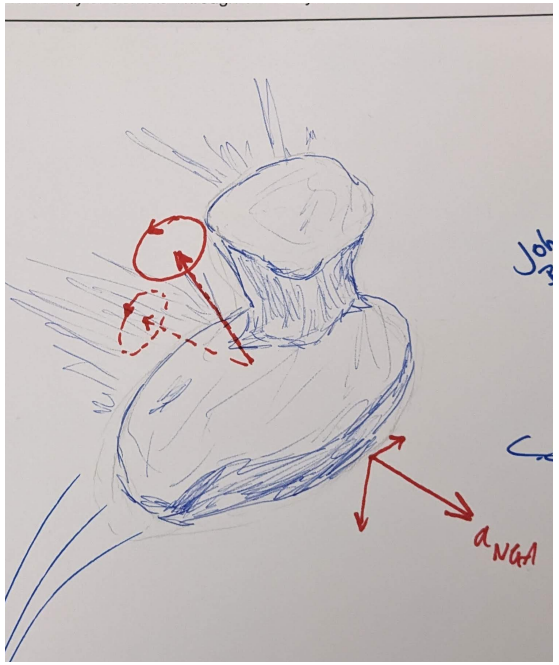
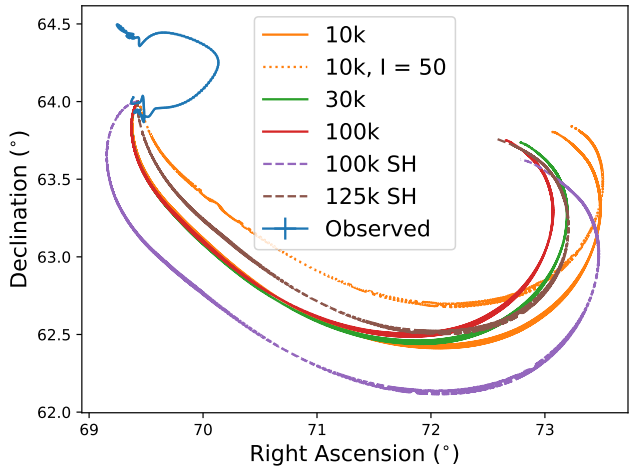
Results of ISSI team #547: Understanding the activity of comets through 67P's dynamics



1 Part of the team, plus a cartoon of outgassing induced NGA/T. Credit: N. Attree & J Bürger.

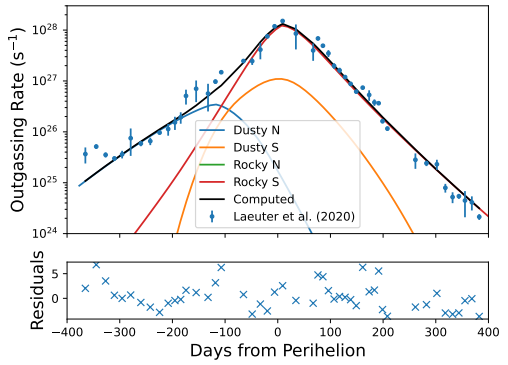
Introduction: This team investigated comet 67P's thermal environment[1] and orbit[2]. We then modelled their interaction through the non-gravitational acceleration (NGA) and torque (NGT) induced by the thermal outgassing, and used this to constrain comet thermophysical[3] and activity models[4].

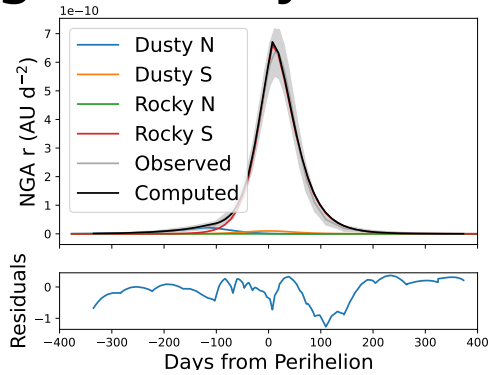


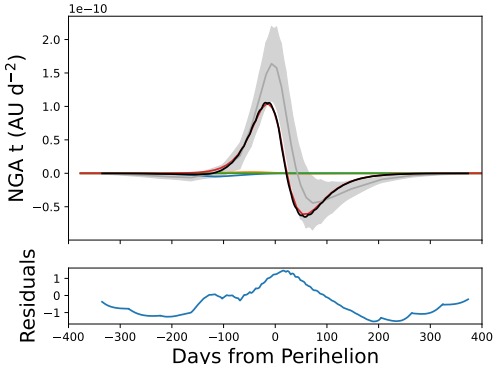
2 Change in the direction of 67P's spin axis observed by ESA/Rosetta and computed with a simple surface outgassing model[4]. In no case (for various shape-model resolutions, with and without facet self heating, SH, and thermal inertia, I) is spatially uniform activity able to reproduce the observations.

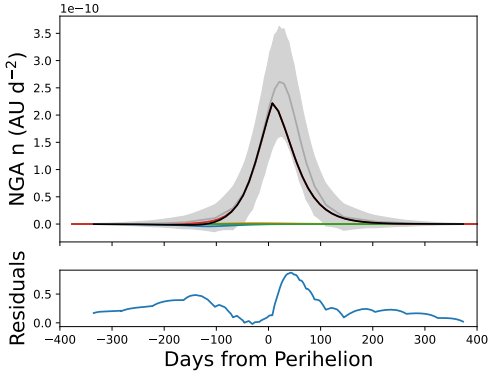
Best-fit (solution two[4]) of a model with spatially and temporally varying outgassing and spatially varying momentum transfer efficiency. Data are, from top left, 67P's: total water production rate, radial, tangential, and normal cometocentric NGA components[1], NGT z component, and spin axis direction (not fitted for).

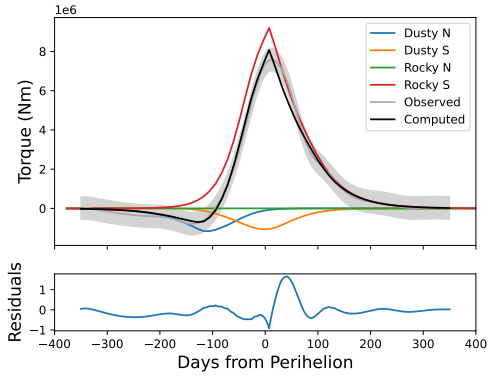
3

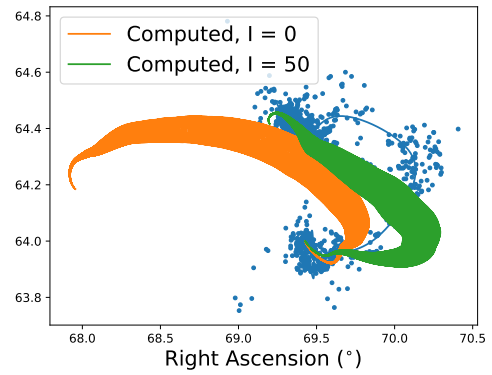












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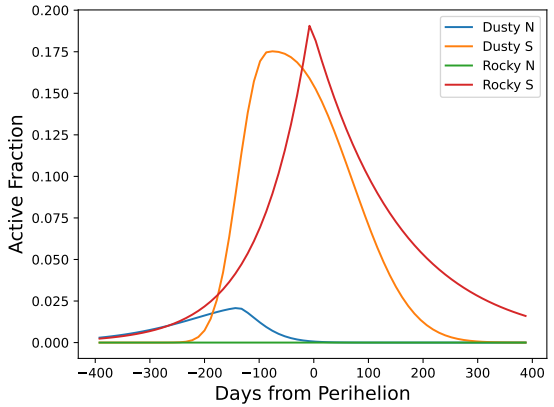
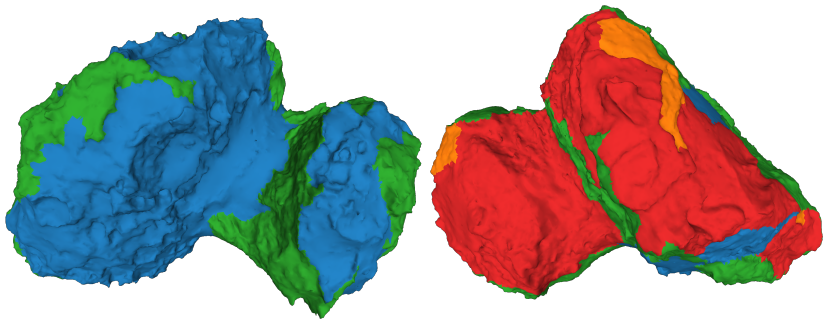


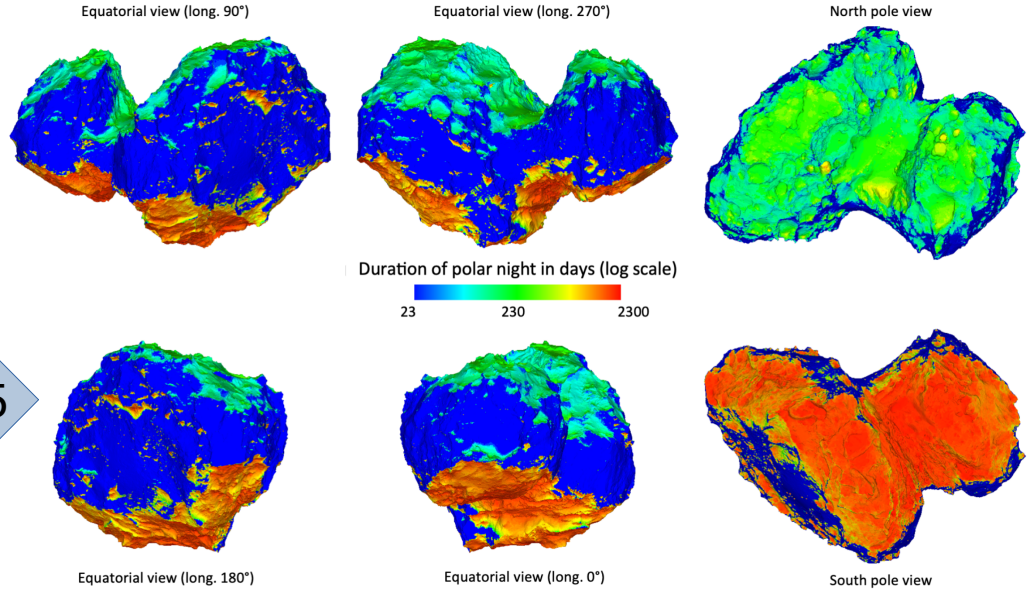


η

Solution	Dusty N	Dusty S	Rocky N	Rocky S
One	0.56	0.15	0.12	0.62
Two	0.85	0.10	0.10	0.57

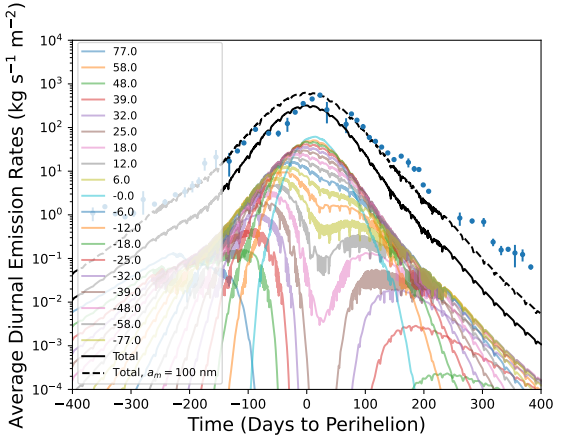
4

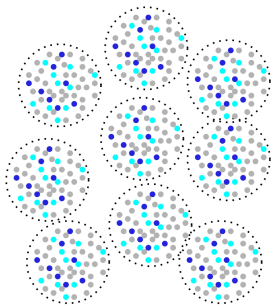
Best-fit (solution two[4]) regions shown on the shape model along with their time-varying activity, relative to a pure water-ice surface, and their momentum transfer efficiency, η.



5

67P's axial tilt leads to very strong seasons, shown here by the duration of polar night[1]. The southern hemisphere also experiences very strong heating during its polar day.





6

Total water outgassing rate of a complex 1D thermophysical model[3] computed for 19 latitudes on a spherical representation of 67P. This model assumes a comet made up of ~cm sized pebbles (right) with the ices contained inside, but the fit to the Rosetta data is not as good as the empirical model presented in Fig. 3. top left.

Conclusions: 67P's outgassing pattern is complex and varies in space and time. Comparing the NGA/T solution with the thermal maps shows that some of the variation can be explained by its strong seasons and peculiar shape. However, differences between areas that have otherwise similar illumination conditions or morphology are still required to explain the data. These variations may come from the long-term effects of the seasons processing the nucleus material.

[1] Groussin et al. 2024 submitted, A&A [2] Lasagni Manghi, R., Zannoni, M., Tortora, P., Budnik, Frank Godard, B., & Attree, N. in Conference proceeding for the 2024 AAS/AIAA Astrodynamics Specialist Conference, EAAS24–33 [3] Attree, N, Schuckart, C, Bischoff, D, Gundlach, B, Blum, J. Localised ejection of dust and chunks on comet 67P/Churyumov-Gerasimenko: testing how comets work, MNRAS 2024, stae2315 [4] Attree, N., Gutierrez, P., Groussin, O., Burger, J., Keller, H.~U., Kramer, T., Lasagni Manghi, R., Lauter, M., Lemos, P., Markkanen, J., Marschall, R., Schuckart, C.. Varying water activity and momentum transfer on comet 67P/Churyumov-Gerasimenko from its non-gravitational forces and torques, A&A 2024, 690, A82

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