Analysis, Integration and Modeling of the Earth System (AIMES)

http://www.aimes.ucar.edu

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Kathy Hibbard

NEESPI Science Team Meeting

2 June, 2008

Helsinki, Finland

Who is AIMES?

NAME	GENDER	COUNTRY	EXPERTISE
AyakoAbe-Ouchi*	F	JP	Paleo Modeling
Jerome Chapellaz	M	FR	Ice Cores
Bob Costanza	M	US	Ecological Economics
Yasuhiro Yamanaka	M	JP	Ocean Modeling
Congbin Fu	M	CN	START; Earth Systems Modeling
Pierre Friedlingstein	M	FR	Earth System Modeling
Suzi Kerr	F	NZ	Economics/Policy
Matt Williams	M	UK	Terrestrial Modeling/Data Assimilation
Laurent Bopp*	M	FR	Marine Biogeochemistry/Modeling
Denise Mauzerall	F	US	Atmospheric Chemistry/Policy
Natalie Mahowald	F	US	Earth Systems Modeling/ dust and BGC
Luiz Martinelli	M	BR	Hydrologist, isotopes, regional analyses
Carole Crumley	F	US	Anthropologist/ Environmental Historian
Anond Snidvongs	M	TH	START: regional monsoon analyses
Claire Granier	F	FR	Global Atmospheric modeling/transport
John Finnegan	M	AU	Complex Systems
Vladimir Kattsov**	M	RU	Climate Modeling/Hydrology

* *ex-officio*

** under discussion

AIMES INTERACTION THEMES

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. E.g., MAIRS

    2. Global change triggers rapid response; human consequences the emphasis (rather than causation). E.g., Northern High Latitudes, NEESPI

3. **INTEGRATIVE EARTH SYSTEM MODELING:** Development of increasingly complex coupled models of climate, bgc, ecology and human dimensions (e.g., IHOPE, C^4MIP to C^5MIP to C^XMIP).

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)

NORTHERN HIGH LATITUDES

Regional/Global Feedbacks and Interactions

- Carbon storage and sequestration (OM, CH_4, clathrates, CO_2)
- Hydrology: ppt/et ratios: runoff, sediment transport, salinity gradients, permafrost, etc.
- Changes in THC; warming, altered CO_2 uptake
- Changes in high latitude albedo
- Changing vegetation biogeography
- Shipping routes
- Human infrastructures, migratory routes,…

Modeling Ecosystems Across Scales: a Proposal

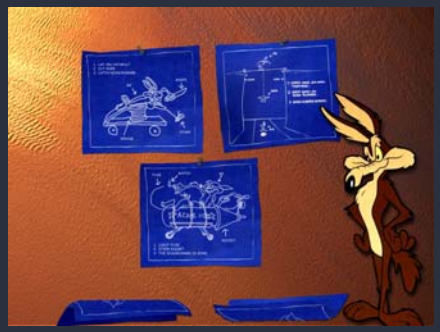
Models and Observations:
An Earth Systems Approach to the NHL:
Carbon, Water and Energy

AGCI: August 2007

ESA: September 2007

Thanks to:
AGCI, ESA, NASA, AIMES

Modeling Ecosystems Across Scales: a Proposal



Problem Statement:

- Models are becoming increasingly complex
- Reflection of stronger community links: e.g., C,N, dynamic vegetation in land components
- What is necessary and sufficient for climate models?

- What will drive future climate change?
  - sink behavior?
  - sensitivity to warming?
  - change in the length of the growing season?
  - disturbance?
  - land use/land cover?
  - technology and economics?

Modeling Ecosystems Across Scales: a Proposal

Ecosystem Processes and Global Models:

- What don't we trust in our models?

- How to develop a systematic test of QUESTIONS, rather than choosing to test a scale we work at:

  - Land use or CO_2 fertilization?
  - Will CO_2 exchange increase or decrease?
  - What is the role of disturbance?
  - Are primary controls temperature or moisture, or both?
  - Does length of growing season matter?

Modeling Ecosystems Across Scales: a Proposal

Can we add it up correctly?

Can we point to a study (model or observation) that has addressed which of these hypotheses would be correct?

How do we resolve conflicts - e.g., source vs. sink?

Are we making the correct measurements or observations to test these questions?

Modeling Ecosystems Across Scales: a Proposal

Challenge:

What are the scaleable processes that translate fundamental understanding from, say leaf to stand to landscape to continental, regional and global analyses?

Proposal:

A multiple model and data evaluation to test processes across scales: e.g., IBM, Ecosystem, DGVM, RCM, EMIC, ESM with focus on northern high latitudes

Modeling Ecosystems Across Scales: a Proposal

Objectives:

1. Quantify uncertainties and sensitivity of bgc feedbacks and interactions with the climate system in NHL
2. Test vegetation dynamics across scales of model complexity to assess feedbacks and interactions with climate system.

Expected Outcomes:

1. Identify scaleable processes and mechanisms across model complexity providing guidance to developing ESM implementation of NHL components (e.g., disturbance, radiation, et, etc.).
2. Based on processes and mechanisms from (1), provide rigorous suite of relevant diagnostics that quantify uncertainties and sensitivity of bgc feedbacks and interactions with global climate system.
3. Provide a baseline for **global** model evaluation with benchmarks (e.g., C-LAMP; http://www.climatemodeling.org/c-lamp/)

Putting it Together -
Linking NEESPI, ESA workshops with IGBP:

- An integrative IGBP crosscutting high latitude regional study. This has been proposed before by AIMES and I think it rightfully should be an AIMES orchestrated integrating study.

- Discussions between AIMES, iLEAPS, IGAC to propose to IGBP a specific meeting in about a years' time or so to get relevant people together and discuss crosscutting joint interests in the NHL.

- With this timeframe we may in a small ad hoc organizing committee with representatives from relevant core projects be able to produce a brief document scoping the possibilities for and purposes of such a regional high latitude study. This could be the starting points for discussions at the meeting.

- Initially, IGBP operational mode with small scoping meeting/conference call in next few weeks: Torben Christensen (iLEAPS), Kathy Law (IGAC), Kathy Hibbard (AIMES), Bette Otto-Bleisner, Julie Brigham-Gette (PAGES), Olga Solamina (IGBP-SC), Ken Drinkwater (GLOBEC), SOLAS, Kevin Noone, NEESPI

An Earth Systems Approach to the NHL: Carbon, Water and Energy

Objective; outline major changes: observed, expected to continue, or accelerate from marine to land to ice sheets.

Focus on recent past through to the near future (20th and 21st Centuries) with goal to feature examination of unquantified thresholds, provide guidance on representation of the NHL in GCMs and place-based models such as DGVMs, landscape models, focusing on model evolution and appropriateness, cross-scale transferability and key missing elements.

Approach: characterise natural variability as a background to projected changes focusing on three principal operating flux domains: energy, carbon and water, including consideration of variable time scales of change: e.g., fire return intervals)

Models and Observations: An Earth Systems Approach to the NHL: Carbon, Water and Energy

Proposed Outcome:

This paper seeks to review models and observations in space and time with regard strengths and weaknesses of observations and models: how are models tested and evaluated. We suggest that observations provide strong constraints for model evaluation. Data assimilation is one potential objective technique for this. Finally, to provide a framework for progress ('what needs to be done').

Integrative and Applied Earth System Science

The Aspen Protocol: Beyond a sequential approach

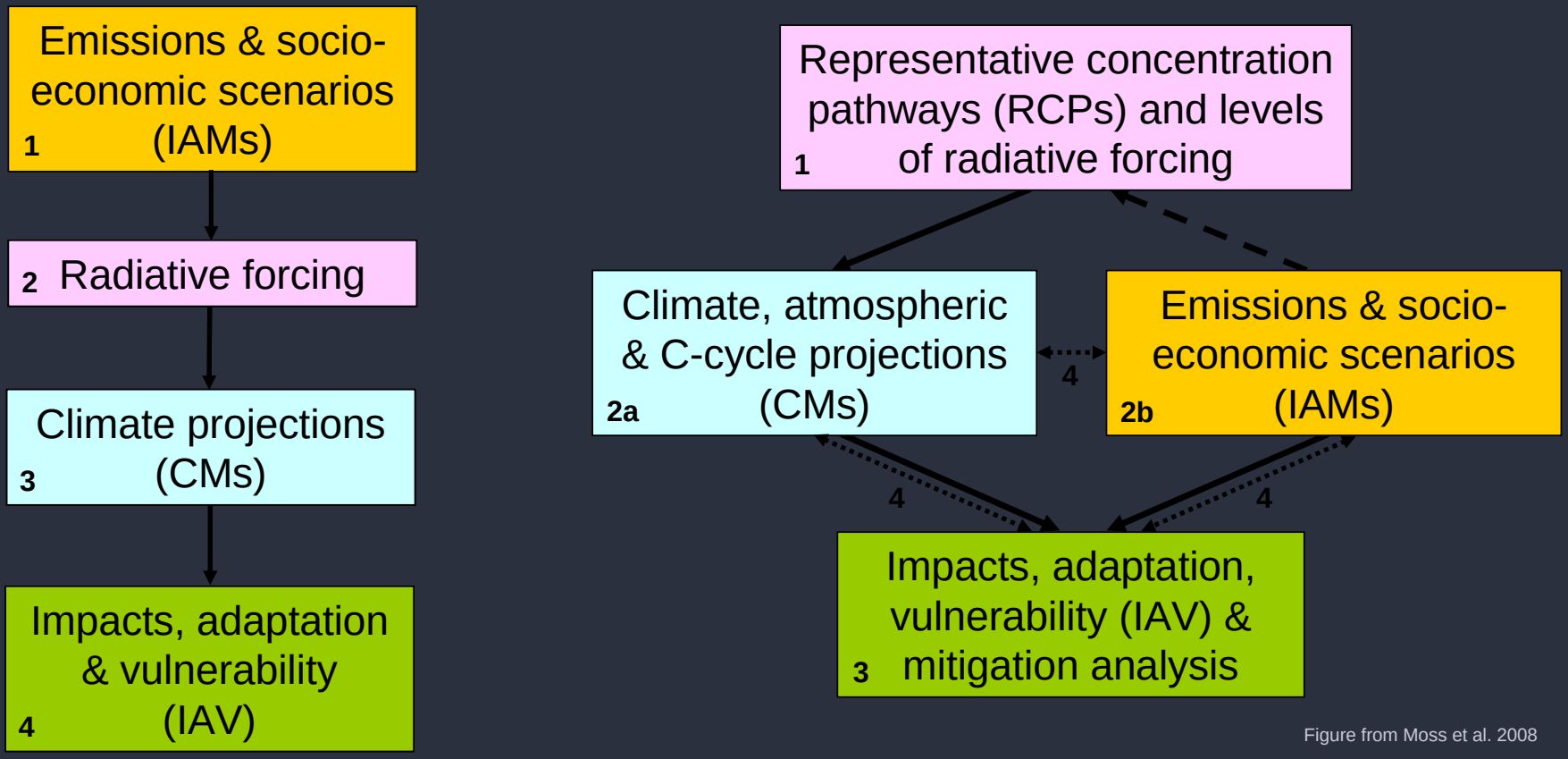


Figure from Moss et al. 2008

Approaches to the development of global scenarios: (a) previous sequential approach; (b) proposed parallel approach. Numbers indicate analytical steps (2a and 2b proceed concurrently). Arrows indicate transfers of information (solid), selection of RCPs (dashed), and integration of information and feedbacks (dotted).

Land Use/Land Cover

- Goal
  - Develop consistent set of land-use/land cover maps that transition historical to future projections smoothly
    - Provide global gridded maps of land use activities and recovering lands: past and future
    - Provide global gridded maps of underlying land-use transitions including the effects of wood harvest and shifting agriculture past and future.
  - Strategy
    - Use gridded historical (Hyde 3.0; Klein and Goldewijk, in prep; and Hurtt et al. 2006) and future from IAM

Emissions

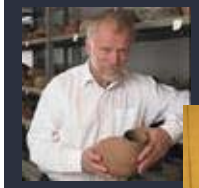
- Reference year 2000 with EDGARFT2000 as baseline (GEIA participation).
  - Only anthropogenic by sector:
    - Biomass burning (agricultural waste, slash/burn (including deforestation), fuel wood)
    - Industrial/process emissions
    - electric power plants (to enable stack-height emissions at 100m)
    - Agriculture (Agricultural Soil Emissions, Other Agriculture)
    - Transportation (Ground Transportation, Air Transportation, International Shipping)
    - Domestic (Residential and Commercial)

Extension to 2300

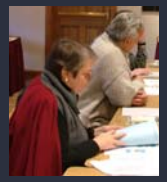
- Simple: Goal is to provide climate models information to explore long-term response of climate system to GHG emissions, concentrations and LU projections
- Deep uncertainties associated with long-term human driving forces (demography, policies, investments).
- Simple as possible and highly stylized
- Global - not to be considered as complete scenarios
- Land use scaled with demography; all IAM emissions to be run through standard EMIC or simple (MAGICC, Bern) for consistent emission and concentrations across all four RCPs.

Current Status (as of May 2008)

- At least 3-4 ESM and all IAMs will participate
- We have 1 degree prototypes of our historical products online for users to experiment with, and a pilot 100 year future based on old IMAGE and two SRES scenarios we can make avail.
- We are planning a new 0.5 degree historical product (1500-2000) based on Hyde 3.0 to be released around May 15. This could be used for ESM spinup, and IAM initial conditions.
- Next we are working on enhanced products, and prepping for IAM output.
- Detlef and others plan to announce/discuss in Paris next week.
- Need to keep getting work out to other ESMs especially.



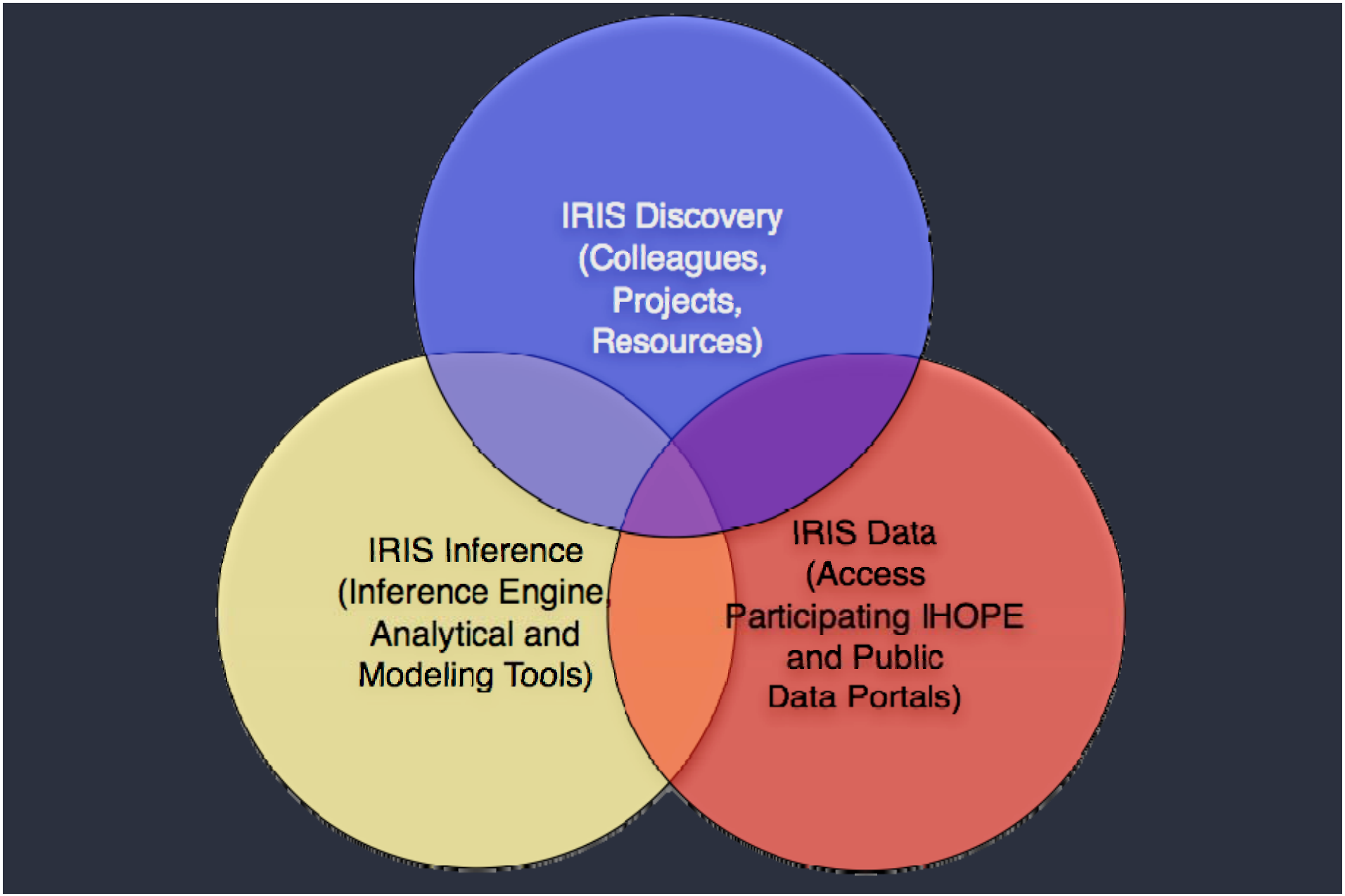
Integrative Earth System Science

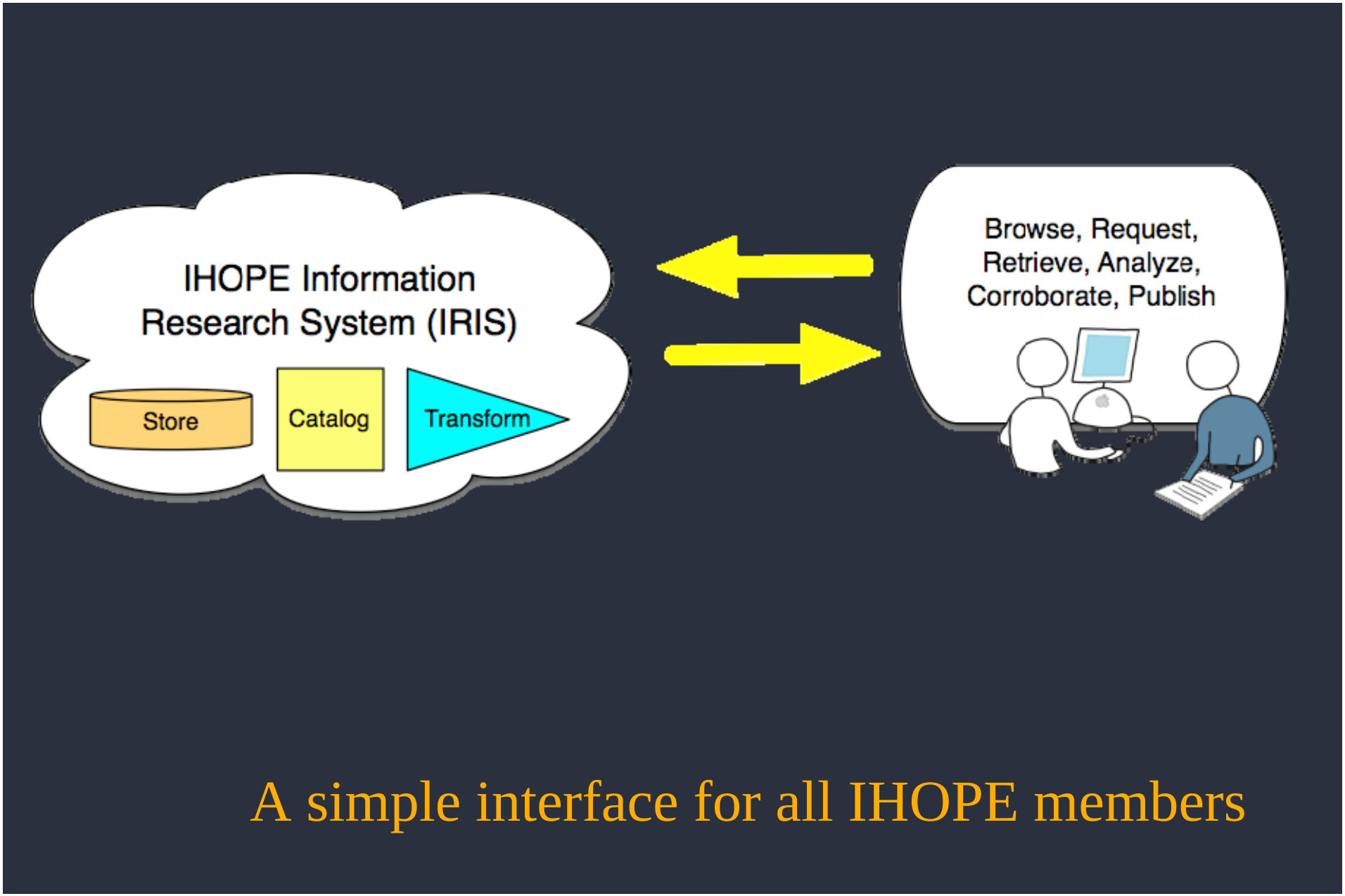


http://www.aimes.ucar.edu/activities/ihope.shtml

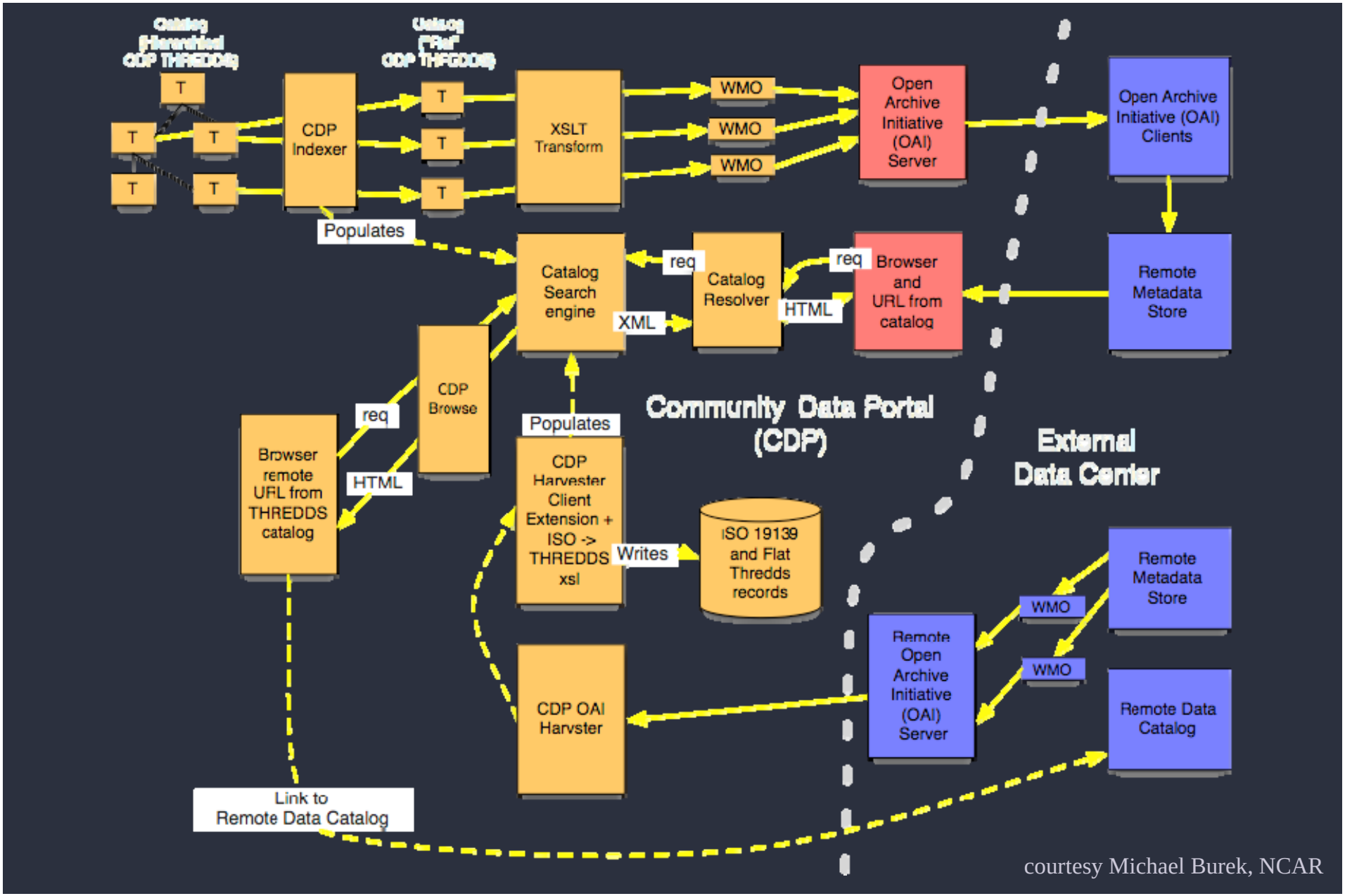
Understanding the history of how humans have interacted with the environment can help clarify options for managing our increasingly interconnected global system. This requires the major task of assembling global historical, archaeological and paleoenvironmental records. In 2008, planning for an IHOPE-AMERICAS was held at the School for Advanced Research (SAR) in Santa Fe, NM and IHOPE convened an international panel at the Stockholm Resilience Centre in April.
IHOPE is developing a flexible research information system (IRIS) in collaboration with Arizona State University and the National Ecological Observatory Network (NEON; http://www.neoninc.org) for data query, collaboration and browsing.

Currently:
- IHOPE RP final edits
- NCEAS data working group; Fall 2008
- IHOPE-Maya; 2009
- IHOPE-Australia; early 2009


IRIS Discovery
(Colleagues,
Projects,
Resources)
IRIS Inference
(Inference Engine
Analytical and
Modeling Tools)
IRIS Data
(Access
Participating IHOPE
and Public
Data Portals)



A simple interface for all IHOPE members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CDP Indexer
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XSLT Transform
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Open Archive Initiative (OAI) Server
Open Archive Initiative (OAI) Clients
Populates
Catalog Search engine
req
XML
Catalog Resolver
req
HTML
Browser and URL from catalog
Remote Metadata Store
CDP Browse
req
HTML
Browser remote URL from THREDDS catalog
Populates
CDP Harvester Client Extension + ISO -> THREDDS xsl
Writes
ISO 19139 and Flat Thredds records
Community Data Portal (CDP)
External Data Center
Remote Metadata Store
WMO
WMO
Remote Open Archive Initiative (OAI) Server
CDP OAI Harvster
Remote Data Catalog
Link to Remote Data Catalog
courtesy Michael Burek, NCAR

Tools and Technologies Accessible to all IHOPE Members

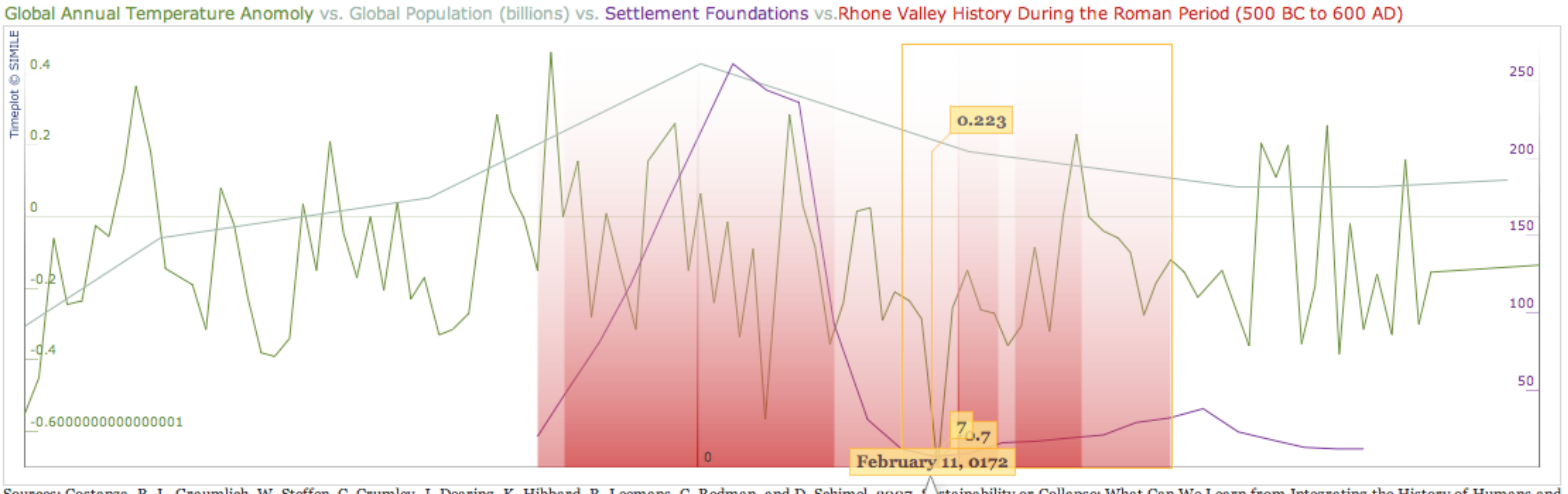
- System built with non-proprietary, Open Source Software (OSS), freely available to all
  - Data served with OSS tools (e.g., Apache Jakarta Tomcat, OPeNDAP, THREDDS catalogs, Open Archives Initiative, Ruby on Rails, Java, “The Next Great Thing”, etc.)
  - Data viewable with OSS clients or, if desired,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

IRIS Data (Access Participating IHOPE and Public Data Portals)

ARCHAEOMEDES Timeplot

Timeplot is a DHTML-based AJAXy widget for plotting time series and overlay time-based events over them (with the same data formats that Timeline supports).

Here is a live example:



Sources: Costanza, R. L. Graumlich, W. Steffen, C. Crumley, J. Dearing, K. Hibbard, R. Leemans, C. Redman, and D. Schimel. 2007. Sustainability or Collapse: What Can We Learn from Integrating the History of Humans and the Rest of Nature? Ambio 36:522-527, United Nations and S.E. van der Leeuw, The ARCHAEOMEDI… …legradation in the lower Rhone Valley during the Roman period, C.R. Geoscience 337 (2005).

Licensing

Timeplot is open source software and is licensed under the BSD license

Credits

This software was created and is maintained by the SIMILE project, in particular:

- Stefano Mazzocchi, <stefanom@mit.edu>

Data to Knowledge

Data Information Knowledge

Basic Elements	Bytes	Numbers		Models		Facts
Services	Ingest	Archive	Visualize	Infer	Understand	Predict
Storage	File	Database	HDF-EOS	GIS/MIS	Ontology	Mind
Interoperability	Syntactic	OPeNDAP	WMS/WCS		Semantic	
Volume/Density	High/Low				Low/High	
Statistics	Checksum	Moments	Descriptive	Inferential		
Analysis	Fourier	Wavelet	EOF	SSA		
Methodology	Exploratory-analysis			Model-based-mining		

Syntax ***Semantics***

Rob Raskin, NASA JPL, OPeNDAP Developers Meeting, February 2007

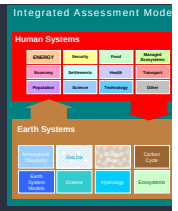
Integrated Assessment: Land Use

Category	Definition
Agricultural	Agricultural area refers to: (a) arable land; (b) permanent crops and (c) permanent pastures.
Arable + permanent crops (cropland)	Land under temporary crops (double-cropped areas are counted only once), temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow (less than five years). Abandoned land from shifting cultivation not included.
Permanent pasture	Land used permanently (five years or more) for herbaceous forage crops, either cultivated or growing wild (wild prairie or grazing land).
Built	Land used for dwellings, industries and other human infrastructure.
Forest plantations[1]	Plantation forests (or man-made forests): forests established by afforestation or reforestation.

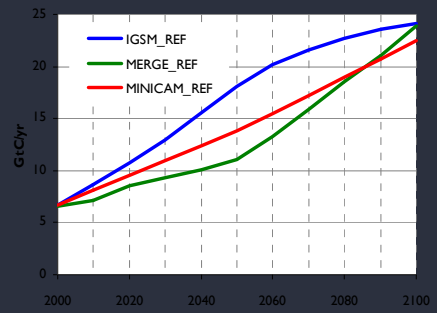
Integrated Assessment: Land Cover

	AIM	MESSAGE	MiniCam	IMAGE
MANAGED				
Cropland	Agriculture	cultivated	Cropland (4 crop types + Hay) Other Arable Land Biomass Crops	Cropland (7 crop types) Biomass crops (3 crop types)
Pasture	Pasture including grassland	*	Permanent Pasture	Pasture Extensive grassland
Forestry	Land for forestry	Managed forests	Managed forests	Regrowth forests after timber
Other		built-up land		built-up land
NATURAL				
Forests		Unmanaged forests	Natural Boreal, Other primary, secondary	Boreal, Cool conifer, Temp Mixed, Deciduous Warm mixed, Tropical woodland, forests
Grasslands		grass/shrub/ woodlands	Other Grass, Shrub Tundra	Grass, Shrub, Savannah Tundra, Wooded tundra
Other		water, desert, rocks, ice	Non-vegetated land	Ice Desert

Integrated Assessment Modeling has three roles in climate change research

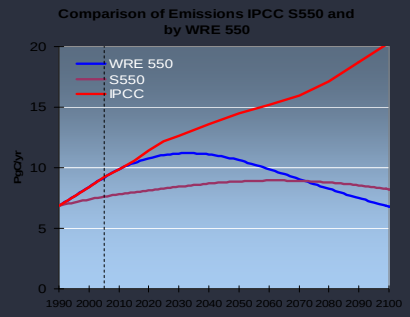


- IAMs provide data and models relevant to understanding the scale and timing of the drivers of climate change over decades to century time scales. (A major interface with the climate modeling community CMC.)



Carbon Cycle and the Economy

- IAMs provide combine knowledge derived from multiple fields of climate research - **human and natural Earth systems** - providing insights otherwise unavailable from the pursuit of focused disciplinary research



- IAMs provide more comprehensive understanding of natural and human processes in the Earth system; e.g., carbon cycle implications of stabilizing CO_2 concentrations at 550 ppm for the global energy system