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Data Set Description:
PI: Alain HAUCHECORNE & Philippe KECKHUT
Instrument: Rayleigh Lidar
Site(s): Observatoire de Haute Provence (43.9N, 5.7E, 683 m)
Measurement Quantities: Temperature (30-90 km)

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Instrument Description:
This lidar uses the second harmonic of a ND:Yag pulse Laser (532.2 nm). The laser provides energy of 800 mJ per pulse at 30 Hz. The beam divergence is reduced using an afocal system to 0.04 mrad. A mosaic of four 0.5-meter diameter mirrors composes the receiving area.

Light is collected using optical fibers (diameter: 300 micrometers) located at each of the four focus points leading to a field of view equal to 0.2 mrad. The four fibers are mixed together in a single fiber. As the main high-gain channel received too many backscattered photons according to the bandwidth of the counting system, a second independent low -channel channel was implemented to cover the lower altitude range (30-40km) and to correct for high flux non linearity of the high-gain channel. A 0.2-m diameter mirror providing a field of view of 0.55 mrad composes it. The both optical fibers drive the photons up to two receiver boxes where filtering is insured using an interference filter of 0.3 nm bandwidth.

Detection is made by cooled Hamamatsu photomultiplier tubes running on photon counting mode. Counting gating is 0.1 microsecond providing a 15 meters vertical resolution. Electronic gating is used on each channel, in an effort to reduce the effects of the large initial burst of light and the resulting signal induced noise. Reasons for the choice of this instrumental configuration have been detailed in Keckhut et al. (1993).

Algorithm Description:
The method used to retrieve temperature profiles from molecular backscattered signal and the associated errors has been described in detail by Hauchecorne and Chanin (1980). A description of the instrumental errors sources and bias has been reported by Keckhut et al. (1993).

Since 1987, the two existing channels have been mixed together to provide a single signal for the entire height range. This is achieved in comparing the both channels in the common altitude range (30-50 km) and in calculating the ratio between the both channels and the high-flux non linearity of the high-gain channel considering the low-gain channel as a reference. The signal-induced noise (SIN) is considerably reduced using electronic gating, but still can be identified from the very low mean background noise. It is estimated by fitting with a parabolic function the background signal between 10 km above the top of the temperature profile and 153 km. The residual atmospheric signal at high altitude is estimated using the MSIS model.

Computation of temperature profiles requires a pressure initialisation. Instead of assuming that the pressure at the top of the profile is equal to the value given by the standard atmosphere model, the scale height of the pressure (which is directly related to the temperature) is adjusting on the MSIS model. Part of the actual algorithm can be found in Keckhut et al. (1993) and in Singh et al. (1996).

Recent data are processed using the V6 version of the Temper code developed by LATMOS. Since the version V4 in 1998 the processing is improved in including in the version V4 an automatic data selection/rejection of data files with too high background signal or too low atmospheric signal (Keckhut et al., 2001).

Expected Precision/Accuracy of Instrument:
The accuracy in determining density and temperature is directly related to photon noise and is associated to temporal and vertical resolution. Statistical noise increases with the altitude and becomes suddenly very large as the signal amplitude reaches the noise level. Relative and absolute uncertainties have been identified and quantified using simulated data (Leblanc et al., 1998).

Error calculation can be found in Hauchecorne and Chanin (1980). For NDSC purposes a 2-km vertical resolution constant with altitude is obtained using a Hanning filter. The integration time is about 4 hours, depending on weather conditions. The amplitude of the correction of the non-linearities of the counting is determined with an accuracy of 1 K. The error due to the initialisation was estimated to be equal to 15 % at the initialisation level. The calculation of uncertainty shows that this error becomes negligible 15 km below as opposed to the noise statistic. The sum of these uncertainties is reported on the NDSC archive. Comparison and data analyses have revealed that the possible bias occurs mainly at the bottom part of the profile induced by miss-alignement problems or by the presence of aerosols. Improvements on signal and noise may have induced some spurious trend in the data series in the upper mesosphere.

Instrument History:
Many instrumental changes have occurred since the first lidar temperature measurements in 1979. In September 1994 the receiving telescopes, electronic counting system (vertical resolution) and computer were replaced. In 2011 a new Spectra Physics Quanta Ray Pro-290 laser was installed. It is shared with the Doppler wind. It emits 800 mJ per pulse at 30 Hz - 532 nm. In 2013 the homemade data acquisition system was replaced by a Licel system. The last intercomparison with the mobile GSFC lidar took place in July 2017 and March 2018. The results will be published in a paper in preparation. A doi was created in 2019 for the NDACC/OHP lidar temperature data set:
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