SURFACE COOLING DUE TO PRECIPITATION OVER THE TROPICAL OCEAN

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1. INTRODUCTION

Precipitation is an important component of the global hydrological cycle. It affects the upper ocean salinity by adding freshwater to the ocean. In addition, precipitation plays a role in cooling the ocean surface since the temperature of the raindrops is lower than the temperature of the surface. However, this cooling term due to precipitation (Q_P) is not included in most models.

Q_P can be as high as 200 W m^{-2} affecting significantly the skin temperature of the ocean (Gosnell et al. 1995). As the skin temperature provides boundary conditions to the atmosphere above it, this is critical to processes within the planetary boundary layer (PBL, Chen and Dudhia 2001).

We will focus on three aspects regarding Q_P: First, we will provide a documentation of the spatio-temporal variability of Q_P over the tropical oceans using a variety of observational datasets. Second, we will discuss the implementation of this process into a simplified 3D ocean model coupled to the WRF model to understand its role on the upper ocean dynamics and thermodynamics. Third, we will explore the role of it on the amplitude and propagation of an MJO event.

2. DATA AND METHODOLOGY

2.1 *Data*

The precipitation data is from TRMM 3B-42, and the pressure is from the NCEP2 reanalysis. The surface latent and sensible heat fluxes, the specific humidity, temperature at 2m and the surface temperature (skin temperature) are provided by the OAFlux datasets.

We also utilize a TAO buoy (0°N, 165°E) data for December 2006 to compare different components of the surface fluxes with Q_P.

The initial and boundary condition for the simulations are from the ERA-Interim reanalysis. The sea surface temperature data (RTG_SST) is from NCEP/MMBA.

2.2 *Model*

Simulations with 2-way nested domains were conducted using the WRF 3.7 model. The outer (inner) domain has a grid spacing of 30 km (10 km). The Q_P and a fresh water input were added to a 3D simplified ocean model (PWP) coupled to the WRF model (Price et al 1994; Price et al 1986).

We conducted 2-day simulations with and without Q_P over a region that had large precipitation during that time with a maximum Q_P of 65 W m^{-2}. Longer simulations are being conducted to explore the role of Q_P on MJO and maritime continent.

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2.3 *Methods*

The Q_P is given by (Gosnell et al. 1995):

$$Q_P = C_W\, R\, (T_0 - T_r) \qquad (1)$$

Where C_W is the specific heat of water (4186 J kg^{-1} K^{-1}), R is the rain rate, T_0 is the bulk SST approximated by the skin temperature, and Tr is the temperature of raindrops when it reaches the surface. Tr is approximated by the wet bulb temperature following Stull (2011).

3. RESULTS

3.1 *Qp Climatology*

The monthly averaged Q_P was calculated from January 1998 to December 2013 in the tropics (30°S to 30°N). The lowest values of Q_P correspond to the driest months (March and April). The highest Q_P occurs during the rainiest months (October to December) that coincides with the ITCZ passage from the northern to the southern hemisphere. There's also a secondary peak of Q_P (May to July) that correspond to the Indian Monsoon and the ITCZ.

The maximum Q_P values are around the equator following the annual march of the ITCZ. The values of Q_P are very low, with higher values only going up to 2 W m^{-2} but, this average considers precipitating and non-precipitating days and is a monthly average. When we consider only precipitating days, some areas with values up to 4 W m-2 appear around 7°N still following the ITCZ movement. However, when we look at specific locations with large precipitation, Q_P values can get much large. One such example is shown in Fig. 1 over a buoy location (0°N, 165°E) for 11-19 December 2006. .

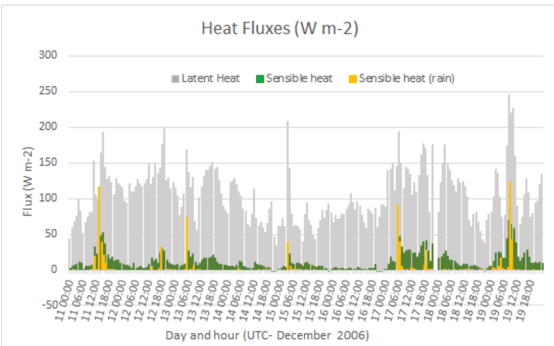

Fig 1. Latent heat flux Q_{LH} (gray), sensible heat flux Q_{SH} (green) and Q_P (yellow) in W m^{-2} for 11-19 December 2006 at 0°N;165°E

It shows that Q_P can exceed 100W m-2 and be up to 5 times the value of Q_{SH} and in certain occasions even exceed the value of Q_{LH}.

3.2 SIMULATED Q_P

Temporal and spatial resolution of observed/reanalysis data is not suitable to take a closer look to the Q_P effects. As a result, we introduce the Q_P term to the PWP model coupled to the WRF model. To test the functionality of the code that introduces Q_P effects over the ocean area, a study period was chosen from 1200 UTC 13 December 2012 to 1200 UTC 15 December 2012. It spans from 15°S to 9°N and from 147°E to 174°E.

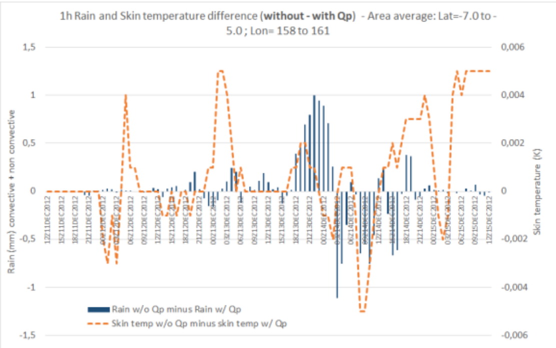

Fig 2. Area averaged difference between without and with Q_P. Rain in mm (blue bars) and skin temperature in Kelvin (orange line).

For this area, the skin temperature and rain appear to have gone down after the addition of effects from precipitation, but the rain duration appears longer (Fig. 2).

4. SUMMARY AND DISCUSSION

The Q_P calculated based on coarse resolution observation/reanalysis shows that climatological values of Q_P are small. However, on specific locations under certain circumstances, Q_P can have the same or larger magnitude compared to the surface sensible heat flux (depending on rain rate and to difference between SST and raindrop temperature) and even latent heat flux.

The Q_P was included for the first time in the WRF model when it was coupled to an ocean model. The simulation with Q_P has significant impact on the upper ocean dynamics and thermodynamics and also on the atmosphere. As Q_P lowers the surface temperature, it tends to reduce the atmospheric convection, but the heat that is transferred from surface to atmosphere would allow the precipitation to last for a longer period of time.

5. ACKNOWLEDGEMENTS

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