Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**

4. TITLE AND SUBTITLE **Dependence of Mesoscale Coastal Predictability on Data Assimilation and Distribution of Observations**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Postgraduate School,Department of Meteorology, Code Mr/Nu,589 Dyer Rd. Root Hall 254,Monterey,CA,93943**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**2**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Dependence of Mesoscale Coastal Predictability on Data Assimilation and Distribution of Observations

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Award Number: N0001499WR30007

LONG-TERM GOALS

The long term goal of this project is to determine the mesoscale atmospheric predictability and how it relates to synoptic scale uncertainty due to sampling and data assimilation of incomplete samples on the larger scale.

OBJECTIVES

The objectives of this research are to determine the ability to numerically predict mesoscale coastal structures in a variety of synoptic scale situations and demonstrate for given small scale structures the time ranges under which they might be considered predictable. The answer is probably dependent on the data assimilation system and one objective is to determine this sensitivity.

APPROACH

The basic approach is to run a series of numerical model experiements with slightly different observational samples and determine the relative spread in mesoscale forecasts. Since mesoscale truth is difficult to obtain from actual observations, we use a COAMPS model forecast as a representation of a true atmosphere. Samples are generated from this true atmosphere and then put into the data assimilation system for the MM5 model and subsequent forecasts are then verified against this truth. In this manner the impact of data sample, sample size, and data assimilation can be compared. This is being done for a variety of synoptic weather regimes to see if particular weather regimes have greater mesoscale predictability than others.

WORK COMPLETED

To address the issue of data assimilation and synoptic-scale error impacts on mesoscale predictability, a set of numerical experiments have been run using the storm of Feb. 5, 1998. This land-falling frontal cyclone was selected to study the predictability of strongly forced baroclinic flows interacting with mesoscale topography. Three numerical experiments have been completed using a model simulation from the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS) to define the “true” mesoscale atmosphere. Differing sets of observations were extracted from this “true” atmosphere and then inserted into the data assimilation system for the MM5 model to generate three slightly different synoptic-scale analyses. Forecasts using these data samples were made using MM5 and the results have been compared on the 4 km grid to the “true” mesoscale atmosphere to examine the growth of mesoscale errors.

RESULTS

The primary results from the experiments completed to date show that the mesoscale error grows very rapidly and that the predictability of mesoscale features near topography is very sensitive to synoptic scale analysis differences. The mesoscale error for individual forecasts from the three experiments is large initially due to a lack of mesoscale data assimilation and this error typically grows over the 24 hour prediction period used in these experiments. Surface wind speed RMS errors start around 6 m/s and grow to as high as 9 m/s by 24 hours. Of greater significance, two experiements that produced nearly identical synoptic scale predictions, produced substantially divergent mesoscale solutions near topography. The growth of surface RMS wind speed deviation between these two experiments showed average wind deviations as large as 2.5 m/s by 24 hours with specific locations having deviations of as much as 20 m/s (more than ¾'s the actual flow) in some regions. The primary reason for these large mesoscale deviations appears to be the impact of slightly altered synoptic-scale stratification and the manner in which the flow interacts with topography. Future experiments are being designed to more completely examine the sensitivity of these mountain/flow interactions. In addition, tests for other synoptic flow situations are also being prepared.

IMPACT/APPLICATION

The impact of these studies will be in furthering our understanding of the limits to mesoscale prediction using actual numerical models and data assimilation approaches. This will greatly aid Navy forecasters in knowing how best to use forecasts from mesoscale models.

TRANSITIONS

These results have been used as classroom examples at the Naval Postgraduate School.

RELATED PROJECTS

The ONR-sponsored project by the same investigators, entitled “Evolution of Low-level Flow Patterns in Littoral Regions when Extratropical Marine Cyclones Encounter Coastal Mountains” is closely related and utilizes some of the same cases to document flow interactions with coastal mountains.