27 July 2001

Mr. Sam Contorno
1325 East-West Highway
SSMC2; Mailcode W/OST12
Room 15326
Silver Spring, MD 20910

Dear Sam,

We are transmitting a report of our CSTAR activities as requested for the six-month period ending 31 July 2001. Our emphasis during this period has been on spinning up research outlined in the CSTAR proposal on cool season heavy precipitation events over the northeastern US, and integrating and coordinating our research efforts with staff members at selected NWS offices (ALB, BGM, BTV, CTP). Three graduate students (David Groenert, David Novak, and Brandon Smith) are actively engaged in the initial research effort. Groenert is focusing on the role of large-scale circulation regimes in the control of heavy precipitation. Novak is exploring mesoscale substructure in extratropical cyclones, and Smith is investigating how cutoff cyclones control the distribution of heavy precipitation as modulated by the underlying terrain. The three graduate students have also established a working relationship with three NWS staff members who are serving as research and operations focal points for NWS collaborators (Richard Grumm at CTP, Jeff Waldstreicher at BGM, and Dan St. Jean at BTV).

During the 2001-2002 academic year we plan to expand our research to warm season heavy precipitation events as outlined in our CSTAR proposal. A new graduate student, Matt Novak, will target his research in this new area. On the NWS side, Kenneth LaPenta of the ALB WFO will serve as the research and operations focal point for the warm season heavy precipitation studies. We also plan to recruit a fifth graduate student to join the CSTAR research team. He/she will be assigned to work on the warm season heavy precipitation problem.

The three graduate students assigned to cool season heavy precipitation projects (Groenert, Novak, and Smith) will present the results of their initial research findings at the Third Annual Northeast Regional Operational Workshop (NROW) to be held in Albany, NY, on 6-7 November 2001. The NROW meeting will also be a good time to discuss ways and means for transitioning our cool season research results into NWS operations.

As of this writing we have no formal publications to report. Problems encountered to date have been minor and mostly involve solvable technical issues.
Our report is organized as follows. Section 1 contains the summary of graduate student research activities on cool season heavy precipitation events. Interactions with NWS staff members are highlighted in these student reports. Section 2 contains a report by Gene Auciello on the NWS perspective while Section 3 presents David Knight's contribution on computer and technology transfer issues.

Sincerely,

Lance F. Bosart
Professor

Daniel Keyser

cc: Gene Auciello
    David Knight
    David Groenert
    David Novak
    Matt Novak
    Brandon Smith
"The Collaborative Science, Technology, and Applied Research (CSTAR) Program"

Title:

"Improving the Prediction of Cool- and Warm-Season Heavy Precipitation Events over the Northeastern United States"

University: University at Albany

Name of University Researchers Preparing Report: Lance F. Bosart and Daniel Keyser


Name of NWS/AFWA/Navy Researcher Preparing Report: Eugene P. Auciello

National Oceanic and Atmospheric Administration Award Number: NA07WA0458

Date: 27 July 2001
SECTION 1: Summary of Graduate Student Research Activities

(a) Large-Scale Circulation Anomaly Indices (David Groenert)

Research Summary:

Construction of a daily time series of large-scale circulation anomaly indices (LSCAI) stems from interest in relationships between these large-scale indices and regional or local precipitation anomalies over the Northeast United States. The first goal of the LSCAI project is to calculate a daily North Atlantic Oscillation (NAO) index from 1948 to the present. Values of the NAO index are found by taking the difference of normalized sea-level pressure and 500 hPa height between Ponta Delgada, Azores (37°45’N, 25°40’W) and Stykkisholmur, Iceland (65°05’N, 22°44’W). This has been accomplished by extracting sea-level pressure and 500 hPa height data from NCEP/NCAR Reanalysis Data CD’s. Both sea-level pressure and 500 hPa height are considered in order to determine the degree of consistency between these complementary representations of the NAO. Due to the 2.5° x 2.5° resolution of the NCEP/NCAR Reanalysis, interpolation of the sea-level pressure and 500 hPa height values at the desired locations was necessary. Computation of the difference of the normalized sea-level pressure and 500 hPa height between the two locations is being completed via a recently coded Fortran program. Validity of the daily NAO time series will be assessed through a comparison of monthly means of the daily NAO index calculated from sea-level pressure data with monthly values of the NAO index calculated by Hurrell (2001). As an example of our calculation procedure, a time series of daily NAO values for the period 1 Jan ’99 through 30 Apr ’99 is shown in Fig. 1.

NWS Contacts:

Continuing contact with the NWS concerning the LSCAI research has been maintained throughout the first half of 2001. An informal meeting with Richard Grumm transpired at the State College WFO on 19 July 2001, in which the logistics of calculating a daily NAO value and relating the indices to heavy precipitation events in the Northeast United States were discussed. Besides the meeting with Rich Grumm, a progress report of the LSCAI project was presented on 25 April 2001 at the Spring 2001 Collaborative Science, Technology, and Applied Research (CSTAR) meeting held at the Albany WFO. Participants discussed possible future applications of the large-scale project.

Once calculations of the major indices have been completed, the frequency and content of the exchanges are anticipated to increase as interpretation and meteorological application of the data becomes possible. Interaction with other CSTAR participating NWS offices is also expected as the LSCAI research is incorporated into the Mesoscale Substructure and Cutoff Cyclones projects.
Future Goals:

Once the dataset of the daily NAO index is complete the software will be modified to calculate other desired indices. Currently the Southern Oscillation Index and Pacific North American index are the next to be calculated. Upon completing the calculations, relationships will be determined between LSCLI and planetary-scale flow signatures crucial to precipitation associated with mesoscale substructures in extratropical cyclones in the northeastern United States.

Reference:

http://www.cgd.ucar.edu/~jhurrell/nao.html

Figure:

![Daily NAO Index](image)

**Fig. 1.** Time series of Daily NAO Index (hPa) calculated as the difference of normalized sea-level pressure between Ponta Delgada, Azores, and Stykkisholmur, Iceland.
Mesoscale Substructure (David Novak)

Research Summary:

Our first task was to identify significant precipitation events in the Northeast United States during the cold season (October through April). This was accomplished by utilizing the Unified Precipitation Dataset (UPD), which incorporates the National Weather Service (NWS) Cooperative Observing Program precipitation observations with conventional measurements. The data are interpolated to a 0.25° x 0.25° grid resolution. A significant precipitation event was defined as a 24 h period total (beginning and ending at 1200 UTC) greater than 1.00” for rain events, and 0.50” liquid equivalent for snowfall events in the research area. The domain of interest is bounded on the west by 85°W, on the south by 36.5°S, on the east by the Atlantic Coast, and on the north by the Canadian border.

The UPD criteria were applied from October 1993 through December 1997, yielding 138 events. An independent comparison between this list and cases identified using the NOAA Daily Weather Maps (DWM) series showed that the UPD method captured all events identified using the DWM (with exception to lake-effect snowfall events), and caught several cases that the DWM did not. A catalog of synoptic summaries for each case was created for reference.

Radar data from the WSR-88D network will be used extensively to examine the mesoscale substructure of each case. We have acquired national mosaic radar data from COMET with 2 km spatial resolution and 5 min temporal resolution to identify banded structure in each case. Initially, three months of radar data have been obtained (November 1996, December 1996, and January 1997) and were used to devise a classification scheme for banded structure. After viewing the radar data it became apparent that some subjectivity was inevitable, since a case may exhibit more than one type of banded structure through time, and individual bands evolve through a life cycle. Keeping these considerations in mind, the following band classification scheme has been proposed (see Table 1), but remains open to modification.

**Table 1: Band Classification Scheme**

<table>
<thead>
<tr>
<th>Band Type</th>
<th>Band Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonbanded</td>
<td>No coherent (both spatial and temporal) linear features</td>
</tr>
<tr>
<td>Multibanded</td>
<td>Several bands separated from each other, with the same spatial orientation</td>
</tr>
<tr>
<td>Nor’easter bands</td>
<td>Structure where smaller bands embedded in the cold conveyor belt continuously merge into a primary single band</td>
</tr>
<tr>
<td>Single</td>
<td>Linear shape with strong dBz gradients coherent for over 2 h, but lacking the merging characteristic of the Nor’easter bands</td>
</tr>
<tr>
<td>Prefrontal</td>
<td>Narrow band ahead of or along the cold front</td>
</tr>
<tr>
<td>Undefined</td>
<td>Some banded structure evident, but not well defined or occurring on a short time scale (&lt; 2 h).</td>
</tr>
</tbody>
</table>
In a parallel effort, case studies of three “Nor’easter” banded structure storms were examined. Frontogenesis in the presence of small symmetric stability was present in all three cases, consistent with findings from previous research efforts (e.g., Sanders 1986, Nicosia and Grumm 1997). Figure 1a shows the WSR-88D Northeast U.S. composite radar at the height of the 5–6 February 2001 storm. Note the single intense band arcing around the storm center. A cross section through this band (Fig. 1b) exhibits a narrow band of maximum ascent along the warm boundary of a sloping region of frontogenesis, coincident with the band location. Note that the updraft tends to follow $\theta_e$ surfaces, consistent with the findings of Sanders and Bosart (1985). Displays such as this can help forecasters better visualize mesoscale substructure.

Educational exchanges:

Consultation with the NWS has been frequent. Two formal meetings were conducted at Binghamton WFO: the first, held 27 February, centered on the logistics of the project and data acquisition; the second, held 27 June, focused on band classification and case studies. Additionally, the spring CSTAR meeting on 25 April facilitated interaction with the Buffalo WFO with respect to lake-effect snow bands. Forecasters were involved in critiquing the UPD methodology and played an integral part in devising the band classification scheme. These activities will continue to mold the research into a form that is both operationally useful and scientifically meaningful to the forecasting community.

NWS contributions to the project have been frequent as well. Dave Nicosia from Binghamton drew attention to a null case for which he has data. Mike Caropollo and Hugh Johnson from Albany created a case list from the DWM from 1996 to the present that was used to supplement the UPD case list. Formal spin-off projects include a mixed precipitation study for the Binghamton CWA headed by Mike Jurawitz, and lake-augmented heavy snow bands in the central New York region headed by Tom Nizioł of the Buffalo WFO.

Obstacles to progress:

The greatest delays have been related to data acquisition. The UPD has not been updated beyond December 1997, although it is scheduled to be updated to the present by the end of this summer. In the meantime we have requested radar data for the dates determined from the DWM case list. Once we obtain the UPD update we can examine the period from January 1998 to the present retroactively, adding any cases not initially requested.

The COMET mosaic radar data is central to identifying banded structure, but is incomplete. Large data gaps (on the order of months) exist through the first year (November 1996–November 1997), and although the latter portions of the dataset are more complete, data gaps on the order of hours are still present. Archives from individual radar sites may be used to fill these data gaps, although these archives are by no means complete as well.
Future work:

We will continue to catalog radar data as it becomes available, developing a banded case list and documenting when, what type, and where banding occurs within the storm. Parallel work will center on refining the case studies—exploring the isentropic viewpoint and the use of Vis5D. Additional case studies of nonbanded and multibanded cases will be conducted, with emphasis on frontogenesis, stability (upright and slantwise), shear, and physiography. We would also like to initiate more spin-off projects such as investigating the rain/snow line and its interaction with topography, exploring the microphysics of banded events, and running mesoscale model simulations of selected cases.

References:


Fig. 1. (a) WSR-88D northeast composite radar image at 0000 UTC 6 February 2001. (b) Cross section (shown as black solid line in Fig. 1a) from the 0000 UTC 6 February Eta analysis depicting frontogenesis (shaded every 4°C/100 km/day), saturated equivalent potential temperature (K, thin solid green lines), and total horizontal wind tangent to the cross-section plane and omega (black arrows).
Research summary:

The rationale for this research is to determine the extent to which the occurrence of heavy precipitation events associated with slow-moving cutoff cyclones over the northeastern United States is controlled by large-scale circulation anomalies. The initial task was to create a cool-season (Oct–Apr) climatology of cutoff cyclones over the northeastern United States and eastern Canada. Keeping in mind the terrain issues that forecasters face in this part of North America, the "Northeast" will be defined as the area from 35°N to 50°N, and 80°W to 65°W. These boundaries were chosen so that the major geographical features that have a significant impact on heavy precipitation are included. This area also correlates well with areas favorable for the occurrence of 500 hPa cutoff cyclones during the cool-season months, as shown in Parker et al. (1989).

The first step was to perform a subjective search for cutoff cyclones. For our purposes, a cutoff cyclone is defined as a 500 hPa height minimum surrounded by at least one closed height contour (6 dam contour interval assumed). The Daily Weather Map Series (DWMS), which includes a once-daily (1200 UTC) 500 hPa constant pressure analysis, was used. The DWMS was inspected, and 500 hPa cutoffs matching the above definition were catalogued and their tracks were plotted. The availability of the DWMS was such that two periods of cool-season cutoffs were considered: 1969–1973 and 1985–1989.

A limitation of the DWMS is that it provides only one (1200 UTC) cutoff cyclone position per day. In order to increase the temporal resolution, twice-daily (0000 UTC and 1200 UTC) gridded analyses of 500 hPa height at a spatial resolution of 2.5° x 2.5° were accessed from NCAR/NCEP reanalysis CDs and mapped using the General Meteorological Package (GEMPAK). For comparison purposes, the same five-year periods as for the DWMS tracks were considered, and cyclones that matched the defined characteristics of a cutoff were identified and catalogued. Once it was clear that the DWMS and the NCAR/NCEP reanalysis yielded the same set of cutoff cyclones, the latter data source was used to create a library of 500 hPa cutoff cyclones for the cool-season months of 1961–2000.

The library of cutoff cyclones over the Northeast was matched with a list of heavy precipitation events over the same area. A heavy precipitation event is defined as a 24 h period in which 1 in (25.4 mm) or greater of rainfall, or 6 in (15 cm) or greater of snowfall occurred. The latter criterion was included rather than liquid equivalent to account for the higher ratios found in very cold air and lake-effect snow. A list of qualifying events was prepared by utilizing the Unified Precipitation Dataset (UPD), which incorporates the National Weather Service (NWS) COOP precipitation observations with conventional measurements. The data were interpolated to a 0.25° x 0.25° resolution using code developed in-house. Gridded data were mapped using GEMPAK. Currently the library of 500 hPa cutoff cyclones is being compared with the list of heavy precipitation events, and the overlapping events are being catalogued.
Preliminary results:

The library contains a total of 847 cutoff cyclones for the 40 cool seasons from 1961 through 2000. This total breaks down to an average of about 21 per season. A signature of the relative maxima of cutoffs during spring and fall, as noted in Bell and Bosart (1989), is evident in the data as well. The distribution of average number of cutoff cyclones by cool-season month follows in Table 1. Initial estimates indicate that approximately 60% of cutoffs were directly related to a heavy precipitation event.

**Table 1:**

<table>
<thead>
<tr>
<th>Month</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>5</td>
</tr>
<tr>
<td>November</td>
<td>3</td>
</tr>
<tr>
<td>December</td>
<td>2</td>
</tr>
<tr>
<td>January</td>
<td>2</td>
</tr>
<tr>
<td>February</td>
<td>2</td>
</tr>
<tr>
<td>March</td>
<td>3</td>
</tr>
<tr>
<td>April</td>
<td>4</td>
</tr>
</tbody>
</table>

An example of a qualifying cutoff cyclone that produced heavy rain in the Northeast for the period 7–10 Nov 1997 is shown in Fig. 1. The 1200 UTC 500 hPa height field is contoured, and accumulated precipitation for the 24 h period ending at 1200 UTC is shaded. The slow movement of the system (it took four days to progress from the Tennessee Valley to coastal Maine), coupled with possible terrain effects in the Appalachians, resulted in copious amounts of rainfall across Central Pennsylvania, New York, and New England. Furthermore, the precipitation over land rotated cyclonically with respect to the cutoff cyclone center and reflects the influence of terrain in the locations of the various precipitation maxima.

Future work:

The next step is to acquire the 0600 UTC and 1800 UTC NCEP/NCAR 2.5° x 2.5° gridded 500 hPa height fields for the Oct–Apr 1961–2000 period. These fields will be used to determine 6 h positions (0000 UTC, 0600 UTC, 1200 UTC, and 1800 UTC) for each qualifying cutoff cyclone. With these four daily positions, better time resolution will be achieved, ensuring a reduced number of "misses" relative to the previous approaches (i.e., systems that may slip through the data network at 0000 UTC or 1200 UTC) and allowing more continuous tracking of cutoff cyclones. The tracking will be performed objectively using procedures developed by Bell and Bosart (1989). The objective tracks should provide us with information on genesis areas, land–ocean as well as terrain effects on precipitation distribution, and assist in preparing conceptual models for future research.
Educational exchanges:

There has been much interaction with Dan St. Jean from NWS Burlington (BTV), who is the focal point assigned to this portion of the CSTAR project. Mr. St. Jean has traveled to Albany on two occasions. On 7–8 March we discussed specific future research directions. Mr. St. Jean is performing four case studies of recent cutoff events that impacted the BTV county warning area (CWA). All four events were forecast to have a heavy precipitation event, only two of which verified. The main challenge is to predict the magnitude of upslope enhancement in slower moving cutoff systems, given the complex terrain in the Burlington CWA. We next met on 25 April to update each other on progress. I plan to travel to BTV for several days in August for our next meeting. At WFO Albany, Tom Wasula has joined the cool-season part of the CSTAR project. Mr. Wasula and I will be meeting frequently over the several months to compare work.

References:


Fig. 1. 500 hPa height (contour interval 6 dam, solid) and 24 h accumulated precipitation valid at: (a) 1200 UTC 7 Nov 1997, (b) 1200 UTC 8 Nov 1997, (c) 1200 UTC 9 Nov 1997, (d) 1200 UTC 10 Nov 1997. Precipitation amounts of 12.5, 25.0, 50.0 and 75.0 mm are indicated by color bands.
The CSTAR Project, *Improving the Prediction of Cool- and Warm-Season Heavy Precipitation Events over the Northeastern United States*, got off to an excellent start after an organizational meeting of National Weather Service (NWS) and University at Albany CSTAR participants on November 6-7, 2001.

The CSTAR kick-off meeting, arranged by the Science and Operations Officer (SOO) in cooperation with University at Albany Co-Principal Investigators (PI), dovetailed with the 2nd Northeast Regional Operational Workshop. The workshop was hosted by the NWS Forecast Office, Albany, New York, the Department of Earth and Atmospheric Sciences, University at Albany, State University of New York, and sponsored by the American Meteorological Society.

The CSTAR Project originally involved six Weather Forecast Offices (WFO), one River Forecast Center (RFC), and the Hydrometeorological Prediction Center, National Centers for Environmental Prediction. Since this project involves nearly 30 NWS meteorologists and hydrologists, focal points were selected at each participating NWS office (in most cases SOOs), and graduate students were assigned to each project area. Two additional NWS offices, WFO State College, Pennsylvania, and WFO Upton, New York, subsequently joined the CSTAR Project.

Final planning for the project continued during the Winter 2001, and work began on cool season projects in the Spring 2001. Throughout the Spring and Summer 2001, graduate students visited focal points and researchers at cooperating NWS offices. NWS researchers will visit with the PIs and graduate students at the University at Albany in the Fall 2001 as part of the 3rd Northeast Regional Operational Workshop.

To date, the efforts of the Albany SOO have focused on the development of data sets, coordinating with NWS project focal points at other offices as necessary, and planning the upcoming 3rd Northeast Regional Operational Workshop where preliminary results will be presented. During the next six months, the Albany SOO will facilitate the development of a CSTAR web site for coordination and scientific transfer purposes. As the cool season research progresses, the Albany SOO will also facilitate the transition of findings and results into forecast office operations across the Northeastern U.S.

There have been no major issues, concerns, or impacts to forecast office operations resulting from operational research requirements at collaborating offices. All cool-season projects are proceeding smoothly, and plans for warm-season projects are in the planning stage.
SECTION 3: Computer and Technology Transfer Issues (David Knight)

Internet E-mail lists have been configured on the DEAS computers to facilitate exchange of information between CSTAR participants. There are currently two email list in operation cstar@atmos.albany.edu, which serves all CSTAR participants, and cstar-bgm@atmos.albany.edu which the CSTAR Mesoscale Structure Group. Work is also underway to create a CSTAR web site on the UAlbany DEAS servers. This web page will be used for exchange of experimental products between the NWS and UAlbany investigators, as well as an additional mechanism for exchanging information and ideas. A Sun workstation and a PC have been installed in the NWS office space in the DEAS. These workstations are used by NWS personnel while they visit, and by students involved in the CSTAR project. Thirty Six Gigabytes of disk space has been added to the UAlbany DEAS Sun servers to store CSTAR data. This provides a central location where both UAlbany and NWS personnel can store, process, and exchange large datasets.