Severe Convective Weather Forecasting in Europe

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European Conf. on Severe Storms – 03 October 2011
Scientific weather forecasting

- Application of scientific understanding to the problem of forecasting
- By human forecasters!!
- The concept of ingredients-based forecasting
- Threat of severe convective storms is non-zero no matter:
  - The map (where one is in the world)
  - The clock (the local time of day)
  - The calendar (the local time of the year)
What is important?

- If the necessary ingredients for severe convective storms are brought together
  - The storms will develop
  - The storms will be the same as those anywhere around the world!
  - What’s unique about Europe?
  - Any severe convective event that can happen in the USA can happen in Europe!!
Physical geography of Europe
A famous USA severe weather outbreak

- Instability created over high, dry terrain
- Overrides inflow of low-level moisture
Topography in Europe is complex

• Primary impact is on mesoscale processes!
  – Synoptic-scale systems
  – Storm-scale systems

• Mesoscale processes:
  – Fronts, drylines, convective mesosystems, etc.
  – Topographically-driven mesoscale processes

• Large impact on the likelihood of bringing together the ingredients

• Very different from the USA!
A Forecaster’s “Defining Moment”

• *Major* severe convective storms - that put people’s lives and property at risk - are relatively *rare* events

• Forecast shift work typically means you work only about 1/5 of the time or less

• Very few events = little or no *practice* - *You must* do it right the *first* time

• Will your actions make a positive difference?
• How will you feel about what you did?
How forecasters do poorly

• Begin the forecast shift without having anticipated all the possibilities - preconceived notions about the expected day’s weather

• When unanticipated events begin, the forecaster wastes valuable time trying to understand what's happening

• For convective storms, by the time the forecaster understands the situation, it’s usually too late to be of much help
How forecasters do well

• Continuously performing a careful diagnosis, looking for low-probability, but high impact possibilities

• Search for signs that those high impact scenarios might be developing

• Called a “metwatch”

• Have a prepared action plan ready for reacting quickly when necessary
Maddox’s Requirements for Making a Short-Term Forecast

1. An accurate **diagnosis**, including continuous monitoring, of the current situation

2. An extensive **physical understanding** of the phenomena occurring, including any anticipated developments
A conceptual model of the forecast process

• Forecast = Diagnosis + Trend … formally:

\[ Q(t_1) = Q(t_o) + \left. \frac{\partial Q}{\partial t} \right|_{t_o} \delta t \]

• Diagnosis (by a human forecaster!) is not just drawing contours - it means an understanding of ongoing meteorological processes
A Schematic Forecast process for $Q$
Poor nonlinear forecast

**simple nonlinear model**
Importance of diagnosis

bad diagnosis + perfect model

Forecast Quantity vs. Time

C
F
Typical result of inadequate diagnosis
DMC Ingredients

- Moisture
- Instability
- Lift

Convective available potential energy (CAPE)

Convective inhibition (CIN)
Sources of lift

- Extratropical cyclone = synoptic-scale (quasigeostrophic) vertical motion ~ a few (say, 2) cm s$^{-1}$
  - LFC = 2 km $\Rightarrow$ 100 000 s $>$ 1 day
- Subsynoptic-scale vertical motion ~ 20+ cm s$^{-1}$ $\Rightarrow$ < 10 000 s (about 3 h)
DMC related to ETCs

Slow ascent over warm front

Rapid ascent along cold front
Where does the lift occur?

• Ascent - especially subsynoptic-scale ascent - does not usually happen in the centers of anticyclones!
• In ETCs, ascent usually is concentrated along dynamic boundaries – Fronts, drylines (mesoscale?)
• Orographic ascent - upslope flow
• Subsynoptic-scale baroclinic boundaries (e.g., land/sea breeze fronts, outflow boundaries)
10 May 2008 case (20Z)
10 May 2008 Case - (04Z)
Subsynoptic Scale (Mesoscale) Boundaries
Severe Wx forecasting challenges

• False alarms!
  – Sufficiency of ingredients
  – Not all necessary ingredients are known

• Each severe weather type represents a different set of problems
  – Convective wind gusts
  – Large hail
  – Tornadoes
  – Heavy, flash-flood producing rainfall
Forecasting practice

• Hand analysis of upper air charts
• Identify key soundings and analyze them
• Routine hand-done surface analysis
  – Not the “industry standard” of fronts and isobars
  – Isotherms and isodrosotherms or … preferably … Potential temperature and mixing ratio
Standard surface analysis = *Useless!*
The “Met Watch”

• Develop a conceptual model of ongoing processes – identify and resolve issues of questionable data
• Monitor satellite imagery, radar
• Surface analysis (at least once every 3 h)
  – Identify signs of impending changes in the ongoing processes
  – Update your conceptual model
• Practice in these methods is most easily obtained in “boring” weather situations
• Be able to anticipate important changes
Use of numerical models

• Trying to identify the “model of the day” is a waste of time!!
• Use the concept of the “ensemble”
  – Gives a sense of what is possible
    • What is most likely
    • Low probability – high impact scenarios
  – Before things begin: forecast what is most probable, but be alert to the possibilities
Nonlinear thinking

- **Anticipating events**
  - Ingredients not yet together? Does it look possible they will be?
  - What kind of events? For deep convection, a critical ingredient for sustained severe wx is **vertical wind shear**
  - Affects degree of organization of convection
    - Pulse severe convective storms
    - Isolated multicell storms
    - Linearly-organized multicell storms
    - Supercells
Nonlinear thinking (cont’d)

• Complex terrain and associated mesoscale processes dominate the weather in Europe!
• Any attempt at scientific forecasting in Europe must include familiarity with the science of these processes
• Local *experience* with these processes is critical!
  – A big factor in becoming a good forecaster of European severe convective storms
ESTOFEX

• These are the best, most experienced severe convective storm forecasters in Europe!

• A good example of what I believe is needed for Europe
For any forecast to be effective

• Your forecasts must be
  – Seen/heard by the users, who must
  – Understand the forecast
  – Believe the forecast
  – Know what it means to them
  – Know what to do with the information
  – Take the appropriate action
Societal infrastructure needed

- Means of getting forecasts to public quickly
- Collaboration between forecaster and emergency managers
- Public education – most Europeans still believe severe convective storms “don’t happen here”
- Formal, permanent funding for a pan-European severe storms forecasting agency
Thank you!!

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