New integrated scenarios approach & Representative Concentration Pathways (RCPs)

Steven Rose (EPRI) – representing many

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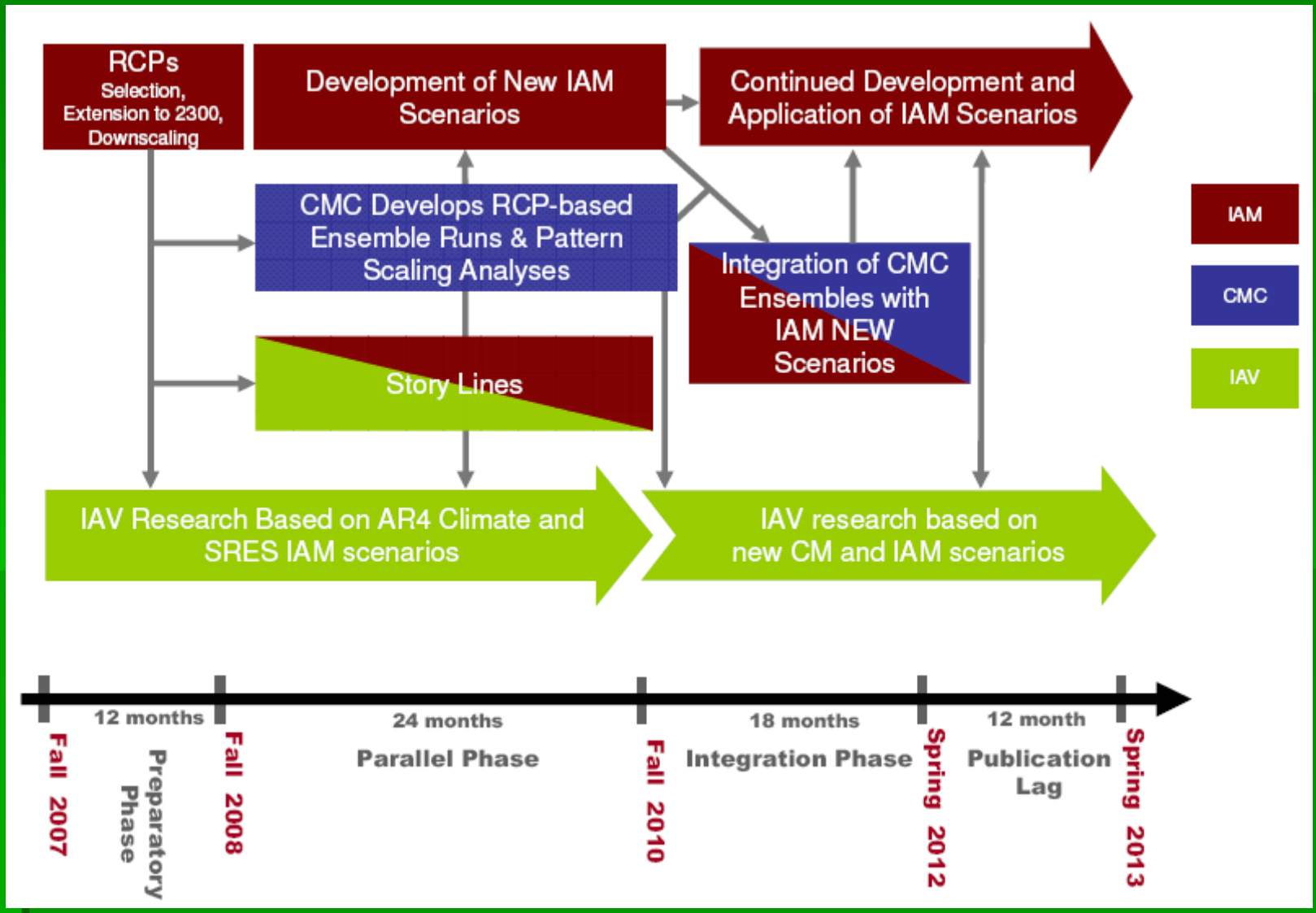
Integrated Assessment Modeling Consortium Meeting, Tsukuba, Japan

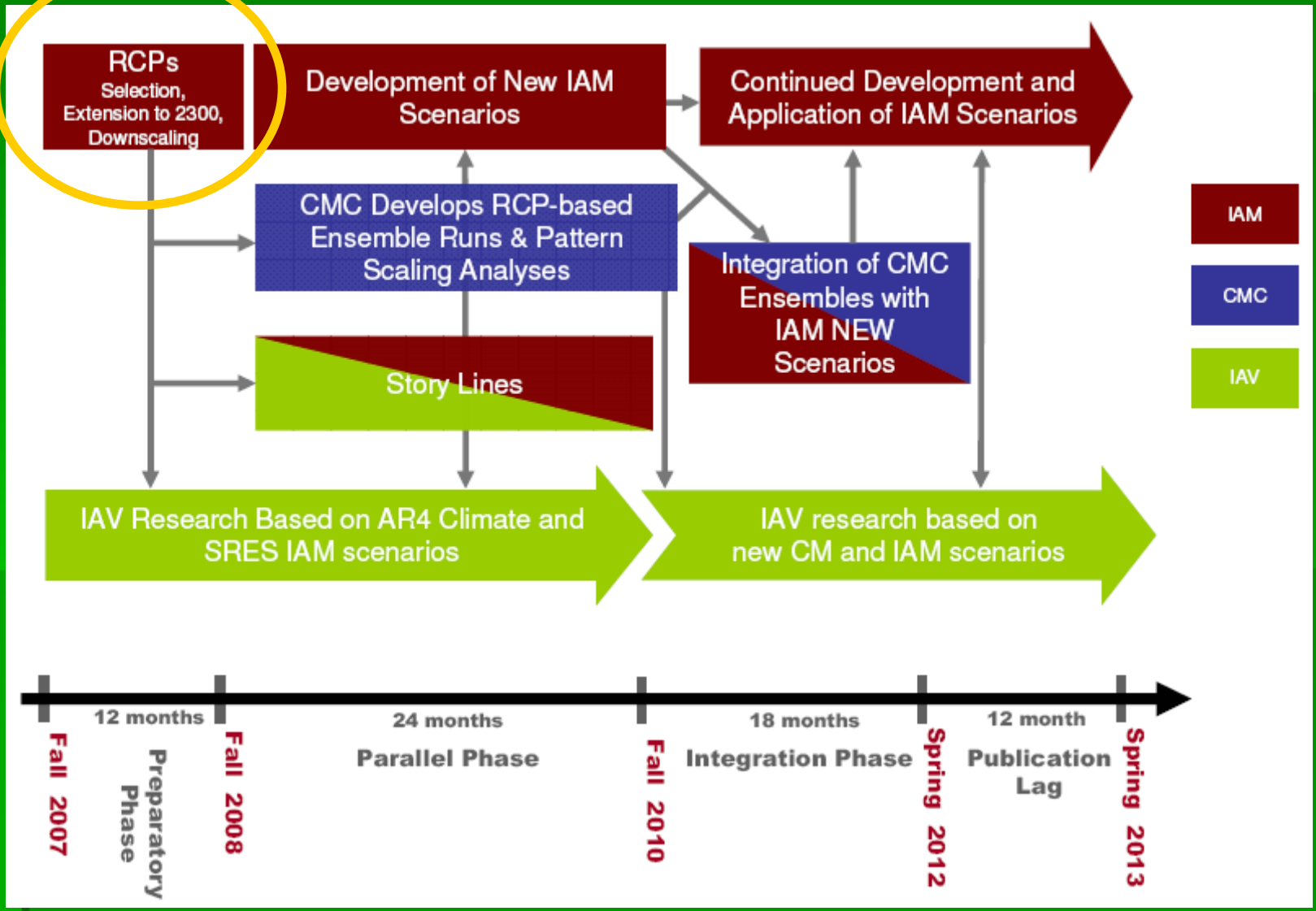
New integrated scenarios approach



New integrated scenarios approach

- In response to…
  - Scientific and policy interest in exploring a broader range of potential climates and uncertainties
  - New opportunities arising from the evolution of modeling
  - Need for improved compatibility & consistency of results across research
  - Need for greater integration and coordination between research communities
  - Need to be able to work concurrently
- …the scenarios related scientific communities have designed a blueprint for a new scenarios development process
- Process starts with a set of representative greenhouse gas concentration and radiative forcing pathways (RCPs = Representative Concentration Pathways)
- RCPs
  - Facilitate the characterization of an expansive climate space
  - Create new opportunities for improving modeling of climate change, impacts, and mitigation

New integrated scenarios approach and RCPs (Representative Concentration Pathways)



RCPs – a scientific community initiative, the work of many

- *Genesis: Aspen, CO 2006 (Meehl et al. 2007; Hibbard et al., 2007)*
- *Joint IAM-CMC-IAV development and vetting and presentation to IPCC (Moss et al, 2008)*
  - Moss, Richard, Mustafa Babiker, Sander Brinkman, Eduardo Calvo, Tim Carter, Jae Edmonds, Ismail Elgizouli, Seita Emori, Lin Erda, Kathy Hibbard, Roger Jones, Mikiko Kainuma, Jessica Kelleher, Jean Francois Lamarque, Martin Manning, Ben Matthews, Jerry Meehl, Leo Meyer, John Mitchell, Nebojsa Nakicenovic, Brian O'Neill, Ramon Pichs, Keywan Riahi, Steven Rose, Paul Runci, Ron Stouffer, Detlef van Vuuren, John Weyant, Tom Wilbanks, Jean Pascal van Ypersele, Monika Zurek, 2008. *Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies: IPCC Expert Meeting Report, 19–21 September, 2008, Noordwijkerhout, The Netherlands*, www.ipcc.ch.
- *Evaluation of the robustness of IMAGE 2.6 for RCP3-PD (Weyant et al., 2009)*
- *RCP data preparation (van Vuuren et al., being finalized, draft available)*
  - *Detlef P. van Vuuren, Johannes Feddema, Jean-Francois Lamarque, Keywan Riahi, Steven Rose, Steve Smith, Kathy Hibbard, in preparation,* "Work plan for data exchange between the Integrated Assessment and Climate Modeling community in support of Phase-0 of scenario analysis for climate change assessment (Representative Community Pathways)"
  - **Dozens more across all the data components (emissions, land-use, 2300 extension, concentrations)**
- *Many meetings and teleconferences along the way*

RCP selection process
(see Moss et al., 2008)

- ***Defined requirements***
  - ***Desirable characteristics for RCPs***
  - ***Desirable types of RCPs***
- ***Identified candidates***
- ***Selected RCPs***

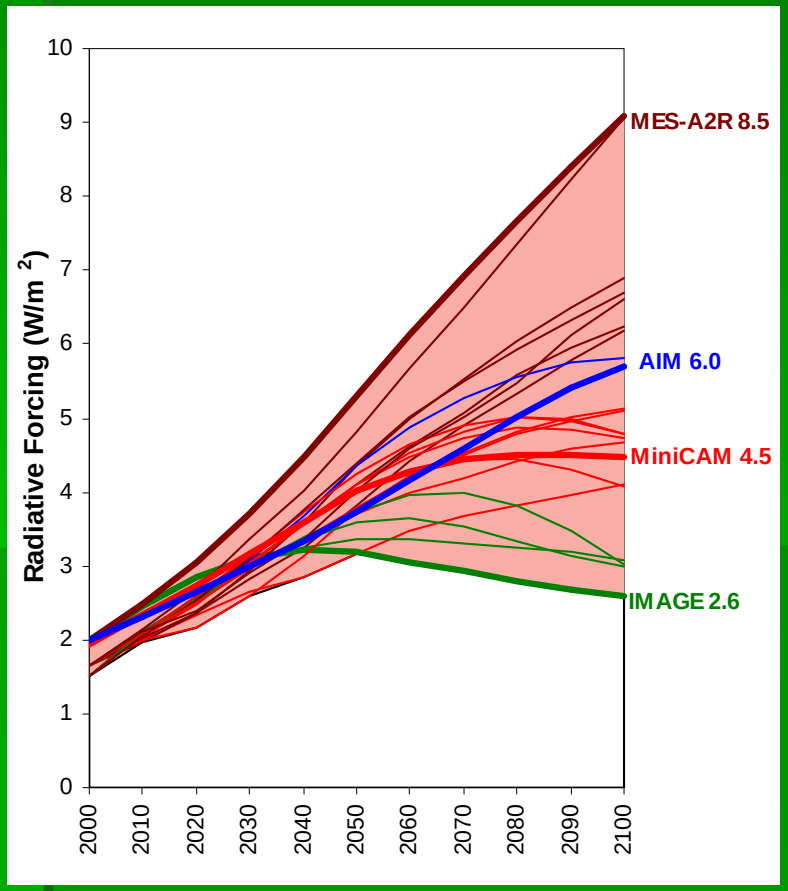
Four Types of desirable RCPs

Table 1. Types of representative concentration pathways.

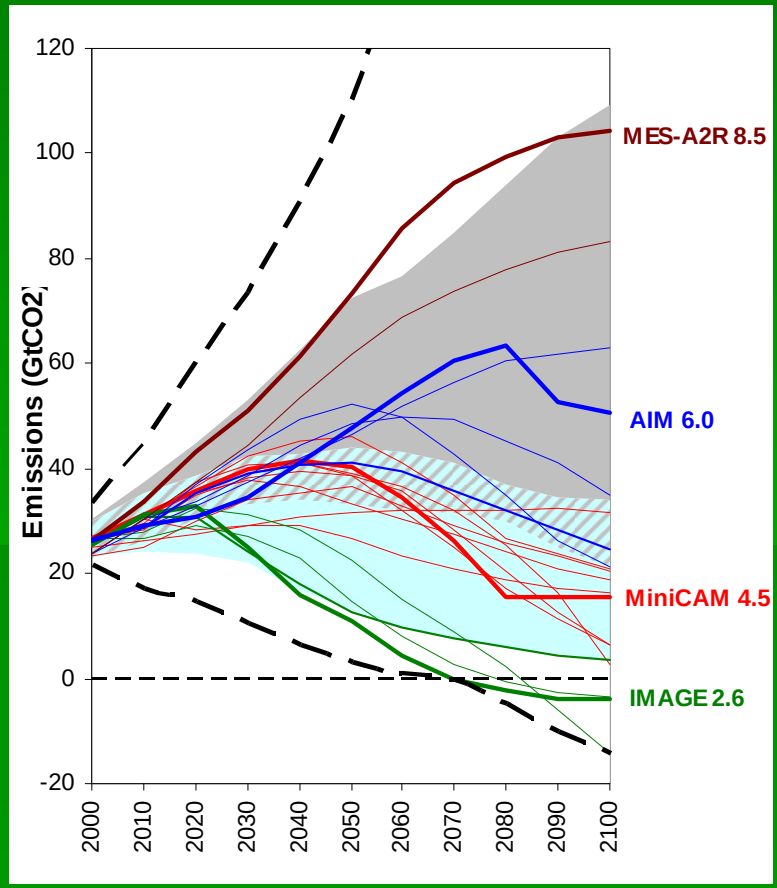
Name	Radiative Forcing[1]	Concentration[2]	Pathway shape
RCP8.5	>8.5 W/m^2 in 2100	> ~1370 CO_2-eq in 2100	Rising
RCP6	~6 W/m^2 at stabilization after 2100	~850 CO_2-eq (at stabilization after 2100)	Stabilization without overshoot
RCP4.5	~4.5 W/m^2 at stabilization after 2100	~650 CO_2-eq (at stabilization after 2100)	Stabilization without overshoot
RCP3-PD[3]	peak at ~3W/m^2 before 2100 and then decline	peak at ~490 CO2-eq before 2100 and then decline	Peak and decline

Selected RCPs are representative

Span RF scenarios



Represent 10-90th emissions



RCP data requirements – full set of radiative forcing & AQ components

Variable	Units	Spatial scale	
		Concentrations	Emissions
Greenhouse gases			
CO_2 (fossil fuel, industrial, land use change)	ppm and Pg/yr	Global average	Sum
CH_4	ppb and Tg/yr	Global average	Grid[1]
N_2O	ppb and Tg/yr	Global average	Sum
HFCs[2]	ppb and Tg/yr	Global average	Sum
PFCs[2]	ppb and Tg/yr	Global average	Sum
CFCs[2]	ppb and Tg/yr	Global average	Sum
SF_6	ppb and Tg/yr	Global average	Sum
Aerosols[2]			
Sulfur (SO_2)	Tg/yr	Generated by CM community[3]	Grid
Black Carbon (BC)	Tg/yr	Generated by CM community[3]	Grid
Organic Carbon (OC)	Tg/yr	Generated by CM community[3]	Grid
Chemically active gases			
CO	Tg/yr	Generated by CM community[3]	Grid
NO_x	Tg/yr	Generated by CM community[3]	Grid
VOCs[2]	Tg/yr	Generated by CM community[3]	Grid
NH_3	Tg/yr	Generated by CM community[3]	Grid
Land use & land cover			
CO_2 flux (land use change)	Tg/yr	n/a	$\leq 1° \times 1°$
Land use & land cover	Fraction of types[4]	Regional results (grid)	

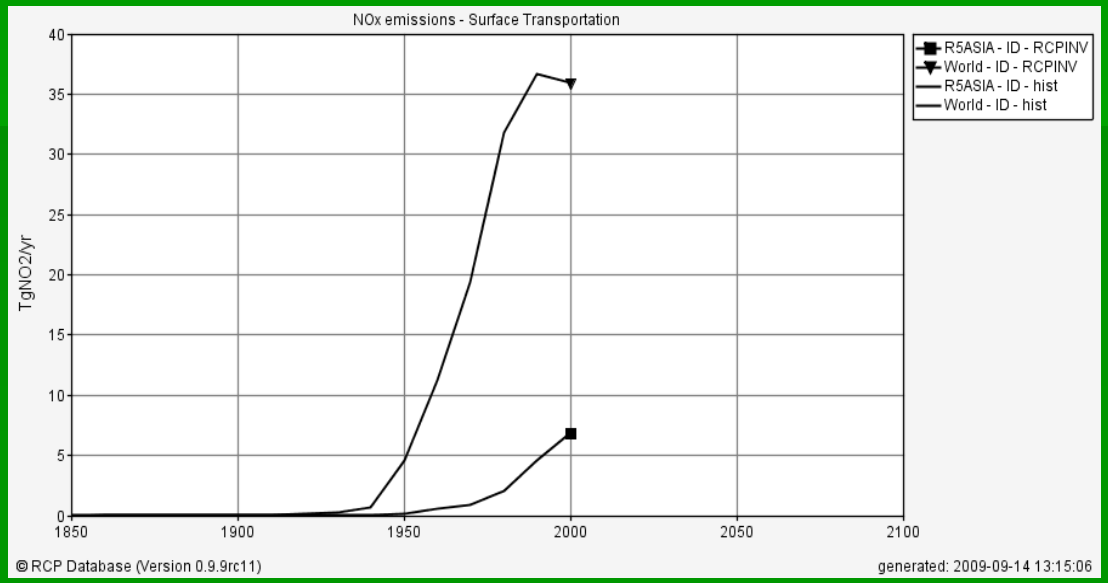
RCP data hand-shake – an IAM-ESM-inventory-chemistry collaboration

- IAM teams need to round-out their published scenarios to satisfy the full data request for climate and atmospheric chemistry modeling
  - Harmonize definitions and historic data (emissions and land-use)
  - Provide additional detail for emissions
  - Provide additional detail for land use & land cover change
  - Extend scenarios to 2300 – currently only 2100
- Consistency and coordination between the communities required and essential to increase comparability and provide a smooth transition from historic to future periods
- Coordination events:
  - February 2008, Washington, DC
  - May 2008, Paris
  - Summer 2008, Snowmass, CO
  - September 2008, Vienna
  - Spring 2009, Hamburg
  - Summer 2009, Snowmass, CO

Harmonized historical emissions
(Reactive gases & aerosol precursors)

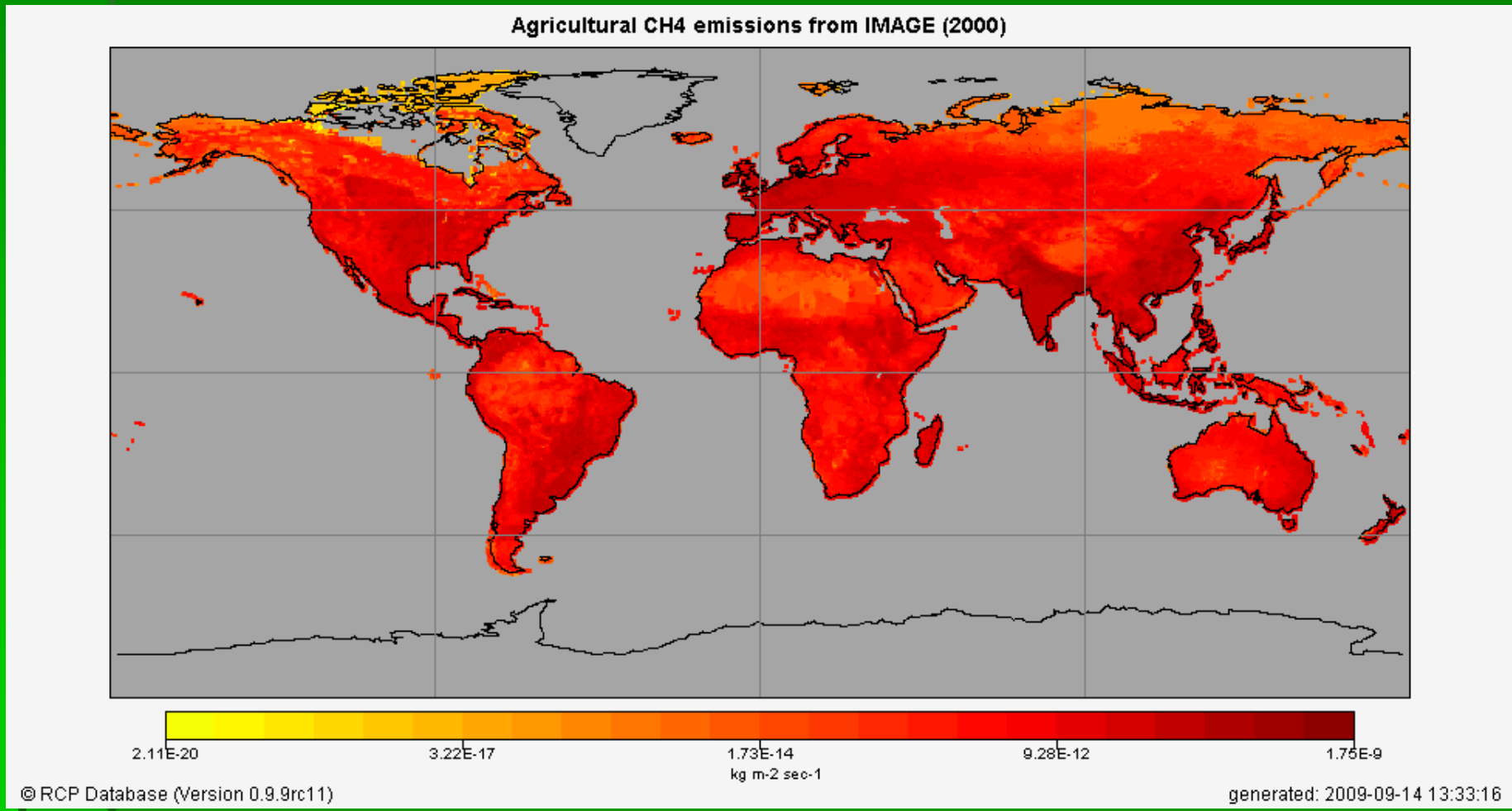
Unique compilation of inventories
Historical emissions: 1850 – 2000
With sectoral disaggregation

- Surface Transportation
- International Shipping
- Aviation
- Power plants, energy conversion, extraction
- Solvents
- Waste (landfills, waste water, non-energy incineration)
- Industry (combustion and processing)
- Residential and Commercial
- Ag. waste burning on fields
- Agricultural (animals, risce, soil)
- Grassland burning
- Forest burning



Gridded emissions
(Reactive gases & aerosol precursors)

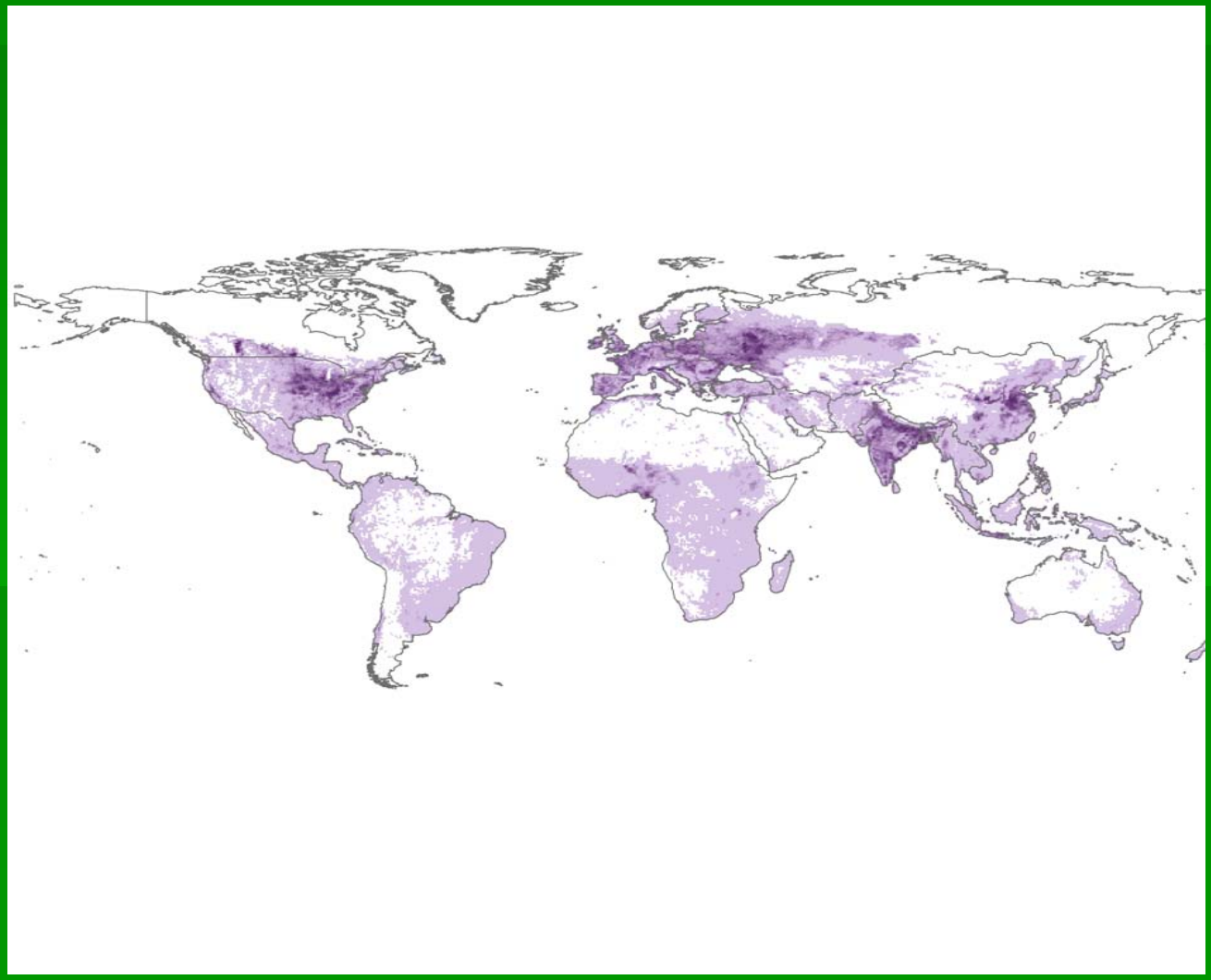
0.5º x 0.5º with sectoral detail – IAM model specific (2000 – 2100)



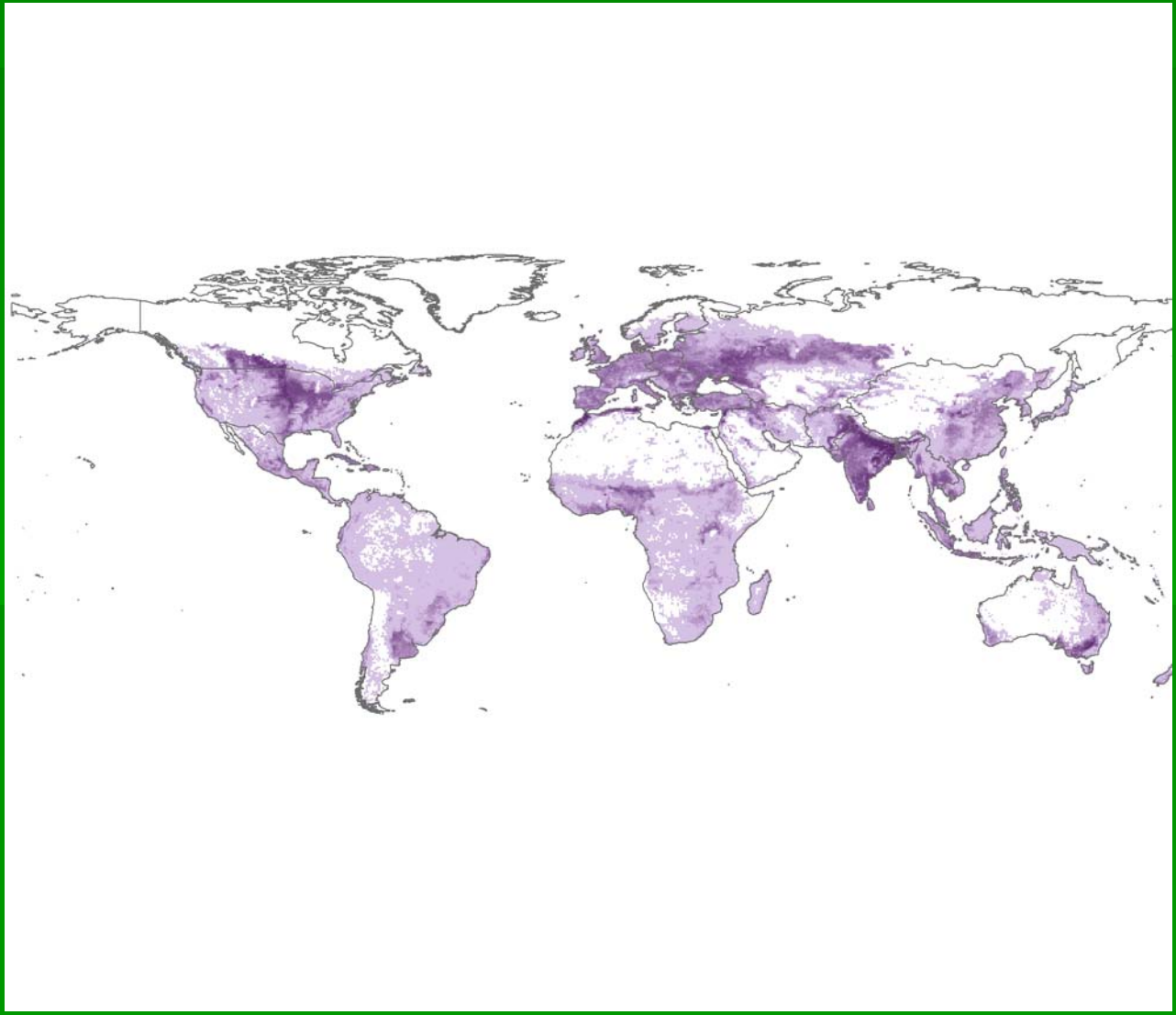
Harmonized land-use transition (in progress)

- Transition harmonization on-going with Univ. of New Hampshire
  - Significant interpretation issues given differences in land modeling within and across IAMs and ESMs
- Key elements of modeling land in CMs:
  - A smooth transition from historic to future land use/cover
  - Land use data must be consistent with the characterization of land cover in each CM
  - Land use must be **clearly** distinguished from land cover
  - Land use and land cover categories require detailed characterizations that are based on their role in biogeophysical and biogeochemical processes

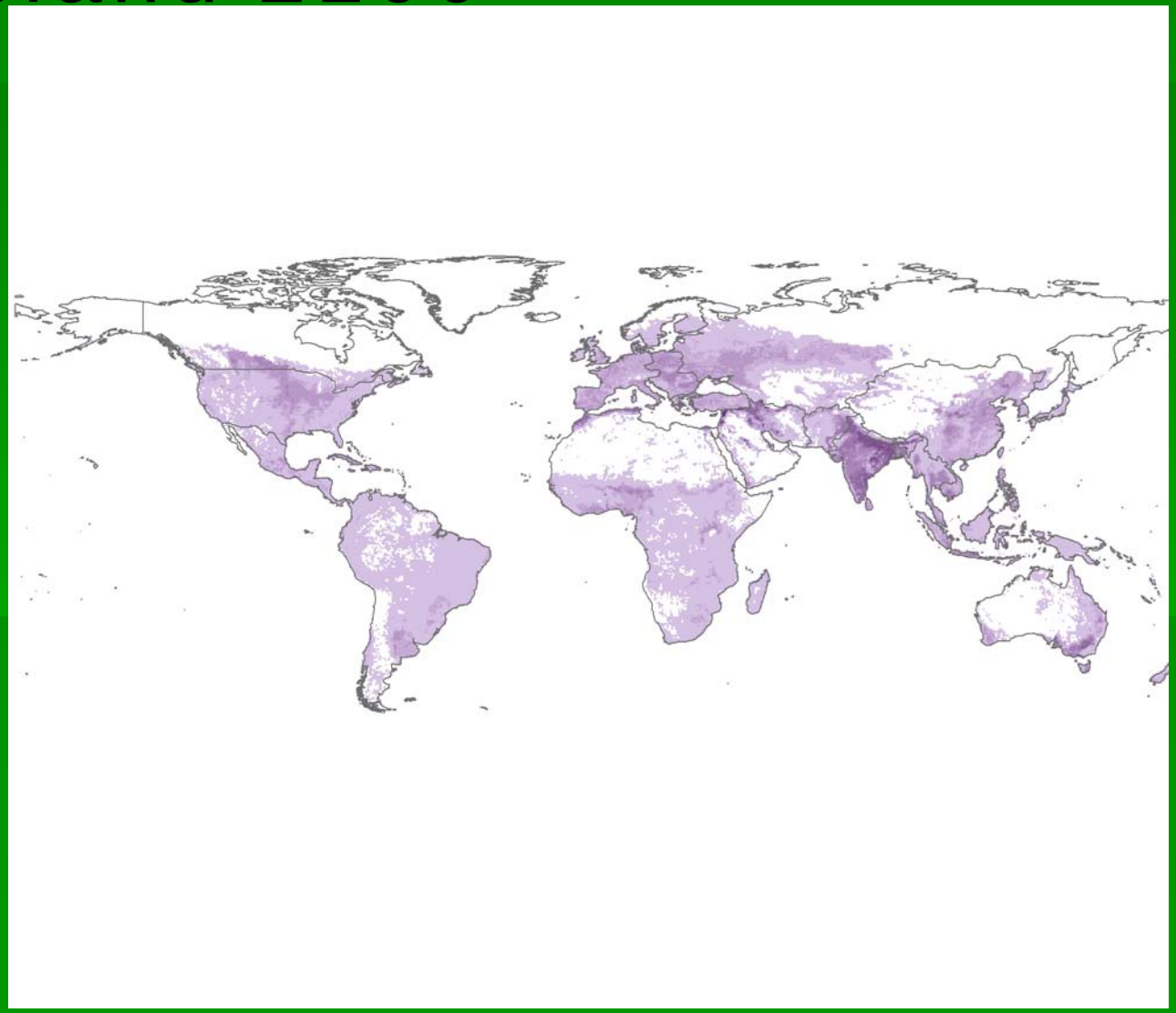
Cropland 1900



MiniCAM DRAFT harmonized cropland 2005



MiniCAM DRAFT harmonized cropland 2100



Extension to 2300
(in progress)

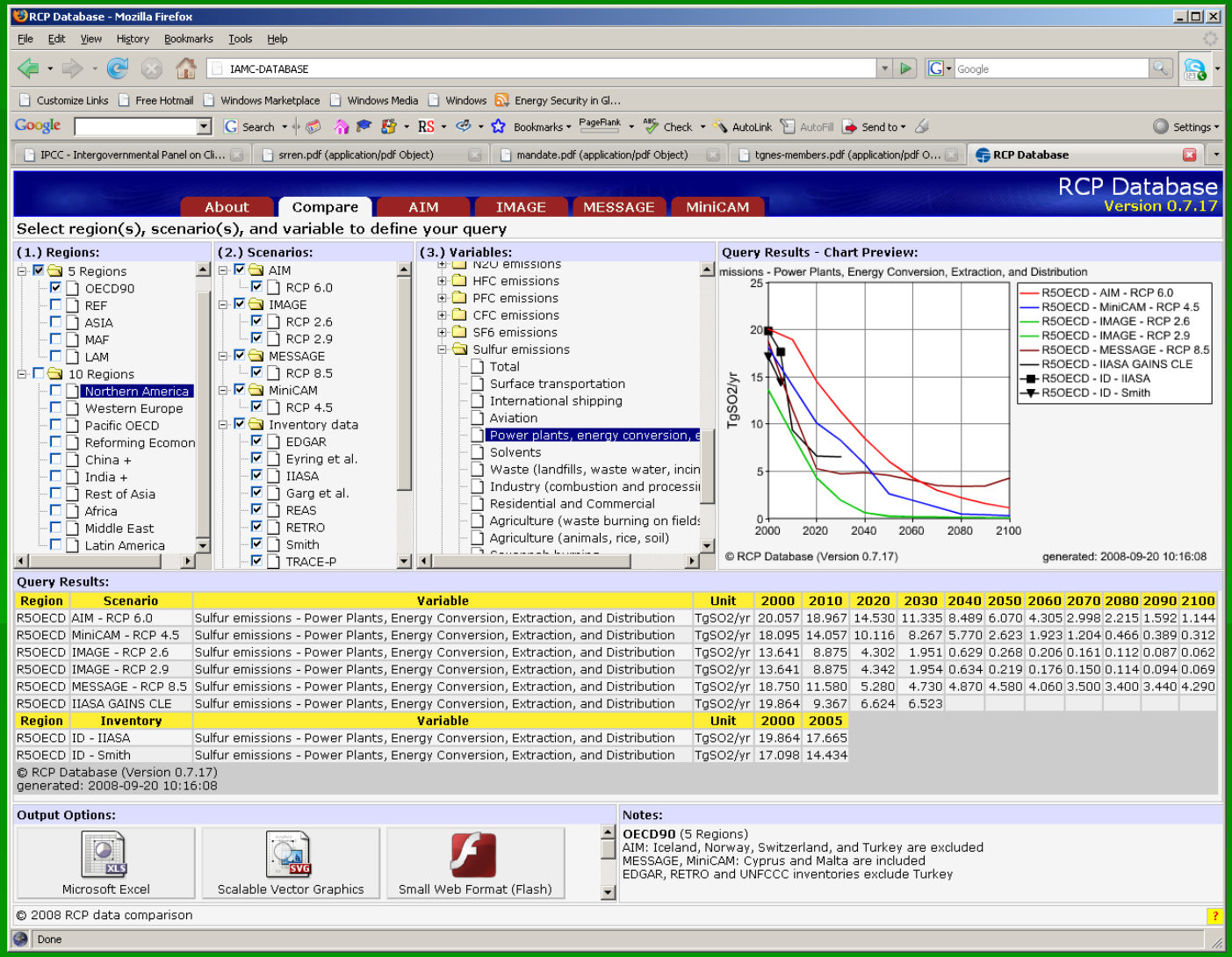
- Facilitate long-term climate experiments to explore response of the climate system and inertia in some components (e.g., sea level rise)
- Approach – as simple as possible. Highly stylized.
  - Only necessary information: emissions, concentrations, and land-use
    - Not full-fledged scenarios, e.g., socioeconomic and technology projections to 2300 will not exist
- Different circumstances across RCPs

Summary of RCP status

- Significant coordination within and outside RCP teams over two years
- Completed IMAGE 2.6 review for lowest RCP (Weyant et al., 2009)
- Developed RCP database: web-based central repository with standardized set of reporting variables
- Developed emissions and land-use standardization data: spatially explicit base year and historic data for standardizing the RCP base years and projections
- Completed detailed internal review (data to 2100)
- Completed outside technical review (for 3 of the RCPs to 2100) – IAM, climate, and atmospheric chemistry communities, as well as others
- Completing internal review of 4th RCP
- Atmospheric chemistry runs in progress
- Forthcoming: Land-use transition standardization, land-use CO2 fluxes, recent request for historic concentrations, and RCP 2300 extensions (outside feedback received)

RCP web accessible database

(potential future central IAM data repository)



http://www.iiasa.ac.at/web-apps/tnt/RcpDb/

RCPs are just a beginning to facilitate research across communities…

the critical work comes next to explore and characterize uncertainties

RCP scenarios selected to span climate space
(also, scientific communities as responsible parties)

RCP user guidance: intended uses and limits

- **Intended uses**
  - Input to climate models to jump-start scenario development across research communities
  - To facilitate pattern scaling of climate model outcomes
  - To explore ranges of socioeconomic conditions consistent with different forcing pathways
  - To explore climate implications of spatial forcing patterns
  - To provide a consistent analytical thread through the literature

- **Limits**
  - Not forecasts or absolute bounds
  - Not policy prescriptive
  - Socioeconomics underlying each RCP are not unique
  - RCPs are not a set or representative of the range of assumptions
  - Uncertainties in the translation of emissions profiles to concentrations and radiative forcing