Long-distance non-linear propagation of ultrashort laser pulses in the atmosphere and Lidar applications

J. Kasparian, G. Méjean, J. Yu, E. Salmon and J.-P. Wolf
Teramobile Project, LASIM, UMR CNRS 5579,Université Lyon 1, 69622 Villeurbanne Cedex, France
R. Bourayou and R. Sauerbrey
Teramobile Project, Institut für Optik und Quantenelektronik, FSU Jena, Max-Wien-Platz 1, D-07743 Jena, Germany
Y.-B. André and A. Mysyrowicz
Teramobile Project, LOA, UMR CNRS 7639, ENSTA—Ecole Polytechnique, 91761 Palaiseau Cedex, France
H. Lehmann, B. Stecklum, U. Laux, J. Eislöffel, A. Scholz, A. P. Hatzes
Thüringer Landessternwarte Tautenburg (TLS), Sternwarte 5, D - 07778 Tautenburg, Germany
M. Rodriguez and L. Wöste
Teramobile Project, Institut für Experimentalphysik, FU Berlin, Arnimallee 14, D-14195 Berlin, Germany

The propagation of ultrashort lasesr pulses in the atmosphere is strongly non-linear. While horizontal propagation can be studied by moving detectors along the laser beam, the effect of the pressure and temperature gradient on vertical propagation has not been investigated so far. Installing the Teramobile laser, a mobile integrated system providing 5 TW peak power in 100 fs pulses[1], near to a 2 m astronomical telescope, we could for the first time image the femtosecond beam from the side up to altitudes of 25 km. The effect of the laser chirp on the supercontinuum generation was clearly demonstrated (Figure 1). Multiple scattering in a cloud layer, recorded in several spectral bands, permits a direct retrieval of the particle size distribution and density.

Spectroscopic measurements of the Lidar return were also performed, in the infrared as well as in the visible. Lidar signals were obtained up to 4 km in the 1.5-1.7 µm band, with a much steeper decrease than expected from previous laboratory measurements[2]. An acquisition of a broadband (680-920 nm) atmospheric absorption spectrum within a single Lidar acquisition was demonstrated, allowing a simultaneous retrieval of the humidity and temperature. This double measurement opens the way to multicomponent remote sensing, which should be a great advantage of white-light Lidars based on ultrashort lasers, we demonstrated recently by measuring ozone vertical profiles using a 80 nm-broad band signal in the UV to correct for the aerosol interference [3].

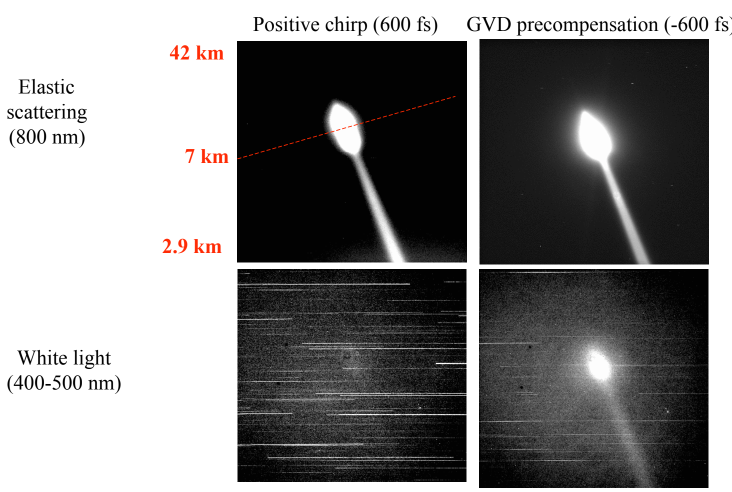

Figure. 1. Images of the fs-beam taken from the ground, in two spectral bands and for two laser chirp values

1. H. Wille *et al.*, European Physical Journal -Applied Physics, **20** (3), 183 (2002). See also www.teramobile.org
2. G. Méjean *et al.*, "*Towards supercontinuum-based white-light Lidar*", To be published in Appl. Phys. B. (2003) (DOI : 10.1007/s00340-003-1183-x)
3. J. Kasparian et al., Science 301, 61-64 (2003)