Philippine YMC Program

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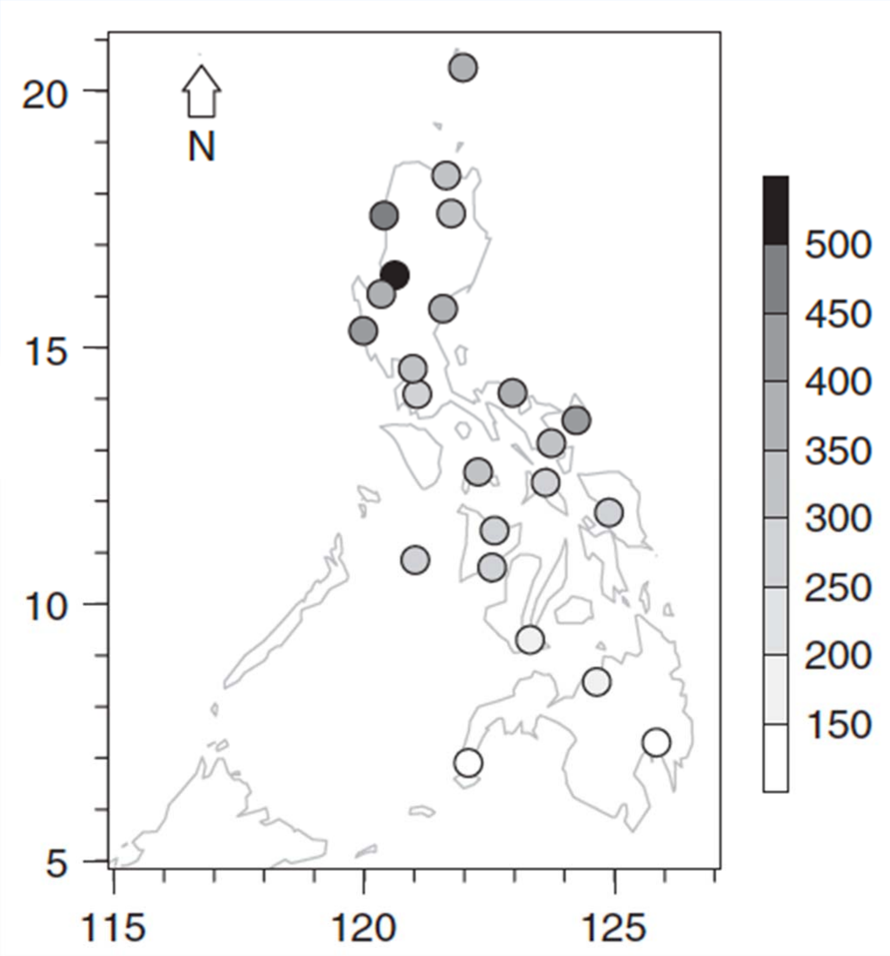
Motivation

Flooding and land/mud slides from extreme rainfall events among top natural disasters in the Philippines

Understanding precipitation variability in a multitude of scales and air-sea-land factors that influence its variability will help improve rainfall forecasting



The estimated 20-year return level of daily rainfall (RL20) for every station (units: mm). from Villafuerte et al., 2014

Research Questions

1. How important is the diurnal cycle in precipitation patterns in the Philippine archipelago?
   - land-sea thermal gradient
   - feedback of freshwater runoff from rivers to the coastal seas
   - regional differences – i.e. area with strong tidal interaction, strong advection? Big and flat vs. steep and small watersheds

1. What are the best weather model parameterization ([1]microphysics, [2]cumulus sub-grid scaling) for model precipitation to fit local observations? What is the value of including aerosol in atmospheric modeling: aerosol – cloud – radiation interaction
2. What is the horizontal and vertical extent (upper-troposphere lower stratosphere, UTLS) of aerosol transport due to typhoons? What is the effect of typhoon-induced aerosol transport on longer-term stratospheric and tropospheric climate
3. Can understanding the diurnal cycle and land-sea-air interaction in coastal areas improve forecasts of extreme rainfall events? How does the diurnal cycle influence seasonal and intraseasonal rainfall in the Philippines?

Sea-Air-Land Interaction in the Context of Archipelago (SALICA)

The tools

Observations

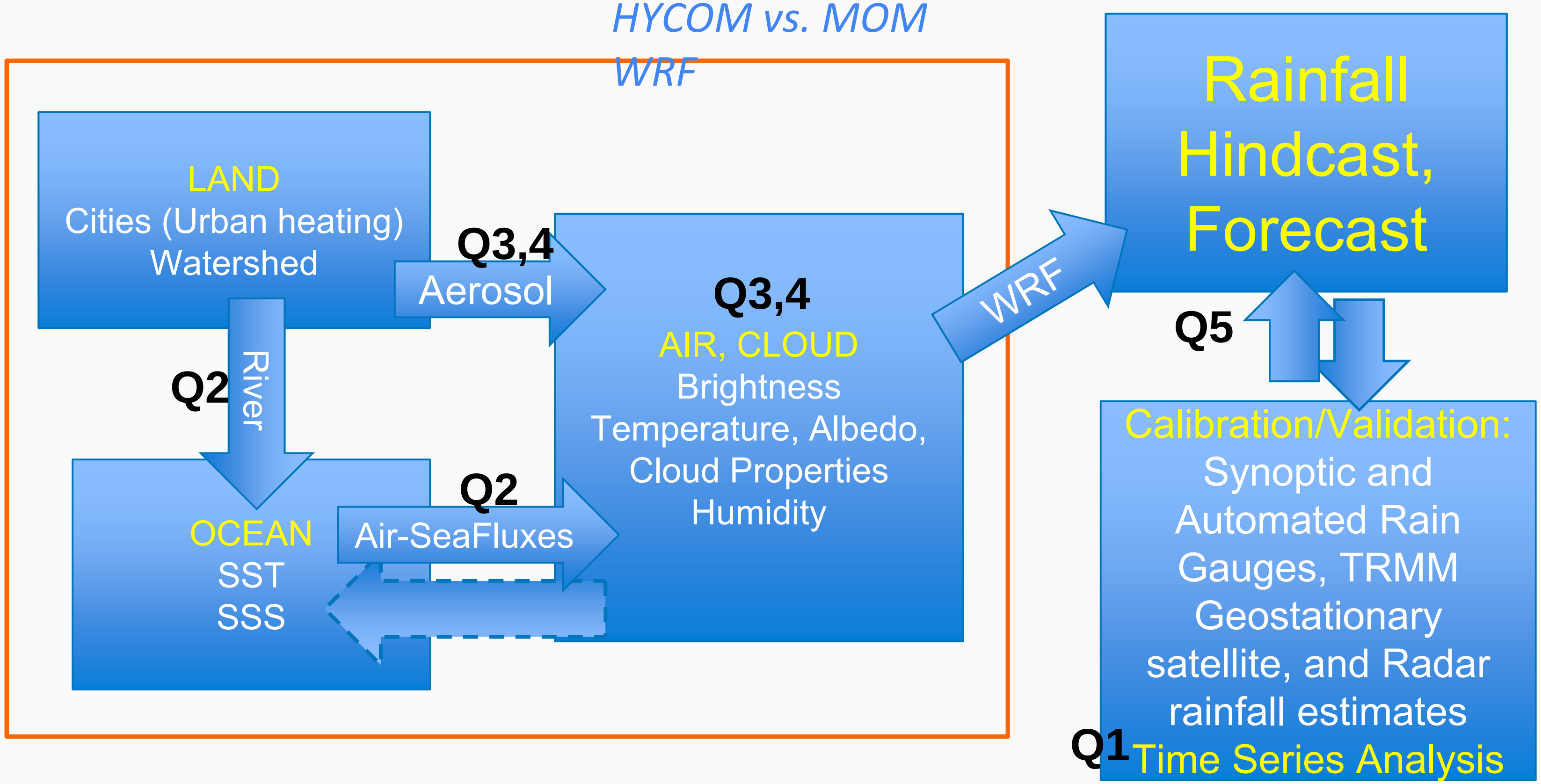
Site: NW Luzon, Macajalar

Models

SWAT

HYCOM vs. MOM

WRF



Component 1: Observing and Modeling the diurnal scale-variability in coastal waters

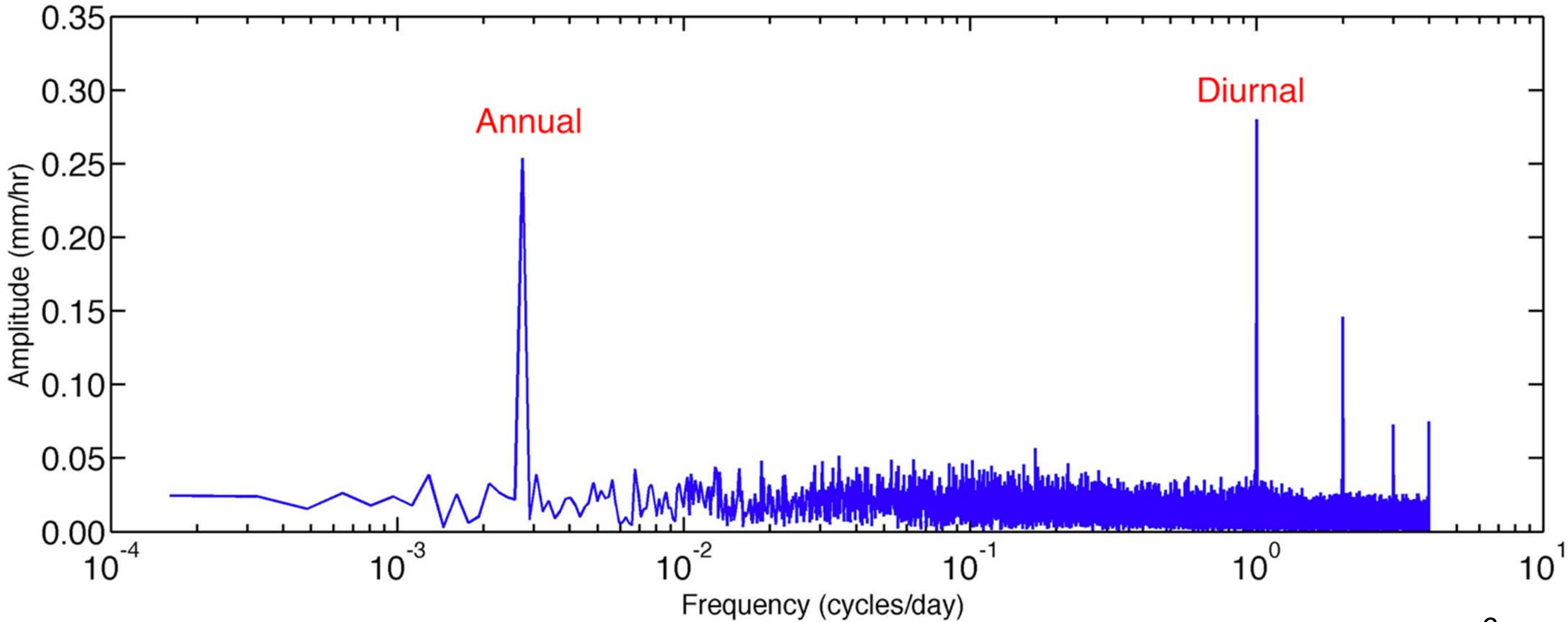
Objectives

There are strong indications that the diurnal cycle contributes significantly to the total rainfall over the Philippines.

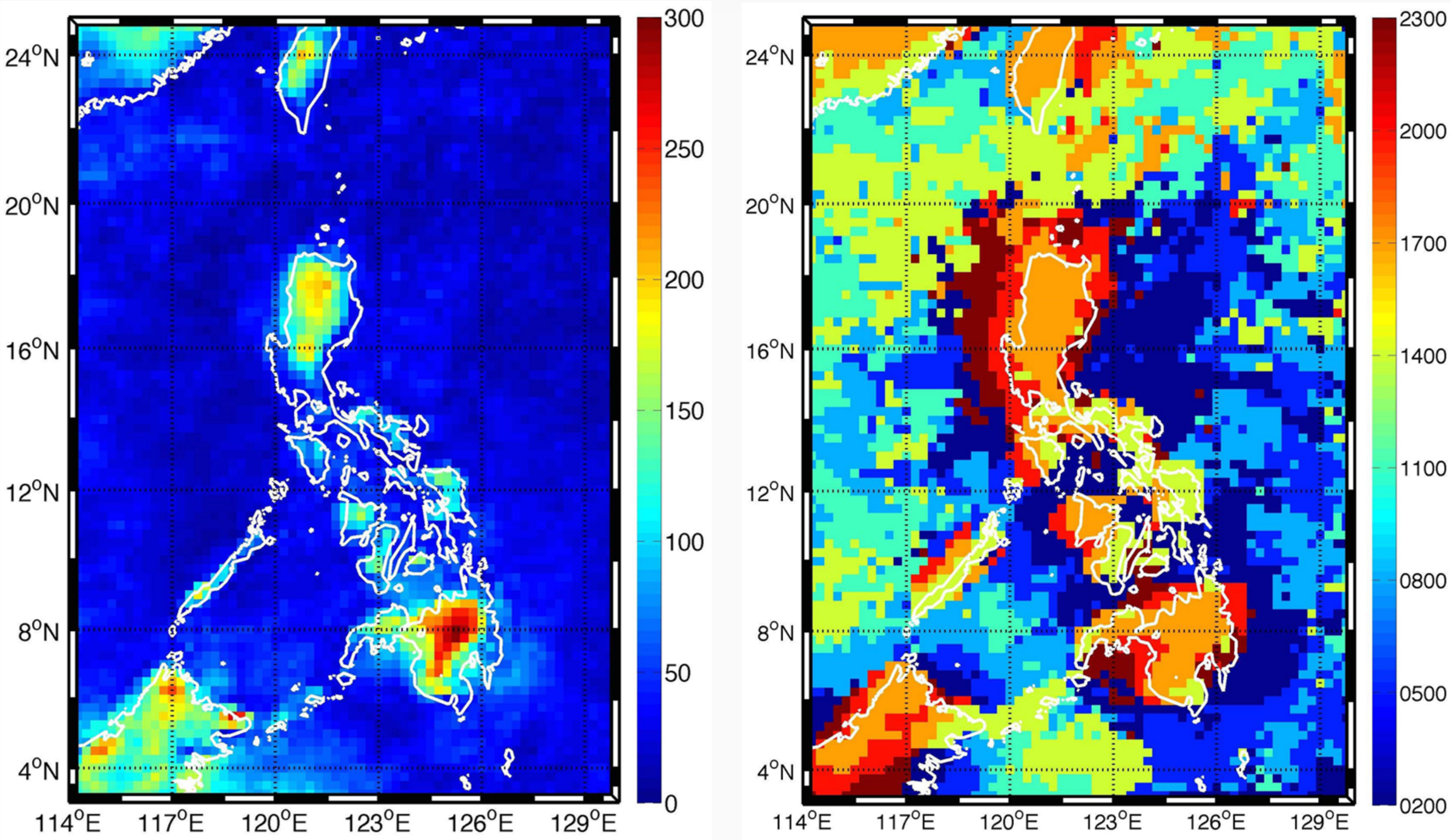
1. Characterize variability of diurnal cycle
2. Relate how the properties of the adjacent waters and watersheds change with the magnitude of the diurnal cycle
3. Test relationships using coupled air sea models.

Overall goal is to improve rainfall prediction

Rainfall amplitude spectrum in Central Luzon showing strong diurnal precipitation cycle relative to total precipitation



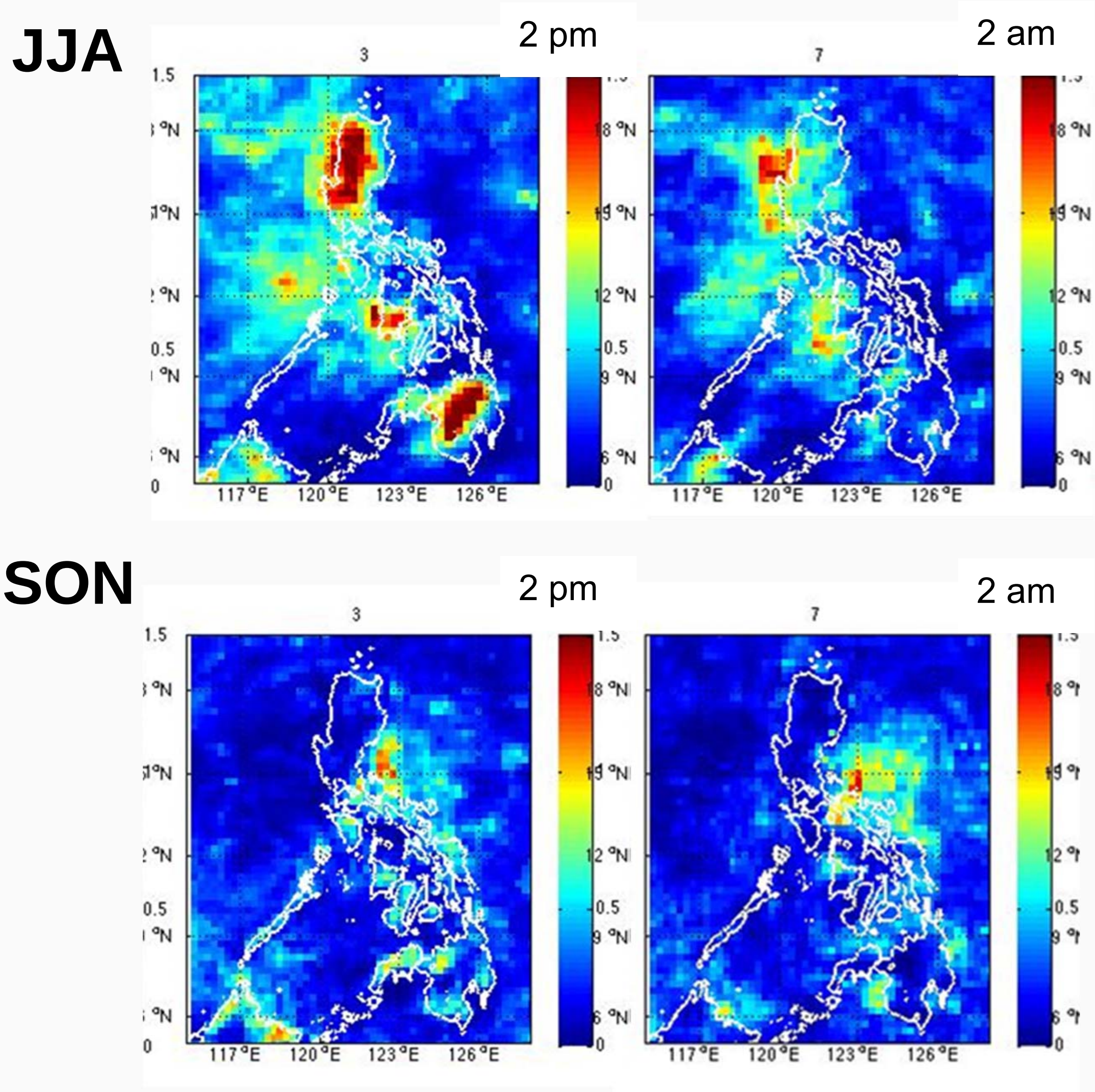
Magnitude and phase of the diurnal precipitation cycle



Magnitude of diurnal cycle (in % calculated from difference between max precipitation within the diurnal cycle and the 24-hour mean) and phase (expressed as time of the day when precipitation is highest)

Highest diurnal cycle magnitudes in Luzon and Mindanao

Diurnal cycle 2004



Hypothesis: different air-sea interaction west & east of Philippines

- NE Monsoon, east is wet, cold & w/ convective mixing
- SW Monsoon, west is wet, warm, w/ less convective mixing, strong barrier layer
- different land-sea temperature gradient results in stronger diurnal pattern west of Luzon during SW Monsoon

- Oceanic – moderate amplitude, early morning peak
- Continental – large amplitude, little landward phase propagation, afternoon peak
- Seaside coastal – large amplitude, offshore phase propagation, starts at the coast afternoon to midnight, peak in late evening to noon of next day
- landside coastal – intense amplitude, landward phase propagation, starts at coast morning to noon, peaks noon to evening. kikuchi and wang (2008)

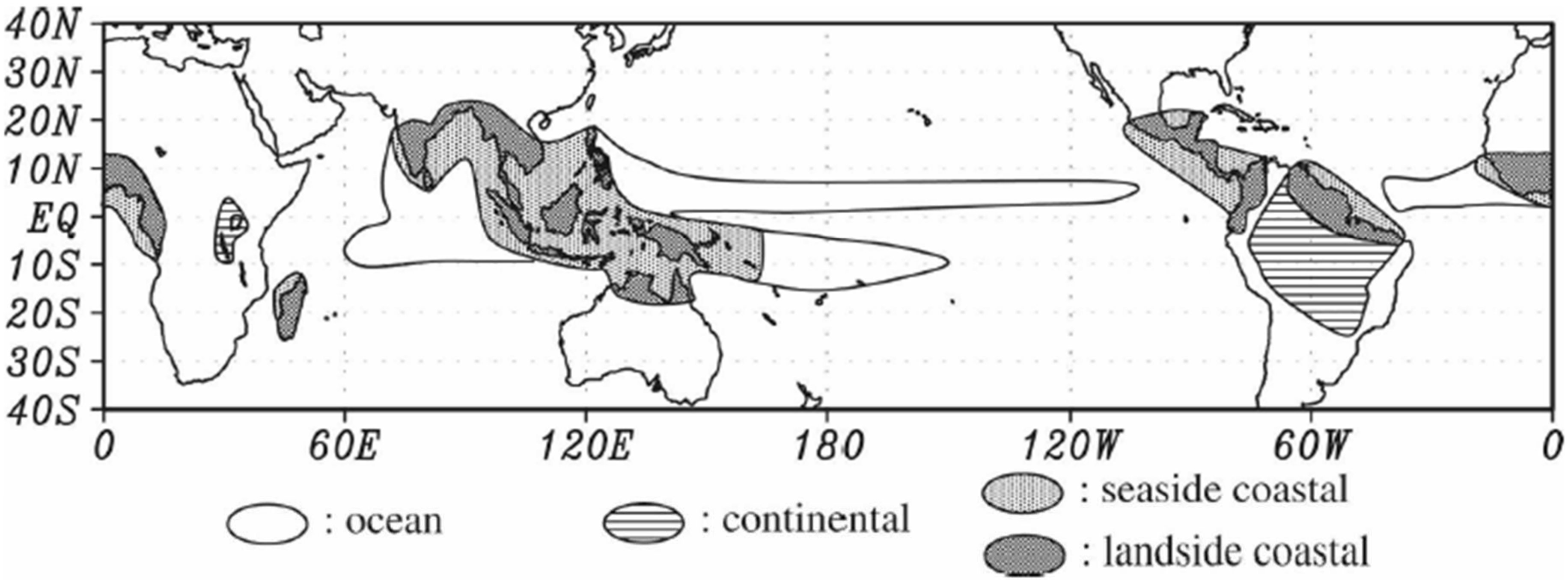
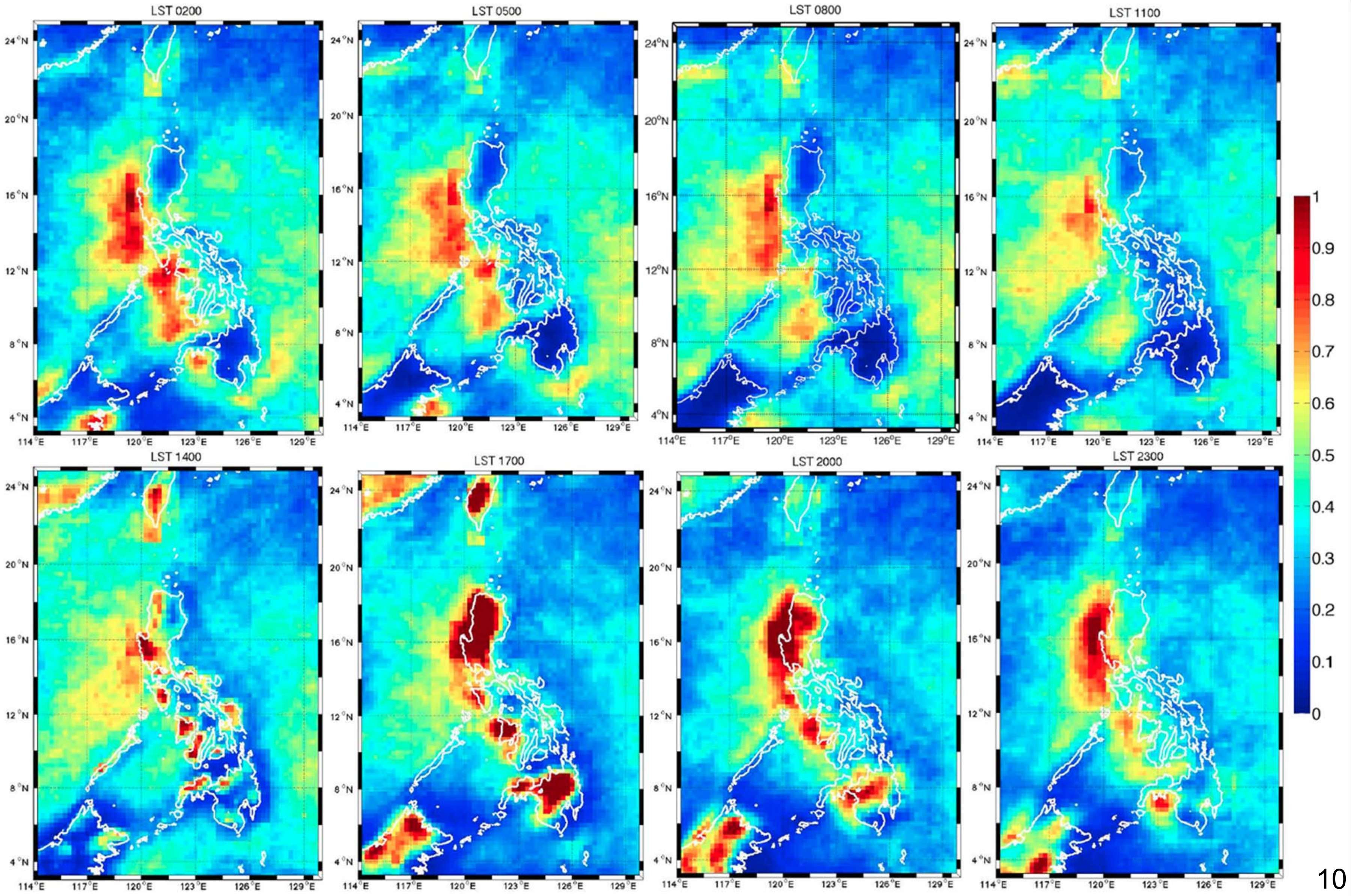
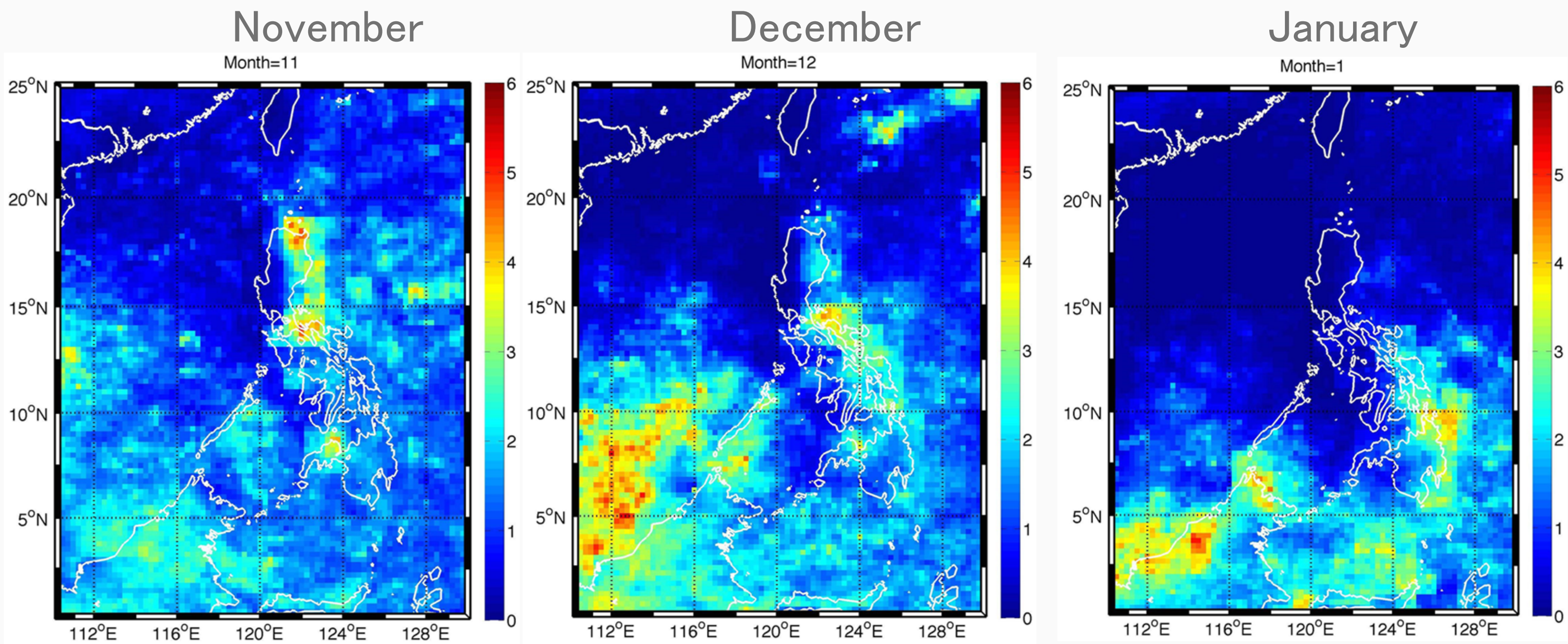


FIG. 10. Schematic diagram showing the global tropical diurnal precipitation regimes. Three regimes, namely oceanic, continental, and coastal regimes, are identified according to the amplitude, peak time, and phase propagation characteristics of the diurnal precipitation.

Climatological diurnal precipitation cycle during JJA from TRMM 3B42 from 1998-2014

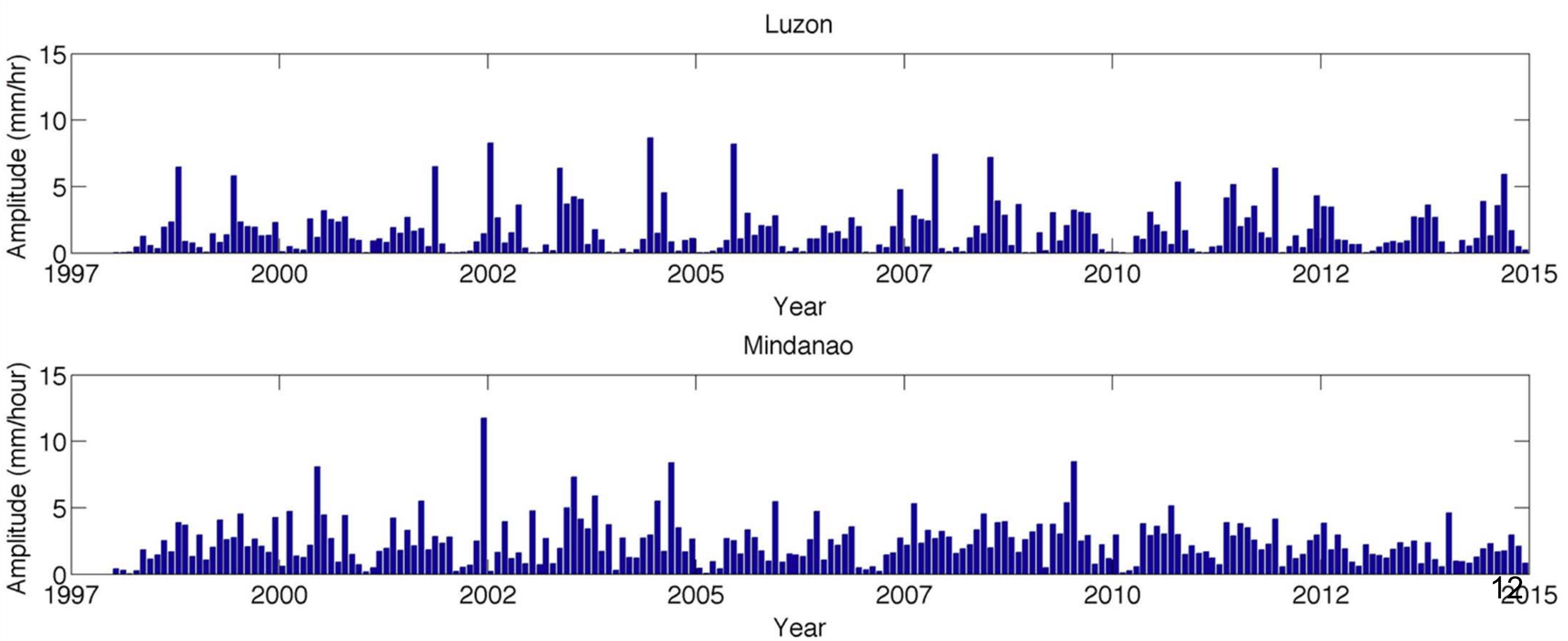


Amplitude of the diurnal precipitation cycle in the Eastern Philippines during the NE Monsoon



Temporal variation of the diurnal cycle amplitude in Luzon and Mindanao

Stronger seasonal variation of the diurnal cycle in Luzon



Methods

1. Sites
    a. Western Luzon and Northern Mindanao (SW Monsoon)
2. Observations
    a. Field observations – Cruises and simultaneous terrestrial measurements (near surface stratification, air–sea fluxes, met observations)
3. Remote sensing
    a. satellite SST, winds, precipitation
    b. Doppler radar (high temporal/spatial resolution precipitation)
4. Coupled atmosphere–ocean–land modeling

Component 2: In-situ parameterization of Aerosols

Remote sensing of aerosols (AOD) provides a larger spatial coverage and temporally resolved AOD measurements. However, there is a need to support the AOD algorithm with critical parameters, such as:

- Aerosol size distribution
- Particle shape
- Particle composition
- Optical characteristics

Hence, in-situ measurements of aerosol physical and chemical parameters are needed for more accurate weather

Proposed Measurement Systems

- Cyclone URG samplers
- Magee 7 λ Aethalometer, Nephelometer
- Aerosol Spectrometer Particle into Liquid Sampler – Ion Chromatograph

Component 3: Weather Model Parameterization

In the Philippines, rain is the most important weather parameter, yet it is 1 of the most difficult parameters to model

2 parts of model calculate precipitation.

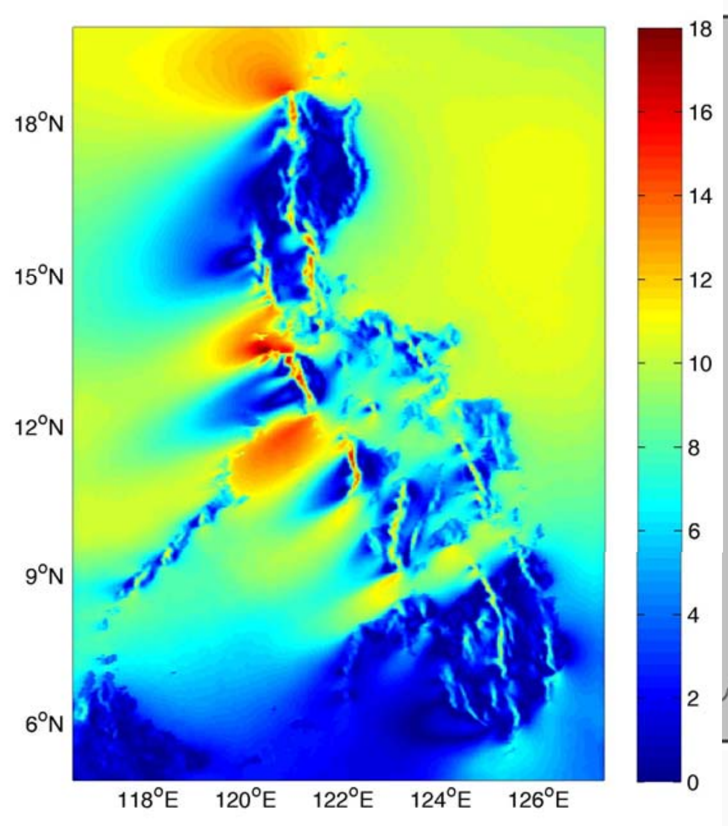
- The **Microphysics** includes explicitly resolved water vapor, cloud, and precipitation processes that computes grid-scale precipitation.
- **Cumulus** parameterization schemes are responsible for the sub-grid-scale effects of convective and/or shallow clouds. These are intended to represent vertical fluxes due to unresolved updrafts and downdrafts and compensating motion outside the clouds.

Sensitivity studies on which parameterization is best

Calibration of schemes to fit local observation

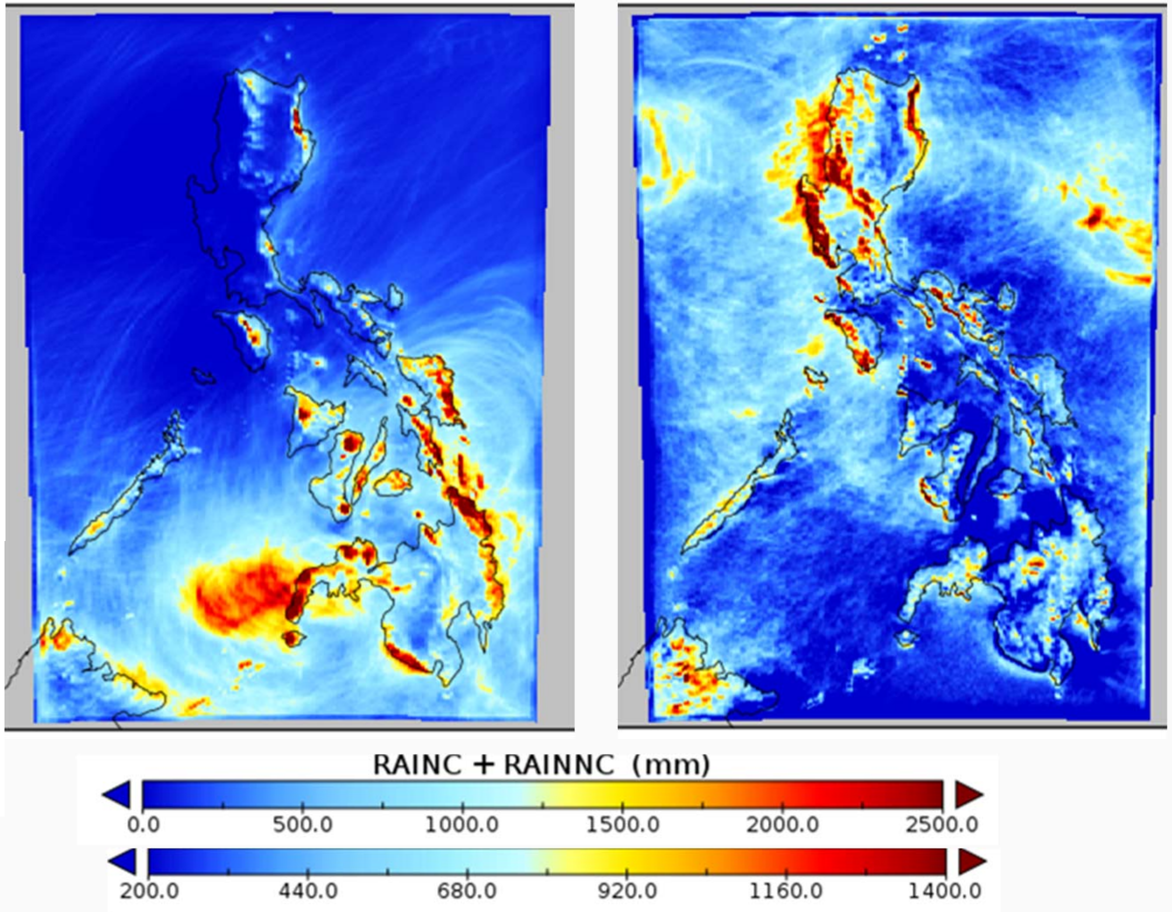
Sample WRF output (single moment microphysics with modified cumulus (Kain-Fritsch) parameterization, updated SST, driven by NCEP-FNL reanalysis

WIND (Jan 2014 mean)

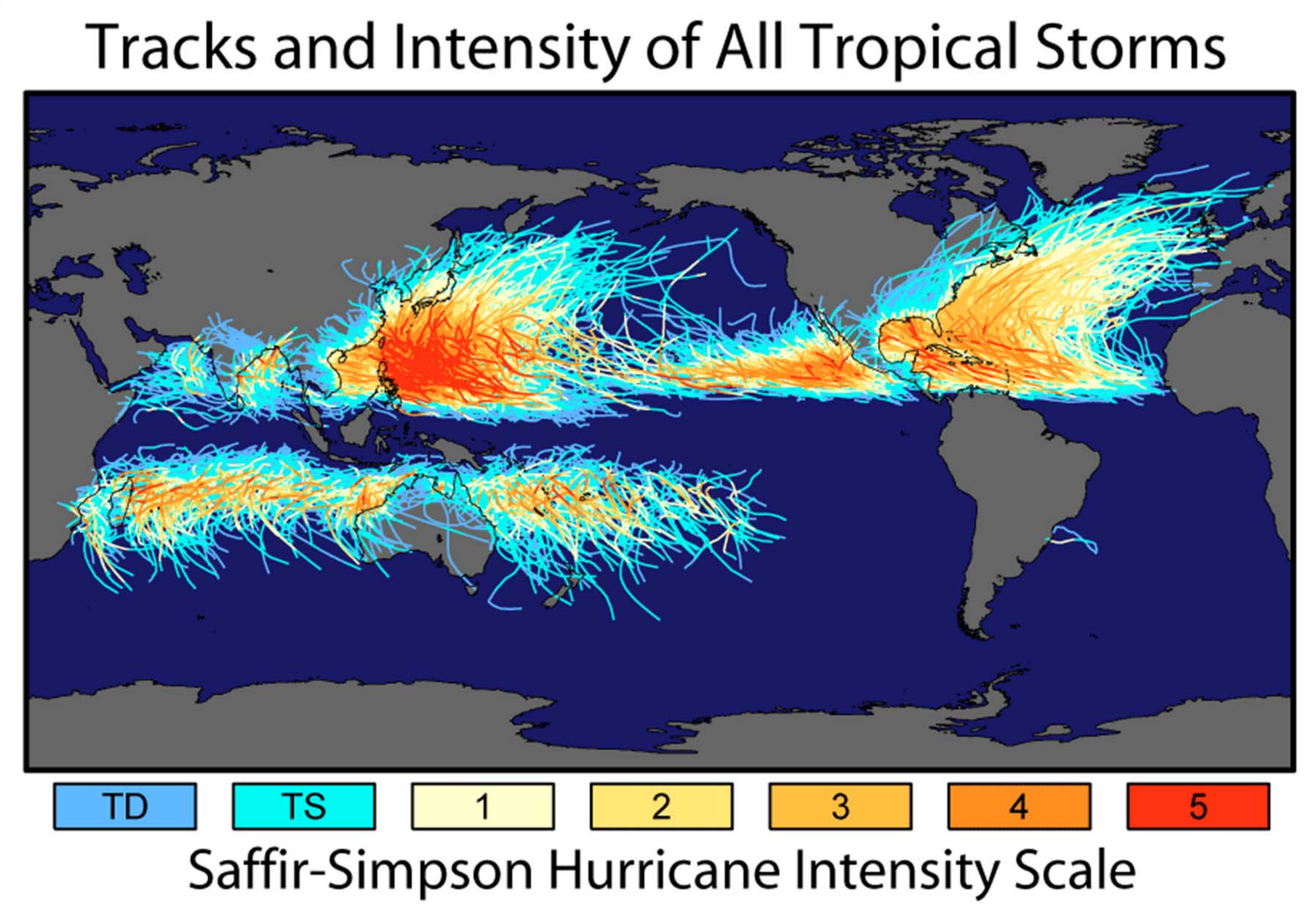


Accumulated Rain

(Jan 2014) Aug 2014



In the Maritime Continent, the Philippines is the most affected by Typhoons



Component 4: Extent of Typhoon-induced Transport of Aerosols

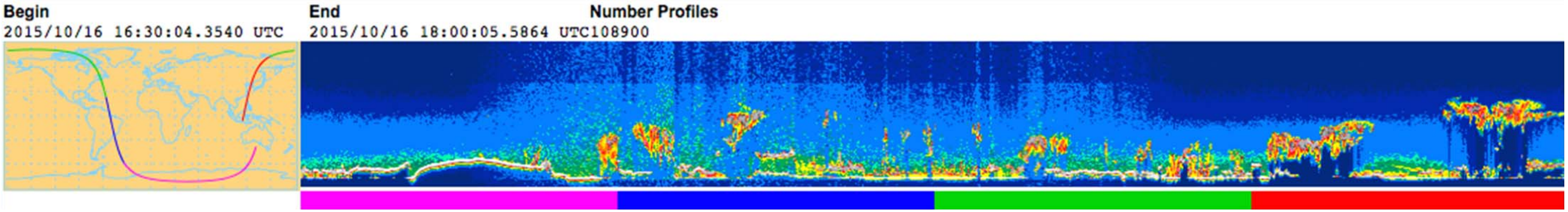
- To determine the horizontal and vertical extent (upper-troposphere lower stratosphere, UTLS) of aerosol transport due to tropical cyclones using a chemistry-coupled numerical weather prediction model
- To validate model simulations with current and new observations that would be setup by the project
- To determine the effects of tropical cyclone induced aerosol transport on longer-term stratospheric and tropospheric climate

Haze transport in October 2015 influenced by Typhoon Koppu affecting Mindanao and parts of Visayas

The recent Indonesian forest fires have garnered more attention this year due to the extent of the burning as a result of El Nino conditions. Together with aerosol emissions from mainland Asia, unhealthy levels of the air quality index have been reported in Thailand, Malaysia and as far as the Philippines during Typhoon Koppu’s passage.

Methods

1. Field Observations
    a. Continuous Profile Measurements (Rationale: To monitor aerosol transport and planetary boundary layer height determination) – Micropulse LIDAR
2. Remote Sensing
    a. Terra and Aqua / MODIS (Aerosol Optical Depth and Fire and Thermal Anomalies)
    b. Cloud-Aerosol LiDAR and Infrared Pathfinder Satellite Observations (CALIPSO)
3. Modeling
    a. Organic aerosol simulations (PM 2.5)
    b. Chemistry-coupled Weather Research and Forecasting model



Continuous Profile Measurements (Rationale: To monitor aerosol transport and planetary boundary layer height determination)

SigmaSpace Micropulse LiDAR

Specifications

Continuous

Can join the NASA Goddard (Dr. Comiso?) Micro-pulse LiDAR Network (MPLNet)

Applications:

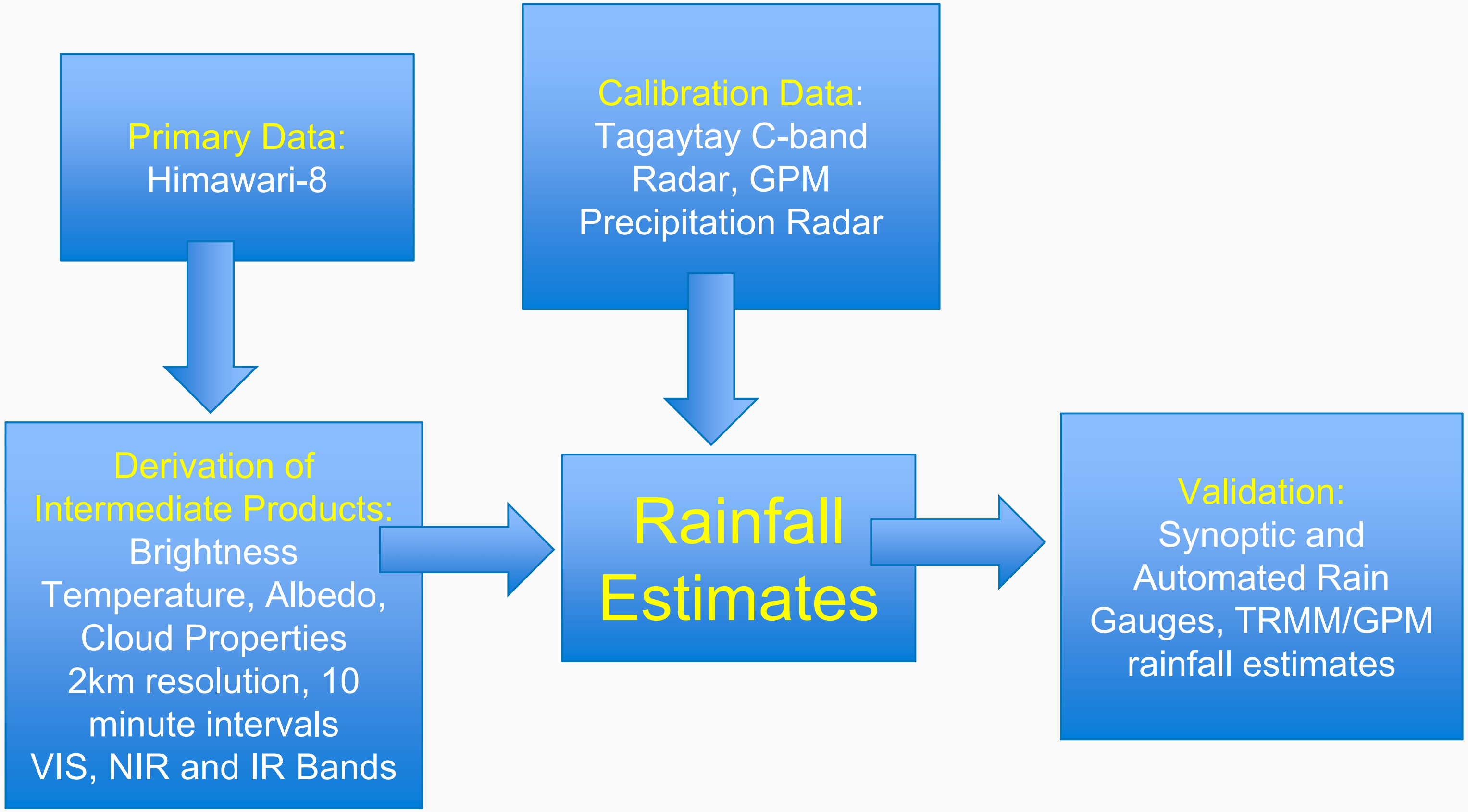
Clouds: determination of cloud height, extent and structure (liquid/ice)

Aerosols: determination of volcanic ash, dust, urban pollution

Planetary boundary layer height determination

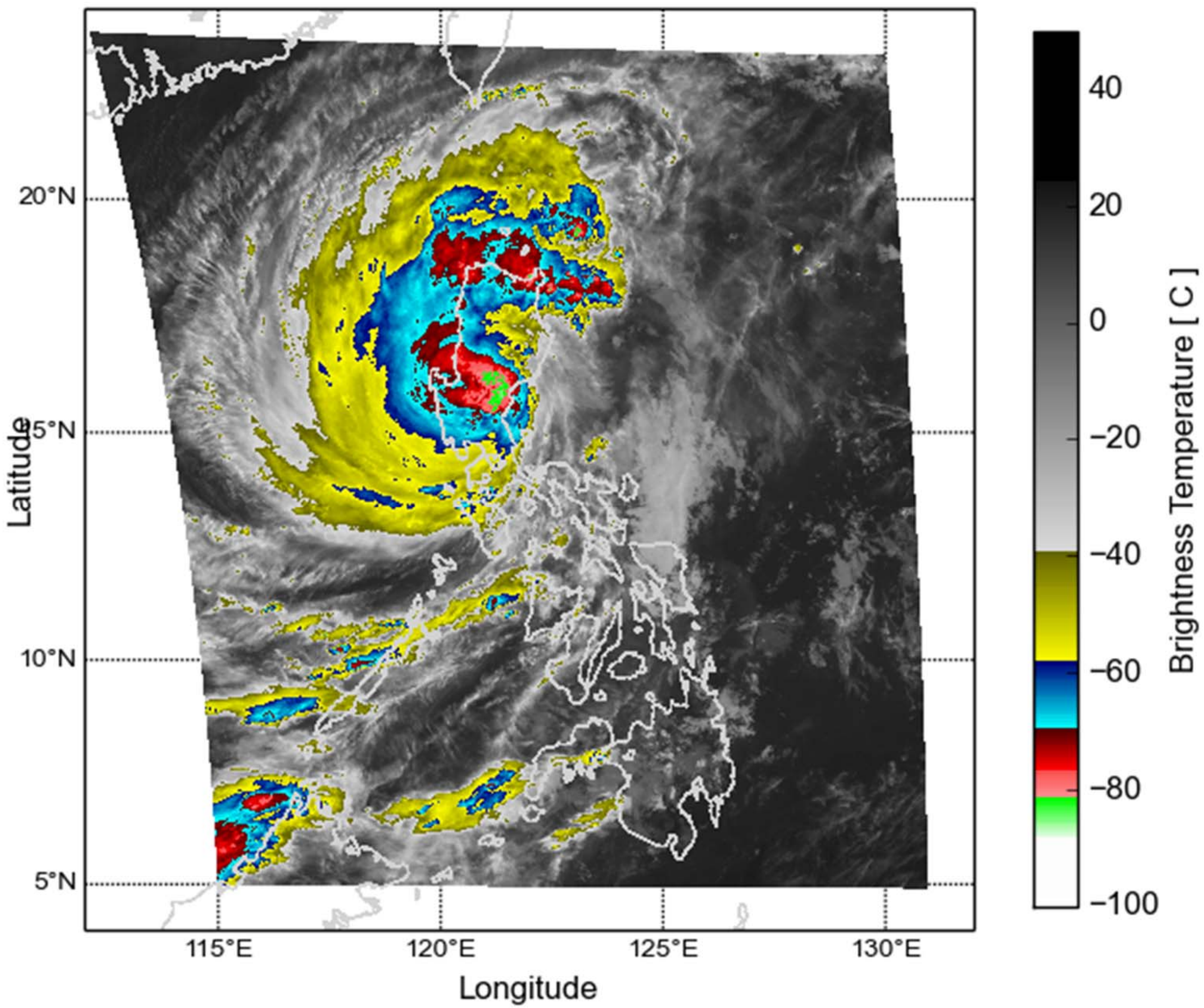
(MiniMPL – can be mounted on a vehicle)

Component 5: Rainfall estimation from Geostationary satellite (Himawari 8)



Qualitative Precipitation Estimation

Yellow – light
Blue – moderate
Red – heavy
Green – intense
White – torrential



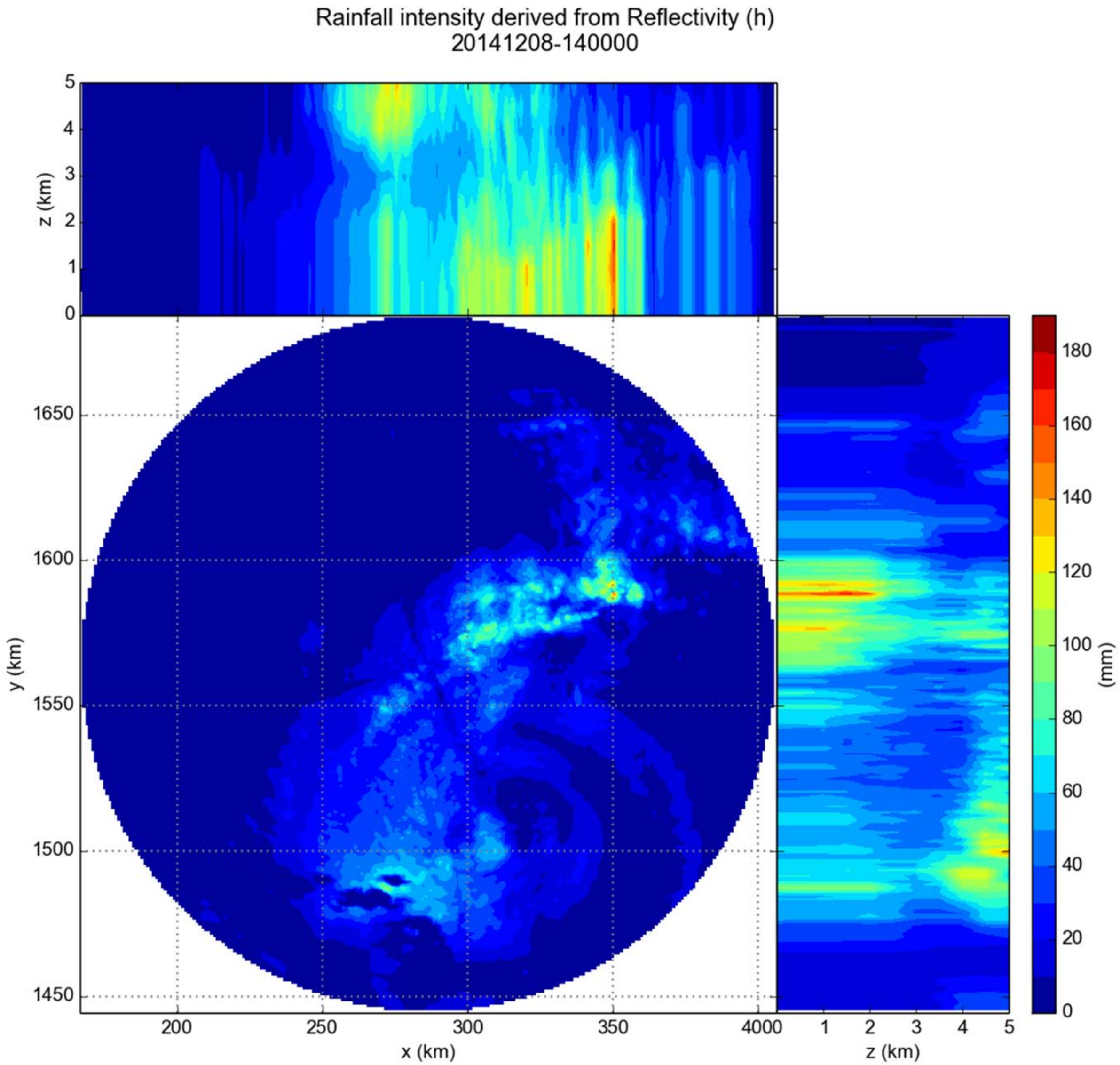
Typhoon Koppu – October 18, 2015 000 UTC, Himawari-8

R Nacario and GP Perez (work-in-progress)

Using Tagaytay C-band Radar for Calibration

- 500 m to 1 km resolution data every 15 min.
- Relate Reflectivity/rainfall with Brightness Temperature
  - Calibration curve
  - Look-up table

Typhoon Hagupit – Dec. 8, 2014 at 1400 UTC



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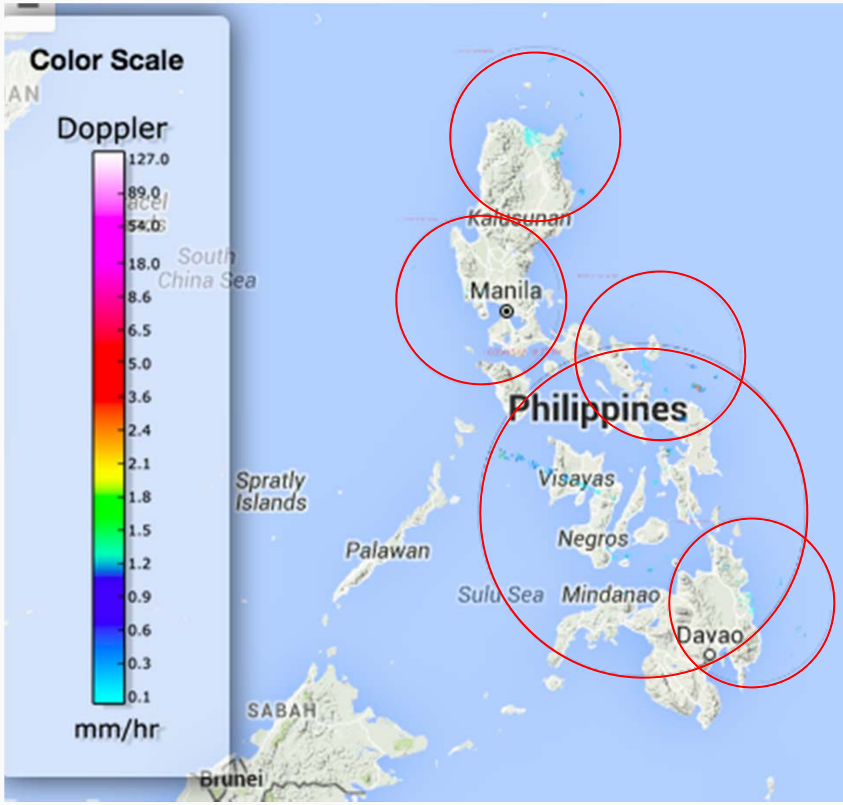
Available resources

PAGASA Radar networks



M/V DA-BFAR

PISTON ship-time

CAMPEX aircraft pass

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