Job Title	Impact of sea-spray on surface turbulent fluxes in tropical cyclones and mid-latitude storms
Main Research Field	Environment and Geosciences (ENV)
Sub Research Field	Physics of the atmosphere
Key words	Air-sea coupling ; turbulent fluxes ; sea spray ; parameterization ; tropical cyclones; midlatitude storms
Job Description	Context : Strong winds over the ocean introduce substantial concentration of droplets (referred to as sea spray) into the lowest layer ~ 100 m of the atmosphere (surface layer). Mechanisms include bursting air bubbles in whitecap and tearing off the wave tips ("spume drops" ; Veron, 2015). This latter mechanism occurs for winds of 10 m/s or above. Droplets with size from 2 up to 500 μm can be transported over large distances and remain in the surface layer for several days, where they can impact the heat fluxes by increasing evaporation and sensible heat transfer. They also lower the aerodynamic roughness perceived by the airflow, resulting in less wind stress by very strong winds (e.g. Andreas et al., 2015). This should directly impact both the turbulent exchanges at the surface and the thermodynamic balance of the surface layer. It is well established that the heat and momentum exchanges at the surface, in turn, control the initiation and intensity of the tropical cyclones. Indeed, the capacity of cyclones to develop and attain their maximum potential intensity largely depends on the ratio of enthalpy to momentum transfer (e.g. Emanuel, 1995). Recent studies underline the necessity to account for the effect of the droplet layer due to sea spray in the turbulent flux parameterizations used in numerical models for tropical cyclones prediction (e.g. Bao et al., 2011). Tests made using existing parameterizations with and without sea spray showed a significantly more intense cyclone when including the sea spray effect. Momentum exchanges also significantly impact the intensity of mid-latitude storms. However, very large uncertainties remain both on the physical content and on the magnitude of the spray effect included in current parameterizations. More specifically, the sea spray generation functions that control the droplets distribution and concentration are very poorly known. For a given wind speed, the concentration of the droplets in the size range supposed to impact the turbulent fluxes cover several orders of magnitude (Veron, 2015).

	Objectives and methods : We aim to improve the representation of the sea spray and its effects (on the surface turbulent fluxes and the thermodynamics of the surface layer) in the atmospheric models used at Meteo-France. These models share their physical parameterizations and their representation of the exchanges at the surface with the research model Meso-NH, which will be used in a flexible way for sensitivity testing. Sea spray generation functions have been implemented and used in the model, but their impact on the turbulent fluxes has not been tested extensively. The proposed work should first consist in finalizing the implementation of sea spray generation functions. As a second step, one ought to test the sensitivity of the fluxes, the intensity of tropical cyclones and mid-latitude storms based on the uncertainties of the generation function on several realistic case studies. The tests will be performed by using an atmosphere-ocean-wave coupled platform. The parameterizations of the turbulent fluxes used in the study can start from existing functions (e.g. Bao et al., 2011 ; Andreas et al., 2015) but should represent in a more comprehensive way the effect of a high concentration of droplets in the thermodynamics of the surface layer, through the microphysical exchanges and the resulting changes of the atmospheric parameters. *References* Andreas EL, Mahrt L, Vickers D. (2015). An improved bulk air-sea surface flux algorithm, including spray-mediated transfer. Quarterly Journal of the Royal Meteorological Society 141(687): 642–654, doi:10.1002/qj.2424 Bao, J. W., Fairall, C. W., Michelson, S. A., & Bianco, L. (2011). Parameterizations of sea-spray impact on the air–sea momentum and heat fluxes. Monthly Weather Review, 139(12), 3781-3797. Emanuel, K. A. (1995). Sensitivity of tropical cyclones to surface exchange coefficients and a revised steady-state model incorporating eye dynamics. Journal of the Atmospheric Sciences, 52(22), 3969-3976. Veron F. (2015). Ocean Spray. Annual Review of Fluid Mechanics 47(1): 507–538, doi:10.1146/annurev-fluid-010814-014651
Supervisors	This post-doc offer is meant to be supervised by two supervisors, Marie-Noelle Bouin (CNRM/LOPS) and Jean-Luc Redelsperger (LOPS). Marie-Noëlle Bouin is working on improving the representation of turbulent exchanges at the air-sea interface in numerical modelling, in particular by taking into account the sea-state effect. Jean-Luc Redelsperger works on developing physical schemes in atmospheric models. Both have developed a strong expertise in using km-scale or LES ocean-wave-atmosphere coupled simulation tools.

	For further information on research topics, please visit the respective Researchgate profiles of Marie-Noëlle Bouin and Jean-Luc Redelsperger *Relevant publications* Bouin, M.-N. and Lebeaupin Brossier, C.: Surface processes in the 7 November 2014 medicane from air–sea coupled high-resolution numerical modelling, Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2019-983, in review, 2019. Sauvage, C., Lebeaupin Brossier, C., Bouin, M. N., & Ducrocq, V. (2020). Characterization of the air–sea exchange mechanisms during a Mediterranean heavy precipitation event using realistic sea state modelling. Atmospheric Chemistry & Physics, 20(3). Redelsperger, J. L., Bouin, M. N., Pianezze, J., Garnier, V., & Marié, L. (2019). Impact of a sharp, small-scale SST front on the marine atmospheric boundary layer on the Iroise Sea: Analysis from a hectometric simulation. Quarterly Journal of the Royal Meteorological Society, 145(725), 3692-3714. Bourras, D., Cambra, R., Marié, L., Bouin, M. N., Baggio, L., Branger, H., ... & Maes, C. (2019). Air-Sea Turbulent Fluxes From a Wave-Following Platform During Six Experiments at Sea. Journal of Geophysical Research: Oceans, 124(6), 4290-4321. Bouin, M. N., Redelsperger, J. L., & Lebeaupin Brossier, C. (2017). Processes leading to deep convection and sensitivity to sea-state representation during HyMeX IOP8 heavy precipitation event. *Quarterly* Journal of the Royal Meteorological Society, 143(707), 2600-2615.
Department /Research	This project is part of a joint effort involving several laboratories (CNRM, LACy, LOPS), to improve the overall representation of wind and turbulent fluxes in severe weather conditions. This post-doc proposal is following a first study on the sea spray impact on tropical cyclones (J. Pianezze, LACy) within the framework of the project RenovRisk that received funding from the European Regional Development Fund (ERDF). In addition, the on-going project Caravele (R. Fernandes, LOPS) addresses the impact of wave breaking in momentum flux parameterization. This latter project is funded by the French National Research Agency (ANR). Eventually, a current PhD position (L. Corale, LACy) aims at implementing ocean-wave-atmosphere coupling in the operational numerical tools of Meteo-France for tropical cyclone forecasting.
Skills Requirements	The candidate should have a recent Ph.D. in atmospheric science or in a related discipline and preferably some experience in atmospheric mesoscale modeling. A good understanding of the physics of turbulence and of the exchanges at the air-sea interface is requested. Additional knowledge in tropical cyclones and/or microphysical atmospheric processes would be positively considered.