Royal Netherlands
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and Water Management

Feedbacks between climate and human activities in a coupled integrated assessment-climate modeling system with focus on emissions

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Presentation outline

- Introduction – ESM vs IAM
- Surface ozone concentration and climate impact
- Surface ozone concentration and agriculture
- Questions

Earth system modeling vs Integrated assessment modeling

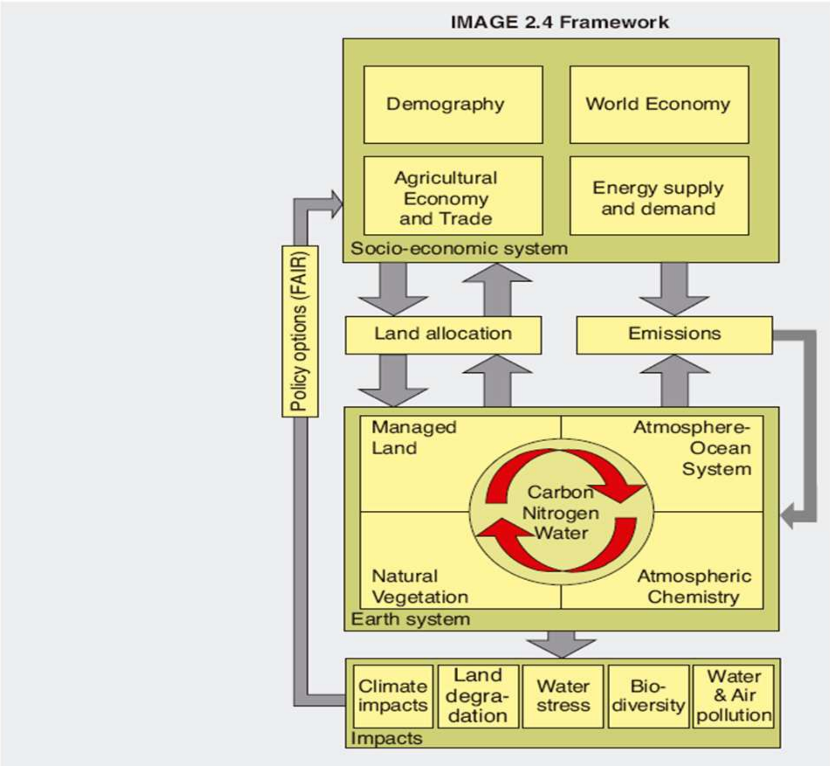
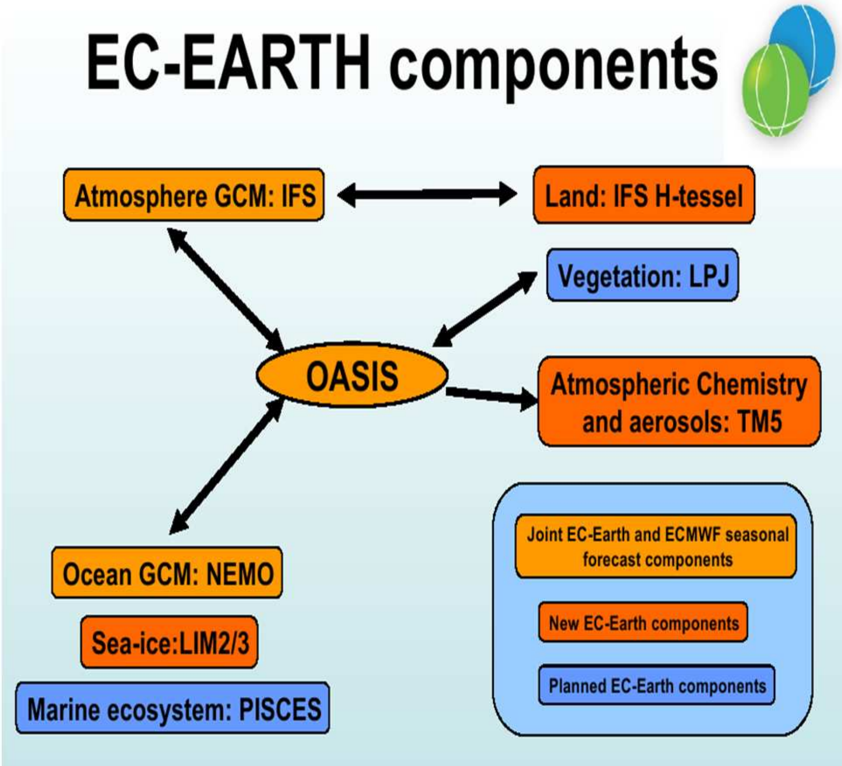
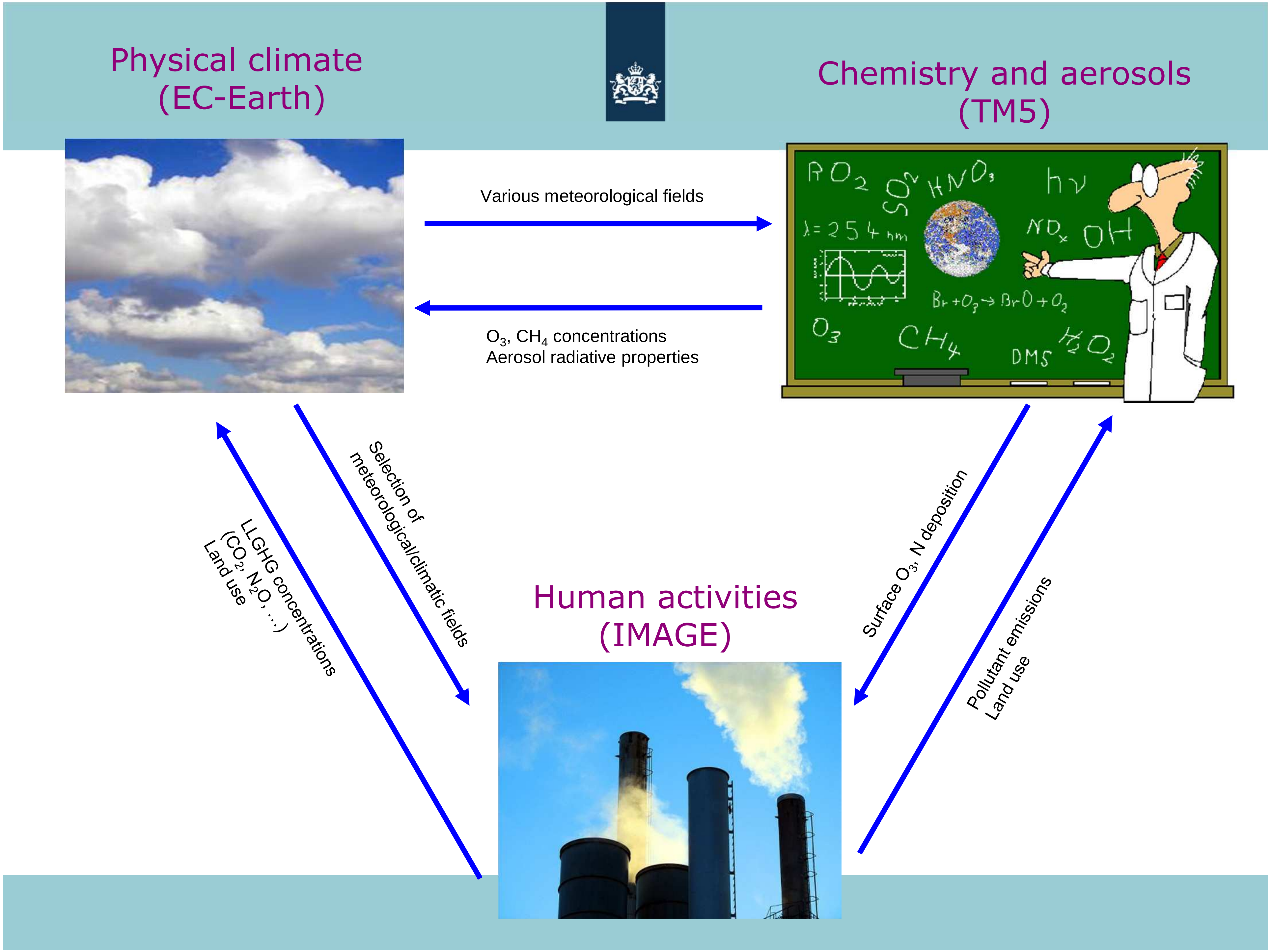


Figure 2.19 IMAGE 2 Integrated Assessment Framework.



Bouwman et al., 2006

Hazeleger et al., 2010

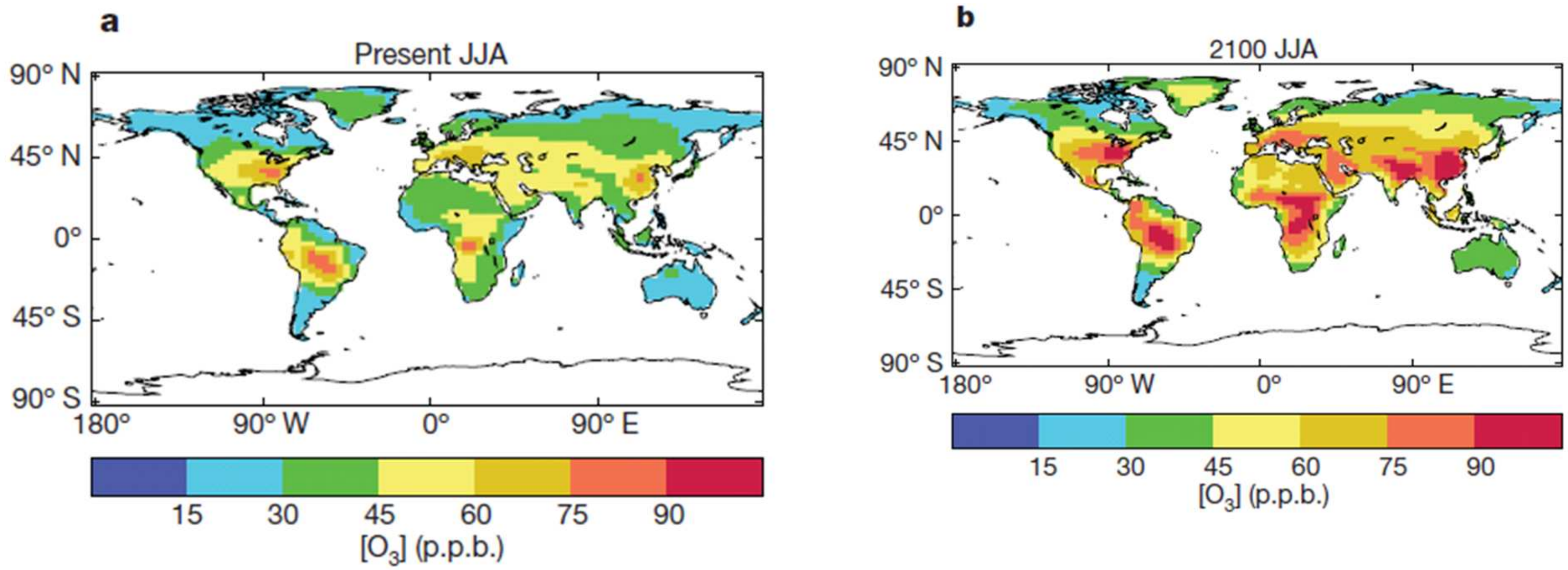

Physical climate
(EC-Earth)
Chemistry and aerosols
(TM5)
Various meteorological fields
O_3, CH_4 concentrations
Aerosol radiative properties
Selection of
meteorological/climatic fields
LLGHG concentrations
(CO_2, N_2O, …)
Land use
Surface O_3, N deposition
Pollutant emissions
Land use
Human activities
(IMAGE)

Scientific questions

- Can we by interactive simulation of the nitrogen cycle improve projections of reactive N emissions, and of associated concentrations and climate forcings?

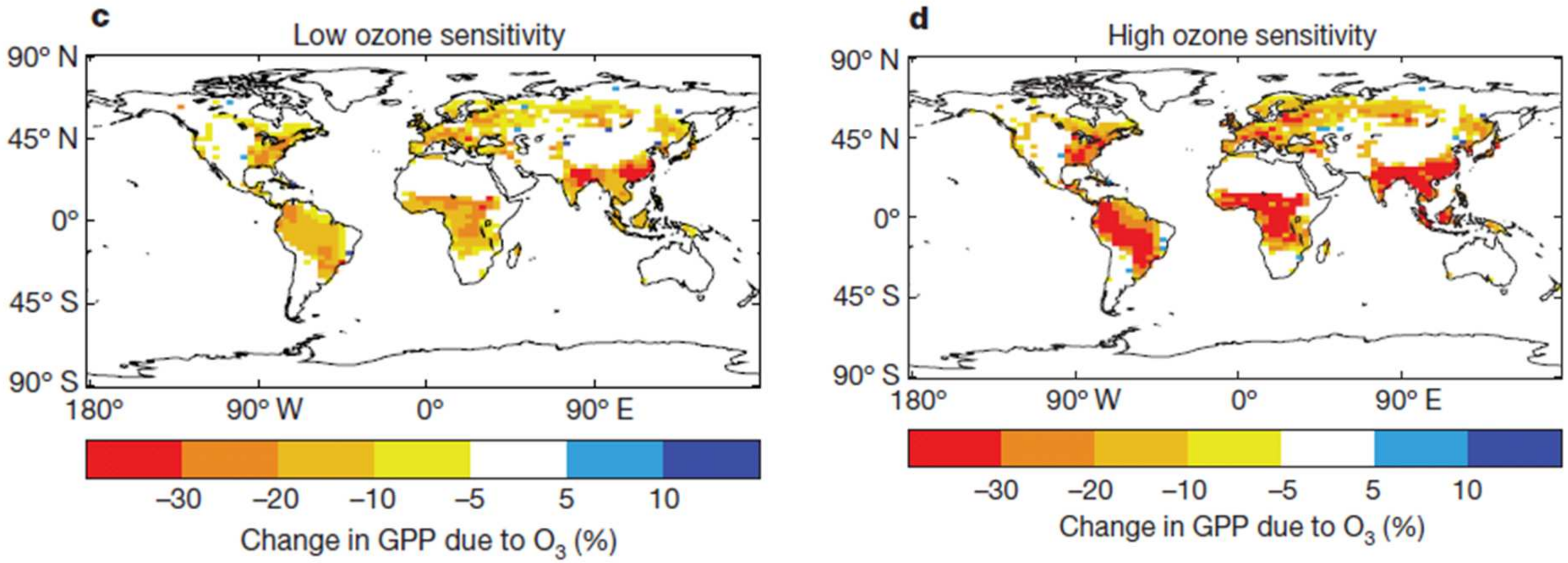
- Can we by including an additional feedback estimate future impacts of surface ozone on agricultural yields?

Surface ozone concentration



Modelled diurnal (24-h) mean surface ozone concentration averaged over June, July and August (JJA) for the present day (a) and the year 2100 under the SRES A2 emissions scenario (b) - Sitch et al., 2007.

Surface ozone concentration and GPP



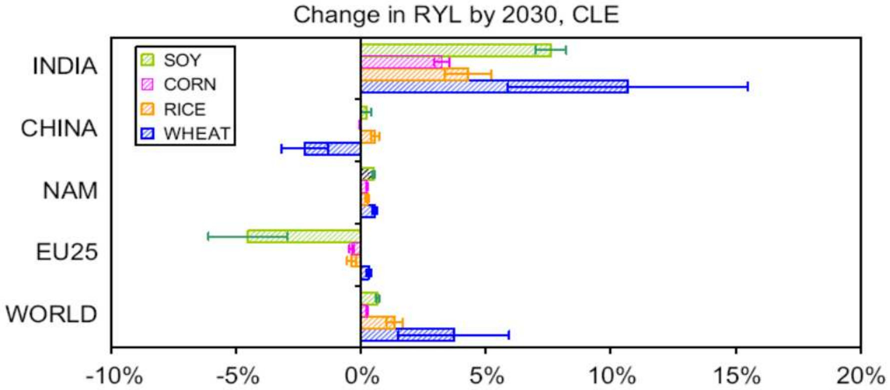
Simulated percentage change in gross primary productivity (GPP) between 1901 and 2100 due to ozone effects at fixed pre-industrial atmospheric CO_2 for 'low' (c) and 'high' (d) ozone plant sensitivity - Sitch et al., 2007.

Surface ozone

- Crop yield reduction:

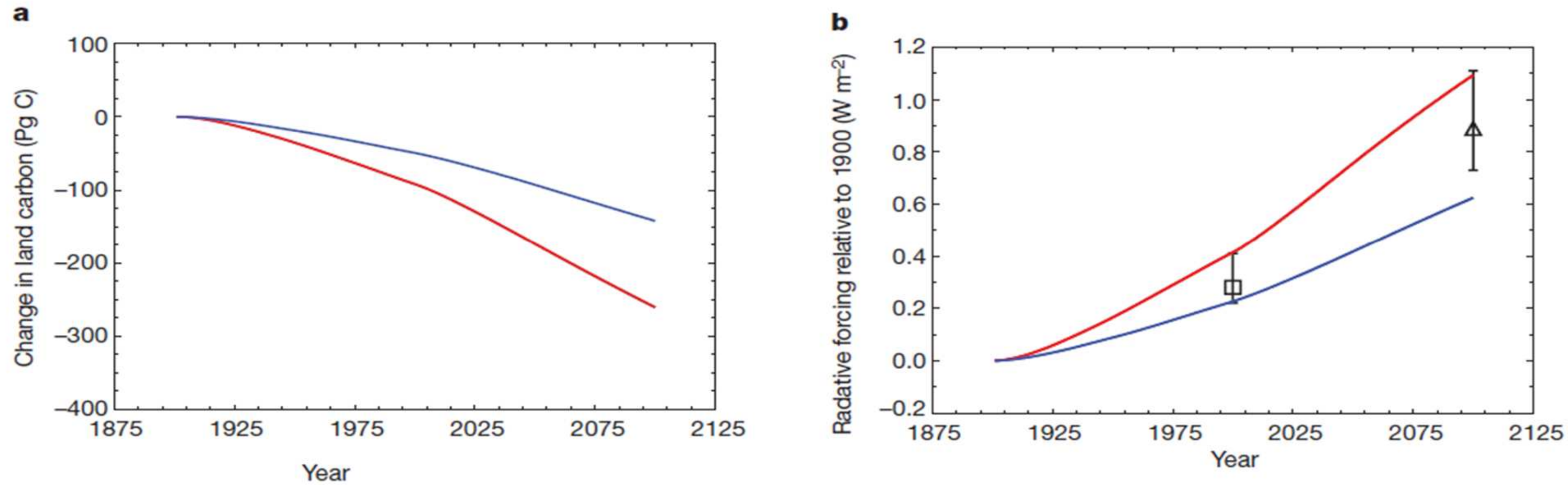
Regionally aggregated relative yield loss RYL for wheat, rice, maize and soybean.

	WORLD	EU25	N.Am	China	India
Wheat					
AOT40	12.3%	4.1%	4.1%	19.0%	27.6%
M7	7.3%	4.6%	4.4%	9.8%	13.2%
Rice					
AOT40	3.7%	4.7%	3.2%	3.9%	8.3%
M7	2.8%	3.5%	2.6%	3.1%	5.7%
Maize					
AOT40	2.4%	3.1%	2.2%	4.7%	2.0%
M12	4.1%	5.1%	3.6%	7.1%	4.0%
Soybean					
AOT40	5.4%	20.5%	7.1%	11.4%	4.7%
M12	15.6%	27.3%	17.7%	20.8%	19.1%



Van Dingenen et al., 2009

Surface ozone concentration



Simulated change in land carbon storage (a).
Indirect RF due to ozone increase alone (b), the present day direct RF from STOCHEM-HadGEM1 tropospheric ozone fields (black square) and model mean from IPCC TAR models (black triangle). The bars show estimates from other models – Sitch et al., 2007.

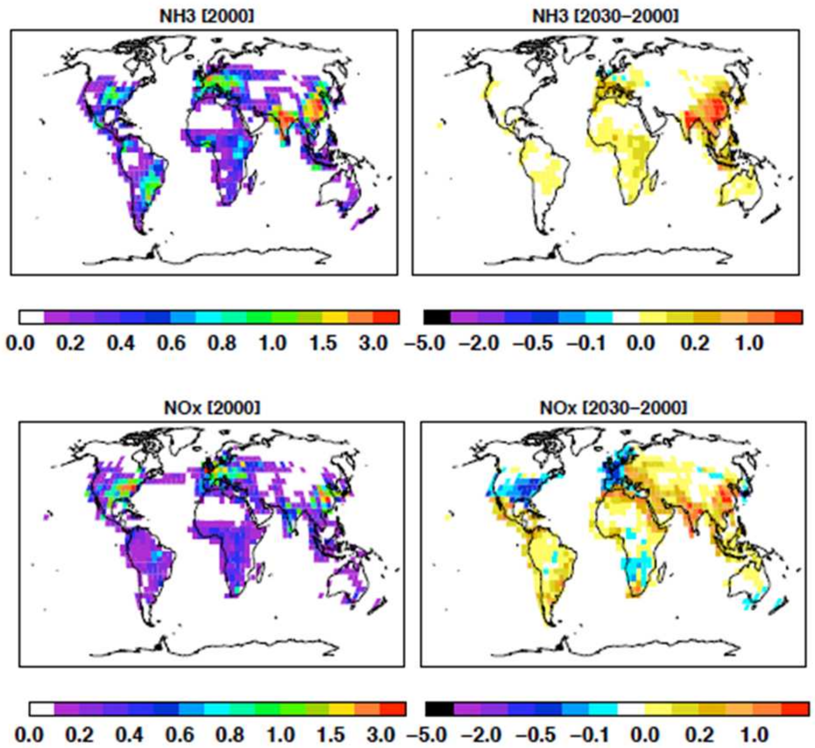
Time for questions

Nitrogen surface exchange(1)

- Largest increase in NH_3 sources is predicted to occur in India and Asia.

- largest source of NH_3 emissions associated with livestock husbandry and the agricultural use of fertilizers.

- Emissions related to industry, fossil fuel and bio fuel likely to increase between 2000 and 2030.



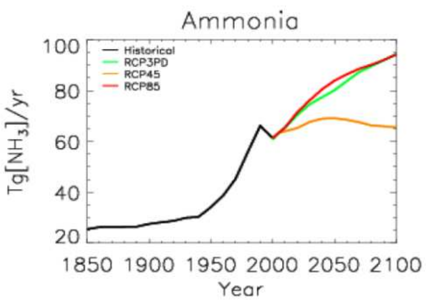
Annual mean emission flux [g/m2/yr] for the year 2000 and the difference between the year 2030 and 2000, of NH_3 and NO_x (Bauer et al., 2007)

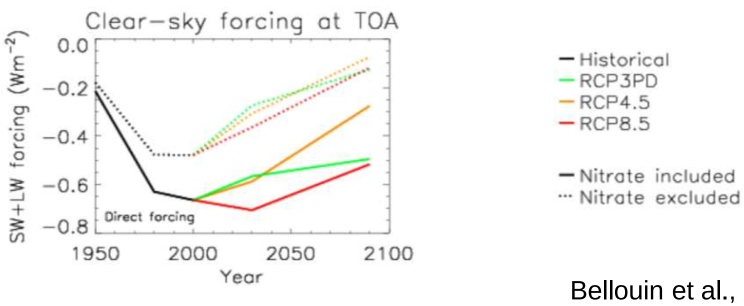
Nitrogen surface exchange (2)

- Emissions (Tg N/yr) - N_2O and NO from mixed intensive agricultural systems; NH_3 from fertilizer and animal manure application and stored manure:

	N_2O	NO	NH_3
1970	2.0	1.1	18
1995	2.7	1.5	34
2030	3.5	2.0	44

- RCP emissions of aerosol precursors and primary aerosols suggest a strong decrease in emissions during the 21st century, except for ammonia.





Bellouin et al., AeroCom 2010

Nitrogen exchange (3)

- Make interactive coupling with TM5 (feedback loop):
  - IMAGE NO and NH_3 emissions
  - TM5 N deposition
- Use either ERA-Interim or EC-Earth (using output fields or one-way coupling) to drive TM5
- Evaluate climate impacts of shorter-lived components offline (a la KRCM)