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TIDAS-SPU: Development and testing of a system for infrared FTS imaging of the atmosphere

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Recent missions studying the Earth's atmosphere have successfully made extensive use of thermal infrared spectrometers. Examples of ESA instruments which have contributed to this success include the Infrared Atmospheric Sounding Interferometer (IASI) and the Michelson Interferometer for Passive Atmosphere Sounding (MIPAS). These instruments have helped to significantly advance the field of Earth observation, producing excellent scientific and operational products and driving new science. Follow-on instruments based on these concepts are therefore highly desirable, as is reflected by proposals currently in place for both operational and research future missions. There is potential within these concepts to exploit recent advances in detector manufacturing which have seen a shift in production towards two-dimensional (2D) arrays rather than single detectors.

Instrument simulation studies have already examined the potentially revolutionary advantages that the development of an imaging thermal infrared spectrometer could bring to an Earth observation mission. For example, it has been demonstrated that an infrared limb imaging spectrometer would be able to retrieve truly three-dimensional data fields of gravity waves (Preusse et al. AMT 2009; Ungermann et al. AMT 2010), which perform a key role in controlling atmospheric composition in the upper troposphere and lower stratosphere. A further advantage offered by an infrared imaging limb spectrometer would be the ability to image cloud cover in parallel with retrieving trace gas and temperature profiles. It has been estimated that the associated improvement in spatial coverage could double the number of retrievable profiles from limb observations of the mid-troposphere upwards (Adams et al. AMT 2009). The feasibility of such an instrument has been investigated by Friedl-Vallon et al. (Advances in Space Research 2006), who concluded that the requirements are demanding but feasible with state of the art technology, and are currently working on an aircraft-based version of their instrument concept (GLORIA-AB).

The practical issues regarding the transition from a signal detector to a 2D detector array and the associated back-end signal processing still require some attention, however, even if the concept has been shown to be theoretically possible. The CEOI (Centre for Earth Observation Instrumentation) TIDAS-SPU (Thermal Infrared Detector Array System and Signal Processing Unit) study has focused on the development and test of a demonstration concept for a 2D thermal infrared detector array system and associated signal processing unit. It has brought together components and expertise from a number of industrial and academic partners: EADS-Astrium have designed and supplied the signal processing unit; Selex-Galileo provided the study with a Hawk model detector array and interface electronics board; STFC-RAL provided FTS technical support, allowed use of their spectrometer (a Bruker IFS-66) and designed the mechanical interface between the detector array and the spectrometer; and the University of Leicester have guided the science requirements, as well as leading the integration and testing of the system.

The design of the system is described here in detail, with emphasis on the simulation of instrumental limitations such as noise, modulation efficiency and lineshape. This part of the study then provided a basis for evaluating the performance of the laboratory demonstrator. We also outline the signal processing chain programmed into the SPU electronics, which employs the Brault sampling system to re-interpolate the recorded interferograms onto regular optical path difference grids, prior to on-board spatial co-addition and Fourier transformation into radiance spectra. Finally we describe the experimental setup used to test the system, and present some preliminary measurements of ammonia absorption spectra. We anticipate that the findings from this study will help improve the future development of satellite-based infrared imaging FTS systems, and

create opportunities for the development of novel ground- and aircraft-based atmospheric measurement techniques.