Diurnal and Semi-diurnal Variations of Rainfall in Southeast China

Judy Huang and Johnny Chan

Guy Carpenter Asia-Pacific Climate Impact Centre
School of Energy and Environment
City University of Hong Kong
Variance of 3-hourly precipitation
Power Spectrum of 3-hourly precipitation

Guy Carpenter Asia-Pacific Climate Impact Centre, School of Energy and Environment, City University of Hong Kong
**Data (1998-2009)**

- **Rainfall**: 3-hourly, 0.25° long x 0.25° lat gridded TRMM 3B42 precipitation dataset

- **Atmospheric conditions**: 3-hourly GEOS5 reanalysis dataset with a spatial resolution of 0.667° long x 0.5° lat, interpolated to a 1° long x 1° lat

- **Precipitation cloud types**: Extended Edited Cloud Reports Archive (EECRA), which provides 3-hourly weather reports from about 15,000 station and ship observations.
High-level clouds ($C_H$) form at heights > 6 km

Middle-level clouds ($C_M$): cloud base between 2 and 6 km

Low-level clouds ($C_L$): cloud base up to 2 km
3-hourly precipitation in different seasons

Guy Carpenter Asia-Pacific Climate Impact Centre, School of Energy and Environment, City University of Hong Kong
Types of precipitating clouds in different seasons

(a) Frequency

Precipitation Frequency %

Drizzle
Nonshowery
Showery

DJF  MAM  JJA  SON

0  5  10  15
Temporal variations of precipitating cloud types in different seasons

Diurnal

Semi-diurnal
Diurnal variations of precipitating clouds in different seasons

(a) DJF; 0900 UTC

(b) JJA; 0900 UTC

(c) DJF; 0900 UTC

(d) JJA; 0900 UTC
Diurnal variations

- Precipitation
- Low clouds
- Middle clouds
- Moisture convergence
- Vertical motion (925 hPa)
- Relative humidity

Guy Carpenter Asia-Pacific Climate Impact Centre, School of Energy and Environment, City University of Hong Kong
Vertical circulation and stability (23-25°N) 00UTC
Vertical circulation and stability (23-25°N) 00UTC

Guy Carpenter Asia-Pacific Climate Impact Centre, School of energy and Environment, City University of Hong Kong
Semi-diurnal variations

- Precipitation
- Low clouds
- Middle clouds
- Moisture convergence
- Vertical motion (925 hPa)
- Relative humidity
Semi-diurnal variations of vertical variations of temperature
Semi-diurnal variations of vertical variations of temperature

S2(∂Tr/∂t) SEC vs. SCS; 0600/1800 UTC

Guy Carpenter Asia-Pacific Climate Impact Centre, School of energy and Environment, City University of Hong Kong
Semi-diurnal variations

vertical stability (contours), vertical motion (shading)

moisture convergence (contours), precipitation (shading)
Mechanism for early morning maximum in rainfall in SEC

1. Upper-level cold air advection
2. Larger S2 of upper-level radiative cooling
3. Convergence of S2(-∇•Q)
4. Warmer and moister

1. Low-level warm air advection
2. Smaller S2 of low-level radiative heating
3. Divergence of S2(-∇•Q)
4. Colder and dryer

Note: Items 1., 2., 3. are possible causes of early morning rainfall over SEA
Item 4. is a feature related to items 1-3
Showery precipitation is the major contributor to diurnal variation of rainfall in the summer, spring and autumn in SEC.

Non-showery precipitation contributes in the winter.

Formation mechanism: diurnal variation of moist convection process and relative humidity.
Summary

- Semi-diurnal precipitation is approximately in phase for all seasons because both the semi-diurnal moist convection and the relative humidity have similar temporal evolution in all seasons.

- Semidiurnal variation of land-sea differential heating between SEC and SCS tends to produce a relative unstable environment in SEC at 0900/2100 UTC, which induces more water vapor flux transporting from SCS into SEC to support the occurrence of semi-diurnal maximum.