

Requirements and Science Goals for Sustained Petascale Climate Science

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Gary Strand

SciApps-10
Oak Ridge National Laboratory
August 6, 2010

Clip art courtesy of "<http://commons.wikimedia.org/>"



U.S. DEPARTMENT OF
ENERGY

Office of
Science

IPCC Assessment Report 4 (AR4)

Think back in time 6 generations...



CCS Cheetah, Circa 2004

<http://www.ccs.ornl.gov/images/Cheetah-Fed.jpg>



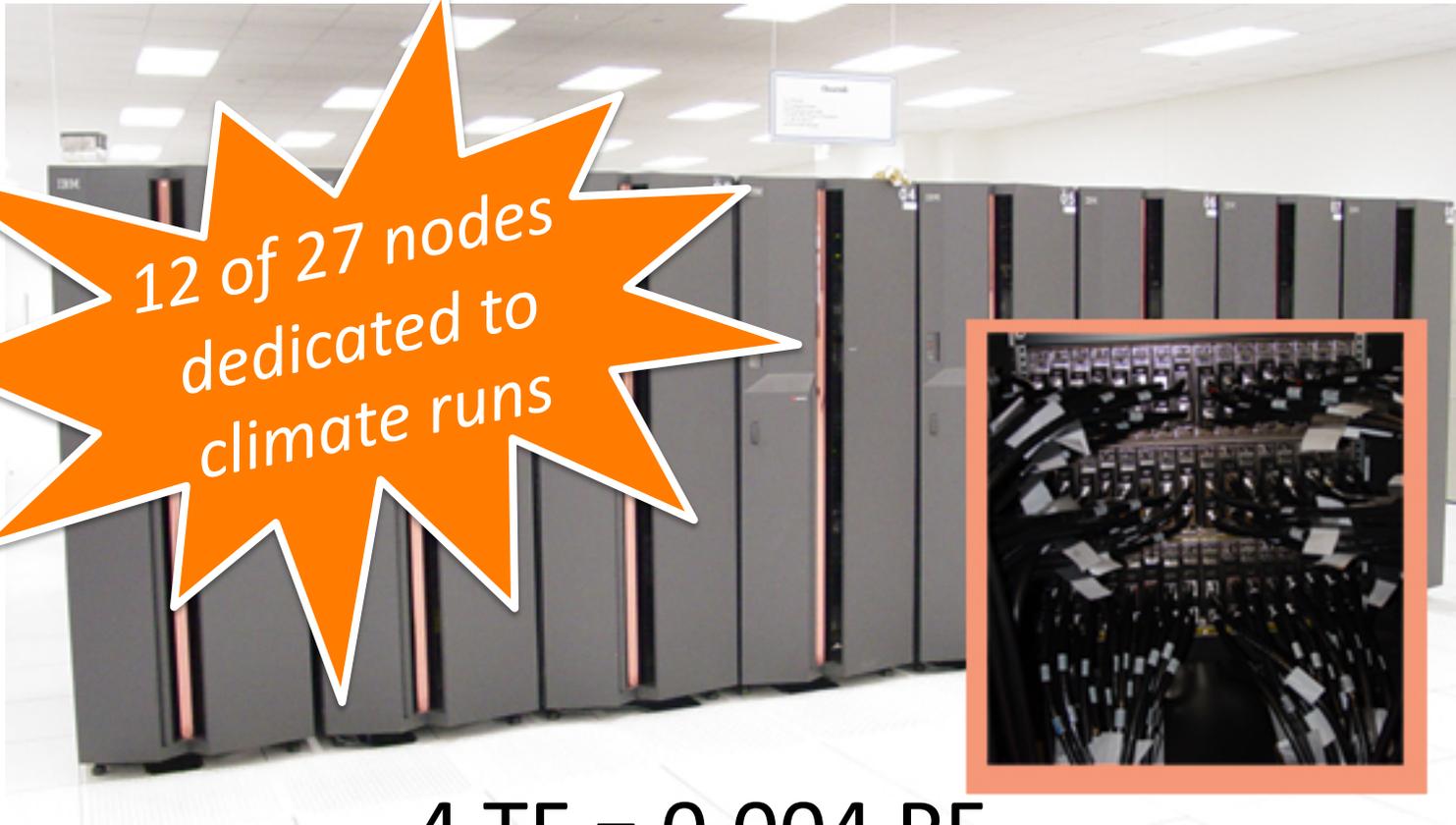
4 TF = 0.004 PF

Science Goals, Circa 2004

- Is the global climate warming?
- If so, are people causing the warming?

CCS Cheetah, Circa 2004

<http://www.ccs.ornl.gov/images/Cheetah-Fed.jpg>

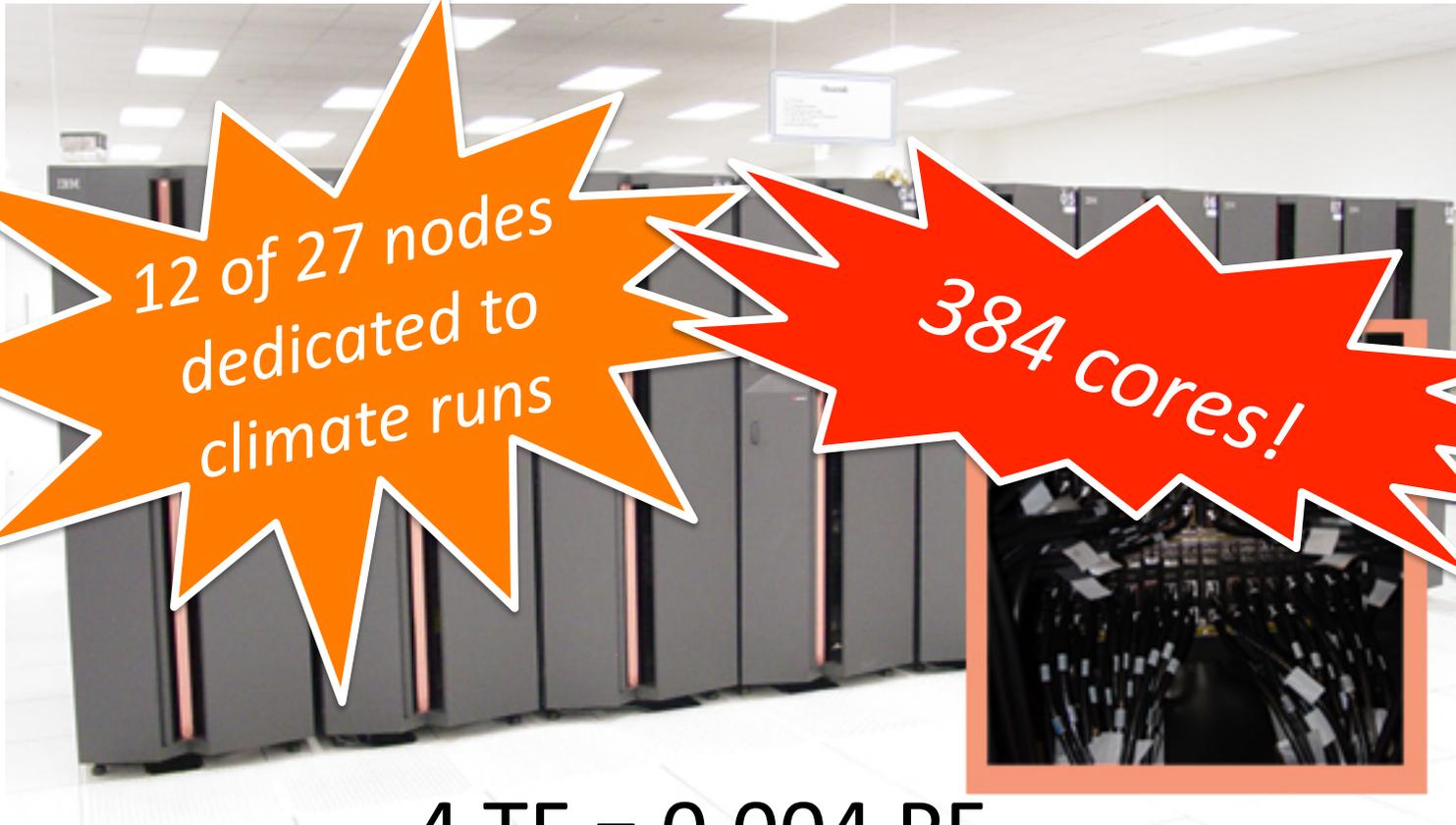


12 of 27 nodes
dedicated to
climate runs

4 TF = 0.004 PF

CCS Cheetah, Circa 2004

<http://www.ccs.ornl.gov/images/Cheetah-Fed.jpg>



12 of 27 nodes
dedicated to
climate runs

384 cores!

4 TF = 0.004 PF

17 TB

35 TB total

Earth System Grid

WCRP CMIP3 Multi-Model Database

https://esg.llnl.gov:8443/index.jsp

WCRP CMIP3 Multi-Model Data

Scientific Discovery through Advanced Computing

Data | About ESG | Login

Data Summary | Errata | Variable Names | Contact ESG

Please [send us](#) comments or feedback.

You may search or browse through the Earth System Grid data holdings. [Registration](#) is required to download data.

The Earth System Grid (ESG) integrates supercomputers with large-scale data and analysis servers located at numerous national labs and research centers to create a powerful environment for next generation climate research. This portal is the primary point of entry into the ESG.

Welcome

Welcome to the WCRP CMIP3 multi-model database. If you are new to this site, please review the help pages:

- [Registration](#)
- [Searching](#)
- [Browsing and Downloading Data](#)
- [Downloading from FTP](#)
- [Downloading from OPeNDAP](#)

NCAR CCSM and PCM datasets are also available from the NCAR [ESG data portal](#). Separate registration is required.

GFDL CM2.0 and CM2.1 datasets and related documentation are also available from the GFDL [Data Portal](#).

Data Search

Search Dataset metadata for:

Examples: c02, B06.77

[Advanced Search](#)

Browse Dataset Catalogs

- [IPCC \(Intergovernmental Panel on Climate Change\)](#)

Visualize Data

ESG Collaborators

- [Argonne National Laboratory](#)
- [Lawrence Berkeley National Laboratory](#)
- [Lawrence Livermore National Laboratory](#)
- [National Center for Atmospheric Research](#)
- [Oak Ridge National Laboratory](#)
- [University of Southern California/Information Sciences Institute](#)

Funded by the U.S. Department of Energy (DOE)

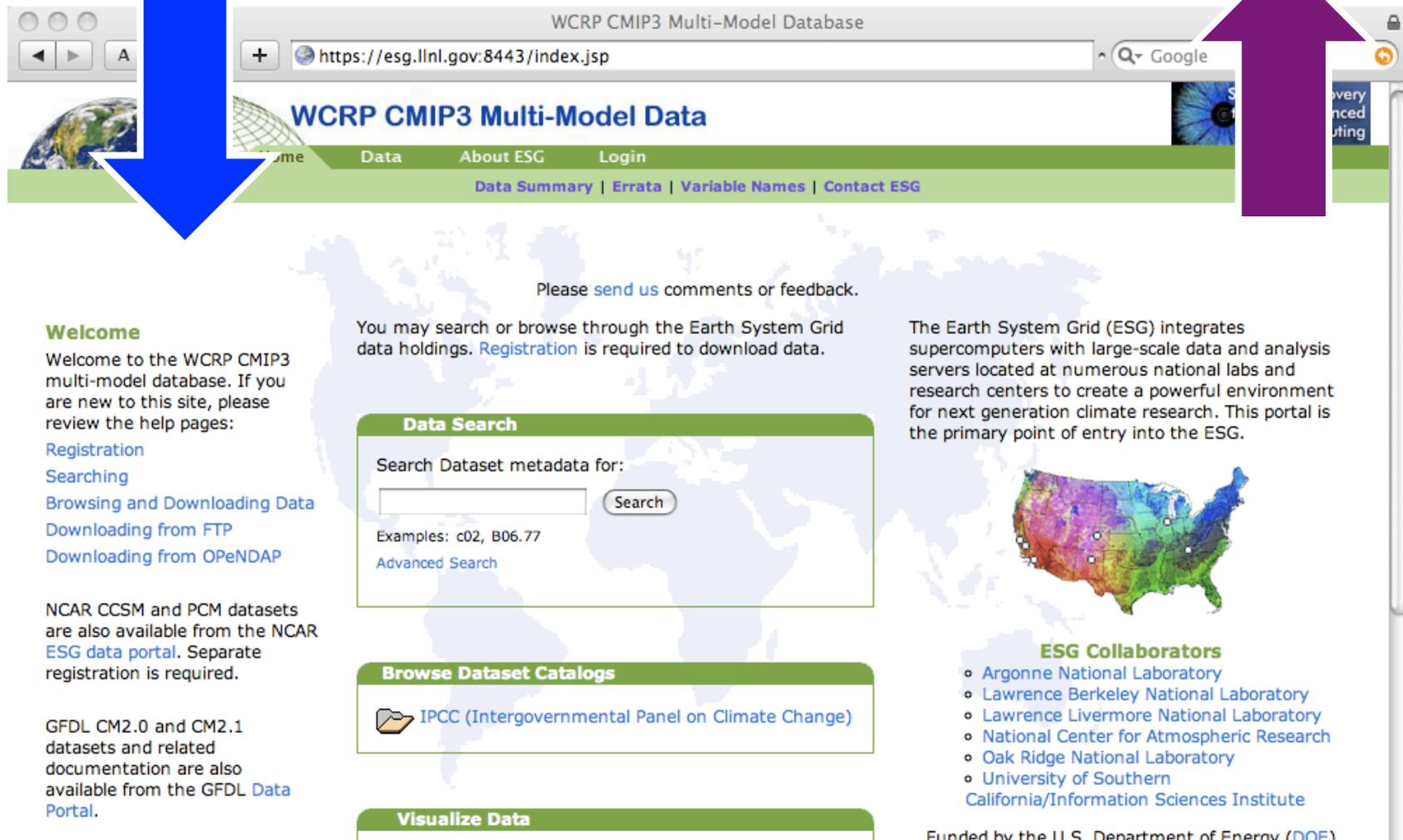
Earth System Grid

17 TB

35 TB total

2500+ scientists

550+ papers



WCRP CMIP3 Multi-Model Database

https://esg.llnl.gov:8443/index.jsp

WCRP CMIP3 Multi-Model Data

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Visualize Data

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- Oak Ridge National Laboratory
- University of Southern California/Information Sciences Institute

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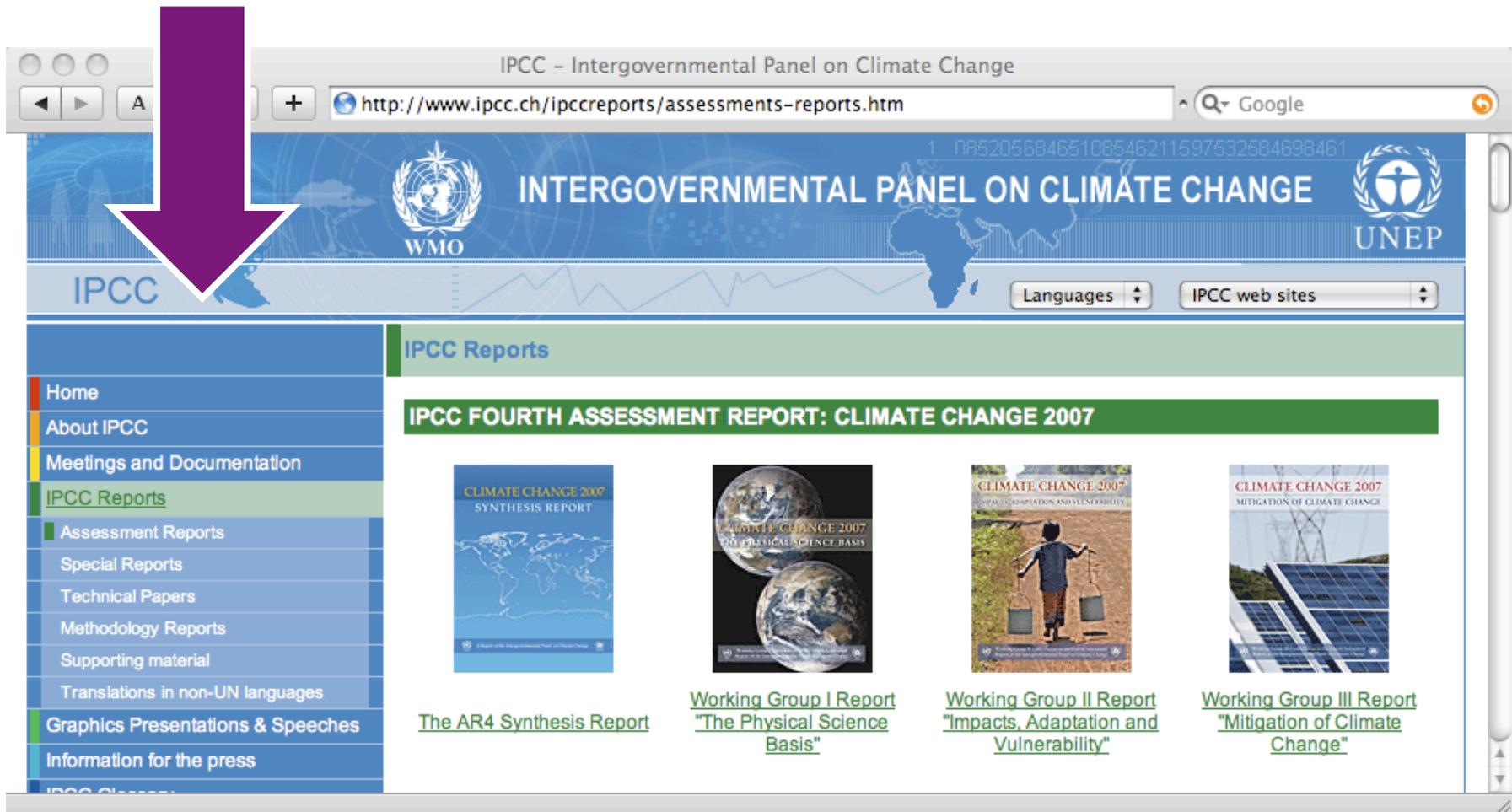
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Intergovernmental Panel on Climate Change

papers



The screenshot shows the IPCC website interface. At the top, the browser address bar displays the URL <http://www.ipcc.ch/ipccreports/assessments-reports.htm>. The main header features the IPCC logo, the text "INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE", and the logos of the WMO and UNEP. A large purple arrow points from the word "papers" to the "IPCC Reports" link in the left-hand navigation menu. The main content area is titled "IPCC Reports" and features a green banner for the "IPCC FOURTH ASSESSMENT REPORT: CLIMATE CHANGE 2007". Below this banner, four report covers are displayed with their respective titles:

- [The AR4 Synthesis Report](#)
- [Working Group I Report "The Physical Science Basis"](#)
- [Working Group II Report "Impacts, Adaptation and Vulnerability"](#)
- [Working Group III Report "Mitigation of Climate Change"](#)

Intergovernmental Panel on Climate Change

papers



The image shows a screenshot of the IPCC website. A large purple arrow points from the word "papers" to the "IPCC Reports" section of the website. The website header includes the IPCC logo, WMO, and UNEP logos, along with the text "INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE". The URL in the browser is <http://www.ipcc.ch/ipccreports/assessments-reports.htm>. The main content area is titled "IPCC Reports" and features four report covers: "CLIMATE CHANGE 2007 SYNTHESIS REPORT", "CLIMATE CHANGE 2007 THE PHYSICAL SCIENCE BASIS", "CLIMATE CHANGE 2007 IMPACTS, ADAPTATION AND VULNERABILITY", and "CLIMATE CHANGE 2007 MITIGATION OF CLIMATE CHANGE". Below each cover is a link to the report. A navigation menu on the left lists various sections including Home, About IPCC, Meetings and Documentation, IPCC Reports, Assessment Reports, Special Reports, Technical Papers, Methodology Reports, Supporting material, Translations in non-UN languages, Graphics Presentations & Speeches, and Information for the press.

IPCC – Intergovernmental Panel on Climate Change

<http://www.ipcc.ch/ipccreports/assessments-reports.htm> Google

1 08520568465108546211597532584698461

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

WMO UNEP

IPCC Languages IPCC web sites

IPCC Reports

Home

About IPCC

Meetings and Documentation

IPCC Reports

Assessment Reports

Special Reports

Technical Papers

Methodology Reports

Supporting material

Translations in non-UN languages

Graphics Presentations & Speeches

Information for the press

IPCC Classification

CLIMATE CHANGE 2007 SYNTHESIS REPORT

CLIMATE CHANGE 2007 THE PHYSICAL SCIENCE BASIS

CLIMATE CHANGE 2007 IMPACTS, ADAPTATION AND VULNERABILITY

CLIMATE CHANGE 2007 MITIGATION OF CLIMATE CHANGE

[The AR4 Synthesis Report](#)

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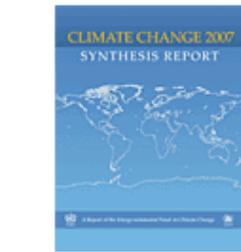
Intergovernmental Panel on Climate Change

papers



Yes.

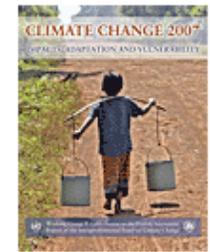
And yes.



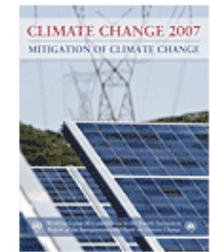
[The AR4 Synthesis Report](#)



[Working Group I Report
'The Physical Science
Basis'](#)



[Working Group II Report
'Impacts, Adaptation and
Vulnerability'](#)



[Working Group III Report
'Mitigation of Climate
Change'](#)

http://www.the-nobel-prize.com/nobel_medal.jpg

Intergovernmental

Climate

papers



Yes.

Alli yes.

IPCC Reports

- Home
- About IPCC
- Meetings and Documentation
- IPCC Reports**
 - Assessment Reports
 - Special Reports
 - Technical Papers
 - Methodology Reports
 - Supporting material
 - Translations in non-UN languages
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CLIMATE CHANGE 2007

<p><u>The AR4 Synthesis Report</u></p>	<p><u>Working Group I Report</u> <u>"The Physical Science Basis"</u></p>	<p><u>Working Group II Report</u> <u>"Impacts, Adaptation and Vulnerability"</u></p>	<p><u>Working Group III Report</u> <u>"Mitigation of Climate Change"</u></p>
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Science Goals, Circa 2004

- Is the global climate warming? **Yes.**
- If so, are people causing the warming? **Yes.**

IPCC Assessment Report 5 (AR5)

A Tale of Two Onions



AR5 Recipe

- CMIP5 defines experiments
- Develop a model
- Run experiments
- Provide simulation output
- Scientists worldwide analyze output
- Scientists worldwide publish papers
- AR5 authors cite papers

AR5 Recipe

- CMIP5 defines experiments ✓
- Develop a model ✓
- Run experiments 🌟
- Provide simulation output
- Scientists worldwide analyze output
- Scientists worldwide publish papers
- AR5 authors cite papers

🌟 *We are here.*

AR5 Recipe

???

- CMIP5 defines experiments
- Develop a model
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Climate Model Intercomparison Project, Phase 5 (CMIP5)



The image is a screenshot of a web browser window. The address bar shows the URL: http://www.wmo.int/pages/prog/wcrp/documents/WCRPnews_20081015.pdf. The browser's search bar contains the text "Google". The main content area features the WCRP NEWS logo, which includes the text "WCRP NEWS" in a large, bold, pink and grey font, with "World Climate Research Programme" written below it. To the right of the logo is a small globe icon. Below the logo is a horizontal line, and to the right of this line is a vertical pink bar. Underneath the line and bar are the logos of the WMO, IOC, and ICSU. The article title is "CMIP5: Preparing climate simulations and projections for the Fifth IPCC Assessment Report", dated "16.10.2008". The article text begins with "The World Climate Research Programme's Working Group on Coupled Modelling (WGCM) held a historic meeting in Paris, France on 22-24 September 2008 where representatives from 20 of the global coupled climate modelling centres from around the world were invited to hear about the next climate model intercomparison project (CMIP5). CMIP5, proposed and". A grey box with the text "Climate model intercomparisons" is partially visible at the bottom right of the article text.

http://www.wmo.int/pages/prog/wcrp/documents/WCRPnews_20081015.pdf

http://www.wmo.int/pages/prog/wcrp/documents/WCRPnews_20081015.pdf

Google

WCRP NEWS

World Climate Research Programme

WMO IOC ICSU International Council for Science

CMIP5: Preparing climate simulations and projections for the Fifth IPCC Assessment Report

16.10.2008

The World Climate Research Programme's Working Group on Coupled Modelling (WGCM) held a historic meeting in Paris, France on 22-24 September 2008 where representatives from 20 of the global coupled climate modelling centres from around the world were invited to hear about the next climate model intercomparison project (CMIP5). CMIP5, proposed and

Climate model intercomparisons

Climate Model Intercomparison Project, Phase 5 (CMIP5)

“The grand challenge of the new set of climate models examined in CMIP5 is to resolve **regional climate changes**, particularly in the **next few decades**, to which human societies will have to **adapt**, and to quantify the magnitudes of the **feedbacks** in the climate system, such as feedbacks in the **carbon cycle**.”

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Climate model intercomparisons

Climate Model Intercomparison Project, Phase 5 (CMIP5)

“The advances of CMIP5 compared to CMIP3 include two classes of models which address two time frames and two sets of science questions: i) **decadal prediction** and predictability for the decade to come until 2035; and ii) **long-term climate prediction** until 2100 and beyond.”

16.10.2008

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Climate model intercomparisons

Climate Model Intercomparison Project, Phase 5 (CMIP5)

“Decadal prediction models are **higher in resolution** (50 km) and will therefore address science questions related to **regional climate** and **extremes**.”

World Climate Research Programme



CMIP5: Preparing climate simulations and projections for the Fifth IPCC Assessment Report

16.10.2008

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Climate model intercomparisons

Climate Model Intercomparison Project, Phase 5 (CMIP5)

“In contrast, the models developed for centennial predictions... will include fully coupled **Earth System Models**, addressing climate feedbacks and other large-scale processes. The latter set of models will be driven by new **emission stabilization (mitigation) scenarios...**”

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Climate model intercomparisons

Climate Model Intercomparison Project, Phase 5 (CMIP5)

Decadal

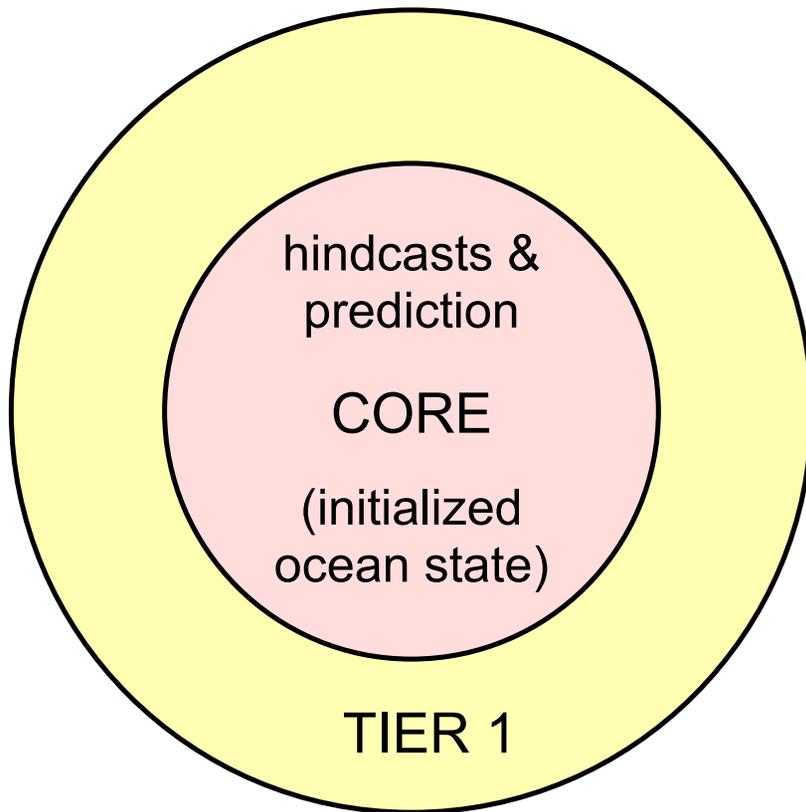
- High resolution
- Regional climate
- Extreme events
- Adaptation

Long Term

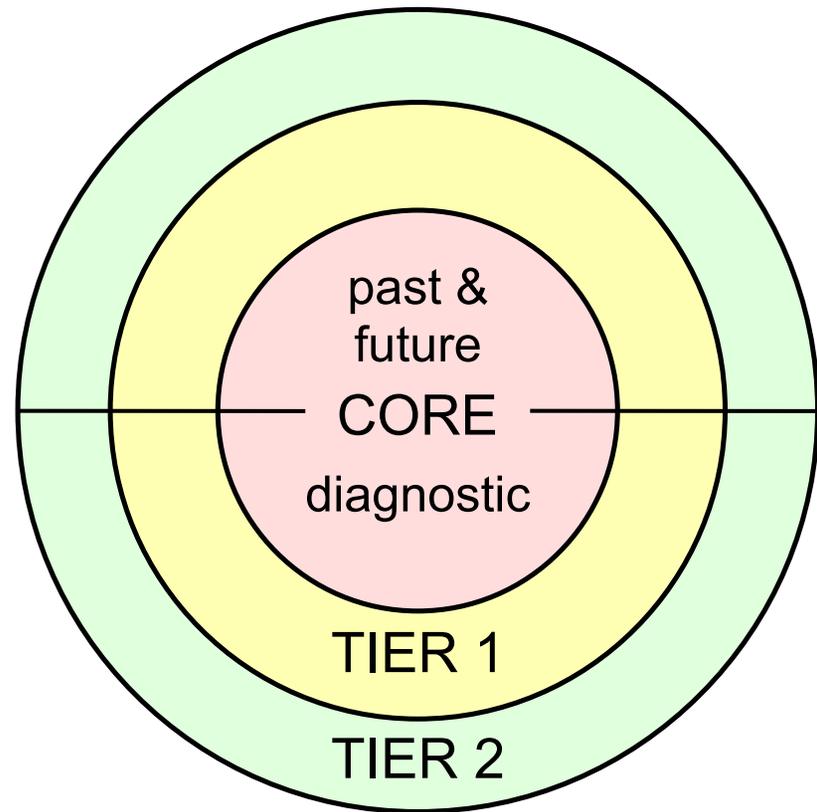
- Earth system
- Climate feedbacks
- Carbon cycle
- Mitigation

CMIP5 Onions

“Near-Term”
(decadal)

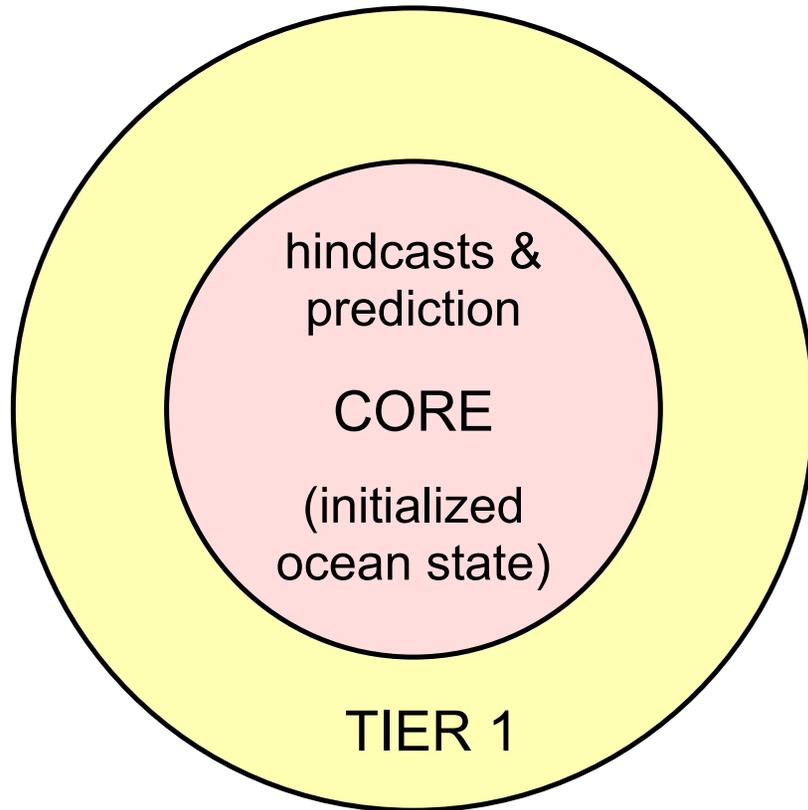


“Long-Term”
(century & longer)

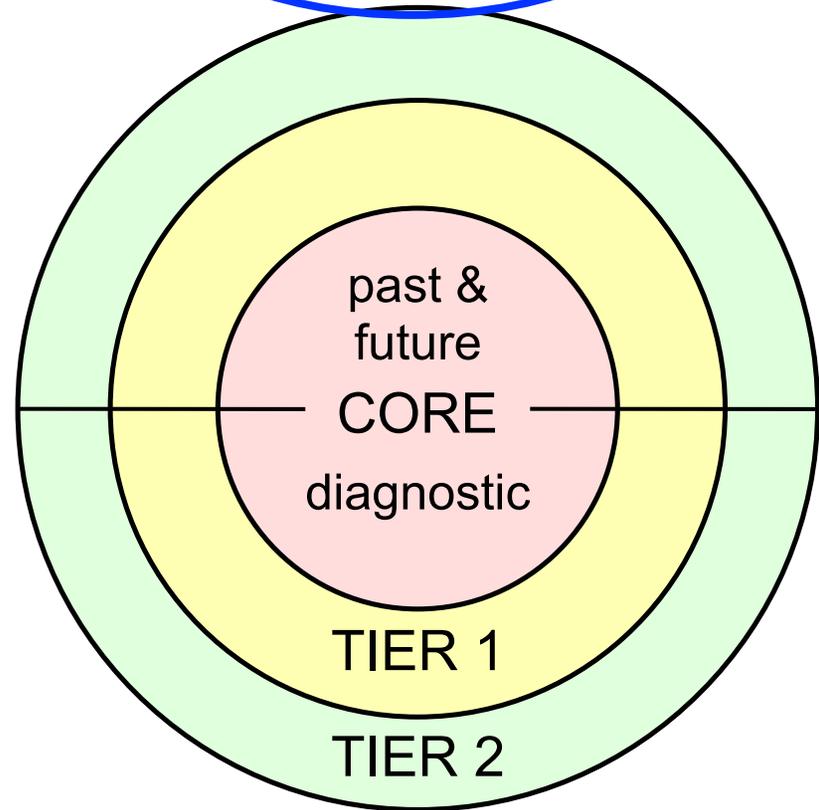


CMIP5 Onions

“Near-Term”
(decadal)

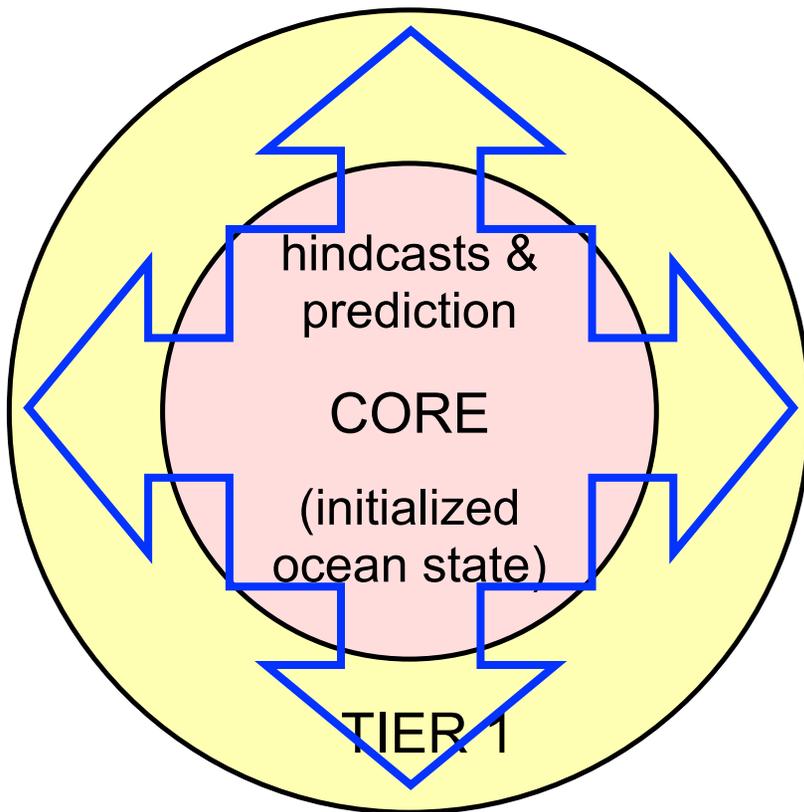


“Long-Term”
(century & longer)

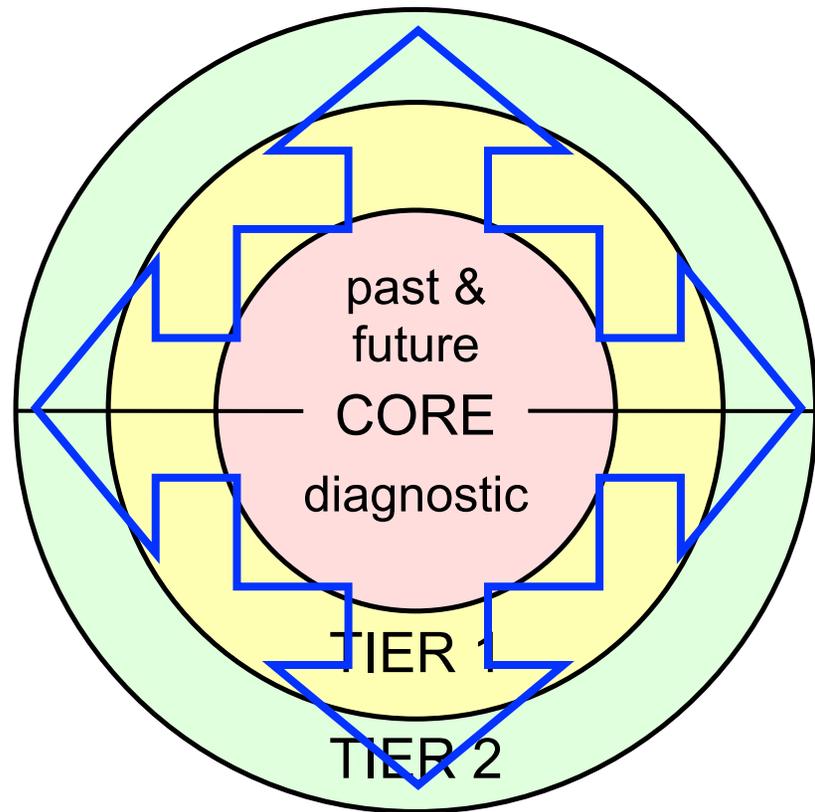


CMIP5 Onions

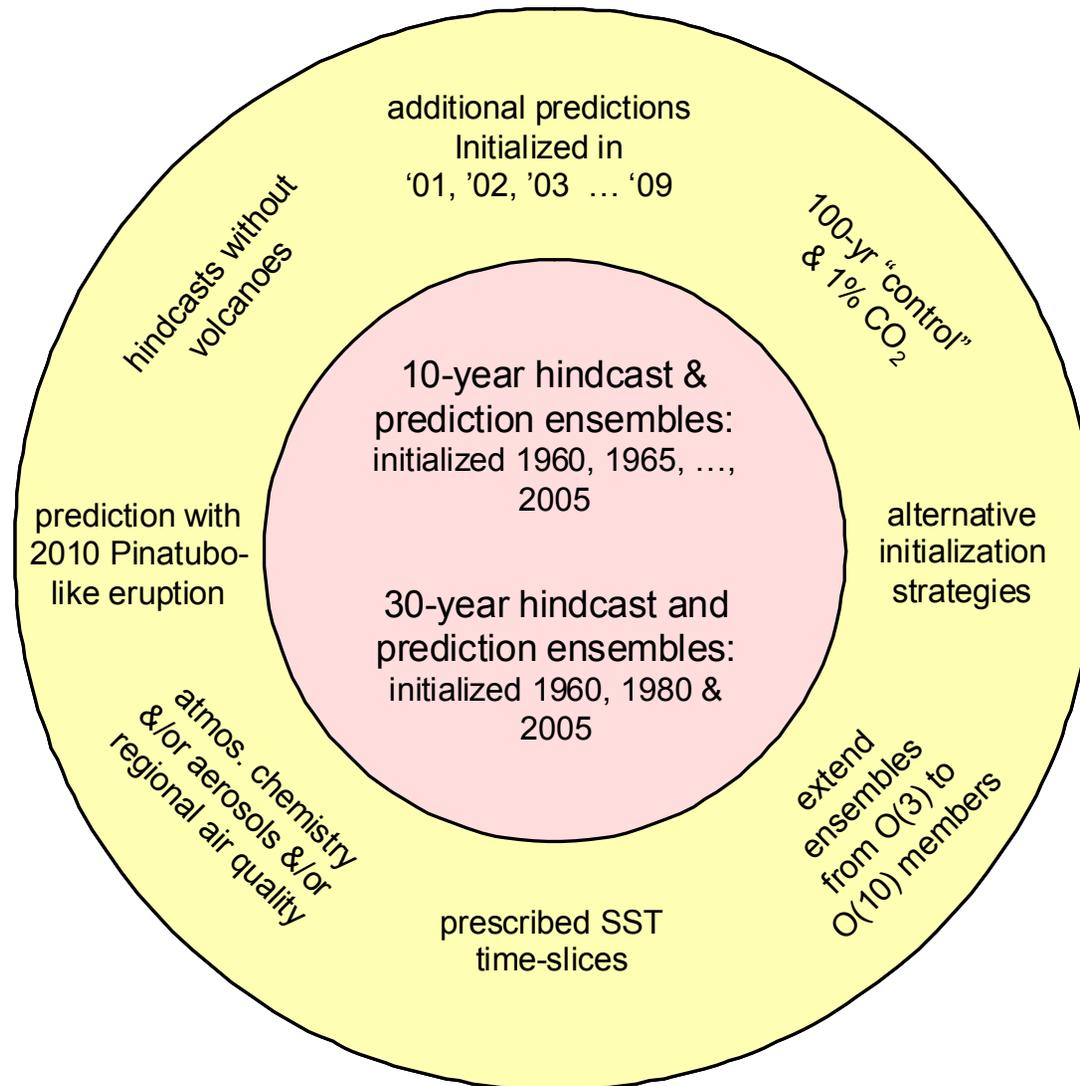
“Near-Term”
(decadal)



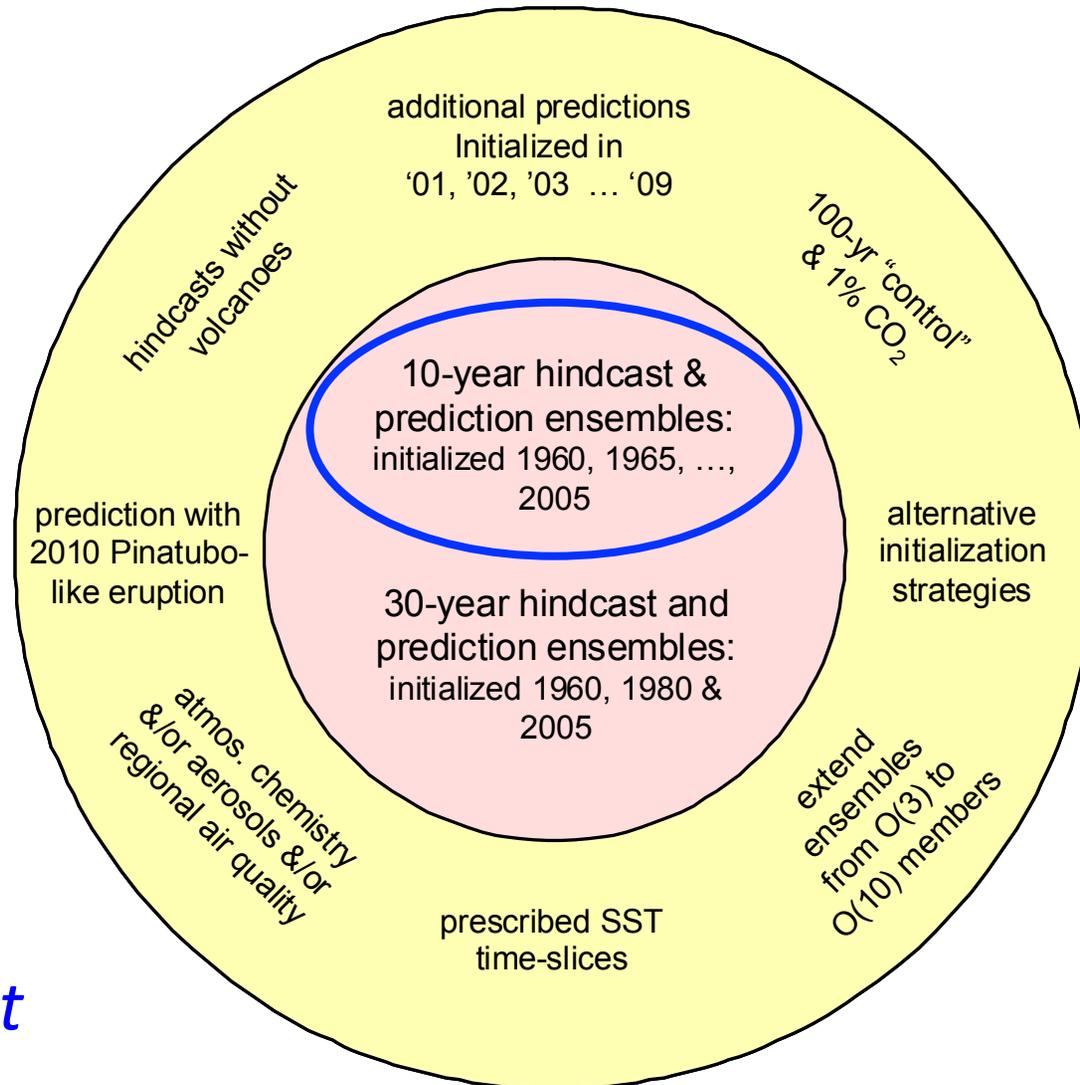
“Long-Term”
(century & longer)



CMIP5 Decadal Onion

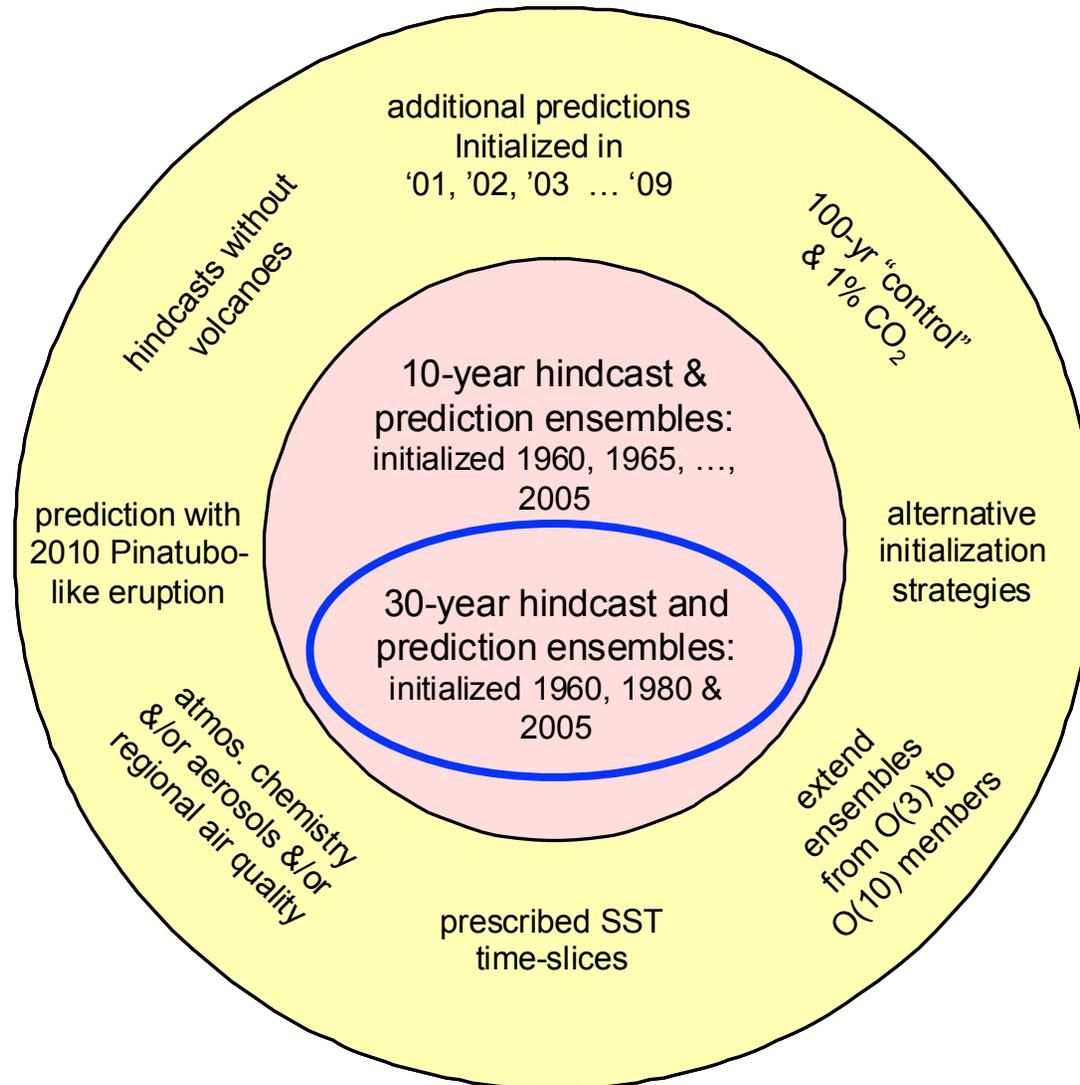


CMIP5 Decadal Onion



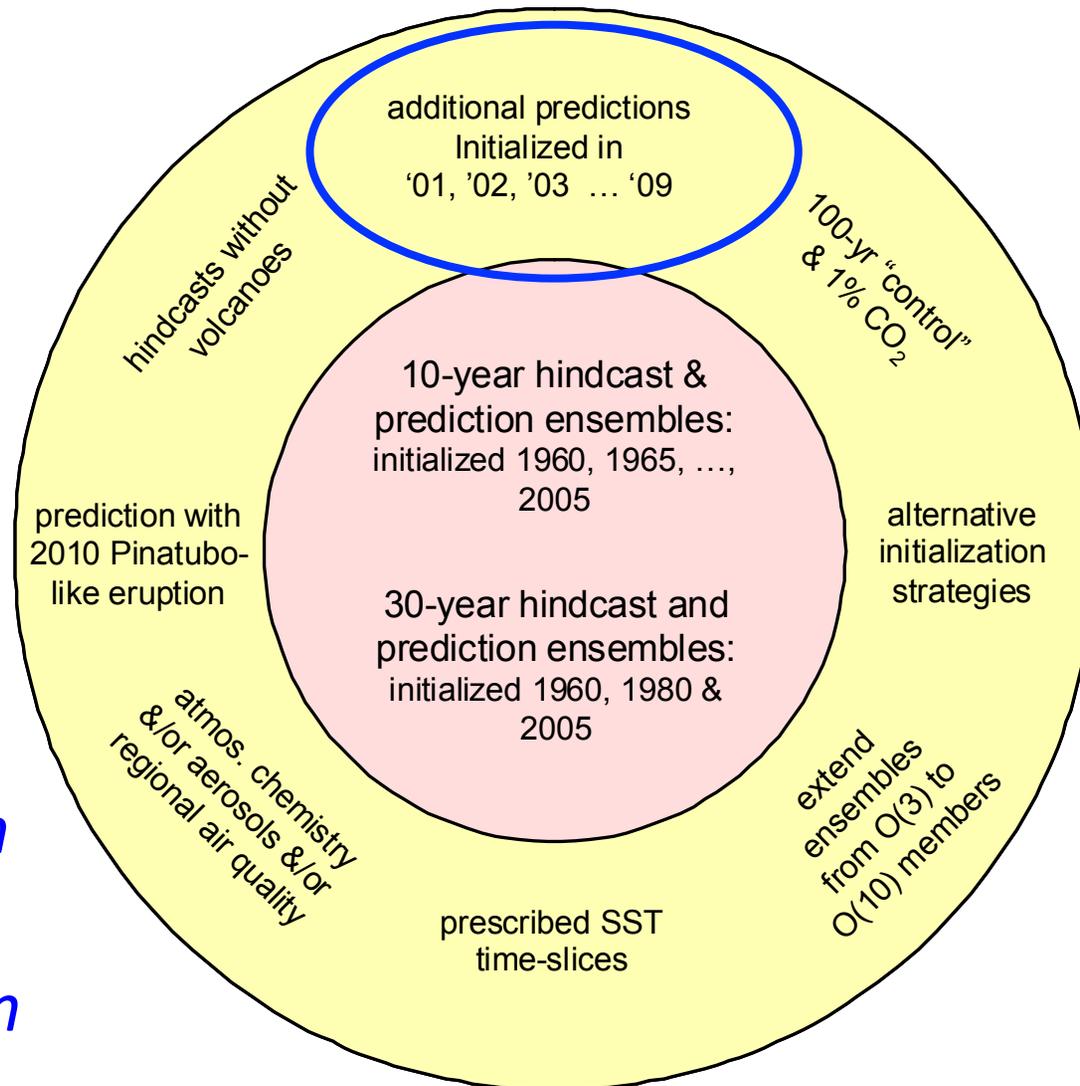
*Initial
conditions
matter most*

CMIP5 Decadal Onion



*Forcings
also matter*

CMIP5 Decadal Onion

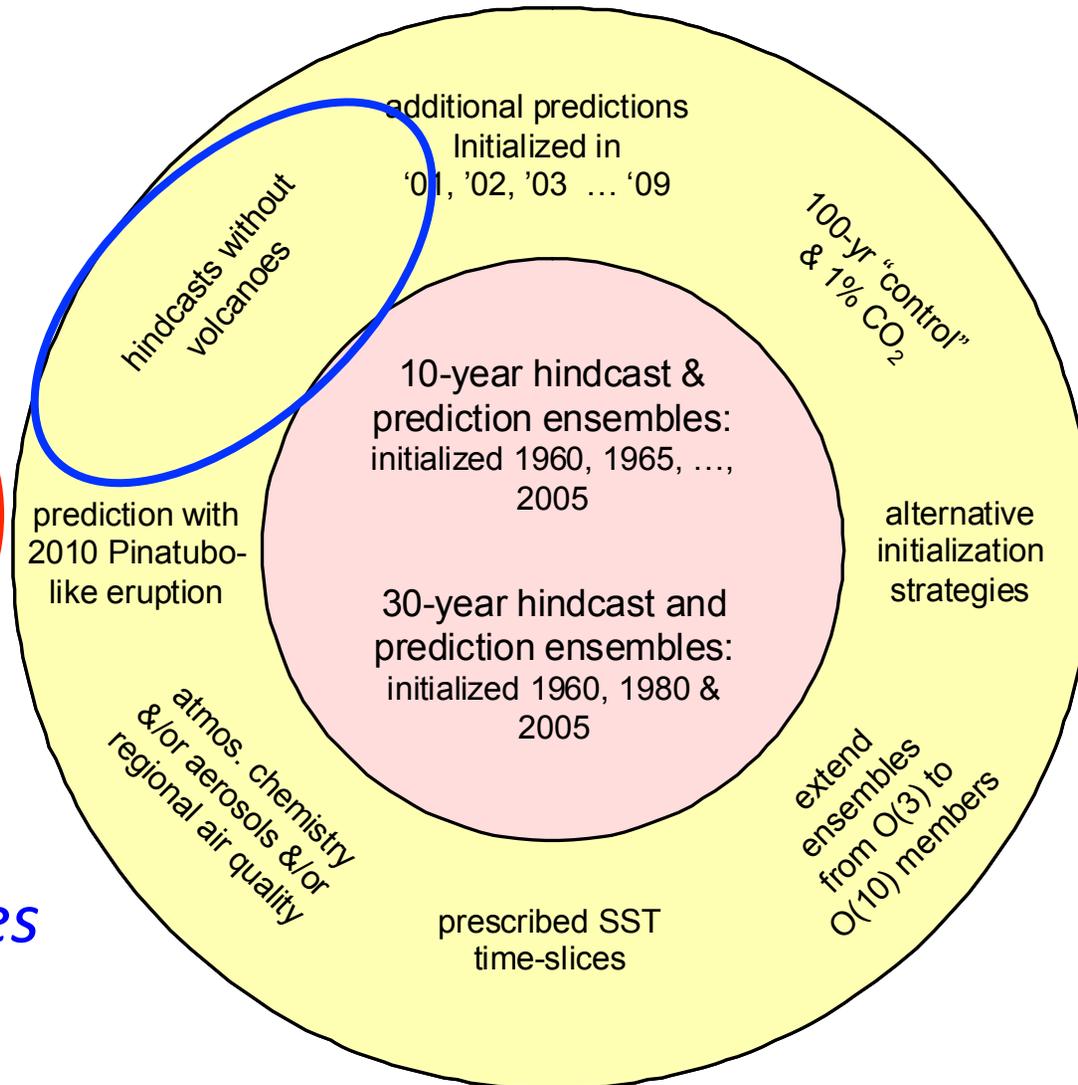


Good ocean data for initialization

CMIP5 Decadal Onion



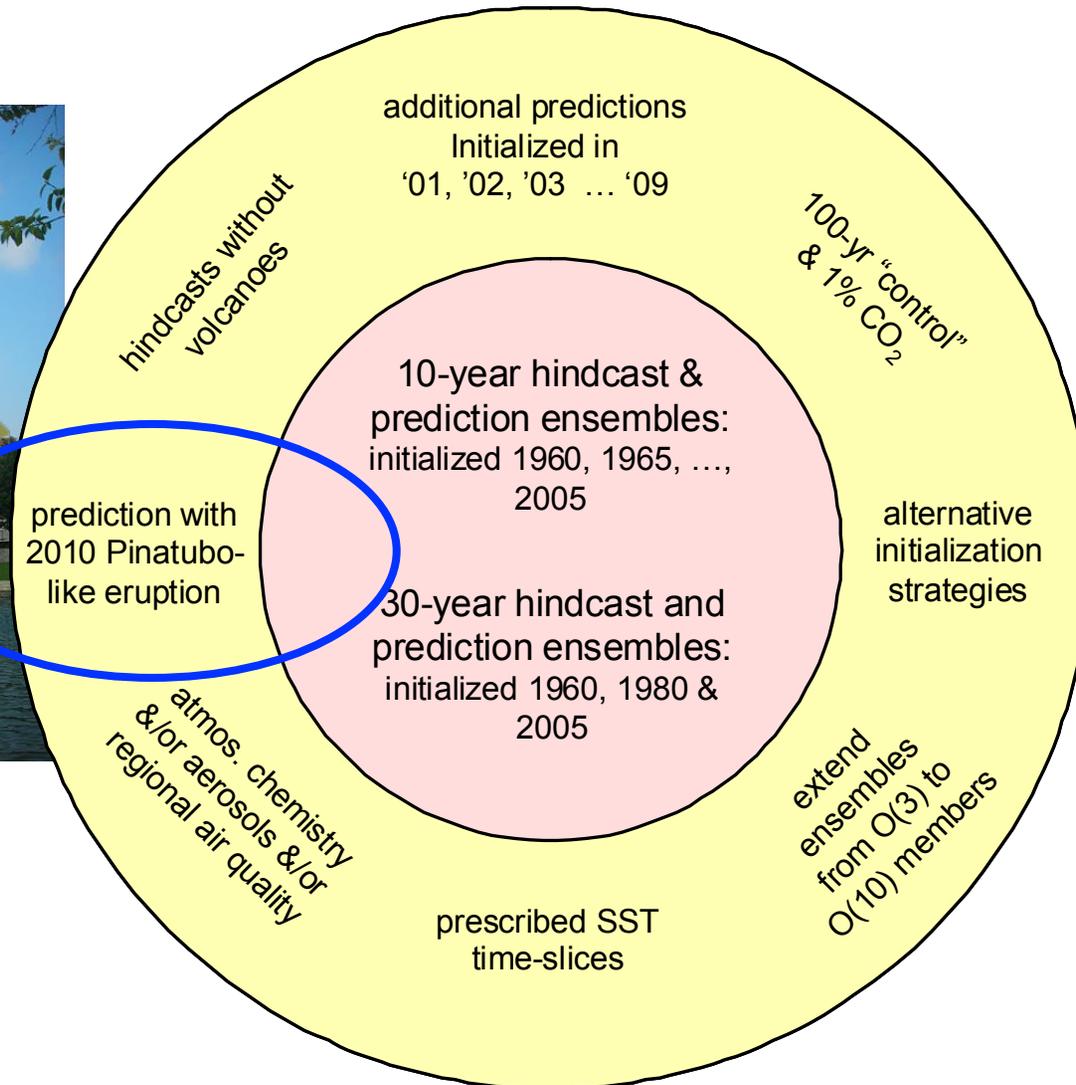
*How much
do volcanoes
matter?*



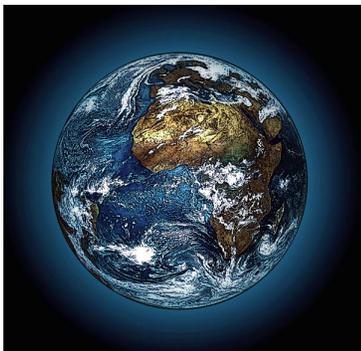
CMIP5 Decadal Onion



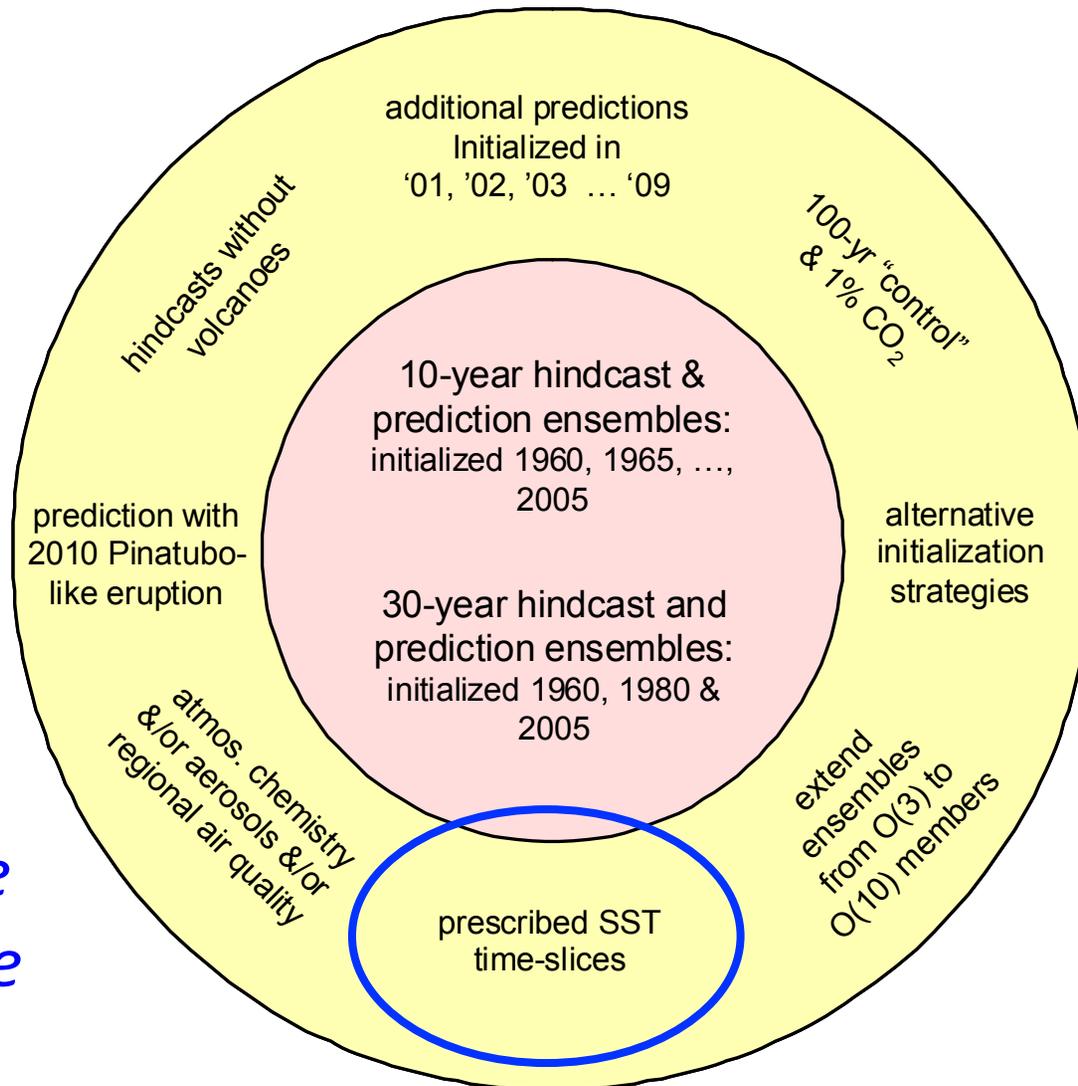
What if we have a big volcano?



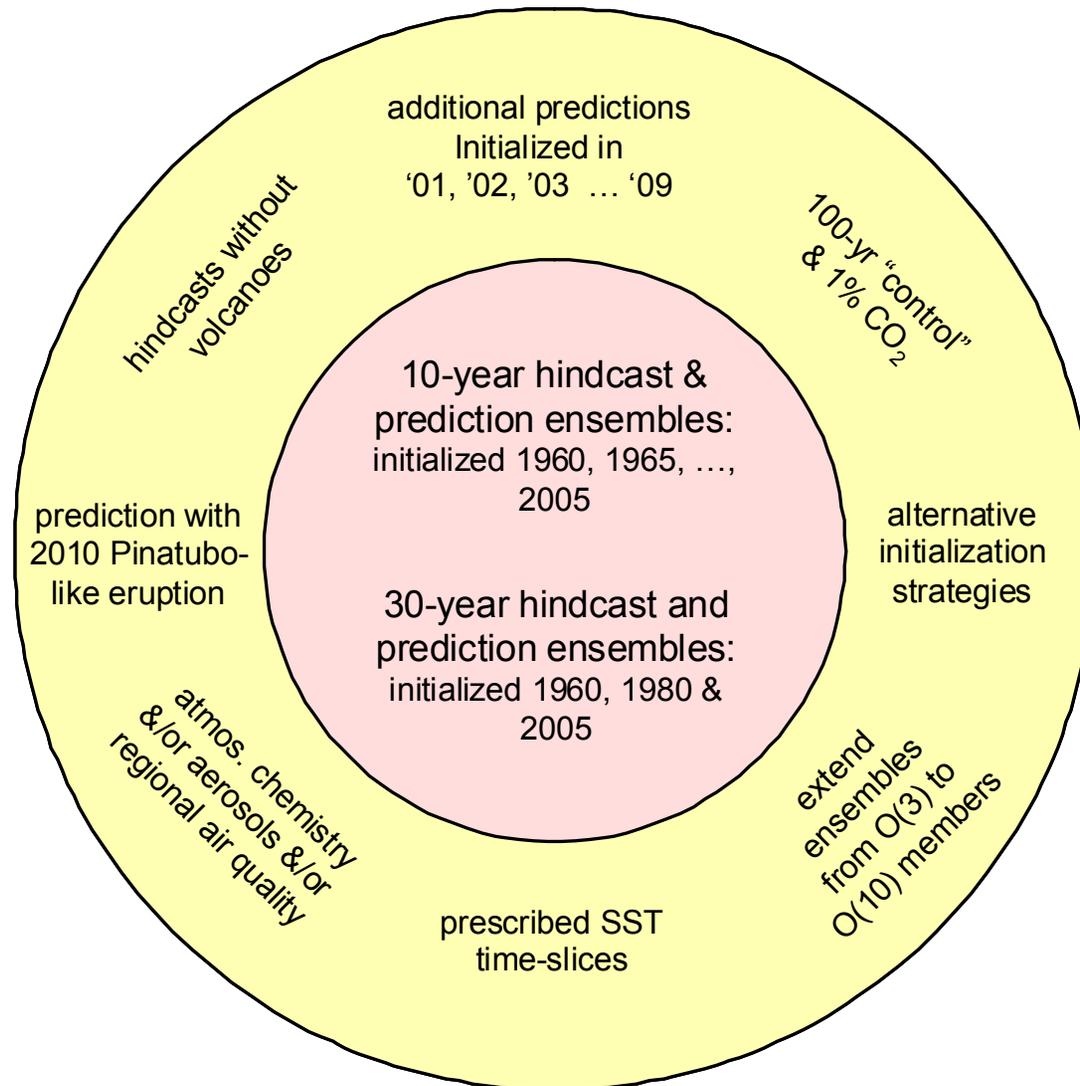
CMIP5 Decadal Onion



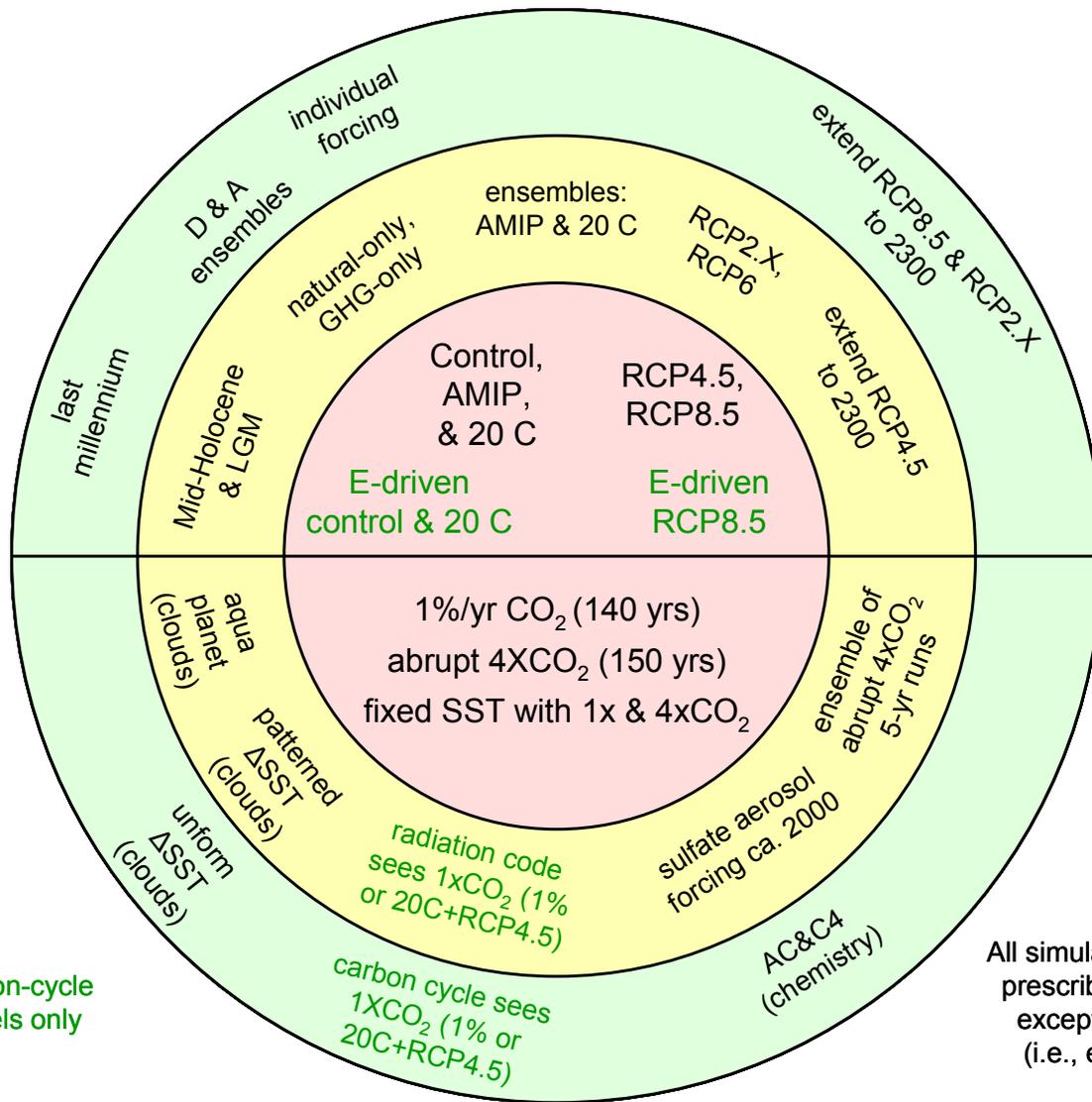
*Ultra-high
resolution
atmosphere
or expensive
chemistry*



CMIP5 Decadal Onion



CMIP5 Long-Term Onion

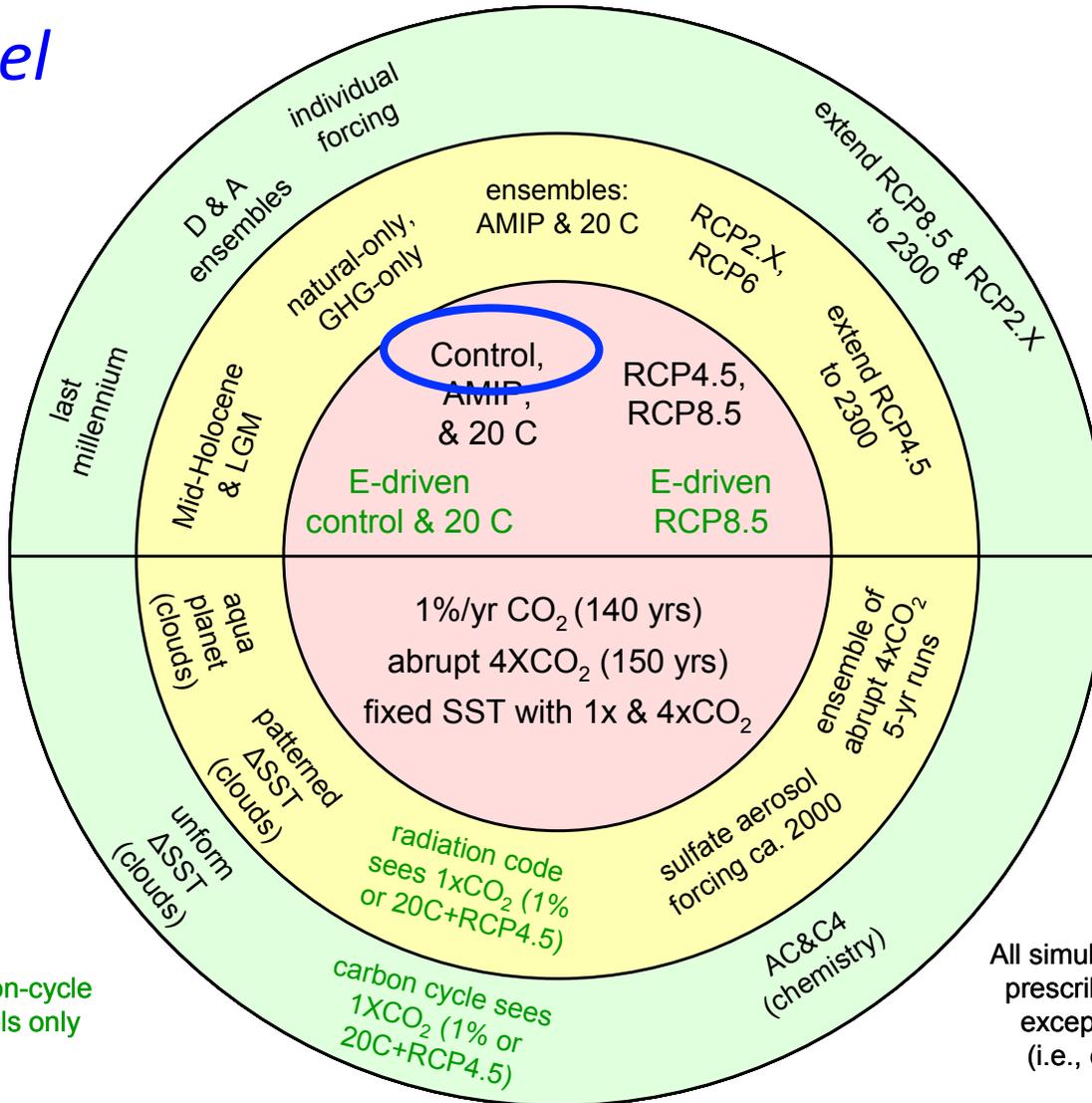
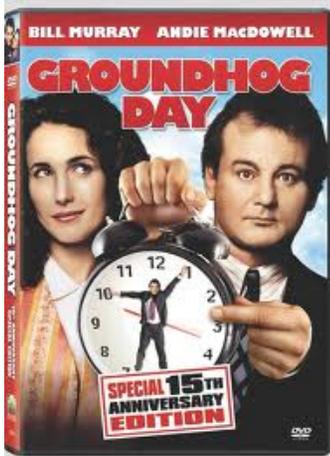


Coupled carbon-cycle climate models only

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

CMIP5 Long-Term Onion

Is the model stable?

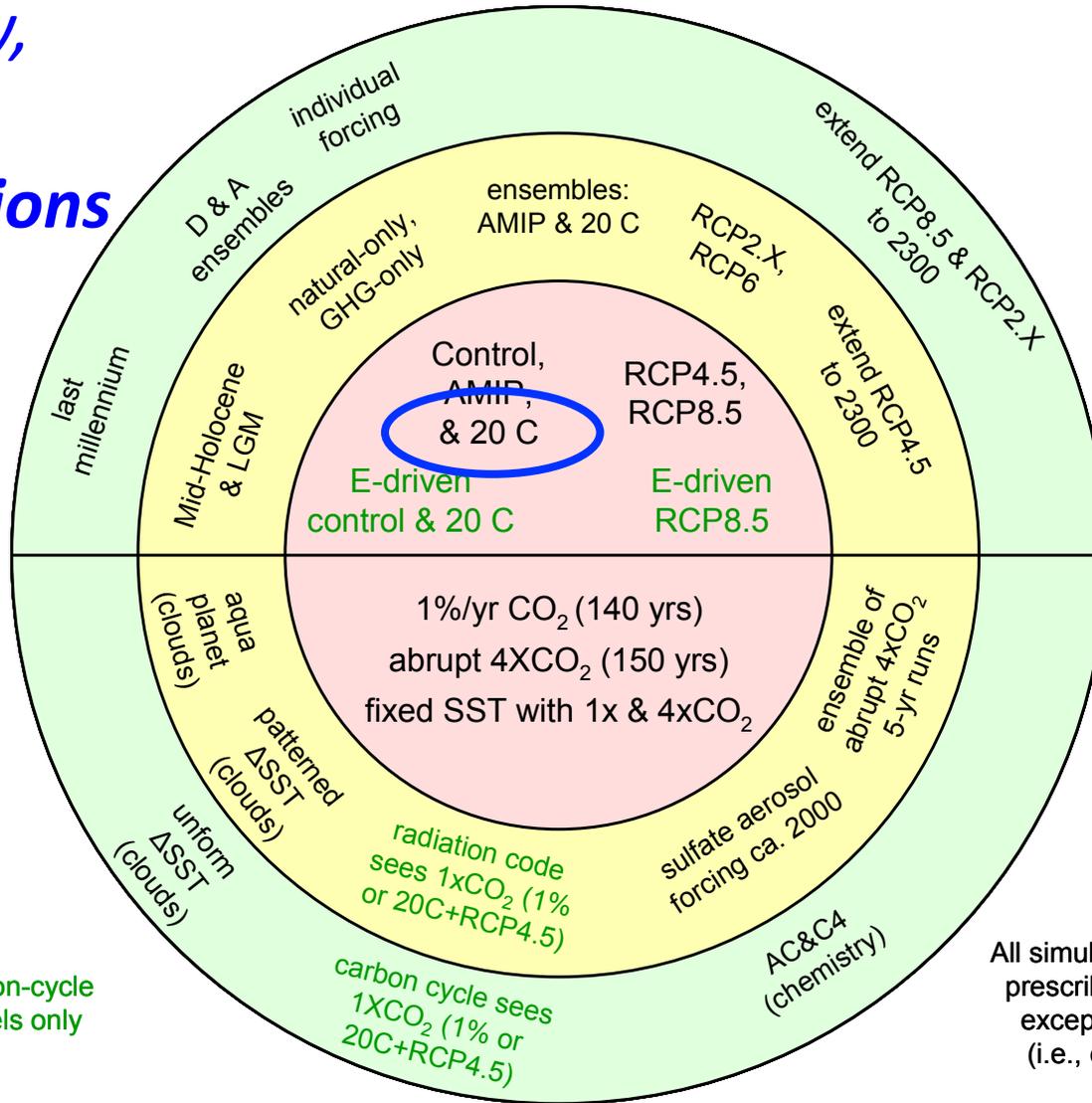


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CMIP5 Long-Term Onion

20th century,
prescribed
concentrations

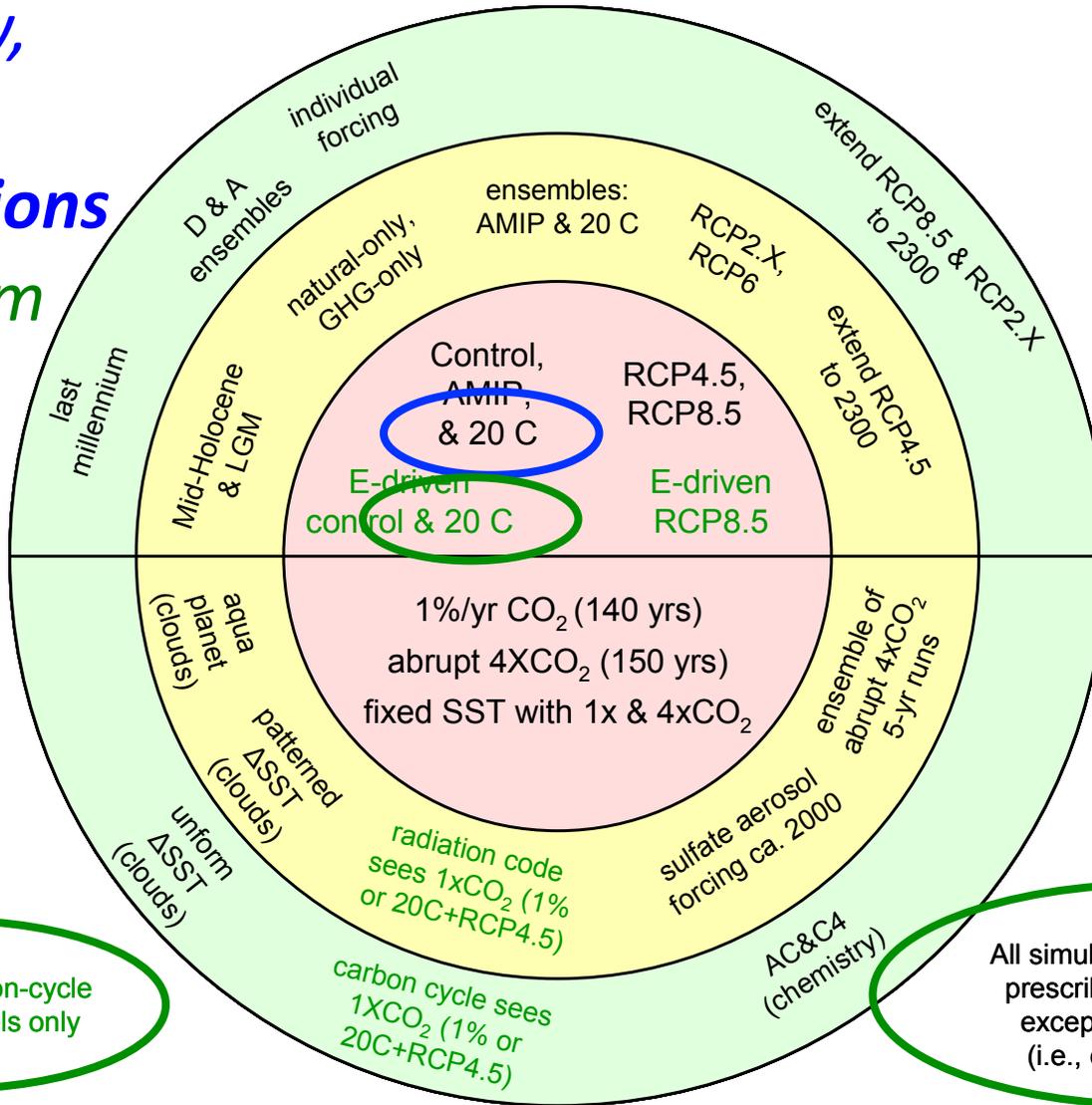


Coupled carbon-cycle
climate models only

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

CMIP5 Long-Term Onion

20th century,
prescribed
concentrations
Earth System
Models
have
prescribed
(and
prognostic)
emissions

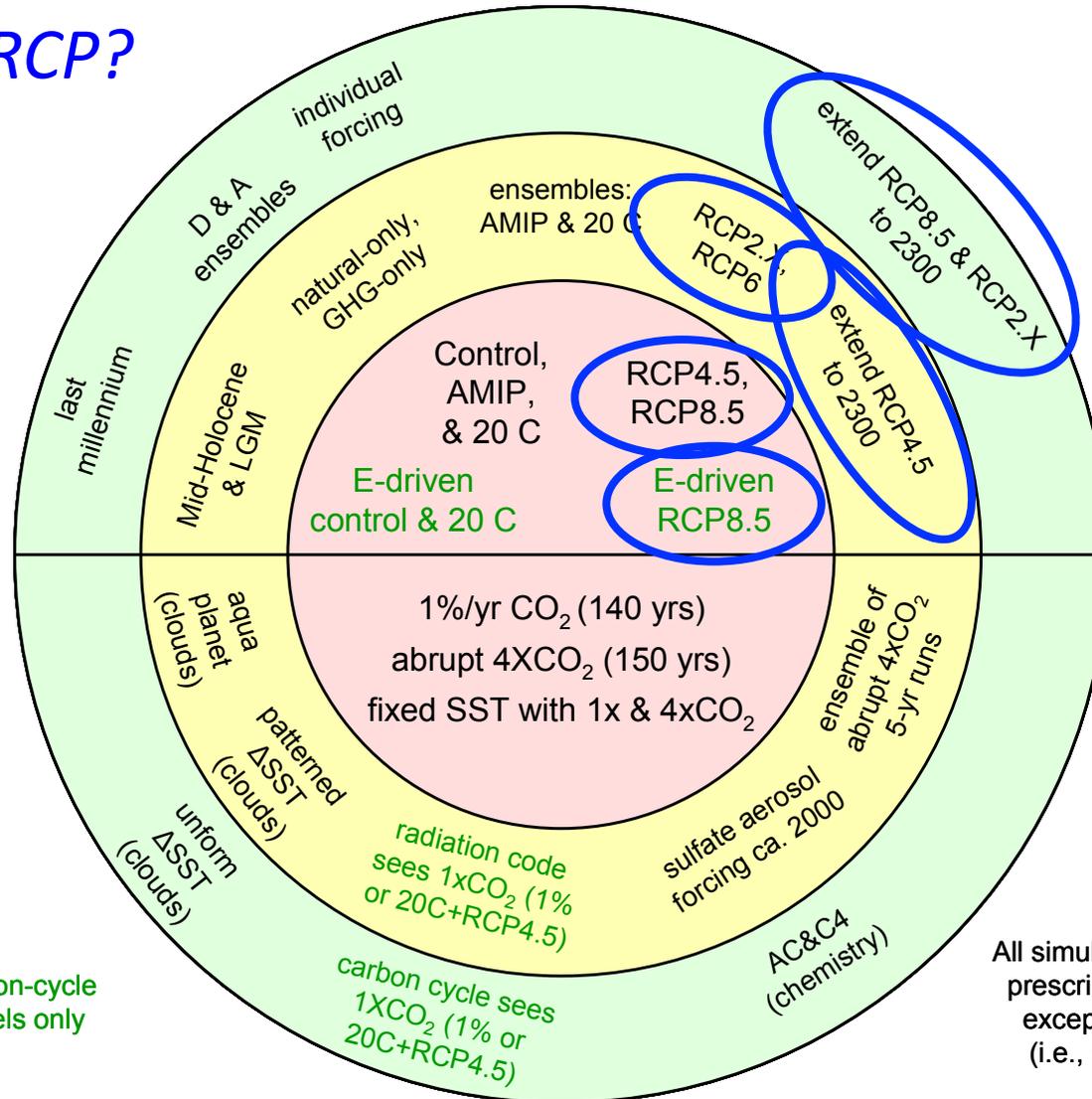


Coupled carbon-cycle climate models only

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

CMIP5 Long-Term Onion

What's an RCP?



Coupled carbon-cycle climate models only

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

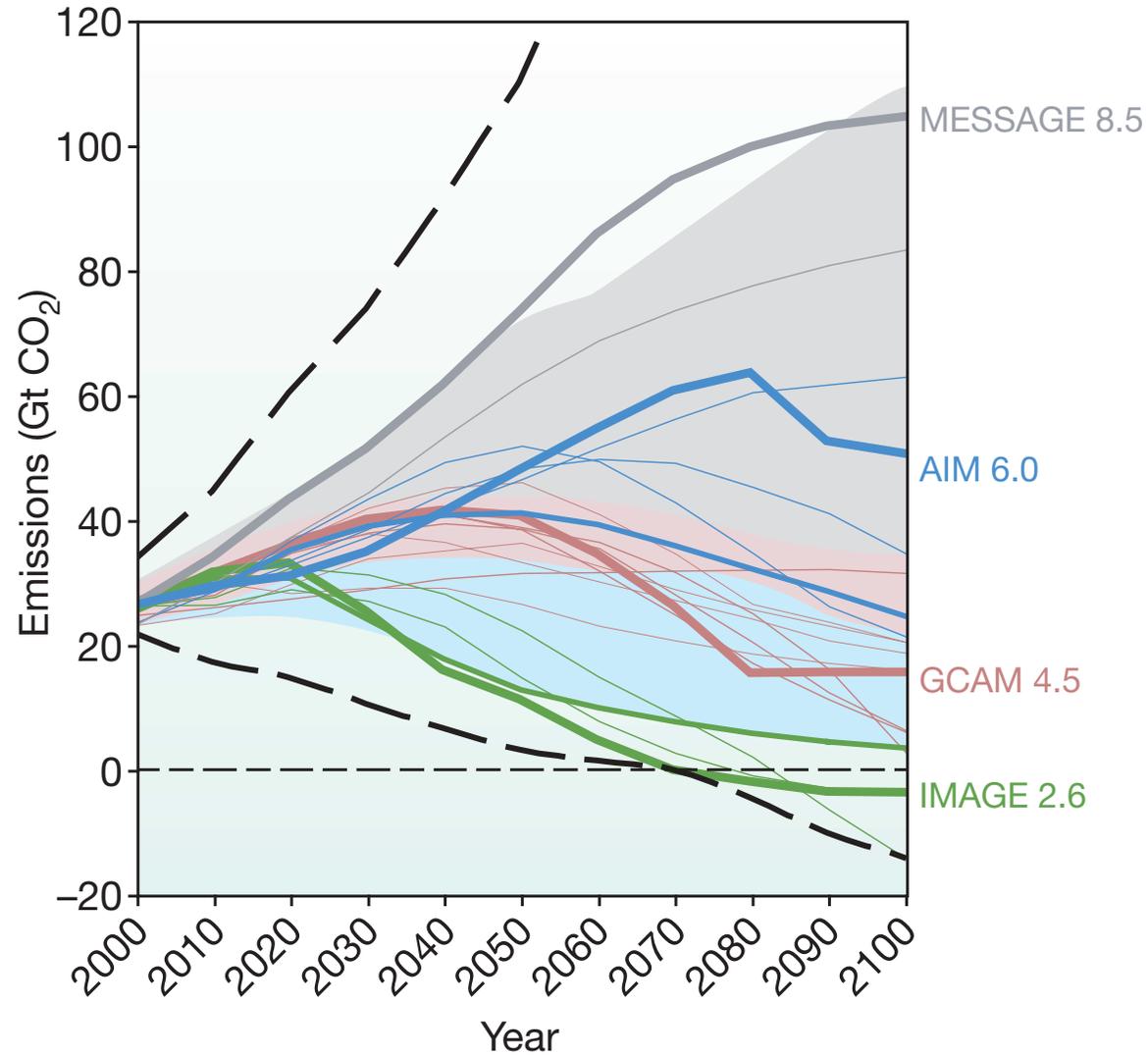
PERSPECTIVES

The next generation of scenarios for climate change research and assessment

Richard H. Moss¹, Jae A. Edmonds¹, Kathy A. Hibbard², Martin R. Manning³, Steven K. Rose⁴, Detlef P. van Vuuren⁵, Timothy R. Carter⁶, Seita Emori⁷, Mikiko Kainuma⁷, Tom Kram⁵, Gerald A. Meehl², John F. B. Mitchell⁸, Nebojsa Nakicenovic^{9,10}, Keywan Riahi⁹, Steven J. Smith¹, Ronald J. Stouffer¹¹, Allison M. Thomson¹, John P. Weyant¹² & Thomas J. Wilbanks¹³

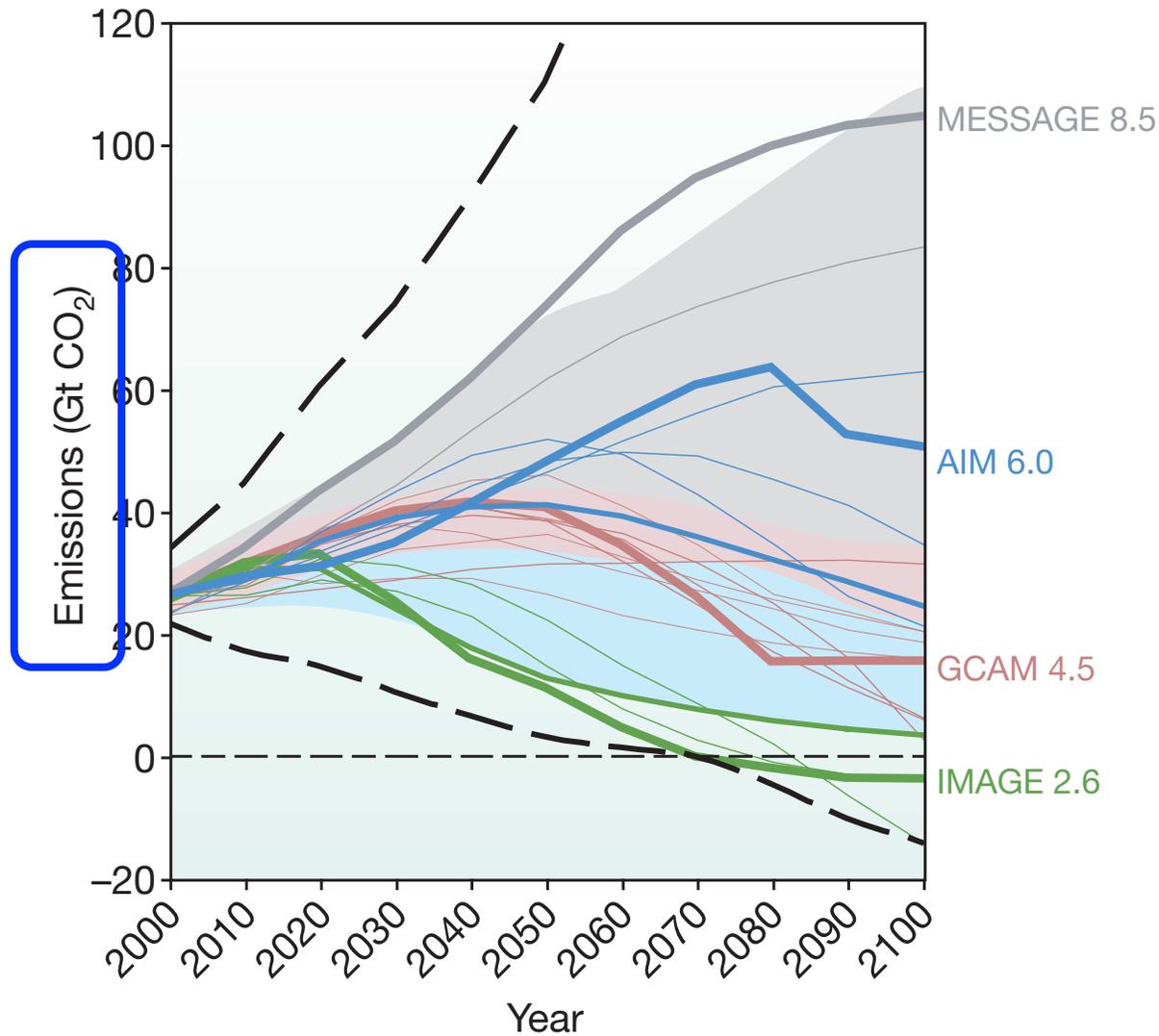
Advances in the science and observation of climate change are providing a clearer understanding of the inherent variability of Earth's climate system and its likely response to human and natural influences. The implications of climate change for the environment and society will depend not only on the response of the Earth system to changes in radiative forcings, but also on how humankind responds through changes in technology, economies, lifestyle and policy. Extensive uncertainties exist in future forcings of and responses to climate change, necessitating the use of scenarios of the future to explore the potential consequences of different response options. To date, such scenarios have not adequately examined crucial possibilities, such as climate change mitigation and adaptation, and have relied on research processes that slowed the exchange of information among physical, biological and social scientists. Here we describe a new process for creating plausible scenarios to investigate some of the most challenging and important questions about climate change confronting the global community.

Representative Concentration Pathways (RCPs)

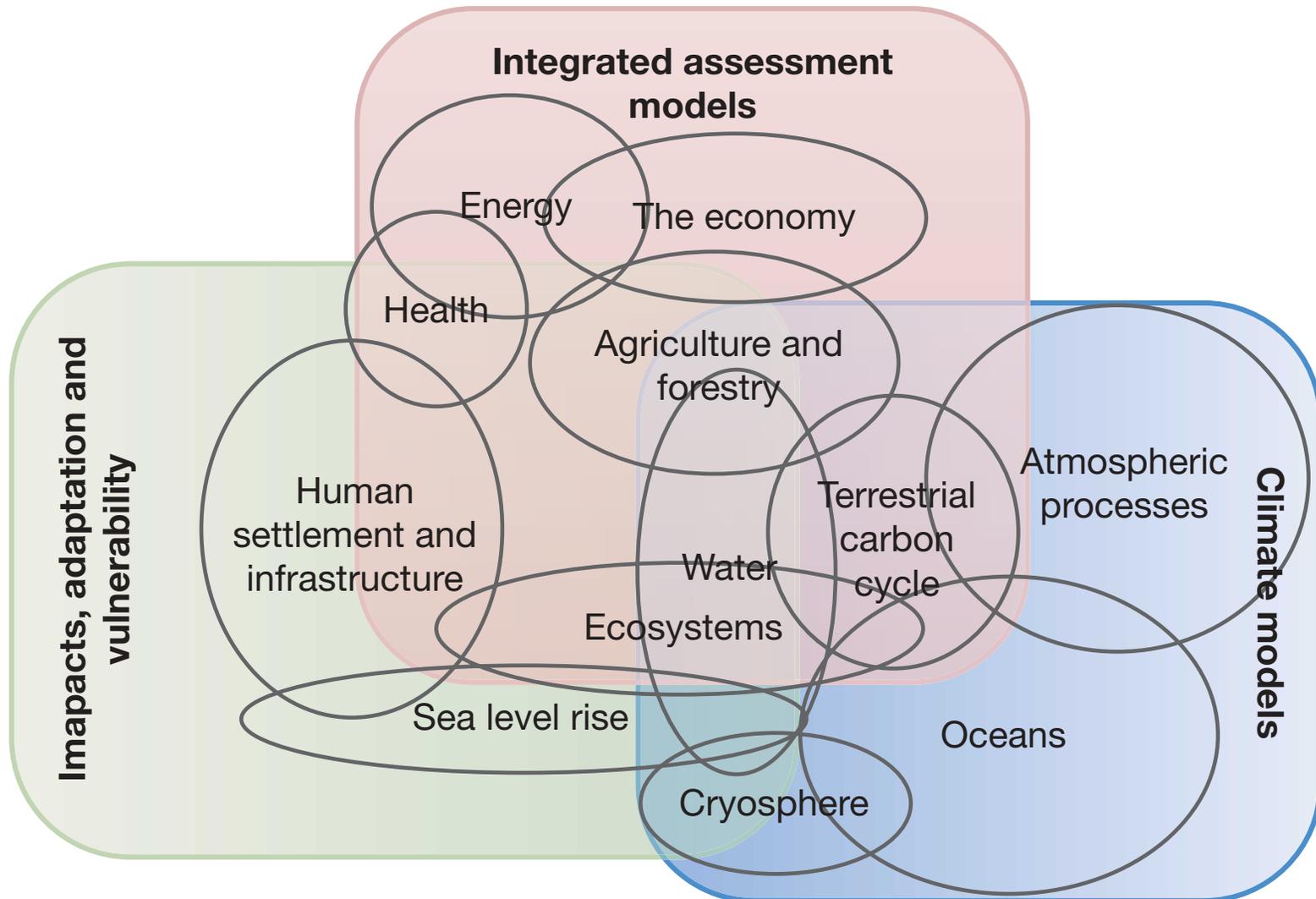


Representative Concentration Pathways (RCPs)

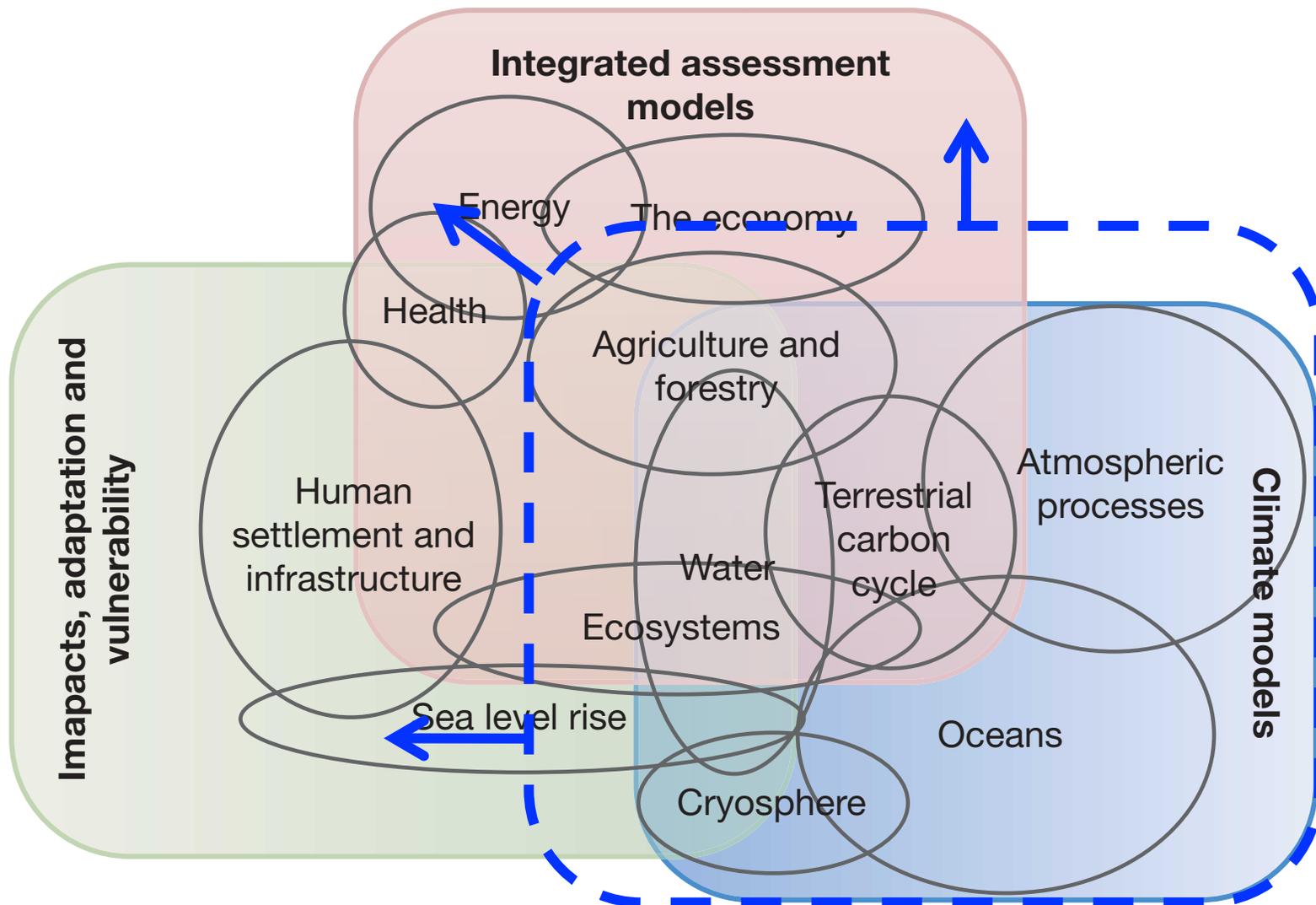
Predicted energy and industry CO₂ emissions from Integrated Assessment Models (IAMs)



What's an IAM?

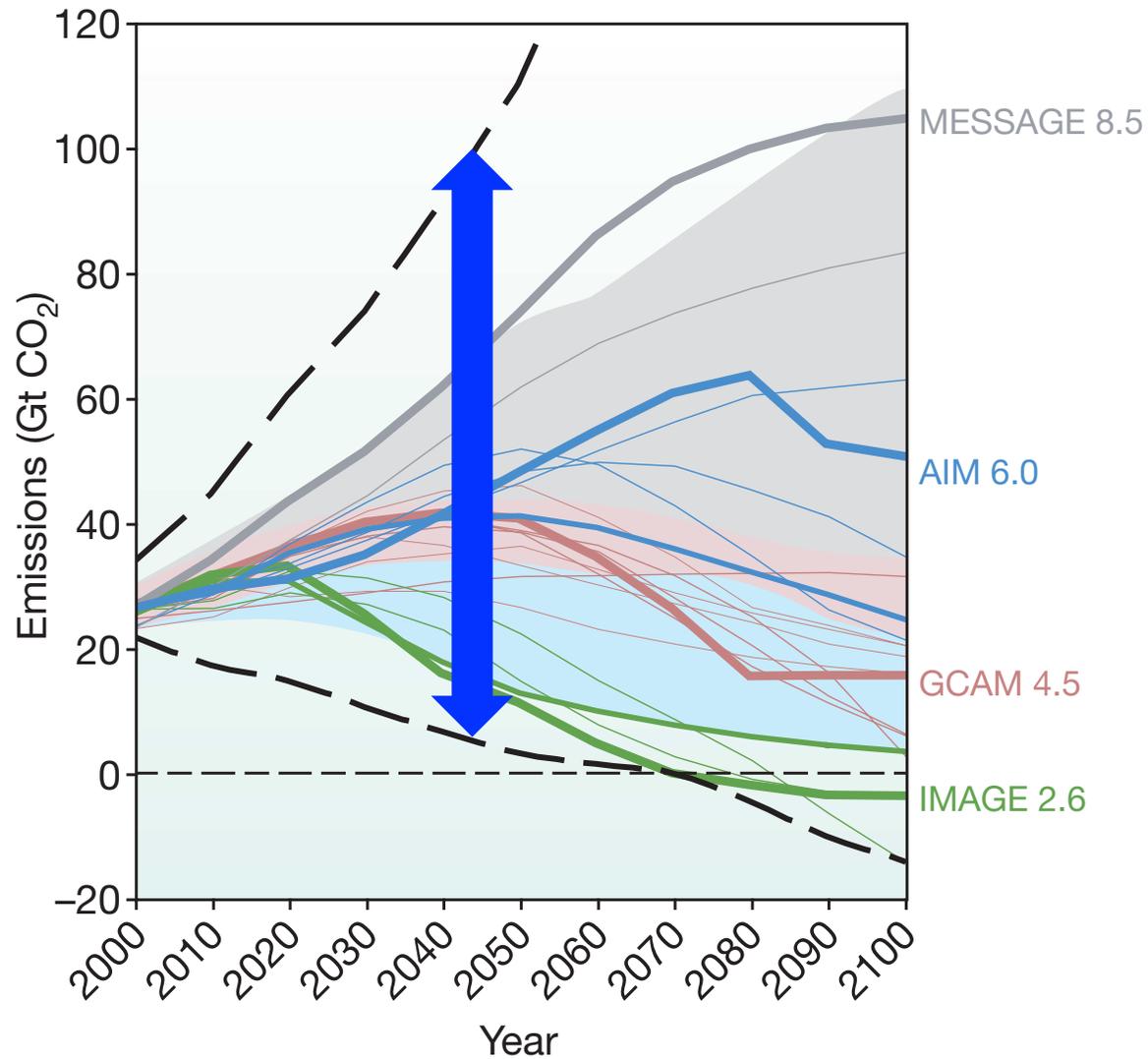


What's an Earth System Model?

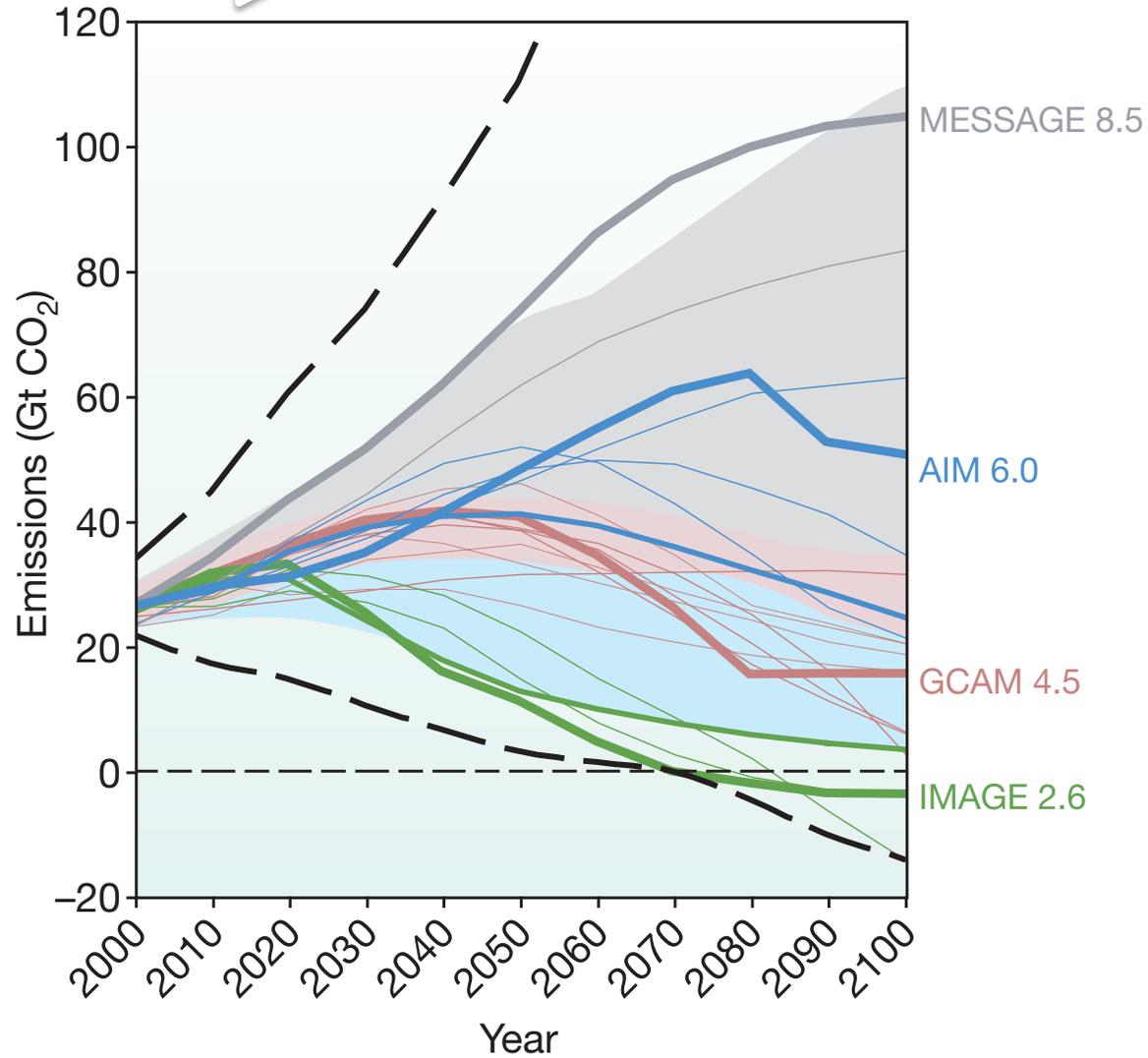


Representative Concentration Pathways (RCPs)

Range of predictions from all IAMs considered



Representation of the Future



IPCC Idol

Judging Criteria

- Winners should represent “the full range of stabilization, mitigation, and reference emissions scenarios available in the current scientific literature”
- Manageable and even number of winners (no “middle one”)
- Far enough apart from each other
- With available output



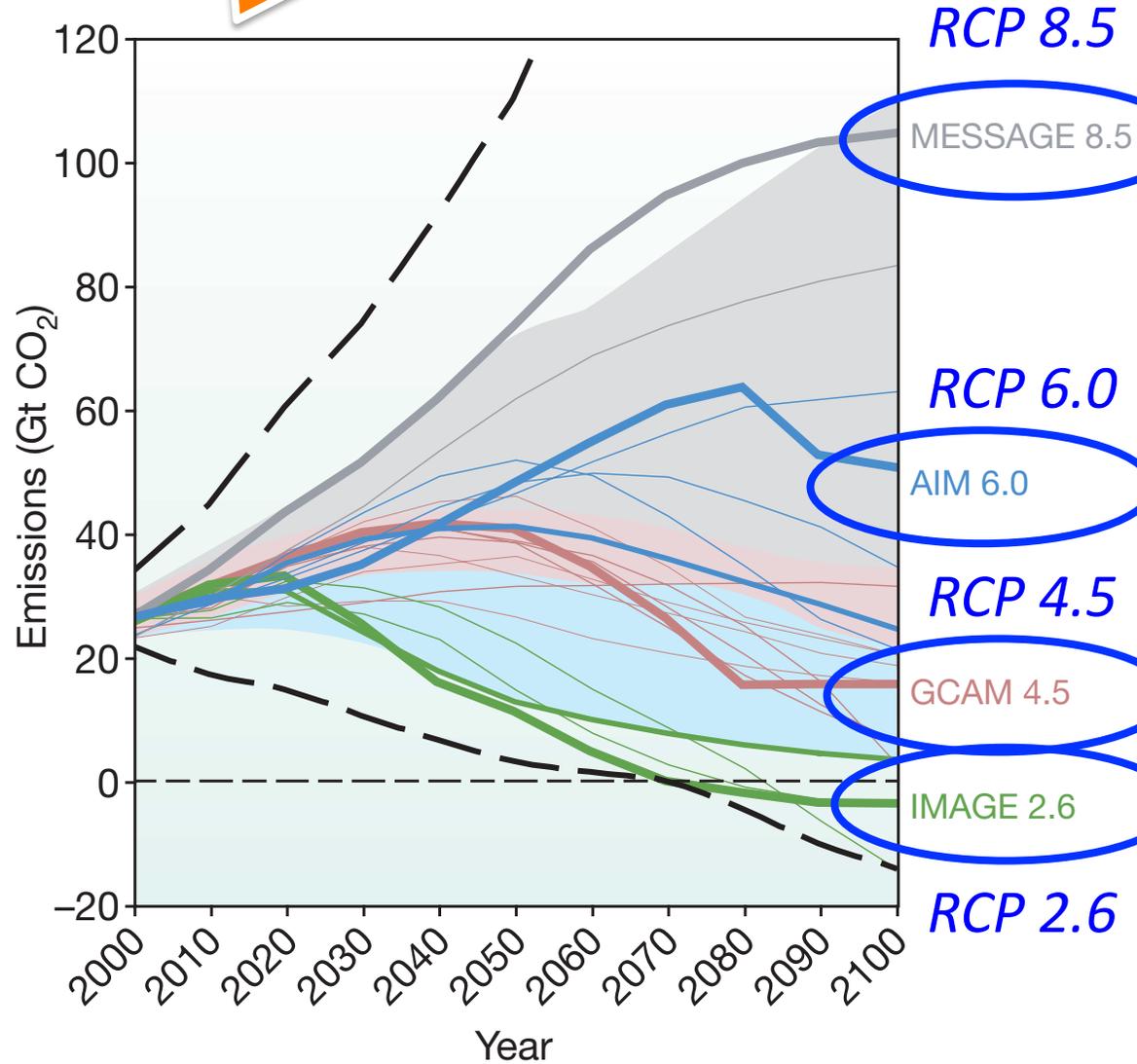
http://www.resilientus.org/library/carri013004_0785268841869_1233004555.png

http://assets.nydailynews.com/img/2008/12/17/alg_idol_judges.jpg

Representation of Future Emissions

IPCC Idol

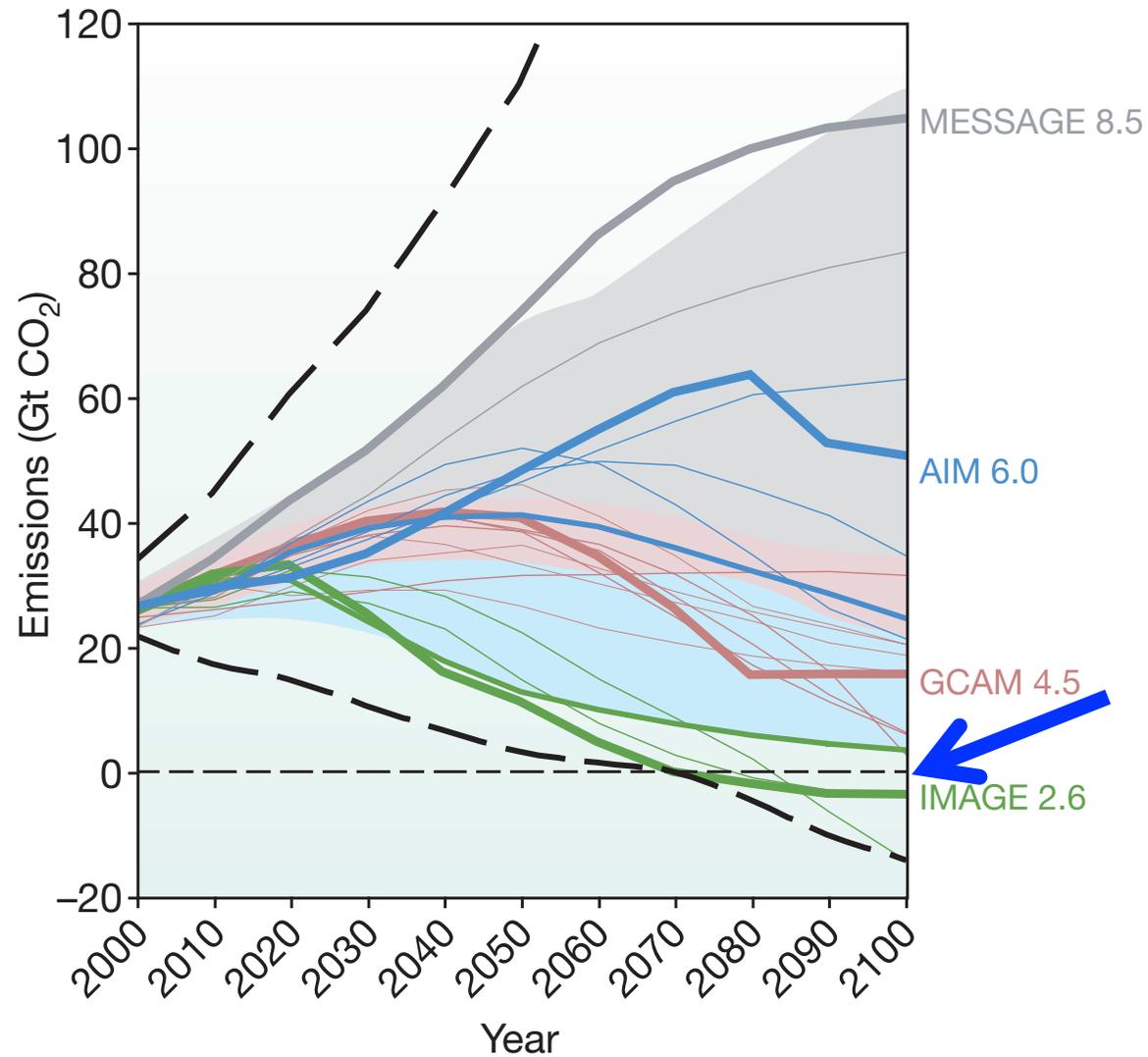
The Winners!



<http://www.nature.com/nature/journal/v463/n7282/pdf/nature08823.pdf>

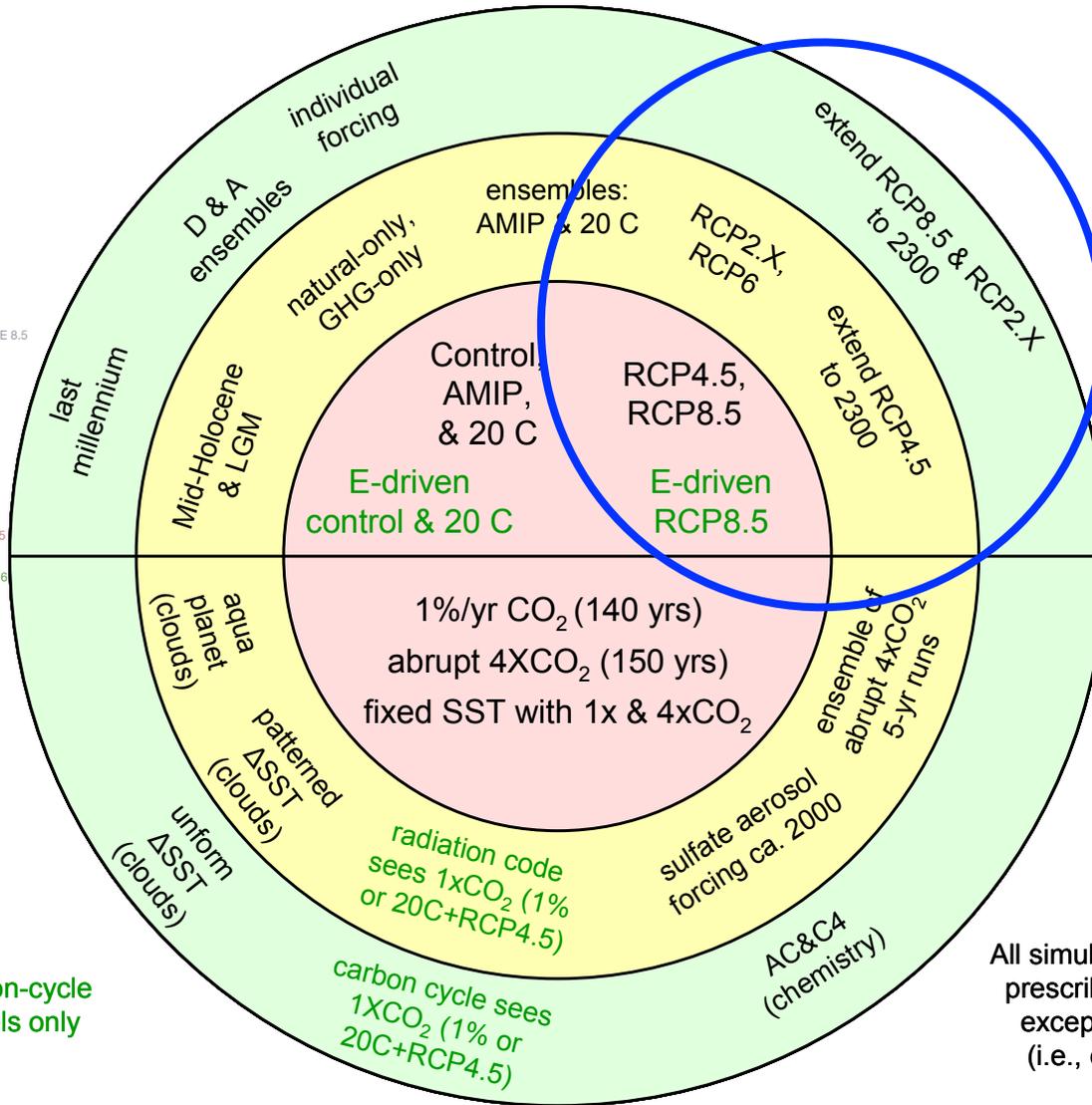
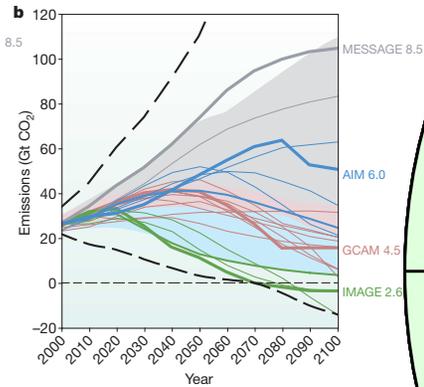
Representative Concentration Pathways (RCPs)

*Net CO₂
sequestration*



CMIP5 Long-Term Onion

Future mitigation scenarios

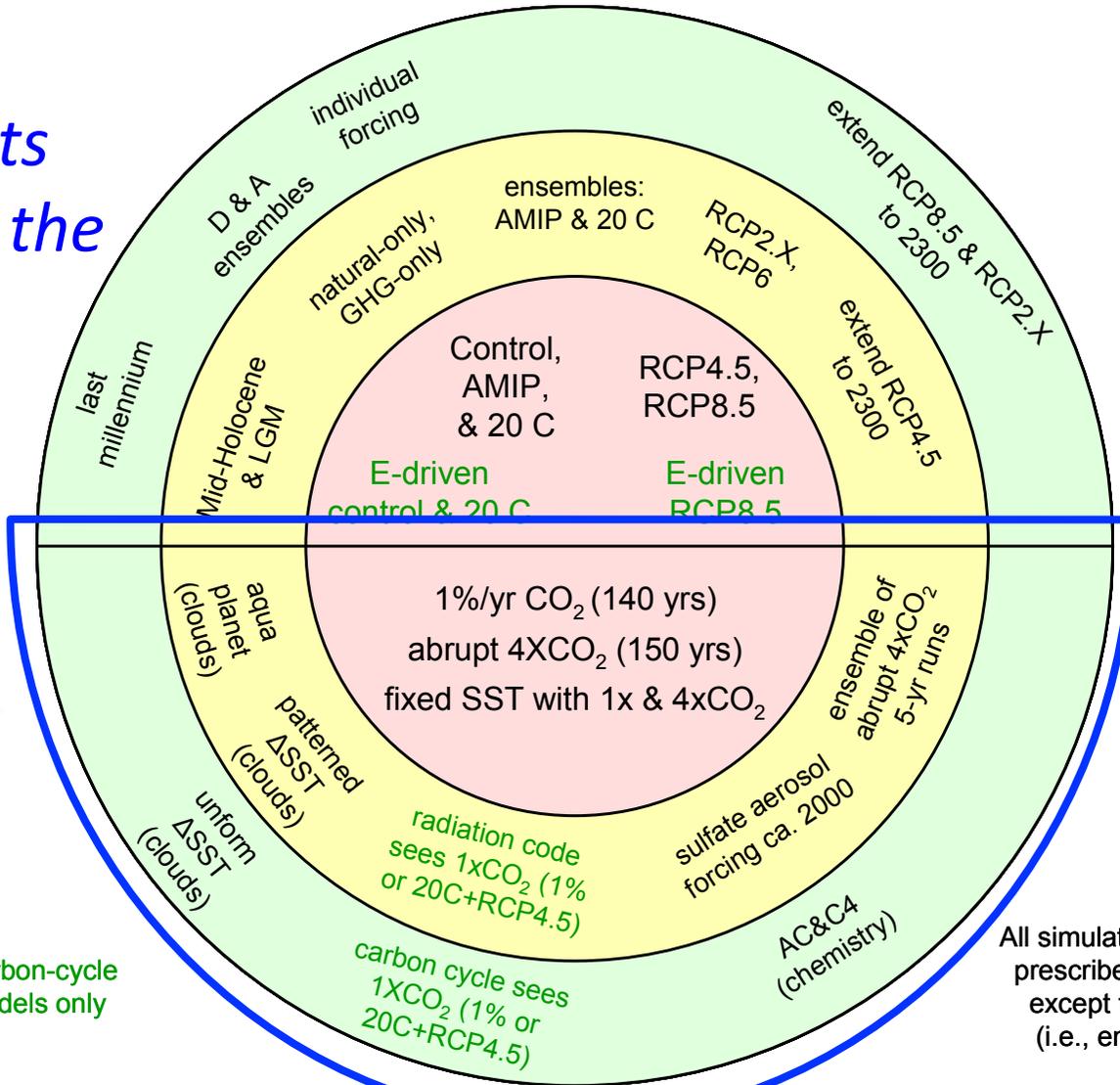


Coupled carbon-cycle climate models only

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

CMIP5 Long-Term Onion

Diagnostic experiments (how does the model behave)

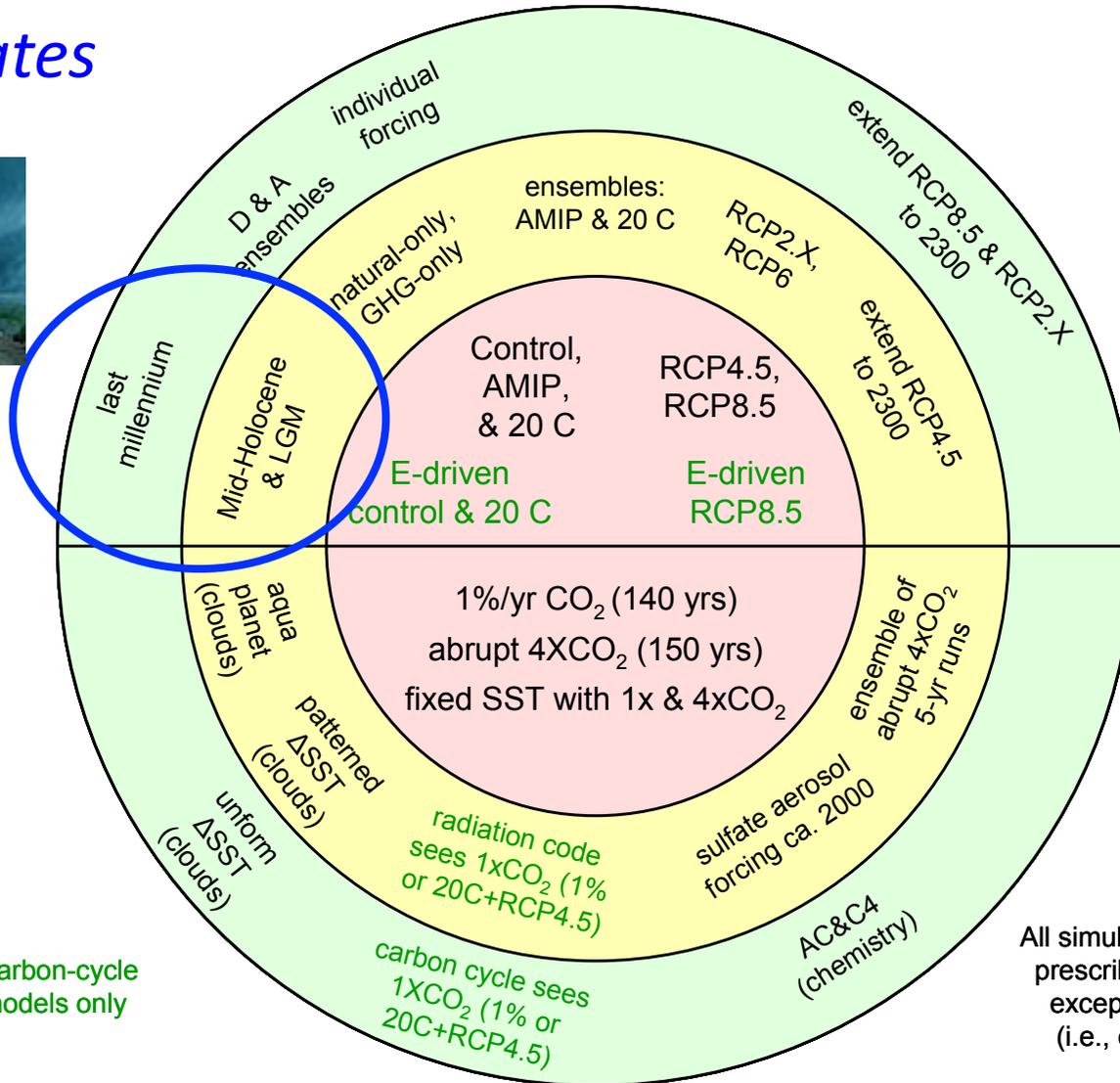


Coupled carbon-cycle climate models only

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

CMIP5 Long-Term Onion

Past climates

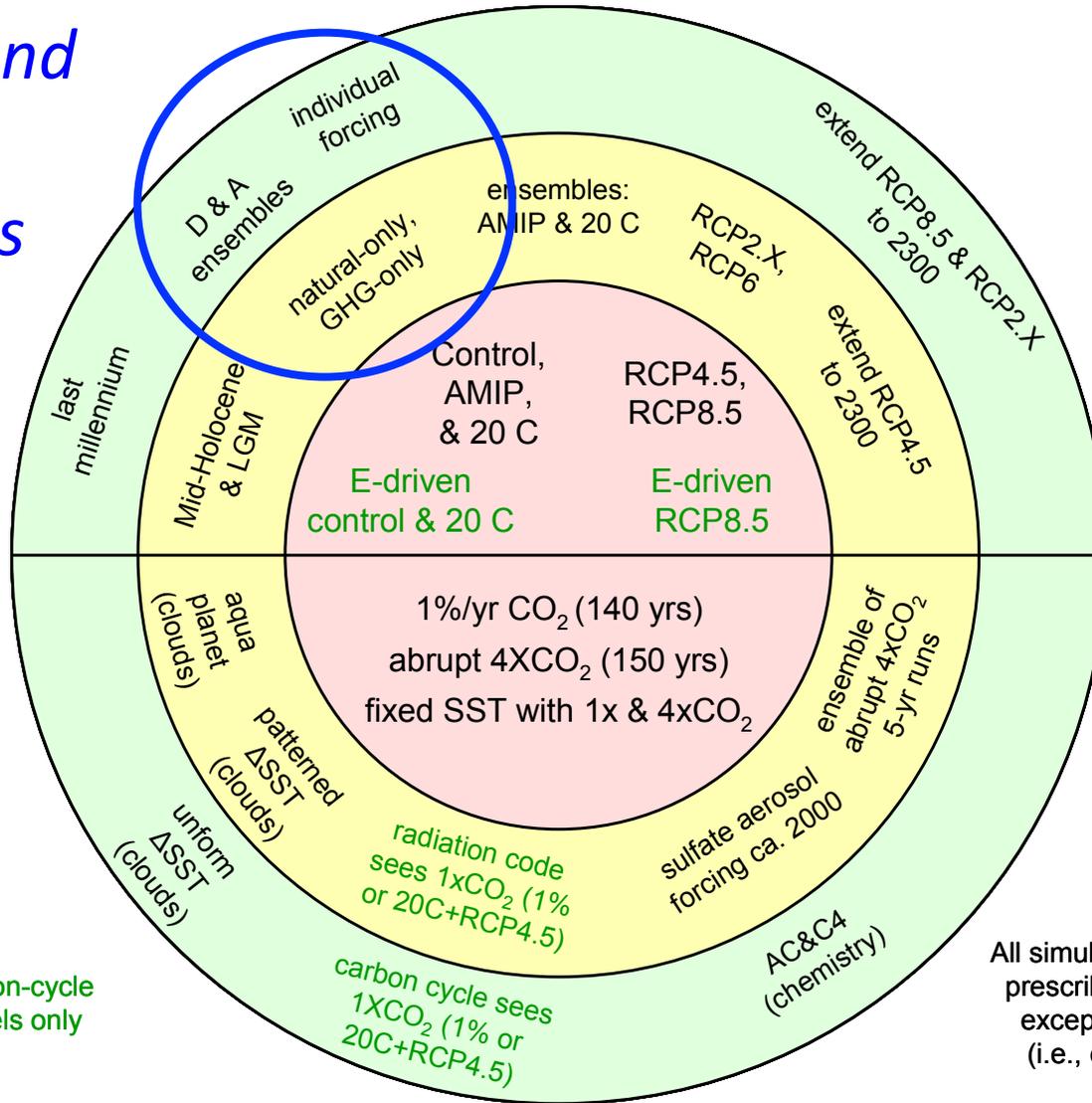


Coupled carbon-cycle climate models only

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

CMIP5 Long-Term Onion

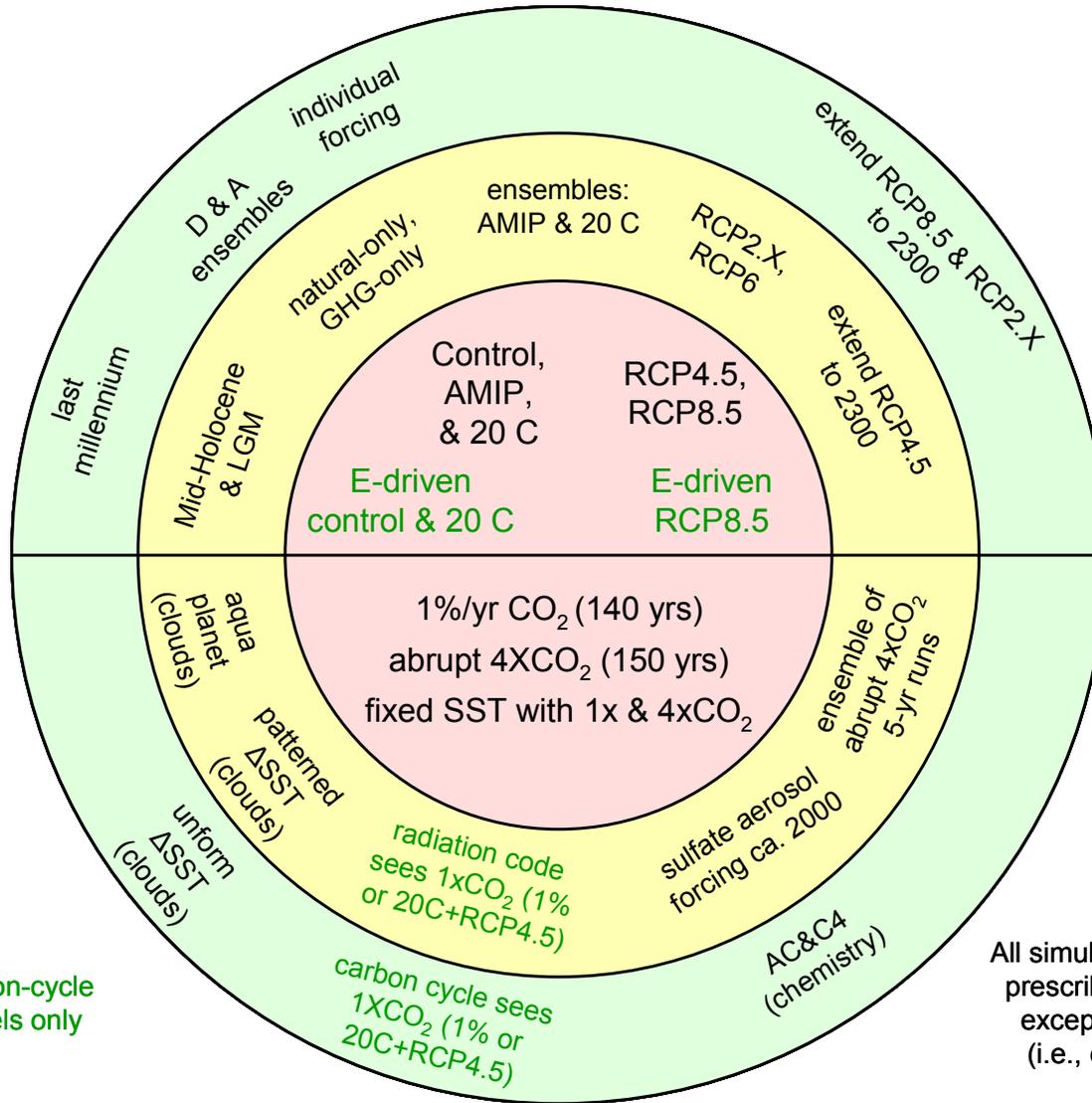
Detection and attribution (who causes what)



Coupled carbon-cycle climate models only

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

CMIP5 Long-Term Onion



Coupled carbon-cycle climate models only

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

AR5 Recipe

- ~~CMIP5 defines experiments~~
- Develop a model
- Run experiments
- Provide simulation output
- Scientists worldwide analyze output
- Scientists worldwide publish papers
- AR5 authors cite papers

MODEL DOCUMENTATION

CESM1.0

[User's Guide](#)

Atmosphere Models

- ▶ Community Atmosphere Model (CAM5)
- ▶ Climatological Data Model (DATM)

Land Models

- ▶ Community Land Model (CLM4)
- ▶ Climatological Data Model (DLND)

Sea Ice Models

- ▶ Community Ice Code (CICE4)
- ▶ Climatological Ice Model (DICE)

Ocean Models

- ▶ Parallel Ocean Program (POP2)
- ▶ Climatological/Slab-Ocean Data Model (DOCN)

Land Ice Models

- ▶ Community Ice Sheet Model (Glimmer - CISM)

CESM Coupler

- ▶ CESM Coupler (CPL7)

External Library Documentation

- [Parallel I/O Library \(PIO\)](#)
- [Model Coupling Toolkit \(MCT\)](#)
- [Earth System Modeling Framework \(ESMF\)](#)

MODEL INPUT DATA

The input data necessary to run the CESM1.0 models is available in the input data repository. Note that the CESM1.0 input data is not available in the CESM1.0 input data repository. **DO NOT** attempt to use the CESM1.0 input data repository. The [User's Guide](#) explains how to obtain the input data.

www.cesm.ucar.edu

PERFORMANCE AND LOAD BALANCING DATA

MODEL SOURCE CODE

Copyright and Terms of Use

All CESM source code is subject to the following Copyright Notice and Disclaimer.

Acquiring the Code

CESM source code is distributed through a public Subversion code repository. This code can be checked out using Subversion client software, such as the command tool svn, or simply [viewed with a web browser](#).

A short [registration](#) is required to access the repository. After registering, you will receive an email containing a user name and password that is necessary to gain access to the repository.

Acquisition of the code is more fully described in the [CESM1.0 User's Guide](#).

Version Summaries and Known Problems

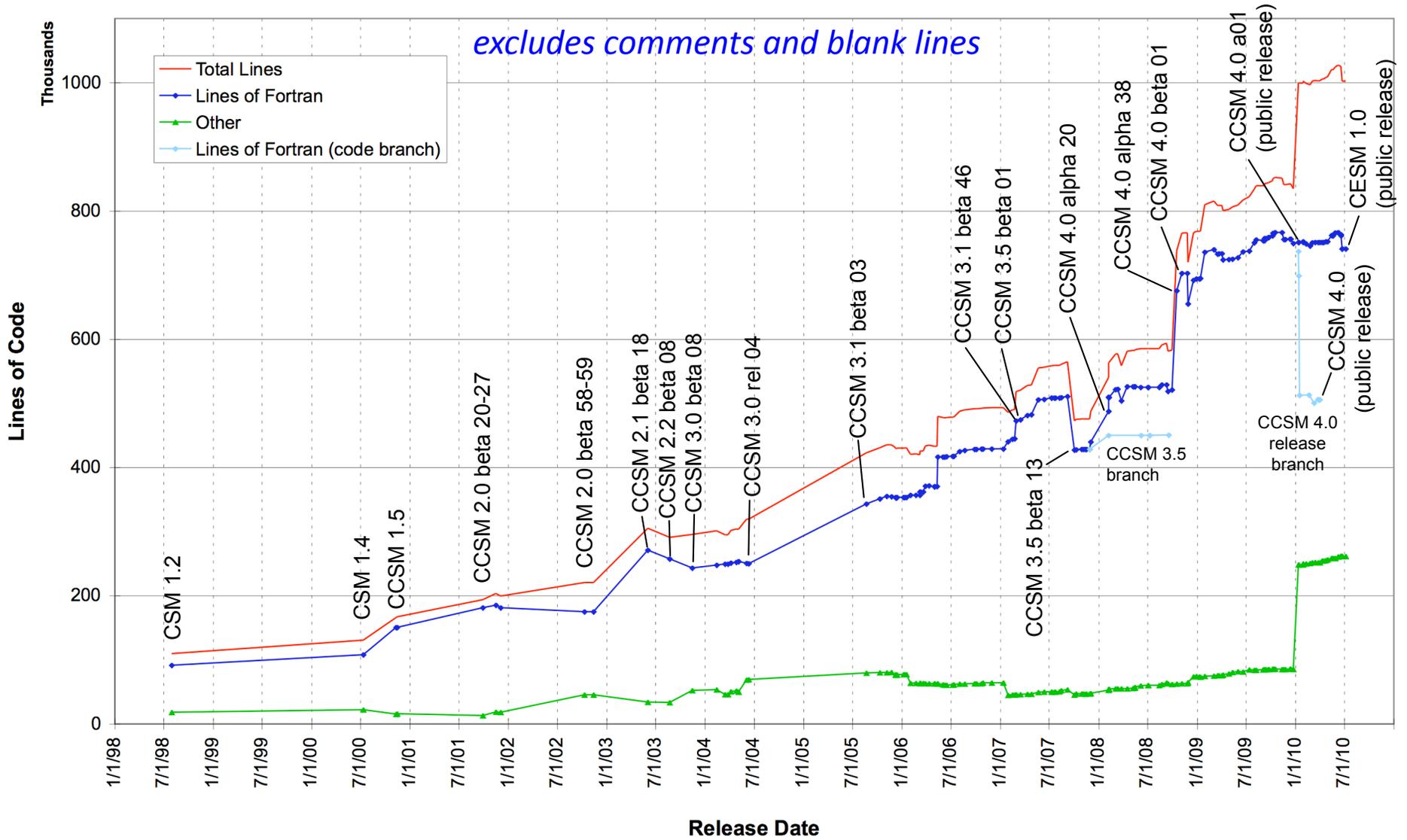
The following table lists the available versions of code along with their test record and any known problems in the code.

- [CESM1.0 Release Versions](#)

Reporting a Problem

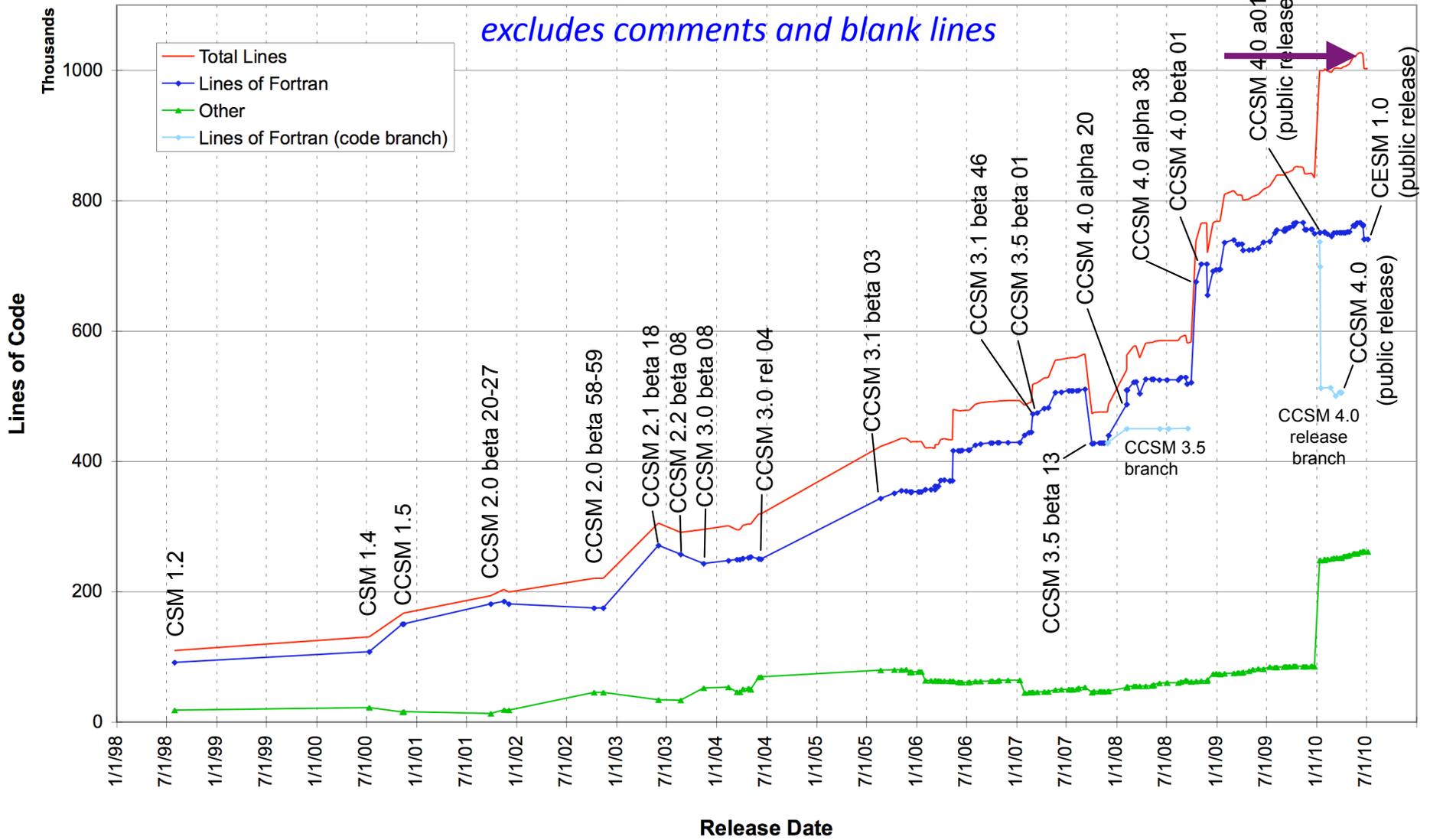
If you have any problems, please first read the User's Guide including the sections on FAQs and Use Cases. Please also refer to the [CESM Bulletin Board](#), which is in place to facilitate communication within the CESM community. Finally, please also refer to the [Known Problems](#) entries that are provided with every release and release update. If questions or problems still exist, then please send an email to cesm-help@cgd.ucar.edu. Support questions will be answered as they are available.

Growth in Lines of Code for CSM/CCSM/CESM, 1998-2010



Courtesy of Steve Easterbrook, University of Toronto

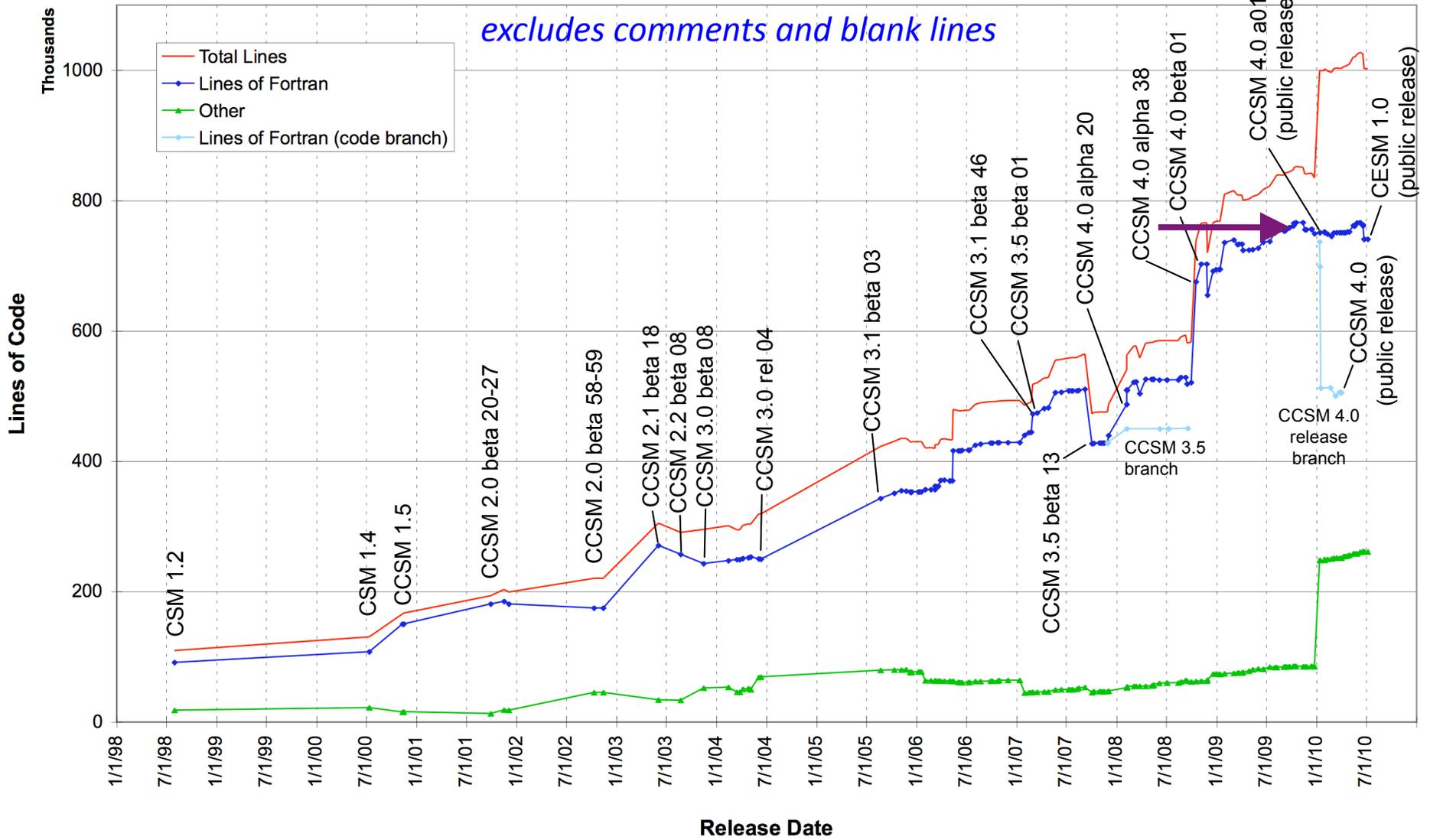
Growth in Lines of Code for CSM/CCSM/CESM, 1998-2010



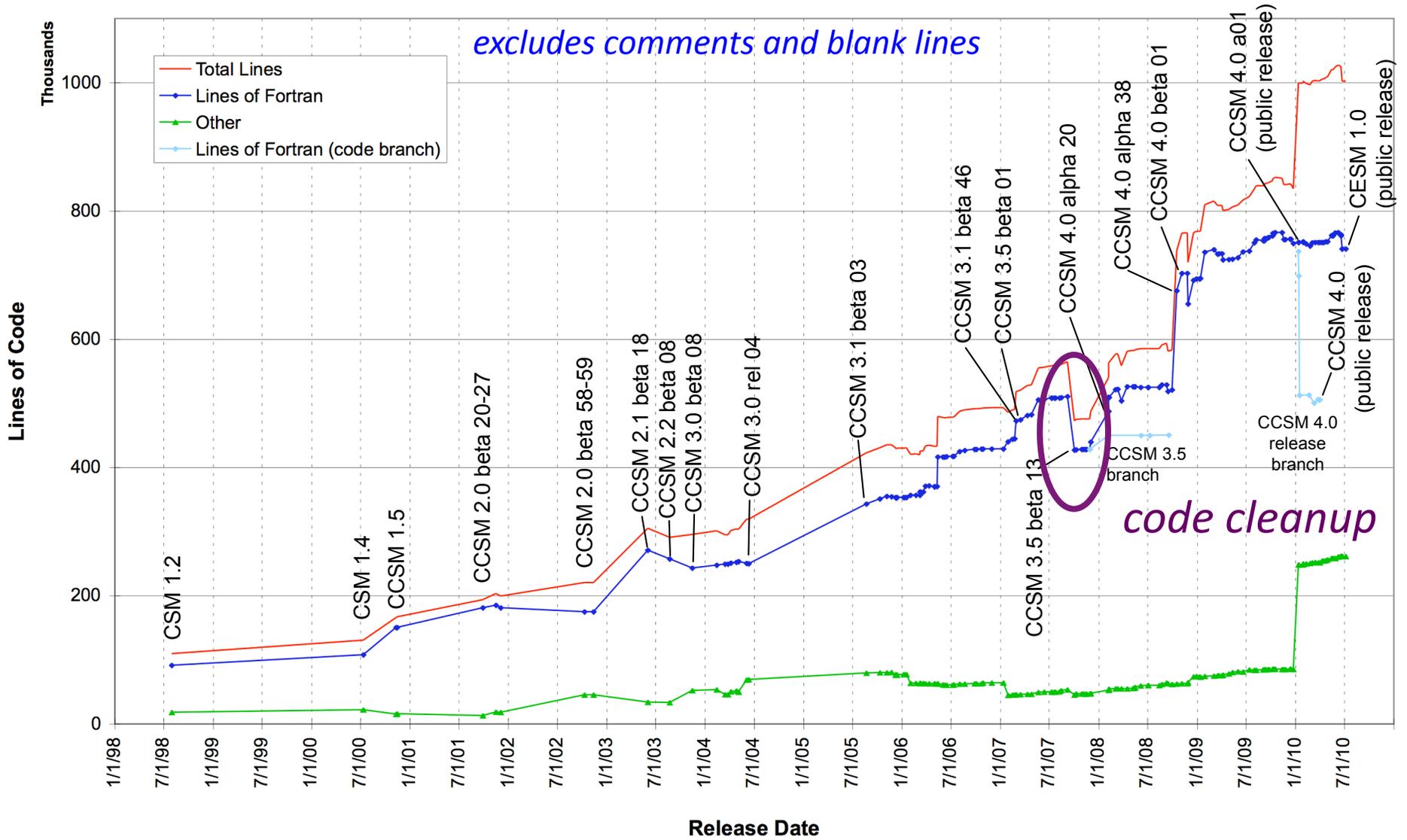
Courtesy of Steve Easterbrook, University of Toronto

Growth in Lines of Code for CSM/CCSM/CESM, 1998-2010

800k lines of Fortran

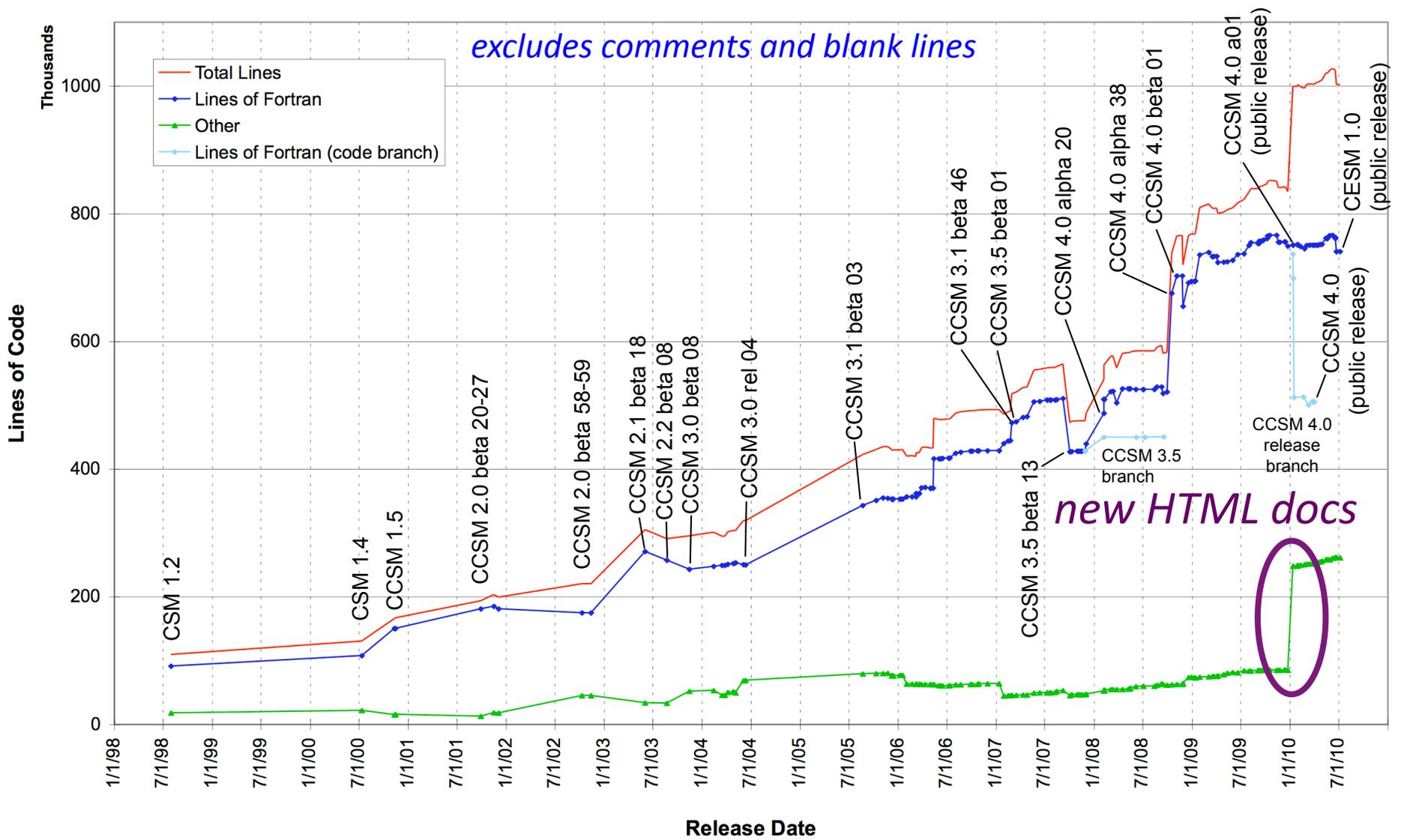


Growth in Lines of Code for CSM/CCSM/CESM, 1998-2010



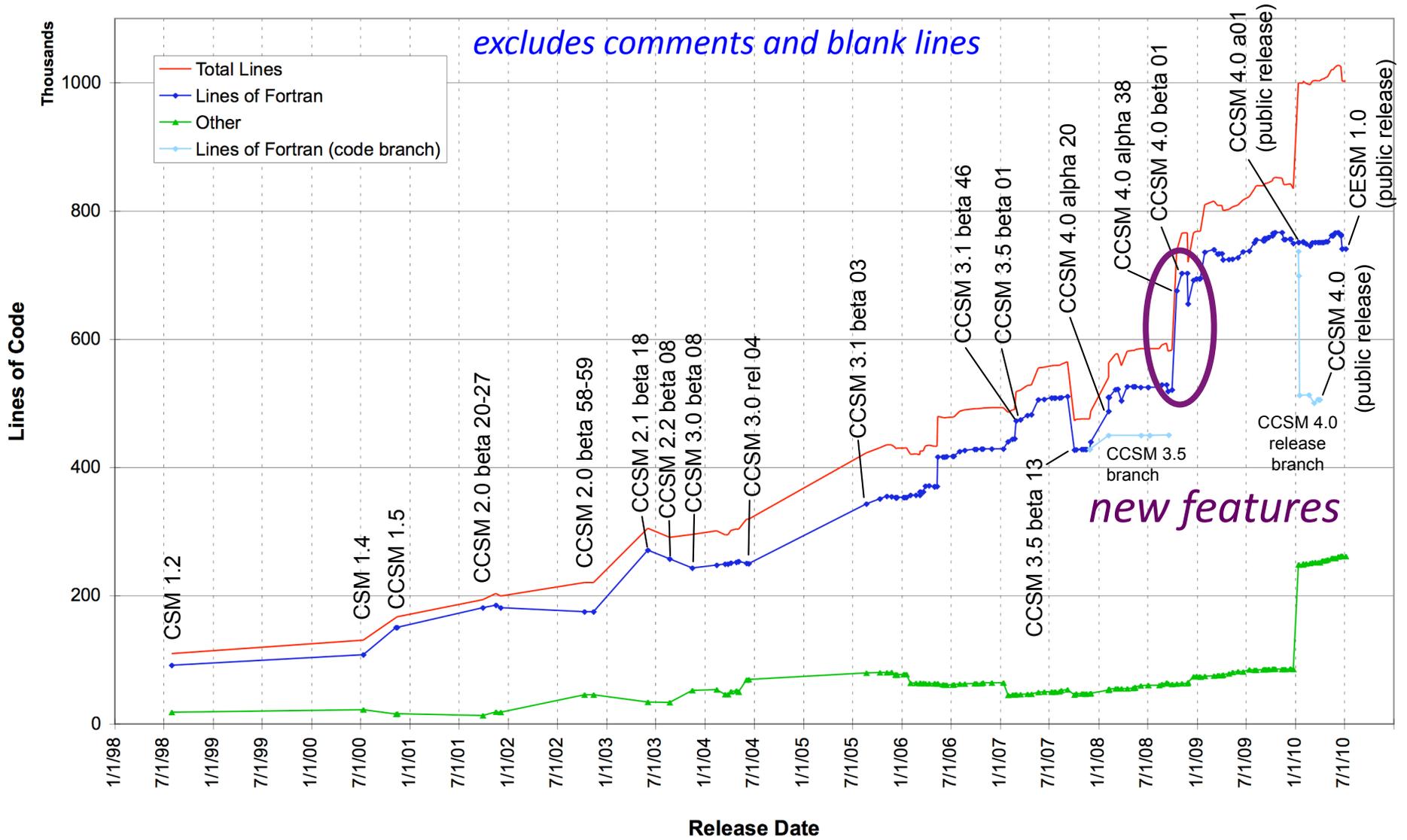
Courtesy of Steve Easterbrook, University of Toronto

Growth in Lines of Code for CSM/CCSM/CESM, 1998-2010



Courtesy of Steve Easterbrook, University of Toronto

Growth in Lines of Code for CSM/CCSM/CESM, 1998-2010



Courtesy of Steve Easterbrook, University of Toronto

Some New Features of CESM

- Parallel I/O, parallel data models
- OpenMP in all components
- New atmospheric physics
- Full and “fast” atmospheric chemistries
- “High top” atmosphere (stratosphere)
- Dynamic vegetation with carbon & nitrogen biogeochemistry
- Ocean ecosystem
- Land ice-sheet model

AR5 Recipe

- ~~CMIP5 defines experiments~~
- ~~Develop a model~~
- Run experiments
- Provide simulation output
- Scientists worldwide analyze output
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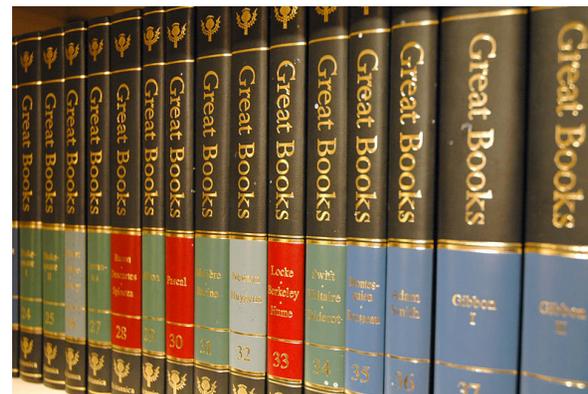
Requirements!

229 Configuration Variables

- 42 variables for the overall experiment
- 58 variables for the “configure” step
- 34 variables for the parallel layout
- 27 variables for the “build” step
- 68 variables for the “run” step

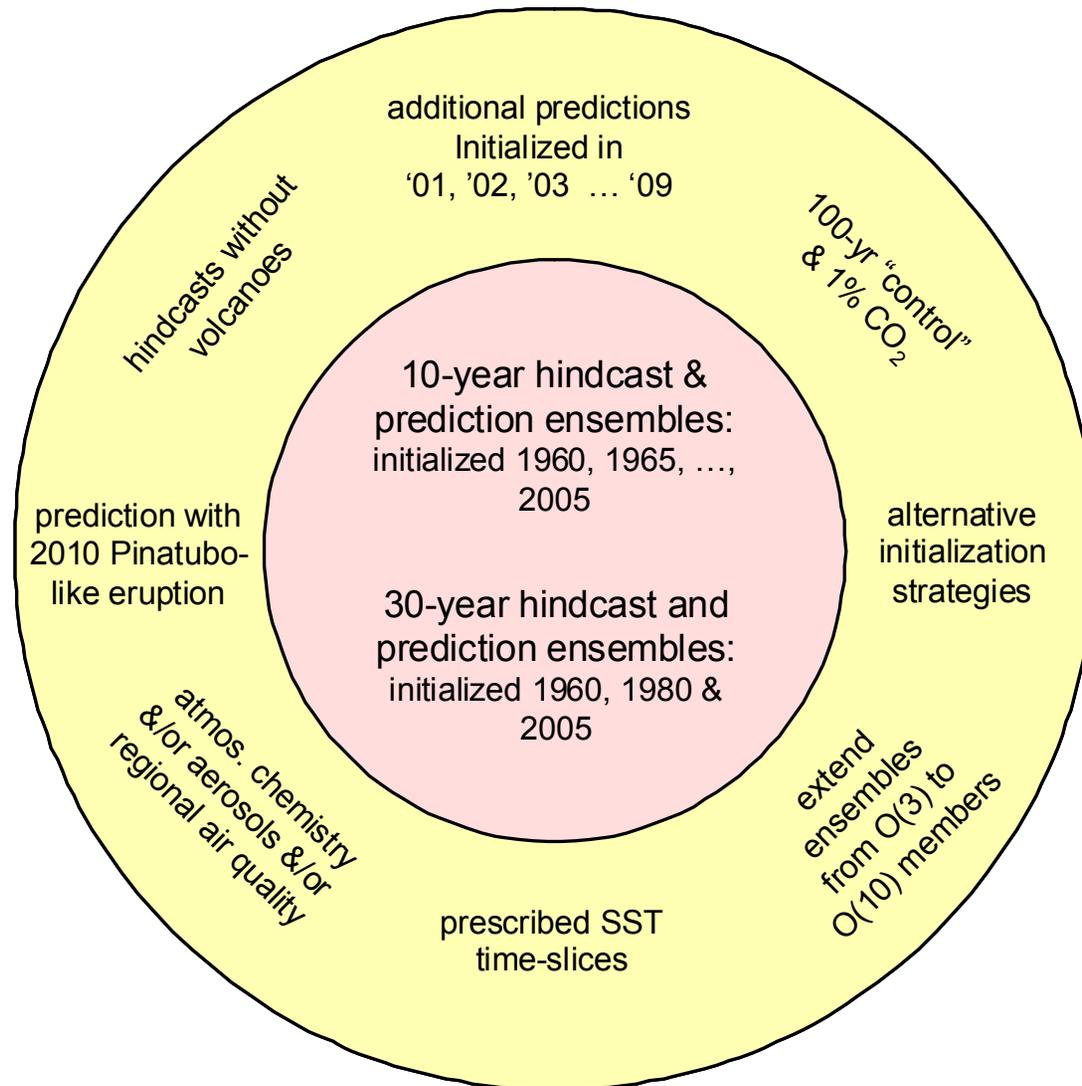


Input Data



- Initial conditions
- Prescribed quantities
(emissions, concentrations, land use)
- 2 TB, 9400 files, and growing
(increasing resolution and model complexity)
- **Requirement: fast, shared, unswept scratch**
(/tmp/proj)

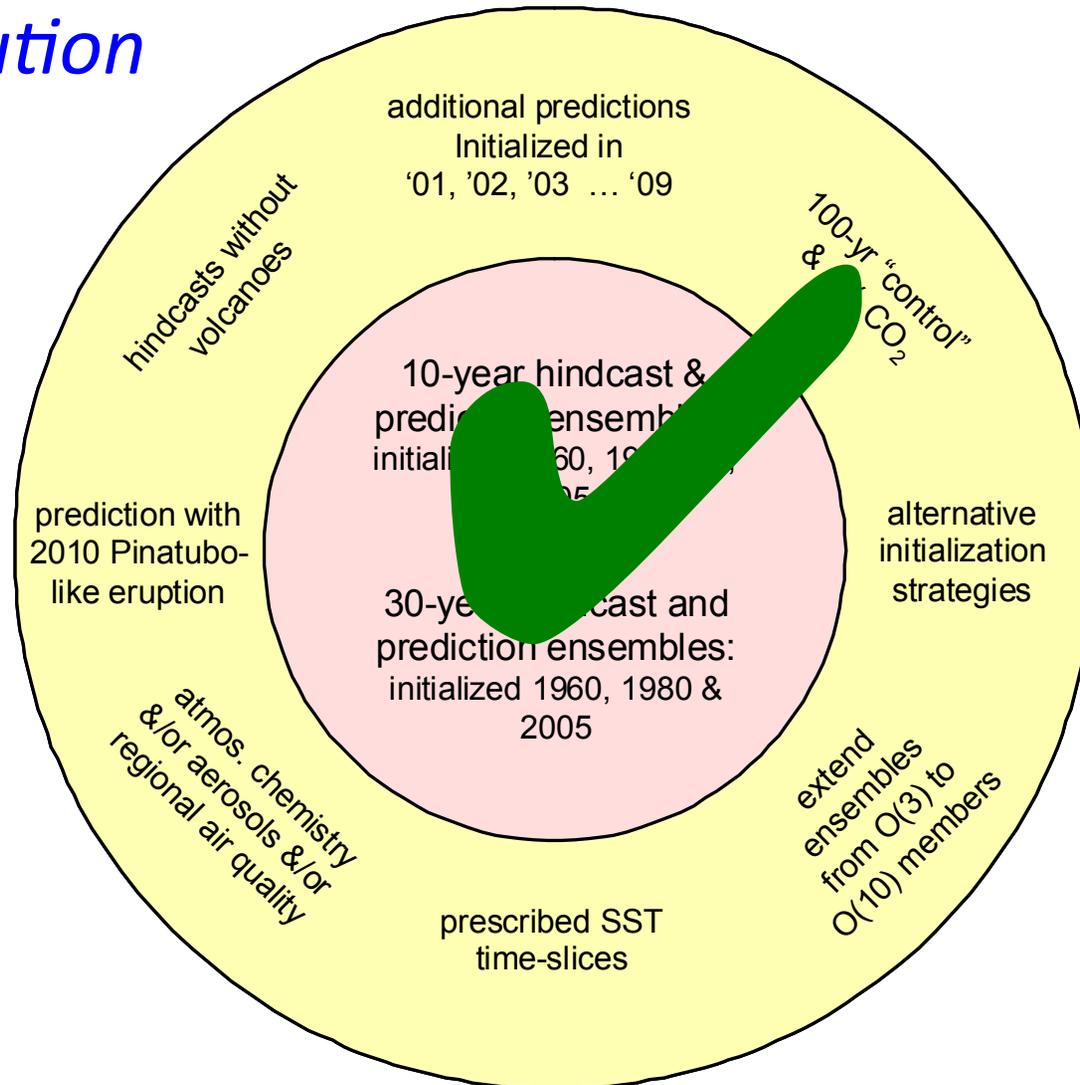
Cooking the CMIP5 Decadal Onion



Cooking the CMIP5 Decadal Onion

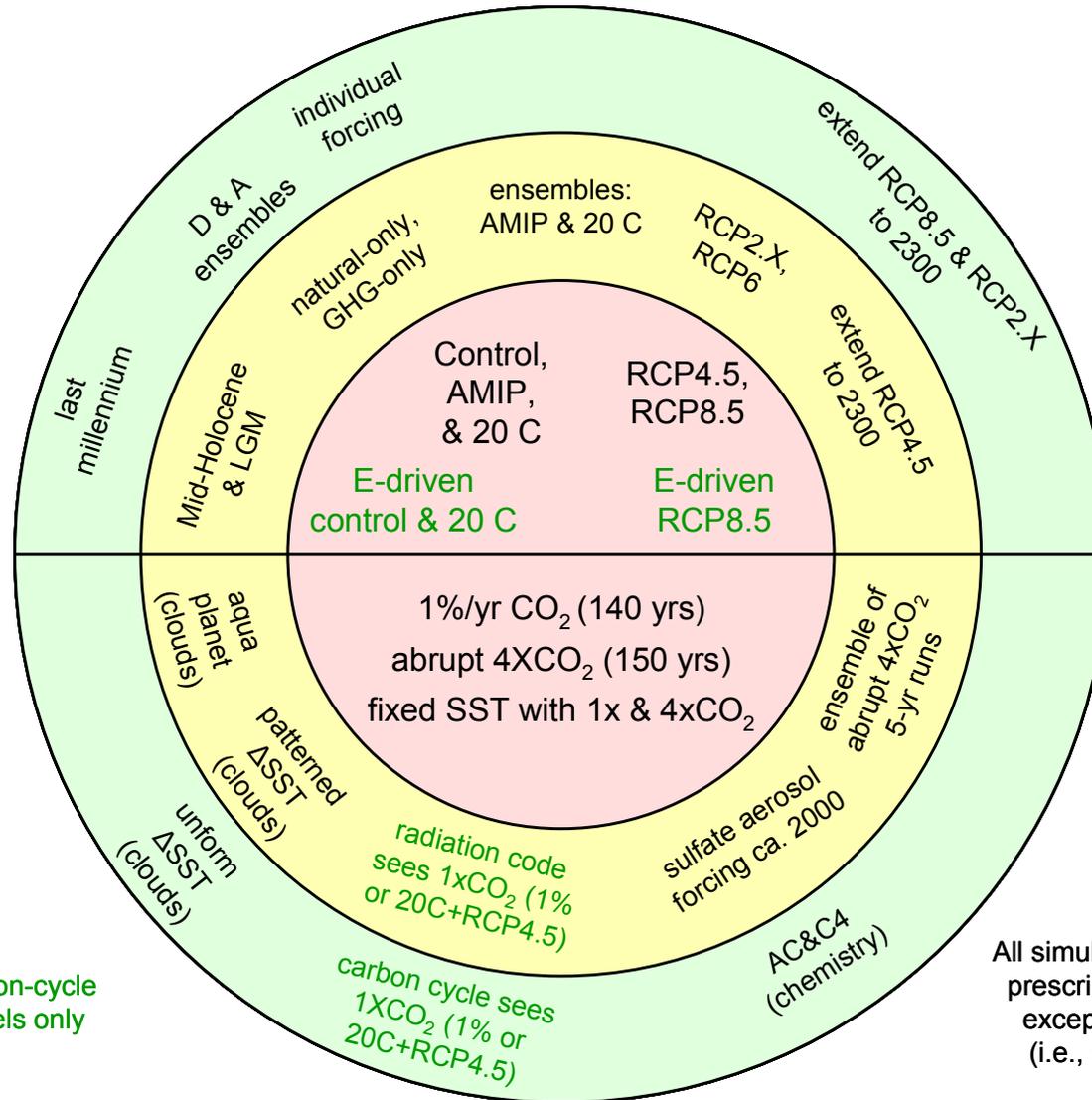
High resolution

Leadership
Computing



Cooking the CMIP5 Long-Term Onion

Lower resolution

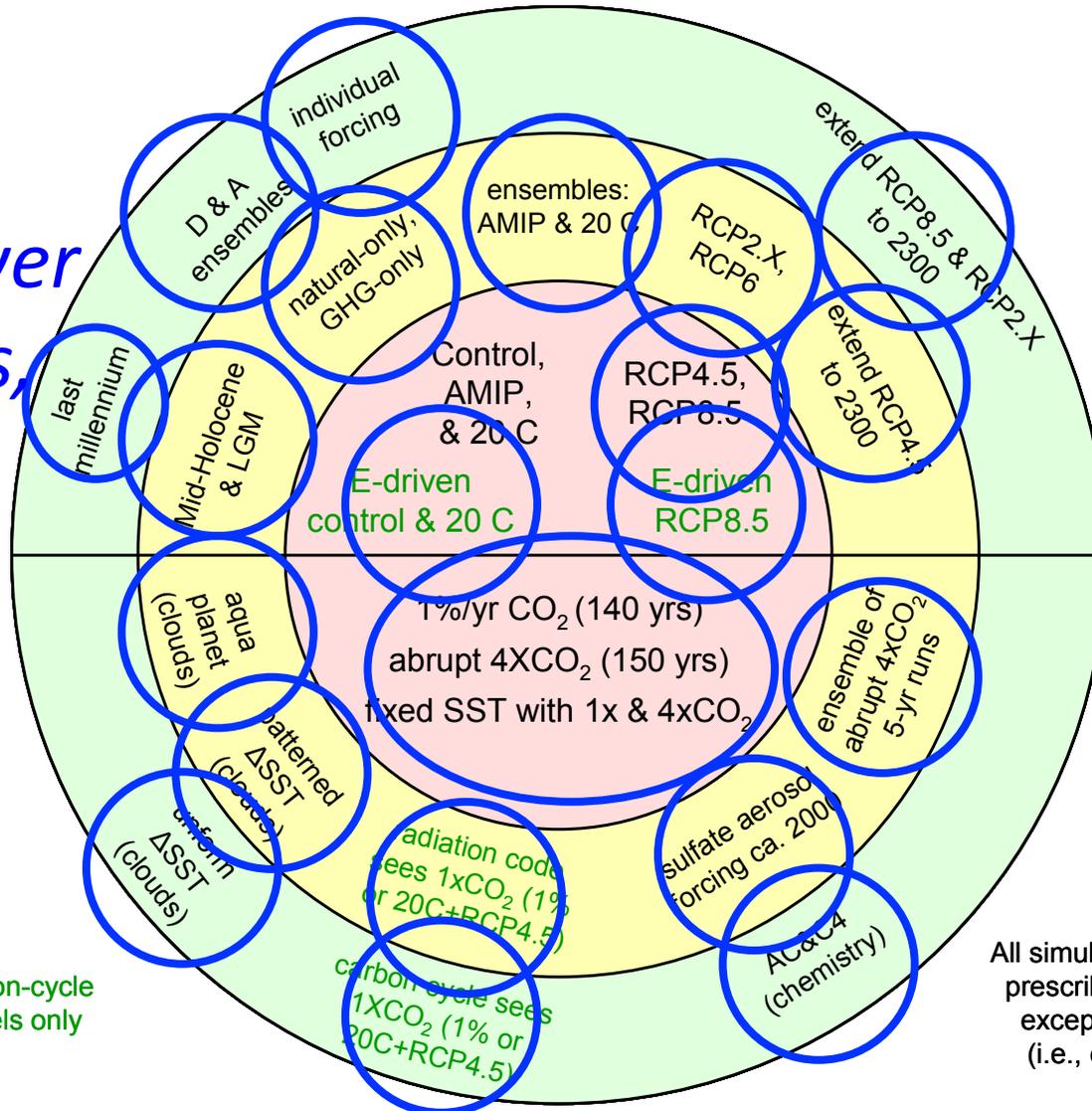


Coupled carbon-cycle climate models only

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

Cooking the CMIP5 Long-Term Onion

*Lower
resolution
Parallel over
ensembles,
RCPs, etc.*

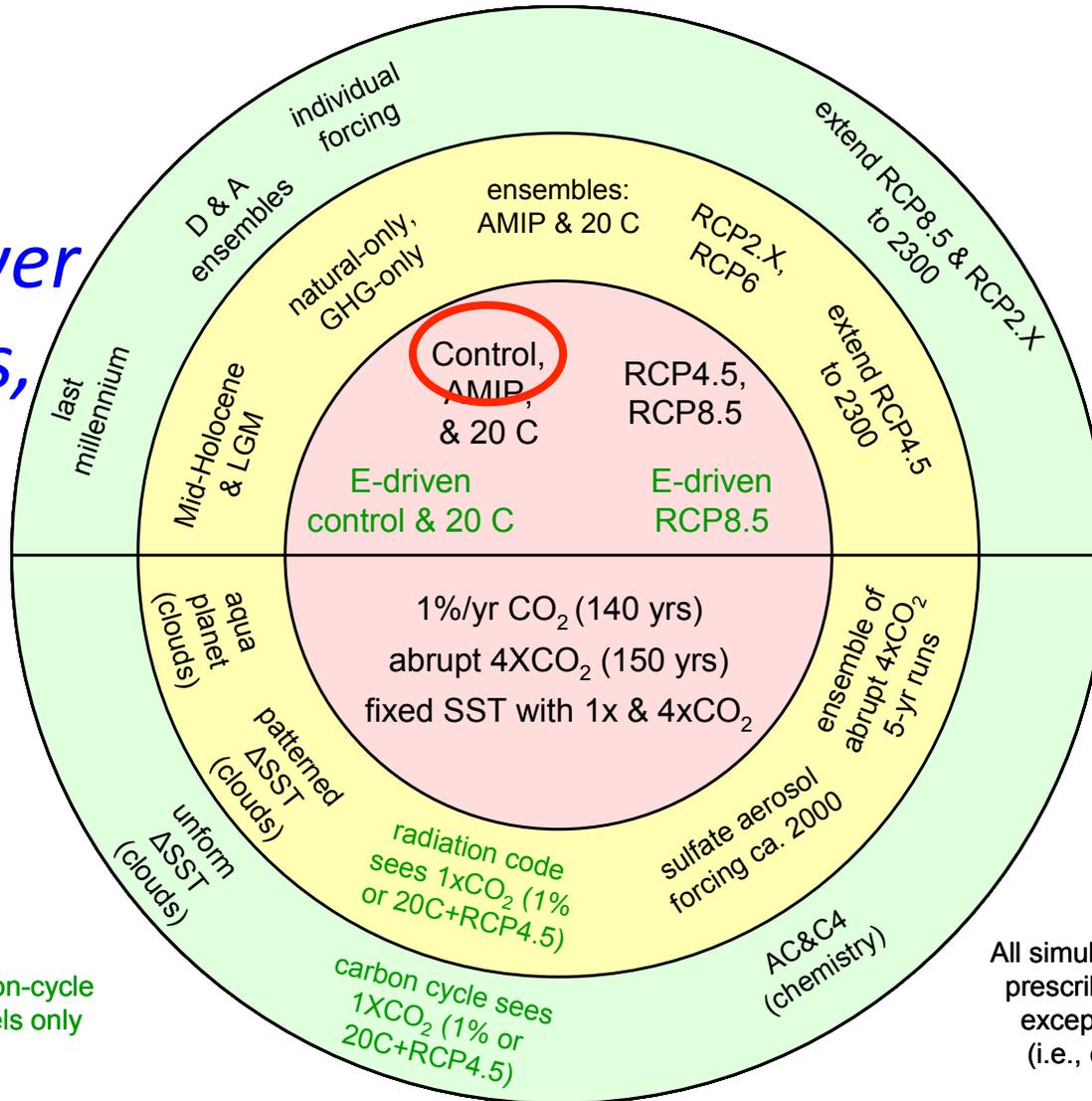


Coupled carbon-cycle climate models only

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

Cooking the CMIP5 Long-Term Onion

Lower resolution Parallel over ensembles, RCPs, etc. Except control runs

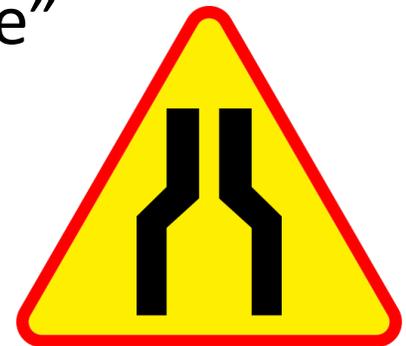


Coupled carbon-cycle climate models only

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

And some development runs

- Code changes resulting in identical (bit for bit) results
 - Short debug runs
 - Use “debug” queue
- Code changes that change results
 - Must prove they don’t change “climate”
 - 20 or more simulated years
 - 1-2 days of runtime



Requirement: Ability to perform
day-to-week-long terascale runs

... to get to petascale runs

“Mother of All Runs” (MOAR)

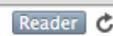
- History output is usually monthly averages
- MOAR adds output high resolution in time
- Ongoing at NCAR
- 20th-century run done
- RCP runs starting



FV 1deg MOAR 20C run

	time type	period	volume (GB)
<u>atm cam2.h0</u> (fincl1)	monthly	1850-1949	983.119
<u>atm cam2.h0</u> (fincl1)	monthly	1950-2005	558.573
<u>atm cam2.h1</u> (fincl2)	daily	entire run	478.580
<u>atm cam2.h2</u> (fincl3)	daily	1950-2005	1,785.795
<u>atm cam2.h3</u> (fincl4)	6-hourly	1950-2005	2,423.257
<u>atm cam2.h4</u> (fincl5)	3-hourly	1950-2005	651.024
<u>atm cam2.h5</u> (fincl6)	daily	1979-2005	3,515.966
<u>lnd clm2.h0</u>	monthly	entire run	202.386
<u>lnd clm2.h1</u>	daily	entire run	299.588
<u>ocn pop.h</u>	monthly	entire run	3,765.242
<u>ocn pop.nday1</u>	daily	entire run	12,655.151
<u>ice cice.h</u>	monthly	entire run	167.463
<u>ice cice.h1</u>	daily	entire run	2,994.626
<u>cpl</u>	daily	entire run	1,813.919
rest		entire run	7,137.883
total			39,432.571

40 TB to archive

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Storage Policy

The full [storage policy](#) that every user agrees to when they apply for an account can be found on the website. http://www.nccs.gov/wp-content/accounts/nccs_storage_policy.pdf

This current page shows a summary of the storage policy. It also discusses some of the changes with respect to archival storage (HPSS) and its quotas.

Introduction

The following policies apply to all projects with allocations on the National Center for Computational Sciences (NCCS) systems. The policies apply equally to all projects regardless of the machine on which they have time.

Storage Policy Summary Table

AREA	ACTUAL LOCATION	QUOTA	PURGE POLICY	RETENTION POLICY
Home Directory	/ccs/home/\$USER	5GB	-	1 month from the date your account is deactivated
NFS Project	/ccs/proj/[projectid]	50GB	-	1 month from the date the project is deactivated
Lustre Project	/tmp/proj/[projectid]	1TB	-	1 month from the date the project is deactivated
Primary Scratch	/tmp/work/[username]	-	Files older than/last accessed 14 days are subject to being swept	-
Local Scratch	varies	varies	Files older than/last accessed 14 days are subject to being swept	-
HPSS Home	/home/[username]	2TB/2,000 Files	-	3 months from the date your account is deactivated
HPSS Project	/proj/[projectid]	45TB/4,500 Files	-	3 months from the date the project is deactivated

Requirement: PB archive space

(see ESG)

AR5 Recipe

- ~~CMIP5 defines experiments~~
- ~~Develop a model~~
- Run experiments < *Diagnostics*
- Provide simulation output
- Scientists worldwide analyze output
- Scientists worldwide publish papers
- AR5 authors cite papers

Requirement

CISL's NCAR Command Language (NCL)

http://www.ncl.ucar.edu/

NCAR CISL VETS Download Contributors

NCL Examples Functions Resources Popular Links What's New Support

NCAR Command Language

Search advanced

NCL is an interpreted language designed specifically for scientific data analysis and visualization.

Portable, robust and free, NCL is available as binaries or open source

Supports netCDF3/4, GRIB1/2, HDF-SDS, HDF4-EOS, binary, shapefiles, and ascii files

Numerous analysis functions are built-in

High quality graphics are easily created and customized with hundreds of graphic resources

Many example scripts and their corresponding graphics are available

Release Information

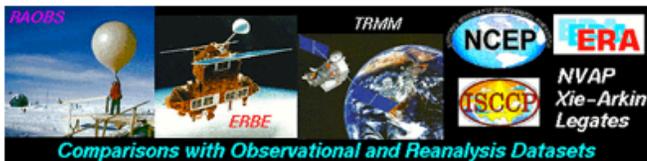
Current Version: 5.2.1
Release Date: July 26, 2010

Announcements

Version 5.2.1 now available!

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AMWG Diagnostics Package cam3655_t341_preind

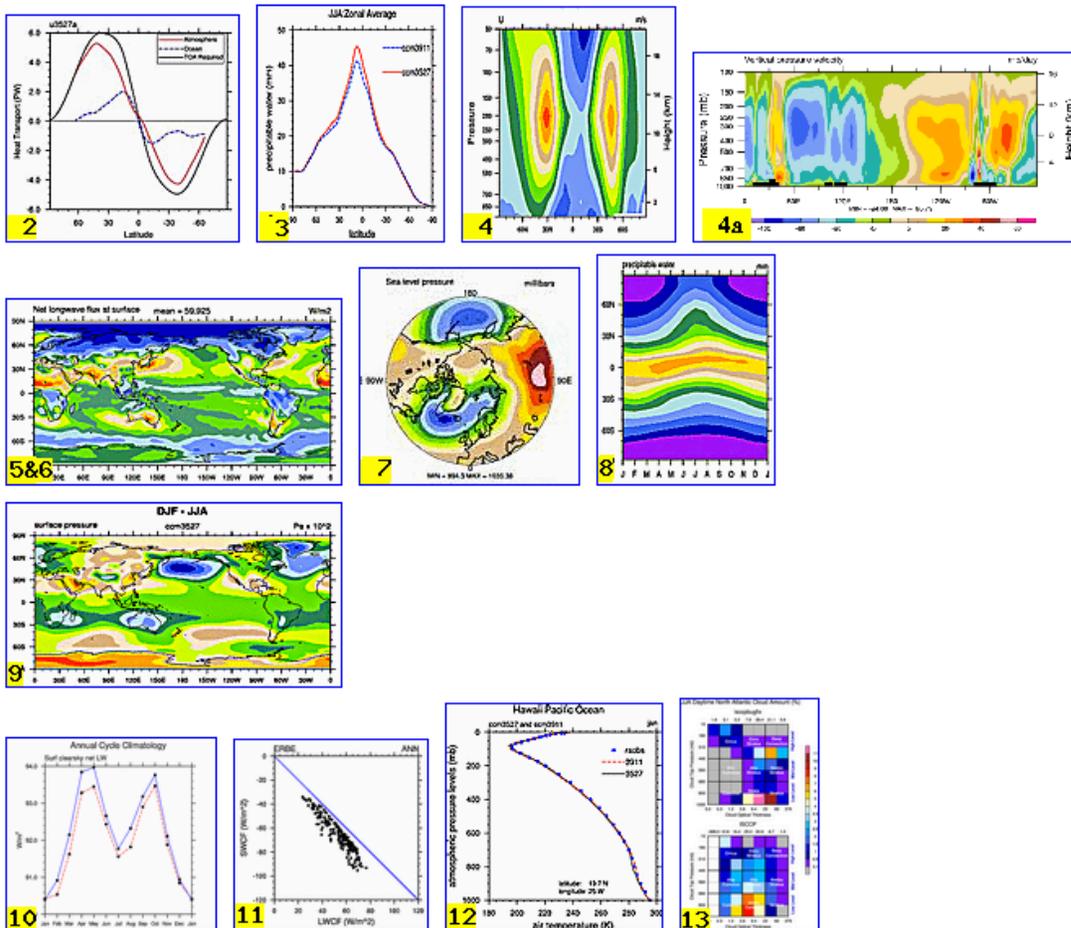


Plots Created
Tue Jan 26 10:40:09 EST 2010

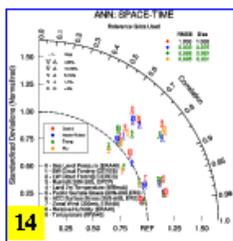
Set Description

- 1 [Tables](#) of ANN, DJF, JJA, global and regional means and RMSE.
- 2 [Line plots](#) of annual implied northward transports.
- 3 [Line plots](#) of DJF, JJA and ANN zonal means
- 4 Vertical [contour plots](#) of DJF, JJA and ANN zonal means
- 4a Vertical (XZ) [contour plots](#) of DJF, JJA and ANN meridional means
- 5 Horizontal [contour plots](#) of DJF, JJA and ANN means
- 6 Horizontal [vector plots](#) of DJF, JJA and ANN means
- 7 Polar [contour and vector plots](#) of DJF, JJA and ANN means
- 8 Annual cycle [contour plots](#) of zonal means
- 9 Horizontal [contour plots](#) of DJF-JJA differences
- 10 Annual cycle [line plots](#) of global means
- 11 Pacific annual cycle, Scatter [plot plots](#)
- 12 Vertical profile [plots](#) from 17 selected stations
- 13 ISCCP cloud simulator [plots](#)
- 14 Taylor Diagram [plots](#)

Click on Plot Type

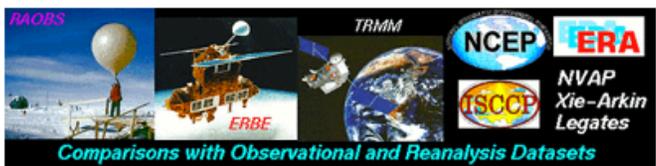


1 TABLES



14 METRICS

AMWG Diagnostics Package cam3655_t341_preind

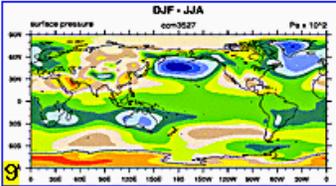
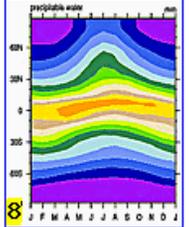
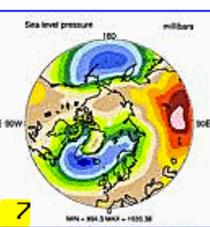
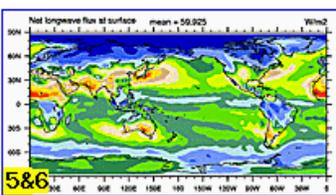
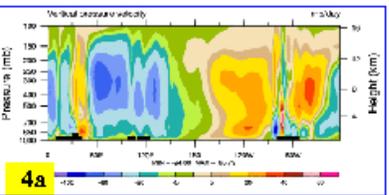
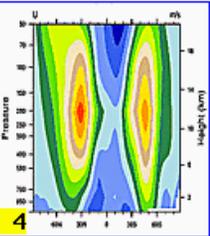
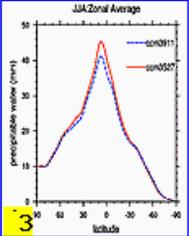
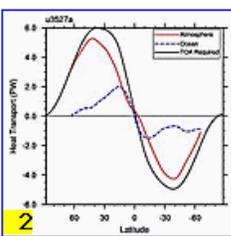


Plots Created
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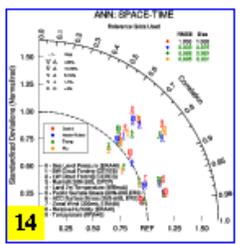
Set Description

- 1 [Tables](#) of ANN, DJF, JJA, global and regional means and RMSE.
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- 4 [Vertical contour plots](#) of DJF, JJA and ANN zonal means
- 4a [Vertical \(XZ\) contour plots](#) of DJF, JJA and ANN meridional means
- 5 [Horizontal contour plots](#) of DJF, JJA and ANN means
- 6 [Horizontal vector plots](#) of DJF, JJA and ANN means
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- 8 [Annual cycle contour plots](#) of zonal means
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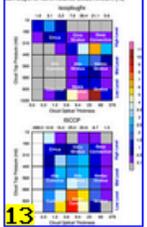
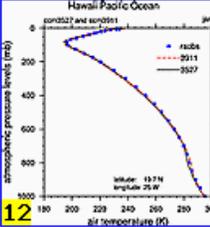
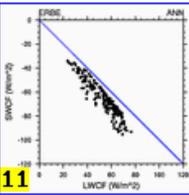
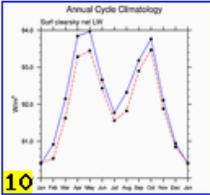
Click on Plot Type



TABLES



METRICS

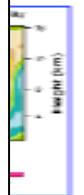




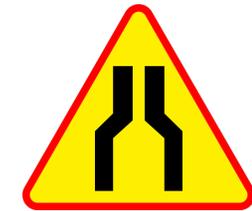
Set Description

Click on Plot Type

- 1 Table
- 2 Line
- 3 Line
- 4 Vert
- 4a Ver
- means
- 5 Hori
- 6 Hori
- 7 Pola
- 8 Ann
- 9 Hori
- 10 Am
- 11 Pac
- 12 Ver
- 13 ISC
- 14 Tay



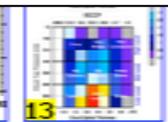
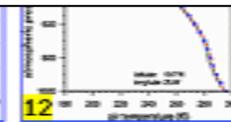
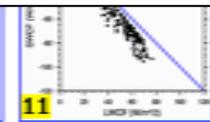
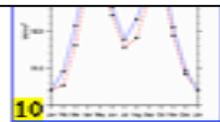
- Serial NCL scripts generate HTML and images
 - Requirement: Analysis nodes with big I/O (Lens)
 - Requirement: Web hosting (\$HOME/www)
- Becoming a bottleneck
 - 8-9 hours for T341 (1/3° resolution)
 - Development need: Parallel analysis scripts
 - Requirement: Parallel analysis system (Lens)



1

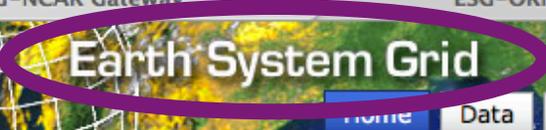
TABLES

METRICS



AR5 Recipe

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 Earth System Grid

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ESG Gateway at the National Center for Atmospheric Research

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 - > [CMIP5/IPCC AR5](#)
 - > [NARCCAP](#)
 - > [PCM](#)
- Model
- Experiment
- Frequency
- Realm
- Variable

Global Climate Models

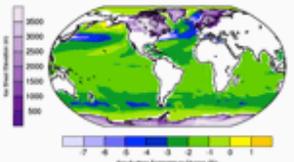
Community Earth System Model  [Community Earth System Model \(CESM\)](#)

- [CCSM 4.0 Model Output](#)
- [CCSM 3.0 Model Output](#)
- [Parallel Climate Model \(PCM\)](#)

Regional Climate Models

 [NARCCAP: North American Regional Climate Assessment Program](#)

Analysis & Visualization Software

 [NCL: NCAR Command Language](#)

- [PyNGL: Python Interface to the NCL Graphic Libraries](#)
- [PyNIO: Python Interface for NetCDF Input/Output](#)

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ESG Gateway at the National Center for Atmospheric Research

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+ Model

+ Experiment

+ Frequency

+ Realm

+ Variable

Global Climate Models

Community Earth System Model

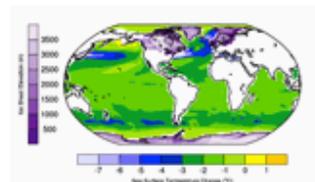
CESM

[Community Earth System Model \(CESM\)](#)[CCSM 4.0 Model Output](#)[CCSM 3.0 Model Output](#)[Parallel Climate Model \(PCM\)](#)

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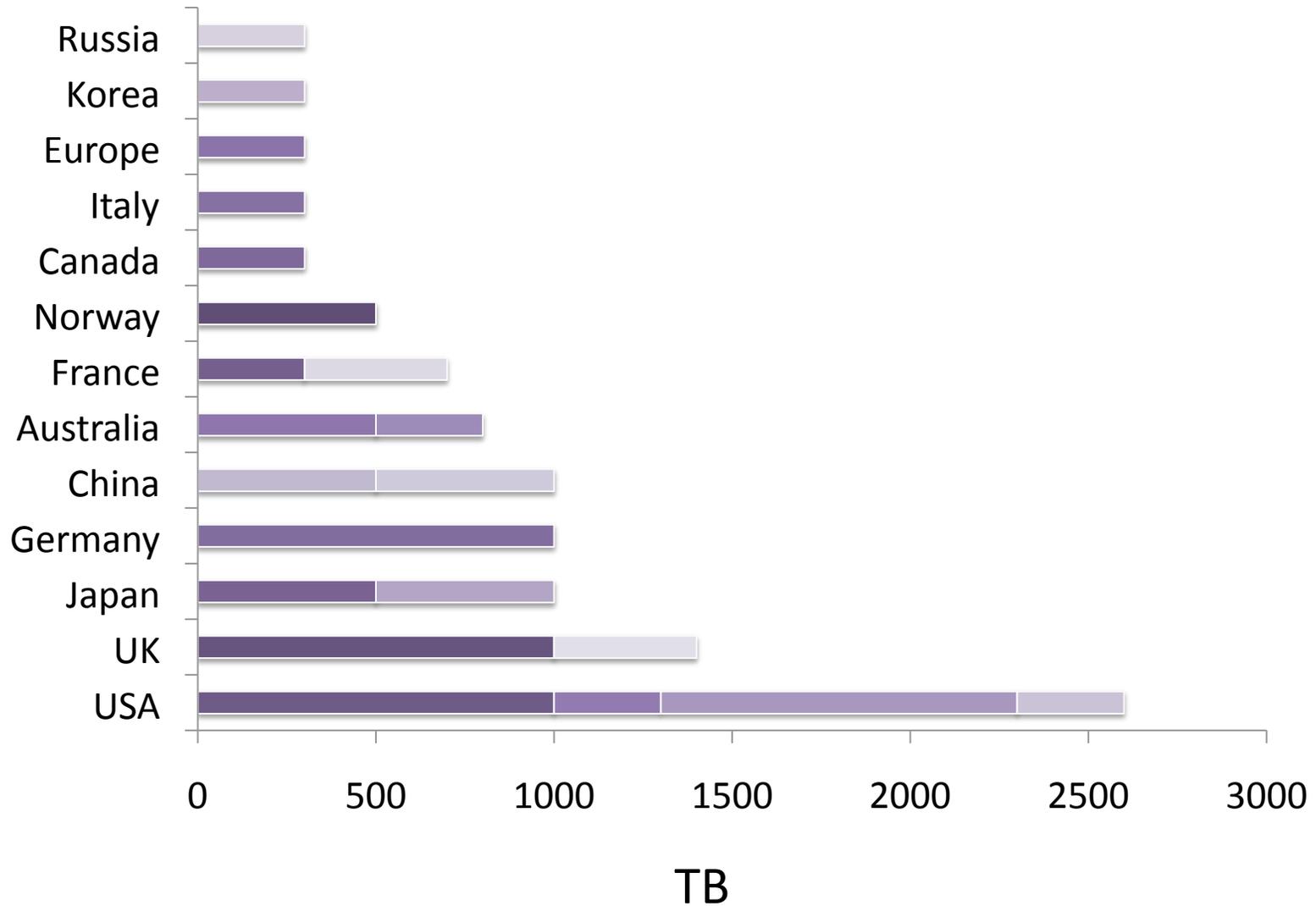
ESG Data Gateways

[NCAR Gateway](#)[ORNL Gateway](#)[PCMDI Gateway](#)

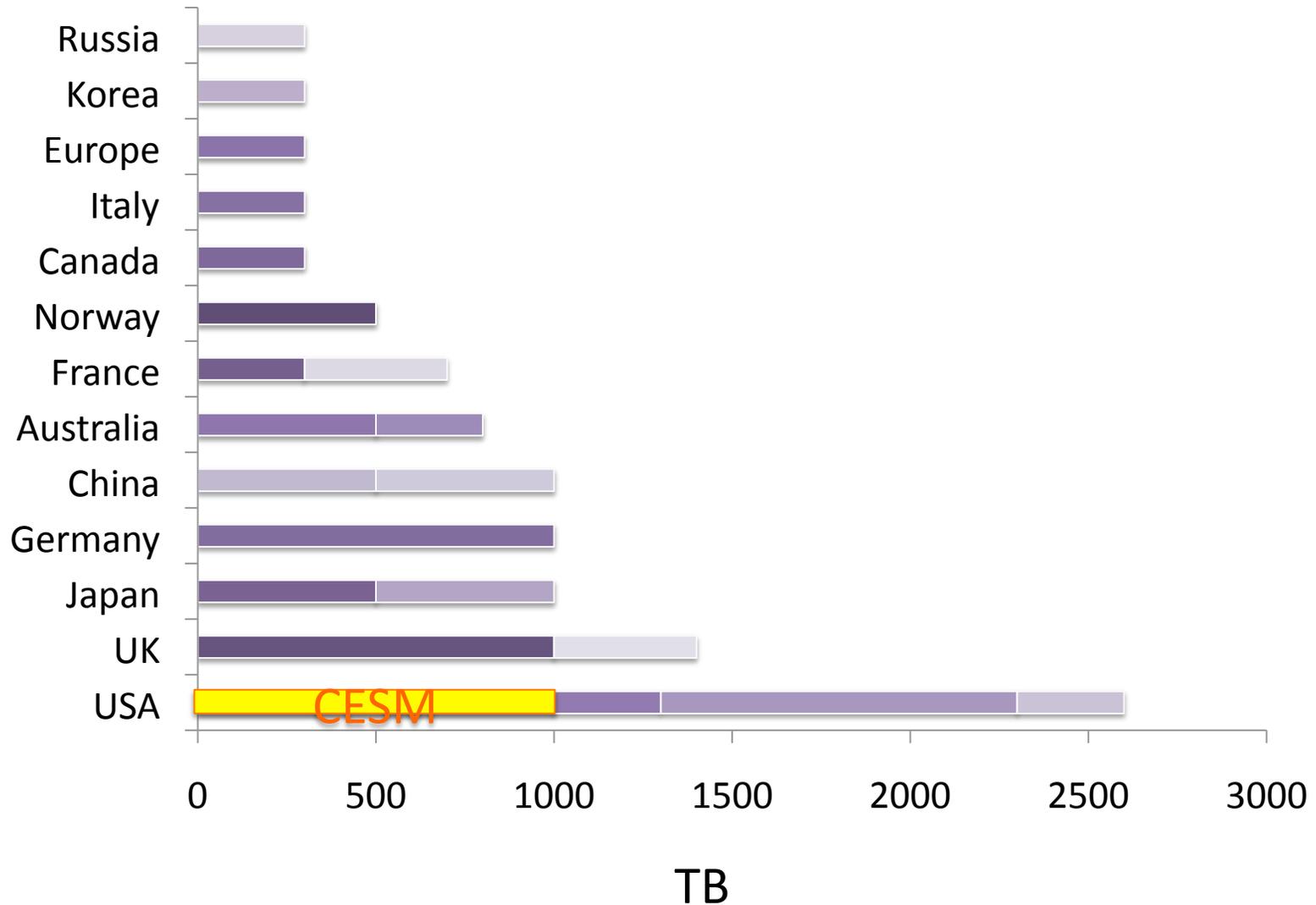
Other Gateways

[CADIS \(Arctic\)](#)

Expected CMIP5 data for ESG

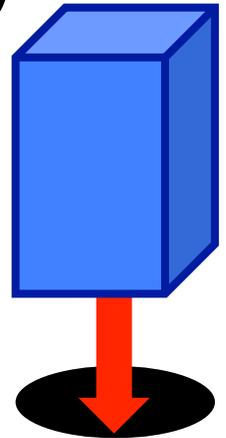


Expected CMIP5 data for ESG



Postprocessing ESG Output

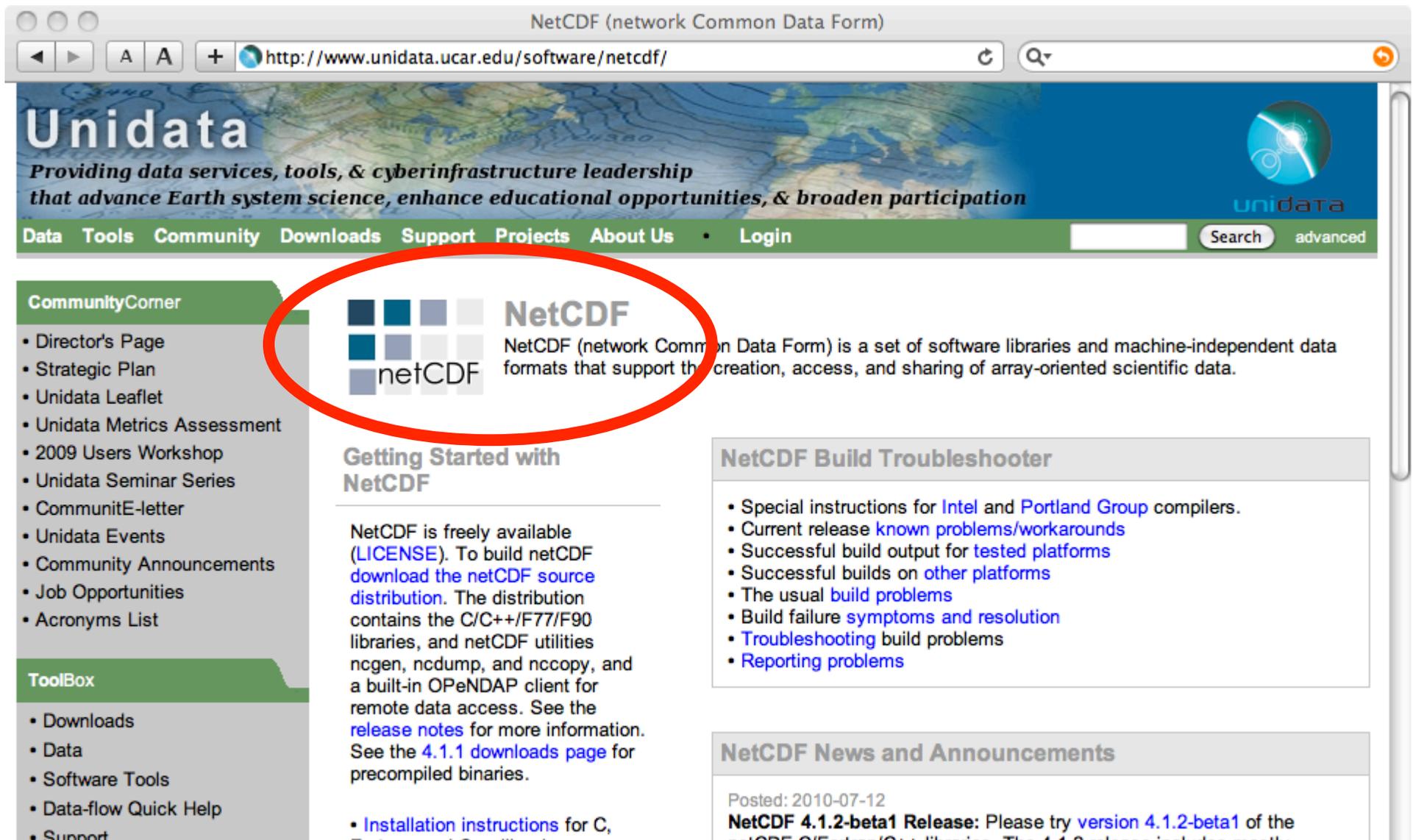
- Simulations produce history snapshots (many fields averaged over a single month)
- Scientists often want time series (one field over many years)
- ESG provides both
- **Requirement: NetCDF Operators (NCO)**
- **Requirement: Analysis cluster with big I/O (Lens)**



AR5 Recipe

- ~~CMIP5 defines experiments~~
- ~~Develop a model~~
- ~~Run experiments~~
- ~~Provide simulation output~~
- Scientists worldwide analyze output
- Scientists worldwide publish papers
- AR5 authors cite papers

Requirement



NetCDF (network Common Data Form)

http://www.unidata.ucar.edu/software/netcdf/

Unidata

Providing data services, tools, & cyberinfrastructure leadership that advance Earth system science, enhance educational opportunities, & broaden participation

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- Community Announcements
- Job Opportunities
- Acronyms List

ToolBox

- Downloads
- Data
- Software Tools
- Data-flow Quick Help
- Support

NetCDF

NetCDF (network Common Data Form) is a set of software libraries and machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data.

Getting Started with NetCDF

NetCDF is freely available ([LICENSE](#)). To build netCDF [download the netCDF source distribution](#). The distribution contains the C/C++/F77/F90 libraries, and netCDF utilities ncgen, ncdump, and nccopy, and a built-in OPeNDAP client for remote data access. See the [release notes](#) for more information. See the [4.1.1 downloads page](#) for precompiled binaries.

- [Installation instructions](#) for C, F77, and C++

NetCDF Build Troubleshooter

- Special instructions for [Intel](#) and [Portland Group](#) compilers.
- Current release [known problems/workarounds](#)
- Successful build output for [tested platforms](#)
- Successful builds on [other platforms](#)
- The usual [build problems](#)
- Build failure [symptoms and resolution](#)
- [Troubleshooting](#) build problems
- [Reporting problems](#)

NetCDF News and Announcements

Posted: 2010-07-12

NetCDF 4.1.2-beta1 Release: Please try [version 4.1.2-beta1](#) of the netCDF C/F77/C++ libraries. The 4.1.2 release includes mostly

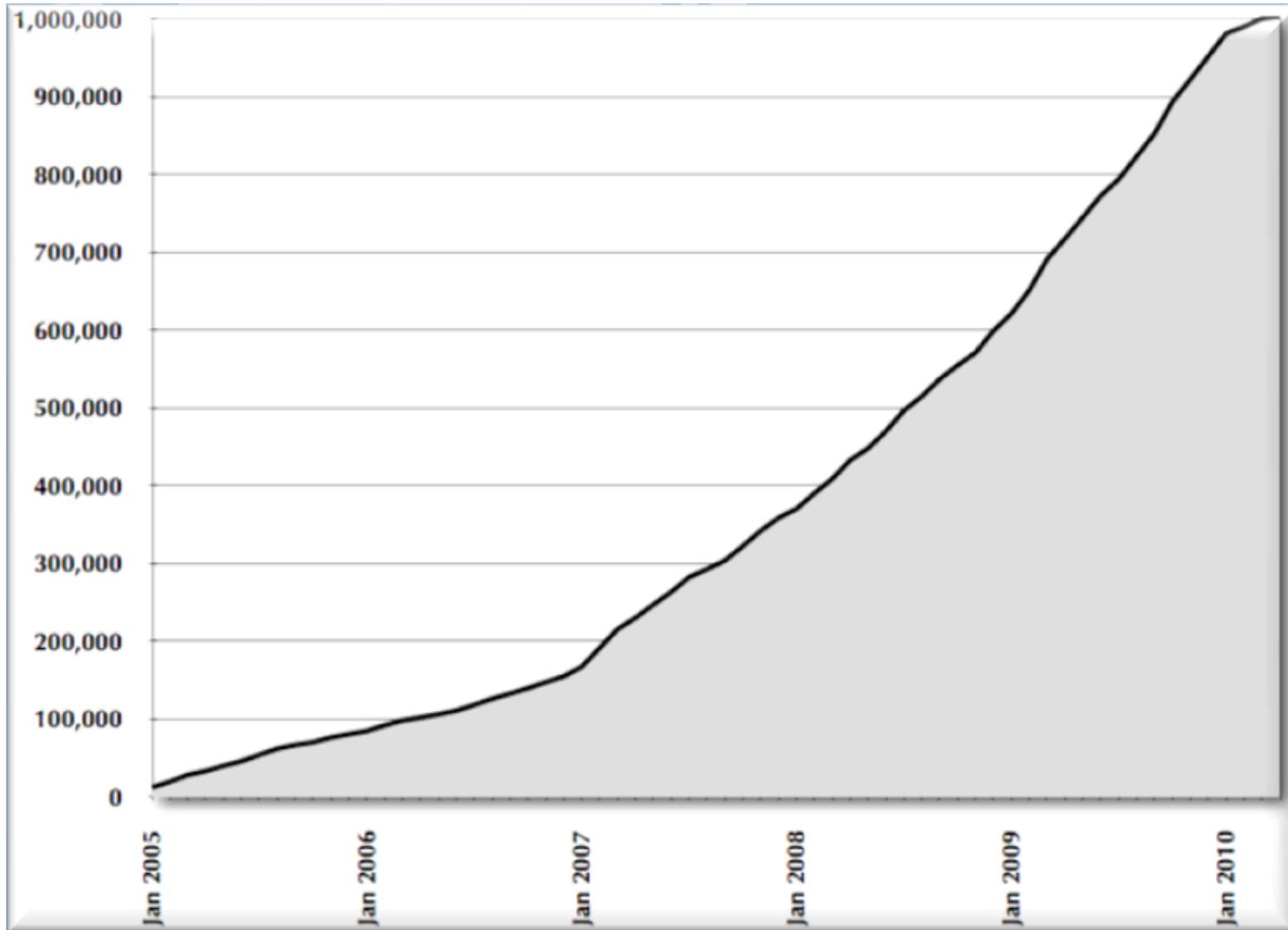
Requirement: NetCDF

- Network Common Data Form
- Portable file format
- Built-in metadata: dimensions, sizes, units
- NetCDF Climate and Forecast (CF) Metadata Convention



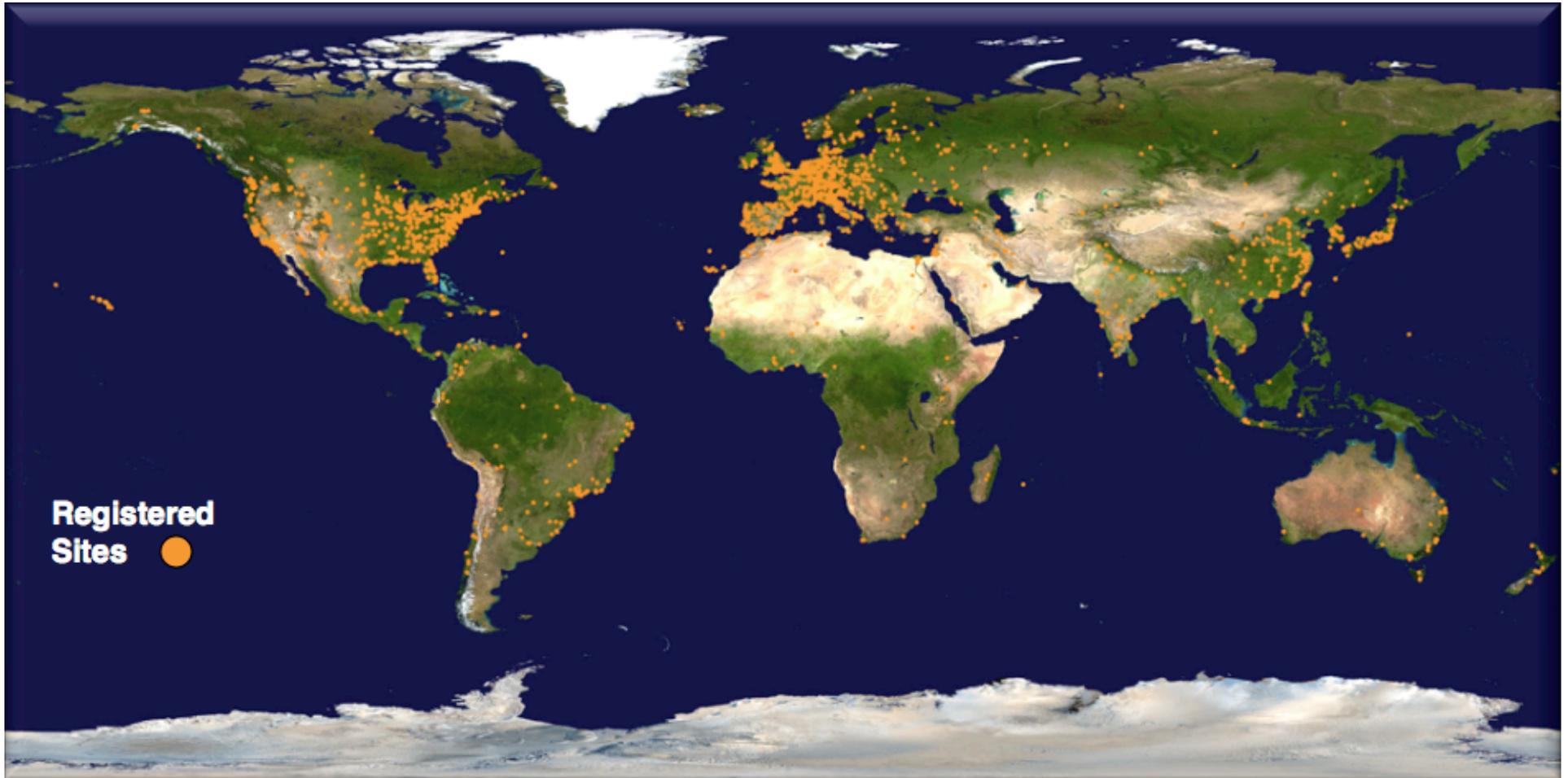
ESG downloads

GB



From "Climate Science—Enabling Worldwide Access to Petascale Climate Data", by Dean N Williams, Gary Strand, Galen Shipman, and James McGraw, to appear at <http://www.es.net/hypertext/requirements.html>.

ESG downloads



From "Climate Science—Enabling Worldwide Access to Petascale Climate Data", by Dean N Williams, Gary Strand, Galen Shipman, and James McGraw, to appear at <http://www.es.net/hypertext/requirements.html>.

Requirement: WAN bandwidth

Transfer Rate	Time to Transport 1 TB of Data	Time to Transport 1 PB of Data
10-Mbps	9.7days	27.20 years
50-Mbps	1.94 days	5.44 years
100-Mbps	23.3 hours	2.72 years
1-Gbps	2.28 hours	97.1 days
10-Gbps	13.65 minutes	9.7 days
100-Gbps	81.9 seconds	23.3 hours

From "Climate Science—Enabling Worldwide Access to Petascale Climate Data", by Dean N Williams, Gary Strand, Galen Shipman, and James McGraw, to appear at <http://www.es.net/hypertext/requirements.html>.

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Results in a moment

Requirements and Science Goals for Sustained Petascale Climate Science

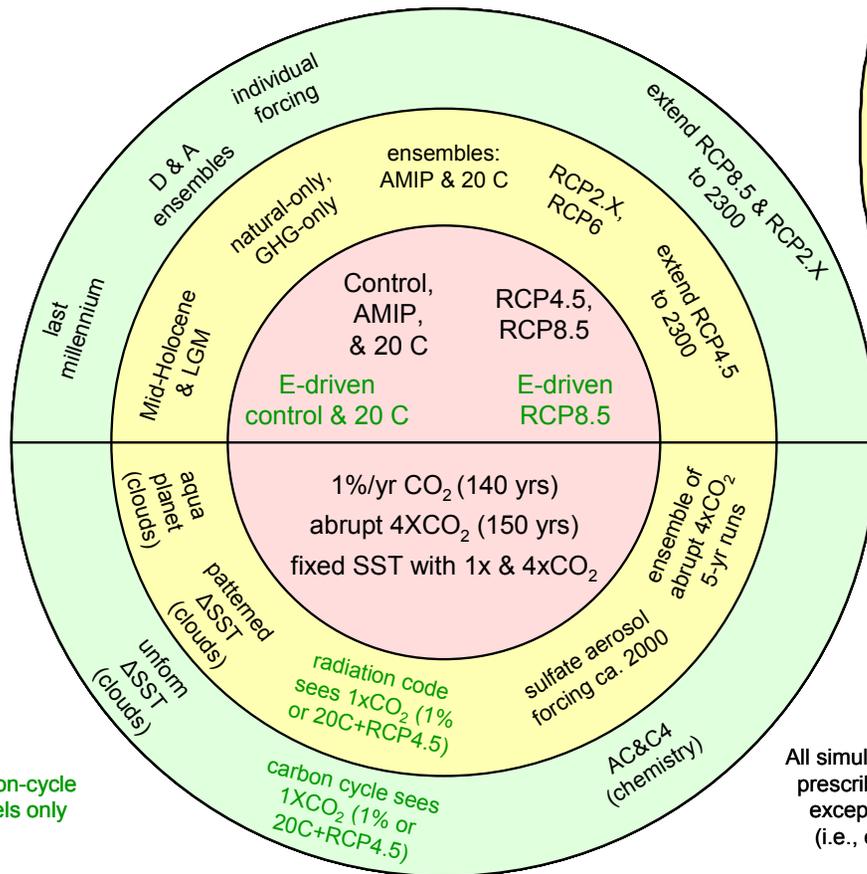
Summary

Petascale Requirements

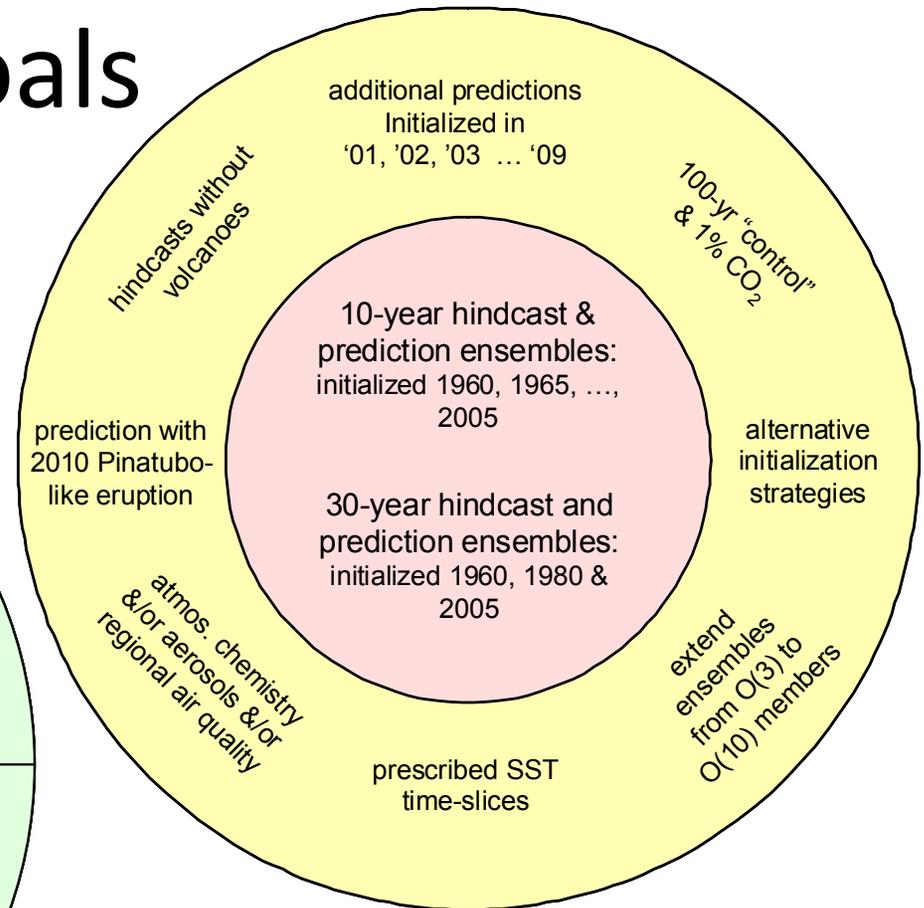
- Shared, unswept scratch
- Day-to-week-long terascale runs
- PB archive space
- Parallel analysis system with big I/O
- Web hosting
- NetCDF, NCO, NCL
- WAN bandwidth

(Some) Science Goals

CMIP5 Long-Term Onion



Coupled carbon-cycle climate models only



CMIP5 Decadal Onion

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

AR5 Recipe: Early Results

- Community Earth System Model
(Oak Ridge, TN)
- Commonwealth Scientific and
Industrial Research Organisation
(Canberra, Australia)
- Institut Pierre Simon Laplace
(Paris, France)

AR5 Recipe: *Bon appétit!*

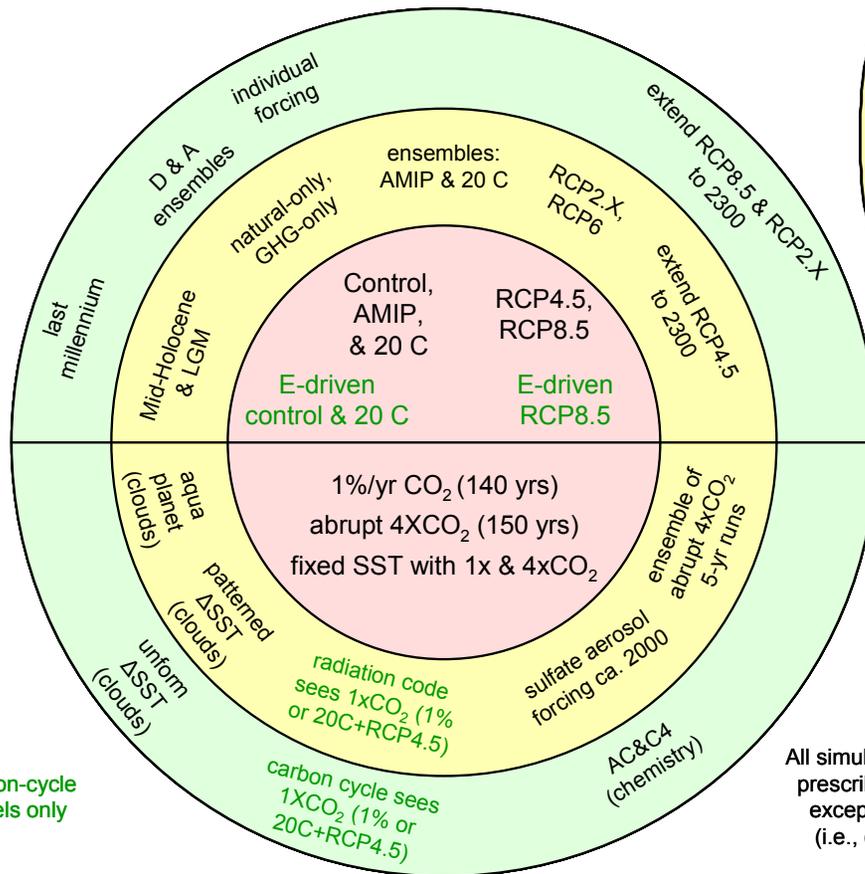
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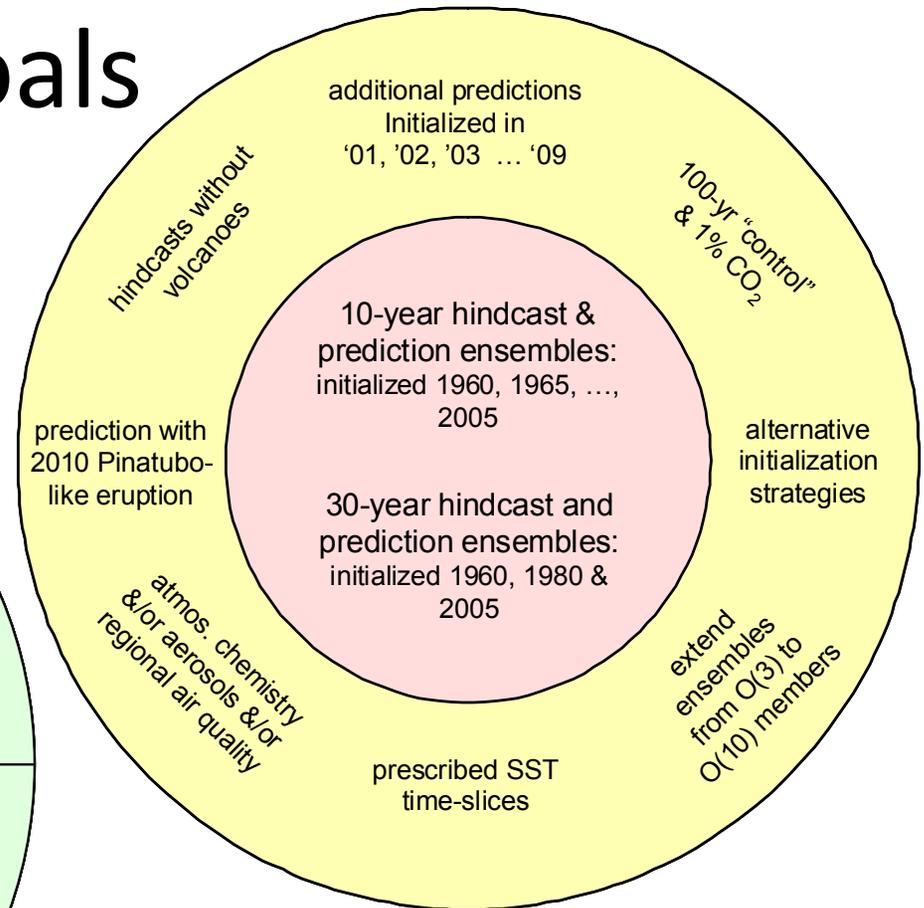
finis

(Some) Science Goals

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