MARBLL

MARs Boundary Layer Lidar

THE ANSWER
MY FRIEND
IS BLOWIN'
IN THE WIND

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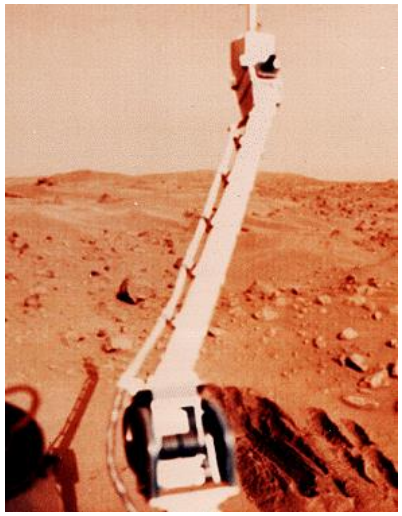
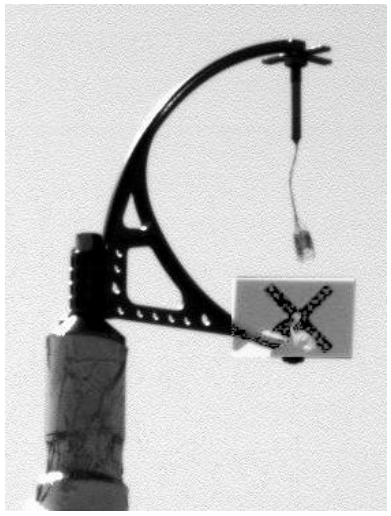
C. Flamant, A. Spiga, A. Määttanen, Chris Howe, G. Déprez, T. Bertrand, L. Kerber, S. Maurice, M. Kahre,

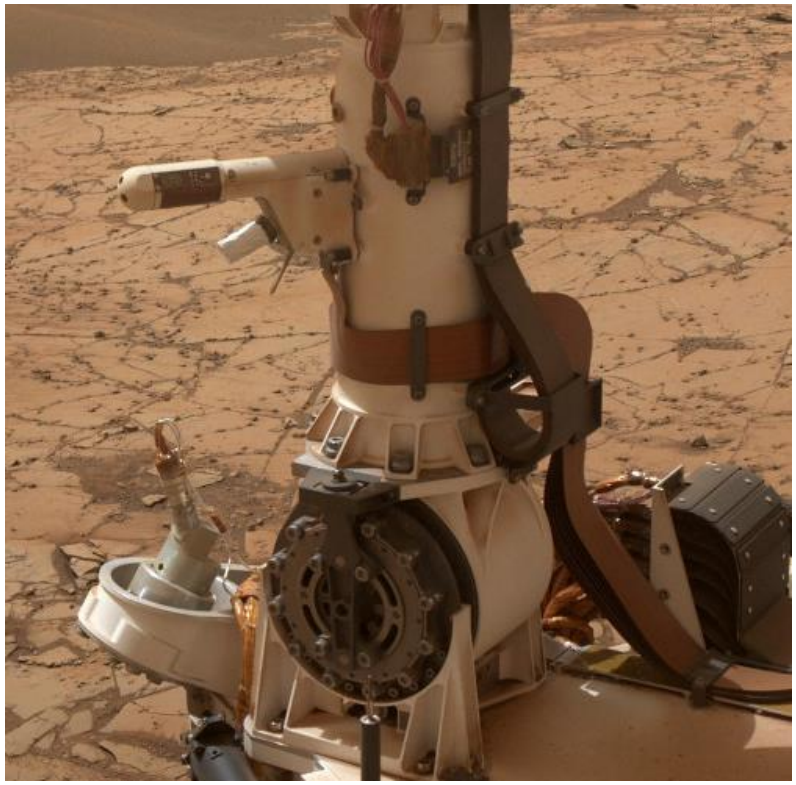
Problem:
Measure winds on Mars

- Lander anemometers
- Even networks remain at the surface





- Difficult mesospheric wind measurements by Earth-based heterodyne spectroscopy (mm + IR)

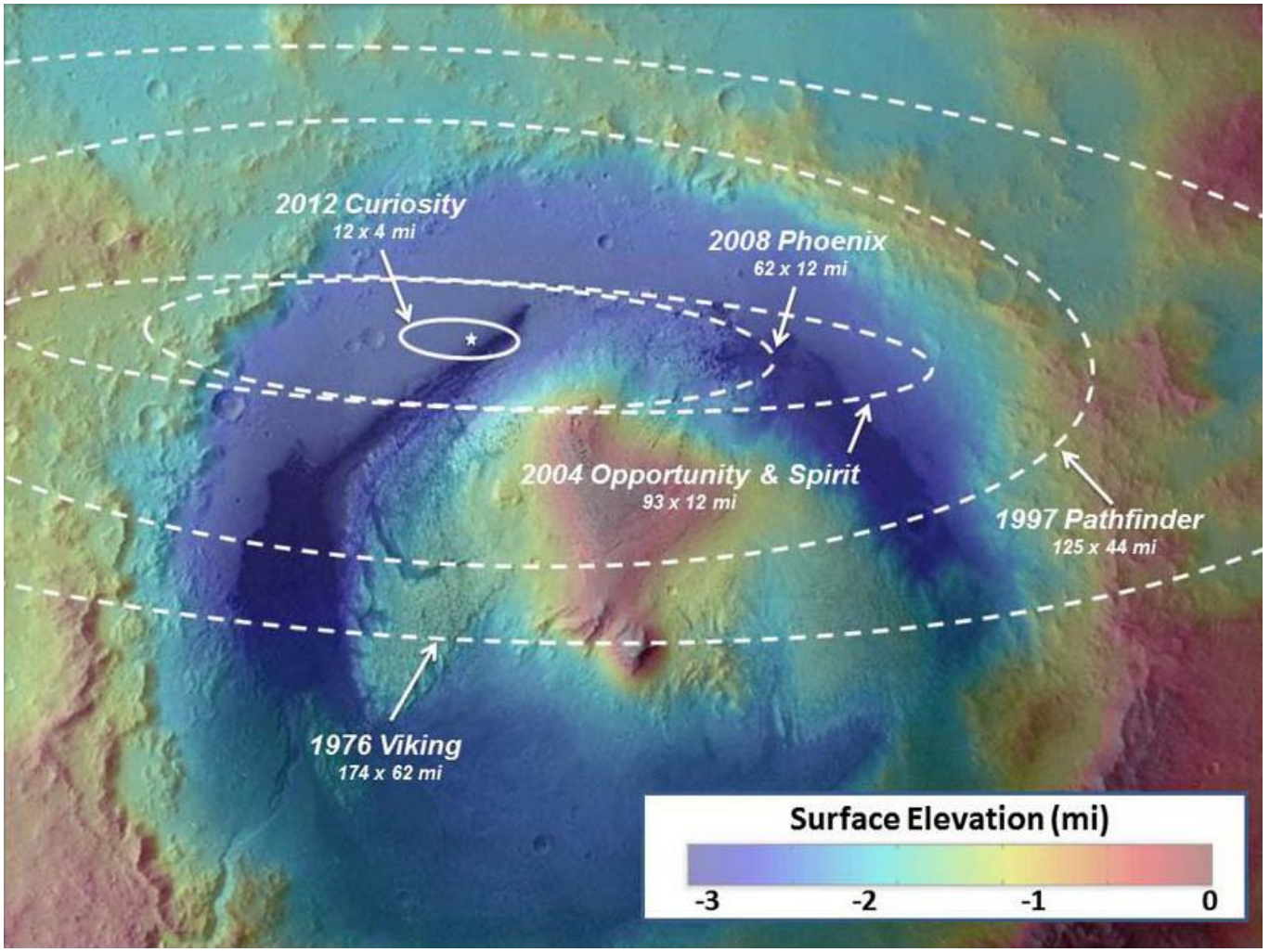


- Low pressure > ~~baloons~~

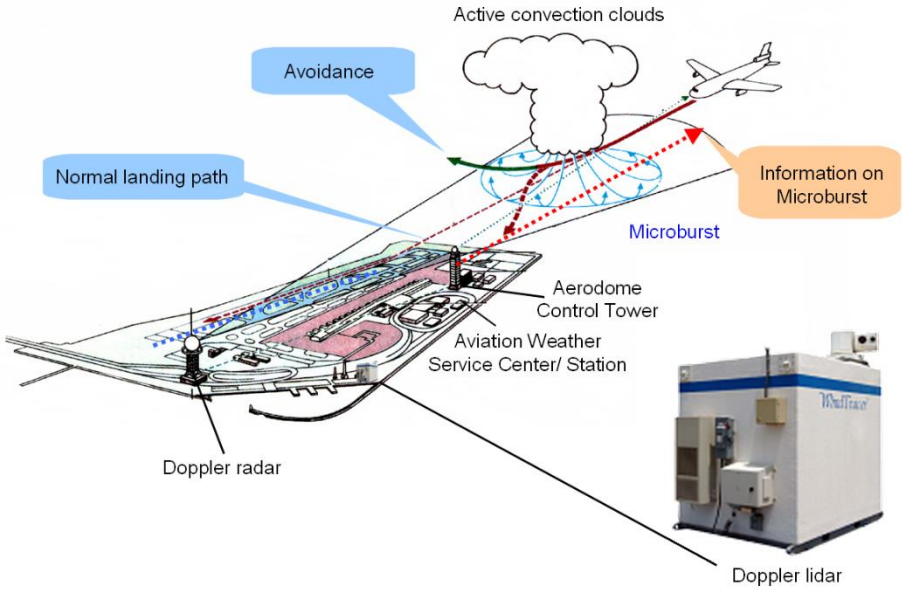
- **Knowledge** = model **predictions**
  but models remain **to be validated**

Key motivation: mission design EDL

- **Horizontal** wind
- **Updrafts** and **downdrafts** in the planetary boundary layer

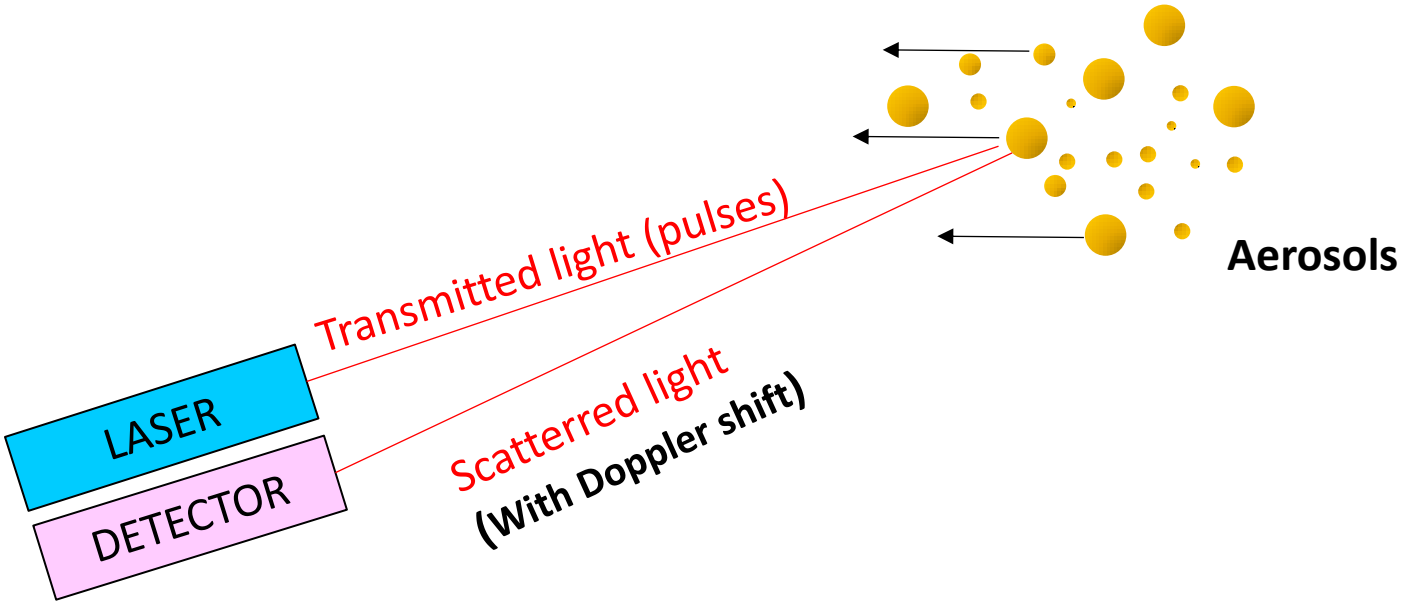


A solution: doppler wind LIDAR



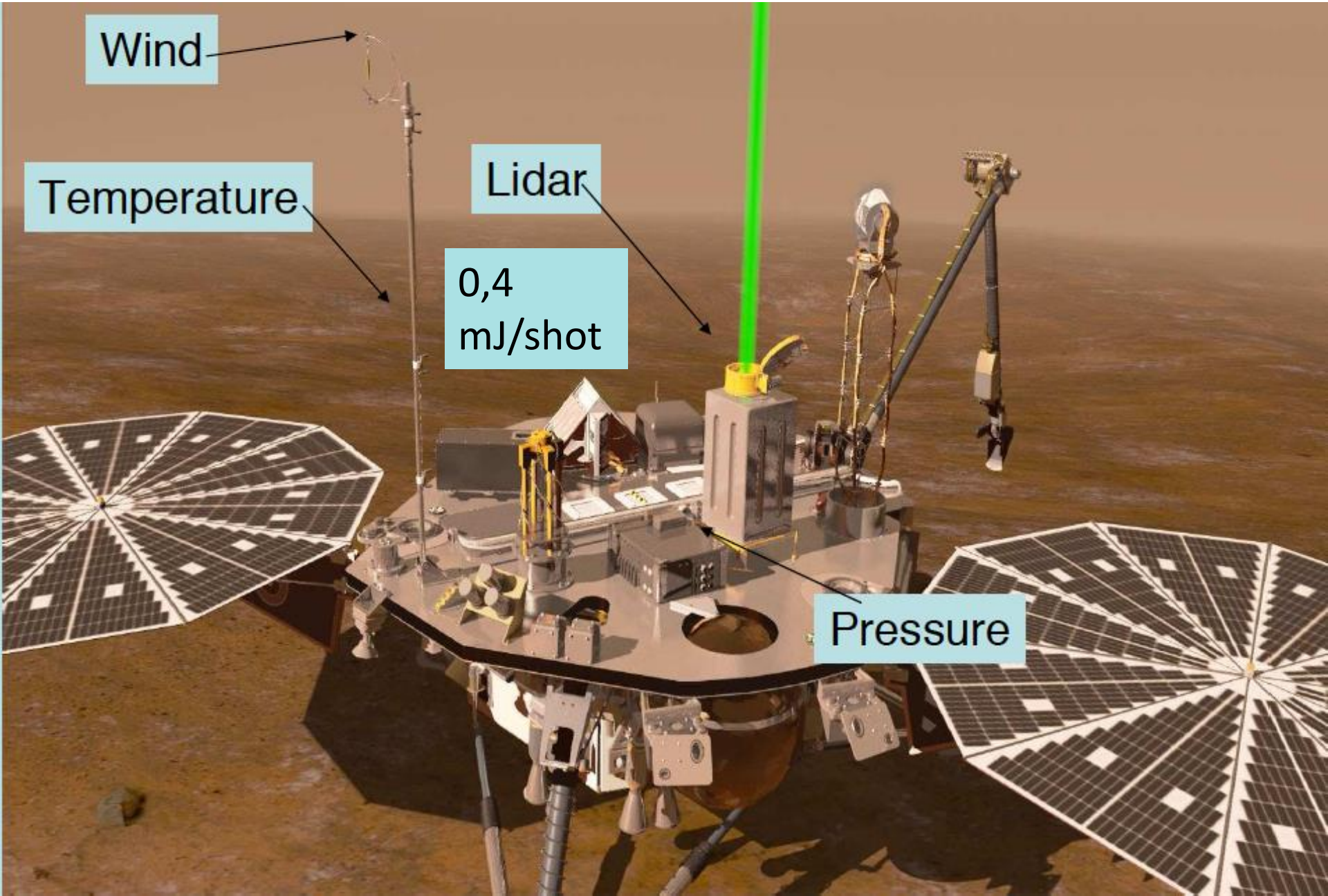
- On Earth: LIDAR used routinely and available as commercial products
  - to monitor wind shear and turbulence above airports and in the wind farms industry.
- On Mars: easier than on Earth!
  - Ubiquitous dust particles which are highly reflective
  - Negligible scaterring by the atmopsheric gas

Doppler LIDAR principle



- Speed aerosols = wind speed
- Doppler shift > wind speed along the **line of sight**

LIDARS already used on Mars



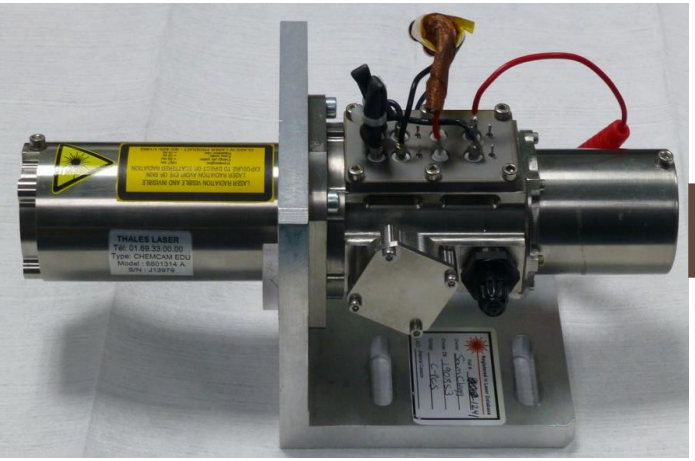
Re-use the ChemCam LASER

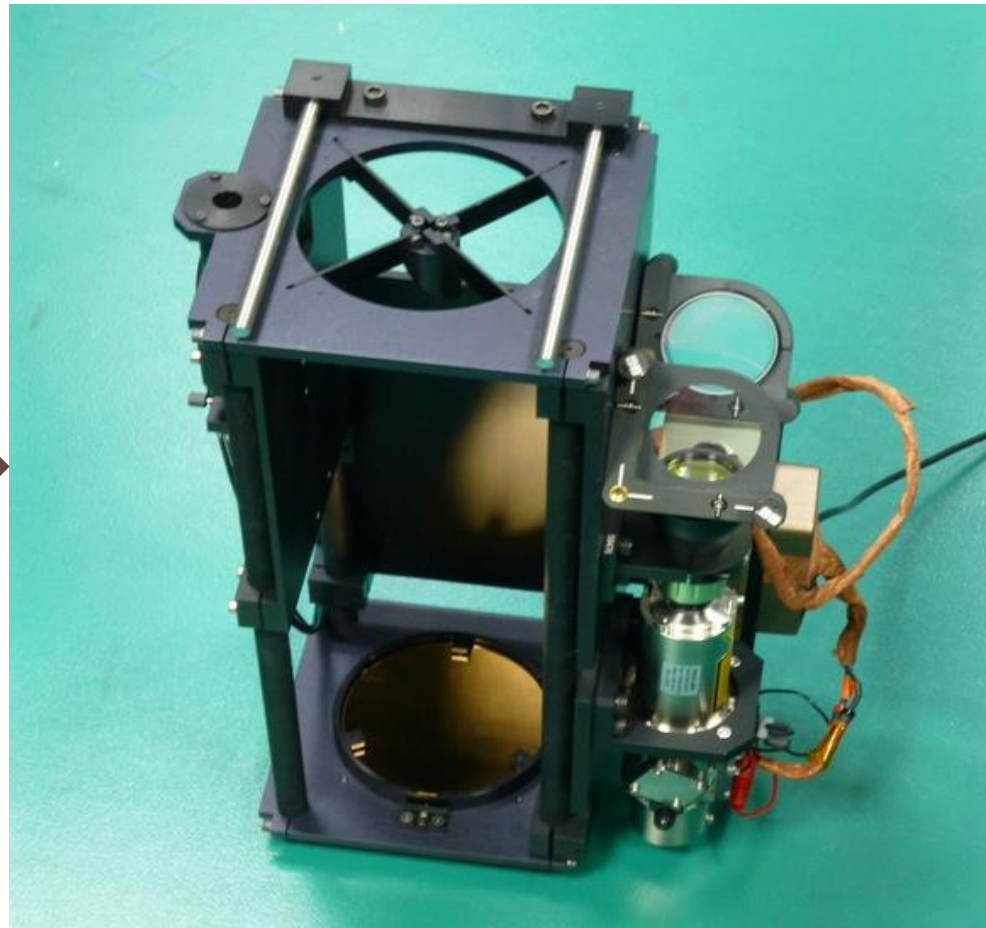
- Made by Thales Toulouse

Prototype of the MARs Boundary Layer Lidar (MARBLL)

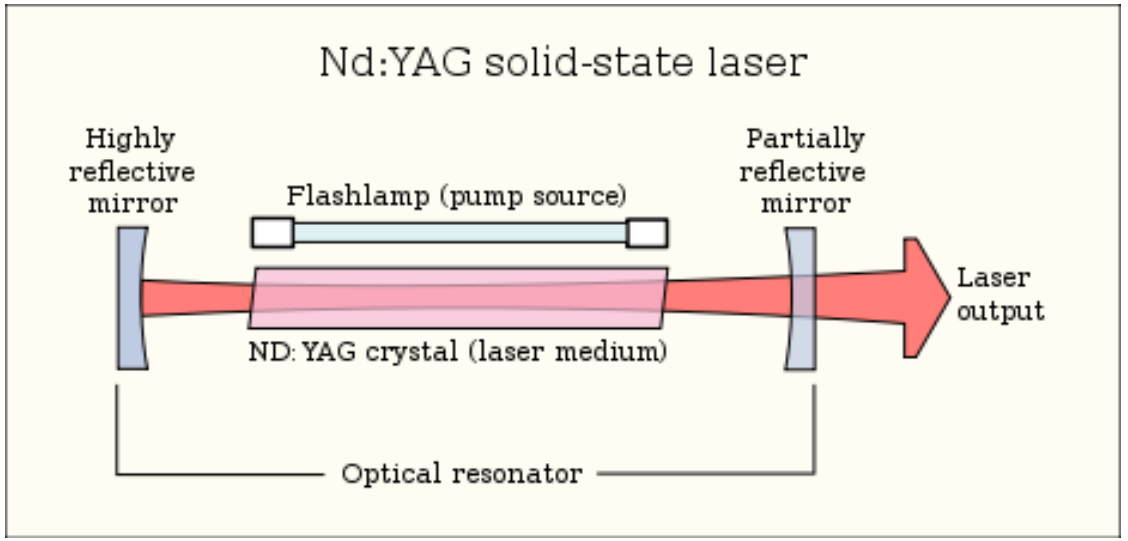
MARBLL

MARs Boundary Layer Lidar



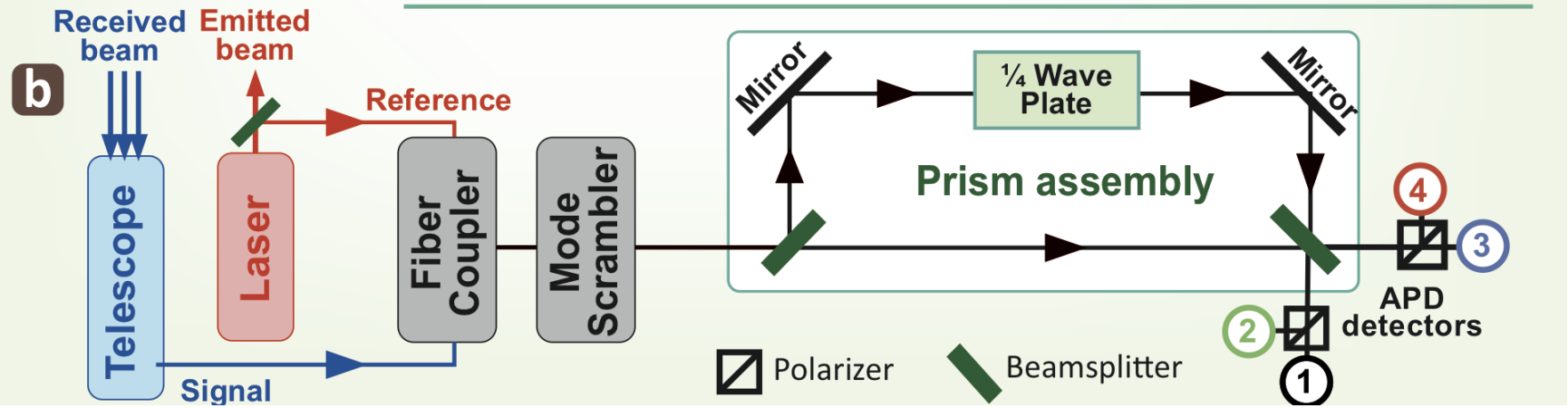


Problem: Frequency stable ?

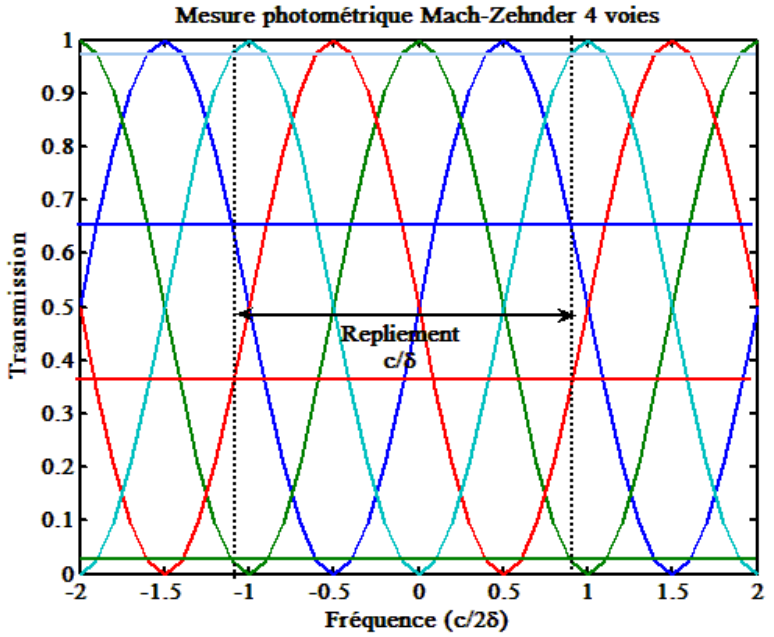


- Temperature variations
- Pressure variations
- Shocks

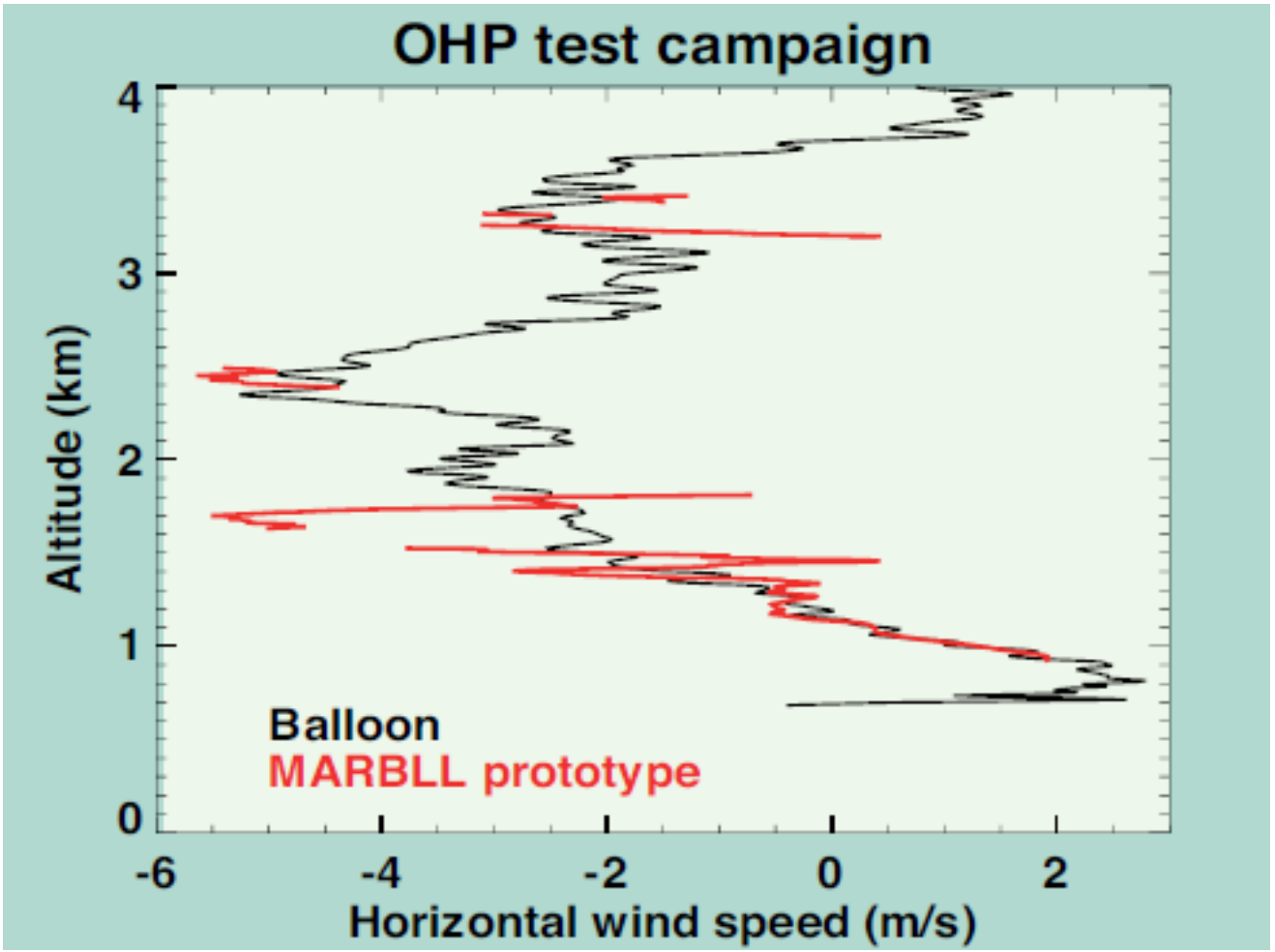
The solution: Mach-Zender interferometer



- Two-wave interference
  - 4 channels in phase quadrature to maximize Dynamic range (+/- 272 m/s)
- Differential measurement between received and emitted laser beams
- Little to no temperature/vibrations influence

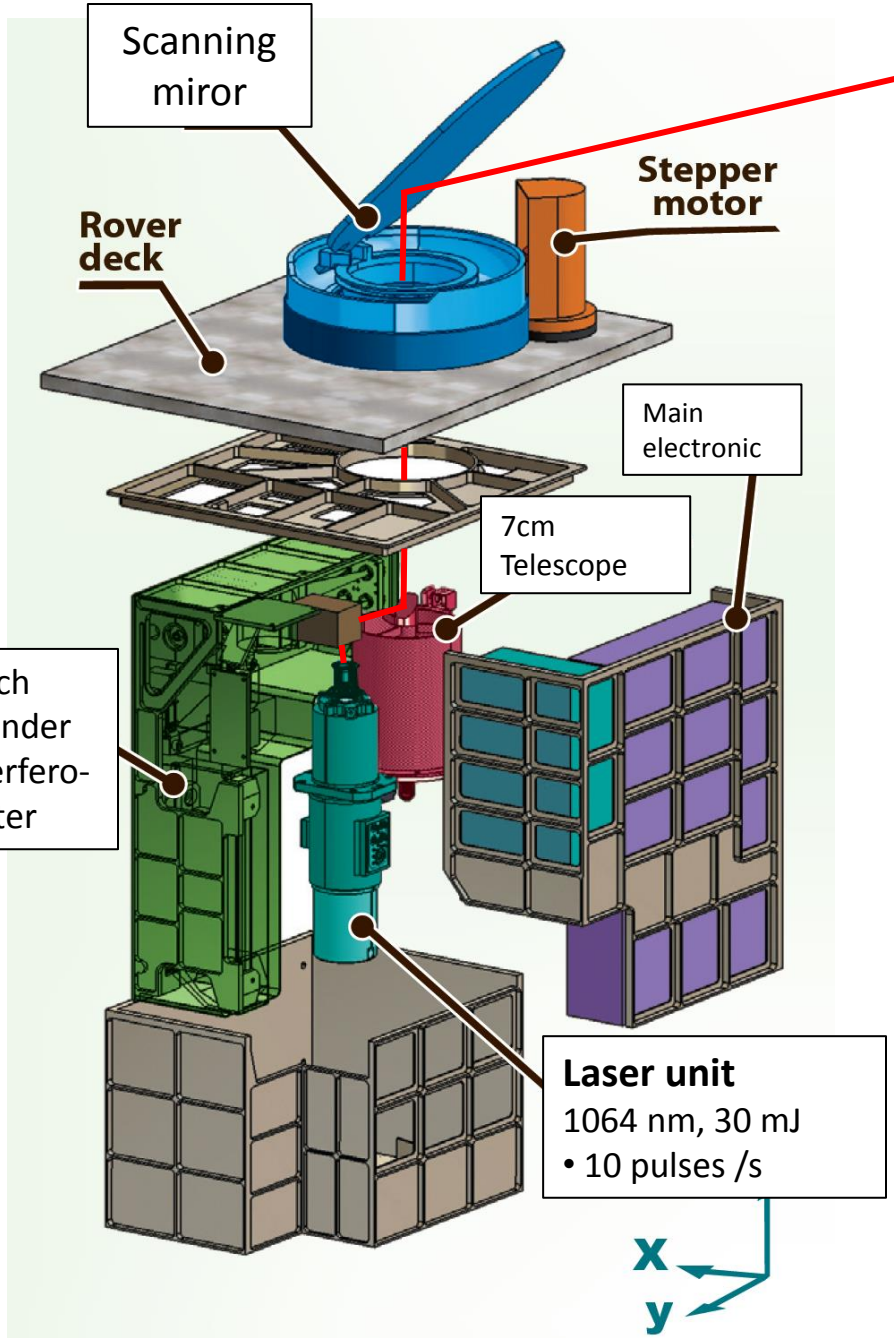


MARBLL prototype test campaign



MARBLL prototype measurements made at 45° elevation angle and compared with balloon radio soundings performed at the same time (*Bruneau et al. 2013*)

MARBLL for MSL 2020



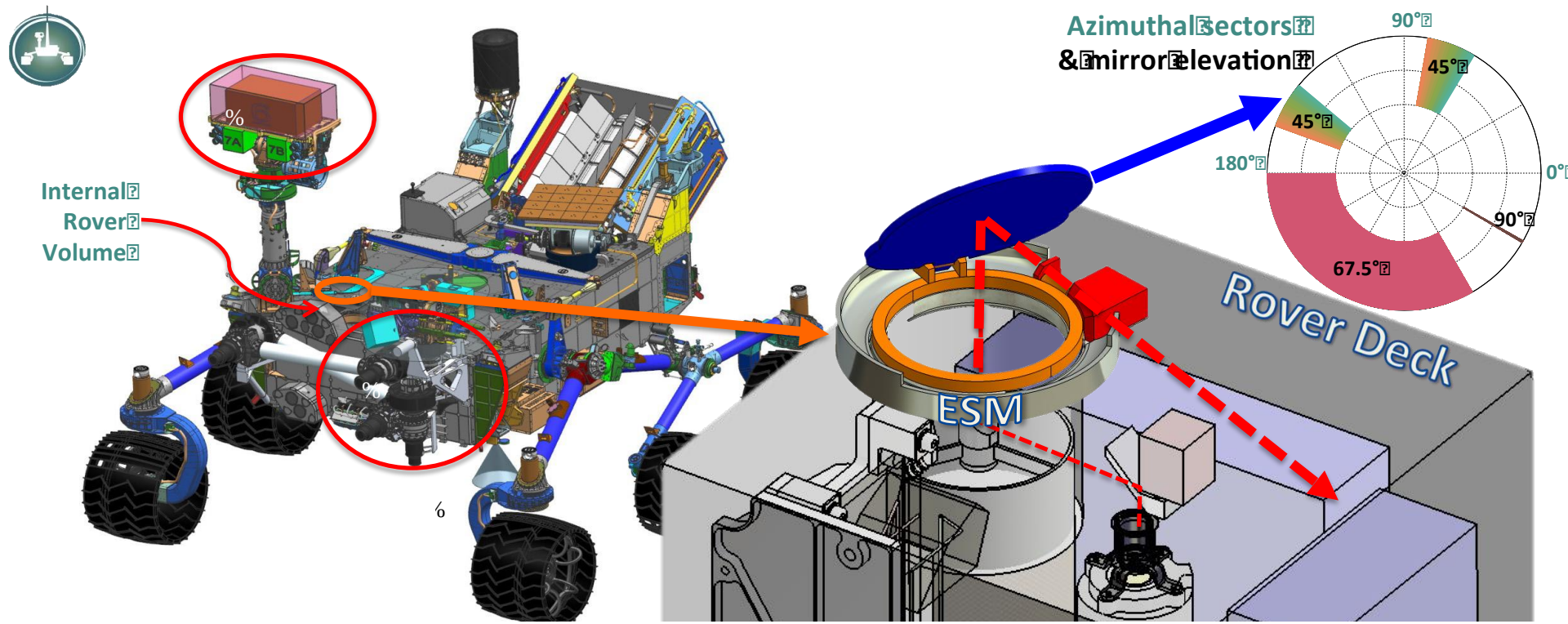
MARBLL Instrument

(exploded view)

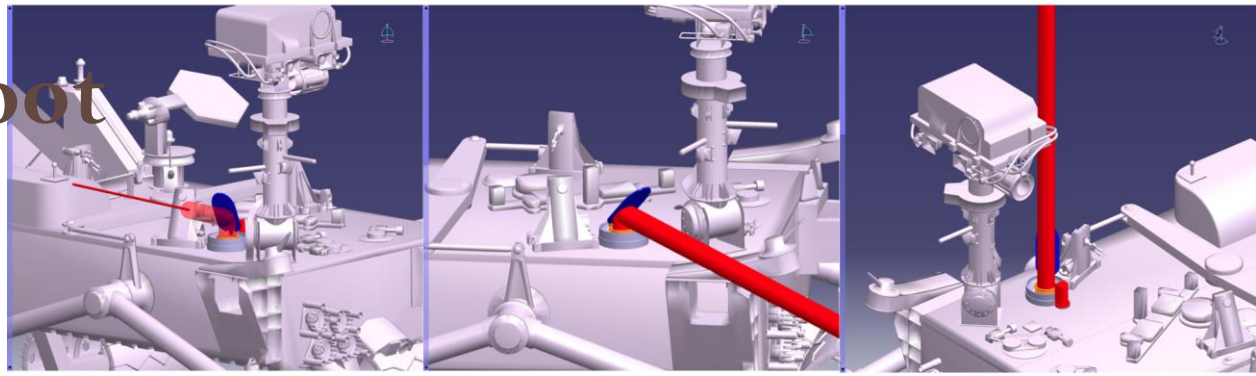
proposed for Mars 2020 rover

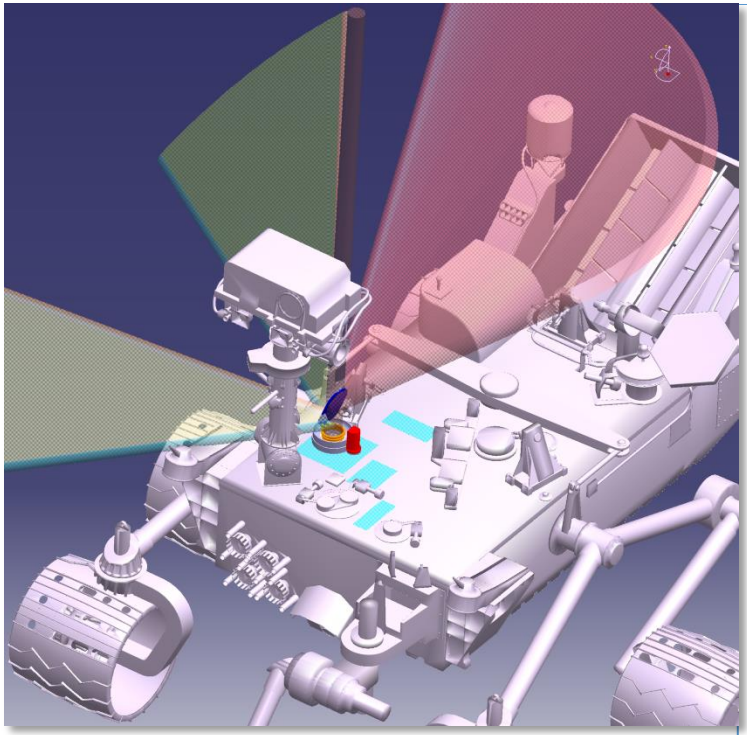
RESOURCE	CURRENT BEST ESTIMATE	CONTINGENCY	TOTAL
Mass (kg)	5.95	25%	7.44
Power (W)	30	25%	38
RAMP Volume (cm3)	12 190	25%	15 238
Data (Mbit/sol)	26	10%	29

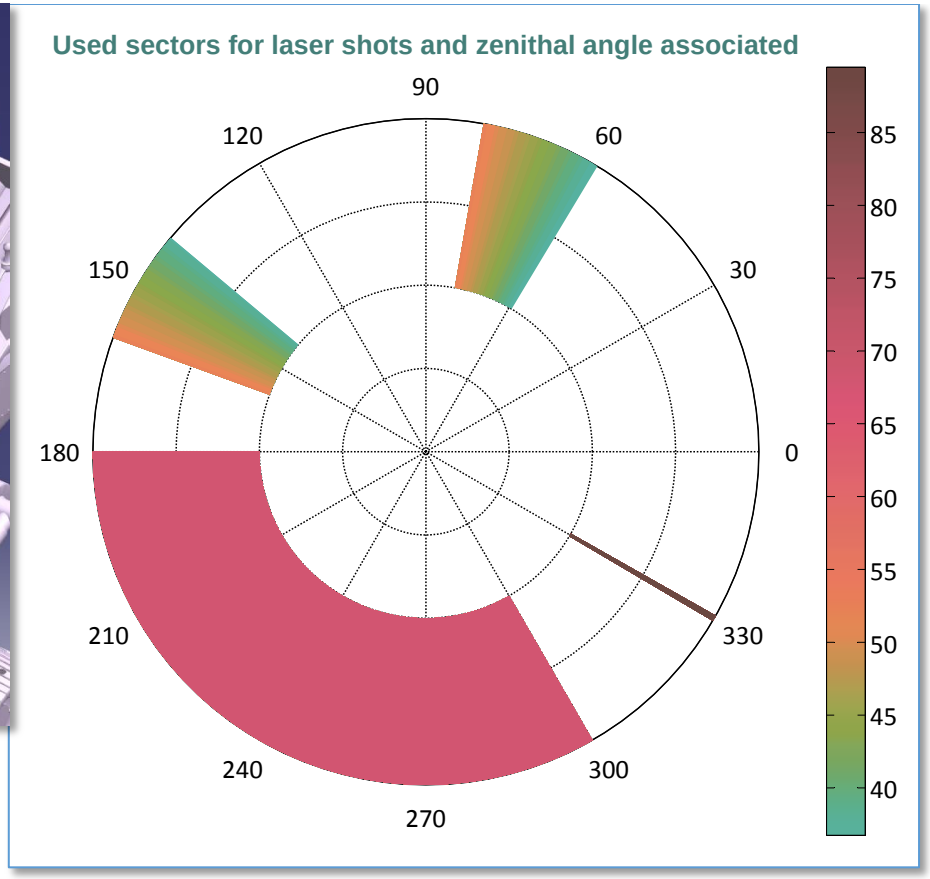
Accomodation



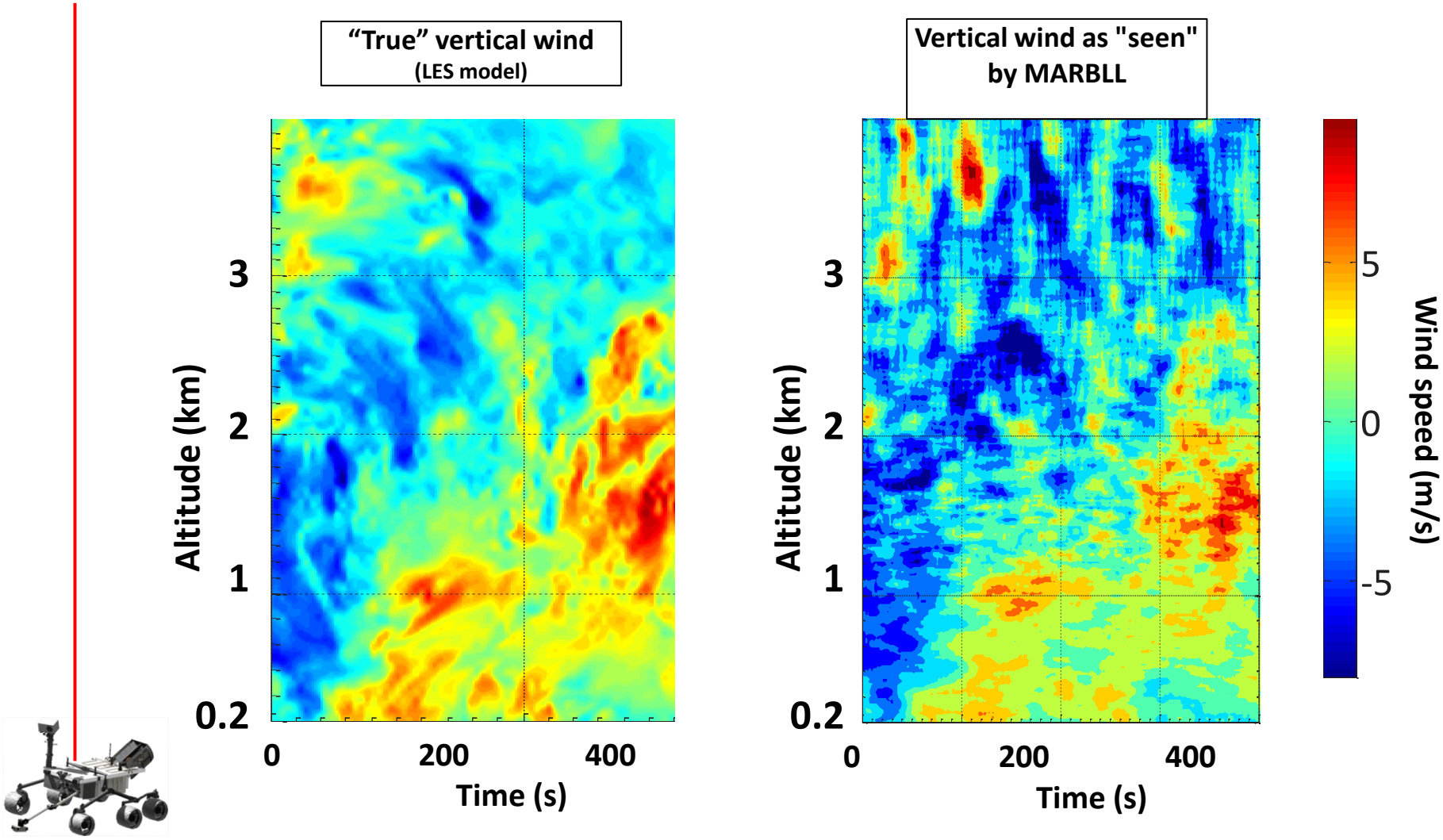
Field of view
And field of shoot



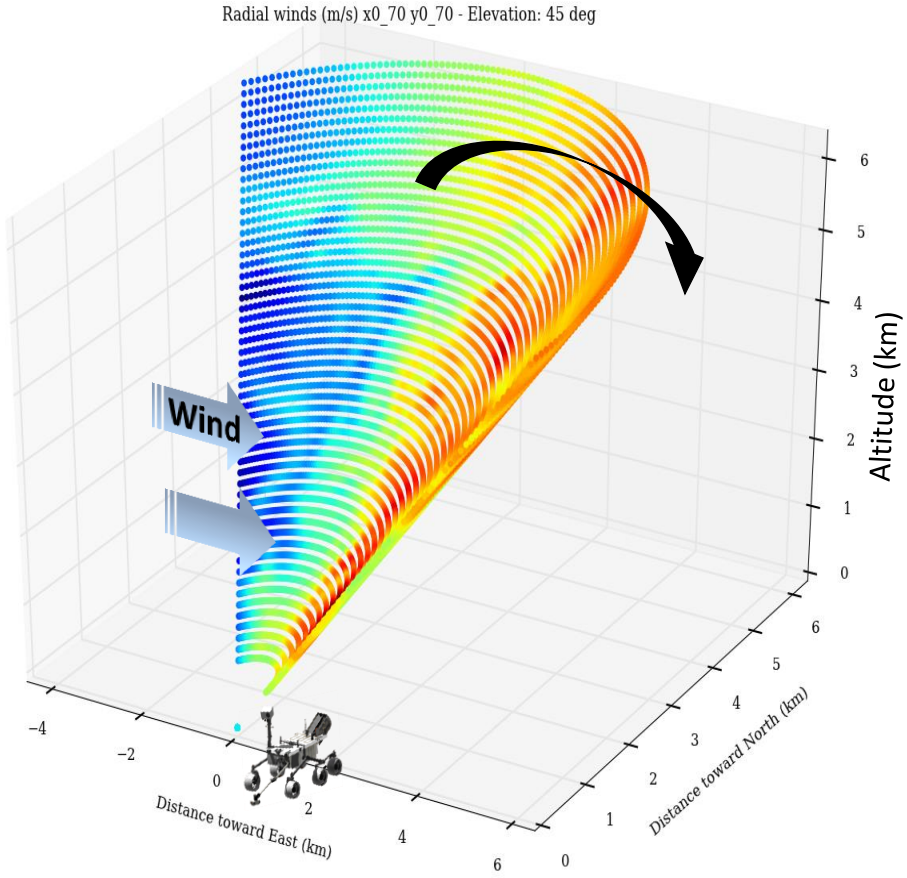


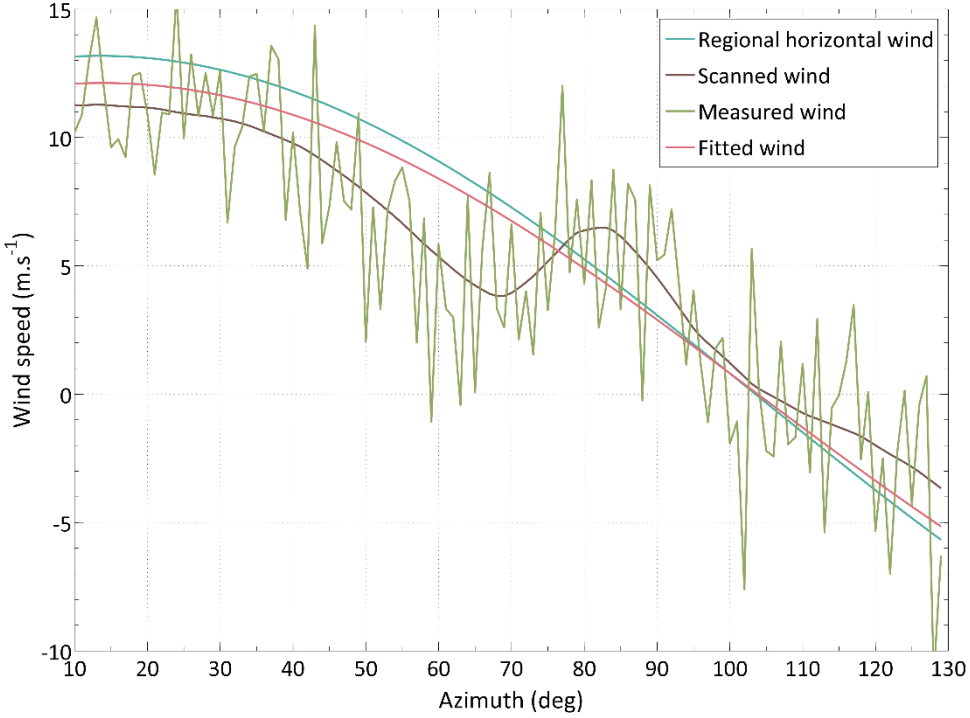


MODE #1: Vertical shoot
Convective Vertical wind "images"



MODE #2: Conical scan
Measuring the mean horizontal wind





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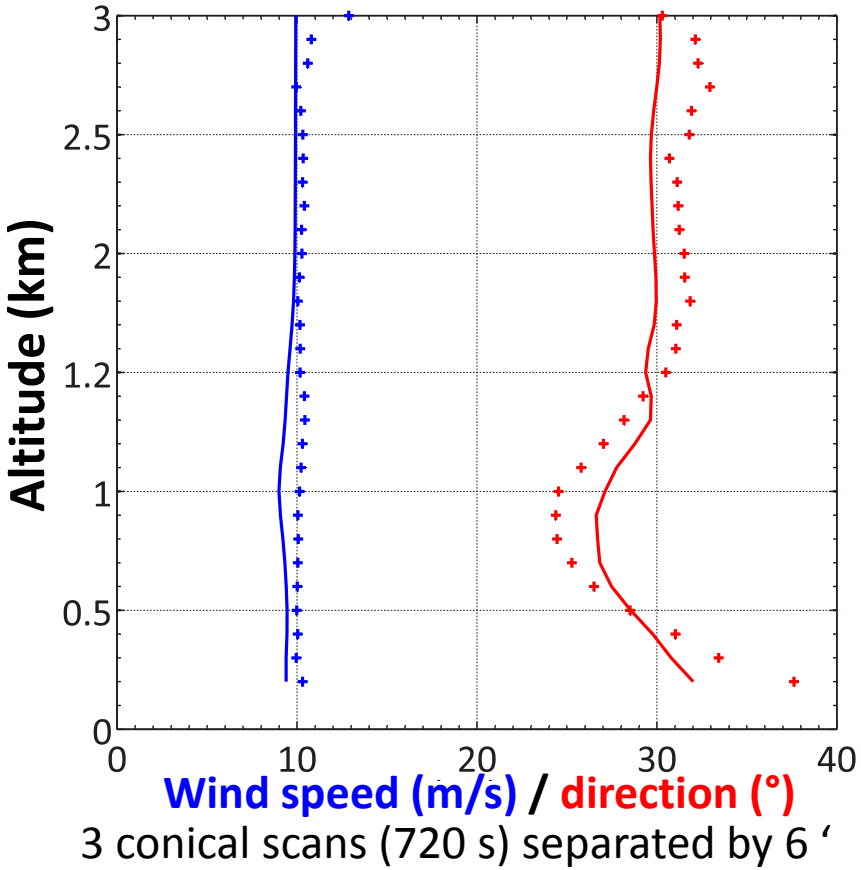
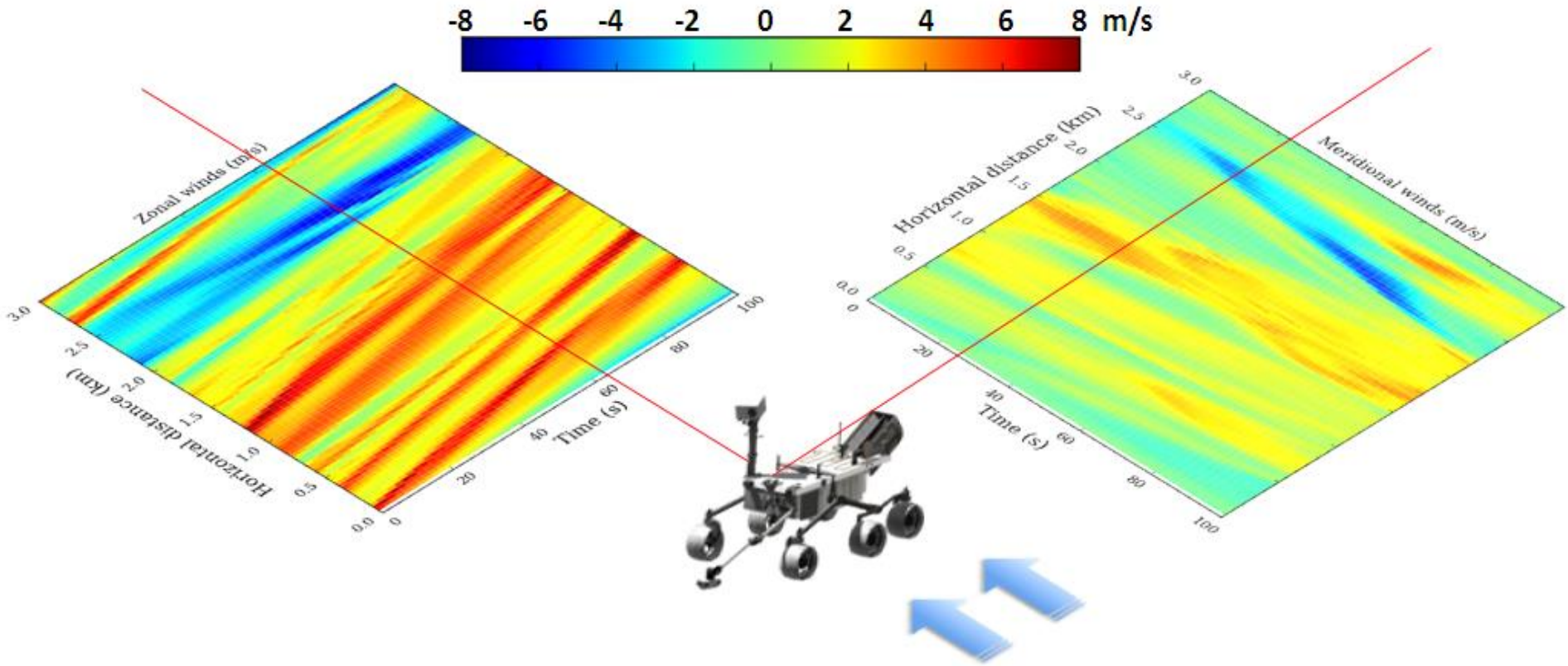


3 conical scans (720 s) separated by 6 ‘

MODE #3: Low elevation souding at 5° elevation

Snapshots" of surface wind gust

2 pm / worst convective case



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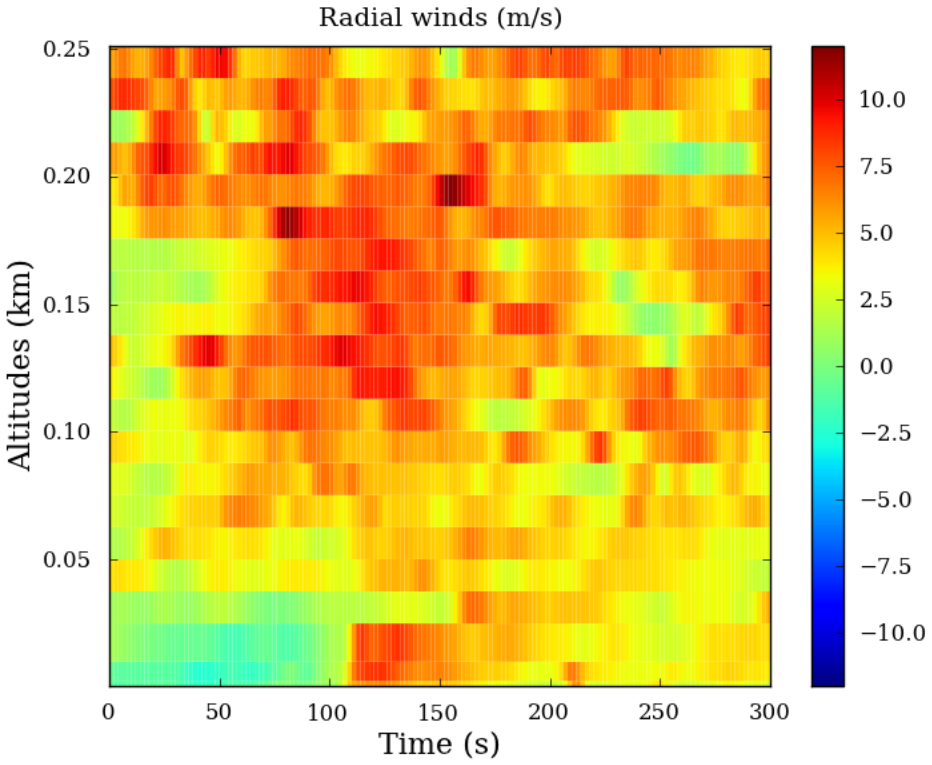
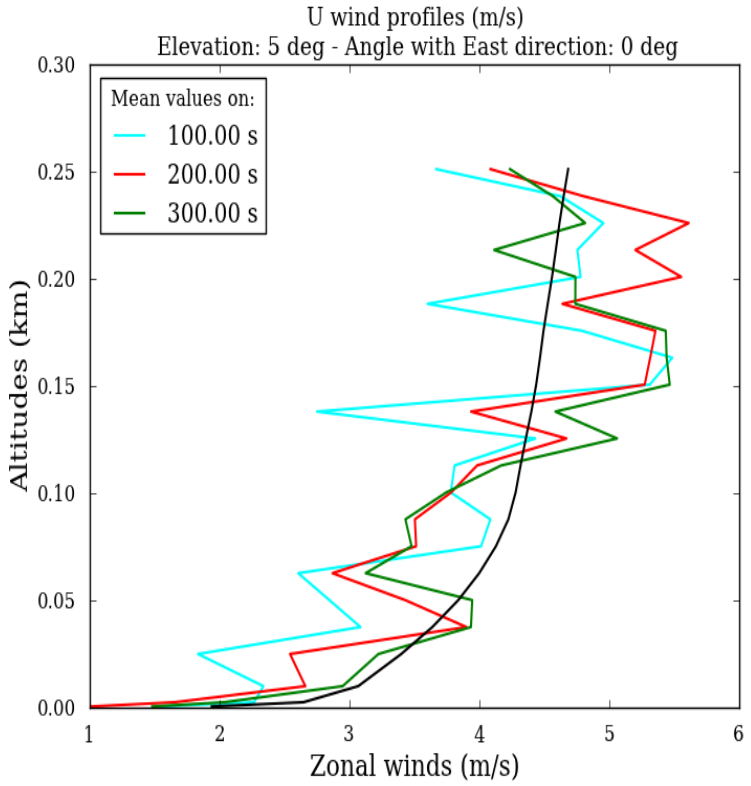
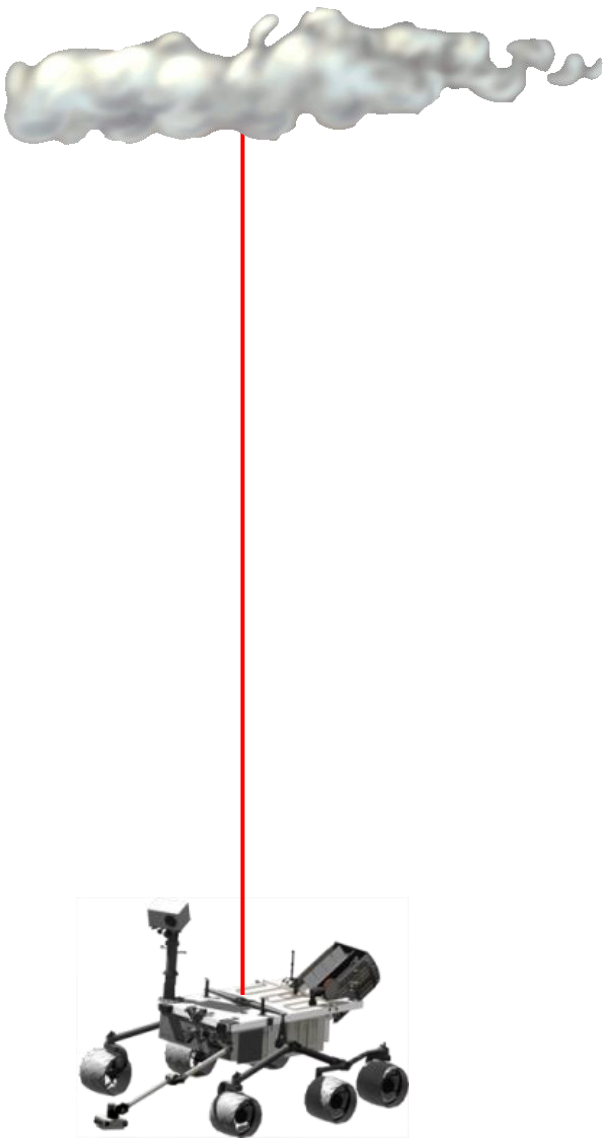
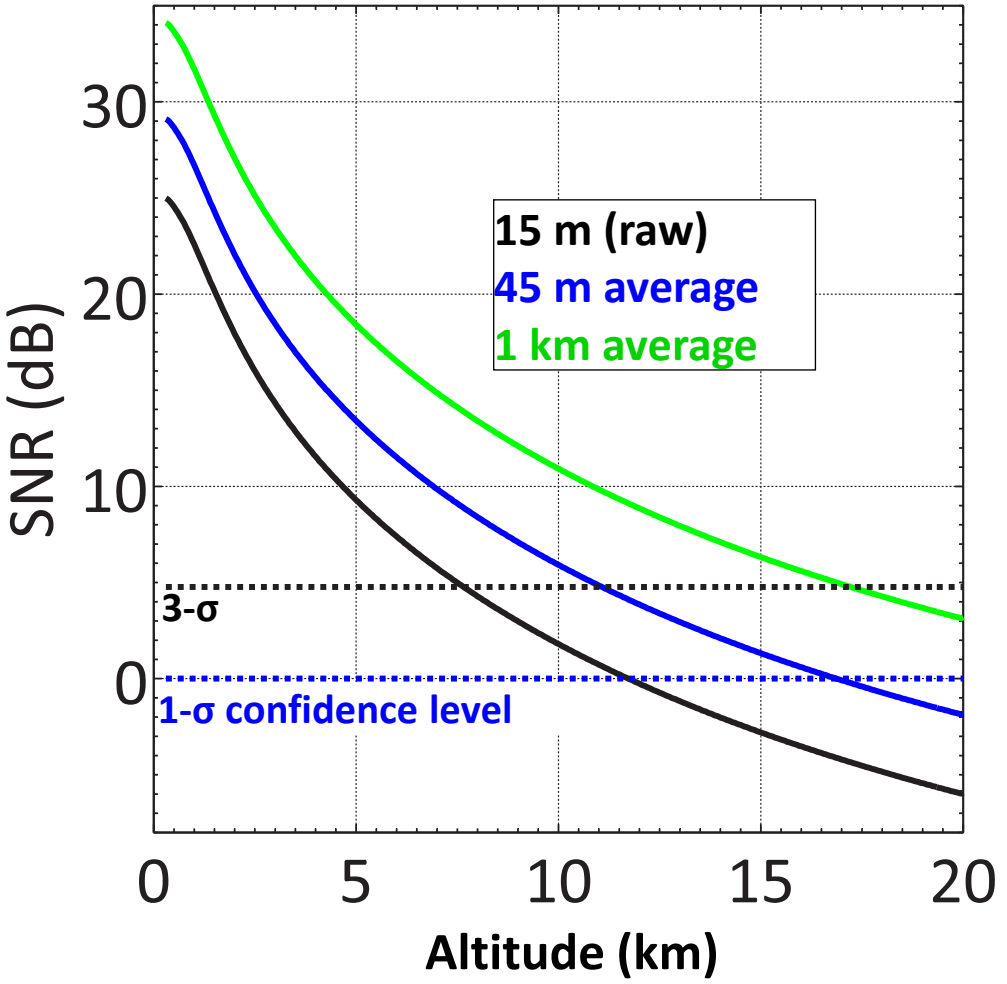




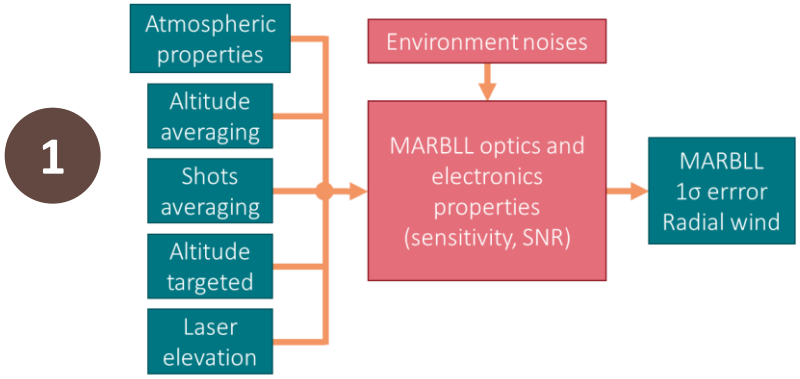
MODE #4: Classical LIDAR operation

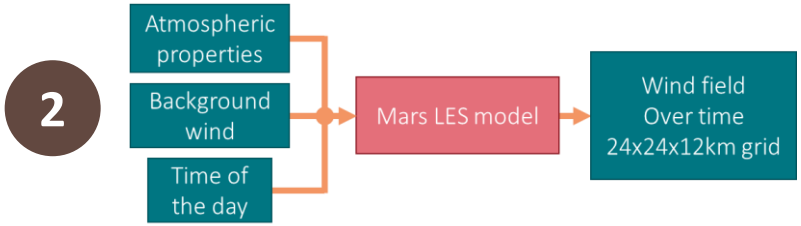


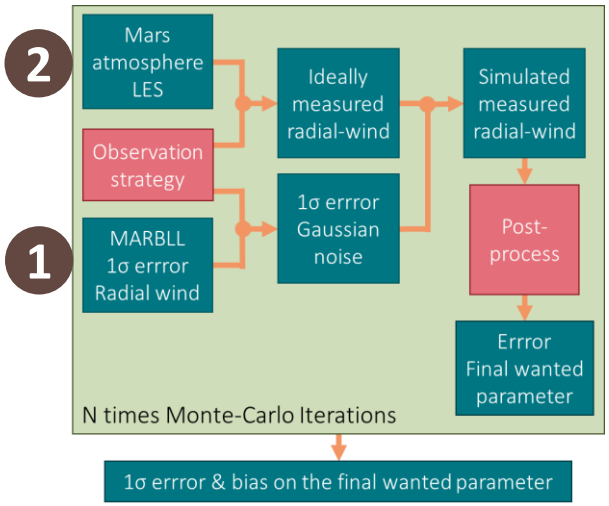
Cloud detection (1000 shots ~100 s integration)

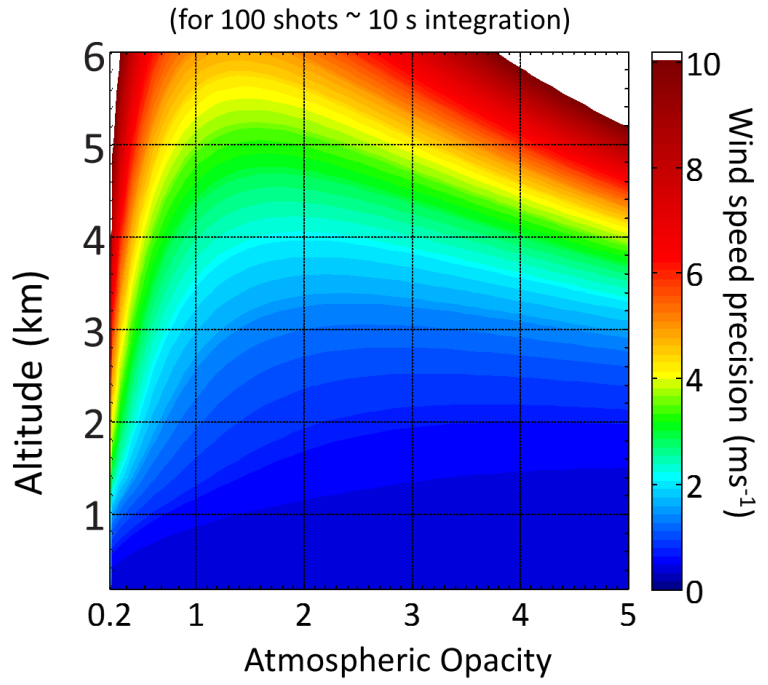


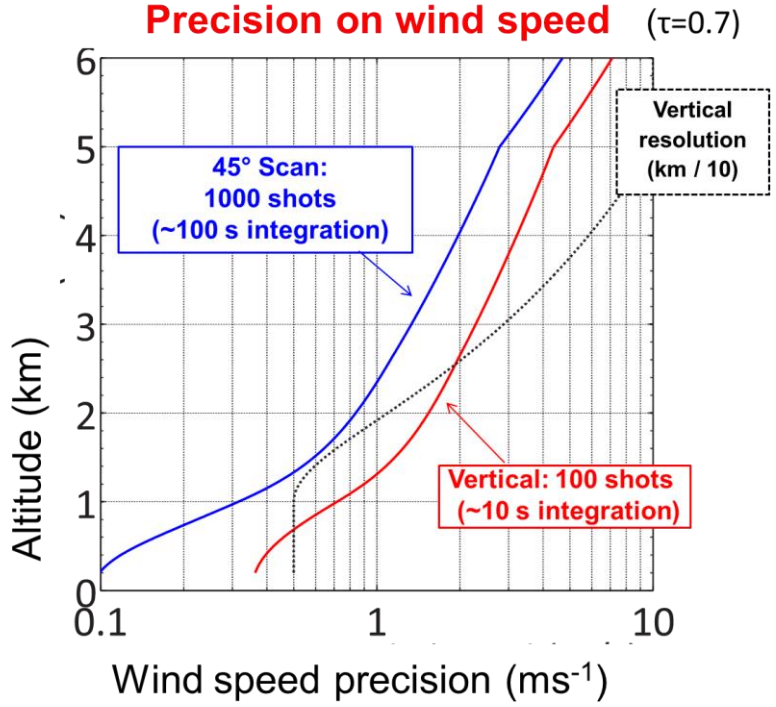
Performance simulation





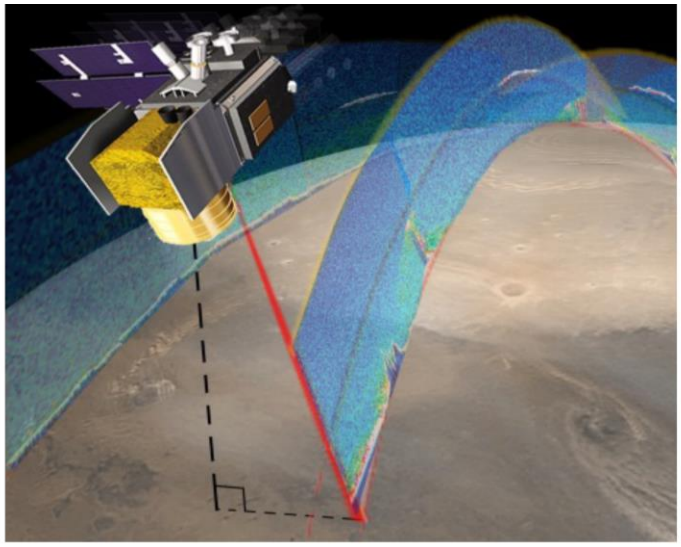


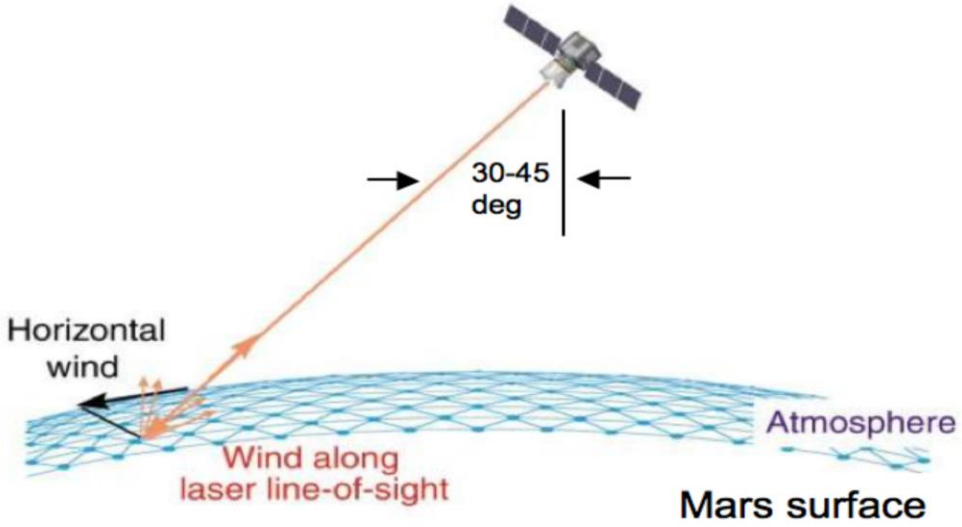




A large scientific community

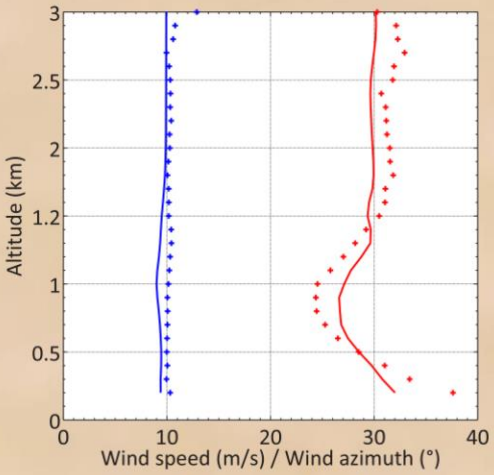
Other solution ?





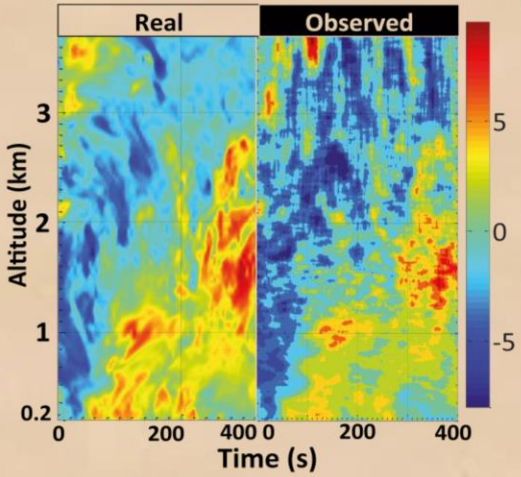
- From the orbit: MARLI

WINDS

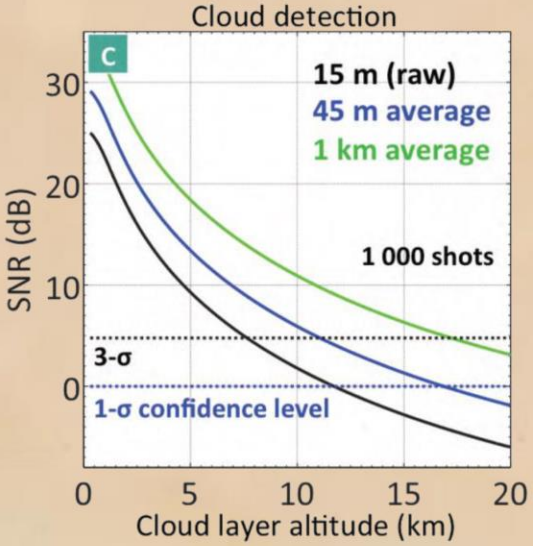


Horizontal winds profiles !

Aerosols

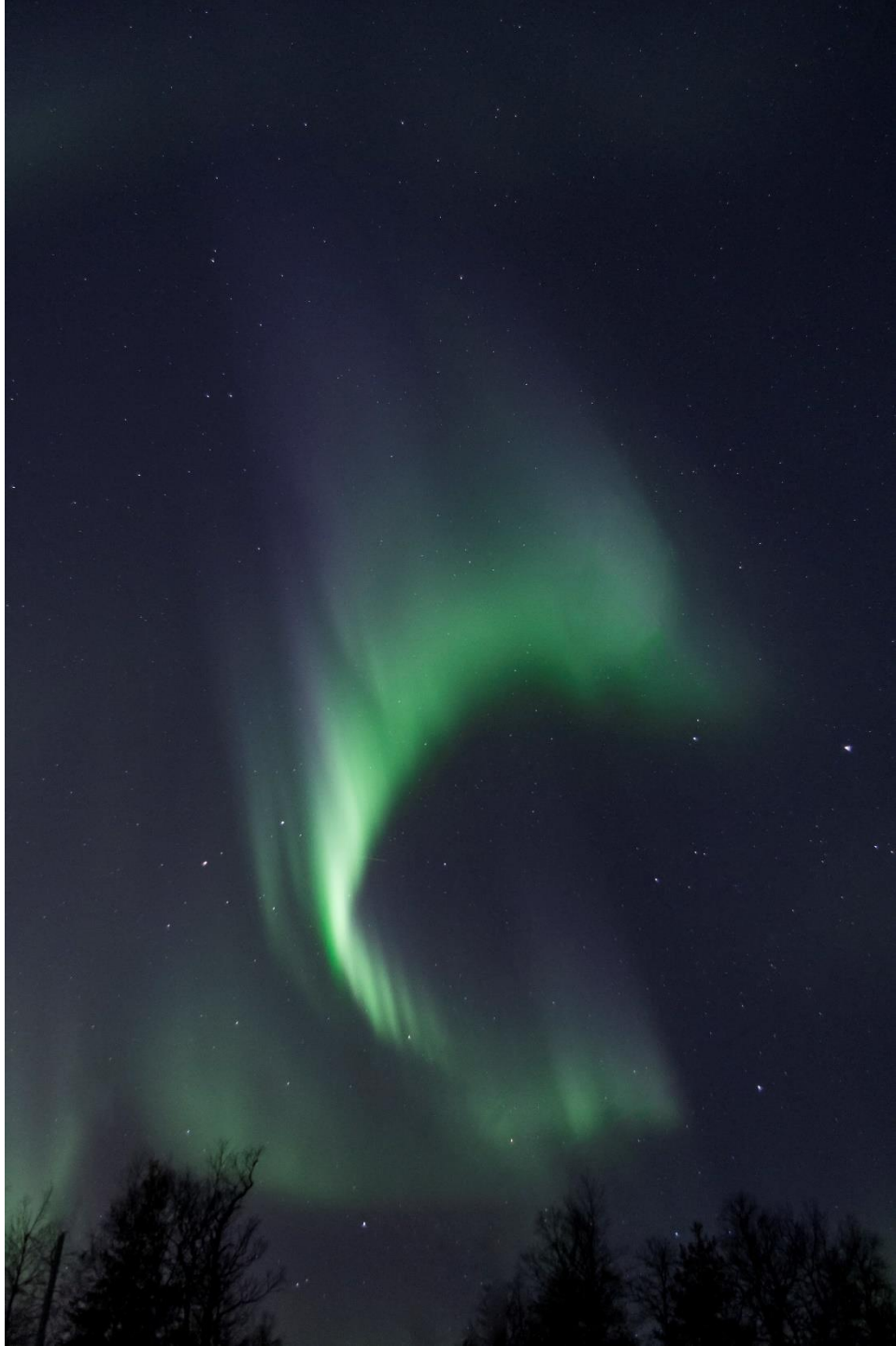


Vertical winds and turbulence !



Aerosol profiles !

PEW PEW PEW LASERS !



Thank you for your attention !

Any questions ?