OPTIMIZING BAND SELECTION FOR THE COMET INTERCEPTOR MIRMIS/TIRI THERMAL INFRARED MODULE. K. A. Shirley[1] (katherine.shirley@physics.ox.ac.uk), N. E. Bowles[1], R. Evans[1], K. L. Donaldson Hanna[2], B. T. Greenhagen[3], A. Näsilä[4], T. Kohout[4], T. D. Glotch[5], C. Howe[6], and G. H. Jones[7], [1]Department of Physics, University of Oxford, UK, [2]Department of Physics, University of Central Florida, Orlando, FL, USA, [3] Johns Hopkins Applied Physics Laboratory, MD, USA, [4]VTT Technical Research Centre of Finland Ltd., Espoo, Finland, [5]Geosciences Department, Stony Brook University, NY,USA, [6]STFC RAL Space, Didcot, UK, [7]MSSL, University College London UK.

Introduction: Multispectral infrared radiometers are ideal for studying both thermophysical and compositional properties of a planetary surface as shown by the current Diviner Lunar Radiometer Experiment onboard NASA's LRO and the MASCOT Radiometer on JAXA's Hayabusa2 mission [1,2], and are currently proposed for numerous upcoming planetary missions including Comet Interceptor, Lunar Trailblazer, and MANTIS [3-5]. These missions have similar goals for thermophysical and compositional analysis, however, their operating scenarios and targets vary widely. Therefore, band selection optimization on a mission by mission basis is vital. New instrument designs [e.g. 3,4] allow for variable numbers of bandpass filters, so selection needs to be balanced between scientific goals and instrument performance.

Here, we focus on the upcoming ESA Comet Interceptor mission, specifically the Thermal InfraRed Imager (TIRI) as part of the Modular Infrared Molecules and Ices Sensor (MIRMIS) module [6], to explore strategies for optimizing bandpass selection based on possible operating scenarios against science return. Comet Interceptor [7,8] aims to be the first mission to a dynamically new comet, with the target likely to be determined after launch. As a result, the scientific instrumentation needs to be able to return useful data from a wide range of possible encounter velocities (e.g. 10 - 80 km/s) and associated instrument integration times.

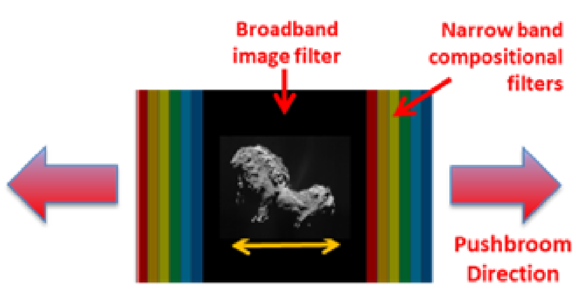

Figure 1. Layout of the filter focal plane for the MIRMIS/TIRI module. A broadband thermal imaging channel (7 -14 µm) is located in the center of the field of view with narrow band compositional channels at either side (Image credit: ESA).

The MIRMIS/TIRI module: The MIRMIS/TIRI baseline design includes a broadband thermal imaging channel (e.g. 7-14 µm) and up to 11 narrower compositional bands, covering the wavelength range 6 – 25 µm (Figure 1). As part of Phase 0/A activities, the spectral position of the compositional channels is currently under investigation.

Initial band position estimates: One of the main MIRMIS/TIRI objectives is to characterize the bulk composition and thermophysical properties of the comet nucleus surface. To optimize compositional detection, we are examining laboratory data sourced from several spectral libraries of anticipated minerals/rocks, and ices to create a range of likely surface composition spectra.

Rock/mineral spectra used in this study include whole rock and particulate samples (< 250 µm) of Tagish Lake, a carbonaceous (C2) type meteorite [9], pyroxenes [10], and hydrated clays [11]. Ice/gas spectra considered include water, carbon dioxide, carbon monoxide, and methane ices [12]. These materials were chosen to be broadly representative of possible comet nucleus compositions, drawing on previous spectral analysis of the Rosetta and Stardust missions [13,14], which identified primitive minerals like pyroxene and olivine.

As an initial example, locations of 7 TIRI bands were chosen based on prominent spectral features within the 6-25 µm range including emission peaks for carbon dioxide ice, methane ice, and silicate mineral Christiansen features, as well as silicate minima within the Reststrahlen bands. These preliminary simulated bands and the compositions they are sensitive to are shown in Table 1.

Spectra were linearly mixed to create possible comet compositions then down-sampled to this 7-band resolution. Figure 2 shows an example of equal amounts of the three ice spectra mixed in proportions with the Tagish Lake meteorite spectrum. The initial bands tested here do well at identifying the methane and carbon dioxide ice features despite their low spectral proportions. However, the low spectral contrast of the Tagish Lake component makes for difficult rock composition detection. Further test cases will compare band locations with a higher mineralogic focus as spectral analysis from VIRTIS indicated a lack of ice on the surface of Comet 67P [13].

Band Center (μm)	Band Center (cm^{-1})	Target Feature
7.0 ± 0.10	1428.6 ± 20	CH_4 ice
7.7 ± 0.12	1298.7 ± 20	CH_4 ice
8.5 ± 0.14	1176.5 ± 20	Silicate Christiansen feature
9.0 ± 0.16	1111.1 ± 20	Silicate Christiansen feature
9.8 ± 0.19	1020.4 ± 20	Silicate Reststrahlen band
14.9 ± 0.44	671.1 ± 20	CO_2 ice
19.3 ± 0.77	518.1 ± 20	H_2O/CO_2 ice

Table 1. Locations for 7 TIRI bands for initial encounter example.

Ongoing Work: A breadboard of the TIRI module is currently (January 2020) under development at the University of Oxford including an infrared detector performance study. These initial band positions (Table 1) will be used for estimates of radiometric performance and then optimized further as part of the TIRI module's Phase 0/A study.

This work represents a portion of a much larger study due to the complex nature of this project and the wide range of encounter scenarios for Comet Interceptor. Further investigations will include: (a) channel optimization for encounters at > 50 km/s where shorter (e.g. ~8 ms) integration times on target will favor broader (e.g. ~ 150 cm^{-1}) channels; (b) optimization for encounter velocities < 50 km/s where the longer integration times (e.g. ~50 -100 ms) allow narrower compositional channels (e.g. 40 – 80 cm^{-1}) and (c) combined observations using all the MIRMIS channels covering 0.9 to 7 μm.

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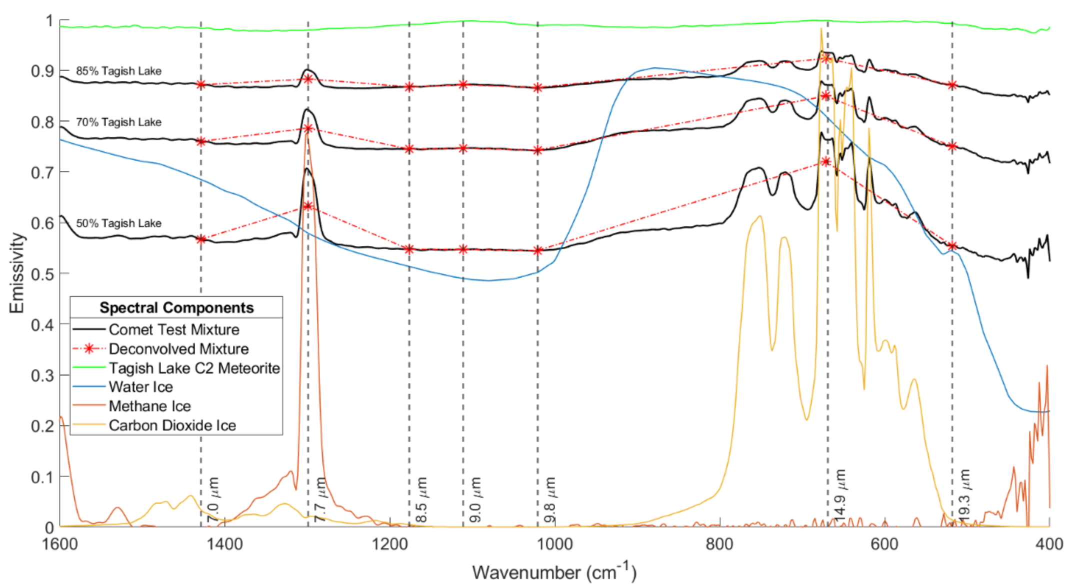

Figure 2. Full resolution laboratory spectra of the endmember components (colors) and mixtures (black), and the down-sampled mixture spectra (red). The Tagish Lake spectral component is listed and ice spectra are mixed in equal amounts for the remaining percentage.