Intraseasonal Variability of the Philippines Diurnal Cycle

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- We examine how the quasi-biweekly oscillation (QBWO) and BSISO impact the diurnal cycle in the Philippines during boreal summer
- Hypotheses on the diurnal cyclone modulation derived using observed datasets are tested using sensitivity tests with the Cloud Model 1 (CM1) for an idealized tropical island the same width as Luzon.

Observational Study Area

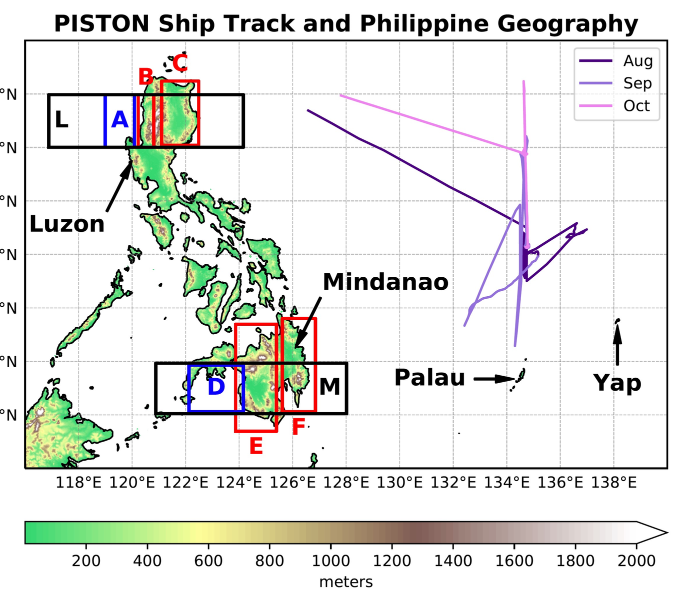


Figure 1: NOAA ETOPO2 Topography (in meters) over the Philippines, with boxes of spatial averaging and important geographic features noted. The track of the R/V Thomas G. Thompson during the August-October 2018 PISTON field campaign is also shown in purple, with August in the darkest color and October in the lightest.

The 2018 PISTON campaign had prominent 10-20 day variability that was noted in soundings from the ship and nearby islands. This timescale is dominated by westward-propagating variability, that does not cleanly maps onto tropical cyclone activity (**Figures 2 and 3**).

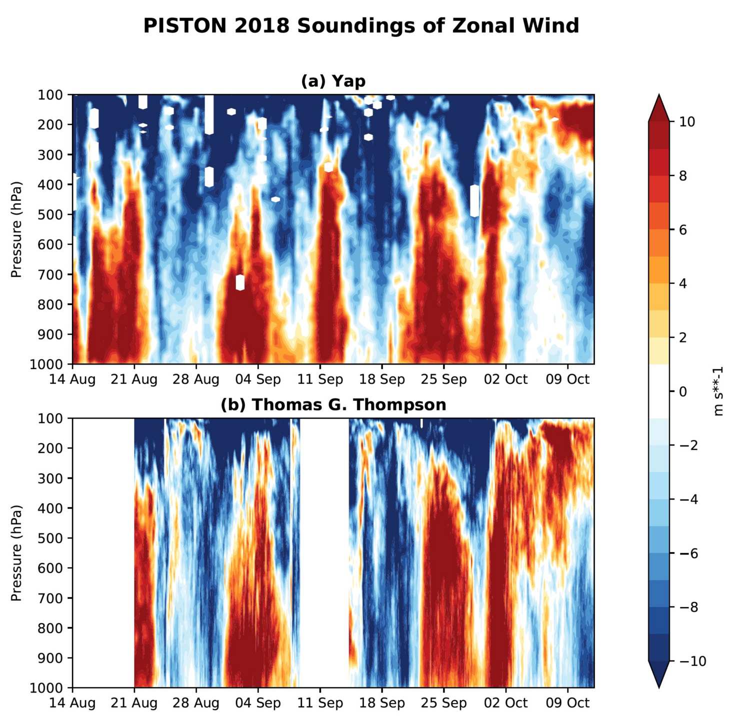


Figure 2: Time-height diagram of zonal wind from each sounding taken as part of the PISTON field campaign between 14 August 2018 and 13 October 2018. Soundings were taken every 12 hours from the island of Yap (top) and every 3 hours from the R/V Thomas G. Thompson during operational periods (bottom).

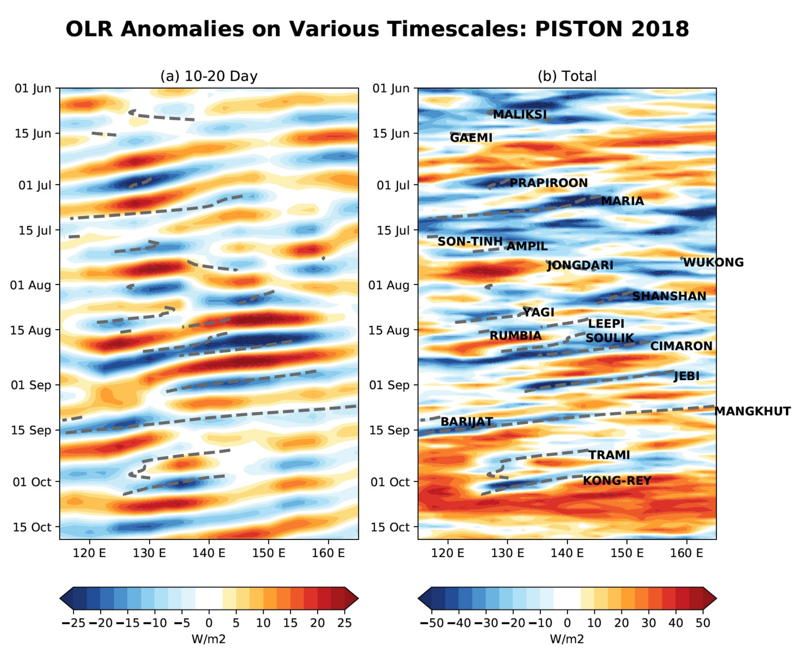


Figure 3: Hovmöller plot of AVHRR OLR averaged between 0 and 25N at each longitude during 1 June-20 October 2018, bandpass filtered to the 10-20 day timescale using a Lanczos filter with 93 weights in W m^{2} (left), and OLR anomalies from the seasonal cycle defined by the average daily climatology smoothed with a 7-day running mean (right). Named tropical cyclone tracks from IBTrACS are superimposed with gray dotted lines when the storm center was inside 0-25N.

Composite QBWO Events over 1998-2020

The leading extended EOF of 10-20 day OLR is now used to create composite QBWO events for the period 1998-2020

The QBWO produces alternating periods of west and east wind anomalies in the Philippines, along with convection and moisture anomalies.

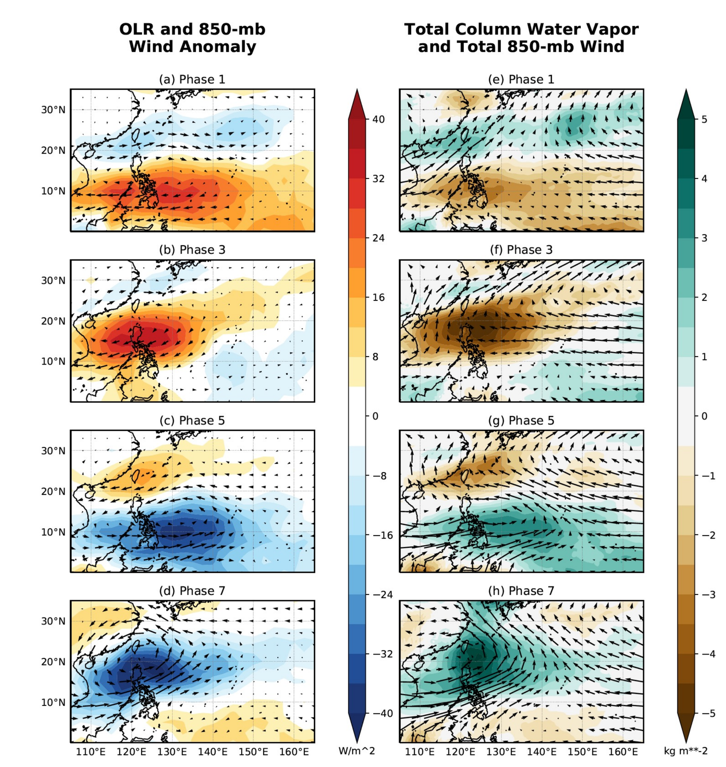


Figure 4: Composite maps by select QBWO phase over the West Pacific ocean of anomalies of OLR (W m^{-2}) and vector anomalies of 850-mb wind from ERA5 (left column), and anomalies of ERA5 total column water vapor (kg m^{-2}) with total 850-mb vector wind (right column).

Diurnal Cycle vs. Intraseasonal Phase

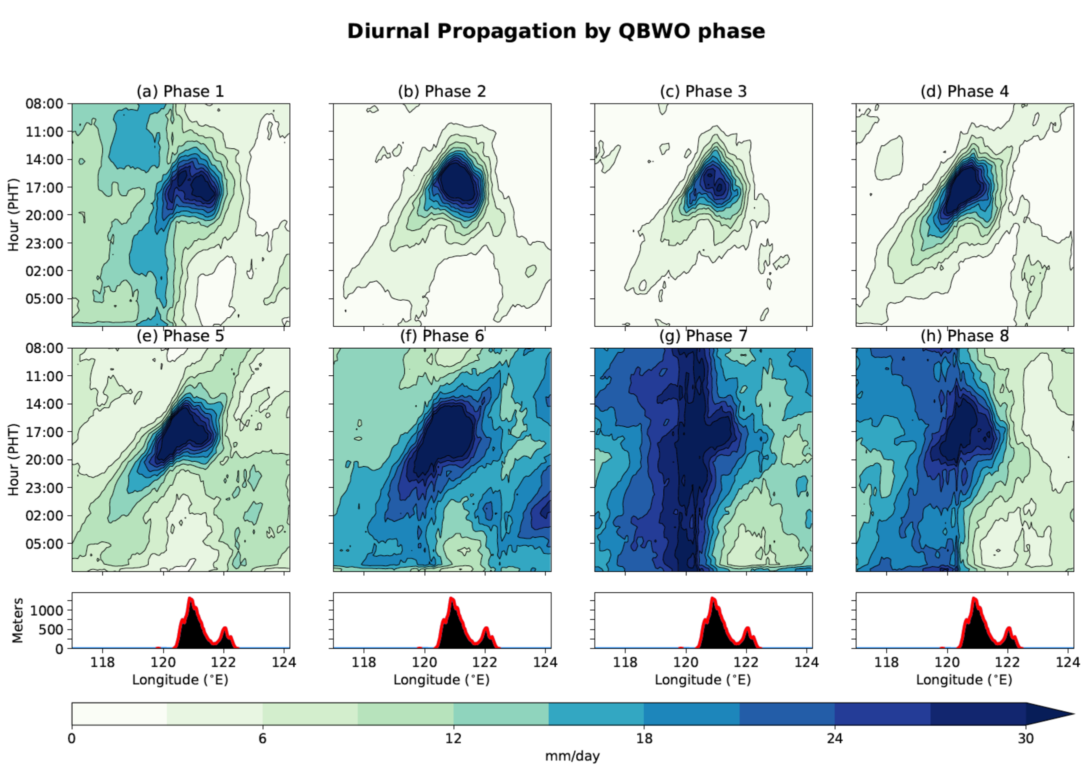
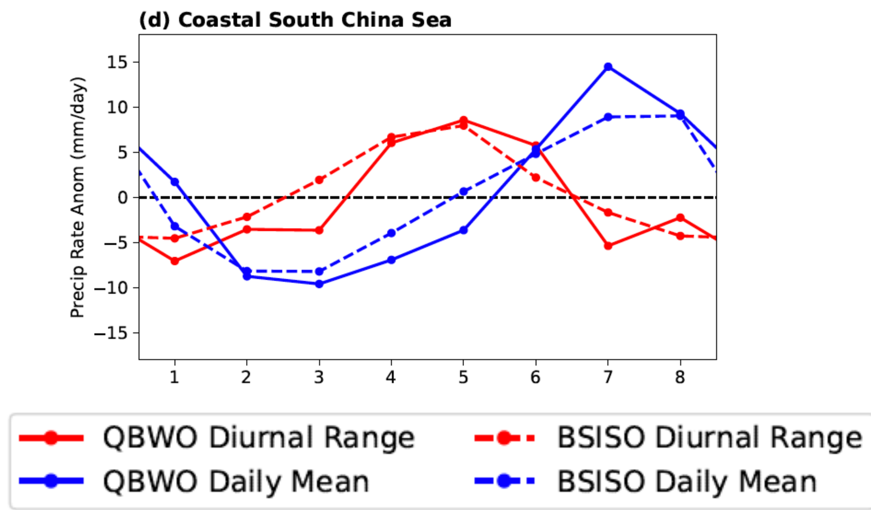
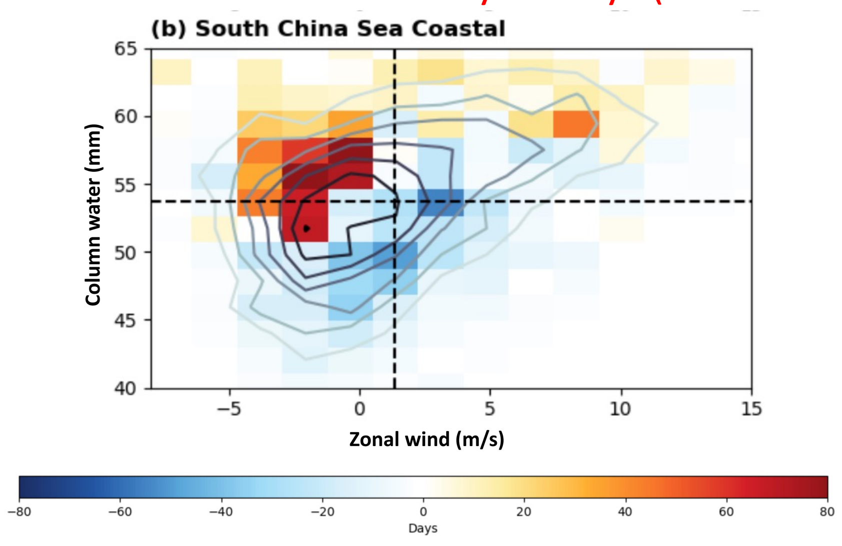


Figure 5: Hovmöller diagrams of the composite diurnal cycle of CMORPH precipitation rate (mm/day) for select phases of the QBWO index calculated by projecting unfiltered OLR anomalies onto the EEOF spatial patterns shown in Fig. 3 (top), and the index calculated by projecting 10-20 day bandpass filtered OLR anomalies onto the same EEOF patterns (bottom). Precipitation rates are averaged across latitude in box L (Fig. 1), with corresponding longitude noted below.

The diurnal cycle in the offshore SCS peaks during QBWO and BSISO phases 4-5, when total low-level winds are lightly offshore, and moisture is increasing.



85th Percentile Diurnal Cycle Days (Anomalies)

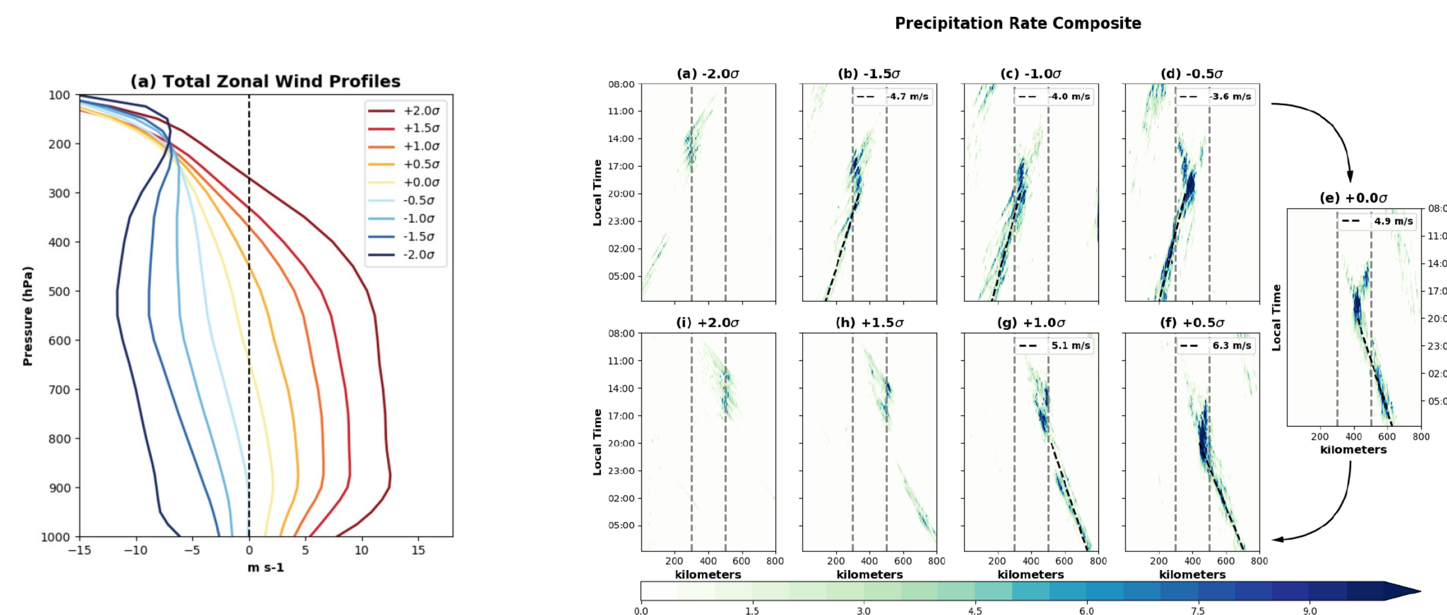


In general, SCS Coastal regions show stronger diurnal cycles when level winds are weak easterly and moisture is near average, or slightly moist.

Figure 7. Contours show the total distribution of days, and shading are anomalies for 85th percentile high amplitude diurnal cycle days

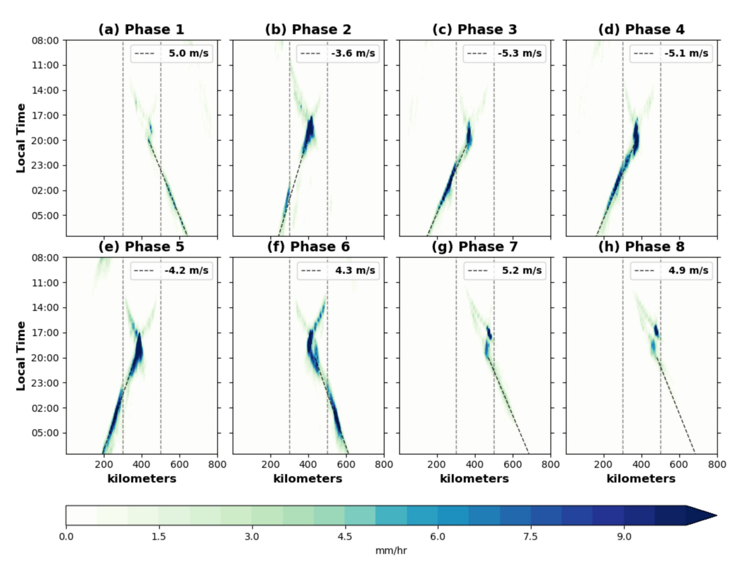
CM1 Experiments

- 2-d and quasi-3d CM1 simulations (1 km grid spacing) with a 200 km-wide flat island are integrated with different domain and daily mean background wind and moisture conditions imposed by nudging, determined by the leading mode of wind profile variability in this region.

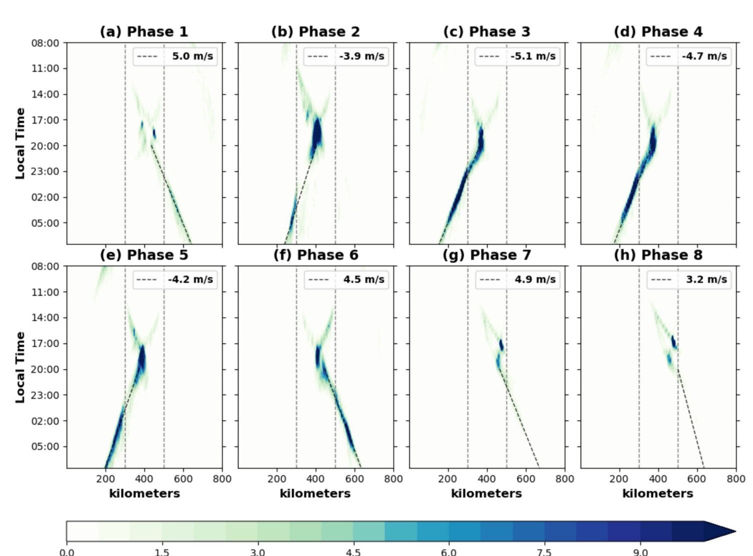


- **CM1 offshore propagation is maximized during times of weak offshore winds (and modest total wind speeds), potentially explaining some of the observed behavior in the diurnal cycle.**
- **Sensitivity tests indicate the wind direction at 700-800 hPa is key to the direction of propagation, although BL wind speed determines diurnal cycle strength.**

Control BSISO Simulations



Nudging only BSISO Wind



Quasi-3d BSISO simulations where all variables are nudged, and then only wind, shows that the wind speed and direction controls most of the response.

Conclusions

- The diurnal cycle of rainfall and offshore propagation of rainfall into the South China Sea are maximized during phases of the QBWO and BSISO with increasing tropospheric moisture, sufficient insolation, and weak offshore easterly flow.
- By prescribing daily mean BSISO background wind variations through nudging in CM1, it is shown that the wind direction and speed are major regulators of offshore propagation of diurnal disturbances.
- Moisture and insolation variations also contribute to the strength of the diurnal cycle and offshore propagation, although these results are being explored more in future investigations

For more details see: *Natoli, M. B., and E. D. Maloney, 2021: Quasi-biweekly extensions of the monsoon winds and the Philippines diurnal cycle. Mon. Wea. Rev., **149**, 3939–3960, and upcoming papers. Contact Eric.Maloney@colostate.edu for more details.*

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