Wavelet Optical Flow for 2-Component Wind Fields from Aerosol Backscatter Lidar Data

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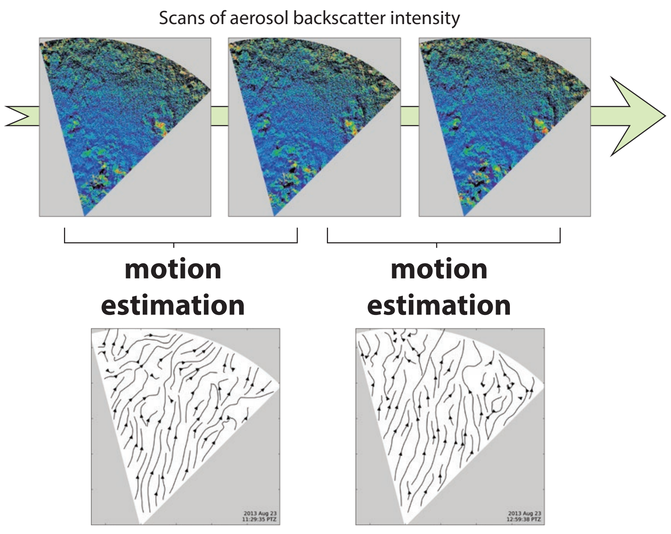
Scientific Objectives

Remotely **measure 2-component vector wind fields**, using **aerosol backscatter lidar** data and **motion estimation** methods.

Evaluate performances of a new estimation algorithm:
"wavelet-based optical flow" (*Typhoon*)
- alternative to the cross-correlation algorithm
- computer vision method
- **multiscale** wavelet representation
- **dense** vector field
- GPU-accelerated for **real-time estimation**

A. Wind Field Estimation

Raman-shifted Eye-safe Aerosol Backscatter Lidar (*REAL*)

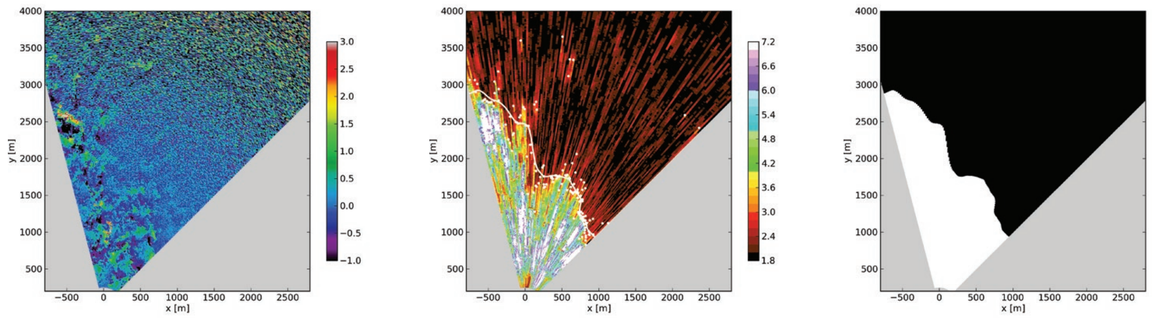


Aerosol features act as passive tracers: their **apparent displacements** in the sequence of scans allows to retrieve the **underlying wind field** using motion estimation algorithms.
Scans from the **REAL lidar** are available typically **every 8-15 s**, up to **5 km range**.

B. Aerosol Features Detection

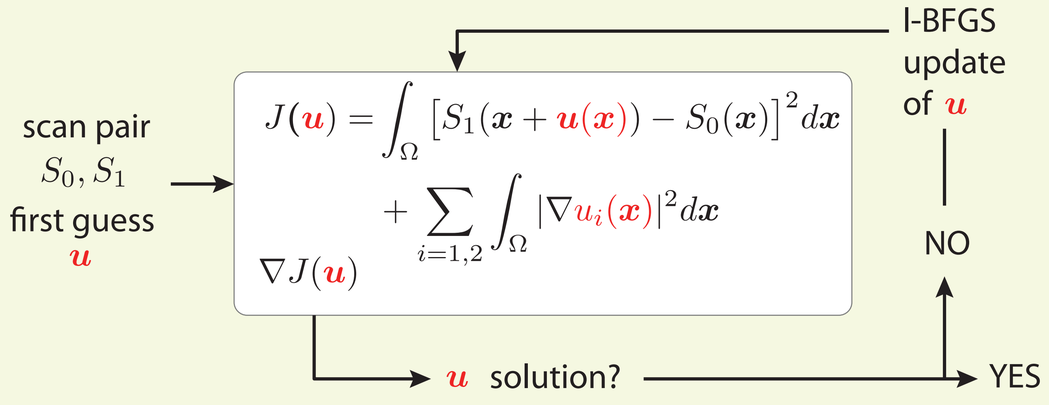
Motion estimation relies on the **presence of aerosol features**. To ensure the best results, a **region of interest** containing such features is **determined dynamically** for each scan using **image SNR**. Motion is estimated within this region only.

Filtered Scan → **Image SNR** → **Region of interest**



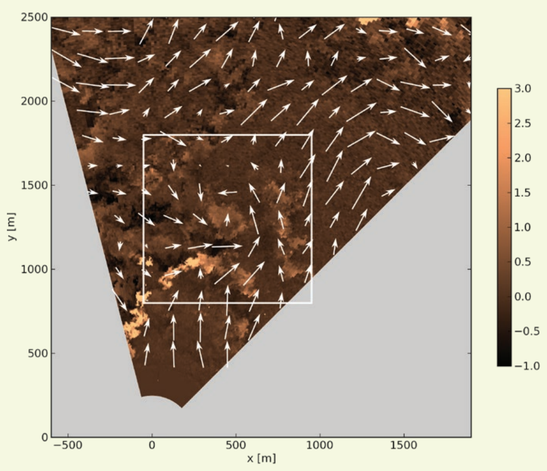
C. *Typhoon*, Optical Flow Algorithm

Typhoon estimates the whole motion field ***u*** from 2 scans by **minimizing a functional** *J(**u**)*. It uses the **Displaced Frame Difference** data model and a **1st order regularization**. Motion ***u*** is represented on a **multiscale wavelet basis**, 1 vector at every data point (**dense motion**).

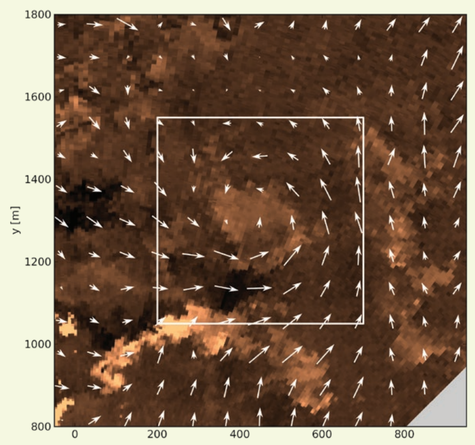


D. Wind Field: Vortex Case

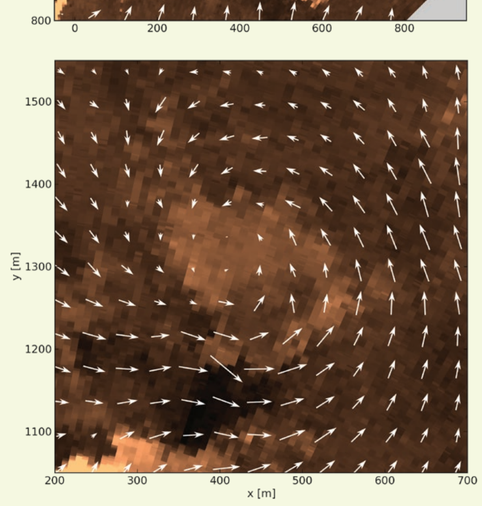
PPI scan recorded by the REAL in Chico
2013 Oct 23
23:32:04 UTC



1x1 km zoom
1 vector every 10,
spacing = 80 m



500x500 m zoom
1 vector every 5,
spacing = 40 m

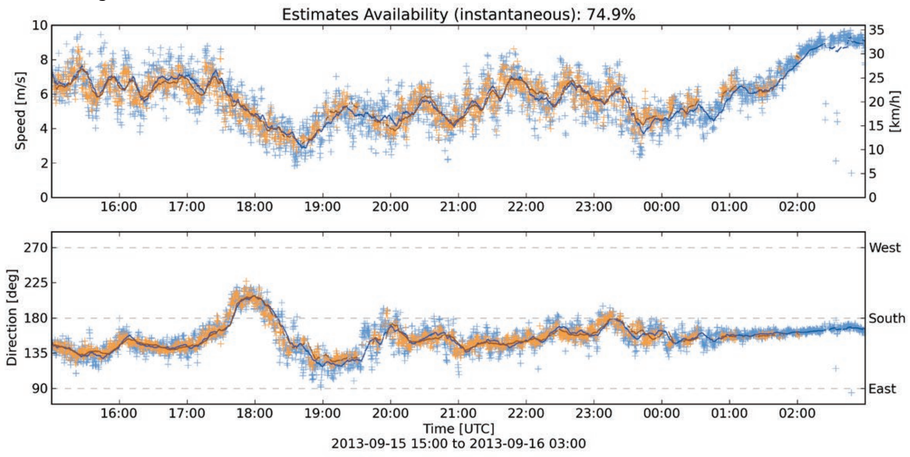


~500 m vortex

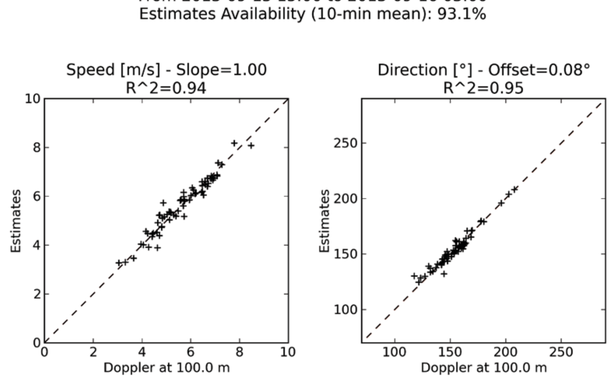
E. Temporal Validation

Using a **HALO Photonics Streamlines** Doppler lidar for **vertical profiling**. The **temporal evolution** of wind speed and direction is monitored at a **single point of space** (1.52 km of the REAL) and compared to results delivered by *Typhoon*. **10-min rolling averages** are considered.

Time-series of wind **speed (top)** and **direction (bottom)** measured by the **Doppler (blue)** or estimated by ***Typhoon* (orange)** on 15 Spetember 2013. Light + markers denotes instantaneous measures, darker lines the rolling means.

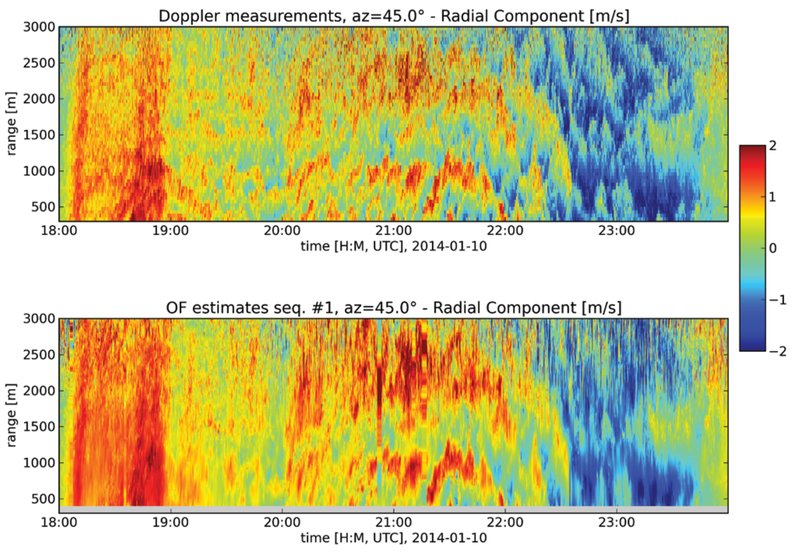


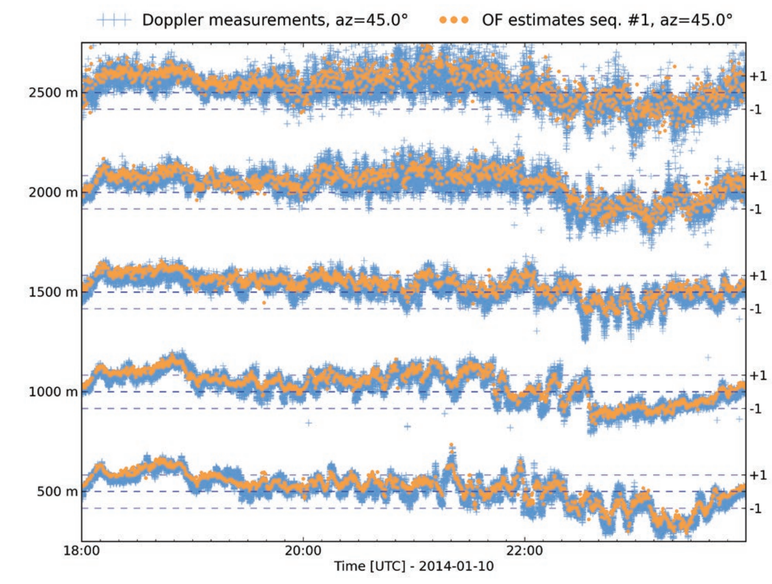
Scatter plot of **10-min means**, **Doppler reference (horizontal)** vs ***Typhoon* estimates (vertical)** showing very good correlation.



F. Spatial Validation

The Doppler lidar is now **staring at 45° azimuth**, and measures the **radial component of velocity only**. The corresponding radial component is derived from the **2D wind fields** estimated by *Typhoon* for comparison.





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