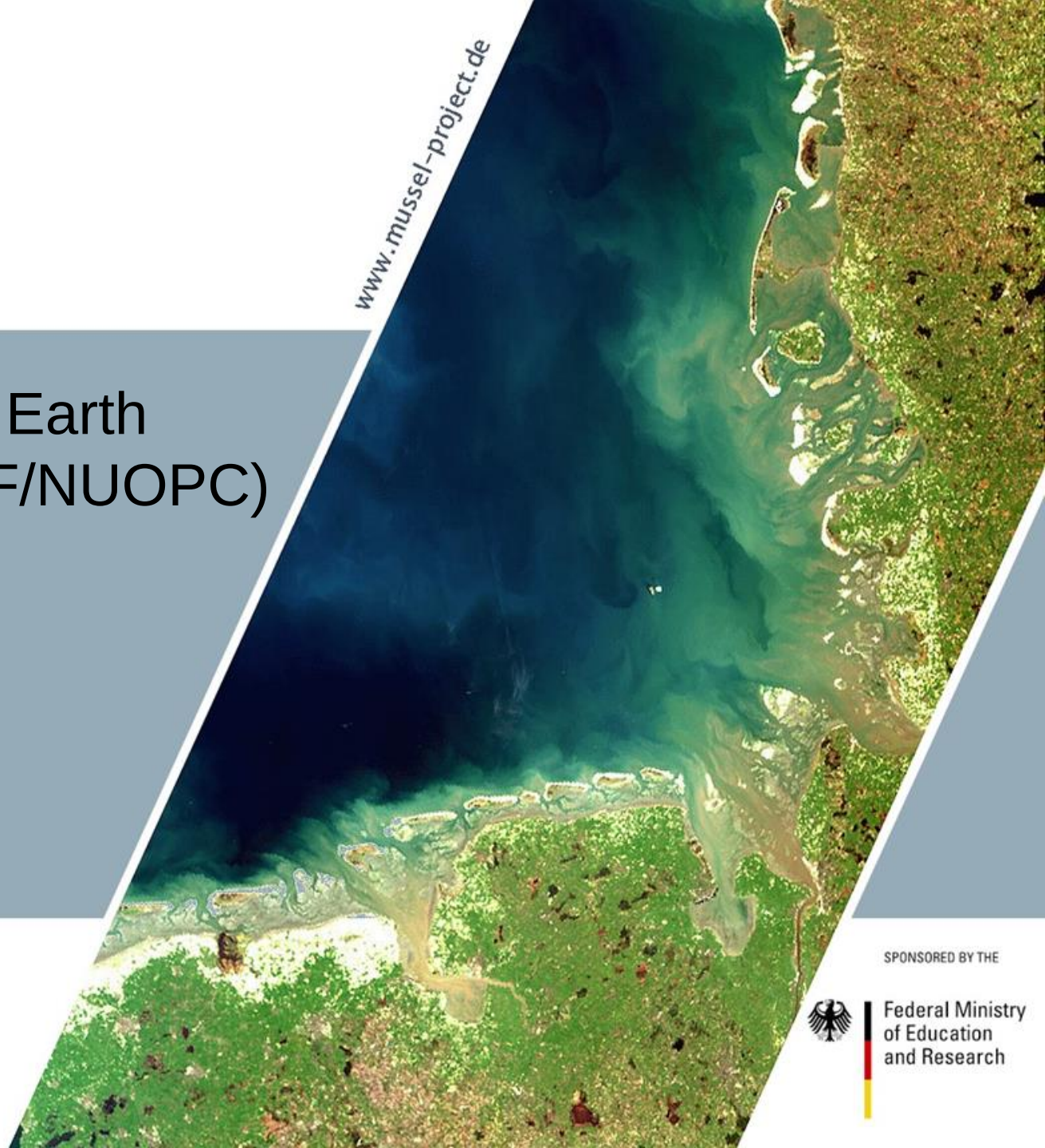
MUSSEL
MULTIPLE STRESSORS ON NORTH SEA LIFE

www.mussel-project.de

The emerging SCHISM APIs for the Earth System Modeling Framework (ESMF/NUOPC) and the Framework for Aquatic Biogeochemical Models (FABM)

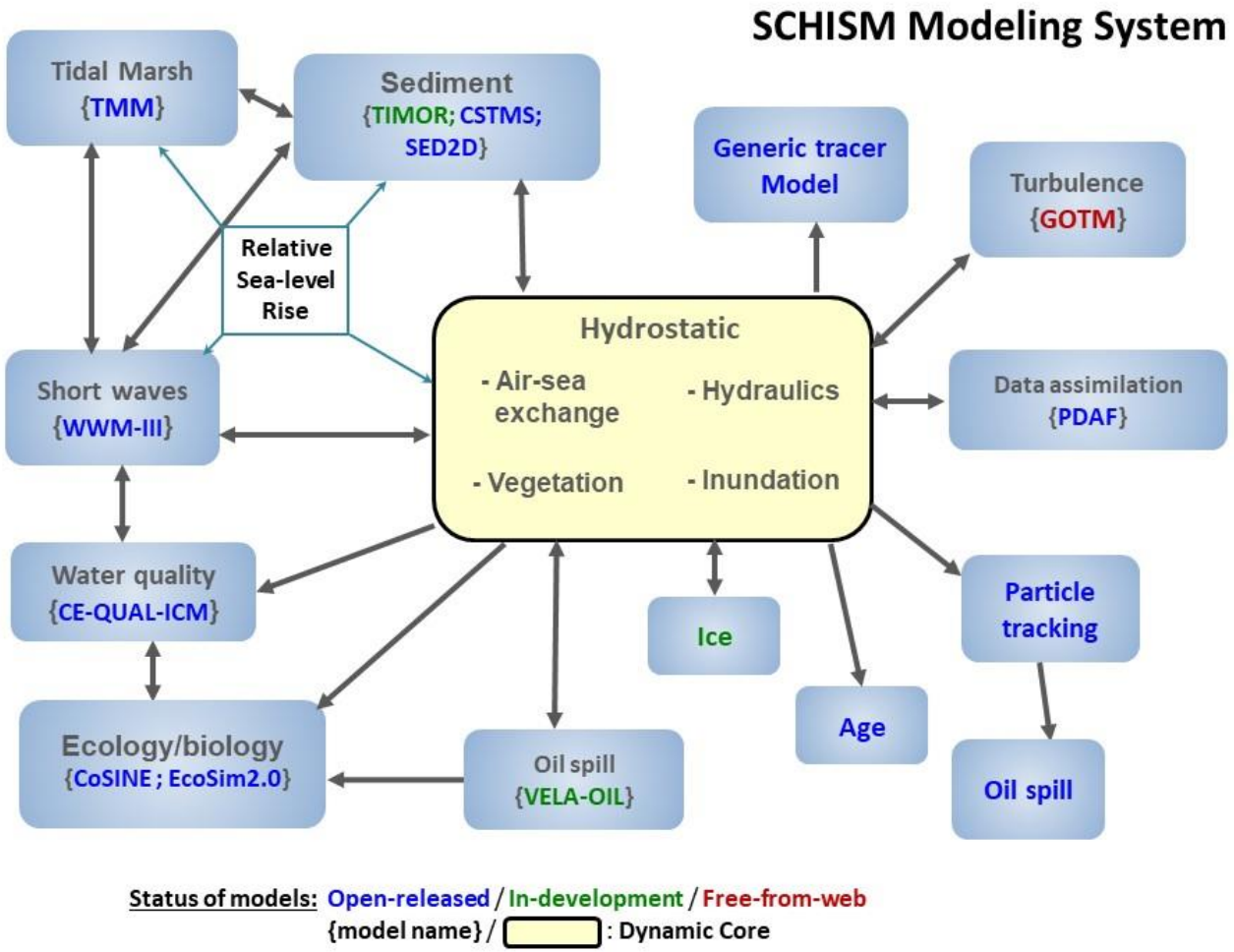


SPONSORED BY THE
Federal Ministry of Education and Research

SCHISM Bootcamp Feb 17-19, 2021

Carsten Lemmen, Helmholtz-Zentrum Geesthacht

Why new APIs to other frameworks?



- ❑ Domain coupling

  ESMF

  Earth System Modeling Framework

- ❑ Interoperability

  ESMF/NUOPC

  National Unified Operational Prediction Capability

- ❑ Online postprocessing

  ESMF/MOSSCO

  Modular System for Shelves and Coasts

- ❑ Generic eco-API

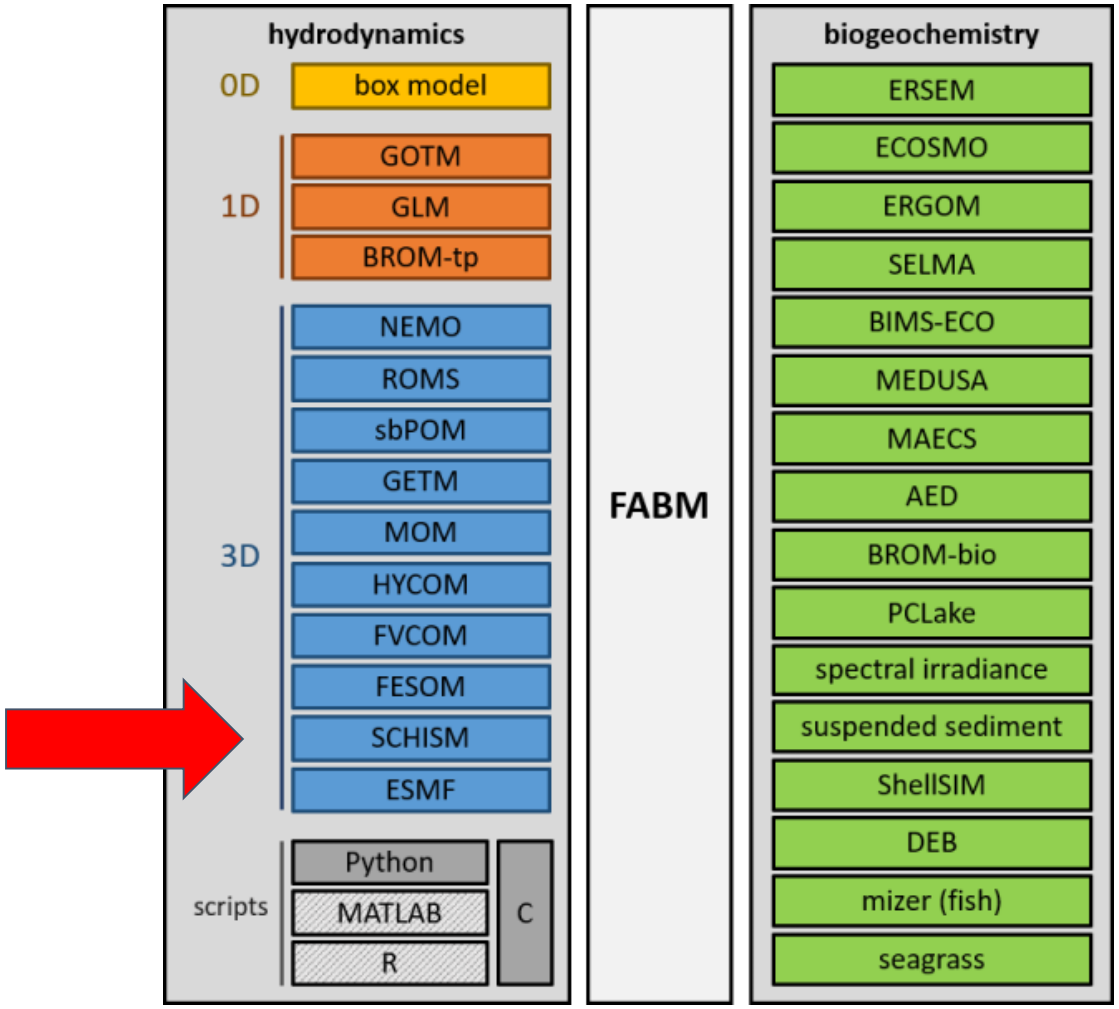
  FABM

  Framework for Aquatic Biogeochemical Models

Framework for Aquatic Biogeochemical Models

- **Code once. Apply anywhere.**
  identical BGC model in 0D, 1D, 3D hydrodynamics and python scripts
- Local source/sink terms in BGC model
- Hydrodynamic model
  - provides I/O
  - stores data
  - integrates advection, diffusion, SMS

https://fabm.net

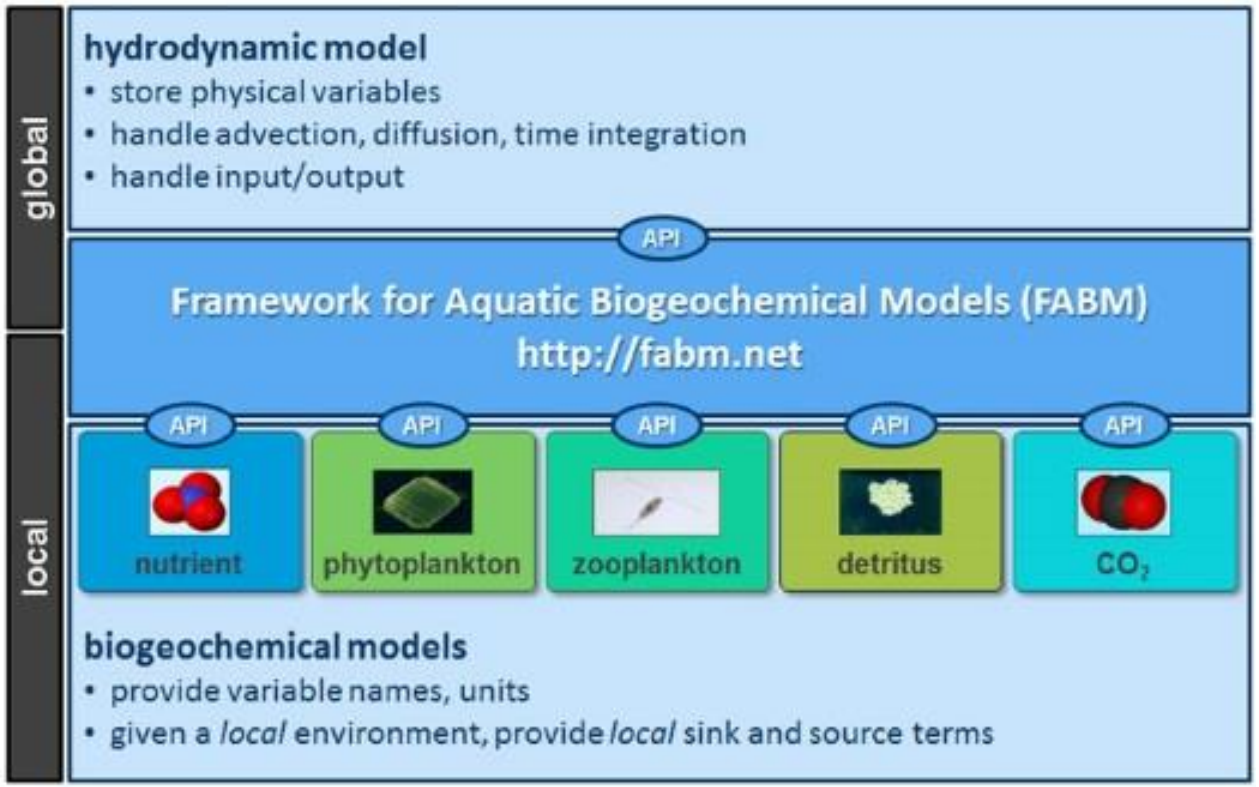


Bruggeman, J., Bolding, K., 2014. A general framework for aquatic biogeochemical models. Environmental Modelling & Software 61: 249–265. DOI: 10.1016/j.envsoft.2014.04.002

Very small code changes "hooks" in SCHISM

```
schism_init.F90:
  call fabm_schism_init_model(ntracers=ntrs(11))
  call fabm_schism_init_stage2()
  call fabm_schism_create_output_netcdf()
  call fabm_schism_init_concentrations()
  call fabm_schism_read_horizontal_state_from_netcdf &
    ('fabm_schism_hotstart.nc',time=time)

schism_step.F90:
  call fabm_schism_do()
  call fabm_schism_write_output_netcdf(time=time)

schism_finalize.F90:
  call fabm_schism_close_output_netcdf()


--


${SCHISM_DIR}/src/Fabm/fabm_schism.F90
```

- ❏ init/run/finalize paradigm
- ❏ FABM as tracer in SCHISM
- ❏ 3D I/O in SCHISM
- ❏ 2D I/O added
- ❏ 2D tracer support missing (ice vars)



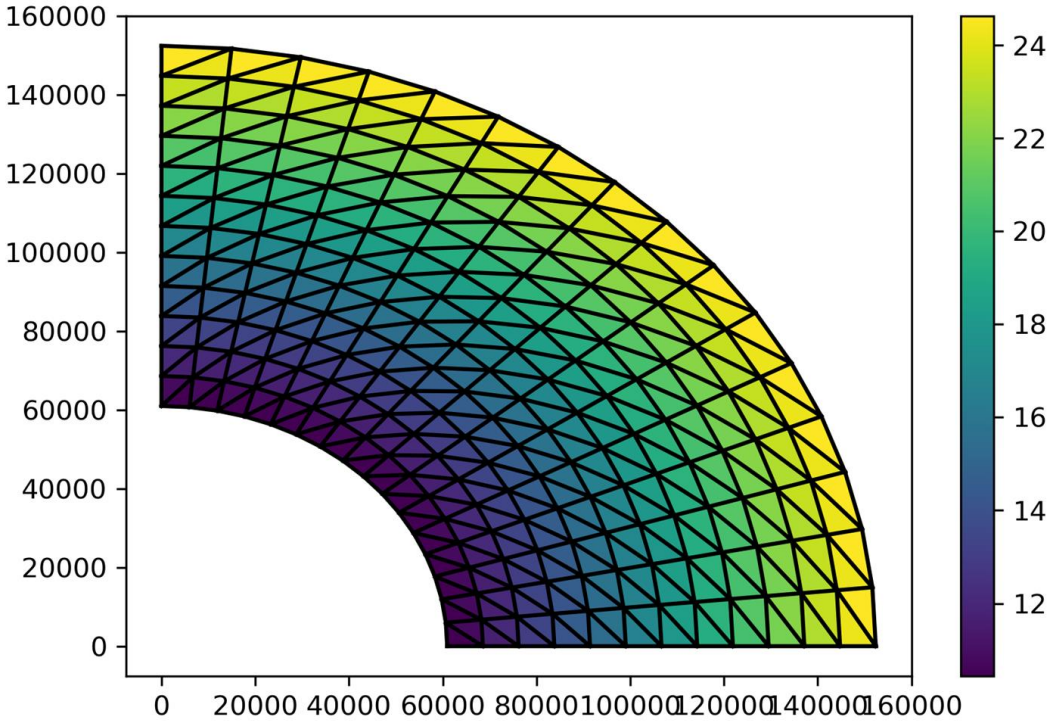
Building and deployment in setup


```
# define your locations ${SCHISM_DIR}, ${BUILD_DIR}, ...
# then download everything from git
$> git clone https://github.com/schism-dev/schism.git
${SCHISM_DIR}
$> git clone https://github.com/fabm-model/fabm.git
${FABM_DIR}

# Build SCHISM with FABM (use CMake && make)
$> cd ${BUILD_DIR} && cmake ../schism/src \
  -DNetCDF_C_DIR=$(nc-config --prefix) \
  -DNetCDF_FORTRAN_DIR=$(nf-config --prefix) \
  -DFABM_BASE=${FABM_BASE} -DUSE_FABM=ON

$> make pschism

$> ls ${BUILD_DIR}/bin
combine_output11    pschism_FABM_TVD-VL pschism_TVD-VL
```

```
# Changed files

fabm.yaml
FBM_1.th
FBM_2.th
FBM_3.th
FBM_4.th
FBM_5.th
FBM_nudge.gr3
bctides.in
hotstart.nc
```

- ❑ independent of BGC model

Offline transport in SCHISM



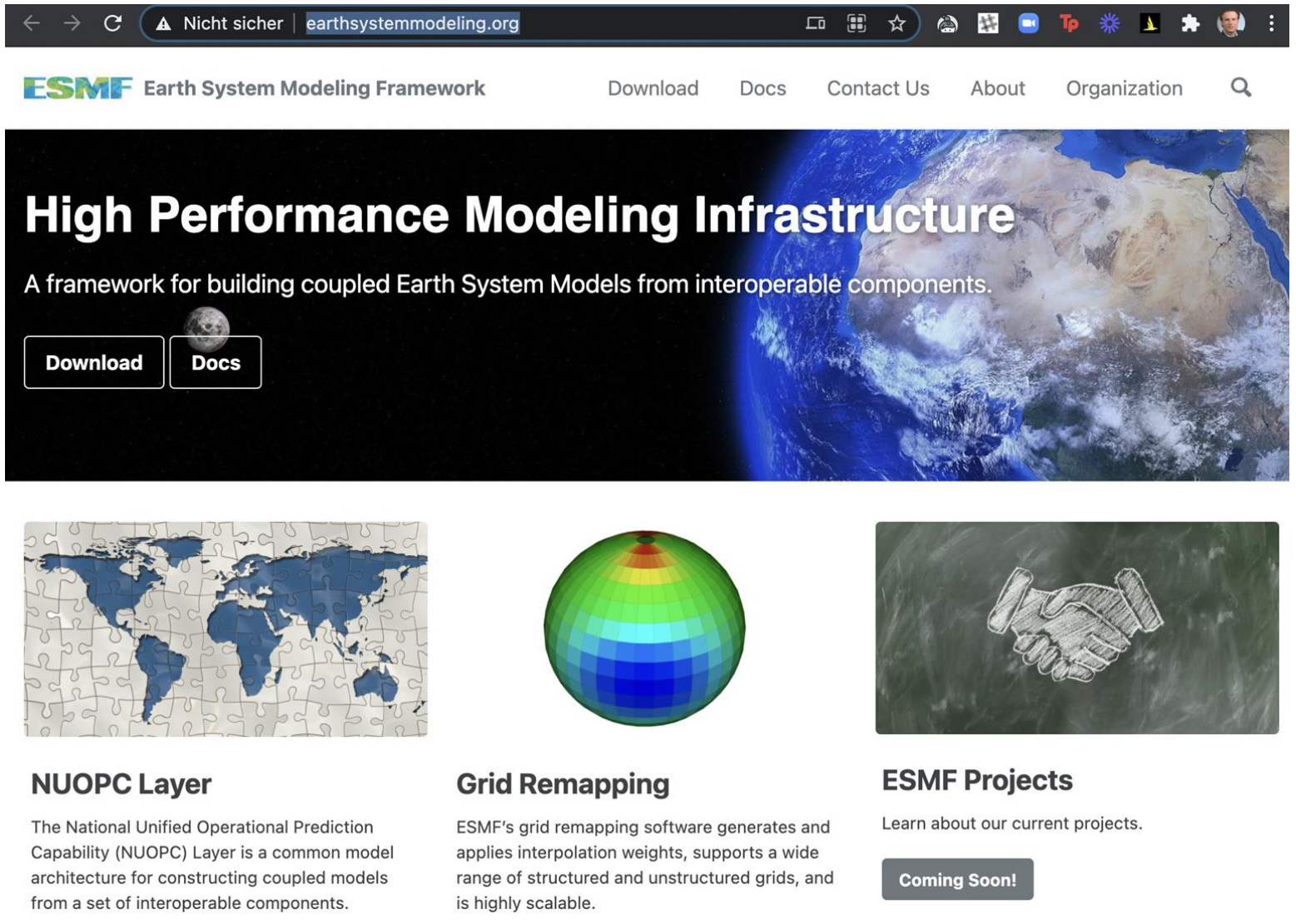

```
! param.nml

! Set to 1 for offline transport,
needs forcing incl.
! hvel_side in subdirectory
./hydro_out
itransport_only = 1

! Set the timestep to the one that
you have in your
! hydrodynamic output in ./hydro_out
dt = 3600.0
```

Speed gain on Apple Silicon M1@8 cores

rnday = 120, 11 layers, 221 nodes, 16 BGC tracers

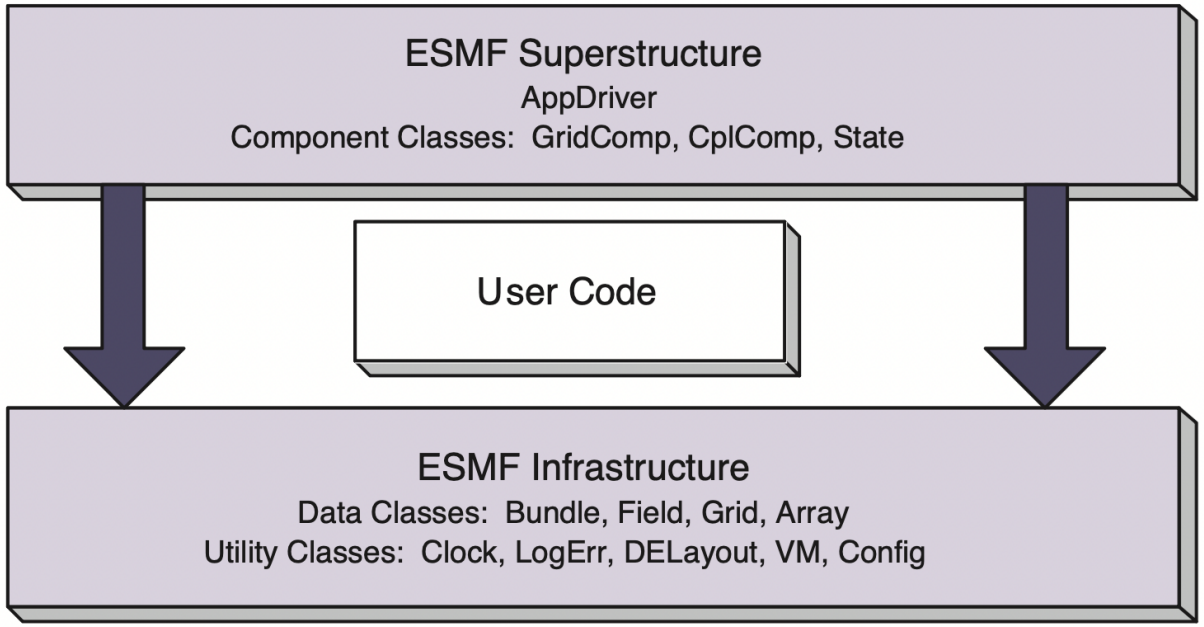
A. Online **19 min**, speedup 9k
B. Offline **3 min**, speedup 57k

Earth System Modeling Framework



- ❏ Remapping
  nco, cdo, ncl
- ❏ Preinstalled on HPC
  module load esmf
- ❏ Library -lesmf
- ❏ Single-executable
  coupled system

ESMF API



➔ Every science model needs a 'cap', or CMI, exposing model to the ESMF

- ❏ Phases: init/run/finalize (BMI)
- ❏ Registration
- ❏ Full grid specification and topology
- ❏ Encapsulation of component
- ❏ Control flow
- ❏ Resource allocation
- ❏ Field exchange

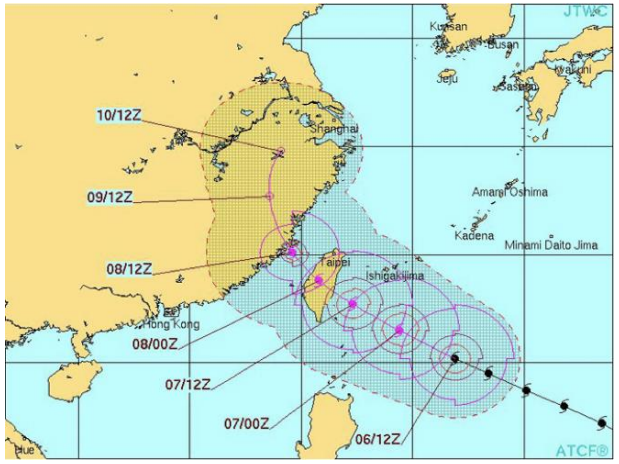
ESMF cap for SCHISM

```
# define your locations ${SCHISM_ESMF_DIR},
# ${SCHISM_BUILD_DIR}, ${ESMFMKFILE}

$> module load esmf
$> git clone https://github.com/schism-
dev/schism-esmf.git \
             ${SCHISM_ESMF_DIR}
$> cd  ${SCHISM_ESMF_DIR}

$> make lib concurrent_esmf_test && ls

libschism_esmf.a

concurrent_esmf_test
```

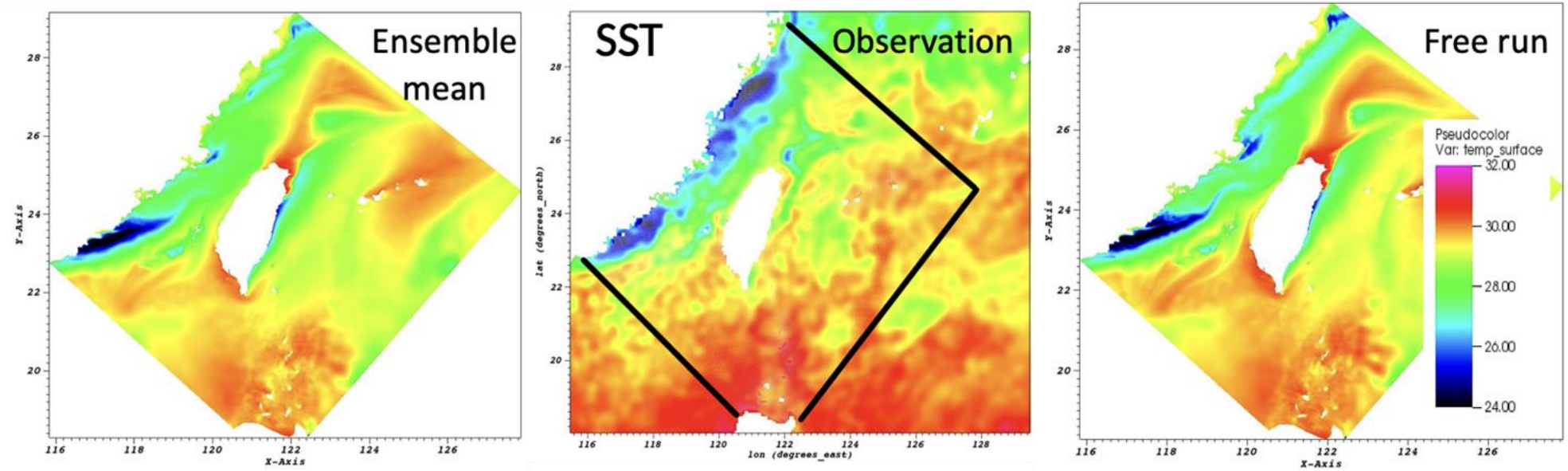
- Independent code base
- Library and test cases
  - multi_schism
  - triple_schism
  - schism_pdaf

SCHISM/ESMF PDAF Typhoon

Parallel Data Assimilation Framework
Work by Yu Hao-Cheng, sponsored by Central Weather Bureau in Taiwan

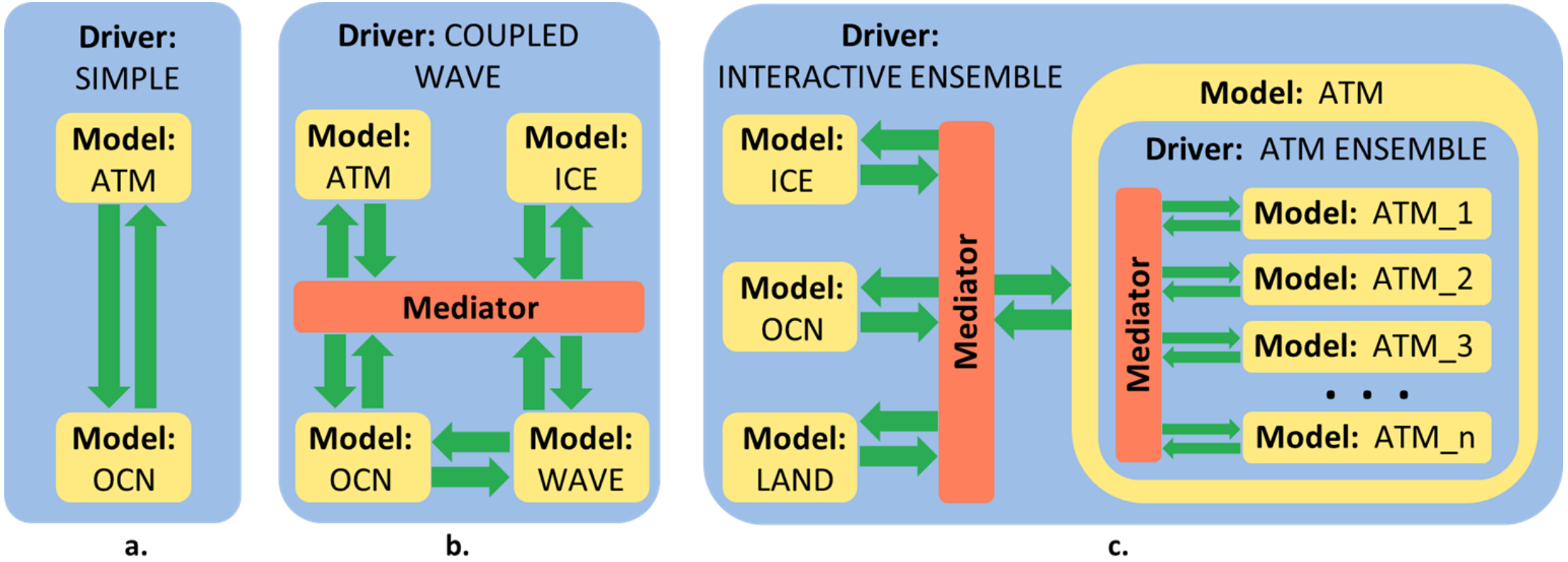


- ❏ 16 ensemble members
- ❏ SST assimilated
- ❏ slight improvement over free run



SCHISM/NUOPC Cap

National Unified Operational Prediction Capability



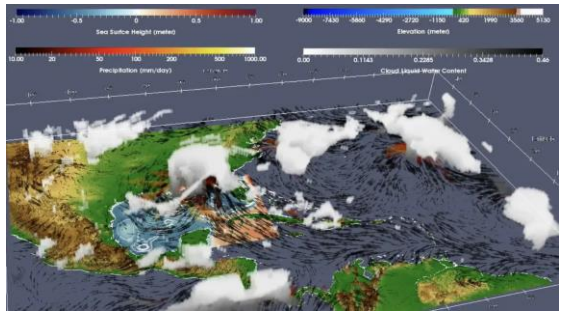
- ❏ Interoperability layer on top of ESMF components
- ❏ Automates coupling and scheduling dependencies
- ❏ SCHISM NUOPC cap under development

ESMF/NUOPC - RegESM Paraview Catalyst

Work by Ufuk Turuncoglu

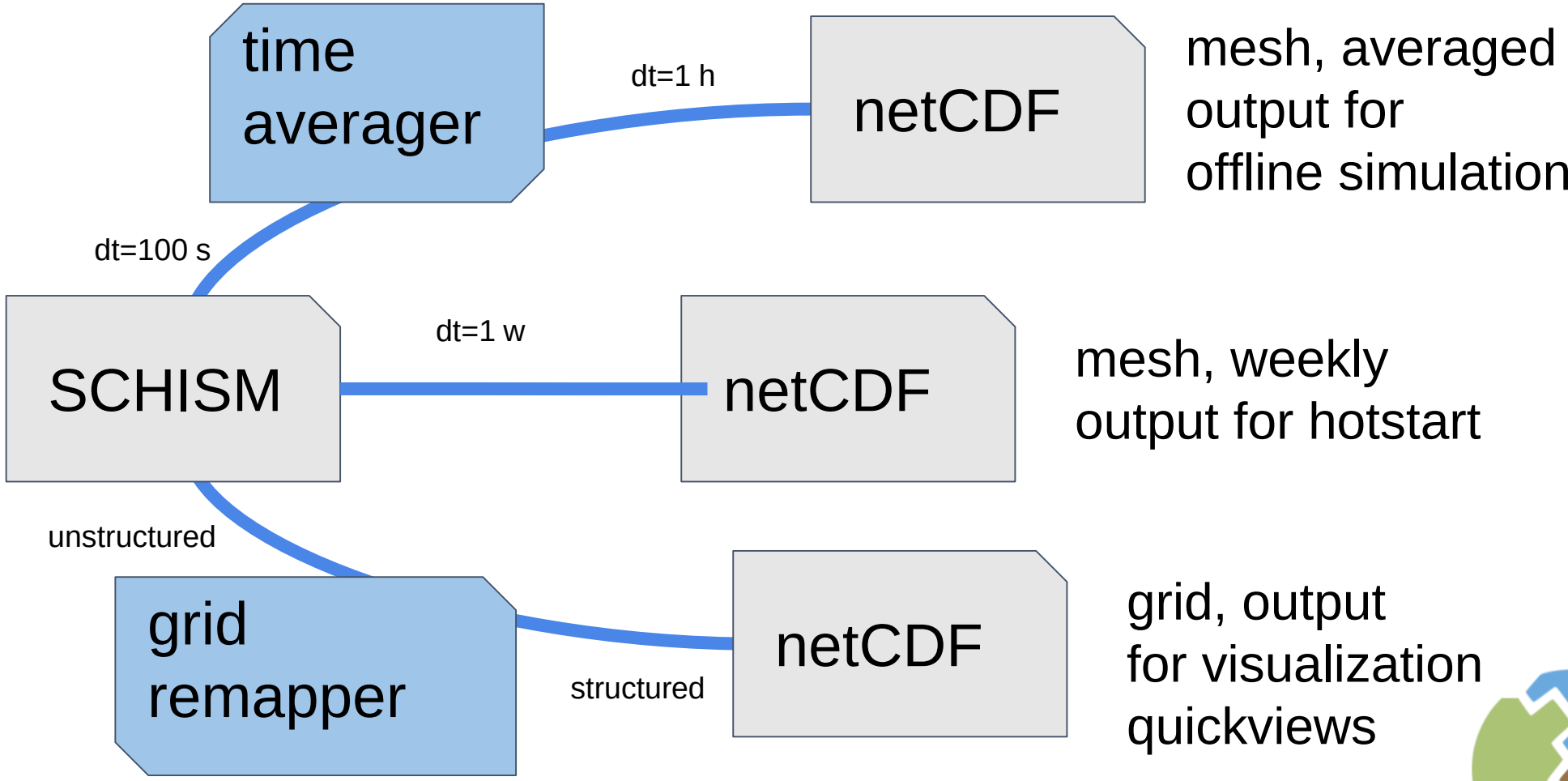
Online remapping and visualization

https://blog.kitware.com/integration-of-paraview-catalyst-with-regional-earth-system-model/



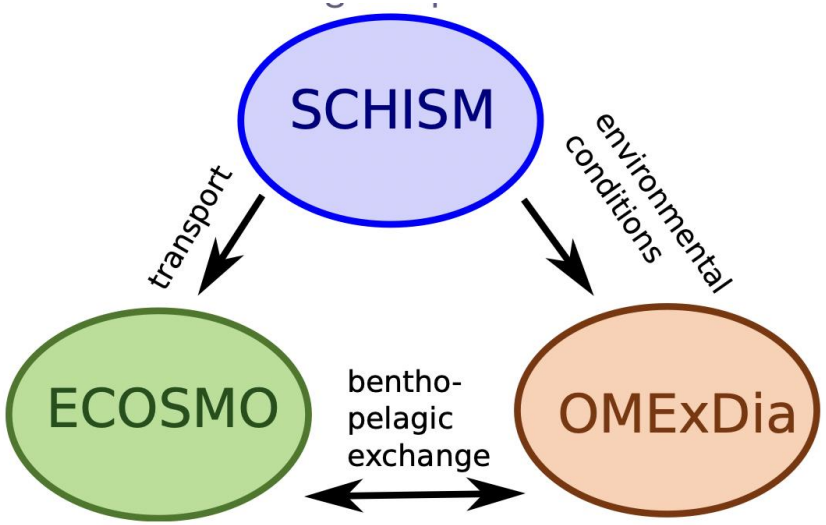
Be sure to watch
https://vimeo.com/208454979

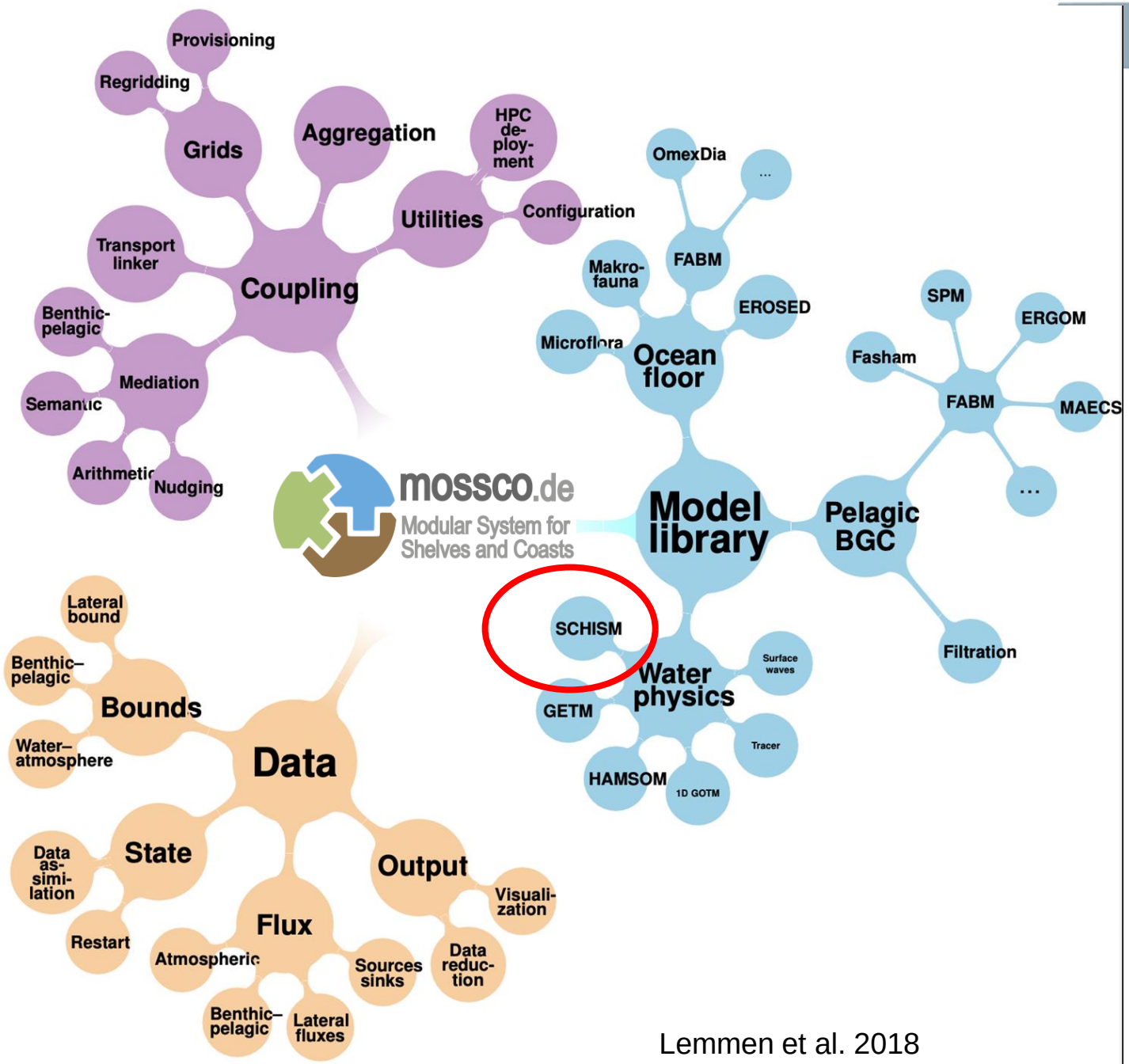
SCHISM/ESMF unified I/O concept



MOSSCO/ESMF

- Modular coupling system
- SCHISM as a "tiny" part in a large system
- SCHISM cross-domain coupling





Lemmen et al. 2018

This is active development!

Institutional efforts

- ❏ HZG: many FABM models to be coupled in SCHISM
- ❏ Dan Yu: SCHISM-PDAF coupler
- ❏ ESMF-Team: NUOPC cap
- ❏ NEMS

Your involvement

- ❏ Free and open source
- ❏ We (Joseph, Dan, and me) need you testing and using these new interfaces!
- ❏ Please fork, create issues, add PR

Thank you!

MUSSEL

MULTIPLE STRESSORS ON NORTH SEA LIFE

www.mussel-project.de

- Domain coupling
  - ESMF
    - Earth System Modeling Framework
- Interoperability
  - NUOPC
    - National Unified Operational Prediction Capability
- Online postprocessing
  - MOSSCO
    - Modular System for Shelves and Coasts
- Generic eco-API
  - FABM
    - Framework for Aquatic Biogeochemical Models

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

HCDC Helmholtz Coastal Data Center

THÜNEN

Universität Hamburg DER FORSCHUNG | DER LEHRE | DER BILDUNG

Hochschule Bremerhaven

Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung

SPONSORED BY THE

Federal Ministry of Education and Research