The AROBASE project

AROME-BASed coupled SystEm
Application de la Recherche à l'Opérationnel pour l'assemBlage d'Arome avec des Systèmes Environnementaux

Towards a kilometer-scale AROME-based multi-coupled modeling and forecasting system

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and the AROBASE team project

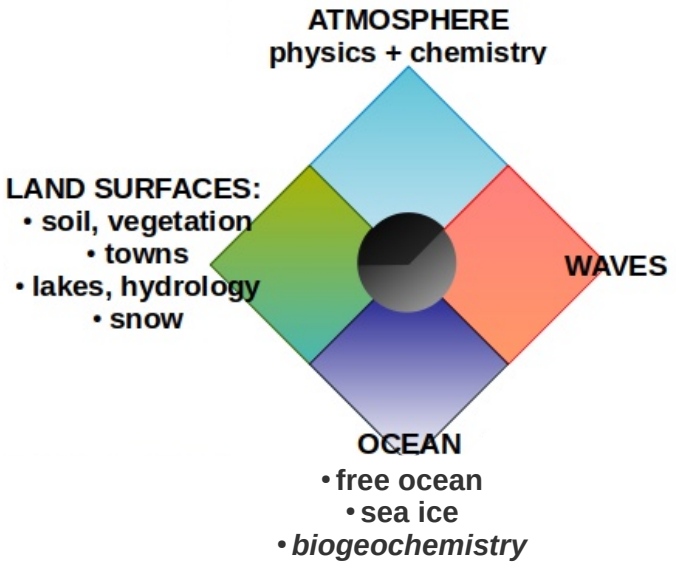
27 March 2023, ACCORD All Staff Workshop, Tallinn, Estonia

Plan

1. Outlines of the AROBASE project
2. Assemble a research numerical tool
3. Which coupling for NWP at km-scale?
4. Synergy with observations
5. Conclusions

Outlines of AROBASE

- Assemble a fine-scale modelling system including atmosphere physics & chemistry + ocean (sea-ice, biogeochemistry) + waves + land surfaces (soil, vegetation, towns, snow, lakes, hydrology)



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- New opportunities of improvements for downstream applications that would benefit from more integrated and consistent forecasts

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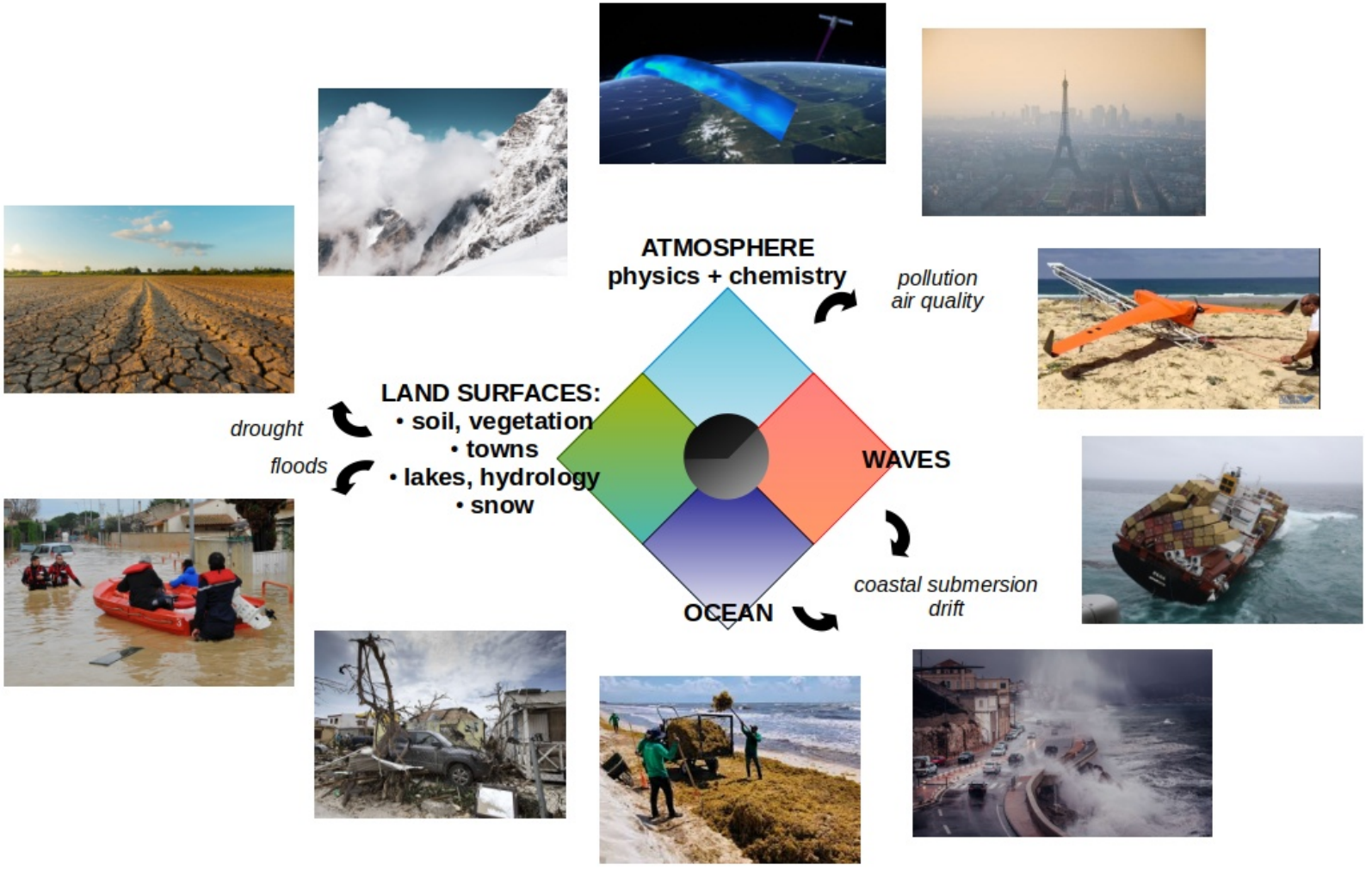

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- Design a system for NWP, in the line of AROME – i.e. AROBASE must be inserted in the same environment as AROME and its forecast must be usable as those from AROME
- New opportunities of improvements for downstream applications that would benefit from more integrated and consistent forecasts
- Use more largely existing observations of the different components and prepare the arrival of new observations for evaluation
- Prepare couplings for the new generation of the regional climate system model CNRM-RCSM (that will based on AROME in 2024-2025)
- Ensure that the assembled system complies with new computing methods inside component models (or that could replace partly them) and manage the evolutions for new HPC architectures

Assemble a research numerical tool

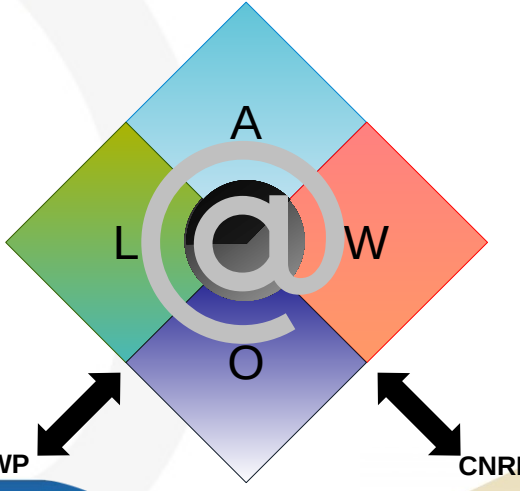
Assemble Earth System components to represent key processes and interactions: atmosphere (physics + chemistry) [AROME + chemistry library from ACCALMIE], land surf. [SURFEX] (ISBA: soil/vegetation, TEB: town, Flake: lakes, snow) + hydrology routing [CTRIP], ocean (blue, white, green) [NEMO (+ SI3 + PISCES)], waves [MFWAM]

Criteria for models choice:

- modularity (possibility to interchange models)
- transportability (different domains)
- Internal expertise(s) or close collaborations
- Continuum for our coupled systems: NWP ↔ AROBASE/research ↔ CNRM-RCSM (-ESM)

Targeted applications for AROBASE :

- process study, case study
- forecast demonstrator, support for campaigns
- evaluation of coupled parameterisations
- integrated regional climate study



Assemble a research numerical tool

Tasks :

Maintain the **SURFEX-OASIS** coupling interface and follow the component models evolution

AROME: Update coupling via SURFEX-OASIS

NEMO: Deploy an internal *git* versioning tool

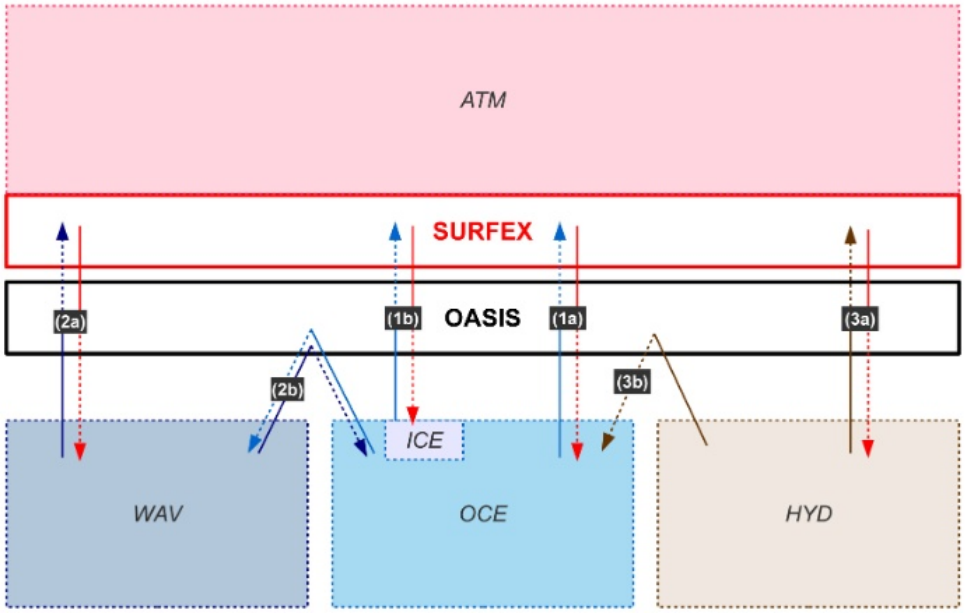
MFWAM:

- Insert OASIS subroutines for standard W-A and W-O coupling
- Progressive enrichment of the interface to examine various options for W-A and W-O interactions.

CTRIP:

- Verify the coupling with AROME via SURFEX-OASIS.
- Going towards km-scale CTRIP (1/12°) for CNRM-RCSM including Mlake (and the anthropic effects with the tank module if available).

Share **transportability tools** (domains, initial and boundary conditions) and documentation



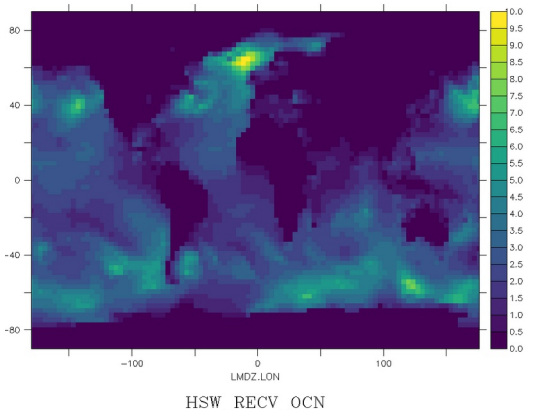
Voldoire et al. 2017

Assemble a research numerical tool

MFWAM wave model developments (A. Dalphinet, Météo-France/DIROP/MAR)

Global configuration MFWAM/NEMO

- MFWAM global at 0.5° coupled with NEMO 4.2 over ORCA2 grid. Test simulation over one day.
- Work currently done at Mercator Ocean international with a higher resolution in NEMO (ORCA0.25)

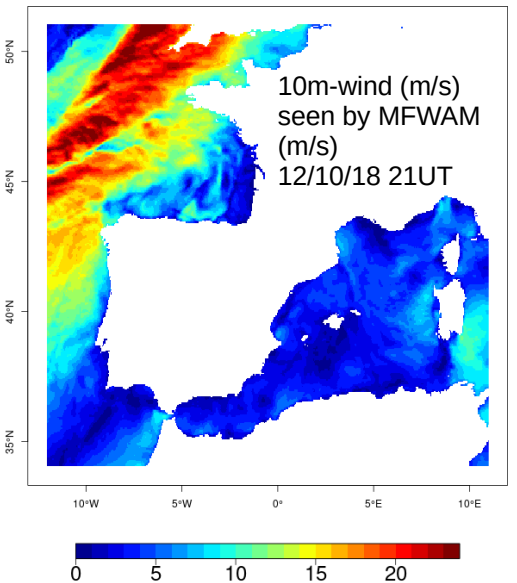


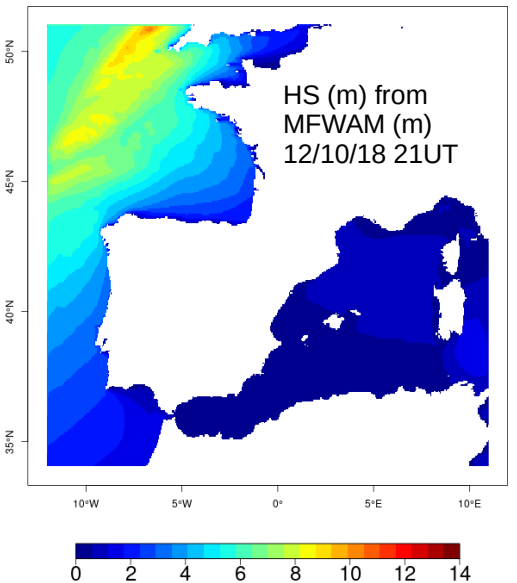
Example of significant wave height Hs (m) from MFWAM received by NEMO

Regional configuration SURFEX/MFWAM

- SURFEX and MFWAM on a same grid at 0.05°
- Test over 7 days (mid-October 2018 ; Pianezze et al. 2022)
- SURFEX uses AROME (2.5km) wind forcing with a 1hr frequency

- Current test with a conformal projection for SURFEX to see how to manage the grid mismatches



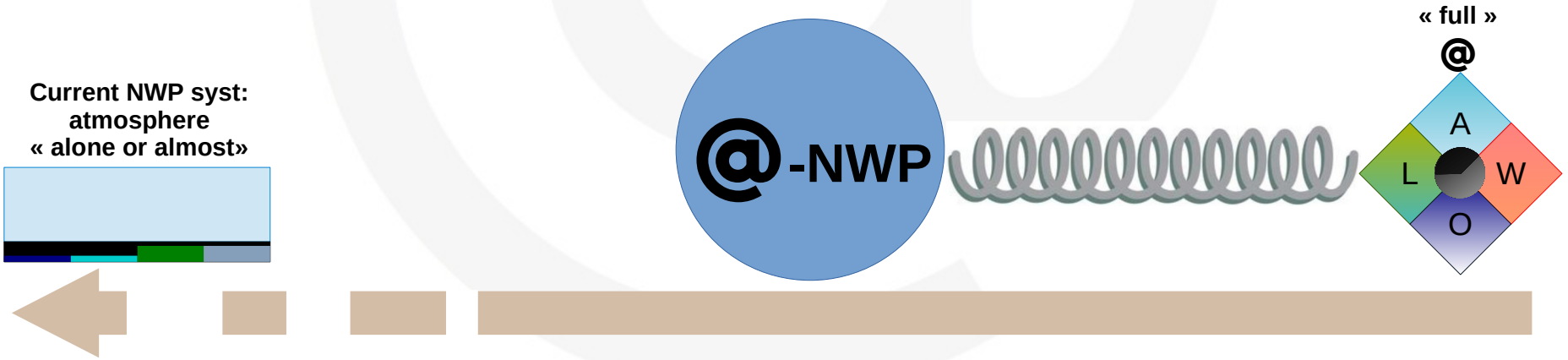


Which coupling(s) for km-scale NWP?

AROBASE is designed as a **numerical prediction** system, and thus must be inserted in the production tools, the dedicated analyse methods and uses, **in line with AROME**.

Benefits of gradual complexity induced by couplings will be examined specifically for numerical prediction taking into account the operational constraints:

- **Evaluation of coupling benefits** on forecasts: skill scores & case studies; several kind of forecasts; advantages for the production chain / sequence
- **Estimate of costs**: numerical costs; running time : constraints on models and coupling methods, costs of pre-/post-treatment, transfers to (new) users, maintenance costs…



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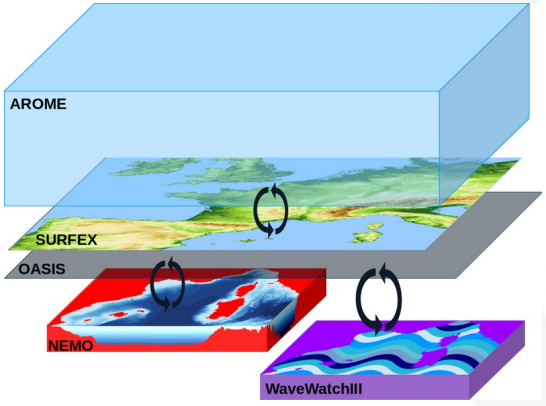
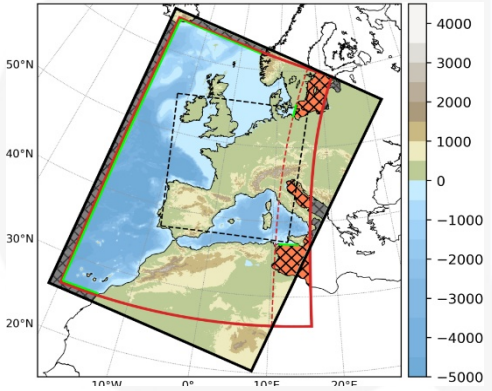
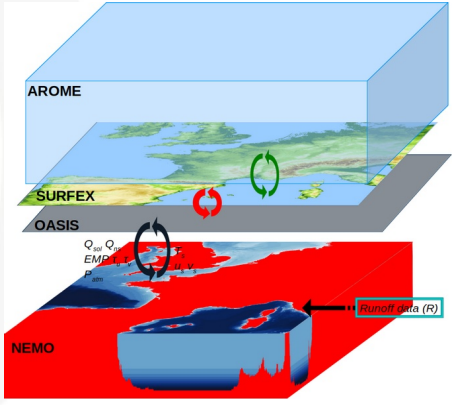


Sauvage et al. 2021



Pianezze et al. 2022



M2 internship Q. Misi (2022)
PhD M. Marquillie (2021-2024)

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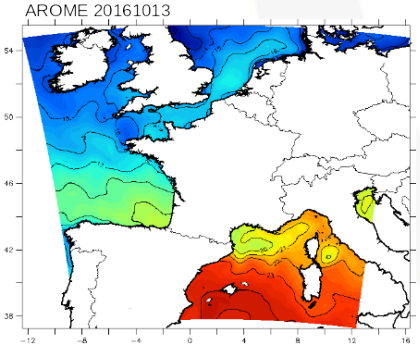

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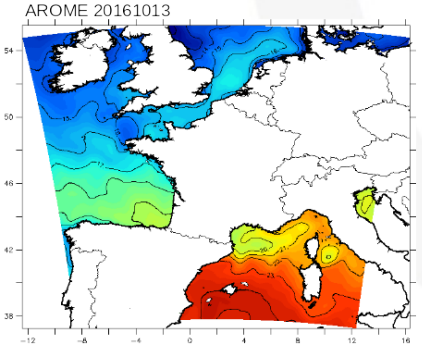
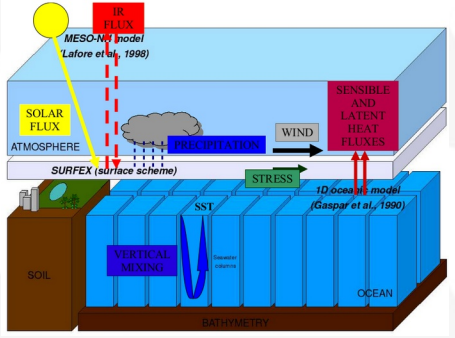
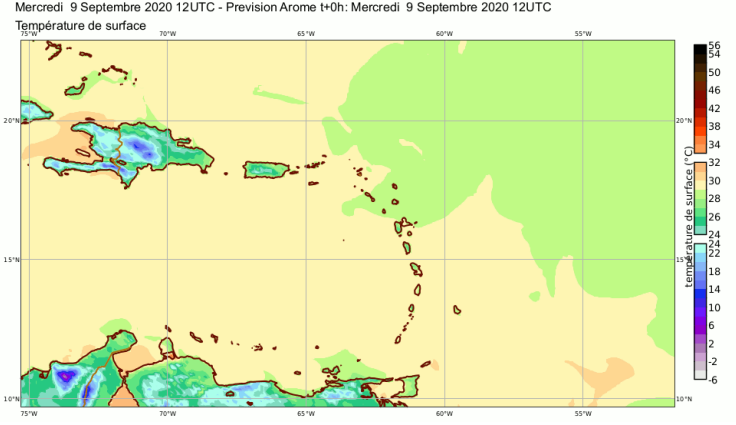




Lebeaupin Brossier et al. 2009



Faure et al. 2020

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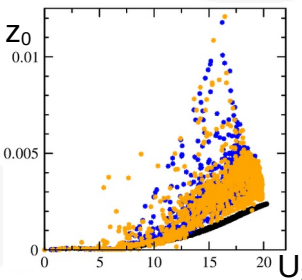

WASP
(Sauvage et al. 2020 ; Bouin et al. sub)

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test several initialisation methods

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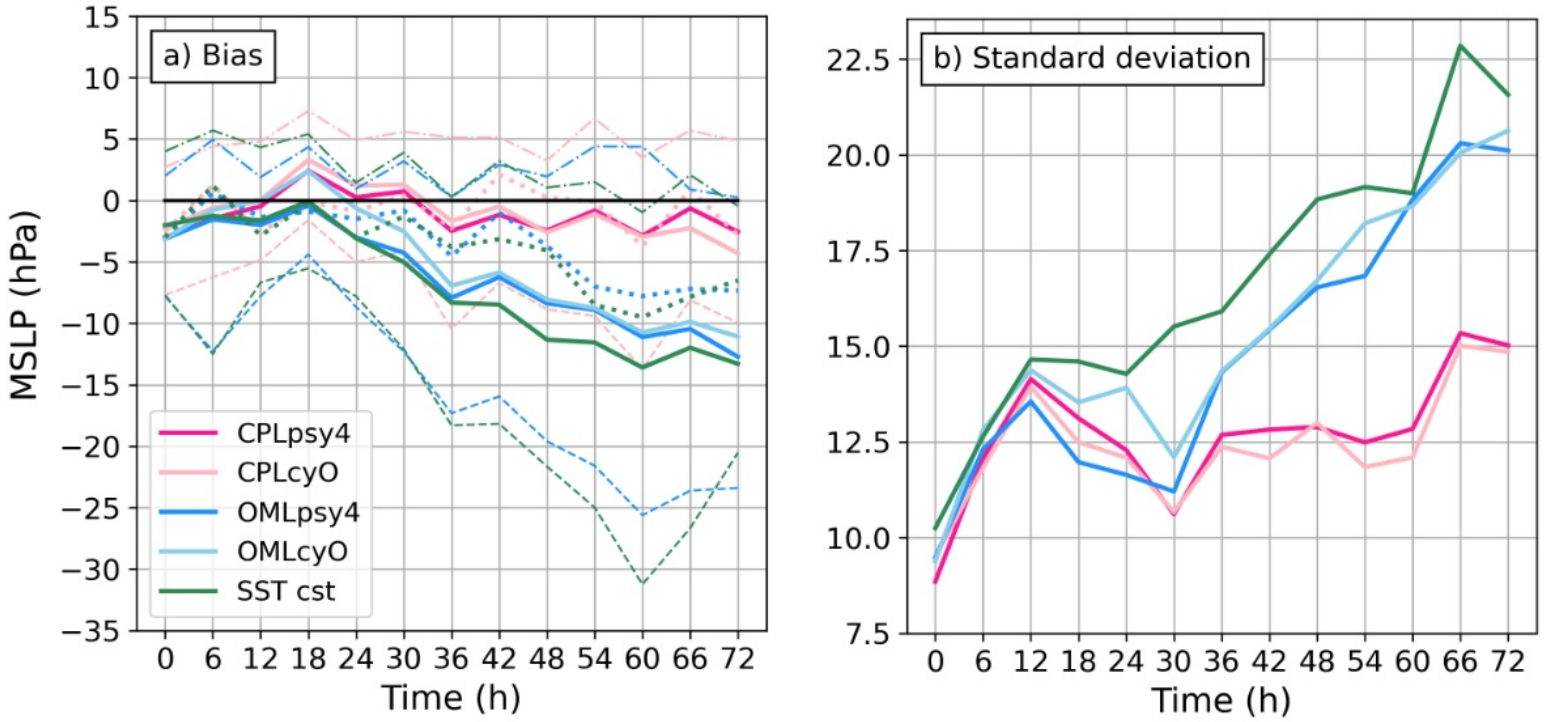
Which coupling(s) for km-scale NWP?

Impact of 3D ocean coupling for tropical cyclone forecast:

Skill scores of AROME Indian-Ocean forecast (7 cyclones, 31 forecast runs)
uncoupled (SST cst), coupled with a 1D model (OML) or NEMO (CPL)
+ ocean starts from global ocean forecast (psy4) or the previous CPL forecast (cyO)



Corale et al. 2023

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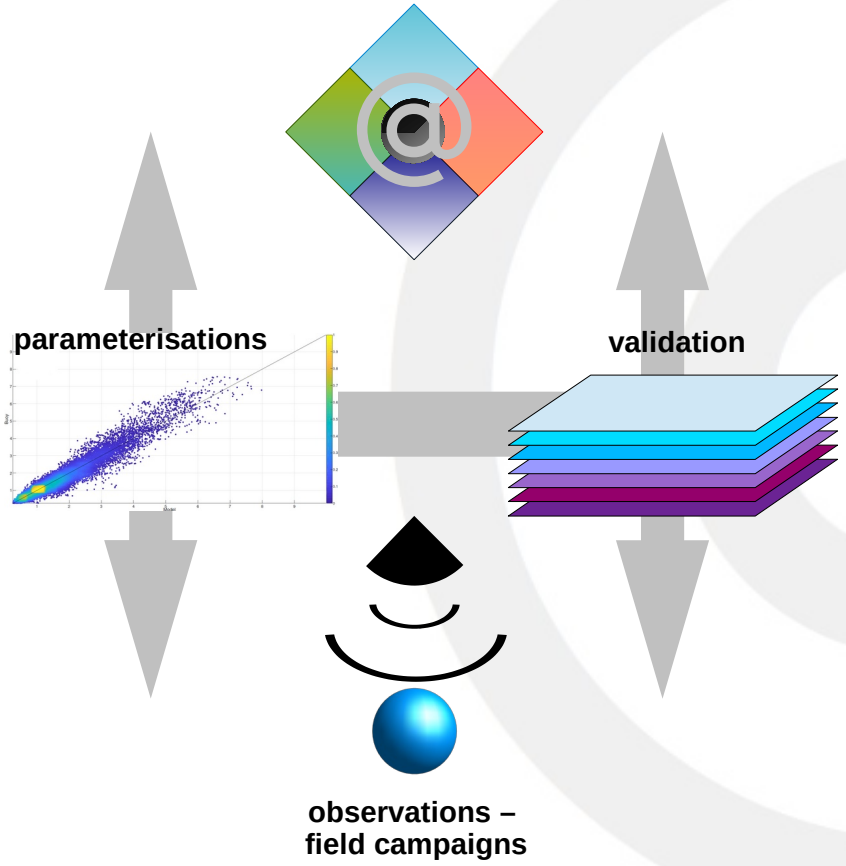
- 2nd phase of evaluation is planned to conclude on the advantage of one component (or bloc) coupling in presence of the others

Synergy with observations



Re-use available **observations** (case studies, field campaigns) for validation of model and/or of parametrization in coupled mode

Provide AROBASE outputs for scientific exchanges and interact to **collect the needs** of downstream production/applications

Evaluate the **possibilities of AROBASE deployment** to compare to new observing systems of components and their interfaces and/or to support observing field campaigns or new measurement platforms

Synergy with observations

Tasks :

Inventory of documented cases of interest for AROBASE validation and physical process studies.

Interactions with users, including forecasters

Running AROBASE on some case studies (define the number during the project) and period of interest

Provide AROBASE forecasts and test their use for downstream applications

If there is an opportunity: running AROBASE to support field campaigns or to support new observing system/platform tests/deployment

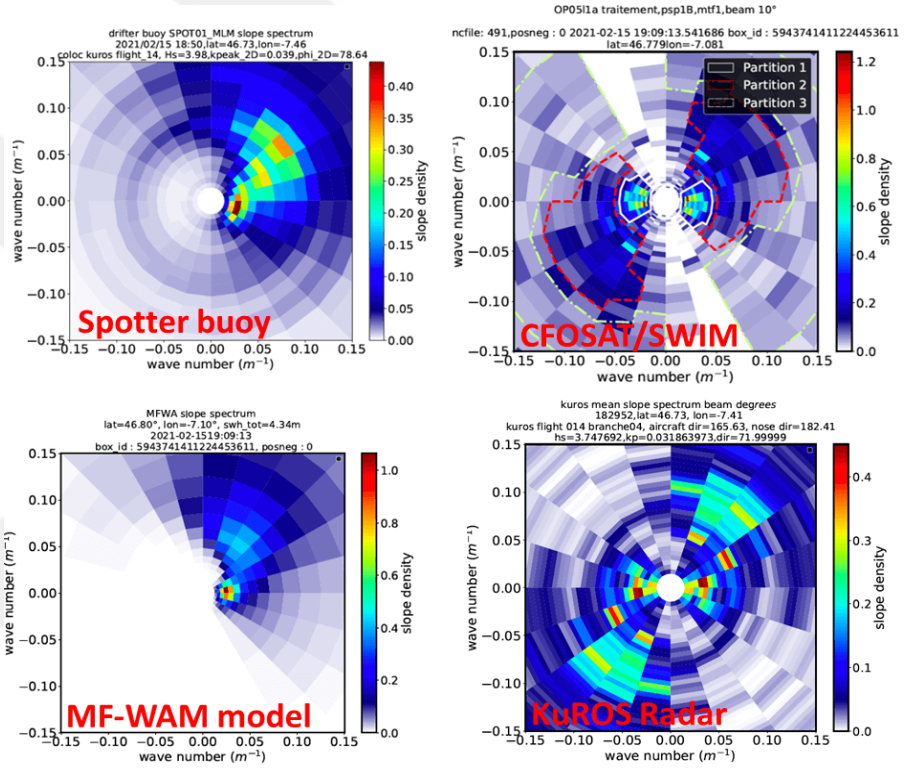


Illustration of obs. vs. model during the SUMOS field campaign
Credits: LATMOS

AROBASE in summary…

- New research tool at km-scale for understanding and representation of exchange processes, with a shared coupling interface between CNRM's climate models, Météo-France's NWP systems and even very small scale models (LES with MESO-NH)
  - Significance of the modularity criteria, that aims to facilitate collaborations with several modelling communities, and to ensure flexibility in order to answer and anticipate the various needs
- A coupled system for numerical prediction (weather, air quality, sea state and upper-ocean) which imposes strong constraints (stability, performance, maintenance,…) but also opportunities to test new developments (physical parametrizations, new numerical methods) with dedicated analyse tools.
- Deployment capacity on regions of interest (transportability), in particular for specific needs related to observation (field campaigns, new observing platforms,...)
- New possibility to provide modelling products, more integrated and more consistent, for the scientific community (ex : boundary conditions for very HR models), institutional product (wave/submersion vigilance, NWP downstream applications) and general public (with more integrated information on severe situations notably)

Thank you
for your attention!

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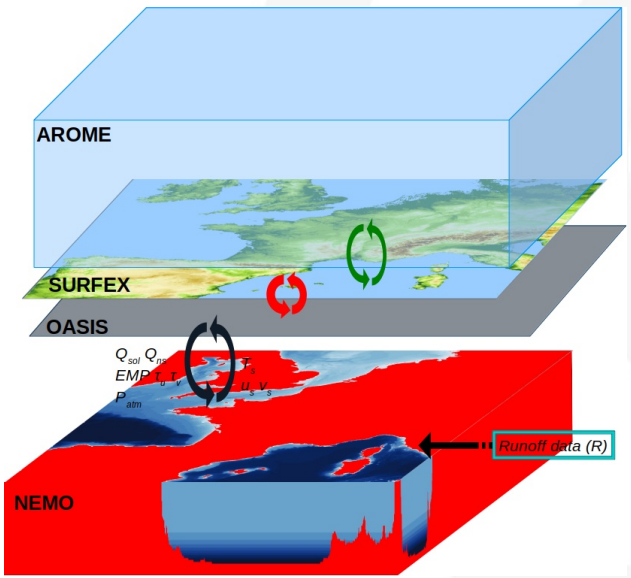
Assemble a research numerical tool

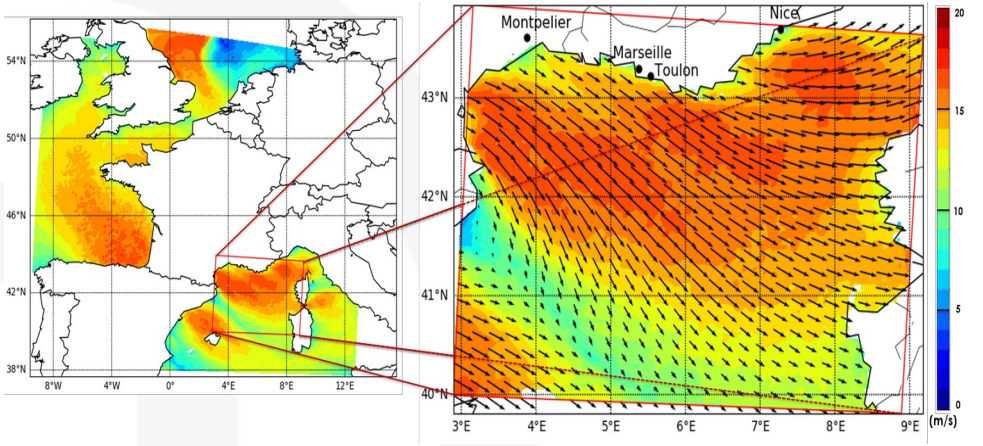
AROME-NEMO coupling (collab. with Mercator Ocean, Q. Misi, M2 internship)

Objective: evaluate the OA coupling impact on ocean stratification during a north-westerly wind (mistral) case (23-29 sept. 2022)

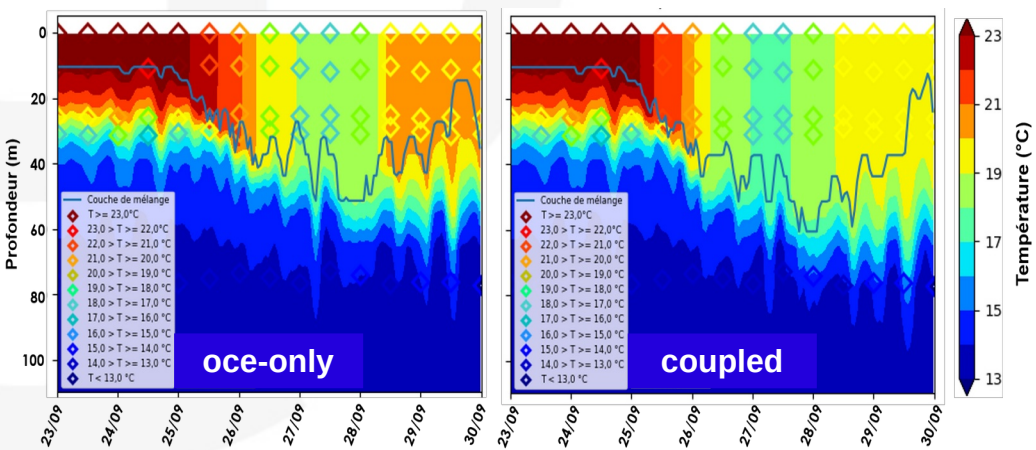


AROME-FR (c43t2, 1.3km, 90 η-levels, Δt=50s)
NEMO-FRA36 (v4.2, 1/36° ORCA grid, 50 z-levels, Δt=150s)
coupling frequency: 600s

FRA36 domain **NW-Med**



Daily-averaged wind velocity (colors, m/s) for 25 Sept. 2020



Hovmöller diagram of ocean temperature, Lion buoy (42°N-4.7°E)