The PISTON 2018-2019 Field Campaign: Propagation of Intra-Seasonal Tropical Oscillations

Eric Maloney

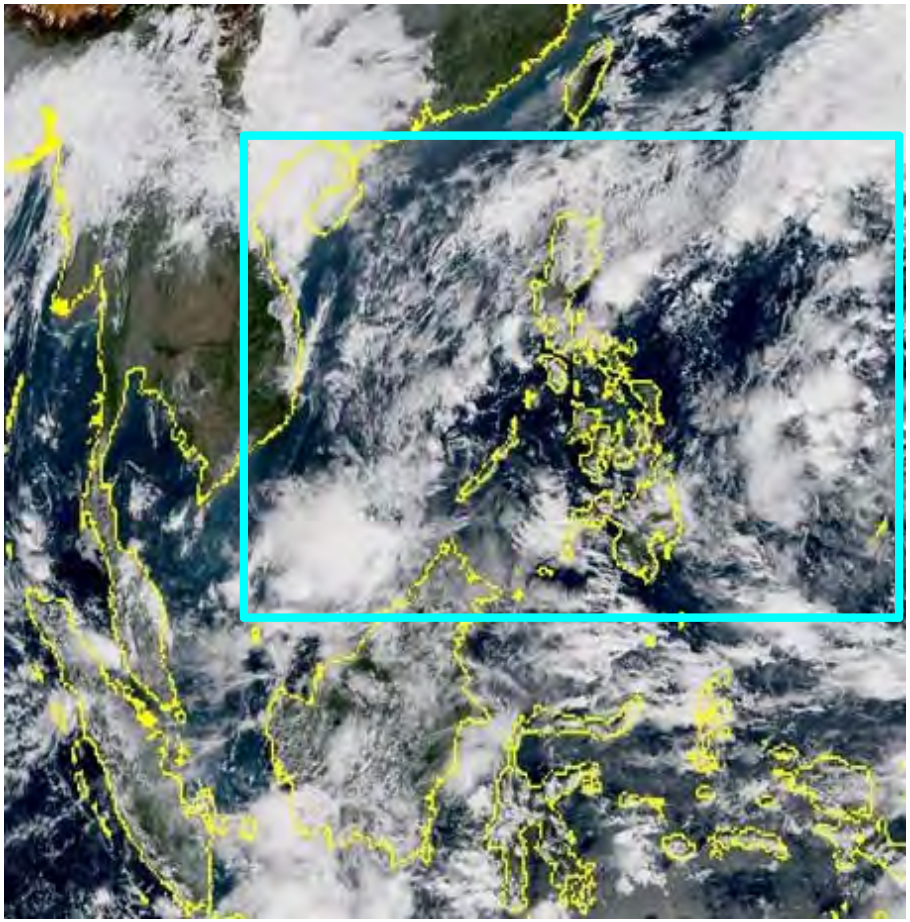
Colorado State University

On behalf of the PISTON Science Team

4th YMC Workshop, Quezon City, Philippines
26-28 February, 2019

PISTON funded by the Office of Naval Research

and 18+ institutions



Outline

- Brief summary of PISTON research goals
- Overview of PISTON 2018 observations and results
- Plans for PISTON 2019

Sue Chen: Modeling results

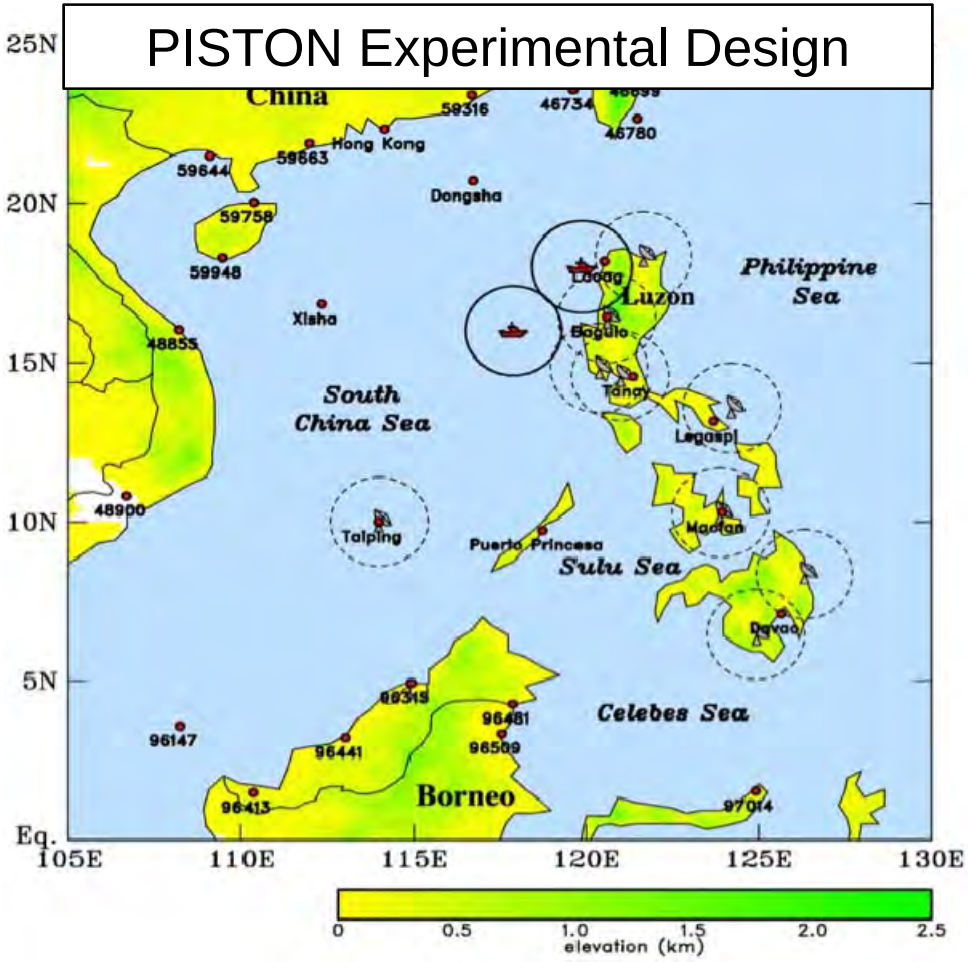
Jeff Reid: CAMP2Ex

Bob Holz: lidar

Propagation of Intra-seasonal Tropical Oscillations (PISTON)

The PISTON experimental design focuses on air-sea interaction, upper ocean mixing, rainfall, and precipitation processes over the SCS west of Luzon with special interest to understanding the diurnal cycle of rainfall and coupling with the boreal summer intraseasonal oscillation (BSISO). **Includes strong modeling component.**

PISTON Experimental Design

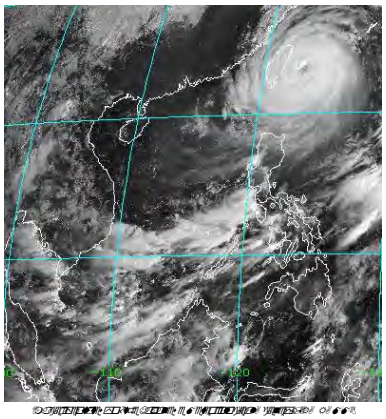


https://onrpiston.colostate.edu

Propagation of Intra-Seasonal Tropical Oscillations (PISTON)

Office of Naval Research Departmental Research Initiative (DRI)

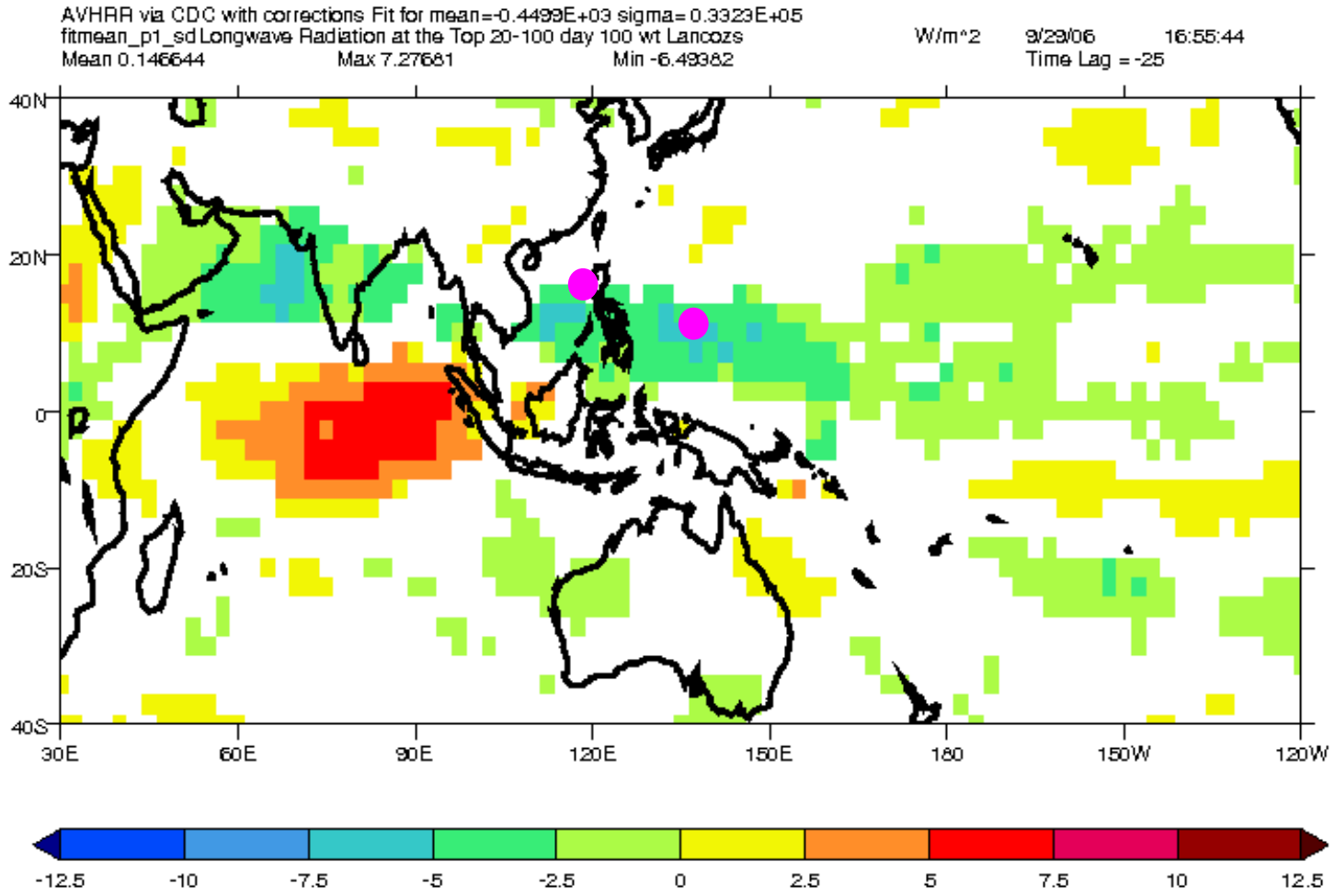
SCIENCE PLAN



Composite Evolution of BSISO

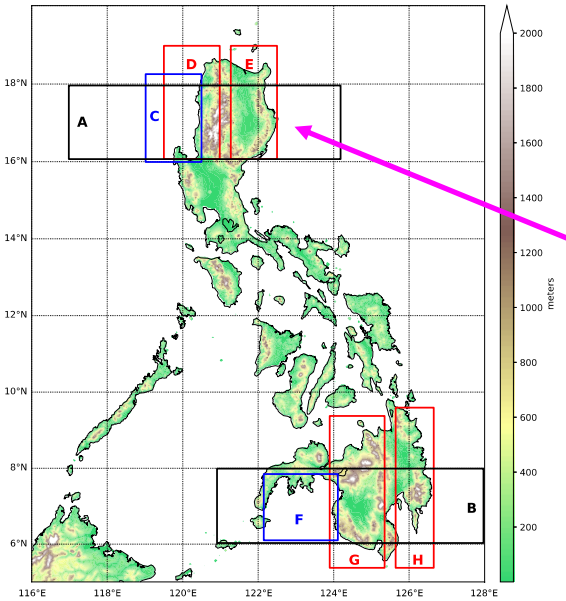
Propagation Dynamics not Well-Understood

Outgoing Longwave Radiation Anomalies

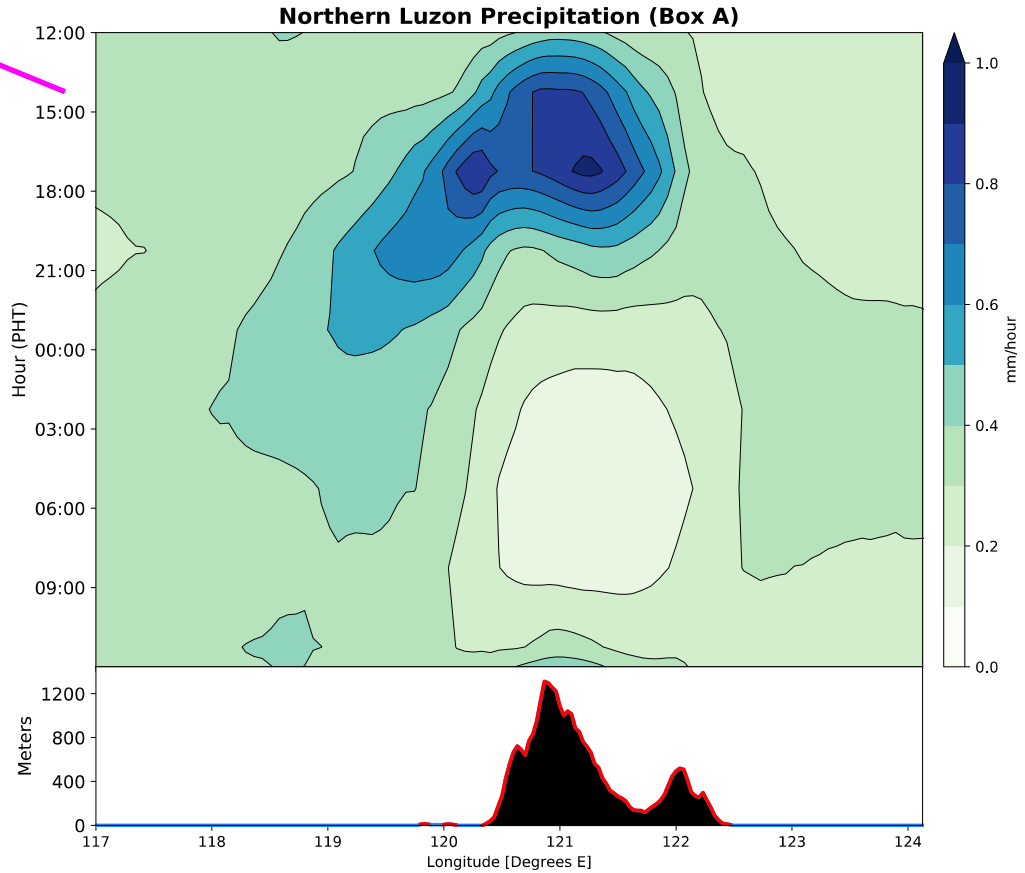


Sperber and Annamalai (2008)

Interactions Between Diurnal Cycle and BSISO



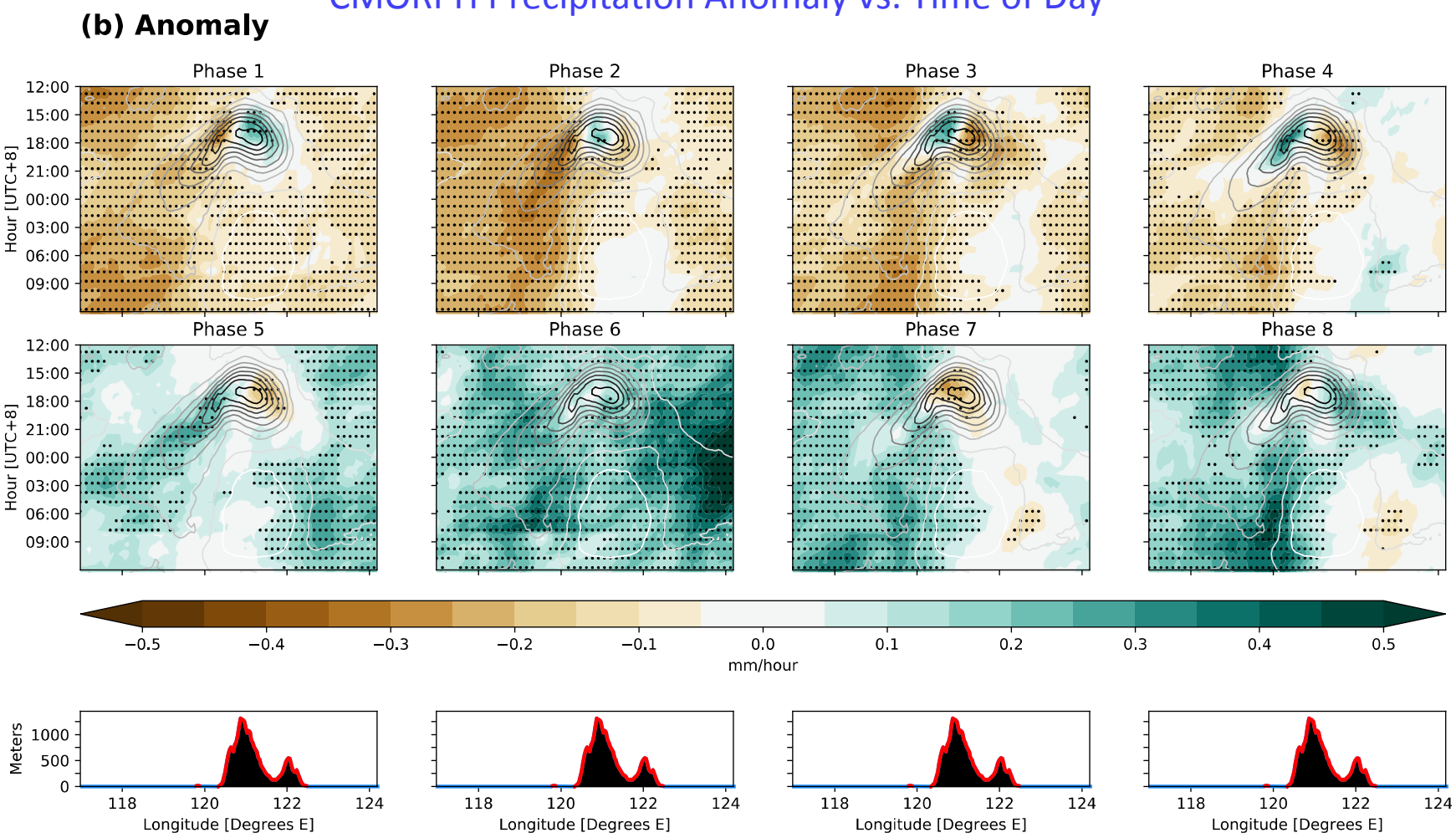
CMORPH Precipitation vs. Time of Day



Natoli and Maloney (2019)

Interactions Between Diurnal Cycle and BSISO

CMORPH Precipitation Anomaly vs. Time of Day



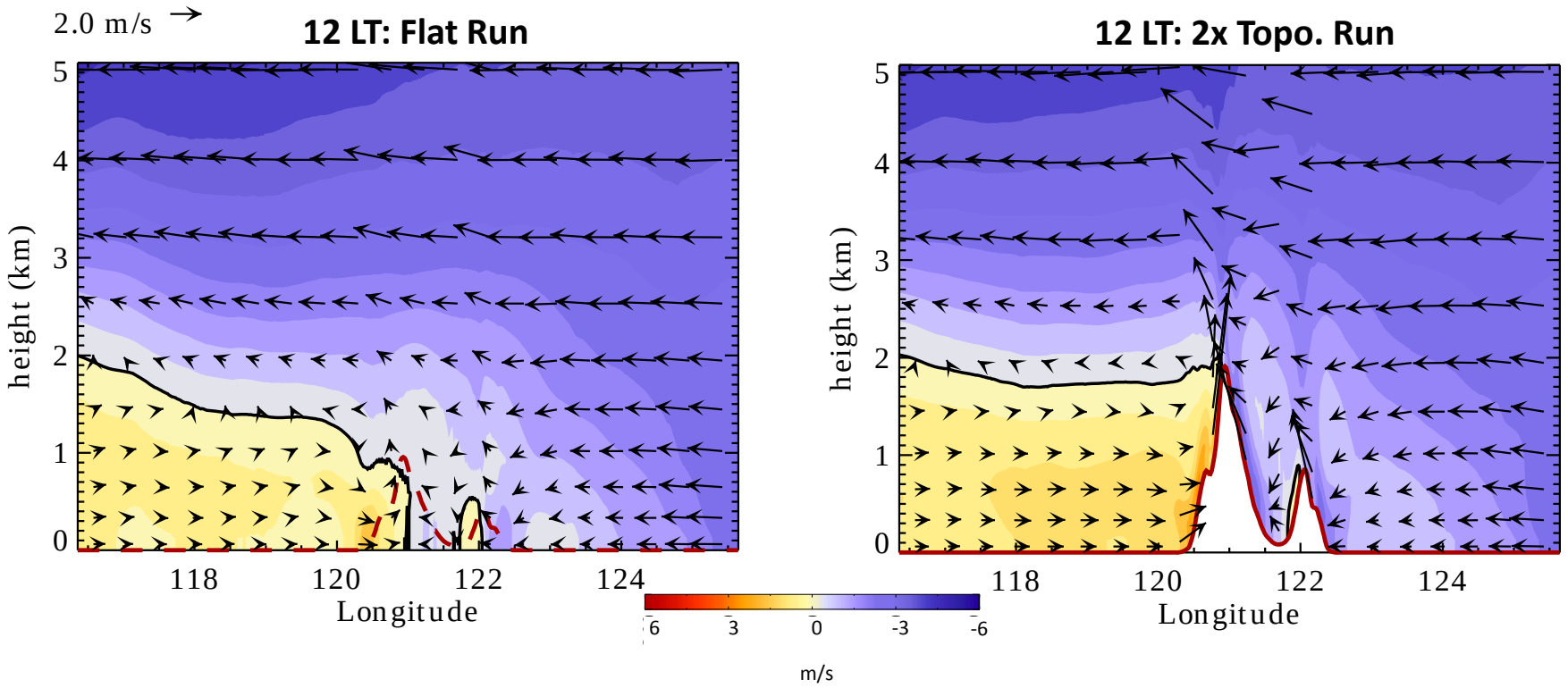
Natoli and Maloney (2019)

Diurnal cycle in South China Sea with offshore propagation peaks in advance of main BSISO convective envelope

Interactions Between Diurnal Cycle and BSISO

Zonal wind at 12 LT in Luzon in CSU RAMS model

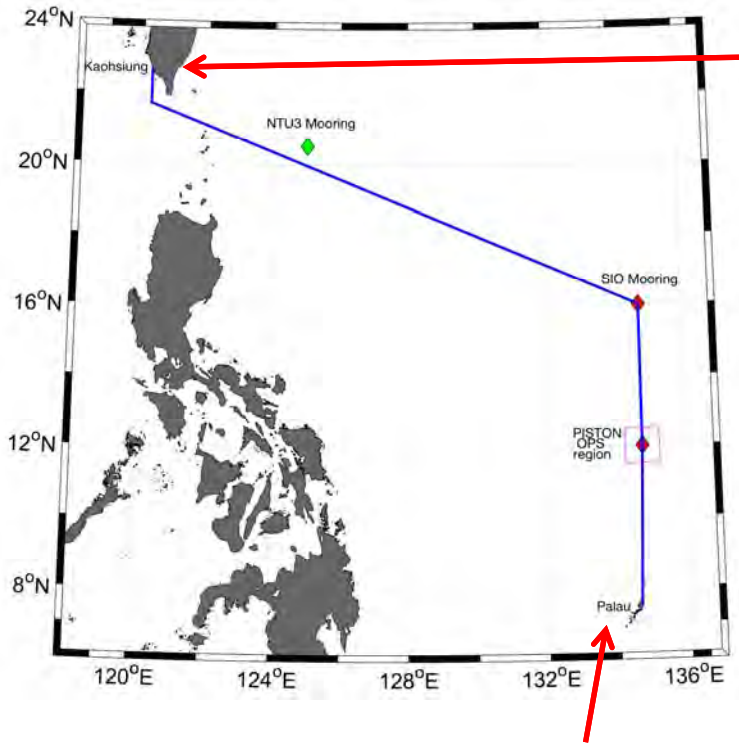
BSISO Phases 1-4:



Topography of Luzon significantly hastens onset of diurnal cycle in CSU regional model relative to flat run

Riley Dellaripa et al. (2019)

2018 Phase of PISTON



Staging at Kaohsiung, Taiwan

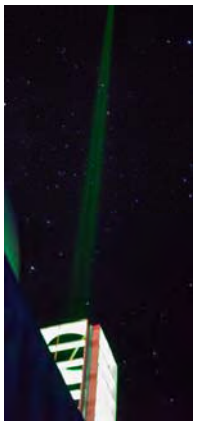
Principal platform was the *R/V Thomas G. Thompson*
PISTON, 10 August – 13 October 2018 (2 ~ 30 days cruises)

Port call at Palau 8-13 Sept 2018

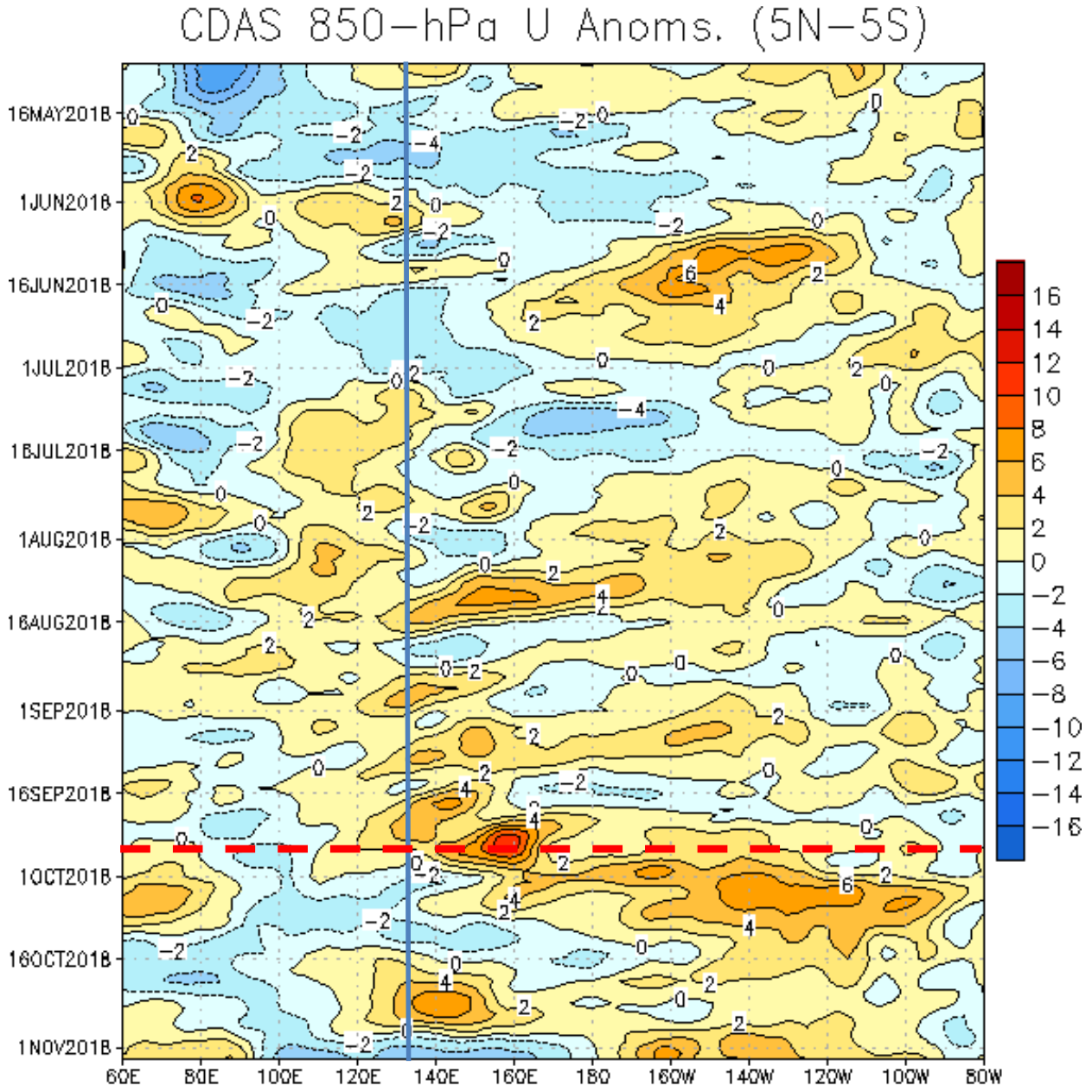
PISTON Observations

- Atmosphere
  - Colorado State University SEA POL 5 cm polarimetric radar
  - CSU radiosonde system (8 per day; Vaisala RS41 sondes; 374 successful launches)
  - NOAA ESRL sensible and latent heat fluxes, W-band radar, solar and IR
  - HSRL Lidar, U. of Wisconsin
    - 532 and 1064 nm
  - Disdrometer, U. of Washington/APL
  - Electric field mill, NASA/MSFC
    - fair weather E field

- Ocean
  - Upper ocean turbulence, Chameleon and Surf Otter, Oregon State U.
  - CTD profiles to 400 m, Scripps
  - Two instrumented moorings, Scripps; deployed on Palau Ridge, 12N and 16N, 135E. Moorings will be recovered in Fall 2019.
  - Floats, Scripps
  - ADCP, SST, salinity, etc provided by ship



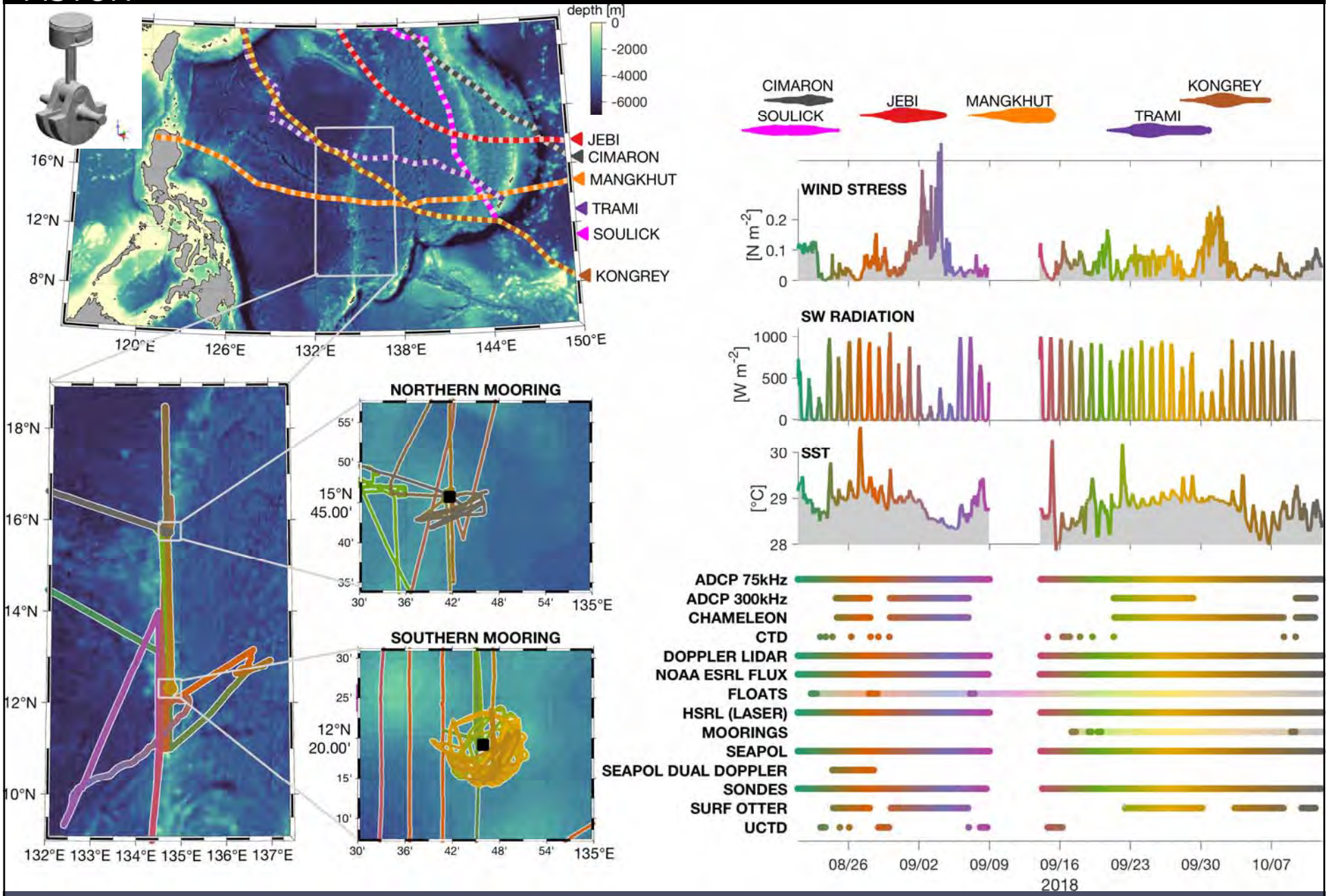
The Bigger Picture (No classic BSISO)



Plot Courtesy of NOAA CPC

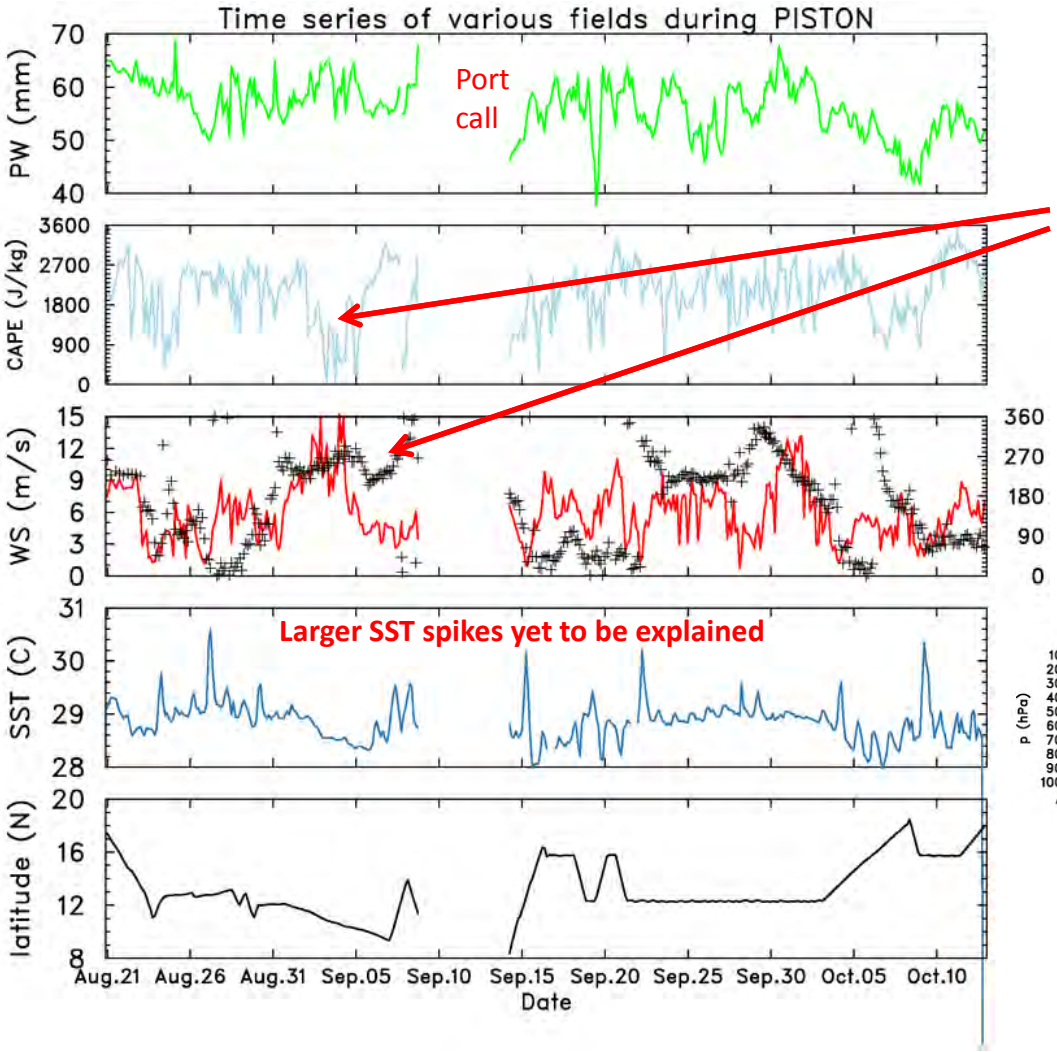
Study period

PISTON



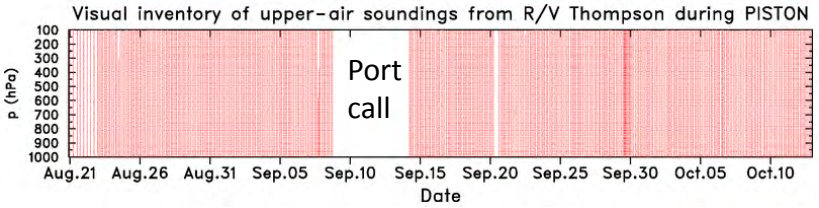
Sally Warner (OSU)

Time Series of Atmospheric Quantities



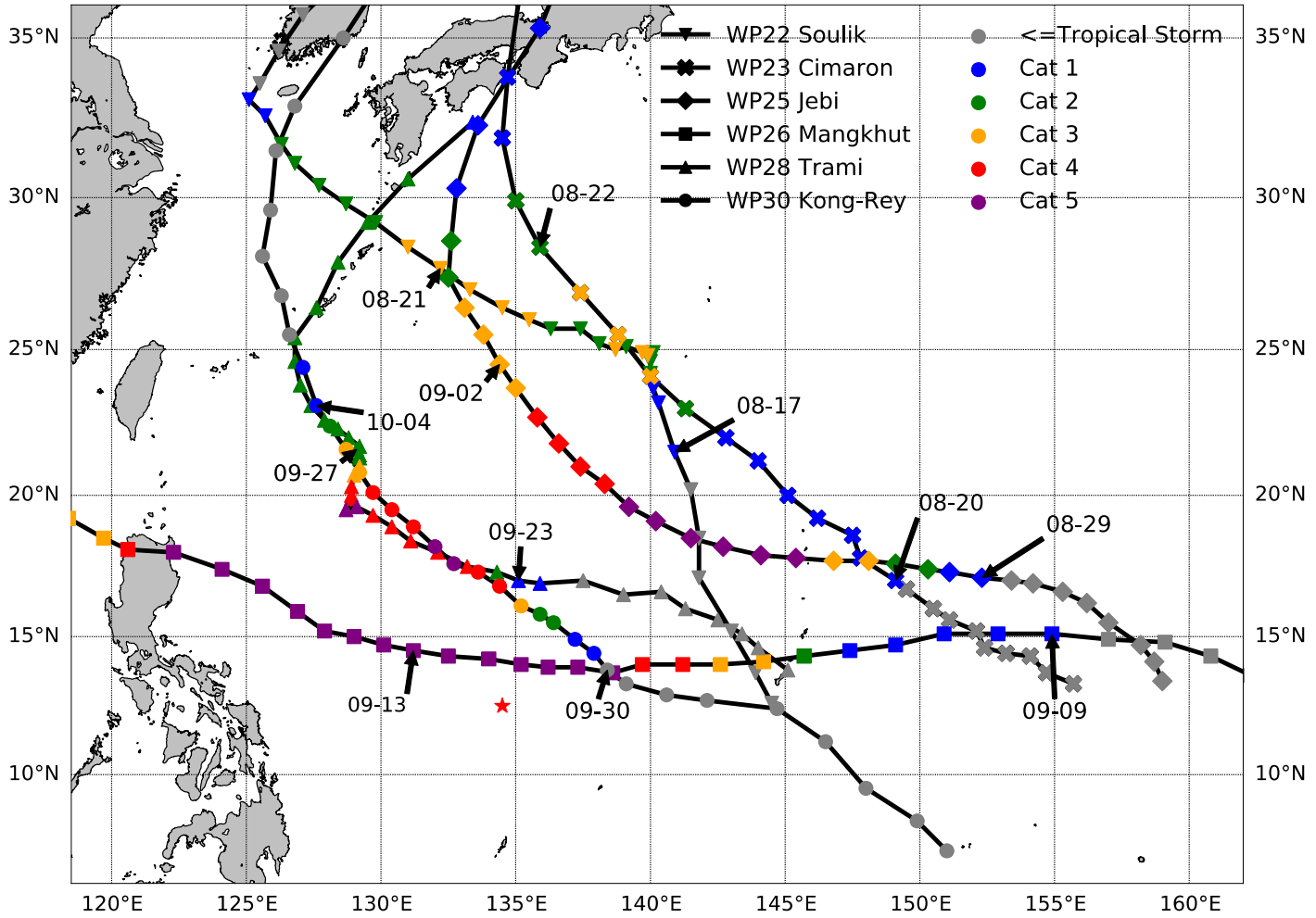
Depressed CAPE and enhanced winds in wake of super typhoon Jebi, yet PW remained high

Sounding inventory

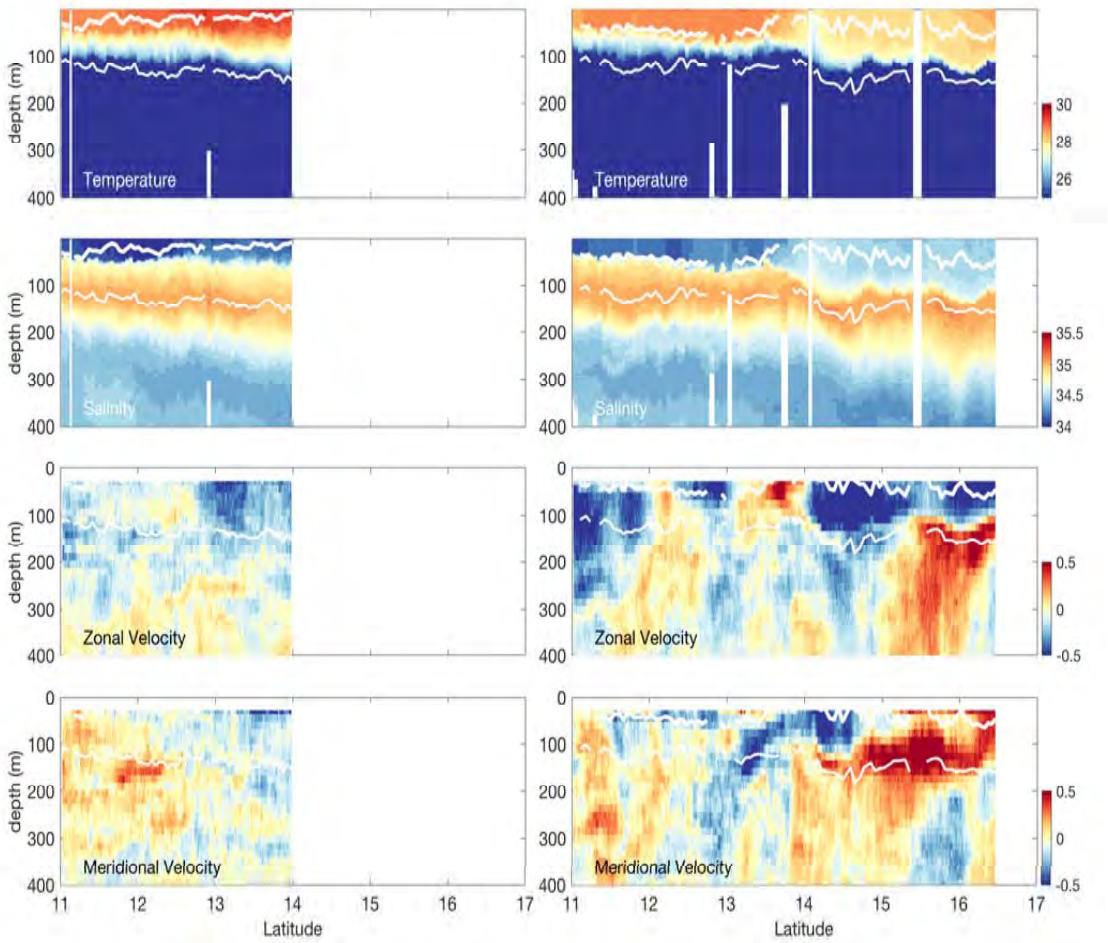


Courtesy: Paul Ciesielski

Overall, significant typhoon activity occurred during PISTON; opportunity to study air sea interaction long with a long list of other science questions…..



Ocean Structure Pre- and Post-Typhoon



Before Typhoon Kong-Rey
southbound to Palau
along 135E

After Kong-Rey
northbound from Palau
along 135E

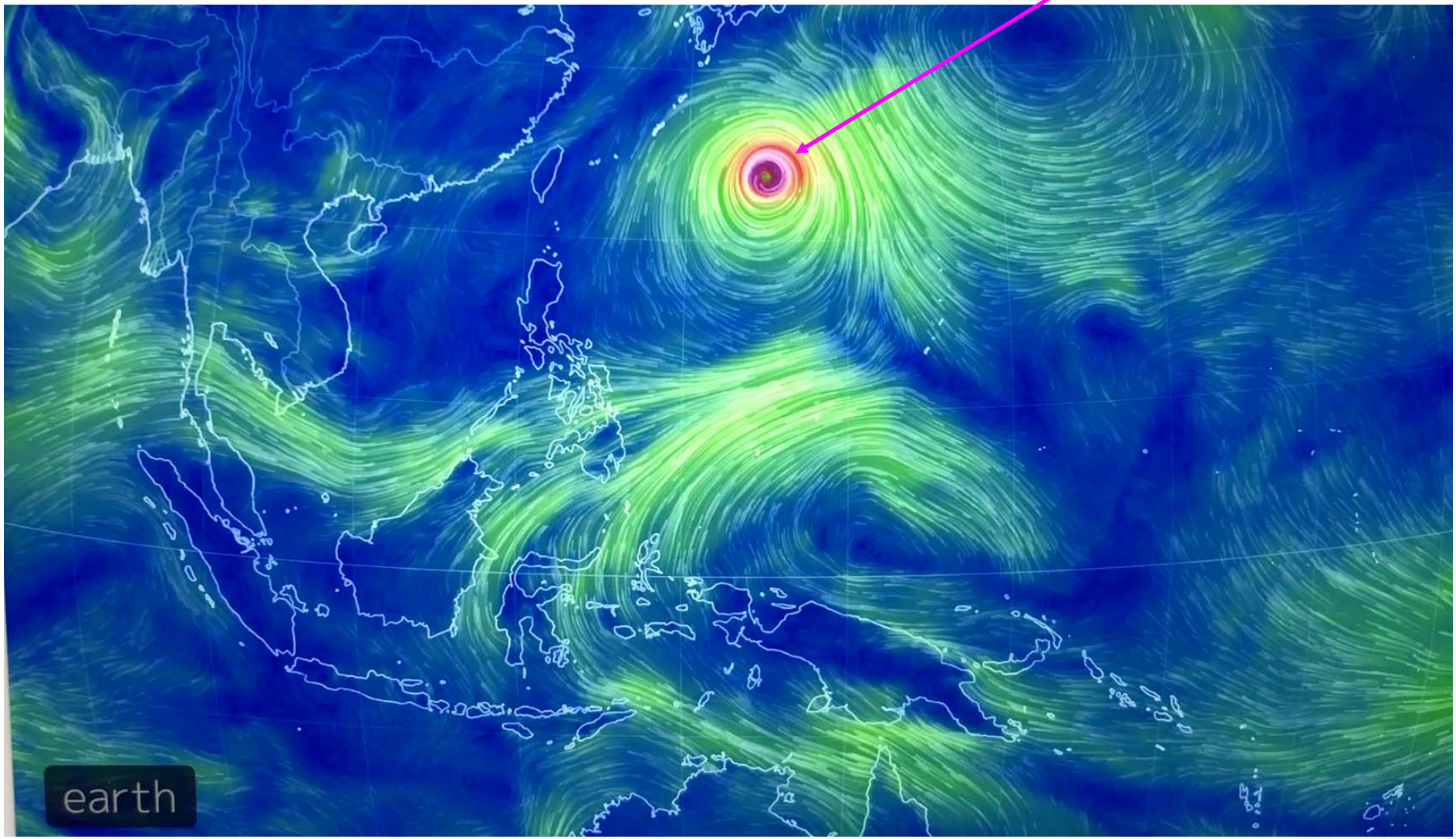
Reduced SST;
Mixing and cloud shading

Surface salinity increased
due to transport of saltier sub-
surface water from below

Strong increase in surface
currents and modification
of shear profile

J. Sprintall, E. Shroyer,
S. Warner and J. Moum

September 3, 850 hPa Flow from NCEP reanalysis

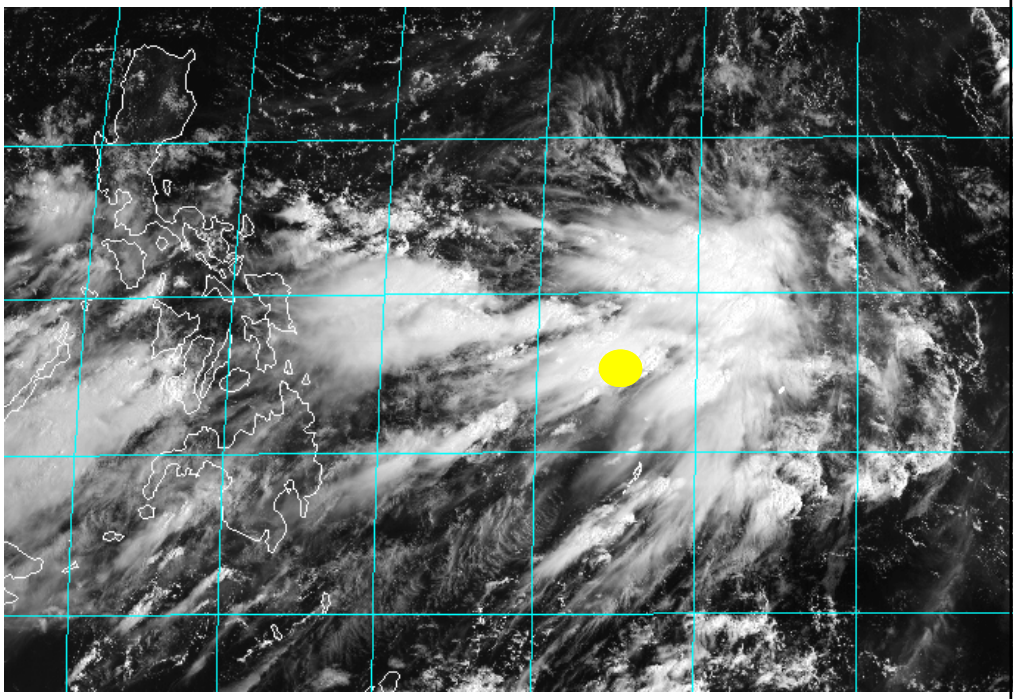


"Monsoon tail"

Monsoon “Tails”

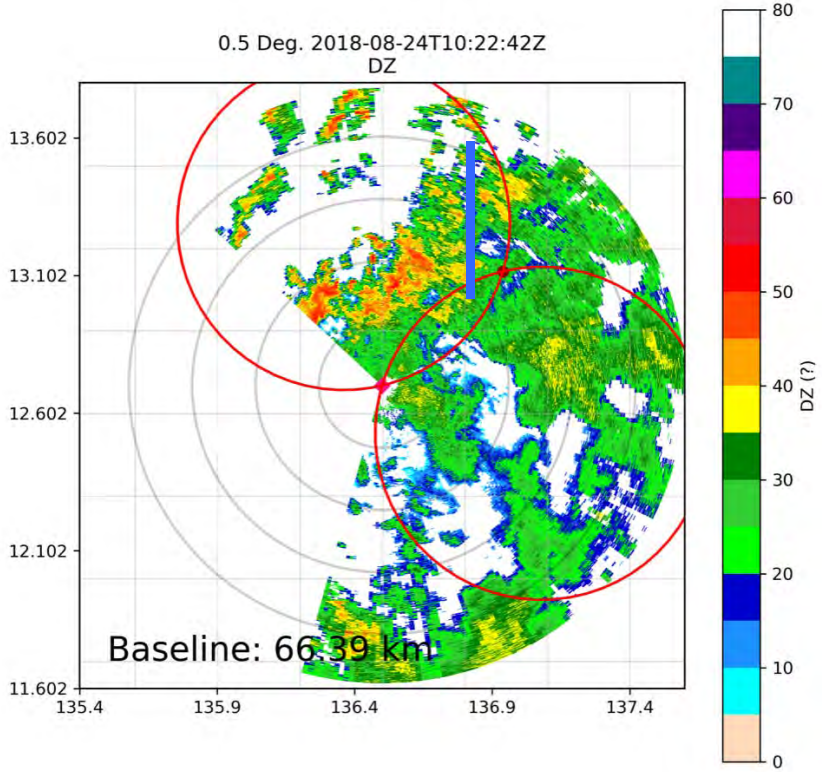
The westerly, disturbed periods occurred in “monsoon tails” of tropical cyclones. The second, Sep. 2-5, following Super Typhoon Jebi, was well sampled, and featured strong net heat flux out of the ocean, due to strong winds and cloud shading.

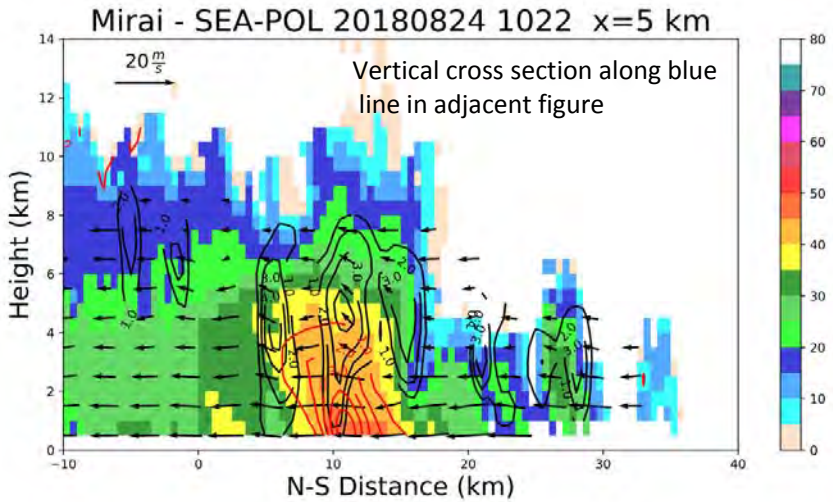
Visible sat image, 9/03 03Z



Dual-Doppler Analysis

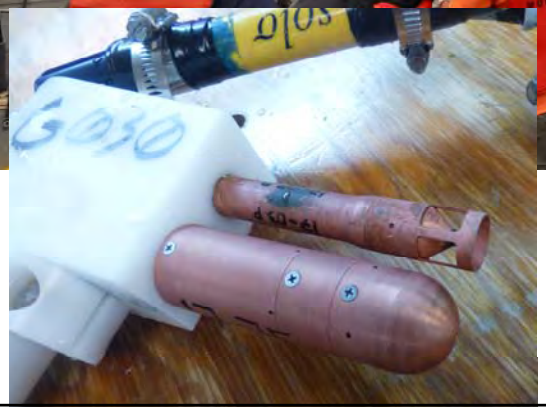
Ship-based dual-Doppler performed with the R/V Mirai. Only second time this has been done. TOGA-COARE in 1992 was the first opportunity. Radial velocities from each radar yield horizontal wind field and divergence. Continuity equation is then integrated to obtain vertical motions.

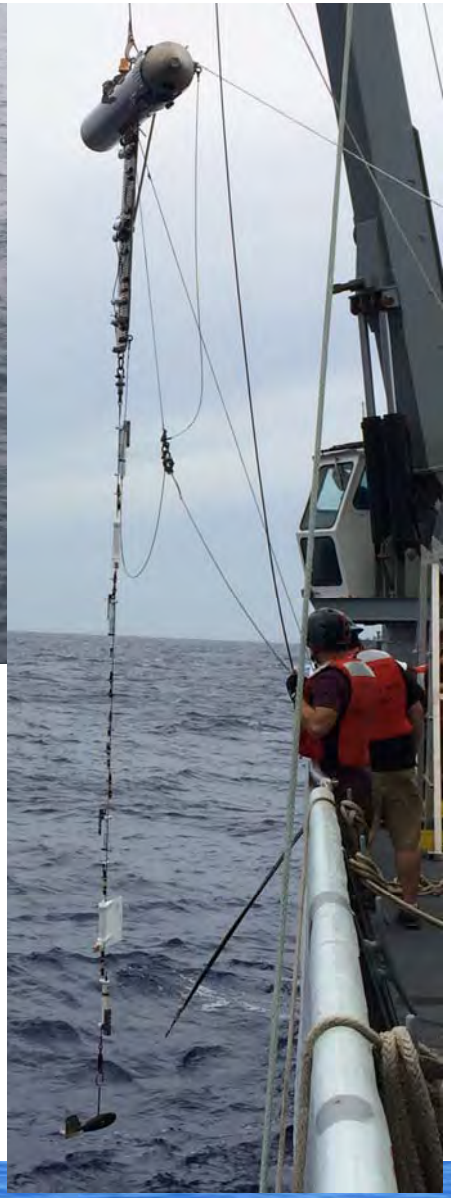




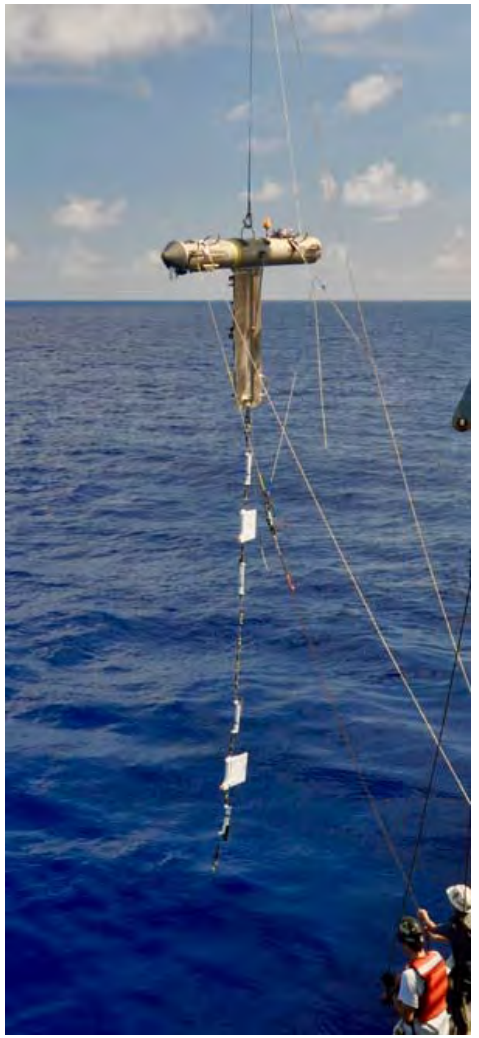
Modest low-level convective updrafts, 4 m s^{-1} yet rain rates are in excess of 100 mm h^{-1} as estimated by specific differential phase field K_{dp} (5 degrees km^{-1}). Upper parts of convective cells have weak updraft. Many more dual-Doppler time periods to analyze.

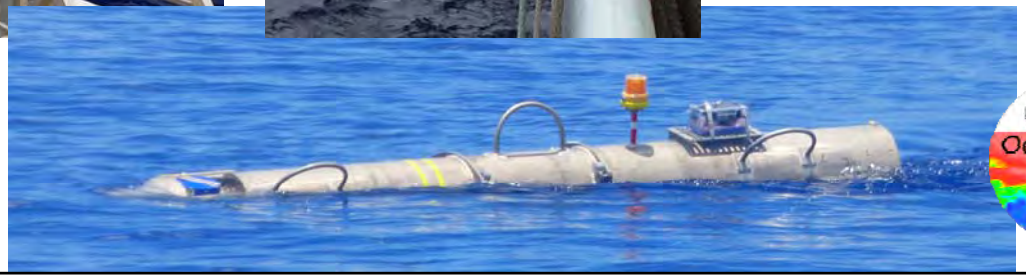
PISTON

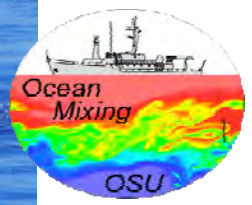




SurfOtter – developed for PISTON (DURIP)







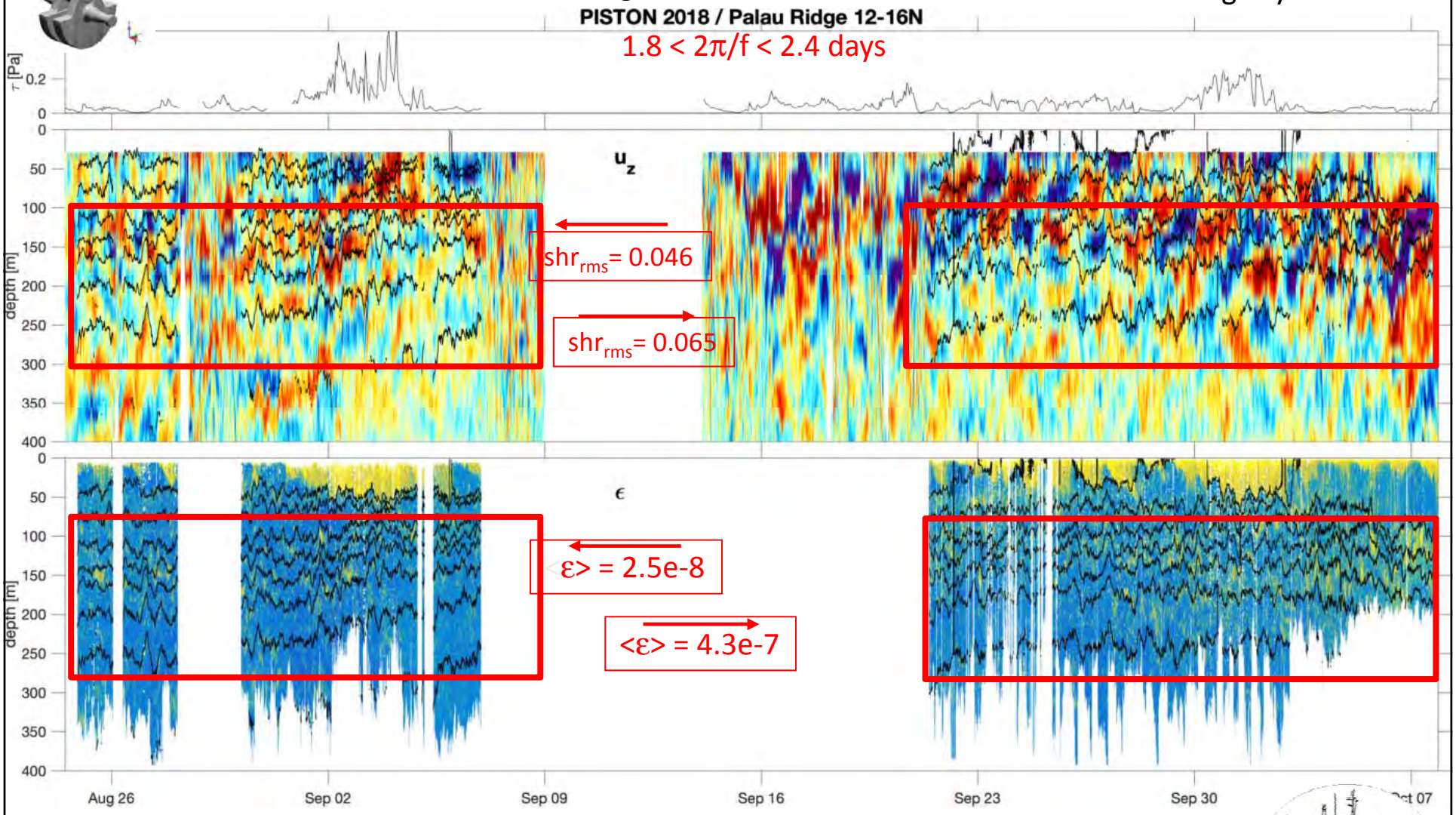
PISTON

deeper ocean structure

WWB

Super Typhoon Mangkhut

Typhoon Kong-rey



pre-cyclones

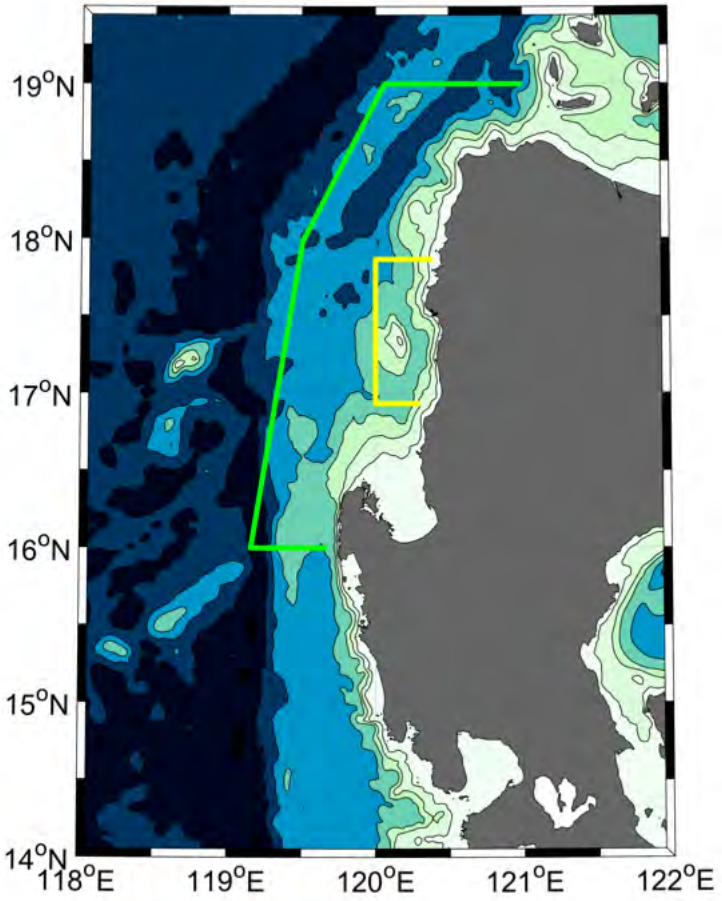
cyclones →

Noel Brizuela (SIO)

Ocean Mixing OSU

Propagation of Intra-seasonal Tropical Oscillation (PISTON 2019)

2019 Emphasis on Diurnal Cycle Near Luzon



- Principal platform is the *R/V Sally Ride*
- Comparable ocean and atmosphere measurements to PISTON 2018
- Overlap with CAMP2Ex (NASA)

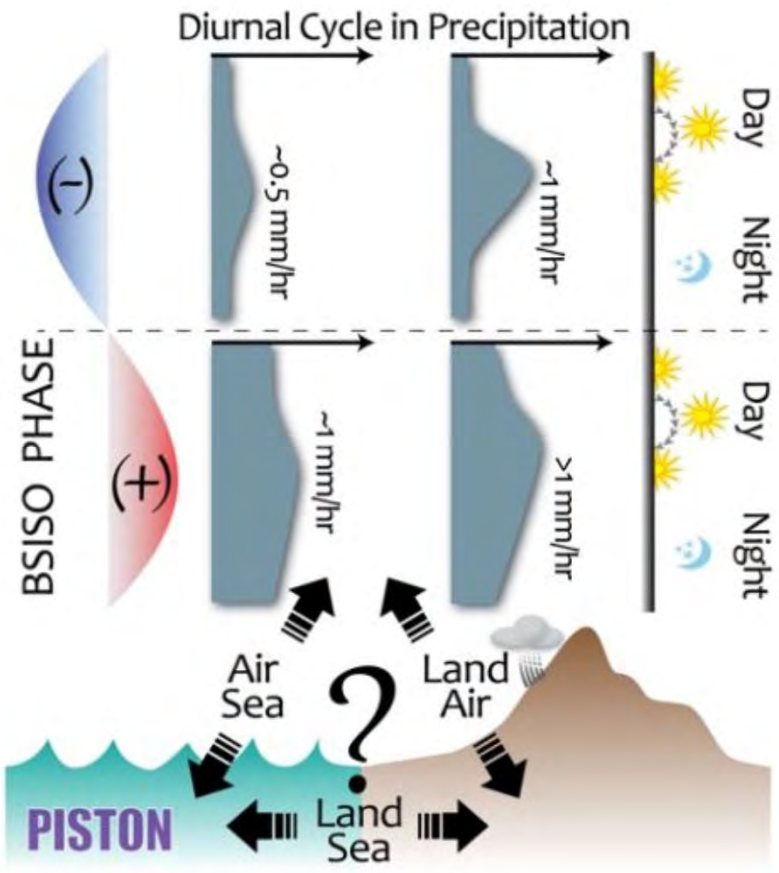
Cruise schedule

- **Sep 2-13, Taiwan to Manila**
- **Sep 15-27 Manila to Taiwan**
- **October 1-14 Taiwan to Palau (mooring recovery)**

Propagation of Intra-seasonal Tropical Oscillation (PISTON 2019)

Hypotheses

- Large scale atmospheric circulation variability over the South China Sea related to the monsoon, intraseasonal oscillations, and convectively coupled waves modifies the local diurnal cycle and air sea interaction in the coastal regions
- Small scale convective processes (e.g., interaction with complex terrain and coastlines, cloud microphysical processes, and the details of convective cold pools) influence the propagation of larger convective systems across the region.
- 3-dimensional oceanic processes are important to BSISO propagation in the SCS.
- Local and mesoscale processes related to the presence of land and topography, atmosphere-ocean interactions, and atmosphere-land and river-ocean interactions influence the development and propagation of the BSISO.



Thanks!

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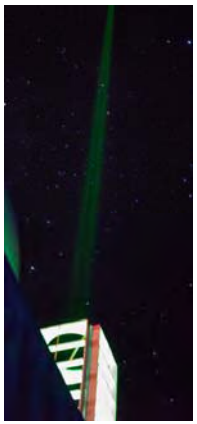
  - NOAA ESRL sensible and latent heat fluxes, W-band radar, solar and IR
  - University of Notre Dame Lidar
  - HSRL Lidar, U. of Wisconsin
    - 532 and 1064 nm **(tentative)**

- Ocean
  - Upper ocean turbulence, Chameleon and Surf Otter, Oregon State U.
  - CTD profiles to 400 m, Scripps
  - Two instrumented moorings, Scripps; deployed on Palau Ridge, 12N and 16N, 135E. Moorings will be recovered in Fall 2019.
  - ADCP, SST, salinity, etc provided by ship



Northward Propagation Dynamics (subset of hypotheses)

- Vertical vorticity generation in the presence of vertical shear (e.g. Jiang et al. 2004)
- Northward propagation caused by eastward propagation of tilted boreal summer MJO structure (e.g. Wang and Xie 1996)
- Beta drift (Boos and Kuang 2010)
- Vorticity advection by the mean meridional flow (Bellon and Sobel 2008)
- Horizontal moisture/MSE advection (e.g. Prasanna and Annamalai 2012; Sooraj and Seo 2013; Jiang et al. 2018)
- SST feedbacks (e.g. Krishnamurti et al. 1988; Sengupta et al. 2001; Bhat et al. 2004; Vecchi and Harrison 2002; Fu and Wang 2004; Klingaman et al. 2008; Sharmila et la. 2013; Li et al. 2018).

PISTON 2018 research topics (partial list)

Atmosphere

- What mechanisms suppressed rainfall at times despite high values of precipitable water (60-70 mm)
- Interactions between easterly waves and convection
- Air-sea interaction processes responsible for generation and maintenance of monsoon tails
- Convective dynamics and microphysics-low level echo centroids and warm rain processes

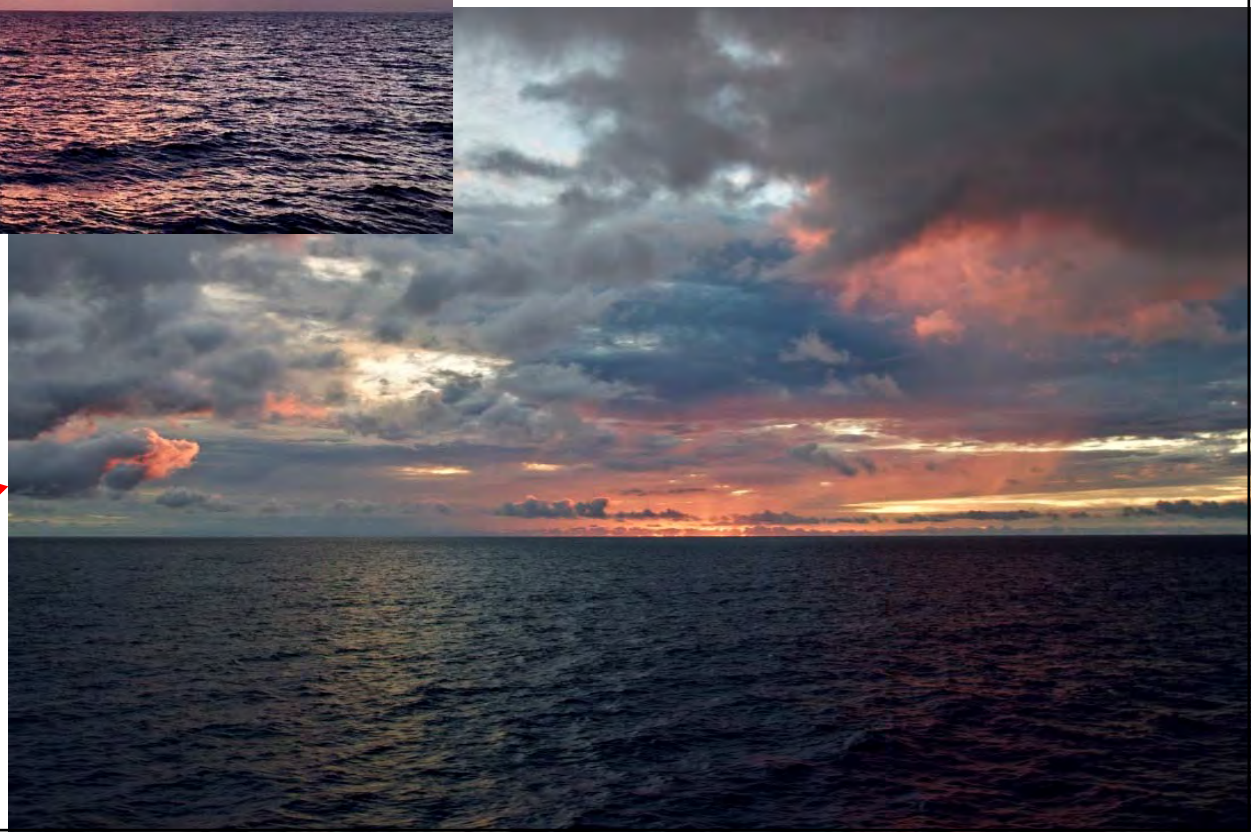
Ocean

- Influence of TC's and other convective systems on upper ocean mixing
- Analysis of one year of mooring data along Palau Ridge
- Modulation of air-sea fluxes by convective and mesoscale precipitation

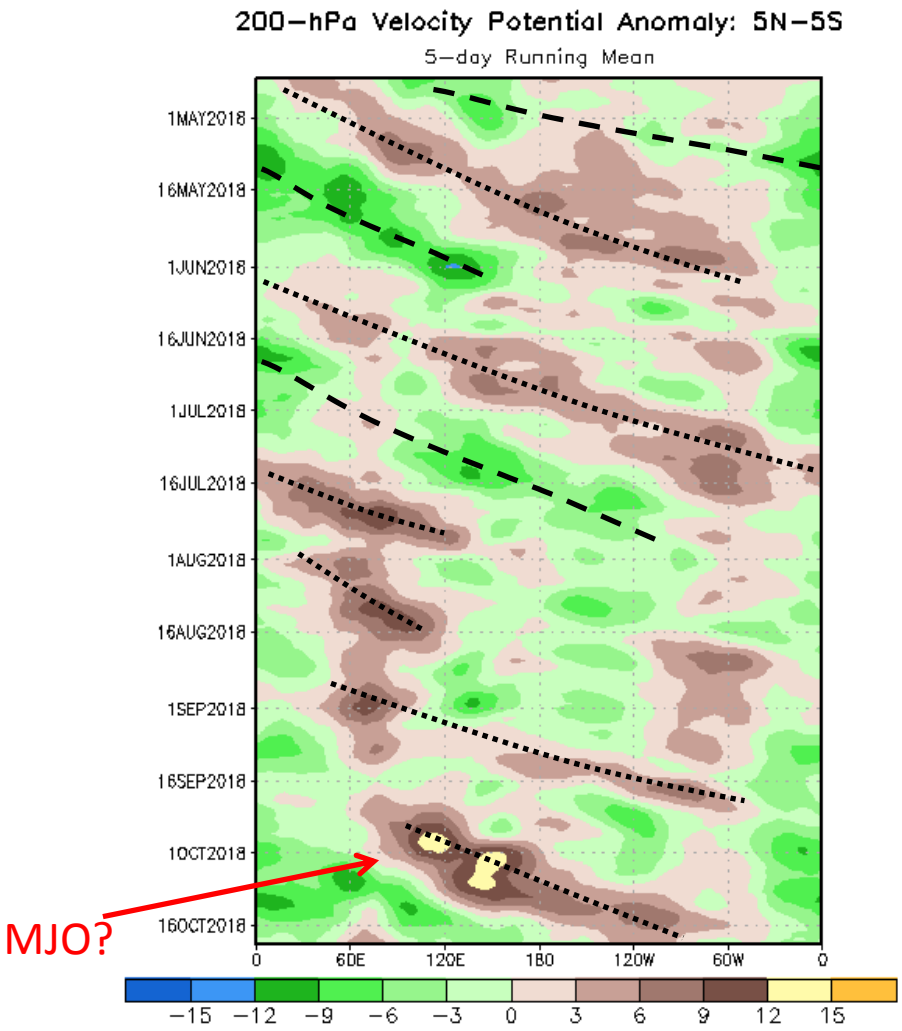
Cruise to the SCS in September 2019 to address more of the original PISTON goals and to contrast that experiment with results from the 2018 cruise

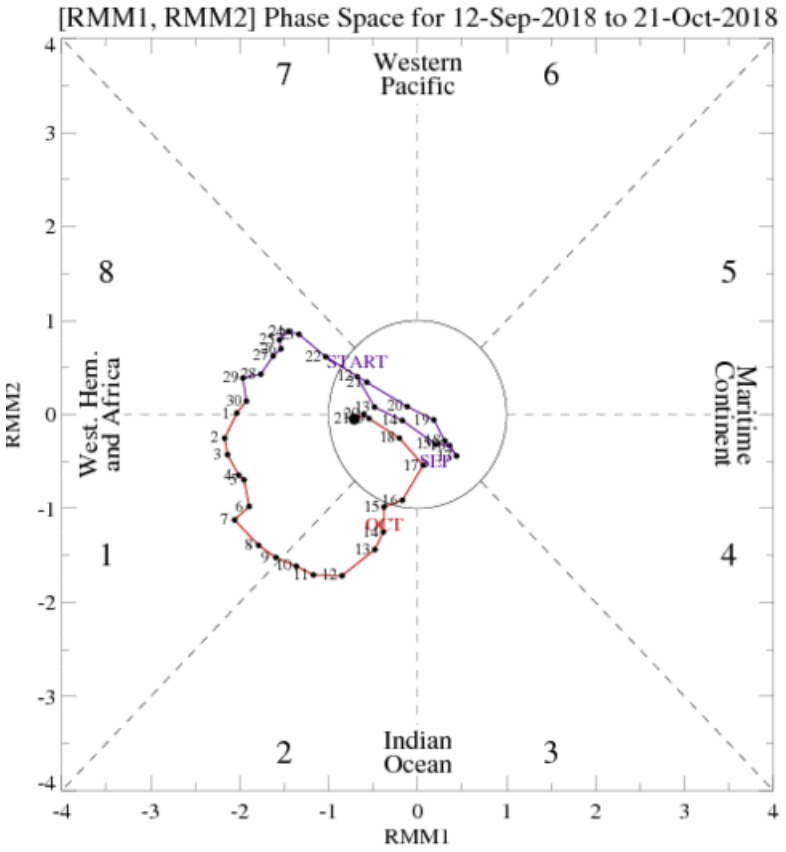
Haze Before
Rain Event

After Rain Event

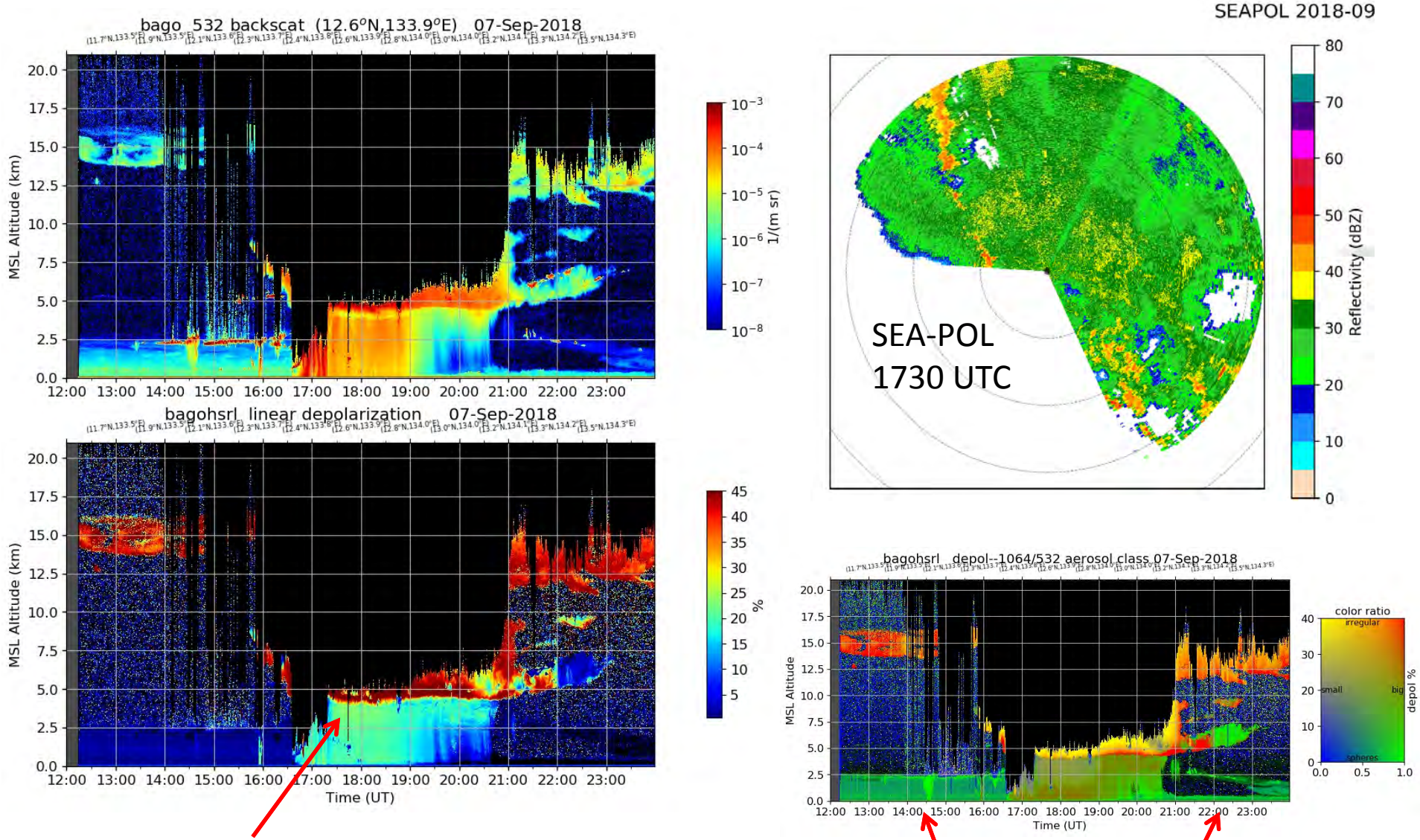


200 hPa Velocity Potential





Plots Courtesy of NOAA CPC



Melting region in stratiform rain with large depolarization due to wet ice particles; thin ice cloud aloft

Large sea salt aerosol ahead of precipitation, which are removed by wet scavenging

HSRL data courtesy: R. Holz and E. Eloranta, U. of Wisconsin

Moum

Chameleon

SurfOtter

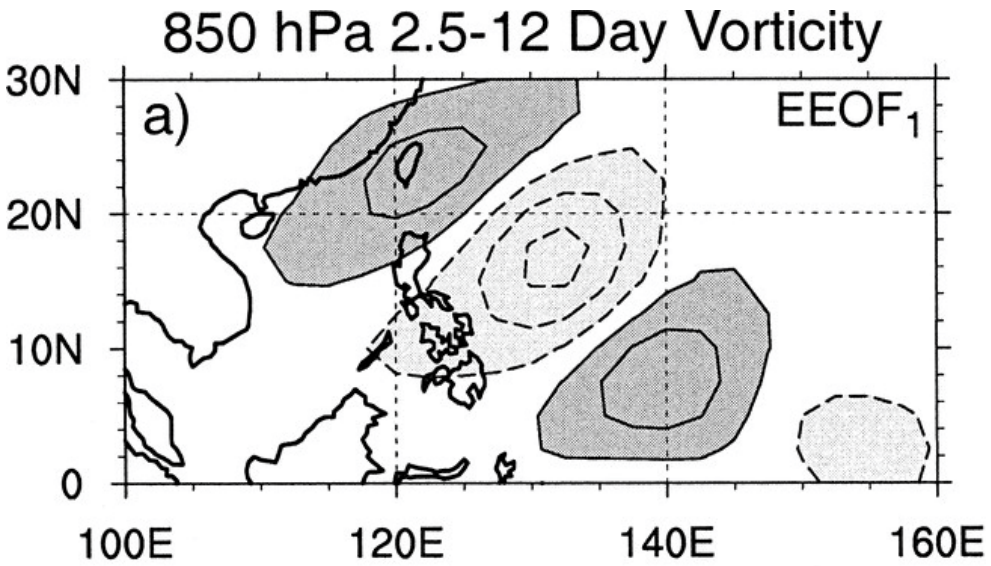
*Surf*ace-following, *Otter*-steered

downward-looking ADCP
T/C sensors at 5-10 cm spacing. 10 turbulence sensors over upper 8 m

HSRL lidar (upward looking)

SEA-POL radar and radome installed on forward 02 deck of the *Thomas Thompson*

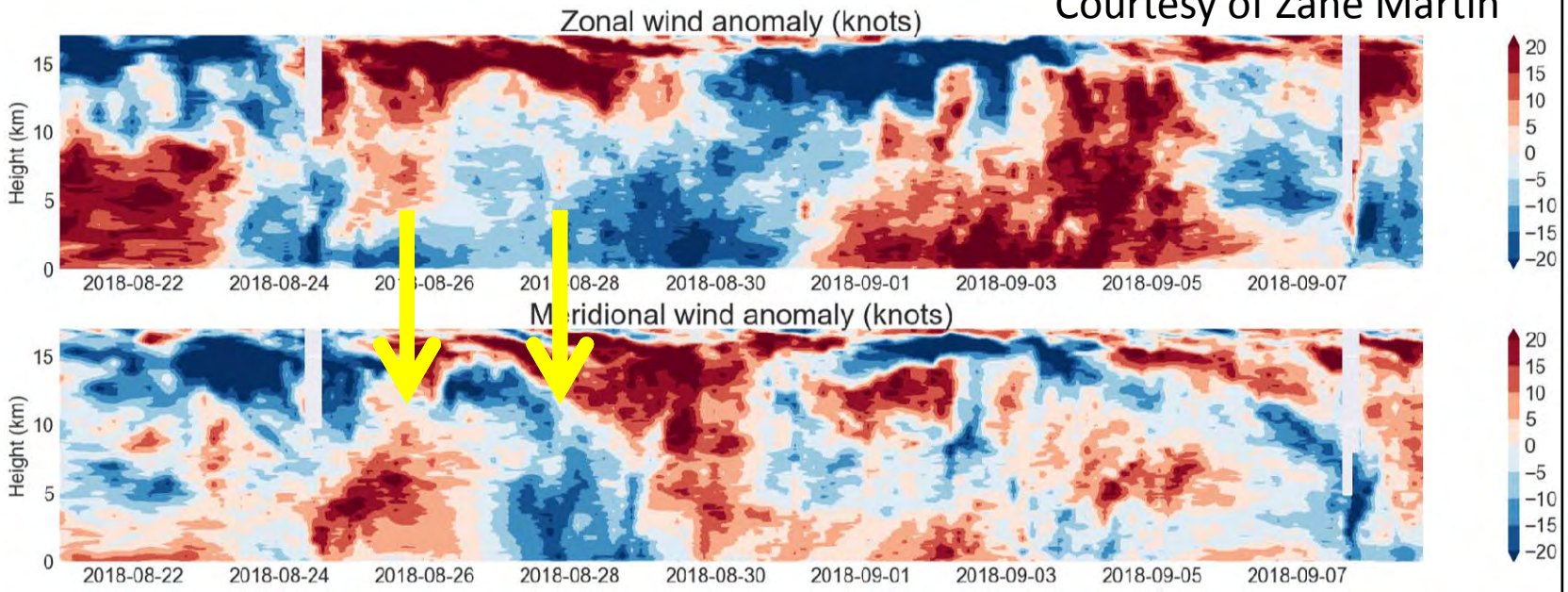
Tropical-Depression Type Disturbances



Maloney and Dickinson (2003)

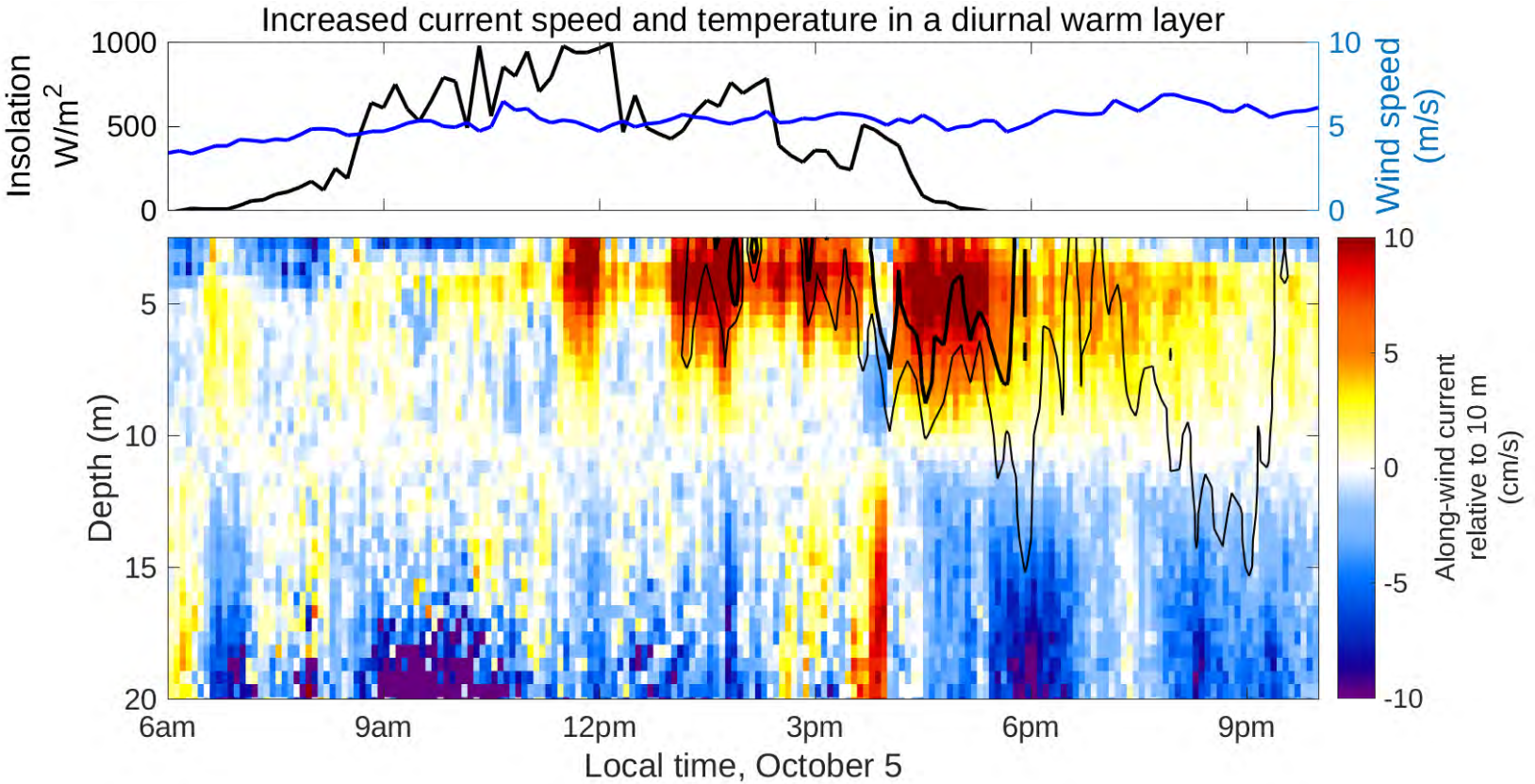
Easterly waves in yellow arrows.

Courtesy of Zane Martin



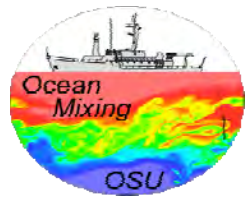
PISTON

diurnal warm layer physics



Ken Hughes (OSU) ⇠ ⎈ *2 leg Hero*

contours - temperatures that are 0.1 and 0.2°C
warmer than the temperature at 20m



September 28, 850 hPa Flow from NCEP reanalysis