Evaluation of the turbulence measured by Doppler lidar with sonic anemometer and atmospheric numerical models

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Outlines

- Why observing turbulence ?
- Campaigns and data
- Results
- Conclusions & perspectives

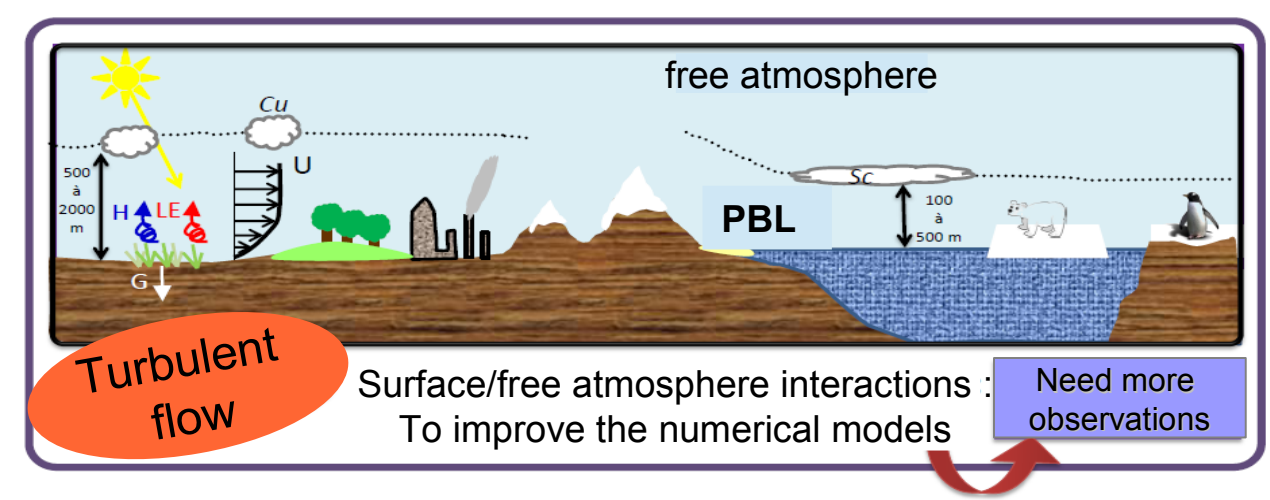


Why observing turbulence ?

Context : the Planetary Boundary Layer (PBL)

- Interaction at small scales
- Small eddies
- Turbulence increases mixing
- Difficult to observe and forecast
- Intensity typically measured by the turbulent kinetic energy, noted $\overline{e}$ or TKE :

$$\overline{e} = 0.5(\overline{u'^2} + \overline{v'^2} + \overline{w'^2})$$



Also, we distinguish the sources and sinks of turbulence by considering the equation of the budget of TKE :

$$\frac{\partial \overline{e}}{\partial t} = \frac{g}{\overline{\theta_v}} \overline{w'\theta'_v} - \left(\overline{w'u'}\frac{\partial \overline{u}}{\partial z} + \overline{w'v'}\frac{\partial \overline{v}}{\partial z}\right) - \frac{\partial \overline{w'e'}}{\partial z} - \frac{1}{\overline{\rho_0}}\frac{\partial \overline{w'p'}}{\partial z} - \epsilon$$

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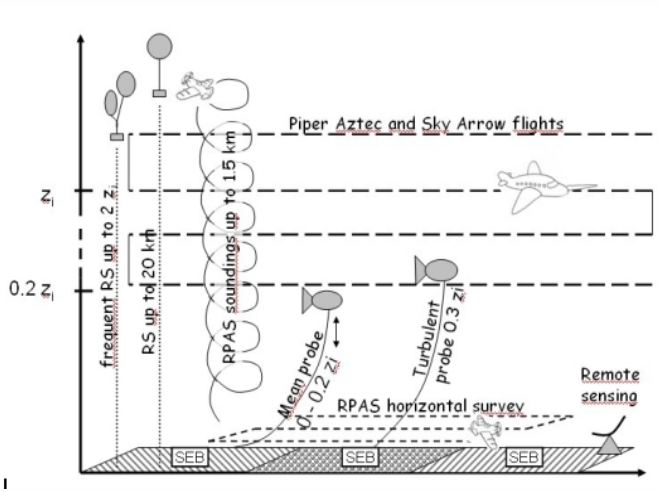
Campaigns and Data

BLLAST

- International campaign (Lothon et al.,2012)
- Several teams and instruments
- June-July 2011
- South-West of France
- Campaign dedicated at the study of the late-afternoon transition of PBL.
- Good opportunity to validate data from a LEOSPHERE Windcube 200
- Doppler lidar operation during 4 days.



BOURGES

- Small campaign involving Leosphere and **CNRM-GAME** (Météo-France)
- August 2013.
- Centre of France (Bourges)
- Dedicated to the validation of a LEOSPHERE Windcube 7
- 2 months and 4 intensive observation days

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Campaigns and Data : 2 Doppler Lidars

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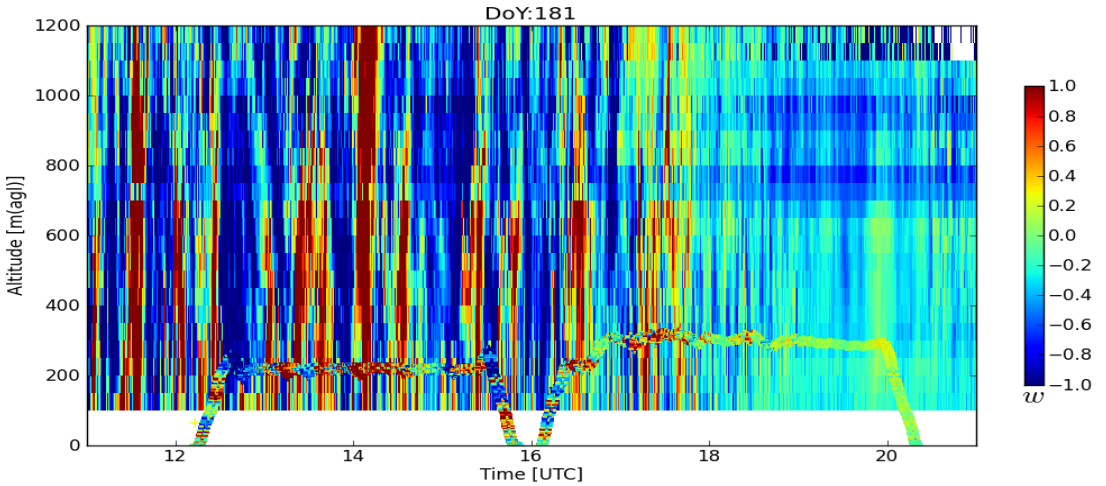
Windcube 200
Single line-of-sight (vertical)
1 wind component: W
Temporal resolution : 4s
Vertical resolution : 50 m
Alt min : 100m
Alt max : 1200m



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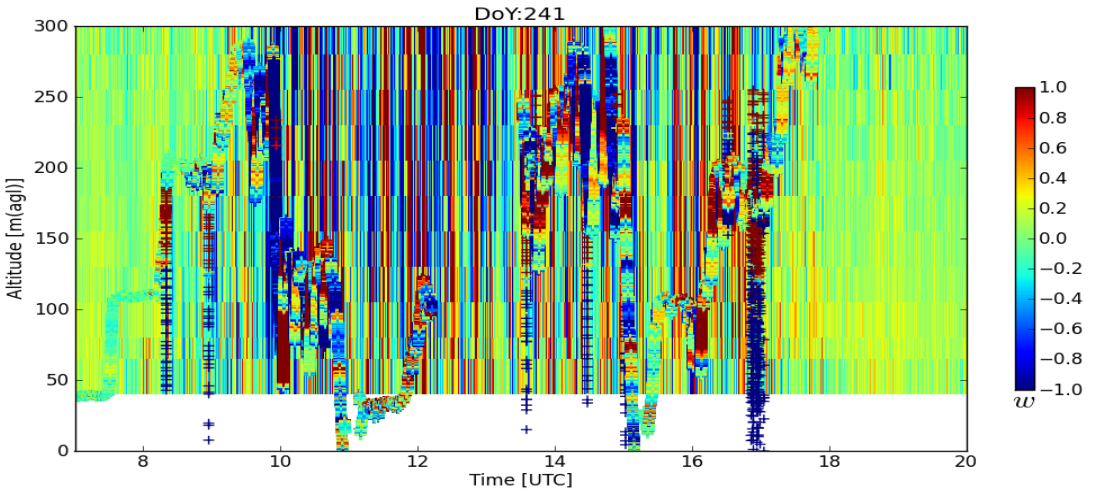
Windcube 7
5 lines-of-sight .
3 wind components : W, U, V
Temporal resolution : 4s
Vertical resolution : 25 m
Alt min : 40m
Alt max : 300m



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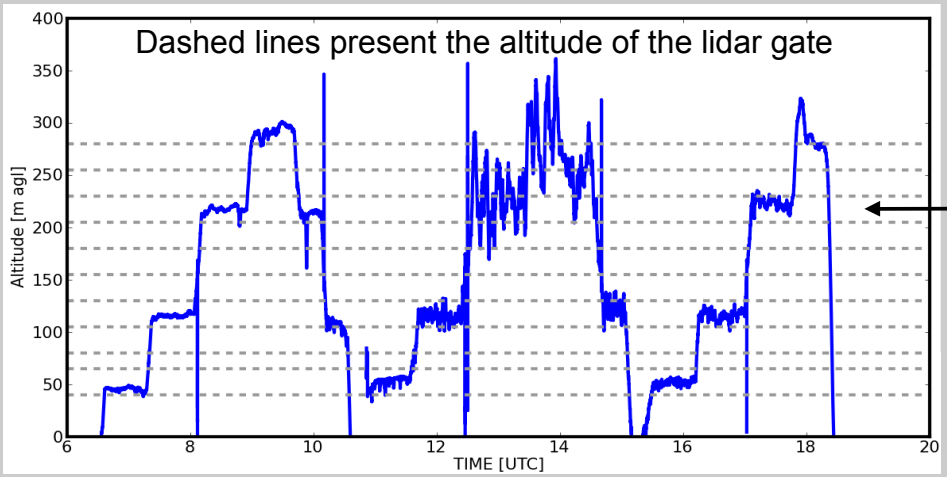
Campaigns and data : Same tools to validate the wind Lidar

Sonic anemometer on a mast

Sonic anemometer below a tethered balloon



altitude of the tethered balloon during the flight

Advantage of this new system:

Explore the middle of the PBL

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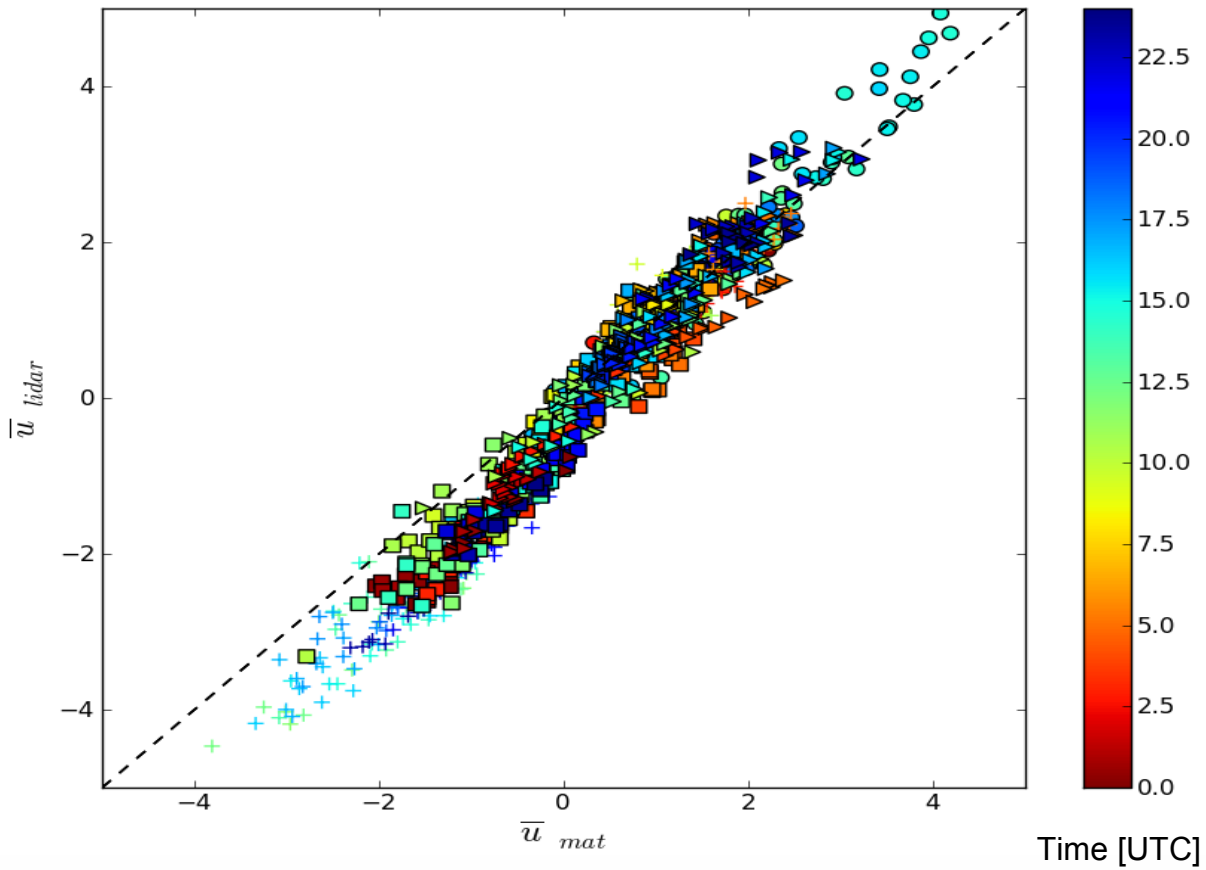
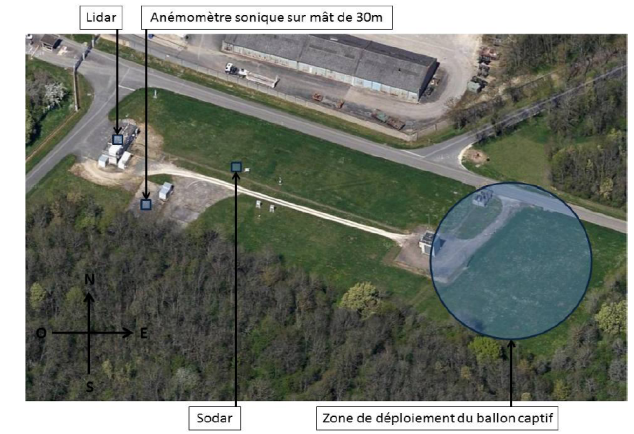
Results : Balloon versus wind lidar

Before to examine the variance of the wind components, we validated the mean winds (estimated every 10 minutes)



Sonic anemometer: 30m
Lidar height-bin: 40m.
4 days



Non-homogenous terrain – forest when the wind direction is SW

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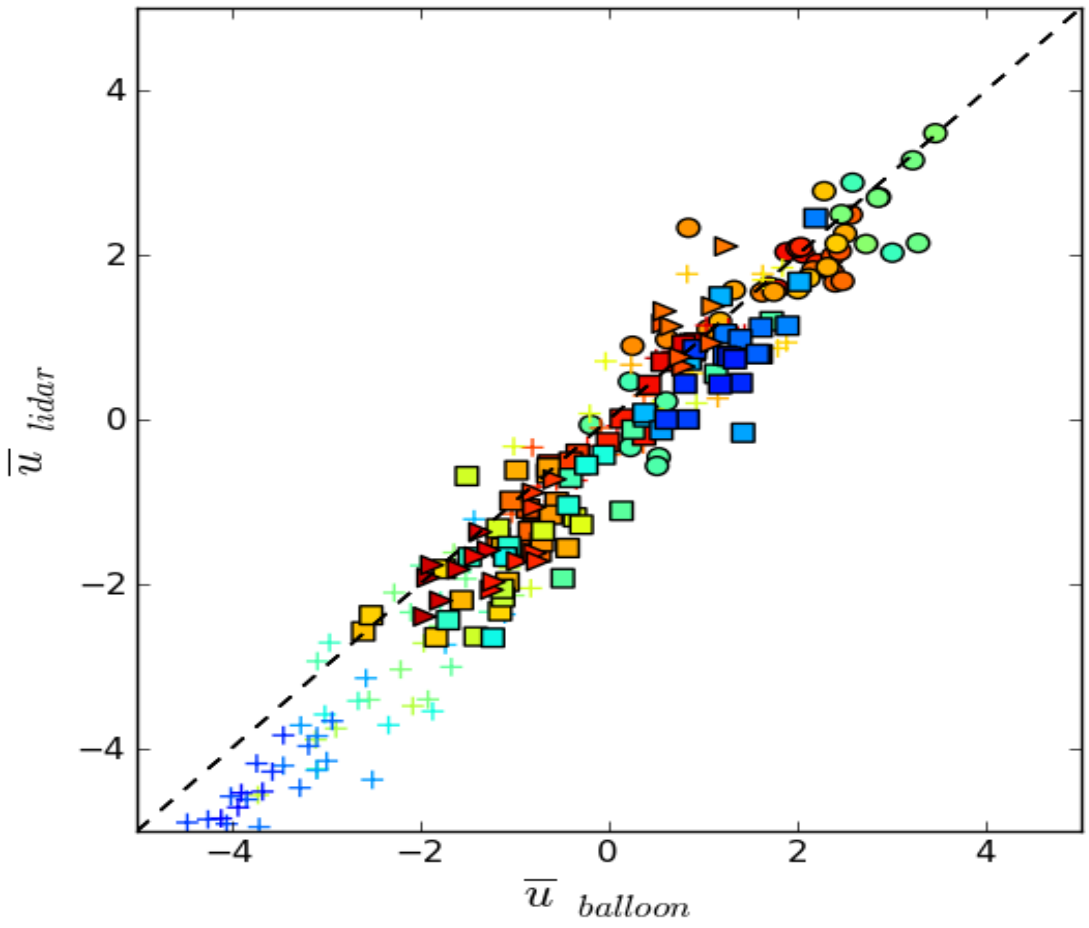

Altitude of the ballon : between 50m and 300m
Lidar height-in : the closer that the altitude of the balloon

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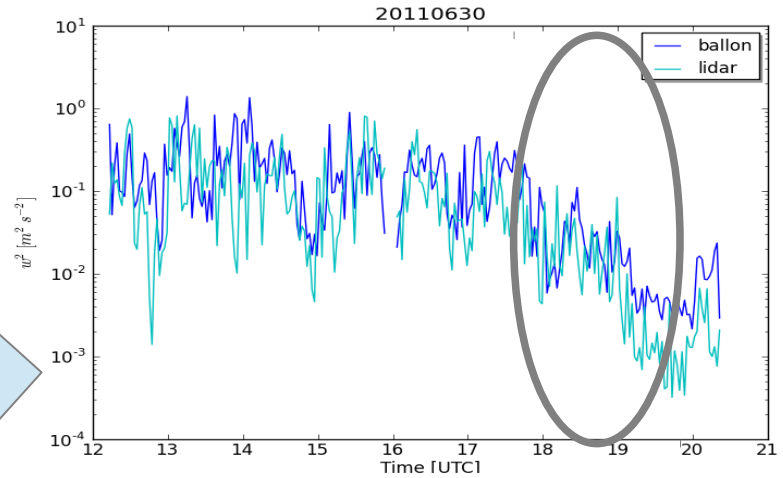
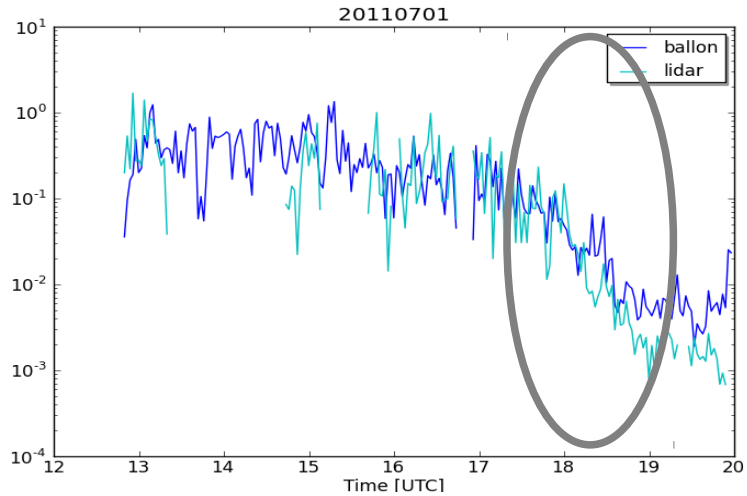
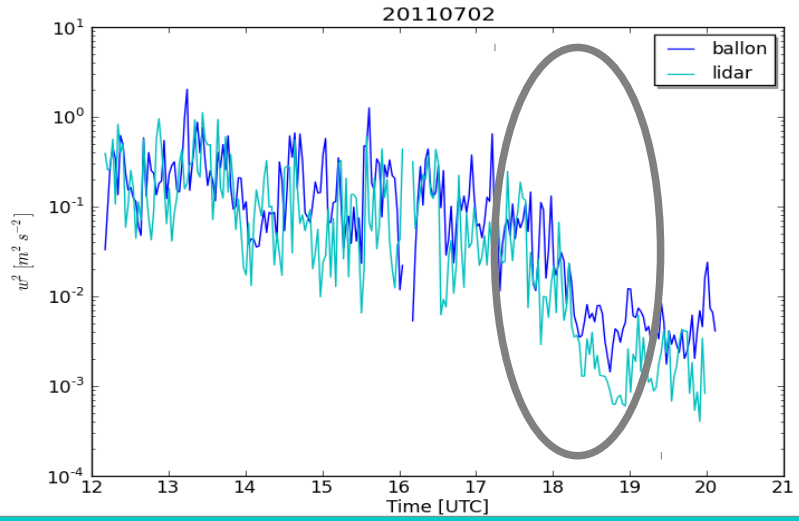
Results : Balloon and wind lidar

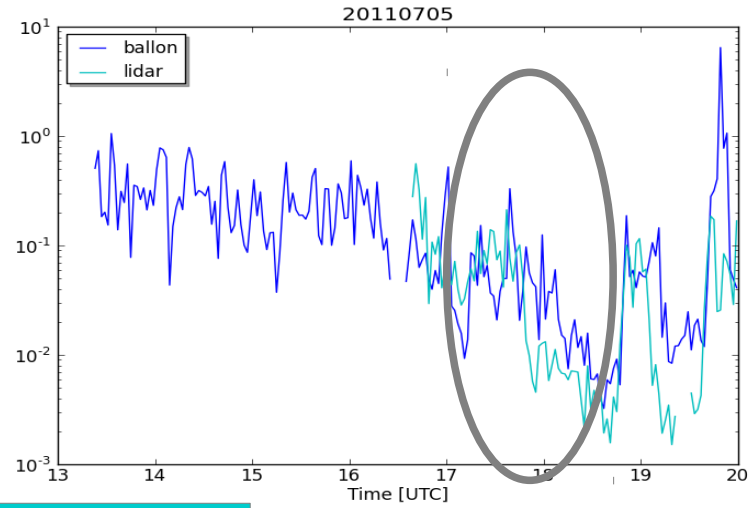
- variance of vertical velocity, w'^2 (every 5 minutes)

BLLAST









The evolution is well represented by the wind Lidar
Both instruments capted the transition period

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Results : Balloon and wind lidar

- variance of horizontal velocity (every 5 minutes)

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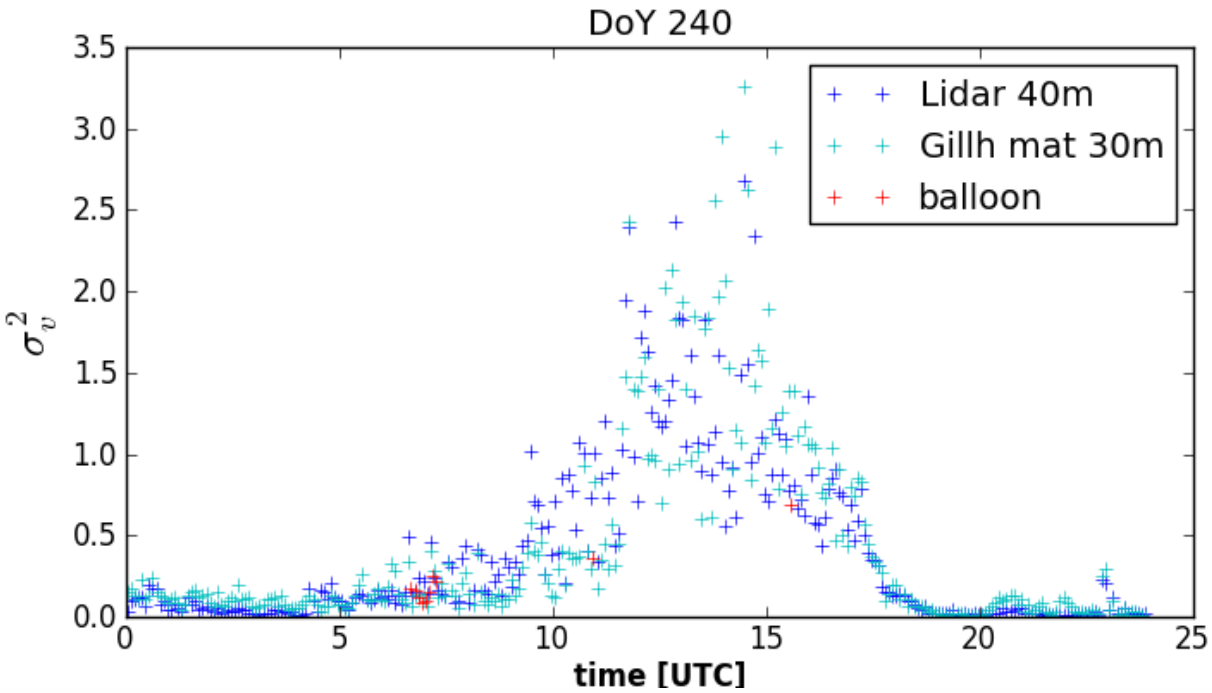

The diurnal cycle of the turbulence linked at the convection is well capted
The intensity of the variance of v is similar

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Results : Balloon and wind lidar

- validation of TKE (estimated every 5 minutes with sonic anemometer)

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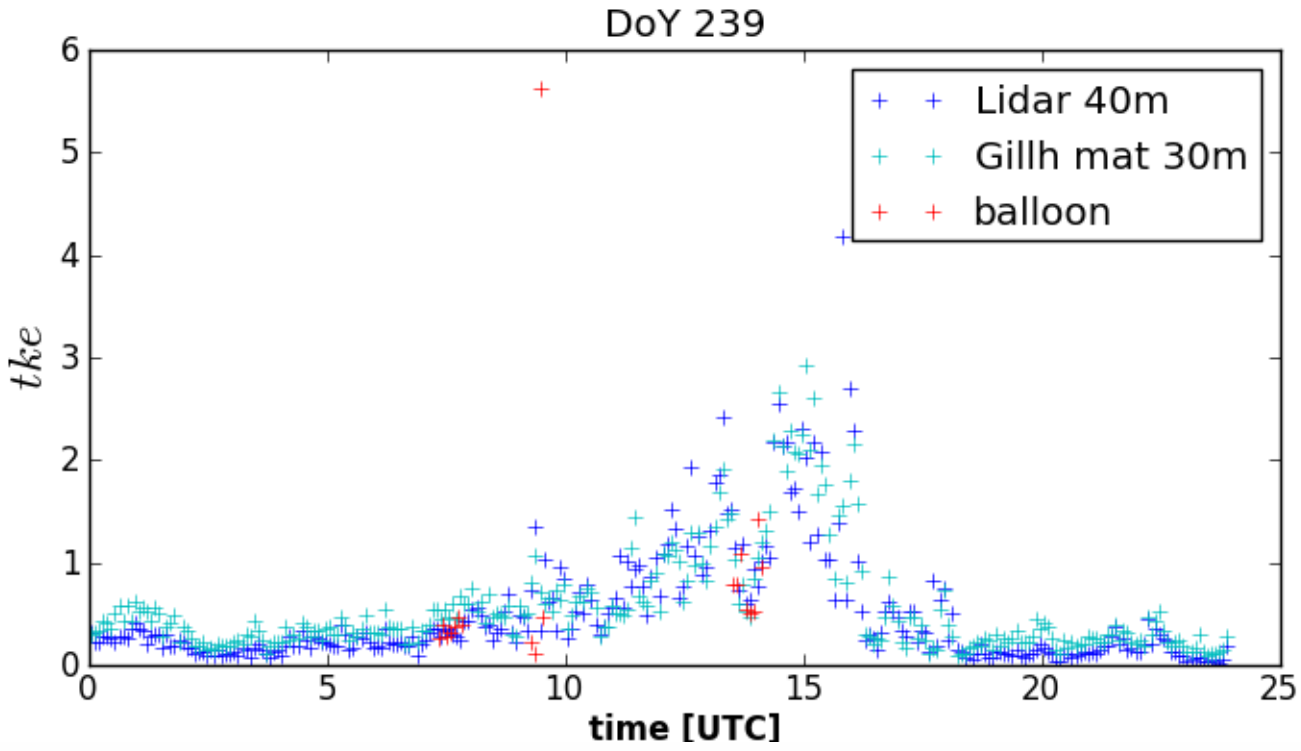

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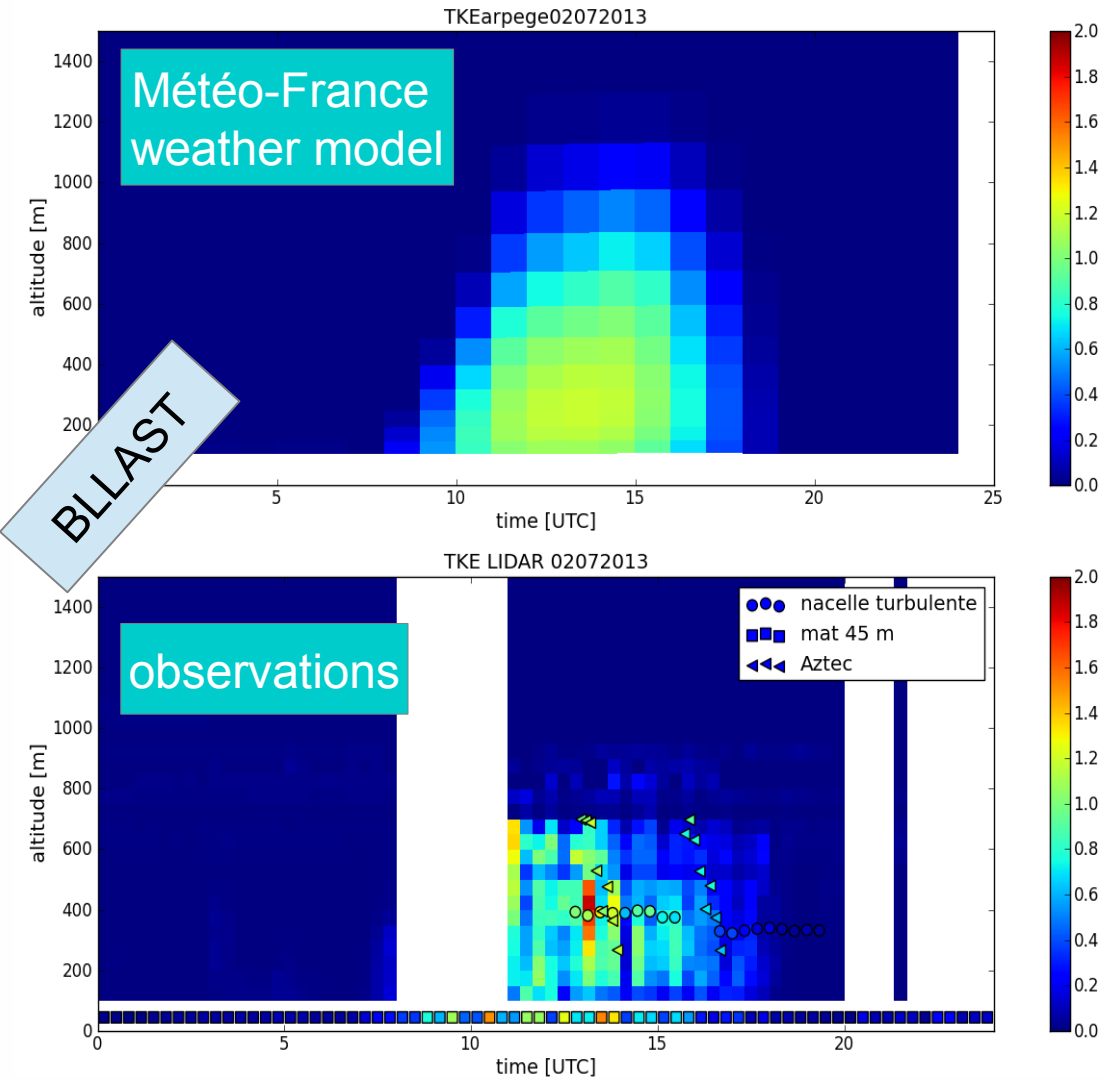
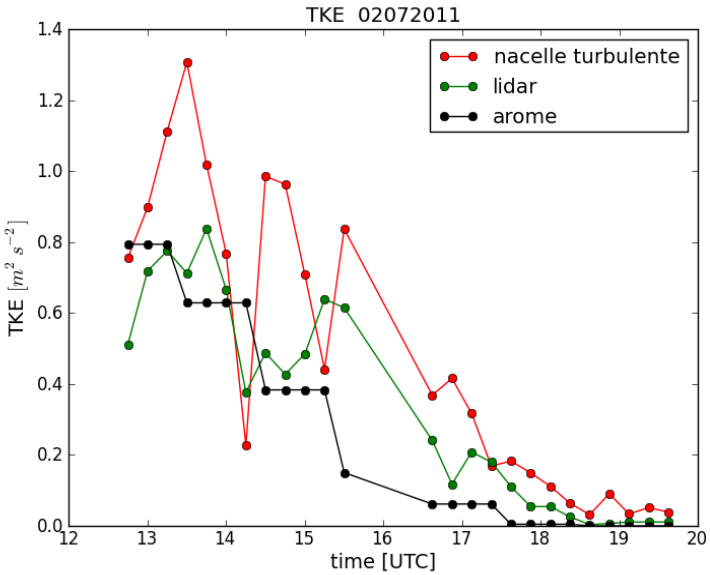
Results : wind lidar and models





Tke by Lidar is a few smaller than the balloon :

we measure not exactly the same eddies, does it link at the small scales contribution?

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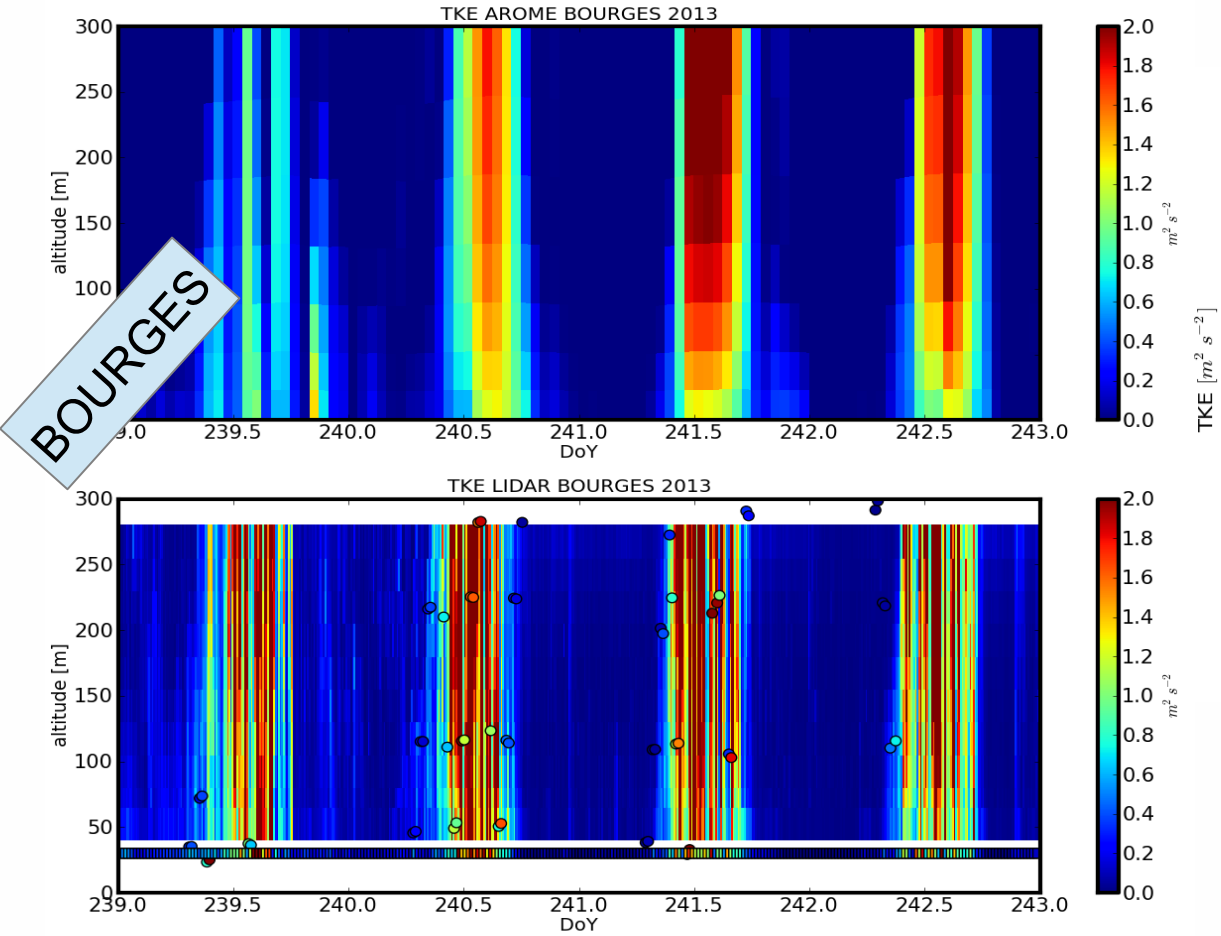
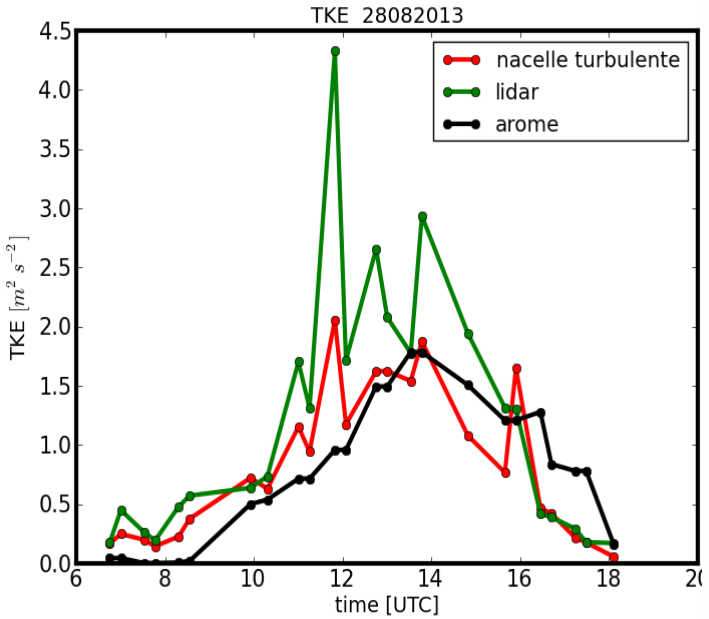
Results : wind lidar and models





Tke by numerical models is smaller than TKE Lidar and TKE balloon.

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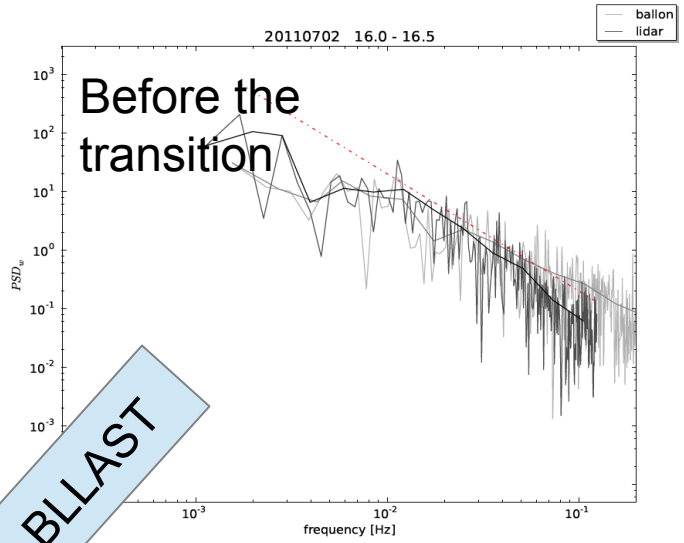
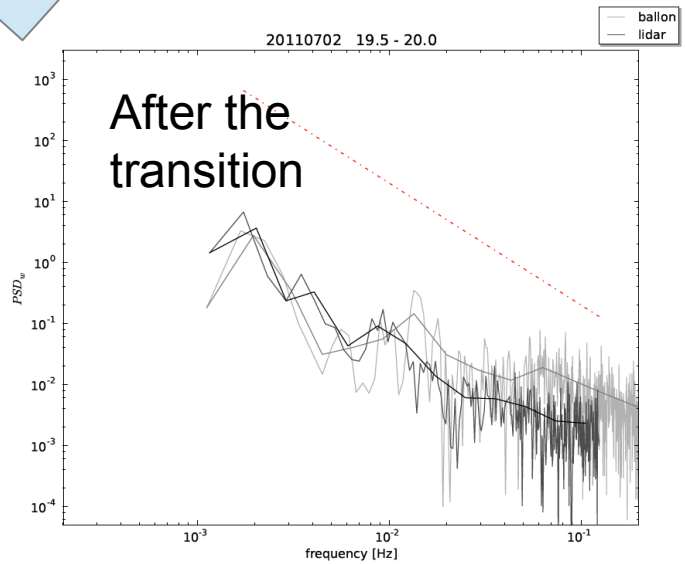
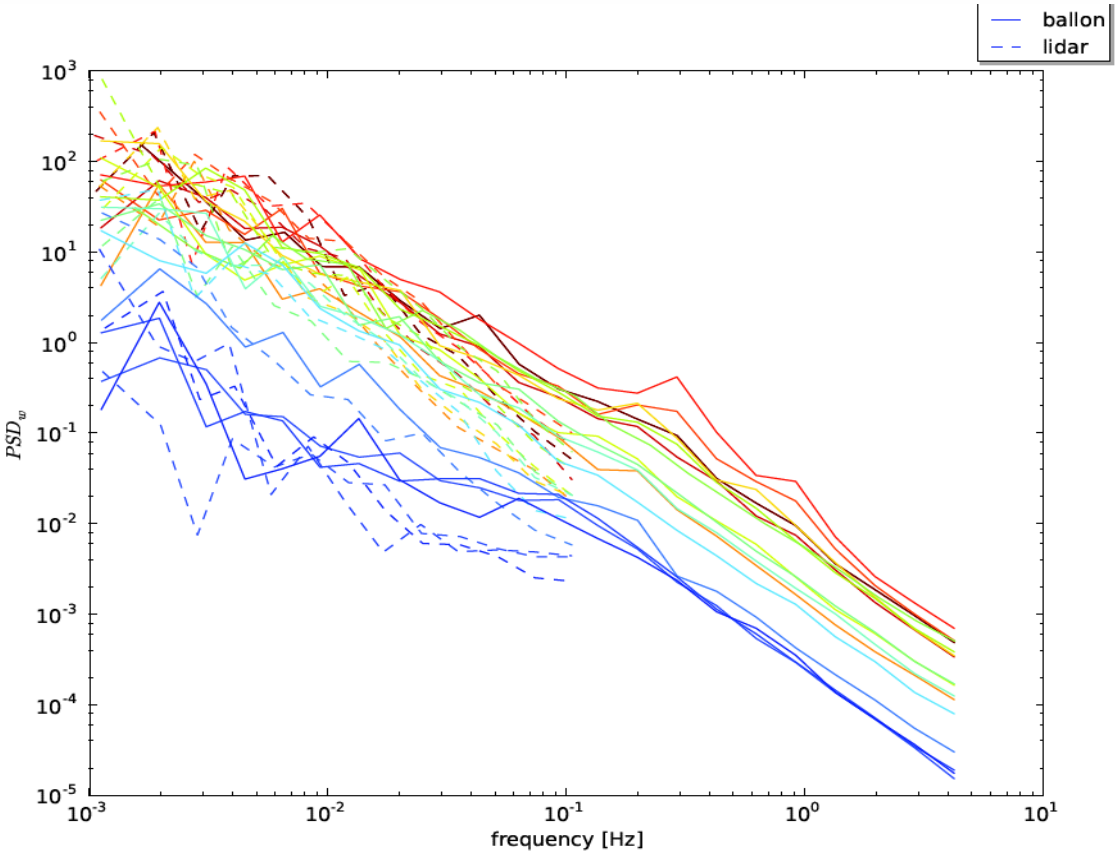
Ongoing work





-Power spectral density of w



Explore the possibility to estimate the dissipation rate by Lidar

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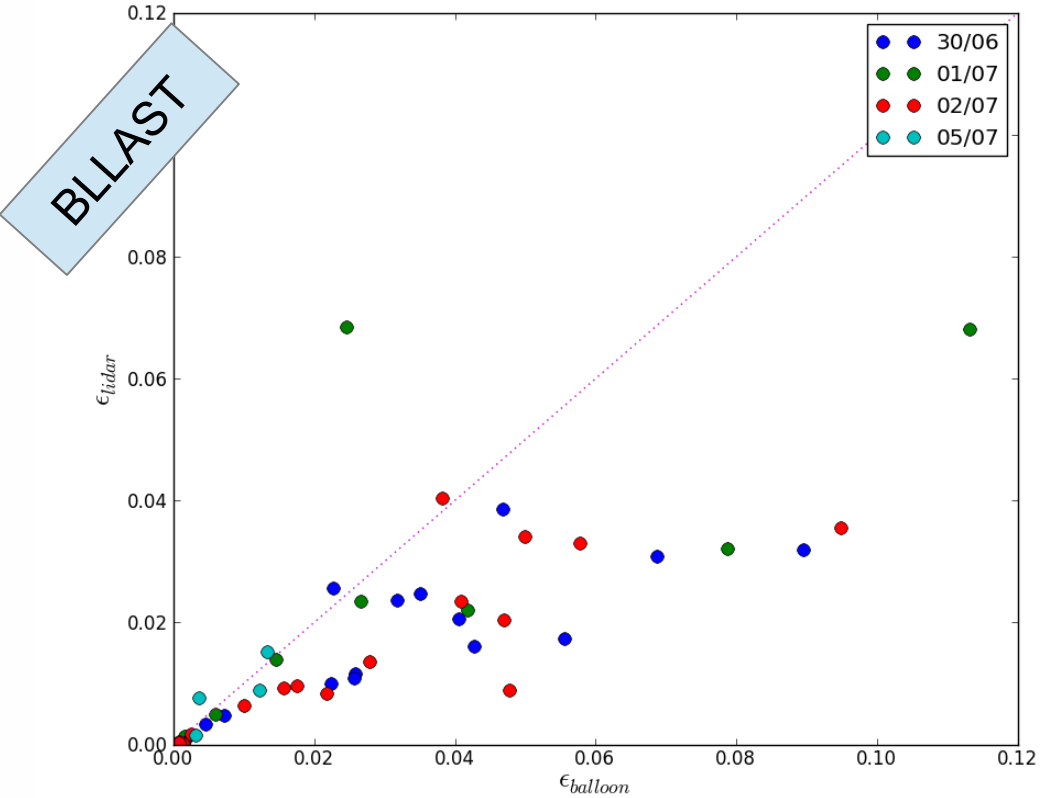
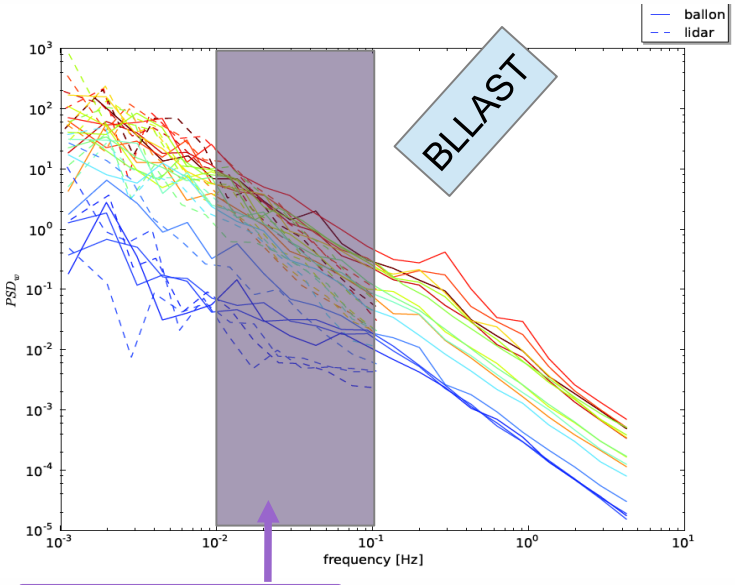
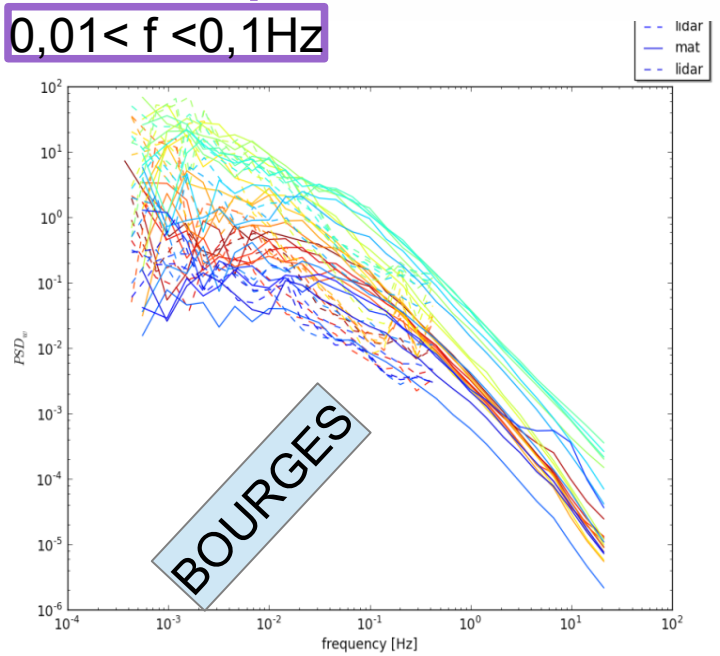
Ongoing work

Comparison between the estimation of the **Dissipation rate** obtained by Lidar and sonic anemometer.





0,01< f <0,1Hz



Conclusions & Perspectives

This study shows :

- a good agreement between the wind Lidar and the sonic anemometer.
- a good characterization of the diurnal cycle of TKE with an underestimation of the intensity of the PBL turbulence by the models

Having continuous vertical turbulent data offers the possibility :

- to improve our knowledge of turbulence profile in the PBL.
- to assess the quality of atmospheric numerical models
- to test current parameterizations and develop new ones.

This study highlights the new possibilities offered by high resolved observations of wind and turbulence with lidars for instance in order to improve the understanding of convective turbulence through the PBL and at the end the weather forecasts by developing advanced models and data assimilation