Towards novel 30-year initialized climate outlooks with the IFS-NEMO4/SI^3 coupled model

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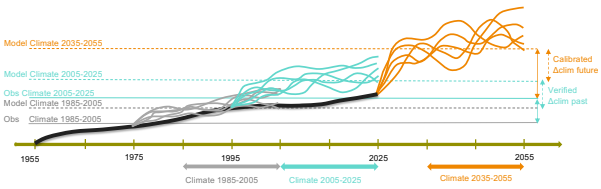
Key Points

- ✓ The ASPECT Project (www.aspect-project.eu) aims to to enhance seamless climate predictions for up to 30 years, supporting climate change adaptation strategies across various sectors and spatial-temporal scales.
- ✓ A key objective is to provide 30-year initialized climate outlooks, offering improved long-term climate information for decision-makers.
- ✓ These outlooks bridge the gap between decadal predictions and climate projections. Initialization from observations presents a cost-effective alternative to expensive multi-centennial sequential climate projections and serves as a novel pathway for integrating high-resolution models to deliver reliable climate information.
- ✓ To this end, a set of multi-decadal multi-ensemble prototype simulations has been performed over the recent historical period, and model performance in terms of long-term biases and trends, as well as efforts at tuning top-of-atmosphere (TOA) radiative fluxes, are discussed.

1. Bridging climate predictions and projections

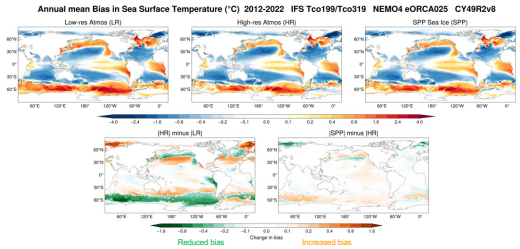


- Analysis similar to projections: Changes in mean, variability, trends and extremes.
- The first set of historical simulations (1995-2025) allows calibration (similar to projections).
- The second set of historical simulations (1975-2005) allows verification (similar to decadal forecasts).
- Further sets of integrations could be used to reduce uncertainty in the calibration.
- Only the last twenty years of each set will be analyzed to eliminate the impact of initialization.

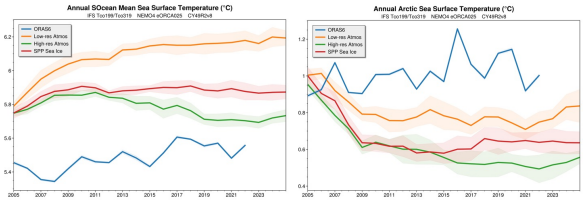
2. Model configuration

- IFS CY49r2 v-version 8
- Ocean: NEMO4/SI^3 eORCA025 (25 km)
- Atmospheric resolution:
  - High (Tco319, 36 km)
  - Low (Tco199, 50 km)
- ERA5 Atmosphere and Land initial conditions
- ORAS6 Ocean initial conditions
- Initialized: 2005-01-01
- Period: 2005-2025
- 11 Ensemble Members
- 21-year prototype coupled simulations:
  - ❑ Low-res atmosphere (LR)
  - ❑ High-res atmosphere (HR)
  - ❑ HR + Stochastic parameterization (SPP) in sea ice[1]

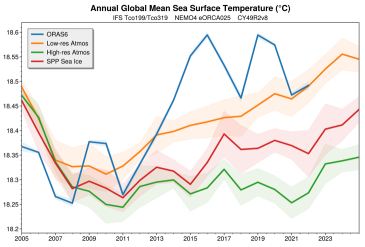
3. Global and regional temperature biases and trends



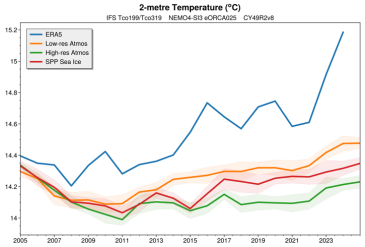
- Long term SST bias is heterogenous with warming in the tropics and Southern Ocean and cooling in the Arctic and gyre regions.
- Impact of resolution:
  - reduced Southern Ocean warm bias
  - increased Arctic cold bias
- Impact of SPP in sea ice:
  - weaker than impact of resolution
  - reduced Arctic cold bias



- Warm bias in the Southern Ocean and cold bias in the Arctic develop in 3-5 years.

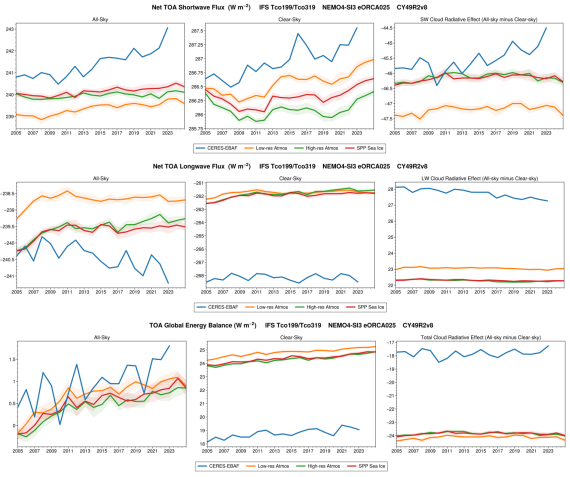


- Global mean SST is sensitive to resolution and SPP in sea ice
- Initialization shock in first year leads to warming
- Cooling drift in following 4 years



- Warm initialization shock in SST not obvious in 2m temperature
- Cooling drift in first 5-6 years.
- Slightly stronger warming after 2022, but not as strong as in observations

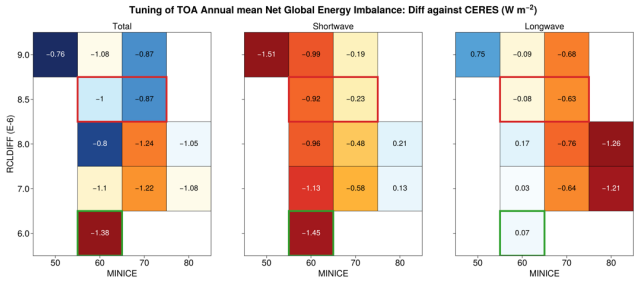
4. Top-of-Atmosphere (TOA) Global Energy Balance and Tuning



- *Clouds in model reflect too much sunlight*
- *Clouds in model trap less longwave*
- *Net cooling in model due to clouds*

- Negative net TOA radiation in model due to initialization shock - recovers in about six years and stabilizes to values lower than CERES-EBAF[2] with an upward trend.
- Model seems to overestimate the clear sky greenhouse effect and underestimate the cloud related greenhouse effect.

- Efforts to better align model TOA fluxes with observed estimates of Earth's energy imbalance focus on tuning of parameters that affect cloud amount (following Rackow et al., 2025)[3] :
  - RCLDIFF: *cloud edge erosion (evaporation) rate multiplier* – affects low cloud amount
  - MINICE: *threshold that limits the minimum size of ice effective radius* – affects high cloud amount
- A combination of these parameters were tested in one-year long atmosphere-only simulations.
- Compared to the CONTROL (Default values RCLDIFF: 6E-6 and MINICE: 60.0, green boxes in figure below), tuning reduces the net TOA biases (e.g., red boxes) compared to CERES-EBAF[2].



- **Further work:**
  - Choose the best set of tuning parameters based on further testing in coupled simulations.

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References

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