Weather Maps

- Weather time (a global standard used by all meteorologists): Greenwich (England) Mean Time, also called Universal Time Convention (UTC).
- Interpreting Surface Observation Symbols
- Understanding contours.
- Combining data resources.
Surface Observations

Temperature (64°F)

Current weather (fog)

Dew Point Temperature (58°F)

Weather Maps

Cloud Cover (75%)

Surface Pressure (1002.7 hPa)

Wind Speed and Direction
(southeasterly at 15 Kts)
Wind Barb

Direction: wind blows towards the station circle.

Cloud Cover

0% Cloud Cover - Observation: Clear Skies
25% Cloud Cover - Observation: Scattered Clouds
75% Cloud Cover - Observation: Broken Clouds
100% Cloud Cover - Observation: Overcast
Vision Obscured
Missing Data
### Common Current Weather Symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Symbol" /></td>
<td>Light Rain</td>
</tr>
<tr>
<td><img src="image2" alt="Symbol" /></td>
<td>Moderate Rain</td>
</tr>
<tr>
<td><img src="image3" alt="Symbol" /></td>
<td>Heavy Rain</td>
</tr>
<tr>
<td><img src="image4" alt="Symbol" /></td>
<td>Light Shower</td>
</tr>
<tr>
<td><img src="image5" alt="Symbol" /></td>
<td>Moderate Shower</td>
</tr>
<tr>
<td><img src="image6" alt="Symbol" /></td>
<td>Heavy T-storm</td>
</tr>
<tr>
<td><img src="image7" alt="Symbol" /></td>
<td>Light Snow</td>
</tr>
<tr>
<td><img src="image8" alt="Symbol" /></td>
<td>Moderate Snow</td>
</tr>
<tr>
<td><img src="image9" alt="Symbol" /></td>
<td>Heavy Snow</td>
</tr>
<tr>
<td><img src="image10" alt="Symbol" /></td>
<td>Light Freezing Rain</td>
</tr>
<tr>
<td><img src="image11" alt="Symbol" /></td>
<td>Moderate Freezing Rain</td>
</tr>
<tr>
<td><img src="image12" alt="Symbol" /></td>
<td>Light Haze</td>
</tr>
<tr>
<td><img src="image13" alt="Symbol" /></td>
<td>Moderate Haze</td>
</tr>
<tr>
<td><img src="image14" alt="Symbol" /></td>
<td>Light Ice Crystals</td>
</tr>
<tr>
<td><img src="image15" alt="Symbol" /></td>
<td>Moderate Ice Crystals</td>
</tr>
<tr>
<td><img src="image16" alt="Symbol" /></td>
<td>Light Fog</td>
</tr>
<tr>
<td><img src="image17" alt="Symbol" /></td>
<td>Moderate Fog</td>
</tr>
</tbody>
</table>

### Understanding Contours

Elevation contours separate lower and higher heights.
Isotherms are contours that separate lower and higher temperatures.
Isotherms – lines of constant temperature

Pressure and Isobars

Isobars are lines of constant pressure
Pressure and Isobars

Isobars are contours that separate lower and higher pressures.

Isobars and Isotherms: Color Adds Information
Isobars and Wind

A low northwest of Hawaii that slows down the northeast trade winds, giving us muggy days lately.
HURRICANE Ioke becomes fifth category 5 hurricane in Central Pacific and unofficially hold the lowest sea level pressure (921MB) record in the Central Pacific...

MAX SUSTAINED WINDS: 130 KT, GUSTS 160 KT

Tropical Storm ERNESTO
Central Pressure: 1005 hPa
Sustained wind: 40 Kts

Tropical Storm Ernesto - GOES-12 IR 1515 UTC Tue 29 Aug 2006
Temperature is a measure of average kinetic energy (speed) of atoms and molecules 

\[ KE = \frac{1}{2} \times \text{mass} \times \text{velocity}^2 \]
Temperature scales

- **Celsius (C):** 0 (freezing), 100 (boiling)
- **Fahrenheit (F):** \( \frac{C}{9} \cdot 5 + 32 \)
- **Kelvin (K):** \( K = C + 273 \)

Pressure

The force exerted against a surface by continuous collisions of gas molecules.

1) Speed of molecules
2) Mass of molecules
3) Frequency of their impacts (~number of molecules)

> **Ideal Gas Law** – Pressure is proportional to the density \( (\rho) \) of the air times the temperature \( (T) \).

\[ P = \text{Constant} \times T \times \rho \]
Pressure

The force exerted on a surface is equal to the weight of the air in a column from that surface to the top of the atmosphere.

Measuring Pressure

- Barometer – instrument used to measure pressure
- Torricelli 1643 – invented the barometer

$\Rightarrow$ Weight of air = 76 cm of mercury
Pressure Decrease with Altitude

Pascal 1647 – predicted
lower press at higher altitude
– verified the next year

1 hPa = 1 mb

Jet cruising level 200 mb
Highest human settlement 500 mb
Top of Mauna Kea 600 mb
Average sea level 1013 mb
Adiabatic change in temperature

\[ T \sim p^\kappa, \text{ with } \kappa = 2/7 \]

**Compression** → requires external work → temperature increases

**Expansion** → does work to outside → temperature decreases

**Icarus**

Son of Daedalus who dared to fly too near the sun on wings of feathers and wax. Daedalus had been imprisoned by King Minos of Crete within the walls of his own invention, the Labyrinth. But the great craftsman's genius would not suffer captivity. He made two pairs of wings by adhering feathers to a wooden frame with wax. Giving one pair to his son, he cautioned him that *flying too near the sun* would cause the wax to melt. But Icarus became ecstatic with the ability to fly and forgot his father's warning. The feathers came loose and Icarus plunged to his death in the sea.
Heat

- Heat is a transfer of energy from one object to another.
- Heat makes things warmer.
- Heat is measured in units called calories.
- A calorie is the heat (energy) required to raise one cubic centimeter of water by 1°C.

Heat in the Atmosphere

There are four ways in which heat is transferred.
1. Conduction – heat transfer by direct contact.
2. Convection – heat carried by currents.
3. Radiation – heat transfer by electromagnetic waves, which are emitted by all objects.
Conduction

<table>
<thead>
<tr>
<th>SUBSTANCE</th>
<th>HEAT CONDUCTIVITY (WATTS(^{-1}) PER METER PER °C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Still air</td>
<td>0.023 (at 20°C)</td>
</tr>
<tr>
<td>Wood</td>
<td>0.08</td>
</tr>
<tr>
<td>Dry soil</td>
<td>0.25</td>
</tr>
<tr>
<td>Water</td>
<td>0.60 (at 20°C)</td>
</tr>
<tr>
<td>Snow</td>
<td>0.63</td>
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<tr>
<td>Wet soil</td>
<td>2.1</td>
</tr>
<tr>
<td>Ice</td>
<td>2.1</td>
</tr>
<tr>
<td>Sandstone</td>
<td>2.6</td>
</tr>
<tr>
<td>Granite</td>
<td>2.7</td>
</tr>
<tr>
<td>Iron</td>
<td>80</td>
</tr>
<tr>
<td>Silver</td>
<td>427</td>
</tr>
</tbody>
</table>

*Heat (thermal) conductivity describes a substance's ability to conduct heat as a consequence of molecular motion.

†A watt (W) is a unit of power where one watt equals one joule (J) per second (J/s). One joule equals 0.24 calories.
Convection

Advection: Transfer of heat, water vapor and other properties by horizontal wind (e.g., passage of a cold front)

Important Heat Concepts

• **Sensible heat** – heat that can be measured by a thermometer.
• **Latent heat** – heat required/released when a substance changes from one state to another. (Latent heat when added/removed from a substance does not change its temperature if a change in state does not occur.)
Latent heat – heat required/released as a substance changes from one state to another.

Latent heat may be transported from one place to another: e.g., much of precipitation in polar regions is due to water vapor transport from lower latitudes.

Moist Convection

fuels hurricanes

Almost a daily occurrence in Hawaii over the mountains -- caused by surface heating, rising buoyant plumes, and the release of latent heat in clouds
Radiation

- Radiation - energy leaving a body in the form of electromagnetic waves.
- Light is a form of electromagnetic radiation.
- The speed of light is $\sim 3 \times 10^8$ m/s through a vacuum (slightly slower through air).

Radiation Quality and Quantity

- The wavelength corresponds to the type (color)
- Duality: wave & photon particle
Heat in the Atmosphere

Latent heat of evaporation

Convection
Conduction
Radiation

The COMET Program