Ice Giant Atmospheric Structures from Spitzer and How the James Webb Space Telescope will Advance Our Understanding. N. Rowe-Gurney[1,2,3,4], L.N. Fletcher[4], G.S. Orton[5], M.T. Roman[4], J.A. Sinclair[5], J.I. Moses[6], P.G.J. Irwin[7], S.N. Milam[2], and H.B. Hammel[8]. [1]Department of Physics and Astronomy, Howard University, Washington, DC, United States, [2]Astrochemistry Laboratory (691), NASA/GSFC, Greenbelt, MD, United States (naomi.rowe-gurney@nasa.gov), [3]Center for Research and Exploration in Space Science and Technology (CRESST), NASA/GSFC, Greenbelt, MD, United States, [4]School of Physics and Astronomy, University of Leicester, Leicester, United Kingdom, [5]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, United States, [6]Space Science Institute, Seabrook, TX, United States, [7]Atmospheric, Oceanic, and Planetary Physics, University of Oxford, Oxford, United Kingdom, [8]Association of Universities for Research in Astronomy, Washington, DC, United States.

NASA's Spitzer Infrared Spectrometer (IRS) acquired mid-infrared (5 – 37 μm) disc-averaged spectra of Uranus and Neptune multiple times between 2004 and 2007. We analyze the differences in temperature and composition between the separate hemispheres to shed light on the variability of the stratospheres and upper tropospheres of both planets. Analyzing all the sets of data with multiple separate longitudes gives us a unique opportunity to compare the longitudinal variability in the thermal emission of the two planets for the first time. At Uranus, there was a considerable variation in stratospheric emission detected in the Spitzer data for multiple epochs [1]. A variation is not present at Neptune in 2005 or late 2004 but may be present in May 2004.

The observations of Uranus in 2007 and Neptune in 2005 have optimized exposure times, multiple observed longitudes, and therefore the least uncertainty. It is these two epochs that we have used to develop a consistent retrieval framework for ice giant middle atmospheres. Building on the forward-modelling analysis of the global average study of Uranus [2,3] and conducting completely novel analysis on the Neptune data, we present full optimal estimation inversions (using the NEMESIS retrieval algorithm, [4]) of the spectra of both planets. At Uranus, we perform spectral inversions for each longitude to distinguish between thermal and compositional variability [1]. At Neptune, we aim to constrain the temperature profile and the abundances of the stratospheric hydrocarbons including the first retrieval of methyl (CH_3).

This disc-averaged thermal and chemical structure from Spitzer will likely be our best characterization of ice giant thermal structure until the James Webb Space Telescope (JWST) Mid-Infrared Instrument (MIRI) acquires spatially-resolved spectroscopy in 2022. We outline the plans for the JWST Guaranteed Time Observations (GTO) and discuss the advancements that the JWST will give with respect to Spitzer.

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References:

[1] Rowe-Gurney N. et al. (2021) *Icarus, 365,* 114506. [2] Orton G. S. et al. (2014) *Icarus, 243,* 494-513. [3] Orton G. S. et al. (2014) *Icarus, 243,* 471-493. [4] Irwin P. G. J. et al. (2008) *Journal of Quantitative Spectroscopy and Radiative Transfer, 109*(6), 1136-1150.