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LIDAR MONITORING OF TRENDS AND NATURAL VARIABILITY IN THE STRATOSPHERE AND MESOSPHERE

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The Service d'Aeronomie team has acquired a data bank of temperature Lidar profiles since 1979 at the Observatoire de Haute Provence (OHP) and since 1986 at the Centre d'Essais des Landes (CEL). Up to now, in this region (30-80 km), Rayleigh lidar is the well adapted method to obtained accurate vertical profiles on a regular basis. For the purpose of detecting long term trends, studies have been performed to evaluate the possibility of the Rayleigh lidar in this particular field of interest.

Long term trend observation

A multiparameter least square fit of the data has been applied to separate the different components of the natural and anthropic variability included in the temporal evolution of the temperature at a given altitude (Hauchecorne et al., 1991). Significant linear trend have been detected using the summer data (April-September) and after removing the period after the Mt Pinatubo eruption. The superimposed effect of the ozone depletion and the increase of greenhouse gases leads in the models to a maximum of cooling around 40 km. Our results show a significant cooling in the mesosphere from 55 up to 75 km, but no significant effects In the stratosphere. Together with radiosondes which indicate a cooling at 20 km, this is in contradiction with model expectation. This could be explained by a wrong estimate of the ozone feedback processes on the atmospheric temperature, but more data concerning other locations or other parameters are obviously needed to better understand this results.

Global data validation

The UARS satellite has obviously been the major source of attention for the atmospheric community due to the expectation of such a mission. We have participated as CMI's through ground validation of temperature measurements with Rayleigh lidar measurements which have contributed to improve the ISAMS retrieval algorithms.

The capability of the NMC analyses to provide consistent temperature fields depend on adjustments derived from ground-truth observations. A collaborative study on the ability for Rayleigh lidar to provide high-quality temperature data was examined by comparing those data with NMC analysis, adjusted by Datasonde measurements. Agreement between the two data base has been found. It is concluded that high-quality lidar data could provide the essential data for future use in the NMC analysis adjustment system (Finger et al., 1993).

Analysis of the data quality

It is necessary for study of long-term trends or satellites validation, to be aware of the possible sources of error and of their time evolution in order to evaluate their contribution to an apparent trend that would be of purely instrumental origin. We have therefore carefully analyze the different possible sources of error (Keckhut et al., 1993). The analysis shows that anticipated instrumental errors are smaller than the ones induced by photon noise in most of the height range. And the random nature of these sources of noise makes us confident as to the determination of long-term trends. The different sources of errors are localized in two distinct height ranges:

-The extraction of background noise, the initialisation of the pressure profile and the photon noise may disturb temperature measurements at the top of the profile. These sources of errors decrease very rapidly however in the middle mesosphere.

-Sources of error in the lower part of the temperature profile (30-35 km) are due to the presence of aerosols, the non-linear correction of the photomultiplier, and the alignment of the emission and reception axes. As the photon noise at this altitude is excellent, it is the most critical zone, and those errors cannot be neglected. It is difficult to precisely quantify the effects on the measurements, nevertheless we can estimate that a accuracy of about 1 K has been achieved in our data set.

Concerning the studies of long-term trends, systematic errors are more important than random ones. As the instrument have changed with time, the systematic errors evolved could have changed and could lead to instrumental drift which could be interpreted as geophysical trend, even if such a bias is smaller than photon noise. Due to the improvements brought along the years in the range of the instrument, the altitude of initialisation have been increased. We have quantified this effect, taking into account the possible difference between our lidar climatology and the model (CIRA 86) used to initialize the profile. However, to be sure to avoid such source of error, the profiles considered in the data base are systematically limited upwards at an altitude 20 km below the altitude of initialisation.

Detection of sources of error by comparison with different instruments is not made easy, as few instruments can make temperature profiles as accurately as a lidar. The first reported comparisons showed differences of several Kelvin (Hauchecorne and Chanin, 1980). This was considered satisfactory at the time, as these measurements were, for the most part, neither taken simultaneously nor from the same site. The number of measurements and instruments is still very low today, and searching for errors of the order of one Kelvin or less remains difficult, but important when long-term trend detection is considered.

Comparison between lidar and radiosondes measurements remain limited to low altitude (30-35 km). Nevertheless, this altitude zone is a critical one, because a number of sources of error may be present in this altitude range, in the temperature measurements by lidar. The principal drawback of balloon measurement is the inaccurate estimation of the geopotential altitude using pressure measurement, except when the altitude of the balloon is radar-monitored. Each time, these comparisons were possible, they show close agreement at 30-35 km with a difference of never more than 1 Kelvin. But as we have very few comparisons, this zone remains critic and the trend results below 35 km have to be considered with cautions.

From January to March 1990, during the DYANA (Dynamic Adapted Network for the Atmosphere) campaign at the CEL station, about 10 vertical temperature profiles were obtained simultaneously between 30 and 90 km by falling spheres and Rayleigh lidar. Statistical comparisons of those measurements revealed imperfections in the falling sphere technique. Specially a systematic bias at 65-75 km where the speed of the sphere passes from a supersonic to an subsonic speed, and a strong dispersion below 45 km where the sphere is affected by vertical winds due to its low speed (Lübken et al., 1992). Between the altitudes of 45 and 65 km, however, the two instruments register the same values with differences of less than 2 K with a 3 K statistical dispersion (95%).

For the largest part of the altitude range from 35 to 80 km, the Rayleigh lidar is the more precise instrument and its validation is actually very difficult as no standard instrument of equal precision is available. One solution for further validation consists in comparing temperatures obtained by two lidar operating simultaneously and at the same site. The french mobile station has allowed us since November 1991 at the OHP station to verify the quite perfect agreement between measurements taken by the two lidars situated on the same site. A very good agreement is also obtained with the NASA/GSFC lidar during the summer 1992 campaign at OHP as part of the NDSC intercomparison.

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