netherlands eScience center

HyMUSE: a multi-model framework for Hydrology

Inti Pelupessy

EGU General Assembly, Vienna, 08/04/2019

netherlands eScience center

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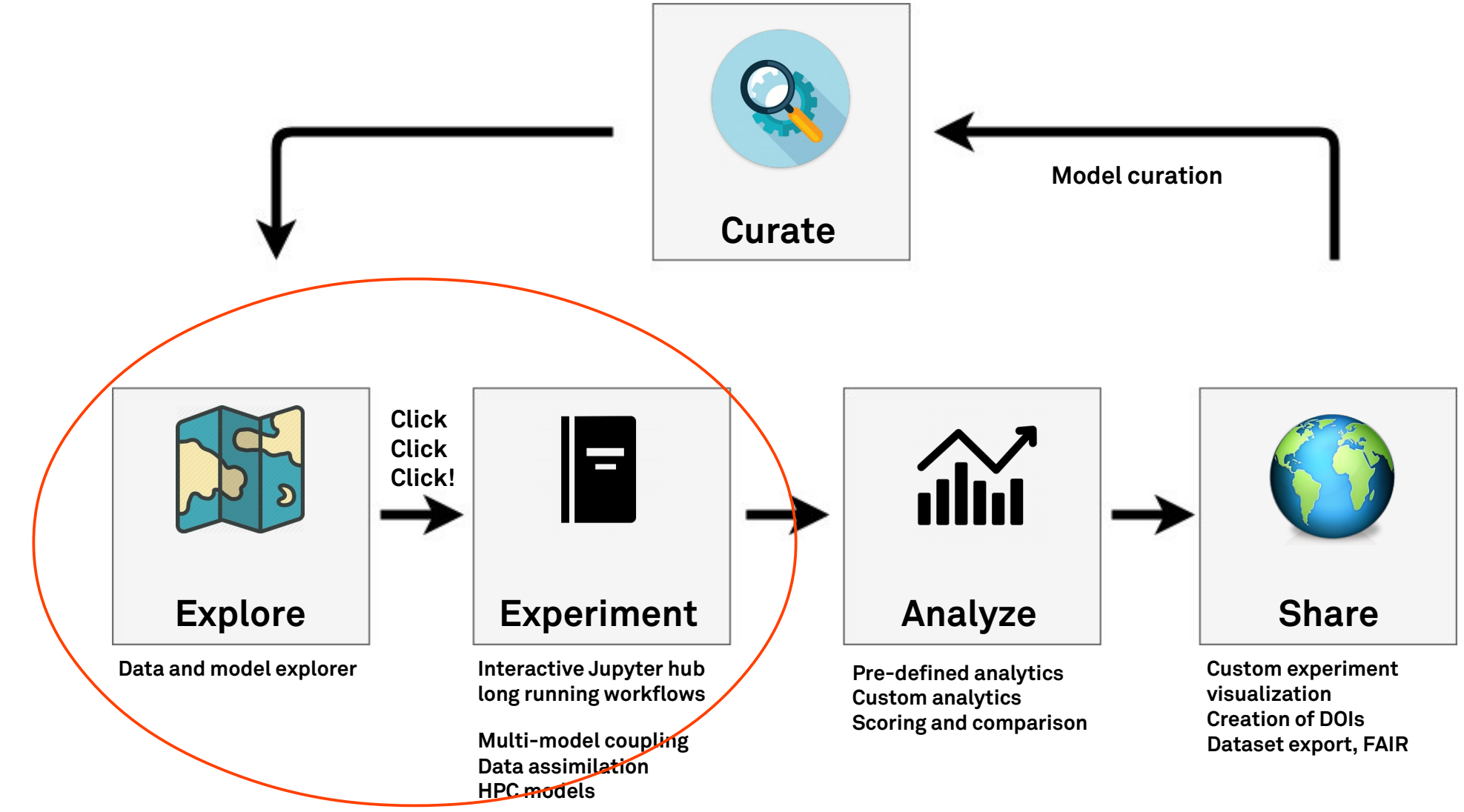
eWaterCycle II Goals

The eWaterCycle II project aims to be a global-scale hydrological modeling platform that allows users to apply hydrological models to answer their research questions.

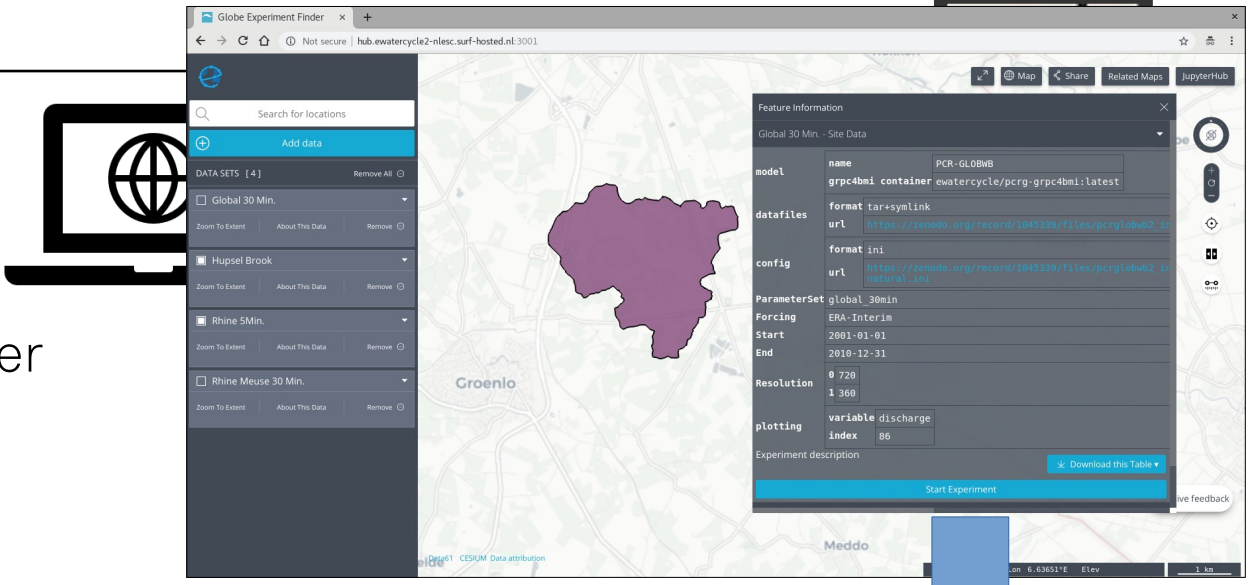
– Combine global hydrological models with local hydrological models, written in different programming languages,
– Recognize findable, accessible, interoperable, and reproducible (FAIR) practices.
– Make it much easier to work together on models.
– Cut down on fte's and time needed to run experiments.
– For this we need a lot of models and a lot of hydrologists to join in.

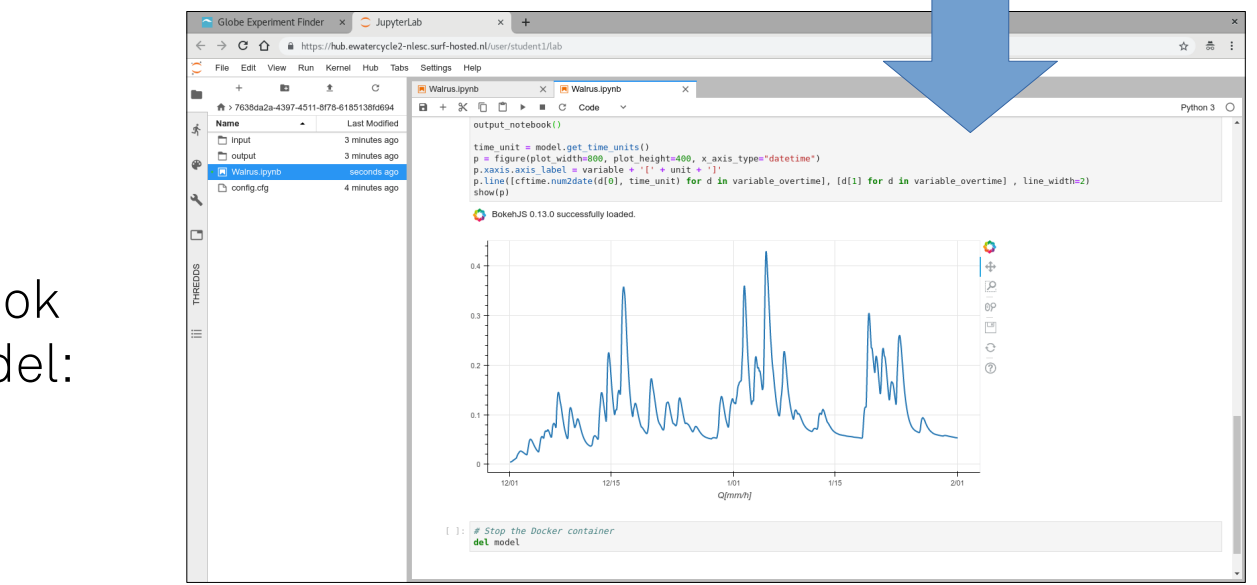
"Towards FAIR & Open Science in Hydrological Modelling"

see also abstracts #12392 (Tue, X3.89) #11014 (Fri, X1.51)
#9276 (Fri 8:30, pico spot 5b) #5580 (Thu, A.17)


Curate
Model curation
Explore
Click
Click
Click!
Experiment
Analyze
Share
Data and model explorer
Interactive Jupyter hub
long running workflows
Multi-model coupling
Data assimilation
HPC models
Pre-defined analytics
Custom analytics
Scoring and comparison
Custom experiment
visualization
Creation of DOIs
Dataset export, FAIR

eWaterCycle II workflow





1. Choose a region in online viewer

2. Get list of available models / forcings / observations for that region.

3. Make a selection and “launch experiment”.

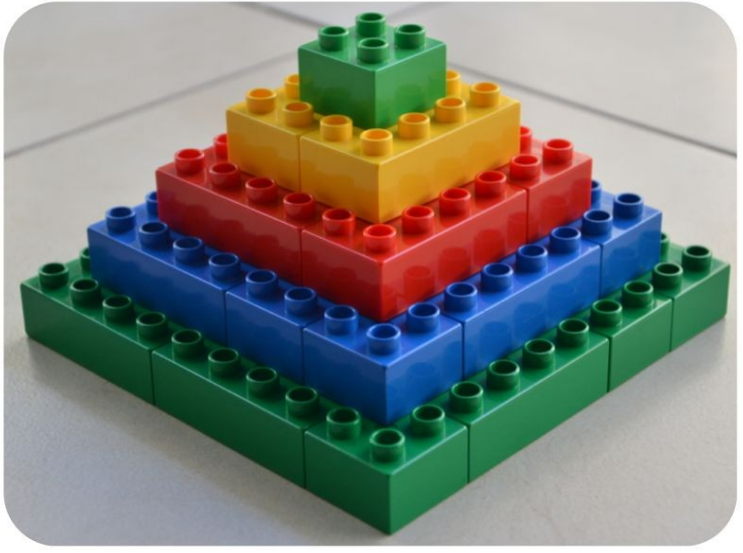
4. Get an (online!) Python notebook with the hello-world for that model: a hydrograph at the basin outlet compared to observations

Building a community

Lorentz workshop in april 2019 to incorporate seven hydrological models

introducing HyMUSE

Problem: we need a method to interact with simulation codes that is:
- simple & intuitive to use
- easy to install
- interfaces codes written in different languages
- uses homogeneous interfaces
- allows the use non-local compute resources



introducing HyMUSE

Problem: we need a method to interact with simulation codes that is:
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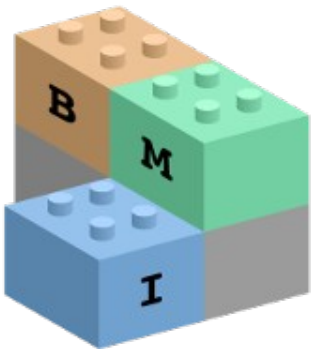
Solution:

AMUSE/ OMUSE

+

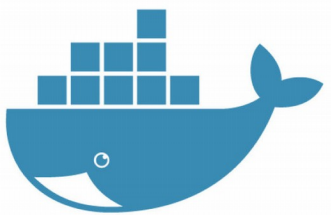


Basic Model Interface

+

GRPC4BMI

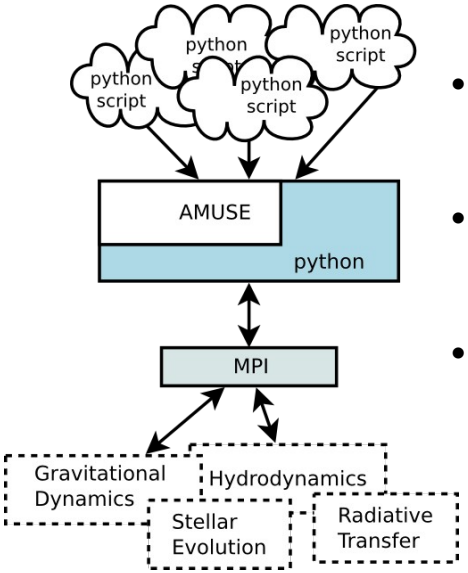
+

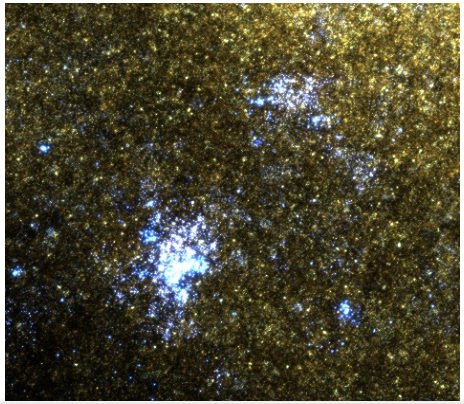


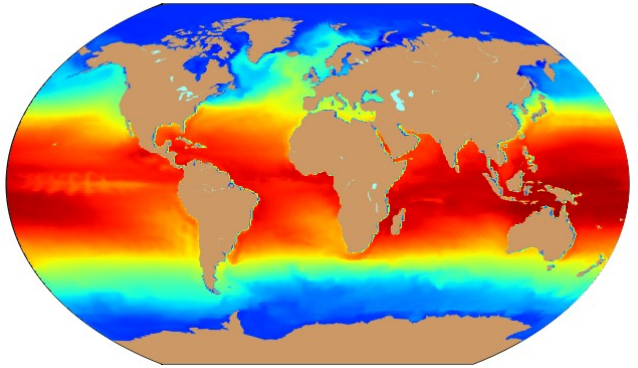
containers

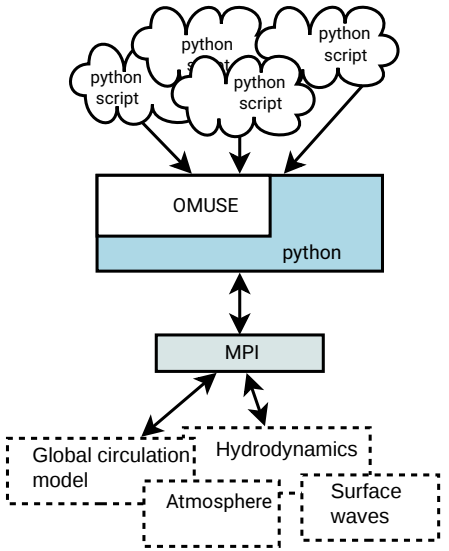
AMUSE & OMUSE

- model coupling frameworks for astrophysics & climate sciences (developed at Leiden Observatory, Utrecht University and the Netherlands eScience Center):
- provide a homogeneous Python enviroment to run community codes
- enable new code couplings and interactions between components
- facilitate multi-physics and multi-scale simulations









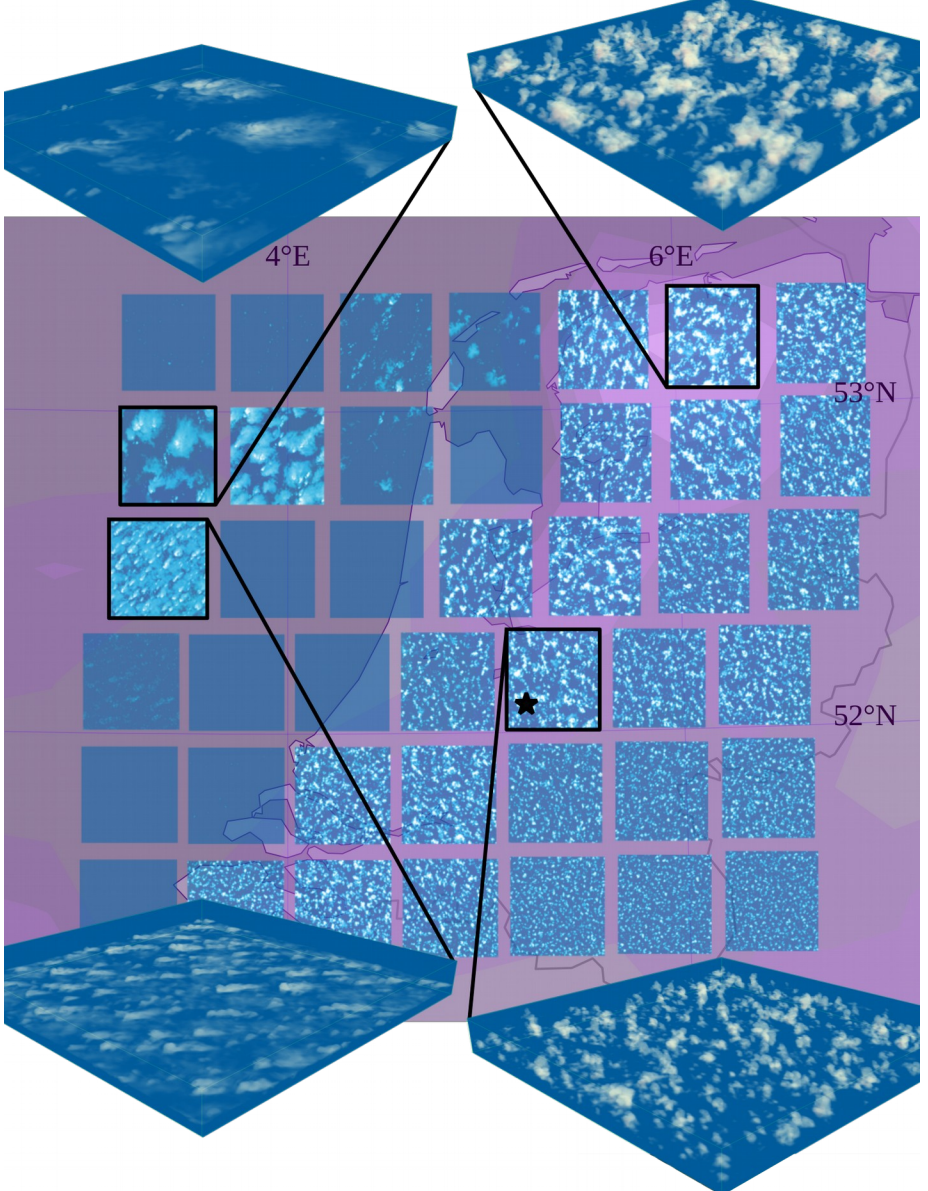
Pelupessy+ 2017
Pelupessy+ 2013

Example:
DALES – OIFS coupling

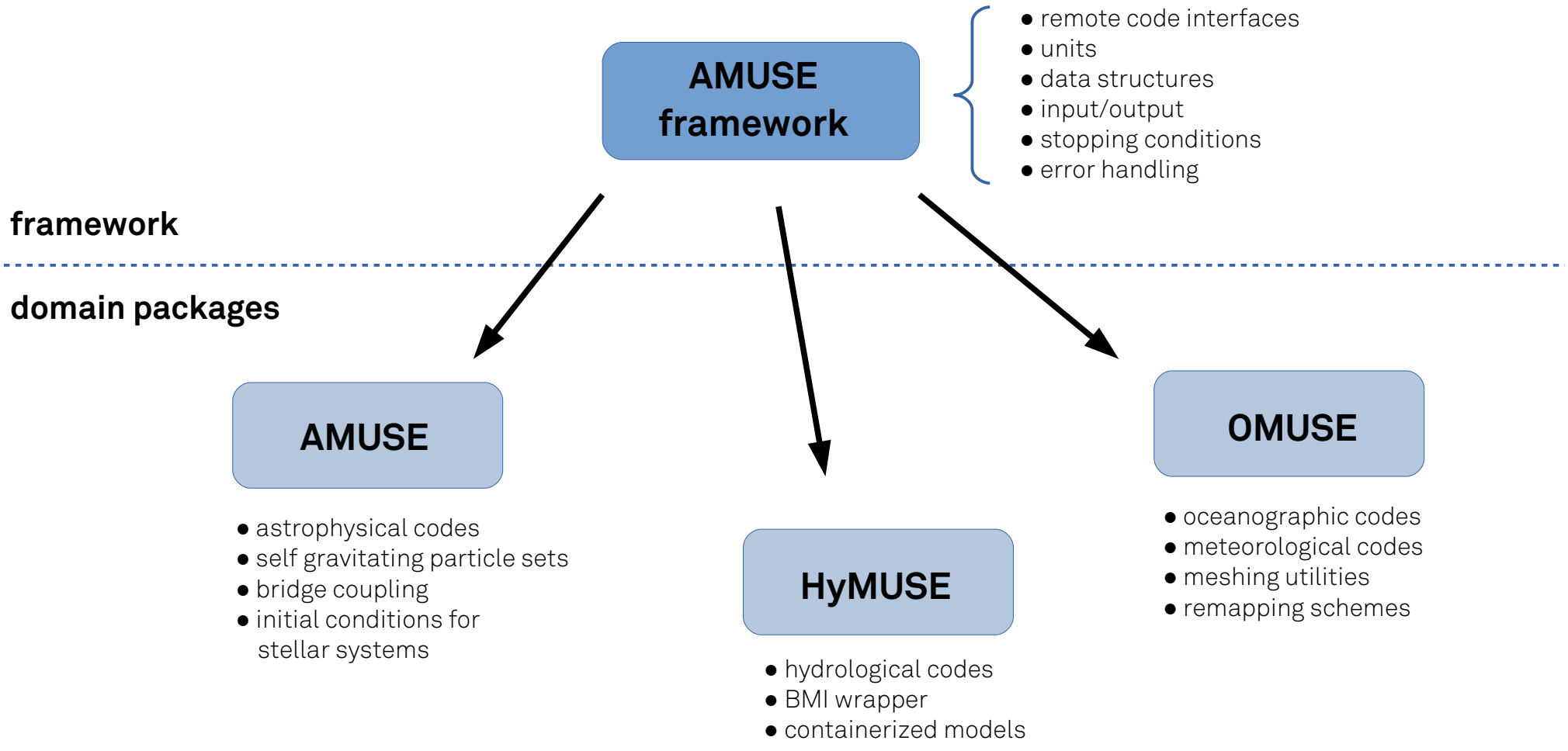
– superparametrization
– embedding of cloud resolving
  in global atmosphere model
– two way coupling
– N models in single global instance

see Jansson et al. #11303 (AS1.1)...

(and other examples:
Pelupessy et al. 2017, GMD 10, 3167)



ABC-MUSE architecture



'Hello Hydro-world'

“imports”

```
from hymuse.units import units
from hymuse.community.pcrglobwb.interface import PCRGlobWB
```

“instantiate code”

```
code=PCRGlobWB()
```

“initialize model”

```
code.parameters.ini_file=”setup.ini”
```

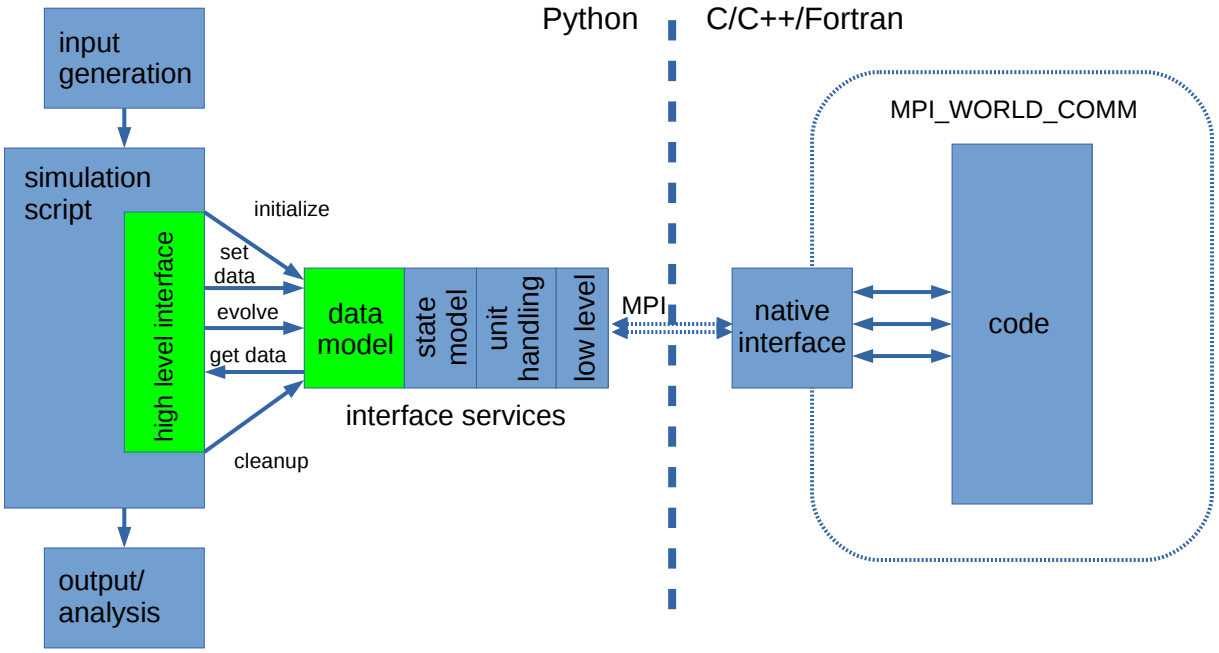
“evolve”

```
code.evolve_model(code.model_time + (1.| units.day) )
```

“analysis”

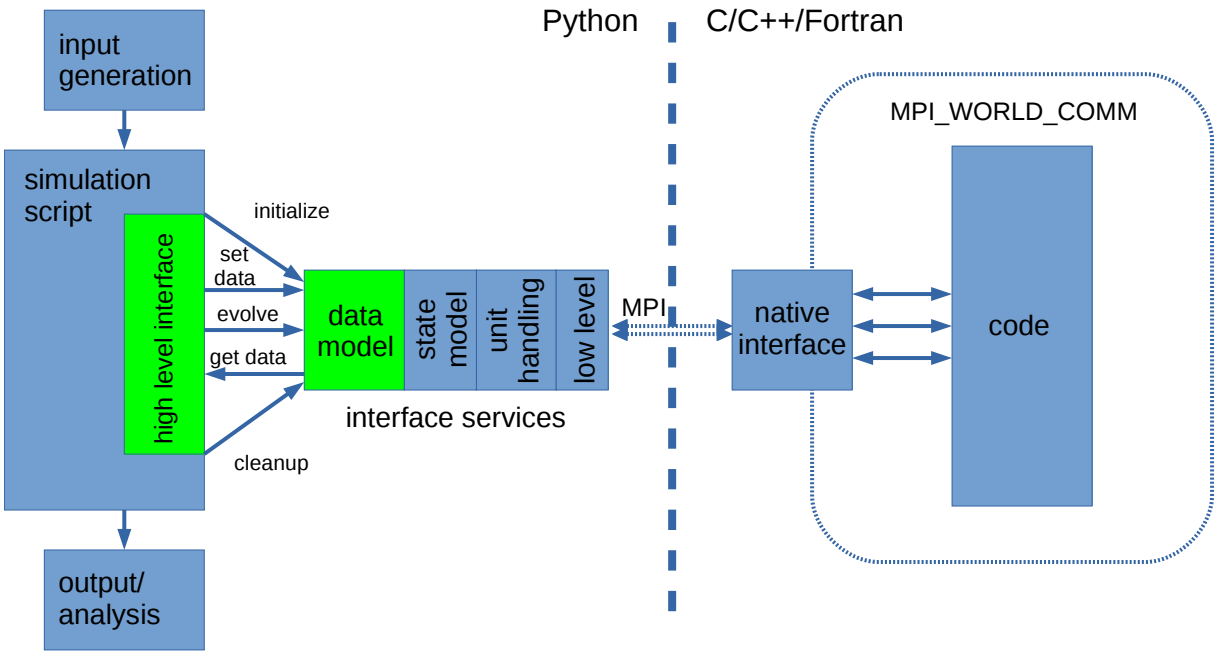
```
station=code.grid_0.samplePoint( lon= 6. | units.deg,
                                 lat= 51. | units.deg )
print("discharge:", station.discharge.in_(units.m**3/units.s) )
```

The HyMUSE interface: a bird's eye view



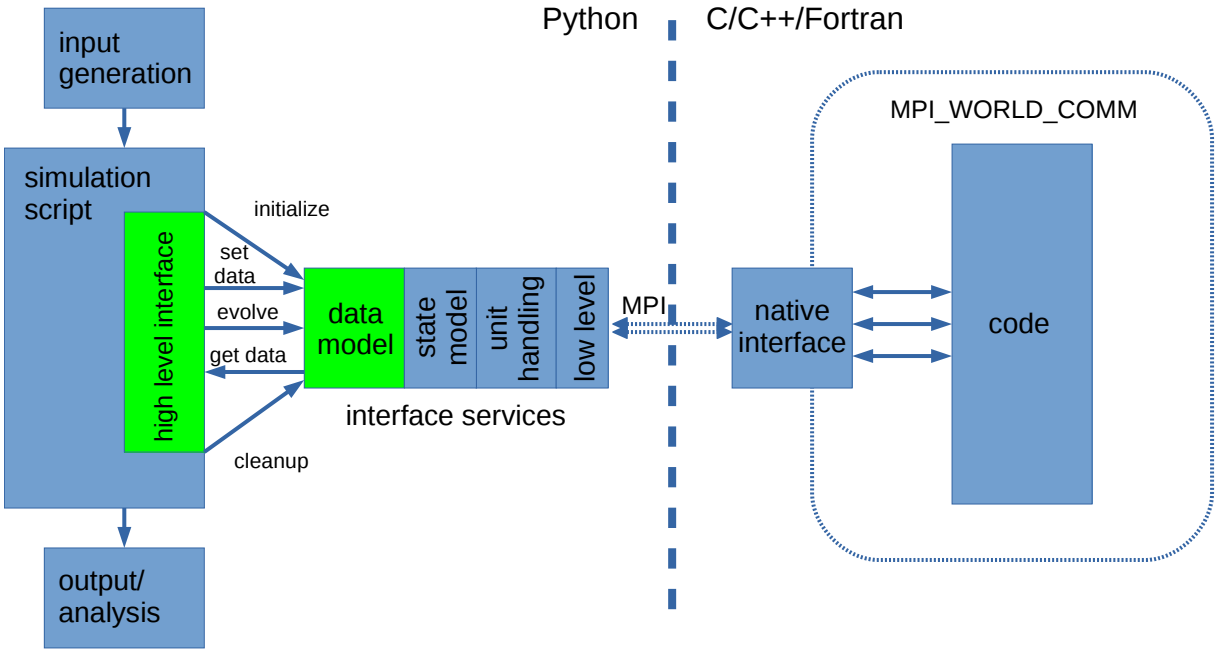
(i) HyMUSE is based on remote code interfaces

The HyMUSE interface: a bird's eye view



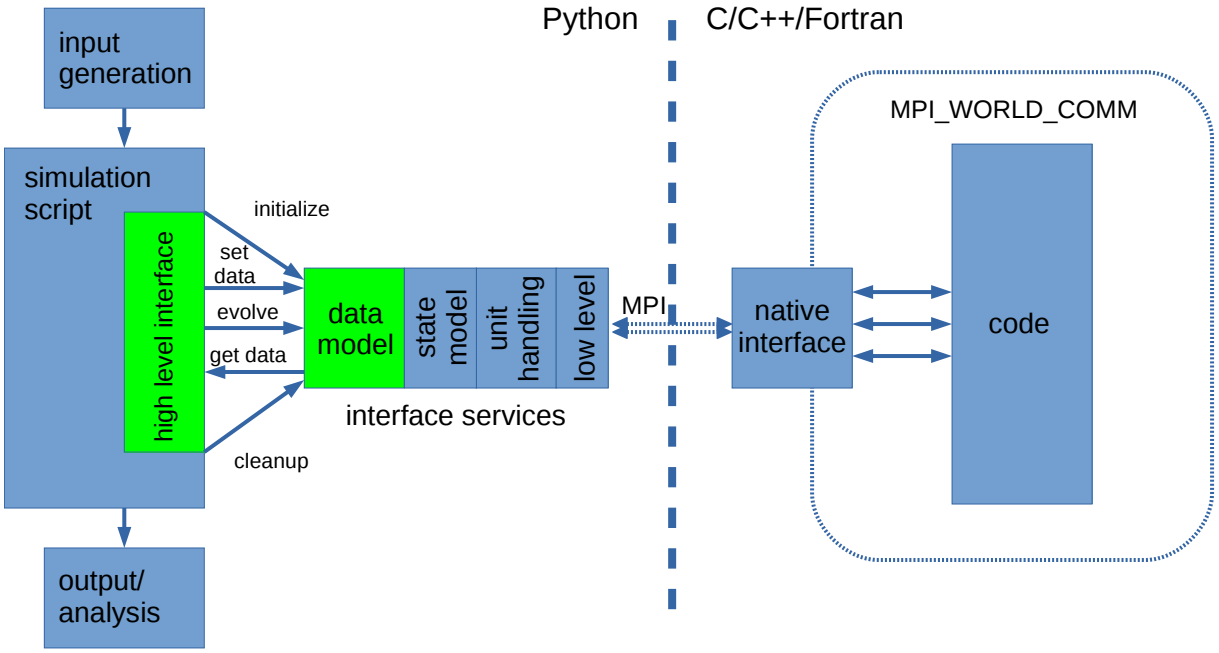
(ii) codes run in parallel & calls can be asynchronous

The HyMUSE interface: a bird's eye view



(iii) HyMUSE provides a number of *interface services:*
unit handling, data structures, code state handling etc..

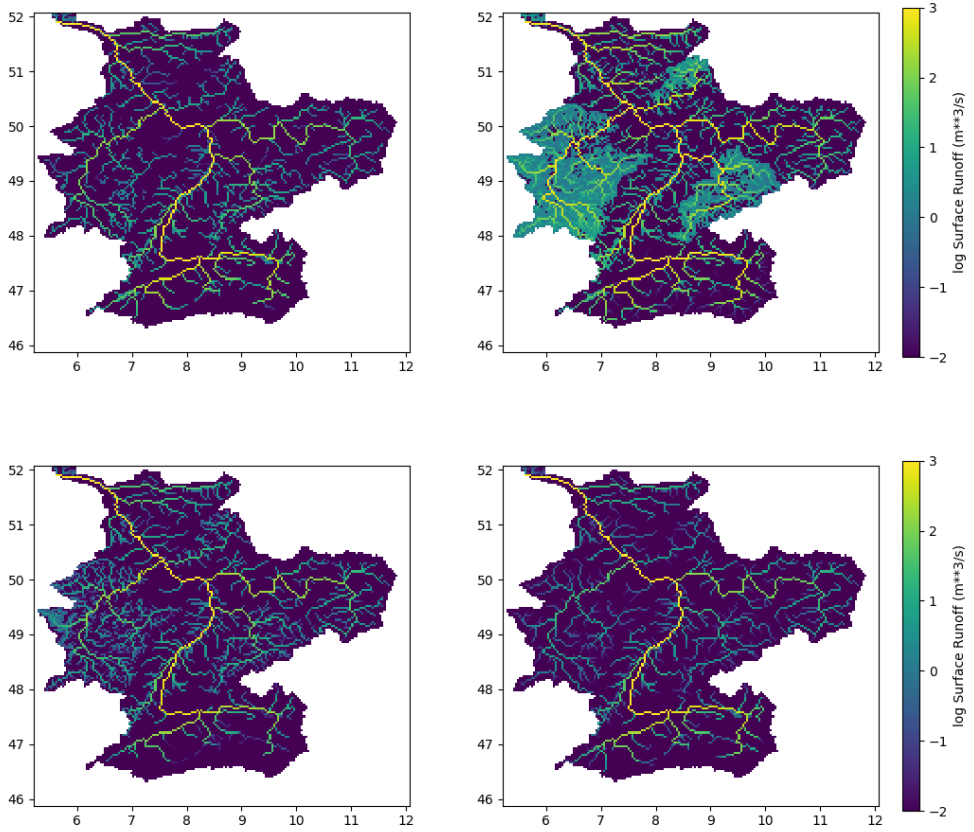
The HyMUSE interface: a bird's eye view



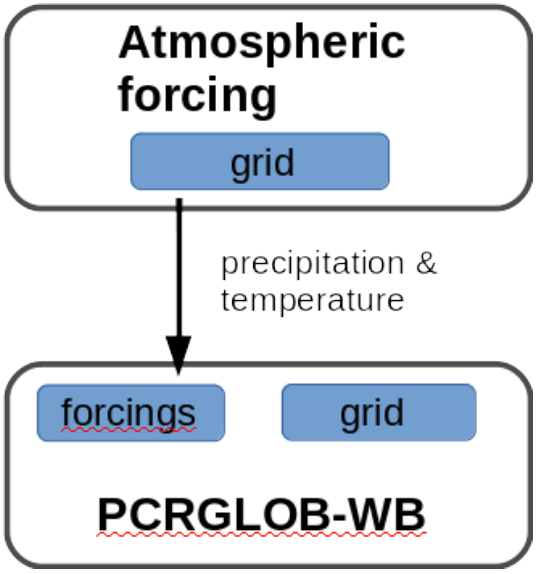
(iv) HyMUSE contributed codes can be containerized and based on BMI, allowing for easy interoperability with e.g. pyMT

What can you do with HyMUSE?

- simplify model setup and runs,
- scripting:
  - event detection,
  - stopping conditions
- 'online' data analysis
- ensemble simulations:
  - parameters searches
  - optimizations (e.g. MCMC)
  - data assimilation
- model comparison: running problems with different codes and methods
- coupling different codes to construct new solvers

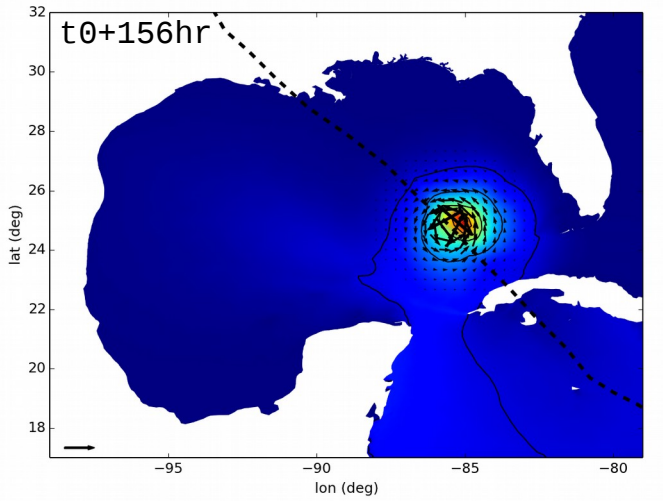


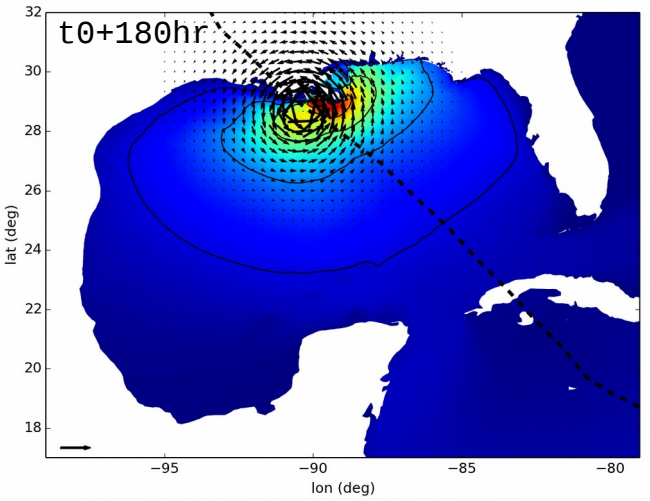
Code couplings with HyMUSE



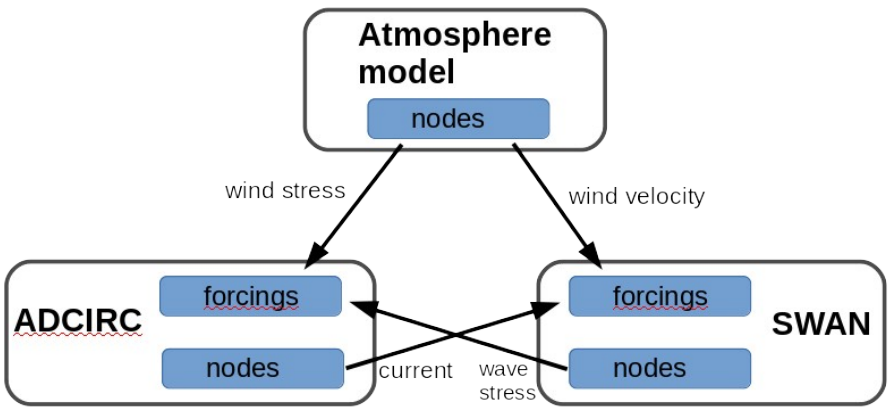

```
pcrglob = PCRGlobWB()

p.parameters.ini_file = ini_file
pcrglob.parameters.use_interface_forcings = True

meteo = netcdf_meteo( "precipitation_2001to2010.nc",
                      "temperature_2001to2010.nc" )

channel = meteo.grid.new_channel_to( pcrglob.forcings )

while pcrglob.model_time<tend:
    meteo.evolve_model( pcrglob.model_time + dt )
    channel.copy_attributes( ["precipitation", "temperature"] )
    pcrglob.evolve_model( pcrglob.model_time + dt )
```

Hurricane Gustav with a coupled hydrodynamic/ wave model





(Pelupessy+ 2017)




```
channel1=hurricane.grid.new_channel_to( swan.forcings )
channel2=hurricane.grid.new_channel_to( adcirc.forcings )
channel3=adcirc.nodes.new_channel_to( swan.forcings )
channel4=swan.nodes.new_channel_to( adcirc.forcings )
while time<tend:
    hurricane.evolve_model(time+dt/2)
    channel1.copy_attributes(["vx","vy"])
    channel2.copy_attributes(["tau_x","tau_y"])
    adcirc.evolve_model(time+dt/2)
    swan.evolve_model(time+dt/2)
    channel3.copy_attributes(["current_vx","current_vy"])
    channel4.copy_attributes(["wave_tau_x","wave_tau_y"])
    time+=dt
```

current status

- basic capability

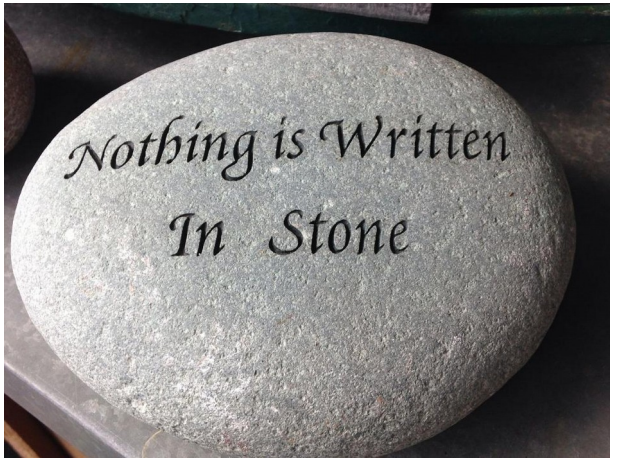
- refinement of high level interfaces needed

- extending community code base

- requirements for "eWaterCycle approved" codes?

- initialization, restarts

- development of BMI:
    * match with eWaterCycle goals?
    * Technical factors: limitations/ shortcomings
    * Human factors: different standards floating around, different opinions on usage



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Deltares
Enabling Delta Life

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Conclusions

- eWaterCycle in development as a FAIR platform for hydrology

- HyMUSE aims to be the flexible multi-model framework for the computational core

- It is in development at the Netherlands eScience Center

- Community driven: we *need* your input!

www.ewatercycle.org
lab.ewatercycle.org
github.com/ewatercycle/hymuse

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Thank you!