The development of the theoretical basics for the detection of clear air turbulence with the aid of airborne lidars

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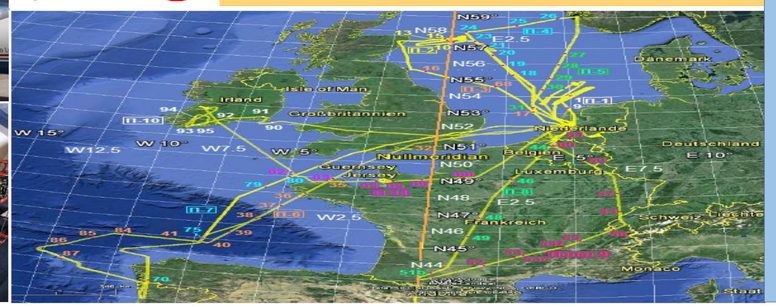
Aircraft length 14.4 m
Max. speed 220 m/s
Max. altitude~ 13 km
Optional equipment:
bow bar, UV window, laser cooling system, etc.

Lidar characteristics:

Development: DLR Receiver diameter: 14 cm
Wavelength: 355 nm Pulse width: 7 ns
Pulse frequency: 100 Hz Angular divergence of the beam: 0.2 mrad
Minimum detection distance 1.5 km Maximum detection distance of 15 km
2 receiving channels: co-and cross polarization
(corresponds to 1 - 1.5 minutes of flight)
Resolution 5 m

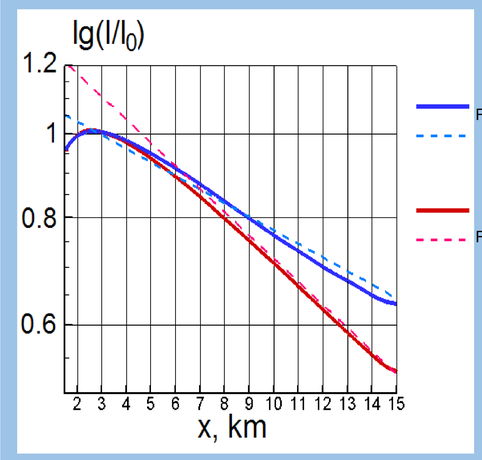
DELICAT - DEmonstration of LIdar based Clear Air Turbulence detection (2009 - 2013)



Project participants:

1. Thales Avionics - an international industrial group that produces information systems for aerospace, military and maritime applications.
2. CNRS - Center national de la recherche scientifique, France
3. DLR - German Aerospace Center, Germany
4. Hovemere, UK
5. Meteo France, France
6. NLR - Netherlands Aerospace Center, The Netherlands
7. ONERA - Office National d'Etudes et de Recherches Aerospatiales, France
8. INOE 2000 - National Institute for Research and Development in Optoelectronic, Romania
9. A.M. Obikhov's IAPh ., Russian Academy of Sciences, Russia (headed by ME Gorbunov)
10. Laser Diagnostic Instruments, Estonia
11. University of Warsaw, Poland
12. EADS- Innovation Works, Germany

Comparison of average relative intensities (solid lines) with relative intensities of molecular scattering (hatch) in areas free of aerosol

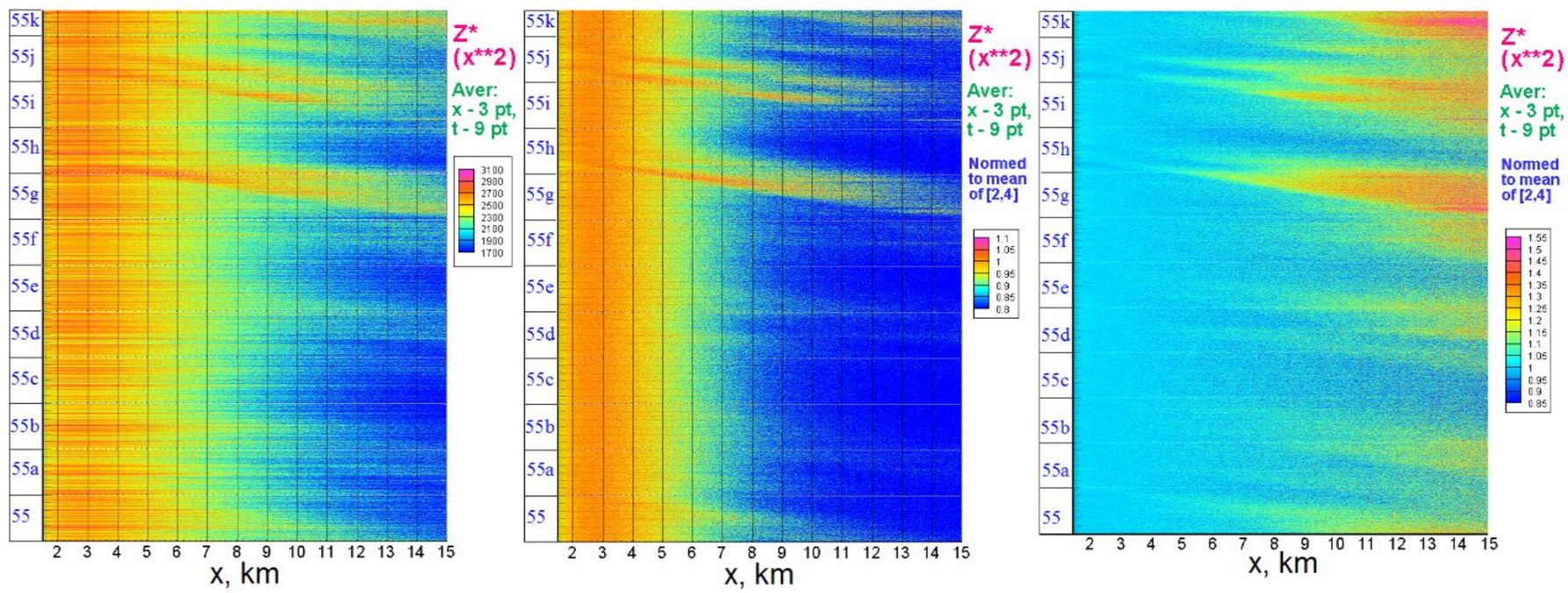


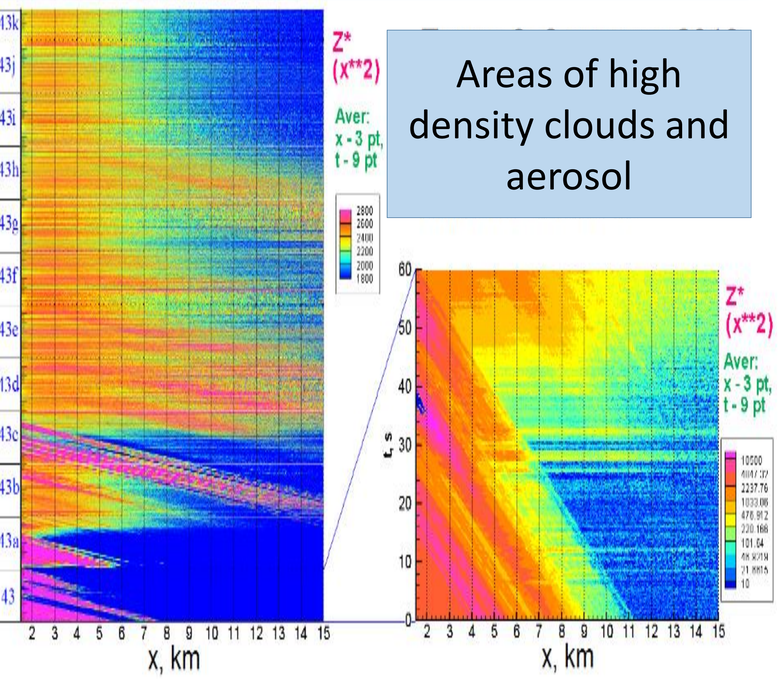
Flight 9, August 8, 2013, zone 21, UTC 20: 11: 18.95 - 20: 12: 18.94, altitude 9300 m

Flight 5, July 31, 2013, zone 8, UTC 15: 37: 09.38 - 15: 38: 09.36, altitude 7750 m

A data processing process that allows to see the fine structure of weak aerosol clusters (Flight 9-10, August 8-9, 2013), zone 21, UTC 20: 08: 18.95 - 20: 19: 53.95, height 9400 m

Baseline Normalization by average over the interval (2-4 km) Normalization to the sensitivity curve





Areas of high density clouds and aerosol

During the implementation of the DELICAT project, interesting data was obtained on the atmospheric aerosol at altitudes from 7.5 to 12 km. An overview of the measurement data in selected areas and their surroundings. Clusters of aerosol and, possibly, areas of turbulence are present in 14 of 27 zones, of which in 2 cases the clusters are weak, in 3 fairly powerful, in the rest - intermediate variants. The data allow us to estimate the characteristic dimensions of aerosol clusters (several km) and track their temporal evolution (lifetimes of 20–30 s). Outside the zones, in the areas of climb and descent, it is possible to obtain estimates of the vertical size of clusters, in some cases they reach 800 m.

REFERENCES

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2. 2. Gurvich A.S. and Kulikov V.A. Airborne lidar sounding of short-lived aerosol clusters // Atmospheric and Oceanic Optics. Vol. 29. P. 410-414.
3. Gurvich, A.S. and Kulikov V.A. Impact of pitch angle fluctuations on airborne lidar sensing ahead along the flight direction // preprint, Atmospheric Measurements Techniques. 2017. https://doi.org/10.5194/amt-2017-132.
4. Mamontov A.E. and Gurvich A.S. The study of the evolution of aerosol concentrations at altitudes of civil aviation // In EGU General Assembly Conference Abstracts. 2017. Vol. 19. P. 1520. 5. Федорова О.В., Коваль О.А., Мамонтов А.Е. Лидарные наблюдения строения и эволюции скоплений аэрозоля в проекте DELICAT. "Турбулентность, динамика атмосферы и климата". Москва, 16-18 мая 2018 г. Сборник тезисов докладов. М.: Физматкнига, 2018, 224 с. ISBN 978-5- 89155-2944. - с. 212.