Investigating Atmospheric Dynamics of Uranus and Neptune: A General Circulation Model Approach with a Parametrization of Convection

Uranus and Neptune, also known as the Ice Giants of the solar system, have received little attention from the scientific community compared to other planets. However, their atmospheric dynamics is much different from other gas giants due to their composition and greater distance from the Sun. Their study will provide new insights on planetary formation, evolution, and the broader dynamics of planetary atmospheres, but also beyond our solar system as there are thought to be the archetype of most exoplanets.

In this talk, I will present a sophisticated General Circulation Model (GCM), known as the Generic Planetary Circulation Model, that we use to investigate the complex meteorological phenomena of giant planets. Recently adapted with success to Jupiter and Saturn, we are extending its application towards Uranus and Neptune with a focus on the role of convection in the troposphere. Our attention is directed towards the parametrization of convection, a crucial driver of atmospheric circulation, as it significantly impacts the transport of energy and the distribution of chemical species throughout the atmosphere.

One of the unique aspects of our study lies in the consideration of methane condensation in the convection parametrization scheme based on a thermal plume model initially developed for the Earth atmospheric boundary layer (Rio & Hourdin 2008). However, unlike for the Earth, the condensable species are heavier than the surrounding atmosphere mainly composed of hydrogen. This phenomenon is suggested to be a powerful driver of intermittent storms activity detected in the atmospheres of the Ice Giants (Guillot 2022). The improved fidelity of our GCM simulations offers valuable implications for interpreting observational data and refining our understanding of the atmospheric processes governing these enigmatic outer planets. This is also particularly timely to prepare the scientific objectives of the Uranus Flagship mission, scheduled for early 2030’s.