

PS.14 THE SENSITIVITY OF WRF SIMULATIONS OF HURRICANE IVAN TO CHOICE OF CUMULUS PARAMETERIZATION

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1. INTRODUCTION

As progressively smaller grid spacing is used in numerical modeling of mesoscale weather systems, explicit simulation of convection without parameterization has become more common. However, to our knowledge, the appropriateness of omitting the cumulus parameterization (CP) scheme at smaller grid spacing (4 km or less) has not been systematically determined in a tropical environment, particularly for tropical cyclones. The objective of this study is to observe the effects of explicitly resolving convection in a tropical cyclone, as opposed to using a convective parameterization. It is our hypothesis that explicit treatment of convection will provide a more realistic representation of the hurricane secondary circulation, eye and eyewall structure, and storm intensity.

2. BACKGROUND

The use of different convective parameterizations and of explicitly resolved convection significantly impacts the simulated track and intensity of tropical cyclones (e.g., Davis and Bosart 2002). Even the choice of CP used on coarser, outer grids affects the explicitly resolved convection on the finer-mesh grids for which they provide lateral boundary conditions. In their three-domain case study of summer convection in the southwestern U.S., Warner and Hsu (2000) concluded that mass field adjustments on the outer grids affect the timing and intensity of precipitation in the innermost finer grid, producing up to a factor of 3 difference in the 24-hour explicit precipitation totals. They proposed possible ways of mitigating this problem which included testing "the adequacy of marginal grid resolutions (3-5 km) for the explicit simulation of convection."

Weisman et al. (1997) simulated squall lines to test the sensitivity of horizontal grid resolution on explicit convection, using grid spacings between 1 and 12 km. This study concluded that 4 km grid spacing could reproduce essential features of the structure and evolution of the squall line seen in a 1 km run. Weisman et al. (1997, p. 546) speculate that this minimal resolution may be smaller in tropical environments in order to resolve the weaker vertical motions found in tropical cyclones relative to that found in intense midlatitude convective systems. Bryan et al. (2003) recommend grid spacings on the order of 100 m to be used as a benchmark in resolution sensitivity studies in order to better represent intracloud motions.

3. METHODS

The Weather Research and Forecasting (WRF) model (Version 2.0.3.1) is used for five different forecasts, all of which used the same physics and grid specifications, except for the CP scheme. In all of the simulations, a one-way nested grid of three domains is used, with 27, 9, and 3 km grid spacing on the outermost to innermost domains, respectively (Fig. 1).

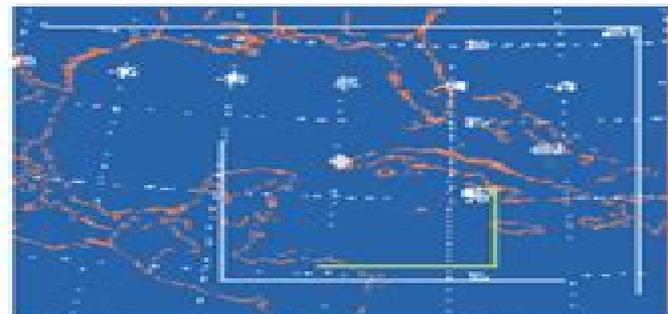


Fig. 1. Domain configuration used with grid spacing of 27, 9, and 3 km on domains 1, 2, and 3, respectively.

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Recent Advances in Intelligent Information Systems and Applied Mathematics Oscar Castillo, Dipak Kumar Jana, Debasis Giri, Arif Ahmed, 2020-01-31 This book describes the latest advances in intelligent techniques such as fuzzy logic neural networks and optimization algorithms and their relevance in building intelligent information systems in combination with applied mathematics The authors also outline the applications of these systems in areas like intelligent control and robotics pattern recognition medical diagnosis time series prediction and optimization of complex problems By sharing fresh ideas and identifying new targets problems it offers young researchers and students new directions for their future research The book is intended for readers from mathematics and computer science in particular professors and students working on theory and applications of intelligent systems for real world applications

Operational Flood Forecasting, Warning and Response for Multi-Scale Flood Risks in Developing Cities María Carolina Rogelis, 2020-04-22 The aim of this book is to contribute to understanding risk knowledge and to forecasting components of early flood warning particularly in the environment of tropical high mountains in developing cities This research covers a challenge taking into account the persistent lack of data limited resources and often complex climatic hydrologic and hydraulic conditions In this research a regional method is proposed for assessing flash flood susceptibility and for identifying debris flow predisposition at the watershed scale An indication of hazard is obtained from the flash flood susceptibility analysis and continually the vulnerability and an indication of flood risk at watershed scale was obtained Based on risk analyses the research follows the modelling steps for flood forecasting development Input precipitation is addressed in the environment of complex topography commonly found in mountainous tropical areas A distributed model a semi distributed model and a lumped model were all used to simulate the discharges of a tropical high mountain basin with a p ramo upper basin Performance analysis and diagnostics were carried out in order to identify the most appropriate model for the study area for flood early warning Finally the Weather Research and Forecasting WRF model was used to explore the added value of numerical weather models for flood early warning in a p ramo area

High Performance Computing in Science and Engineering '14 Wolfgang E. Nagel, Dietmar H. Kröner, Michael M. Resch, 2015-02-14 This book presents the state of the art in supercomputer simulation It includes the latest findings from leading researchers using systems from the High Performance Computing Center Stuttgart HLRS The reports cover all fields of computational science and engineering ranging from CFD to computational physics and from chemistry to computer science with a special emphasis on industrially relevant applications Presenting findings of one of Europe's leading systems this volume covers a wide variety of applications that deliver a high level of sustained performance The book covers the main methods in high performance computing Its outstanding results in achieving the best performance for production codes are of particular interest for both scientists and engineers The book comes with a wealth of color illustrations and tables of results

Monitoring and Prediction of Tropical Cyclones in the Indian Ocean and Climate

Change U.C. Mohanty, M. Mohapatra, O.P. Singh, B.K. Bandyopadhyay, L.S. Rathore, 2013-10-12 This book deals with recent advances in our understanding and prediction of tropical cyclogenesis intensification and movement as well as landfall processes like heavy rainfall gale wind and storm surge based on the latest observational and numerical weather prediction NWP modeling platforms It also includes tropical cyclone TC management issues like early warning systems recent high impact TC events disaster preparedness assessment of risk and vulnerability including construction archiving and retrieval of the best tracking and historical data sets policy decision etc in view of recent findings on climate change aspects and their impact on TC activity The chapters are authored by leading experts both from research and operational environments This book is relevant to cyclone forecasters and researchers managers policy makers graduate and undergraduate students It intends to stimulate thinking and hence further research in the field of TCs and climate change especially over the Indian Ocean region and provides high quality reference materials for all the users mentioned above for the management of TCs over this region

Meteorological Tsunamis: The U.S. East Coast and Other Coastal Regions Ivica Vilibić, Sebastian Monserrat, Alexander B. Rabinovich, 2014-11-16 The book encompasses a set of papers on meteorological tsunamis covering various aspects on this rare but potentially destructive multiresonant phenomenon Altogether an editorial and 15 contributions are part of this book eight of the contributions deal with different aspects of meteotsunamis along the U S East Coast and in the region of the Great Lakes including one paper introducing a new methodology in meteotsunami research Seven more papers are documenting meteotsunamis in various coastal areas of the world oceans All continents except Antarctica have been covered with the authors representing 11 countries Previously Published in Natural Hazards Volume 74 No 1 2014

The Adaptation to and Mitigation of Climate-Sensitive Natural Hazards Diandong Ren, Gen Li, Mervyn Lynch, Anning Huang, Bo Lu, 2022-11-29

Encyclopedia of Atmospheric Sciences, 2025-11-15 Encyclopedia of Atmospheric Sciences Third Edition offers comprehensive insights into the role of the atmosphere in weather climate and life It covers all principal processes and phenomena including intensive measurement and simulation techniques used to predict weather project climate change and assess human impacts on the atmospheric environment The past decade has seen rapid advancements in the atmospheric sciences necessitating the inclusion of several new topics in this updated edition The book highlights key areas of progress such as anthropogenic climate change high resolution numerical modeling and the use of machine learning and AI in forecasting and climate simulation It also covers advances in observational technologies and the study of planetary atmospheres providing multimedia animations of weather phenomena and model simulations to enhance understanding Geoengineering as a controversial yet significant subject is also addressed within the broader scope of climate change topics With over 280 chapters written by world experts in the field Encyclopedia of Atmospheric Sciences 3rd edition once again provides students and researchers with a comprehensive one stop reference work covering the entire field Around 280 chapters written by world leading experts in atmospheric sciences Provides current and comprehensive

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differences due to choice of microphysics parameterization scheme and to choice of sea surface temperature SST data source for the 23 December 2000 case while only the sensitivity of QPF to choice of microphysics parameterization scheme was tested for the 21-22 January 2003 case. It was by [New Permafrost and Glacier Research](#) Max I. Krugger, 2009. In geology, permafrost or permafrost soil is soil at or below the freezing point of water (0°C or 32°F) for two or more years. Ice is not always present as may be in the case of nonporous bedrock but it frequently occurs and it may be in amounts exceeding the potential hydraulic saturation of the ground material. Most permafrost is located in high latitudes, i.e., land in close proximity to the North and South poles but alpine permafrost may exist at high altitudes in much lower latitudes. The extent of permafrost can vary as the climate changes. Today approximately 20% of the Earth's land mass is covered by permafrost including discontinuous permafrost or glacial ice. A glacier is a large, slow-moving mass of ice formed from compacted layers of snow that slowly deforms and flows in response to gravity and high pressure. The word glacier comes from French via the Vulgar Latin *glacia* and ultimately from Latin *glacies* meaning ice. Glacier ice is the largest reservoir of fresh water on Earth and second only to oceans as the largest reservoir of total water. Glaciers cover vast areas of polar regions and are found in mountain ranges of every continent and are restricted to the highest mountains in the tropics. The processes and landforms caused by glaciers and related to them are referred to as glacial. The process of glacier growth and establishment is called glaciation. Glaciers are sensitive monitors of climate conditions and are crucial to both world water resources and sea level variation. This book presents the latest research on both permafrost and glaciers.

The Sensitivity of Tropical Cyclone Simulations in the WRF Model to Surface Layer and Planetary Boundary Layer Parameterization, 2003. The high wind speeds found in tropical cyclones fundamentally change the physical processes by which heat, moisture, and momentum are transferred between the ocean and the lower atmosphere. Despite this fact, surface and boundary layer parameterization schemes in many numerical models that are frequently used for tropical cyclone simulations are based on assumptions made in more tranquil atmospheric conditions. Limited observations in the high wind speed conditions found in strong tropical cyclones suggest that spray and foam can enhance the transfer of heat and moisture from the ocean to the atmosphere while reducing drag. Inclusion of the effects due to sea spray in a numerical model leads to stronger tropical cyclones. Wang et al. (2001), Perrie et al. (2005). Based upon the absence of sea spray effects and the values of the exchange coefficients in the WRF model, it was anticipated that simulations using an idealized vortex and ambient environment would not reach the thermodynamically estimated theoretical maximum intensity (MPI) limit of Emanuel (1986). In addition, it was expected that simulations of Hurricane Ivan would not reach the intensity of the observed storm. The sensitivity of the model results to surface layer and PBL parameterization and model grid spacing was tested with the hypothesis that the simulated tropical cyclones would remain weaker than MPI theory for the idealized simulations or observations for the Hurricane Ivan studies regardless of the model physical parameterization choice. Grid spacing was also hypothesized to impact the simulated TC.

intensity with the expectation that simulations with smaller grid spacing would produce more intense TCs based on the results of previous studies. Simulated TC intensity is found to be highly sensitive to model grid spacing in experiments with Hurricane Ivan or with an idealized initial vortex. Simulations using 4 km grid spacing were able to produce TCs that exceeded the MPI of the idealized environment.

A Comprehensive Sensitivity Analysis of the Weather Research and Forecasting Modeling System Over Southern Ontario, Canada Md Mostofa Kamal, 2017

Every year weather events cause billions of dollars property damage and take many lives globally. Preventing as much damage as possible is crucial and one way to help is through having the most accurate advance warning of extreme weather events. Therefore this thesis investigates the sensitivity of precipitation temperatures and surface energy fluxes i.e. sensible heat flux SHF, latent heat flux LHF and ground heat flux GHF in four cumulus cloud CU, five cloud microphysics MP and four planetary boundary layer PBL parameterization schemes over five years 2002, 2007, 2008, 2014 and 2015 with significantly different climatological atmospheric conditions, horizontal grid spacing, two seasons winter and summer and feedback between the nest and its parent domain using the dynamical downscaling technique of the Weather Research and Forecasting WRF model. The main objectives are 1) to identify a combination of physics schemes that realistically reproduce observed atmospheric conditions and 2) to improve current understanding of factors influencing the micro climate of southern Ontario, a region of complex land water atmosphere interactions. Ontario is also the most populous province and the largest manufacturing hub of Canada. WRF simulated precipitation and temperature agree well with DAYMET model gridded observations with correlation coefficients of nearly 0.3 to 0.8 and 0.9 respectively. Precipitation showed an average systematic bias for July of 50 to 30 mm and for January of 10 to 30 mm. The simulated precipitation was more sensitive to CU and PBL schemes. WRF simulated temperatures showed good reproducing skill with biases within the range of 1.0 C to 1.0 C in most parts of the domain. Model predicted temperature was quite sensitive to PBL and MP schemes. Model simulated precipitation variability increased when the horizontal grid resolution was refined from 8.0 to 2.67 km. However simulated temperature variability decreased. Overall the model performed better in the 2.67 km resolution simulation than in the highest resolution simulations with grid spacing of 0.888 km, an unexpected finding that suggests the need for carefully designed high resolution dynamical downscaling experiments. WRF's limitation to capture all variation that may occur at a resolution of 1 km, particularly of precipitation in mountainous areas, may result from uncertainties in our understanding of the climate and our inability to parameterize sub-grid scale processes realistically. WRF reproduced the diurnal variability of the SHF very well but systematically overestimated LHF compared to eddy covariance EC tower measurements for June of 2007 and 2008. For the interior of all three domains in July 2002, spatial distribution was overestimated for SHF and underestimated for LHF with biases ranging from 30 to 30 W m² over most of the area when compared to the North America Land Data Assimilation System NLDAS model gridded analysis. WRF showed little sensitivity to the choice of PBL scheme except for January 2002's LHF, the hottest January of the five

studied If forced with distinctively different annual climatological boundary conditions such as extreme cold in January 2014 and below average temperatures in January 2015 the model s simulated spatial distribution of energy flux bias indicates behavior that clearly differs from NLDAS analysis A large energy flux bias occurs over the smaller shallow northern lakes perhaps due to incorrect representation of their water temperatures Overall the Kain Fritsch KF CU Yonsei University YSU PBL and WRF Single Moment 6 class WSM6 microphysics parameterization schemes exhibit superior results over the domain studied The WRF model shows a high skill score over southern Ontario while reproducing observed climate means and statistics Nevertheless the model s performance depends on the meteorological variables season and synoptic conditions The Great Lakes strongly influence atmospheric conditions in southern Ontario by affecting precipitation and surface temperatures ranging from the diurnal to the seasonal timescales These results affirm the need for extensive sensitivity analysis for both research and operational applications However the findings are limited by the shorter spin up time and by having only one month simulation although WRF ran for a month in both the winter and summer over multiple years

Impacts of Physical Parameterization Schemes and Soil Moisture Initialization on Boundary Layer Evolution in the Weather Research and Forecasting (WRF) Model Grace M. Cutting,2022 Numerical weather prediction NWP models have become a necessary addition to the atmospheric research community over the last several decades and atmospheric modeling has been used internationally for numerous operational and research purposes NWP models contain a vast number of combinations of physical and dynamical parameterization schemes however they are not always accurate in forecasting weather phenomena at a particular location as different combinations of parameterization schemes represent differing conditions Weather Research and Forecasting WRF model simulations were run to explore which of the commonly used planetary boundary layer PBL schemes best represented upper air data as well as PBL evolution over northeastern Colorado southeastern Wyoming southwestern Nebraska and northwestern Kansas Additionally errors in soil moisture initialization were investigated to determine if there was an impact on boundary layer evolution Based on model soundings the Grenier Bretherton McCaa GBM scheme was the most representative of this region in terms of the overall PBL structure and there was no evidence to suggest that errors in soil moisture initialization impacted boundary layer evolution but rather the choice in surface layer scheme tended to influence the modeled boundary layer when paired with specific PBL schemes

Modeling the Sensitivity of the February 22-23, 2017 Winter Storm to Microphysics Parameterization and Microphysics Processes Over Colorado and Wyoming Ethan Collins,2019 Accurate weather forecasts are crucial to the profitability of industry in the United States such as the transportation of goods across the country via semi trailer trucks air travel recreation activities etc This topic is of particular concern over the state of Wyoming as wintertime weather forecasts are often prone to error Wyoming not only has a sparse network of surface and upper air observations but also complex terrain that cannot be properly represented in regional numerical models Model forecast errors can have a substantial

impact on the ability to issue advisories and close highways if necessary We focus on improving our understanding of why regional numerical weather prediction NWP models often fall short of predicting accurate snow totals via a case study of an event that occurred on February 22 24 2017 High resolution simulations are run using the Weather Research and Forecasting WRF model Four different microphysics parameterizations are utilized in this study Thompson Morrison two moment Predicted Particle Properties P3 and the WRF Single Moment 6 Class Scheme The coupling between cloud properties and radiation as well as the role of latent heat release due to individual microphysical processes are also explored The simulated precipitation is compared with both Snow Telemetry SNOTEL and Parameter elevation Relationships on Independent Slopes Model PRISM to quantify model errors and improvements using higher resolution simulations and advanced microphysical parameterizations The results support past studies that suggest a dependency exists regarding the choice of microphysics parameterization and resolution over this region All of the parameterizations utilized in this study overpredict snowfall accumulation no clear bias as a function of altitude is identified The coupling between the cloud microphysics and radiation is also found to have a minimal impact on storm strength storm track and snowfall amounts Lastly certain microphysical processes and the resultant latent heating are found to affect the storm characteristics No cooling due to sublimation and no warming due to deposition have the largest influences on snowfall accumulation and cyclone track No cooling due to sublimation was found to decrease negative buoyancy production resulting in deeper clouds and more snowfall accumulation While no warming due to deposition was found to reduce buoyancy production deeper clouds and thus less snowfall accumulation Furthermore reducing ice fall speeds by 50 % was found to increase snowfall accumulation while increasing ice fall speeds by 50 % was found to decrease snowfall accumulation

Characterizing the Effect of Increasing Albedo on Urban Meteorology and Air Quality in Cold Climates, a Case Study for Montreal Ali

Gholizadeh Touchaei, 2015 The higher temperature of urban areas compared to their surrounding rural areas is called urban heat island UHI UHI during summer may harm inhabitants and aggravate cooling energy demand Increasing urban albedo is proposed to counter the undesirable impacts of UHI To analyze the effect of albedo enhancement on urban climate land atmosphere interactions and various physical processes in the atmosphere and on the land should be modeled Weather Research and Forecasting WRF model urban canopy model UCM building energy model BEM and chemical transport model CHEM are coupled to accurately investigate the effect of an increase in the urban albedo To select appropriate models sensitivity of near surface air temperature and near surface wind velocity to the choice of parameterization is evaluated Montreal and Toronto as the two most populated Canadian cities are selected for evaluation of UCMs and an increase in the urban albedo Seasonal performance of the increase in albedo of roofs walls and road by 0.45 0.4 and 0.25 respectively results in an average decrease of 0.25 C during summer and a negligible effect during winter

Reviewing **Wrf Model Sensitivity To Choice Of Parameterization A**: Unlocking the Spellbinding Force of Linguistics

In a fast-paced world fueled by information and interconnectivity, the spellbinding force of linguistics has acquired newfound prominence. Its capacity to evoke emotions, stimulate contemplation, and stimulate metamorphosis is actually astonishing. Within the pages of "**Wrf Model Sensitivity To Choice Of Parameterization A**," an enthralling opus penned by a very acclaimed wordsmith, readers embark on an immersive expedition to unravel the intricate significance of language and its indelible imprint on our lives. Throughout this assessment, we shall delve in to the book is central motifs, appraise its distinctive narrative style, and gauge its overarching influence on the minds of its readers.

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Wrf Model Sensitivity To Choice Of Parameterization A Introduction

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