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

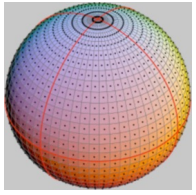
Understand mechanisms at different space & time scales

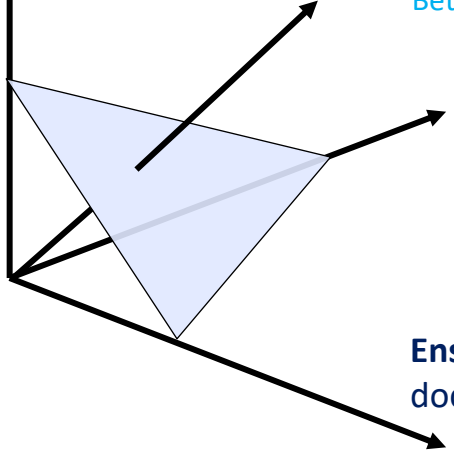
Evaluate models on past observed climates, incl. paleoclimates, e.g. deglaciation

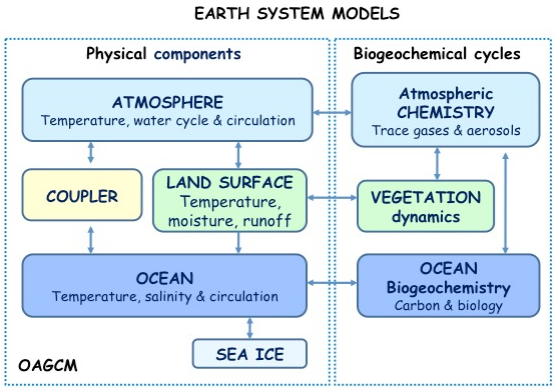
Spatial Resolution:

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:

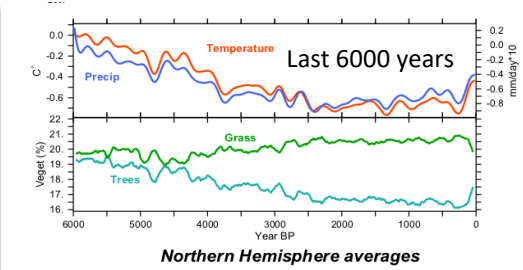
document internal variability, quantify uncertainties

Today 10-30 > larger ensembles

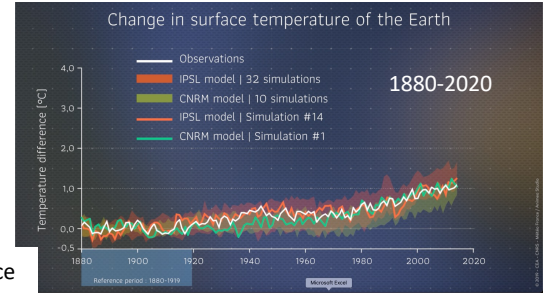
Computational needs & challenges

Exascale:

an opportunity & a challenge (Complex architectures)

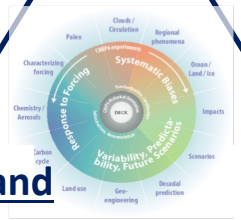


Braconnot et al. (2019)



Coupled Model Intercomparison Project
Phase 6 (CMIP6)

Predict/Project



Understand **Evaluate**

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

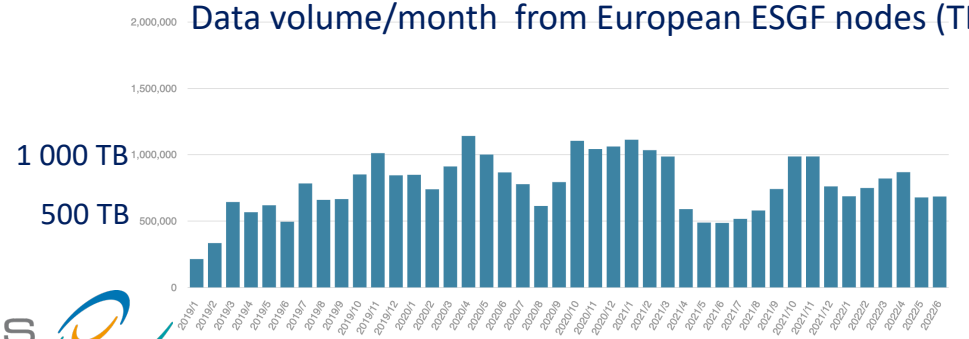
is-enes
INFRASTRUCTURE FOR THE EUROPEAN NETWORK FOR EARTH SYSTEM MODELLING

GA 824084

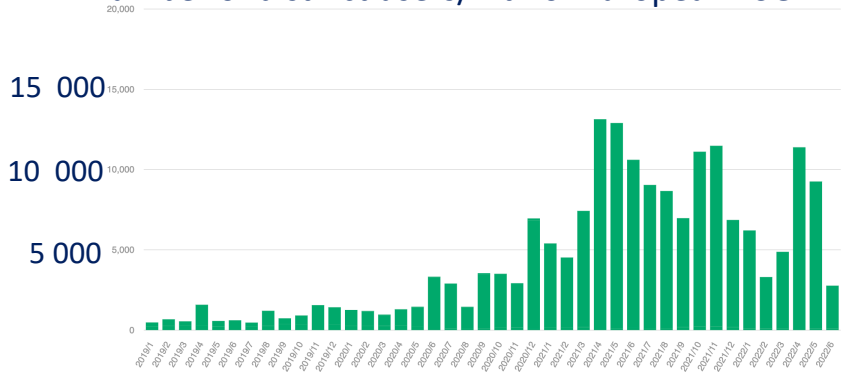
Subset

Climate Change Service

Data volume/month from European ESGF nodes (TB)



Number of distinct users/mth of European ESGF nodes



2019/01

2022/06

ESGF
Earth System Grid Federation

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

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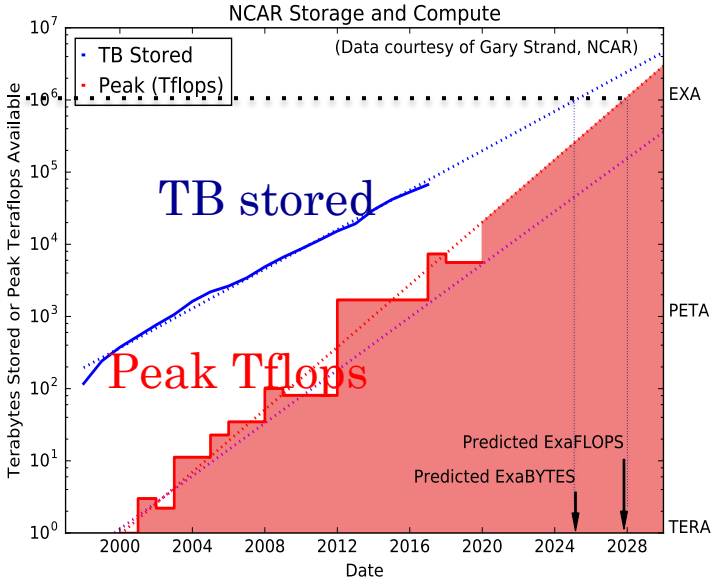
Exabytes to be reached before exaflops

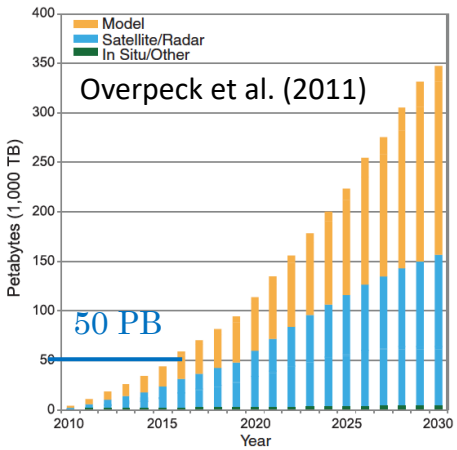


From NCAR (Gary Strand)

Data
needs & challenges

Increase of data

➢ **Data workflow**
Compute services
Wide range of users



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