Observational characterization of mountain breezes and their impacts on CO_2 mixing ratios

C. Román-Cascón[1,2], C. Yagüe[1], J.A. Arrillaga[1], M. Lothon[2], E. Pardyjak[3], F. Lohou[2], RM. Inclán[4], M. Sastre[1], G. Maqueda[1], S. Derrien[2], Y. Meyerfeld[2], C. Hang[3], P. Campargue-Rodríguez[2], I. Turki[2]

P2OA
Matinée scientifique
14 November 2018
Toulouse

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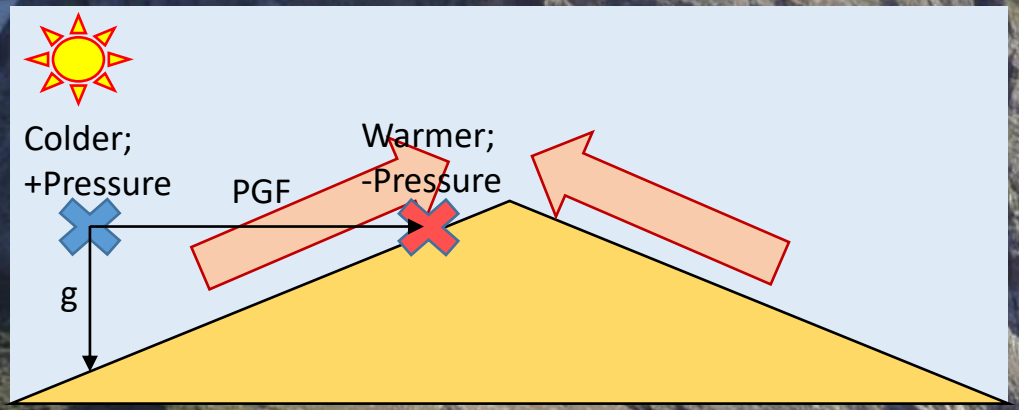

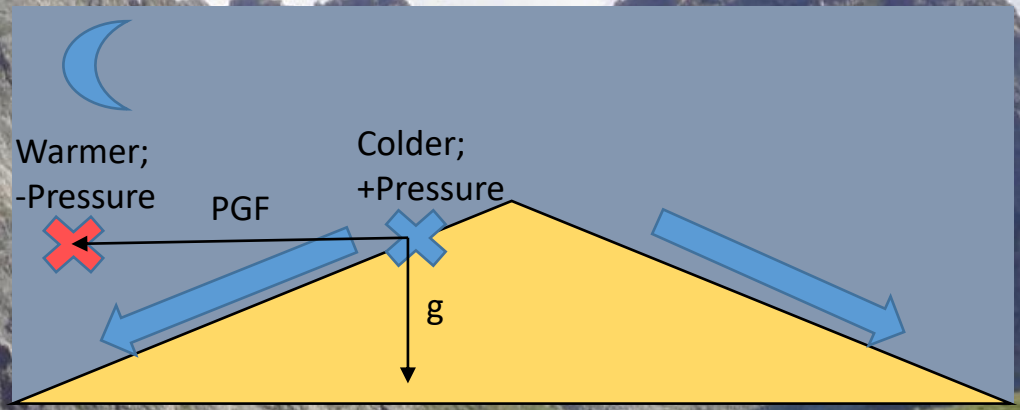

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Project context and objectives

ATMOUNT II project

- **Obj. 1:** Characterization of mountain breezes
  - **- Guadarrama Mountains (Herrería) (Spain)**
  - - Pyrenees (France)
  - - Salt Lake Valley (US)
- **Obj. 2:** Impacts of mountain breezes in CO_2 (micro-mesoscale interactions)

Mountain breezes detection

* Based on criteria in Arrillaga et al. 2018 (QJRMS)

DETECTION ALGORITHM*

CENTRE DE RECHERCHES ATMOSPHÉRIQUES (CRA, Pyrenees)

(2017 Example)

- **<u>LARGE SCALE</u>: Synoptic conditions** - NCEP: u, v, T, RH

→ 365 days analysed

- Filter 1: Wind at 700 hPa	<	9-10 m/s	→ 179 days pass Filter 1
- Filter 2: Fronts passage; $\Delta\theta_e$ 700 hPa	>	-1.45 K/6 hours	→ 168 days pass Filter 1 and 2
- Filter 3: Rainfall	<	0.2 mm/day	→ 135 days pass Filter 1, 2 and 3

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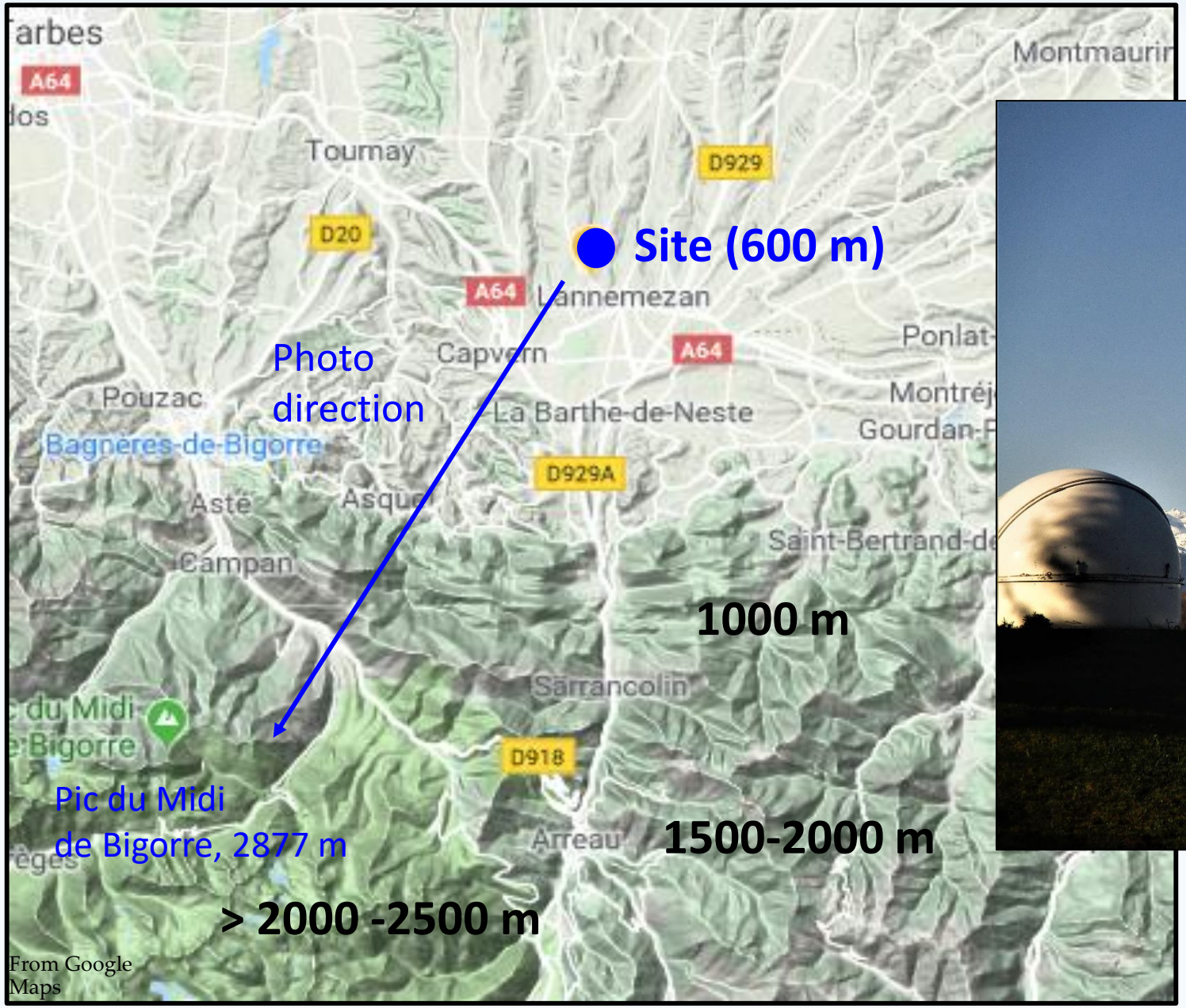
- **<u>SMALL SCALE</u>: Local conditions** - Wind Direction (WD) from tower

- Ranges of WD for down (nighttime) / up (daytime) events
- WD persistence (80% of event) in the appropriate range → **112 nighttime & 56 daytime events**
- Minimum duration of events (3 hours min)

CRA (Pyrenees)

From Google Maps

CRA (Pyrenees)



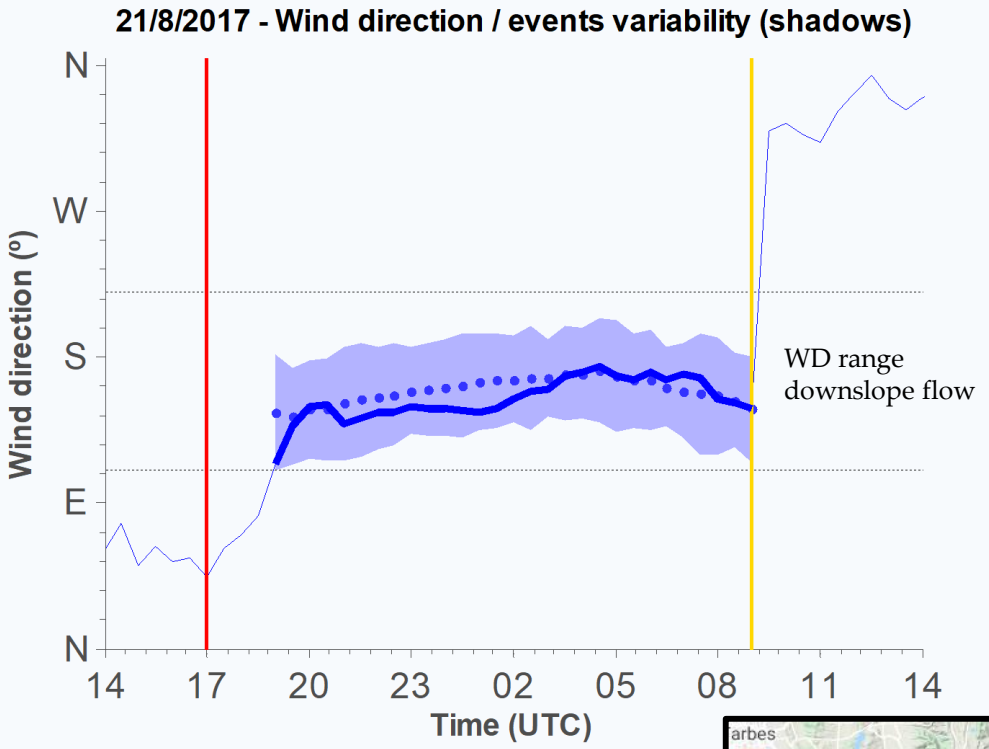
From Google Maps

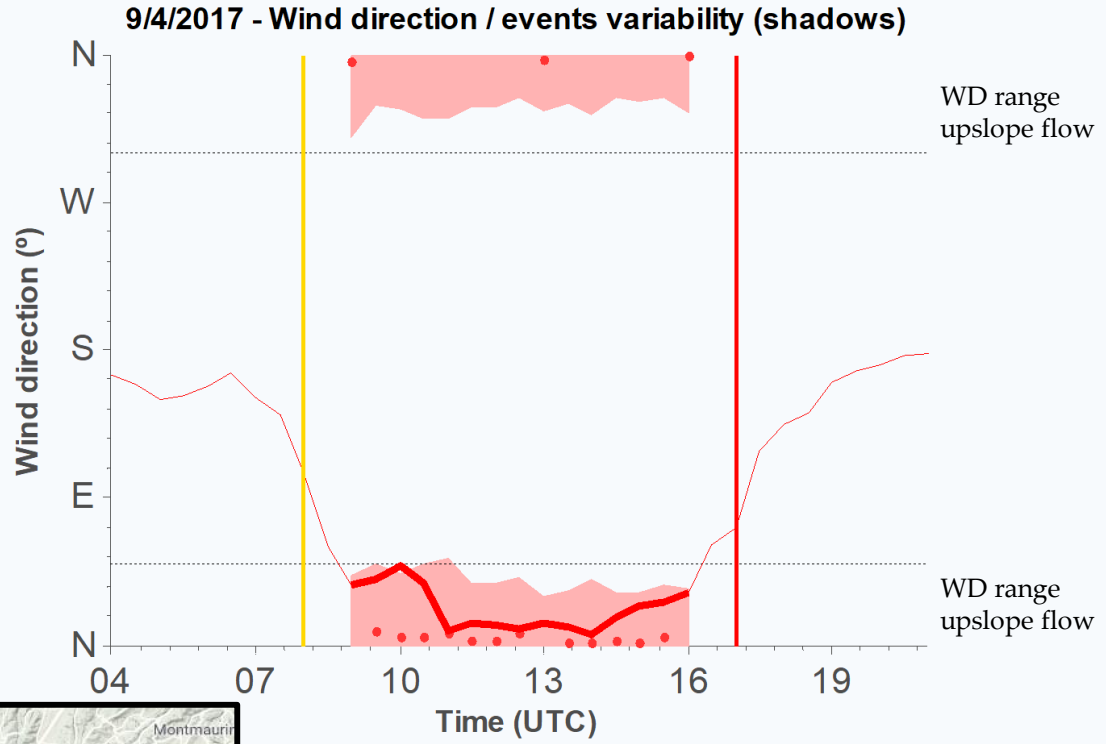
Mountain breezes events (examples)

Nighttime event

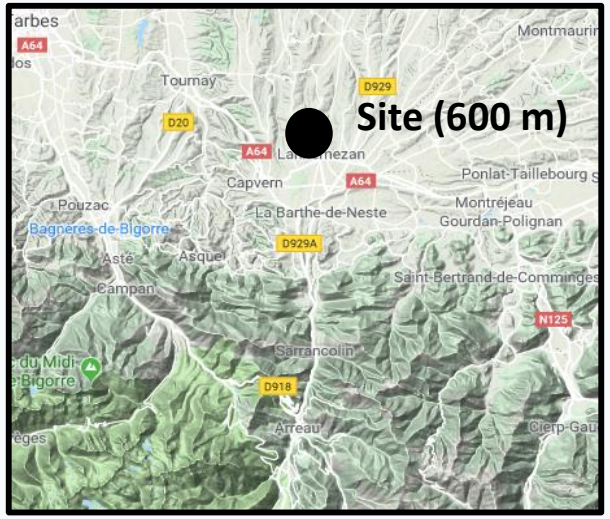
Daytime event

CRA example





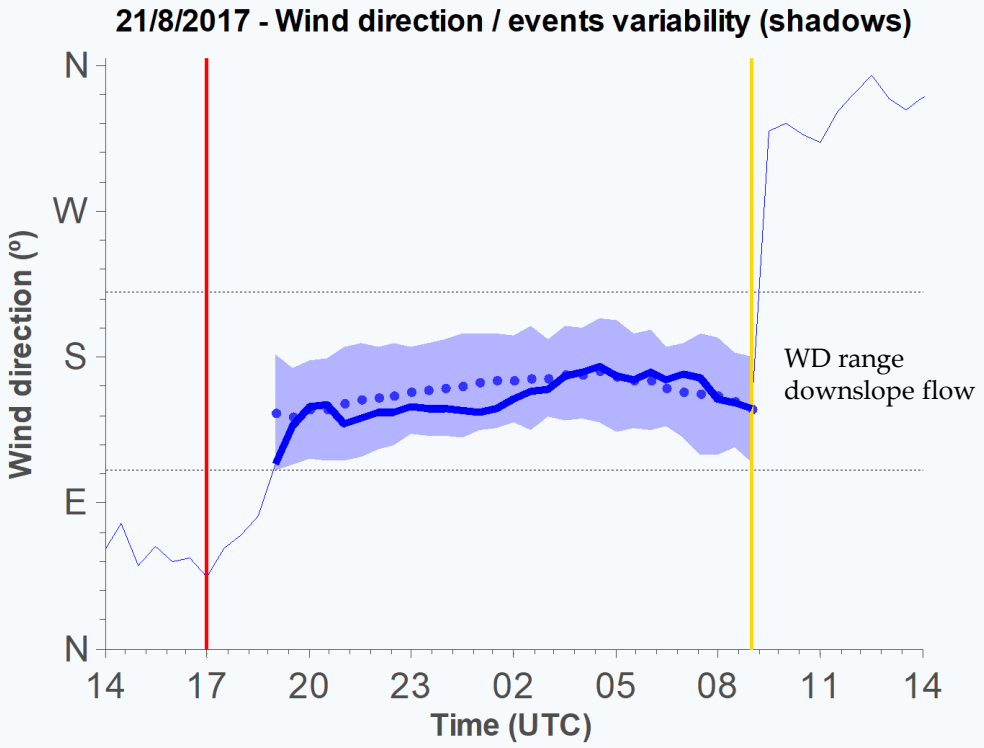
- Nighttime event example
- Daytime event example
- Nighttime events mean + sd
- Daytime events mean + sd
- SH sign change (+ to -) (- to +)



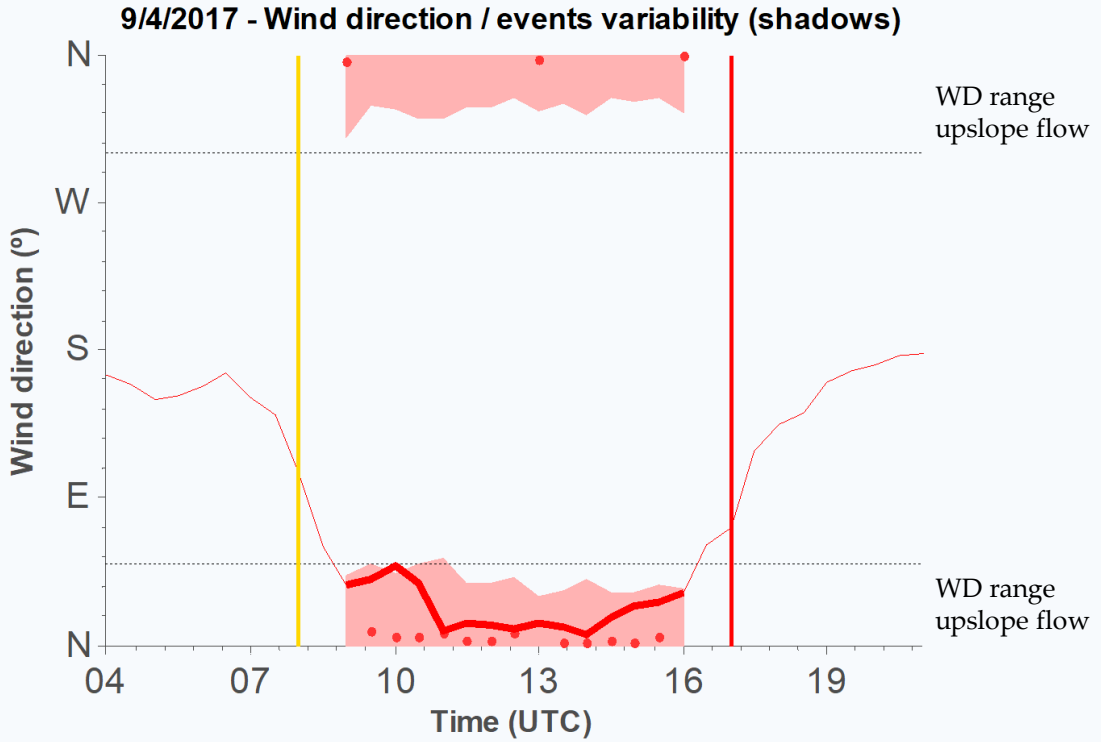
Mountain breezes events (examples)

Nighttime event

CRA example



Daytime event



- Nighttime event example
- Daytime event example
- Nighttime events mean + sd
- Daytime events mean + sd
- SH sign change (+ to -) (- to +)

With all the events…

Mountain breezes statistics

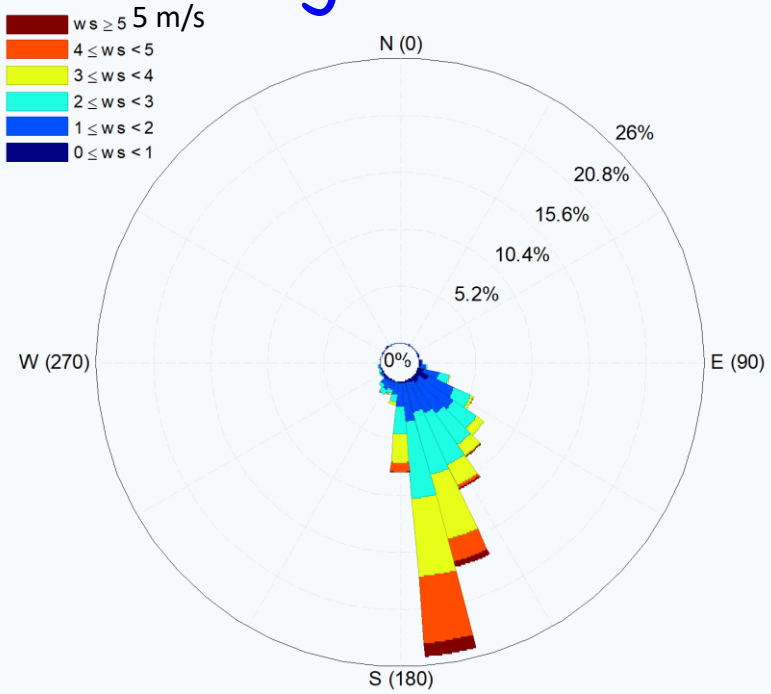
Timing / duration of events.

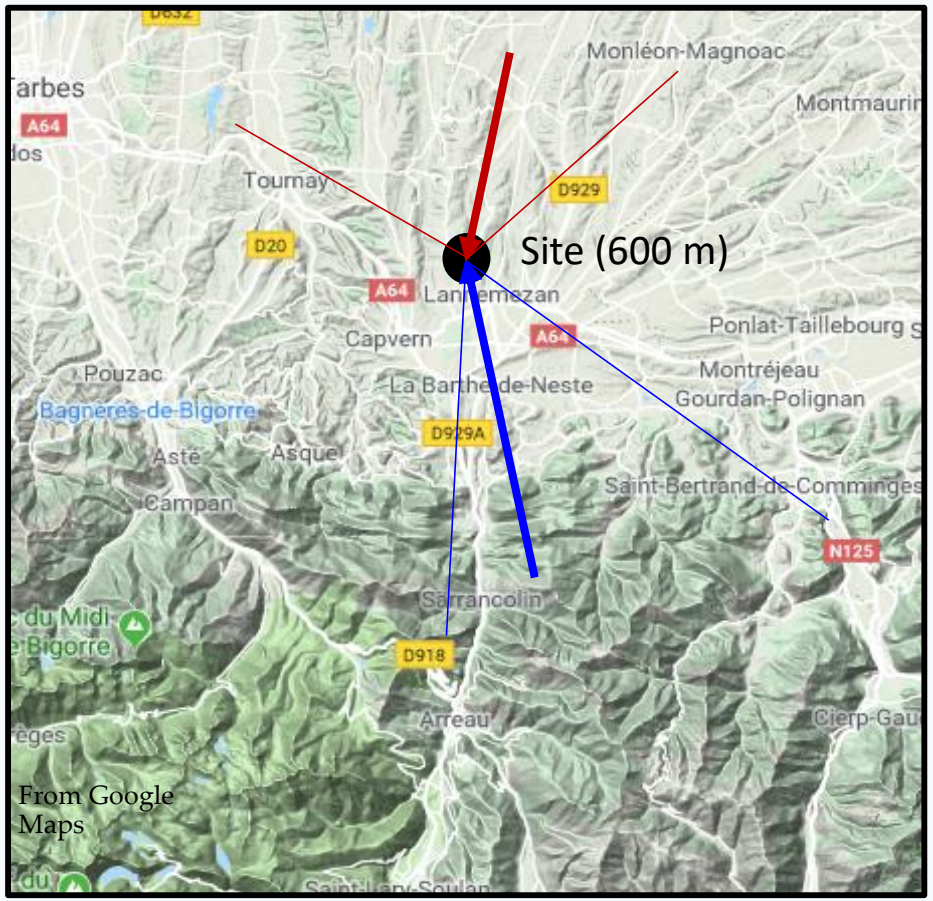
Wind speed & Wind direction (mean and variability).

Impacts on → greenhouse gases concentration

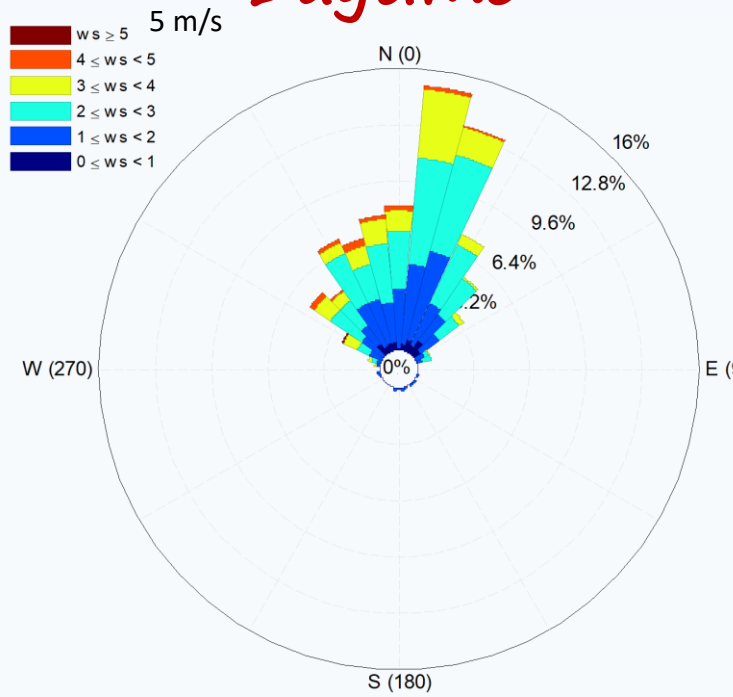
CRA (Pyrenees)

Nighttime





Daytime



EVENTS NUMBERS:

365 days analysed

112 nighttime

56 daytime

La Herrería (Guadarrama) - HER

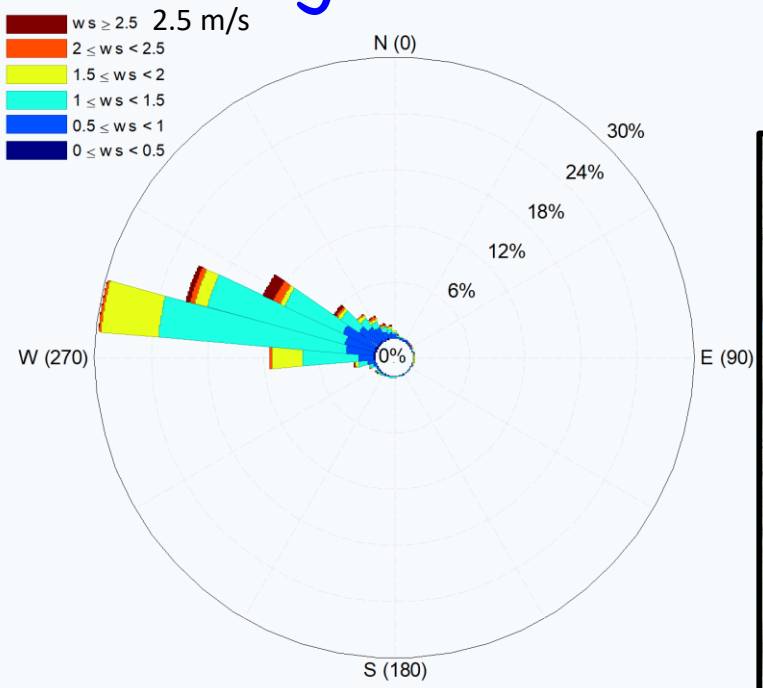
From Google Maps

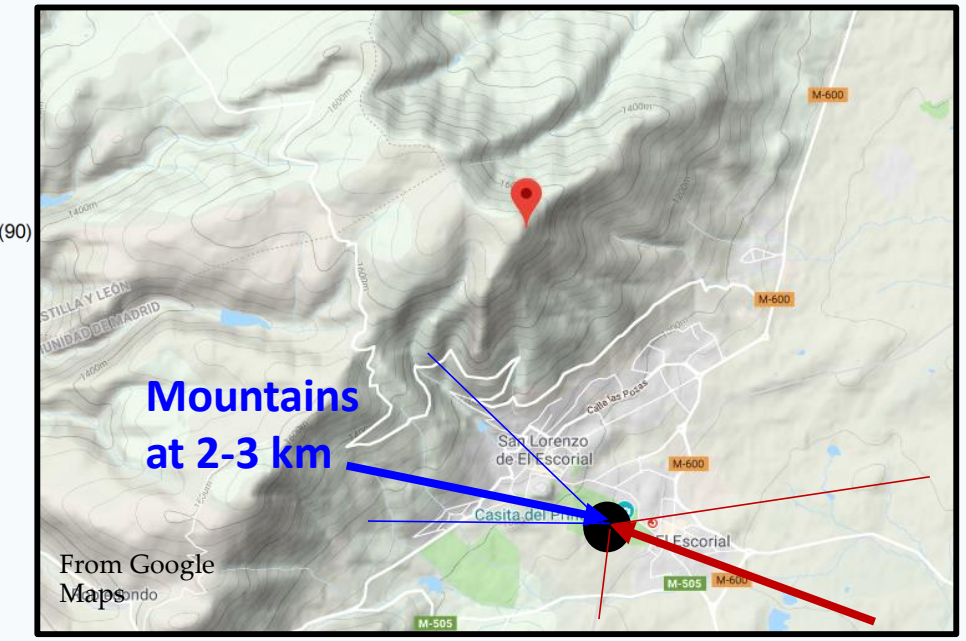
La Herrería (Guadarrama) - HER

From Google Maps

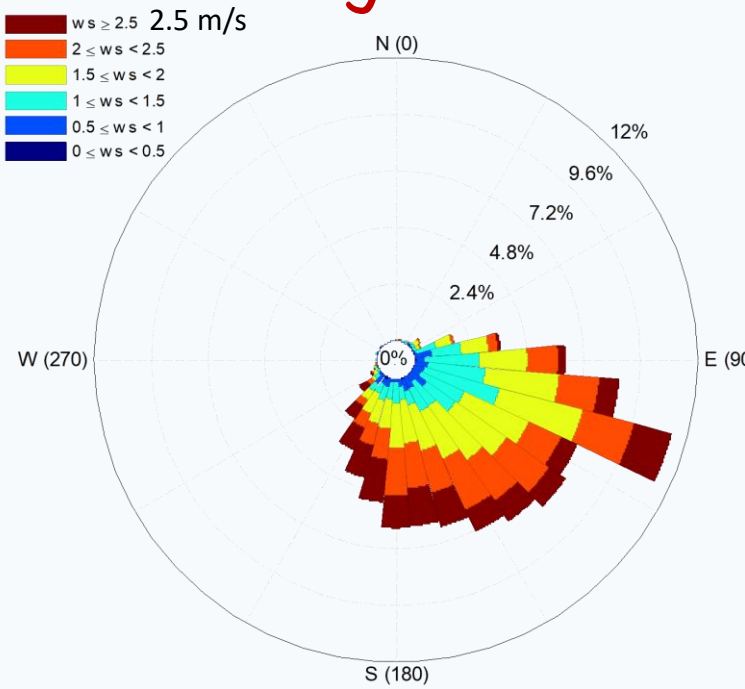
La Herrería (Guadarrama) - HER

Nighttime





Daytime



EVENTS NUMBERS:

365 days analysed

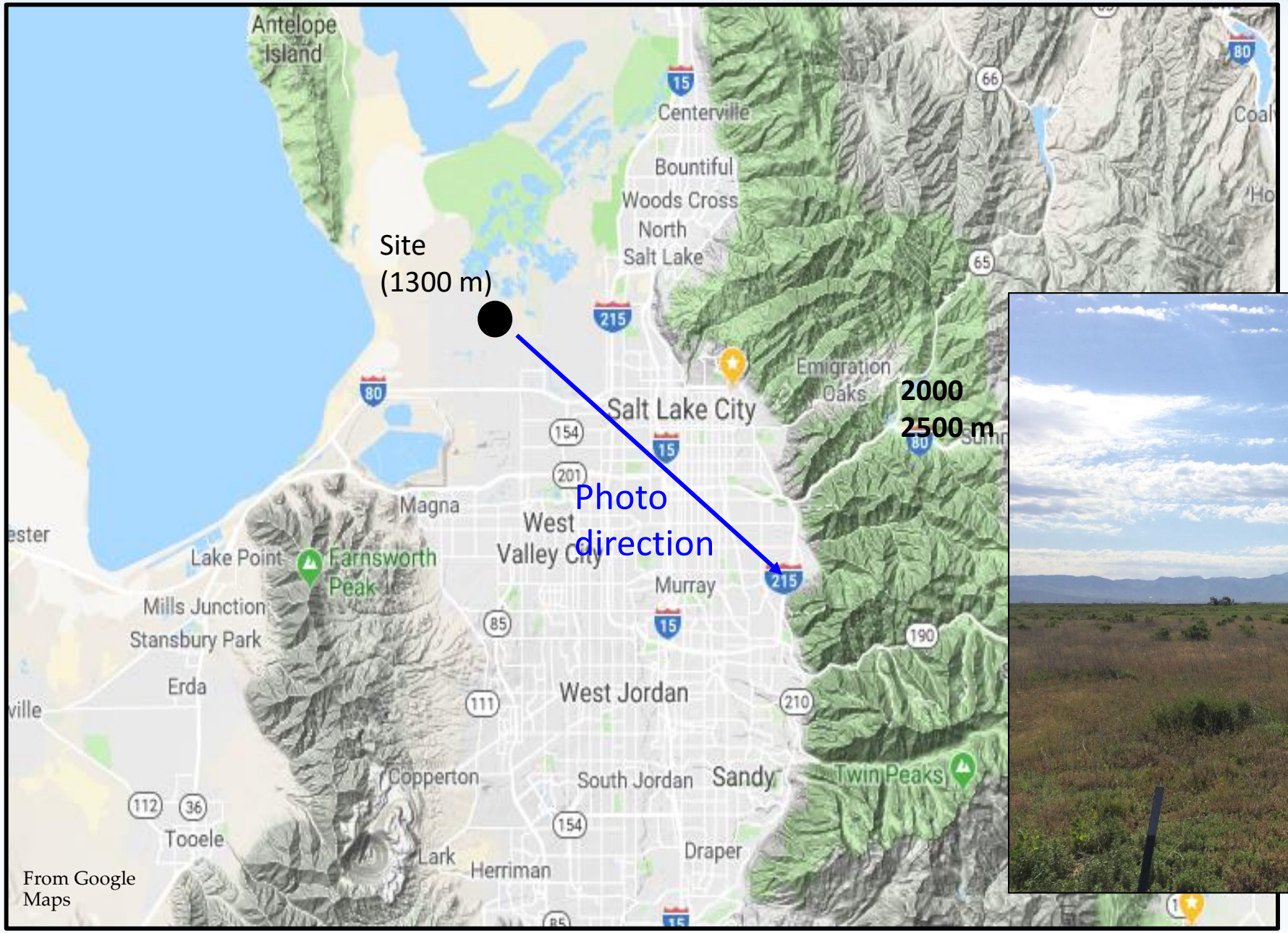
177 nighttime

136 daytime

Salt Lake Valley (Rocky Mountains) - SLV

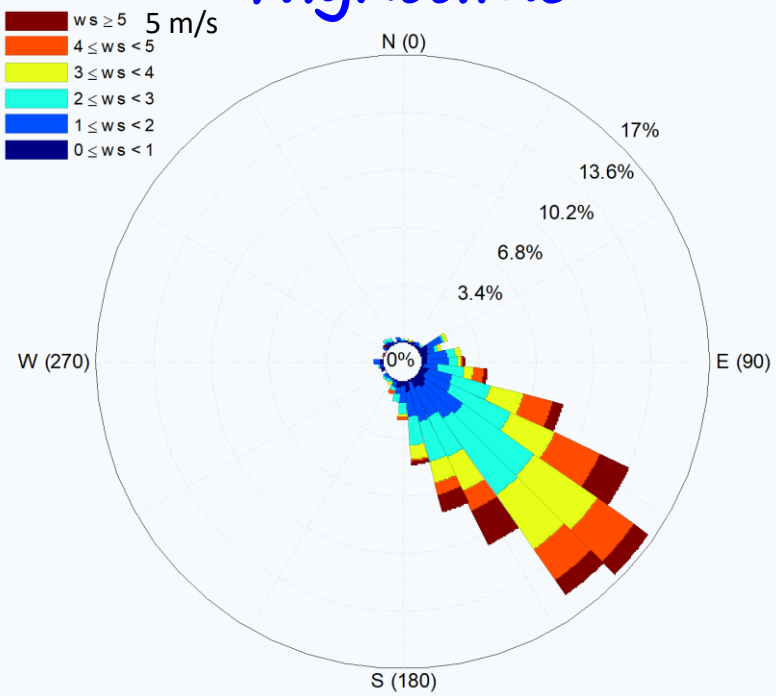
From Google Maps

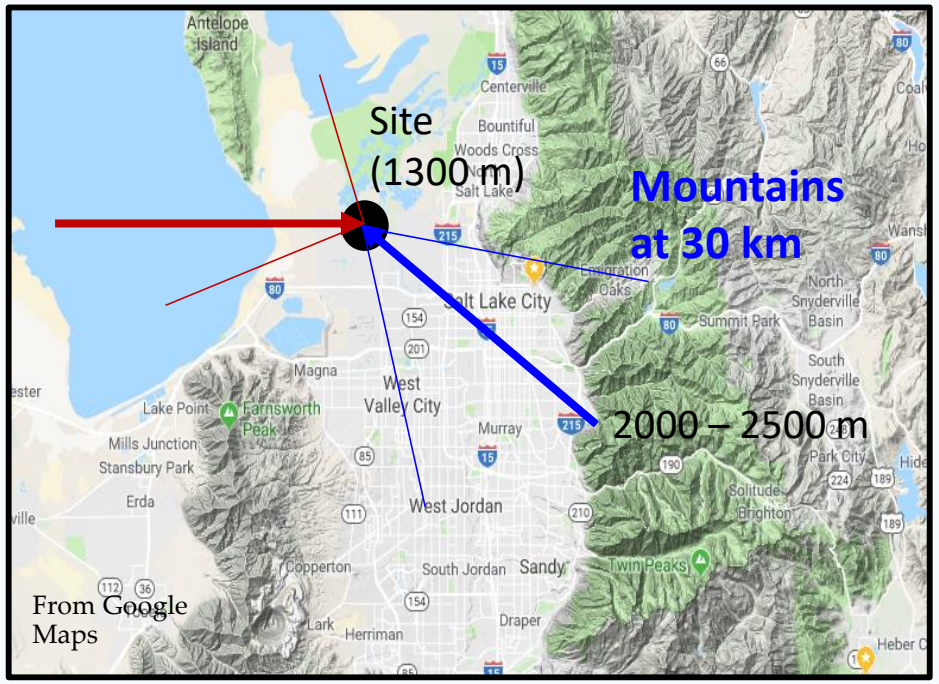
Salt Lake Valley (Rocky Mountains) – SLV



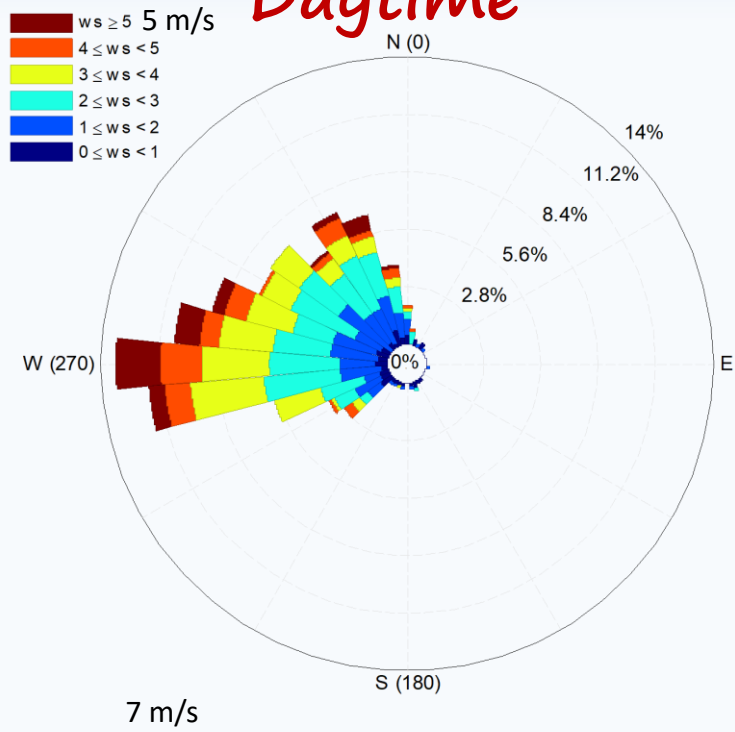
Salt Lake Valley (Rocky Mountains) - SLV

Nighttime





Daytime



EVENTS NUMBERS:

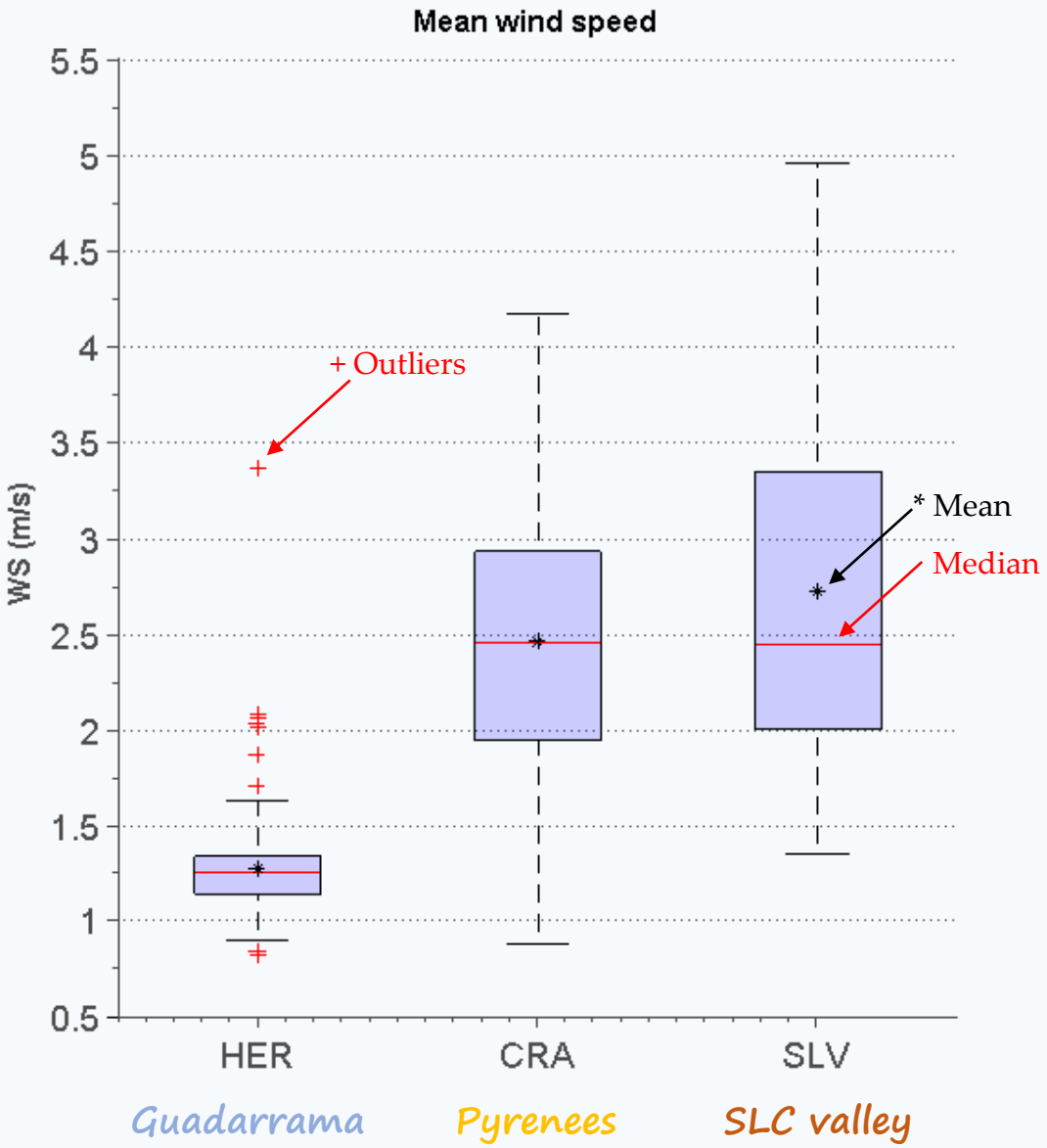
201 days analysed

30 nighttime

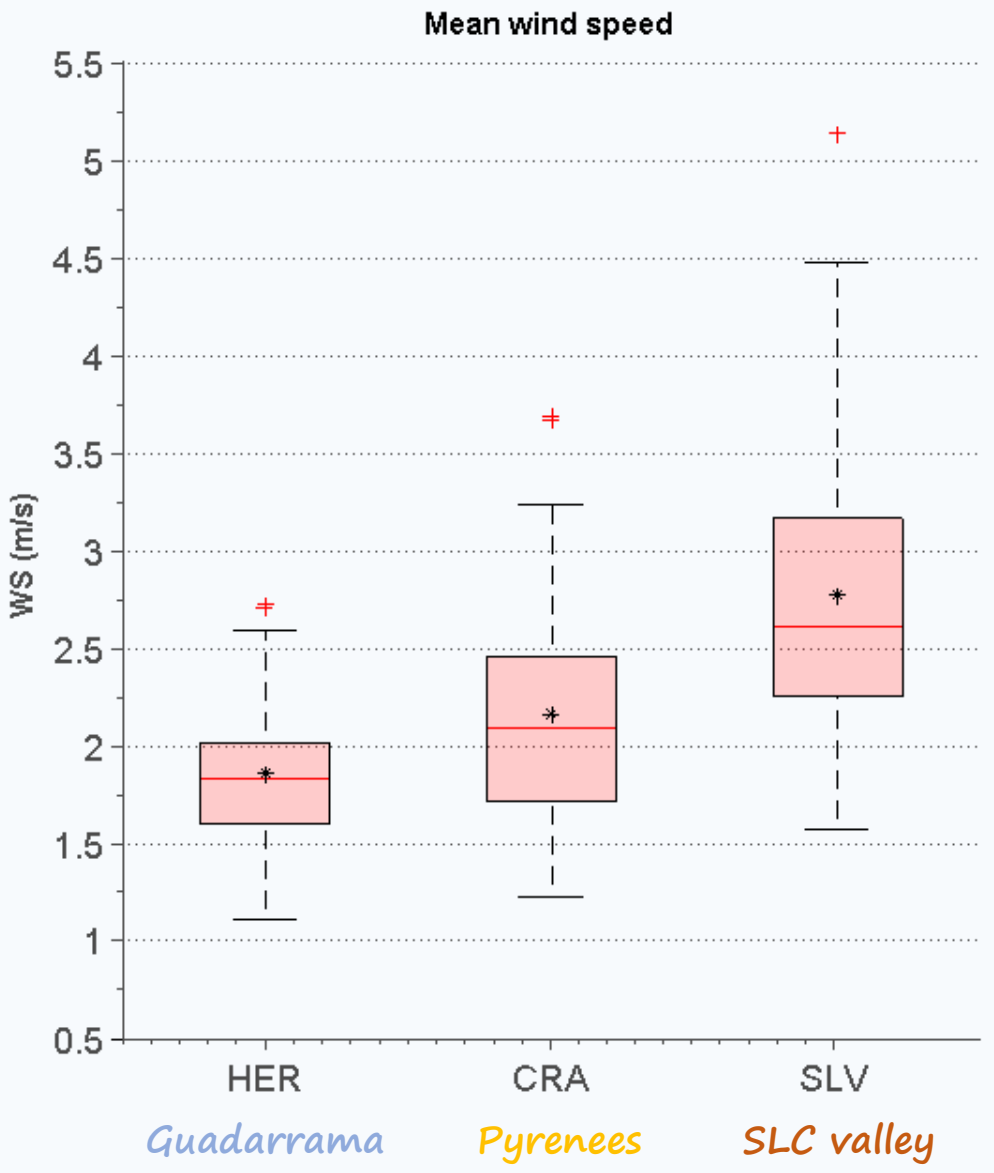
31 daytime

Mean WIND SPEED

Nighttime events

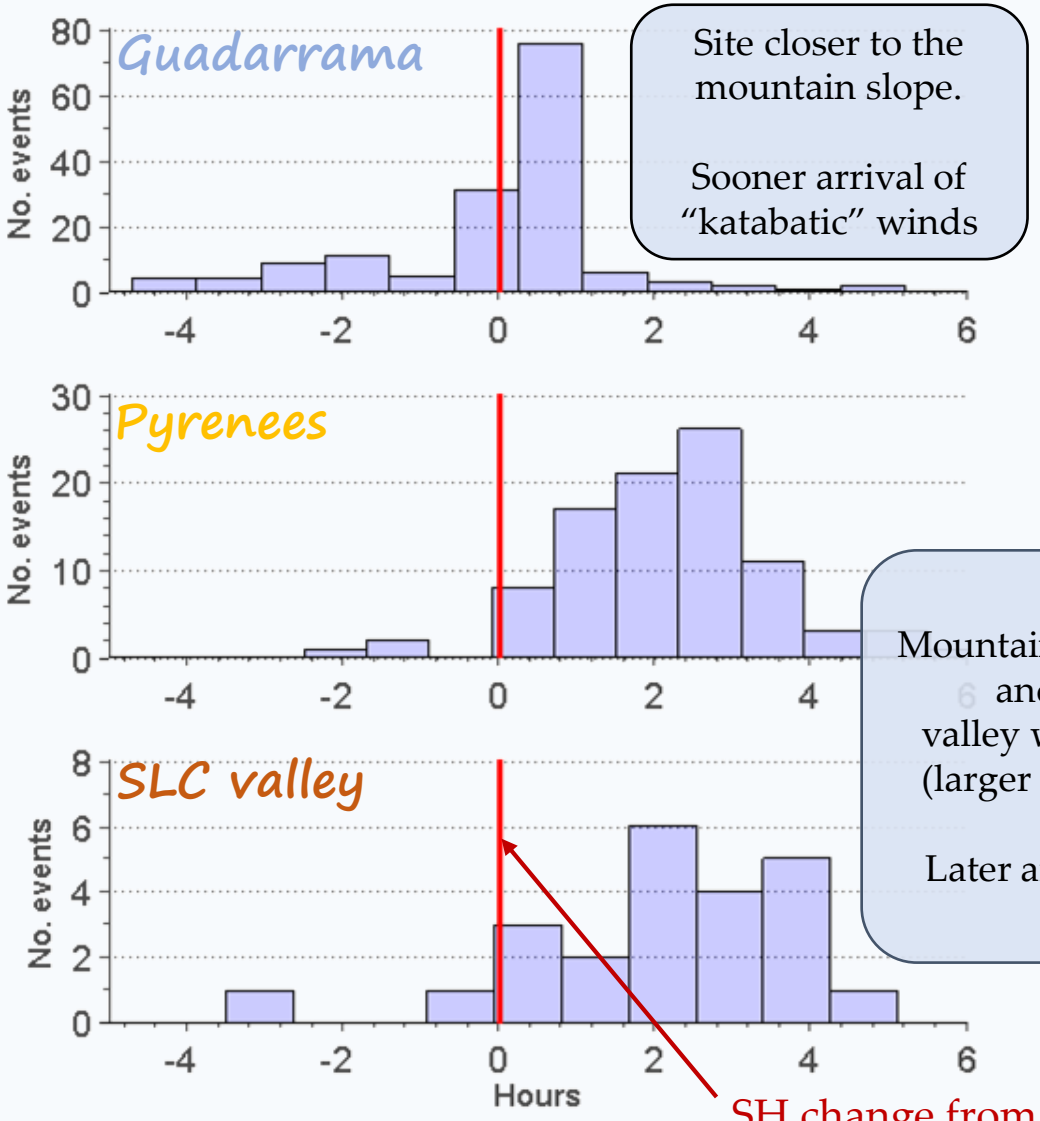


Daytime events



Mountain breezes arrival time (regarding sunset)

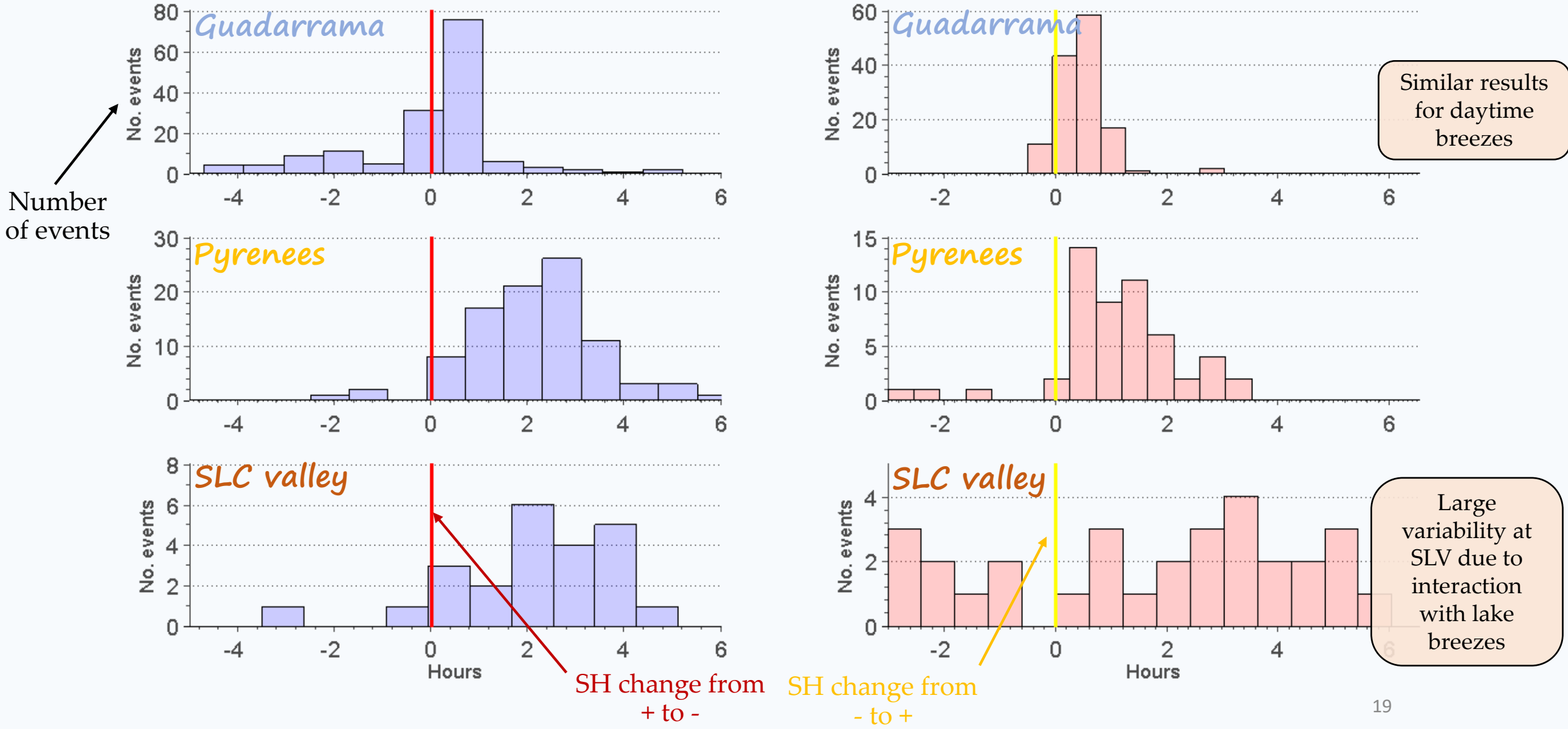
Nighttime events *Daytime events*



Mountain breezes arrival time (regarding sunset)

Nighttime events

Daytime events



Similar results for daytime breezes

Large variability at SLV due to interaction with lake breezes

Objective 2. CO_2 & mountain breezes

CO_2 diurnal cycle. What is the influence of the mountain breezes?

CO_2 evolution
- Plant activity
- "Soil" respiration

  → DAYTIME → Less CO_2 (photosynthesis)
  → NIGHTTIME → More CO_2 (respiration)
- PBL dynamics (height)*
- Degree of turbulence*
- Advection*
- Mixing from "above"*

* Potentially influenced by mountain breezes

Objective 2. CO_2 & mountain breezes

CO_2 jump

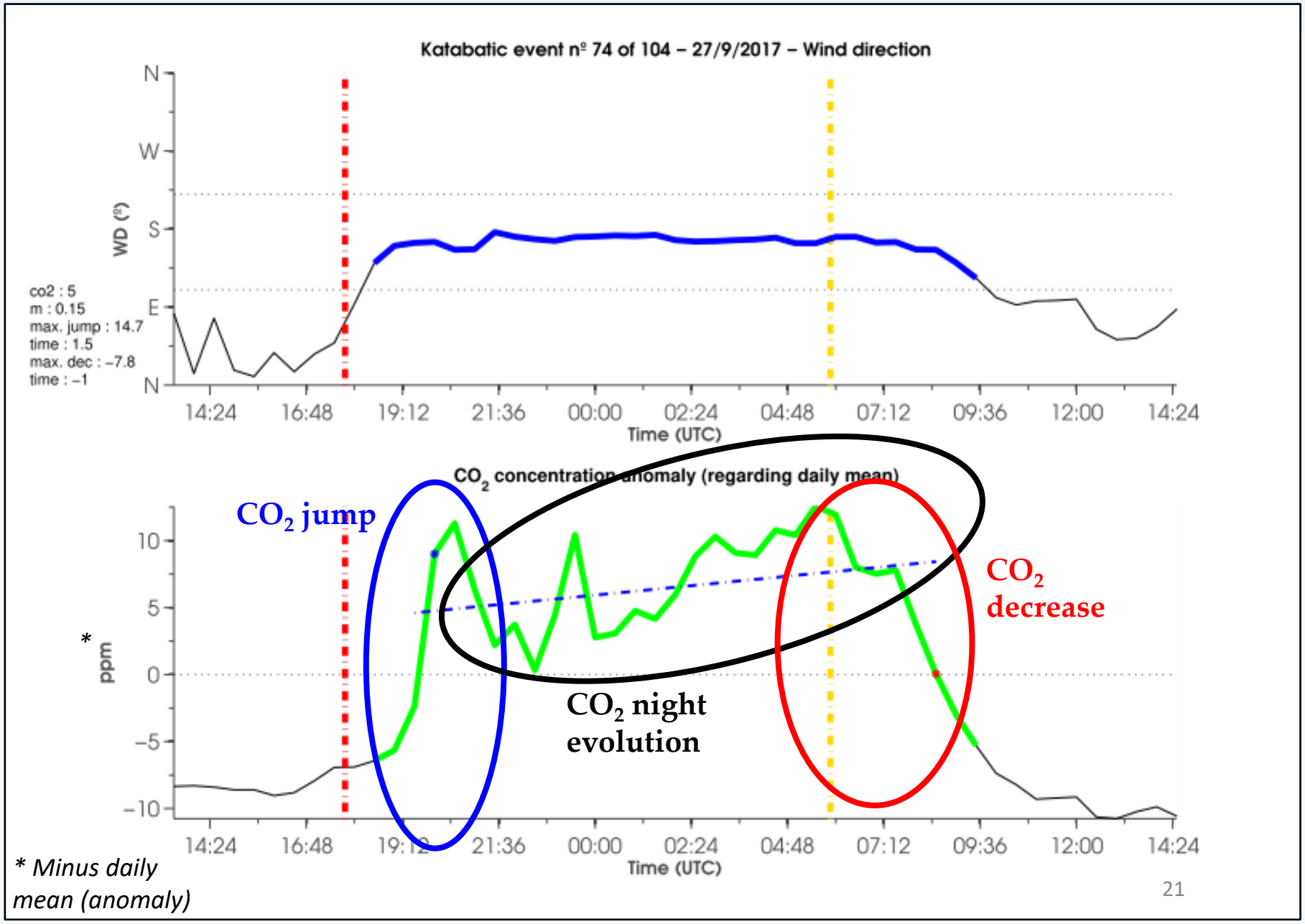
Katabatic onset?

CO_2 night evolution (slope)

TKE?

CO_2 decrease

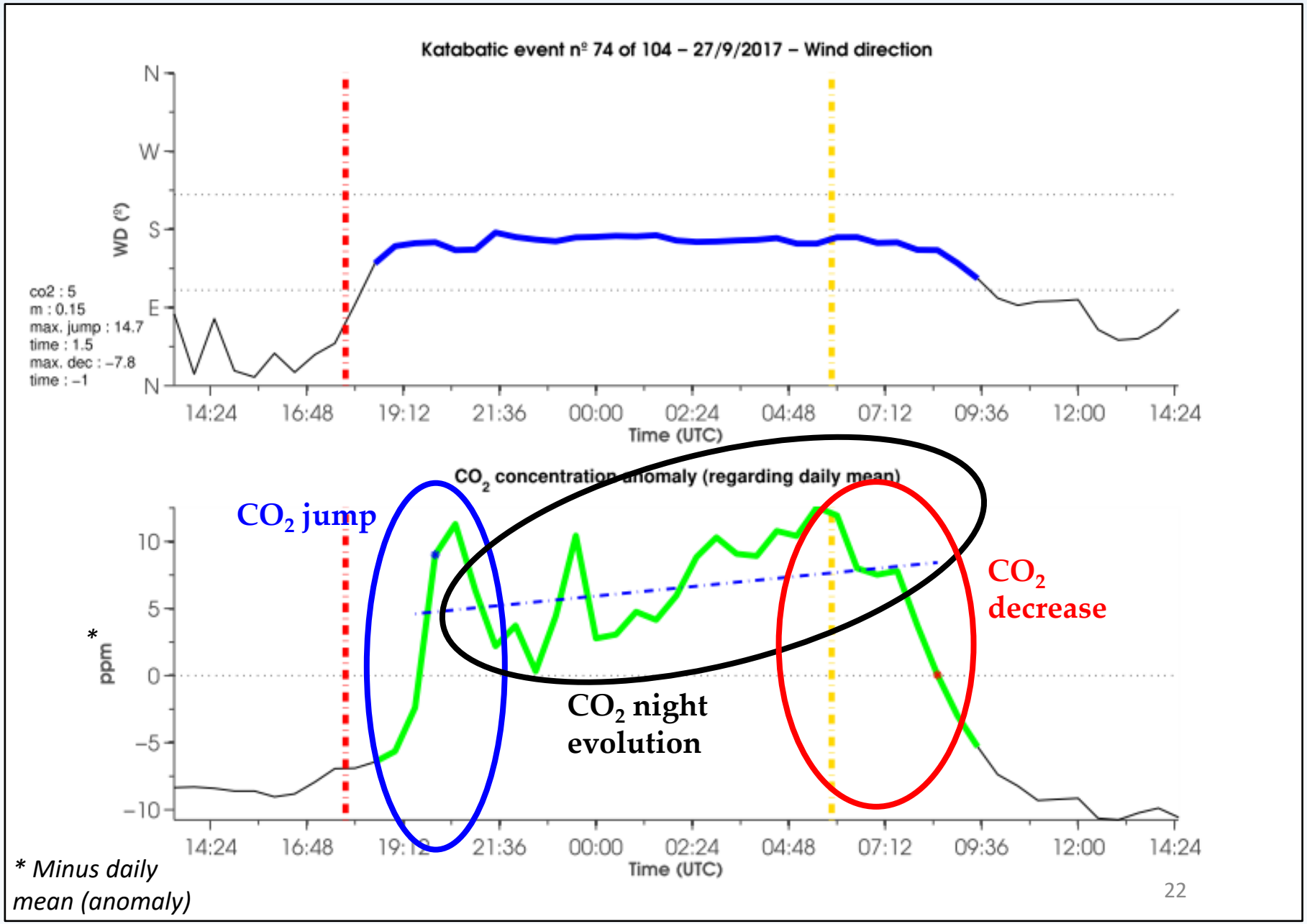
Anabatic onset?



** Minus daily mean (anomaly)*

Mean CO_2 concentration* during events

MEAN CO_2 during the events??



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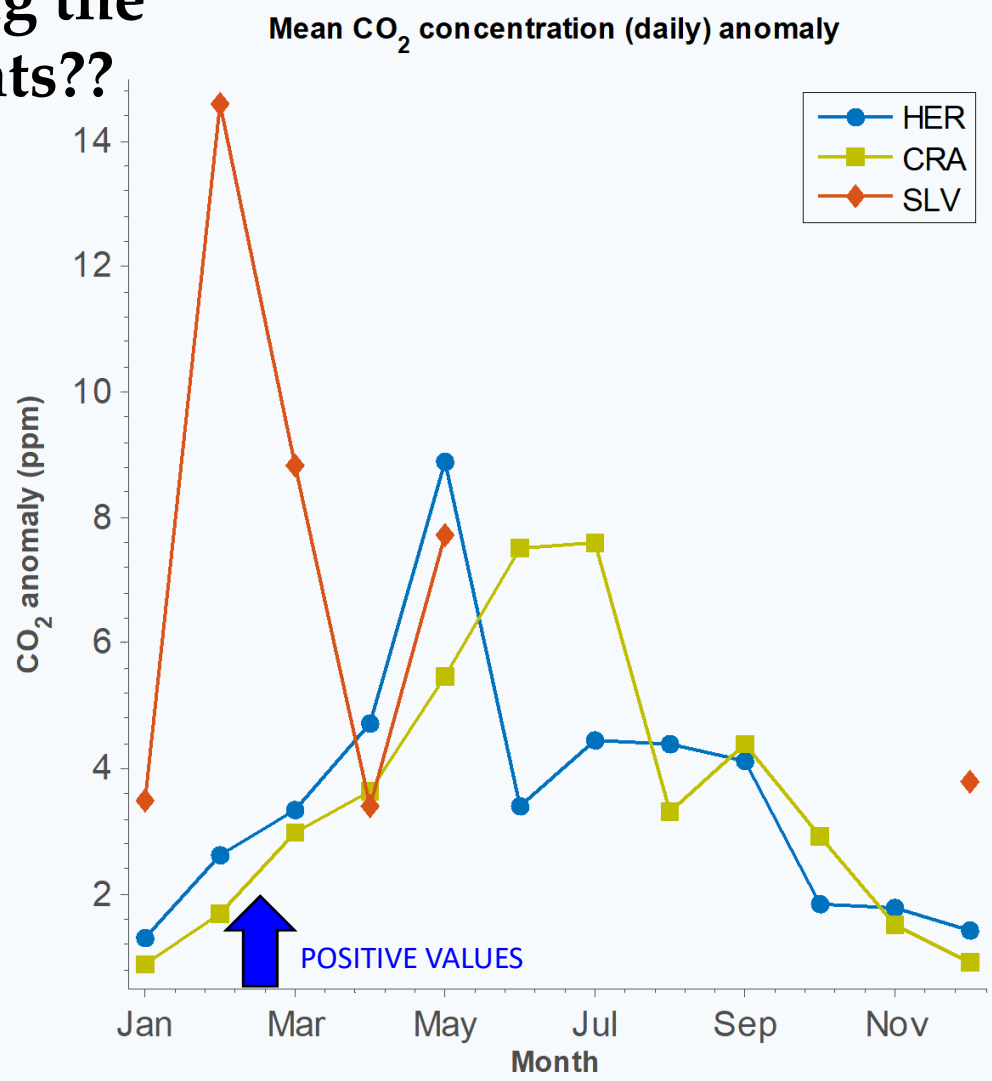
Mean CO_2 concentration* during events

* Minus daily mean (anomaly)

MEAN CO_2 during the events??

Nighttime events

Daytime events



Mean CO_2 concentration* during events

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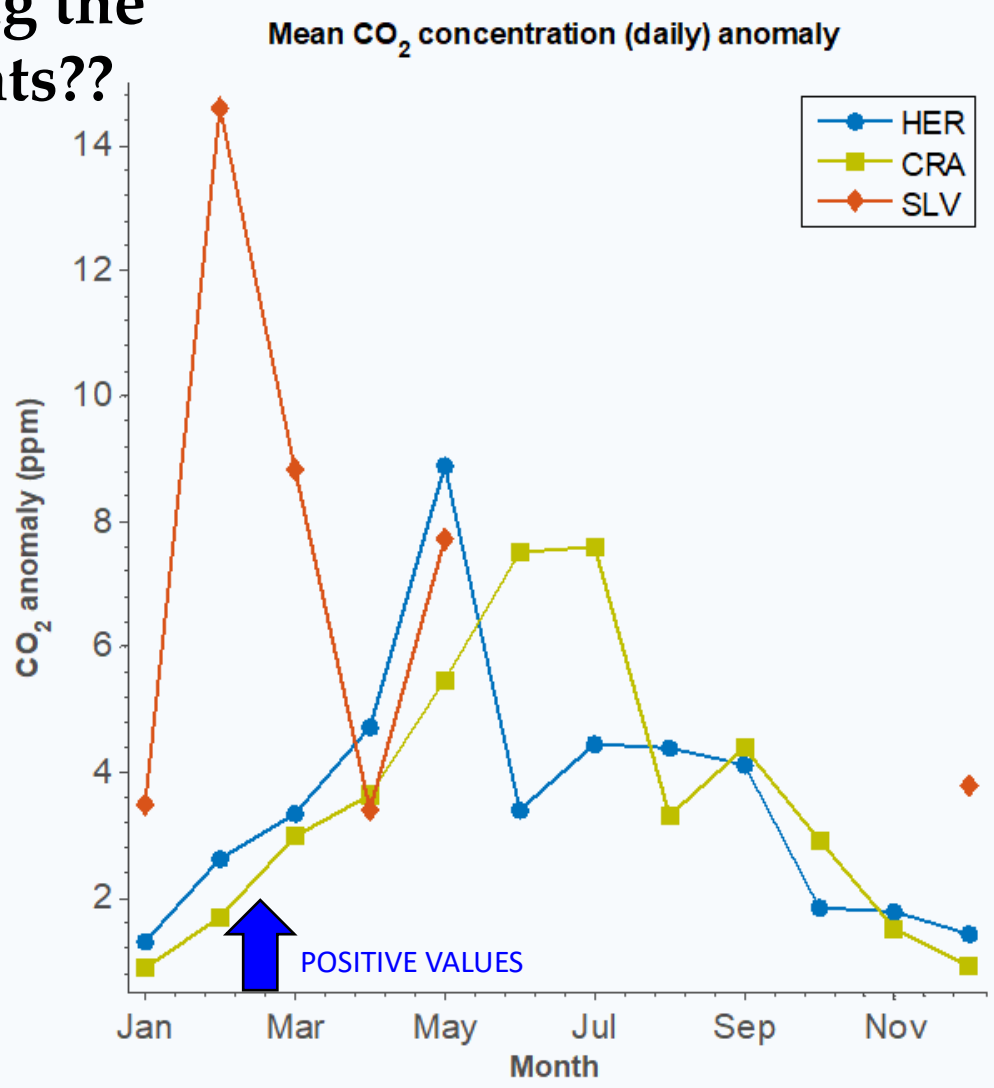
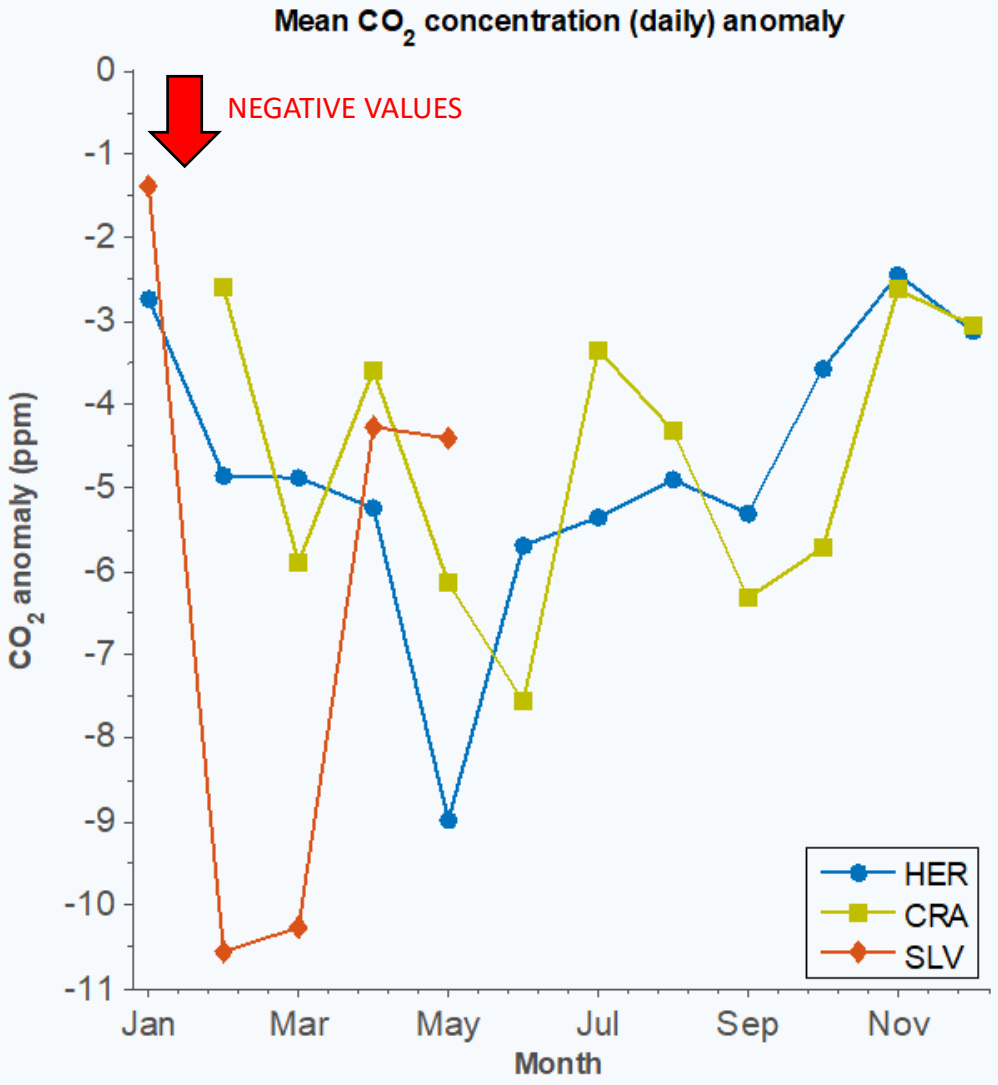
MEAN CO_2 during the events??

Nighttime events

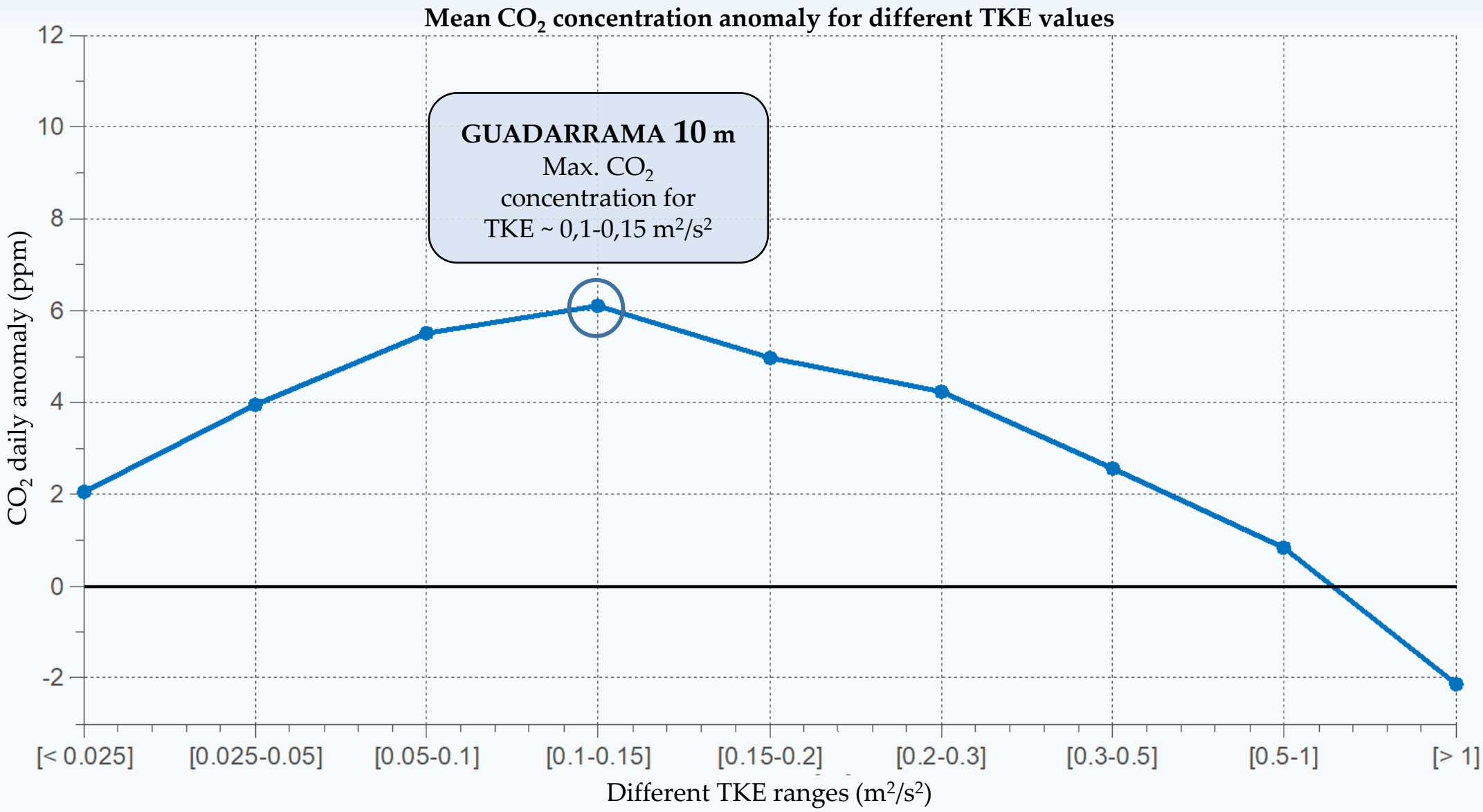


Daytime events



CO_2* vs TKE during nighttime events

** Minus daily mean (anomaly)*



CO_2* vs TKE during nighttime events

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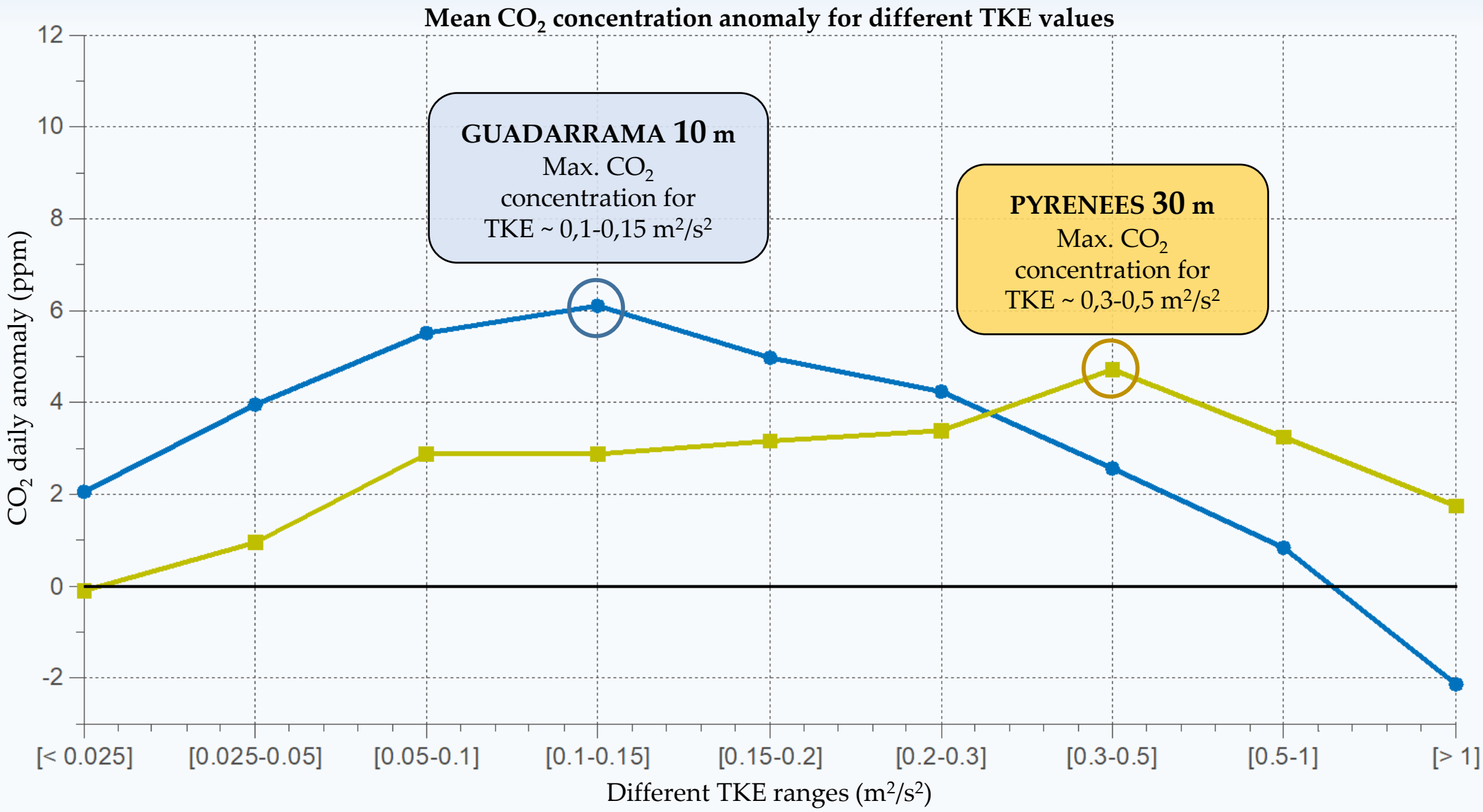


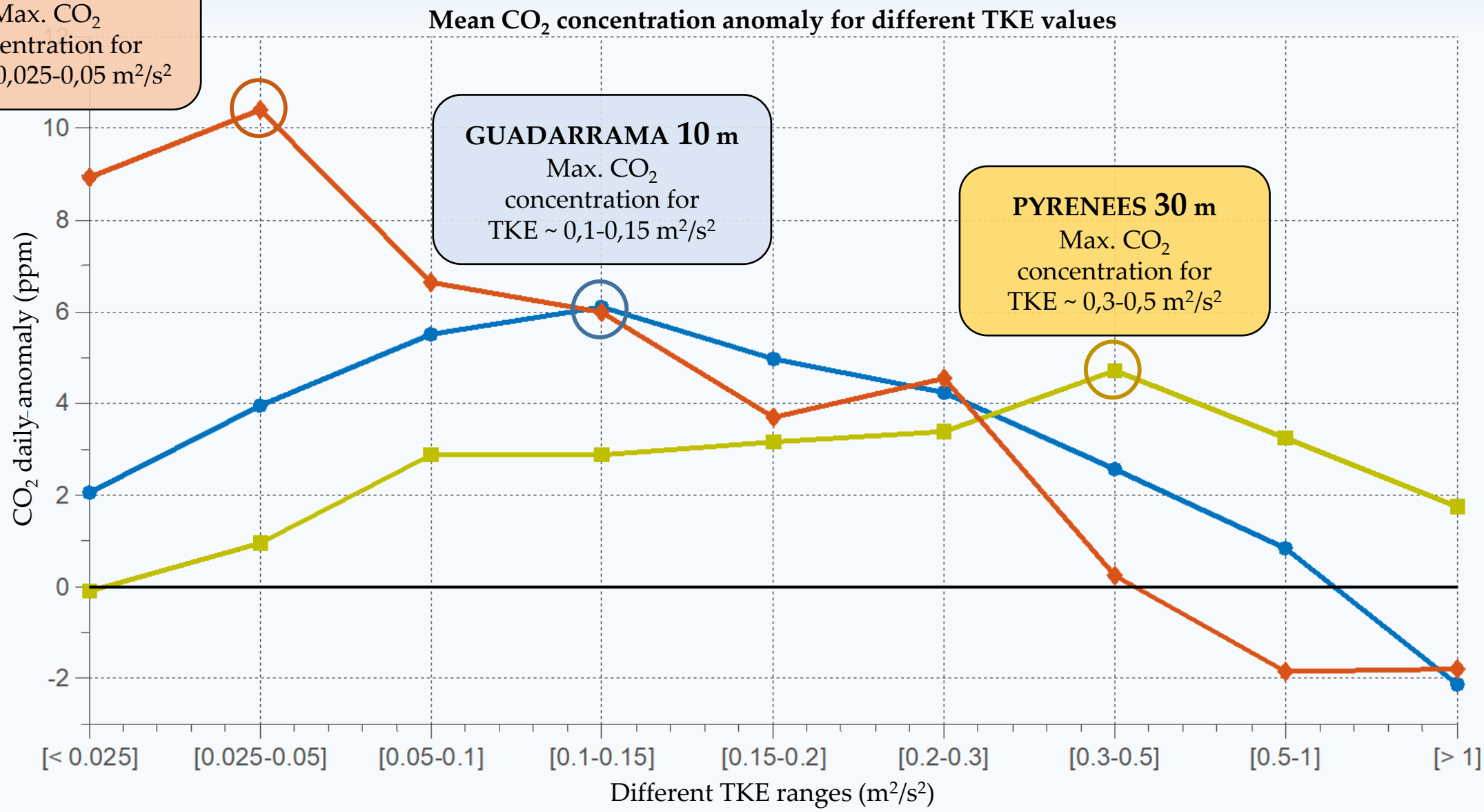
CO_2* vs TKE during nighttime events

** Minus daily mean (anomaly)*

SLC 10 m
Max. CO_2 concentration for TKE ~ 0,025-0,05 m^2/s^2

GUADARRAMA 10 m
Max. CO_2 concentration for TKE ~ 0,1-0,15 m^2/s^2

PYRENEES 30 m
Max. CO_2 concentration for TKE ~ 0,3-0,5 m^2/s^2

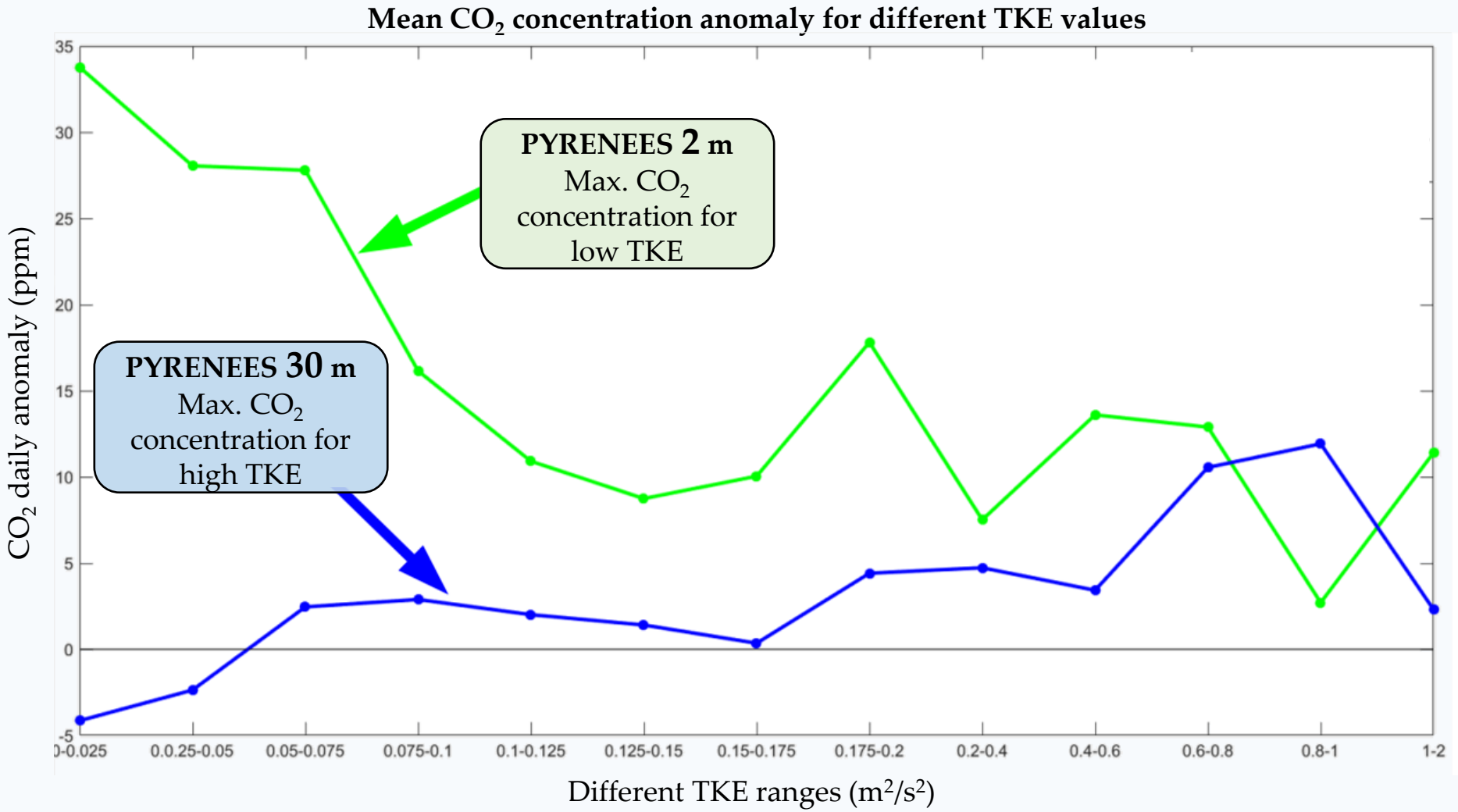


CO_2* vs TKE during nighttime events

** Minus daily mean (anomaly)*

Different dataset (BLLAST 2011)

Work of P. Campargue-Rodriguez and I. Turki (M1 students)

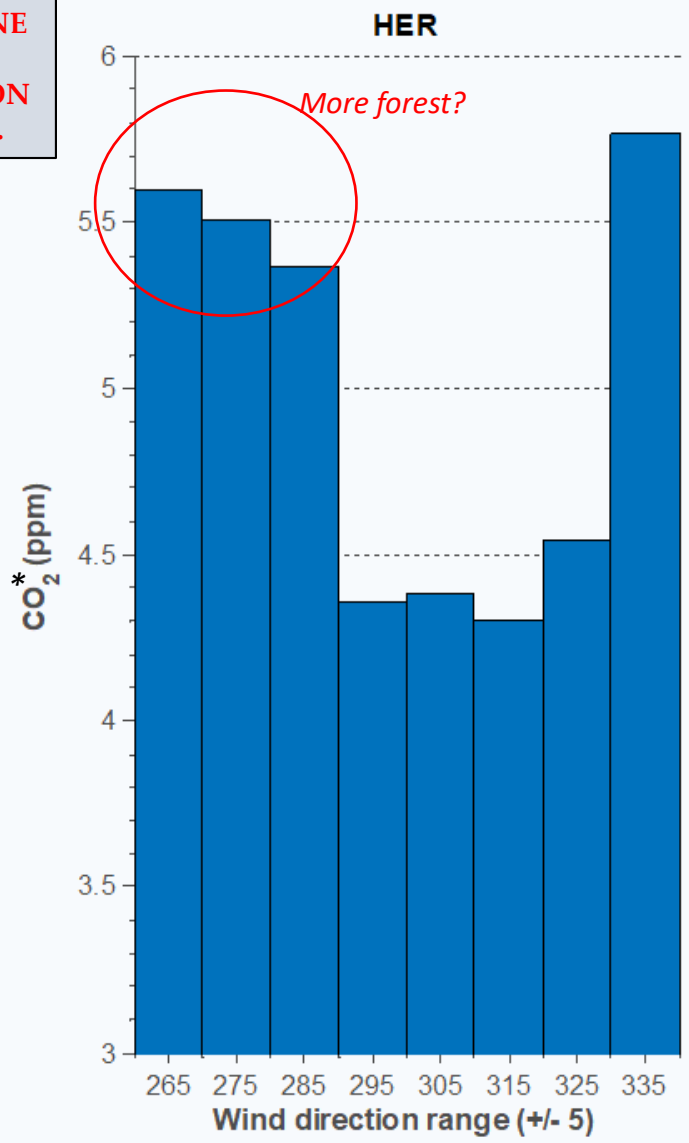


Nighttime events

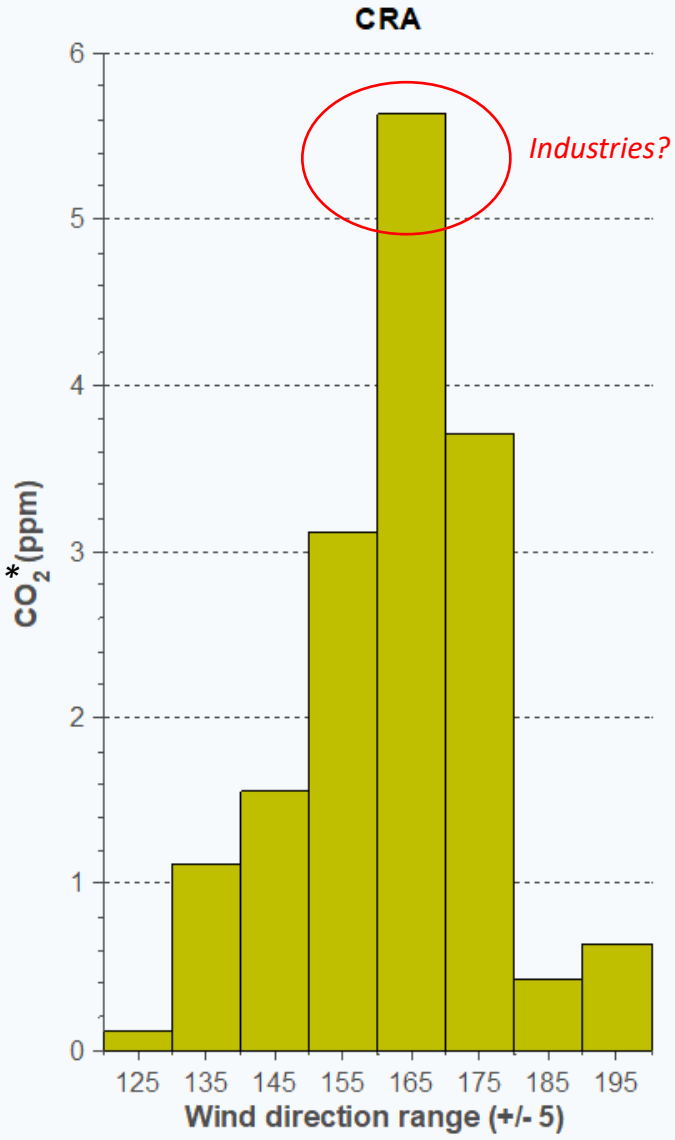
CO_2* concentration for different WD

* Minus daily mean (anomaly)

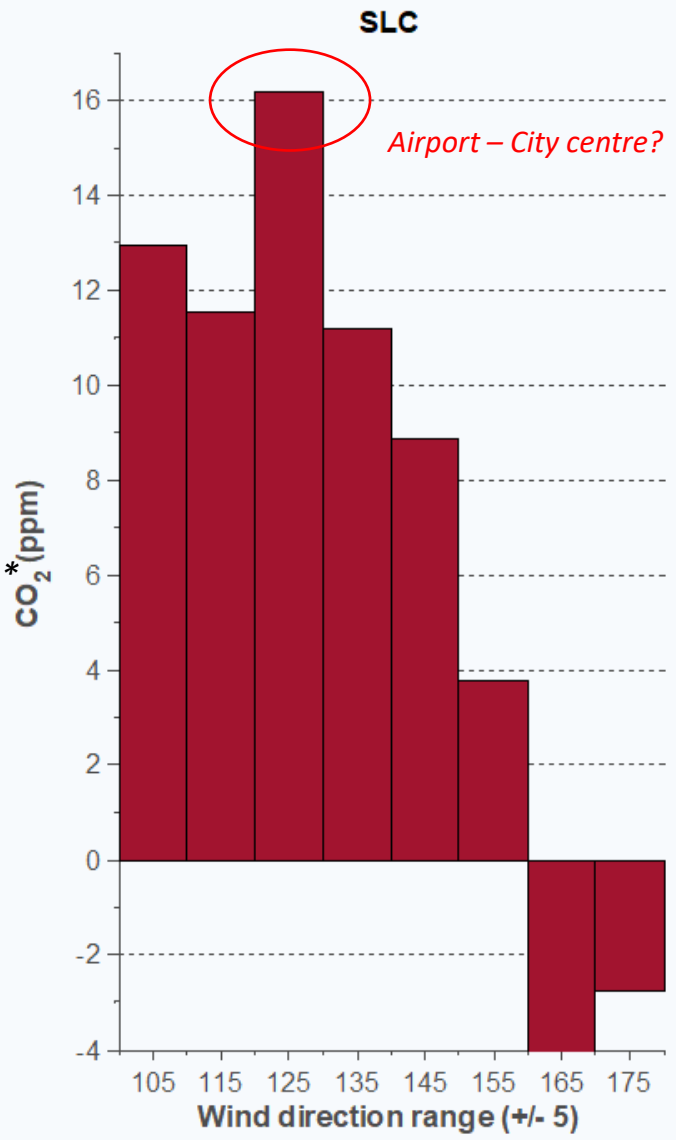
TRYING TO DETERMINE THE ADVECTION EFFECT…



Guadarrama



Pyrenees



SLC valley

Conclusions

- Different features of MOUNTAIN BREEZES due to:
  - Type of phenomena (katabatic, mountain-plain, valley-channelled flows)
  - Distance to the mountains, tower location…

- CO_2 modulated by:
  - **PBL transitions: stable ⟷ convective**
  - **Turbulence (especially during nighttime)**
  - **Wind direction (advection) in very heterogeneous sites (SLC)**

Mountain breezes influence CO_2 concentrations

and…

- Mixing from "above" in SBL (Gravity waves? Residual eddies?)
- Soil respiration??
- Plants activity??


CRA looking S-SW with Pic du Midi behind the 60-m tower.
Merci!