

# The CLDMSK/CLDPROP Continuity Cloud Products for MODIS and VIIRS: Status and Product Updates

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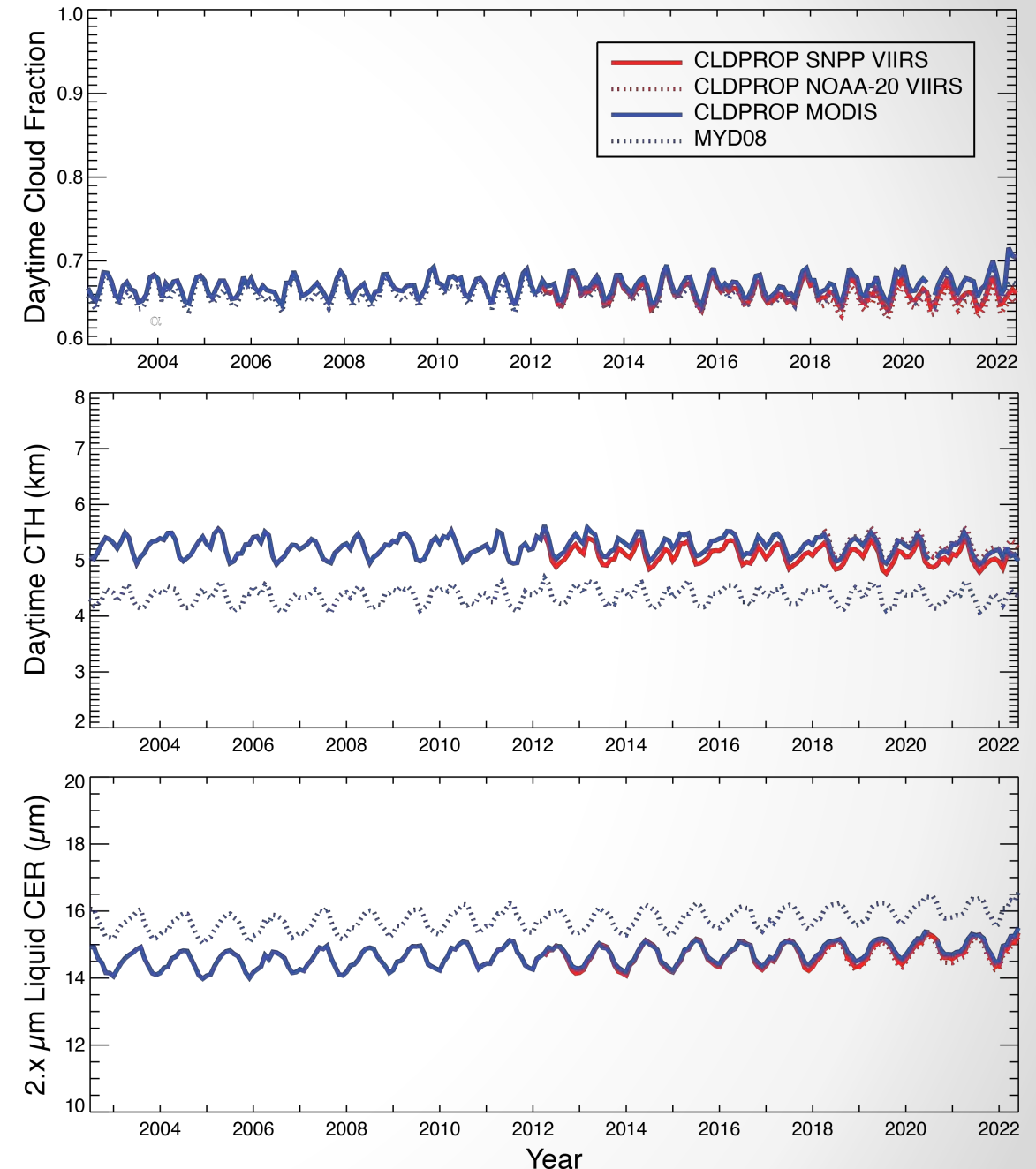
5. NOAA

# Background/Challenges

- **Continuity Challenge:** Direct porting of the EOS MODIS cloud algorithms to VIIRS is not possible due to key instrument differences.
  - Spectral channel omissions on VIIRS (H<sub>2</sub>O and CO<sub>2</sub> IR absorbing channels) – impacts on cloud height/phase
  - Spectral shift in the 2 $\mu$ m SWIR channel (VIIRS 2.25 $\mu$ m vs MODIS 2.13 $\mu$ m) – impacts on cloud phase/particle size
  - Differences in spatial resolution/sub-pixel information
- **CLDMSK/CLDPROP:** Common cloud masking and cloud-top/optical properties algorithms using only a subset of channels available on both MODIS and VIIRS
  - **Current product streams: Aqua MODIS; SNPP and NOAA-20 VIIRS**
  - Note: CLDMSK/CLDPROP are parallel product streams to the “standard” MODIS Science Team products for Terra (MOD35/MOD06), Aqua (MYD35/MYD06)

**CLDMSK:** Frey, R. A., S. A. Ackerman, R. E. Holz, S. Dutcher, Z. Griffith (2020), The continuity MODIS- VIIRS cloud mask, *Remote Sens.*, 12, 3334, doi:10.3390/rs12203334.

**CLDPROP:** S. Platnick, K. Meyer, G. Wind, R. E. Holz, N. Amarasinghe, P. A. Hubanks, B. Marchant, S. Dutcher, and P. Veglio (2021), The NASA MODIS-VIIRS continuity cloud optical properties products, *Remote Sens.*, 13, 2, doi:10.3390/rs13010002.



# CLDMSK/CLDPROP Product Status

Product	Sensors	Current Version	Version Notes
<b>CLDMSK_L2</b> (pixel-level cloud mask)	Aqua MODIS SNPP VIIRS NOAA-20 VIIRS	v1.0	Initial product release
<b>CLDPROP_L2</b> (pixel-level cloud-top/optical properties)		v1.1	Reprocessing of initial product release (late 2019) to address bug in cloud optical properties thermodynamic phase algorithm
<b>CLDPROP_D3/M3</b> (global gridded CLDMSK_L2 and CLDPROP_L2 statistics)		v1.1	Initial product release; includes statistics for CLDMSK_L2 v1.0 and CLDPROP_L2 v1.1

Aqua MODIS data record: 2002 – present

SNPP VIIRS data record: 2012 – present

NOAA-20 VIIRS data record: 2018 – present

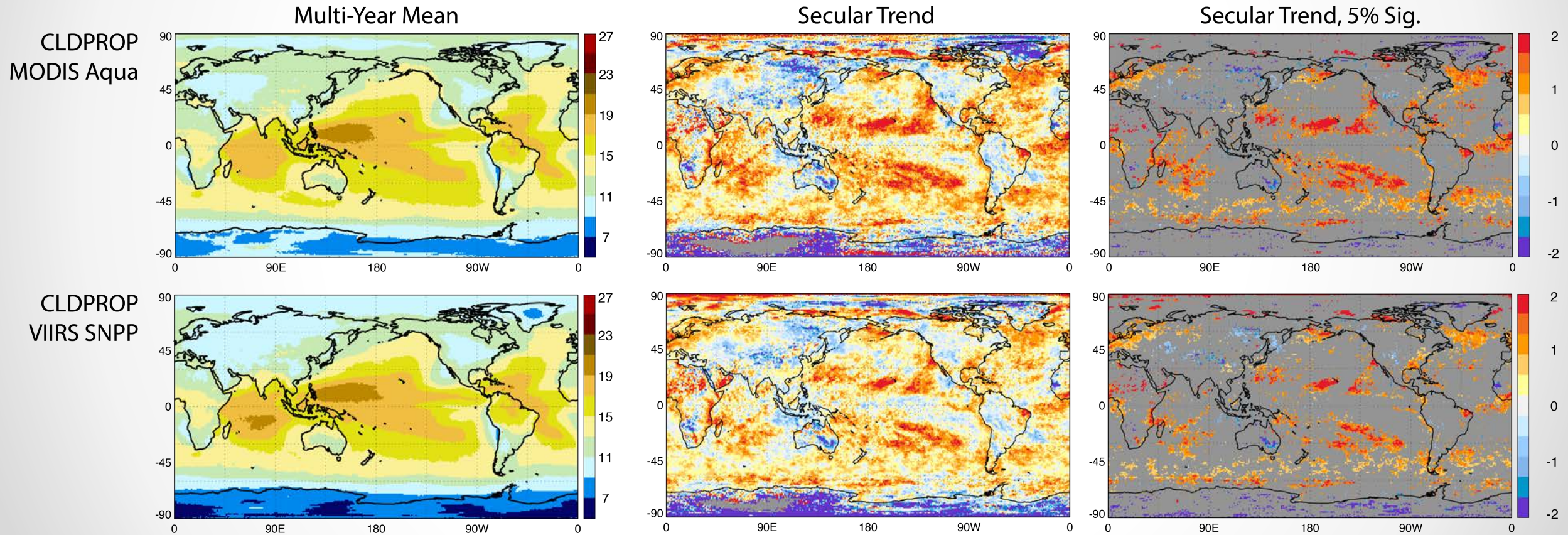
# CLDMSK/CLDPROP Product Status

- Notable Issues:
  - Post-Aqua safe hold status:
    - Safe hold from March 31 – April 14. Data after resumed science operations on April 17 through July 26 suffered increased cross-talk in several channels
      - MCST cross-talk fix entered forward production July 27
    - CLDMSK/CLDPROP products now reprocessed post-safe hold through July 26 using updated L1Bs.
      - Look for production dates in 2023
  - Full list of known issues for all MODIS/VIIRS continuity products:
    - <https://atmosphere-imager.gsfc.nasa.gov/continuity/issues>



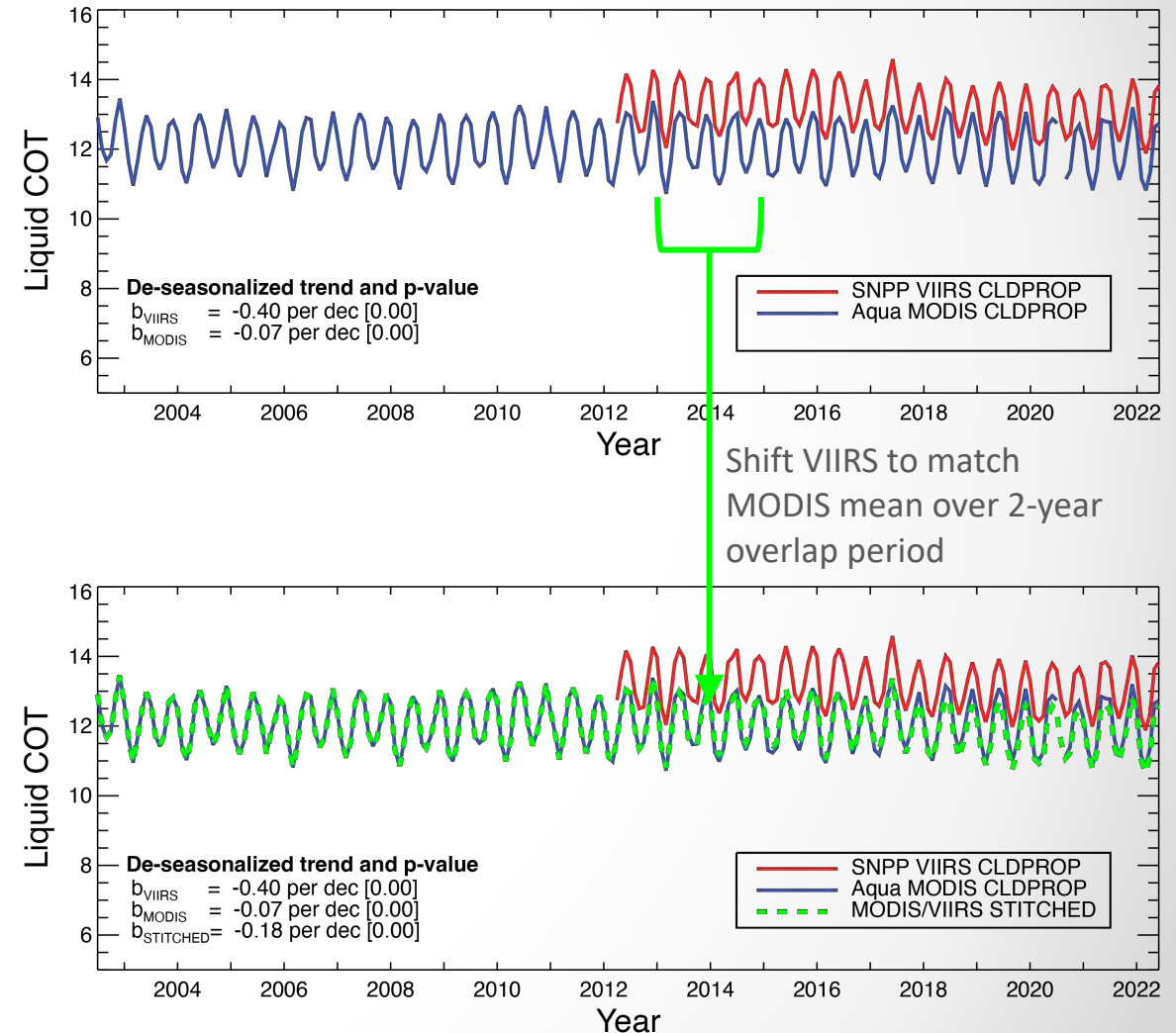
# CLDPROP Evaluation

MODIS Aqua vs VIIRS SNPP Liquid Cloud Effective Radius  
July 2012 – June 2020 ( $\mu\text{m}$  per decade)



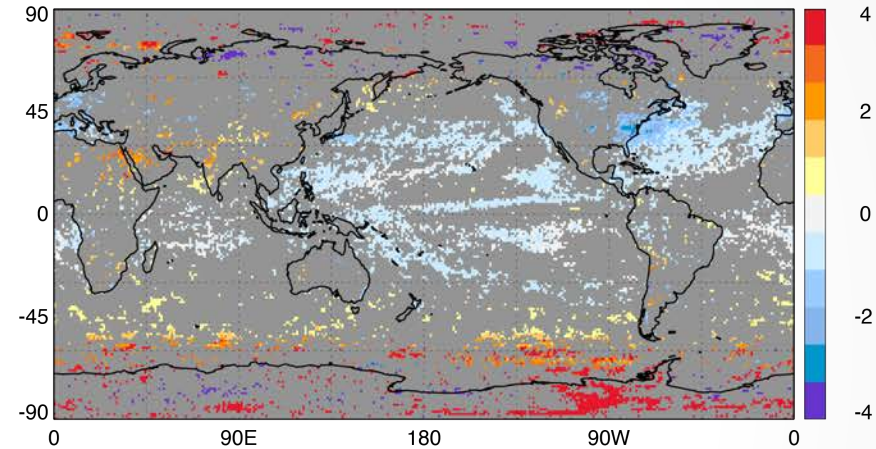
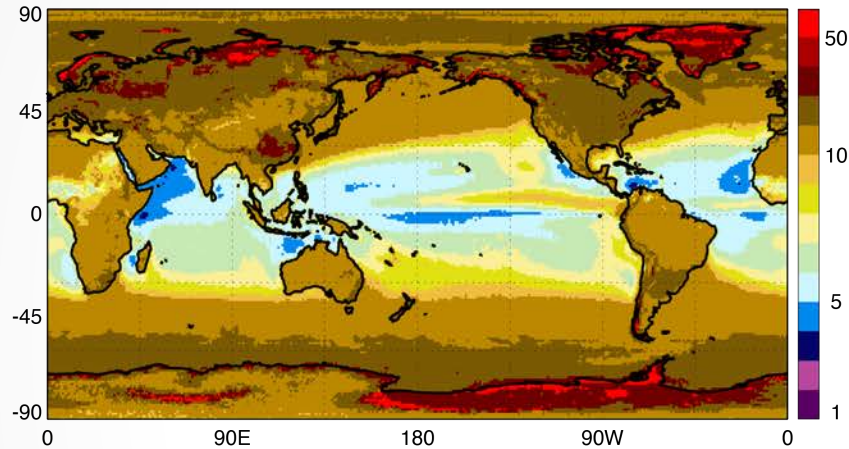
# MODIS + VIIRS Data Record “Stitching”

- Goal: Identify optimal approaches for merging, or “stitching”, the Aqua MODIS and SNPP/NOAA-20 VIIRS data records to achieve a continuous, multi-decadal cloud property dataset for trend studies, etc.
- Initial “stitching” approach (Aqua MODIS + SNPP VIIRS):
  - Shift the VIIRS time series by the mean MODIS – VIIRS difference computed for a 2-year overlap period (January 2013 – December 2014)
  - “Stitch” the MODIS and VIIRS time series (MODIS ends and VIIRS begins) at March, 2012
  - Evaluate the resulting MODIS + VIIRS “stitched” time series/trends against the full Aqua MODIS time series/trends (July 2002 – June 2022)



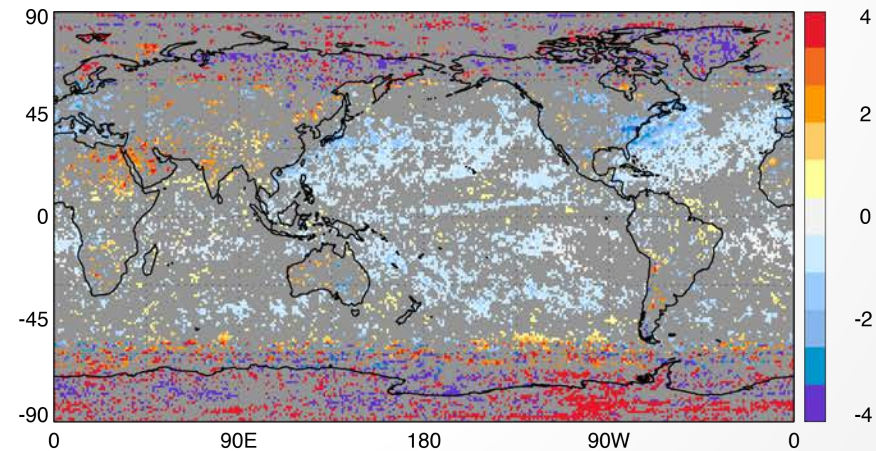
# MODIS + VIIRS Data Record “Stitching”

CLDPROP MODIS  
Multiyear Mean  
(July 2002 – June  
2022)



MODIS  
COT/decade  
( $p \leq 0.05$ )

## Liquid COT

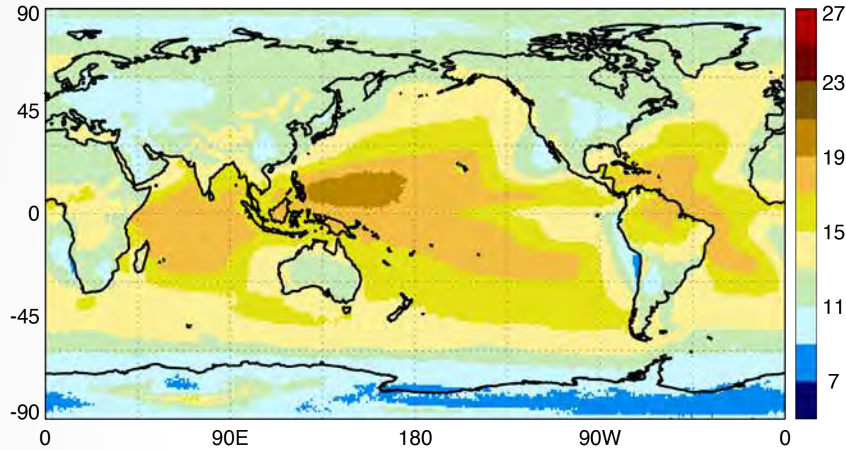


MODIS + VIIRS  
"Stitched"  
COT/decade  
( $p \leq 0.05$ )

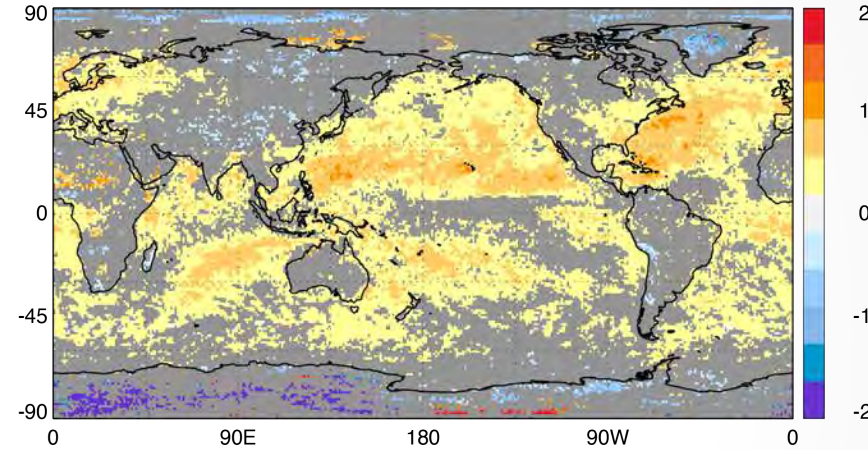


# MODIS + VIIRS Data Record “Stitching”

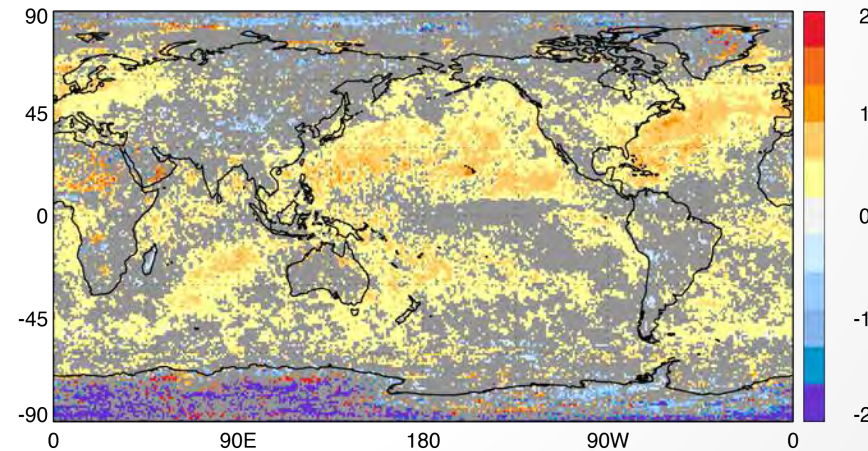
CLDPROP MODIS  
Multiyear Mean  
(July 2002 – June  
2022)



Liquid CER ( $2.x \mu\text{m}$ )



MODIS  
 $\mu\text{m}/\text{decade}$   
( $p \leq 0.05$ )

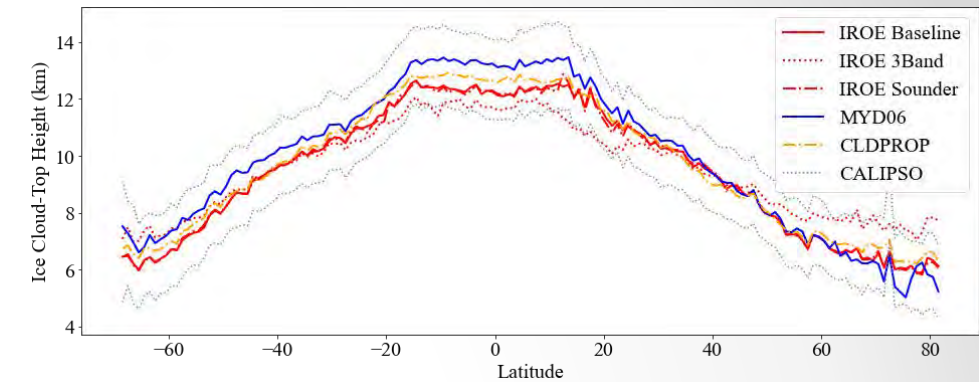


MODIS + VIIRS  
“Stitched”  
 $\mu\text{m}/\text{decade}$   
( $p \leq 0.05$ )

# Major v2 Science Updates

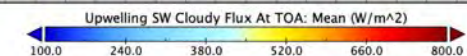
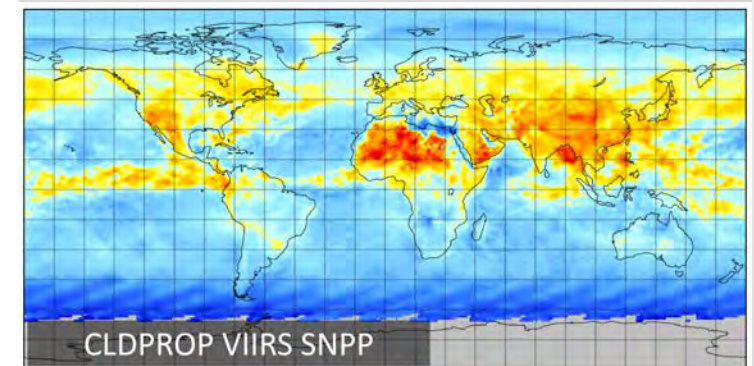
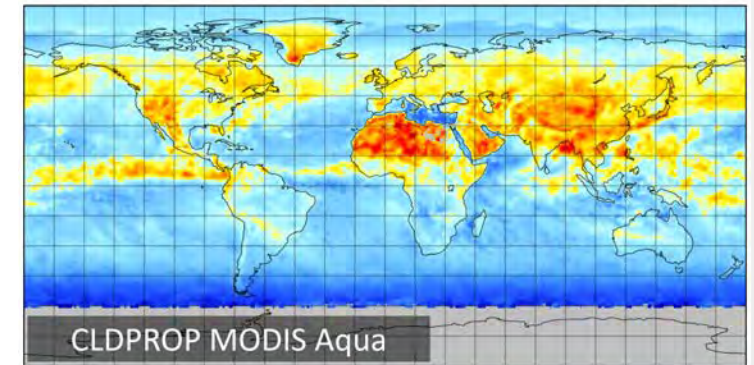
- **New cloud-top properties algorithm [in science testing]**
  - Infrared Optimal Estimation (IROE, Wang et al. 2016a,b) will supplement NOAA CLAVR-x.
  - Will provide ice cloud-top height and day/night ice cloud optical properties with pixel-level uncertainties. Will be vehicle to incorporate H<sub>2</sub>O, CO<sub>2</sub> absorption channel information from co-located sounders (MODIS/AIRS, VIIRS/CrIS).
  - See Wang et al. poster
- **Pixel-level broadband flux calculations [in science testing]**
  - RRTMG integrated into the CLDPROP (and MOD06) retrieval code base to enable TOA/surface shortwave/longwave flux calculations using cloud property retrievals as input
  - See Peterson et al. poster
- **Machine learning cloud thermodynamic phase algorithm [in science testing]**
  - Random Forest models (IR only, IR+NIR/SWIR) show improved skill over current hand-tuned algorithms (Wang et al 2020)
  - Will provide a consistent phase classification across both cloud-top and optical properties retrievals; IR-only approach also enables consistency across day/night
  - See Wang et al poster

## MODIS IROE CTH vs CALIOP, MYD06, CLDPROP



## Engineering test of CLDPROP flux (RRTMG)

*TOA Upwelling SW Cloudy Flux*



# Other v2 Science Updates

- Leverage high-resolution VIIRS 375m I-bands for sub-pixel information
  - CLDMSK 375m cloud mask analogous to MOD35 250m mask [in science testing]
    - See Veglio et al. poster
  - Sub-pixel heterogeneity QA and partly cloudy (PCL) pixel classification for CLDPROP cloud optical properties (analogous to MOD06)
- Complementary thin cirrus optical thickness retrievals using the 1.38 $\mu$ m water vapor absorption channel (Meyer and Platnick 2010) [in science testing]

# Plans for NOAA-21

- We expect to add NOAA-21 VIIRS to the current CLDMSK\_L2 (v1.0), CLDPROP\_L2 (v1.1), and CLDPROP\_D3/M3 (v1.1) production streams once the L1B is available and vetted
  - L1B vetting includes SW radiometric intercalibration assessment (see Meyer et al., 2020)
- Will be included in v2 reprocessing

# Beyond MODIS and VIIRS

- The CLDMSK/CLDPROP common algorithm approach provides internally consistent cloud retrievals across any imager having spectral capabilities like MODIS/VIIRS, thus is a key enabling effort for NASA Earth Science beyond climate data records
  - MODIS/VIIRS along with the new generation of advanced GEO imagers (e.g., GOES-16/17 ABI, Himawari AHI, etc.) form an imager **Program of Record (PoR)** that is expected to be a key contributor to the synergistic science envisioned for the upcoming NASA Decadal Survey Designated Observable missions, such as AOS, currently in formulation
    - CLDMSK/CLDPROP ported to GEO imagers leveraging seed funding and ESROGSS 2019
  - Imagers having high spatial resolution and/or multi-angle capabilities support NASA field campaign efforts and are of interest for studies of scale and angle effects
    - MODIS/VIIRS cloud algorithms ported to eMAS/RSP (airborne), Landsat-8 OLI, Sentinel-2A/B leveraging CAMP2Ex, ARCSIX, and many previous field campaign funding
  - ***The above efforts also highly leverage MODIS/VIIRS Science Team funding***