HIGH-RESOLUTION OBSERVATIONS OF THERMAL EMISSION FROM THE SOUTH POLE OF ENCELADUS. J. R. Spencer[1], C. J. A. Howett, A. J. Verbiscer[2], T. A. Hurford[3], M. E. Segura[3], and J. C. Pearl[3], [1]Southwest Research Insitute, 1050 Walnut St. Suite 300, Boulder CO 80302, [2]Dept. of Astronomy, University of Virginia, Charlottesville, VA 22904, [3]NASA-Goddard Space Flight Center, Greenbelt, MD 20771.

Introduction: Endogenic thermal emission from the active "tiger stripe" fractures [1] in the south polar region of Enceladus was discovered by the Composite Infrared Spectrometer (CIRS) instrument on the Cassini spacecraft [2] during Cassini's July 2005 flyby of Enceladus [3]. Those initial observations were limited in wavelength coverage (9 – 16 µm only) and spatial resolution (complete coverage at 25 km resolution, plus sparsely scattered observations at 6 km resolution). Seven flybys between March 2008 and August 2010 have greatly improved our knowledge of the thermal emission. During this period CIRS has obtained many spectral image cubes using its "FP3" (9 – 17 µm, 600 – 1100 cm^{-1}) and "FP4" (7 – 9 µm, 1100 – 1500 cm^{-1}) detectors, including full south polar coverage at ~6 km resolution and maps of a few selected regions at ~1 km resolution. In addition, many 16 – 500 µm (20 – 600 cm^{-1}) spectral scans with ~10x lower spatial resolution have been taken by the CIRS "FP1" detector.

The examples shown here represent a small fraction of this very rich data set.

Spectral Distribution and Temperatures: Discrete spectral features have not been identified in the tiger stripe thermal emission spectra. Spectra can be well fit with combinations of blackbodies at different temperatures occupying a small fraction of the detector field of view (Fig. 1). Multiple observations show peak best-fit blackbody temperatures in the brightest parts of the tiger stripes in the range 180 – 200 K, with few reliable temperature fits warmer than 200 K. Assuming the warm source is an unresolved linear region, its width can be determined from the best-fit filling factors: in the brightest regions (Fig. 1, B) temperatures > 180 K occupy a total width 100 m or less (Fig. 1, B).

Spatial Distribution: Emission is present along the full length of the tiger stripe fractures (Fig 2. Right). There are large variations in intensity along strike: intensity varies smoothly at ~6 km resolution. The brightest regions are along Baghdad Sulcus near the south pole and Damascus Sulcus near longitude 300 W (Fig. 2, right). The highest-resolution observations of the brightest part of Damascus, taken in August 2010 (Fig. 2, left) show that most of the emission is concentrated within 0.4 km of the center of the Sulcus. It is not possible from the CIRS data to determine whether the ~100 m total width of the emission determined from the spectral fits (Fig. 1) results from a single fracture, or multiple parallel fractures within the 0.8 km field of view of the detector.

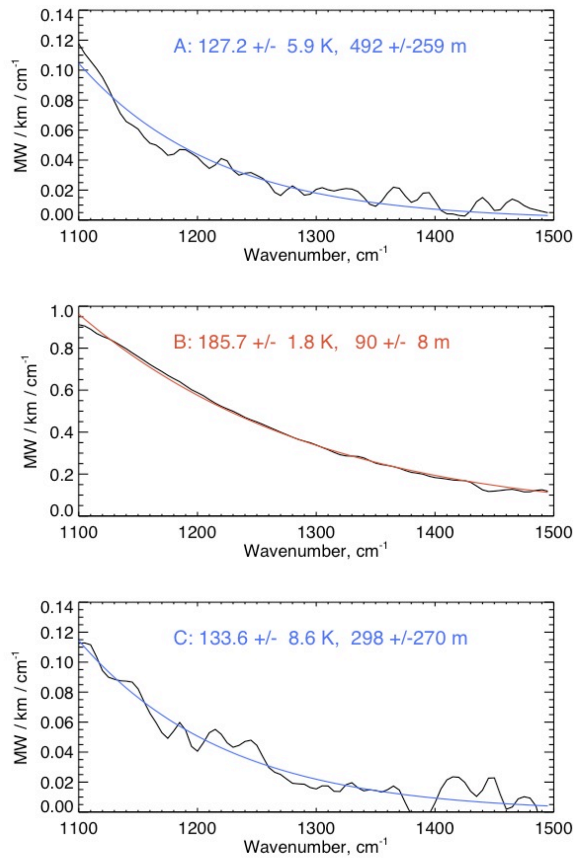

Figure 1. Spectra of emission from selected 0.8 x 2 km regions along Damascus Sulcus near its brightest part (Fig. 2) taken by the CIRS FP4 detector in August 2010. Region B is centered on the Damascus Sulcus fracture, while regions A and C flank the fracture on either side. Best-fit black body spectra, are shown, along with their temperatures and equivalent widths, assuming a linear geometry for the emission source. All discrete spectral features are due to noise.

The August 2010 data show that significant emission is also present in pixels adjacent to those centered on Damascus Sulcus (Fig. 2, left, and Fig. 1, A,C). Pre-flight mapping of the spatial response of the FP3 and FP4 detectors [4], and in-flight observations, rule out the possibility that this "flanking" emission is an instrumental artifact. Best-fit temperatures of the flanking radiation are near 130 K, lower than in the center of the tiger stripes (Fig. 1, A,C), and occupy a larger fraction of the field of view.

Temporal Variability The 2.5-year time span of these observations, combined with earlier low-resolution observations, allows constraints to be placed on the time variability of the thermal emission. While earlier data [5] show little temporal variability in total south polar emission between July 2005 and November 2006, there are indications of temporal variability in the more recent data: these indications are still being explored.

Discussion: The observed thermal emission is probably brought to the surface by the flow of vapor and ice particles that generates the plumes, along near-vertical fractures [3,5,6,7]. The fractures themselves are likely to be less than a few meters wide [6,7], much less than the inferred width of the emission source, so most observed emission probably results from heat conducted from the fracture to the surface on either side of the fracture [6]. However, single fractures cannot easily conduct enough heat to match the emission intensity along the brightest fractures [6,7], and multiple parallel fractures may be required. Indeed, the highest-resolution ISS images (Fig. 2, left) appear to show multiple fractures in the interior of the parts of the tiger stripes. Simple conductive models [6] predict that surface temperatures should drop below 100 K within 100 meters of an active fracture, and thus cannot explain the August 2010 observations of radiation from the flanks of Damascus Sulcus, which is many hundred meters from the center of the Sulcus. These new data will thus enable refinement of models for the delivery of heat to the surface, and improved constraints on subsurface conditions.

References: [1] Porco, C. P et al. (2006) *Science*, **311**, 1393–1401. [2] Flasar, F. M. et al. (2004) *Space Science Rev.* **115** 169–297. [3] Spencer, J. R. et al. (2006) *Science*, **311**, 1401–1405. [4] Nixon, C. A. et al. (2008) *Appl. Optics.* **48** 1912–1925. [5] Nimmo, F. et al. (2007) *Nature* **447** 289–291. [6] Abramov, O. and Spencer, J. R. (2009) *Icarus* **199** 189–196. [7] Ingersoll, A. P. and Pankine, A. A. (2010) *Icarus* **206** 594–607. [8] Spitale, J. N. and Porco, C. P. (2007) *Nature* **449** 695–697.

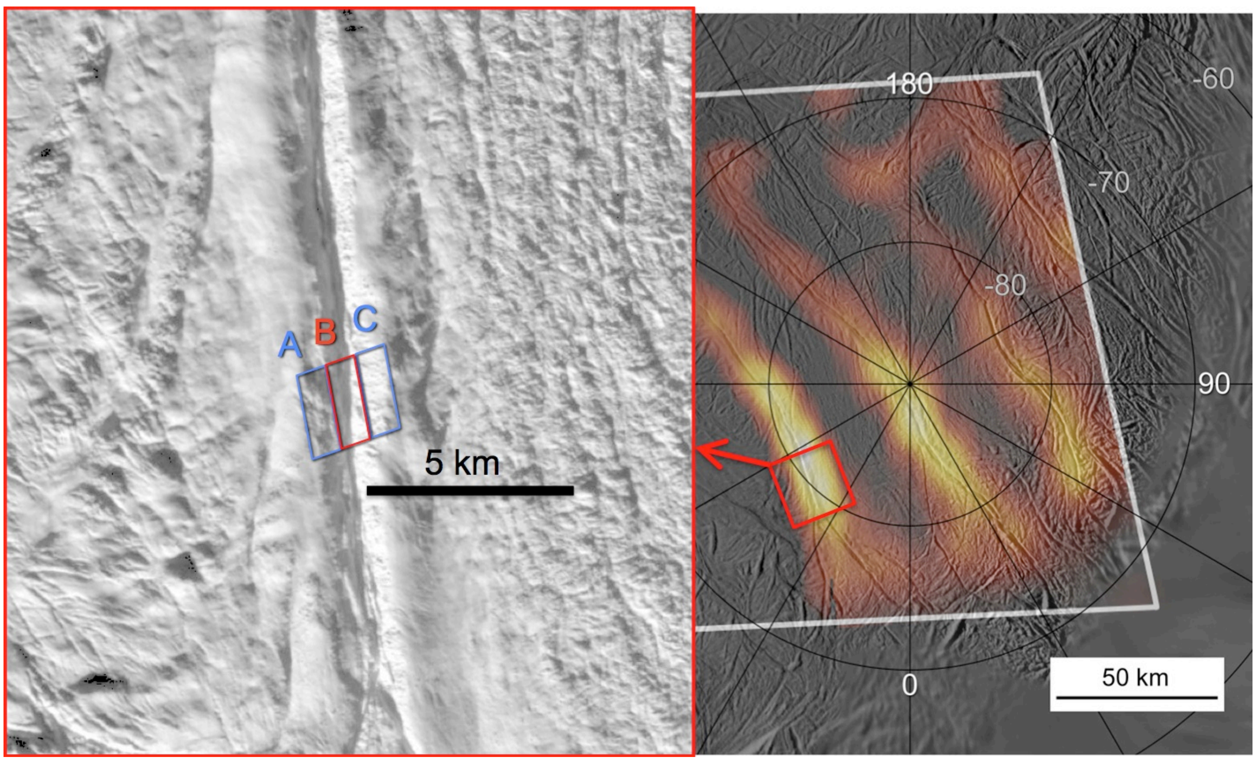

Figure 2. Right: Map of thermal emission along most of the tiger stripe system, taken by the CIRS FP3 detector in March 2008, with ~6 km spatial resolution. The background is a map based on Cassini ISS images obtained in July 2005. The location of the left-hand panel is shown by the red rectangle. Left: An enlargement of the brightest region of Damascus Sulcus, the left-most tiger stripe in the right panel, centered near the source of plume II [8]. The parallelograms show the approximation locations of the three spectra shown in Fig. 1, obtained in August 2010. The background image is an ISS image taken in August 2008.