SERIAL OBSERVATIONS OF COMETS USING IR SPECTROSCOPY: IMPLICATIONS FOR ASTROBIOLOGY. M. A. DiSanti[1], M. J. Mumma[1], Boncho P. Bonev[1,2], Geronimo, L. Villanueva[1,2], Lucas Paganini[1,2], Erika L. Gibb[1,3]. [1]Goddard Center for Astrobilogy, Code 690, NASA-Goddard Space Flight Center, Greenbelt, MD (michael.a.disanti@nasa.gov), [2]Department of Physics, Catholic University of America, Washington, DC, [3]Department of Physics and Astronomy, University Missouri – St. Louis, St. Louis, MO.

Introduction: High resolution spectroscopy of comets at IR wavelengths (principally 2.8 – 5.0 µm) is a powerful tool for characterizing the chemical abundances of ices contained in their nuclei. These abundances encode information pertaining to conditions in the formative epoch of our Solar System, and building a taxonomy of comets based on volatile composition reflects differences in physical and/or chemical conditions in the nascent environment ([1]-[3]).

Taxonomic studies reveal a range of compositions among comets, however for the most part observations of individual comets represent mere snapshots of their activity rather than studies over a range of heliocentric distances (R_h). They are also typically conducted at R_h approaching or often exceeding 1 AU, with relatively few comets observed over a range of R_h (e.g., Figure 1). This can bias our interpretation for comets having heterogeneous compositions, or for instances in which one or perhaps more additional sources of volatile release become activated at smaller R_h, e.g., from grains heated in the cometary atmosphere (i.e., the coma).

The apparition of dynamically new, sun-grazing comet C/2012 S1 (ISON) in 2013 afforded serial IR measurements from beyond R_h = 1 AU to within 0.35 AU. In addition to H_2O, eight trace volatiles were measured with the high spectral resolution ($\lambda/\Delta\lambda \sim$ 25,000) facility spectrometers NIRSPEC at Keck 2 and CSHELL at the NASA-IRTF (Figure 2; [4]). Several molecules (CO, C_2H_6, CH_4, CH_3OH; Fig. 2a) showed little if any evidence for evolution in their abundance ratios with decreasing R_h, while NH_3, H_2CO, and HCN showed pronounced increases for R_h < 0.5 AU (Fig. 2b-2d). These latter three molecules are precursors of particular importance to Astrobiology – H_2CO is linked to sugars, and HCN and NH_3 to amino acids/proteins – and their potential delivery to the young Earth is of keen interest.

Near-future Capabilities: Due to limited solar elongation, studying comets at smaller R_h often requires daytime observations – in the IR, the IRTF offers a unique capability in this regard. A powerful new facility spectrometer (iSHELL) will replace CSHELL in early 2016 and provide greatly increased efficiency in characterizing the volatile composition of comets [5]. We will present examples for optimizing its use, and discuss implications for Astrobiology.

References: [1] Mumma, M. J. and Charnley, S. B. (2011) *Ann. Rev. Astron. & Astrophys.*, 49, 471-524. [2] DiSanti, M. A. and Mumma, M. J. (2008) *Planet. & Space. Sci.,* 138, 127-145. [3] Bockelée-Morvan, D., Crovisier, J., Mumma, M. J., Weaver, H. A. 2004, in Comets II, M. C. Festou, H. U. Keller, and H. A. Weaver (eds.), University of Arizona Press, Tucson, p. 391. [4] DiSanti, M. A., et al. 2015, *Astrophys. J.* (submitted). [5] Rayner, J., Bond, T., Monnet, M., Jaffe, D., Muller, G., and Tokunaga, A. (2012) SPIE, 8446, 12pp.

Acknowledgements: This work was supported through the NASA Astrobiology, Planetary Astronomy, and Planetary Atmospheres Programs, and the National Science Foundation. M.D. acknowledges Strategic Science support through the Planetary Sciences Division at NASA-GSFC, for his role in the Comet ISON Observing Campaign.

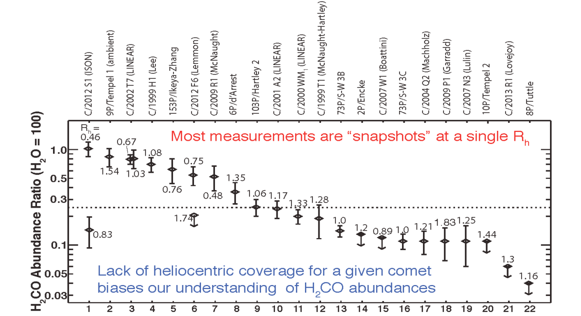

Figure 1. Abundance ratios of monomeric formaldehyde (H_2CO/H_2O) measured in 22 comets, expressed as a percentage of water production and with heliocentric distances indicated for each measurement.

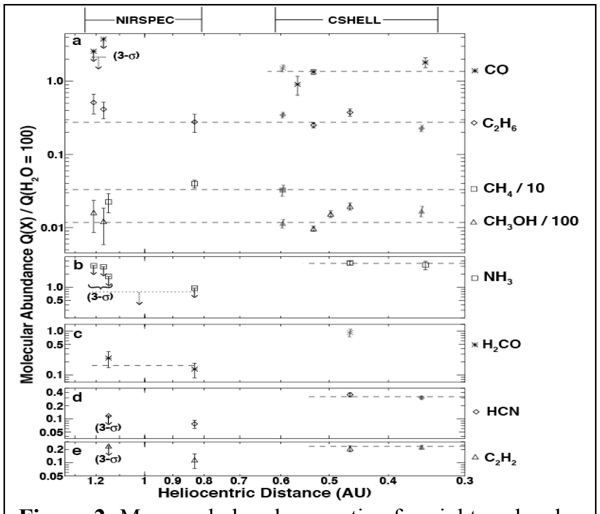

Figure 2. Measured abundance ratios for eight molecules in comet C/2012 S1 (ISON).