ASYMMETRY OF GASEOUS CO_2 AND H_2O IN THE INNER COMA OF COMET TEMPEL 1.

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Introduction: Deep Impact (DI) encountered comet 9P/Tempel 1 on July 4th, 2005, continuously monitoring the coma for 15 days prior to impact with the HRI-IR spectrometer. Infrared spectra of the coma, 1-5μm, were acquired every 4 hours during the approach phase and more frequently leading up to impact. Gaseous CO_2 and H_2O emission bands at 4.26μm and 2.66μm, respectively, are detected in these spectra [1]. The distribution of the gas in the inner coma was mapped and an asymmetry was found in both the CO_2 and H_2O. The CO_2 is more prevalent in the southern coma, while the H_2O is more prevalent in the sunward direction. The ratio of CO_2 compared to H_2O is over a factor of 2 larger in the southern, anti-sunward direction than in any other region. Further study of this asymmetry will give insight to the chemistry of the near-nucleus ambient coma as well as the anisotropic outgassing of the nucleus.

Observations: The pre-impact coma observations include data with spatial resolution of 120 km/pixel improving to better than 160 m/pixel minutes before impact. The infrared data were typically acquired as spatial scans across the comet nucleus, with each spatial pixel having a unique spectrum. The data highlighted in this abstract are part of a 64 frame north-to-south scan of the comet 10 minutes prior to impact. The data include signal from the northern and southern coma. (The anti-saturation filter in the spectrometer, required to limit the thermal contribution of the nucleus, introduces artifacts during the data analysis and is to be studied in more detail in the future.) A spatial image of the data can be made at any of the observed wavelengths. Figure 1 shows the data in the 2μm band, oriented such that ecliptic north is up and the sun is to the right.

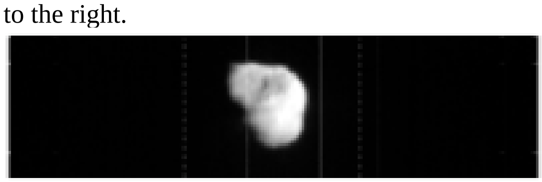

Figure 1. 2μm spatial map of comet 9P/Tempel 1 from the 64 frame north-to-south scan acquired 10 minutes prior to impact. North is up and the sun is to the right.

The spectra associated with these data have three components [2], a visible continuum at shorter wavelengths due to reflected solar light, a thermal continuum at longer wavelengths due to the thermal radiation of the nucleus and dust, and emission/absorption bands of species found at the comet as can be seen in Figure 2.

Distribution of the Coma: Asymmetries in the OH in comae have been detected in a handful of comets [3,4]. The OH in the coma of comet 2P/Encke, for example, has an asymmetry along the comet-sun line, with more OH in the sunward direction. No asymmetries have ever been noted in CO_2, due in part to the limited space-based detections [5,6,7]. DI data are the first in which the distribution of the inner coma can be studied in detail at 1/10th of a kilometer scale.

Spatial Maps. The top and middle panels of Figure 3 are maps of the distribution of the CO_2 and H_2O gas, respectively. They are created from the continuum-removed, integrated, line flux over the spectral range of 4.18-4.32μm and 2.55-2.76μm, respectively. Several pixels of continuum flanking the emission bands are averaged together and fit with a line in order to subtract the continuum. There is more CO_2 in the southern coma as compared to the northern coma, possibly implying that active outgassing regions are chemically heterogeneous. Thermal lag and a subsurface gradient of CO_2/H_2O could also contribute to this asymmetry. The map of H_2O emission shows a near-nucleus (within 5-10 km of the nucleus) enhancement in the sunward direction. In regions beyond 10 km from the nucleus and in the anti-sunward direction, the H_2O distribution is much more uniform. A ratio of the CO_2/H_2O flux is shown in the bottom panel of Figure 3. The ratio is highest in the southern, anti-sunward direction, increasing by more than a factor of 2 in this region as compared to the other regions surrounding the nucleus.

Spectral Analysis. The spectra presented in Figure 2 complement the spatial distribution maps. Four representative spectra are shown in this figure, 2 for the northern coma and 2 for the southern coma. Each spectrum is a resistant mean of 30 by 4 spatial pixels to increase the SNR. All 4 regions were selected to be on the anti-sunward side of the nucleus where the water abundance is most uniform. The "near coma" regions are 5-10 km from the nucleus, while the "far coma" regions are 10-15 km from the nucleus. (The spectrum of the 0-5 km region is not presented here due to the complications from the anti-saturation filter.) In the regions of uniform H_2O distribution, the CO_2/H_2O ratio is much larger in the southern coma, with the greatest enhancement in the "near coma" as opposed to the "far coma".

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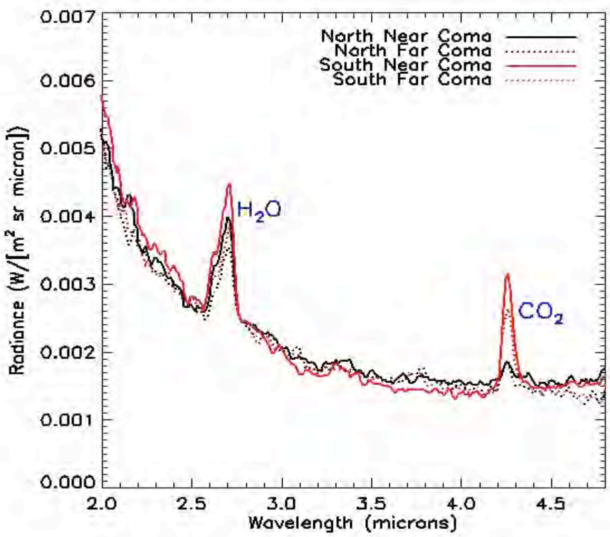

Figure 2. Spectra of the ambient coma of 9P/Tempel 1. 4 spectra are displayed and correspond to the anti-sunward coma 10 minutes prior to impact. The black lines are northern coma (solid 5-10 km from the nucleus and dotted 10-15 km from the nucleus); the red lines are of the southern coma. H_2O and CO_2 are clearly visible in the spectrum. The CO_2 flux is greatly enhanced in the southern coma.

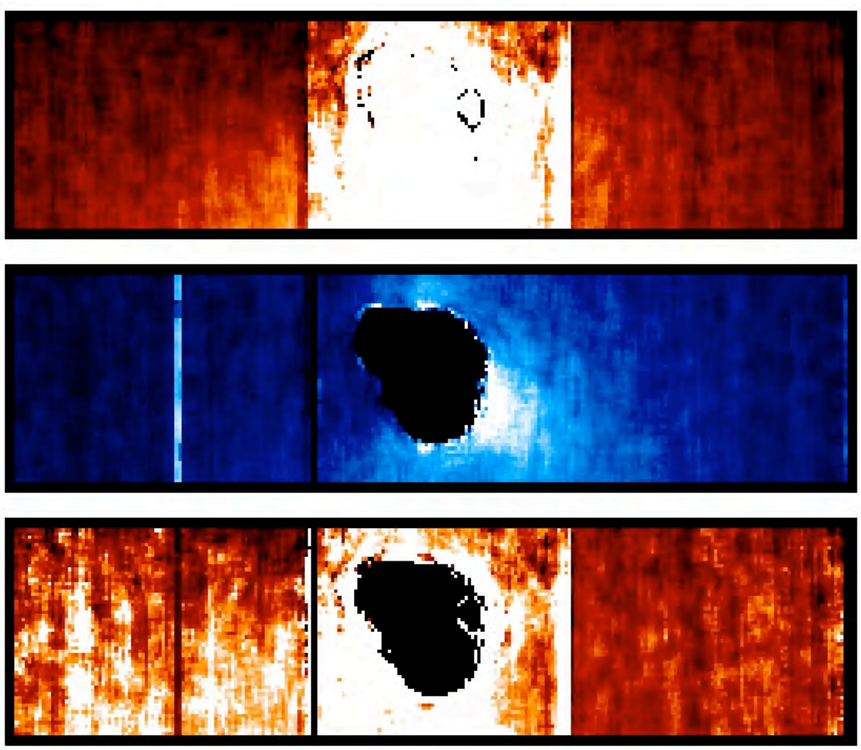

Figure 3. Top panel is the spatial distribution of CO_2, with an enhancement in the southern direction. Middle panel is a map of the H_2O distribution with a sunward enhancement. Bottom panel is the ratio of CO_2/H_2O. Same orientation as Figure 1. Heavily saturated pixels in the center of each panel are due to the anti-saturation filter as explained in the text.