Mt. Adams Cumulus Mediocris and Haze

Meteo 300 Final Project

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Observation

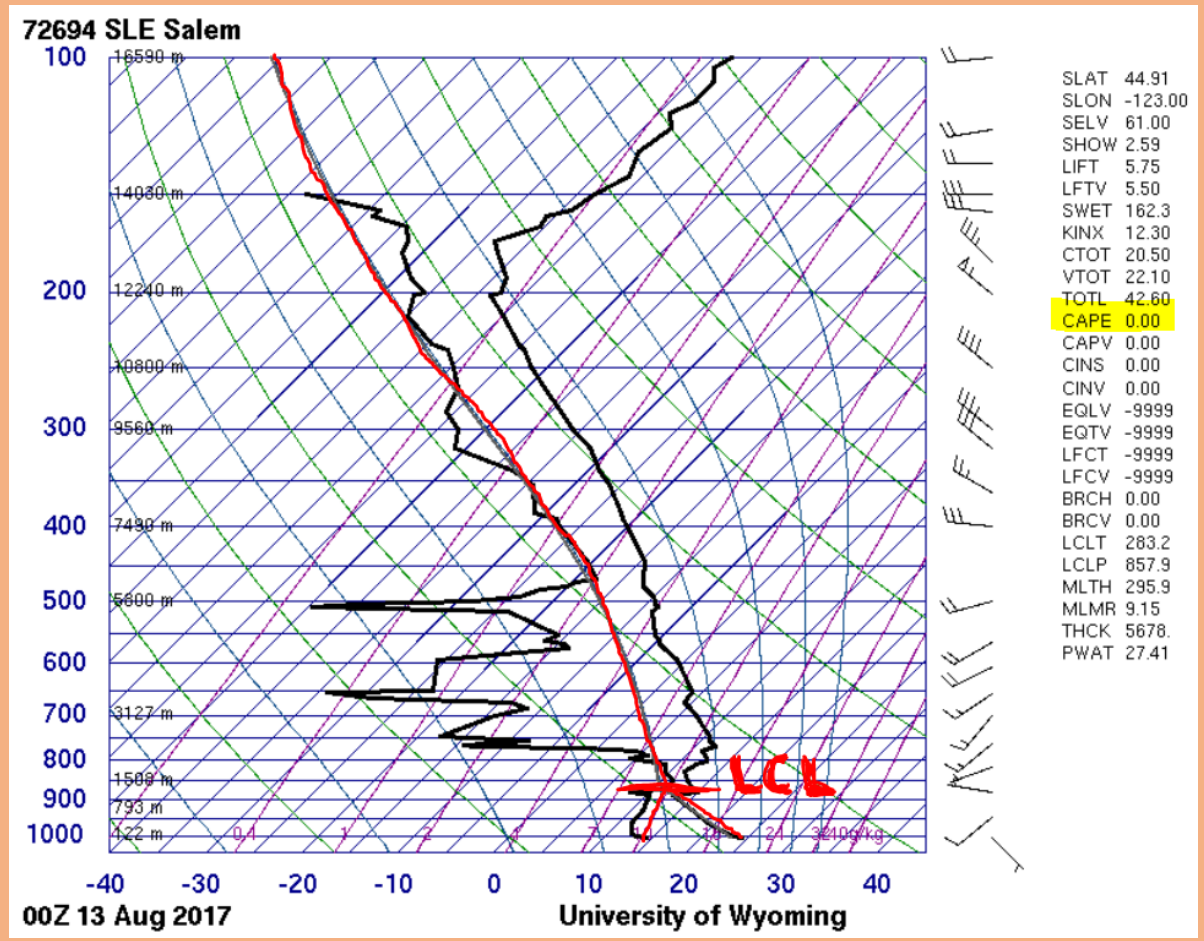
- Mt. Adams, WA
- August 12, 2017 – 3:21 PM PDT
- ~11,000 ft. elevation

- Cumulus mediocris clouds
  - Moderate vertical extent
  - No significant precipitation
- Haze below limiting visibility
  - Smoke from wildfires

Skew-T: Salem, OR (8/12/17 – 5 PM PDT)

(Lessons 2 & 3)

- Initial conditions:
  - P = 1000 mb, T = 25°C, T_d = 15°C
- Follow constant w line and dry adiabat up to LCL (~875 mb)
- Relative Humidity at LCL [3.4]
  - $RH = \left(\frac{w}{w_s}\right) \times 100 = \left(\frac{15}{17}\right) \times 100 = 88\%$
- Continue up moist adiabat
  - Less than than environmental lapse rate, so air is stable
- Low-level clouds (stratus) and possibly a few high clouds (cirrus)
  - Where T and T_d are close together



Skew-T: Salem, OR (8/12/17 – 5 PM PDT)

(Lessons 2 & 3)

Potential Temperature [2.58]:

$$\boldsymbol{\theta = T(1000/p)^{0.286}}$$

$$\theta_1 = (-9 + 273)(1000/500)^{0.286} = 322\ K$$

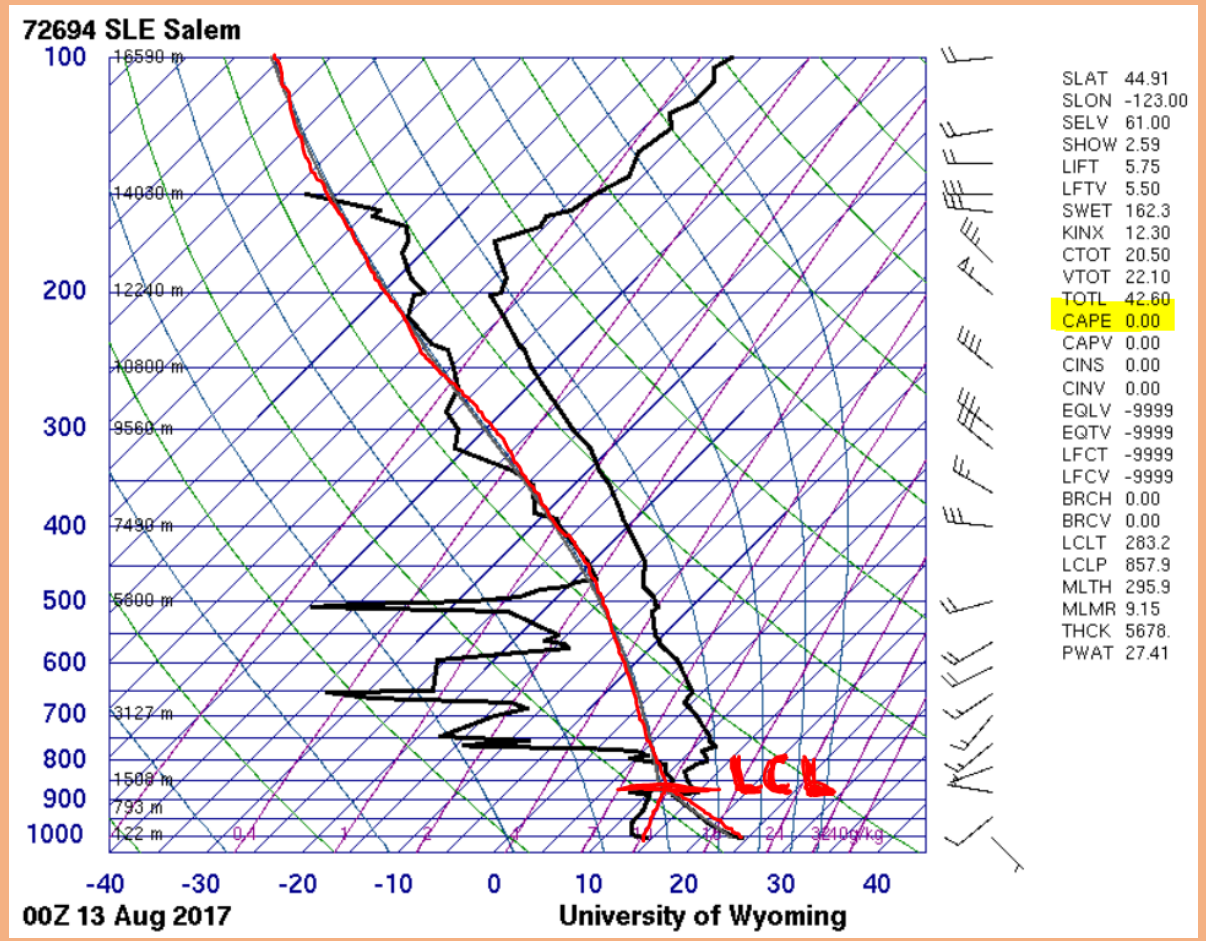
$$\theta_2 = (7 + 273)(1000/700)^{0.286} = 310\ K$$

Buoyancy Equation [2.69]:

$$\boldsymbol{B = -g\Delta z \frac{1}{\theta}\frac{d\theta}{dz}}$$

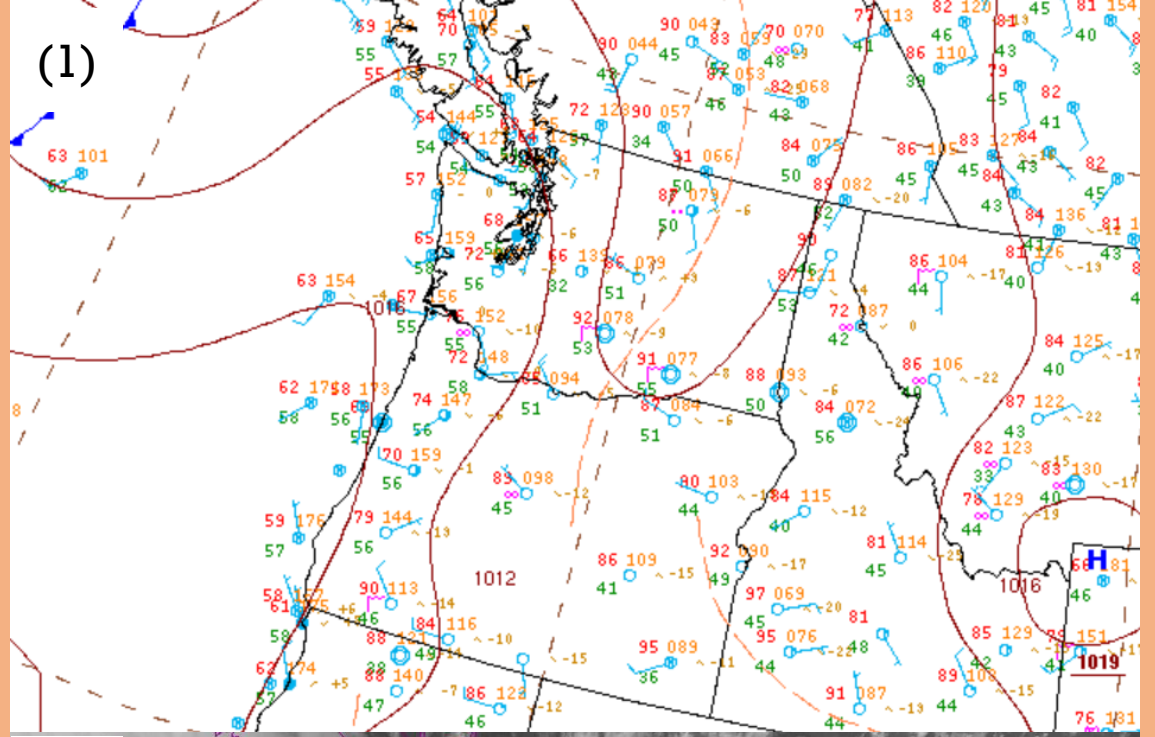
$$\frac{d\theta}{dz} \approx \frac{\Delta\theta}{\Delta z} = \frac{(322 - 310)}{(5800 - 3127)} > 0$$

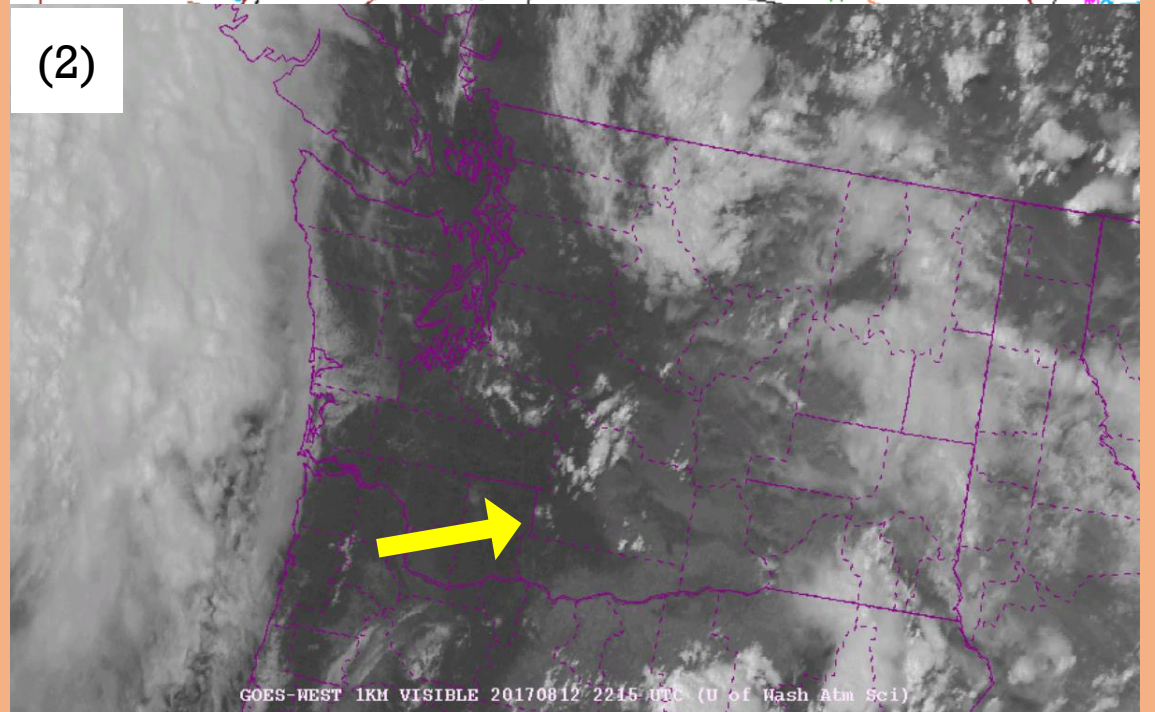
B < 0 for $\Delta z > 0$, thus the parcel will accelerate downward (stable air)



Synoptic Scale *(Lesson 7)*

- (1) WPC surface analysis map for 8/12/17 at 2 PM PDT
  - Offshore cold front approaching, but mostly clear skies around Mt. Adams
- (2) GOES-WEST visible satellite image for 8/12/17 at 3:15 PM PDT
  - Two faint white spots as result of snow and isolated cumulus cloud reflecting sunlight
- (3) Radar composite for 8/12/17 at 3:25 PM PDT
  - Localized convective precipitation, but no widespread rain



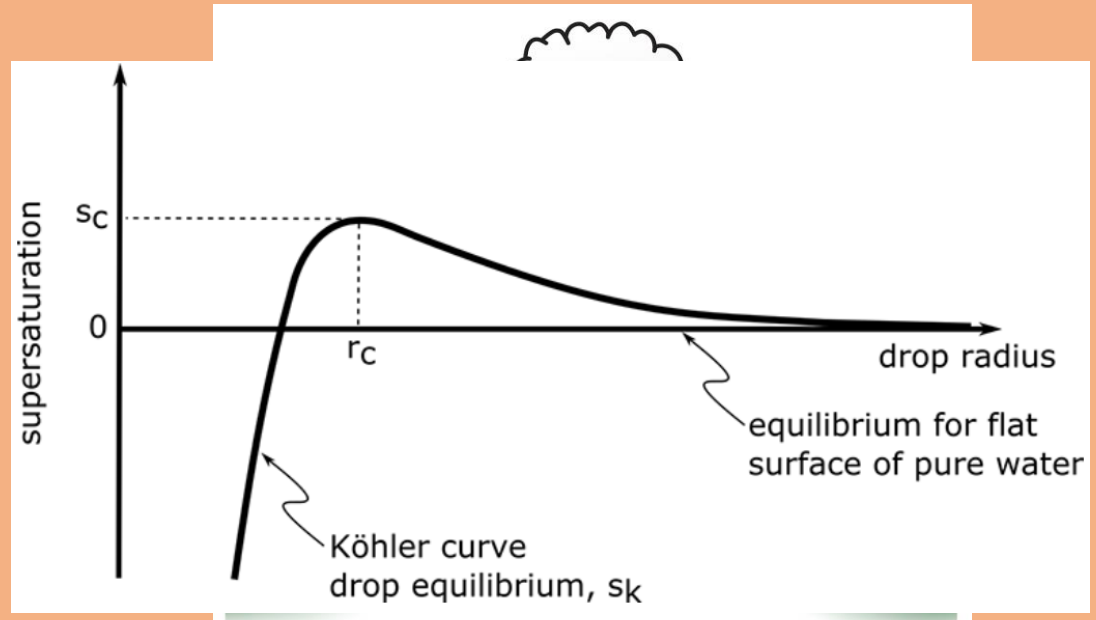


Uplift by Mountain *(Lessons 2,3, & 5)*

- Cumulus cloud signifies instability and positively buoyant air parcels
  - Contrary to SLE sounding & synoptic images support isolation of cloud(s)
- Mountain influences convection!
  - Warm air (less dense) rises up heated slopes
  - Cools to saturation - cloud base (LCL) at 600-700 mb
  - As parcel rises in cloud, air remains saturated with RH = 100%, T = T_d, w = w_s, e = e_s
- **M**oisture, **A**erosol (CCN), **C**ooling → cloud drop
  - Kelvin (curvature) effect vs. Raoult (solute) effect described by Koehler Equation [5.13]:

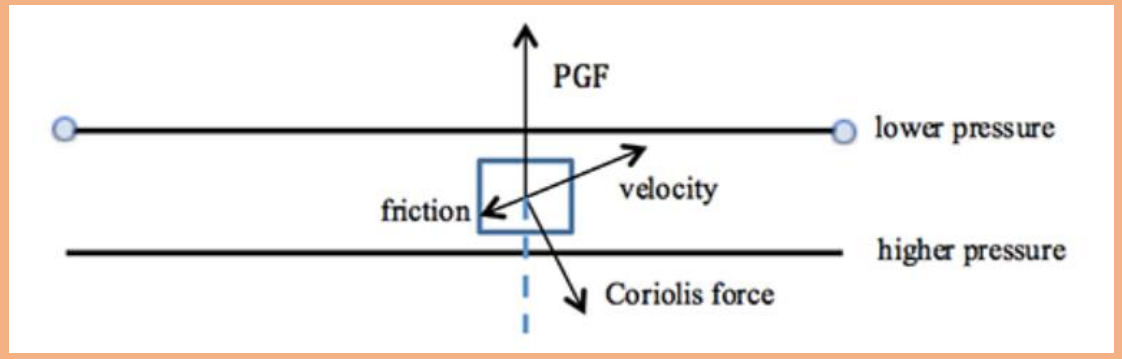
$$s_k = \frac{a_k}{r_d} - \frac{BiN_s}{r_d^3}$$

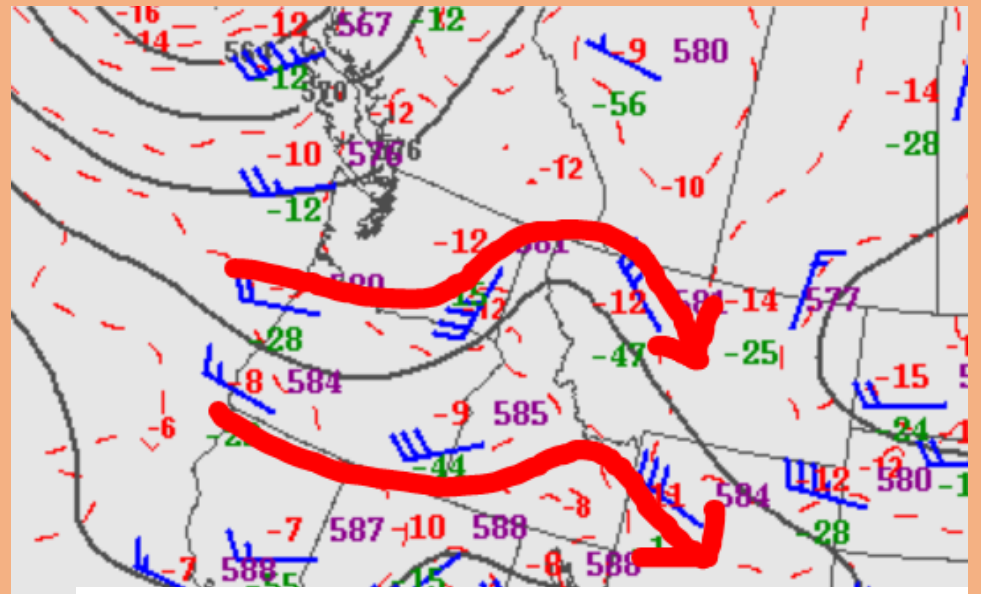
  - If $s_k < s$, net condensation will occur, drop will grow



Winds and Forces *(Lessons 9 & 10)*

- Westerly flow aloft likely caused cloud to move to eastern side of mountain
  - Streamlines drawn parallel to the wind barbs on 500 mb map show this
- Wind speed increases in direction of streamlines → divergence
- Actual wind direction closer to NW
  - Factor in turbulent drag because cloud probably below 500 mb level & over hilly terrain

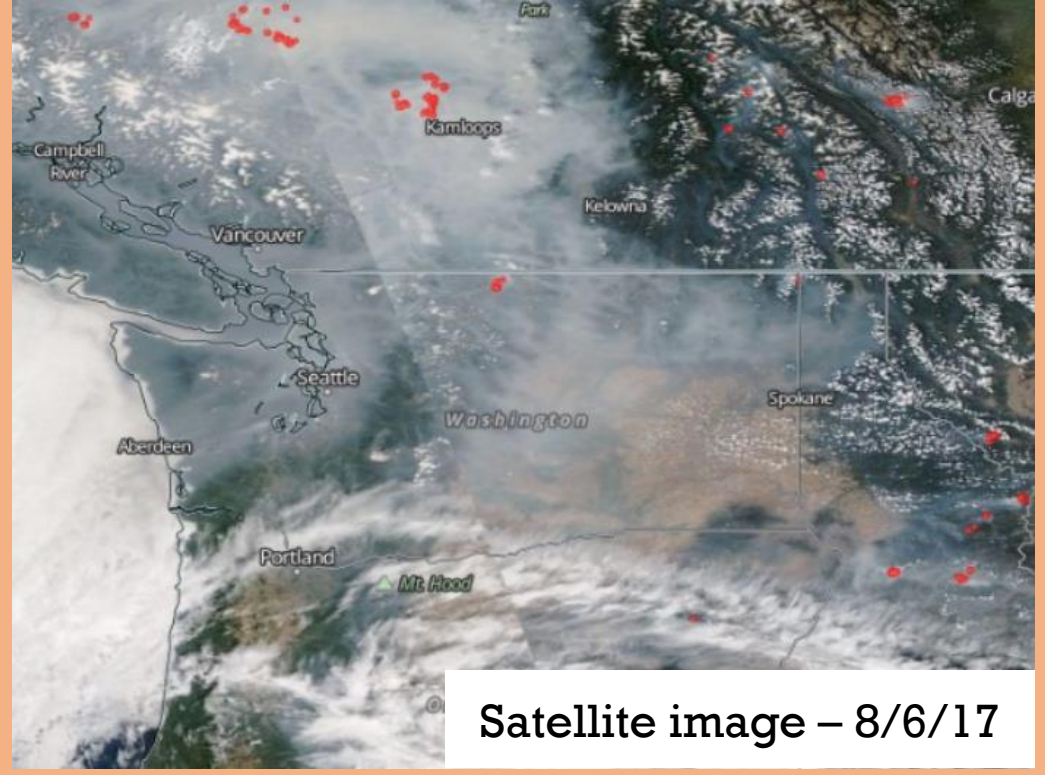




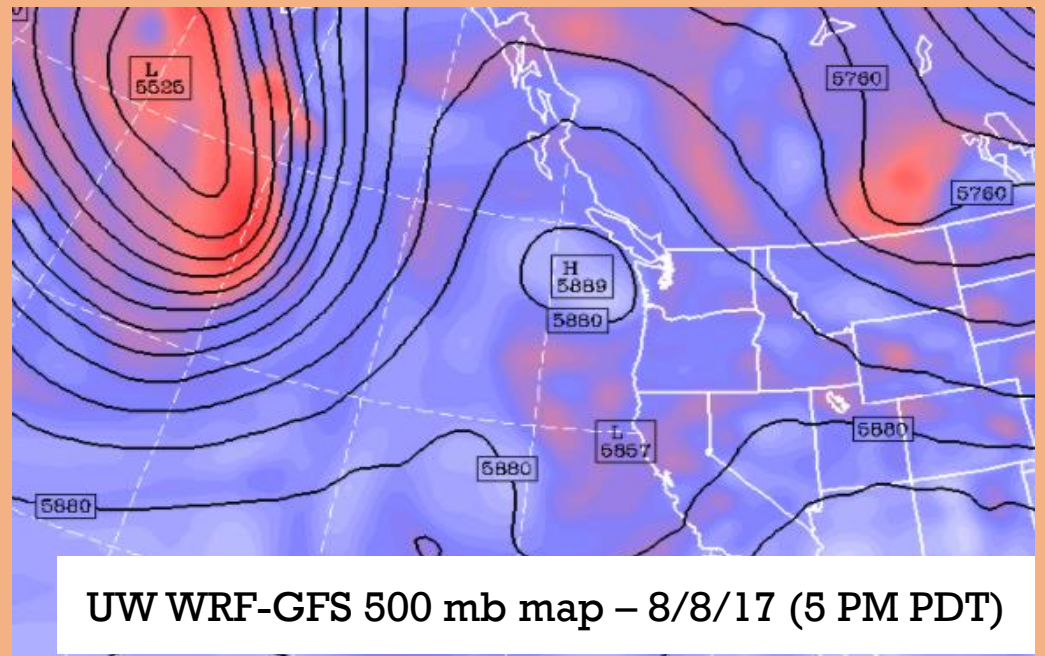
SPC 500 mb map – 8/12/17 (5 PM PDT)

Dry Haze *(Lessons 4, 6, & 11)*

- Isolated thunderstorms in the mountains earlier in the day, but dry otherwise
  - No measurable precip for 57 consecutive days
  - RH = 23% at 2:53 PM PDT at The Dalles, WA
- Ridge of high pressure and relatively clear skies for the past week → aerosols stay in boundary layer
- PM 2.5 particles from forest fires (smoke)
  - Scattered light quite effectively, with r near visible λ
  - Mie scattering (x = 0.2-2000)
  - Size parameter [6.18]: $$x = \frac{2\pi r}{\lambda}$$
- Particles well-mixed in boundary layer
  - Transport of heat, moisture, & momentum
  - Net downward radiation, but $Q_H > Q_E$ (B > 1) because of aridness



Satellite image – 8/6/17



UW WRF-GFS 500 mb map – 8/8/17 (5 PM PDT)

Works Cited

"500mb @170813/0000." *SPC Upper Air Maps Archive*, www.spc.noaa.gov/cgi-bin-spc/getuadata.pl?MyDate1=170813&Time1=00&MyDate2=&Time2=12&align=V&Levels=500.

"72694 SLE Salem." *Wyoming Weather Web*, weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF:SKEWT&YEAR=2017&MONTH=08&FROM=1212&TO=1300&STNM=72694.

Brune, William H. *METEO 300: Fundamentals of Atmospheric Science | METEO 300: Fundamentals of Atmospheric Science*. www.e-education.psu.edu/meteo300/.

Gabbert, Bill. "Maps of Wildfires and Smoke in the U.S. Northwest and British Columbia." *Wildfire Today*, 6 Aug. 2017, wildfiretoday.com/2017/08/06/maps-of-wildfires-and-smoke-in-the-u-s-northwest-and-british-columbia/.

"GOES-WEST 1KM VISIBLE 20170812 2215 UTC." *Online Weather Data Archive*, archive.atmos.washington.edu/cgi-bin/wxloop.cgi?vis1km_archive+start+2017080903+end+2017081303+interval+3h.

Works Cited (continued)

Mass, Cliff. “The End of Smoke, the First Rain, and Cooler Temperatures Return: But Are There Dangers with This Change?” *Cliff Mass Weather and Climate Blog*, 11 Aug. 2017, cliffmass.blogspot.com/2017/08/the-end-of-smoke-first-rain-and-cooler.html.

Mass, Cliff. “Thunderstorms and Convection over the Mountains.” *Cliff Mass Weather and Climate Blog*, 30 May 2015, cliffmass.blogspot.com/2015/05/thunderstorms-and-convection-over.html.

“Mt. Adams.” *Mountain Stamp*, www.mountainstamp.com/USA_pages/Adams.html.

“NEXRAD 1 KM MOSAIC 12 AUG 17 22:25.” *UCAR Image Archive*, www2.mmm.ucar.edu/imagearchive/.

“Surface Analysis 21Z Sat Aug 12 2017.” *WPC Surface Analysis Archive*, www.wpc.ncep.noaa.gov/html/sfc-zoom.php?h=21&y=2017&m=08&d=12.

“Weather History for KDLS - August, 2017.” *Weather Underground*, www.wunderground.com/history/airport/KDLS/2017/8/12/DailyHistory.html?req_city=&req_state=&req_statename=&reqdb.zip=&reqdb.magic=&reqdb.wmo=.