

# MARBLL

## MARs Boundary Layer Lidar

THE ANSWER  
MY FRIEND  
IS BLOWIN'  
IN THE WIND

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VERSAILLES  
SAINT-QUENTIN-EN-YVELINES



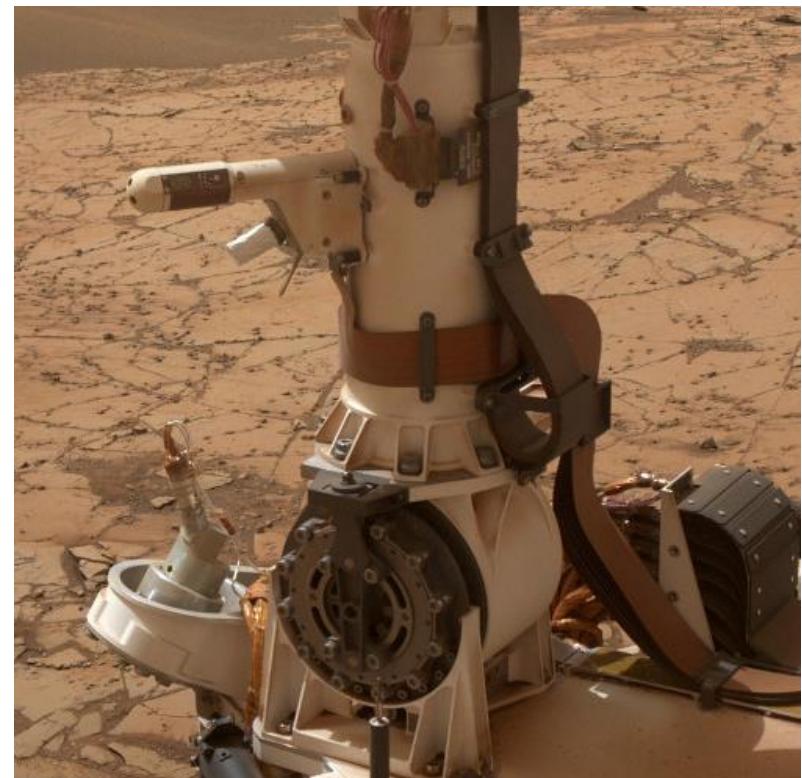
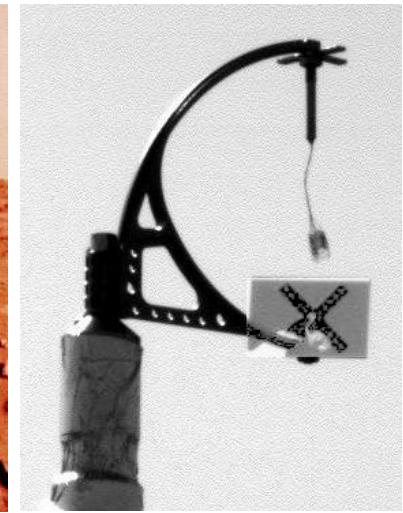
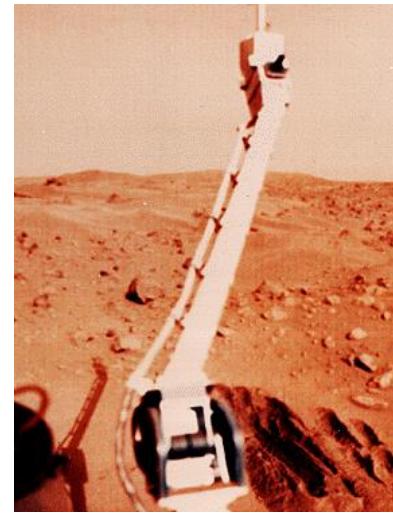
LMD  
Modélisation & prévision

irap



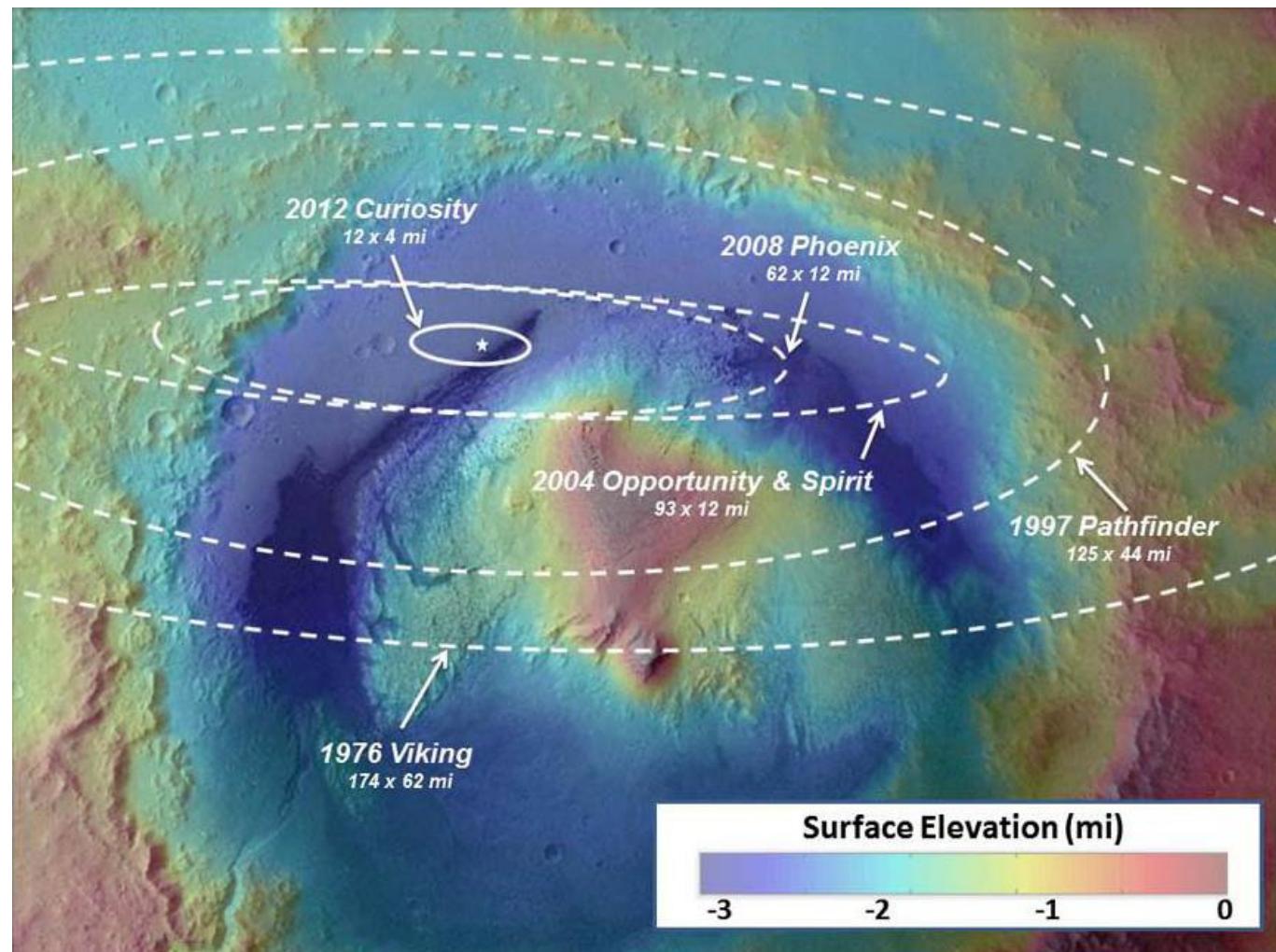
# Problem: Measure winds on Mars

- Lander anemometers
- Even networks remain at the surface
- Difficult mesospheric wind measurements by Earth-based heterodyne spectroscopy (mm + IR)
- Low pressure > ~~balloons~~
- **Knowledge** = model **predictions** but models remain **to be validated**



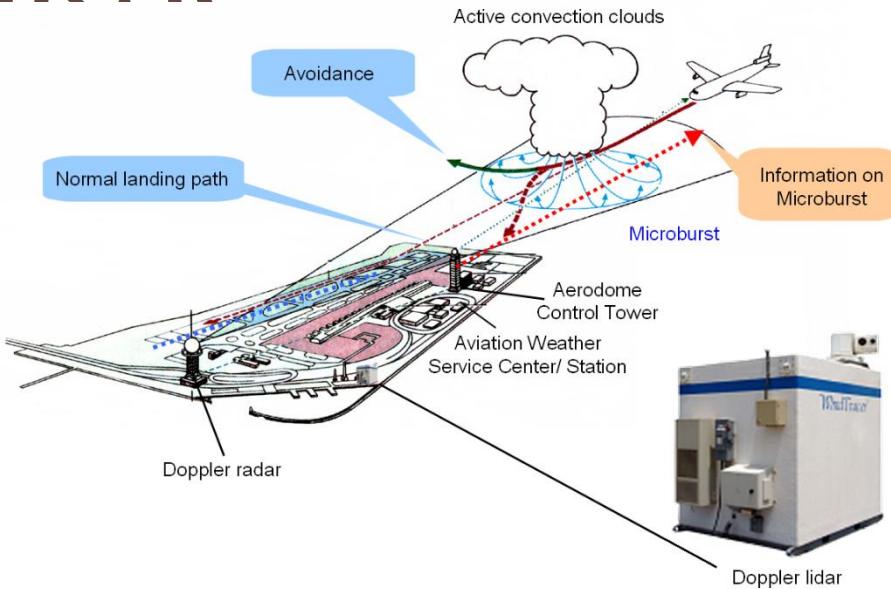
# Key motivation: mission design EDL

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



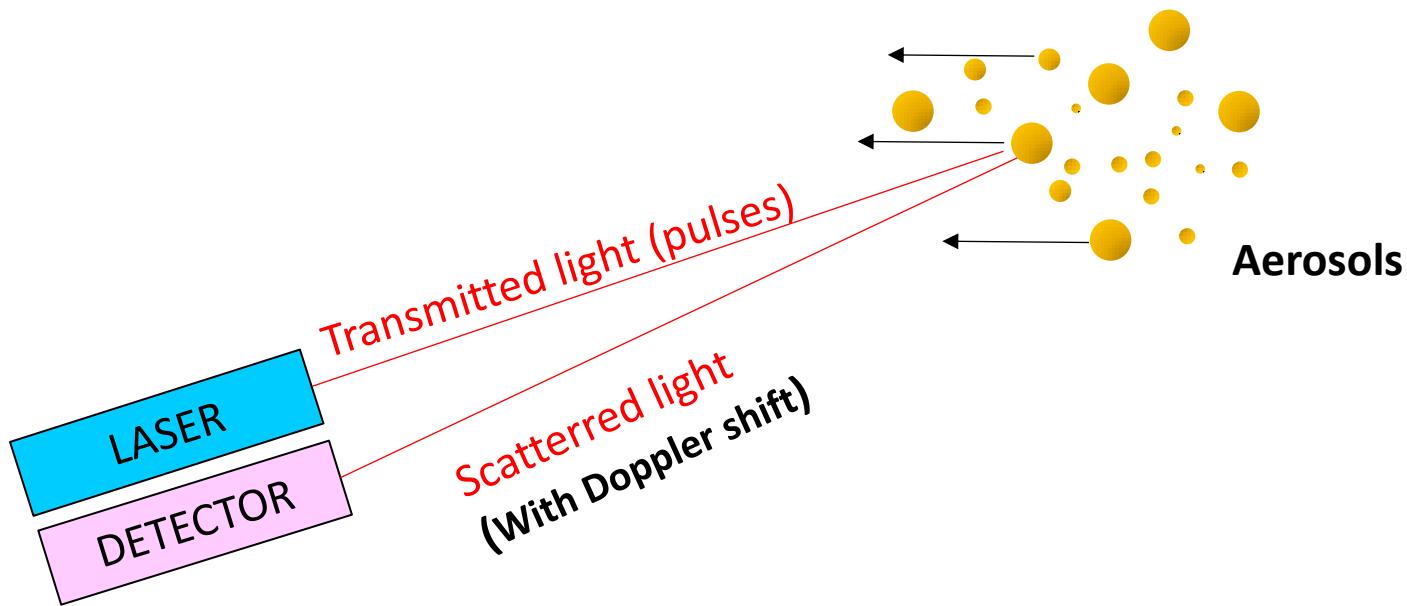
# A solution: doppler wind

## LIDAR



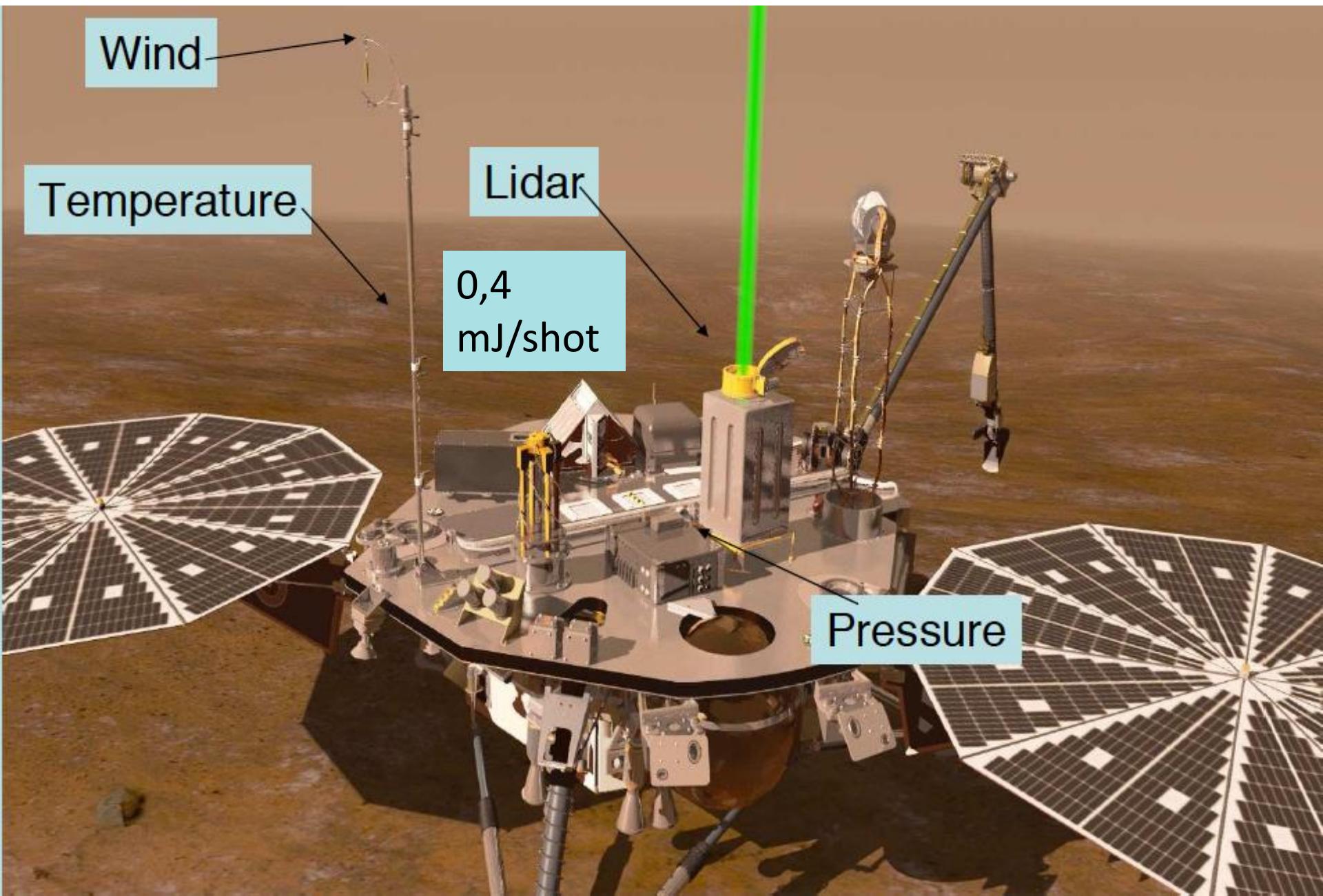
- **On Earth:** LIDAR used routinely and available as commercial products
  - to monitor wind shear and turbulence above airports and in the wind farms industry.
- **On Mars:** easier than on Earth!
  - Ubiquitous dust particles which are highly reflective
  - Negligible scattering by the atmospheric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

# Doppler LIDAR principle

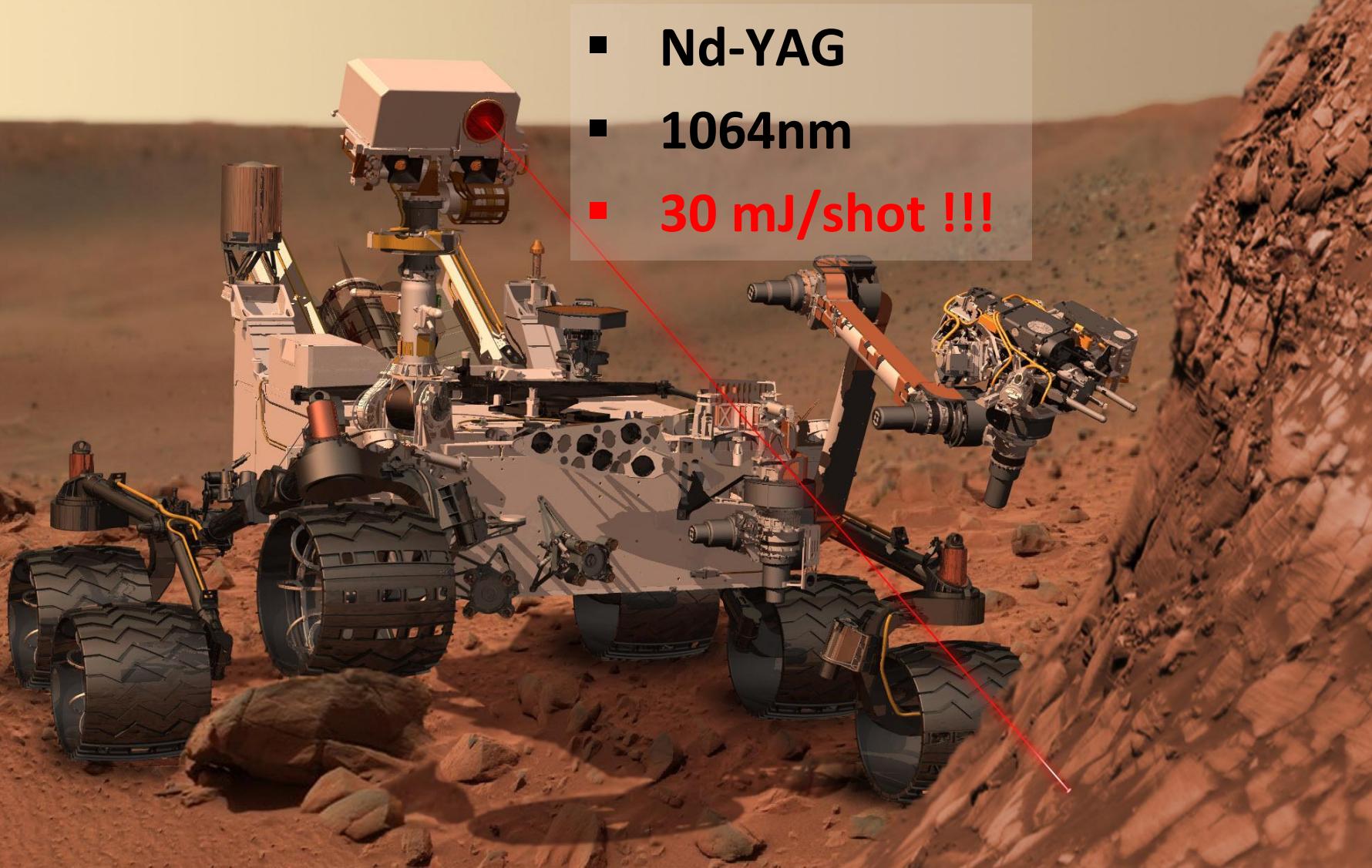


- Speed aerosols = wind speed
- Doppler shift > wind speed along the **line of sight**

# LIDARS already used on Mars



# Re-use the ChemCam LASER

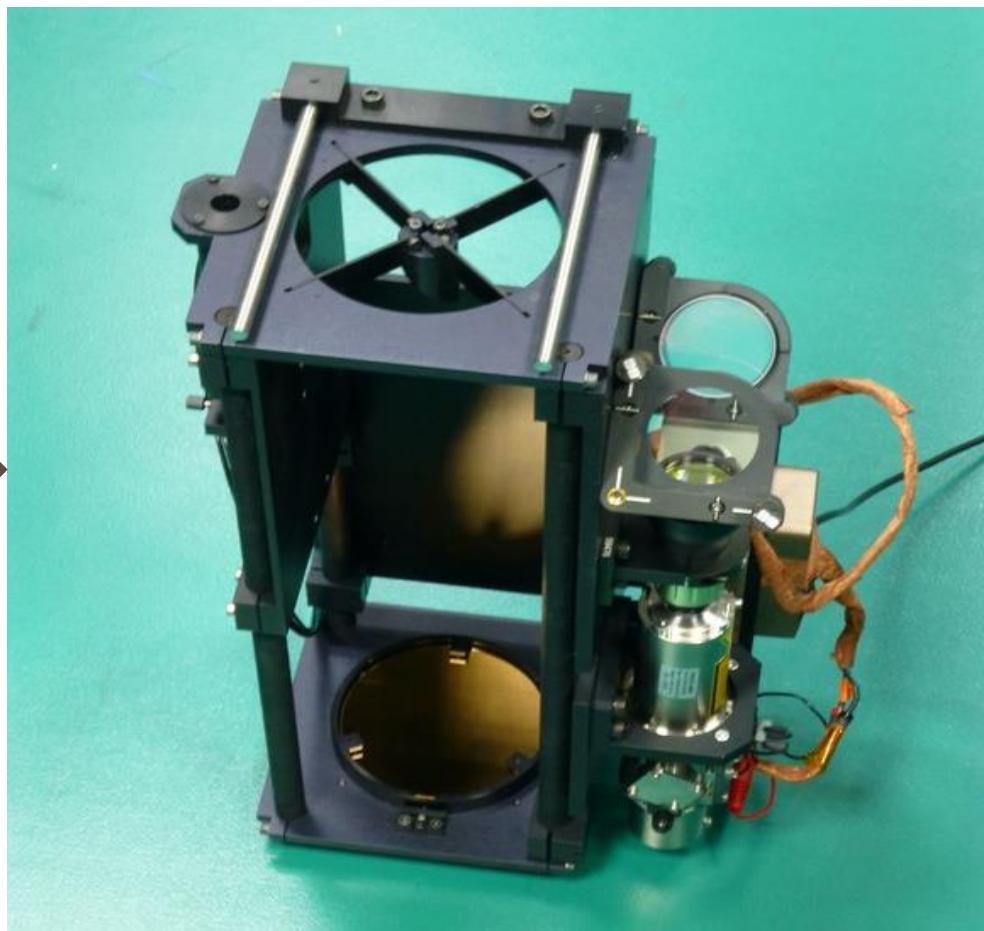
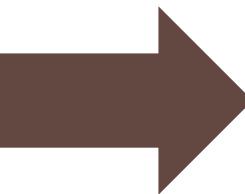
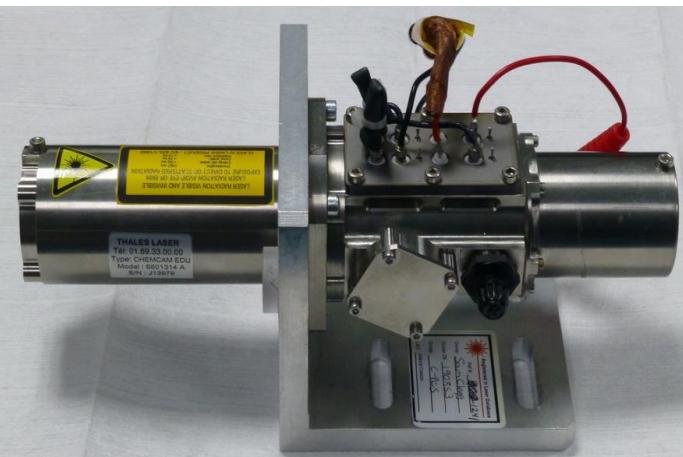


- Made by Thales Toulouse

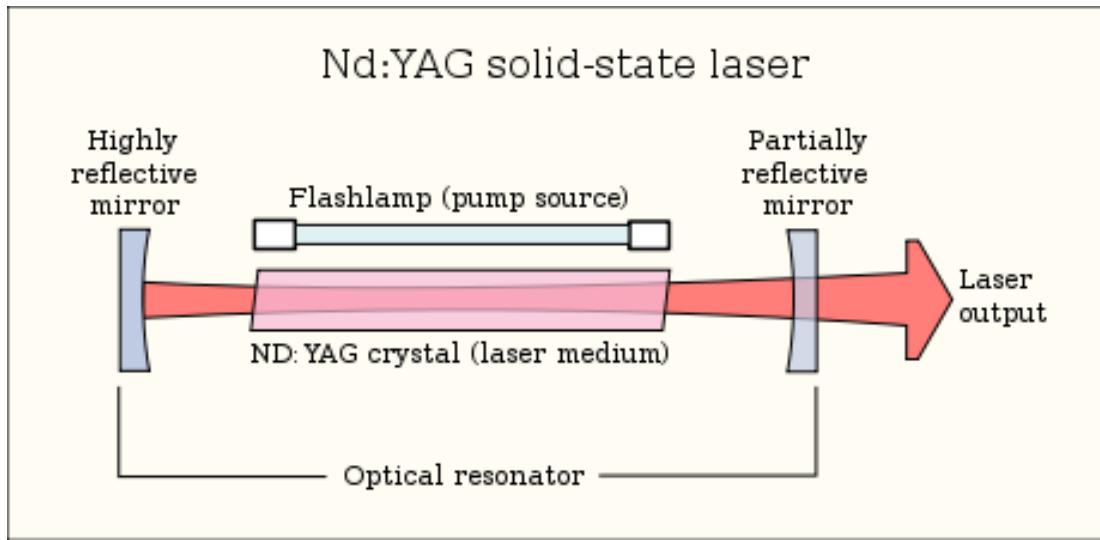
# Prototype of the MARs Boundary Layer Lidar (MARBL)



**MARBLL**  
MARs Boundary Layer Lidar

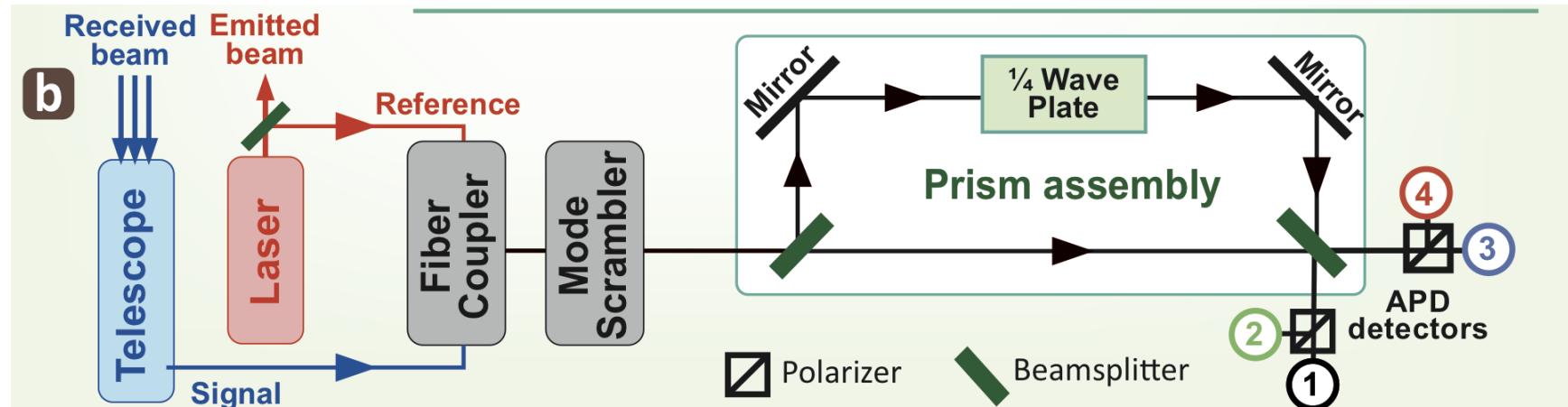


# Problem: Frequency stable ?

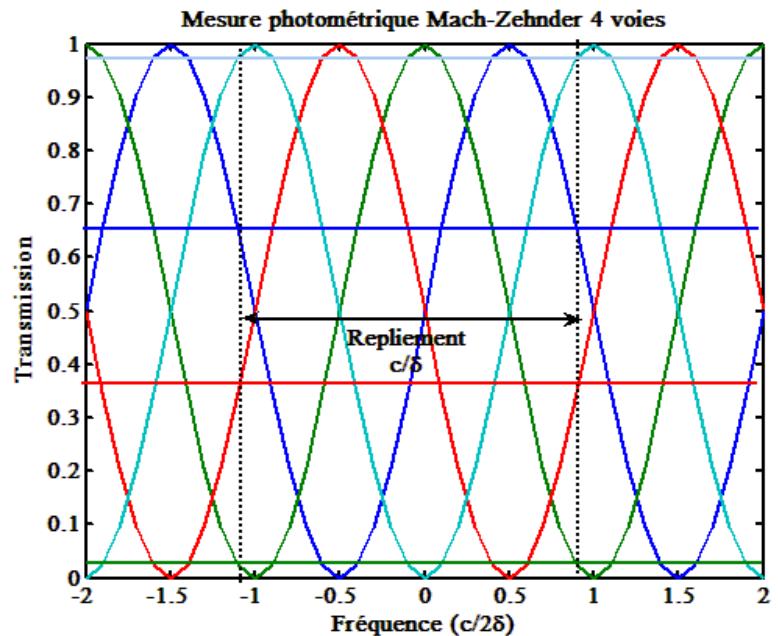


- Temperature variations
- Pressure variations
- Shocks

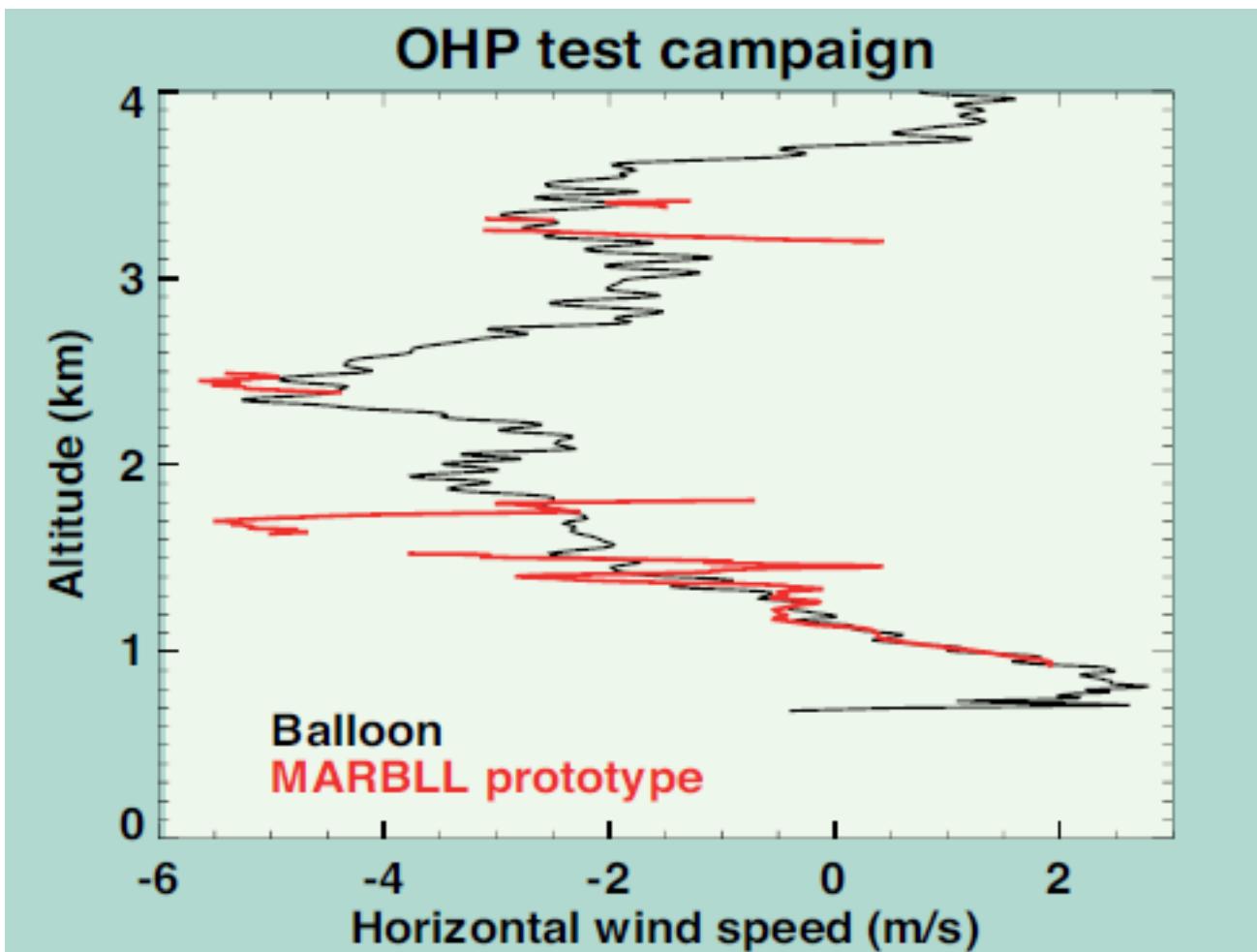
# The solution: Mach-Zender interferometer



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

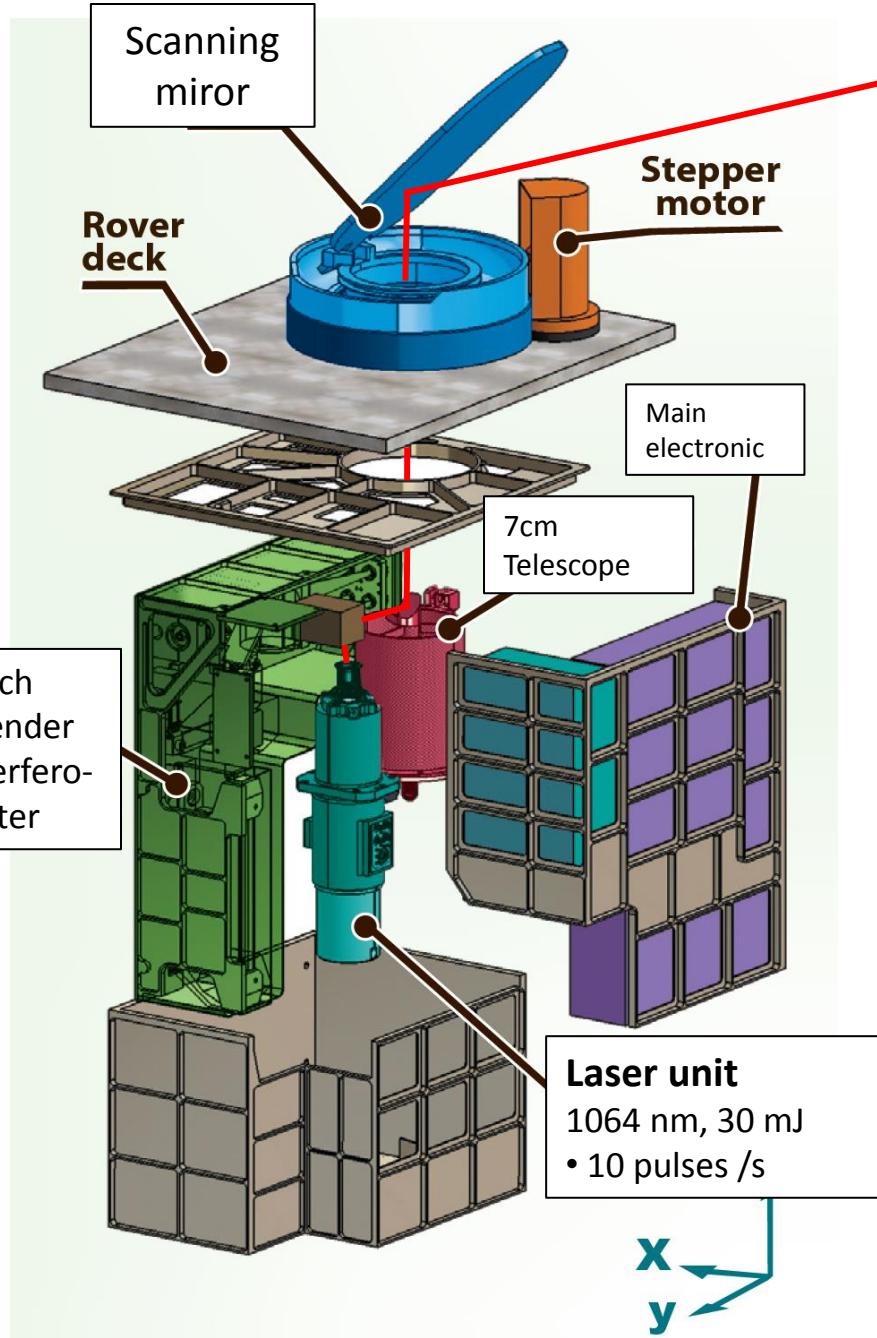


# MARBLL prototype test campaign



MARBLL prototype measurements made at  $45^\circ$  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)

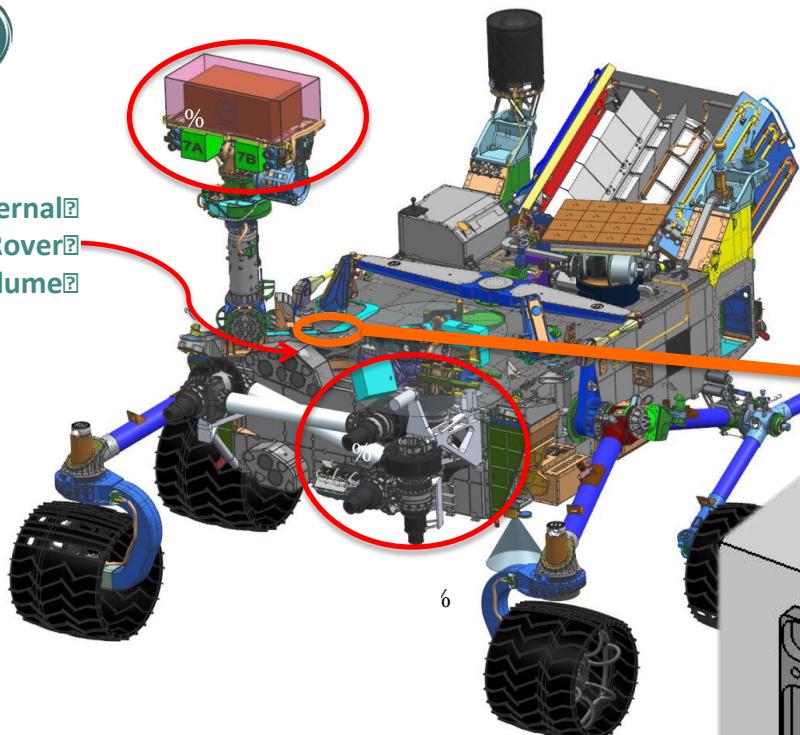
*proposed for  
Mars 2020 rover*

RESOURCE	CURRENT BEST ESTIMATE	CONTINGENCY	TOTAL
Mass (kg)	5.95	25%	7.44
Power (W)	30	25%	38
RAMP Volume (cm <sup>3</sup> )	12 190	25%	15 238
Data (Mbit/sol)	26	10%	29

# Accommodation



Internal Rover Volume



Azimuthal Sectors & mirror elevation

90°

45°

0°

90°

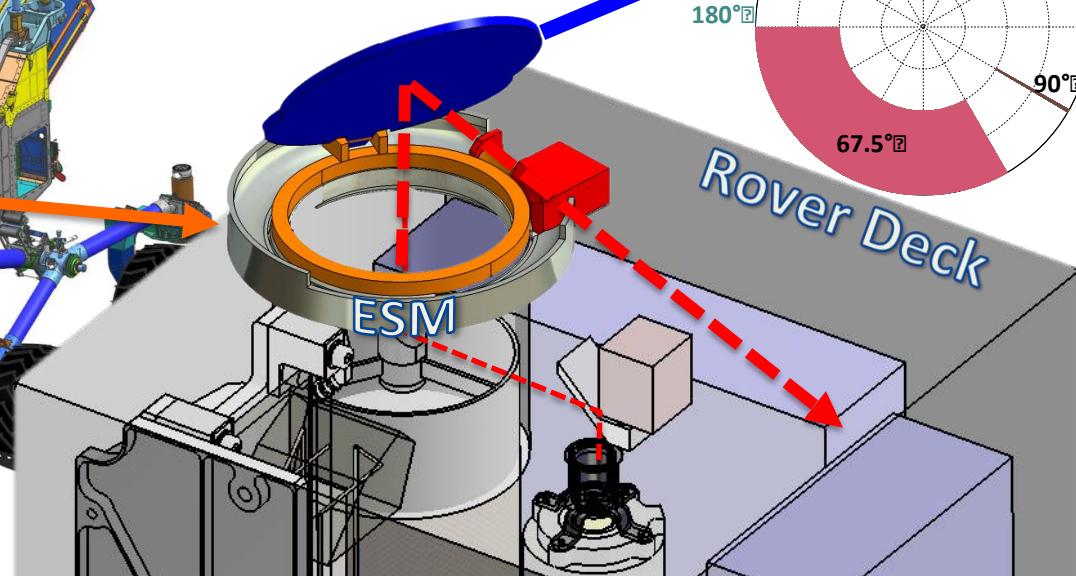
67.5°

45°

180°

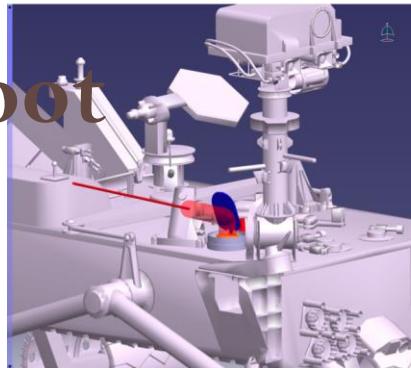
0°

Rover Deck

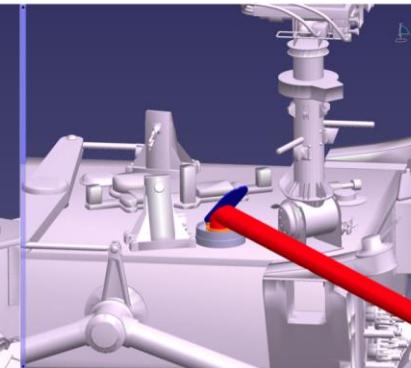


# Field of view And field of shoot

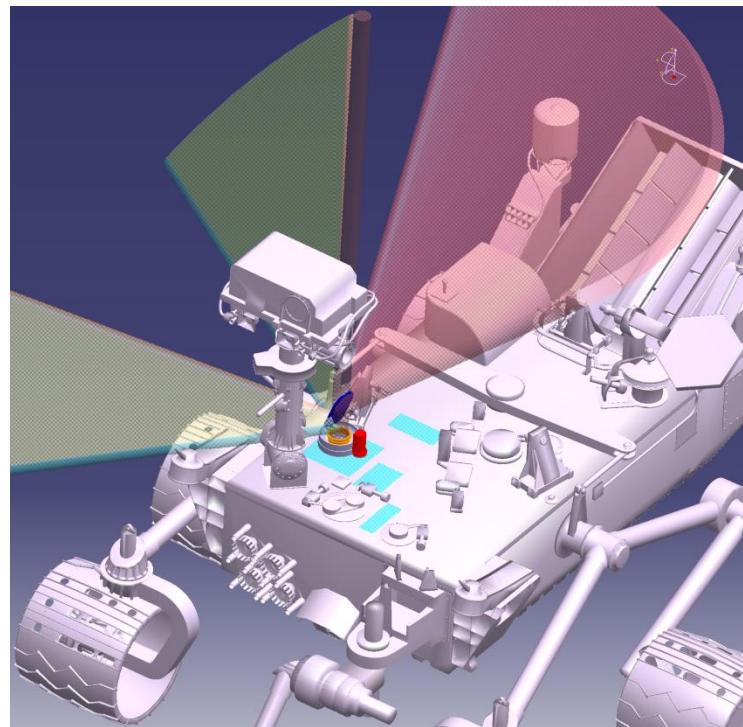
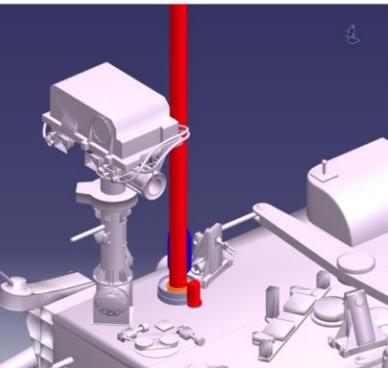
Tir à 45° élévation



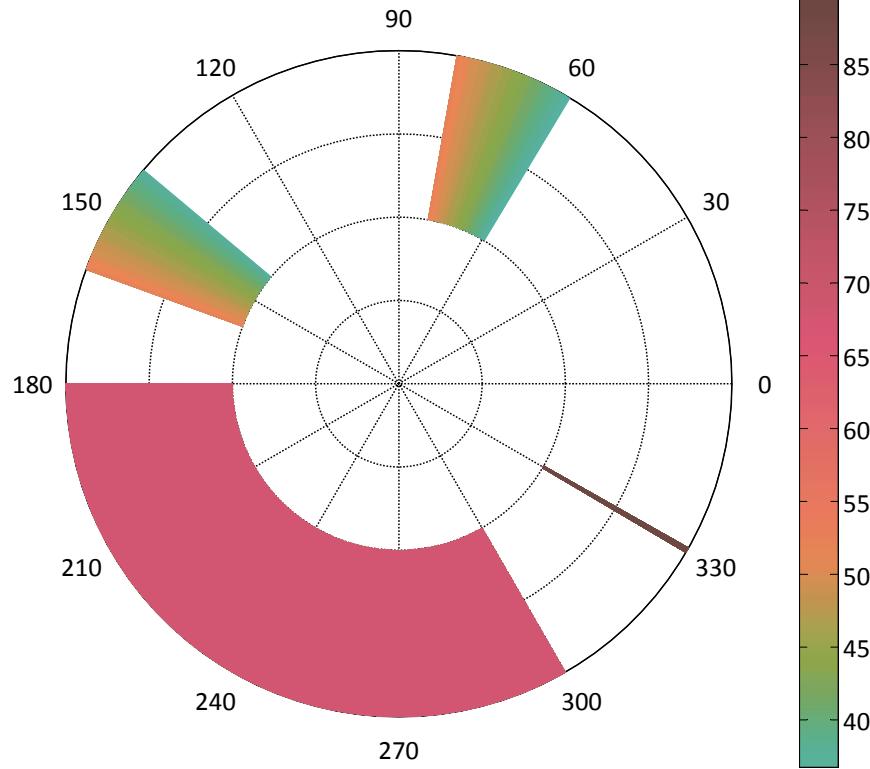
Tir horizontal



Tir Vertical

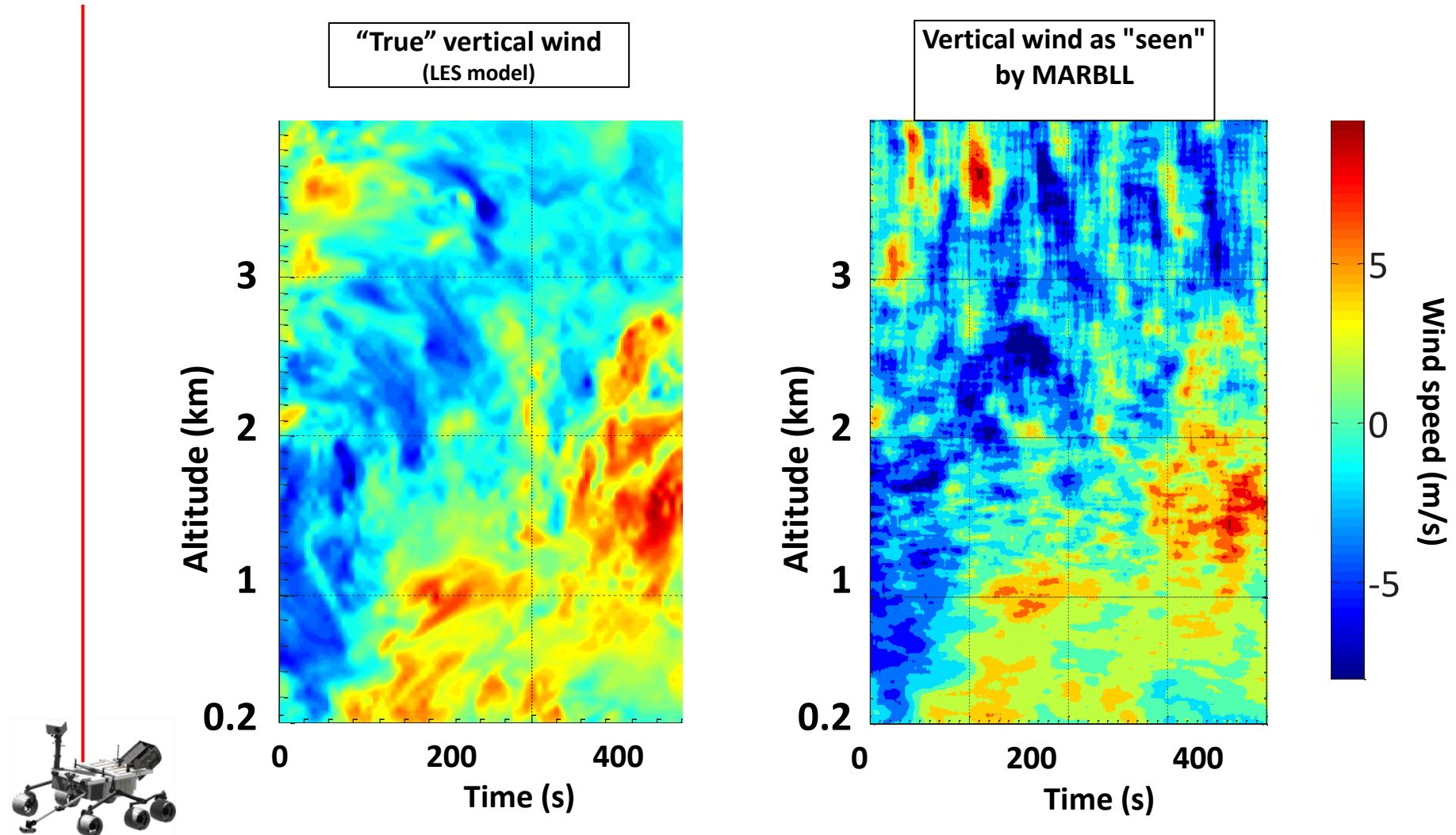


Used sectors for laser shots and zenithal angle associated



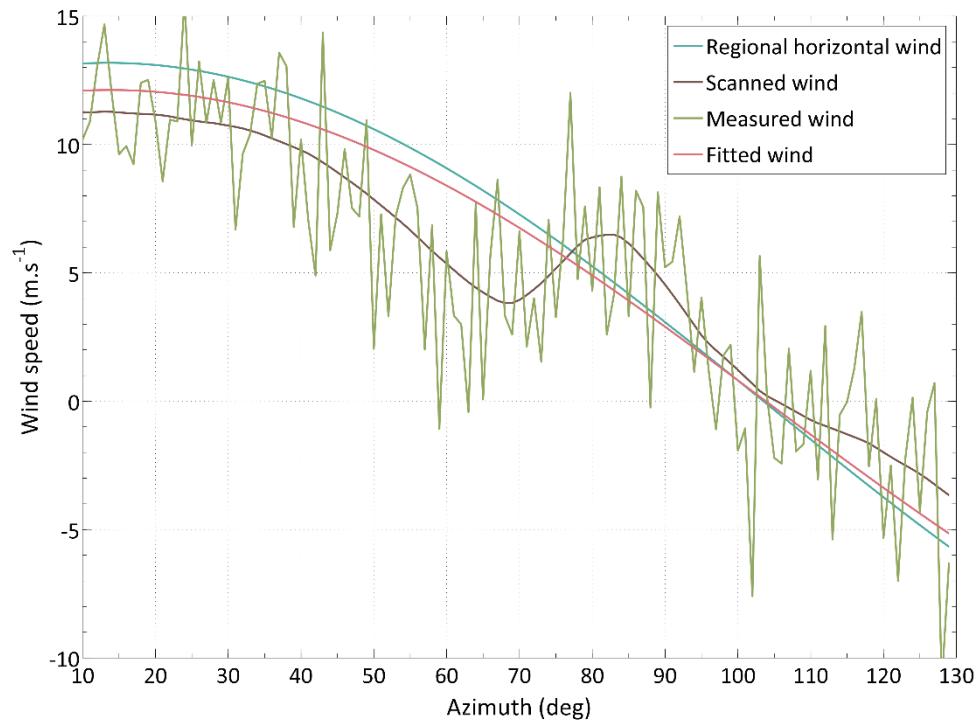
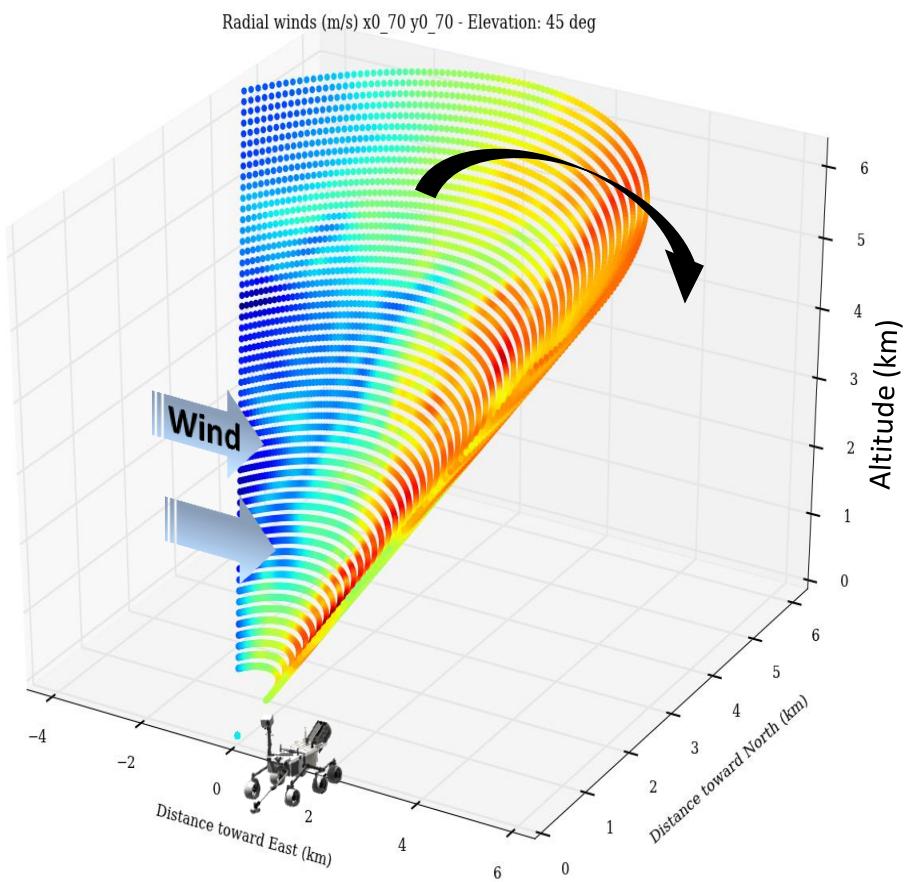
# MODE #1: Vertical shoot

## Convective Vertical wind "images"



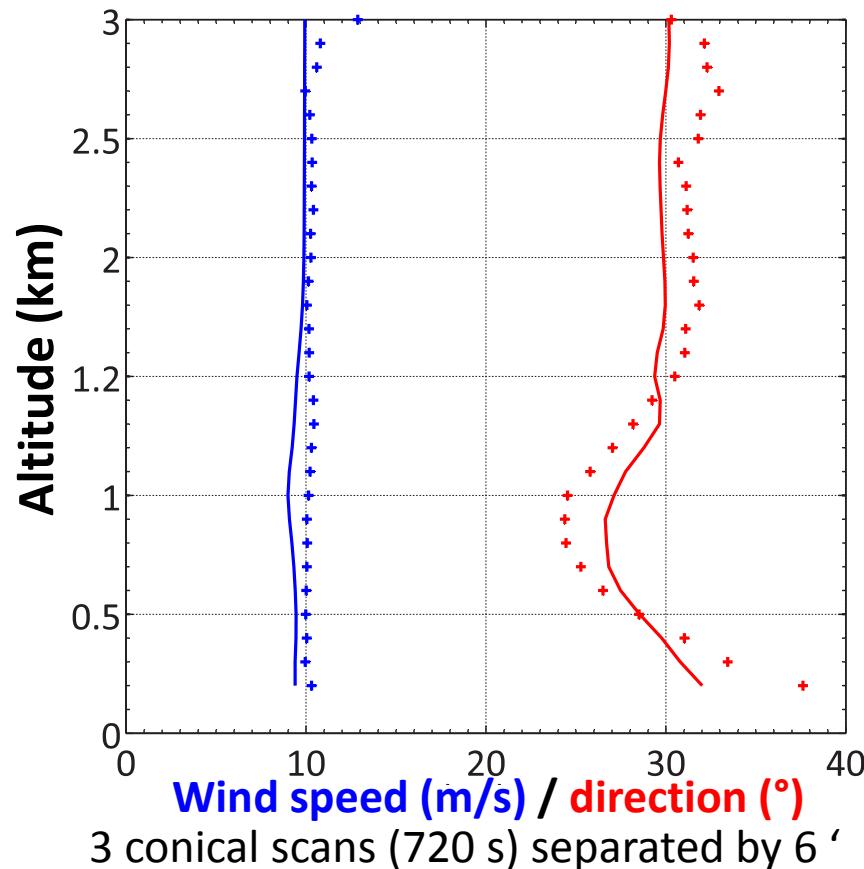
# MODE #2: Conical scan

## Measuring the mean horizontal wind



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## Measuring the mean horizontal wind



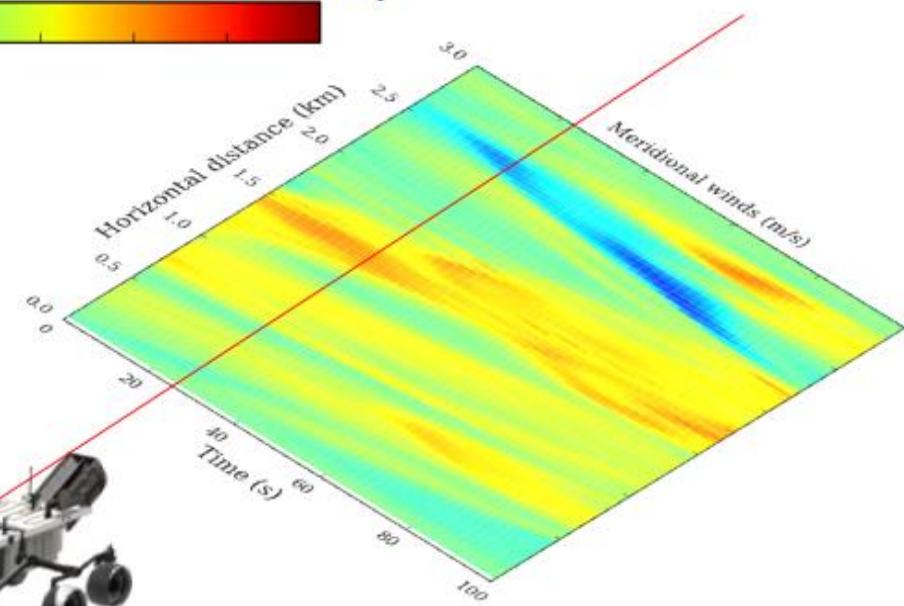
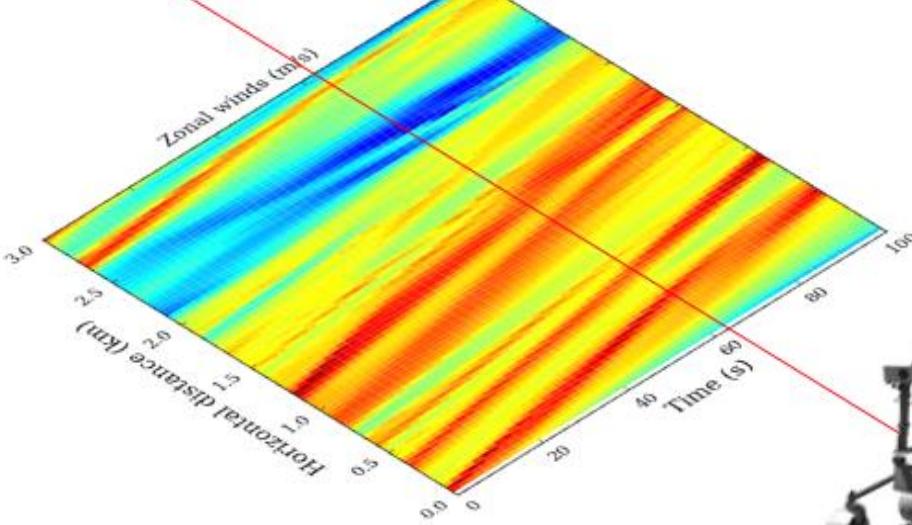
# MODE #3: Low elevation souding at 5° elevation

Snapshots” of surface wind gust



300 m

2 pm / worst convective case

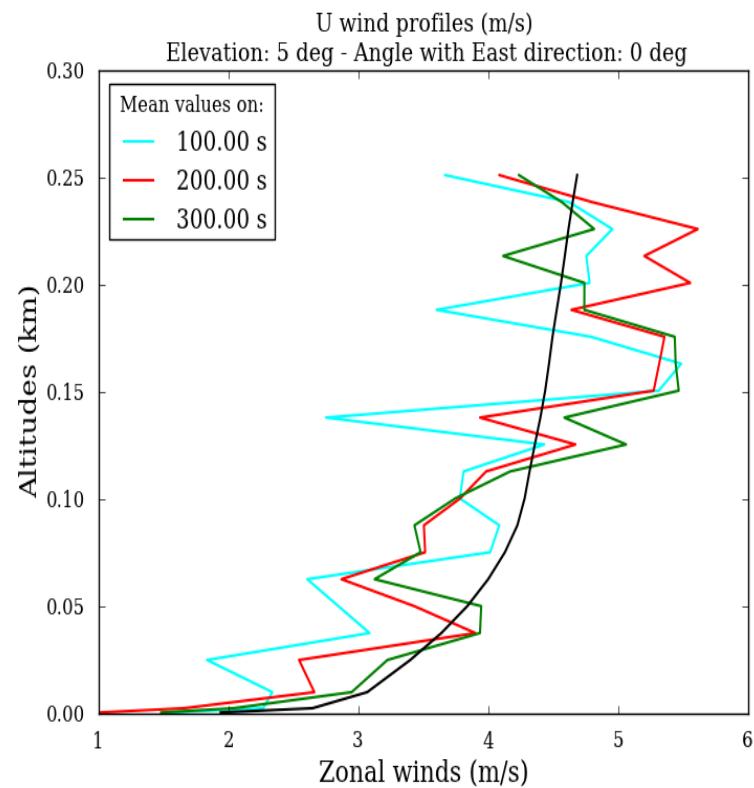
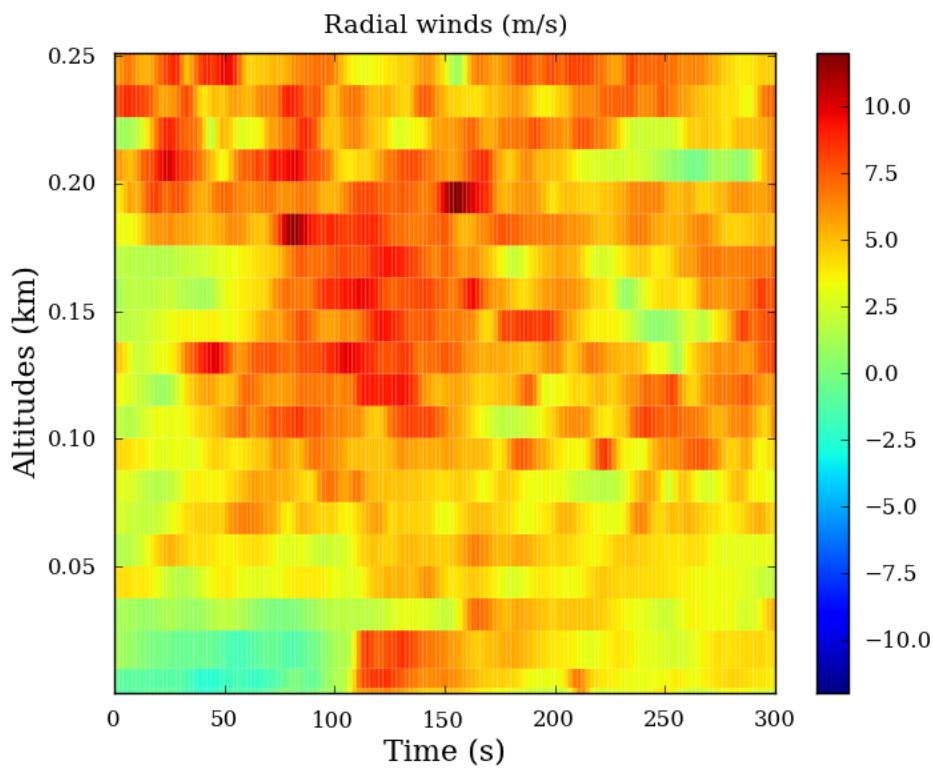


# MODE #3: Low elevation souding at 5° elevation

Snapshots” of surface wind gust



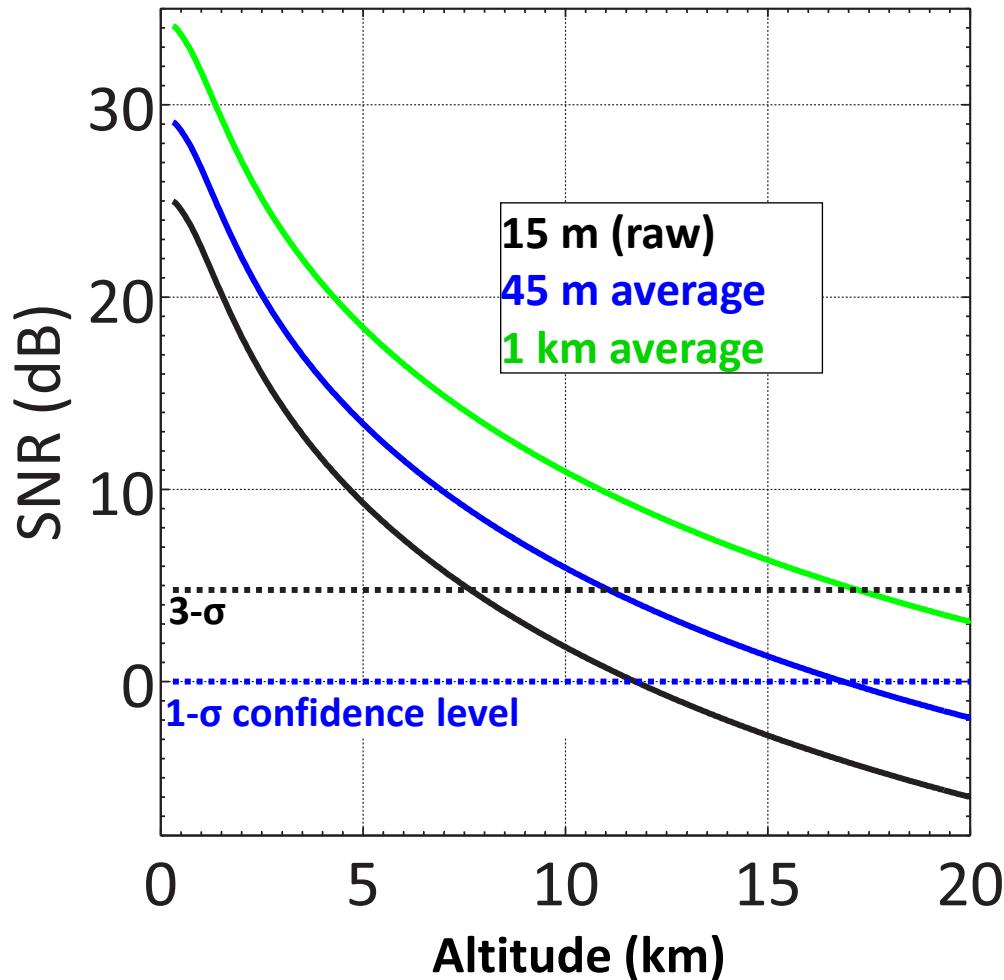
2 pm / worst convective case



# MODE #4: Classical LIDAR operation

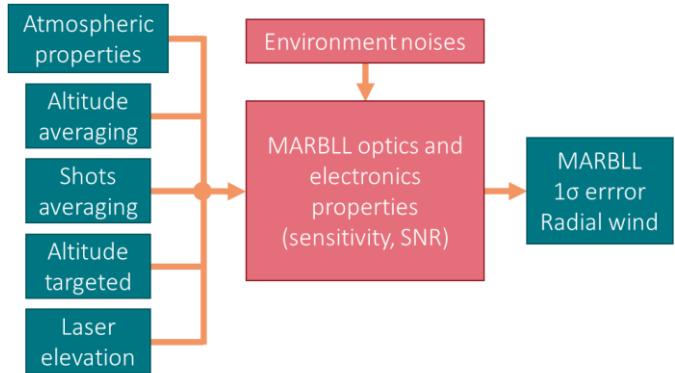


**Cloud detection** (1000 shots ~100 s integration)

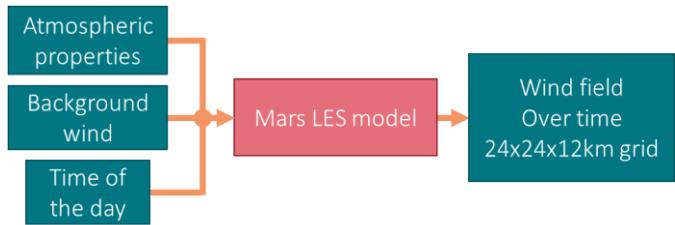


# Performance simulation

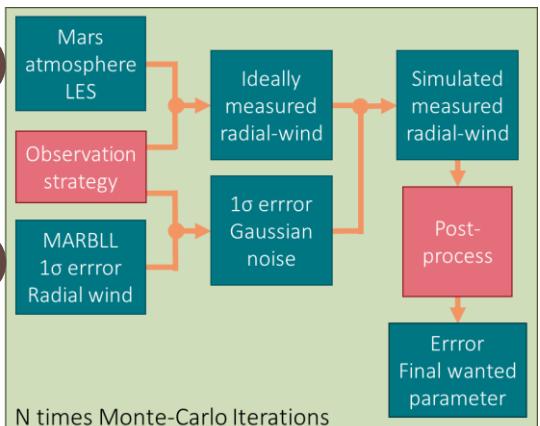
1



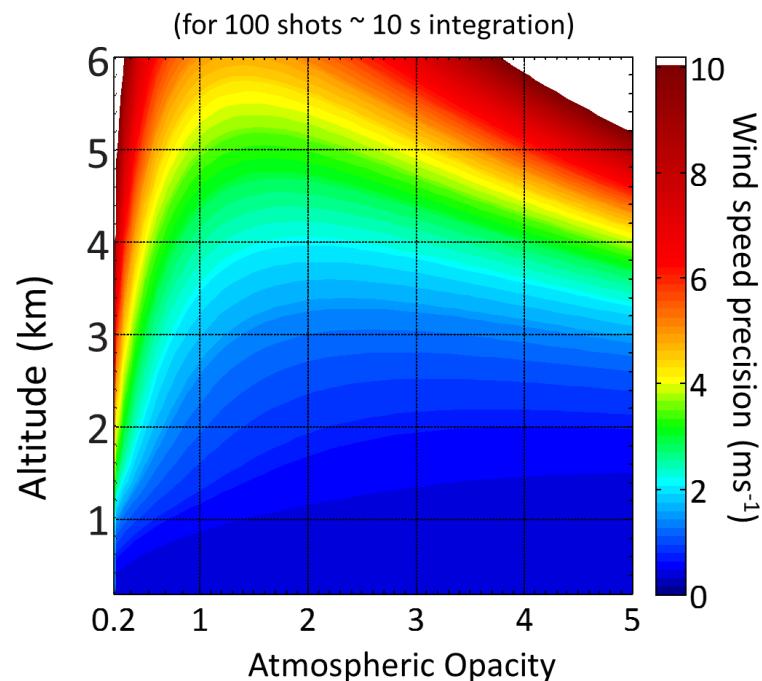
2



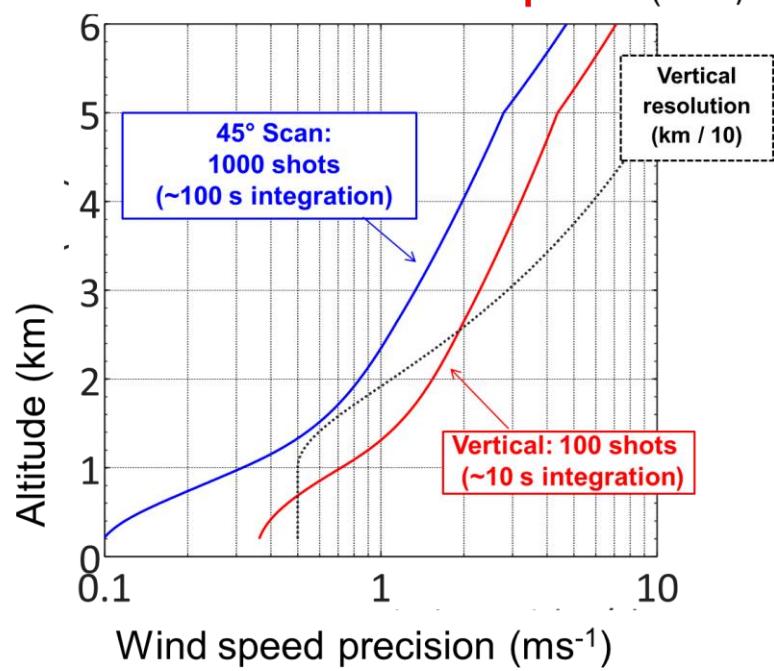
2



1σ error & bias on the final wanted parameter



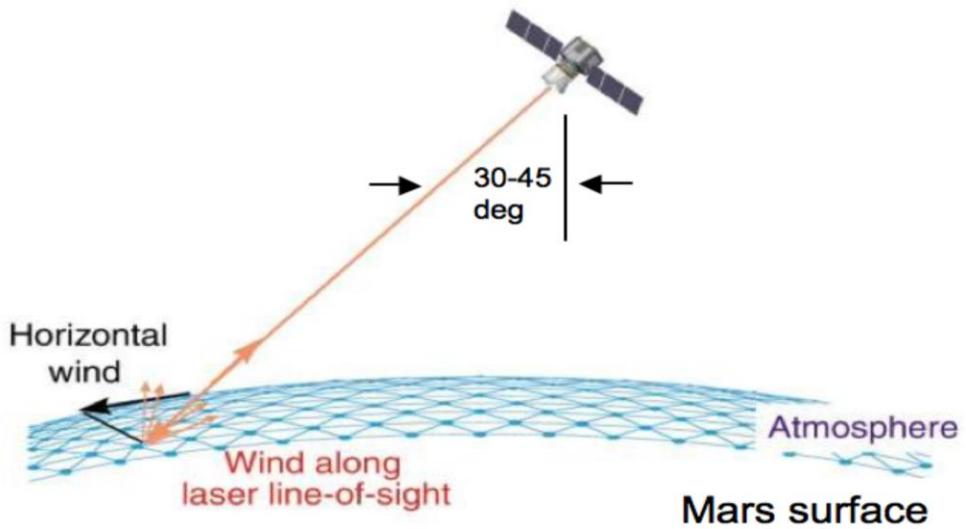
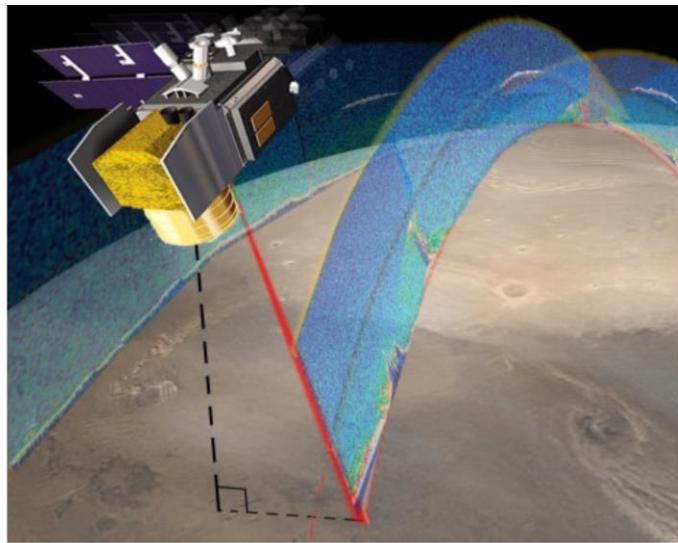
Precision on wind speed ( $\tau=0.7$ )



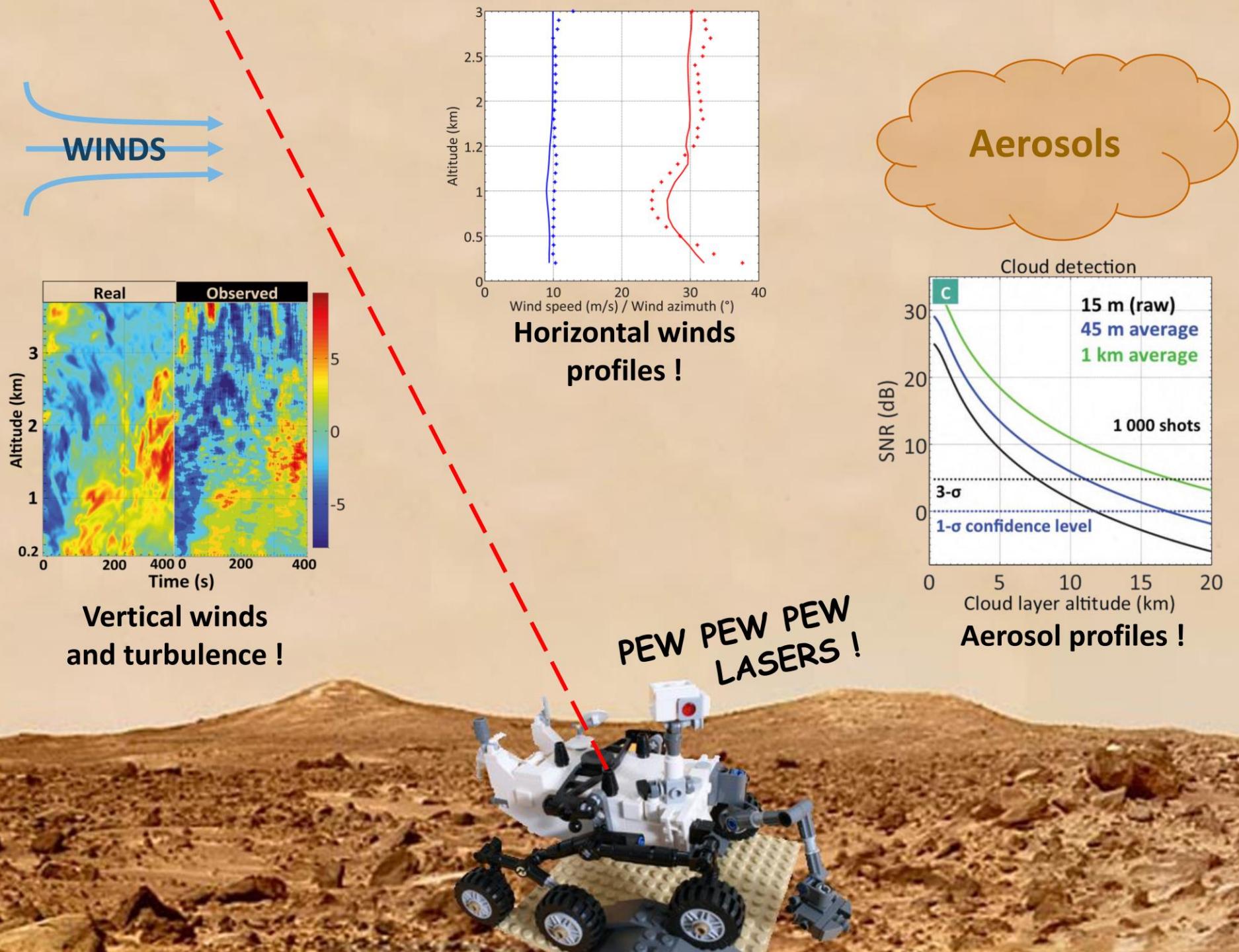
# A large scientific community

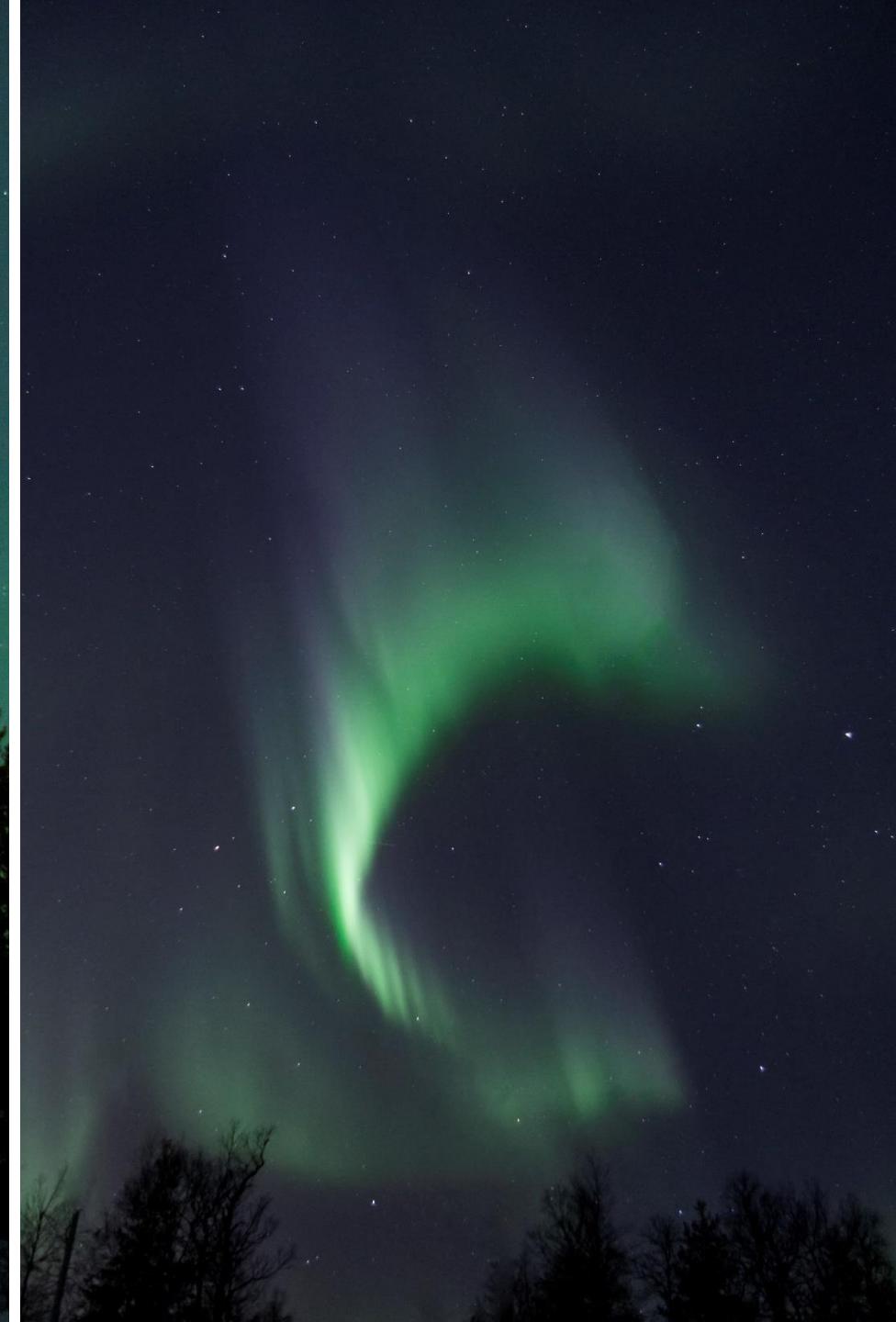


# Other solution ?

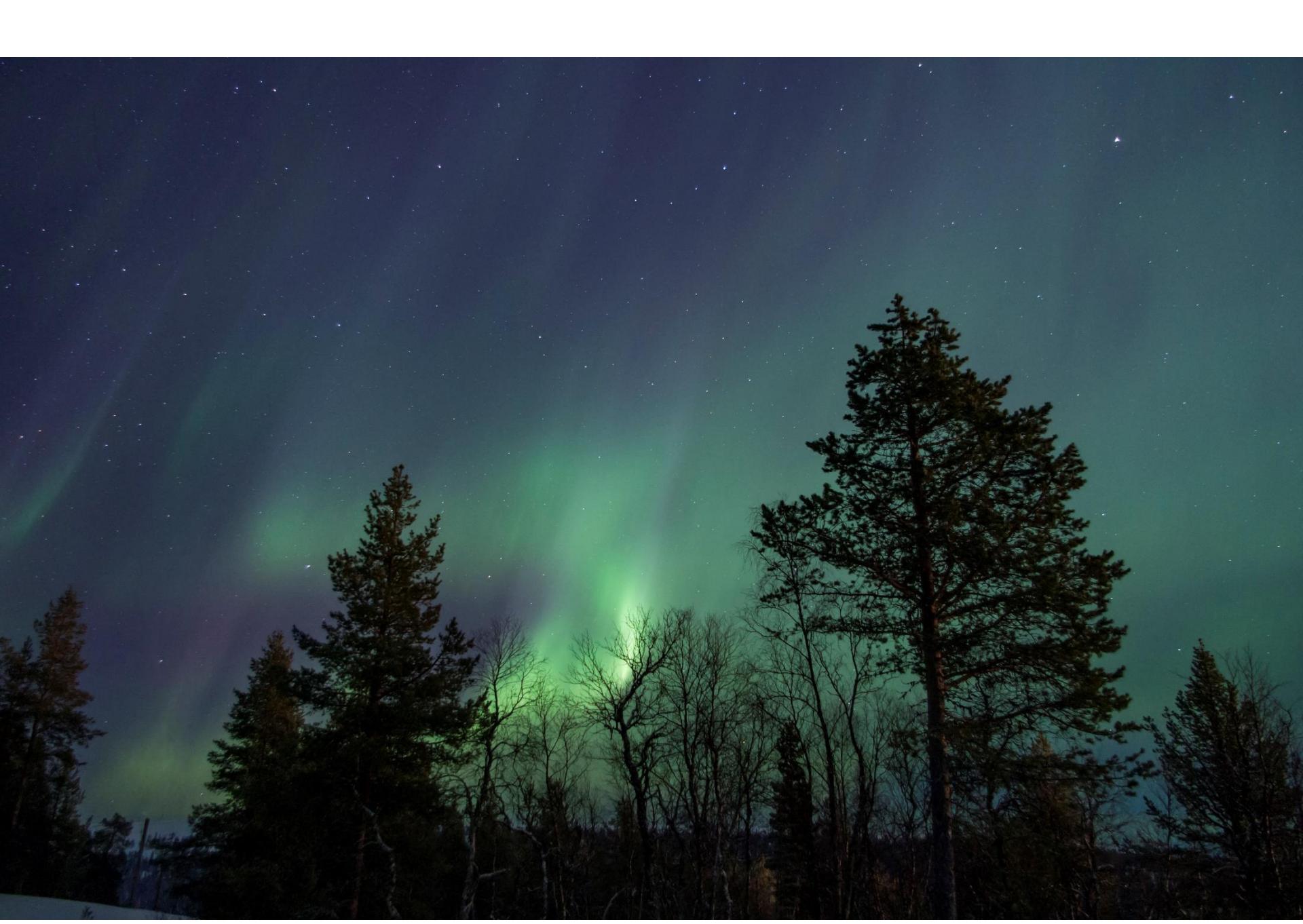


- From the orbit: MARLI









# Thank you for your attention !

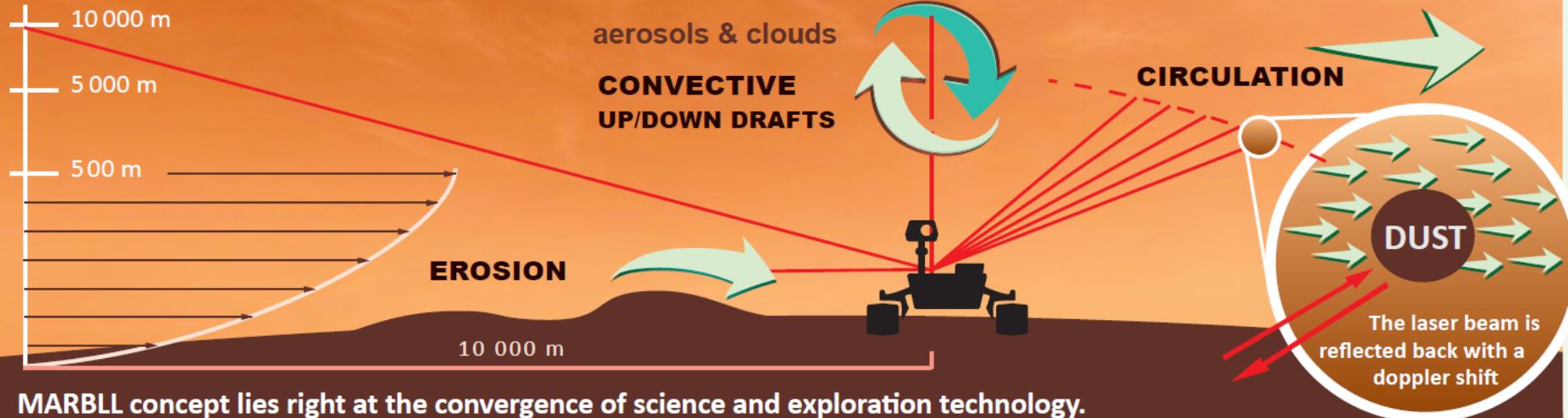
## Any questions ?



**MARBL**

### The Mars Boundary Layer Lidar investigation

*An in situ lidar to profile winds and aerosols  
in the Martian atmospheric boundary layer onboard the Mars 2020 mission.*



**MARBL concept lies right at the convergence of science and exploration technology.**

MARBL was designed to achieve long-standing objectives of Mars exploration: the wind profiles retrieved by MARBL will provide critical inputs to help design the Entry-Descent-Landing (EDL) for the future sample return mission and will give to the Mars climate community an incomparable dataset to validate existing meteorological models.