IPCC Assessment Report 5 (IPCC-AR5)

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What do we know about the process towards a AR5?

- IPCC makes an assessment of climate change, mitigation and adaptation based on scientific literature

- IPCC does not coordinate
  - scientific research
  - model simulations
  - development of scenarios

- Coordination of climate change simulations by the Working Group on Climate Modelling (WGCM)
  → Coupled model intercomparison project (CMIP)

- Scenarios proposed by scientific community
  (catalyzed by IPCC)

What do we know about the process towards a AR5?

Time lines

- AR4 published in 2007
- AR5 decided at IPCC meeting in Budapest in April 2008
  - 5th IPCC assessment report in 2013/2014
  - WG1 report (Physical science of climate change) ~1 year earlier than WG3 report (Mitigation)

- Implied timetable
  - 2013: publication of WG1 report
  - 2011+2012: scientific evaluation of simulations (→publications) + drafting and reviewing of the report.
  - 2009+2010: CMIP5 = coordinated experiments for ESMs
  - 2008
    - Summer: decision on scenarios
    - Fall: decision on CMIP simulations

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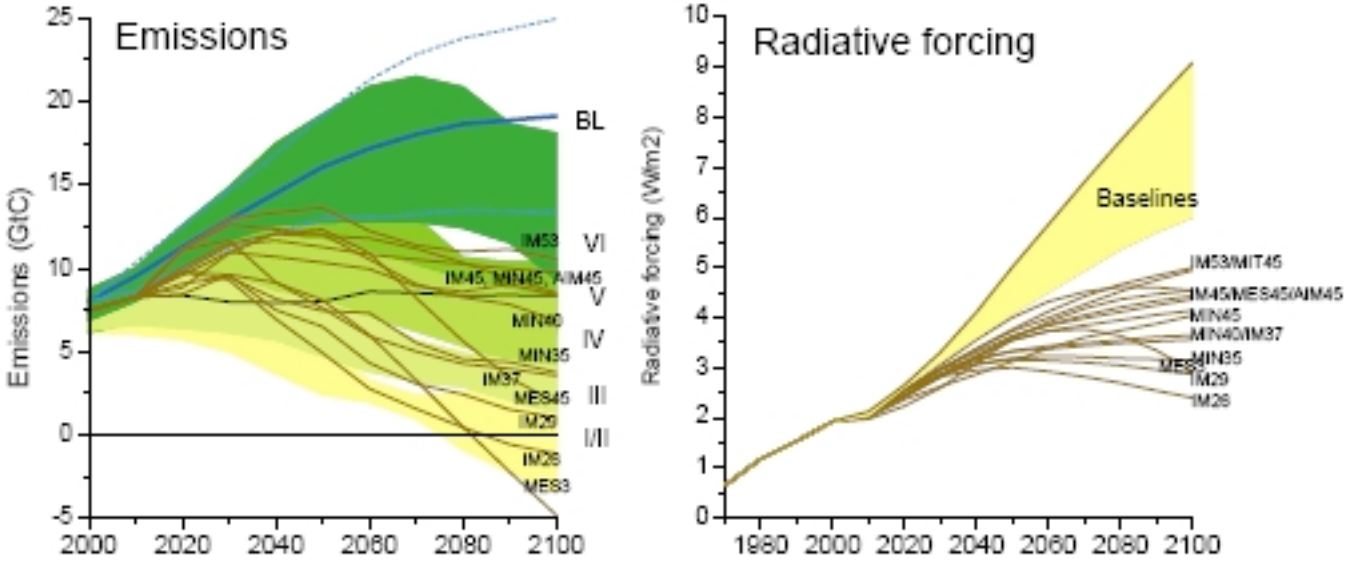
Scenarios

- IPCC Expert Meeting
  "Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts, and Response Strategies."
  Netherlands, 19-21 September 2007.

- Decision on scenarios for climate projections in mid 2008
  → must be based on existing and published scenarios

- Choice of scenarios:
  - Scenarios should span a wide range
  - High scenario, similar to SRES A2 (continuity)
  - Low (overshoot) stabilization scenario
  - Intermediate stabilization scenarios

Scenarios discussed for AR5



- Low benchmark concentration scenarios imply negative emissions!
- Questions: Which anthropogenic CO2 emission (direct and indirect) is compatible with concentration pathways, or other types of pathways (e.g. dT<2°C goal of EU)?

- Cf.: SRES used for AR4: A2: 8 W/m2, A1B: 6 W/m2, B1: 4 W/m2

CMIP experiments for AR5/WG1

- Workshop at Aspen Global Change Institute, August 2006
  → Meehl and Hibbard, WRCP Rep. 3, 2007
  → EOS (Hibbard et al., EOS, 2007).

- Experiments over two timescales
  - **Long / Centennial climate projections**
    - Pre-ind. – 20th century – 2100 – …
    - Include carbon cycle
    - Compute anthrop. CO2 emissions that are compatible with selected CO2 concentration scenarios
  - **Short / Decadal climate prediction**
    - ~1960 – 2005 – 2030
    - Initialized based on observations
    - Large ensemble size
    - High resolution
    - Air quality

- Discussion/proposal of CMIP simulations for both time scales by the Working Group on Coupled Modelling (WGCM)

Centennial experiments: Use of AOGCMs and ESMs

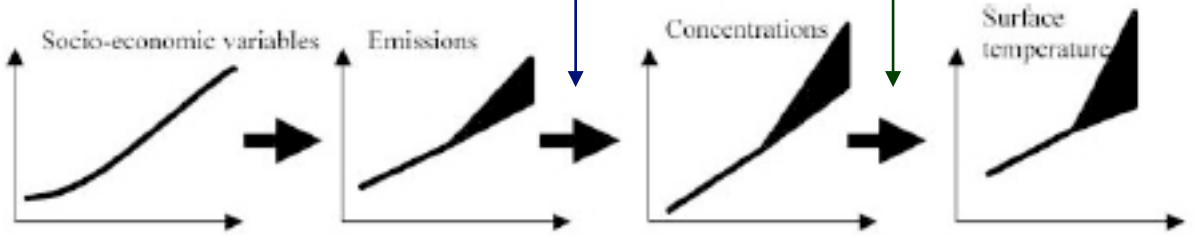
AOGCMs = atmosphere ocean general circulation models

ESM = Earth system model, include carbon cycle

ESMs with carbon cycle

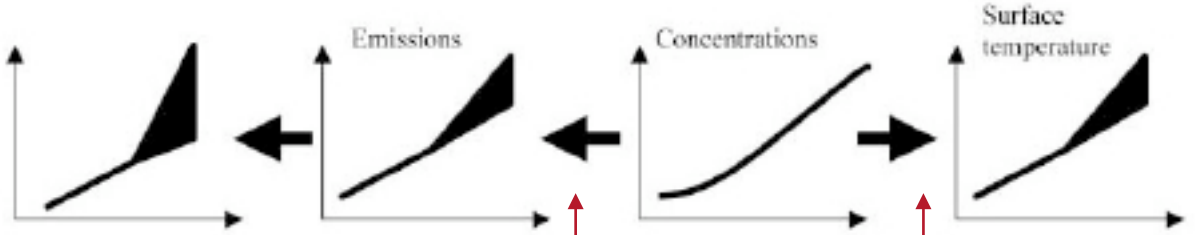
AOGCMs (e.g. for AR4)

AR4/5 "fwd"



→ WG2

AR5 "inv."



→ WG2

ESMs with coupled carbon cycle

1. Prescribed CO2 conc.: dCO2/dt|atmo → F_{CO2}|atm
2. Prescribed land use: dCO2/dt|land → F_{CO2}|land
3. Modeled carbon flux: → F_{CO2}|model
4. Residual flux: F_{CO2}|res = F_{CO2}|atm + F_{CO2}|land - F_{CO2}|model

→ WG3

Centennial climate projections: 1860 – 2100 (– 2300)

- **Under discussion**

- Pre-industrial control

- Idealized climate change experiments
  - +1% CO2/year to 4xCO2
  - +1% CO2/year to 4xCO2 for C cycle, but constant CO2 for radiation
  - +1% CO2/year to 4xCO2 for radiation, but constant CO2 for C cycle

- CO2 concentration scenarios [Ensemble]
  - Scenarios given by “Representative Concentration Pathways” (RCPs):
    - “8.5 W/m2”, “3 W/m2” (2.9 or 2.6)
    - Optional: “6 W/m2” and “4.5 W/m2”
  - AOGCMs → climate projection
  - ESMs → climate proj. + CO2 emissions compliant with RCPs

- CO2 emission scenarios [Ensemble]
  - Emissions of “8.5 W/m2” RCP
  - ESMs → climate projection incl. carbon cycle feedbacks

Centennial Simulations

Spin-up	?
Pre-industrial control run after spin-up	200
3 x +1%CO2/yr to 4xCO2	520
CO2 concentration driven (single / ensemble size = 5)	
Pre-ind. – 20C	150 / 750
2 RCPs, 2000-2100	200 / 1000
2 RCPs, 2100-2300, single only	200
CO2 emission driven (ens. size = 5)	
Pre-ind. – 20C	150 / 750
1 RCP, 2000-2100	100 / 500
1 RCP, 2100-2300, single member	200
Estimate of total of simulated years after spin-up	**1320 / 4120**

Decadal climate predictions (~1970 – 2005 – 2030)

- **Under discussion**

- Possible characteristics:
  - High resolution
  - No carbon cycle required
  - Optional with aerosols + chemistry
  - “Large” ensemble (~10)
  - “4.5 W/m2” RCP, 2000-2030

  - Hindcasts to evaluate climate prediction skill dependent on initial data and methodology, (~10 to 20 years)

  - Initialized experiments ~2000-2030
    - Exploit predictability of the climate system by initialization of the coupled system
    - High resolution encouraged
    - Air quality modeling optional

  - Alternative: Enlargement of centennial ensembles for ~1970-2030
    - Large ensemble size (~10)

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Set of simulations for Decadal Experiments

Hindcasts Spin-up (anomaly assimilation method) Control after spin-up (anomaly assimilation method) 4 start dates, ens. size = **10**, length = 20 yr	 ? 200 4x10x20 = 800
Initialized climate prediction/projection 1 start date, ens. Size = **10**, length = 30 yr	1x10x30 = 300
Enlarging the centennial ensemble for 1970-2030 Add 5 more simulations to have **10** realizations based on 1 or 5 existing simulations	9x60 / 5x60 = 540 / 300
Estimate of total of simulated years - Decadal climate prediction - Enlarging the centen. climate projection ensemble	 **1300** **540 / 300**

What kind of models are required?

- Minimum configuration
  - Coupled atmosphere ocean model as for AR4
    → centennial exp. based on concentration scenarios

- Basic configuration for full set of experiments
  - Coupled atmosphere ocean model including the **C cycle** for centennial climate projections based on concentration and emission scenarios
  - Coupled atmosphere ocean model with **observation based initialization** for decadal experiments.

- Model configurations beyond this basic configuration
  - Process models for radiative agents:
    aerosols, O3, CH4, N2O
  - Other substance cycles: N-cycle, …
  - ...

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Models at MPI-M (proposal to be discusses)

- Centennial climate projections
  - COSMOS with carbon cycle (“asob”)
    + aerosols (+chemistry?)
    - Atmosphere: ECHAM5 T85 L47 (or better?)
      Aerosols of **HAM**
      Chemistry for O3, CH4 of “fast” MPI-C chem.?
    - Ocean: MPIOM TP0.4
      Biogeochemistry of **HAMOCC**
    - Land: JSBACH
      Dynamic vegetation

Models at MPI-M (proposal to be discusses)

- Decadal climate prediction
  - COSMOS (“asob” or “ao”)
    - Atmosphere: ECHAM5 T159 L95
      Aerosols?
    - Ocean: MPIOM TP0.4
  - COSMOS based on ECHAM5-HAMMOZ including aerosols + chemistry, low resolution
    Cooperation with FZJ, EPFL, and ETHZ, “low” resolution

Resources

- Costs/yr. for models on new IBM computer at DKRZ?
  - Similar IBM Power 6 available for tests beginning in May/June
- Computing resources (CPUh)
  - At DKRZ, provided through BMBF/WLA?
  - Other facilites (FZJ)?
- Any other German institutions competing for computing resources at DKRZ for IPCC simulations (or other concurrent large scale projects)?

Current work

- COSMOS-asob at low resolution (T31 / GR3.9) used for:
  - "Stream 2" climate projections in the ENSEMBLES FP6 project, based on simulations suggested for IPCC AR5
    - SRES A1B
  - "Millennium" project
    - Climate dynamics of 800-2000
      → Johann Jungclaus
- Embedding of HAM in COSMOS
- IBM currently works on the optimization of ECHAM5 and MPIOM for IBM Power6

Conclusions

- Time lines:
  - Models: need to be ready in early 2009
  - Scenarios: to be decided in mid 2008

- CMIP5 experiments
  - Centennial: relatively well defined
  - Decadal: in discussion
  - Number of years: ~5000-7000 + spin-ups (~2x AR4)

- Models: COSMOS based
  - Cent.: T85L47 / MPIOM TP0.4
    Aerosols and ozone chem.?
  - Dec.: T159L95 / MPIOM TP0.4

Thank you