Cloud Detection, Height, and Optical Properties: Status of MYD06/35 & MODIS/VIIRS Product Continuity

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MODIS/VIIRS Science Team Meeting
Silver Spring, MD
15 October 2018

Topics

- MODIS C6.1 Cloud Property Product Status
- Continuity Product Status
  - Continuity paradigm
  - Algorithm/production status and initial results
  - Next steps

MODIS Atmosphere Team Collection History

Collection	Start of Reprocessing MODIS Terra	Start of Reprocessing MODIS Aqua
6.1	Sept. 2017 (completed Dec. 2017)	Dec. 2017 (completed March 2018)
6.0	2014	2013
5.1	2008	2008
5.0	2005	2005
4	2002	2002
3	2001	2002
1	2000	–

C6.0/C6.1 Highlights for Cloud Products

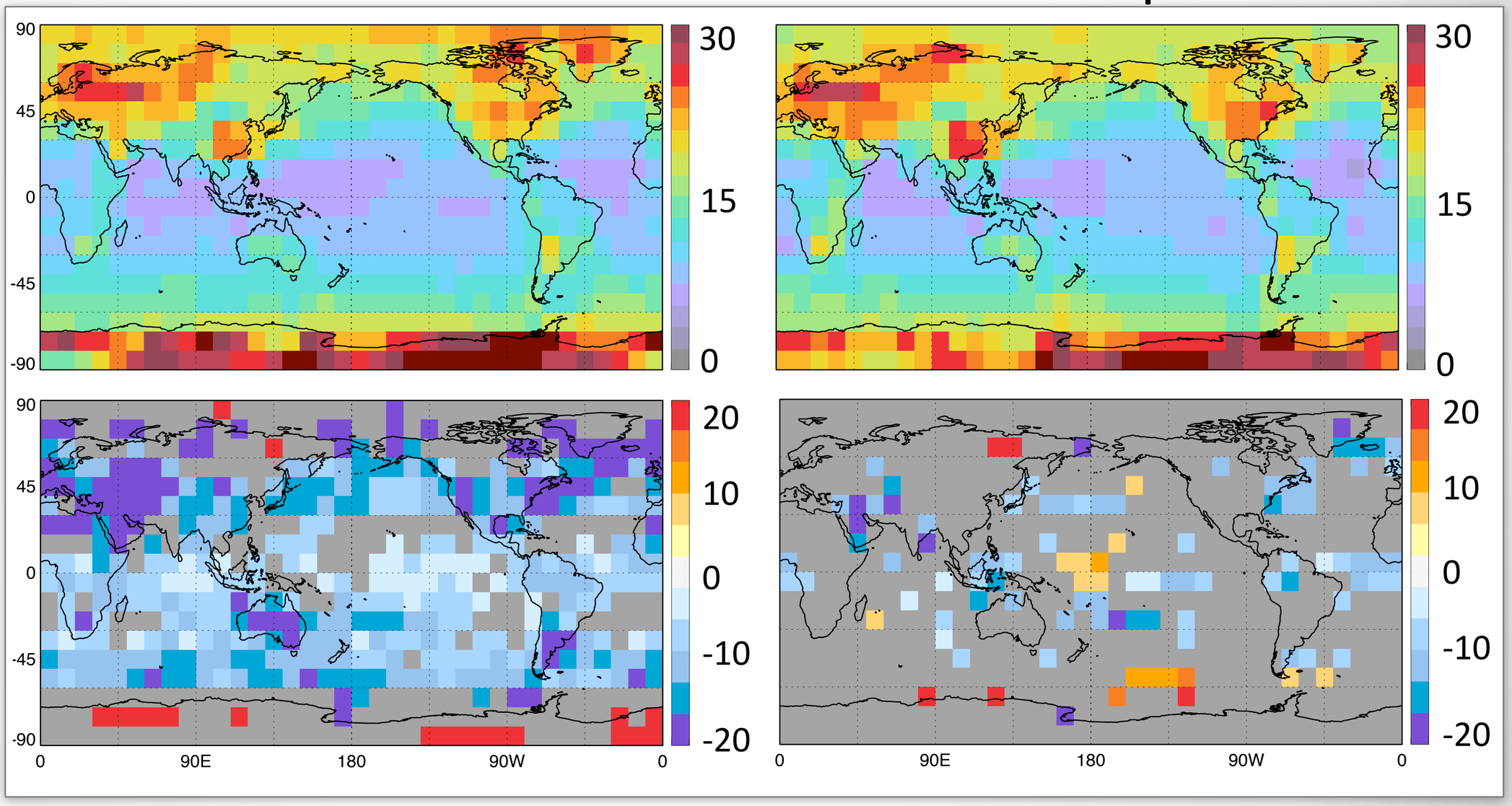
- L1B
  - C6.0: Aqua VNIR spatial “re-registration”, Terra VNIR/SWIR radiometric corrections (RVS)
  - C6.1: Terra IR cross-talk corrections, further Aqua/Terra RVS corrections
- C6 L2 cloud properties
  - Cloud mask threshold updates
  - New 1km cloud-top dataset
  - Optical/microphysical: numerous updates
    - New radiative transfer, ice particle models, phase algorithm, surface (C5 gap-filled land spectral albedo, variable wind speed ocean model). Additional error sources in pixel-level uncertainty calculations. Spectral effective radius retrievals explicit. Processing of lower quality “partly cloudy” pixels + failed retrieval info.

Climate Record Challenges: Terra VNIR Calibration Story

Climate Record Challenges: Terra VNIR Calibration Story

C5.1 Cloud Optical Thickness (COT) annual mean, liq. water clouds

C5.1 COT trend (%/dec) July 2002-June 2010, 5% sig. level



Climate Record Challenges: Terra VNIR Calibration Story

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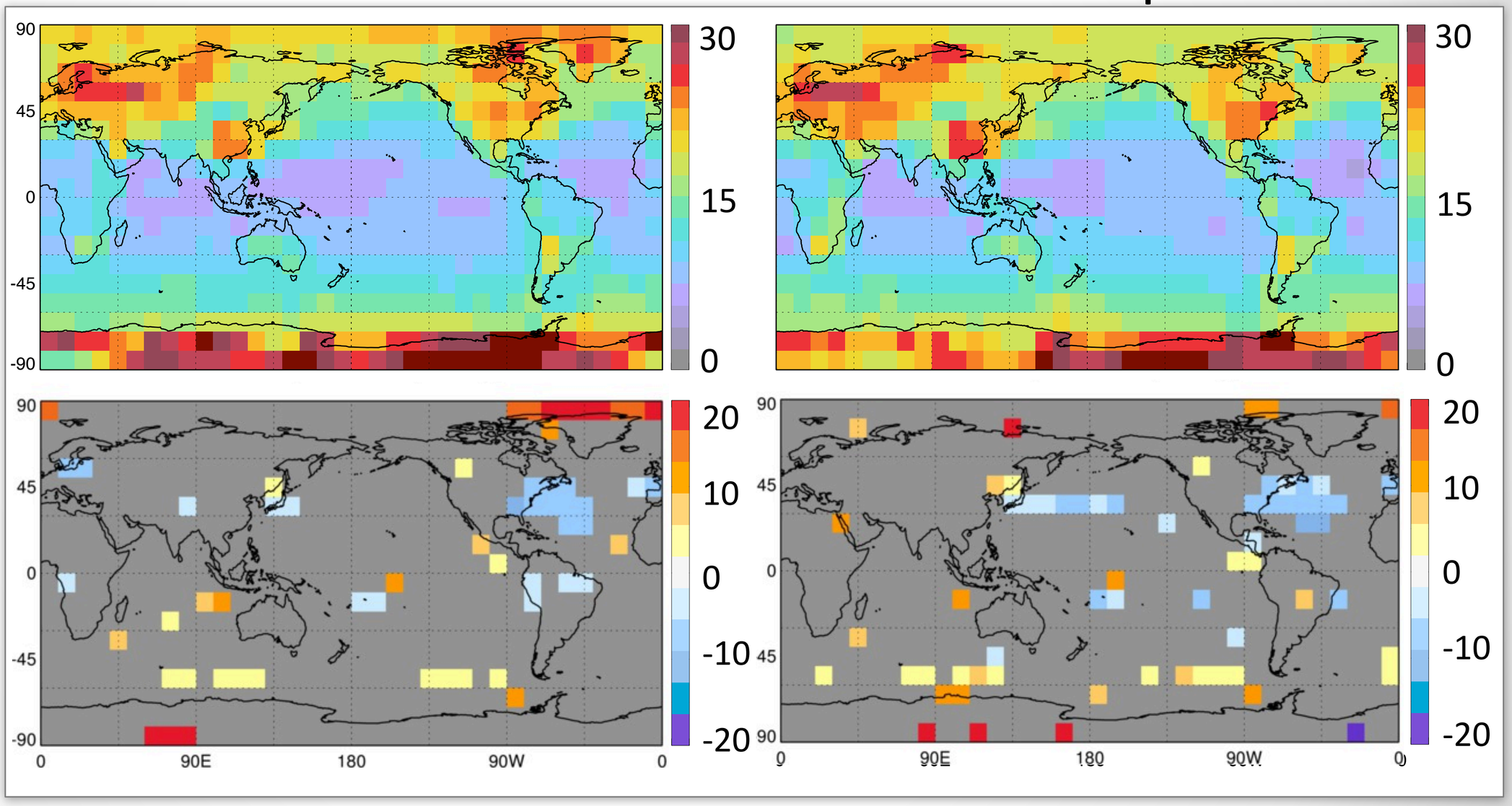
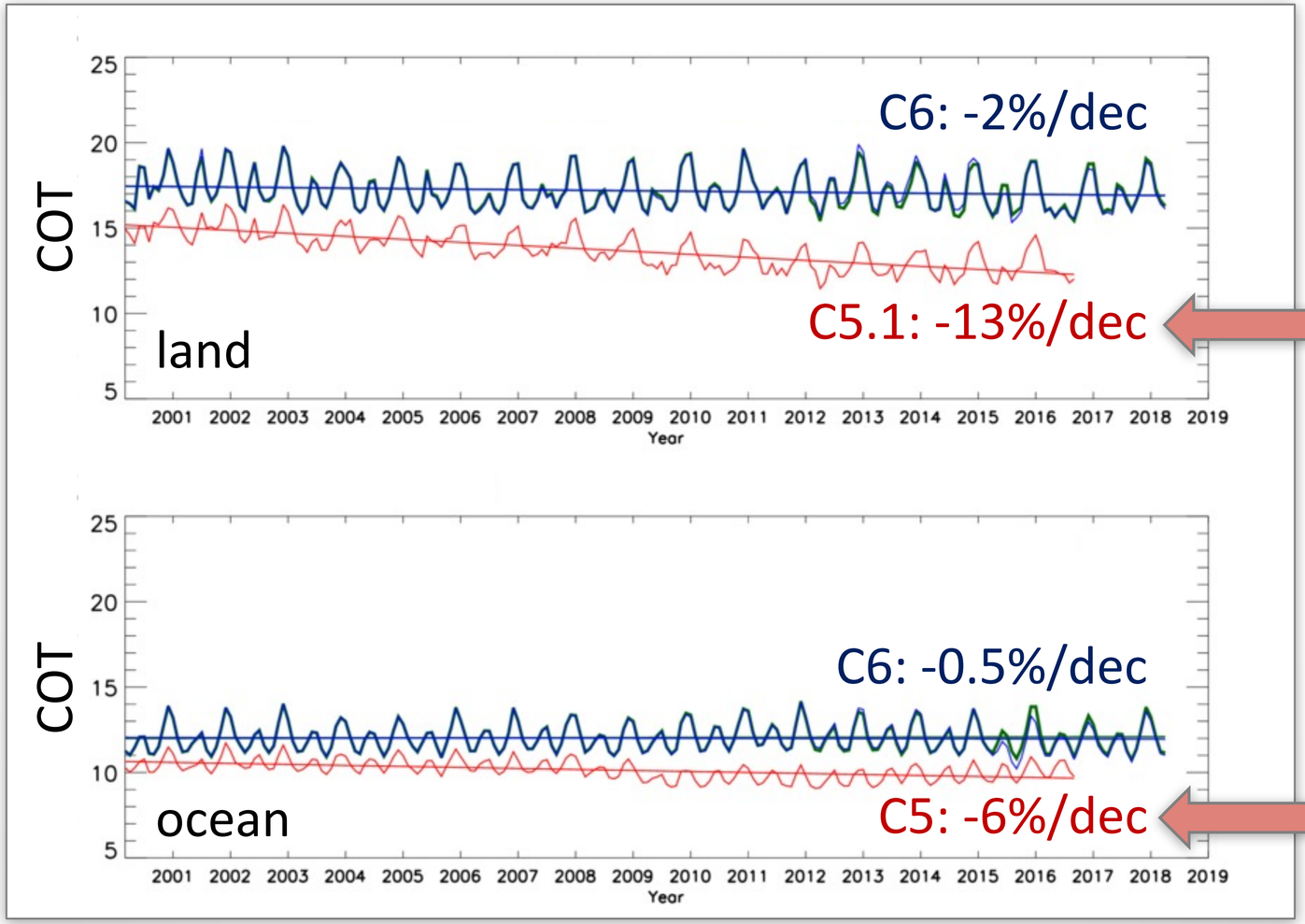


Climate Record Challenges: Terra VNIR Calibration Story

Terra MODIS Liquid water Cloud Optical Thickness (COT) Trends

18-yr time series, ±60° zonal mean

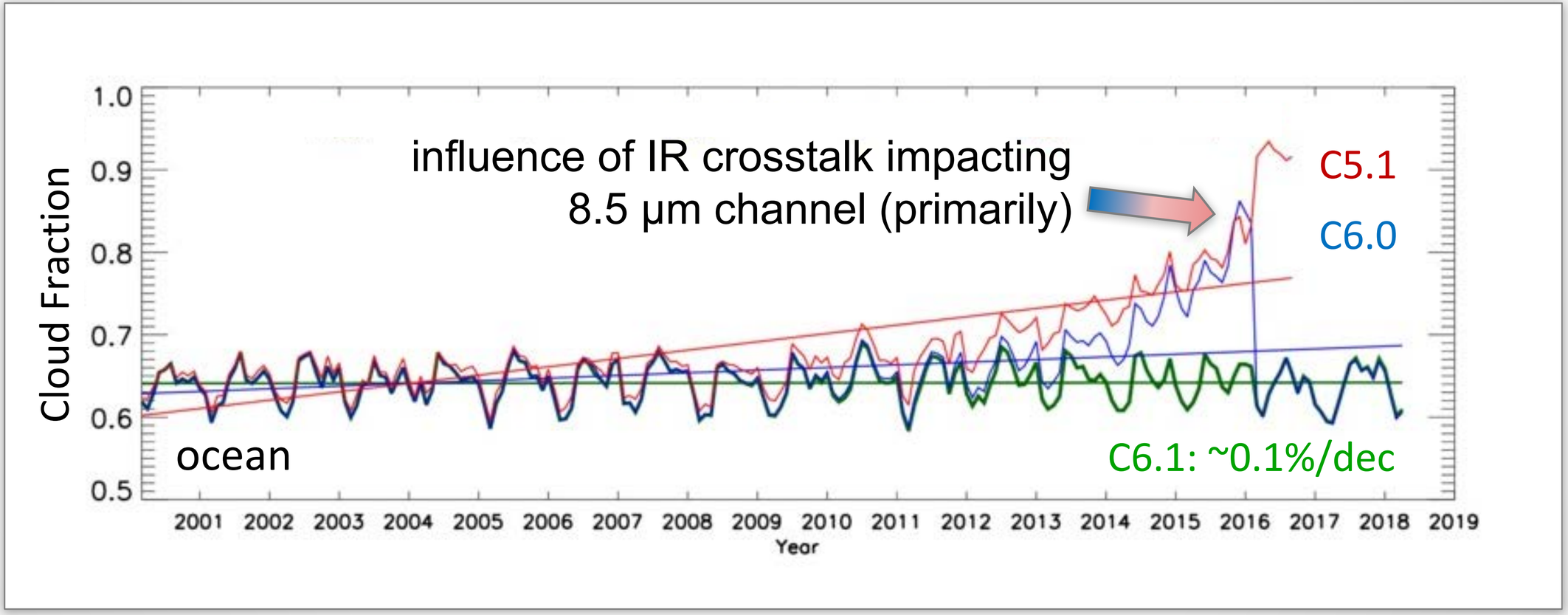


influence of 0.67 μm channel calibration drift

0.86 μm drift

Climate Record Challenges: Terra IR Calibration Story

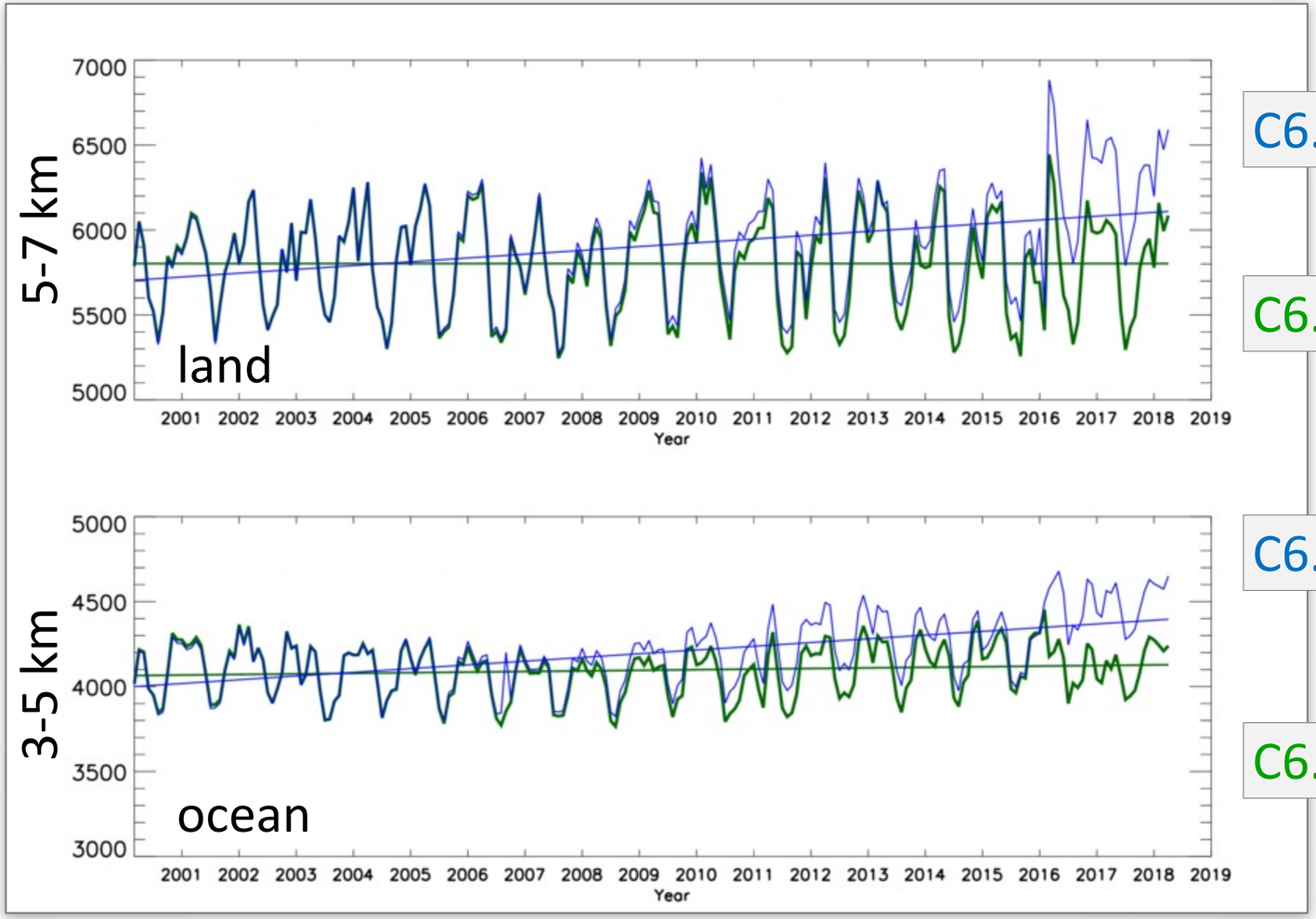
Cloud Fraction, Terra 18-yr time series, ±25° zonal mean over ocean



Climate Record Challenges: Terra IR Calibration Story

Cloud Top Height, Terra 18-yr time series, ±60° zonal mean

influence of IR crosstalk



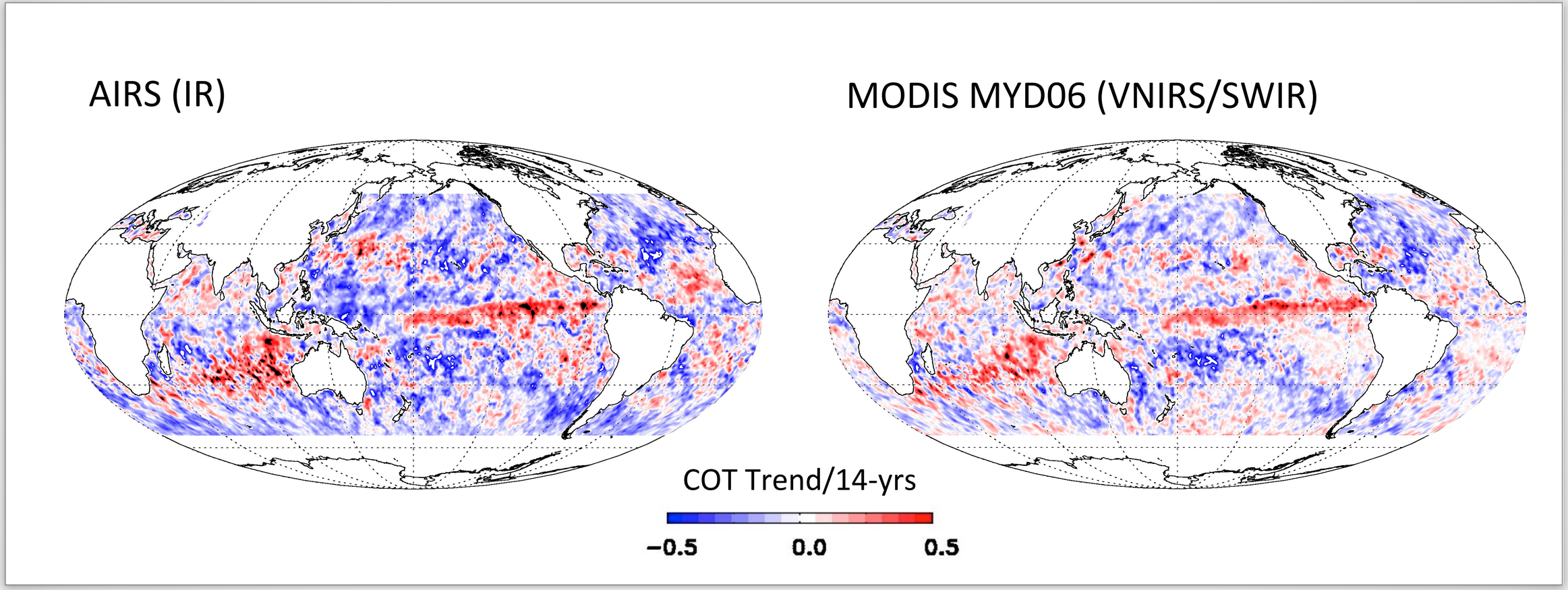
C6.0: 4%/dec

C6.1: ~0%/dec

C6.0: 5%/dec

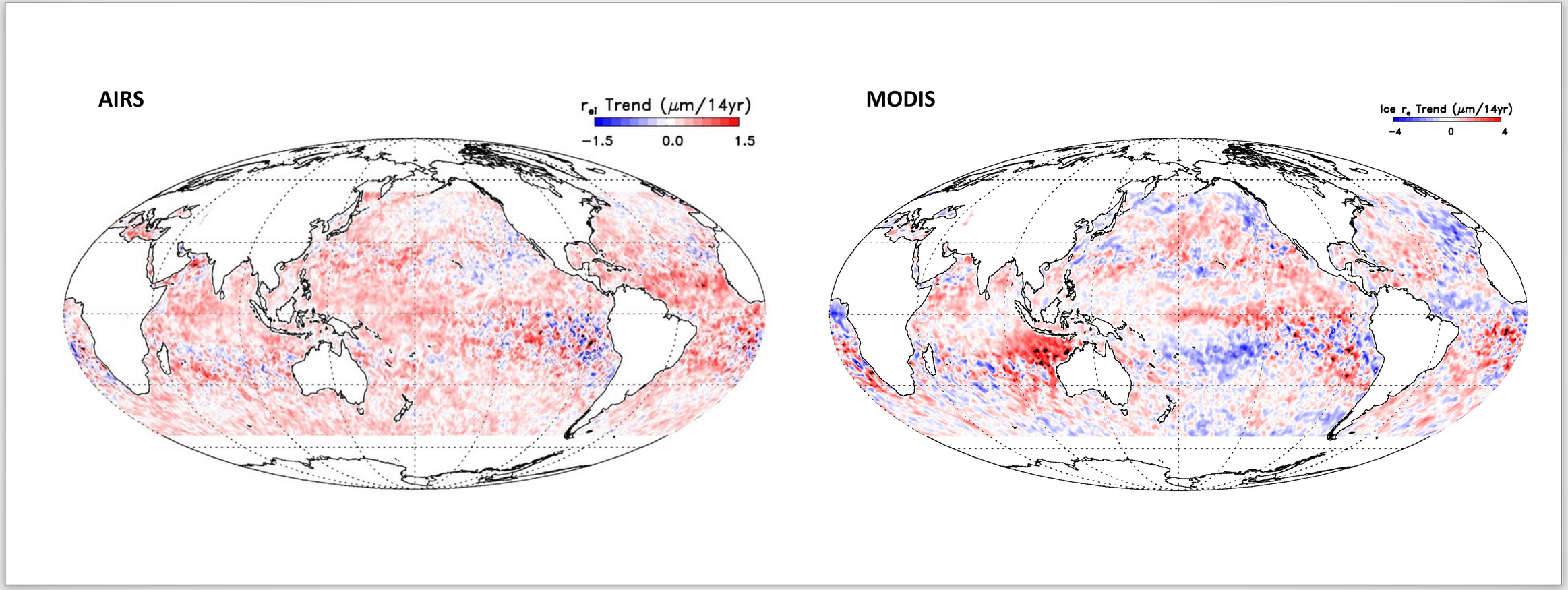
C6.1: ~1%/dec

AIRS & MODIS Ice COT Trend (2002-2016)



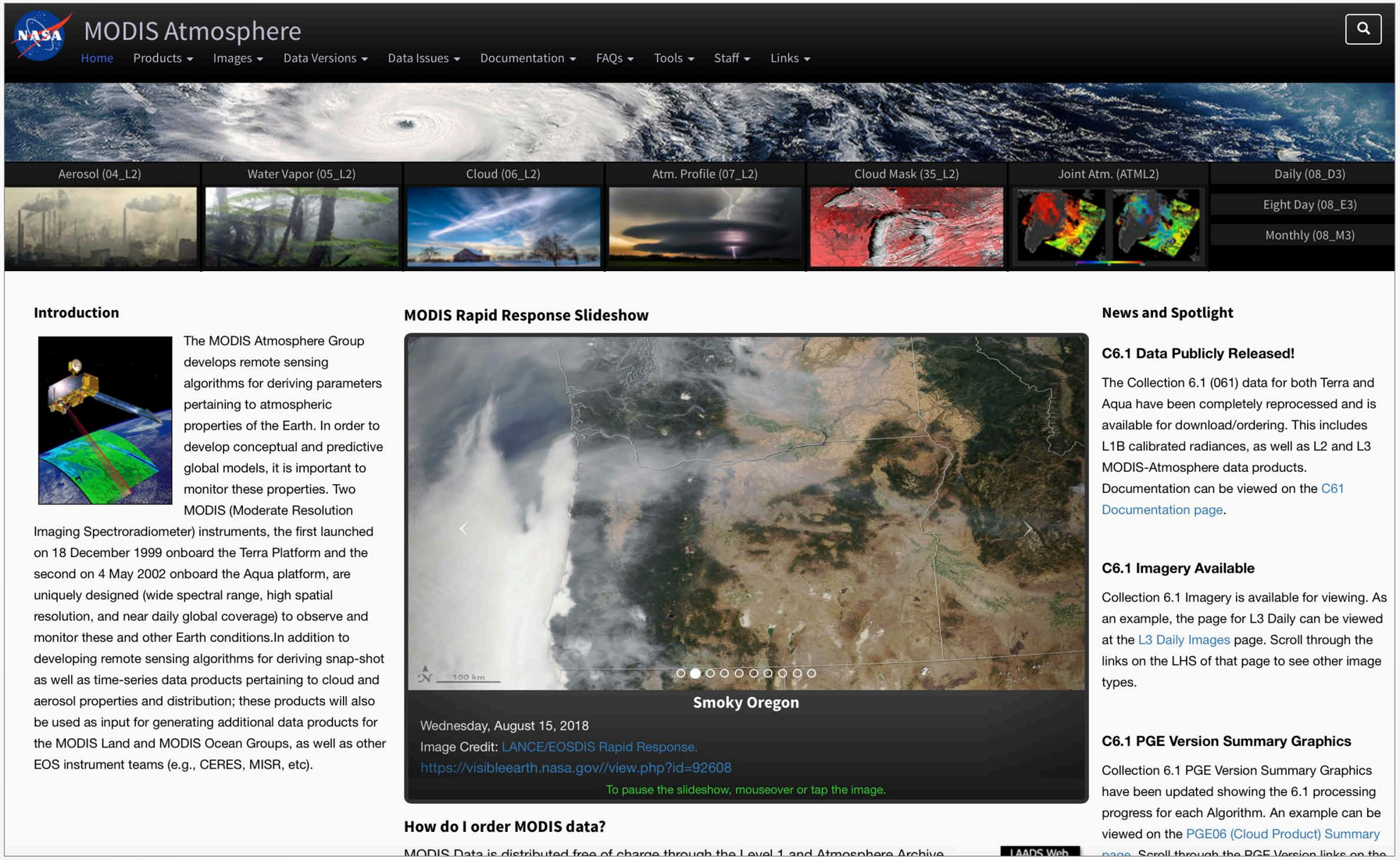
Brian Kahn (JPL)

AIRS & MODIS Ice CER Trend (2002-20016)



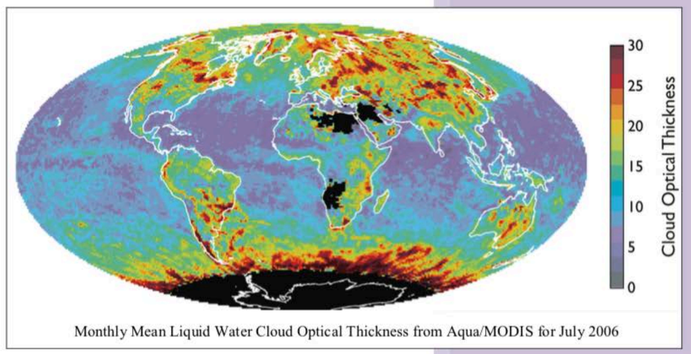
Brian Kahn (JPL)

New Atmosphere Team Web Site



MODIS User Guides

MODIS Atmosphere L3 Gridded Product Algorithm Theoretical Basis Document (ATBD) & Users Guide



Monthly Mean Liquid Water Cloud Optical Thickness from Aqua/MODIS for July 2006

PAUL HUBANKS[1], STEVEN PLATNICK[2], MICHAEL KING[3] AND BILL RIDGWAY[4]

MODIS Algorithm Theoretical Basis Document No. ATBD-MOD-30
for Level-3 Global Gridded Atmosphere Products (08_D3, 08_E3, 08_M3)
and Users Guide

(Collection 006, Version 4.3, 11 April 2018)

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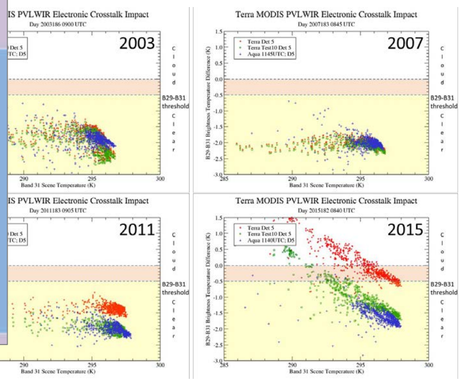
3 Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO
4 SSAI Corp, Greenbelt, MD

123 pp.

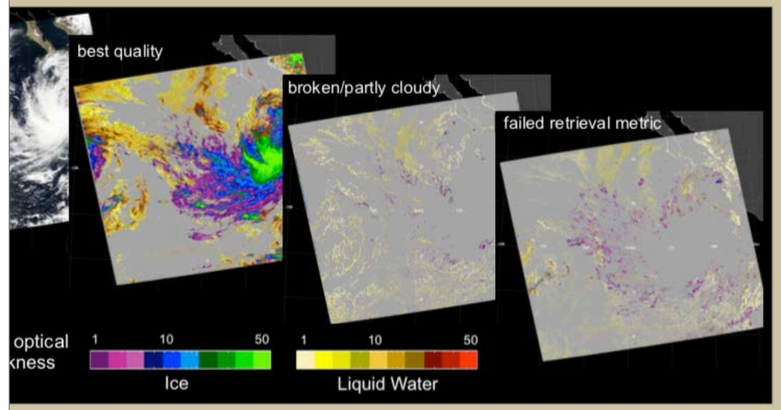
MODIS Collection 6.1 Calibration and Cloud Product Changes
Version 1.0 (27 June 2017)
Authored by Chris Moeller and Richard Frey (University of Wisconsin)

D021KM)

S Photovoltaic (PVLWIR) bands 27-30 are known to experience an electronic crosstalk
The influence of the crosstalk has gradually increased over the mission lifetime, causing
rth surface features to become prominent in atmospheric band 27, increased detector
g term drift in the radiometric bias of these bands. The drift has compromised the
f C6 Terra MODIS L2 products that depend significantly on these bands, including cloud
cloud fraction and cloud top properties (MOD06), and total precipitable water (MOD07).
k correction algorithm has been developed and tested by MCST. It uses band averaged
cients based upon monthly lunar views by Terra MODIS and has been adopted for
into C6.1 operational L1B processing (Wilson et al. 2017). In stressing test cases from
eriods of the Terra mission lifetime, the correction algorithm maintains or restores the
band radiances to nominal performance as indicated through comparisons to Aqua
s. The Figure 1 example for band 29 shows that the crosstalk influence has increased
g the Terra MODIS C6 brightness temperatures (red) away from the C6 Aqua MODIS
eratures (blue). For crosstalk corrected C6.1 data (green), the Terra and Aqua MODIS
eratures are brought much more closely into agreement.



MODIS Cloud Optical Properties: User Guide for the Collection 6/6.1 Level-2 MOD06/MYD06 Product and Associated Level-3 Datasets



Version 1.1
July 2018

146 pp.

Topics

- MODIS C6.1 Cloud Property Product Status
- Continuity Product Status
  - Continuity paradigm and strategy
  - Algorithm/production status and initial results
  - Next steps

Background

- History: direct continuity between MYD35/MYD06 not feasible

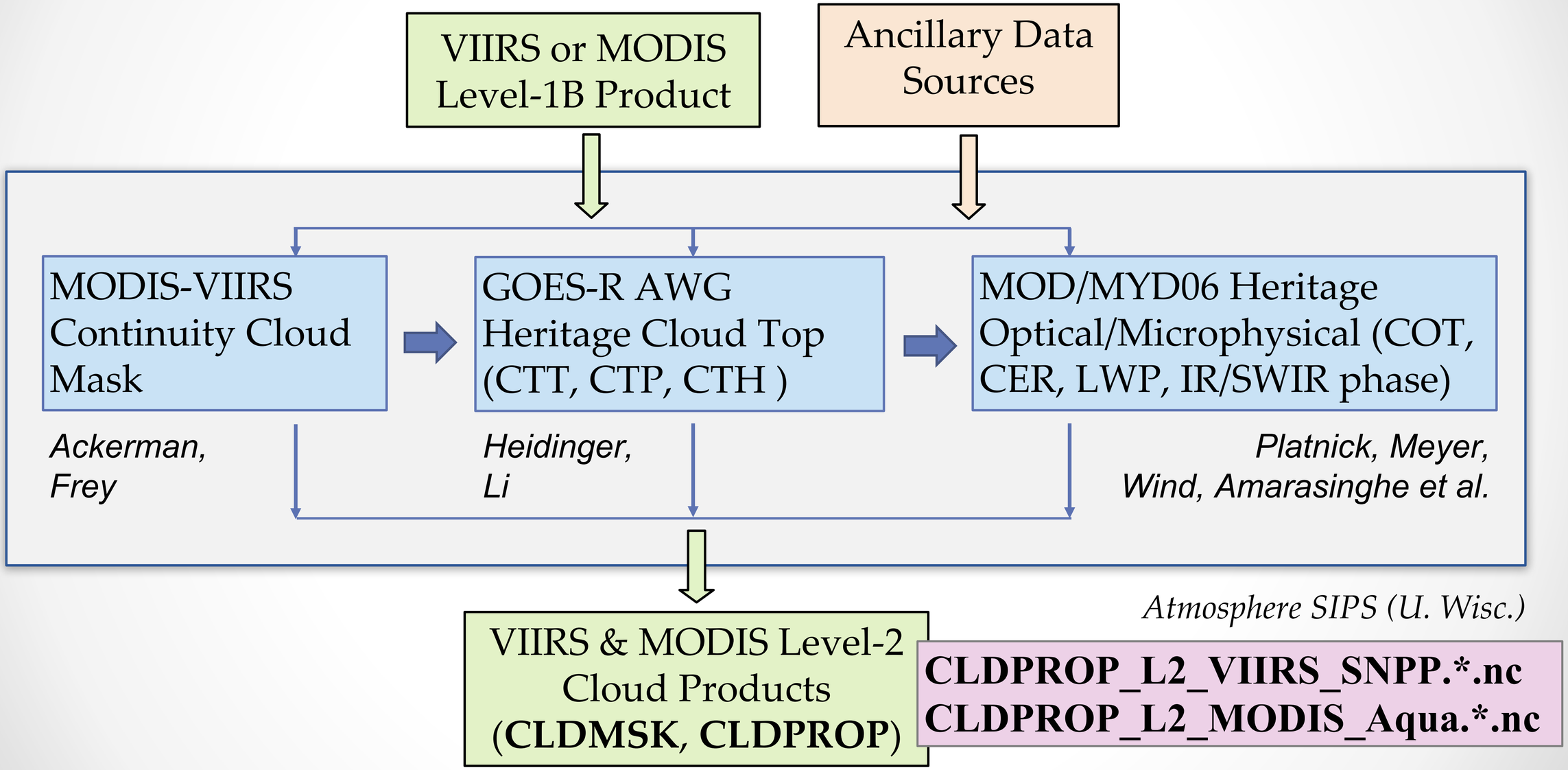
  ROSES-funded VIIRS Cloud EDR Assessment Report (2013), EOS-SNPP Continuity White Paper (2011/12), ROSES 2013 & ROSES 2017 proposals

- Approach: apply common algorithms to both VIIRS and MODIS using common/near-common subset of spectral bands.
  - cloud mask and optical properties (MOD06/MOD35 Collection 6 heritage: *Ackerman, Platnick, et al.*)
  - cloud-top properties (GOES-R AWG heritage: *Heidinger et al.*)
  - MOD08-consistent L3 via SIPS code/infrastructure + algorithm team config. file (not orphaned).

Major Challenges for MODIS/VIIRS Cloud Product Continuity

- Spectral coverage (most direct challenge)
  - "**2.x *μ*m**" window band: **VIIRS 2.25 *μ*m vs. MODIS 2.13 *μ*m** channel
  - VIIRS missing MODIS CO_2 and H_2O absorption channels
- Spatial resolution and spatial/temporal sampling
  - VIIRS (750, 375 m) vs. MODIS (1000 , 500 , 250 m) at nadir
  - VIIRS pixel size DOES NOT increase as substantially with scan as MODIS
  - Missing M-band bow-tie pixels are "added" by Atmosphere SIPS for all results that follow
- Relative radiometric calibration in solar reflectance channels
  - Requires spectral bias corrections (*Meyer et al.* presentation)

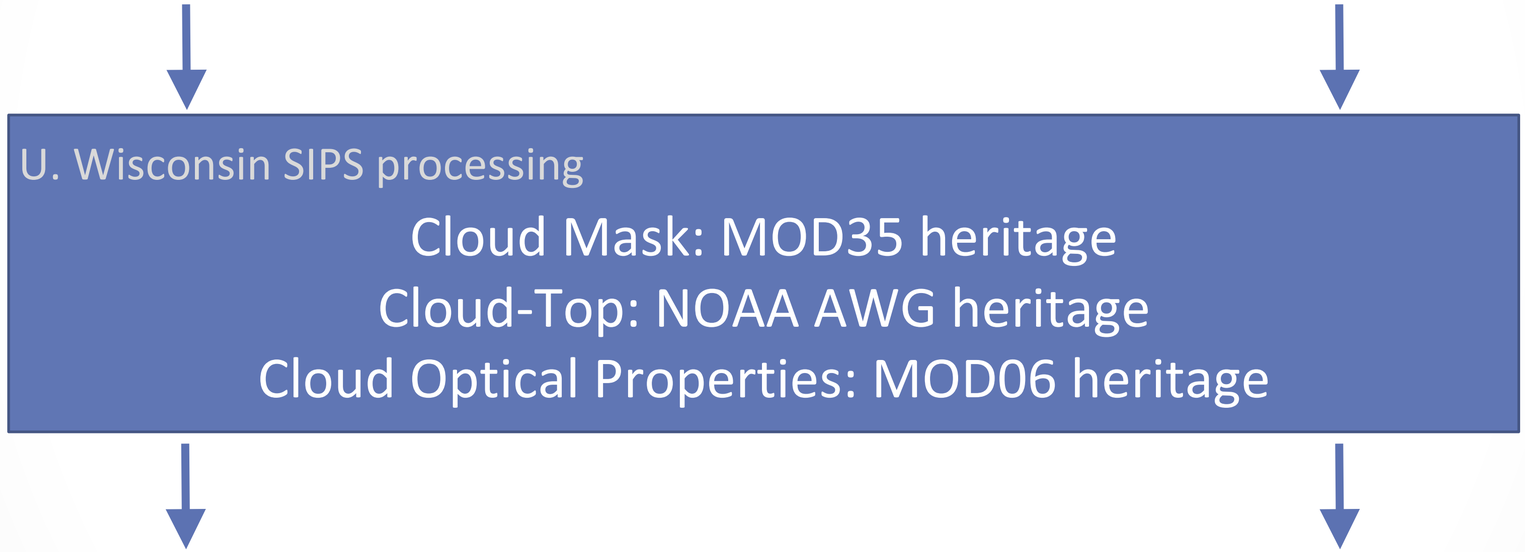
Strategy for Spectral Differences: Common MODIS & VIIRS Algorithm



Strategy for Spectral Differences: Common MODIS & VIIRS Algorithm

MODIS L1B + Geolocation
MOD02, **MOD03**
(channel subset common w/VIIRS)

NASA VIIRS L1B (with restored bow-tie pixel deletions* + VNIR/SWIR radiometric adjustments*) + Geolocation
VNP02MOD, **VGEOM**



MODIS Continuity Products
CLDMSK_L2_MODIS_Aqua
CLDPROP_L2_MODIS_Aqua

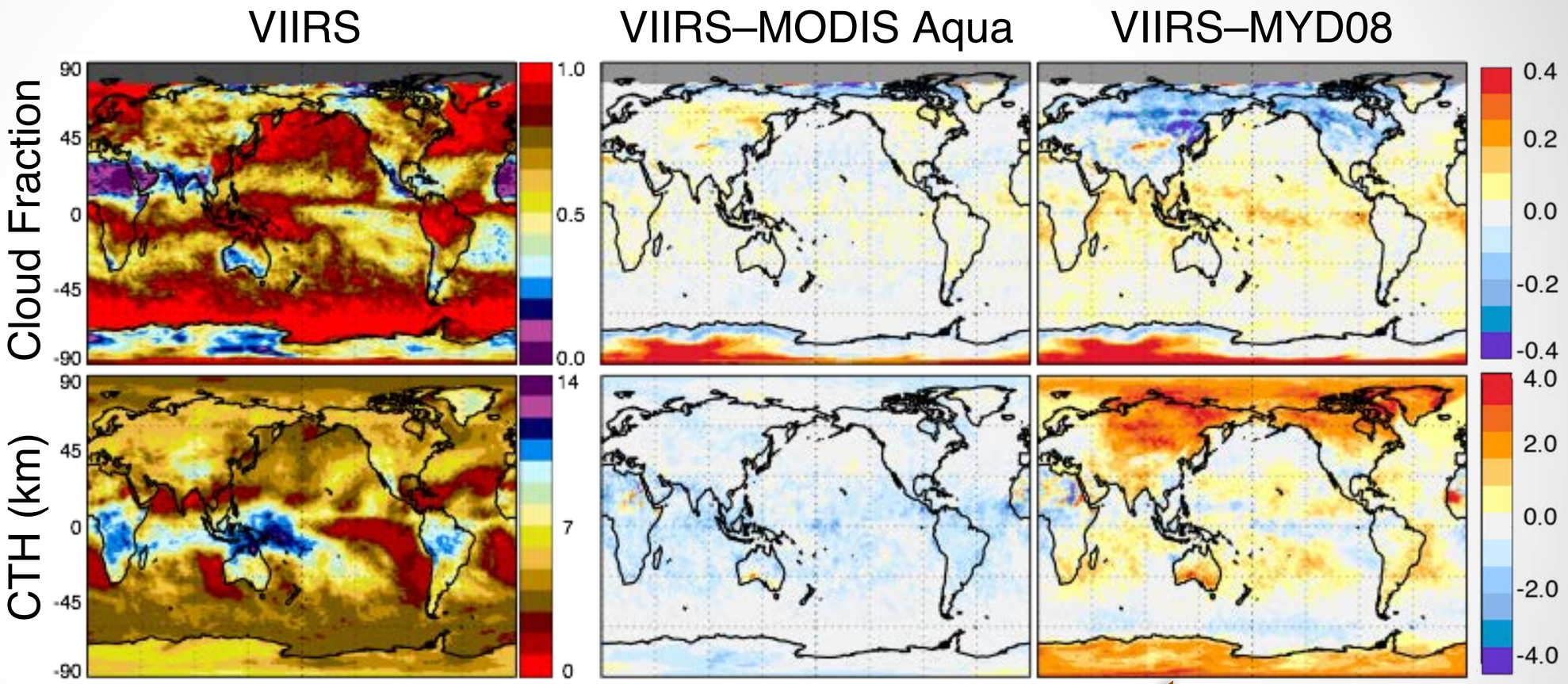
VIIRS Continuity Products
CLDMSK_L2_VIIRS_SNPP
CLDPROP_L2_VIIRS_SNPP

* Atmosphere SIPS intermediate L1B product

Monthly Means
Feb 2014

- Most recent version of common algorithm, includes SW Radiometric Bias Correction
- Pixel-weighted multi-day aggregation over common MODIS swath
- Day + Night

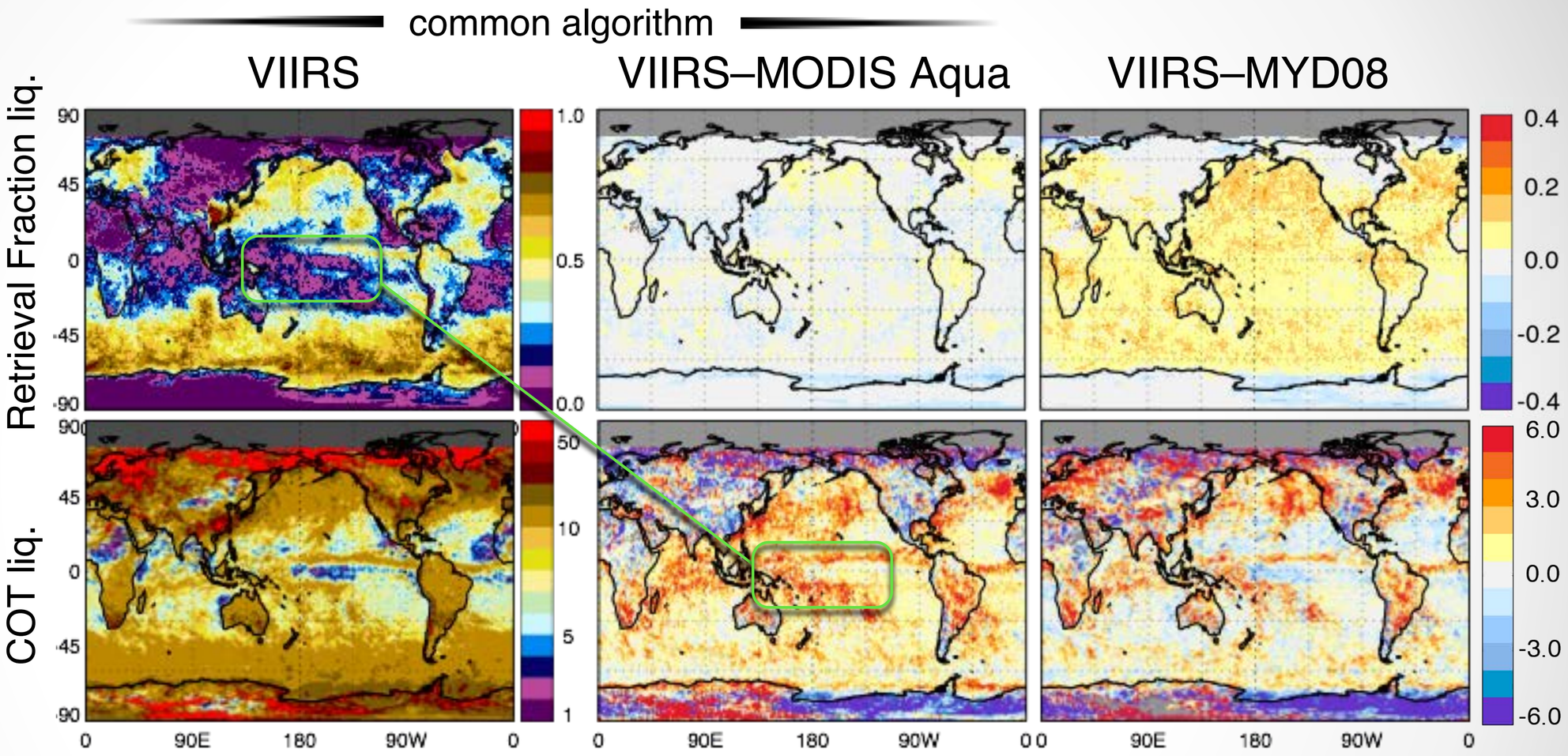
common algorithm



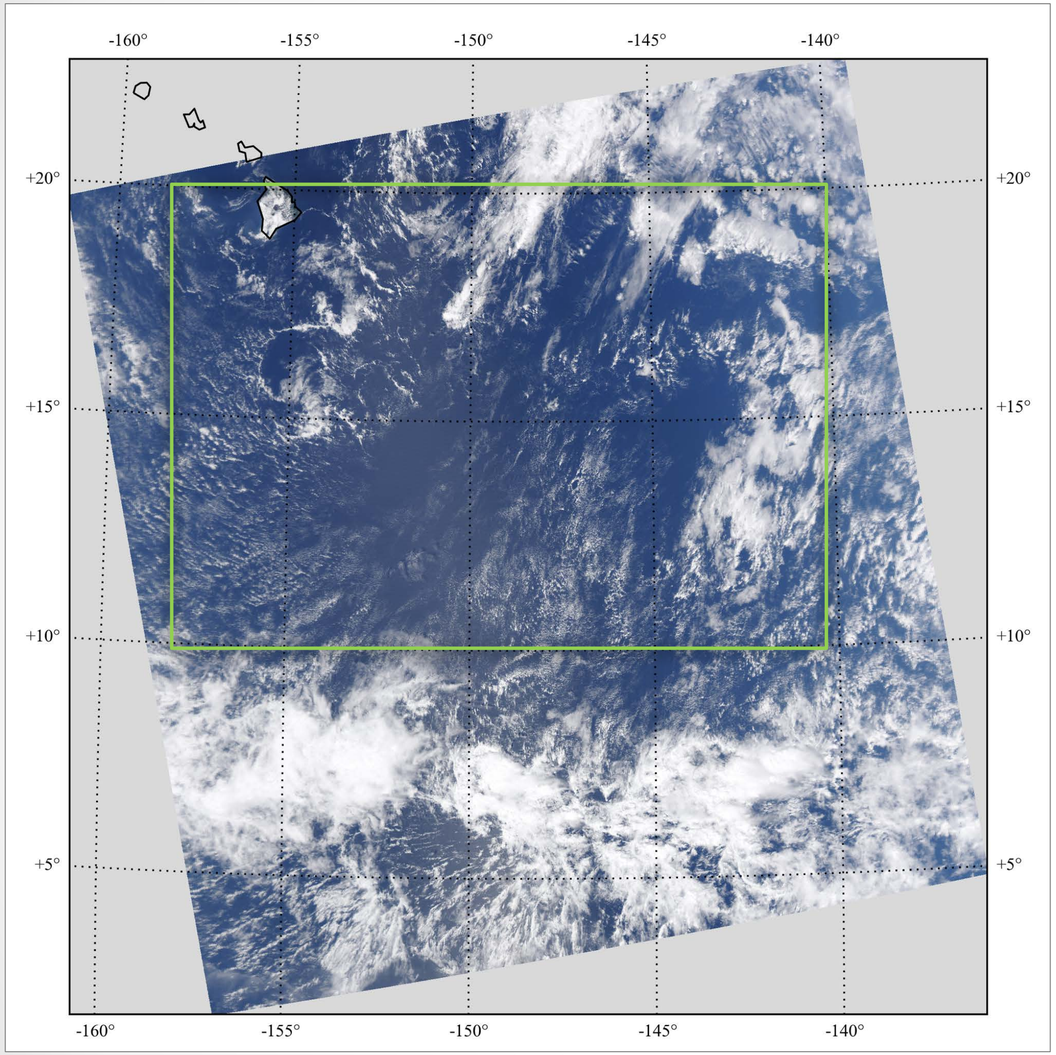
a separate MODIS product run with the common algorithm is required for continuity

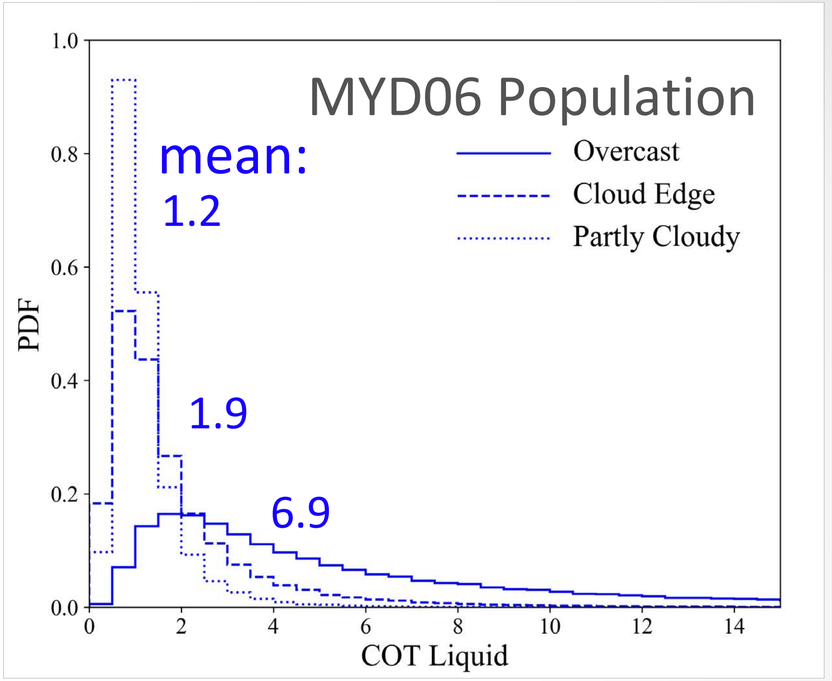
Monthly Means
Feb 2014

- Most recent version of common algorithm, includes SW Radiometric Bias Correction
- Pixel-weighted multi-day aggregation over common MODIS swath
- Daytime only
- Highest Quality (non-“Partly Cloudy” pixels)

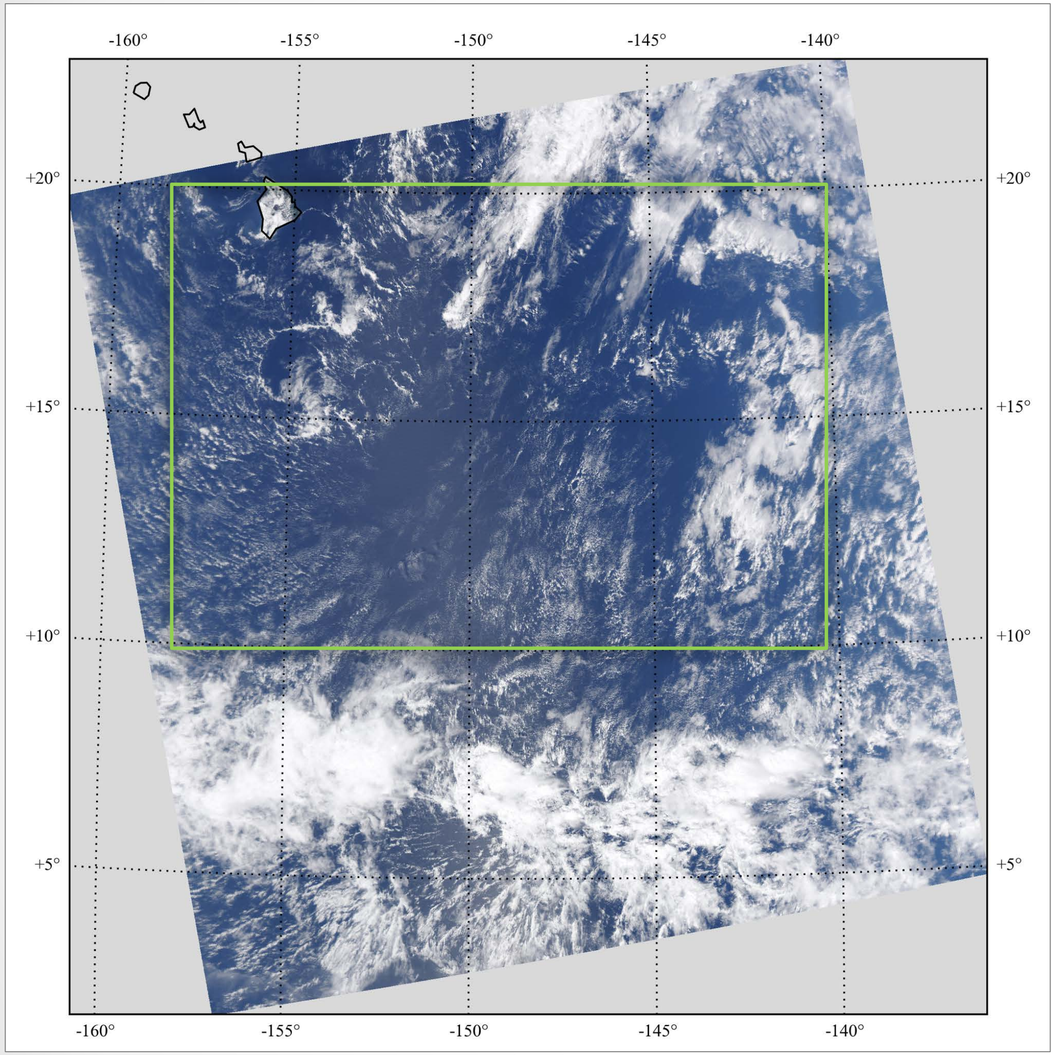


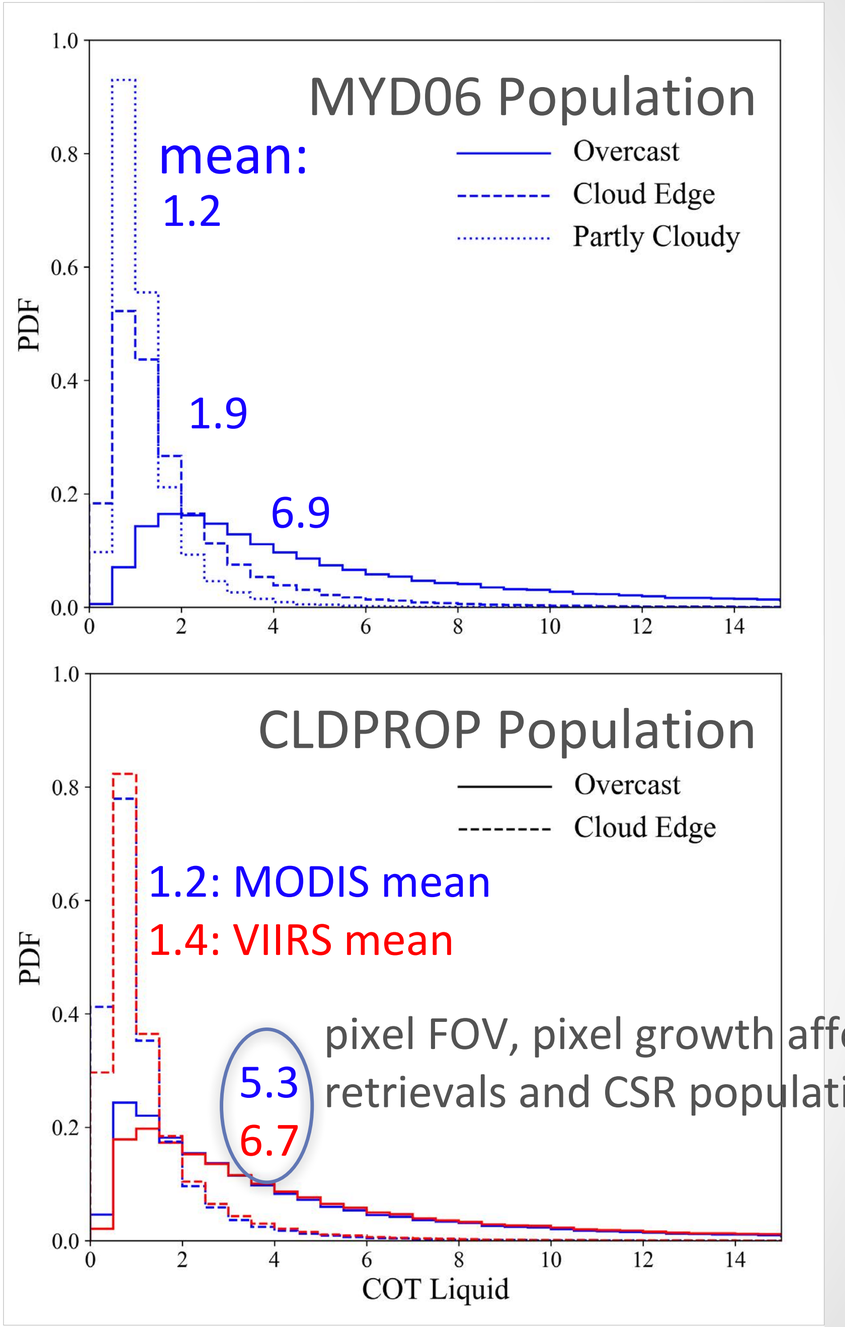
19 Feb. 2014 (N. Pacific)





19 Feb. 2014 (N. Pacific)





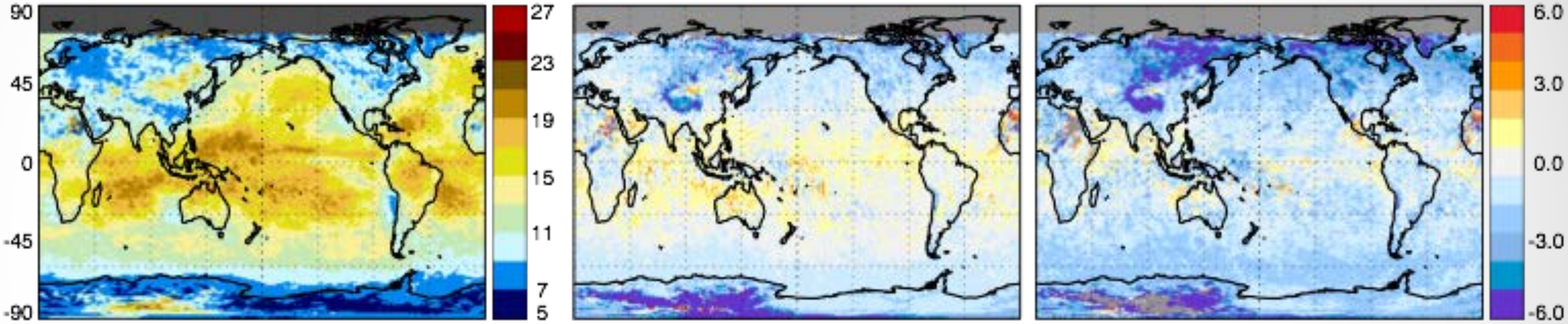
Liquid Water CER_2.x (μm) Comparisons

Monthly Means
Feb 2014

- Most recent version of common algorithm, includes SW Radiometric Bias Correction
- Pixel-weighted multi-day aggregation over common MODIS swath
- Daytime only
- Highest Quality (non-“Partly Cloudy” pixels)

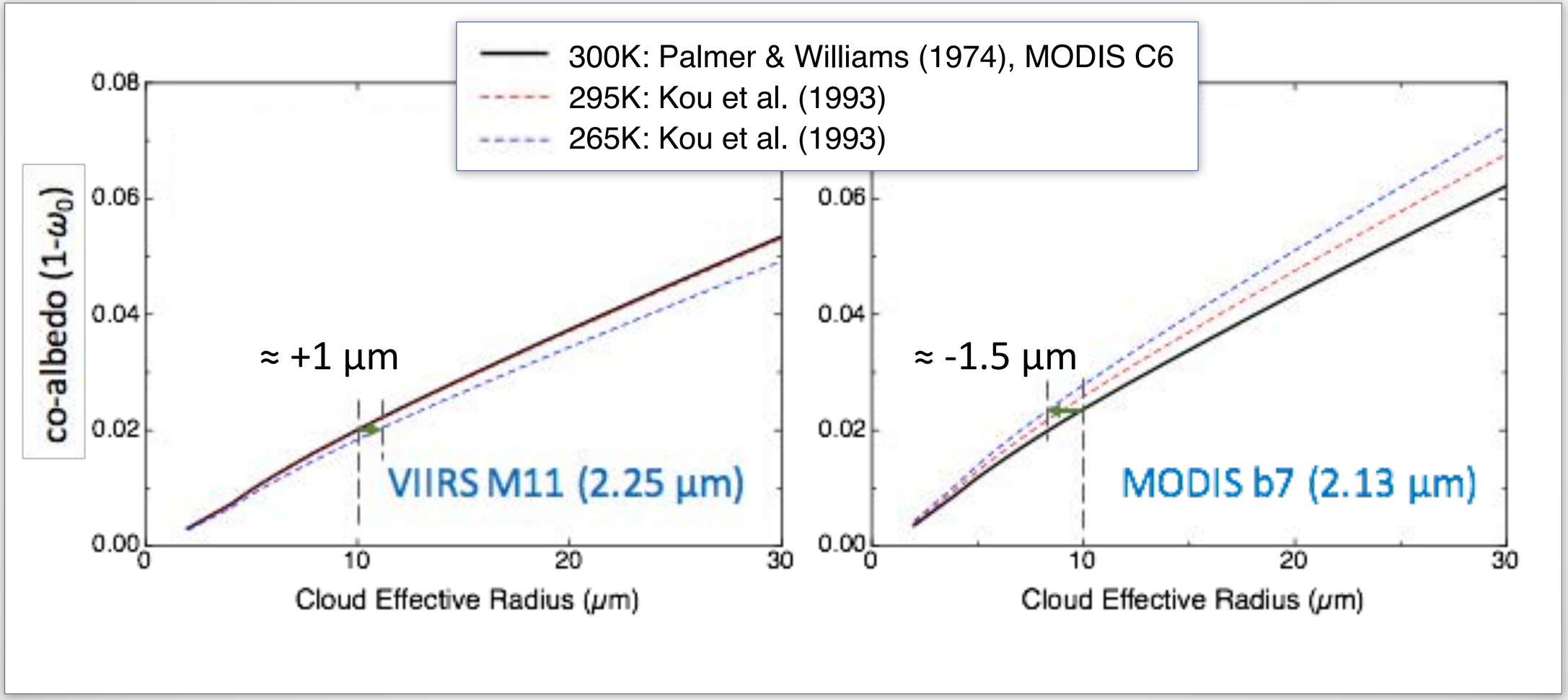
common algorithm

VIIRS | VIIRS–MODIS Aqua | VIIRS–MYD08

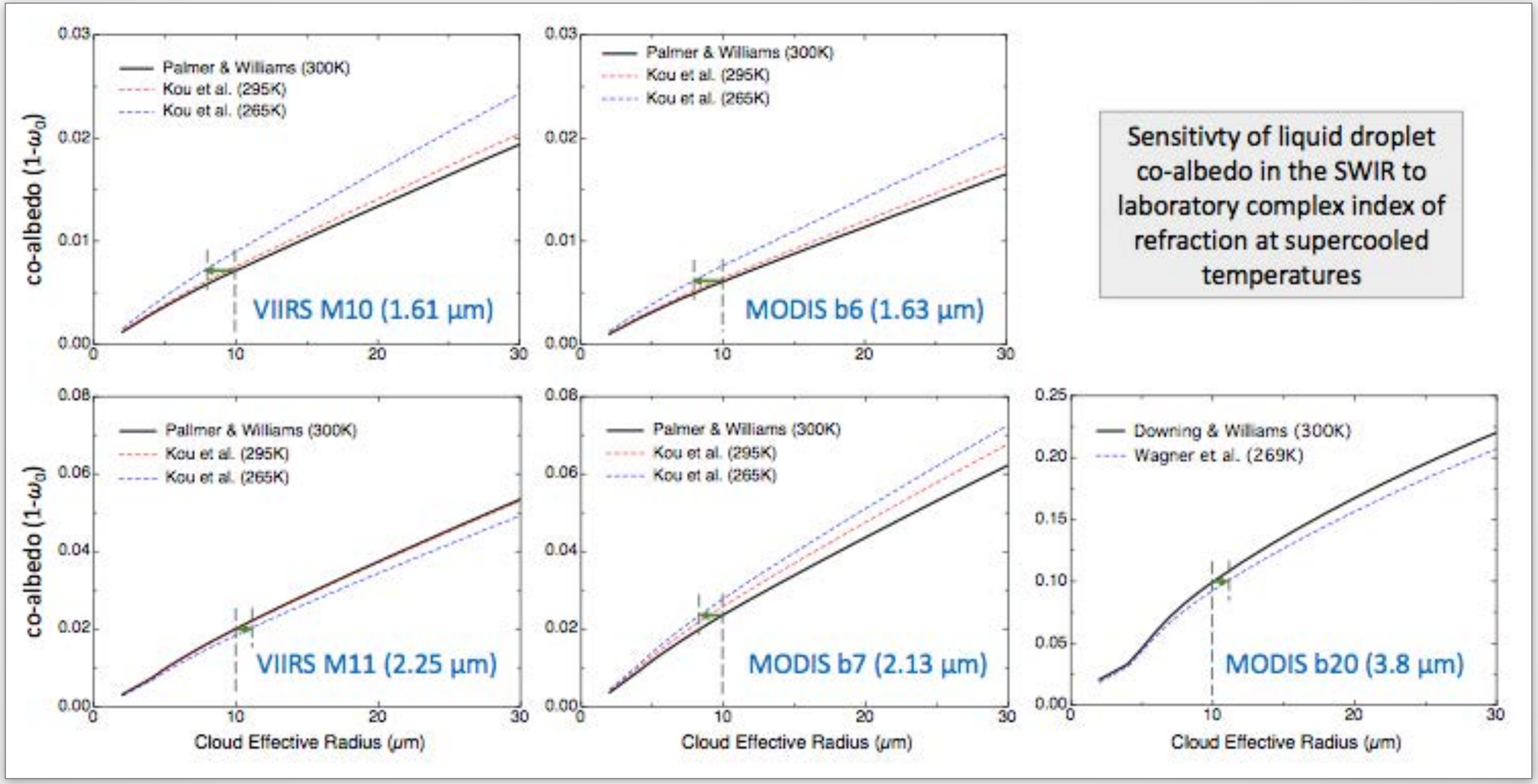


Pixel-level analysis of bias between CER_2.25 *μ*m (VIIRS) and CER_2.13 *μ*m (MODIS) suggested a fundamental inconsistency in the RT fwd model. ???

Sensitivity of 2.x μm co-albedo to complex index of refraction



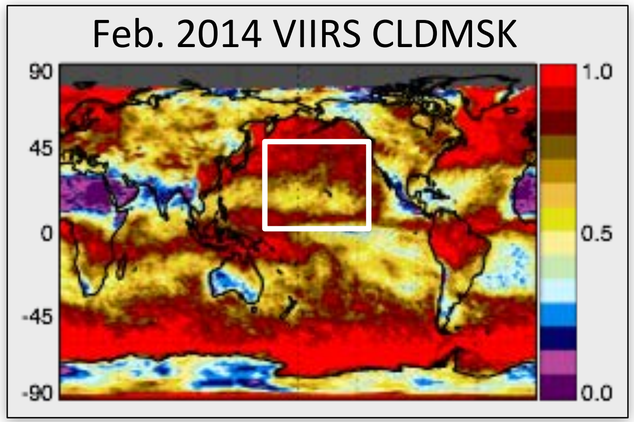
Sensitivity of SWIR co-albedo to complex index of refraction at supercooled temperatures

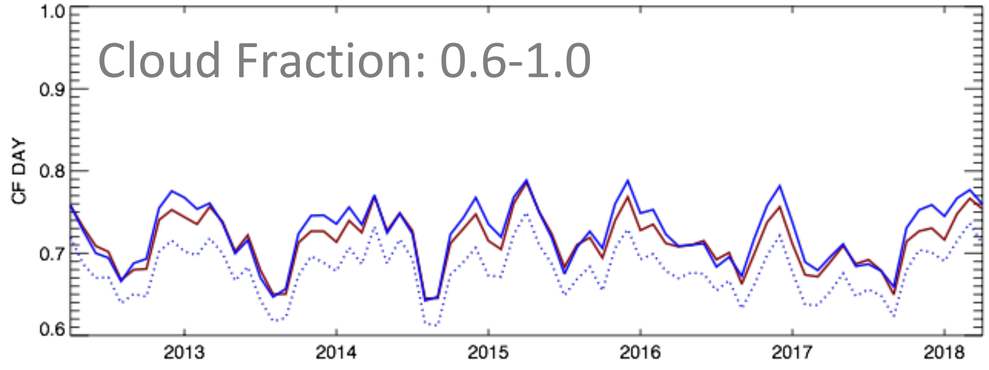


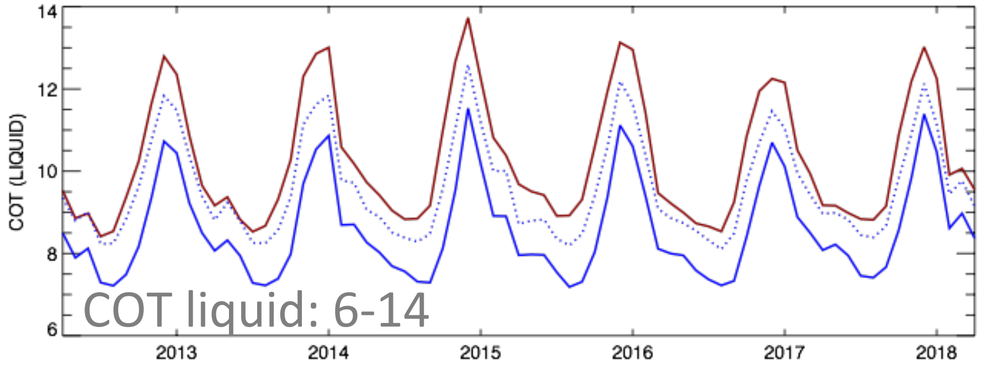
AMS Rad-Cloud 2018, 14.1, Platnick et al.

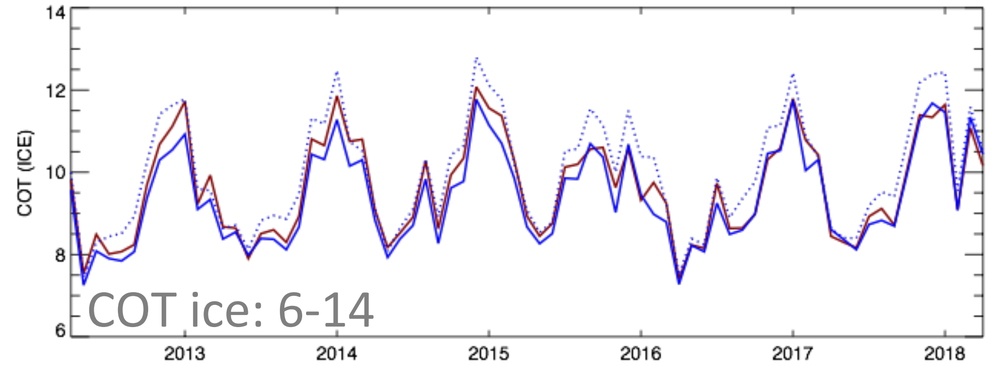
6-yr Time Series, N. Pacific

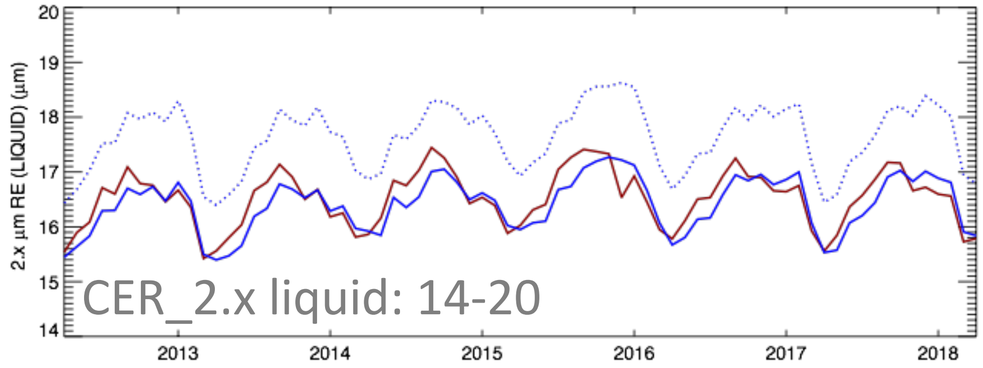
— VIIRS continuity — MODIS continuity ····· MYD08

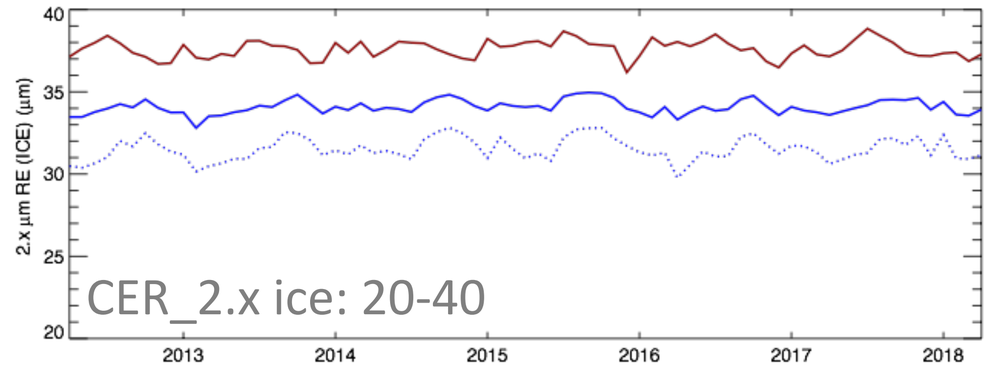










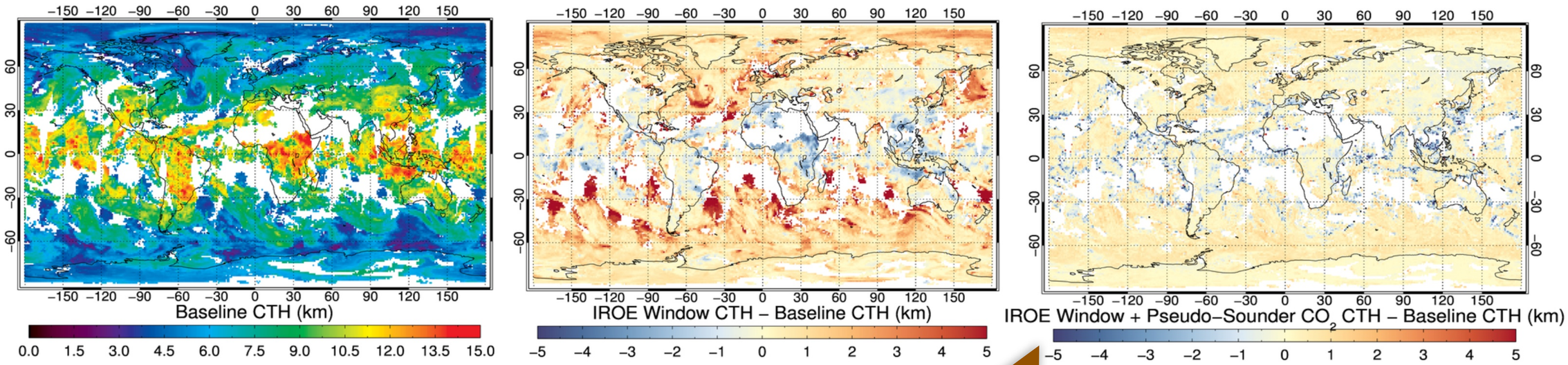


VIIRS+CrIS Ice Cloud Height Retrieval Concept Study Using Aqua MODIS

IR Optimal Estimation Algorithm, *Chenxi Wang et al.*

Daily Cloud-top Height Comparisons (April, 17, 2015)

Day + Night



Baseline Algorithm:
Window (8.5, 11, 12) +
CO_2 (13.3, 13.6, 13.9 µm) bands

Window – Baseline

[Window + CO_2 avg'd over sounder FOV] – Baseline

pseudo-sounder CO_2 channel spatial resolution biases relatively small except near cloud edges

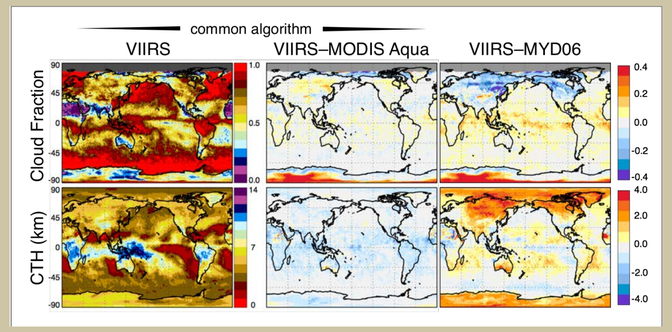
MODIS/VIIRS L2 Cloud Continuity Product Status

- Final version 1 code successfully delivered to SIPS on 12 October 2018
- User guide draft completed
- Filename convention

CLDMSK_L2_VIIRS_SNPP	VIIRS/SNPP Cloud Mask 6-Min Swath 750m
CLDPROP_L2_VIIRS_SNPP	VIIRS/SNPP Optical Cloud Properties 6-min Swath 750m
CLDPROP_D3_VIIRS_SNPP	VIIRS/SNPP Optical Cloud Properties Daily 1°
CLDPROP_M3_VIIRS_SNPP	VIIRS/SNPP Optical Cloud Properties Monthly 1°
CLDMSK_L2_MODIS_AQUA	MODIS/AQUA Cloud Mask 5-Min Swath 1km
CLDPROP_L2_MODIS_AQUA	MODIS/AQUA Optical Cloud Properties 5-min Swath 1km
CLDPROP_D3_MODIS_AQUA	MODIS/AQUA Optical Cloud Properties Daily 1°
CLDPROP_M3_MODIS_AQUA	MODIS/AQUA Optical Cloud Properties Monthly 1°

50+ pp. w/references to C6.1 user guide sections as appropriate

EOS MODIS and SNPP VIIRS Cloud Properties:
User Guide for the Climate Data Record Continuity
Level-2 Cloud Top and Optical Properties Product
(CLDPROP)



Version 1
October 2018

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ANDREW HEIDINGER[2], YUE LI[6], ANDI WALTHER[6]
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7 Wyle……

MODIS/VIIRS Cloud Continuity Summary

- Shortwave radiometric data record continuity is challenging, even with the same instrument (MODIS Aqua/Terra). More so for different instruments.
- Impact of 2.x μm window channel placement on optical properties (ice as well as liquid) requires understanding spectral imaginary index of refraction.
- Next Steps:
  - Public release: Imminent
  - Algorithm: Further investigation of index of refraction sensitivity (ice as well as liquid), FOV/sampling aggregation sensitivities, and use of CrIS to compensate missing VIIRS IR absorption channels (longer term).
  - Science assessment: time series analysis, include “cloud radiative effect” datasets and assess radiative continuity, user community feedback, …