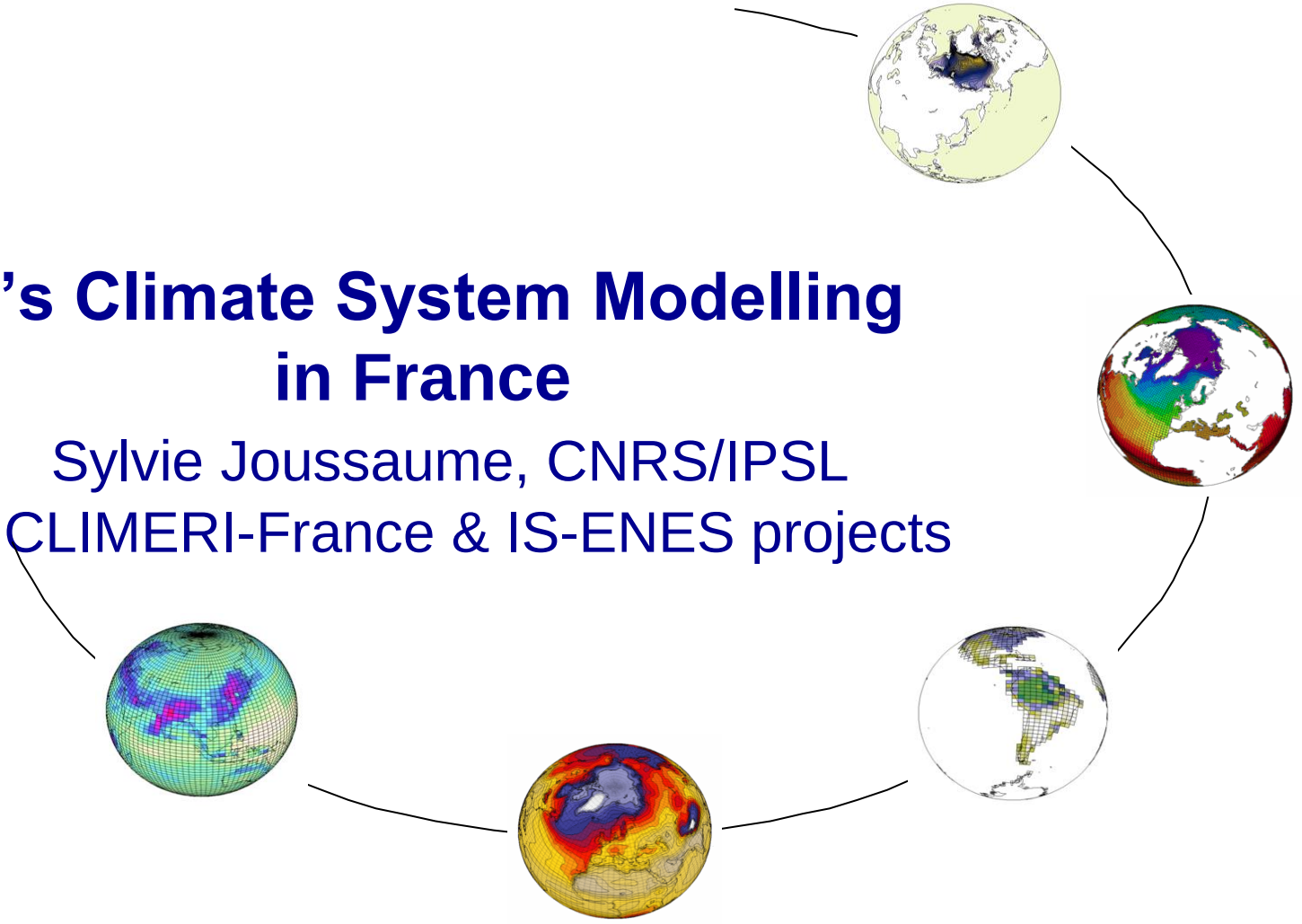
Earth's Climate System Modelling in France

Sylvie Joussaume, CNRS/IPSL
coord. CLIMERI-France & IS-ENES projects



With contributions from Olivier Boucher, Pascale Braconnot, David Salas y Melia

Earth's climate system models in France

IPSL

Paris area

CNRM-CERFACS

Toulouse area

CNRS, CEA, Sorbonne U.
(Ministry of Research)

Academic

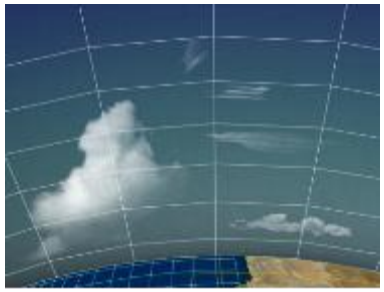
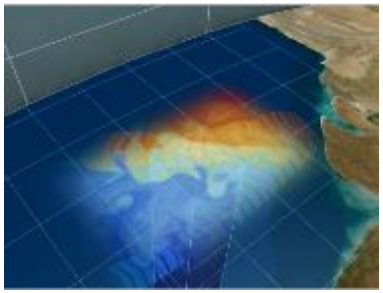
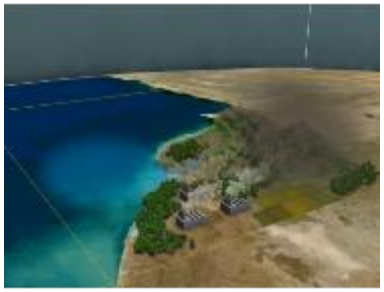
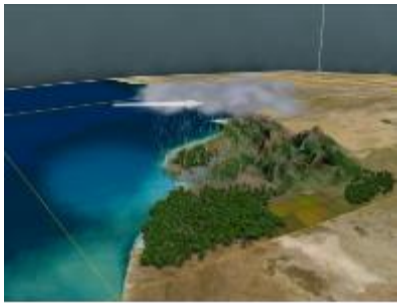
Meteo France (Min. Envt),
CNRS, CERFACS

Link with NWP

National collaboration with other laboratories
Ocean: Brest (LPO), Grenoble (IGE), Toulouse (LEGOS),
Bordeaux (EPOC)
Cryosphere: Grenoble (IGE)

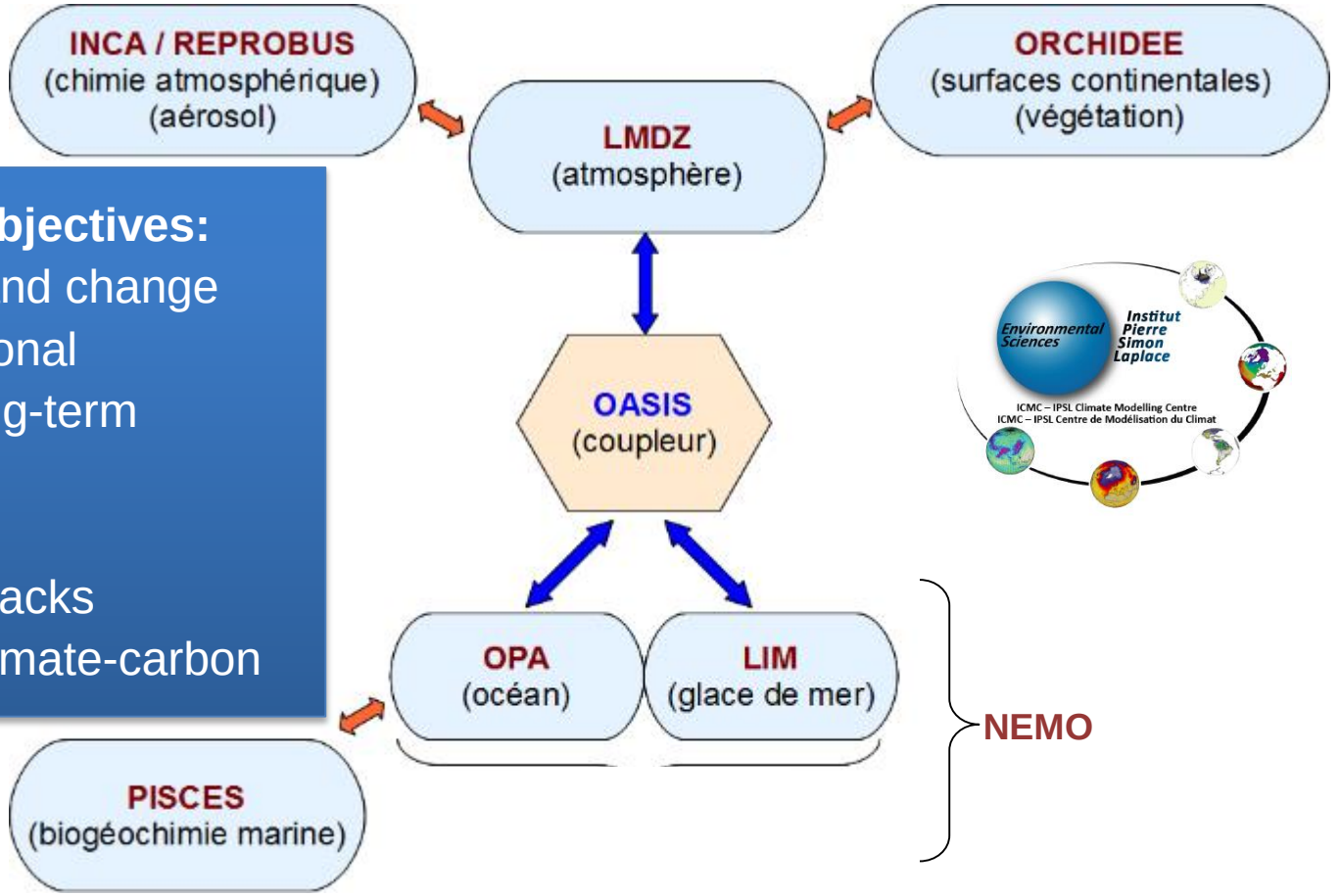
IPSL Earth's Climate System Model

IPSL Climate Modelling Center (IPSL-CMC) https://cmc.ipsl.fr/

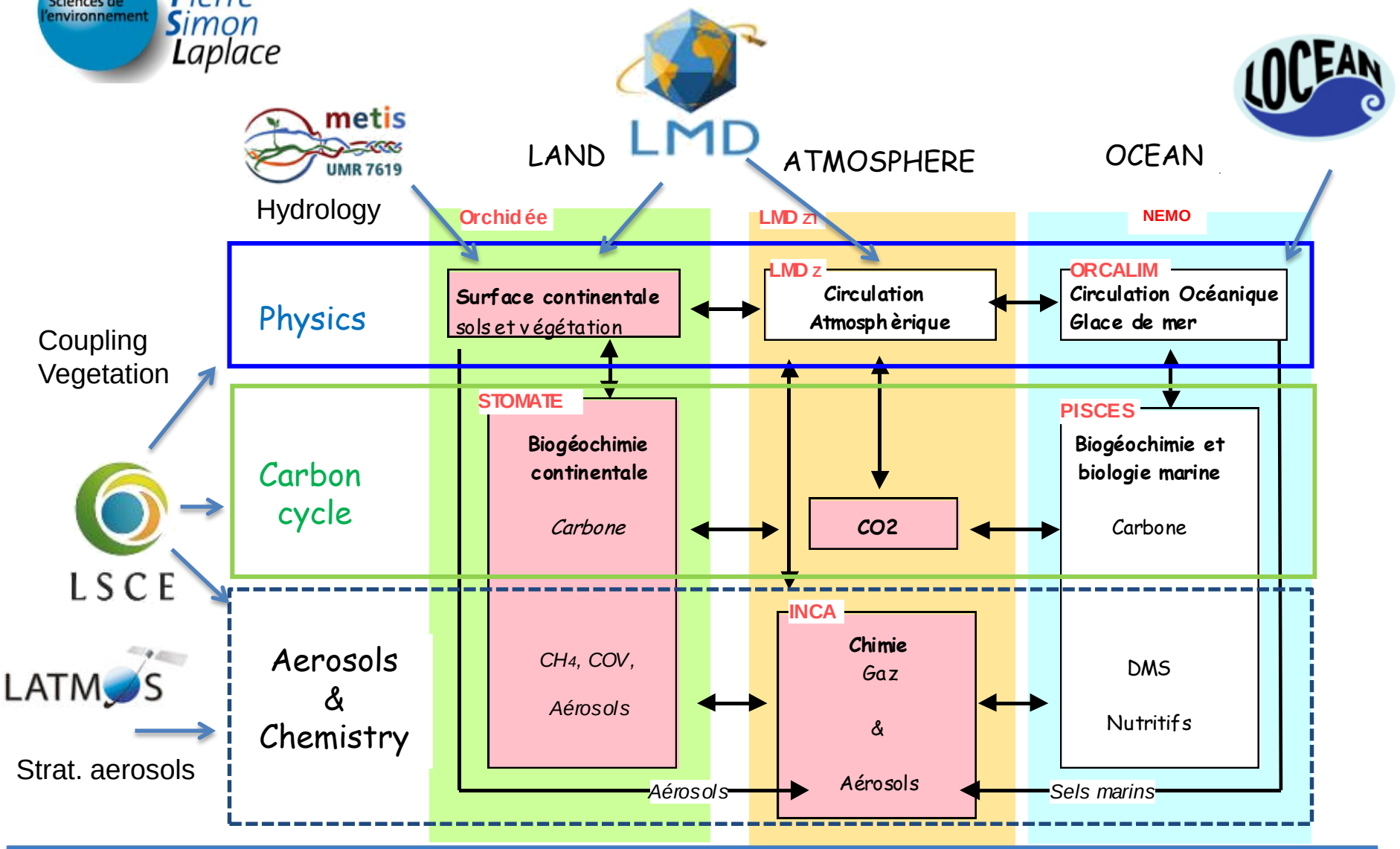





Main scientific objectives:

- Climate variability and change
  - Global/regional
  - Decadal to long-term
- Paleoclimates
- Climate system:
  - Cloud feedbacks
  - Climate-aerosols/Climate-carbon



IPSL Earth System Model

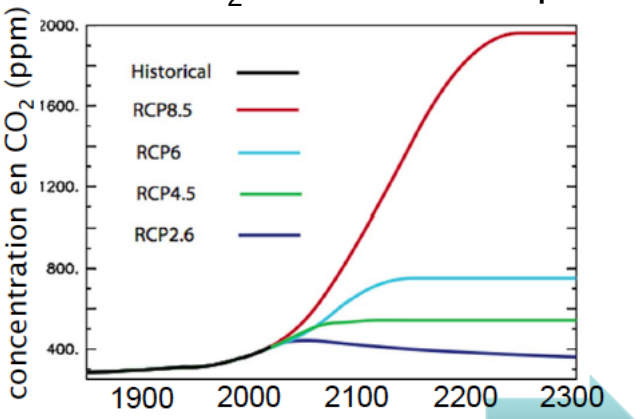


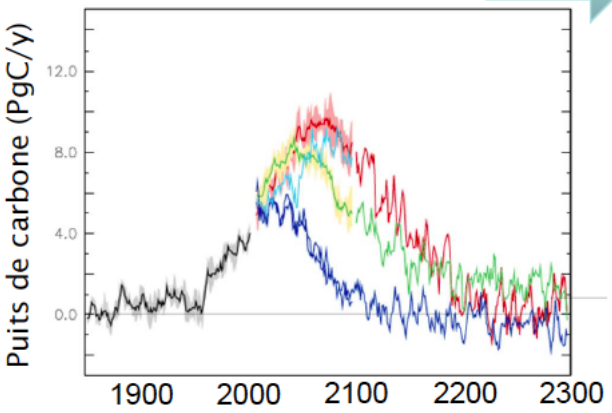
IPSL: a federation of laboratories to study global change (since 1991)

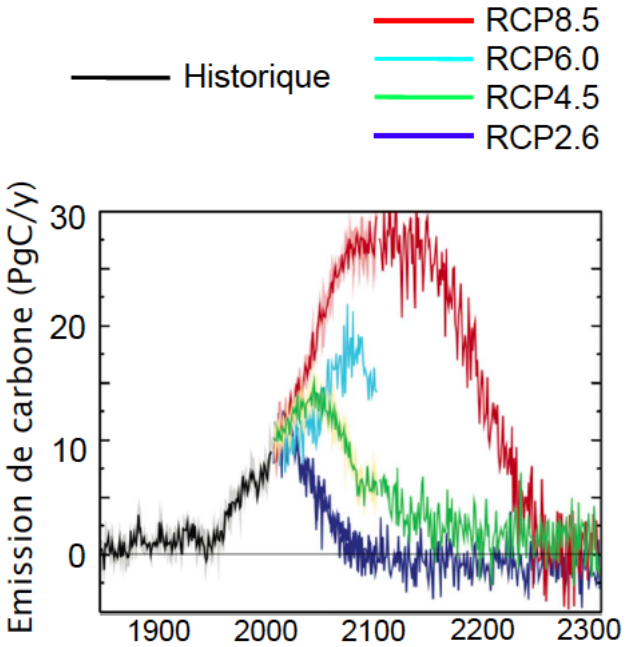
IPSL Earth's Climate System Model

First coupled climate-carbon simulations

CO_2 emissions compatible with RCP pathways





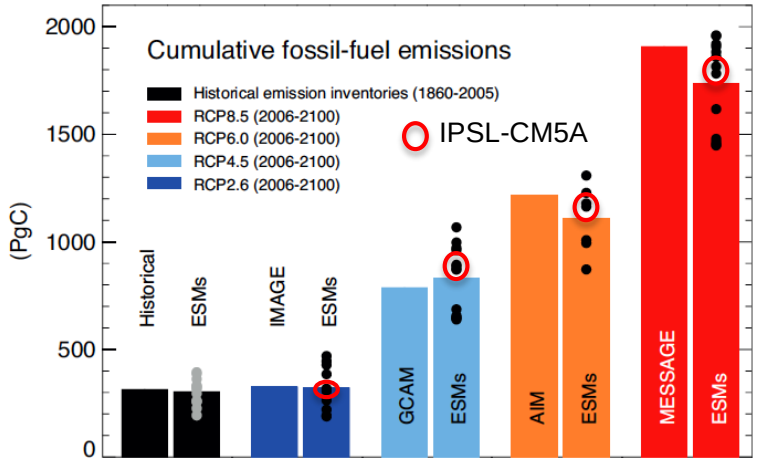


Among first coupled climate-carbon models Dufresne et al. (GRL, 2002)

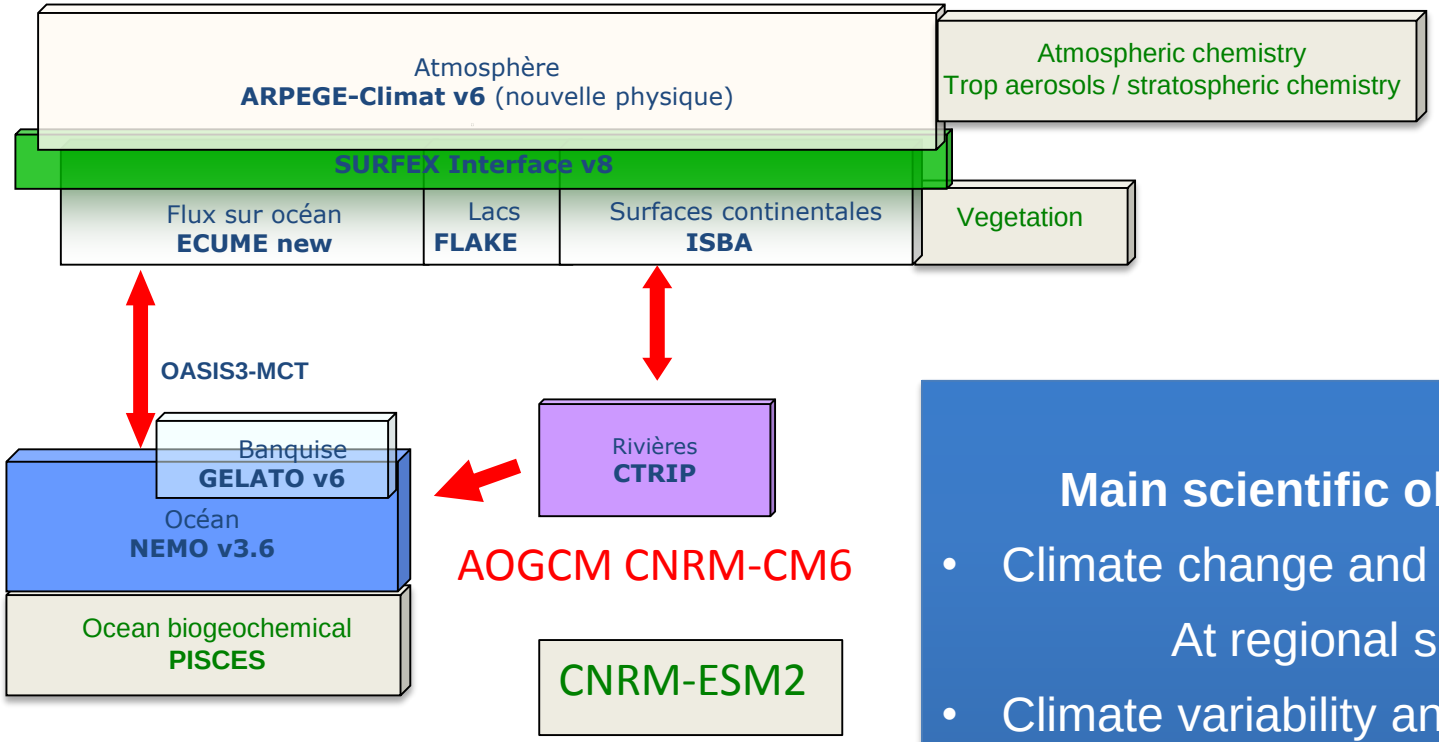
CMIP5

IPCC AR5 Chap6

Jones et al. (2013)



CNRM-CERFACS climate/Earth system model



Main scientific objectives

- Climate change and their impacts
  At regional scale
- Climate variability and predictability
  Seasonal to decadal
- Climate system:
  Atmospheric chemistry
  Climate-aerosol interactions
  Ocean-atmosphere interactions

METEO FRANCE
Toujours un temps d'avance

CERFACS

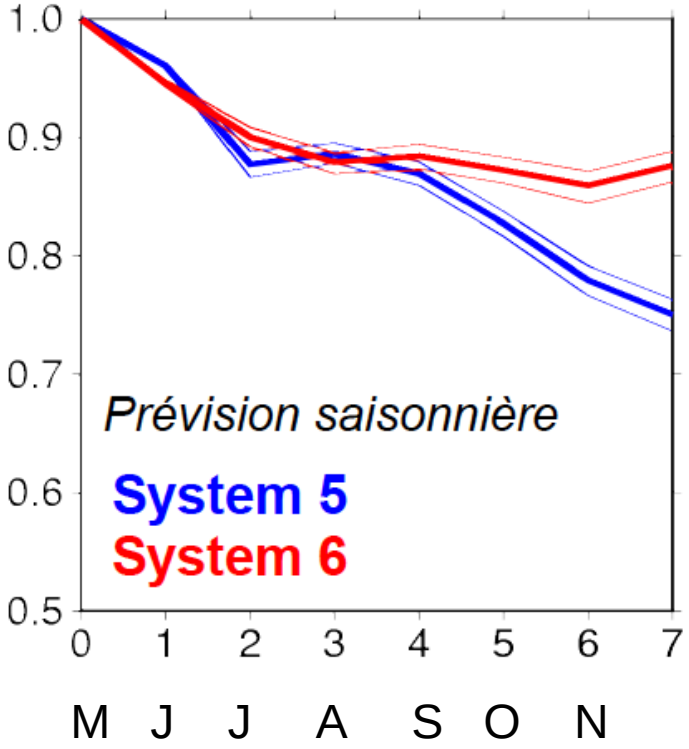
CNRM-CERFACS : synergy with NWP

ARPEGE

IFS dynamical core (ECMWF) +added stretched grid (Europe)

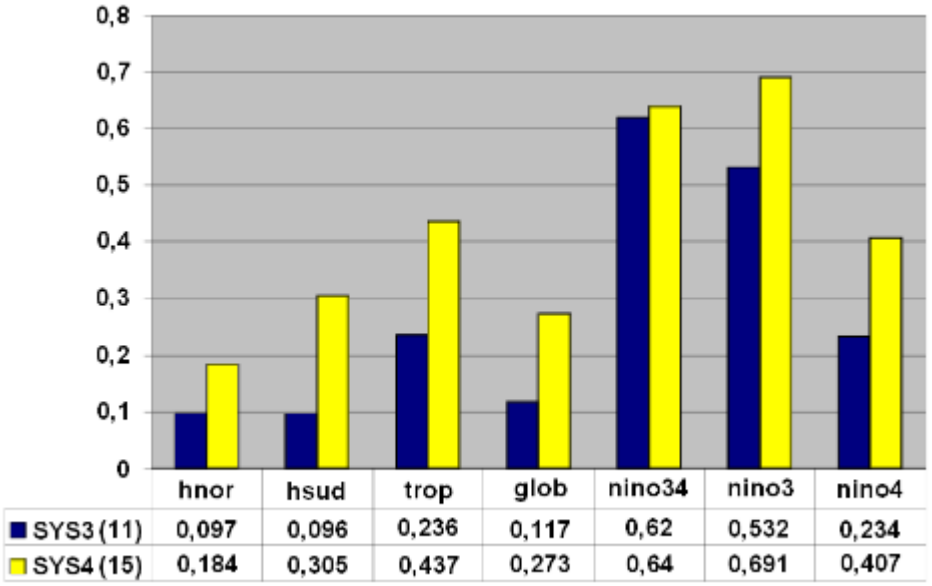
ARPEGE Physics with NWP

Seasonal prediction of El Nino
CNRM-CM6 80 km for the atmosphere



From CMIP3 (blue) to CMIP5 (yellow) : improvement of the seasonal forecast system based on CNRM-CM

Correlation between forecast and observed anomalies (JJA) 1991-2011



	hnor	hsud	trop	glob	nino34	nino3	nino4
SYS3 (11)	0,097	0,096	0,236	0,117	0,62	0,532	0,234
SYS4 (15)	0,184	0,305	0,437	0,273	0,64	0,691	0,407

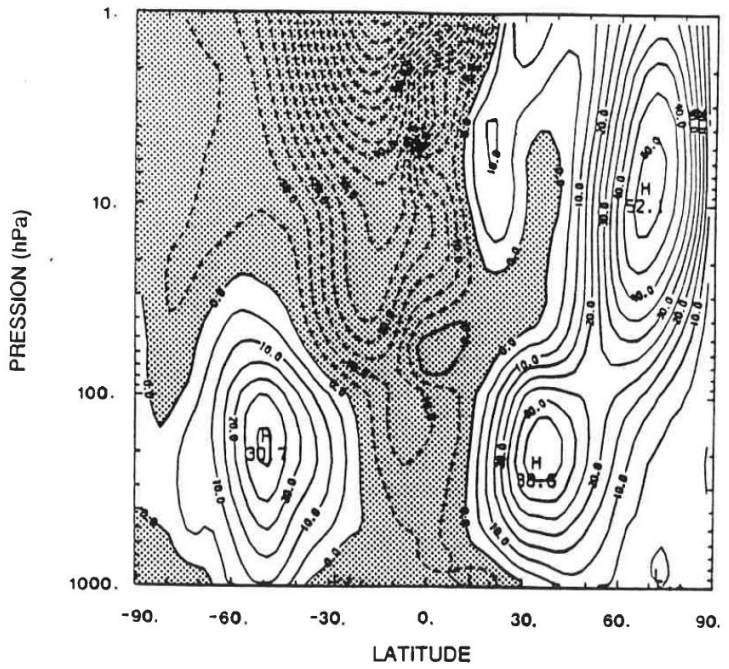
LES UNIVERSITES

L'EVOLUTION DU CLIMAT ET DE L'ENVIRONNEMENT GLOBAL

LE MODELE COMMUNAUTAIRE FRANCAIS

"Cahier des charges"

Février 1991



Modélisation des jets dans l'atmosphère en hiver

Community climate model initiative 1990-1992

Use ARPEGE as a common AGCM

ARPEGE with ECMWF (late 80s)
Adapted to multitasking computer

Did not work !
Kept LMDZ & ARPEGE

Why ?

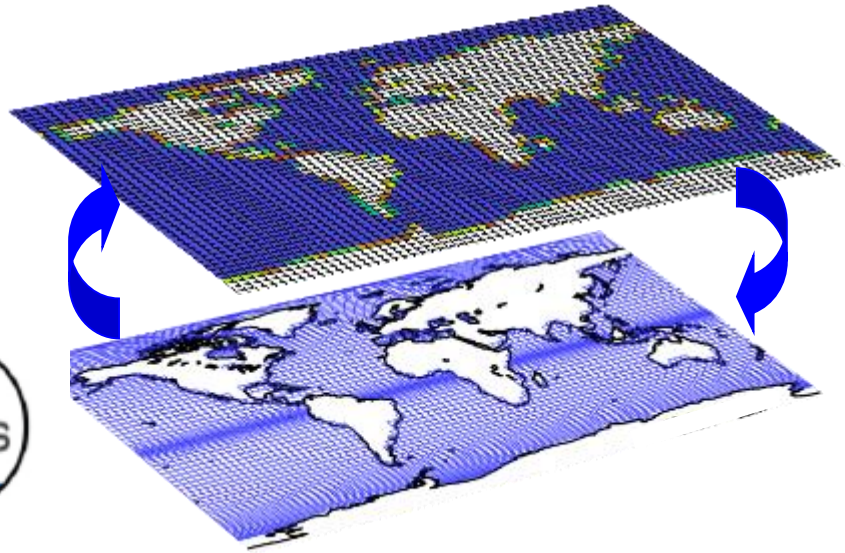
- Flexibility issue: NWP versus academic research
- Need for « hands-on » and code knowledge (not just use of an AGCM)

Common Ocean model & coupler
NEMO and OASIS

Comes back from collaboration in the 1990s:
A common objective:
develop coupled AOGCMs with no flux corrections
« GASTON group » under national INSU program

Common ocean model : OPA – now NEMO
Developed at LOCEAN

Common coupler developed: OASIS
by CERFACS



But different sea-ice models:
LIM developed by UCL (BE)
GELATO (Météo France)

Now:
towards a new common European sea ice code
to replace LIM, GELATO & CICE

CMIP3/AR4 « ESCRIME » White Paper 2003-2007

2007

National demand to contribute to AR4
Support from
CNRS, CEA & Météo France

Common focus: Analyses

Climate scenarios
Climate sensitivity
Variability
Regional climate and extremes
Hydrological cycle
Polar regions and cryosphere
Carbon cycle
Detection/attribution

MissTERRE « Modélisation Intégrée du Système TERRE »
Integrated Earth System Modelling

Pascale Braconnot & Serge Planton

2003-2016

Support from LEFE national program from CNRS-INSU

A common framework for Earth's climate system modelling in France
CMIP5/6 & IPCC

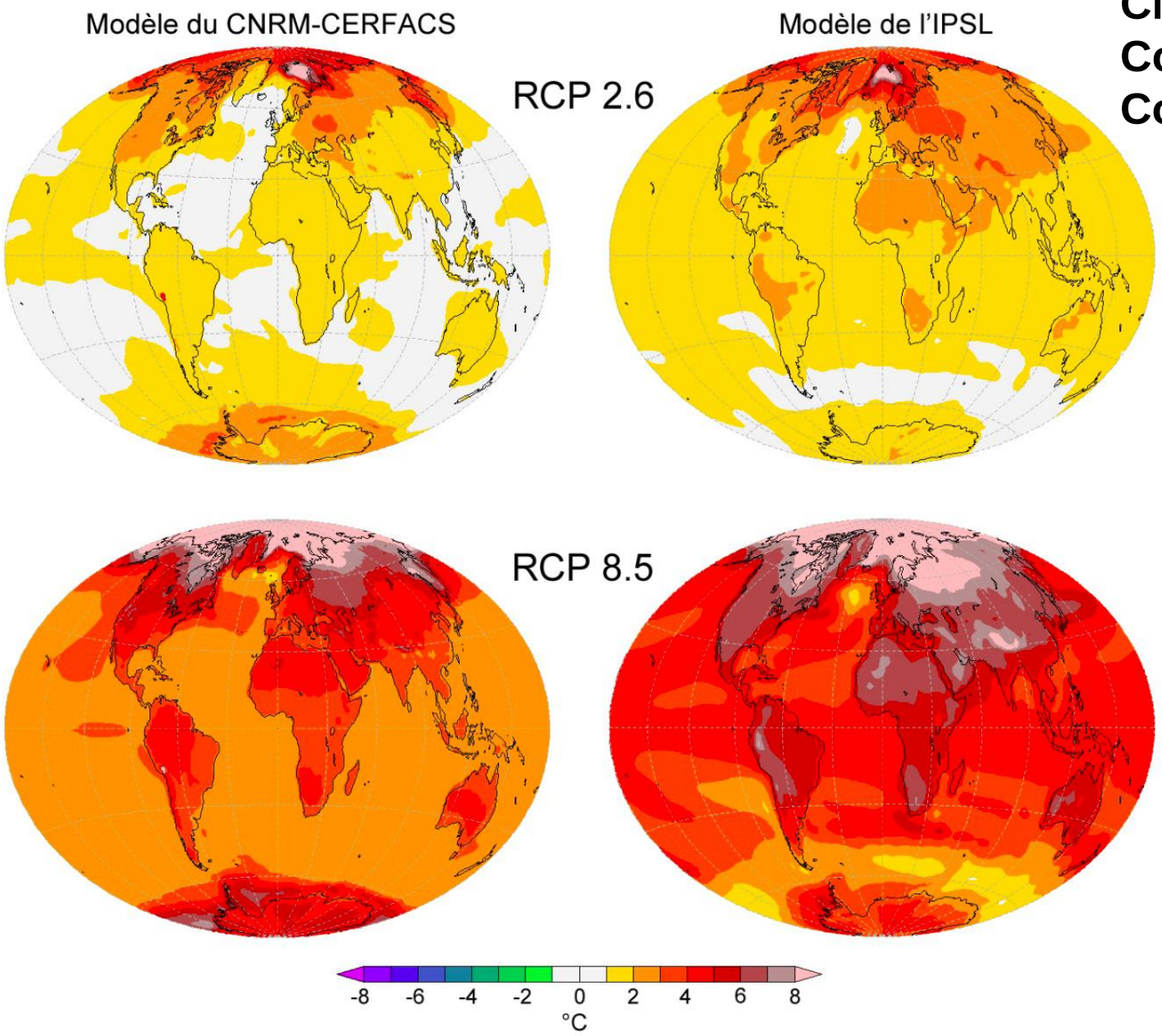
Improve our understanding of the climate system and its changes
Improve models of the Earth's climate system
Support the WCRP international coordinated experiments

Scientific coordination / regular meetings
CNRM-CERFACS & IPSL and collaborators

Generation of different common projects

Changement de température en surface entre 1961-1990 et 2071-2100

CMIP5 Common Communication



Collaboration on atmospheric physics

Mid 2000s:
Towards a « Common physics » for ARPEGE and LMDZ AGCMs?

Evolved towards a long-term collaboration
DEPHY: A framework for collaboration on common developments of the physics
« Developpement et Evaluation Physiques des modèles atmosphériques »
Development and evaluation of the atmospheric physical models
Supported by CNRS-INSU

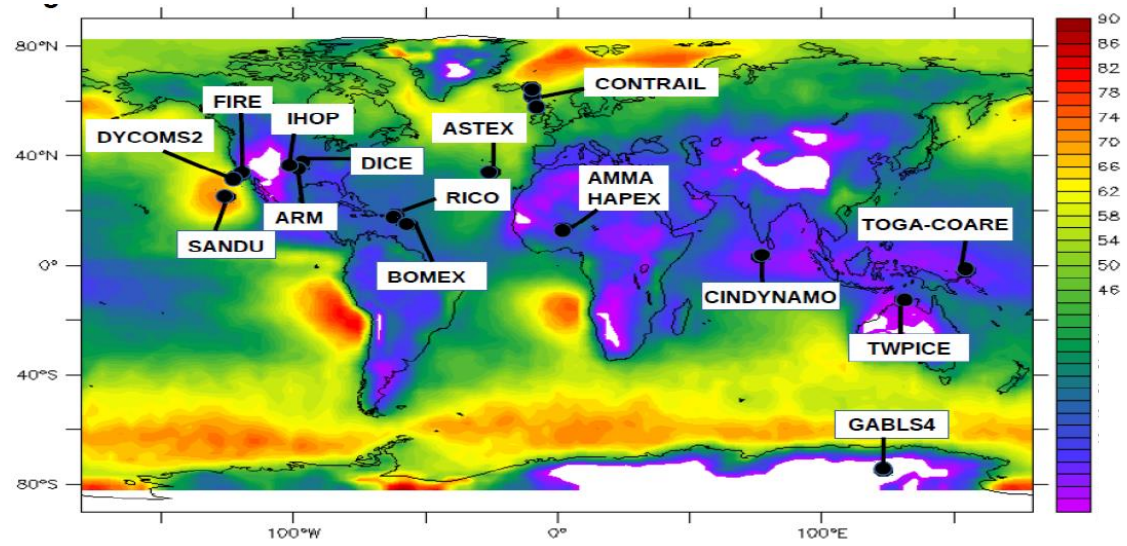
Common objective:
Improve the physical parameterisations of atmospheric models

- Improve mesoscale, NWP and climate models
- Common methodologies, tools, codes
- Common work with observations

Topics:

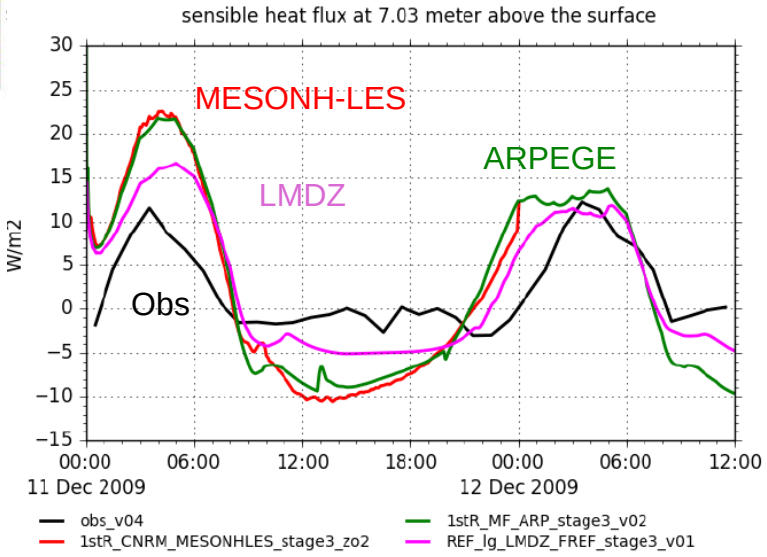
Turbulence and surface fluxes / Transport - convection
Clouds and radiation / Reduction of systematic errors

DEPHY some examples of results

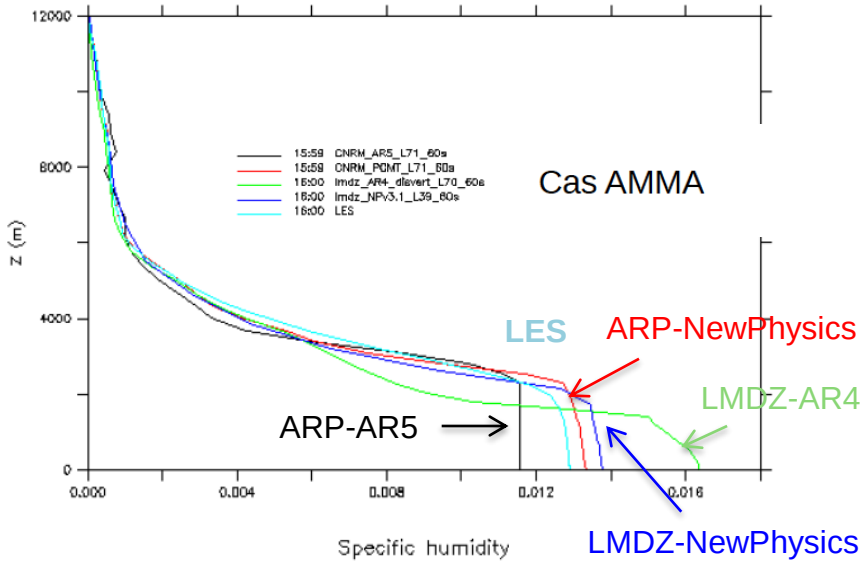


Sharing 1D case studies
PBL, convection ….

Cas GABLS4



Eric Bazile

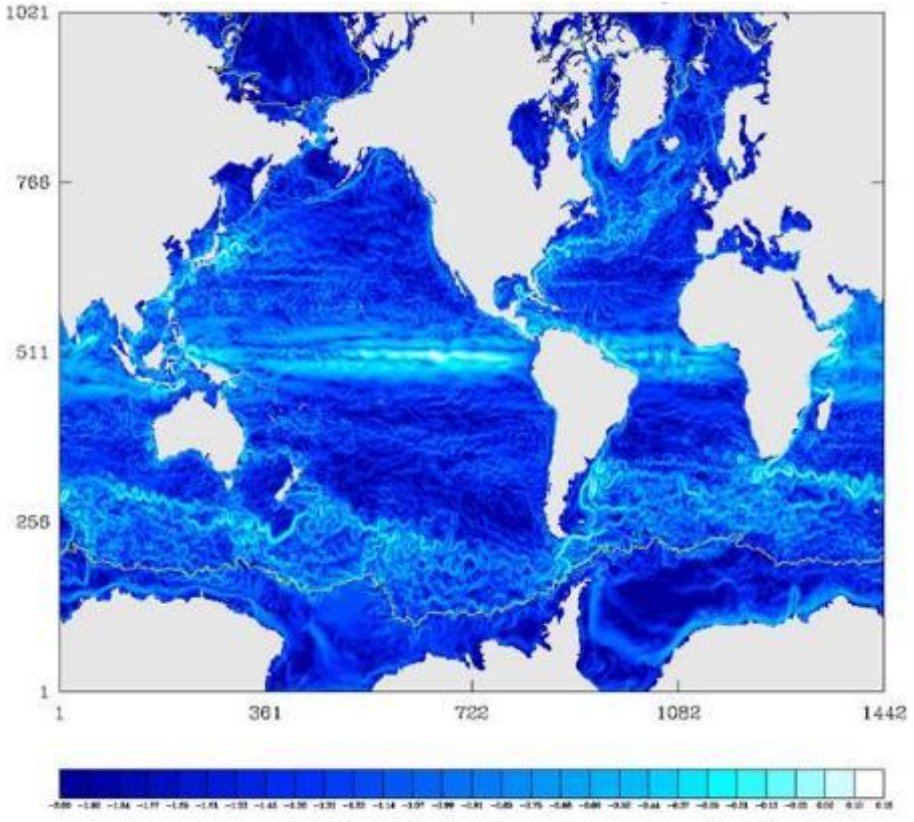


Source: Catherine Rio & Marie-Pierre Lefebvre, Banyuls 2017

Collaboration on the ocean model
DRAKKAR group

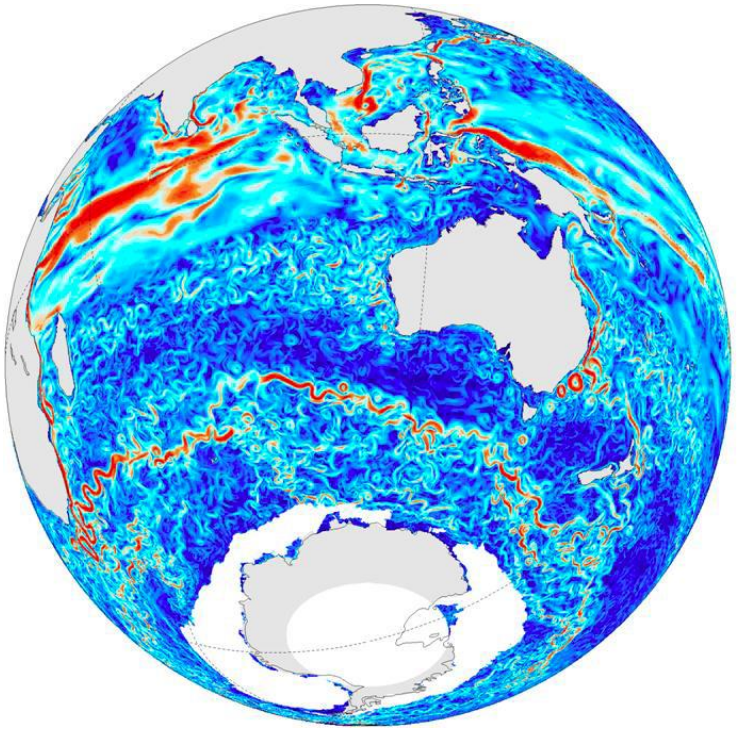
FR (IGE, LOCEAN, LOP), UK (NOC), DE (GEOMAR)

Development of ORCA025
(started in 2003)

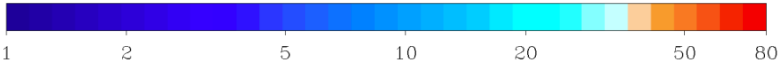


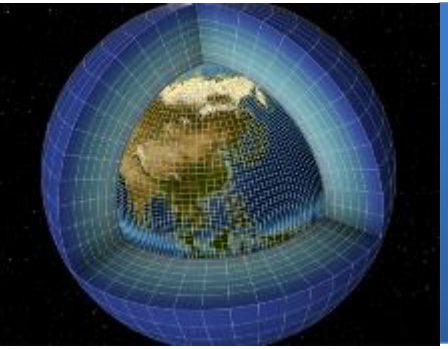
Surface currents (CNRS/IGE & CINES)

ORCA12
Barnier et al., Drakkar 2014-2017 report



Instantaneous surface velocity





CLIMERI-France
Climate modelling
National research infrastructure
Roadmaps 2016, 2018

Support to international reference climate simulations
IPSL & CNRM-Cerfacs

Coordination & strategy

http://climeri-france.fr

Reference models

Computing & Reference simulations

Storage & Multi-model analyses

Synergy with

is-enes
https://is.enes.org

Data dissemination & user interface

10 M€ /year
60 FTE

cnrs

cea

METEO FRANCE
Toujours un temps d'avance

Participation to CMIP6

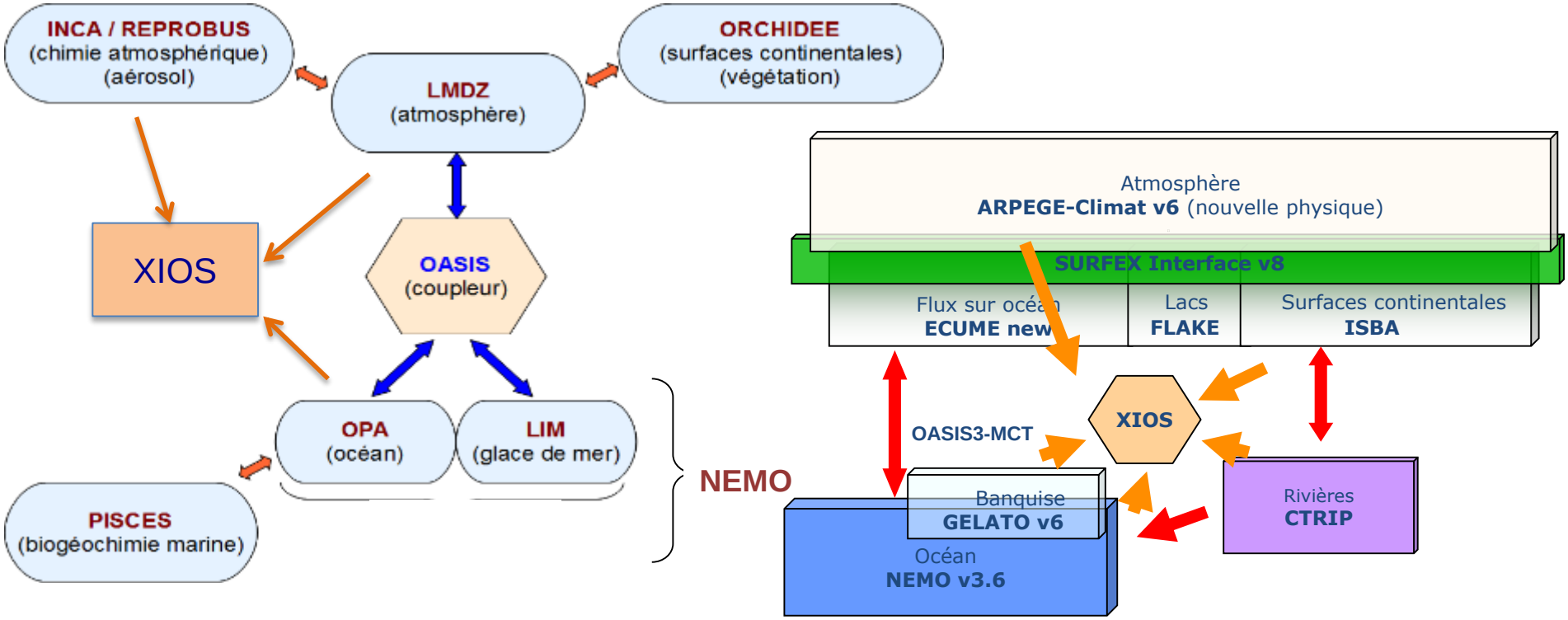
Acronyme	Thématique	CNRM-CERFACS		IPSL	
AerChemMIP	Aerosols et Chimie atmosphérique				
C4MIP	Cycle du carbone				
CFMIP	Rétroactions nuageuses				
DAMIP	Detection et attribution				
DCPP	Précision climatique décennale				
FAFMIP	Flux radiatifs				
GeoMIP	Geoenginierie				
GMMIP	Mousson				
HighResMIP	Modèles haute résolution				
ISMIP6	Calottes	LGGE		LGGE	
LS3MIP	Surface continentale, neige et humidité		LGGE		LGGE
LUMIP	Utilisation des terres				
OMIP	Modèles d'océan				
PMIP	Palaeoclimat				
RFMIP	Forçage radiatif				
ScenarioMIP	Scenario				
VolMIP	Forçage d'origine volcanique				
CORDEX	Modélisation régionale et descente d'échelle		MedCordex		
DynVar	Dynamique et variabilité				
SISMIP	Glace de mer				
VIAXSAB	VIA Advisory Board for CMIP6				

Rôle dans le projet
- contribution aux protocoles
- membre bureau
- coordination

Participation
- minimale
- forte

Sharing XIOS IO software

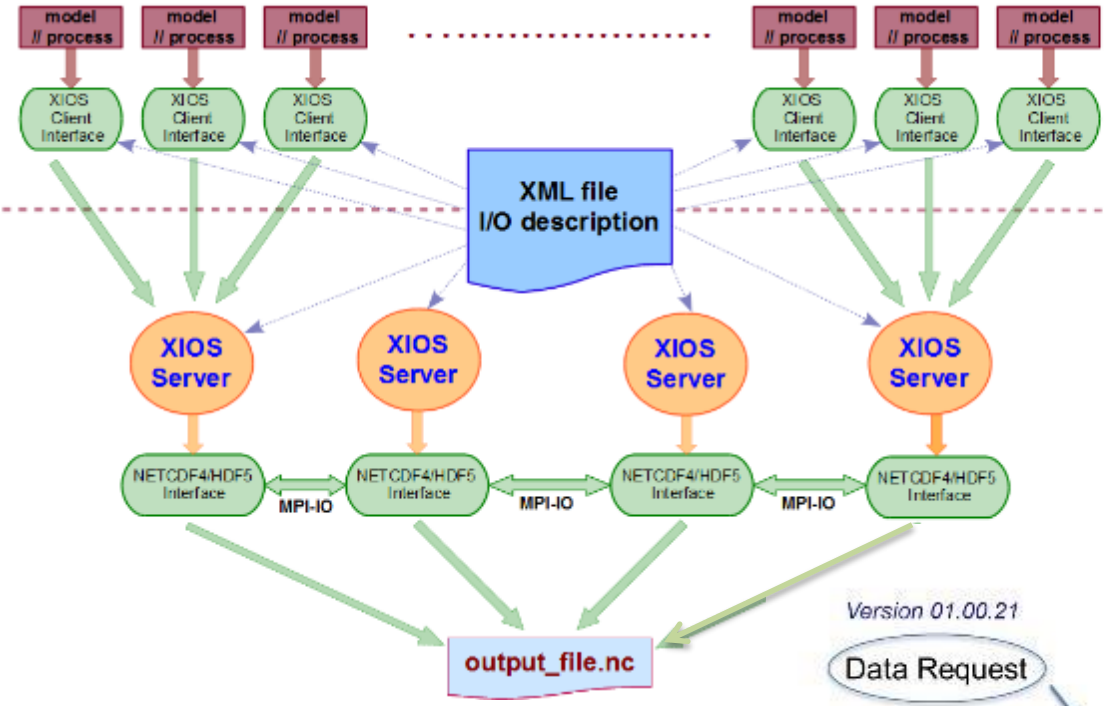
ANR Convergence project

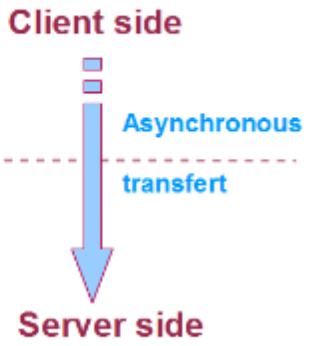


XIOS parallel IO servers : asynchronous processes exclusively dedicated to output

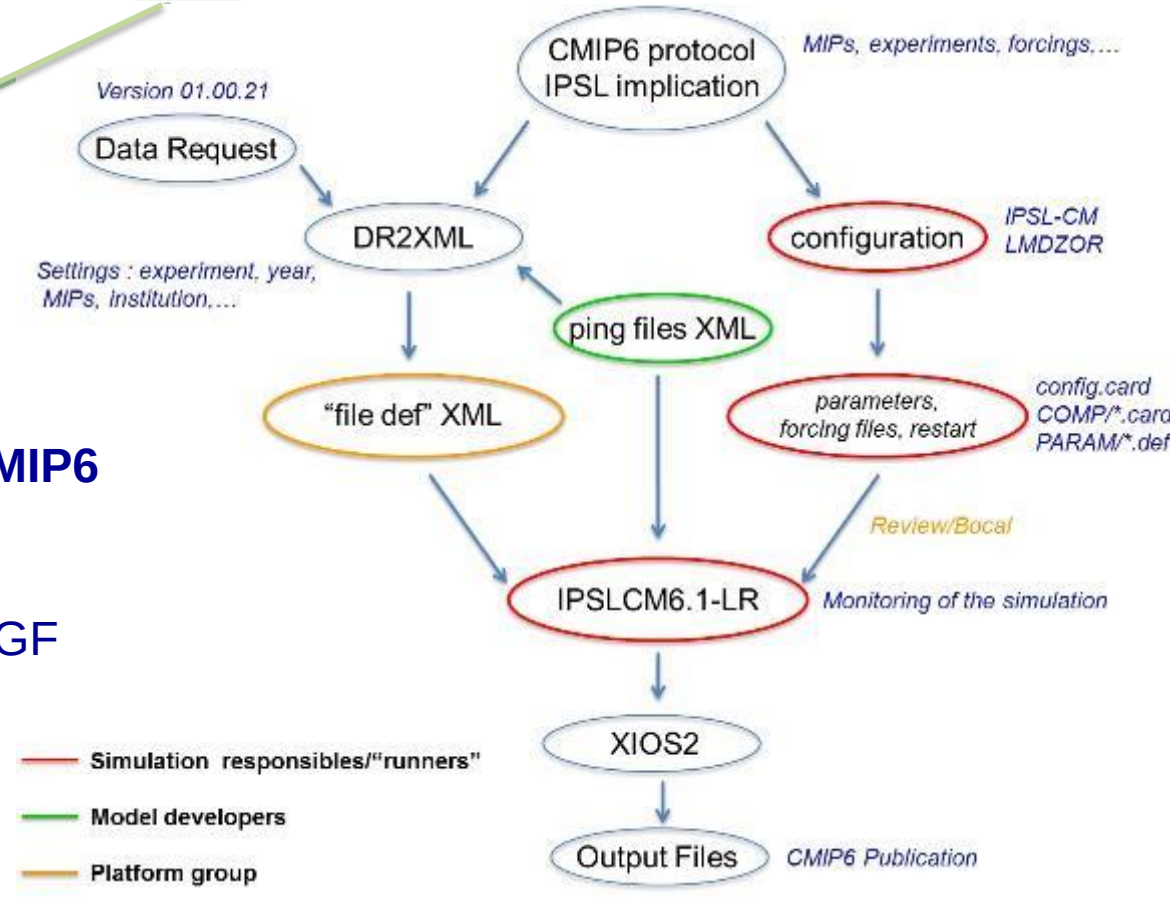
Flexible data output description through an external XML file:

XIOS + dr2xml: **CMIP6 workflow**





XIOS



Common data workflow for CMIP6 based on XIOS

in both models

very efficient to publish on ESGF

Sharing tools for model result analyses

Joint development

ANR Convergence project

CliMAF

Sharing – Simplifying – Optimizing

Climate Model Assessment Framework

Scripting environment to share science

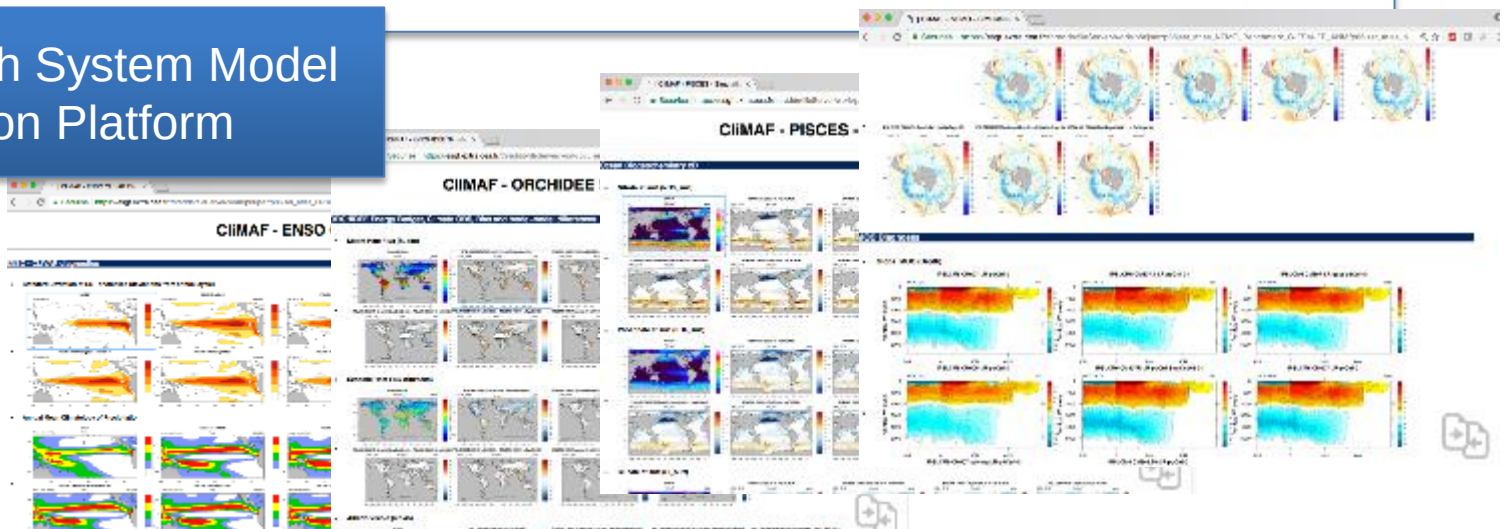
CLIMAF dataset: Python object with standard attributes

Flexible data treatments: based on CDO and user scripts

Produces netcdf files or figures

Automatic handling of outputs and smart cache to avoid computing

CLIMAF-Earth System Model Evaluation Platform



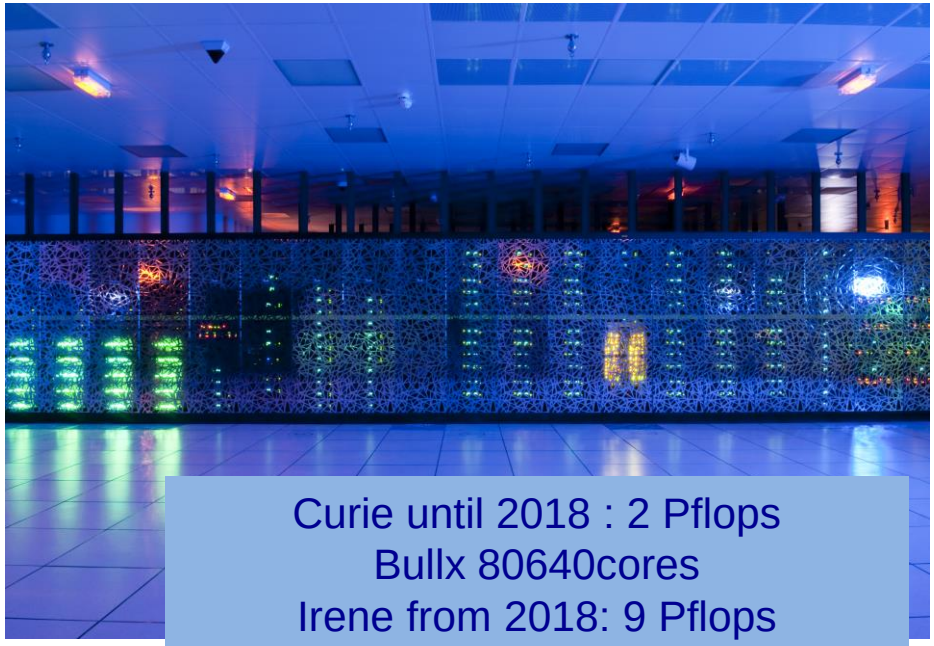
HPC for climate modelling in France

IPSL:
GENCI national research facilities
Mainly TGCC and IDRIS centers

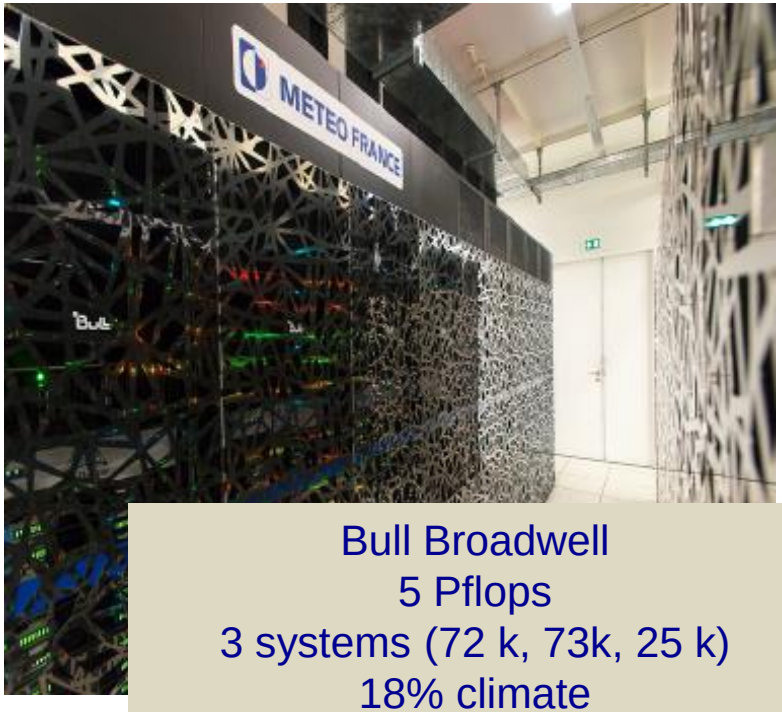
CMIP6: 291 Mh dedicated (2016-18)

CNRM-CERFACS:
Meteo France dedicated facilities

CMIP6: 215 Mh 2017-2019



Curie until 2018 : 2 Pflops
Bullx 80640cores
Irene from 2018: 9 Pflops
Sequana SKL & KNL

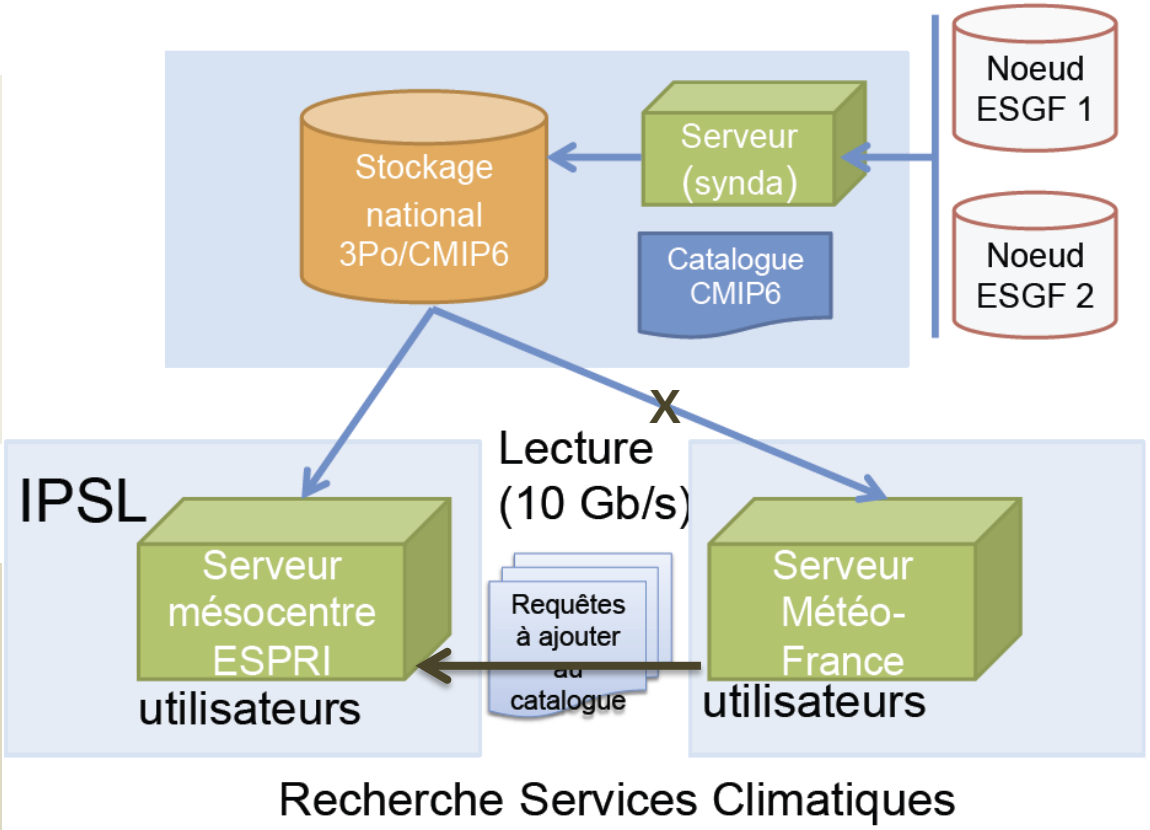


Bull Broadwell
5 Pflops
3 systems (72 k, 73k, 25 k)
18% climate

Multi-model analyses platform

National storage
for CMIP6 multi-model data
Installation IDRIS
end 2018
4 Po

On-going:
Share IPSL
analyses servers
ESPRI-MOD
For Meteo France
2018



Conclusions

Two climate models
but with a long tradition of collaboration
& increasing sharing of software and even hardware

Lessons learned:

Favorable factors:

- **Key importance of a shared common scientific objective**
- Common funding to support common developments
- Mutual recognition and trust

Limiting factors:

- Hands-on is key: not just users of climate models
- Differences in “missions”
- Limitations in man power & computing resources & common funding