Significance of ocean's response to climate warming in the global carbon cycle

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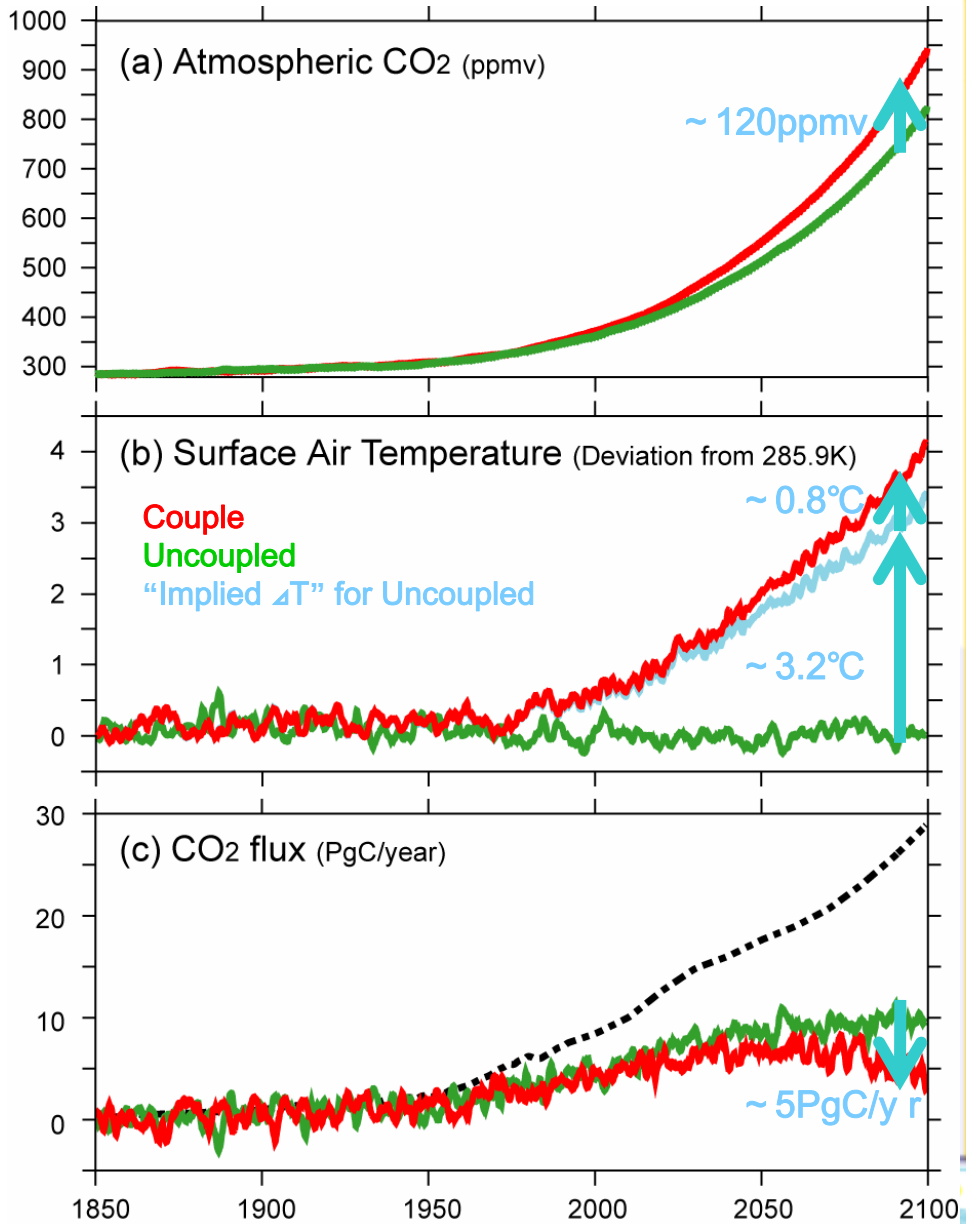
Experimental design for IPCC AR5

M. Kawamiya, C. Yoshikawa, T. Kato and T. Matsuno

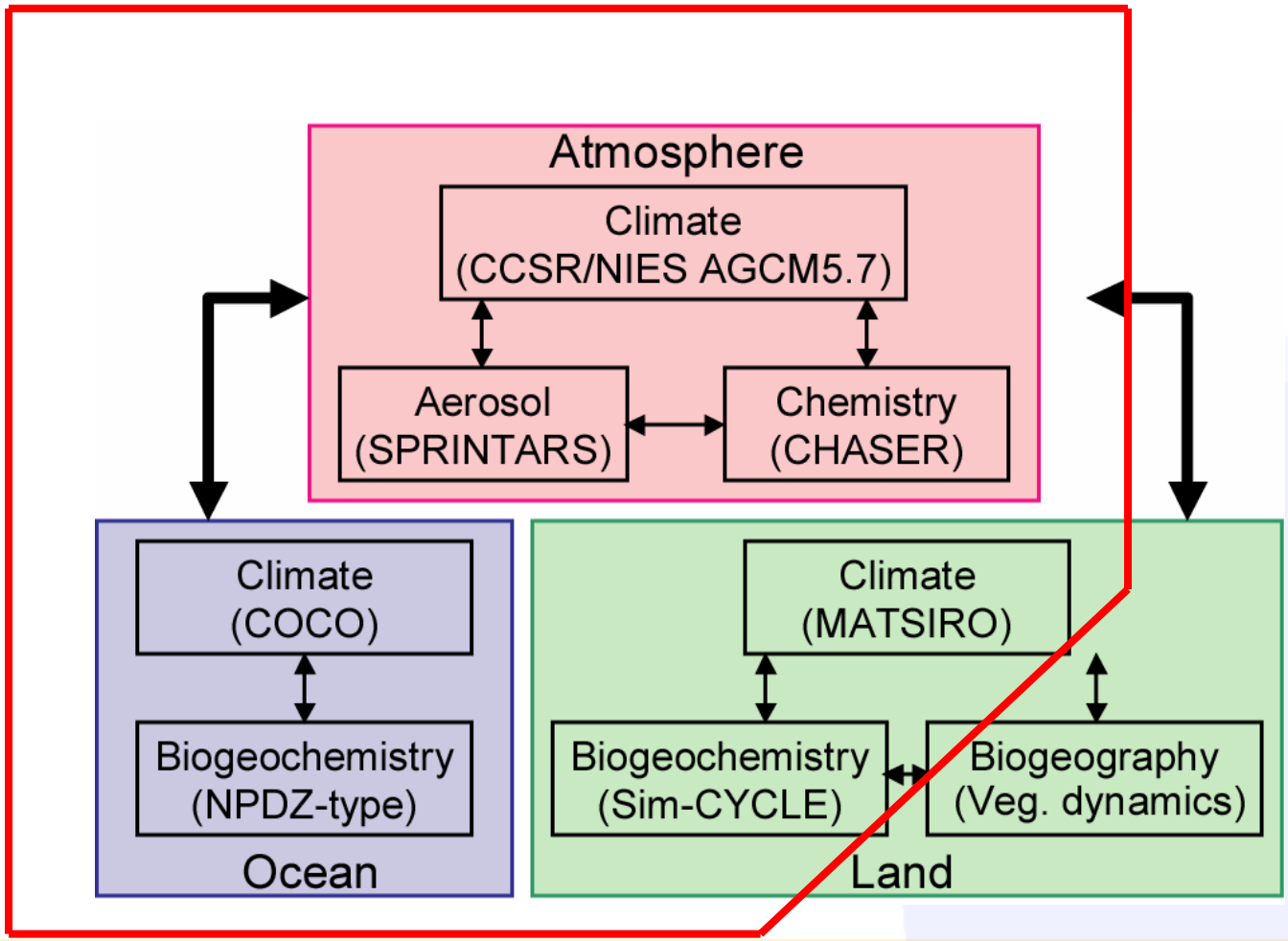
JAMSTEC

C4MIP focus: climate – carbon cycle feedback

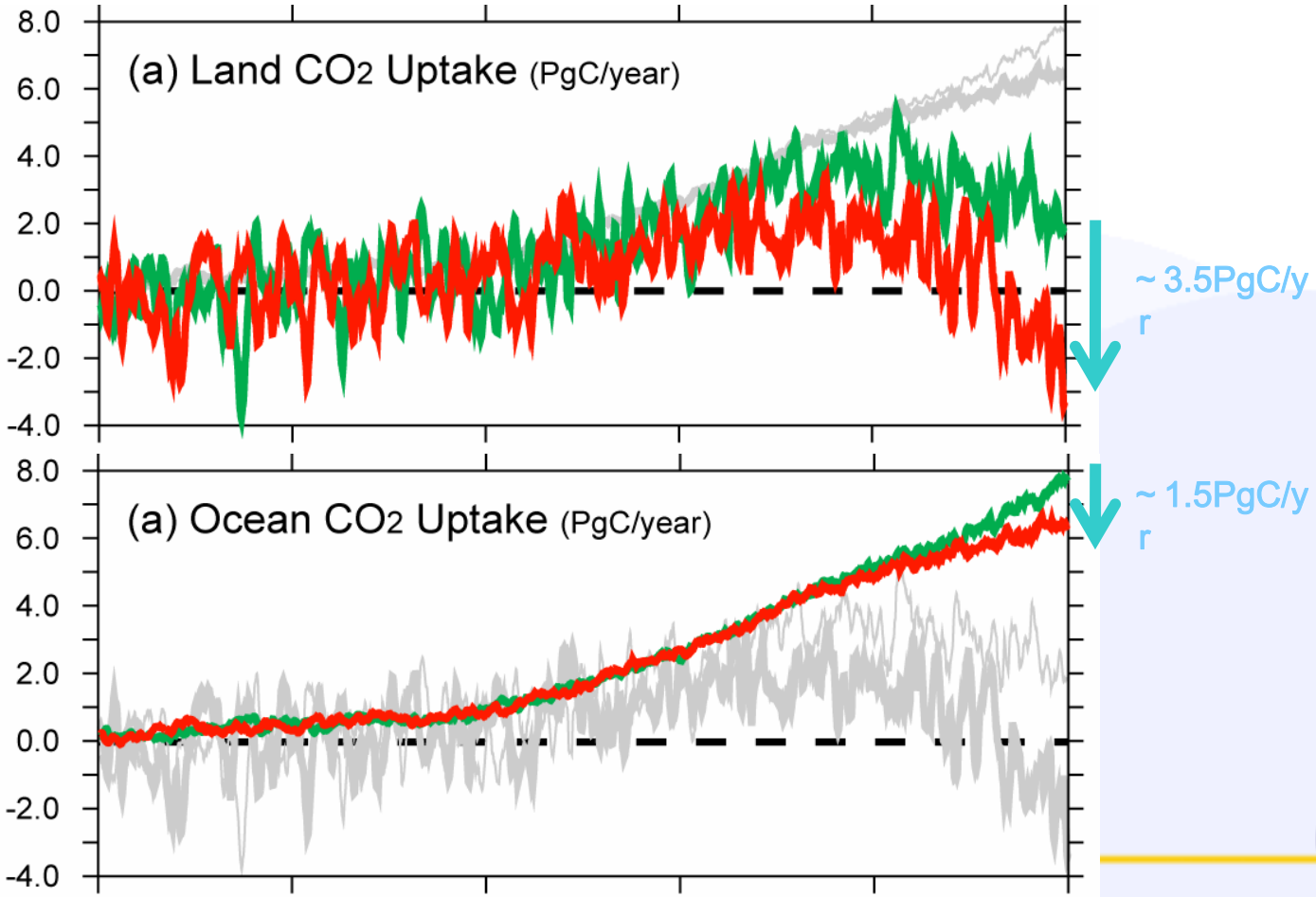
C4MIP: Coupled Climate Carbon Cycle Model Intercomparison Project



Earth system model (ESM) by FRCGC/JAMSTEC

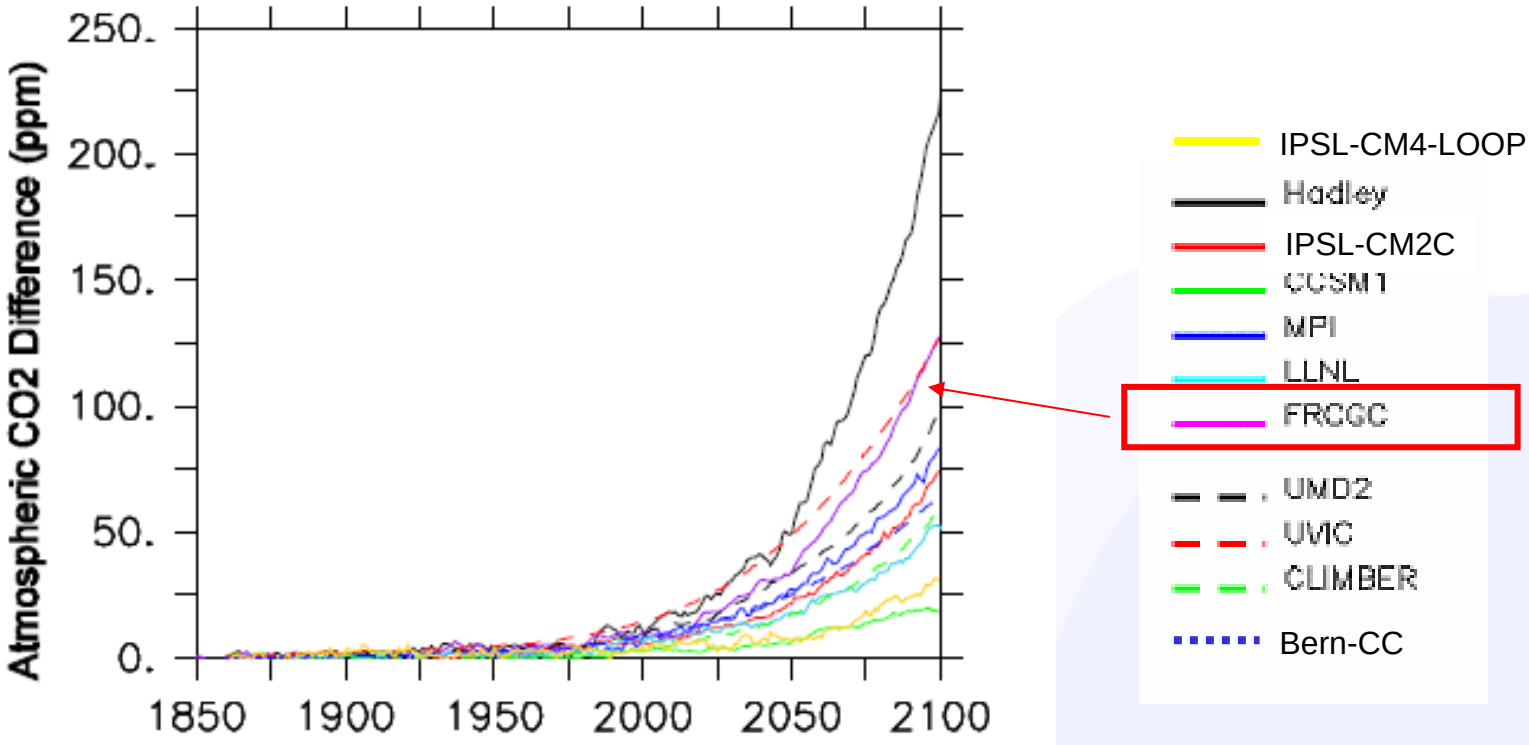


Feedback by land & ocean



C4MIP

(Coupled Climate - Carbon Cycle Model Intercomparison Project)

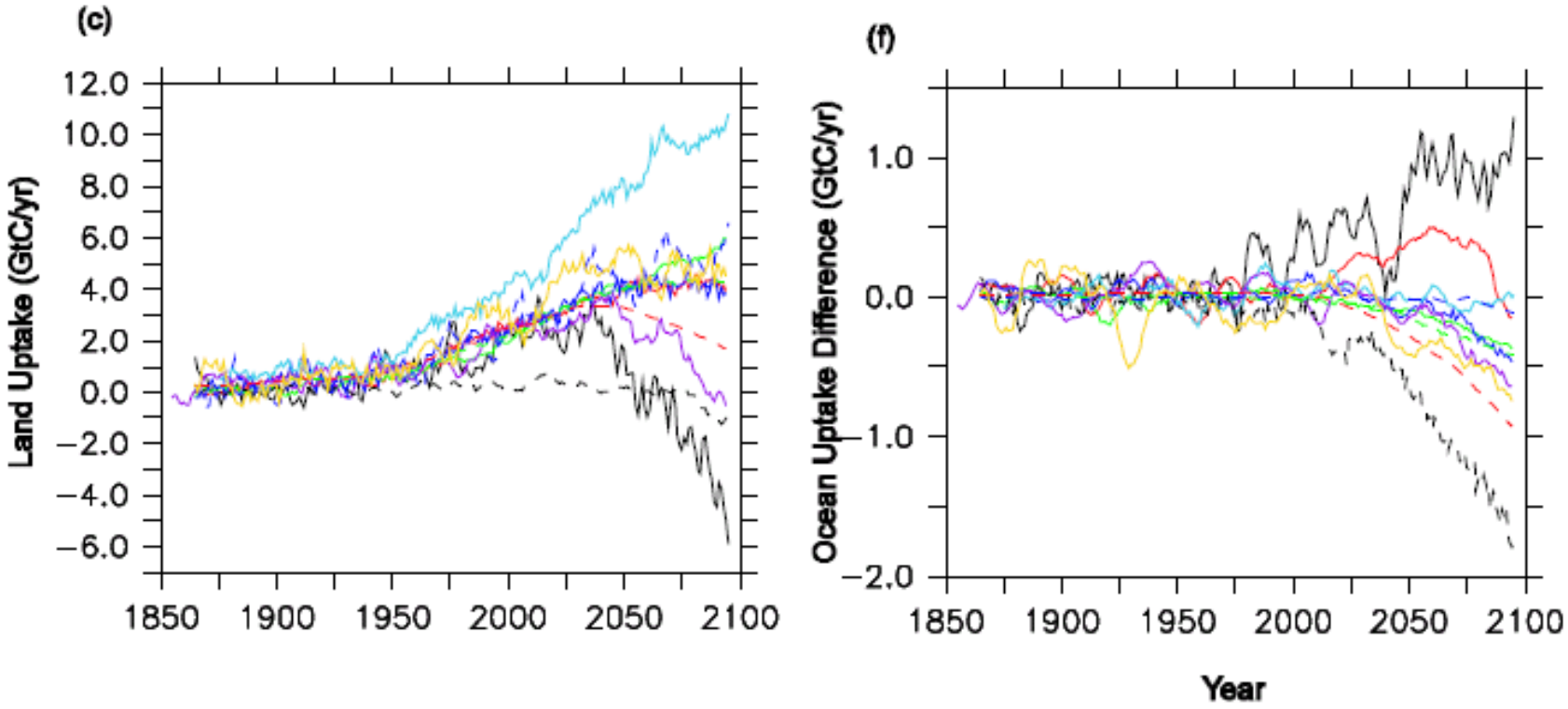


Friedlingstein et al. (2006)

Feedback by land & ocean in C4MIP models

Land

Ocean



Lessons learned from C4MIP

- Climate – carbon cycle feedback is likely to be positive, and may be significant in terms of radiative forcing.
- Carbon cycle response should be considered for long-term projections of global warming, e.g., projections with CO2 stabilization scenarios.

Experimental design for IPCC AR5 (published in 2013?)

- Short-term prediction
  - 2005 - 2030
- Long-term projection
  - 2005 - 2100 and beyond (2300?)

Short-term prediction (2005-2030)

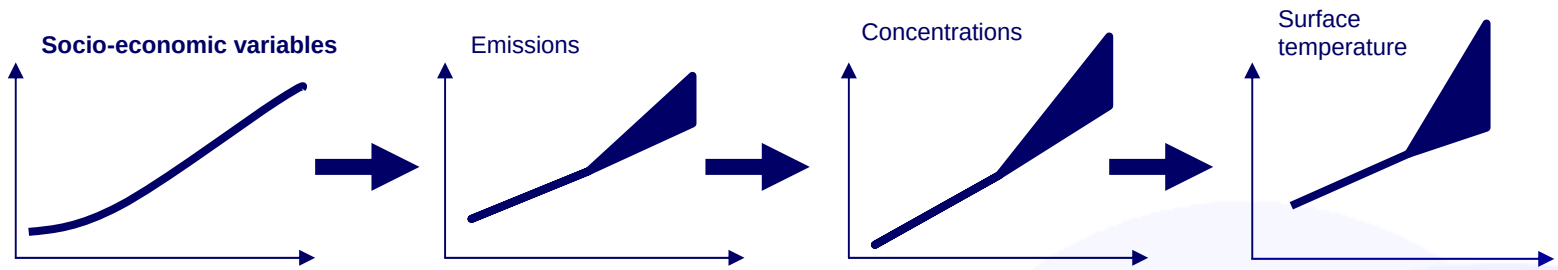
- Focus: probability of extreme events
  - Hi-resolution atmosphere (~1 deg.) with atmospheric chemistry
  - Starting from some point in the late 20th century
  - With a single scenario
- Problems:
  - Ocean initialization (salinity)
  - How to avoid model drift

Long-term projection (-2100 and beyond)

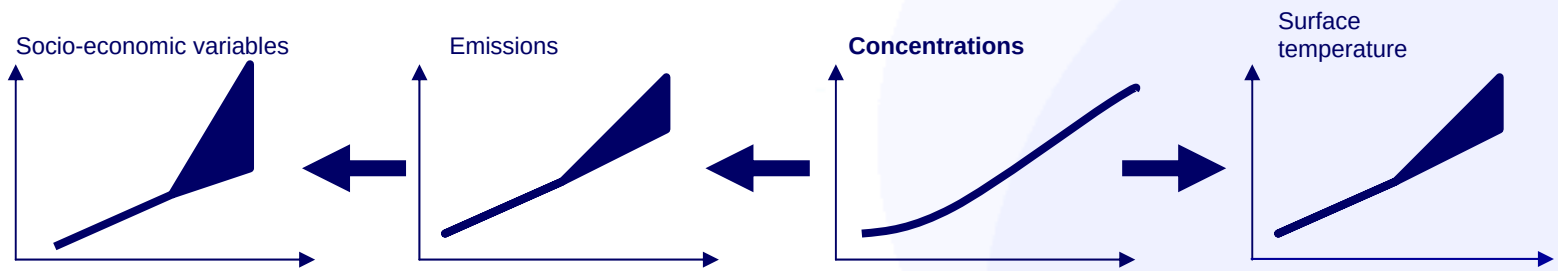
- Focus: stabilization scenario
  - With carbon cycle (DGVM for land, NPZD for ocean), multiple scenarios
  - “Conventional” models w/o carbon cycle components can also participate.
  - Designed to catalyze communications among WG1-3

“Quasi inversion” of anthropogenic CO2 emission using an ESM

- Forward approach: start with socio-economic variables



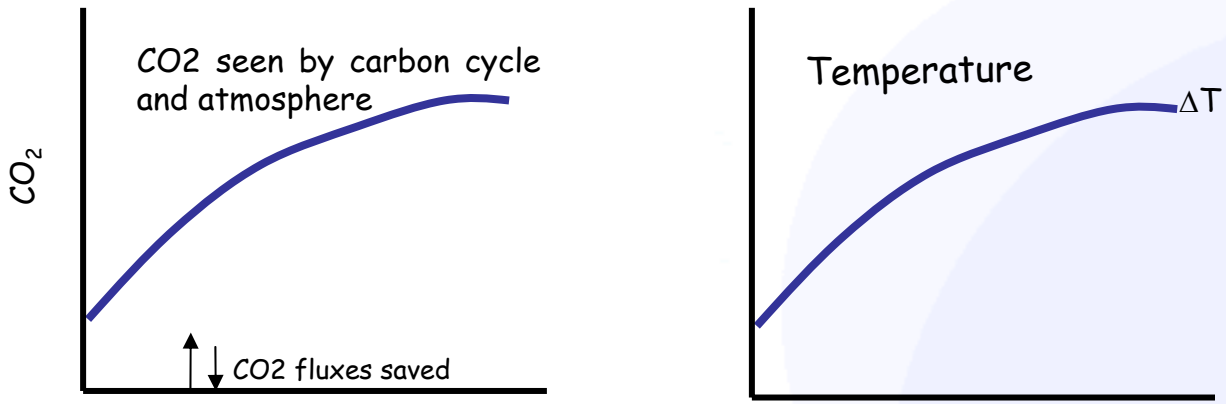
- Reverse approach: start with stabilization scenario concentrations



Expl. design for the long-term (1)

Experiment #1:

Carbon Cycle sees increasing CO2 Concentrations and ΔT;
Land/Ocean CO2 fluxes saved to derive emissions for WG3



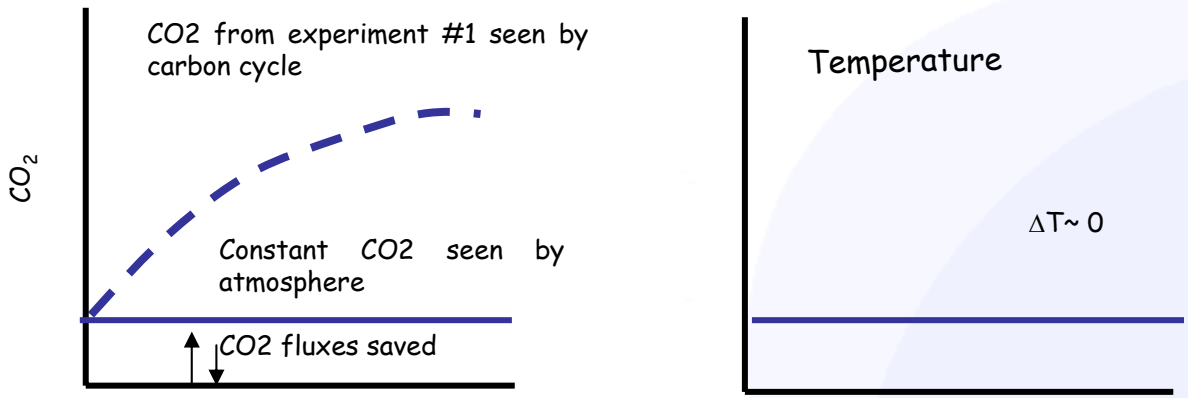
Land/Ocean CO_2 fluxes are NOT interactive with atmosphere

* Groups w/o an ESM can participate for the projection of warming. The projected climate fields are utilized for impact assessment (WG2).

Expl. design for the long-term (2)

Experiment #2:

Carbon Cycle sees CO2 Concentrations from Experiment #1;
atmospheric CO2 and T are constant;
Land/Ocean CO2 fluxes saved to derive emissions for WG3

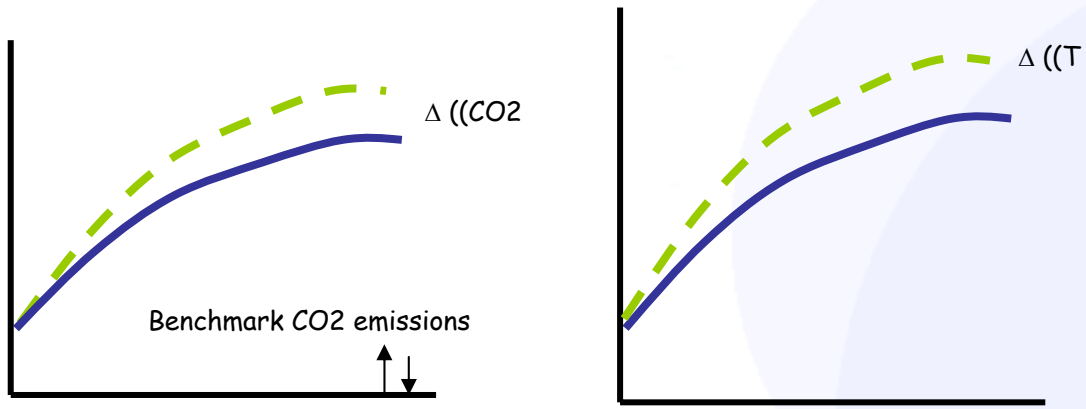


Land/Ocean CO_2 fluxes are NOT interactive with atmosphere

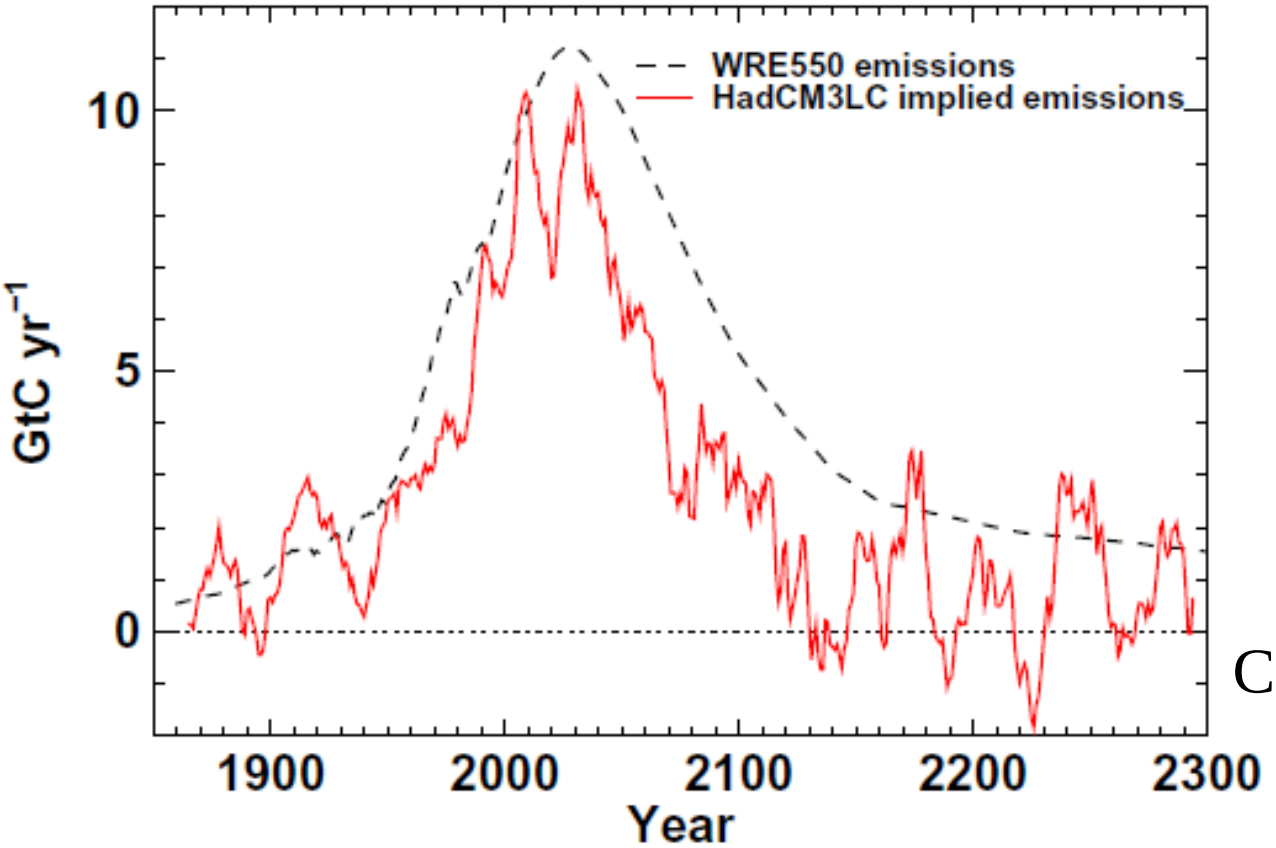
Expl. design for the long-term (3)

Experiment #3 (optional):

"Benchmark" emissions are used to drive carbon cycle-climate model to evaluate the feedback strength in terms of CO2concentration



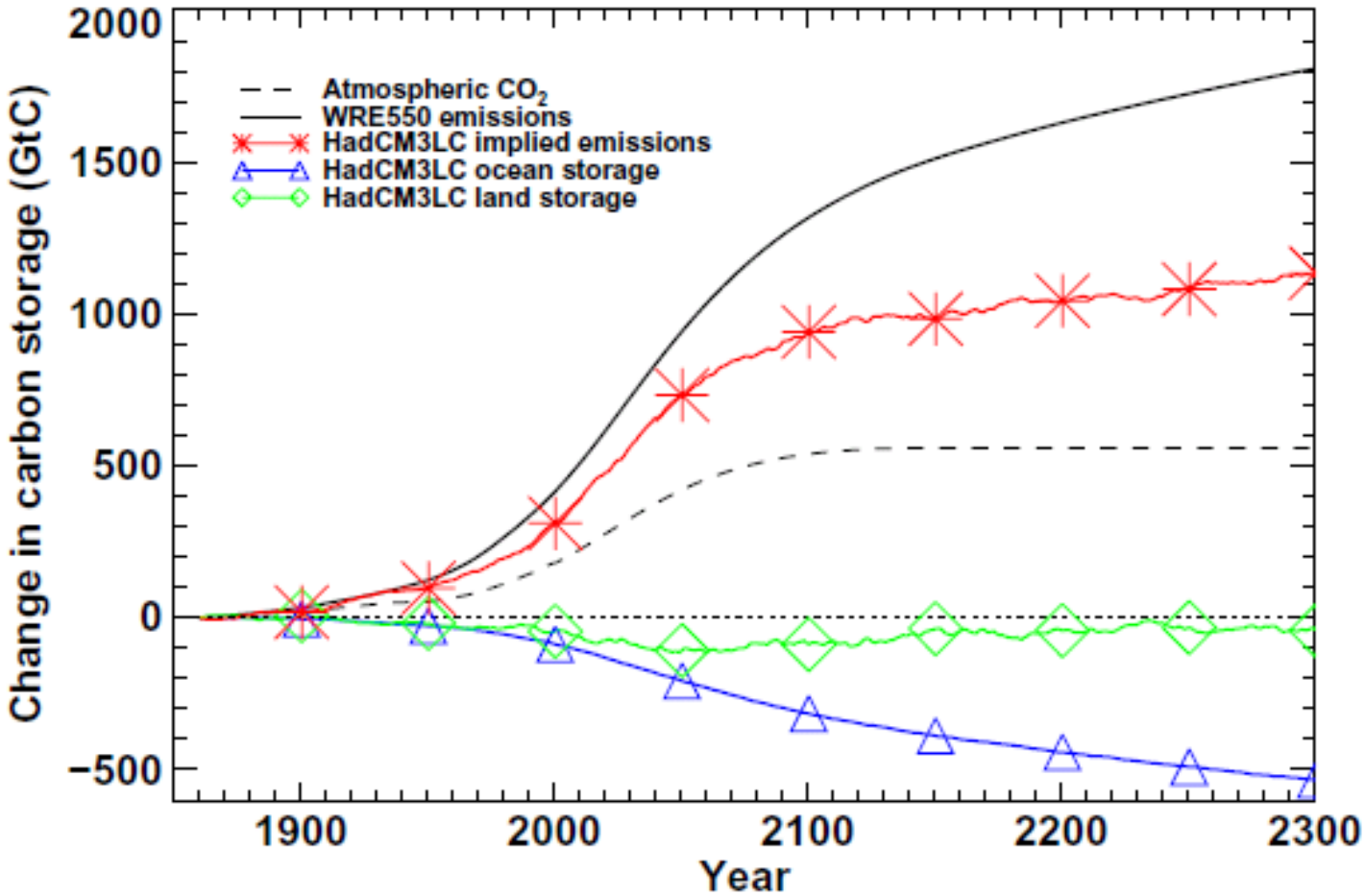
Prototype results (1)



C. Jones et al. (2005)

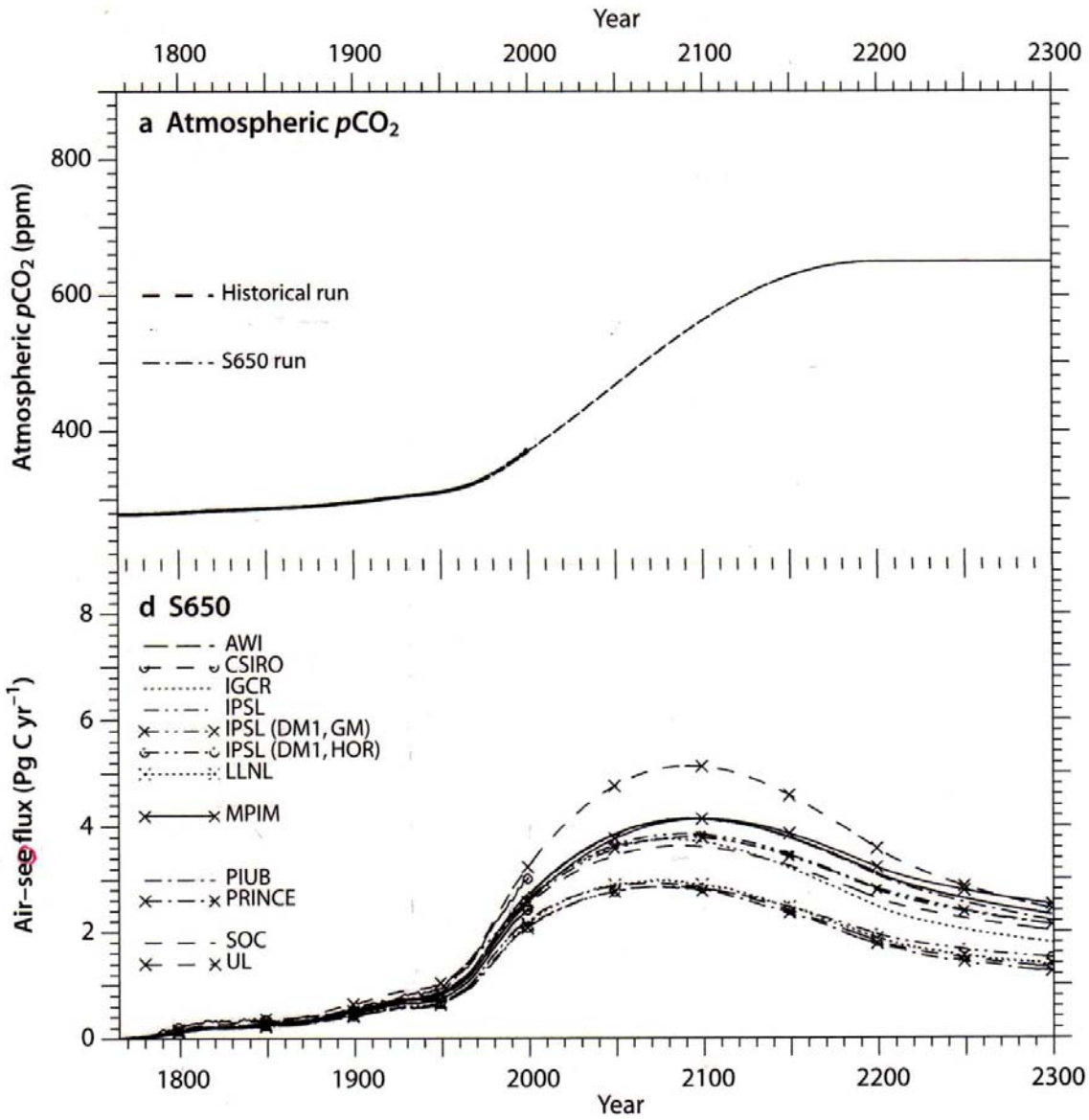
Derived emission will be handed over to WG3 (scenario developers) for further discussions and development of new scenarios.

Prototype results (2)
・・・Ocean matters more



C. Jones et al. (2005)

Inter-model differences in future CO2 uptake



Fasham (2003)

Tasks

- Identification of the cause for model-model differences in future CO2 uptake
  - Ventilation rate -> NADW? AABW? Intermediate Waters?
  - What determines the ventilation rate?
  - etc.
- Model development & verification
  - Faithful representation of ML development, biogeochemical tracer distribution etc.

Summary

- Positive feedback in the climate - carbon cycle system, confirmed by C4MIP, will be considered in AR5.
- Two target time scales
  - Decadal : extreme events
  - Centennial : stabilization <- quasi inversion by ESMs
- Ocean's role is more critical for the latter time scale.

* Summry for the AR5 expl. design will appear in "EOS", and is available from the AIMES/IGBP web site. Search "AGCI report".