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Data Set Description:

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Instrument: Rayleigh-Mie Doppler Lidar
Site(s): Observatoire de Haute Provence (43.9N, 5.7E, 683 m)
Measurement Quantities: Horizontal wind components (5-70 km)

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Instrument Description:

The complete instrument description can be found in Souprayen et al. (1999) and Khaykin et al. (2020). The lidar comprises a monomode Nd:Yag laser emitting at 532 nm, three telescope assemblies, and a double-edge Fabry-Perot interferometer for detection of the Doppler shift in the backscattered light. The transmitter is based on a Quanta-Ray Pro290 Q-switched, injection-seeded Nd:YAG laser emitting at 532 nm with a repetition rate of 30 Hz and 800 mJ per pulse energy. The receiver comprises three telescope assemblies with four collecting parabolic mirrors of 500 mm diameter each, which translates to the total collective area for each telescope of 0.78 m^2.

The backscattered light is collected by means of 200 µm multimode optical fibers located at the focal point of each mirror and linked to an optical commutation chamber, which transfers the collected light through a 600 µm fiber from a given telescope to the entrance of the FPI (Fabry-Perot Interferometer) etalon in a thermally-stabilized pressure-controlled chamber, a 0.3 nm interference filter for reducing the sky background and a mode scrambler, which serves for homogenizing the incidence angles of light projected onto the FPI.

The detection of the spectrally-processed light is done with two pairs of cooled super-bialkali Hamamatsu R9880-110 photomultipliers (PMTs), receiving respectively 95% and 5% of the flux (high- and low-gain channels). The high-gain PMTs are electronically gated at 100 µs, i.e. 15 km radial distance. The acquisition is done using a four-channel Licel transient recorder featuring 32760 gates of 50 ns width (i.e. 7.5 m radial resolution).

Algorithm Description:

A complete description of the algorithm can be found by Khaykin et al. (2020). An absolute measurement of the wind velocity requires a careful determination of the null Doppler shift reference, which is done through 1-minute zenith-pointing acquisition within each 5-minute cycle. The measurement cadence is such that the zenith, north and east lines of sight are alternated in a cycle of 1-2-2 minutes respectively. A typical acquisition lasts 5 hours during nighttime, that is 2 h integration for each tilted pointing, which ensures signal-to-noise ratio better than 2 all the way up to about 80 km altitude a.s.l.

The lidar returns are aggregated over 1-minute intervals and downsampled to 1 μs bins (150 m radial resolution). The off-line signal pre-processing includes subtraction of background due to sky light and PMT thermal noise as well as dead-time correction, after which the response profiles are calculated for each line-of-sight using eq. 1 in Khaykin et al. (2020). Then, the Doppler shift is computed using the instrument calibration function with account for atmospheric temperature profile, provided by ECMWF analysis. Finally, the zonal and meridional wind components are obtained by comparing the tilted East and North pointings to the corresponding zenith pointing (see eq. 2) in (Khaykin et al., 2020).

The retrieval uses height-dependent vertical resolution Δz, which is set to 115 m (150 m radial) below 25 km and then increased quasi-exponentially with altitude, from 500 m at 40 km to 4000 m at 70 km.

Expected Precision/Accuracy of Instrument:

For a typical lidar acquisition lasting 5 hours (i.e. 2 hours of a given tilted pointing acquisition, blue curve), the statistical error is less than 2 m/s below 33 km and does not exceed 6 m/s throughout the stratosphere. In the mesosphere, the error increases from 6 m/s at 55 km to 16 m/s at 70 km.

Over the 4-yr period, spanning June 2015 to June 2019, the validation of the LIOvent wind lidar was conducted using 12 radiosonde (RS) ascents performed at OHP during the time of lidar acquisition. The mean differences obtained from the individual comparison cases varies between -1.3 and 0.9 m/s for the zonal wind, and between -2 and 0.9 m/s for the meridional wind. For the total wind and direction, the differences vary between -1.1 and 0.7 m/s and between -4.9 and 9.6 degrees respectively. The averages of all intercomparison cases amount to +0.1 m/s and -0.1 m/s respectively for the zonal and meridional components, 0.0 m/s for the total wind and 0.3 degrees for the wind direction. The mean standard deviation of the differences for the 12 collocated soundings amounts to 2.26 m/s for the zonal and 2.22 m/s for the meridional wind profiles. These values are consistent with the estimated shot error for a 2 hours lidar acquisition (i.e. duration of a radiosounding), which increases from 0.2 m/s to 3.4 m/s in the altitude range of lidar-radiosonde intercomparison.

Instrument History:

The OHP wind lidar was originally designed to cover the height range of 25 – 50 km (Garnier and Chanin, 1992), i.e. where the contribution of Mie scattering by aerosol particles can be neglected in most cases. After the eruption of Pinatubo volcano in 1991 polluting the stratosphere with aerosol up to 35 km, the OHP wind lidar was redesigned to minimize the effect of Mie scattering (Souprayen et al., 1999a,b). The new Rayleigh-Mie Doppler lidar named LIOvent was deployed at OHP in late 1993 and was operated on a regular basis during 1995 – 1999.

After a long period of sporadic operation and limited maintenance, the upgrade of OHP wind lidar (LIOvent) was started in 2012. The upgrade of the lidar included replacement of the laser, optical filtering elements, and detectors. These efforts were largely motivated by the ESA Aeolus satellite mission carrying ALADIN instrument, which exploits the same principle of Doppler shift detection, i.e. double-edge Fabry-Perot interferometry.

Along with the hardware upgrades and development of the new data processing software, the instrument has undergone a through qualification/validation procedure through comparison against collocated radiosoundings in the upper troposphere/lower stratosphere as well as using ECMWF analysis/reanalysis in the upper stratosphere/lower mesosphere. The results of this exercise were reported by Khaykin et al. (2020).

A DOI was created in 2020 for the OHP lidar wind data: https://doi.org/10.25326/45

Reference Articles:

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Chanin, M. L., Garnier, A., Hauchecorne, A., and Porteneuve, J.: A Doppler lidar for measuring winds in the middle atmosphere, Geopys. Res. Lett., 16, 1273–1276, https://doi.org/10.1029/GL016i011p01273, 1989.

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