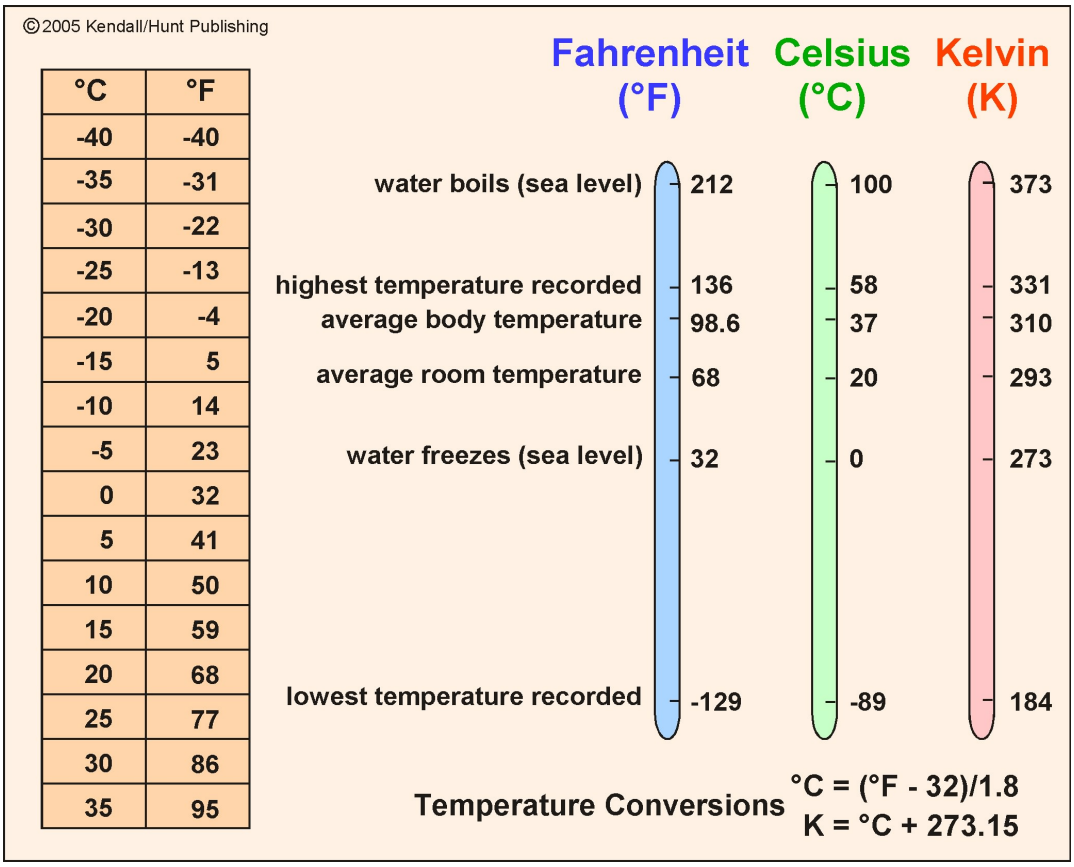
Atmospheric Properties

As atmospheric scientists what properties of the atmosphere do we care about?

How do these properties vary in space and time?

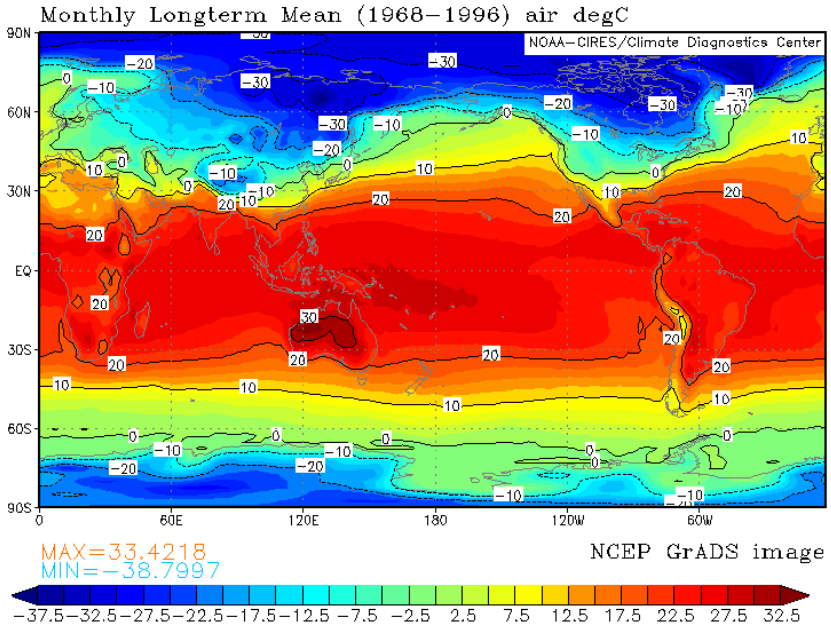
A key goal of this class, and other ATOC core classes, is to explain why these properties vary in this manner.

Temperature

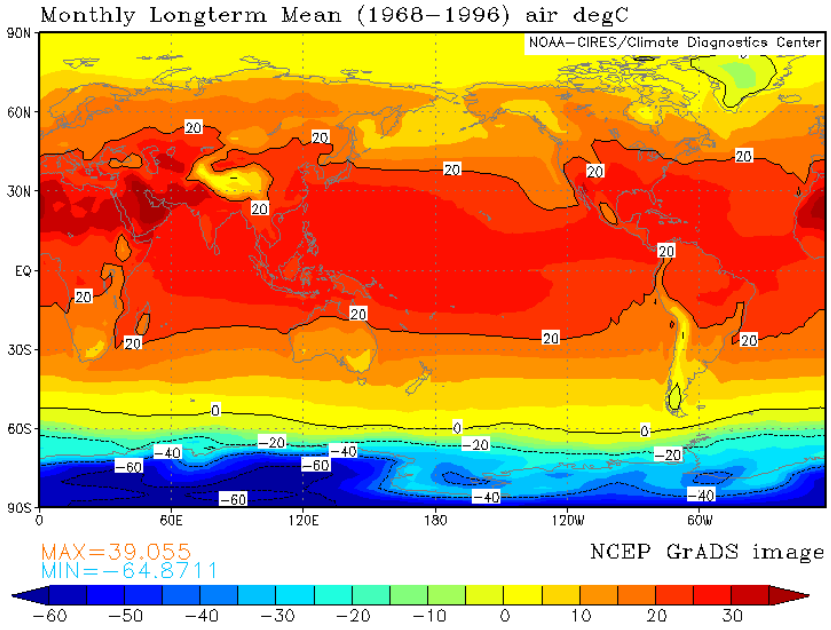


Horizontal Variations in Temperature

Surface Air Temperature - January



Surface Air Temperature - July

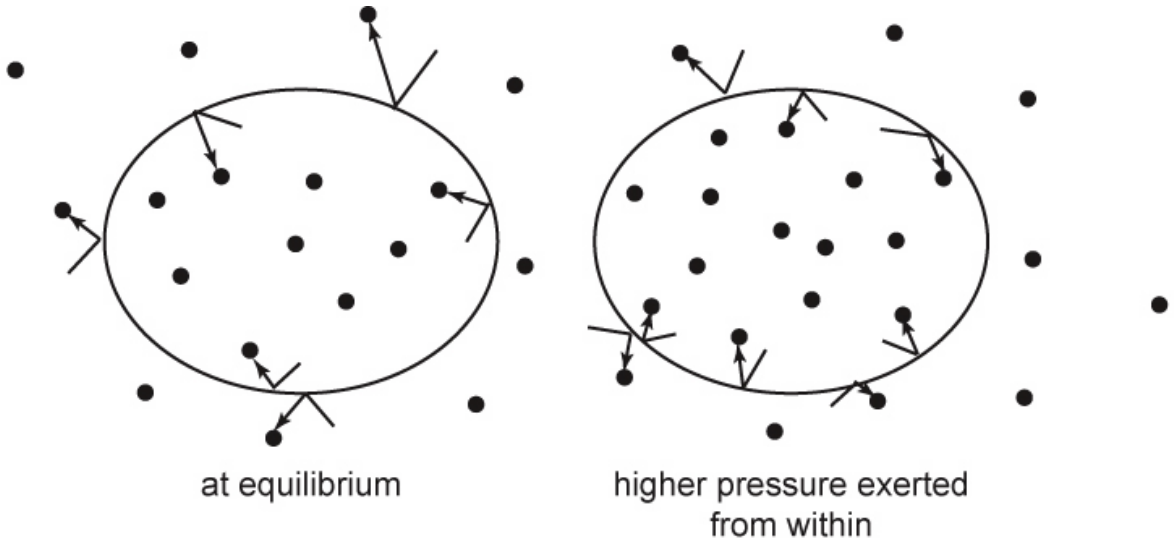


Atmospheric Pressure

Horizontal and vertical variations in pressure give rise to the atmospheric motions, which are one focus of ATOC 5050.

What is atmospheric pressure?

A molecular perspective…



SI Units for pressure

Pressure is a force per unit area exerted by a fluid

From Newton's second law: F=ma

Force has units of kg m s^{-2} (or Newtons – N)

Force per unit area has units of: kg m^{-1} s^{-2} = N m^{-2} (or Pascals – Pa)

Other commonly used units of pressure:

1 hPa = 100 Pa
1 millibar (mb) = 1 hPa

In the atmosphere the observed pressure is also equal to the weight of air per unit area above the observation point.

At the surface of the earth the pressure, p_s, is given by:

$$p_s = \int_0^\infty \rho g dz$$

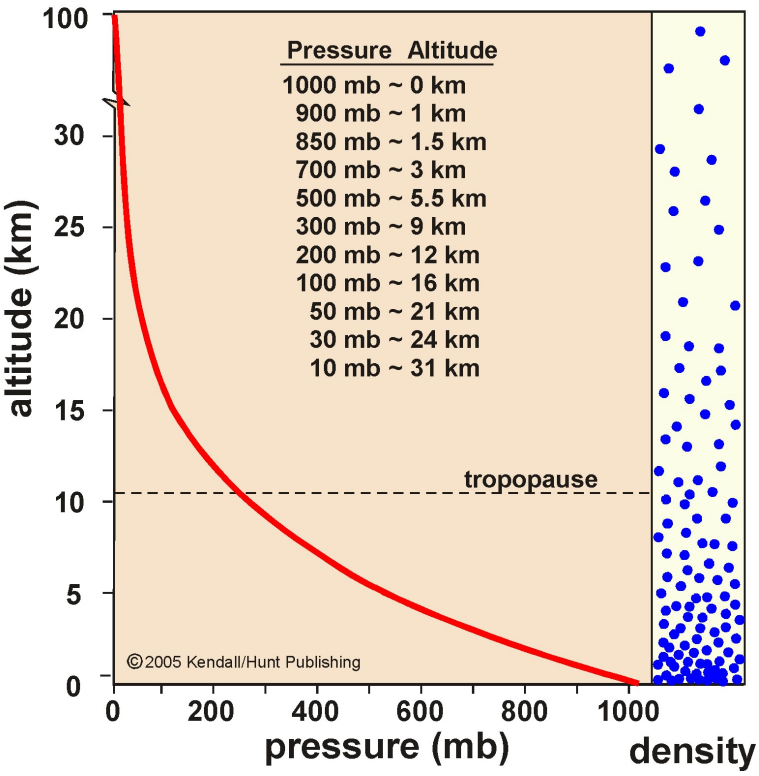
Neglecting variations in *g* this becomes:

$$p_s = g_0 \int_0^\infty \rho dz = m g_0$$

where $m = \int_0^\infty \rho dz$ is the mass per unit area of the overlying air

and g_0 = 9.807 m s^{-2}

Therefore, pressure decreases with increasing altitude in the atmosphere.



Surface pressure – the actual air pressure measured at the surface of the earth

What is the rate of decrease of pressure in the lower atmosphere?

Example: Estimate the surface pressure in Boulder, CO.

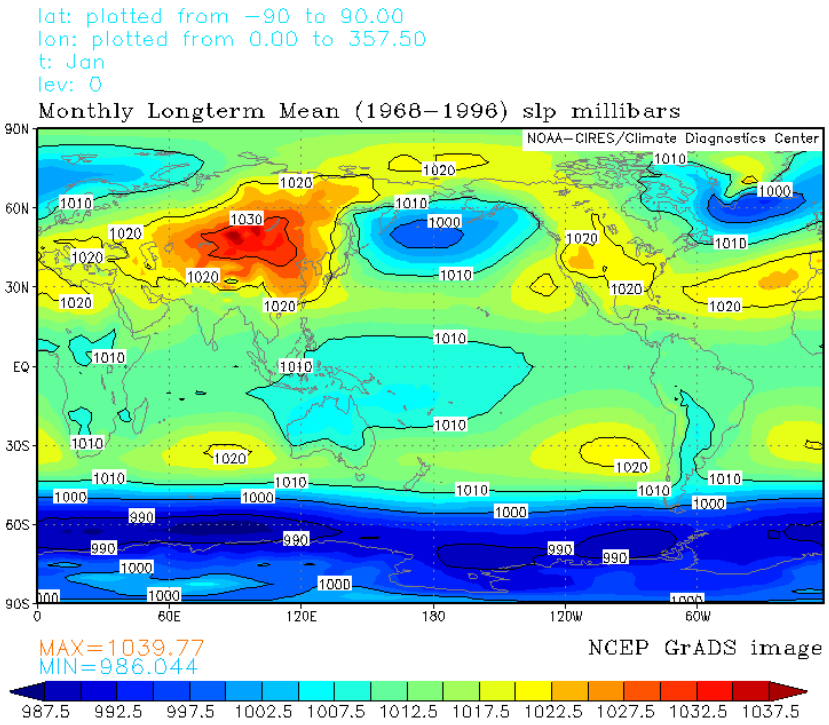
Sea-level pressure (SLP) – surface pressure interpolated to zero elevation (sea level)

Example: Comparison of weather maps of surface and sea level pressure

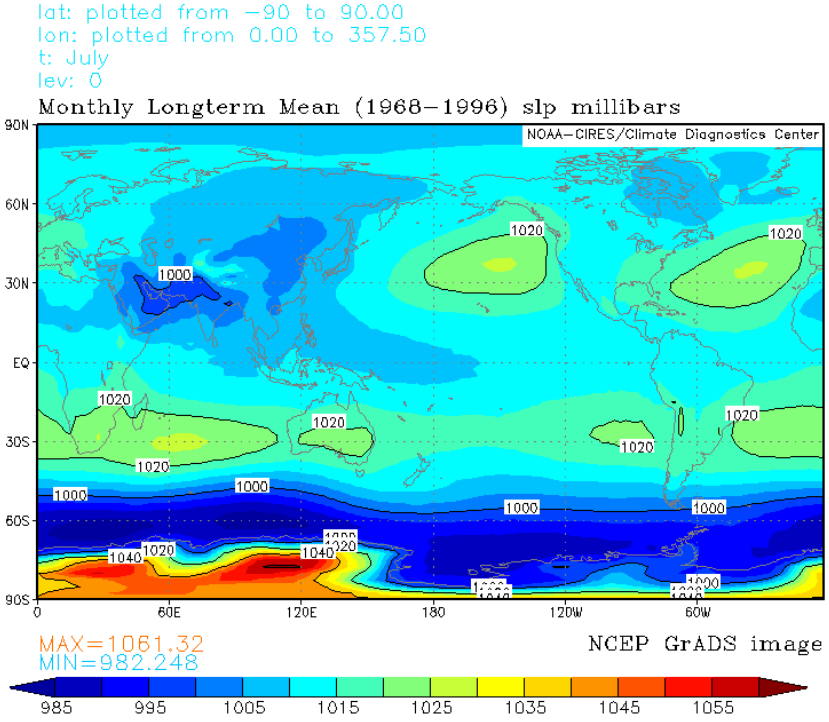
Why do meteorologists use SLP instead of surface pressure?

Horizontal Variations in Pressure

Sea Level Pressure - January

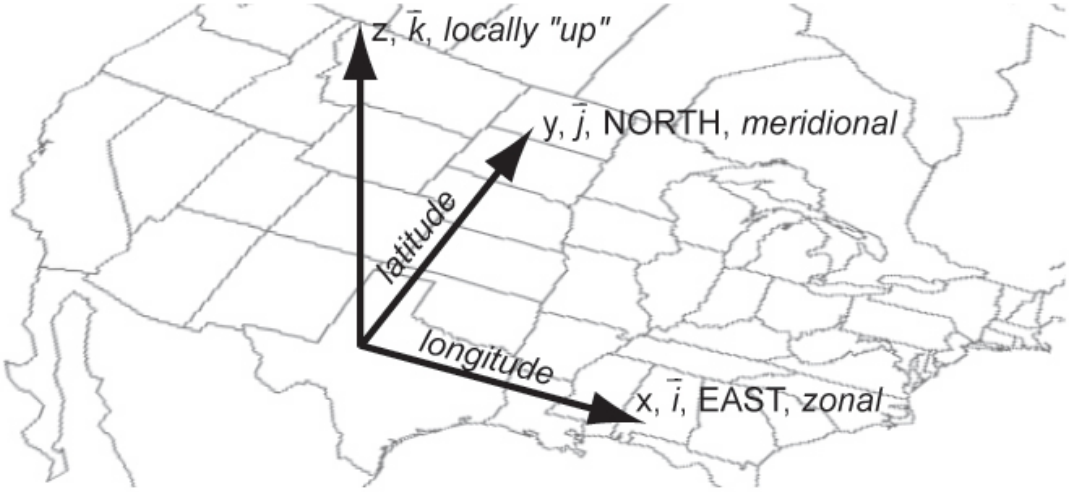


Sea Level Pressure - July



Wind

Using the following coordinate system:



the horizontal wind can be given as the vector:

$$\vec{V} \equiv u\vec{i} + v\vec{j}$$

where:

$\vec{i}$ is a unit vector directed towards the east

$\vec{j}$ is a unit vector directed towards the north

u is the east/west or zonal component of the wind

v is the north/south or meridional component of the wind

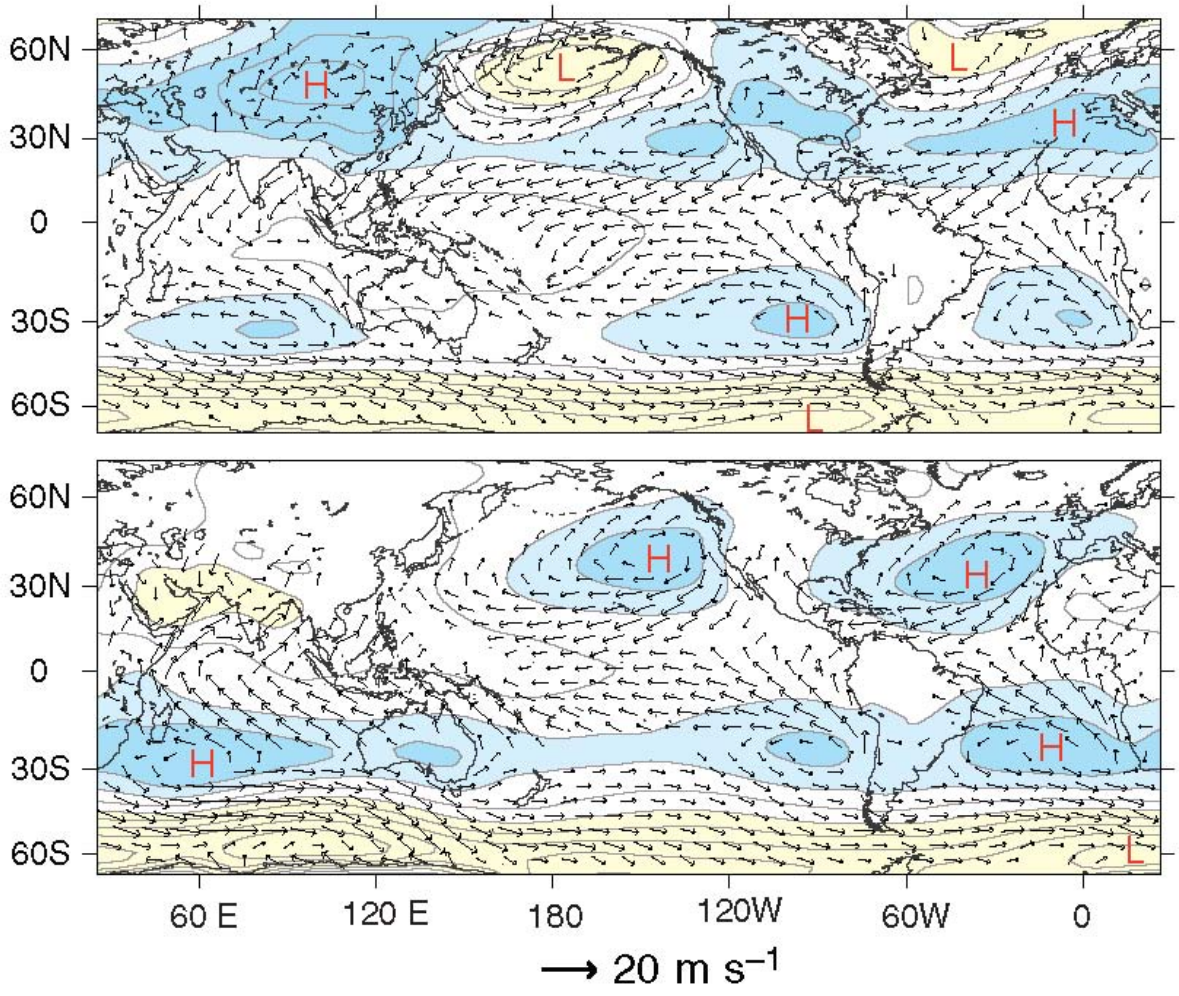
By convention meteorologists indicate the direction of the horizontal wind vector as the direction the wind is coming from.

What sign would the horizontal wind components have for:

An east wind?
A south wind?
A northwest wind?

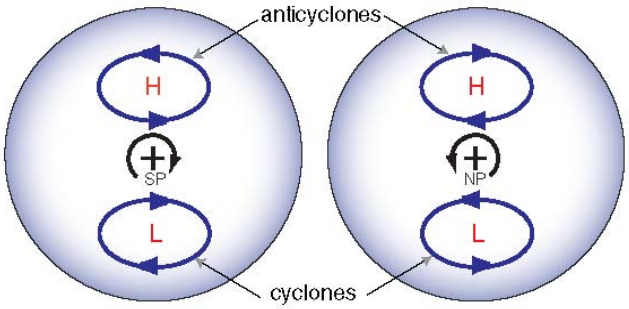
Horizontal Variations in Wind

\What is the relationship between surface winds and SLP?



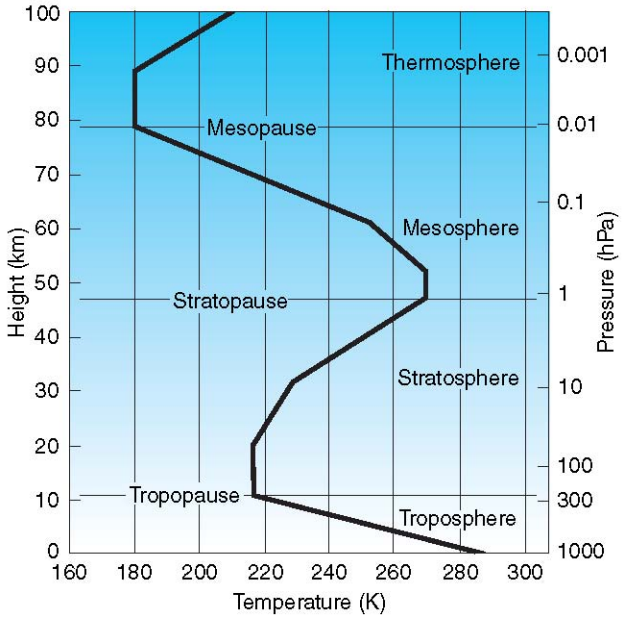
Cyclonic – winds rotating in the same sense as the Earth's rotation

Anticyclonic – wind rotating in the opposite sense as the Earth's rotation



Vertical Variations in Temperature

Standard Atmosphere



What features of the standard atmosphere temperature profile are notable?

Lapse rate – rate of *decrease* of temperature with increasing height

$$\Gamma \equiv -\frac{\partial T}{\partial z}$$

What is the lapse rate in the troposphere?

What is the lapse rate in the stratosphere?

Inversion – a layer in which temperature increases with height

What is the significance of a temperature inversion?

Atmospheric layers:

- Troposphere
  Tropo – turning or changing

- Stratosphere
  Strato - layered

Why does the temperature decrease with height in the troposphere?

Why does the temperature increase with height in the stratosphere?

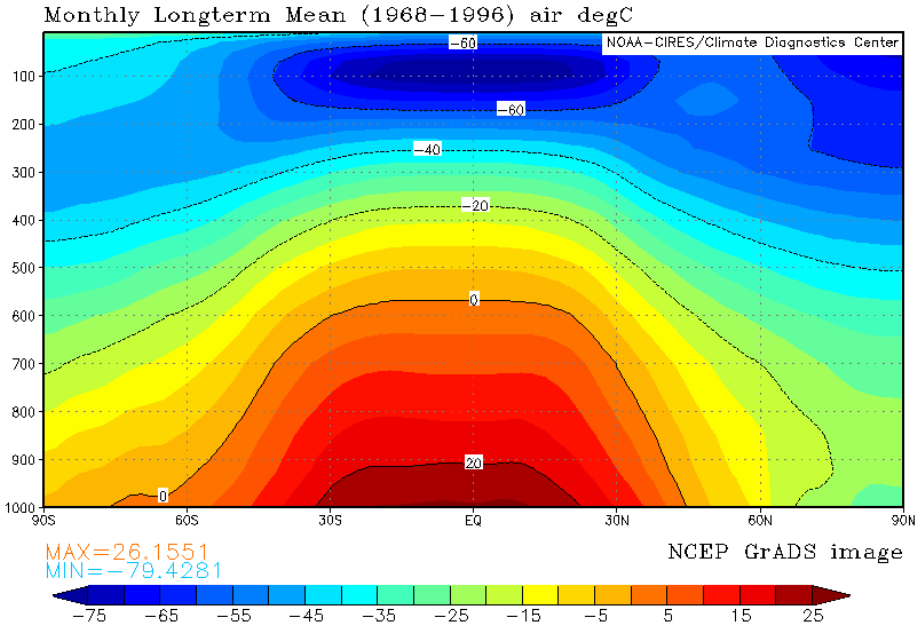
Tropopause - boundary between troposphere and stratosphere
Tropo – turning or changing
Pause – limit of

The height of the tropopause varies in both space and time.

What impact does the height of the tropopause have on weather?

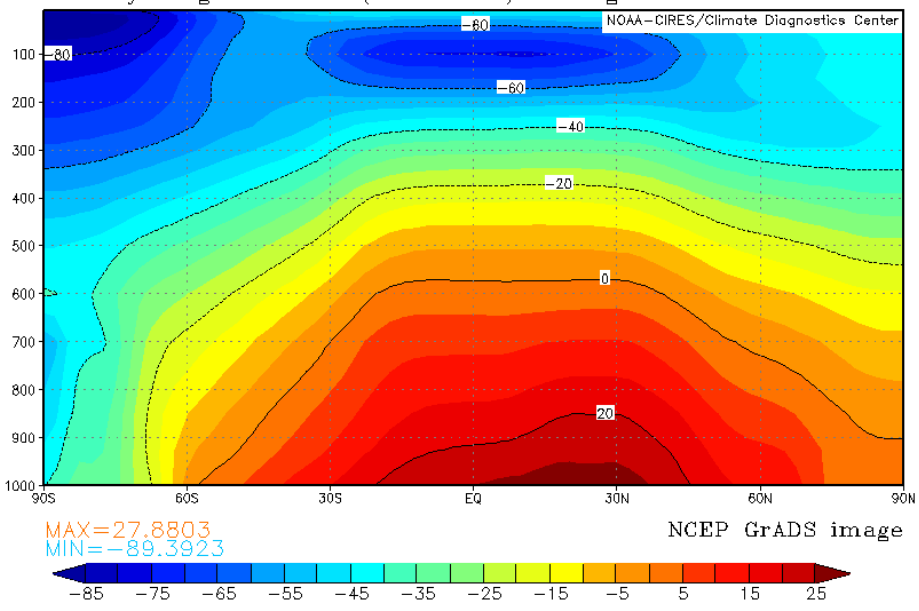
Zonally Averaged Temperature Cross-Section - January

lat: plotted from −90 to 90.00
lev: plotted from 1000.0000 to 10.0000
lon: averaged over 0.0000 to 357.5000
t: Jan



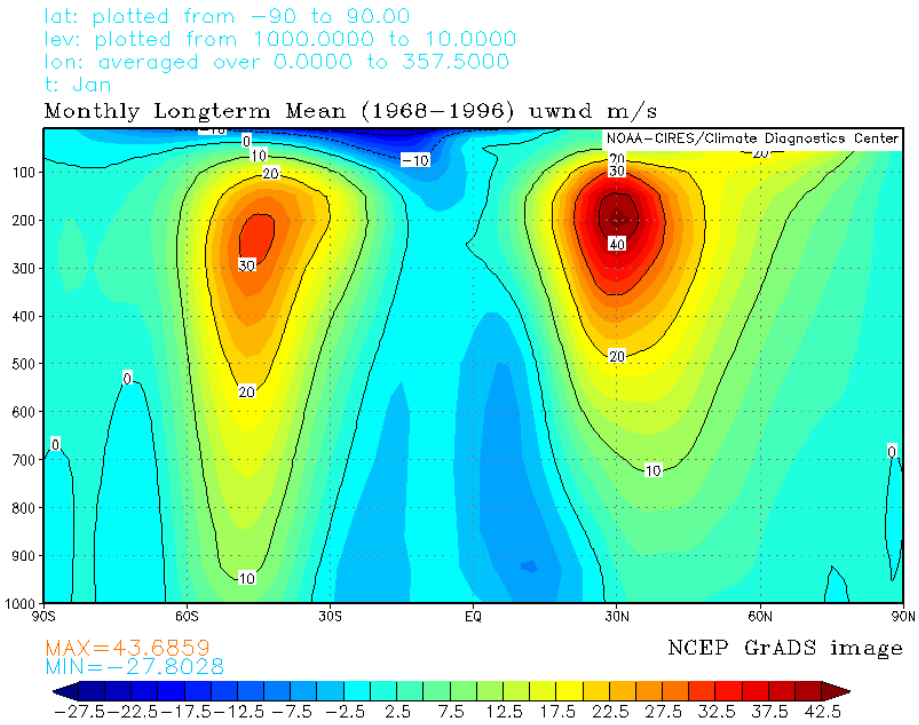
Zonally Averaged Temperature Cross-Section - July

lat: plotted from −90 to 90.00
lev: plotted from 1000.0000 to 10.0000
lon: averaged over 0.0000 to 357.5000
t: July

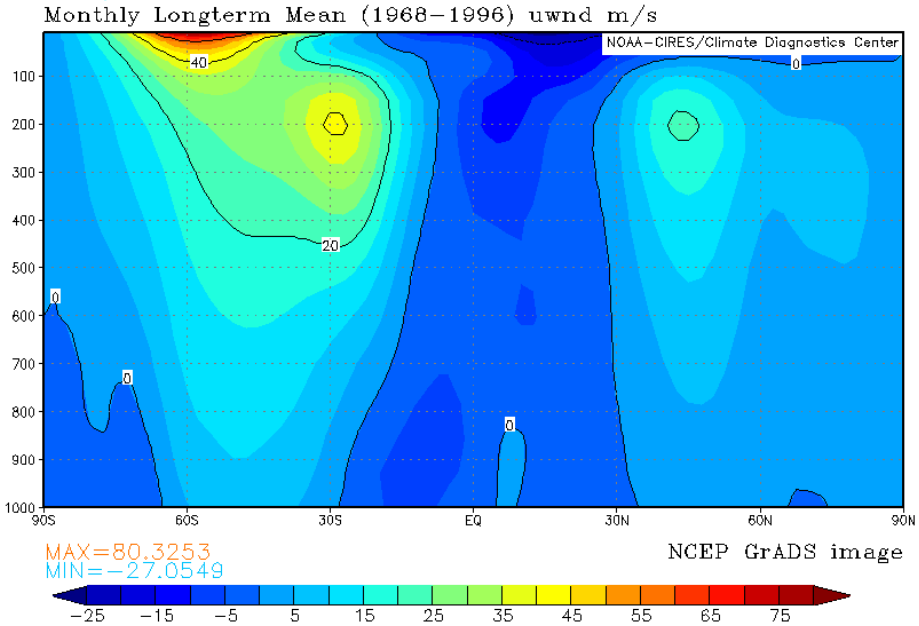


Vertical Variations in Wind

Zonally Averaged Zonal Wind - January



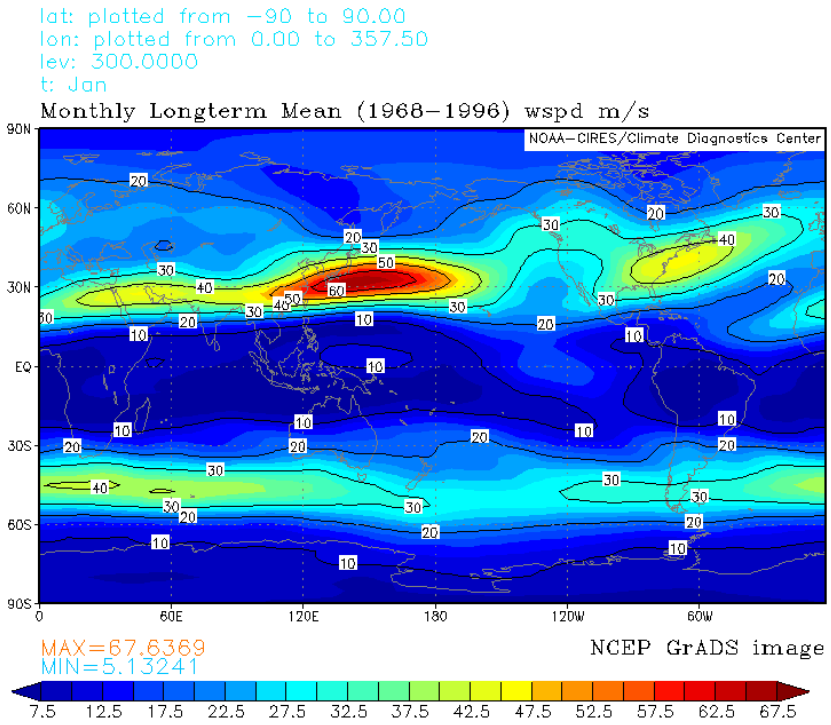
Zonally Averaged Zonal Wind - July



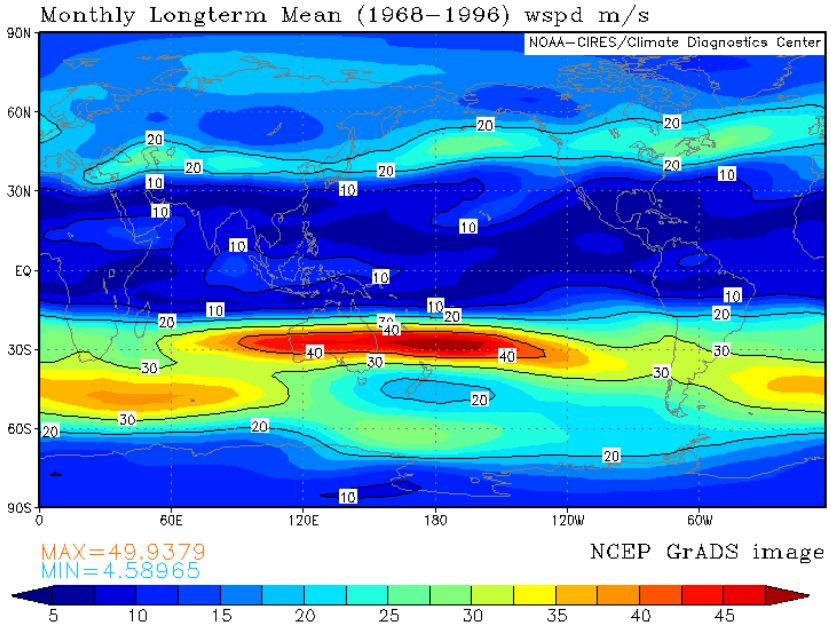
Jetstream - narrow band of strong winds

The Jetstream

300mb Wind Speed - January



300mb Wind Speed - July

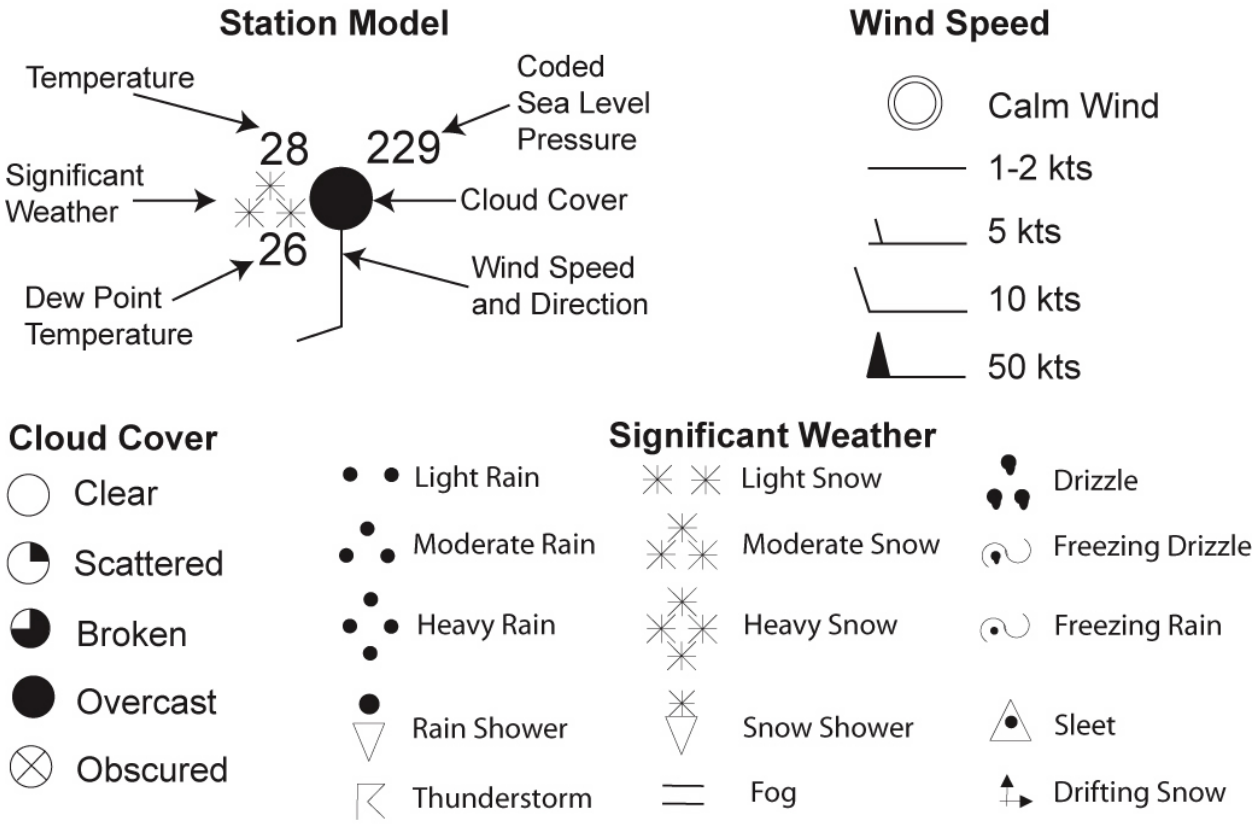


How does the position of the jetstream change between winter and summer?

How does the speed of the jetstream change between winter and summer?

What is the relationship between the strength of the jetstream and the horizontal temperature gradient?

Surface Weather Maps



Dew point temperature – the temperature to which a small volume of air must be cooled at constant pressure in order for the air to become saturated

Dew point temperature indicates the amount of moisture contained in the air.

What units are used for temperature and dew point temperature reported on surface station models?

Significant weather

Cloud cover

Wind direction – the direction the wind is coming from

Wind speed

Units for wind speed

SI: m s^{-1}

Meteorological convention: Knots (kts)

1 kt = 0.51 m s^{-1}

Station model wind speed plotting convention:

- Wind speed symbols shown in figure are additive
- Actual wind speed is within $\pm$2 kts of plotted wind speed

Sea level pressure

Decoding sea level pressure reported on station models

If coded SLP is greater than 500:

Put a 9 in front of the 3 digit coded SLP
Insert a decimal point between the last two digits
Add units of mb
Example: coded SLP = 956
Decoded SLP = 995.6 mb

If coded SLP is less than 500:

Put a 10 in front of the 3 digit coded SLP
Insert a decimal point between the last two digits
Add units of mb
Example: coded SLP = 052
Decoded SLP = 1005.2 mb

The normal range of sea level pressure is 950 to 1050 mb.

Record high sea level pressure: 1086 mb (Tosontsengel, Mongolia)
Record low sea level pressure: 870 mb (Typhoon Tip, western Pacific)

Time and weather observations

UTC – Universal time coordinate
GMT – Greenwich Mean Time
Z – Zulu time

Quick facts about Universal Time Coordinate (UTC)

UTC is based on a 24 hour clock (so add 12 to any times after 12:59PM)

> 6AM UTC would be written as 06 UTC
> 12 noon UTC would be written as 12UTC
> 6PM UTC would be written as 18UTC

If UTC time is given as both hours and minutes it looks like this:

> 2:15AM UTC would be written as 0215 UTC
> 12:00 noon UTC would be written as 1200 UTC
> 10:20PM UTC would be written as 2220 UTC

UTC never switches from standard time to daylight savings time

> This means we need to change how we convert between UTC and Mountain time depending on whether we are on standard time or daylight savings time

How do I convert from UTC to MST or MDT?

MST = UTC - 7 hours
MDT = UTC - 6 hours

How do I convert from MST or MDT to UTC?

UTC = MST + 7 hours
UTC = MDT + 6 hours