What turbulent processes in the lower atmosphere are observed over a irrigated and no irrigated surface during the LIAISE campaign?

G. Canut [1] , M. Lothon [2] , L.Joly [3] , A. Boone [1] , J. Couzinier [1] , J.C Etienne [1] , E. Moulin [1,] T. Lunel[1], A. Philibert[2] and A. Roy [1]

[1]*CNRM, Météo-France UMR 3589 CNRS, Toulouse, France*
[2]*LAERO, Univ. of Toulouse, CNRS, UPS, Toulouse, France*
[3]*GSMA, Université de REIMS, CNRS, France*

Thanks to the P2OA team, to the CNRM/GMEI team, and to Salomé Avrillaud (ENM student 2022) and Emmeline Francois (master's student 2023)

LIAISE project

LIAISE = **L**and surface **I**nteractions with the **A**tmosphere over the **I**berian **S**emi-arid **E**nvironment

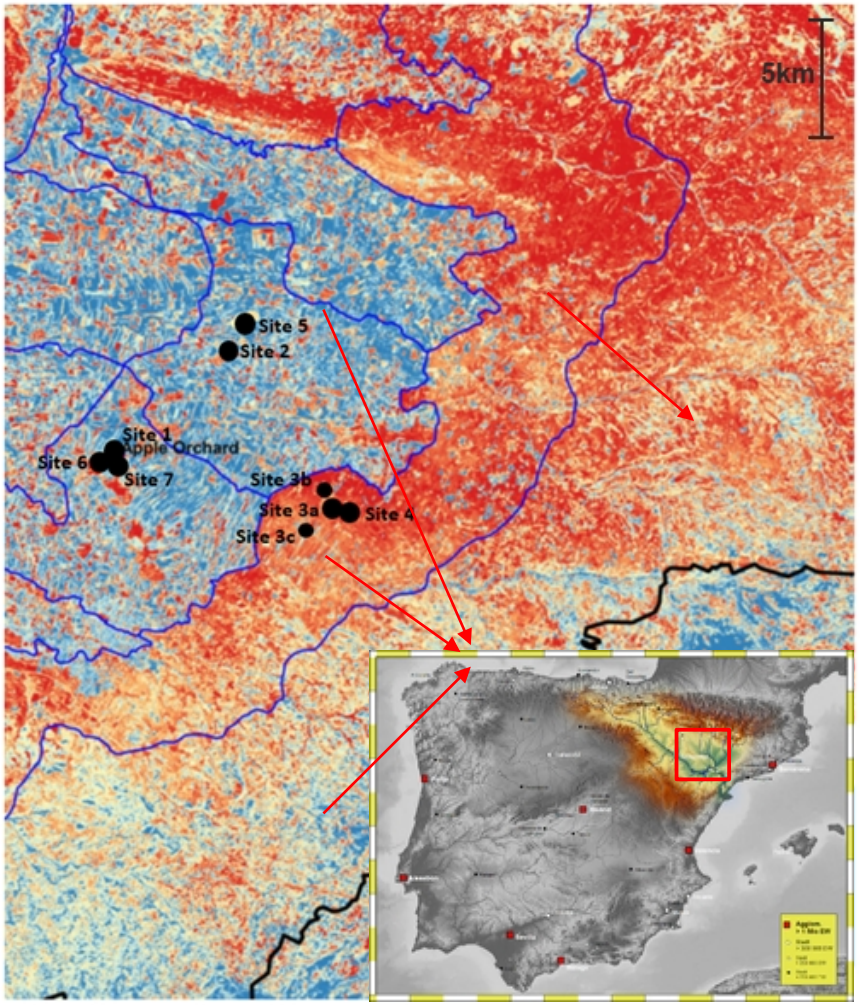
A. Boone[1], M. Best[8], J. Cuxart[7], J. Polcher[2], P. Quintana-Segui[4], J. Bellevert[3], J. Brooke[6], G. Canut-Rocafort[1], J. Price[6], O. Hartogensis[7], J. R. Miro[8], P. LeMoigne[1]

1 CNRM Météo-France/CNRS, Toulouse, France
2 LMD, IPSL, Paris, France
3 IRTA, Lleida, Spain
4 Observatori de l'Ebre, Roquetes, Spain
5 UIB, Balearic Islands, Spain
6 UKMO, Exeter, UK
7 U. Wageningen, Netherlands
8 SMC, Barcelona

GEWEX project : 2020-2024

Focus on the LIAISE fiel campaign

Heterogeneity of land cover



SENTINEL2 Land Surface temperature -
Courtesy : H. Nieto, IRTA





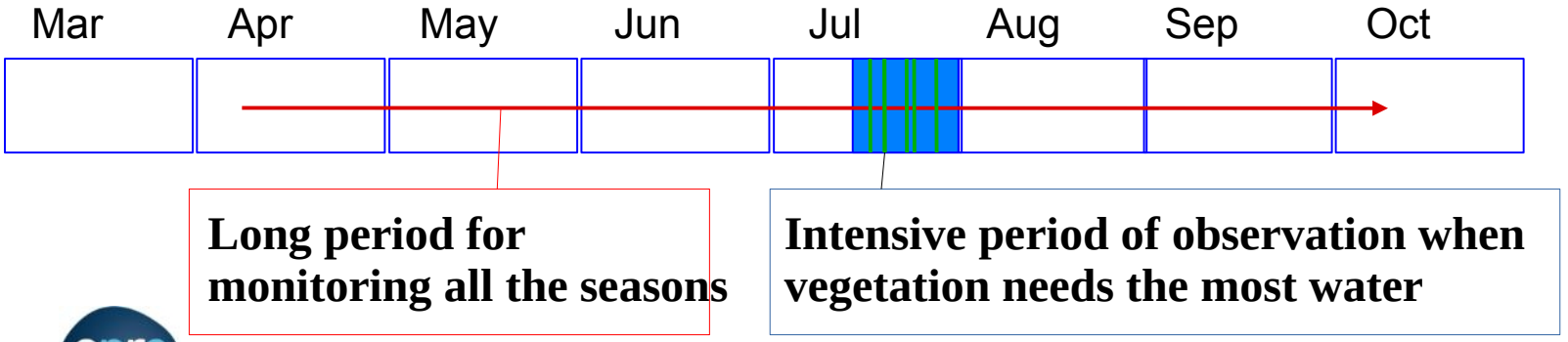



Focus on the LIAISE fiel campaign

LIAISE = **L**and surface **I**nteractions with the **A**tmosphere over the **I**berian **S**emi-arid **E**nvironment

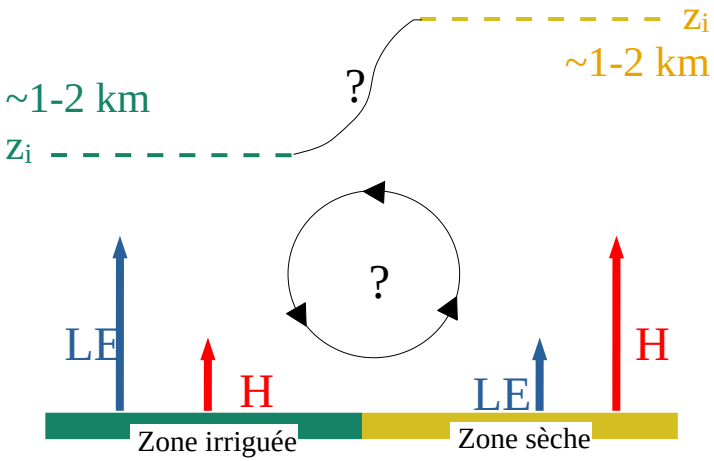
One of the objectives: **Study of the influence of surface heterogeneity artificially created by irrigation on the atmospheric boundary layer**

→ **Field campaign**



Focus on the LIAISE fiel campaign

LIAISE = **L**and surface **I**nteractions with the **A**tmosphere over the **I**berian **S**emi-arid **E**nvironment



. **2 super sites :**

- La Cendrosa (BL1) : humid zone (agricole irriguée)
- Els Plans (BL2) : natural and semi-arid zone

. UHF wind profiler, 50 meters tower for SEB, hourly radiosoundings in both si

Outlines

- Overview of strong heterogeneities

  1- at the surface from 50 m tower

  2- within the ABL from UHF wind profiler

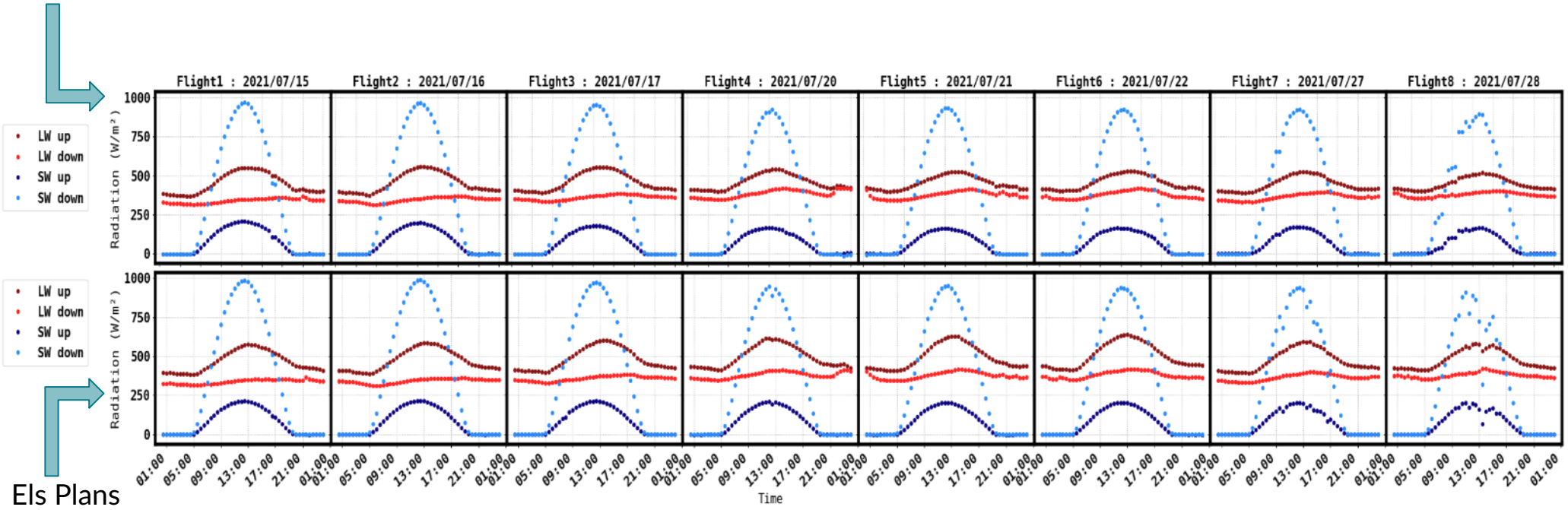
  3- within the ABL from aircraft and tethered balloon
- Some details on the mast and thetered ballon measurements
- Surface energy balance on the lake
- Study with mesonh numerical models

Overview of strong heterogeneities : 50m towers

LC = La Cendrosa
EP = Els Plans

Radiative fluxes (W/m²)

La Cendrosa



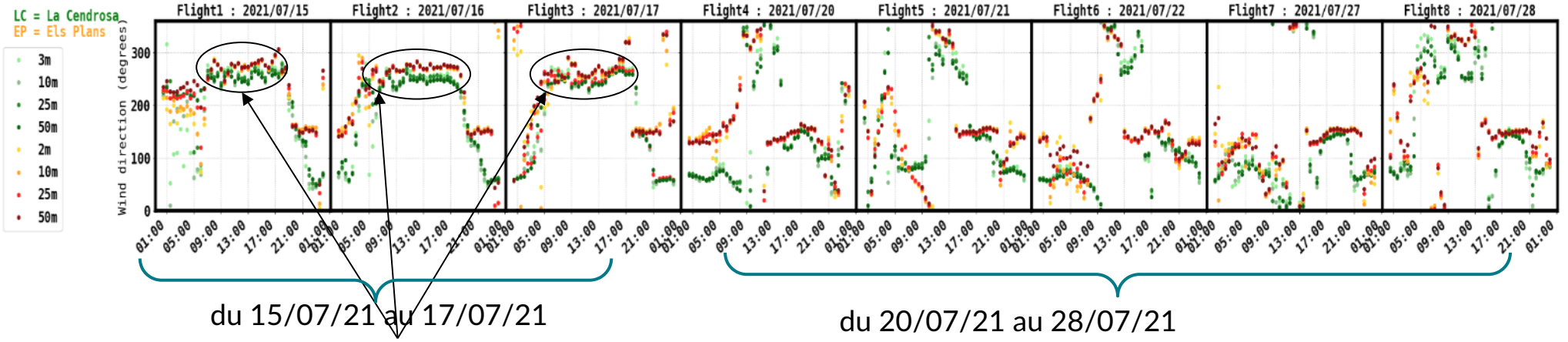
Els Plans

Similar Swd, no clouds

Overview of strong heterogeneities : 50m towers

LC = La Cendrosa
EP = Els Plans

- Wind direction



du 15/07/21 au 17/07/21

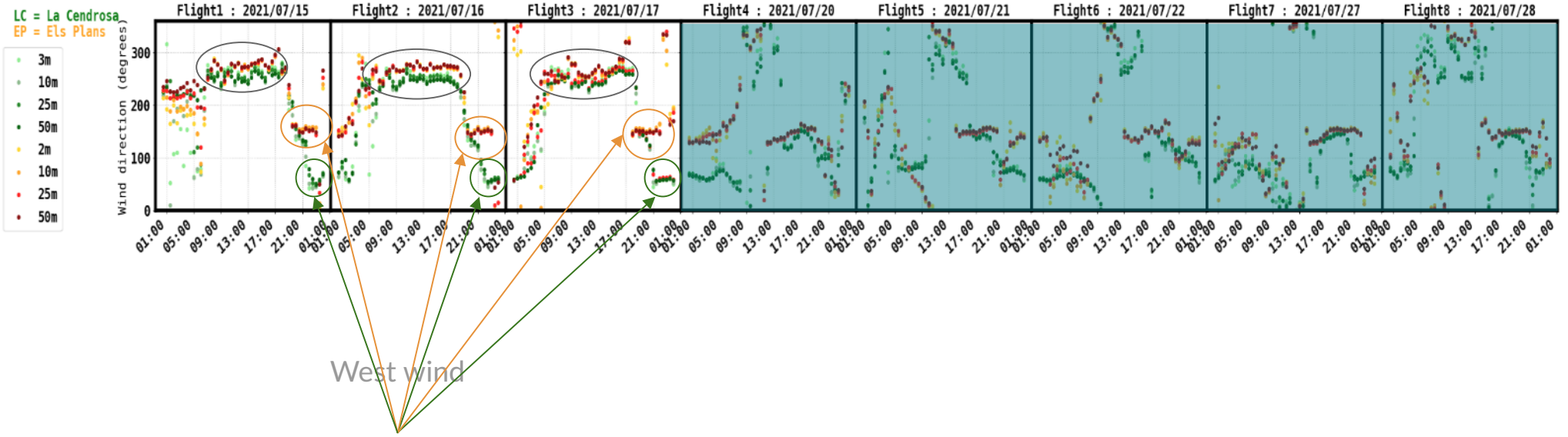
West wind during the day

du 20/07/21 au 28/07/21

Overview of strong heterogeneities : 50m towers

LC = La Cendrosa
EP = Els Plans

- Wind direction



Change during the night

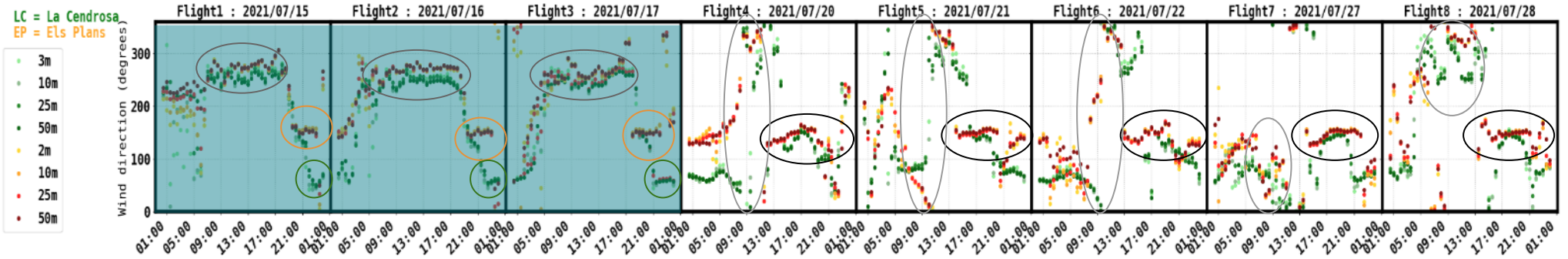
⇒ North-Est at La Cendrosa

⇒ South at Els Plans

Overview of strong heterogeneities : 50m towers

LC = La Cendrosa
EP = Els Plans

- Wind direction



2nd period :
-more direction during the day
-south west from 13UTC : La MARINADA

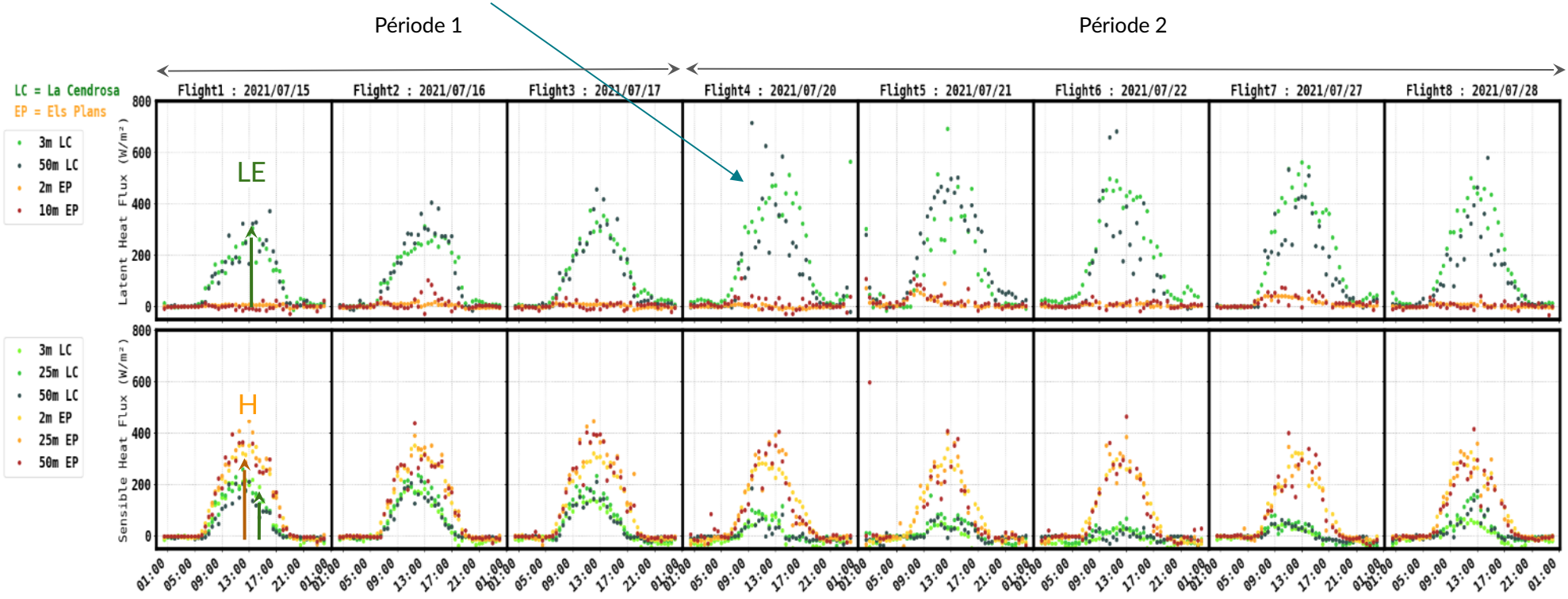
Marinada = inflow of sea air from the eastern Mediterranean coast

Overview of strong heterogeneities : 50m towers

LC = La Cendrosa
EP = Els Plans

- Latent and sensible heat fluxes

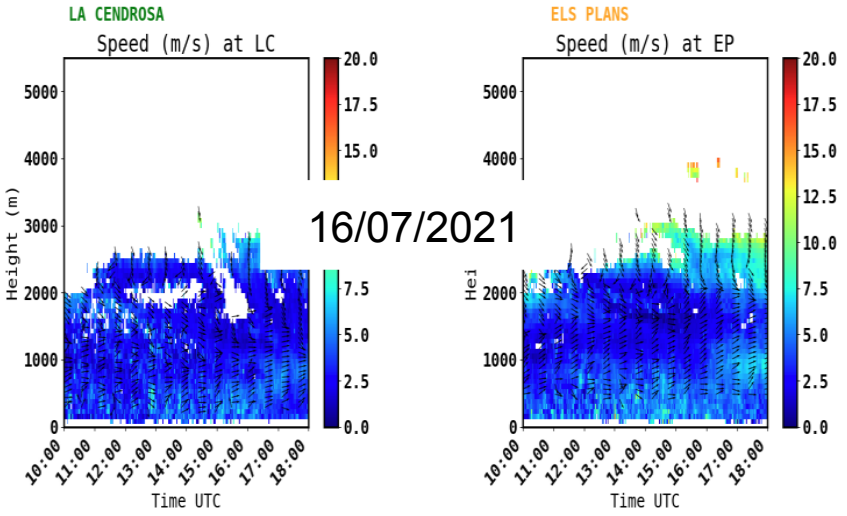
- intensification of LE in La Cendrosa from 20 july
- LE almost zero at Els Plans



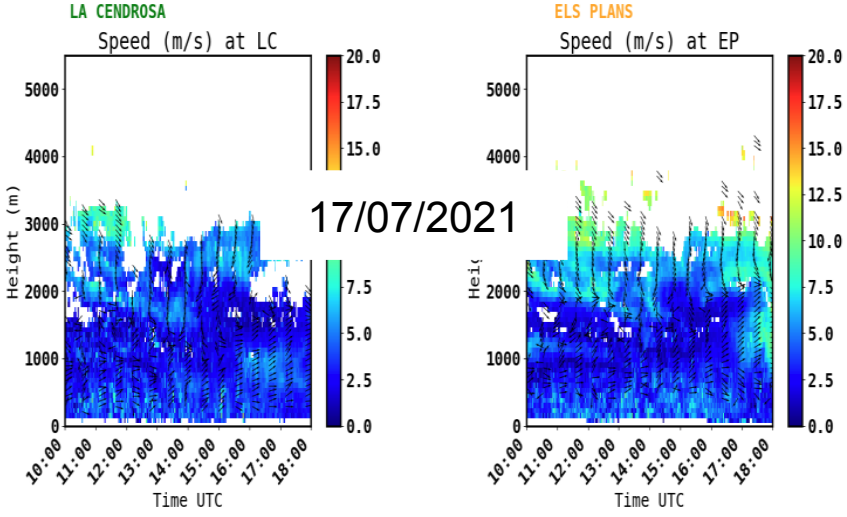
Overview of strong heterogeneities : UHF wind profilers

LC = La Cendrosa
EP = Els Plans

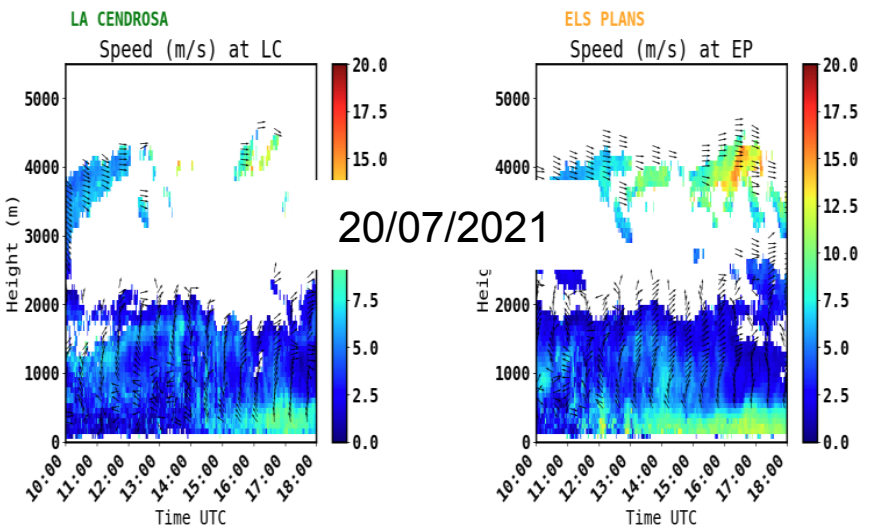
UHF LOW MODE, Flight 2: 20210716, moyenne sur 2min



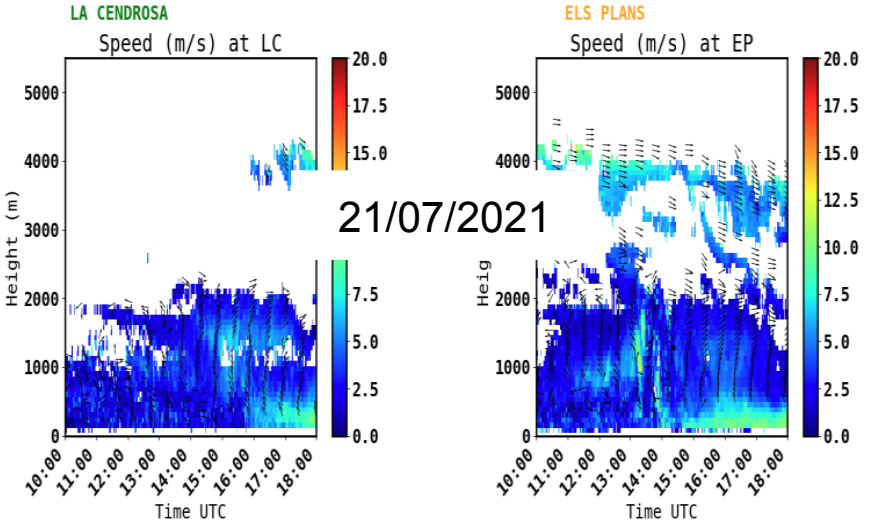
UHF LOW MODE, Flight 3: 20210717, moyenne sur 2min



UHF LOW MODE, Flight 4: 20210720, moyenne sur 2min

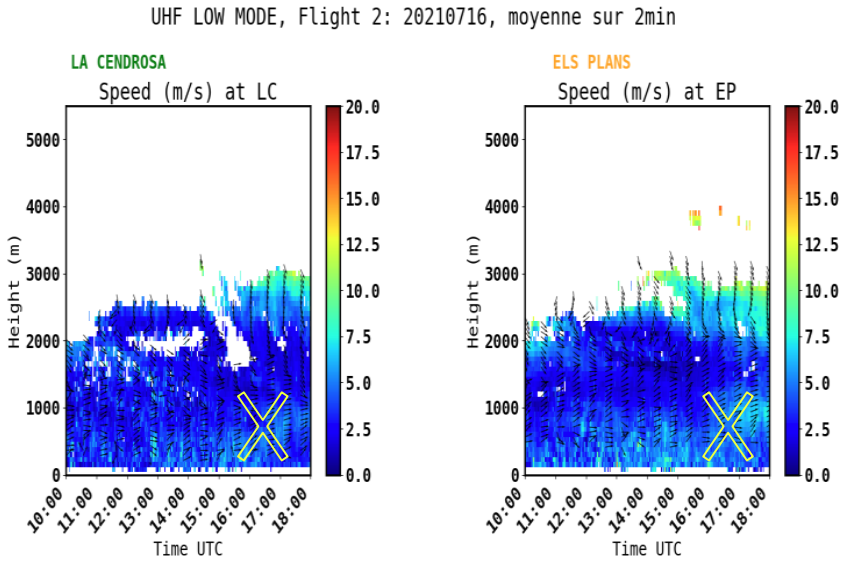


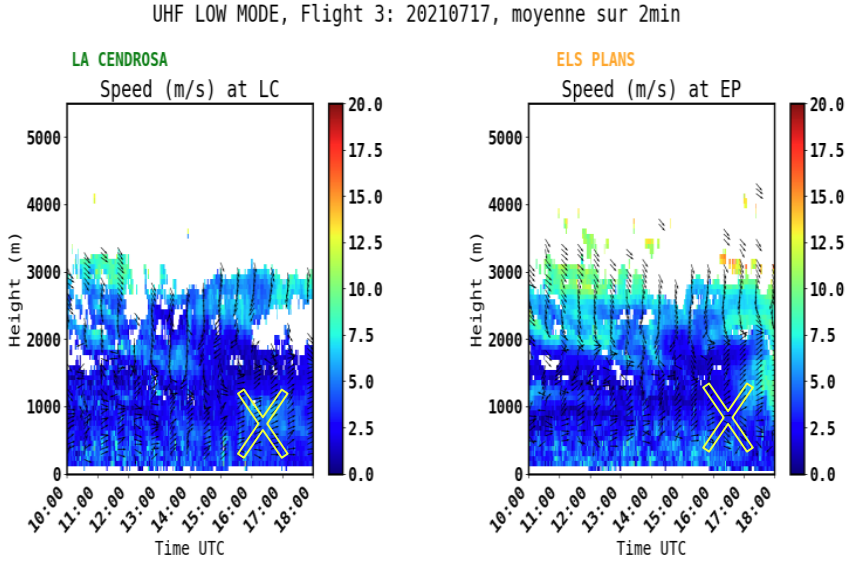
UHF LOW MODE, Flight 5: 20210721, moyenne sur 2min



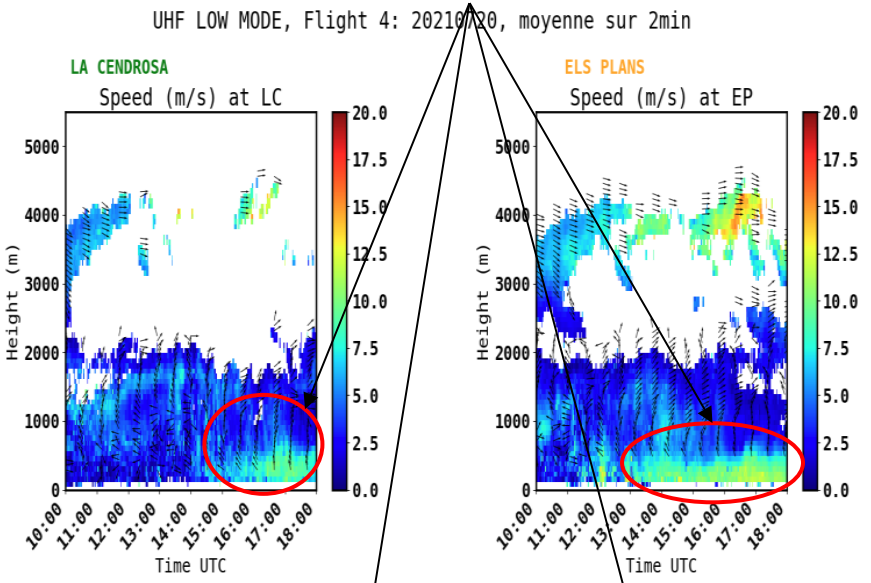
Overview of strong heterogeneities : UHF wind profilers

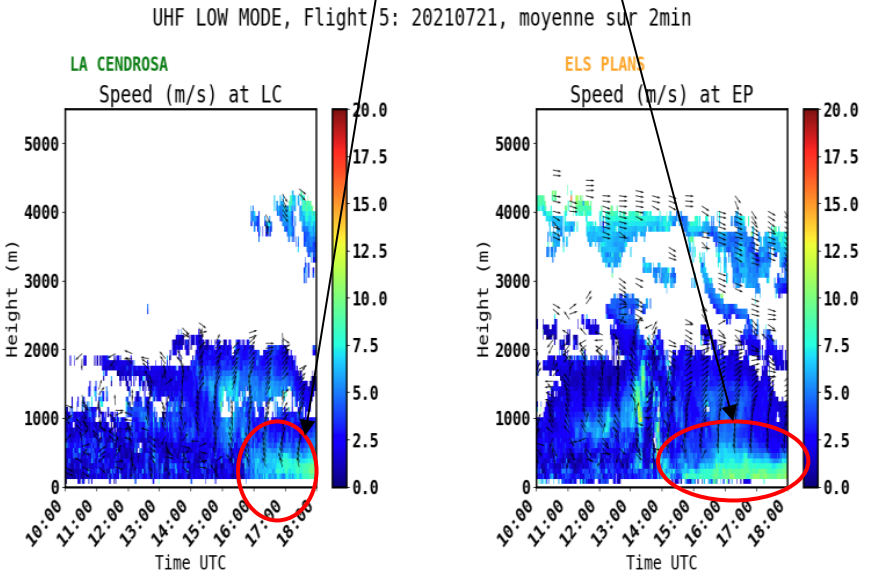
LC = La Cendrosa
EP = Els Plans





arrival of la marinada,easterly wind, later at EP than LC

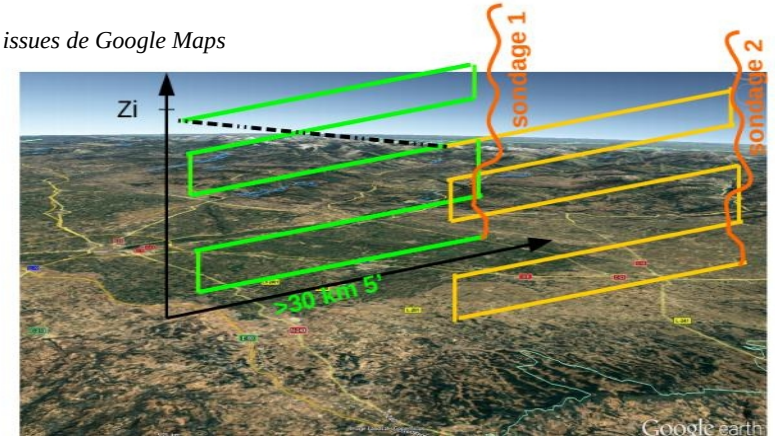




Overview of strong heterogeneities : ABL exploration

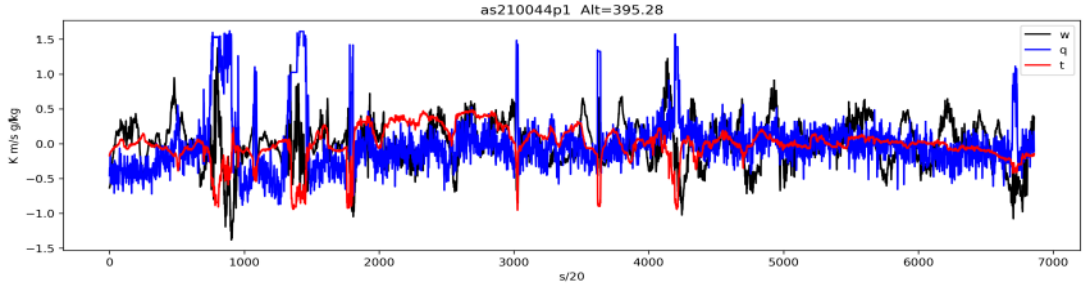
During the SOP, 8 flights with the french aircraft ATR42
- (15, 16, 17, 20, 21, 22, 27 and 28 july 2021)
- 80 horizontal stacked legs at midday

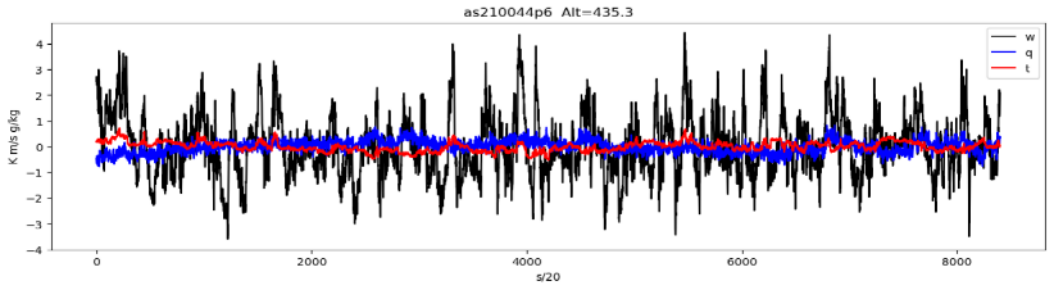
Images issues de Google Maps



Flight plan :
- Soundings (s1)
- 5 paliers (p1 à p5) — BL1
- Soundings (s2)
- 5 paliers (p6 à p10) — BL2

Fluctuations of u', v', w', θ', r' @ 25hz





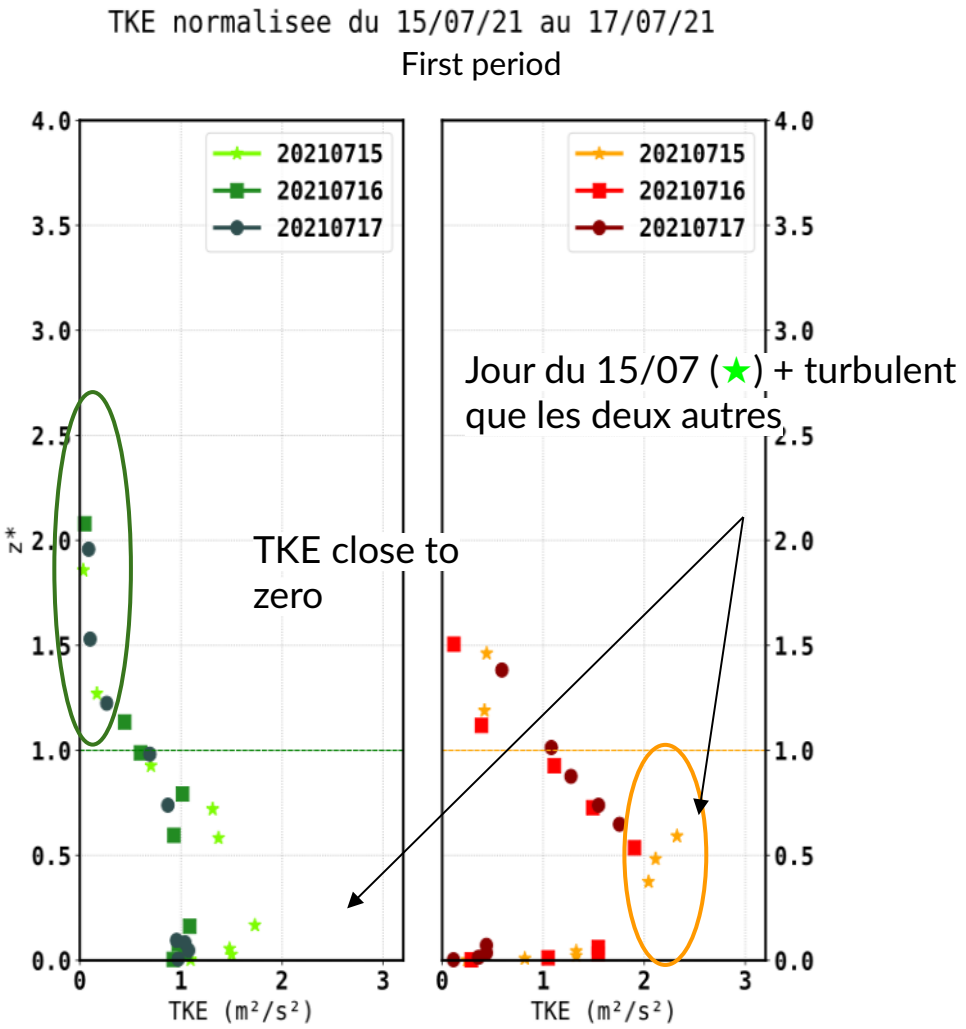
→ Computation of turbulent moments at each levels → Vertical profils

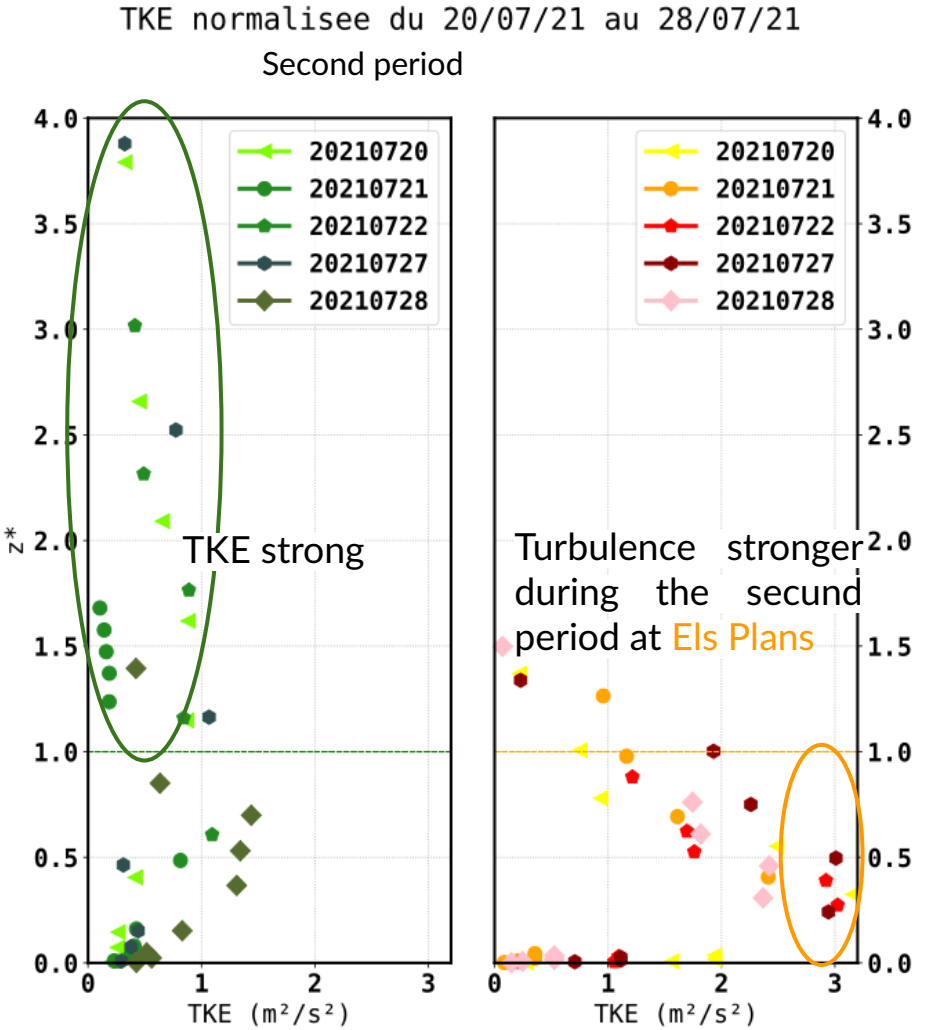
Overview of strong heterogeneities : ABL exploration

Zi EP ~ [750 m,; 2000 m]
Zi LC ~ [300 m ; 1000 m]

LC = La Cendrosa
EP = Els Plans

- Turbulent kinetic energy





Overview of strong heterogeneities: ABL exploration

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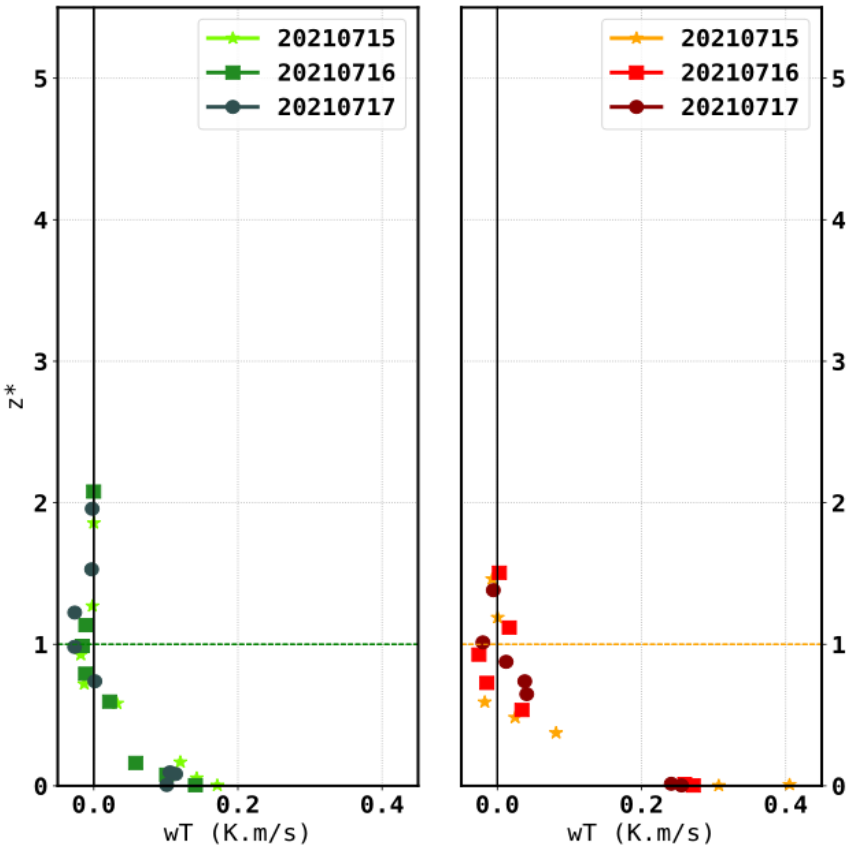
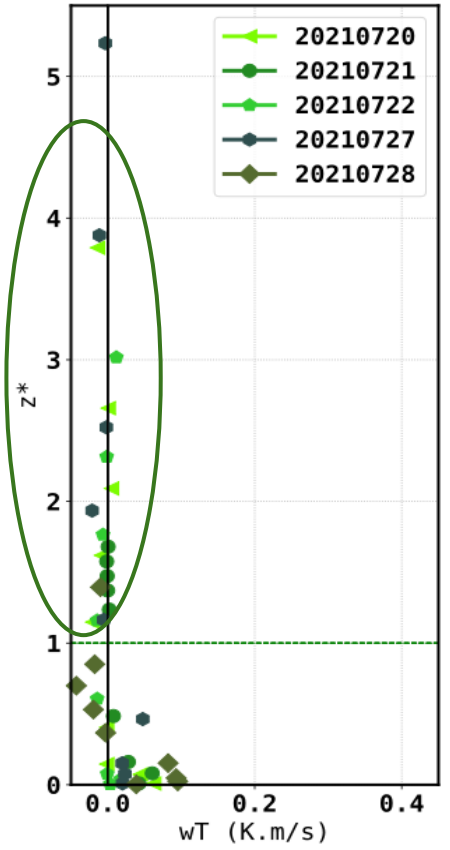
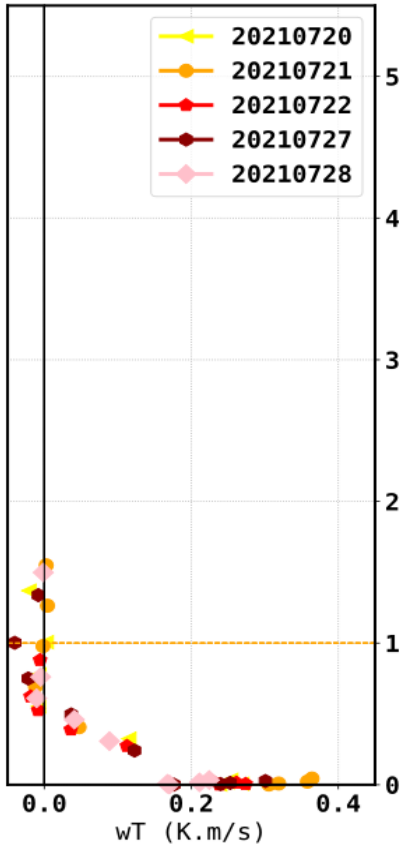
wT normalise du 15/07/21 au 17/07/21



wT normalise du 20/07/21 au 28/07/21

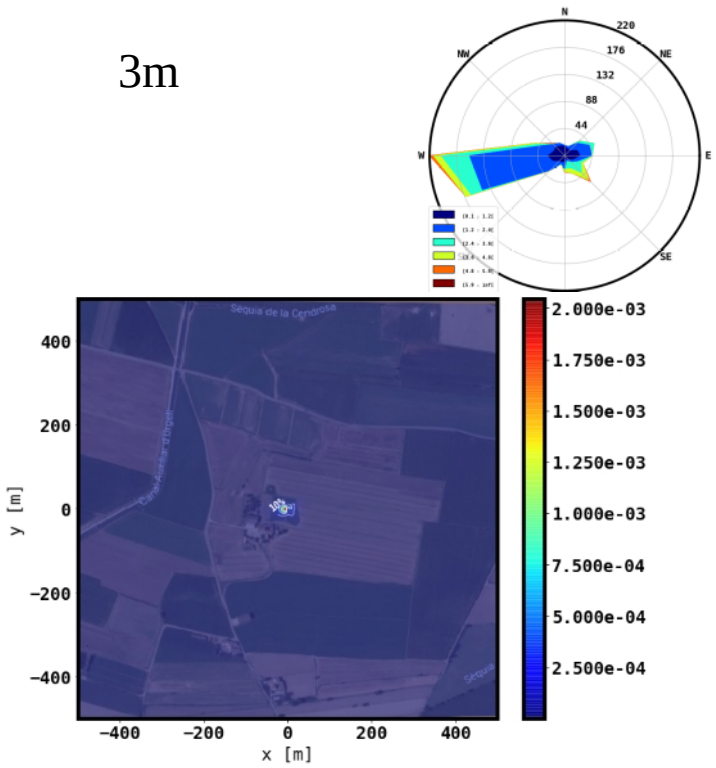




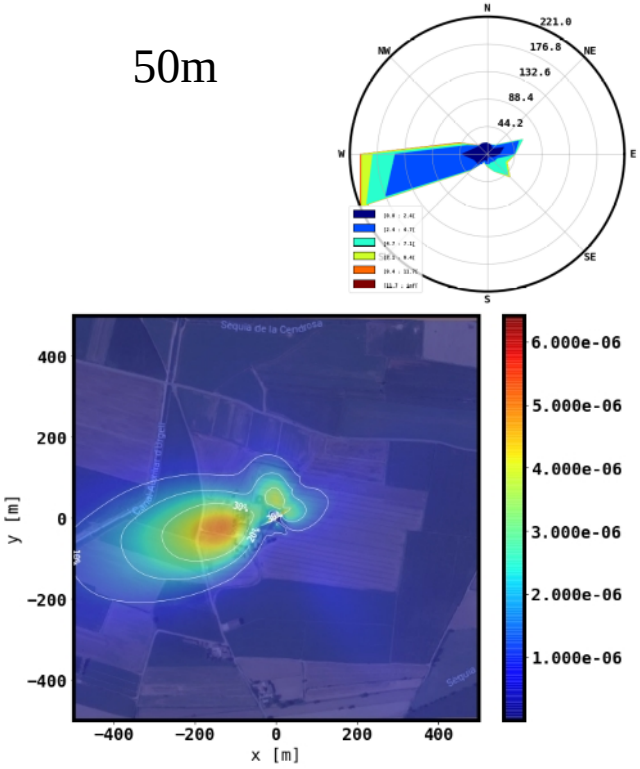
More details on the measurements : 50 m tower at La cendrosa

- Footprint (Kljun 2014, 2D) (july when net radiation>20W/m2)

3m



50m



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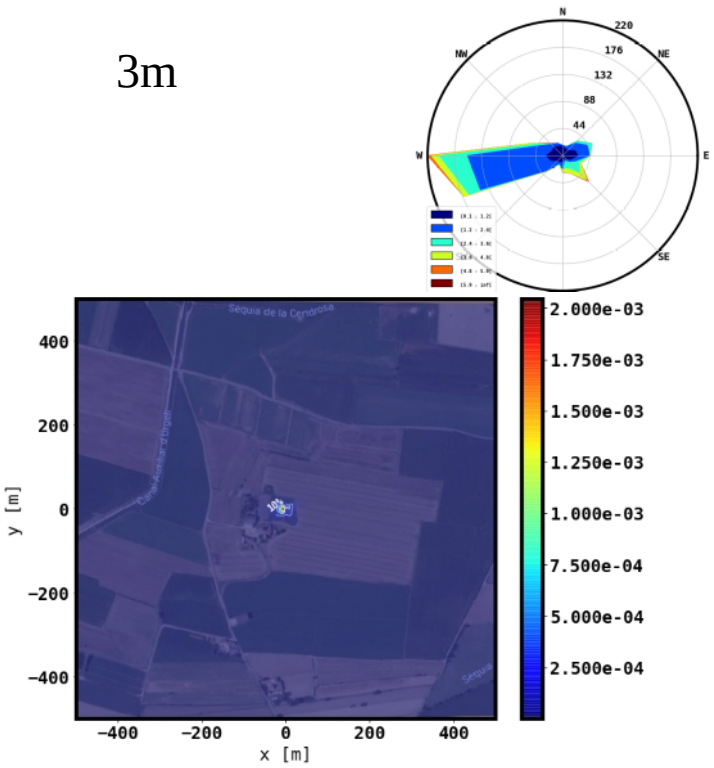
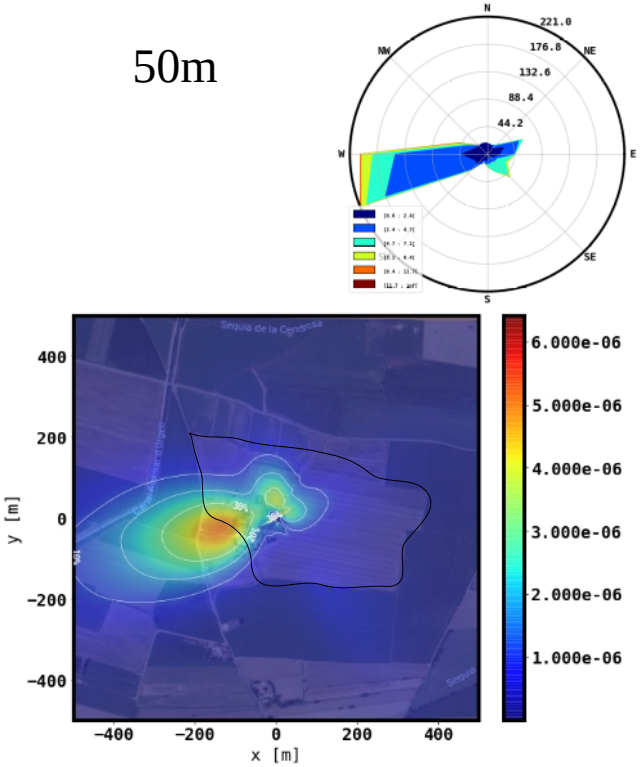


50m



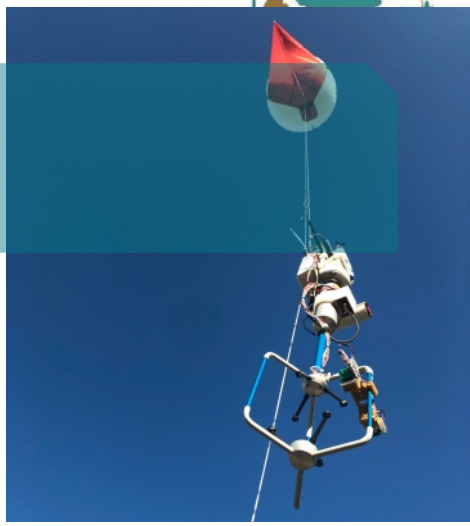
Be careful , footprint at west of the alpha alpha field

More details on the measurements : tetherballoon

- To better understand what is happening as a turbulent exchange in the boundary layer, use of aircraft measurement and surface station.
- The tethered ballon fills the area between the two
- Since 2010, a turbulence probe with sonic and motion sensor
- Since 2020, sonic and motion sensor and FAMOUS (Fast humidity sensor in collaboration with GSMA of Reims (france))

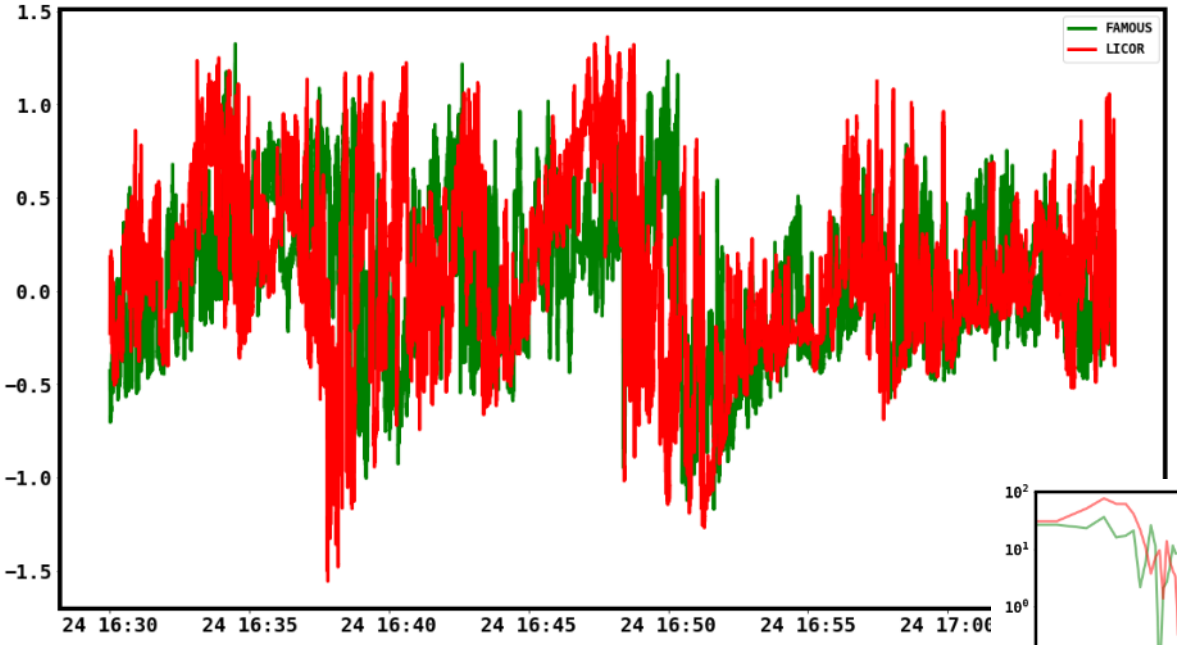
→ **Famous project, LIAISE first campaign**
A favorable context to measure humidity exchange

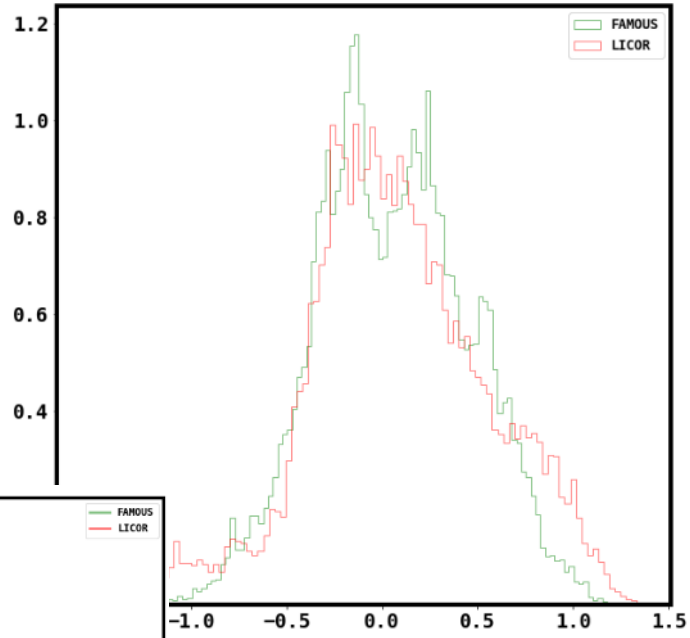
More details on the measurements : tetherballoon

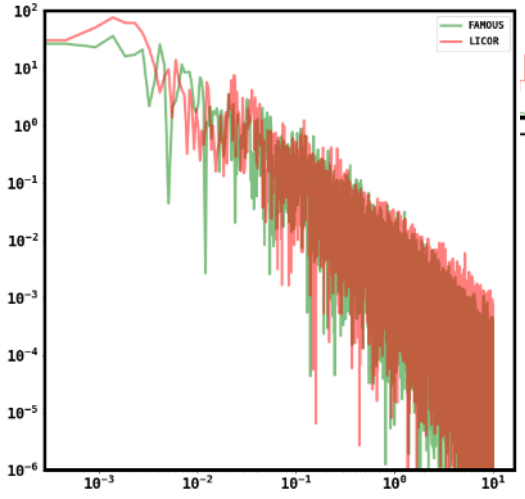


- Validation of humidity fluctuation at 20 hertz

Famous vs licor 7500 @50m

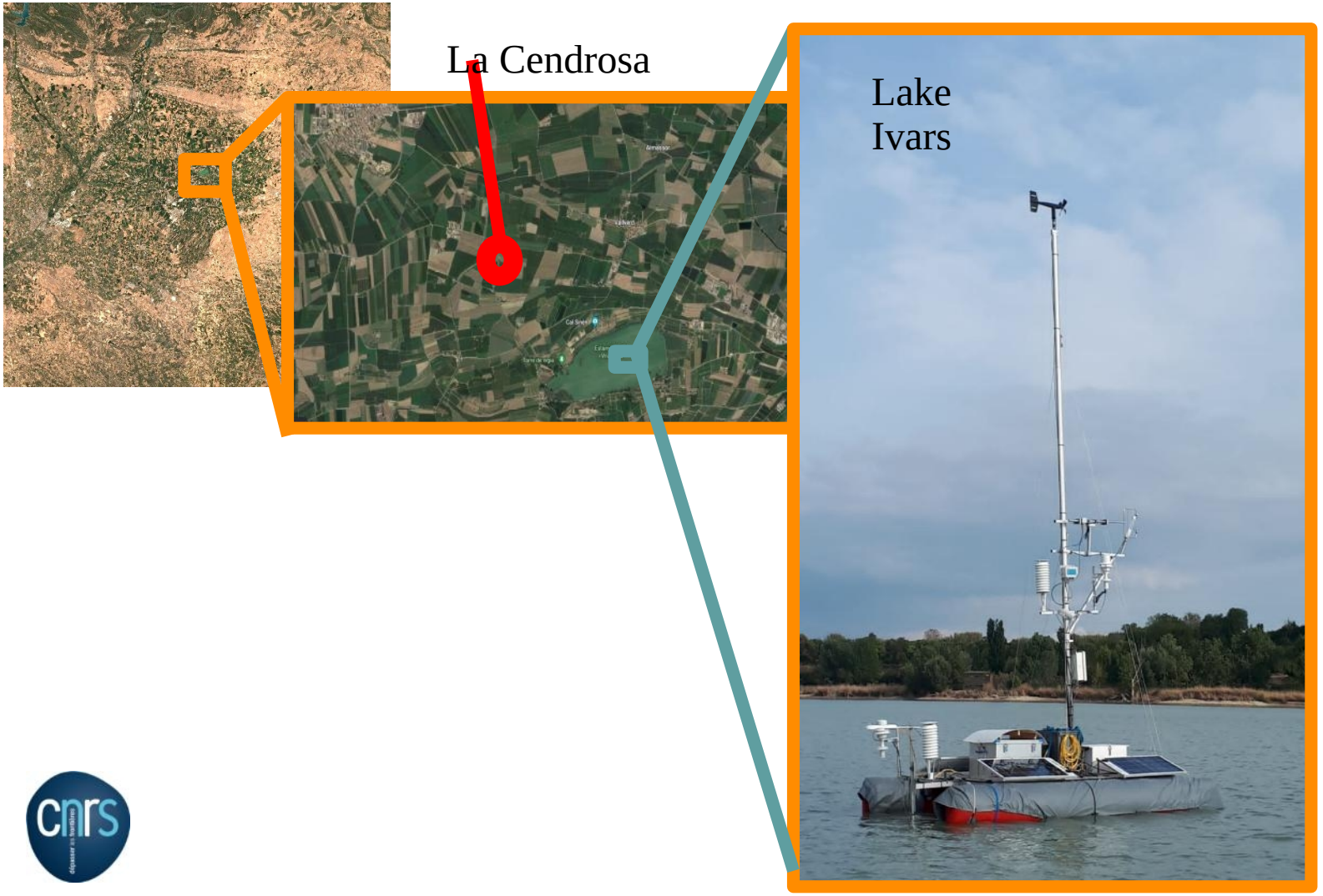






More details on the measurements : mesure on a small boat

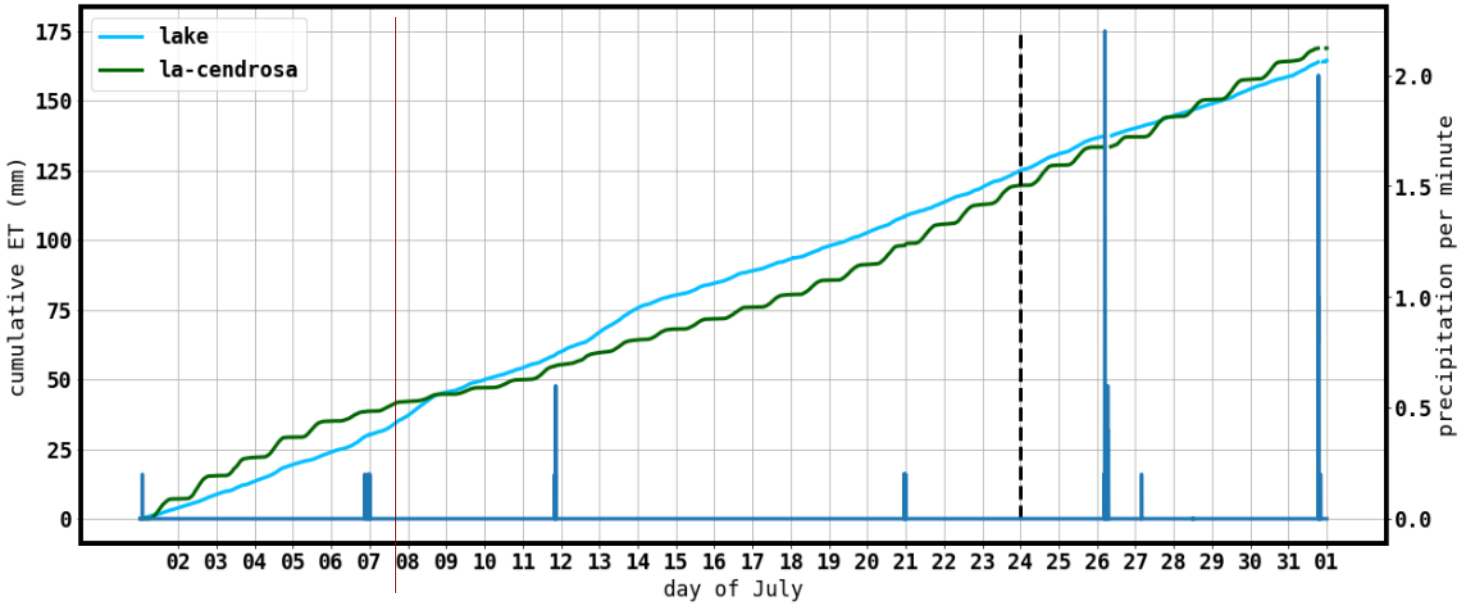
Within the irrigated area, in the middle of Ivars Lake, only a few kilometres from the La Cendrosa a mobile platform was deployed from may to octobre 2021 to measure SEB

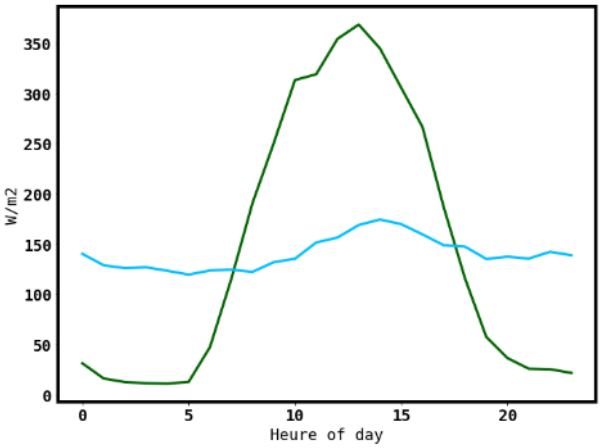


More details on the measurements : from the boat

← *time series of the cumulative evapotranspiration during the month of july for (blue) the lake and (green) la-cendrosa.*

→ *mean diurnal cycle of evapotranspiration flux for july.*





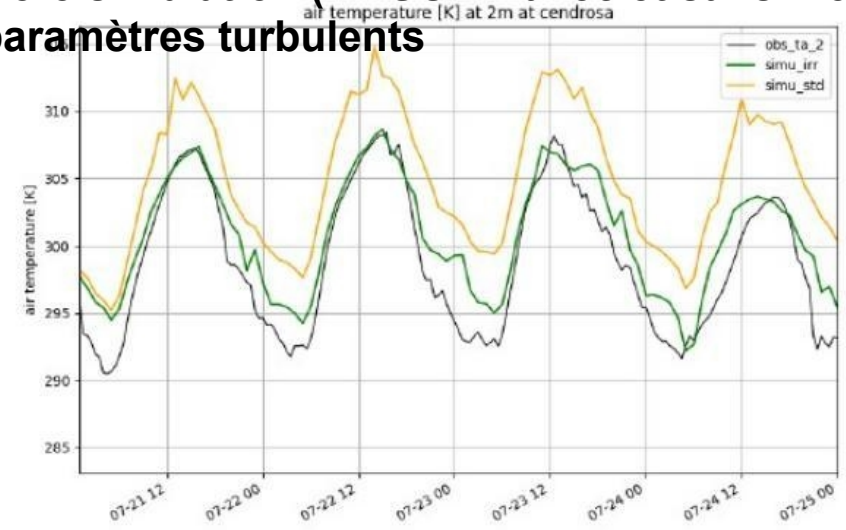
A similar total evapotranspiration is observed above the lake and at la-cendrosa on the alphaalpha culture. We observe after the harvest a decreasing of the evapotranspiration. At the end of july the culture reaches 60cm and the evapotranspiration becomes superior to the lake again. In the diurnal cyle we observe a contrast behavior between the both site. Druring the night, the evapotranspiration stay high on the lake and the diunal cycle is less marked.

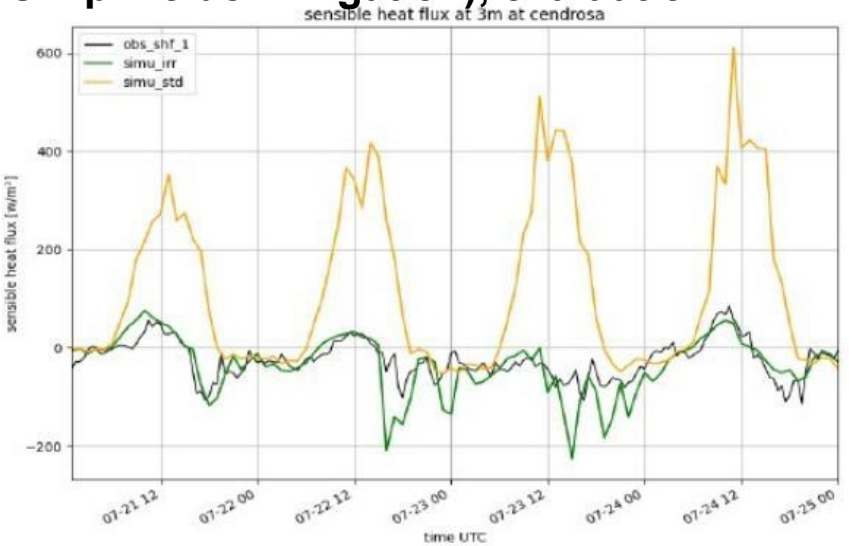
Study with mesonh numerical models

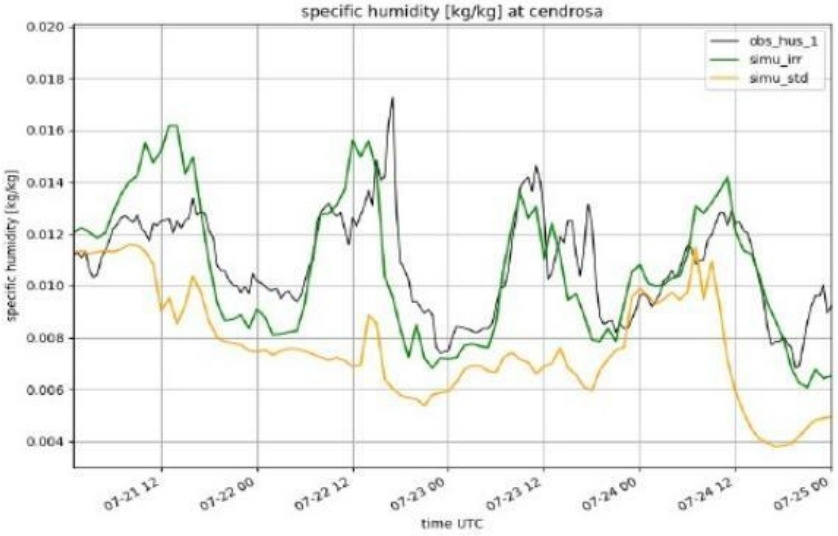
WG2: Atmosphere

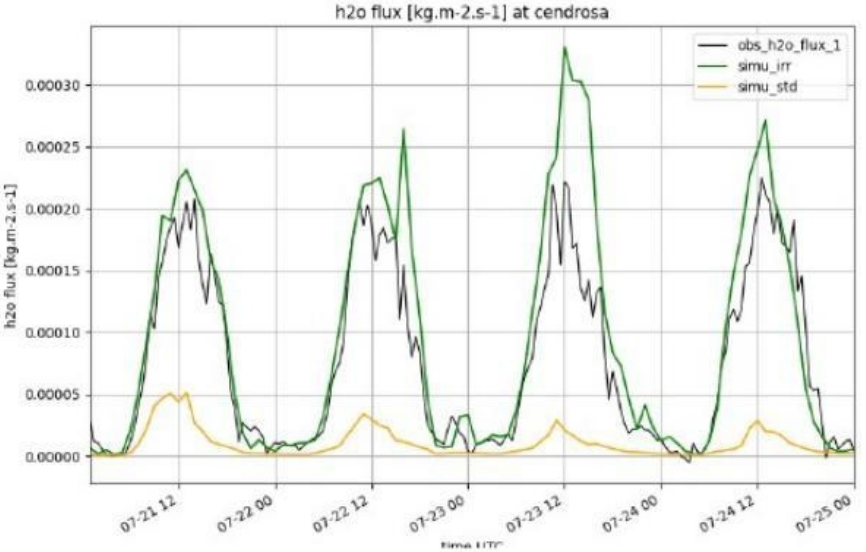
GMME (CNRM) , phd student Tanguy lunel

Premiere simulation (MESONH avec et sans module simplifié de l'irrigation), evaluation des paramètres turbulents

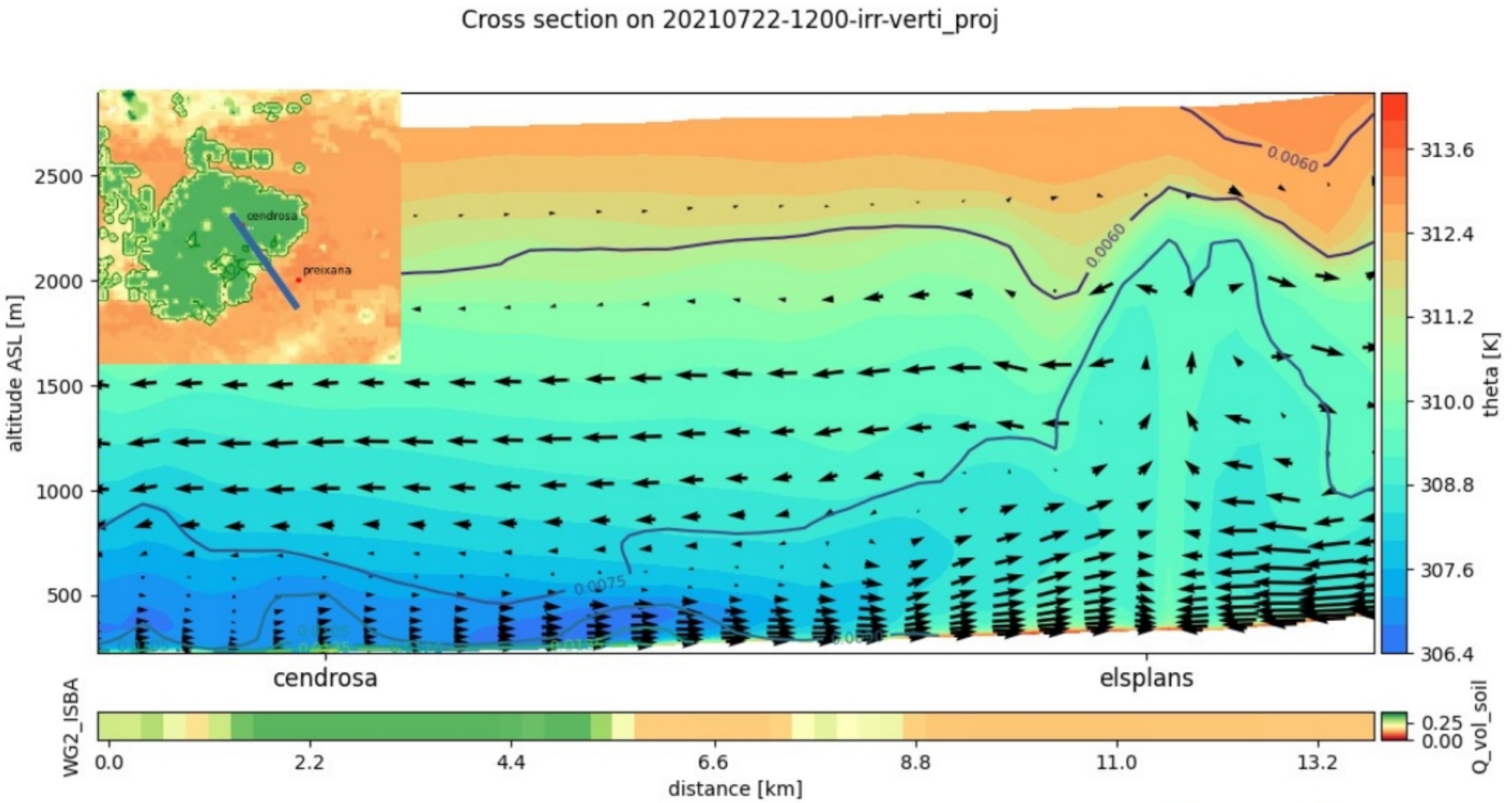








Study with mesonh numerical models



Three LIAISE working groups were created after the November 2021 field campaign. The aim of these groups is to provide a forum for exchanging information on the progress of research within LIAISE.

WG 1: surface
- Bilans de l'eau, de l'énergie et du carbone
- processus dans l'interaction entre la surface et l'atmosphère (l'ET étant un processus clé qui intègre les trois bilans)

WG 2: atmosphere
- Verticale: ABL processes
- Horizontale: Mesoscale circulations related to wet-dry, topography, sea breeze interaction
- Feu

WG 3: Hydrology
- Irrigation & streamflow/discharge
- Reservoirs (and their regulation)
- Regional scale estimates of surface properties related to soil water

Perspectives & Conclusions

- Need to continue work with all this dataset
- most of the data is available on the aeris database
- good quality data from the humidity sensor under the tethered ballon
- LIAISE field campaign : a good dataset to improve the knowledge of the vertical profile of the turbulence in a irrigated surface
- Dataset similar between the two contrasted sites els plans to identify
  - difference behaviour,
  - instrumental synergy: wind profiler, SEB station, RS, Aircraft
  - horizontal circulation & Internal boundary layer

2- Doppler lidar Windcube

Availibilty data : 8june-10 october

Leosphere (Vaisala company) Wincube7, 4 lasers
3 wind components : W, U, V
Temporal resolution : 1s and 10 minutes processing
Vertical resolution : 20 m
Alt min : 40m
Alt max : 240m

Research mode with data available every second → estimation of **variance and TKE**

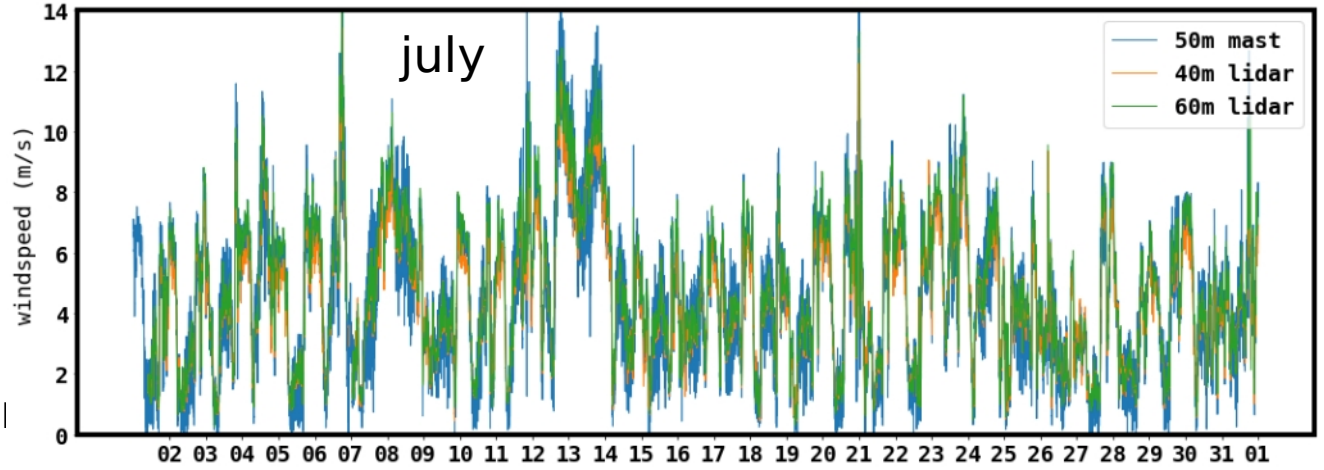
2- Doppler lidar Windcube

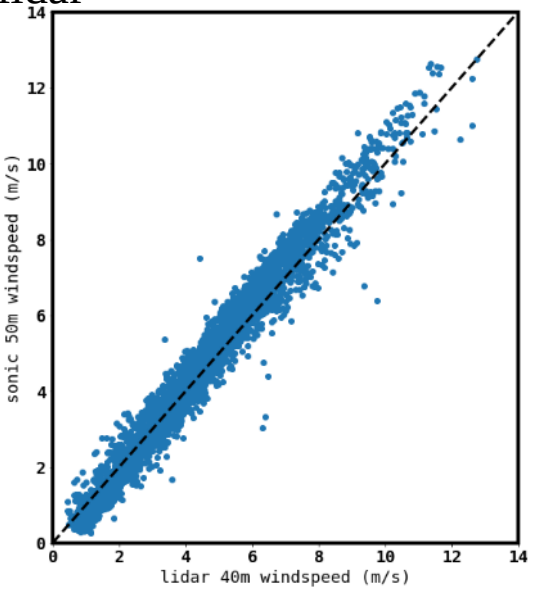
Availibilty data : 8june-10 octobre

Leosphere (Vaisala company) Wincube7, 4 lasers
3 wind components : W, U, V
Temporal resolution : 1s and 10 minutes processing
Vertical resolution : 20 m
Alt min : 40m
Alt max : 240m

Research mode with data available every second → estimation of **variance and TKE**

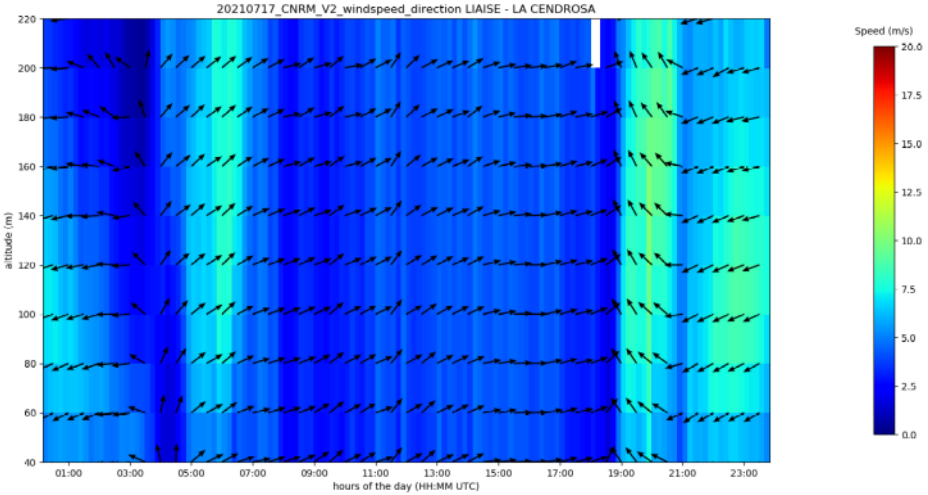
→ Mean data : good agreement between sonic anemometer and wind from lidar



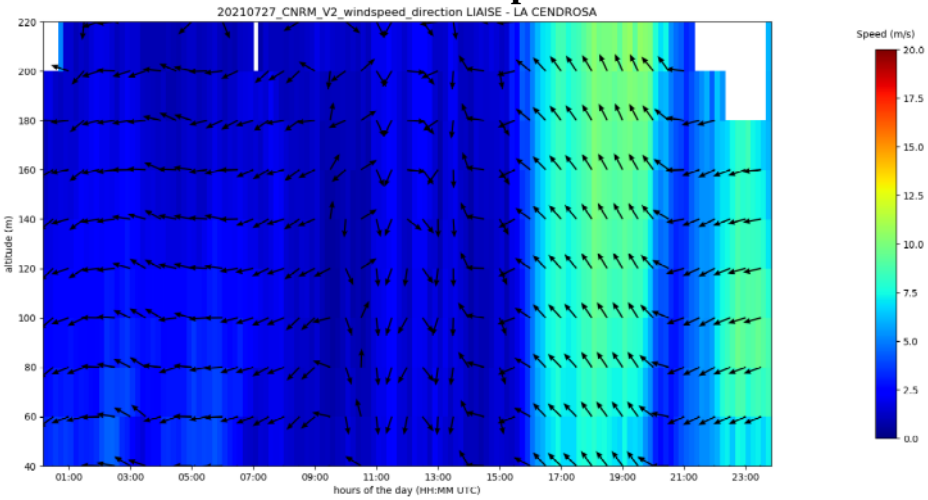


2- Doppler lidar Windcube

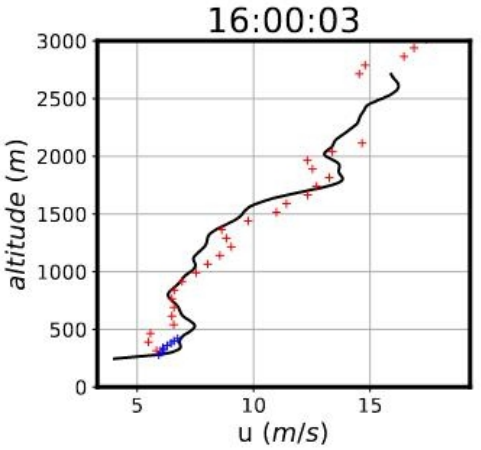
17/07/2021 10 minutes wind speed and direction



27/07/2021 10 minutes wind speed and direction



- A fine description of the low layer
- ideal for identifying wind shifts
- A complement to the UHF wind profiler



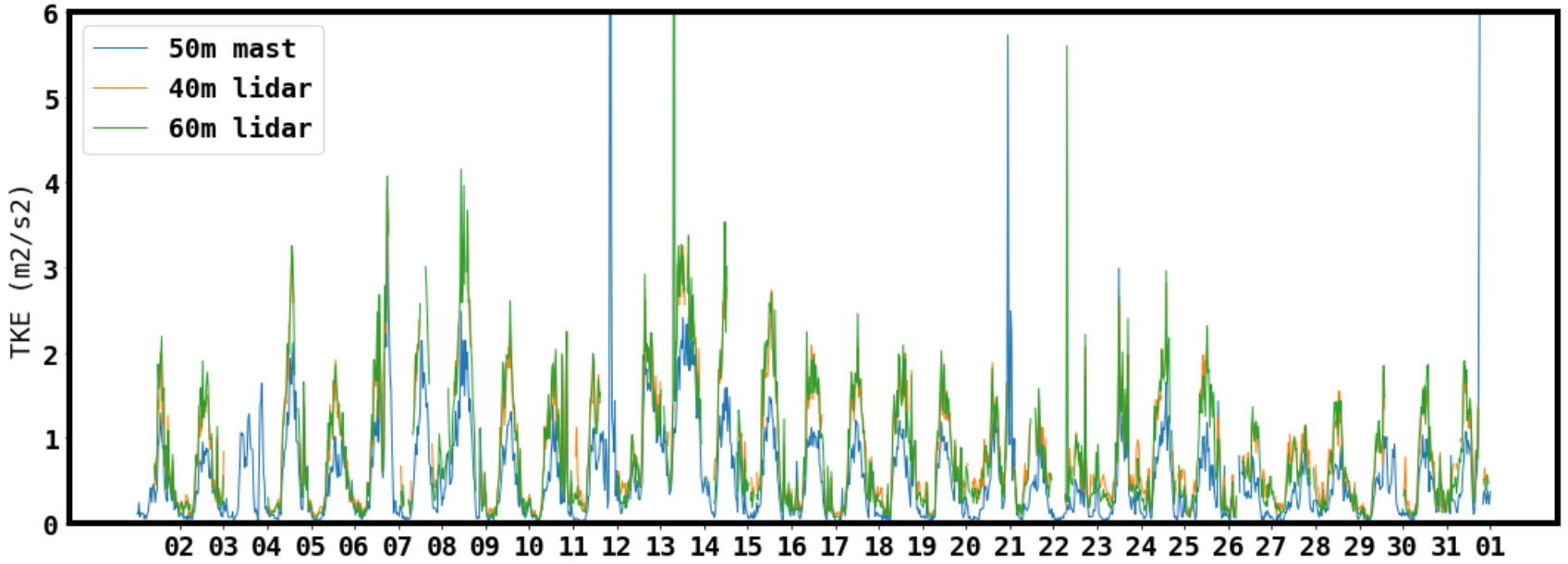
- RS
+Lidar
+UHF

2- Doppler lidar Windcube

Why to know TKE in the low layer?

- **It is one of the most important variables used to study turbulent boundary layers since it quantifies the intensity of turbulence which controls vertical mixing**
- Pronostic equation on various models (AROME or meso-NH models from Météo-France) for turbulence

TKE calculated every 30 minutes with 1s data for july



→ **Similar behaviour but differences in daytime amplitude**

2- Doppler lidar Windcube

Why to know TKE in the low layer?

- **It is one of the most important variables used to study turbulent boundary layers since it quantifies the intensity of turbulence which controls vertical mixing**
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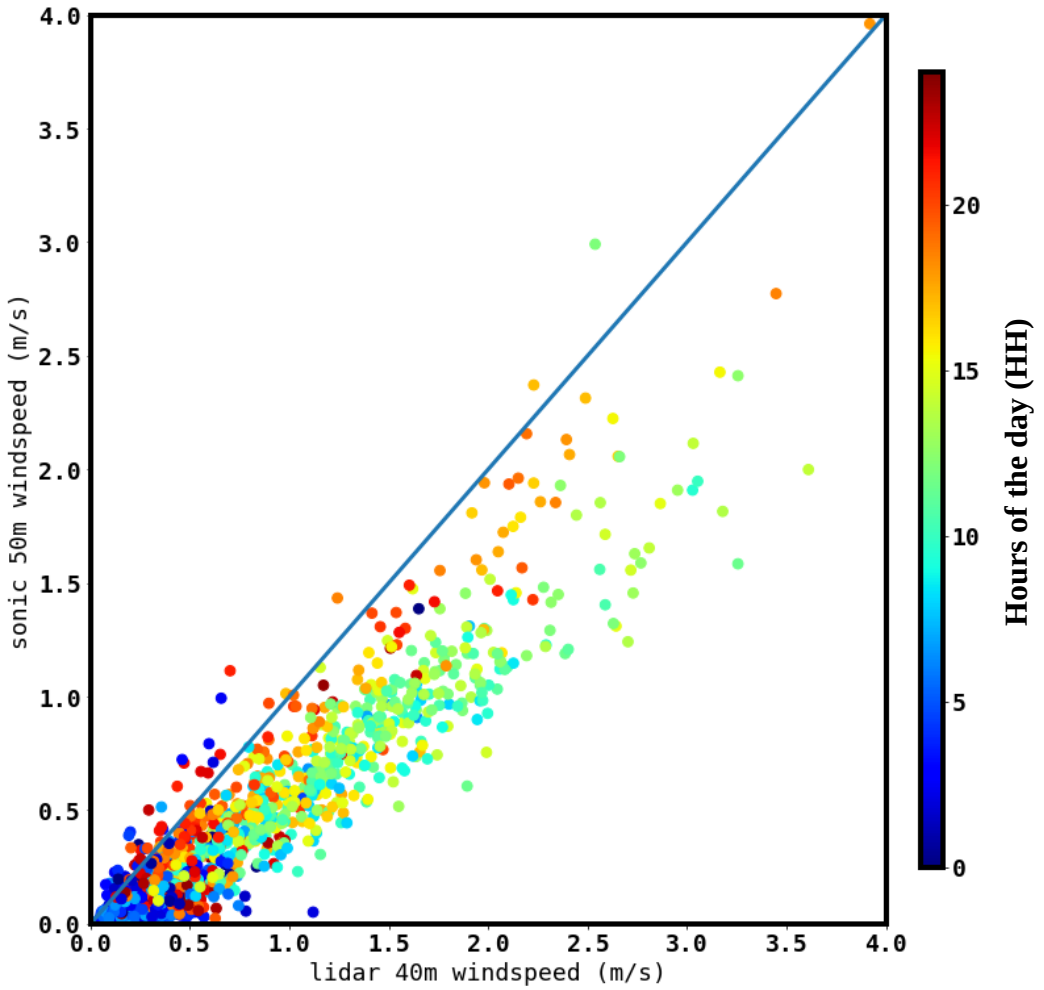
TKE calculated every 30 minutes with 1s data for july

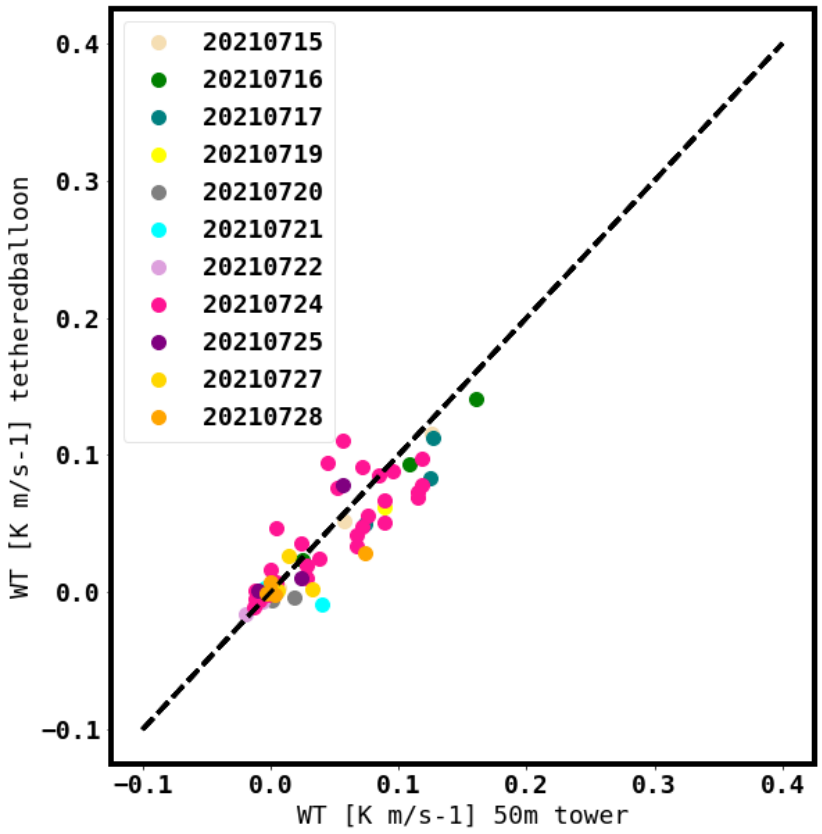


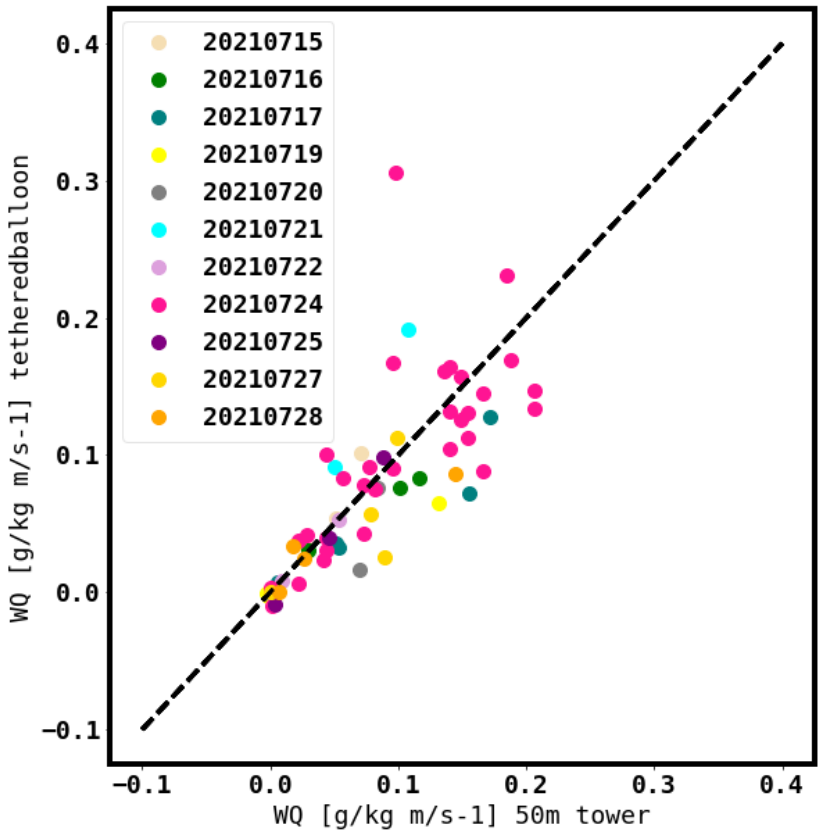
- underestimation by lidar
- needs to be further investigated

3-Tethered ballon

- Validation of heat fluxes

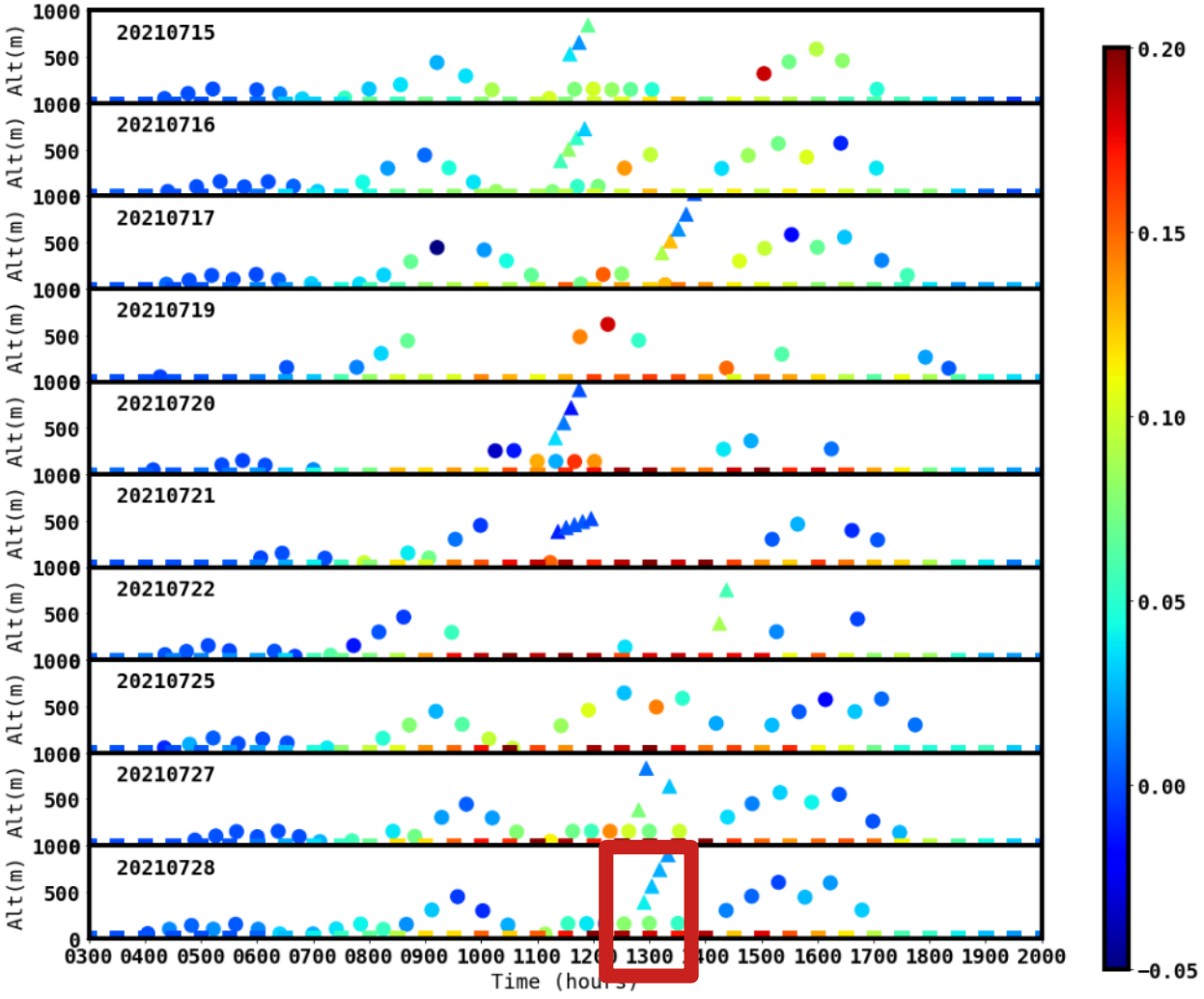
  Famous vs licor 7500 @50m





3- Tethered ballon

- Overview of the variance of humidity at differents levels



Avion (licor)

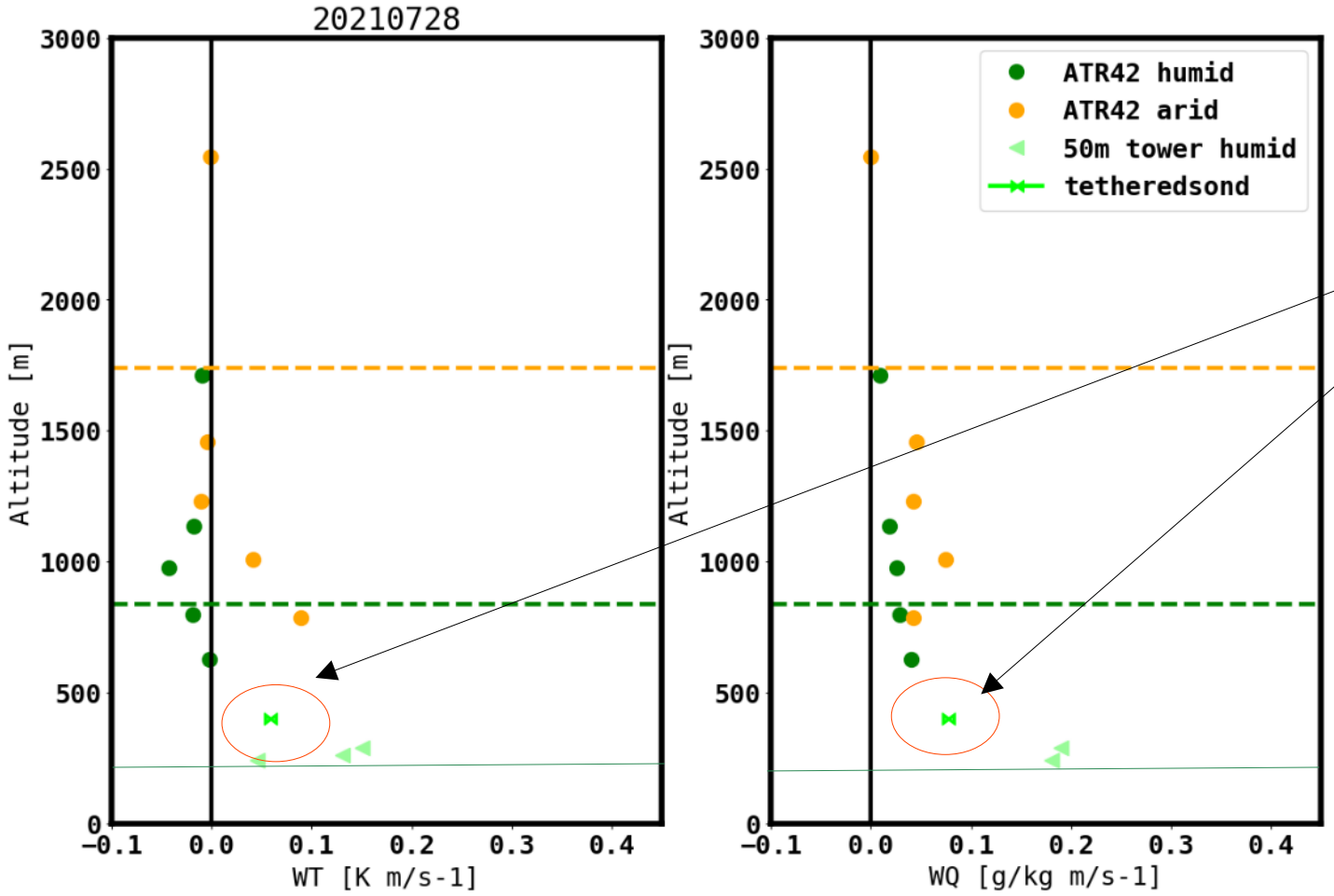
Ballon (Famous)

Mat de 50m (licor)

10 days with 8 with aircraft

3- Tethered ballon

- Overview of the heat fluxes at differents levels



Tethered ballon

10 days with 8 with aircraft

→ rapid decrease of fluxes and variance (not show)

Perspectives & Conclusions

- Need to continue work on lidar tke