VARIABILITY AND PREDICTABILITY OF THE INTERTROPICAL CONVERGENCE ZONE OVER INDONESIA

Orbita Roswintiarti
Lembaga Penerbangan dan Antariksa Nasional

Abstract

The Intertropical Convergence Zone (ITCZ) is a zone of low-pressure near the equator where two easterly winds originating from the Northern and Southern hemispheres converge. Characterized by enhanced convection, cloudiness, and rainfall this zone constitutes the rising branch of the meridional Hadley circulation. The non-uniform distribution of the lands and seas introduces zonal asymmetries in heating which drive an east-west overturning, known as the Walker circulation, wherein air rises at longitudes of heating and sinks at the other longitudes. The three-quasi permanent centers of the rising branch of the Walker circulation are located over Indonesia, central Africa, and the Amazon basin. The structure, position, and migration of the ITCZ are important in defining and analyzing not only the tropical climate, but also the global climate. In this study, we firstly examine the variability of the ITCZ over the tropics. Secondly, we evaluate model performances of long-term and short-term ITCZ predictions over Indonesia based on statistical approaches and numerical simulations, respectively.

One of the most striking characteristics of the ITCZ is its variability on a wide range of temporal and spatial scale. On the interannual time scales, the ITCZ is known plays a key role in the El Niño/Southern Oscillation (ENSO) episodes. During ENSO the anomalous warm sea surface temperatures (SSTs) in the eastern-central tropical Pacific Ocean shift convection over the Indonesian-Australian regions to the central Pacific. On the annual time scales, the ITCZ moves in association with the zone of maximum seasonal temperature. In general, the ITCZ marches south in the Northern Hemisphere fall and winter seasons and north in Northern Hemisphere spring and summer seasons. Over the Asian-Australian regions, the annual cycle of convection is dominated by monsoon that implies a complete reverse of wind regimes in the course of the year. On the intraseasonal time scales, the migration of the ITCZ especially over the Indian and western Pacific oceans is dominated by the Madden-Julian Oscillation. Enhanced convective activity over the Indian Ocean within this intraseasonal oscillation is associated with suppressed convective activity over the western Pacific Ocean. On day-to-day basis, the weather in the tropics is dominated by the local to mesoscale diurnal variations of the cumulus convection and surface wind circulations. The inland regions display a maximum convection during late morning or afternoon, while the marine/coastal regions show a maximum convection during night or early hours in the morning.

A better understanding of ENSO-related climate anomaly over Indonesia and improved climate prediction with sufficient lead times are investigated. Two sets of linear statistical models are used to predict monthly Outgoing Longwave Radiation (OLR) anomaly over the Indonesian-Pacific regions and monthly SST anomaly over the tropical Pacific Ocean for July and December 1998. These models are constructed using a combination of the Empirical Orthogonal Function (EOF) and Canonical Correlation Analysis (CCA) from the period 1975 to 1997 (with a gap in 1978). The results show that warm SSTs over the eastern-central Pacific Ocean during ENSO episodes are associated

with decreased deep convection over Indonesia. These relationships are seasonally dependent, which are strong during fall and winter seasons and weak during spring and summer seasons. The predictive skills are generally high during winter months and low during summer months. The high predictability in winter is at least partially due to the strongest El Niño signal during its mature phase. Meanwhile, the poor predictability in spring and summer may be from the weakest condition of the Southern Oscillation and from the so-called spring barrier.

Numerical simulations of the circulation dynamics and planetary boundary layer heights over Indonesia during the 1997 ENSO episode are performed utilizing the Fifth Generation of the Pennsylvania State University-National Center for Atmospheric Research (PSU-NCAR) Mesoscale Model (MM5). A three-dimensional non-hydrostatic version of the model is run from 00 UTC 21 September to 00 UTC 25 September 1997 using double-nest grids with grid resolutions of 45 km and 15 km. Over four day simulations, the model can produce a reasonable forecast of wind patterns and diurnal cycle of planetary boundary heights that compared well with the analyses. This study, furthermore, suggests that applications of the MM5 with at least 45 km grid resolution can be a useful tool for the weather prediction for research and operational purposes

INTRODUCTION

Role of the ITCZ

- Global atmospheric energy balance (« Latent heat release)· Planetary albedo (« Enhanced cloudiness)
- Tropical climate (« Structure, position, and migration of ITCZ)

Tropics :

- Population : 45% of world's population
- Main sector : agriculture

- Global climate (« Monsoon, ENSO)

Characteristics

A wide range of temporal and spatial scales:

· Interannual time scale

· Annual time scale

· Intraseasonal time scale

. Diurnal variation

DATA

· Monthly SST anomaly (30.5°N-29.5°S; 120.5°E-67.5°W) - (2°x2°)

· Monthly OLR anomaly (30°N-30°S; 80°E-80°W)-(2.5°x2.5°)

· Period: Jan 1975 - Dec 1997 (with a gap in 1978)

ENSO: 76/78, 79/80, 82/83, 86/88, 91/92, 93, 94/95, 97/98

La Nina: 84/85, 88/89, 95/97

METHOD

· Empirical Orthogonal Function (EOF): data reduction techique eigenvectors « spatial patterns; eigenvalues « time series

· Canonical Correlation Analysis (CCA): multivariate statistical technique used to find a linear combination of two sets data that are most highly correlated.

· Prediction: July and December 1998.

Numerical Simulations of short-term Circulation Dynamics and PBL Heights During the 1997 Forest Fire in Indonesia.

Data And Method

. Simulated winds derived from the fifth Generation of the Pennsylvania State University-National Center for Atmospheric Research Mesoscale Model (PSU-NCAR MM5):

- Initial conditions : 00 UTC 21 September 1997 (ECMWF)

- 4 day simulations : 00 UTC 22 September to 00 UTC 25 September 1997

.Double nested grids :

(15.5^0 N – 15.3^0 S ; 86.9^0 E – 142.8^0 E), 45 km x 45 km, (79 x 140)

(10.5^0 N – 9.9^0 S ; 105.0^0 E – 124.7^0 E), 15 km x 15 km, (159 x 148)

Vertical coordinate : 17 half 0 levels.

.Forest skills :

Mean, Bias error (BIAS), Root mean square error (RMSE) and correlation of coefficient (CORR).

Principal Features of PSU- NCAR MM5

Governing equation	Non hydrostatic
Vertical coordinate	$\sigma = (p-p)/(ps-p)$
<u>Numerical methods</u>	
Grid structure	Arakawa B-grid
Finite difference scheme	Second order F. D
Time integration scheme	Semi implicit of Klemp and Wilhemson
Lateral B. C	Nudging method
<u>Model Physics</u>	
Horizontal diffusi	Second and fourth order diffusion
Dry convective adjustment	Simple scheme
Precipitation physics :	
Non convective precipitation	Dudhia's simple ice
Convective precipitation	Kuo-Anthes scheme
PBL processes scheme :	
Surface layer	Similarity theory
Mixed layer	Blackadar scheme
Land surface :	
Land use	13 categories
Soil type	11 categories
Half σ-coordinate	0.025, 0.1, 0.2, 0.299, 0.399, 0.5, 0.599, 0.698, 0.784, 0.845, 0.887, 0.920, 0.946, 0.966, 0.981, 0.991, 0.997.
Horizontal resolution	45 km x 45 km, 15 km x 15 km.

CONCLUSIONS

The ENSO has a strong impact on the climate in Indonesia. The relationships and predictability of the SST over the tropical Pacific Ocean during ENSO on convective anomaly over Indonesia.

Strong during boreal fall and winter ↔ strongest El Nino Signal and peak rainy season.

Weak during spring and summer ↔ weakest Southern Oscilation and spring barrier

The regional –scale winds, turbulence, a shallow boundary layer, and synoptic-scale subsidence are the primary mechanisms responsible for transporting air pollutants and aerosol during forest fire in Kalimantan.

These winds are generally easternly/south easterly driven by the pressure gradients between the Indonesian-Australian regions and South Asia.

This study suggest that applications of the PSU-NCAR-MM5 with at least 45 km grid resolutions can be a useful tool for the weather prediction for research and operational purposes.

Forecast Skill Statistics

Date	Var	Mean (ms^{-1})	BIAS	RMSE	CORR	
		ANL	MM5	(ms^{-1})	(ms^{-1})	(ms^{-1})
00 UTC	U	-3.1	-2.2	0.9	2.9	0.89
22 Sep '97	V	1.3	1.3	0.0	2.1	0.77
00 UTC	U	-3.8	-2.2	1.4	3.2	0.85
23 Sep'97	V	0.6	1.1	0.5	2.5	0.67
00 UTC	U	-4.2	-2.2	2.0	3.5	0.82
24 Sep'97	V	1.3	1.9	0.6	2.9	0.54
00 UTC	U	-3.5	-1.4	1.9	3.4	0.83
25 Sep'97	V	0.9	1.5	0.6	2.7	0.66