ห้องสมุดงานวิจัย สำนักงานคณะกรรมการวิจัยแห่งชาติ
E47222

A NUMERICAL SIMULATION OF VORTEX FORMATION IN THE GULF OF THAILAND

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE
(APPLIED MATHEMATICS)
DEPARTMENT OF MATHEMATICS
FACULTY OF SCIENCE
KING MONGKUT'S UNIVERSITY OF TECHNOLOGY THONBURI
2011

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2011

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Thesis Credits	12
Candidate	Miss Phattamon Samanworakit
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Program	Master of Science
Field of Study	Applied Mathematics
Department	Mathematics
Faculty	Science
B.E.	2011

Abstract

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This research formulates a mathematical model for tropical cyclone formation in the Gulf of Thailand based on a collision of two wind streams. Data of two typhoons generated in the Gulf of Thailand, Gay (1989) and Vamei (2001), are used in model development. The concept of the model is to determine a spiral flow pattern of tropical cyclone vortex that matches the spiral cloud in the corresponding satellite image. The critical parameter in the model that has to be obtained by trial and error is the wind ratio parameter m. In the Gulf of Thailand the value of m for tropical cyclone vortex is in the range [-0.2,-0.24]. For tropical cyclone to form in this area, there must be a collision of strong northeast monsoon wind and another wind stream. Verification of the model shows that wind direction from the model is accurate but wind speed is too low. To combine the models for Gay and Vamei with different values of parameters, a linear regression model between the spiral flow direction and the distance from storm center is proposed.

Keywords: Vortex / Gulf of Thailand / Tropical Cyclone

หัวข้อวิทยานิพนธ์	การจำลองเชิงตัวเลขของการเกิดลมวนในอ่าวไทย
หน่วยกิต	12
ผู้เขียน	นางสาวภัทธมน สมานวรกิจ
อาจารย์ที่ปรึกษา	ดร.ดุษฎี ศุขวัฒน์
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ภาควิชา	คณิตศาสตร์
คณะ	วิทยาศาสตร์
พ.ศ.	2554

บทคัดย่อ

E 47222

งานวิจัยนี้เป็นการสร้างแบบจำลองทางคณิตศาสตร์ สำหรับการก่อตัวของพายุหมุนเขตร้อนในอ่าวไทยบนพื้นฐานของการชนกันของลมสองกระแส ข้อมูลจากไต้ฝุ่น 2 ลูกที่ก่อตัวในอ่าวไทย คือ เกย์ (1989) และฮัวเหม่ย (2001) ได้นำมาใช้ในการพัฒนาแบบจำลอง แนวคิดของแบบจำลอง คือ การกำหนดแบบรูปการไหลเวียนก้นหอยของกระแสวนในพายุหมุนเขตร้อน ซึ่งเข้าคู่กับเมฆเวียนก้นหอยในภาพถ่ายดาวเทียมที่สมนัยกัน ตัวแปรเสริมวิกฤตในแบบจำลองซึ่ง ต้องหาโดยการลองผิดลองถูก คือ ตัวแปรเสริมอัตราส่วนลม m ในอ่าวไทย ค่าของ m สำหรับกระแสวนในพายุหมุนเขตร้อนอยู่ในพิสัย [-0.20, -0.24] การที่พายุหมุนเขตร้อนจะก่อตัวในบริเวณนี้จะต้องมีการชนกันของลมมรสุมตะวันออกเฉียงเหนือกำลังแรงกับกระแสลมอื่น การทวนสอบแบบจำลองแสดงว่าทิศลมจากแบบจำลองมีความถูกต้อง แต่อัตราเร็วลมต่ำเกินไป เพื่อที่จะรวมแบบจำลองสำหรับเกย์และฮัวเหม่ย ซึ่งมีค่าตัวแปรเสริมต่างกัน จึงได้เสนอแบบจำลองถดถอยเชิงเส้นระหว่างทิศทางการไหลแบบเวียนก้นหอยกับระยะห่างจากจุดศูนย์กลางพายุ

คำสำคัญ :กระแสวน / อ่าวไทย / พายุหมุนเขตร้อน

ACKNOWLEDGEMENTS

I would like to express my gratefully thank to many people who encouraged and help me throughout the course of this study: Dr. Dusadee Sukawat, my thesis supervisor, for his great elaborate guidance, friendly encouragement and tolerance with problem solving during the course of study, I am also grateful to the member of the examination committee, Assoc. Prof. Dr. Suwon Tangmanee from The Centre of Excellence in Mathematics, Dr. Sumlearng Chunrungsikul and Dr. Chatchawan Watchararuangwit from the Department of Mathematics for their valuable comments and suggestion.

Also, I am gratefully indebted to all the lectures who have taught me. Sincere thanks are extended to Miss Duenpen Kirdnark and Mrs. Peangpit Podpan for their kind assistance and encouragement. I also with to thank Miss Jeerawan Saelao, Miss Butsakorn Kong-ied, Miss Chiranya Surawut, Miss Sunisa Saiuparad, Miss Sugunyanee Yavinchan and My family for their help in computer program installation. I would like to thank my good friends for friendly helps whenever I need. Thank also to the Department of Mathematics, King Mongkut's University of Technology Thonburi for giving partial 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 with all their.

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LIST OF SYMBOLS

SYMBOL

$\vec{F}_{PGF}$	pressure gradient force
$\vec{F}_{CF}$	Coriolis force
$\vec{F}_{GF}$	gravity force
m_f	mass
ρ	air density
p	pressure; $\nabla p = \frac{\partial p}{\partial x}\vec{i} + \frac{\partial p}{\partial y}\vec{j}$
$\vec{\Omega}$	angular velocity of the rotation
$\vec{V} = u\vec{i} + v\vec{j}$	horizontal velocity
$\vec{g}$	gravity force
$f = 2\Omega \sin\phi$	Coriolis parameter
ϕ	latitude
∇_p	the horizontal gradient operator applied with pressure held constant
r	distance from the center, radial distance
$V_r = dr/dt$	radial wind component
$V_t = r(d\theta/dt)$	cross-radial (tangential) wind component
dz/dt	vertical component
m	the wind speed ratio
r_{initial}	initial radius
$r(0)$	the initial value of $r(\theta)$
M	the probability of tropical storm formation
α	α-cut or α-level subset
V_t	tangential wind components
$V_t(r)$	the tangential speed at the distance radial r
$V_t(R_{\max})$	the maximum speed of tangential wind

$R_{\max}$	the radius of the maximum wind (V_t is maximum at $R_{\max}$)
γ	the shape parameter
θ	the angle between the radius and the reference axis
$V(r,\theta)$	the wind speed of a moving cyclone at distance r from the center and the angle θ
$V_t(r)$	the Rankine vortex wind speed at distance r from the center
V_{center}	the translation speed of the center
θ_{tc}	the angle of the line BA
θ_{ss}	the tangential wind direction at point A (symmetric wind)
θ_{vv}	the spiral wind direction
km	kilometer
m	meter
s	second
hPa	hectopascal
UTC	Coordinated Universal Time
nm	nautical mile
°C	Celsius

LIST OF TECHNICAL TERMS AND ABBREVIATIONS

WMONEX	International Winter Monsoon Experiment
RMW	Radius of Maximum Winds
PSU	Pennsylvania State University
NCAR	National Center for Atmospheric Research Mesoscale Model
ECMWF	European Centre for Medium-Range Weather Forecasts
JTWC	Joint Typhoon Warning Center
RSME	Regional Specialized Meteorological Center
GMS	Geostationary Meteorological Satellite
MTSAT	Multi-function Transport Satellite