IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Life and Microgravity Sciences on board ISS and beyond (Part II) (7)

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ATMOFLOW - SIMULATING ATMOSPHERIC FLOWS ON THE INTERNATIONAL SPACE STATION. PART II: EXPERIMENTS AND NUMERICAL SIMULATIONS

Abstract

The main objective of the AtmoFlow experiment is the investigation of convective flows in the spherical gap geometry that are of interest for geophysical, astrophysical, and especially for atmospheric research. The main feature of AtmoFlow is its spherical geometry and the aim of the project is to observe flows in thin gaps that are subjected to a central force field. Such a condition is impossible to achieve on ground. In microgravity conditions, e.g. on the ISS, buoyancy driven convection is simulated by means of a central dielectrophoretic field in within the gap. Without losing the overall view on the complex physics involved, circulation in planetary atmospheres can be reduced to a simple model of the in- and outgoing energy (e.g. radiation) and rotational effects. Both input parameters are determined by the boundaries of the system. This strongly simplified assumption makes it possible to break some generic cases down to test models which can be investigated by laboratory experiments and numerical simulations. In this way it is possible to study atmospheric circulations by means of a spherical shell experiment, where varying differential rotation rates and temperature boundary conditions represent different types of planets. This is a very basic approach, but various open questions regarding weather, climate change, and global warming can be answered with this simplified setup. To prepare the experiment, it is necessary to determine the exact parameter space of the boundary conditions and the radius ratio, with which the highest variety of different cells and global structures will most likely occur. This task is covered by performing a detailed numerical study, in which the lateral thermal boundary conditions, the radius ratio, and the rotational velocity are varied. The critical Rayleigh and Taylor numbers are evaluated, which provide important information for the lower limit of the temperature difference and the minimum rotation rate. First numerical results for the proposed geometry are presented. We find a rich variety of typical flow patterns for radius ratio 0.7, including baroclinic waves, occluded fronts, strong tropical convergence, sub-tropical jets, and complex polar vortices.