FORECASTING SEVERE STORMS

Adapted from a presentation given by Steve Corfidi.

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1. The Forecast Task

- Are thunderstorms possible
- Will they become severe?

2. Ingredients For Thunderstorms

- Moisture: The greater the amount of low-level moisture, the greater the amount of latent heat release a parcel of air will experience as it rises above its lifted condensation level (LCL): a) evaporation/evapotranspiration-an important source of moisture during the warm season, b) moisture pooling-often occurs along boundaries as well as regions that experienced heavy precipitation during the last few days, c) advection-often observed to occur within the warm sector of developing extratropical cyclones as strengthening low-level southerly flow rapidly draws moisture from the Gulf of Mexico northward
- Instability: The tendency for a parcel of air to move up or down when displaced from rest. An environment characterized by a rapid change in temperature with height (steep lapse rate) may be conditionally unstable. If the boundary layer is very moist, then a parcel may become warmer then its surrounding environment at its level of free convection (LFC). At this point, the parcel will rise freely through the atmosphere due to its own buoyancy. Eventually the parcel will become cooler than its surrounding environment (the equilibrium level; EL), and the parcel will then experience a negative acceleration. The cumulative amount of buoyant energy available to a parcel from the LFC to the EL is called convective available potential energy (CAPE): a) diabatic heating-destabilizes the boundary layer, b) differential advection-cool dry steep lapse rate mid level air overspreading a moist boundary layer airmass can lead to large potential instability
- Lift: A parcel of air must be lifted through any remaining convective inhibition (CIN) and to its LCL and LFC, or else the parcels CAPE will never be realized: a) upper level divergence/low level convergence-acts to destabilize the atmosphere, b) low level warm air advection-acts to destabilize the atmosphere and often is the location of thunderstorm initiation, c) low level boundaries-most likely location for thunderstorm initiation, d) upslope flow-can aid or be directly responsible for thunderstorm initiation, e) surface heating-acts to destabilize the atmosphere and can sometimes result in thunderstorm initiation

3. Organized Convection

- Requires vertical wind shear: a) allows updraft/downdraft couplet to develop, which results in a stronger/longer-lived thunderstorm

4. Thunderstorm Type

- Single Cell
- Multicell
- Supercell
- MCS

5. Convective Mode

- Discrete
- Mixed
- Linear

6. Thunderstorm Hazards

- Large Hail
- Tornadoes
- Damaging Wind: a) Begins with a downdraft, which is initiated by negative buoyancy, and can be enhanced by precipitation drag, b) small precipitation particles hasten evaporation, sublimation, and melting, which in turn hastens the cooling rate within the parcel, c) strong downdrafts require environmental lapse rates which are steep enough to overcome compresional warming within the descending air parcel (evaporation and sublimation lead to cooling which might off set compresional warming as well)
- Heavy Rainfall/Flooding
- Lightning

7. The Forecast Process

- Forecast = Diagnosis + Trend
- Diagnosis requires good analysis
- Trend is determined via a) extrapolation, b) climatology, c) forecaster knowledge-c1) pattern recognition (conceptual models), c2) ingredient evaluation (composite

charts), d) numerical model guidance (synoptic and mesoscale models plus ensemble techniques)

- Determining the forecast trend depends on which time frame the forecast is required
- Climatology: a) provides a useful starting point when beginning the forecast, b) most useful when responsible physical processes are understood, c) can provide a useful first guess when small scale forcing mechanisms are not known or unresolvable
- Numerical model guidance: a) knowledge of model physics/dynamics and parameterization are necessary, b) convection, precipitation, moisture, and boundary layer processes are poorly resolved, c) model resolution may be very useful when evaluating synoptic scale evolution, but can be of limited use when resolving mesoscale features, d) a models poor precipitation forecast can negatively impact its depiction of instability and convective evolution, e) data display is important-4 panel charts can aid in applying conceptual models, d) ensemble model forecasts can be very useful in developing a probabilistic sense of the likelihood of a certain convective evolution-calibrated ensemble forecasts are one example
- Conceptual models: a) provide a starting point for meteorologists (such as the structure and life cycle of the classic mid-latitude cyclone), b) the forecaster must know when/where to deviate from the conceptual model, because mesoscale features may alter the end result, c) conceptual models must be linked with the actual physical processes/dynamics responsible for weather features
- Composite charts: a) combine information from observations and numerical guidance in order to develop relevant conceptual models, b) emphasis is on juxtaposition of storm ingredients, limiting factors, and their 4-D evolution

8. Diagnosis

- The first step in forecasting
- Need to know how the atmosphere reached its current state before a forecast can be made
- Successful diagnosis requires a good analysis-a poor analysis reduces forecast accuracy
- Must understand the interaction between the synoptic, meso, and storm scales
- Analysis is not simply producing weather charts, but synthesizing all information so that you gain an understanding of how and why weather features are occurring (i.e., observed banded precipitation is occurring due to mid-level frontogenesis, etc.)
- Analysis should lead to a diagnosis of the ingredients causing current observed weather, and how those ingredients came together-the forecast then creates a trend of how those ingredients will change in the future, and subsequently how the current weather feature will change, or lead to new weather

9. Analysis of Sounding Data

10. Wind Profiles and Hodographs

11. Subjective Surface Analysis

- Surface observations are a rich data source.
- Facilitates mental process of synthesizing data from various platforms
- Helps develop valid conceptual models
- Necessary for tracking the development and motion of low-level boundaries
- Provides a reality check-helps the forecaster and computer forecasts connected to the real world
- Surface analysis must be performed regularly in order to maintain skill as well as maintaining a constant weather watch of subtle features
- Boundaries are one of the most important features that can be analyzed through surface analysis: a) often a location for convective initiation, b) are regions of enhanced low-level shear, c) supercell/tornado development is often confined to boundaries, especially when the ambient SRH is weak, d) convective mode is often a function of boundary orientation and type (i.e., a cold front versus a dryline), e) boundary identification is facilitated by synthesizing other data sources such as radar and satellite

12. Objectively Derived Fields

- SPC Mesoanalysis fields
- Combination of computer derived fields plus human forecast analysis/knowledge maximizes analysis skill and therefore forecast potential