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NCAR SUMMER COLLOQUIUM ON SYNOPTIC METEOROLOGY SHORT NOTE SUMMARY

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The theme of the Summer Colloquium held at the National Center for Atmospheric Research (NCAR) was Synoptic Meteorology. Both operational and research meteorologists were invited to attend the summer session. The topics covered all aspects of synoptic scale meteorology.

1. Theoretical Meteorology (Howard Bluestein, University of Oklahoma)

Professor Bluestein noted the renewed emphasis that is being placed by many researchers on the use of Isentropic Potential Vorticity (IPV) in analyzing and understanding the atmosphere. This revisited concept uses potential vorticity on isentropic surfaces as a means to analyze and forecast weather events. Several basic theories (baroclinic instability, Rossby waves, etc.) were examined using the isentropic frame of reference.

2. Blocking Patterns (Steve Mullen, University of Michigan, and Steve Colucci, University of Virginia)

It was suggested that a 24 hour height fall analysis at 500 mb (AFOS chart 5AC) is a good tool to identify storm tracks around the Northern Hemisphere, as well as follow synoptic scale "eddies" through the mean upper tropospheric flow pattern. Such synoptic scale eddies are responsible for the beginning phase of a "block." First, a split in the upper level flow develops, then a rapid development of a low occurs downstream of the upper ridge. The low moves rapidly up the ridge causing strong warm air advection into the ridge at all levels. The ridge then builds into a semi-permanent blocking feature by the movement of a series of other more minor lows up its axis.

1 Ernie Goetsch, a forecaster at WSFO Louisville, Kentucky, represented the Central Region at the NCAR Summer Colloquium on Synoptic Meteorology. We asked Ernie to provide a short summary or highlight of the main topics presented at the Colloquium.

3. Synoptic Scale Eddies and Mobile Troughs (Fred Sanders, Professor Emeritus, Massachusetts Institute of Technology)

Professor Sanders defined mobile troughs as upper level synoptic scale systems that move around the Northern Hemisphere. Favored areas for trough development are along the lee of mountain ranges, like the Rockies and the Central Asia Highlands. These systems can be tracked, as they rotate around the globe, by overlaying the 500 mb 5520 meter contour for a sequence of analysis times on the same chart. Such mobile troughs move through the long wave pattern and frequently trigger major surface cyclone development when they approach a baroclinic zone. On the average, the troughs form 8.5 days before surface low development. When a trough approaches a frontal system, 24 hour height fall patterns at 500 mb plus the surface pressure change chart can be used to estimate vorticity advection. An extreme case was shown in which one trough tracked around the globe three times.

NOTE: The operational tracking of mobile troughs may be extremely useful in both short and long range forecasting.

4. Jet Streaks (Louis Uccellini, NASA/Goddard Space Flight Center)

The discussion of jet streaks was an extremely informative one. The vertical motion patterns associated with a typical jet streak is caused by a direct transverse circulation in the entrance region of the jet maximum, causing vertical motion in the right rear quadrant. An indirect circulation is found in the exit region, resulting in vertical motion and divergence in the left front quadrant. A typical three dimensional flow pattern for East Coast snow storms involves a split flow, double jet streak pattern.

NOTE: The tracking of jet streaks in both satellite and conventional upper air data can be helpful in precipitation forecasting.

5. Rapid Cyclogenesis (Bombs) (John Gyakum, McGill University)

Rapidly intensifying cyclones (a 24 hour pressure fall of at least 1 mb per hour) were discussed. Though most of these systems occur off the East Coast near the Gulf Stream and in the Pacific, sometimes development occurs over land in the southeast U.S. These cases occur when a very strong upper level jet is present.

In the cases of East Coast development, rapid and intense cyclogenesis occurs on a frontal zone near the coastline. The front is enhanced by cold air funnelling down the eastern slopes of the mountains.

6. Topography Influences (Clifford Mass, University of Washington, and Lance Bozart, State University at New York)

Extensive research has been done on cold air damming along the East Coast of the U.S., east of the Appalachians. This phenomenon may also be significant along the eastern slopes of the Rockies. Cold air damming is defined as cold air pinned up against the mountains as a pressure ridge forms along the slopes.

As long as a strong pressure gradient exists, the damming effect continues. Cold air damming may also cause squall line development in the western Central Plains.

On the East Coast, coastal fronts often develop due to cold air damming. In these cases, MOS guidance is usually bad as significant overrunning occurs that is not forecast by model output. Bad forecasts of precipitation type also occur.

7. MCC's (Mike Fritsch, Pennsylvania State University)

MCC's form south of a baroclinic zone in weak upper flow in a weak shear environment. They form in the lee of major mountain ranges, and have also been documented in South America. Mesohighs and wake depressions are frequently found beneath MCC's in surface data. Aloft, the flow is anticyclonic, with a jet streak often found on the northern cloud edge.

A vorticity maximum is often generated in the low levels by the MCC and left behind after the convection dissipates. The vortex speeds up during the day and slows down at night (tropical characteristic). Circulation around the center can be seen in the individual cell movement pattern. A comma cloud pattern is frequently depicted by the vorticity maximum. These vortex systems can last days, and may trigger new convection. The convection strengthens the vortex itself each day. Convection associated with such a residual vorticity maximum will start out scattered during the day due to forcing and diurnal heating. Consolidation of the convection occurs at night due to a focus of processes. Mesoscale subsidence aloft around the system during the day may be the cause of convection firing only near the vortex. Movement of the core of a MCC follows the 1000-500 thickness field.

The genesis stage of an MCC when diurnal heating occurs with intense instability and positive shear is the severe stage. The mature stage occurs later at night, after heating stops and when the shear and heating is lost. Flash flooding and heavy rain become the main problem.

8. Numerical Modeling (Bill Bonner, Ron McPherson, Steve Tracton, NMC, and Fred Carr, University of Oklahoma)

The first step in numerical weather prediction is the analysis. There is presently no one observation system that completely samples the atmosphere. Therefore, the objective analysis must blend different types of observations while interpolating the values onto an analysis grid. Present observations include: dropsondes from aircraft, radiosondes, surface data, cloud drift winds from satellite imagery, sounding data from GOES satellite, and sounding data from polar orbiting satellites. In the future, data from NEXRAD, ASOS, Profilers, etc., will be added

The method now used to blend observations is called "Optimum Interpolation." To get values for the grid points, the different types of observations are weighted so that the most reliable observation is given most worth. Interpolation to the grid point location is then done so that value at each grid point is obtained.

Even with the current resolution and imperfections of the data, present models have a reasonable amount of forecast accuracy through 6.5 days. Although the 6-10 day forecast is now being issued by the Medium Range Section of NMC, it was stated that there is only modest levels of forecast skill beyond seven days. Recent research has shown that the 1-7 day forecast contains most of the value in the 30 day outlook. Therefore, these two forecasts are often very close in appearance.

Dr. Bonner indicated that regional models still have problems with boundary conditions. Also, rapid intense cyclogenetic systems (bombs) are still poorly forecast by operational models.

Here are the basic steps in producing a forecast:

1. Analysis - the observed data are interpolated to the forecast grid network using a six hour forecast from the Global Data Assimilation System as the first guess field.

2. Initialization - the interpolated data are manipulated to insure the correct boundary conditions are set and that non-meteorological "noise" is reduced to an acceptable level before the forecast is begun.

3. Forecast - the model is turned on and allowed to advance in time until the desired forecast length is reached.

4. Post-Processing - the output data are manipulated into the final form that is sent to the field forecaster.

IMPORTANT NOTES:

1. Observations that are extremely different from the first guess may be thrown out by the model or by the NMC Senior Duty Forecaster.

2. The two steps, analysis and initialization can, at times, be the reason that small scale weather systems are missed during their early stages of development. For example, if only one observation site registers data signaling the development of a small scale vorticity maximum, the data may be either thrown out by the model during the analysis step, or "smoothed" out during the initialization step. During later analysis runs, as the system grows and is reflected by more observation sites, the feature finds it way into the model run. Because of this, when sequential model runs continue to forecast the same development for a system at the same valid time, it does not necessarily mean that prognoses are doing well! This also explains why it sometimes takes a while for a model to detect a developing system.

   During such occurrences, the forecaster has to recognize these facts and modify the models. Remember that the models are still just synoptic scale models!

3. Extensive satellite sounding data is presently going into the models. When available, both GOES and NOAA polar orbiting satellite soundings are used. This is especially true in conventional data sparse areas.

9. Satellite Imagery (Jim Purdom, NOAA)

Recent research using satellite data and aircraft penetration information indicates that almost the same amount of air goes into a thunderstorm from its downdraft as it enters from outside environmental moist air. In addition, there may be a decoupled rear inflow jet, which helps accelerate and intensify the downdraft of the storm.

10. Lightning Data (Greg Gerwitz, WSFO Albany)

Lightning data as an extremely valuable new type of real-time observation. It can accurately differentiate between embedded convection and stratiform rain. Many operational uses and techniques are now being developed using lightning data. A new AFOS test product (NMCGPHLDS) was recently added to the network for field evaluation.

11. NEXRAD (John McGinley, PROFS)

One of the major improvements of the Doppler system will be improved rainfall estimates. Programs are now being developed that will do a real-time comparison of reflectivity data with actual real-time ground truth from automated rain gauge network reports. Operational use of NEXRAD data at the Denver WSFO through various severe weather episodes has shown that this new type of radar information allows forecasters to issue warnings with greater lead time and accuracy.

12. Profilers (Tom Schlatter, PROFS, and Ralph Petersen, NOAA)

Wind profilers will be the next type of technology to be placed in the operational field environment within a few years. Uses will include:

1. Tracking short waves, upper level cold cores.
2. Monitoring the mountain top level winds to aid in forecasting downslope wind storms.
3. Supplementing present radiosonde data network and adding additional data between 12 hourly RAOB times.
4. Tracking jet streaks.
5. Monitoring the low level jet.
6. Detailing mesoscale systems such as thunderstorm outflows, mesoscale circulation centers, inflow into storm systems, etc.

All in all the Summer Colloquium was a worthwhile experience. It enabled operational and research meteorologists to come together, share their ideas and findings, and leave with a sense of accomplishment. Hopefully, this type of research/operational "interactive" colloquium will continue in the future.