Building a Greater Understanding of Northwest Flow Snow in the Southern Appalachians

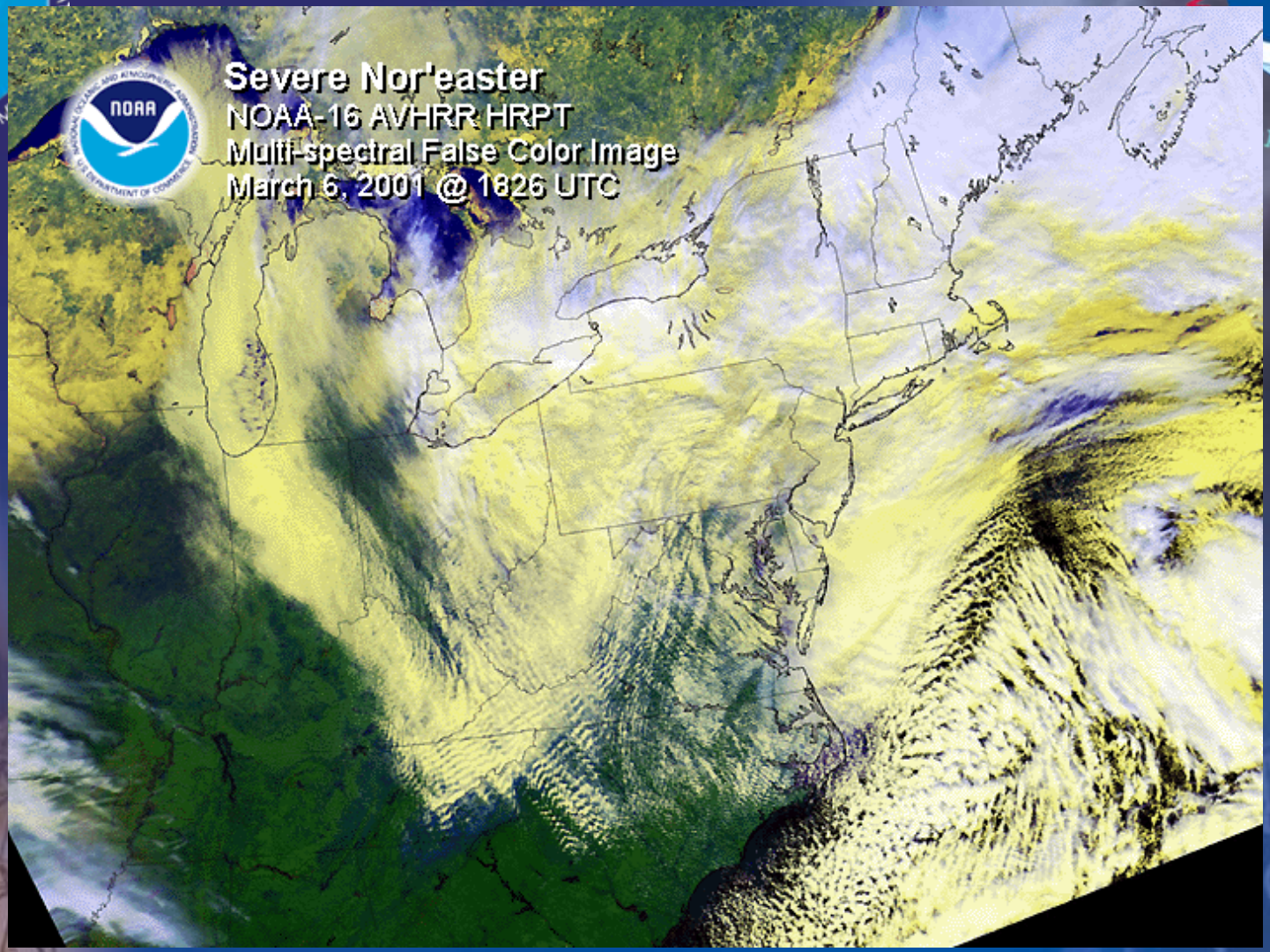
- A Collaborative Approach -

Steve Keighton

NOAA/NWS Blacksburg, VA

33rd Annual NWA Meeting - Louisville

November 7, 2008



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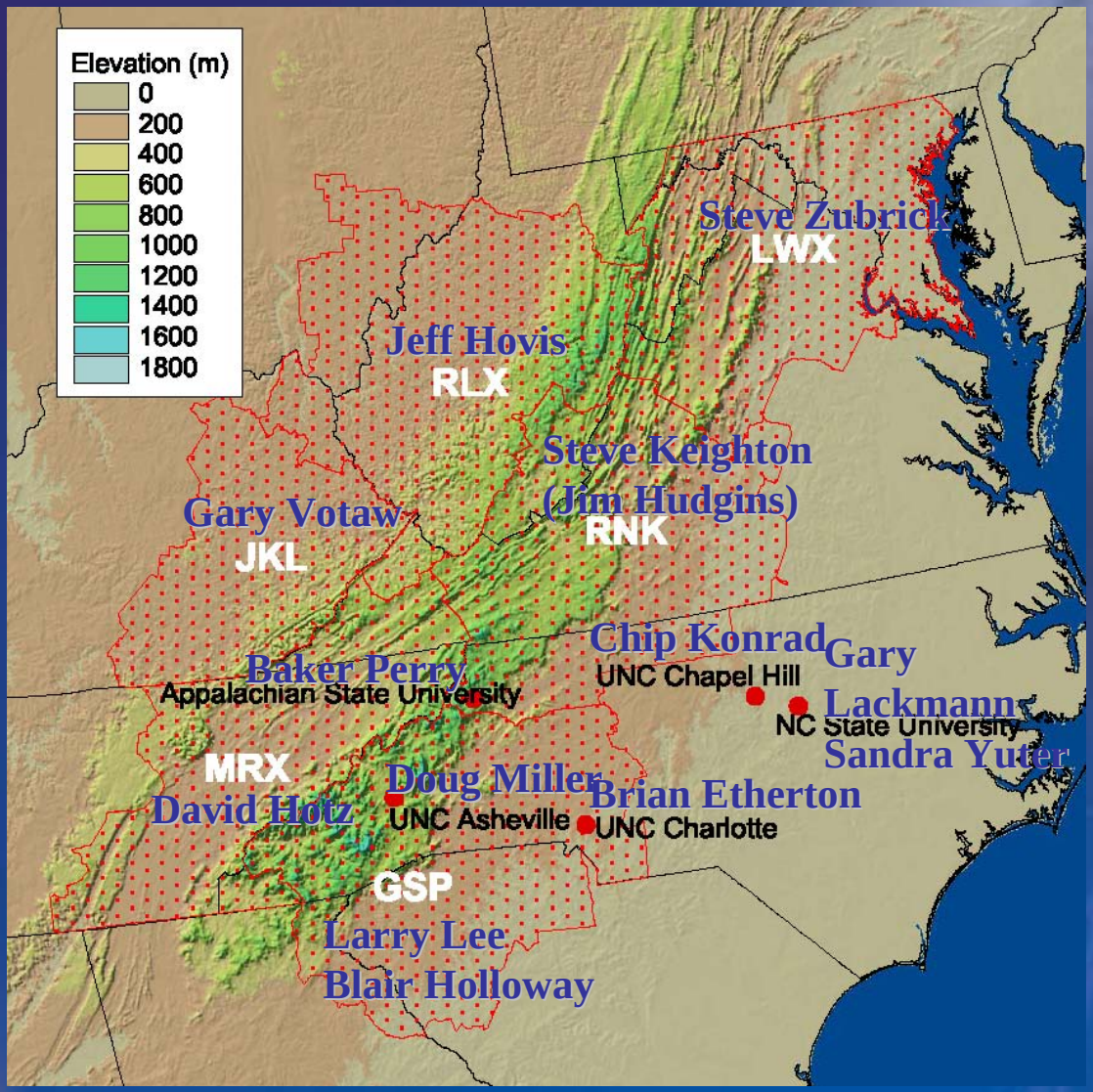
Study Area & Collaborators



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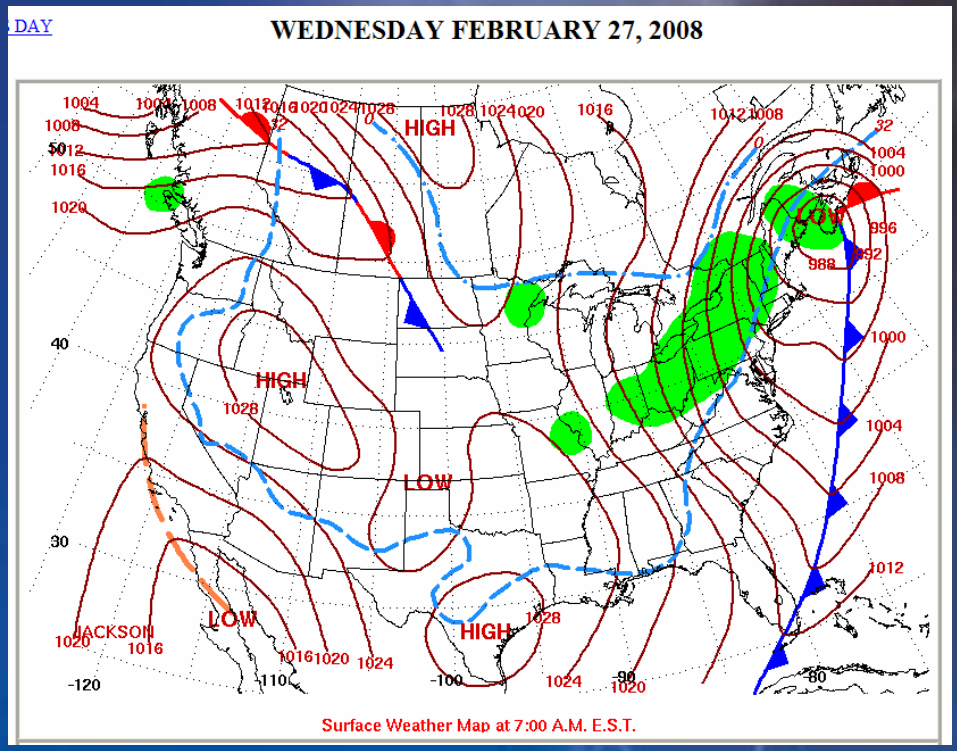
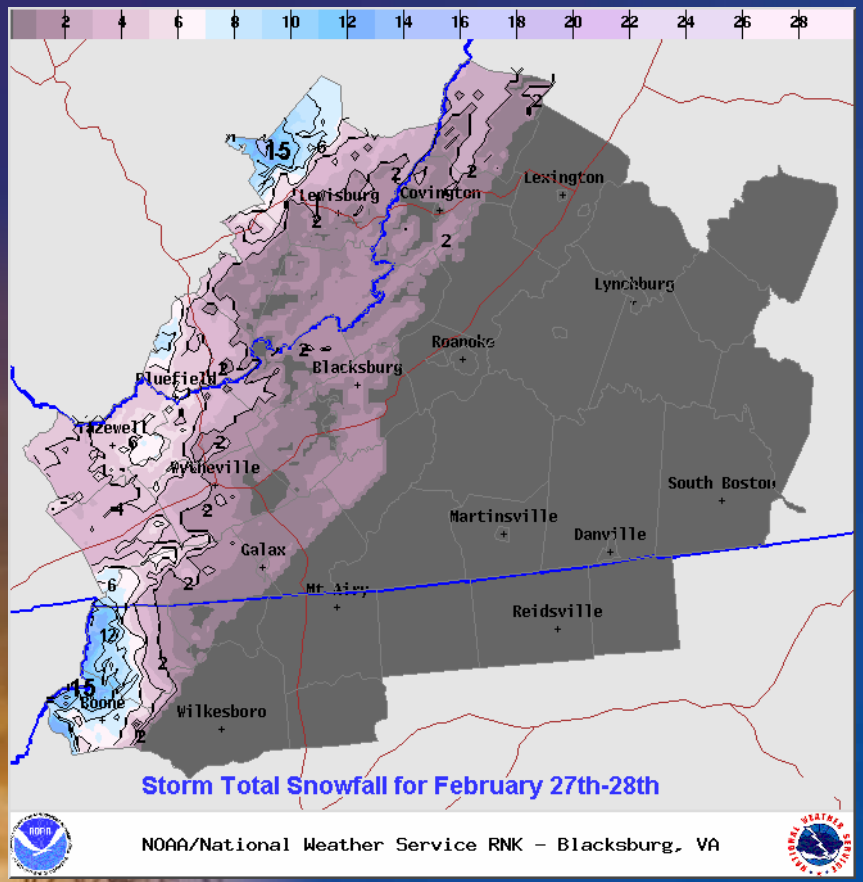
Northwest Flow Snow (NWFS)

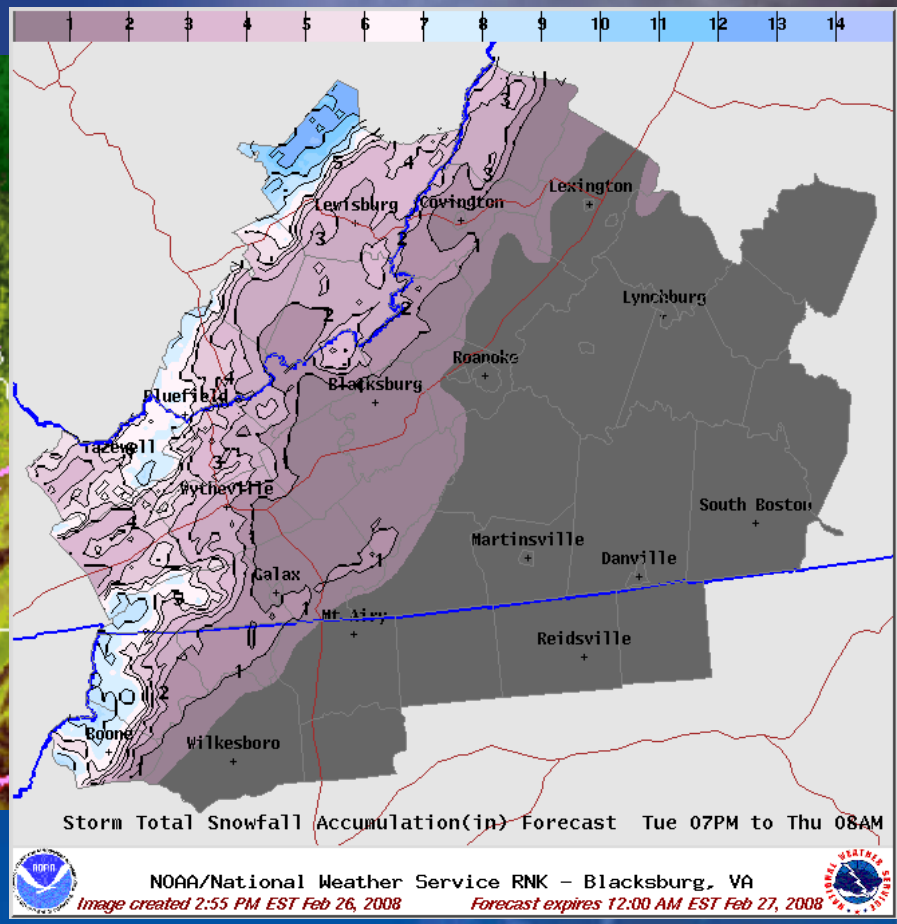
as defined for the Southern Appalachians:

- NW low level winds (upslope component on western slopes)
- Typically post-frontal, with absence of deep moisture and synoptic scale upward motion (in fact, large scale subsidence more common)
- Shallow moist and unstable layer below deep stable layer
- Cold air advection and cold enough temperatures in moist layer for good ice crystal growth
- Localized heavy snowfall rates and significant accumulations can result in highly variable snowfall distributions



February 27-28, 2008





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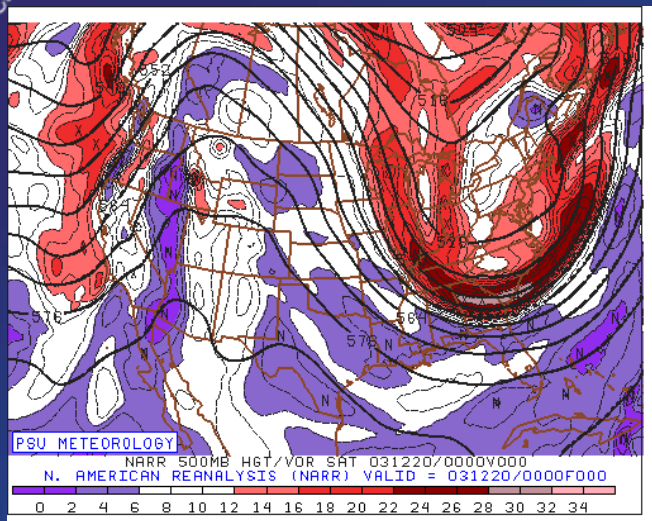
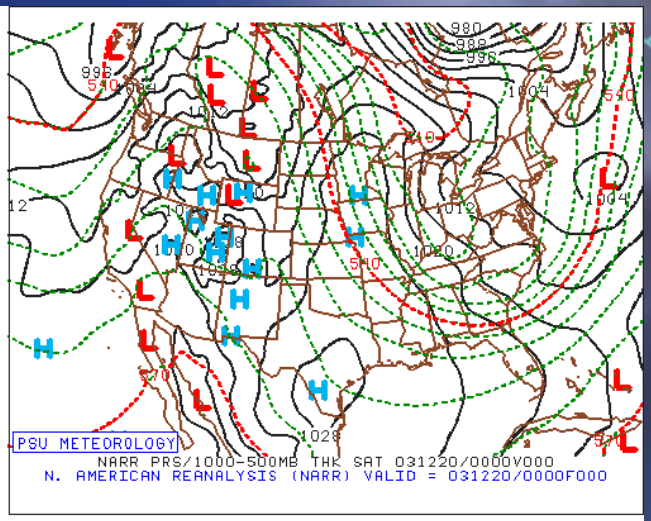
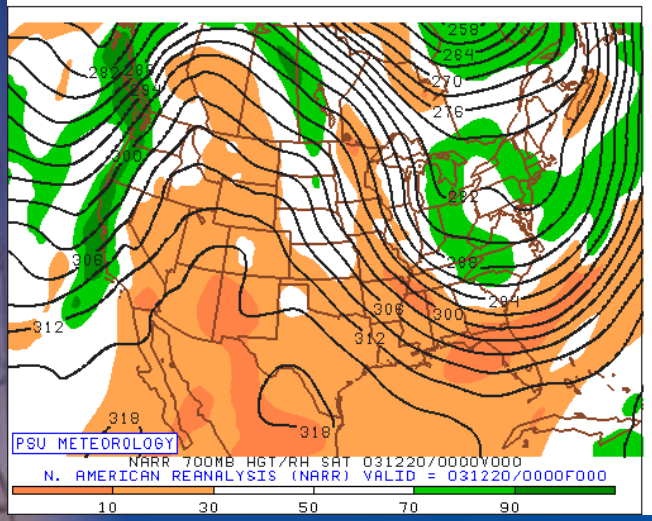
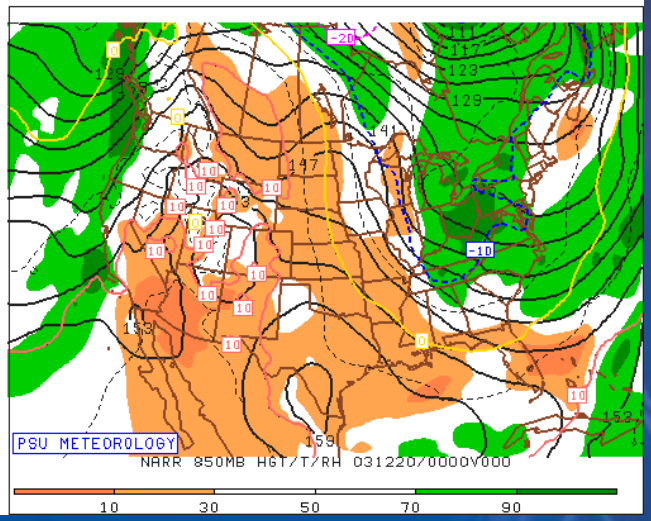
December 18-20, 2003









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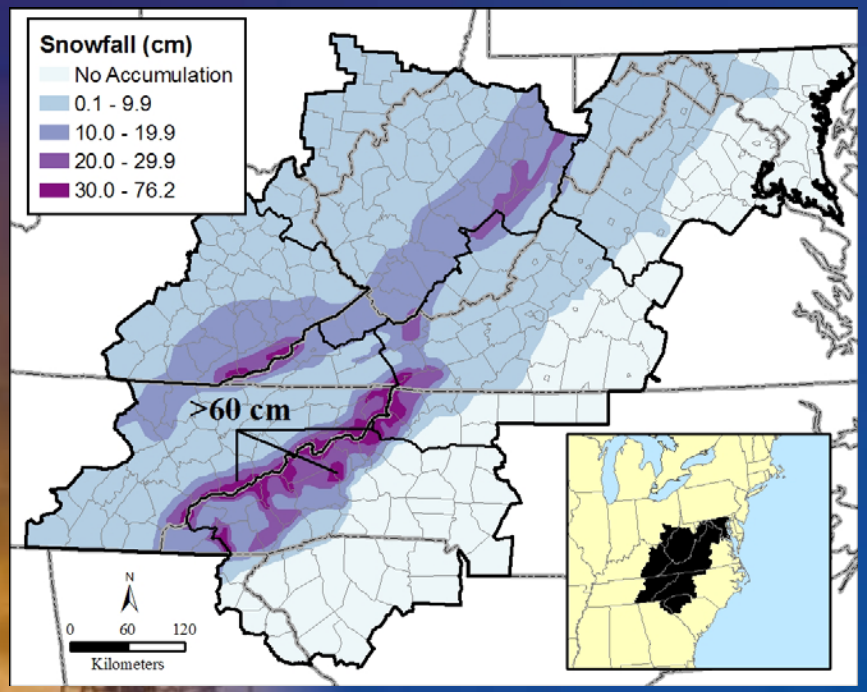
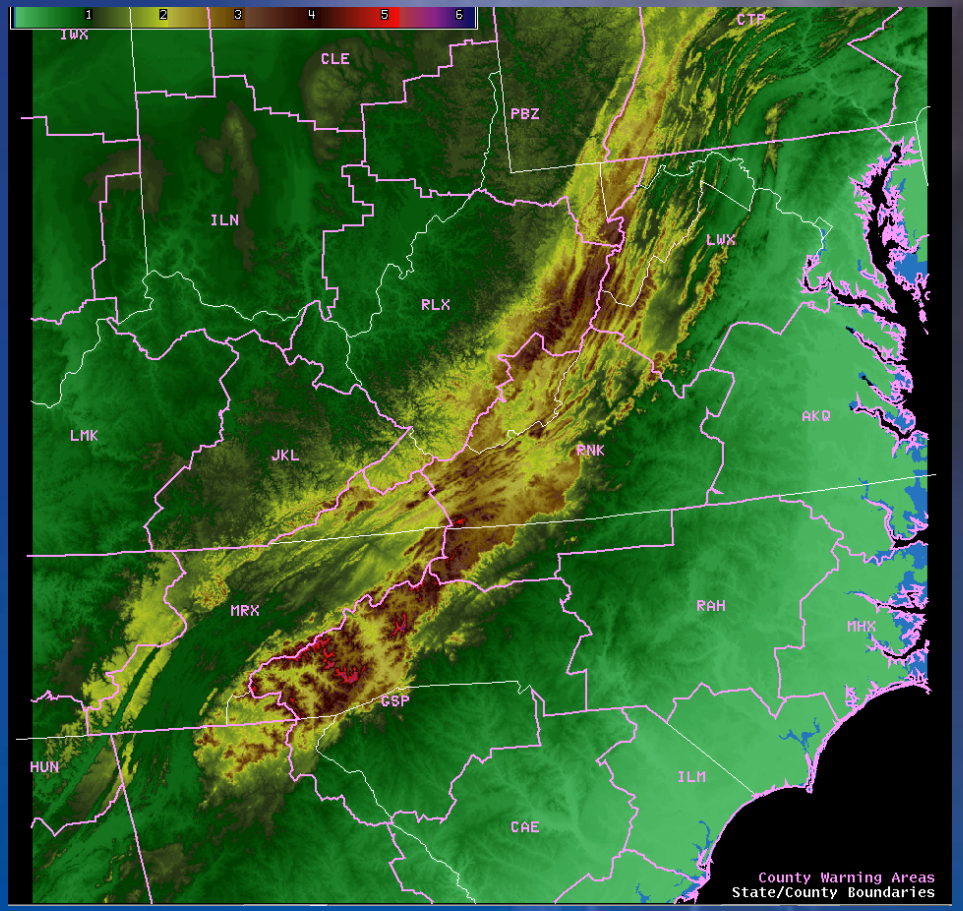


Storm total snowfall 18-20 December 2003



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Motivation

- **Prior to NWS Modernization (mid 1990s), NWFS was not well understood and its potential significance was often underestimated:**
- Course observational network (radars, sfc obs, other human observers)
- Course NWP resolution
- Forecasts for Appalachian region in these scenarios often mentioned only flurries or snow showers

Motivation cont.

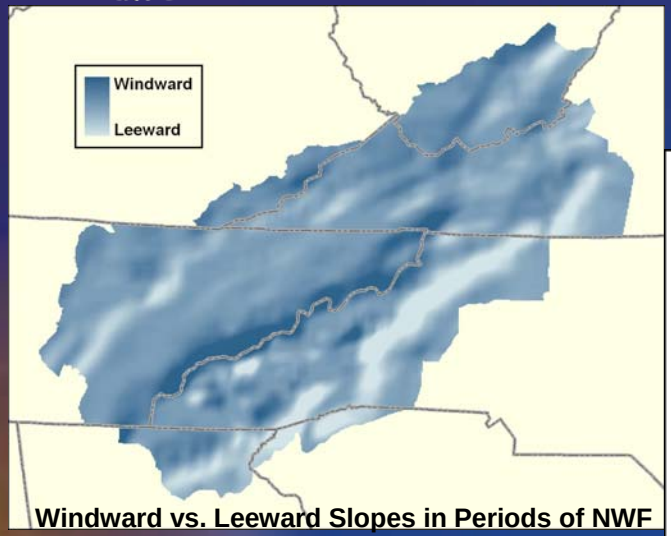
- Modernization brought better radar and observational coverage, more meteorologists at additional weather offices, and opportunity for university collaboration
- Ever-improving NWP resolution and skill
- Population increases and winter tourism in many Appalachian locations

Academic Interest

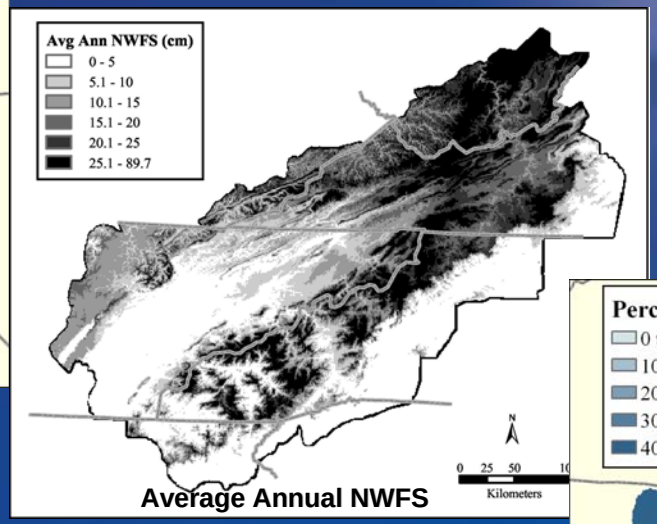
- **Chip Konrad (UNC – Chapel Hill) and Baker Perry (Appalachian State Univ) began some climatology work related to NWFS in 2003-04:**
- Distribution/frequency related to topography and low level flow direction
- Trajectories and potential Great Lakes influence

Distribution/frequency related to topography

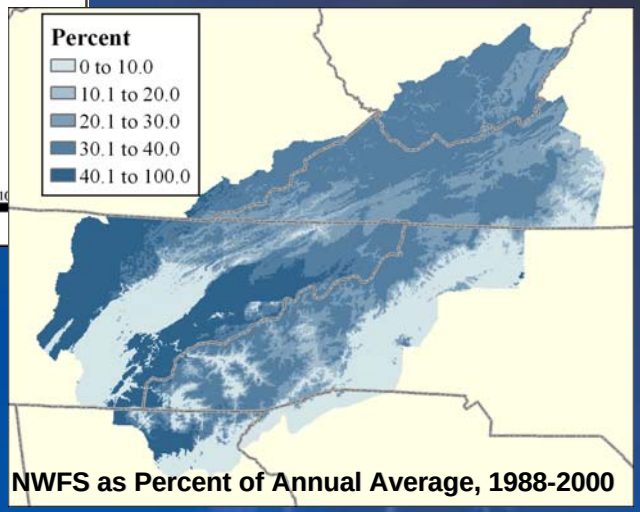
(from Perry and Konrad)



Windward vs. Leeward Slopes in Periods of NWF



Average Annual NWFS



NWFS as Percent of Annual Average, 1988-2000

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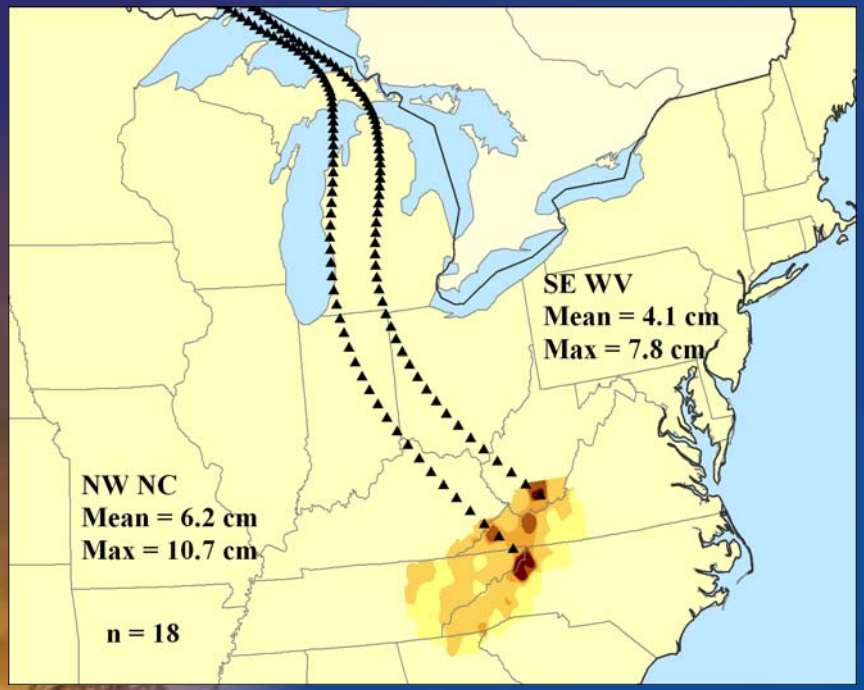
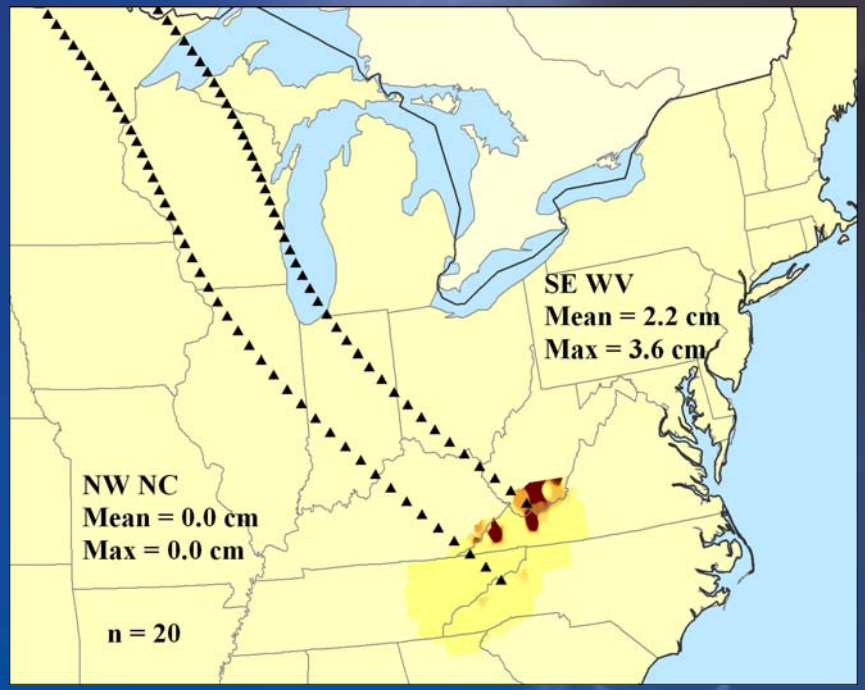
Great Lakes Connection
(from Perry and Konrad)

Favored for NW NC Mtns



Favored for SE WV Mtns



Opportunity for Collaboration

- Collaborative Science, Technology, and Applied Research (CSTAR) program established between NC State Univ and surrounding NWS offices in the late 1990s.
- “CSTAR II” in 2003 focused on cool season precipitation
- NWFS was not a primary topic, but provided unique opportunity for those with mutual interest to begin sharing ideas on this topic
- In late 2005, a “spin-off” group was formed to begin focusing more effort on NWFS
- Separate support for mesoscale modeling work at NC State, as well as special observational data sets from UNC-Asheville and NCSU

NWFS Study Group Goals

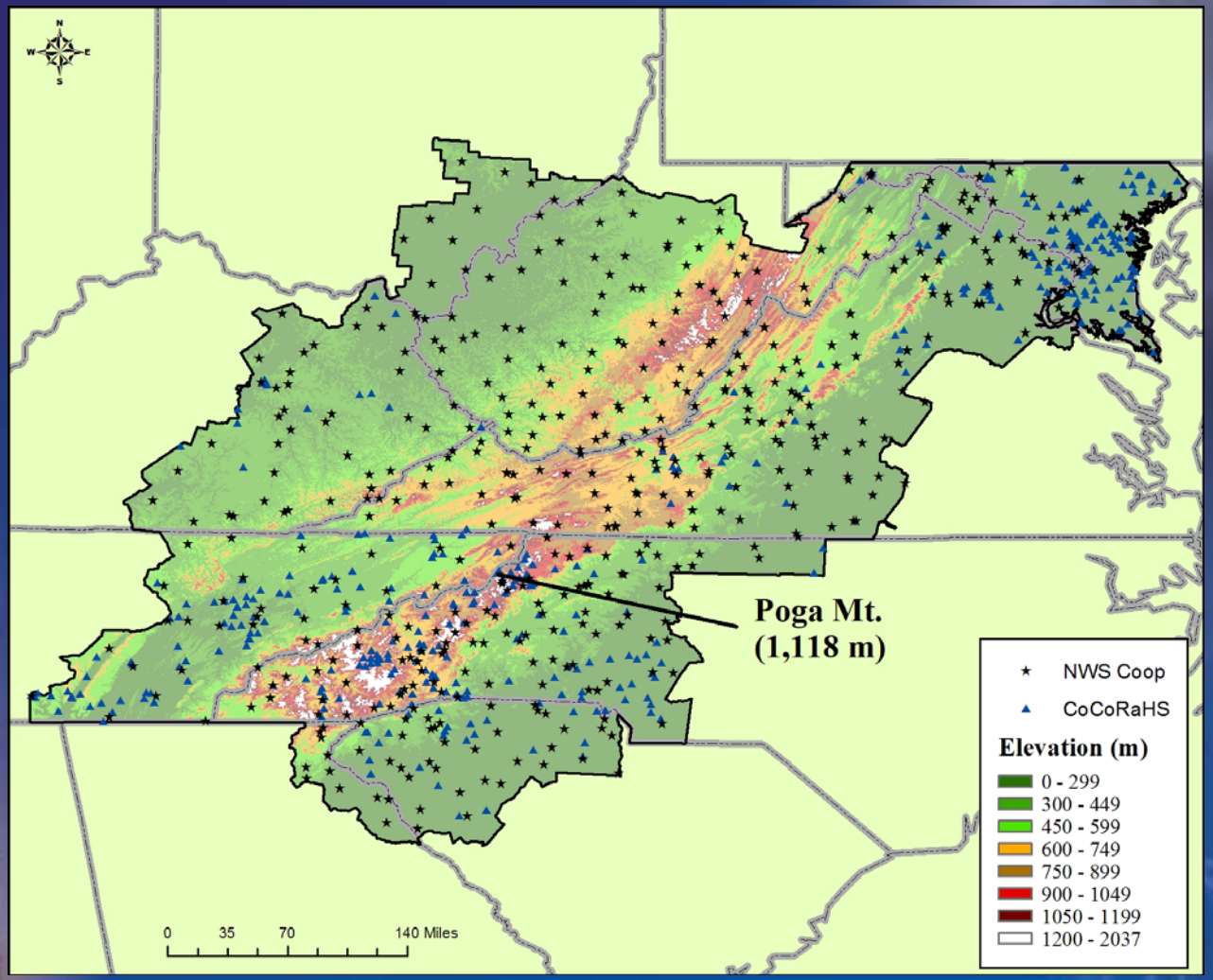
- **Improve understanding and forecast accuracy of NWFS events through:**
- Increased understanding of climatology
- Exploring use of multiple observational data sets (some experimental)
- Conducting mesoscale NWP experiments, plus diagnosing several locally run real-time mesoscale models
- Real-time collaborative discussions before/during/after events, and producing post event analyses
- Better anticipation of snow-to-liquid ratios by greater understanding ice crystal growth habits in these events
- Identify topics requiring additional research (opportunities for formal research funding and student support)
- Developing improved operational forecast strategies/methods
- **Foster continued relationships between operational and academic community**

Methods of Collaboration

- Routine conference calls
- Listserv (includes interested operational staff at WFOs as well as HPC)
- Web page (conf call notes, links to model and observational data, event reviews, and publications):

  http://www.erh.noaa.gov/gsp/localdat/NWFS_discussion_group/nwfs_discussion_group.html
- Collaborating on journal article, conf presentations

Observations



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Poga Mtn "Lab"

(Baker Perry Farm)

Photos courtesy of Baker Perry

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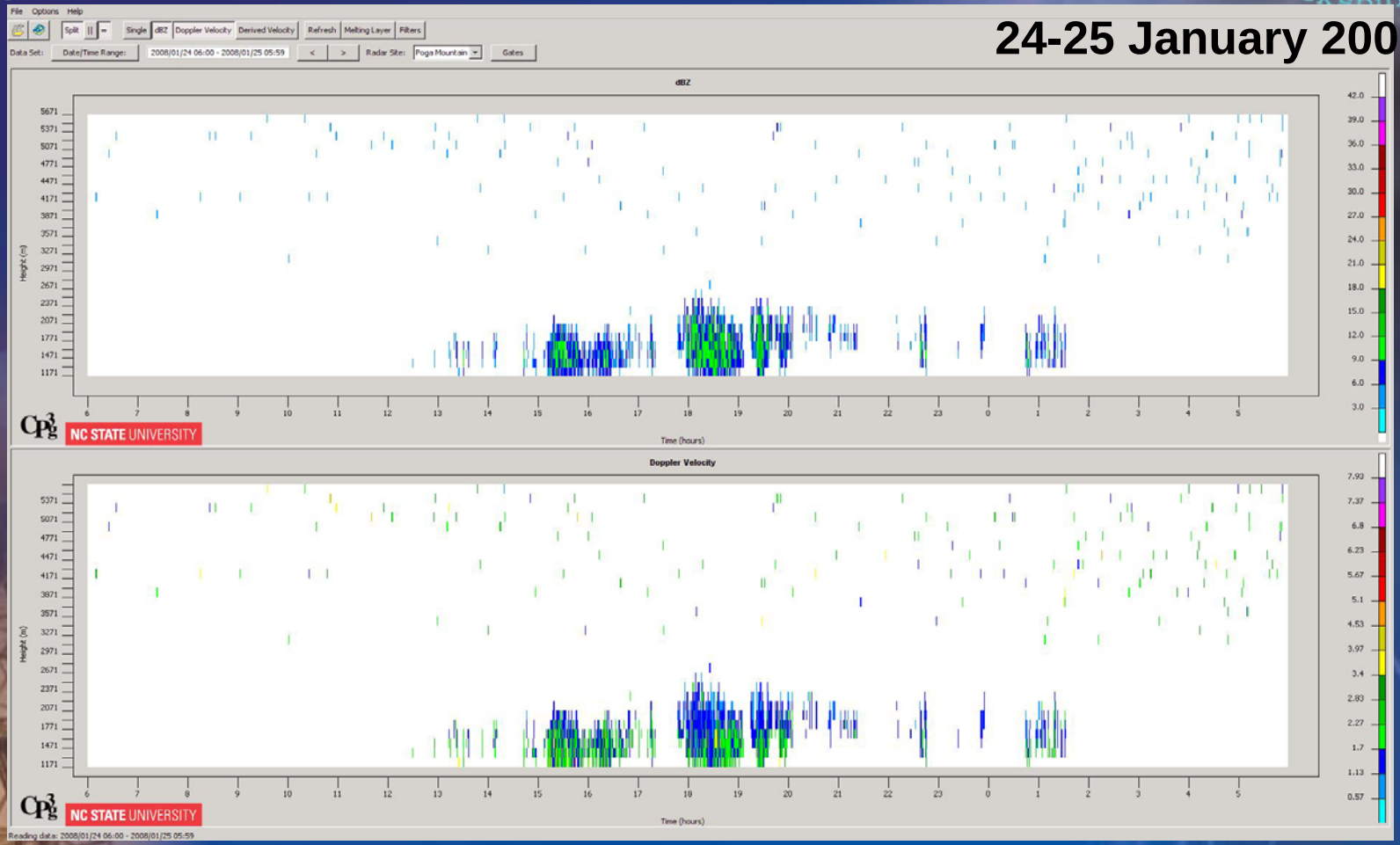
Vertically-pointing Micro Rain Radar
(Sandra Yuter – NCSU)

24-25 January 2008



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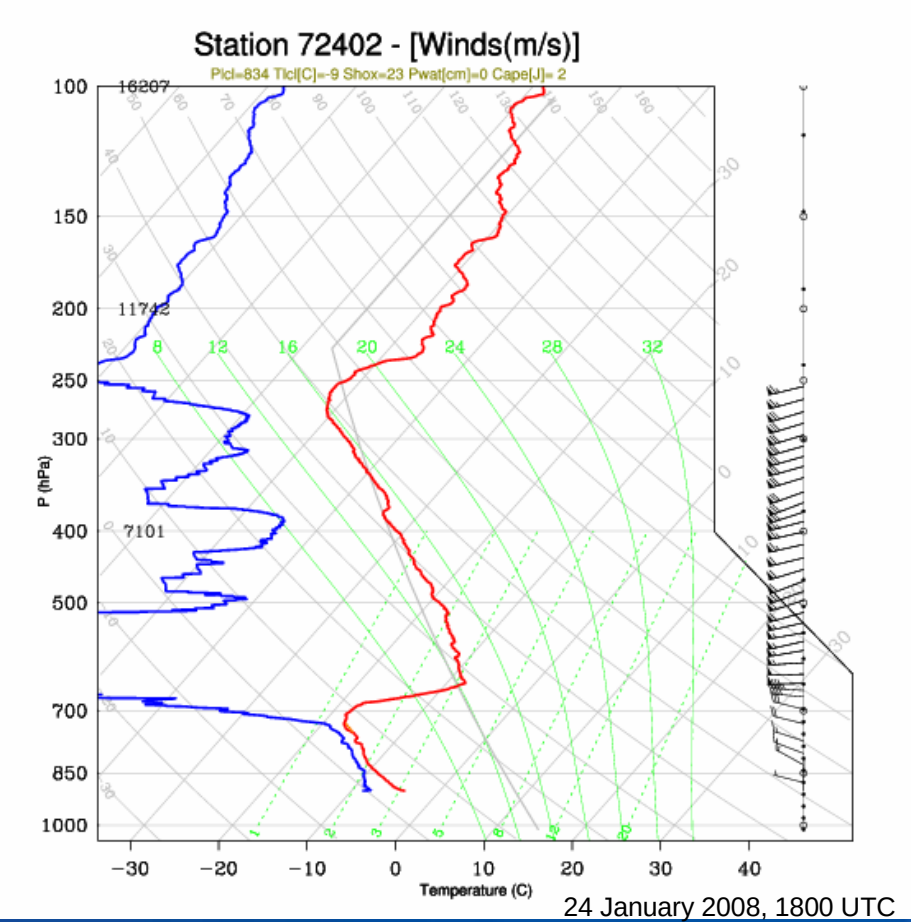
Radiosondes from mobile unit launched by UNC-Asheville crew during declared events

(Doug Miller)



24 January 2008, 1800 UTC

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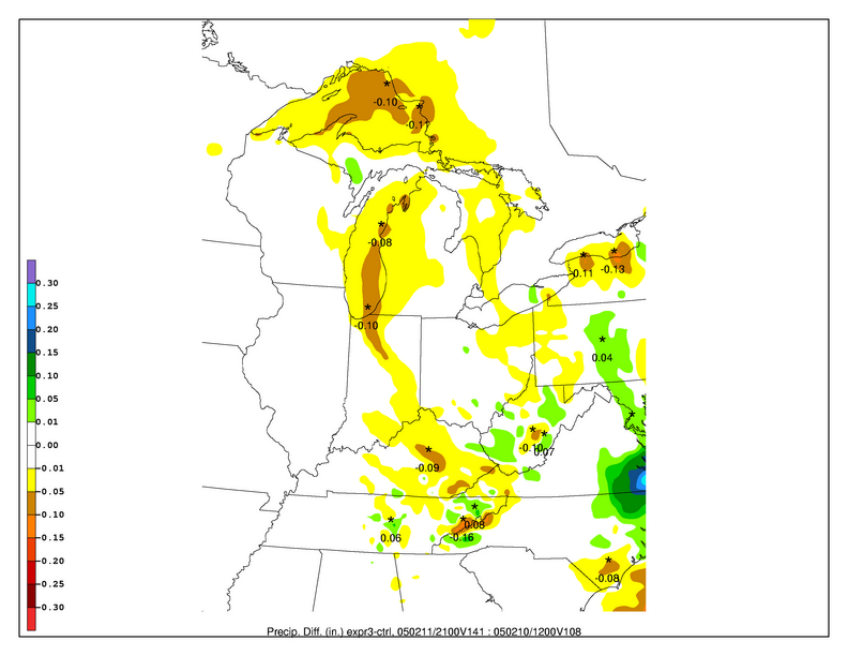
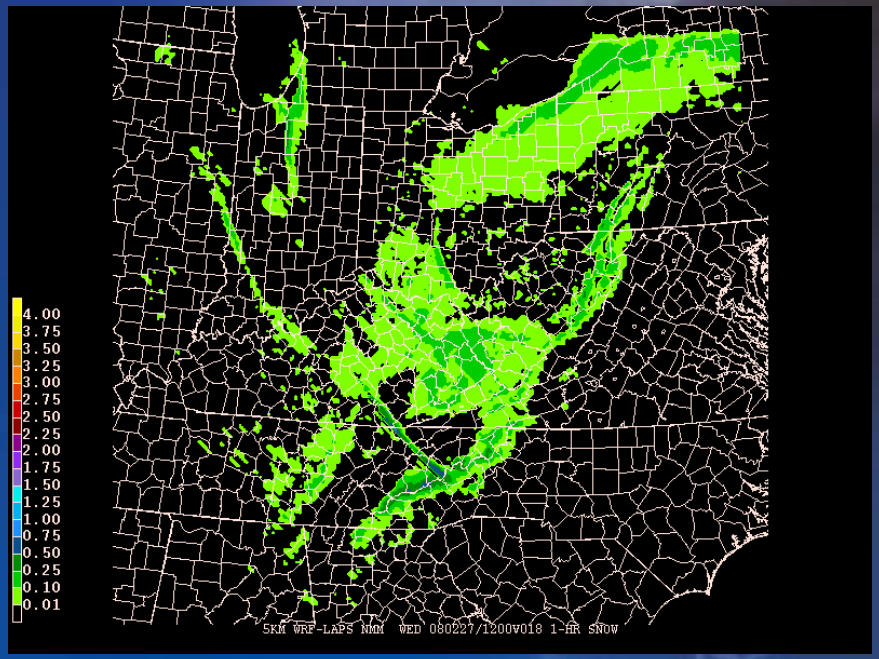
Mesoscale Modeling



Experimental run using 24km WRF ARW showing QPF differences with Great Lakes heat/moistures fluxes removed. 11 Feb 2005. (Courtesy of Blair Holloway, WFO GSP)



Operational run of 5km WRF NMM showing a 1-hr snowfall field. 28 February 2008. (Courtesy of WFO RLX)

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NWFS Collaboration Group
Major Benefits

- Partnerships between operational and academic communities benefit both groups
- Knowledge sharing through cross-discipline approach (forecasting, climatology, modeling, observations)
- Real-time feedback & discussion on pending/ongoing/recent events
- Access to real-time experimental data sets
- Greater understanding of mesoscale model strengths and weaknesses, and sharing of local real-time models
- Developing improved common forecast methodologies across the region

Future Plans

- Continue with communication during 2008-09 winter season (conf calls, listserv, case reviews)
- Diagnosing/tweaking local mesoscale models, better sharing
- Continue assessing MRR data and soundings as available (depends on formal funding)
- Complete ongoing research efforts and publish related papers
- Develop specific methods/procedures/tools for enhancing short term forecasts
- Look for new opportunities to collaborate on related topics, and maintain the strong relationships!

NWFS Posters Thursday!

- P3.3: The Role of the Great Lakes in the 10-11 February 2005 NWFS Event in the Southern Appalachian Mtns (Blair Holloway and Gary Lackmann)
- P3.4: Mesoscale Snowbands Persisting Downstream of the Southern Appalachians During NW Flow Upslope Events (Jim Hudgins)
- P3.5: Snowfall Accumulation Forecasting Challenges for the Southern Appalachians (Doug Miller, Perry, Yuter, Lee, Keighton)

References

- Holloway, B.S., 2007: The role of the Great Lakes in northwest flow snowfall events in the southern Appalachian Mountains. M.S. thesis, Dept of Marine, Earth, and Atmos Sci., NC State Univ, 204 pp. [Online at http://www.lib.ncsu.edu/theses/available/etd-11022007-181739/]
- [Keighton, Lee, Holloway, Hotz, Zubrick, Hovis, Votaw, Perry, Lackmann, Yuter, Konrad, Miller, Etherton, 2009: A Collaborative approach to study northwest flow snow in the southern Appalachians. Under review for Bulletin of the AMS.]
- Perry, L.B., and C.E. Konrad, 2006: Relationships between NW flow snowfall and topography in the southern Appalachians, USA. *Climate Research*, **32**, 35-47.
- Perry, L.B., C.E. Konrad, and T.W. Schmidlin, 2007: Antecedent upstream air trajectories associated with northwest flow snowfall in the southern Appalachians. *Wea. Forecasting*, **22**, 334-352.
- St. Jean, D., P.A. Sisson, L.F. Bosart, D. Keyser, and B. Smith, 2004: Characteristics of upslope snowfall events in northern New York state and northern Vermont: Diagnoatics and model simulations of several northwest flow cases. *Preprints, 20th WAF Conf.,* Seattle, WA, AMS, 18.4.
- Yuter, S.E., and L.B. Perry, 2007: Storm structures and precipitation characteristics of snow events in the southern Appalachian mountains. *Abstracts, 12th Conf on Mesoscale Processes,* Aug 2007, Waterville Valley, NH.