Scenarios

Uniwersytet Warszawski
Master Program in Sustainable Development
Climate Change

Students:
Ania Frączyk, Michał Kruszyński, Alfonso Mendoza,
Gabriela Uberna, Kseniya Rusak.

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II. SRES Scenarios (Alfonso)
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If you were to create a projection/scenario:

What variables would you include??

Concepts

Definition of scenario

Scenarios provide a basis for assessing the risk of crossing identifiable thresholds in both physical change and impacts on biological and human systems.

Scenarios describe plausible trajectories of different aspects of the future that are constructed to investigate the potential consequences of anthropogenic climate change.

Scenarios represent many of the major driving forces:

- including processes,
- impacts (physical, ecological, and socioeconomic)
- potential responses that are important for informing climate change policy.

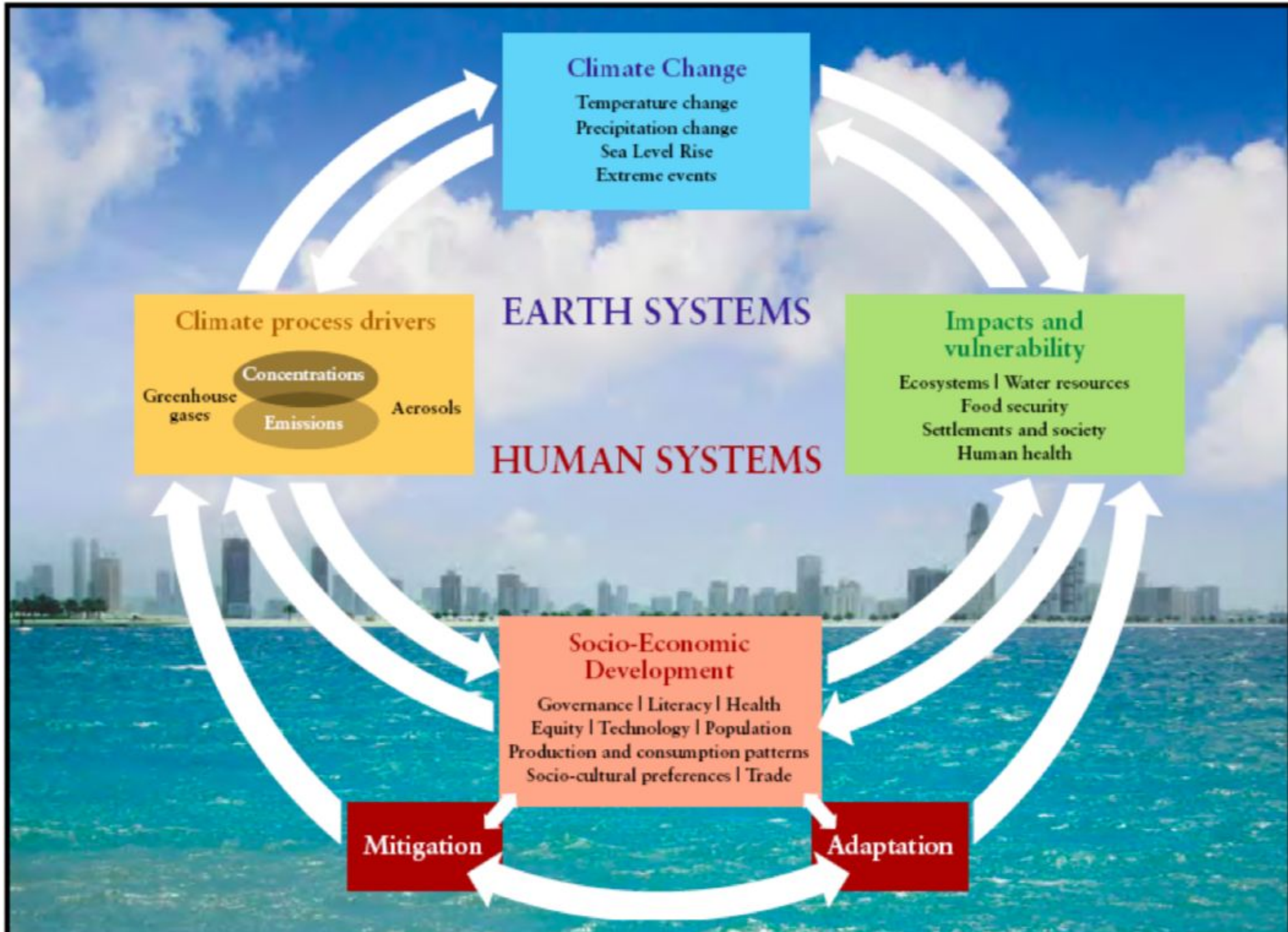
"Scenarios are images of the future or alternative futures"

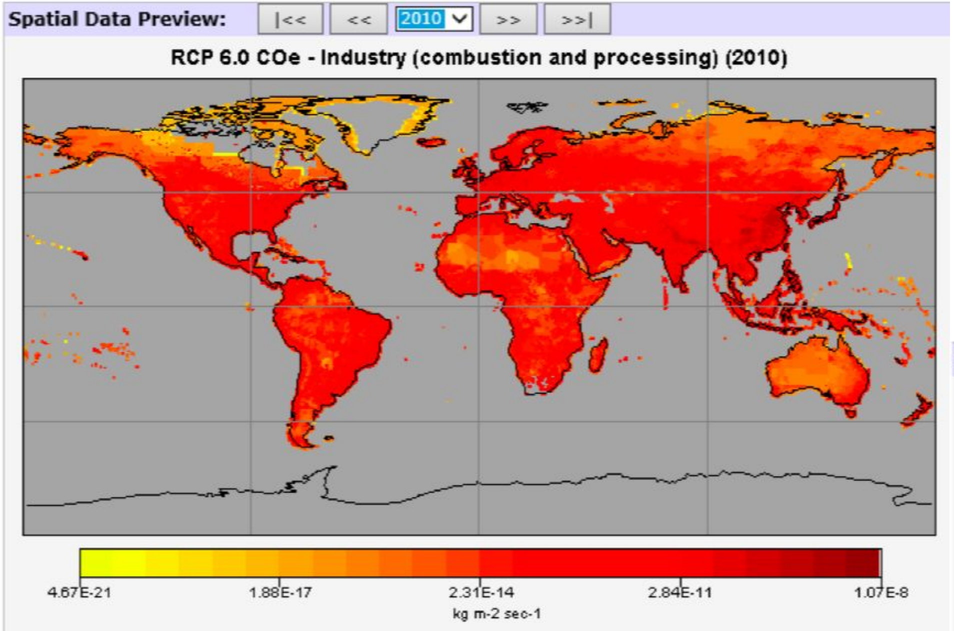
Purpose of scenario

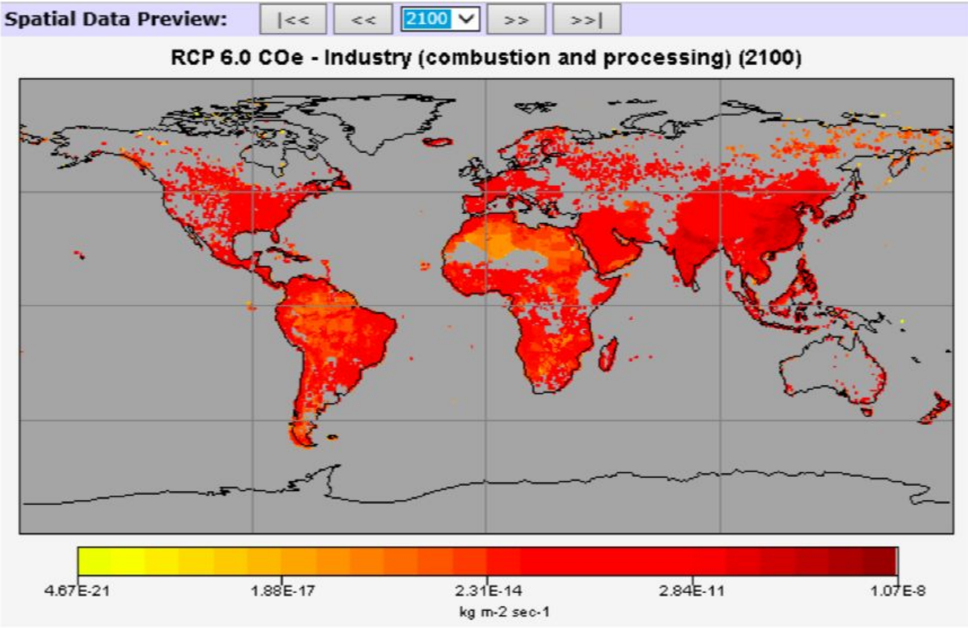
They are used to hand off information from one area of research to another (e.g., from research on energy systems and greenhouse gas emissions to climate modeling)

- Many climate modelling teams are working at the same time
- There is a need to compare studies
- It creates possibility of validation of other models
- Easier and less time consuming communication between teams
- Lower cost of running models
- Short supply of powerful computers

Why it is important?







What RCPs consist of?

Limitations and problems

- Uncertainties
- Disagreements
- Scenarios help in the assessment of future developments in complex systems that are either inherently unpredictable, or that have high scientific uncertainties.
- Methodological differences
- Different sources of data
- Computer calculating power

Scenario driving forces

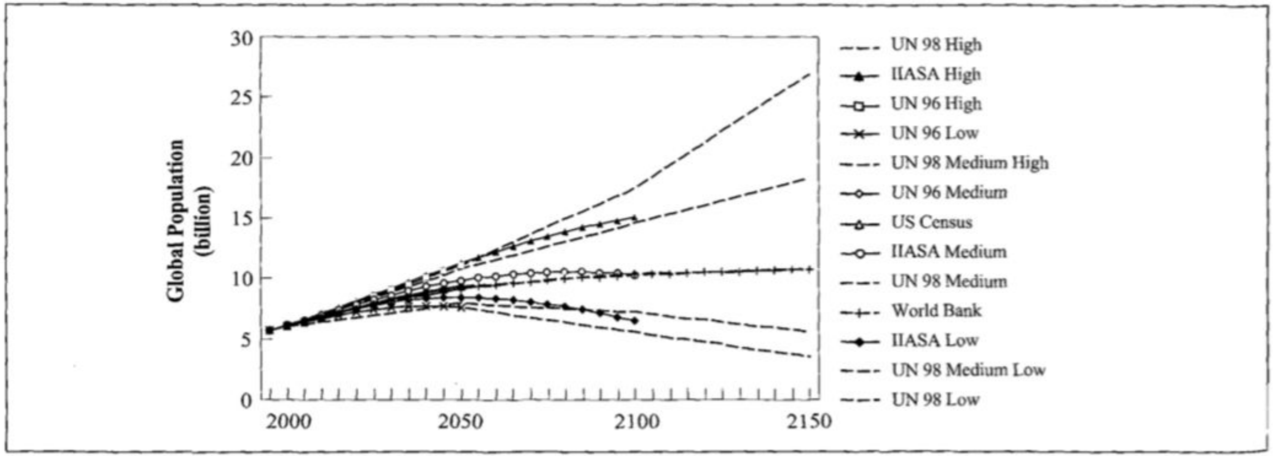
- **Population** (trends, projections, demography, aging, urbanization, economic growth)
- **Economic and social development** (social and institutional changes, international trade, innovations, social advancement of the poor, behavior of the wealthy)
- **Energy and technology** (energy use and emissions by major sectors as [agriculture, industry, buildings, transport], energy resources, fossil and fissile resources, renewables, energy supply technologies)
- **Agriculture and land use** (carbon dioxide from anthropogenic land use, methane from rice production, nitrous oxides emission,
- **Other gas emission** (Nitrous oxide, methane, sulfur dioxide, ozone precursors, halocarbons)
- **Policies and their influence**

Table 3-1: Population of the world and by major areas between 1800 and 1996 in millions. Data source: UN, 1998.

	1800	1850	1900	1950	1996
World	978	1262	1650	2524	5768
Africa	107	111	133	224	739
Asia	635	809	947	1402	3488
Europe	203	276	408	547	729
Latin America and Caribbean	24	38	74	166	484
Northern America	7	26	82	172	299
Oceania	2	2	6	13	29

Population trends

Population estimations



Economic growth trends

Table 3-2: Per capita GDP growth rates for selected regions and time periods, in percent per year. Data source: Maddison, 1995.

	1870–1913	1913–1950	1950–1980	1980–1992
Western Europe	1.3	0.9	3.5	1.7
Australia, Canada, New Zealand, USA	1.8	1.6	2.2	1.3
Eastern Europe	1.0	1.2	2.9	-2.4
Latin America	1.5	1.5	2.5	-0.6
Asia	0.6	0.1	3.5	3.6
Africa	0.5	1.0	1.8	-0.8
World (sample of 199 countries)	1.3	0.9	2.5	1.1

Oil reserves, resources and occurrences

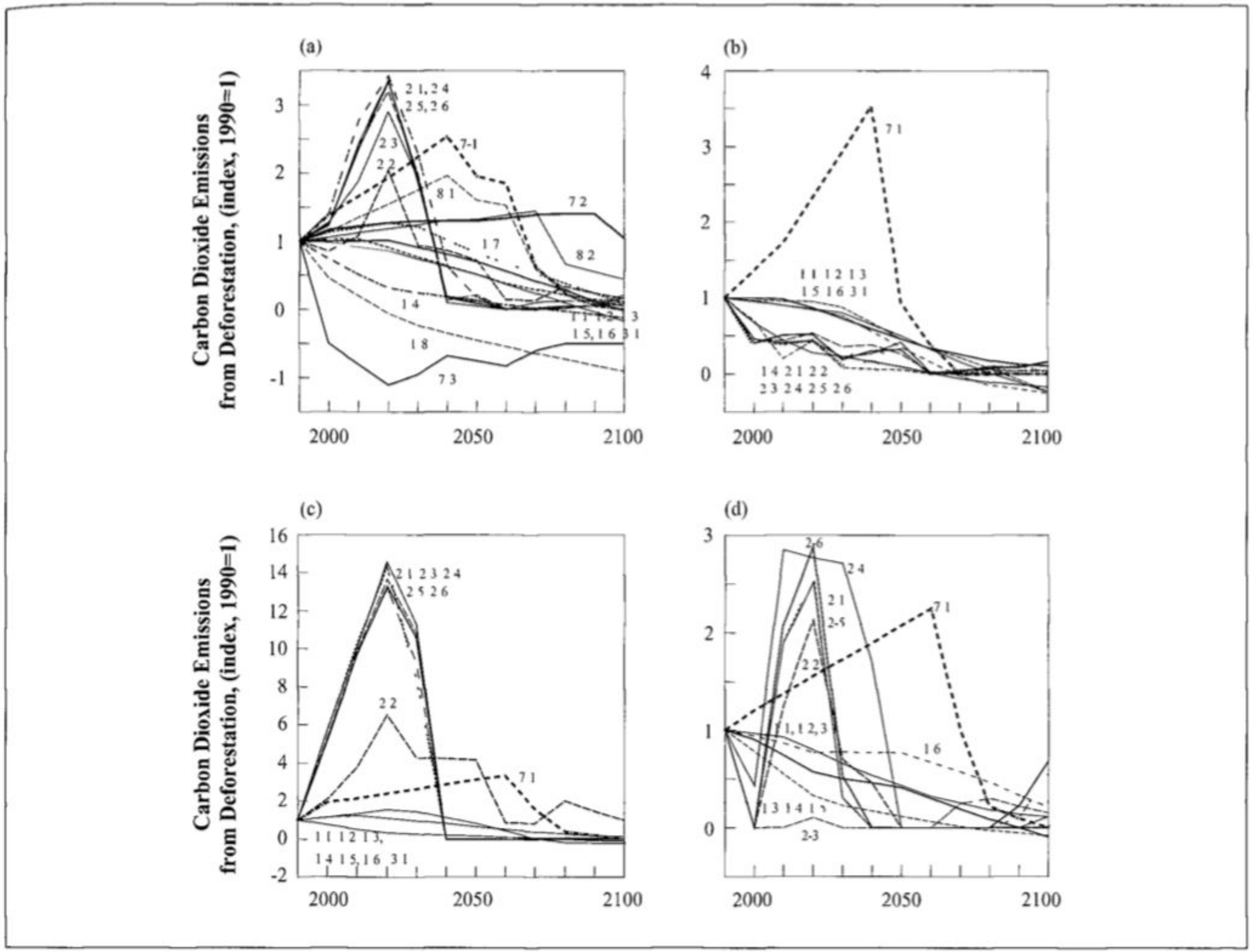
Table 3-5: Global fossil and fissile energy reserves, resources, and occurrences (in ZJ (10^{21}J)). Global and regional estimates are discussed in detail in Rogner (1997) and Gregory and Rogner (1998).

	Consumption 1860–1990	Consumption 1990	Reserves Identified	Conventional Resources Remaining to be Discovered Low	Conventional Resources Remaining to be Discovered High	Recoverable with Technological Progress	Additional Occurrences
Oil							
Conventional	3.35	0.13	6.3	1.6	5.9		
Unconventional	—	—	7.1			9	>15
Gas							
Conventional	1.70	0.07	5.4	9.4	22.6		>10
Unconventional	—	—	6.9			20	>22
Hydrates	—	—					>800
Coal	5.20	0.09	22.9			80	>150
Total	10.25	0.29	48.6	>11.0	>28.5	>109	>987
Nuclear	0.21	0.02	2.0			>11	>1,000

Renewable energy potential

Table 3-6: Global renewable energy potentials for 2020 to 2025, maximum technical potentials, and annual flows, in EJ. Data sources: Watson et al., 1996; Enquete-Kommission, 1990.[2]

	Consumption 1860–1990	Consumption 1990	Potentials by 2020–2025	Long-term Technical Potentials	Annual Flows
Hydro	560	21	35–55	>130	>400
Geothermal	–	<1	4	>20	>800
Wind	–	–	7–10	>130	>200,000
Ocean	–	–	2	>20	>300
Solar	–	–	16–22	>2,600	>3,000,000
Biomass	1,150	55	72–137	>1,300	>3,000
Total	1,710	76	130–230	>4,200	>3,000,000



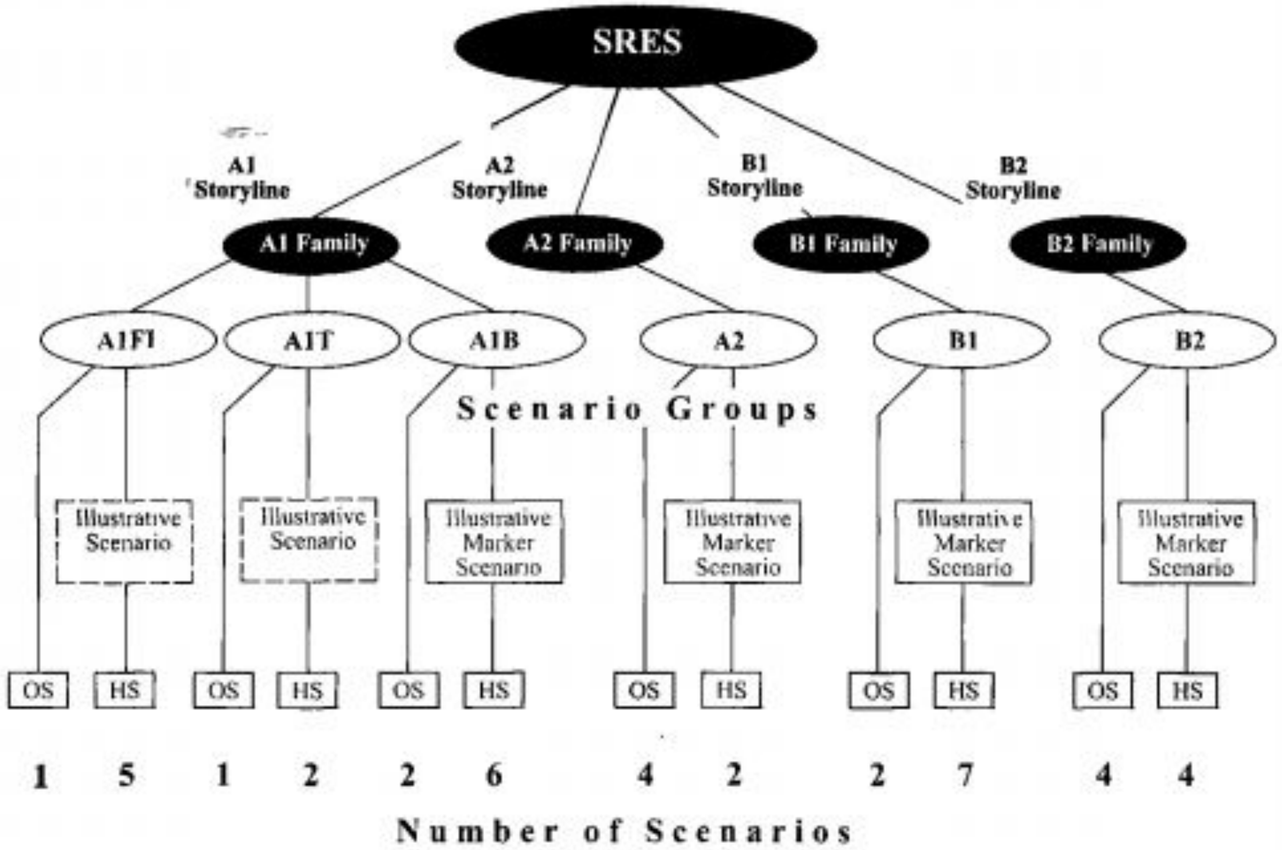
Agriculture and deforestation

SRES
Methodology & Scenarios

Storylines driving forces

- Population growth: fast, moderate, slow.
- Economic growth *vis à vis* Environmental-friendly policies.
- Development: Regional *vis à vis* Global.
- Technological development: fast or slow.
- GHG emissions: high, low.

IPCC assessment report projections for the future are often made in the context of a specific scenario family.



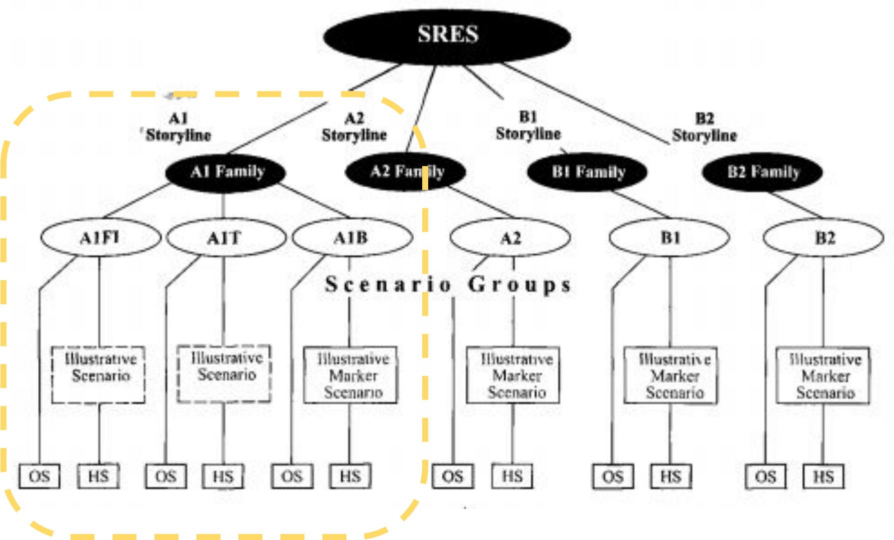
Source:
SRES, IPCC, 2000 – Nebojsa Nakicenovic and Rob Swart (Eds.) Cambridge University Press, UK.

https://www.ipcc.ch/site/assets/uploads/2018/03/emissions_scenarios-1.pdf

Four from 40 scenarios are designated as *marker scenarios*.

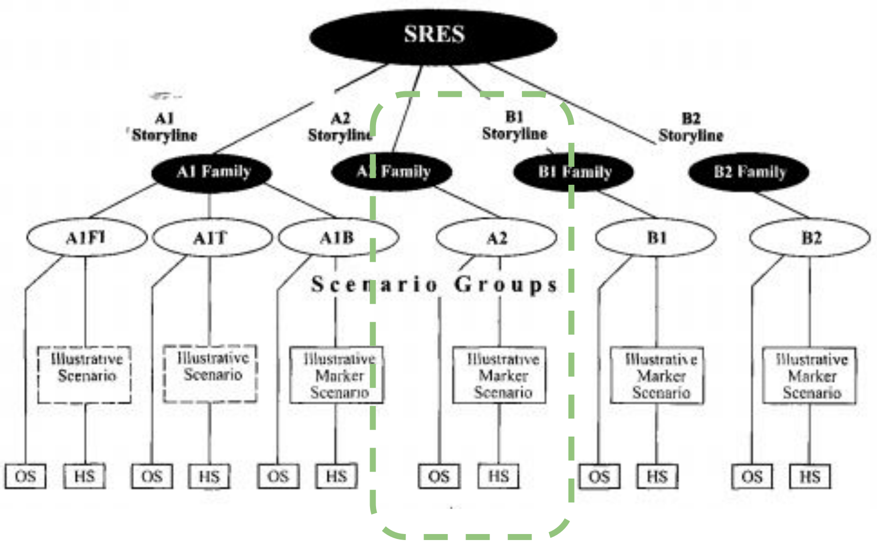
A1 Family

- Rapid economic growth.
- Global population peaks in mid-century, declines thereafter.
- Rapid introduction of new and more efficient technologies.



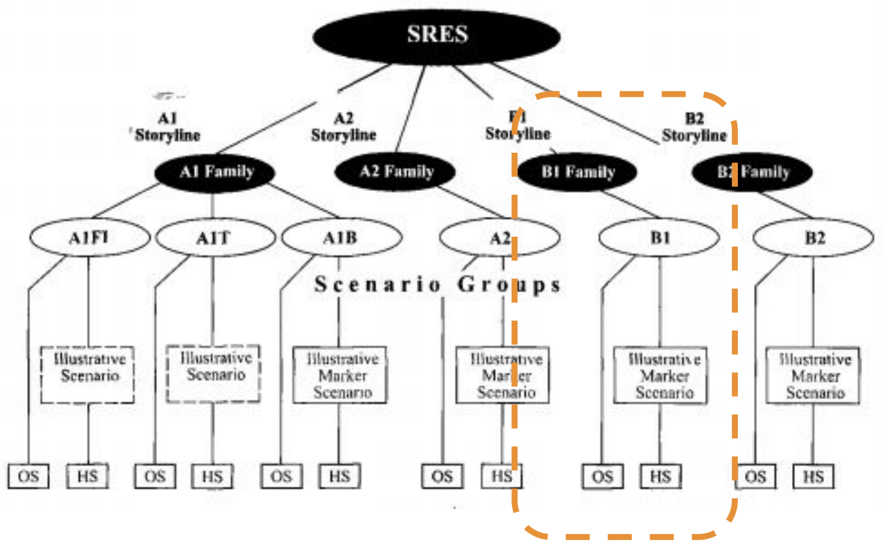
A2 Family

- Very heterogeneous world with continuously increasing global population.
- Regionally oriented economic growth (more fragmented and slower than in other storylines).



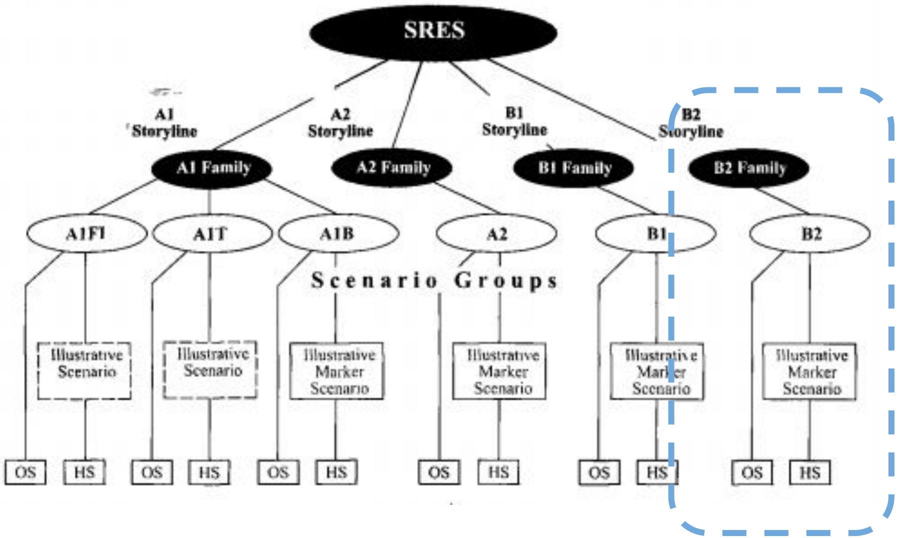
B1 Family

- Convergent world with the same global population as in A1.
- Rapid changes in economic structures toward a service and information economy.
- Reductions in material intensity.
- Introduction of clean and resource-efficient technologies.



B2 Family

- Emphasis on local solutions to sustainability.
- Continuously increasing population (lower than A2).
- Intermediate economic development.



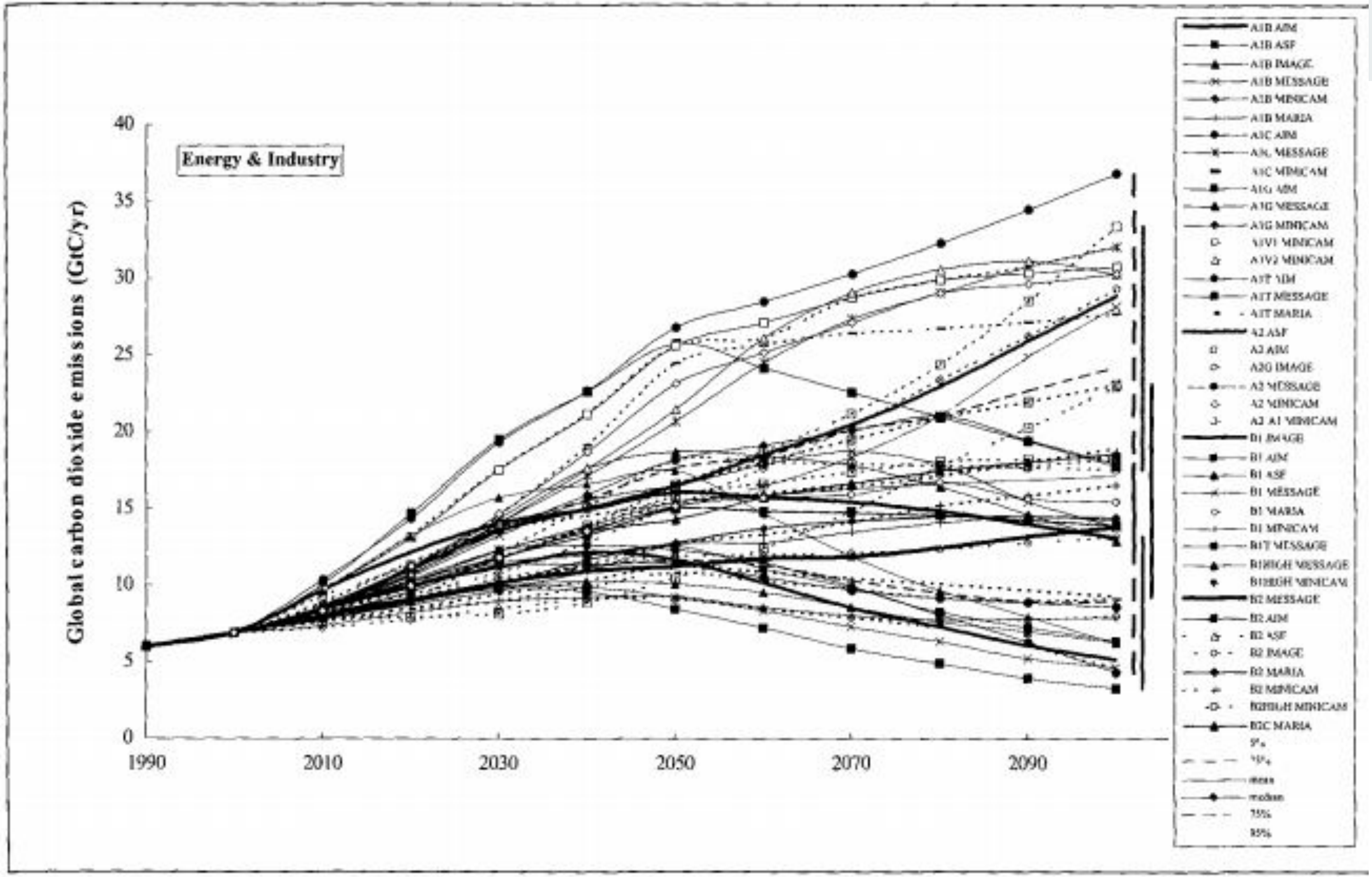
Variable	A1	A2	B1	B2
Economic growth	Very rapid.	Slow.	Rapid change, towards services and in information.	Intermediate.
Population growth	Low.	High.	Low.	Moderate.
Tech change	Rapid introduction of new and efficient technologies.	Fragmented and slow.	Introduction of clean and resource-efficient tech.	Compared to A1, B1: Less rapid, more diverse.
Globalization	Convergence among regions.	Heterogenous world. Regionally oriented.	Convergent world.	Emphasis on local solutions.
Environmental approach	--	--	Reduction of materials intensity.	Oriented to environmental protection.
Society approach	Capacity building, increased cultural and social interactions.	Preservation of local identities.	Improved equity.	Oriented to social equity.

Source: SRES, IPCC, 2000 – Nebojsa Nakicenovic and Rob Swart (Eds.) Cambridge University Press, UK. https://www.ipcc.ch/site/assets/uploads/2018/03/emissions_scenarios-1.pdf
Elaboration: Own.

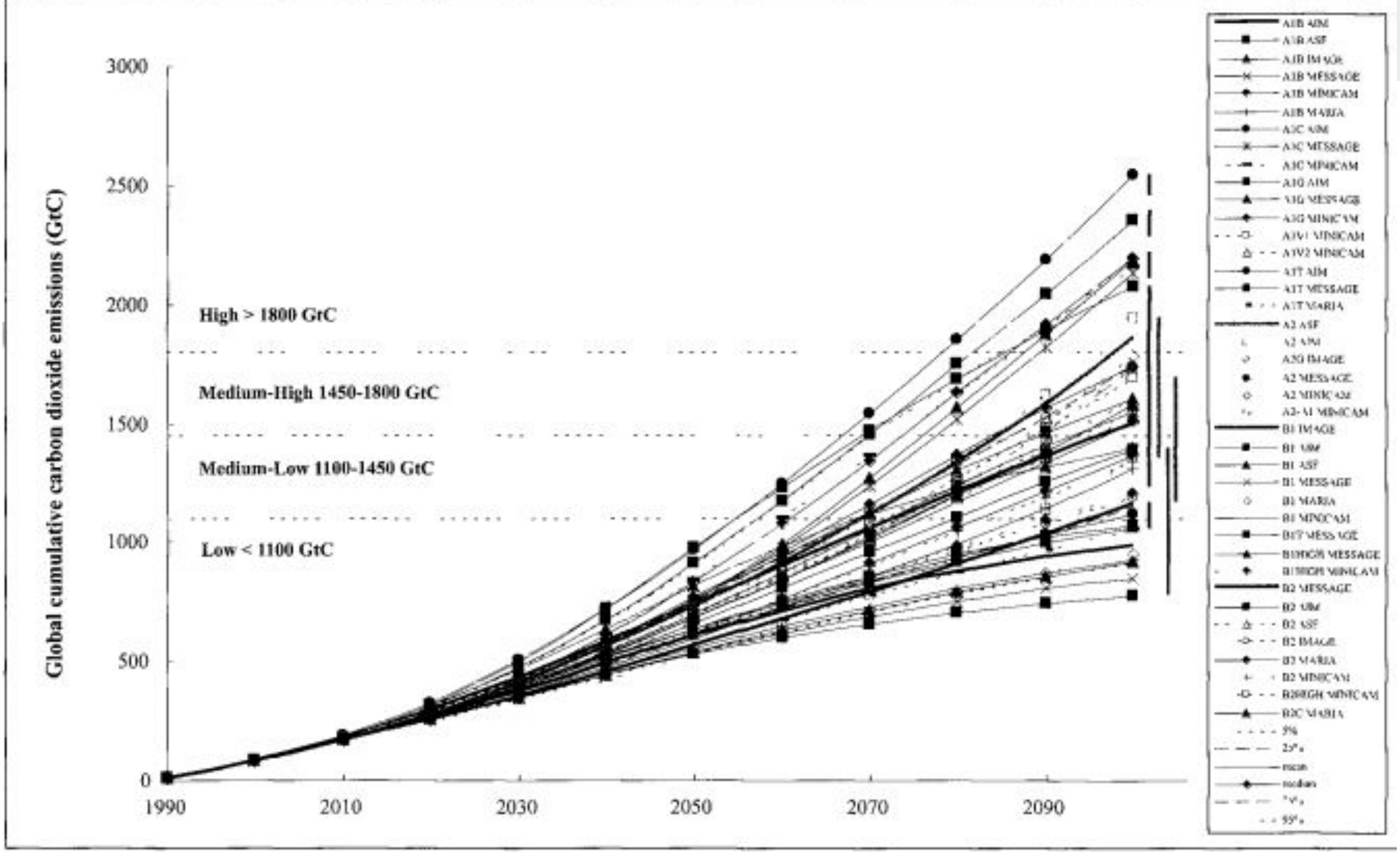
Modeling approach	From
Asian Pacific Integrated Model (AIM)	National Institute of Environmental Studies in Japan.
Atmospheric Stabilization Framework Model (ASF)	ICF Consulting in the USA.
Integrated Model to Assess the Greenhouse Effect (IMAGE)	National Institute for Public Health and Environmental Hygiene (RIVM) + Dutch Bureau for Economic Policy Analysis (CPB) WorldScan model, the Netherlands.
Multiregional Approach for Resource and Industry Allocation (MARIA)	Science University of Tokyo in Japan.
Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE)	International Institute of Applied Systems Analysis (IIASA) in Austria.
Mini Climate Assessment Model (MiniCAM)	Pacific Northwest National Laboratory (PNNL), USA.

These scenarios are based on a thorough review of the literature, the development of narrative "storylines", and the quantification of these storylines with the help of six different integrated models from different countries.

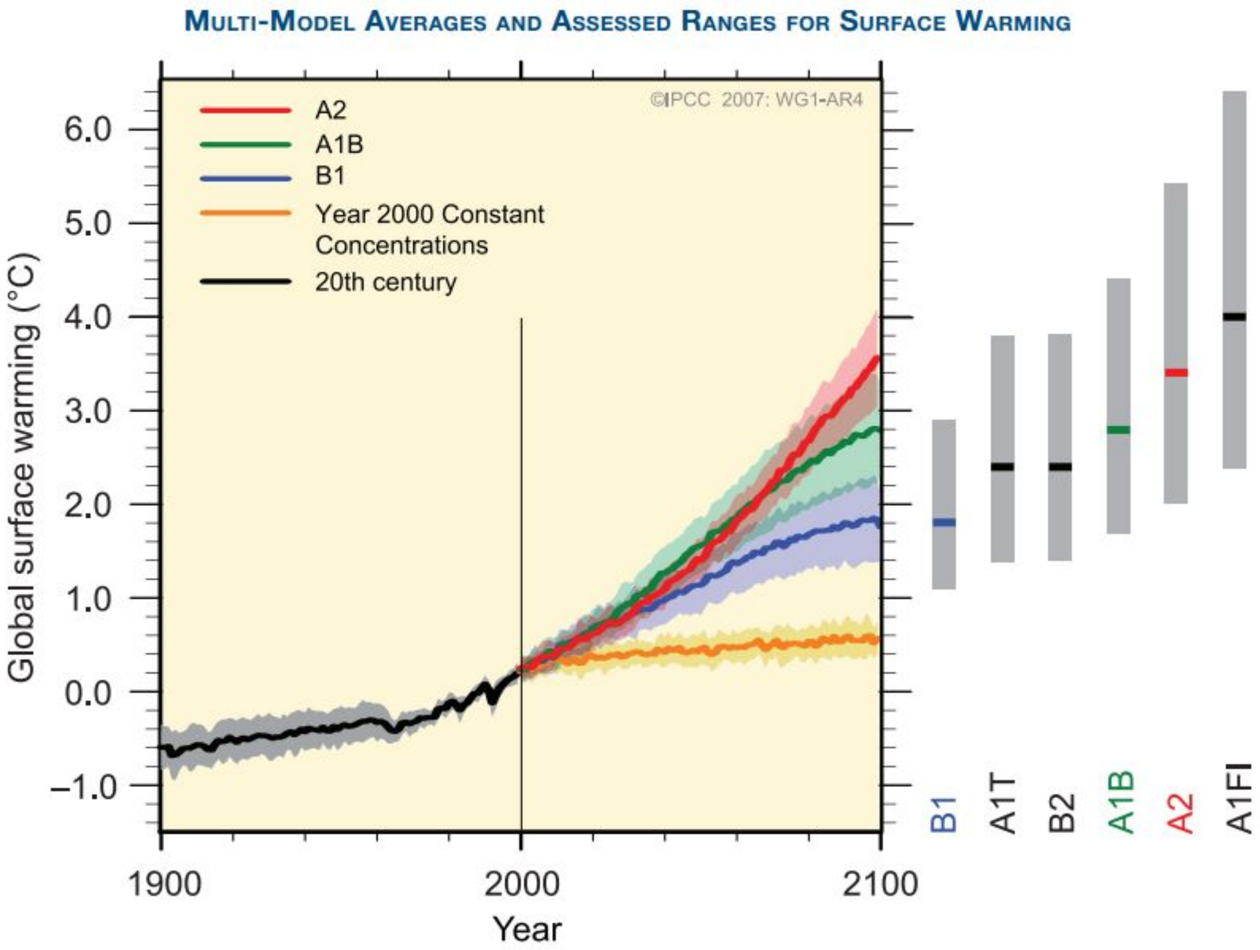
Global atmospheric concentrations of GHG have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values.



Energy & Industry
Global carbon dioxide emissions (GtC/yr)
0
5
10
15
20
25
30
35
40
1990
2010
2030
2050
2070
2090
A1B AIM
A1B ASF
A1B IMAGE
A1B MESSAGE
A1B MINICAM
A1B MARIA
A1C AIM
A1C MESSAGE
A1C MINICAM
A1G AIM
A1G MESSAGE
A1G MINICAM
A1V1 MINICAM
A1V2 MINICAM
A1T AIM
A1T MESSAGE
A1T MARIA
A2 ASF
A2 AIM
A2G IMAGE
A2 MESSAGE
A2 MINICAM
A2 A1 MINICAM
B1 IMAGE
B1 AIM
B1 ASF
B1 MESSAGE
B1 MARIA
B1 MINICAM
B1T MESSAGE
B1HIGH MESSAGE
B1HIGH MINICAM
B2 MESSAGE
B2 AIM
B2 ASF
B2 IMAGE
B2 MARIA
B2 MINICAM
B2HIGH MINICAM
B2C MARIA
mean
median
75%
95%



Global cumulative carbon dioxide emissions (GtC)
3000
2500
2000
1500
1000
500
0
1990
2010
2030
2050
2070
2090
High > 1800 GtC
Medium-High 1450-1800 GtC
Medium-Low 1100-1450 GtC
Low < 1100 GtC



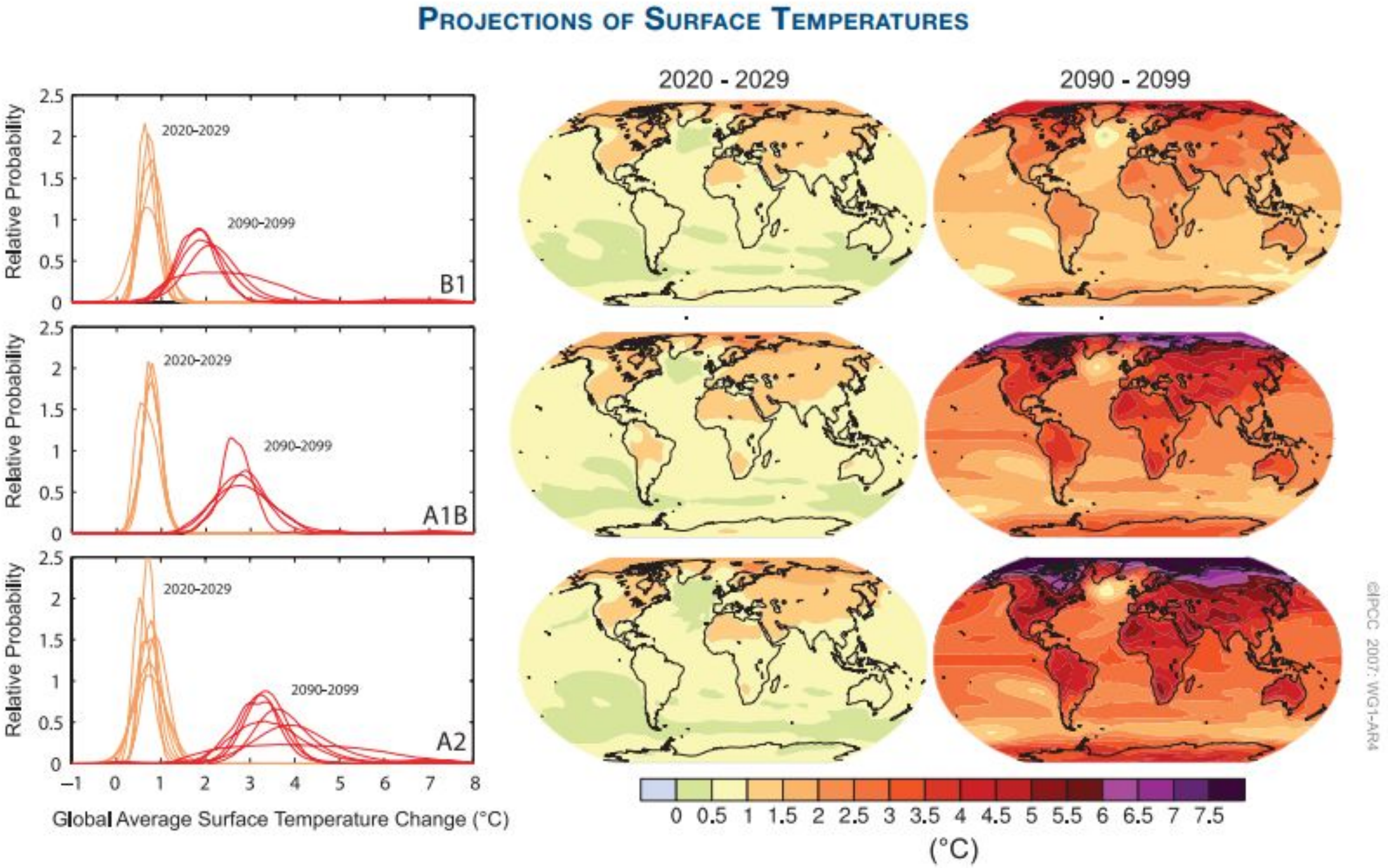
Source:
IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-spm-1.pdf

B1

A1B

A2



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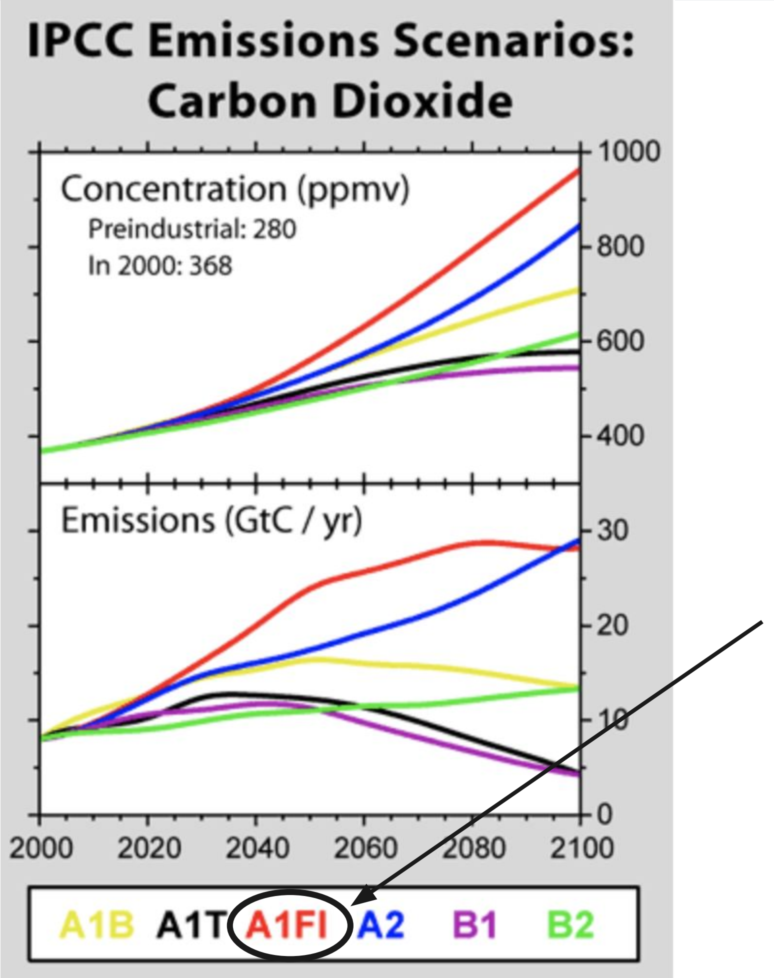
Estimated CO2 concentrations (top) and Annual Carbon Emissions (bottom) for the Various IPCC SRES Scenarios.



Representative Concentration Pathways

- Internally consistent
- Time-dependent
- Multiple socioeconomic scenarios

SRES vs RCP

The Special Report on Emissions Scenarios (SRES)	The Representative Concentration Pathways (RCPs)
Released by the IPCC in 2000	Adopted by the IPCC for the 5th Assessment Report (AR5) in 2014 (replaced SRES)
Families: A1, A2, B1, B2	Pathways: RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5
No-policy	RCP2.6, RPC 4.5, and RPC6.0 are climate-policy scenarios
The sequential approach	The parallel approach

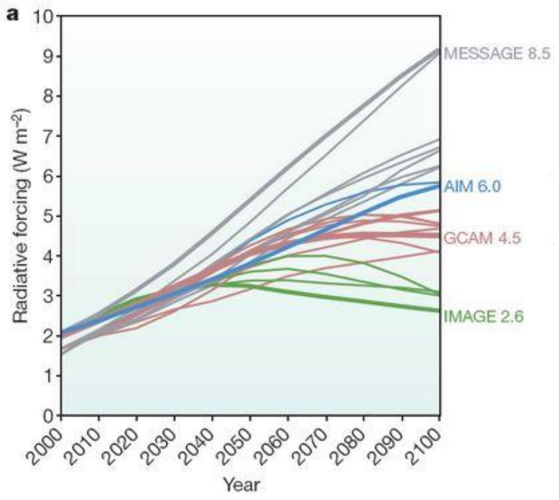
The goal of working with scenarios is not to predict the future but to better understand uncertainties and alternative futures, in order to consider how robust different decisions or options may be under a wide range of possible futures.

The Representative Concentration Pathway (RCP)

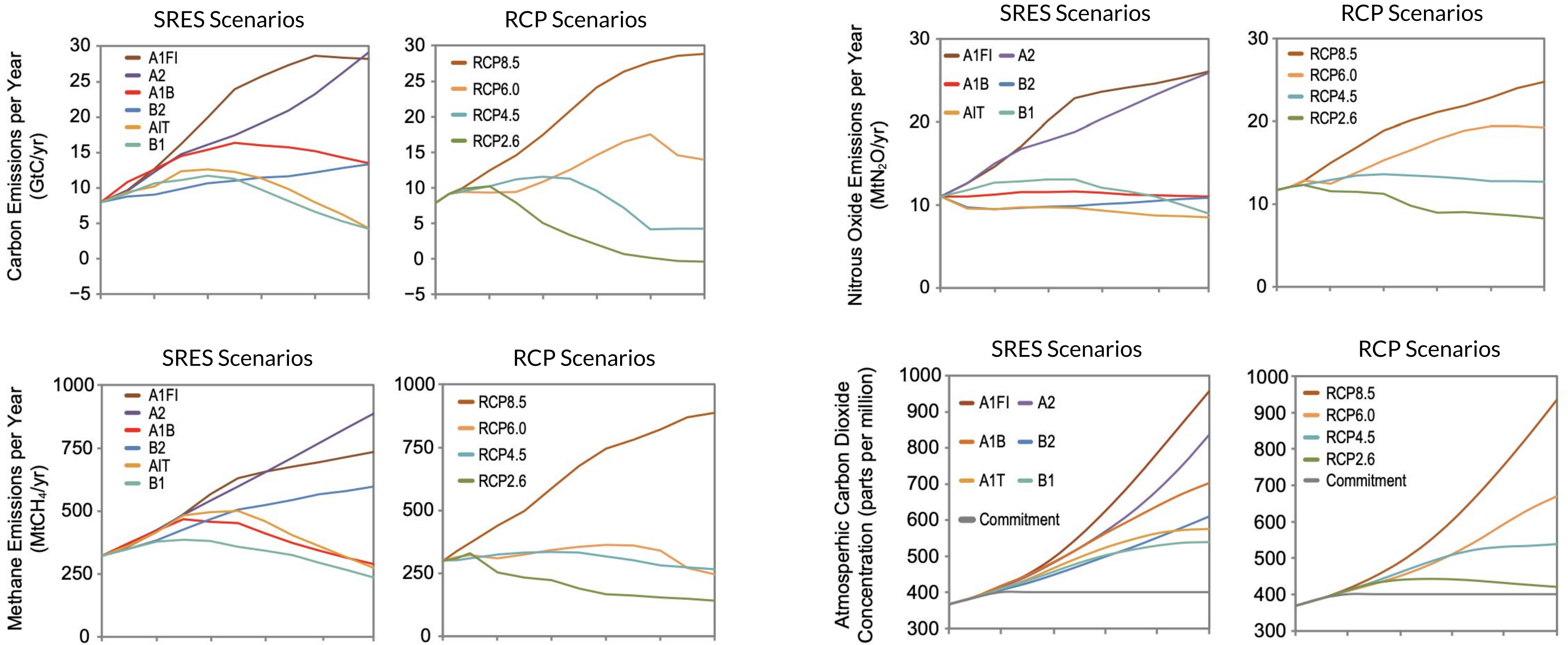
- Radiative forcing scenarios - not emissions scenarios
- The 5th Assessment Report (AR5) in 2014
- Supersedes the Special Report on Emissions Scenarios (SRES)
- Extended Concentration Pathways (ECPs)

The Representative Concentration Pathway (RCP)

- **RCP 2.6** - stringent mitigation scenario
- **RCP 4.5** - intermediate stabilization pathway
- **RCP 6.0** - intermediate stabilization pathway
- **RCP 8.5** - very high GHG emissions



Emissions, Concentrations, and Temperature Projections



Below 2 °C

3650 $GtCO_2$

To keep global warming likely below 2°C the cumulative CO_2 emissions from all anthropogenic sources has to remain below this amount.

About 1900 $GtCO_2$ were emitted by 2011

Estimated total fossil carbon reserves exceed remaining amount (1000 $GtCO_2$) by a factor of **4** to **7,** with resources much larger still

RCP 2.6

- global warming **below 2°C** (between 0.3°C to 1.7°C)
- “**peak-and-decline**” scenario
    - GHG peak between in 2020 & then declines
    - radiative forcing level peak up to **3 W/m2** by mid-century & then returns to **2.6 W/m2** by 2100
- very strict climate policy interventions
- substantial net negative emissions
- the cumulative emission reduction over century amounts about **70%**

Scenarios without additional efforts to cut emissions lead to pathways ranging between RCP6.0 and RCP8.5

Baseline scenario

- Assumes that some of the historical trends continue in the next decades.
- GHG concentrations rise substantially over time leading to a **radiative forcing of about 7.2 W/m2** by 2100.
- The global mean temperature increase of about **4°C**

Beyond year 2100

- Warming will continue beyond 2100 under all RCP scenarios except RCP2.6
- Surface temperatures will remain at elevated levels for many centuries
- Stabilization of global average surface temperature does not imply stabilization for all aspects of the climate system.
- A great amount of is irreversible on a multi-century to millennial timescale.

Emissions Scenarios
Global Carbon Project

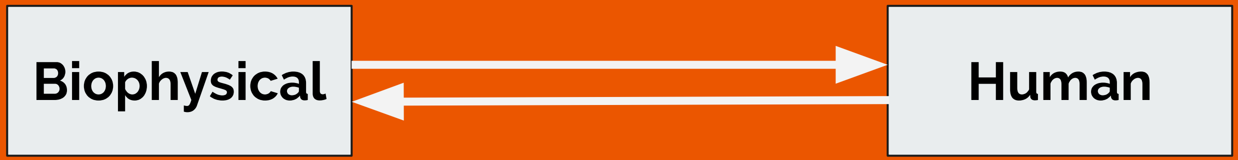
Global Carbon Project is the way of Advancing Knowledge on the Global Carbon Cycle and its Management.

Established in 2001 as a framework for international coordinated research:

- carbon cycle
- fundamental understanding
- supports policy development
- stabilization of GHGs in the atmosphere.

The scientific goal

develop a complete picture of the global carbon cycle



Research areas of GCP

patterns and variability

processes and interactions

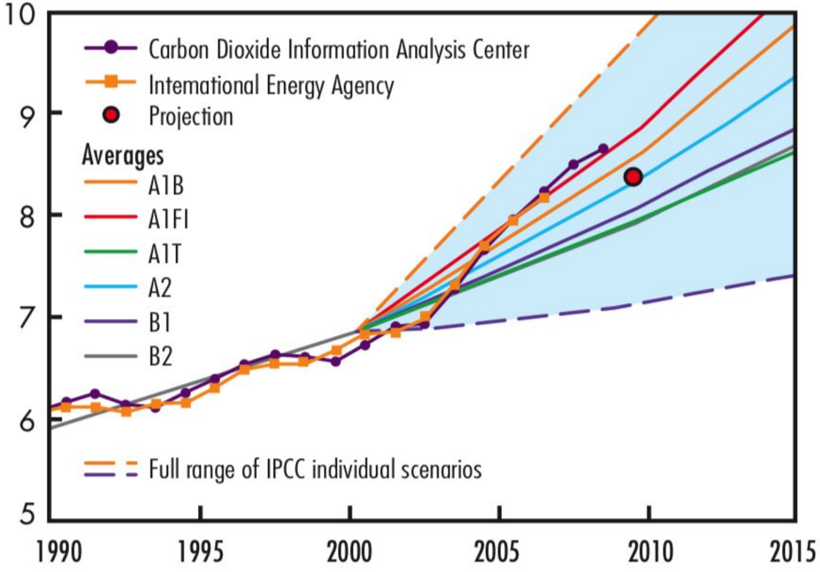
carbon management

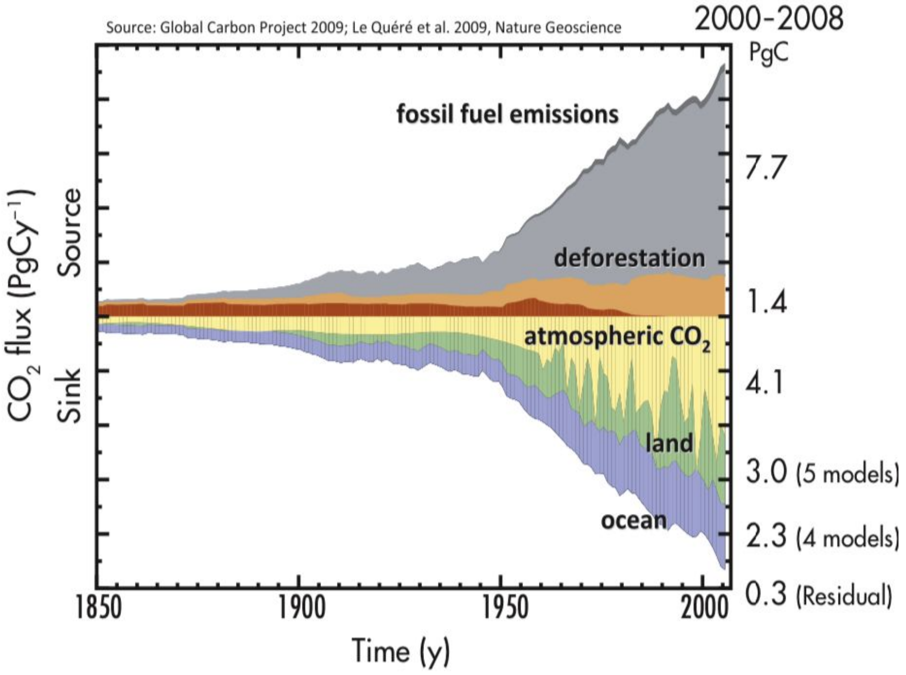
Find current geographical and temporal distributions of the major pools and fluxes in the global carbon cycle through:
- observations coordination and standardization;
- model - data fusion techniques;
- carbon budget methodologies and sector analyses

Dynamics of the carbon - climate - human system in the future, points of intervention and windows of opportunities available to human societies for system management:
- mitigation options through land, ocean and energy systems
- portfolios and development for carbon management and sustainability
- carbon consequences and management of regional and urban development

Unveil control and feedback mechanisms, both anthropogenic and non-anthropogenic, that determine the dynamics of the carbon cycle through:
- integrated carbon sink mechanisms
- new modelling approaches for emergent properties of the carbon - climate - human system

1. State of the Global Carbon Budget





- Fossil fuel emissions: Actual vs. IPCC scenarios
- Human Perturbation of the Global Carbon Budget

2. Vulnerabilities of the Carbon Cycle

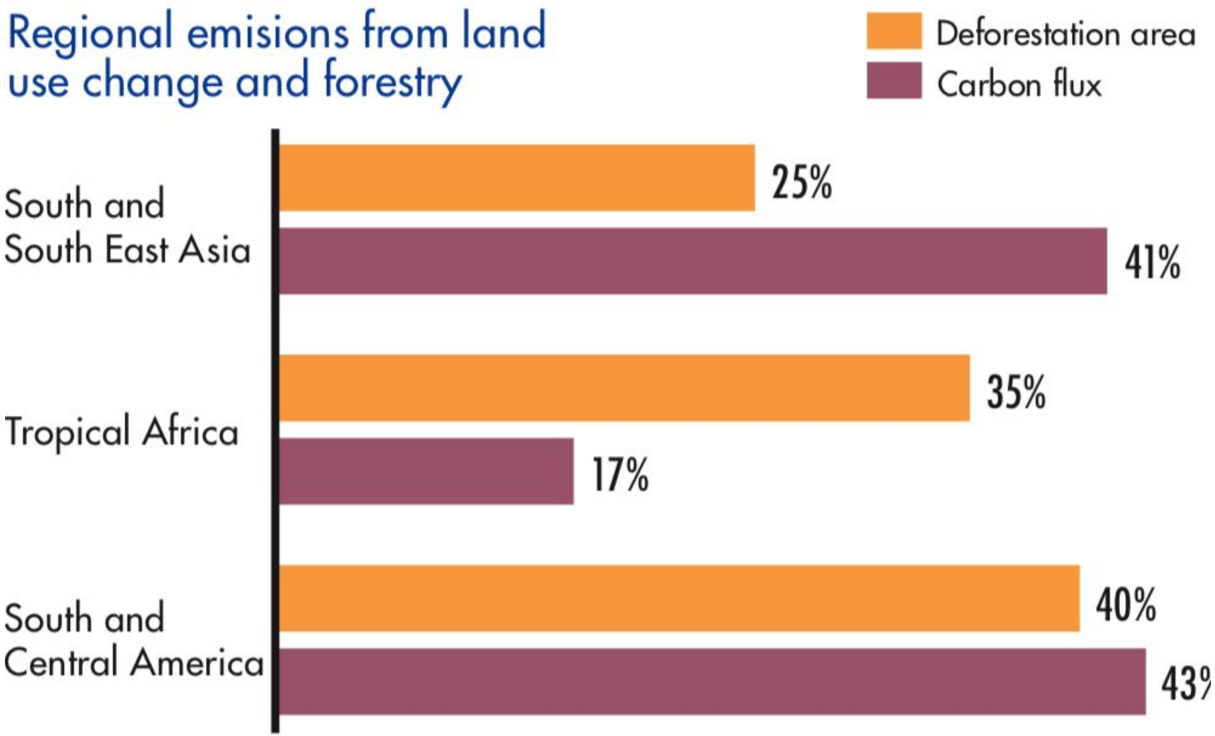
The GCP has focused on permafrost, methane hydrates, vegetation fires, tropical peatlands and ocean pumps in terms of their: carbon pool size, drivers and processes that can lead to destabilization of pools resulting in carbon emissions, and internal dynamics of these pools. Researches are considering by revealing the mechanisms of functioning and its influence on Carbon Cycle of Frozen Carbon, **Methane Hydrates, Tropical Peatlands, Oceans, Fires and Drought.**

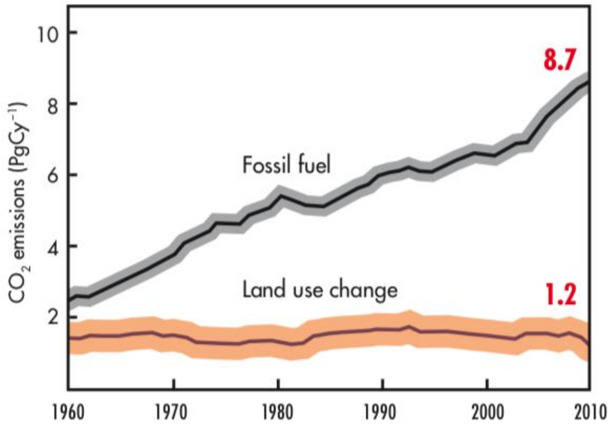
3. Low Carbon Pathways: Urbanization and Cities

Cities and Urbanization are responsible for the majority of global energy related CO2 emissions.

The GCP launched the Urban and Regional Carbon Management Initiative since late 2005 in order to:

1. Understand urbanization and urban development pathways from top-down and bottom-up analyses;
2. Develop scientific networks, modelling forums, scientific information consolidation, synthesis, and contributions to international assessments and science-policy interaction.





- Land Use Change and Forestry Regional carbon emissions' shares (2000-2005)

- and historical emissions (1960 - 2010)

4. Land Use, Forest and Carbon

Land-based carbon management - a key area in science and policy development.

The GCP community has contributed to:

- **Assessment** of global potentials for the development of Reduced **Emissions** from Deforestation and Degradation (REDD);
- **Consolidation** of scientific information on carbon accounting methods consistent with policy requirements;
- **Monitoring, Reporting, and Verification** (MRV) for land-based carbon management, such as REDD.

5. Global Assessments and Synthesis

GCP has initiated the Regional Carbon Cycle Assessment and Processes (RECCAP) initiative, a large global coordination effort among researchers and institutions planning to:

- **Establish** the mean carbon balance of large regions of the globe, including their component fluxes;
- **Test** the compatibility of regional bottom-up estimates with global atmospheric constraints;
- **Evaluate** the regional ‘hot-spots’ of inter-annual variability and possibly the trends.

6. Policy Links and Outreach

Online platform shows the activities and research outcomes of the project and acts as a scientific resources center for the broader carbon cycle research and policy communities.

Discussion

Discussion

1) Do you think that different types of scenarios help to understand how the world could look like? (in terms of sociological understanding)
2) Which driving force in your opinion is the most important?
3) What scenario you think is the most likely to happen?
4)

Would you propose another scenario narrative?

Scenarios

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How will the world's climate change in the coming century?

It depends on how human societies develop in terms of demographics and economic development, technological change, energy supply and demand, and land use change.

Global and continental temperature change.

Considering natural and anthropogenic forcings.

Source:
IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

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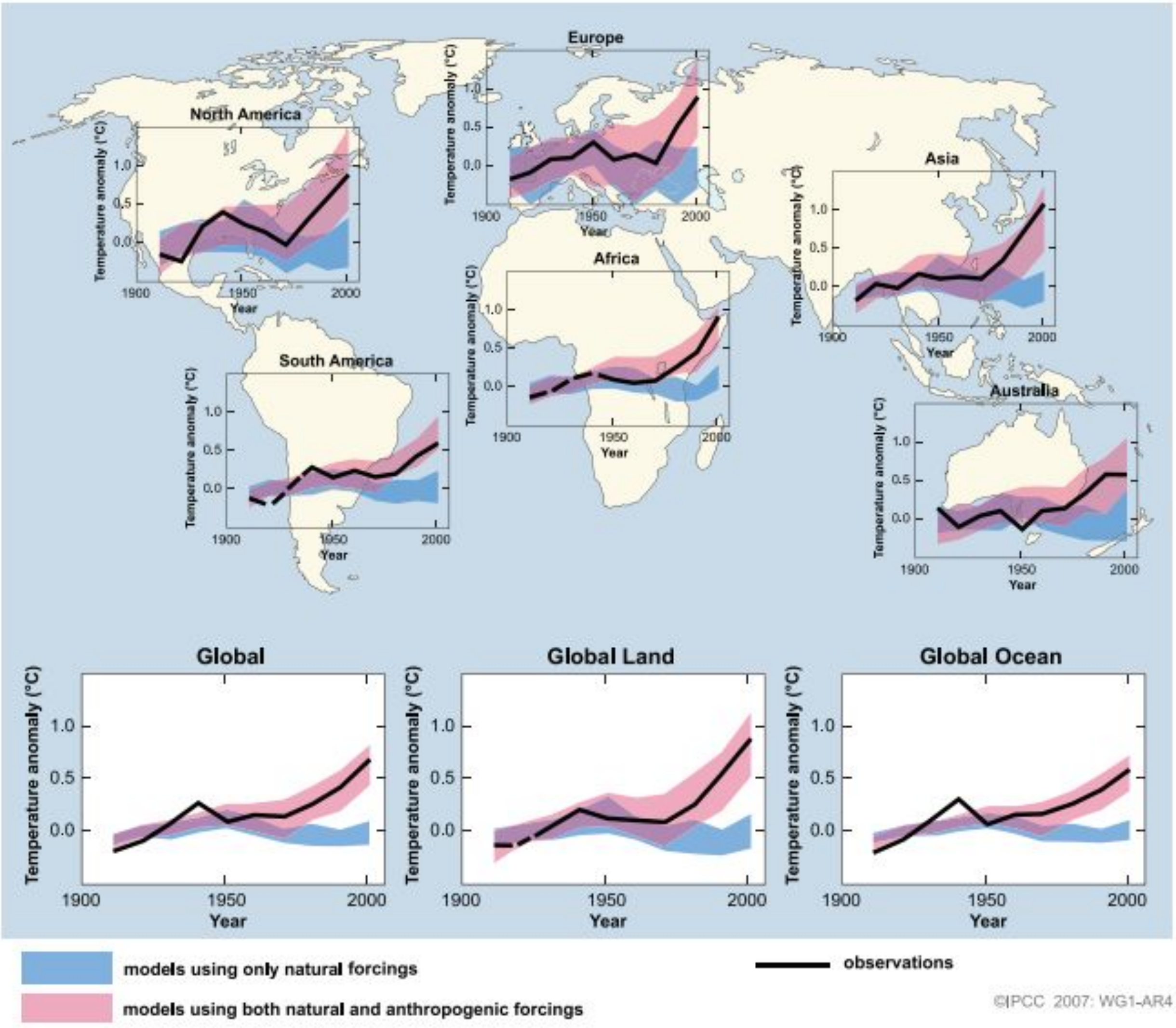

Proposed Structure [current]

a. Michal K	b. Alfonso	c. Ania	d. Gabriela	e. Kseniya
Concepts SRES + RCP	SRES Methodology SRES Scenarios	RCP2.6 & RCP4.5	RCP6 & RCP8.5	Emissions Scenarios Global Carbon Project
Definition of “scenario”, purpose, characteristics, uses, limitations, types. + Driving forces: Population , Projections, Economic Development, Structural and Technological Change.	Storyline, Scenario. Drivers. Prospects. Modeling approaches. + Leads~moderates discussion.	Narrative, Scenario. Drivers. Prospects. Development. Energy. Resource availability. Tech change. Prospect Future Energy. Land use changes. Env. policies.	Íbidem.	Emissions Scenarios for all families. (Carbon dioxide, other greenhouse, aerosols). + Regional distribution.