# Storm- and eddy-resolving simulations with IFS-FESOM/NEMO at the kilometre scale


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# Horizon 2020 nextGEMS' objectives

https://nextgems-h2020.eu
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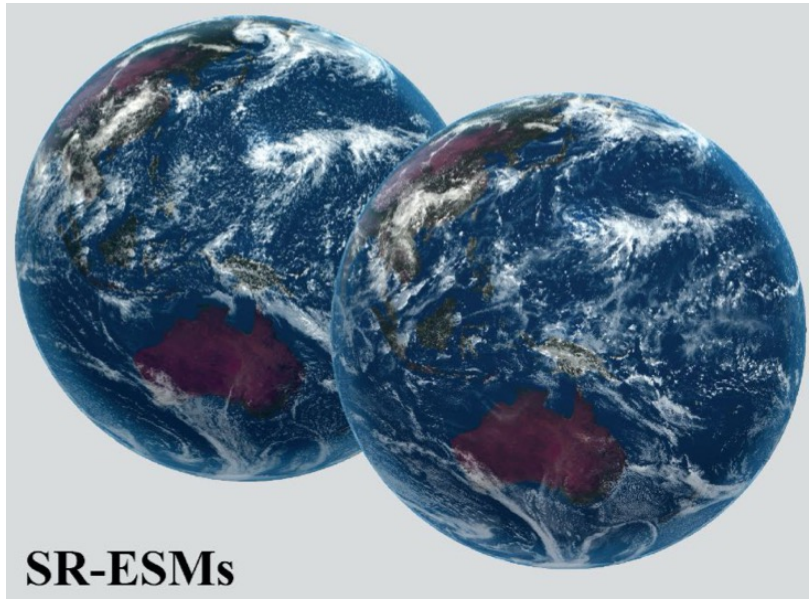
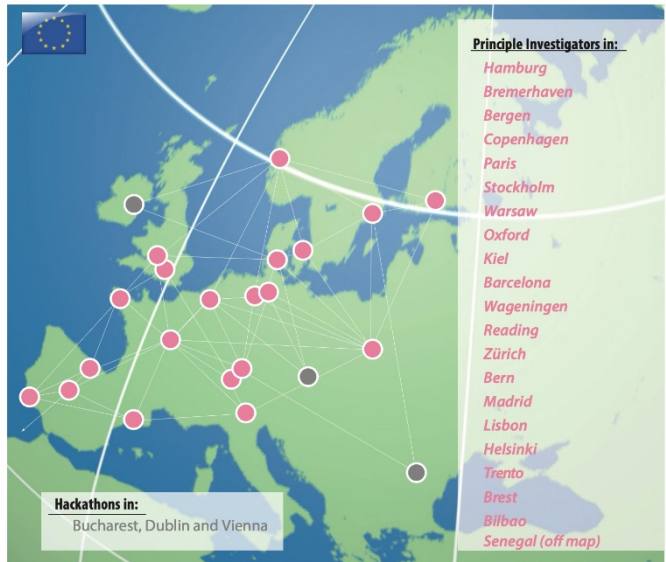
Two storm & eddy-resolving
Earth System Models (**SR-ESMs**)




ECMWF/AWI with IFS-NEMO/FESOM
MPI-M/DWD with ICON

- **Develop two SR-ESMs**
  (O(3km) in the atmosphere & ocean)
- Use SR-ESMs to study the Earth system and **test emerging and long-standing hypotheses underpinning our understanding of climate change**
- Build new, more integrated communities of ESM users through **knowledge-coproduction activities**

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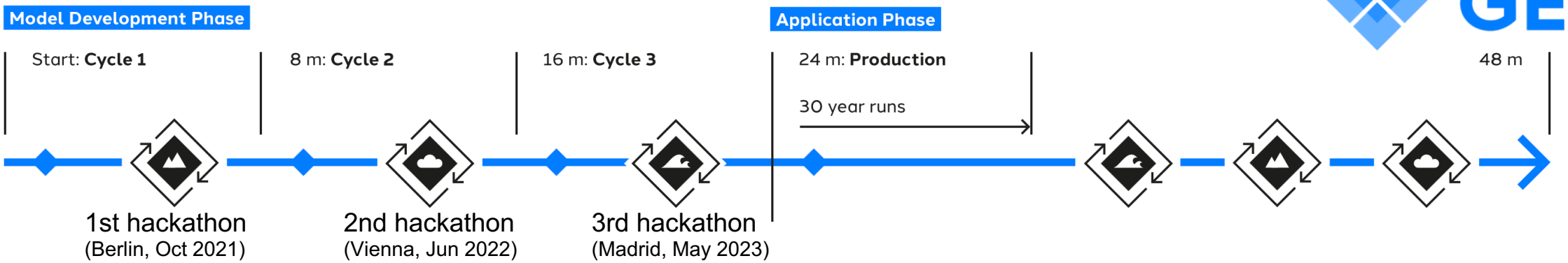
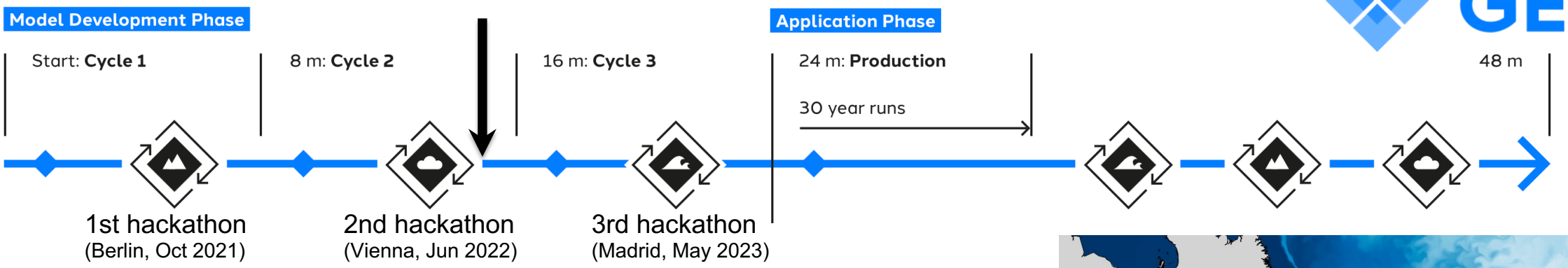
MAX-PLANCK-INSTITUT
FÜR METEOROLOGIE

# Different development cycles



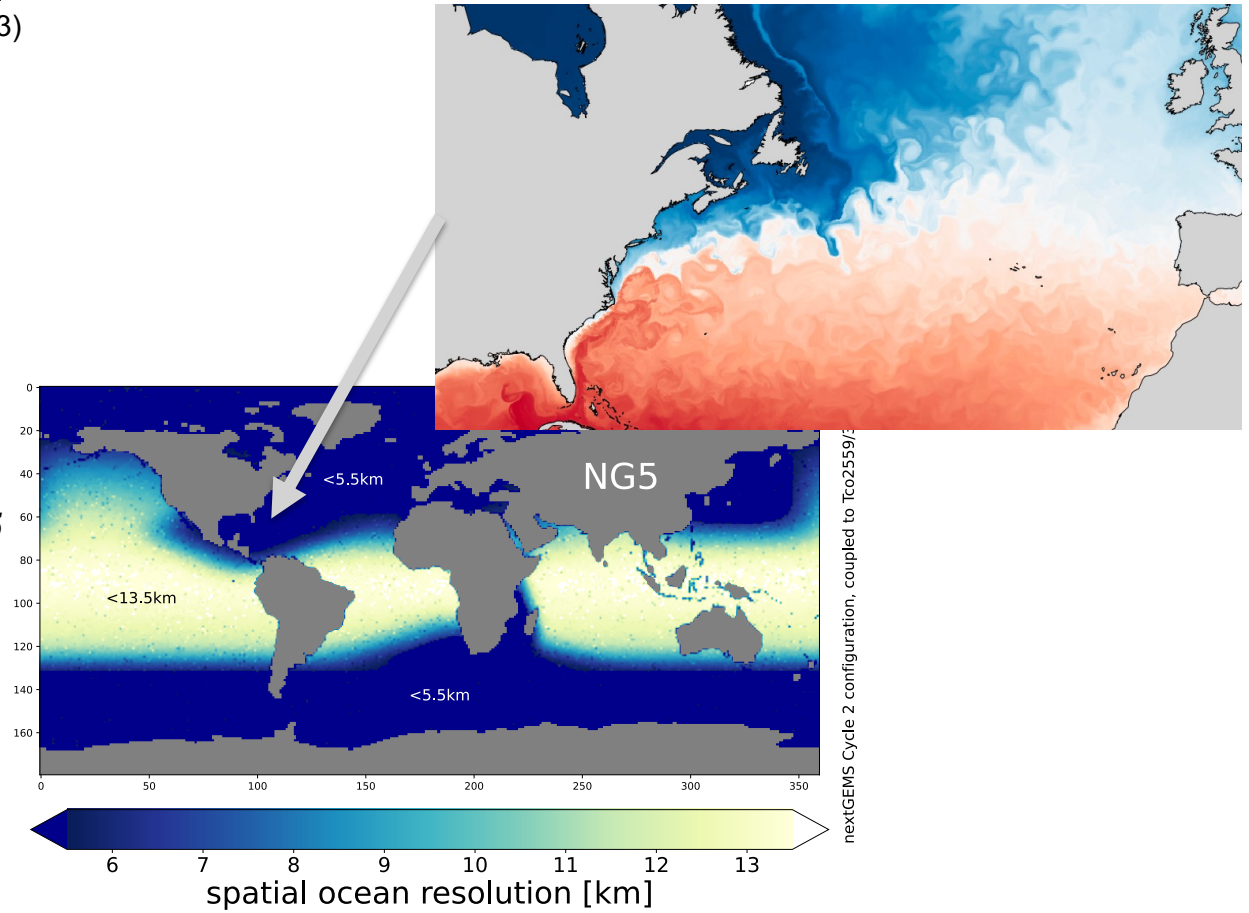
# Different development cycles : IFS-FESOM/NEMO




- ☒ **Cycle 1 and 2:** from **75 days to - 2 years**
- ☒ **Atmosphere**: **9 km / 4.4 km / 2.8 km**
- ☒ **Ocean**: **25km** NEMO; **4-13km** FESOM2 NG5 grid (on average 5km)

**8 months at 2.8 km & FESOM 5km**
**1 year at 4.4 km & FESOM 5km**

*Ocean resolution of the **NG5** FESOM2 grid*

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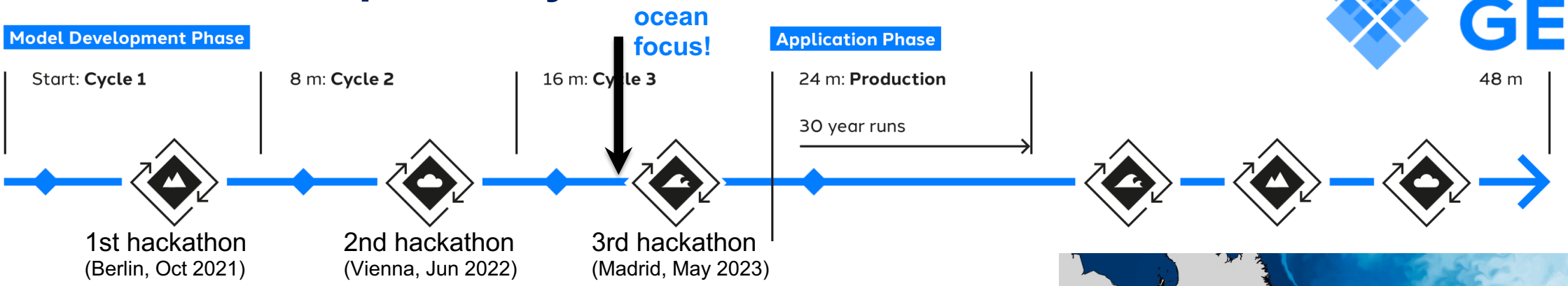


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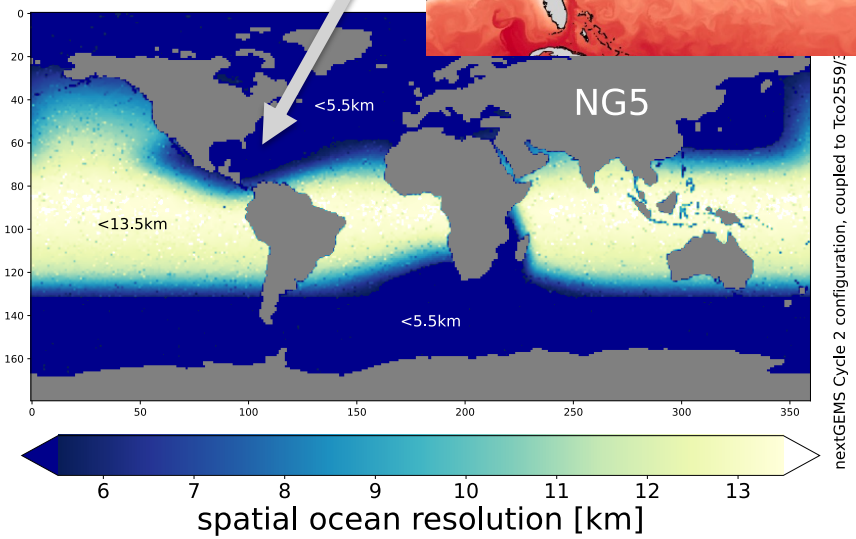
- ❑ **Cycle 3:** **2 - 4 years** at 4.4 km atmo; FESOM2.5 + NG5 ocean
- ❑ **Production runs:** **up to 30 years**

*Ocean resolution of the **NG5** FESOM2 grid*

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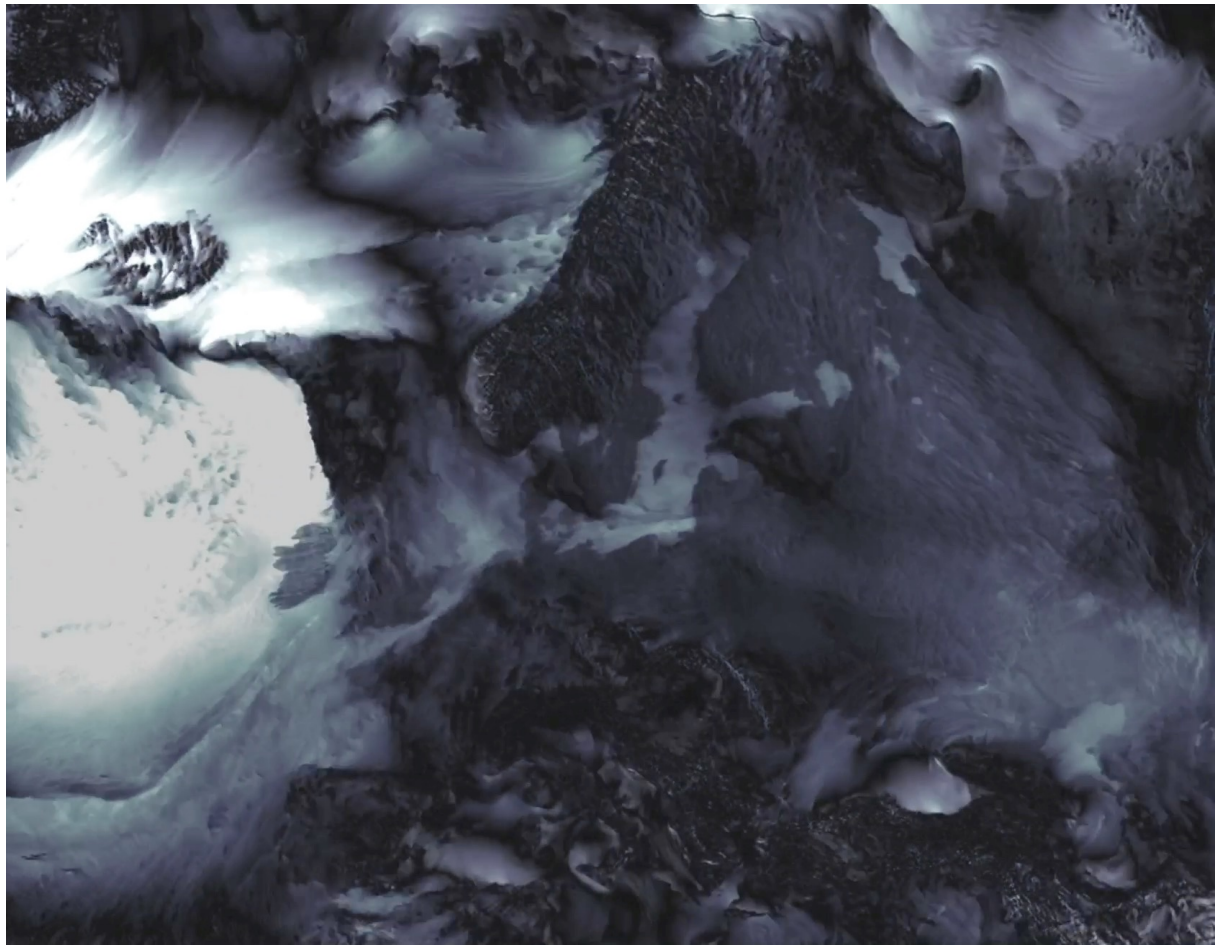
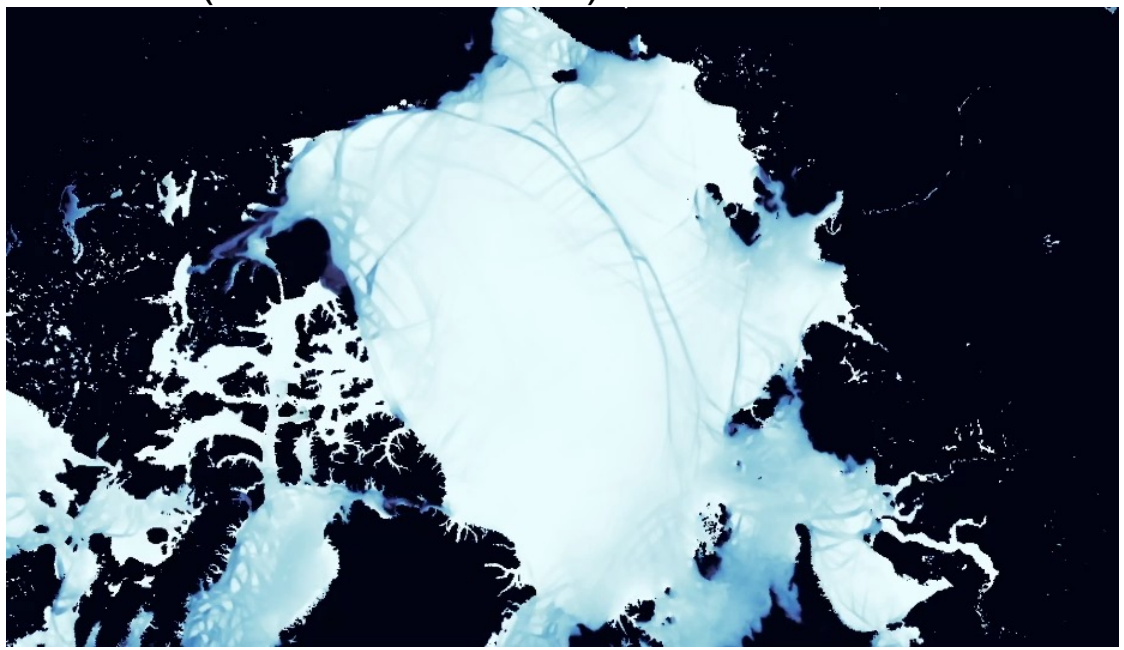
# Cycle 1 & 2 simulations with IFS-FESOM

Wind gusts over Europe (IFS at 4.4km)



Simulated sea ice leads/cracks in the Arctic Ocean (FESOM at 4-5km)



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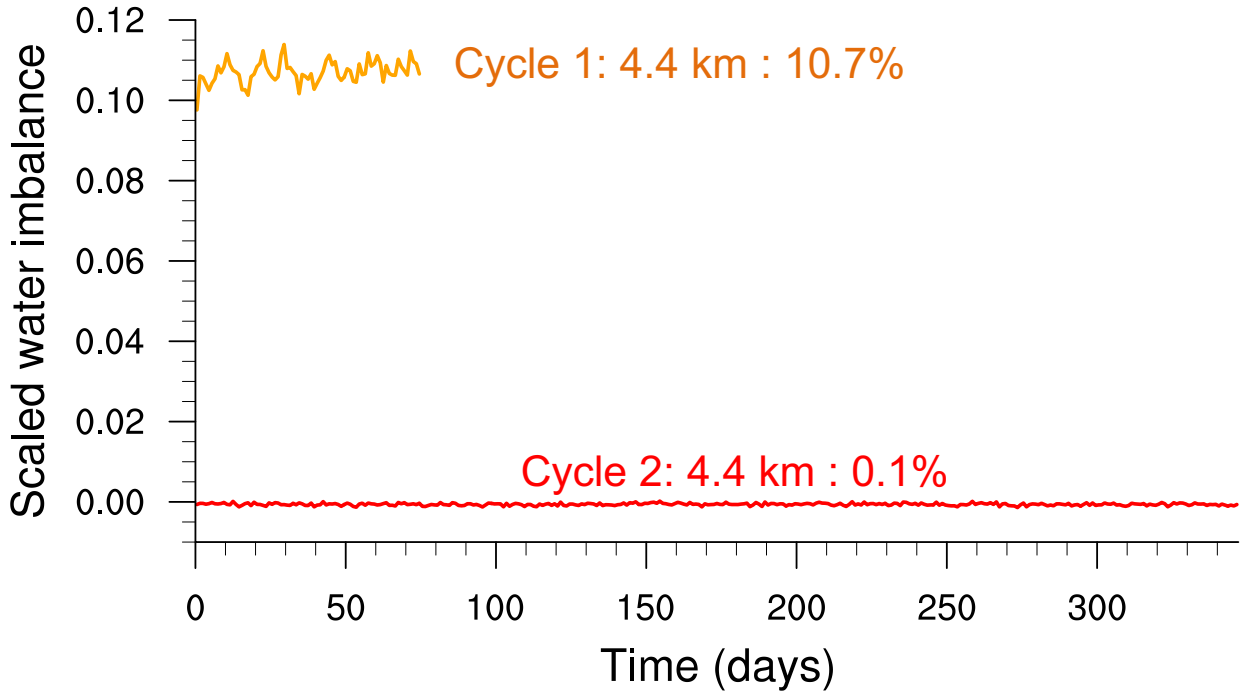
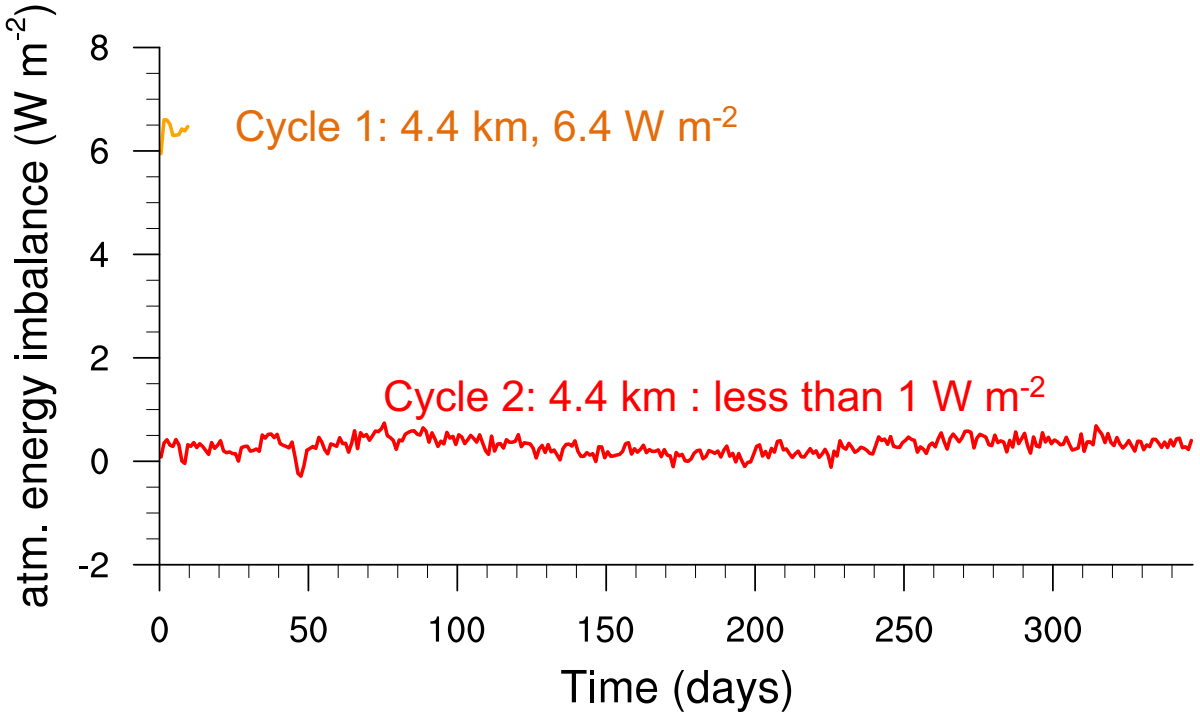
*N. Koldunov, AWI, T. Rackow, ECMWF*
*@oceanographer ; @thomas_rackow*

# Hackathon 1 surprise: water and energy imbalance in IFS

IFS: semi-Lagrangian dynamics is non-conserving:
worse at higher resolution & when deep convection is switched off

To fix the water imbalance for Cycle 2, we activated tracer mass fixers for all moist species

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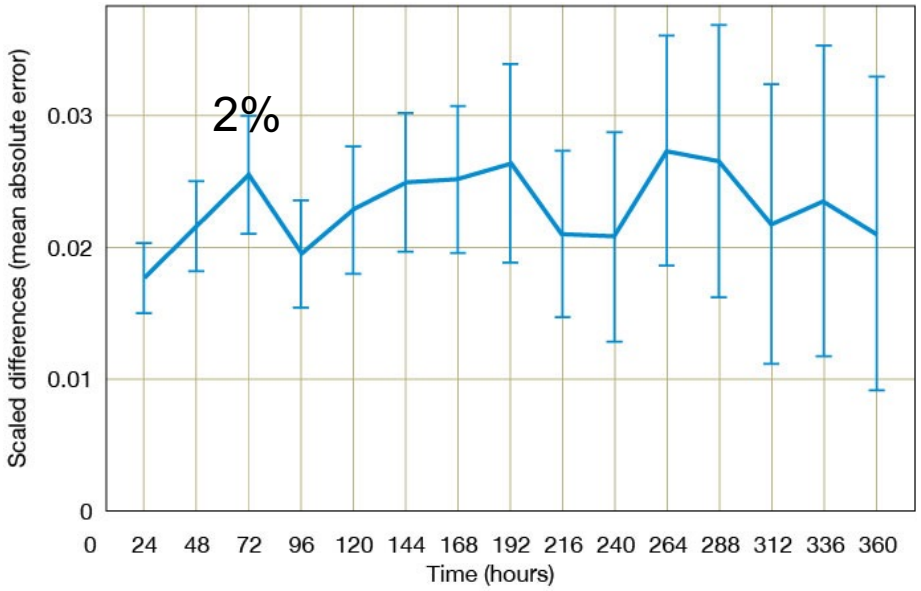
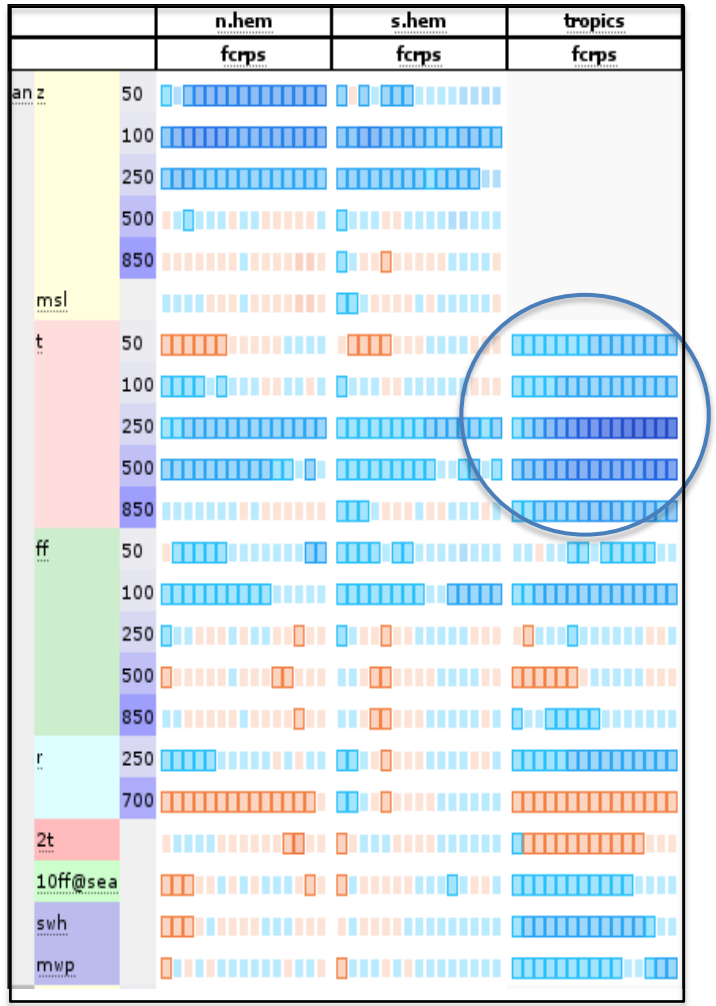
*T. Becker & modelling teams at ECMWF*

# Impact of water conservation changes on forecast skill across resolutions

Precipitation mean absolute error

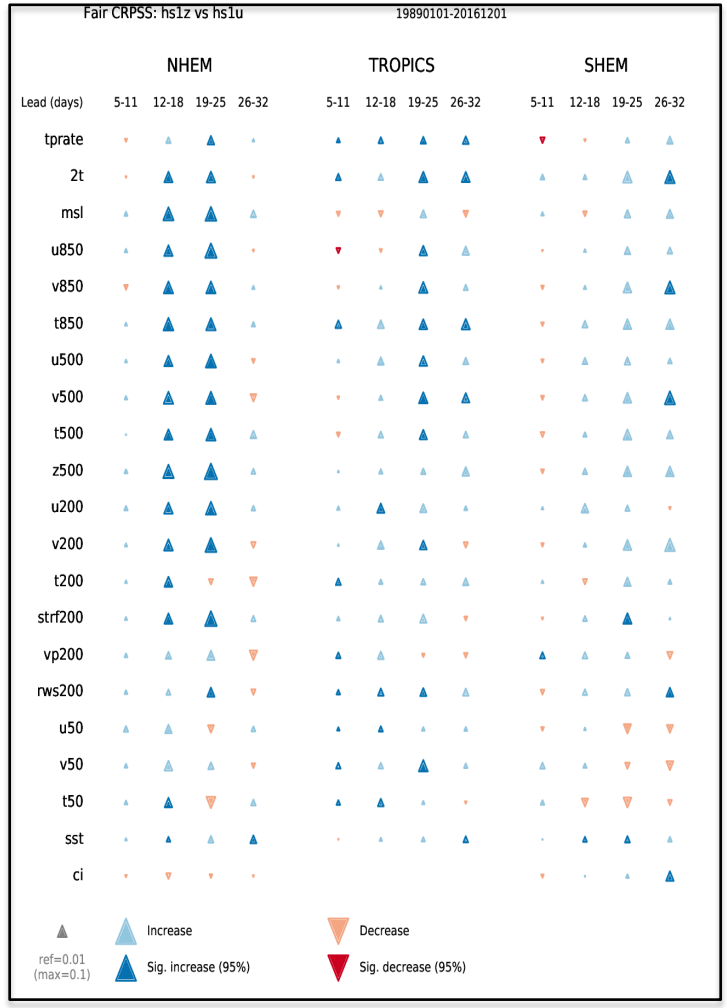



9km ENS




8-member d(fCRPS)

Monthly forecast (Tco 199)

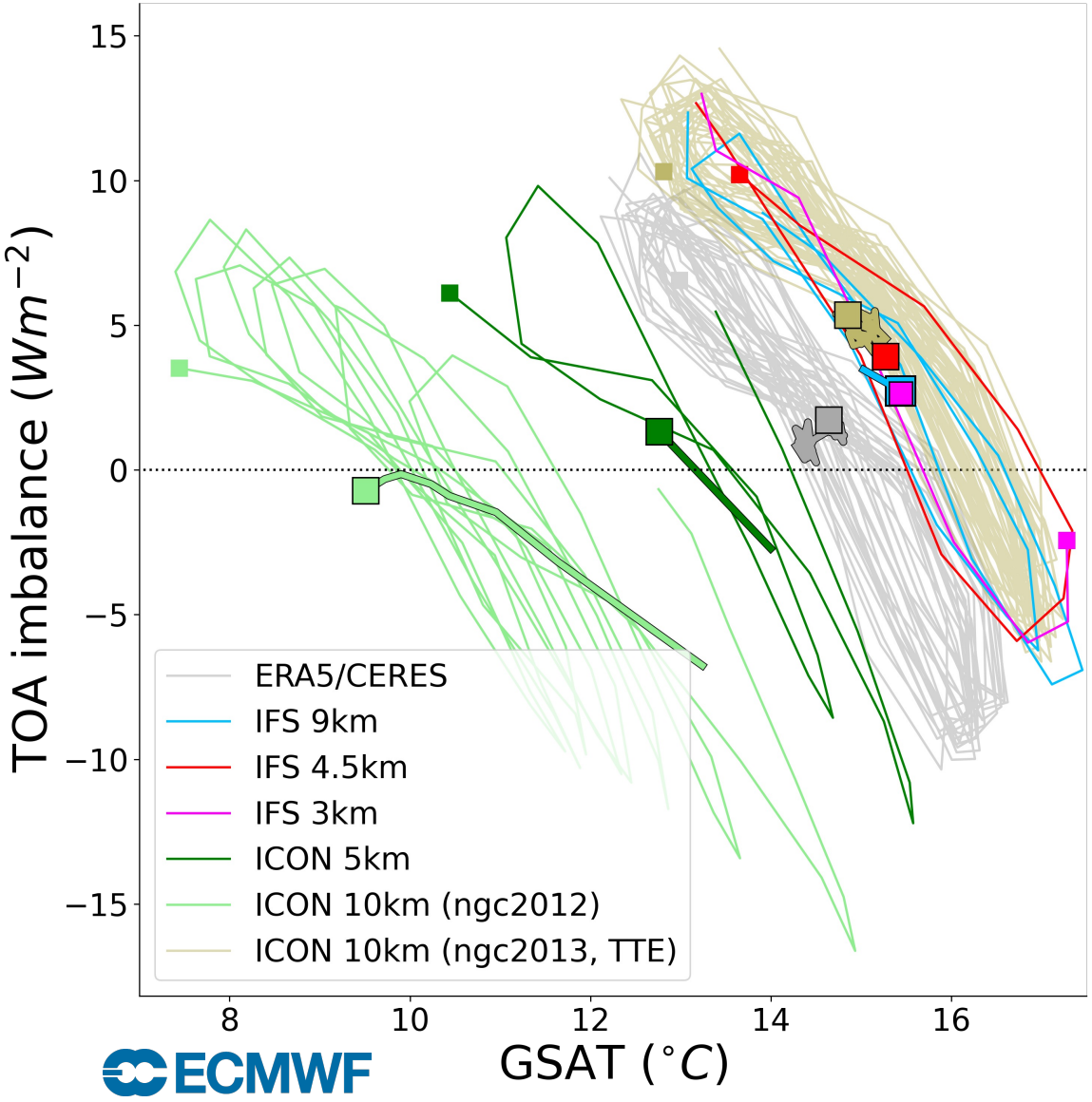



10 members , dCRPSS

ECMWF

*T. Becker, R. Forbes, S. Lang, C. Roberts*

# Hackathon 2 surprise: TOA imbalance in Cycle 2 setups



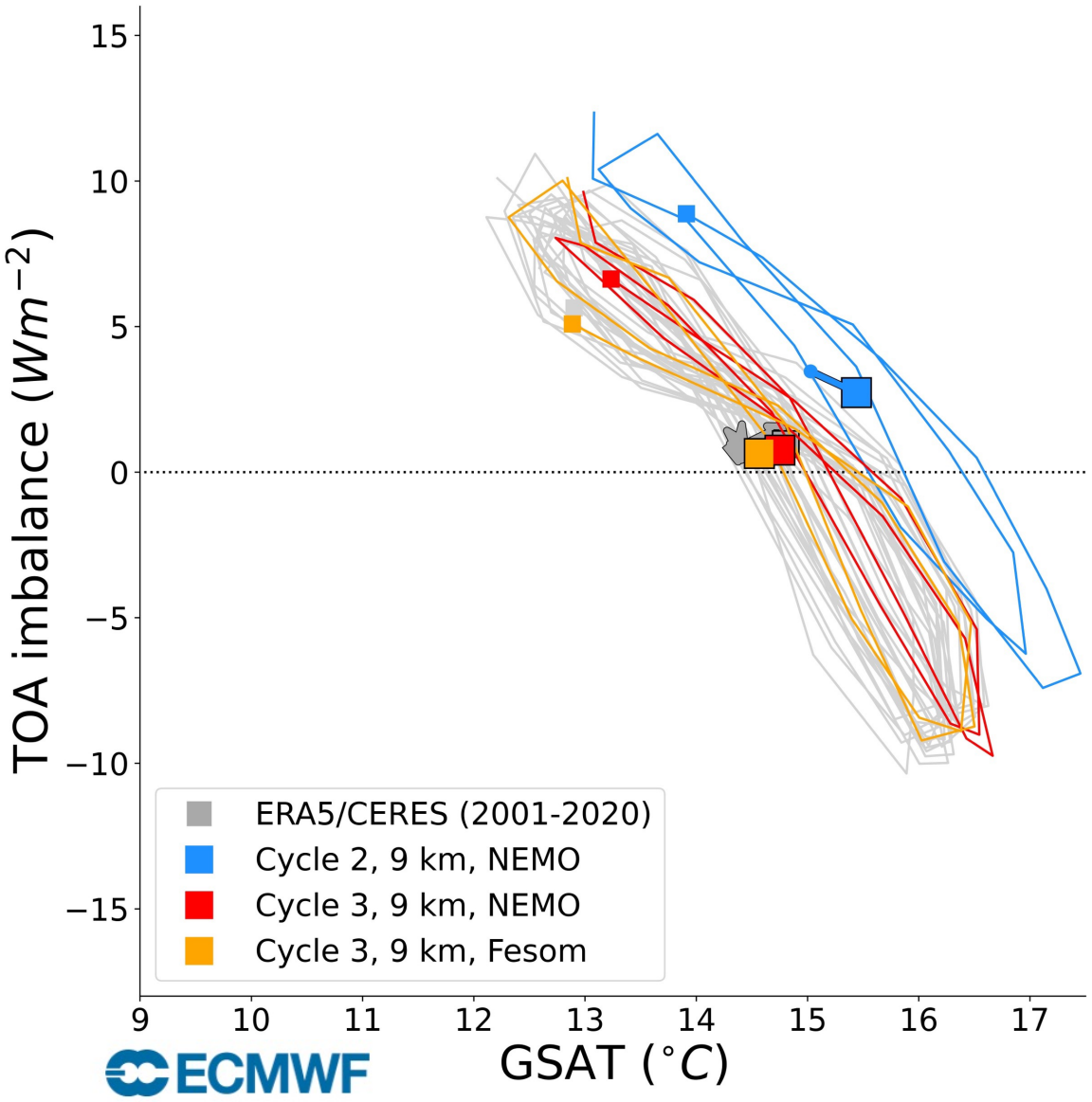

IFS 9km Cycle 2 is warming slightly in the second year and has a positive TOA imbalance (~2 W/m$^2$)

ICON 5km Cycle 2 is cooling and has a negative TOA imbalance (~ -2 W/m$^2$)

ICON 10km Cycle 2 with TTE has a positive TOA imbalance but stable temperature (atm. energy leak)

*S. Milinski*

# Sneak peak: TOA imbalance in Cycle 3 setups




IFS 9km Cycle 2 is warming slightly in the second year and has a positive TOA imbalance (~2 W/m$^2$)

IFS 9km Cycle 3 setup (NEMO ocean) has a slight positive TOA imbalance as in observations (~ +1 W/m$^2$)

IFS 9km Cycle 3 setup (FESOM ocean) has a slight positive TOA imbalance as in observations (~ +1 W/m$^2$)

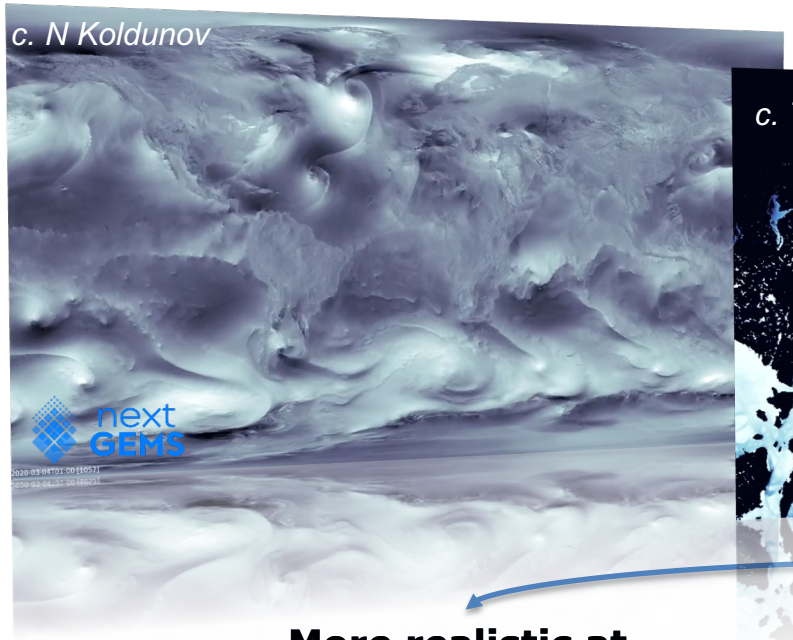
IFS-FESOM is closer to the mean of 2001-2020 CERES (radiation) and ERA5 (temperature), while IFS-NEMO is closer to the individual year 2020

Might point to different ocean initialisation in the high-res vs operational ocean

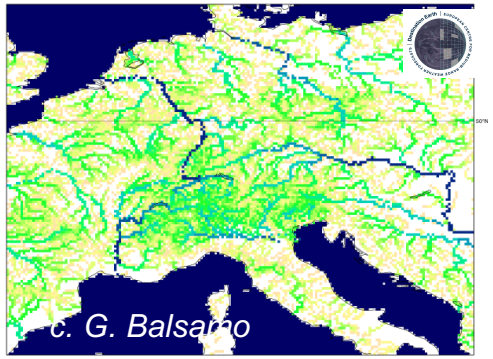
*S. Milinski*

# **Destination Earth's Digital Twins:** Quality + Impacts + Interaction

1. **Better simulations** based on **more realistic models**
2. **Better ways of combining all observed and simulated information** from entire Earth system (physical + food/water/energy/health) **supporting action scenarios**
3. **Interactive and configurable access to all data, models and workflows**








**More realistic at *global* scale**

**More realistic at *local* scale**

**Include impacts where they matter**

**Trial different adaptation and mitigation scenarios**

ECMWF