A new Climatology of Sundowner Winds in Coastal Santa Barbara, California, Based on 30-yr High Resolution WRF Downscaling

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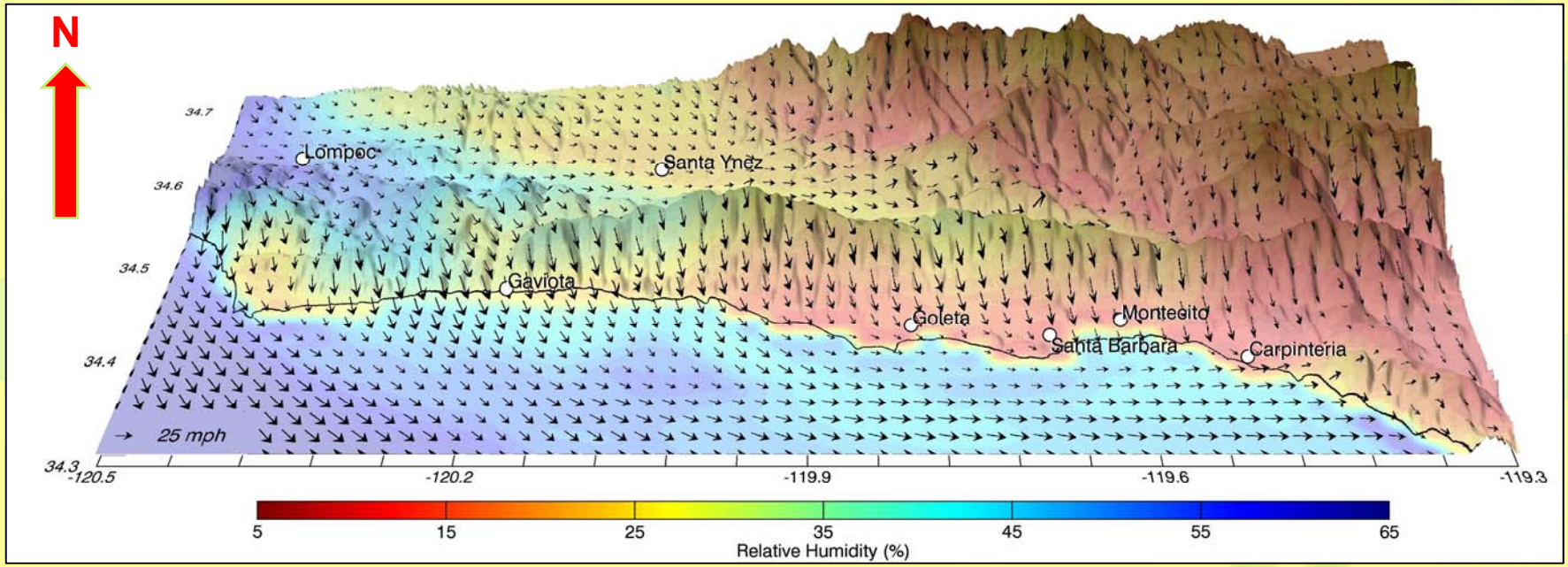
Sundowner winds

- ✓ Northerly downslope winds in the Santa Ynez Mountains
- ✓ Onset in late afternoon lasting through early morning
- ✓ Sustained winds ≥ 30 mph and/or gusts ≥ 35 mph
- ✓ Strong surface pressure gradient (SBA, SMX and BFL)
- ✓ Early evening
  - Temperatures ≥ 90F
  - Relative humidity ≤ 15%

  } *Highly variable*
- ✓ Interaction of surface winds with marine boundary layer
- ✓ Most critical fire-weather regime in Santa Barbara County



Objectives of this study

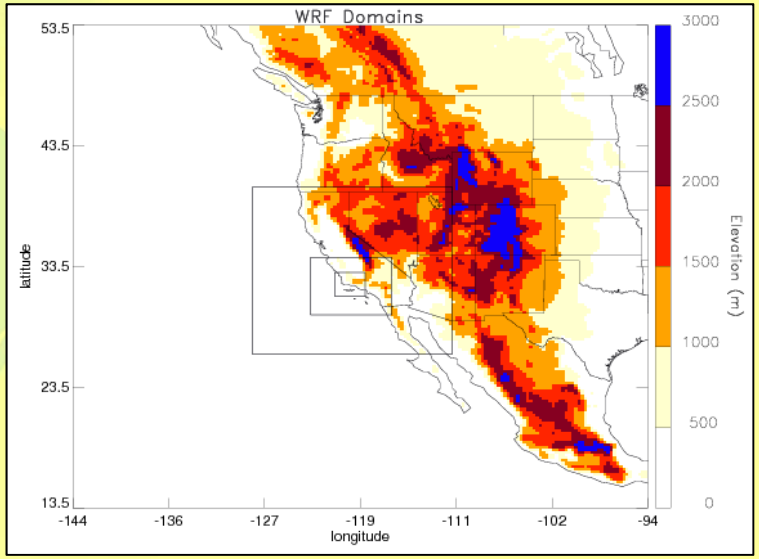
- ❑ **Develop an objective index to identify Sundowners; not dependent on specific sites**
- ❑ **Identify distinct Sundowner wind regimes**
- ❑ **Characterize diurnal-to-seasonal variability of Sundowner winds**

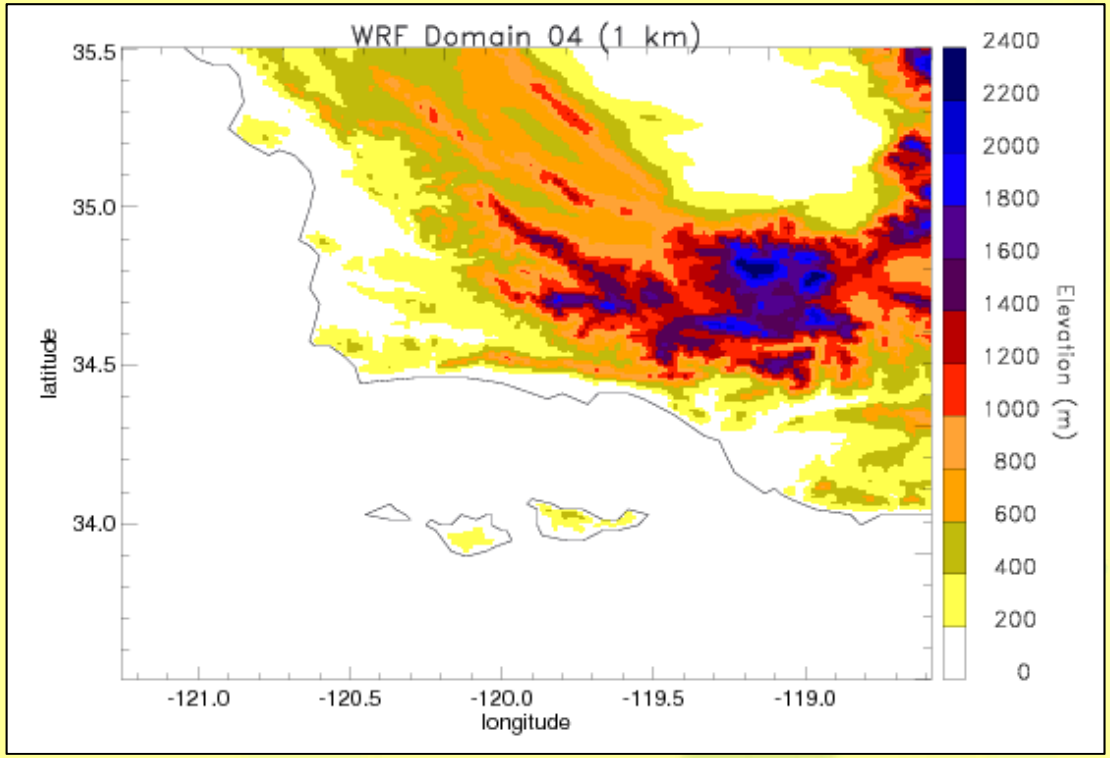
NSF PREEVENTS: Understanding Extreme Fire Weather Hazards and Improving Resilience in Coastal Santa Barbara, California

Climatology of Sundowner winds

WRF model

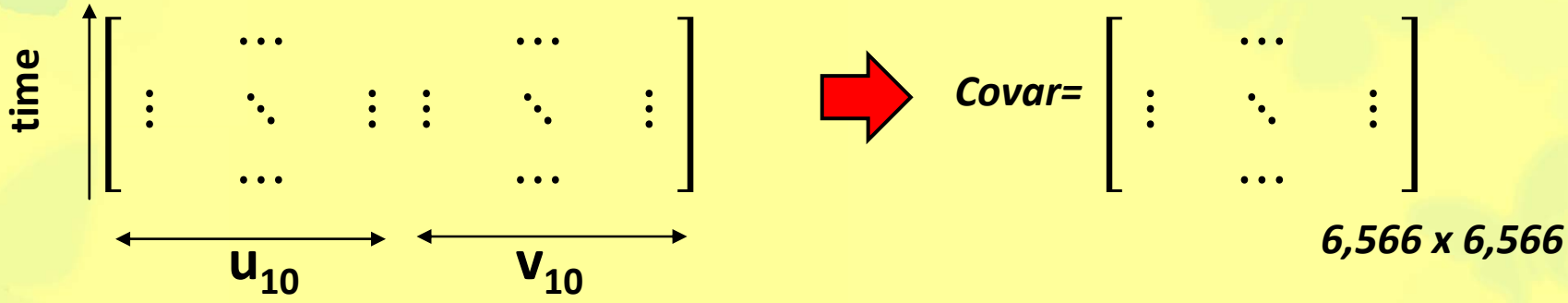
- 4 nested grids: 27, 9, 3, 1-km
- 55 vertical levels
- ERAI initialization & BC
- 30 years
  - 1 July Yr1 – 1 Sep Yr2
  - Discard first 2 months (spin up)
- Output saved hourly
- Validation against surface stations
- Big data ≅ 125 terabytes ★





Methodology: empirical orthogonal functions (EOF)

Apply combined EOF method to 30-yr of gridded hourly winds (u, v) (10 m) at 1-km grid spacing



- EOF analysis expresses the data as a function of spatial patterns and time coefficients:

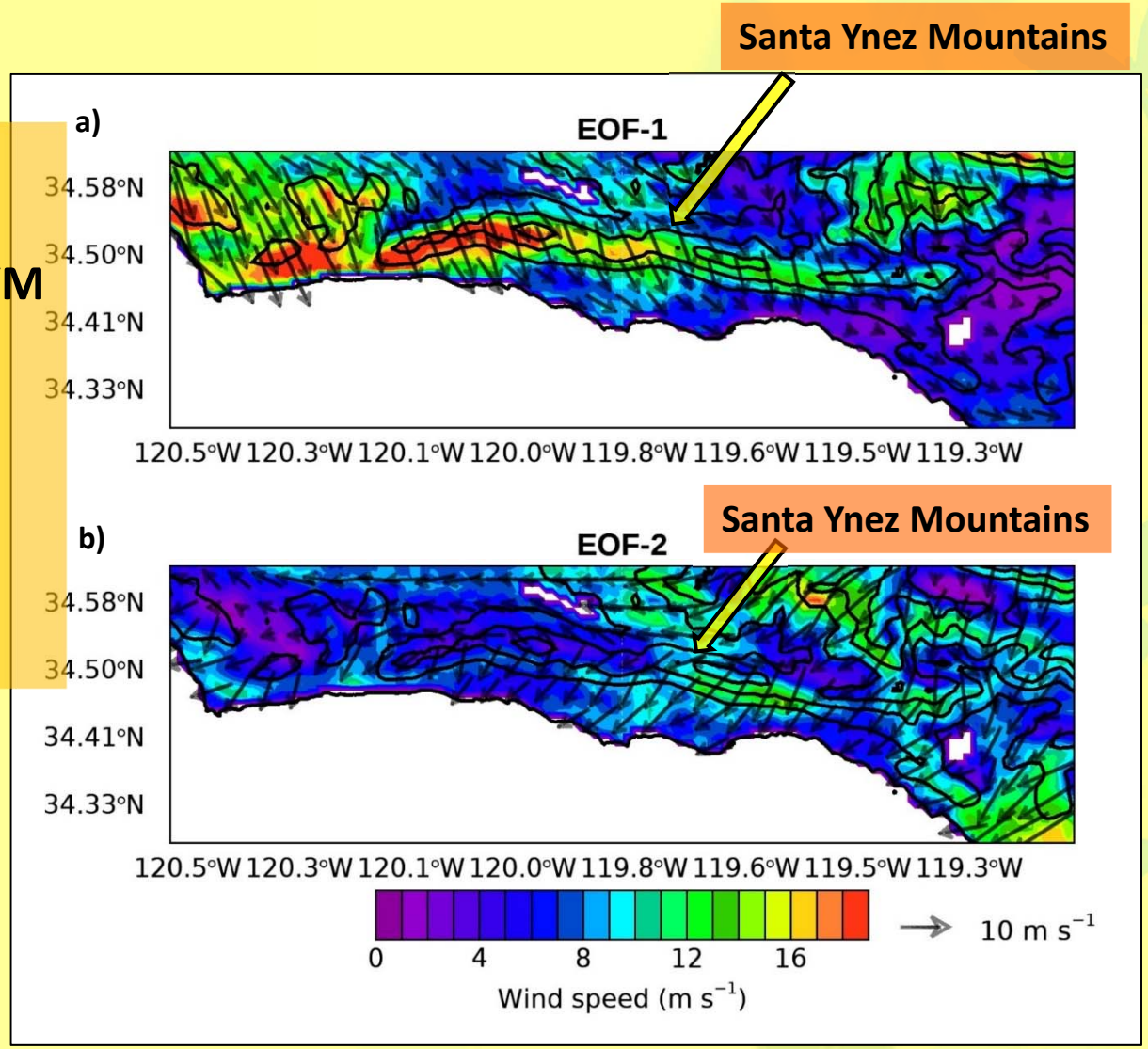
$$A(x, y, t) = EOF_1(x, y) \times PC_1(t) + EOF_2(x, y) \times PC_2(t) + \ldots$$

- First EOF_1 mode: largest percentage of the variance; EOF_2 mode: second largest percentage of the variance and so on.
- Time coefficients (PCs) describe temporal evolution

Downslope winds in the Santa Ynez Mountains: spatial patterns (EOFs)

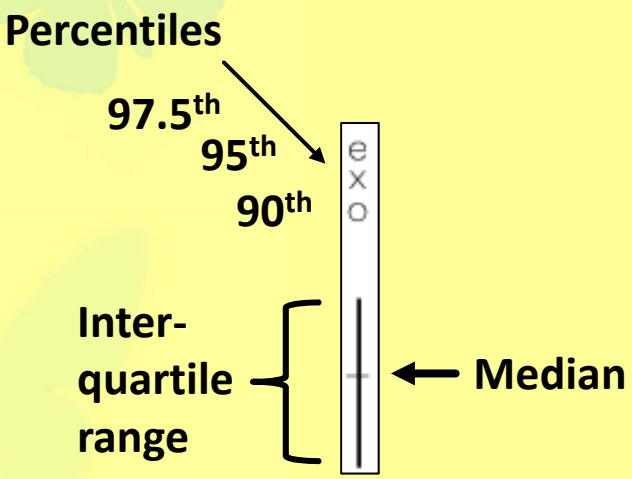
EOF-1:
- **34.9% of total variance**
- **Strong winds in western SYM**

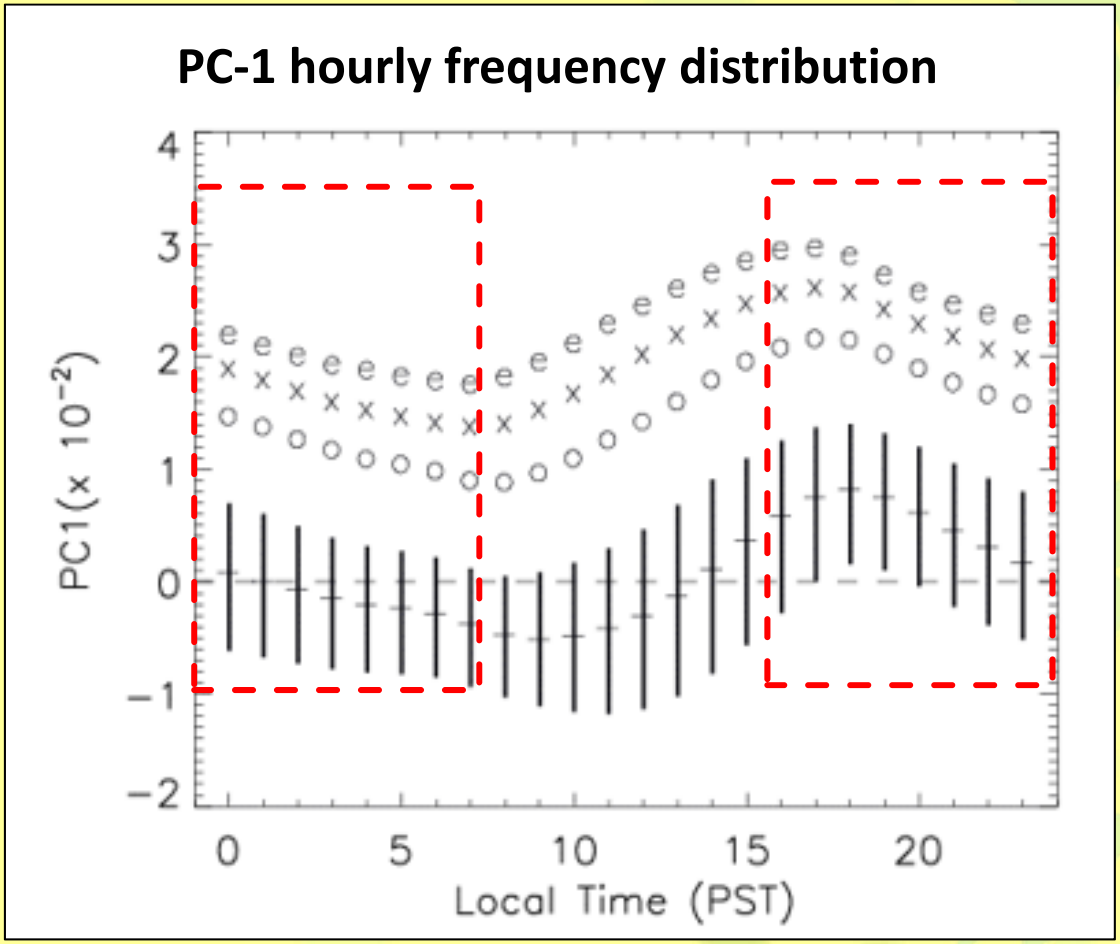
EOF-2:
- **23.1% of total variance**
- **Strong winds in eastern SY and San Rafael Mountains**



Temporal variability: PCs

262,992 data points ➡ Compute hourly frequency distribution of PC1 and PC2



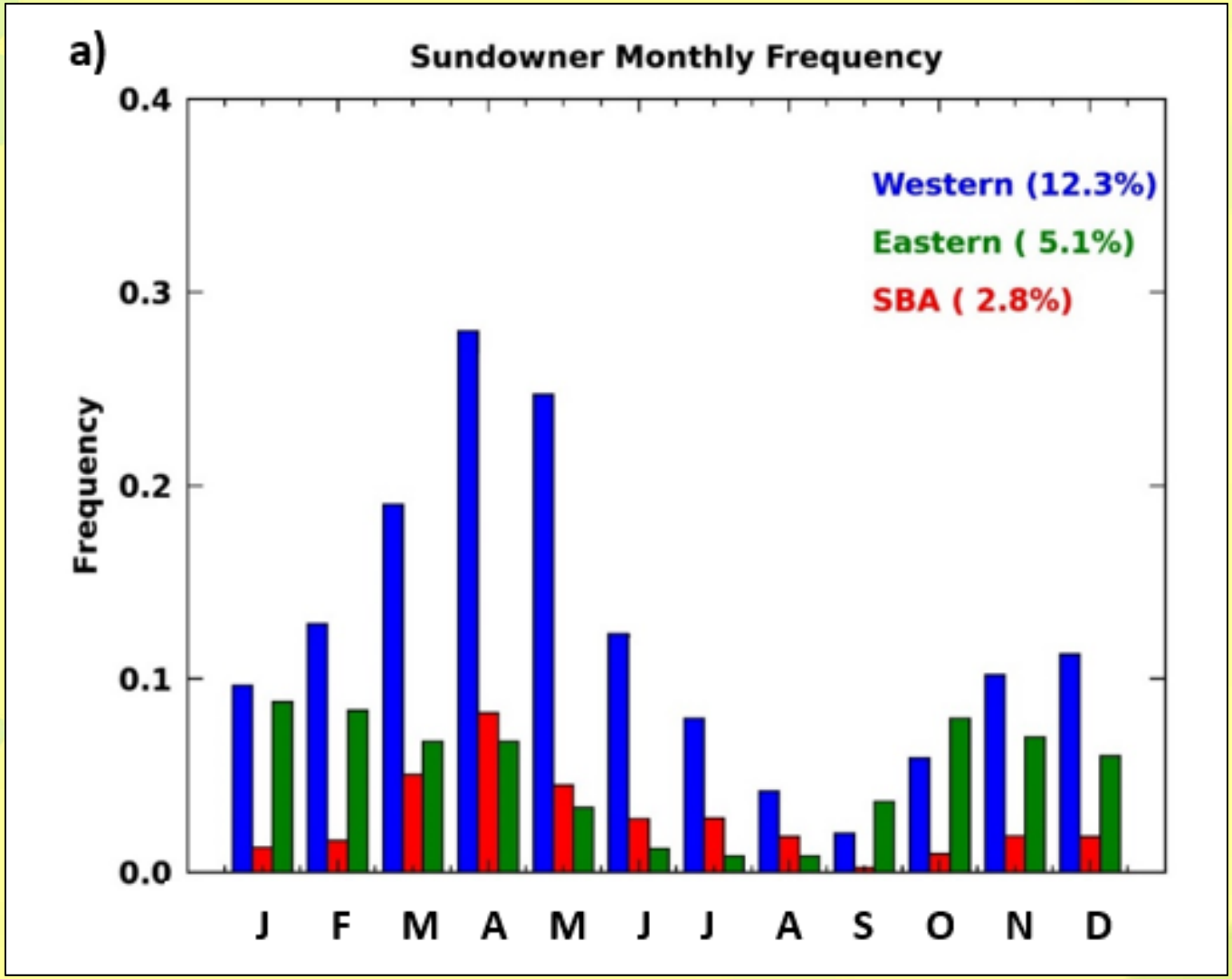


Similar for PC2 frequency distribution

Sundowner Regimes Identification

- ***Western Regime***: hourly PC1 $\geq$ 90th percentile 16:00-7:00 PST, 2) hourly PC2 < 95th percentile 20:00-7:00 PST
- ***Eastern Regime***: hourly PC1 < 90th percentile 16:00-7:00 PST, 2) hourly PC2 $\geq$ 95th percentile 20:00-7:00 PST.
- ***Santa Barbara Regime***: hourly PC1 $\geq$ 90th percentile 16:00-7:00 PST and hourly PC2 $\geq$ 95th percentile 20:00-7:00 PST
- Event lasts at **least two consecutive** hours.

Sundowner Climatology: Monthly frequency

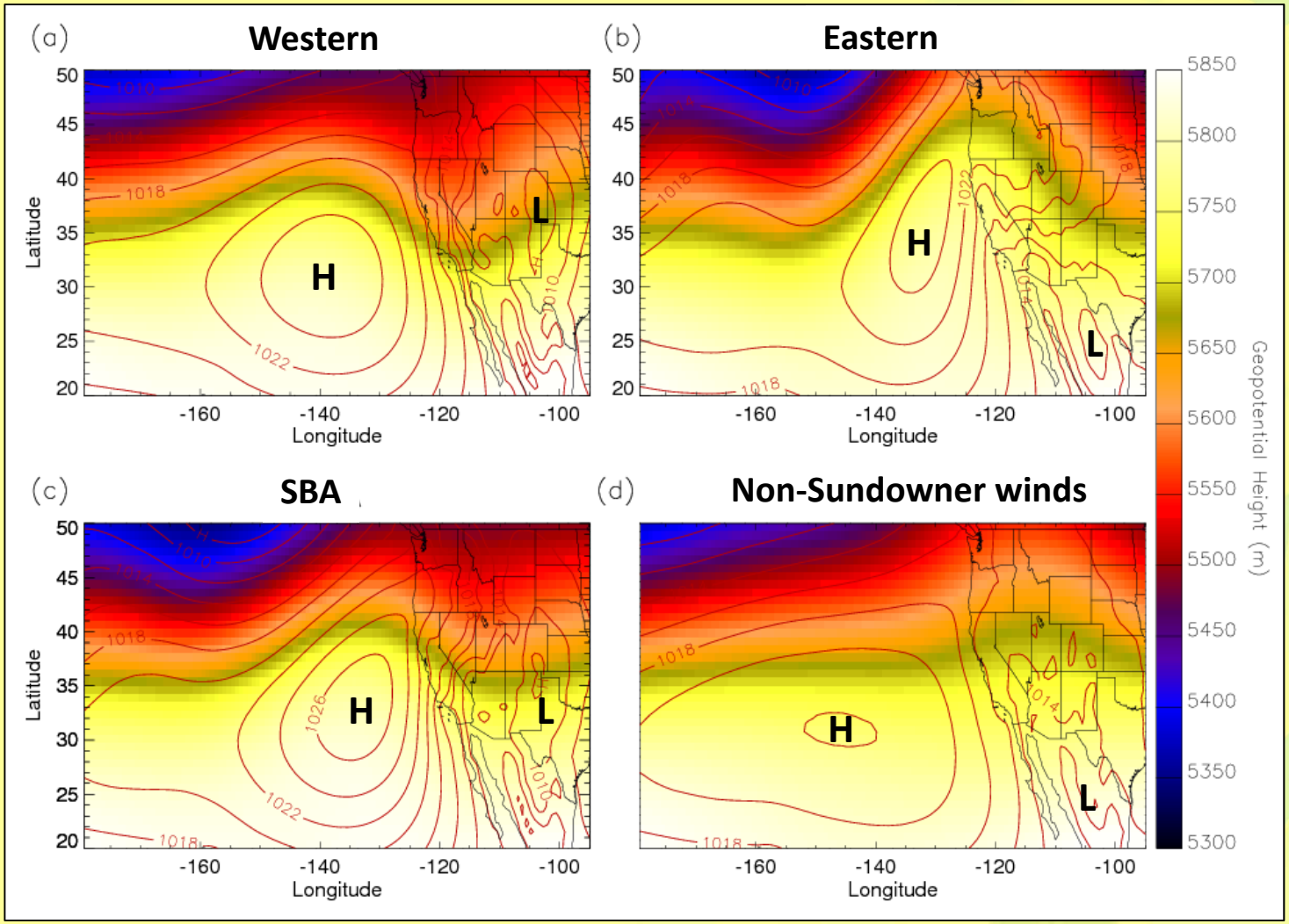


Sundowner Climatology: Mar-Apr- May

Synoptic patterns

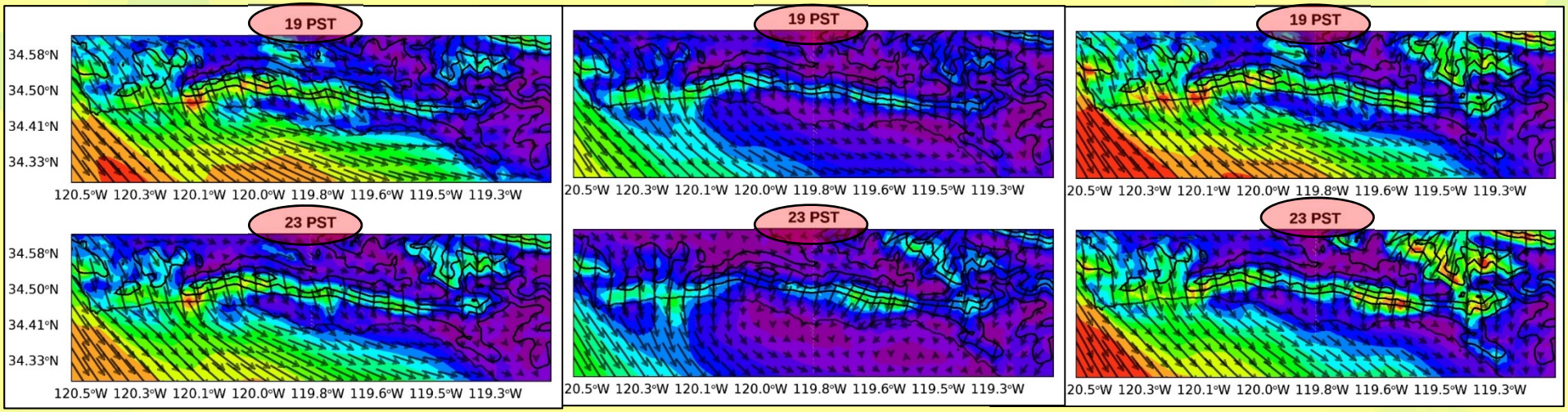
Contours:
Sea level pressure

Colors:
Geopotential Height at 500-hPa



Sundowner Climatology Mar-Apr- May

Surface winds (10m) Composites



Western regime

- Strong downslope winds in western SYM
- Strong coastal jet and winds in the SBA Channel

Eastern regime

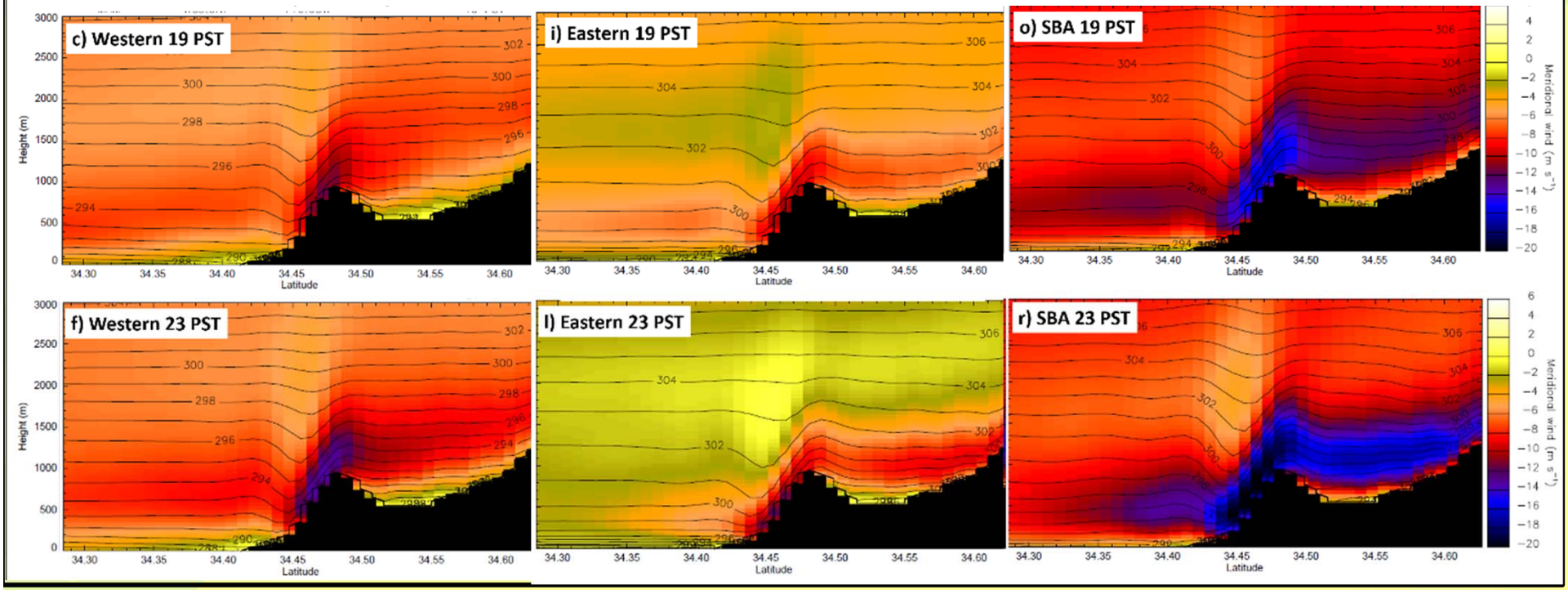
- Strong downslope winds in eastern SYM and SRM
- Weaker winds in the SBA Channel

SBA regime

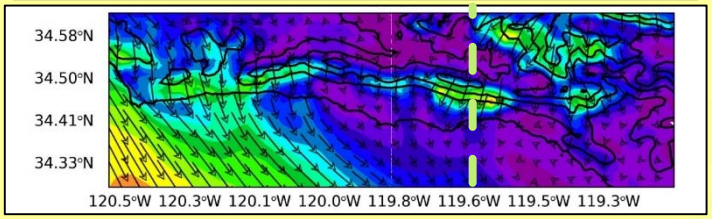
- Strong downslope winds in western and eastern SYM
- Strong downslope winds in San Rafael Mountains
- Strong coastal jet

Sundowner Climatology Mar-Apr- May

Montecito (119.63W)



Vertical cross section



Potential temperature (contours)
Meridional winds (colors)

Sundowner winds: summary

- ✓ **30-yr climatology based on high-resolution WRF model**
- ✓ **Combined empirical orthogonal functions (CEOF): powerful methodology to objectively classify Sundowners; highly efficient to process large model data**
- ✓ **Three types of regimes: western, eastern and SBA**
- ✓ **Sundowner regimes associated with distinct synoptic patterns**
- ✓ **Maximum frequency: April-May**
- ✓ **Persistence: 1-2 days, but in extreme cases 4-7 days**

WRF

Physics

- **Microphysics: Single–moment 6–class Scheme**
- **Radiation: RRTMG**
- **Surface layer: MYNN scheme**
- **Land surface: Noah MP**
- **PBL: MYNN**
- **Cumulus (27 km, 9km): Tiedtke Scheme**