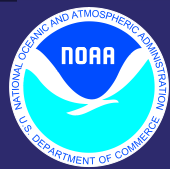


CWSU ZLA MOUNTAIN WAVE PLAYBOOK

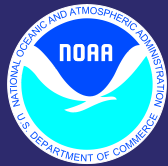




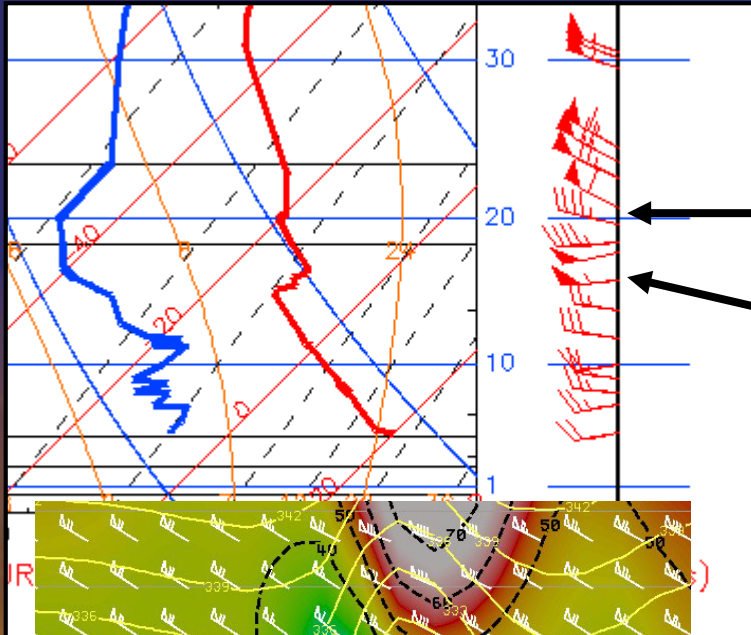
Forecasting Mountain Waves



- **Identify areas with:**
 - Low-level flow with strong perpendicular component (≥ 20 kt at mountain top)
 - A stable layer/inversion
- **From the wind shear, determine wave type**
 - Trapped lee waves: Strong positive wind shear (increasing with height)
 - Vertically-propagating: Weak or negative wind shear (constant or decreasing with height and instability aloft)
Development of a self-induced critical level or reverse flow aloft



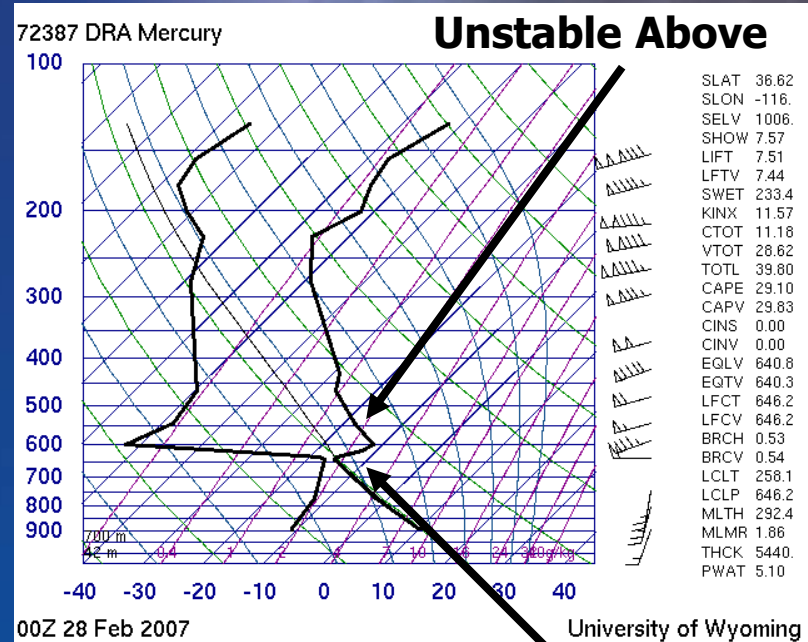
Assessing Wind Shear



Negative Shear

45 knots

55 knots



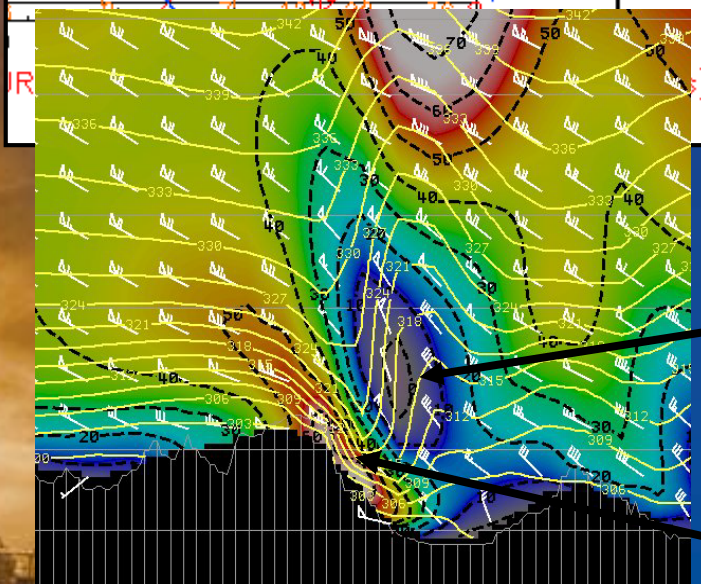
Unstable Above

Stable/Inversion

Self-Induced Critical Level

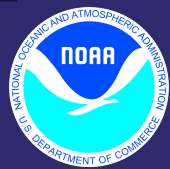
Vertical Isentropes Signify Wave Breaking

Enhanced Downslope Flow

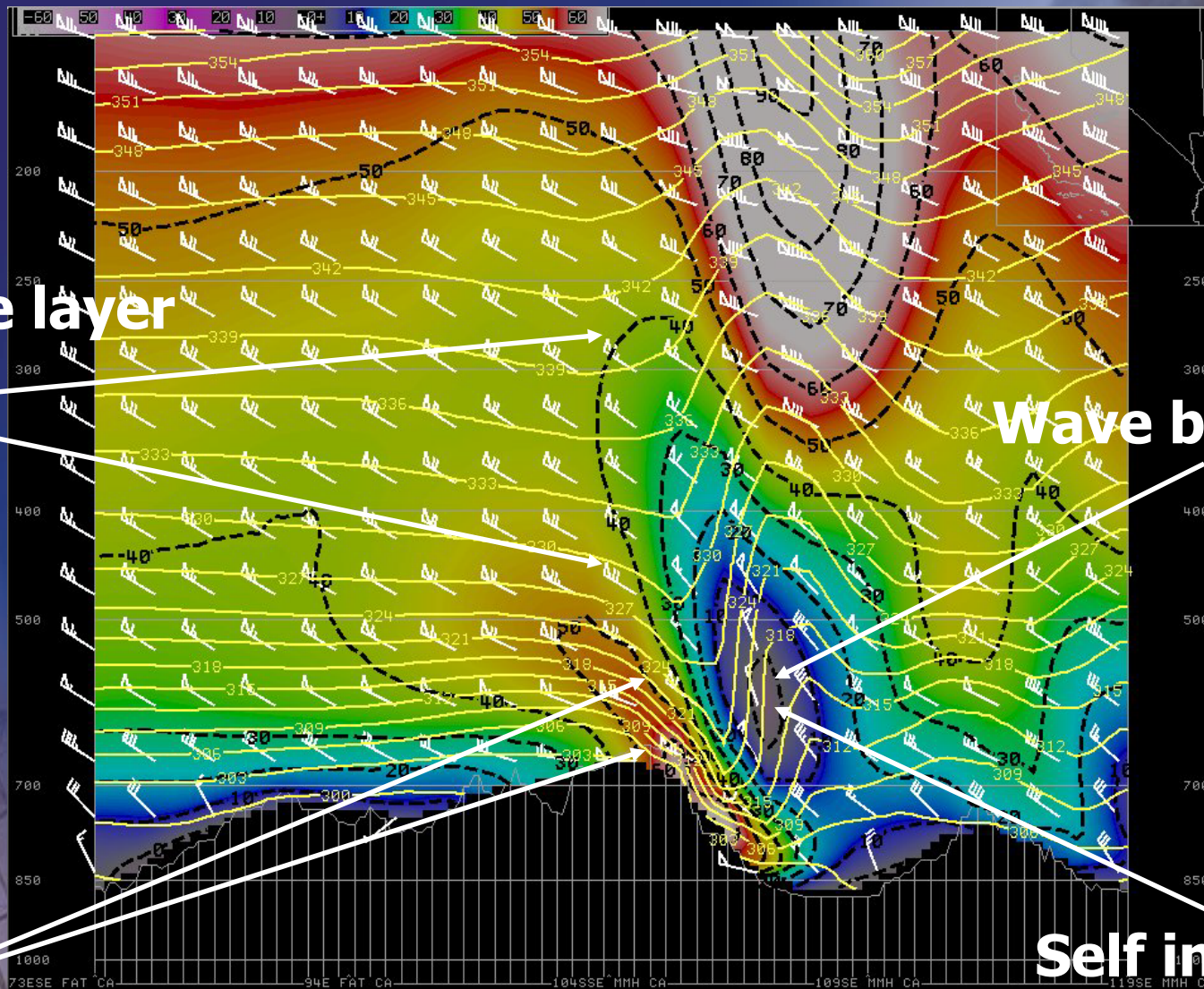
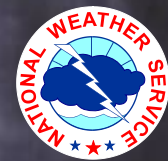


00Z 28 Feb 2007

University of Wyoming



November 14, 2006 - 4 km WRF (ARW)



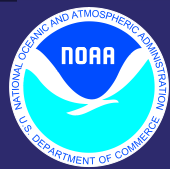
Unstable layer

Wave breaking

Stable layer

Self induced critical level

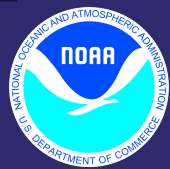
wrf_arw_4km lineF Component Along Img(kt) 14.00 15HR Tue 15:00Z 14-Nov-06
wrf_arw_4km lineF Potential Temp (K) 14.00 15HR Tue 15:00Z 14-Nov-06



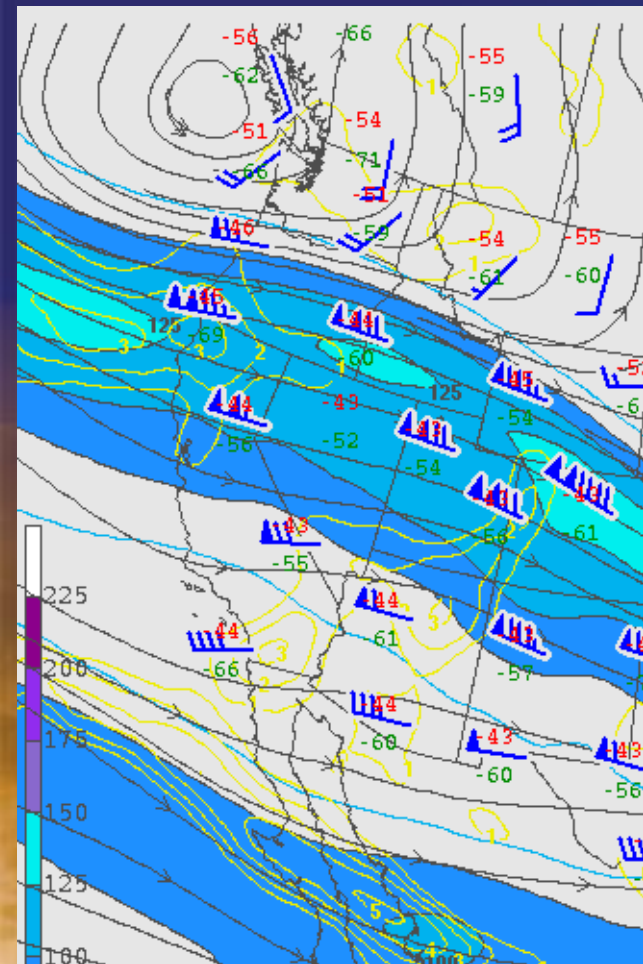
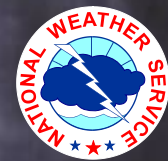
Two Distinct Types of Events

- **Type 1 (all extreme events)**
 - Long duration
 - Trough axis offshore
 - Stronger upper level jet (north of area)
 - Rotor Circulation
- **Type 2**
 - Short duration
 - Trough axis overhead

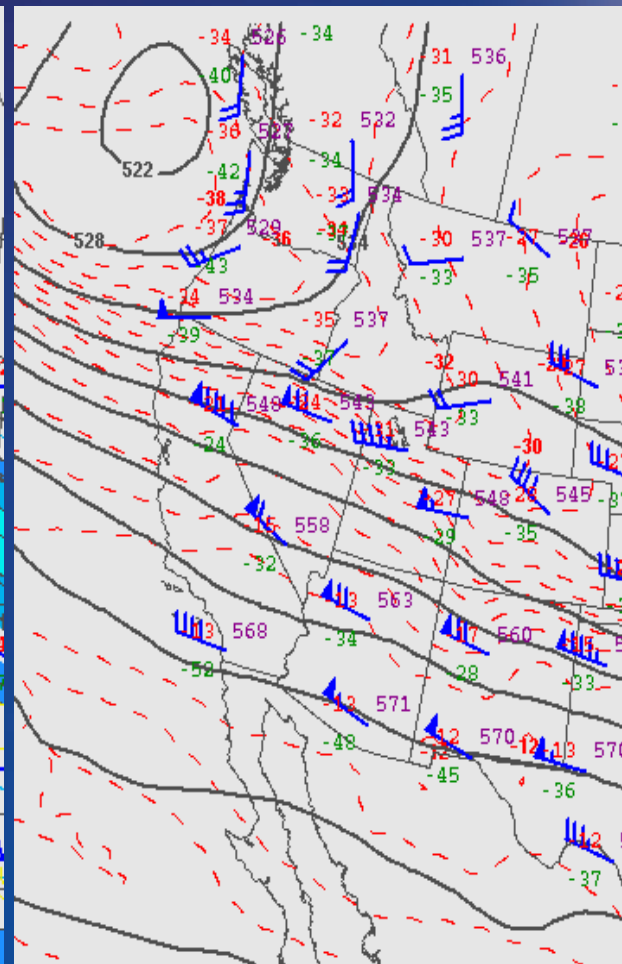




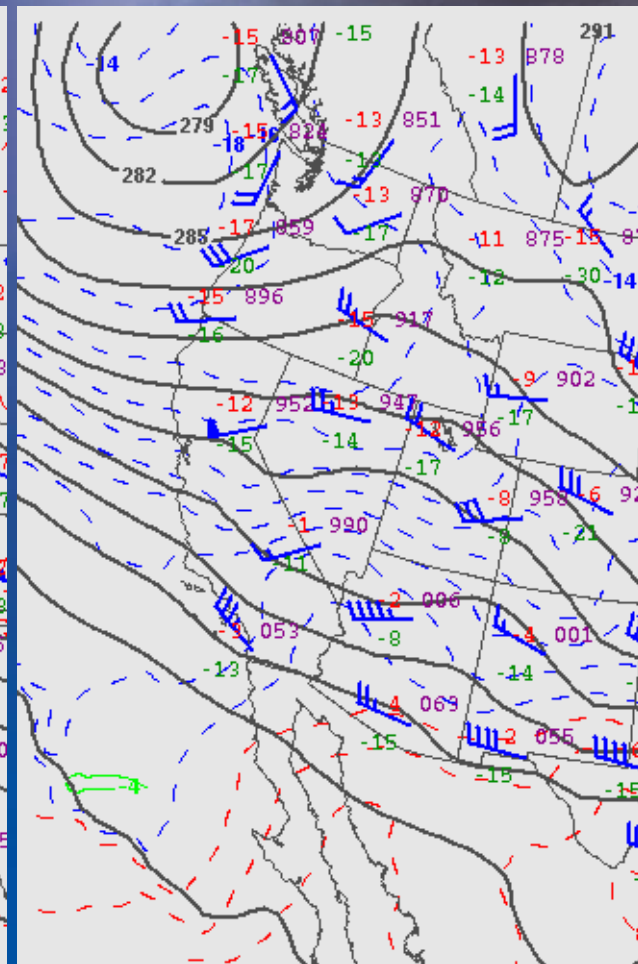
Type 1 Event – Feb. 26, 2007



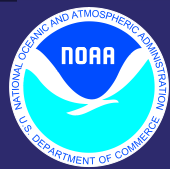
300 mb



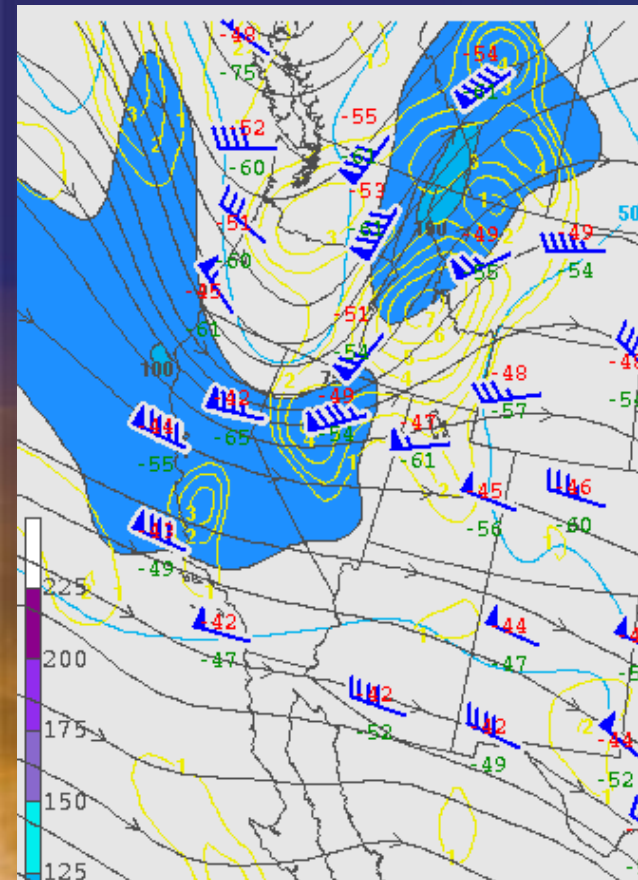
500 mb



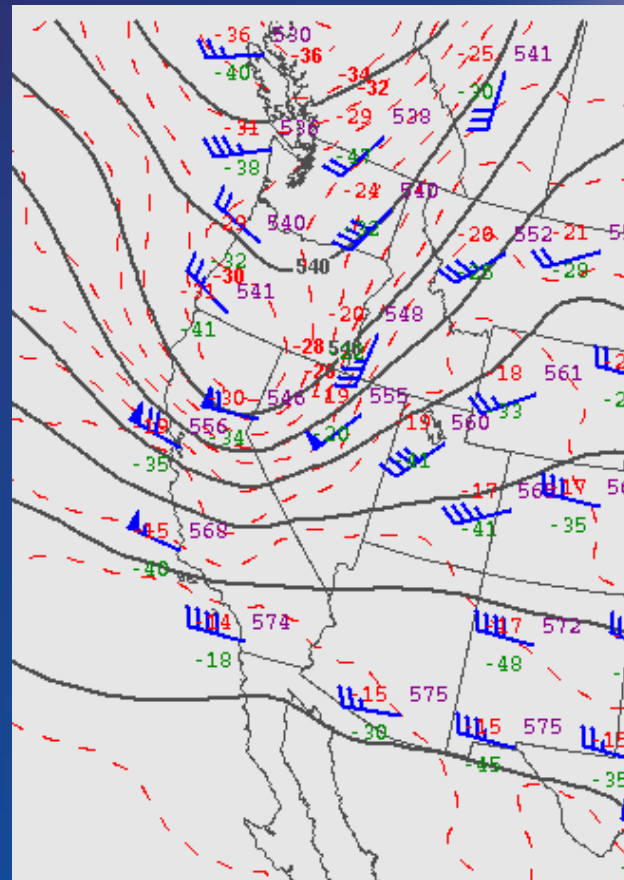
700 mb



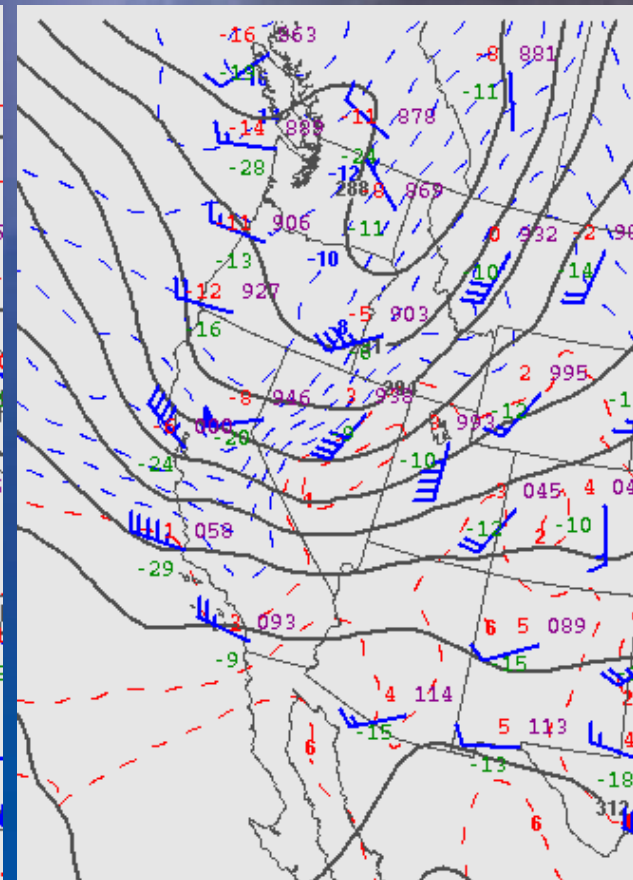
Type 2 Event – Mar. 26, 2006



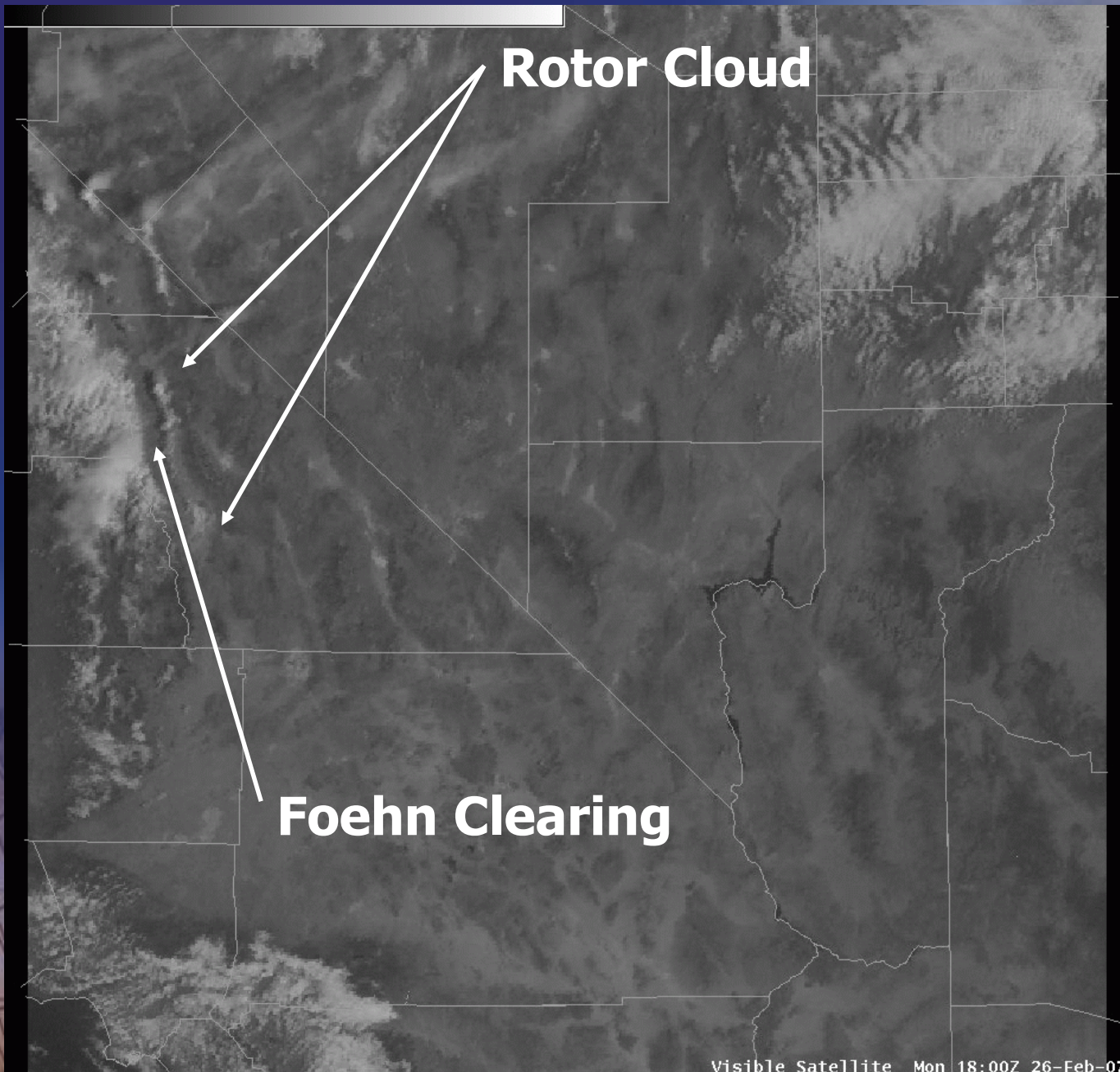
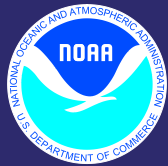
300 mb



500 mb

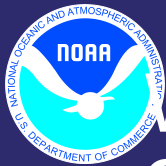


700 mb



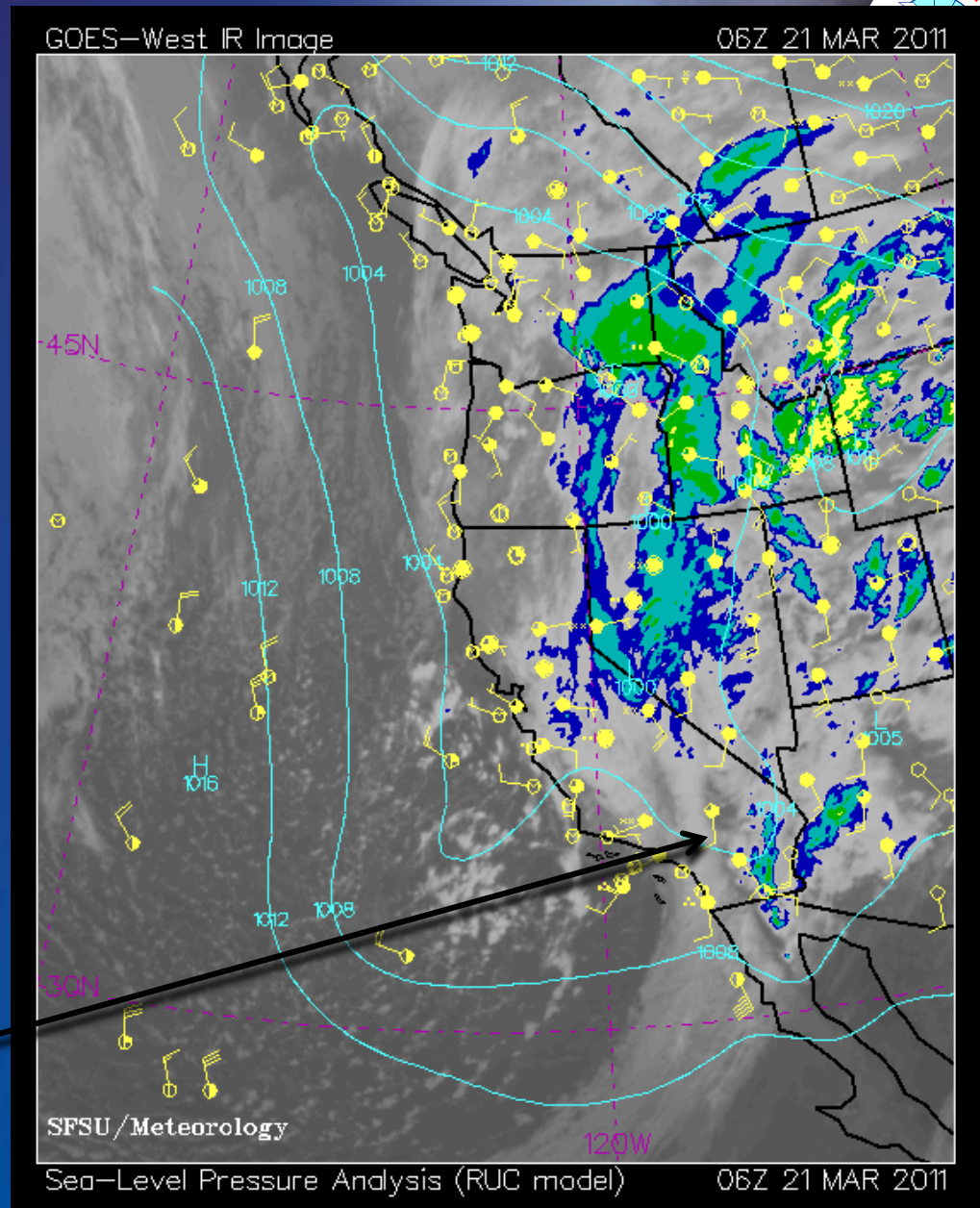
Rotor Cloud

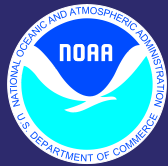
Foehn Clearing



West Coast IR Satellite Imagery (Every 3 hours) (12Z Mar 20 thru 06Z Mar 21)

- Surface Pressure and observations are overlain.
- Focus of event





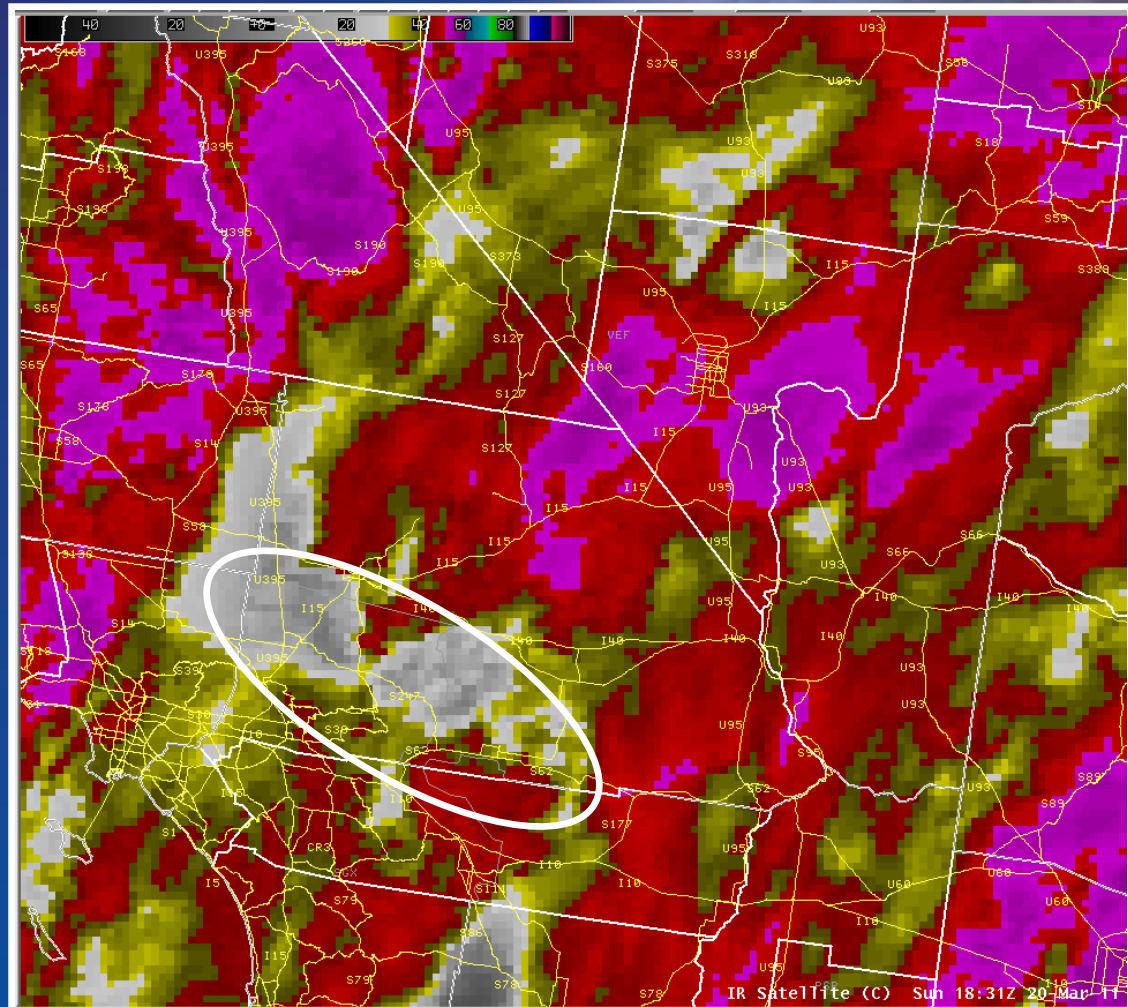
IR Satellite 1830Z-0040Z

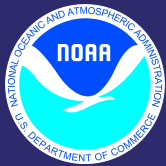
(on average every 30 min)



“Foehn
Clearing”
in the lee

Clearing
gradually
shifts further
east
during the
period





Visible Satellite 1601Z-2330Z

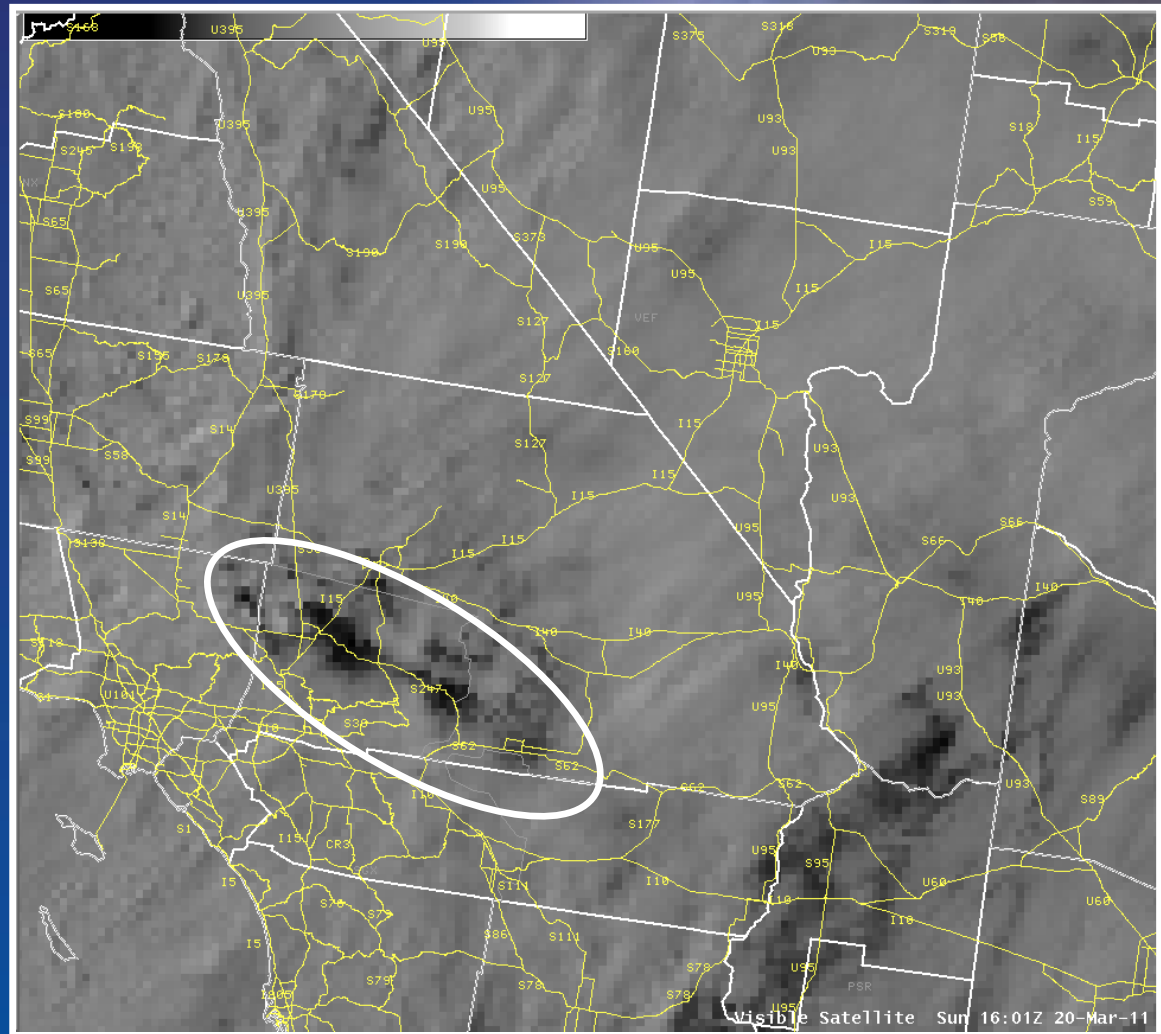
(on average every 30 min)

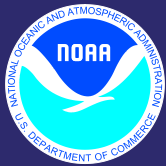


“Foehn Clearing” in
the lee

Clearing gradually
Shifts further east
during the period

Multiple waves and
rotor clouds apparent
especially in last few
images



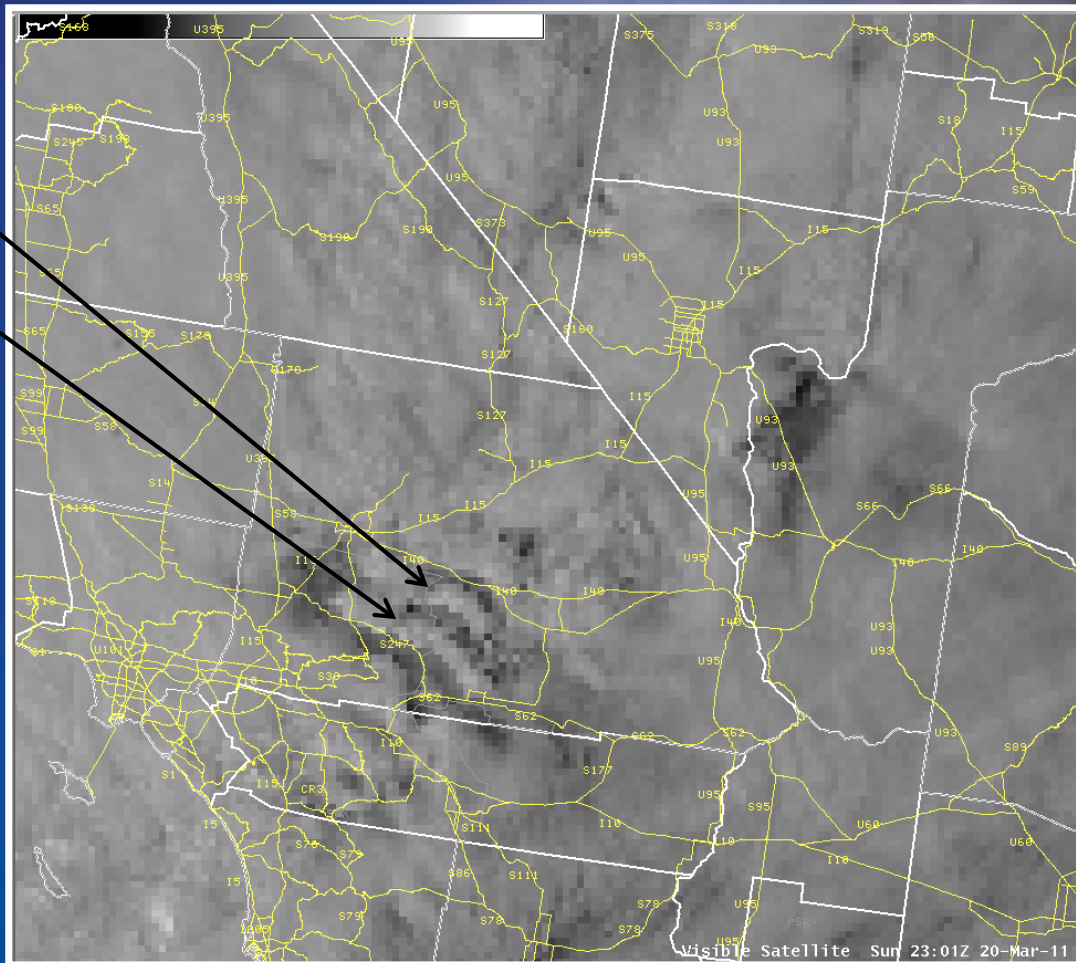


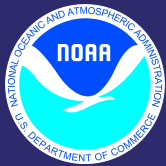
Visible Satellite 2301Z



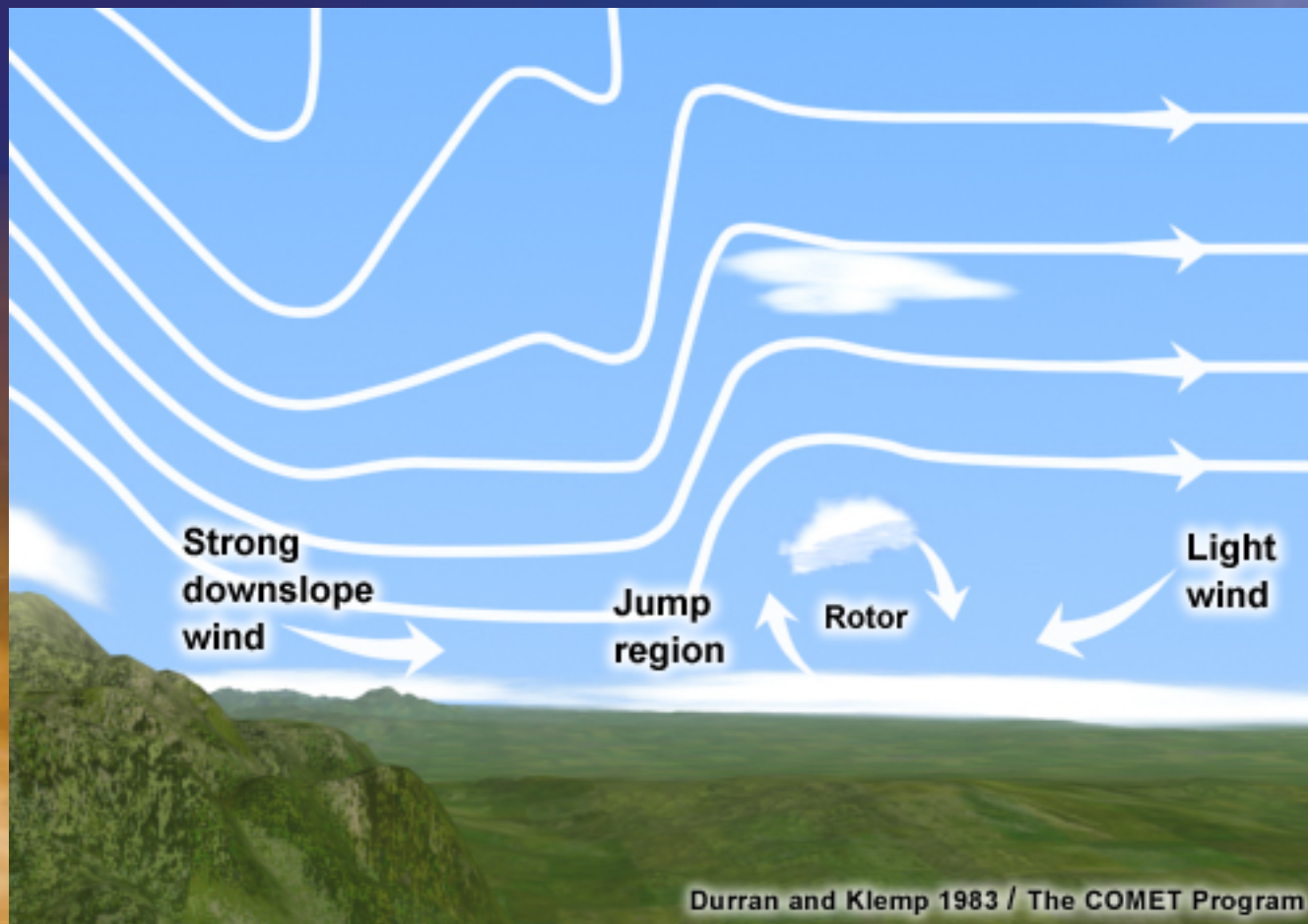
Multiple waves and rotor clouds apparent especially in last few images

Surface observations confirmed areas of light and variable winds as well as north/northeast winds indicative of a rotor footprint. Lucerne Valley had N/NE Winds and KDAG was lgt & var.



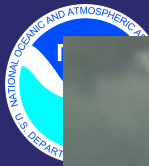


Downslope and Rotors



- Rotors occur at or below ridge top level and within 20 miles of barrier

Durrant and Klemp 1983 / The COMET Program



Lenticular cloud above rotor cloud

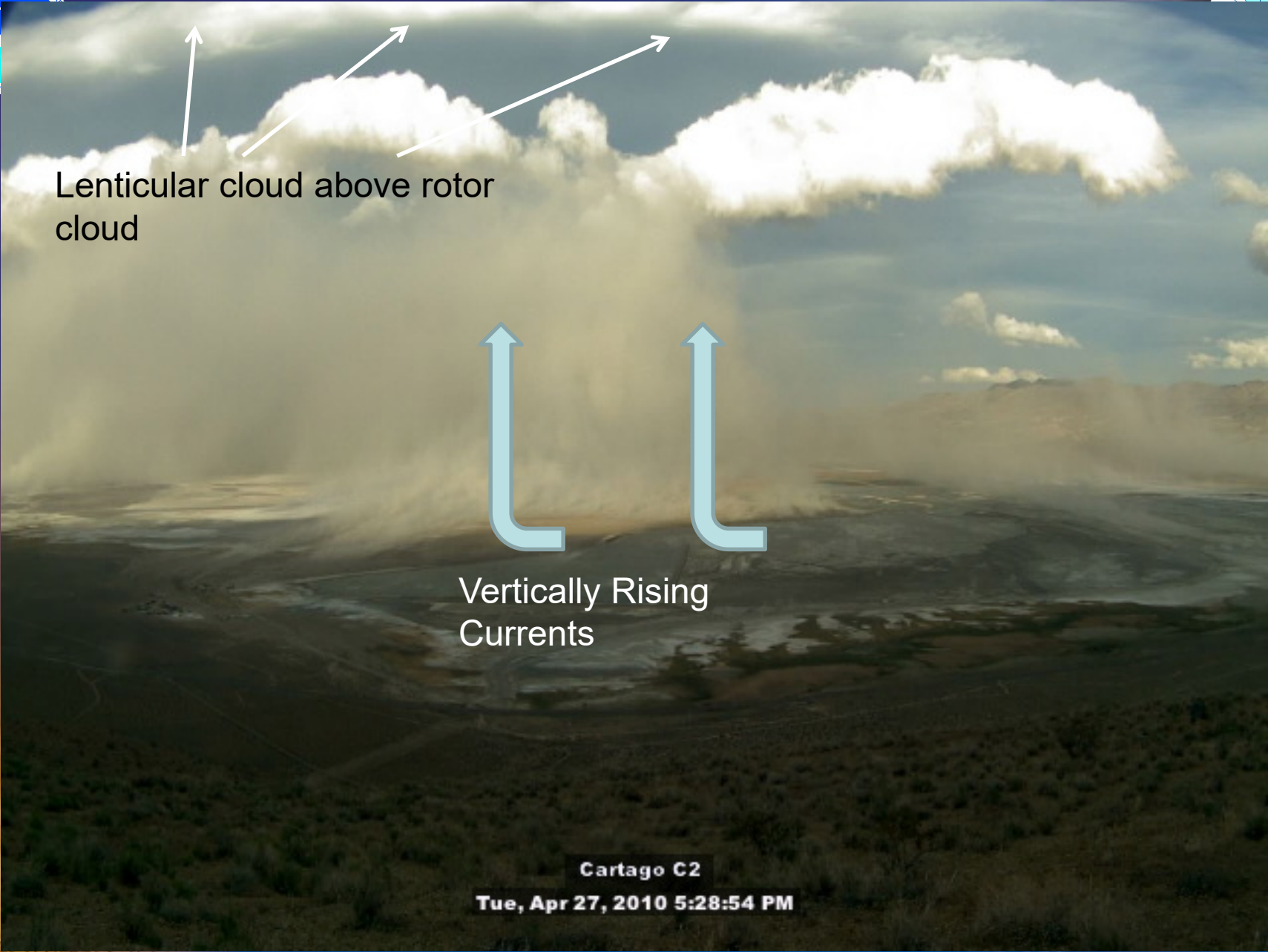
Rotor Cloud



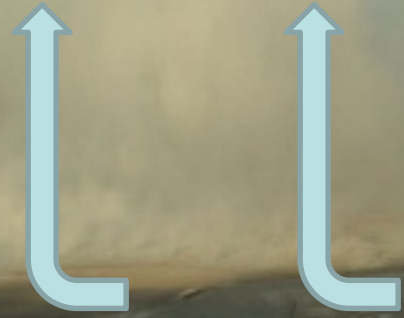
Increasing westerly winds

Cartago C1

Tue, Apr 27, 2010 3:44:19 PM



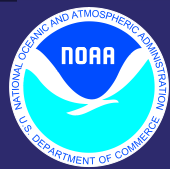
Lenticular cloud above rotor cloud



Vertically Rising Currents

Cartago C2

Tue, Apr 27, 2010 5:28:54 PM



Mountain Wave Decision Tree



CWA/MIS Criteria for mid and large aircraft (small GA use best judgement):

- Moderate: UDDS = 350-599ft/min, or Speed Change +/- 15-25kt*
- Severe: UDDS = >600 ft/min (depending upon size of aircraft), or Speed Change > +/- 25kt, net neutral change 1,000 ft or more*

ZLA Mountain Wave Areas

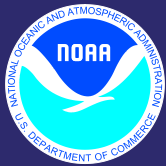


Area 1 – Southern Sierra

Area 2 – San Gabriel/ San Bernadino Mountains

Area 3 – Tehachipi Mountains

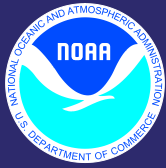
Area 4 – Riverside/San Diego Mountains



CWSU ZLA Mountain Wave Impact Area 1

- Southern Sierra Nevada Mountains and adjacent Owens Valley

Strong westerly flow aloft over Northern and/or Central CA from ridge tops and above. This is the most common of mountain wave events in ZLA Airspace. (WFO VEF coordination)

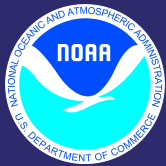


CWSU ZLA Mountain Wave Impact Area 2



- San Gabriel and San Bernadino Mountains (Palmdale Wave)/ and adjacent Antelope/Apple Valleys

Look for deep troughs digging along or off the coast of Southern CA with strong south to southwesterly flow ridge tops and above. Not as common as Sierra events. (WFO LOX/SGX coordination)

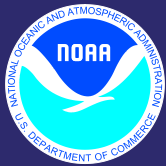


CWSU ZLA Mountain Wave Impact Area 3



- Tehachapi Mountains and adjacent Mojave Desert

Look for strong northwest flow aloft over Central/Southern CA behind passing shortwave over the Great Basin, ridge tops and above. (WFO HNX/VEF coordination)



CWSU ZLA Mountain Wave Impact Area 4



- Riverside and San Diego Mountains and adjacent deserts of Palm Springs, Indio and Imperial Valley

Strong westerly flow aloft over Southern CA from ridge tops and above. May be more common during El Nino years. (WFO SGX coordination).