

September 15, 2015

Summary of the impact of the MODIS Terra Band 29 (8.6  $\mu\text{m}$ ) radiometric calibration drift on cloud products

### Statement of Problem

MOD35 includes a spectral test using the brightness temperature difference (BTD) between band 29 (8.6  $\mu\text{m}$ ) and band 31 (11  $\mu\text{m}$ ), referred to here as the b29-b31 BTD test. This test is used only over water surfaces.

In April 2015, it was noticed that recent Terra Collection 6 (C6) cloud top pressure products contained ocean regions with an anomalously high incidence of low clouds. This was traced to false clouds being reported by the cloud mask (MOD35). In turn, this was found to be the result of errors in the b29-b31 BTD high (ice phase) cloud test. As a result, a substantial number of clear pixels were being flagged as cloudy by this test.

The root problem is a gradual warming in the Terra MODIS b29 channel over the years, that is not being captured by the on-board calibration systems and apparently related to crosstalk issues. Monthly time series trend analysis of Terra MODIS cloud products indicates that the significance of the impact may extend back to 2010 (see **Sect. 3** analysis below).

In lieu of a successful fix to the L1B algorithm for b29, an adjustment to the 8.6-11  $\mu\text{m}$  MOD35 test threshold was delivered to the production test system to quantify the impact. The new threshold was considered to be appropriate for data beginning in January 2015. A month of data (April 2015) was processed and the impact to key monthly gridded mean cloud products is shown in **Sect. 2**.

### Analyses

Three types of analyses were undertaken, each described in its own section below:

1. A data granule (pixel-level) example
2. April 2015 monthly mean differences (C6 production minus science test with updated b29-b31 BTD threshold) to quantify the expected impact for that month.
3. Trend analysis of monthly means and comparisons of Terra and Aqua MODIS. this is used to quantify the particular year in which the current C6 b29-b31 BTD test thresholds begin to impact trend analysis.

**Advice to Users:** Those using MODIS Terra for trend or other cloud fraction/phase climate analyses should expect potentially significant biases in some oceanic regions, specifically a high bias in low/warm cloud detection in tropical/subtropical regimes that have a relatively small overall monthly mean cloud fraction. Subsequent phase algorithms overwhelmingly characterize these clear pixels as liquid. Optical property statistics can be affected when the clear sky restoration (CSR) algorithm does not eliminate the clear pixels coupled with a successful retrieval; however, both CSR and failed retrievals routines capture the majority of the false cloud pixels and the resulting monthly mean sensitivity is much smaller than for cloud fraction and phase datasets.

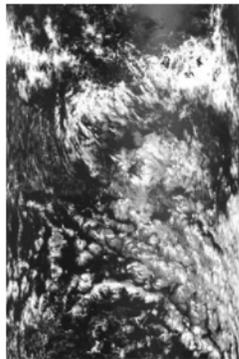
**Future Efforts:** The MODIS Characterization and Support Team (MCST) is currently testing/evaluating crosstalk fixes for Terra MODIS b29. When this is completed, testing against MOD35 and MOD06 products will occur. Depending on the results, a reprocessing of the time period in question will be discussed.

## 1. Granule Level Analysis

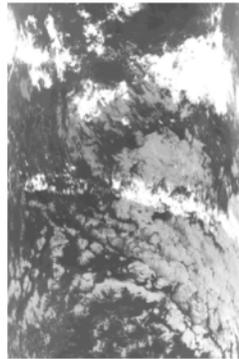
The figures below show an example of the test results before and after the thresholds were adjusted.

Terra MODIS band 2 reflectance (left) and band 31 brightness temperature (right) for a granule located in the southeastern subtropical Pacific Ocean at 16:40 UTC on April 15, 2015.

Results of the 8.6-11  $\mu\text{m}$  cloud test before and after threshold adjustments were made to correct the problem.



Band 2  
Reflectance



Band 31  
Brightness Temperature



Cloud Test Before  
Threshold Adjustments



Cloud Test After  
Threshold Adjustments

## **2. Monthly Mean Analysis: comparison of Collection 6 MOD08 vs. “corrected” MOD35 code with updated b29-b31 threshold values**

The following images include monthly (April 2015) means and difference images for the cloud mask (MOD35) and several downstream cloud products found in MOD06. The sign of the difference maps is chosen to represent the current C6 production bias for April 2015 (i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold).

Cloud optical property sensitivities are shown for three spectral band combinations (VNIR/SWIR + 1.6  $\mu\text{m}$ , VNIR/SWIR + 2.1  $\mu\text{m}$ , and VNIR/SWIR + 3.7  $\mu\text{m}$ , ).

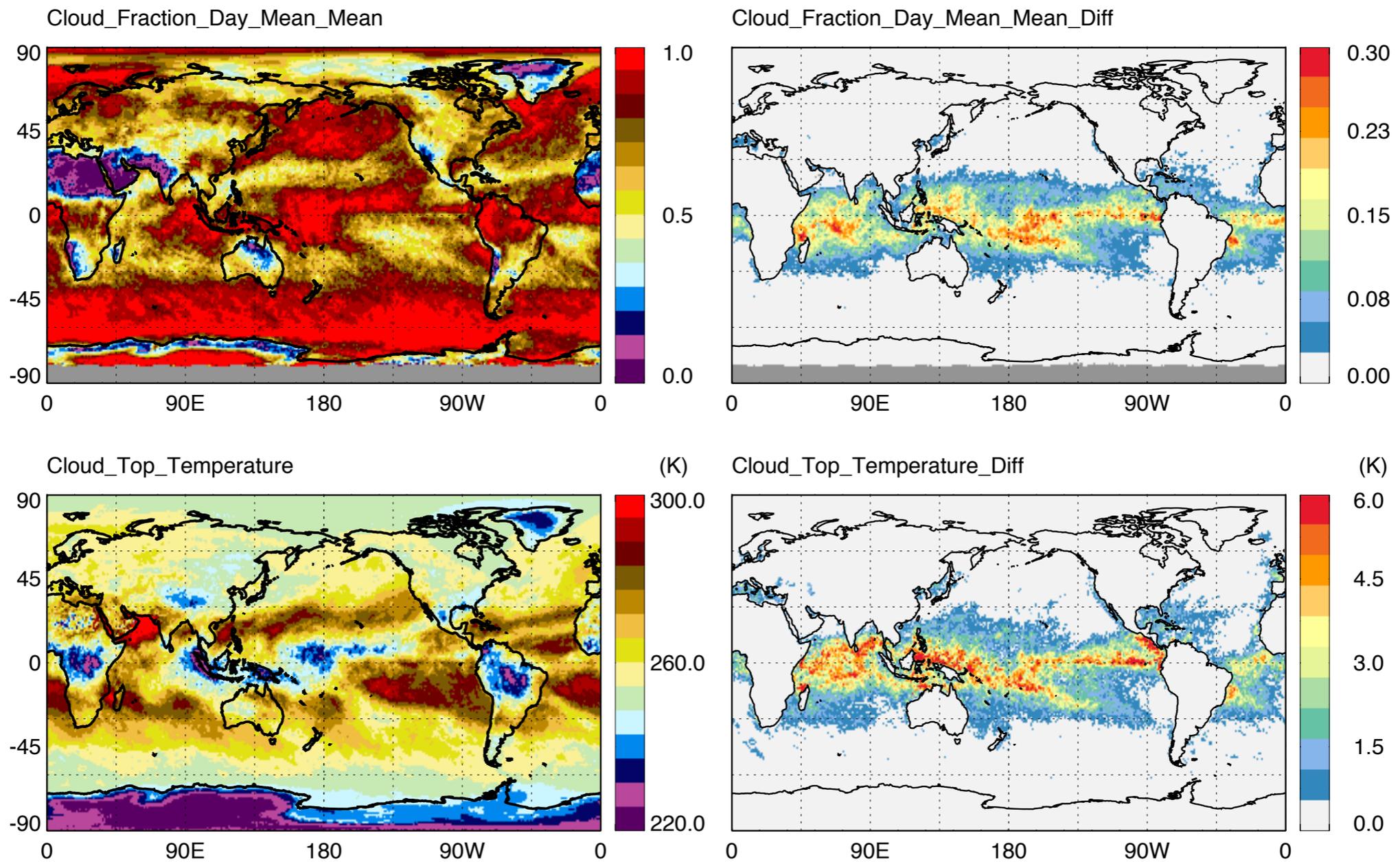
MDO06 optical property CSR integer values in the figure heading have the following meaning:

CSR=0: 1km pixels identified as cloudy by the cloud mask are interpreted to be not partly-cloudy and therefore assumed suitable for optical retrievals

CSR=2: identified as not cloudy despite being flagged as a cloudy FOV by the cloud mask

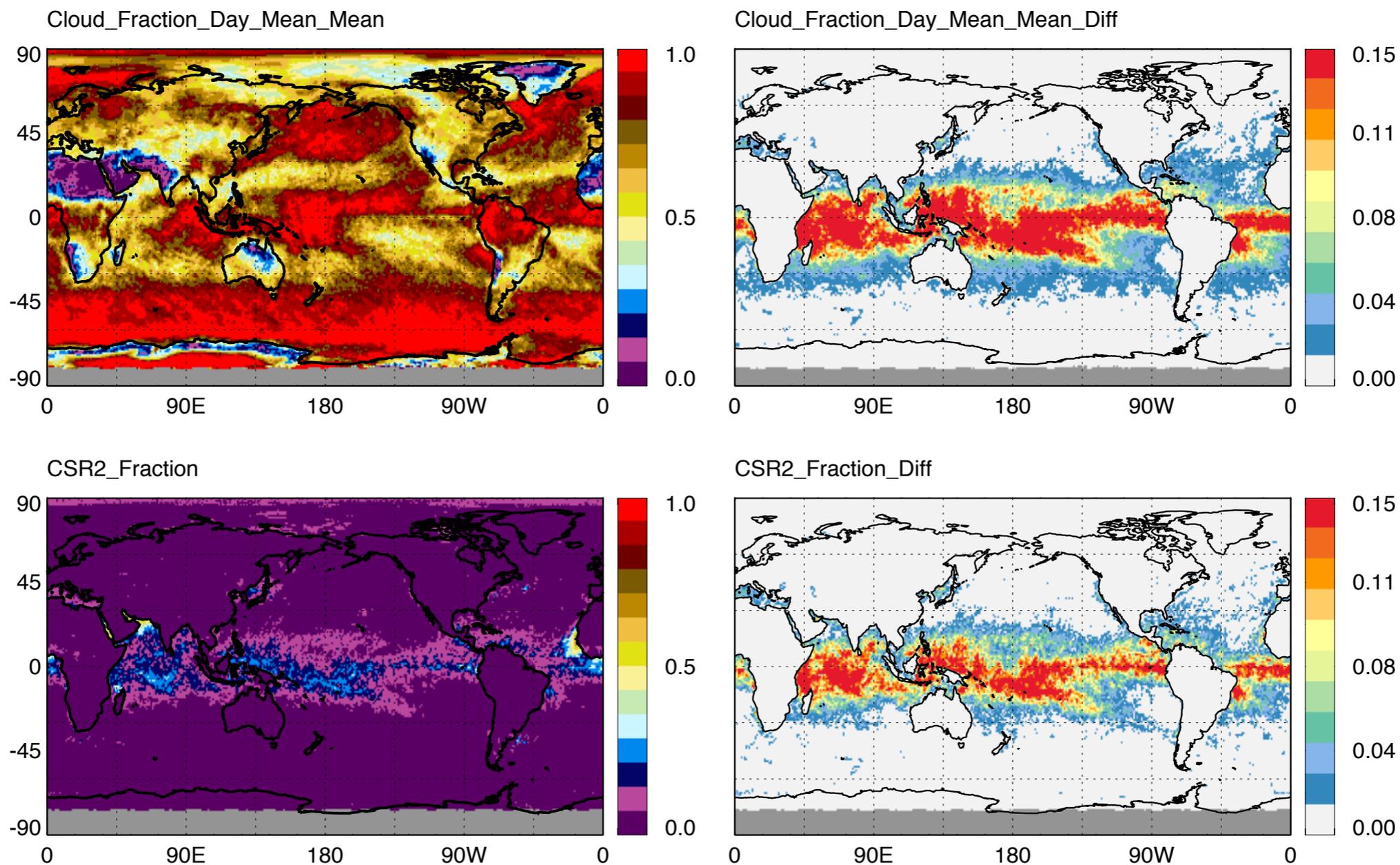
CSR=1 or 3: 1km pixels identified as partly cloud FOVs (either internally based on 250m cloud mask tests, or from clear/cloud edges)

# Daytime Cloud Fraction from the Cloud Mask (MOD35) & Cloud-Top Temperature (5km, MOD06)



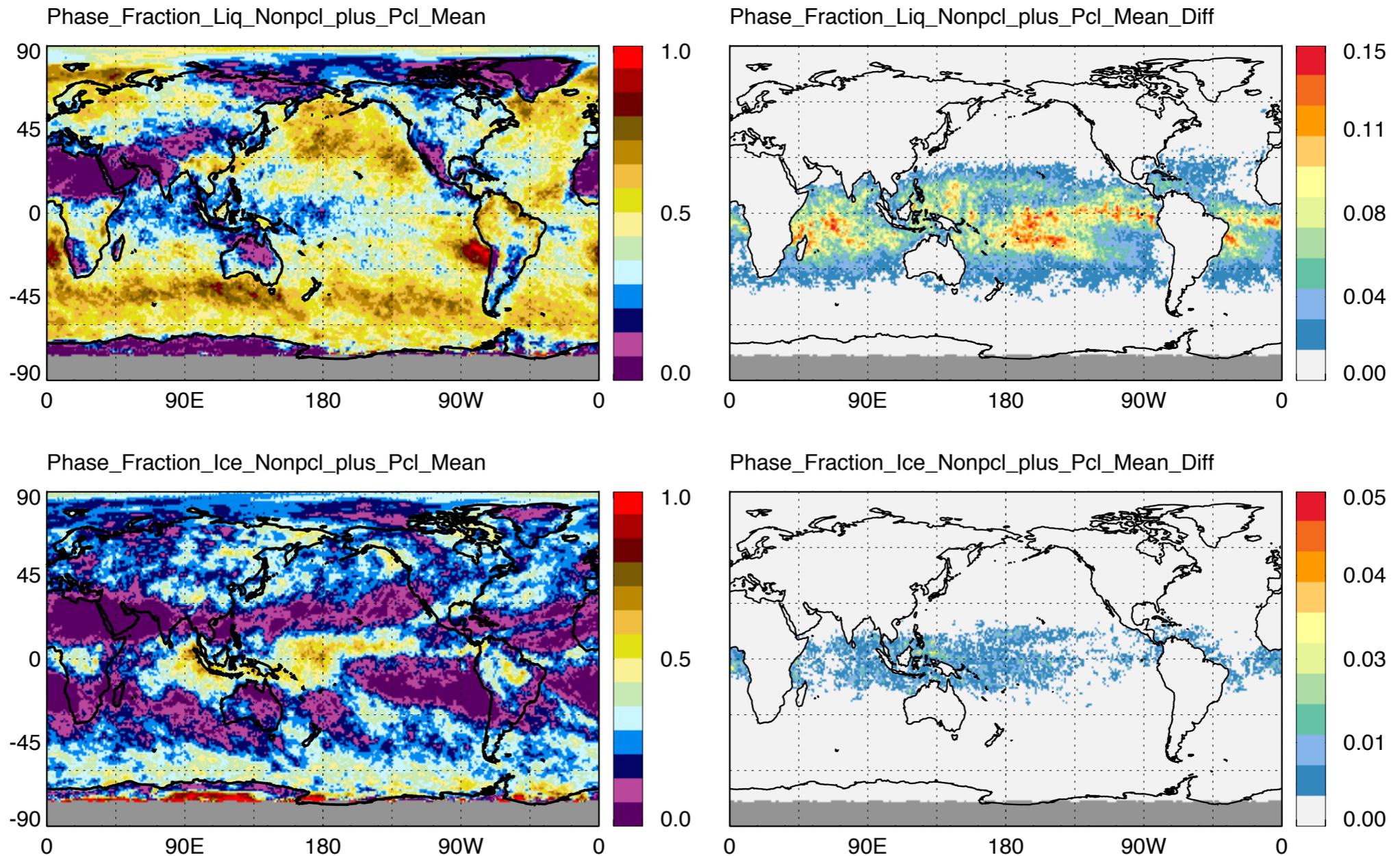
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

# Daytime Cloud Fraction from the Cloud Mask (MOD35) & Daytime Fraction of MOD35 cloudy pixels restored to clear (CSR=2) in MOD06



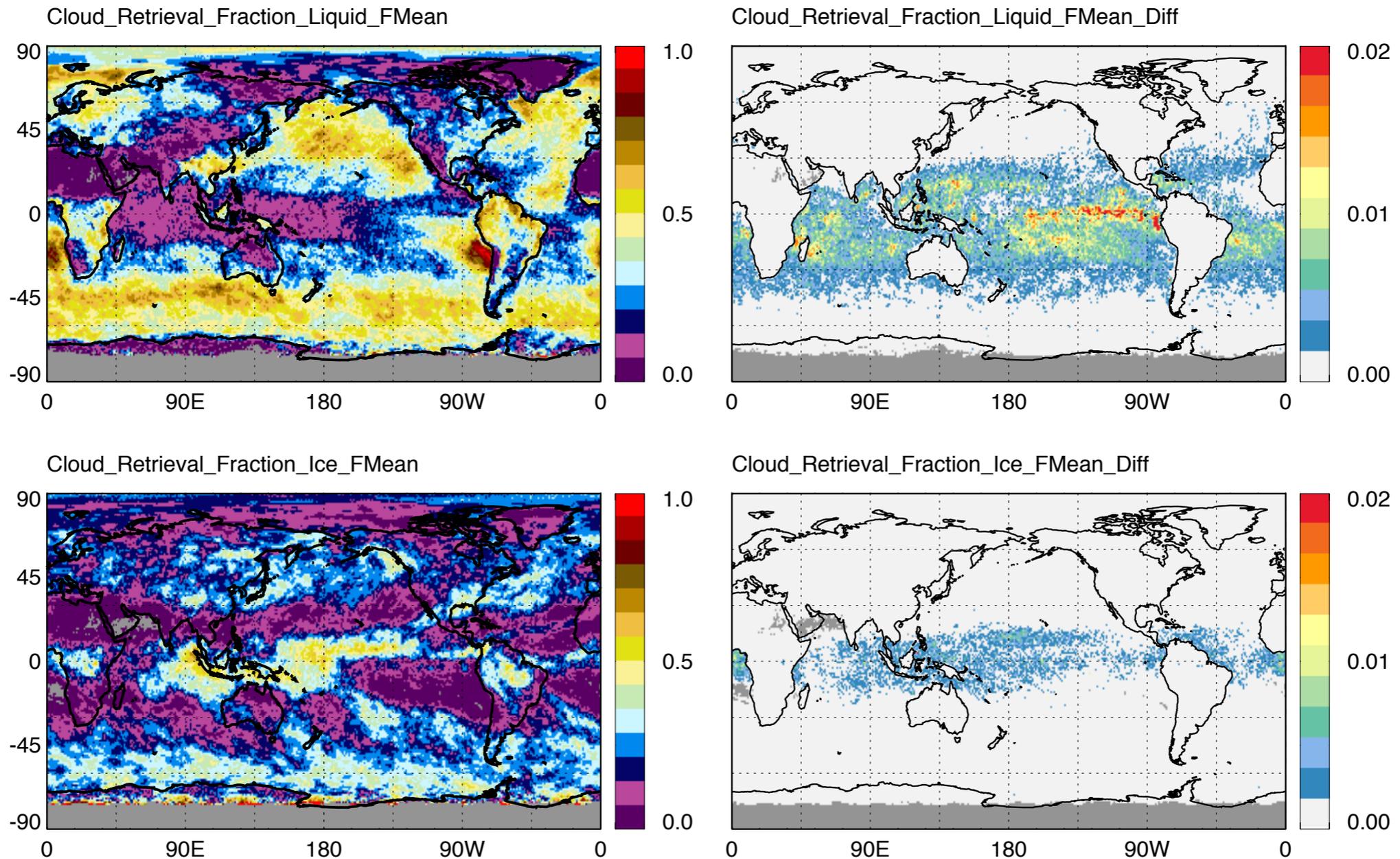
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

Daytime Liquid Retrieval Phase Fraction (MOD06 optical properties) & Daytime Ice Retrieval Phase Fraction (MOD06 optical properties): CSR=0, 1, 3 (all cloudy pixels not restored to clear)



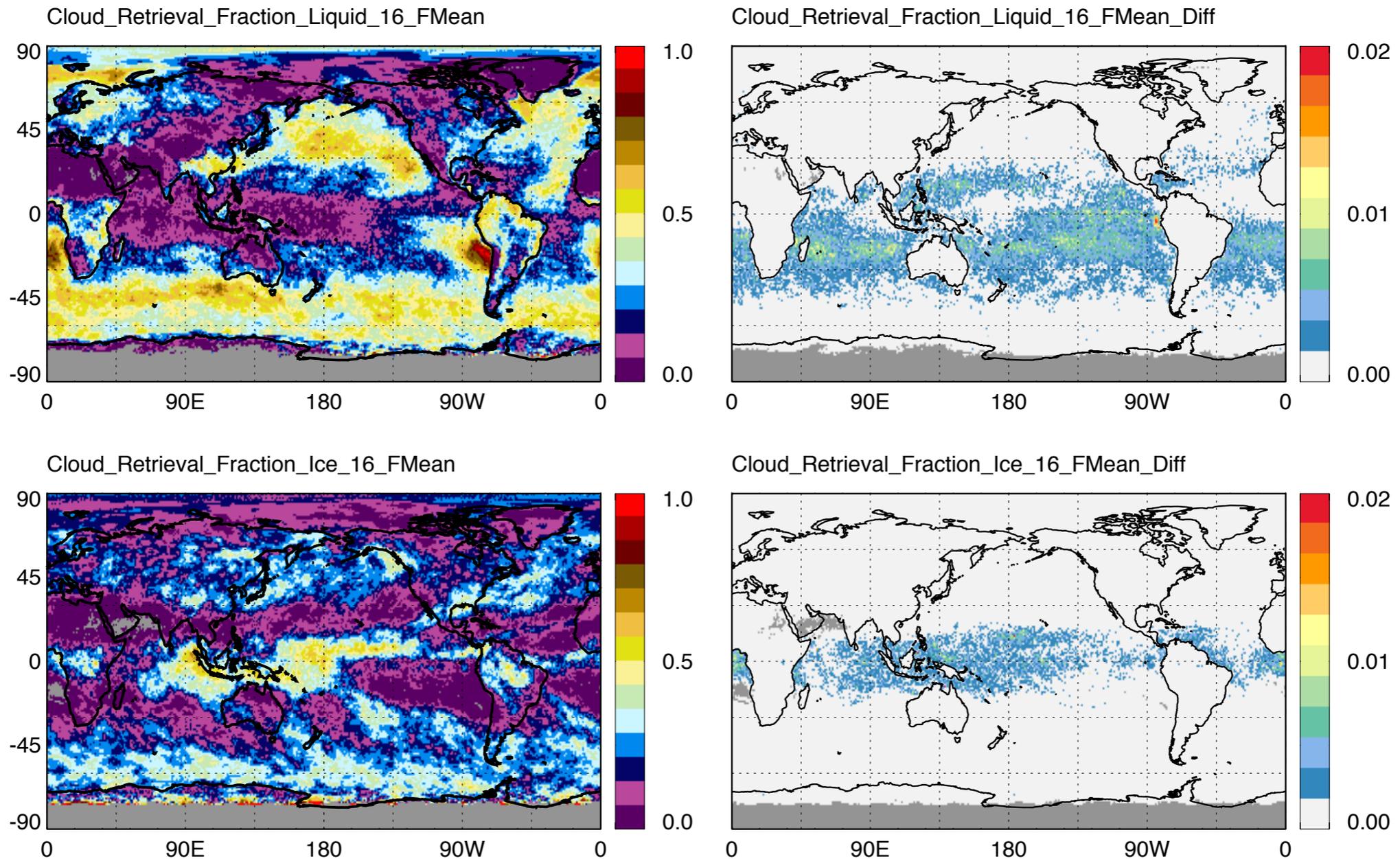
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

Daytime Liquid Cloud Successful Retrieval Fraction &  
Daytime Ice Cloud Successful Retrieval Phase Fraction:  
CSR=0, 1, 3 (all cloudy pixels not restored to clear), CER\_2.1 $\mu\text{m}$



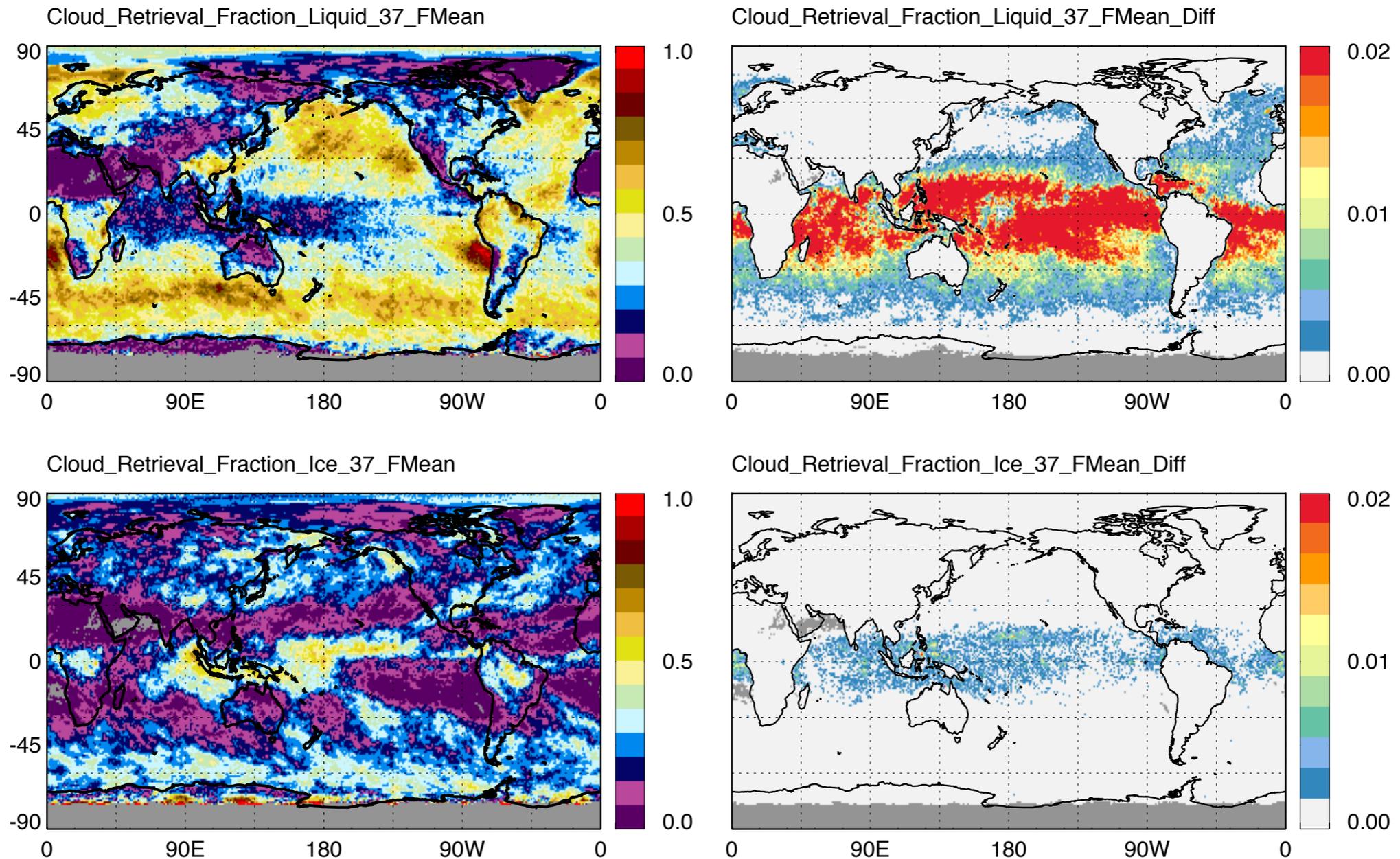
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

Daytime Liquid Cloud Successful Retrieval Fraction &  
Daytime Ice Cloud Successful Retrieval Phase Fraction:  
CSR=0, 1, 3 (all cloudy pixels not restored to clear), CER\_1.6 $\mu\text{m}$



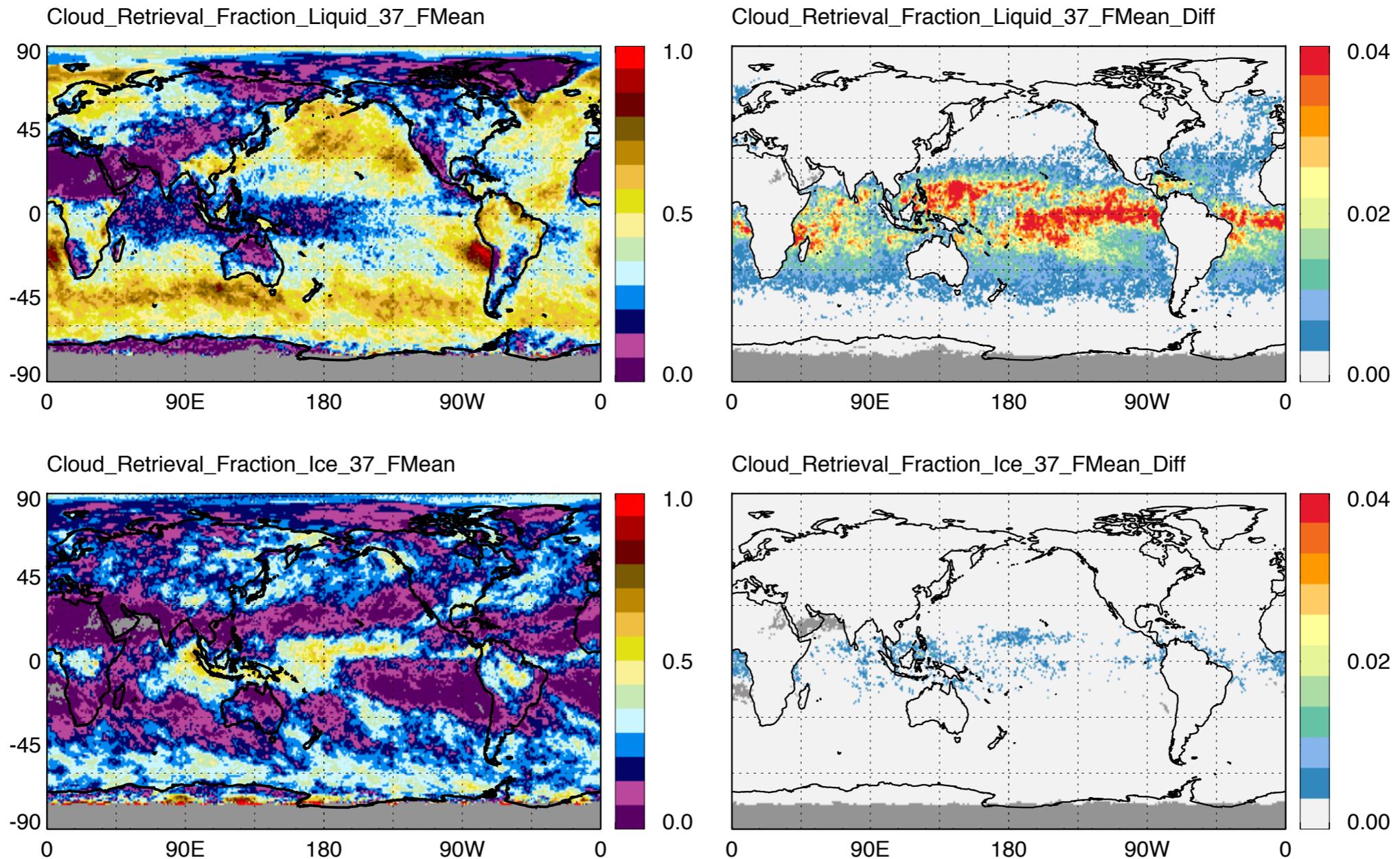
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

Daytime Liquid Cloud Successful Retrieval Fraction &  
Daytime Ice Cloud Successful Retrieval Phase Fraction:  
CSR=0, 1, 3 (all cloudy pixels not restored to clear), CER\_3.7 $\mu\text{m}$



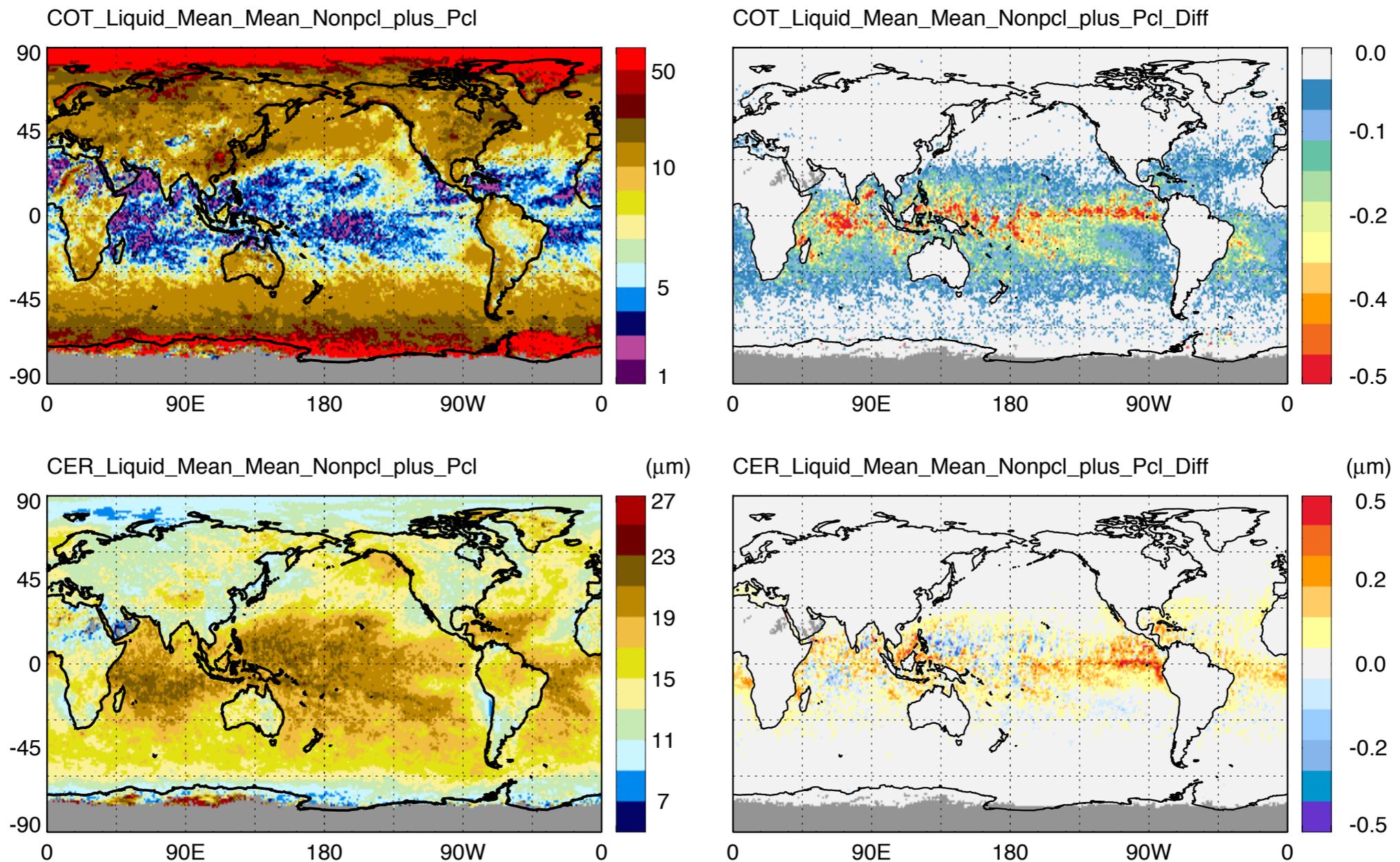
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

Daytime Liquid Cloud Successful Retrieval Fraction &  
Daytime Ice Cloud Successful Retrieval Phase Fraction:  
CSR=0, 1, 3 (all cloudy pixels not restored to clear), CER\_3.7 $\mu$ m  
note: same as previous image but difference images use expanded color bar



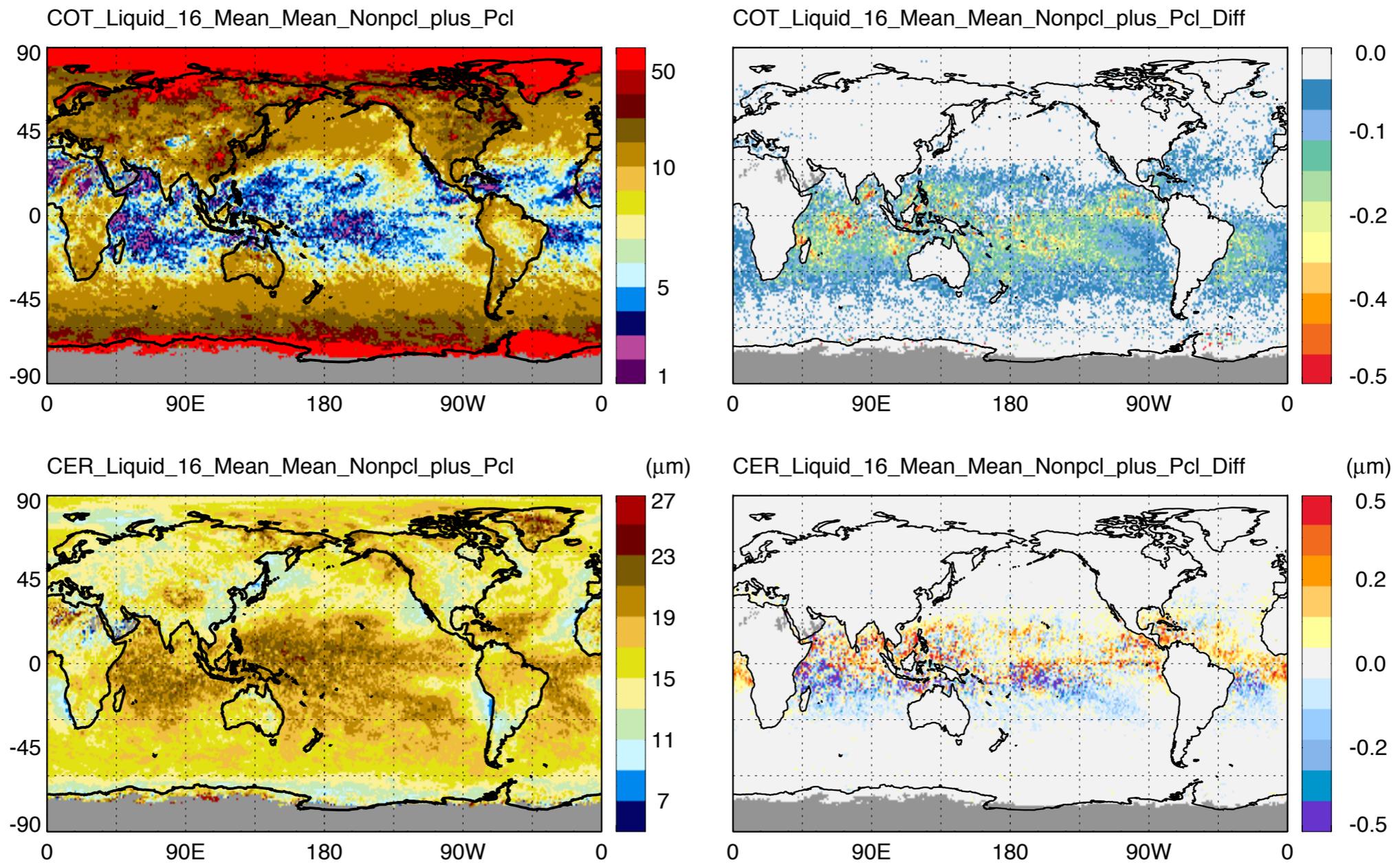
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

# Daytime Liquid Cloud Retrievals, COT<sub>2.1μm</sub> & CER<sub>2.1μm</sub> CSR=0, 1, 3 (all successful cloudy pixels not restored to clear)



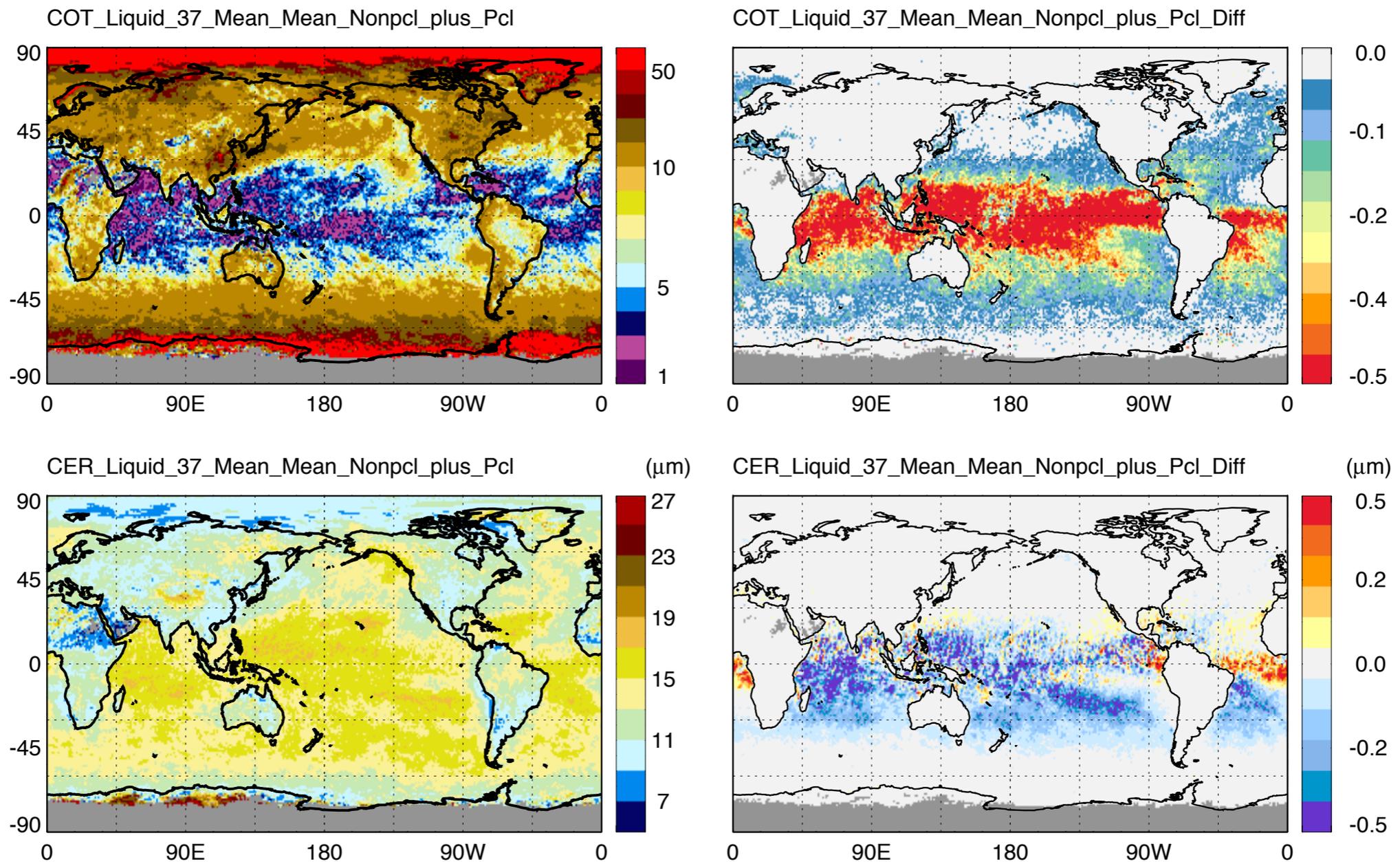
Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

# Daytime Liquid Cloud Retrievals, COT<sub>1.6μm</sub> & CER<sub>1.6μm</sub> CSR=0, 1, 3 (all successful cloudy pixels not restored to clear)



Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

# Daytime Liquid Cloud Retrievals, COT<sub>3.7μm</sub> & CER<sub>3.7μm</sub> CSR=0, 1, 3 (all successful cloudy pixels not restored to clear)

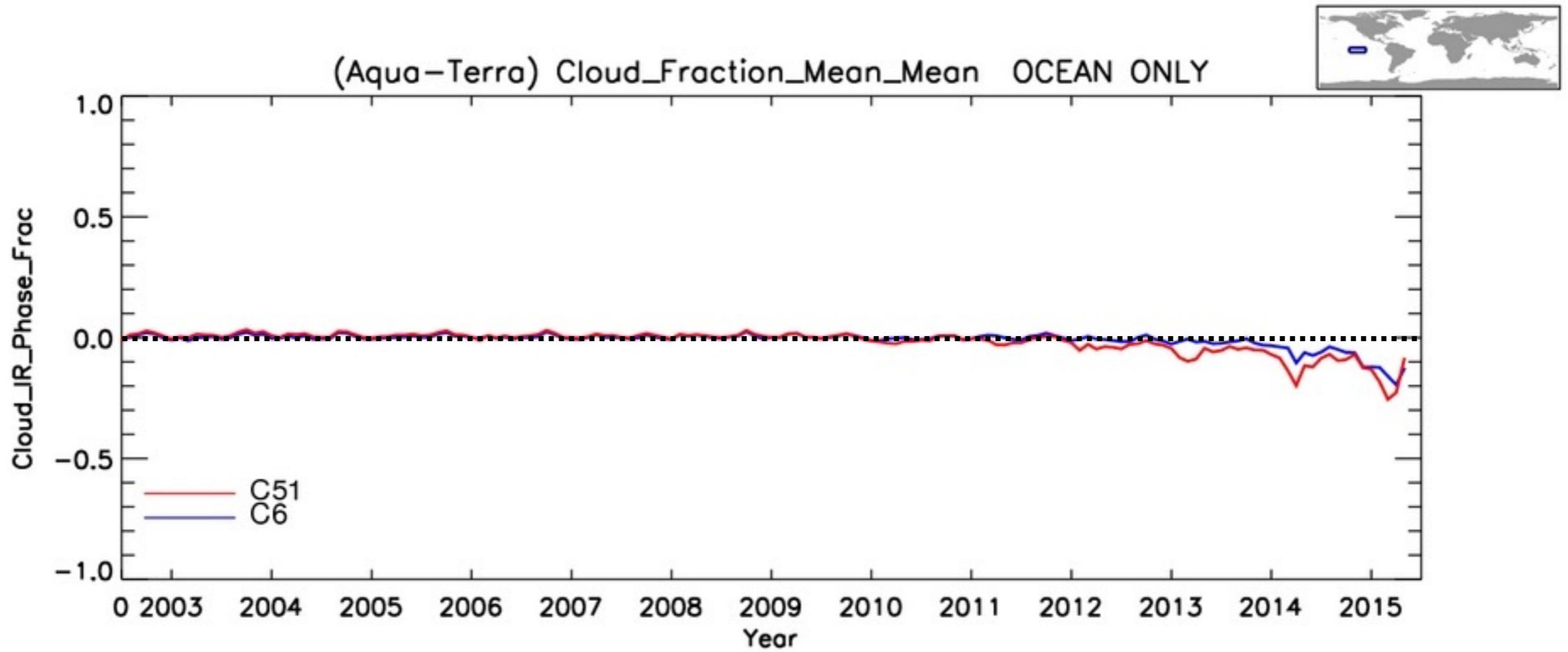


Differences represent the current C6 production bias for April 2015  
(i.e., MOD35 w/C6 production b29-b31 threshold value minus MOD35 w/new b29-b31 threshold)

### **3. Monthly Mean Trend Analysis for Collection 6 MOD08**

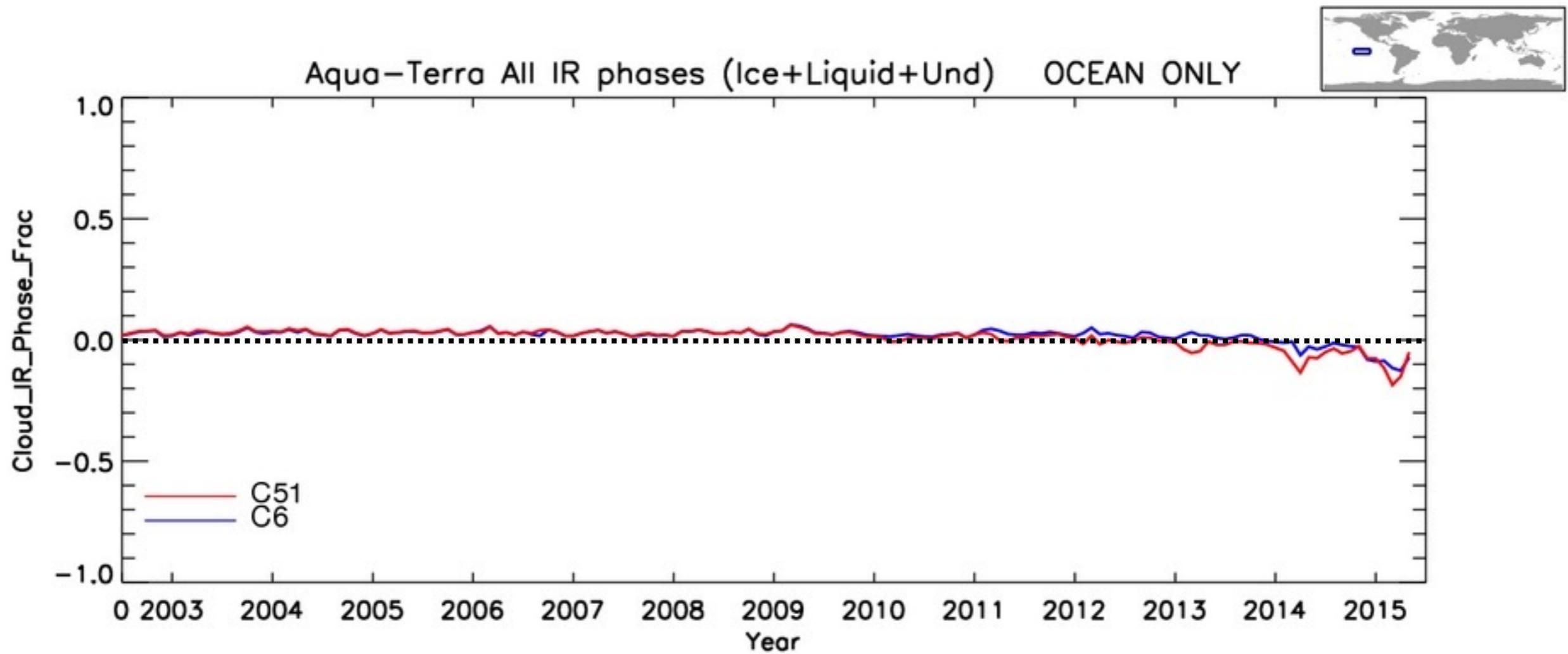
The following plots show Terra and Aqua MODIS trends for a variety of cloud products. To the extent that Aqua does not have a known b29-b31 BTD bias, it represents a reference trend for which to compare Terra trends.

# Monthly Daytime Cloud Fraction (MOD/MYD35) time series for Terra and Aqua MODIS



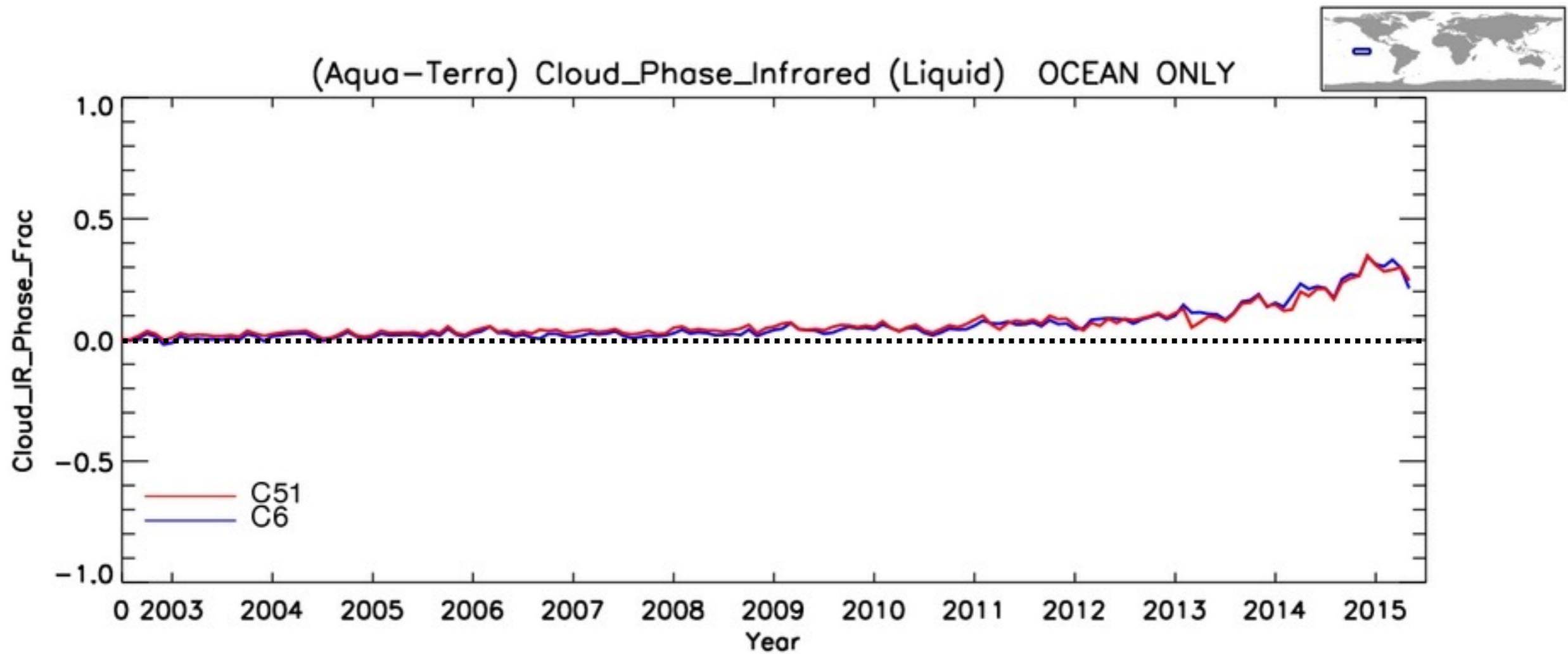
Pacific region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: All phases



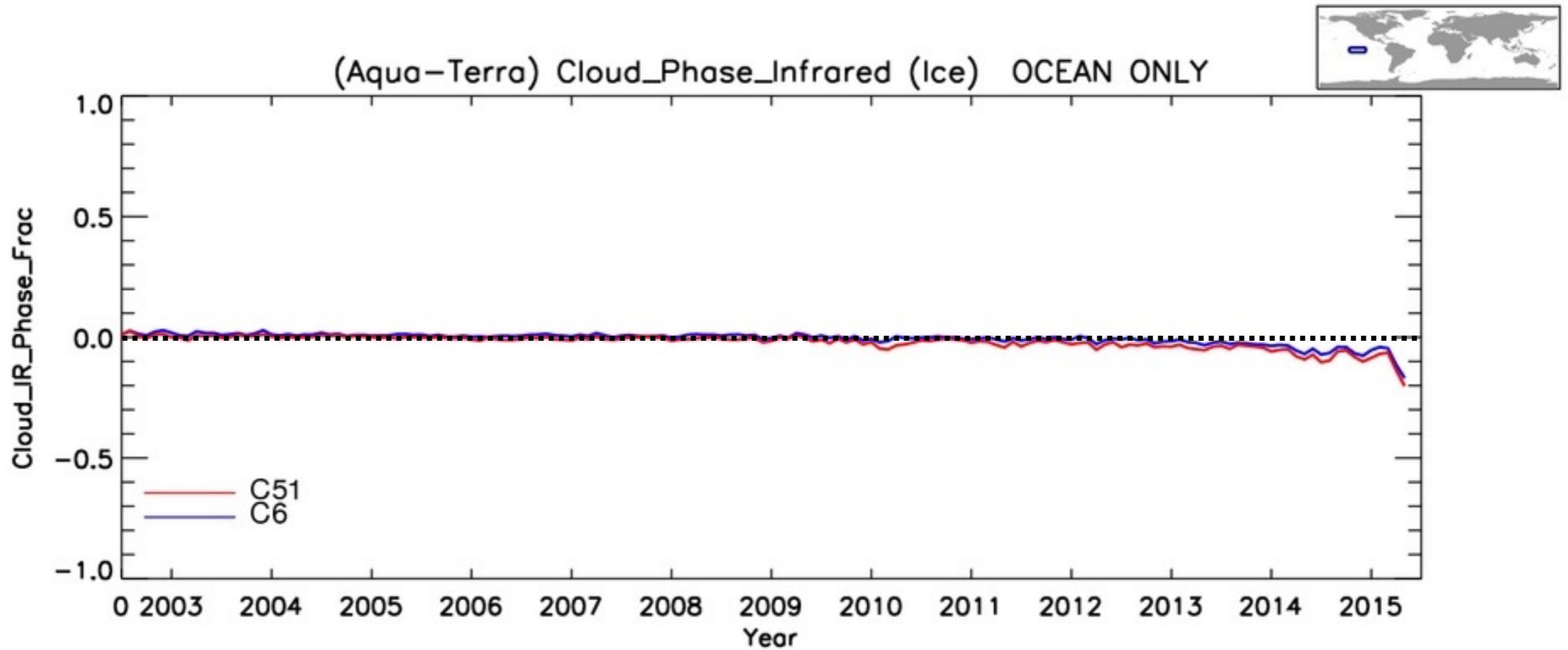
Pacific region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: Liquid



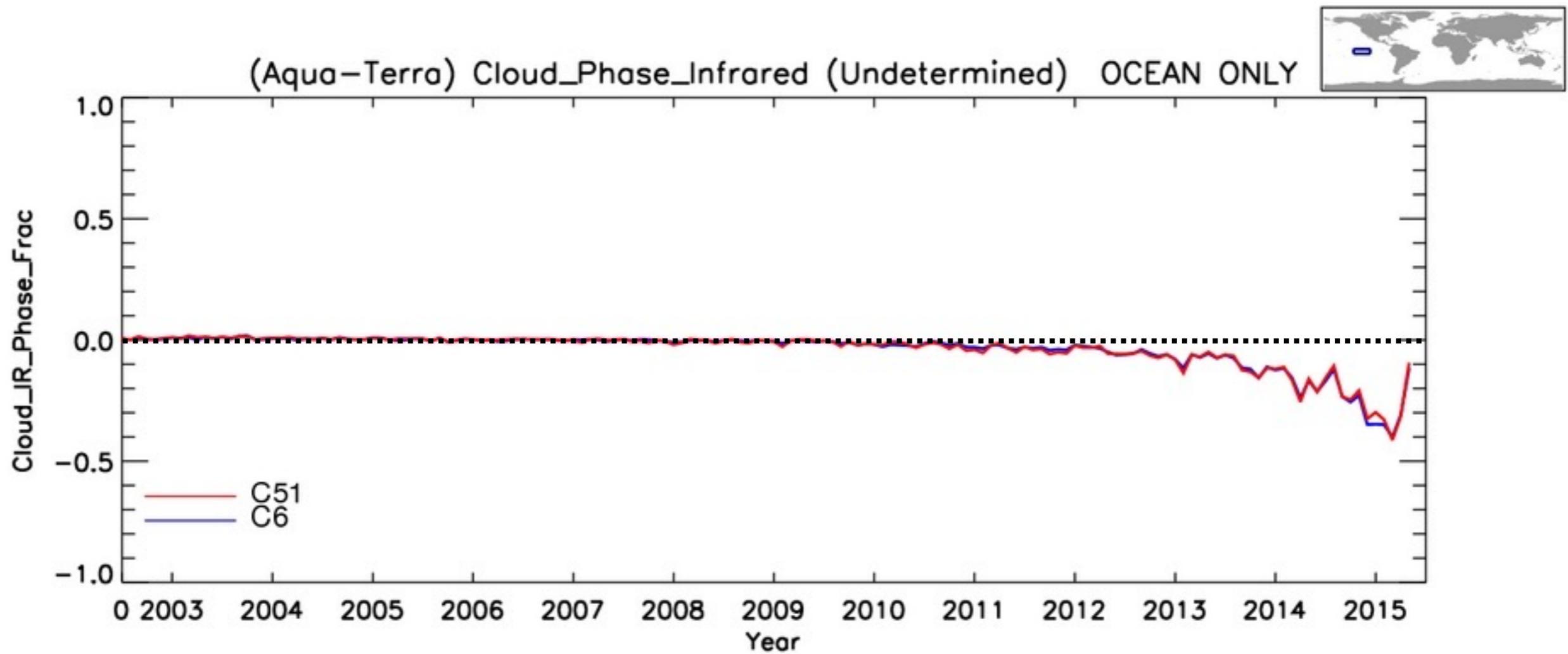
Pacific region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: Ice



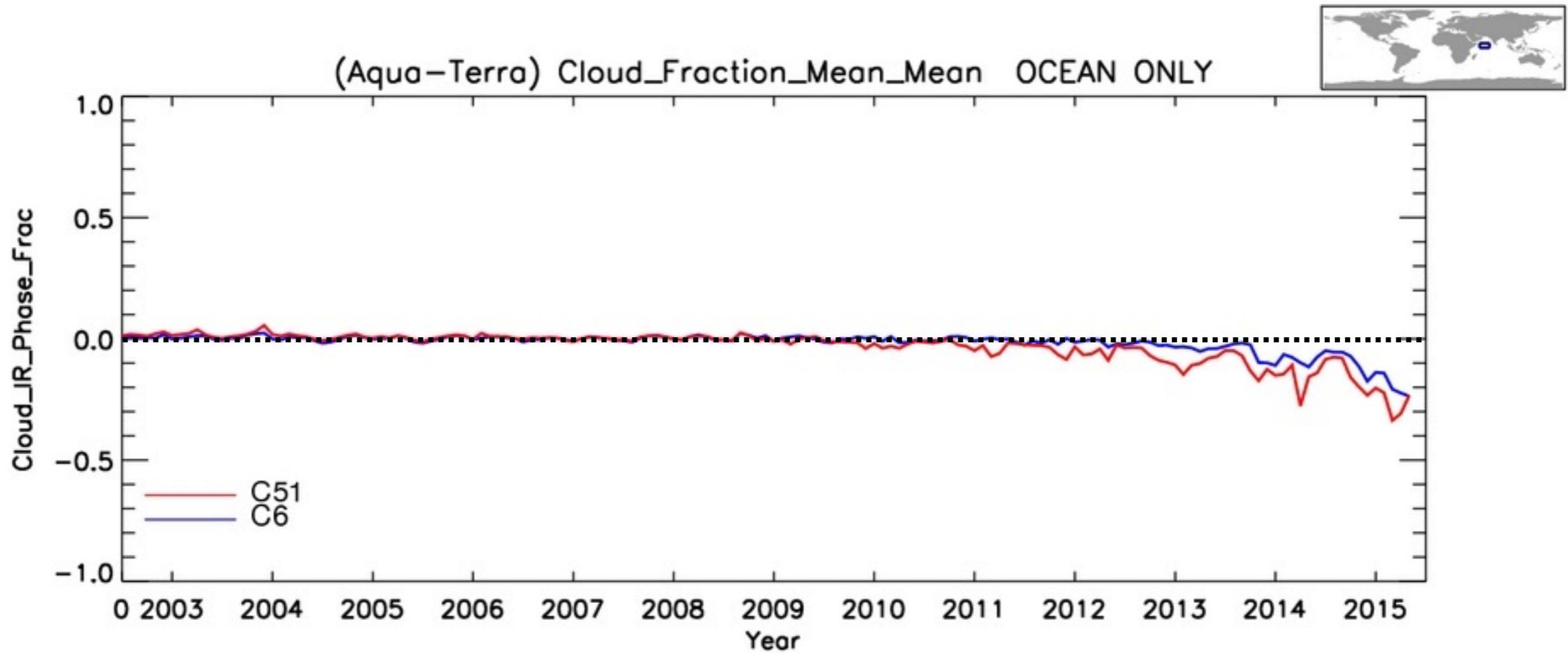
Pacific region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: Undetermined



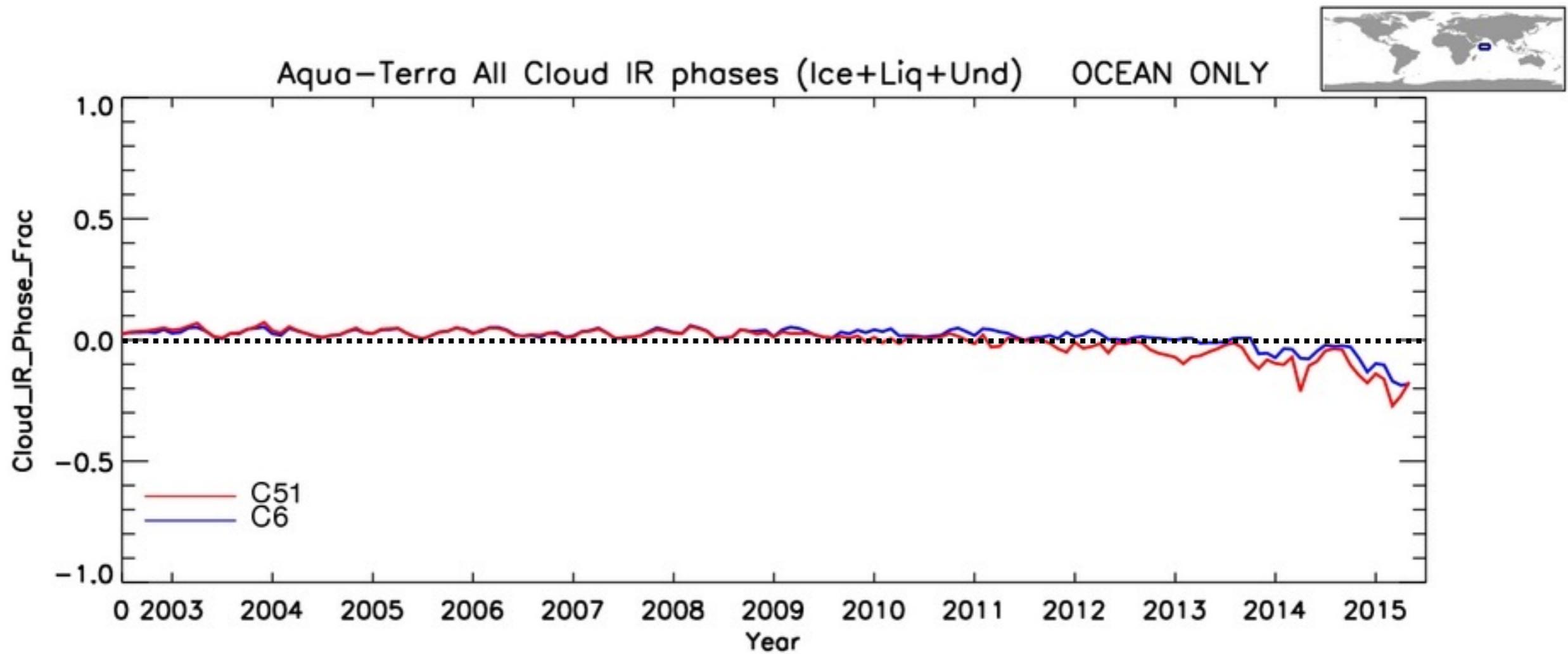
Pacific region of interest

# Monthly Daytime Cloud Fraction (MOD/MYD35) time series for Terra and Aqua MODIS



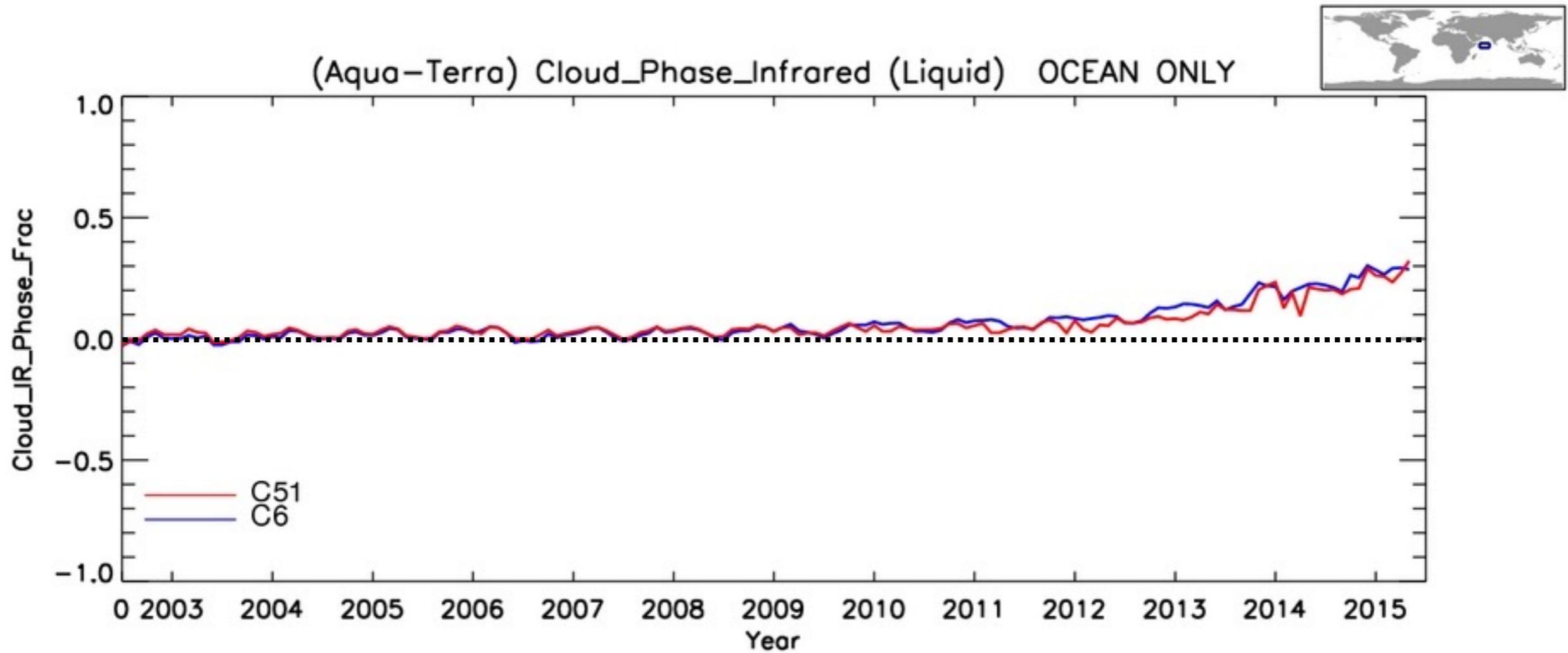
Indian Ocean region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: All phases



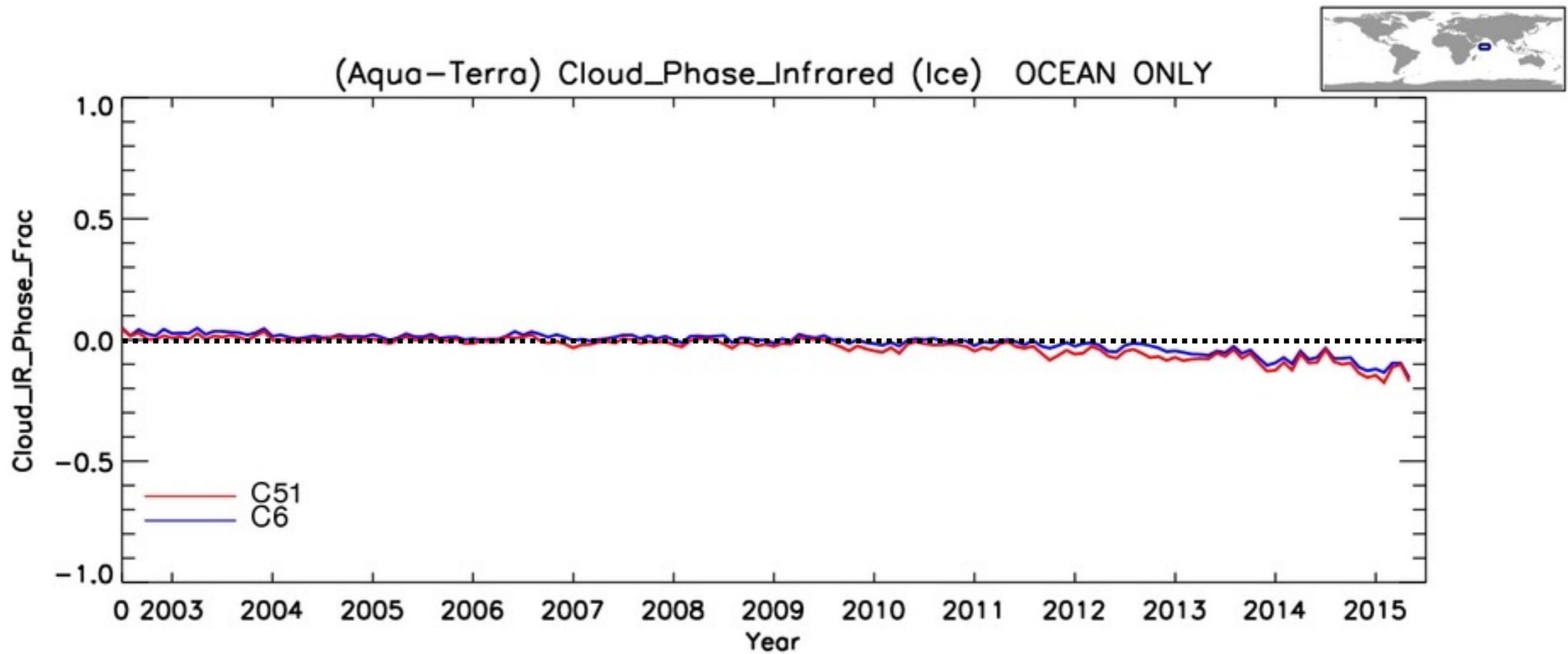
Indian Ocean region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: Liquid



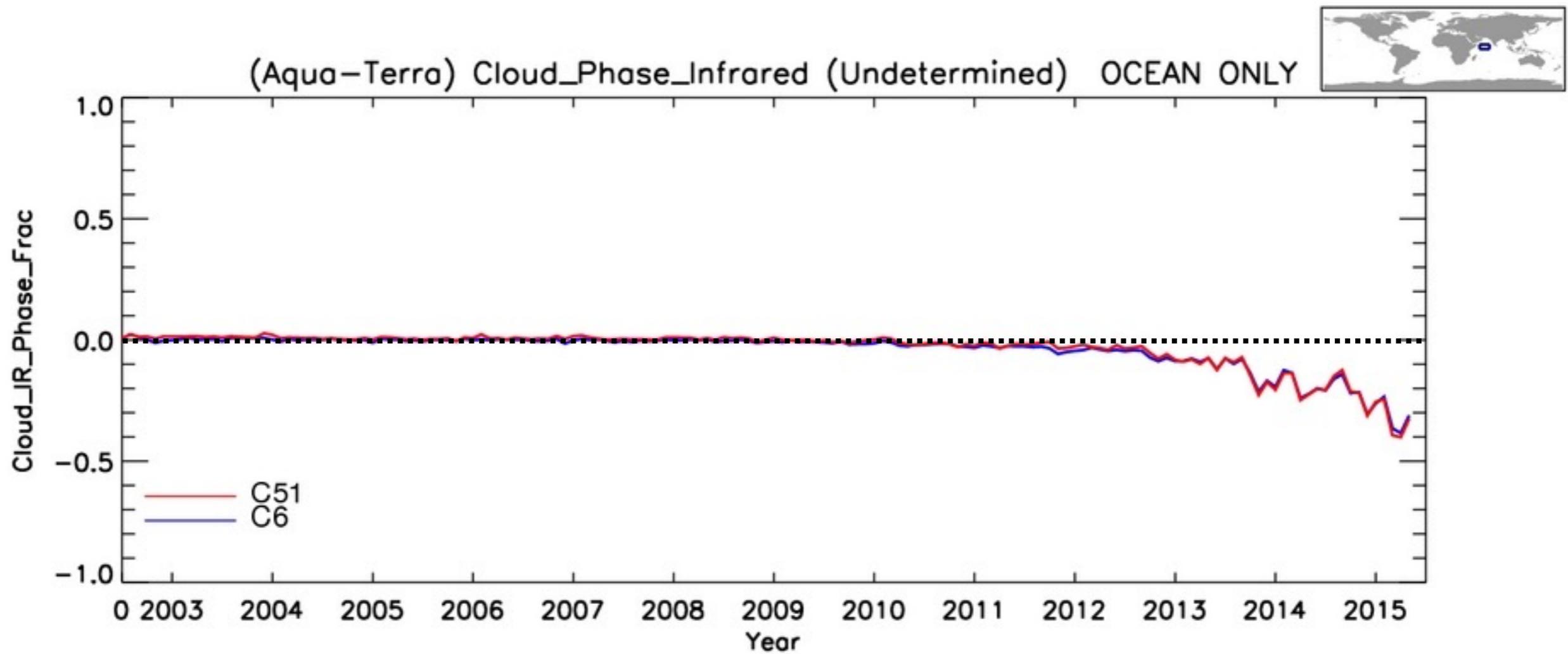
Indian Ocean region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: Ice



Indian Ocean region of interest

# Monthly Daytime IR Phase Fraction (MOD/MYD06) time series for Terra and Aqua MODIS: Undetermined



Indian Ocean region of interest