INTENSITY-BASED REGISTRATION FOR PLANETARY CARTOGRAPHY: APPLICATION TO NEW HORIZONS LEISA APPROACH SCANS OF PLUTO. L. R. Gabasova[1], B. Schmitt[1], W. Grundy[2], C. B. Olkin[3], J. R. Spencer[3], L. A. Young [3], K. Ennico[4], H. A. Weaver[5], S. A. Stern[3], and the New Horizons Composition Team; [1]Université Grenoble Alpes, CNRS, IPAG (Grenoble, France, leila.gabasova@univ-grenoble-alpes.fr), [2]Lowell Observatory (Flagstaff, AZ, USA), [3]SwRI (Boulder, CO, USA), [4] NASA Ames Research Center (Mountain View, CA, USA), [5]JHU-APL (Laurel, MD, USA).

Introduction: In order to compare or combine multiple spatially resolved datasets, they must be co-registered in the same coordinate system. In planetary science this comes into play when comparing data measured with different sensors, at different spatial resolutions, or at different times or locations.

When co-registering multiple 2D datasets, i.e. images, a 'target' or 'fixed' image is selected, generally the one at the highest spatial resolution, and the other 'source' images are transformed to match the target. Remote sensing data is most frequently registered using feature-based methods, where distinctive objects or regions are identified in the images either manually or automatically, and attempts are made to match the feature locations between the target and source images [1]. The transformations used can be global, where operations such as translation, rotation, scaling or shear are uniformly applied to the entire image, or local, i.e. defined by a deformation field that varies in effect across the image.

Feature-based registration is limited in its efficacy when it comes to datasets which don't present sharply delineated features. This is the case for the surface composition maps of Pluto produced using the pre-closest approach New Horizons LEISA datasets: their spatial resolution is low and the value transitions are gradual, and so any attempt at feature mapping is arbitrary and imprecise. However, these pre-approach scans are the only data we have of Pluto's far hemisphere, and so co-registering them with the high-resolution closest approach data is necessary in order to produce a complete compositional map of Pluto. In order to do this, we adapt intensity-based registration methods from those frequently used in the medical field.

Intensity-based registration involves comparing intensity patterns in the images to be registered. Different metrics can be used to evaluate their similarity, such as cross-correlation, mutual information, or sum of squared intensity differences. Intensity-based registration is a very common tool in medical imagery processing, where it's used for MRI or CT images [2]. This means most toolkits developed for intensity-based registration are designed around medical uses, but are very easily adapted to planetary data.

Methods: We process 13 approach cubes in order to have complete global coverage, with native pixel resolutions ranging from 30 to 304 km/px. The highest-resolution of these is registered using the closest-approach high-resolution data as a target image and each subsequent cube is registered to the one above it in resolution order (e.g. second-highest resolution to highest, third-highest to second-highest, etc.). This is done to maximise overlap between the source and target images and provides overall more accurate registration, despite the risk of error propagation.

The LEISA hyperspectral datacubes are captured over a short time, which means the same transformation matrix will be applicable to all wavelengths. This means we can calculate the transformation matrix using a subset of the datacube – one which features large contrasts and clear patterns – and apply it to all the other wavelengths. The CH_4 ice map produced by [3] using the integrated band depth of the 1.7 μm band group has precisely these properties, and serves as the basis for the registration.

We combine intensity-based registration algorithms from Matlab and ITK (Insight Segmentation and Registration Toolkit, an open-source library). As we expect the misalignment between the datasets to be due entirely to imprecisions in the spacecraft pointing information, we restrict ourselves to global similarity transformations (i.e. translation, rotation, and scale). We use an evolutionary algorithm-based optimizer and a Mattes mutual information metric [4].

Preliminary results: We verify the registration accuracy using a small number of control points based on identifiable features (see Figure 1). With 60% of the cubes processed so far, the results are accurate to better than 1 pixel of each cube's native resolution.

The complete set of compositional maps (CH_4, N_2, CO, H_2O, red material) will be shown and compared with the MVIC slope and CH_4 maps [5] at the meeting. Its geological and climatic implications will also be discussed.

References: **[1]** B. Zitova and J. Flusser. *Image and vision computing*, 21(11):977–1000, 2003. **[2]** J. P. W. Pluim, et al. *IEEE transactions on medical imaging*, 22(8):986–1004, 2003. **[3]** B. Schmitt, et al. *Icarus*, 287:229–260, 2017. **[4]** D. Mattes, et al. In *Medical imaging 2001: image processing*, volume 4322, pages 1609–1621. SPIE, 2001. **[5]** A. M. Earle, et al. *Icarus*, 314:195–209, 2018.

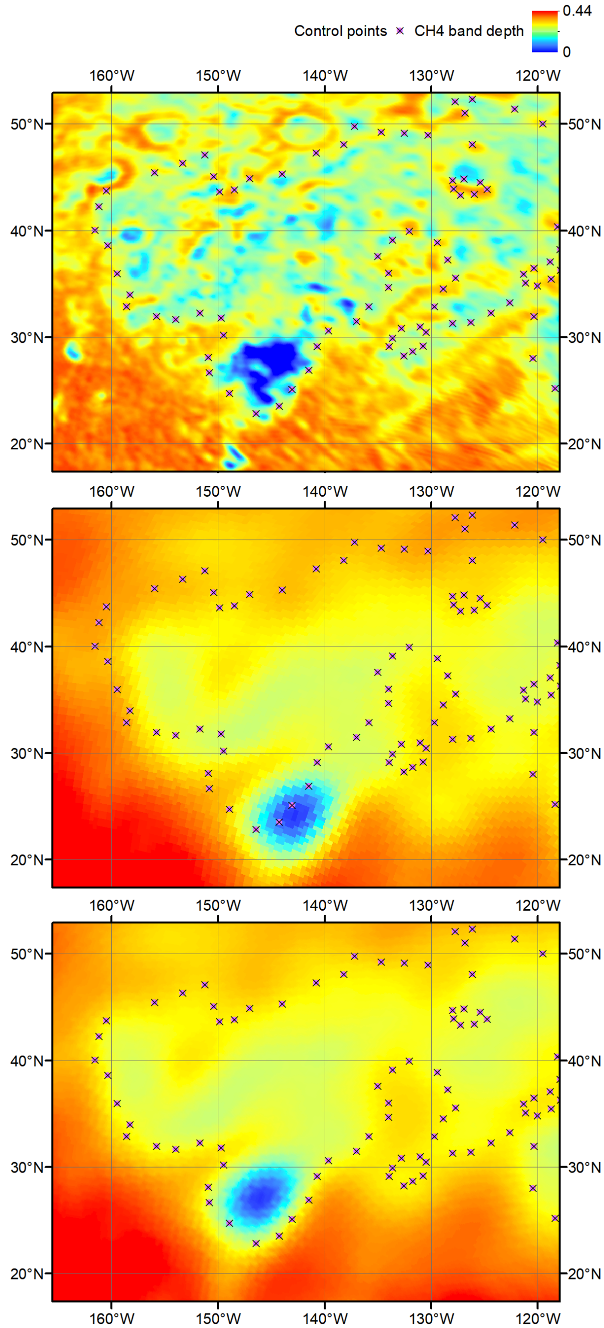

Figure 1: Example of intensity-based registration results for the Pluto CH_4 1.7 μm band depth map, showing the Pulfrich crater area. Top: high-resolution image, center: unregistered lower-resolution image (MET=299127869, native resolution 30 km/px), bottom: registered lower-resolution image.