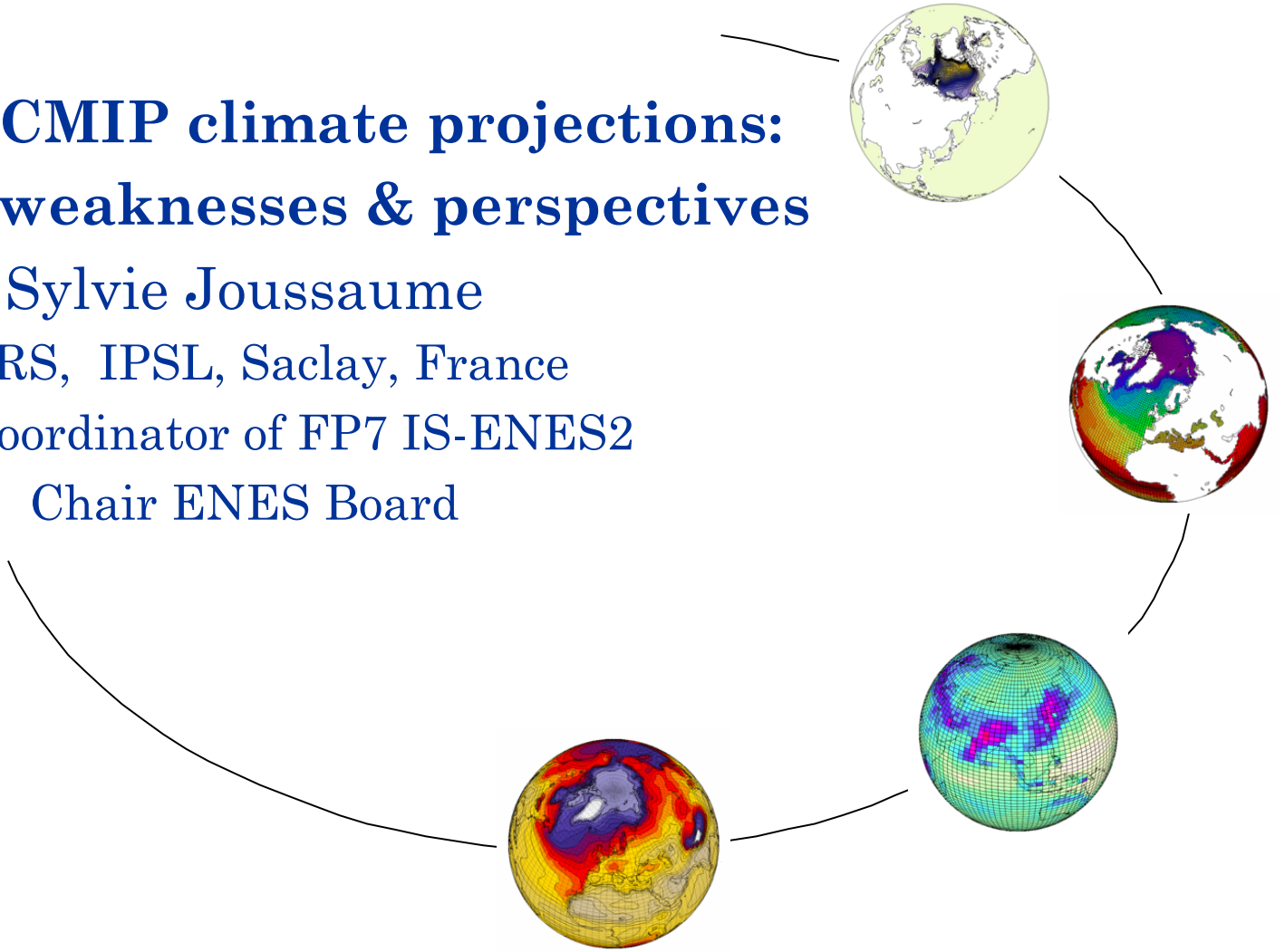
Copernicus C3S Projection Workshop
20-21 April 2015
Reading

Access to CMIP climate projections: strengths, weaknesses & perspectives

Sylvie Joussaume
CNRS, IPSL, Saclay, France
Coordinator of FP7 IS-ENES2
Chair ENES Board



Modeling Intercomparison Project Cycles
WCRP & WGNE

AMIP (atmosphere only) started in 1990 – PCMDI - Larry Gates vison
From then the "MIP family" has grown (PMIP the second one in 1991)

Working Group on Coupled Models (since 1995): **CMIP**
WCRP Working Group on Coupled Models
CMIP + other MIPs - used in TAR
CMIP3 + other MIPs - used in AR4
CMIP5 : NEW DESIGN, more extensive - used in AR5
CMIP6 starting now

Coordinated numerical experiments
In support of climate science & larger user communities
Extensively used for IPCC ARs:
Model evaluation / Future climate / Process studies

Common database & common analyses
CMIP3 : > 250 publications (2007) / CMIP5 > 750 publications (2014)
2500 registered users / 2014 : ESGF 10 000 users

CMIP5

Taylor et al., (BAMS, 2011)

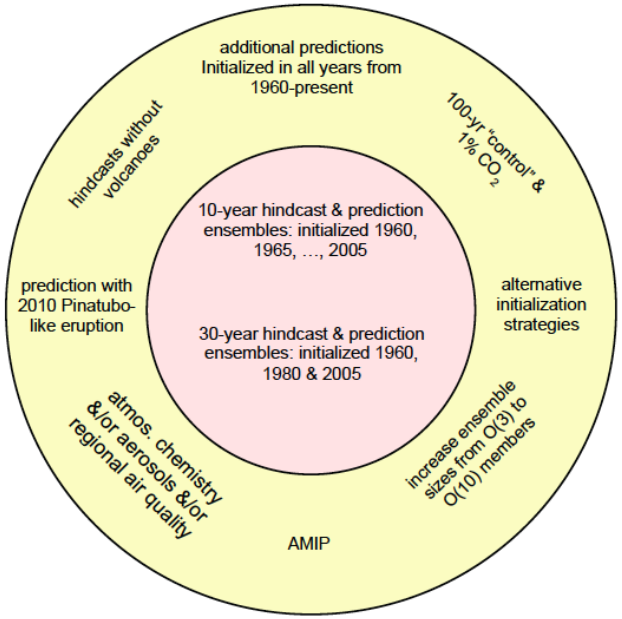
WCRP World Climate Research Programme

Near-term experiments (10-30 years)	Long-term experiments (century)
Decadal Prediction (initial conditions) Hindcasts/ Future	Future projections Model evaluation Understanding
AOGCMs	AOGCMs & ESMs

Large number of experiments

3400 simul. yrs up to > 12000 yrs

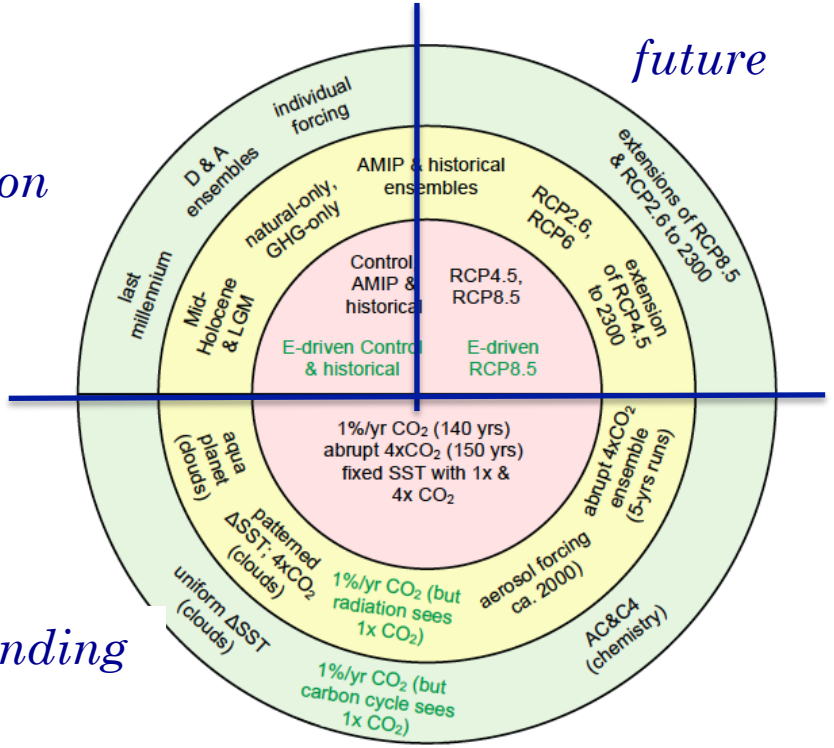
50 expts up to > 160 expts



evaluation

future

understanding



Status of CMIP5 experiments

27 modelling groups
58 models

1 Canada

CCCma	CanAM4 CanCM4 CanESM2
NSF-DOE-NCAR	CESM1(BGC) CESM1(CAM5) CESM1(CAM5.1, FV2) CESM1(FAST CHEM) CESM1(WACCM)
NCAR	CCSM4
NOAA GFDL	GFDL-CM2.1 GFDL-CM3 GFDL-ESM2G GFDL-ESM2M GFDL-HIRAM-C180 GFDL-HIRAM-C360
NASA GMAO	GEOS-5
NASA GISS	GISS-E2-H GISS-E2-H-CC GISS-E2-R GISS-E2-R-CC
NCEP	CFSv2-2011

6 USA

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
INM	INM-CM4

7 in Europe

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

1 Russia

4 Japan

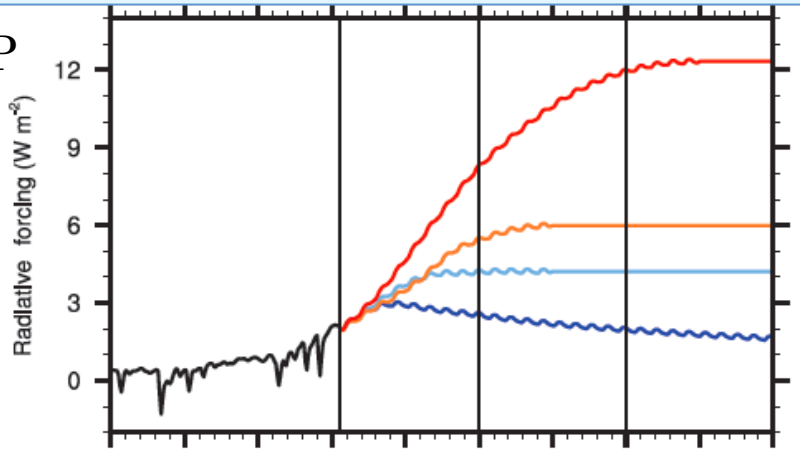
2 Australia

5 China / 1 Korea

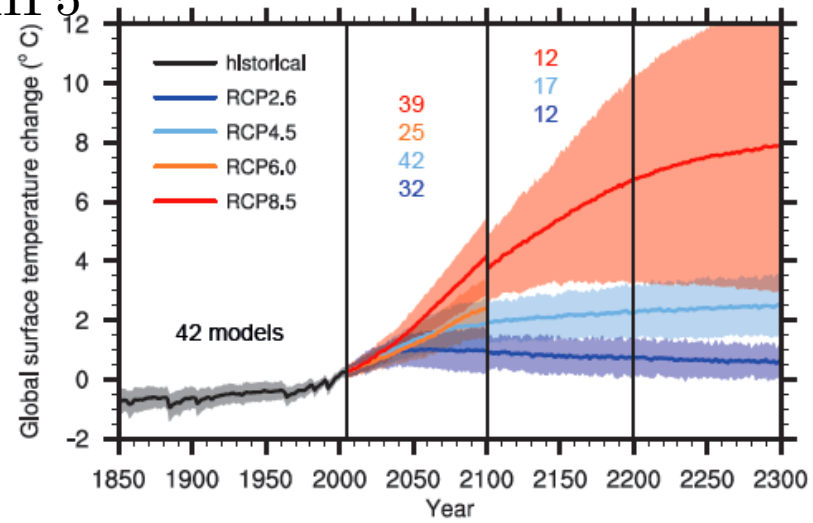
LASG-IAP	FGOALS-gl FGOALS-s2
LASG-CESS	FGOALS-g2
GCESS	BNU-ESM
FIO	FIO-ESM
BCC	BCC-CSM1.1(m) BCC-CSM1.1
NIMR/KMA	HadGEM2-AO
NICAM	NICAM.09
MRI	MRI-AGCM3.2H MRI-AGCM3.2S MRI-CGCM3
MIROC	MIROC-ESM MIROC-ESM-CHEM
MIROC	MIROC4h MIROC5
CSIRO-QCCCE	CSIRO-Mk3.6.0
CSIRO-BOM	ACCESS1.0 ACCESS1.3

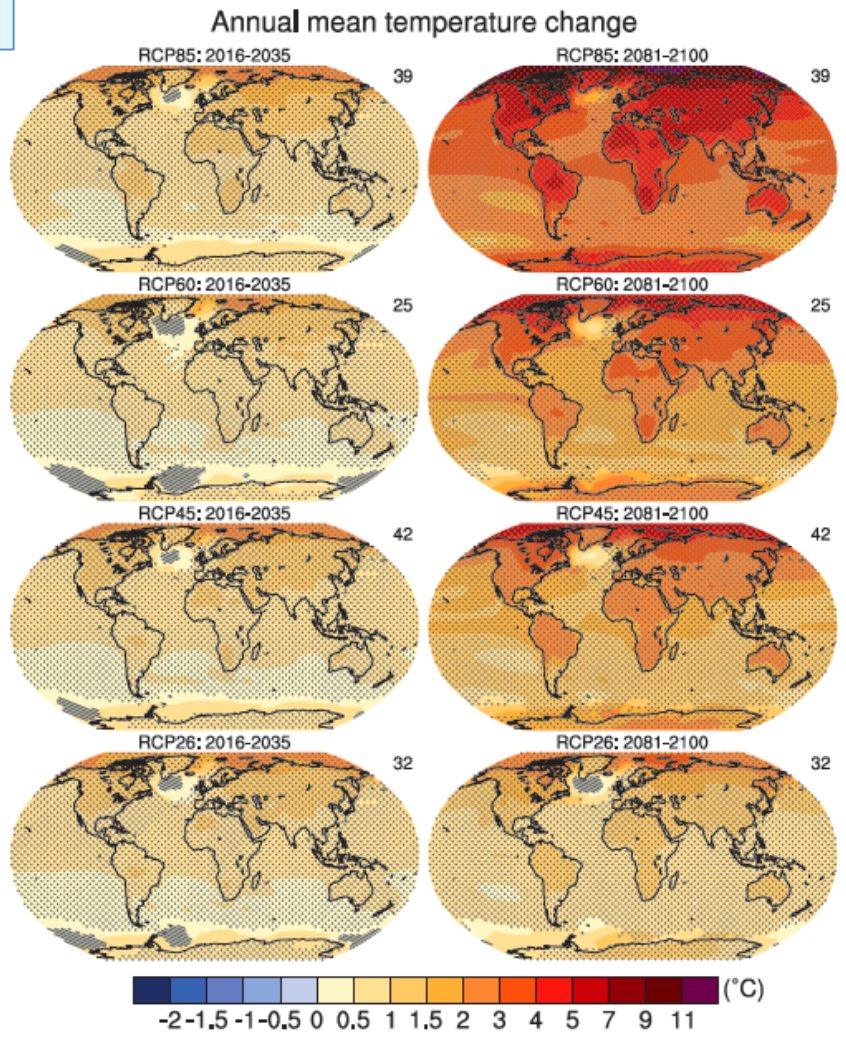
Projections of future climate change

RCP



CMIP5



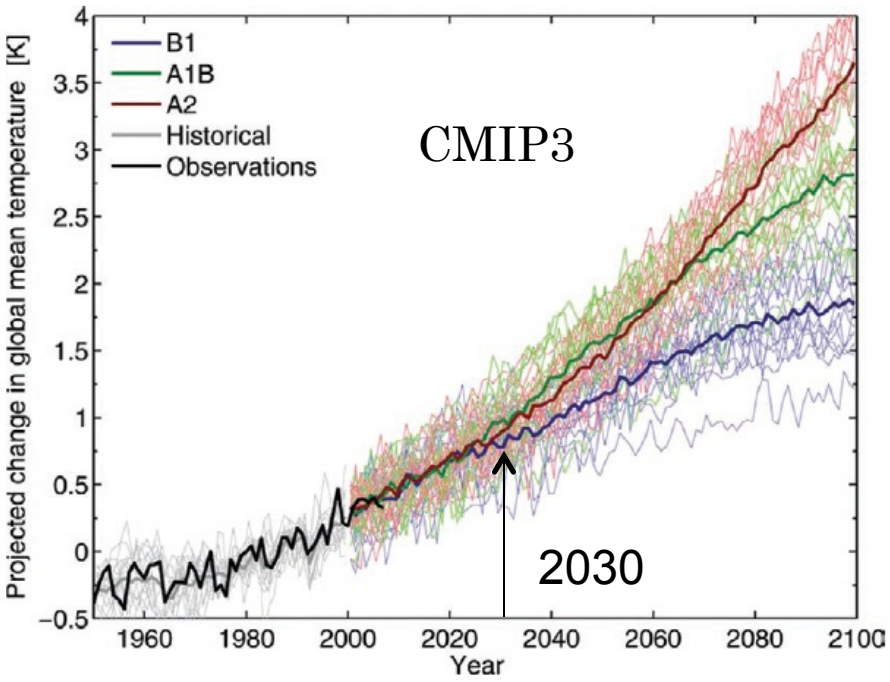


IPCC AR5 TS (2014)

	Scenario	2046–2065 Mean	2046–2065 *Likely* range[c]	2081–2100 Mean	2081–2100 *Likely* range[c]
Global Mean Surface Temperature Change (°C)[a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8

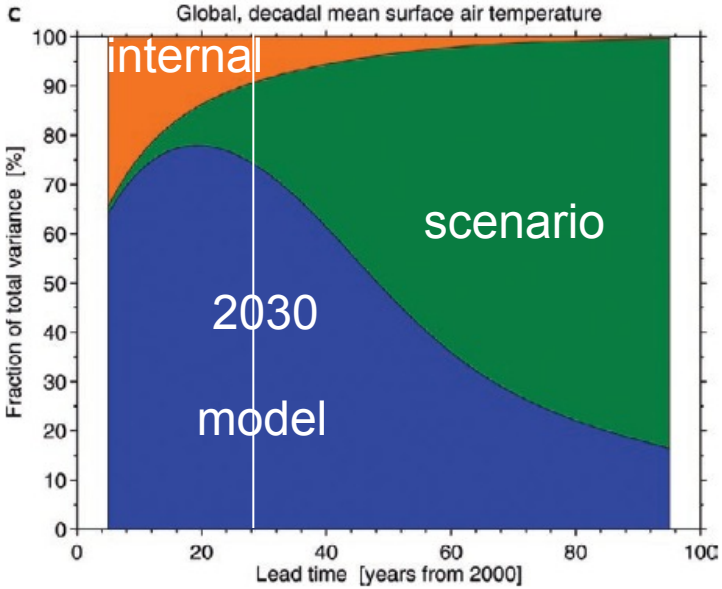
Model projections: Sources of uncertainties

Internal variability
Socio-economic scenarios
Models

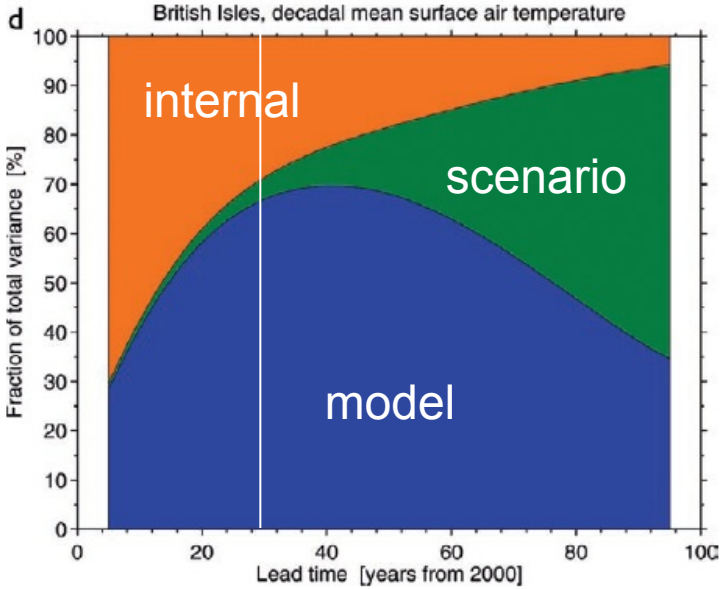


Hawkins and Sutton, BAMS, 2009

Global



Regional

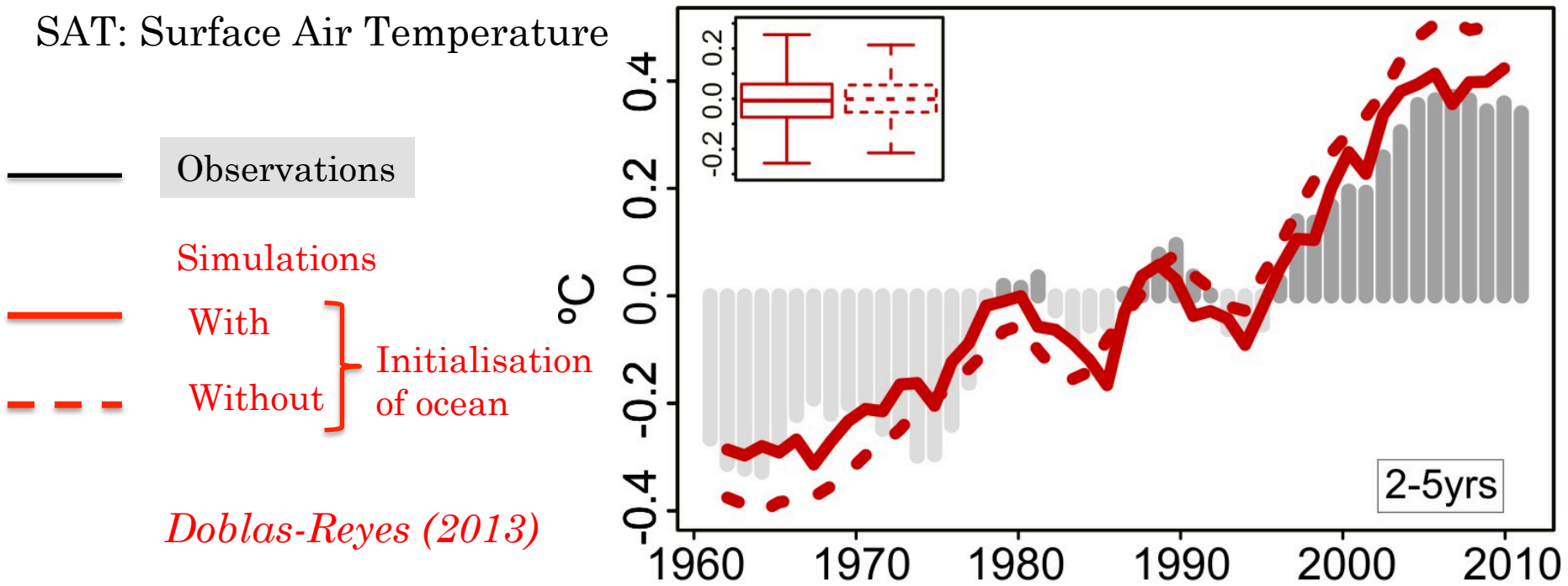


Decadal climate predictions

Multi-model decadal predictions
10 yr simulations at every 5 years
With ocean initial conditions
CMIP5

SAT

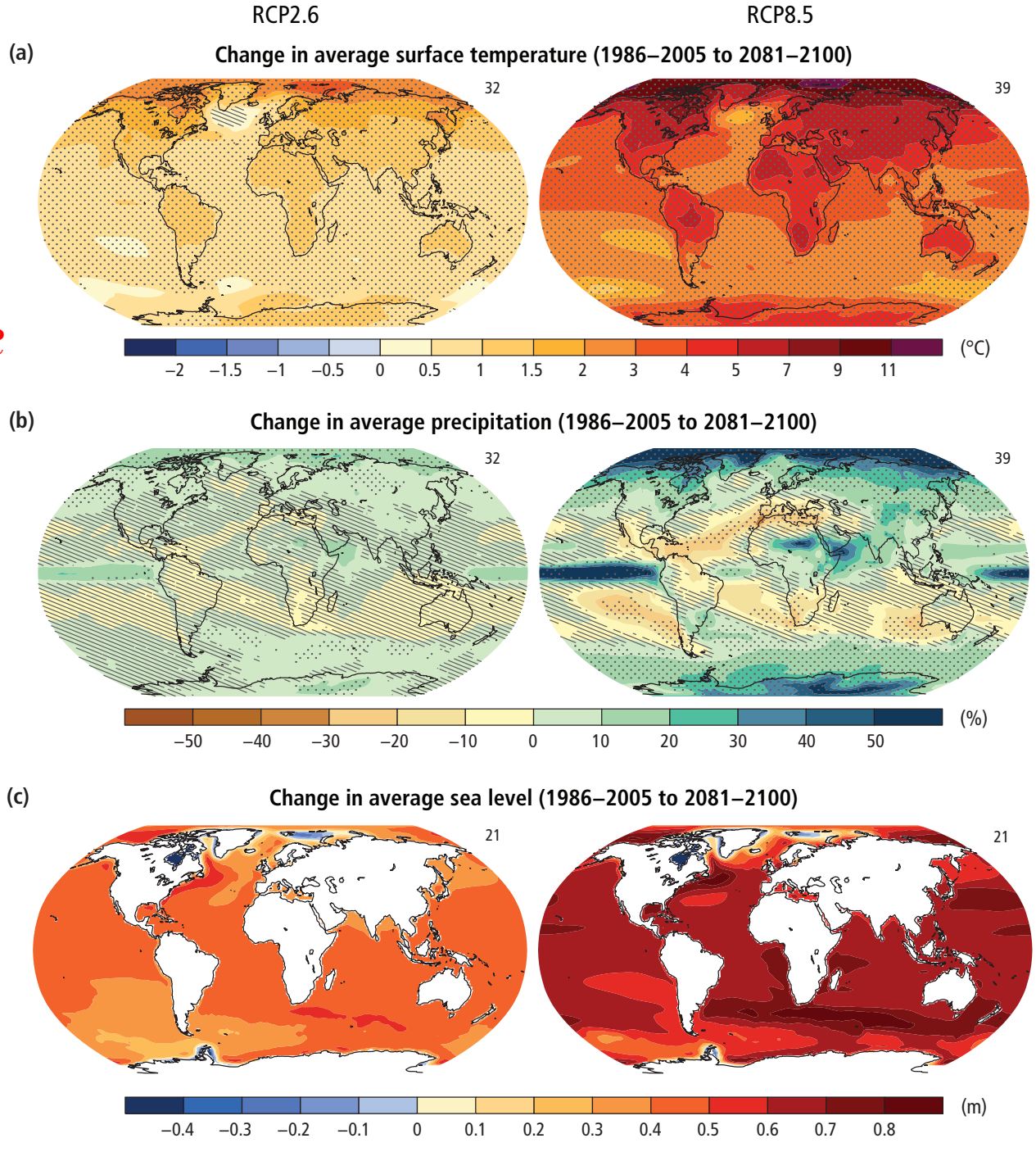
SAT: Surface Air Temperature



Doblas-Reyes (2013)

See talk by Francisco Doblas-Reyes

IPCC AR5 SYR

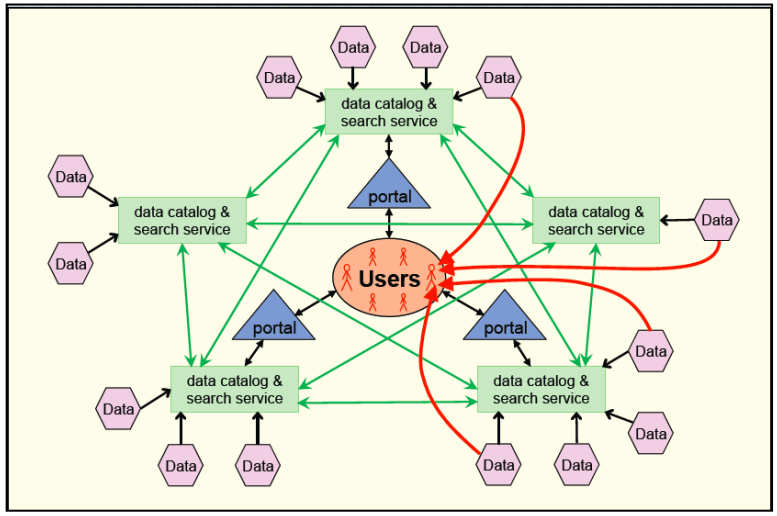

RCP2.6
RCP8.5
(a)
Change in average surface temperature (1986–2005 to 2081–2100)
32
39
–2 –1.5 –1 –0.5 0 0.5 1 1.5 2 3 4 5 7 9 11
(°C)
(b)
Change in average precipitation (1986–2005 to 2081–2100)
32
39
–50 –40 –30 –20 –10 0 10 20 30 40 50
(%)
(c)
Change in average sea level (1986–2005 to 2081–2100)
21
21
–0.4 –0.3 –0.2 –0.1 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
(m)

A common infrastructure distributed database & standards

ESGF Earth System Grid Federation

CMIP5: 2 PB

PCMDI



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

See my talk at CDS WK

Adoption of common standards/ conventions for the:

Structure and format of climate data

Metadata used to describe climate data

Vocabulary used for categorizing the diversity of model output

& Documentation of Model/experiments **(ES-DOC)**

Standardization enables/facilitates

Automation in the preparation of model output

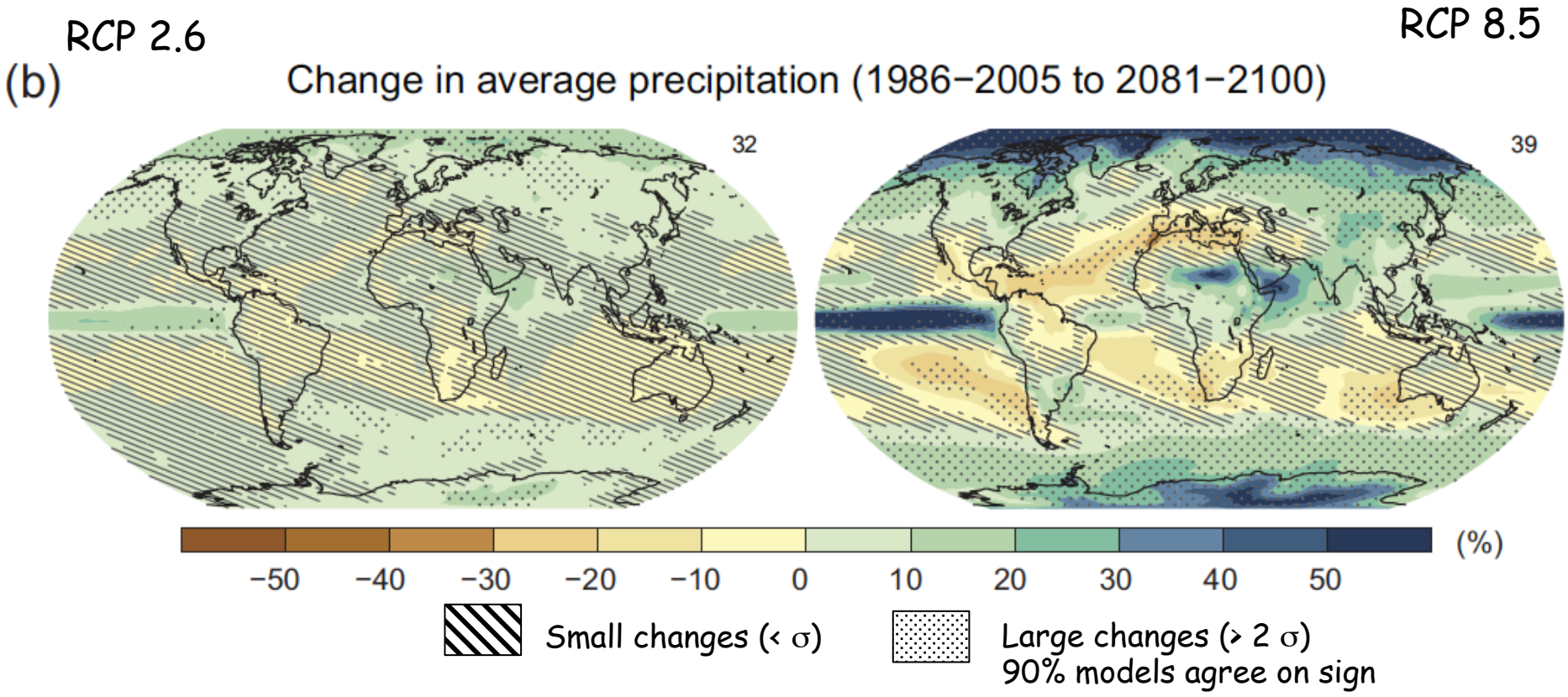
Analysis by researchers using uniform methods for reading and interpreting data

Unique identification of files

Sharing of data across the ESGF network

Ref: from Doutriaux and Taylor, 4th ESGF meeting, 12/2014

Multi-model ensemble : informs on robustness of changes



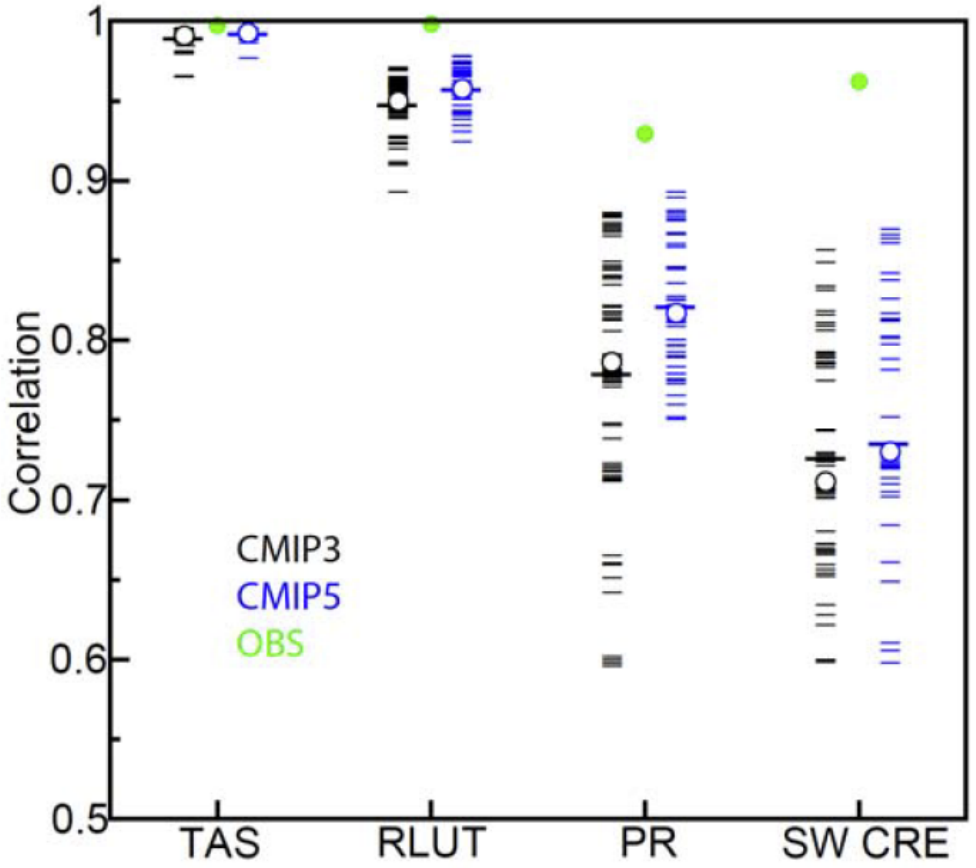
Model evaluation

Pattern correlations between models and observations
Annual 1980-1999

Ensemble mean

Median

IPCC AR5 WGI, Ch 9



Models ca 2005
CMIP3

Models ca 2012
CMIP5

Surface air temperature

Precipitation

LW outgoing radiation

SW cloud radiative effect

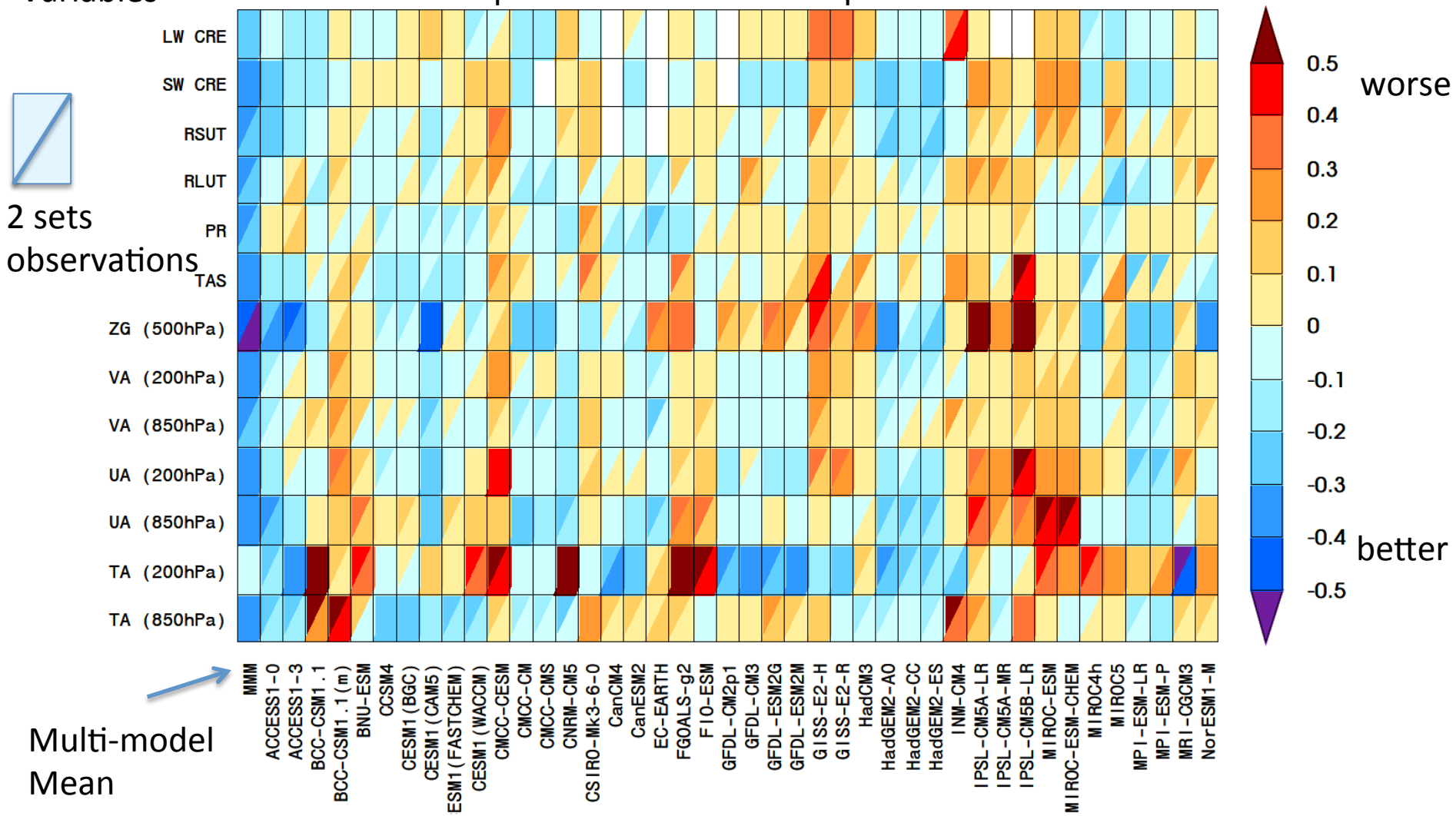
OBS other set of observations

CMIP5 model performance

IPCC AR5 WGI, chap 9
Based on Gleckler etal. (2008)

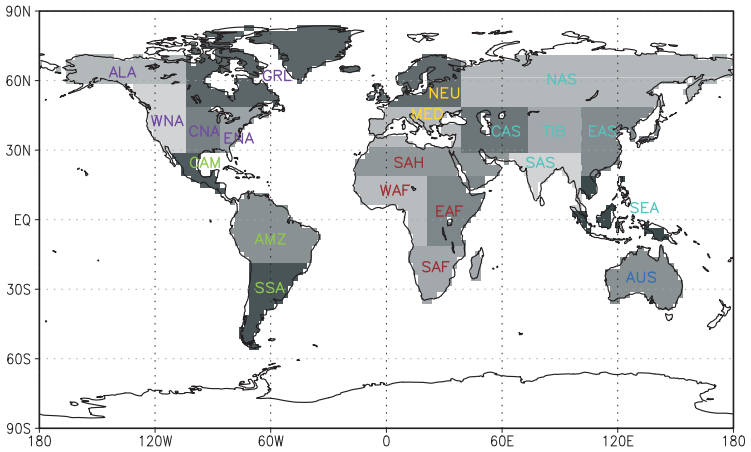
1980-2005
Space-time root mean square error

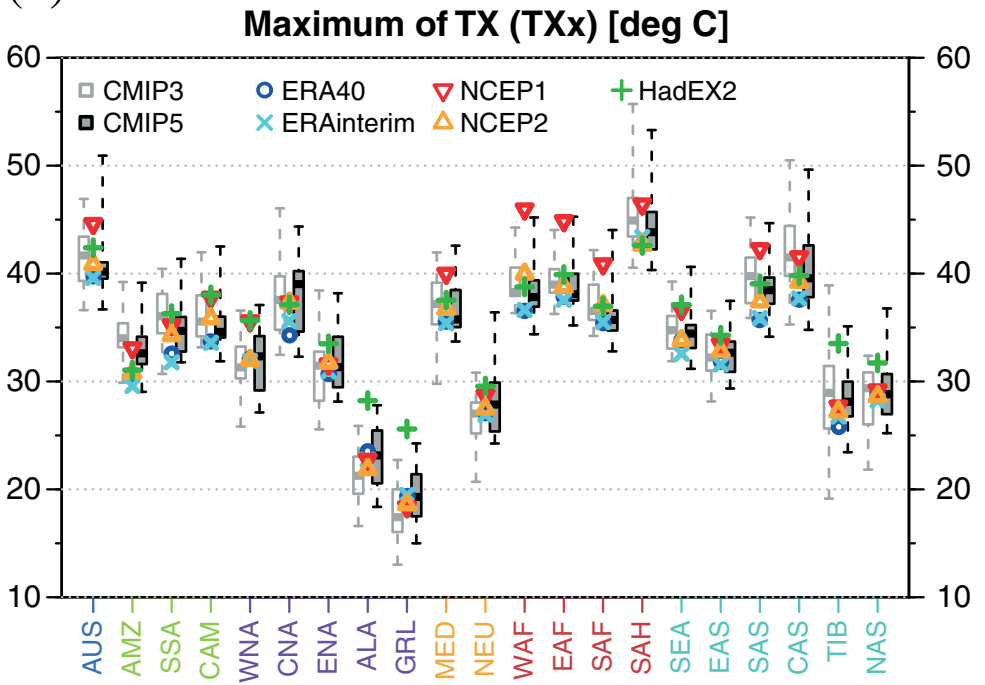
Normalized
Vs median error
Of all models

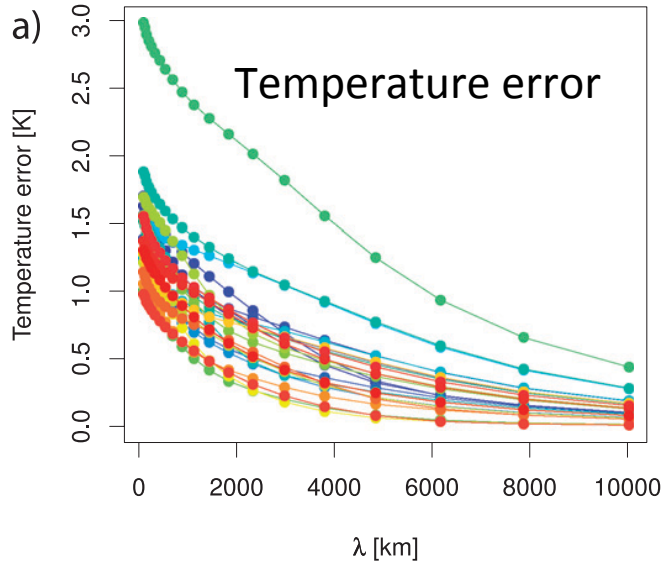


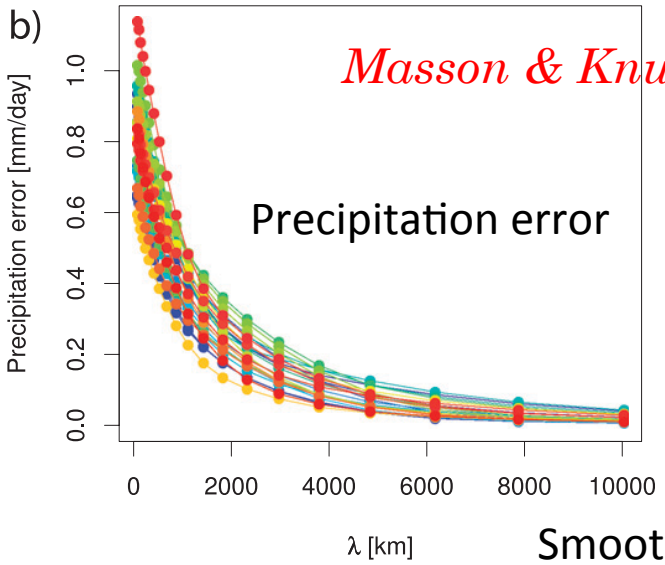
Good performance at large regional scale/ weak at smaller scale

Sillmann et al, JGR, 2013









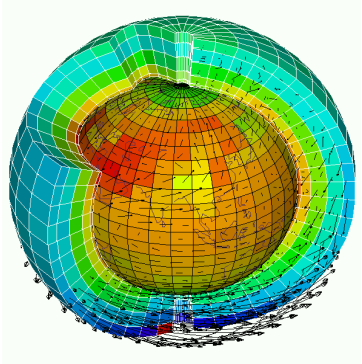
Masson & Knutti, J. Clim. (2011)

CMIP3
ERA 40/CMAP

Smoothing scale

Downscaling

Dynamical downscaling

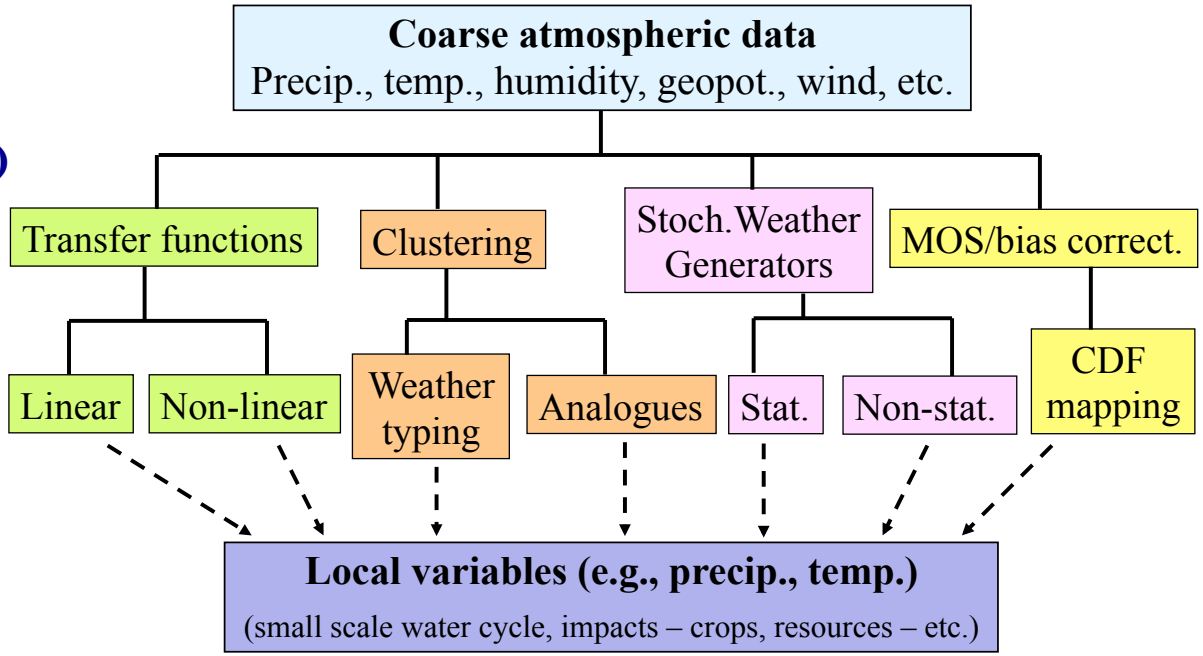


Global model (~100-200 km)

Regional climate model (~ 44-12 km)

Statistical downscaling &/or Bias corrections

Applied to GCMs or RCMs

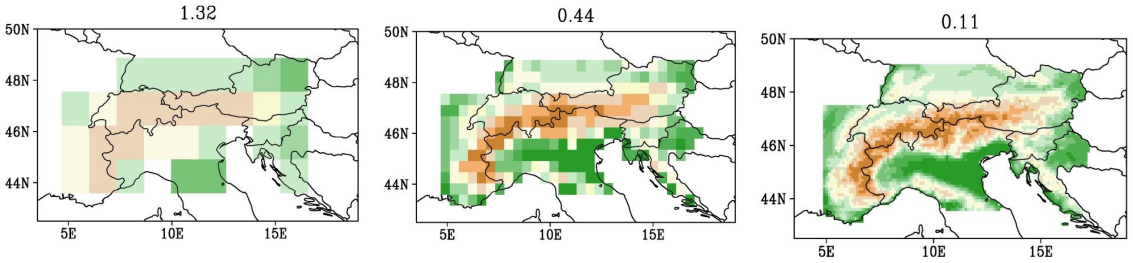


M. Vrac, pers. Comm.

See CORDEX talks
Daniela Jacob& Filipo Giorgi

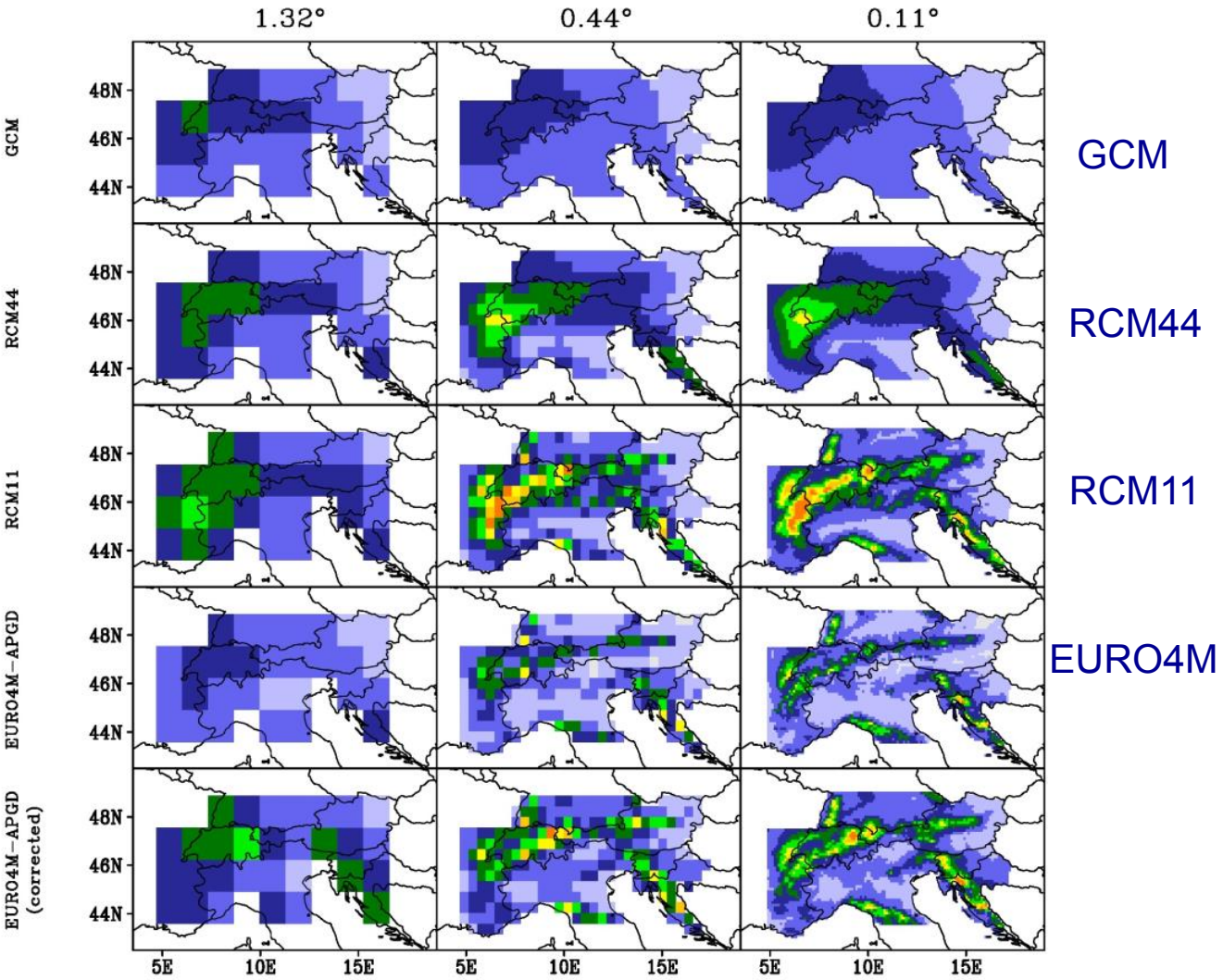
Added value of RCM

Alpine region topography



Precipitation DJF 1976-2005

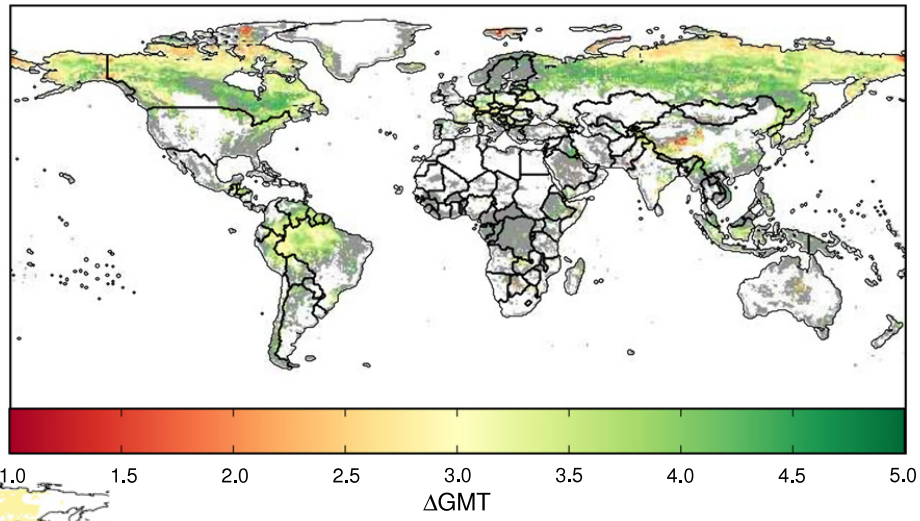
Torma et al., in rev
F. Giorgi pers. Comm.



Impact models: use of bias corrected GCM simulations

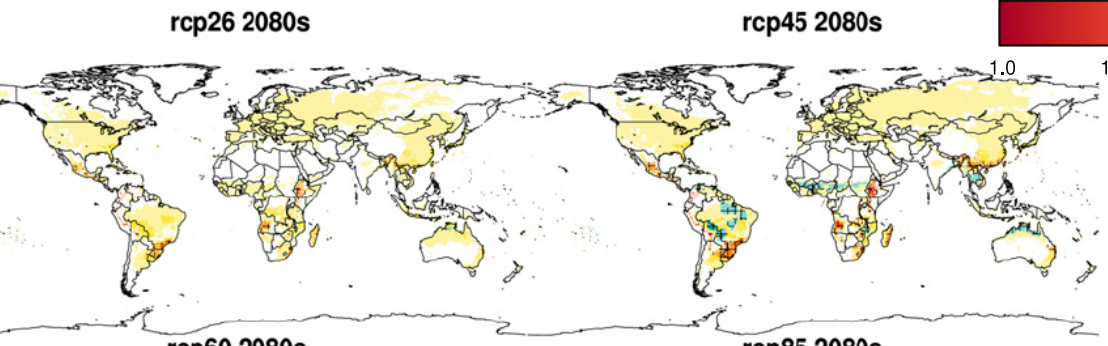
Inter_Sectoral Impact MIP

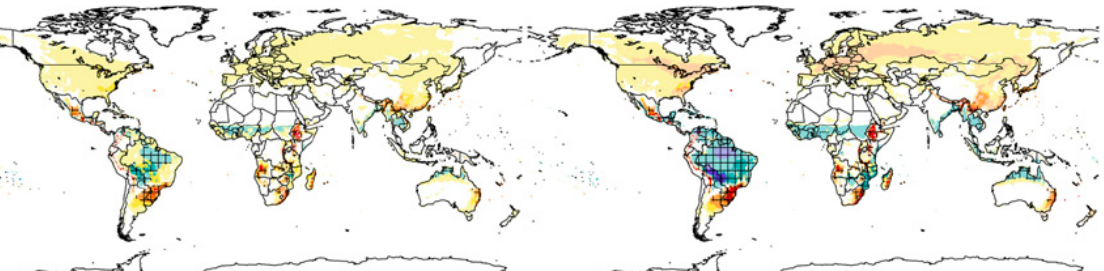
Temperature change
at which ecosystems are at severe risk of change
ISIMIP from CMIP5



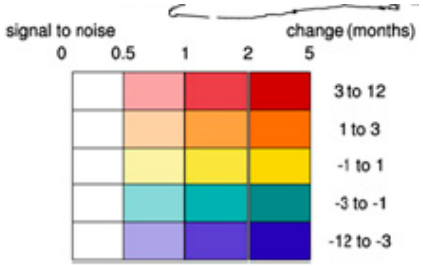
Warszawski et al. ERL (2013)

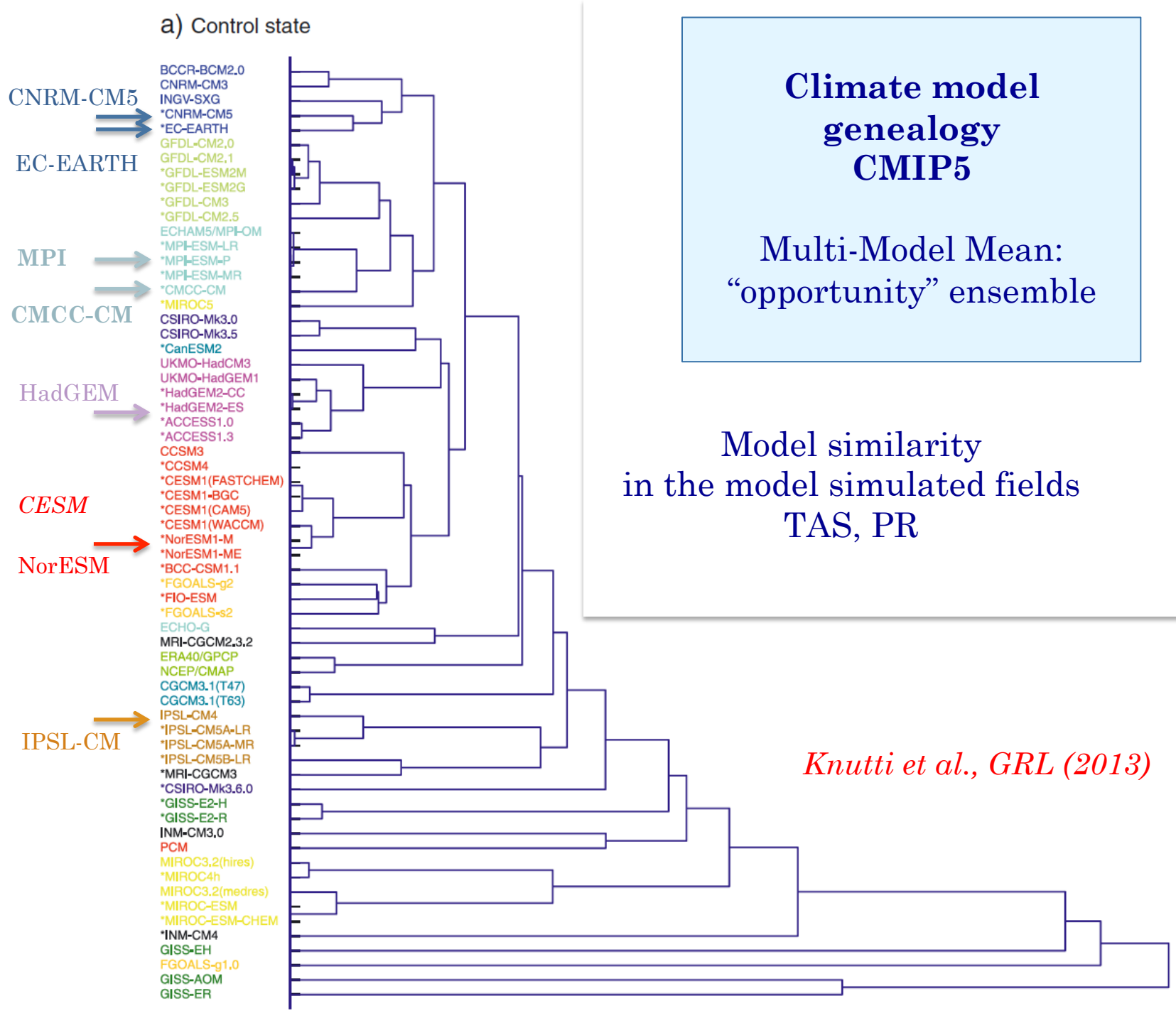
Impact on malaria distribution





Caminade et al., PNAS (2013)





Climate model genealogy CMIP5

Multi-Model Mean:
"opportunity" ensemble

Model similarity
in the model simulated fields
TAS, PR

Knutti et al., GRL (2013)

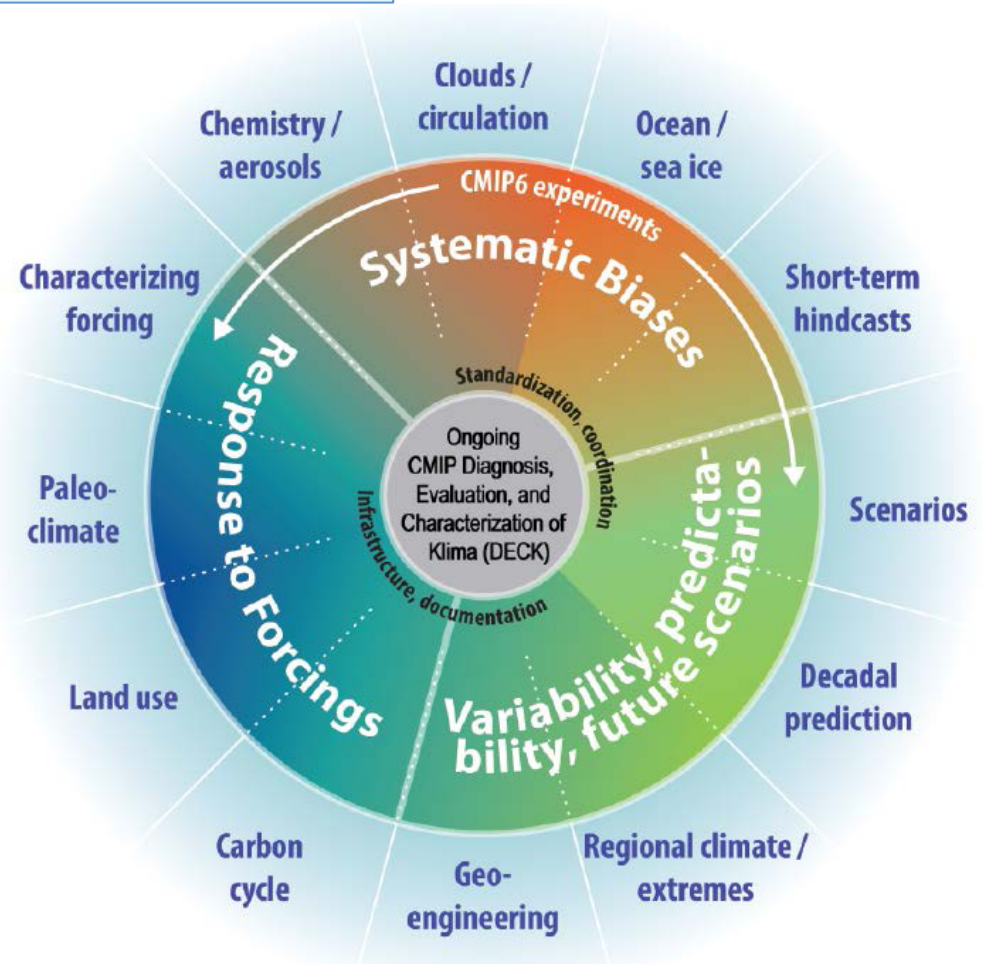
Perspectives

Working Group on Coupled Models

CMIP6
2015-2020

Meehl et al., EOS, 2014

Updated climate models
Improved resolution
Process studies to improve models



WCRP Grand Challenges: (1) Clouds, circulation and climate sensitivity, (2) Changes in cryosphere, (3) Climate extremes, (4) Regional climate information, (5) Regional sea-level rise, and (6) Water availability, plus an additional theme on “Biogeochemical forcings and feedbacks”

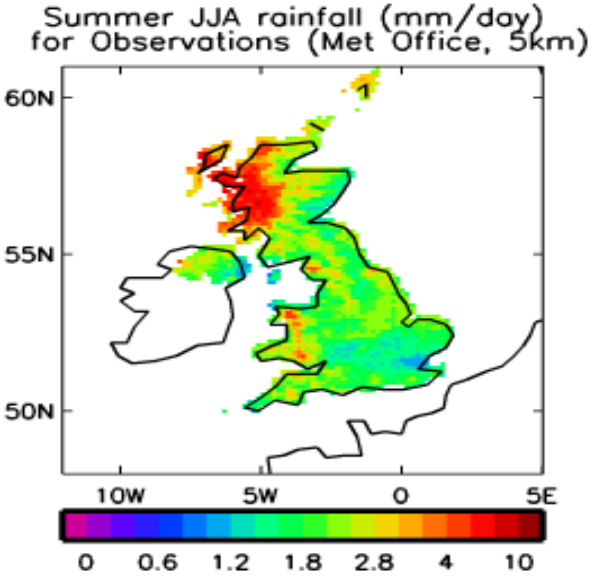
Towards higher spatial resolution

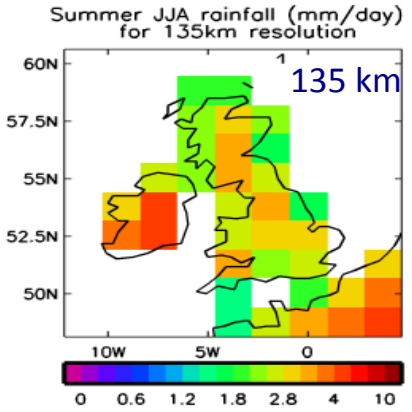
Summer precipitation 2005 Simulations
global climate model HADGEM3
Resolutions 135km → 12km
PRACE UPSCALE project

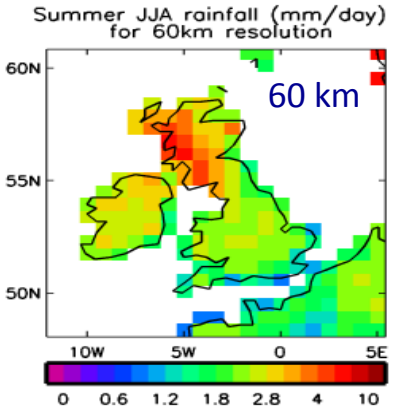
HiResMIP :
investigate 25 km resolution
1950-2050 - AMIP / Coupled
R. Haarsma& M/ Roberts

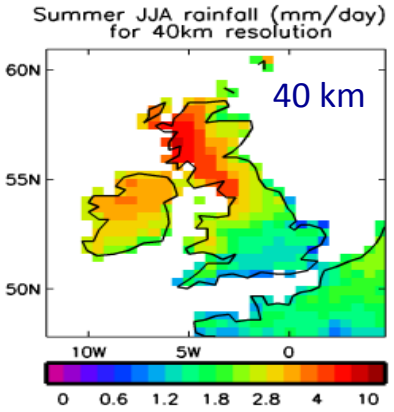
H2020 PRIMAVERA Project
M. Roberts & P.L. Vidale

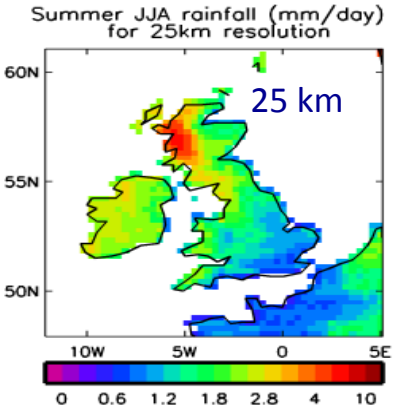
Observations

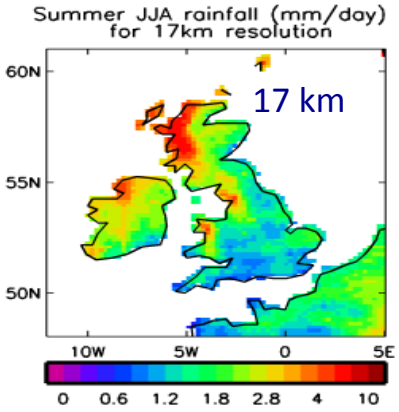


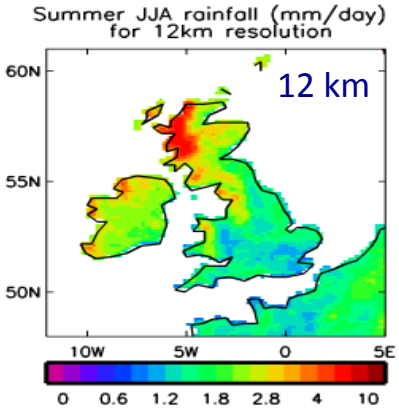












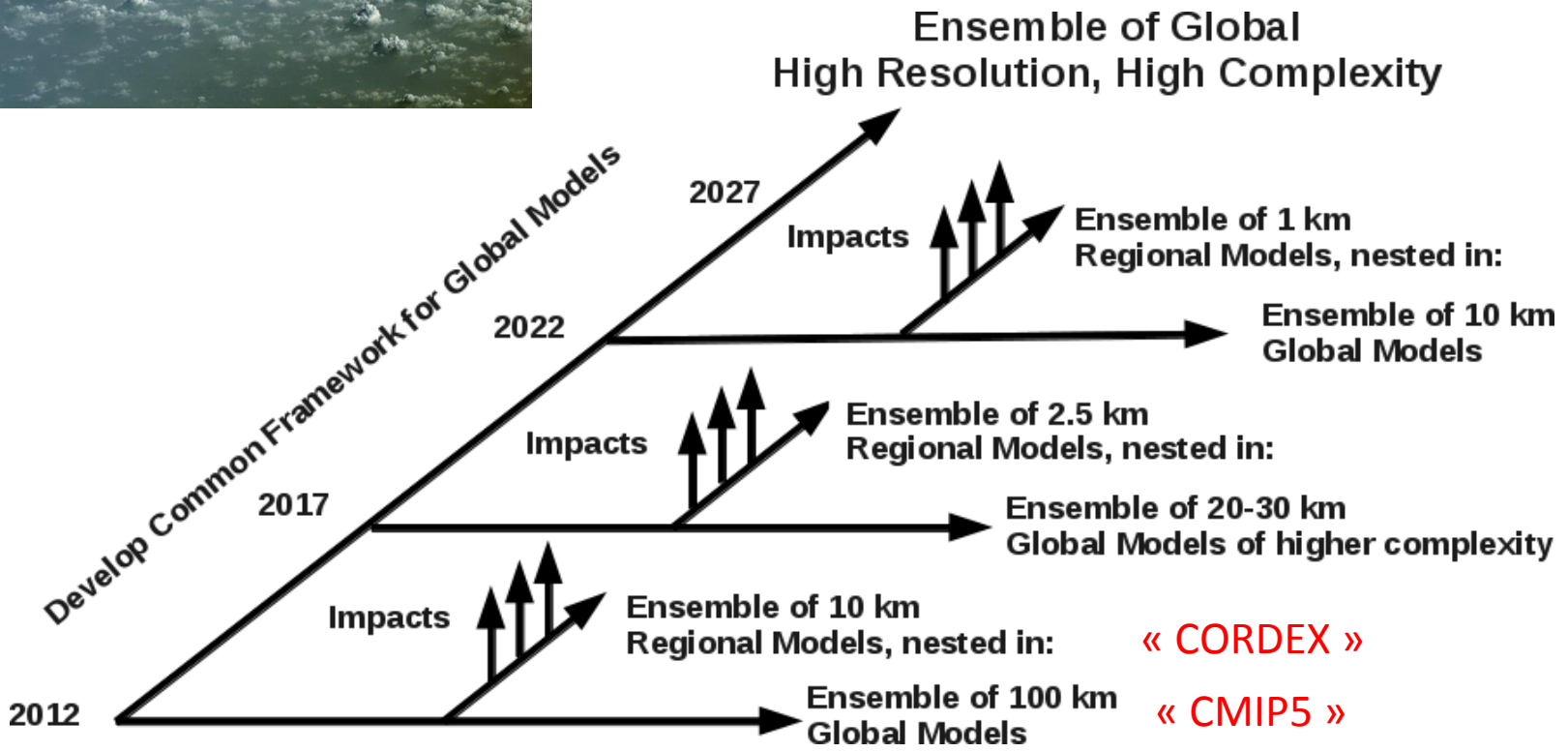
Courtesy ofPL Vidale (NCAS) & M. Roberts (MO/HC)

enes
EUROPEAN NETWORK
FOR EARTH SYSTEM MODELLING

http://enes.org/

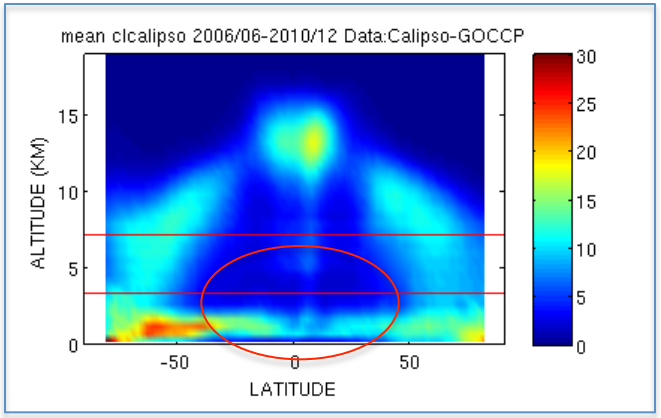
Infrastructure Strategy Roadmap

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

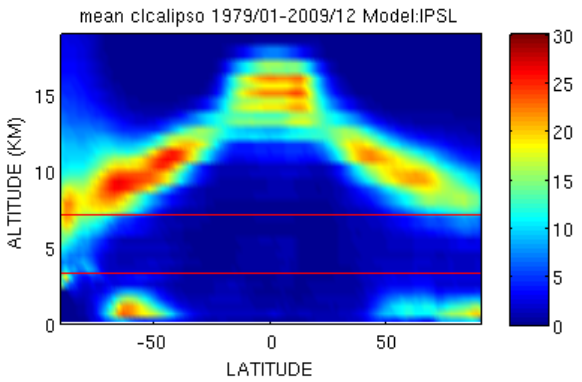


Need to improve model parameterisations e.g. clouds

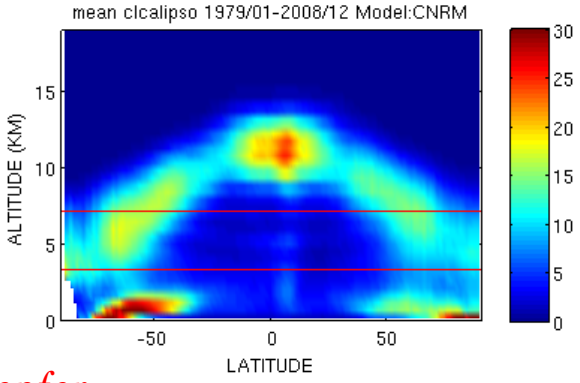
Observations
CALIPSO-GOCCP

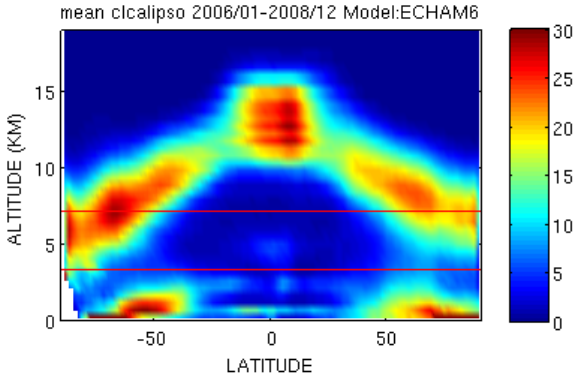


Models

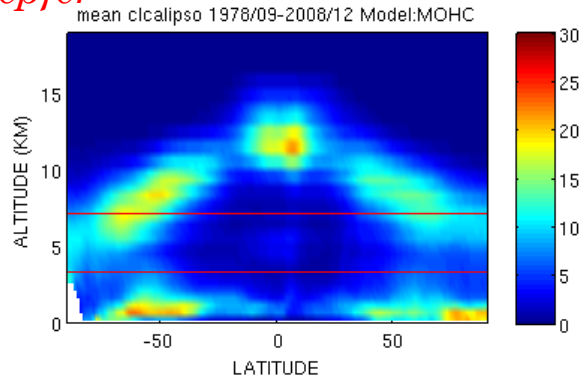


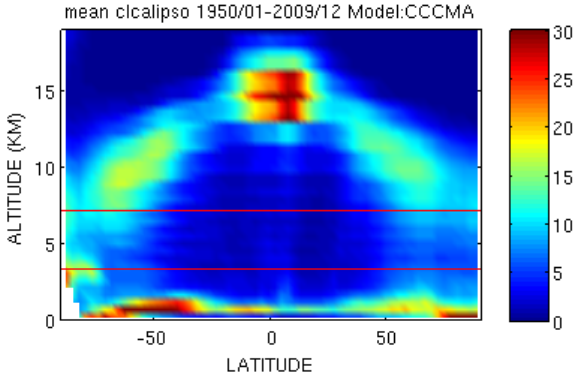
Models





Cesana and Chepfer GRL, 2012

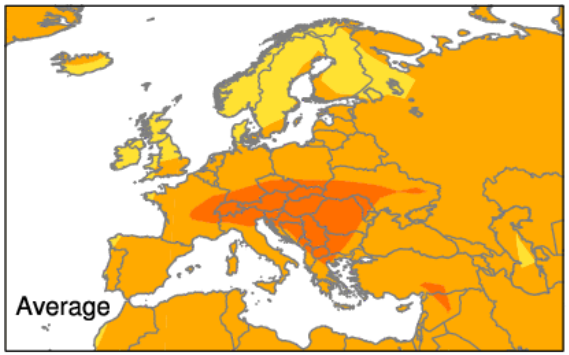


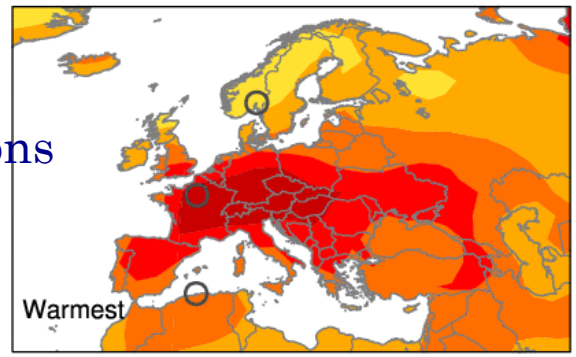


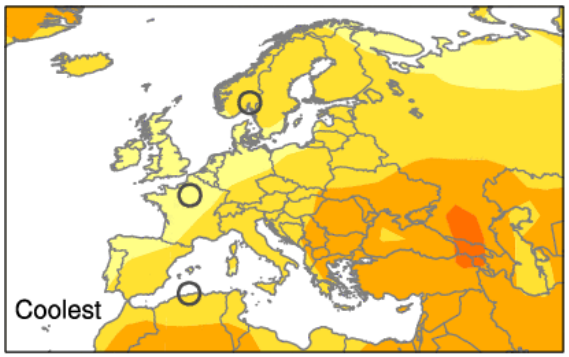
Better documented uncertainties associated with internal variability

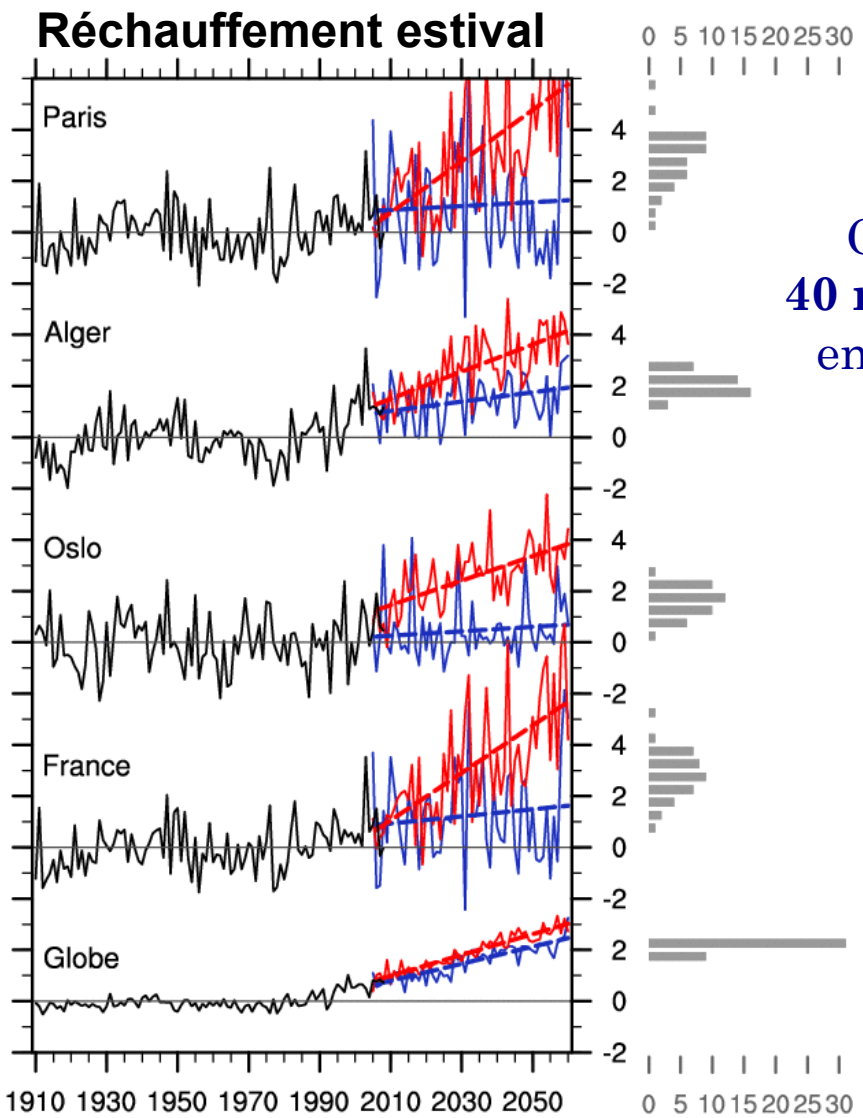
L. Terray, Workshop Adaptation and uncertainties, June 2012, http://www.gisclimat.fr

Simulations









CESM
40 member
ensemble

Deser et al., 2012, Nature Climate Change

IS-ENES, Circle2 Eranet and EEA

Data needs for the impact community

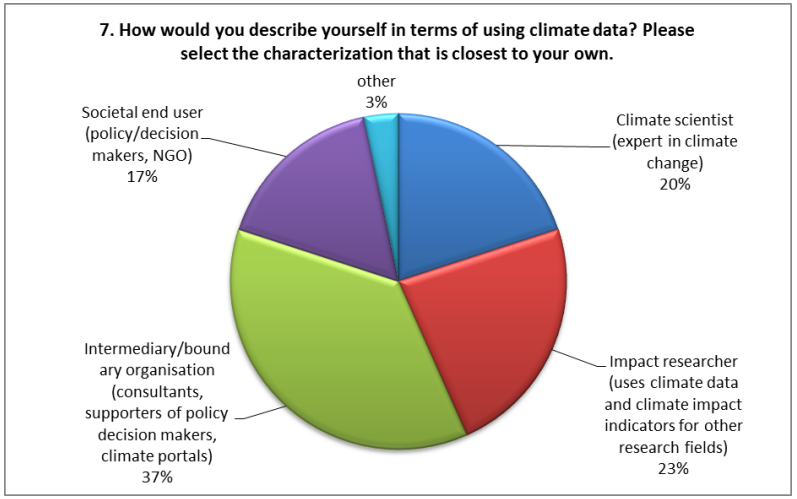
Copenhagen, 11-12 january 2011

Access to both global and regional climate change simulations
Need for processing tools and processed data
Provide guidance on uncertainties and how to use climate models results
Eventually provide different sources of information in one linked system
Improve access to data and training

IS-ENES Climate4impact portal

- Need multiple access routes – uncluttered for the expert user, with detailed guidance and explanation of options for others;
- Clear need for a stable interface – research project portals which come and go will not meet user needs;
- Regular data updates;
- Clear guidance;
- Multiple data formats;
- Etc;

Climate Information Portal



Summary

Strengths

Coordinated large ensemble:
- Better ensemble mean, range of uncertainty
- Set of consistent experiments
- Well evaluated

Source for downscaling, computation of various indicators

Infrastructure**:** common database with common standards for data & metadata

Weaknesses / Limitations

Limited resolution, better at large regional scale (>2000 km)

Biases
- Downscaling & bias corrections
- CORDEX added value - Also with limitations

Perspectives

New CMIP6 set: increased model resolution, improved processes
- CMIP6 and beyond: future global coupled simulations at 25 km
- Strong limitations of computing power

C3S Access to projections : CMIP as a strong basis
- Overview of climate changes – complemented by CORDEX
- Source for tailored downscaling and indicators
- Need for guidance


Thank you !
SeaWIFS Project (NASA/GSFC et Orbimage)