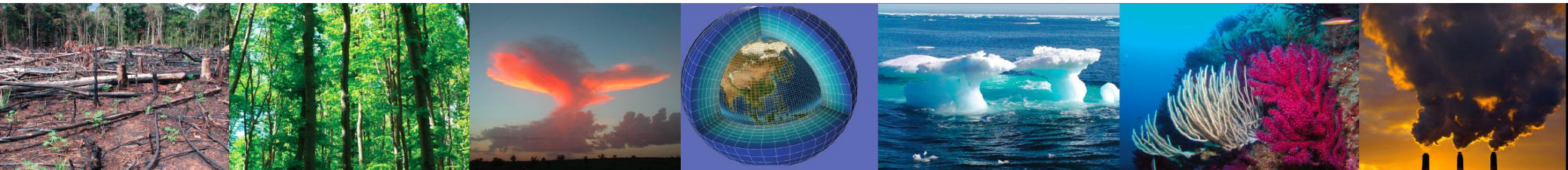


HPC for CMIP6 and beyond

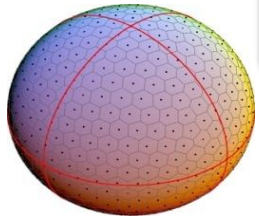
Sylvie Joussaume
CNRS, IPSL

Coordinator IS-ENES2, Infrastructure for ENES

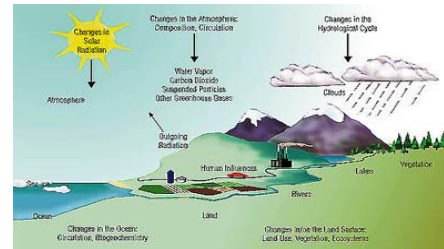


$\times 3 \approx \times 27$
 $\times 100 \approx \times 10^6$

Needs for HPC



EO,
Data Assim.



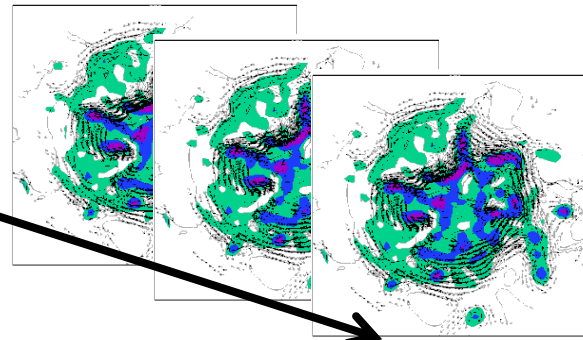
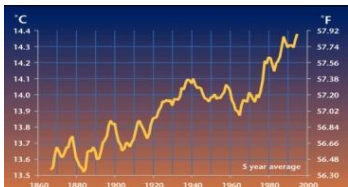
$\times 5-10$

Computing
Resources

Complexity

*From Jim Kinter,
the World Modelling Summit, 2008*

Duration and/or Ensemble size



ensemble: $\times 10$

duration: $\times 10-100$

Earth System modelling in Europe CMIP5

CMIP5

Evaluate/Understand/Projections

3400 simul. yrs up to > 12000 yrs

50 expts up to > 160 expts

1000 – 3000 Tbytes (CMIP3: 36)

29 modelling groups

61 models

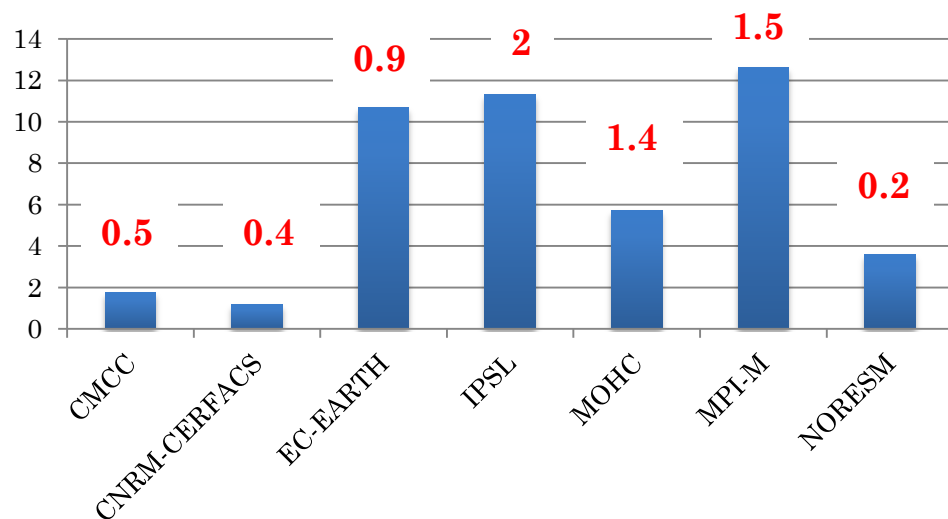


CMIP5 in Europe

7 European modelling groups

17 models

CMIP5 Mcore hours



PB

NCC	NorESM1-M NorESM1-ME
MPI-M	MPI-ESM-LR MPI-ESM-MR MPI-ESM-P
MOHC	HadCM3 HadGEM2-A HadGEM2-CC HadGEM2-ES
EC-EARTH	EC-EARTH
IPSL	IPSL-CM5A-LR IPSL-CM5A-MR IPSL-CM5B-LR
CNRM-CERFACS	CNRM-CM5
CMCC	CMCC-CESM CMCC-CM CMCC-CMS

ENES HPC TF, M. Carter & M.A. Foujols

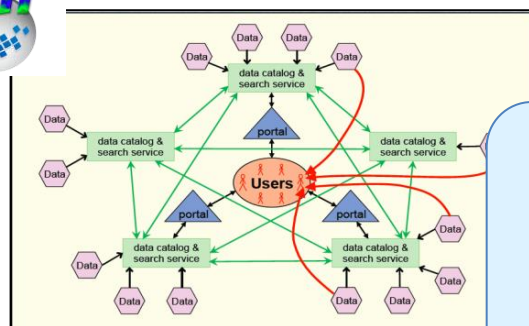
1st phase: March 2009- Feb 2013, 18 partners

2nd phase: Apr 2013- March 2017, 23 partners

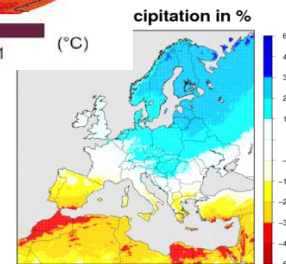
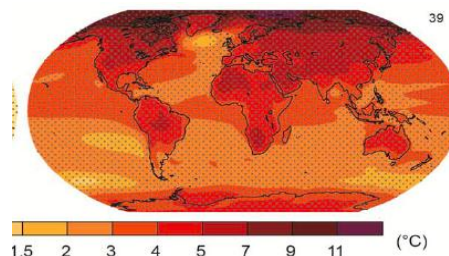


Climate models
Environment software tools
ESM ca 1000 man years

**High-performance computers
& storage facilities**



Data & metadata
Standards
Distributed database ESGF
10 000 registered users worldwide
Open access



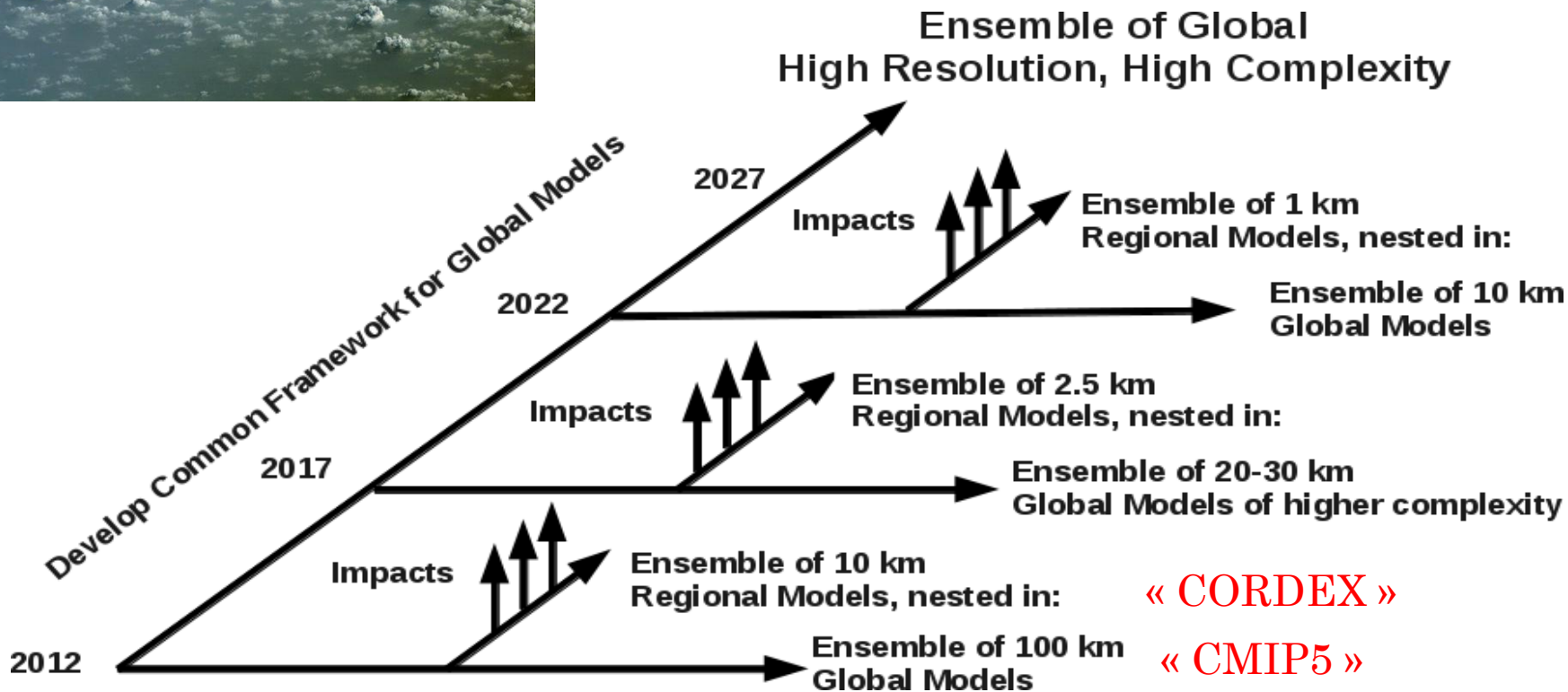
Climate research & Impact research
Climate services

Support WCRP international experiments
Used in IPCC Assessments Reports

<http://enes.org/>



A grand challenge :
Towards ≈ 1 km scale for atmosphere
resolving deep convective clouds
in global climate models

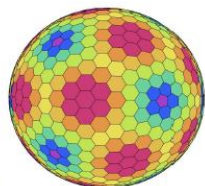
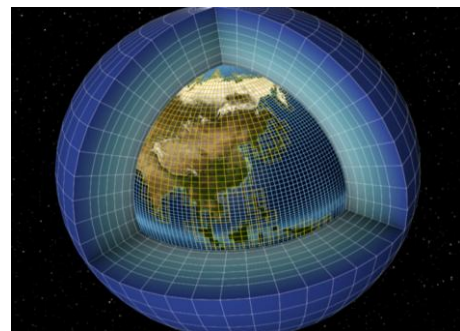


Infrastructure strategy for ENES for 2012-2022

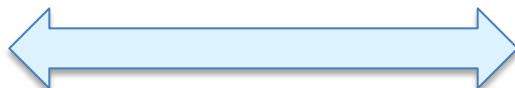
Writing team:

J. Mitchell, R. Budich, S. Joussaume, B. Lawrence & J. Marotzke

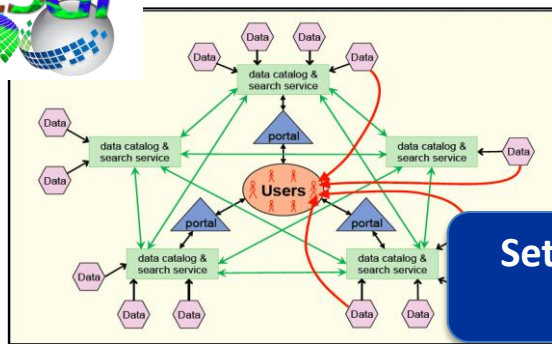
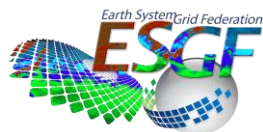
52 contributors from BE, CZ, DE, DK, FI, FR, IT, NO, SE, SP, UK



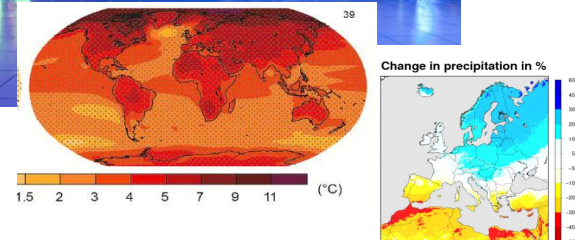
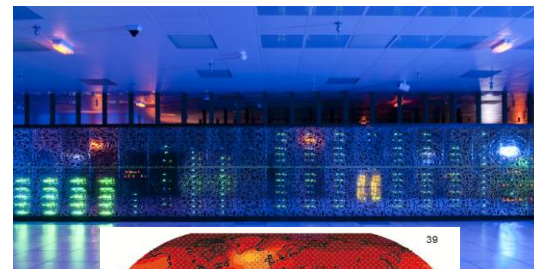
Develop next-generation of climate models



Strengthen european expertise and networking



Access world-class computers



Improve physical network

Set up data infrastructure for Large range of users

Impact research

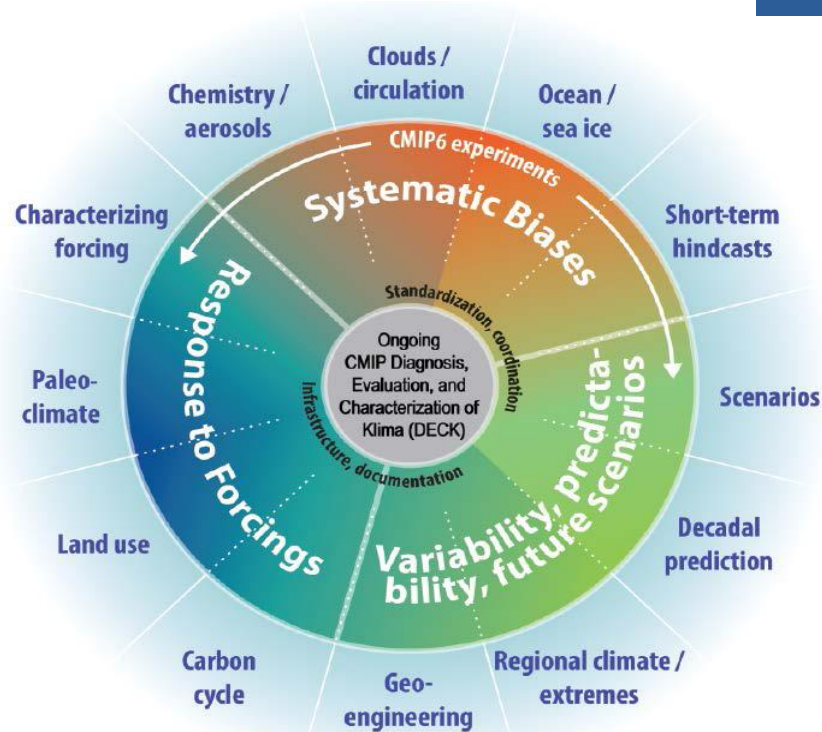
Climate Services

HPC and CMIP6

Coupled Model Intercomparison Project Phase 6 2015-2020



Numbers
TBC

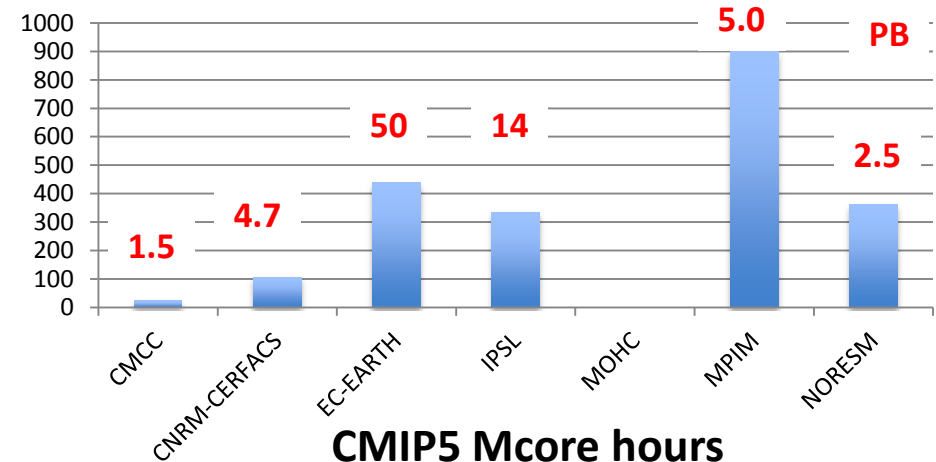


Meehl et al., EOS, 2014

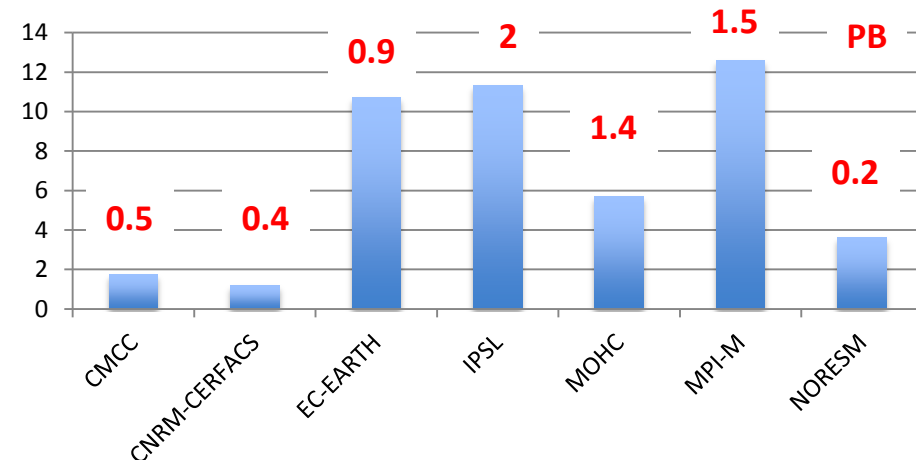
Europe

7 modelling groups of CMIP5
At least

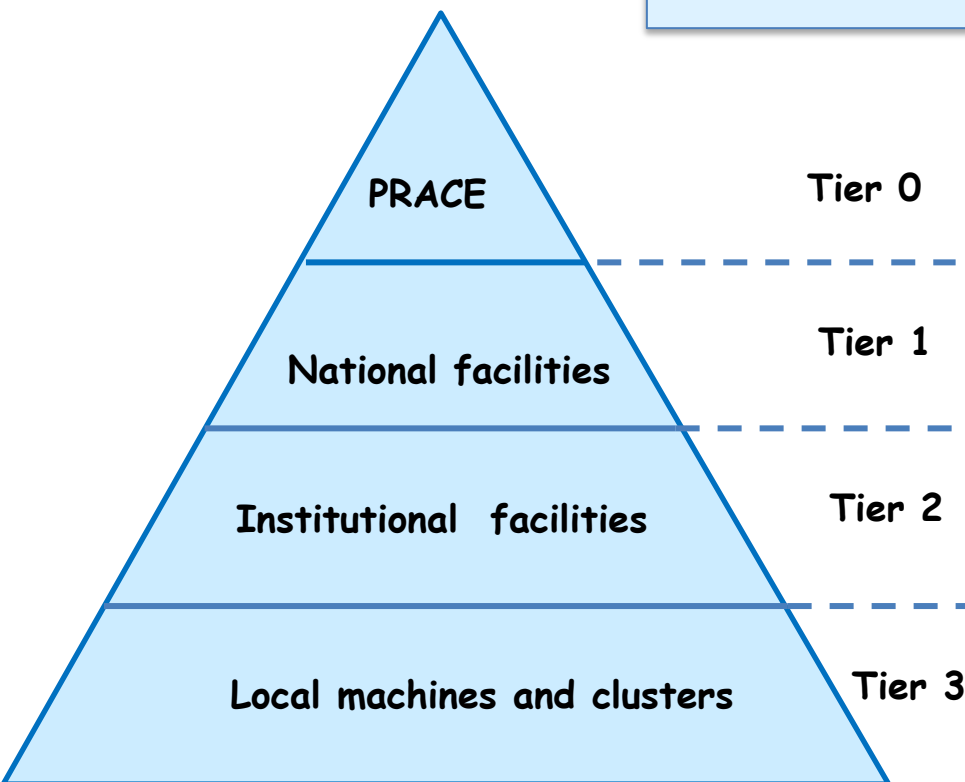
CMIP6 Mcore hours (est. 01/2015)



CMIP5 Mcore hours



HPC for climate modelling in Europe



Shared
« best science »

Dedicated
DKRZ, UKMet, CMCC, Meteo France
Some shared
IPSL, UK Univ, KNMI

Projects on Tier0 machines:

- UPSCALE	Pier Luigi Vidale (UK)	Hermit
- PULSATION	Sébastien Masson (FR)	Curie
- HIRESCLIM	Colin Jones (SE)	MareNostrum3
- SPRUCE	Eric Maisonnave (FR)	Curie

PRACE operations after 4 years

> 15 Pflop/s provided

**8 BILLION CORE HOURS
awarded since 2010**

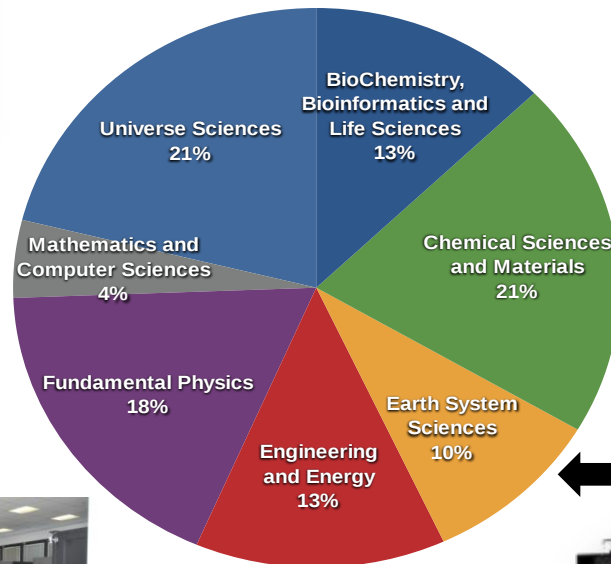
MareNostrum: IBM
BSC
Barcelona, Spain



JUQUEEN : IBM BlueGene/Q
GAUSS/FZJ
(Forschungszentrum)
Jülich, Germany



SuperMUC: IBM
GAUSS/LRZ (Leibniz-
Rechenzentrum)
Garching, Germany



**Earth system
Sciences
10%**



CURIE : Bull Bullx
GENCI/CEA
Bruyères-le-Châtel,
France



FERMI: IBM BlueGene/Q
CINECA
Bologna, Italy



HERMIT : Cray
GAUSS/HLRS (High Performance Computing
Center Stuttgart)
Stuttgart, Germany

CMIP6
2015-2020

Multi model
Global 25 km

HiresClim
PRIMAVERA

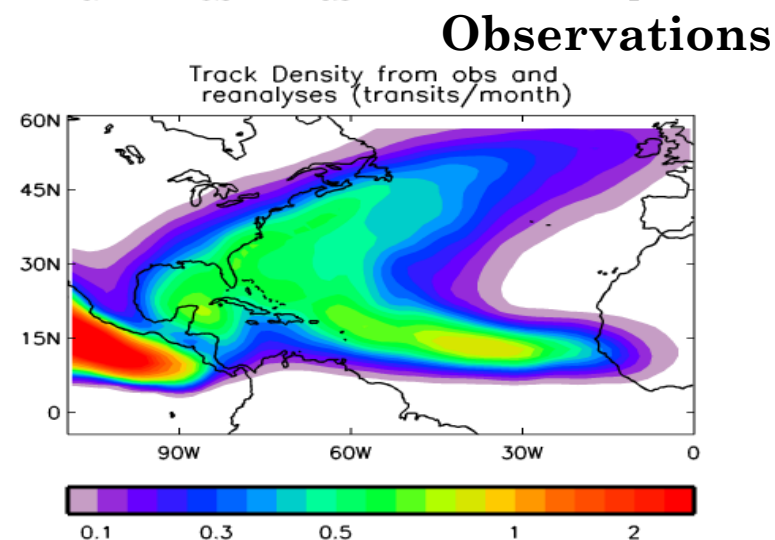
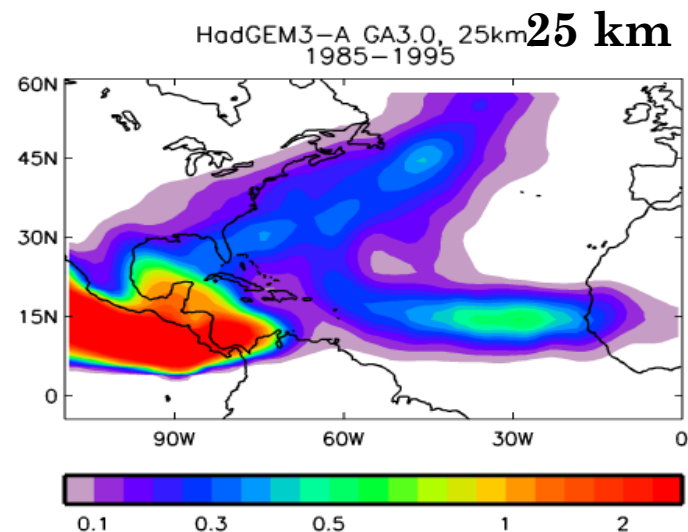
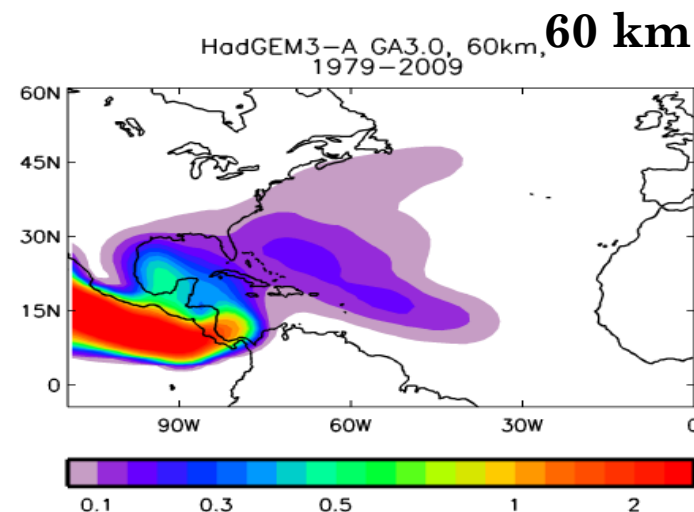
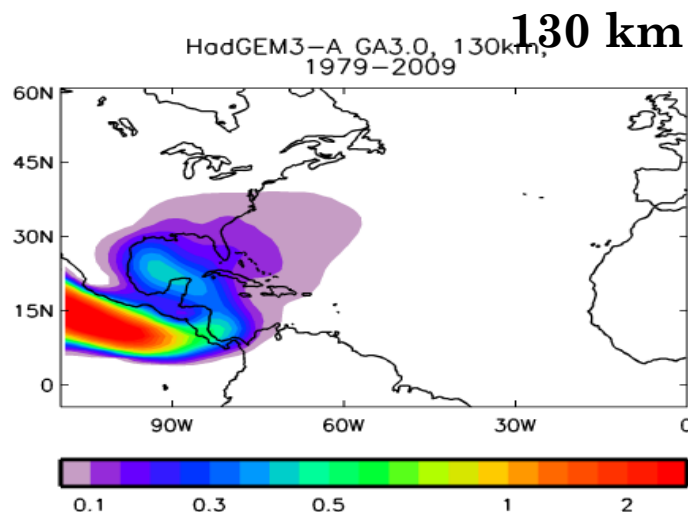
Challenge
For HPC

PRACE 2 ?

*HADGEM3
PRACE UPSCALE
PL Vidale (NCAS)
M. Roberts (MO/HC)*

Increasing spatial resolution:
an important step to represent extreme events

Impact on simulated tropical cyclones



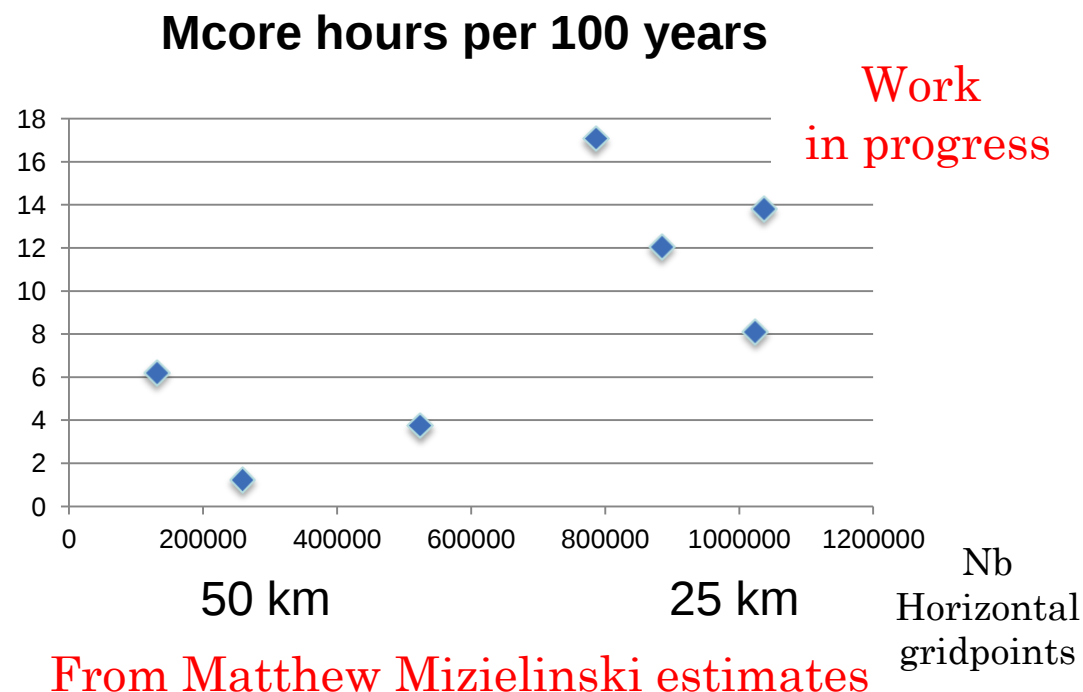
PRACE for CMIP6

Work with ENES HPC Task Force

- **High-end experiments on Tier 0**
HiResClim (PL Vidale) and
possibly DCPD (F. Doblas-Reyes) at high resolution
- **Specific needs:** large multi-year project / large storage /
 stability of architectures / types of architectures

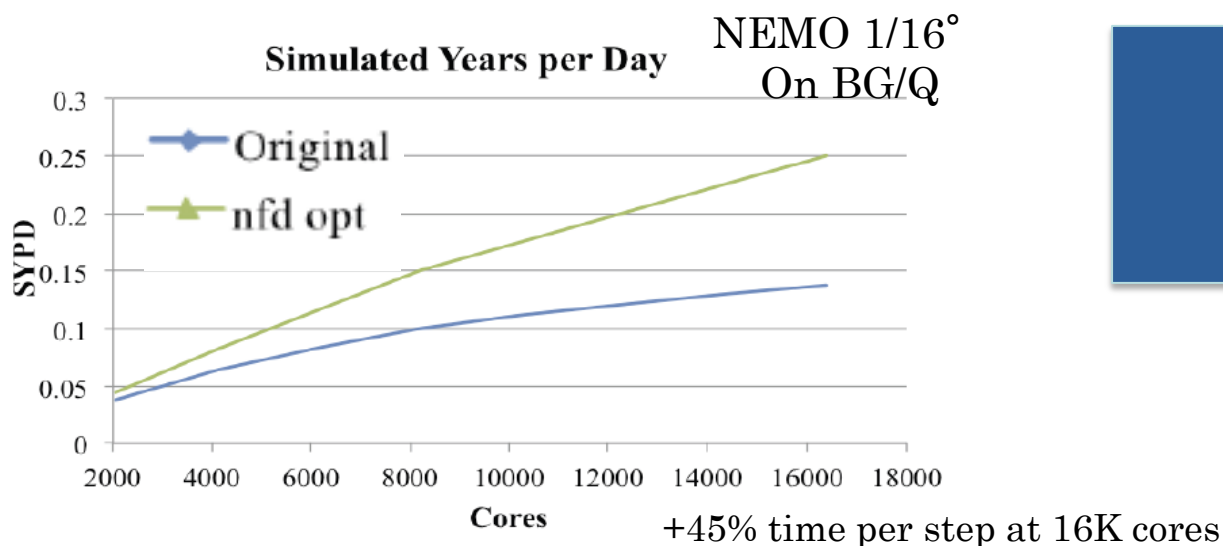
First estimate
 1000 Mcore hours over 2016-
 2018
 Storage ca 5 PB

HiResClim (PRIMAVERA)
 ca 700 Mcore hour
 6-7 PB
 Preliminary estimates



Improving HPC performance
& Preparing the future

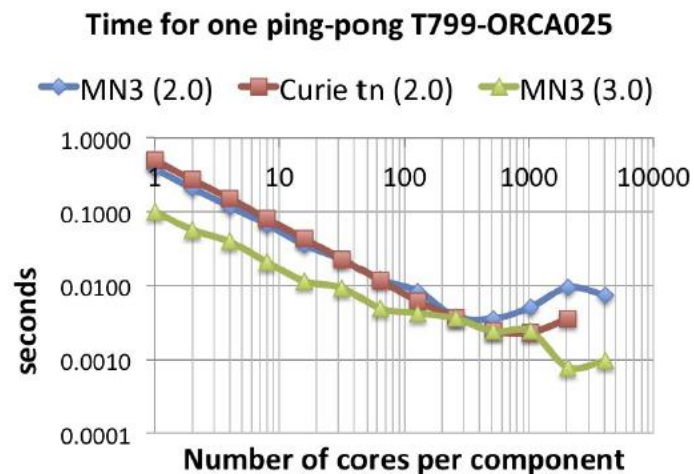
Scalability performance



NEMO performance
Kernel analyses
G. Aloisio et al.

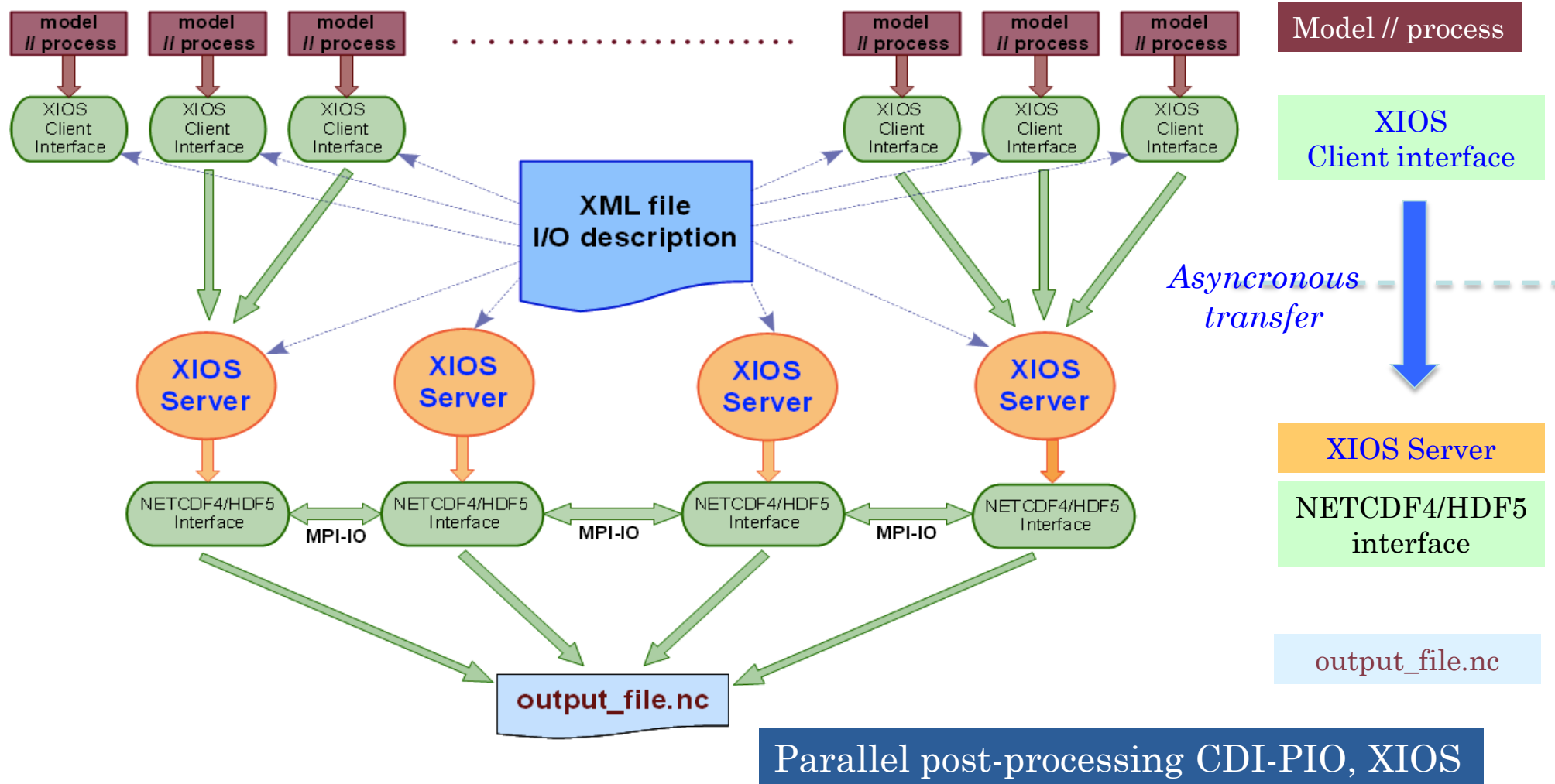
Nfd: north pole folding

Coupler OASIS
Parallelised version
OASIS3-MCT
S. Valcke et al.



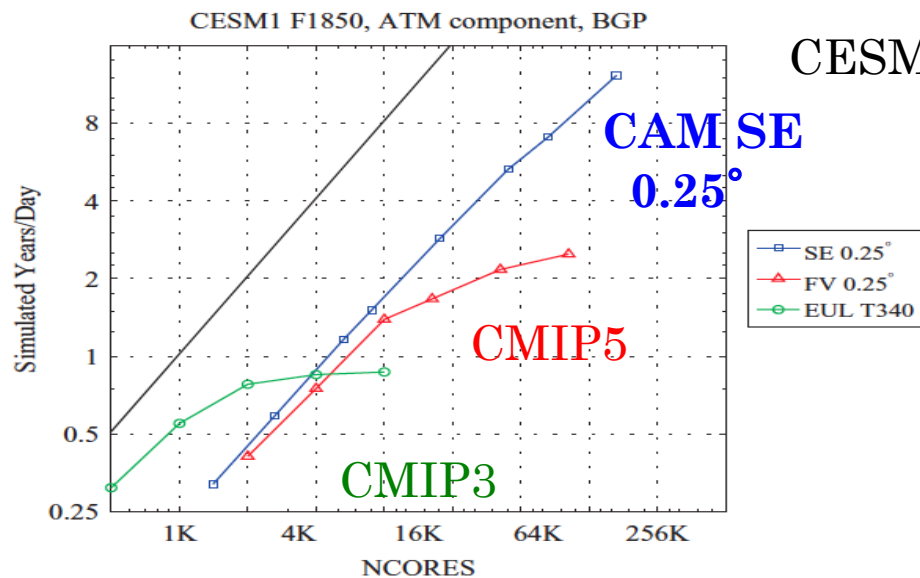
Implemented first in NEMO, now in more codes

XIOS *Y. Meurdesoif (IPSL)*



Model performance: Need to revisit dynamical cores

Cubed-sphere
(CAM-SE)



CESM1, 0.25° , BGP

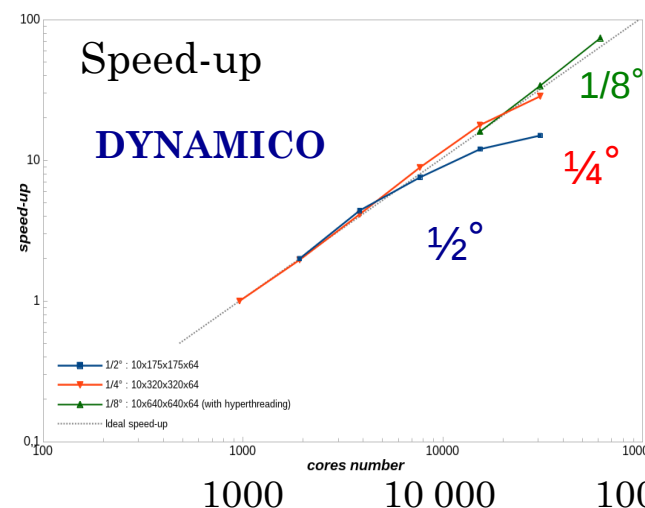
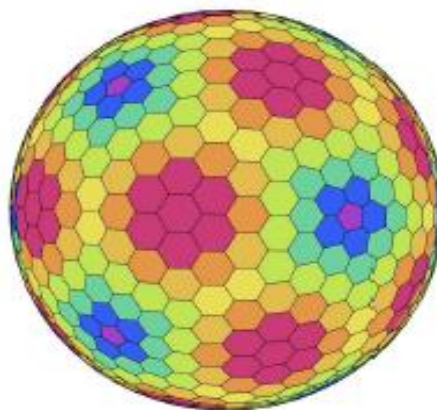
CAM SE
0.25°

CMIP5

CMIP3

*Collaboration NCAR-Sandia,
Dennis et al. (IJ HPC appl, 2012)*

Europe: 3 projects
ICON (DE)
DYNAMICO (FR)
LFRIC (UK)



At 1/4°
15 SYPD
40 000
cores

Court. T. Dubos et Y. Meurdesoif (IPSL)

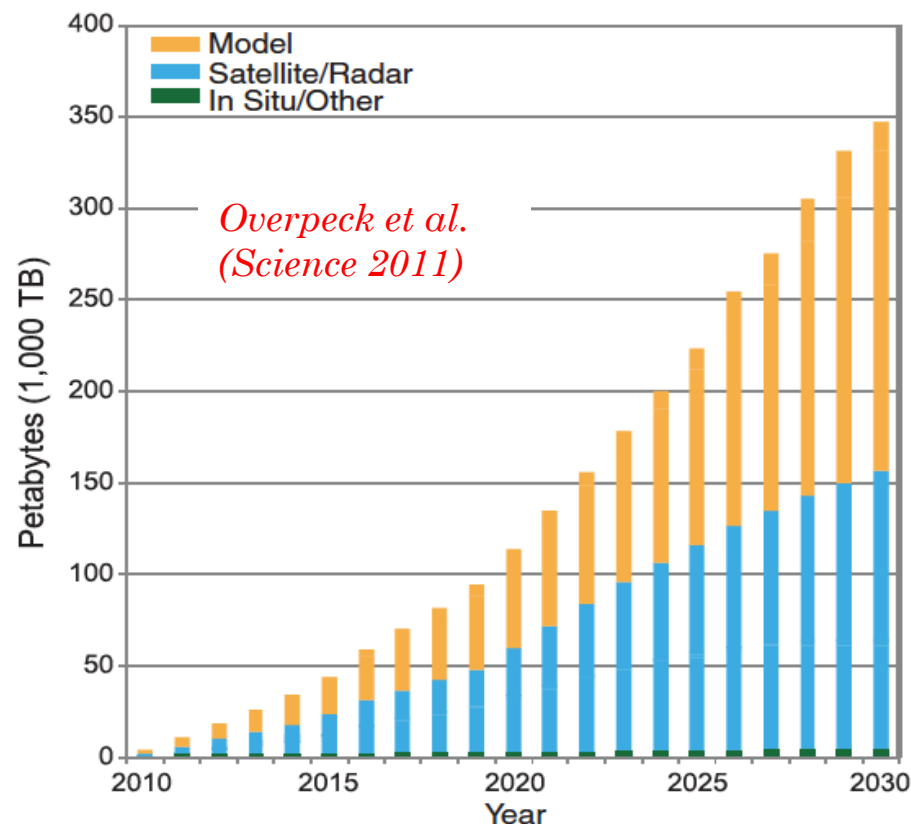
Nb of cores

Data challenge :

Exabyte even more challenging
than Exaflops

Different levels

I/O servers (XIOS, CDI-IO);
Compression; Storage;
Post-processing;
Distributed archive & compute
(ESGF)



G8 ExArch project

Climate analytics on distributed exascale data archives

Centre of
Excellence in **S**imulation of **W**eather and **C**limate in **E**urope

Serving the community

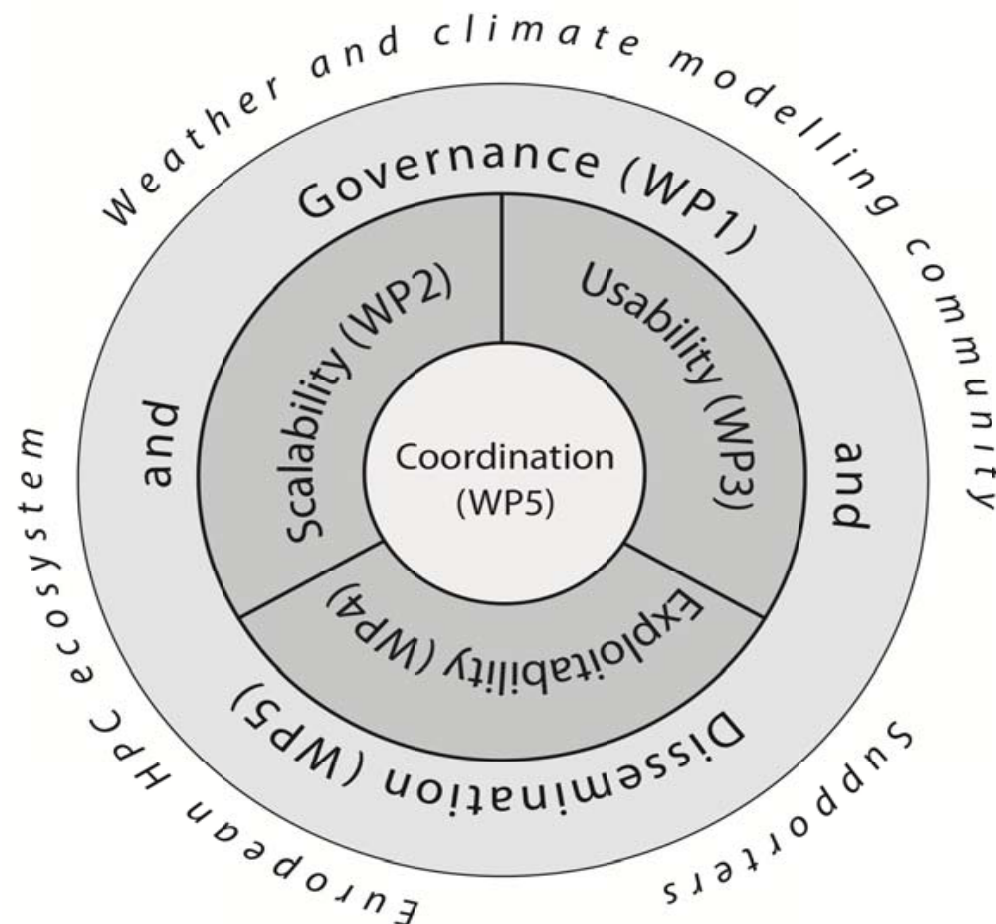
HPC : Interface with
Industry (ETP4HPC) &
Facilities (PRACE)

Scalability & performance

Usability: workflow SW

Exploitability:
data & storage

09/2015 – 48 months



DKRZ, ECMWF, CNRS-IPSL, MPG, CERFACS, BSC, STFC, MetO, UREAD, SMHI, ICHEC, CMCC
BULL, SEAGATE, ALLINEA

CliM-ERI

Earth's CLImate system Modelling

European Research Infrastructure

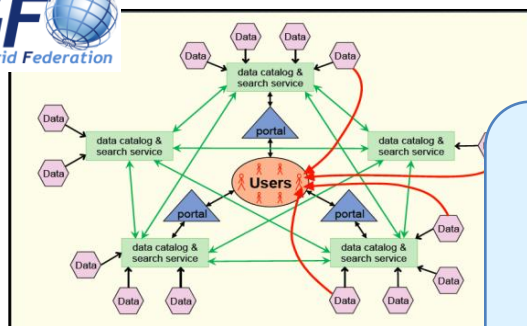
ESFRI 2018 ?



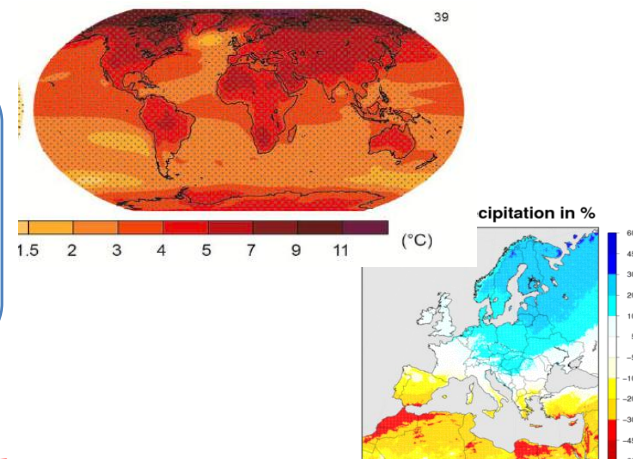
Climate models
Environment software tools
ESM ca 1000 man years

High-performance computers
& storage facilities

ESGF
Earth System Grid Federation



Data & metadata
Standards
Distributed database ESGF
10 000 registered users worldwide
Open access



Climate research & Impact research
Climate services

From IS-ENES (2009-2017) – opportunity for IS-ENES3 in WP 2018

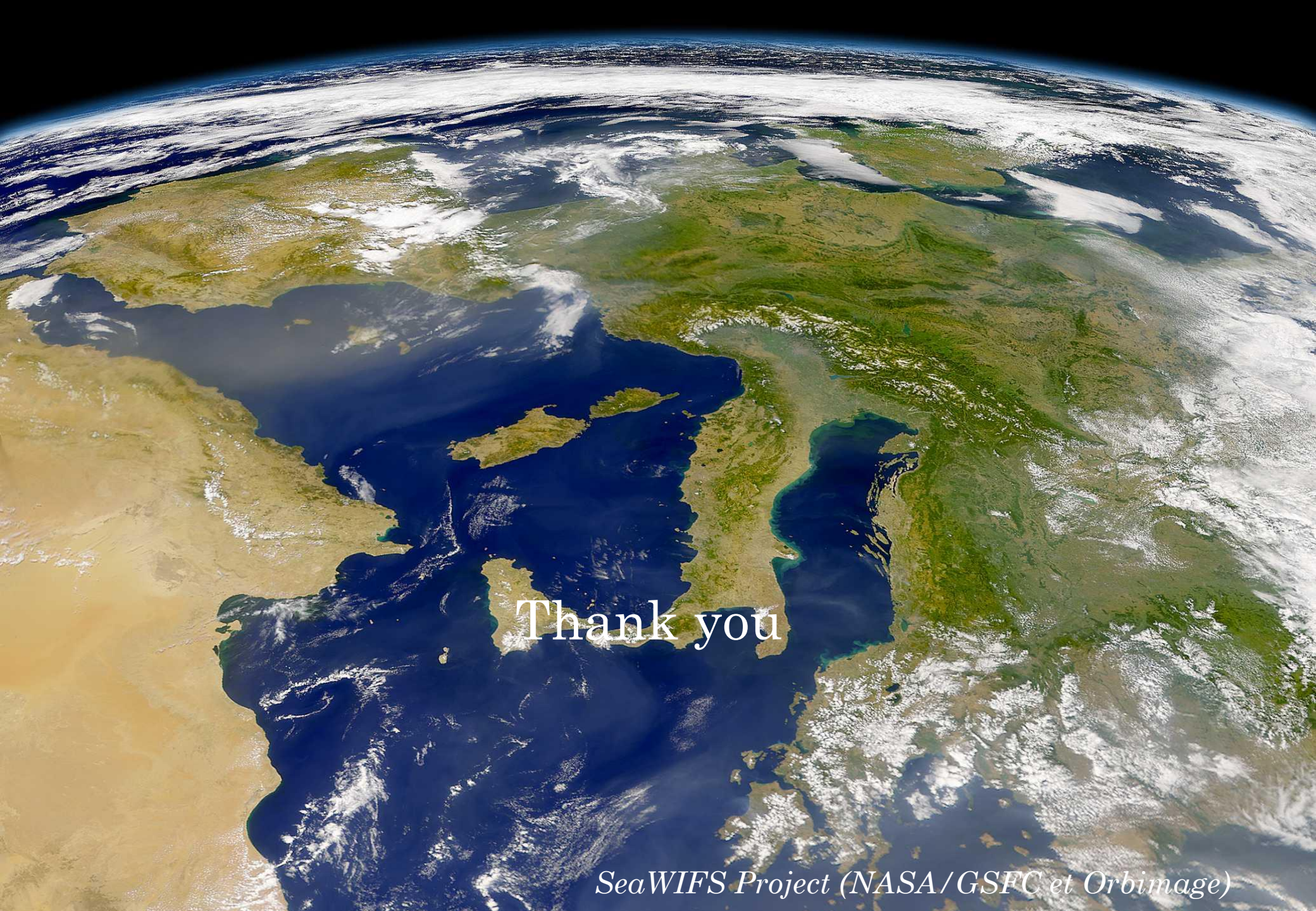
Towards a sustained research infrastructure

Support WCRP international simulations & Sharing of software

➤ 33 M€/yr (9 countries) - Human resources & computing/storage facilities

Conclusions

- **HPC key for climate modelling, in particular WCRP CMIP**
National support – Possibly PRACE2
- **Improve performance**
Scalability, IO, coupler ...
BUT also compare performance (Collaboration with Balaji)
- **Prepare next generation of climate models for future architectures**
Dynamical cores, data ...
but also need better adaptability to future architectures
- **Important to share developments & expertise**
EC support to RI: IS-ENES (1, 2), 3 ?
Center of Excellence dedicated to HPC - possible longer-term support
- **Towards a sustained European infrastructure for climate modelling**
National and European support to CMIP



Thank you

SeaWiFS Project (NASA/GSFC et Orbimage)