Ocean-Wave-Atmosphere coupling with SURFEX and OASIS for mesoscale simulations and numerical weather predictions of tropical cyclones

Sylvie Malardel, Soline Bielli, Joris Pianezze, Cindy Lebeaupin-Brossier, Marie-Noëlle Bouin, Laetitia Corale

LACy/Tropical Cyclones

- Why I am here today ?
- Why do we need OWA coupling for Mesoscale modeling of TCs ?
- How we do it at LACy ?

From PDC to OWAC

The "other" coupling workshop : Physics-Dynamics Coupling (PDC14, 16, 18, 21)

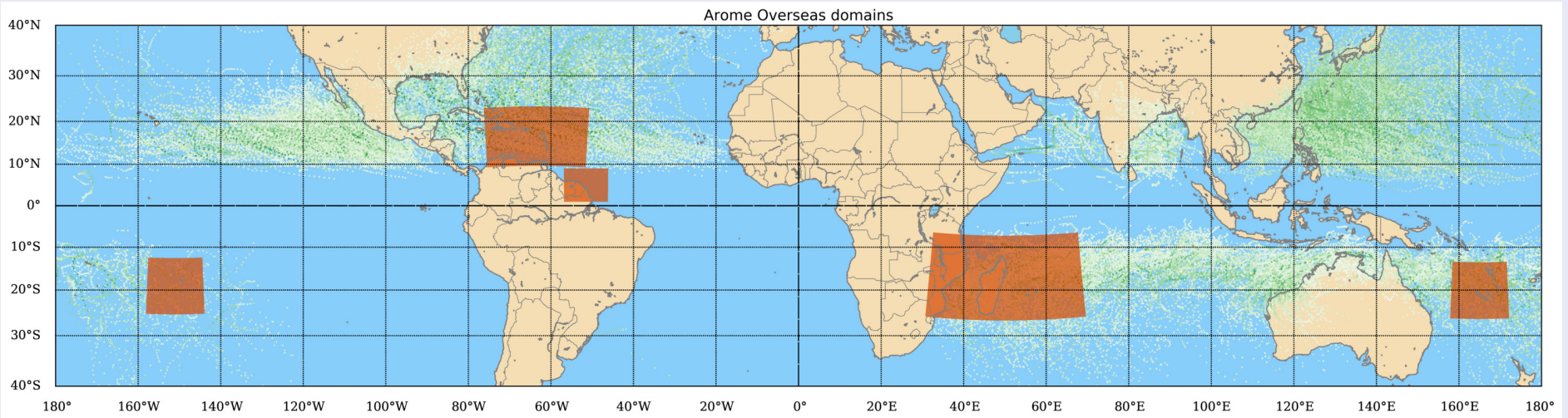
- contacts and discussions between CW and PDC organization committees
- would it be a good idea to have the 2 workshops one after each other at the same venue, the same week ?
- we should try, at least once, and see... No final plans yet.
- I am here as a "spy" from PDC to get some ideas how to best couple the two workshops (and communities)
- and use this opportunity to give a quick overview of why the OWA coupling is important for the work on TCs at LACy.

One word about LACy - La Réunion, Indian Ocean

- $\Rightarrow$ "Laboratoire de l'Atmosphère et des Cyclones" (LACy) is a joined lab between La Réunion University, Centre National de Recherche Scientifique (CNRS) and Météo-France.
- Météo-France in La Réunion has been formally designated as Regional Specialized Meteorological Centre (RSMC) - Tropical Cyclones for the South-West Indian Ocean by the World Meteorological Organization (WMO) in 1993
- $\Rightarrow$ Research on tropical cyclones and deep convection

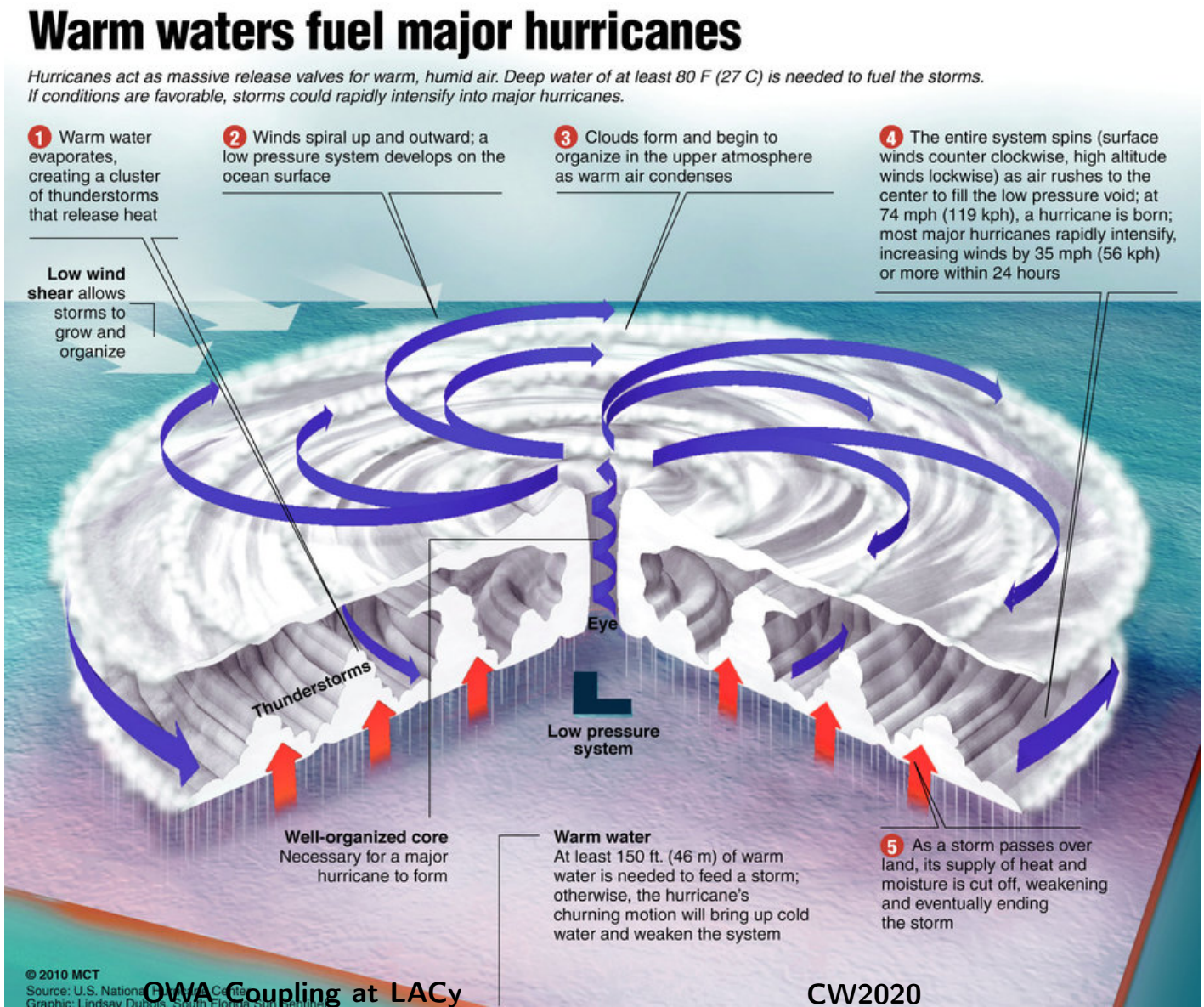
AROME OverSeas (G. Faure, O. Nuissier, GMAP)

5 domains over French tropical overseas territories



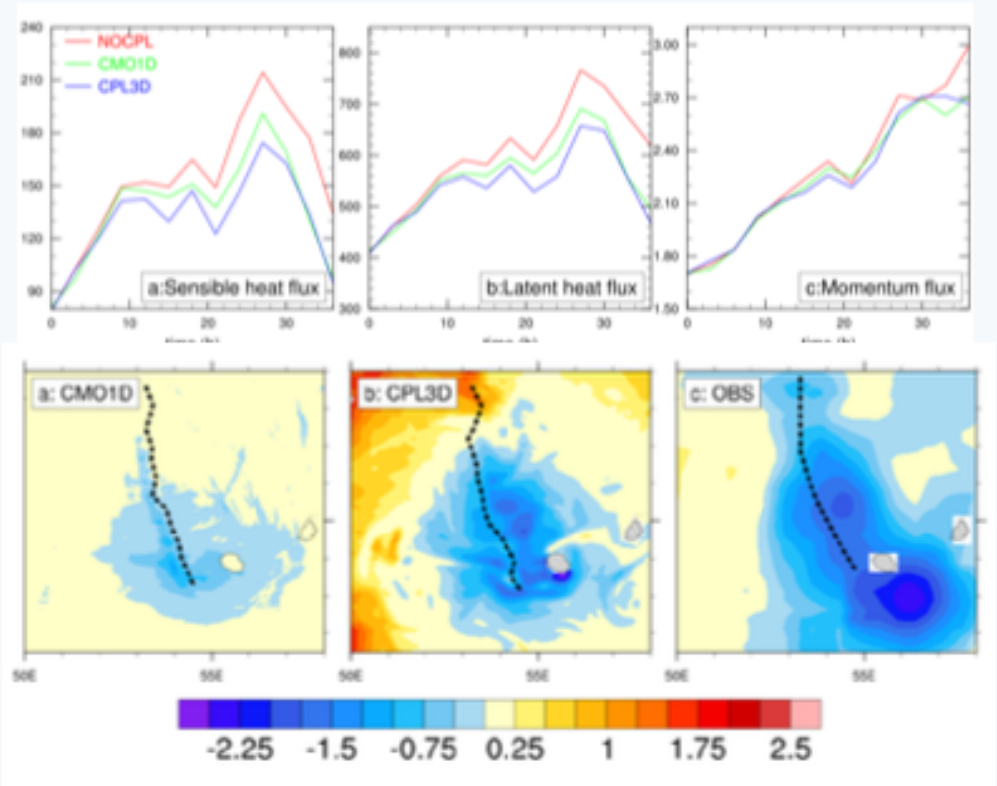
- in operation from 2016,
- dynamical adaptation from HRES IFS, LBC every hour, +42h (+78h if needed), 4 times a day,
- 2.5 km hor. resolution, 90 levels, 60s time step
- **Ocean Mixed Layer Parametrisation, IC from Mercator-Ocean.**

Why OWA coupling is so important for TCs, even at short time scale



Feedback between the Ocean and TCs

Example: MésoNH-NEMO (Bielli et al, 2020)

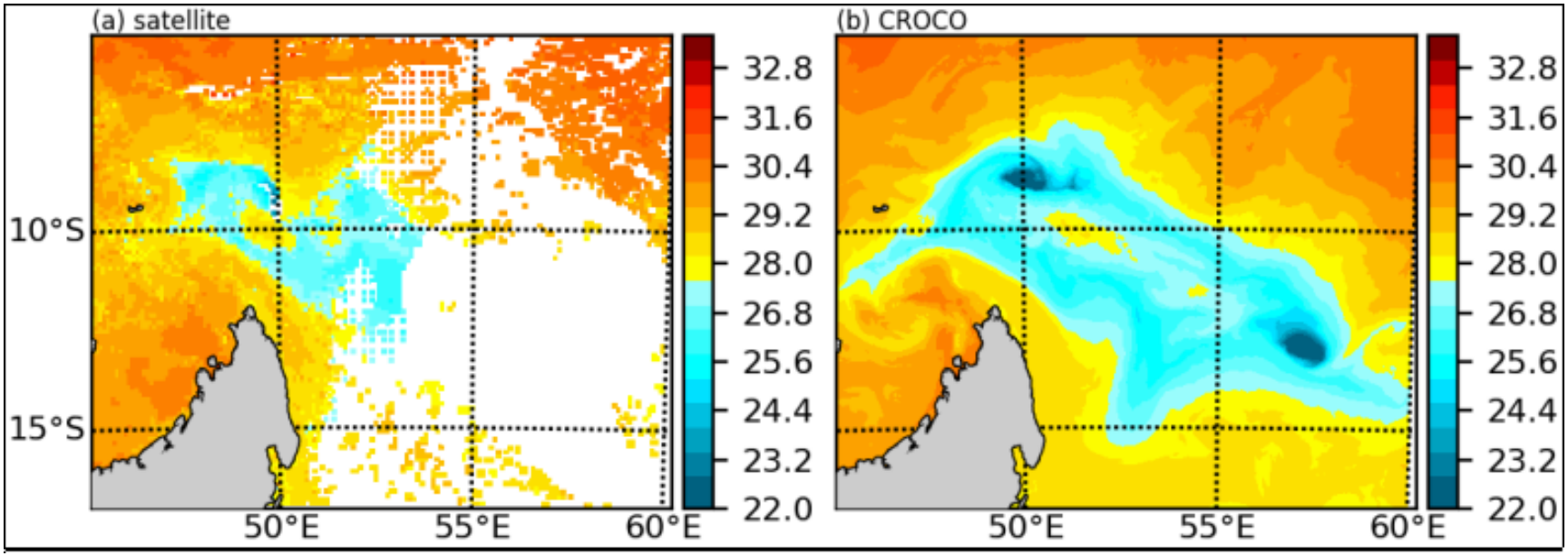


3 different simulations of Cyclone Bejisa (2014) : no coupling, 1D couling, 3D coupling

Surface fluxes

SST change between 01/01/2014 06UTC and 02/02/2014 12UTC

Feedback between the Ocean and TCs



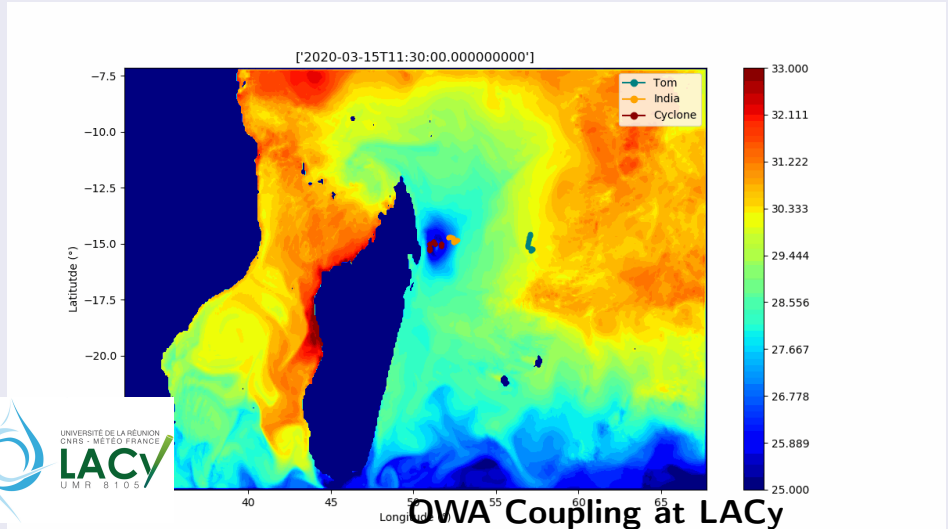
Pianezze et al, 2020

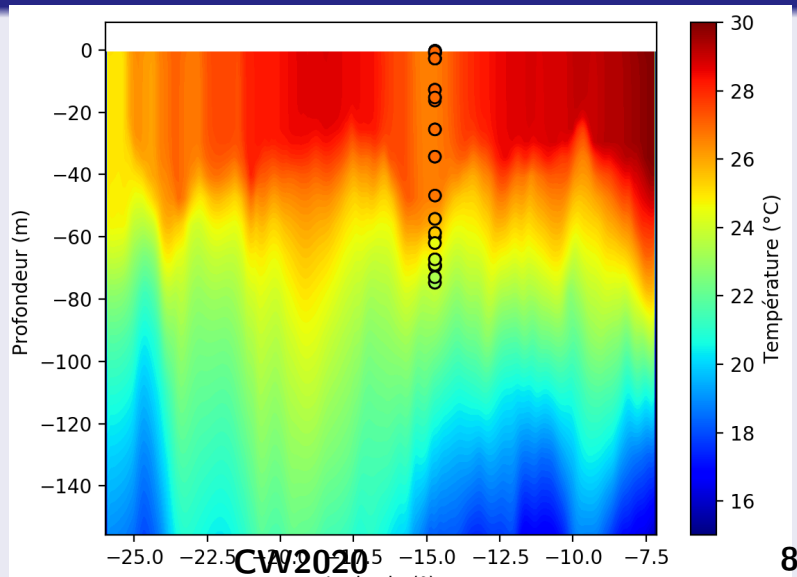
Simulation of TC Fantala (2016) with Méso-NH, Croco and WW3. Comparison of the SST after 9 days of similation with the ODYSSEA (marine Copernicus) satellite product.

Observation : Validation, Data assimilation

Experimental Campains : gliders, aeroclippers

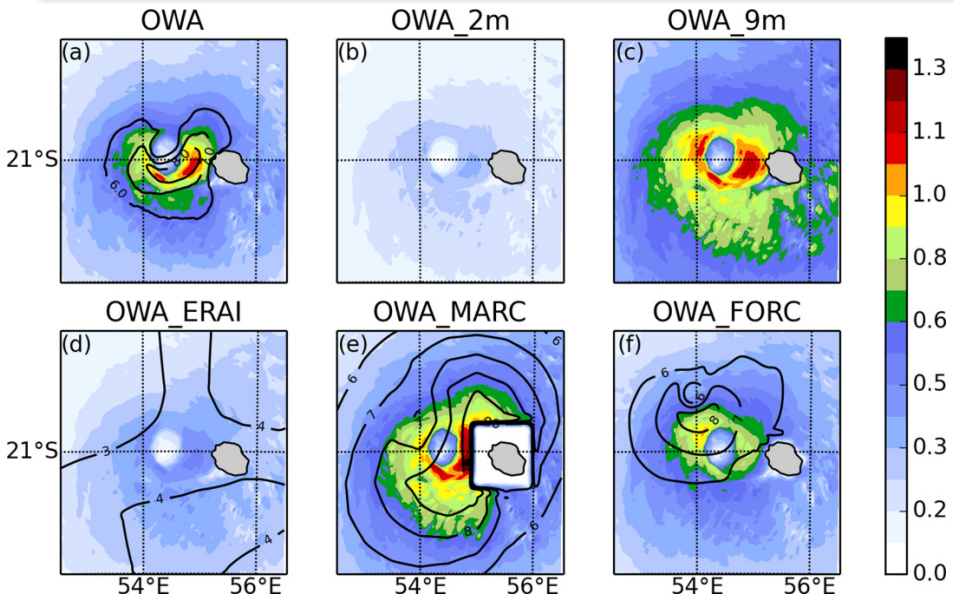
Sea Turtle biologging (STORM project, O. Bousquet, M. Bocquet)





Why do we need the coupling with a wave model ?

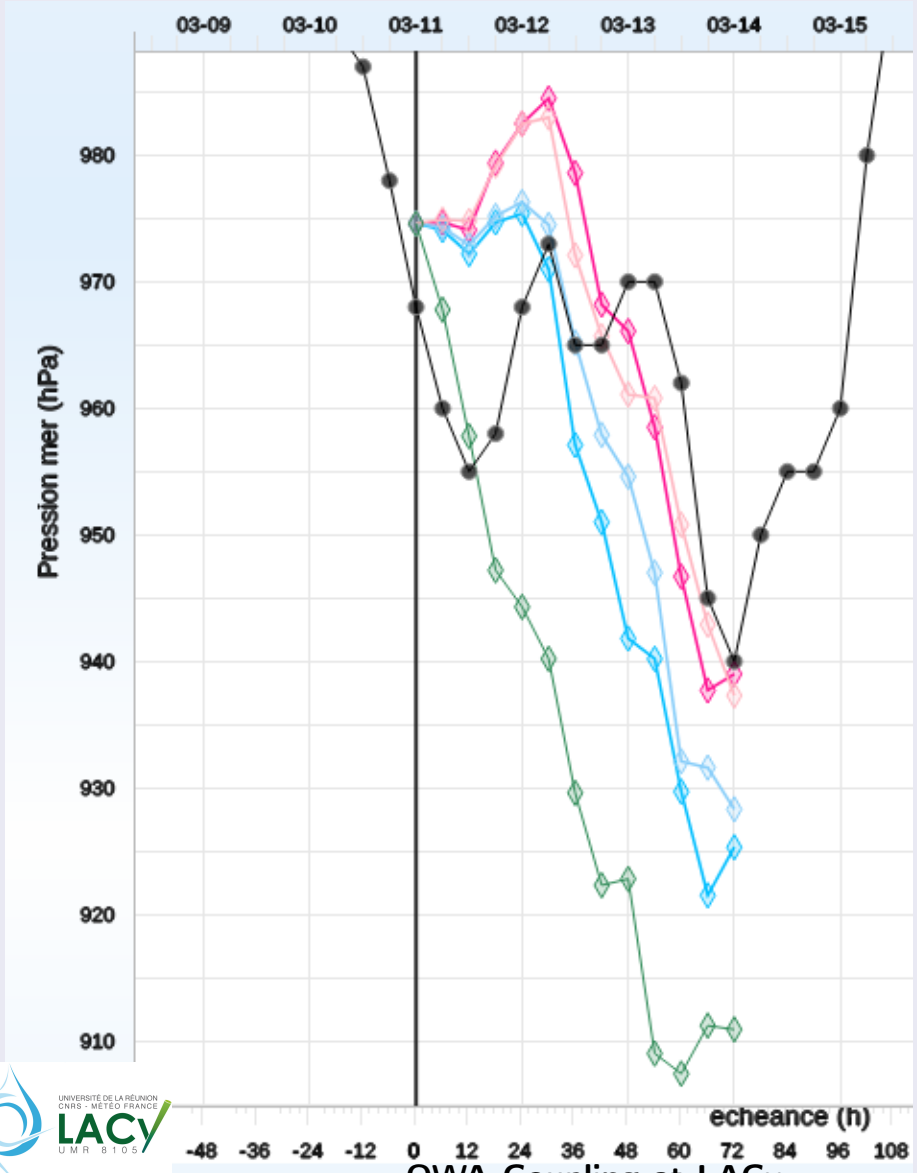
- NWP : wave forecast
- OWA feed back at the OA interface (roughness, sea spray) :
  - surface flux parametrisation = a large source of uncertainty for TC modeling
  - coupling with cloud microphysics : marine aerosols (sea salt)

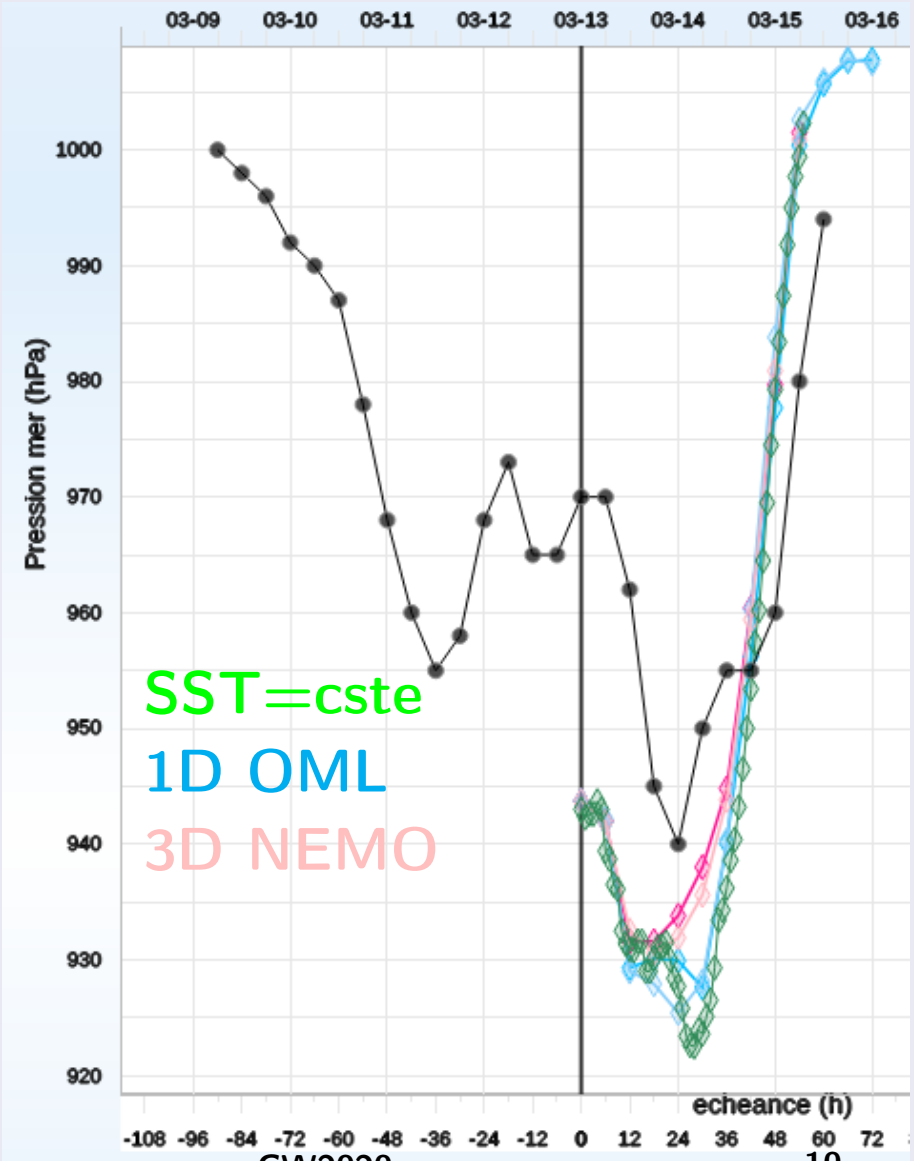


From Pianezze et al, 0018, JAMES. Total instantaneous net sea salt aerosol flux (μ.m^{-2}.s^{-1}, colors) at 06 UTC on 2 January for the (a) OWA, (b) OWA_2m, (c) OWA_9m, (d) OWA_ERAI, (e) OWA_MARC, and (f) OWA_FORC simulations.

Very first results of AROME-NEMO-OI for TCs - L. Corale

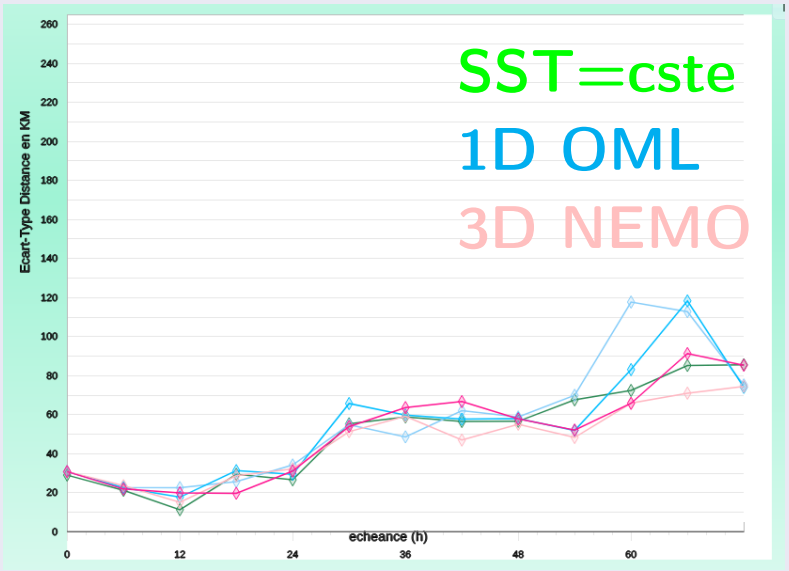
TC IDAI - 11032019 00UTC - 13032019 00UTC



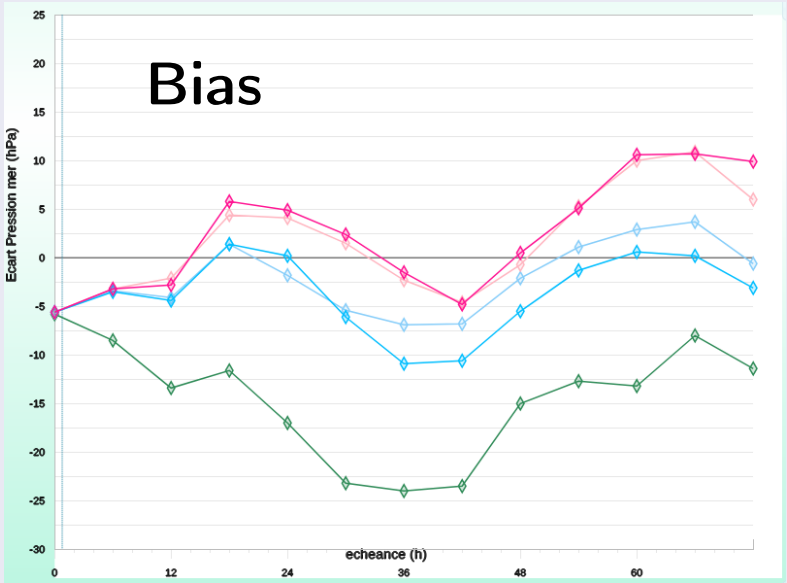


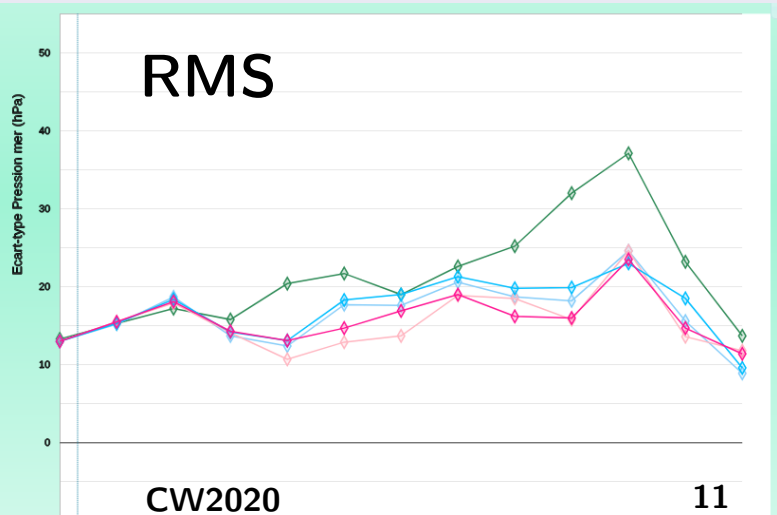
NWP : Very first results of AROME-NEMO-OI for TCs - L. Corale

Trajectory error (RMS)

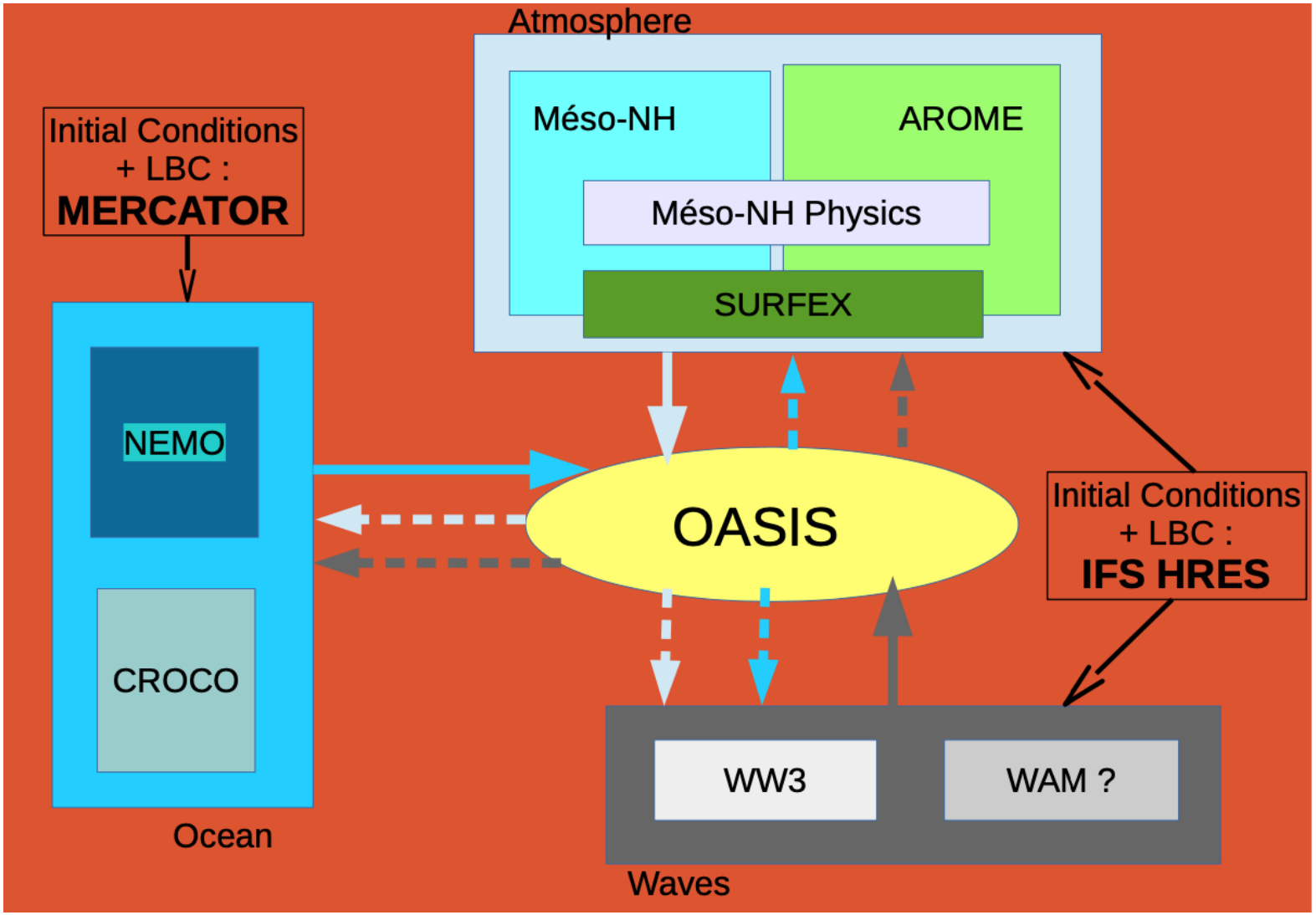


Pmin error (Bias, RMS)





OWA coupling using OASIS and SURFEX at LACy



SURFEX : shared Externalized SURFace plateform

A $\leftrightarrow$ SURFEX $\leftrightarrow$ OASIS3-MCT

- Ready interfaces in SURFEX package to communicate with OASIS
- Actual communication with OASIS are done at a level of MPI decomposition of A model : need to gather/distribute OPEN-MP blocks of SURFEX state in AROME, ARPEGE $\Rightarrow$ communication with OASIS outside the SURFEX main call.

Variables

- **A/Surfex** $\Rightarrow$ **O** : stress components, heat (L+H) flux, net solar flux, evaporation+precipitation flux
- **O** $\Rightarrow$ **A/Surfex** : SST, current components
- **A/Surfex** $\Rightarrow$ **W** : U_{10}
- **W** $\Rightarrow$ **A/Surfex** : z_o, H_s

Conclusion

- OWA coupling is a key aspect of TCs modeling
- At LAcy, different O, W and A
  - all application use OASIS3-MCT coupler (almost no cost compared to A, O cost is little compared to A),
  - all A use SURFEX to communicate with OASIS.
- Other users sharing similar configs (MésoNH community, M-F (NWP, mesoscale, Climate), HIRLAM-ALADIN Consortium, MERCATOR,
- Still a few technical problem to be solved, for example I/O servers
- Physical consistency of coupling : different computation of drag both in A and W model $\Rightarrow$ need of a "norm" for variables best to exchange ? (following work by Best et al, 2004 for Surf/BL coupling).
- What about the coupling between PDC and CW ? Feel free to tell us what you think...