

Numerical Simulation of the Active and Break of the Summer Monsoon over Southeast  
Asia under Climate Change Scenarios

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A Thesis Submitted in Partial Fulfillment of the Requirements for  
the Degree of Doctor of Philosophy (Applied Mathematics)

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2012

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Thesis Title	Numerical Simulation of the Active and Break of the Summer Monsoon over Southeast Asia under Climate Change Scenarios
Thesis Credits	36
Candidate	Miss Chularat Srikul
Thesis Advisor	Dr. Dusadee Sukawat
Program	Doctor of Philosophy
Field of Study	Applied Mathematics
Department	Mathematics
Faculty	Science
B.E.	2555

### Abstract

The objective of this research is to investigate characteristics of 850 hPa wind during the active and break of the summer monsoon over Southeast Asia under A2 and COMMIT climate change scenarios. A single level primitive equation model (SILEPE) is used to simulate the monsoon with the initial condition obtained from BCCR-BCM2.0 climate model. Verification of the forecasts from SILEPE shows that the model can be used for 2 to 3 days forecast. To reduce uncertainties associated with the SILEPE simulation, ensemble forecasts based on the singular vector method are performed. Each ensemble forecast consists of 1 control run and 50 ensemble members. The ensemble members are generated by applying the singular vector method to a linear version of SILEPE. Two active monsoon and 2 monsoon break cases in the year 2086 are selected as the study cases. Results from the experiments show that for active summer monsoon, wind at 850 hPa is southwesterly while for summer monsoon break is westerly. For wind speed, the selected cases show that the active monsoon has stronger wind speed than the monsoon break.

Keywords : Summer Monsoon / Ensemble Forecast / Singular Vector

หัวข้อวิทยานิพนธ์	การจำลองเชิงตัวเลขของช่วงกำลังแรง และกำลังอ่อนของมรสุมฤดูร้อนบริเวณเอเชียอาคเนย์ภายใต้การจำลองการเปลี่ยนแปลงสภาพภูมิอากาศ
หน่วยกิต	36
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ภาควิชา	คณิตศาสตร์
คณะ	วิทยาศาสตร์
พ.ศ.	2555

### บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อตรวจสอบหาลักษณะเฉพาะของลม 850 เฮกโตปาสกาล ระหว่างช่วงกำลังแรงและกำลังอ่อนของมรสุมฤดูร้อนบริเวณเอเชียอาคเนย์ภายใต้การเปลี่ยนแปลงสภาพภูมิอากาศ A2 และ COMMIT ได้ใช้แบบจำลองสมการปฐมฐานระดับเดียว (SILEPE) ในการจำลองมรสุมด้วยเงื่อนไขเริ่มต้นที่ได้จากแบบจำลองภูมิอากาศ BCCR-BCM2.0 การทวนสอบการพยากรณ์จาก SILEPE แสดงว่าสามารถใช้แบบจำลองนี้พยากรณ์ได้ 2 ถึง 3 วัน เพื่อลดความไม่แน่นอนซึ่งเกี่ยวข้องเนื่องกับการจำลองด้วย SILEPE จึงได้ทำการพยากรณ์รวมชุดที่ตั้งอยู่บนวิธีเวกเตอร์เดี่ยว แต่ละการพยากรณ์รวมชุดประกอบด้วย การดำเนินการแบบควบคุม 1 ครั้งและ 50 สมาชิกรวมชุด สมาชิกรวมชุดสร้างโดยการประยุกต์วิธีเวกเตอร์เดียวกับ SILEPE แบบเชิงเส้น ช่วงมรสุมกำลังแรง 2 ภูมิและมรสุมกำลังอ่อน 2 ภูมิ ในปี ค.ศ. 2086 ได้ถูกเลือกเป็นกรณีศึกษา ผลจากการทดลองแสดงว่าสำหรับช่วงมรสุมกำลังแรงลม 850 เฮกโตปาสกาล เป็นทิศตะวันตกเฉียงใต้ ในขณะที่ช่วงมรสุมกำลังอ่อนจะเป็นทิศตะวันตก สำหรับอัตราเร็วลมผลจากกรณีที่ได้เลือกไว้แสดงว่าช่วงมรสุมกำลังแรงมีอัตราเร็วลมแรงกว่าช่วงมรสุมกำลังอ่อน

คำสำคัญ : มรสุมฤดูร้อน / การพยากรณ์รวมชุด / เวกเตอร์เดี่ยว

## ACKNOWLEDGEMENT

I would like to express my gratefully thanks to many people who encouraged and helped me throughout the course of this study: Dr. Dusadee Sukawat, my thesis supervisor, for his great elaborate guidance, friendly encouragement and tolerance with problems solving during the course of study. I am also grateful to the members of the examination committee, Assoc. Prof. Dr. Ungsana Chundang and Asst. Prof. Dr. Nitima Aschariyaphotha from the Department of Mathematics, and Assoc. Prof. Dr. Veerasak Udomchoke from Kasetsart University, for their valuable comments and suggestion.

Also, I am gratefully indebted to all lecturers who have taught me. Sincere thanks are extended to Miss Duenpen Kirdnark and Mrs. Peangpit Rodpan for their kind assistance and encouragement. I would like to thank my good friends and Dr. Porpattama Hammahukiattikul for friendly helps whenever I need, Rajamangala University of Technology Tawan-Ok (RMUTT-OK) Chakabongse Bhuvanarth Campus for the financial support and the Department of Mathematics, King Mongkut's University of Technology Thonburi for the financial support during the preparation of the thesis. Finally, I express my deep gratitude to my family who has always been my inspiration and my guiding light. They always support me with all their love.

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## LIST OF SYMBOLS

### SYMBOL

$u$	wind component in $x$ direction
$v$	wind component in $y$ direction
$w$	wind component in $z$ direction
$f$	coliolis parameter
$g$	acceleration due to gravity
$M$	time integration of the numerical scheme from the initial condition to time $t$
$L$	tangent linear model of $M$
$L^T$	adjoint tangent linear model of $M$
$x(t)$	state at time $t$
$y(t)$	perturbation state at time $t$
$t_0$	initial time
$t_1$	time at step 1
$P$	pressure
$\rho$	density
$\phi$	geopotential height
$\Omega$	angular velocity of the earth
$\theta$	latitude
$\zeta$	relative vorticity
$\psi$	streamfunction

$V_\chi$	divergent part of wind
$V_\psi$	non-divergent part of wind
$\mathbf{x}$	state vector
$\mathbf{x}(t)$	state at time $t$
$\mathbf{x}(t_0)$	state at the initial time
$\mathbf{y}(t)$	perturbation state at time $t$
$\mathbf{y}(t_0)$	perturbation state at the initial time
$\zeta_i, \boldsymbol{\eta}_i$	right and left singular vectors of $L$ , respectively
$S_v$	circular variance
$E$	error range
$P_i(E)$	probability of $E$ at grid point $i$
$N_i(E)$	number of ensemble member that satisfies $E$ at the grid point $i$
$F_i$	the $i^{\text{th}}$ ensemble member
$N$	the total of number of ensemble member
$E_{\text{CONTROL}}$	error of control run
$E_{\text{ENSEMBLE}}$	average error of ensemble mean

## LIST OF TECHNICAL TERMS AND ABBREVIATIONS

AM	Asian Monsoon
AR4	The Fourth Assessment Report
BCCR	Bjerknes Centre for Climate Research
BCM	Bergen Climate Model
BV	Bred Vector
CMIP3	Coupled Model Intercomparison Project Phase3
CTCZ	Continental Tropical Convergence Zone
CTL	Control Run
EAM	East Asian Monsoon
ECMWF	European Centre for Medium-Range Weather Forecasts
EM	Ensemble Member
EOF	Empirical Orthogonal Function
EPS	Ensemble Prediction System
GHG	Greenhouse Gas
IOM	Indian Ocean Monsoon
IPCC	Intergovernmental Panel on Climate Change
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environment Prediction
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical Weather Prediction
PDF	Probability Density Function

PO	Perturbed Observation
RSS	Relative Skill Score
SILIEPE	Single Level Primitive Equation
SRES	Special Report on Emissions Scenario
SV	Singular Vector
TLM	Tangent Linear Model
WCRP	World Climate Research Programme