Downslope windstorms in coastal Santa Barbara from observations and numerical simulations

Gert-Jan Duine[1]
Leila MV Carvalho[1,2]
Charles Jones[1,2]
Katelyn Zigner[2]

[1]Earth Research Institute
[2]Department of Geography
UC Santa Barbara, CA, USA

UC SANTA BARBARA

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duine@eri.ucsb.edu

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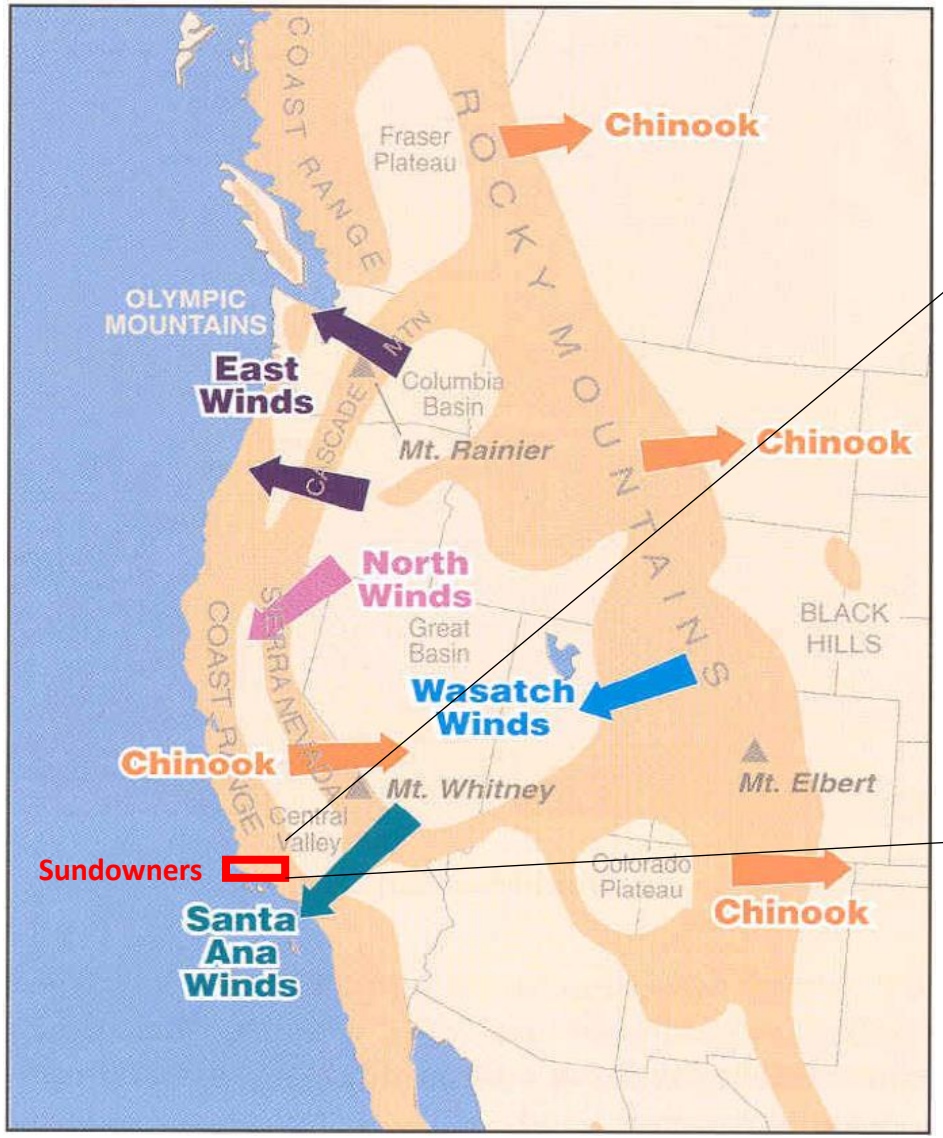
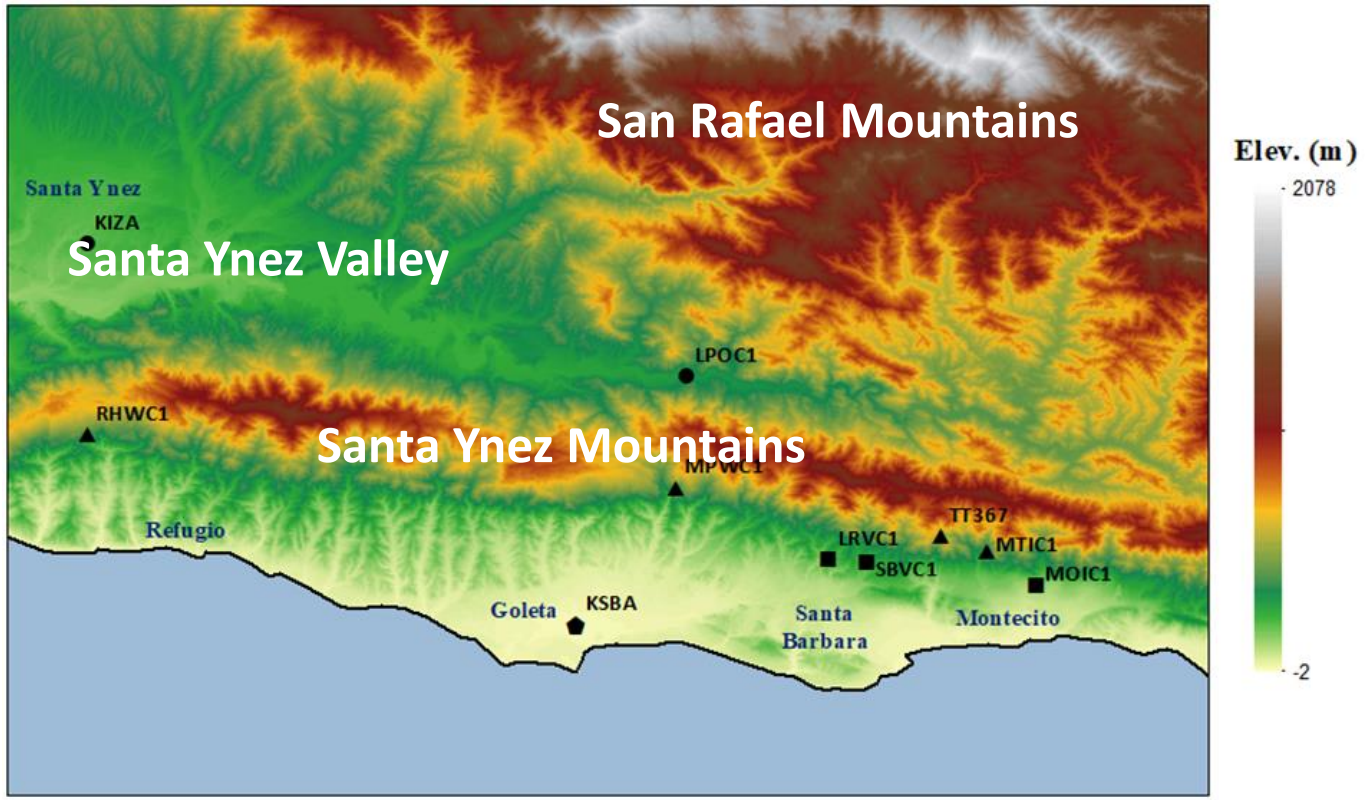
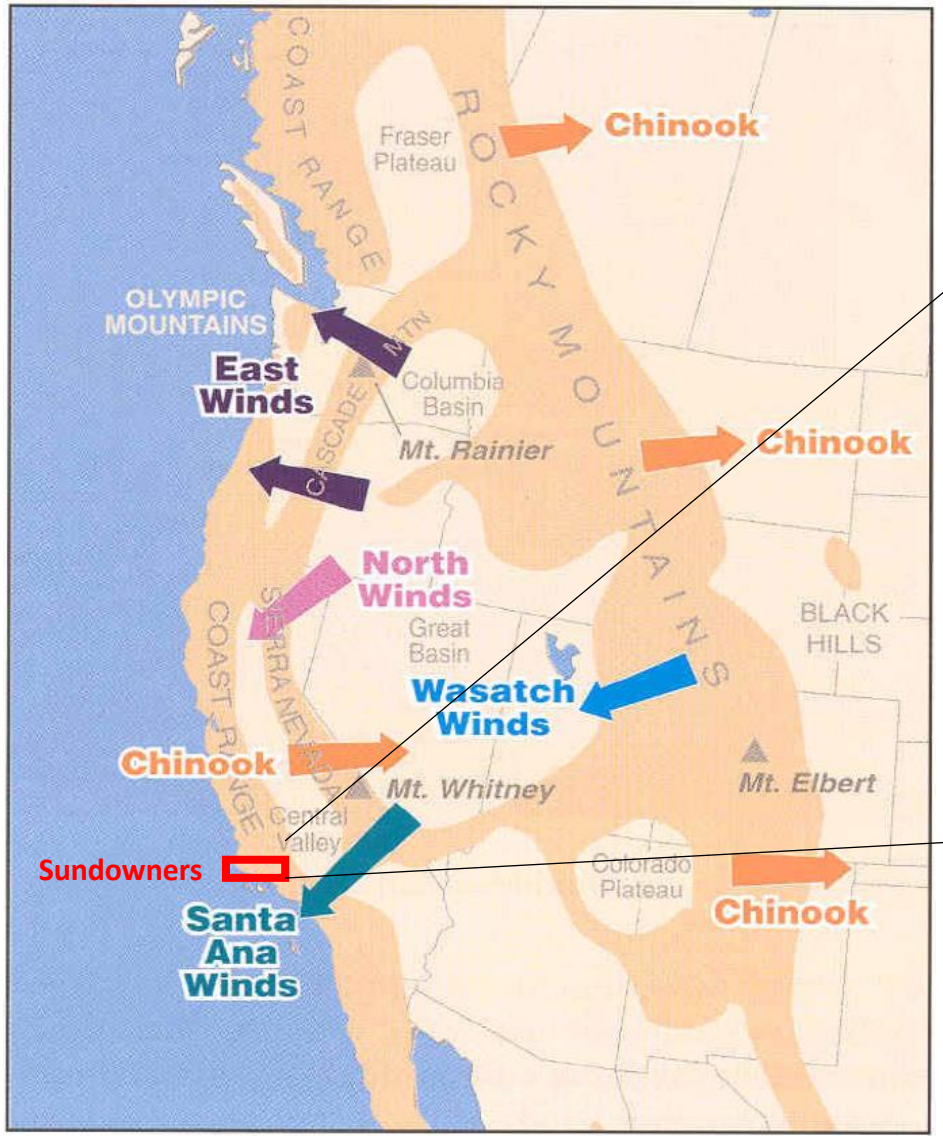
Photo of Cave Fire
November 25, 2019
Photo credit: Tracy Linn

Sundowners: downslope windstorms in Santa Ynez Mountains





Largest wildfires in SBA have intensified under influence of Sundowners



Sundowners intensify wildfires

Name implies a relation to sunset

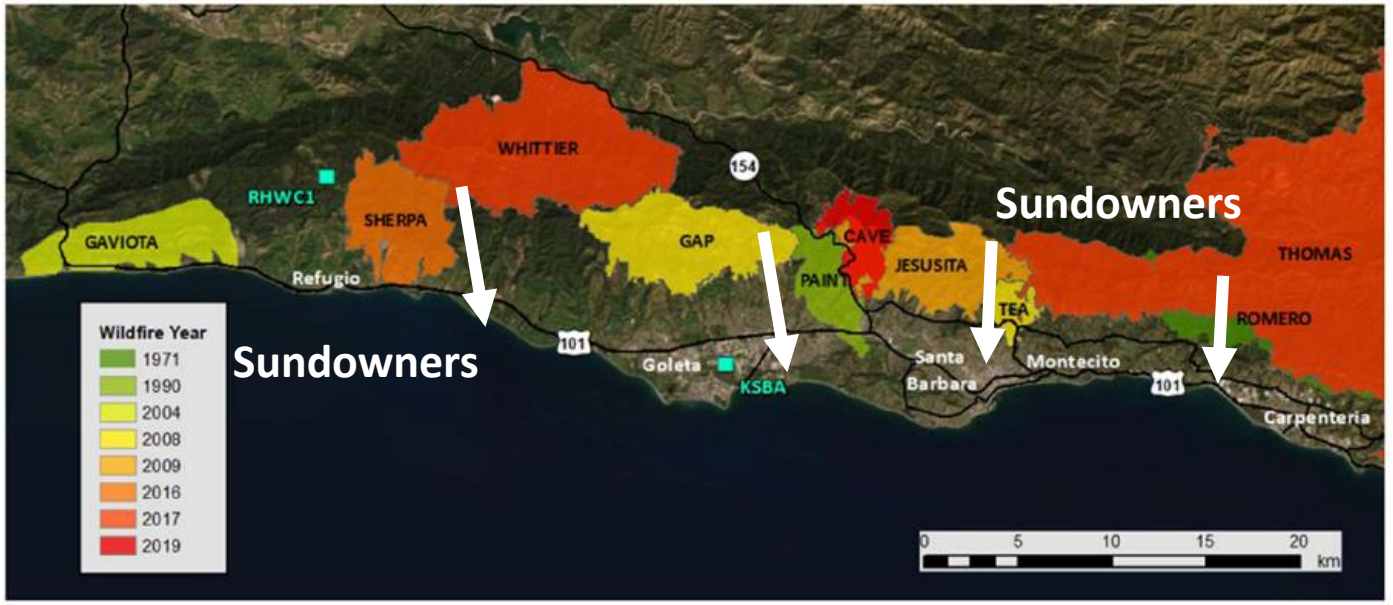


Figure adopted from Zigner, K. and co-authors. Evaluating fire models Evaluating the Ability of FARSITE to Simulate Wildfires Influenced by Extreme, Downslope Winds in Santa Barbara, California, *Fire, minor revisions.*

What is known?

Sundowners …

… peak from late afternoon and last through early morning (Hatchett, 2018; Carvalho 2020)

… are associated with mountain waves and wave breaking (Blier, 1998; Smith 2018; Carvalho 2020)

… increase temperature and decrease RH, in some cases (Hatchett, 2018)

… occur year-round, with a highest frequency in Spring months (Smith 2018, Jones, in revision)

… characteristics differ from case to case (Cannon et al 2017, Duine et al. 2019)

… can be predicted on synoptic scale by MSLP gradient (Ryan 1996; Sukup 2016)

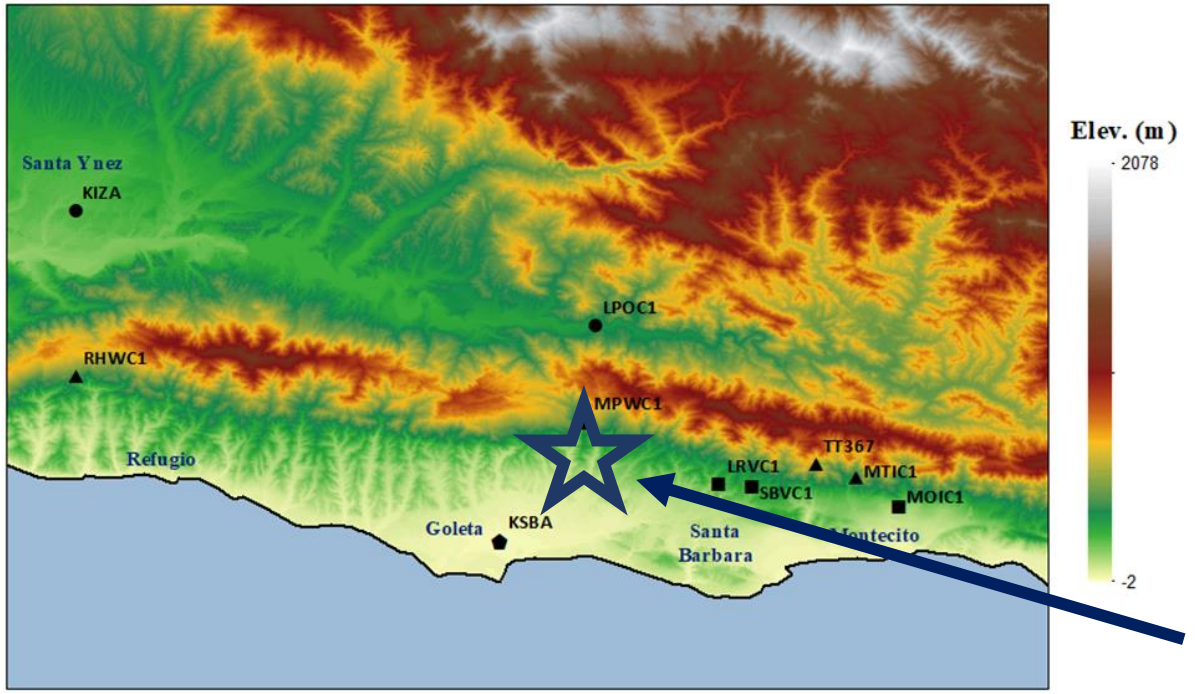
… can be subclassifed in three different regimes: western, eastern, SBA regime (Jones et al. in revision)

→ See talk 6.5: Climatology of Sundowner winds (Charles Jones)

… are spatiotemporally highly variable along the Santa Ynez Mountains → <u>this talk</u>

SWEX pilot experiment

- Sundowner Winds EXperiment
- April 28/29 2018
- 3-hourly radiosoundings in the lee of Santa Ynez Mountains
- Goal: evaluate critical mechanisms for lee slope winds using observations
- Results showed remarkable spatiotemporal differences in the lee of SYM
- WRF simulations (details in Duine et al. 2019)



Santa Barbara Fire Department Headquarters

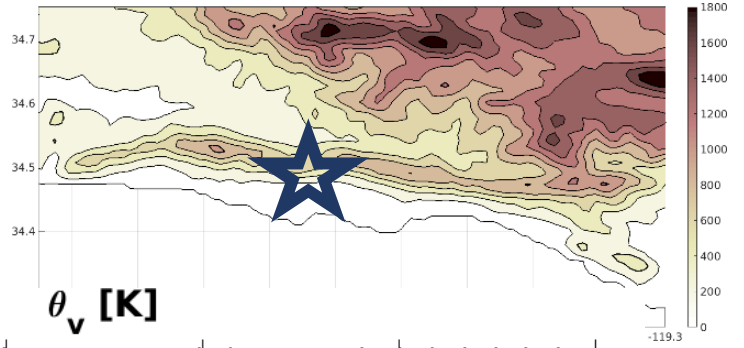
Investigate the role of upstream terrain and cross-barrier flow direction on diurnal variability of Sundowners

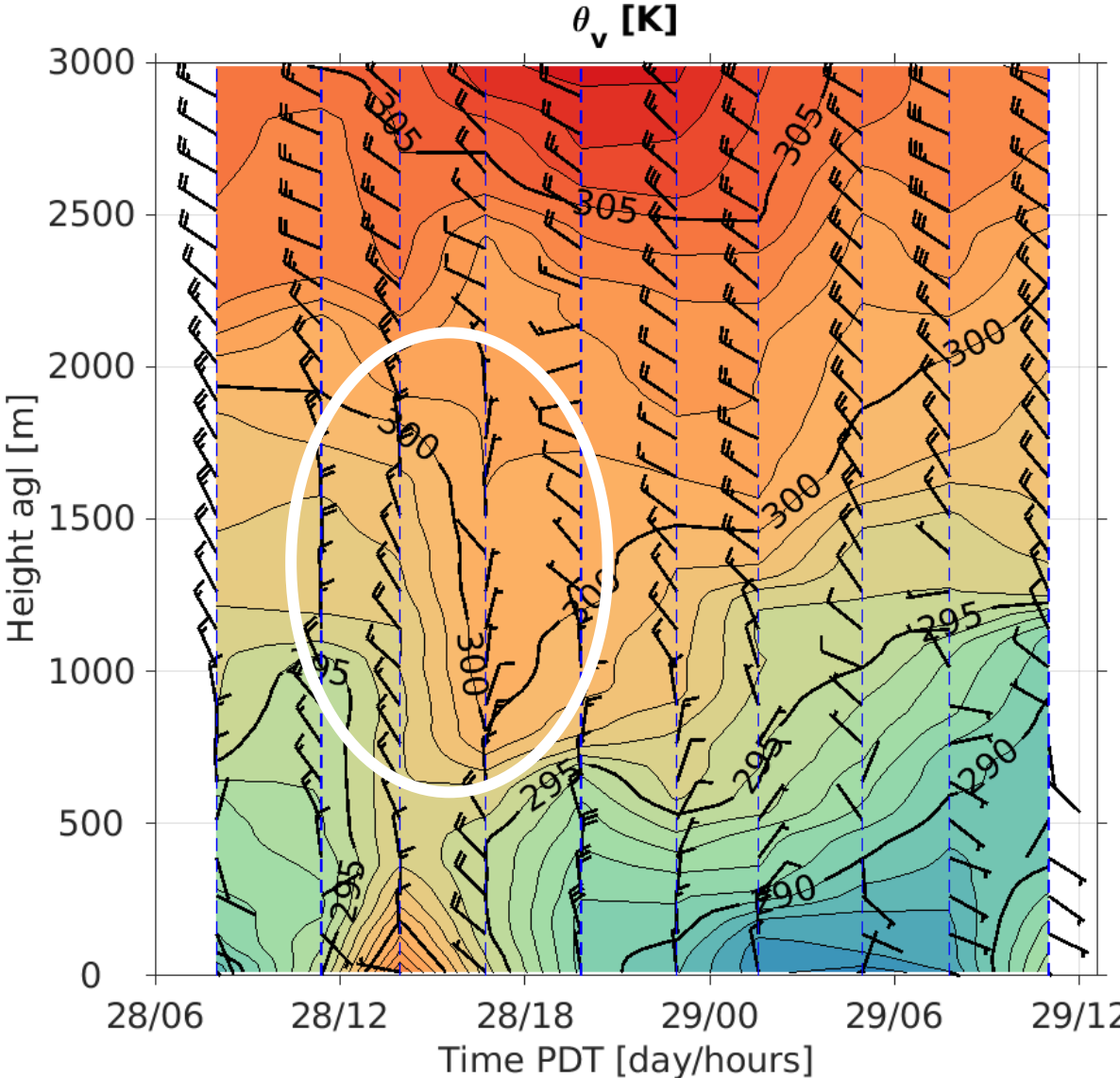
Further reading:

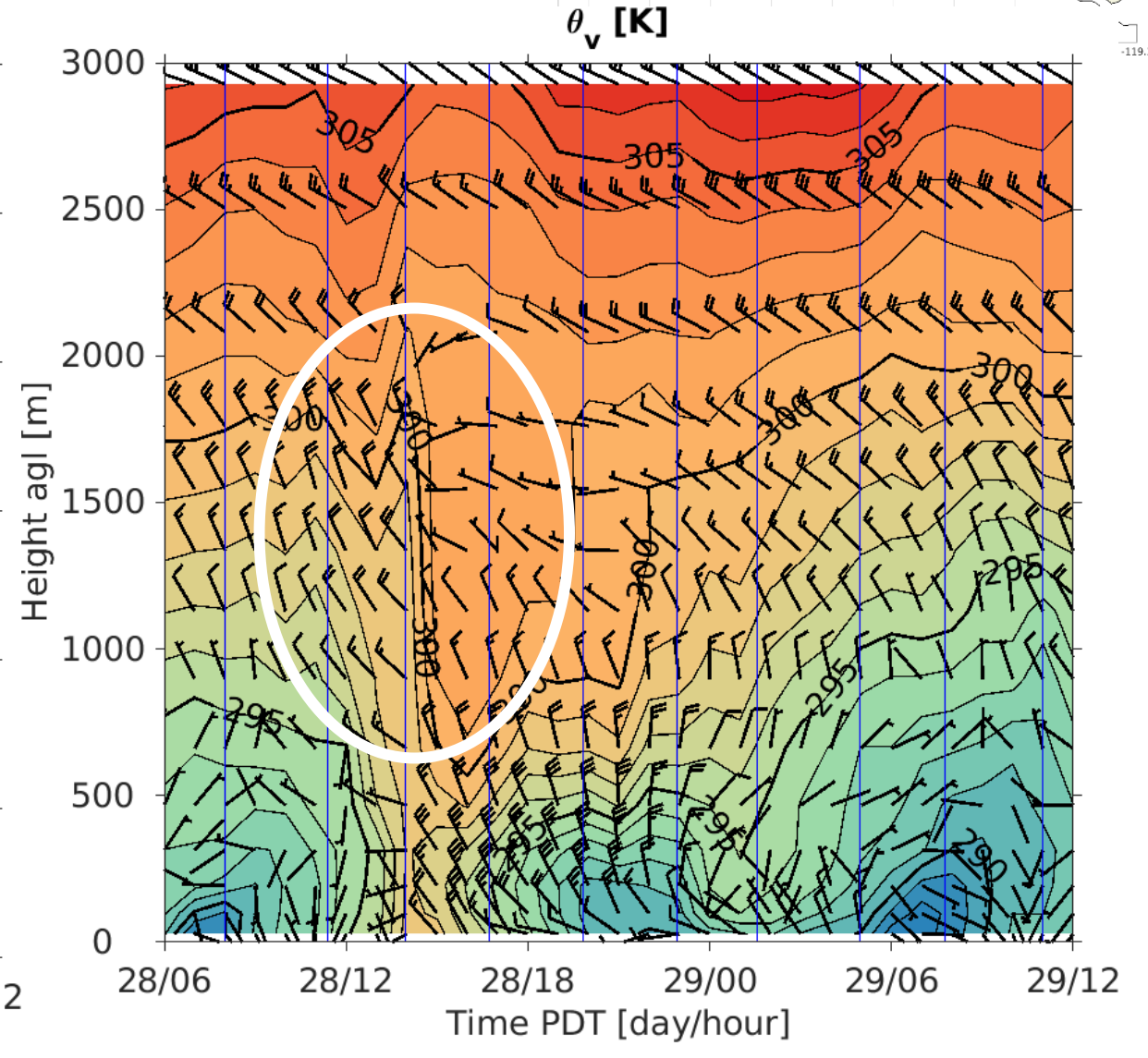
Carvalho, L.M.V., G.J. Duine, C. Jones, K. Zigner, C. Clements, H. Kane, C. Gore, G. Bell, B. Gamelin, D. Gomberg, T. Hall, M. Jackson, J. Dumas, E. Boldt, R. Hazard and W. Enos, 2020: The Sundowner Winds Experiment (SWEX) Pilot Study: Understanding Downslope windstormsin the Santa Ynez Mountains, Santa Barbara, California. *Mon. Wea. Rev.*, 148 (4), 1519–1539.

Observations vs. model

Carvalho et al. 2020





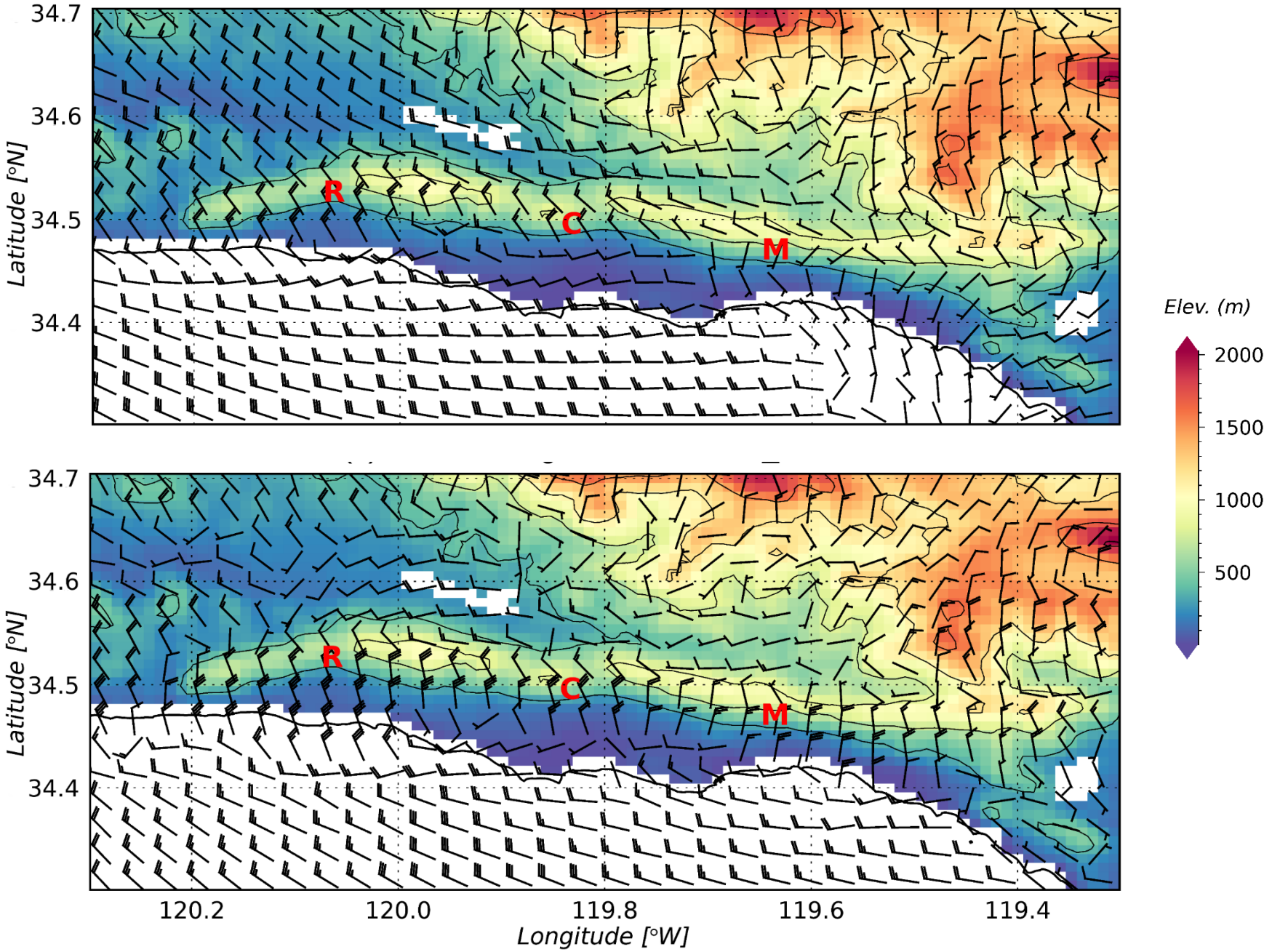


Spatial variability of 10 m winds

April 28 12:00 PST

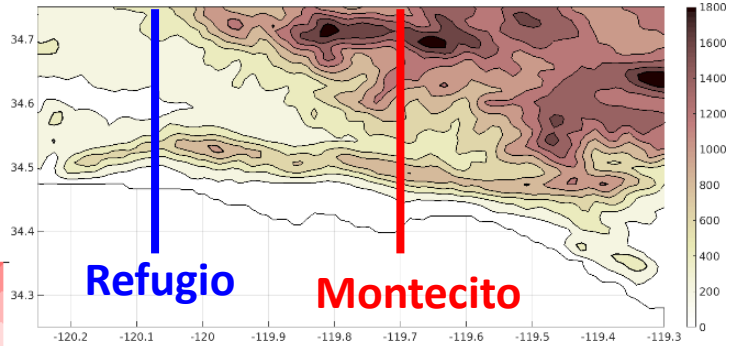
April 28 20:00 PST

Strongest in western SYM:
35 knots ~ 18 m/s



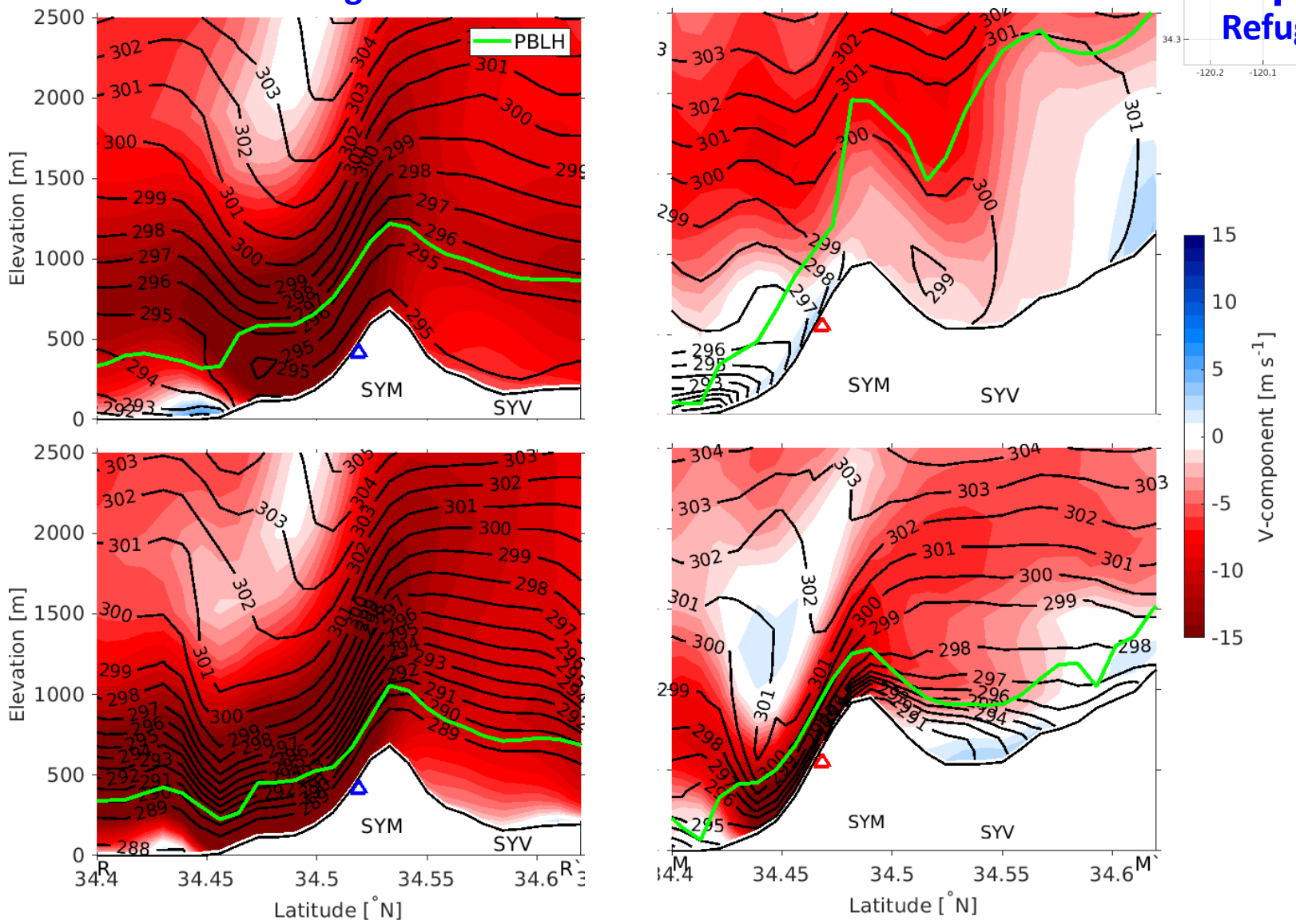
Variability of θ_v, winds and PBL along SYM range

April 28-29 2018



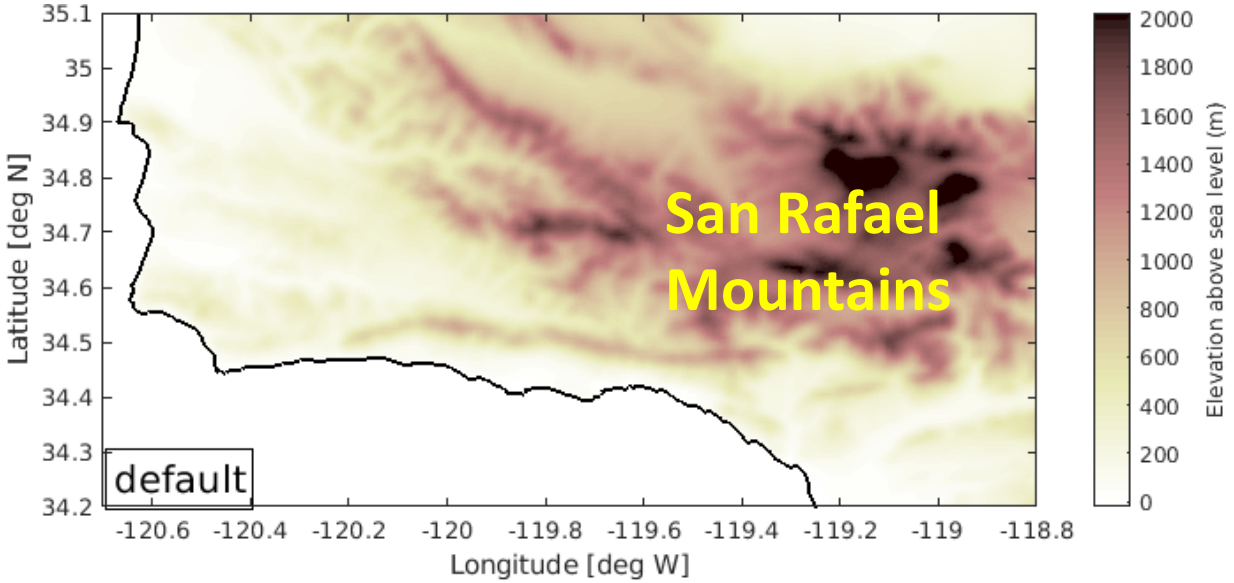
Noon

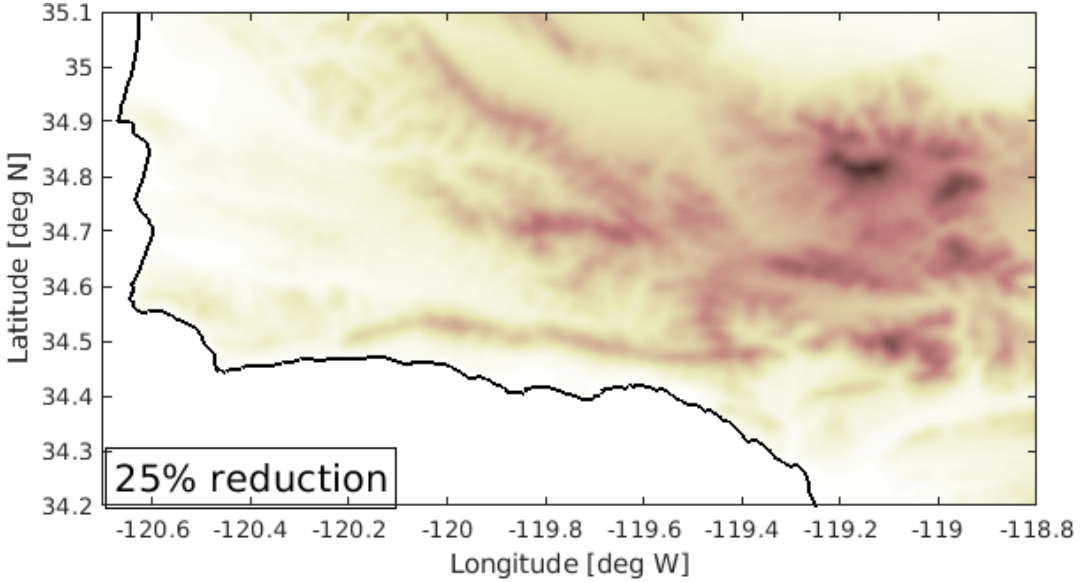
18 PST

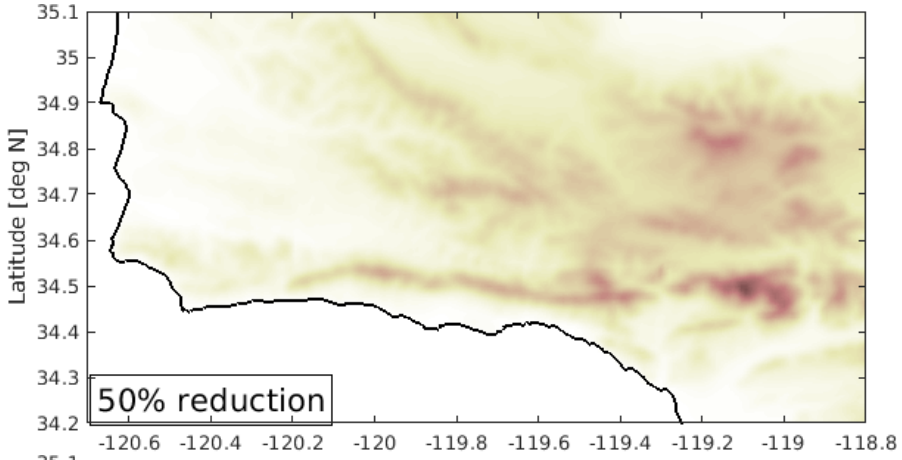


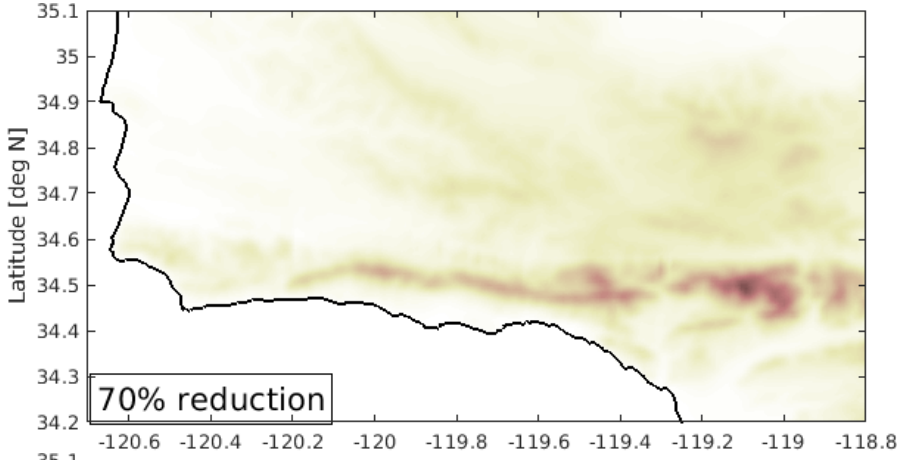
Altering the terrain upstream of SYM to investigate diurnal manifestation of Sundowner winds

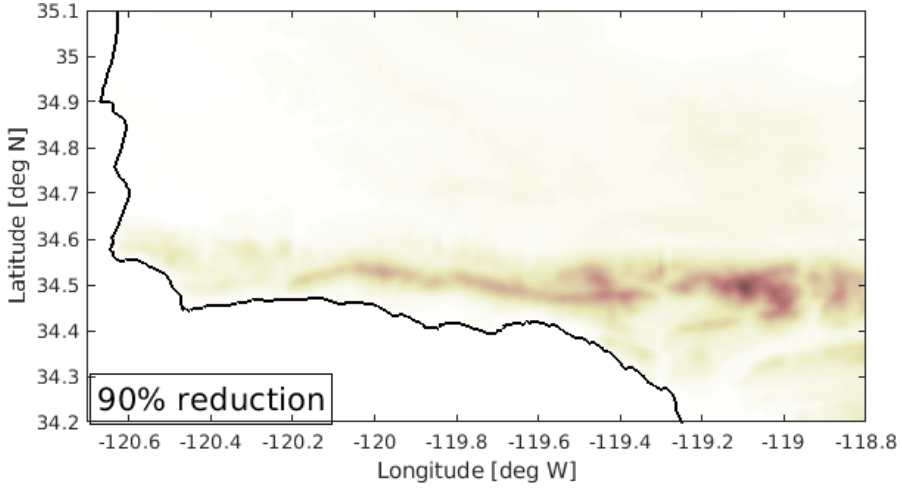
Duine et al. in preparation





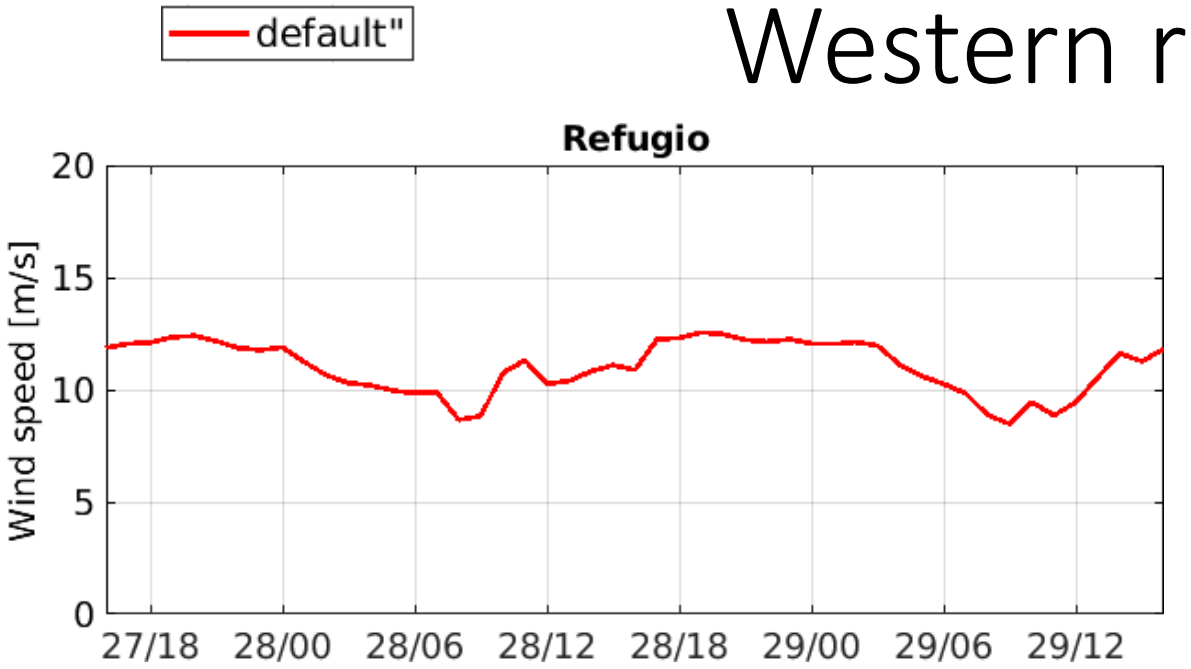


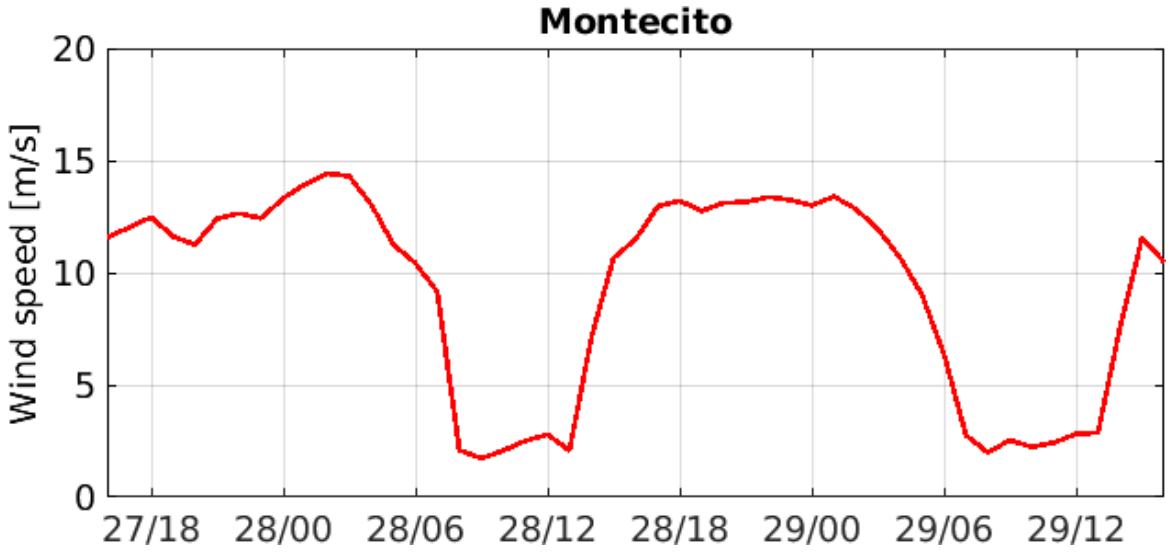




Duine et al. in preparation

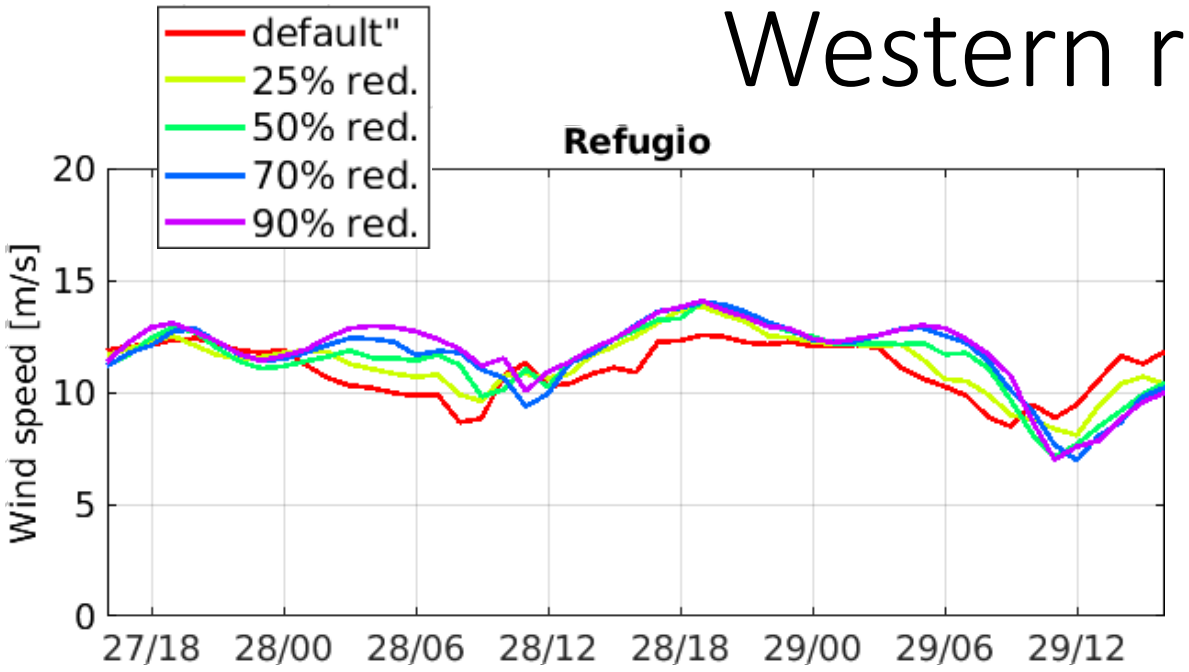
Western regime case

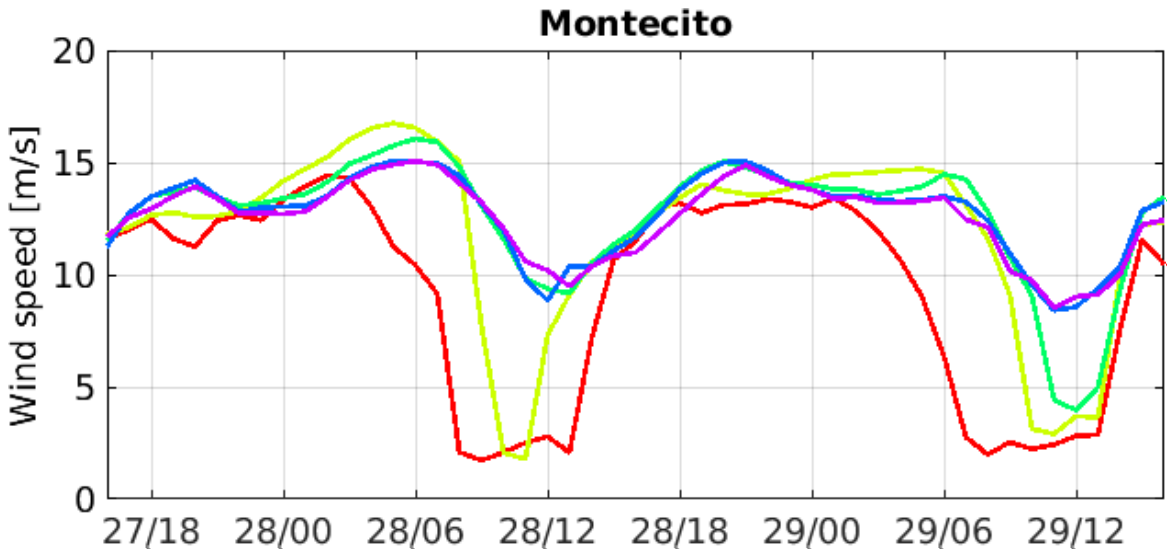




Duine et al. in preparation

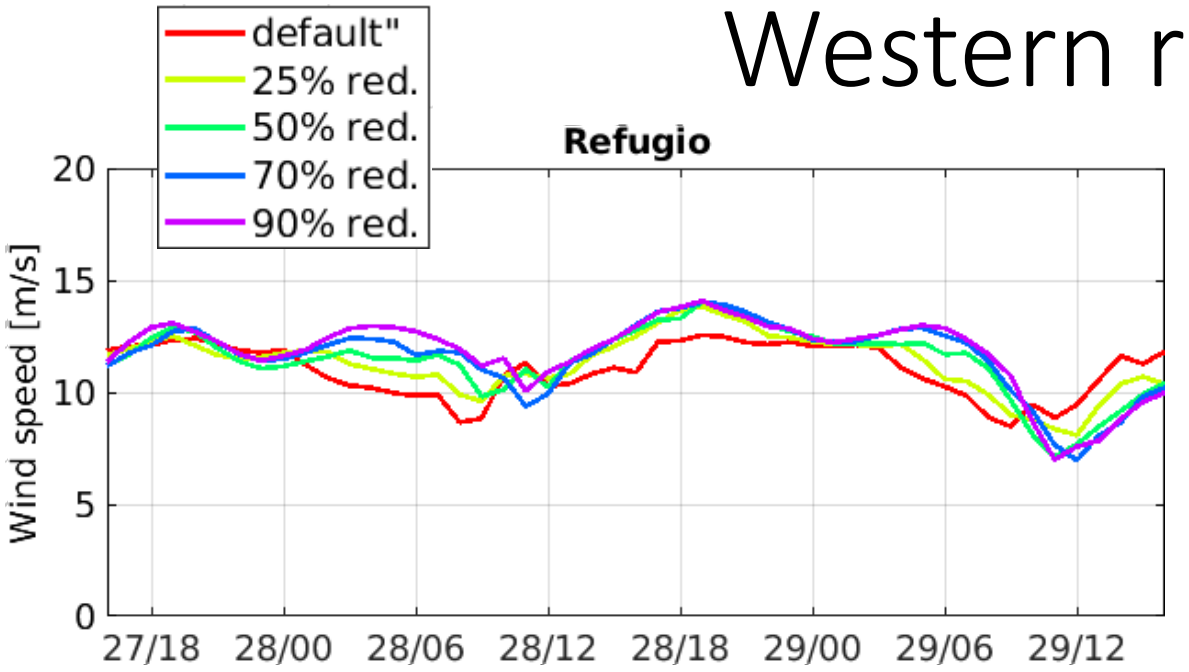
Western regime case

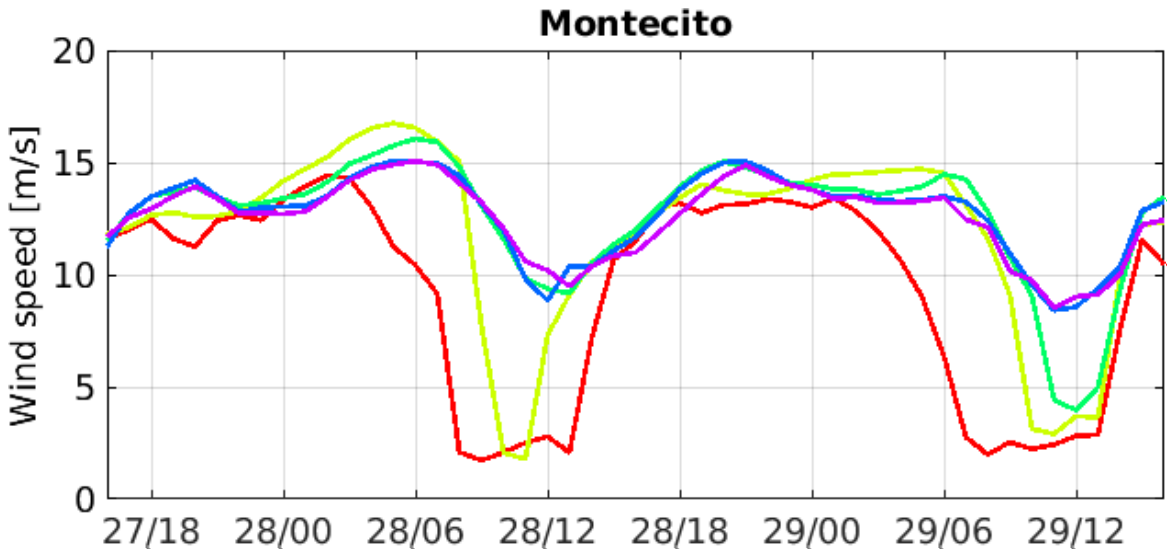


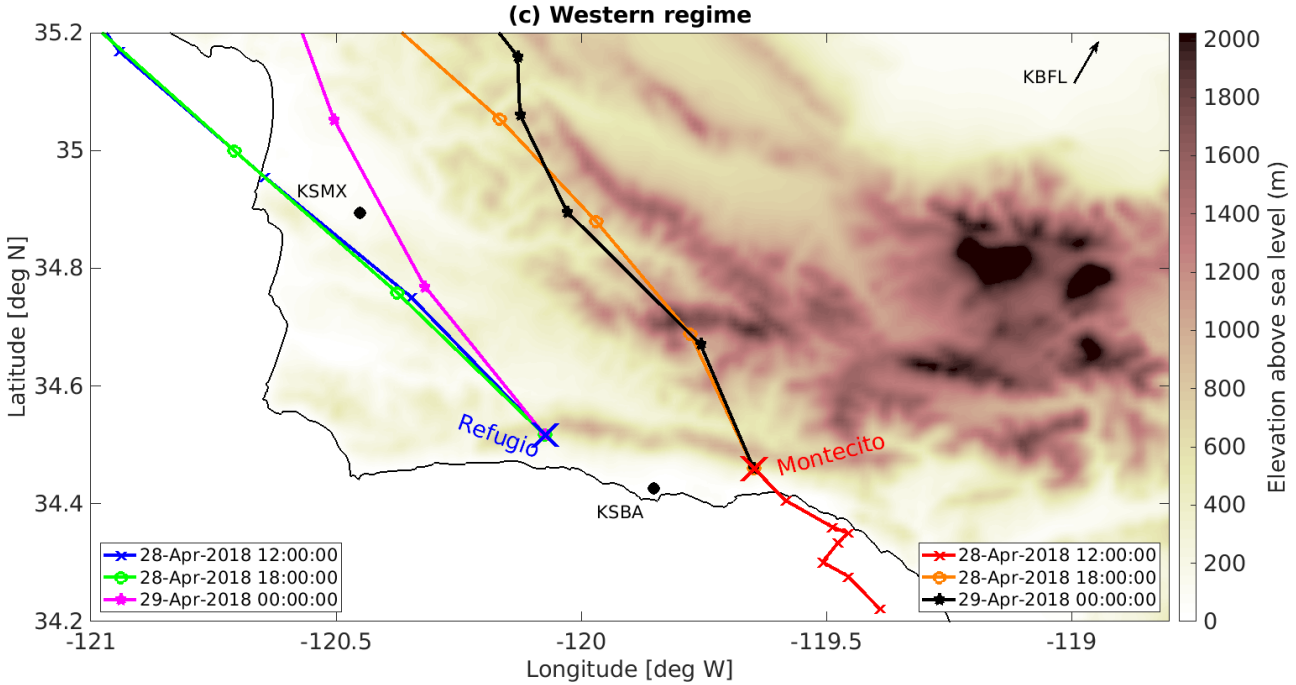


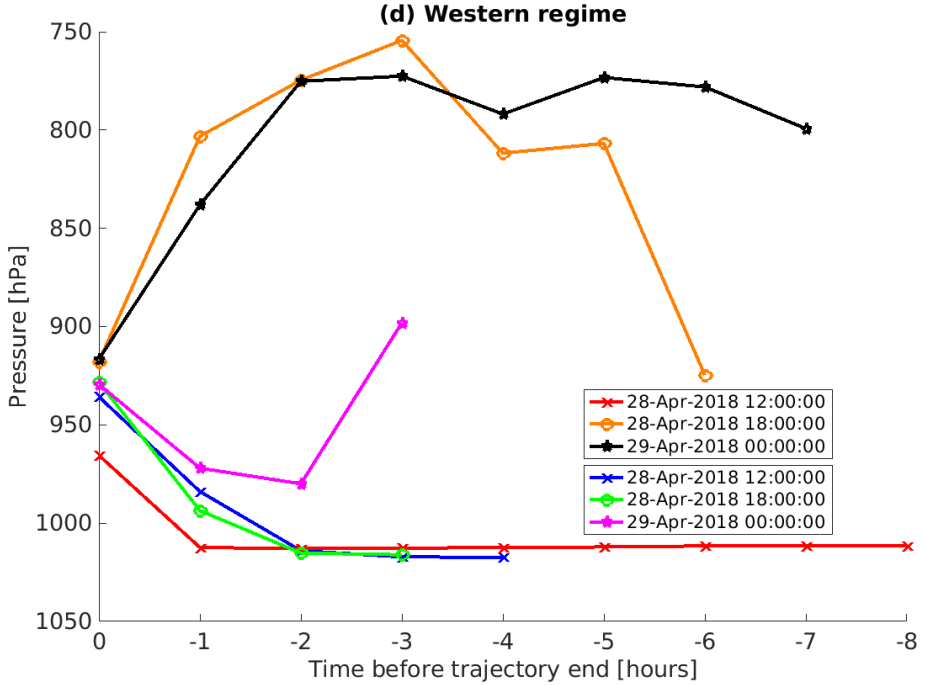
Duine et al. in preparation

Western regime case

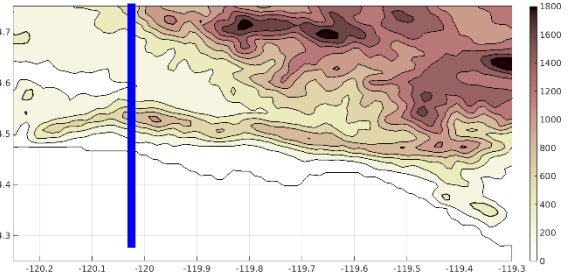






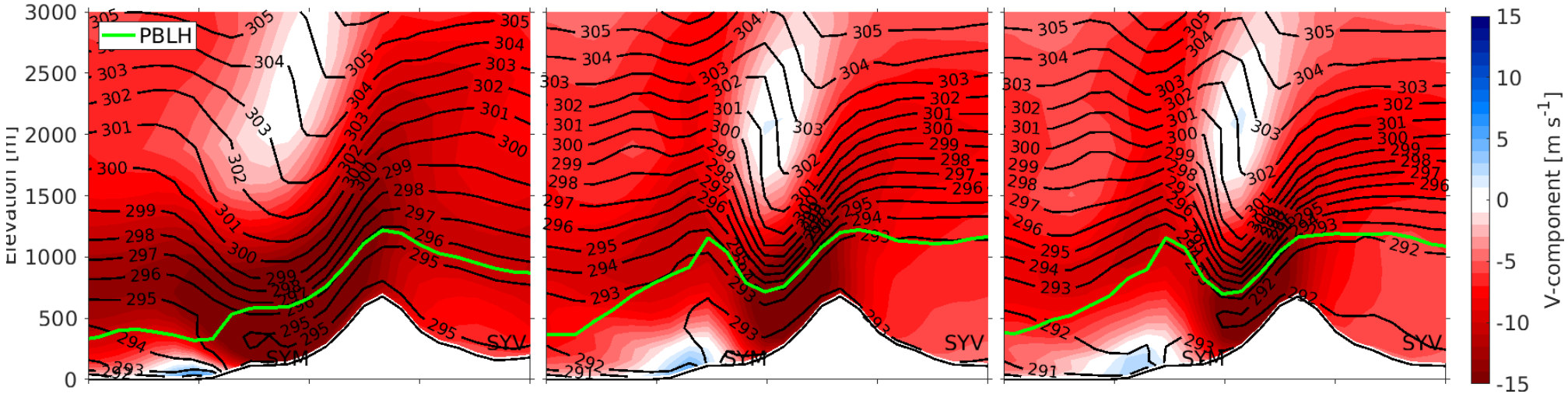


Cross sections – western regime



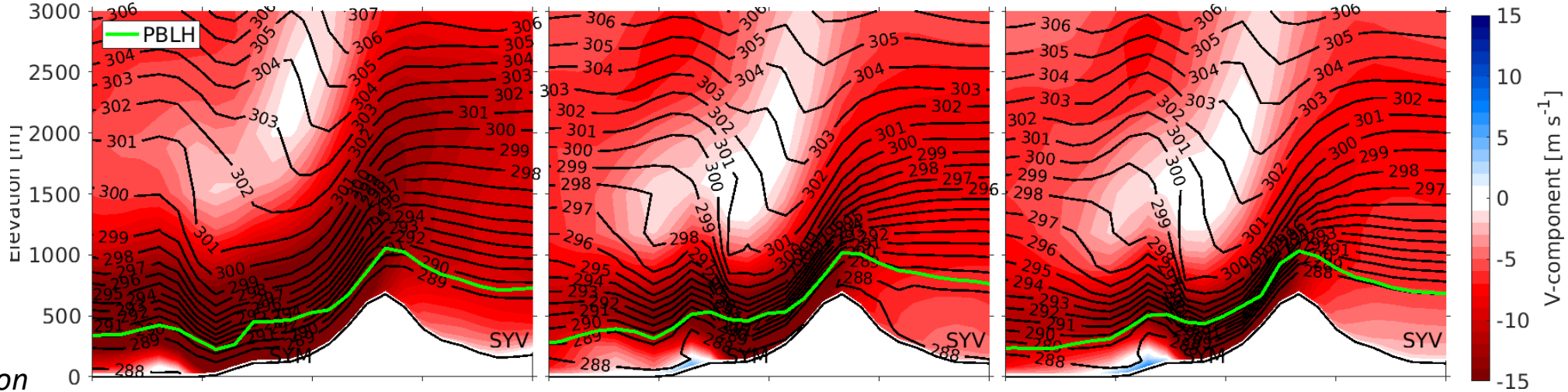
Control | **Half SRM** | **No SRM**

12 PST



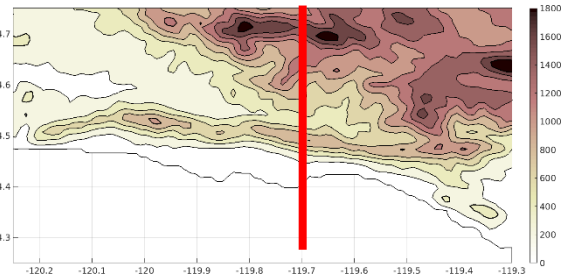
Control | **Half SRM** | **No SRM**

18 PST



Duine et al. in preparation

Cross sections – western regime

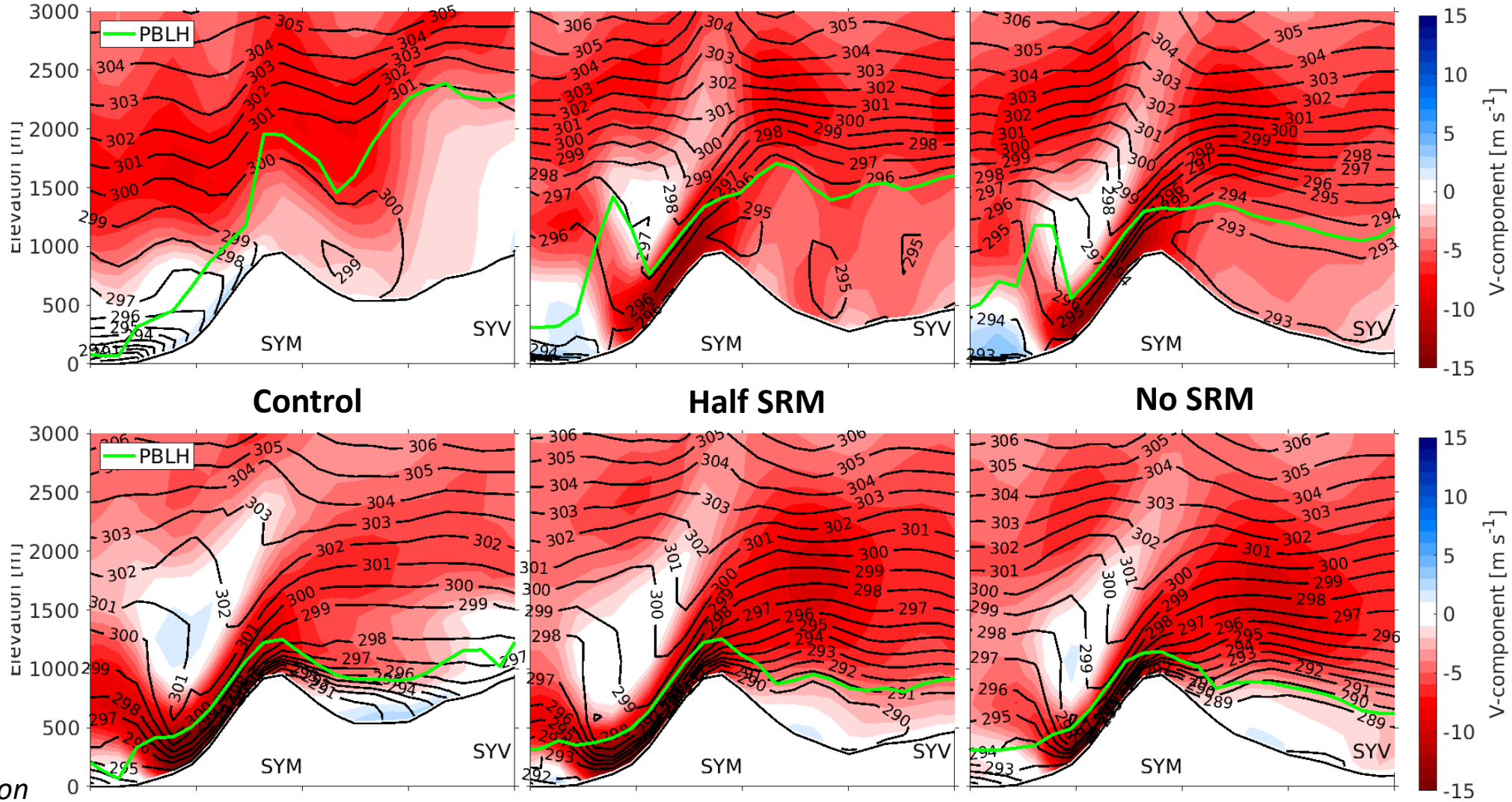


Control **Half SRM** **No SRM**

12 PST

Control **Half SRM** **No SRM**

18 PST

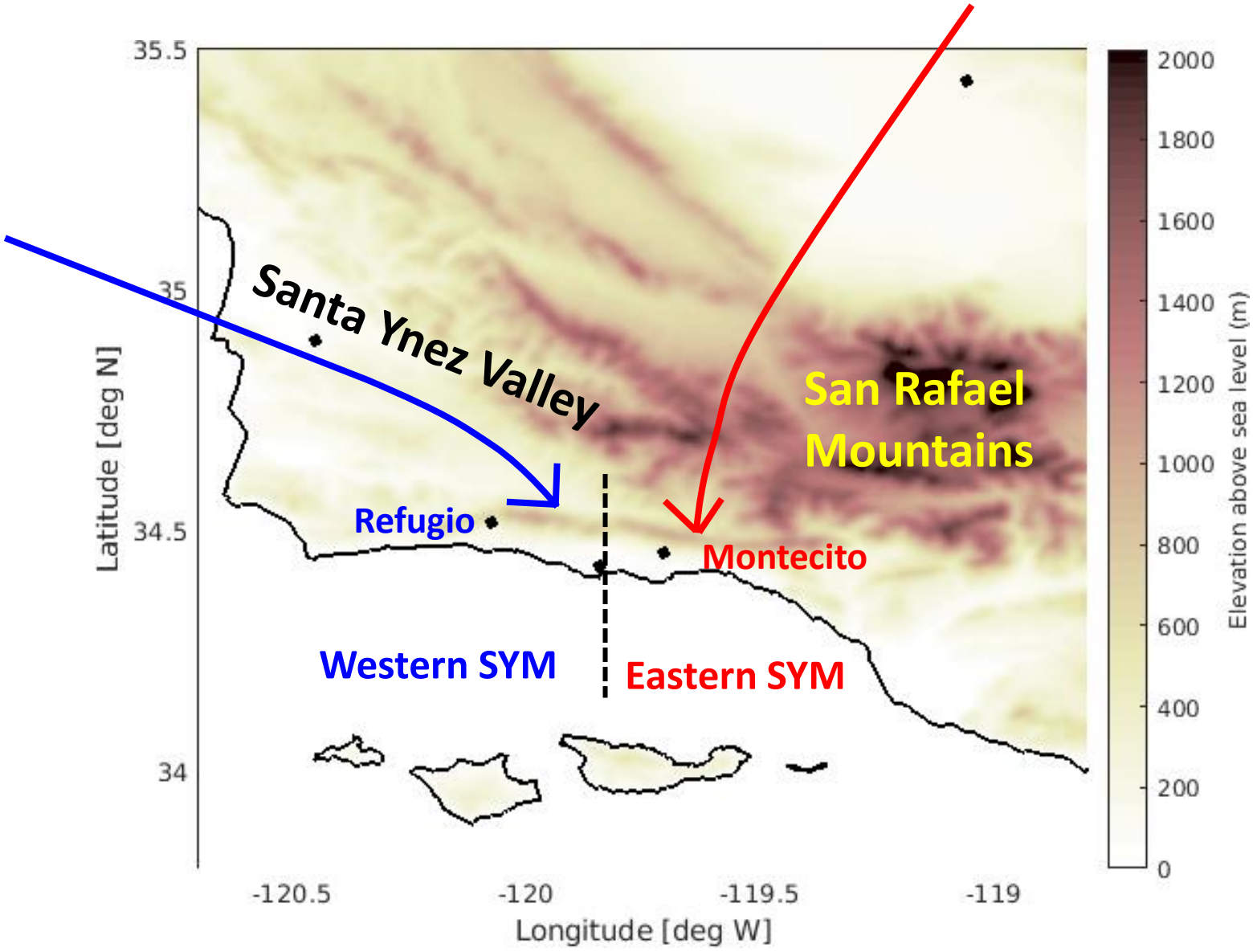


Duine et al. in preparation

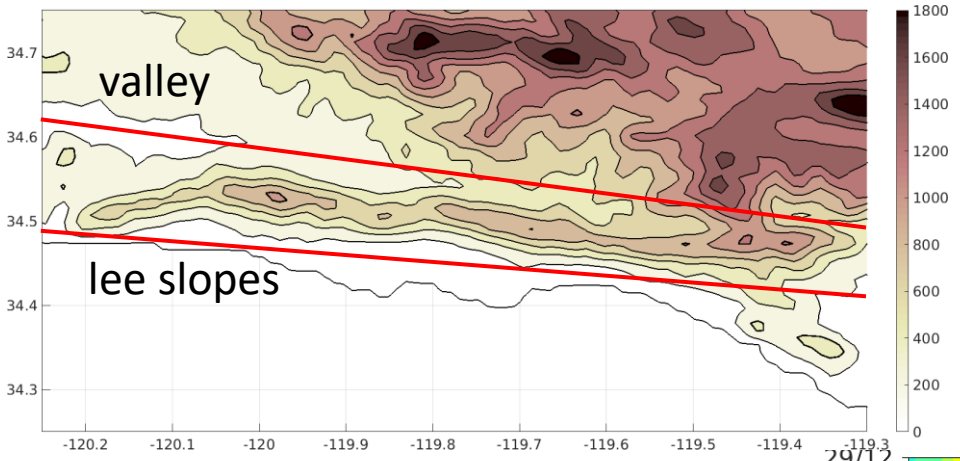
Role of upstream terrain and cross-barrier flow direction

Upstream terrain (north of SYM):

- **Western SYM:** more open terrain, *lower* than SYM
- **Eastern SYM:** complex terrain, *higher* than SYM



Role of Convective Boundary Layer (CBL) in Santa Ynez Valley not very well understood

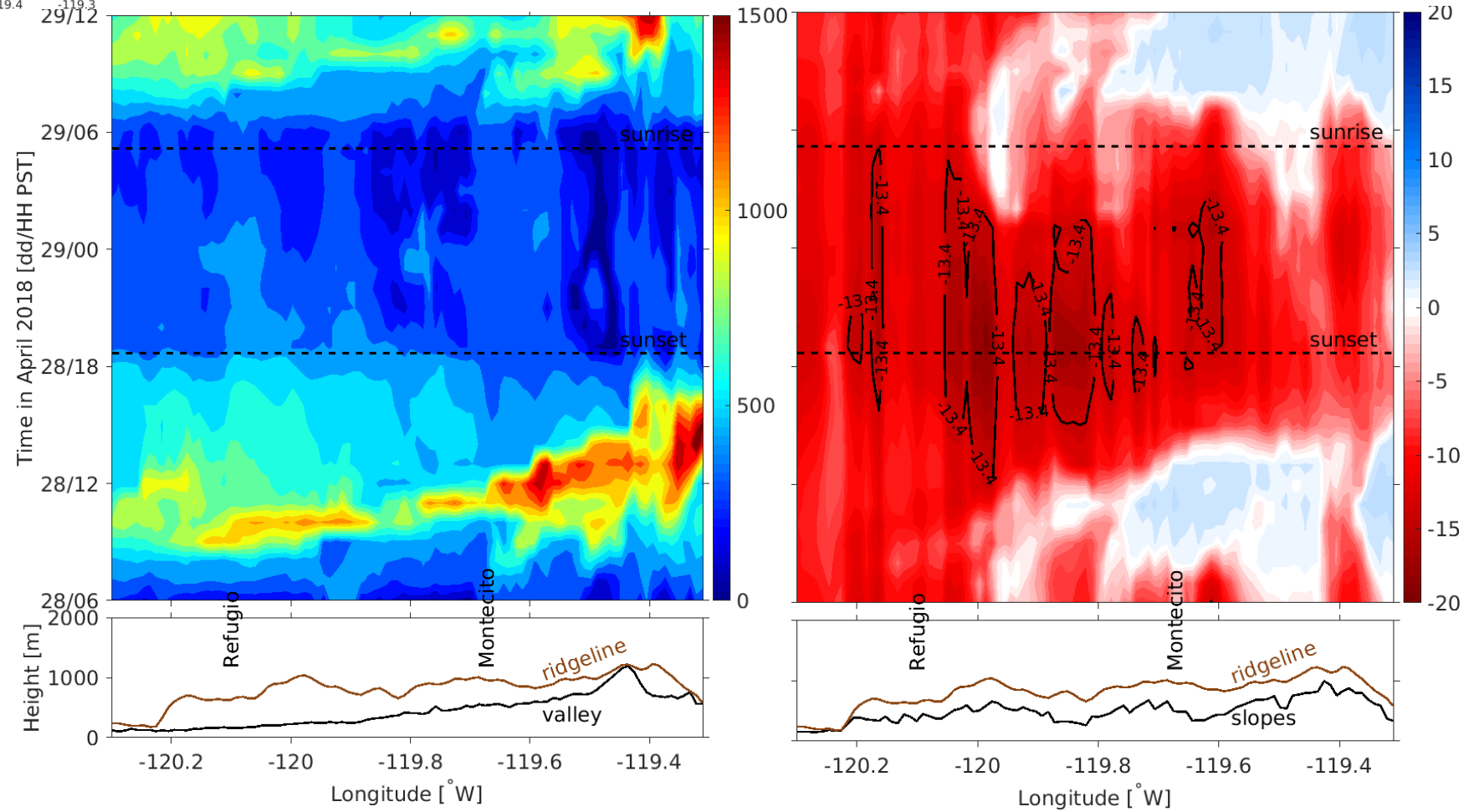


Nocturnal boundary layer

Daytime boundary layer

PBL top valley [m]

V-component lee slope [m/s]



Duine et al. in preparation

Conclusions

- Sundowner is a type of **downslope windstorm**, with a typical onset and maximum wind speed around sunset
- Strong winds may occur earlier, and depend on **synoptic settings** and location on **Santa Ynez Mountains**
- **Upstream terrain** controls diurnal manifestation on Sundowners:
  - Western side SYM: more open terrain
  - Eastern side SYM: onset largely controlled by the presence of San Rafael Mountains and so the presence of Santa Ynez Valley
    → Main synoptic flow direction is crucial
- Control of upstream terrain confirmed by eastern regime case and month-long simulations (not shown here)
- Possible mechanisms include CBL development in Santa Ynez Valley upstream of Santa Ynez Mountains

Further reading/references

- Blier, W., 1998: The sundowner winds of Santa Barbara, California.Wea. *Forecasting*, **13 (3)**, 702–716
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- Carvalho, L.M.V., G.J. Duine, C. Jones, K. Zigner, C. Clements, H. Kane, C. Gore, G. Bell, B. Gamelin, D. Gomberg, T. Hall, M. Jackson, J. Dumas, E. Boldt, R. Hazard and W. Enos, 2020: The Sundowner Winds Experiment (SWEX) Pilot Study: Understanding Downslope windstorms in the Santa Ynez Mountains, Santa Barbara, California. *Mon. Wea. Rev.*, **148 (4)**, 1519–1539.
- Duine, G.-J., C. Jones, L. M. Carvalho, and R. G. Fovell, 2019: Simulating Sundowner Winds in Coastal Santa Barbara: Model Validation and Sensitivity. *Atmosphere,* **10 (3)**, 155.
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- Sukup, S., 2013: Extreme Northeasterly Wind Events in the Hills Above Montecito, California. Western Region Technical Attachment NWS WR-1302. National Weather Service Western Region, Salt Lake City, UT.