MINI-OUTBURSTS IN COMETS CHURYUMOV-GERASIMENKO AND TEMPEL 1. M. F. A'Hearn[1], J.-B. Vincent[2] and the OSIRIS team, [1]University of Maryland (Dept. of Astronomy, College Park MD 20742-2421; ma@astro.umd.edu), [2]Max-Planck-Institut für Sonnensystemforschung.

Introduction: The long-duration Rosetta mission at comet 67P/Churyumov-Gerasimenko (C-G) has allowed us to observe frequent mini-outbursts in dramatically more detail than outbursts have ever been observed previously. The only other comet for which frequent mini-outbursts are known is 9P/Tempel 1 (T1), for which most of the outbursts were observed very much further from the comet, during the two-month, high speed approach [1-3]. In this work we will compare the observed properties of the outbursts in the two comets in order to determine whether the process is likely to be similar on both comets. For both comets, most of the outbursts are observed only in broad-band filters and the images are dominated by sunlight reflected from grains. There are few observations of gas associated with the outbursts.

Outburst Timing and Location: For both comets, the outbursts have been observed only within a few months of perihelion (August 2015), with one exception having been observed in March of 2015. For C-G there are sufficient pre-perihelion observations at large distance to say that such outbursts are at least rare if not non-existent more than several months prior to perihelion. Unfortunately, for T1, there are no relevant observations outside the two-month, pre-perihelion window, so we can only infer that it is plausible that both comets exhibit frequent mini-outbursts only near perihelion.

For C-G the outbursts can often be traced to the surface and they are typically within ±20° of the sub-solar latitude, occurring during both day and night but with a preference for the morning sunlit hours. For T1 the situation is not as clear, but apparently similar. Belton et al. determined the great circles along which the outbursts must occur (using the projection of the material onto the sky plane) and provided two interpretations, one based on the intersection regions of the great circles and the other based on the local surface density of the great circles (even if they do not intersect) with slightly different results. After updating the locations deduced in [3. to the improved coordinate system derived after the Stardust NExT flyby (a shift of the pole by 8°) [4] and find that the locations are all within ±20° of the sub-solar latitude with the exception of a single outburst.

On C-G the outbursts usually occur in daylight but they also occur during the night. The two interpretations of the locations by Belton et al. are very different in the time of day of the outbursts – the interpretation as crossings of the great circles leads to them occurring in both day and night, while the interpretation as the highest surface density of tracks has them occurring only in the mid-morning and in the evening (near local sunset).

Outburst Duration. For both comets, the outbursts are characteristically of short duration. Outbursts on C-G appear to decay away typically in tens of minutes, rarely lasting as much as an hour. On T1 they appear to decay more slowly (sometimes being observable for more than an hour, but that difference is almost certainly due to the larger spacecraft range of the observations and the consequently longer transit times for slowly moving dust grains. We infer that the durations are very similar for both comets.

Activity drivers. The observations of parent volatiles during the outbursts are sparse for both comets. For C-G the primary reason for the lack of correlated spectroscopic data is due to pointing and the relative .fields of view of the primary remote sensing spectrometers – ALICE, MIRO, and VIRTIS. An isolated example with ALICE (Feldman and A'Hearn private communication) shows a night-side outburst that is FOLLOWED by CO emission on the night side only. Other outbursts for which the ALICE slit is well-placed show nothing obvious. ALICE did observe outbursts not associated with the outbursts seen by OSIRIS and some of these may be driven by CO_2 while others are almost certainly driven by near-nucleus plasma changes (Feldman et al. 2015). For T1 only the outbursts very close to the encounter were seen with sufficient spatial resolution and thus brightness to be measured with the infrared spectrometer on Deep Impact. The outburst two days prior to encounter was observed to be enhanced in CO_2 both in absolute terms and relative to water, which was unchanged in the outburst [6].

Amplitude: For both comets, the amplitudes of the outbursts span a wide range, exceeding a factor 10.

Conclusion: All data currently available and analyzed are consistent with a common process for mini-outbursts between the two comets so that we can combine the obxervations to better understand the process and we can use the unprecedented data from C-G to extrapolate to other comets.

References: [1] A'Hearn, M. F. et al. (2005) *Science*, 310, 258. [2] Farnham, T. L. et al. (2007) *Icarus*, 187, 26. [3] Belton, M. J. S. et al.(2008) *Icarus*, 198, 189. [4] Thomas, P. et al. (2013) *Icarus*, 222, 453. [5] Feldman, P. D. et al. (2015) *A&Ap*, 583, A8. [6] Moretto, M. et al, in prep.