# Water World Exoplanet Atmospheric and Spectral Data Analysis via Thermodynamic Modeling and Unsupervised Machine Learning

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Recent discoveries like GJ 9827 d's water-rich atmosphere have brought to light an understudied class of exoplanets—water worlds. The discovery of water in this exoplanet atmosphere simultaneously showed current telescopic capabilities while demonstrating a need to understand this planet class better with many similar discoveries soon likely. The current understanding of water world exoplanet detection is limited by models—through modeling exoplanetary processes, astronomers develop expectations and can optimize their searches accordingly. Water worlds are currently only known by their key atmospheric signature, water vapor, and due to this many planetary scientists have suggested that these worlds would be exceedingly hard to identify based on atmospheric spectroscopy. This study confronts this problem by developing 1.5 million data point resolution thermodynamic models of water world atmospheres relative to pressure and temperature (via equilibrium chemistry), using these to create a database of over 5,000 synthetic spectra. A K-Means clustering algorithm is trained to identify different water world subtypes in the spectral dataset, and several new atmospheric tracers are identified from three main clusters such as carbon dioxide, sulfur dioxide, hydrogen fluoride. This study also, in tandem, develops an analytical pipeline for modeling exoplanet atmospheres given initial conditions at a higher resolution than any previous study. This study marks a notable advancement in the modeling of these water world atmospheres.

**Awards Won:**