TIPPING POINTS FOR TROPICAL WINDS

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A crucial point in the public debate about global warming is the existence of "tipping points", i.e. bifurcations in the dynamics of the climate system, potentially leading to abrupt climate change [1, 5]. Geological archives indicate that such events have occurred in earth's past, sometimes on timescales which do not exceed a decade (Fig. 1, left). Yet, it remains virtually unknown whether the atmospheric circulation, which corresponds to the fastest timescales of the system, may undergo such transitions at the planetary scale. The main objective of this project is to establish on a robust scientific basis the existence of tipping points due to nonlinear feedbacks in the atmospheric circulation. This is a key question, because of the role of the atmosphere in the global climate through the transport of momentum, energy and water vapor across latitudes, but also because it acts as a forcing for other components of the climate system, such as the ocean and vegetation. The project focuses on the circulation of the tropical atmosphere, which has the potential for large-scale reorganization and could affect climate worldwide through its coupling with the tropical ocean [4].

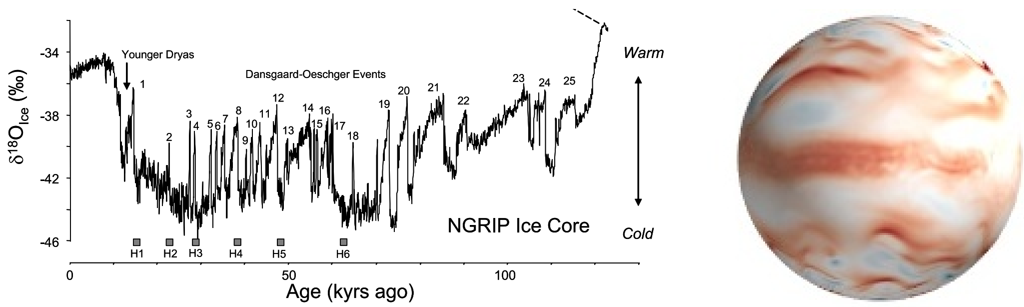

Figure 1: Left: Abrupt climate changes (*Dansgaard-Oeschger events*, ∼5 degree warming of the Northern Hemisphere on timescales of years to decades) observed in the isotopic abundance of ^{18}O over the last glacial cycle from ice core data in the Greenland ice sheet [2]. Right: Superrotating atmosphere in a numerical simulation with an idealized General Circulation Model.

The student will test the hypothesis that the atmospheric circulation can support multiple steady-states — the conventional circulation, and a state of strong eastward jet velocities at the equator, referred to as *superrotation* (Fig. 1, right) — potentially leading to complex dynamics such as hysteresis phenomena, self-sustained oscillations and spontaneous transitions triggered by random fluctuations of the turbulent dynamics, and study the impact of such phenomena on global climate. This will involve both studying precisely physical mechanisms in idealized models (e.g. wave-jet resonance in the shallow-water equations [3]) and conducting numerical experiments with a state-of-the-art General Circulation Model. The project is at the interface between geophysical fluid dynamics, nonlinear dynamics and climate modeling. The balance between theoretical and numerical work can be adjusted to the taste of the student, but a strong motivation to work with climate models is required.

References

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