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INVESTIGATING THE USE OF LINEAR VARIABLE FILTERS FOR GAS DETECTION ON EARTH OBSERVATION INSTRUMENTS

Abstract

The objective of this work was to study the applicability of Linear Variable Filter technology in Earth Observation instruments, as well as to look at extending their wavelength range. The hope was that this technology might enable the design of a miniaturised gas detection instrument suitable for CubeSats. Three applications were examined with wavelengths of interest shown in parentheses: firstly nitrogen dioxide (430-450nm) then the climate gases carbon dioxide (1.6um and 2.1um) and methane (1.6um) and then finally the chemical weapons gases Sarin (8.5-13um) and Sulphur Mustard (8-14um).

Detector technologies appropriate to each band was selected resulting in the choice of a CMOS detector for nitrogen dioxide and an Indium Gallium Arsenide or Mercury Cadmium Telluride detector for the carbon dioxide and a Mercury Cadmium Telluride detector for the methane and Sarin and Sulphur mustard applications. A survey of the commercially available linear variable filters was performed and the best performing ones were selected.

Absorption features and in some cases specific spectral channels are usually used to identify gases, by quantifying their signal relative to the noise of the instrument. An analytical model was therefore developed to take an input spectral radiance from a scene with and without the gas in question and to

pass it through a radiometric transfer model of the optical system and a detector model to produce the flux from the scene. This could then be appraised to determine if the SNR ratio was sufficient to be able to identify the gas above the background noise. The scenes used as inputs to the climate gas and nitrogen dioxide models were generated by the SCIATRAN radiative transfer model. The scenes used as inputs to the Sarin and sulphur mustard models were generated by dispersion modelling and use of the Reference Forward Model.

The outcome of this study was that whilst the LVF approach initially looked promising, for each area there are different technology limitations with no obvious development path. For the nitrogen dioxide detection, the limiting factor is that the available Linear Variable Filters do not have sufficiently narrow bandwidth (FWHM). For climate gas detection, the setup was not able to achieve sufficient signal to noise ratio on the detector without large apertures. For chemical weapons gas detection, there is a necessity for cooling a Mercury Cadmium Telluride detector and it is not available in a suitably large 2D format to work with a Linear Variable Filter.