"Turbulent Mixing Processes in the Earth System": New Max Planck Research Group at MPI-M

On 1 August 2010 a new Max Planck Research Group began its work at the Max Planck Institute for Meteorology (MPI-M): Dr. Juan Pedro Mellado was one of eight researchers, and the only in the Earth sciences, selected by the Max Planck Society to lead an independent research group for early career scientists in the chemical, physical and technical sciences. He chose to locate his group "Turbulent Mixing Processes in the Earth System" at the MPI-M in Hamburg.

Turbulence is omnipresent – and can be observed, for instance, early in the morning while pouring milk into a cup of coffee and mixing it. In the mug, parcels of fluids interact with each other and form chaotic whirls/eddies that accelerate the final homogenization of the mixture. But these turbulent motions can hardly be predicted. This is why describing turbulent flows still remains one of the biggest unsolved problems in classical physics.

Details of turbulent mixing at the cloud boundaries face a similar problem as coffee and milk: These processes play a fundamental role in the evolution of clouds, and clouds can have in turn a profound impact on planetary scale circulation. But how long does it take a cloud to mix with the surrounding, cloud-free area? When does it entirely disappear? "In our new group we are going to study some of these small-scale processes by using direct numerical simulations (DNS), which can resolve scales from meters to millimeters", explains the group leader, Dr. Mellado. Its results will then be integrated into the Large Eddy Simulations (LES) and General Circulation Models (GCM) of the MPI-M and allow for more reliable climate projections.

Dr. Mellado studied Aeronautical Engineering at the Polytechnic University of Madrid, and he received his PhD degree in Aerospace Engineering from the University of California, San Diego / USA, in 2004. After one year of postdoctoral research at the Technical University in Munich, he became Assistant Professor at the School of Aeronautical Engineering at the University of Seville, from 2005 to 2006, joining the Institute for Combustion Technology at the RWTH Aachen University in 2007.

Aeronautical engineering and Earth system sciences? This combination is not as unusual as it may at first seem. Many of the fundamental concepts in the study of Earth's atmosphere or ocean have roots in aeronautical engineering, and in the contributions of its pioneering figures such as Ludwig Prandtl and Theodore von Kármán. These contacts were deepened with the help of a priority program, Metsroem, of the German Science Foundation, which brought together the interests of Prof. Dr. Bjorn Stevens (then at the University of California in Los Angeles (UCLA)), researchers in fluid dynamics at the RWTH Aachen University, and applied mathematicians at the Free University of Berlin. Together they were funded to explore the turbulent mixing processes in stratocumulus

clouds. “Turbulence is everywhere you find fluids moving on a human or a larger scale”, says Dr. Mellado. “This applies to flow conditions in combustion engines, for example, as well as to geophysical flows. Only some of the vocabulary we use in these two fields is different.”

The mission of Dr. Mellado’s new group is to explore how mixing processes regulate phenomena important for Earth system dynamics, and in so doing complement larger scale, more traditional, studies of geophysical flows. “We cannot attack the problem as a whole simply by putting it into a computer, at least not yet, but we can definitely contribute with a little but useful piece to the puzzle“. More specifically, the objective is to identify those regions of the planet where the local turbulent mixing processes are believed to play a fundamental role, derive simplified archetypal problems that contain some of the essential physics of the original system, perform direct numerical simulations of them and analyze the data.

As an example, recent work on the cloud boundary has helped us to understand some aspects of turbulent mixing at the top of stratocumulus clouds, in particular, the possible role of the local cooling due to the evaporation of the droplets at the cloud interface. Figure 1 shows one of the corresponding publications, which was recently featured on the cover of the Journal of Fluid Mechanics.

The research group will continue this fundamental approach applied to other sub-systems of the atmosphere and the ocean, e.g. boundary layers next to the sea surface, ground or ice boundaries. The research group will be formed by two postdoctoral fellows and one PhD student.

Group pages at

http://www.mpimet.mpg.de/en/wissenschaft/atmosphaere-im-erdsystem/arbeitsgruppen/turbulente-mischungsprozesse-im-erdsystem.html

Contact:

Dr. Juan Pedro Mellado
Phone: +49 (0)40 41173 354
Email: juan-pedro.mellado@zmaw.de