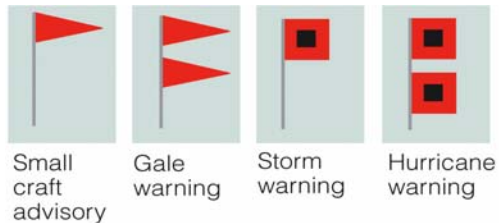


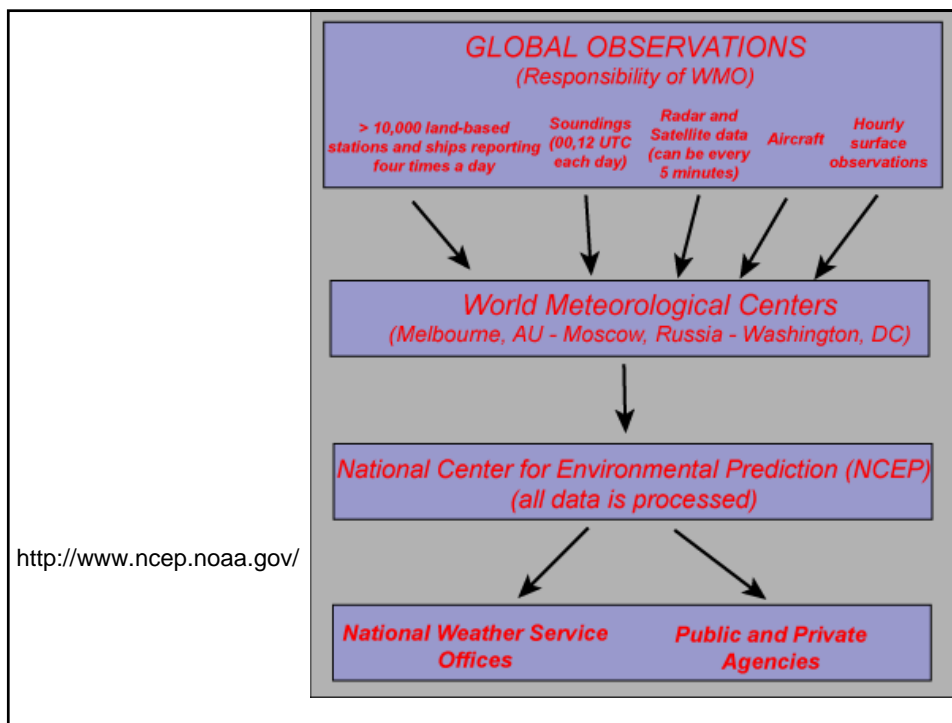
Weather Forecasting - Introduction

- Weather affects nearly everyone nearly every day
- Weather forecasts are issued:
 - to save lives
 - reduce property damage
 - reduce crop damage
 - to let the general public know what to expect
- Forecasts are often utilized to make many important decisions on a daily basis
- So, how is it done, and how is it done correctly?



National Weather Service Mission

- The **National Weather Service (NWS)** provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters, and ocean areas for the protection of life and property and the enhancement of the national economy. NWS data and products form a national information data base and infrastructure which can be used by other governmental agencies, the private sector, the public, and the global community.

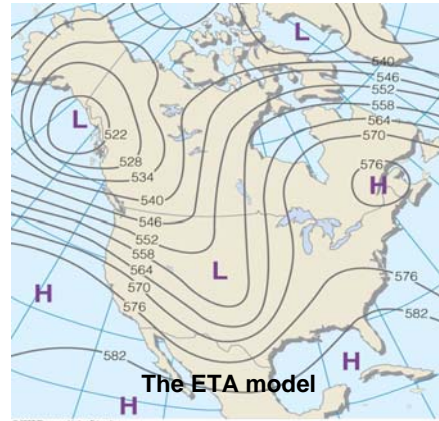
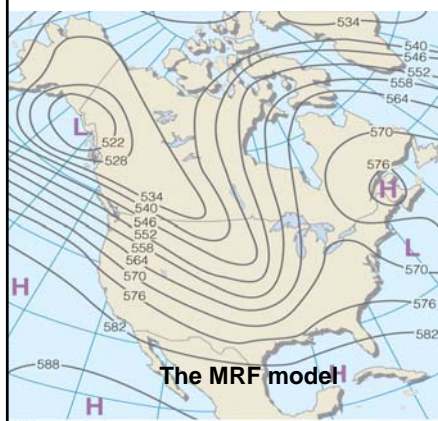


Forecasting Tools

- Weather Observations:
 - Surface data:
 - Soundings
 - Ship and buoy data
 - Satellite data
 - Radar data
 - Commercial aircraft data (ACARS)
 - Wind profilers
- Weather Analysis: *from observations to weather patterns*
- Numerical weather prediction – *using current and past observations to predicate weather in near future*

Atmospheric Model

- **Mathematical model**– equations describe how atmospheric temperature, pressure, wind, and moisture change with time.
- The models are programmed into the computer.
- **Prognostic Chart (prog)**: the final forecast chart representing the atmosphere at a specified future time.



A forecaster uses the progs as a guide to predicting the weather.
 A good forecaster needs to know model limitations:

- A personalized practical interpretation of model outputs
- Local geographic features

• TABLE 13.1

A Few Forecasting "Rules of Thumb"*

FORECAST QUESTION	USE OF FORECAST CHART
Cloudy or clear?	On the 700-mb forecast chart, the 70 percent relative humidity line usually encloses areas that are likely to have clouds.
Will it rain?	(a) On the 700-mb forecast chart, the 90 percent relative humidity line often encloses areas where precipitation is likely. If upward velocities are present, the chance of measurable precipitation is enhanced. (b) Along the west coast of North America, precipitation is much more likely north of the 5640-meter height contour on the 500-mb forecast chart.
Will it rain or snow?	On the 850-mb forecast chart, snow is likely north of the -5°C (23°F) isotherm, whereas rain is likely south of this line. On the 1000-mb to 500-mb thickness chart, the 5400-meter thickness line is widely used (east of the Rockies) as the dividing line between rain and snow.
Will the surface low intensify?	For the storm to intensify (deepen), an area of upper-level divergence must be over the cyclonic storm. On a 500-mb forecast chart that shows vorticity, look for a vorticity maximum (vort max) and remember from Chapter 12, p. 329, that to the east of an area of positive vorticity we usually find upper-level divergence, upward air motions, and cyclonic storm development.

*The forecast charts (progs) found in this table can be obtained from the World Wide Web.

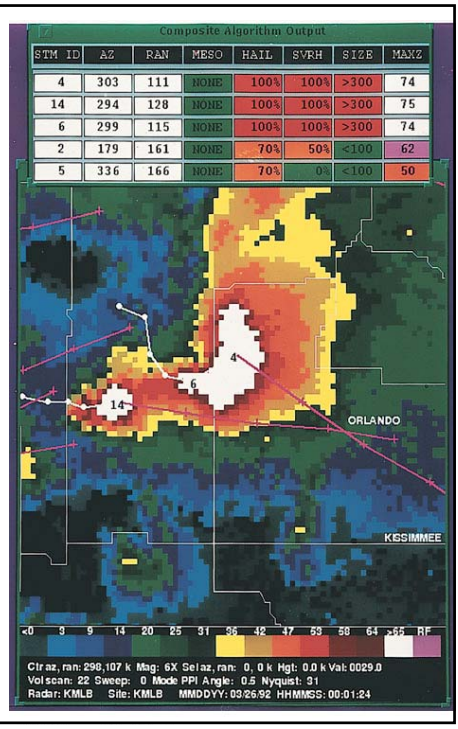
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Forecasting Tool

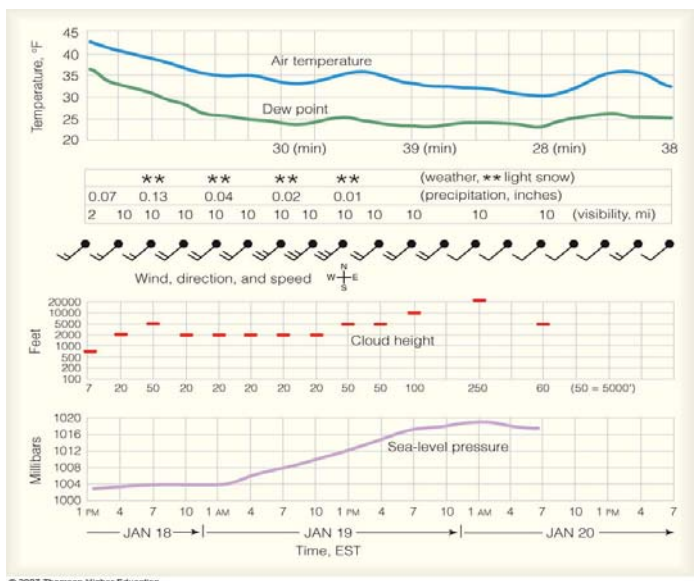
- AWIPS: Advanced Weather Interactive Processing System
 - Data communications, storage, processing, and display



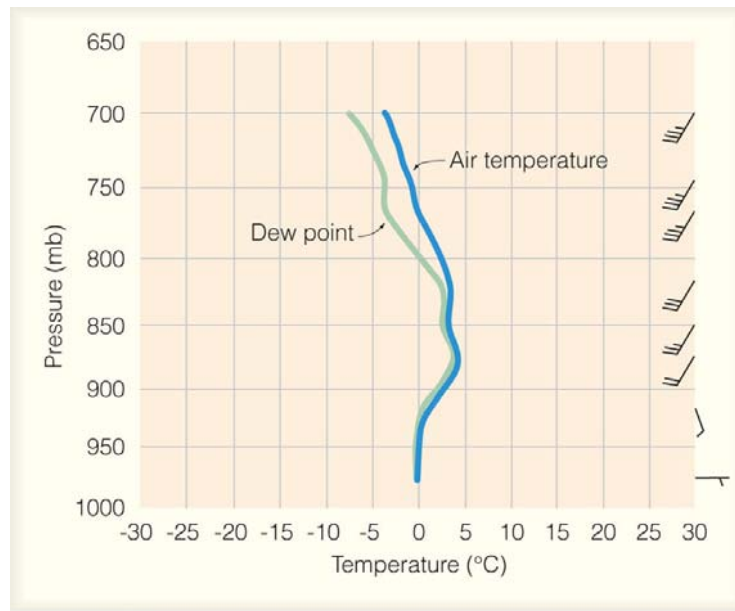
Doppler radar data from Melbourne, Florida, during the time of a severe hailstorm in the Orlando area. In the table near the top of the display, the hail algorithm determined that there was 100 percent probability that the storm was producing hail and severe hail. The algorithm also estimated the maximum size of the hailstones to be greater than 3 inches. A forecaster can project the movement of the storm and adequately warn those areas in the immediate path of severe weather.



- The **Meteogram** is a chart that show how one or more weather variables has changed at a station over a given period of time.



Vertical Profiles of temperature, wind, and RH



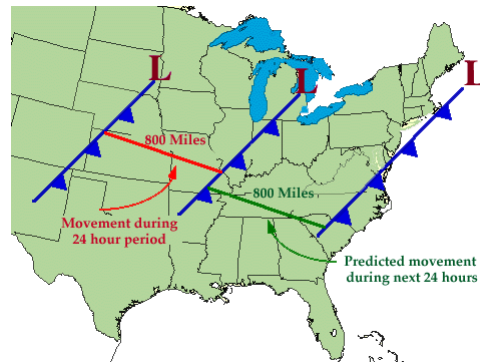
Other Forecasting Techniques

1. Persistence

- There are a variety of forecasting techniques
- The easiest one is called **persistence** - Tomorrow's weather is same as today's weather
 - most accurate for time scales of minutes - hours
 - not so accurate on time scale of a day or longer

2. The Trend Technique

- If a phenomenon is in steady state, or is moving at constant speed, the trend technique can be used.
- $rate \times time = distance$
- so if distance traverse by cold front is known over a given time period, its position can be extrapolated in time.
- More accurate on shorter time scales (minutes to hours)
- A short term forecast is called a "nowcast"



3. The Analogue Technique

- Identify existing features on a weather chart that resemble those that occurred in the past
- Use previous weather events to guide forecast
- "pattern recognition"
- useful method for longer-term forecasts (3 days - months)
- NWS issues:
 - 6-10 day extended forecasts
 - 30 day outlooks

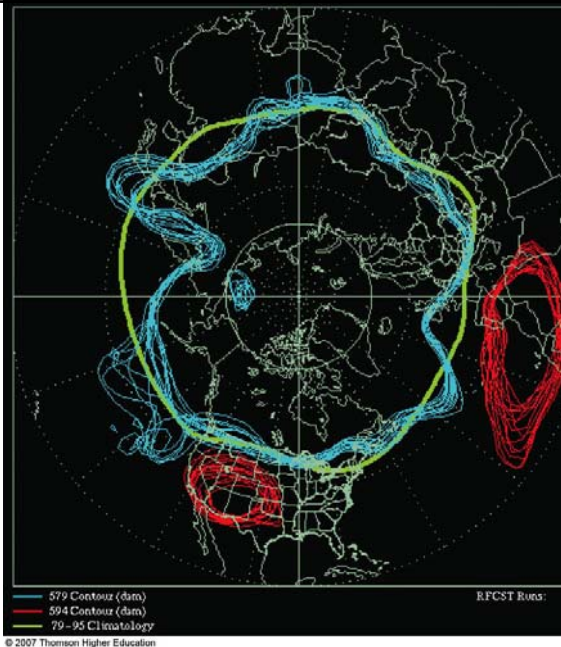
Why Forecasts go awry and steps to improve them

- **Model limitations:**
 - Models represent a "simplified" atmosphere - not every real process in atmosphere can be resolved in the models
 - The model equations compute quantities at grid points. Currently, grid spacing ranges from 30-50 km apart. Any phenomena smaller in size than grid spacing will not be resolved in models (e.g., thunderstorm)
 - models can not resolve boundary layer very well.
- **Boundary condition errors**
 - Many are not global in coverage
- **Initial condition errors**
 - Initial atmospheric state is not well-known - want a dense, global network of observations
 - Have many data-poor regions, particularly over the oceans.
 - The data may also have errors in it.

Why Forecasts go awry and steps to improve them

- **Local impacts-not represent in model**
 - small-scale terrain features will not be handled properly
- **The *chaotic* nature of atmosphere**
 - small differences in the model initial conditions can produce radically different results later in time
- **Each model can produce different predictions.... which do you believe?**
- **Solution:**
 - Improve models and observations
 - Ensemble forecasting

Ensemble 500-mb forecast chart for July 21, 2005 (48 hours into the future). The chart is constructed by running the model 15 different times, each time beginning with a slightly different initial condition. The blue lines represent the 5790-meter contour line; the red lines, the 5940-meter contour line; and the green line, the 500-mb 25-year average, called *climatology*.



<http://www.cdc.noaa.gov/map/images/ens/ens.html#us>
http://www.cdc.noaa.gov/map/images/ens/ens_desc.html

• **TABLE 13.2**

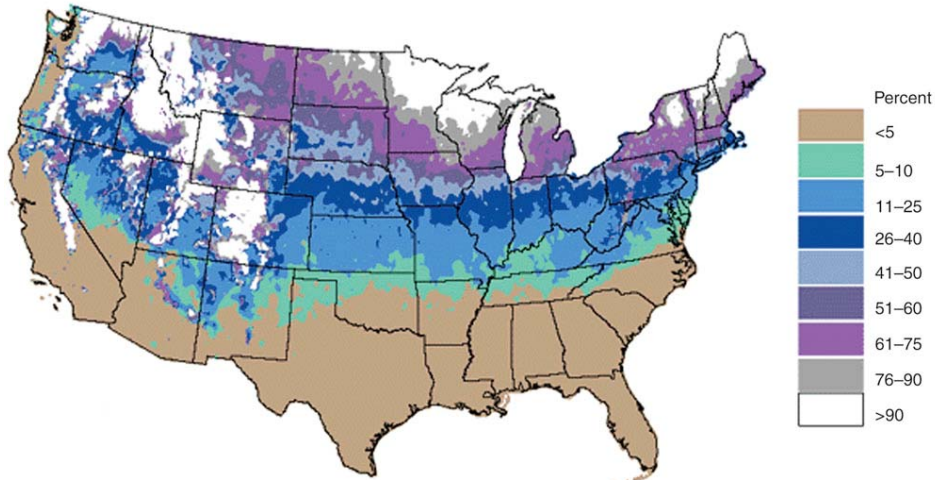
Forecast wording used by the National Weather Service to describe the percentage probability of measurable precipitation (0.01 inch or greater) for steady precipitation and for convective, showery precipitation

Statistical Forecast

PERCENT PROBABILITY OF PRECIPITATION	FORECAST WORDING FOR STEADY PRECIPITATION	FORECAST WORDING FOR SHOWERY PRECIPITATION
20 percent	<i>Slight chance</i> of precipitation	<i>Widely scattered</i> showers
30 to 50 percent	<i>Chance</i> of precipitation	<i>Scattered</i> showers
60 to 70 percent	Precipitation <i>likely</i>	<i>Numerous</i> showers
≥80 percent	Precipitation,* <i>rain, snow</i>	<i>Showers</i> *

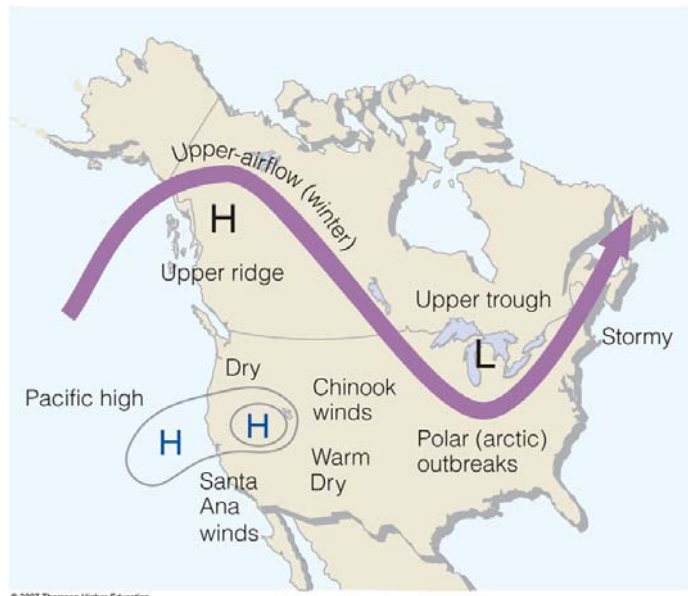
*A forecast that calls for an 80 percent chance of rain in the afternoon might read like this: "... cloudy today with rain this afternoon. . . ." For an 80 percent chance of rain showers, the forecast might read "... cloudy today with rain showers this afternoon. . . ."

Probability of a “White Christmas”—one inch or more of snow on the ground—based on a 30-year average. The probabilities do not include the mountainous areas in the western United States. (NOAA)



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Predicting the weather by weather types



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Climatological Forecast

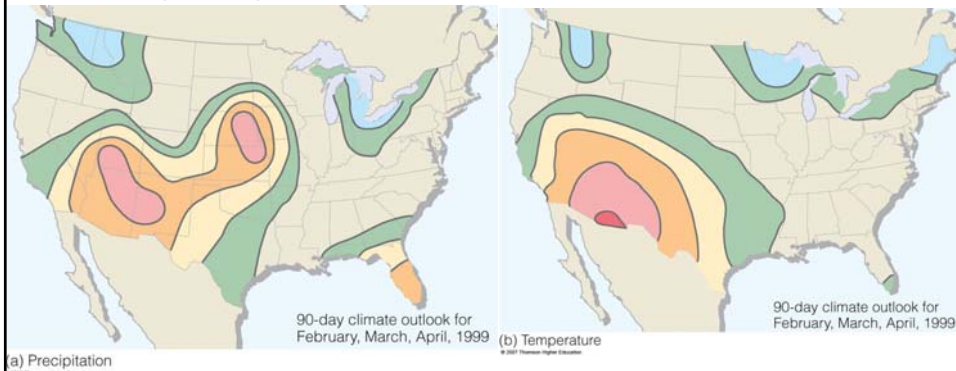
- A forecast that is based on "climatology" or average weather
- Example:
 - Lets say the climatological records show that it rains only 1 day out of 100 during the summer months in LA.
 - Then, if you forecast "no rain" for any day in July and August, the probability you will be wrong is 1/100.
 - Therefore, the probability you will be right is about 99%
- NOTE: precip forecasts are usually given as probabilities
 - ex: "there is a 60% chance of rain today"
- This means that there is a 60% chance of measurable precip at any random place in the forecast area

Accuracy and skill in forecasting

- What is an accurate forecast?
 - your forecast for tonights min temp is 0°F
 - if the actual min was 1°F, is in inaccurate?
 - if the actual min was 10°F, is in inaccurate?
 - Accuracy (in forecasting) is arbitrary and relative - it's not clearly, objectively defined
- How does a forecast show skill?
 - must be more accurate than utilizing persistence or climatology
 - persistence is "hard to beat" on a time frame of minutes to hours
 - skill is often shown on time frame of hours to a few days
 - Beyond 10 days, forecasts are generally no better than those generated by climatology

Types of Forecasts

- **A very short-range forecast:** up to few hours
- **A short-range forecast:** six hours to a few days
- **A medium-range forecast:** from 3 to 8.5 days into the future.
- **A long-range forecast:** beyond about 8.5 days.



Forecasting from local signs and common sense

- You can forecast very short-range weather with local signs and common sense
 - Air masses– different features
 - Frontal systems: clouds, high pressure and low pressure system changes
- You need to learn some basics to local signs with atmospheric processes
 - This class is building this for you

A halo around the sun (or moon) means that rain is on the way. A weather forecast made by simply observing the sky.



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• **TABLE 13.3**

Forecast at a Glance—Forecasting the Weather from Local Weather Signs: A few forecasting rules that may be applied when making a short-range local weather forecast.

OBSERVATION	INDICATION	LOCAL WEATHER FORECAST
Surface winds from the S or from the SW; clouds building to the west; warm (hot) and humid (pressure falling)	Possible cool front and thunderstorms approaching from the west	Possible showers; possibly turning cooler; windy
Surface winds from the E or from the SE, cool or cold; high clouds thickening and lowering; halo around the sun or moon (pressure falling)	Possible approach of a warm front	Possibility of precipitation within 12–24 hours; windy (rain with possible thunderstorms during the summer; snow changing to sleet or rain in winter)
Strong surface winds from the NW or W; cumulus clouds moving overhead (pressure rising)	A low-pressure area may be moving to the east, away from you; and an area of high pressure is moving toward you from the west	Continued clear to partly cloudy, cold nights in winter; cool nights with low humidity in summer
Winter night (a) If clear, relatively calm with low humidity (low dew-point temperature) (b) If clear, relatively calm with low humidity and snow covering the ground (c) If cloudy, relatively calm with low humidity	(a) Rapid radiational cooling will occur (b) Rapid radiational cooling will occur (c) Clouds will absorb and radiate infrared (IR) energy to surface	(a) A very cold night (b) A very cold night with minimum temperatures lower than in (a) (c) Minimum temperature will not be as low as in (a) or (b)

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Summer night		
(a) Clear, hot, humid (high dew points)	(a) Strong absorption and emission of IR energy back to surface by water vapor	(a) High minimum temperatures
(b) Clear and relatively dry	(b) More rapid radiational cooling	(b) Lower minimum temperatures
Summer afternoon		
(a) Scattered cumulus clouds that show extensive vertical growth by mid-morning	(a) Atmosphere is relatively unstable	(a) Possible showers or thunderstorms by afternoon with gusty winds
(b) Afternoon cumulus clouds with limited vertical growth and with tops at just about the same level	(b) Stable layer above clouds (region dominated by high pressure)	(b) Continued partly cloudy with no precipitation; probably clearing by nightfall
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The instant weather Forecast chart

• TABLE E.1

Instant Weather Forecast Chart

SEA-LEVEL PRESSURE (MB)	PRESSURE TENDENCY	SURFACE WIND DIRECTION	SKY CONDITION	24-HR WEATHER FORECAST (SEE WEATHER FORECAST CODE)
1023 or higher (30.21 in.)	rising, steady, or falling	any direction	clear, high clouds, Cu	1, 18 (in winter, 14)
1022 to 1016 (30.20 in. to 30.00 in.)	rising or steady	SW, W, NW, N	clear, high clouds or Cu	1, 18
	falling or steady	SW, S, SE	clear, high clouds	1, 3, 17, 5
	falling	SW, S, SE	middle or low clouds	6, 17
	falling	E, NE	middle or low clouds	6, 14
1015 to 1009 (29.99 in. to 29.80 in.)	falling or steady	E, NE	clear or high clouds	3, 5, 14
	rising	SW, W, NW, N	clear	1, 14
			overcast	2, 16
			precipitation	11, 2, 16
	falling	any direction	clear	3, 17 (dry climate summer, 1, 15)
	falling or steady	SW, S, SE	high clouds	3, 17, 5
falling	SW, S, SE	middle or low clouds	7	
falling	E, NE	middle or low clouds	7, 12, 14	
falling	SE, E, NE	overcast, precipitation	9	
falling	S, SW	overcast, precipitation	10, 13	
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1008 or below (29.79 in.)	rising	SW, W, NW, N	clear	1, 12
	rising	SW, W, NW, N	overcast	2, 12, 16
	rising	SW, W, NW, N	overcast with precipitation	11, 12, 16
	rising	NE	overcast	4, 12, 13, 14
	rising	NE	overcast with precipitation	11, 12, 13, 14
	rising or steady	SW, S, SE	clear	3, 6, 8, 12, 15
	falling	SW, S, SE	overcast	7, 8, 12, 13
	falling	SW, S, SE	overcast with precipitation	8, 10, 12, 13, 16
	falling	N	overcast	4, 14
	falling or steady	E, NE	overcast	7, 12, 14
	falling	E, NE	overcast with precipitation	8, 9, 12, 13

Weather Forecast Code

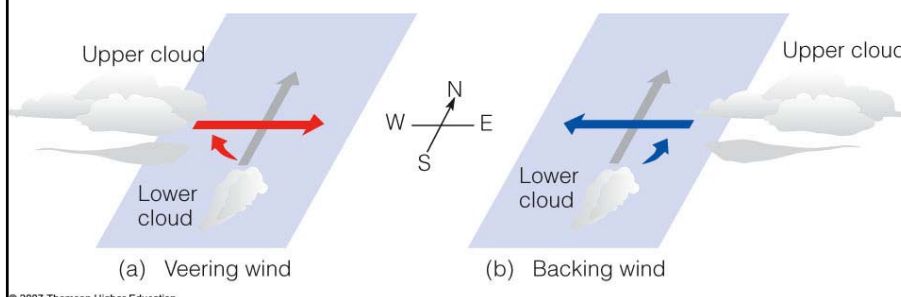
1 = clear or scattered clouds	7 = precipitation possible within 8 hours	13 = possible wind shift to W, NW, or N
2 = clearing	8 = possible period of heavy precipitation	14 = continued cool or cold
3 = increasing clouds	9 = precipitation continuing	15 = continued mild or warm
4 = continued overcast	10 = precipitation ending within 12 hours	16 = turning colder
5 = precipitation possible within 24 hours	11 = precipitation ending within 6 hours	17 = slowly rising temperatures
6 = precipitation possible within 12 hours	12 = windy	18 = little temperature change

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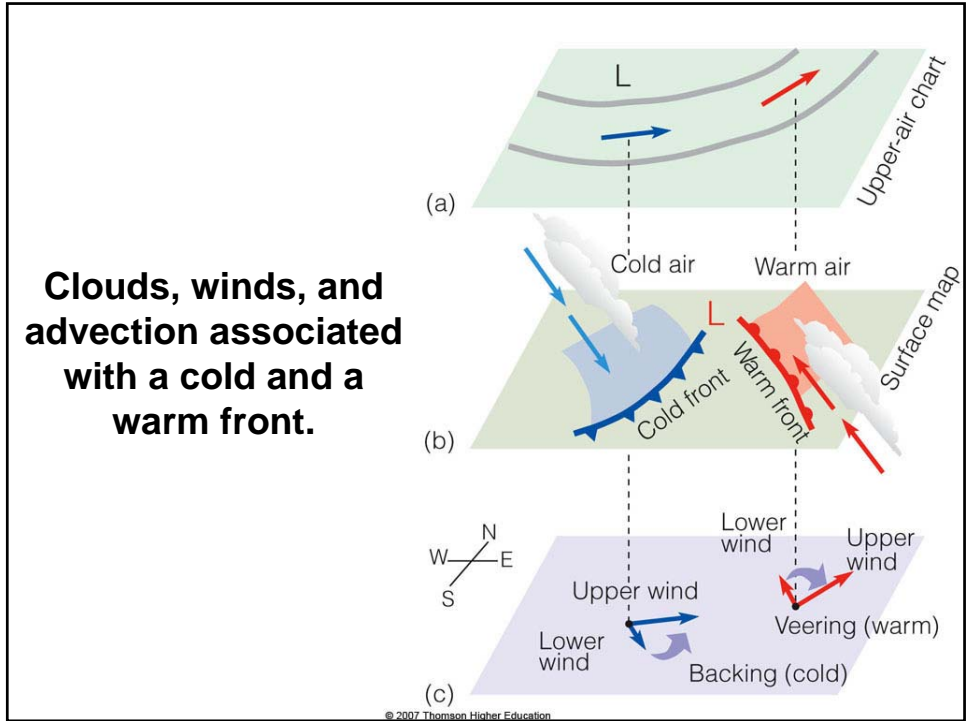
Table E-1b, p. A-12

Forecasting temperature advection by watching clouds

- Winds that back with height (change counterclockwise) indicate *cold advection*
- Winds that veer with height (change clockwise) indicate *warm advection*.

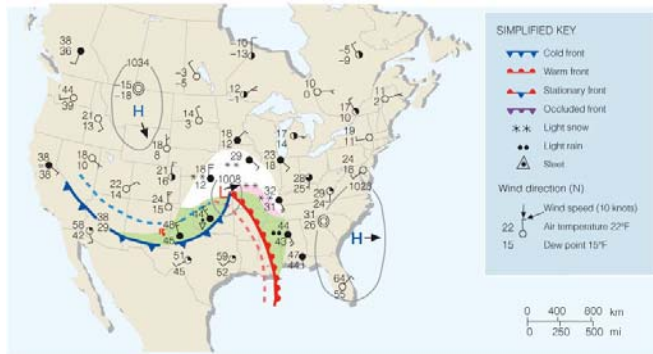


Clouds, winds, and advection associated with a cold and a warm front.



Weather Forecasting Using Surface Chart

- Given that we know the weather associated with common features on a surface weather chart, for example:
 - cold front - narrow band of showers
 - NE of warm front - light/moderate wide spread precip.
 - warm sector - hot, humid
 - etc.
- if we can predict the movement of these feature based on its previous motion, we can then make a forecast with this information.



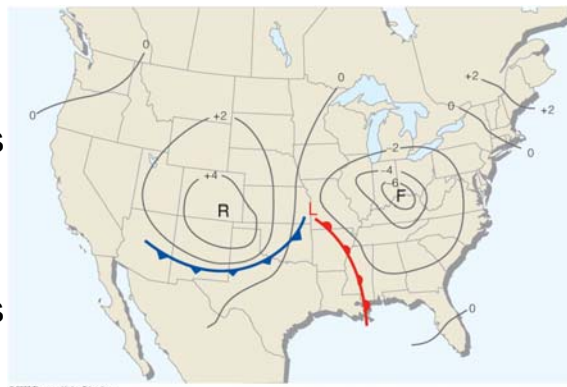
Determining the Movement of Weather Systems

1. For short-time intervals, storms and fronts tend to move in the same direction and at approximately the same speed as they did during the previous six hours.
2. Low pressure areas tend to move in a direction that parallels the isobars in the warm air ahead of the cold front.
3. Lows tend to move toward the region of greatest pressure drop, while highs tend to move toward the region of greatest rise.
4. Surface pressure systems tend to move in the same direction as the wind at 5500 m (18,000 ft)– the 500-mb level. The speed at which surface systems move is about half the speed of the winds at this level.

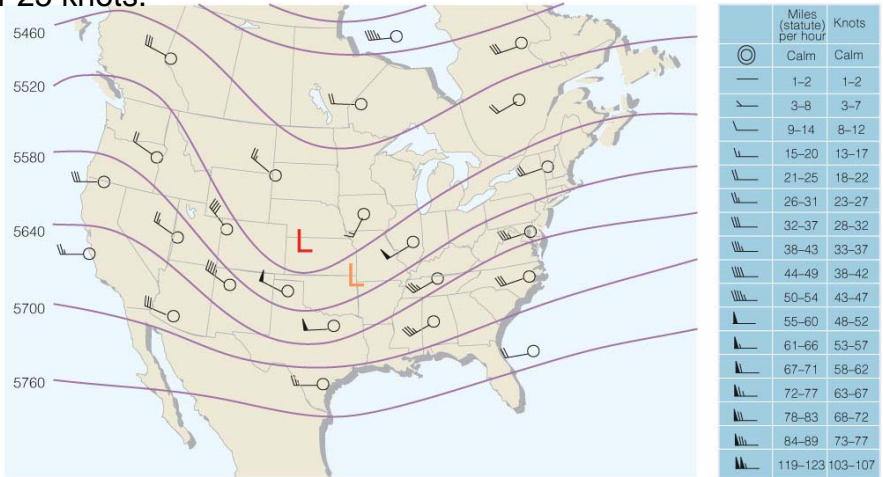


Forecasting weather system movement with pressure tendency

- Pressure tendency - The rate at which pressure is changing for a given period of time. (mb/hr)
- Lines of constant pressure change are called isallobars.
- Lows will tend to move to region of largest negative pressure tendencies
- Highs will tend to move to region of largest positive pressure tendencies

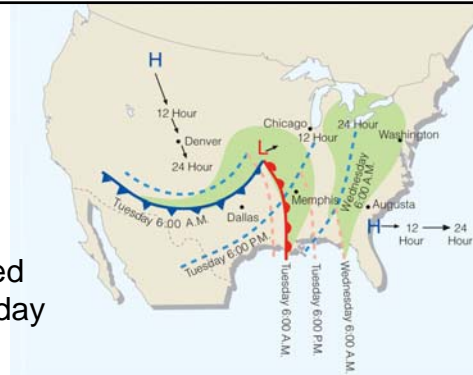


A 500-mb chart for 6:00 A.M. Tuesday, showing wind flow. The light red L represents the position of the surface low. The winds aloft tend to steer surface pressure systems along and, therefore, indicate that the surface low should move northeastward at about half the speed of the winds at this level, or 25 knots.

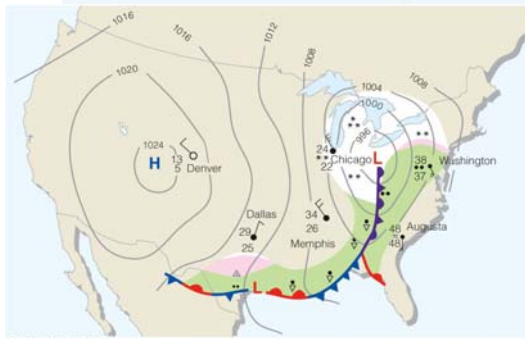


A Forecast for Six Cities

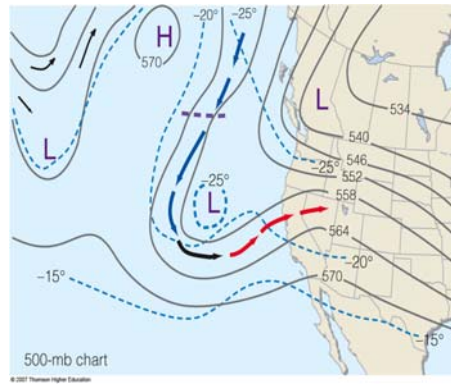
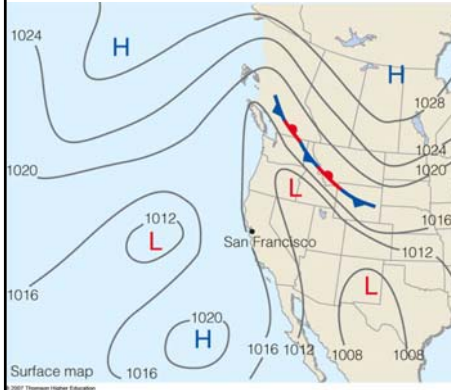
Projected 12- and 24-hour movement of fronts, pressure systems, and precipitation (shaded green area) from 6:00 A.M. Tuesday until 6:00 A.M. Wednesday.



Surface weather map for 6:00 A.M. Wednesday.



A Meteorologist makes a Prediction



No weather front approach from west
Weak low pressure center is developed !!

Omega high— blocking high
High wind, warm and cold advection
Baroclinic instability do exist !
Favorable conditions for the surface low
develop into a major storm
??

Observations

4:00 P.M. Sunday, March 25.

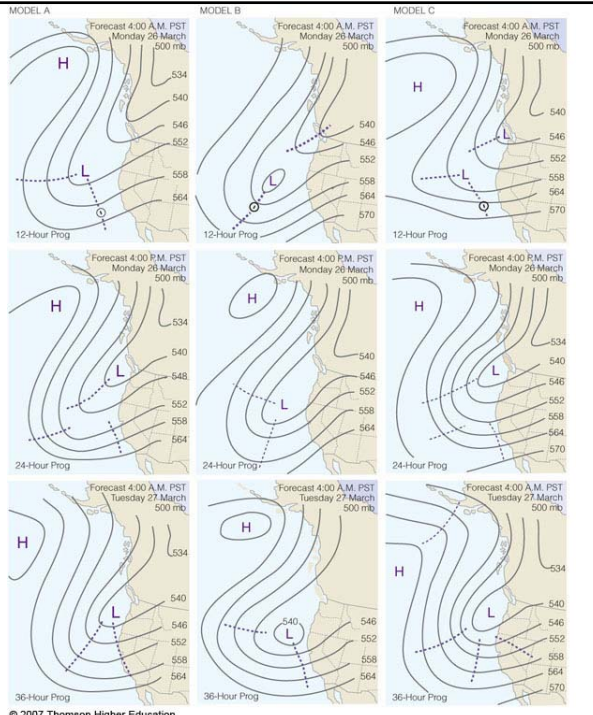
Computer Model outputs 500 mb

The forecaster has more confidence in Model A and C.

4:00AM Monday

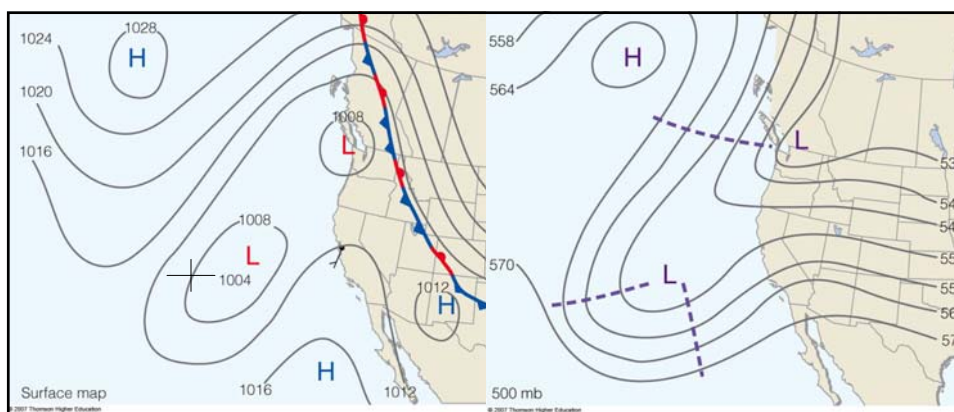
4:00PM Monday

4:00AM Tuesday



Forecast

- Increasing cloudiness Sunday night with rain beginning Monday morning. Periods of Rain likely through Tuesday Morning.



Low pressure center get lower

Upper trough deepen

Observations

4:00 A.M. (PST) Monday, March 26.

Satellite— allow you to see weather moving

