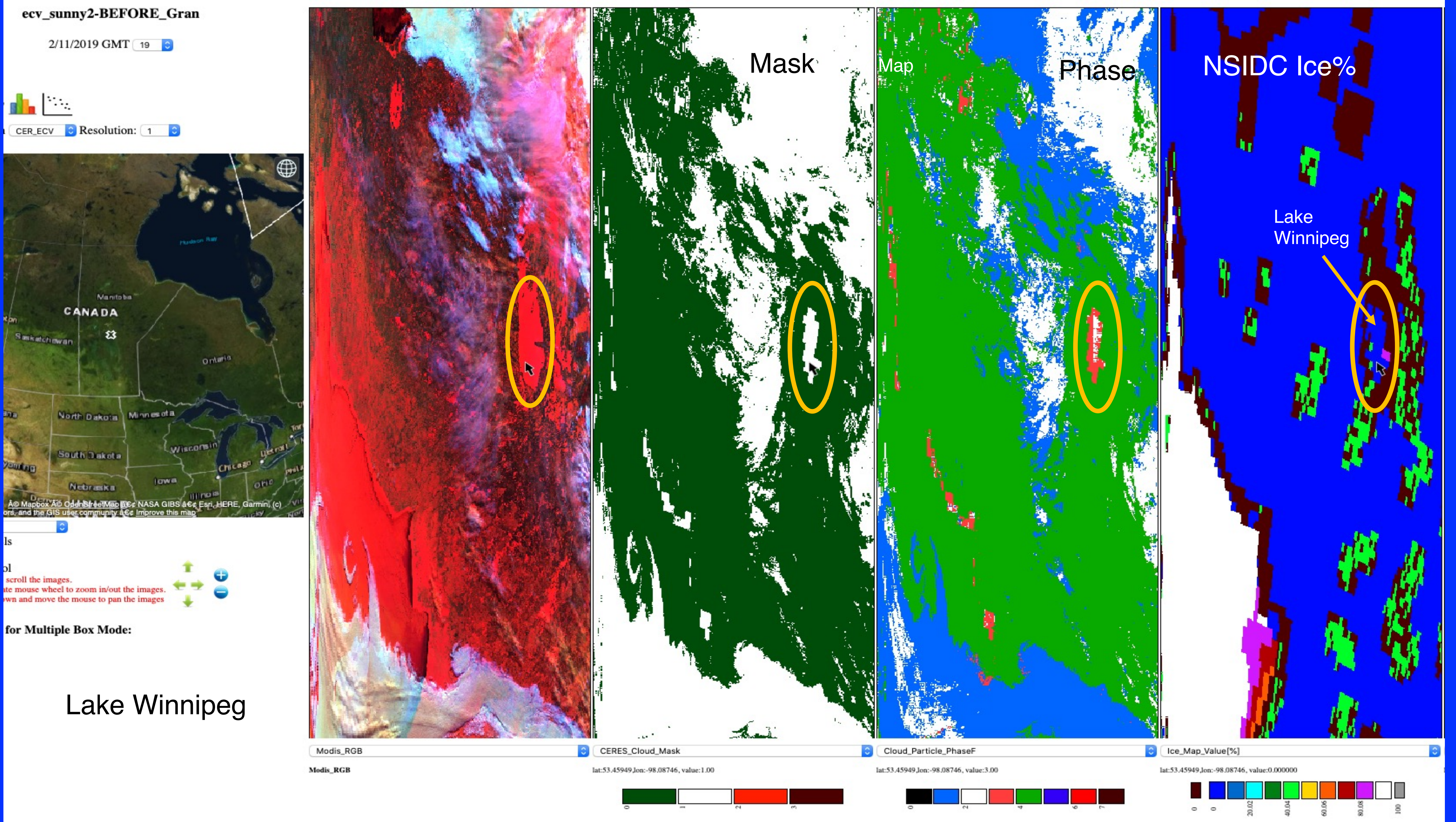
e images.
e wheel to zoom in/out the images.
move the mouse to pan the images

ultiple Box Mode:

Coastal issue
Hudson Bay



Sea-ice concentration on lakes always 0 from NSIDC


ecv_sunny2-BEFORE_Gran
2/11/2019 GMT 19
CER_ECV Resolution: 1
Hudson Bay
Manitoba
CANADA
Saskatchewan
Ontario
North Dakota
Minnesota
South Dakota
Wisconsin
Chicago
Iowa
Nebraska
Ohio
Illinois
Detroit
© Mapbox © OpenStreetMap © NASA GIBS © Esri, HERE, Garmin, (c)
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CERES_Cloud_Mask
Cloud_Particle_PhaseF
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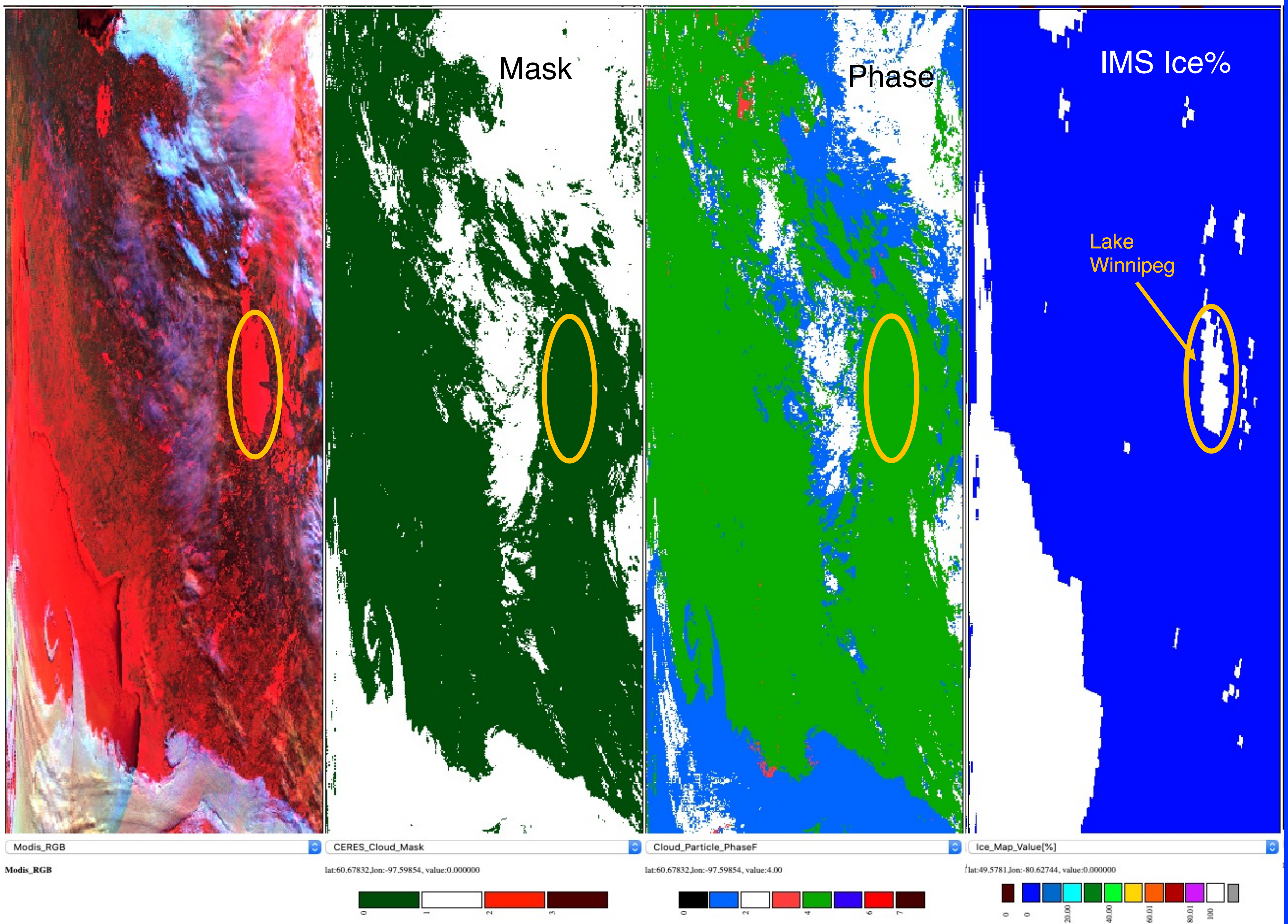

Lake Winnipeg

2021 CWG Publications

Chen, H., Schmidt, S., King, M. D., Wind, G., Bucholtz, A., Reid, E. A., Segal-Rozenhaimer, M., Smith, W. L., Taylor, P. C., Kato, S., and Pilewskie, P.: The effect of low-level thin arctic clouds on shortwave irradiance: evaluation of estimates from spaceborne passive imagery with aircraft observations, Atmos. Meas. Tech., 14, 2673–2697, https://doi.org/10.5194/amt-14-2673-2021, 2021. **Validation**

Kang, L., Marchand, R. T., & Smith, W. L. (2021). Evaluation of MODIS and Himawari-8 low clouds retrievals over the Southern Ocean with in situ measurements from the SOCRATES campaign. Earth and Space Science, 8, e2020EA001397. https://doi.org/10.1029/2020EA001397. **Validation**

Rybka, H., Burkhardt, U., Köhler, M., Arka, I., Bugliaro, L., Görsdorf, U., Horváth, Á., Meyer, C. I., Reichardt, J., Seifert, A., and Strandgren, J.: The behavior of high-CAPE (convective available potential energy) summer convection in large-domain large-eddy simulations with ICON, Atmos. Chem. Phys., 21, 4285–4318, https://doi.org/10.5194/acp-21-4285-2021, 2021. **Model Evaluation**

Benjamin, S. G., James, E. P., Hu, M., Alexander, C. R., Ladwig, T. T., Brown, J. M., Weygandt, S. S., Turner, D. D., Minnis, P., Smith, W. L., Jr., & Heidinger, A. K. (2021). Stratiform Cloud-Hydrometeor Assimilation for HRRR and RAP Model Short-Range Weather Prediction, Monthly Weather Review, 149(8), 2673-2694. **Assimilation**

Rugg, A., J. Haggerty, D. Adriaansen, W. L. Smith Jr., 2021: Extrapolating shortwave geostationary satellite imagery of clouds into nighttime using longwave observations, J. Appl. Rem. Sens. 15(3) 038501 (8 July 2021) https://doi.org/10.1117/1.JRS.15.038501 **Nighttime clouds**

Painemal, D., Corral, A. F., Sorooshian, A., Brunke, M. A., Chellappan, S., Afzali Gorooh, V., Ham, S.-H., O'Neill, L., Smith Jr., W. L., Tselioudis, G., Wang, H., Zeng, X., and Zuidema, P.: An Overview of Atmospheric Features Over the Western North Atlantic Ocean and North American East Coast—Part 2: Circulation, Boundary Layer, and Clouds, Journal of Geophysical Research: Atmospheres, 126, e2020JD033423, https://doi.org/10.1029/2020JD033423, 2021. **Validation**

Scarino, B., D. R. Doelling, K. Khlopenkov, W. L. Smith, and M. Nordeen "Improving the CERES SYN cloud and flux products by identifying GOES-17 scan anomalies using a convolutional neural network", Proc. SPIE 11829, Earth Observing Systems XXVI, 1182904 (1 August 2021); https://doi.org/10.1117/12.2594637. **DATA QC**

Painemal, D., Spangenberg, D., Smith Jr., W. L., Minnis, P., Cairns, B., Moore, R. H., Crosbie, E., Robinson, C., Thornhill, K. L., Winstead, E. L., and Ziemba, L.: Evaluation of satellite retrievals of liquid clouds from the GOES-13 Imager and MODIS over the midlatitude North Atlantic during NAAMES campaign, Atmos. Meas. Tech. Discuss. [preprint], https://doi.org/10.5194/amt-2021-7, Accepted, 2021. **Validation**

Dong, X. and P. Minnis, 2021: Chapter 8: Stratus, stratocumulus, and remote sensing, In Fast Physics in Large Scale Atmospheric Models: Parameterization, Evaluation, and Observations, Y. Liu, P. Kollias, and L. Donner, Eds., AGU-Wiley Publ., in press. **Book Chapter**

Valero, F. P. J., A. Marshak, and P. Minnis, 2021: LaGrange point missions: The key to next generation integrated Earth observations. DSCOVR innovation. Front. Remote Sens., doi:10.3389/frsen.2021.745938. **ERB**

*Minnis, P., et al., 2021: VIIRS **Ed1A Clouds Data Quality Summary**, just completed*

*Minnis, P., S. Sun-Mack, W. L. Smith, Jr., Q. Z. Trepte, Y. Chen, C. R. Yost, G. Hong, F.-L. Chang, R. A. Smith, P. W. Heck, C. Liu, and P. Yang, 2022: Continuing the CERES cloud record with SNPP VIIRS Edition 1 cloud property retrievals. Part 1: Algorithm and results., in preparation for Remote Sens. **ED1A Retrievals (in preparation)***

*Yost, C. R., Minnis, P., S. Sun-Mack, W. L. Smith, Jr., Q. Z. Trepte, and Y. Chen, 2022: Continuing the CERES cloud record with SNPP VIIRS Edition 1 cloud property retrievals. Part 2: Evaluation with CALIPSO., in preparation for Remote Sens. **ED1A validation (in preparation)***

QUESTIONS ?