Lidar Wind-Shear Monitoring: Nice Airport Trials

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Nice airport

- Nice airport is number 3 in France for the number of passengers (after Paris-CDG and Paris-Orly) .
- The topography around the airport is complex:
  - Located on the shore of the Mediterranean Sea.
  - Bordering the city of Nice (~400000 inhabitants).
  - Alps to the North with peaks above 4000ft within 9nm of the airport.
  - At the exit of the Var valley

Complex wind field with interactions between large-scale circulations, sea-breeze and down-slope winds, making the airport difficult for pilots.

http://www.niceairport.com/eng/page_clim.htm

Possibility of wind shear on final 04/22 combined with a strong tail wind component at medium altitude and cross wind on short final (confluent gradient wind and sea breezes).

Serious risk of cross or full crosswind component due to the sea and river valley proximity and in particular RWY 04 threshold (close to the Var estuary).

During strong westerly winds there may be high turbulence on short final that could result in missed approaches ; in this case the traffic may be carried exceptionally on RWY 22L.

Nice airport

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Nice airport

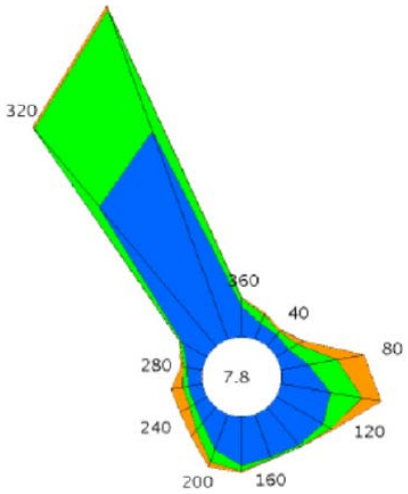
ROSE DES VENTS

Vent horaire à 10 mètres, moyenné sur 10 mn

Du 01 JANVIER 1997 au 31 DÉCEMBRE 2008

NICE (06) *Indicatif : 06088001, alt : 2 m., lat : 43°38'54"N, lon : 07°12'30"E*

Fréquence des vents en fonction de leur provenance en %



Valeurs trihoraires entre 0h00 et 21h00, heure UTC

Tableau de répartition
Nombre de cas étudiés : 35057
Manquants : 7

Dir.	[2.9;8.7 [	[8.7;15.5]	> 15.5 kts	Total
20	1.1	0.6	0.1	1.9
40	1.0	0.3	0.1	1.4
60	1.0	0.7	0.4	2.1
80	1.9	1.9	1.8	5.6
100	3.4	2.1	1.3	6.8
120	3.6	0.6	0.2	4.4
140	3.3	0.2	+	3.4
160	3.1	0.1	+	3.2
180	3.3	0.4	+	3.7
200	2.5	0.9	0.3	3.8
220	1.4	0.6	0.5	2.5
240	0.9	0.4	0.8	2.1
260	1.0	0.4	0.7	2.1
280	1.0	0.3	0.2	1.5
300	1.9	0.2	+	2.2
320	12.1	6.8	0.2	19.1
340	14.8	8.6	0.3	23.7
360	2.0	0.5	0.1	2.7
Total	59.2	25.7	7.3	92.2
[0;2.9 [				7.8

Groupes de vitesses (kts)
[2.9;8.7 [[8.7;15.5] > à 15.5

Pourcentage par direction
0% 5% 10%

Sea-breeze prevailing (side winds),

but strong winds (>15kts) are from the east or the west.

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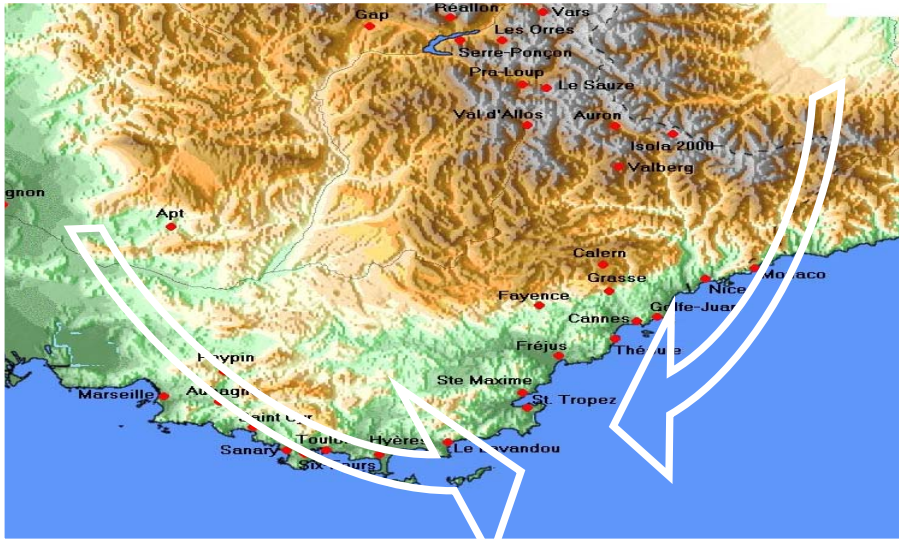
Sources of wind-shear and turbulence

- Standard sources
  - Thunderstorms (29 days/yr in Nice).
  - Wind gusts (winds above 16m/s 40 days/yr with a max prob of ocurrence in April)
- Related to the complex topography
  - Sea breeze
    - Rather weak (typically 2 to 12kt), but transverse relative to the runway and causing many changes of QFU) → significant impact on the operations.
    - Vertical extension: surface to ~1000m.
  - Down-slope winds potentially channeled by the Var valley:
    - Usually moderate winds (6 and 10kt), but may approach 18kt at the end of the winter.
    - Side-wind.
    - Vertical extension ~800 meters
    - Causing weak to moderate turbulence.
- Enemy n°1: Wind reversals (20 episodes in 2007)
  - 180 deg rotation (from east to west, or vice versa) of strong winds (above 15kts) below 1000 to 2000 meters → big impact on the aircraft if present in the approach area (missed approaches) .
  - Occur in clear-sky conditions (no cloud, no precipitation, good visibility).
  - Difficult to monitor because the approach is above the sea…

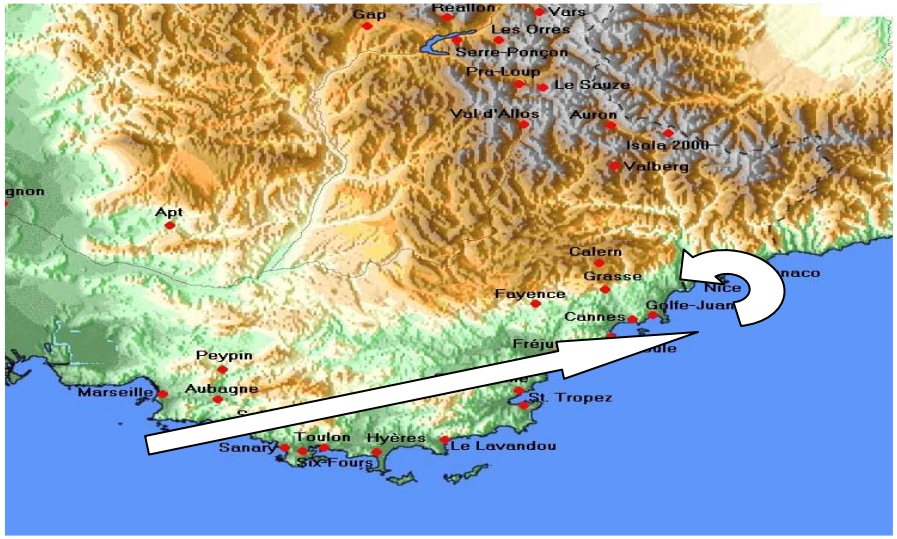
Wind reversals



Opposition between two large-scale wind circulations.

The weather conditions favoring its occurrence are rather well predicted, but the models are not presently able to forecast with precision if and when it will affect Nice.

Wind vortices forming in the lee of the topography



Research studies are currently under way in order to improve the forecast of wind reversals in Nice.

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Present monitoring systems

- Anemometers on the airport and on both sides in Cap-Ferrat and Cap-d'Antibes.

Useful, opposite winds at both capes suggest the presence of a wind-shear somewhere in between. But does not allow any spatial exploration, either horizontally nor vertically. May not see a strong wind shear in altitude (no signature at the surface).

- Test of a UHF profiler located on the airport.

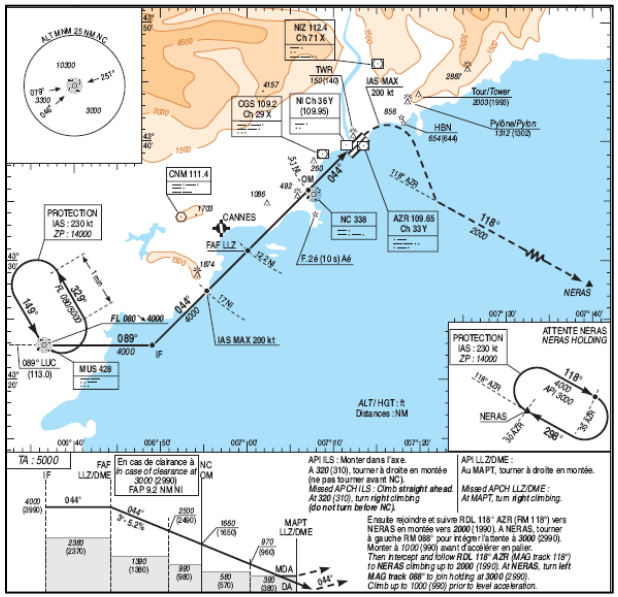
Detects the wind shear as it passes over the airport, not when it is in the approach area above the sea.

Need for a remote sensor able to probe the wind field above the sea in the approach area up to ~1000 meters.

Considering wind shears are mainly occurring in clear sky conditions, the Doppler lidar is the best candidate.

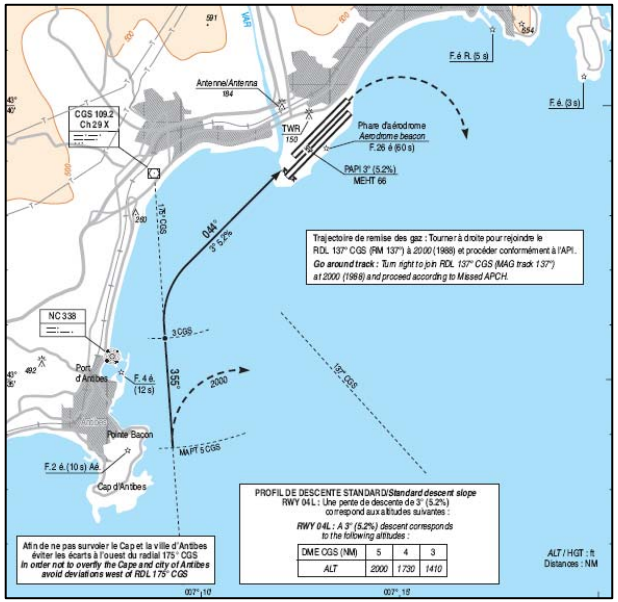
How far is the wind to be monitored ?

ILS 04



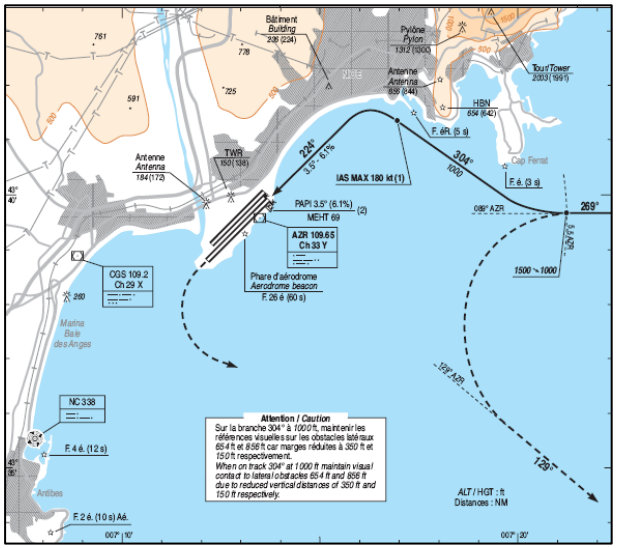
30% of arrivals.

RIVERIA



60% of arrivals.

SALEYA 22R



10% of arrivals, but 120 days / year

A range of 10km or more allows for the exploration of the glide path up to the turning points of RIVERIA and SALEYA.

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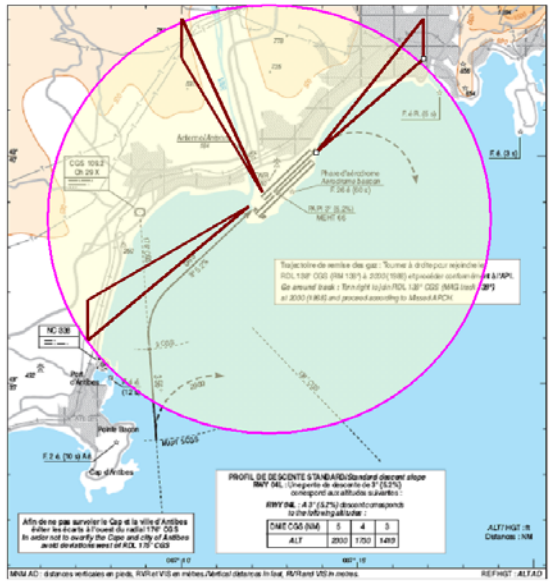
Test experiment

- Conducted in March-May 2009 with a rented WindTracer system from Lockheed Martin.
  - 2µm heterodyne lidar → detects aerosol particles → max range depends on aerosol loading in Nice.
  - Typical range of 8 to 10km.
  - One radial profile of line-of-sight wind velocities every 0.1s.
  - Range resolution ~100 meters
  - Hemispherical scanner.
- The lidar was deployed on the airport.
- A 3-minute measuring sequence was defined consisting of 3 PPI scans (elevation 2°, 4° and 70°) and 3 RHI (azimuth 44°, 224° and 335°).



Deployment of the lidar on the airport on the 10th of March, 2009

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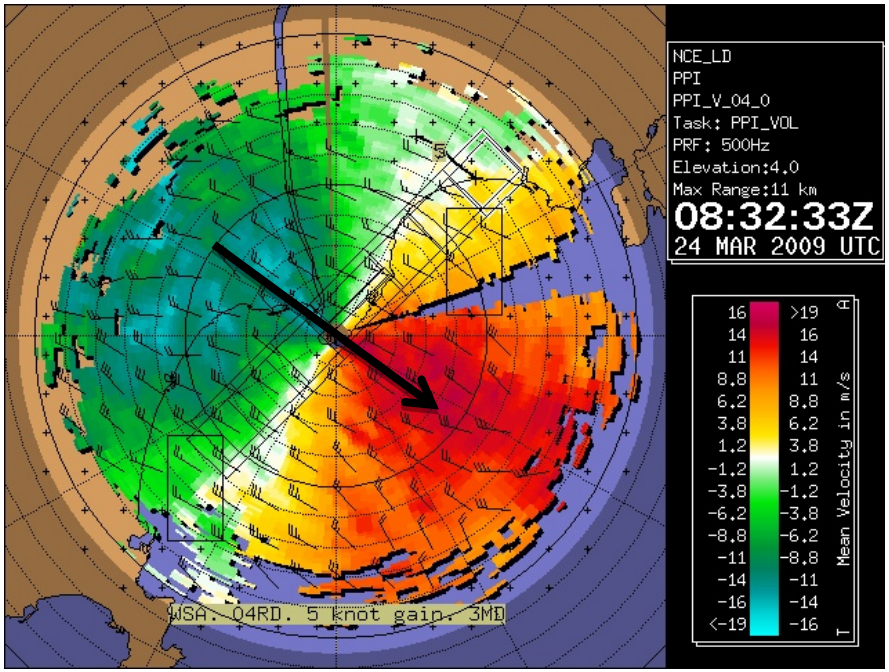
Data type

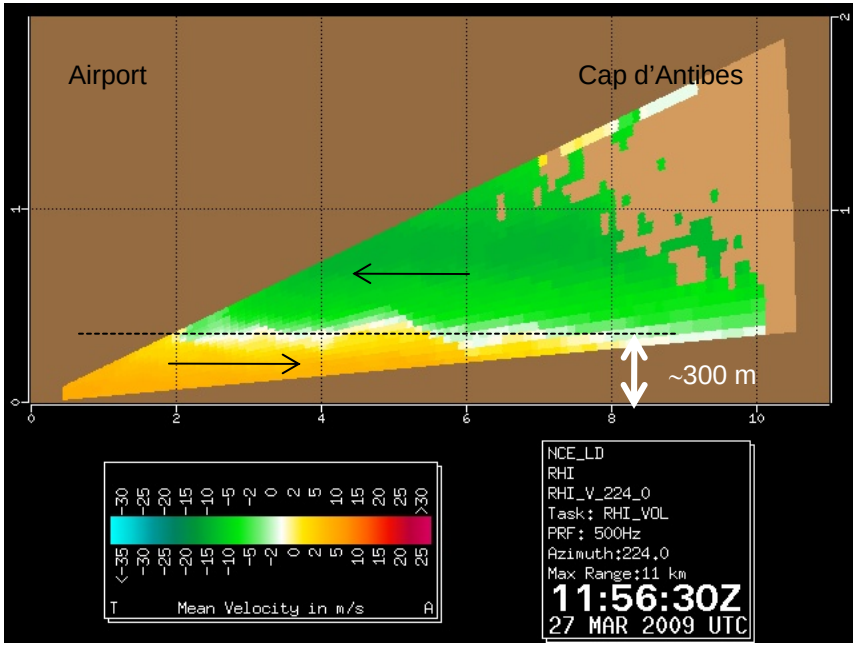
24 March 2009 – PPI 4°



Color coded plot of line-of-sight velocities (positive = away from the lidar) at a function of the azimuth and range.

Here, the colors indicate the prevailing wind is blowing from the North-West

27 March 2009 - RHI – Az: 224°



Color coded plot of the line-of-sight velocities as a function of distance (x-axis) and altitude asl (y-axis).

Here, the wind is blowing away from the lidar (towards the east) below 300m, and towards the lidar above.

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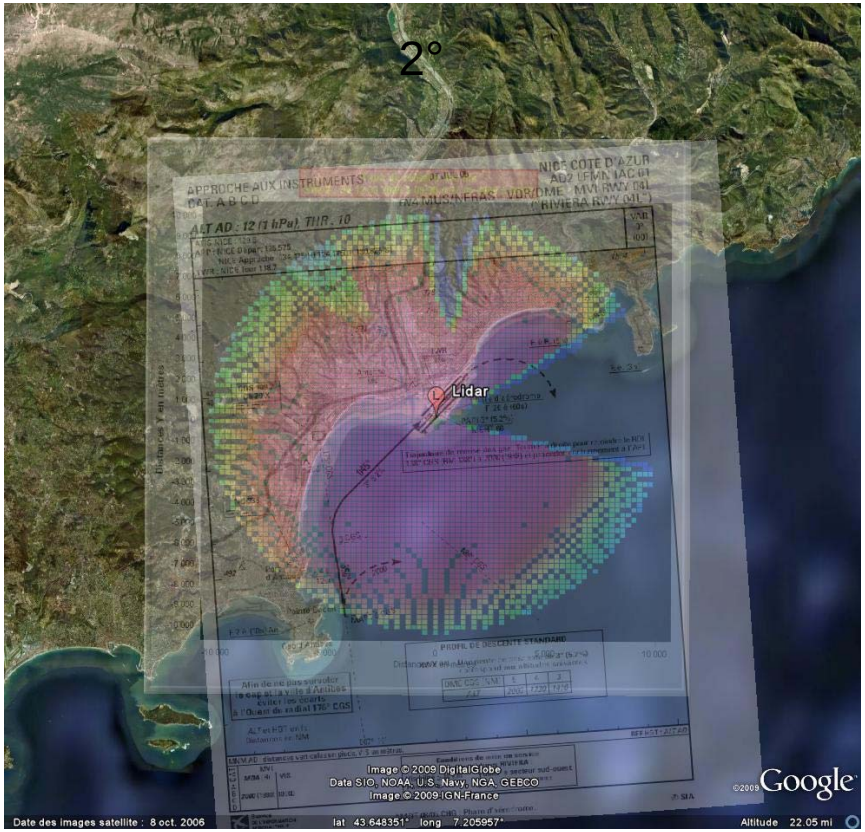
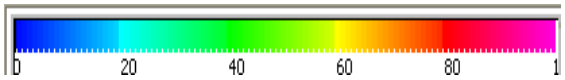
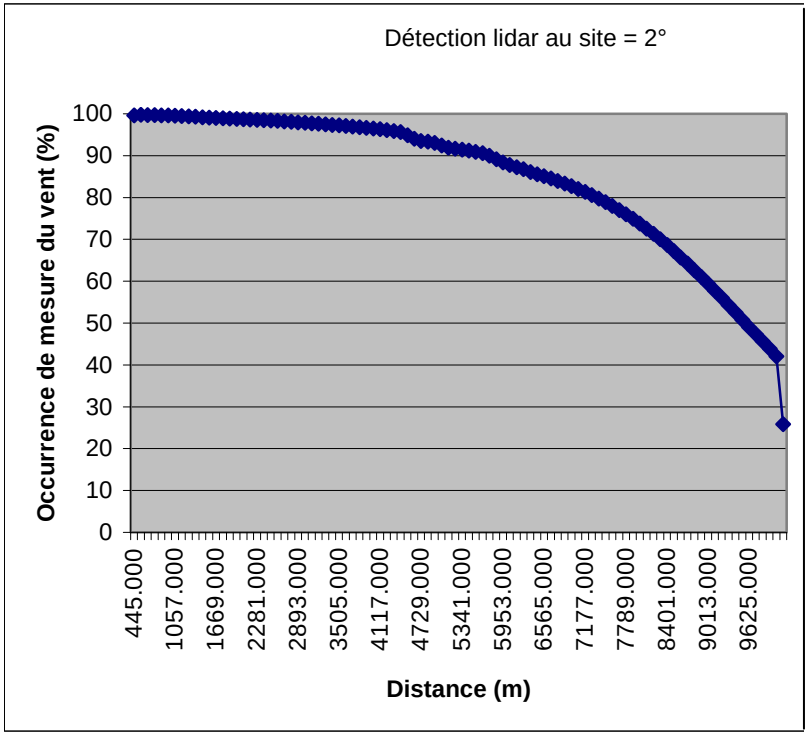
Data availability





% availability



The 3 possible approaches are well covered.

In windy conditions, the aerosol loading in the atmosphere is heavier, the range is beyond the average.

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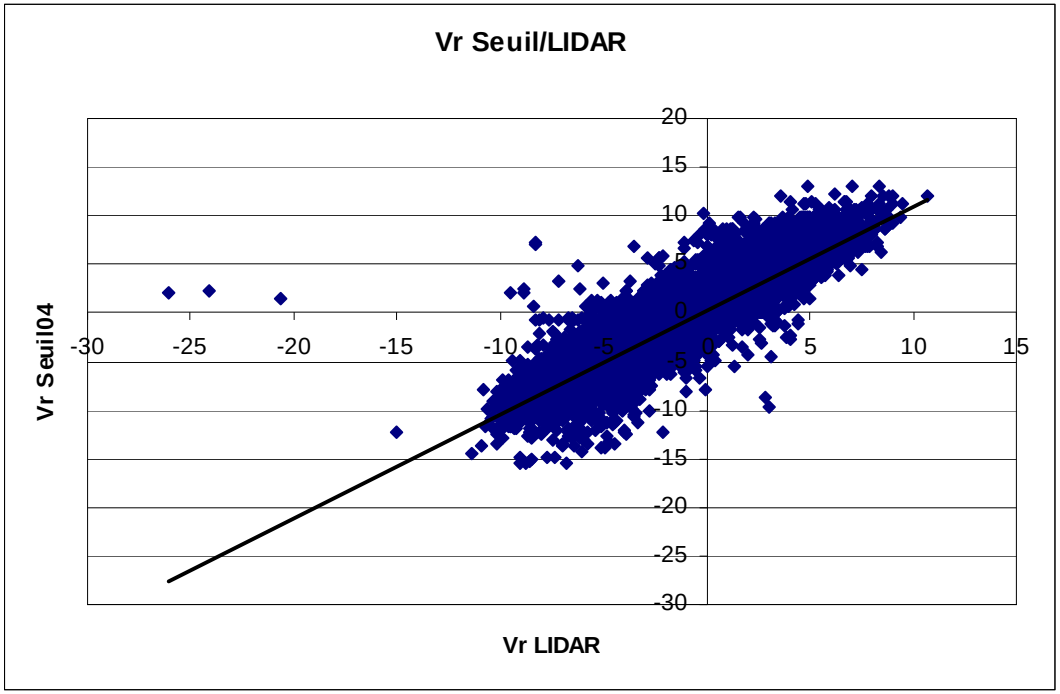
Validation against anemometer



Comparison between the radial velocity measured by the lidar in the vicinity of the airport anemometer (10m above the surface, 1000 meters away from the lidar) and the anemometer radial velocity (projection of the anemometer 2D wind on the line-of-sight).

The slope of the best linear fit is very close to 1.
The dispersion about the best fit (1.2m/s) is rather large, but is due for a great part to the fact that a lidar and an anemometer do not measure the same quantity. The lidar velocity is an average along a beam that is a few centimeters large and about 100 meters long!

Wind-shear detection 29/04/2010

- 3 cases of wind-reversals were observed by the lidar during the whole experiment.
- For the 29/04/2010:

10:30 AF210 missed approach due to wind and turbulence.

14:53 DLH73 missed due to wind-shear on short final (Saleya).

15:10 KLM43 missed approach due to wind shear.

15:14 AF706 missed approach due to wind shear.

15:23 Exceptional landing of an aircraft on ILS04 because tailwinds are reported on either end of the runway (22: 15kt, 04: 7kts).

15:30 Airport operations switch to ILS04 approach.

PPI 4° elevation

RHI Azimuth 44° (→ Cap Ferrat)

Conclusion

- The experiment has proven the capacity of a Doppler lidar to probe the wind field above the sea around the airport with adequate range (8 to 10km), spatial resolution (100m) and temporal resolution (rep rate of information 3 minutes).
- The lidar has proven its capacity to provide useful information on turbulence and wind-shear. In particular, it is able to detect wind-shear before it affects the glide path due to its ability to scan on either side (horizontal exploration is necessary).
- RHI very useful, it allows for the detection of wind-shears in the altitude with no signature at the surface.
- A fine rep rate (a few minutes) is necessary for the wind-shear may sweep across the airport very quickly.