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Land-use modeling with IMAGE 2

EMF-22, December 13, 2006
Tsukuba, Japan

Netherlands Environmental
Assessment Agency

Contents

- Coordinated baseline: Millennium Ecosystem Assessment's Adapting Mosaic (AM)
  - IMAGE 2.2 in conjunction with IFPRI's IMPACT model
  - Variations of coordinated baseline: CC feedback

- New IMAGE 2.4 baseline
  - Coupled with LEITAP
  - Sensitivity cases: crop yield assumptions

- Future plans:
  - Bioenergy: GTAP-E
  - Dynamic climate/vegetation/crop growth (not today!)
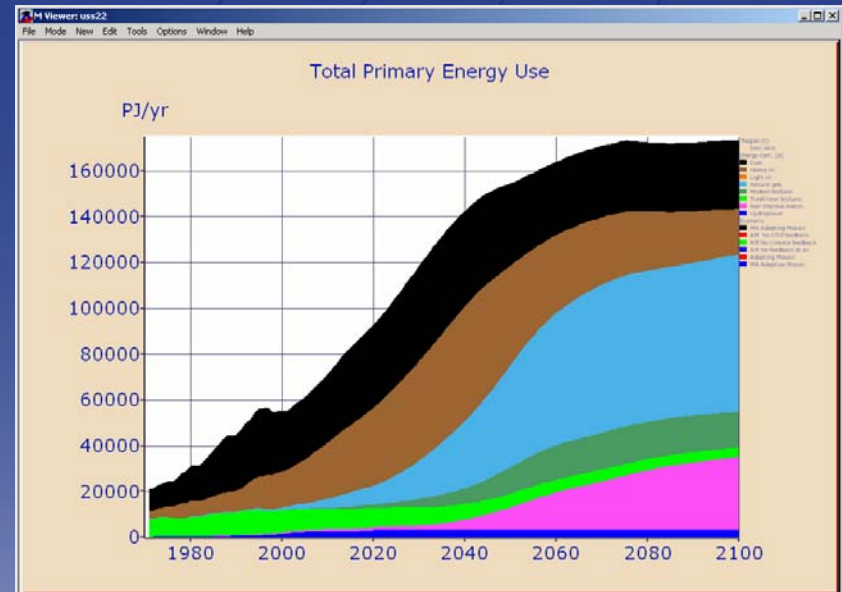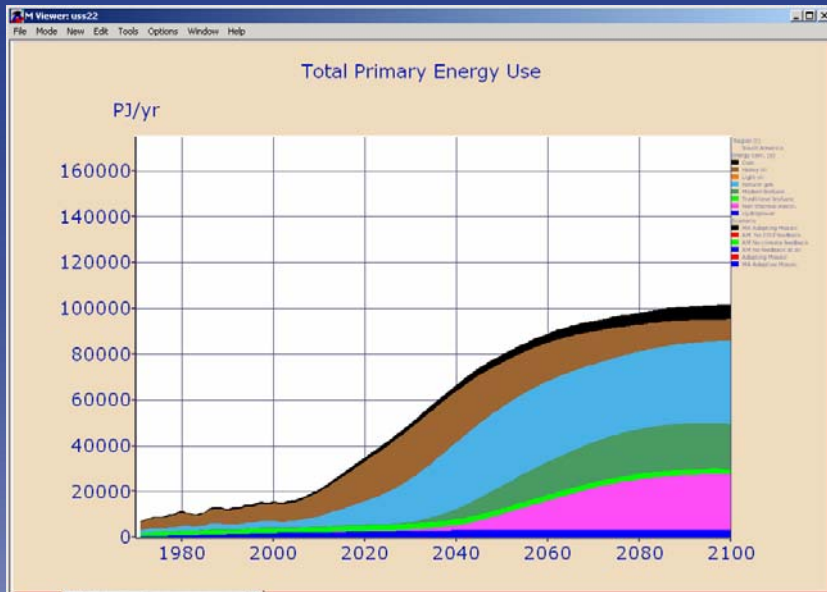
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Model structure in MA
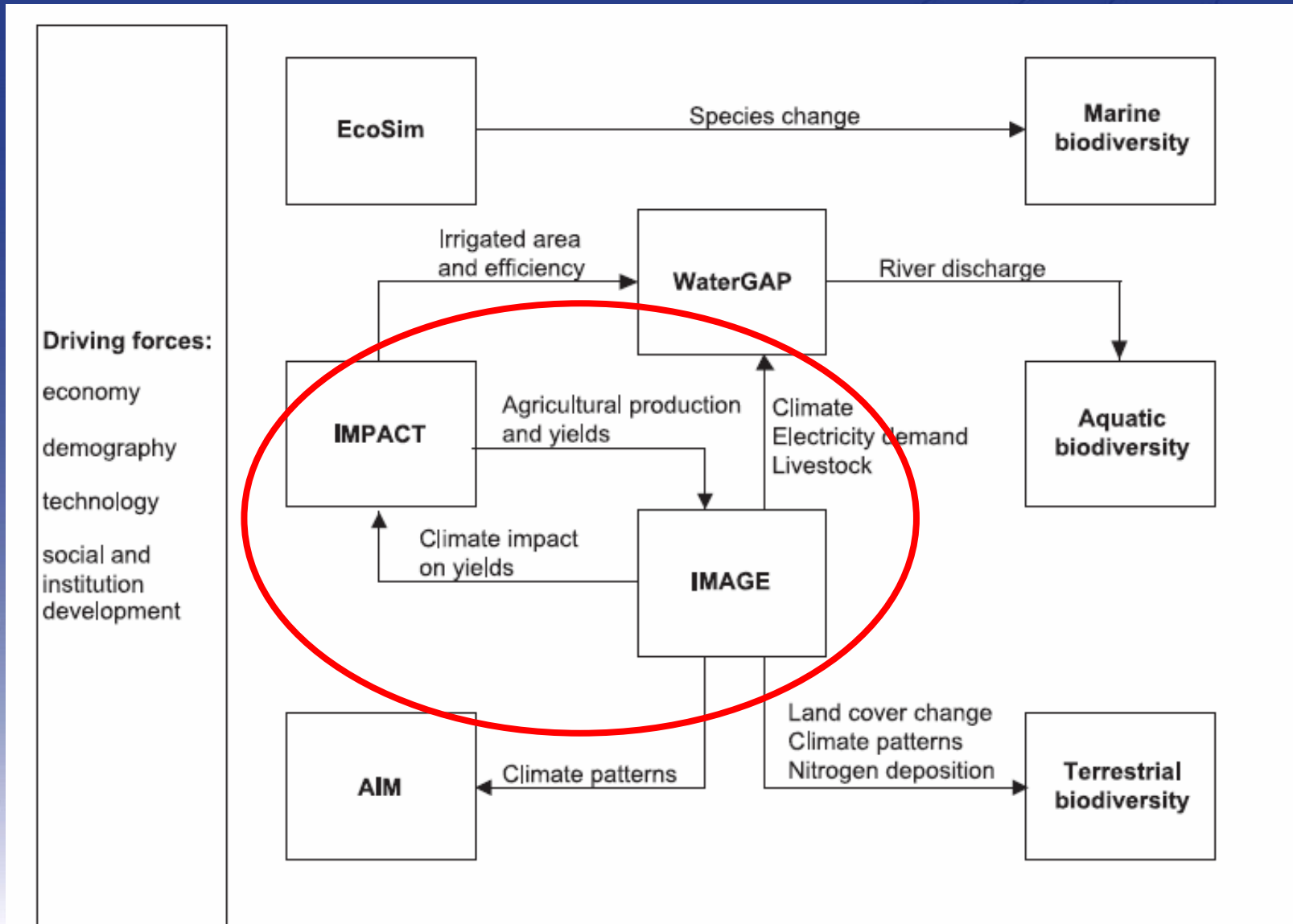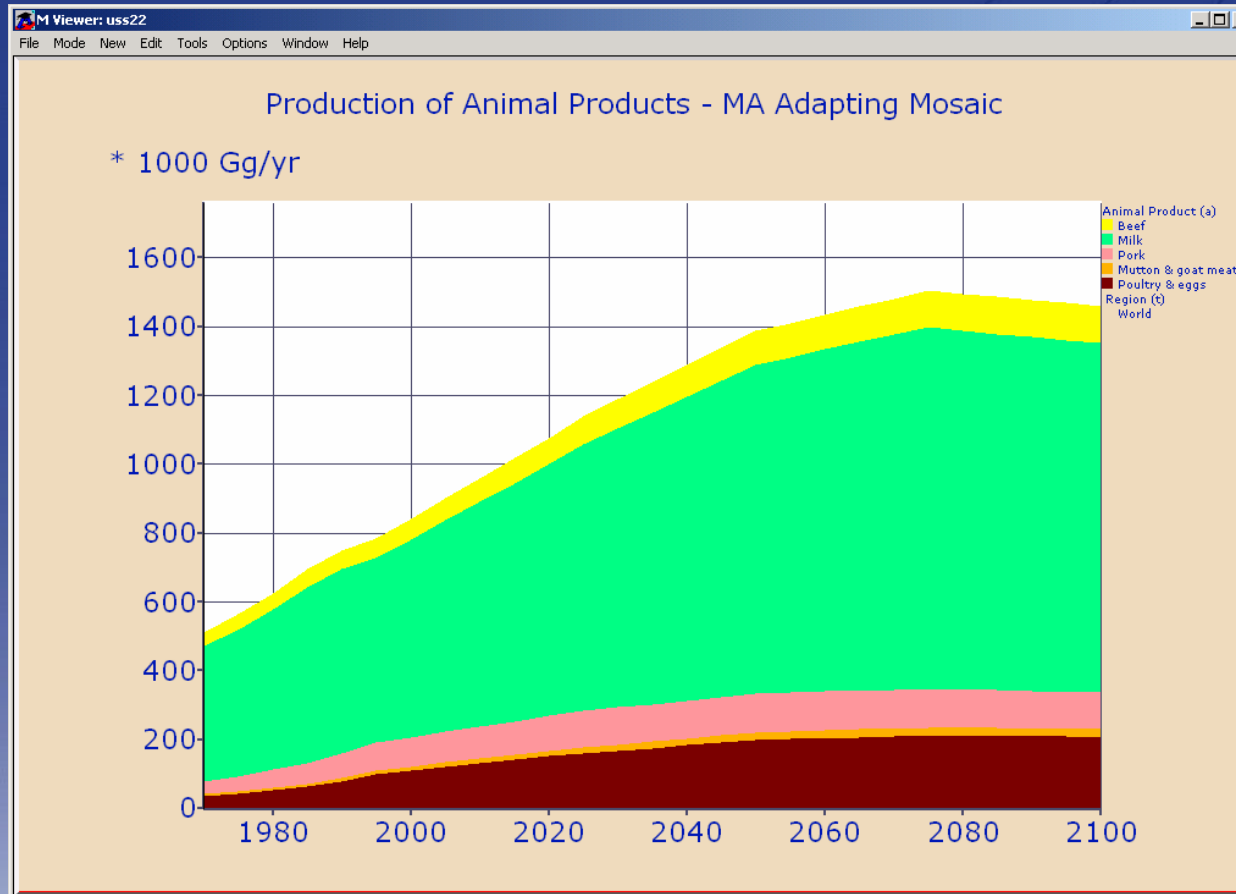
Coordinated baseline: energy use
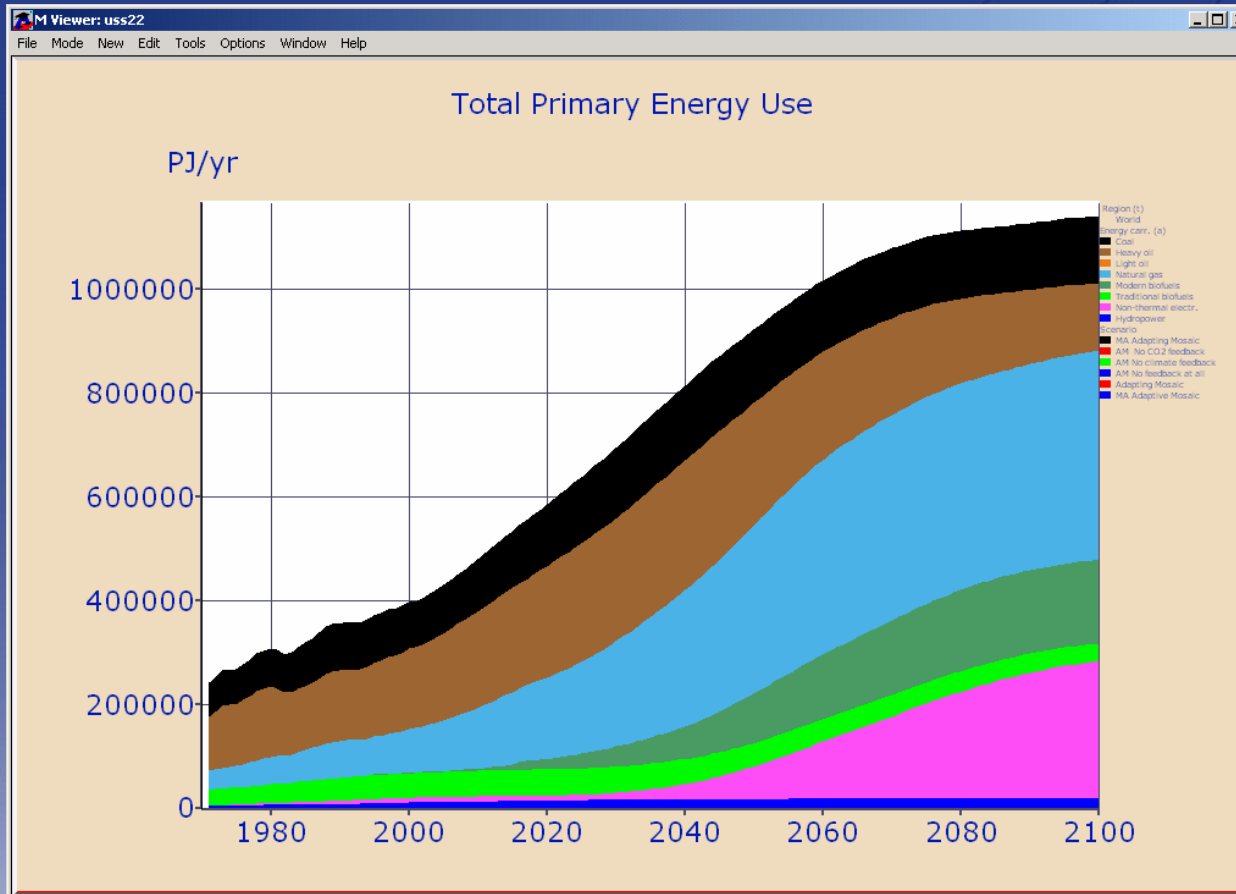
Regionally: South America versus China

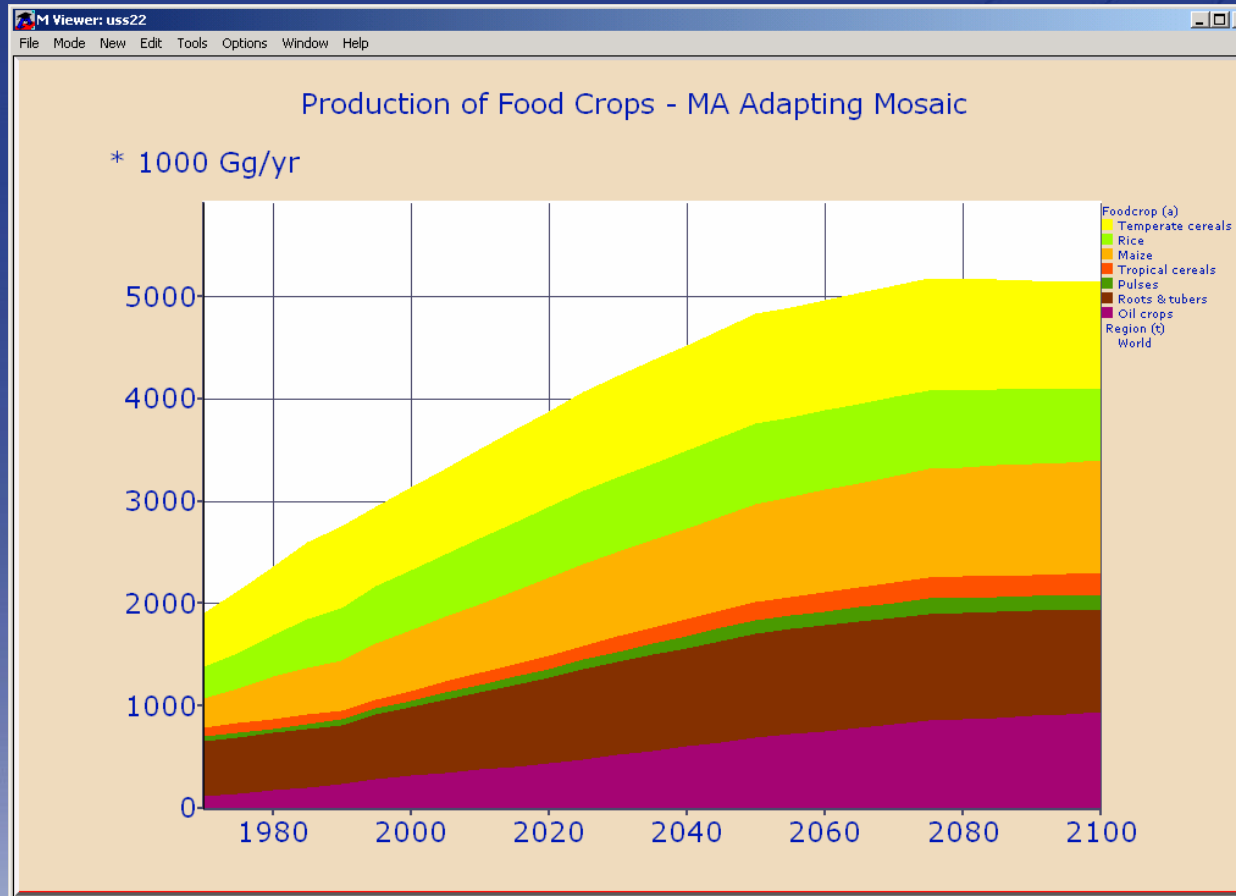

More modern bioenergy in South America

More coal in China
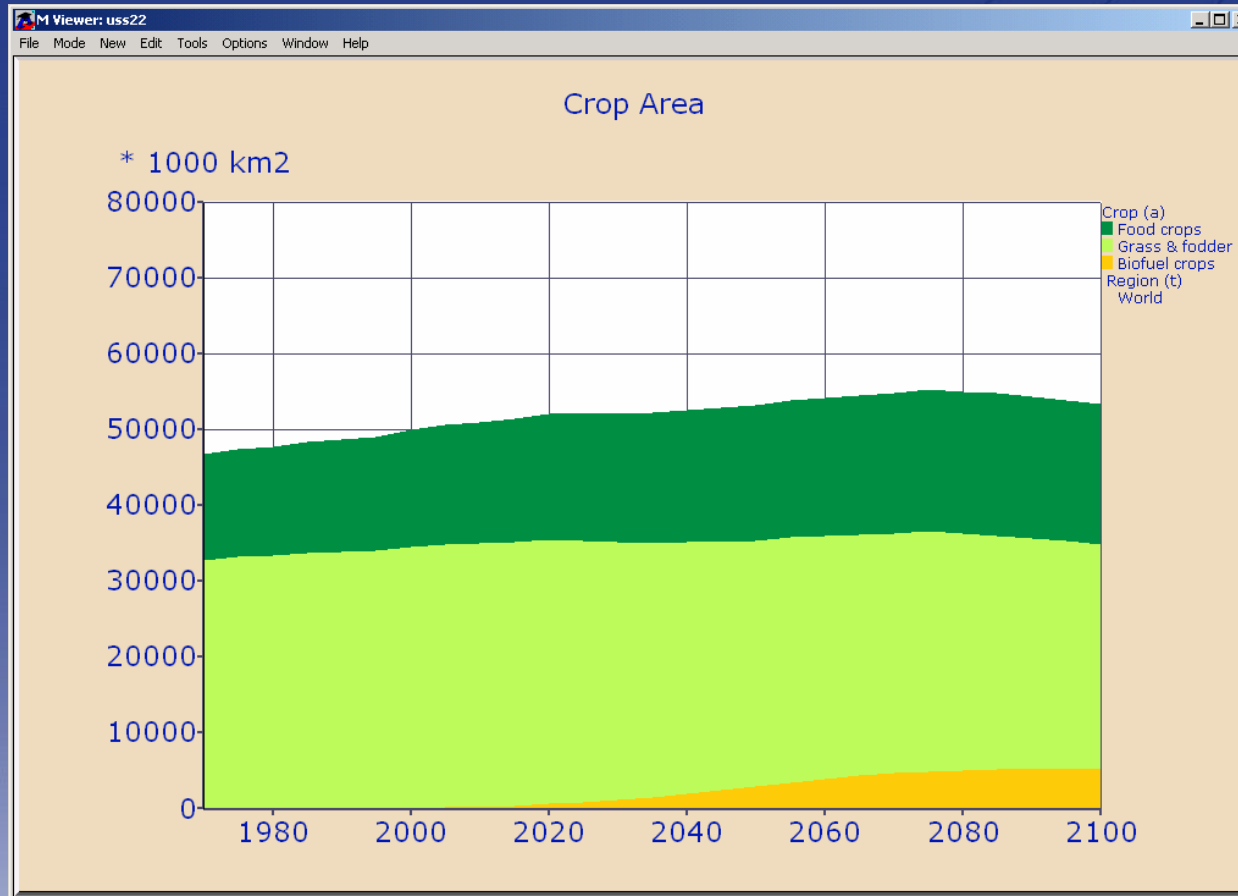
Agricultural production from IFPRI: animal products

Note: large increase in dairy products

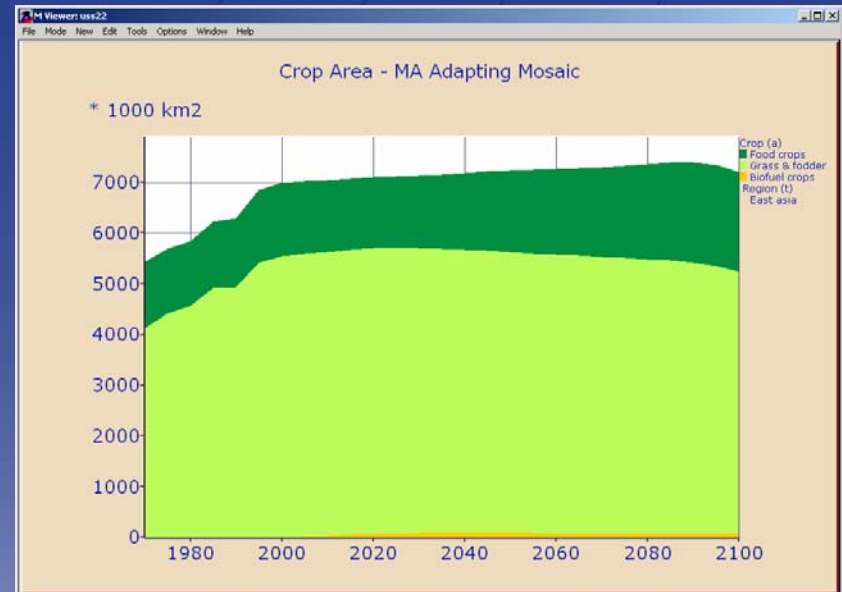# Agricultural production from IFPRI: food crops

Production of Food Crops - MA Adapting Mosaic

Stronger growth in feed crops like maize and oil crops

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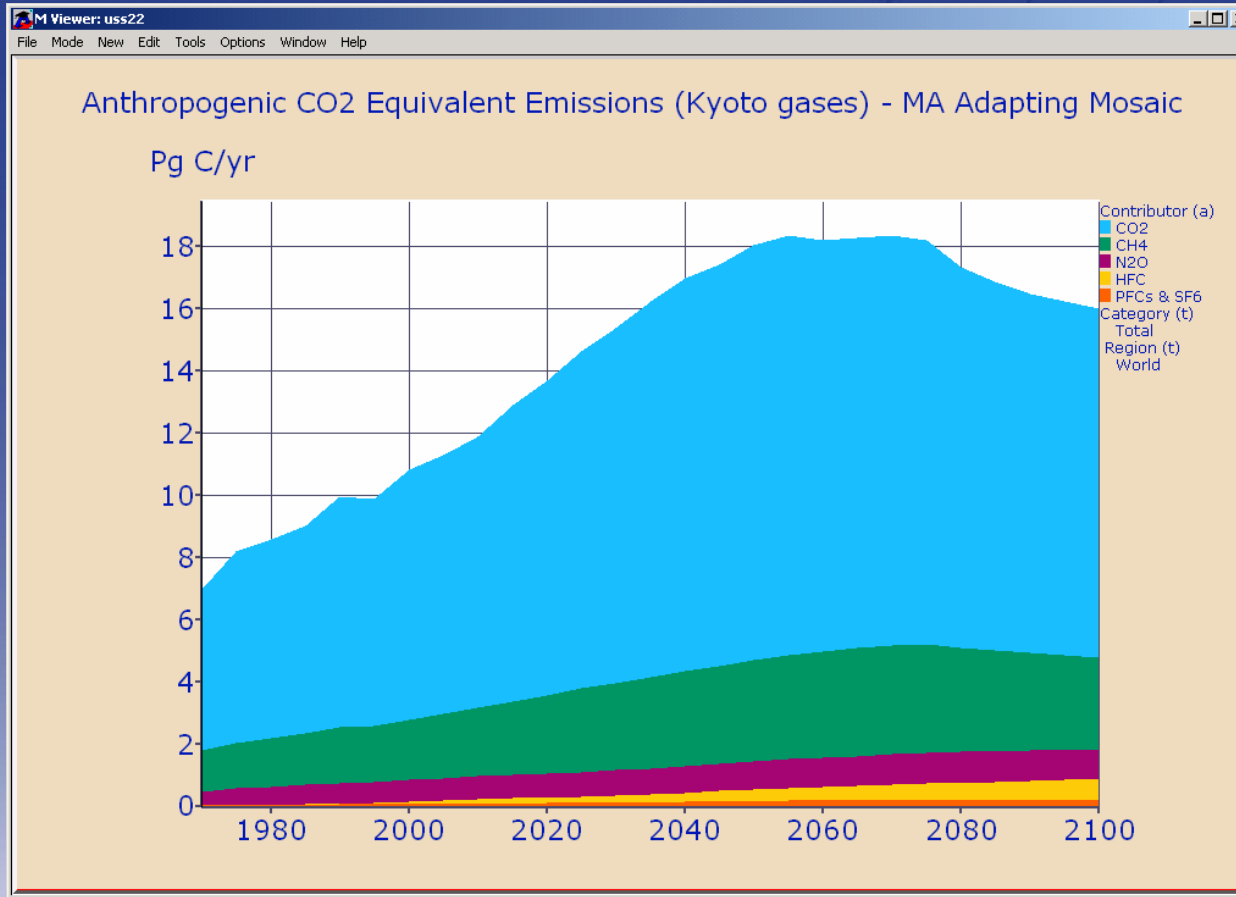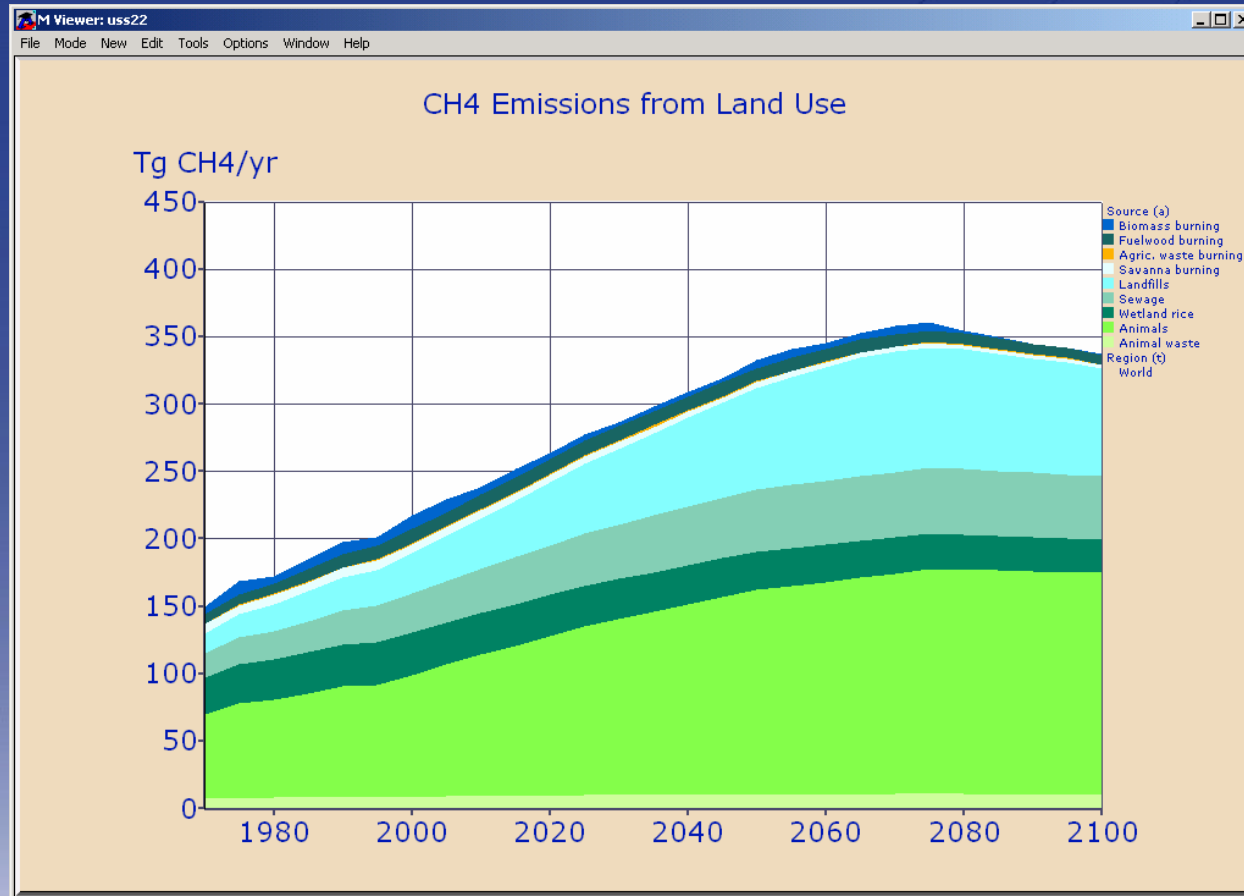
Land-use change

Land-use change regionally
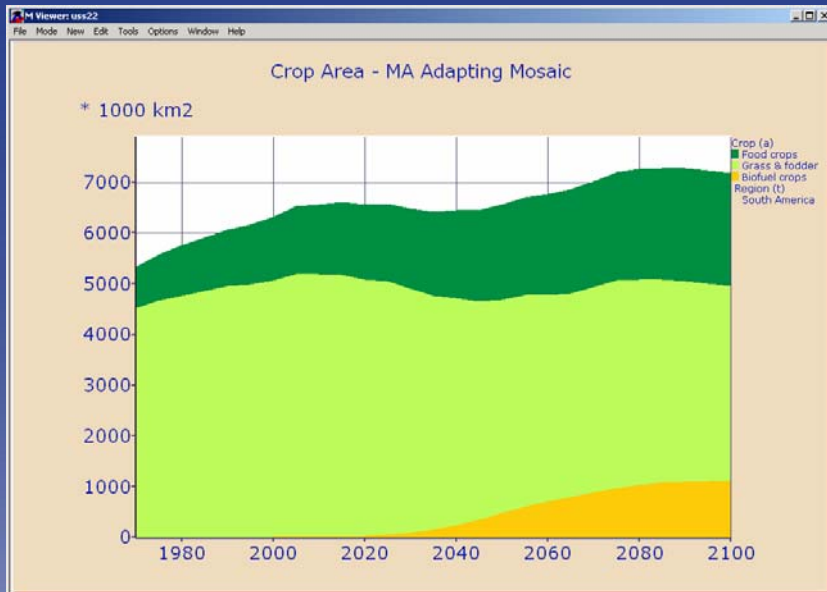
South America versus China: most increases in China already achieved. Regions where expansion is to be expected are South America and Africa.
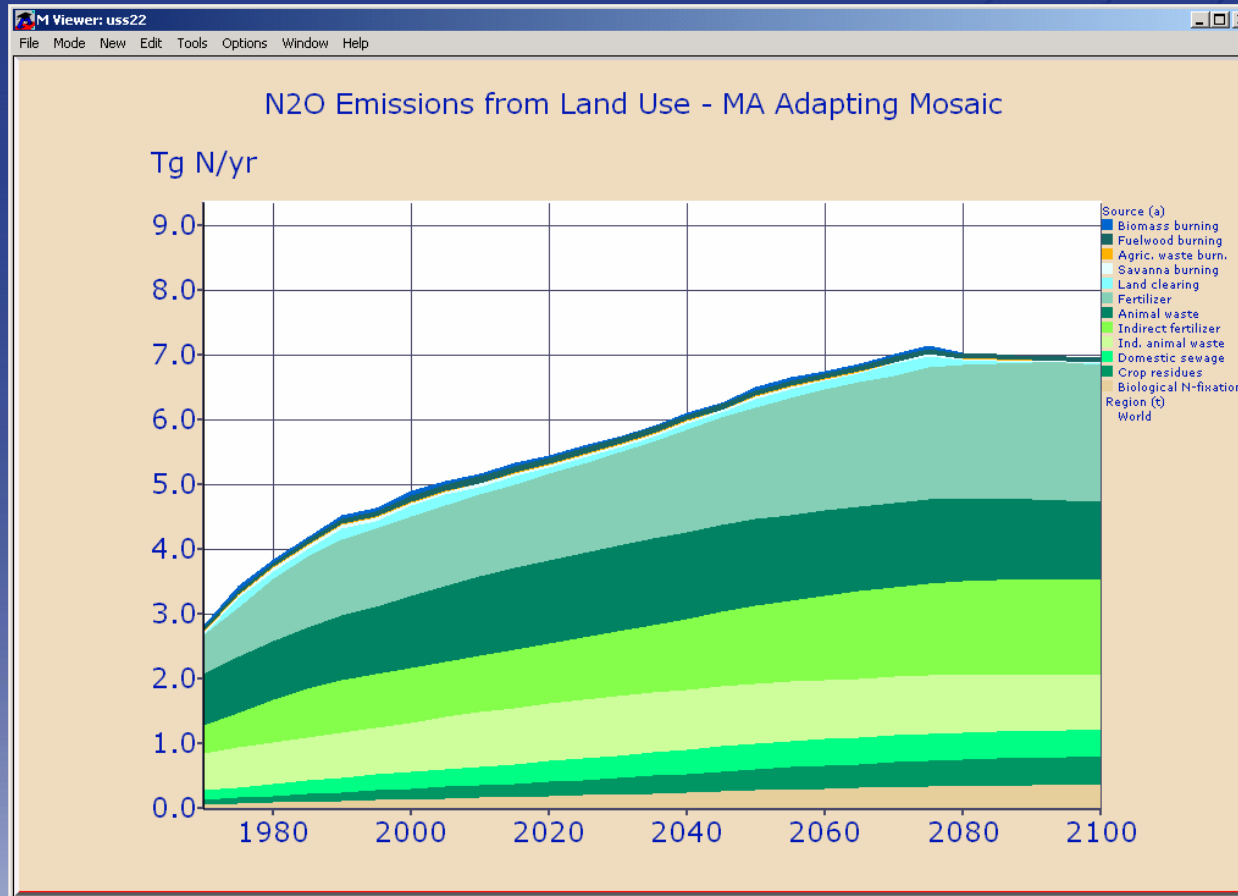
Changes in emissions largely driven by energy

But land-use emissions also increase (Methane: mainly animals and landfills)
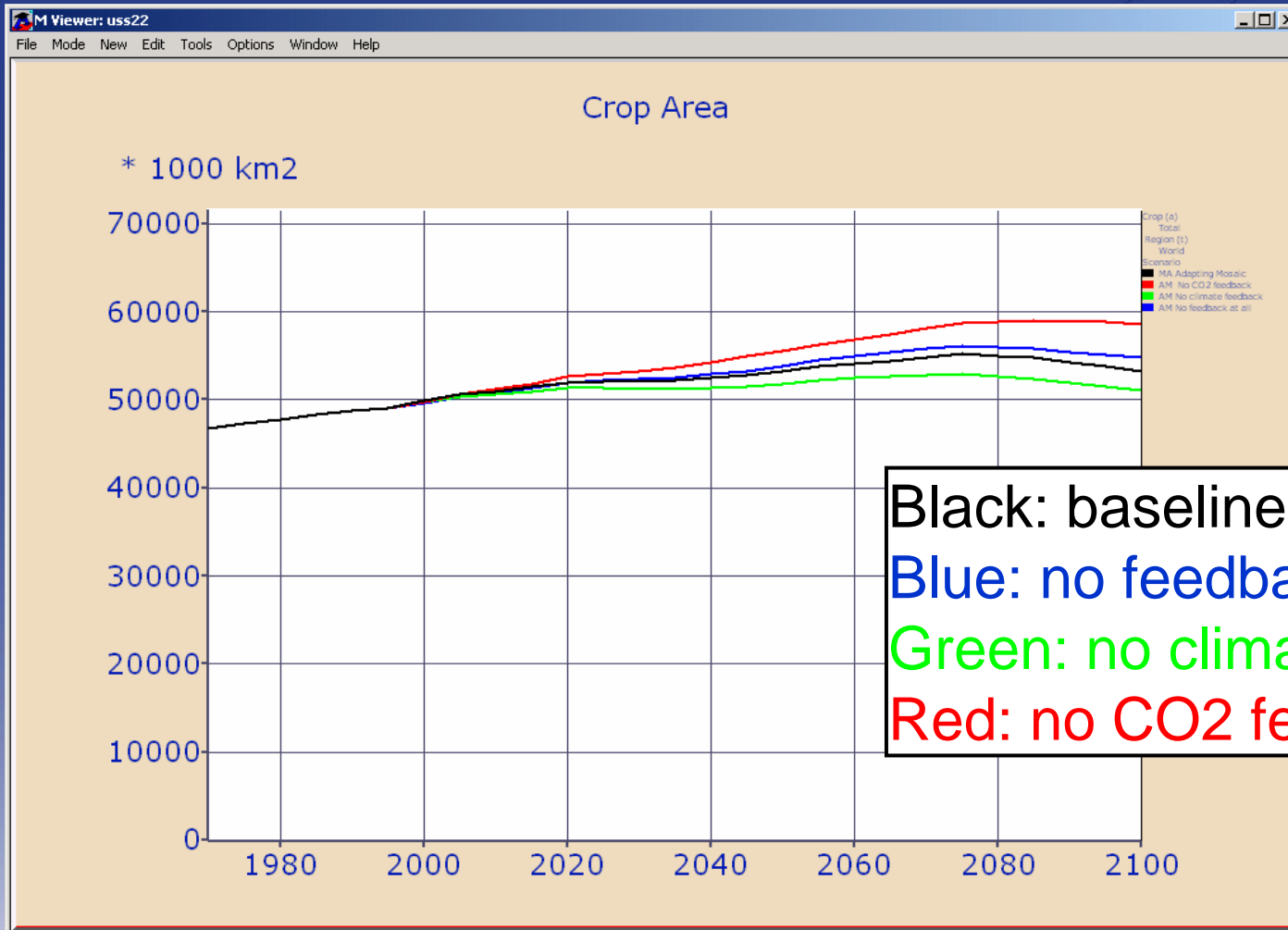
And for Nitrous oxide: fertilizer use

EMF22-LU: Co-ordinated baseline

- These were results from Millennium Ecosystem Assessment
- IMAGE 2.2 includes several feedbacks
- What is the importance of CO_2, climate and no feedbacks?

Land-use changes

Black: baseline
Blue: no feedback at all
Green: no climate feedback
Red: no CO2 feedback

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Change in yields
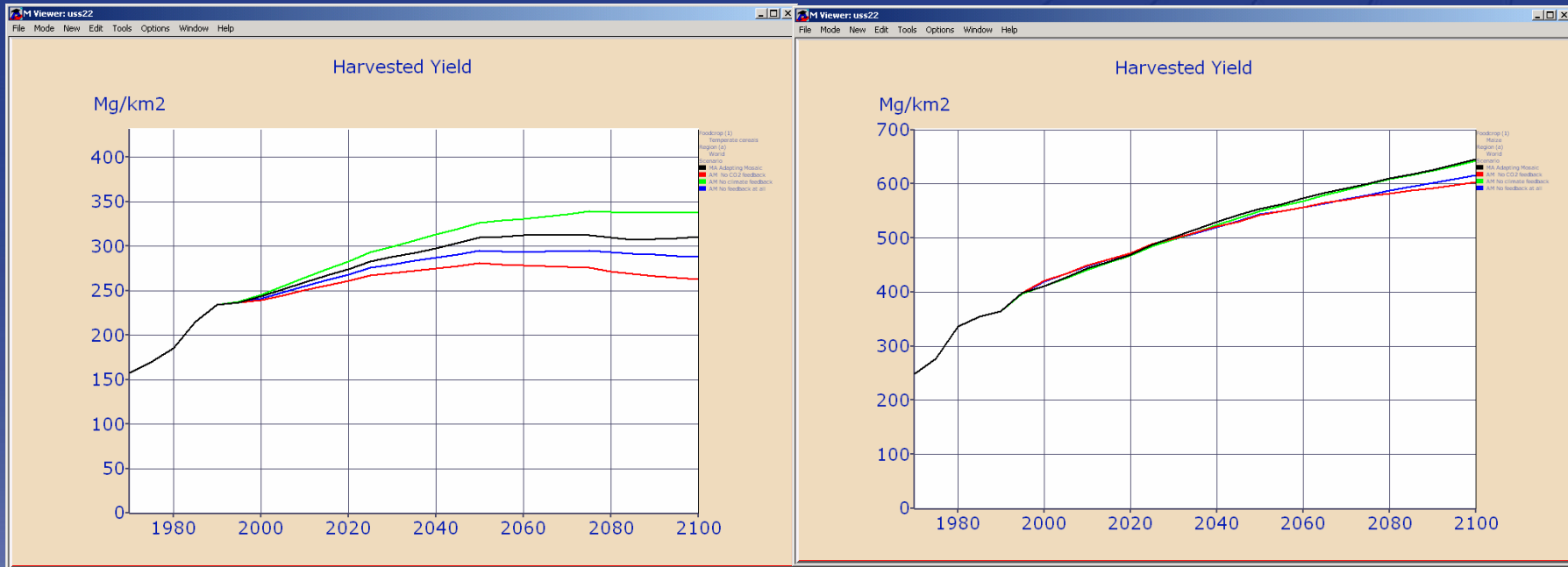
Temperate cereals versus maize:
- cereals affected by climate -- maize hardly
- both impacted by CO2 fertilization

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Consequences for CO2 uptake
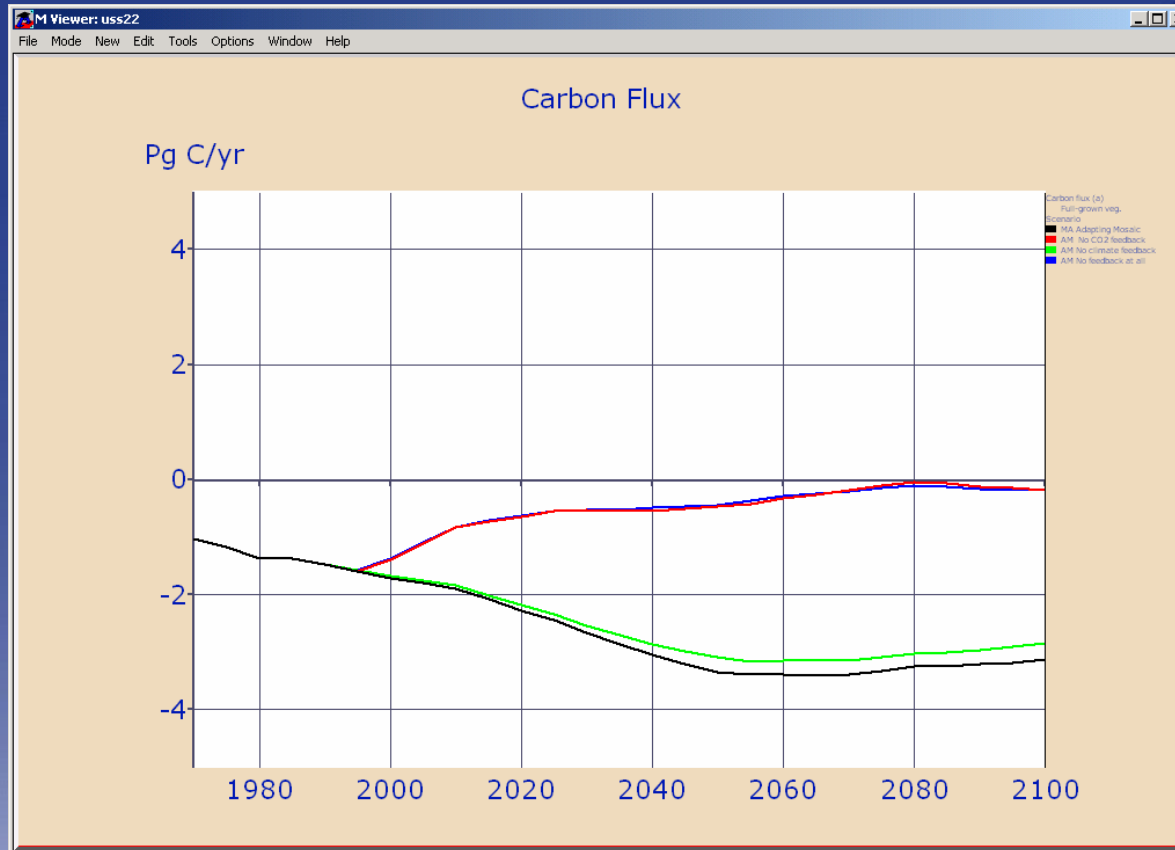
- CO2 uptake collapses in absence of CO2 fertilization
- Temperature effect seems small.

NPP constant without feedbacks (especially when no CO2 fertilization effect is assumed)

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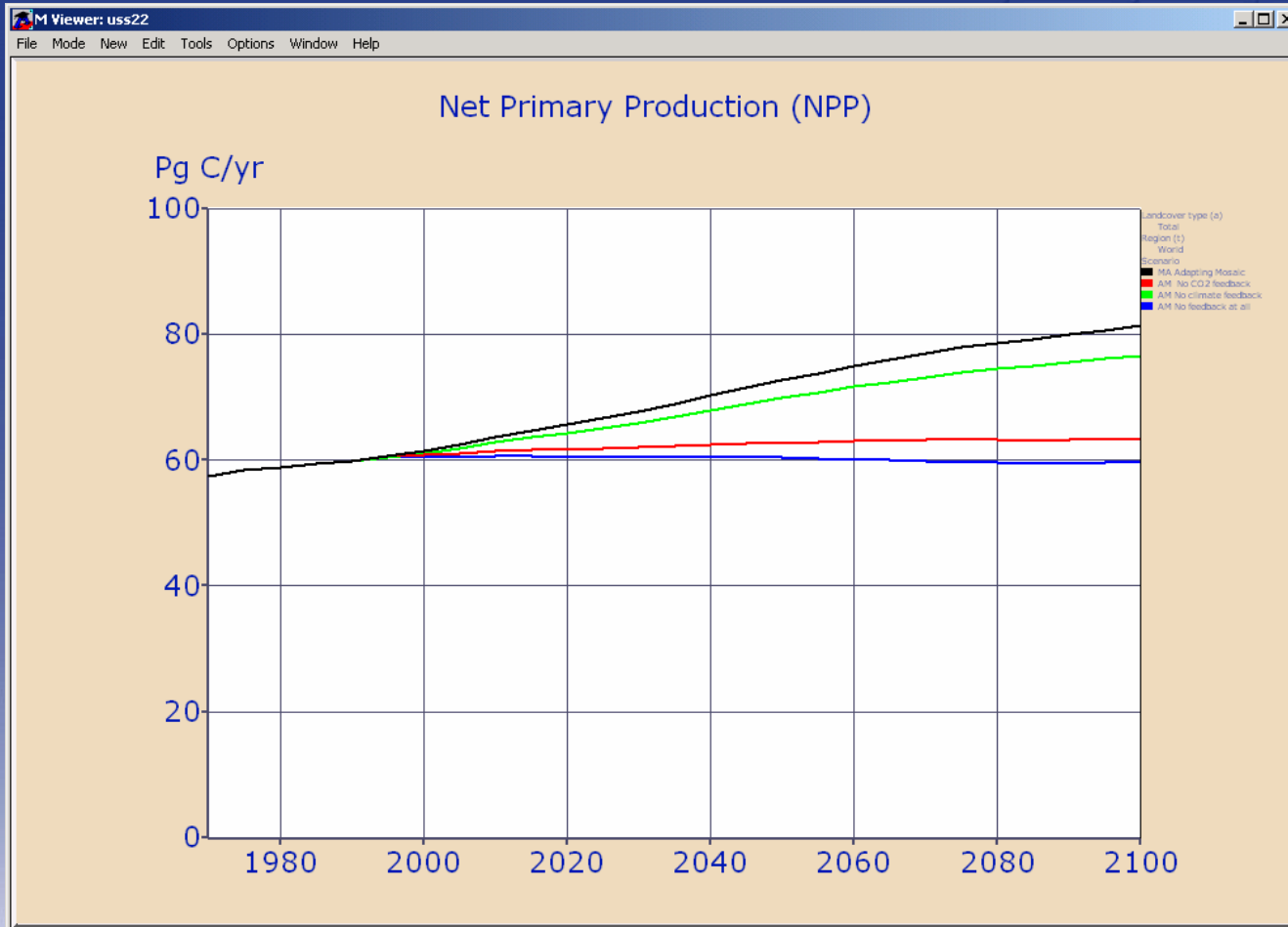
Regionally different results

- CO2 fertilization always increases NPP
- Climate effect can work in two directions:
  – Boreal: climate and CO2 have comparable effect (left)
  – Tropical: NPP is higher without climate feedback (right)
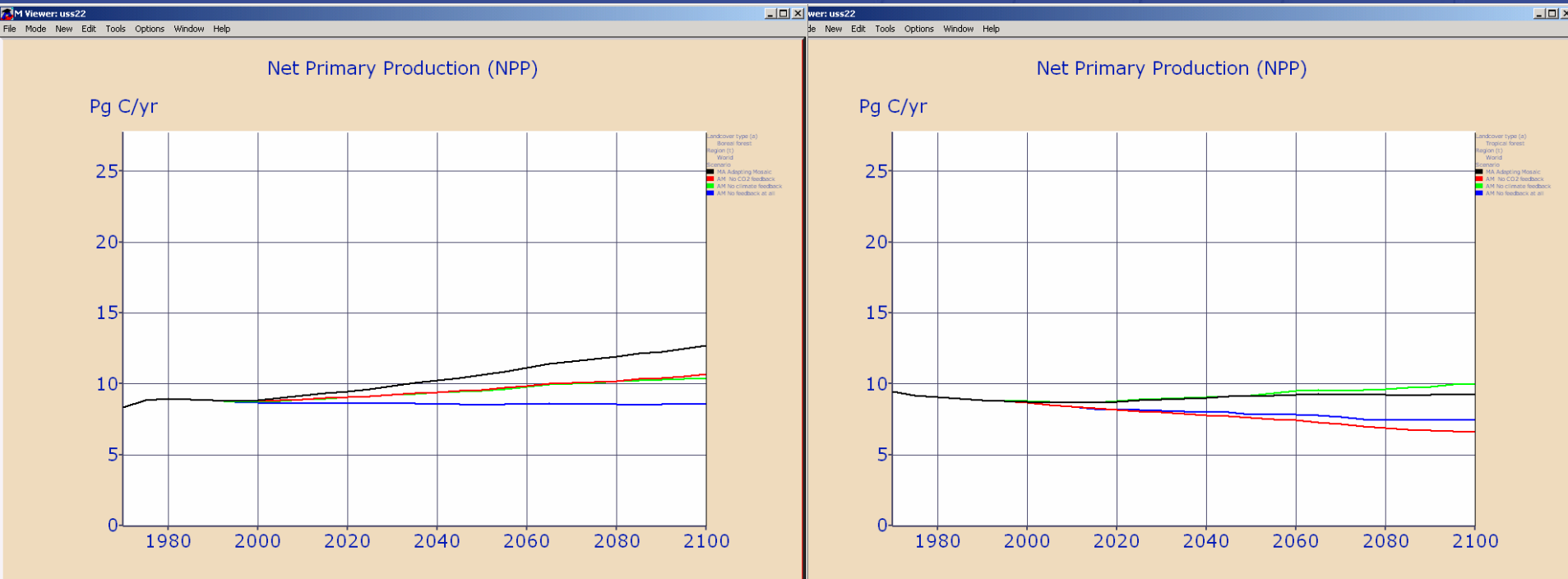
CO2 concentration: big fertilization effect; hardly a net climate effect
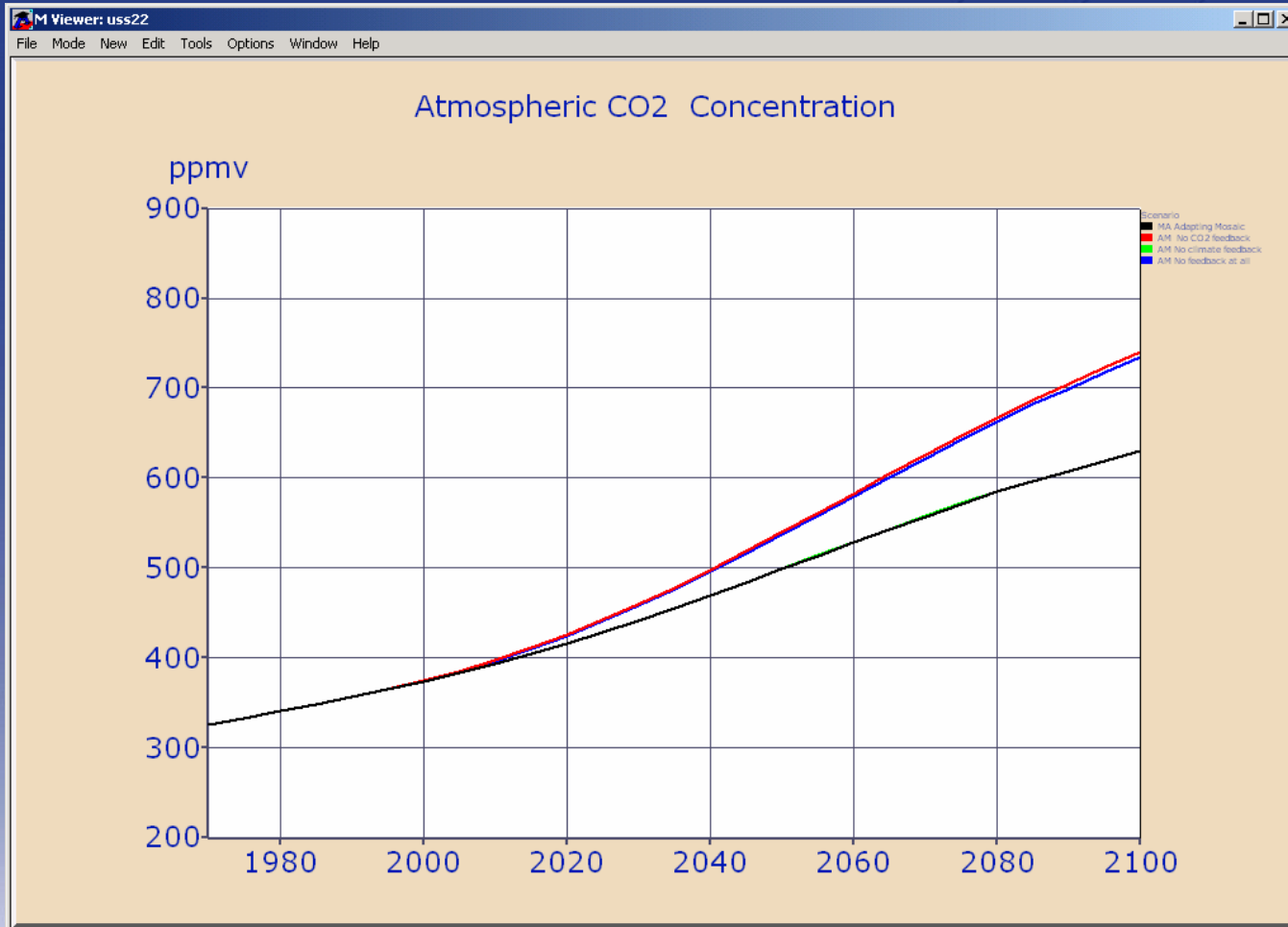
Temperature increase: no CO2 fertilization leads to larger temperature increase
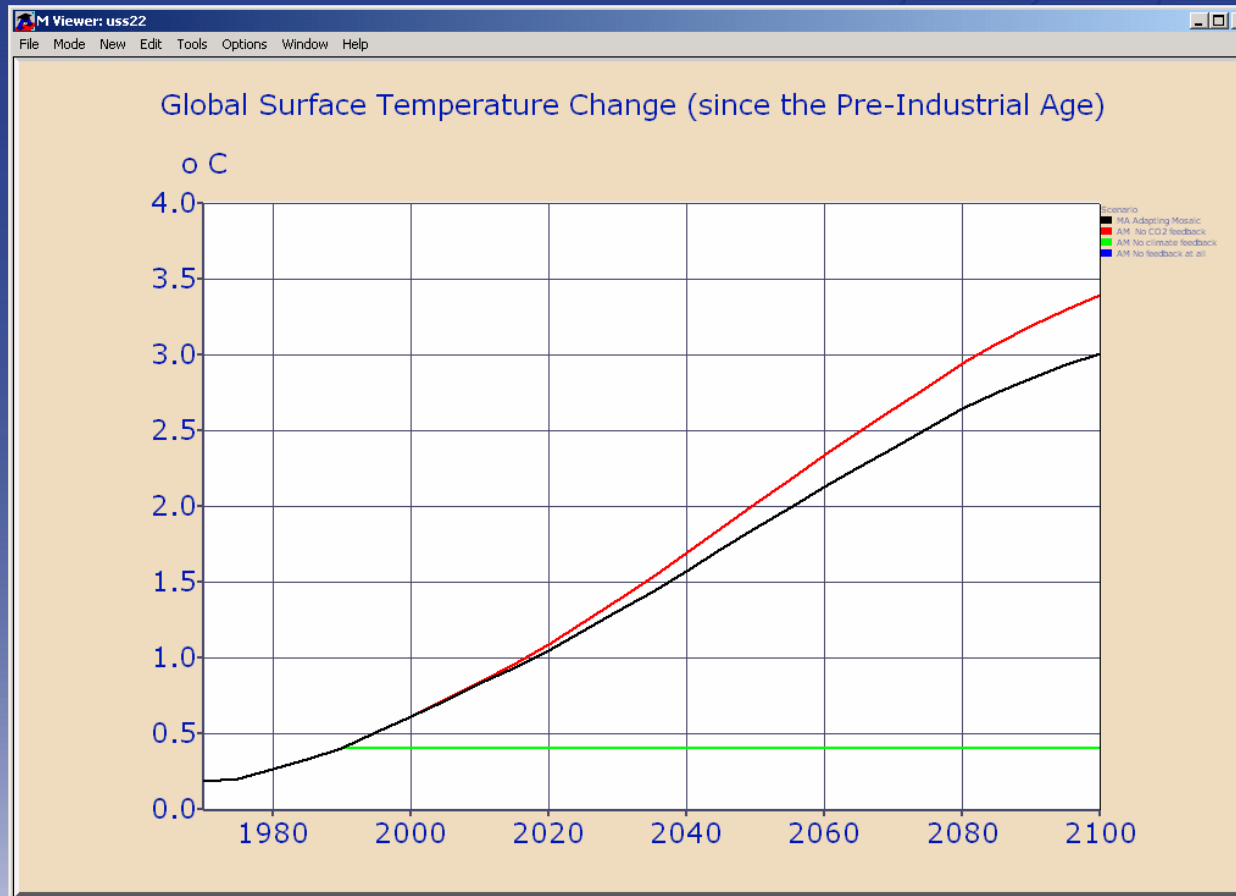
IMAGE 2.4

- Release of IMAGE 2.4 book
- Update of base year to 2000
- 24 regions
- More environmental impacts (nitrogen deposition, biodiversity)
- Linking IMAGE with LEITAP

IMAGE 2.4 Framework
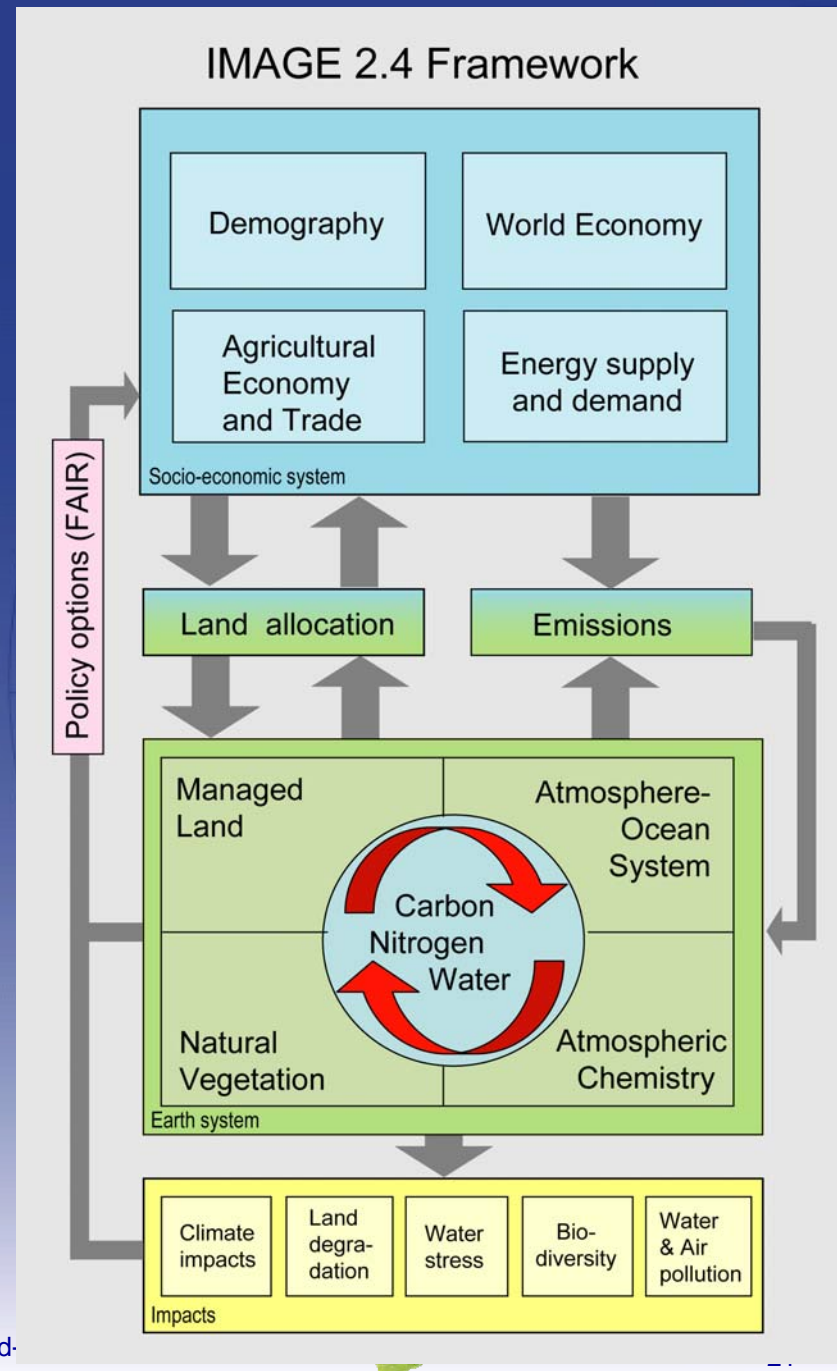
Linking IMAGE and LEITAP

- Endogenizing land supply within LEITAP
  - Availability of land
  - Quality of land

- Including environmental feedbacks into LEITAP
  - CC effects on crop productivity

- Accounting for intensive livestock production
  - Use of grass/fodder and foodcrops

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Taking environmental feedbacks into account

World Vision
(four scenarios
story lines)

economic policy
global technical progress

social development

Economic growth

consumption pattern
international cooperation

Population growth

sectoral technical progress

Demand on and
trade in agricultural
products (GTAP)

production,

mana-

yield,

feed

gement

factor

Land use and
environmental
development
(IMAGE)

conversion

Source: Eickhout et al., in press

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Estimation results of the land supply curve

Land supply curve for :

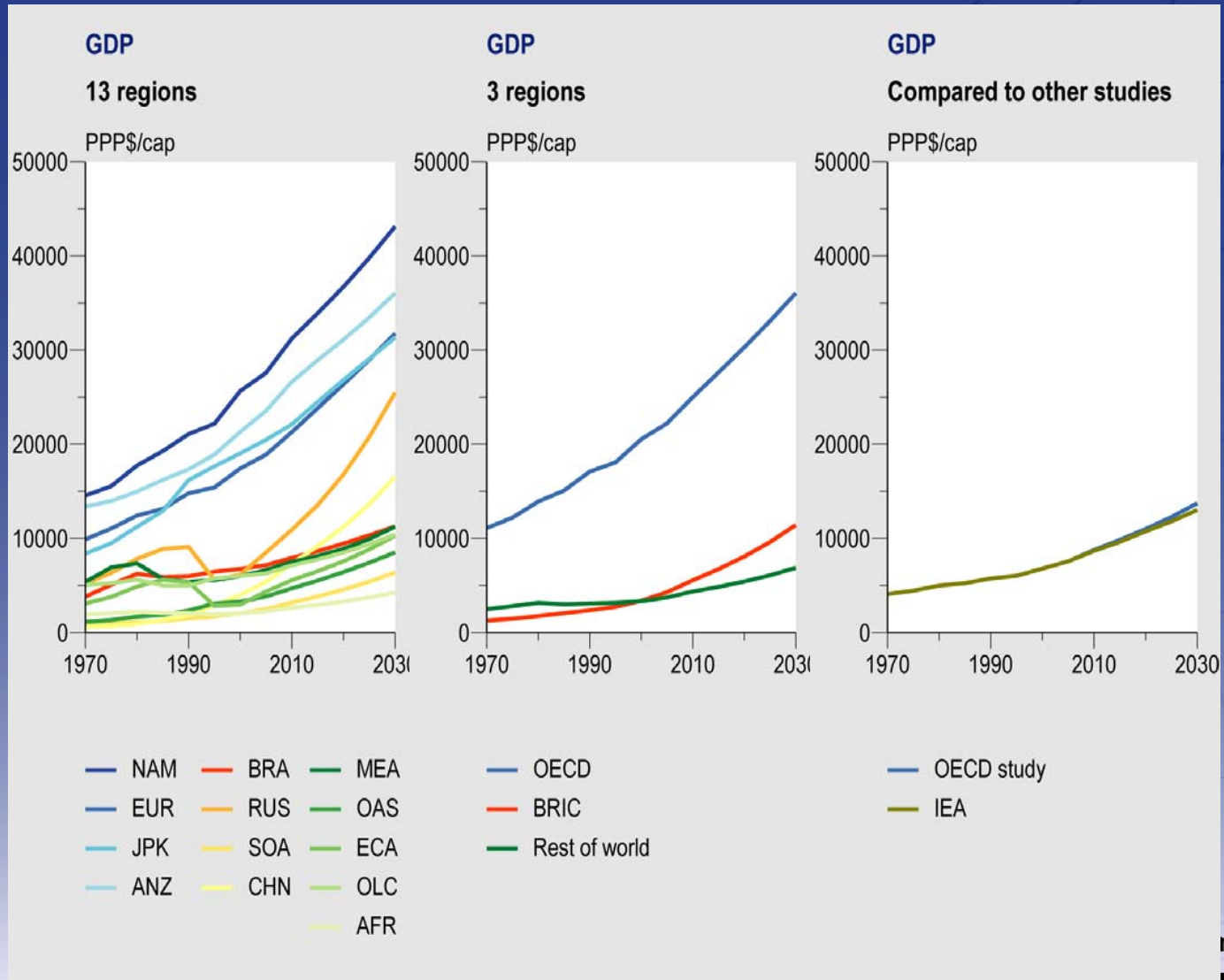| land used	(%)	r	R square
Canada	8.8	3.4	0.97
China	73.0	16.0	0.99

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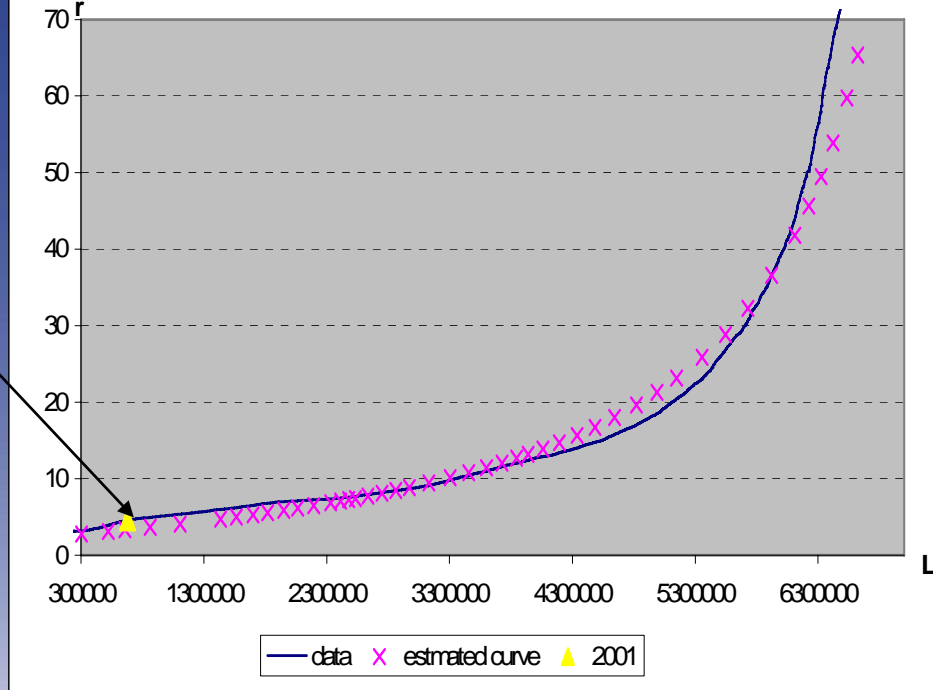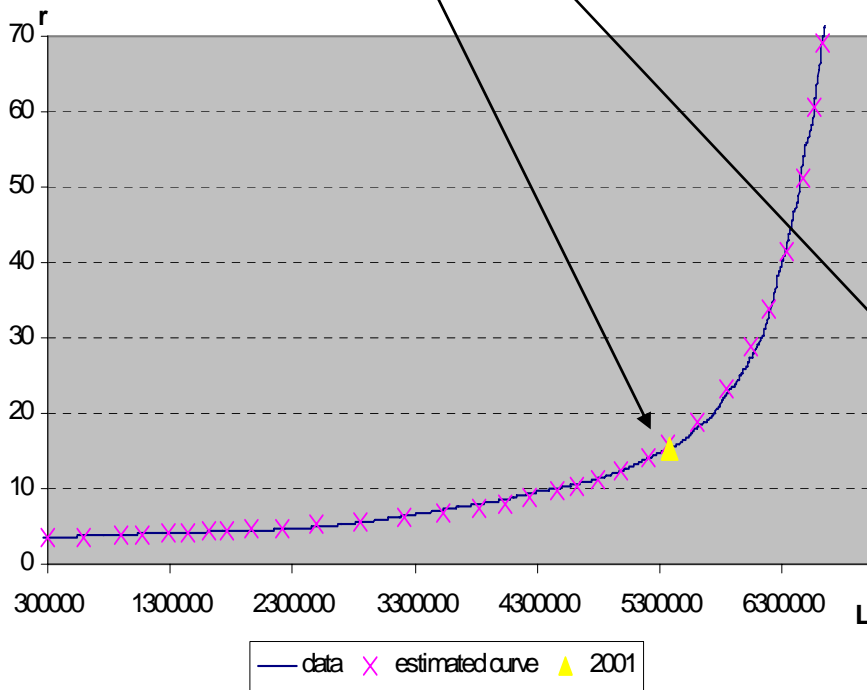
IMAGE 2.4 baseline

- Population: UN Medium
- OECD economic scenario (ENV-Linkages)
- Convergence in labour participation and productivity -> growth rates
- No new policies assumed
- Range of environmental impacts: CC, air quality, land cover, nutrient loading, N-deposition, water stress, risk of erosion, biodiversity
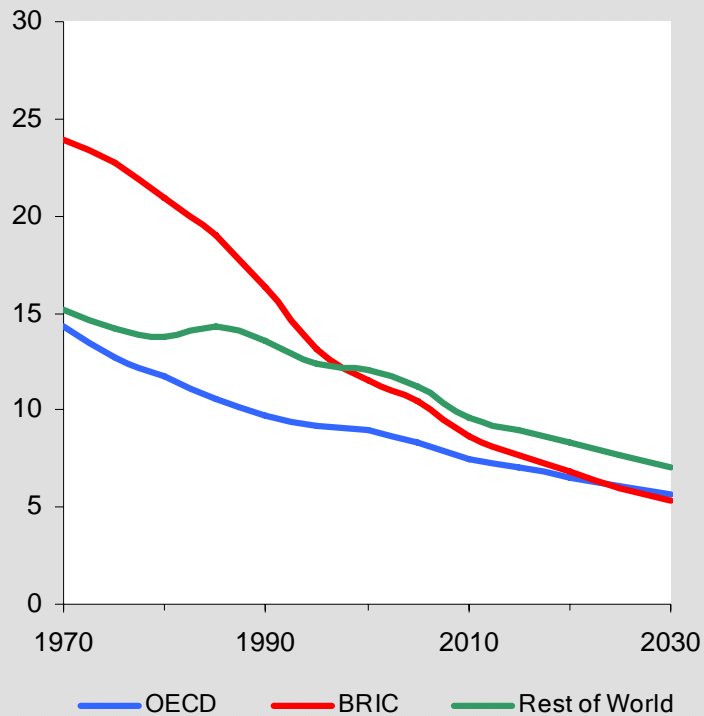
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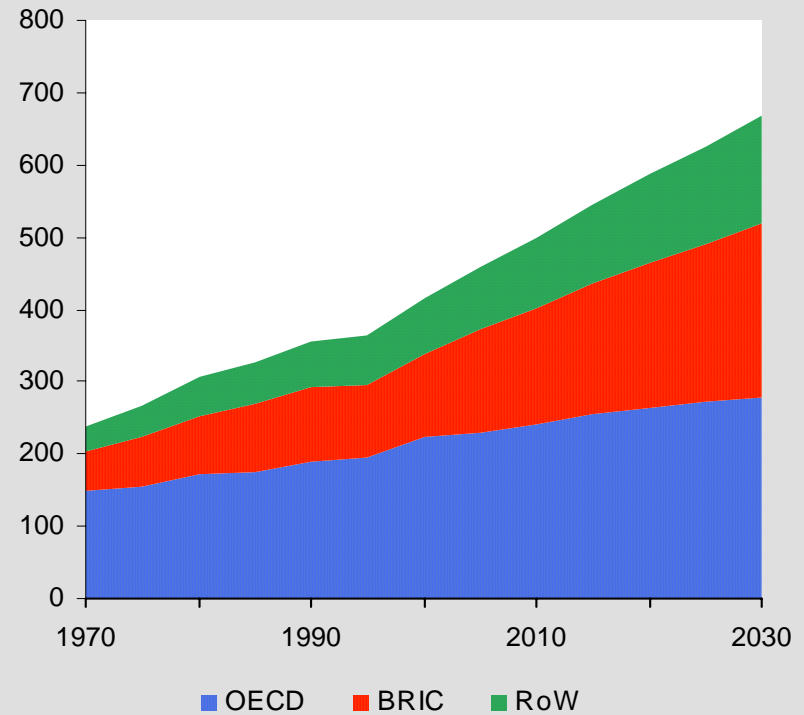
GDP per capita

Energy use

Primary Energy Intensity

MJ/$ppp

OECD — BRIC — Rest of World

Total Primary Energy

EJ

OECD — BRIC — RoW

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CO2 emissions from energy

Global emissions of carbon dioxide — Per sector (billion kg C): Industry, Transport, Residential, Services, Other, Energy transformation, Power generation, Losses/leakages, Bunkers

Global emissions of carbon dioxide — Total emissions per 3 regions (billion kg C): Rest of world, BRIC, OECD

Global emissions of carbon dioxide — Emissions per capita (ton C/cap): OECD, BRIC, Rest of world, World

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Crop production

Production of food crops

Gton/yr

Legend:
- Oil crops
- Roots & tubers
- Pulses
- Tropical cereals
- Maize
- Rice
- Temperate cereals

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Animal production (more poultry)

Production of animal products

Mton/yr

Legend:
- Poultry & eggs
- Mutton & goat meat
- Pork
- Milk
- Beef
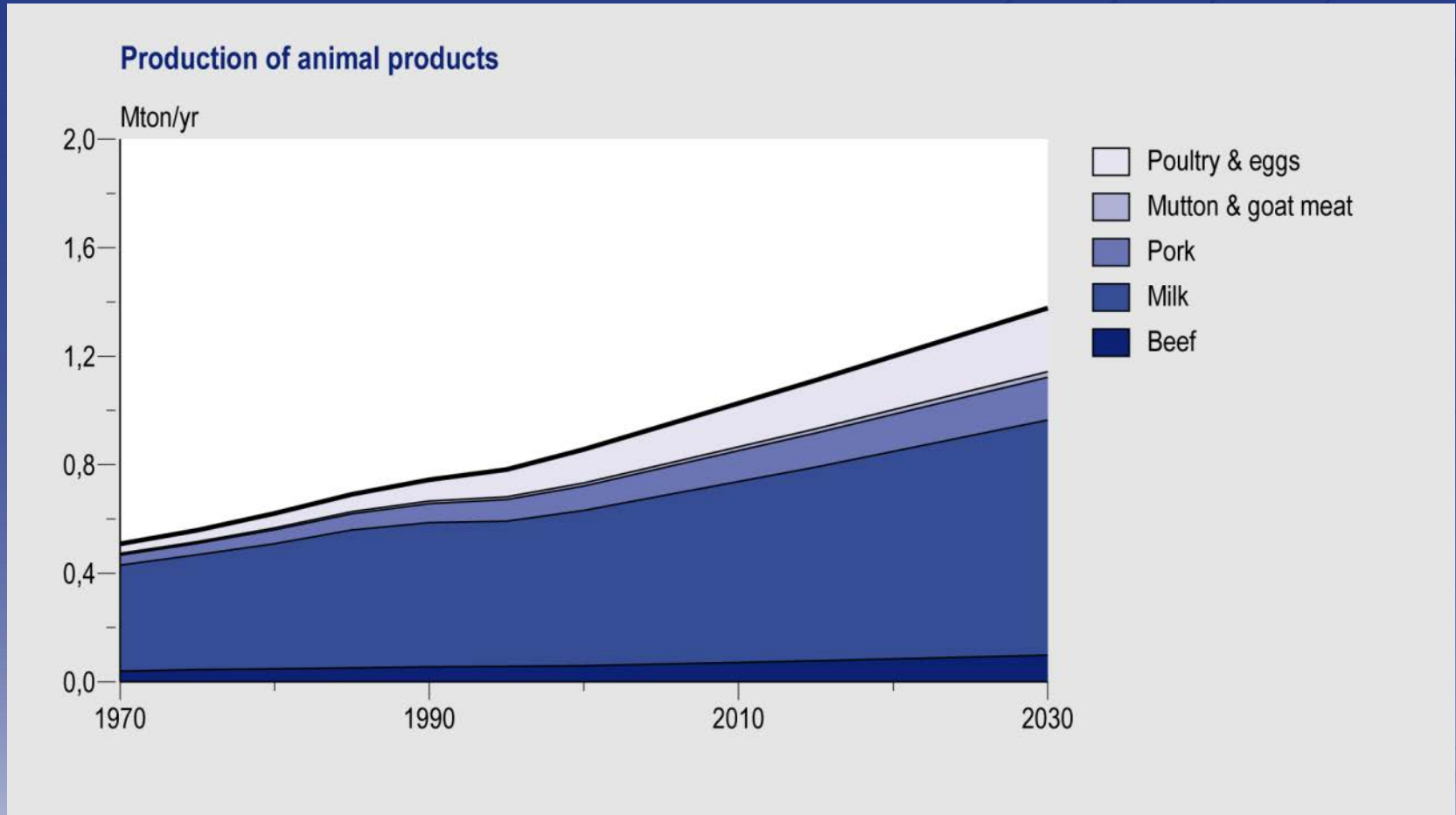
Land-use
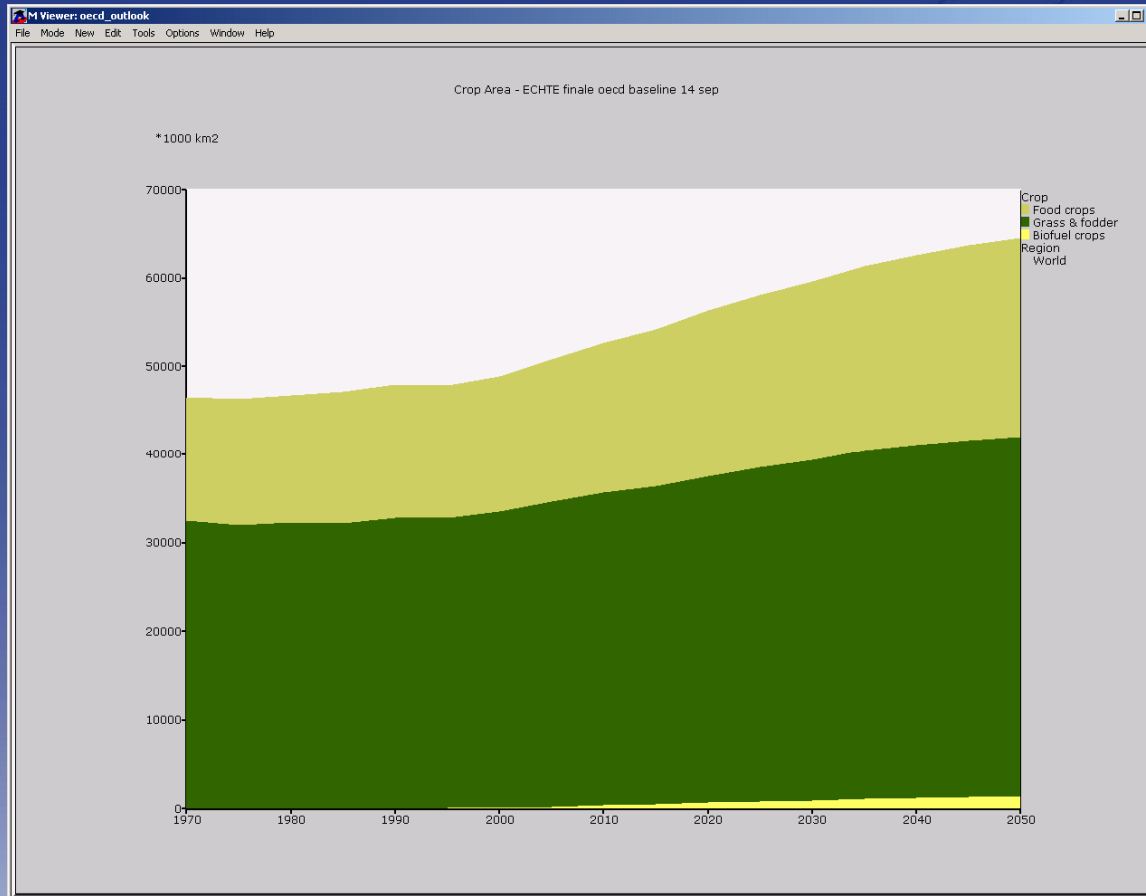
Land Cover - 2000 - OECD Baseline
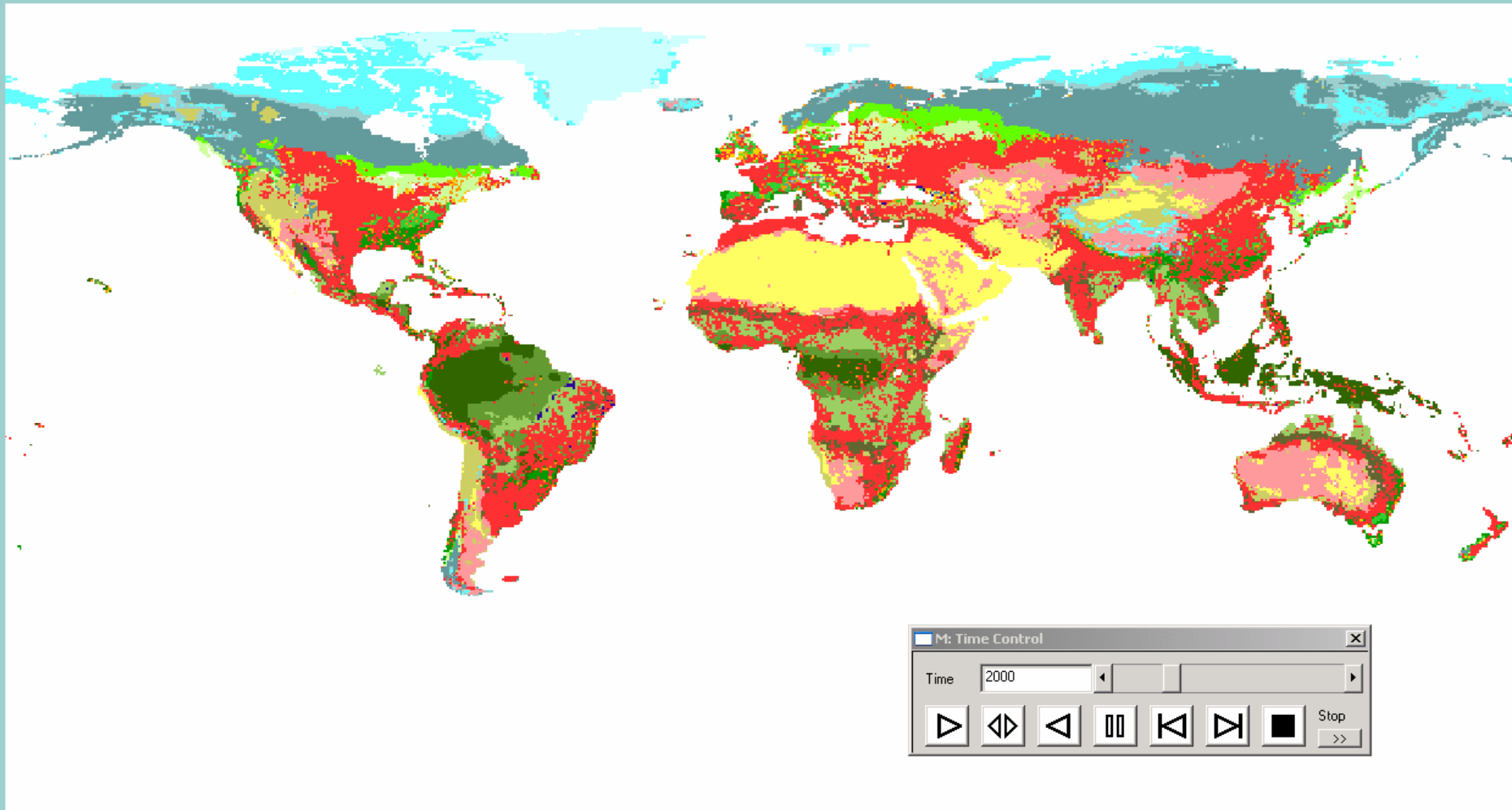
Agricultural land	Tundra	Grassland/ steppe
Extensive grassland	Wooded tundra	Hot desert
C plantations	Boreal forest	Scrubland
Regrowth forest (Abandoning)	Cool conifer	Savanna
Regrowth forest (Timber)	Temp. mixed forest	Tropical woodland
Biofuel	Temp. decid. forest	Tropical forest
Ice	Warm mixed forest	

Land Cover - 2030 - OECD Baseline
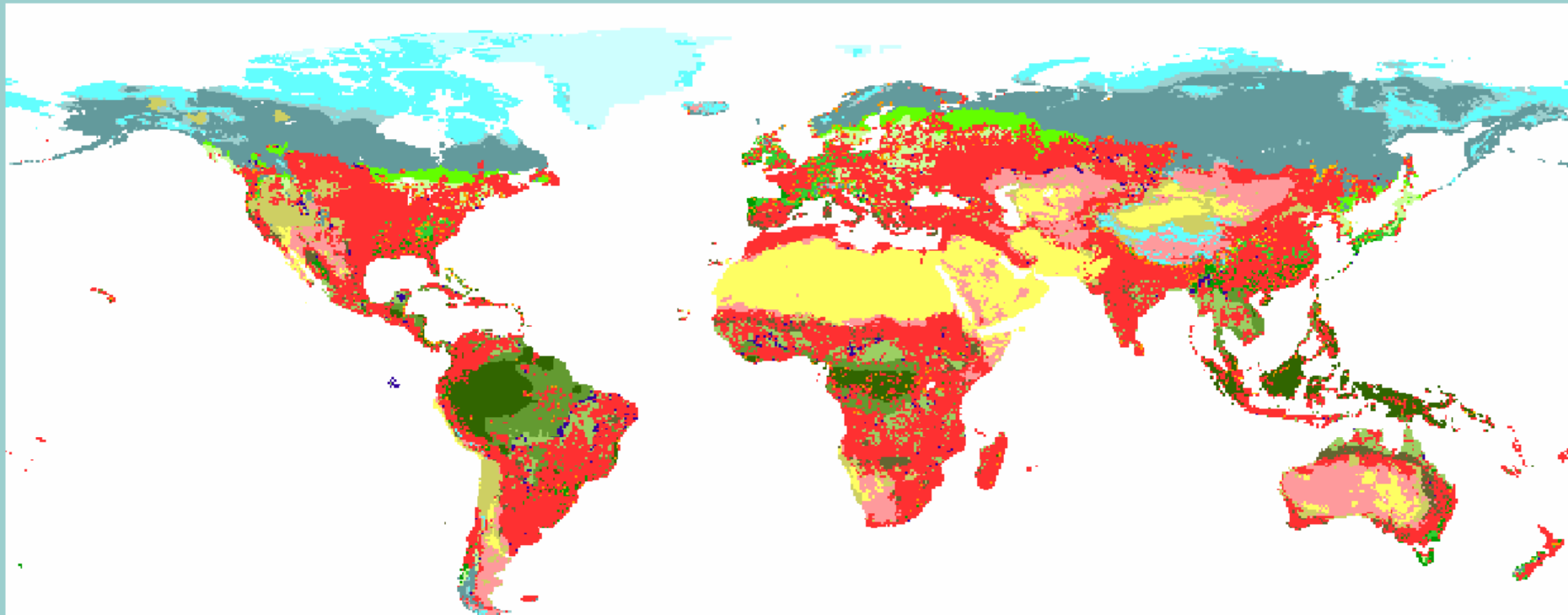
Agricultural land	Tundra	Grassland/ steppe
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Regrowth forest (Timber)	Temp. mixed forest	Tropical woodland
Biofuel	Temp. decid. forest	Tropical forest
Ice	Warm mixed forest	

Sensitivity: increasing / decreasing yields ..

Blue: central assumption
Black: 2x yield increase rate
Red: 0.5x yield increase rate

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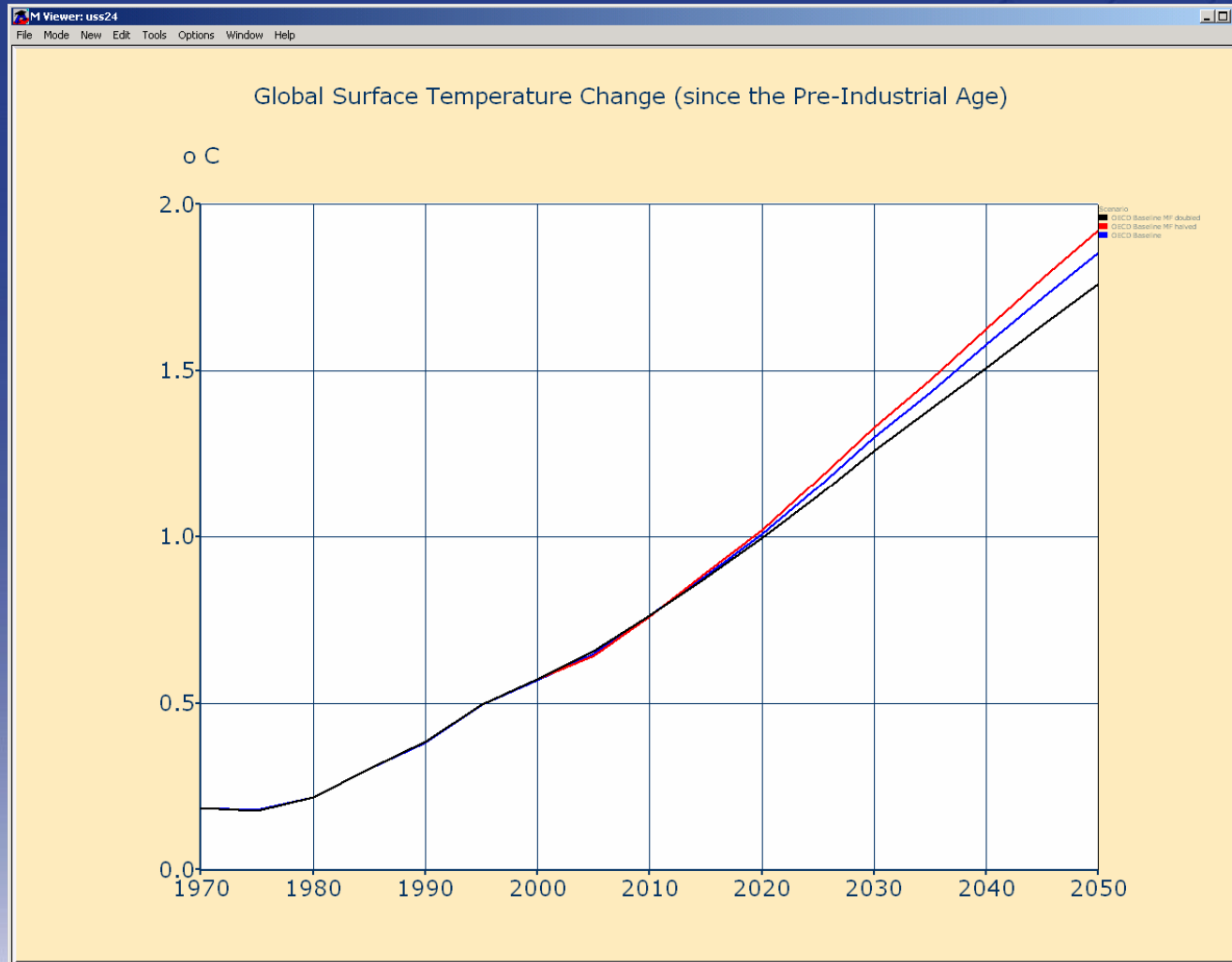Assessment Agency
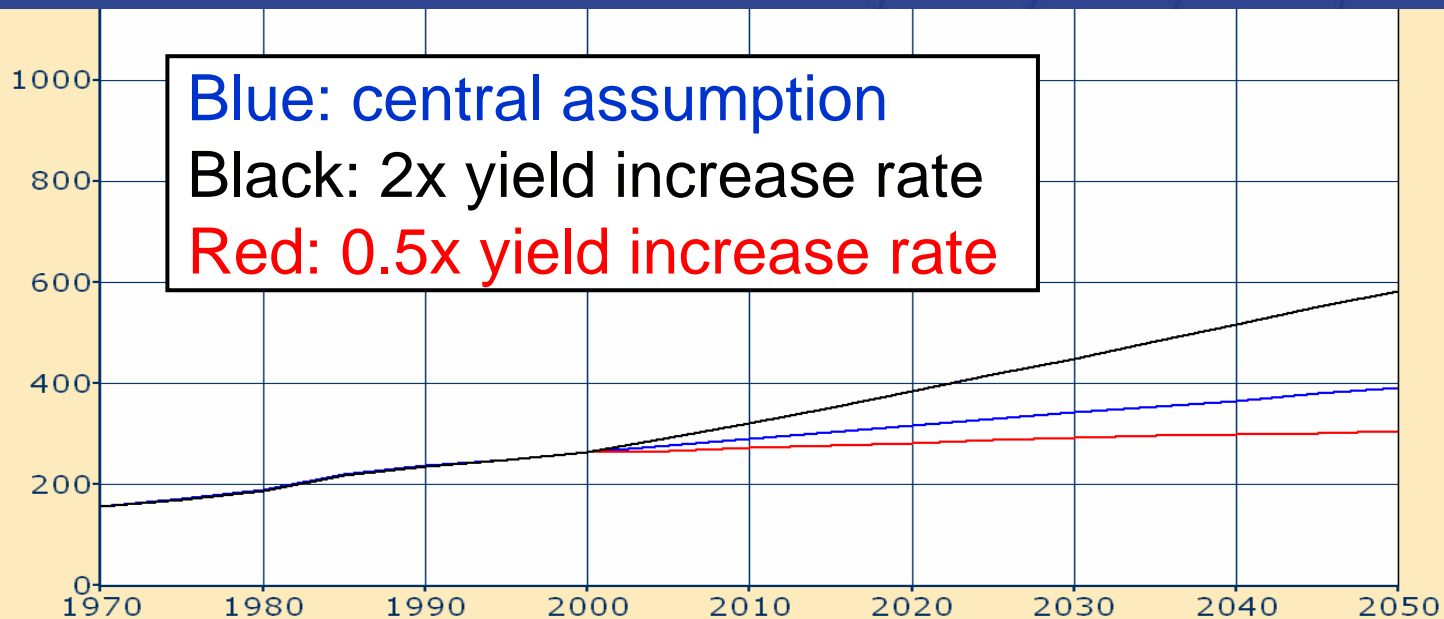
.. have a big effect on foodcrop area

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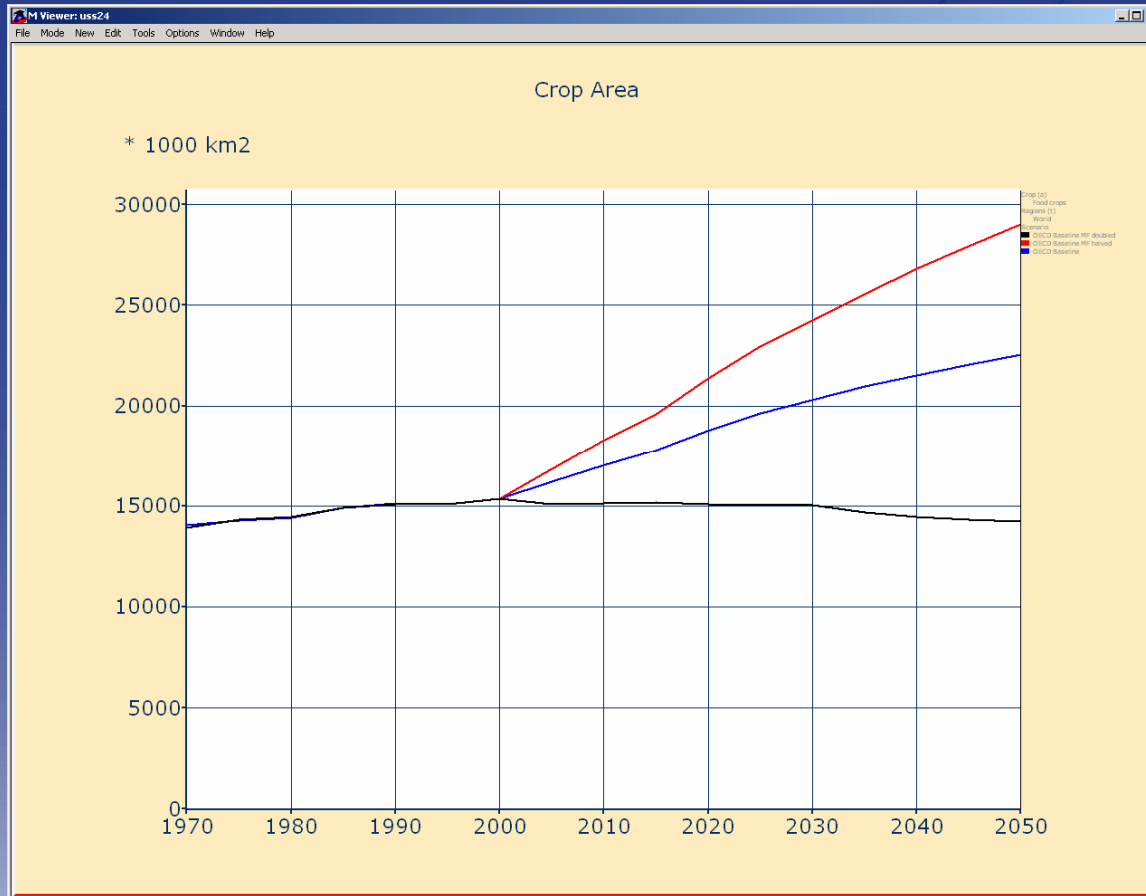
.. on CO2 concentration
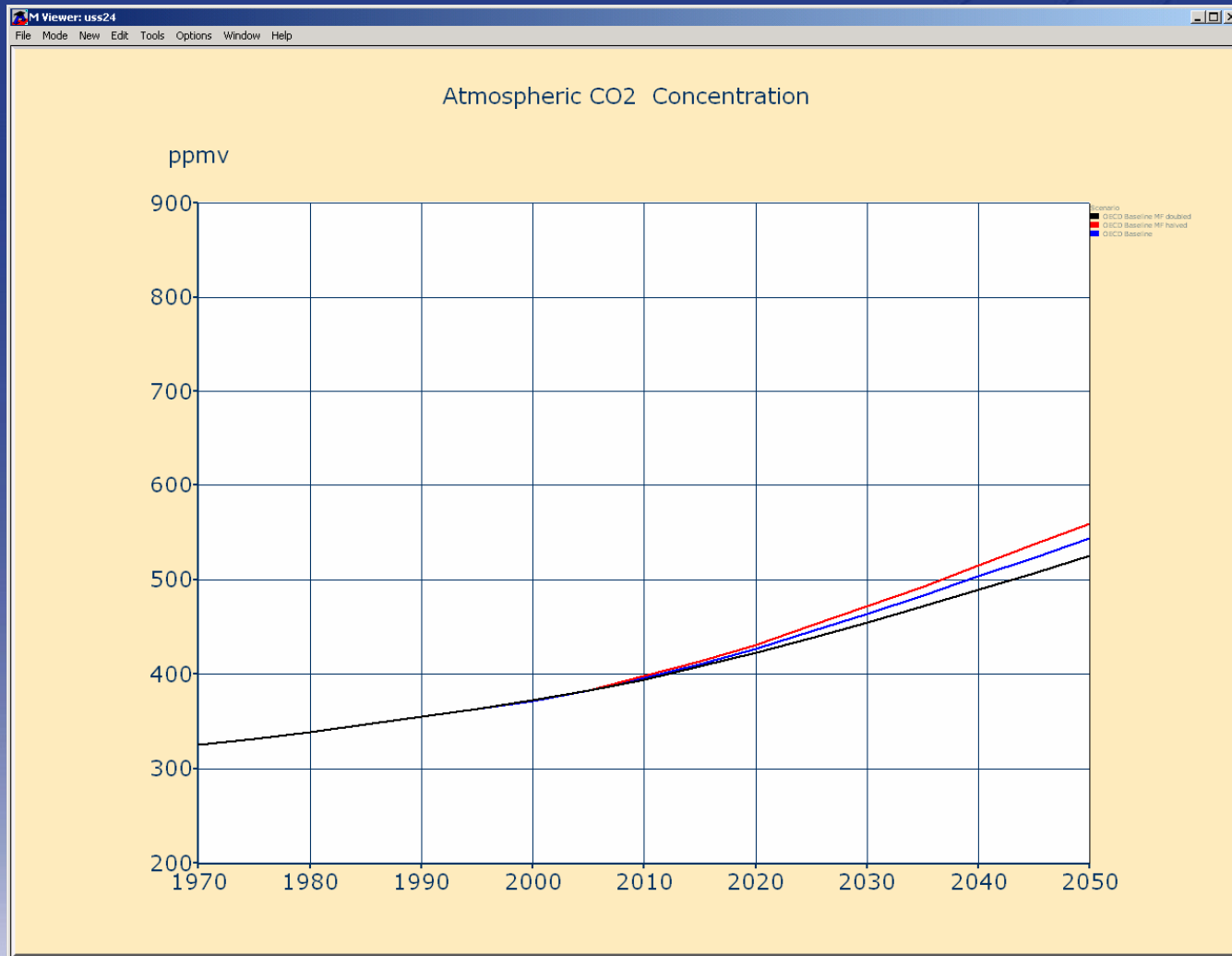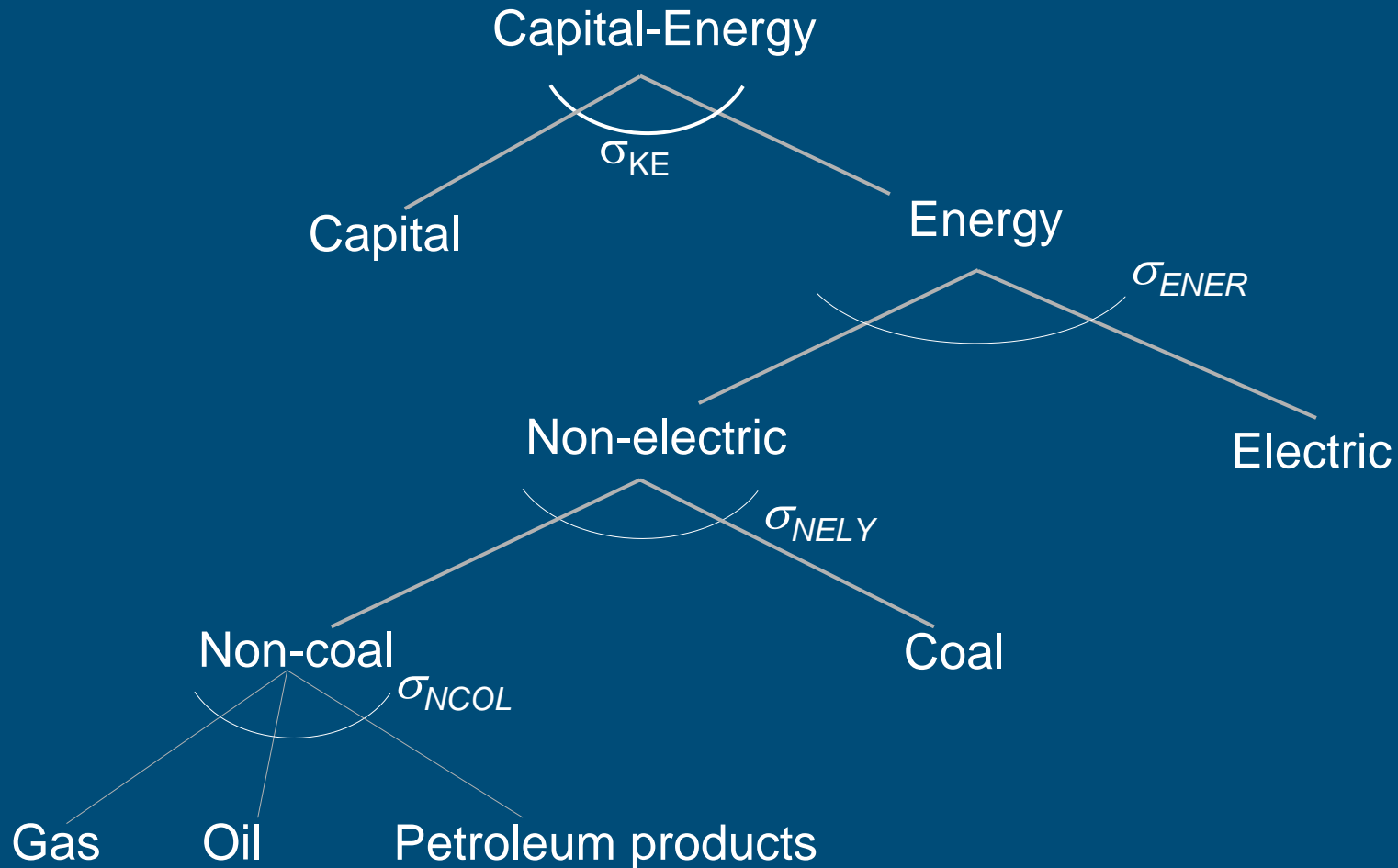
… and mean global surface temperature

Future plans

- Work of LEITAP (Martin Banse and Hans van Meijl) on including bio-energy production coupled with IMAGE/TIMER

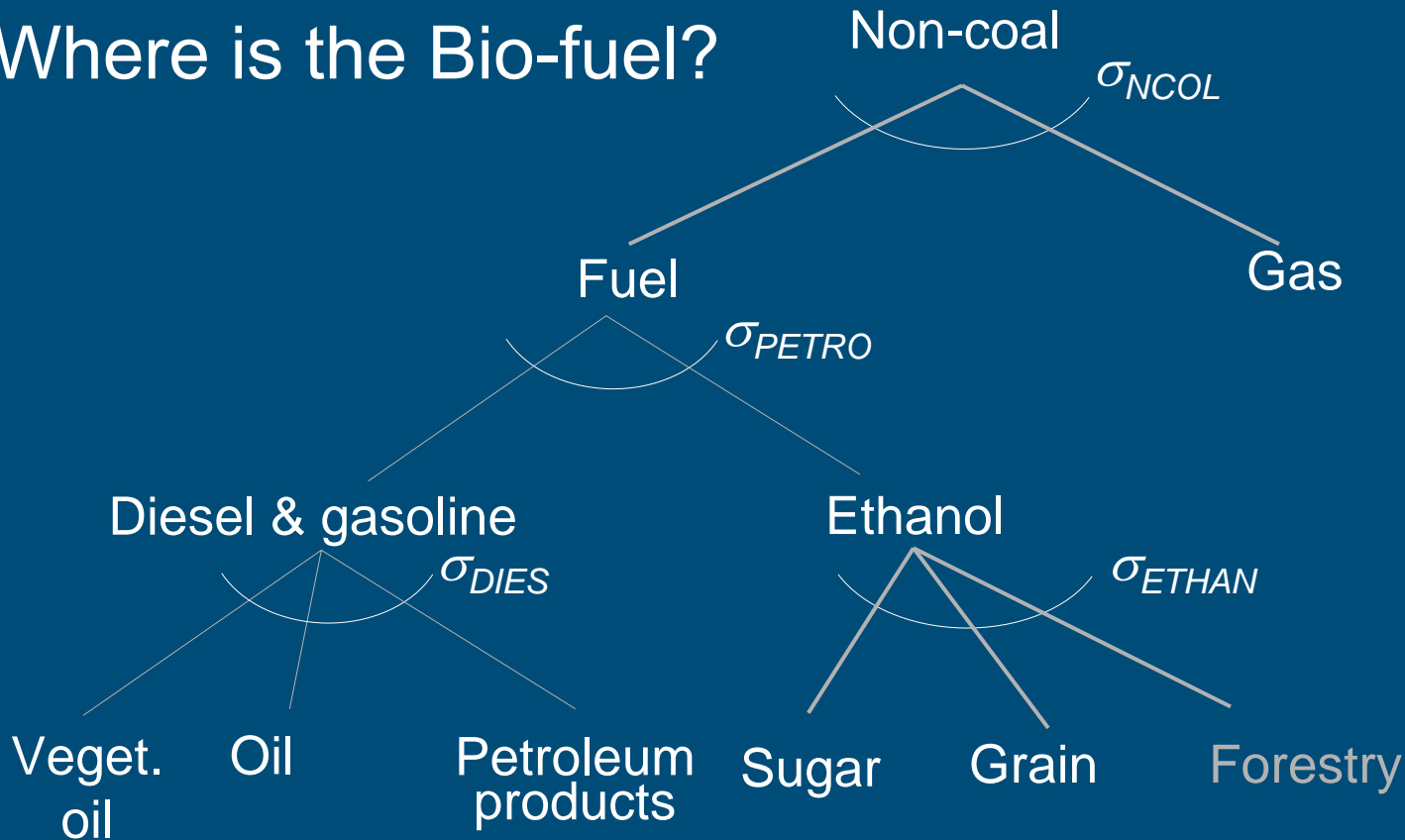- Dynamic climate (SPEEDY), vegetation (LPJ) and crop growth (LPJ-ml/Lintul) – not today!

Figure: GTAP-E: Capital-Energy Composite

Where is the Bio-fuel?

Thank you for your attention

www.mnp.nl/en
or
www.mnp.nl/image

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