DETECTING MOLECULES IN EXOPLANET ATMOSPHERES: LESSONS LEARNED FROM HOT JUPITERS. J. Lustig-Yaeger[1,3,4], M. R. Line[2], J. J. Fortney[2], and V. Meadows[1,3,4], [1]Univ. of Washington, Department of Astronomy (jlustigy@uw.edu), [2]Univ. of California, Santa Cruz, [3]NAI Virtual Planetary Laboratory, [4]Univ. of Washington, Astrobiology Program.

Introduction: Armed with a sizable and ever growing list of confirmed extrasolar planets we are beginning to face the question of atmospheric characterization: *What are these planets made of?* Current efforts to answer this question rely on transit transmission and secondary eclipse spectroscopy, which allow the composition of the atmosphere to be probed and enable molecular abundances to be calculated.

With the launch of the James Webb Space Telescope and the construction of ground-based 30-meter class telescopes, we will begin the age of terrestrial exoplanet atmospheric characterization. However, retrieving molecular abundances and potential biosignatures from these future observations will face similar challenges to those faced with current technology for hot Jupiters today. The transit method of detecting extrasolar planets is biased towards finding planets with large radii and short period orbits. Indeed, current spectroscopic observations of transiting exoplanets are at the very edge of detectability, even for the most readily observed hot Jupiters. Thus it is crucial that we develop and test atmospheric retrieval techniques that are capable of extracting the most information from the crude gaseous exoplanet spectra of today to ensure that we effectively characterize the Earth-like targets of tomorrow.

In this work[1], we revisit previously published secondary eclipse spectra of nine hot extrasolar planets in order to rigorously determine the confidence with which we detect individual molecules in their atmospheres.

Methods Overview: In order to get the most information possible about the atmospheric composition for each extrasolar planet, we utilize all available secondary eclipse measurements to construct an emission spectrum in the near-infrared. These observations range from ground-based broadband photometry to high-resolution space-based spectroscopy. We employ the data-driven atmospheric retrieval suite, CHIMERA[2], to infer molecular abundances and their uncertainties. For each planet, we perform Bayesian hypothesis tests in order to quantify the confidence with which we detect trace gases the atmospheres of these planets. In particular, we calculate molecular detection significances for individual species and combinations of H_2O, CH_4, CO, and CO_2.

Result Highlights: We find that the detection of molecules with only broadband ground-based and space-based photometry generally fails to breach the 3-sigma confidence level. This is depicted graphically in the top figure, where even the model that omits all four gases fits the six broadband data points for WASP-19b. On the other hand, observations that include spectral data lead to strong molecular detections. This is seen in the bottom figure where the 'no H_2O' model fails to fit the WASP-43b observations, thus we have a detection of water. Most interestingly, we show that when broadband photometric observations complement high-resolution spectral observations, but covering different wavelengths, strong constraints can be imposed on molecules otherwise undetected.

Conclusions: Broadband photometry is most effective at characterizing extrasolar planet atmospheres when complementing spectra. In future work we will explore which observations are most efficient at breaking spectroscopic degeneracies. Furthermore, the techniques explored in this work will be used for terrestrial extrasolar planet retrieval models.

References: [1] Lustig-Yaeger et al. (in prep) *ApJ*. [2] Line M. R. (2013) *ApJ*, 775, 137.