Climate Physics

Room: Auditorium 7
Session chair: Matias Duran (TU/e)

This session will explore physical processes crucial to understanding and predicting the future of the Earth's climate. We will start with contributions on two small-scale ingredients: cloud and ice dynamics. The following contributions will examine processes at a global scale from two different perspectives: laboratory experiments and global models.

Capturing clouds in the climate system
Dr. Franziska Glassmeier (TU Delft)

Clouds in the sky exhibit a variety of forms and patterns. Their complexity not only puzzles the casual observer but is also a challenge for climate science: by interacting with solar and terrestrial radiation, clouds play a vital role in the planetary energy balance. The response of clouds to particulate pollution and their feedback to climate change remain especially hard to quantify. We will discuss chances and challenges for addressing these key uncertainties of climate projections.

How the growth of ice depends on the fluid dynamics underneath
Prof. dr. Federico Toschi (TU/e)

Convective flows and ice formation or melting in water bodies play a leading role in shaping geophysical landscapes. Particularly, in relation to global warming, it is essential to accurately quantify how water environments interact with ice formation and melting. Previous studies have revealed the complex nature of the icing process but have often ignored one of the most remarkable particularities of water, its density anomaly, and the induced stratification, which complexly interact in the presence of turbulence. By combining experiments, numerical simulations, and theoretical modeling, we investigate solidification of freshwater, considering physical properties of ice and water phases, including the phase transition and water density anomaly. We show this to be essential for correctly predicting different behaviors.
Wang, Z., Calzavarini, E., Sun, C., & Toschi, F. (2021). How the growth of ice depends on the fluid dynamics underneath. Proceedings of the National Academy of Sciences, 118(10), e2012870118.

The weather in the water tank: laboratory experiments on geophysical flows and climate
Prof.dr. Uwe Harlander (Brandenburg University of Technology (BTU) Cottbus)

The large-scale flows of the oceans and the atmosphere are driven by a non-uniform surface heating over latitude, and rotation. For many years, scientists have tried to understand fundamental aspects of these flows by doing laboratory experiments. The differentially heated rotating annulus experiment at the Brandenburg University of Technology (BTU) Cottbus cools the inner cylinder and heats the outer wall to generate a radial temperature gradient in analogy to the atmosphere. I will present recent findings from this experiment with a focus on climate dynamics. In particular, we investigate the effect of polar warming on the mid-latitude jet stream. Theory suggests that a reduced north-south temperature gradient leads to a slowdown of the jet and a larger probability for extreme weather. We try to verify this suggestion using the laboratory data.

Harlander, U., Sukhanovskii, A., Abide, S., Borcia, I. D., Popova, E., Rodda, C., ... & Vincze, M. (2023). New Laboratory Experiments to Study Large-Scale Circulation and Climate Dynamics. Atmosphere, 14(5), 836.
Vincze, M., Hancock, C., Harlander, U., Rodda, C., & Speer, K. (2023). Extreme temperature fluctuations in laboratory models of the mid-latitude atmospheric circulation. Scientific Reports, 13(1), 20904.

Tipping of the Atlantic Ocean Circulation
Prof.dr. Henk Dijkstra (Utrecht University)

The Atlantic Meridional Overturning Circulation (AMOC) is one of the tipping elements in the climate system. The AMOC is sensitive to freshwater perturbations and may undergo a transition to a climate disrupting collapsed state within a few decades under continuing greenhouse gas emissions. The potential climate impacts of such a collapse are enormous and hence reliable estimates of AMOC transition probabilities before the year 2100 are crucial information for policy makers. In this presentation, I will give an overview of the efforts to determine such probabilities with a focus on the physical processes affecting AMOC transitions.

Van Westen, R., Kliphuis, M. and H. A. Dijkstra. New Physics-Based Early Warning Signal shows AMOC is on Tipping Course. Science Advances, in press (2024), doi:https://doi.org/10.48550/arXiv.2308.01688.
Westen van, R. and H. A. Dijkstra. Asymmetry of AMOC Hysteresis in a State-of-the-Art Global Climate Model System Model. Geophysical Research Letters, 50, e2023GL106088 (2023).
Castellana, D., Baars, S., Wubs, F.W. and H. A. Dijkstra, Transition Probabilities of Noise-induced Transitions of the Atlantic Ocean Circulation, Nature Scientific Reports, 9:20284, (2019).