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Pre-Launch Validation of the Wind-Lidar on ADM-Aeolus

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At present, our Information on the global wind field, especially over the Oceans and the southern hemisphere, is insufficient due to missing measurement data. However, a complete and accurate knowledge of the atmospheric wind field is of highest priority for numerical weather forecast. Thus, the European Space Agency (ESA) initiated the Atmospheric Dynamics Mission ADM-Aeolus, planning to use a satellite Doppler Lidar (light detection and ranging) for measuring globally the atmospheric wind field with high vertical resolution (250 m – 2 km) and accuracy (1-2m/s). The ADM-Aeolus mission is currently under development and the satellite launch is foreseen for 2014. For the pre-launch validation of the ADM-Aeolus measurement principle and the calibration and validation algorithms, an airborne prototype of the ADM-Aeolus instrument - called A2D - was developed by DLR (Deutsches Zentrum für Luft- und Raumfahrt). The A2D is the first airborne direct-detection Doppler lidar for atmospheric observations worldwide. Since the start of the Dragon 2 Programme in April 2008, several ground and airborne campaigns have been performed with the A2D instrument aiming to validate the ADM-Aeolus instrument. In September 2009, an airborne campaign over Greenland, Iceland and the Atlantic Ocean was conducted using two instruments, the A2D and a well-established coherent 2-µm lidar for aerosol and cloud backscatter as a reference system. Thus, two wind lidar instruments measuring Mie and Rayleigh backscatter in parallel were operated on the same aircraft. These airborne measurements were used to demonstrate the measurement principle and the calibration procedure of the ADM-Aeolus instrument. Via a statistical comparison of line of sight (LOS) winds the systematic and random error of the direct-detection wind lidar A2D was assessed, yielding -0.7 m/s and 1.9 m/s for the Rayleigh and 1.1 m/s and 1.3 m/s for the Mie channel, respectively. Furthermore, from January to March 2009, a ground campaign from a mountain observatory was performed to investigate the line shape of molecular scattered light in air. This work was important, as the knowledge of the line shape of molecular scattered light has a direct influence on the accuracy of the retrieved wind speed from ADM-Aeolus data. With the performed measurements it was shown that the line shape of scattered laser light in air can be adequately modeled by using a complex line shape model (Tenti S6 model). To be able to describe the line shape with the same accuracy but less mathematical complexity, an analytical line shape model was derived empirically. In addition, flight tracks over the Baltic and the Mediterranean Sea were performed to study the surface reflectance in the ultraviolet (UV) (the spectral region of the ADM-Aeolus instrument) for different incidence angles. The comparison of observed and modeled reflectance showed that the sub-surface reflectance must be included for UV wavelengths (in particular for a laser wavelength of 354.88 nm) and incidence angles larger than 15° as used for ADM-Aeolus. A summary of the obtained results from the performed ground and airborne campaigns will be presented.

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ADM-Aeolus中测风激光雷达的先期验证研究

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现在，我们获取的全球风场信息还是严重不足的，特别是海洋上空和南半球。一种完整和准确的大气风场获取技术对于数值天气预报是急需的。欧空局已开始了地球探测计划--大气动力任务（ADM-Aeolus），计划采用星载多普勒激光雷达技术测量全球风场，距离分辨率可达250m-2km，测量精度达1-2m/s。现ADM-Aeolus任务正在进行中，预计发射时间为2014年。为了先期验证测风系统的测量原理和改进校准和验证算法，德国空间中心DLR搭建了一套机载演示样机（A2D），该机载系统是国际上第一个应用于大气测量的直接探测机载多普勒激光雷达。自从2008年4月龙计划Ⅱ项目开始，A2D系统已经完成了多次地面和机载飞行测量实验，以验证具有相同测量原理的ADM-Aeolus测量设备。2009年，A2D系统进了格陵兰岛、冰岛和大西洋上空的飞行实验，并同步搭载了一套2μm相干激光雷达系统，以便进行气溶胶和云散射数据的参考比对。两部测风激光雷达在同一架飞机上同步测量，以实现ADM-Aeolus设备测量原理和校准算法的验证。通过A2D测量的视线风速误差统计分析，瑞利散射探测通道达到-0.7m/s-1.9m/s，米散射探测通道达到1.1m/s-1.3m/s。除此之外，从2009年1月至3月，我们在山峰上进行了一次地面测量实验任务，以研究空气中分子散射的线形，这项工作对于认识分子散射线形对ADM-Aeolus测量数据反演精度的影响具有重要的意义。 实验结果表明激光分子散射线形可以通过复杂的线形模式给出（Tenti S6模型），但为了简化数学复杂性，我们推导出了一个经验公式线形模型。另外，通过飞行实验数据，我们也研究了在Baltic和Mediterranean海域的激光海表面反射率（UV波段，ADM-Aeolus测量波段），测量结果和反射率模型的对比结果表明，在UV波段（特别是355nm激光波长）和入射角大于15°的情况下，水下散射贡献是不能忽略的。我们将会对多次地面和机载实验结果进行总结。

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