Tropical Diurnal Cycle of TOA Radiative Fluxes within Large-Scale Circulation Regimes

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Motivations

• The cloud life cycle and its variability has a large influence on the earth energy budget.

• The diurnal cycle represents an important time scale in the cloud life cycle.

• Climate models poorly represent diurnal cycle of precipitation (and therefore clouds).

Trenberth et al. 2007
Annual Mean Diurnal Range—OLR (top) and LW CRF (bottom)
ERA Interim 500 hPa omega—Annual Mean
Diurnal Amplitude—OLR

Ocean
Land

W m$^{-2}$
Diurnal Amplitude—OLR

All Tropics

Frequency of Occurrence

Diurnal Range—OLR (W m⁻²)

- Strong Ascent
- Moderate Ascent
- Weak Ascent
- Weak Descent
- Moderate Descent
- Strong Descent
Diurnal Amplitude—OLR

- Minimum OLR > 200.0 Wm\(^{-2}\)
- 160.0 < Minimum OLR < 200.0 Wm\(^{-2}\)
- Minimum OLR < 160.0 Wm\(^{-2}\)
Daily Mean TOA Fluxes:
Tropical Ocean

- OLR and RSW are weaker functions of OLR diurnal amplitude at larger diurnal amplitudes.
- Net CRF is varies little with amplitude of OLR diurnal cycle due to compensating LW and SW cloud effects, dependent upon dynamical regime.

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Dynamical Regime Diurnal Cycle Composites
Conclusions and Future Work

• The annual mean OLR diurnal amplitude is a function of dynamical regime over ocean and nearly independent over land.
• The annual mean LW CRF diurnal amplitude is a function of dynamic regime independent of surface type.
• The intensity and frequency of deep convection drive the distribution of OLR amplitude.
• Over ocean, large amplitude diurnal cycles have a strong CRF throughout the day.
• Use TWP ARM data to study the process-level.
• The diurnal cycle of OLR seems to be different and convective precipitation, in that the phase is generally insensitive to the strength of the convection.
• We also believe that similar analyses are a good test of GCMs.
Diurnal Cycle Schematic

Lin et al. 2000
Mean Cloud Fraction Diurnal Cycle: Omega bin 0, ocean

Low Cloud
Low/Mid Cloud
Mid/High Cloud
High Cloud

Cloud Fraction

Local Time

LW CRF (W m^-2)
Mean Cloud Fraction Diurnal Cycle: Omega bin 2, ocean

- Low Cloud
- Low/Mid Cloud
- Mid/High Cloud
- High Cloud

Cloud Fraction vs. Local Time
CERES Synoptic Data Product

• 1°x1° regional 3-hourly mean fluxes
• Synergistically combines CERES and Geostationary (GEO) satellite observations to resolve the diurnal cycle.
• GEO radiances are converted to broadband fluxes and normalized to place on same scale as CERES.
Diurnal Amplitude—OLR

Ocean

- Strong Ascent
- Moderate Ascent
- Weak Ascent
- Weak Descent
- Moderate Descent
- Strong Descent

The graph shows the frequency of occurrence of diurnal range in OLR (W m$^{-2}$) with different shades and markers indicating different intensity levels of ascent and descent.
Diurnal Amplitude—OLR
Land

Strong Ascent
Moderate Ascent
Weak Ascent
Weak Descent
Moderate Descent
Strong Descent
Mean Cloud Fraction Diurnal Cycle: Omega bin 0, ocean

- Low Cloud
- Low/Mid Cloud
- Mid/High Cloud
- High Cloud

Cloud Fraction

Local Time

LW CRF (W m$^{-2}$)
Diurnal Phase—OLR

Ocean

Land

Max

Min

Local Time of Maximum OLR

strong  mod.  weak  weak  mod.  strong

0  3  6  9  12  15  18  21  24
Diurnal Phase—LW CRF
• What clouds are contributing to this LW CRF diurnal cycle amplitude?
  – One main point is that the percentage of high clouds drives aspects of the mean OLR diurnal cycle within dynamical regimes.
• Frequency and intensity of convection drives the PDF of amplitude.
• Phase is really unanswered right now.
• How does diurnal cycle affect mean OLR?
  – Use the plots of mean OLR for different size diurnal amplitudes
  – Does the mean OLR depend on local time of max or min OLR, or LW CRF.
Approach

• Define Tropics as 30 N to 30 S
• Define dynamical regime using ERA-interim 500-hPa vertical velocity
• Analyze characteristics of the diurnal cycle within this framework.