

# A Seven-Year Wind Profiler-Based Climatology of the Windward Barrier Jet along California's Northern Sierra Nevada

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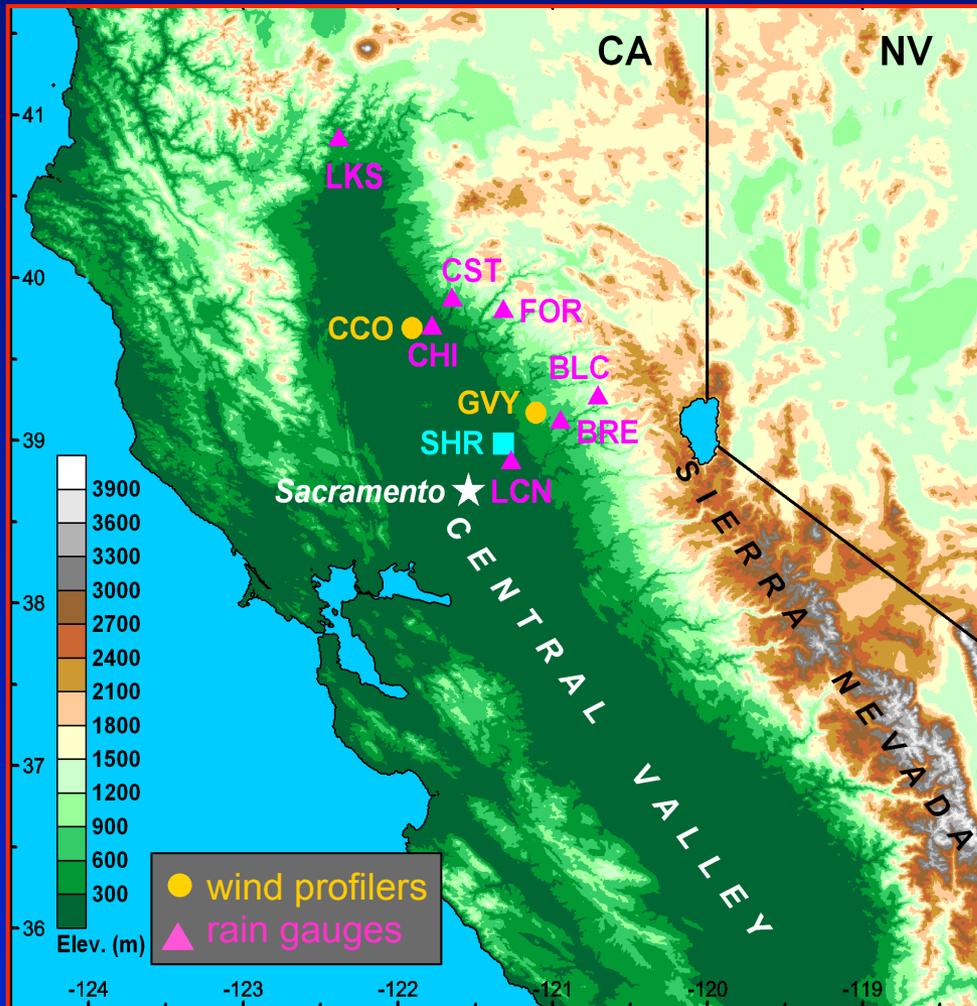
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Atop 13160-ft Seven Gables  
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# Sierra barrier jet (SBJ) observations



- 100,000+ hourly profiles at CCO (41 m MSL) and GVV (689 m MSL) 2000-2007 [●].
- SBJ profiles: local max of terrain-parallel wind  $\geq 12$  m/s, located above the lowest range gate and below crest level ( $< 3$  km MSL).
- ~9,200 hourly profiles observed with SBJ attributes.
- 250 SBJ cases were observed, where a case is  $\geq 8$  consecutive hourly SBJ profiles, during the cool season (Oct.-Apr.)
- Significantly extends Smutz (1986) study from SCPP at SHR [■].
- Rain gauge transects were used [▲].

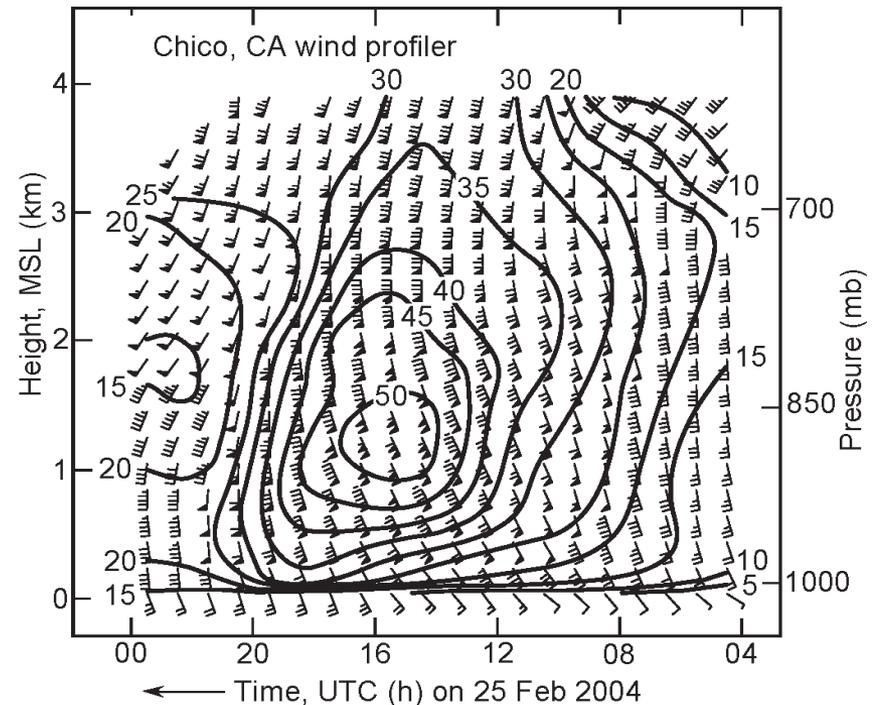
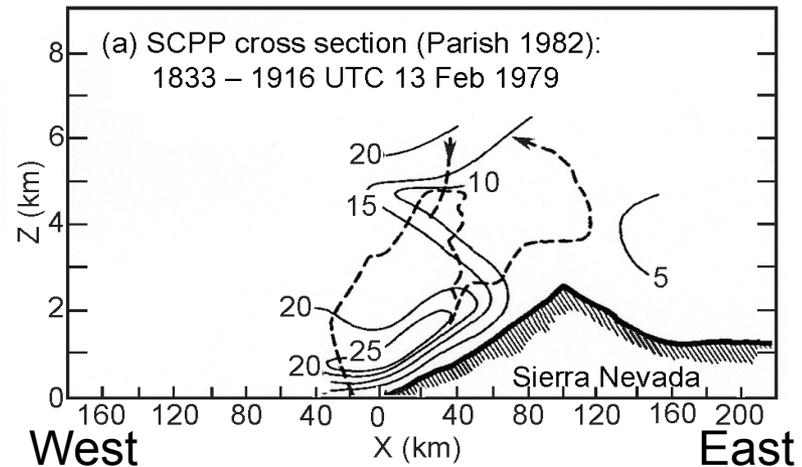
# Sierra barrier jet

## Spatial perspective: Aircraft

- SBJ centered ~ 1km
- Below crest level
- Core extends west into Central Valley & east up Sierra slope

## Temporal perspective: Wind profiler

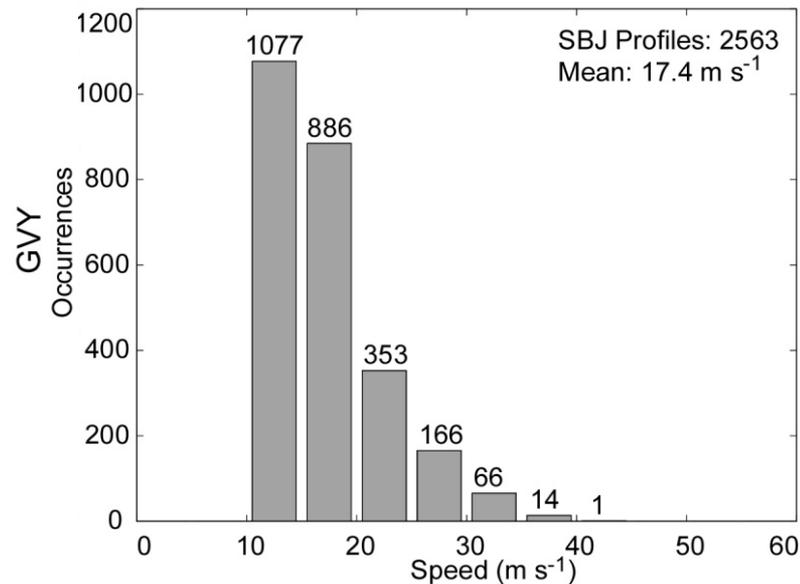
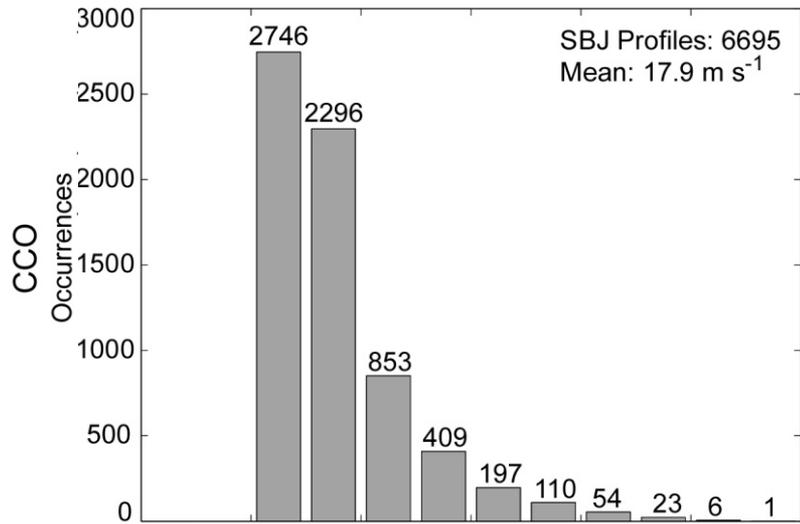
- SBJ centered ~ 1.2 km
- Below crest level
- Core strength > 50 m/s
- Duration of core ~ 3 h



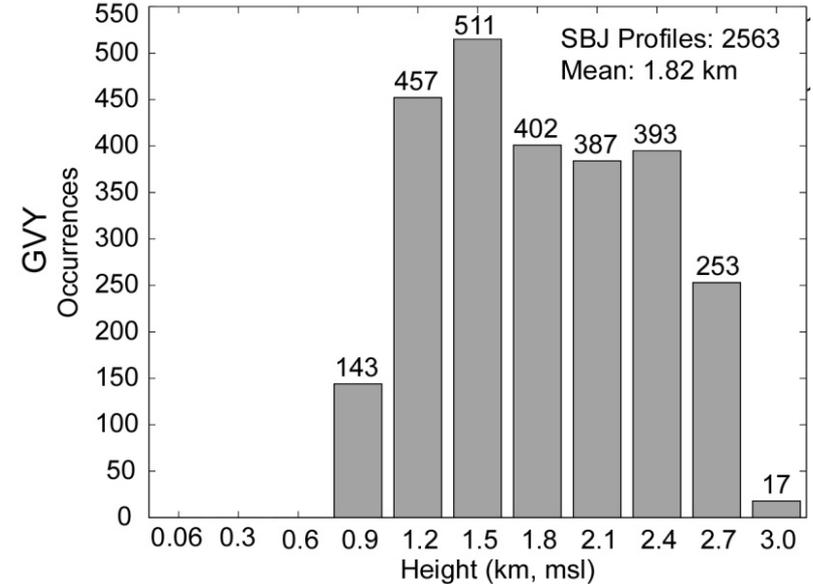
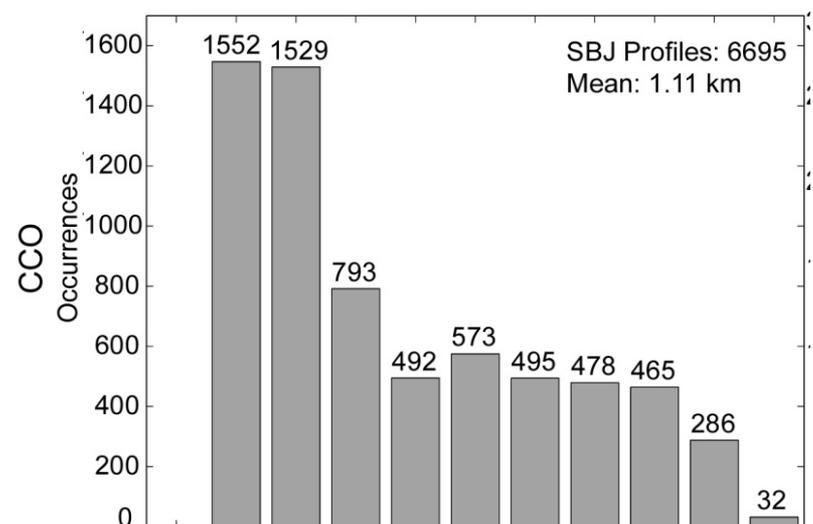
Isotachs ( $\text{m s}^{-1}$ ) of terrain-parallel flow (from  $160^\circ$ )

# SBJ bulk characteristics at CCO and GVV

## Speed



## Height

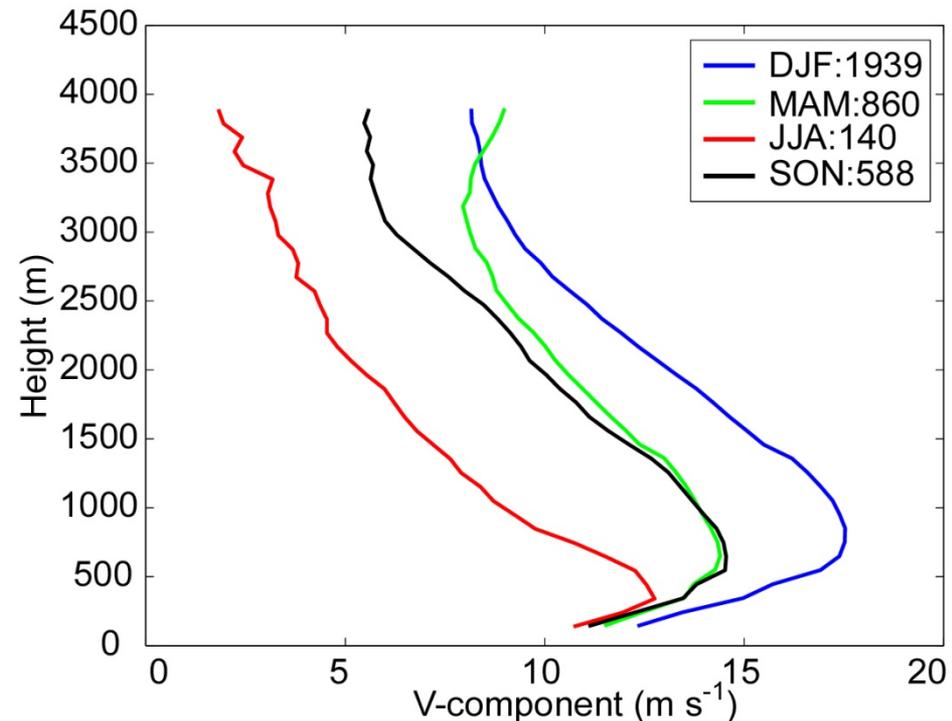
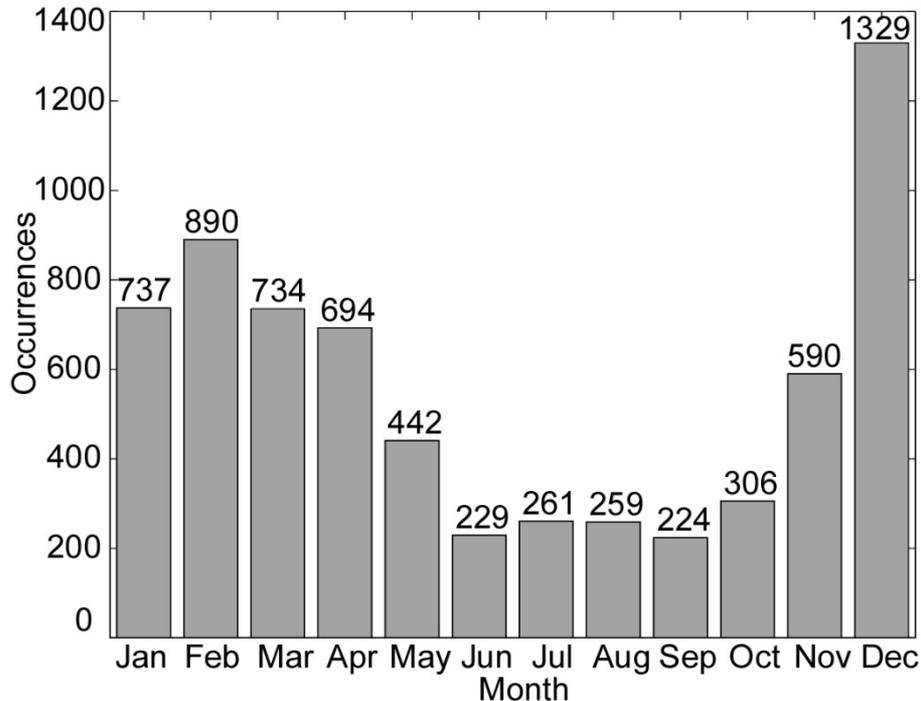


# SBJ seasonality at CCO

(similar results at GVV)

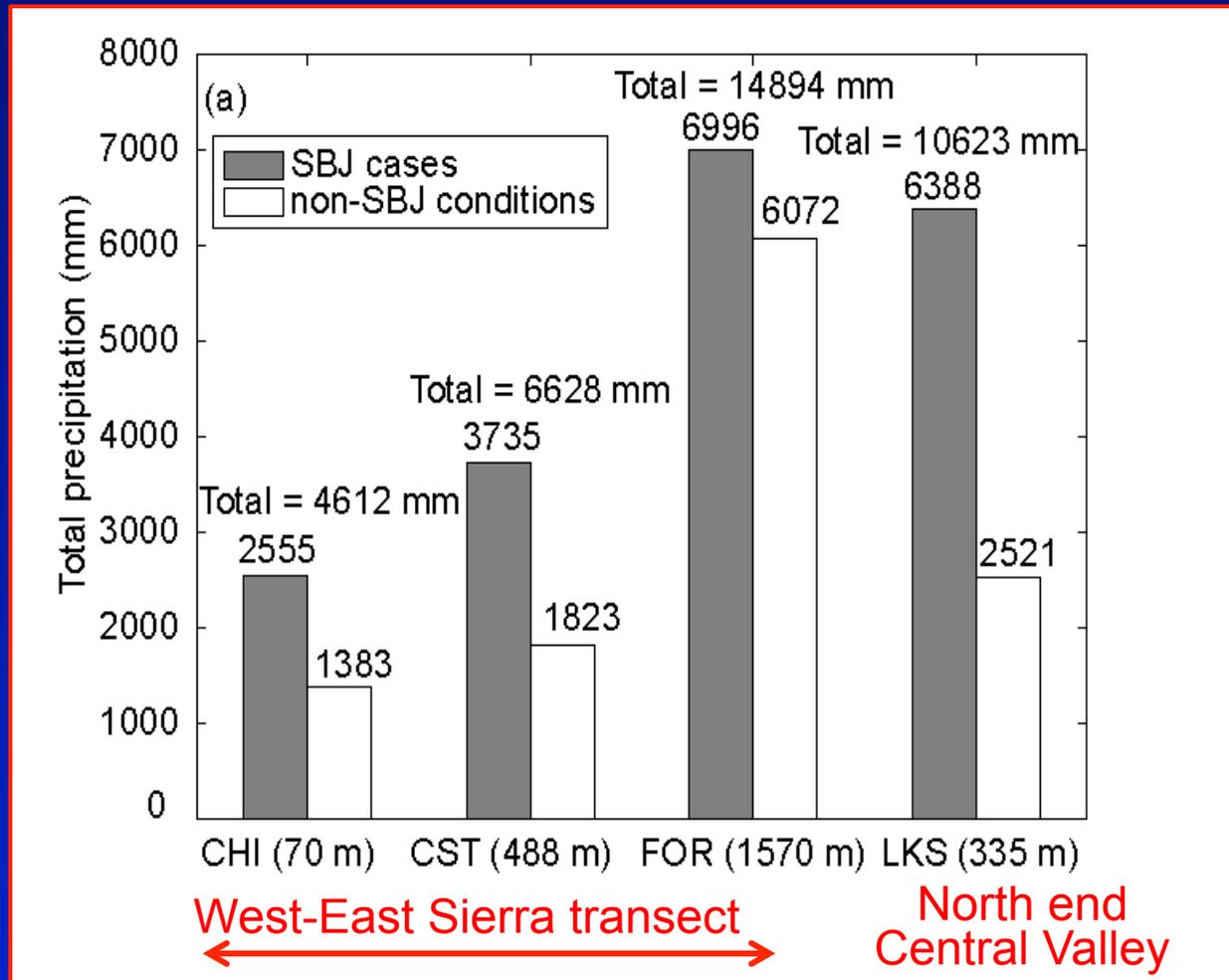
Frequency of occurrence:  
winter max.; summer min

Vertical structure:  
winter strong; summer weak



The remainder of the talk will focus on the climatologically wet cool season (Oct.-Apr.) at CCO.

# Precipitation gauge sites

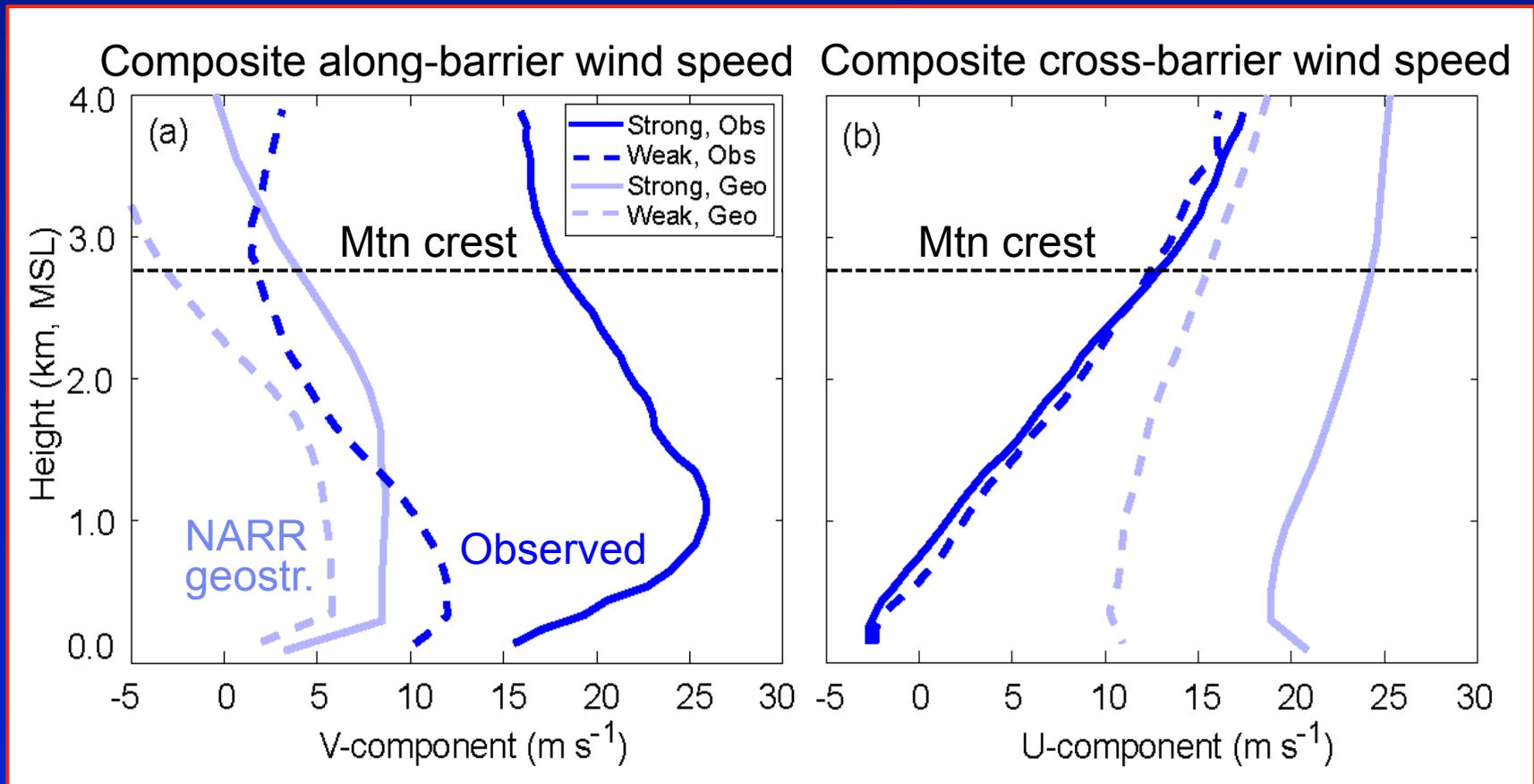


- 47-60% of cool-season precipitation fell during SBJ cases.
- SBJ cases shifted precipitation down the windward slope.
- SBJ cases enhanced precipitation at the north end of Central Valley.

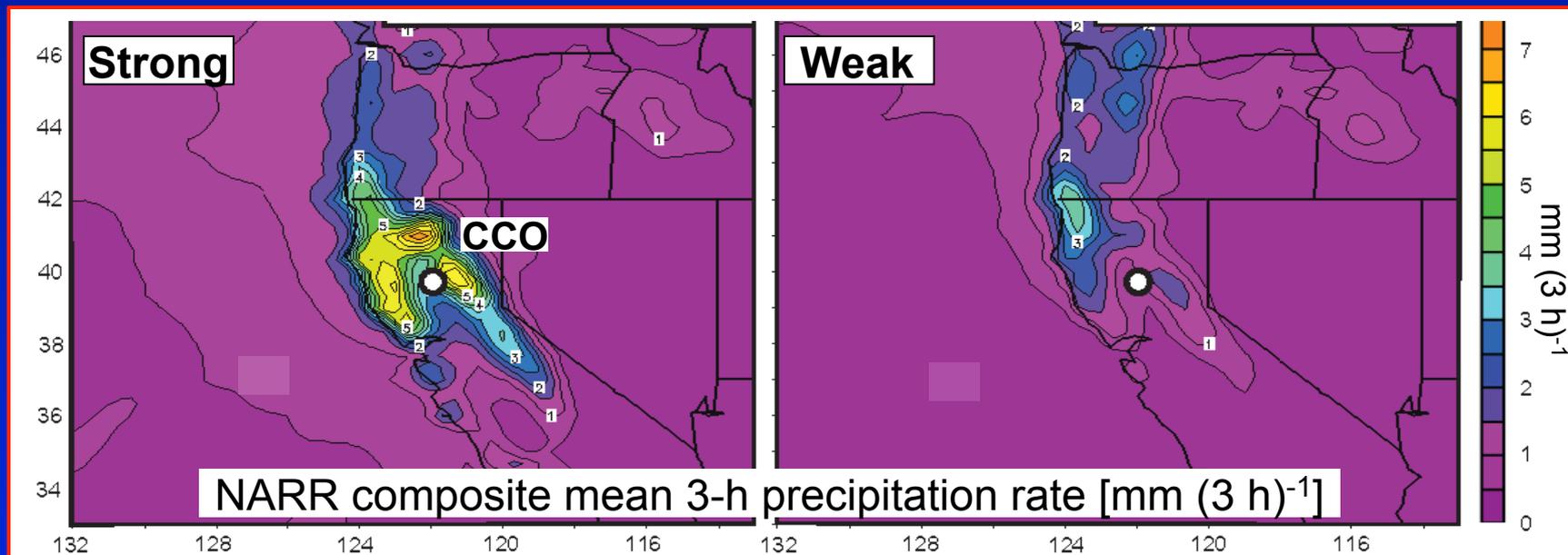
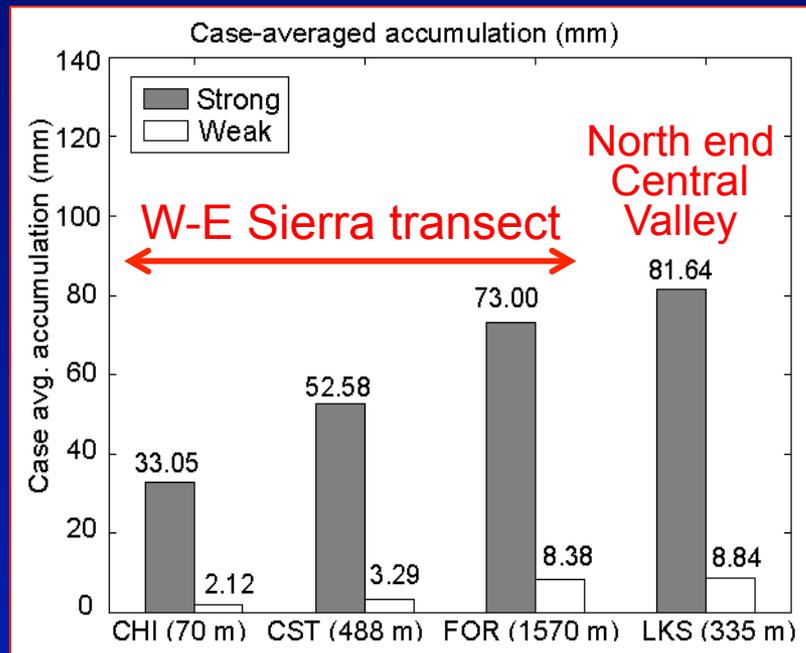
# SBJ stratifications

- 172 cool-season SBJ cases were stratified by strength, altitude, & duration.
- Top/bottom 20 ranked cases in each of these 3 classes were plotted.

## SBJ Strength



# SBJ strong/weak precipitation distributions

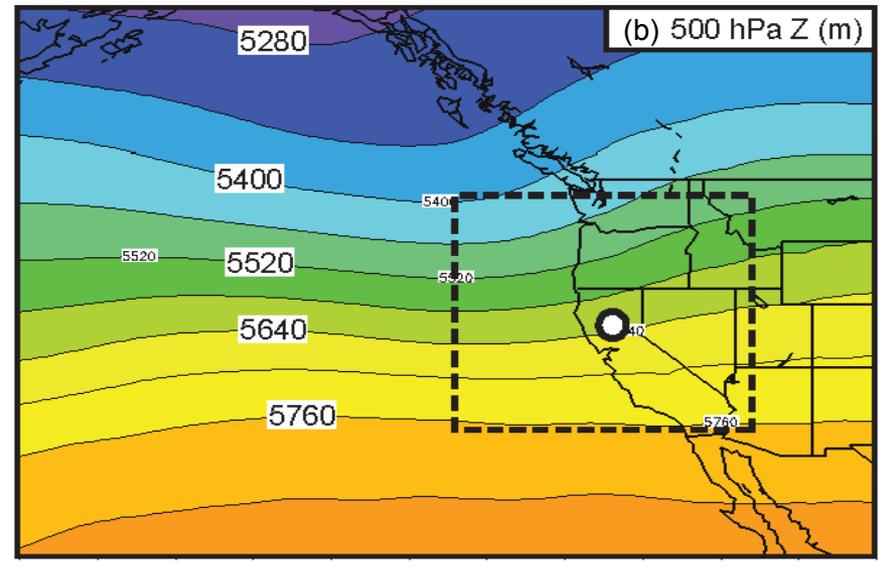
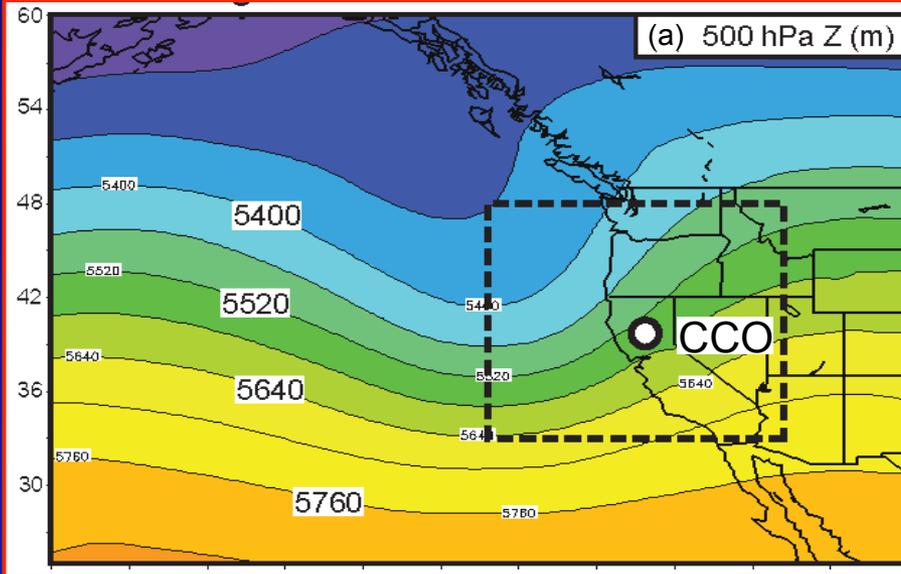


# NARR composite means

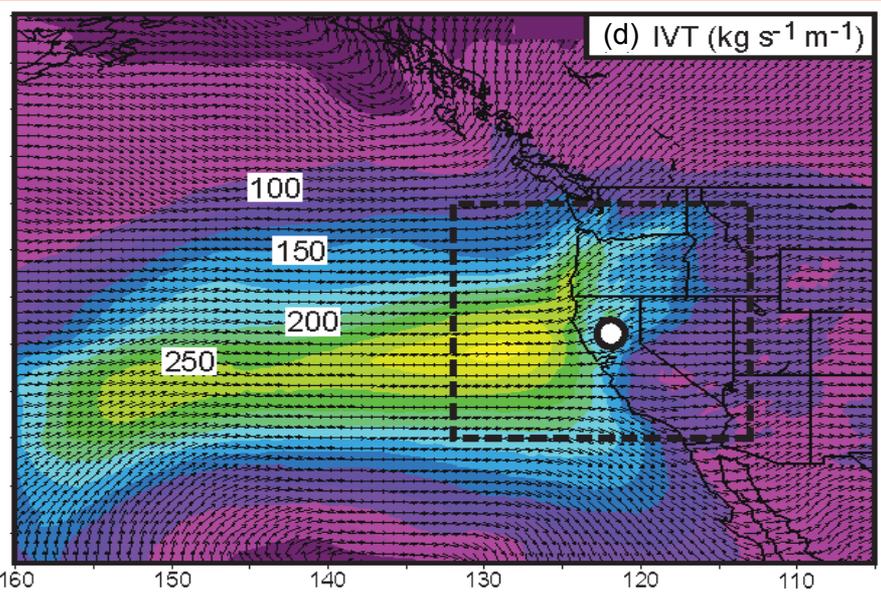
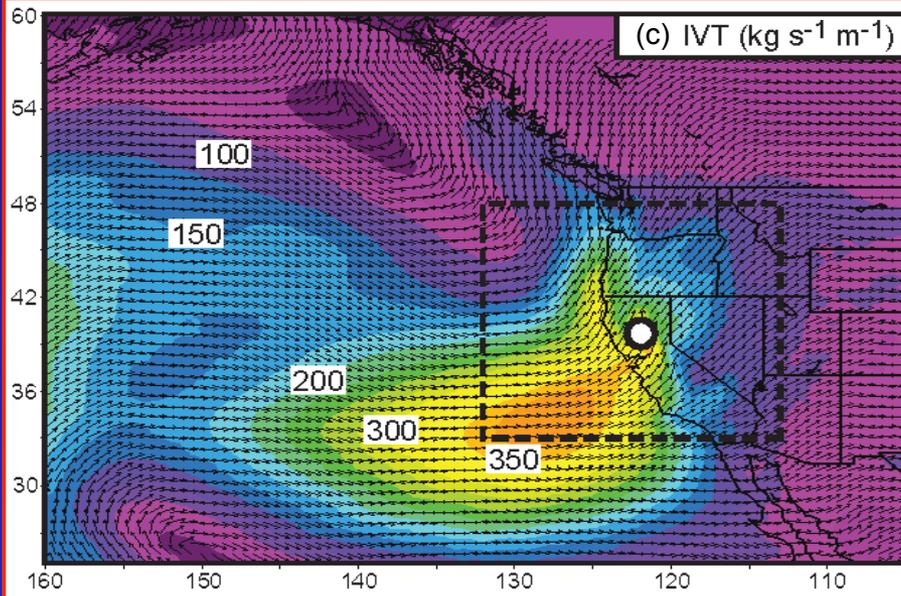
Strong

Weak

500 hPa geopotential Z (m)



Integrated vapor flux ( $\text{kg s}^{-1} \text{m}^{-1}$ )



# Concluding Remarks

- Continuously operating wind profilers provided a multi-year climatology of the windward barrier jet (i.e, the SBJ) in California's northern Sierra Nevada.
- SBJs occur most often, and are strongest, during the climatologically wet cool season when the baroclinic storm track is most active.
- Up to 60% of cool-season precip. falls during SBJ cases, which shift the precip. down the windward slope and enhance the precip. at the north end of the Central Valley.
- Compositing of the observations based on SBJ strength reveals stark differences in the magnitude and vertical positioning of the SBJ, and uniquely different regional precip. characteristics.
- Companion NARR composites demonstrate markedly different meso- to synoptic-scale characteristics responsible for strong-vs.-weak SBJ cases.
- Follow-on research is underway that couples multiyear wind profiler obs. at multiple sites with a 6-km resolution downscaled reanalysis dataset to explore the dynamics and precip. modulation of SBJs along the entire Sierra chain.

Thank you!

# Extension of Smutz Barrier Jet Climatology

- Time resolution:
  - Smutz had 3-hrly soundings during wintertime storms; we have 1-hrly wind profiles 24/7 for 5-7 years.
- Spatial variability:
  - Smutz analyzed data from one site at the base of the Sierra (Sheridan, CA); we have two sites: one at the base of the Sierra (Chico, CA) and another in the Sierra foothills (Grass Valley, CA).
- Sample size:
  - Smutz had 1849 sounding profiles; we have 100,000+ wind profiles from two sites.
  - Our larger sample size allows us to stratify our results much more effectively.
- Vertical resolution:
  - Smutz had 300-m vertical sounding resolution; we have 100-m vertical wind profile resolution.
- Vertical structure:
  - Smutz did not analyze vertical structure composites... we will.
- Statistical analysis:
  - Smutz does not do a statistical analysis of BJ cases... just profiles.
  - With our 1-hr wind profiles, we can do statistical analyses of both BJ profiles and BJ cases.
  - Through analysis of BJ cases, we can assess mean BJ evolution.
- North American Regional Reanalysis data:
  - Unlike Smutz, we have a dynamically consistent mesoscale dataset in the NARR that can be used for dynamical and precipitation compositing.
  - We can assess the BJ-precipitation relationship using NARR data.
- Melting layer:
  - We have hourly information on melting level.
- Seasonal variation:
  - Since we operated the wind profilers year-round, we can look at interseasonal variations in the occurrence and characteristics of BJs.
- BJ constraints:
  - Our BJ constraints are more rigorous than Smutz's BJ constraints.