MET 3502 Synoptic Meteorology

Lecture 3:

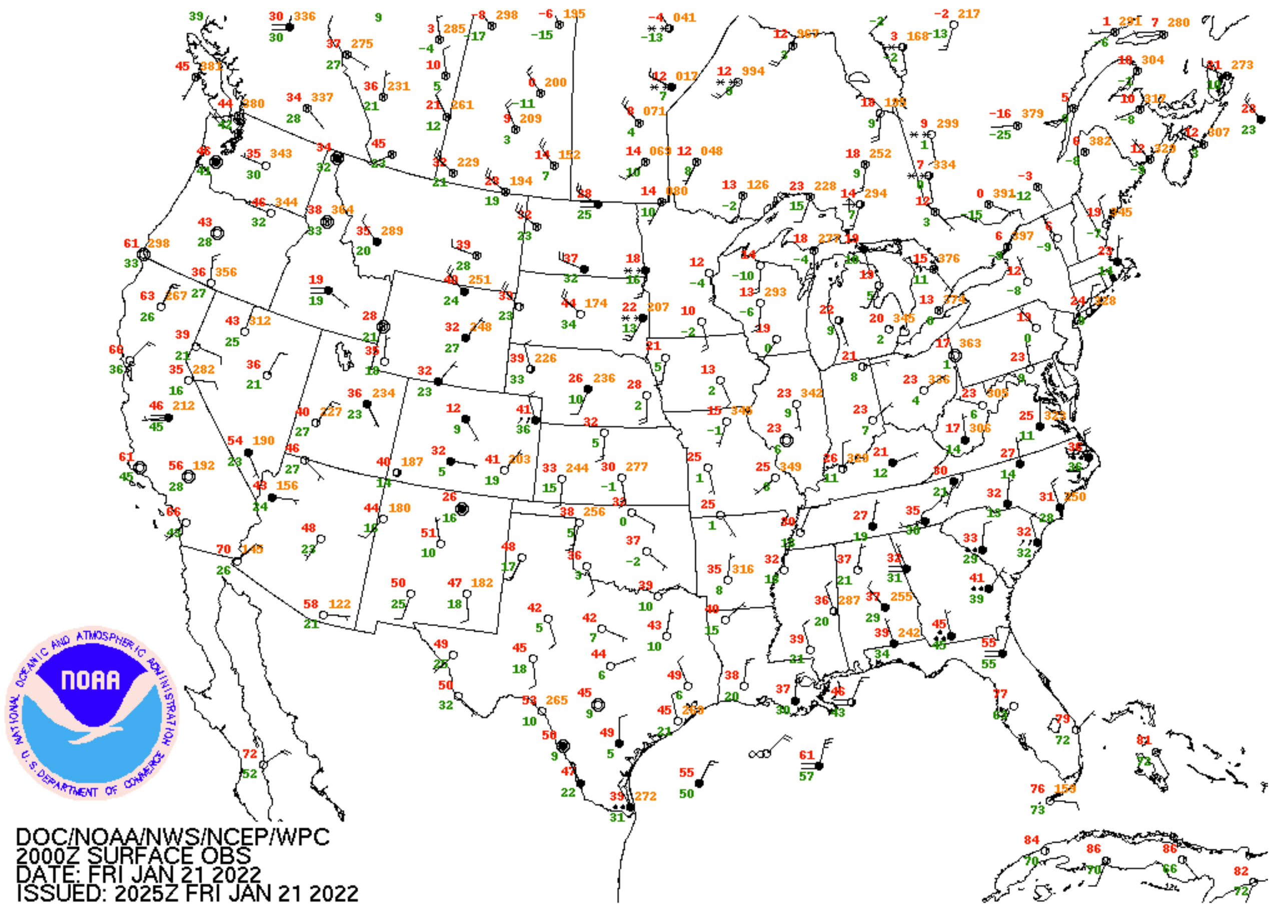
Surface Weather Elements

Surface Weather Elements

- Not observations *of* the surface, but
- Observations made by an observer (or instrument) *at* the surface
- Example: ASOS (Automated Surface Observing System), below

Example Hourly Surface Weather Map from NOAA WPC

- https://www.wpc.ncep.noaa.gov/sfc/sfcobs/sfcobs.shtml (NOAA weather prediction center, WPC)
- We need to learn how to read the surface station models plotted on the map



NOAA Office of the Federal Coordinator for Meteorology

Mission: To ensure the effective use of federal meteorological resources by leading the systematic coordination of operational weather requirements and services, and supporting research, among the federal agencies.

Federal Meteorological Handbook No. 1

--a 101 page PDF document (entitled "Surface Weather Observations and Reports") describing the surface weather observing program of the U.S. National Weather Service.

https://www.icams-portal.gov/resources/ofcm/fmh/FMH1/fmh1_2019.pdf

NWS reporting change

On July 1, 1996 the National Weather Service changed from the SAO (Surface Airways Observations) to the METAR/SPECI code for reporting hourly observations of surface weather data.

METAR/SPECI Code

METAR , message d'observation météorologique régulière pour l'aviation, which is the French expression for Aviation Routine Meteorological Report.

SPECI is derived from the French expression for Aviation Selected Special Meteorological Report.

The METAR Code

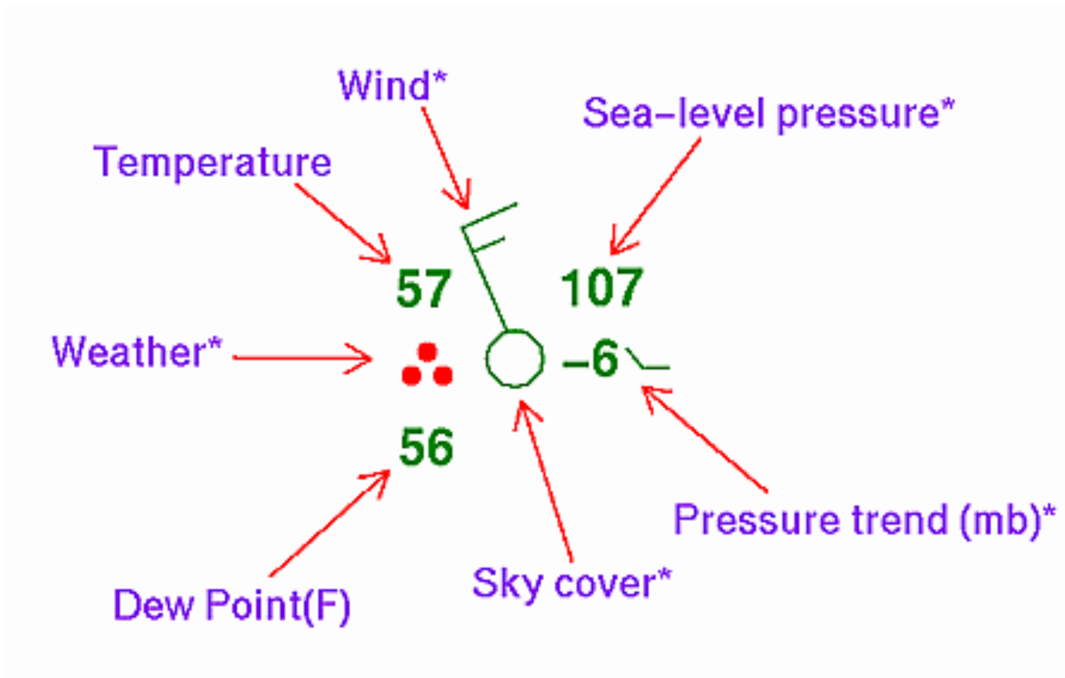
METAR or SPECI CCCC YYGGggZ AUTO or COR dddff(f)G$f_mf_m(f_m)$KT $d_nd_nd_nVd_xd_xd_x$ VVVVVSM [$RD_RD_R/V_RV_RV_RV_R$ or $RD_RD_RV_NV_NV_NV_NVV_XV_XV_XV_X$FT] w'w' [$N_sN_sN_sh_sh_sh_s$ or $VVh_sh_sh_s$ or SKC/CLR] T'T'/$T'_dT'_d$ $AP_HP_HP_HP_H$ RMK (Automated, Plain Language) (Additive Data and Automated Maintenance Indicators)

The Surface Station Model

Surface data contained in METAR reports are plotted in a specific organized pattern known as the surface station model.

The consistent organization of the station model makes it easier for the meteorologist analyzing a surface weather map to locate and to identify important information.

Sample Station Plot



Wind Speed and Direction

Wind speed and wind direction are plotted using a wind arrow.

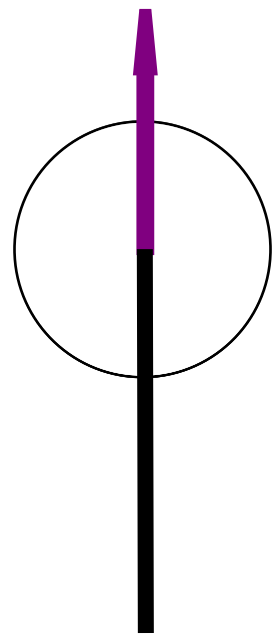
The wind direction is plotted with the wind arrow indicating the direction of the wind blowing into the station circle.

Wind Speed

Wind Speed is indicated by the number of half barbs, whole barbs, and flags.

The wind speed is indicated by the sum of the wind speeds represent by the half barbs, whole barbs and flags.

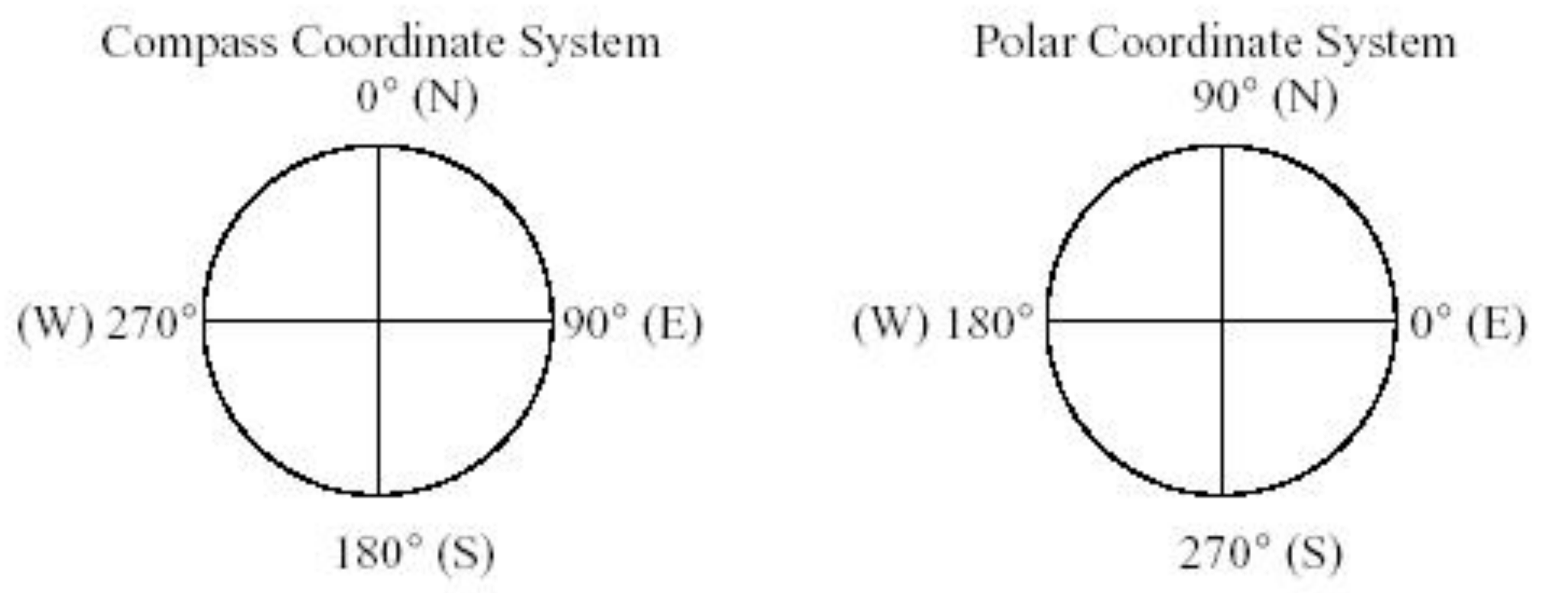
Wind Direction



The top of the arrow is not usually plotted any more to save space.

indicates a wind from the south (i.e 180 degrees)

National Weather Service (NWS) uses the **compass coordinate system** to express wind direction



Wind Speed

A half barb indicates 5 knots.

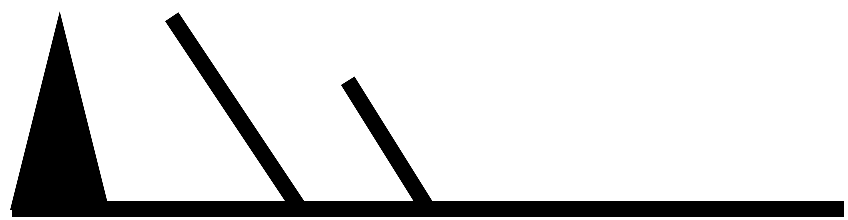
Wind Speed (cont.)

A whole barb indicates 10 kts.

Wind Speed (cont.)

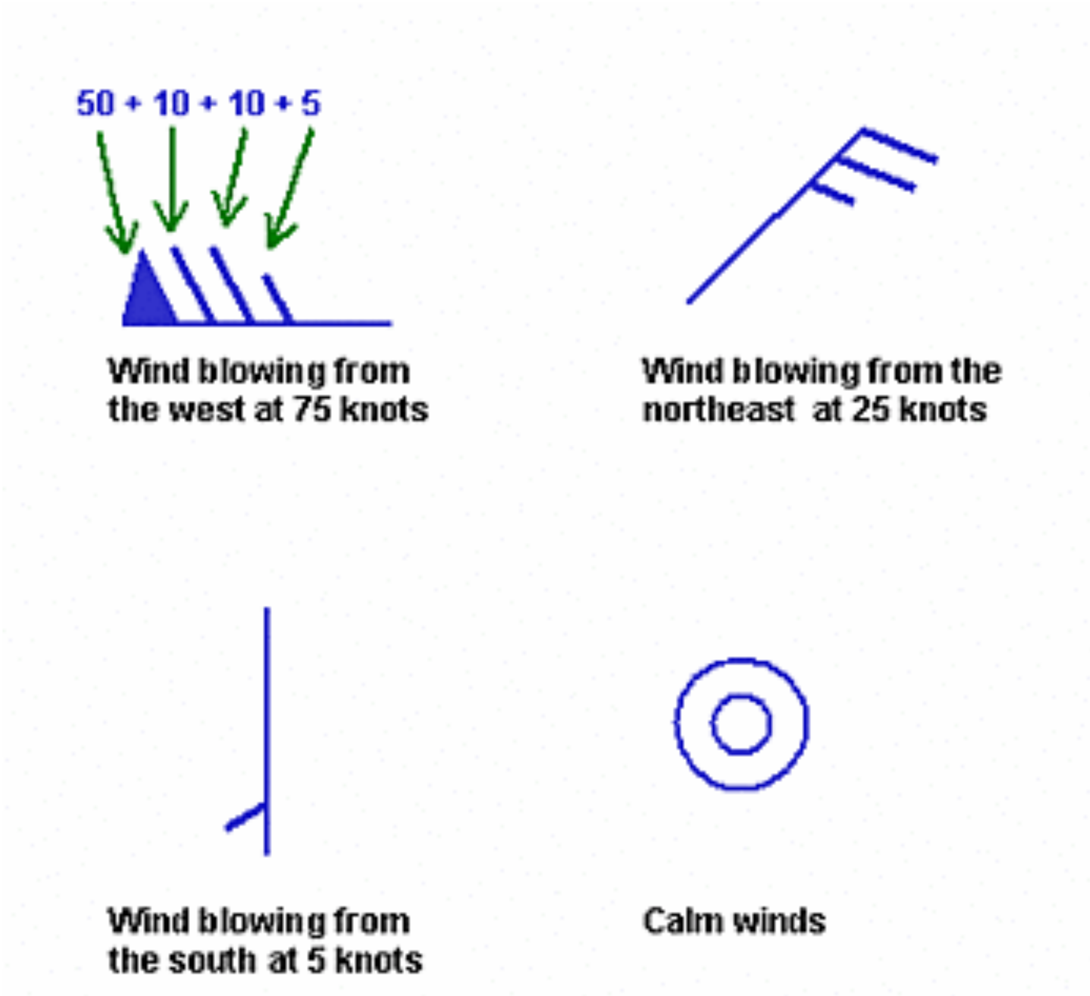
A flag indicates 50 knots.

Wind Speed (cont.)



Indicates a wind speed of 50+10+5 = 65 knots.

Wind Bars



50 + 10 + 10 + 5
Wind blowing from the west at 75 knots
Wind blowing from the northeast at 25 knots
Wind blowing from the south at 5 knots
Calm winds

PRESSURE

- **Sea-level pressure is plotted in tenths of millibars (mb), with the leading 10 or 9 omitted.**
- **Below are some sample conversions between plotted and complete sea-level pressure values:** Add either a 10 or 9 in front based on which would bring the value closer to 1000. Sea-level pressure<950mb is rare (only in tropical cyclones) and METAR code is unable to distinguish 1049 mb & 949 mb. You'll need to decide according to conditions. However, over continental US, the lowest sea-level pressure recorded is >950mb. **So for METAR pressure code <=500, usually you should add 10 in front; for METAR pressure code >500, usually you should add 9 in front: :**

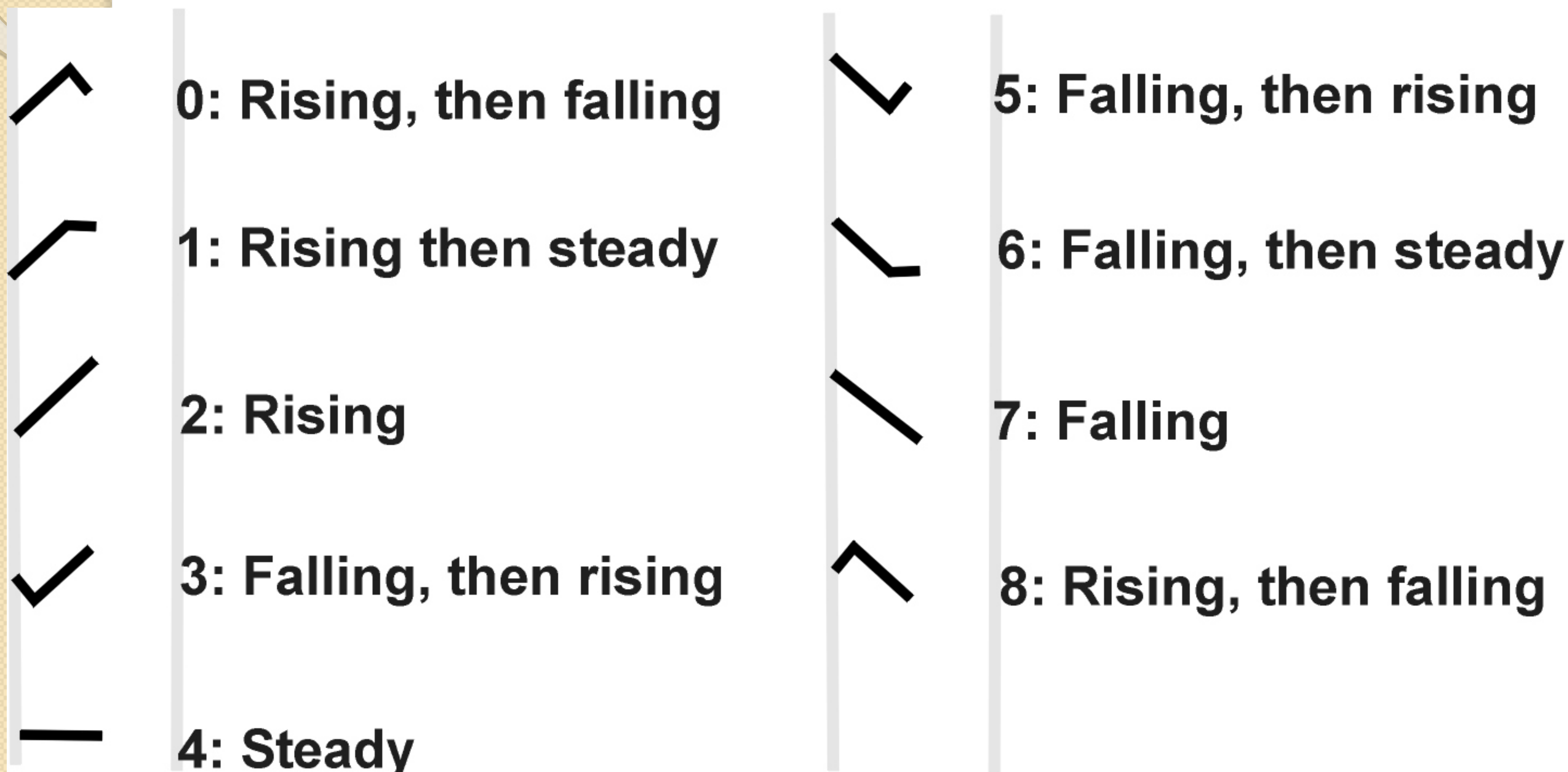
  410: 1041.0 mb
  103: 1010.3 mb
  987: 998.7 mb
  872: 987.2 mb

PRESSURE TREND

- **The pressure trend has two components, a number and symbol, to indicate how the sea-level pressure has changed during the past three hours. The number provides the 3-hour change in tenths of millibars (for example: -20 means pressure decreasing by 2.0 mb), while the symbol provides a graphic illustration of how this change occurred. Below are the meanings of the pressure trend symbols:**

Cartoons are intuitive, for example

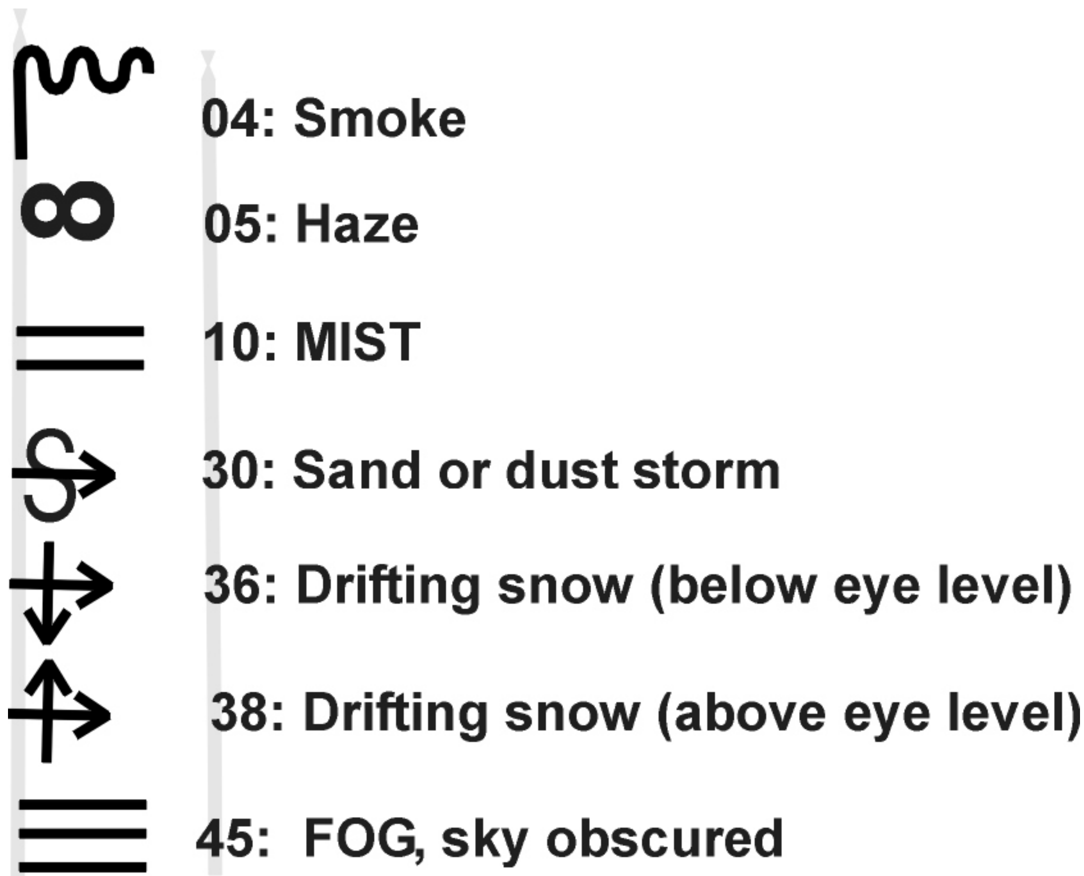
Barometric Tendency



WEATHER

- **A weather symbol is plotted if at the time of observation, there is either precipitation occurring or a condition causing reduced visibility. Below is a list of the most common weather symbols:**

Selected Current Weather That Affects Visibility



Precipitation

- 60: Intermittent, slight RAIN
- 61: Continuous, slight RAIN
- 62: Intermittent, moderate RAIN
- 63: Continuous, moderate RAIN
- 64: Intermittent, heavy RAIN
- 65: Continuous, heavy RAIN
- 50: Intermittent, slight DRIZZLE (Works like rain)
- 70: Intermittent, slight SNOW (Works like rain)

- 80: Rain SHOWER
- 85: Snow SHOWER
- 17: Lightening, but no precipitation, unless combined with rain, snow, etc, symobls

Most common symbols

All Weather Symbols

Present Weather Symbols

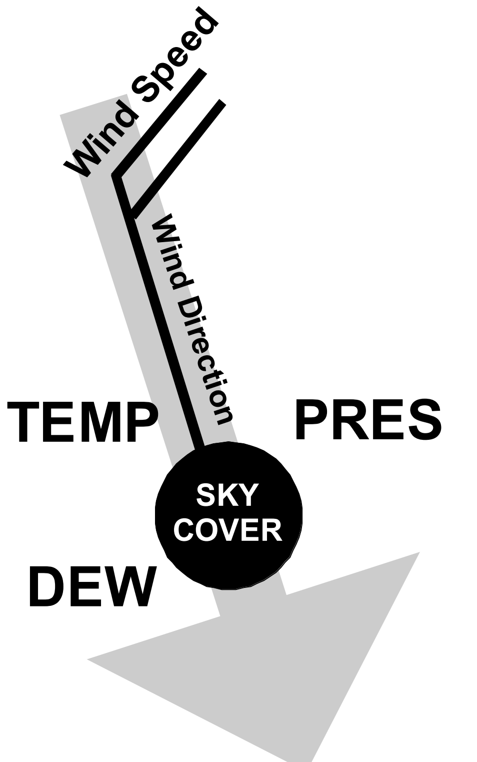
00 Cloud development NOT observed during past hour (not plotted)	01 Clouds generally becoming less developed (not plotted)	02 State of sky on the whole unchanged during past hour (not plotted)	03 Clouds generally forming or developing during past hour (not plotted)	04 Visibility reduced by smoke	05 Haze	06 Widespread dust in the air, not raised by wind at or near station	07 Dust or sand due to wind at or near the station but no dust whirl/sandstorm	08 Well developed dust whirl and/or sand whirl but no dust storm/sandstorm	09 Dust storm or sandstorm within sight or at the station during past hour
10 Mist	11 Patches of shallow fog at station, NOT deeper than 6 feet on land	12 More or less continuous shallow fog at station, NOT deeper than 6 feet	13 Lighting visible, no thunder heard	14 Precipitation within sight, but NOT reaching the ground	15 Precipitation within sight, reaching the surface, but more than 3 miles away	16 Precipitation within sight, reaching the surface within 3 miles	17 Thunder heard, but no precipitation at the station	18 Squall(s) within sight during past hour	19 Funnel cloud(s) and/or Tornado(es) during the preceding hour
20 Drizzle (not freezing) or snow grains, not as shower(s), has ended	21 Rain (not freezing) not falling as shower(s), ended in the past hour	22 Snow not falling as shower(s) ended in the past hour	23 Rain and snow or ice pellets, not as shower(s) ended in the past hour	24 Freezing drizzle or freezing rain, not as shower(s) ended in the past hour	25 Shower(s) of rain ended in the past hour	26 Shower(s) of snow, or of rain and snow ended in the past hour	27 Shower(s) of hail, or of rain and hail ended in the past hour	28 Fog or ice fog ended in the past hour	29 Thunderstorm (with or without precipitation) ended in the past hour
30 Slight or moderate dust storm or sandstorm (has decreased in past hour)	31 Slight or moderate dust storm/sandstorm (no change during past hour)	32 Slight or moderate dust storm or sandstorm (has begun or increased)	33 Severe dust storm or sandstorm, decreased during the past hour	34 Severe dust storm or sandstorm, has no change during past hour	35 Severe dust storm or sandstorm has begun or increased	36 Slight or moderate drifting snow (generally below eye level)	37 Heavy drifting snow (generally below eye level)	38 Slight or moderate blowing snow (generally above eye level)	39 Heavy blowing snow (generally above eye level)
40 Fog at a distance, but not at the station during the preceding hour	41 Fog in patches	42 Fog, sky visible (has become thinner during preceding hour)	43 Fog, sky obscured (has become thinner during preceding hour)	44 Fog, sky visible (no appreciable change during the past hour)	45 Fog, sky obscured (no appreciable change during the past hour)	46 Fog, sky visible (has begun or has become thicker during past hour)	47 Fog, sky obscured (has begun or has become thicker during past hour)	48 Fog, depositing rime ice, sky visible	49 Fog, depositing rime ice, or ice fog, sky obscured
50 Drizzle, not freezing, intermittent (slight at time of observation)	51 Drizzle, not freezing, continuous (slight at time of observation)	52 Drizzle, not freezing, intermittent (moderate at time of observation)	53 Drizzle, not freezing, continuous (moderate at time of observation)	54 Drizzle, not freezing, intermittent (heavy at time of observation)	55 Drizzle, not freezing, continuous (heavy at time of observation)	56 Drizzle, freezing, slight	57 Drizzle, freezing, moderate or heavy	58 Drizzle and rain, slight	59 Drizzle and rain, moderate or heavy
60 Rain, not freezing, intermittent (slight at time of observation)	61 Rain, not freezing, continuous (slight at time of observation)	62 Rain, not freezing, intermittent (moderate at time of observation)	63 Rain, not freezing, continuous (moderate at time of observation)	64 Rain, not freezing, intermittent (heavy at time of observation)	65 Rain, not freezing, continuous (heavy at time of observation)	66 Rain, freezing, slight	67 Rain, freezing, moderate or heavy	68 Rain or drizzle and snow, slight	69 Rain or drizzle and snow, moderate or heavy
70 Intermittent fall of snowflakes (slight at time of observation)	71 Continuous fall of snowflakes (slight at time of observation)	72 Intermittent fall of snowflakes (moderate at time of observation)	73 Continuous fall of snowflakes (moderate at time of observation)	74 Intermittent fall of snowflakes (heavy at time of observation)	75 Continuous fall of snowflakes (heavy at time of observation)	76 Ice needles (with or without fog)	77 Snow grains (with or without fog)	78 Isolated star-like snow crystals (with or without fog)	79 Ice pellets (sleet)
80 Rain shower(s), slight	81 Rain shower(s), moderate or heavy	82 Rain shower(s), violent	83 Shower(s) of rain and snow mixed, slight	84 Shower(s) of rain and snow mixed, moderate or heavy	85 Snow shower(s), slight	86 Snow shower(s), moderate or heavy	87 Shower(s) of snow pellets or small hail, slight with or without rain or rain/snow	88 Shower(s) of snow pellets or small hail, moderate or heavy w/ or w/o rain/snow	89 Shower(s) of hail, slight, w/ or w/o rain or rain/ snow mixed, no thunder
90 Shower(s) of hail, w/ or w/o rain or rain/snow, no thunder, mod. or heavy	91 Thunderstorm during past hour w/ slight rain at time of observation	92 Thunderstorm during past hour w/ current moderate/ heavy rain	93 Thunderstorm ended w/ current slight snow, rain/ snow mixed, or hail	94 Thunderstorm ended w/ current moderate/heavy snow, rain/snow, or hail	95 Thunderstorm, slight or moderate, w/o hail but w/ rain and/or snow	96 Thunderstorm, slight or moderate, with hail at time of observation	97 Thunderstorm, heavy, w/o hail but with rain and/or snow	98 Thunderstorm combined with dust storm or sandstorm	99 Thunderstorm, heavy, with hail at time of observation

JetStream - An Online School for Weather
http://www.srh.noaa.gov/srh/jetstream/synoptic/wxmaps.htm

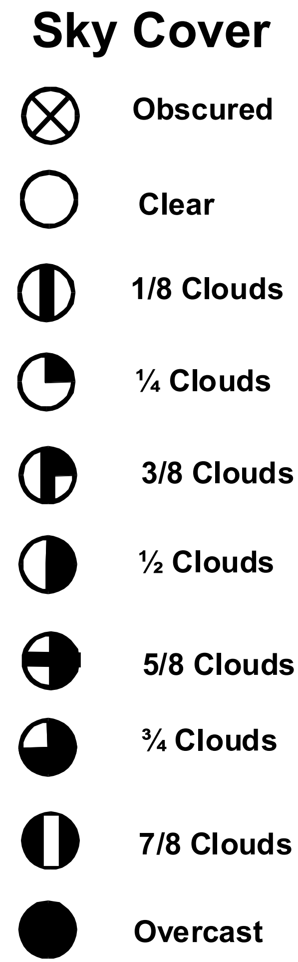
SKY COVER

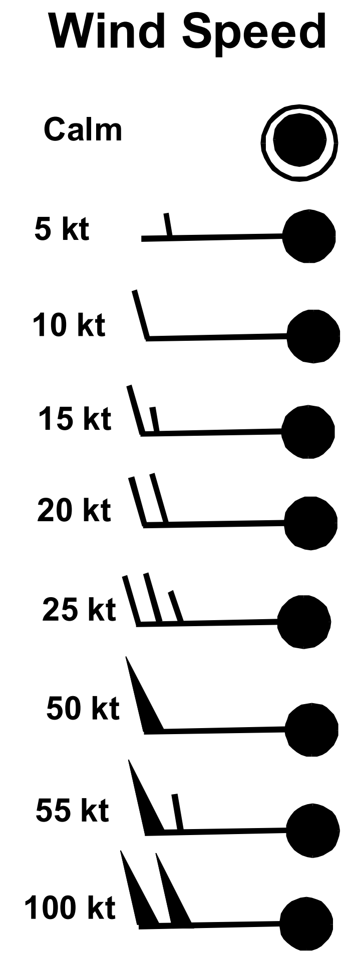
- **The amount that the circle at the center of the station plot is filled in reflects the approximate amount that the sky is covered with clouds.**

Surface Station Model

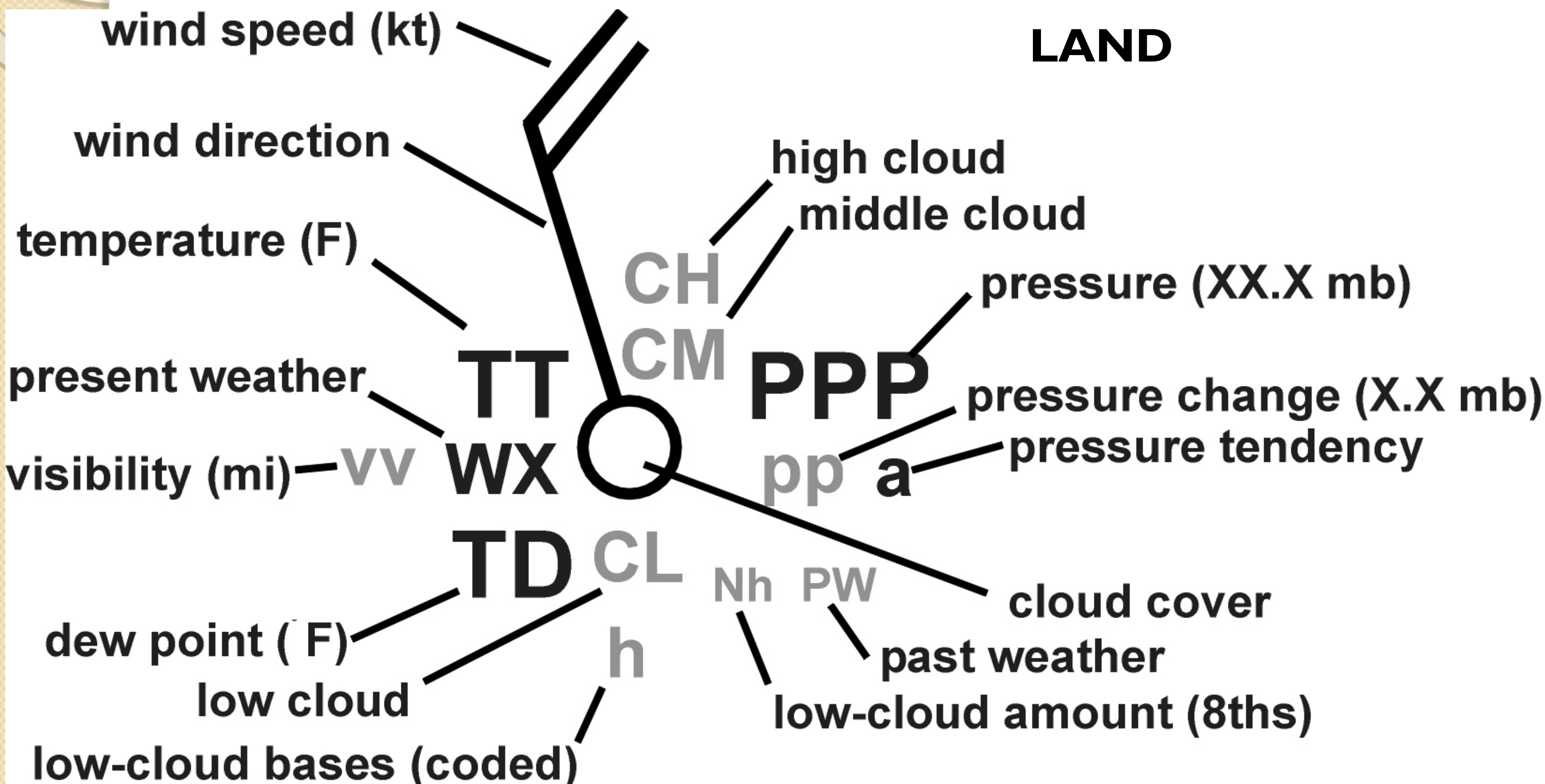


TT & TD are in °F (US)
PP is in mb and tenths





Complete Surface Station Model



Grey elements are generally not used in automatic plotting

FIU Cloud Atlas

FIU CLOUD ATLAS 2006

Names link to cloud type descriptions. Pictures link to photo galleries.

High Clouds
Cloud base:
Tropics, 6-18 km
Mid Lat, 5-13 km
Polar, 3-8 km

Cirrostratus

Cirrocumulus

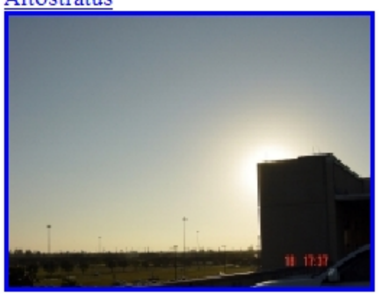
Cirrus

Clouds of Vertical Development

Cumulonimbus

Middle Clouds
Cloud base:
Tropics, 2-8 km
Mid Lat, 2-7 km
Polar, 2-4 km

Altostratus



Altocumulus

FIU
FLORIDA INTERNATIONAL UNIVERSITY
Miami's public research university

Low Clouds
Cloud base below
2 km in all
latitudes

Stratus

Stratocumulus

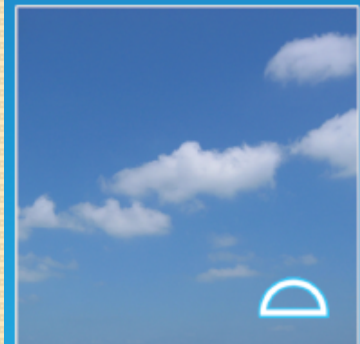
Nimbostratus

Cumulus

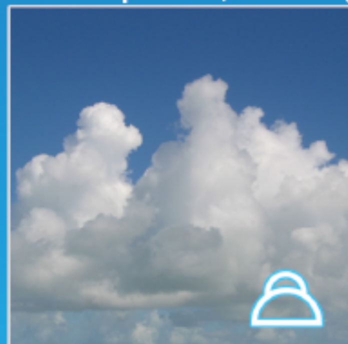
Low Clouds:

Typical Types: Stratus (St), Stratocumulus (Sc), Cumulus (Cu), Cumulonimbus (Cb)

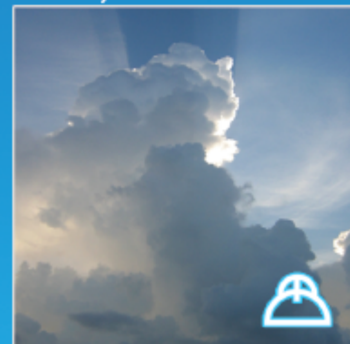
Low Clouds: cloud bases Up to 6,500 ft (0-2km)



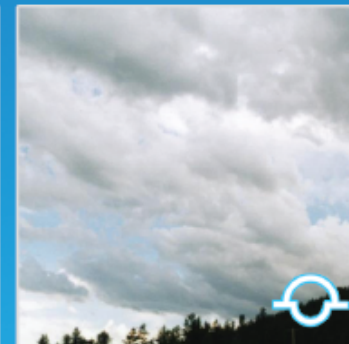
L1: Cumulus
Cumulus of fair weather with flattened appearance



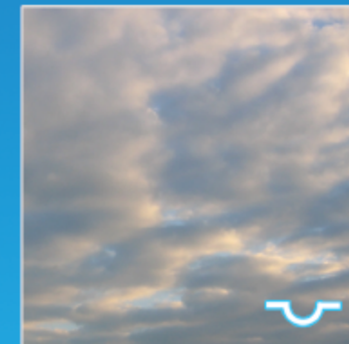
L2:Cumulus
Moderate/strong vertical extent, or towering cumulus



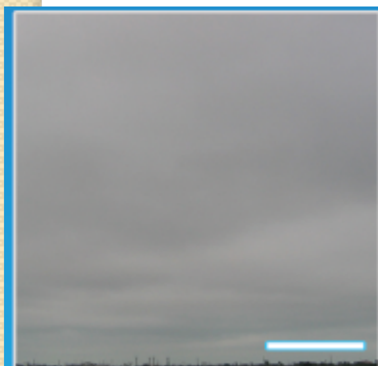
L3: Cumulonimbus
Tops not fibrous, outline not completely sharp, no anvil



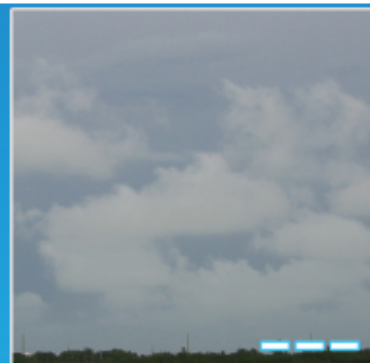
L4: Stratocumulus
From the spreading and flattening of cumulus



L5: Stratocumulus
Not from the spreading and flattening of cumulus



L6: Stratus
In a continuous layer and/or ragged shreds



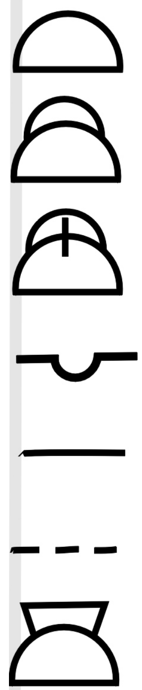
L7: Stratus Fractus
and/or Cumulus Fractus occurs with rain or snow

L8: Cumulus & Stratocumulus
Not spreading, bases at different levels

L9: Cumulonimbus
With fibrous top, often with an anvil

Bases below 2 km

Low Clouds



L1: Fair weather Cumulus

L2: Towering Cumulus

L3: Cumulonimbus without an anvil

L5: Stratocumulus

L6: Stratus

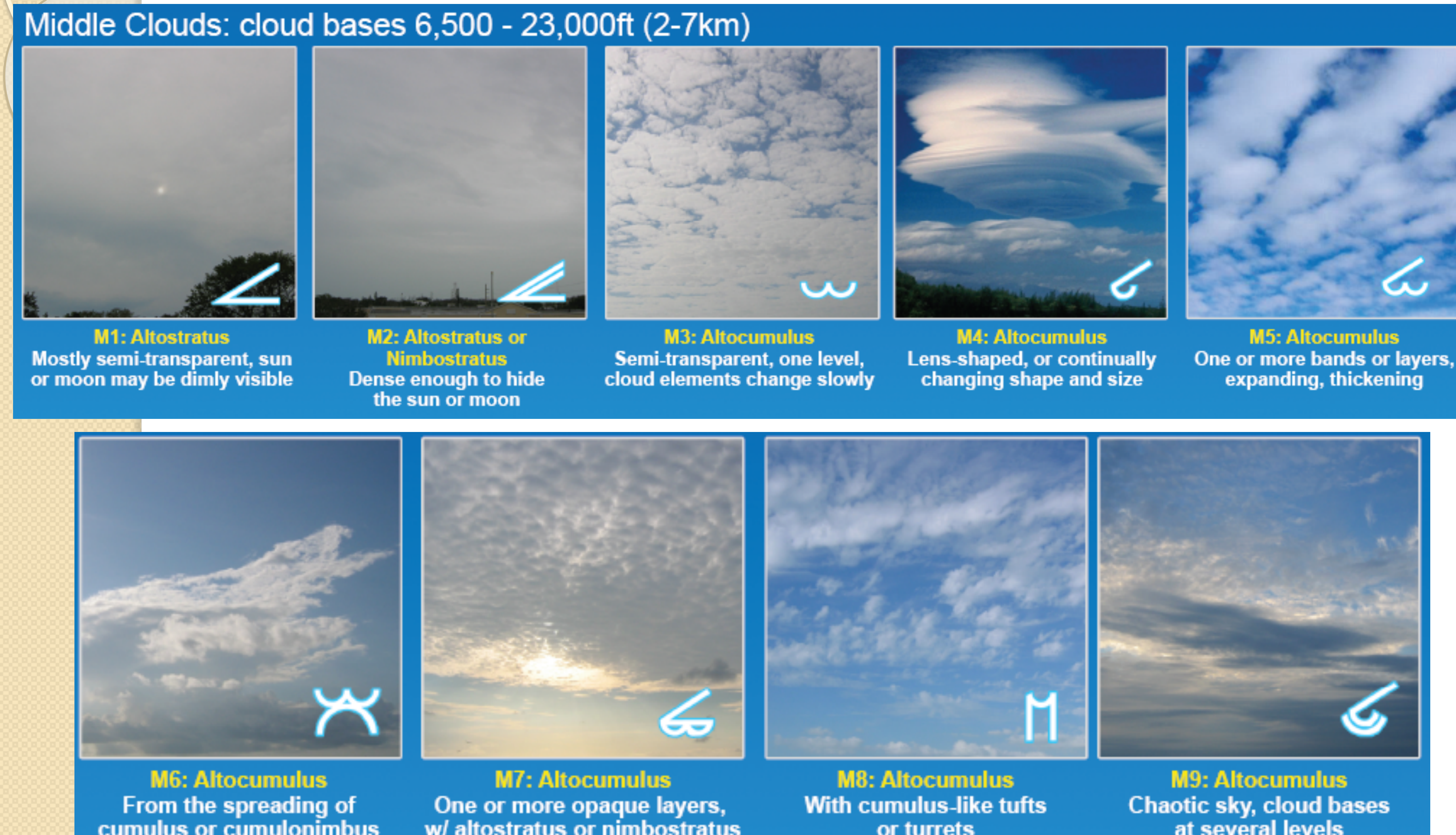
L7: Stratus fractus of bad weather (scud)

L9: Cumulonimbus with an anvil

Bases below 2 km

Middle Clouds:

Typical Types: Altostratus (As), Altocumulus (Ac), Nimbostratus (Ns)



Bases 2-7 km

Middle Clouds

M1: Thin Altostratus

M2: Thick Altostratus OR Nimbostratus

M3: Thin Altocumulus

M4: Thin Altocumulus in patches

M5: Increasing thin Altocumulus

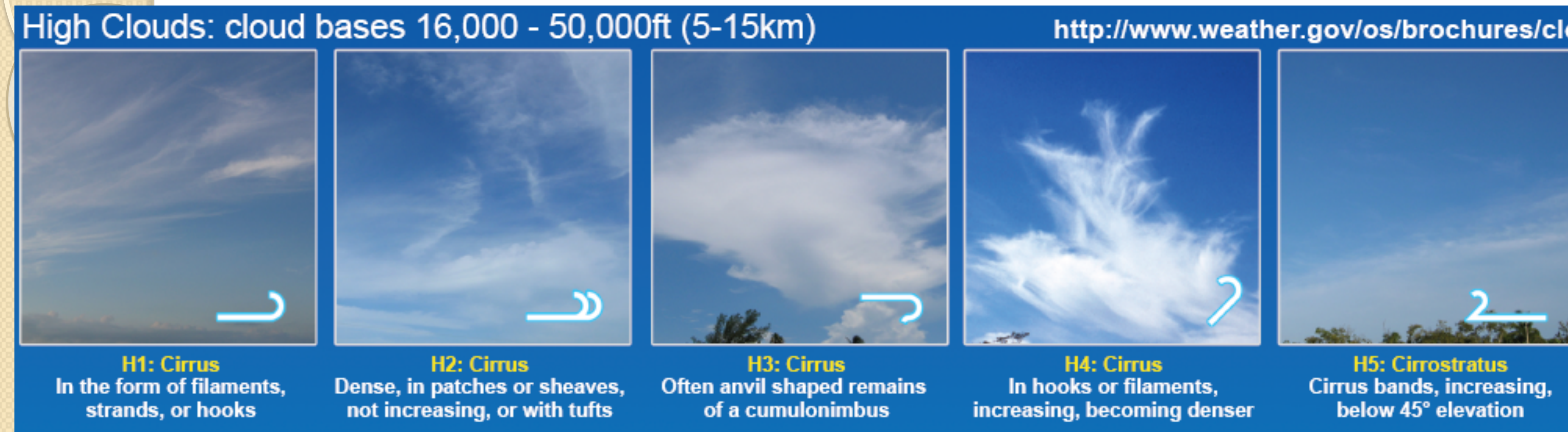
M7: Thick Altocumulus, not increasing

M9: Altocumulus of a chaotic sky

Bases 2-7 km

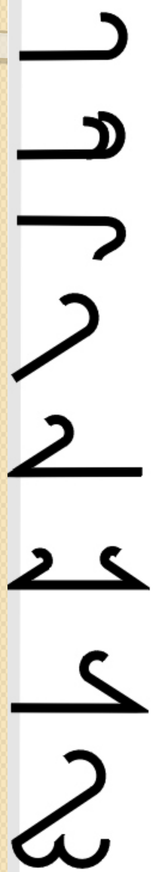
High Clouds:

Typical Types: Cirrus (Ci), Cirrostratus (Cs), Cirrocumulus (Cc)



Bases 5-13 km

High Clouds



H1: Scattered Cirrus, not increasing

H2: Dense Cirrus, not increasing

H3: Cirrus formed by spreading Cumulonimbus anvils

H4: Increasing Cirrus

H5: Increasing Cirrostratus, not covering entire sky

H7: Cirrostratus veil covering entire sky

H8: Cirrostratus, not increasing and not covering entire sky

H9: Cirrocumulus

Bases 5-13 km

More Clouds

Shelf Cloud
Represents the leading edge of strong winds in advance of a thunderstorm

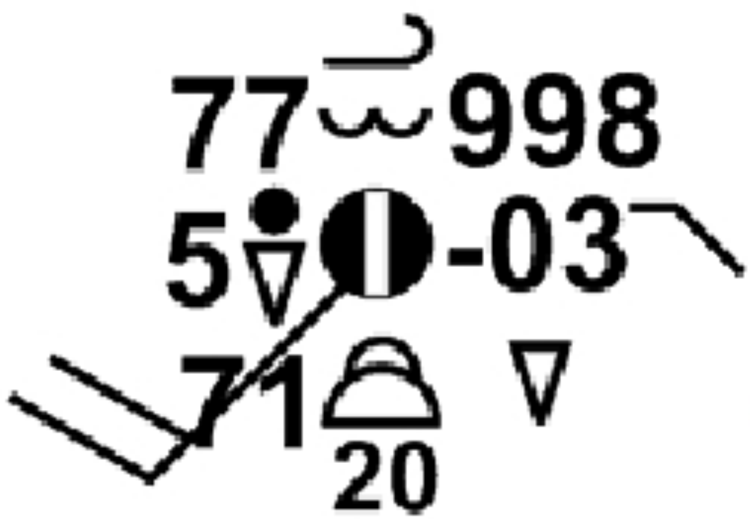
Wave Cloud
Formed by strong horizontal winds over uneven terrain

Mammatus
Drooping underside of heavy, rain-saturated clouds

Tornado
Rapidly rotating column under a cumulonimbus cloud that touches the ground

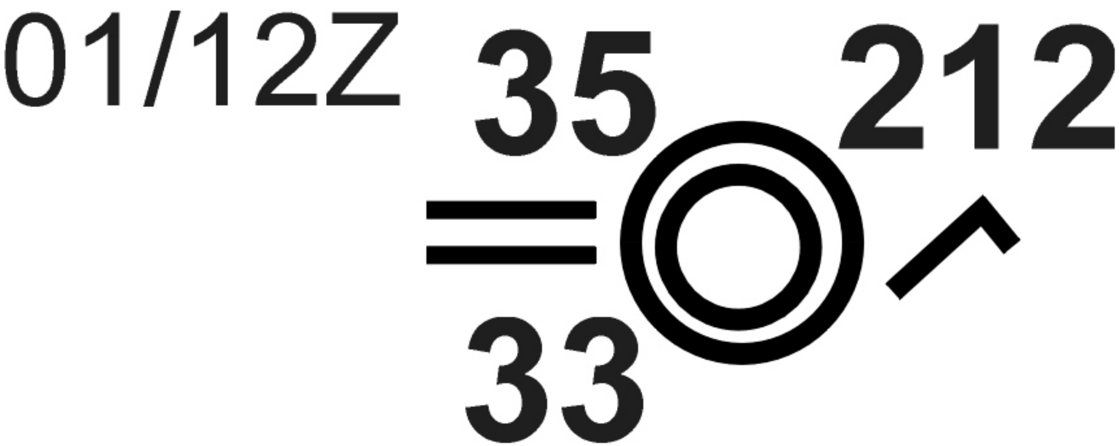
Wall Cloud
Lowering of the rain free base of a thunderstorm, often prior to tornado formation

A surface station interpreted



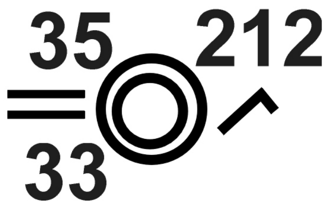
- Sky 7/8 Cloudy
- T & TD: 77 and 71°F
- Pressure: 999.8 mb
- Visibility 5 mi
- Present weather: RAIN Showers
- Barometer steady then falling by 0.3 mb
- Low Clouds: Towering Cumulus
- Middle Clouds: Thin Altocumulus
- High Clouds: Cirrus
- Past Weather: Showers
- Low cloud base: 2000 ft

A Sequence of Observations at a Station in the Heartland (central US)

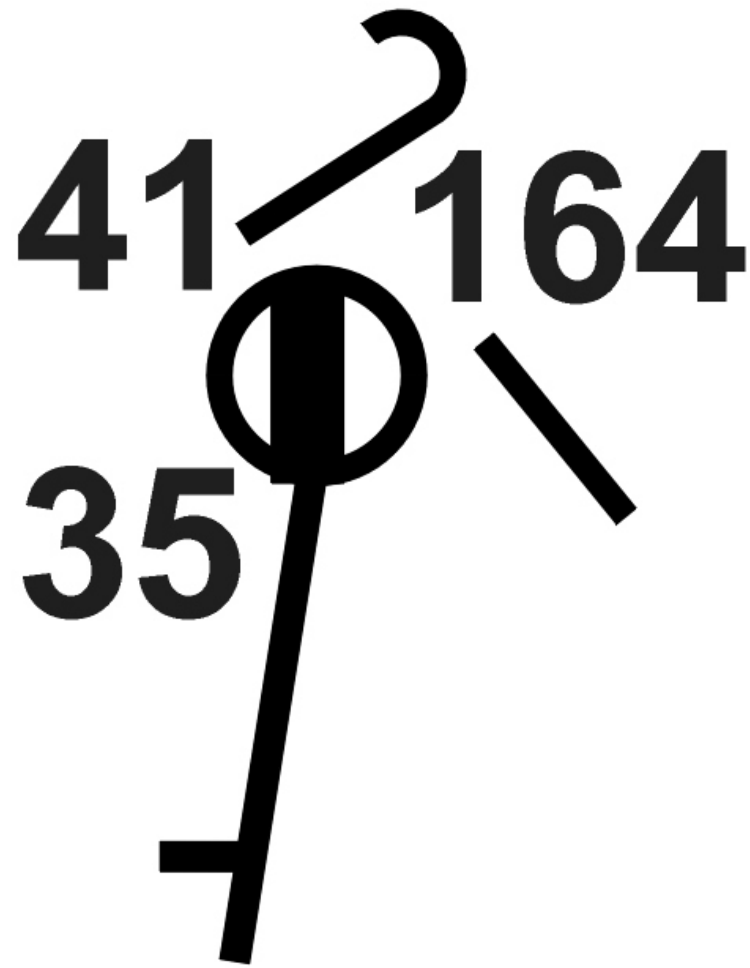


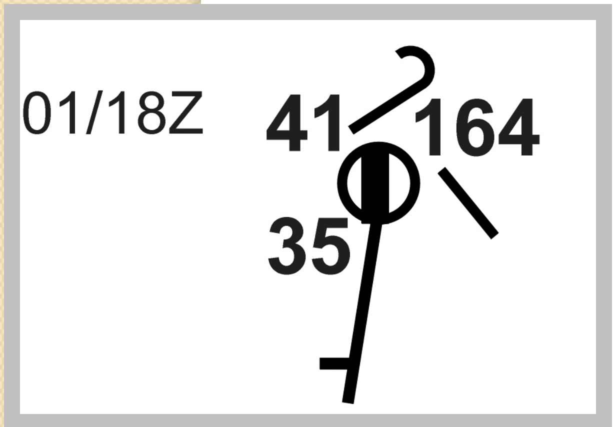
- Please practice by yourself by describing all the weather elements displayed in the plot in this and the next 8 slides (slide#40-48), similar to the example given in slide #39.
- You should describe the following weather elements: Sky cover, T &TD, Pressure, Visibility, Present weather, pressure trend, Low, Middle, & High Clouds, Past Weather & Low cloud base.
- You can omit elements not plotted.

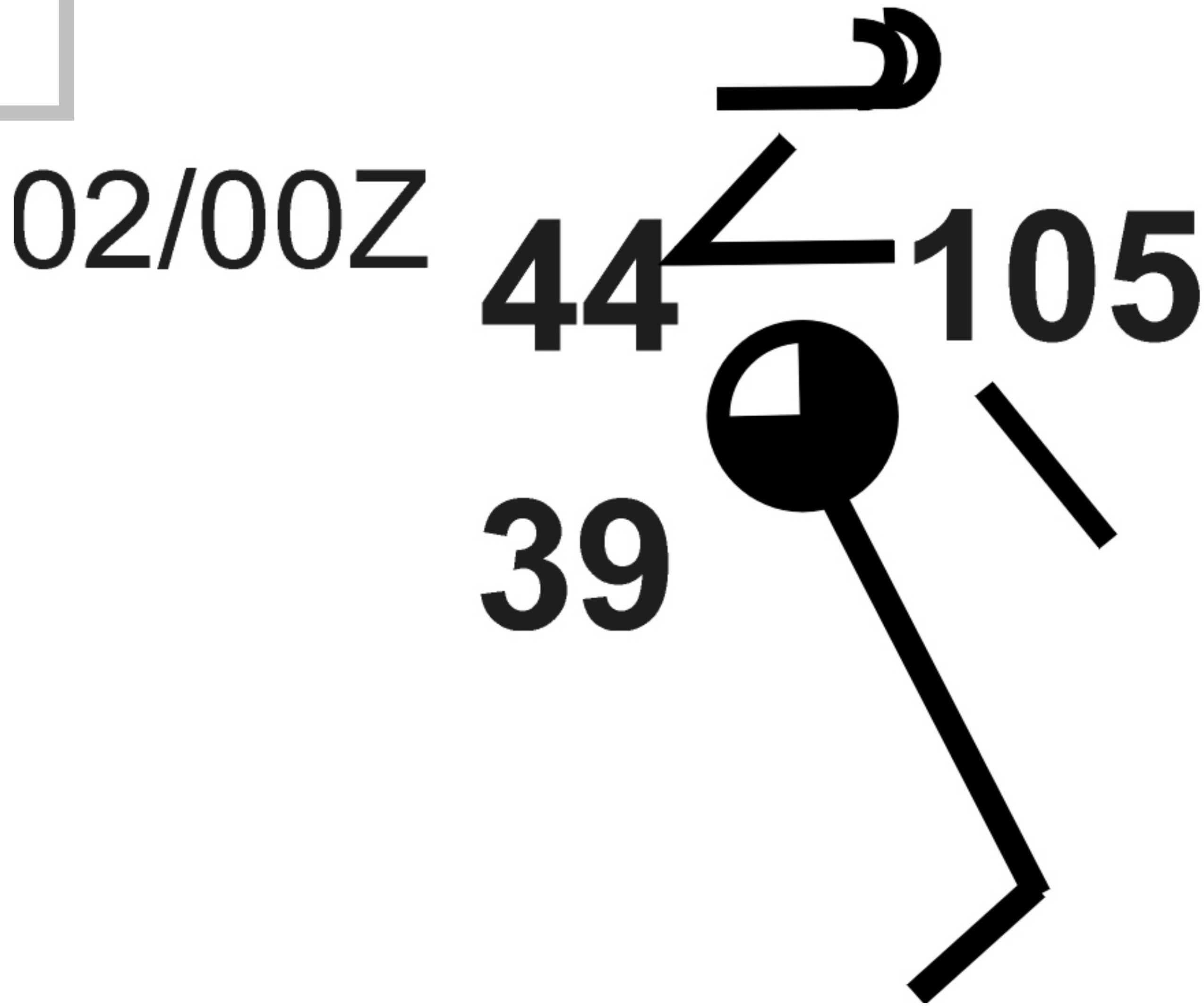
01/12Z

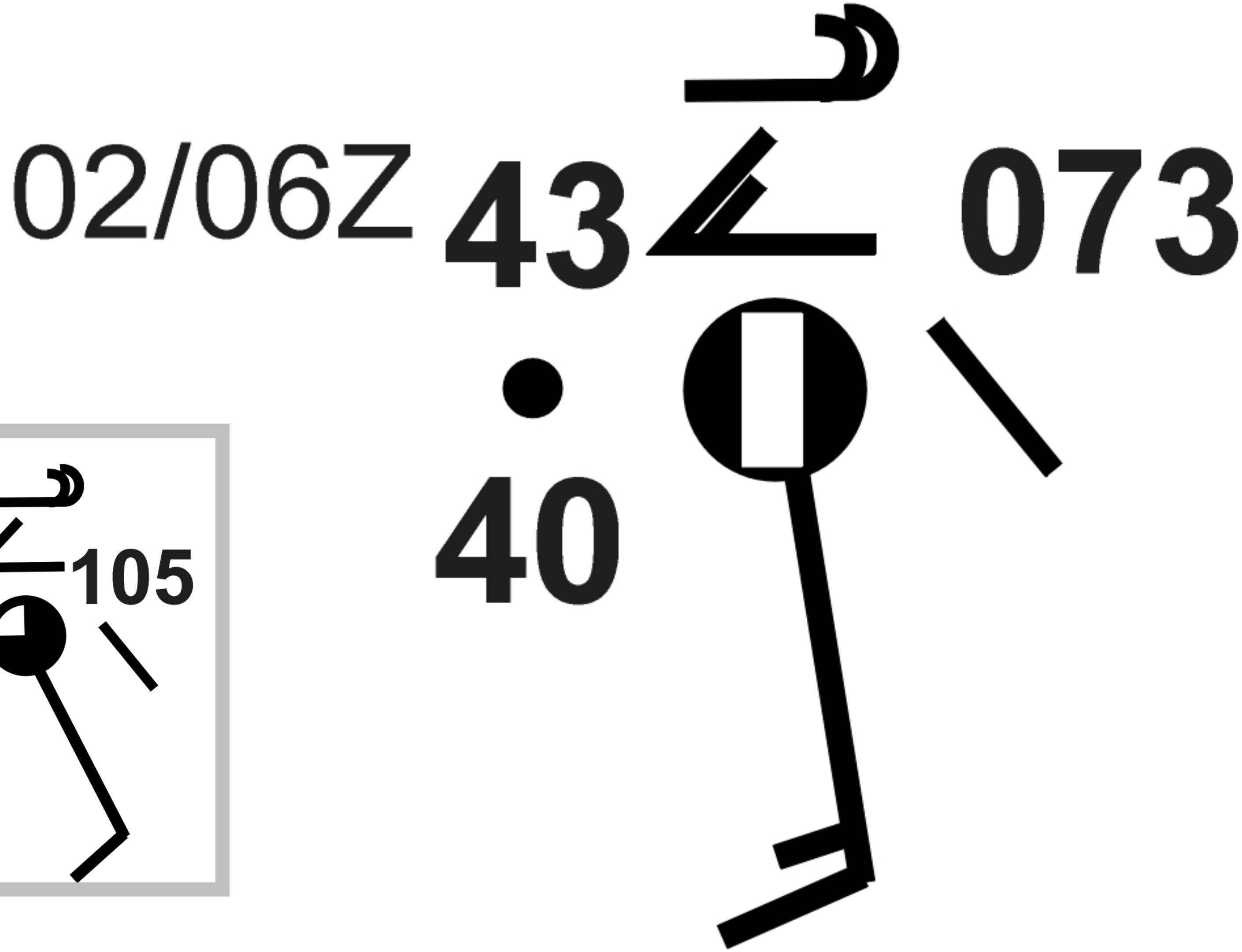


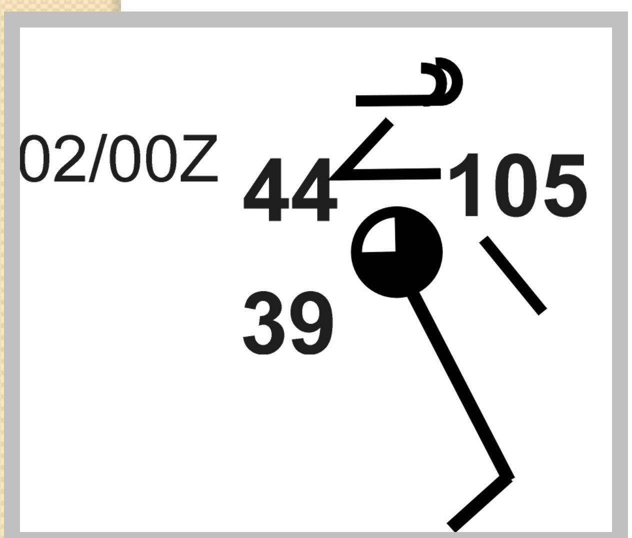
01/18Z




01/18Z
41
164
35


02/00Z
44
105
39


02/06Z
43
073
40


02/00Z
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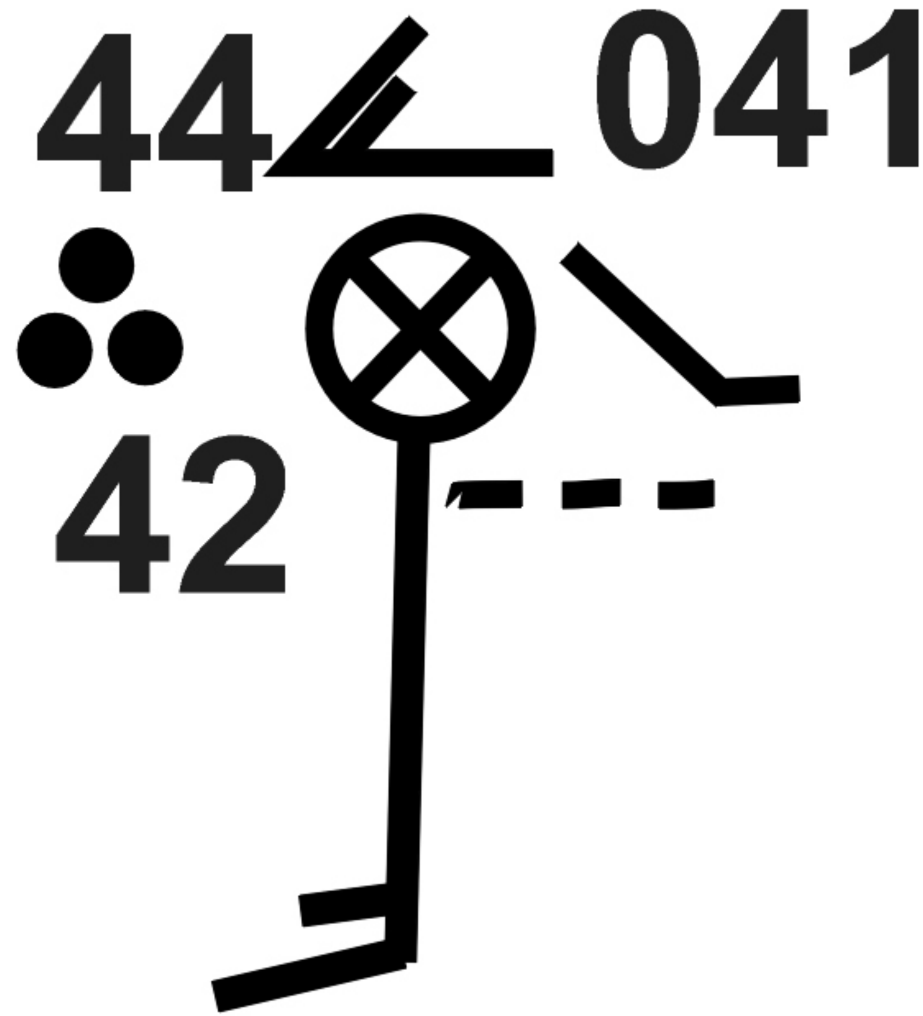
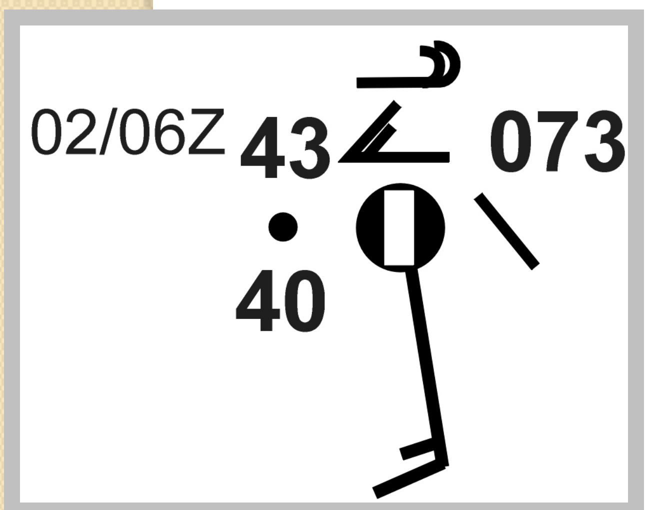
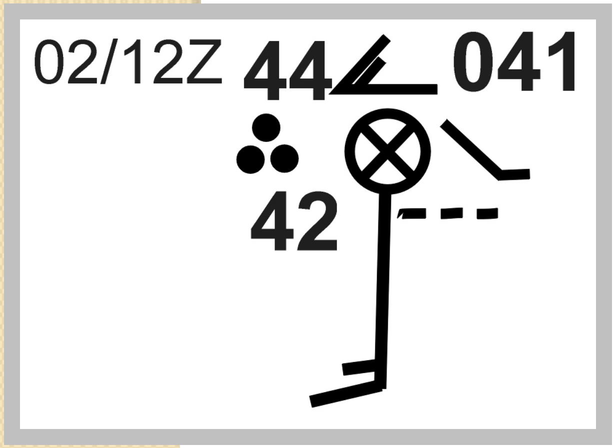
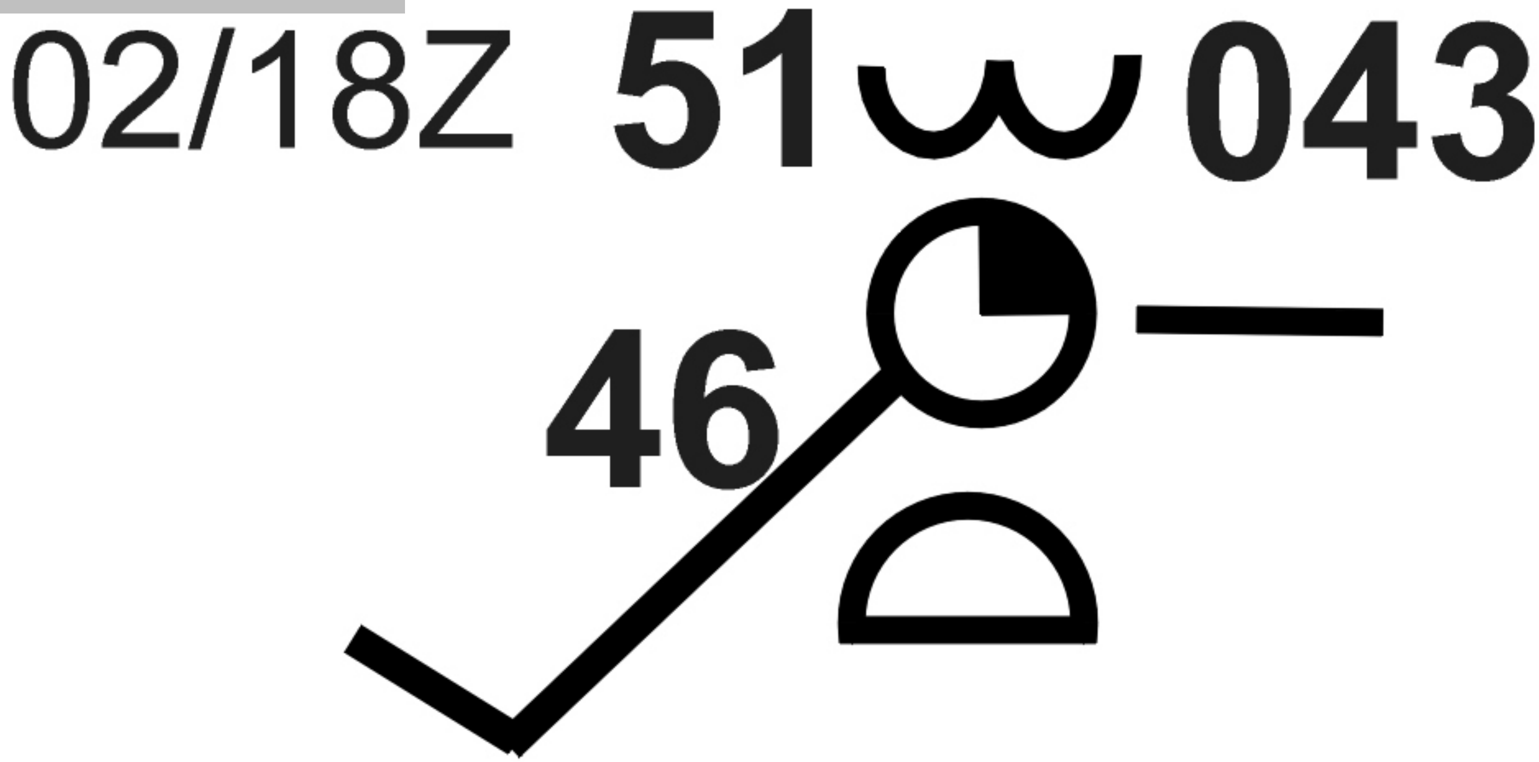

02/12Z
44
041
42

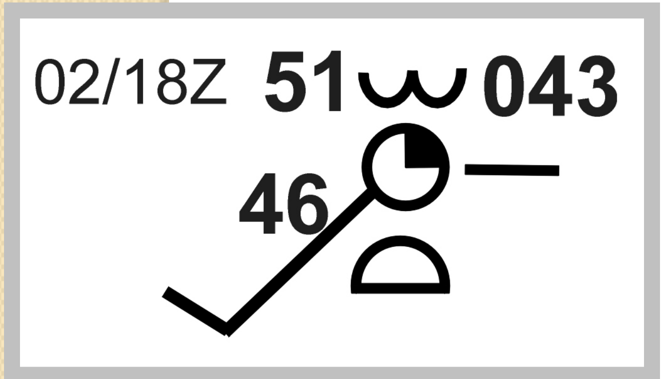

02/06Z
43
073
40

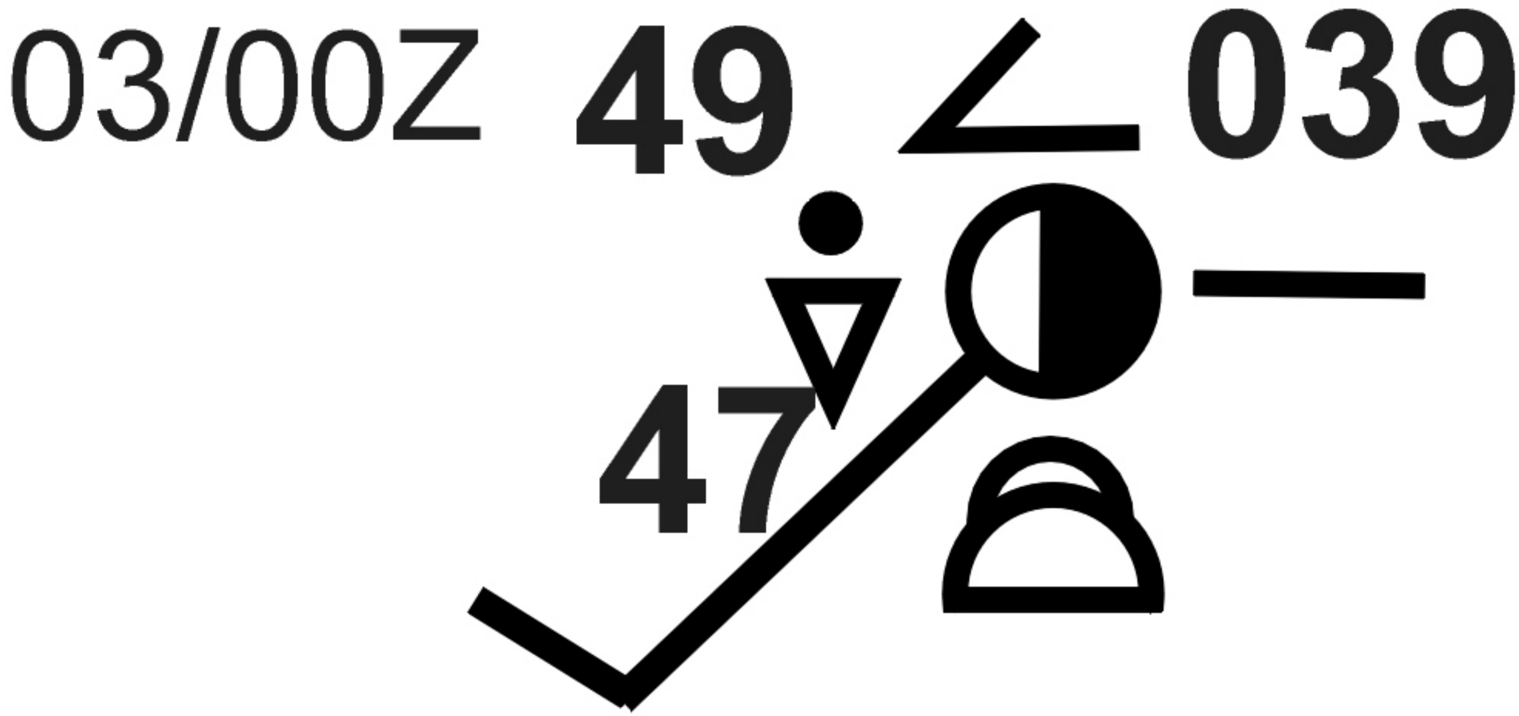


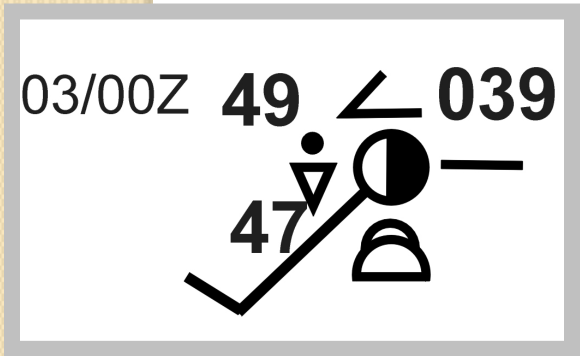
02/12Z
44
041
42



02/18Z
51
043
46


02/18Z
51
043
46


03/00Z
49
039
47


03/00Z
49
039
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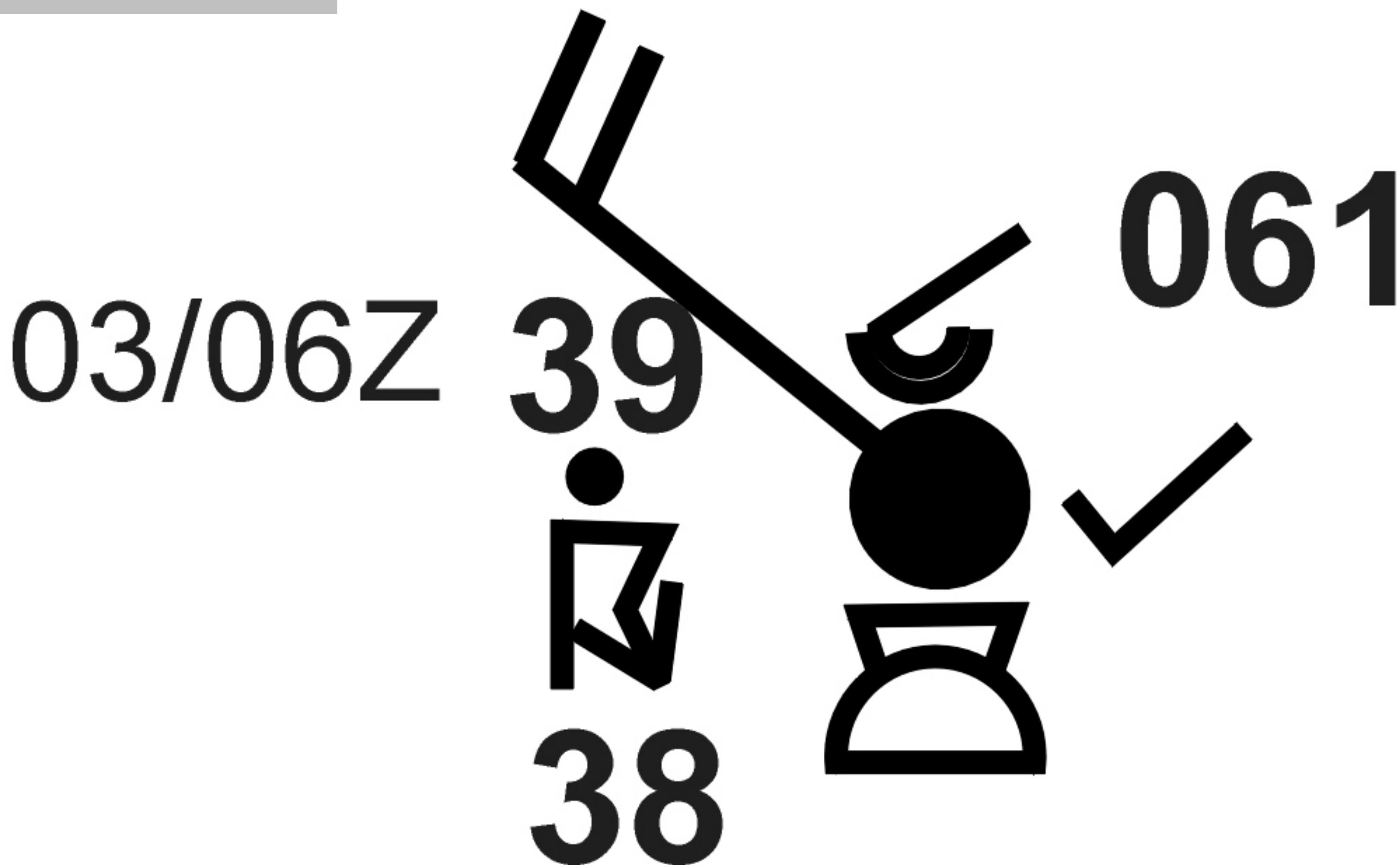
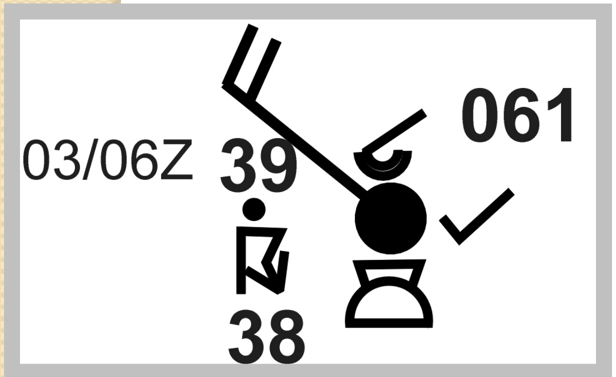

03/06Z
39
061
38


03/06Z
39
061
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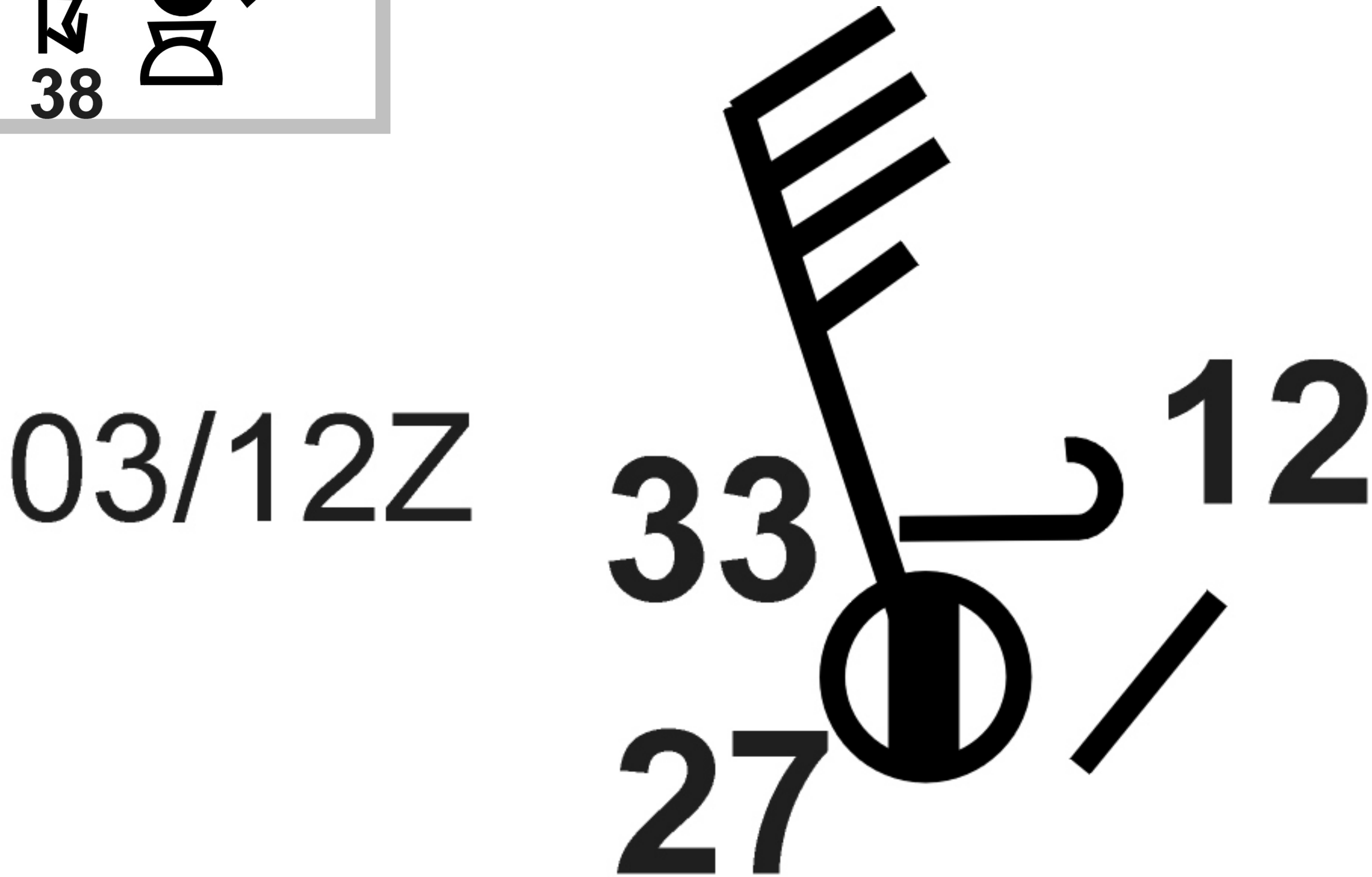
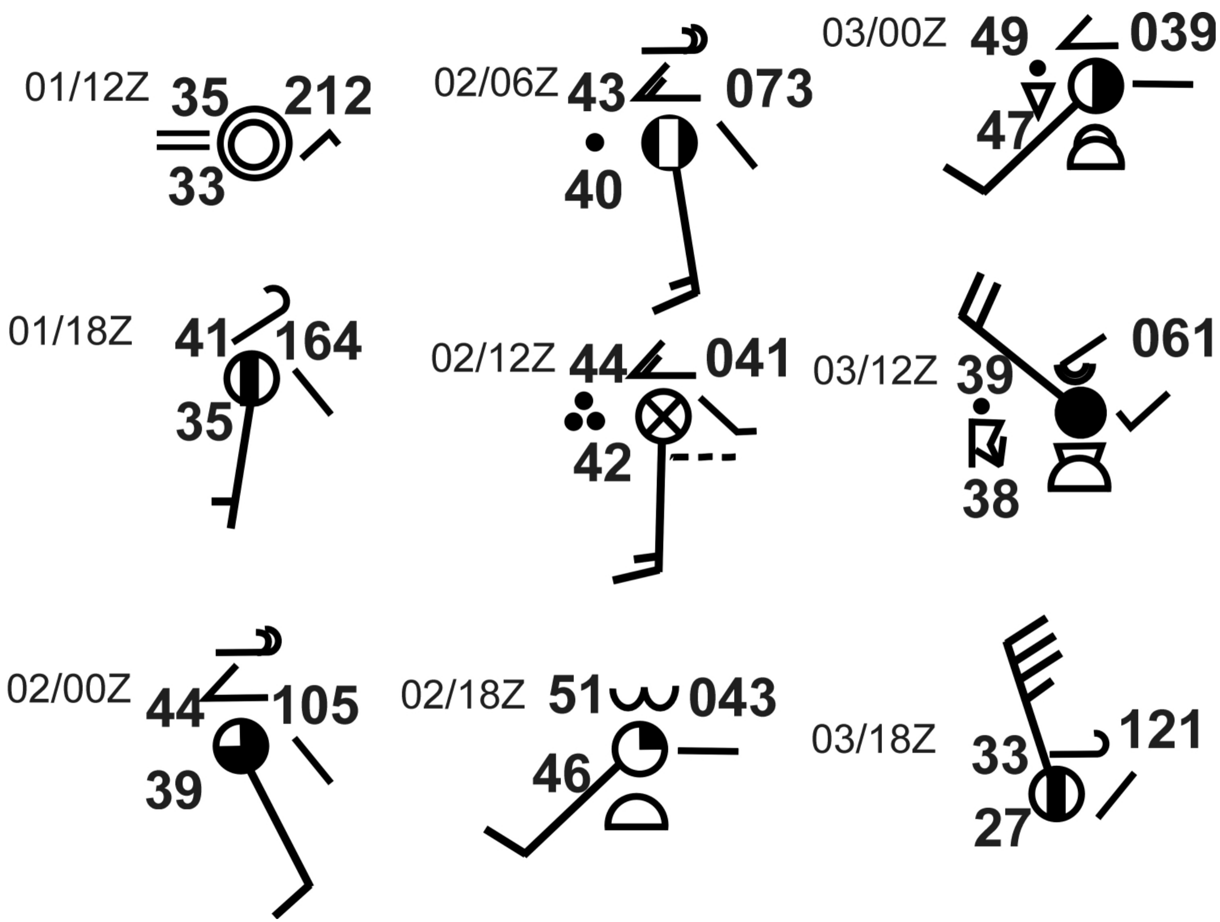

03/12Z
33
12
27

Weather summary of all previous plots



- **This is an event of frontal cyclone passage of a station. The state experienced warm front first, then behind the warm front, in front of a cold front, and cold front passage**. Changes in winds, temperature, dew point, weather and cloud covers indicate this event.

Surface Fronts and Boundaries

- **Cold Front** - a zone separating two air masses, of which the cooler, denser mass is advancing and replacing the warmer.

Warm Front

- **Warm Front** - a transition zone between a mass of warm air and the cold air it is replacing.

Stationary Front

- **Stationary Front** - a front between warm and cold air masses that is moving very slowly or not at all.

Occluded Front

- **Occluded Front -** a composite of two fronts, formed as a cold front overtakes a warm or quasi-stationary front. Two types of occlusions can form depending on the relative coldness of the air behind the cold front to the air ahead of the warm or stationary front. A cold occlusion results when the coldest air is behind the cold front and a warm occlusion results when the coldest air is ahead of the warm front.

Trough

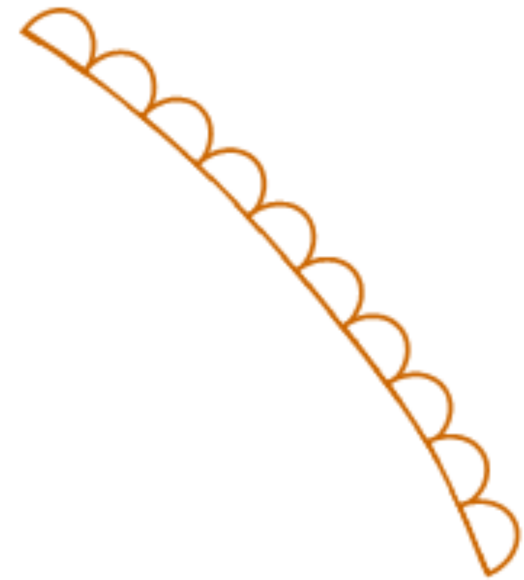
- **Trough** - an elongated area of relatively low atmospheric pressure; the opposite of a ridge. On WPC's surface analyses, this feature is also used to depict outflow boundaries.

Squall Line

- Squall Line - a line of active thunderstorms, either continuous or with breaks, including contiguous precipitation areas resulting from the existence of the thunderst

Dry Line

- Dry Line - a boundary separating moist and dry air masses. It typically lies north-south across the central and southern high Plains states during the spring and early summer, where it separates moist air from the Gulf of Mexico (to the east) and dry desert air from the southwestern states (to the west).

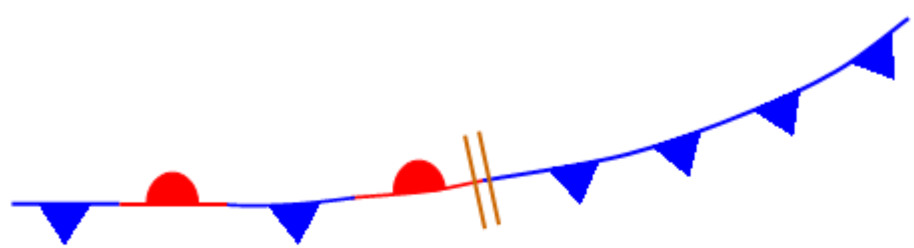


Tropical Wave

- Tropical Wave - a trough or cyclonic curvature maximum in the trade wind easterlies.

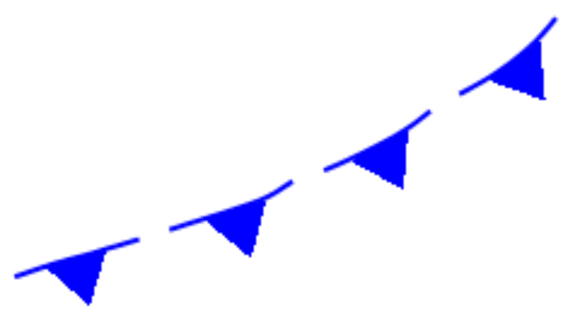
Hash marks

- Hash marks: A hash mark denotes a change in frontal type, as in the example below. The hash mark will always be drawn perpendicular to the boundaries. They are not drawn at "triple points" (the intersection of an occluded, cold and warm or stationary front) and where a low pressure center separates the different frontal types.



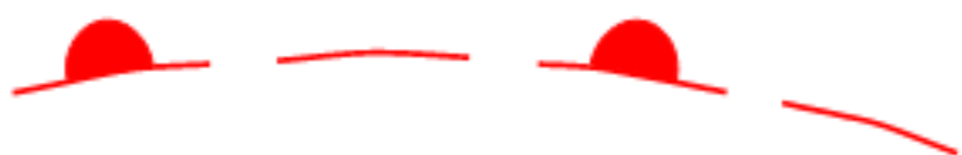
Depiction of frontogenesis and frontolysis

- Frontogenesis refers to the initial formation of a surface front or frontal zone, while frontolysis is the dissipation or weakening of a front. Frontogenesis is depicted on HPC's surface analysis and forecast charts as a dashed line with the graphical representation of the developing frontal type (the blue triangle for cold fronts, the red semicircle for warm fronts, etc...) drawn on **each** segment. For example, the image below shows a forming cold front.

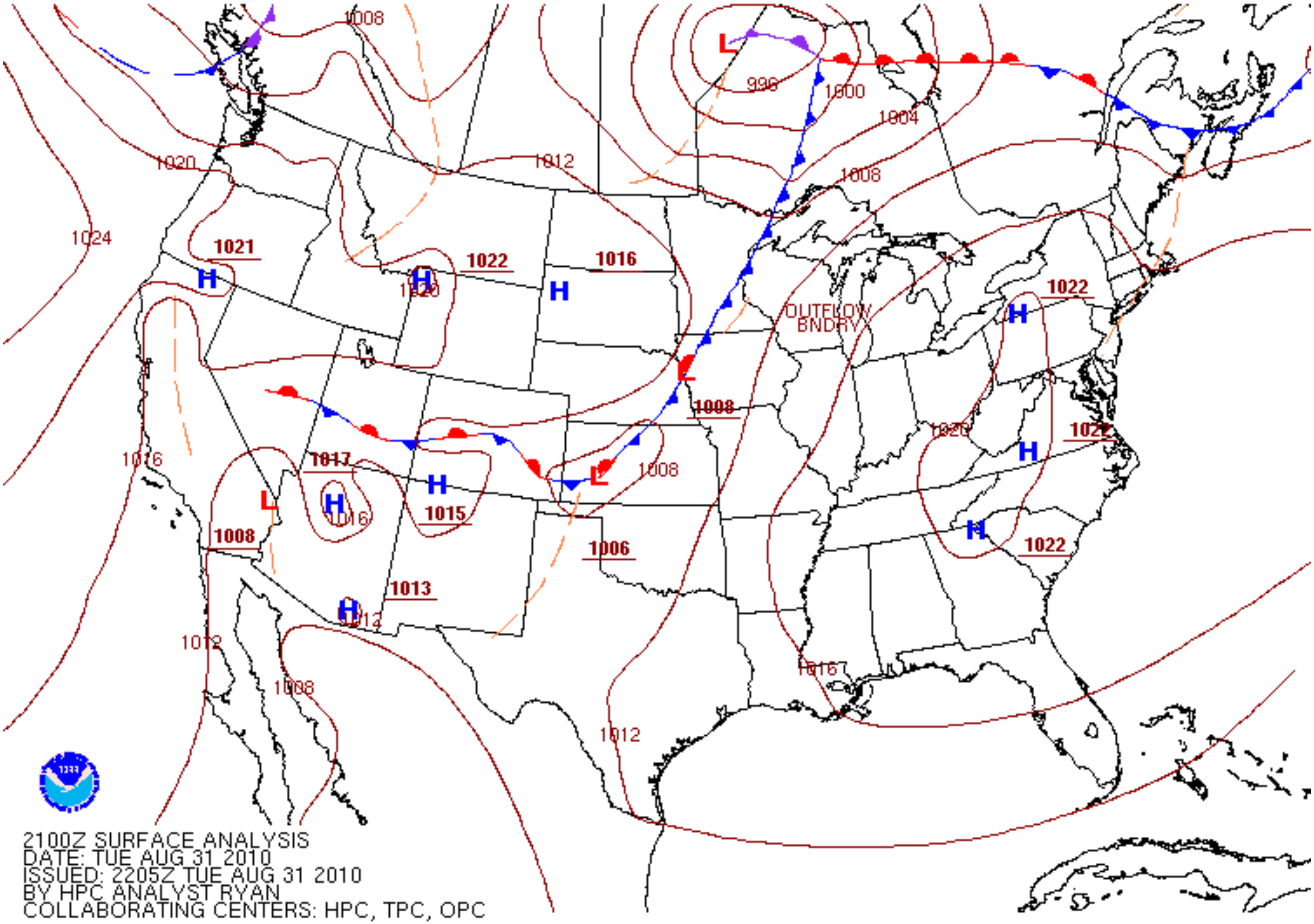


Frontolysis

- Frontolysis is depicted as a dashed line with the graphical representation of the weakening frontal type drawn on every **other** segment. Below is an example of a dissipating warm front.



An example of surface weather analysis



Another example of surface weather analysis