J20.8 COLLABORATIVE EFFORTS BY THE ATMOSPHERIC RESEARCH AND OPERATIONS COMMUNITES FOR IMPROVING A THUNDERSTORM NOWCASTING SYSTEM

Amanda R. S. Anderson, Rita D. Roberts
National Center for Atmospheric Research, Boulder, Colorado

Matthew R. Volkmer, David W. Sharp
National Weather Service, Melbourne, Florida

1. INTRODUCTION

The National Center for Atmospheric Research (NCAR) is collaborating with the National Oceanic and Atmospheric Administration's National Weather Service (NWS) forecast office in Melbourne, Florida to further advance the AutoNowCaster (ANC) system. The ANC was developed at NCAR for the purpose of providing short-term, rapidly updating nowcasts of thunderstorm initiation, growth, and decay (Mueller et al. 2003). The system ingests model data (specifically the Rapid Update Cycle – RUC), surface observations, satellite, and radar data. These data are processed and run through a system of fuzzy logic equations and weights to produce 1-hour interest field nowcasts that update approximately every 5 minutes. In addition to these data, forecaster input is an essential component of the system. The value of human input into an automated system is being tested with the ANC as part of the Forecaster Over the Loop (FOTL) project (Roberts et al. 2005). The forecaster selects a particular weather regime (e.g. cold front) that is in effect on a given day, and the corresponding set of fuzzy logic equations and weights are activated within the ANC. The equations and weights are tuned to different types of weather patterns, or regimes, as the important environmental and triggering factors for some regimes (e.g. summertime air mass thunderstorms) are not necessarily the same for others (e.g. a cold front situation). Forecasters can also draw in convergence boundaries for the system (e.g. fronts, sea breezes, thunderstorm outflow) that, under favorable environmental conditions, can trigger new convection (Fig. 1). These boundaries add additional interest to the nowcasts. Another forecaster interaction is the adjustment of the initiation interest field higher or lower ("nudge") when the forecaster determines that some of the input fields are not representative of the environment. For example, if RUC moisture is too high, the nowcast interest fields may also register too high and over-alert. With the nudge tool, the forecaster can adjust the nowcast product accordingly. In this RUC moisture example, one would decrease the initiation interest to counteract the incorrectly high RUC moisture. These forecaster actions, combined with the automated system, produce a final nowcast product for consumption by a variety of customers, the scope of which remains quite open. The final nowcast product highlights areas of expected thunderstorm initiation as well as expected location and size of existing radar echoes that have been extrapolated and grown/decayed accordingly. An example of the initiation interest field is found in Fig. 2, and an example of the final nowcast is found in Fig. 3.

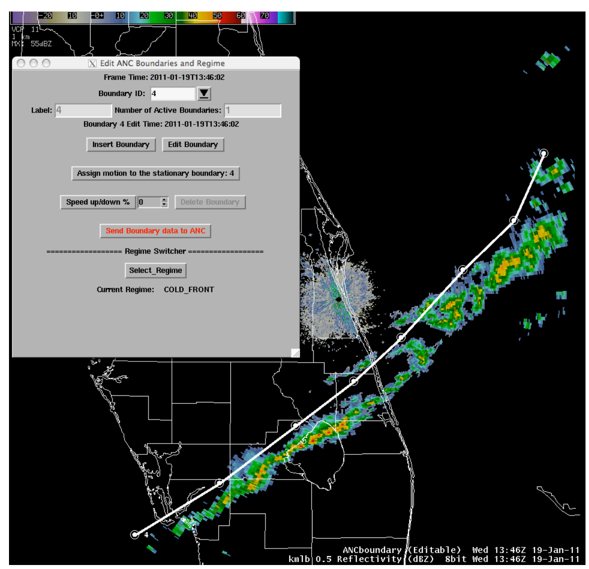

Figure 1: An example of boundary entry for the ANC system. A boundary dialog box (upper left) allows the forecaster to assign an ID number and motion while the boundary itself appears as an adjustable object (white).

* *Corresponding author address:* Amanda R. S. Anderson, National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307;
email: aander@ucar.edu

Nowcasts from the ANC system are envisioned as contributing to the Federal Aviation Administration's Next Generation Air Transportation System (FAA's NextGen). Weather is an important component of this plan for the future of air traffic management. The NWS is involved in the creation of a definitive source for NextGen weather data called the Four Dimensional Weather Data Cube (Souders et al. 2009). The ANC is being analyzed and tested to determine its potential contributions to the weather cube. In particular, in an operational capacity the forecaster will have an important role in interacting with the ANC to produce the final products that may contribute to the weather cube. Inclusion in NextGen and the ultimate forecaster involvement has been one of the driving forces behind collaboration between NCAR and the NWS on the ANC.

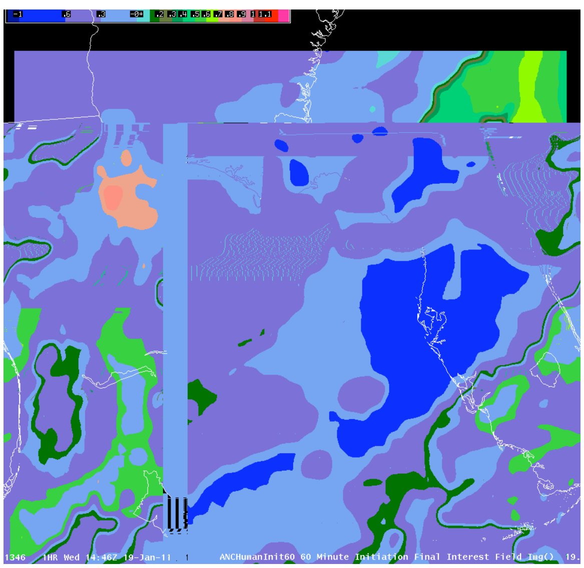

Figure 2: An example of a final ANC initiation interest nowcast. Increasingly lighter shades of green are approaching the initiation threshold, while areas above the threshold appear in salmon. Darker blues indicate areas where initiation is not expected (negative interest).

The ANC was installed in the Fort Worth, Texas Weather Forecast Office (WFO) in 2005. The forecasters in Fort Worth provided a great deal of feedback on the system that led to many improvements. At the initial installation, the ANC ran with one default set of fuzzy logic weights and functions, but through collaboration with Fort Worth the system evolved to 7 sets of weights and functions for 7 different regimes identified by the WFO. Additionally, the ANC technology was transferred to the NWS Meteorological Development Laboratory (MDL), which took responsibility of operational monitoring and troubleshooting of the technical aspects of the ANC. Collaboration with both MDL and Fort Worth led to MDL rendering specific ANC fields and tools on a prototype Advanced Weather Interactive Processing System (AWIPS) display that allowed the forecasters to interact with ANC system and display fields on the same platform they use for the rest of their daily tasks (Figs. 1, 2, and 3).

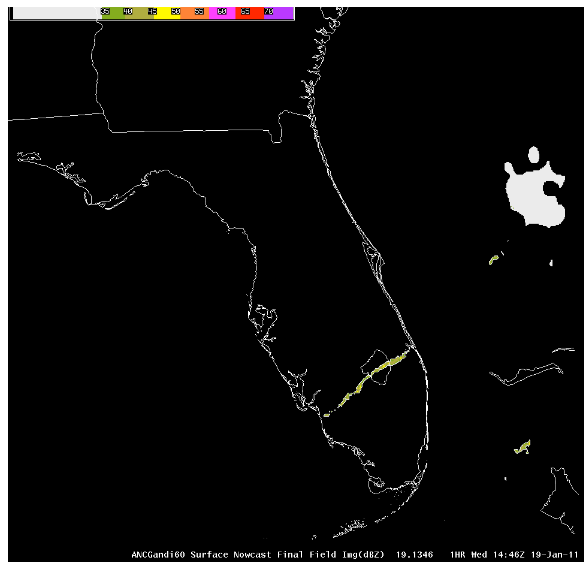

Figure 3: An example of the final ANC nowcast. Areas of expected initiation appear in light gray. Grown/decayed, extrapolated radar echoes appear in shades of dark yellow to red.

In April 2010, the ANC was installed in the Melbourne WFO to continue to develop and test the ANC in a subtropical climate. This paper discusses the ongoing collaborative efforts between NCAR and NWS Melbourne to develop a set of ANC regimes for the Florida warm, wet season, which has a tropical nature unique from the midlatitude regimes developed for the Fort Worth area.

2. COLLABORATION

To begin the collaboration process, members of NCAR and MDL met with Melbourne staff in December 2009 to provide background on the ANC and learn about the WFO's ideas for incorporating the ANC into their concept of operations. NCAR also received information on the Florida warm season, including lightning climatology maps stratified by wind flow pattern and ridge axis location (Lambert et al. 2006) and additional mesoscale information on wind flow patterns and the numerical weather prediction parameters of importance for Florida (Shafer and Fuelberg 2008). NCAR scientists explored this information as they researched how best to develop warm season regimes for the ANC for the Florida area. Additionally, work was done by NCAR to tweak the existing cold front and mixed regimes for the remainder of the cool, dry season. However, a combination of unusual weather patterns and few cases prevented a thorough tuning of these regimes, and NCAR continues to work on adjusting the cold season regimes for Florida as more cases are collected.

In April 2010, NCAR and MDL scientists again traveled to Melbourne to further discuss attributes of the Florida warm season and how the ANC would be used in Melbourne WFO daily operations as well as to train staff how to use the system. Prior to this meeting, MDL had transferred the AWIPS-ANC code to Melbourne technicians for installation. Researchers demonstrated the AWIPS interface to the ANC, which included an overview of the fields available for viewing and how to use the interaction tools to change regimes, enter boundaries, and nudge the nowcast (Fig. 4). Forecasters gave feedback on the ease of use, including field naming conventions they felt would be more helpful in an operational setting than the current ones. The field names used by the researchers were not always immediately intuitive to a new user. The staff members also explored entering many different shapes and movements of boundaries, pleased that shapes such as a circularly expanding gust front, which is common in Florida, were easily handled by the interface. For this demonstration, the WFO chose to limit the training audience to a core group of forecasters that would ultimately be responsible in training the rest of the staff in the future.

After the second meeting, NCAR scientists began work developing the warm season ANC regimes based on the wind flow pattern classifications provided by Melbourne. As a first pass, the existing air mass (locally forced summertime convection) regime from the Fort Worth system was used as a base. Melbourne's lightning climatologies were added as an interest field, and the membership functions and weights of different parameters were tweaked as case studies of past events were run and the forecasts compared with observations. This work involved collecting warm season cases occurring in the Florida peninsula and rerunning the ANC with the new sets of fuzzy logic functions and weights. After several cases were examined, these first pass regimes were delivered to the Melbourne WFO so that the forecasters could use them in an operational setting and provide feedback on their performance. Along with installation of the new regimes, a list of the fuzzy logic weights and functions were given to the office so that the forecasters were not working with a "black box" system. The Melbourne WFO's ANC focal point began using the system during this time, and the newly arrived Hollings Scholar was assigned to use the system on a daily basis and document its performance as part of his summer research. It was quickly observed that basing the warm season regimes on the existing Fort Worth air mass regime was not working well. The forecasters described their concerns and suggestions for the system, such as using forecast parameters commonly used by the office, e.g. precipitable water. Additionally, both forecasters and researchers agreed that the regimes' heavy use of satellite predictors was not optimal for Florida. Based on discussions between NCAR, MDL, and the Melbourne WFO, researchers began updating the warm season regimes with common forecast parameters used by Melbourne forecasters, parameters provided in Shafer and Fuelberg (2008), and the lightning climatologies. The same process of case study reruns was used to determine the best settings of fuzzy logic functions and weights. These updated regimes are currently running operationally for the Melbourne WFO. The ANC focal point has continued working with the system and the WFO has assigned a new Student Career Experience Program (SCEP) student to monitor the system on a daily basis. The SCEP student has provided detailed summaries of cases and the ANC performance for each. The WFO has shared these cases and suggestions for improvement with researchers, and after discussions in science meetings NCAR researchers have begun to examine how to implement some of these improvements.

3. IMPORTANCE OF COMMUNICATION BETWEEN RESEARCH AND OPERATIONS

There have been several benefits for involving operational forecasters in the process of developing the ANC system before it is fully available for widespread use. A major assistance for the researchers is the local expertise of the forecasters. Forecasters are able to quickly point out nuances of forecasting in their county warning area that researchers unfamiliar with the area may not pick up on right away. This was especially helpful in development of the warm season regimes. After it was determined that basing the warm season regimes off the existing Fort Worth air mass regime would not work, NCAR was able to speak with forecasters about the logic they use to forecast daily and use those parameters as a base for updating the regimes. Forecasters also brought up several challenges unique to their area. These included the structure and movement of the sea breeze and importance of thunderstorm outflow boundaries, which can become so numerous that it would be impossible to enter each boundary into the system in an operational setting. For the forecasters' benefit, the researchers have the experience, resources, and most importantly time to take their input and incorporate it into the advancement of the ANC guidance tool. Specifically, with all their other duties, the Melbourne office would have difficulty fitting much ANC work into their schedules. On the other hand, NCAR has blocks of time dedicated specifically to the ANC as well as the familiarity with the system to see how forecaster ideas can be implemented. By dedicating time to working with the ANC, forecasters can also have a direct impact on the development of a tool that may be deployed operationally in the future and become a part of their day to day operations.

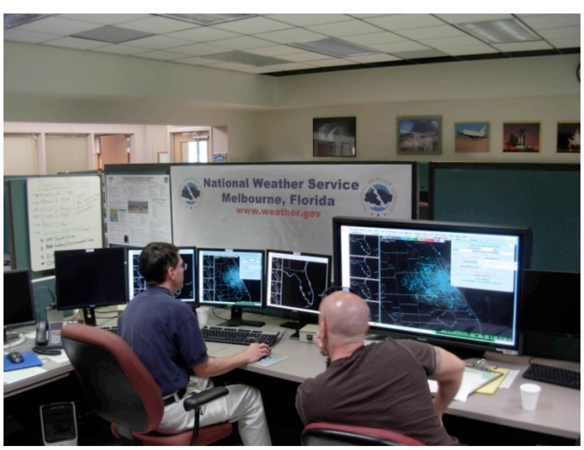

Figure 4: Forecasters at the Melbourne WFO receive training on how to use the ANC interface (photo by Eric Nelson, NCAR).

In addition to benefits for the theoretical development of the system, having the ANC in a WFO setting allows its evaluation from an operational point of view. The WFO is able to observe how the ANC system fits into their concept of operations and alert researchers to any potential issues. An important example of this occurred at the Fort Worth WFO, where it was recognized that little interaction was occurring with the ANC because it resided on a separate workstation and required use of a different interface (a display program used at NCAR). Modifying the AWIPS for display of ANC fields allowed forecasters to observe and interact with the ANC within their normal display system and resulted in increased system interaction. This in turn benefited the researchers that were evaluating the effects of forecaster input.

4. CRITERIA FOR SUCCESS

In order for this type of collaboration between research and operations communities to be successful, both sides need to facilitate communication by recognizing the expertise of each, budgeting adequate time for the project, and working at keeping each other informed of progress and research goals.

Researchers must recognize the importance of the local expertise possessed by the forecasters and be willing to consider and implement their suggestions. For the ANC project, meetings with the WFO to identify the data and parameters used for their day to day forecasts was a way for researchers to tap into this local knowledge and incorporate it into development of the warm season regimes. It was also a chance to understand the forecast challenges that needed to be addressed, such as the extremely important role various types of boundaries play during the warm season, where convection is predominately locally forced. It is also important for researchers to make the project accessible to the forecasters and straightforward for them to use. This was demonstrated through both MDL's development of an ANC interface for AWIPS and use of intuitive naming conventions. NCAR and MDL scientists also endeavored to respond to WFO requests, such as including a lightning-potential product that had been developed but was not currently running in the system.

On the forecaster side, the WFO must be willing to budget the time and resources to work with the research project and lend their skills in both developing and testing. The Melbourne WFO has been making the ANC one of their research priorities and has developed a concept of operations to integrate the ANC into their daily work. This included limiting exposure to the ANC to a core group of forecasters envisioned to train others in the office over time, assigning a Hollings Scholar and SCEP employee to monitor the system daily, and assigning an ANC focal point. Additionally, the forecast office must be enthusiastic about the research project. If the forecasters are disinterested in the project, they likely will not find the resources to provide valuable input to the researchers. The Melbourne office has been eager to learn how the system works, including details about the fuzzy logic itself, and have their own ideas on how their office can use ANC output to fulfill their mission statement. For example, the Melbourne office has expressed interest in using ANC products to produce graphical forecasts for their website.

Most importantly, open communication must be maintained between the research and operations entities. For the ANC project, NCAR keeps communication with Melbourne through periodic e-mails with questions, suggestions, and performance ratings, and scheduled meetings and teleconference calls. Both researchers and forecasters endeavor to actively participate in the discussions and respond to suggestions provided from both sides. This communication also allows both sides to reach a consensus on the direction in which ANC research is envisioned to go given time and resource constraints on both the research and operations sides. One example of this type of consensus involved the ability of NCAR to produce regimes that worked well for the Florida climate. The Melbourne office mentioned a large set of different types of regimes, such as tropical cyclone and transition season nocturnal convection. Further discussion led to a compromise on how many regimes could be realistically developed and delivered to the operational ANC system.

Collaboration between research and operations groups benefits both sides as well as the goals of the research project in which they are involved. Early involvement of forecasters can pinpoint issues with the research product and offer solutions early in the development process. In addition to aiding researchers, such collaboration can help the forecast office advance its own research goals and have a voice in products that may eventually find their way into the office operationally. Rather than simply transferring research to operations, the ANC project involves collaboration between the two entities that uses expertise on both sides to enhance thunderstorm nowcasting capabilities.

5. ACKNOWLEDGEMENTS

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