

Role of cold pool formation on the diurnal cycle of precipitation over the maritime continent

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Background - importance of the diurnal cycle -

•Diurnal cycle (DC) is a dominant mode in convective features over tropics which plays an important role in driving a global-scale atmospheric circulation.

•Conventional GCMs, that use cumulus parameterizations, fail to simulate the amplitude and phase of the precipitation DC (e.g., Dai, 2006).

•Heating anomaly over the maritime continent has significant impact on the global atmospheric circulation (Neale and Slingo, 2003).

(1) High resolution GCMs



Arakawa and Kitoh (2005)

(2) Multi-scale Modeling Framework (MMF or Super parameterization)

Local Time of Precip-Freq Max



Tao et al. (2009)

(3) Global cloud resolving model

NICAM (Nonhydrostatic ICosahedral Atmospheric Model) -Simulation by Miura et al. (2008, *Science*) Satoh et al. (2008)

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Experiments

Period: <u>15th Dec. 2006 through 14th Jan. 2007</u> Initial: NCEP final analysis Grid size: 14 km (31 days), 7 km (31 days), and 3.5 km (7days) Cumulus parameterization: Not used

Satellite data used

- TRMM 3B42 (31days; 15 Dec.2006 14 Jan.2007)
 - Grid size: 0.25 x 0.25 degree
 - Interval: 3 hourly (+/- 90 minute)
 - optimal combination of 2B-31, 2A-12, SSMI, AMSR and AMSU precipitation estimates, to adjust IR estimates from geostationary IR observations.
- <u>TRMM 3G68</u> (DJF climatology, 1998-2007)
 - Grid size: 0.5 x 0.5 degree
 - Based on PR observation
 - Interval: 3-hourly composite



Averaged diurnal cycle over 15°S-15°N





Diurnal cycle of rainfall (NICAM-7km)





Frequency of cold pool formation over oceans

Cold pool definition: dT/dt < -1.5°C/90min







Conclusion

- This is the first study to investigate DC in GCRM.
- GCRM well simulates the DC in tropical regions.
- Prominent resolution dependence is recognized in phase and amplitude of the DC, in particular over land. The highest resolution run (3.5km mesh) shows very similar phase to the observed one.
- Spatio-temporal characteristics of the cold pool is shown using NICAM simulation. We found the cold pools are often formed over the oceans with high rainfall rate, such as ITCZ and SPCZ.
- Near the offshore regions around the maritime continent, the formation of cold pool is consistent to the low-level atmospheric circulation and the convectively active areas.



Mean diurnal cycle of precipitation in warm season. Dai (2006)









• Dynamics (grid-scale)	
Governing equations	Full compressible non-hydrostatic system
Spatial discretization	2 nd -order centered scheme (Tomita et al. 2002, J
	2 nd -order upwind biased scheme (Miura, 2007, N
Horizontal grid	Icosahedral grid (Tomita et al. 2001/2002, JCP)
configuration	Lorenz grid
Vertical grid configuration	Terrain-following coordinate
Topography	
Conservation	mass, tracers, total energy (Satoh 2002,2003, MWR)
Temporal scheme	Slow mode – explicit scheme (RK2)
	Fast mode – Horizontal Explicit Vertical Implicit
	scheme Nakanishi and Niino (2004)
• Physics (subgrid-scale)	
Turbulence / surface flux	Yamada and Mellor (1979)
	/Louis(1979), Uno et al.(1995)
Radiation / aerosol	MSTRNX (Sekiguchi 2004) / SPRINTARS (Takemura et
	al. 2003)
Cloud physics	Grabowski(1998), Lin (1983)
Surface process	Rucket land model / fixed SST_MATSIRO / slah ocean

Studying diurnal cycle in GCMs

(1) High resolution GCM

- Maritime continent: Arakawa and Kitoh (2005)
- Continental US: Lee et al. (2007)
- (2) Multi-scale Modeling Framework (MMF or Super parameterization)
 - Khairoutdinov et al. (2005)
 - Tao et al. (2009)
- (3) Global cloud resolving model
 → This study