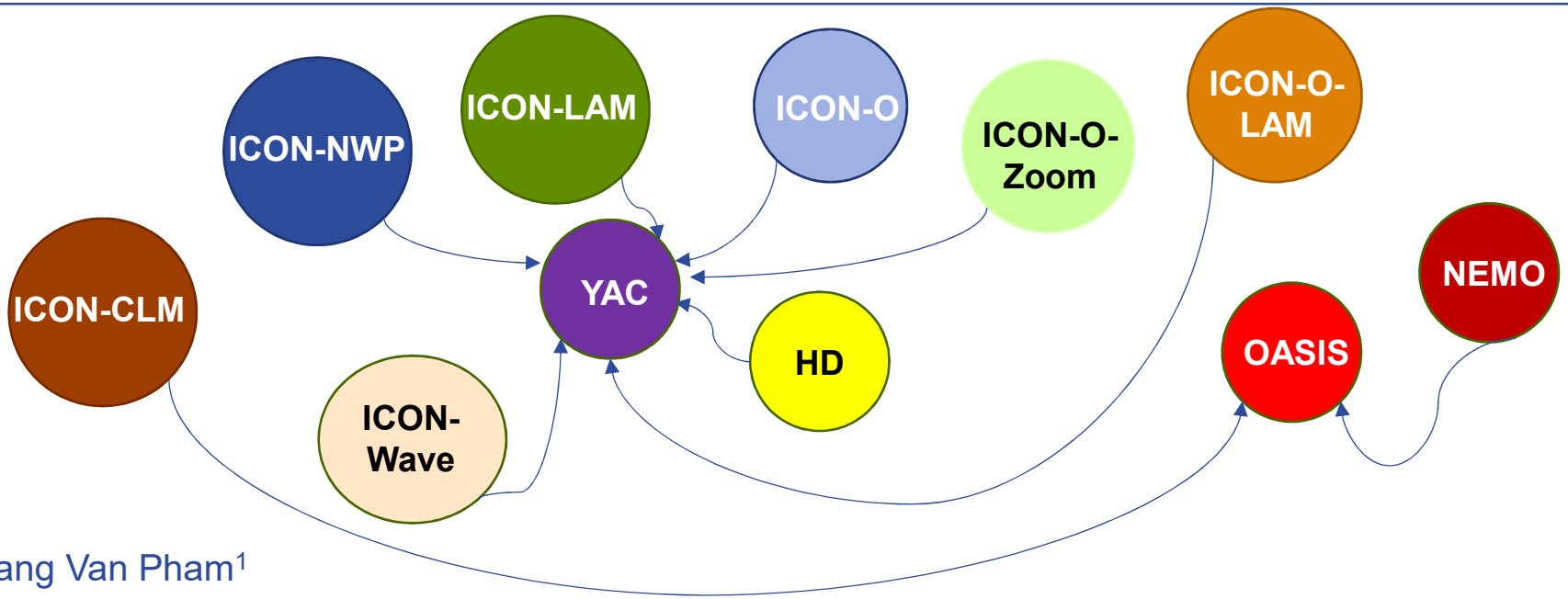
Coupling in ICON-Seamless

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Trang Van Pham[1]

M. Köhler[1], S. Lorenz[2], M. Dobrynin[1], M. Hanke[3],

S. Hagemann[4], V. Maurer[1], R. Wirth[1], K. Fröhlich[1], B. Früh[1] &

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[5] Zentrum für Geoinformationswesen der Bundeswehr

Seamless Prediction System

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Started Nov 2020:

Model and data assimilation for

- ✓ **Numerical Weather Prediction** (NWP)
- ✓ **Climate Prediction** (seasonal, decadal)
- ✓ **Climate Projection** (global and regional)
- ✓ **Air quality** (aerosol optics & burden, emissions, ...)

based on **NWP physics**.

- One **consistent model** (incl. atmosphere, ocean, land, tracers)
- **Configurations** for different applications: weather forecast, climate predictions...

→ in collaboration with **MPI-M, KIT, DKRZ, UHH, MPI-BGC, ...**

Components considered in ICON-Seamless

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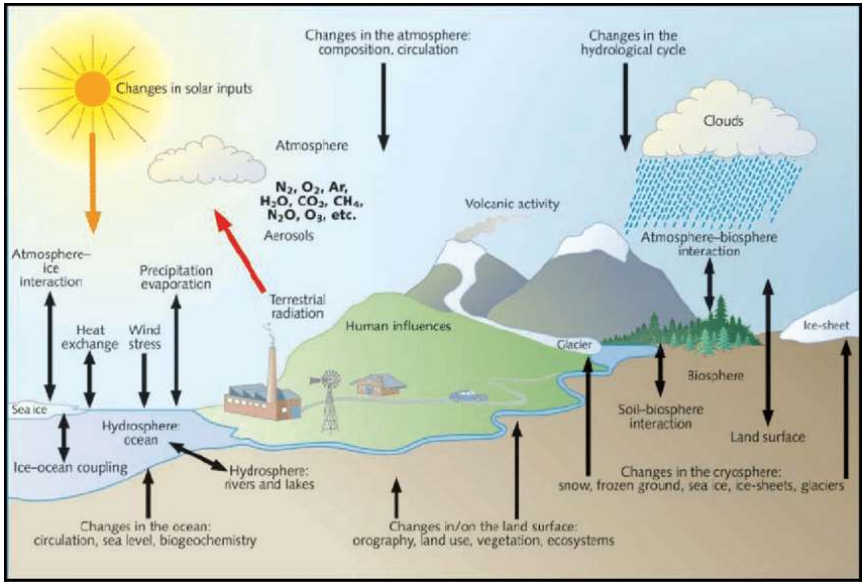
Wetter und Klima aus einer Hand

ICON-NWP for operational weather forecast since 2015

Interactions in climate system: e.g air-sea heat exchange, land-ocean water exchange

Climate prediction requires other components of Climate system:

- ➔ atmosphere
- ➔ land
- ➔ river discharge
- ➔ ocean
- ➔ ...



Components considered in ICON-Seamless

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Wetter und Klima aus einer Hand

ICON-NWP

(Zängl et al., 2015)

ICON-O

(Korn , 2017, Korn et al., 2021)

Climate system

HD

(Hagemann & Ho-Hagemann, 2021)

ICON-Waves

(Group, T. W., 1988)

JSBACH/vdiff
TERRA/turbtran

(Reick et al., 2013, 2021
Schulz, J.-P. and G. Vogel, 2020)

Components considered in ICON-Seamless

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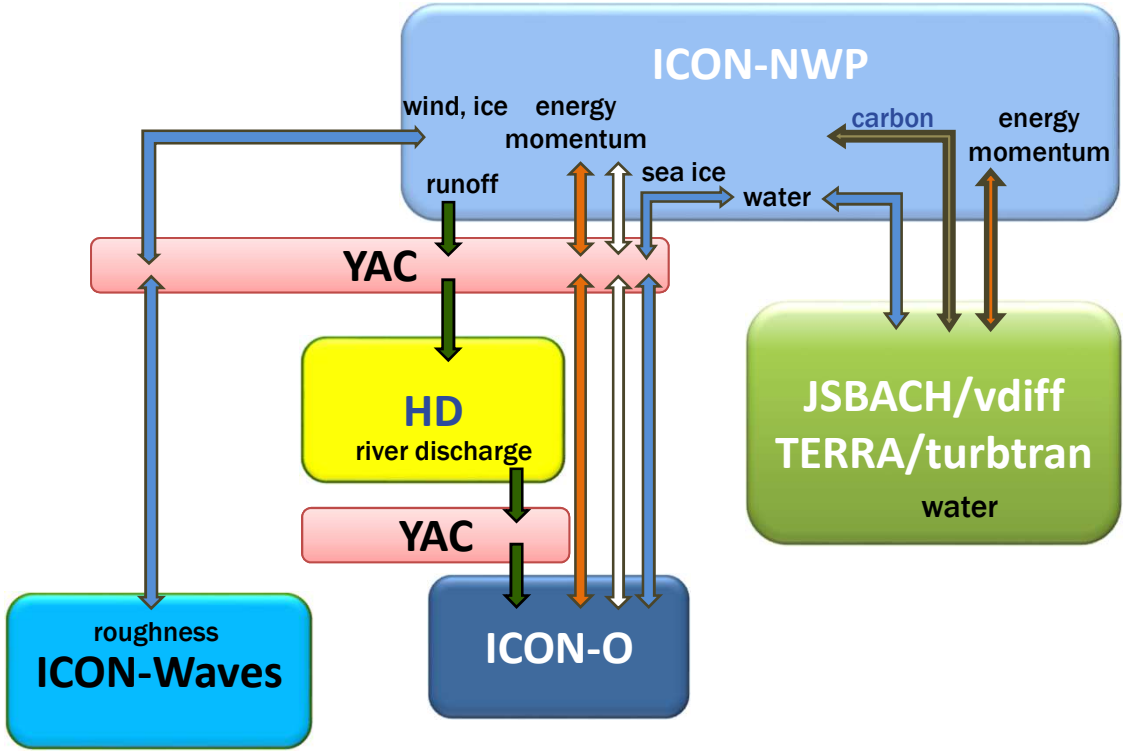
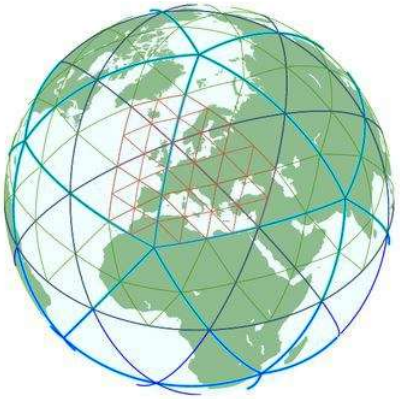
Wetter und Klima aus einer Hand

Coupling via YAC:

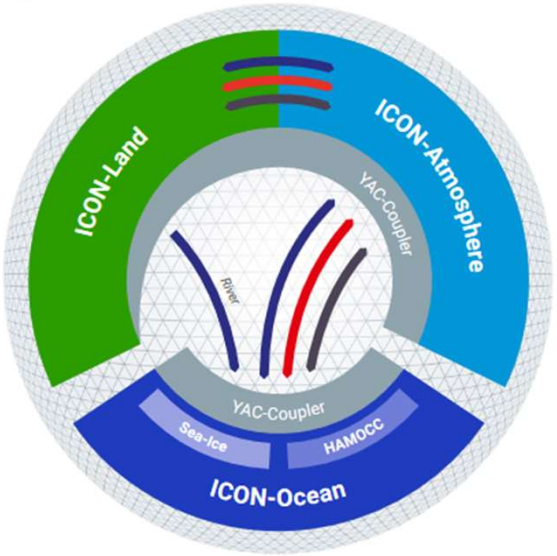
- ICON-NWP ⟷ ICON-O
- ICON-NWP ⟷ WAM
- ICON-NWP ⟶ HD ⟶ ICON-O



Yet Another Coupler - YAC



- Multiple interpolation schemes possible, depending on coupled variables
- Variables interpolated
  - ocean ↔ atmosphere: 22
  - Atmosphere-river: 2
  - River-ocean: 1
  - Atmosphere ↔ waves: 4
- Coupling at fixed timesteps
- Couplings can be configured in one single *yaml file



Exchange of Variables: Atmosphere - Ocean

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Wetter und Klima aus einer Hand

Bernstein Bezier method:
- Atmospheric Flux Stresses
- 10m Wind Speed
- Precipitation
- Evaporation
- Snowfall

Conservative method:
- Heat Fluxes
- Sea Level Pressure

Conservative method:
- Ice Variables
- U & V
- SST

- atm R2B4 – oce R2B6 (160km-40km)
- atm R2B5 – oce R2B6 (80km-40km)

Coupling frequence atm-oce: 30 minutes

Exchange of Variables: Atm – HD - Ocean

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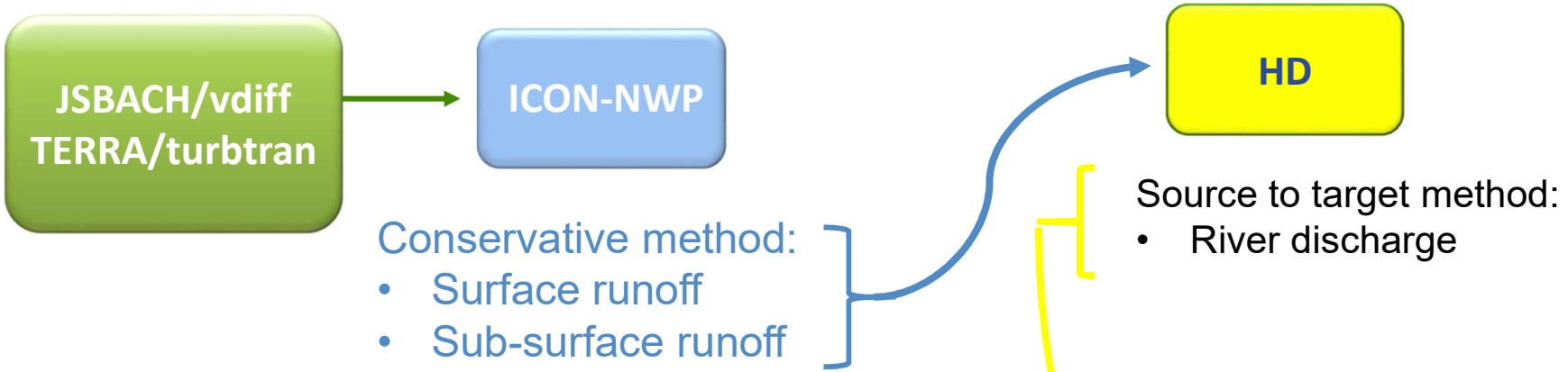
Wetter und Klima aus einer Hand



- atm R2B4 – oce R2B6 – HD 0.5 deg (160km-40km)
- atm R2B5 – oce R2B6 – HD 0.5 deg (80km-40km)

Coupling frequence atm-oce: 30 minutes
Coupling frequence atm-hd-oce: 1 day

Exchange of Variables: Atmosphere - Wave

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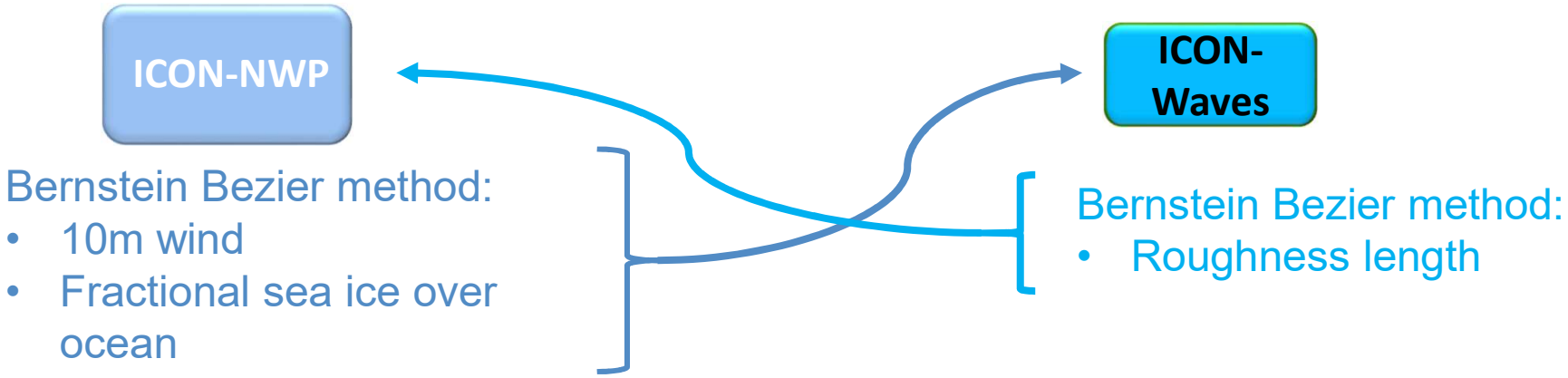
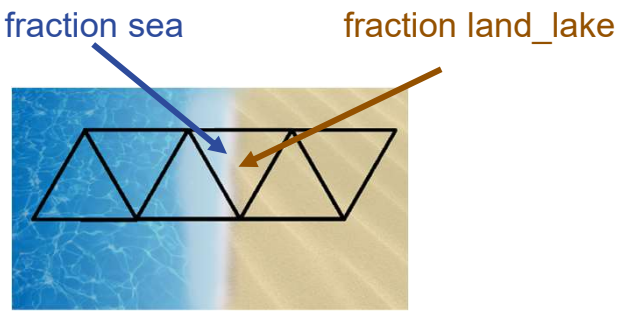
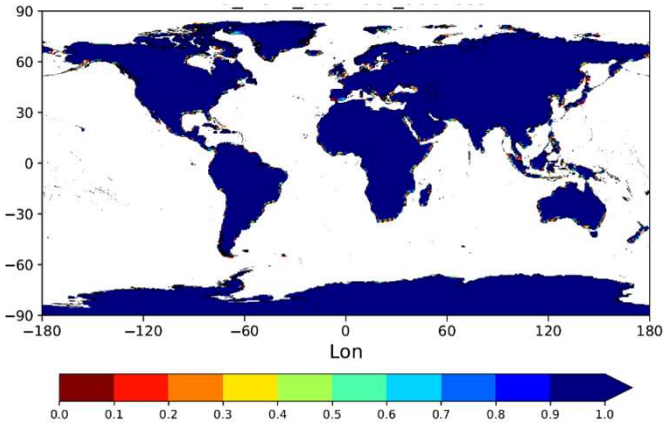
Wetter und Klima aus einer Hand



atm R2B4 – wave R2B4
Coupling frequence atm-wave: 60 minutes

Coupling masks



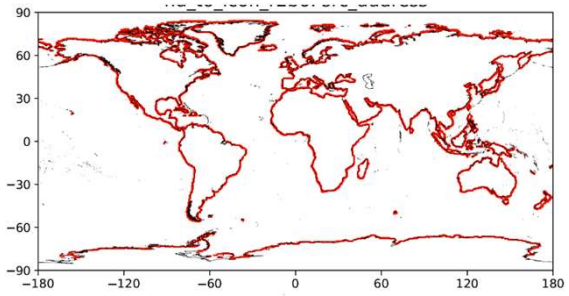


Valid for atm-oce coupling:

- atmosphere mask: fraction sea >= 0.05 (atm lsm adjusted acc. to ocean lsm)
- ocean mask: open ocean + coast

Valid for atm-hd coupling:

- atmosphere mask: fraction land_lake >= 0.05
- HD mask: HD land point (HD lsm adjusted acc. to ICON-NWP lsm)



For HD-oce coupling:

- HD mask: river mouth
- ocean mask: ocean coast

Atm-Waves:

- Atm mask: all icon-nwp cells
- Wave mask: all icon-waves cells (consist only water cells)

Setting up coupling frames

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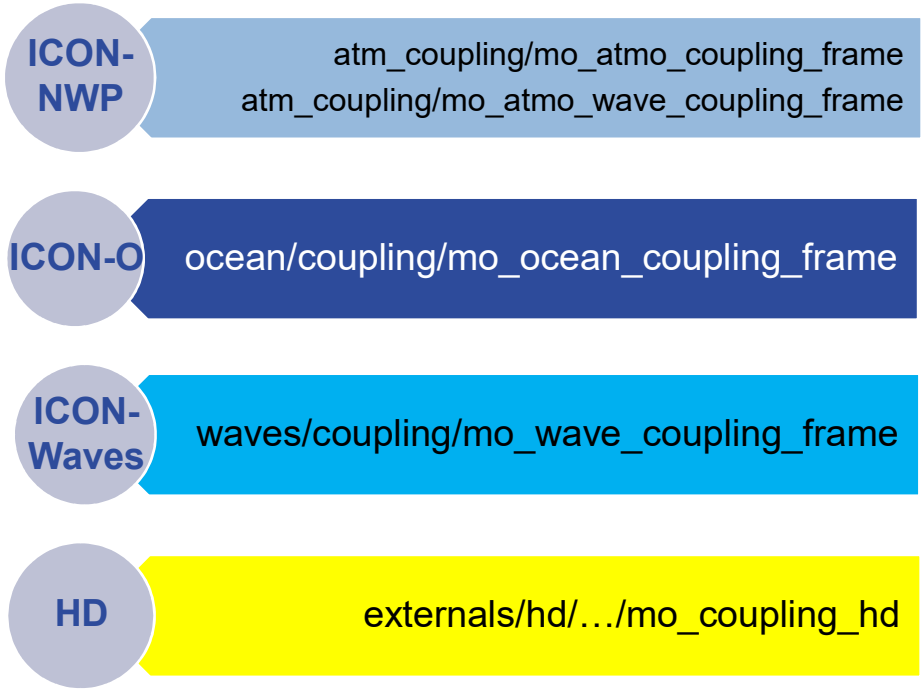
Wetter und Klima aus einer Hand



yac_fdef_comp : inform YAC component name/id

yac_fdef_grid : register component grid

yac_fdef_points : define center points in cells

yac_fset_global_index: set global id for grid cells

yac_fset_core_mask : If local field data contains halo cells which do not contain valid data

yac_fdef_mask : define coupling mask

yac_fdef_field_mask : fields are linked to masks

yac_fenddef : End definition of coupling fields and compute weights

Coupling interfaces

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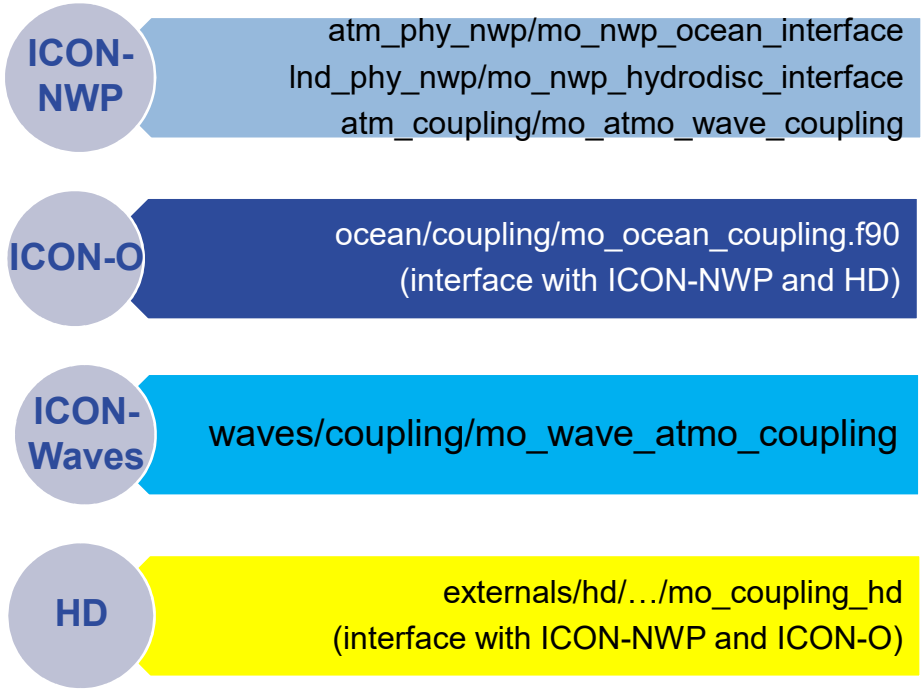
Wetter und Klima aus einer Hand



Interfaces = where the coupled fields are exchanged

yac_fput: send field to YAC

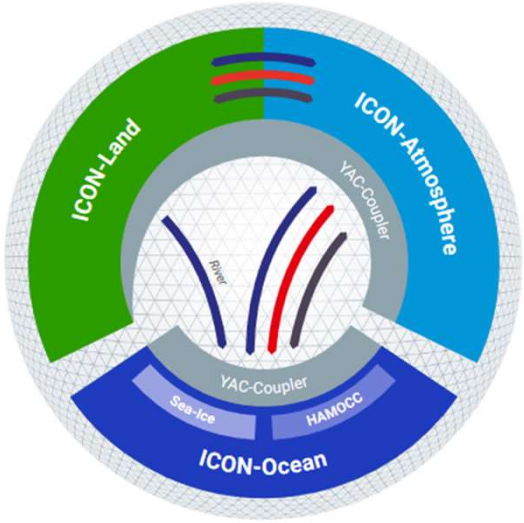
yac_fget: get field from YAC

One call for each field or bundled field

Called every coupling timestep

ICON coupled in regional configurations

Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Work in progress:

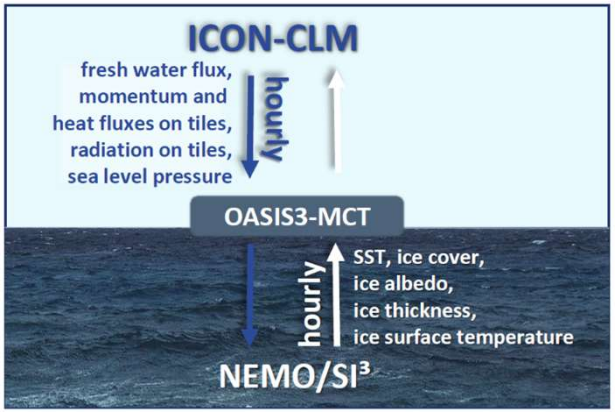
- **ICON-LAM / ICON-O-LAM + ICON-O-Zoom** (global grid with local refinements) + **ICON-Wave-LAM**
  - ESM-W: „**E**arth **S**ystem **M**odelling at the **W**eather scale“
  - DWD project in cooperation with GeoInfoDienst Bundeswehr (2022-2030)
  - **Focus:** weather forecasting lengths between 0-10 days

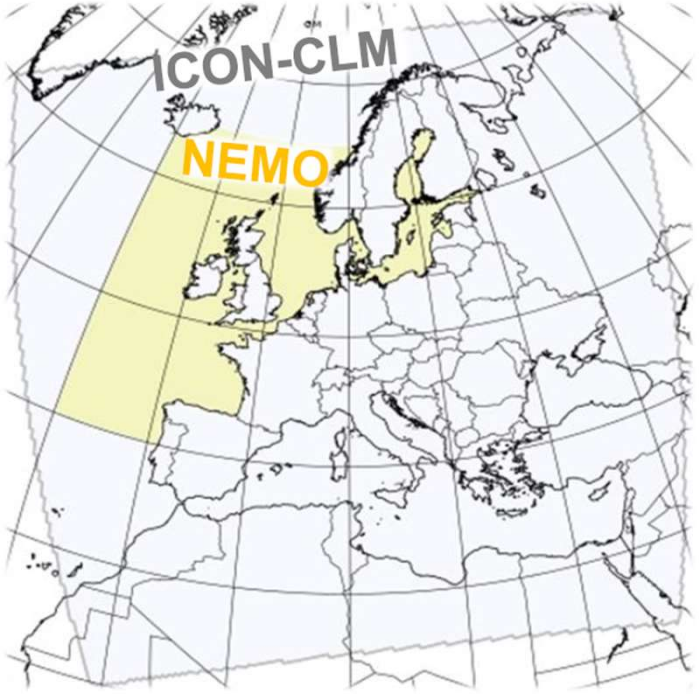
Work in plan:

- **ICON-CLM / ICON-O-LAM / HD**
  - Helmholtz-Zentrum Hereon
  - Focus: long-term climate, perspective with nutrition transport in HD

ICON coupled in regional configurations

Deutscher Wetterdienst
Wetter und Klima aus einer Hand





ICON-CLM /NEMO coupled via OASIS3-MCT
Configuration for Europe:

- ICON-CLM: 12km (R13B5), EU-Cordex
- NEMO: ~3.6 km, North/Baltic Seas
- Land model Terra

Vera Maurer (DWD)