National Aeronautics and Space Administration

Role of water rich surface ice features in cometary activity in 67P

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Program: Innovative Spontaneous Concept

Project Objective:

JPL's MIRO (Microwave Instrument on the Rosetta Orbiter) spectrometer on *Rosetta* [1] monitored simultaneously the outgassing and the subsurface temperatures of a comet nucleus providing an ideal data set to study if water ice is present in the dusty surface layers. Images [2], however, suggest surface ice patches are typically smaller than the beam size of MIRO. Our objective was to develop a deconvolution technique to improve our ability to retrieve the thermal properties of the surface on smaller scales, and study ice sublimation/gas emissions from regions containing water ice or frost patches.

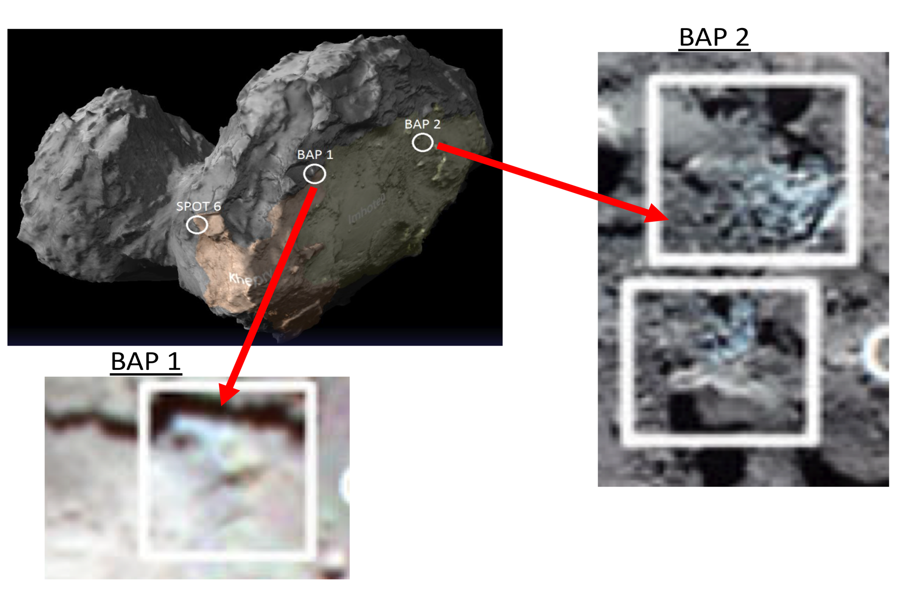
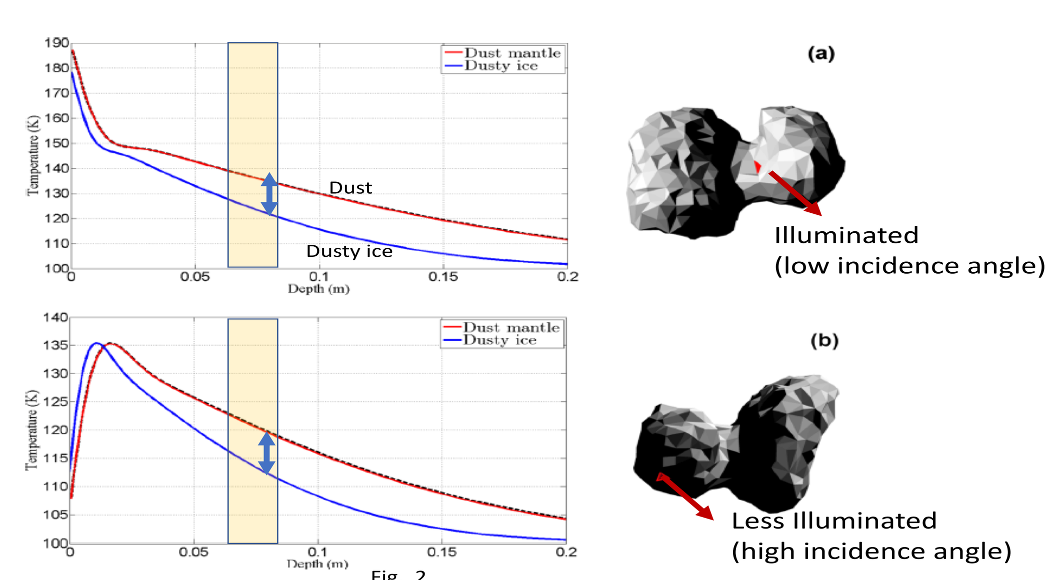


Fig. 1

Fig. 1 Long lived ice patches selected for study. The main image shows their location on a nucleus shape model. Insets are images of the ice patches BAP1 & BAP2 observed on 2014 Sept 05 [2,3]. The box sizes in the insets are approximately 200m x 200m.

Fig. 2 Sub-surface nucleus temperature profiles from a thermal model at two locations, (a) well illuminated, and (b) less illuminated [4]. The red curve are for surfaces of pure dust, the blue are for ice-dust mixtures. The shaded area represents the sub-surface layers probed by the MIRO *mm & submm* bands. Note the decrement in surface temperature when ice is present.



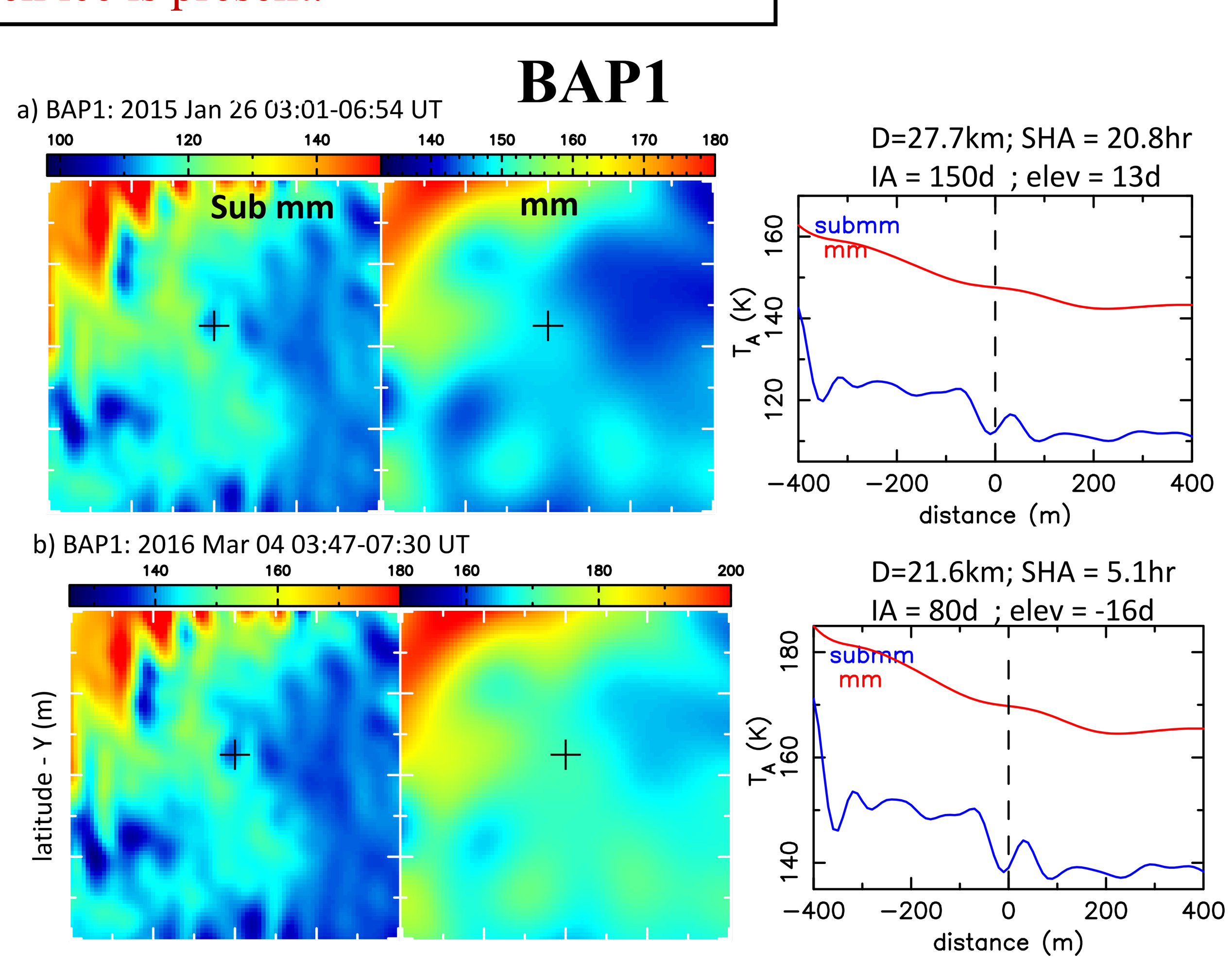


Fig. 4

FY18/19 Results:

- To study the characteristics of ice patches as observed in the MIRO *mm & submm* continuum emission maps we identified two regions, namely, BAP1 & BAP2 [2] which are shown to contain long lived ice patches [2,3] (see Fig. 1).
- Thermal modeling [4] for surface layers with dust and dusty ice, show a decrement in the sub-surface temperature between the dust and dusty ice cases, ~ 10 K in illuminated regions and ~ 5K in less illuminated regions (see Fig. 2), suggesting it is possible to delineate the ice patches using MIRO *mm* & *submm* temperature maps.
- Searching MIRO data when the comet distance to the space craft was less than 30 km, we identified map data at 4 epochs for the BAP2 region and at two epochs for BAP1.
- For comparison with image data, MIRO scan data were re-projected, correcting for nucleus rotation during the several hours required to generate a MIRO map, and deconvolved to account for the MIRO beam shape.
- Our results are summarized in Figures 3 & 4. The temperature maps show a local minimum near the ice patches qualitatively consistent with the model shown in Fig. 2.
- Our MIRO results produced as fits images will be useful for more detailed analysis including MIRO spectrometer data on gas emissions and other instruments on *Rosetta.*

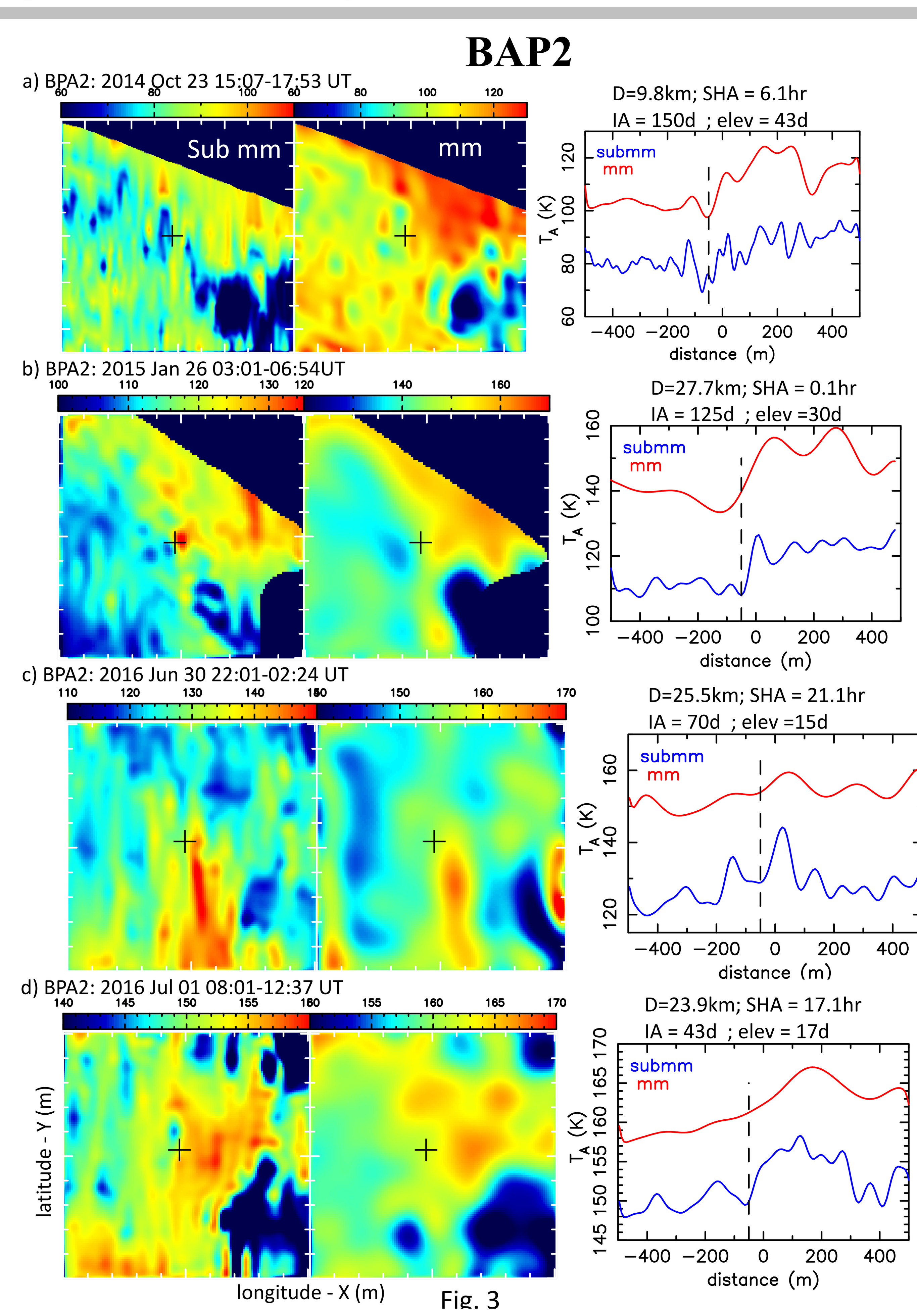


Fig. 3

Figs 3 & 4 MIRO temperature maps in *mm & submm* bands of the BAP1 (longitude = 118° & latitude = 13°) & BAP2 (longitude = 180° & latitude = -4°) regions containing ice patches. The maps are shown as projected on the surface of the nucleus with X- and Y- axes along the longitude and latitude. The extent of the map region is 1 km X 1 km (BAP2) and 800m x 800m (BAP1). The epoch of the map is shown at the top of image panels. The cross marks the ice patch. The color bar represents the temperature scale. The right panels show the temperature profile across the ice patch (center) along the X-direction. The dashed lines highlight the ice feature. The relevant observational parameters are listed: distance to comet from the space craft (*D*); local Solar hour angle (*SHA* , noon at 12hr, and midnight at 0 or 24 hr); solar incidence angle (*IA* , degrees) defining the solar illumination; solar elevation (*elev* degrees) defined as sub-solar latitude – latitude of the ice patch.

Benefits to NASA and JPL (or significance of results):

We demonstrated the observability of ice patches in the MIRO *mm & submm* maps as a depression in the surface temperatures caused by the presence of ice. Our result is important to JPL's exploration of the solar system bodies, looking for near surface ice and to the design & mapping strategies of new ultra-compact MIRO-type spectrometers & radiometers.

Refrences:

[1] Gulkis, S., Frerking, M., Crovisier, J., et al. 2007, "MIRO: MICROWAVE INSTRUMENT FOR ROSETTA ORBITER", Space Sci. Rev., 128, 561

[2] Filacchione et al. 2016," Exposed water ice on the nucleus of comet 67P", Nature, 529,368

[3] Oklay et al. et al., 2017, "Long-term survival of surface [1] water ice on comet 67P", MNRAS, 469, S582

[4] Hu, X., et al. 2017," Thermal modelling of water activity on comet 67P/ with global dust mantle and plural dust-to-ice ratio", MNRAS, 469, S295

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