Storm-resolving simulations with IFS-NEMO/FESOM in the nextGEMS project

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Different Development Cycles

- **Cycle 1** ~75 days 9km/4.5km w/ Deep On/Off
- **Cycle 2**
  - 2 years baseline: 9 km Deep On (NEMO)
  - 1 year 4.5 km Deep Off (FESOM)
  - ~8 months 2.9 km Deep Off (FESOM)
- **Cycle 3** (planned): 2-4 years at 2.9 km
- **Production runs**: 30 years

Wind gusts over Europe (N. Koldunov, AWI)
The nextGEMS ocean grid for Cycle 2: NG5

- **Cycle 1**: IFS-FESOM ran with 0.25 degree ocean only, coupled to IFS cycle 46r1
- **Cycle 2**:
  - refactored FESOM code that supports hybrid MPI/OpenMP
  - new NG5 grid with higher ocean resolution (7.5 million surface nodes)
  - coupled to operational IFS cycle 47r3.3
  - Eddy-resolving in large areas; Tropical Instability Waves resolved
NG5 grid allows for linear kinematic features (sea ice cracks) in both hemispheres.
Water and energy imbalance

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

Deep On, 9 km: excess precipitation of 4.6%
Deep Off, 4.5 km: excess precipitation of 10.7%

Deep On, 9 km: 2 W m$^{-2}$
Deep Off, 4.5 km: 6.4 W m$^{-2}$
Water and energy imbalance

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

Deep On, 9 km: excess precipitation of 4.6%
Deep Off, 4.5 km: excess precipitation of 10.7%
remaining imbalance: about 0.1%

Deep On, 9 km: 2 W m\(^{-2}\)
Deep Off, 4.5 km: 6.4 W m\(^{-2}\)
remaining imbalance: less than 1 W m\(^{-2}\)

Scaled water imbalance

atm. energy imbalance (W m\(^{-2}\))
2m temperature

- all simulations show temperature increase of 0.5 to 1 K by the end of 2020
- temperature increase slows down in 2021, equilibrium at 0.8-0.9 K warming?
- two FESOM simulations with very similar temperature evolution
- FESOM warm bias Aug 2020: combined signal from NH mid lats and SH high lats
- longer-term warming trend stems mostly from tropics, particularly with Deep Off

![Graph showing global 2m temperature difference with respect to ERA5](image)

- ALL: Cycle 2, Deep On, 9 km, Nemo
- Cycle 2, Deep Off, 9 km, Nemo
- Cycle 2, Deep Off, 4.5 km, Fesom
- Cycle 2, Deep Off, 2.9 km, Fesom

- TROPICS
- OCEAN
- LAND
global mean TOA radiation bias rel. to CERES climatology

- too much OLR
- not enough reflection of shortwave radiation
- biases compensate in Cycle 1 but not anymore in Cycle 2
Precipitation

- Deep Off: mean precipitation strongly overestimated over NH Pacific ITCZ
- precipitation too intense with Deep Off and not intense enough with Deep On
Precipitation

- Deep Off: mean precipitation strongly overestimated over NH Pacific ITCZ
- Precipitation too intense with Deep Off and not intense enough with Deep On
- Please visit me at my poster for sensitivity study that investigates these problems and offers possible solutions
Low cloud cover in IFS 2.5 km (Nikolay Koldunov, AWI)