Nested coupled air/sea modeling for multi-scale processes in the Maritime Continent

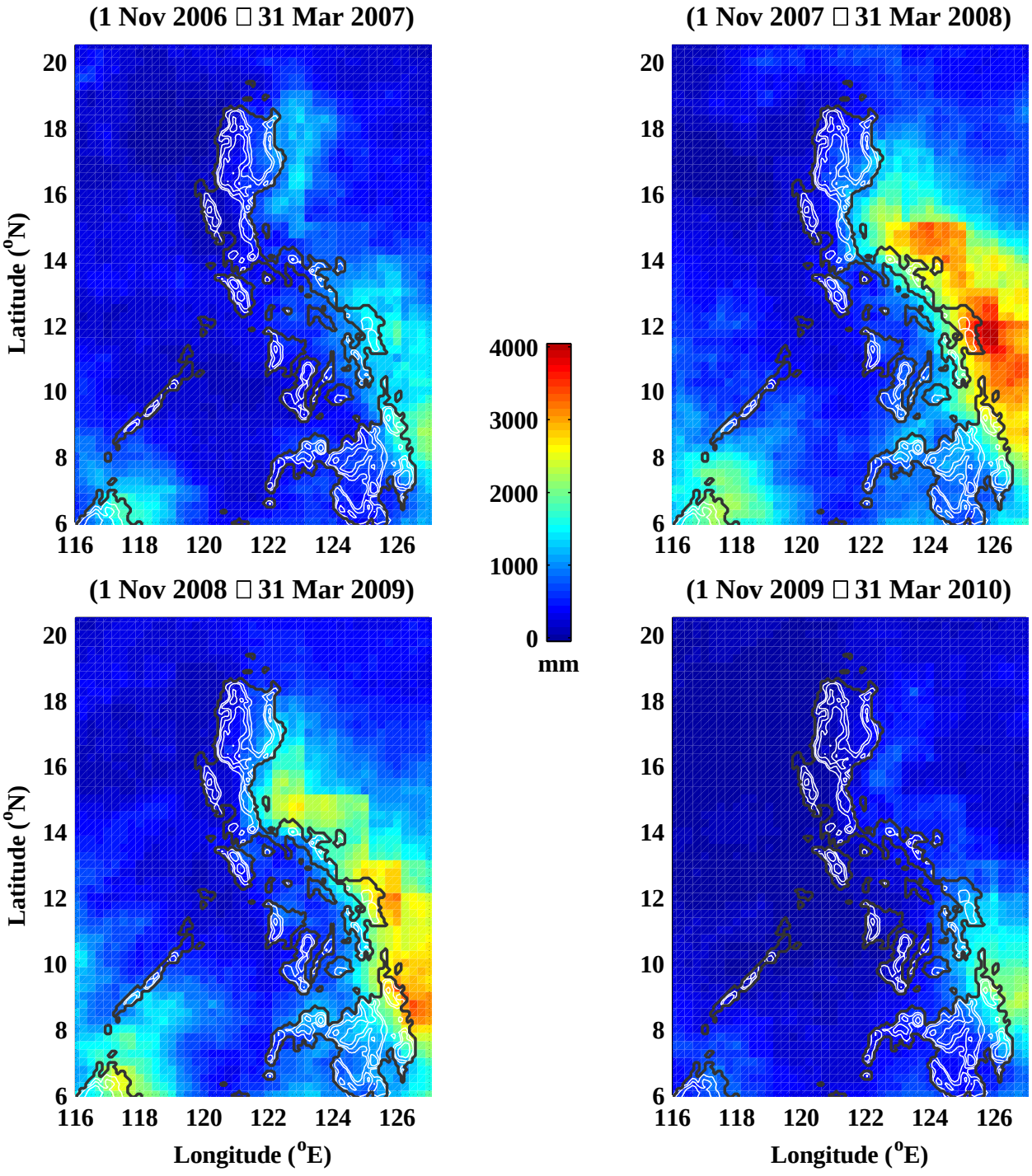
Julie Pullen
Stevens Institute of Technology

Arnold Gordon
Columbia University

Maria Flatau & James Doyle
Naval Research Laboratory

Cesar Villanoy & Olivia Cabrera
University of the Philippines

(JGR-atmospheres, 2015)



TRMM Totals

Rainiest winter in 40 years

Objective

- How is rainfall modulated by different multi-scale and orographic factors and their interaction?

Tools

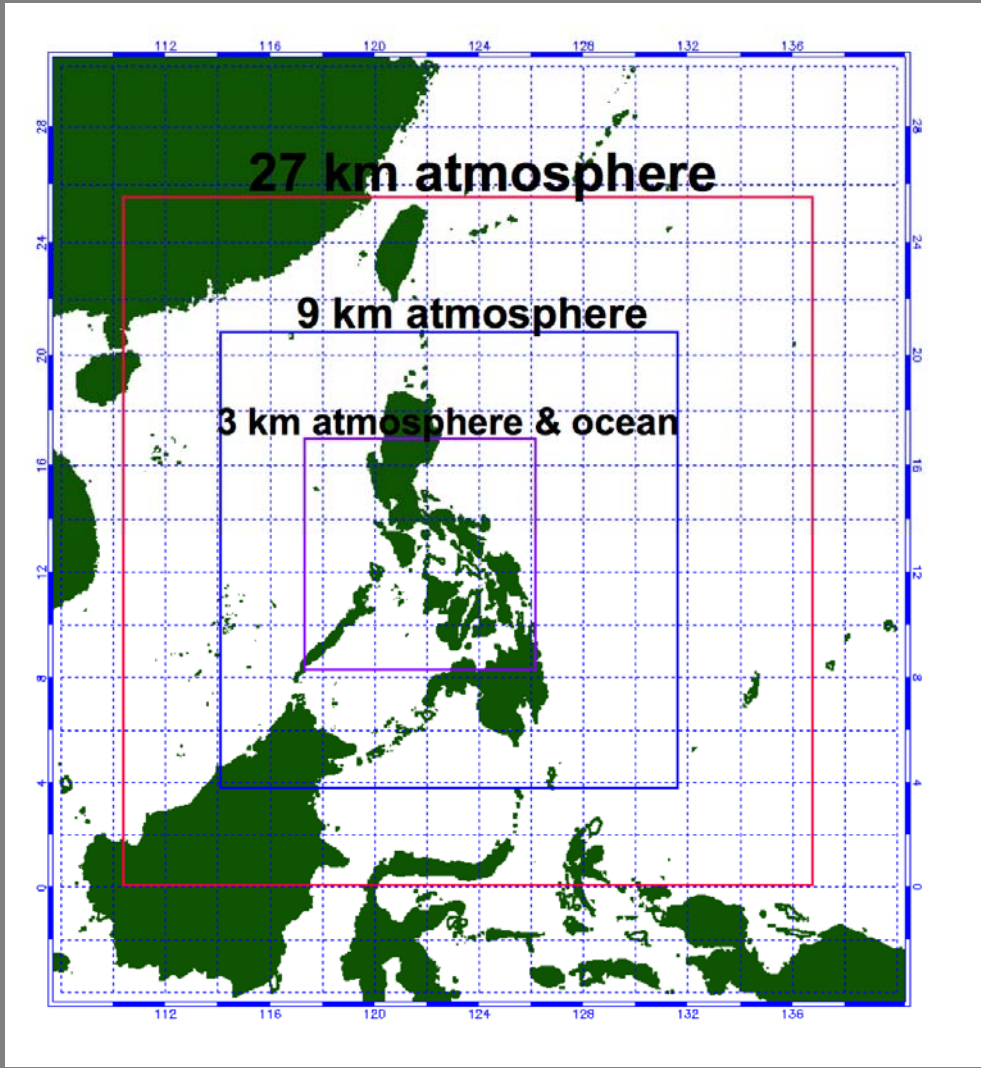
- High-resolution (3 km) two-way coupled ocean/atmosphere modeling

- Observational datasets including satellite, land-based, moored and underway observations from the ocean and atmosphere as part of ONR PhilEx program.

Meteorological data

- 3-hourly data from ~50 meteorological stations (red dots) maintained and archived by the Philippines National Weather Service (PAGASA) for the period 1 November 2007 – 31 March 2008.
- TRMM microwave satellite precipitation – 3-hourly

Model configuration: 2-way coupled



(12 min coupling frequency using ESMF)

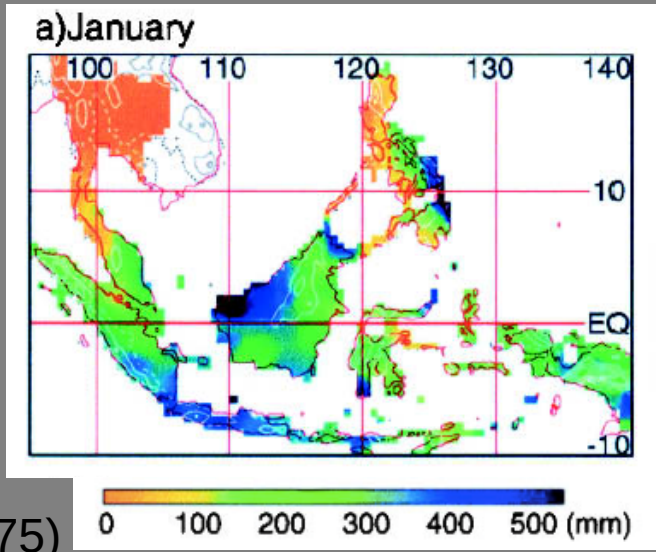
Contributing factors

interannual

- A moderately strong La Niña peaked in Jan/Feb 2008 (elevated rainfall across the Philippines: Lyon et al., 2006)
- Negative to neutral Indian Ocean Dipole (associated with strong MJO activity: Wilson et al., 2013)

seasonal

- Northeasterly monsoon (east-west rain gradient)

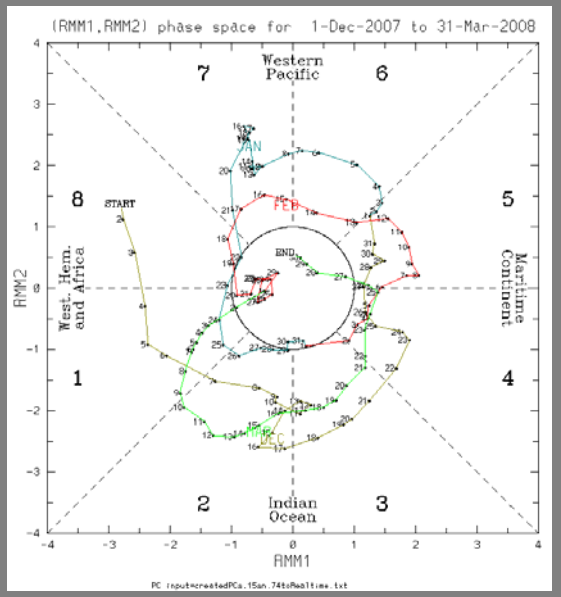


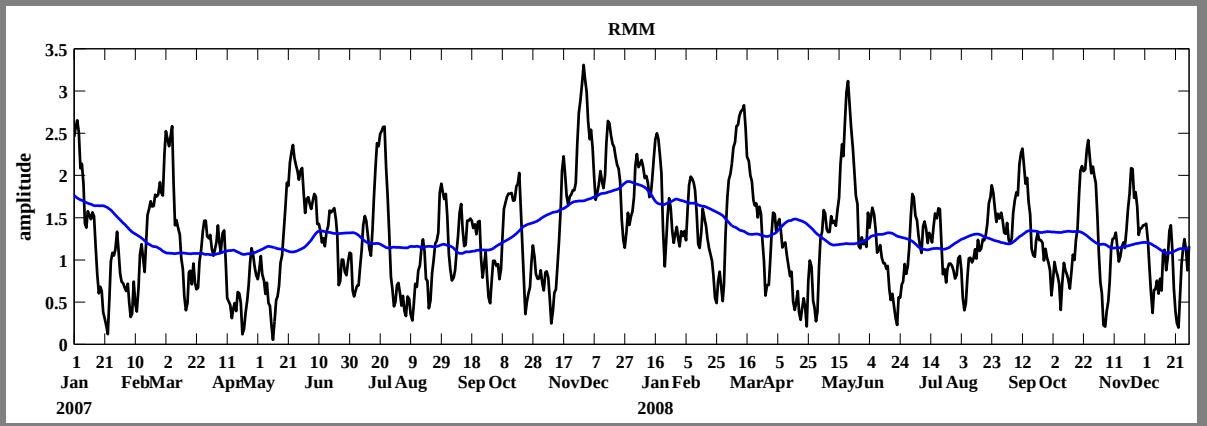
Chang et al. (2005): 25+ years of rainfall station data (1950-1975)

Contributing factors, cont.

intraseasonal

- Strong MJO (multiple events: Lin, 2012; RMM amplitude was greatest since 2005: Wheeler, 2008)



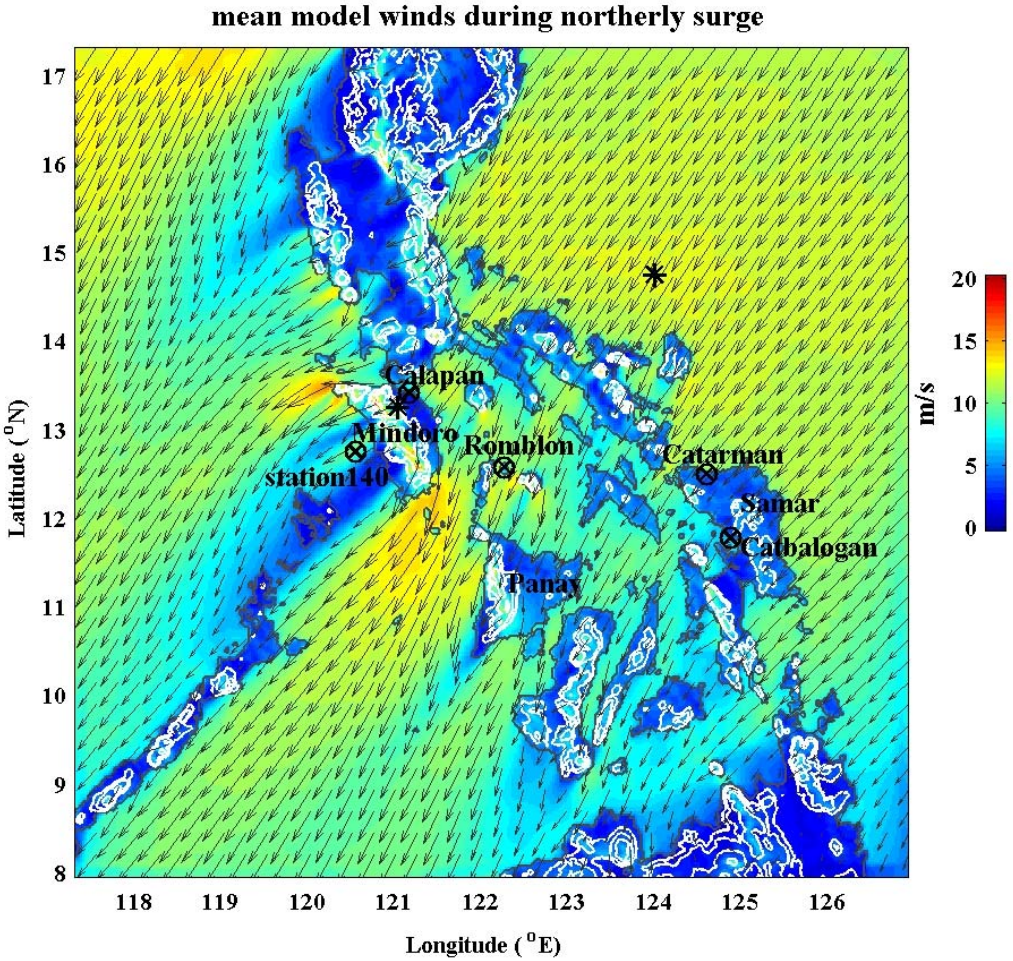


synoptic

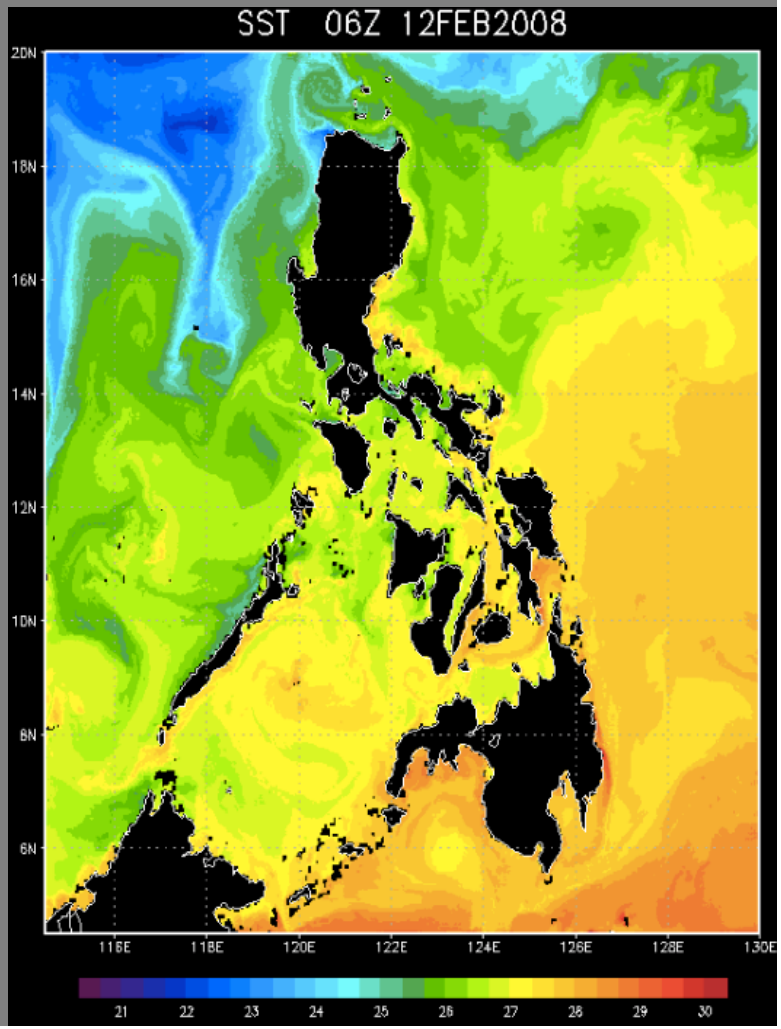
- Prolonged cold surge event in Feb (unusually long & strong: Hong and Lin, 2009; pronounced impact on Philippines: Pullen et al., 2011)

Model cold surge winds & SST

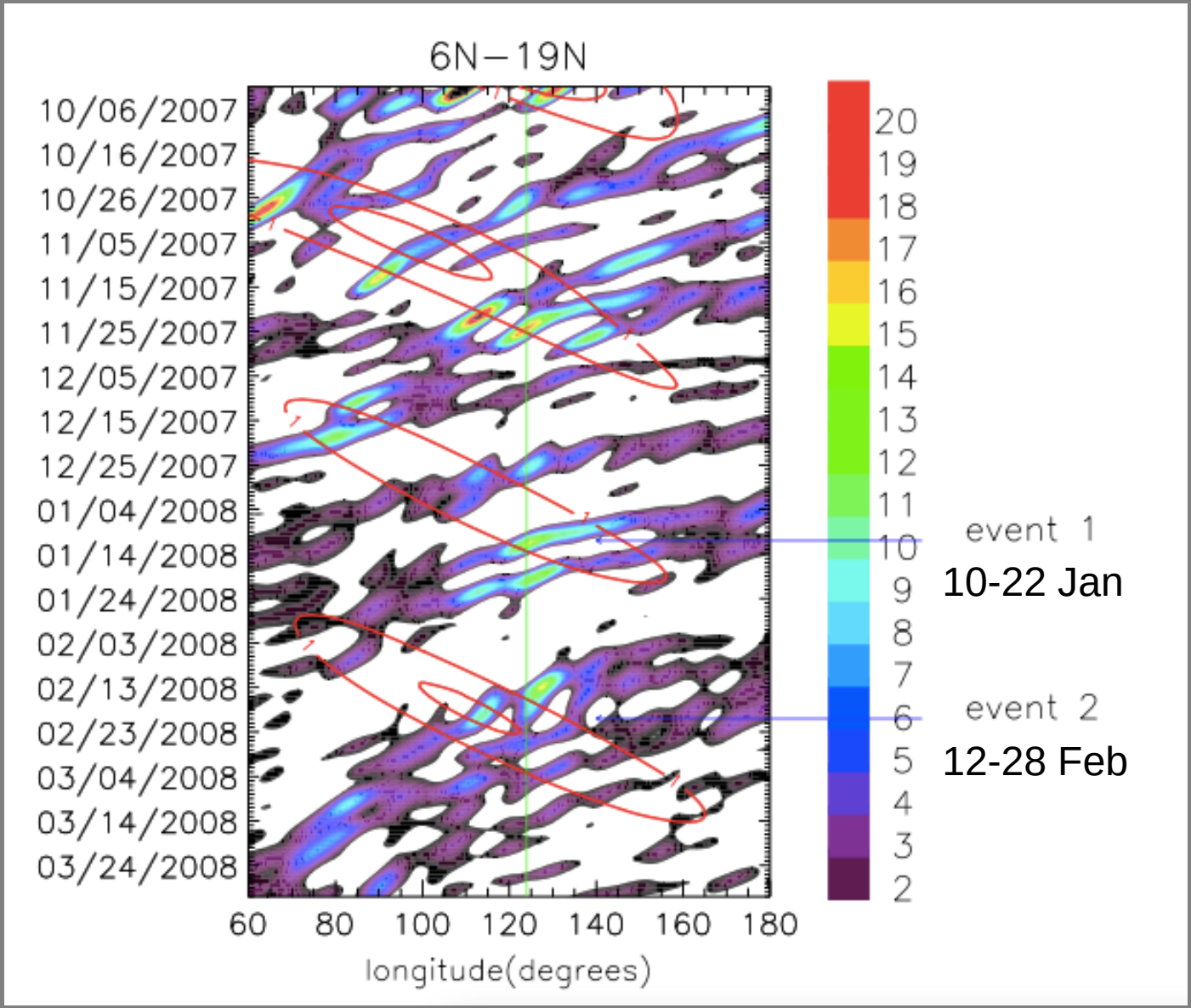
9-16 February 2008



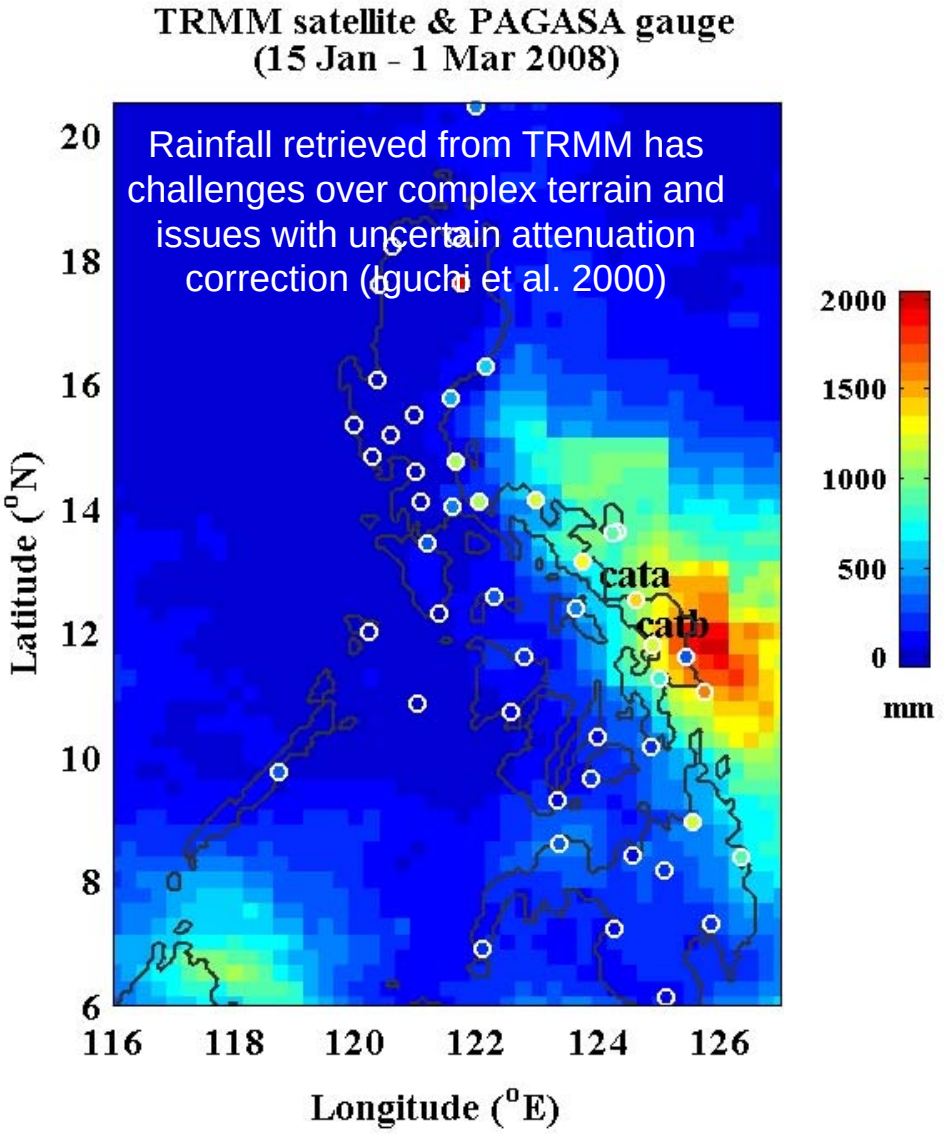
12 February 2008

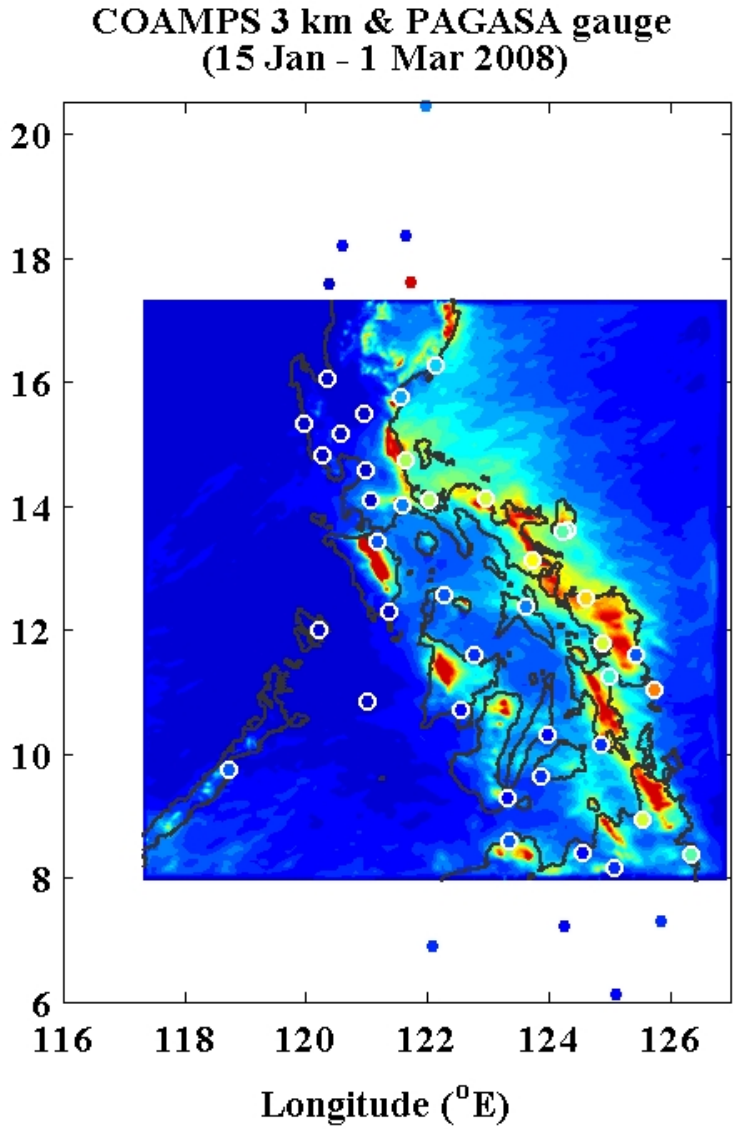


MJO events in the Philippines

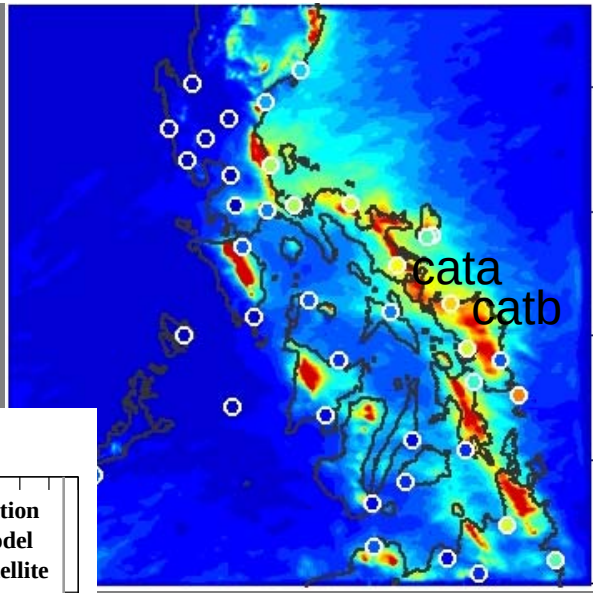


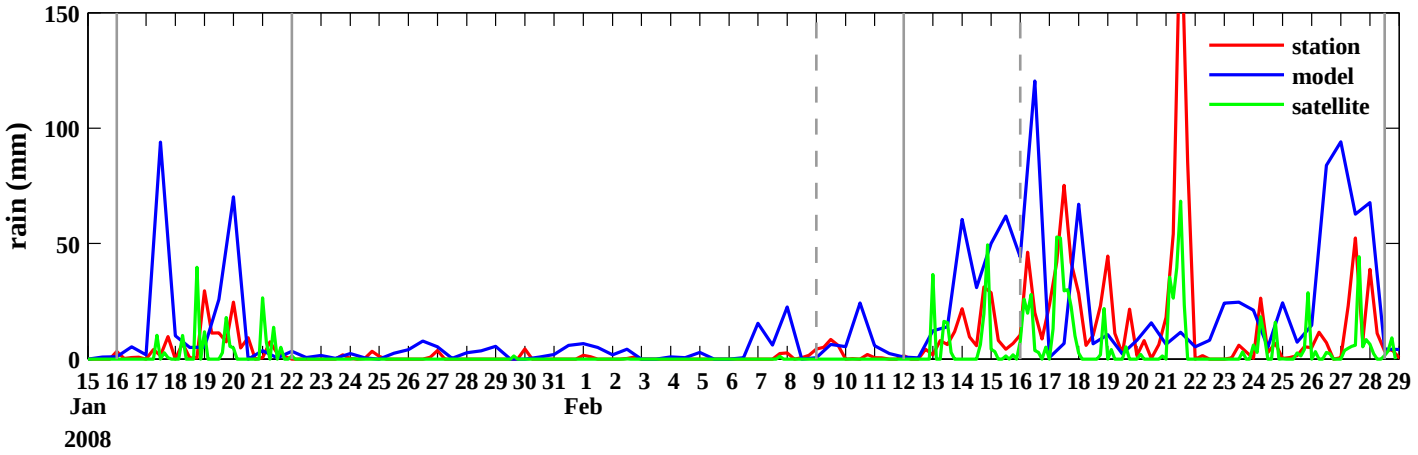
Model-obs comparison

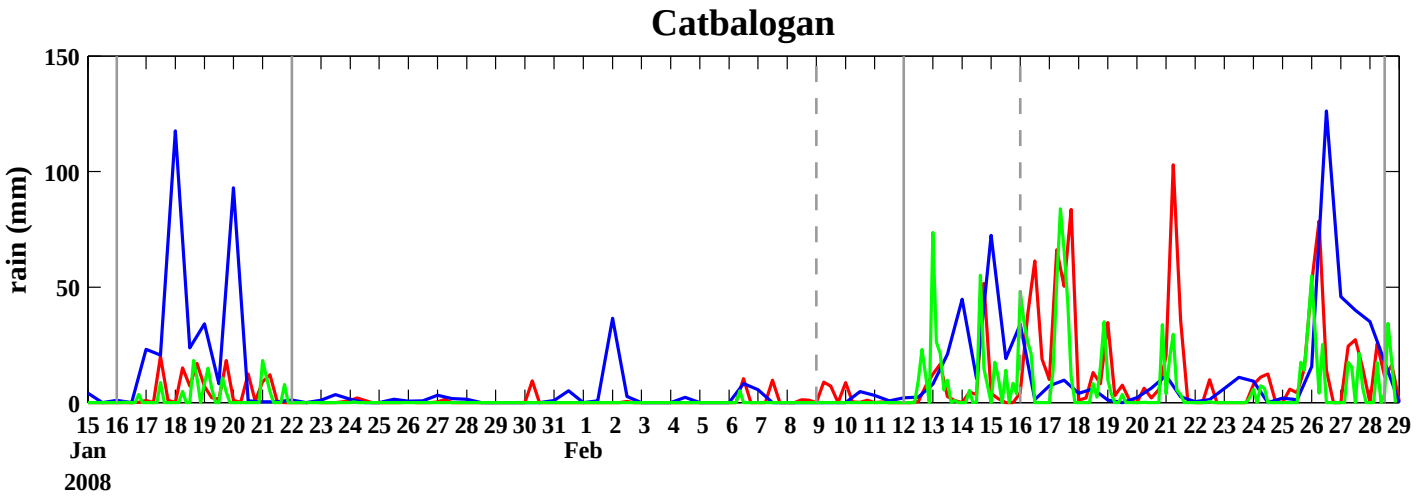




Rainfall record

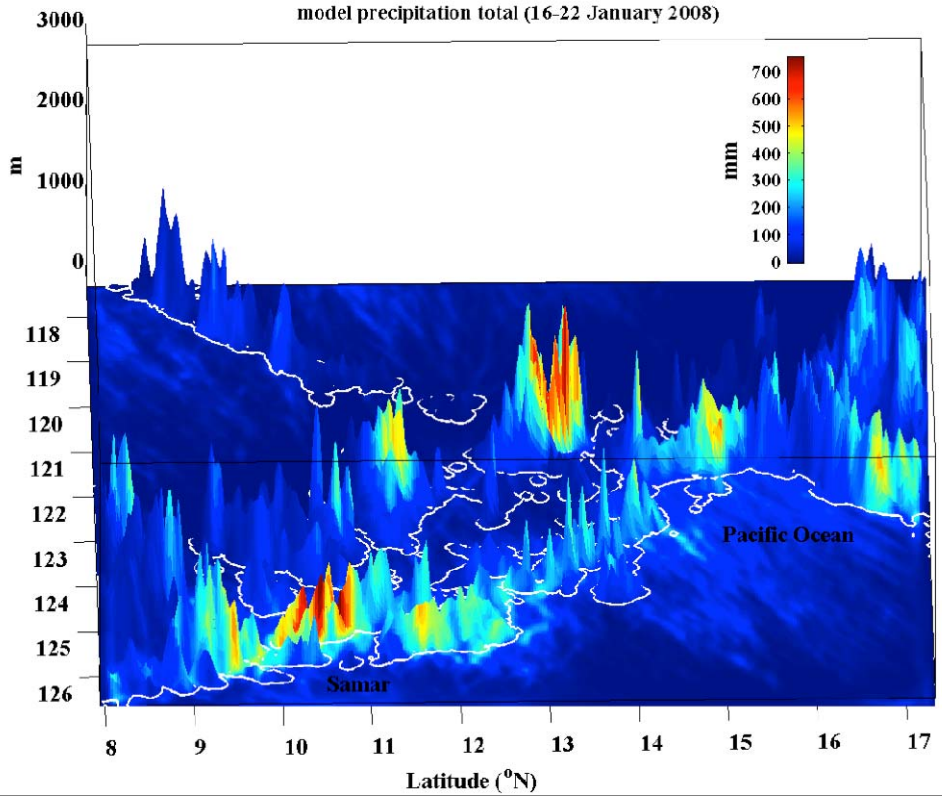




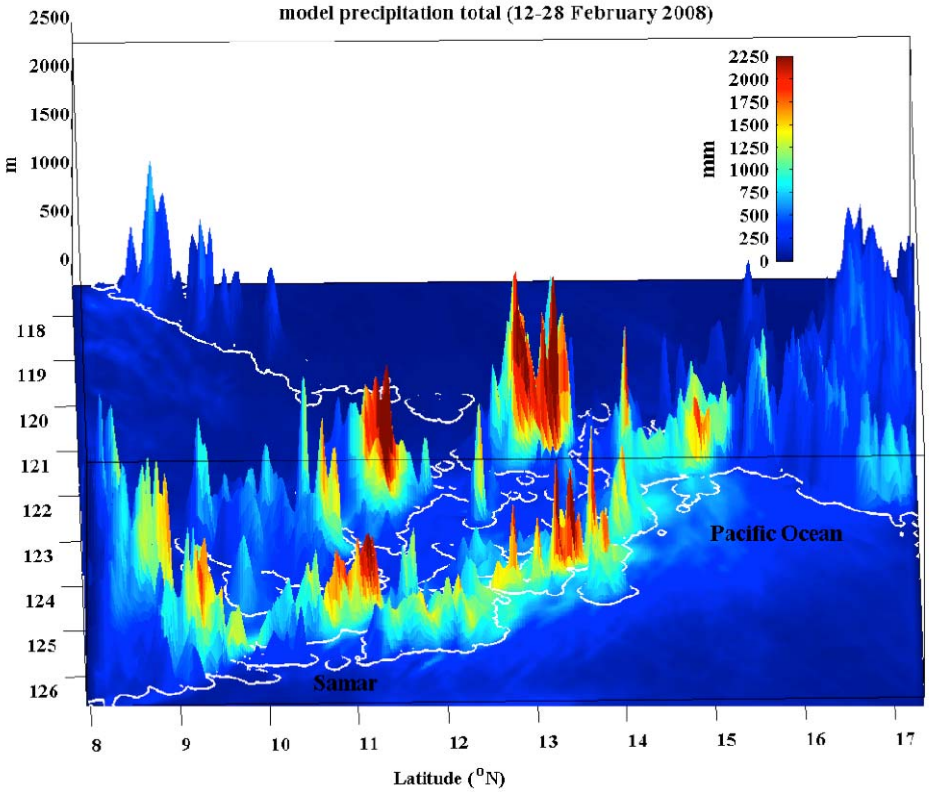


MJO event
model precipitation

Event 1



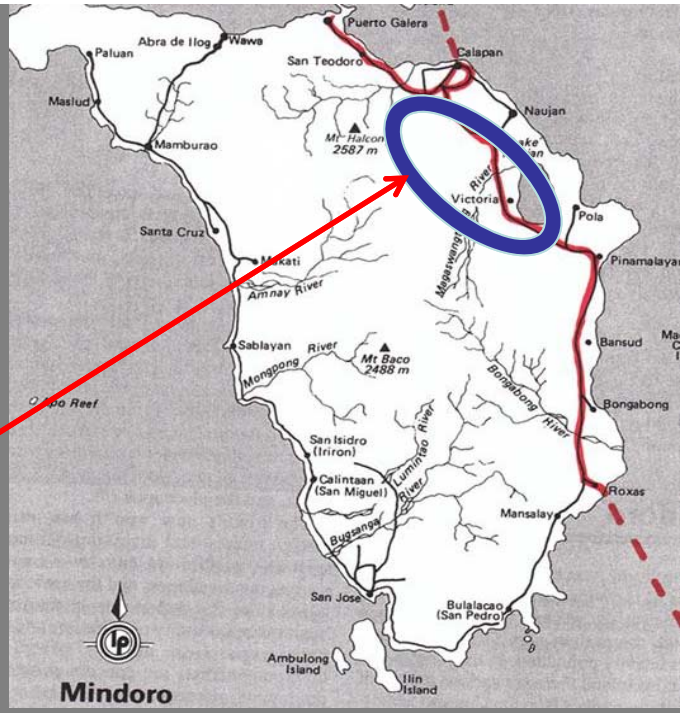
Event 2



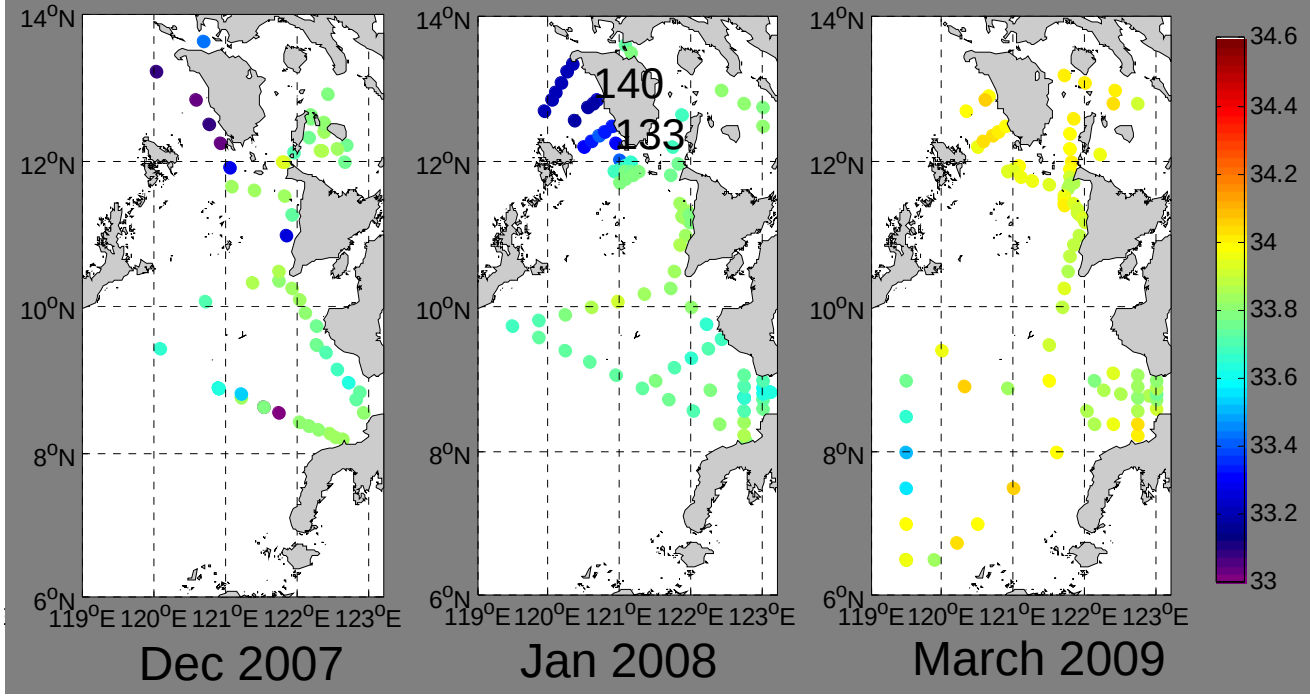
On Samar, flooding and landslides affecting over 45,000 people was reported during event 2 (National Disaster Coordinating Council (NDCC), 2008)

River run-off considerations

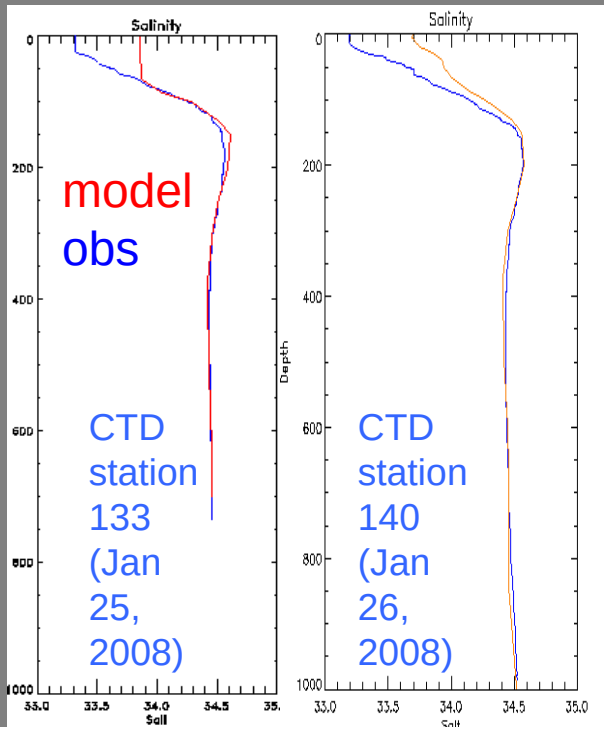
Location of 19 Feb rain-induced river flooding & evacuations affecting over 15,000 people in 20 villages (NDCC, 2008), during MJO event 2



Salinity



Dec 2007 Jan 2008 March 2009



Summary

- Multiple contributing factors played a role in the heavy rainfall of winter 2007-2008 with generally highest values on the eastern side of the Philippines.

- The 3-km coupled air/sea model produced precipitation in the mountainous areas of the Philippines, also suggested by government reports of flooding on Mindoro Island.

- In the observations and model, discrete precipitation events delivered the bulk of the rain to the area and coincided with intense MJO activity over the archipelago and a late February cold surge.

- Shipboard measurements from January 2008 revealed fresh water to the southwest of the island of Mindoro, which likely originated from river run-off, consistent with model-produced rainfall in the mountains.

Publications

J. Pullen, A.L. Gordon, M. Flatau, J. D. Doyle, and C. Villanoy, “Multiscale influences on extreme winter rainfall in the Philippines,” Journal of Geophysical Research - Atmospheres, 120, doi:10.1002/2014JD022645, 2015.

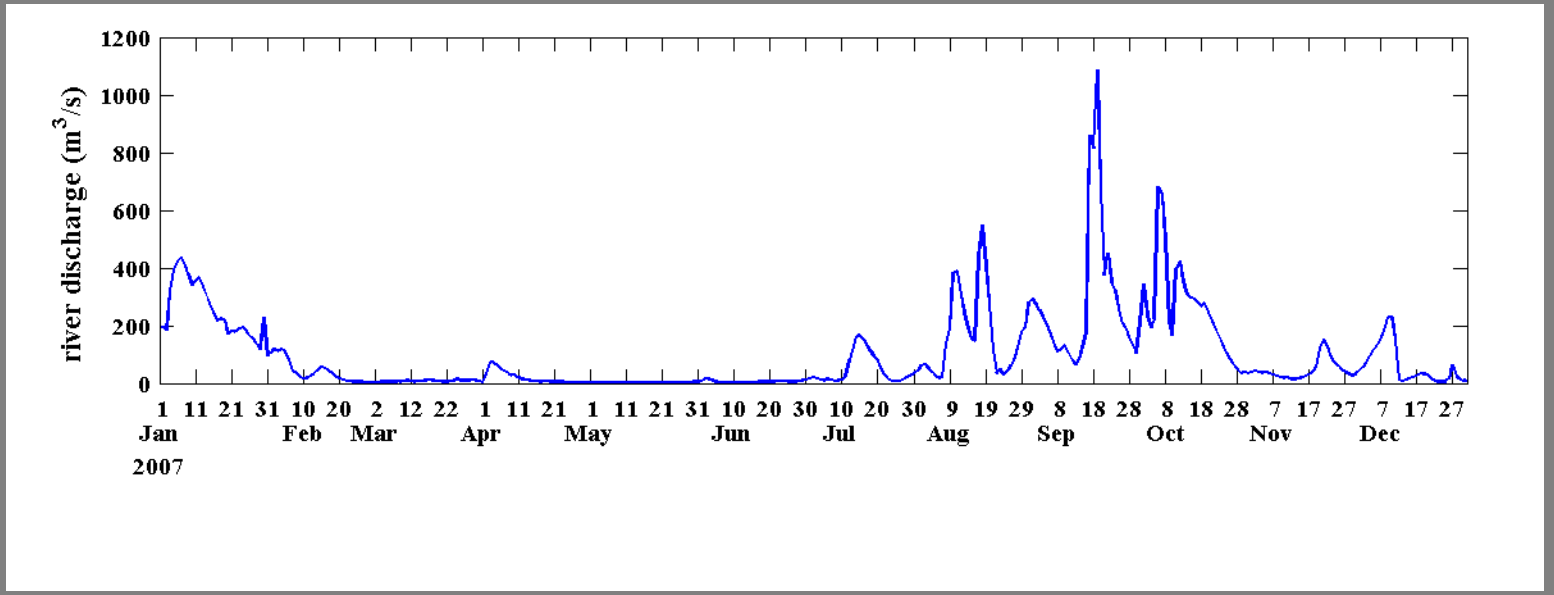
Julie Pullen, Arnold L. Gordon, Janet Sprintall, Craig M. Lee, Matthew A. Alford, James D. Doyle, Paul W. May, “Atmospheric and oceanic processes in the vicinity of an island strait,” Oceanography, 24(1), 112-121, 2011.

Paul W. May, James D. Doyle, Julie Pullen, and Laura David, “Two-way coupled atmosphere-ocean modeling of the PhilEx intensive observational period,” Oceanography, 24(1), 48-57, 2011.

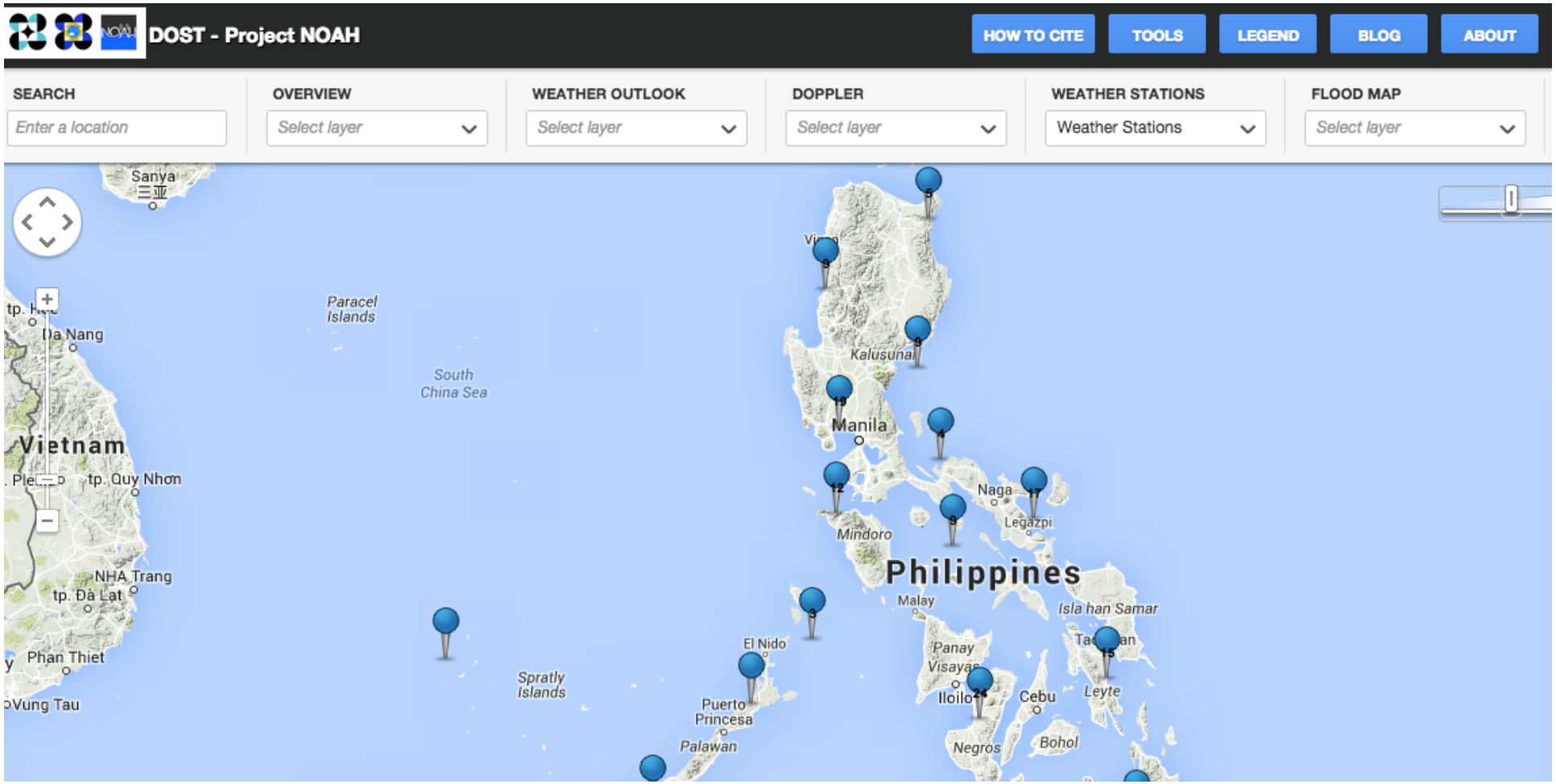
Irina Rypina, Larry Pratt, Julie Pullen, Julia Levin and Arnold Gordon, “Chaotic advection in an archipelago,” Journal of Physical Oceanography, 40(9), 1988-2006, 2010.

Julie Pullen**,** James Doyle, Paul May, Cedric Chavanne, Pierre Flament, and Robert Arnone, “Monsoon surges trigger oceanic eddy formation and propagation in the lee of the Philippine Islands,” *Geophysical Research Letters,* 35, L07604, doi:10.1029/2007GL033109, 2008.

Pagbahan River gauge



Courtesy of Cesar Villanoy, University of the Philippines



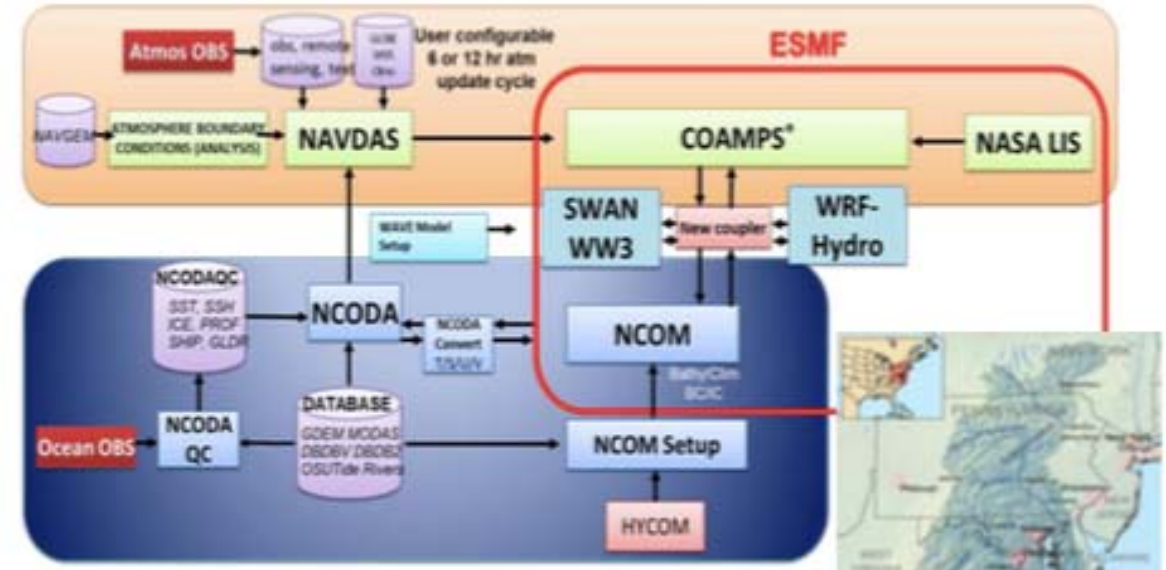
http://noah.dost.gov.ph/

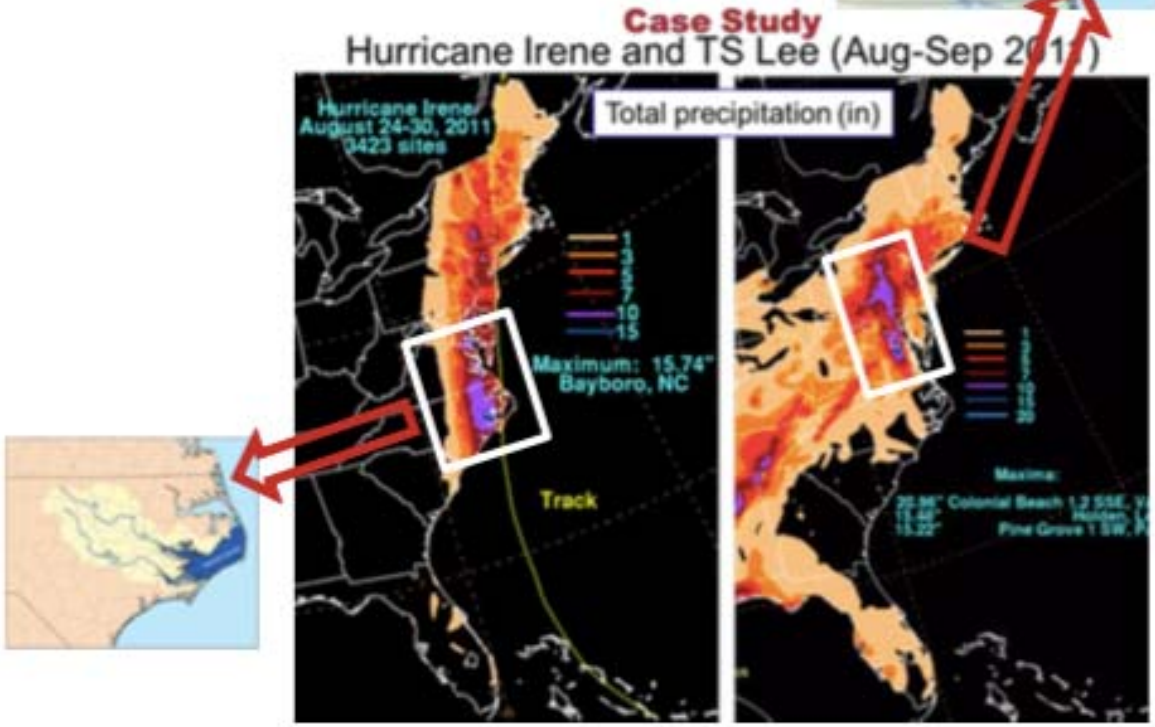
YMC opportunity

<u>Coupled air/sea/hydro modeling 2015-2019</u>

ONR/NOPP-funded

Naval Research Lab: T. Holt, S. Chen, etc.



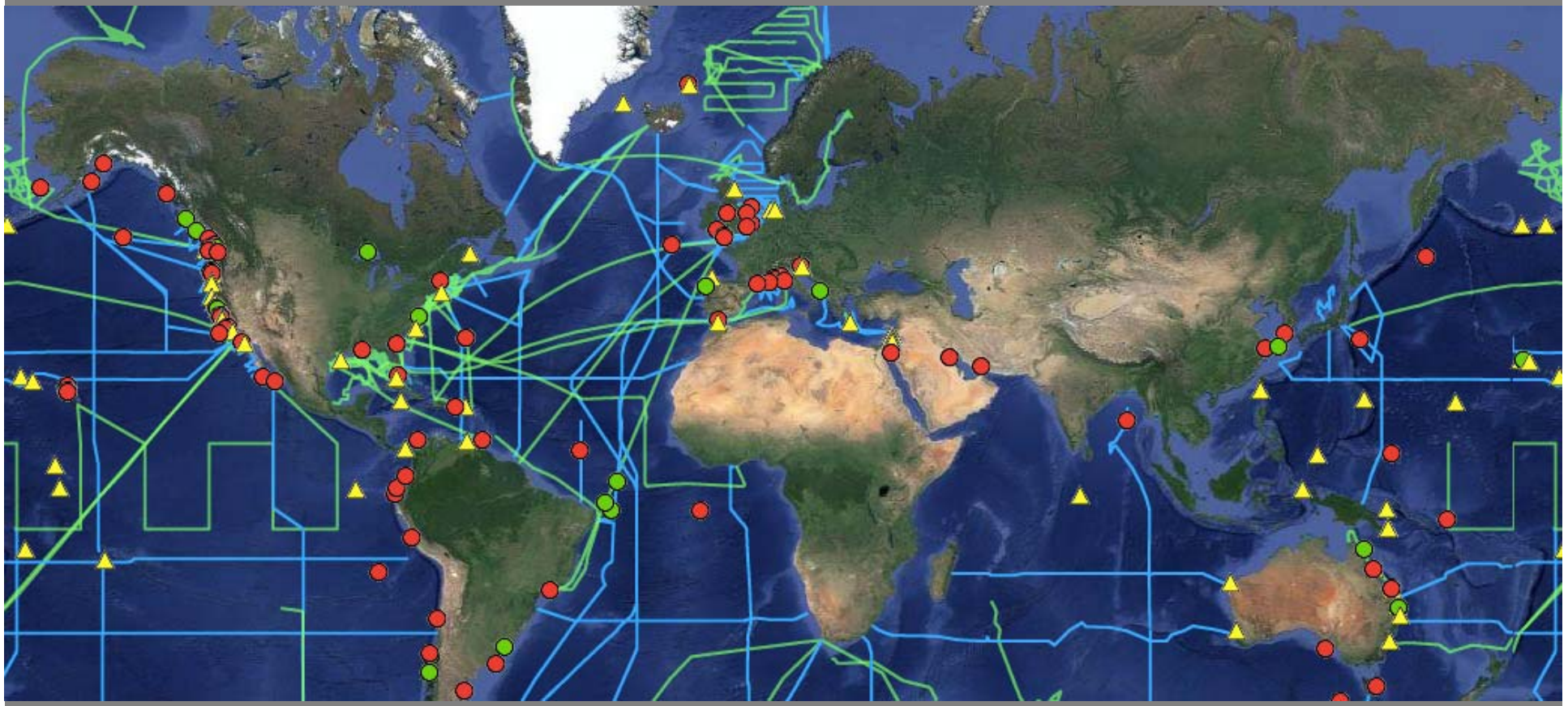


New WRF-hydro component + Improved soil moisture (NASA LIS)

GOA-ON

Global Ocean Acidification Observing Network

The Global Ocean Acidification Observing Network (GOA-ON) is a collaborative international approach to document the status and progress of ocean acidification in open-ocean, coastal, and estuarine environments, to understand the drivers and impacts of ocean acidification on marine ecosystems, and to provide spatially and temporally resolved biogeochemical data necessary to optimize modeling for ocean acidification.



X-Prize awarded end of July to ~$1000 pH sensor i-SAMI (by Sunburst Sensors)

now under commercial development

potential to use for coastal applications (e.g., pH near river discharge sites)