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Airborne Hyperspectral Skydome: A New Dimension for Hyperspectral Sensing

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The Natural Environment Research Council's (NERC) Strategy 'Next Generation Science for Planet Earth' identified the support of the development of new and innovative technologies for environmental science. This paper describes the development of an instrument supported by the NERC Technology Proof of Concept programme that will enable atmospheric parameters to be determined from a relatively unstable platform (e.g. aircraft, moving vehicle, ship).

The properties of the lower part of atmosphere, i.e. troposphere and stratosphere, are important in terms of weather, air pollution and global warming. For decades, the processes occurring in this region have been studied 1) to minimize the discrepancy between observations and models, and, 2) to understand their dynamics. Such information is also essential for the operational use of airborne hyperspectral imaging spectrometers (HIS). The planetary boundary layer above the altitudes at which survey aircraft fly plays an important role in radiative forcing, and is affected by the ground reflected spectral signature, e.g. Ozone, aerosol and water vapour. Furthermore, the atmosphere below the aircraft is highly variable over time and across space.

Airborne multi-channel and hyperspectral sunphotometers, such as the NASA AATS14 showed the potential of such instruments to make in situ measurements over large areas, filling in the gap between ground-based and spaceborne observations. Flexible operational height also helps to reconstruct realistic details of atmospheric conditions in both temporal and spatial aspect. Like conventional ground-based sunphotometers, NASAs airborne version involves complicated moving parts. It requires higher maintenance cost and, more importantly, takes time for a single probe to scan the entire sky. Simpler multi-channel hemispheric spectral radiometers are used with a number of HIS, however, the range of information from such instruments is limited.

The novel design in the skydome spectrometer addresses the limitations of existing systems. The main features of the new instrument are 1) no moving parts for reliable operation, 2) instantaneous VNIR hyperspectral measurements with fine angular distribution of diffuse radiance over the sky dome regardless of platform motion, and 3) an algorithm to retrieve the direct-beam solar radiance, total diffuse irradiance, aerosol properties and atmospheric gases, made possible by the unique design of the instrument.

The presentation covers both feasibility tests of theoretical based algorithm and comparing results from in situ measurements that demonstrate the new concept. Numerical sensor model (SM) was developed to simulate the instrument and experiment with retrieval algorithms and for application development. A prototype Engineering Model (EM) was in completion and first ground based field campaign is conducted next to an AERONET site. The SM takes into account various parameters of the expected operation range of the instrument with atmospheric conditions. It also helps not only to demonstrate the capability of retrieving useful atmospheric parameters as an alternative means of sunphotometer with benefit of operating on unstable platform, but also to show how the new development contributes to wider applications in Earth Observation. It concludes with discussion about future applications and collaboration plans with the new instrument in research organisations and institutes.