12-month post-doctoral position

Analysis of the surface layer in tropical cyclones

In the framework of the MICA (Measurements of the Intensity of Cyclones using Aeroclippers) project, a 12-month post-doctoral position is proposed to prepare the analysis of future measurements in the surface layer of tropical cyclones and to analyze first results of planned field campaigns.

The MICA project

A precise monitoring of tropical cyclone (TC) intensity is of great interest for operational weather monitoring and forecast. However, there is currently no instrument capable of continuously monitor this intensity. Satellites give somewhat sporadic and indirect estimates of the overall TC intensity and some approaches, like the Dvorak technique, still need to be calibrated over basins where no in-situ measurement is available. The main objective of the MICA project is to use Aeroclipper devices to provide continuous measurements in the surface layer in the eye of TCs.

The Aeroclipper (Duvel et al, 2009) is a unique instrument which can measure directly the low atmosphere condition at a fine time resolution (1 min). It is a system made up of a balloon, a guide-rope and a gondola for data acquisition and transmission. The balloon is vertically stabilized near the ocean surface (~40 m) by the guide-rope floating on the ocean. The Aeroclipper can measure low-level wind and thermodynamic parameters (e.g. pressure, temperature, humidity) for several weeks along quasi-Lagrangian trajectories following the surface wind in remote regions of tropical oceans. If properly deployed at the right place and at the right time, the balloon is attracted into the eye of a TC where it stays until TC decay. This gives continuous monitoring of TC intensity by measuring surface pressure into the eye. These balloons will also provide direct measurements of surface wind and thermodynamic parameters in the TC inner core region during their convergence toward the eye.

The main objectives of the MICA project are:

- to provide an in-situ measurement of the surface pressure into the eye and derive near real time monitoring of the cyclone intensity, including rapid intensifications or decays;
- to evaluate TC intensity derived by different satellite observation approaches (including the Dvorak technique), in particular in basins with no or poor in situ monitoring (such as for the Indian Ocean);
- to improve forecast of both TC trajectory and intensity by assimilating Aeroclipper continuous time series of surface parameters measurements in Numerical Weather Prediction (NWP) models.

There are some additional scientific objectives for the knowledge of the TC dynamics, such as:

- to derive series of quasi-Lagrangian surface measurements in trajectories converging toward the eye of a cyclone;
- to measure variations of the low-level moist enthalpy in the eye in relation with the eye dynamics and during intensity changes.

Purpose of the post-doctoral work

The main objectives of the work are:

- To prepare the interpretation of Aeroclipper measurements by analyzing simulations of these observations in cloud-resolving models.
- To compare and analyze simulated TC lifecycle (e.g. RI, ERC) and measurement obtained from in situ (Aeroclippers, radiosondes and surface stations) and spaceborne (e.g. scatterometer, AMSU, SSM/I, GPM, SAL), in particular during the Aeroclipper field campaigns planned in February/March 2021 from La Reunion Island and in October 2021 from the Guam Island.

The work will be based on mesoscale model simulations, e.g. Meso-NH and/or AROME, at different resolutions from a few hundred meters to a few kilometers. Moreover, selected TC events that occurs during the field campaigns will be simulated using a state-of-science ocean-wave-atmosphere (OWA) coupled modelling system (Pianezze et al., 2018), i.e. Meso-NH (atmosphere), CROCO (ocean), and WW3 (wave). The OWA system calculates explicitly the sophisticated dynamics and thermodynamics of low level considering local scale processes, e.g. air-sea surface turbulent exchange, ocean-heat content, sea spray emission, etc., that modify the thermodynamic environment at the bottom atmospheric layers of TCs and their role controlling the TC's intensification. Virtual Aeroclipper trajectories will be simulated in model surface fields in order to analyze dynamical and thermosdynamical variations along typical trajectories.

A particular emphasis of the analysis of these trajectories will be put on:

- the evolution of the ratio between radial and the tangential winds that is related in part to the surface friction in TCs;
- the origin of dynamic and thermodynamic (T, RH) perturbations of the surface layer in trajectories converging toward the TC eye, in particular through spiral convective bands;
- surface layer perturbations into the eye resulting from:
  - the presence of meso-vortices;
  - an eye replacement cycle (ERC);
  - a phase of rapid intensification (RI);
  - a phase of TC decay.

Supervision

The post-doctoral fellow will be employed by CNRS, and will mainly work either at LACy (La Réunion) and possibly partly at LMD (Paris). The post-doctoral fellow will be mainly supervised by Keunok Lee (LACy, La Réunion) in the framework of a team including:

- Sylvie Malardel, LACy, La Réunion, expertise in numerical simulations
- Soline Bielli, LACy, La Réunion, expertise in numerical simulations
- Hugo Bellenger, LMD, Paris, expertise in the observation of air-sea interface
- Jean-Philippe Duvel, LMD, Paris, leader of the MICA project

The postdoc contract is expected to begin before 1 July 2021 for a period of 12 months.

Required Qualifications, Skills and Experience

Essential:

- PhD in atmospheric science,
- Good understanding of the physics of the atmospheric boundary layer,
- Programming experience (fortran, python, matlab, ...),
- Ability to write high level scientific reports and publications,
- Good ability to communicate in English,
- Scientific rigor.

Strongly desirable:

- Experience with numerical modelling, preferably of the atmosphere.

Duvel, J.P., C. Basdevant, H. Bellenger, G. Reverdin, A. Vargas, and J. Vialard, 2009: The Aeroclipper: A New Device to Explore Convective Systems and Cyclones. *Bull. Amer. Meteor. Soc.*, **90**, 63–71.

Pianezze, J., Barthe, C., Bielli, S., Tulet, P., Jullien, S., Cambon, G., 2018: A new coupled ocean-waves-atmosphere model designed for tropical storm studies: Example of tropical cyclone Bejisa (2013-2014) in the south-west Indian Ocean. Journal of Advances in Modeling Earth Systems, 10, 801–825.