EChO detectability analysis

using the NEMESIS radiative transfer and retrieval tool

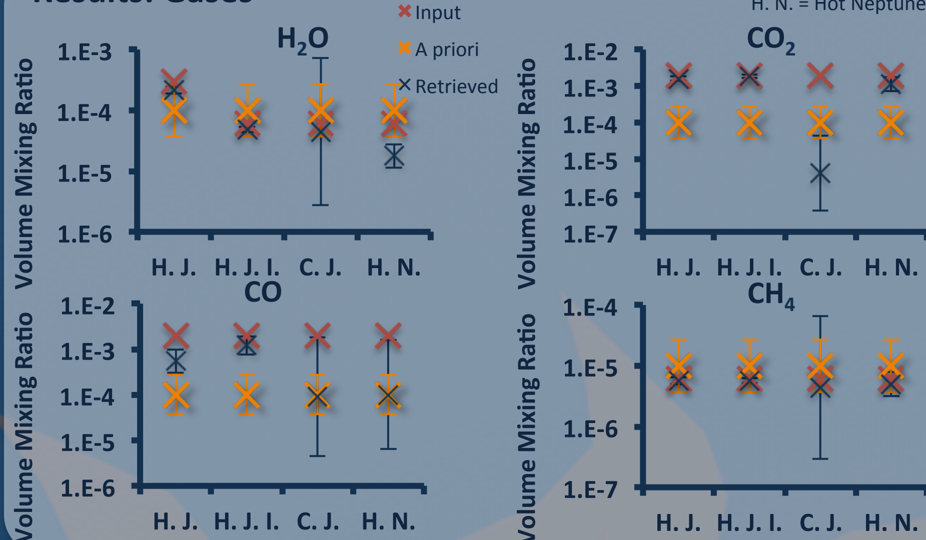
J. K. Barstow*, S. Aigrain, P. G. J. Irwin, J.-M. Lee & N. Bowles *barstow@atm.ox.ac.uk

UNIVERSITY OF OXFORD

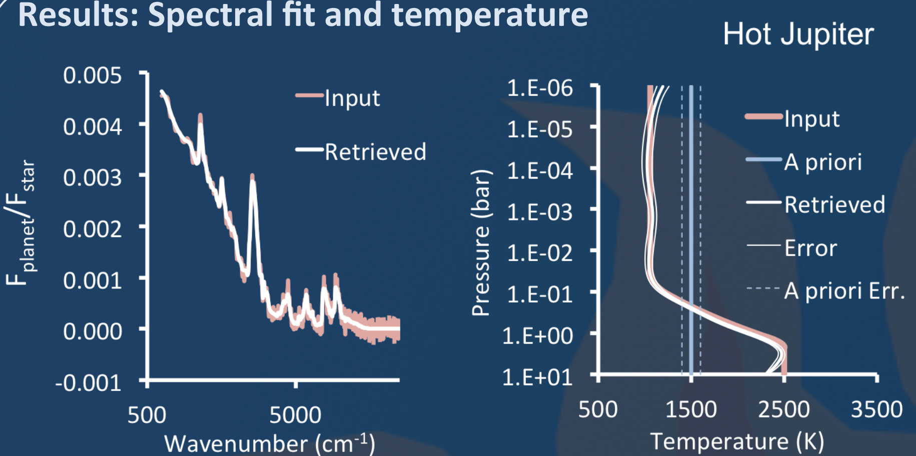
Introduction: The launch of the EChO (Exoplanet Characterisation Observatory; Tinetti et al. 2011) space telescope has the potential to introduce a new era in the study of extrasolar planet atmospheres. The proposed design incorporates a 1.5 m Cassegrain telescope and a 6- or 7-channel detector, spanning the wavelength range from 0.4 to a maximum of 16 µm. It will significantly improve our ability to retrieve the atmospheric state of extrasolar planets from transit spectroscopy. However, the degree of improvement is highly dependent on the spectral range, resolution and signal to noise of the instrument. We use the NEMESIS radiative transfer and retrieval tool (Irwin et al. 2008, Lee et al. 2012) to generate synthetic spectra for model planets under different conditions, with the expected EChO spectral range and resolution. We then add Gaussian noise to the synthetic spectra and feed them back into NEMESIS to retrieve the atmospheric properties of the model planet. We compare the retrieved and input atmospheric states to see whether EChO could provide sufficient information for NEMESIS to correctly solve the retrieval problem for a real planet under similar conditions.

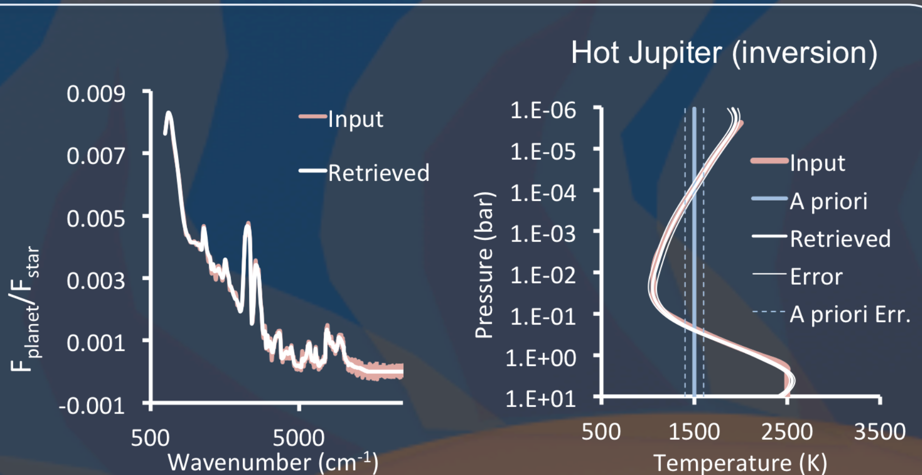
Method: NEMESIS uses the correlated-k approximation (Lacis & Oinas 1991) to calculate fast forward models. It minimizes a cost function that represents the difference between the measured and computed spectra and which takes into account errors in the data and model. The stellar spectrum, planet radius and mass and bulk atmospheric composition are specified, as well as an *a priori* atmospheric temperature structure and trace gas abundances. We retrieve temperature as a function of atmospheric pressure and an altitude independent volume mixing ratio for each of H_2O, CO_2, CO and CH_4, for a hot Jupiter (HD189733b-like), a hot Jupiter with temperature inversion (HD209458b-like), a cold Jupiter and a hot Neptune, all orbiting the Sun.

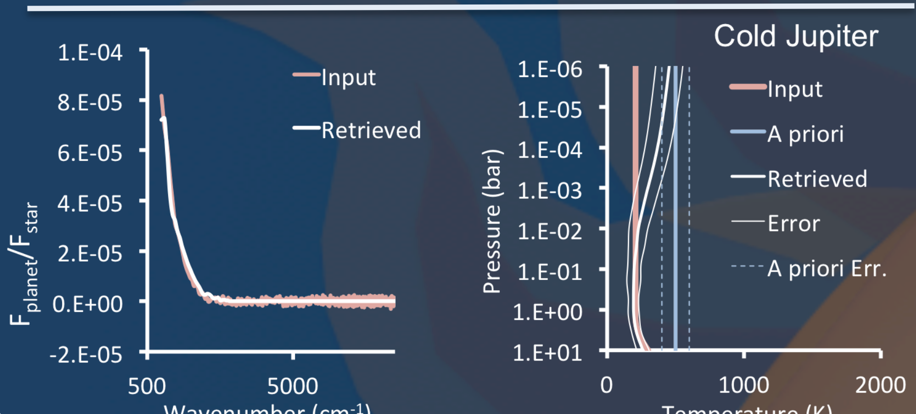
Results: Gases

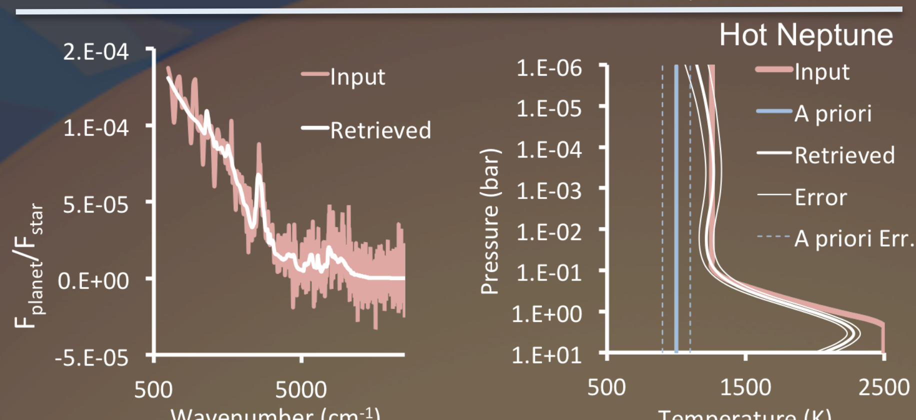


Results: Spectral fit and temperature









Conclusions: We obtain a good fit to the temperature profile except in the case of the cold Jupiter, for which the signal to noise is low. CH_4 is well-retrieved in all cases and H_2O and CO_2 are reasonably well-retrieved, but CO is poor because there are fewer spectral lines. Temperature profiles should be reliably retrieved with EChO for hot planets.

References: Tinetti, G. et al. "EChO: Exoplanet Characterisation Observatory" *Experimental Astronomy* (In Press)
Irwin, P., Teanby, N., de Kok, R., Fletcher, L., Howett, C., Tsang, C., Wilson, C., Calcutt, S., Nixon, C. and Parrish, P. "The NEMESIS planetary atmosphere radiative transfer and retrieval tool" *JQSRT* (2008)
Lee, J.-M., Fletcher, L. and Irwin, P. "Optimal estimation retrievals of the atmospheric structure and composition of HD 189733b from secondary eclipse spectroscopy" *MNRAS* (2012)
Lacis, A. and Oinas, V. "A description of the correlated-k distribution method for modelling nongray gaseous absorption, thermal emission, and multiple scattering in vertically inhomogeneous atmospheres" *JGR* (1991)