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To Whom It May Concern:

THESIS REPORT by Dr. Jimy Dudhia (National Center for Atmospheric Research, Boulder, Colorado, USA) – External Examining Committee Member

THESIS TITLE: "ENSEMBLE FORECASTING AND DATA ASSIMILATION IN NUMERICAL WEATHER MODELING FOR EGYPT"

by Hamada Sultan Soliman Badr
for Master of Science at Cairo University
under the supervision of Prof. Atef O. Sherif, Assoc. Prof. Basman M. N. Elhadidi, and Assoc. Prof. Hamdy A. Kandil

Summary

The thesis has applied an advanced numerical weather prediction model and its data assimilation techniques to a significant practical use, which is to produce a modern forecast system for applications in Egypt. The work has been substantial in its scope and content, showing both a wide range of knowledge gained, and expertise in applying this knowledge that makes this a work of value by international standards.

Content

The thesis is organized into seven Chapters and an extensive Appendix with seven sections.
Chapter 1 (Introduction) introduces the primary concepts to be developed in the thesis, including numerical weather prediction, data assimilation and its history, datasets, and a literature review. It then introduces the organization of the thesis.
Chapter 2 (Modeling System) gives a very thorough overview of the MM5 modeling system programs including the pre-processors and their functions, and the model physics and dynamics. It also introduces the scripting that allows these programs to run together that had some development for the thesis.
Chapter 3 (Observational Data) describes the data sources for the various data used in the thesis project. These include gridded weather data, observational weather data, and satellite data from NOAA sources. This includes descriptions of how the satellite data are transmitted, collected, corrected, and combined, with particular attention to AVHRR surface characteristic data.
Chapter 4 (Data Assimilation) covers analysis methods that add data to improve gridded analyses, and then extends to four-dimensional data assimilation techniques by nudging that are available in MM5. The overview of these methods is accurate and thorough. The chapter ends with a description of experiments to investigate the effectiveness of data assimilation methods in the Egypt application.

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Chapter 5 (Ensemble Forecasting) introduces the various methods of and some of the theory behind ensemble forecasting quite thoroughly, and ends with a description of the ensemble experiments done for the thesis.
Chapter 6 (Results and Discussion) is the main new work bringing together the knowledge introduced in previous chapters. The experiments conducted tested and compared a variety of data assimilation methods, model set-ups, and an ensemble of model runs against data from Egypt in a range of cases large enough to gain significant results from a statistical viewpoint. The results were beneficial in determining how to choose an optimal set-up for a forecasting system in Egypt that will be of value to others doing similar work.
Chapter 7 (Conclusion and Future Work) summarizes the results in a useful way, and identifies remaining open questions that need to be addressed in future work.
The Appendices (Parts A-G) represent substantial background information for this thesis, being of a similar length to the first seven chapters. They cover diverse subjects in very much detail. These include the history of numerical weather prediction, MM5 physics details, global observations of all major types, traditional analysis techniques, methods of operational ensemble forecasting, extensive detailed results of the verification against observations, and the scripting codes that were developed for the project.

Evaluation

The writing was of high quality, and the thesis was well organized as a whole. The content was as comprehensive as it could be for a very large subject area, and the candidate showed impressive versatility in the broad range of topics that were described. It was clear from the description that the candidate understood the basic ideas very well in each of the chapters.
The number of model runs for this work was substantial leading to a lot of data to analyze. These areas of the work were carried out well, and allowed robust conclusions to be drawn from the results. This was helped by a good experimental set-up that was designed to separately test various aspects of the forecast system.
The conclusions were focused on the data assimilation method, and ensemble methods, and were reasonable interpretations of the results, and are likely applicable to other forecasts systems.
My comments sent to the student were mostly on minor aspects relating to clarifying the description in places, and I had no requirements for any major changes or added work. The candidate was able to answer all of my requests to my satisfaction.
I also mentioned that I would like to have seen more on the analysis of the physics sensitivities (mostly since my specialty area is physics), because this is a part that the thesis does not include in depth. The response included a conference paper that shows that the candidate is continuing to study the physics aspects related to his results, so I find that is certainly adequate.

Recommendation

In my view, this candidate has met or exceeded the requirements for the thesis as part of his Master of Science qualification, and on this basis I recommend granting the degree.

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Sincerely,

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