Modelling the Earth’s climate system
Understand & Predict climate variability and changes

Climate change

**Multi-decadal to centuries**
- Scenarios and feedbacks
  - e.g. overshoot, clouds, carbon cycle
- Risks of Tipping points
  - e.g. permafrost, amazon dieback

**Multi annual to multi-decadal**
- Improve reliability at regional scale
  - e.g. extreme events (floods, droughts ...)
- Impacts on food, resources, health

Mitigation

Adaptation

Accounting for multi-scale internal variability
- Investigating different forcing factors

Uncertainties in models: structural, parametric

Understand mechanisms at different space & time scales

Evaluate models on past observed climates, incl. paleoclimates, e.g. deglaciation

Sylvie Joussaume, ICES, 30/09/2022
Spatial Resolution:
Resolution x 2 -> Computing x 8
25 to 150 km > 5-10 to 100 km

Complexity:
carbon cycle, aerosols, chemistry, biosphere (x 5-10)
Better account for N cycle, aerosols, land processes

Duration: need for long simulations
Multi-decadal to multi-centennial (> 5 SYPD)
Deep-ocean, variability, past climatic transitions

Ensemble size:
document internal variability, quantify uncertainties
Today 10-30 > larger ensembles
Coupled Model Intercomparison Project
Phase 6 (CMIP6)

CMIP6
23 endorsed MIPs
Model Intercomparison Projects

Deck: 30 modelling groups
(59 models)

Per model:
20 to 50,000 simulated years
HPC: 100s Mh/model
Data: 1 – 10 PB produced/model

Input to IPCC AR6 2021

Data volume/month from European ESGF nodes (TB)

Number of distinct users/mth of European ESGF nodes

GA 824084
Subset
Data needs & challenges

Increase of data

- Data workflow
- Compute services
- Wide range of users

Dashboard stat
ESGF: 13.5 M datasets
33.3 PB

CMIP6: 12.5 M datasets
23.8 PB (w/o replica 13.1)
CMIP5: 5.3 PB (1.5)

ca 15 000 registered users

Exabytes to be reached before exaflops

From NCAR (Gary Strand)

Overpeck et al. (2011)
Climate models: at the core of climate information for mitigation and adaptation
But also needed for understanding

A range of model configurations will be needed
From high to very-high resolution
To lower resolutions with large ensembles, multi-models, complexity, long-term variability
Both approaches needed and complementary

Digital challenges

**HPC**: prepare for future architectures although using legacy codes, ensemble of codes, complex workflows and having international production runs

**Data**: from managing large amounts of data near HPC to ease a wide access to large multi-model ensembles

**IA**: from model data analyses to model parameterisations and emulators