WEATHER IN SOUTHERN CALIFORNIA?

• Planning daily life
  – Choice of clothing
  – Travel: rain, fog, snow and ice, high seas
  – Recreation: lakes & oceans, beaches, mountains, deserts

• Anticipating adverse conditions
  – Droughts
  – Floods
  – Destructive winds/fires
Severe weather threat continues from Great Lakes to Gulf Coast and Mid-Atlantic

The NWS Storm Prediction Center is forecasting a risk of severe weather Tuesday afternoon and into Tuesday from the Great Lakes southward to the central and eastern Gulf Coast and eastward to the Carolinas and Virginia. The greatest risk is from eastern Mississippi to central Alabama, where a Moderate Risk is in place. Several tornadoes, large hail and straight line damaging winds are likely.

High Wind Warning is in effect until May 1, 05:00 PM PDT
Red Flag Warning in effect from April 30, 02:00 AM PDT until May 1, 08:00 PM PDT

Current Conditions

Laguna Beach CA
7 Day Forecast

Detailed Forecast

Click Map For Forecast

Topographic

NWS Weather Forecast Office
Severe weather threat continues from Great Lakes to Gulf Coast and Mid-Atlantic

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Read More...

HAZARDOUS WEATHER CONDITIONS

High Wind Warning is in effect until May 1, 05:00 PM PDT
Red Flag Warning in effect from April 30, 02:00 AM PDT until May 1, 08:00 PM PDT

Current Conditions

Far
95°F
35°C
Humidity 59%
Wind Speed NE 17 G 31 MPH
Barometer 29.97 in (1014.6 mb)
Dewpoint 13°F (-11°C)
Visibility 10.00 mi
Heat index 90°F (32°C)
Last Update on 26 Apr 2:36 pm PDT

Current conditions at
Santa Ana, John Wayne Airport-Orange County Airport (KSNA)
Lat: 33.66°N Lon: 117.66039°W Elevation: 52 ft.

Irvine CA

7 Day Forecast

TODAY
Mostly Clear
Low: 61°F
High: 98°F
WEDNESDAY
Mostly Clear
Low: 63°F
High: 97°F
WEDNESDAY NIGHT
Mostly Clear
Low: 64°F
High: 97°F
THURSDAY
Mostly Clear
Low: 63°F
High: 91°F
THURSDAY NIGHT
Mostly Clear
Low: 63°F
High: 91°F
FRIDAY
Mostly Sunny
Low: 61°F
High: 82°F
FRIDAY NIGHT
Mostly Clear
Low: 56°F
High: 91°F
SATURDAY
Sunny
Low: 61°F
High: 82°F
SATURDAY NIGHT
Patchy Fog
Low: 36°F

Detailed Forecast

Tonight: Mostly clear, with a low around 61. Northeast wind 15 to 20 mph, with gusts as high as 30 mph.

Wednesday: Sunny, with a high near 98. Windy, with a northeast wind 25 to 30 mph, with gusts as high as 50 mph.

Wednesday Night: Mostly clear, with a low around 63. Northeast wind 10 to 20 mph, with gusts as high as 30 mph.

Thursday: Sunny, with a high near 97. Northeast wind around 15 mph, with gusts as high as 30 mph.

Thursday Night: Mostly clear, with a low around 63. North wind around 5 mph becoming calm in the evening.

Friday: Sunny, with a high near 91.

Friday Night: Mostly clear, with a low around 61.

San Diego, CA

NWS Weather Forecast Office

Click Map for Forecast  Topographic
Temperatures:

- SANTA ROSA: 56°F
- NOVATO: 52°F
- NAPA: 59°F
- FAIRFIELD: 56°F
- CONCORD: 57°F
- OAKLAND: 59°F
- LIVERMORE: 57°F
- SUNNYVALE: 58°F
- SAN JOSE: 57°F
- SAN FRANCISCO: 60°F
- SANTA CRUZ: 59°F

San Francisco Police Lieutenant will be arraigned tomorrow on assault charge.
ATMOSPHERIC SCIENCES

• Meteorology
  – Short term weather systems in time spans of weeks or months
  – Emphasize forecasting near term weather

• Climatology
  – Frequency and trends of weather systems over years and millenia
  – Emphasize changes in long term weather patterns
SOME FUNDAMENTAL SCIENCES

- Thermodynamics
- Fluid mechanics
- Computer modeling
- Instrumentation

Chaos theory: “even detailed atmospheric modeling cannot, in general, make precise long-term weather predictions”
METEOROLOGY: AN INTRODUCTION TO THE WEATHER
PROFESSOR ROBERT G FOVELL

• Lecture 1: Nature abhors extremes
• Lecture 2: Temperature, pressure, and density
• Lecture 3: Atmosphere—composition and origin
• Lecture 4: Radiation and the greenhouse effect
• Lecture 5: Sphericity, conduction, and convection
• Lecture 6: Sea breezes and Santa Anas
• Lecture 7: An introduction to atmospheric moisture
• Lecture 8: Bringing air to saturation
• Lecture 9: Clouds, stability and buoyancy Part 1
• Lecture 10: Clouds, stability and buoyancy Part 2
• Lecture 11: Whence and whither the wind Part 1
• Lecture 12: Whence and whither the wind Part 2
A POSSIBLE SECOND SEMESTER
FIVE WEEKS NEXT FALL

• Lecture 13: The global atmospheric circulation
• Lecture 14: Fronts and extratropical cyclones
• Lecture 15: Middle troposphere—troughs and ridges
• Lecture 16: Wind shear—horizontal and vertical
• Lecture 17: Mountain influences on the atmosphere
• Lecture 18: Thunderstorms, squall lines and radar
• Lecture 19: Supercells, tornadoses, and dry lines
• Lecture 20: Ocean influences on weather and climate
• Lecture 21: Tropical cyclones
• Lecture 22: Light and lightning
• Lecture 23: Prediction and probability
• Lecture 24: The imperfect forecast
LECTURE ONE
NATURE ABHORS EXTREMES

Nature relieves stresses
Some terms/concepts

• Heat flow: diabatic, adiabatic
• Phase change: gas-liquid-solid; latent heat
• Wind shear: change in wind direction or velocity
• Front: zone of contact between air masses of different densities
• Cyclones: tropical/extratropical
• Etc.
LECTURE ONE

NATURE ABHORS EXTREMES

Nature relieves stresses
Some rules of thumb (heuristics)

• Temperature differences cause weather
• Less dense air rises and more dense air sinks (buoyancy)
• Warmer air is less dense than colder air
• Fluids of different densities resist mixing
• Moister air is less dense than drier air
• The ability of air to hold moisture is a very sensitive function of temperature
• The temperature of the atmosphere decreases quickly with increasing elevation
Nature relieves stresses

Some more rules of thumb

• Atmospheric pressure differences drive winds
• Pressure gradients determine wind speeds
• Winds are named for the **direction they come from**
• Atmospheric pressure decreases with elevation
LECTURE ONE
NATURE ABHORS EXTREMES

DVD
# LECTURE TWO
## TEMPERATURE, PRESSURE AND DENSITY

### Temperature Scales

<table>
<thead>
<tr>
<th>Celsius °C</th>
<th>Fahrenheit °F</th>
<th>Absolute °K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( T ) ( K = t °C + 273.2 )</td>
</tr>
</tbody>
</table>

Some benchmark temperatures

- **Boiling Water (sea level)** 100 °C 212 °F
- **Hot day** 38 °C 100 °F
- **Body temperature** 37 °C 98.6 °F
- **Warm day** 30 °C 86 °F
- **Indoors** 20 °C 68 °F
- **Cool day** 10 °C 50 °F
- **Freezing (impure water)** 0 °C 32 °F
- **Freezing (pure water)** -40 °C -40 °F (Supercooled water)
CELSIUS TO FAHRENHEIT

- Exactly $t^\circ F = \frac{9}{5} t^\circ C + 32$

- Approximately $t^\circ F \approx 2 t^\circ C + 28$
UNITS OF PRESSURE & DENSITY

• PRESSURE
  – Force per unit area
    Newton / meter$^2$ = 1 Pascal
    Hectopascal (hPa) = 100 Pascals = 1 millibar (mb)
    Pound (force) / in$^2$ (psi) = 69 hPa
    Inch of mercury (inHg) = 33.9 hPa

  Standard atmospheric pressure at sea level
    1013.25 hPa, mb
    14.7 lb/in$^2$
    29.9 inHg

• DENSITY: Mass per unit volume
  – 1.20 Kg/m$^3$ dry air at sea level
  – 0.012 g/cm$^3$ dry air at sea level
  – 0.75 lb/ft$^3$ dry air at sea level
LECTURE 3
ATMOSPHERE: COMPOSITION AND ORIGIN

DVD: STRUCTURE OF THE ATMOSPHERE
STRUCTURE OF THE ATMOSPHERE

- **International Standard Atmosphere**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Base altitude km</th>
<th>Lapse rate °C/km</th>
<th>Base temperature °C</th>
<th>Base pressure mb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Troposphere</td>
<td>0</td>
<td>-6.5</td>
<td>+15</td>
<td>1013</td>
</tr>
<tr>
<td>Tropopause</td>
<td>11</td>
<td>0</td>
<td>-56</td>
<td>226</td>
</tr>
<tr>
<td>Stratosphere</td>
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<td>-56</td>
<td>55</td>
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<tr>
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<td>+2.3</td>
<td>-44</td>
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<tr>
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<td>-2.0</td>
<td>-58</td>
<td>0.04</td>
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<tr>
<td>Mesopause</td>
<td>86</td>
<td>0</td>
<td>-86</td>
<td>0.004</td>
</tr>
</tbody>
</table>

- **Ideal gas law** $PV = NRT$ or $P = \rho R'T$ or $\rho = P/R'T$
COMPOSITION OF THE ATMOSPHERE

• Dry air: major components
  – Nitrogen $N_2$ 78%
  – Oxygen $O_2$ 21%
  – Argon $Ar$ 1%

• Some minor components of dry air
  – Carbon dioxide $CO_2$ * 0.04 %
  – Methane $CH_4$ * 0.002%
  – Ozone $O_3$ *

• Moist air also contains water vapor: $H_2O$ *

• The capacity of the atmosphere to hold water vapor is a very sensitive function of temperature

  * Greenhouse gases
LECTURE 4
RADIATION

• Solar radiation is the principal energy source for the atmosphere

• Solar radiation is scattered, reflected, or absorbed and converted to other forms of energy
  – Thermal
  – Chemical—hydrocarbons & oxygen
  – Mechanical—winds & waves
  – Potential—evaporation & precipitation
  – Less energetic radiation: greenhouse effect

• The spatial distribution of thermal energy partially depends on absorptive properties of materials
ELECTROMAGNETIC SPECTRUM
EMISSION OF RADIATION

• All objects emit radiation
• The intensity depends strongly on the temperature of the object: $\sim T^4$
• All objects emit the whole spectrum of radiation
• The distribution of frequencies depends on the temperature of the emitter
• Emission by black bodies is described by Planck’s Law
Radiation Transmitted by the Atmosphere

- Downgoing Solar Radiation: 70-75% Transmitted
- Upgoing Thermal Radiation: 15-30% Transmitted

Percent Absorption and Scattering:
- UV
- Visible
- Infrared

Major Components:
- Water Vapor
- Carbon Dioxide
- Oxygen and Ozone
- Methane
- Nitrous Oxide
- Rayleigh Scattering

Image created by Robert A Rhode/Global Warming Art
ABSORPTION

• Atmospheric gases are highly selective absorbers
  – Absorption of visible light is very small
  – Absorption of long wave radiation by water and carbon dioxide is substantial but selective
• Non-selective absorbers are called ‘black bodies’
• The Earth’s surface is nearly a perfect black body
• Therefore the troposphere is heated from below
Radiation Transmitted by the Atmosphere

- **Downgoing Solar Radiation**: 70-75% Transmitted
- **Upgoing Thermal Radiation**: 15-30% Transmitted

Spectral Intensity

- **Wavelength (μm)**
  - 0.2
  - 1
  - 10
  - 70

**Percent**

- Total Absorption and Scattering

**Major Components**
- Water Vapor
- Carbon Dioxide
- Oxygen and Ozone
- Methane
- Nitrous Oxide
- Rayleigh Scattering

Image created by Robert A Rhode/Global Warming Art
LECURE FIVE

CONDUCTION & CONVECTION

• Thermal energy is that part of the internal energy of an object that is responsible for the object’s temperature -- its unit of measure is the joule

• Thermal energy transfers (when possible) from high temperature to low temperature objects—called “heat transfer”

• Three processes make thermal energy transfer to and from the atmosphere possible
  – Radiation/absorption
  – Conduction
  – Convection
Conduction, Convection, and Radiation
SOME PROPERTIES OF MATERIALS RELATING TO CONDUCTIVE HEAT TRANSFER

• Thermal conductivity: joules/meter sec °K
  - Air 1 atm 27° C 0.03
  - Water 27° C 0.6
  - Dry sand 0.25-1.4

• Heat capacity: joules/kg °K
  - Air 1 atm 27° C 1000
  - Water 27° C 4180
  - Dry sand 830

• Thermal inertia “tiu”
  - Air 1 atm 27° C 5.8
  - Water 27° C 1530
  - Dry sand 540-640
NEXT CLASS : MAY 14
WEDNESDAY 1:30-3:30

Remaining class schedule
All classes 1:30-3:30 Onken Classroom
Wednesday May 14
Wednesday May 21
Tuesday May 27
NEXT CLASS
WEDNESDAY MAY 14

• Lecture 6: Sea breezes and Santa Anas
• Lecture 7: An introduction to atmospheric moisture
• Lecture 8: Bringing air to saturation