

GLOBAL  
I G B P  
CHANGE

# AIMES

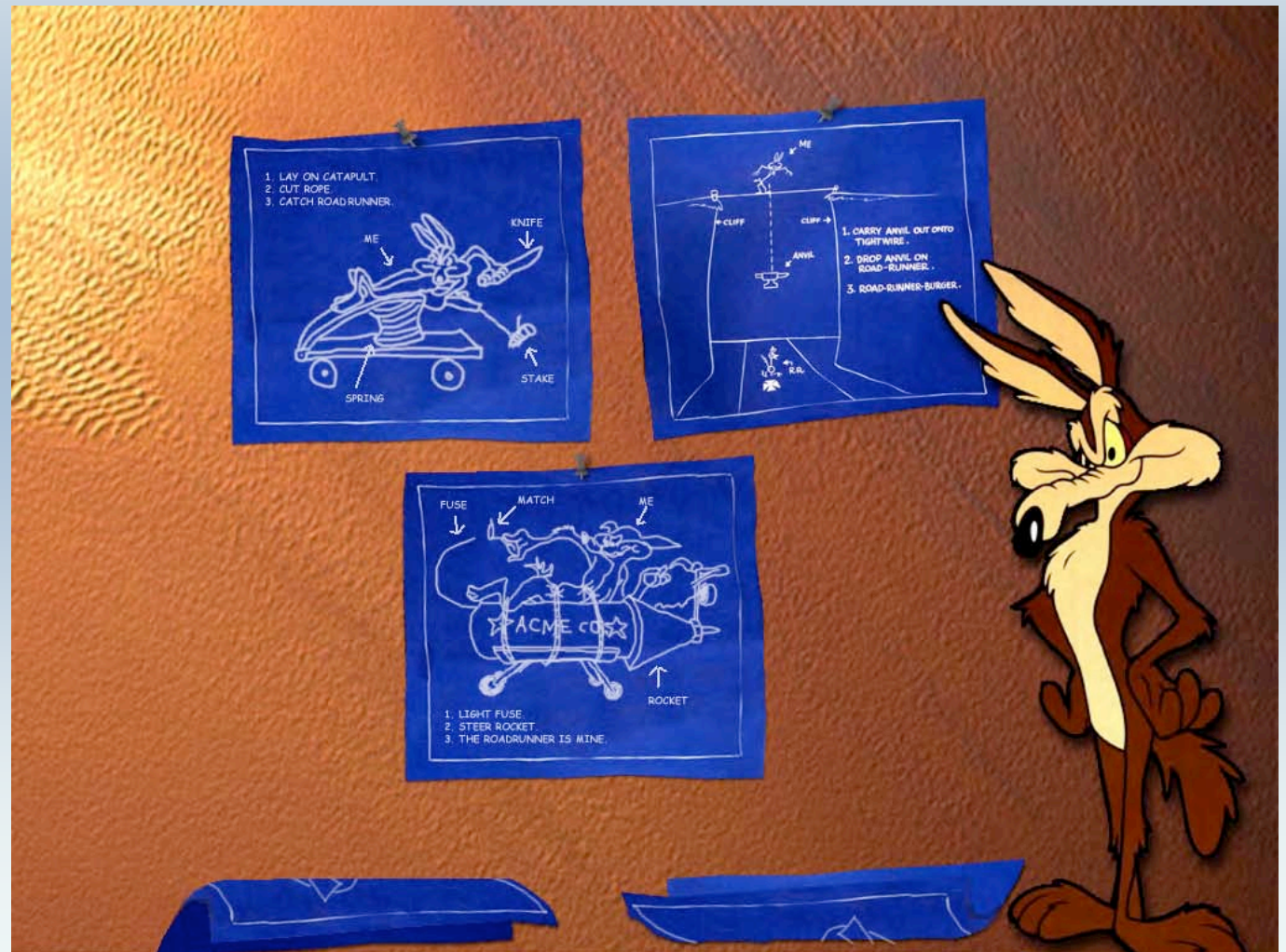
<http://www.aimes.ucar.edu>



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David Schimel  
Colin Prentice



# PART I: AIMES ROADMAP



# AIMES INTERACTION THEMES

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1. **PROCESS AND PARAMATERIZATION:** Observations and process models for global model development, evaluation and implementation.
2. **REGIONAL/GLOBAL:** Focus on regions where rapid rates of HD trigger changes:
  1. Rapid changes in human systems trigger global response either directly through transport or indirectly through teleconnections. For instance, MAIRS
  2. Global change triggers rapid response; human consequences the emphasis (rather than causation). For instance, Northern High Latitudes
3. **INTEGRATIVE EARTH SYSTEM MODELING:** Development of increasingly complex coupled models of climate, bgc, ecology and human dimensions (e.g., IHOPE, C<sup>4</sup>MIP to C<sup>5</sup>MIP to C<sup>X</sup>MIP).
4. **APPLIED EARTH SYSTEM SCIENCE:** End-to-end analyses that track fundamental research and transition to application and communication (e.g., AIMES/WGCM for AR5)

## PART II: SOME AIMES PROJECTS





# AIMES and WGCM

AIMES/WGCM led series of workshops towards the use of Earth system models in climate change assessments (the Aspen Protocol);



# ASPEN PROTOCOL RATIONALE

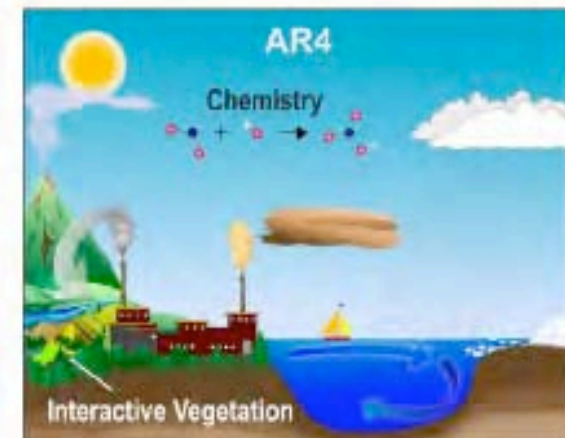
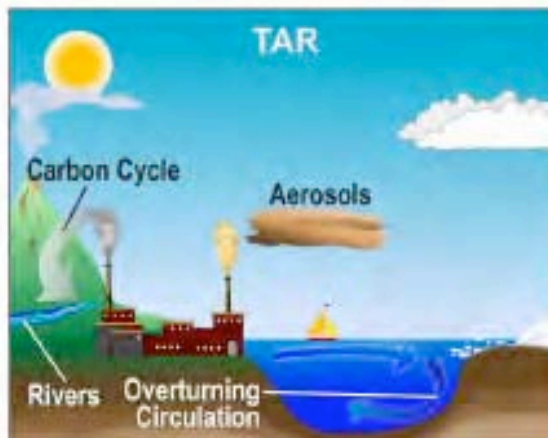
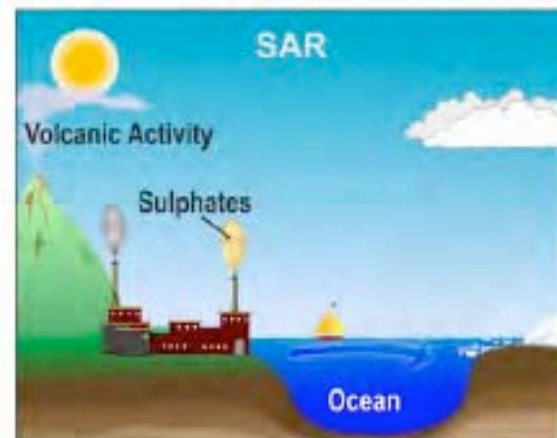
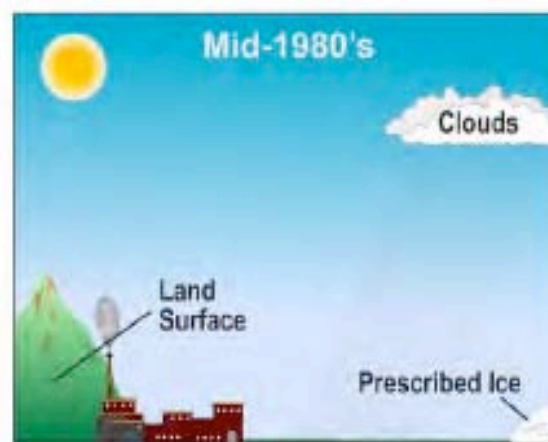
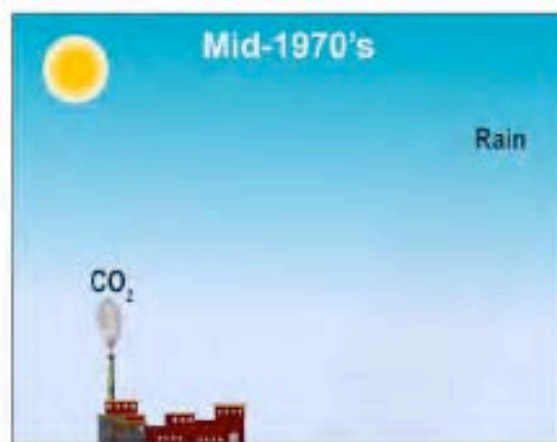
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Propose a strategy involving coordinated policy relevant climate change projection experiments to be run by the international climate modeling community, with two classes of models to address two time frames:

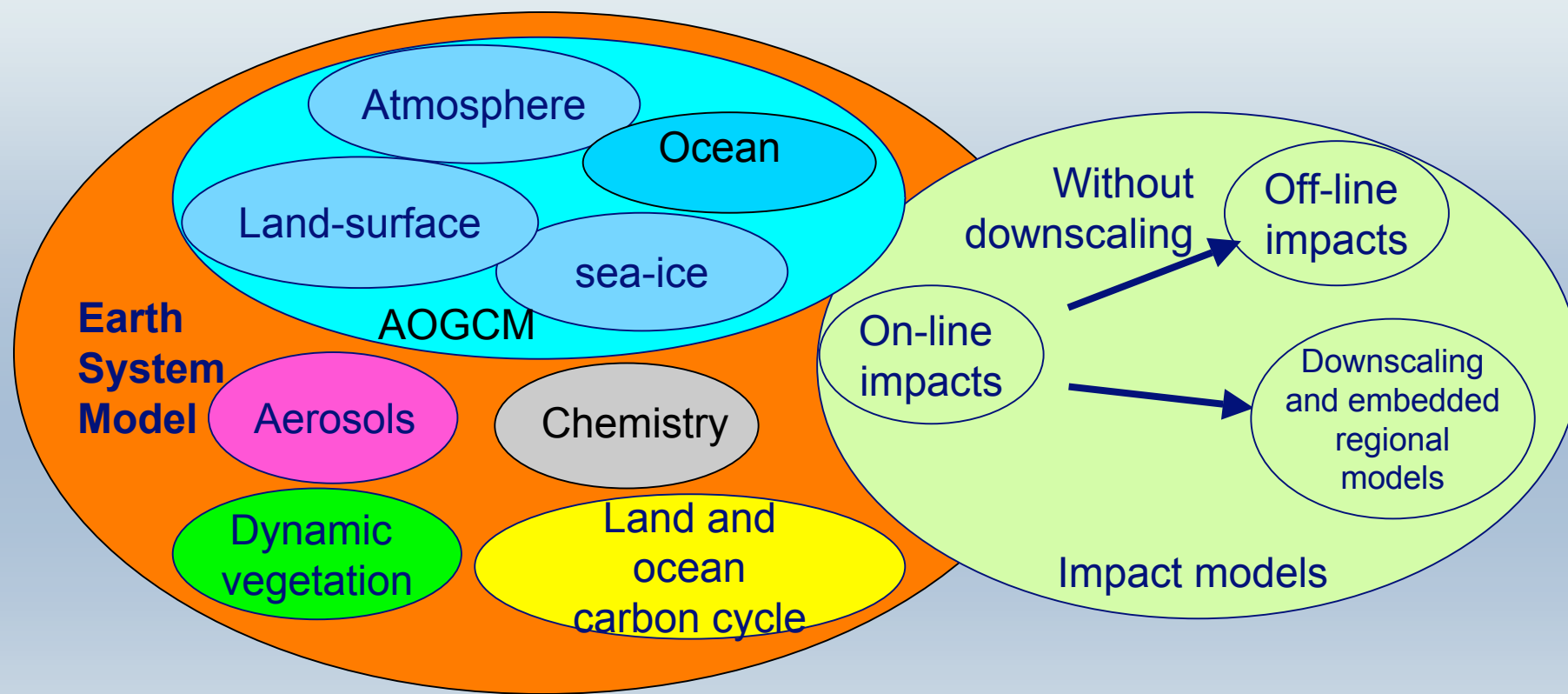
- Near-Term (2005-2030)
- Longer term (to 2100 and beyond)



# FROM AGCMs TO ESMs

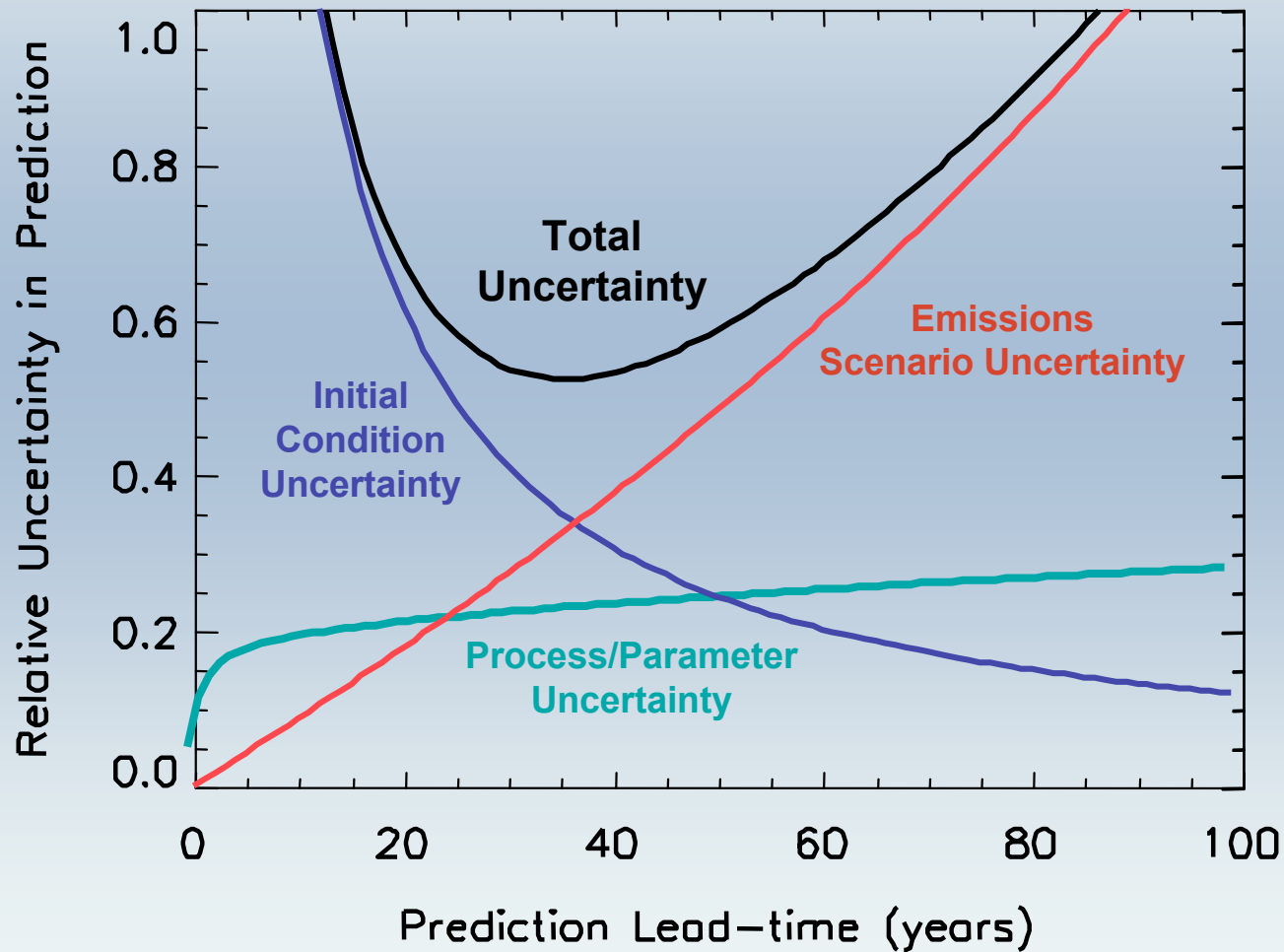


# FROM ESMs TO IMPACTS



AOGCM (oval at upper left) and Earth System model (in orange oval) and interactions with impact models (right).

# Contributions to uncertainty in predicted decadal mean temperature versus the lead-time of the prediction



From Cox and Stephenson 2007

# “VANGUARD” COMPONENTS in ESMs

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- Nitrogen cycling and nitrogen limitations on the terrestrial carbon cycle.
- Anthropogenic impacts on fire (including ignitions, suppression).
- More sophisticated ocean ecosystem models, with resolution of more phyto- and zoo-plankton functional groups.
- River biogeochemistry (especially dissolved organic carbon (DOC) fluxes from land-to-ocean).
- Micronutrient limits (e.g., Fe) on ocean biogeochemistry.
- Ocean bottom carbon chemistry, calcite formation (only important on 300-1000 yr timeframe, e.g. for stabilization scenarios)
- Interactive biogenic fluxes of methane, VOCs etc. (for coupling to atmospheric chemistry).
- Advanced vegetation dynamics with improved succession based-on more PFTs and possibly explicit dispersal mechanisms (the latter is only applicable in high-resolution ESMs).
- Multiple agriculture (crop x management) PFTs and associated local/regional land use practices
- Transient urban fractional cover.
- Improved spatial resolution of the land-surface based on either a higher resolution regular-grid and/or an irregular land-grid defined by river-catchments.
- Impact of tropospheric ozone on vegetation.
- Improved treatment of organic soils including carbon dynamics and links to thermal and hydraulic impacts of peatlands.

# ATMOSPHERIC COMPONENTS in ESMs

	Aerosols	Chemistry
Within about 1 year (ready to run for next IPCC)	<p><u>GISS</u>: Sulfate / BC / OC / dust / sea-salt</p> <p><u>Hadley</u>: bulk, sulfate /BC / OC / dust driven from DGVM / sea-salt / SOA climatology</p> <p><u>NCAR</u>: Both bulk and modal approaches are available and being considered</p> <p><u>MPI</u>: A seven-category modal approach predicting total number and species mass in each category (M7)</p> <p>Limited ability to represent aerosol indirect effect processes, especially in mixed phase, ice and convective clouds.</p>	<p>Cost is under evaluation for all groups.</p> <p>At least snapshots / asynchronous coupling will be done with full chemistry (tropospheric and stratospheric) with a coupling every 5/10/20 years?</p>
Beyond AR 5	<p>Full aerosol scheme</p> <p>Comprehensive mixed and ice phase cloud microphysics</p>	Full chemistry

# NEAR TERM EXPERIMENTS

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Goal: better guidance towards likelihood of changes in climate extremes at regional scales (aim for policy relevance):

- 2000-2030 time horizon
- High resolution AOGCMs/ESMs
- Interactive aerosols
- Interactive atmospheric chemistry
- One mid-range scenario: many ensembles

# PROPOSED EXPERIMENTS

## Long Term (beyond 2100)

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WHAT ARE CARBON CYCLE FEEDBACKS ON CLIMATE SYSTEM (and how do these feedbacks and other climate system feedbacks play a role in the possible stabilization of climate change)?

- Long-term runs provide an opportunity to contribute to a policy perspective on avoiding consequences of climate change (e.g. mitigation/stabilization)
- Lower resolution AOGCM and/or ESM (roughly  $2^\circ$ ) w/pre-industrial spinup including 20<sup>th</sup> century experiments with natural and anthropogenic forcings (at least 10 ensemble members for detection/attribution up to 2005; single members thereafter)
- Multi-model ensembles important to quantify uncertainty

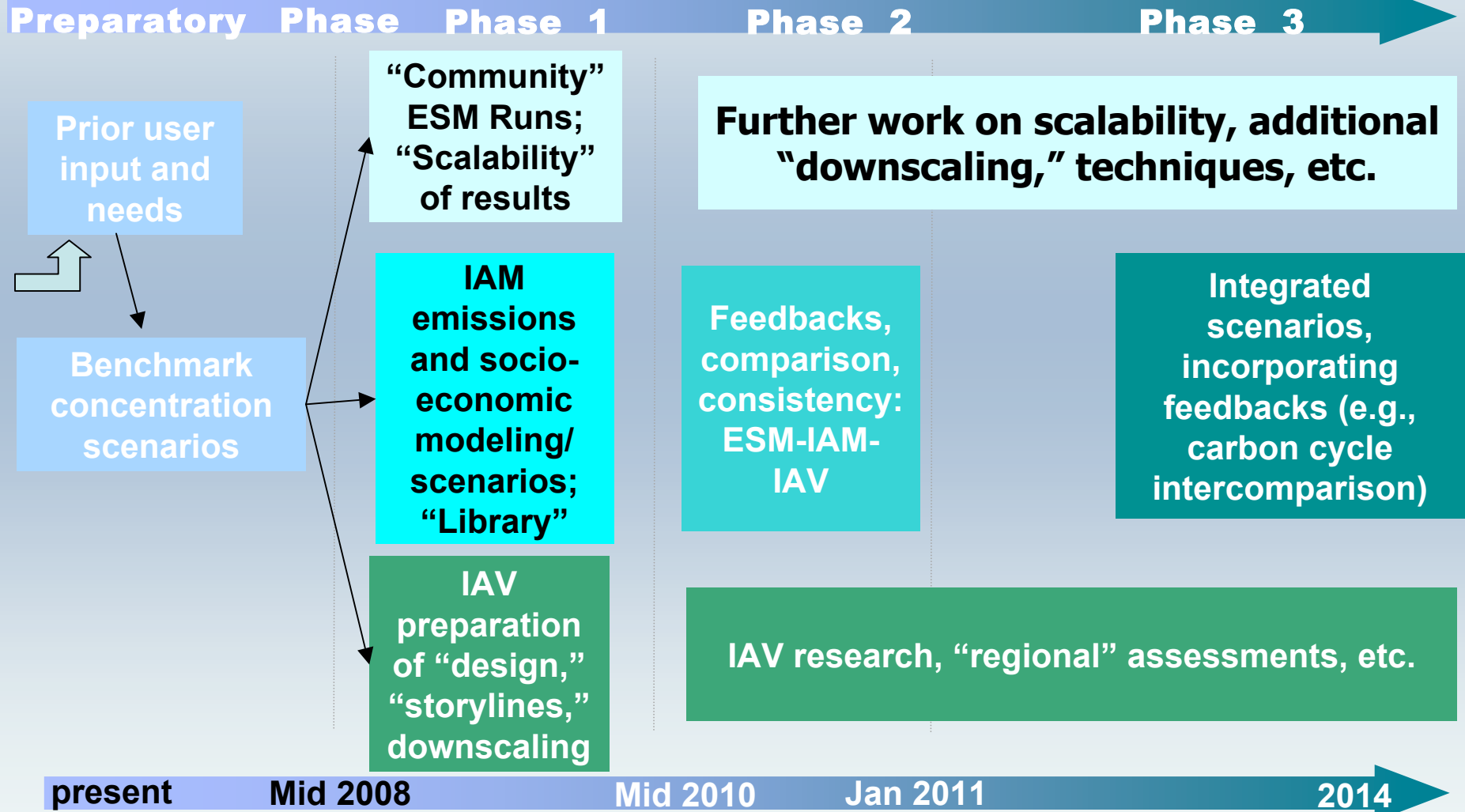
# PROPOSED EXPERIMENTS

Long Term (2100 and beyond; Hibbard et al. 2007)

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- Control simulation
- Expt #1: Force climate w/concentrations -> diagnose industrial and land use emissions consistent with stabilizing concentrations
- Expt #2: Land/ocean fluxes forced with CO<sub>2</sub> concentrations from Expt 1; climate sees constant CO<sub>2</sub>
  - Climate change (AOGCM or ESM)
  - Carbon cycle and compatible emissions (ESM or offline carbon cycle model)
- Benchmark simulations: emissions driven
  - CMIP 1%/yr (AOGCM)
  - C<sup>4</sup>MIP linear increase in emissions (ESM)
    - Coupled
    - Uncoupled

# PROPOSED PHASES OF SCENARIO DEVELOPMENT AND RESEARCH



**DO NOT CITE!!**



Old  
Stone  
Age

New  
Stone Age  
Commences

New  
Stone  
Age

Bronze  
Age

Iron  
Age

Middle  
Ages  
Modern  
Age

# IHOPE

- 2005:

– HOPE-Dahlem

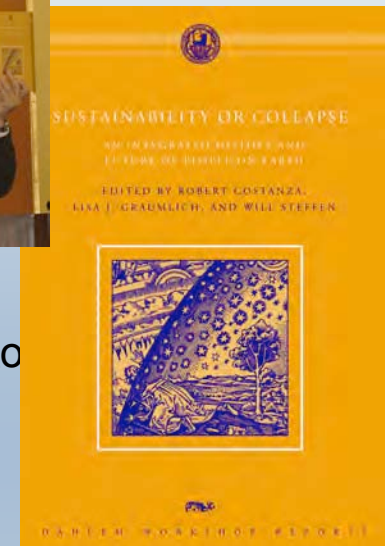
- 2006:

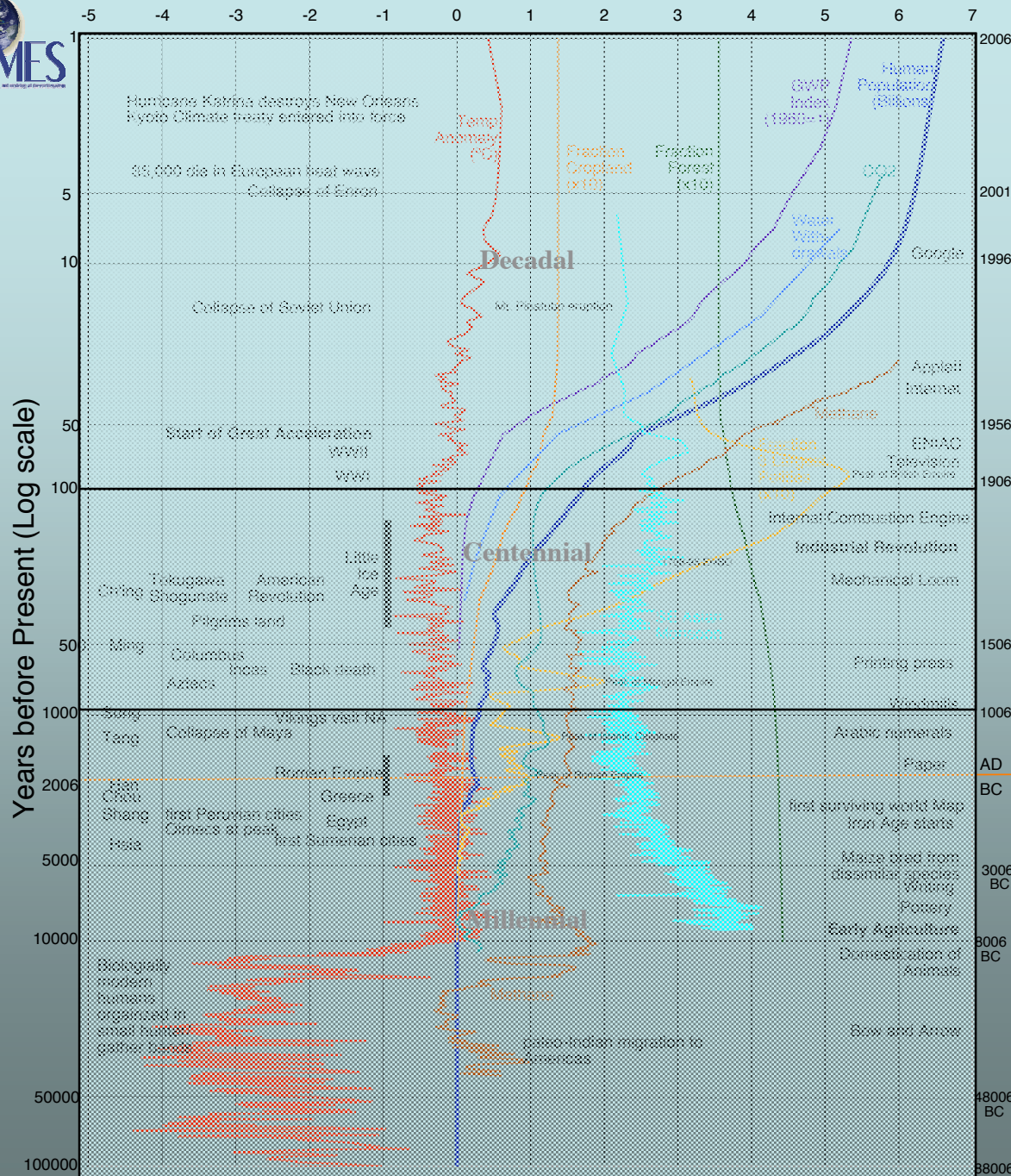
–Planning meeting/Stockholm

- IHOPE RP to PAGES, IHDP
- FORMAS/MISTRA/IHOPE Secretariat award; Resilience Center, Stockholm

- 2007:

- Costanza et al. 2007: Sustainability or Collapse - Dahlem
- Costanza et al., 2007: *in press* to Ambio
- IHOPE Research Information System (IRIS) vignette dataset from Sander van der Leeuw Archaeomedes under development at NCAR
- Asia IHOPE 21-25 March in Akita Prefecture, Japan
- Initial planning for IHOPE-AMERICAS (Graumlich/van der Leeuw)
- IHOPE OZ Planning with Will Steffen Libby Robin (ANU/NMA)
- IHOPE Secretariat planning at Stockholm Resilience Centre
- IHOPE co-sponsored by PAGES, IHDP
- IHOPE Research Plan to be published late 2007





The challenge for IHOPE is drawing inferences about the reciprocal impacts of the evolution of human and environmental systems from the historical and paleo-environmental narrative.

- The environment and its dynamic processes are always a factor in human decision making and the evolution of societies.
- In some cases, environmental change may be decisive in the fate of human societies leading to well-known collapses
- In other cases, environmental change is decisive in the progress of human institutions and technology.
- Human and environmental change have always occurred together and some of these parallel developments are illustrated against the background of environmental variability.



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# IHOPE

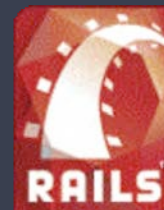
## IHOPE RESEARCH INFORMATION SYSTEM (IRIS)

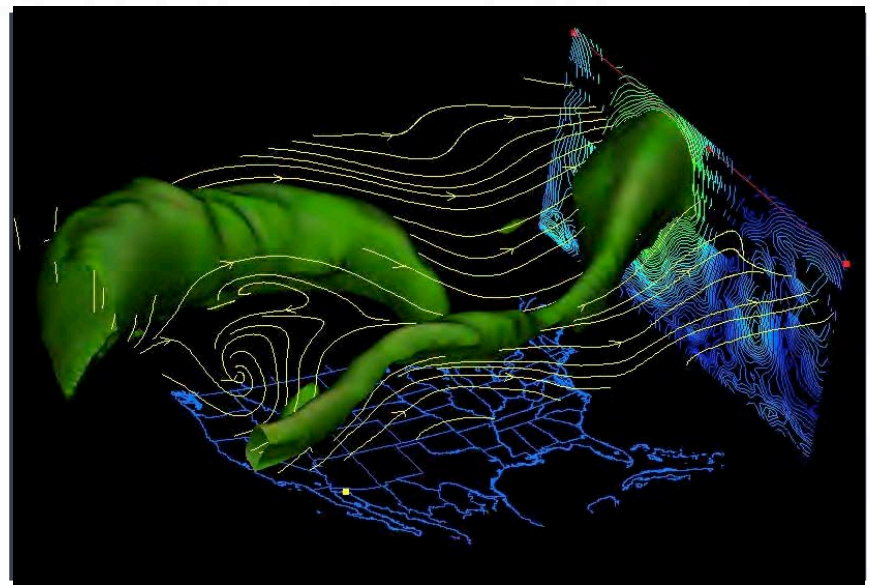
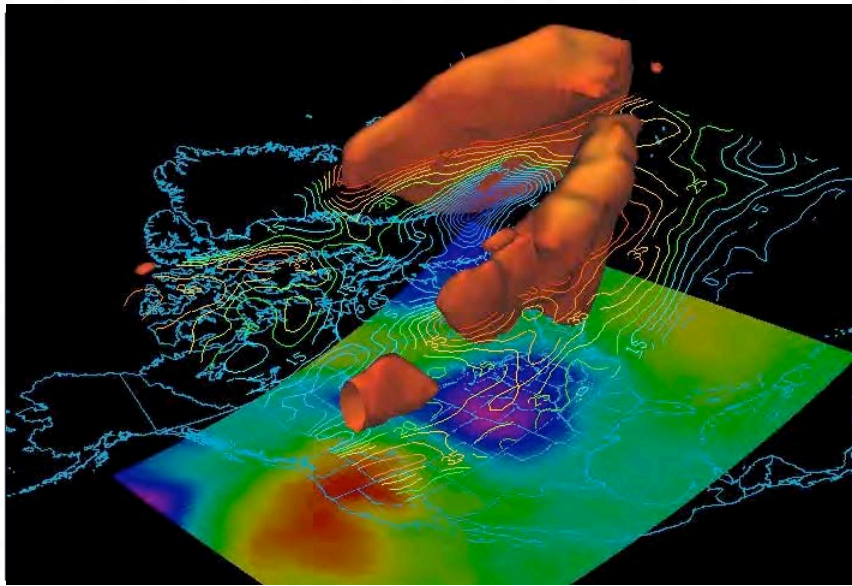
### – GOALS:

- An integrated data system with no single point of political control (eg., no dedicated server)
- PI with full control over data visibility
- A fully 'localized' information system:
  - language
  - data format
  - geographic representation
  - cultural interpretation: disciplinary translation to common meanings: regional/vernacular - appropriate global understanding

# Tools and Technologies Accessible to all IHOPE Members

- ▶ System built with non-proprietary, Open Source Software (OSS), freely available to all
- ▶ Data served with OSS tools (e.g., Apache Jakarta Tomcat, OPeNDAP, THREDDS catalogs, Open Archives Initiative, Ruby on Rails, etc.)
- ▶ Data viewable with OSS clients or, if desired, proprietary tools that can access the OSS protocols





# Unidata Integrated Data Viewer

IDV “understands” time. Uses a 5D data model (latitude, longitude, altitude, time, units). Real-time interaction with data systems (local and remote) and models. THREDDS and OPeNDAP compatible.



# Future IHOPE:

## 1. Proposed Workshops:

1. Planning Meeting SAR this year
2. Workshops:
  - Climate and Human Interactions
  - Environmental Stress (Drought) and Humans
  - Data, Research Systems (NCEAS)
  - IHOPE-OZ latter half 2008

## 2. Proposed Summer Institutes:

- IHOPE YSN - 2009
- From Towada to Megata: a transect of human settlement in Japan
- End-to-end: from Data to Analysis to Models: a Cairo Institute
- Maya in Belize

## 3. Stockholm Resilience Centre (SRC) - IHOPE Secretariat

## PART III: AIMES, NEESPI & BEYOND

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# NORTHERN HIGH LATITUDES:

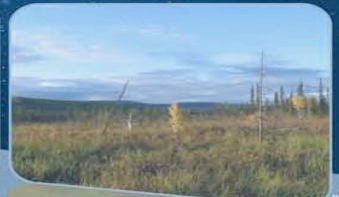
## Regional/Global Feedbacks and Interactions

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- Carbon storage and sequestration (OM, CH<sub>4</sub>, clathrates, CO<sub>2</sub>)
- Hydrology: ppt/et ratios: runoff, sediment transport, salinity gradients, permafrost, etc
- Changes in THC; warming, altered CO<sub>2</sub> uptake
- Changes in high latitude albedo





# AIMES AND NEESPI

- This workshop:



September 07

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# NEESPI AND AIMES, IGBP,...

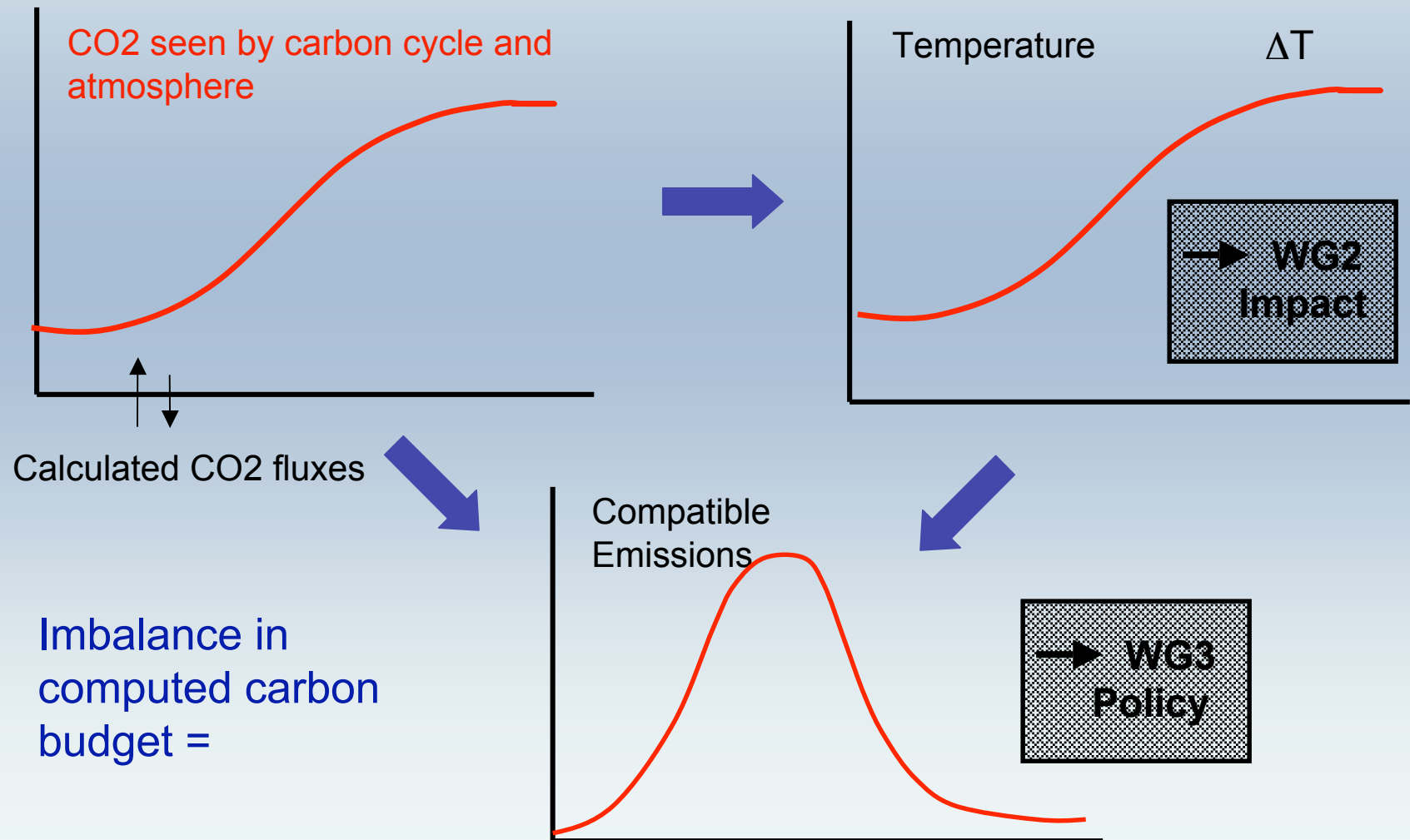
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- Strategy for coordinated data/model evaluation regional/global interactions
- Hooks for links with scenarios/land use
- Link with IHOPE in future



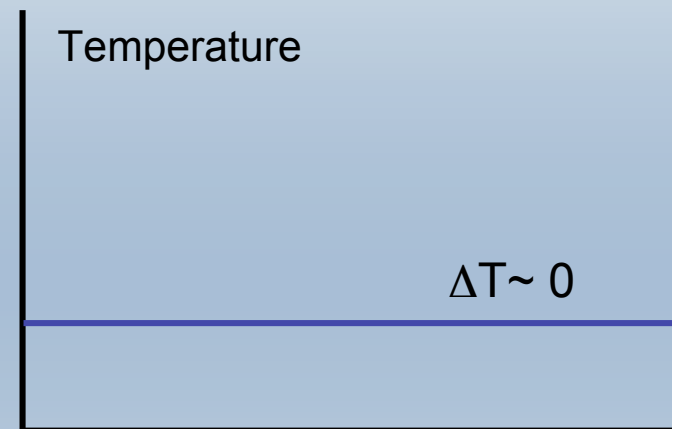
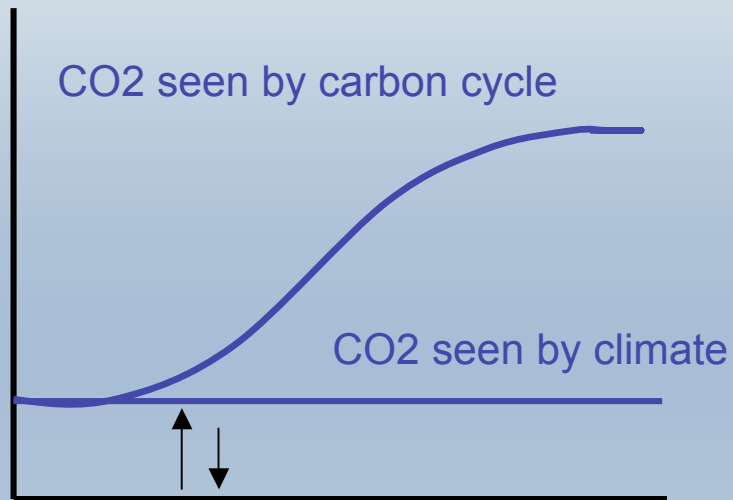
# EXPERIMENT #1: FULLY COUPLED:

Diagnose climate and carbon cycle feedbacks



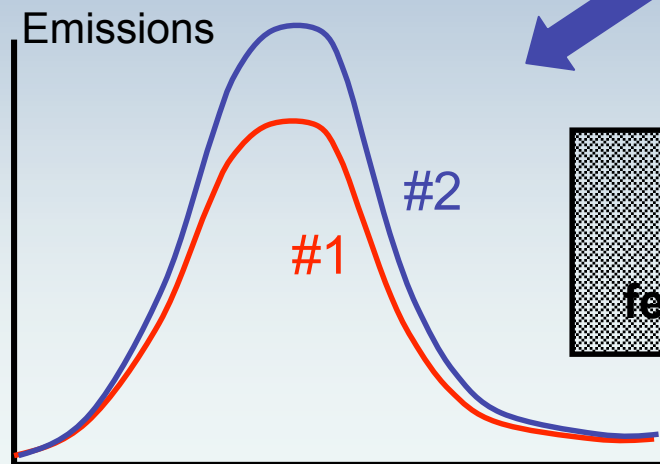
# EXPERIMENT #2: CLIMATE UNPLUGGED

- Climate change (AOGCM or ESM)
- Carbon cycle and compatible emissions (ESM or offline CC model)



Calculated CO2 fluxes

#2 - #1 =  
effect of climate feedbacks on  
compatible emissions



WG1  
C-C  
feedback

# EXPERIMENT #3:

## Emissions-Driven Carbon Cycle/Climate

This experiment is driven by emissions rather than by concentrations. Each ESM calculates the concentrations resulting from an idealized prescribed standard emissions time series (e.g., 1% per year for CO<sub>2</sub>) with a fully interactive carbon cycle.

Specified emissions corresponding to 1% CO<sub>2</sub> increase drive fully interactive carbon cycle; CO<sub>2</sub> changes in atmosphere, and climate changes as a consequence; temperature differences quantify the magnitude of carbon cycle feedback

