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Greenhouse Observations of the Stratosphere and Troposphere (GHOST): a novel shortwave infrared spectrometer developed for the Global Hawk unmanned aerial vehicle

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The tropospheric distribution of greenhouse gases (GHGs) is dependent on surface flux variations, atmospheric chemistry and transport processes over a wide range of spatial and temporal scales. Errors in assumed atmospheric transport can adversely affect surface flux estimates inferred from surface, aircraft or satellite observations of greenhouse gas concentrations using inverse models. We present a novel, compact shortwave infrared spectrometer (GHOST) for installation on the NASA Global Hawk unmanned aerial vehicle to provide tropospheric column observations of CO_2, CO, CH_4, H_2O and HDO over the ocean to address the need for large-scale, simultaneous, finely resolved measurements of key GHGs. These species cover a range of lifetimes and source processes, and measurements of their tropospheric columns will reflect the vertically integrated signal of their vertical and horizontal transport within the troposphere. The primary science objectives of GHOST are to: 1) provide observations which can be used to test atmospheric transport models; 2) validate satellite observations of GHG column observations over oceans, thus filling a critical gap in current validation capabilities; and 3) complement in-situ tropopause transition layer tracer observations from other instrumentation on board the Global Hawk to provide a link between upper and lower troposphere concentration measurements. The GHOST spectrometer system comprises a target acquisition module (TAM), a fibre slicer and feed system, and a multiple order spectrograph. The TAM design utilises a gimbal behind an optical dome, which is programmed to direct solar radiation reflected by the ocean surface into a fibre optic bundle. The fibre slicer and feed system then splits the light into the four spectral bands using order sorting filters. The fibres corresponding to each band are arranged with a small sideways offset to correctly centre each spectrum on the detector array. The spectrograph design is unique in that a single grating and detector is used for all four spectral bands. The whole instrument is housed within a liquid nitrogen cooled cryostat to ensure thermal stability. We summarise the GHOST project and its objectives, and will provide a detailed overview of the instrument concept, development, and proposed deployment on board the Global Hawk.