Multi scanning lidar measurements for resource assessment:
A case study in complex terrain

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Motivation & Objectives

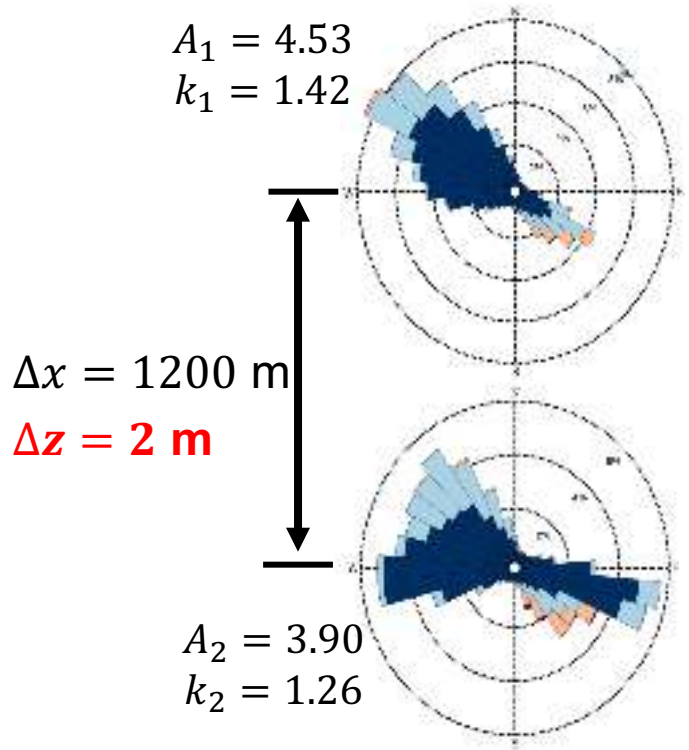
- Wind lidars >> established way to vertically extended traditional met masts;
- Scanning lidars >> new way for horizontal extension;

Multi scanning lidar measurements promise the possibility to:

- Perform wind reconstruction in multiple points;
- Capture atmospheric phenomena not well modelled with current commercial microscale models.

This presentation aims to:

1. Present a multi-lidar full-scale experiment that represent a “real-case” scenario;
2. Analyse flow patterns and wind reconstruction by multiple scanning lidars.



Alaiz Full-Scale Experiment (ALEX17)

Campaign and Data Report: 10.5281/zenodo.3187482

Go deeper into the micrometeorology of heterogeneous large-scale terrain with non-homogeneous flow across an unprecedented measurement area (~20x20 km) with strong mesoscale forcing.

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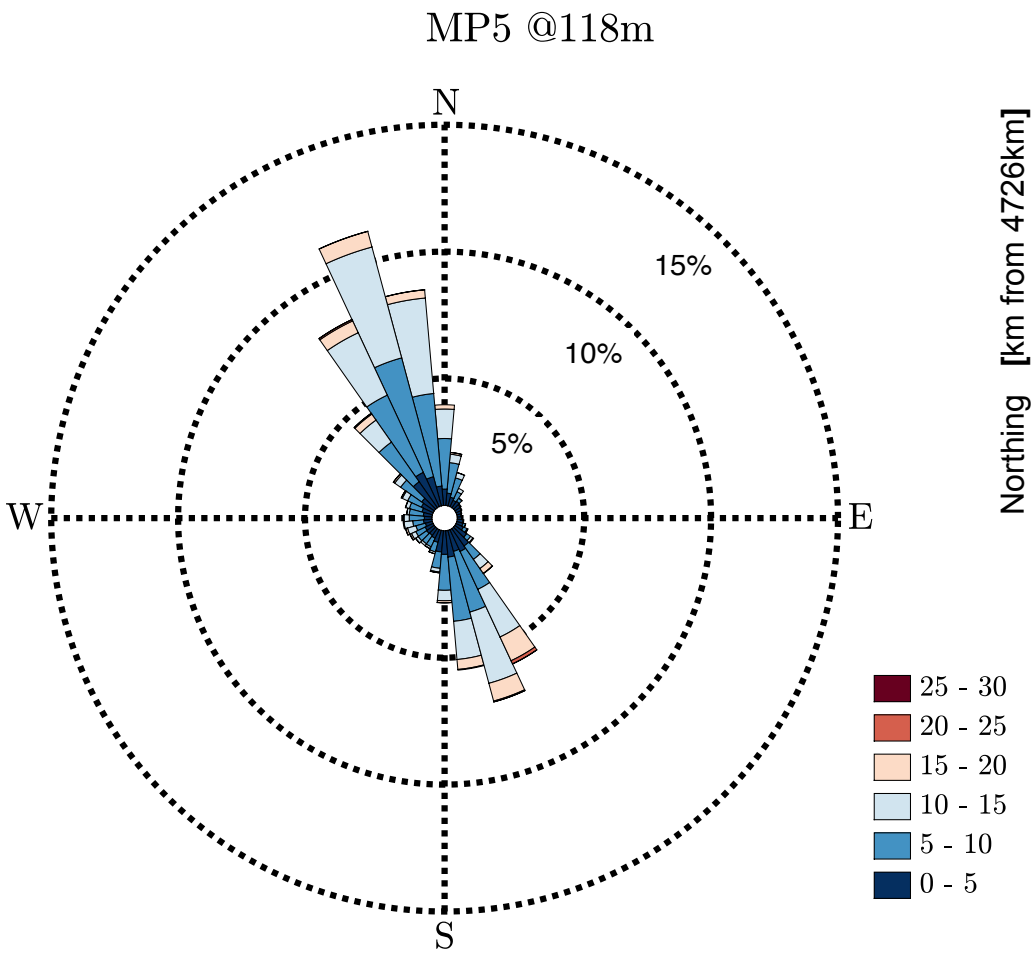
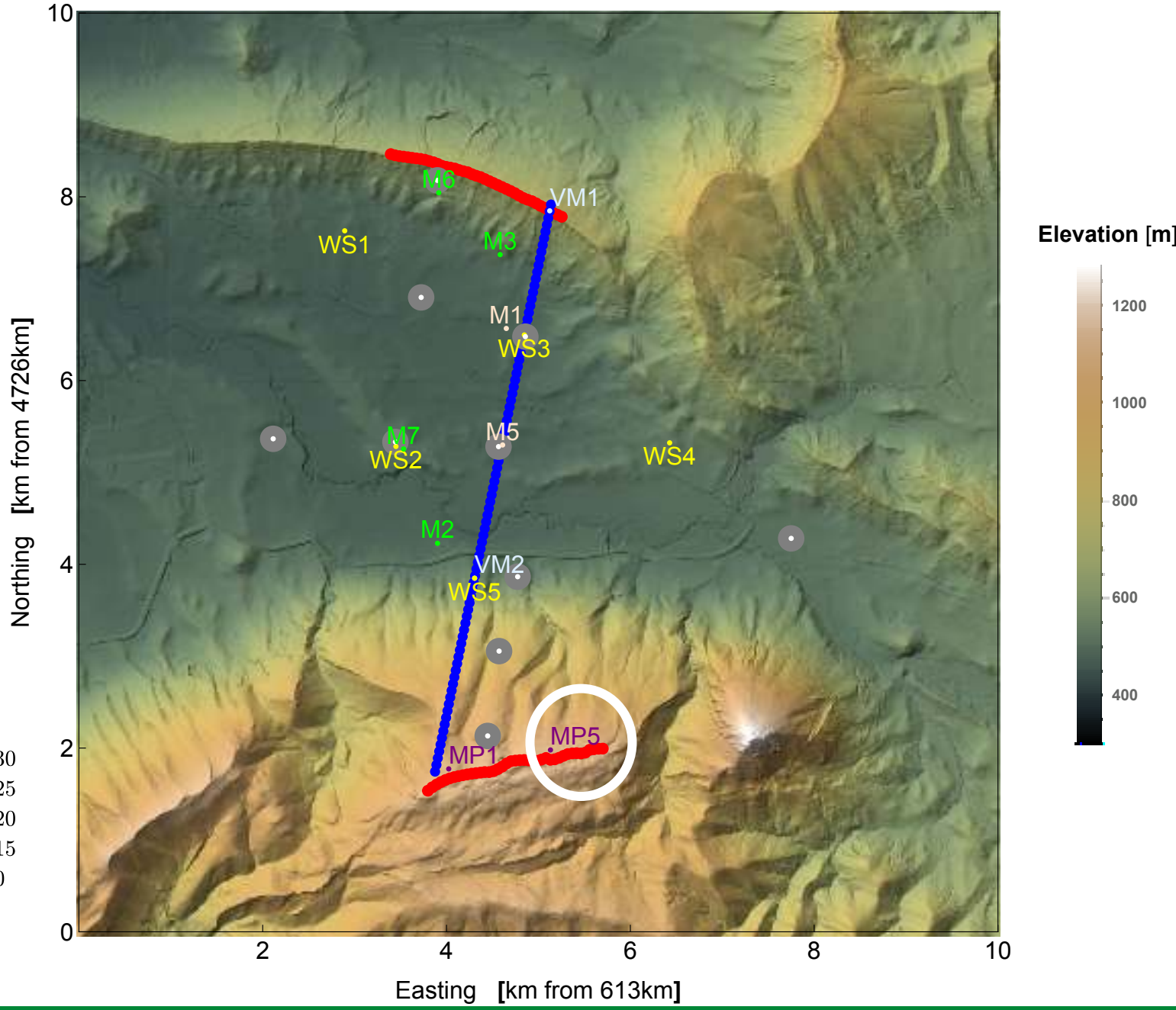
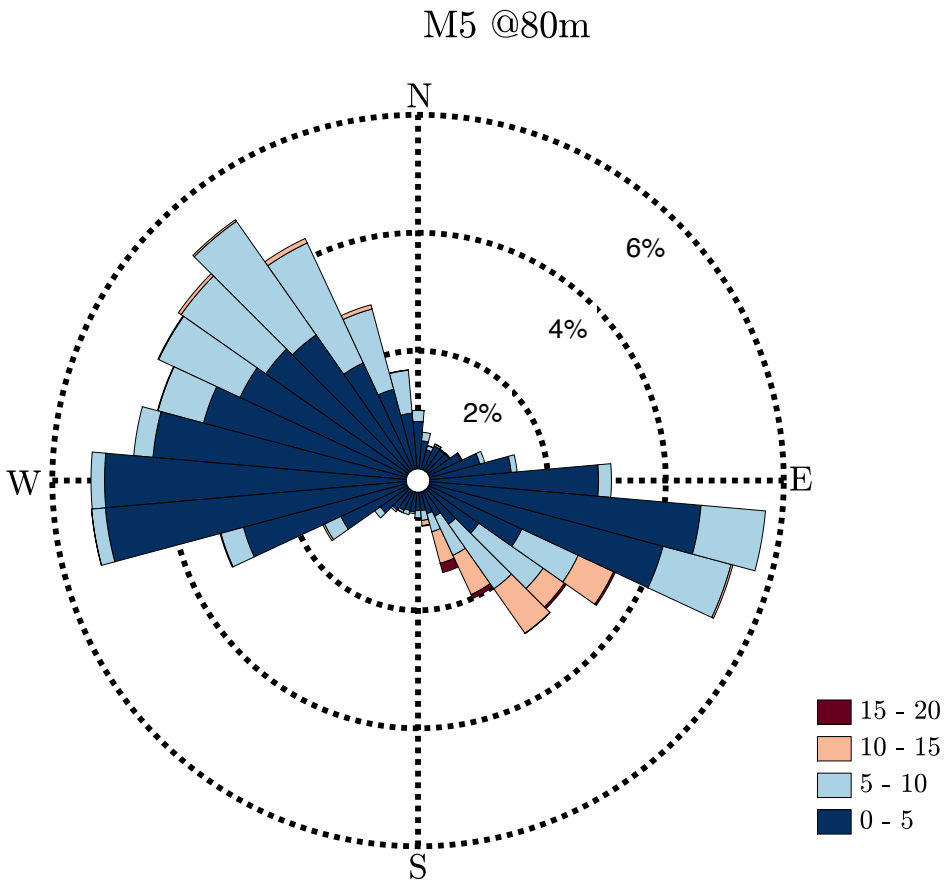
ALEX17 Layout

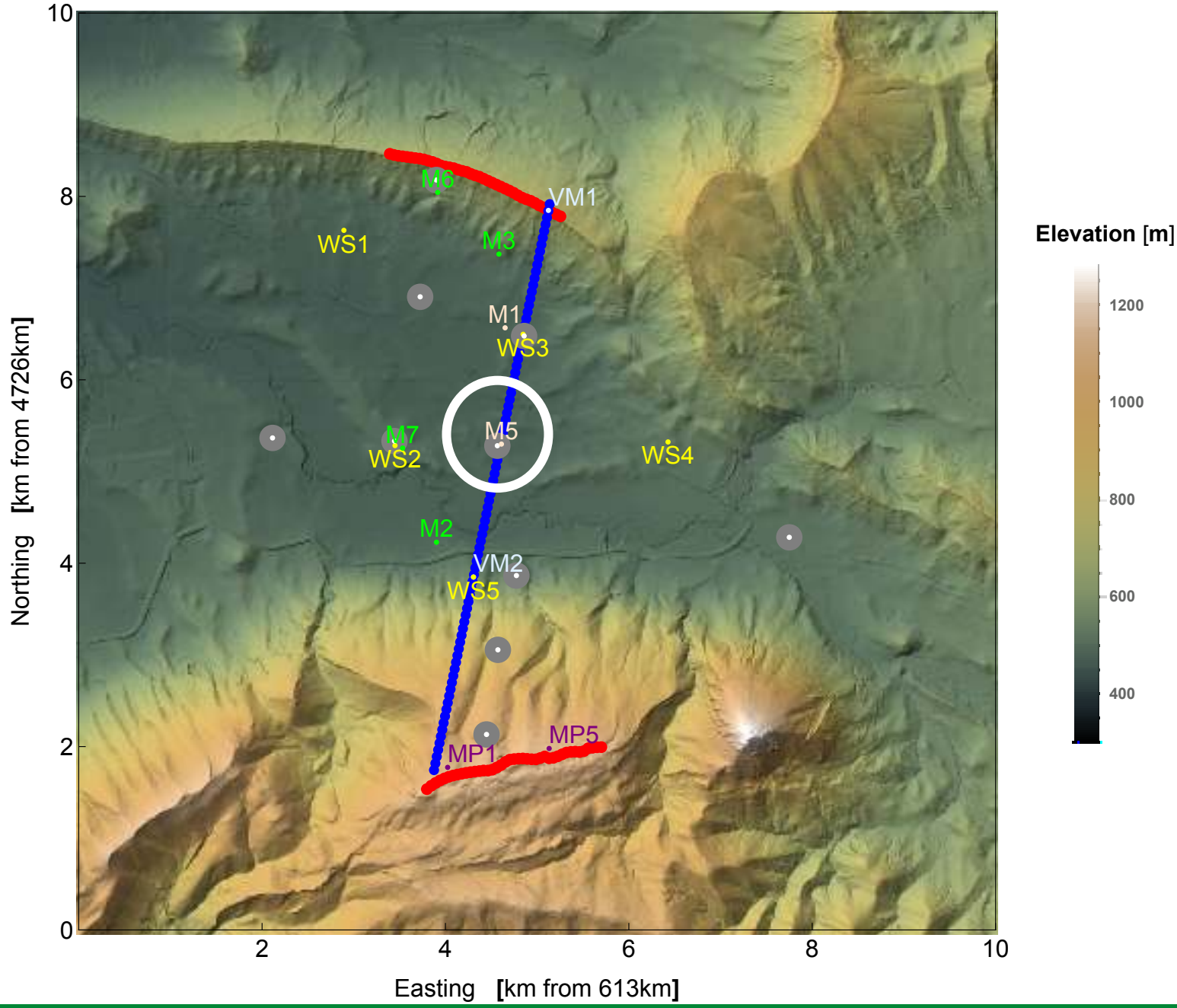




ALEX17 Layout

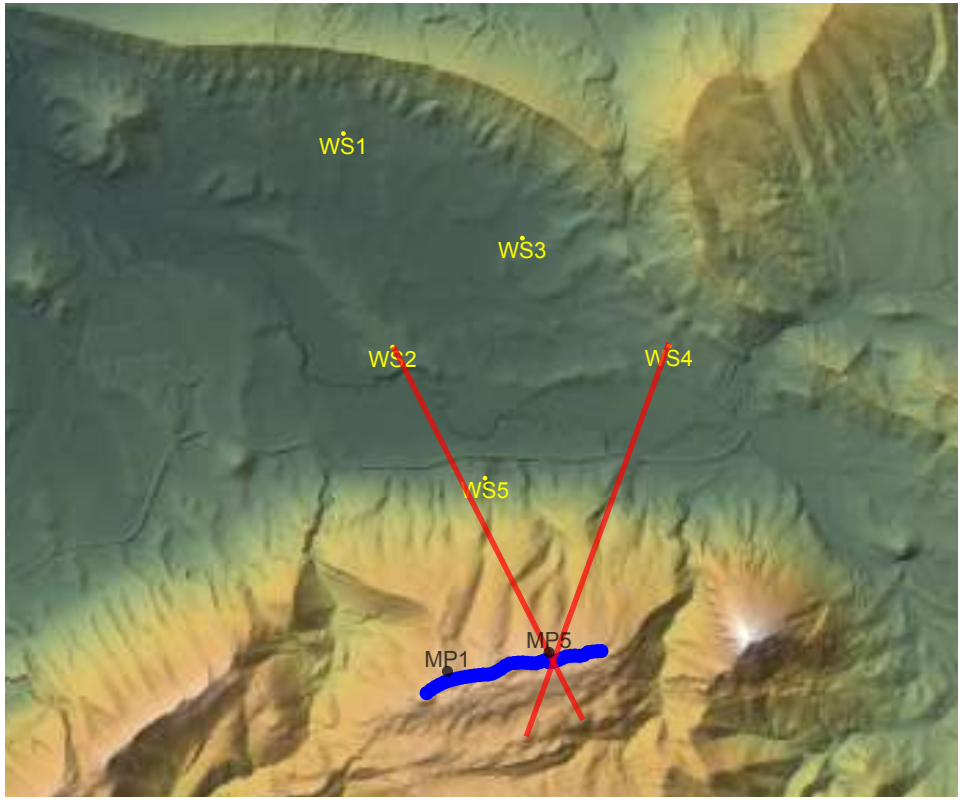
- Spatial variations of prevailing wind;
- Valley winds stronger from E;

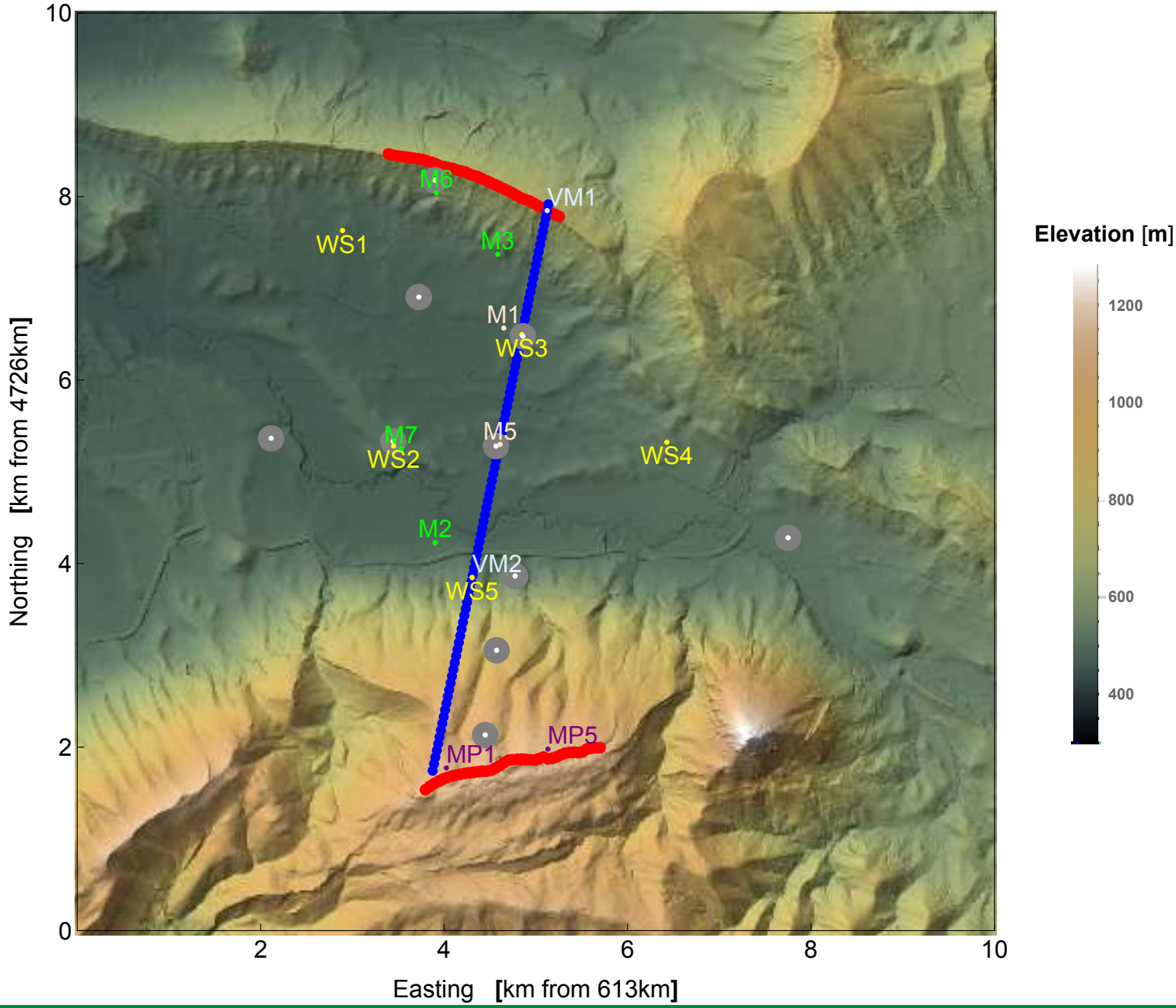




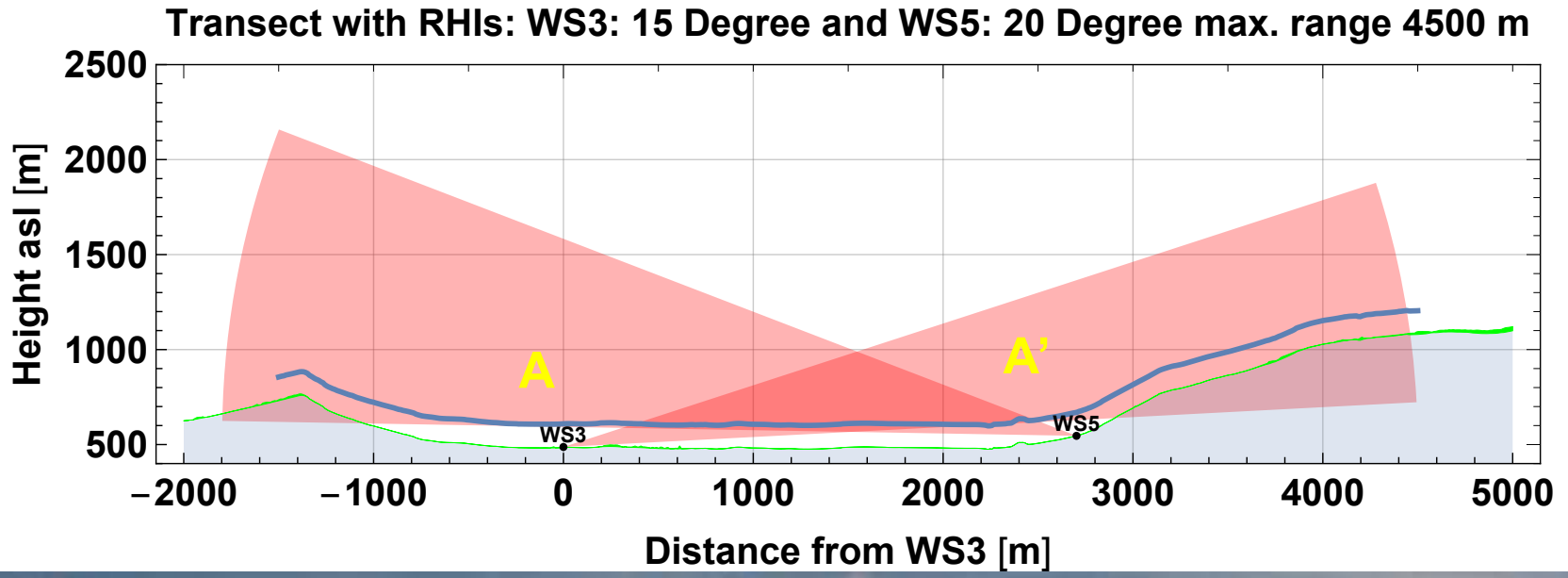
Multi-lidar scans

- 3 x 10min periods with distinct scans;
- 10km Z-shaped transect;





Transect Line

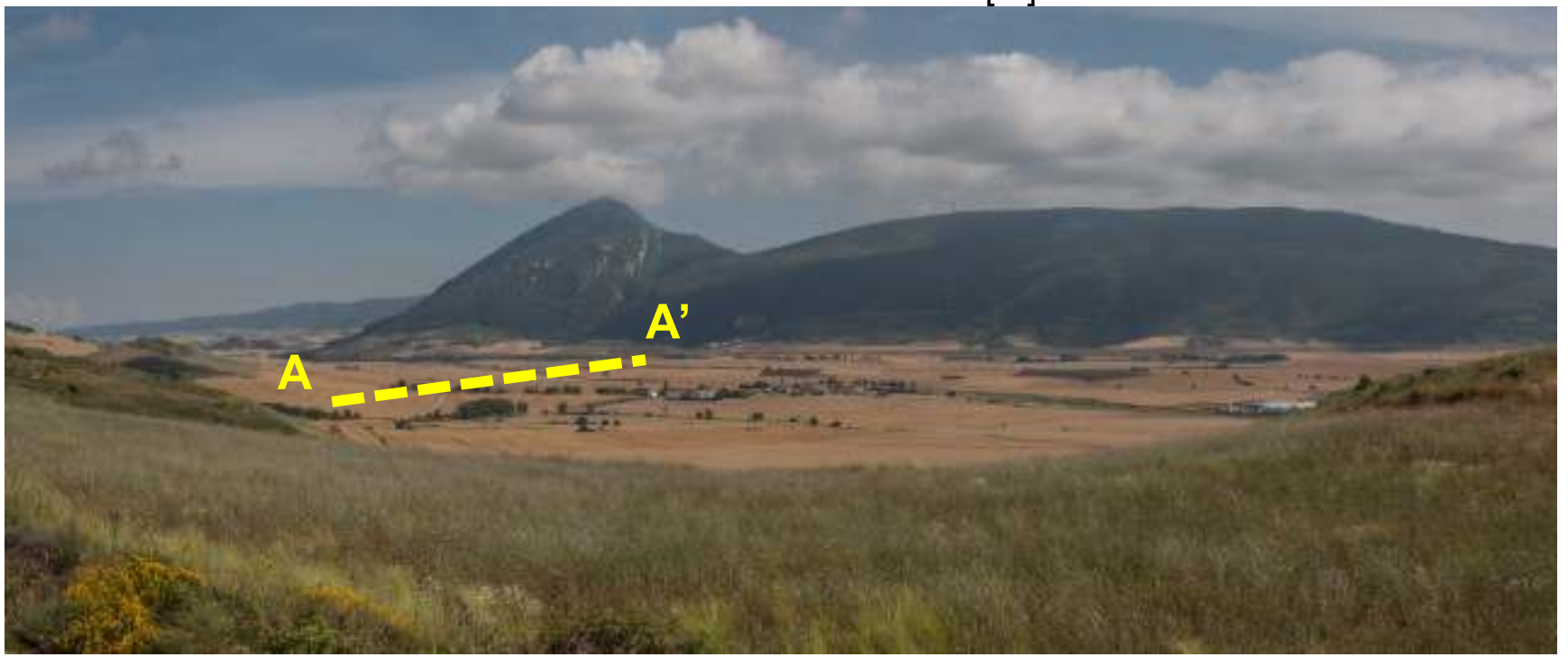


<u>6 km transect line:</u>

- 3D wind reconstruction;
- Combination of 4 WSs;
- Ongoing analysis (not today);

<u>Flow patterns from V_r:</u>

- Impact of NR on SR (vice-versa);
- S-winds: Turbine wakes;
- S-winds: Speed-ups;
- N-winds: Gravity waves;

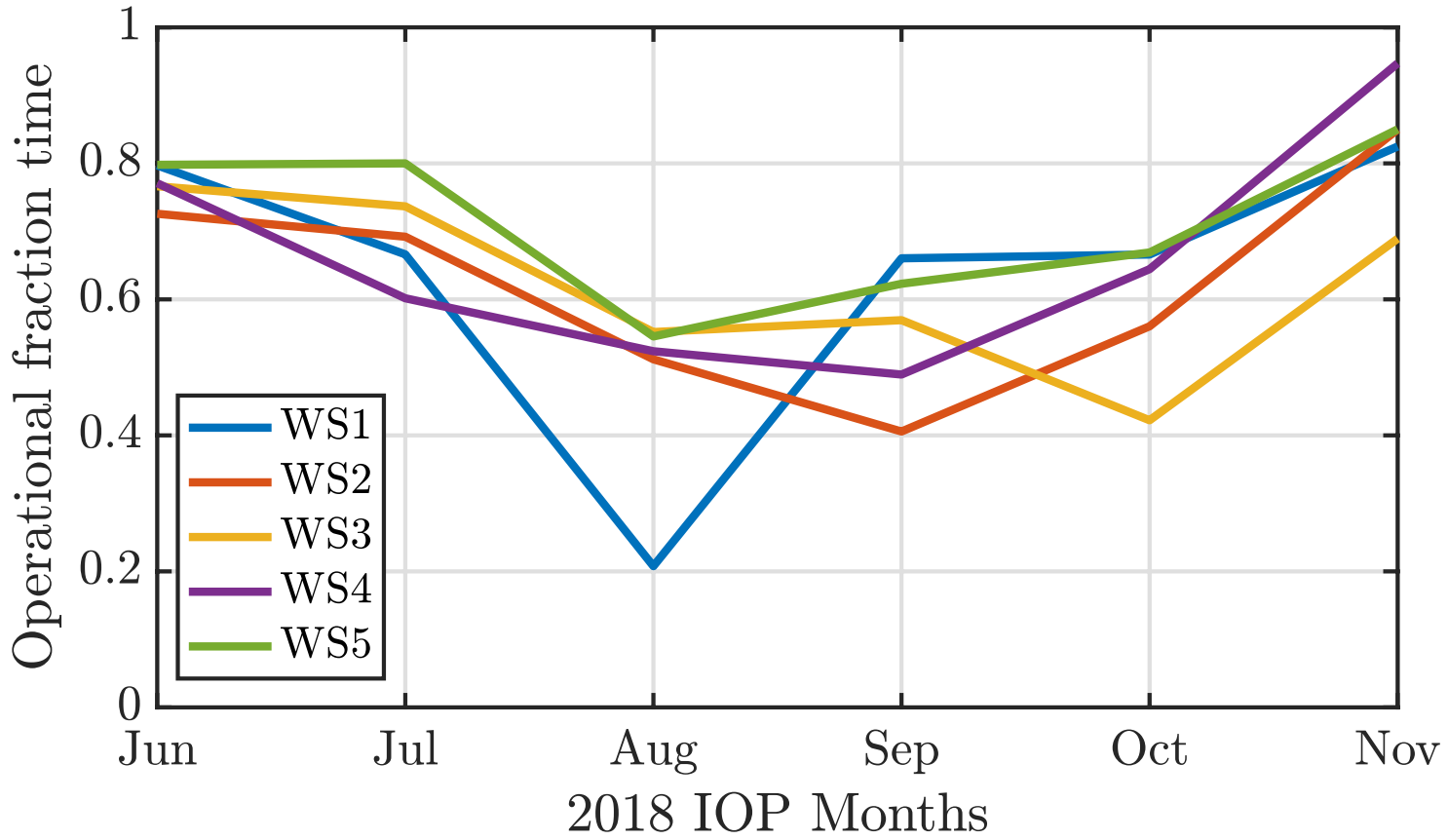


WS Uptime & Challenges

- Extensive Measurement Period (**EMP, 2 years**): July/2017 to July/2019;
- Intensive Observational Period (**IOP, 7 months**): May/2018 to December/2018;

Challenges:

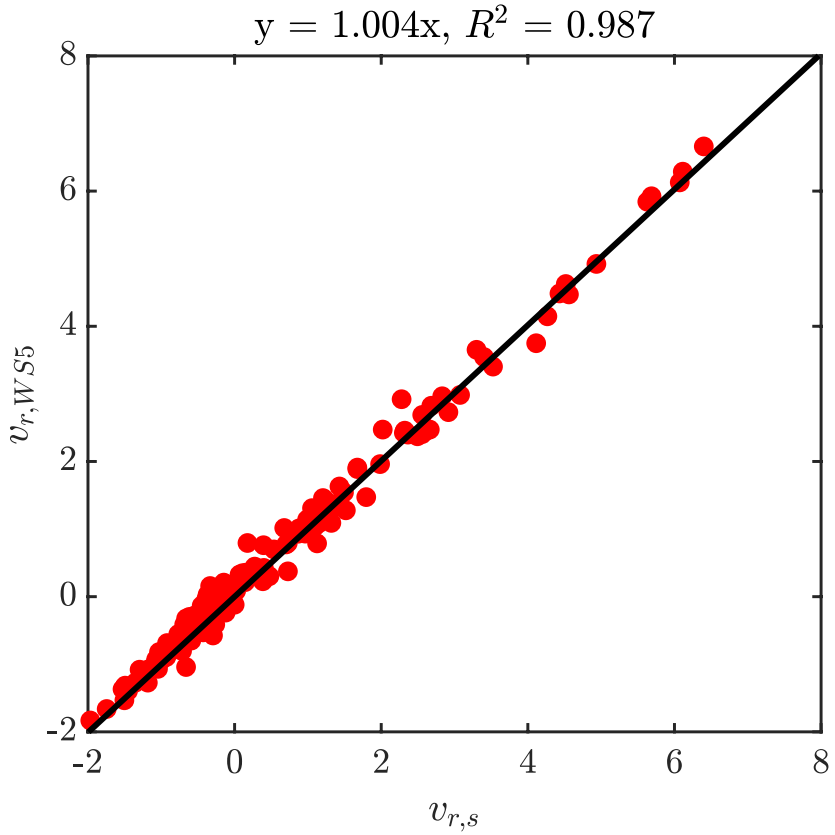
- Unfavorable atmospheric conditions (clouds, fog);
- Limited concurrent data for reconstruction;

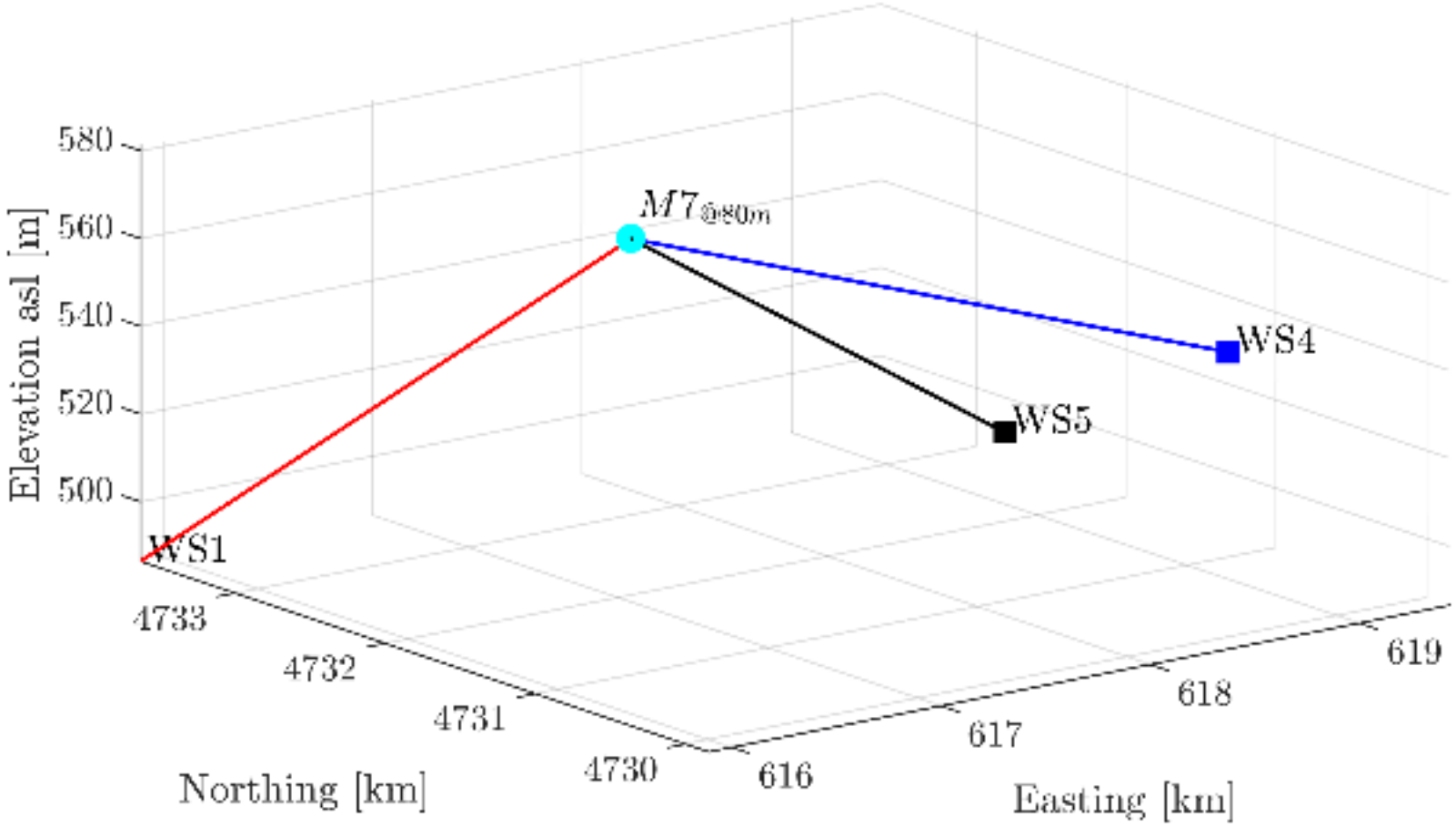


How the WS compare with a sonic?

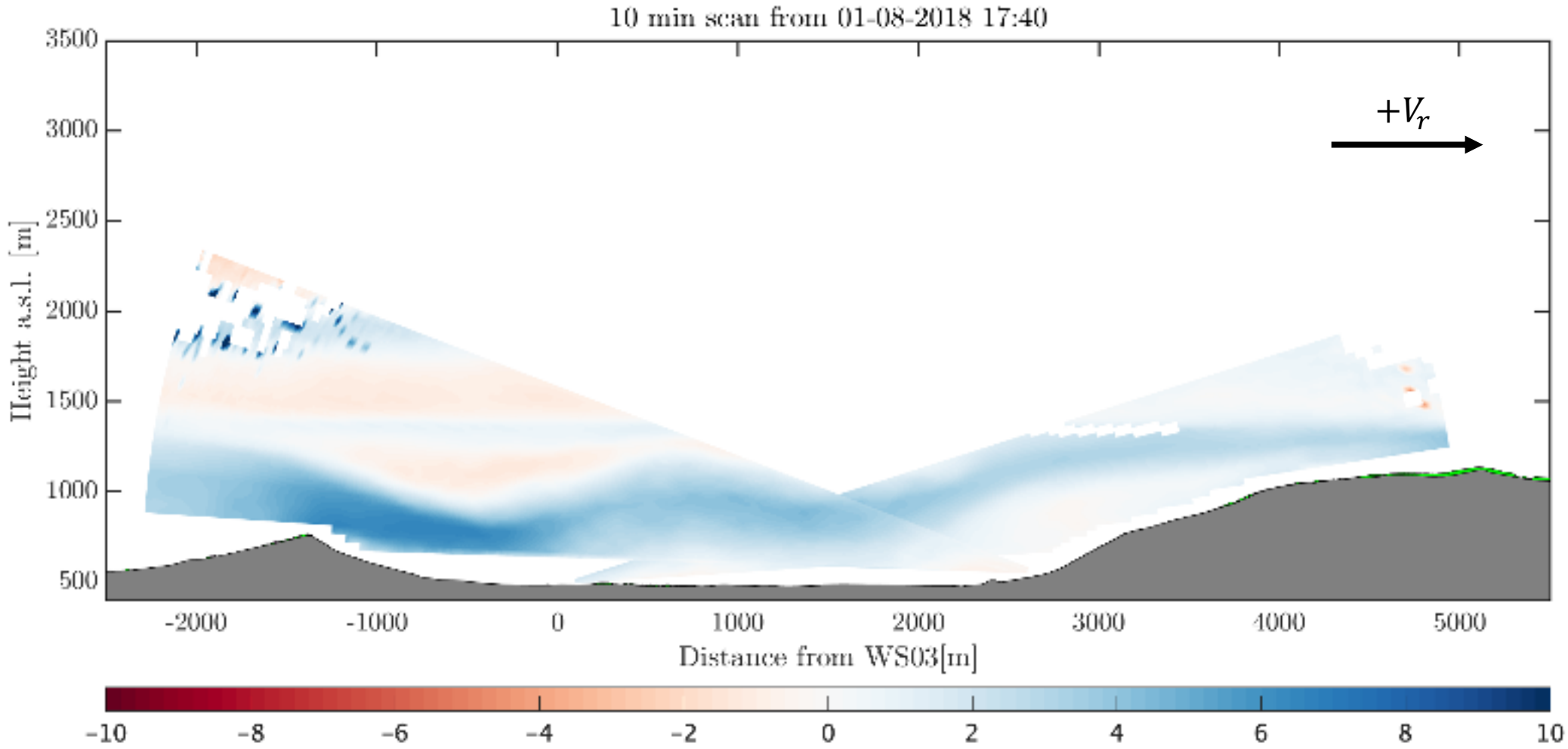
- 3 x Synchronized WS systems staring to 3D sonic;

$$\begin{bmatrix} V_{LoS,1} \\ V_{LoS,2} \\ V_{LoS,3} \end{bmatrix} = \begin{bmatrix} \sin\theta_1\cos\phi_1 & \cos\theta_1\cos\phi_1 & \sin\phi_1 \\ \sin\theta_2\cos\phi_2 & \cos\theta_2\cos\phi_2 & \sin\phi_2 \\ \sin\theta_3\cos\phi_3 & \cos\theta_3\cos\phi_3 & \sin\phi_3 \end{bmatrix} \cdot \begin{bmatrix} u \\ v \\ w \end{bmatrix}$$



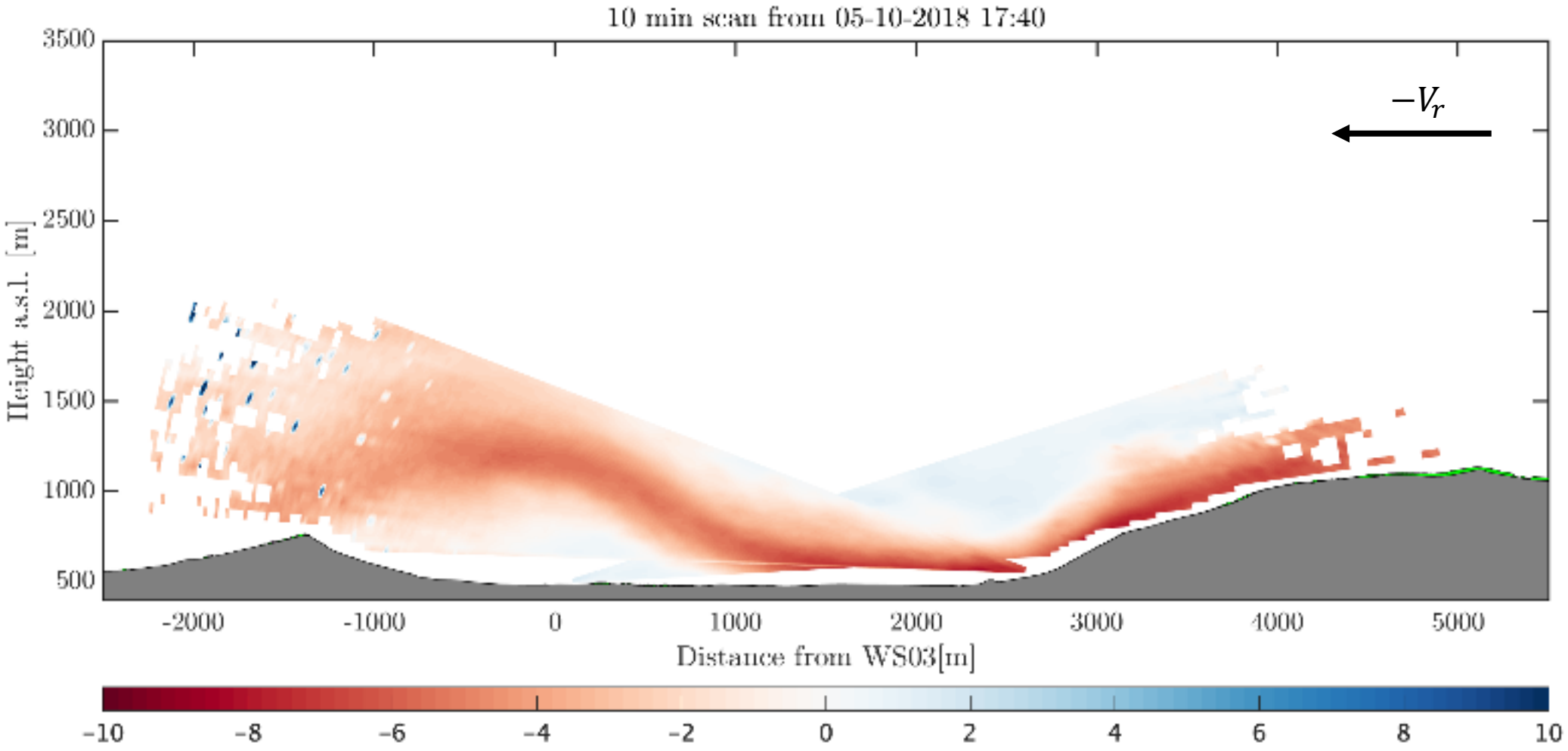


Flow Patterns: Gravity Waves (N-winds)



Radial velocity, V_r $[ms^{-1}]$

Flow Patterns: Hydraulic jump (S-winds)



Radial velocity, V_r $[ms^{-1}]$

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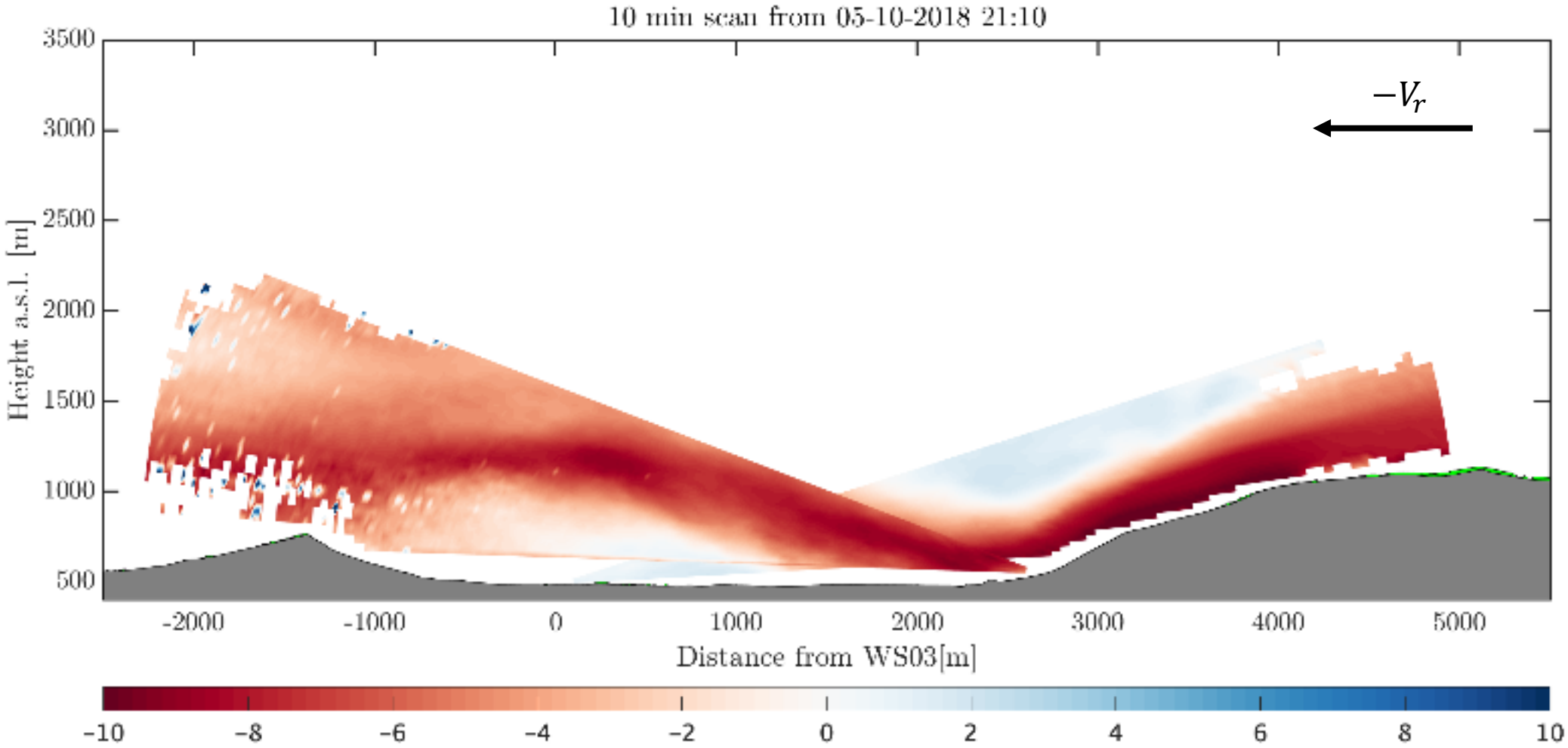
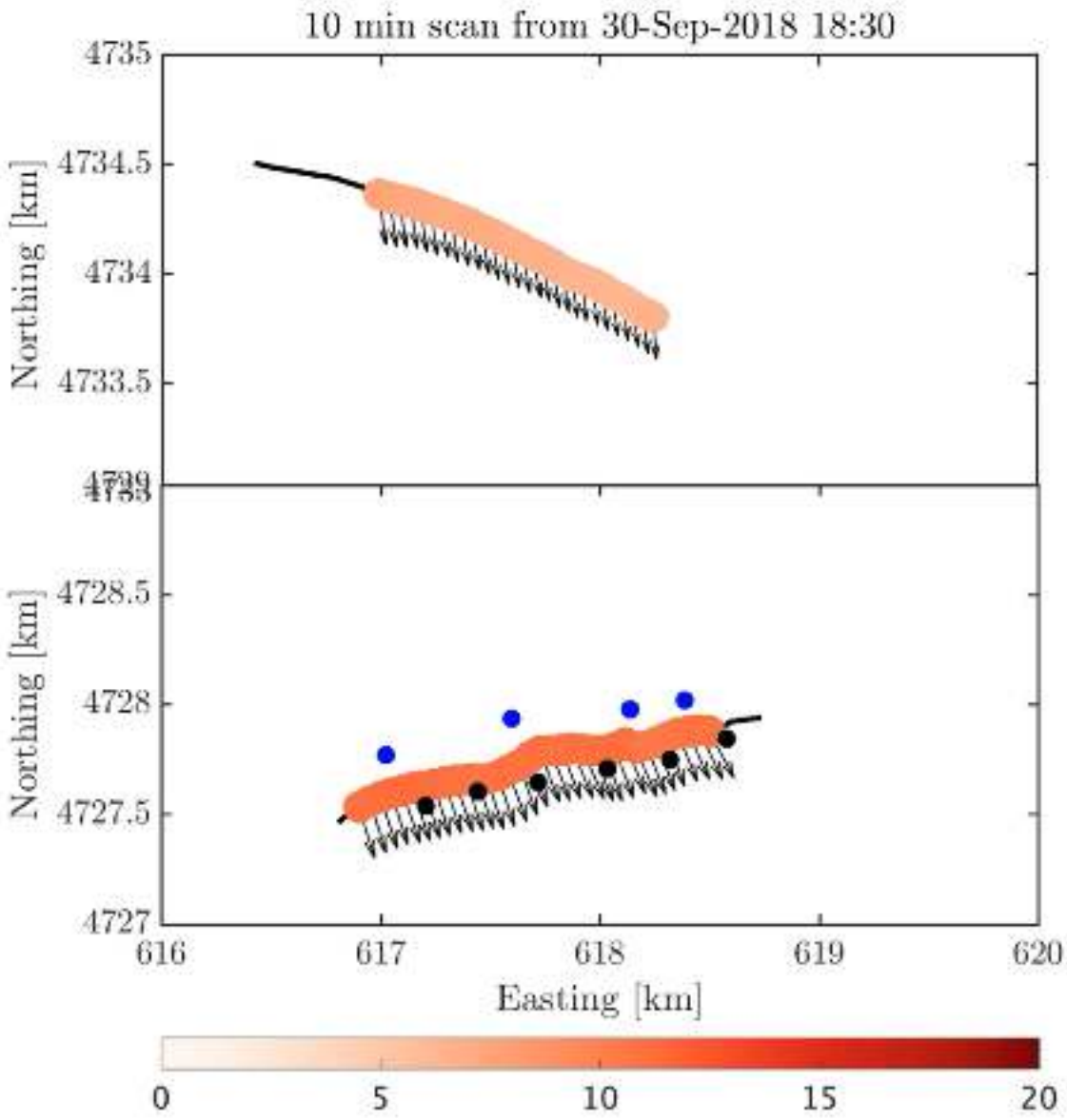


Wind Reconstruction

See the supplementary video

- $\vec{V}_{2D}$ along the plane spanned by two WS systems (elevation angle $\phi \approx 11°$);
- Two selected periods are shown (see video):
- South ridge was compromised by clouds and fog;
- When 3 full months are analyzed (Sep-Nov/2018):

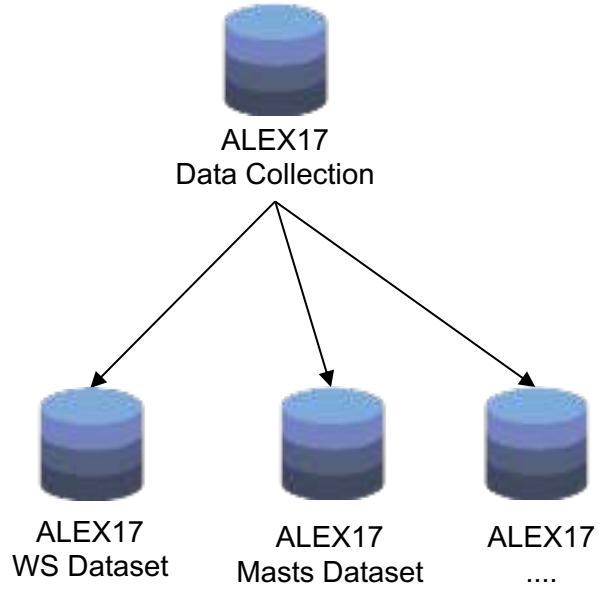
	# 10-min means	$\vec{V}_{2D}$ recovery rate
North Ridge	7741	59,1%
South Ridge	3514	26.8%



Summary & Conclusions

- We present a preliminary analysis of the ALEX17 dataset (see graph);

10.11583/DTU.c.4508597



Multi-lidar campaign

- ALEX17 pushed the WS systems to its limits;
- Challenges which hinder higher data availability have to be tackled;

Resource assessment with scanning lidars

- Next step: build significant statistics from measurements (impact on AEP);
- Analyze higher-order moments (i.e. variance) from this setup;

Flow patterns and wind reconstruction

- We visualized gravity waves (from N) and hydraulic jumps (from S);
- Scanning lidars shown as tool to extend (vertically and horizontally) a reference mast;
- $\vec{V}_{2D}$ as well as radial velocities, V_r, will be compared with microscale models in upcoming Benchmark;

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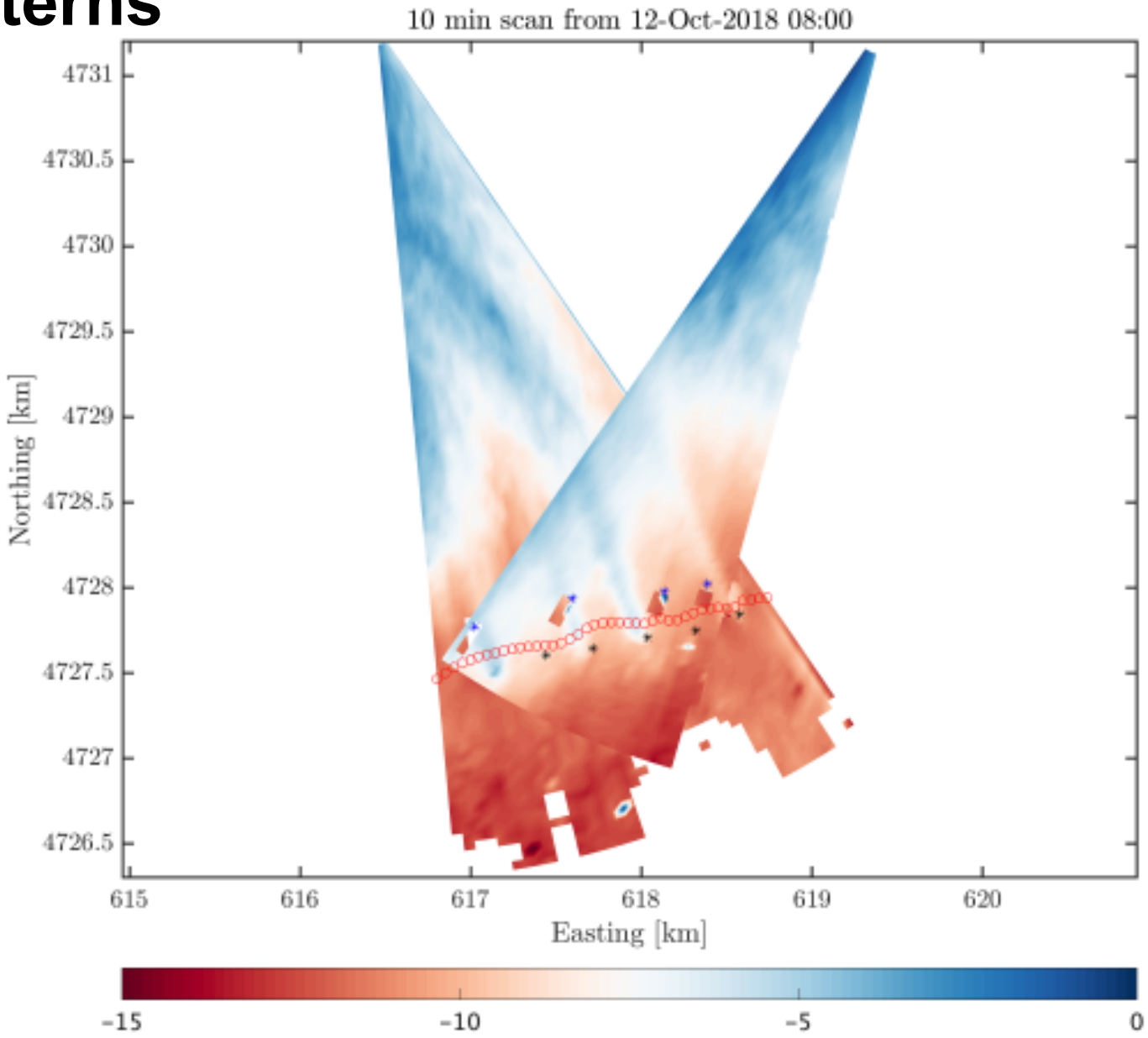
The Alaiz Experiment:

Flow patterns in a large-scale and complex topography

Backup slides

Flow Patterns



SANTOS, P. (2019)