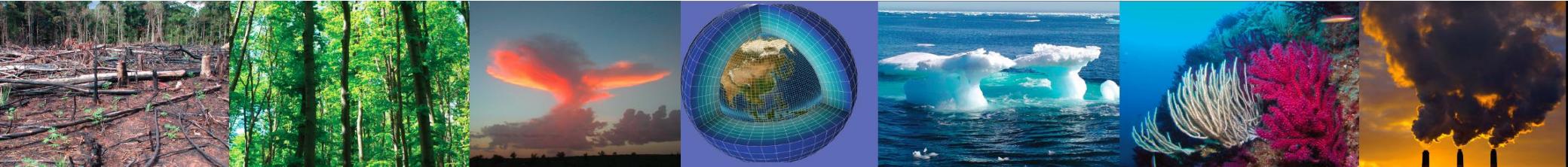
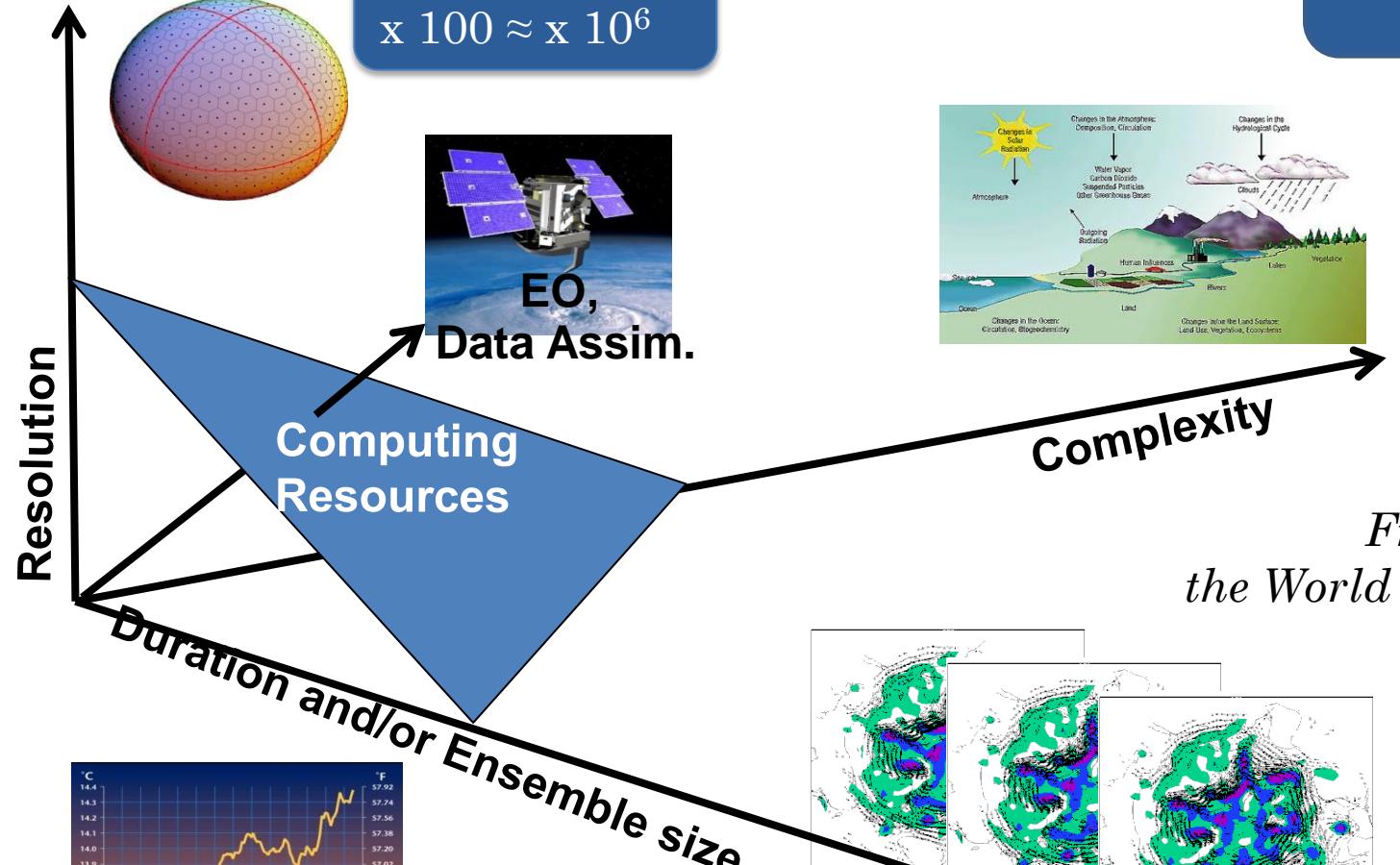


HPC for CMIP6 and beyond

Sylvie Joussaume
CNRS, IPSL

Coordinator IS-ENES2, Infrastructure for ENES





Needs for HPC

$x 5-10$

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

ensemble: $x 10$

duration: $x 10-100$

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

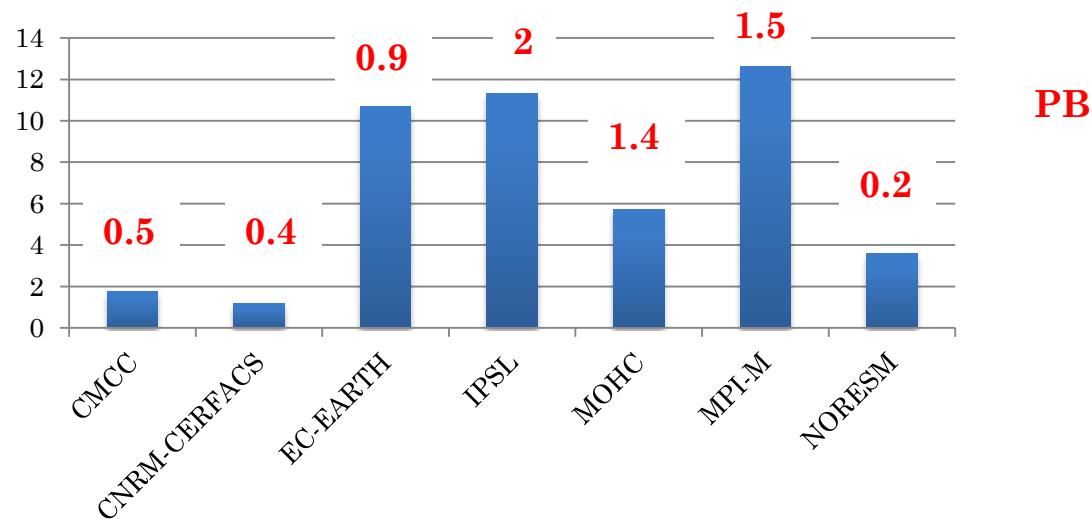
61 models



CMIP5 in Europe

7 European modelling groups
17 models

CMIP5 Mcore hours



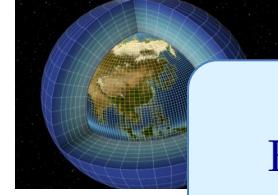
ENES HPC TF, M. Carter & M.A. Foujols

IS-ENES : Infrastructure for ENES

FP7 project « Integrating Activities »

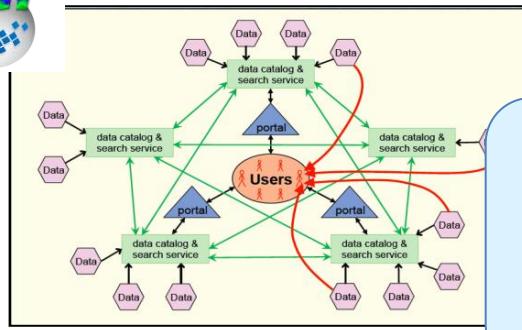
1st phase: March 2009- Feb 2013, 18 partners

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

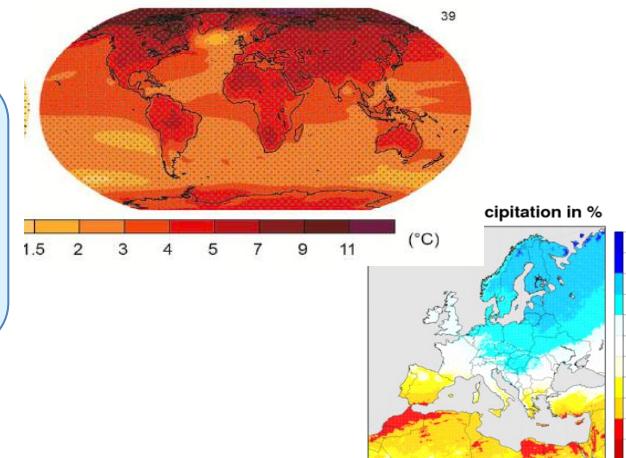


Climate models
Environment software tools
ESM ca 1000 man years

High-performance computers
& storage facilities



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



Climate research & Impact research
Climate services

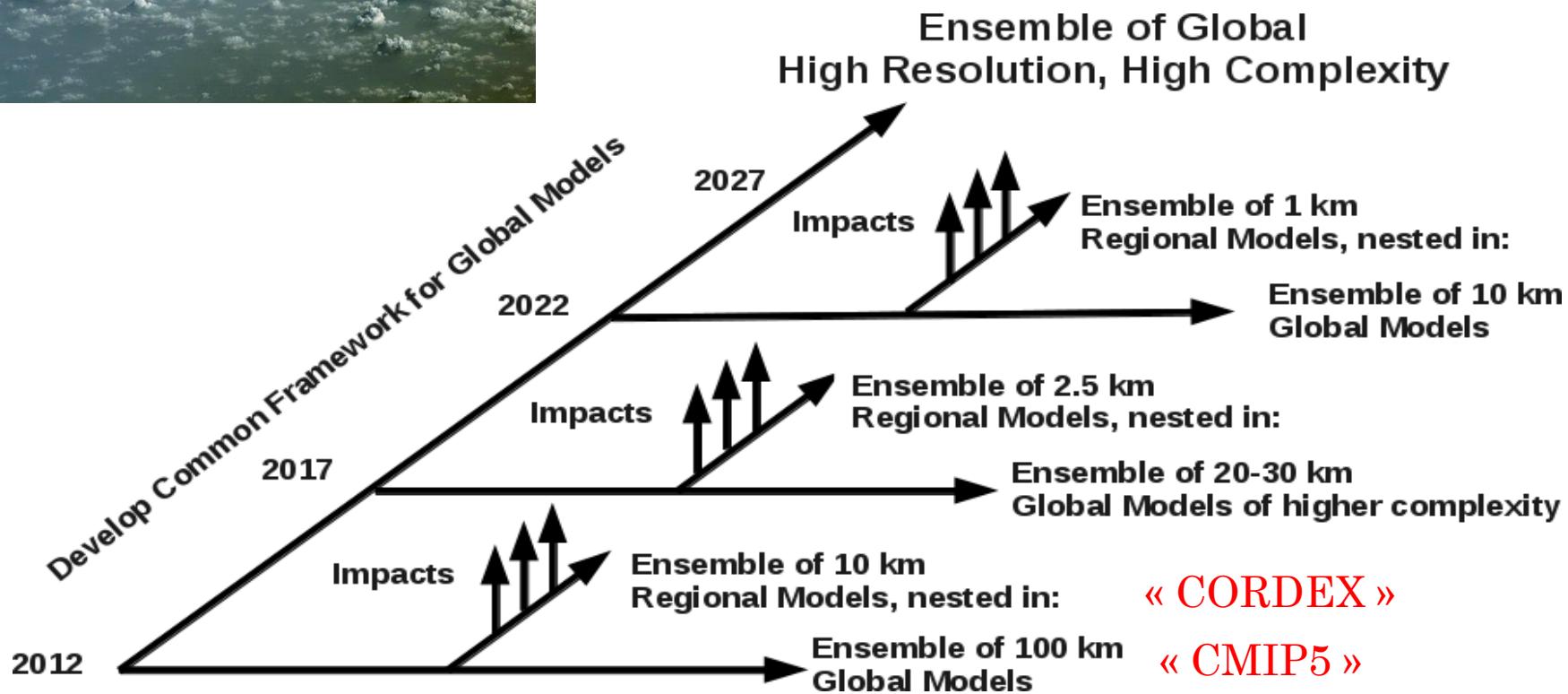
Support WCRP international experiments

Used in IPCC Assessments Reports



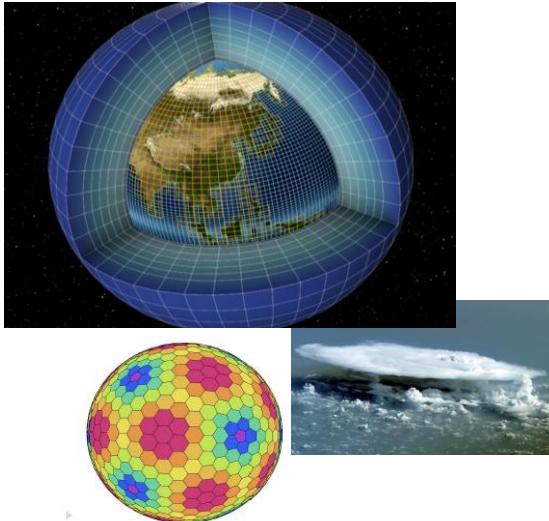
A grand challenge :

Towards ≈ 1 km scale for atmosphere
resolving deep convective clouds
in global climate models



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



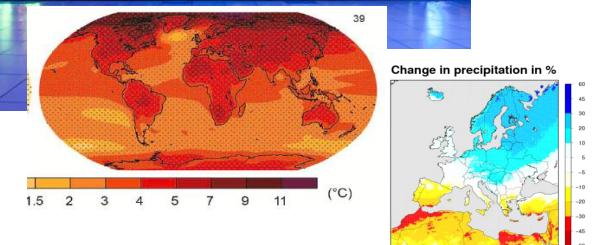
Develop next-generation of climate models

Strengthen european expertise and networking



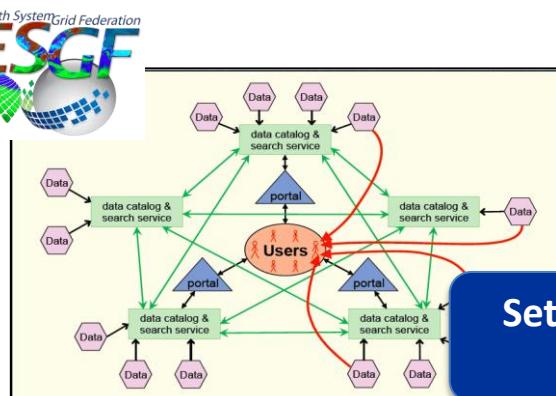
is-enes
INFRASTRUCTURE FOR THE EUROPEAN NETWORK
FOR EARTH SYSTEM MODELLING

Access world-class computers



Improve physical network

Set up data infrastructure for Large range of users

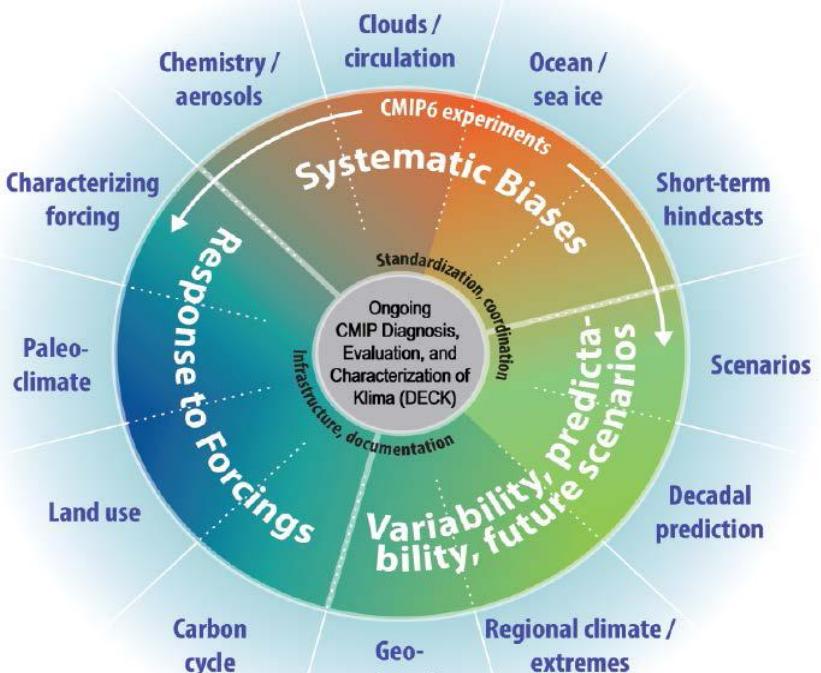


Impact research

Climate Services

HPC and CMIP6

Coupled Model Intercomparison Project Phase 6 2015-2020



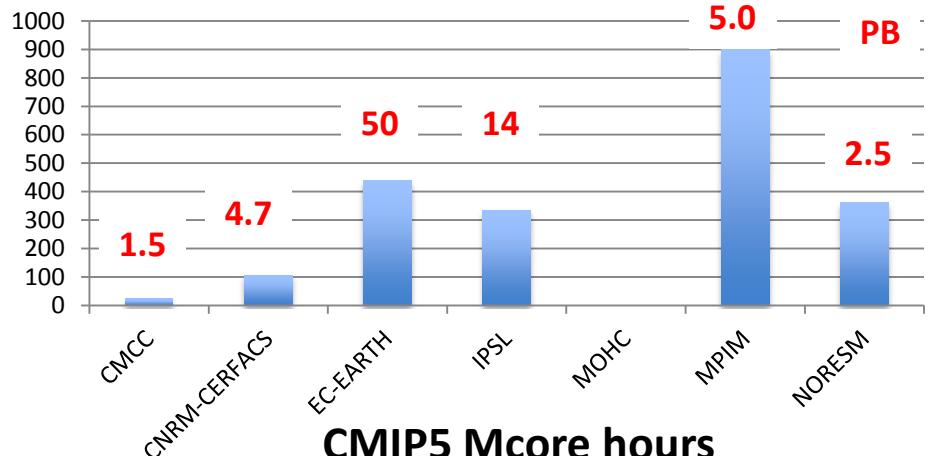
Meehl et al., EOS, 2014

Numbers
TBC

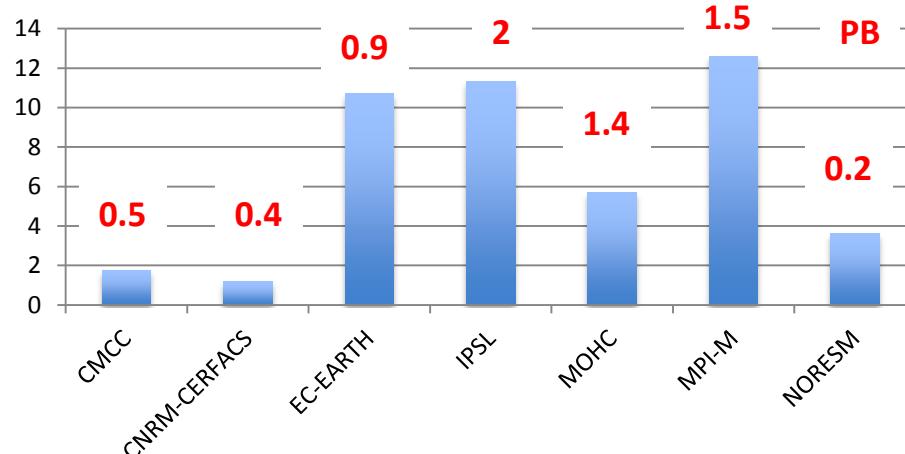
Europe

7 modelling groups of CMIP5
At least

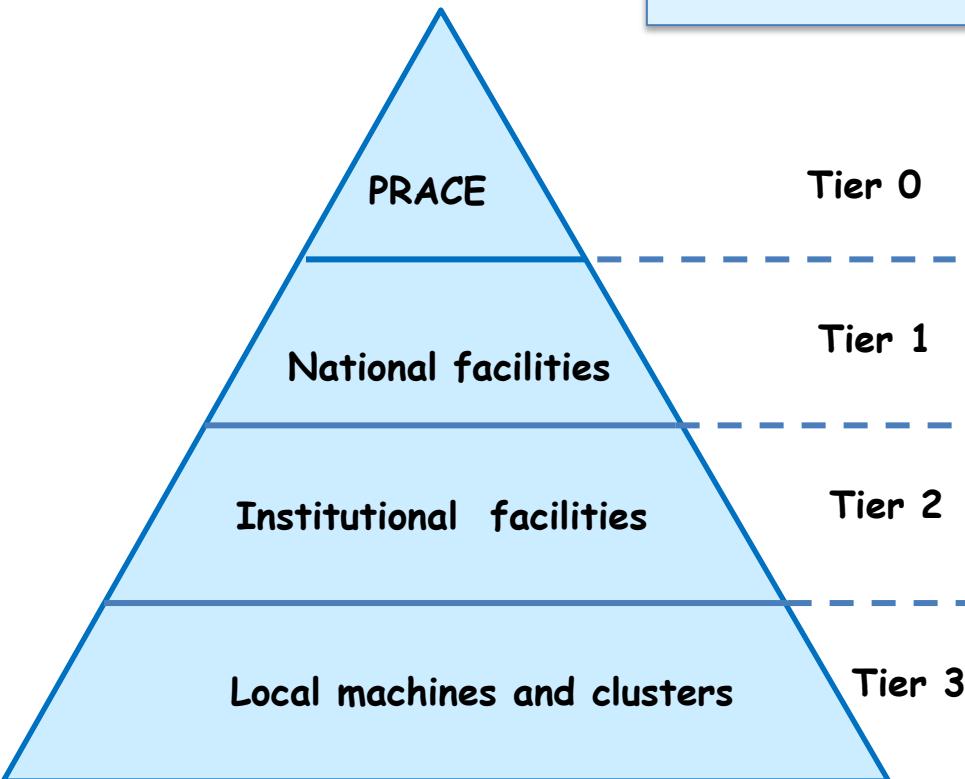
CMIP6 Mcore hours (est. 01/2015)



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
- PULSATION
- HIRESCLIM
- SPRUCE

Pier Luigi Vidale (UK)	Sébastien Masson (FR)
Colin Jones (SE)	Eric Maisonnave (FR)

Hermit	
Curie	
MareNostrum3	
Curie	

PRACE operations after 4 years

MareNostrum: IBM
BSC
Barcelona, Spain



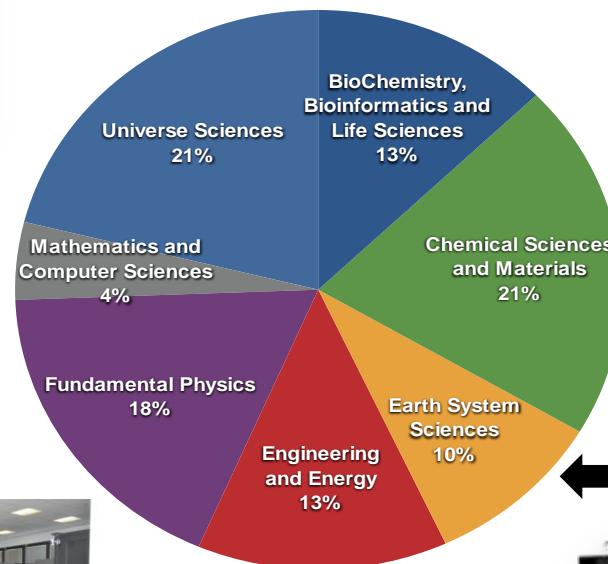
CURIE : Bull Bullx
GENCI/CEA
Bruyères-le-Châtel,
France



FERMI: IBM BlueGene/Q
CINECA
Bologna, Italy

> 15 Pflop/s provided

8 BILLION CORE HOURS
awarded since 2010



**Earth system
Sciences**
10%



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



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



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

CMIP6
2015-2020

Multi model
Global 25 km

HiresClim
PRIMAVERA

Challenge
For HPC

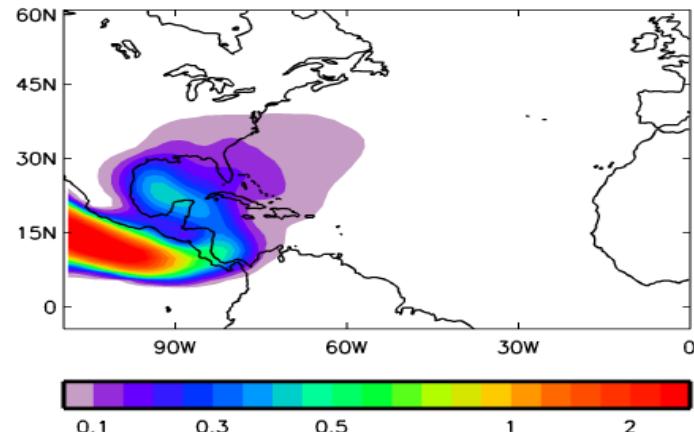
PRACE 2 ?

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

Increasing spatial resolution: an important step to represent extreme events

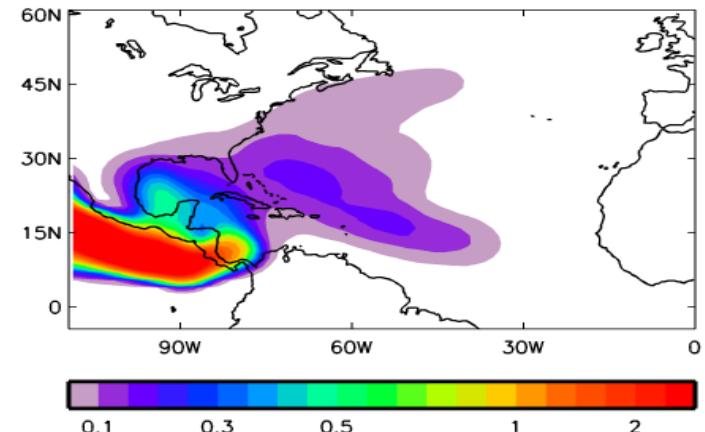
Impact on simulated tropical cyclones

HadGEM3-A GA3.0, 130km,
1979–2009



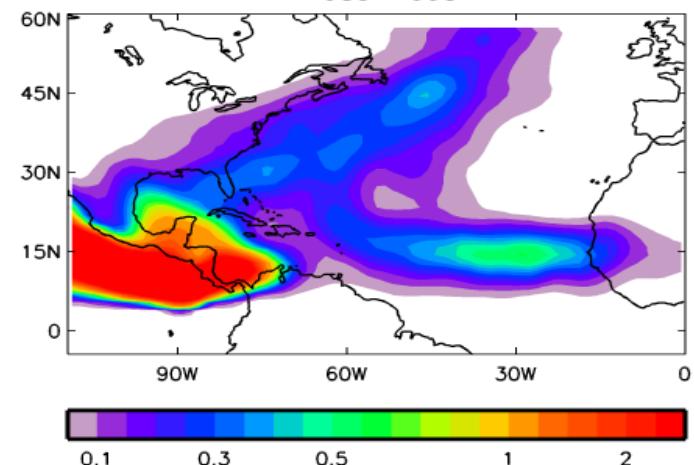
130 km

HadGEM3-A GA3.0, 60km,
1979–2009



60 km

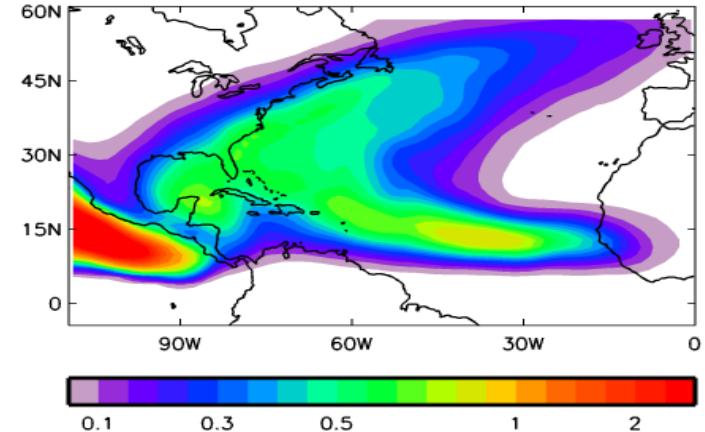
HadGEM3-A GA3.0, 25km
1985–1995



25 km

Observations

Track Density from obs and
reanalyses (transits/month)



PRACE for CMIP6

Work with ENES HPC Task Force

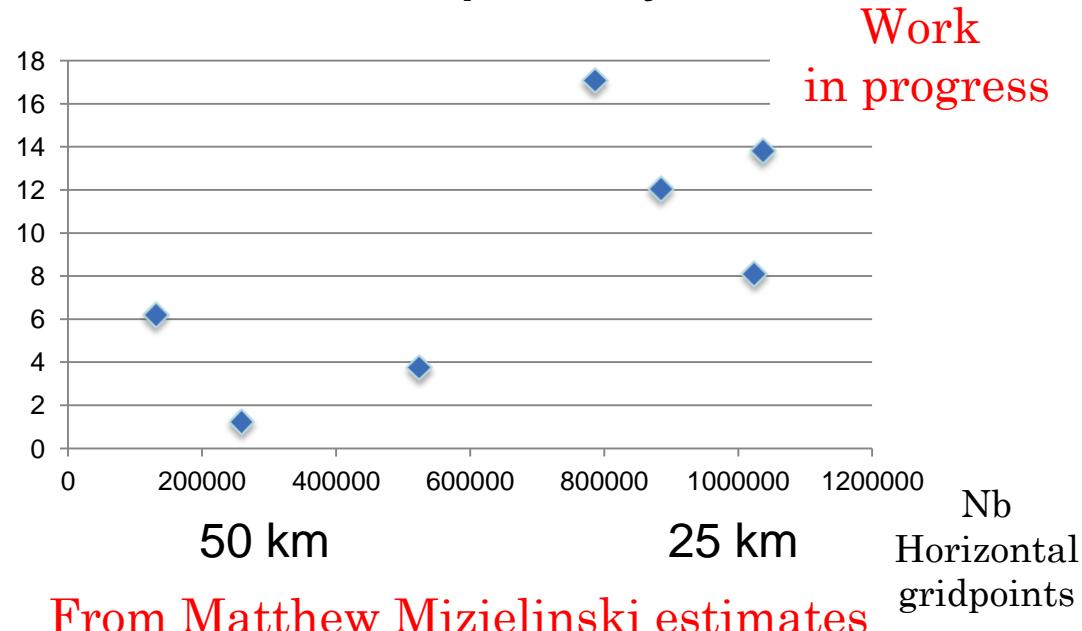


- **High-end experiments on Tier 0**
 HiResClim (PL Vidale) and
 possibly DCPP (F. Doblas-Reyes) at high resolution
- **Specific needs:** large multi-year project / large storage /
 stability of architectures / types of architectures

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

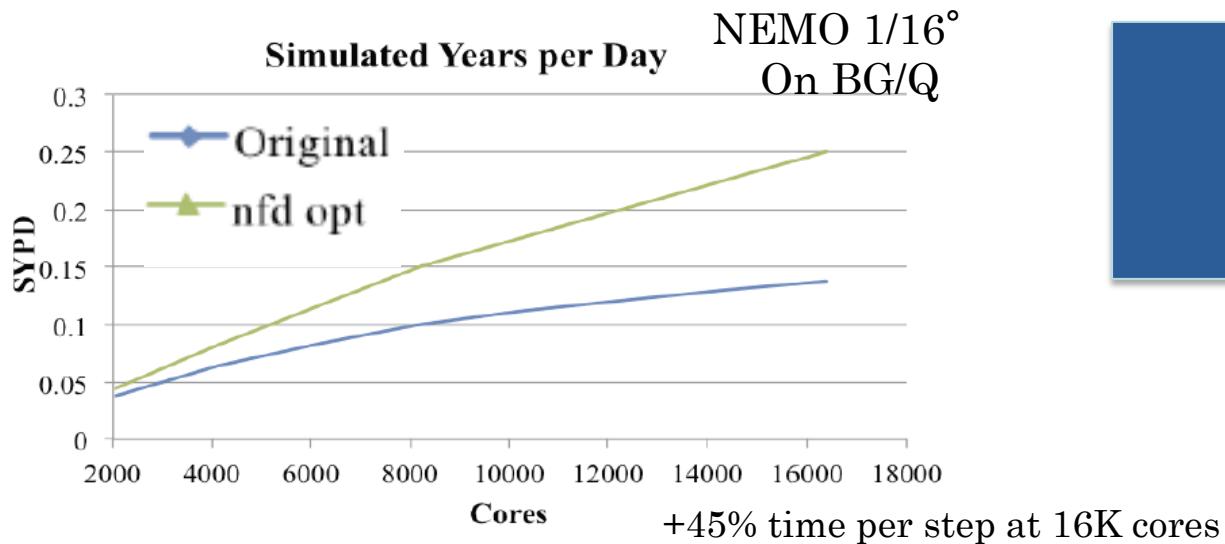
HiResClim (PRIMAVERA)
 ca 700 Mcore hour
 6-7 PB
 Preliminary estimates

Mcore hours per 100 years



Improving HPC performance
& Preparing the future

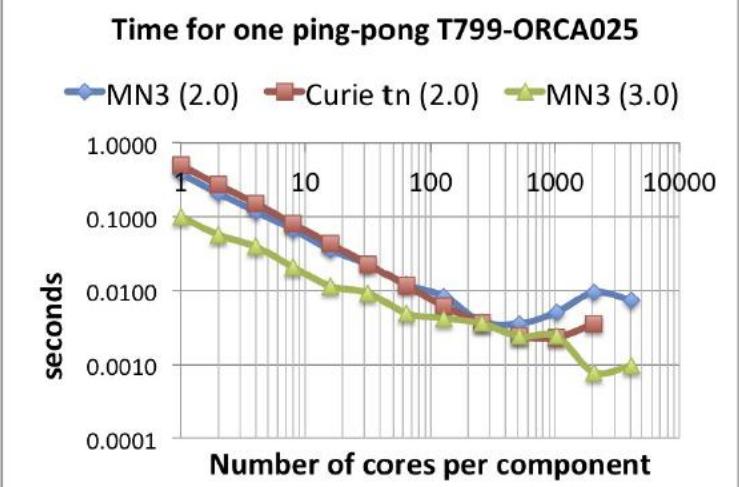
Scalability performance



NEMO performance
 Kernel analyses
 G. Aloisio et al.

Nfd: north pole folding

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

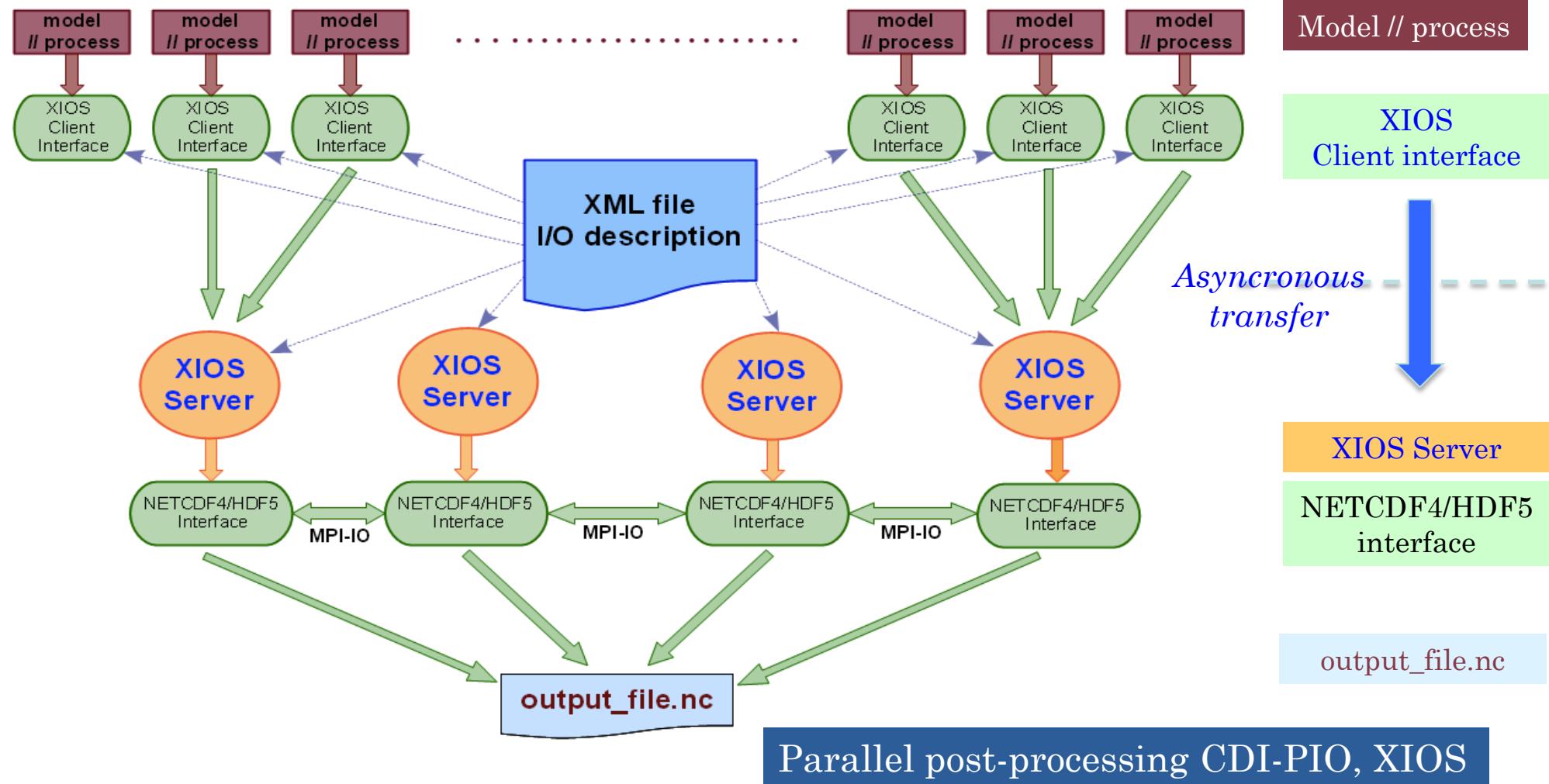


Parallel IO server



XIOS *Y. Meurdesoif (IPSL)*

Implemented first in NEMO, now in more codes



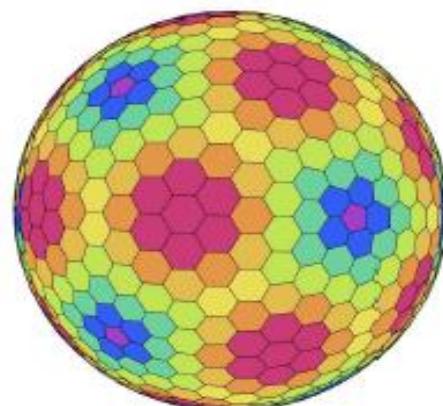
Model performance: Need to revisit dynamical cores

Cubed-sphere
(CAM-SE)

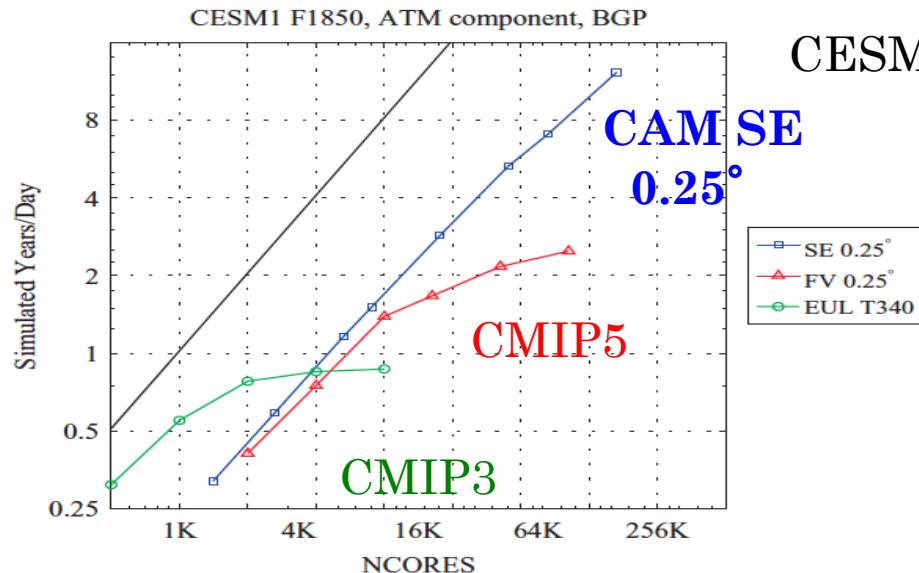


*Collaboration NCAR-Sandia,
Dennis et al. (IJ HPC appl, 2012)*

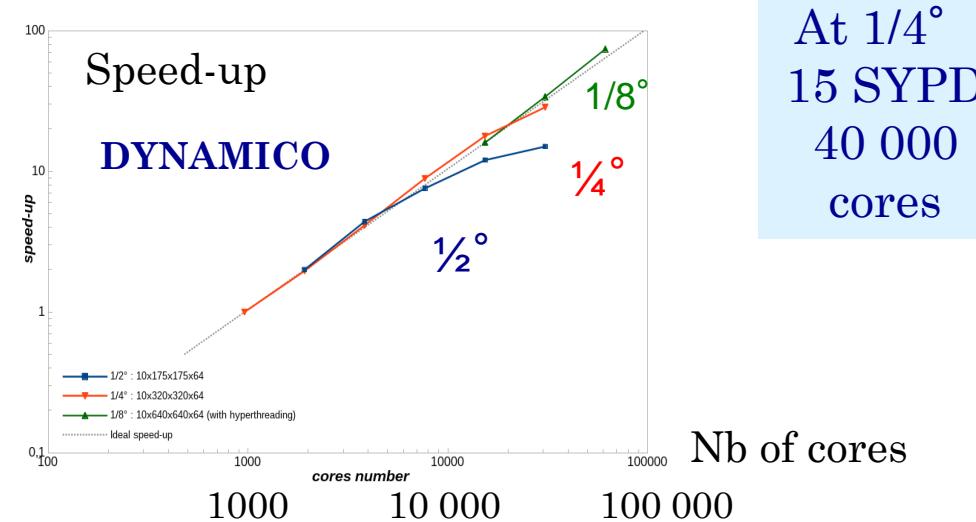
Europe: 3 projects
ICON (DE)
DYNAMICO (FR)
LFRIC (UK)



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



CESM1, 0.25° , BGP

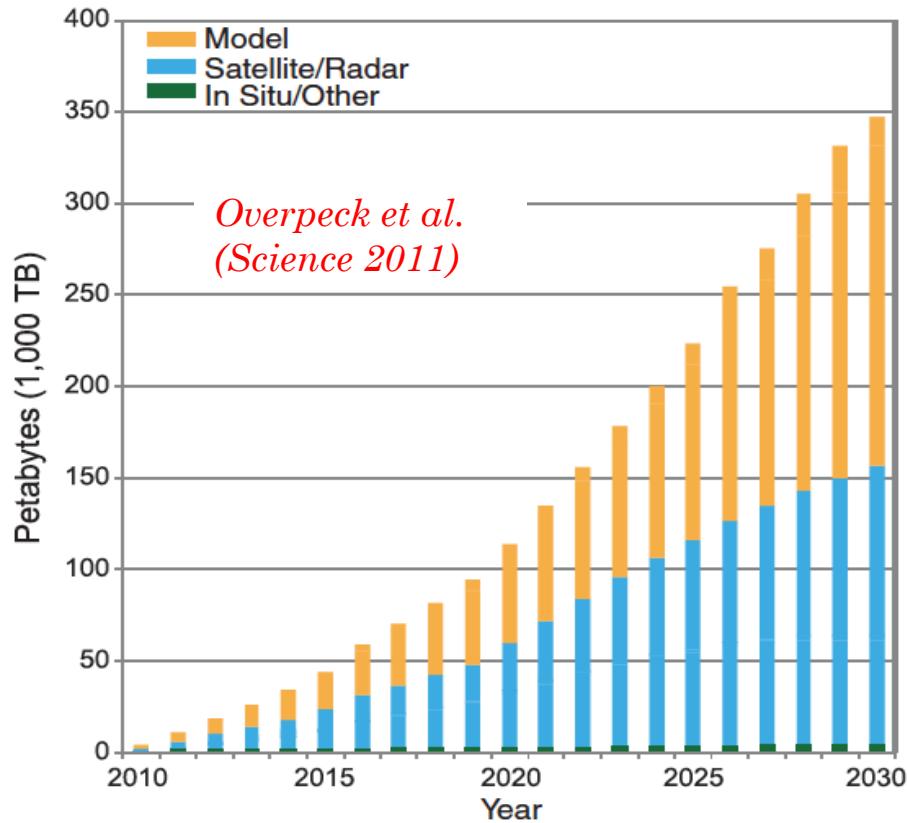


Data challenge :

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 **Simulation of Weather and Climate in Europe**

Serving the community

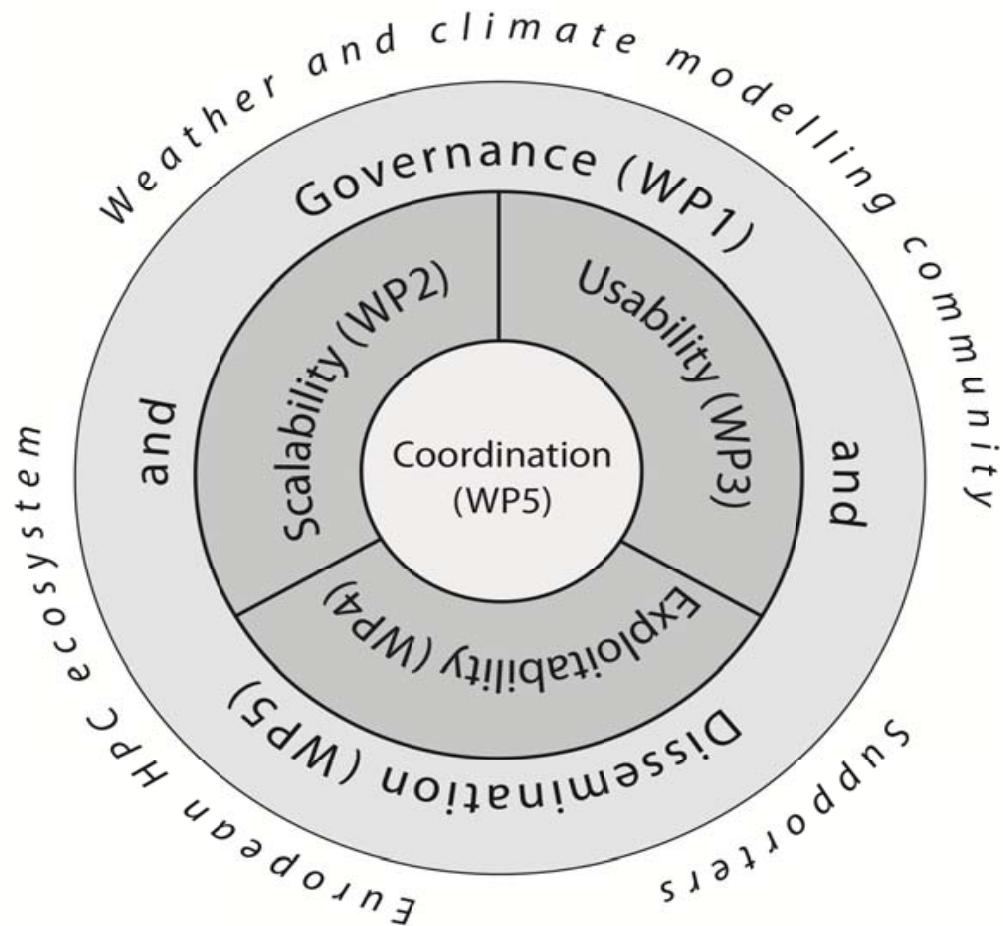
HPC : Interface with
Industry (ETP4HPC) &
Facilities (PRACE)

Scalability & performance

Usability: workflow SW

Exploitability:
data & storage

09/2015 – 48 months



CliM-ERI

Earth's CLImate system Modelling European Research Infrastructure

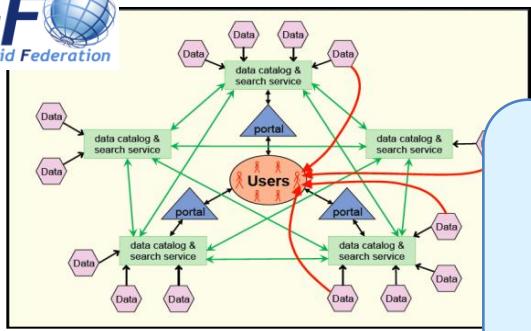
ESFRI 2018 ?



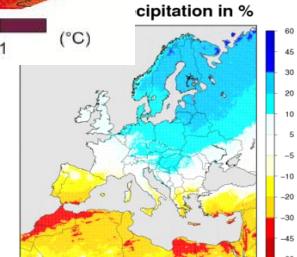
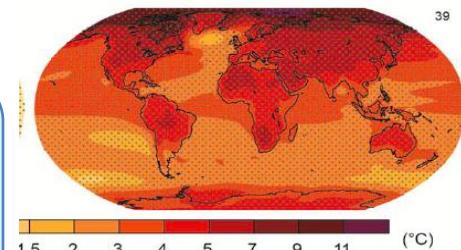
Climate models
Environment software tools
ESM ca 1000 man years

High-performance computers
& storage facilities

ESGF
Earth System Grid Federation



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



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

Climate research & Impact research
Climate services

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

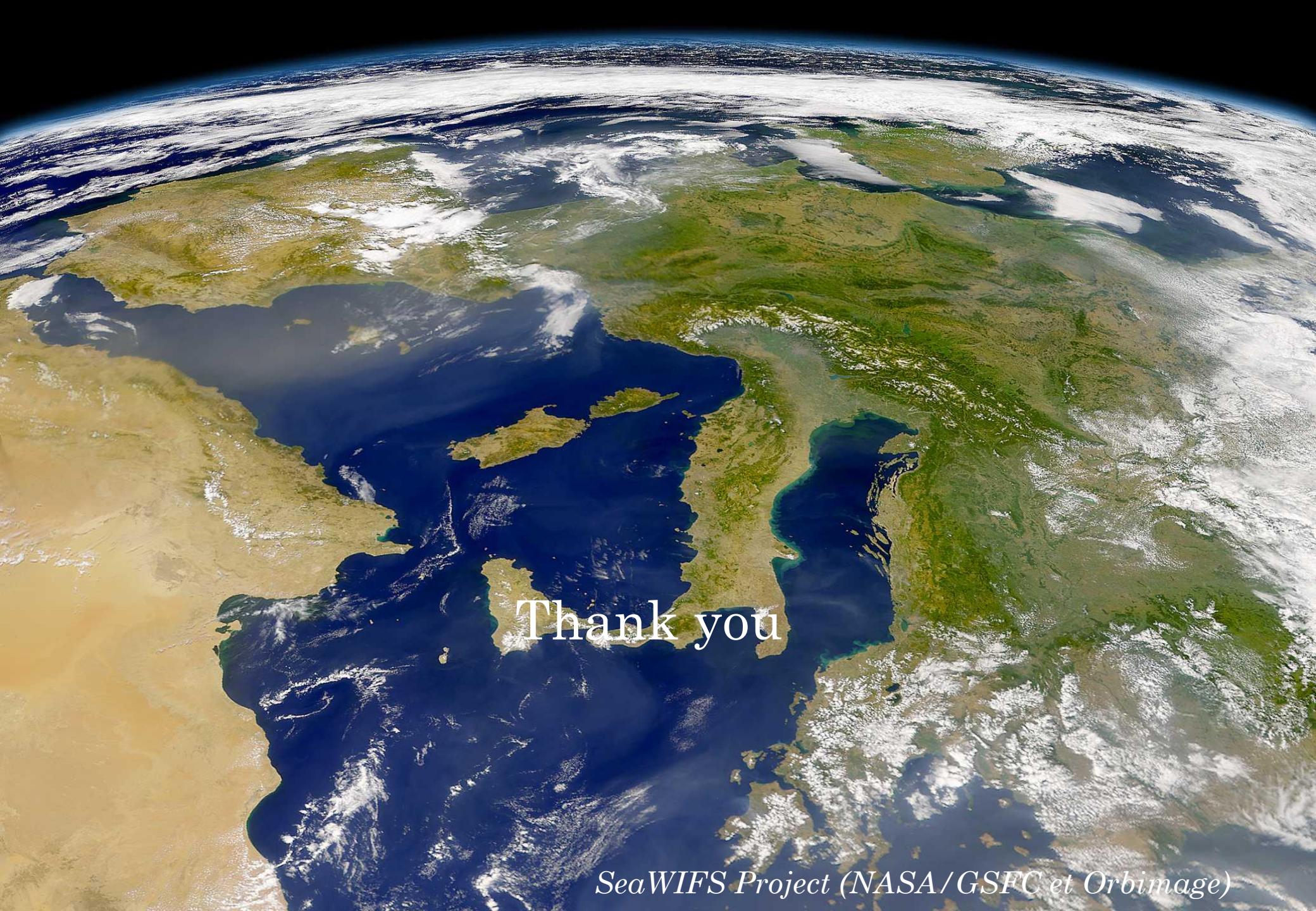
Towards a sustained research infrastructure

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)