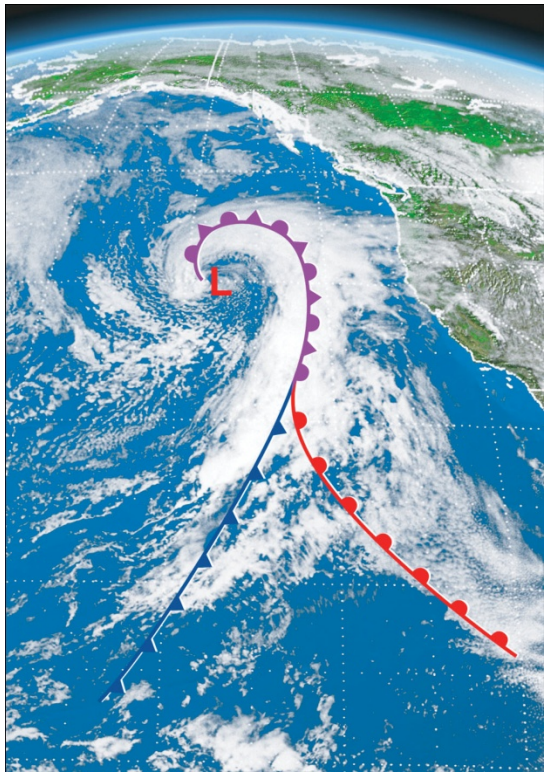
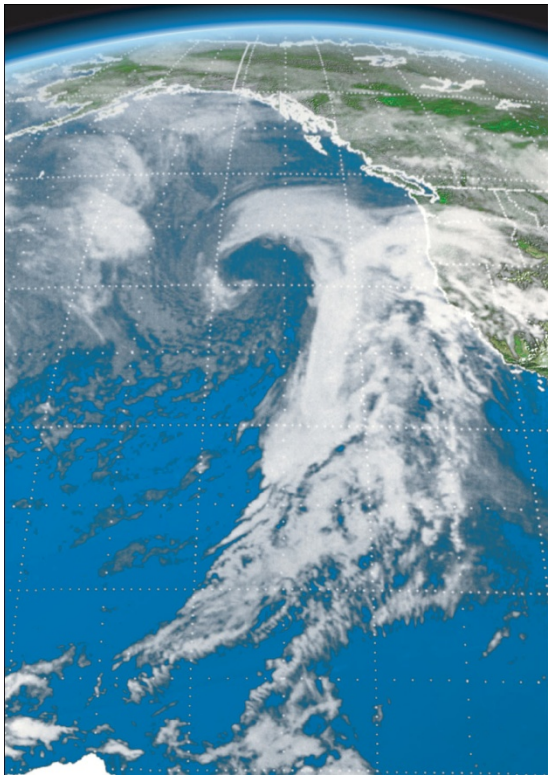
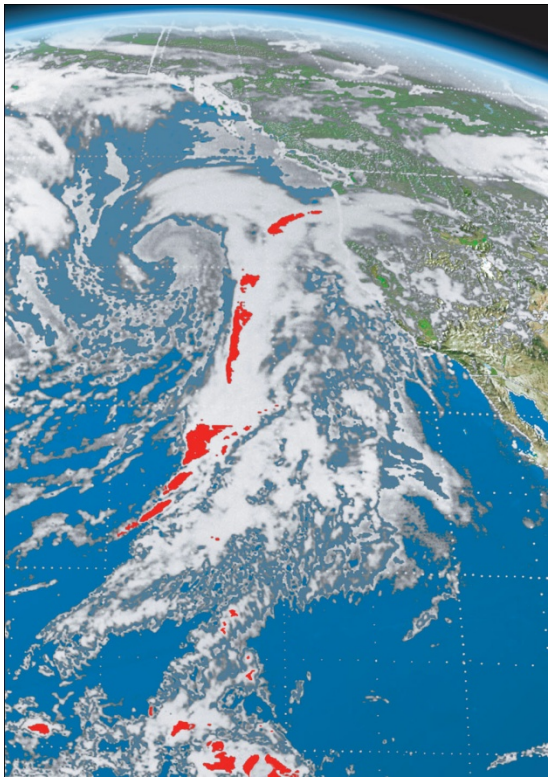
Chapter 12 – Weather Analysis and Forecasting



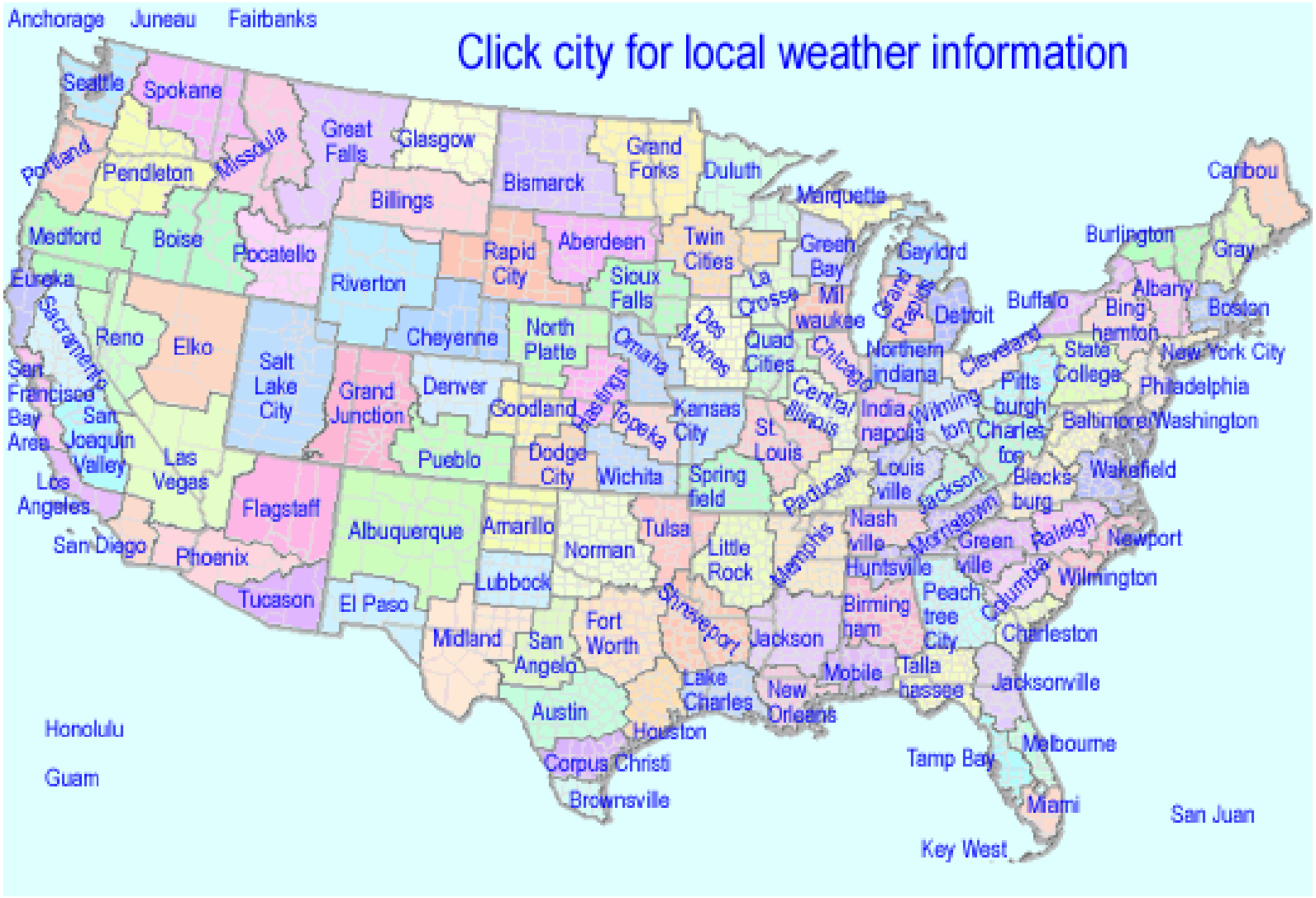




The National Weather Service

- The National Weather Service (NWS) is responsible for forecasts several times daily
    - Different weather forecast offices (WFOs) are responsible for their specific region
    - WFOs are also responsible for warnings in their specific region
    - NWS forecasters rely heavily on the Advanced Weather Information Processing System (AWIPS) to understand current conditions and make forecasts

The National Weather Service WFOs



- 122 Weather Forecast Offices (CONUS, AK, HI, Guam and Puerto Rico)

The National Weather Service

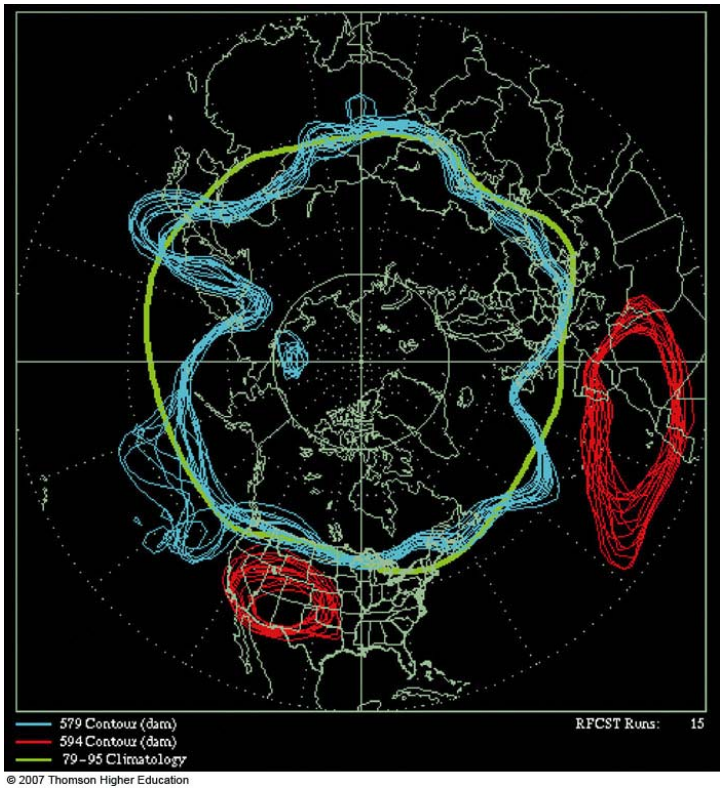
- A variety of products are created at NWS WFOs
    - Short-term forecasts
    - 7-day zone forecasts
    - Aviation forecasts
    - Marine forecasts
    - Forecast discussions

- Forecasts from now out to a few hours is called **nowcasting**
    - Strongly based on observations (radar, satellite images, surface, observations)

- Forecasts beyond 6 hours is based mostly on numerical weather prediction (**NWP**) models

Numerical Weather Prediction

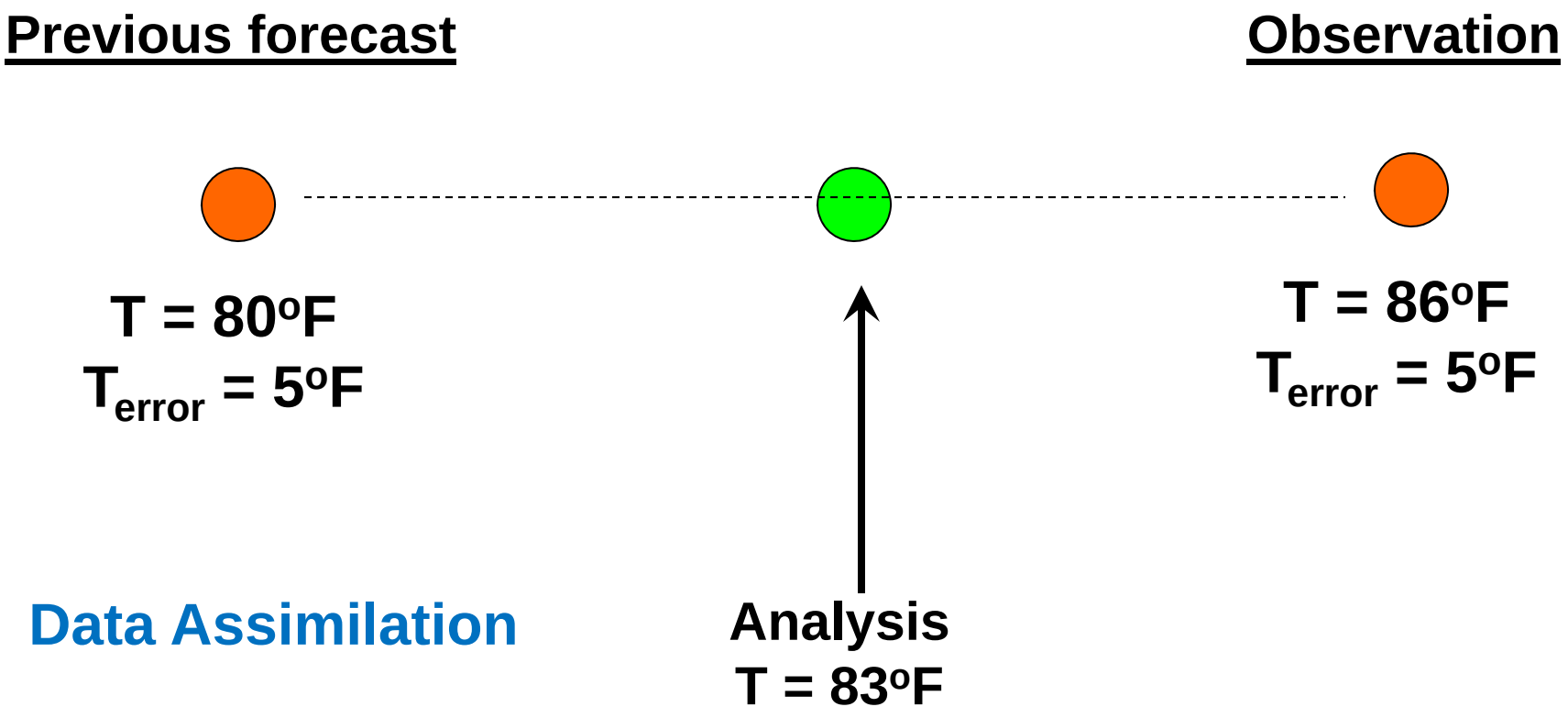
- Numerical weather models operate in 3 main phases:
    1) Analysis
    2) Prediction
    3) Post-processing



Progs: prosnostic chart for weather forecast for a specific future period

Numerical Weather Prediction – The Analysis Phase

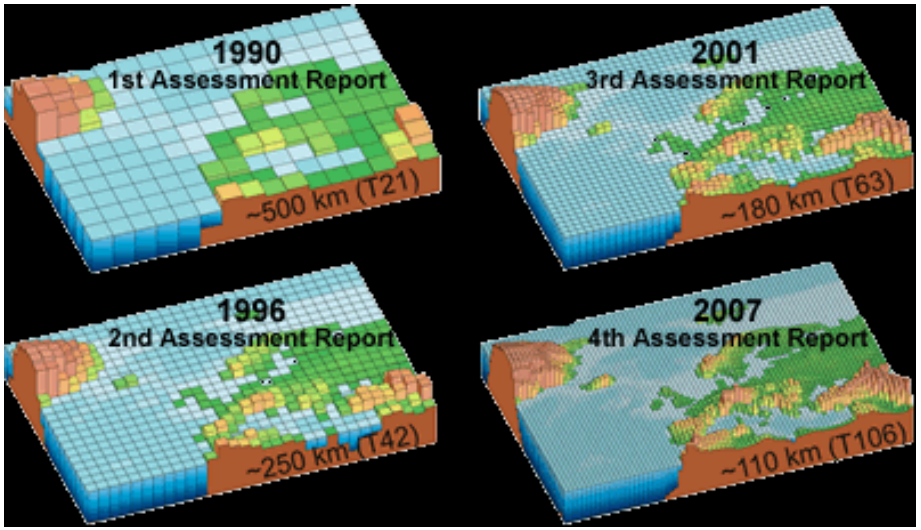
- A gridded, 3-dimensional analysis is produced with
  1) A previous forecast
  2) Observations

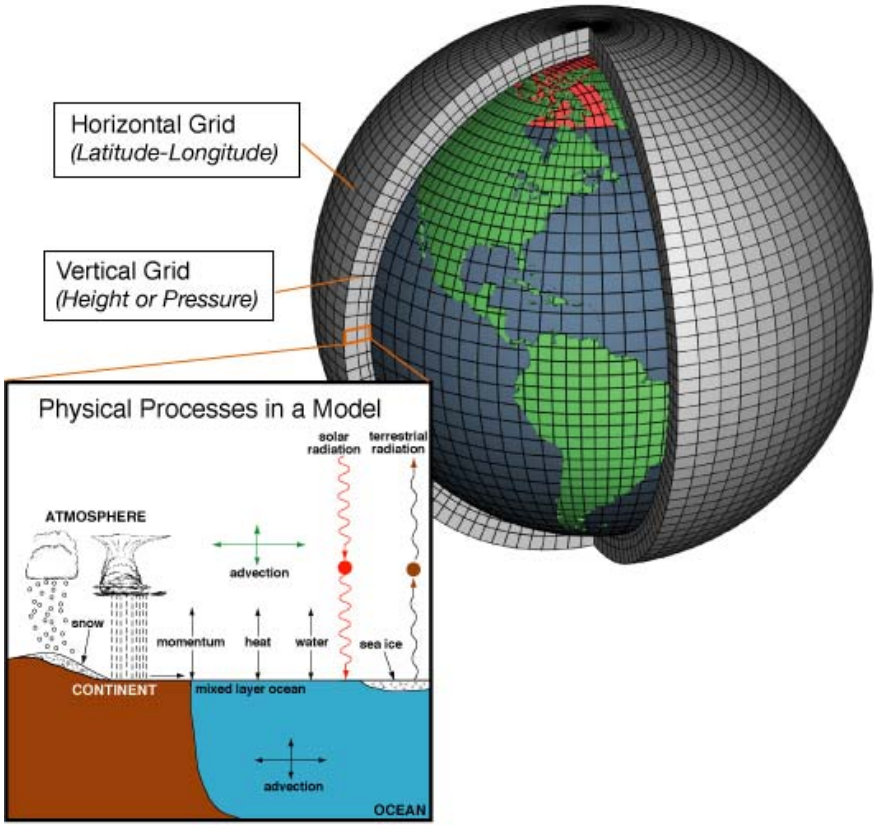


Numerical Weather Prediction – The Prediction Phase

- The prediction phase of NWP involves calculating the future state of the atmosphere (starting point = the analysis) under the following **governing equations**:

  1) Conservation of momentum
  2) Conservation of mass
  3) Conservation of energy





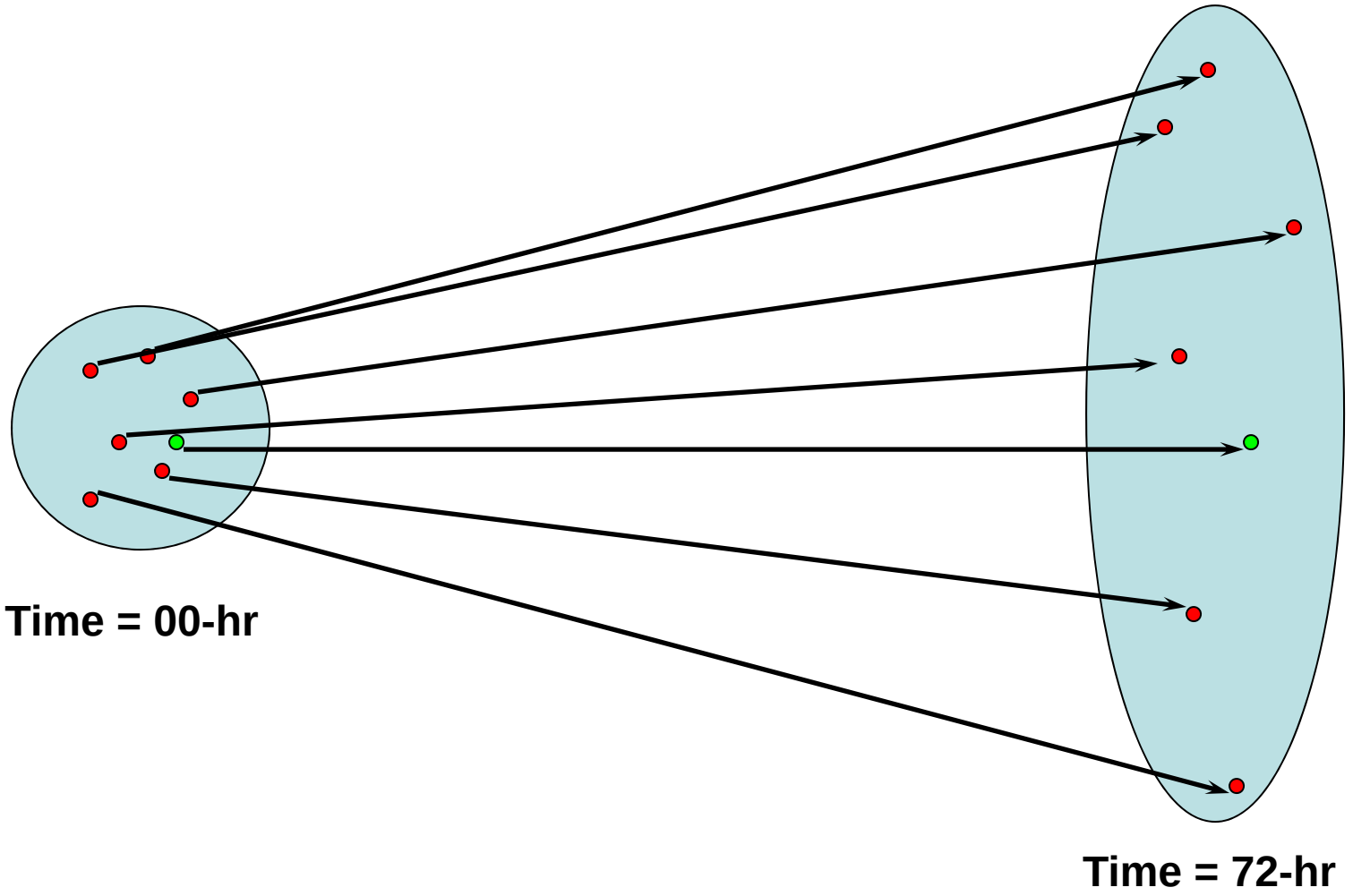
Numerical Weather Prediction – The Prediction Phase

- NWP can be classified in 2 ways:

    1) **Deterministic** – a single forecast is produced and relied upon

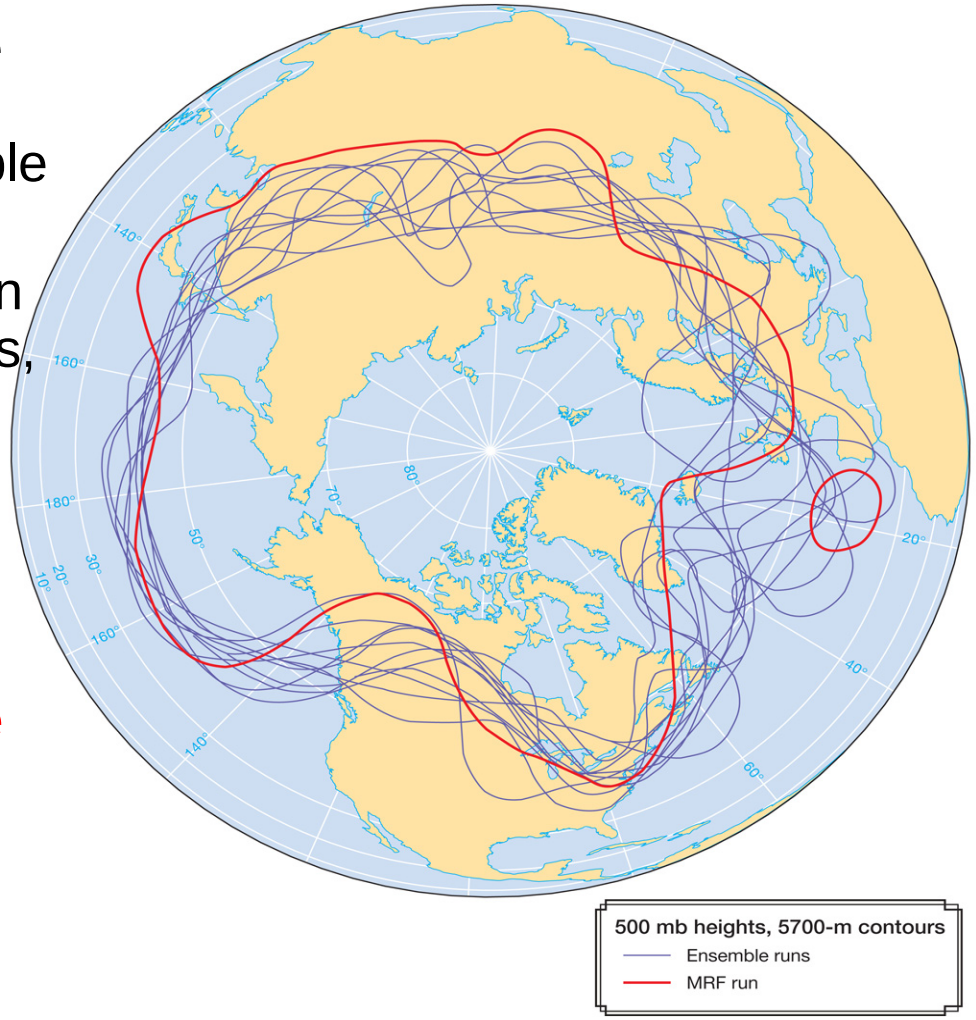
    2) **Probabilistic** – many forecasts are produced and forecast probabilities can be generated (**ensemble forecasting**)

Deterministic vs. Probabilistic Forecasting



Probabilistic Forecasting

- There are several ways to produce probabilistic information but the most viable and popular is ensemble prediction.
- Instead of running one forecast, run a collection (ensemble) of forecasts, each starting from a different initial state or with different physics.
- The variations in the resulting forecasts can be used to estimate the uncertainty of the prediction.
- The ensemble mean is on average more skillful than any individual member.



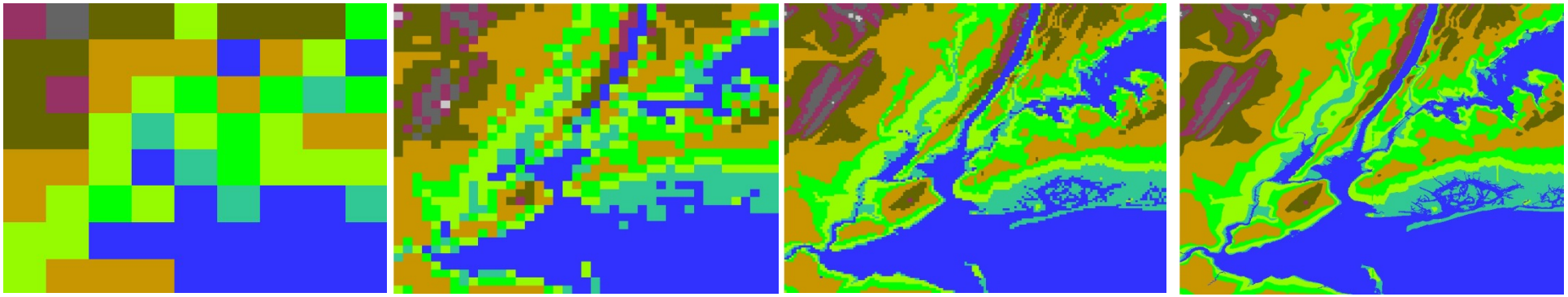
10-day forecasts

The Prediction Phase: Forecasts Gone Bad

- There are 2 main sources of error in NWP forecasts:

  1) **Initial condition error** – errors in the analysis stage

  2) **Physics errors** – model algorithms, mostly associated with surface processes (radiation, frictional turbulence, convection, clouds), issues of scale (40 km for global models)

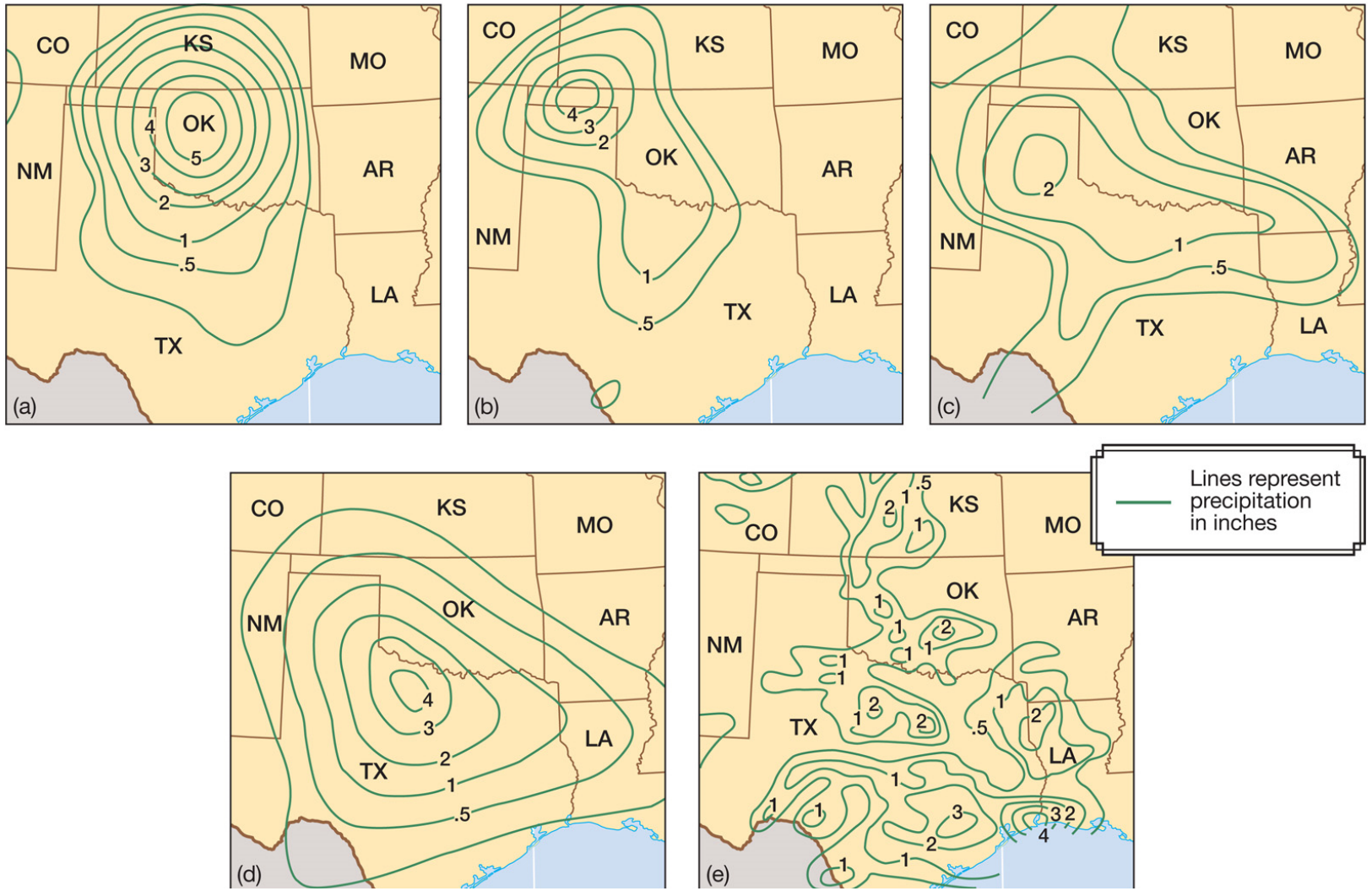


Numerical Weather Prediction – The Post-processing Phase

- The post-processing phase of NWP involves creating graphics of the forecast:

    1) 500-mb height
    2) SLP
    3) Surface wind
    4) 3-hr precipitation
    5) 1000-500mb thickness

NWP Post-processing



- The final forecast product includes the human factor – judgments based on both a forecaster's experience and NWP

NWP Post-processing

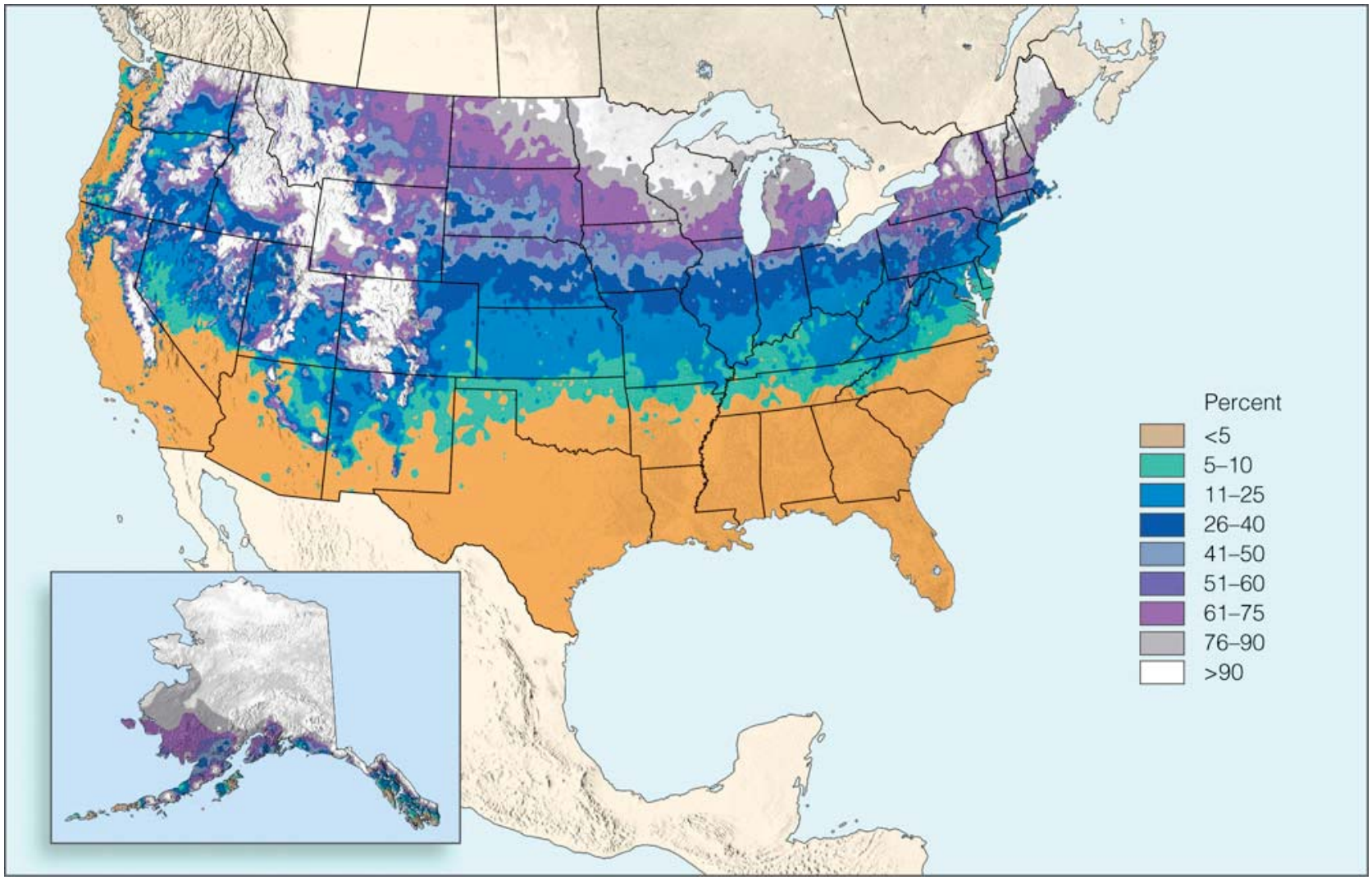
- Model Output Statistics (MOS) – a post-processing technique that correlates relationships between a model forecast and reality over many, many forecasts

- MOS produces a forecast incorporating these statistical relationships

Other Forecasting Methods

- **persistence forecast**: using current state to predict future; not bad for Tucson in June
- **trend forecast**: assuming constant change rate
- **analogue method**: search for similar chart in history
- **statistical forecast**: routinely used; Model Output Statistics (MOS)--correct known model errors
- **probability forecast**: particularly for precipitation
- **climatological forecast**: using climatology to predict future; good for Tucson rainfall in June

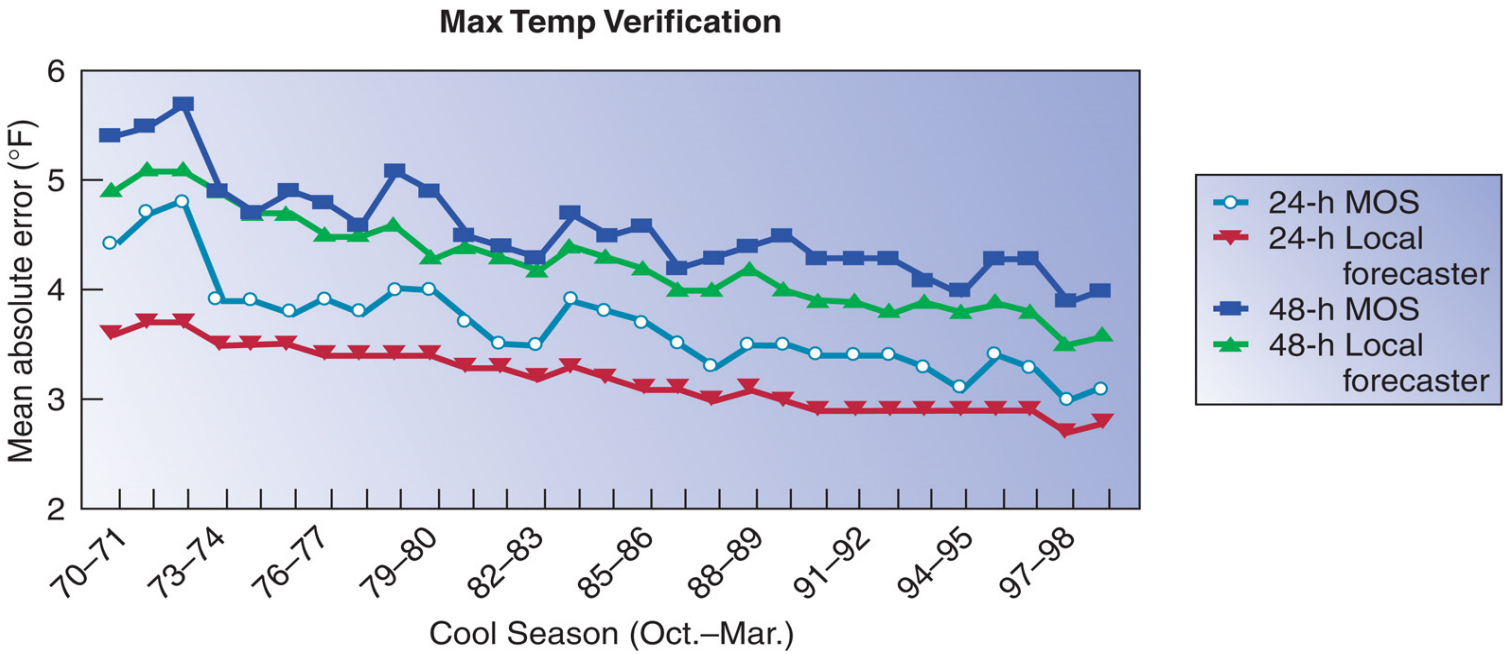
Climatological forecasting



Probability for a `white Christmas' – 1 inch or more of snow

Forecast Verification

- Forecast verification is the process of measuring the skill of a forecast (model, human forecaster, MOS…)



(a)

Types of Forecasts

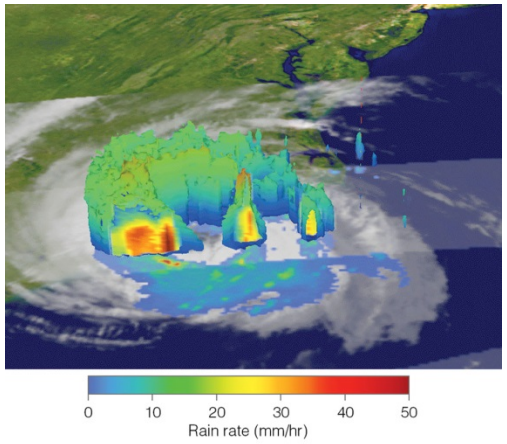
- very short range forecast or nowcast: 0-6 hr
- short range forecast: 6 hr – 2.5 days
- Medium-range (or extended) forecast: 3-8.5 days
- long range forecast: 8.5 days – 2 weeks
- Monthly and seasonal outlooks: above, near, or below normal conditions

The **Climate Prediction Center (CPC)** is responsible for forecasts valid more than 1 week into the future (numerical models and statistics)
http://www.cpc.ncep.noaa.gov/

Seasonal forecasts are also made by the CPC that indicate above or below probabilities of warm/cold or wet/dry seasons

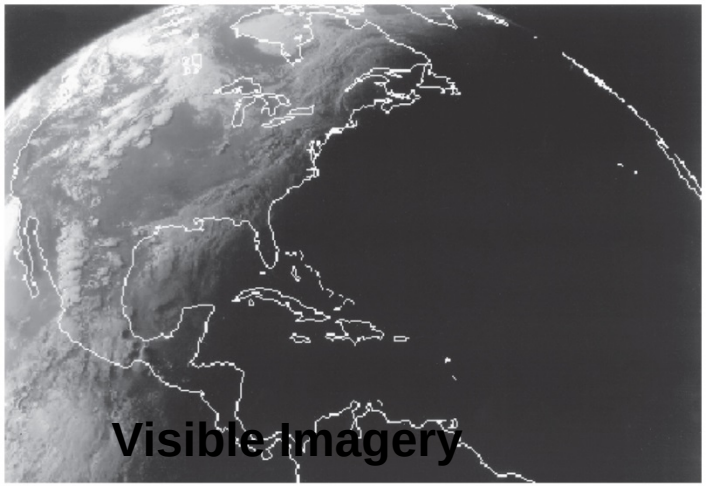
Weather Analysis

- Forecaster awareness is a major aspect of forecasting, and focuses on knowing the current atmospheric conditions using:
    1) Observations (radar, satellite, radiosondes, surface station obs)
    2) Weather maps
        - Surface
        - Aloft (850, 700, 500, 300mb)

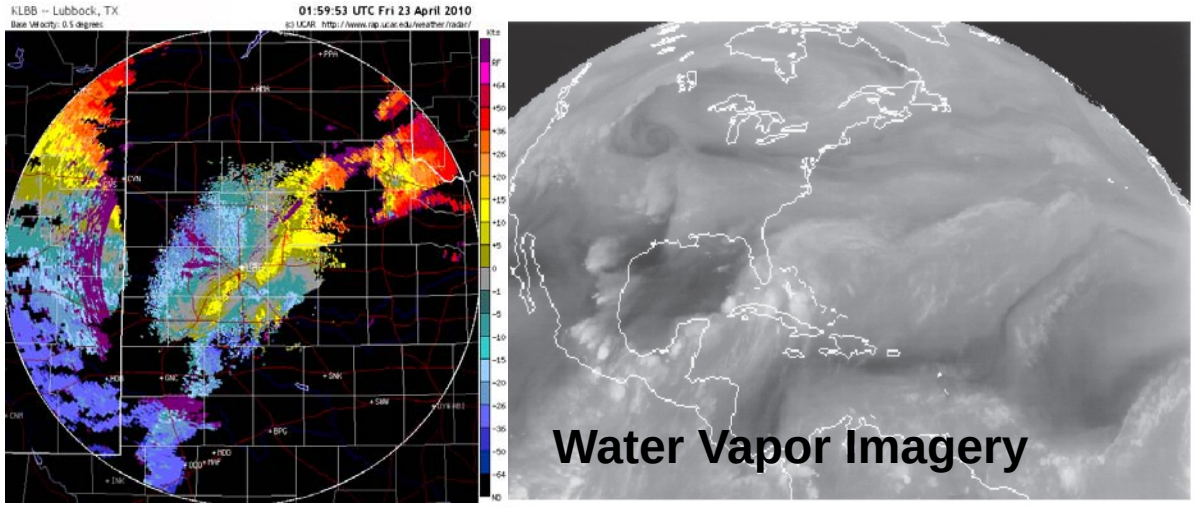


Observations

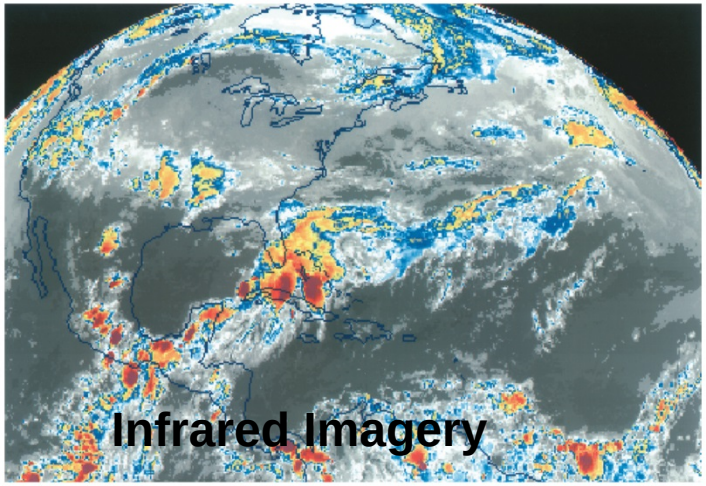
- 4 main observation types help forecasters familiarize themselves with current weather conditions:
  1) Satellite images
  2) Radar images
  3) Data output from radiosondes
  4) Surface station plots



(a)



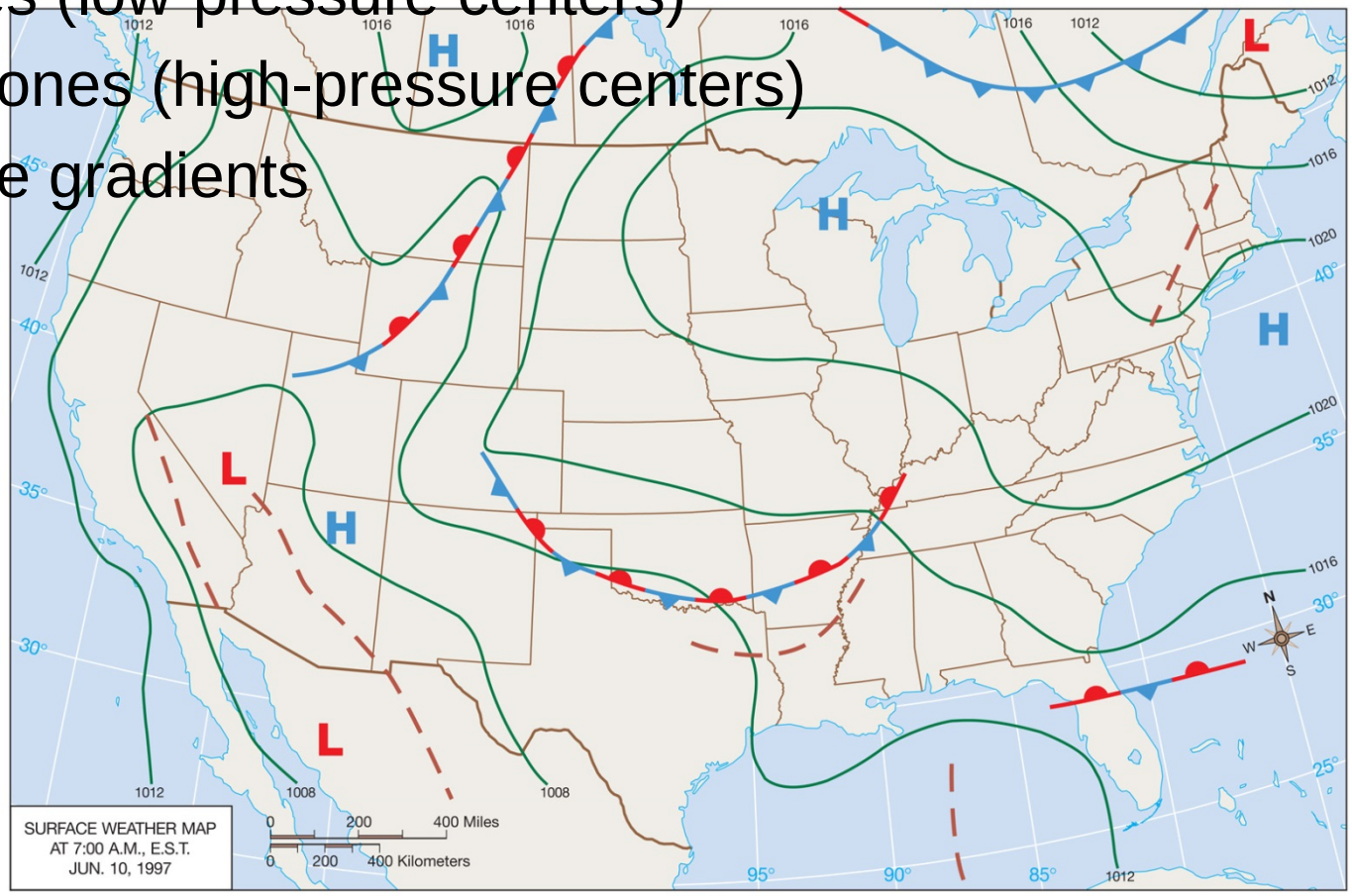
(c)



(b)

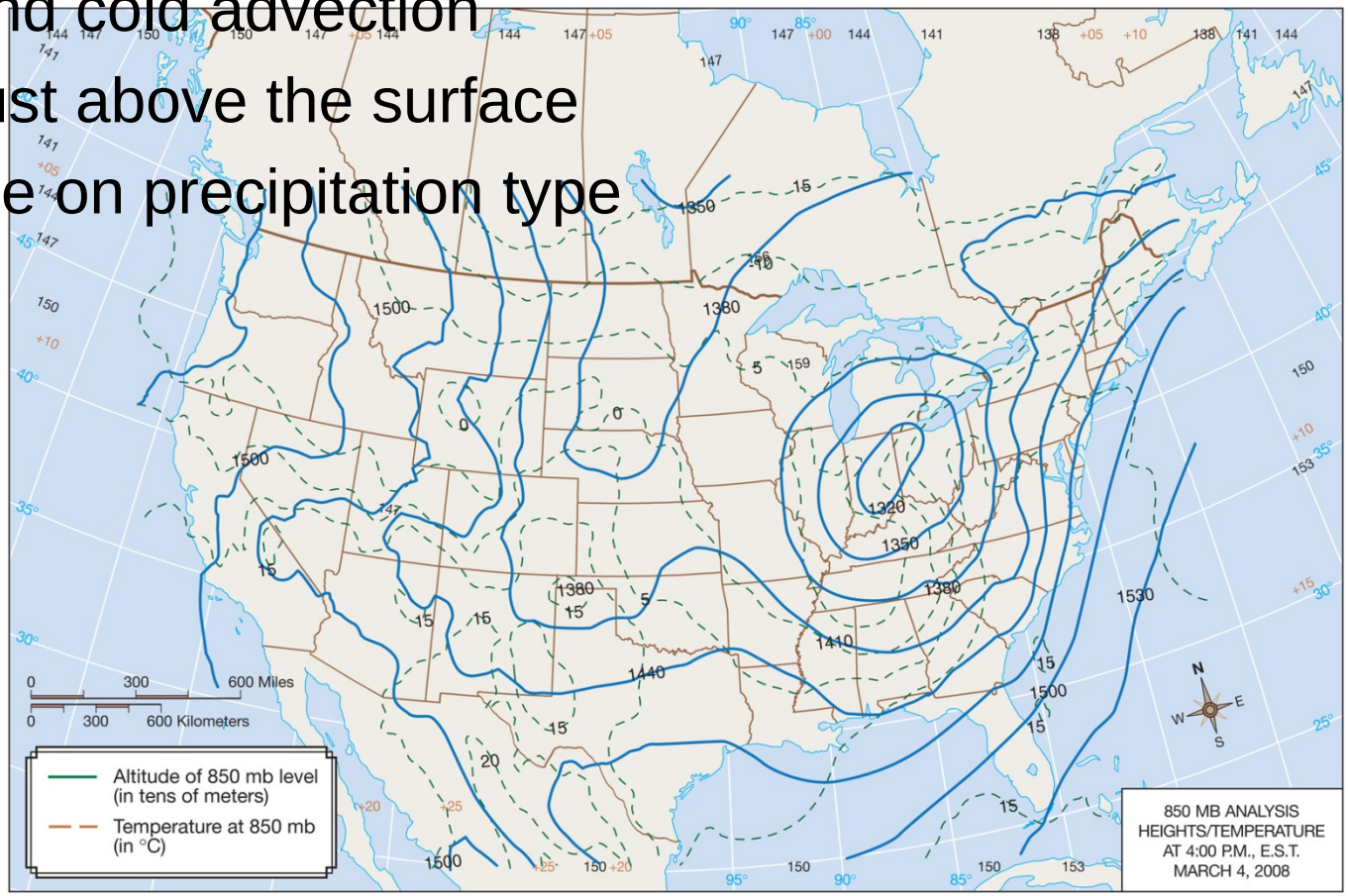
Weather Maps

- Surface maps – reveals locations:
    1) Fronts
    2) Cyclones (low-pressure centers)
    3) Anticyclones (high-pressure centers)
    4) Pressure gradients



Weather Maps

- 850-mb maps – reveals locations of:
  1) Fronts
  2) Warm and cold advection
  3) Winds just above the surface
  4) Guidance on precipitation type



Weather Maps

- 700-mb, 500-mb, and 300-mb maps – reveal locations of:
  1) Jet stream position
  2) Location of jet stream troughs and ridges
  3) Location of jet streaks
  4) Location of warm/cold air aloft