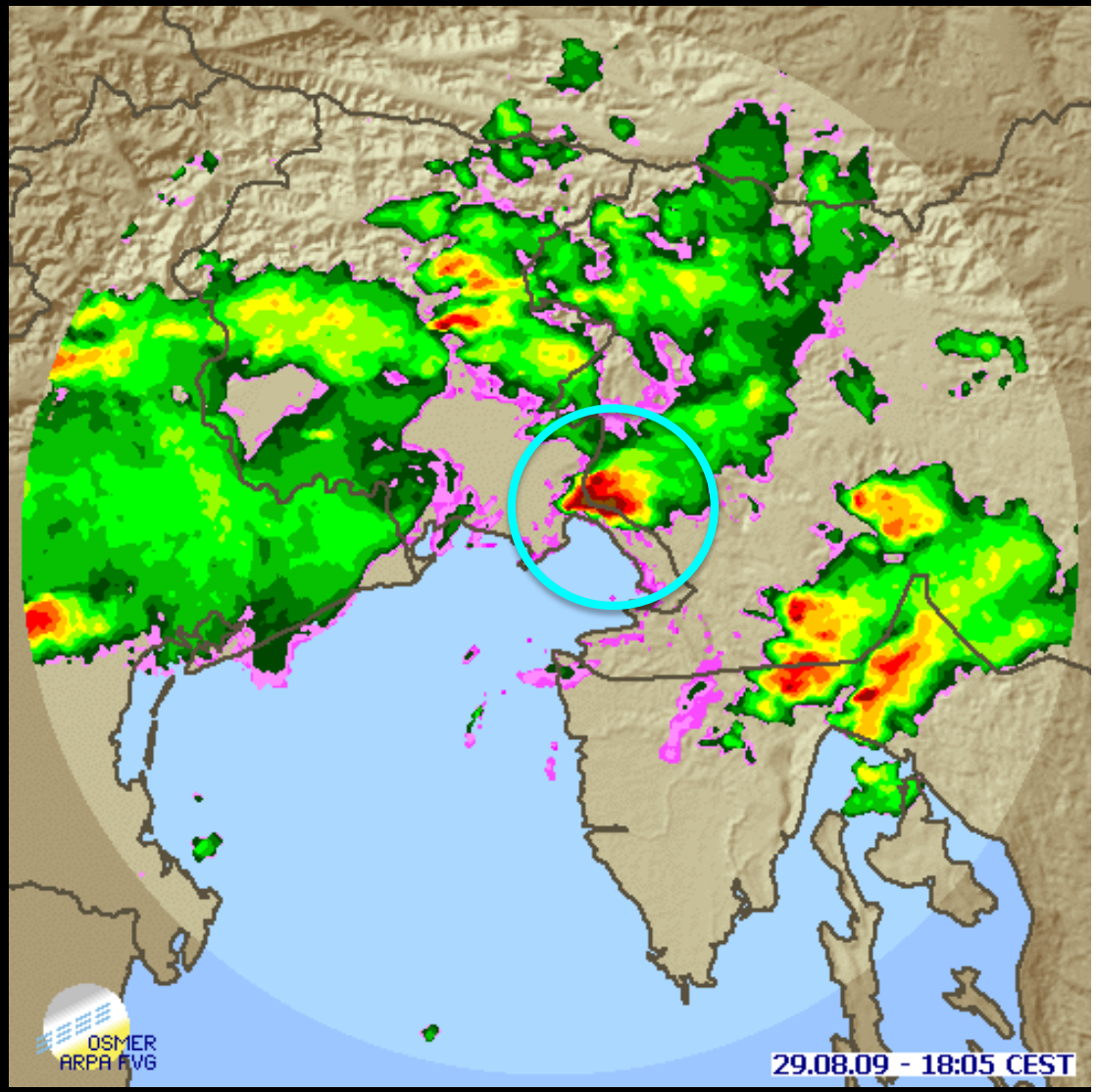
Severe Convective Weather Forecasting in Europe



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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)

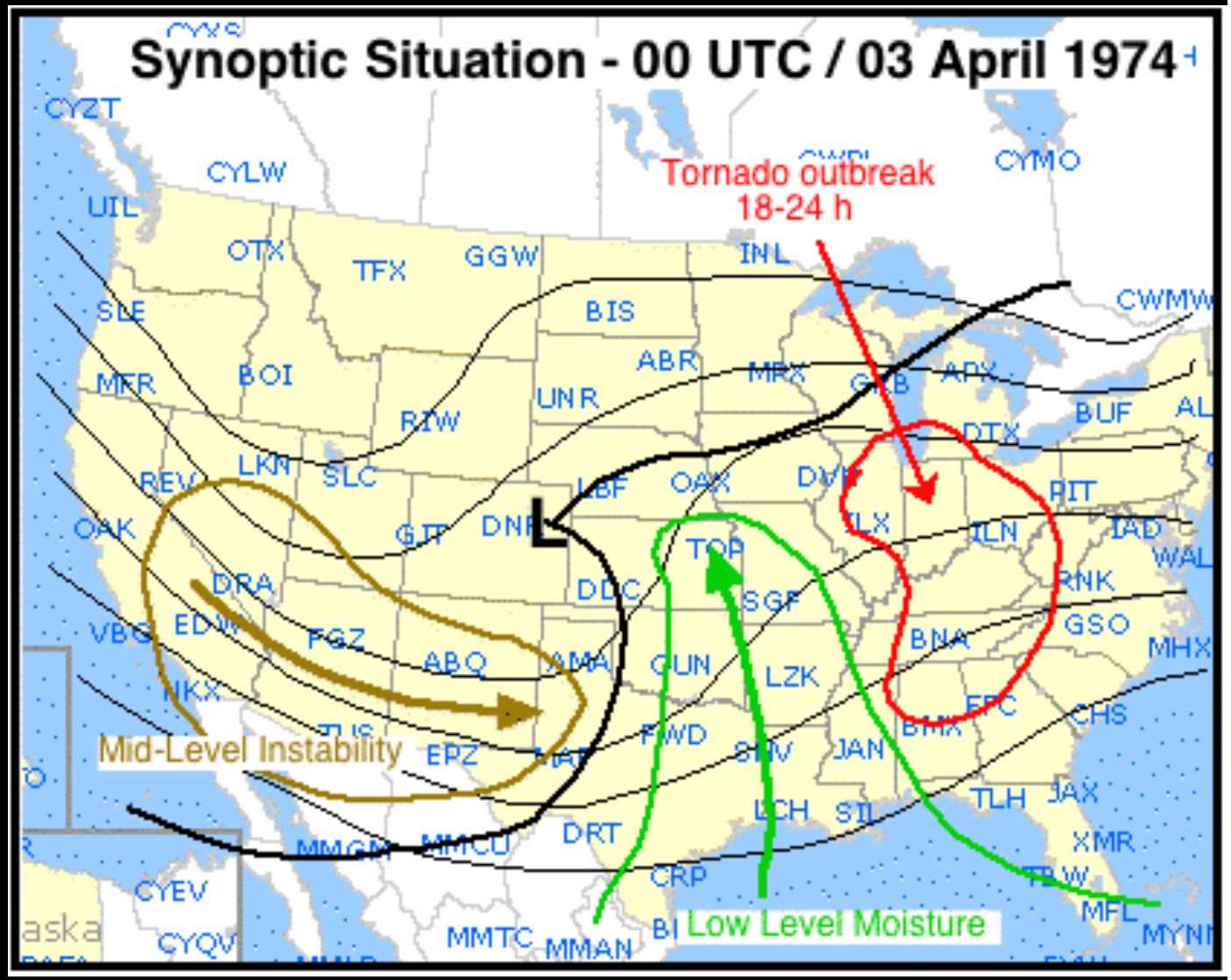
What is important?

- 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

  } similar around the world
- 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

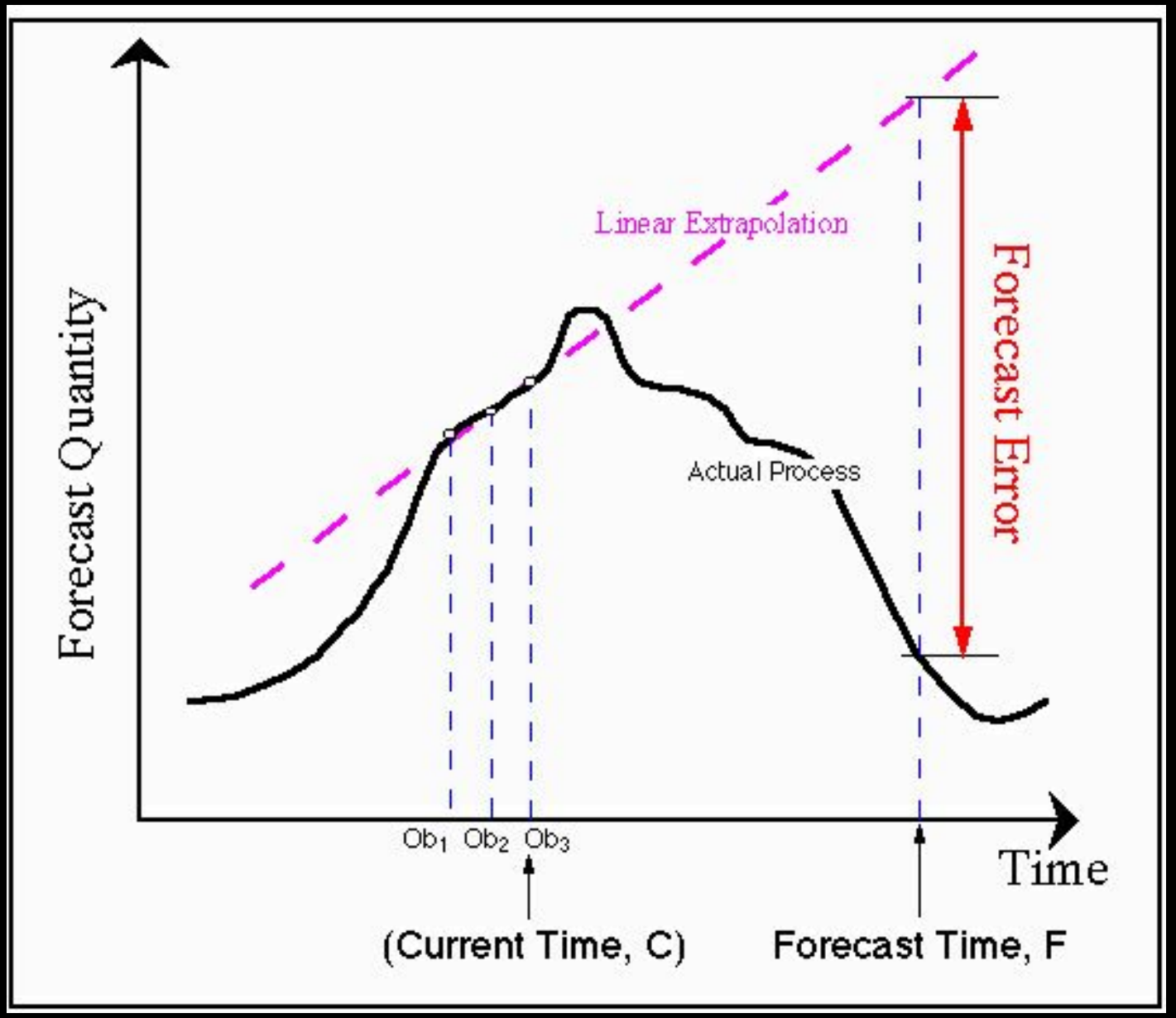
A conceptual model of the forecast process

- Forecast = Diagnosis + Trend … formally:

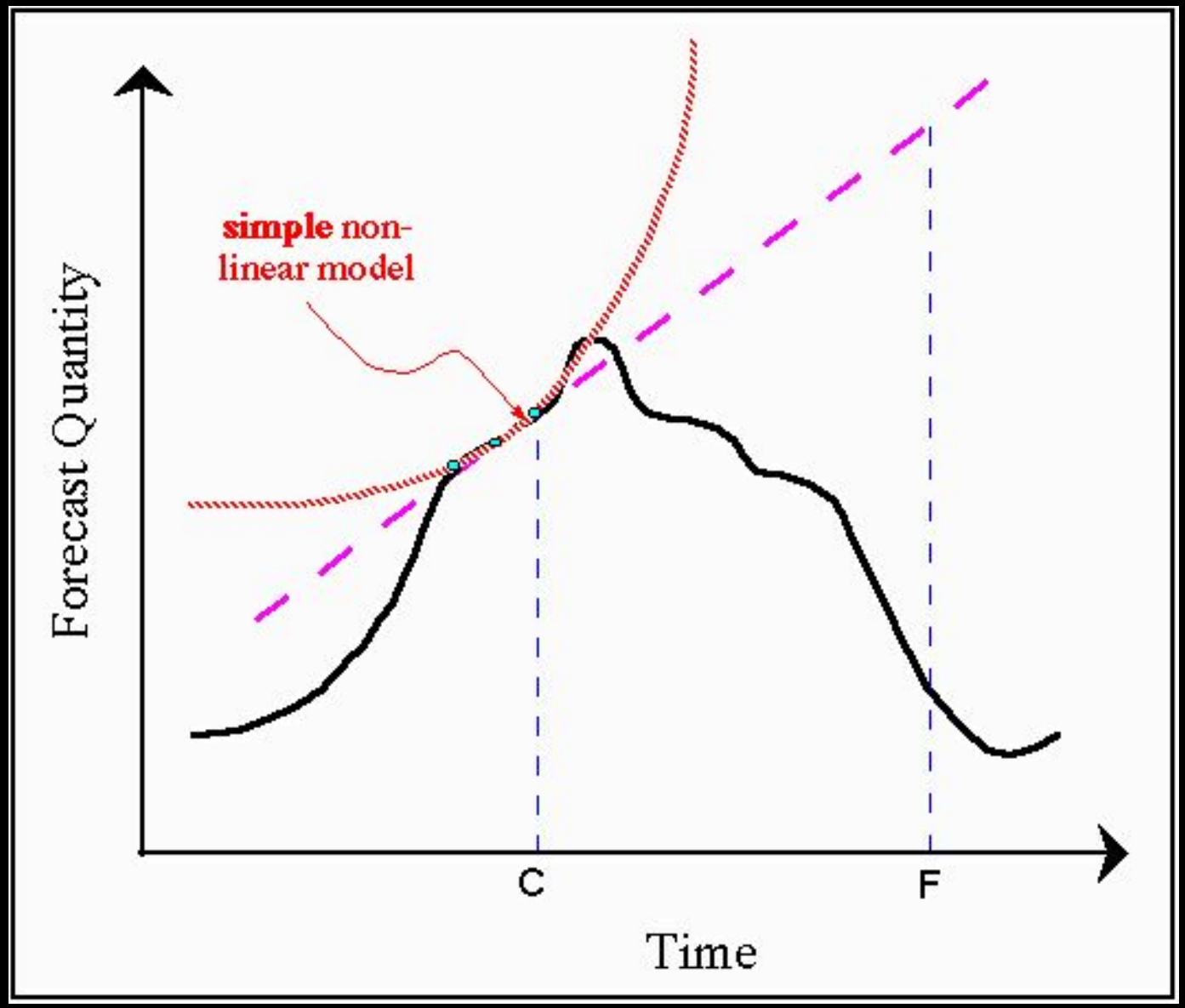
$$Q(t_1) = \underbrace{Q(t_o)}_{diagnosis} + \underbrace{\left.\frac{\partial Q}{\partial t}\right|_{t_o} \delta t}_{trend}$$

- Diagnosis (by a human forecaster!) is *not* just drawing contours - it means an understanding of ongoing meteorological processes

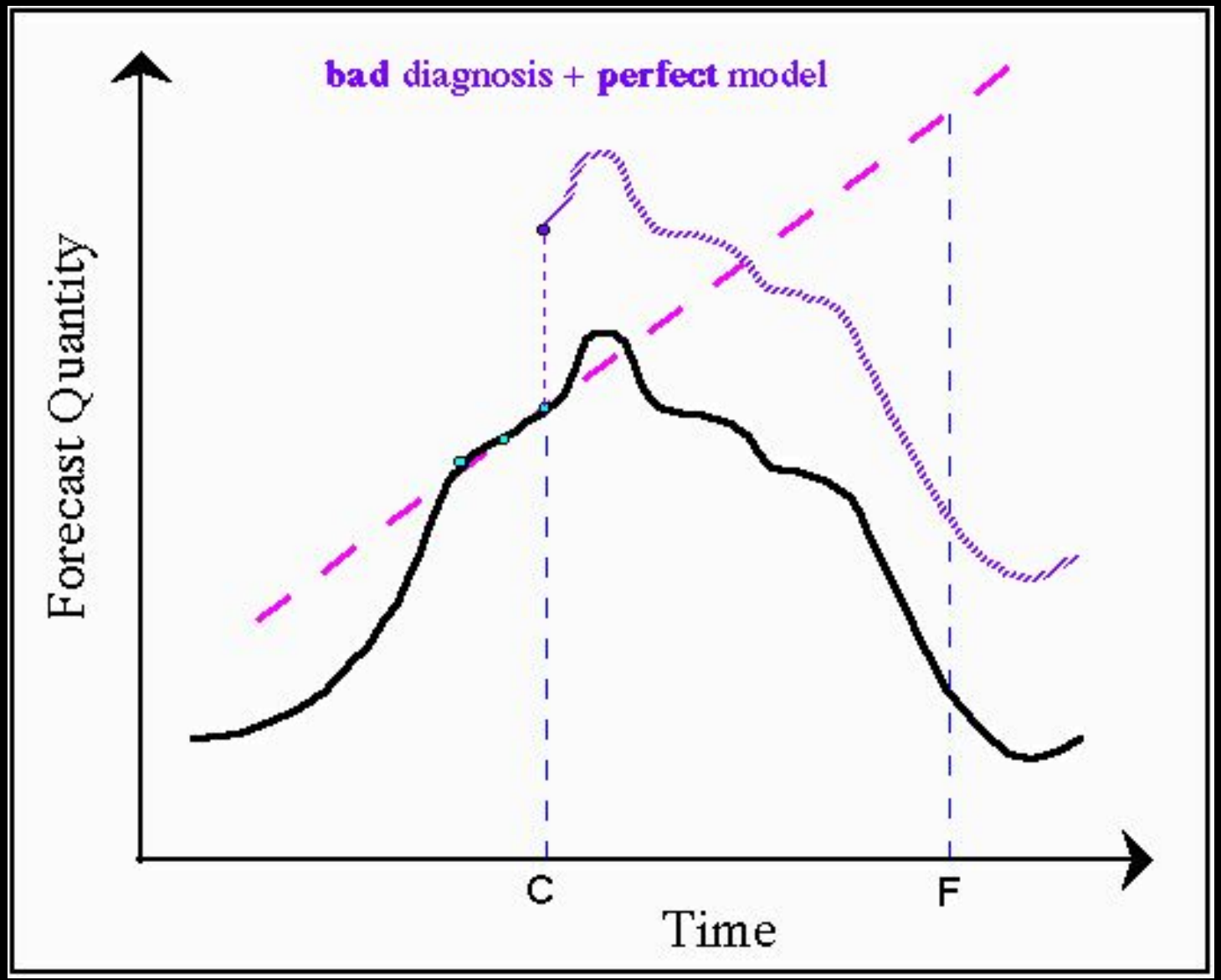
A Schematic Forecast process for Q



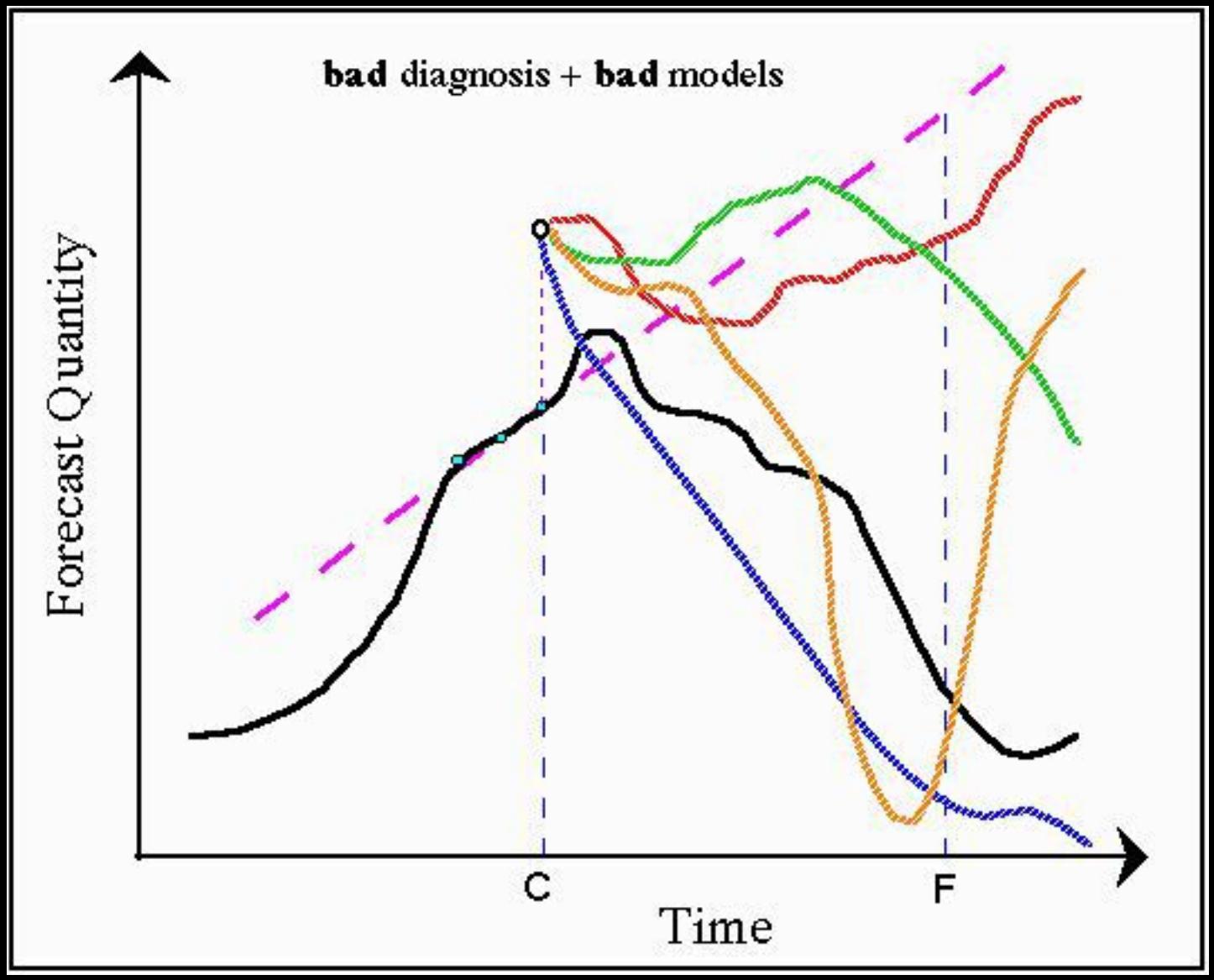
Poor nonlinear forecast



Importance of diagnosis



Typical result of inadequate diagnosis

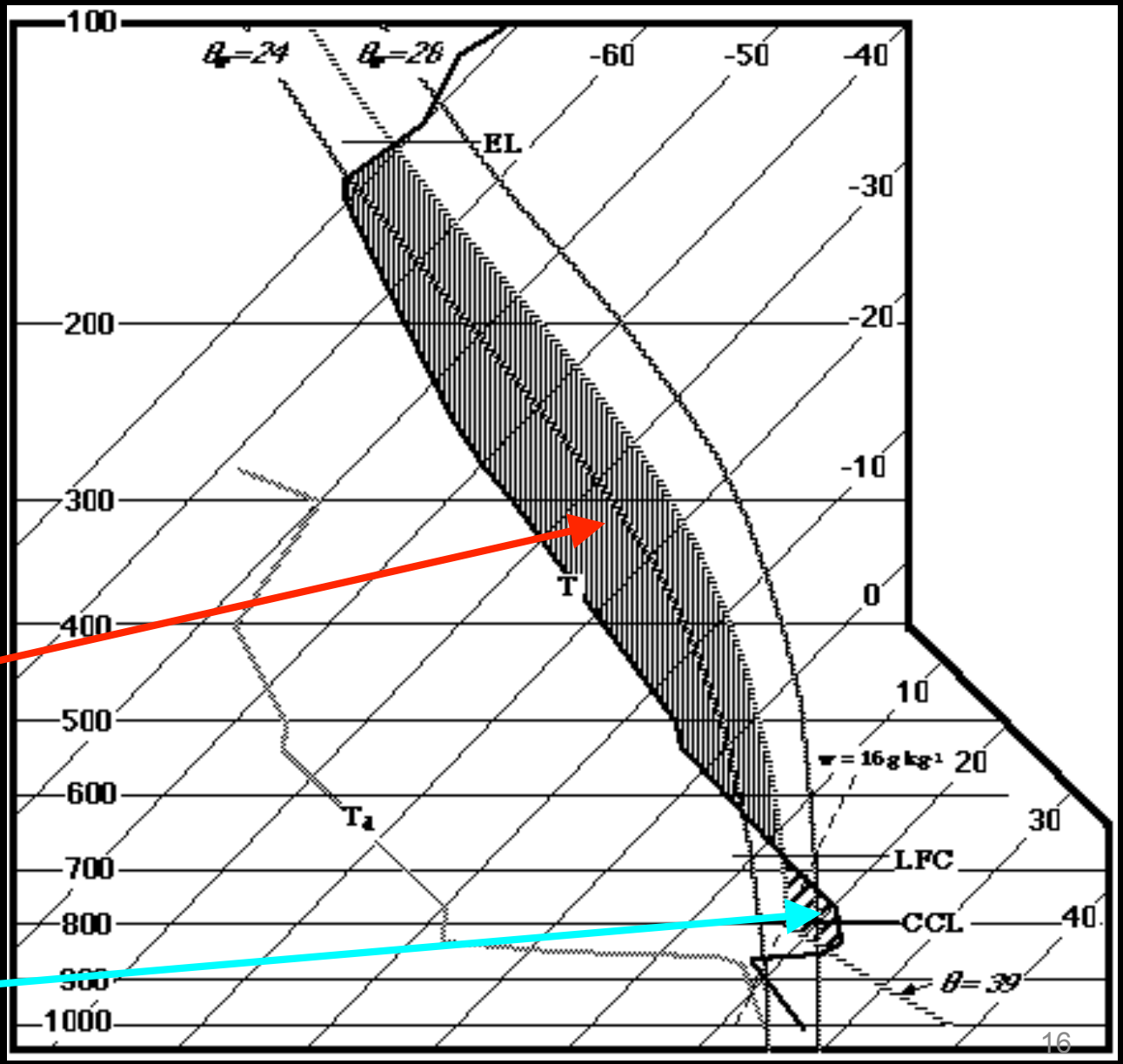


DMC Ingredients

- Moisture
- Instability
- Lift

Convective available potential energy (CAPE)

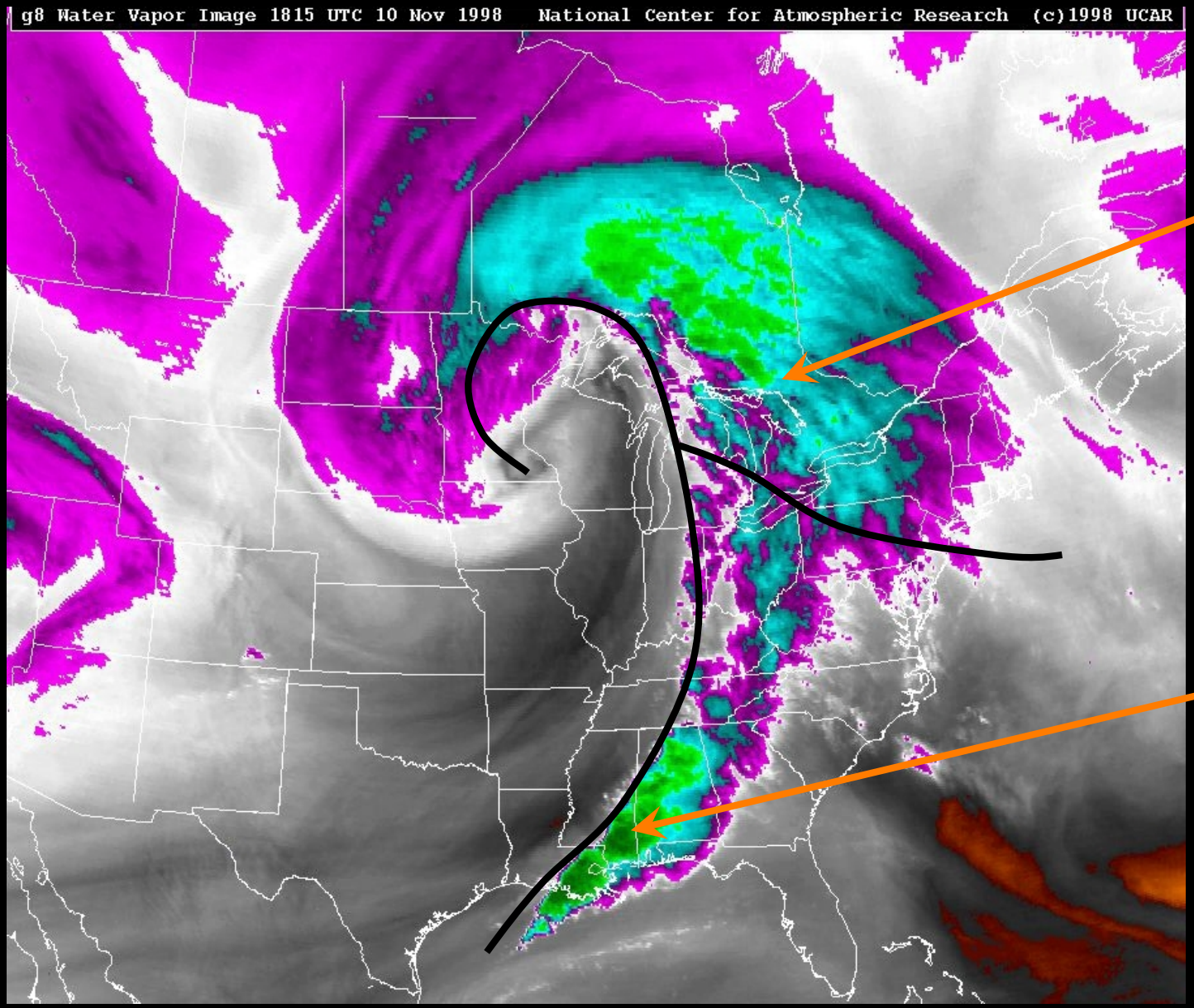
Convective inhibition (CIN)



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



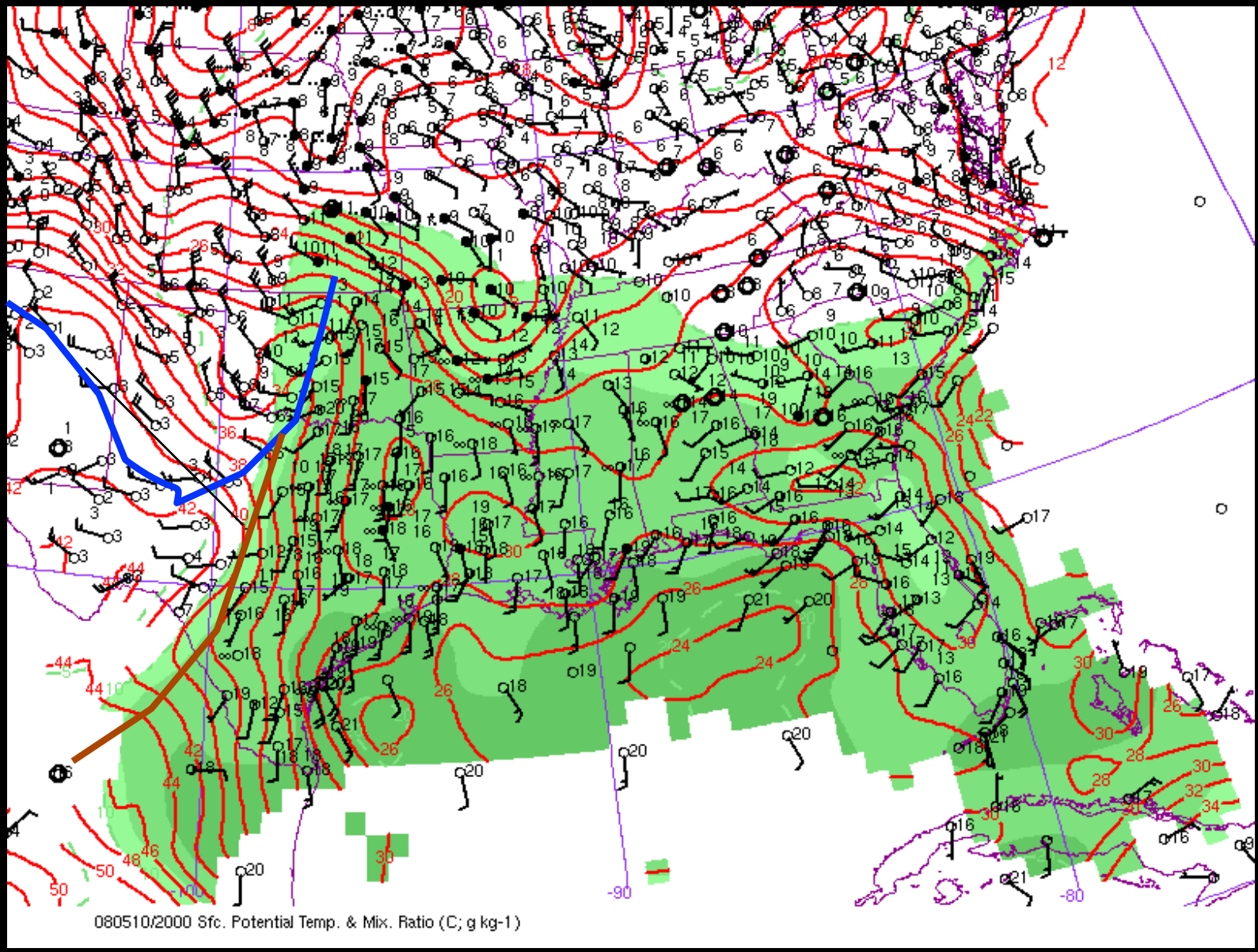
Slow ascent over warm front

Rapid ascent along cold front

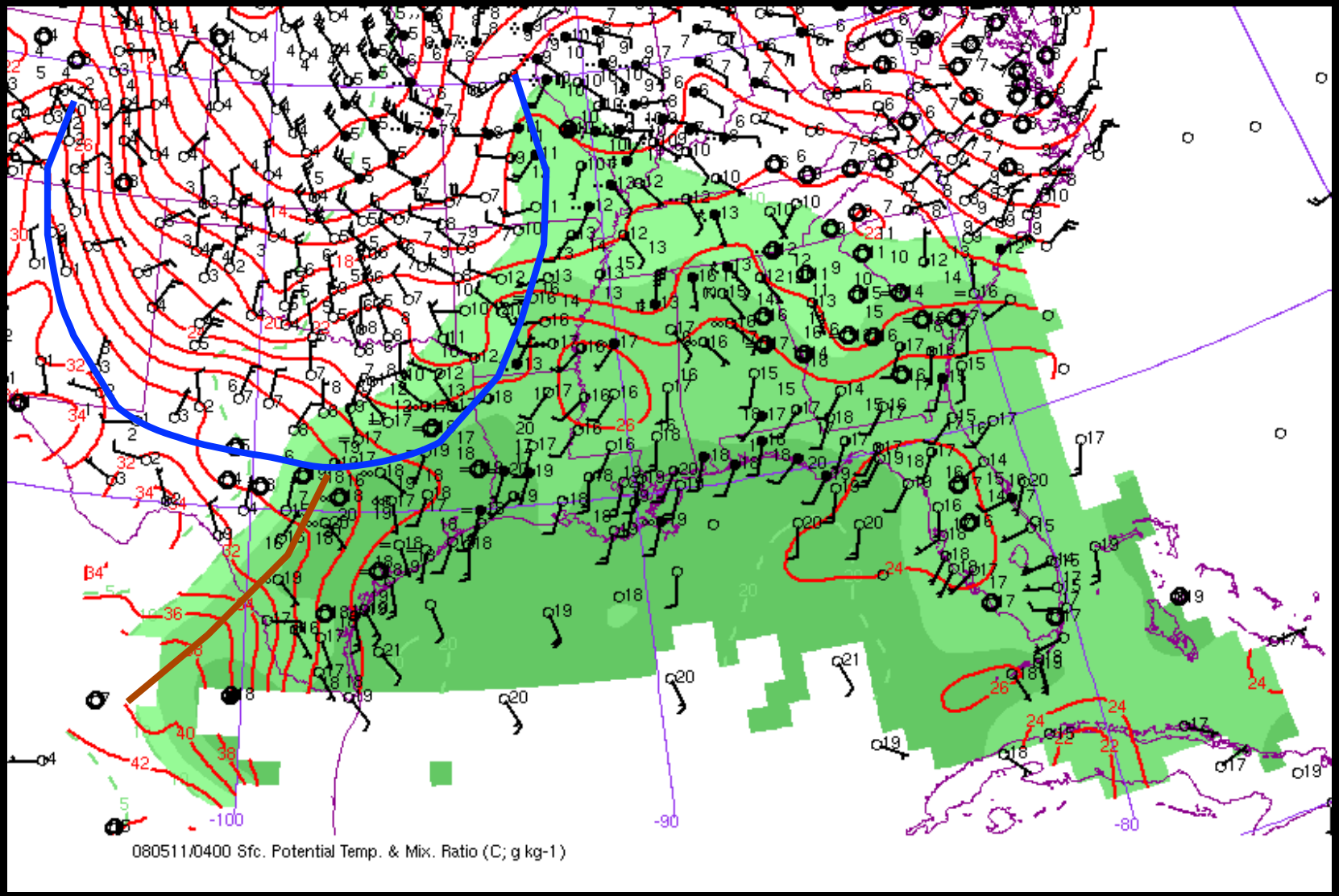
Where does the lift occur?

- 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)

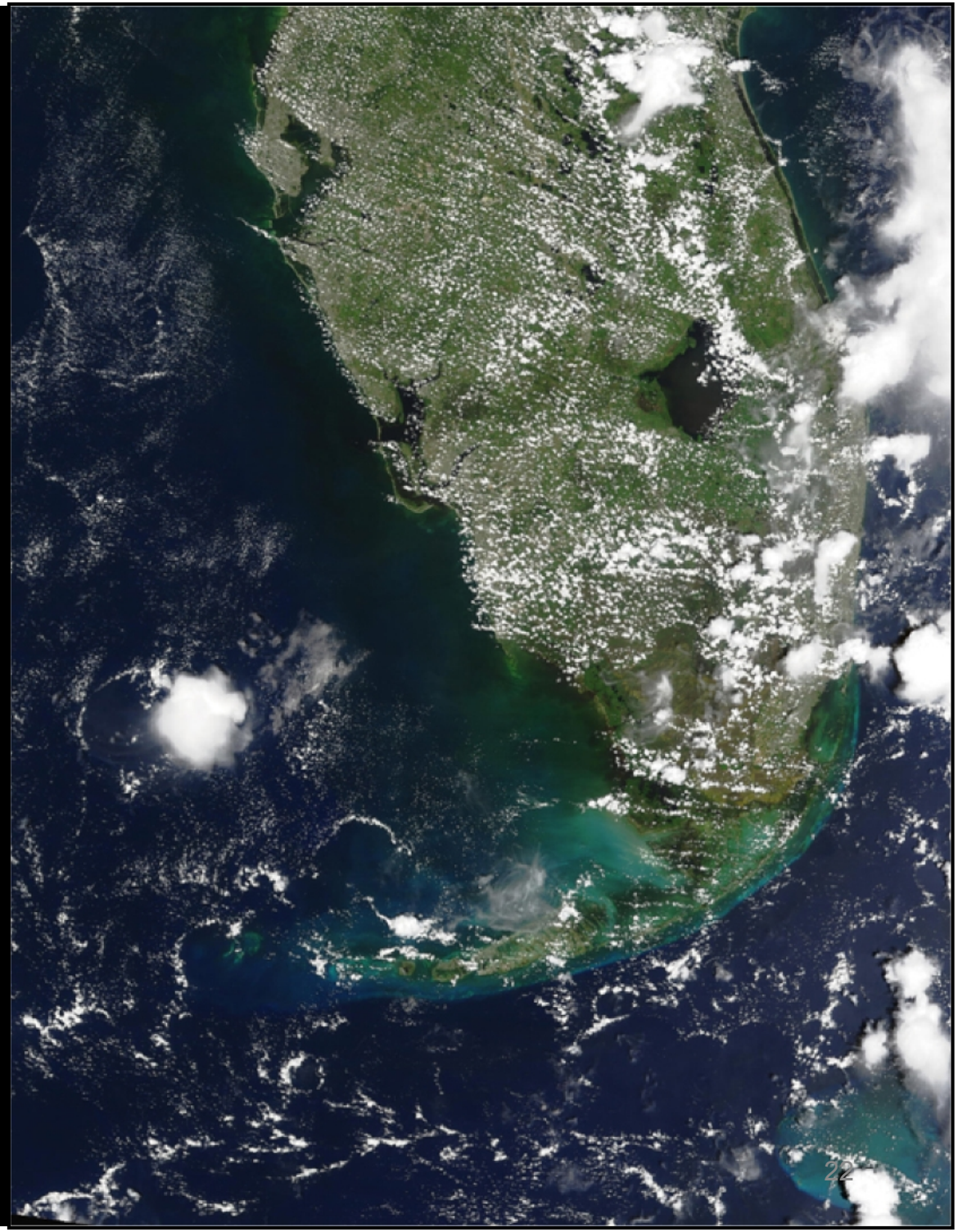
10 May 2008 case (20Z)



10 May 2008 Case - (04Z)



Subsynoptic Scale (Mesoscale) Boundaries



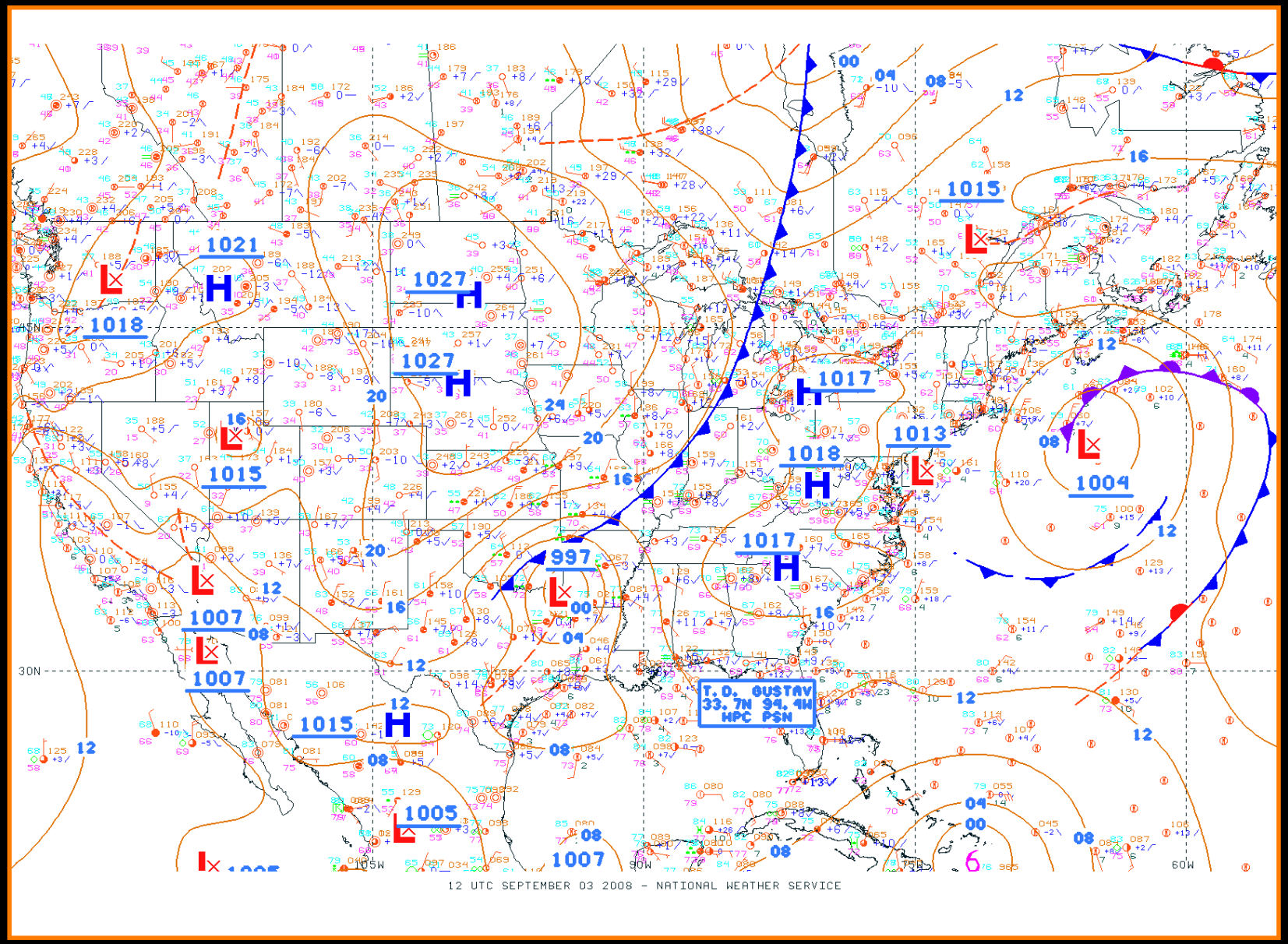
Severe Wx forecasting challenges

- 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

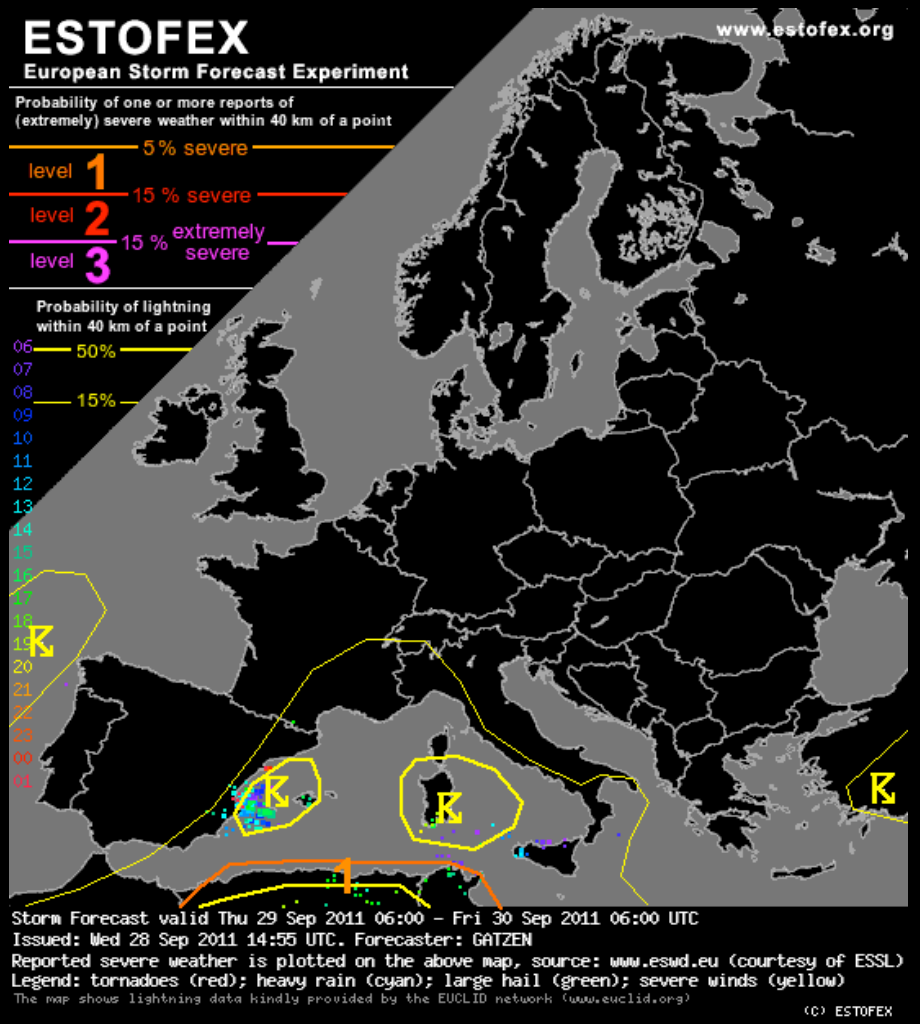
- Anticipating events
  - Ingredients not yet together? Does it look possible they will be?
  - What kind of events? For deep convection, a critical ingredient for sustained severe wx is vertical wind shear
    - Affects degree of organization of convection
      - Pulse severe convective storms
      - 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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