Topic 15: The Atmosphere and Climate

https://geowiki.ucsd.edu/sio15

short videos are test material!

HW5 online
video/Gradescope submission portal also open

test #5 will include HW3 questions
(see geowiki under 'tests' tab)

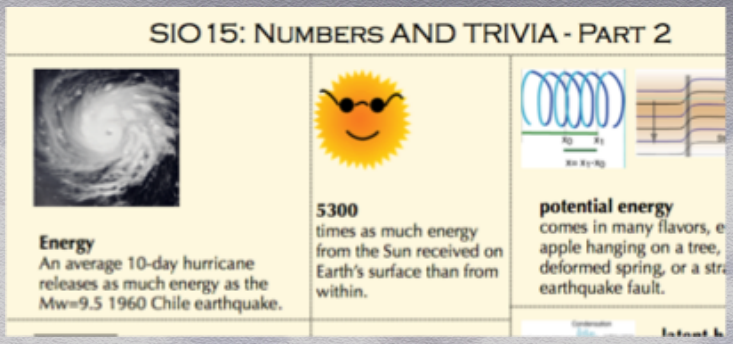
beachwalk signup open online for
Sat 11/2 noon PDT
Sun 11/3 noon PST

watch beachwalk prep video!

virtual beachwalk opens later today

short videos 11a, 11b

SIO15 Numbers & Trivia Flyer #2



… also see Lecture 2 …

global warming increases amount of energy in the atmosphere → severe weather

short Videos 11a, 11b

Climate and Weather

climate: average long-term condition;
controlled by location
regional to global
weather: short-term condition;
controlled by atmospheric anomalies
local to regional

climate:
"I live in San Diego because it rains in Seattle"

weather:
"San Diego got soaked last week"

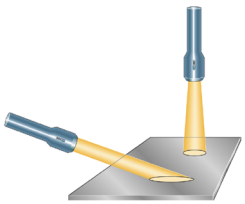
The Two Factors Controlling Climate

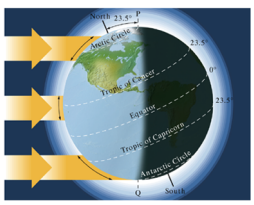
how much solar radiation is **received** in an area?

Seasons
Short video 11a

1) Insolation

zenith





Marshak: Earth, Portrait of a Planet

insolation
- radiation/area
- greatest when Sun is overhead

annual average:
2.4 times greater
at equator than at poles

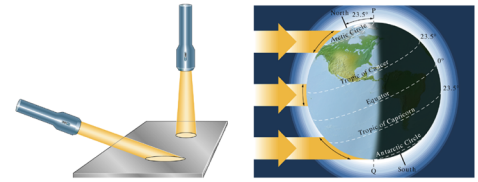
The Two Factors Controlling Climate

how much solar radiation is **retained** in an area?

Seasons
Short video 11a

2) Albedo

Albedo:
fraction of insolation reflected back to space



Marshak: Earth, Portrait of a Planet

-80% fresh snow
- 30-90% clouds
- 25% grass
- 10% oceans

The Dual Role of H_2O

Seasons
Short video 11a

WATER VAPOR:
most abundant greenhouse gas (warms)

CLOUDS:
reflect sunlight back into space (cools)

Earth's Albedo and Energy Budget

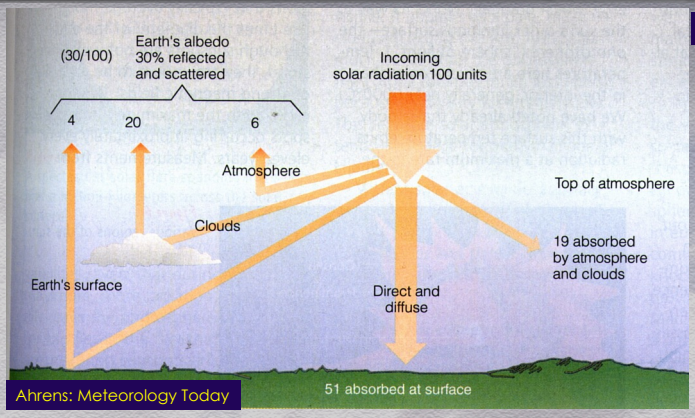


Fig 11.4

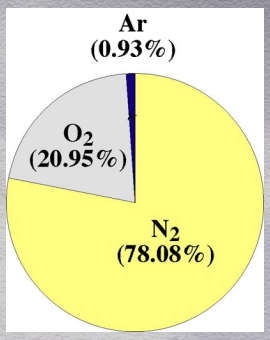
external energy
~ 5300 larger
than internal energy

- 30% reflected back to space
- 51% absorbed at surface
- 19% absorbed by atmosphere

Earth's surface emits more heat (IR) than it receives

Poll – Earth's Atmosphere's Main Contributors

Composition of Earth's Atmosphere



mainly N_2 and O_2

+1% other stuff
- 0.93% Ar
- CO_2 419ppm (0.04%) 2023
- Ne 18ppm
- He 5ppm
- CH_4 2ppm
- Kr 1ppm

+ 0-4% water vapor (H_2O) (variable)

Greenhouse Gases: H_2O, CO_2, CH_4

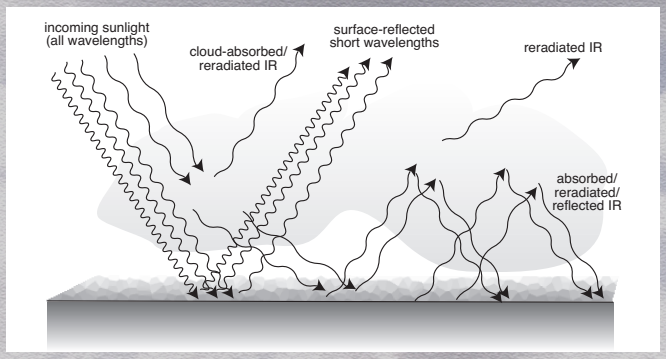
short Video 11b

Greenhouse Gases and the Greenhouse Effect

Earth's atmosphere acts like a greenhouse

H_2O most abundant greenhouse gas

Fig 11.8



greenhouse gases: H_2O, CO_2, CH_4
- transparent to visible, UV light
- absorb infrared
- reflect IR back to Earth
-> trap heat

Earth with greenhouse:
16°C/61°F
Earth without greenhouse:
34°C/61°F colder -> -18°C/0°F

Poll

Atmosphere 1

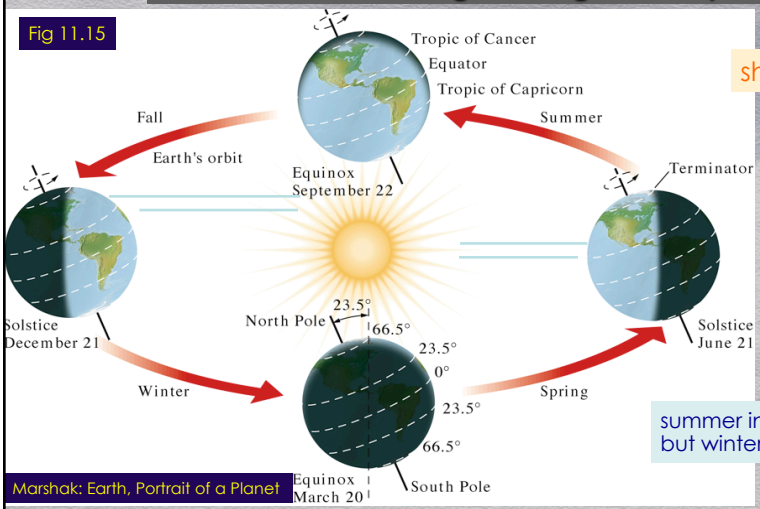
What causes seasons? — Single Choice

- Sun's changing distance from Earth
- Sun's migration above/below the ecliptic
- Earth tides
- orbiting of Earth's tilted rotation axis
- changing solar output

Why does Earth have Seasons?

3) Earth's tilted axis orbits Sun
- sun in zenith at different times (+/- 23.5° N/S)
- local insolation changes throughout the year

Fig 11.15



Marshak: Earth, Portrait of a Planet

short Video 11a

summer in San Diego
but winter in Santiago, Chile

Poll

Atmosphere 2

Which of these have summer when it is summer in San Dieg | Single Choice

- Mexico City
- Santiago, Chile
- Manila, Philippines
- Canberra, Australia
- Cape Town, South Africa
- Jakarta, Indonesia

Poll

opposite seasons between N and S hemispheres

Continents/Countries in S. Hemisphere

continents:
much of South America
1/3 of Africa
Australia/New Zealand

Africa:
Angola, Namibia
South Africa
Botswana, Zimbabwe, Zambia
Mozambique, Malawi, Tanzania
much of Dem. Rep. Congo
Madagascar

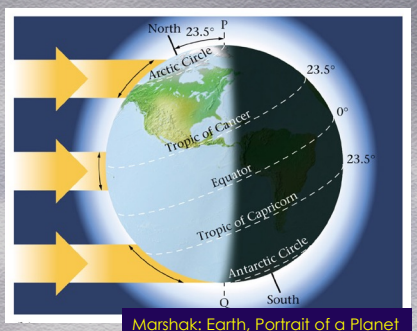
South America:
Peru
Brazil
Bolivia
Chile
Argentina
Uruguay
Paraguay

most of Indonesia
Papua New Guinea
Tonga, etc.

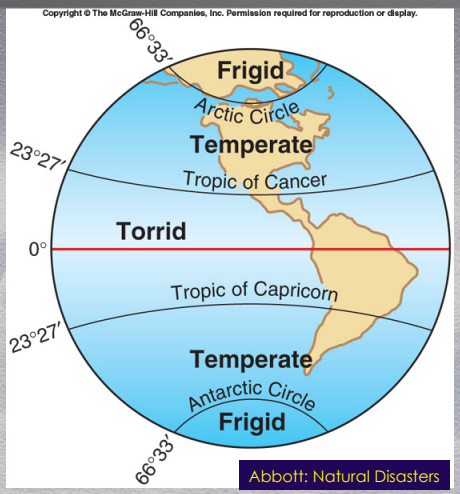
opposite seasons between N and S hemispheres

Poll

Earth's Climate Zones



Marshak: Earth, Portrait of a Planet



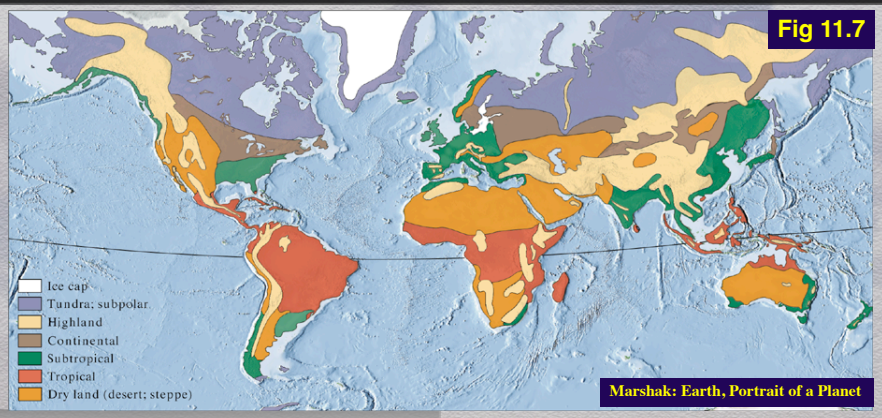
Abbott: Natural Disasters

IDEALIZED:
no tilted rotation axis
no continents, only oceans
-> 3 climate zones
✧frigid
✧temperate
✧torrid

Earth's Climate Zones

Depends on: - latitude
- altitude
- vicinity to ocean (buffer), warm/cold currents

polar ice, subpolar Tundra, subtropical (temperate), dry land (desert), tropical
plus: highland, continental



The Role of the Oceans

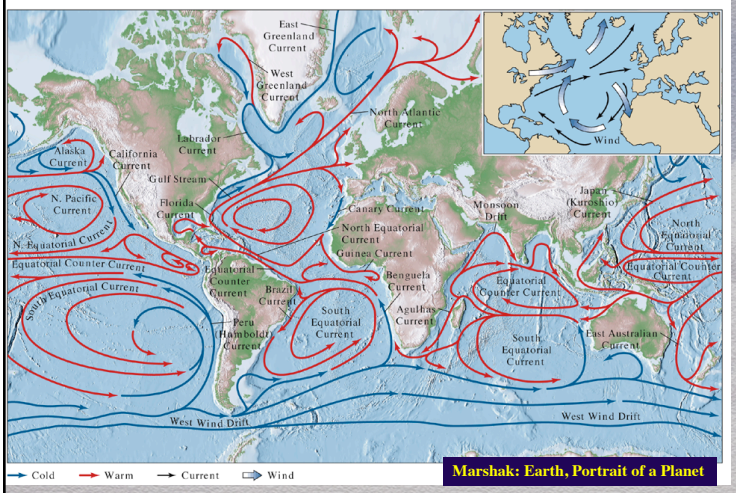
Heat Capacity: ability to absorb heat without getting hot

Air:	0.00031
cal/cm^3/°C	
Quartz Sand:	0.31
Granite:	0.51
Water:	1.0
Aluminum:	0.215
Copper:	0.0924
Glass:	0.20
Human body:	0.83

- oceans store more heat than atmosphere
- oceans are climate moderators (negative feedback)
  - ➢ coastal areas have less extreme climate

Ocean Surface Currents – Climate Moderators

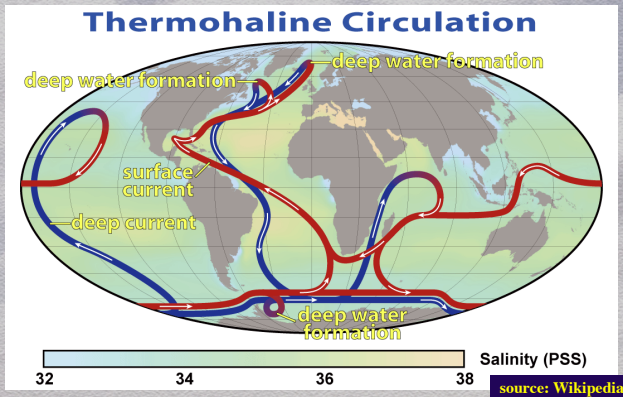
- warm western boundary currents (e.g. Gulf Stream)
- cold eastern boundary currents (e.g. California Current) (think May Grey/June Gloom!)



Marshak: Earth, Portrait of a Planet

Ocean Global Heat Conveyor

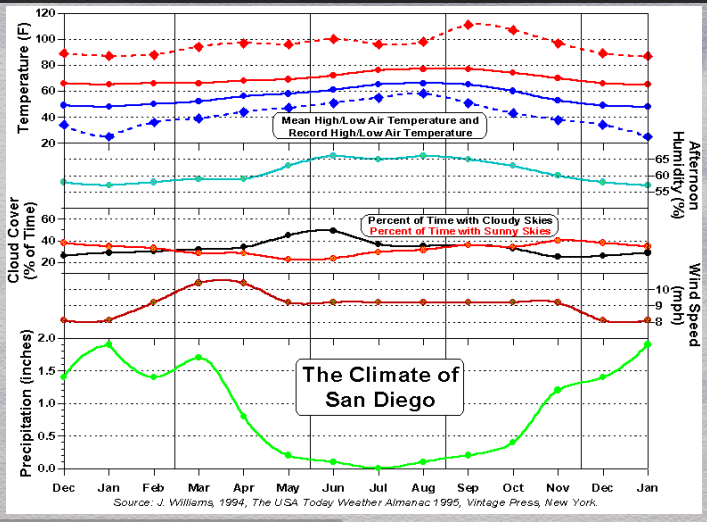
-ocean processes longer-term than atmospheric processes
-> ocean currents slower than atmospheric winds
- currents blocked by continents
- Driving Mechanism: cold and salty water sinks (thermohaline circulation)



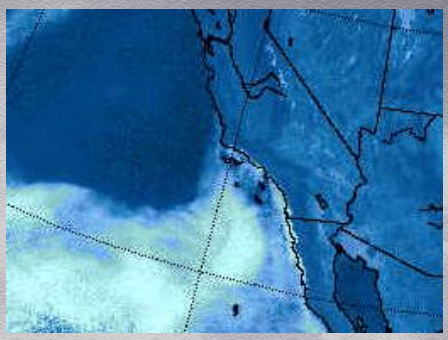
exact shape of heat conveyor not well known

San Diego's Climate Throughout the Year

- dry, cool summer – wet, mild winter
- May/June cloudiest - Nov/Dec least cloudy/sunniest
- Jul - Sep warmest on ave. but Sep/Oct peak T during Santa Ana

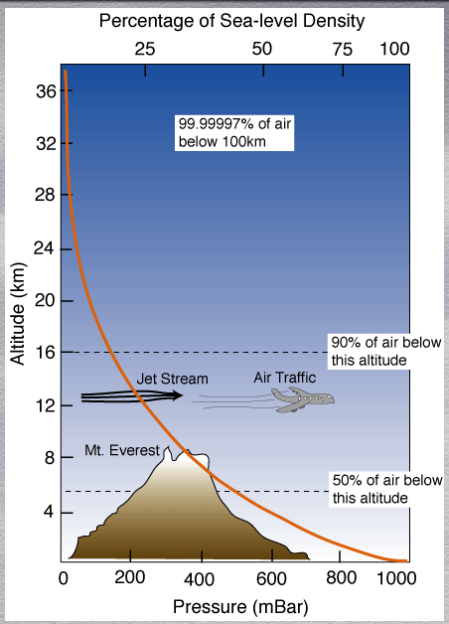


San Diego's May Grey/June Gloom



- usually during spring
- land heats faster than oceans
- warm air pushes over cool marine air
- ocean cools air at bottom -> condensation -> fog
- inversion layer -> cold air can't rise -> fog remains
- formation of smog in polluted areas (L. A.)
- particularly bad during La Niña (colder SST)

Pressure and Density as Function of Altitude



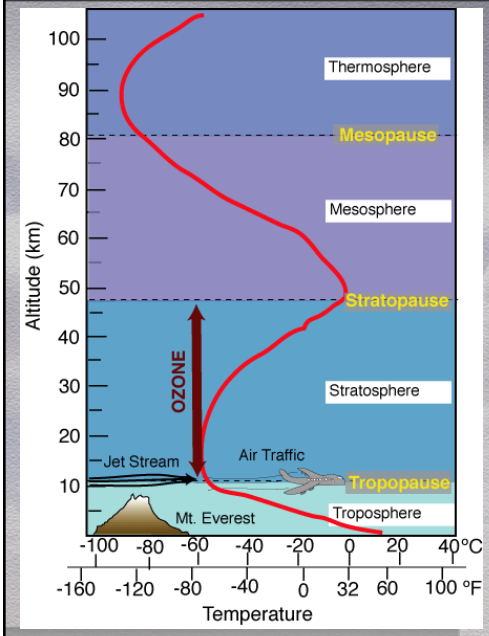
simple

- air pressure: push due to weight of atmosphere above
- greatest at sea level:
  1 atmosphere,
  14.7 PSI,
  1035 mbar (g/cm^2)
- pressure and density decrease exponentially with altitude

50% air below 5.6 km
90% air below 16 km
99.99997% below 100km

short Video 11b

Temperature as Function of Altitude



complicated

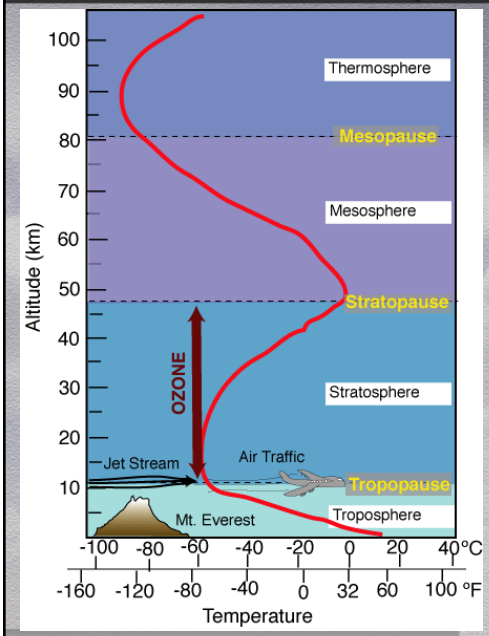
- T-function changes with altitude

- decreases from 18°C to -55°C in troposphere
- increases in stratosphere
- decreases in mesosphere
- increases in thermosphere

short Video 11b

SIO15 2024: Topic 15 - The Atmosphere and Climate

Atmospheric Layers



Layers follow T-function

troposphere:
lower 10km; weather layer, mixing
stratosphere:
next 35km; very dry, no vertical mixing, O_3 layer
mesosphere:
less O_3; meteorites burn up
thermosphere:
< 1% air; (ISS at ~350 km)

short Video 11b

SIO15 2024: Topic 15 - The Atmosphere and Climate

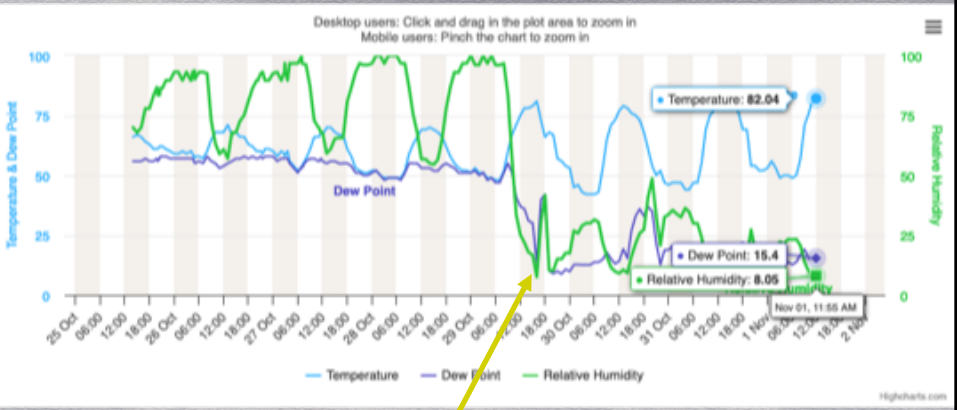
Moist and Dry Air

absolute humidity:	actual water vapor content; e.g. by volume; 0.3% deserts/ 4% tropics
relative humidity:	water vapor content with respect to maximum that air can hold under current conditions (saturated)
dew point:	T to which air with current rel. hum. has to cool to become saturated
condensation:	air cools below dew point -> fog/clouds/frost

Weather - Current Santa Ana (2023)

weather.gov

Miramar/UCSD



Santa Ana

* drop in rel. humidity
* difference in day/night T more extreme, due to lack of water vapor

Weather - Current Santa Ana (2023)

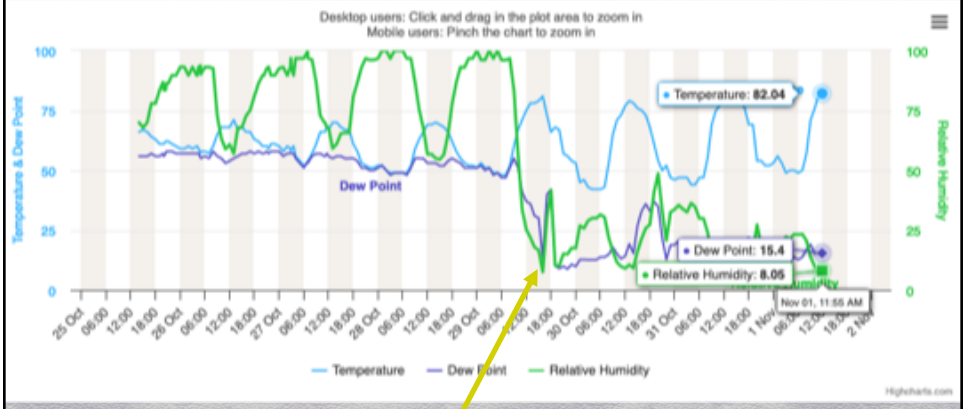
Ramona – Wind Speed

Santa Ana

- winds increase
- easterly

San Diego Air in October 2023

* Miramar/UCSD



Santa Ana

The January 2007 Big Freeze

- unusually (unexpected???) dry air (low rel. humidity)
- low dew point

-> temperature could drop below freezing
==> $1 Billion damage to CA citrus industry

Fig. 11.13

CA farmers did NOT have time to do this to protect citrus

Lecture 2:
condensation releases latent heat
freezing releases latent heat

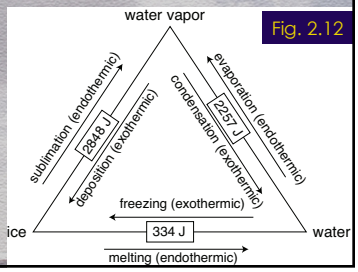
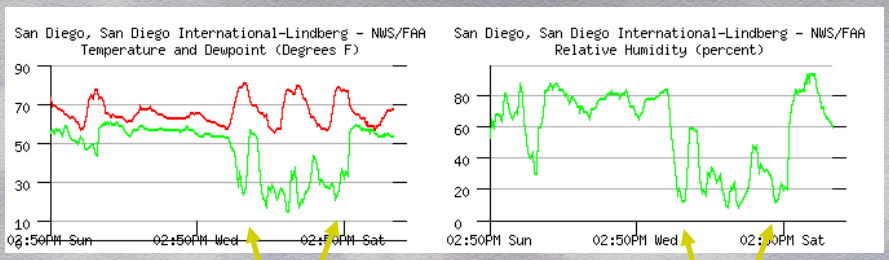


Fig. 2.12

San Diego Air in October 2007

T and Dew Point

Relative Humidity



Santa Ana

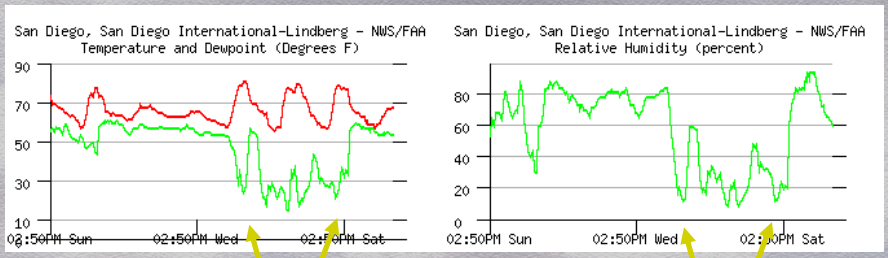
Santa Ana

difference in day/night T more extreme, due to lack of water vapor

San Diego Air in October 2007

T and Dew Point

Relative Humidity



Santa Ana

Santa Ana

if T drops below dew point, fog forms/less cooling
- high dew point -> higher night time T
- low dew point -> lower night time T

winter: low dew point could spell freezing!

condensation releases latent heat!