The new load balancing tool in OASIS3-MCT_5.0

… and more

E. Maisonnave (CERFACS)

OASIS3-MCT v5.0

Valcke et al., 2021a

Release: January 2022

> Services: `git` Version Control System, Short Private Online Course (SPOC)

> Additional functionalities, e.g. :

- Python, C & C++ API
- Locally-conservative interpolation (for river runoff coupling)
- Unified environment to generate regridding weights with SCRIP, ESMF or XIOS
- Load balancing tool

What's next ?

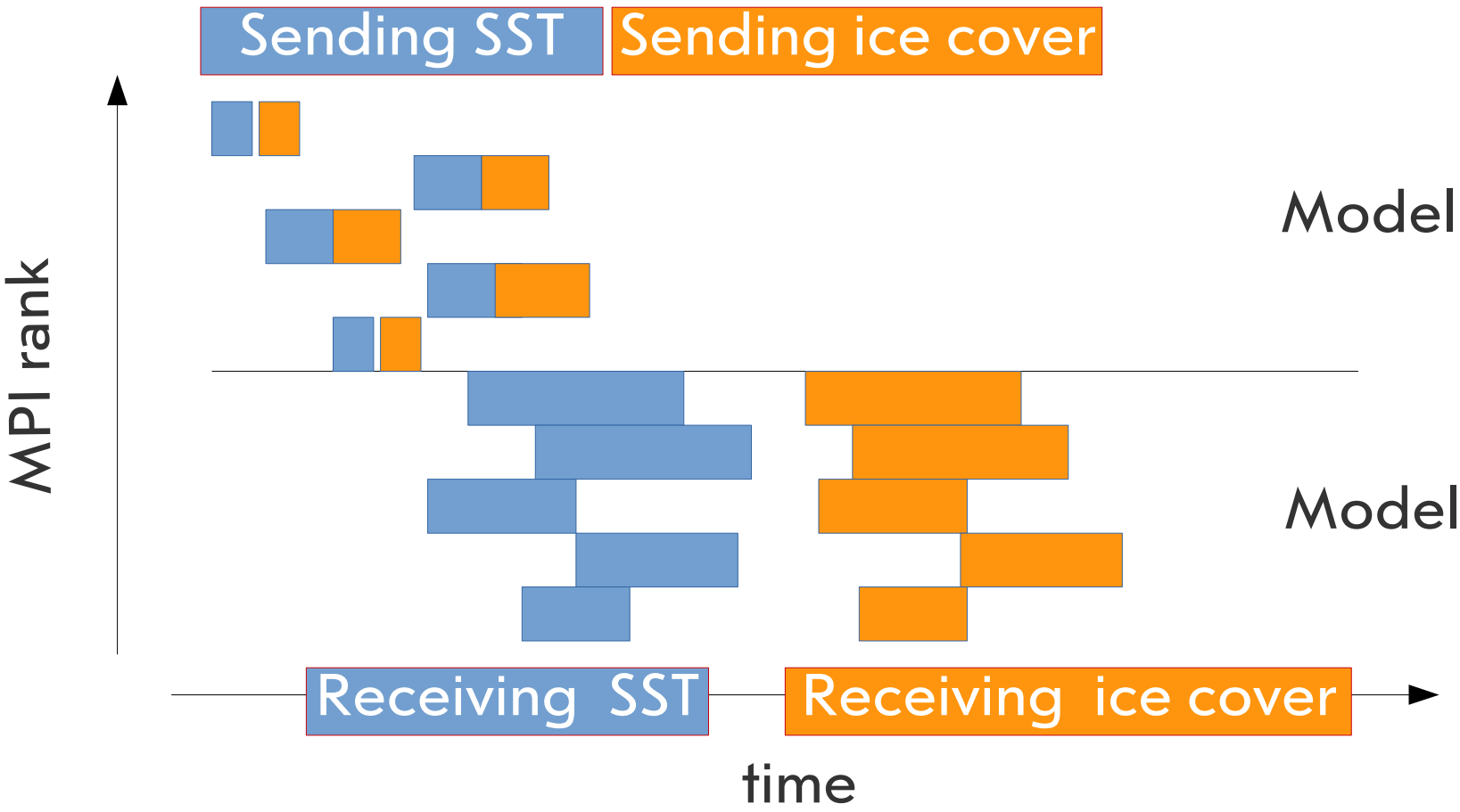
Load balancing

Internal tool to measure and visualise
every kind of coupling cost on every coupled process

Piacentini & Maisonnave, 2021

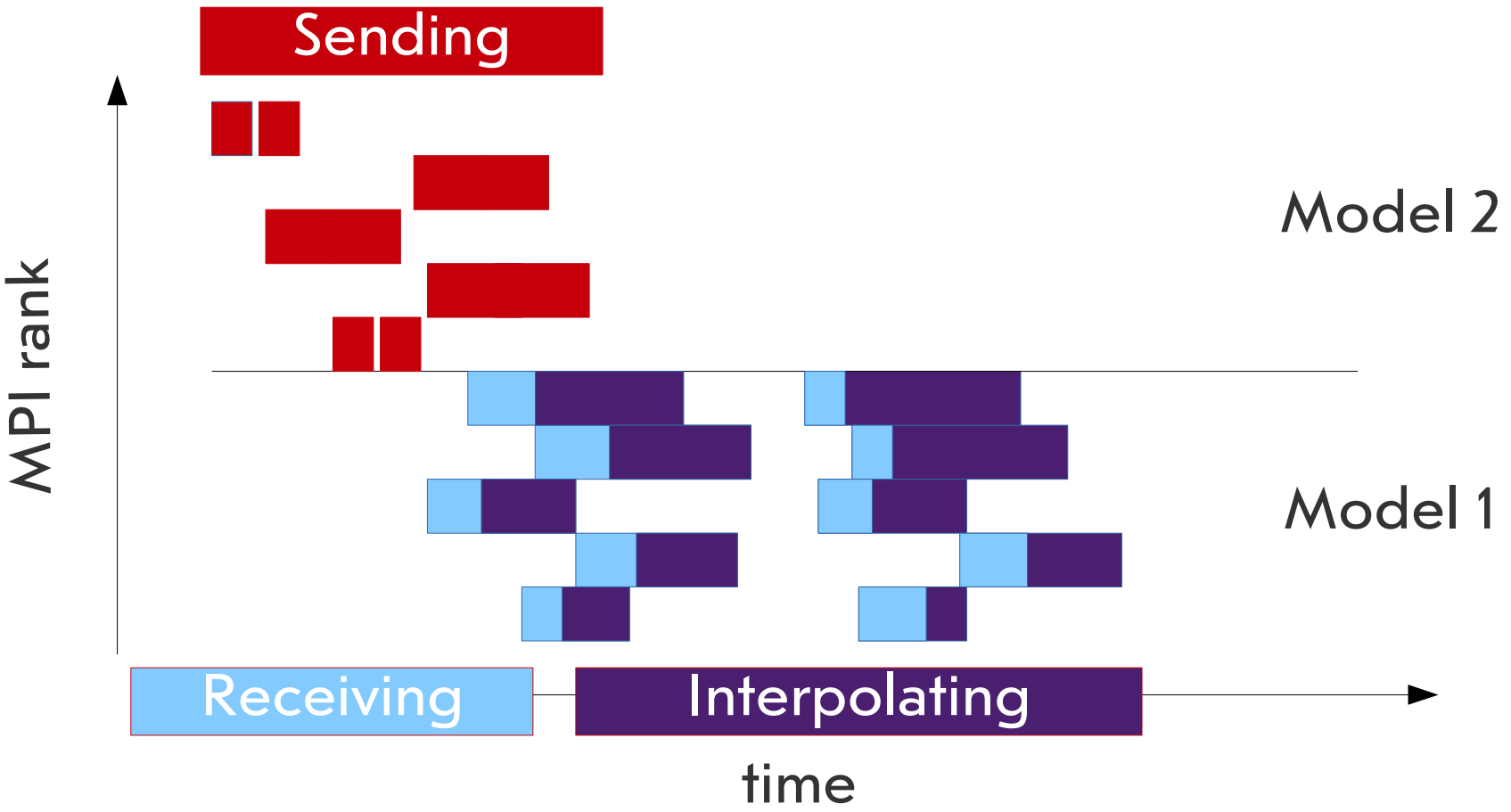
Load balancing

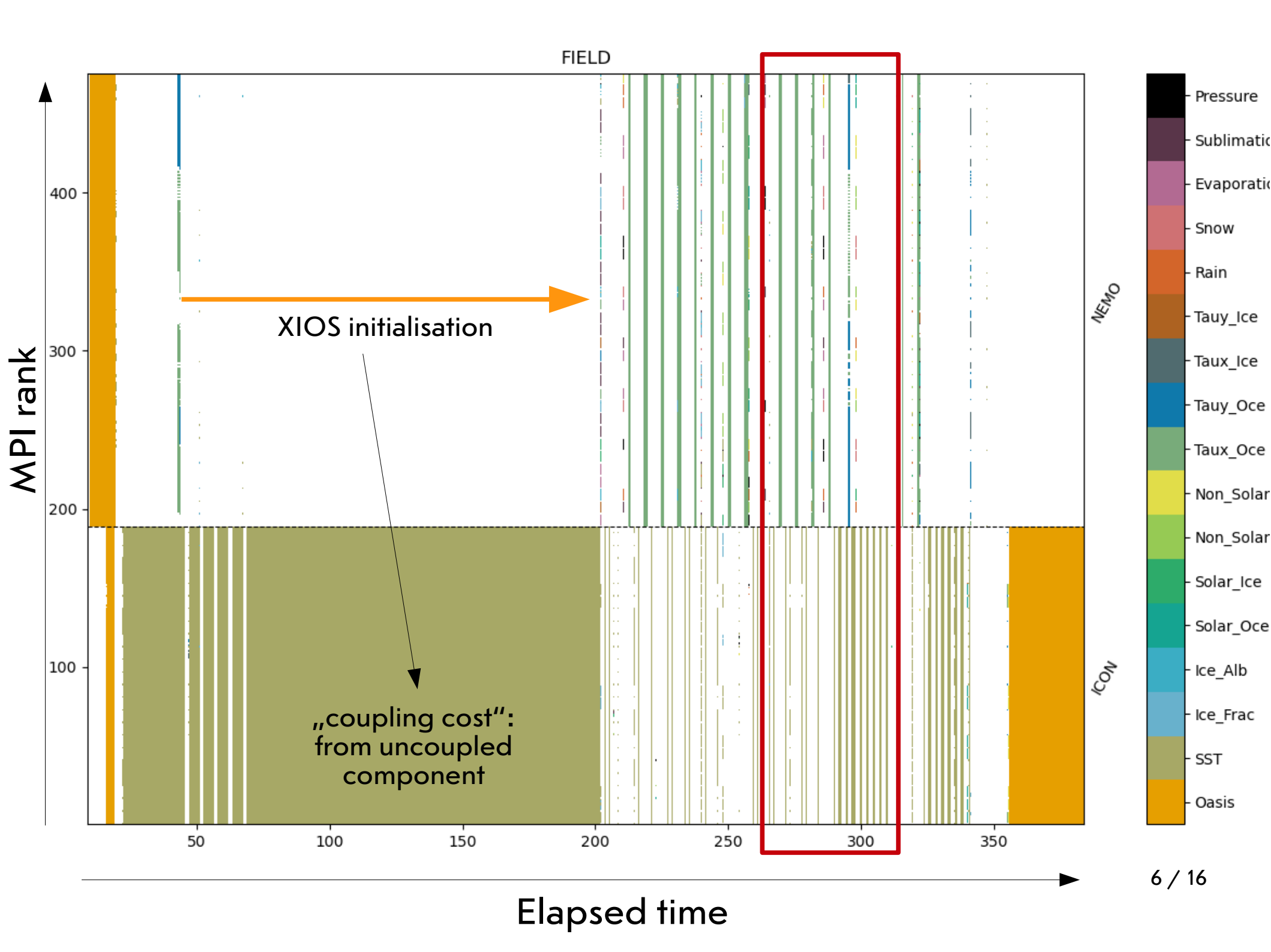
Internal tool to measure and visualise
every kind of coupling cost on every coupled process

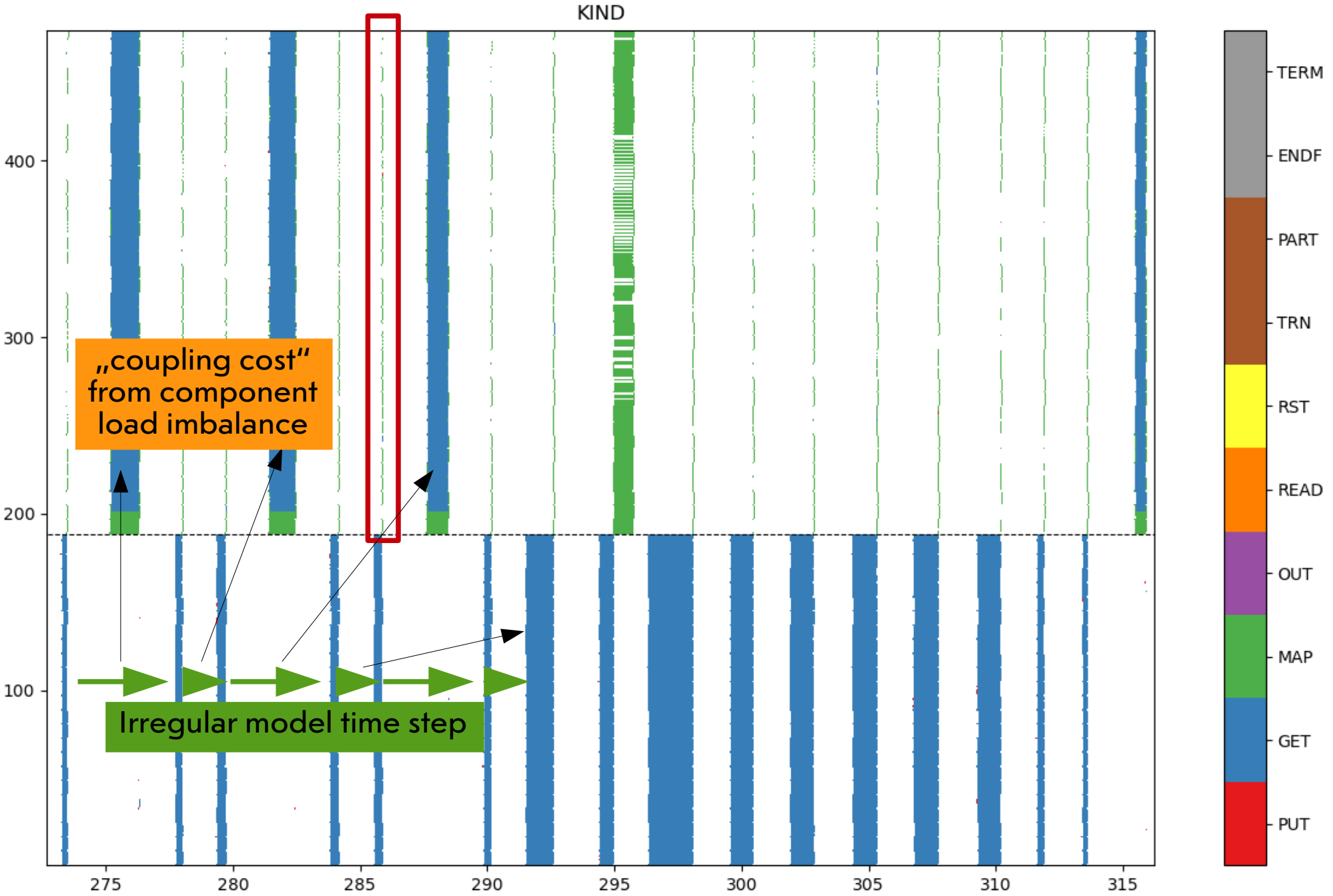


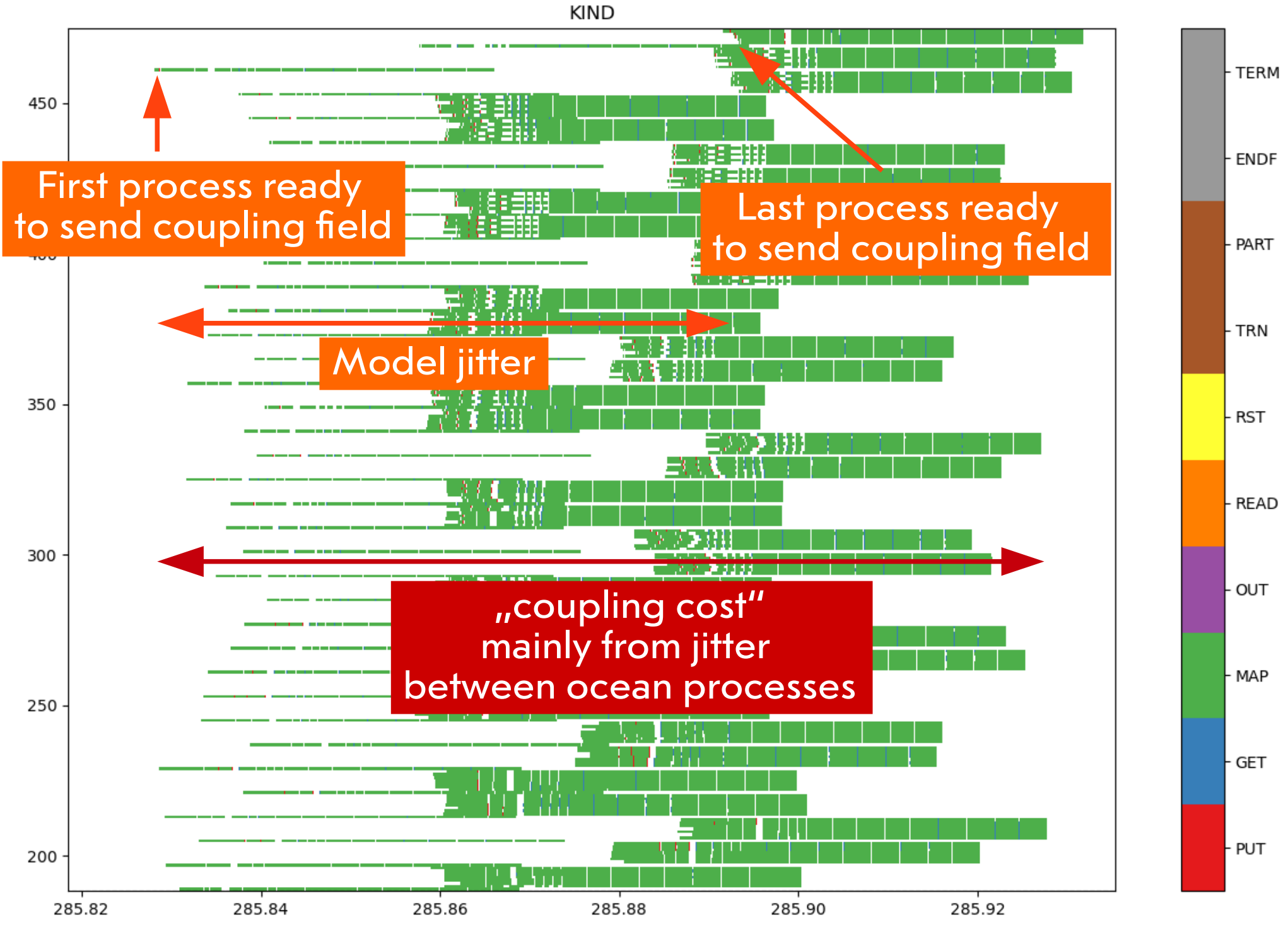
Load balancing

Step by step
OASIS exchanges




FIELD
MPI rank
400
300
200
100
XIOS initialisation
„coupling cost“:
from uncoupled
component
NEMO
ICON
Pressure
Sublimatic
Evaporatic
Snow
Rain
Tauy_Ice
Taux_Ice
Tauy_Oce
Taux_Oce
Non_Solar
Non_Solar
Solar_Ice
Solar_Oce
Ice_Alb
Ice_Frac
SST
Oasis
50
100
150
200
250
300
350
Elapsed time


KIND
400
300
200
100
275
280
285
290
295
300
305
310
315
TERM
ENDF
PART
TRN
RST
READ
OUT
MAP
GET
PUT
„coupling cost“ from component load imbalance
Irregular model time step


KIND
450
350
300
250
200
285.82
285.84
285.86
285.88
285.90
285.92
TERM
ENDF
PART
TRN
RST
READ
OUT
MAP
GET
PUT
First process ready
to send coupling field
Last process ready
to send coupling field
Model jitter
„coupling cost"
mainly from jitter
between ocean processes

Load balancing

Our tool helps users to address the load balancing issues & (**potentially**) reduce the "coupling cost"

2D interpolations/exchanges are problems of **secondary importance**

Services for a community

- Open source code (FORTRAN) available with `git` (`gitlab` for distribution)
  - Services: Short Private Online Course (SPOC)

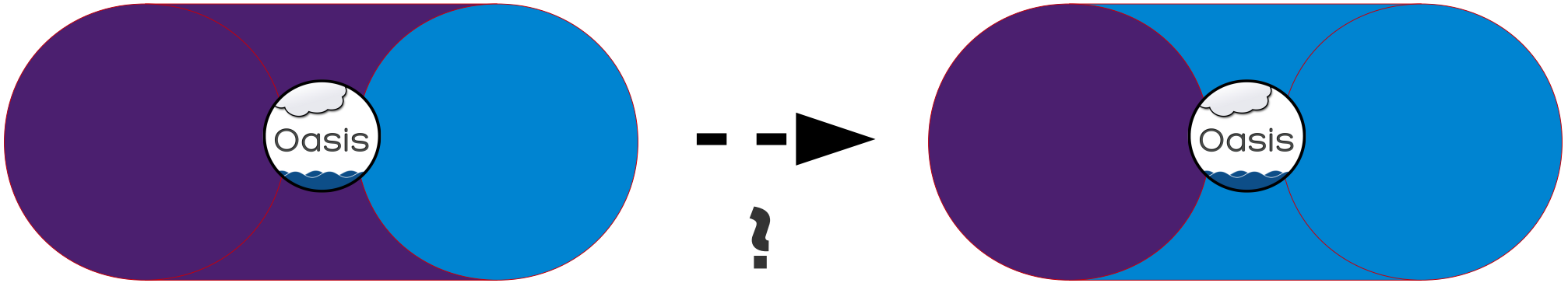
NEW !

- *Growing* community: (2019 survey): ~60 laboratories, 80 models, 5 out of the 7 CMIP6 EU ESMs
- Community of *active* users: debug & interface development >> *Community driven* tool
- Many NEMO and WRF users: importance of modular interfaces that create a *de facto standard* and speed up the implementation
- How to keep involving the climate community developers ? FORTRAN is the key (*really open* source) but ...

New API

Kedward, L. et al., 2022

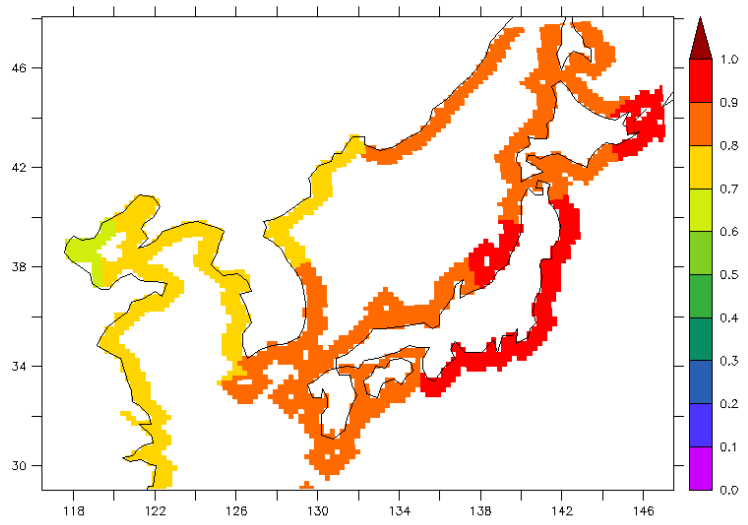
Python, C, C++ API Gambron, P. et al., 2020

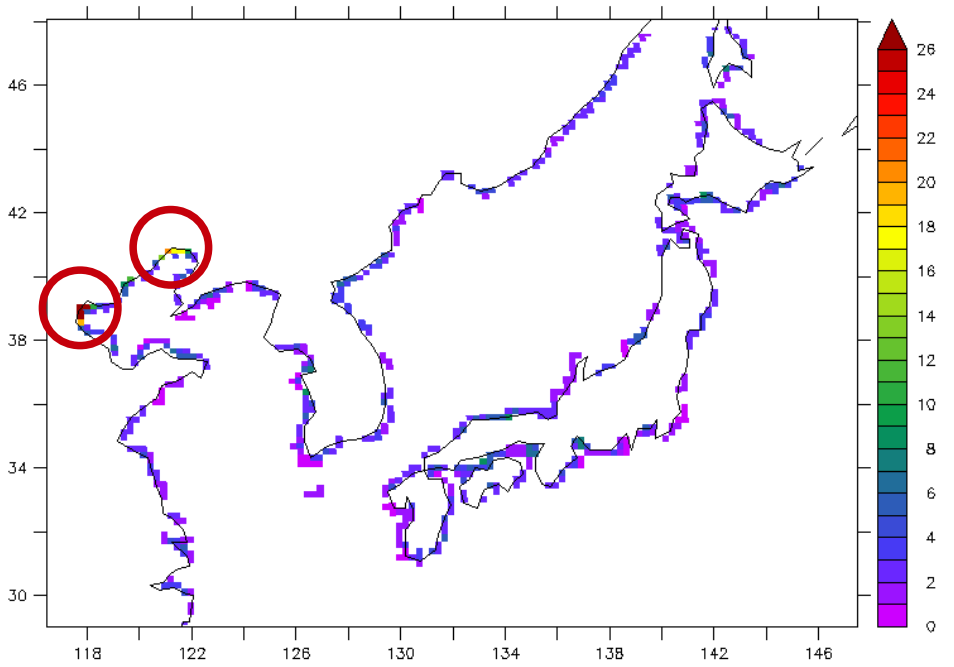


Domain specific interpolation

Dedicated interpolation for river runoff Voldoire, 2020

Coast line mismatch between model grids: river mouth grid points of land and ocean models have no intersection: need for a „Domain Specific" interpolation





Towards an Exascale coupler ?

Valcke et al., 2021b

- Benchmarking of **SCRIP, ESMF, XIOS, YAC**, *ATLAS, MOAB*
- Unified environment to generate regridding weights

- Compatibility with manycore technology or GPU
- Dynamical regridding

- But not all computing cores involved in coupling (e.g. Sunway) / Boundary conditions usually offloaded on CPU host (e.g. CSCS' GPU)
- But dynamical grids expensive (see neXtSIM ice model evolution from Lagrangian to Eulerian grid)

What does Exascale coupler mean ?

Coupler: noun, \ kə-p(ə-)lər \
Definition of *coupler*

1. A runtime library that collects and provides boundary conditions at model interface

- OASIS was created in 1991 to couple a tropical Pacific ocean with a regional atmosphere model. Release after release, it is departing from the original engineered design
- It is written in a language that soon won't be understandable by the newcomers

Coupler: noun, \ kə-p(ə-)lər \ Definition of *coupler*

2. The community activity which aims to represent the model interface physics

- Actual Ocean-Atmosphere parametrisation limits : flux correction better than bias coupling, incoherences in time and space
- To improve ocean-atmosphere interactions, a full parametrisation of OA surface layers is required, e.g. a boundary layer model, including waves
- Which coherence in time (Schwarz method) ? Which coherence in space (stochasticity, exchange grids) ?
- Clear interaction between geophysics and coupler development

An OASIS renewal can be a part of this community activity towards a better representation of the interface physics

Dommenget & Rezny, 2018 / Lemarié et al, 2013 / Rackow & Juricke, 2020

References

* Dommenget, D., & Rezny, M., 2018: "A Caveat Note on Tuning in the Development of Coupled Climate Models" in JAMES, 10, 78 – 97
* Gambron, P., Ford, R., Piacentini, A. & Valcke, S., 2021: "pyOASIS – a python and C interface for OASIS3-MCT", Technical report TR-CMGC/21/56
* Kedward, L. et al., 2022: "The State of Fortran," in Computing in Science & Engineering, doi: 10.1109/MCSE.2022.3159862.
* Lemarié, F., Debreu, L., & Blayo, E., 2013: "Toward an optimized global-in-time schwarz algorithm for diffusion equations with discontinuous and spatially variable coefficients", in *Electronic Transactions on Numerical Analysis*, 40, 148-169.
* Piacentini, A., & Maisonnave, E., 2020: "Interactive visualisation of OASIS coupled models load imbalance" , Technical Report TR/CMGC/20/177
* Rackow, T., & Juricke, S., 2020: "Flow-dependent stochastic coupling for climate models with high ocean-to-atmosphere resolution ratio", in *QJRMS*, 146(726), 284-300.
* Valcke, S., Craig, A., Maisonnave, E. & Coquart, L., 2021: "OASIS3-MCT User Guide, OASIS3-MCT 5.0", Technical report TR-CMGC/21/161
* Valcke, S., Piacentini, A. & Jonville, G., 2021: "Benchmarking of regridding libraries used in Earth System Modelling: SCRIP, YAC, ESMF and XIOS",Technical Report TR/CMGC/21-145
* Voldoire, A., 2020: "River to ocean models interpolation", Research Report, HAL Id : meteo-02986574

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