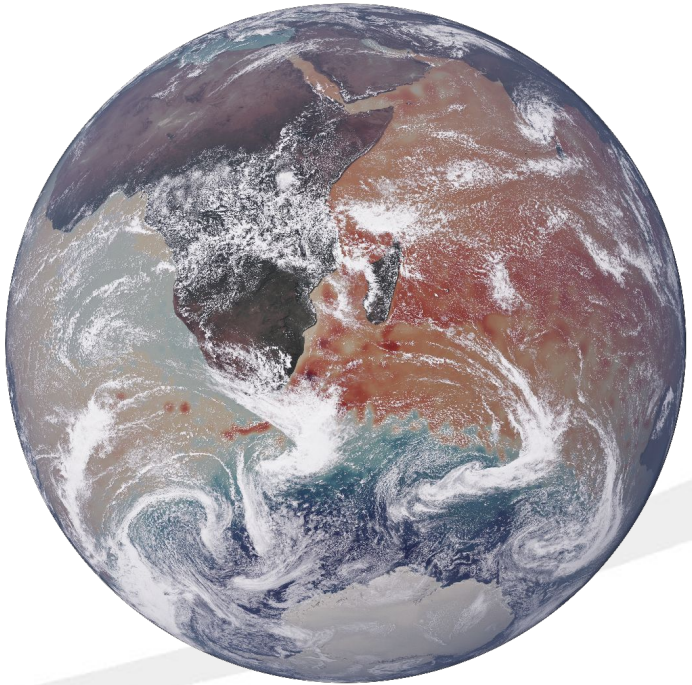
YAC 2/3 and coupled high resolution ICON



Moritz Hanke (Deutsches Klimarechenzentrum)

Short YAC (Yet Another Coupler) overview

- YAC 1 2014-07
- YAC 2 2020-01
  - internal rewrite
  - Python interface
- YAC 3 2023 Q1/2
  - dynamic online configuration of coupling
  - replacing XML with much simpler YAML configuration file
- runs on Piz Daint[1], JUWELS[2], Levante[3], LUMI[4], MAC OS, and Linux systems with little to no porting effort

[1]: https://www.cscs.ch/computers/piz-daint/
[2]: https://www.fz-juelich.de/en/ias/jsc/systems/supercomputers/juwels
[3]: https://www.dkrz.de/en/systems/hpc/hlre-4-levante?set_language=en
[4]: https://www.lumi-supercomputer.eu/

YAC 2

- Internal rewrite
  - better load balancing (online weight computation is equally distributed among all source and target processes)
  - simpler communication scheme
- Python interface
  - used for rapid prototyping of external output and visualisation components
- Additional interpolation capabilities
- Support for multiple parallel YAC instances

YAC 2 - Python interface example

```
from yac import *
import numpy as np

yac = YAC()
yac.def_datetime("2022-11-14T13:23:00", "2022-11-14T13:23:05")
comp = yac.def_comp("python_component")

x = np.linspace(-np.pi,np.pi,100)
y = np.linspace(-0.5*np.pi,0.5*np.pi,50)
grid = Reg2dGrid("python_regular_grid", x, y)

points = grid.def_points(Location.CORNER, x, y)

field = Field.create("tas", comp, points, 1, "1")

yac.search()

while True:
  data, info = field.get()
  plot or analyze(data)
  if info == Action.GET_FOR_RESTART:
    break
```

YAC 2 - New interpolation capabilities

- Average (bilinear)
  - new barycentric coordinate based weighting option
- Conservative
  - improved support for concave cells
- Source Point Mapping (Nearest destination to source)
  - new spread distance option
  - new maximum search distance option
- new Creep fill
  - thanks to ESMF presentation[1] at CW2020
  - with option to specify creep distance
- new User callback
  - weights are computed by the user through a callback method
  - supports arbitrary combination of cell, vertex, and edge based source fields

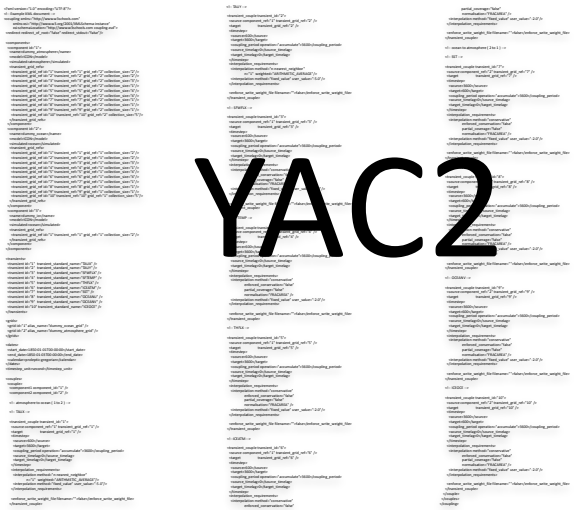
[1]:https://raw.githubusercontent.com/IS-ENES3/IS-ENES-Portal-Website/master/pdf_documents/CW2020_2009_Oehmke.pdf

YAC 3

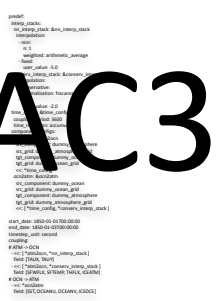
- Dynamic online configuration of coupling
  - component can:
    - query fields available on other components
    - add coupling configurations at runtime in the definition phase
- Replacing XML with YAML
  - new YAML configuration file is much simpler
    - clearer layout
    - does not replicated information which is also provided at runtime by interface

YAC 3 - XML vs. YAML configuration file

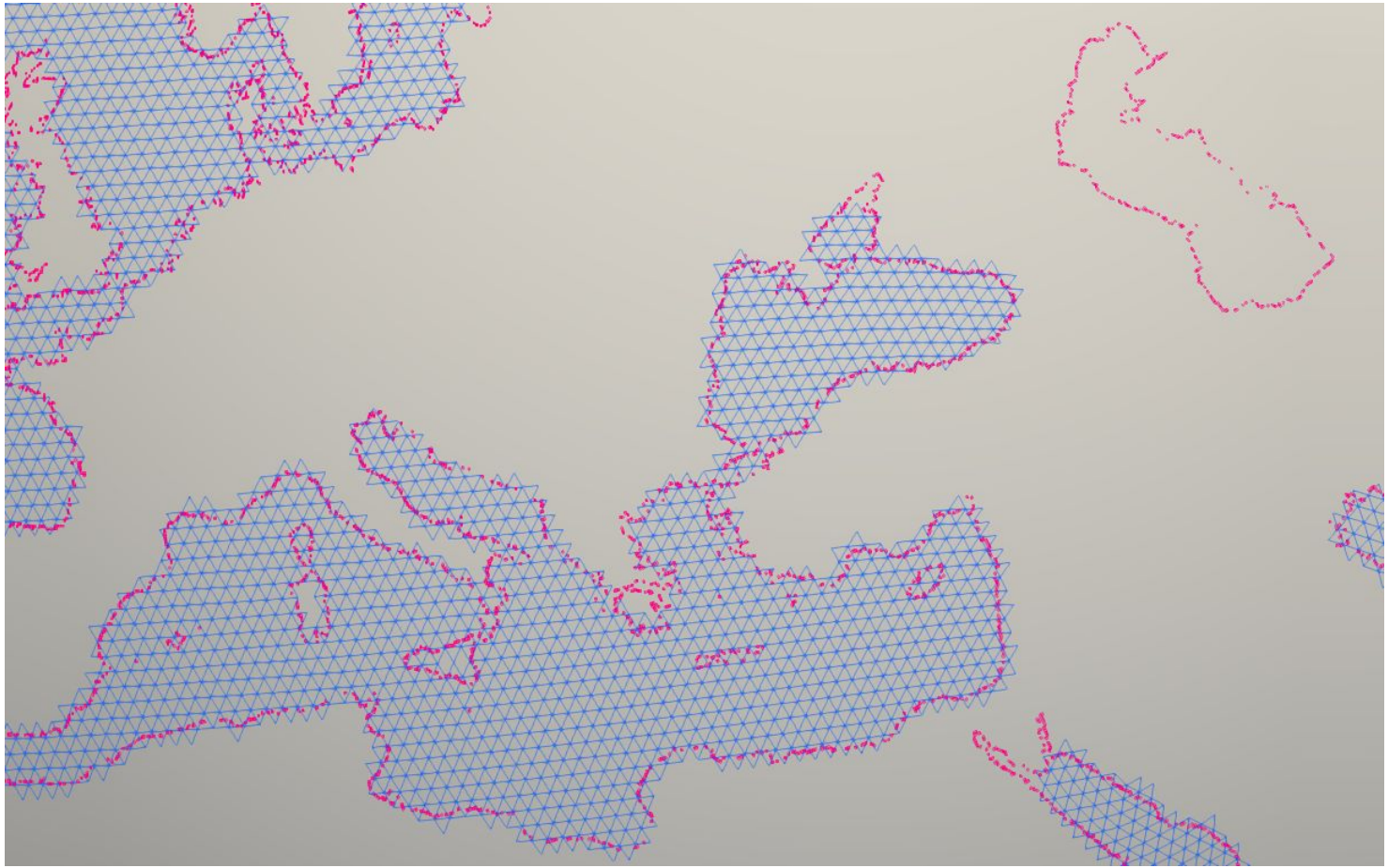
YAC2



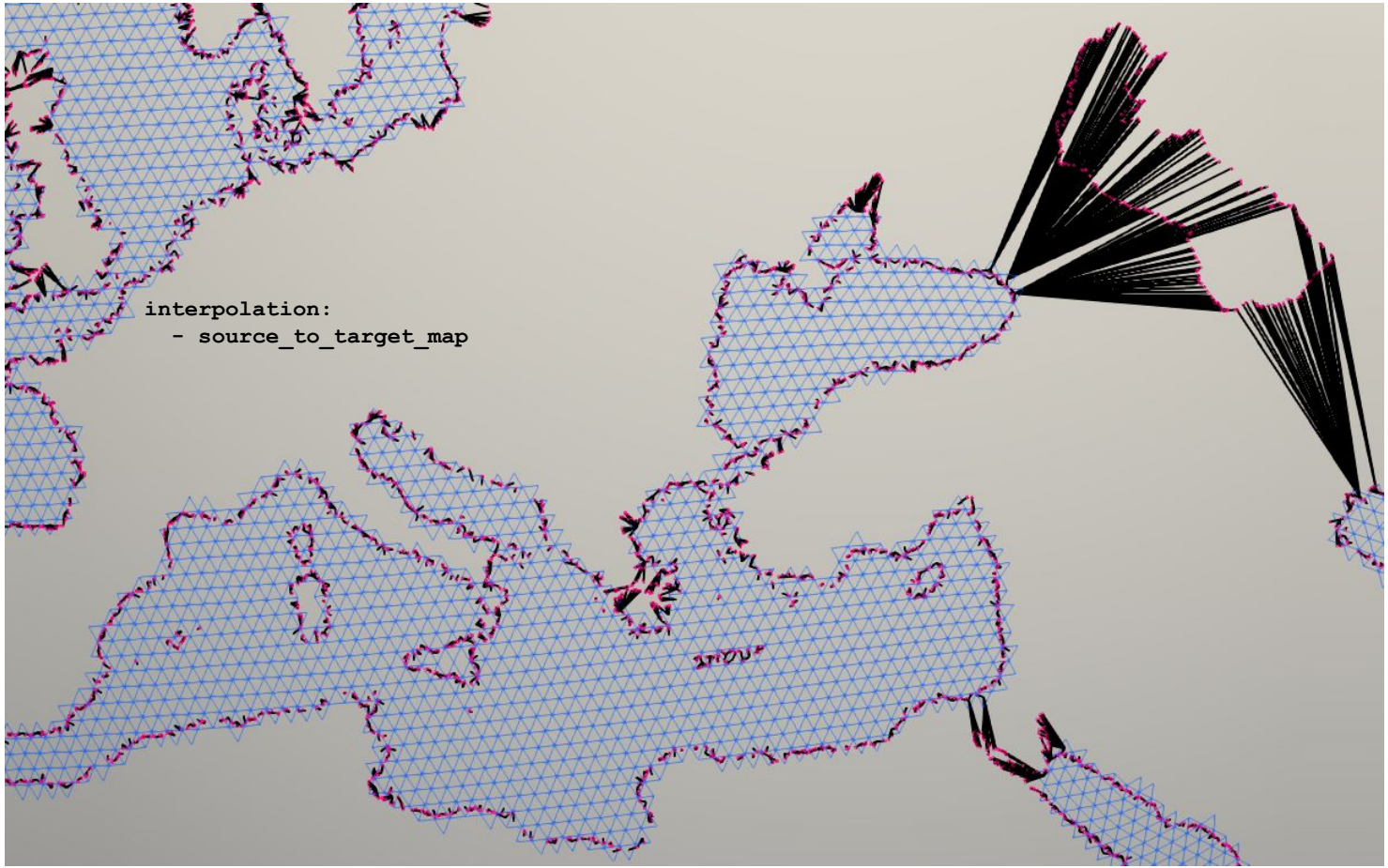
YAC3



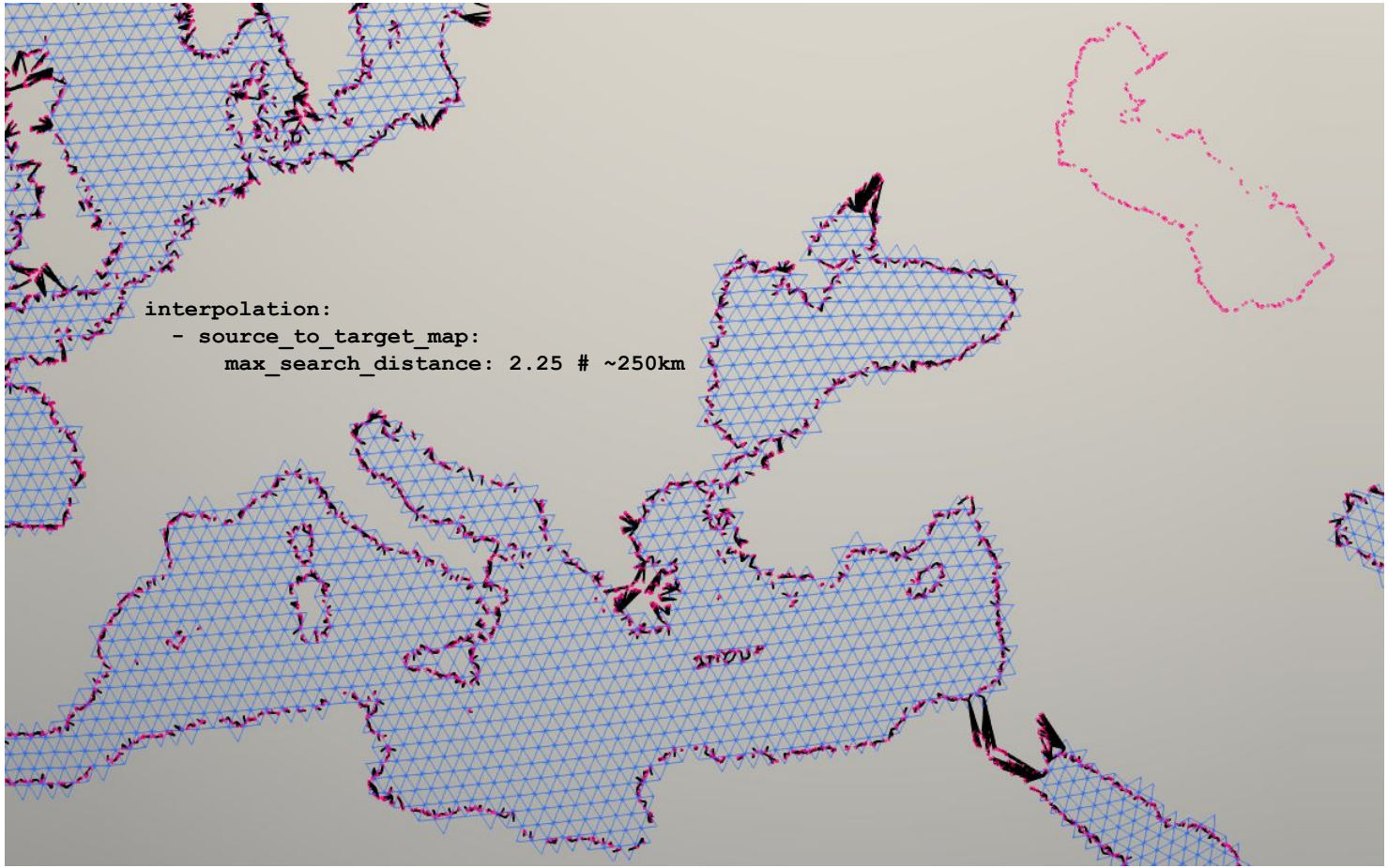
YAC 3 - Visualising weights



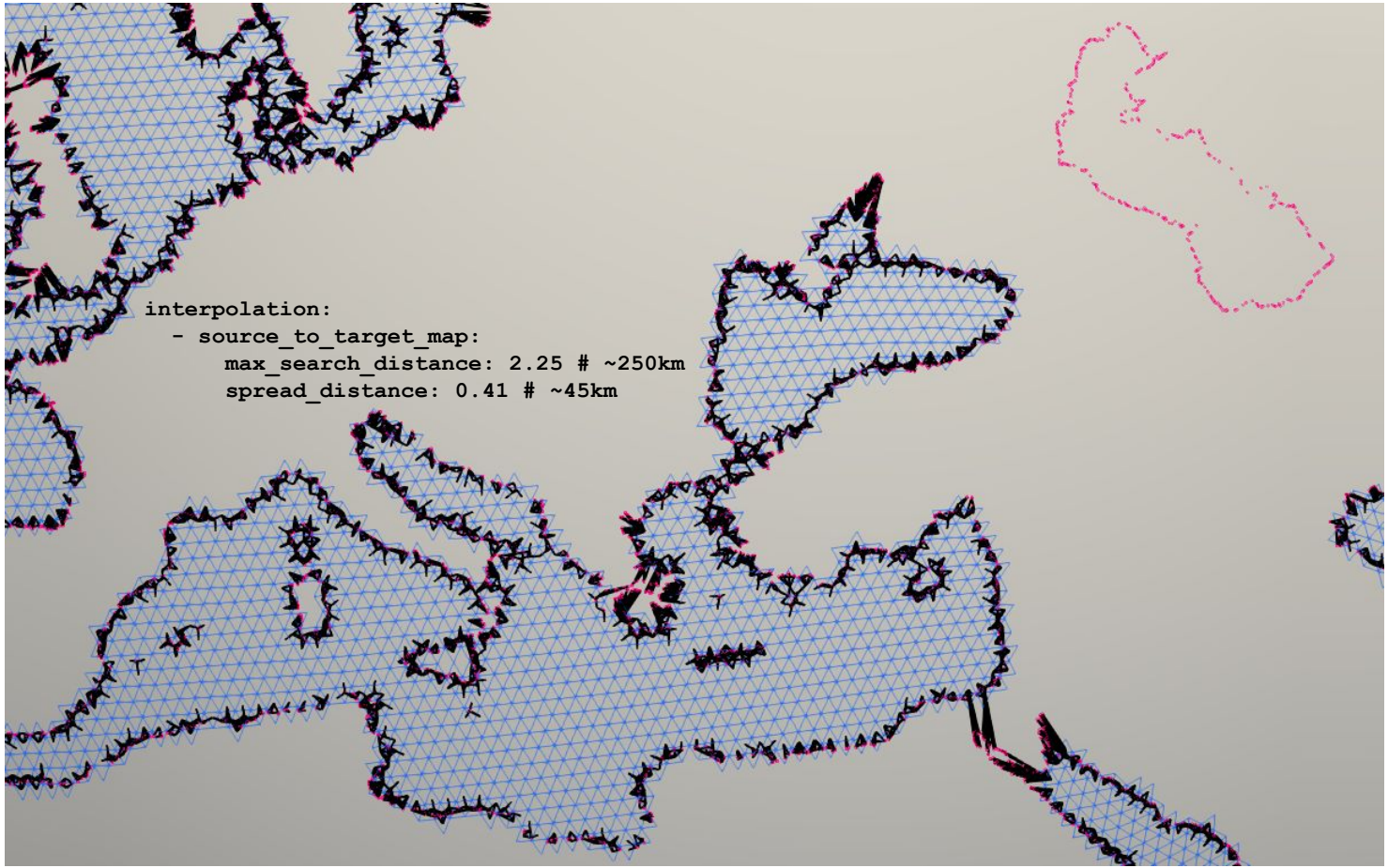
YAC 3 - Visualising weights



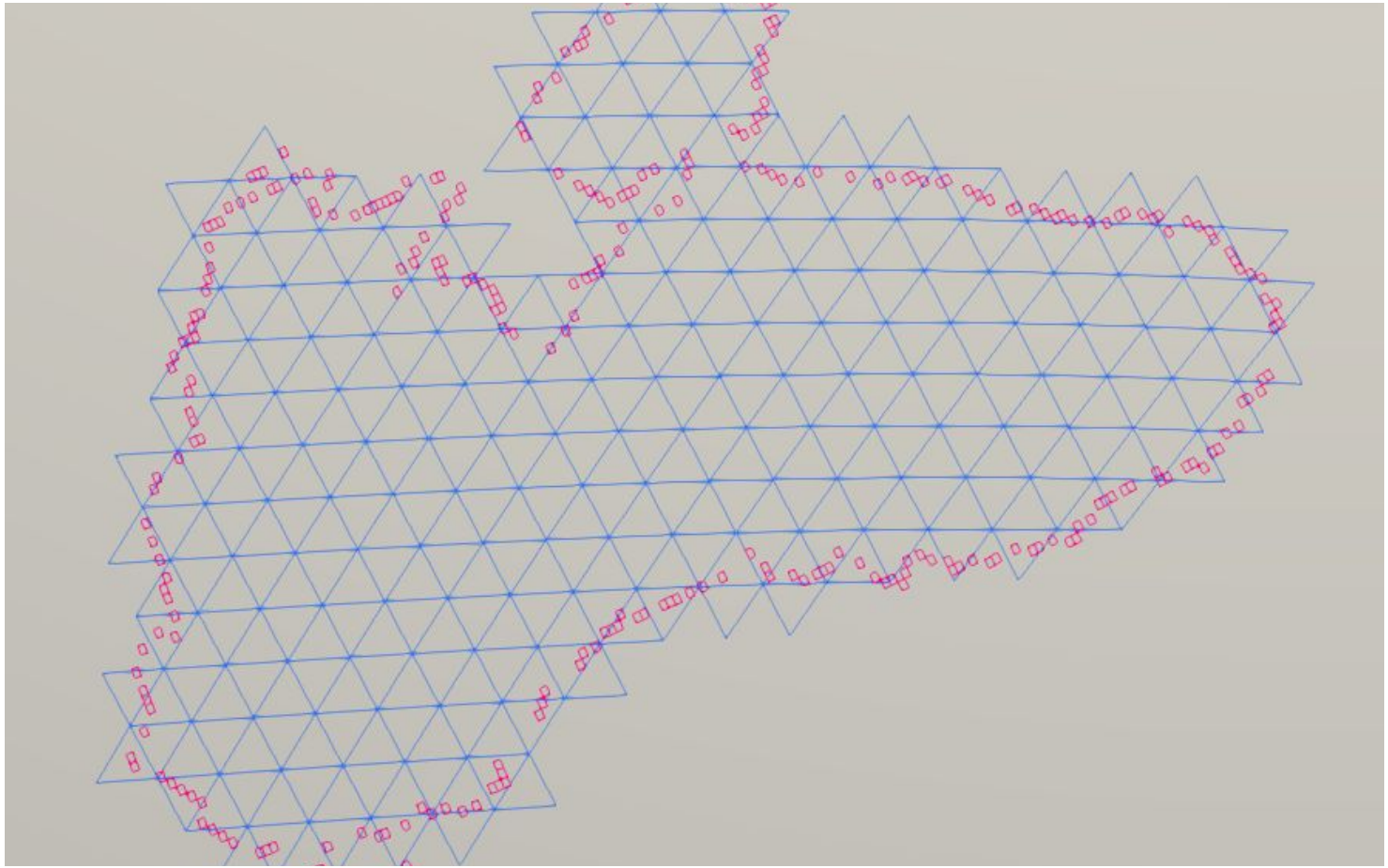
YAC 3 - Visualising weights



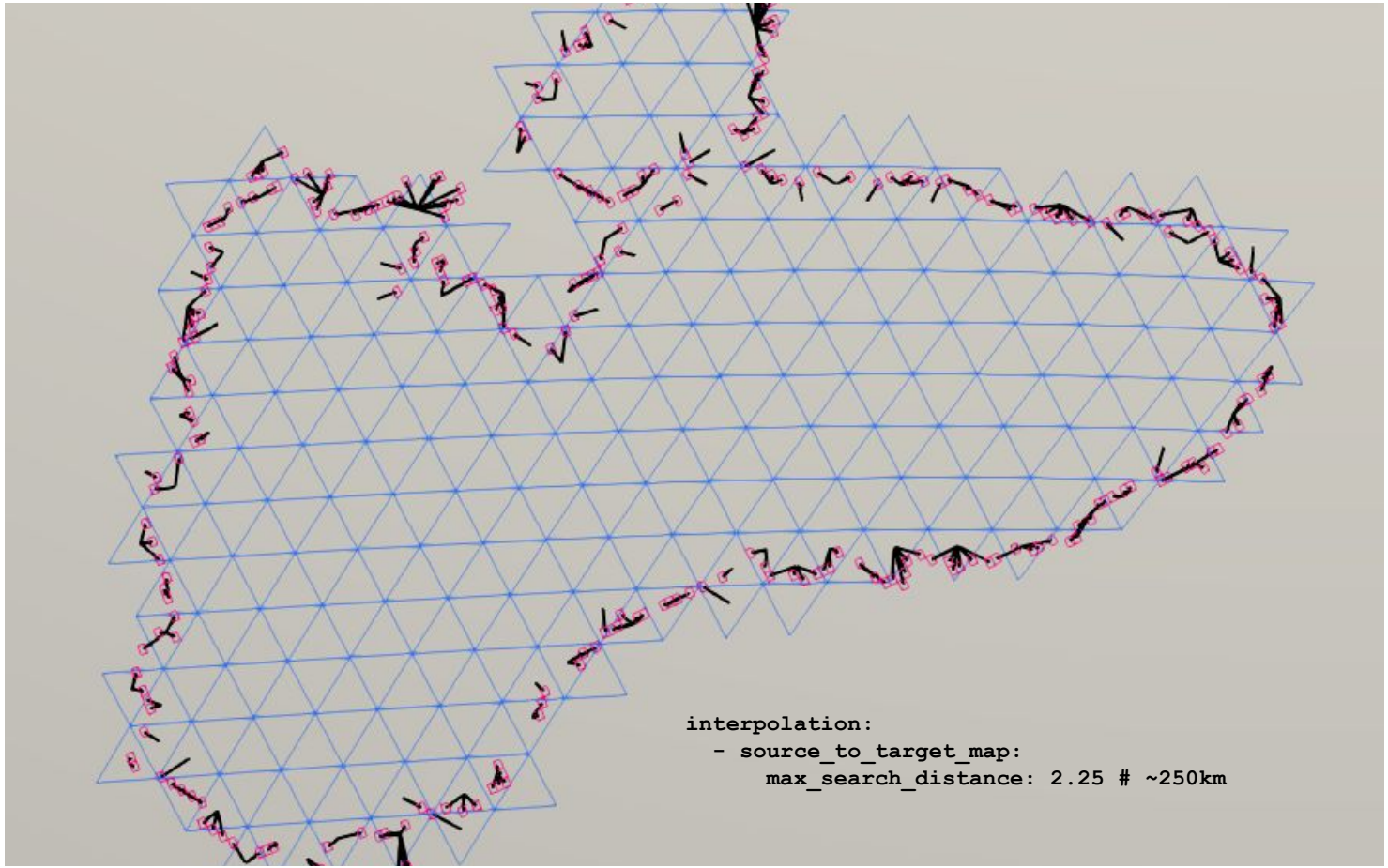
YAC 3 - Visualising weights



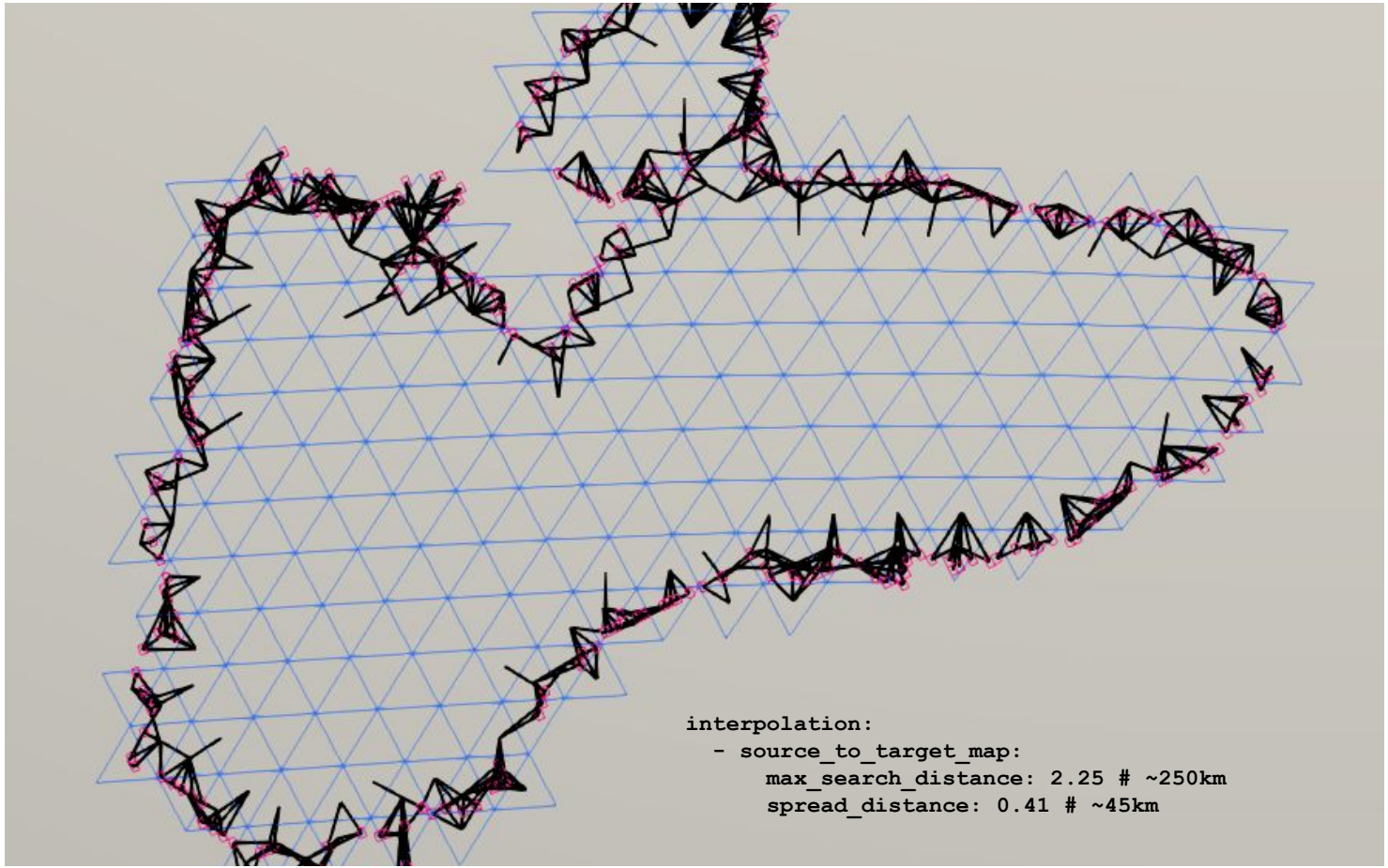
YAC 3 - Visualising weights



YAC 3 - Visualising weights



YAC 3 - Visualising weights

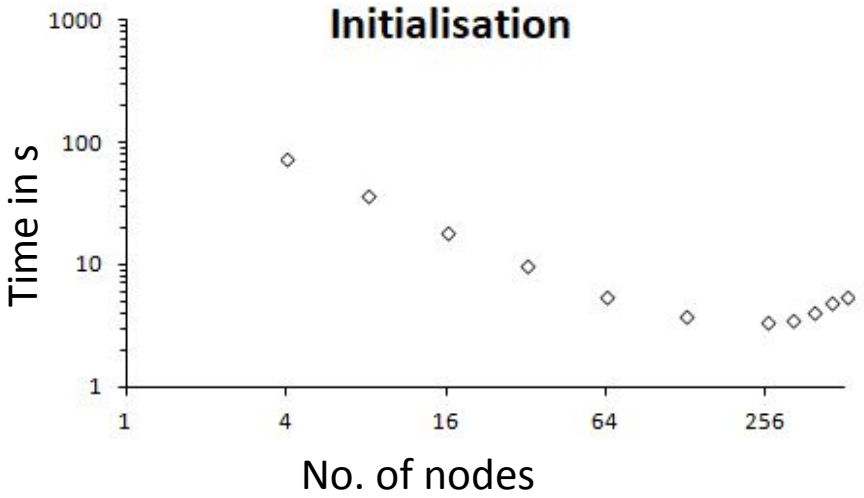


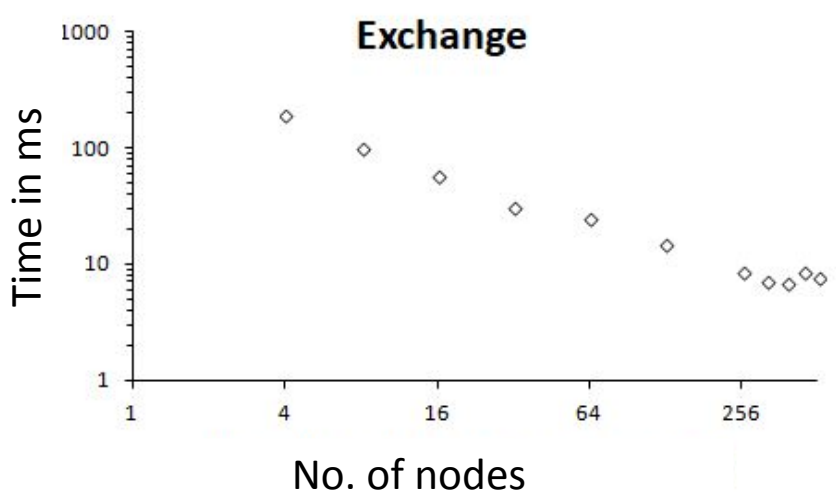
YAC performance

- System
  - Atos BullSequana XH2000 with two AMD 7763 per node[1]
  - OpenMPI 4.1.2
- Test configuration
  - 128 processes per node
  - Two toy models
    - global cubed sphere C6000 (216.000.000 cells)
    - global icosahedral grid R02B11 (335.544.320 cells)
  - Online weight computation in both directions
    - CONSERV = 1st order conservative interpolation
  - Initialisation: time for internal initialisation for coupling
  - Exchange: average time for exchange of data in both directions

[1]:https://www.dkrz.de/en/systems/hpc/hlre-4-levante?set_language=en

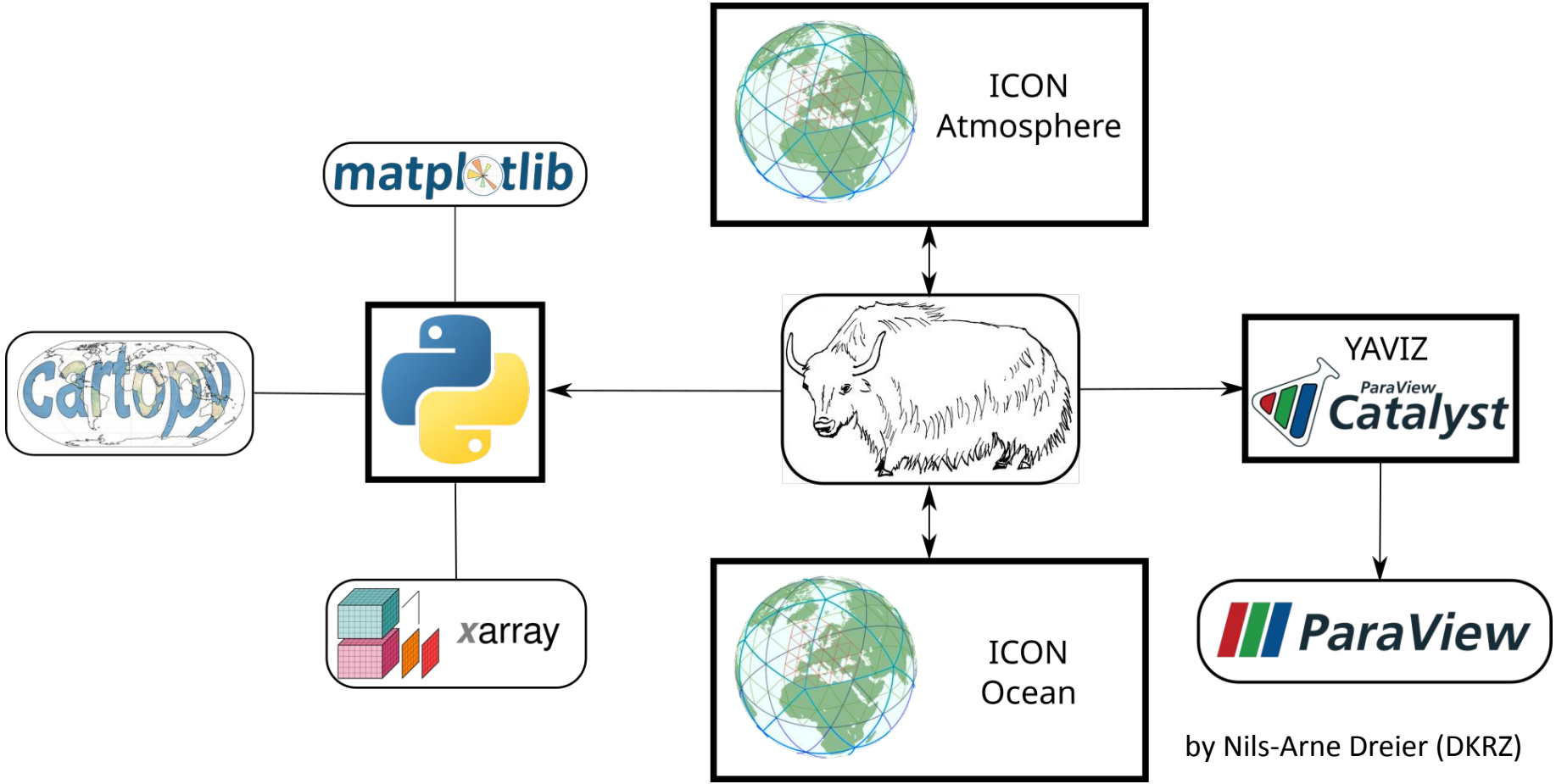
YAC 2/3 - performance





C6000 (216.000.000 cells) coupled to R02B11 (335.544.320 cells)

YAC for output and visualisation



YAC 2 in ICON

- new YAC 2 initialisation interface allows ICON-ESM to be coupled to external components
  - e.g. hydrology, other atmosphere/ocean, I/O, and visualisation
- currently being used in various high resolution configurations
  - coupled R2B8, R2B9, R2B10 and R2B11 all with matching grids
  - R2B9 atm w/ "zoomed" Ocean (R2B10 equivalent)
  - R2B5 NWP atmosphere - R2B6 ocean
  - more to come…

R2B8	10 km
R2B9	5 km
R2B10	2.5 km
R2B11	1.2 km

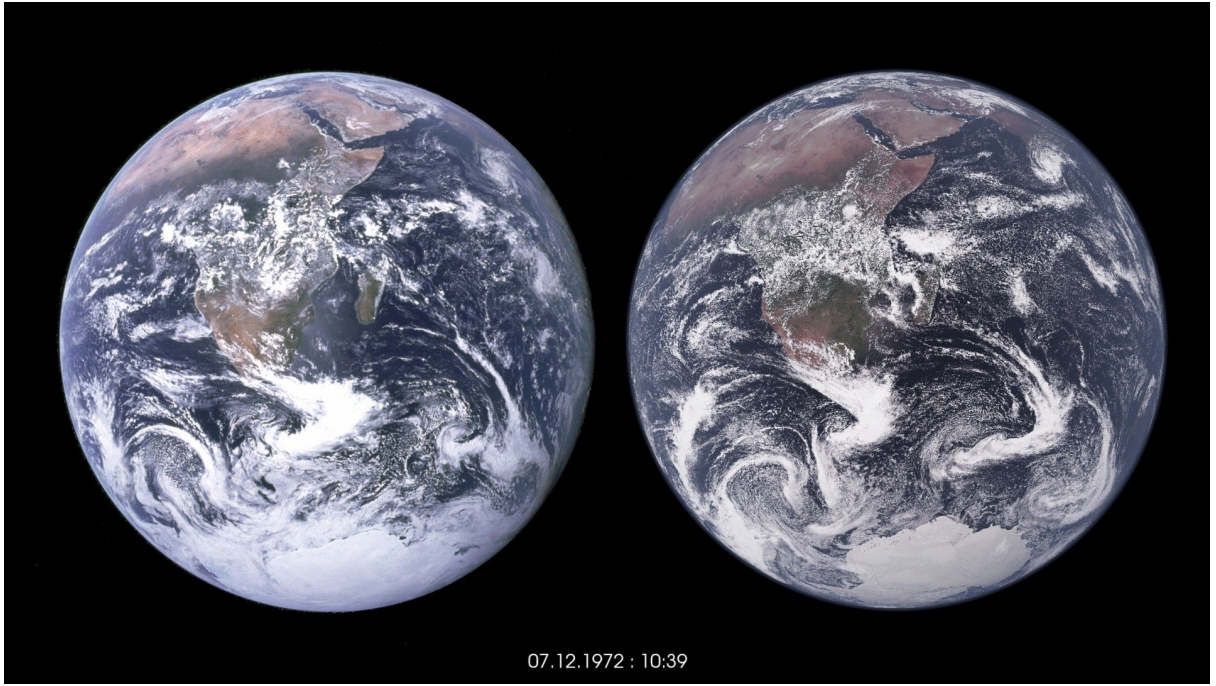
YAC 2 in ICON performance

- ICON Global Atmosphere Ocean-telescope[1,2,3]
  - 400 nodes on Levante
  - ATM
    - global uniform R2B9 grid (5km)
    - timestep: 30s
  - OCE
    - global R2B9 with zoomed region (equivalent to R2B10)
    - timestep: 30s
  - Coupling interval: 12min
  - Interpolations used:
    - 1st order conservative + 4-Nearest-Neighbour
    - Hybrid cubic spherical Bernstein-Bézier patch + 4-Nearest-Neighbour
- Performance
  - runtime: 6h (for 10 simulated days)
  - YAC
    - initialisation: 20s (atm) and 60s (oce)
    - exchange: 60s (excluding first exchange)

[1]: https://doi.org/10.5194/gmd-2022-171
[2]: https://doi.org/10.16993/tellusa.54
[3]: https://doi.org/10.1029/2021MS002813

“Blue Marble”

- ICON reproduced NASA “Blue Marble”-photo taken 1972 from Apollo



Original NASA “Blue Marble”-photo left, visualisation right. Credit: MPI-M, DKRZ, NVIDIA

End

- Questions?
- References
  - Documentation: https://dkrz-sw.gitlab-pages.dkrz.de/yac/
  - Download: https://gitlab.dkrz.de/dkrz-sw/yac.git
  - Moritz Hanke, René Redler, Teresa Holfeld und Maxim Yastremsky, 2016: YAC 1.2.0: new aspects for coupling software in Earth system modelling. Geoscientific Model Development, 9, 2755-2769. DOI:10.5194/gmd-9-2755-201
  - Moritz Hanke und René Redler, 2019: New features with YAC 1.5.0. Reports on ICON, No 3. DOI: 10.5676/DWD_pub/nwv/icon_003