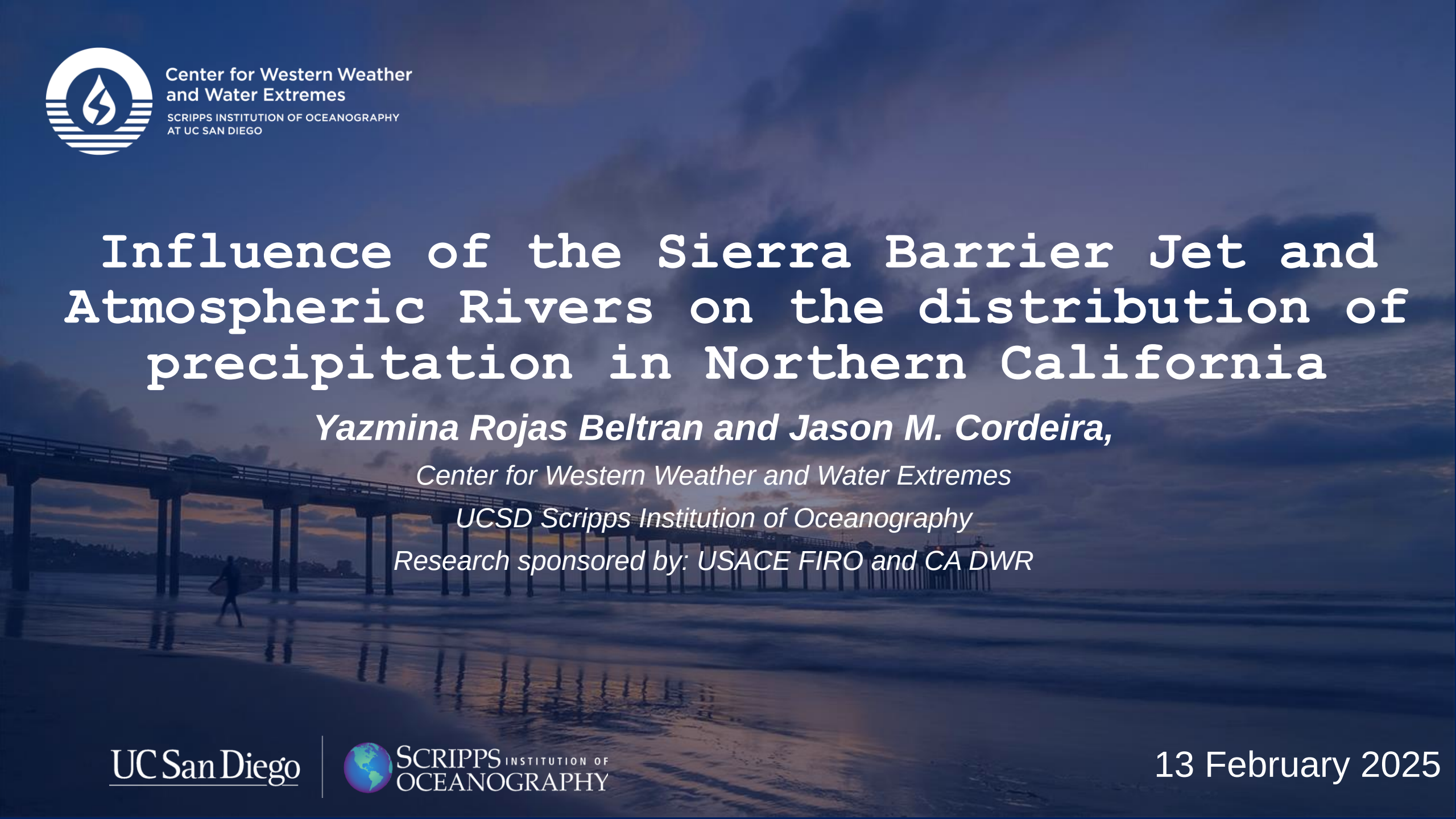


Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Influence of the Sierra Barrier Jet and Atmospheric Rivers on the distribution of precipitation in Northern California

Yazmina Rojas Beltran and Jason M. Cordeira,

Center for Western Weather and Water Extremes

UCSD Scripps Institution of Oceanography

Research sponsored by: USACE FIRO and CA DWR

UC San Diego | SCRIPPS INSTITUTION OF OCEANOGRAPHY

13 February 2025

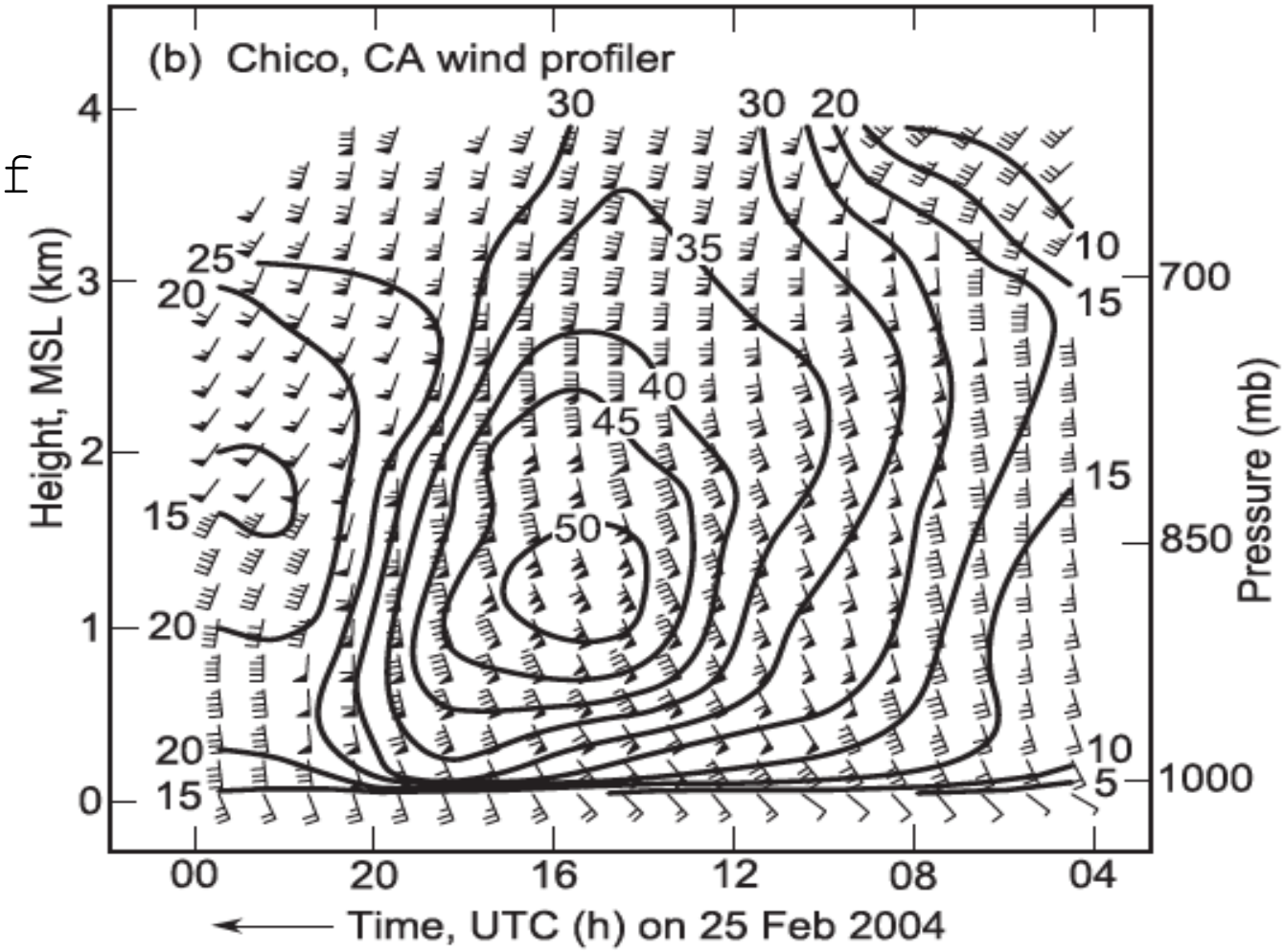
Sierra Barrier Jet

What is a SBJ?

- Terrain-parallel core of locally enhanced winds composed primarily of ageostrophic flow at ~1 km AGL (Parish 1982).

How does it form?

- Forms in response to deceleration of stably stratified flow approaching the western Sierra Nevada.



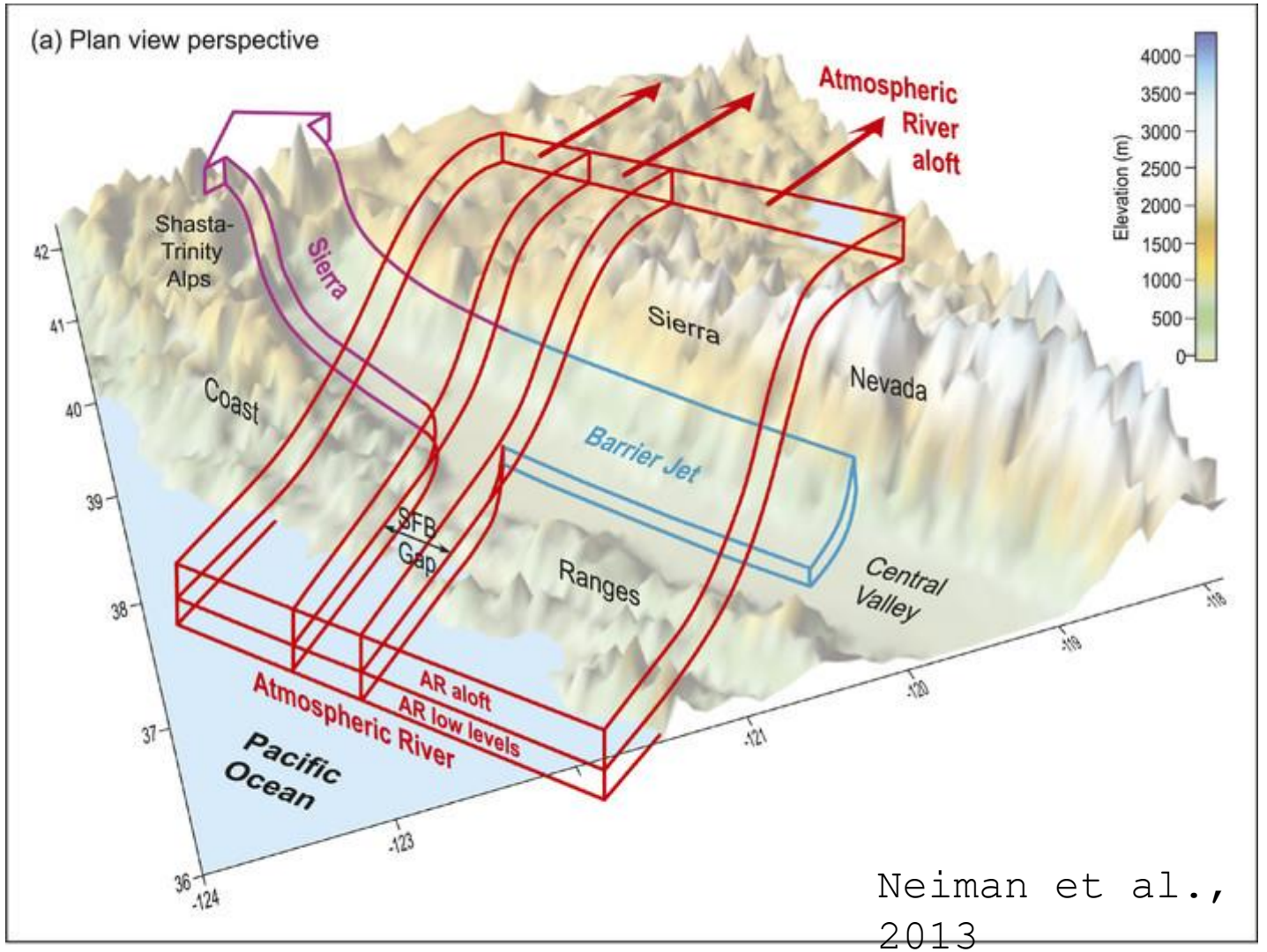
Neiman et al., 2010

Interaction of SBJ and AR

Sierra barrier jet acts as a virtual barrier

Moist and unstable air from the AR can lift upstream of the Sierra

Modify precipitation distribution in Northern California



Neiman et al., 2013

Research questions

What is frequency and characteristics of SBJ over the Central Valley of California?

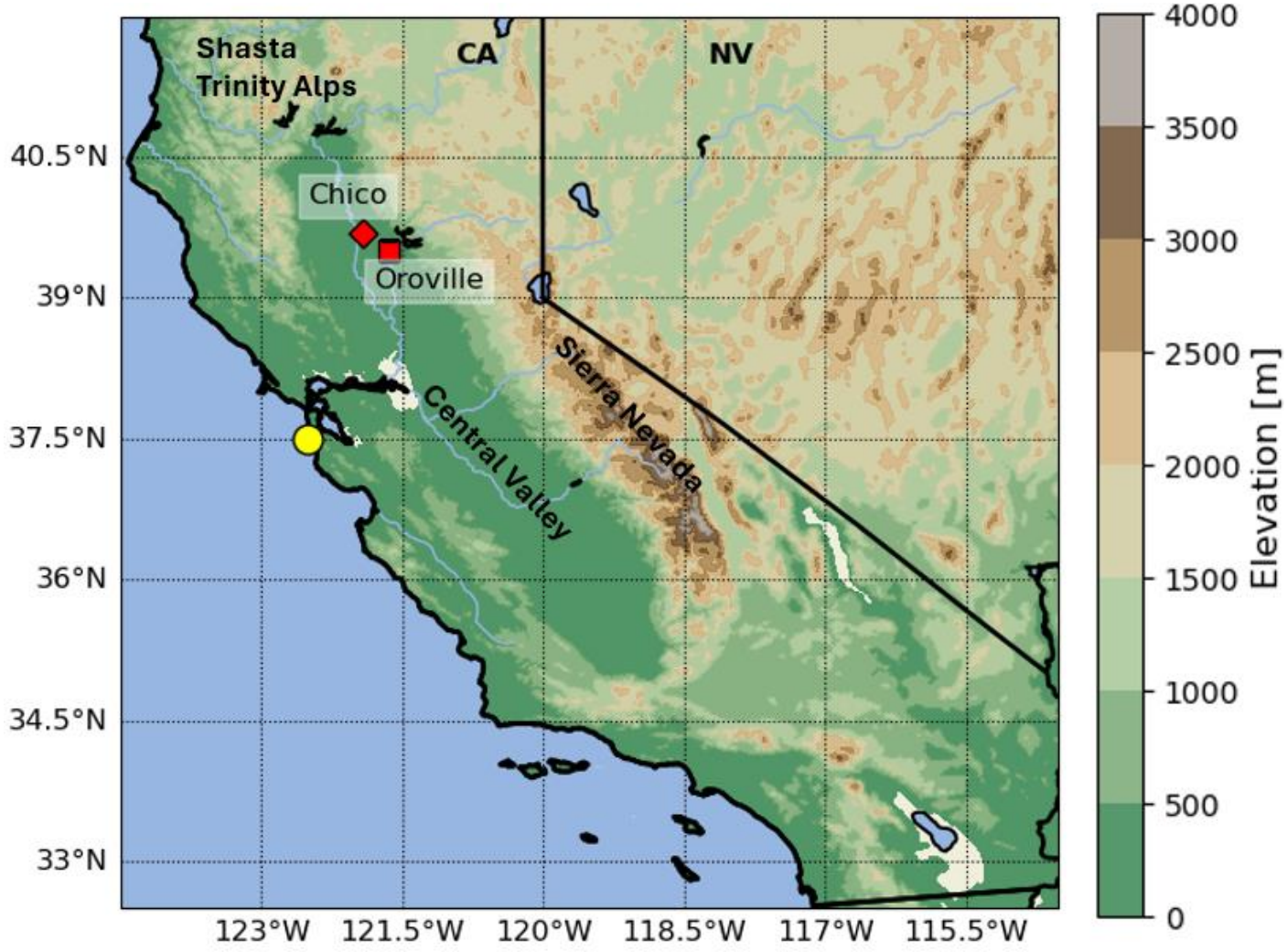
What is relationship between landfalling ARs and SBJ?

How is the annual precipitation influenced by SBJ and ARs?

How does WRF resolves the vertical structure, intensity and duration of the SBJ?

Data

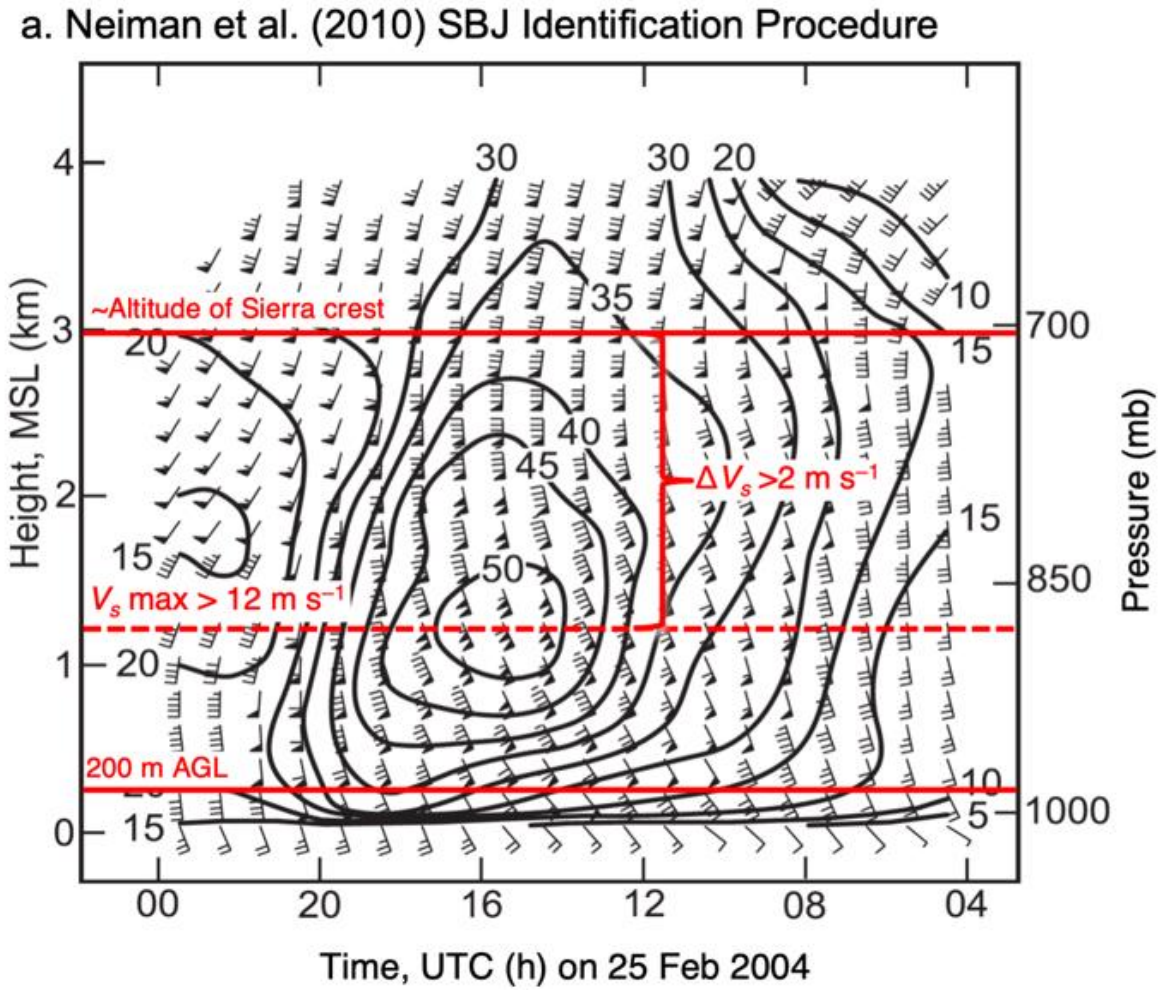
- **Chico/Oroville wind profiler data**
- Temporal resolution: hourly
- Water years: 2001 to 2023
- Cool-season: October – March
- **Analysis of Record for Calibration (AORC) precipitation data**
- **AR events from CW3E Coastal Landfalling AR Catalog**



Methodology – SBJ Classification

Evaluating hourly profiles and following Neiman et al. (2010) methodology:

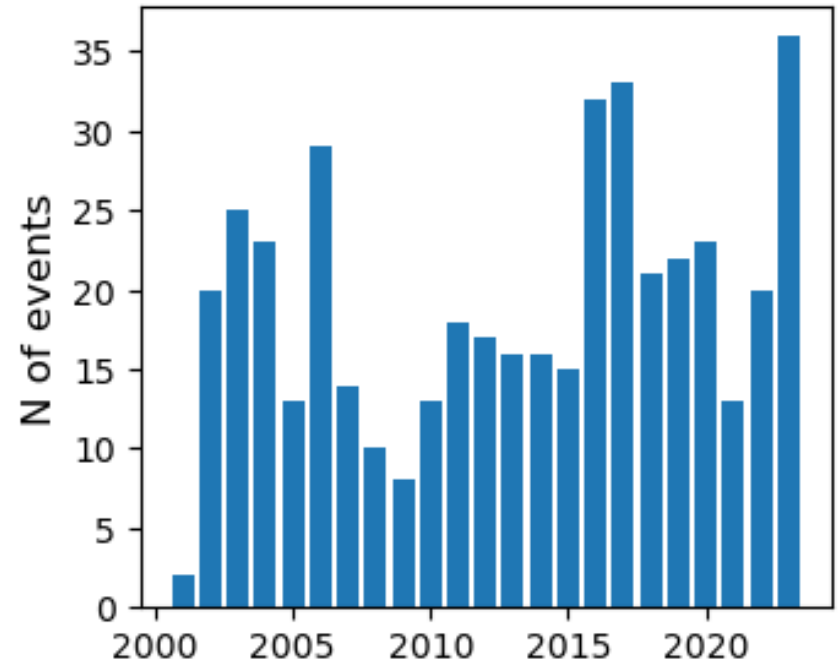
- **Sierra-parallel (160°) wind speed (V_s)**
- **V_{max} : V_s > 12 m/s below 3 km**
- **$Z(V_{max})$ >= 200 m AGL**
- **V_{max} that decreases >2 m/s between level of V_{max} and 3km**
- **Range gates adjacent to V_{max} must contain data**
- **8 consecutive hours = event**

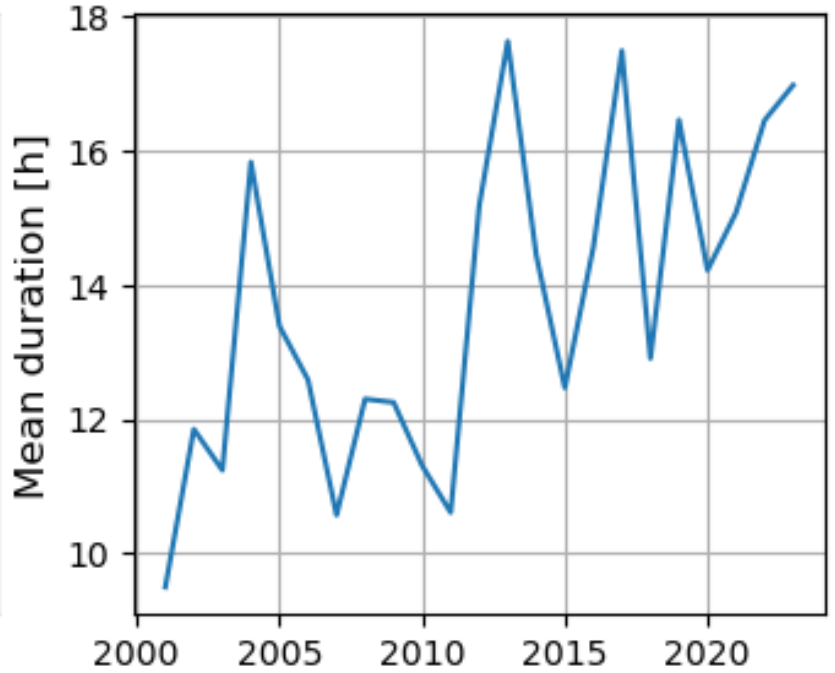


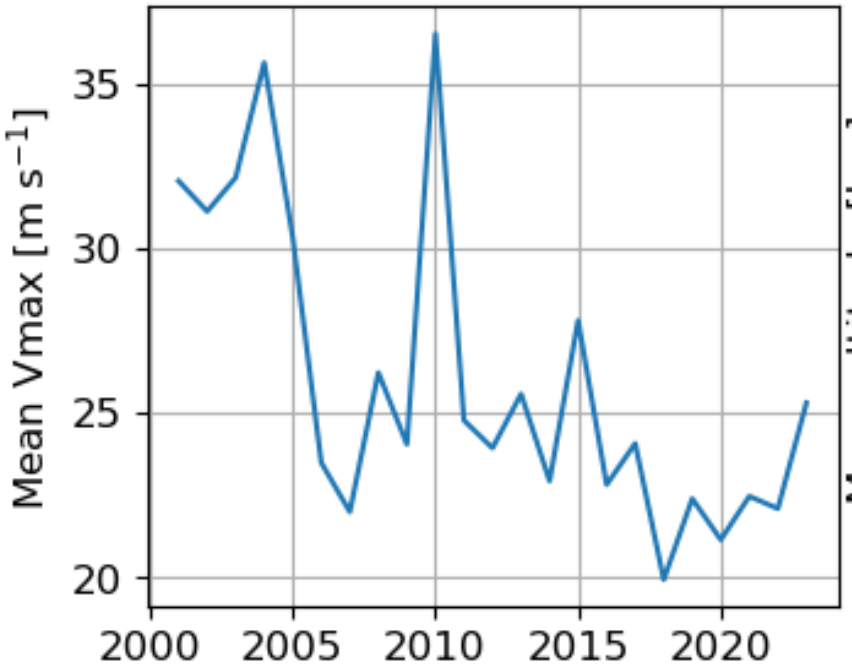
What is frequency and characteristics of SBJ over the Central Valley of California?

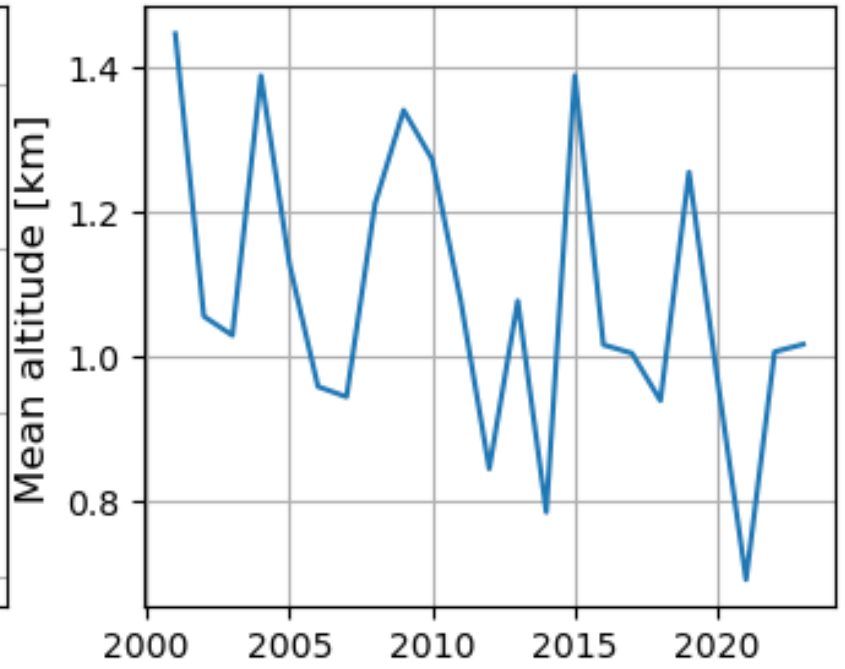
Water year cool-season Variability

- 8 to 30+ events per year
- Mean: 19 events



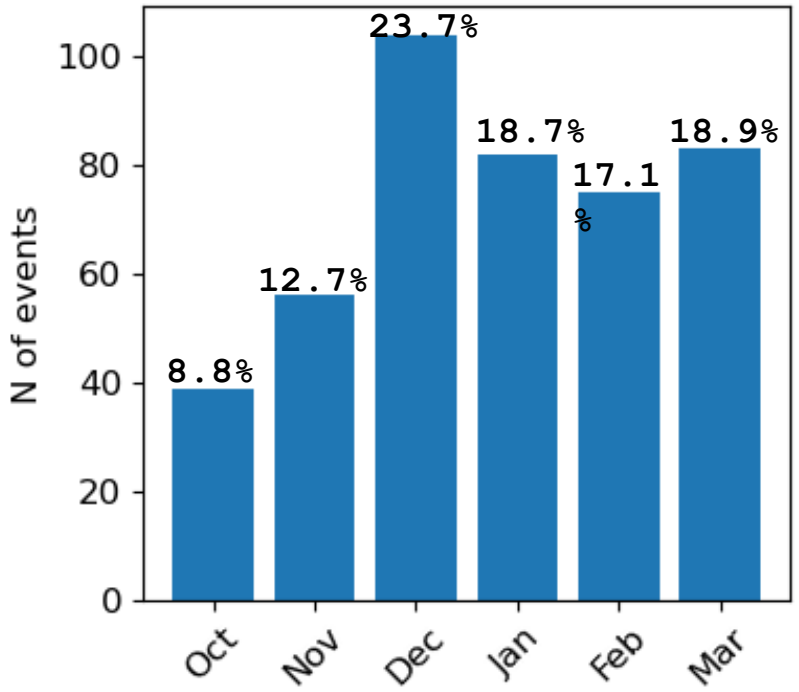


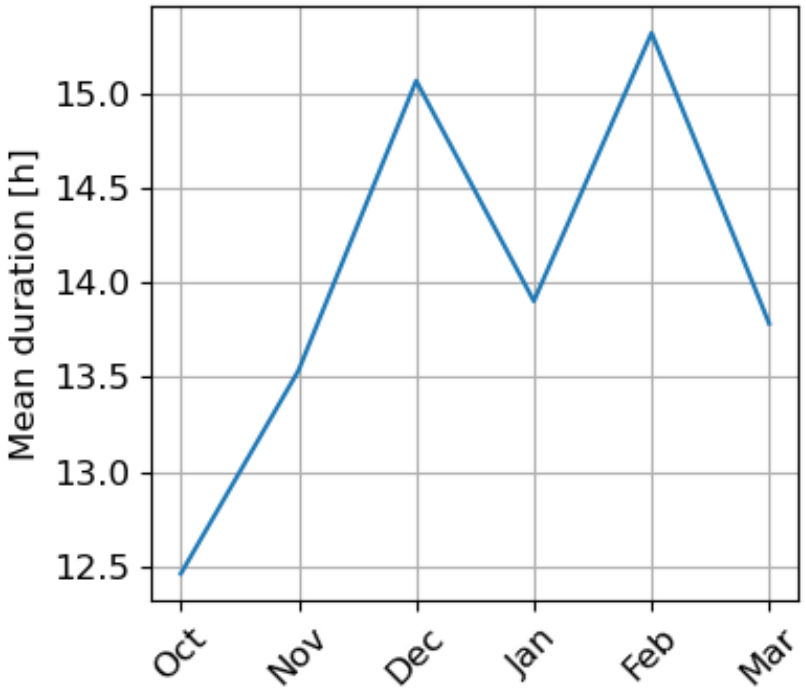


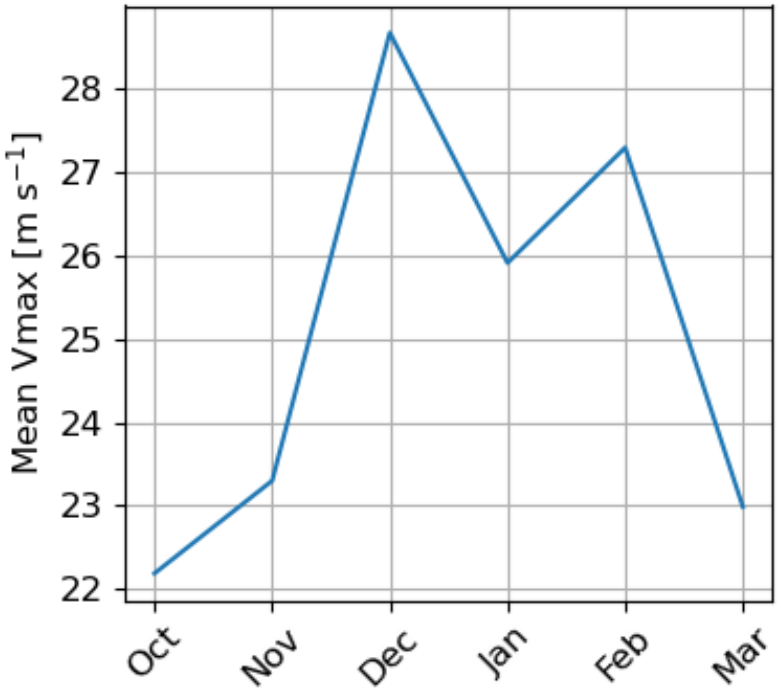


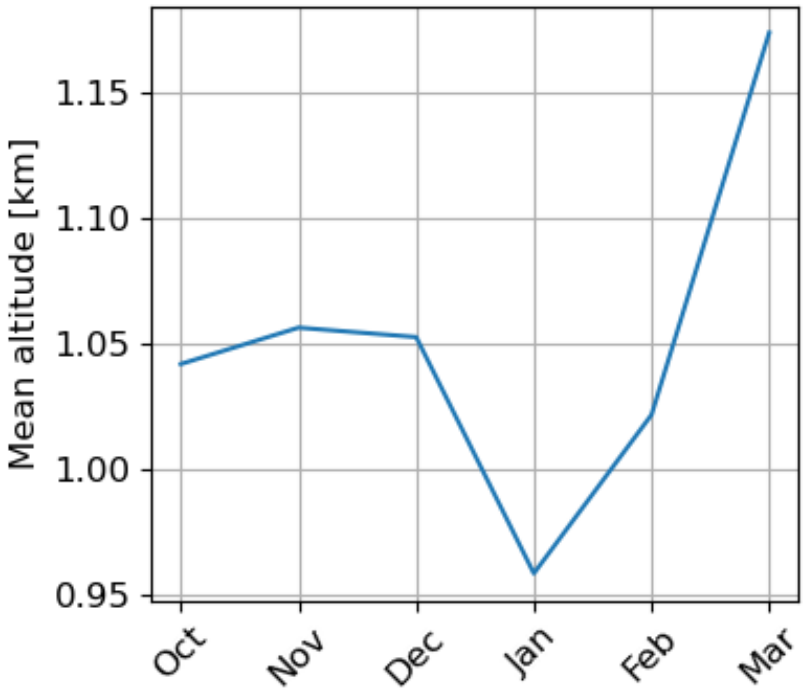
Monthly Variability of SBJ

~24% of SBJ events occur in December



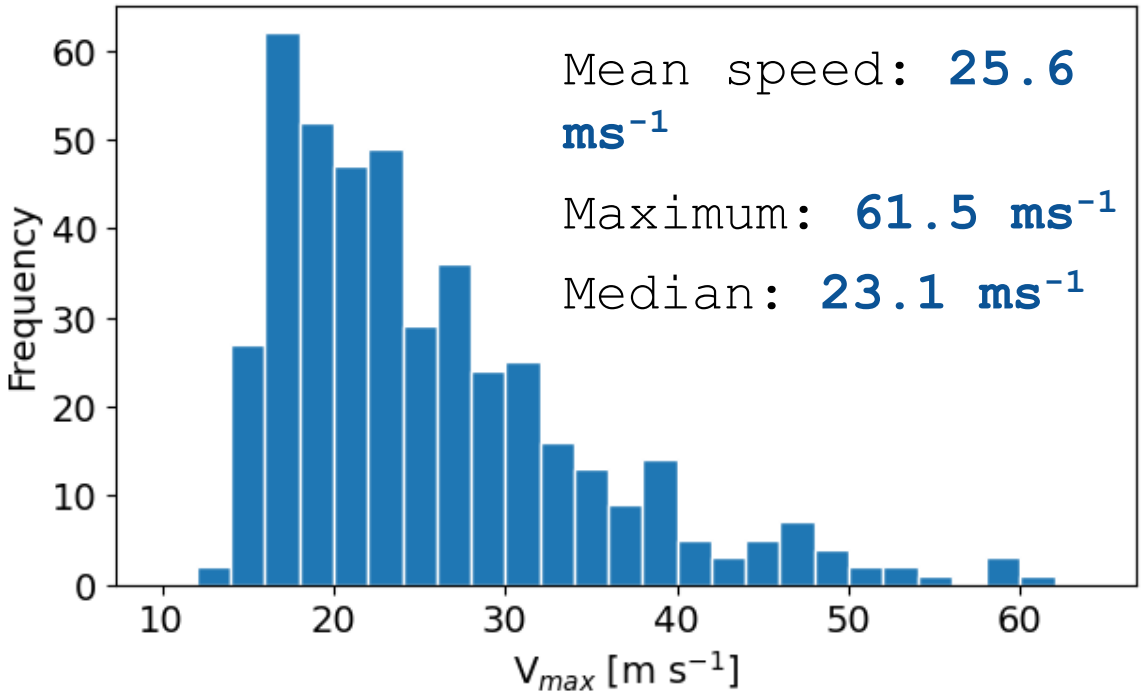


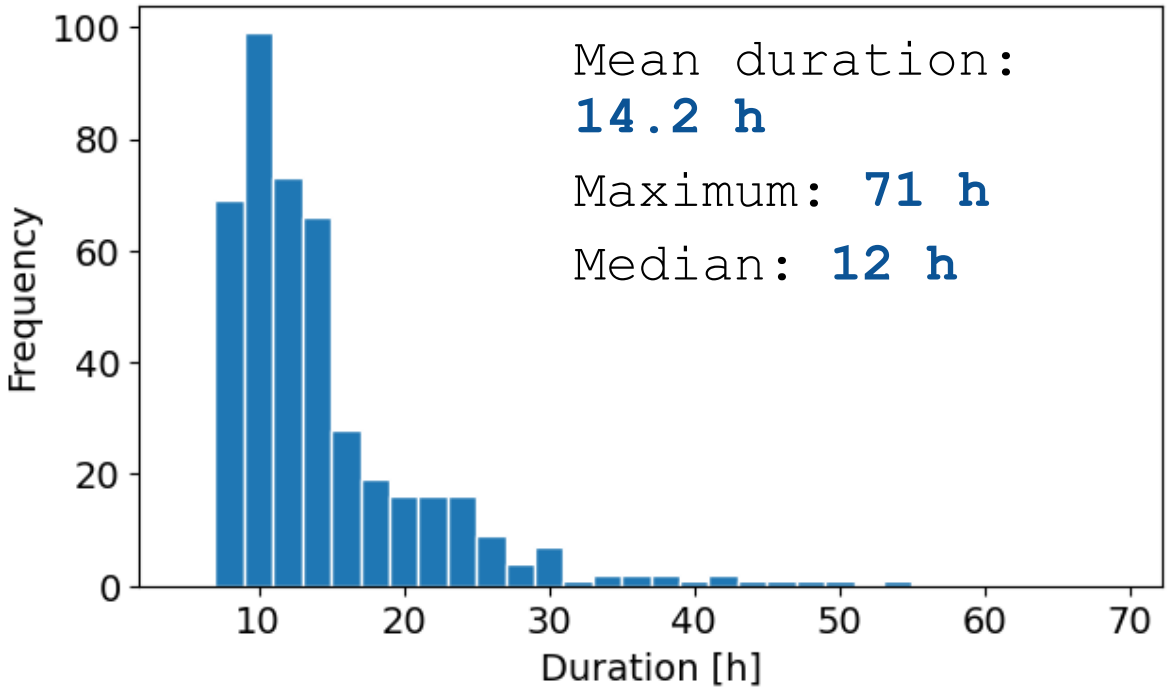


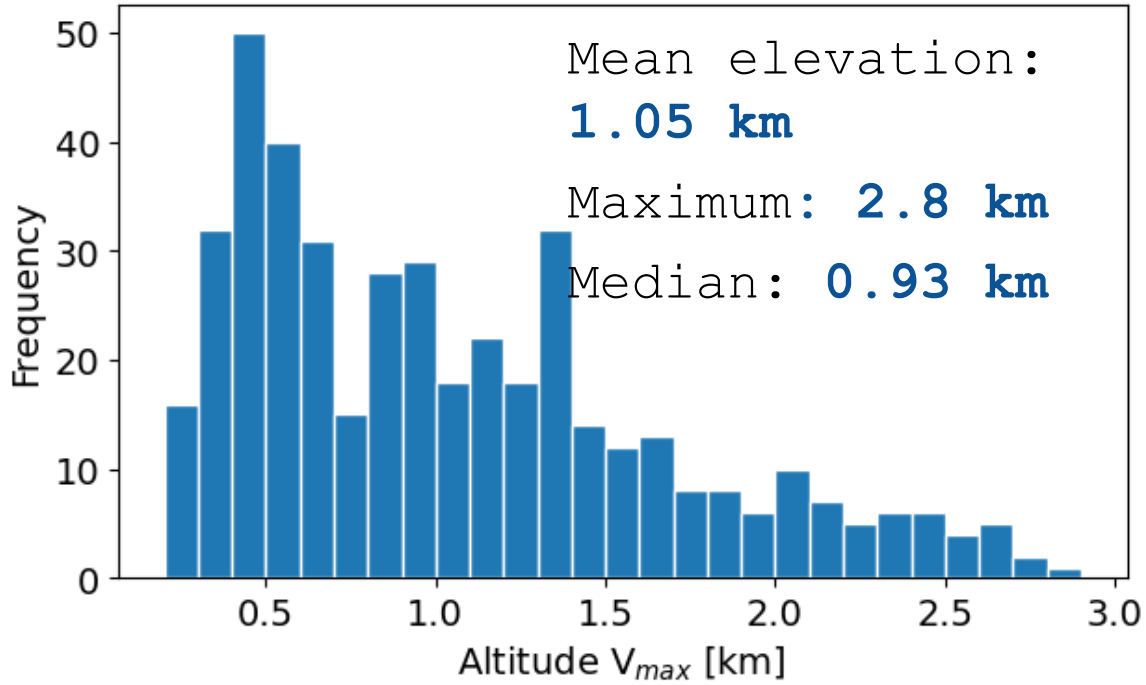


SBJ characteristics

439 SBJ events







What is relationship between landfalling ARs and SBJ?

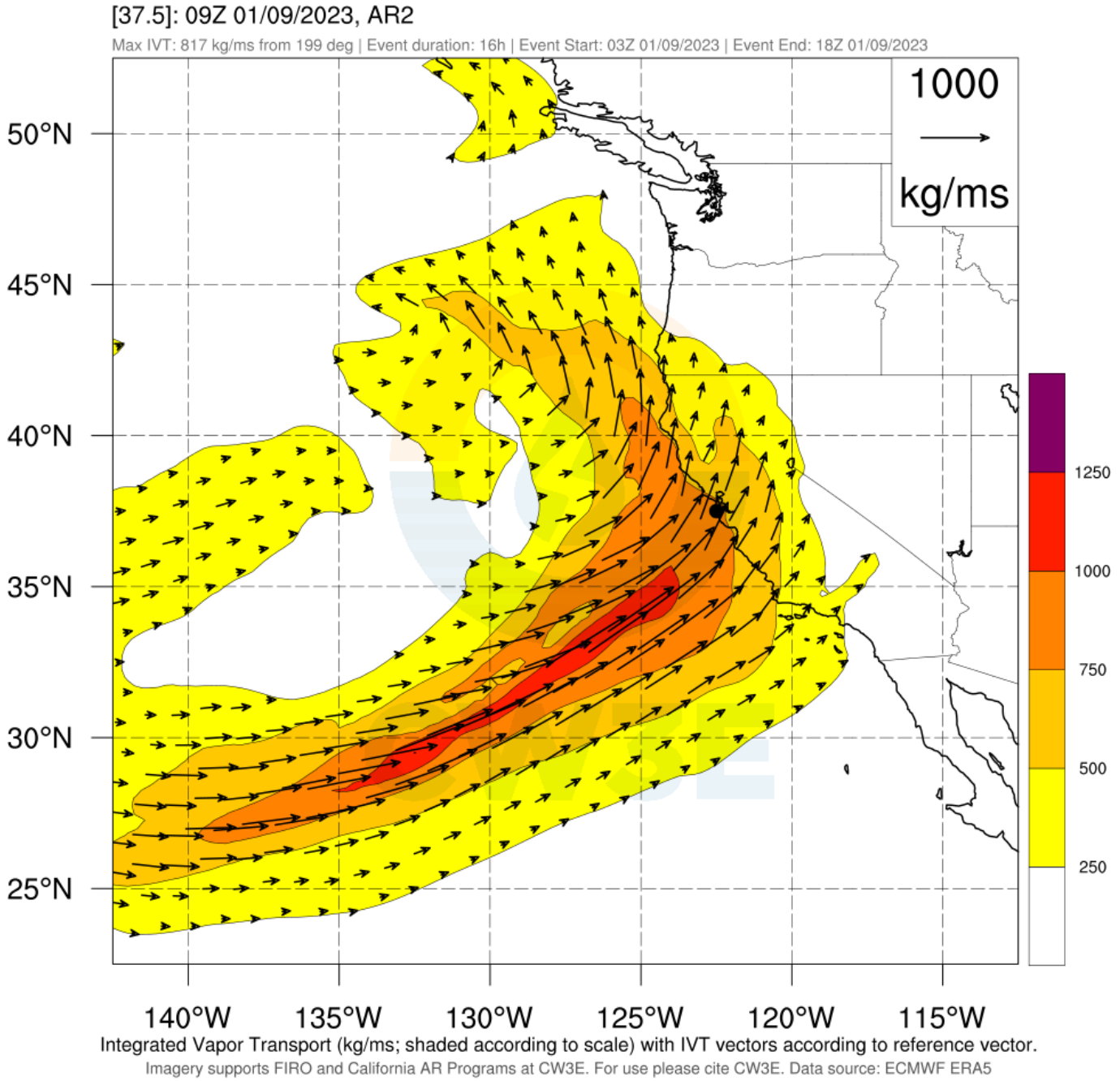
How is annual precipitation influenced by SBJ and ARs?

SBJ & AR

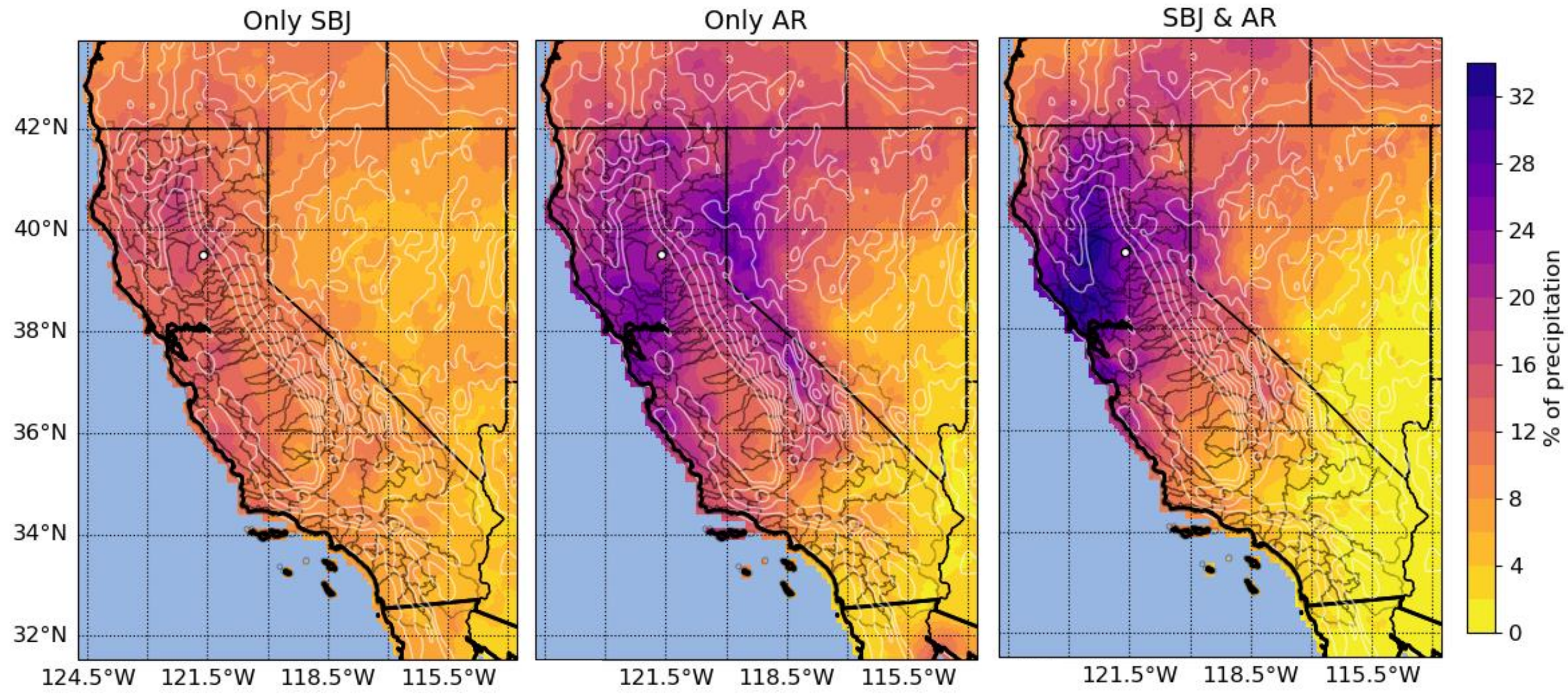
Cold season ARs events: **226**

- 250 out of 439 SBJs occur without an AR (57%)
- 37 out of 226 ARs occur without a SBJ (16%)
- 189 out of 226 ARs occur with a SBJ (84%)
- 189 out of 439 SBJs occur with an AR (43%)

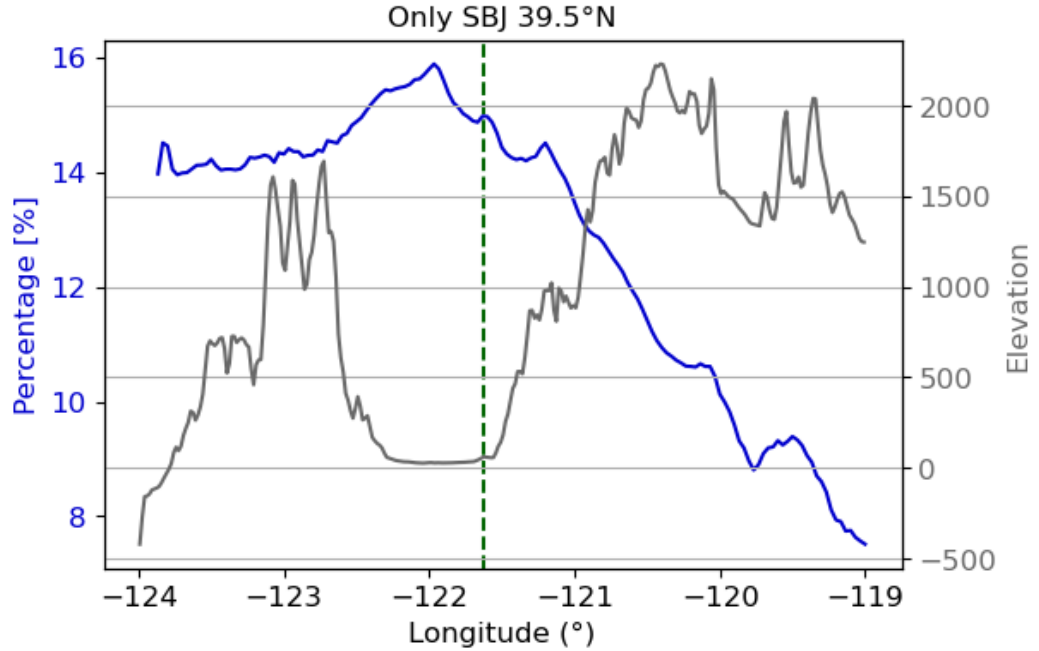
- Most ARs produce SBJs but not all SBJs are associated with ARs.

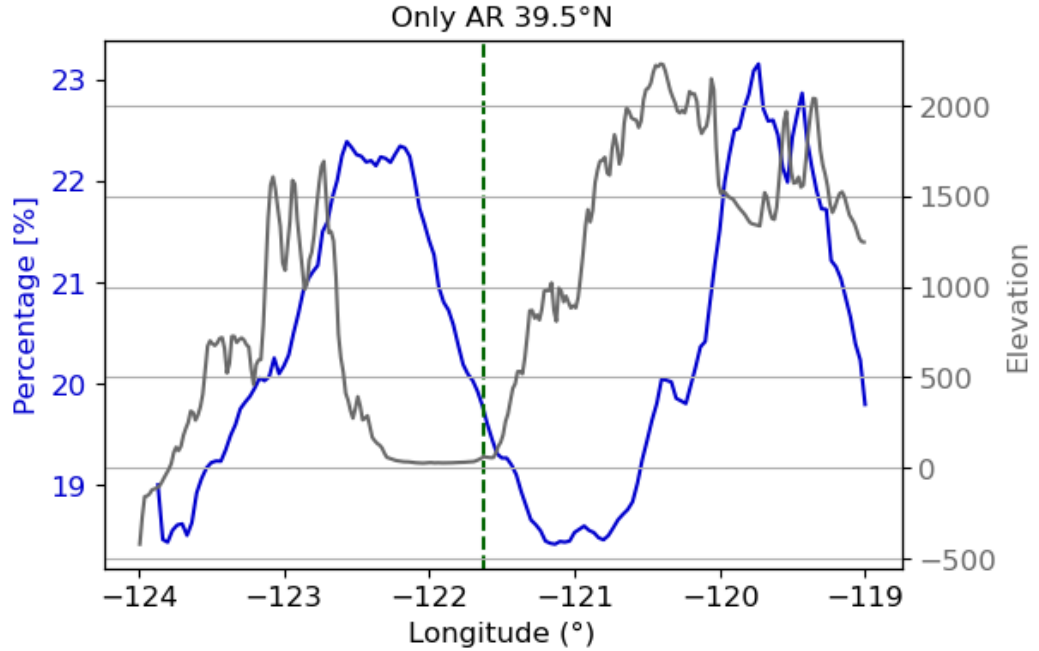


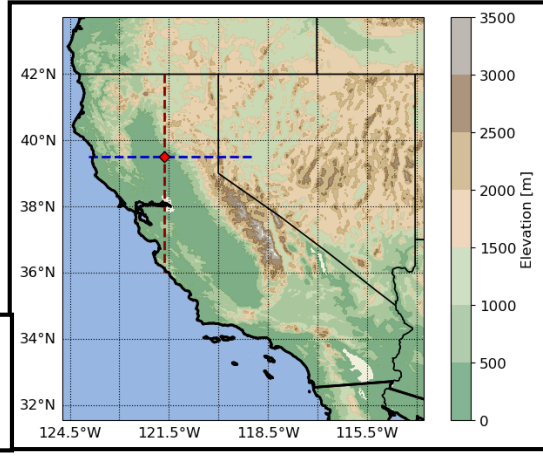
Percentage of annual precipitation



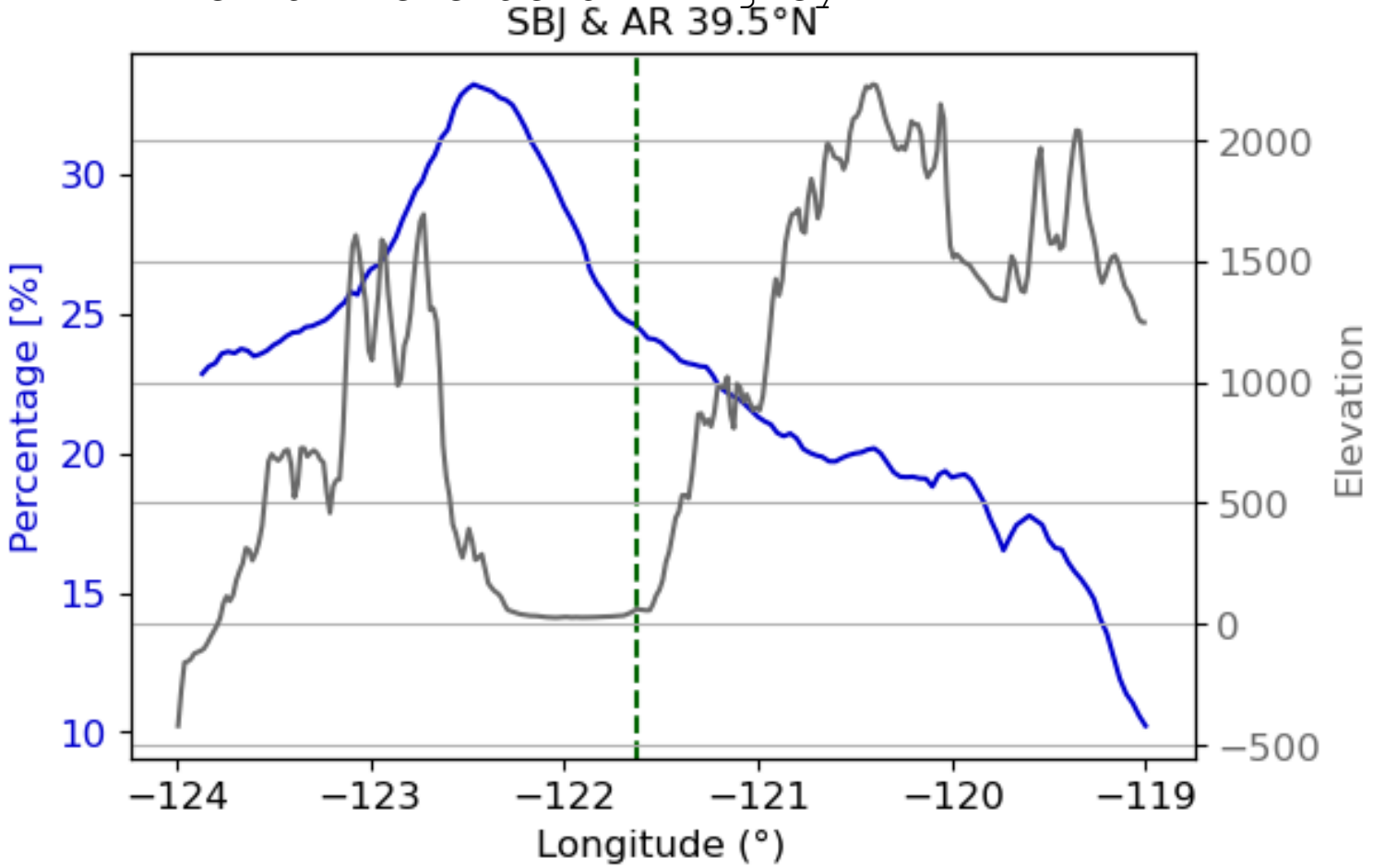
Percentage of annual precipitation – Cross sections



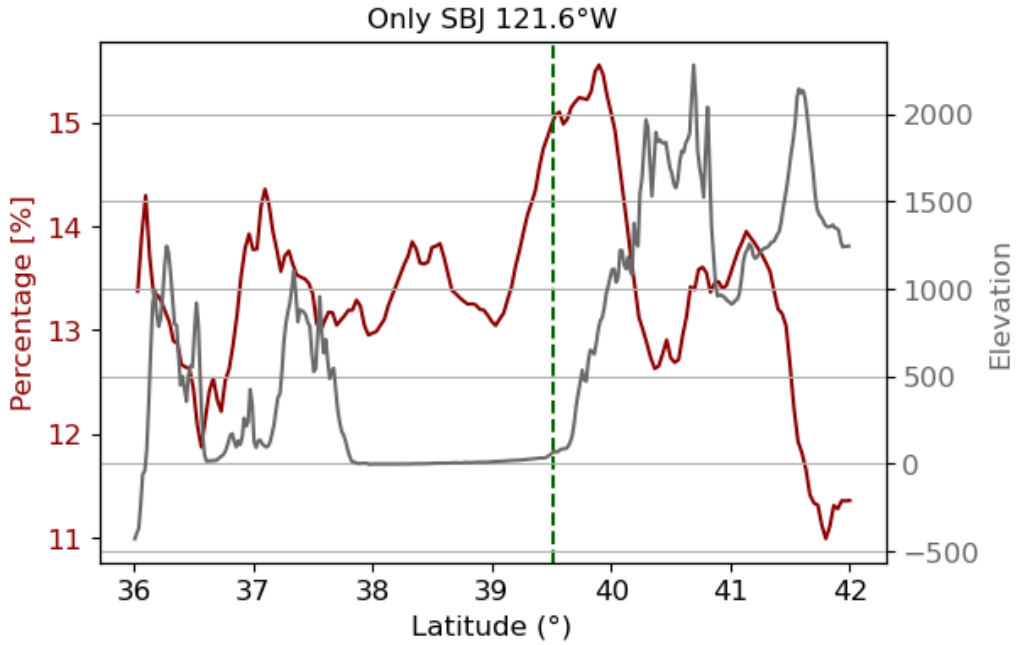


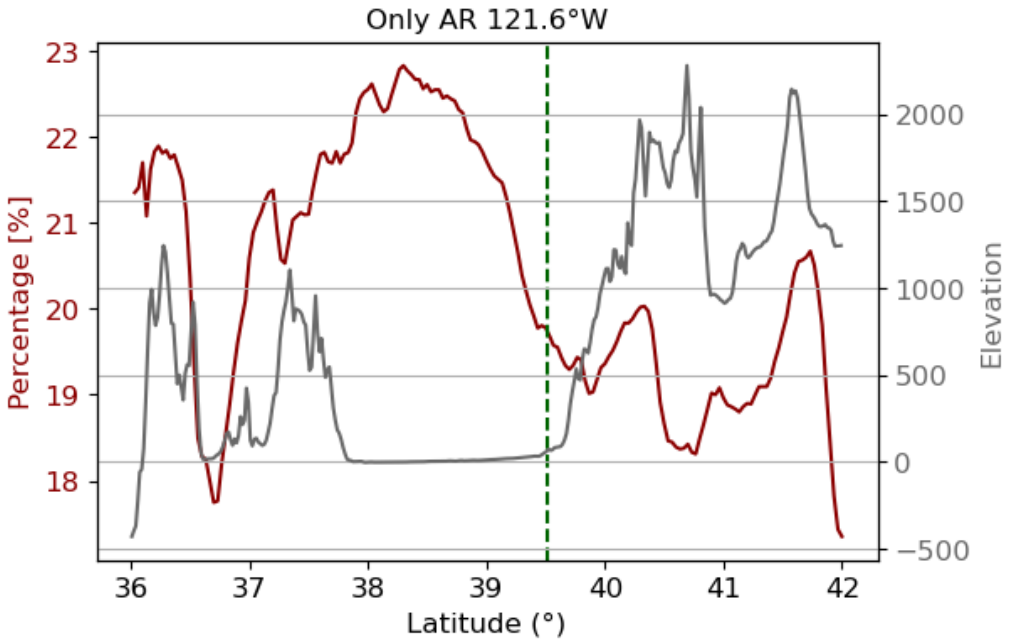


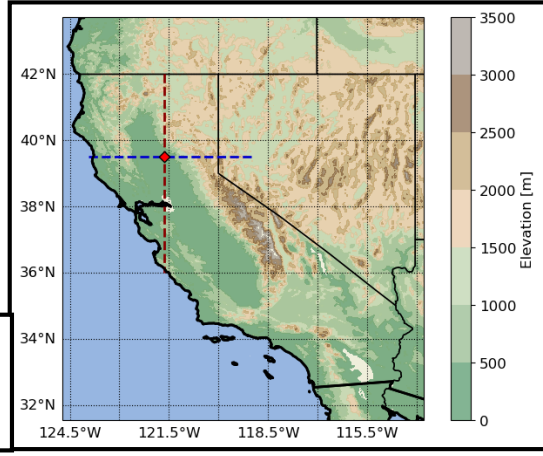
Percentage of precipitation in blue
Terrain elevation in grey



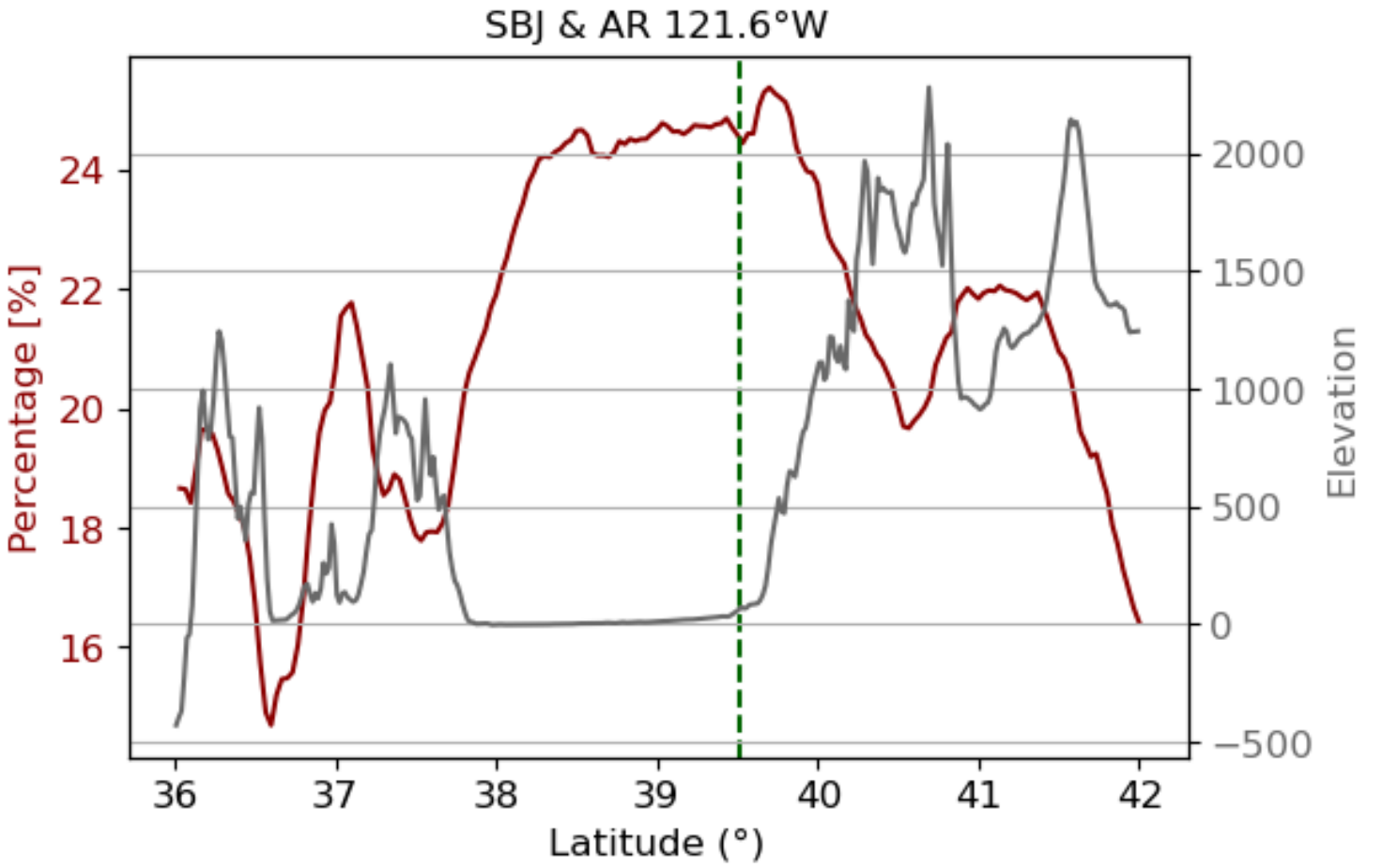
Percentage of annual precipitation – Cross sections







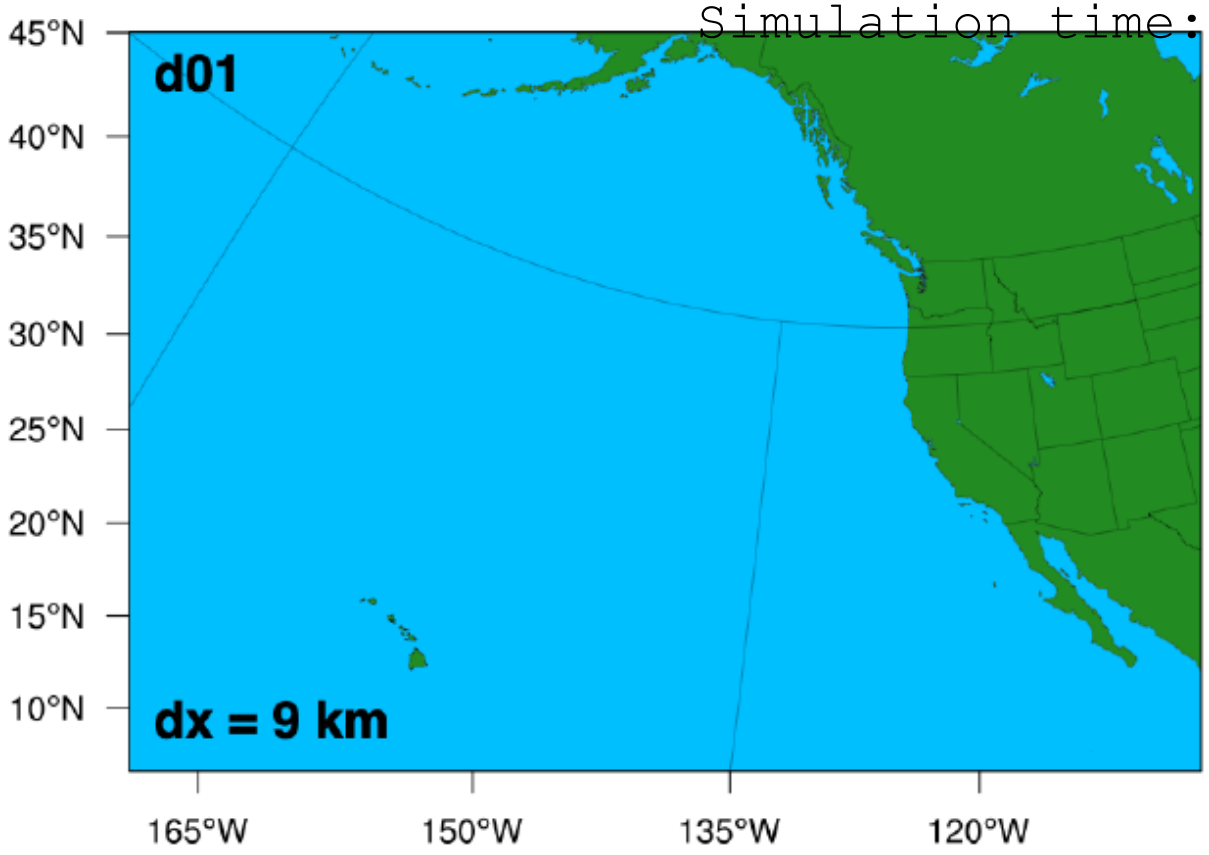
Percentage of precipitation in blue
Terrain elevation in grey



How does WRF resolves the vertical structure, intensity and duration of the SBJ?

Methodology – WRF simulation

WRF output from 10 member ensembles
2 PBL schemes used MYJ, ACM2
Start time: 2023-01-09-0000 UTC
Simulation time: 5 days



Physics Category	Scheme
Microphysics	Thompson
PBL	*varied*
Radiation	RRTMG
Cumulus	Grell-Freitas
Surface Layer	*varied w/pbl*
Land Surface	Unified Noah LSM

Single Domain Configuration	Value
dx	9000 m
ny x nx	570 x 828
nz	140 (custom)
IC/BCs	GFS GEFS (10 mem)
dt	10 s

Fig. and Tables: Kevin Lupo

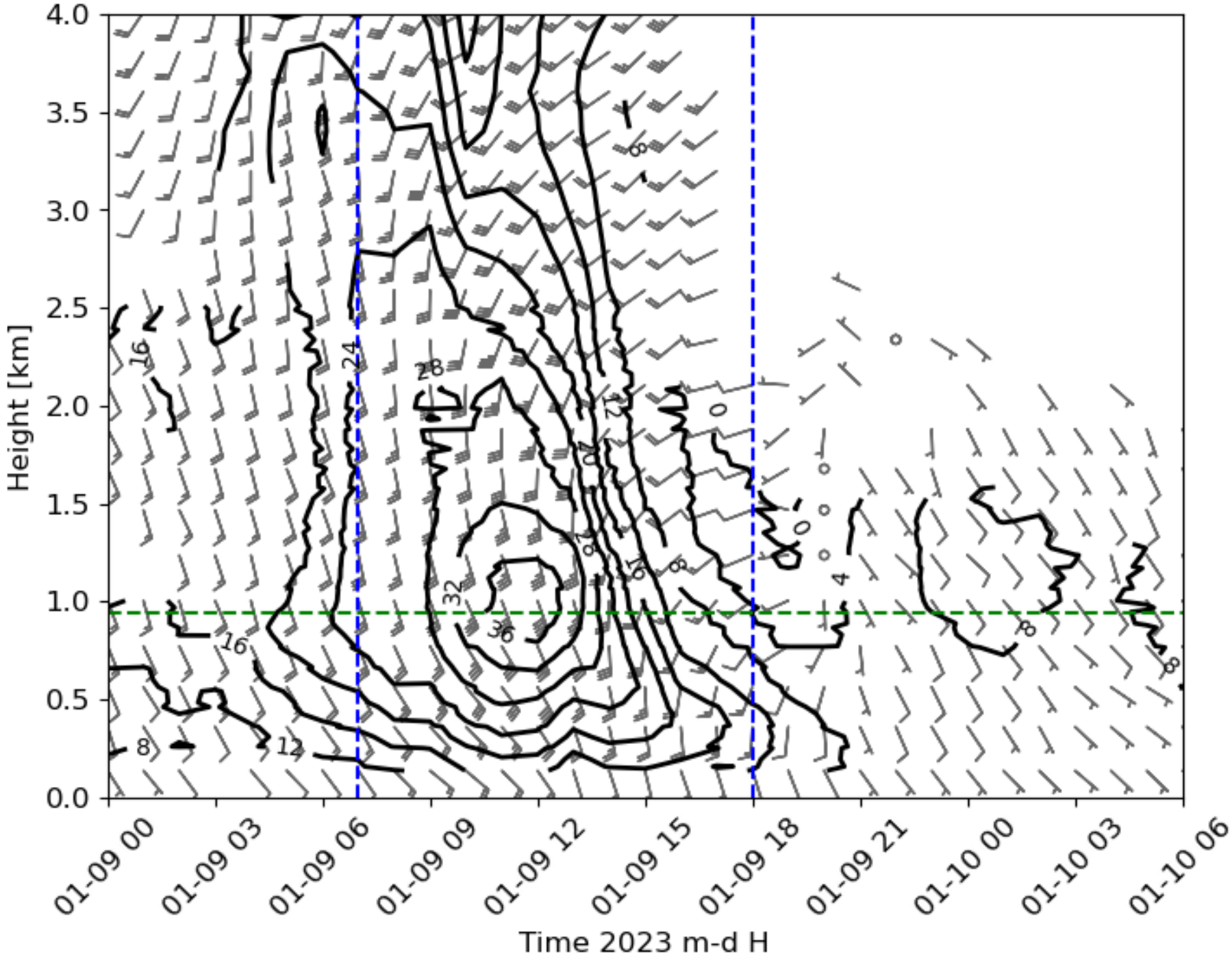
Multiphysics ensemble consists of 10 ensemble members using: YSU, **MYJ**, QNSE-EDMF, MYNN2, MYNN3, **ACM2**, UW, Shing-Hong, GBM, and BouLac PBL schemes.

Observations

V_s max = 39.7 ms^{-1}

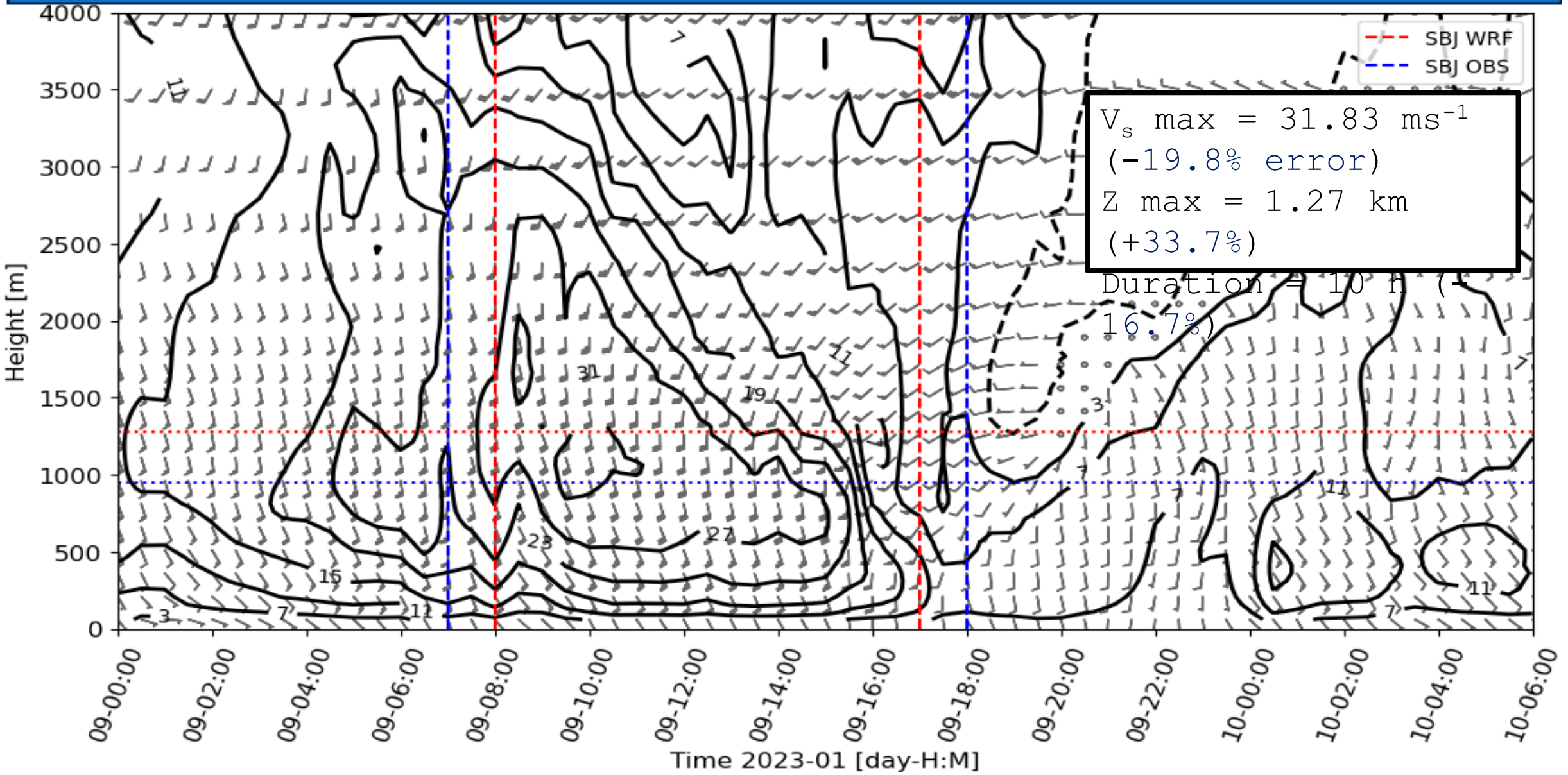
Z = 0.95 km

Duration= 12 hours



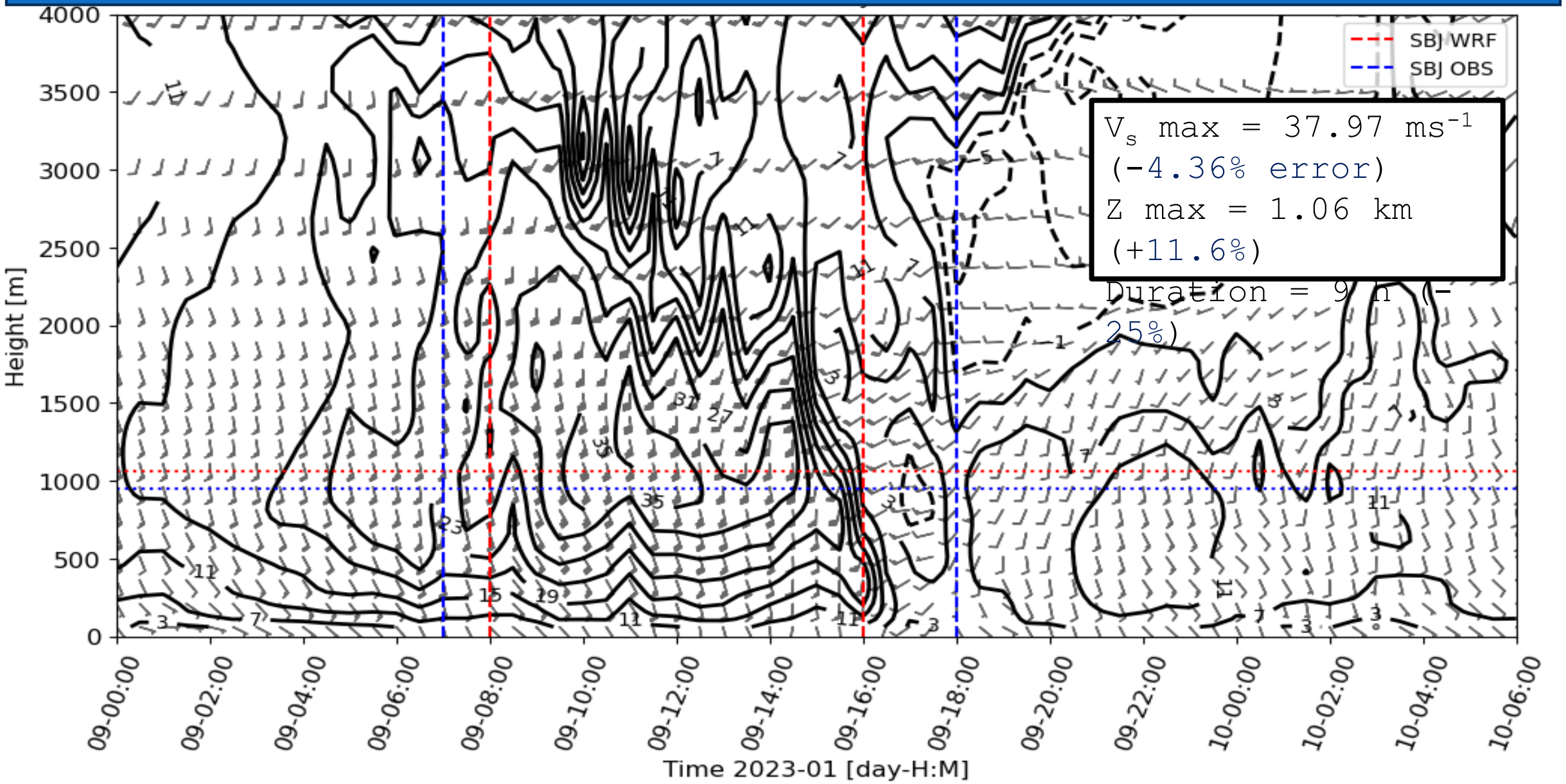
Time height wind profiles (wind barbs) and Sierra-parallel (160°) isotachs

WRF simulation - ACM2



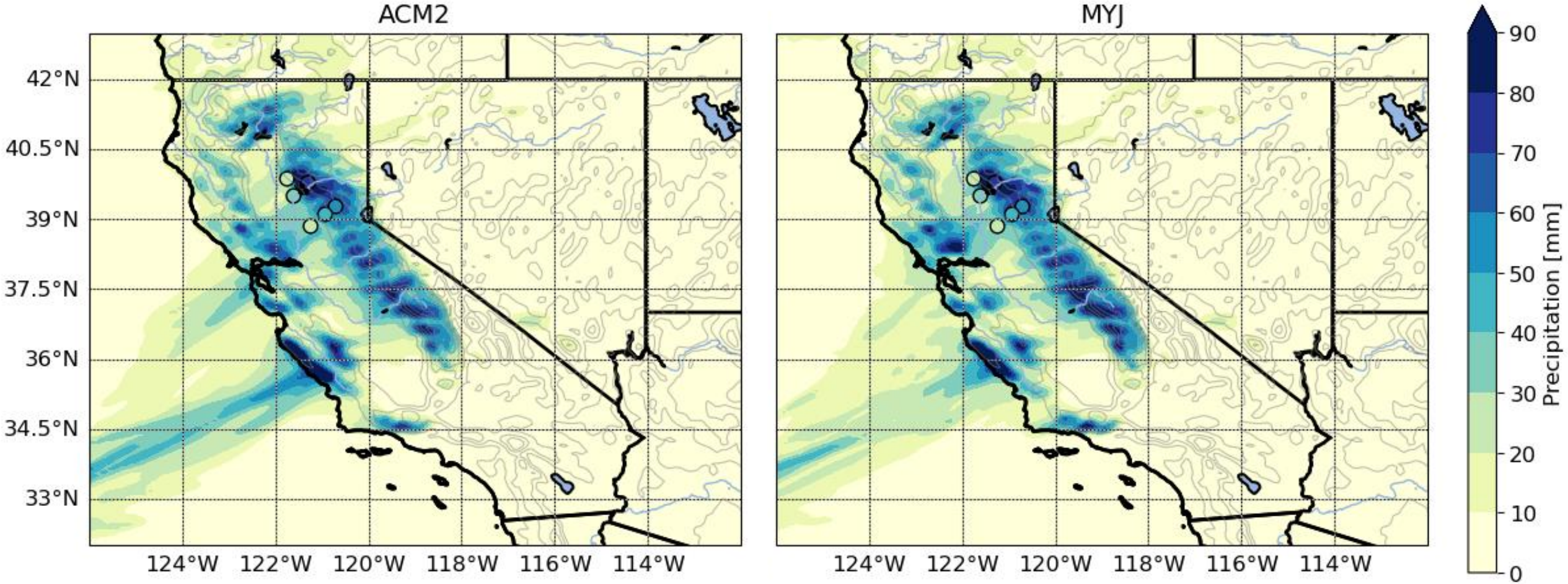
Time height wind profiles (wind barbs) and Sierra-parallel (160°) isotachs (contour)

WRF simulation - MYJ



Time height wind profiles (wind barbs) and Sierra-parallel (160°) isotachs (contour)

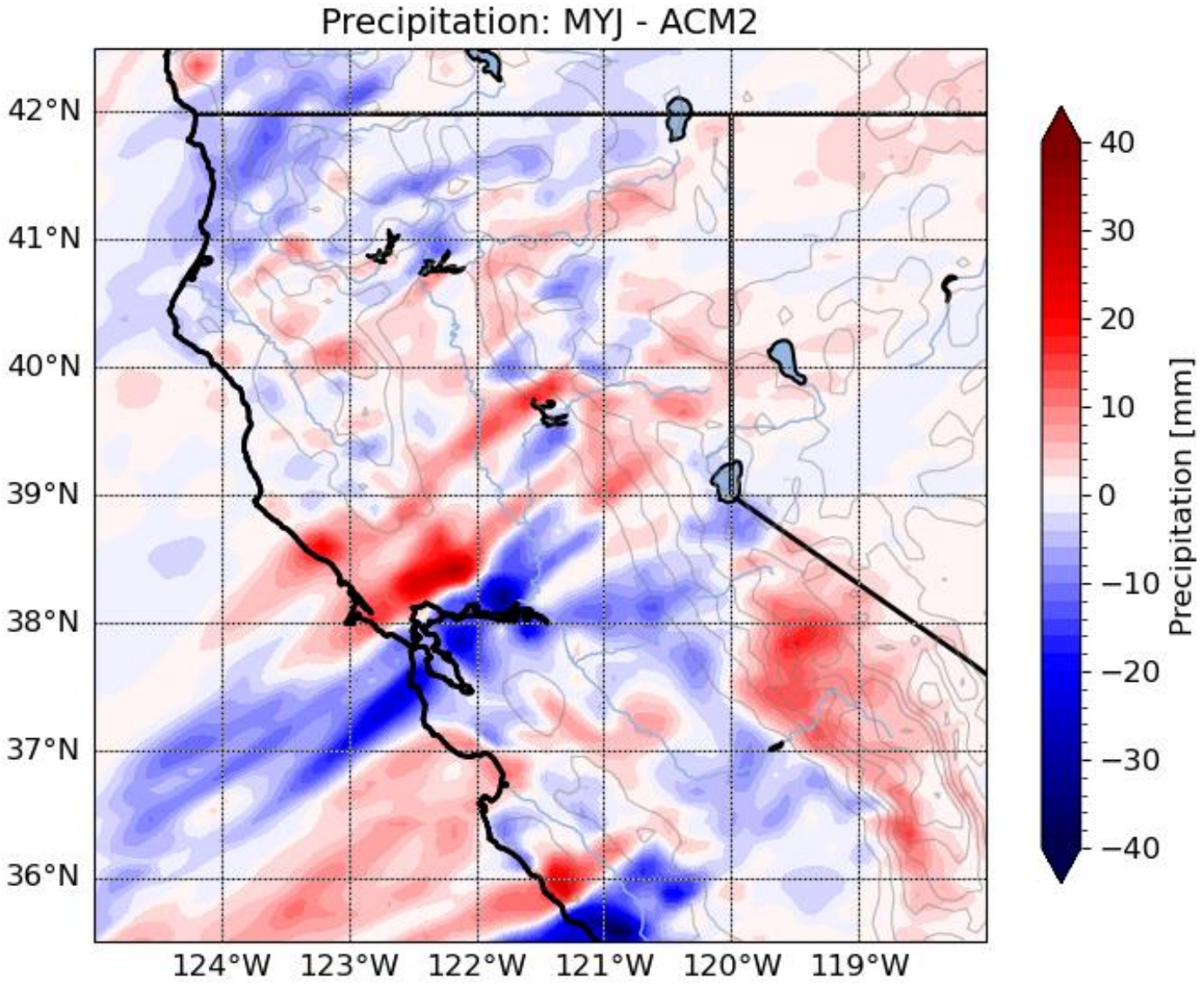
WRF simulation – Accumulated precipitation



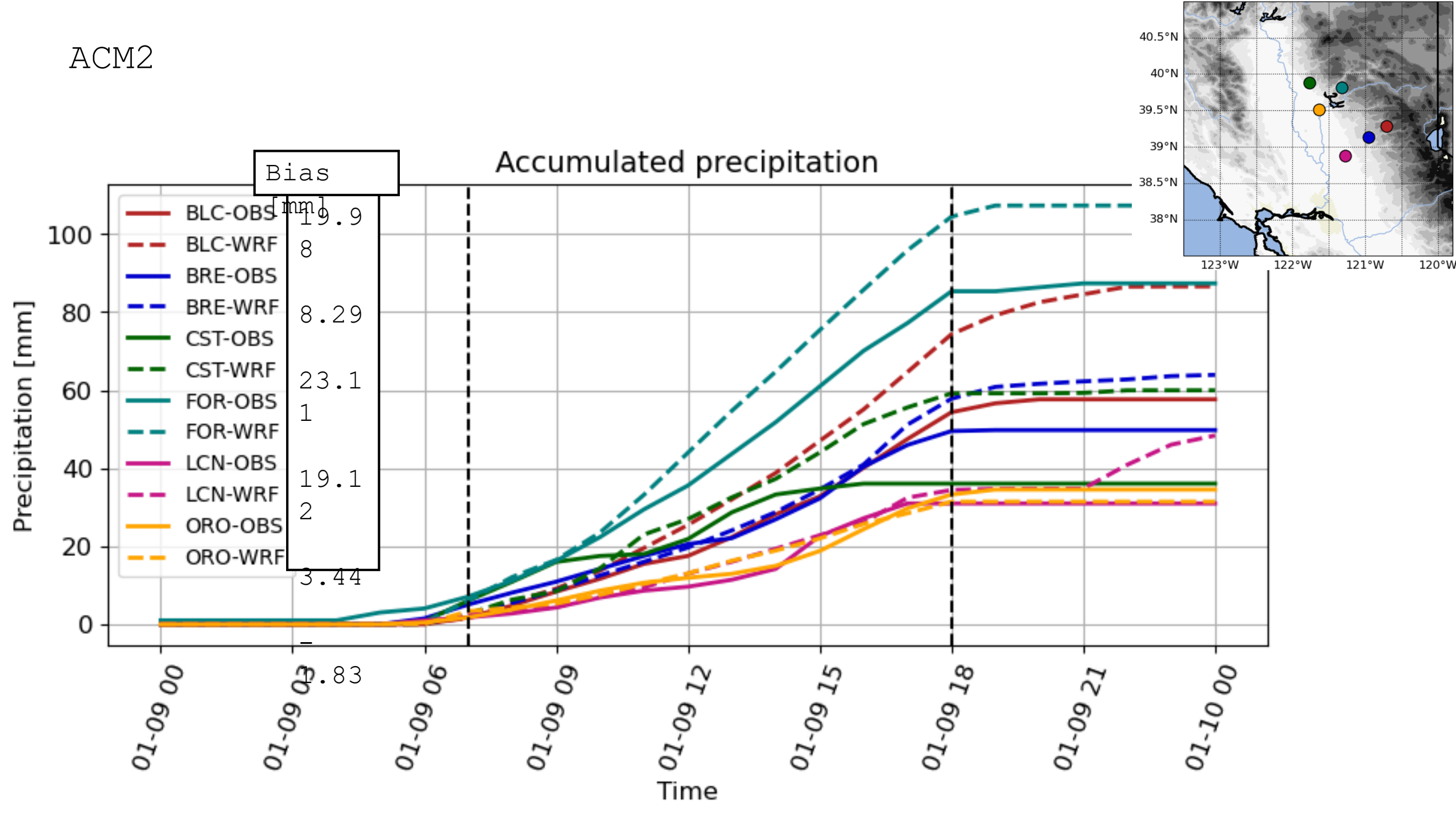
r = 0.946

r = 0.946

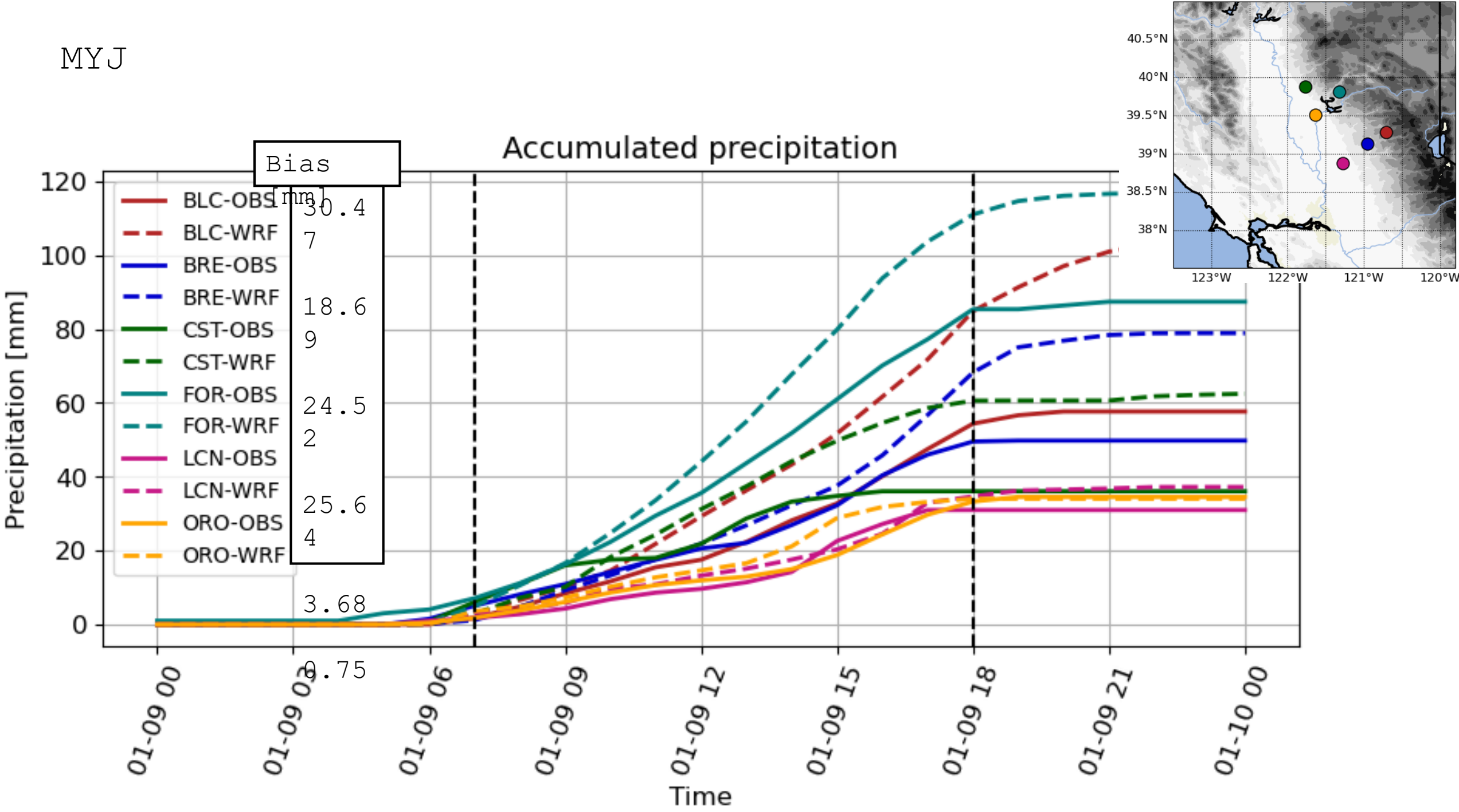
WRF simulation – Accumulated precipitation



ACM2


Accumulated precipitation
Bias [mm]
BLC-OBS 19.98
BLC-WRF
BRE-OBS 8.29
BRE-WRF
CST-OBS 23.11
CST-WRF
FOR-OBS 19.12
FOR-WRF
LCN-OBS 3.44
LCN-WRF
ORO-OBS -3.83
ORO-WRF
Precipitation [mm]
0
20
40
60
80
100
01-09 00
01-09 03
01-09 06
01-09 09
01-09 12
01-09 15
01-09 18
01-09 21
01-10 00
Time
40.5°N
40°N
39.5°N
39°N
38.5°N
38°N
123°W
122°W
121°W
120°W

MYJ


Accumulated precipitation
Bias [mm]
BLC-OBS
BLC-WRF
BRE-OBS
BRE-WRF
CST-OBS
CST-WRF
FOR-OBS
FOR-WRF
LCN-OBS
LCN-WRF
ORO-OBS
ORO-WRF
30.47
18.69
24.52
25.64
3.68
9.75
Precipitation [mm]
Time
01-09 00
01-09 03
01-09 06
01-09 09
01-09 12
01-09 15
01-09 18
01-09 21
01-10 00
40.5°N
40°N
39.5°N
39°N
38.5°N
38°N
123°W
122°W
121°W
120°W

Conclusions

What is frequency and characteristics of SBJ over windward slopes of Sierra and Shasta-Trinity Alps?

- 439 events 2001-2023
- Characteristics: Vs=25.6 ms-1, Duration= 14.2 h, Elevation=1.05 km

What is the relationship between landfalling ARs and SBJ?

- 189 SBJ events occur in conjunction with ARs (43%)
- 189 ARs events occur in conjunction with SBJ

How is annual precipitation influenced by SBJ and ARs?

- Only SBJ events : up to 16%
- Only ARs events: up to 23%

How does WRF resolves the vertical structure, intensity and duration of the SBJ?

- MYJ PBL scheme simulates a closer Vmax of the SBJ (-4.4% error), with also a similar elevation (+11.6% error).
- Although ACM2 was better at capturing the duration (-16.7% error)