JP2.9 **FORECASTER TRAINING ON NWP THROUGH CASE EXAMPLES**

Stephen D. Jascourt* and William R. Bua
UCAR/COMET at NCEP, Camp Springs, Maryland

1. INTRODUCTION

Improving forecasters' understanding of numerical weather prediction (NWP) models and improved use of model guidance was declared a priority by the Field Requirements Group (FRG) of the National Weather Service (NWS) several years ago. In response, the Cooperative Program for Operational Meteorology, Education and Training (COMET®) Program, in coordination with NWS, has developed an extensive web-based suite of training materials on numerical weather prediction (NWP) models. Different stages of developing this material were presented previously, in a poster at the last NWP/WAF conference and in Cianflone, et al (2000) and Cianflone, et al (1999). Presently, this suite includes the following five components:

- Concepts in NWP: how models work and how that affects their capabilities/limitations. Topics include physical parameterizations, resolution, vertical coordinate, and data assimilation. Accessible from the left column in the table at http://meted.ucar.edu/nwp/pcu2/ and through the NWP course with exam at http://meted.ucar.edu/nwp/course

- Description of *current* operational model characteristics, including operationally relevant details of the various model parameterizations. *This information is updated as the models are changed*. Information for a particular model is accessible from the column headed by that model name in the table at http://meted.ucar.edu/nwp/pcu2/

- Case examples applying concepts in NWP or illustrating a particular model behavior. These are discussed in more detail in the remainder of this article and are accessible at http://meted.ucar.edu/nwp/pcu3/cases/

- VISITview teletraining allows live interaction with trainees during scheduled sessions and individual self-paced instruction at any time. Thus far, two topics have been delivered, available at http://www.cira.colostate.edu/ramm/visit/nwptop10.html and http://www.cira.colostate.edu/ramm/visit/eta12.html

**Corresponding Author Address:* Stephen Jascourt, NCEP/HPC, Room 410, 5200 Auth Rd, Camp Springs MD 20746; email: Stephen.Jascourt@noaa.gov

- Email newsgroups for forecasters to ask questions about the model and COMET Program meteorologists at NCEP to post updates concerning model changes and other issues. The newsgroups can be accessed via http://meted.ucar.edu/nwp/newsgroups/

2. ROLE OF CASES IN NWP TRAINING

The goal of NWP training is to improve human forecasts. Thus, emphasis is needed on application of NWP concepts in actual operational situations. Case examples provide an opportune approach. However, short operational training windows and rapid turnaround required to make seasonally-relevant cases with current or very recent versions of the NCEP models necessitates that the cases be brief, to the point, and clearly illustrate key points. Thus, the cases do not delve into all possible levels of complexity and are not nearly as in-depth as case studies published, for instance, in *Monthly Weather Review*. They are, however, peer reviewed, usually by a NWS Science and Operations Officer (SOO), to strengthen the presentation clarity for their primary audience, NWS field forecasters.

Critical thinking is the single most important forecast skill, including knowing the right questions to ask and how to figure out the answers or recognize the extent to which the answers cannot be determined from all available information. Many of the cases are intended to promote critical thinking in the forecast process and emphasize case-specific considerations of model limitations and strengths based on the model's construction, including the parameterizations employed and the data assimilation methods. The goal is for forecasters to make the most scientifically sound use of model output as forecast tools rather than blindly accepting or rejecting all aspects of a particular model run.

Some of the cases are simpler in design – they just point out particular kinds of spurious behavior the models generate. Others illustrate how to use new tools or how NCEP model changes affect or don't affect how the model handles particular kinds of situations.

A complete list of the needs intended to be met by the collection of cases and the instructional components underlying their design can be found at http://www.nwstc.noaa.gov/nwstrn/d.ntp/meteor/nwppcu3.html

Eta-12 Forecasts For Historic Lake Effect Snows In Buffalo, NY	An examination of how the updated Eta-12 model, with its higher resolution, improved topography, and upgraded cloud and precipitation package, performed in forecasting the initiation and evolution of the first portion of the Buffalo, NY historic lake effect snow event (24-26 December 2001).
When Good Models Go Bad	A look at how the Eta model led to two different forecasts during the East Coast snow storm of December 2000, due to boundary-layer forcing from SST
How Good Data Can Lead to a Poor Model Analysis	An example of limitations in detecting and analyzing mesoscale phenomena in the Eta model
How Different Data Types Impact the Eta Analysis and Forecast	A discussion of how different data types impact the analysis and forecast, based on the results of the Zapotocny et al. case study published in *Weather and Forecasting* (2000)
Climatology of Forecast and Observed Precipitation	Provides maps to compare model-predicted and observed frequency of 24-hour and 48-hour precipitation exceeding various thresholds to serve as a reference of characteristic model behavior
Spurious Grid-Scale Convection in the Eta Model: A Case Example	The AVN produces spurious precip "bombs." Now the Eta does too. Here's a detailed look at Eta model forecast fields leading up to and during an event, including forecast impact and explanation of what's going on inside the model
Allison Rains in Houston, TX: Were their magnitude predictable from NWP models?	This first of three cases considers whether the volume of rain that occurred over the Houston, TX area, particularly on 8 June, was predictable using the Eta-22 and Eta-10 NCEP models
Tropical Storm Allison in the Southeast U.S.	An examination of the possible role of initial conditions, resolution, and precipitation processes in the predictability of Allison's movements from LA to NC from 11–14 June 2001

Figure 1. List of some of the available cases

How Good Data Can Lead to a Poor Model Analysis

MENU

Introduction

Why? Clues in conventional data

First guess, analysis, and radiosonde soundings

What else is influencing the analysis?

Good data pulled analysis away from raob report

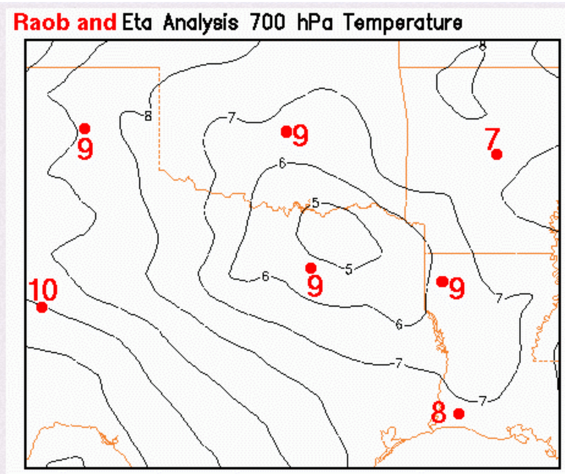
Sampling limits detection of mesoscale features

How representative is an observation?

Assumed length scales prevent inclusion of mesoscale features

Summary

Background: Understanding Data Assimilation



The operational 22-km Eta model analysis differed considerably from radiosonde 700 hPa temperature reports over a broad swath of Oklahoma and northeast Texas on 13 August 2001. The radiosonde temperatures are almost the same across this entire area. Although it turns out that the first guess (not shown) agreed well with the 700 hPa temperature from FWD (Fort Worth, TX), the analysis has the largest disagreement in this area. This caselet includes a series of questions to help a forecaster probe what happened and the implications for detecting and analyzing mesoscale atmospheric features.

Learning objectives

In this case study, the student will gain concrete awareness of:

1) Limitations caused by inadequate observation sampling
2) Limitations on the representativeness of observations
3) Effects of horizontal spreading of information in the analysis ("correlation length")
4) The role of variable linkages in an analysis
5) A key motivation and goal of analysis changes currently under development

Figure 2. Table of contents in left panel includes links to background material, and the introductory page includes learning objectives.

3. EXAMPLES OF TOPICS AND DESIGN

A description of some of the cases is shown in Figure 1. Several cover extreme weather events, such as the 20-inch rains dropped by tropical storm Allison. Others cover particular characteristics of model parameterizations, or, in the case of spurious precipitation bulls-eyes, how model parameterizations interact with each other and model dynamics to produce poor forecasts. Some, such as the historic Buffalo lake-effect snow event, examine capabilities following a model upgrade (grid spacing reduced to 12-km and new mixed-phase microphysics with advecting precipitation introduced). Some, like that shown in the companion paper JP2.2 (Bua and Jascourt, 2002), explain how to utilize new tools such as the NCEP Short Range Ensemble Forecast (SREF) system. And others, like the one discussing the impact of different data types on the analysis, simply highlight application of key NWP concepts.

The layout of a case, with a frame containing the table of contents and a frame in which each page is displayed, is shown in Figure 2. The nine links in the table of contents indicate that the case has nine pages, which is more than most. Note that the left frame also includes links to background material. The first page (shown in the figure) includes learning objectives, making the goals for the student clear.

Questions are utilized to engage the learner, the answers are marked, and some material is presented in discussion form following questions, as shown in Figure 3. If there are multiple correct answers and not all are selected, a pop-up box says this without indicating which unselected answers are correct, and the student may try again. The discussion is hidden until the question is answered. Not all cases have questions.

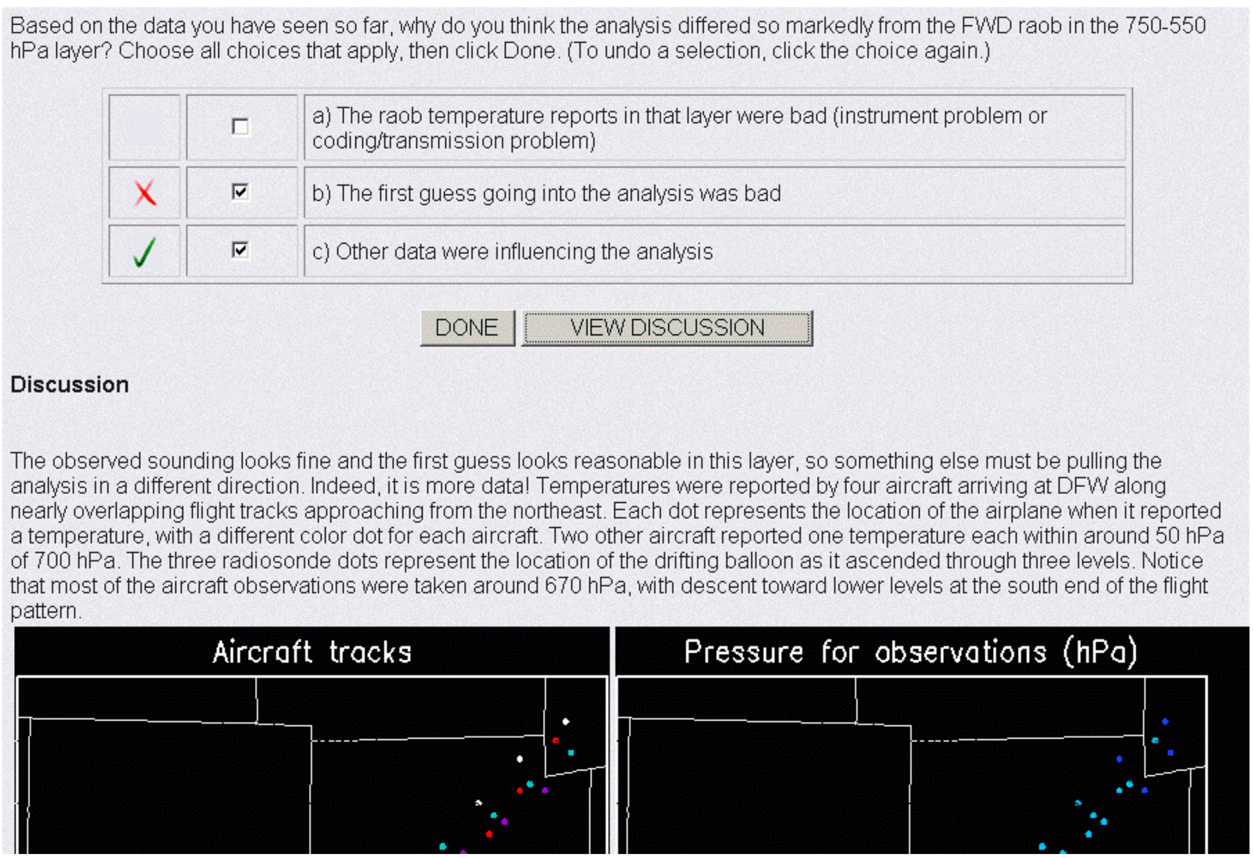


Figure 3. Many cases include questions for the reader to answer, with further information and explanations following. The example shown here is from the same case shown in Figure 2. This further explanation includes presenting data ingested into the model analyses but which forecasters seldom examine. The peculiar analysis seen by the forecaster and shown in Figure 2 resulted from 3D-VAR applying large-scale isotropic covariances to data capturing an undersampled long-but-narrow mesoscale feature. Forecasters may be surprised to learn that observed mesoscale details resolvable by the Eta model with grid spacing at 12 km cannot be added to the analysis without aliasing to larger scales and interested to know that NCEP is working on improving this by developing anisotropic covariances for assimilating mesoscale data .

The content includes evaluations of model forecast fields as in Figure 4, illustrating performance of the 12-km Eta model for the lake effect case. Content includes applications and model-specific details, such as for precipitation type forecasts as in Figure 5. This shows an example where the AWIPS grids of model precipitation type disagree with the model's own microphysics parameterization. Figure 5 also illustrates the interactive capability of VISITview teletraining.

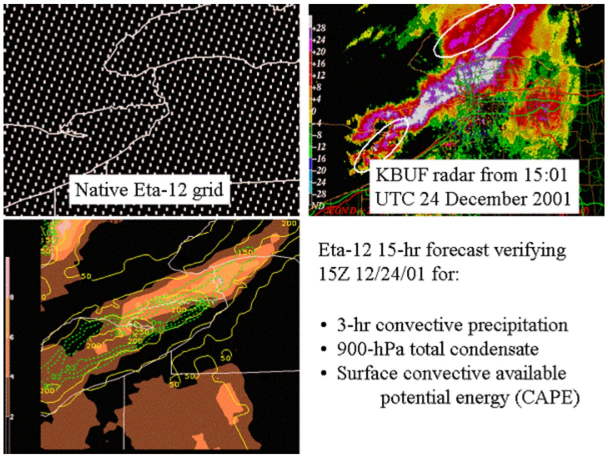


Figure 4. Lower left: dashed contours are convective precipitation and shading is grid-scale condensate. The case notes that the position of the lake-effect snowband in the 15-hour forecast compares remarkably well to the radar (upper right), but the mesoscale detail (southwest circle on radar image) cannot be resolved by the model and the Lake Ontario appendage to the snowband (also circled) was missed.

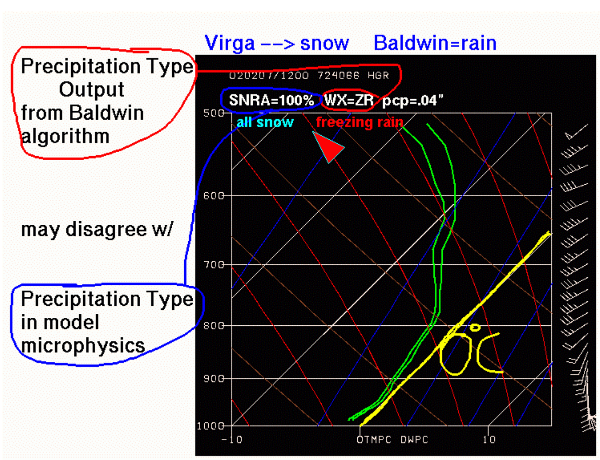


Figure 5. The new microphysics parameterization is predicting 100% snow with this entirely-subfreezing model sounding, while the model output grids of precipitation type come from an independent algorithm which is calling for freezing rain. This case was presented in a VISITview teletraining session, during which the instructor and the students can mark up the images such as with the hand-drawn annotations/highlights illustrated here.

Some content pertains to interpretation of model fields in light of new research findings. For instance, with finer model resolution and forecasters keying in on regions where strong vertical motion is predicted, we are finding model soundings with moist absolutely unstable layers (MAULs, Bryan and Fritsch, 2000). To forecasters, they look unrealistic and highly unstable, but actually they may be neither.

4. FUTURE DEVELOPMENT

Many cases are under development and should be online at the time of the conference. The need for new cases will continue as the models are changed, new model behavior is found, cases arise which nicely illustrate application of NWP concepts or present good critical thinking challenges that can be presented quickly, and when new model tools such as the short-range ensembles are developed. Effort will be made to have the collection of cases meet the varied instructional goals and to provide broad geographic coverage. Also, the cases list on the home page will be structured to be more useful, perhaps sortable geographically and by topic and season.

However, urgent matters such as new sudden recurrent pathological behavior of an NCEP operational model will instead be discussed in the newsgroups facilitated by the COMET Program at http://meted.ucar.edu/nwp/newsgroups/

5. ACKNOWLEDGEMENTS

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