



# Sensitivity of Aerosol Multi-Sensor Daily Data Intercomparison to Level 3 Dataday Definition

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# Why people use Level 3 products?

- Satellite Level 2 data are difficult to work with because of:
  - Complex formats
  - Complicated projection (swath)
  - Data volume
  - Number of files
- Level 3 products are widely used by modelers, application users, climate change scientists
- Level 3 data **are easy to use** ... but also **are easy to misuse**



# Why something might go wrong with Level 3 products?

- Usually, **Science Teams are tasked** to produce & validate **Level 2** data
- **Level 3** products are **treated** mostly as just **imagery**, to assess gross features and variability of geophysical parameters
- **Usability of L3** data usually is **not a high priority**
- L3 data are **constructed differently** for **different instruments**
- **L2 errors** usually are **not propagated to L3**
- At best, **standard deviations** (mostly reflecting variability within a grid box), sometimes pixel counts and quality histograms are provided
- The L3 “validation”, in most cases, is done by consistency checking and comparing with L3 data from other sensors or models
- **No consistent efforts to characterize & quantify L3 uncertainties**



# So, what do we need to do?

*Despite Science Teams/Data Providers not encouraging using L3, these products are widely used, so their quality and differences between them need to be addressed*

- **Instrumental issues:** measurement precision, differences in calibration and instrument sensitivity, changes or drift in calibration or sensitivity over time, etc.
- Fundamental differences in the **retrieval algorithm method (multispectral vs. multi-directional)** and **assumptions:** aerosol models employed, wavelengths used, cloud filtering, surface reflection handling
- **Observational issues:** rapidly varying cloud cover, viewing angles and conditions, time(s) of observation, changing surface characteristics, etc.



# Differences in L3 from different sensors, cont.

When comparing data from different sensors, it is important to understand and (where possible) consistently process the data.

## **L3 data processing:**

- **Spatial and temporal binning (L2 → L3 daily):**
  - Measurements (L2 pixels) from one or more orbits can go into a single grid cell → different within-grid variability
  - Different weighting: pixel counts, quality
  - Thresholds used, i.e., > 5 pixels
- **Data aggregation (L3D → L3monthly → regional → global):**
  - Weighting by pixel counts or quality
  - Thresholds used, i.e., > 2 days

While these algorithms have been documented in ATBD, reports and papers, the typical data user is not immediately aware of how a given portion of the data has been processed.



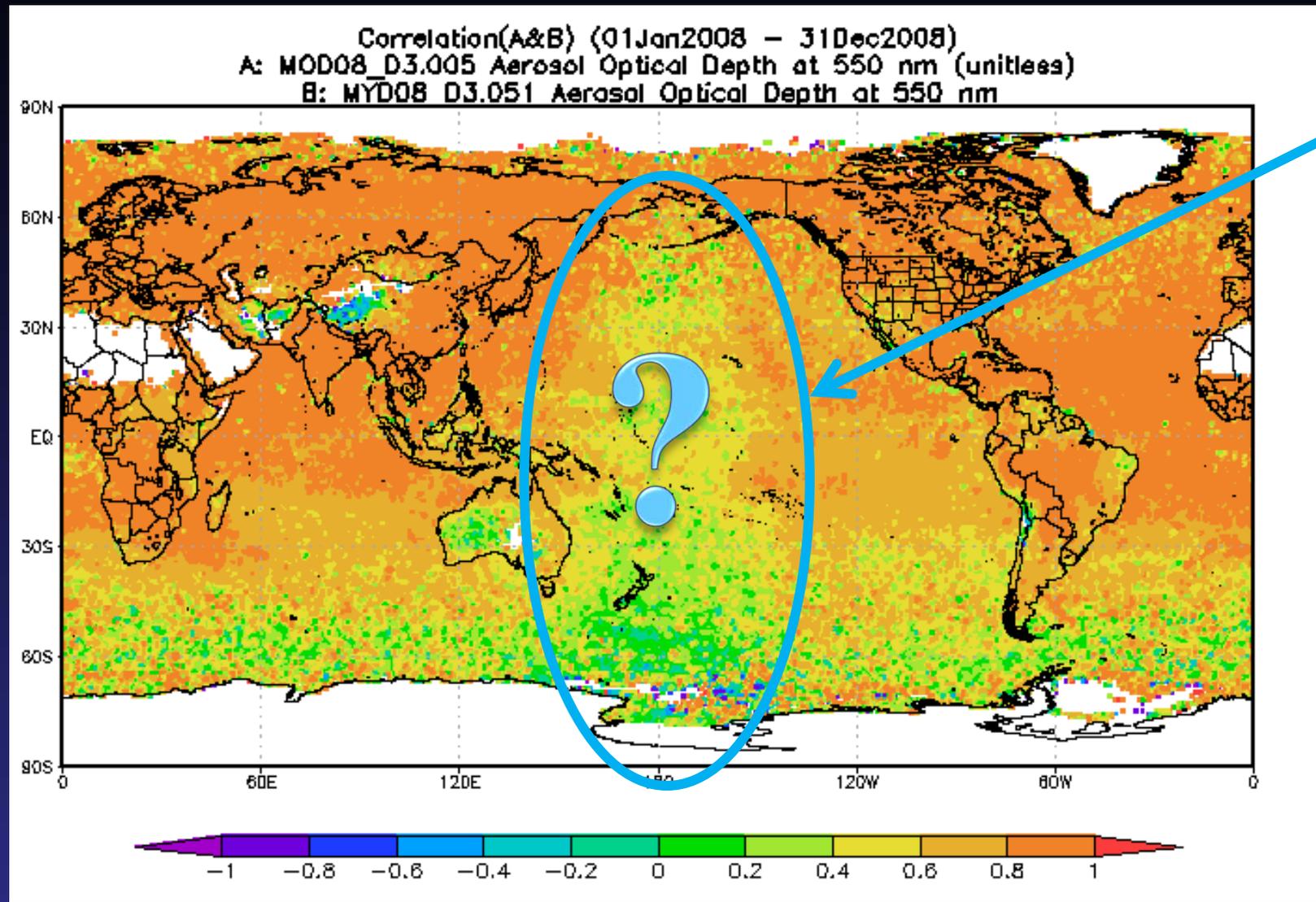
# Level 3 dataday definition

Here we address one more aspect of potential incompatibility between Level 3 data coming from different sensors: the dataday issue.

Let's compare Level 3 daily data between MODIS-Terra and MODIS-Aqua:



# MODIS vs. MODIS



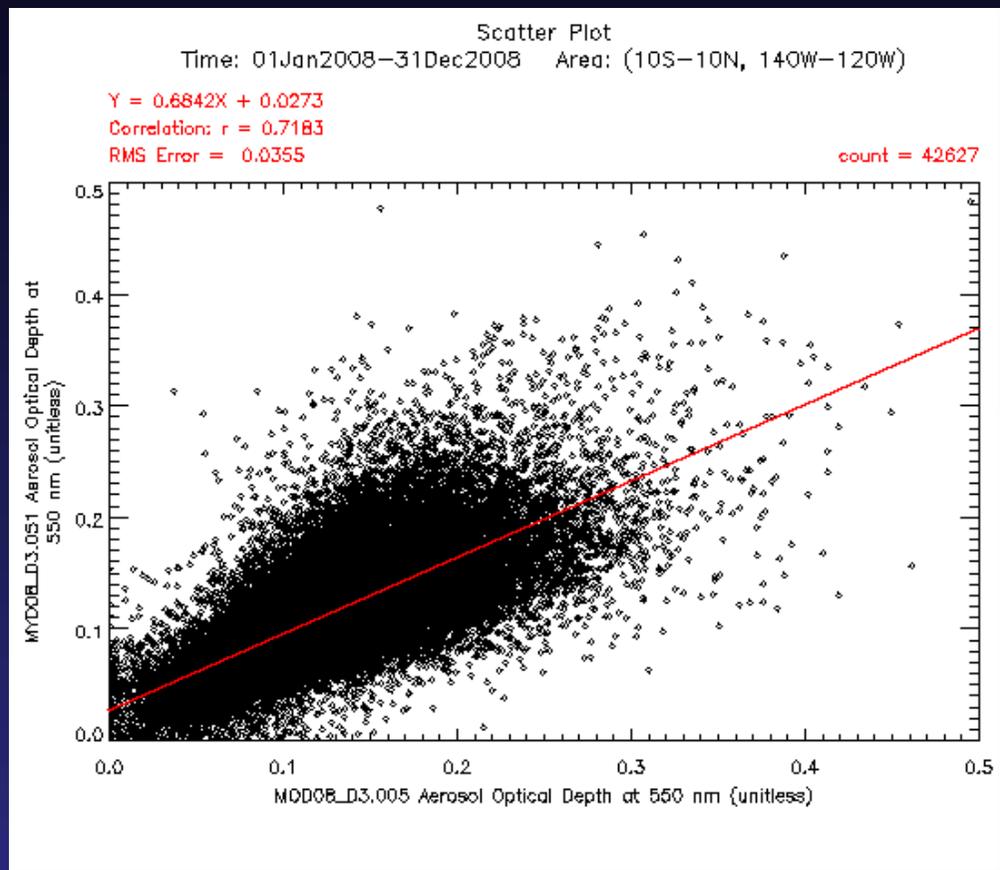
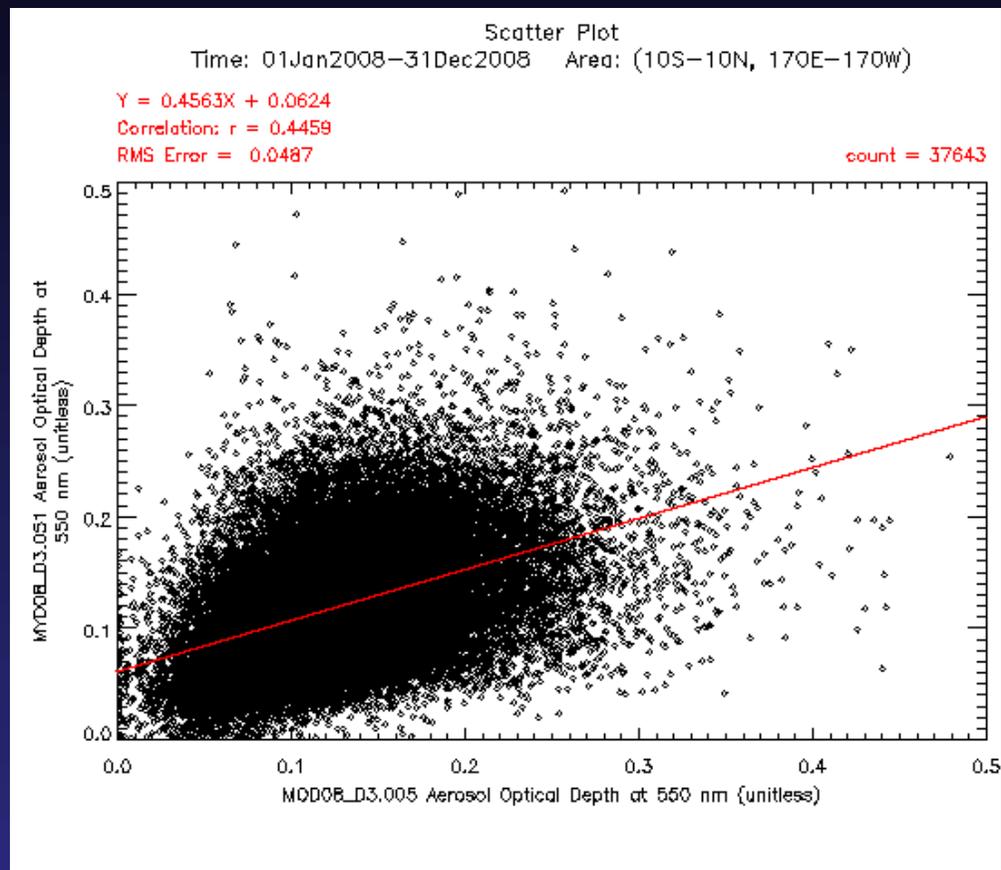
MODIS-Terra vs. MODIS-Aqua: Map of AOD temporal correlation, 2008



# AOD MODIS Terra vs. Aqua in Pacific

## Over the dateline

## Away from the dateline

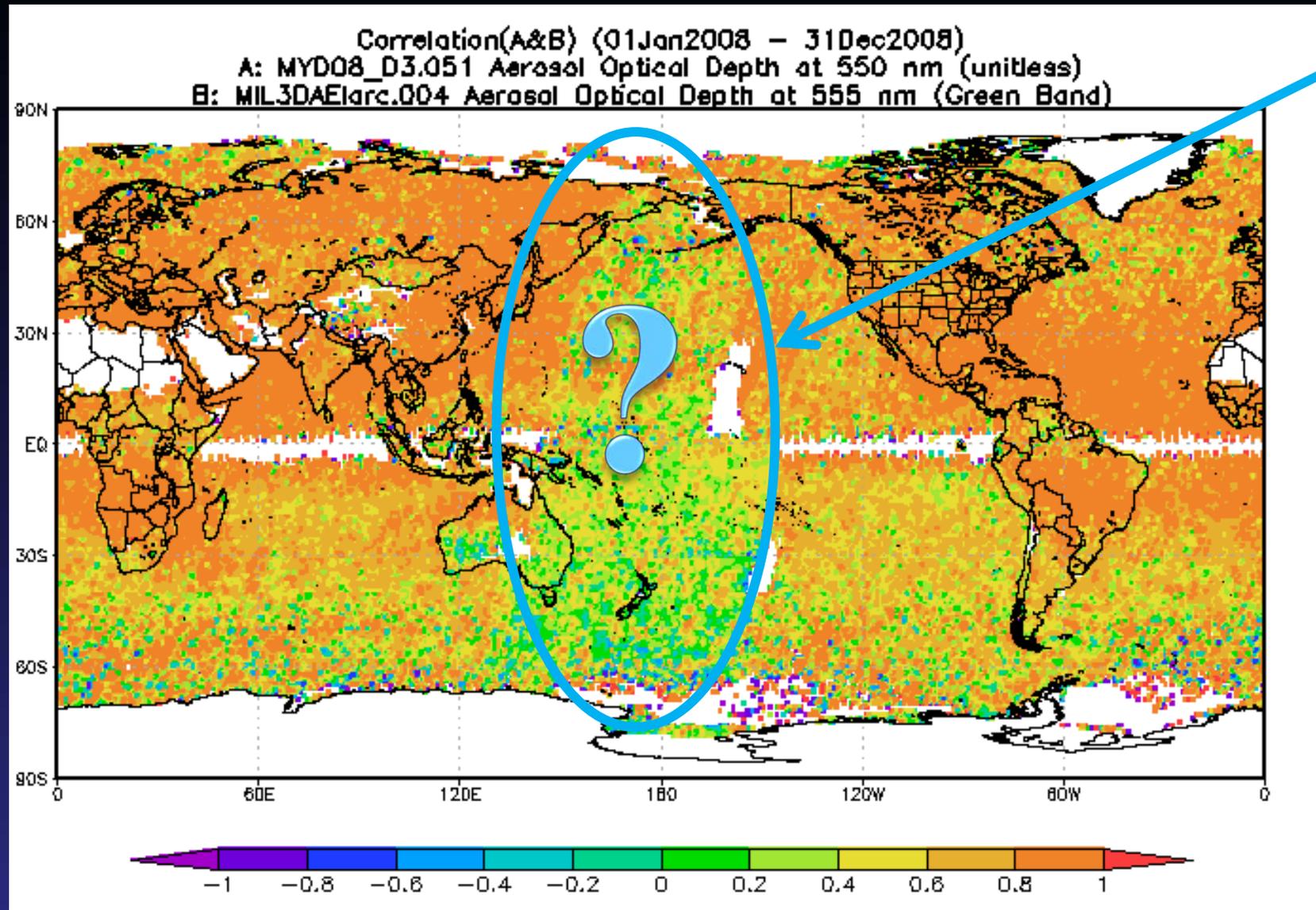


$R^2 = 0.45$   
RMS = 0.05

$R^2 = 0.72$   
RMS = 0.036



# AOD Aqua MODIS vs MISR correlation map

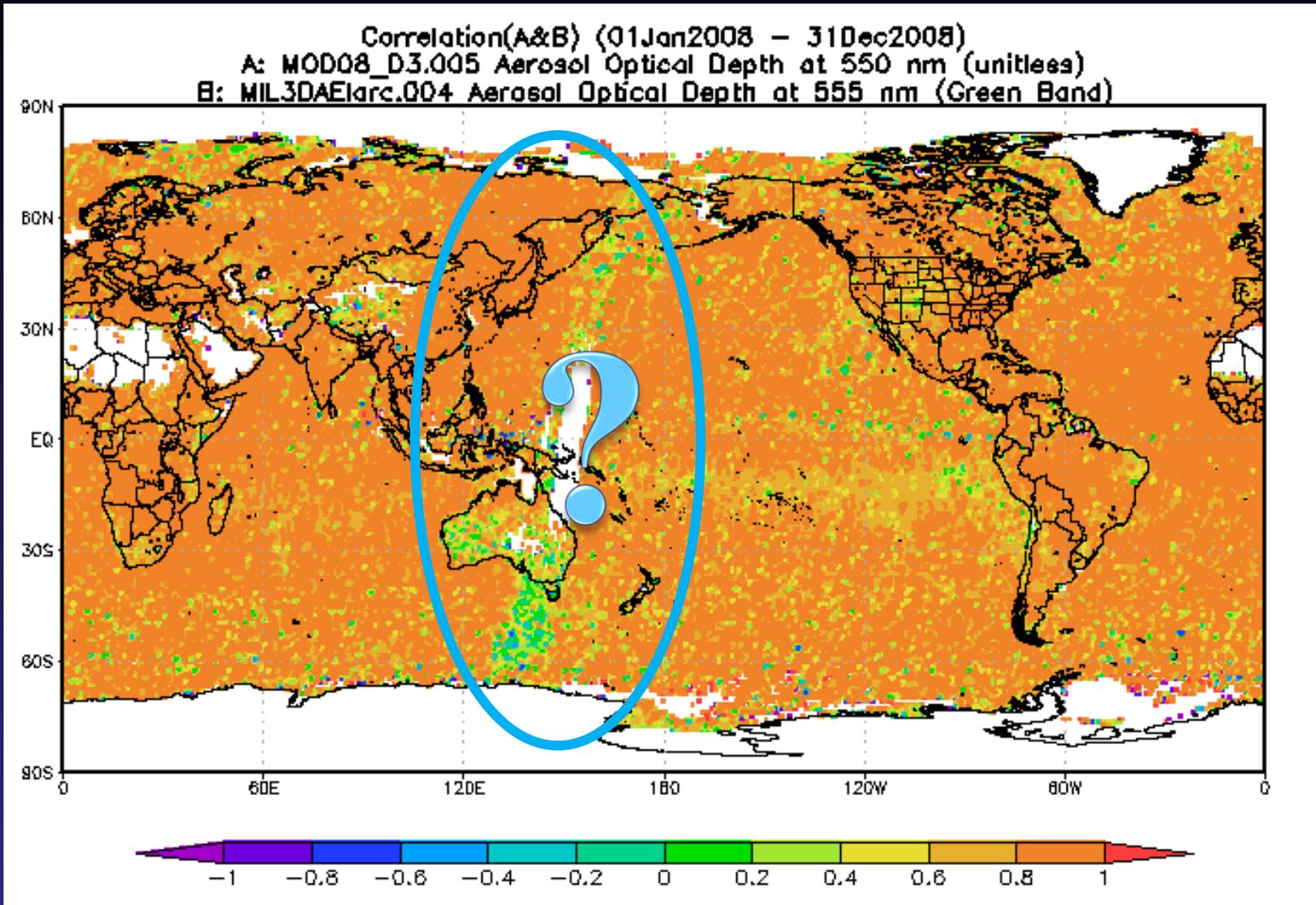


## AOD Aqua MODIS vs MISR correlation map for 2008

Note: It is basically the same sensor but on different platform,  
but correlation is not that good



# MODIS vs. MISR on Terra



MODIS-Terra vs. MISR-Terra: Map of AOD temporal correlation

Note: a very good correlation globally besides a narrow area



# MODIS Atmos. Data day definition

Level 3 daily products are generated by binning Level 2 data belonging to one day onto a certain spatial grid according to a dataday definition.

*Dataday might be different for different sensors and sometimes even for the same sensor but defined by different teams.*

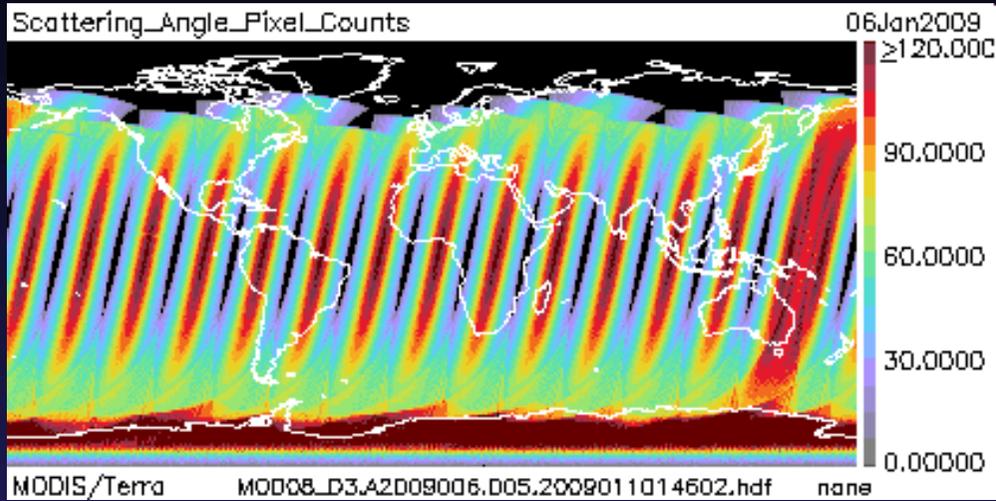
MODIS Atmospheric products (from MODIS L3 ATBD):

The Daily L3 product contains statistics computed from a set of L2 MODIS **granules** (HDF files) that span a 24-hour (00:00:00 to 23:59:59 UTC) interval. In the case where a L2 parameter is only computed during the daytime, then only daytime files are read to compute the L3 statistics.

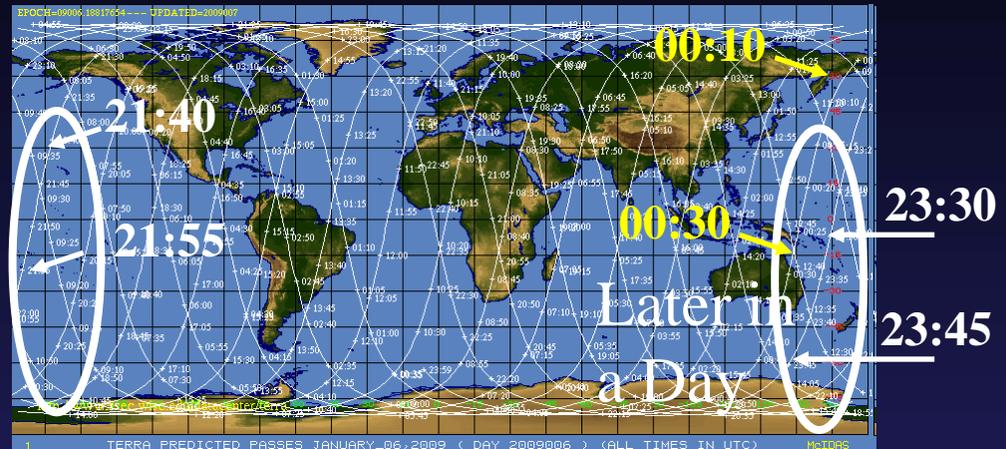


# Orbit Time Difference for Terra and Aqua 2009-01-06

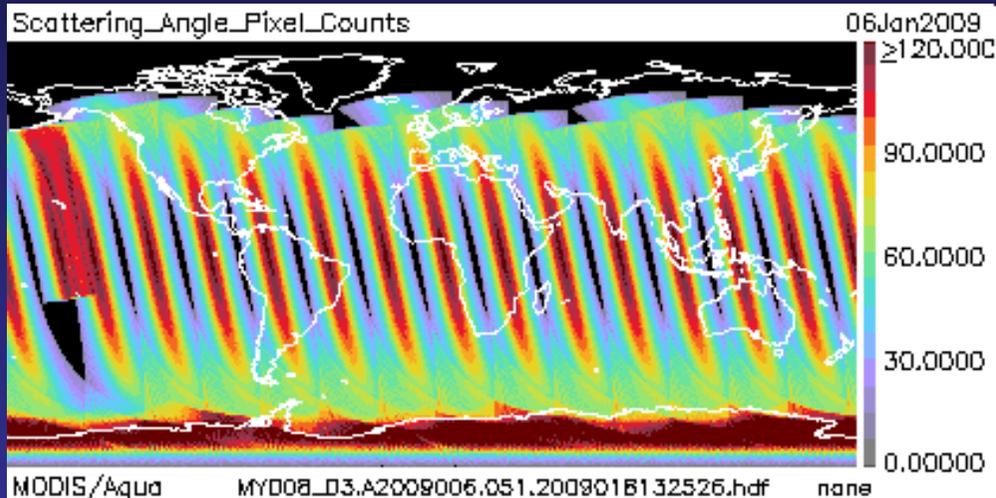
## Terra



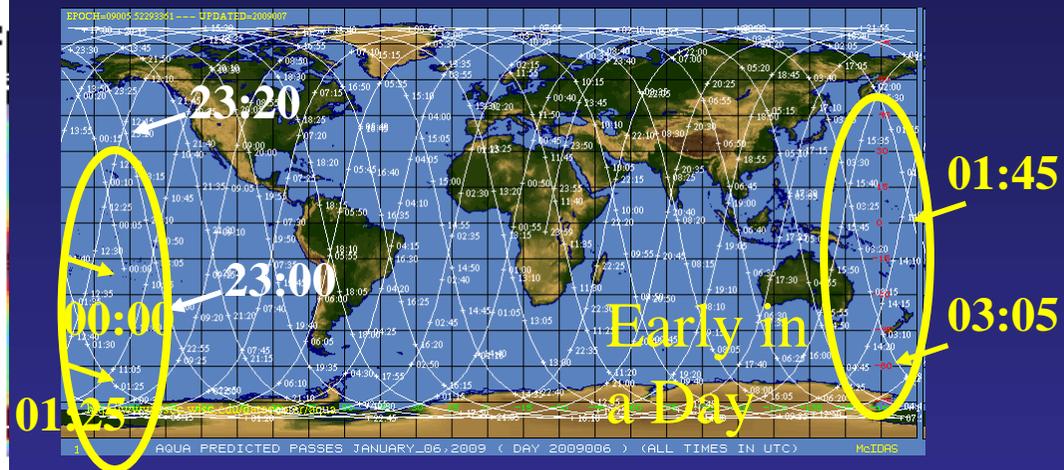
## Terra



## Aqua



## Aqua

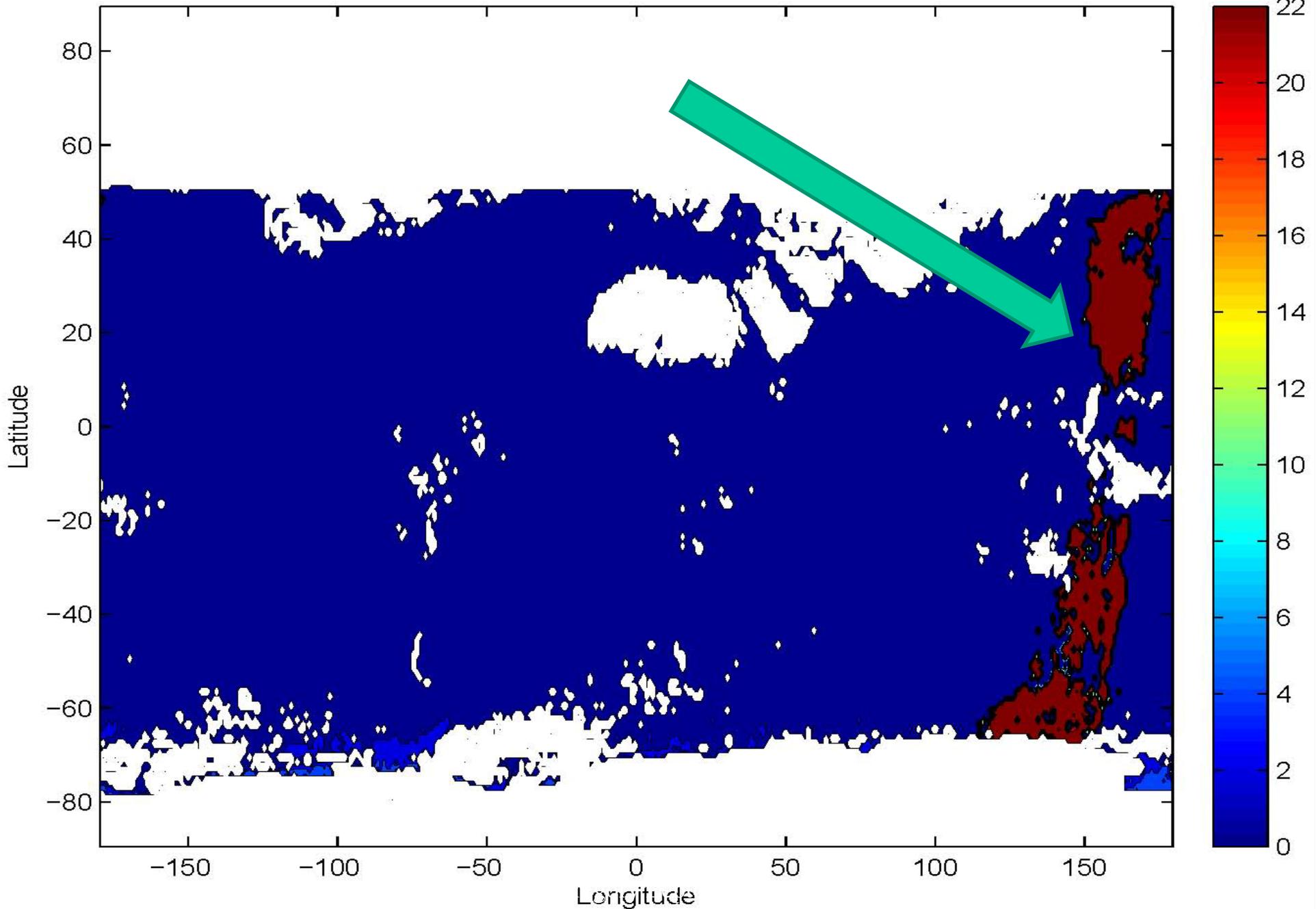


Orbit track from: <http://www.ssec.wisc.edu/datacenter>



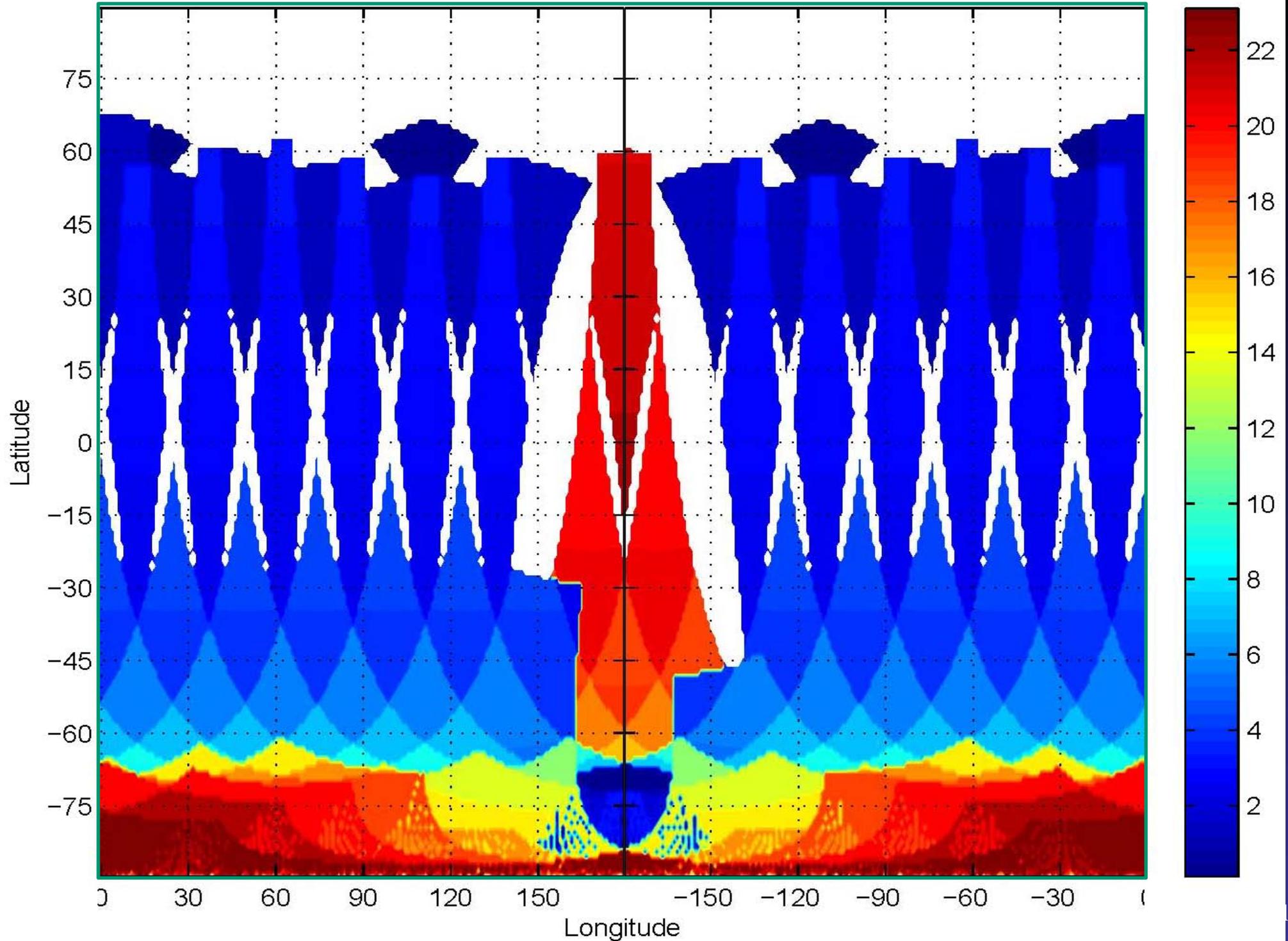
# Max Time diff. for Terra (calendar day)

Maximum Local Time Difference for Calendar day definition



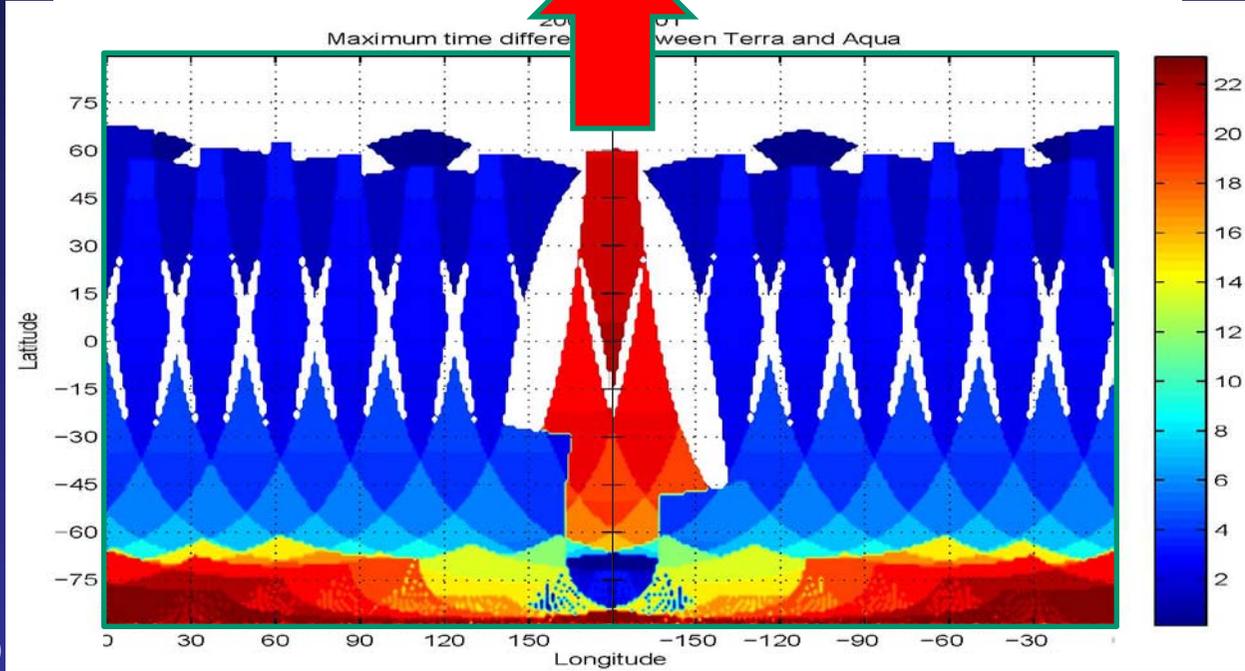
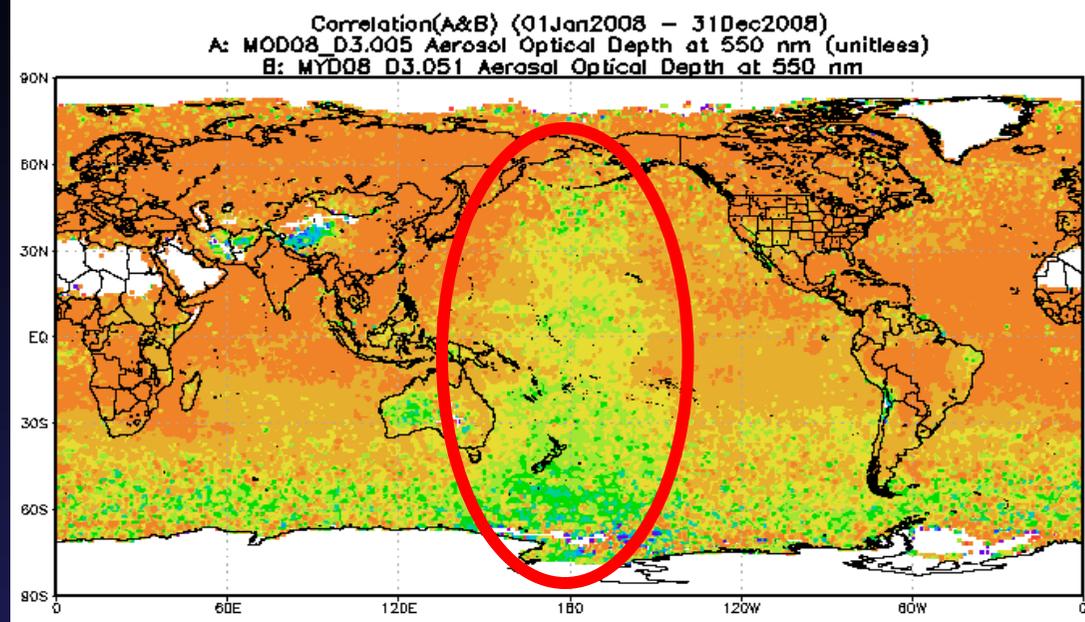
2008-01-01

Maximum time difference between Terra and Aqua





# Artifact explained



Aerosols change sufficiently within 22 hours to cause significant drop in correlation



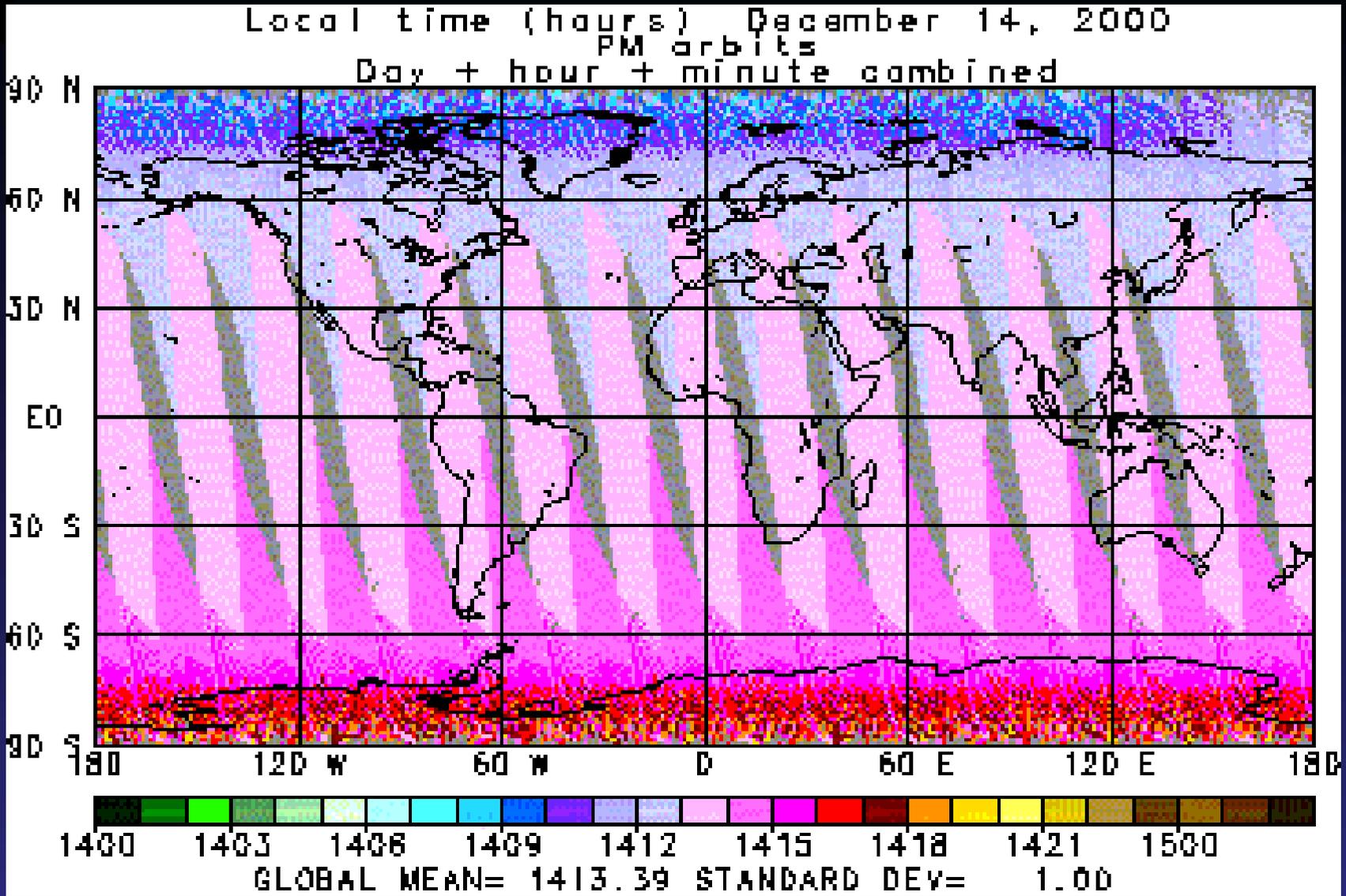
# Data day definitions

OK, now we know where the artifact has come from. Is there a way to fix it, i.e., the right dataday definition?

1. Calendar dataday: all granules between 00:00 – 24:00 UTC:  
MODIS Atmospheric products, OMI L2G – **problematic**
  
1. Local time (pixel-based): uses local date/time for each pixel  
and ensures spatial continuity - **good**:  
TOMS, AVHRR, AIRS, OMI, MODIS Ocean, SeaWiFS, MERIS



# Local time distribution



AIRS image courtesy of L. Iredell GSFC

A sensor on sun-synchronous orbits visits every point on Earth around the same **local** (!) time, e.g., 13:30 for Aqua



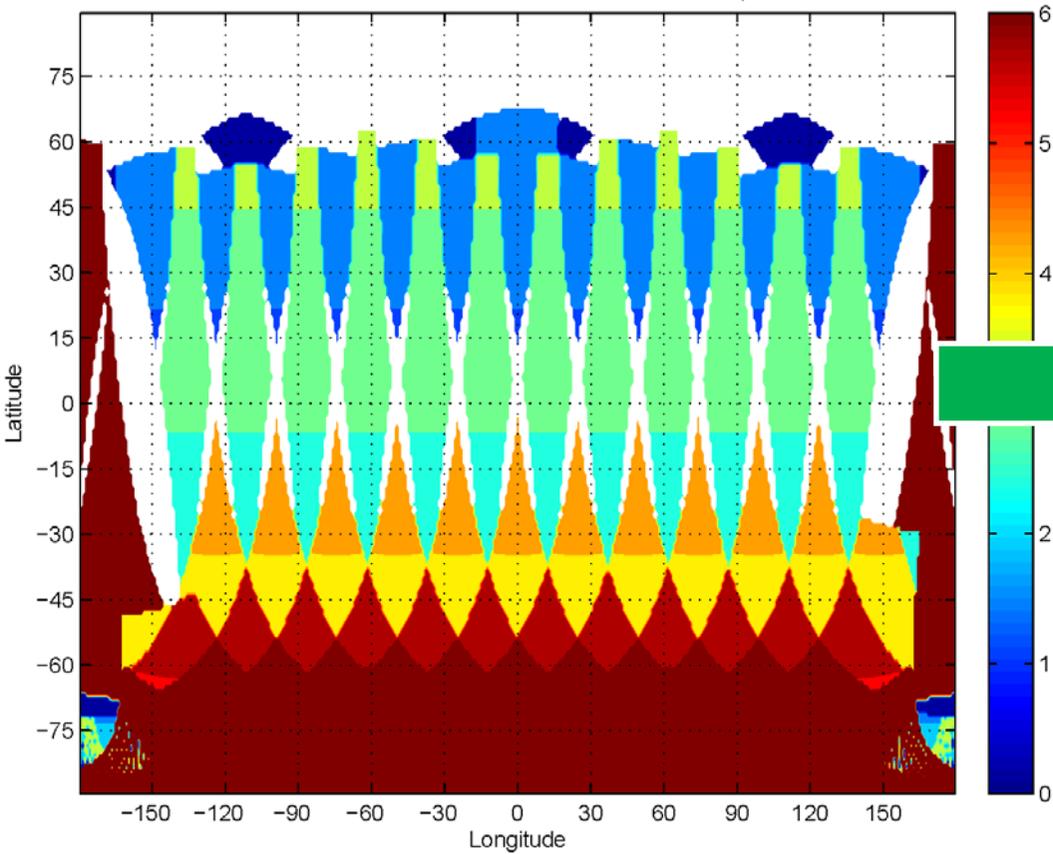
# Spatial (local time) Data Day definition

- Each data set contains information for 24 hours of local time, e.g., 13:30
- The gridding starts at the dateline and progresses westward, as does the satellite
- Parts of scan lines that cross the dateline are included in the current date data set or the next, depending on which day is at the local time/day at that longitude.
- For Aqua, the p.m. orbit starts at roughly 1:30 Z on the day and ends on roughly 1:30 Z of the following day.

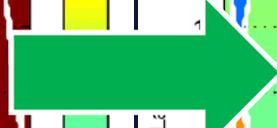
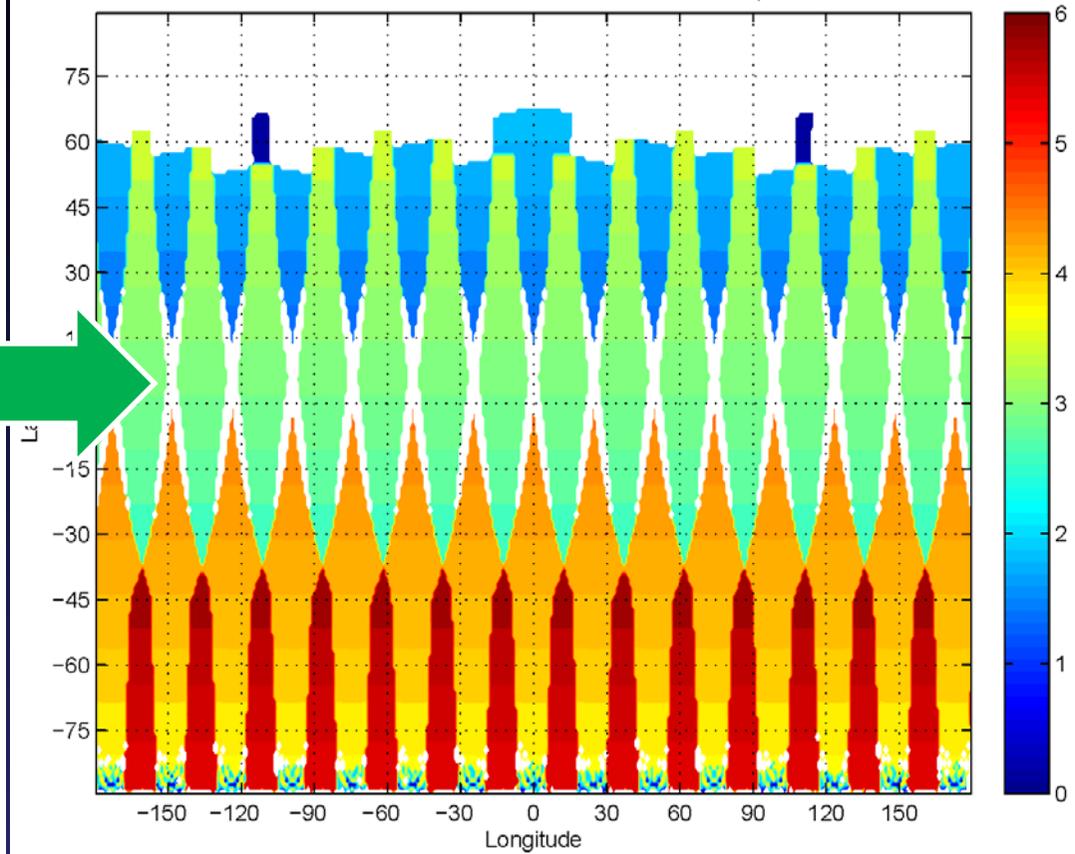


# Max time diff. between Terra and Aqua

2008-01-01 Calendar Day Definition  
Maximum time difference between Terra and Aqua



2008-01-01 Data Day Definition  
Maximum time difference between Terra and Aqua



## Calendar UTC (MODIS) dataday

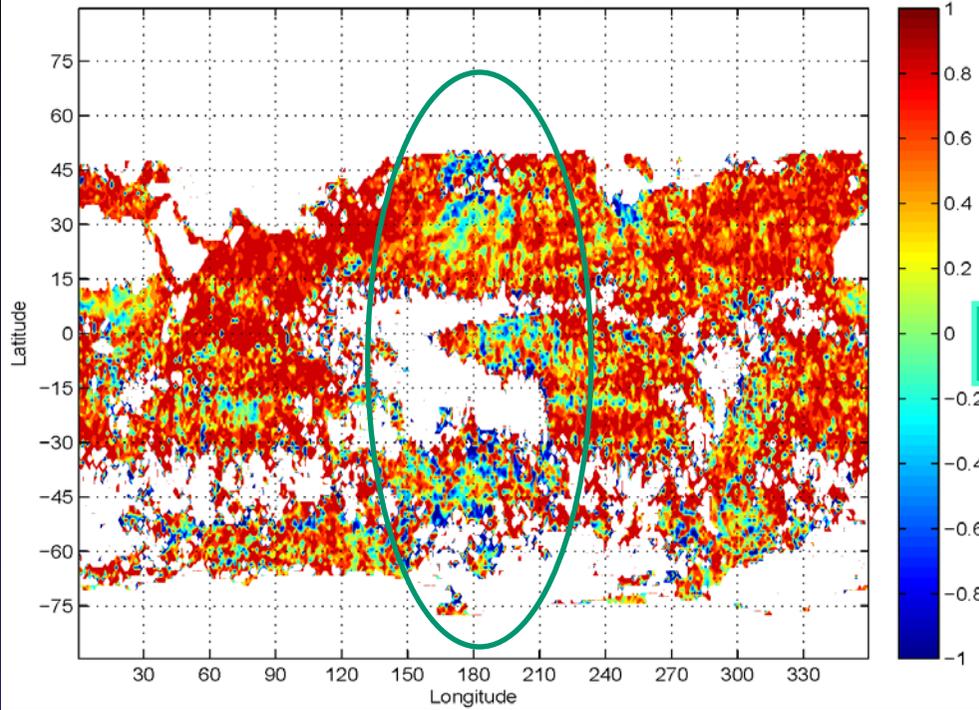
## Spatial (local time) dataday

The artifact around the dateline disappears. In other areas, results are exactly the same for the (-7, 18) latitude belt.  
 At higher latitudes, the additional restriction for one orbit time around the local time produces different results for two dataday definitions.

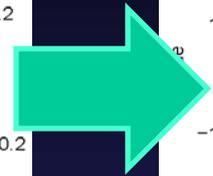
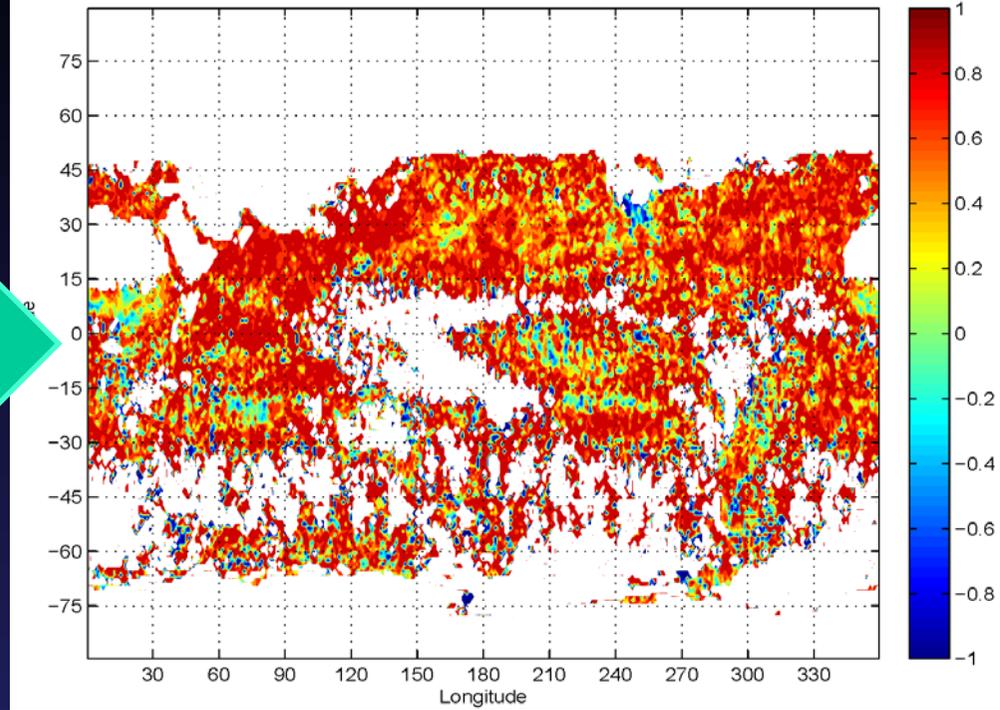


# Removing the artifact in 16-day AOD correlation

2008-01-01 to 2008-01-16 Calendar Day Definition  
Correlation between Terra and Aqua AOD

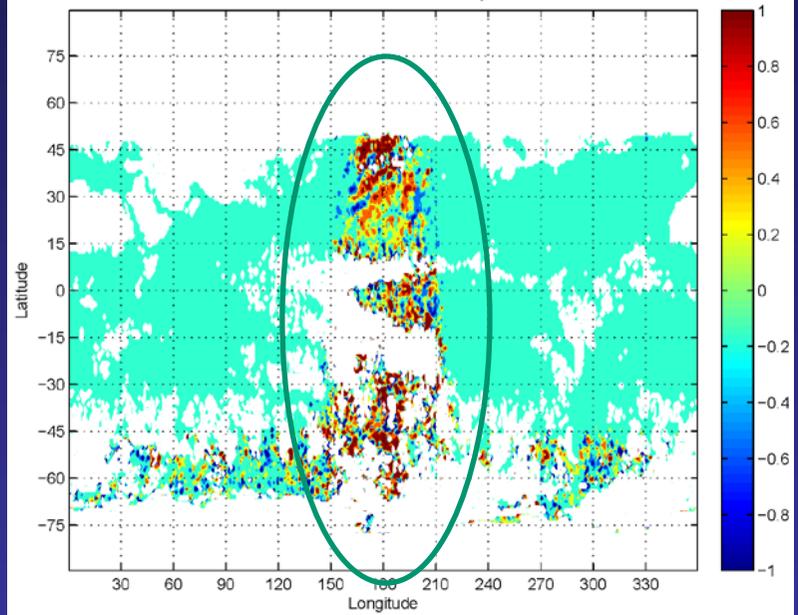


2008-01-01 to 2008-01-16 Data Day Definition  
Correlation between Terra and Aqua AOD



Calendar dataday

2008-01-01 to 2008-01-16 Difference between Day Definitions  
 $\Delta$  Correlation between Terra and Aqua AOD

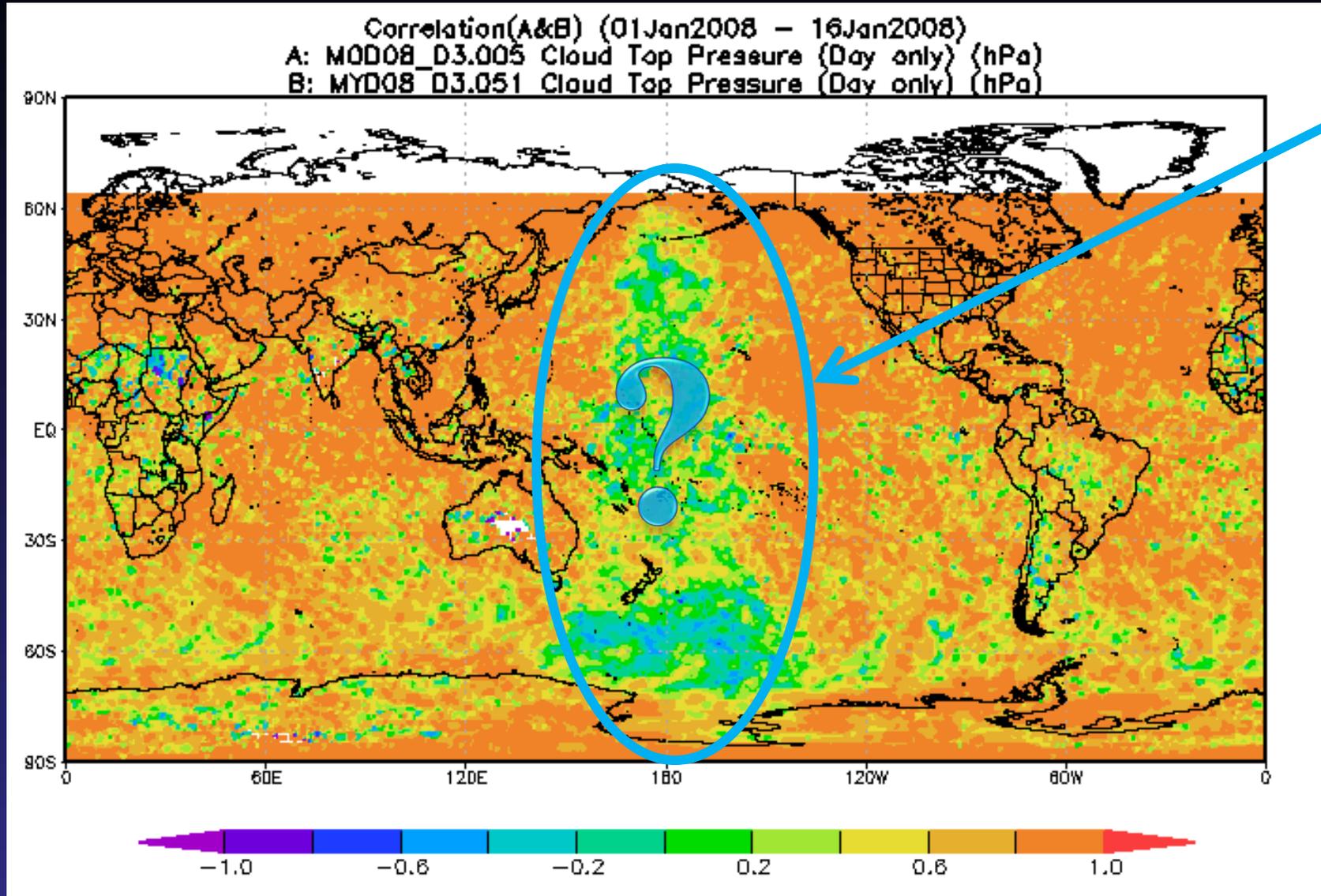


Spatial dataday

**Artifact:** difference between calendar and spatial dataday defs.



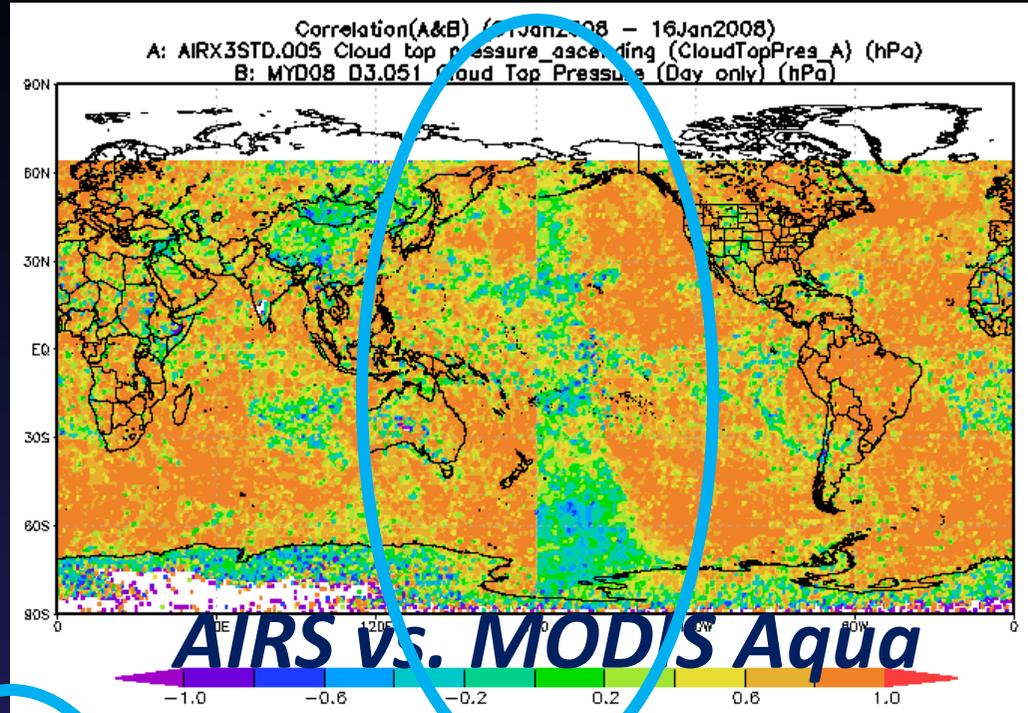
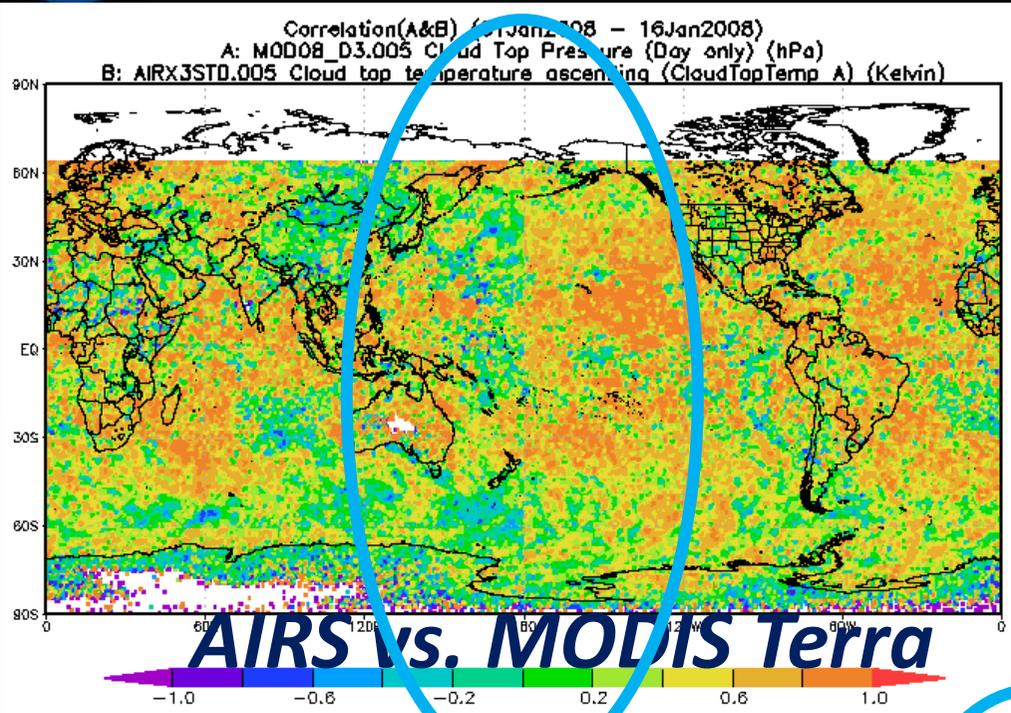
# MODIS Cloud Top Pressure



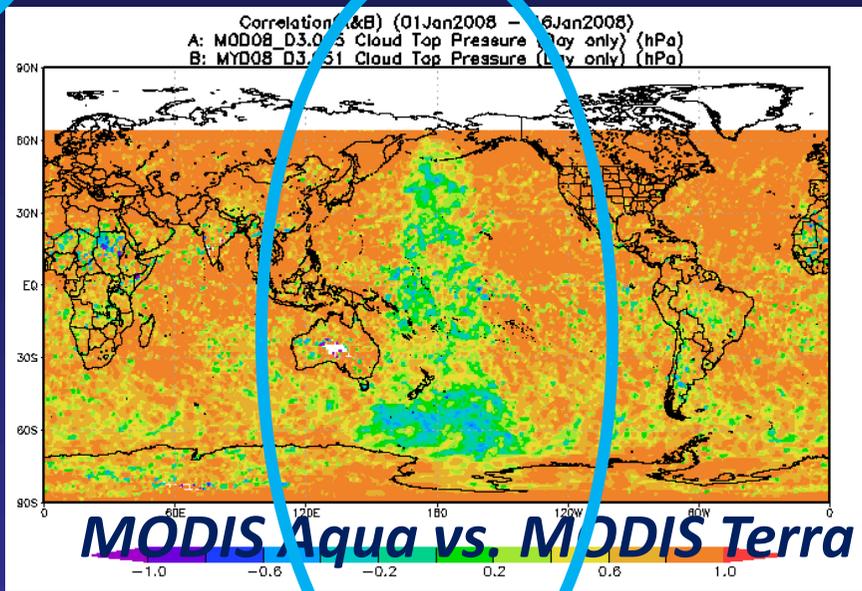
MODIS-Terra vs. MODIS-Aqua: Map of CTP temporal correlation, Jan 1-16, 2008



# MODIS Terra & Aqua vs. AIRS Cloud Top Pressure



Correlation maps for Jan 1 – 16, 2008



Different dataday definitions lead to different artifact patterns



# Conclusions and recommendations

- The calendar UTC 00-24 (MODIS) dataday definition leads to artifacts around the dateline due to  $\Delta t$  between measurements reaching up to 23 hours
- Spatial (local-time-pixel-based) dataday definition insures consistently small  $\Delta t$  between measurements from different satellites, thus removing artifacts
- Different “packaging” of L2 into L3 makes a difference
- Dataday effect is just one of many sources causing differences between Level 3 products from different sensors that need to be assessed and characterized