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MESOSCALE METEOROLOGY "PRIMER": TRAINING FOR THE OPERATIONAL FORECASTER

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1. INTRODUCTION

Mesoscale meteorological processes and the numerical models designed to analyze and forecast these processes are currently in use by the majority of operational forecasters. Although National Weather Service (NWS) forecasters typically have an undergraduate or higher degree in meteorology, forecasters in the Department of Defense typically do not have college degrees. Even though they are quite well trained in synoptic scale processes and forecasting, there is little or no information available, at the proper level, to merge their synoptic skills with the mesoscale processes that actually affect their daily forecasts. To meet this need whereby the less-formally educated forecaster can develop an understanding of mesoscale processes and their application to mesoscale model guidance and forecasting, a Mesoscale Meteorology Primer is being developed.

This Primer is meant for the operational forecaster and is initially targeted at the military (Navy, Marine and Air Force) forecaster. Meteorological processes will be treated from a non-mathematical perspective with emphasis placed on an intuitive, graphic interpretation. "Forecasting fronts and eddies and their associated weather is best approached by a marriage between our mesoscale modeling capability and forecaster knowledge of local rules of thumb, appropriate mesoscale conceptual models, and an understanding of modeling factors that influence the reliability of the model forecast, such as the effects of warm and cold starts on data assimilation, disparities between the "modeled" topography or other surface characteristics and reality, and lateral boundary condition (LBC) errors on the forecast. This requires a robust forecaster training program for understanding model principles and know model limitations, as well as a robust command training program." (Reiss, 1999).

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The Primer builds on the current strengths of military forecasters. Emphasis is placed on basic meteorological links between synoptic and mesoscale processes. The Primer uses a web-based, interactive module architecture to develop appropriate conceptual models of mesoscale phenomena that are related to operational forecast scenarios. Case studies are provided to tailor the lesson to specific localities around the world for which military forecasters have responsibilities. The modules are aimed at addressing both a need for initial training in mesoscale forecasting as well as refresher training throughout the forecasters career.

2. BACKGROUND

Perhaps the first true military meteorologist was Navy Lieutenant Matthew Fontaine Maury who charted marine temperatures, winds and currents during the mid 1800's. It wasn't until World War I that organized training was provided to military weathermen. Lieutenant William F. Reed Jr, on loan from the Weather Bureau, provided meteorological training to enlisted Quartermasters and Officer Candidates. In 1918, the first detachment of Aerographer Officer and Enlisted weathermen departed for Europe. In 1919 the first weather school for both Officer and Enlisted opens in Pensacola FL. The

Navy established its enlisted weather school in 1929 in Lakehurst NJ, the later site of the infamous Hindenburg crash. The number of Officer and Enlisted meteorologists continued to grow during the 1930's and peaked at nearly 6500 during World War II.

Computer generated meteorological forecasts began in 1954 as the Navy, Air Force and National Weather Service (NWS) joined to form the Joint Numerical Weather Prediction Group in Suitland MD. The Navy's Fleet Numerical Weather Facility was established in 1961 with the purchase of a CDC –1604 mainframe computer. Navy, Marine Corps, and Air Force forecasting training was consolidated into one joint curriculum at Chanute AFB IL in 1978 and subsequently moved to Keesler AFB MS in 1993. This joint service school provides all meteorological training to the Enlisted observers and forecasters. Although NWS forecasters typically have an undergraduate or higher degree in meteorology, forecasters in the Department of Defense (DoD) typically do not have college degrees. The current DoD curriculum ensures that enlisted forecasters are quite well trained in synoptic scale processes and forecasting. However, there is little or no information available, at the proper level, to merge their synoptic skills with the mesoscale processes that actually affect their daily forecasts. Operationally, military forecasters are adept at accessing and comparing results from mesoscale model output such as the Navy's Coupled Oceanographic and Atmospheric Mesoscale Prediction System (COAMPS), the Air Force's application of the NCAR/Penn State Mesoscale Model (MM5), as well as the National Weather Service Eta or the Rapid Update Cycle (RUC) models. Lacking the formal training in mesoscale relationships, they will often blindly accept the apparently "more correct" (high-resolution) model output without questioning the synoptic scale initial and boundary conditions. What is missing is an in-depth understanding of mesoscale forcing, terrain interaction and model tendencies. Recent updates in the DoD curriculum point towards inclusion of mesoscale processes and model information along with high-resolution satellite interpretation. The Mesoscale Primer will become an integral part in both initial forecaster training as well as on-going refresher training for operational forecasters.

Of particular concern for military forecasters is the requirement to provide timely, precise, environmental forecasts that often determine safety of flight and navigation or just possibly when and where specific weapons can be successfully employed. Complex mesoscale processes govern the success rate for all precision-guided weapons as well as determination of exactly which sites are environmentally applicable for consideration. Today's military forecaster is required to tailor his product to specific target regions, which in most cases involve complex terrain and/or land/sea interfaces. Additionally, unlike the majority of NWS forecasters, military forecasters are required to shift areas of responsibility (AOR) often during their career. While onboard Navy vessels, they are faced with changing forecast areas on a daily basis, negating any benefit provided by regional experience. They are faced with grasping the synoptic and mesoscale complexities of varied locales on a worldwide basis. An additional problem faced by the majority of military forecasters is the lack of refresher training during their career. After completing the DoD forecaster training, normally at the 4-7 year mark, most forecasters receive little to no further education for the remainder of their active duty. It is not difficult to understand the problem of mastering a complex subject like Mesoscale Meteorology.

The Mesoscale Primer also provides a means to remain current in the evolving science through increased understanding of mesoscale weather systems. "In general, the forecasting challenges (on the mesoscale) include increased knowledge in data assimilation, lateral boundary conditions, model physics and parameterization" (Monterrosa, 1999). These challenges can only be met by understanding how mesoscale phenomena typically evolve in order to recognize potential deficiencies in a numerical forecast.

3. MESOSCALE PRIMER MODULES

In 1997, Sivillo, Ahlquist and Toth (1997) stressed the use of the World Wide Web via the Internet for training in the development of an Ensemble Forecasting Primer. The Mesoscale Primer will also be distributed as a web-based or CD ROM series of modules directed towards specific mesoscale processes. Included in each module will be realistic scenarios related to the operational impacts of the particular process. Figure 1 shows an example of a strike forecast scenario of a hypothetical flight from an offshore carrier to North Carolina. The forecast is for Jan. 2-3 during an evolving cold air damming event. Needless to say the forecast goes wrong due the forecasters failure to recognize the onset of cold air damming. Following this common forecaster experience of busting on a seemingly straight-forward forecast, the module goes on the develop a conceptual model of cold air damming and examine some factors that influence its evolution. Actual forecast products that forecasters have at their disposal are used as much as possible to help develop knowledge of what to look for in their operational products to recognize the particular mesoscale phenomena. For example, Figure 2 depicts the vertical structure of the winds and temperature in a model cross section from the Navy's COAMPS model, which Navy forecasters routinely use.

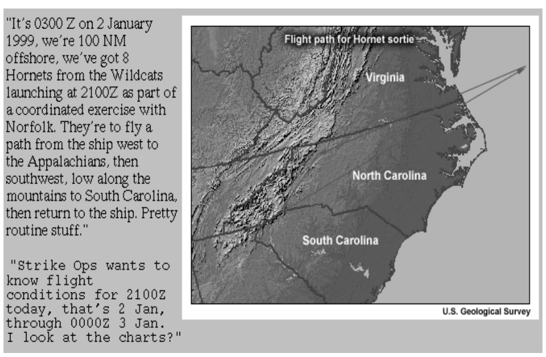

Fig. 1 – Web page from Cold Air Damming (CAD) training module showing example flight track for weather brief. Case study example of blown forecast due to cold air damming.

Each module will also have interactive questions and answers enmeshed within the text as well as a final exam. Of particular note, the Primer will contain case studies based on geographic occurrences of each process. For example, when describing the theory of topographically induced gap winds, the student will have available case studies from regions such as southwest US (Santa Ana), the Mediterranean (Mistral) or Asia (Taiwan Straits). These case studies can be added and changed over time in order to provide examples that may be more relevant to specific users.

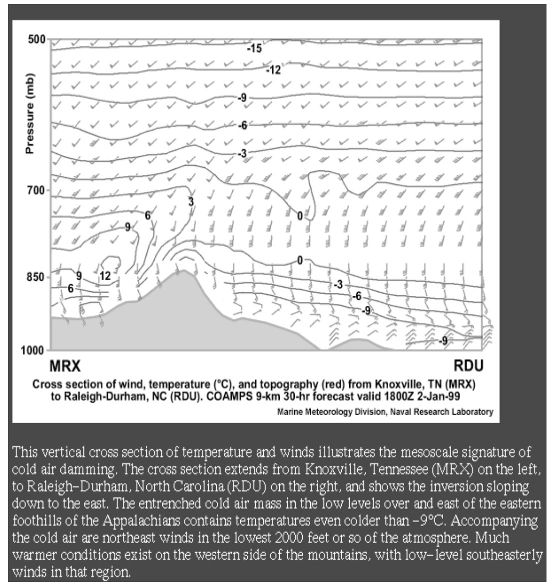

Fig. 2 – Cross section of temperature from the Navy's COAMPS model to show structure of CAD in mesoscale model fields used by forecasters.

Topic	Low Ceilings	Poor Visibility	Heavy Precip	Turbu-lence	High Winds
Advection Fog	✓	✓			
Radiation Fog	✓	✓			
Coastally Trapped Wind Reversals	✓	✓			
Cold Air Damming and Coastal Fronts	✓	✓			
Lee Vortices and Eddies	✓	✓	✓		
Orographic Precipitation		✓	✓		
Coastal Effects on Wind and Precipitation		✓	✓		
Mesoscale Rainbands			✓		
Severe Convection and Hail		✓	✓	✓	
Mesoscale Convective Complexes			✓	✓	
Squall Lines			✓	✓	✓
Microbursts				✓	✓
Mesoscale Gravity Waves, including Mountain Waves				✓	✓
Downslope Winds				✓	✓
Coastal Jets					✓
Gap Winds				✓	✓

Fig. 3 – Web page table of the sixteen training modules planned as part of the Primer.

Sixteen individual processes have been identified and will have scenario-base modules developed for worldwide student access. These modules are shown in this copy of the present entry web-page developed by COMET. As noted in the table of modules (Fig. 3), the types of forecast hazards that accompany a particular mesoscale topic are included to help focus a learner's attention on the types of applications where these phenomena may impact.

Seven additional modules will be developed to provide background information applicable to various specific processes. While not scenario-based, background modules will have applicable case studies included. The background modules are shown in this copy of the entry web-page developed by COMET (Fig. 4). In addition to the tabular entry points, an interactive map that highlights the types of mesoscale events that occur in a particular geographic region is also included. This map allows a forecaster to quickly pick out which topics he should study for his AOR.

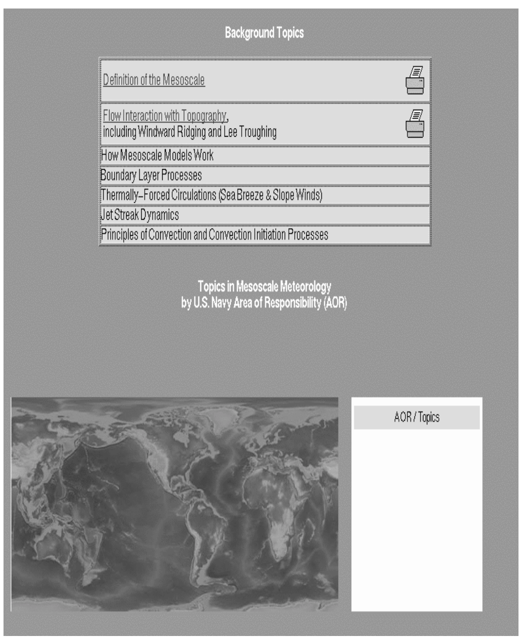

Fig. 4 – Web page of the seven background modules used to cover basic topics pertinent to all the training modules.

The first scenario-based module on Cold Air Damming (CAD) is available in May 2001 and will be highlighted in the poster. Additional modules on radiation fog, west coast fog, and gap winds are under development and should be available by the end of summer 2001. All sixteen modules and the seven background modules will be completed by the end of 2003.

4. TRAINING INITIATIVE

The military forecaster is often challenged with limited communications bandwidth that will hinder many Distance Learning techniques. The Primer is primarily a series of webcast CBT modules available via the Internet. CD-ROM copies will also be available for those students unable to maintain adequate web links (often experienced while at sea or in foreign locations).

Of significance, the Mesoscale Primer will contain imbedded questions and answers as well as a summary final test at the end of each module. The imbedded questions are structured to enhance the student's understanding and guide him to appropriate conclusions. The Navy's Professional Development Center (PDC), a subordinate unit of the Commander Naval Meteorology and Oceanography Command (CNMOC), is tasked with managing this computer based training and providing the testing accountability for all command personnel.

5. SUMMARY

The development of a web-based Mesoscale Meteorology Primer is underway through support by CNMOC. The Naval Postgraduate School, Cooperative Operational Meteorological Education and Training (COMET) program of the University Corporation of Atmospheric Research (UCAR), and the Science and Technology Officers (STO's) at the Navy's Meteorological and Oceanographic Centers are working together to develop these materials. The training modules will become a part of the training for Navy forecasters in order to bring them up to a new level of meteorological understanding to effectively use the available mesoscale numerical model products. These modules will provide a community resource for use by other forecasters and academic institutions to aid in the instruction on mesoscale topics.

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6. REFERENCES

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