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The MARs Boundary Layer Lidar experiment (MARBLL): Winds at last!

Franck Montmessin and the MARBLL Team
LATMOS, Guyancourt, France

MARBLL is an optical remote sensing instrument using a mature state-of- the-art Doppler wind lidar technology specifically designed to operate at the surface of Mars. The instrument includes an emitting device (laser) and a spectral analyzer (Mach-Zehnder interferometer). Wind profiling is inferred from the 1064 nm beam emitted by the laser and subsequently backscattered to the telescope by the suspended aerosols. The received signal has a Doppler shift induced by the radial velocity component of the particles, which is quantified by the interferometer.

Doppler wind lidars (DWL) offer a unique combination of accuracy and spatial resolution making them the most efficient technique to profile winds in the terrestrial boundary layer (see e.g. Gentry, 2000; Frehlich, 2008). Existing DWL methods usually require a quasi-monochromatic laser emission and a precise frequency locking between the emitter and the spectral analyzer to infer the wind Doppler shift. These requirements lead to specific laser designs (single mode emission) associated with delicate servo-loops. The technical readiness level (TRL) of such systems remains too low to plan their use in the upcoming Mars missions. The conceptual approach of MARBLL started from this consideration: instead of developing space-qualified lasers to meet specific system detection requirements, MARBLL concept was led by the idea to design a detection system matching the specifications of an existing space-qualified laser (ChemCam) and by the need to guarantee high performances in the harsh Martian environment. The mature MARBLL design, which has undergone five years of Research and Development (R&D), ensures high performances for a large range of temperature and for any atmospheric condition (e.g. dust opacity) known to prevail on Mars. The relative detection method of MARBLL does not require the use of frequency control for both the emitter and the spectral analyzer. MARBLL will be able to derive wind velocity and orientation with a typical accuracy of respectively 0.1 to 10 m/s and 1 to 10°, a dynamic range of ±272 m/s and with a vertical resolution of 50 m up to 1 km within the first 5 km above the surface. Aerosol abundance can be retrieved up to 10 km with a vertical resolution ranging from 50 meters to 1500 m. Atmospheric dust loading affects MARBLL performances in a quantified way: high dust opacities (>2) reduce the sounding depth capability by >1 km, but increases SNR in the lowest atmospheric layers. At the laser wavelength, dust is non-absorbing and all photons are scattered, maintaining high levels of backscattered flux even at high dust opacity. MARBLL thus guarantees that performances exceed baseline requirements for all dust opacities (from 0.2 to 5), with an optimum estimated around 0.7, lying close to the average dust conditions prevailing on Mars.