Monitoring Global Precipitation—Climate Diagnostics to Floods

Robert Adler

Guojun Gu

Huan Wu

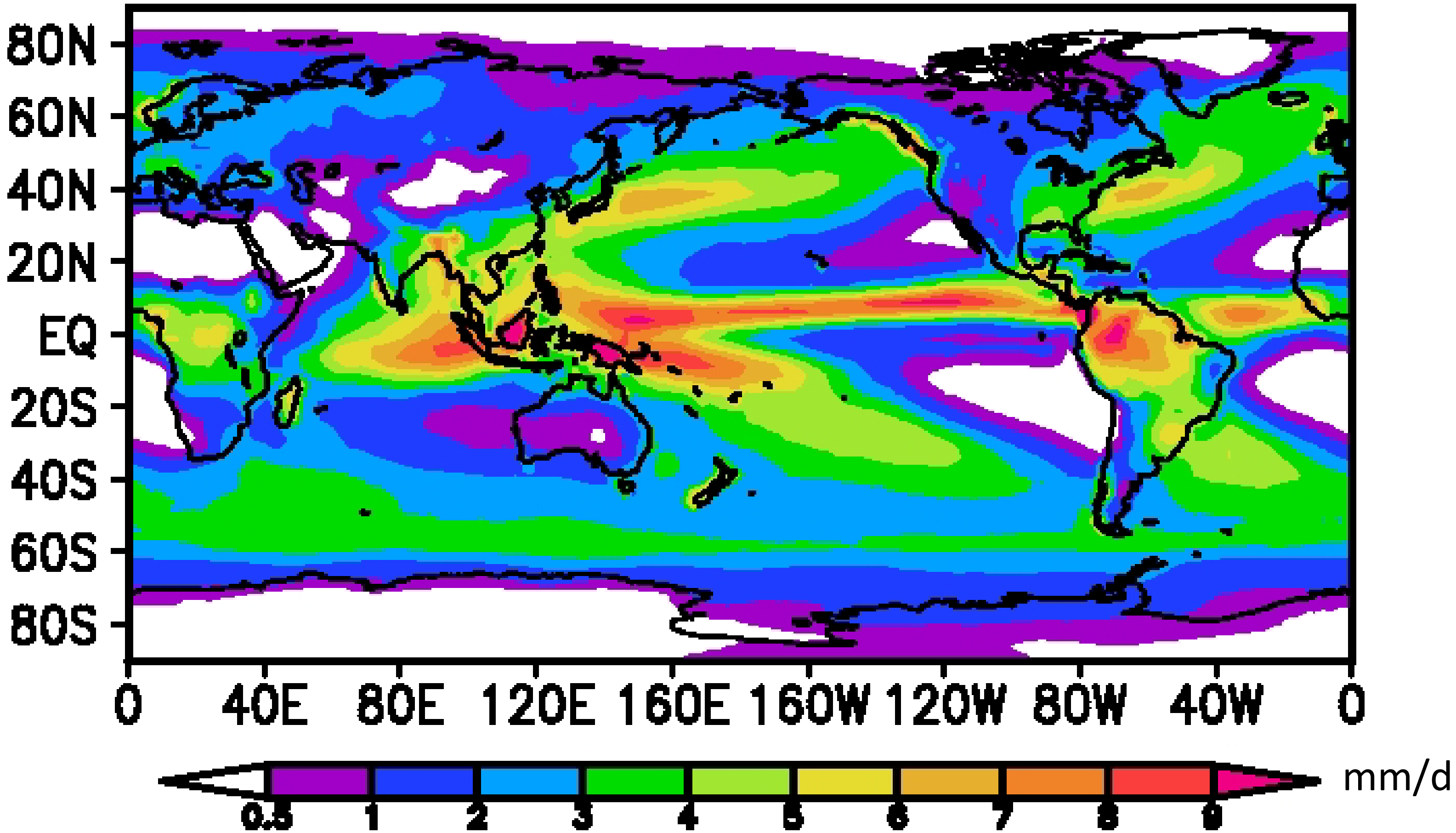
Jian-Jian Wang

Matt Sapiano

University of Maryland

Global Precipitation Climatology Project (GPCP)

Climatology (1979-2013)



GPCP is an often-used analysis based on satellite and gauge data (1979-near present).

No TRMM, GPM or Cloudsat data are in the current GPCP.

Adler et al., 2003 J. Hydromet

Huffman et al., 2009 GRL

Absolute Magnitude of Global Precipitation

	Ocean	Land	Ocean + Land
Precipitation	2.90 mm/d	2.24 mm/d	2.69 mm/d

*

Current GPCP global long-term number is <u>2.69 mm/d +/- ~7%</u>

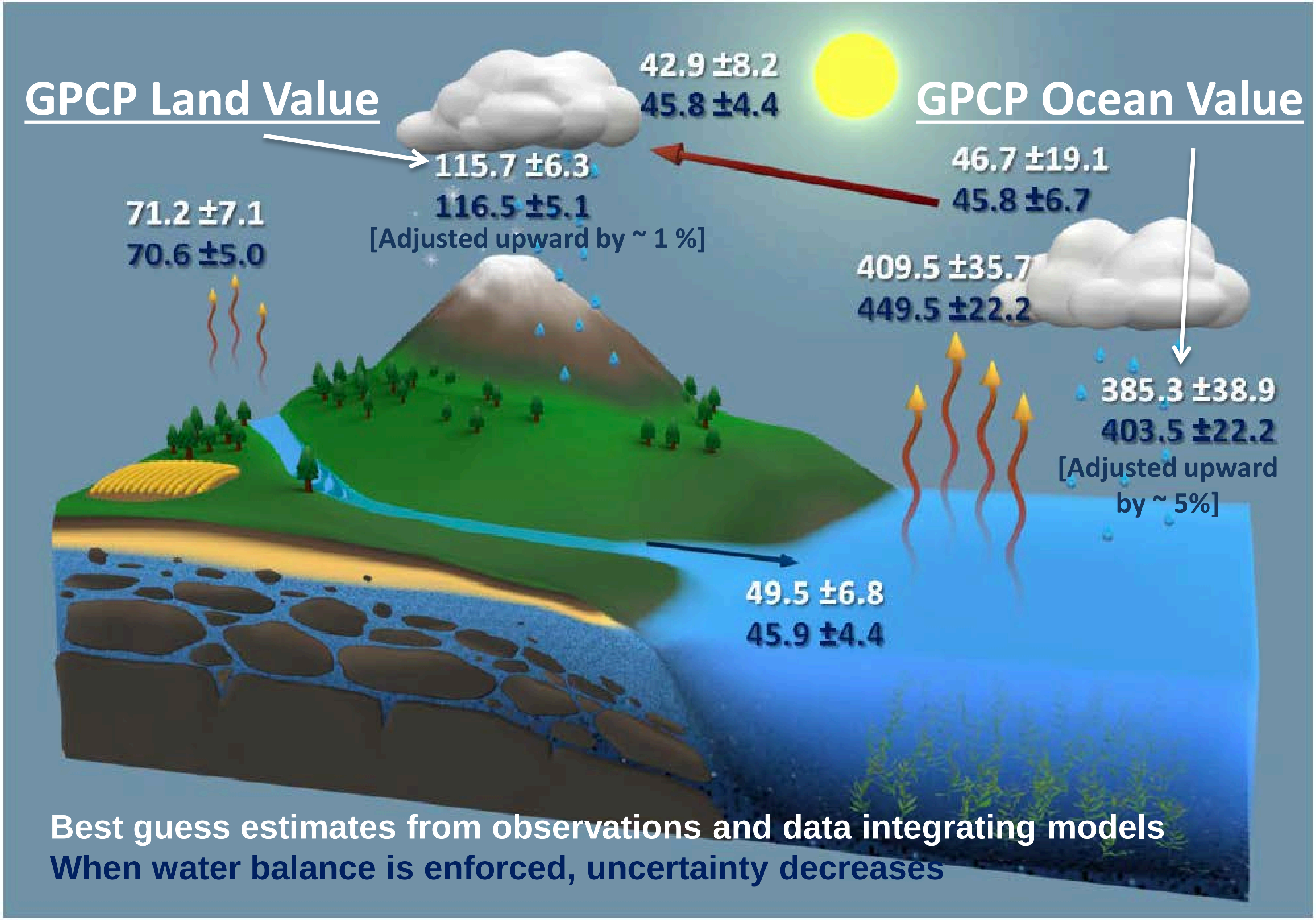
With the error based on variations among different estimates (including TRMM)
(Adler et al. 2012 JAMC)

But, how well do these very large-scale precipitation numbers compare <u>with more recent data sets</u> and fit in with <u>other components of the water cycle</u>?

* New values based on not-released GPCP V2.3 (in testing)—slightly higher (~1%) over ocean

Global Mean Annual Water Cycle

Global mean water fluxes (1,000 km³/yr) at the start of the 21st century



From Rodell et al., 2015 J. Clim.

Tropical Mean (Ocean) Rainfall Estimates

mm/d	TRMM Radar (2A25 NS--adjusted)	TRMM Composite Climatology (TCC)*	GPCP	TRMM PR + CloudSat**
35N-35S (ocean)	2.9	2.9	2.9	3.0 (3 years)

There seems to be a remote sensing consensus emerging of the mean magnitude of tropical ocean rain—this doesn't mean that this is the correct answer, but that current remote sensing information (TRMM and CloudSat) does not lead to significant "missed rain" in the tropics.

*Adler et al. 2009 JMSJ; Wang et al., 2014 JCLIM

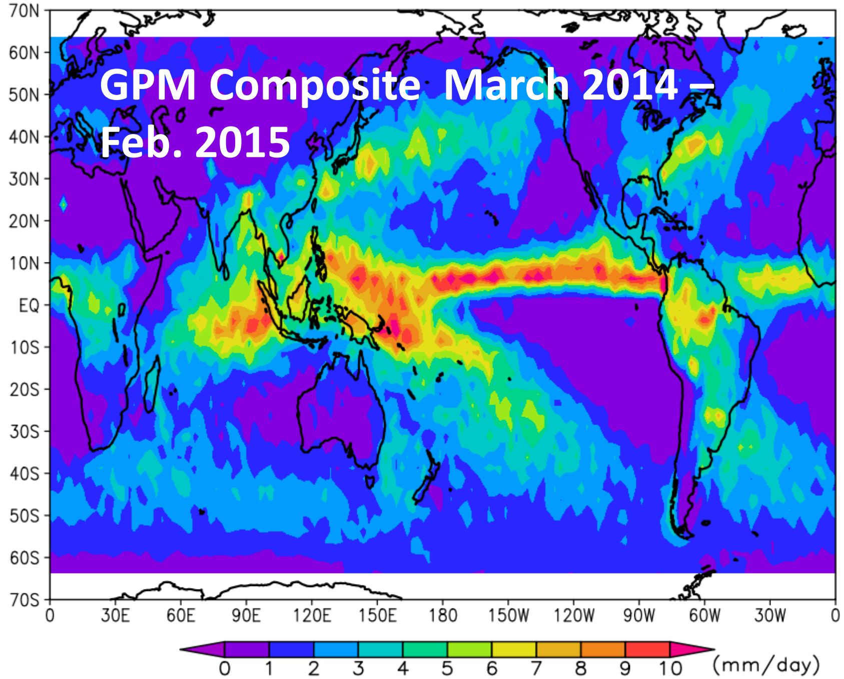
**Behrangi et al., 2014 JClim

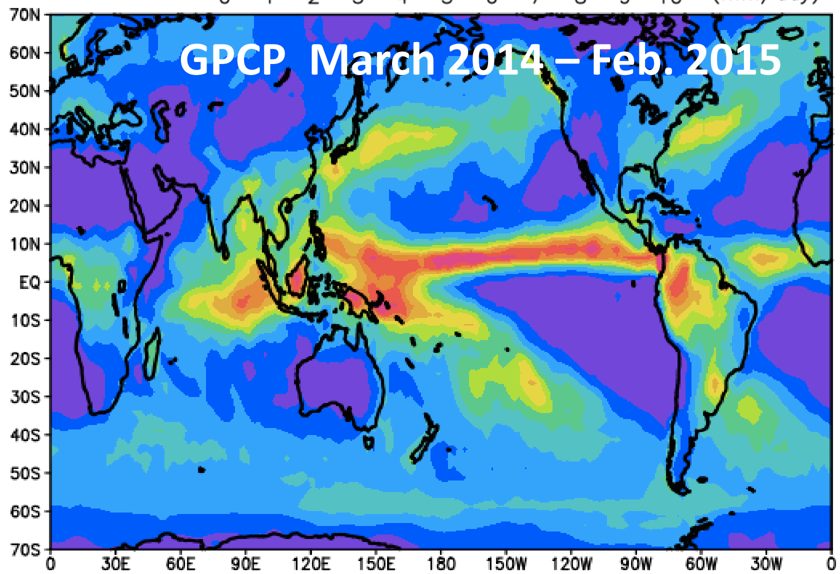
Global Mean (Ocean) Rainfall Estimates

	GPCP	PR + CloudSat; AMSR + CloudSat Behrangi et al. 2014 JClim
60N-60S (ocean)	2.97 mm/d	3.13 *[GPCP + ~ 5%]*

*GPCP global ocean number still seems reasonable, but needs to be examined again with improved data (e.g., GPM, etc.). If there are faults in the global precipitation magnitude (e.g., underestimation) it probably doesn't have to do with light rain or snow, but perhaps with **intense convective rainfall** in the tropics.*

GPM First Year Precipitation from Passive Microwave (GMI) and Radar (DPR)





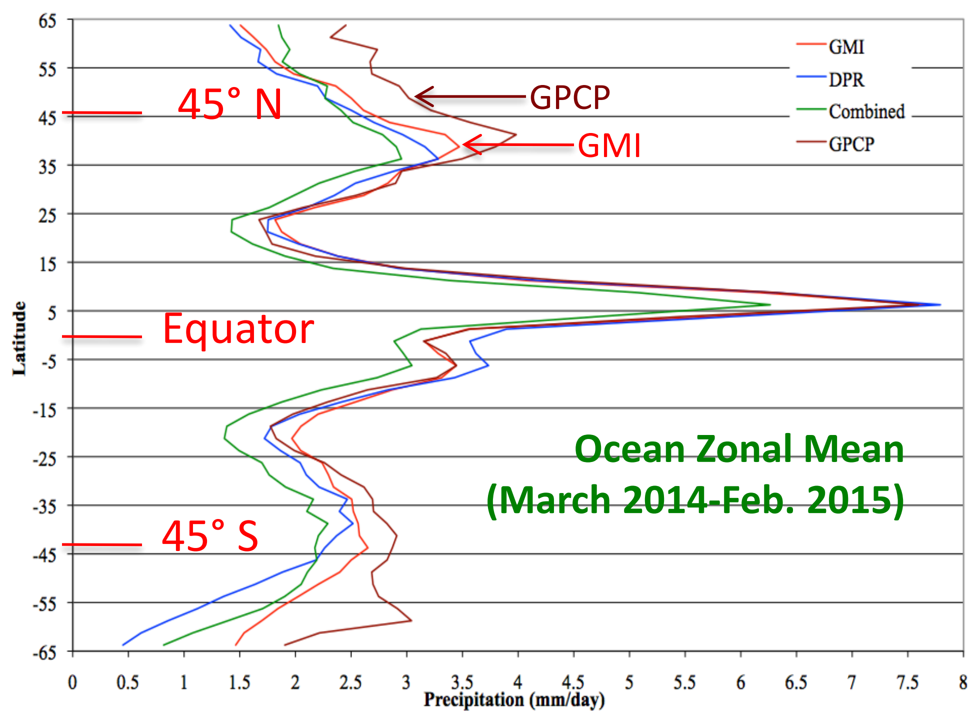
Ocean

	GPCP	GMI	DPR
25S-25N	3.22	3.31	3.36
65S-65N	2.99	2.84	2.70

GPM: GMI, DPR

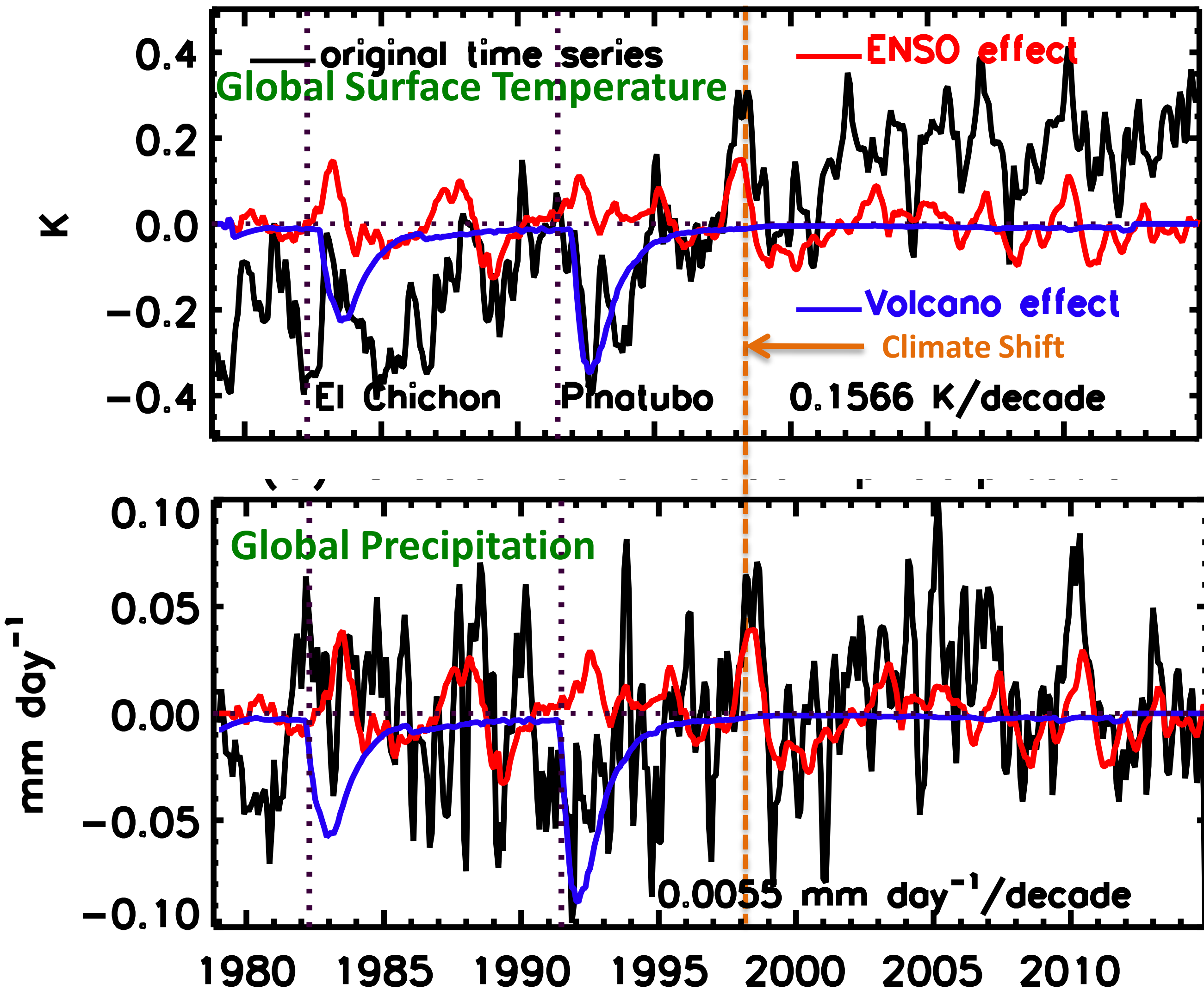
Preliminary GPM Products

- ***GPM slightly higher than GPCP in tropics***
- ***GPM lower in extra-tropics***



Variations in Global Surface Temperature and Precipitation

Trends, Inter-decadal Shifts and ENSO and Volcano Effects



Surface Temperature:

Trend: .15 C/decade

ENSO: 0.2C amplitude

Volcano: 0.4C amplitude

Precipitation:

Trend: ~ zero

ENSO: .05 mm/d (2%) amplitude

9%/K

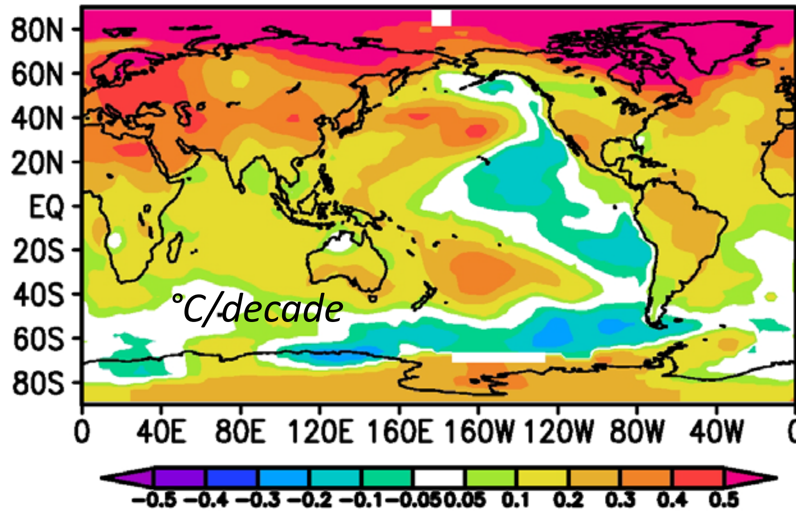
Volcano: .09 mm/d (3%) amplitude

8%/K

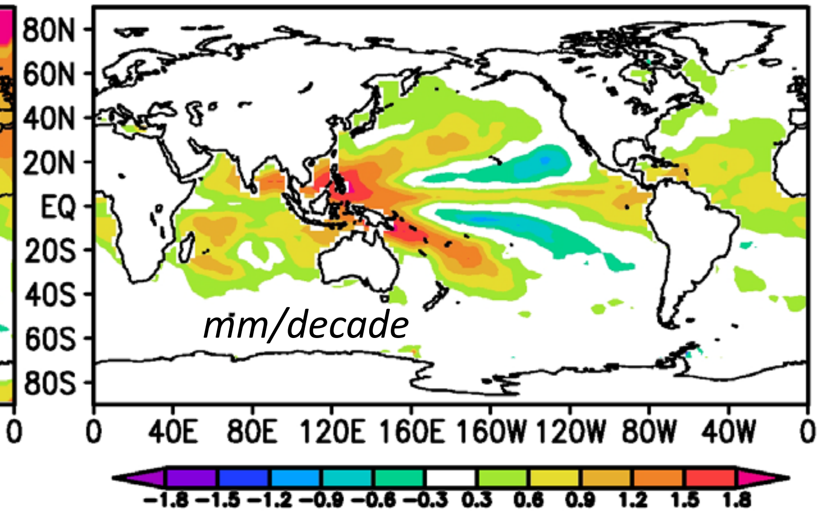
New GPCP V2.3
Beta Test

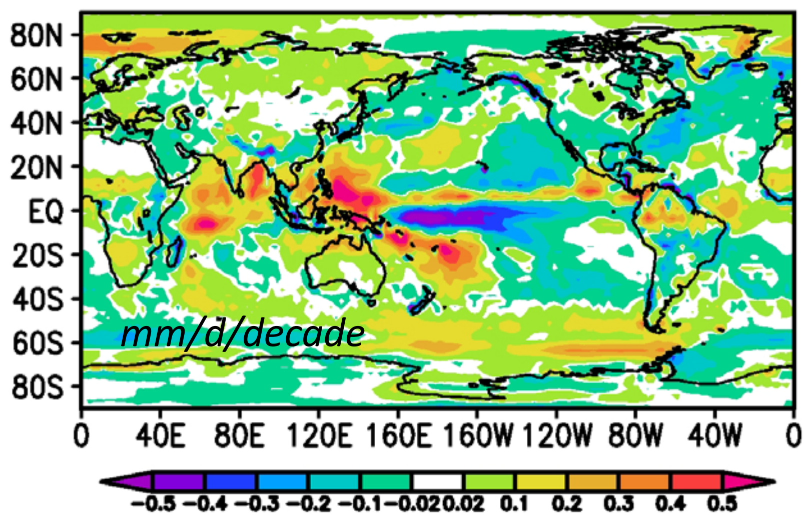
Patterns of Trends (1979-2013)

Surface Temperature from GISS



Water Vapor from SSMI (ocean)

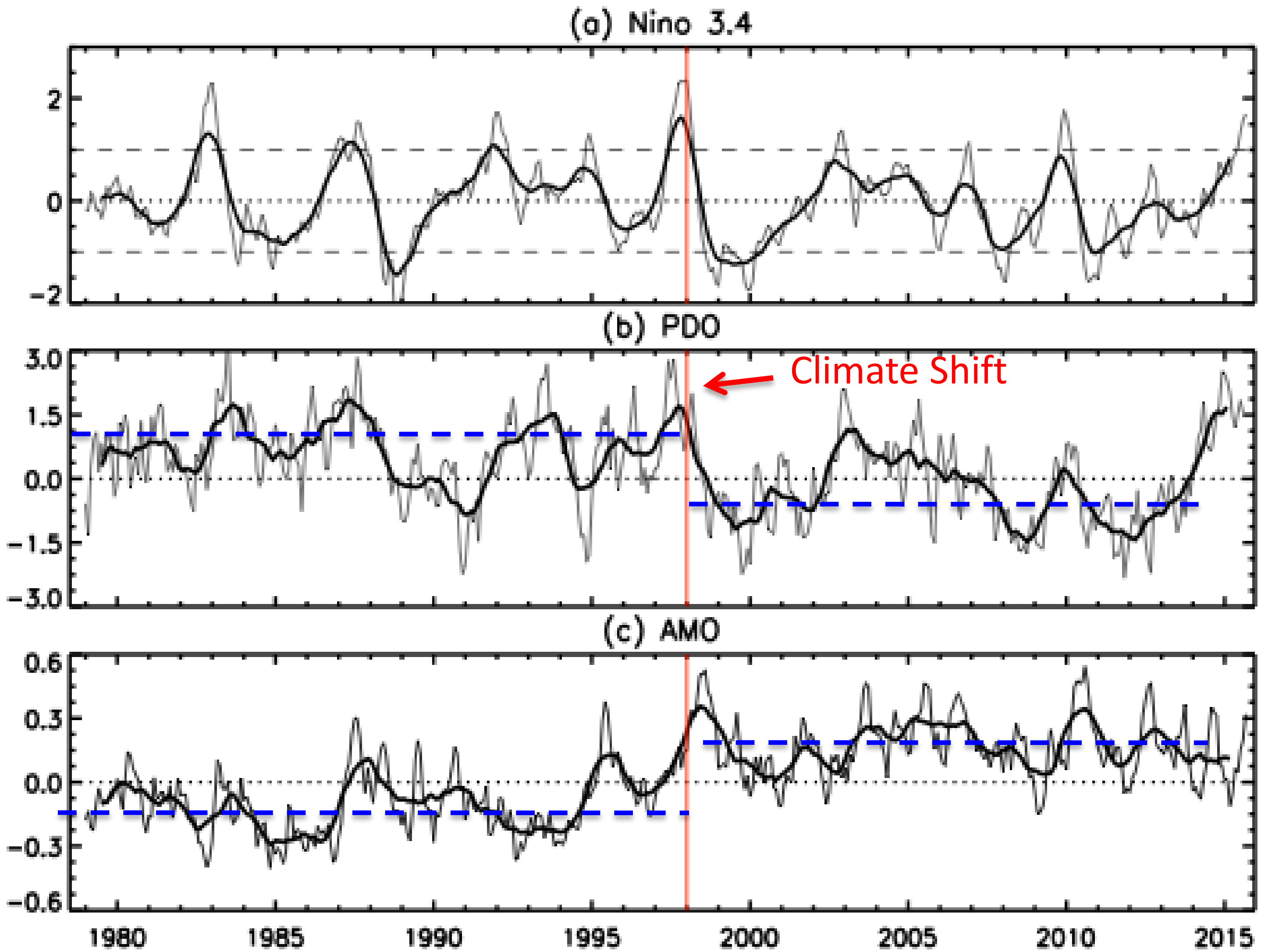




Precipitation Trend from GPCP

Is this the pattern of precipitation change related to global warming?

Variations of ENSO, PDO and AMO Indices During Satellite Era

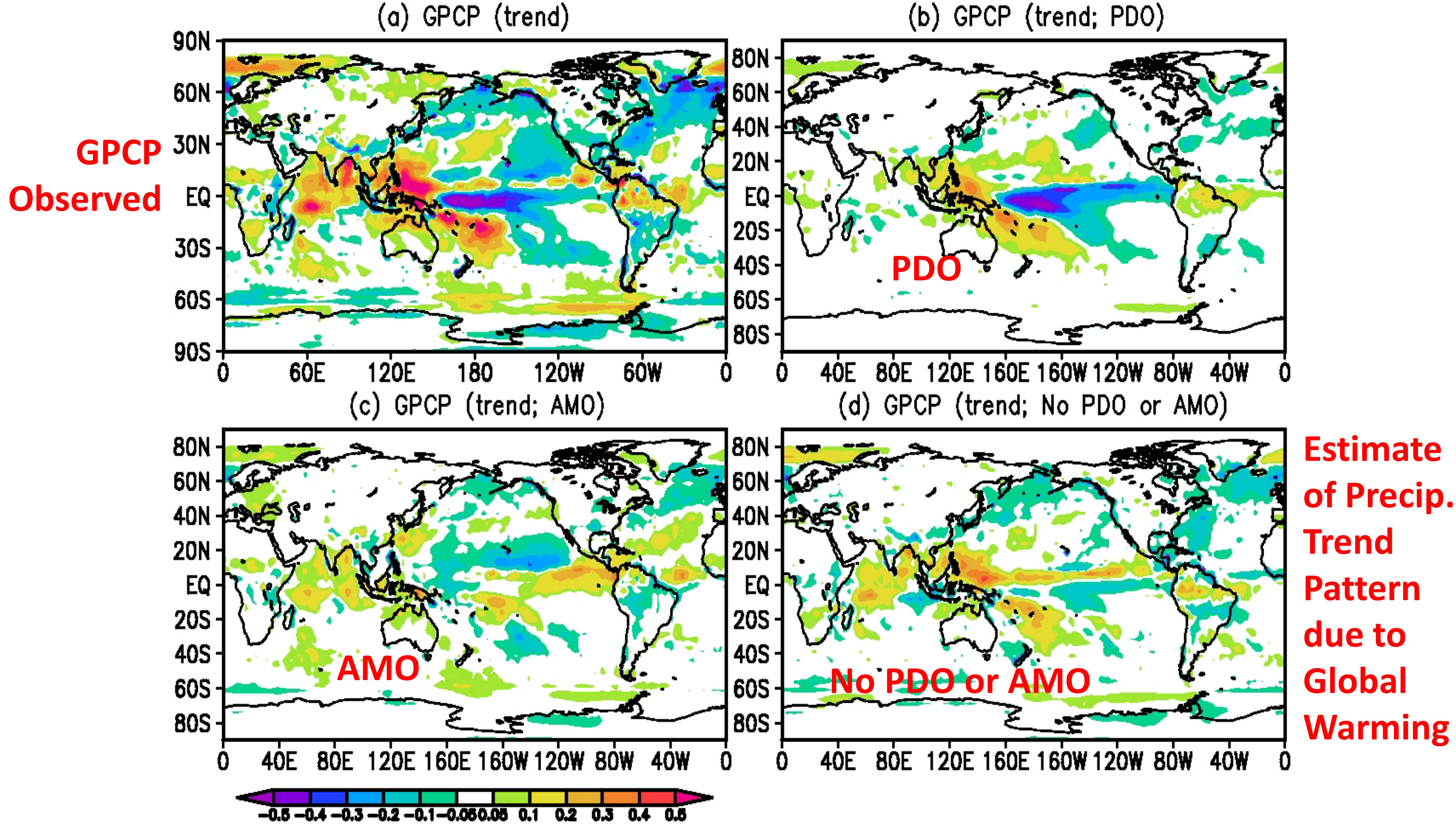


Nino 3.4
ENSO

PDO
Pacific Decadal Oscillation

AMO
Atlantic Multi-decadal Oscillation

Precipitation Trend Patterns During Satellite Era

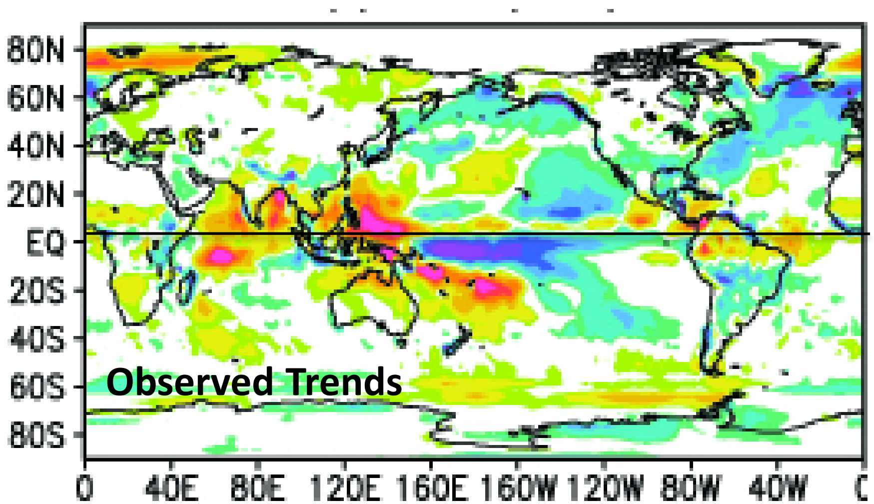


Estimate of Precip. Trend Pattern due to Global Warming

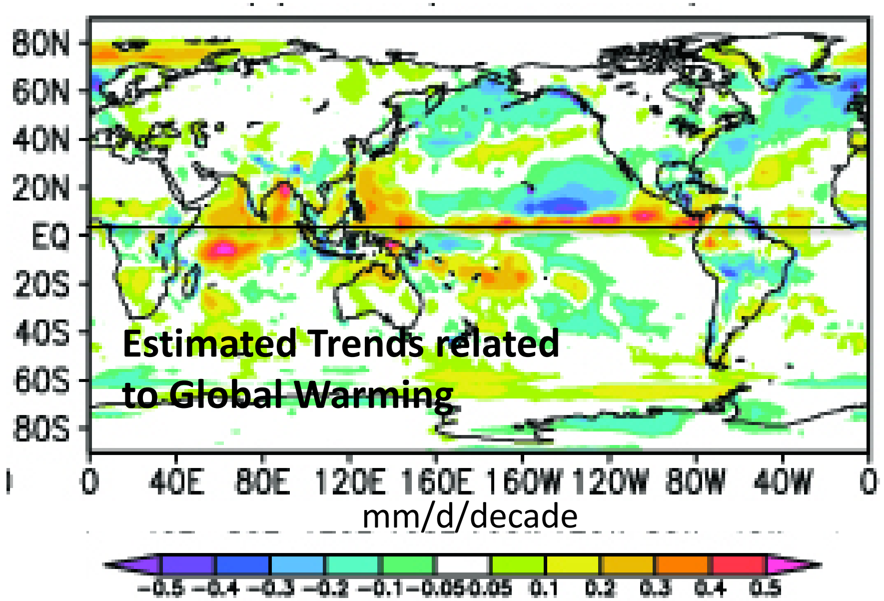
Technique uses PDO and AMO indices and regression analyses

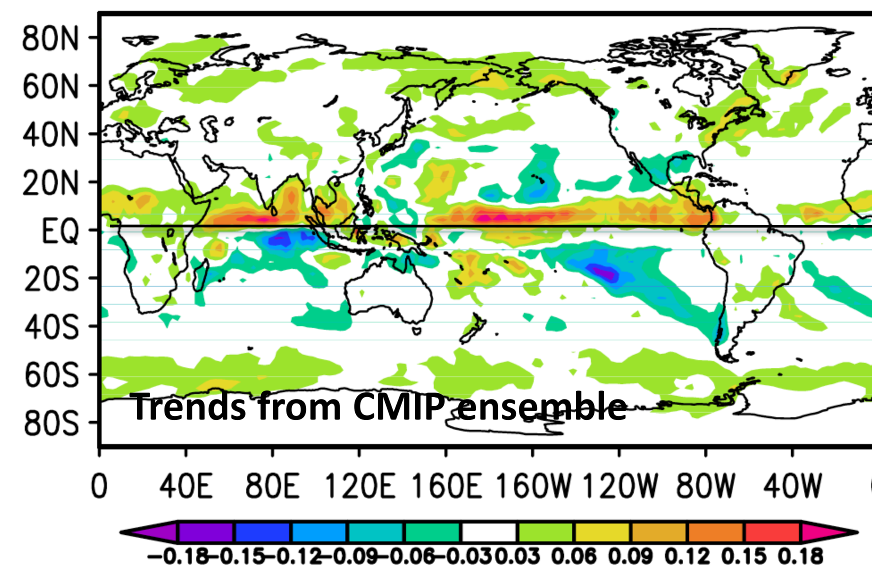
Gu, Adler and Huffman (2015) Climate Dynamics

Trends in Global Precipitation During Satellite Era (1979-2013)



Although the trend in global total precipitation is near zero (in GPCP analysis), the pattern of observed regional trends (left panel) is related to Global Warming (GW) plus inter-decadal signals such as PDO and AMO (ENSO impact is small). Bottom left panel shows trend pattern after PDO effect is removed, a better estimate of of GW impact on precipitation regional trends and also a pattern closer to that predicted by CMIP climate models (bottom right), but with smaller magnitudes—by factor of 2-3.





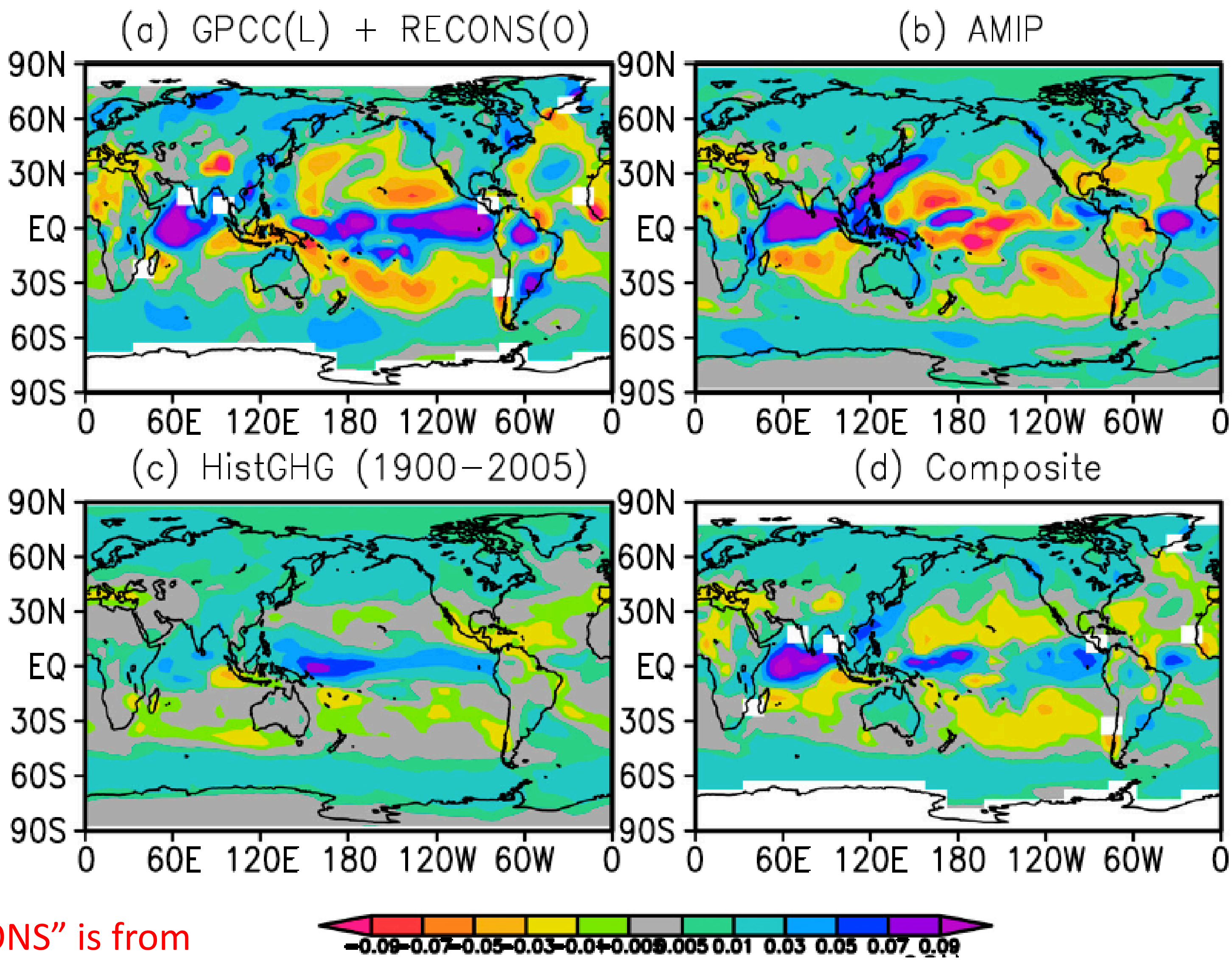
Gu, Adler and Huffman (2015) Climate Dynamics

Trends in Precipitation (1900-2010) due to Global Warming

[with aerosol effect taken out]

Gauges over land; "reconst-ruction" over water

Climate model forced by CO_2



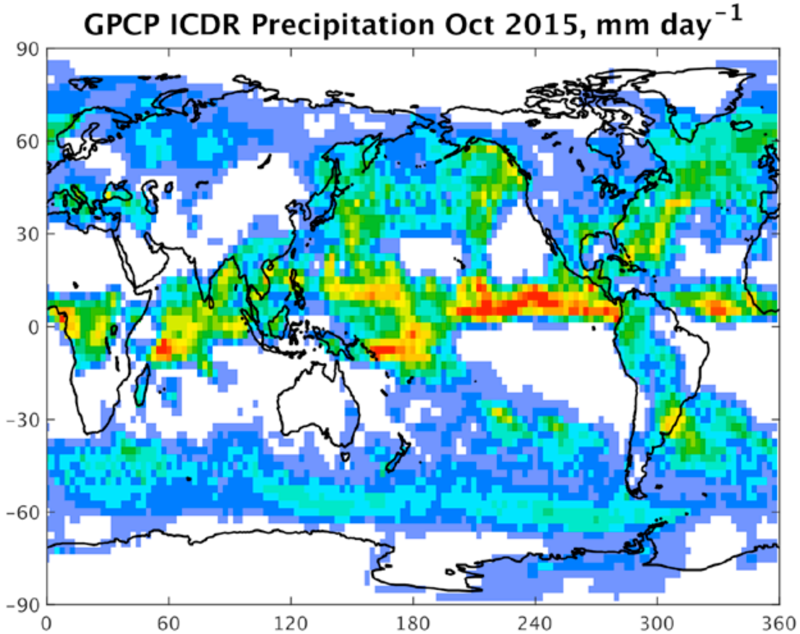
Climate model forced by observed SST, etc.

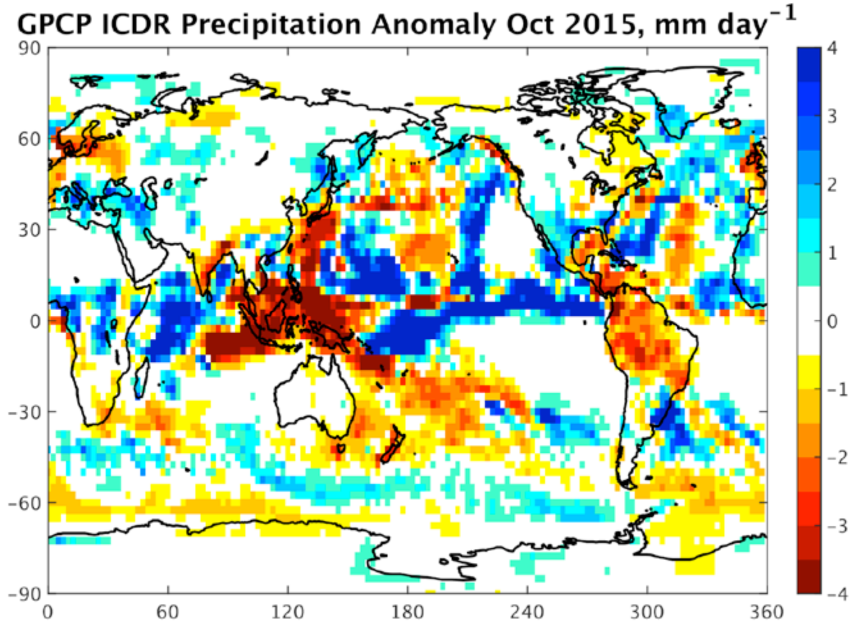
Composite, i.e., mean of the three other fields

"RECONS" is from Tom Smith (STaR)

Gu and Adler (2015) J. Clim.

GPCP NOAA ICDR (Interim Climate Data Record) for October





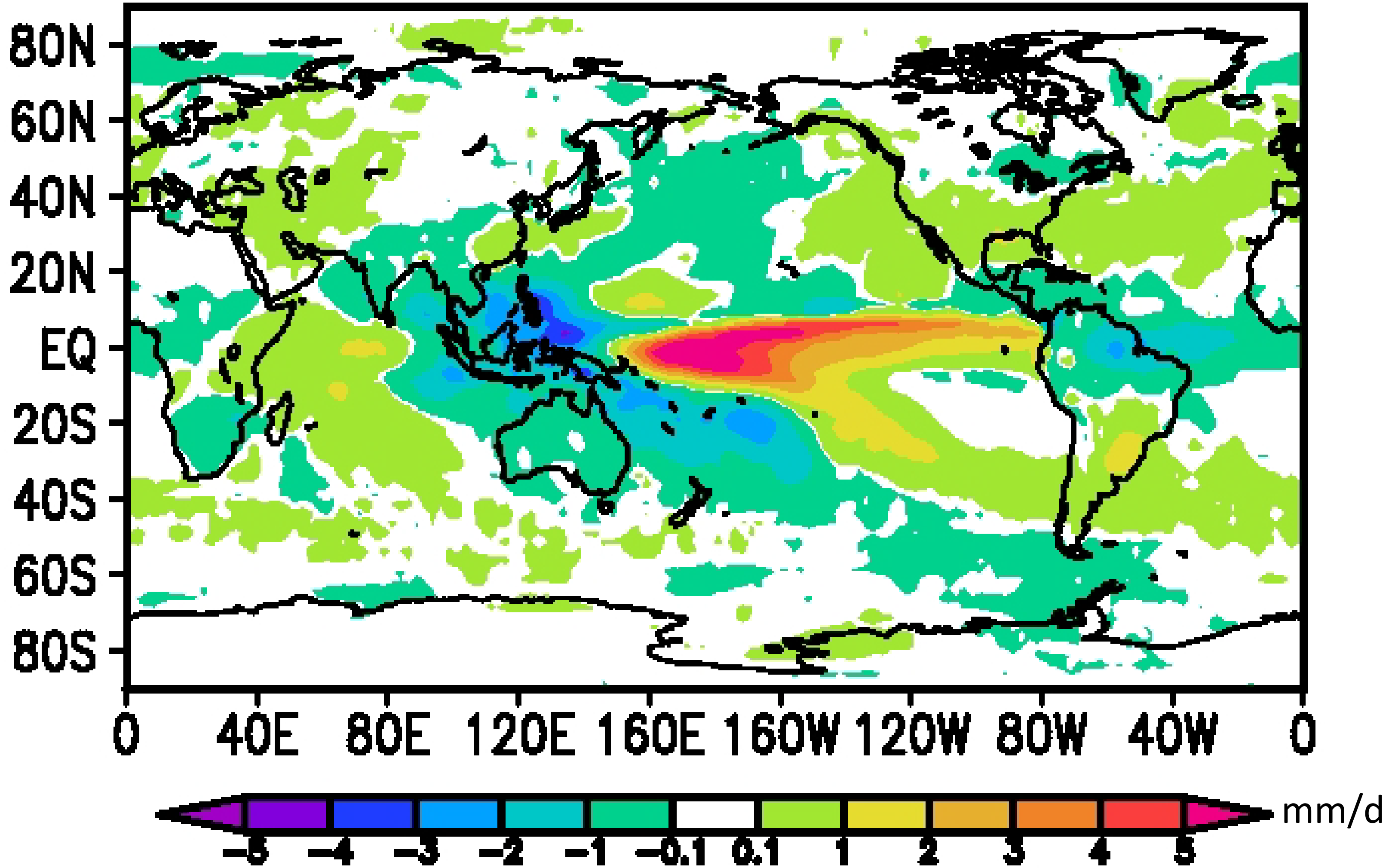
The GPCP Interim CDR for October 2015 continues to show with El Nino-related positive precipitation anomalies over central and eastern Pacific and negative anomalies over the Maritime Continent. Additional features include negative anomalies over northern South America and the Caribbean and positive anomalies over the Arabian Sea and central Africa. A positive anomaly is evident over Mexico and into the southwest of the U.S.

Comparison of the October anomaly pattern with the typical El Nino pattern for October can be found on the next slide.

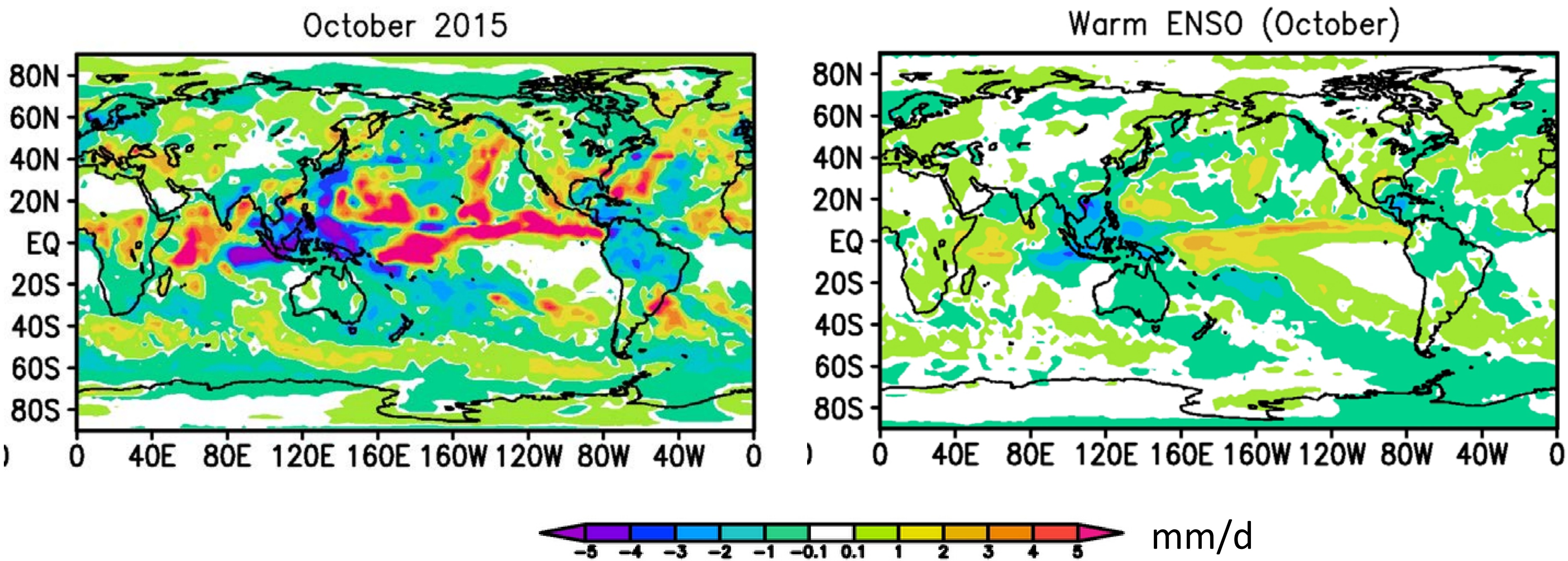
Adler/Wang/Gu/Sapiano U. of Maryland

El Nino minus La Nina Precipitation Anomalies

Top 1/3rd –Bottom 1/3rd of months Using Nino 3.4 Index

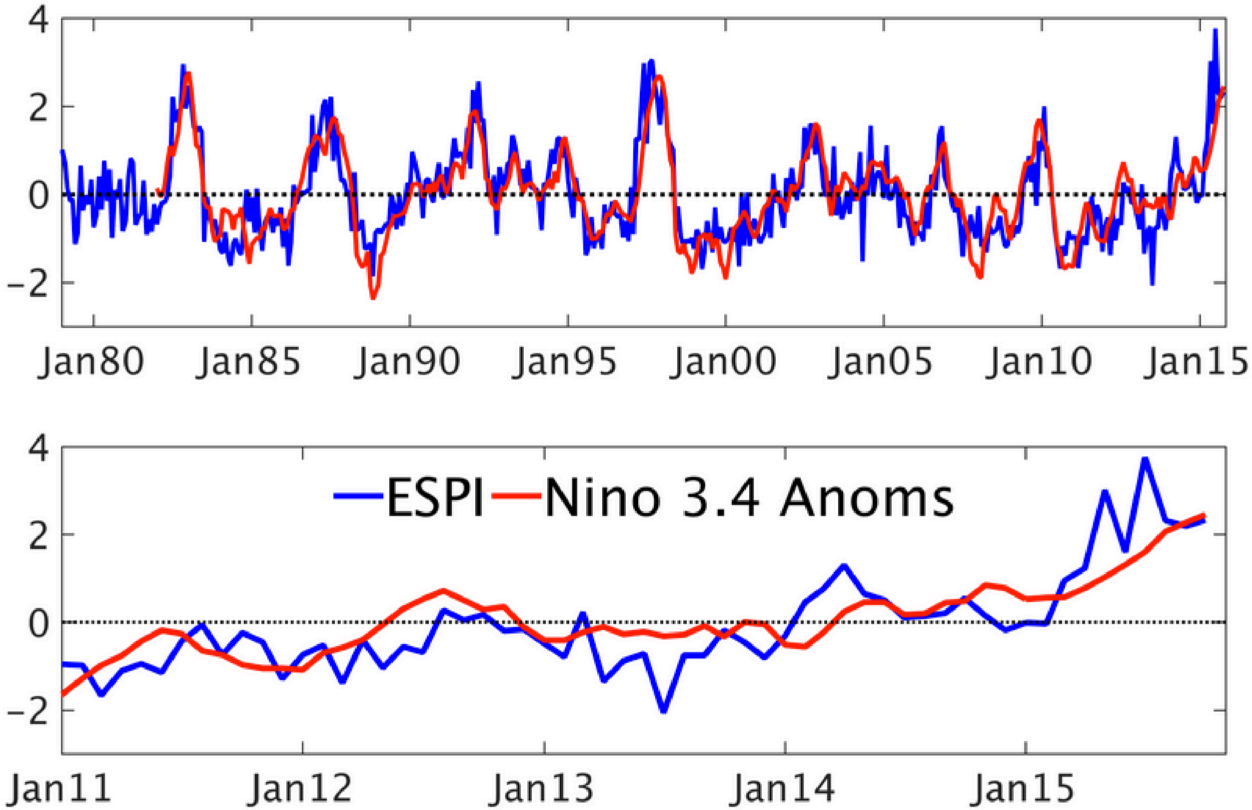


Precipitation Anomaly Pattern for October 2015 vs. Pattern for "Mean" El Nino



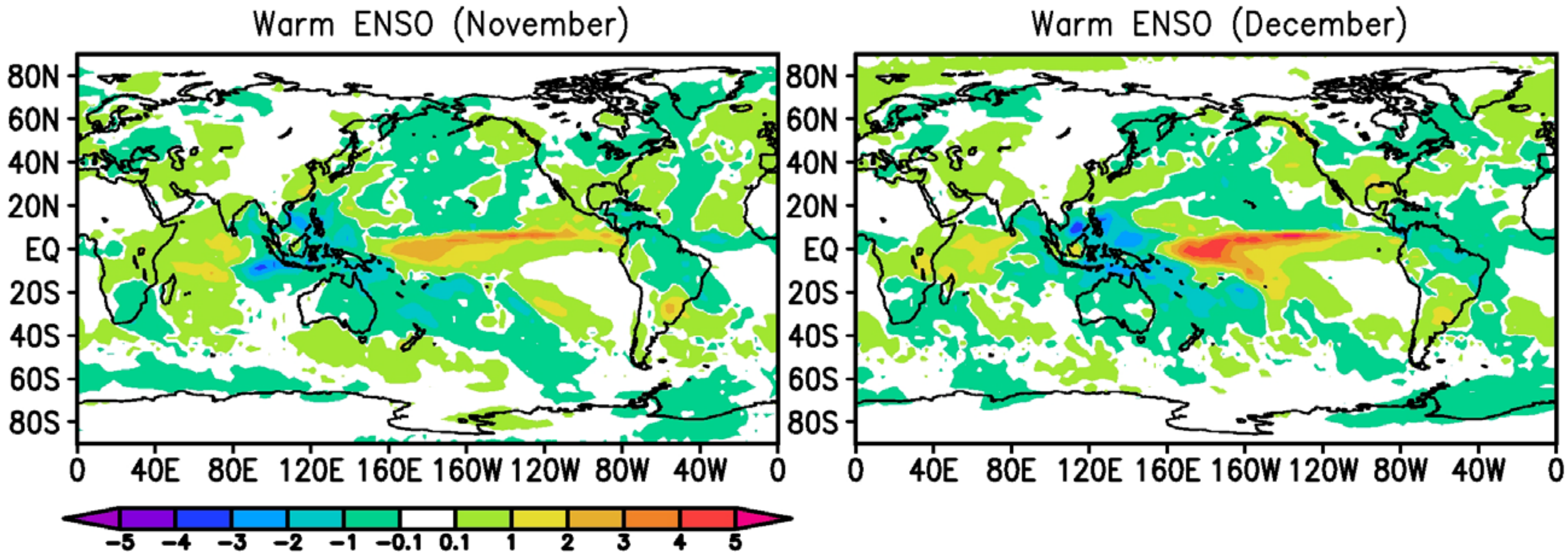
Anomaly pattern for Oct. 2015 (left) shows strong patterns, may of which are similar to patterns seen in the "mean" pattern for El Nino for October (using Octobers having Nino 3.4 values in the top third of Octobers). The magnitudes of the mean pattern on the right are smaller due to averaging. Besides the patterns of the tropical Pacific, Maritime Continent and Amazon, one can also see the positive anomalies over the Arabian Sea and eastern Africa (e.g., Horn of Africa) and southeastern South America. Across the U.S. southern states the anomalies are positive, a stronger signal than seen in the mean map.

ENSO Precipitation Index (ESPI)



Pacific Ocean and Maritime Continent rain anomalies are used to compute various indices, including ENSO Precipitation Index (ESPI) [Curtis and Adler (2000) J. Clim.] which shows sharp increase over last several months to near record maximum. The ESPI is highly correlated to Nino 3.4 (shown above) and SOI, but has given an early indication of major changes, e.g., jump from Feb. 2015)

Mean El Nino Precipitation Anomalies for November and December

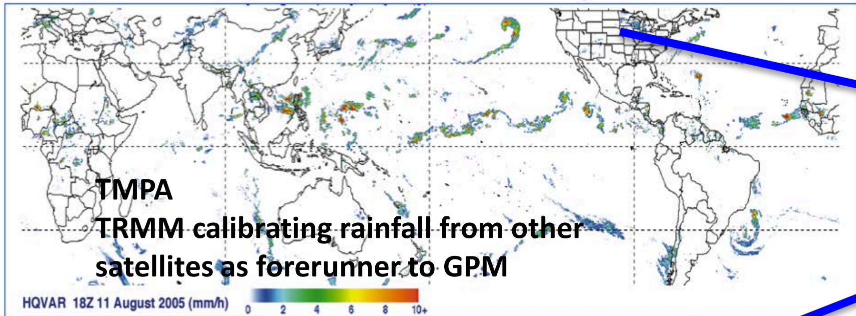


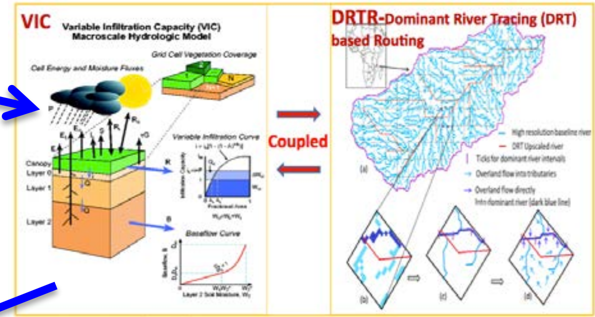
The figures above show the mean patterns of precipitation anomalies for the months when Nino 3.4 values were in the top third for that month. Since the current El Nino is expected to continue these maps represent an estimate of expected anomalies for November and December, at least due to ENSO. The Arabian Sea and eastern Africa have positive anomalies and have already been hit by floods during early November in Somalia and in Yemen with unusual cyclone activity. In southeast South America (extreme southern Brazil and northeastern Argentina) floods have also occurred during November, right in the area of the maximum positive anomaly.

Global Flood Monitoring System (GFMS)

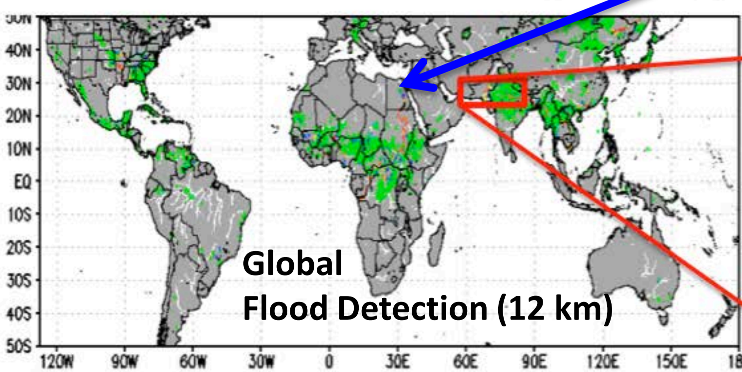
http://flood.umd.edu/

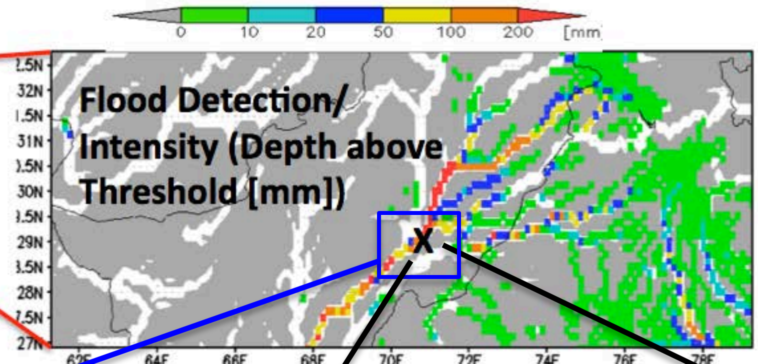
Global Real-time Flood Calculations Using Satellite Rainfall and Hydrological Model



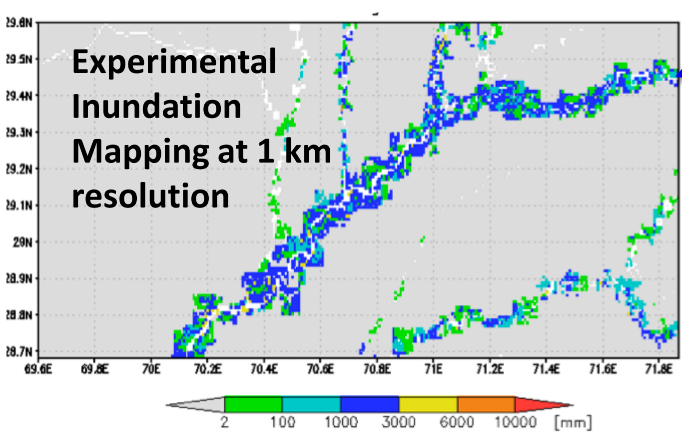


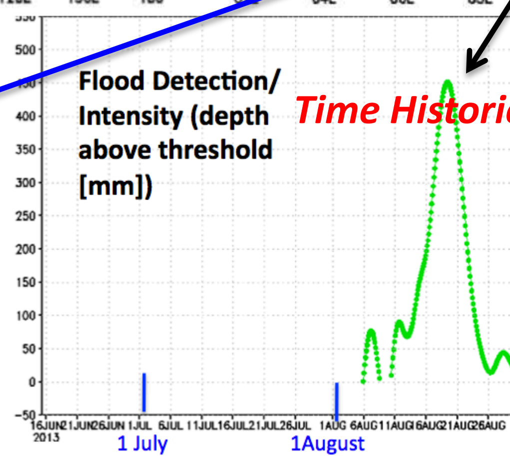
TRMM/GPM rainfall into land surface and routing models for water depth and stream flow calculations compared to flood thresholds



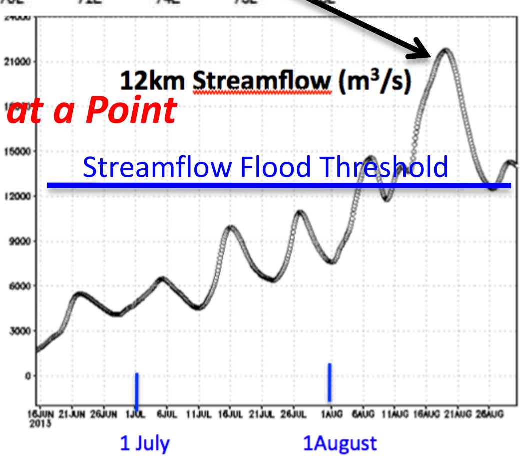


Indus River basin Aug. 20 2013



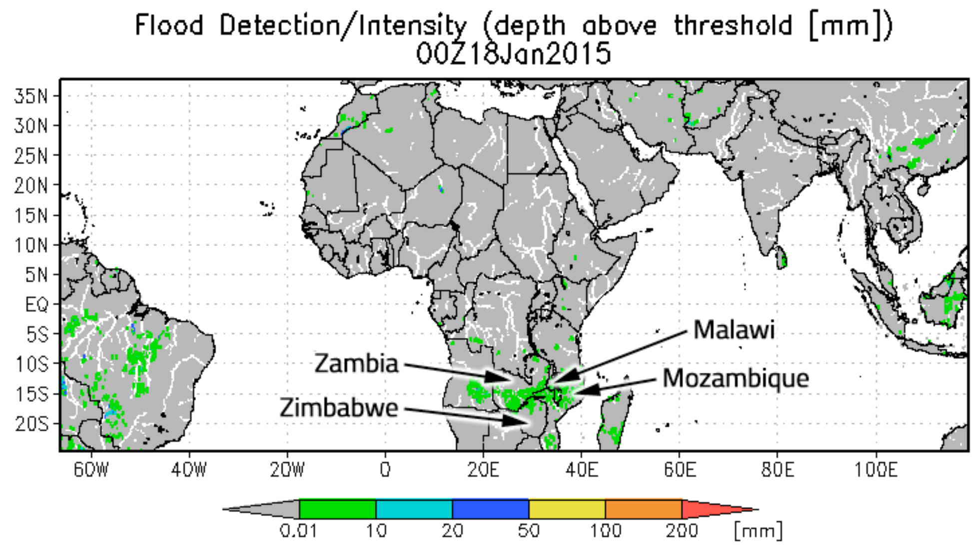


Time Histories at a Point



Global Flood Monitoring System (GFMS) Cited by World Food Program

"The Global Flood Monitoring System (GFMS) provides one key step further by indicating how an excess rainfall event will impact river flow, and also whether there is a potential for flooding downstream away from the heavy rain event," said Emily Niebuhr of the UN's World Food Program (WFP) in Rome. "We check the GFMS nearly every single day to monitor current flood concerns, and also to assist in discovering new flood events that may not have been reported yet or are developing".



For full article see: http://pmm.nasa.gov/articles/improving-flood-predictions-gpm

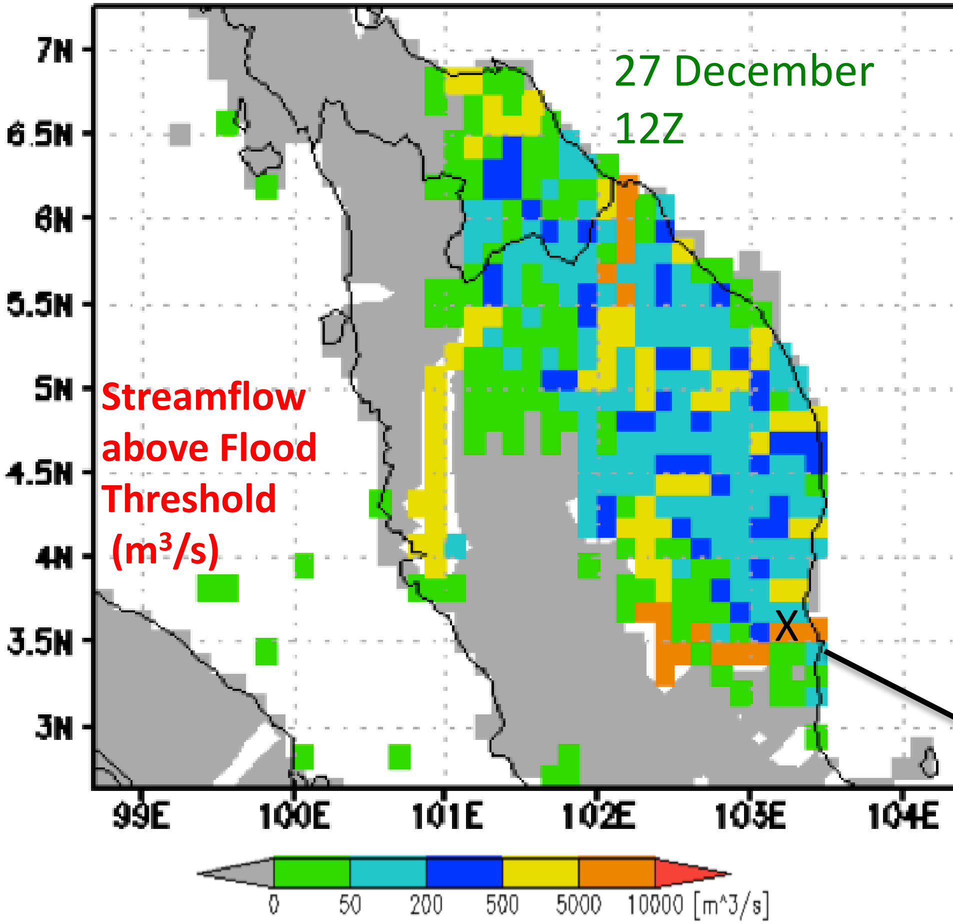
Global Flood Monitoring System (GFMS)
Adler/Wu University of Maryland
flood.umd.edu

Recent (27 July – 2 Aug. 2015) Visitors/Users of GFMS website (http://flood.umd.edu)

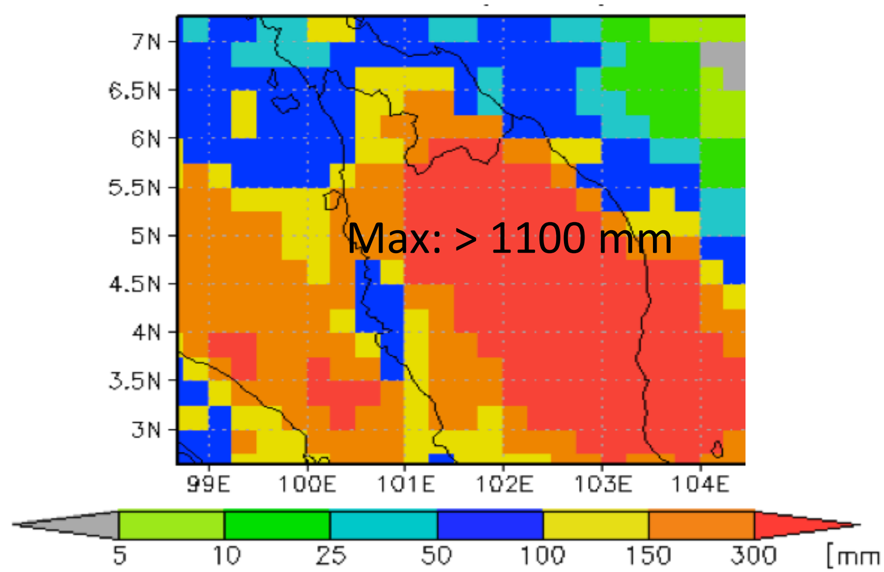
Weekly Stats Report: 27 Jul - 2 Aug 2015
Project: Global Flood Monitoring System

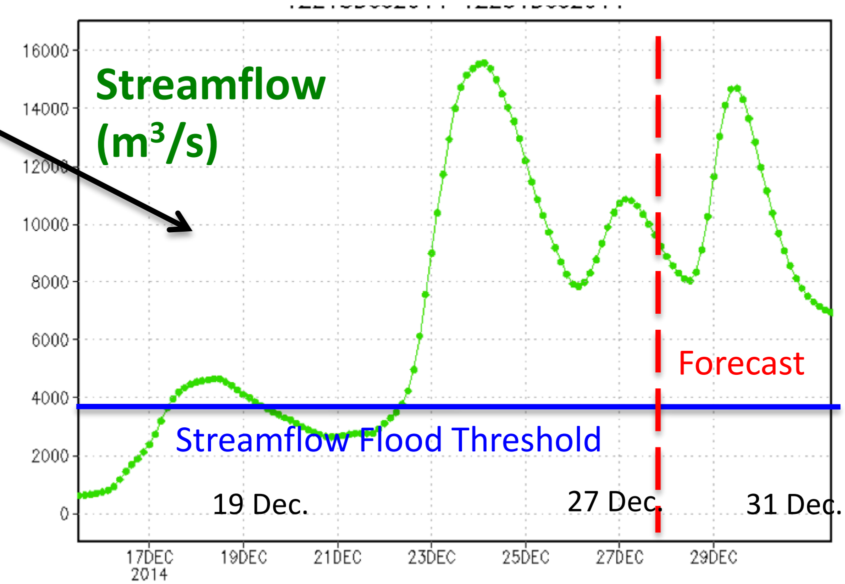
	Mon	Tues	Wed	Thur	Fri	Sat	Sun	Total	Avg
Pageloads	167	254	350	166	152	62	77	**1,228**	175
Unique Visits	131	188	267	134	97	44	57	**918**	131
First Time Visits	100	151	235	100	64	26	36	**712**	102
Returning Visits	31	37	32	34	33	18	21	**206**	29

Malaysia Flooding (December 2014)



7-day rain ending 12Z 27 December

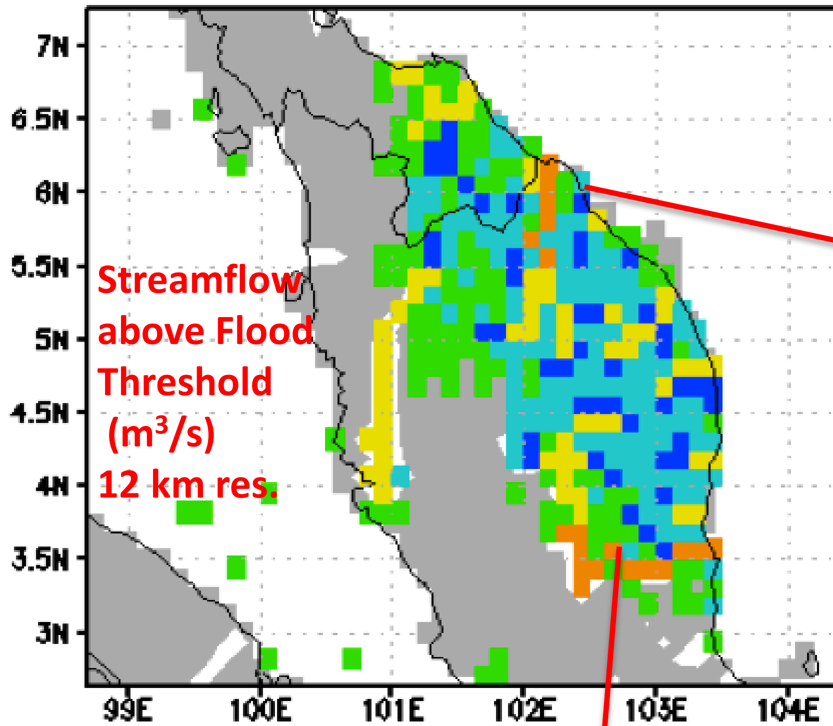


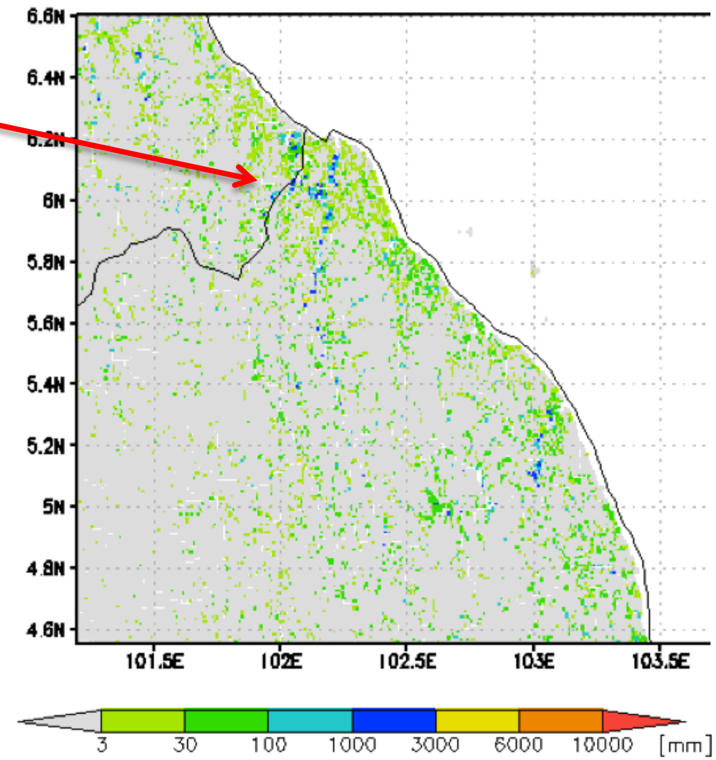


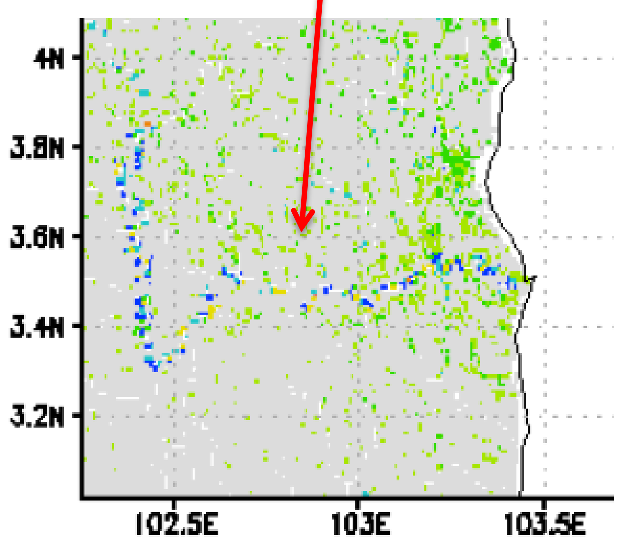
Heavy rains (over 1100mm) over the last seven days (and more before that), have produced widespread flooding in Malaysia and southern Thailand.

Global Flood Monitoring System—Adler/Wu (U. of Maryland) *flood.umd.edu*

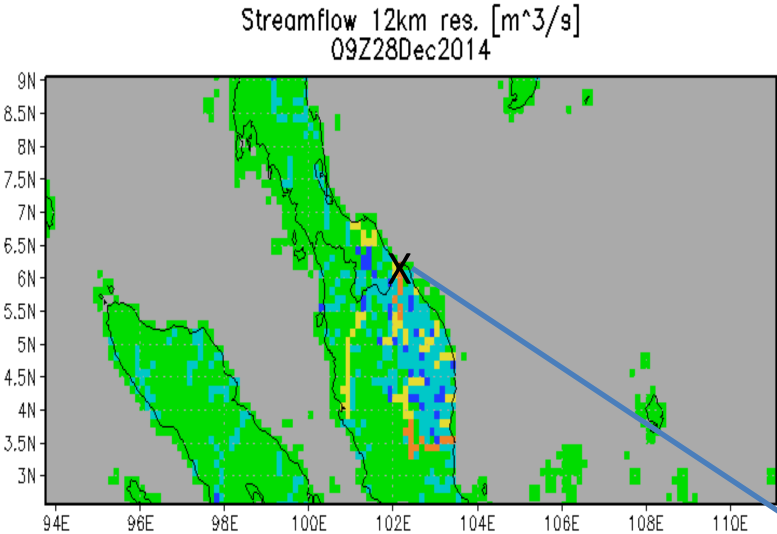
1 km Inundation Estimates
27 December







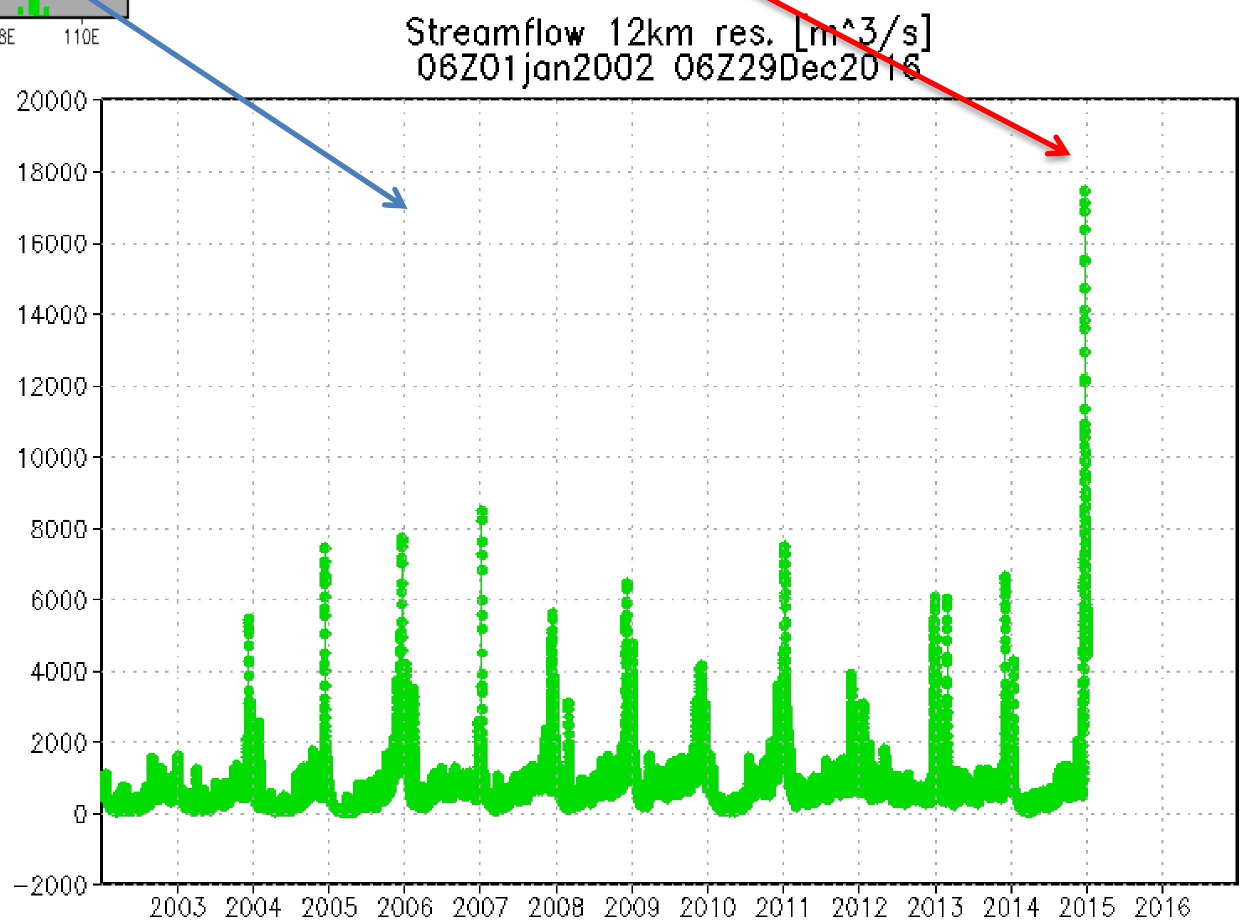
In addition to 12 km estimates of streamflow, etc., the GFMS also does routing at 1 km resolution and this leads to inundation estimates at 1 km resolution



Comparing the Current Event with Previous Events

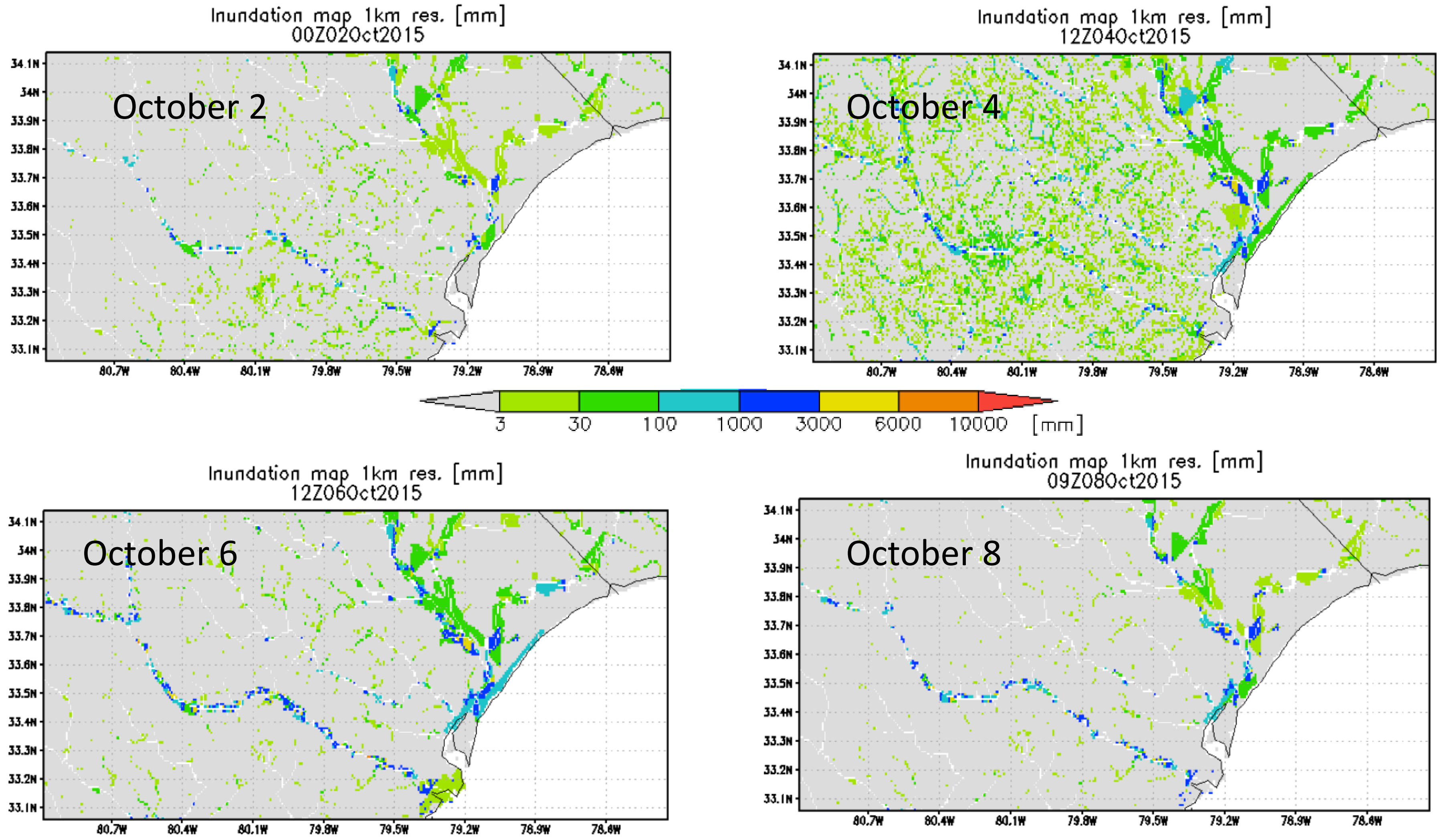
Floods in Malaysia Largest Seen in 17-year history of GFMS Record—using streamflow at key river near Thai border

December 2014 event



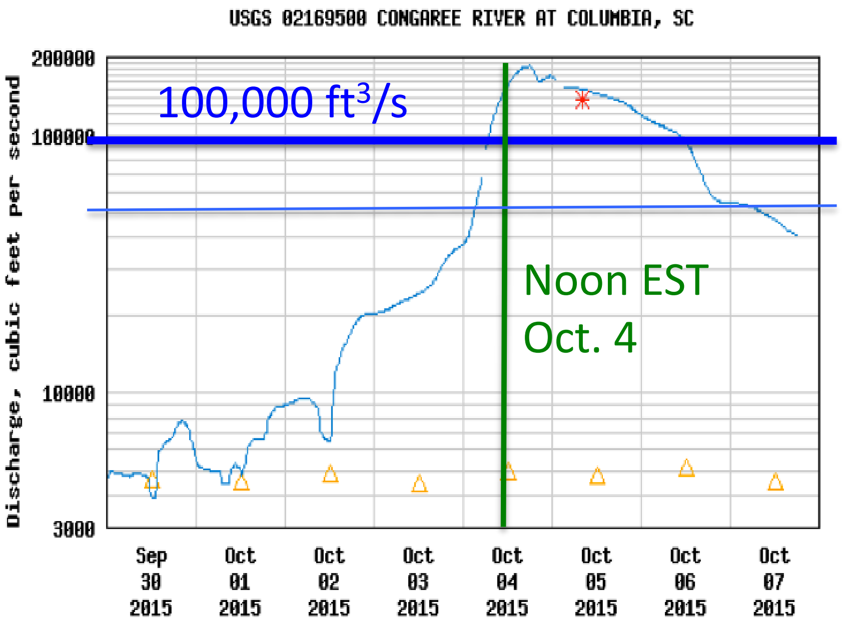
South Carolina Floods--Estimated Inundation Maps (Oct. 4-8)

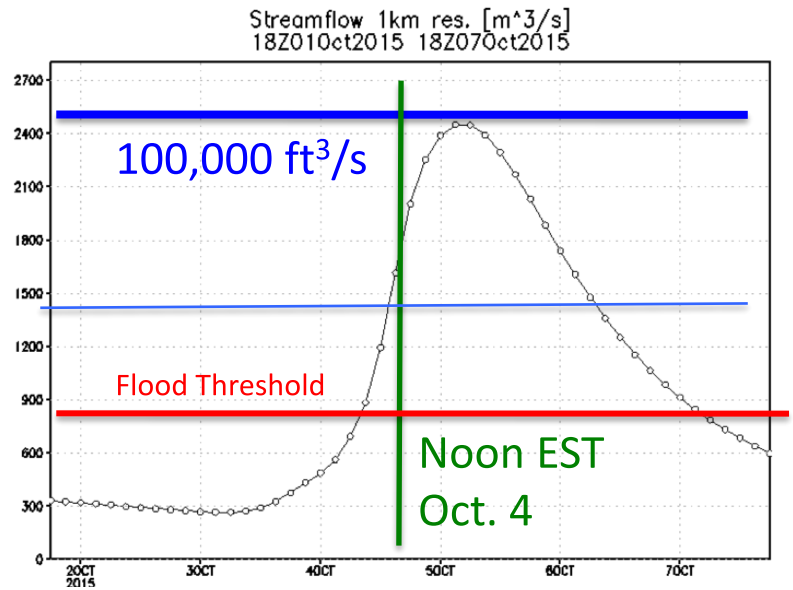
Calculated inundation maps at 1 km resolution showing inundation widespread on 4 October and condensing into main branches of rivers by 6 October, with continued, but decreasing flooding today, 8 October.

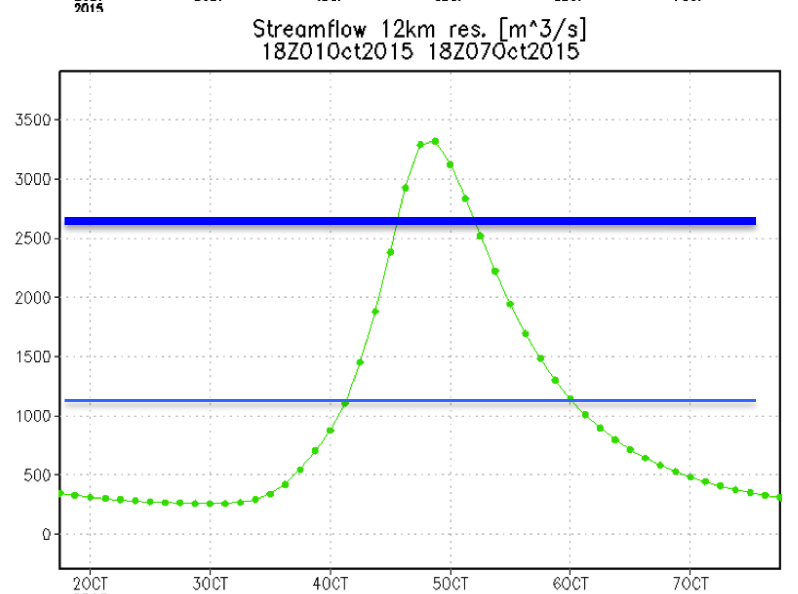


Streamflow along Congaree River near Columbia

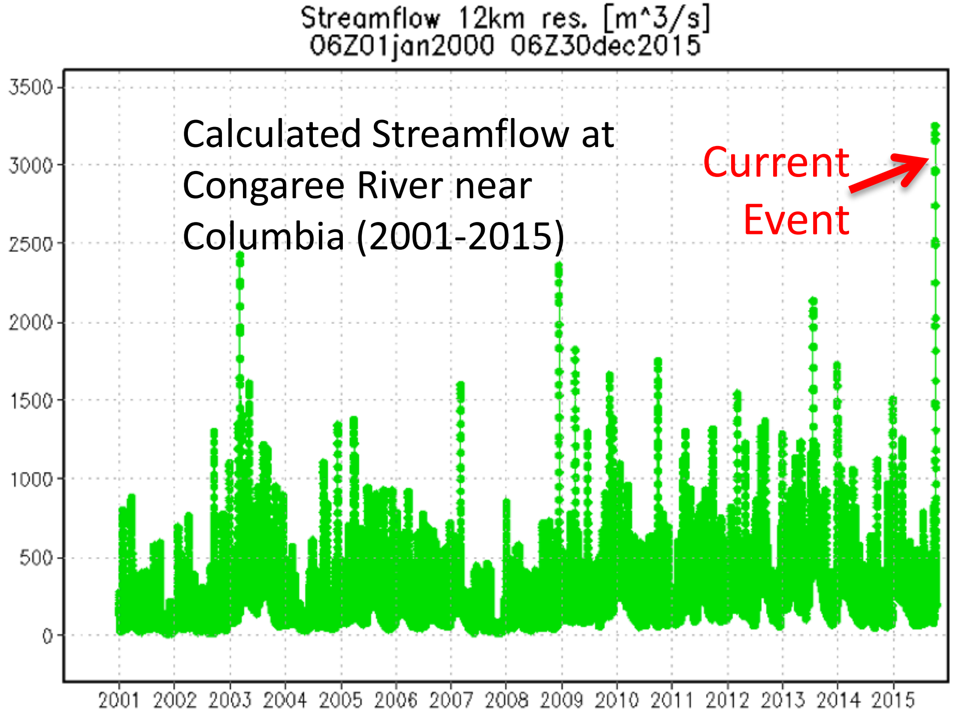
34.00N
81.05W

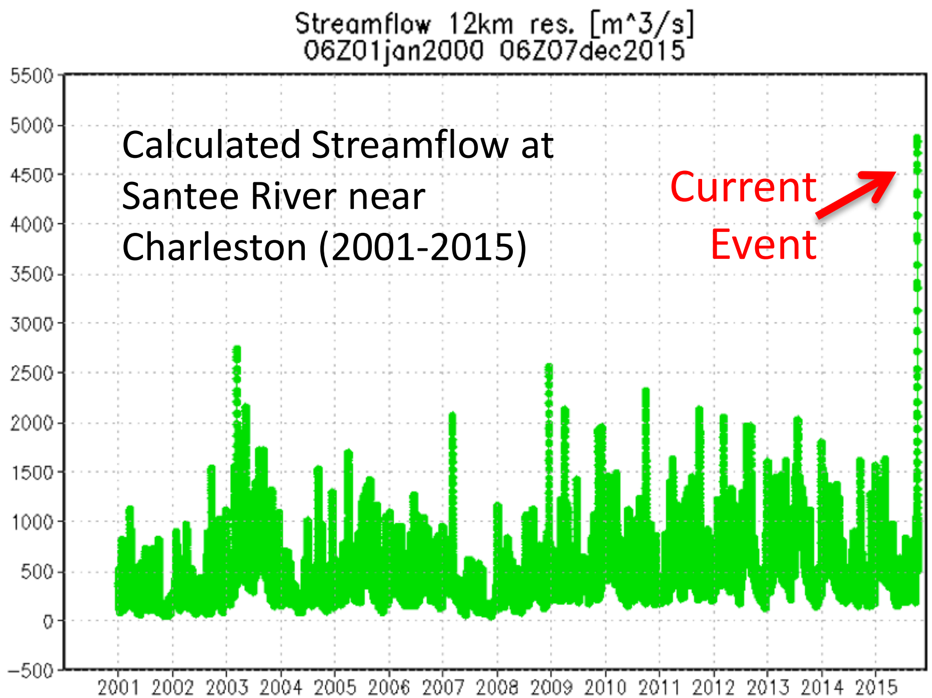






Note differences in units, vertical scale (log vs. linear) and time zone





Context of Current Flood Event Compared to Last 15 years

Calculated streamflow at two key points along Congaree and Santee Rivers over the last 15 years sets the context of the current event. At both locations the current event is the largest, with other peaks evident in the past. Other points: 1) The estimated satellite rainfall was lower by about 25% than raingauges on ground in areas of the highest amounts, producing an underestimate on peak streamflow; 2) Downstream toward Charleston our calculated streamflow is higher than observed due primarily to the effect of dams holding back significant amounts of water, which may in turn be affecting our estimated inundation maps—moving water too fast toward coast.

Summary

Satellite precipitation estimations have allowed for a planetary view of magnitudes, spatial and temporal variations (even trends) that are due to a number of major factors on various time scales, including global warming.

“Real-time” global precipitation now being monitored for climate diagnostics in relation to ENSO and other phenomena.

High-time resolution precipitation information is being used in numerous applications, including estimating and forecasting floods.

New satellite missions and new ideas and analyses make for a promising future in this area.