

# THE CMIP PROCESSES IN CESM : From Spin-up to the ESG

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**NCAR Earth System Laboratory (NESL)**



CESM is sponsored by



**The National Science Foundation**



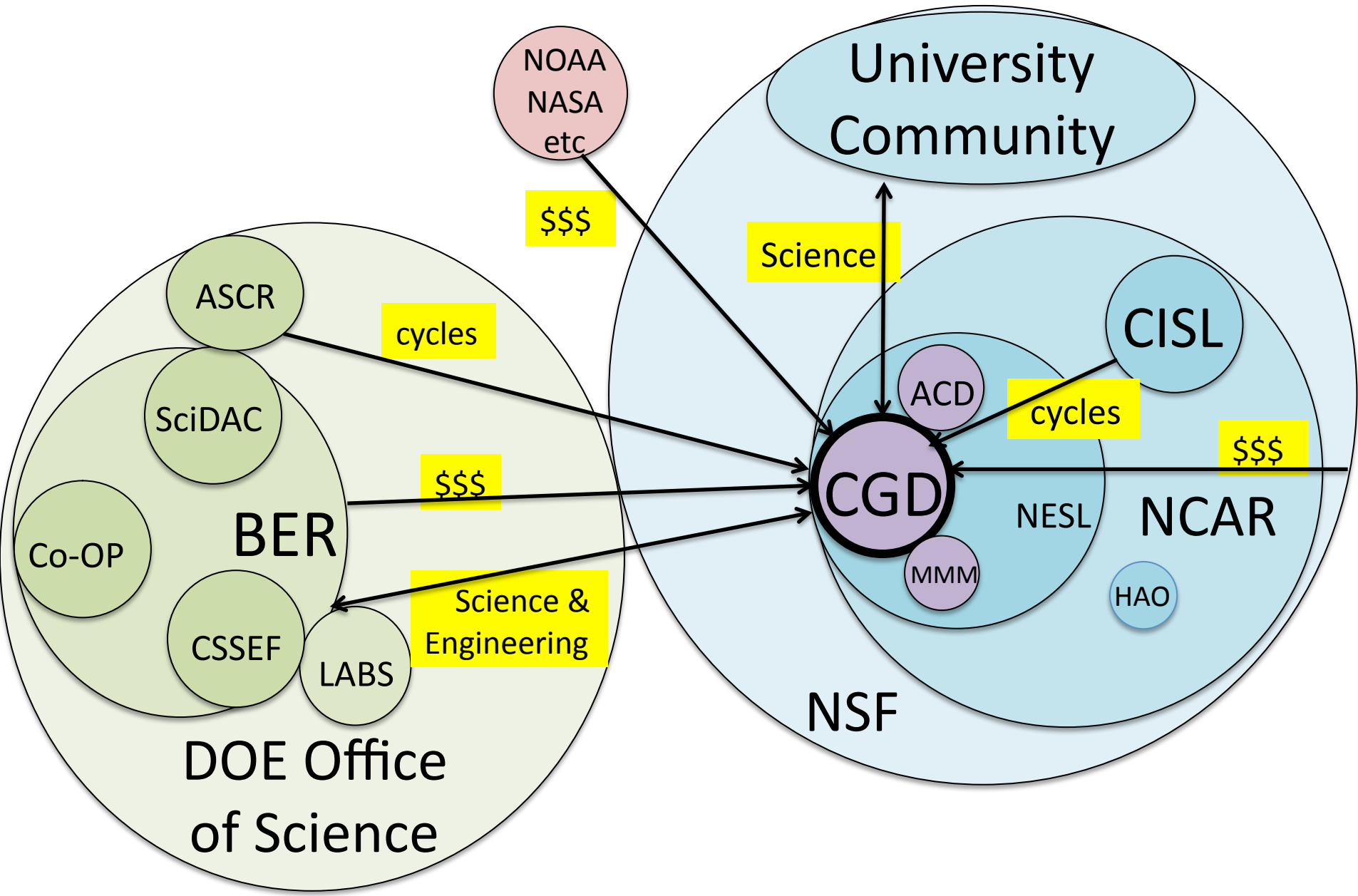
**U.S. DEPARTMENT OF  
ENERGY**

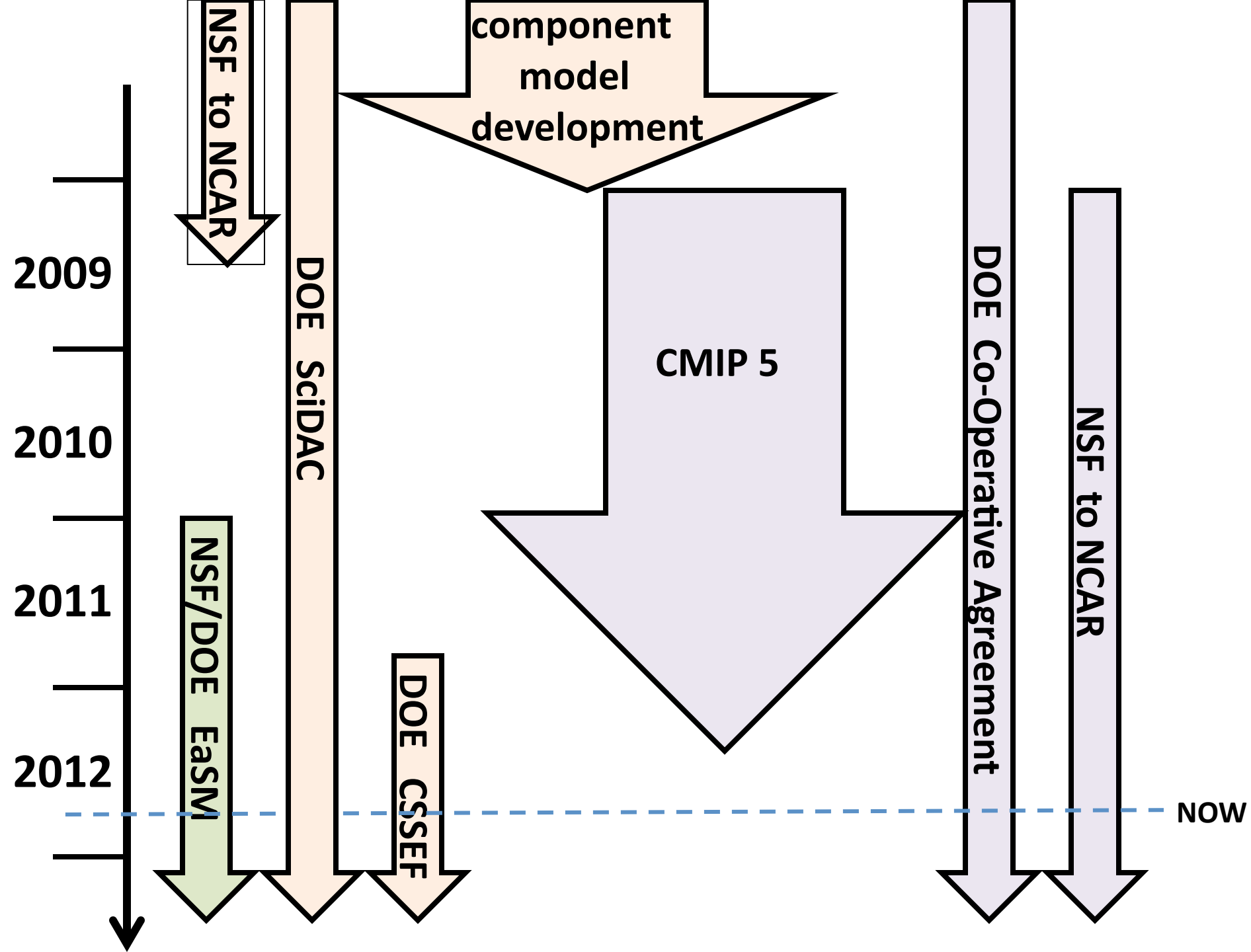
**Office of Science**

# Outline :

- Background State
- CMIP 5
- Post-Mortem: A Guide to the Future

# THE CESM UNIVERSE





# CMIP5

-- CCSM4

-- CESM1 (CAM5, BGC, WACCM, CAM-CHEM)

- Schedule and Secure Resources
- Component Coupling
- Spin-up (1850) → Pre-industrial Control
- 20<sup>th</sup> Century Ensembles
- Future Scenarios (4); Ensembles
- Publication ( J. Climate, JHPC)
- Extensions to 2300, Decadal Predictions
- Data to Earth System Grid

# Computational Resources (CMIP5/AR5)

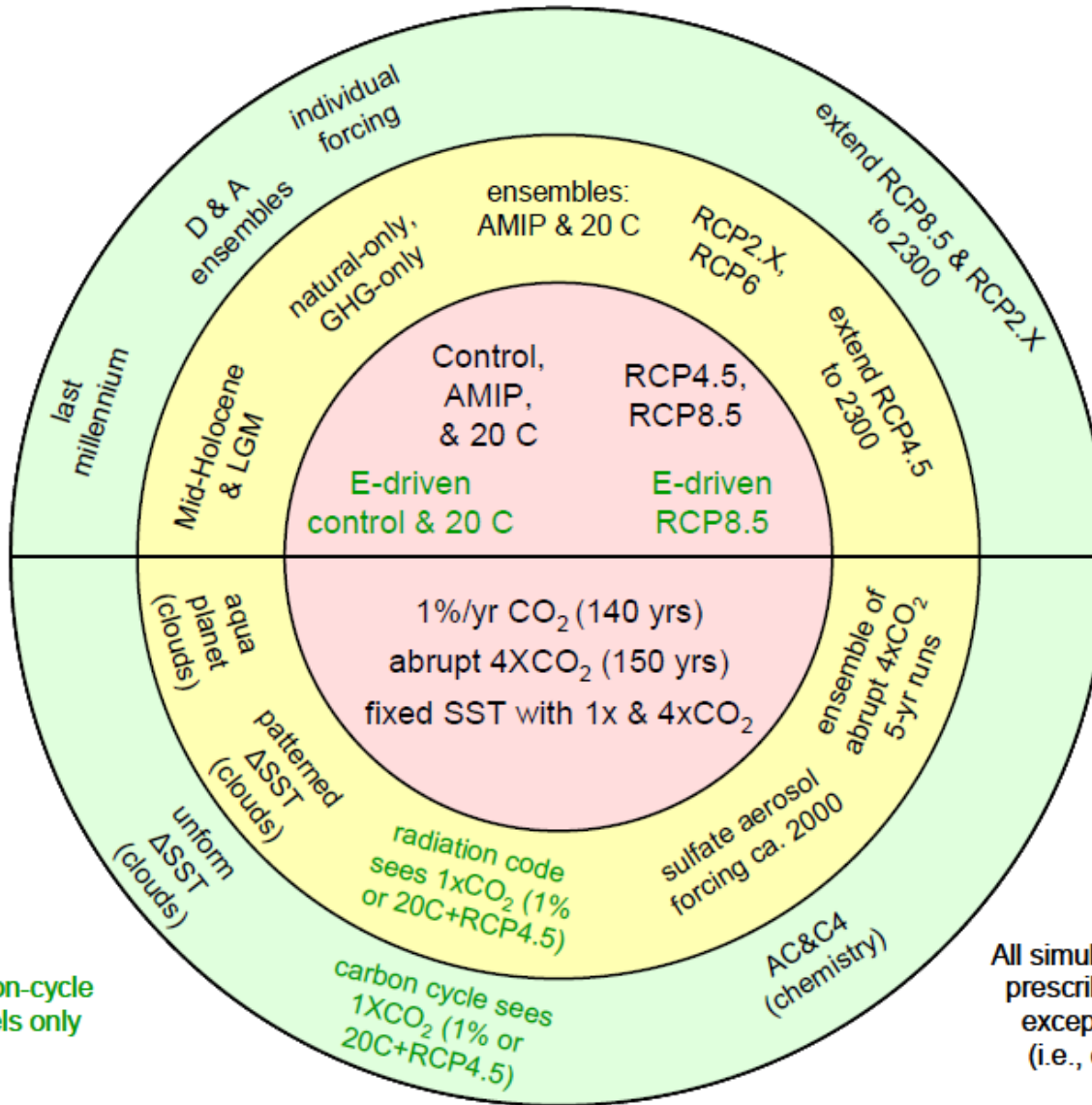
DOE cycles

**Tier 1  
High Res**

**Tier 2  
High Res**

NCAR/CISL/CSL

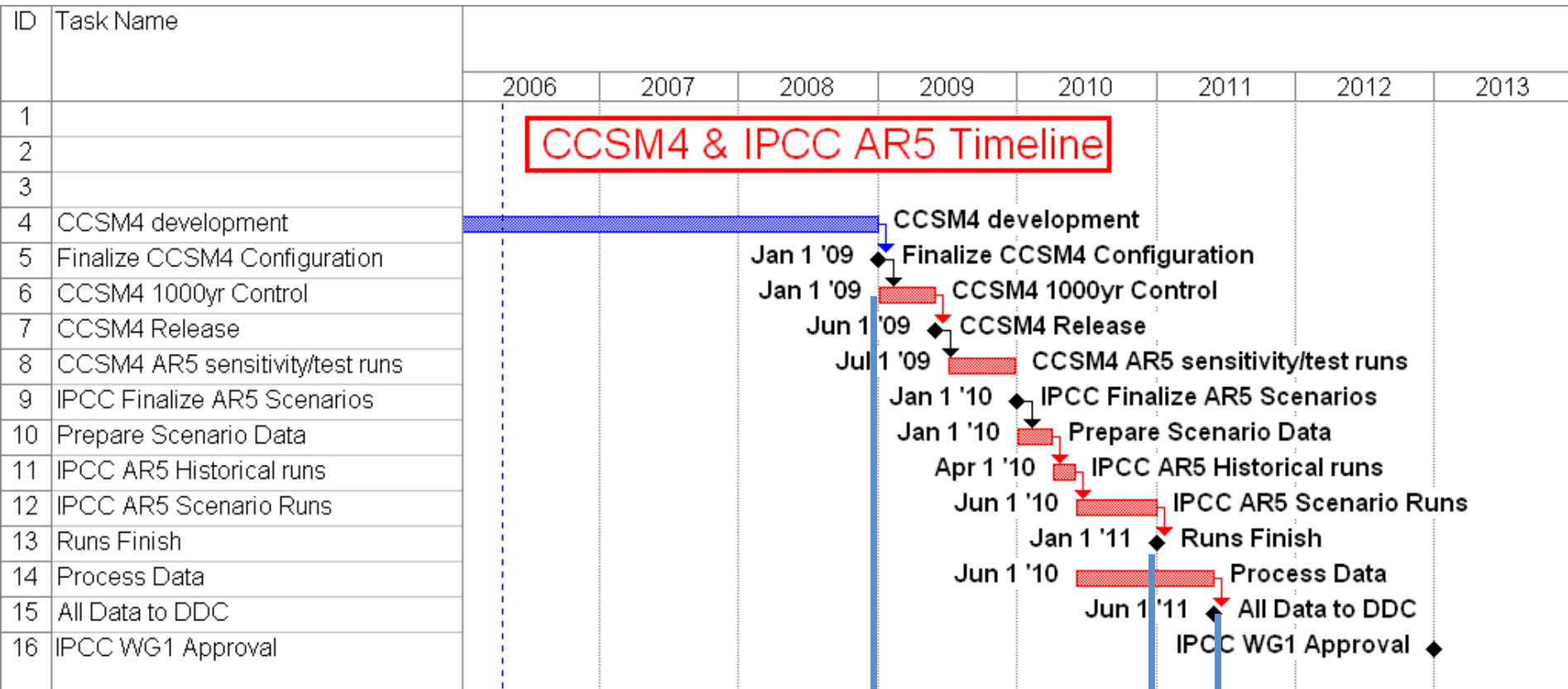
**CORE  
(Standard Res)**



Coupled carbon-cycle climate models only

All simulations are forced by prescribed concentrations except those "E-driven" (i.e., emission-driven).

# Implementation Plan for the CCSM 4, February 2008



**IN REALITY**

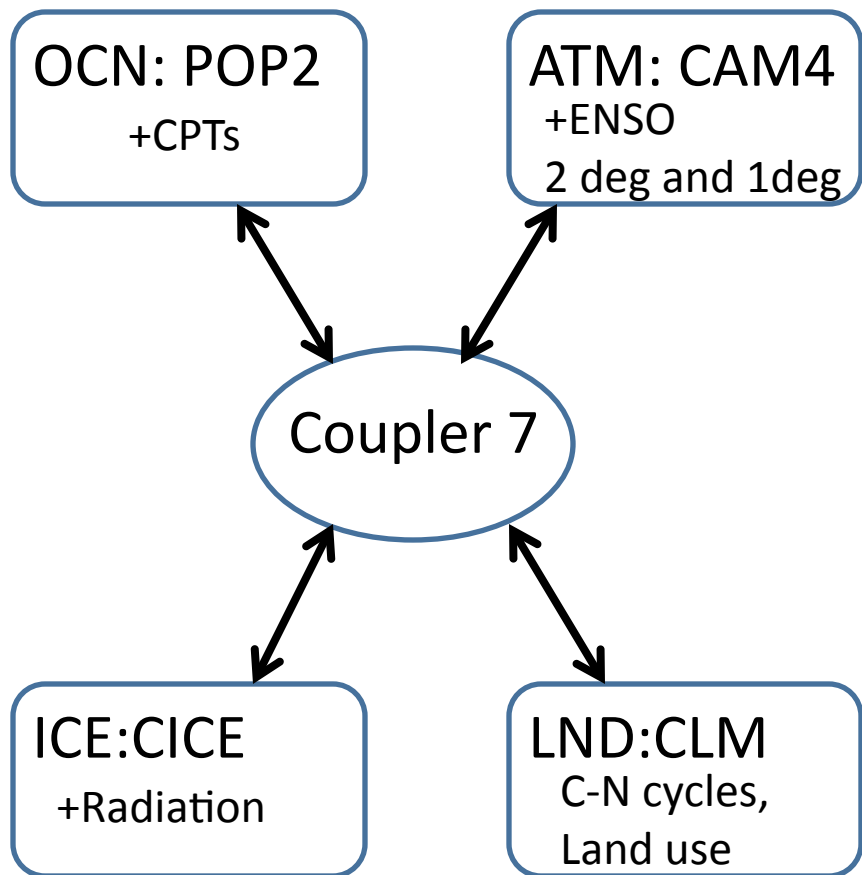
**CMIP5**

**CCSM4**

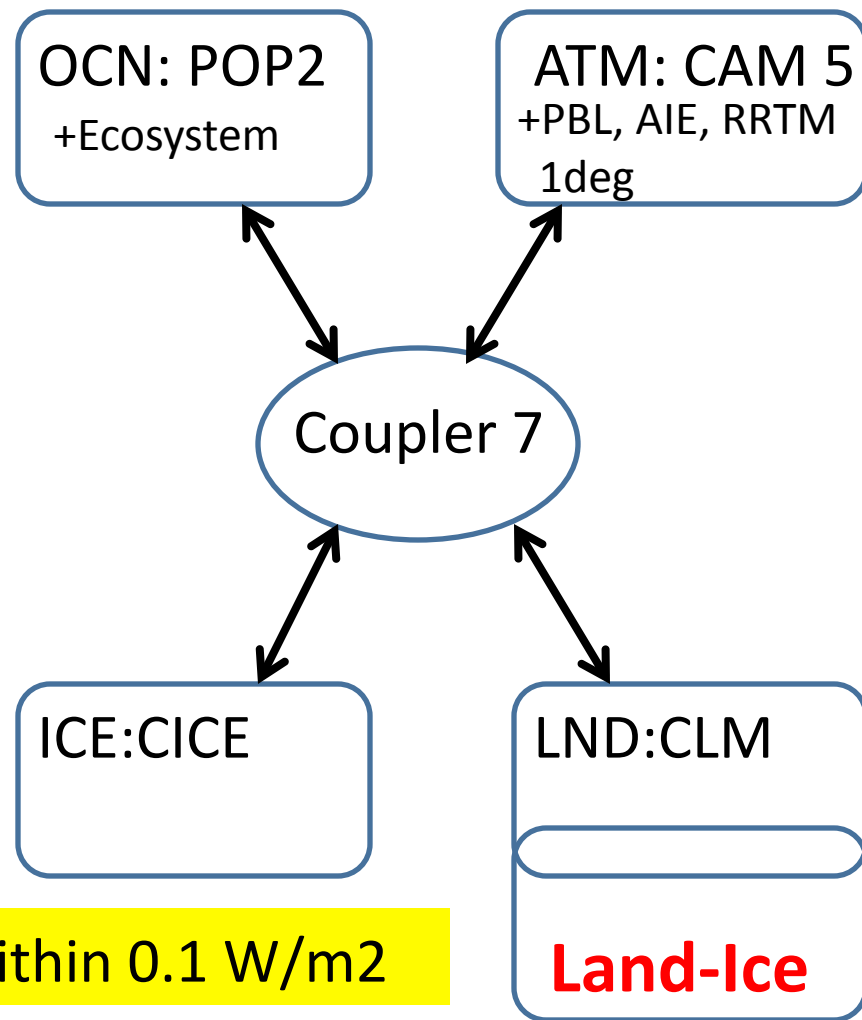
**CESM**

# Component Coupling

CCSM4



(WACCM)  
CESM1 (BGC)  
(CHEM)

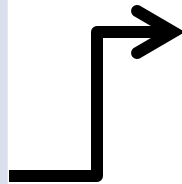


Target: Balance TOA Energy to within 0.1 W/m<sup>2</sup>



# Pre-industrial Spin-up & Control

	CCSM4 CESM1
TOA	Several 100yr runs
Sea-ice	
Control	1300 yrs
Ensemble Branches at 863, 893, 934 983, 1031	

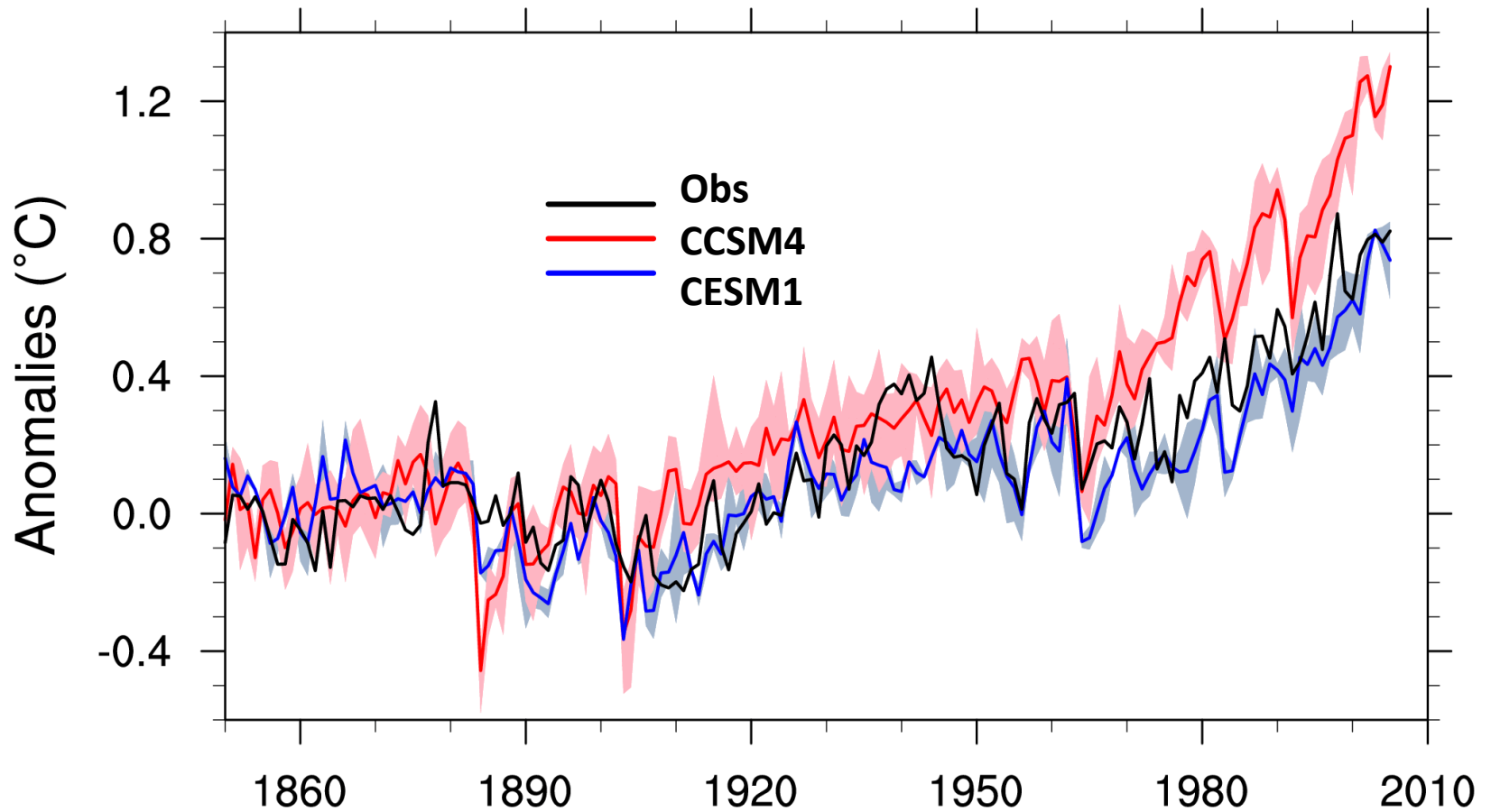


CESM1 (BGC)	
Ocean	Land
Decoupled Spin-up	
5 yr repeat	30 yr
900 yrs	690 yrs
CO2 flux=0	Nitrogen
1000 yr control	
Ensemble Branches	

CESM1 (WACCM) (CHEM)	
2 degree ATM	

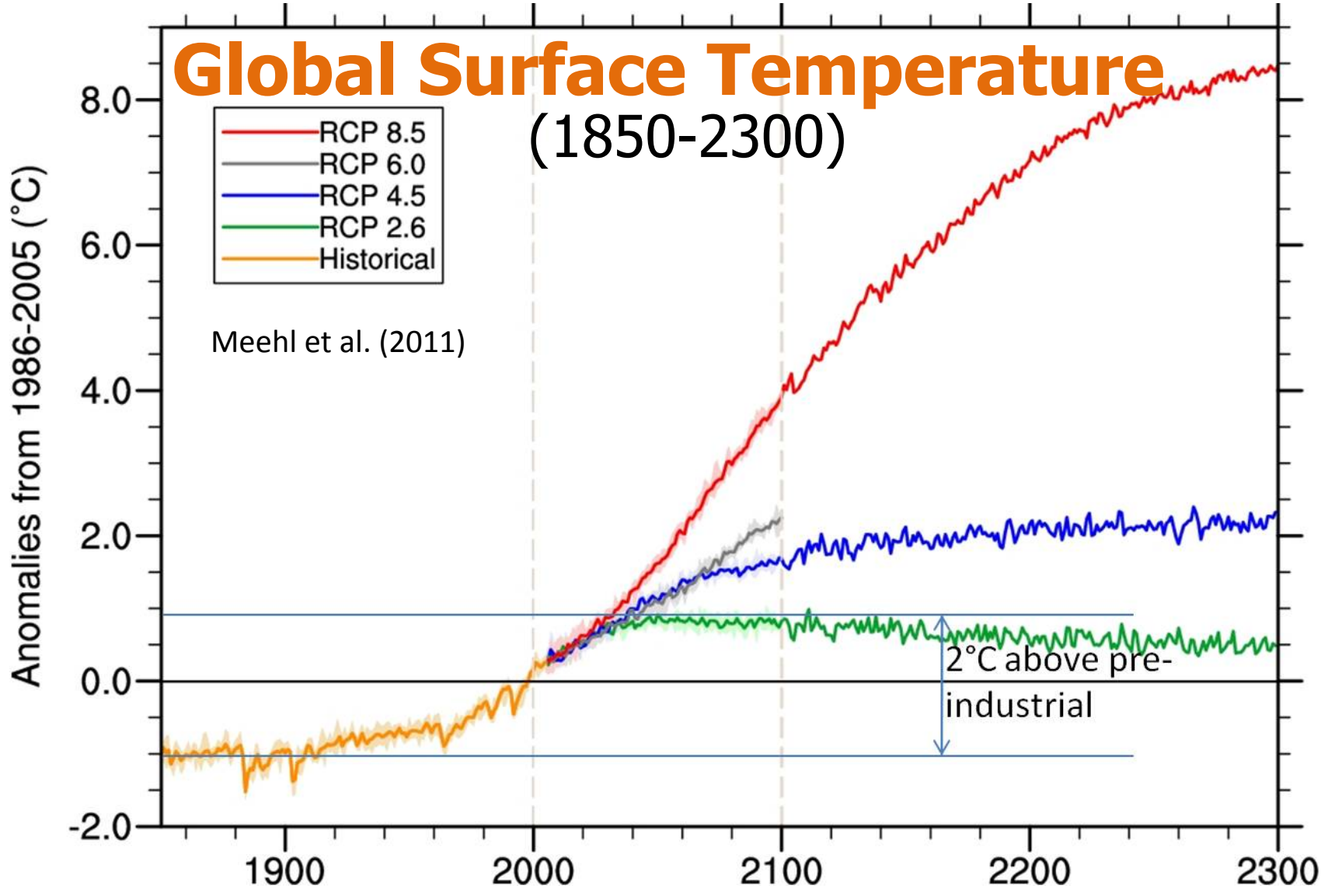
# 20<sup>th</sup> Century Ensembles

CORE  
(Standard Res)



# Future Scenarios

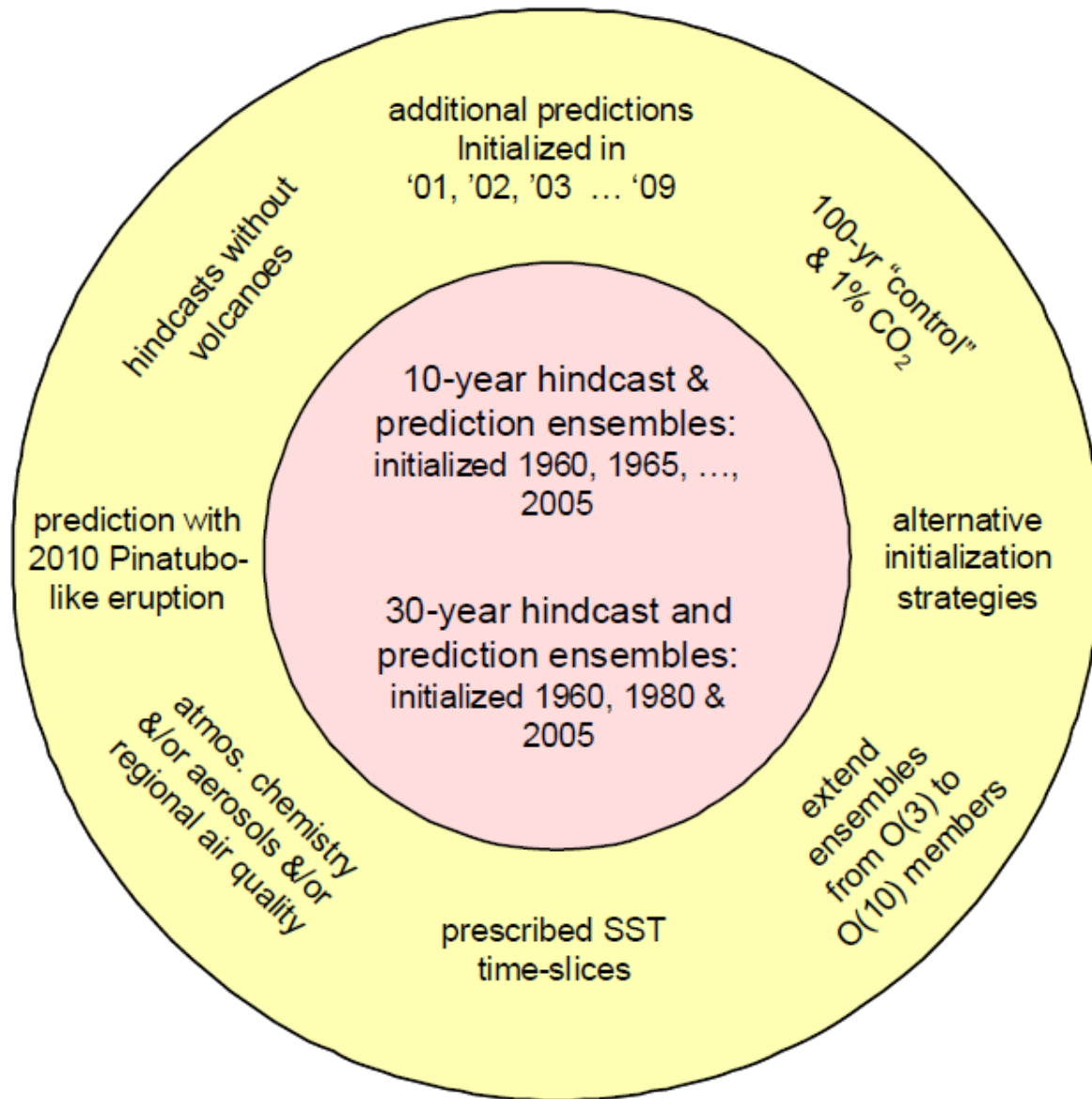
CORE  
(Standard Res)



# Publications: 78 in 3 Special Issues/Collections

Working Group	CCSM4 J. Climate	CESM1 J. Climate	J.H.P.C Feb 2012
Joint	4	4	
Atmosphere Model	4	10	
Ocean Model	7	2	
Land Model	4		
Polar Climate	5		
Climate Change	4		
Climate Variability	5		
Paleo Climate	4		
Software Engineering			8
Whole Atmosphere		4	
Land Ice		3	
Chemistry Climate		2	
Bio-Geo-Chemistry		8	
	37	33	8

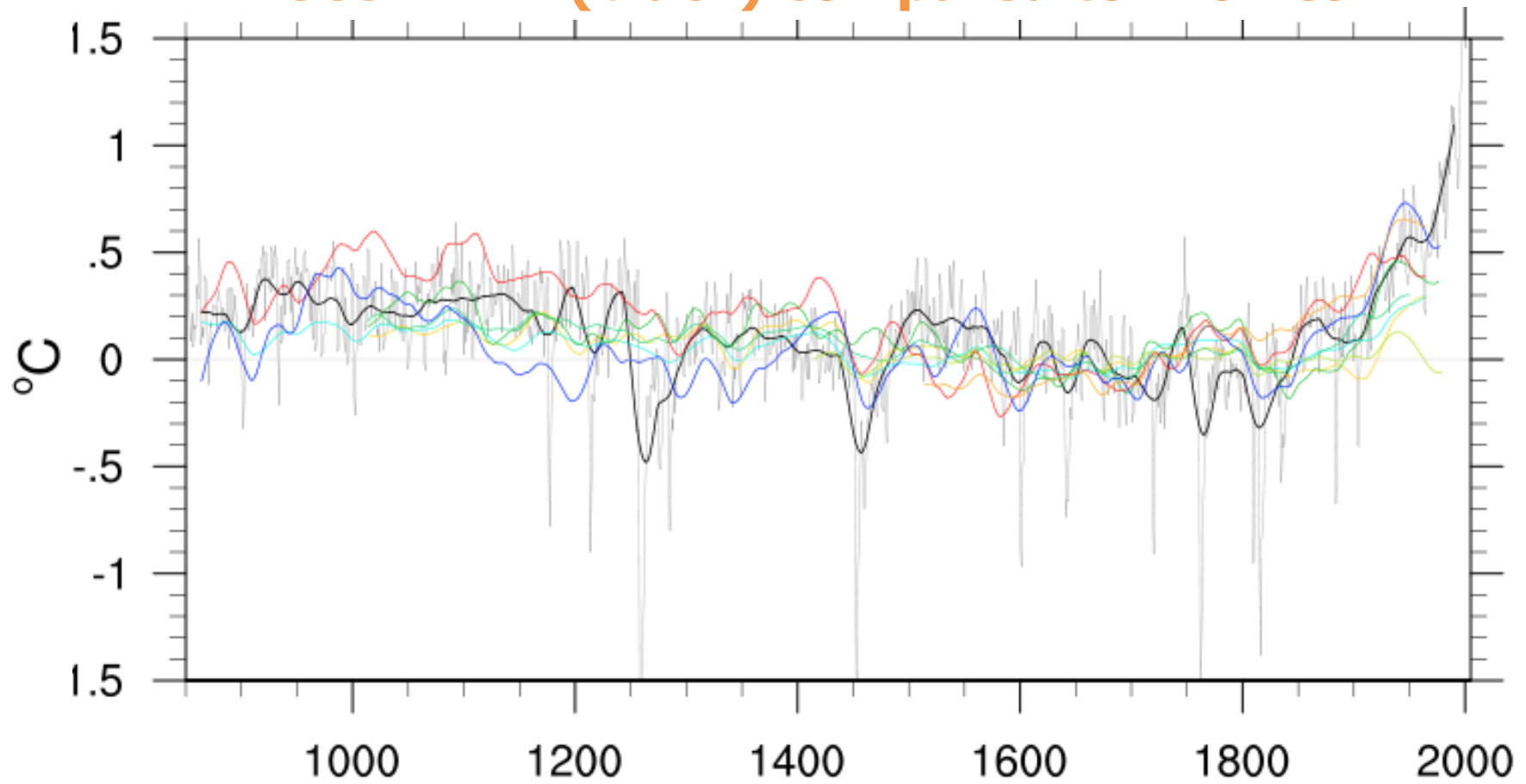
# Extensions/ Predictions



# Northern Hemisphere Temperature (Last Millennium 850-2005)

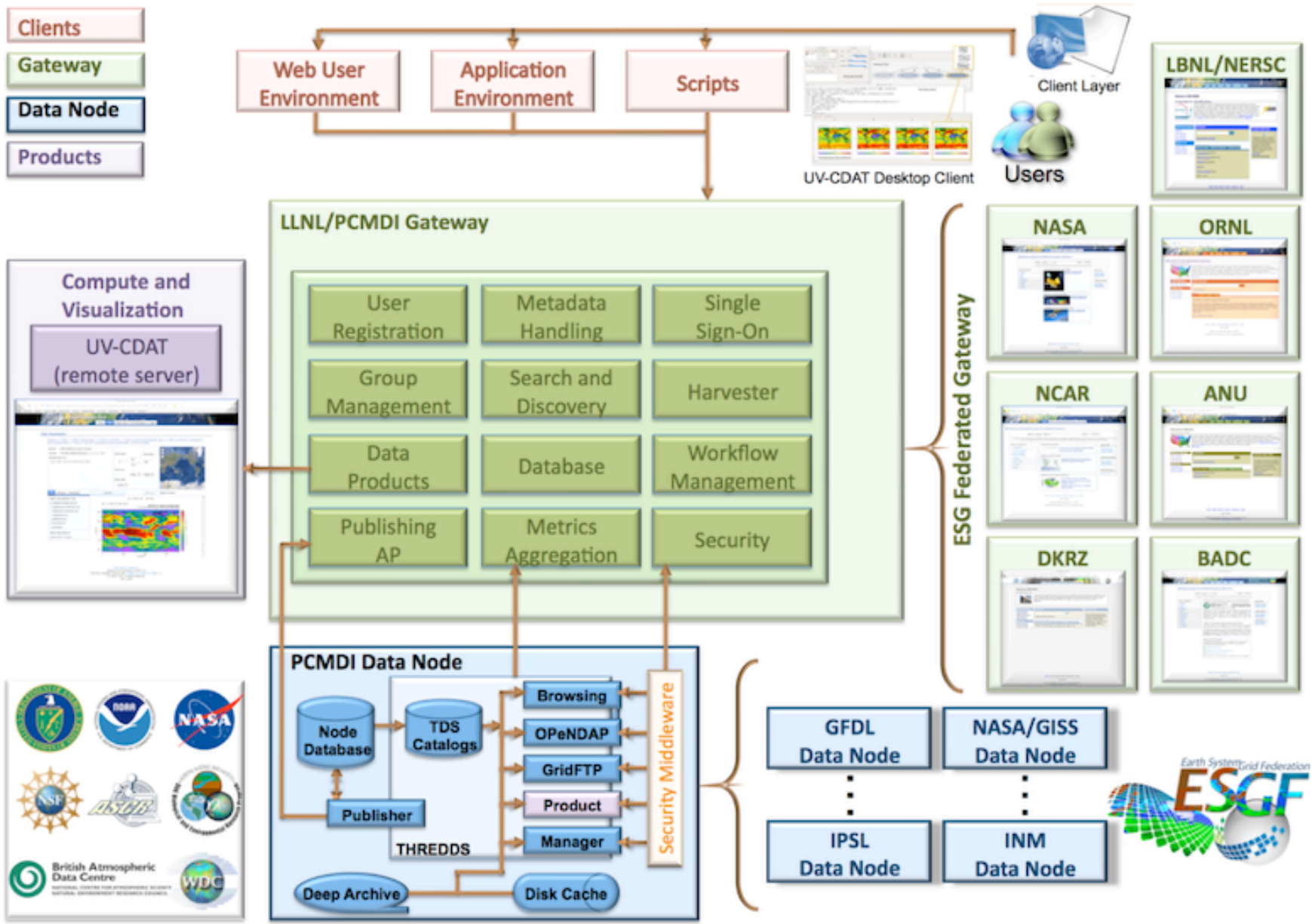
Tier 2  
Low Res

CCSM4 1° (black) compared to Proxies

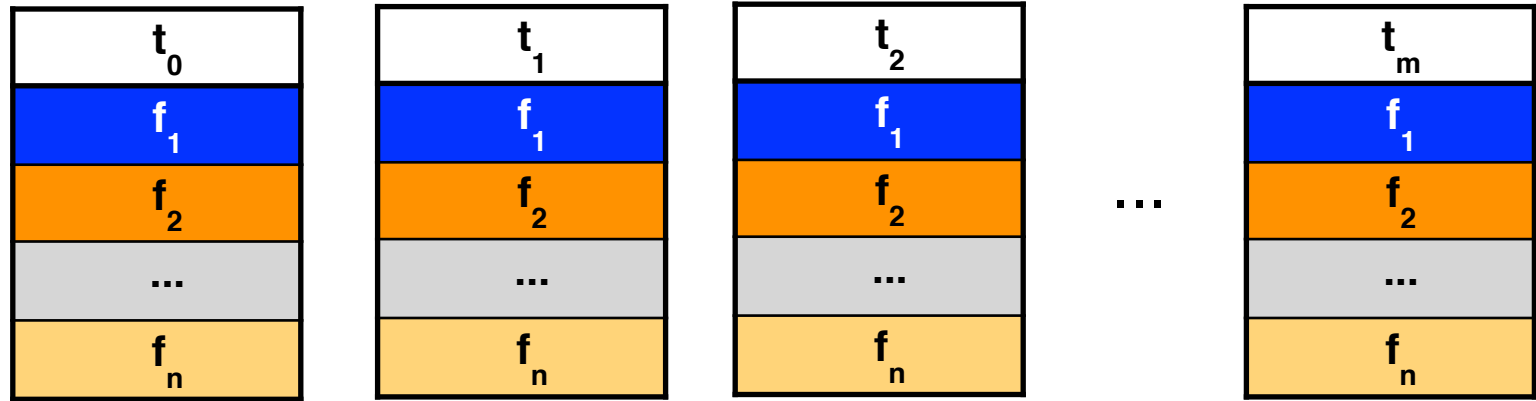


Courtesy Bette Otto-Bliesner

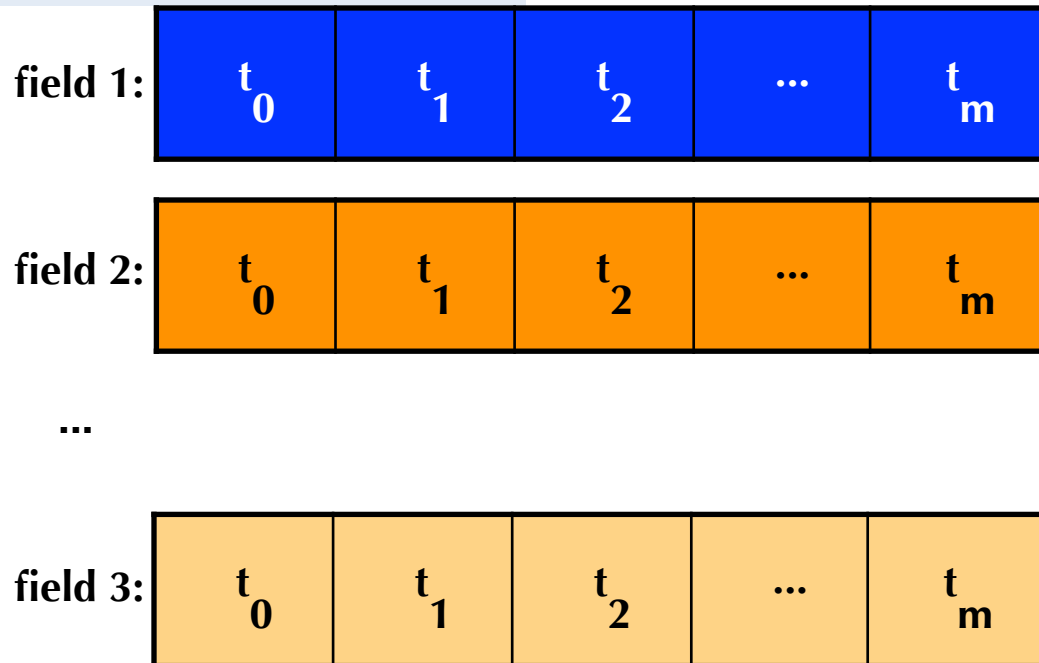
# The ESG Federation



# CESM output data arrangement

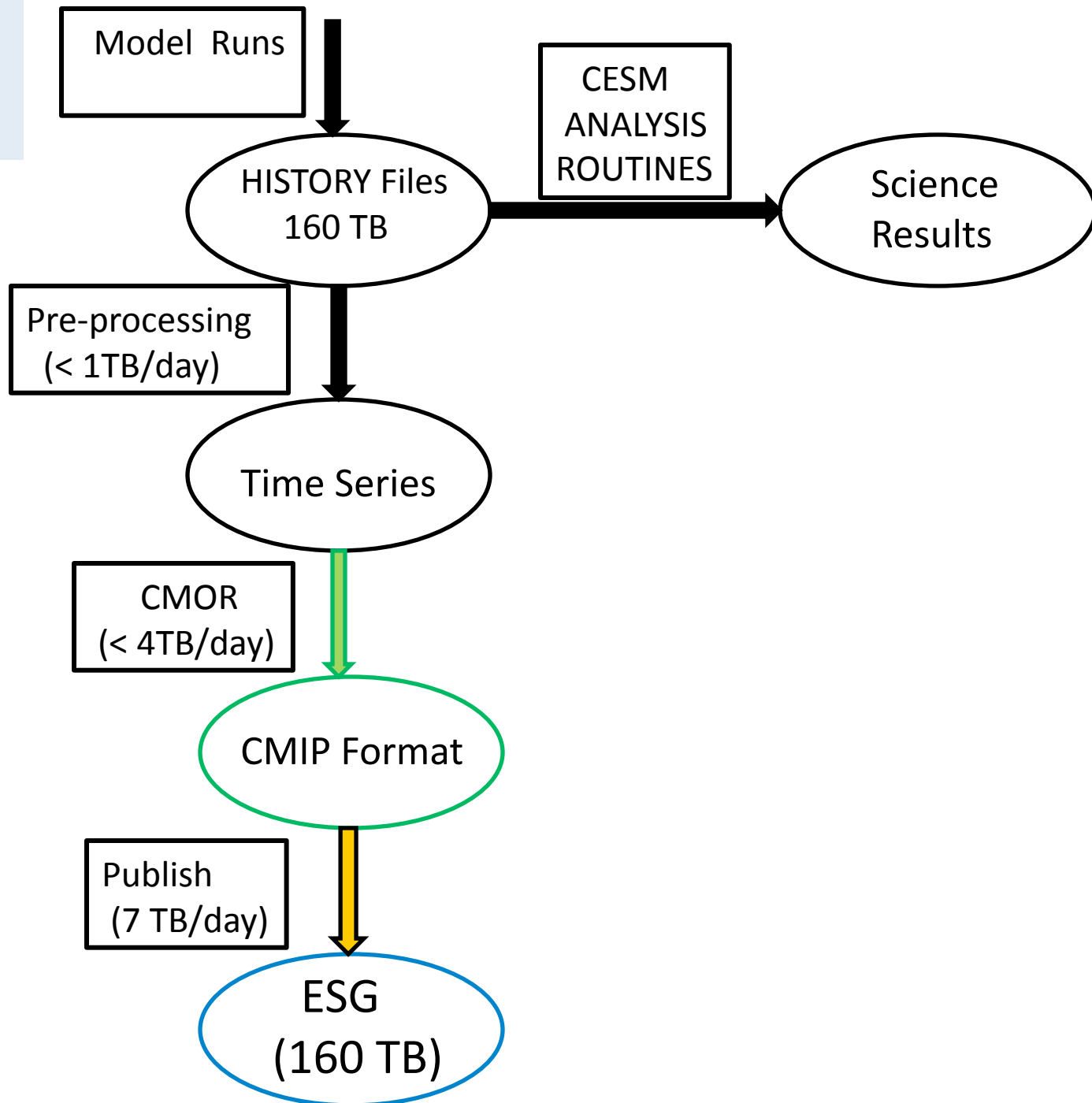


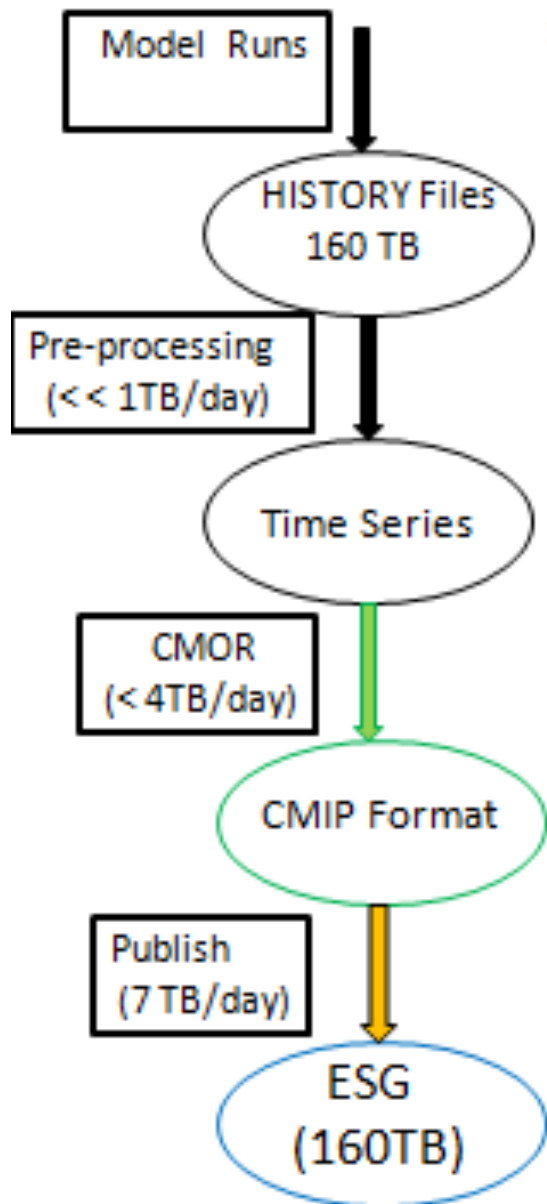
# CMIP5 arrangement



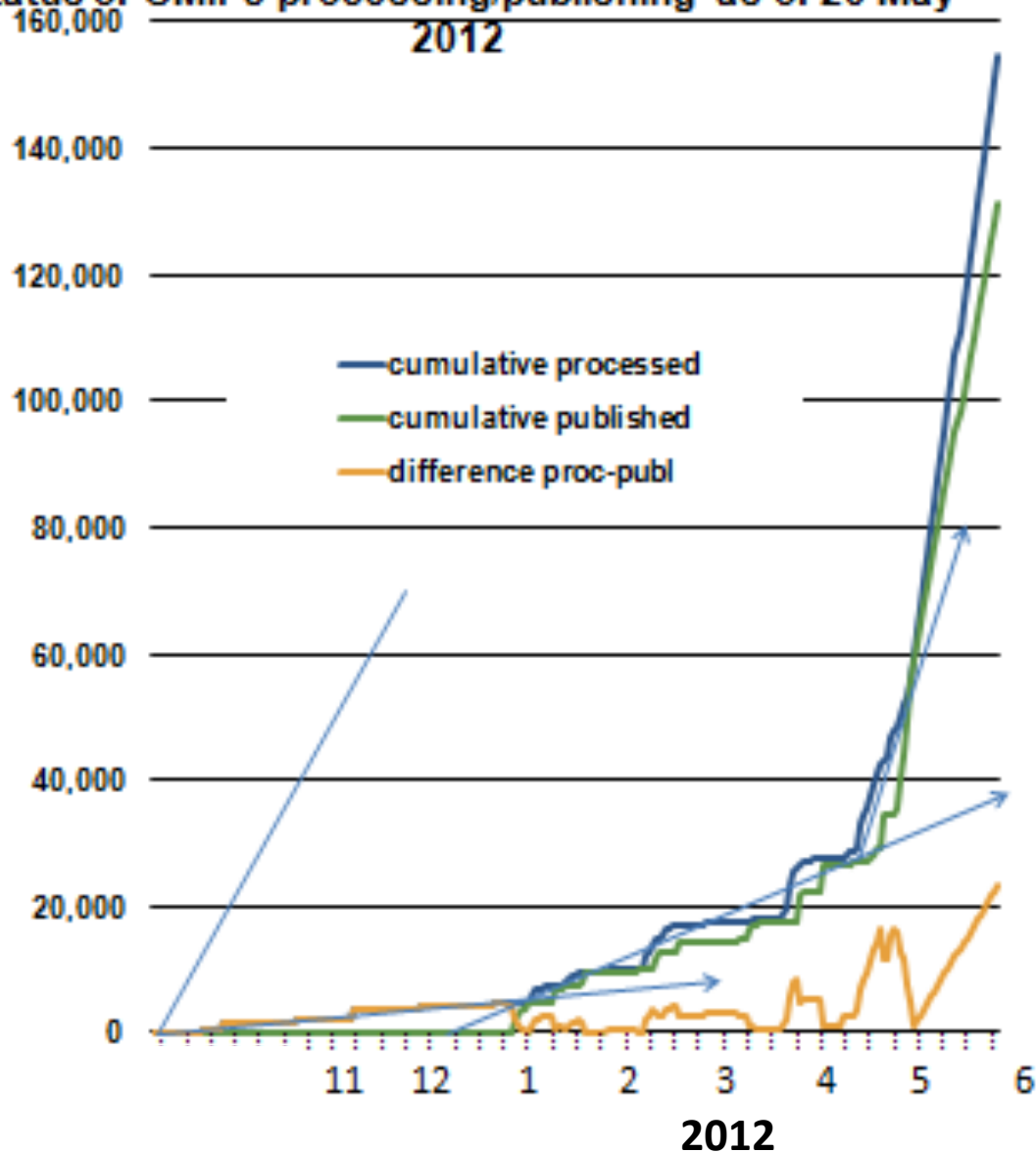


# ESG Publishing





Status of CMIP5 processing/publishing as of 26 May 2012



# •CMIP3 vs. CMIP5 comparison

Category	CMIP3	CMIP5
Modeling centers	16	32
Models	24	64
Total volume (TB)	35	1,482
Files	75,000	3,223,000
Experiment classes	12	37
Output types	6	19
Fields requested	137	951

# Post Mortem of CMIP 5:

- Major contribution of CESM and its partners to IPCC AR5 through simulations performed with both CCSM4.0 and CESM1.0
- CSL, NCAR and DOE computer resources decisive
- CMIP5 Experimental Design (Taylor et al. 2009):

A set of coordinated climate model experiments to:

- ✓ address outstanding scientific questions from AR4
- ✓ improve understanding of climate variability/change
- ✓ provide estimates of future climate change

- CMIP5 is a 5-year experimental design, but a significant fraction of the experiments were done in time to be included in AR5
  - ✓ Initialized decadal prediction and long-term climate change
  - ✓ CCSM4.0 and CESM (CAM5, CAM-CHEM, WACCM, BGC, Land-ice) and paleoclimate (>600 Tb history output)
  - ✓ All Core, and most Tier 1 and 2, experiments complete & available (ESG)
  - ✓ Simulation output being formatted/released to formal CMIP5 data base

CISL Computational & Information Systems Laboratory



# • **ESG Federation**

- A far more complicated system than for CMIP3
- Requirements changes from WGCM/WCRP during design process
- National and international collaboration difficulties
- Differing policies between modeling centers and organizations - e.g., EU privacy laws
- Publishing software in flux until late 2011
- Funding for US institutions ended in Sep 2011

## Some thoughts on CMIP5 and beyond...

Too early to get a complete picture of gaps or issues.

Data flow / transfer requirements that the participants are committing to should be determined up front. This includes storage, post-processing, and people time.

There should be a longer period between CMIPs so that the results can be analyzed more thoroughly, leading to meaningful improvements in models.

Feasibility of requested configurations, additional model physics, new sets of experiments, etc. should be seriously assessed a priori, e.g., were decadal prediction experiments too premature?.

## FINAL REMARK:

Entire CESM data flow is being redesigned end-to-end for the future ; not for past CMIP5.