POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Exploration of the SSP space with the ReMIND-MAgPIE integrated assessment framework

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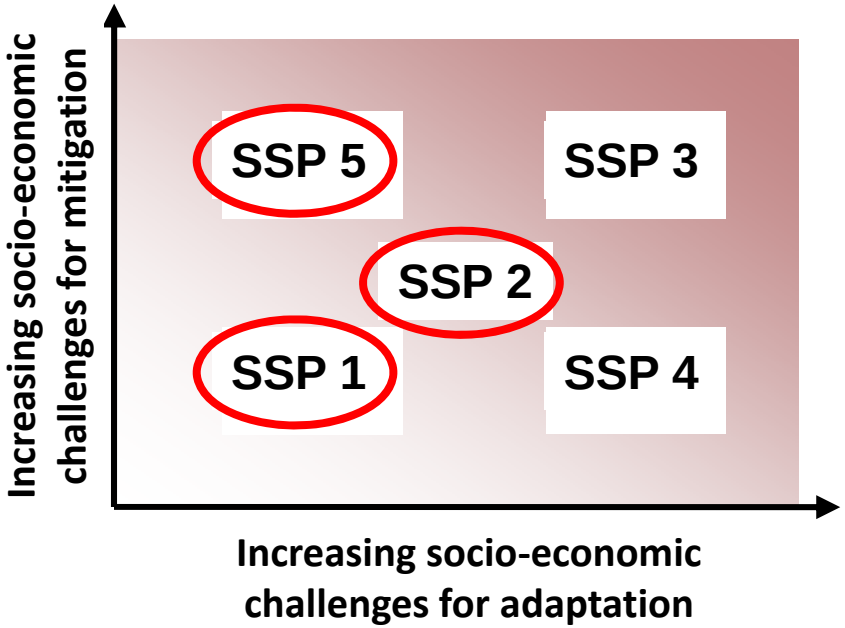
SSP workshop, Snowmass, 25 July 2012

Leibniz Gemeinschaft

Potsdam Institute for Climate Impact Research
Research Domain Sustainable Solutions

Exploring the SSP space



- What IAM input assumptions to vary across SSP1, 2, 5 (beyond GDP & Pop)?
- What fossil fuel use / energy demand / emissions / forcing range (relating to challenges for mitigation) is spanned between SSP1 &5?

Focus on SSP1, 2, 5 because of global market assumption in model framework

All results are preliminary!

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Model framework

ReMIND - global energy-economy-climate model

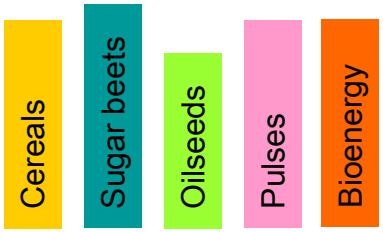
- Ramsey optimal growth model
- 11 economic regions
- detailed energy sector (~70 conversion techs)
- international trade (capital, emissions allowances, oil, coal, gas, biomass)

Leimbach, Bauer, Baumstark, Edenhofer (2009) Environ. Modeling and Assessment
Bauer, Baumstark, Leimbach (2012) Climatic Change
Luderer, Pietzcker, Kriegler, Haller, Bauer (2012) Energy Economics

Climate projection

LPJmL - global vegetation and hydrology model

Crop yields
Land & Water constraints



LPJ (50x50 km grid)

Biophysical inputs

Bioenergy price, land use emissions ⇑

Bioenergy demand, emissions price ⇓

MAgPIE – global land use optimisation model

- spatially explicit (0.5°), 10 economic regions
- 30 production activities (13 crops, livestock, irrigation, bioenergy, land conversion)
- internal feed balances, international trade
- endogenous land expansion
- endogenous technological change

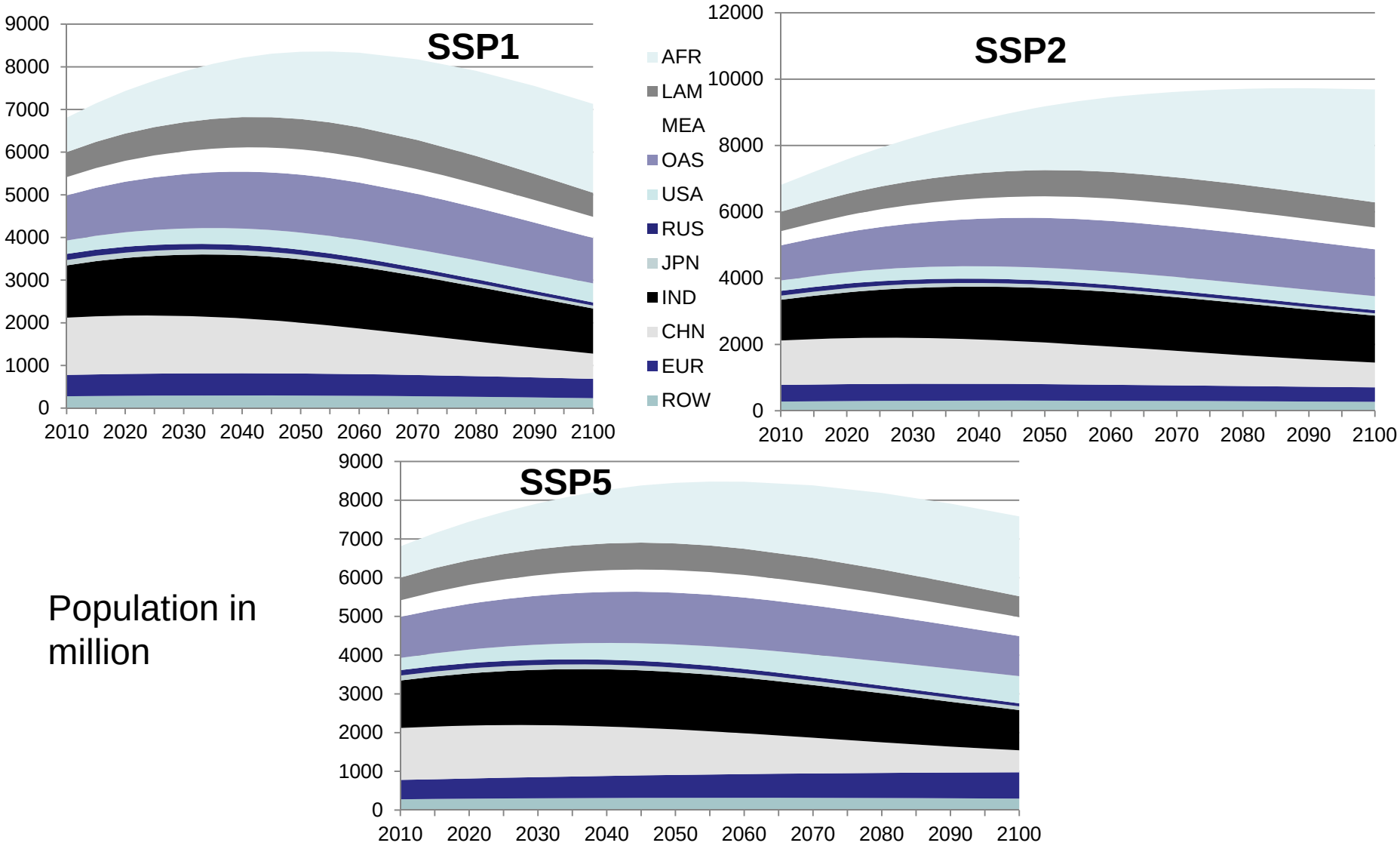
Lotze-Campen , Popp et al. (2008), Agricultural Economics

P I K

Variation of SSP input assumptions

Indicator	Parameter	SSP1	SSP5	SSP 2
Population	Population growth (IIASA scenarios)	Low	Low	Medium
Economy	GDP growth (OECD scenarios)	Very High	High	Medium
	Convergence of per capita income (OECD scenarios)	Fast	Fast	Medium
	Convergence of capital intensities	Yes	Yes	No
Technology	Resource extraction Coal/oil/gas	Low/low/low	High/high/medium	Medium/medium/medium
	Solar (PV and CSP) and wind power	Optimistic / low cost	Pessimistic / high cost	Optimistic / medium cost
Environment	Fossil fuel subsidies	Phase out until 2030	Constant	Phase out until 2050
	Petrol / diesel taxes	Convergence to 10 $/GJ by 2050	Constant	Constant
	Taxes on air pollutants	High	High	Medium
	Energy intensity	Low	High	Medium
	Forest/ecosystem protection	High	Low.-Medium	Low-Medium
Behaviour	Food demand incl food waste (Total calory per capita)	Low	High	Medium
	Per capita demand for livestock products	Low	High	Medium
Globalization/Trade	Free trade pool (MAgPIE)	Medium	High	Low

SSP Population Scenarios (IIASA)



Population in million

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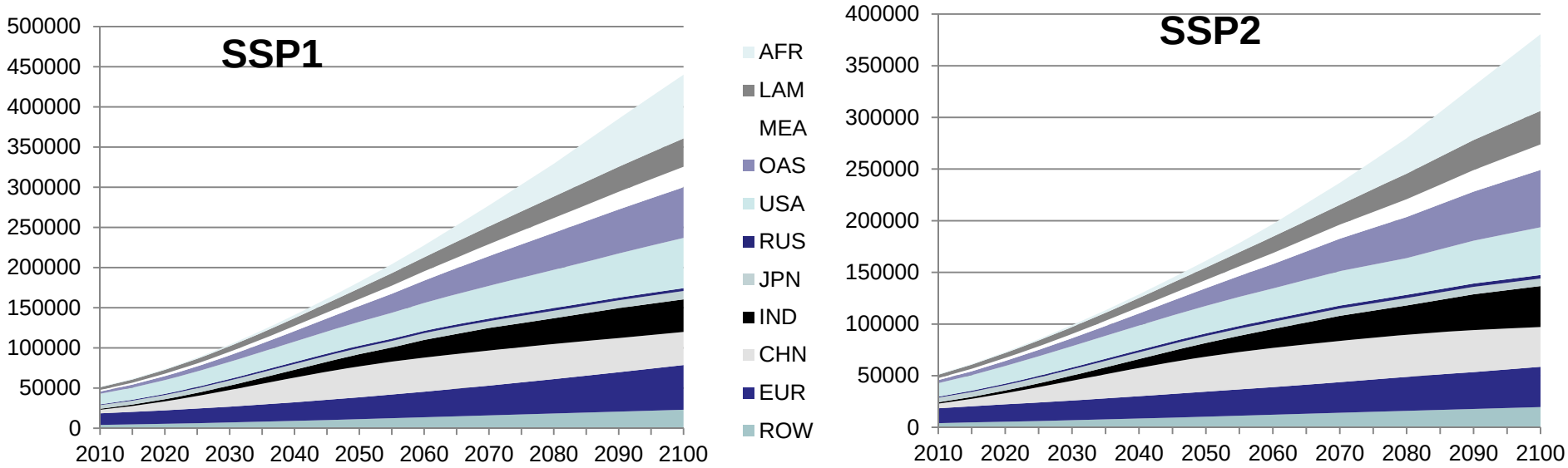
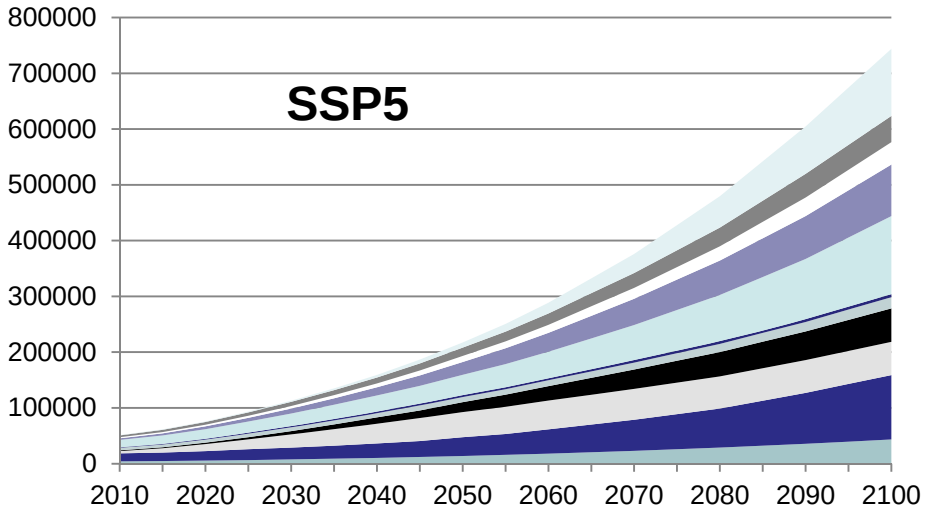
SSP GDP scenarios (OECD)



GDP in billion USD(2005) at MER



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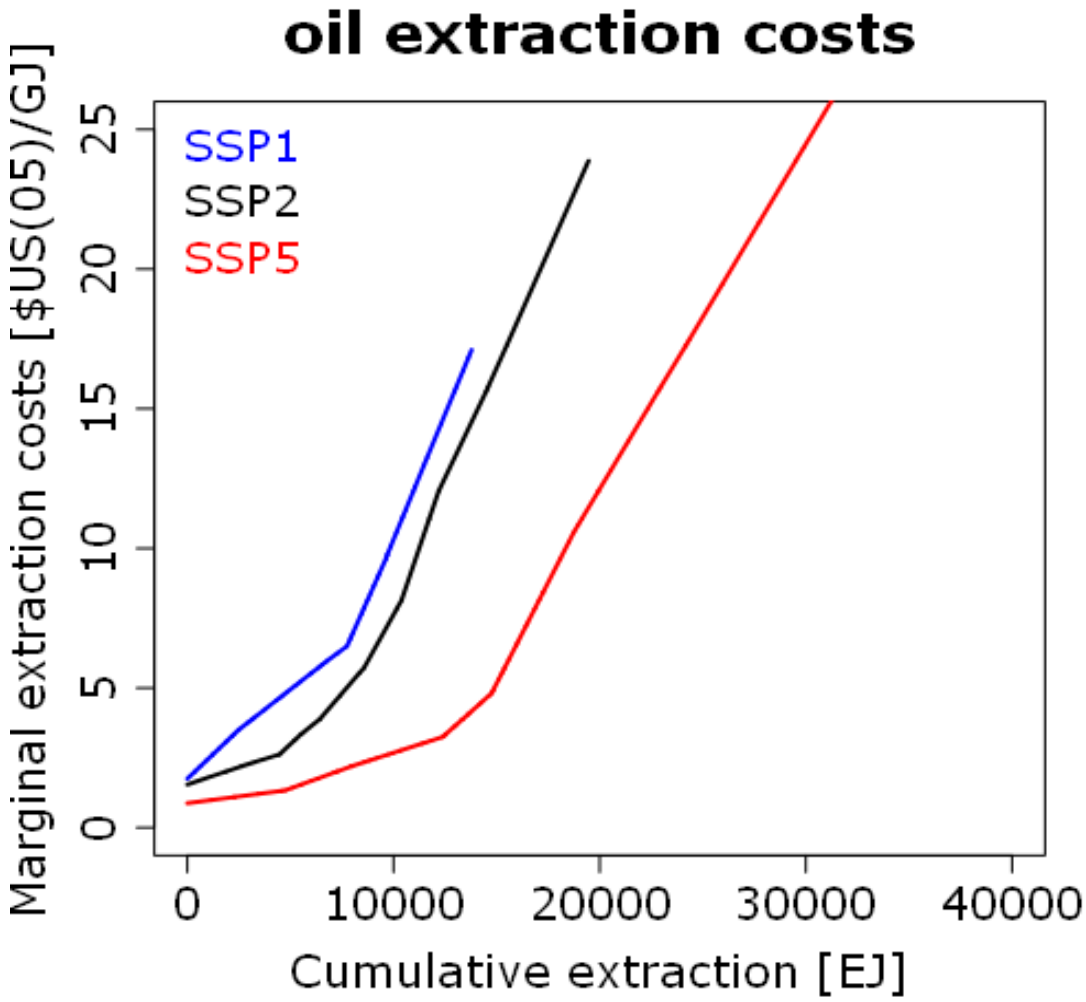
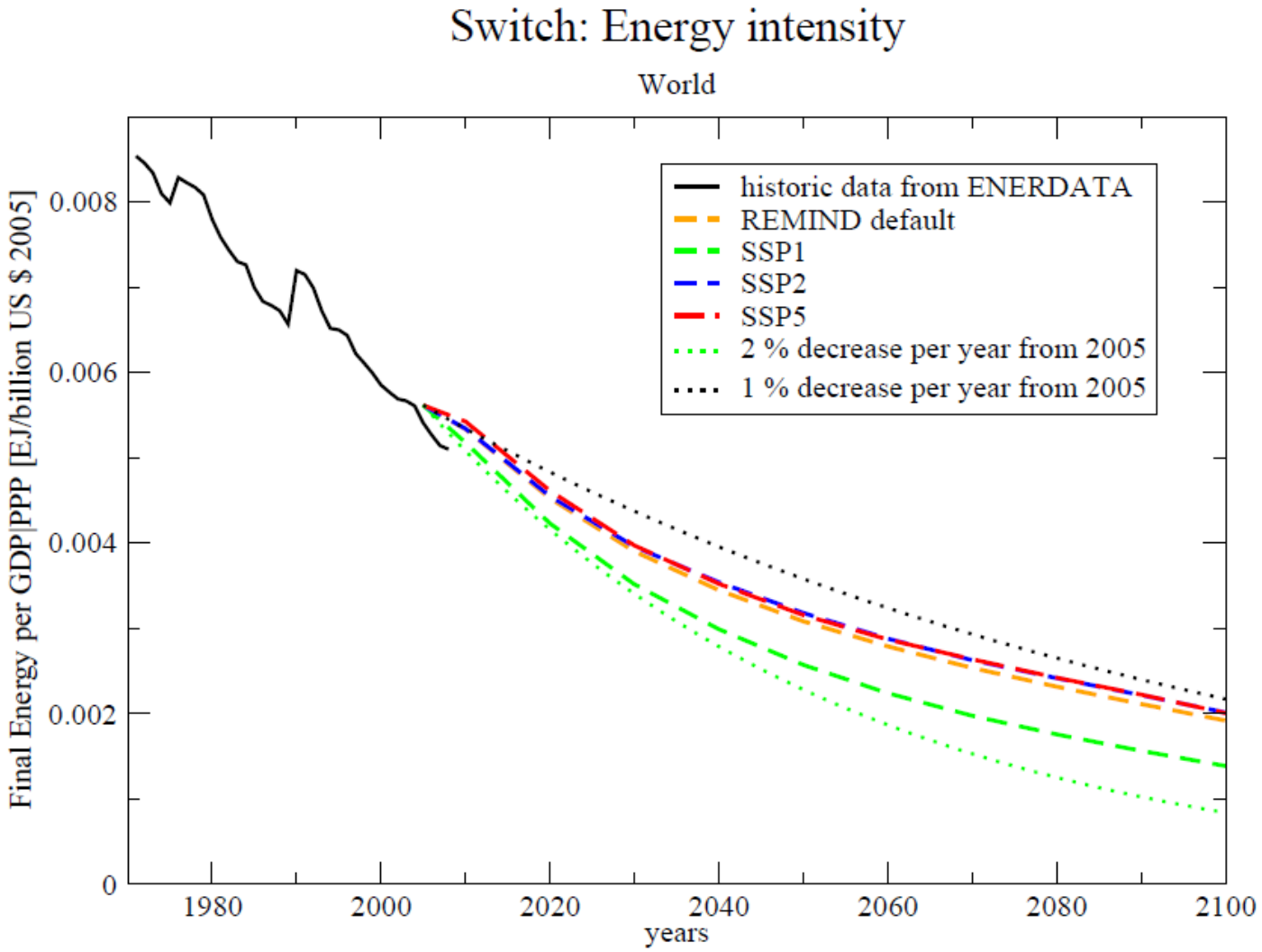
Fossil resource assumptions



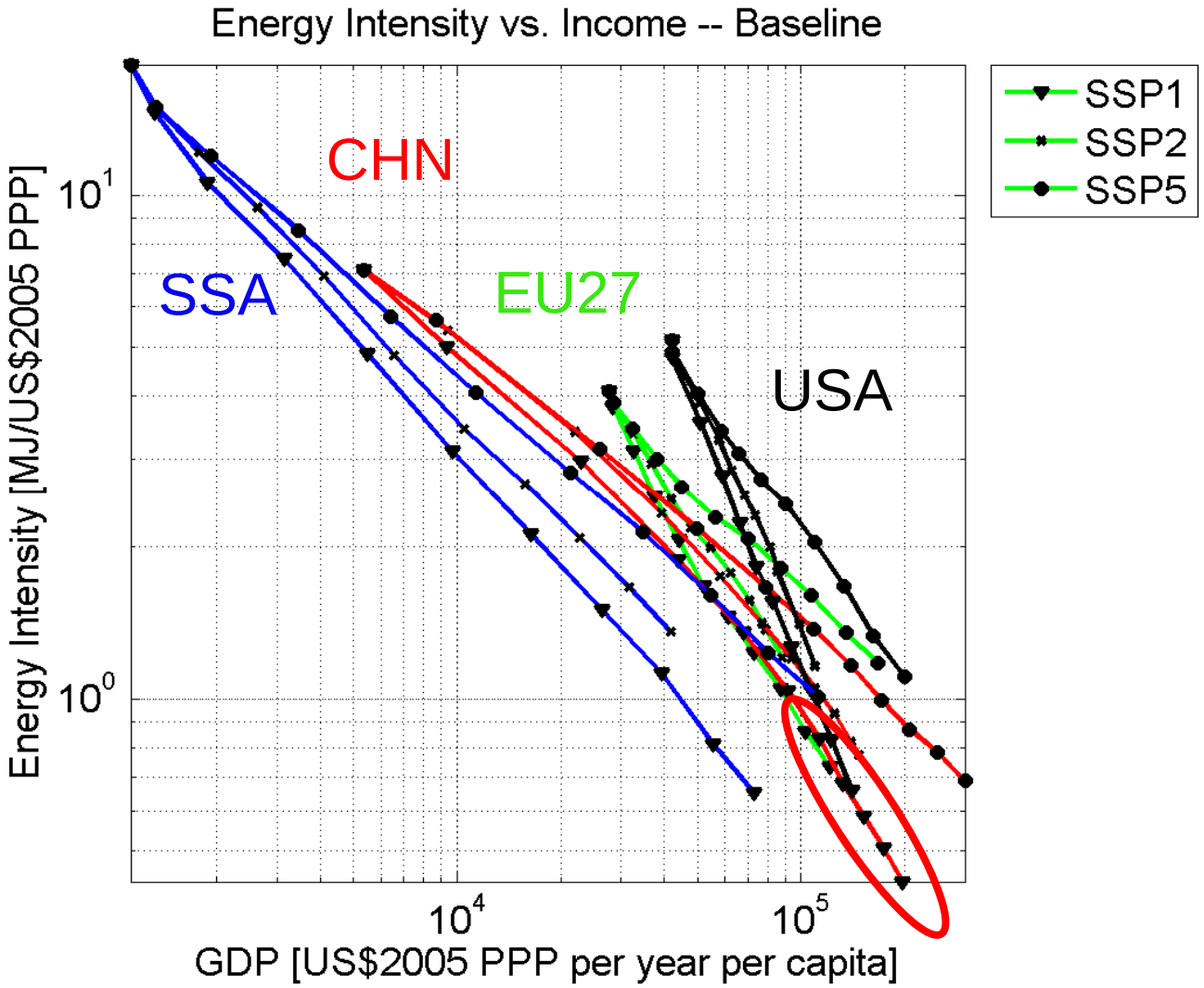
Preliminary

Assumptions on final energy intensity improvements



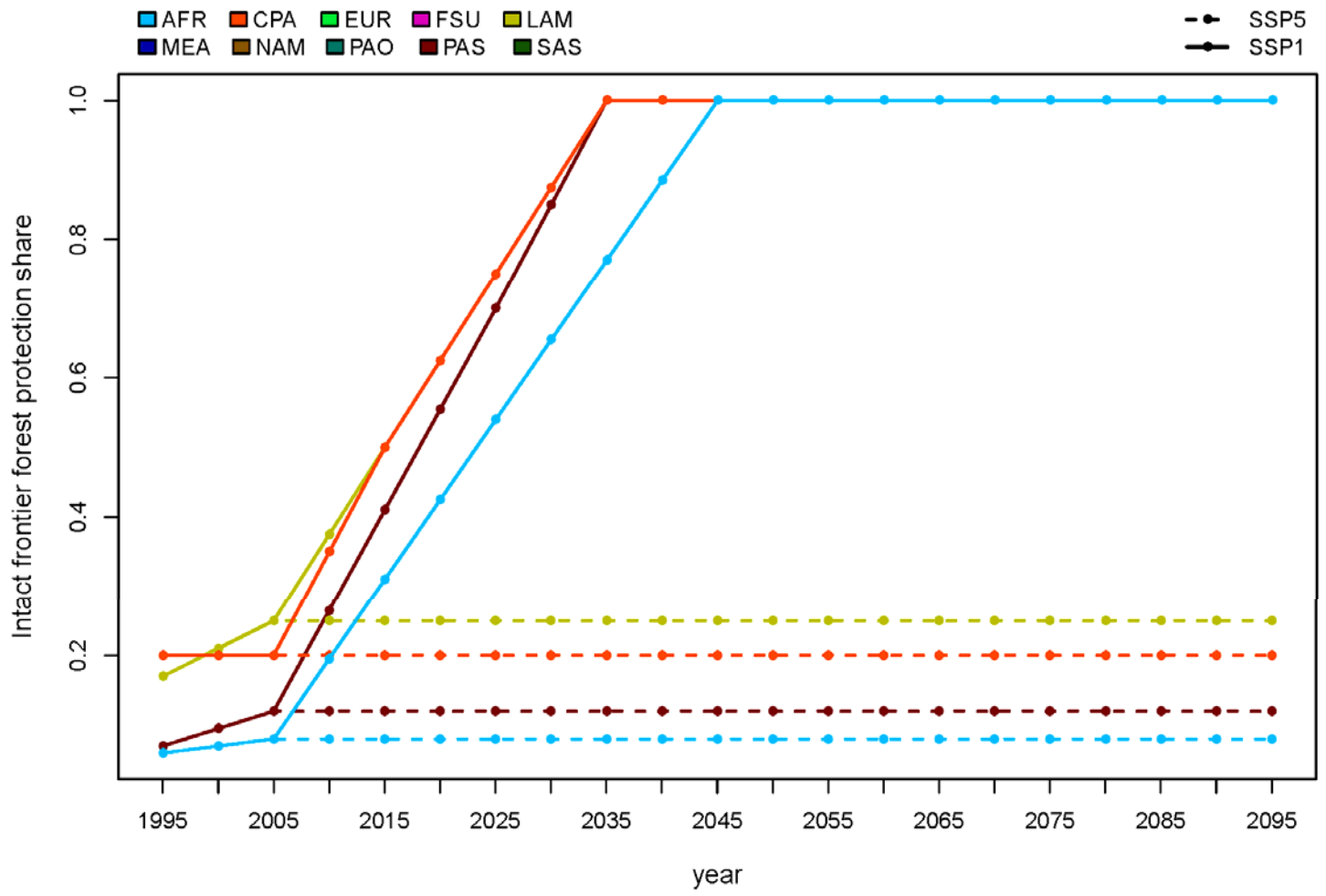
Preliminary

Energy intensity improvements – Regional pattern



Preliminary

Forest/ecoystem protection SSP1 vs SSP5



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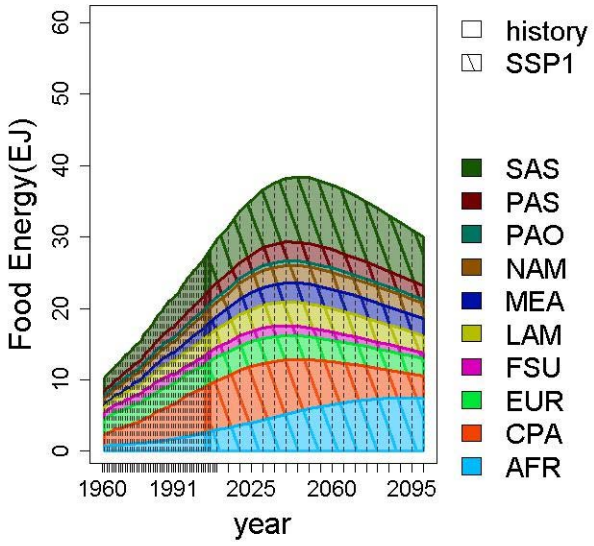
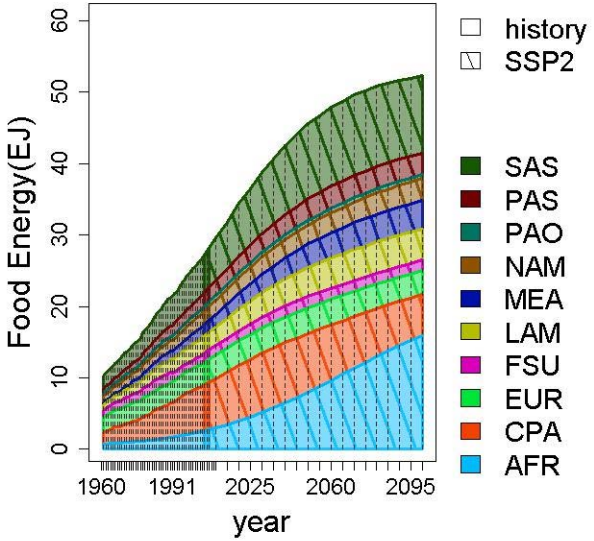
Assumption on food energy demand

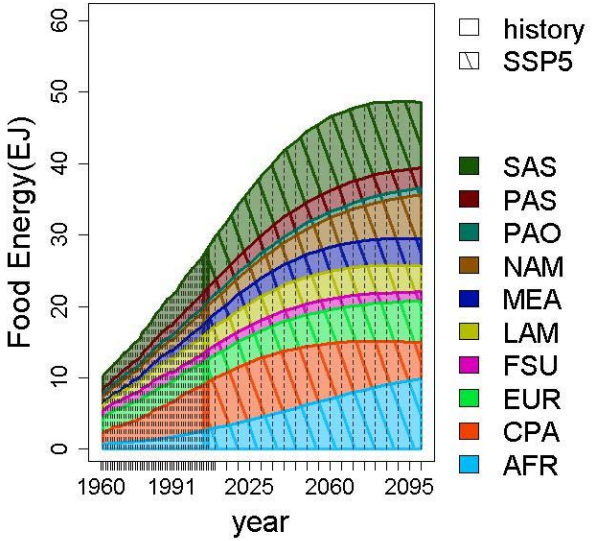
SSP1



SSP2



SSP5



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Preliminary results

from ReMIND-MAgPIE

based on these input assumptions

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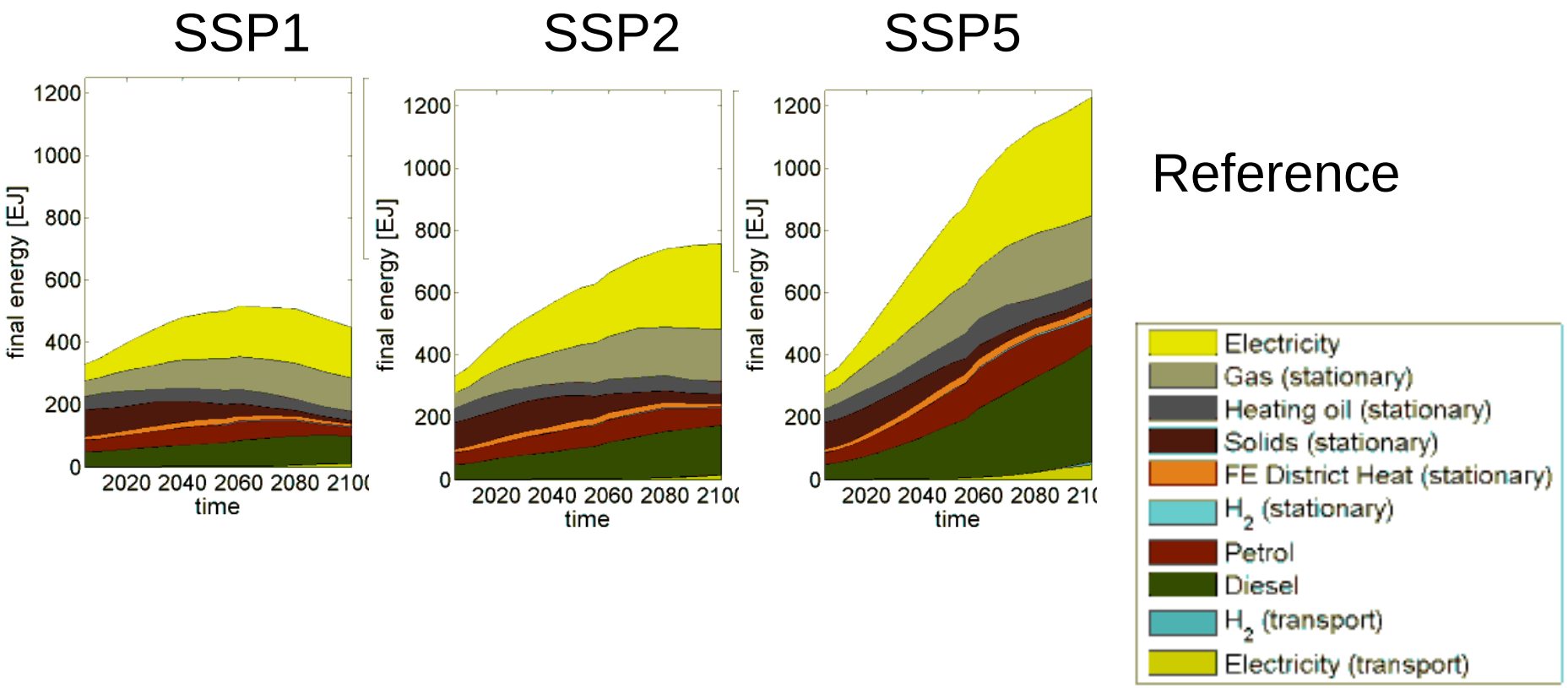
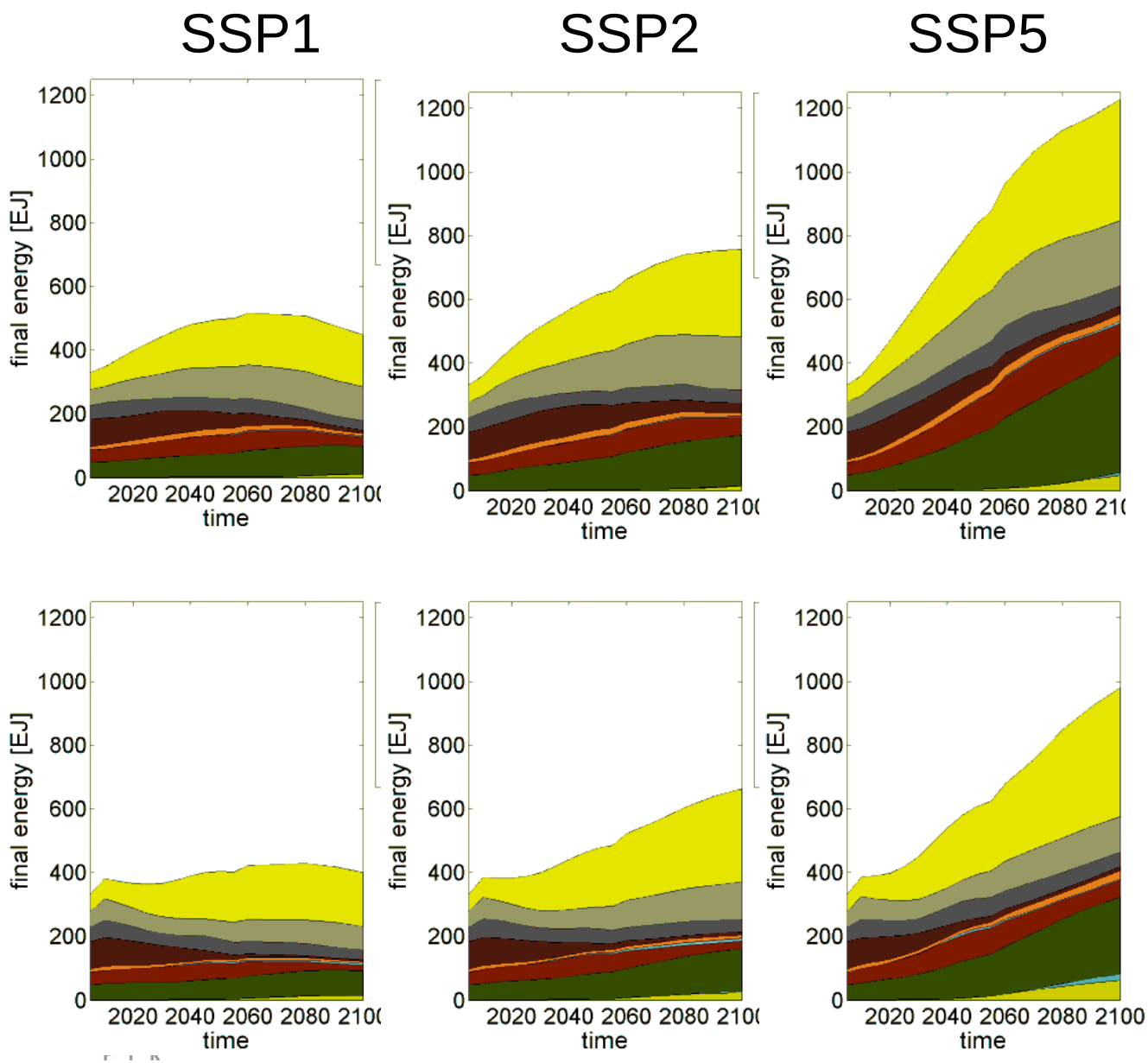
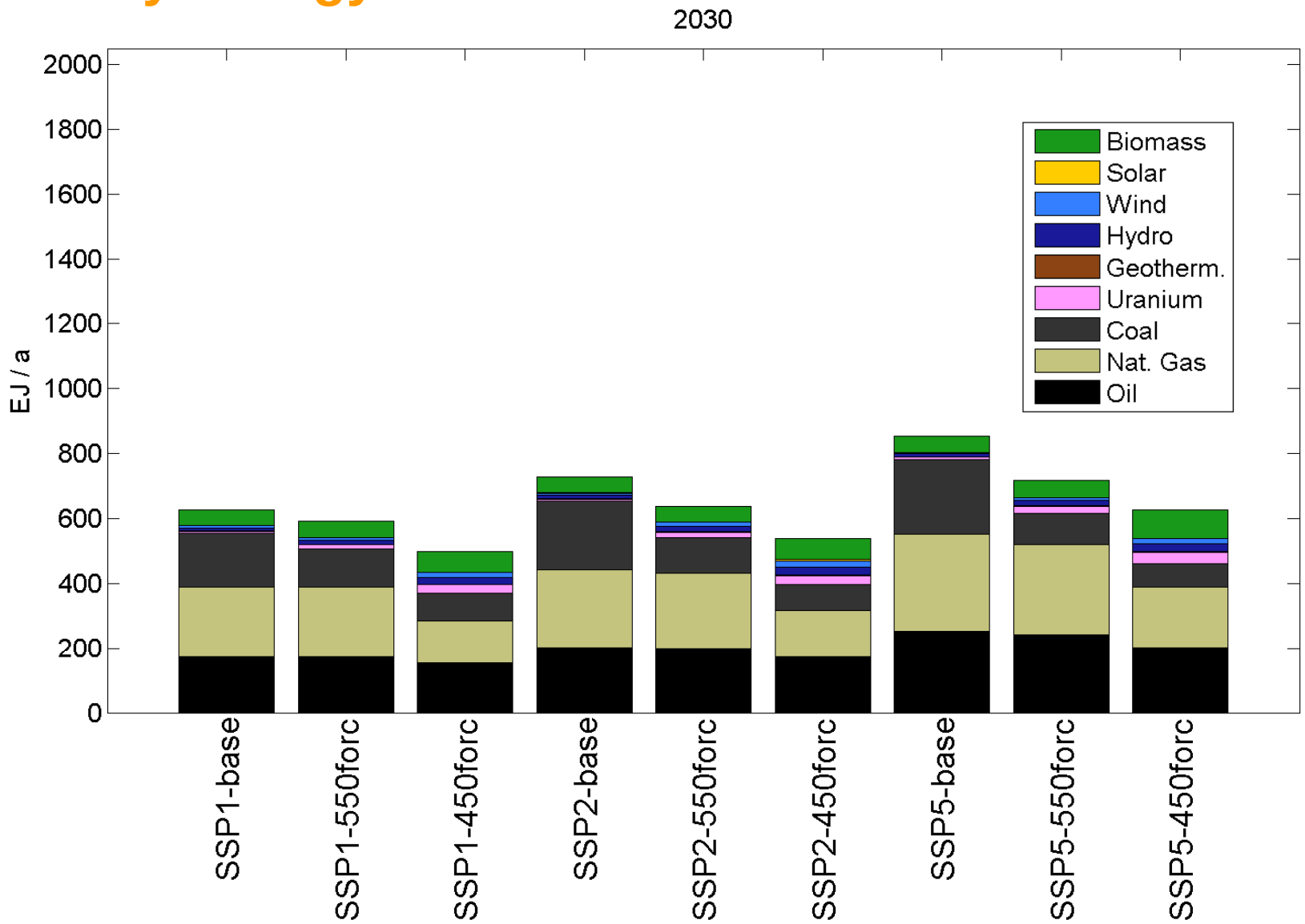
Energy demand in SSP reference cases



Energy demand in SSP reference and policy cases



Primary Energy Mix - 2030



Preliminary results

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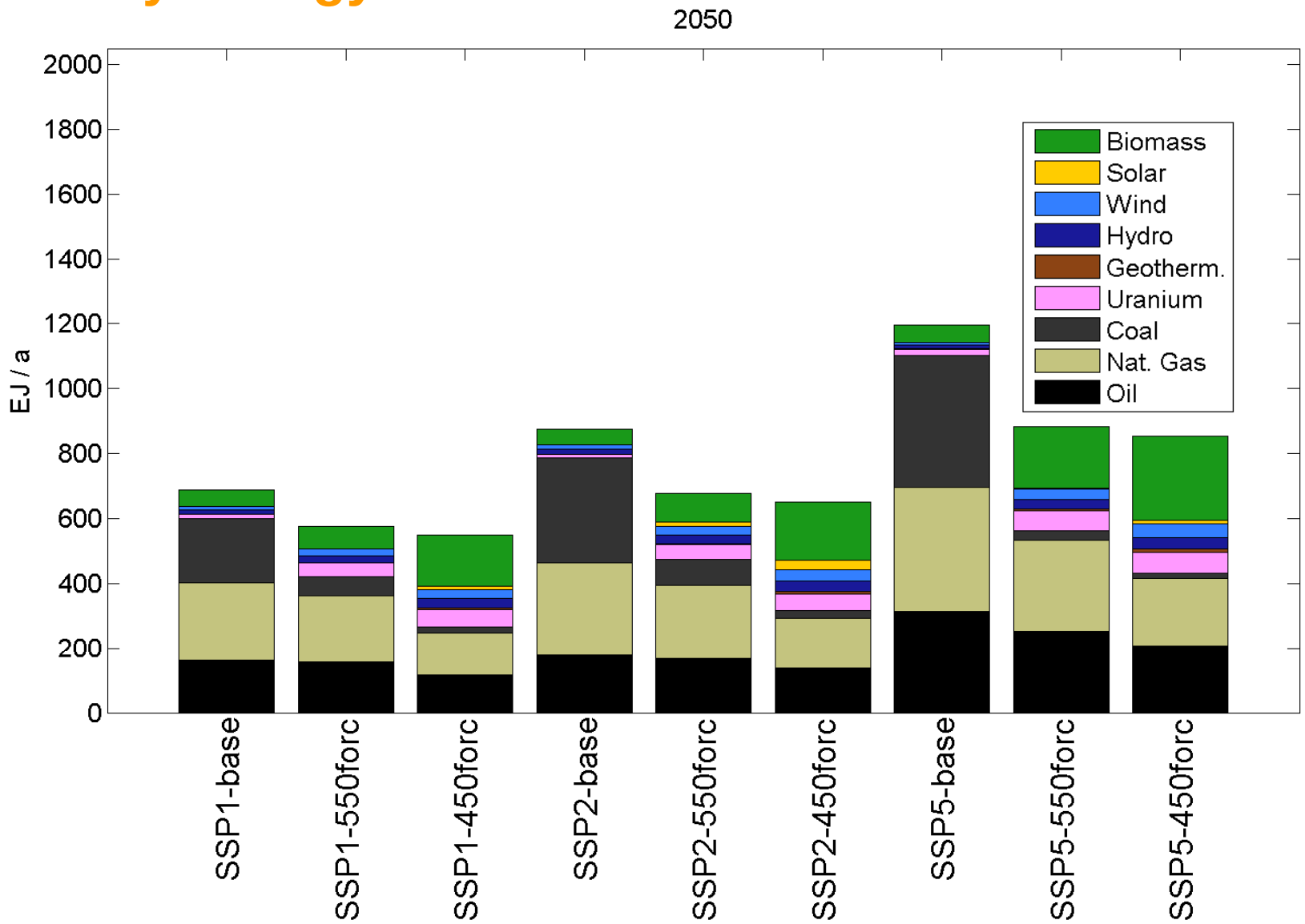
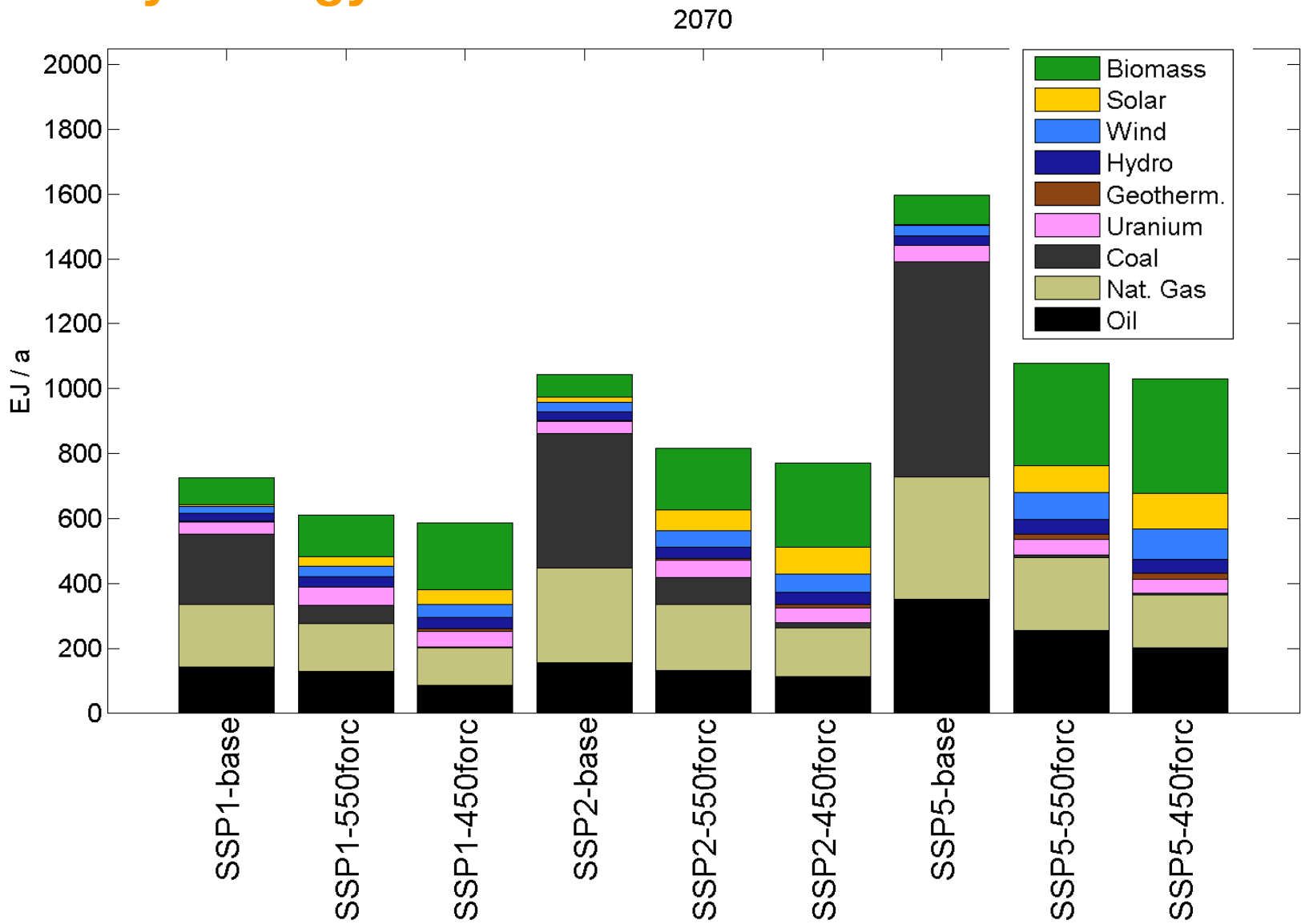
Primary Energy Mix – 2050



Preliminary results

PIK

Primary Energy Mix - 2070



Preliminary results

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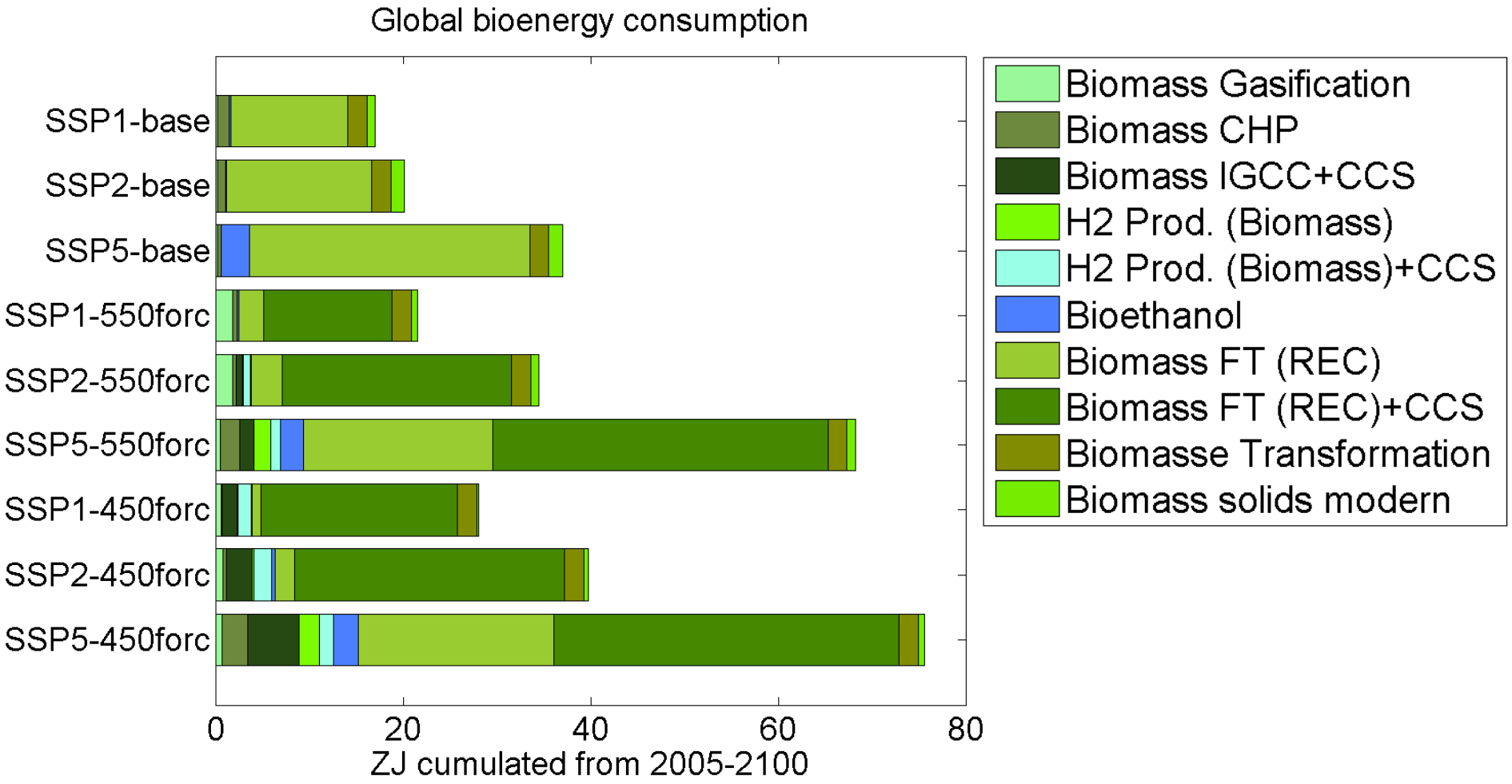
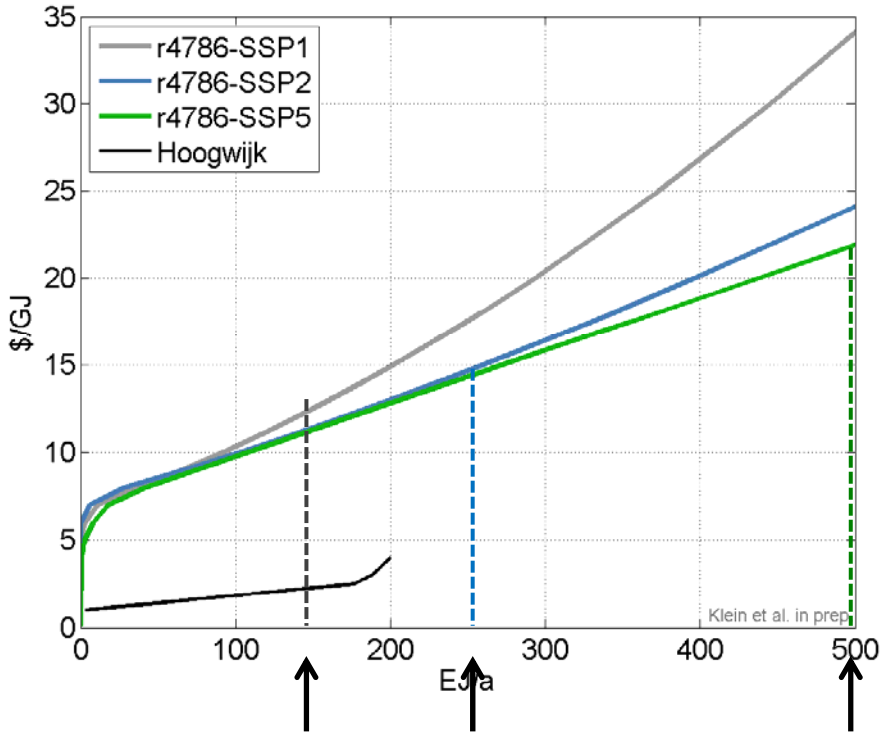
Bioenergy consumption



Bioenergy supply curve (MAgPIE emulation)

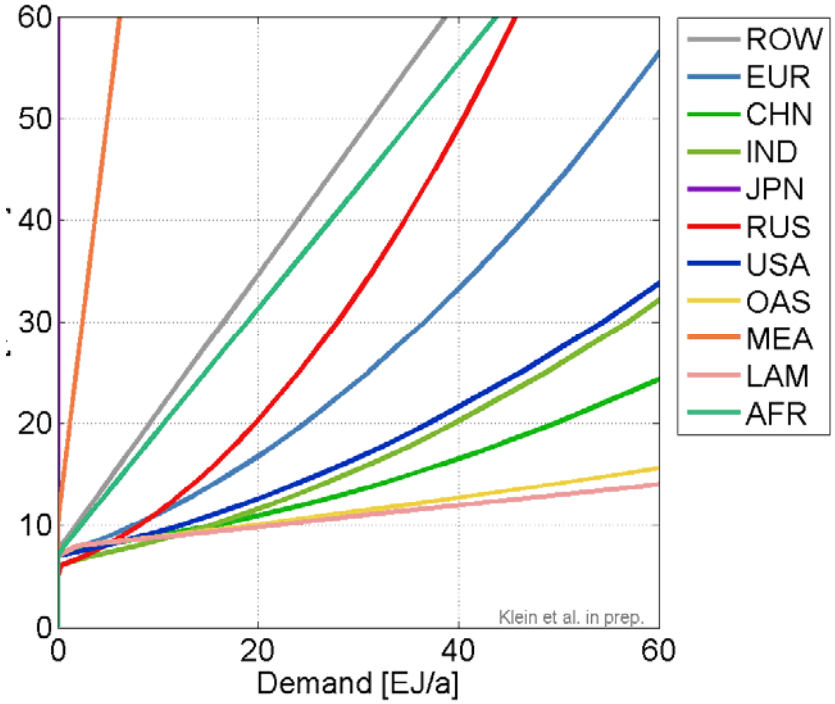
Purpose-grown energy crops only

Global



Purpose-grown bioenergy use in year 2100 in 450 ppm scenario

Regional (SSP2)

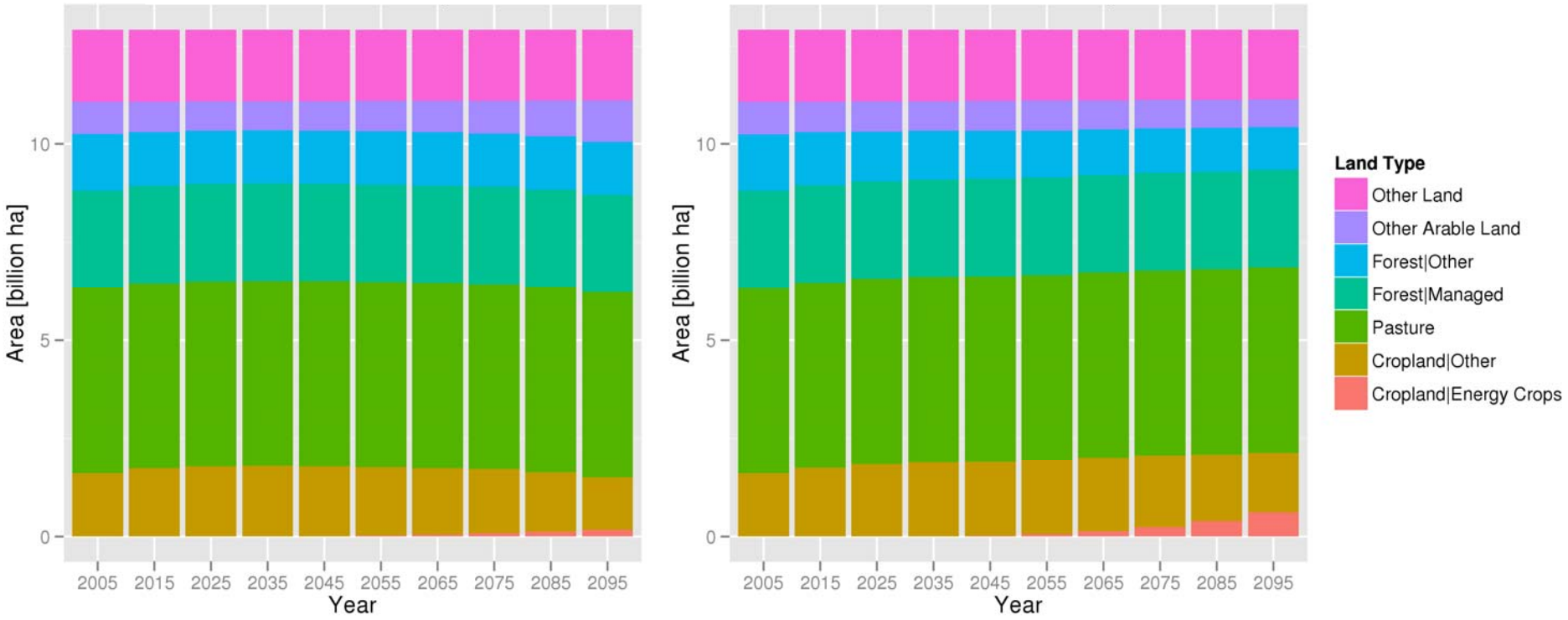


Preliminary results

Land use - Global

SSP1-bau

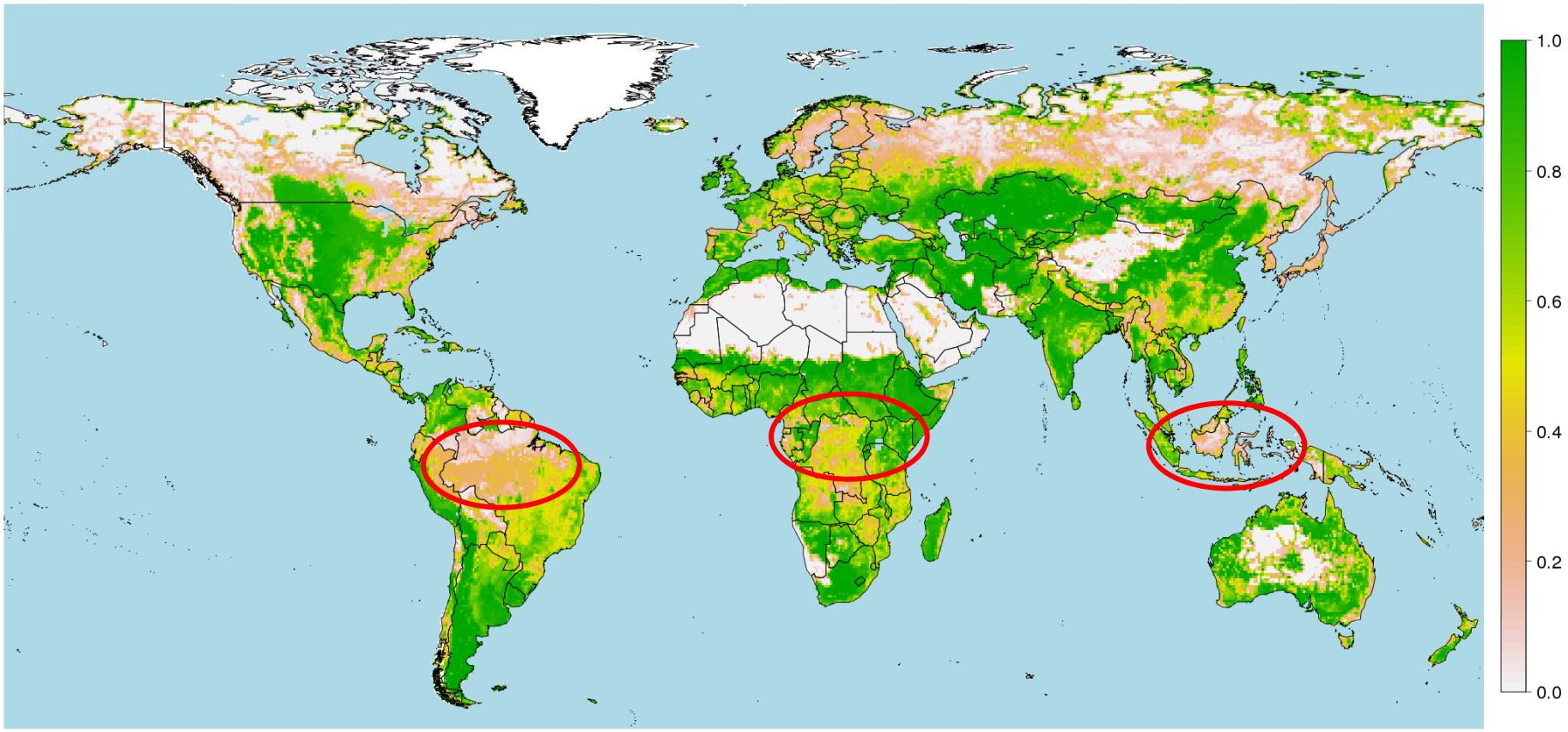
SSP5-bau



Preliminary results

Cell-specific share of total agricultural land (crop & pasture)

SSP1-bau - 2095

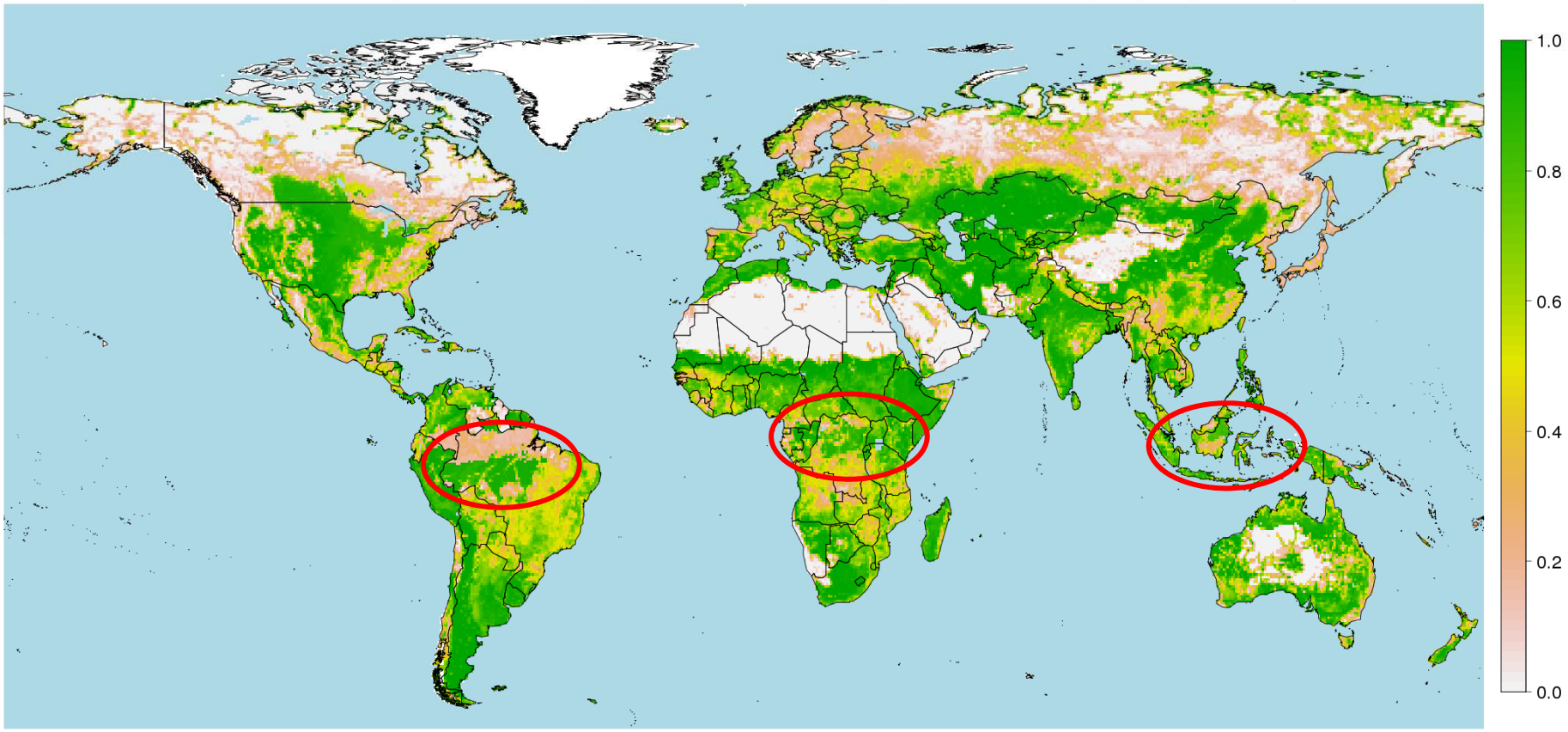


PIK

Preliminary results

Cell-specific share of total agricultural land (crop & pasture)

SSP5-bau - 2095



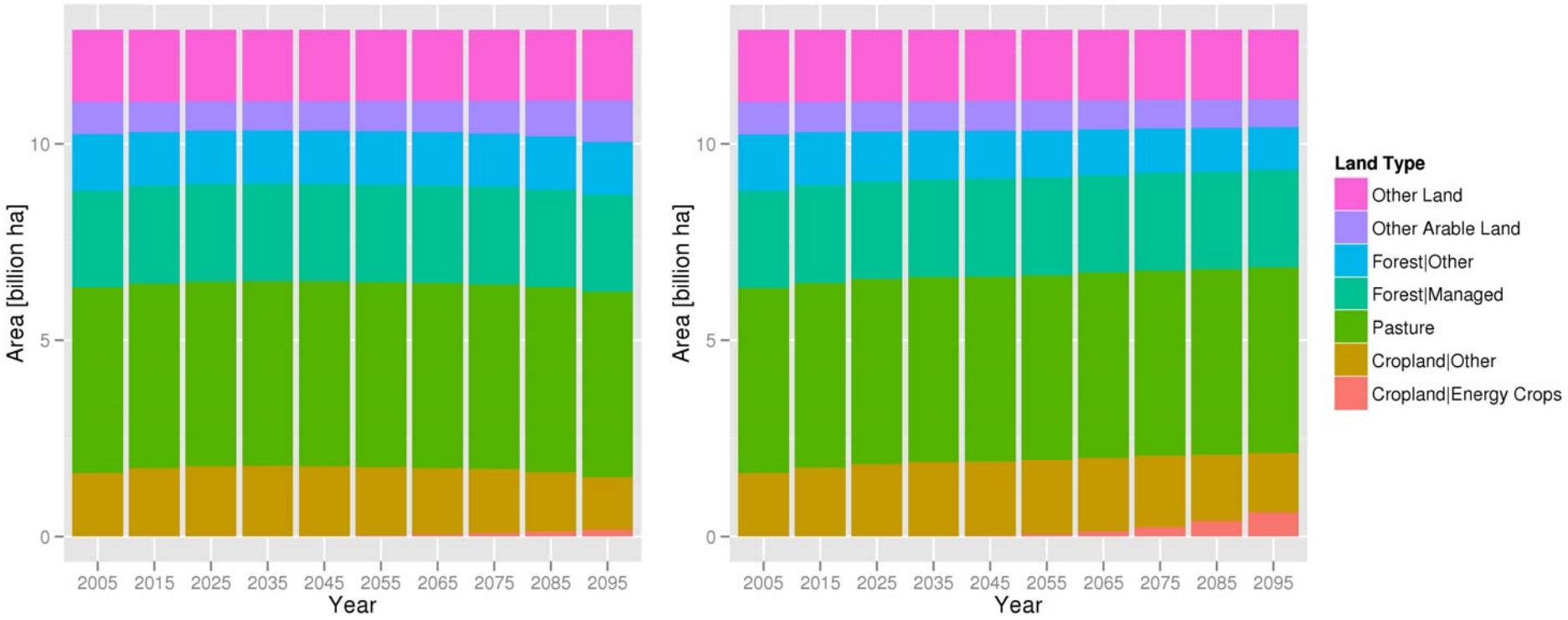
PIK

Preliminary results

Land use - Global

SSP1-bau

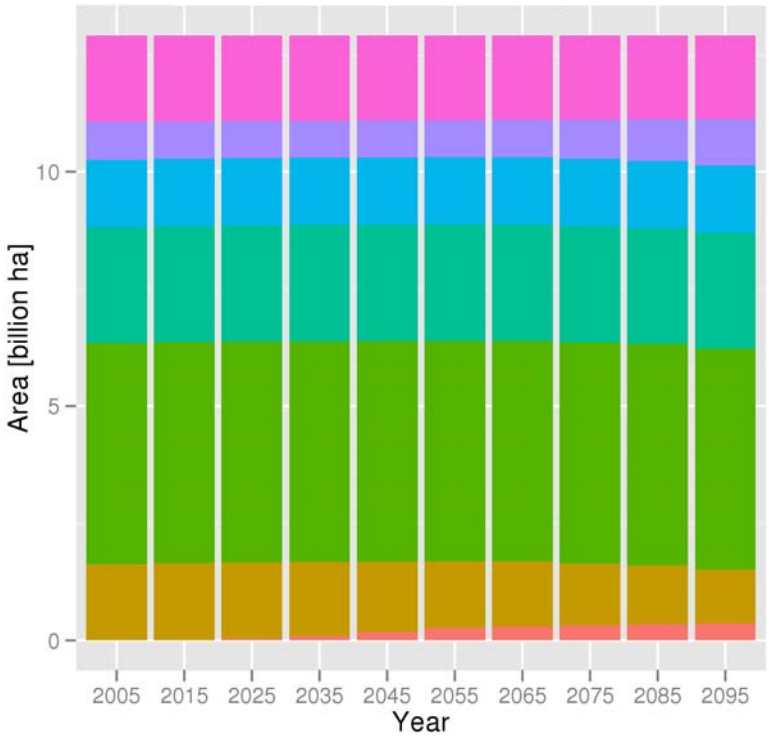
SSP5-bau



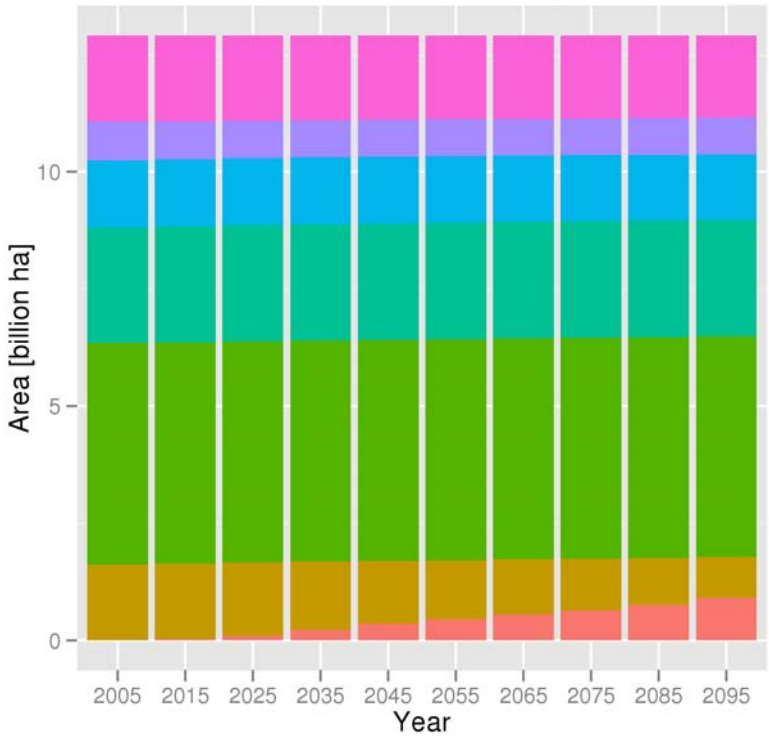
Preliminary results

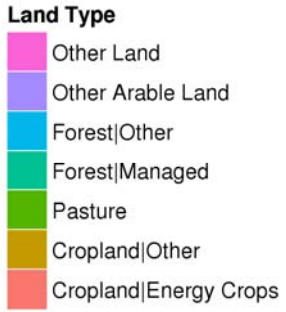
Land use - Global

SSP1-450ppm



SSP5-450ppm





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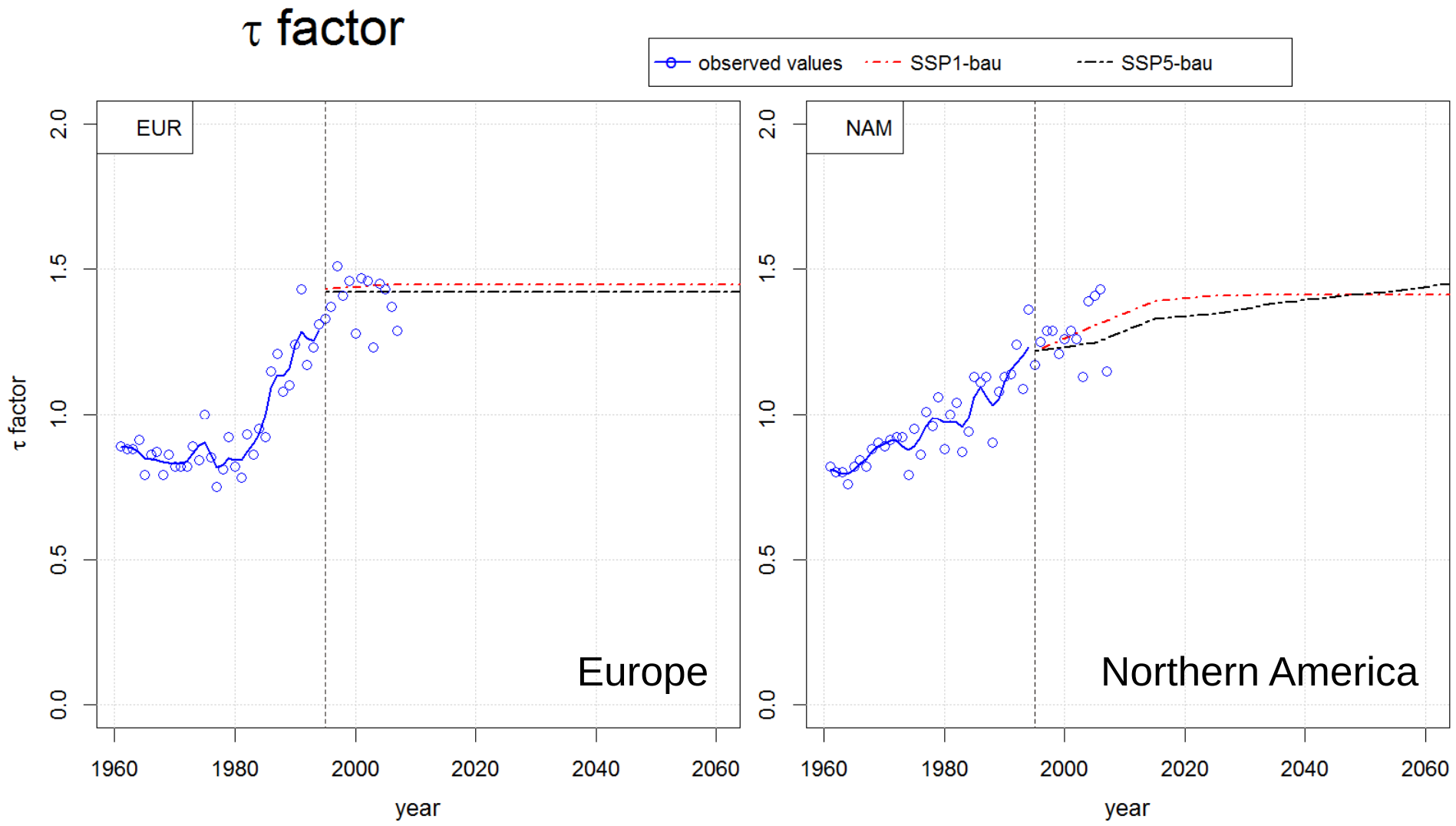
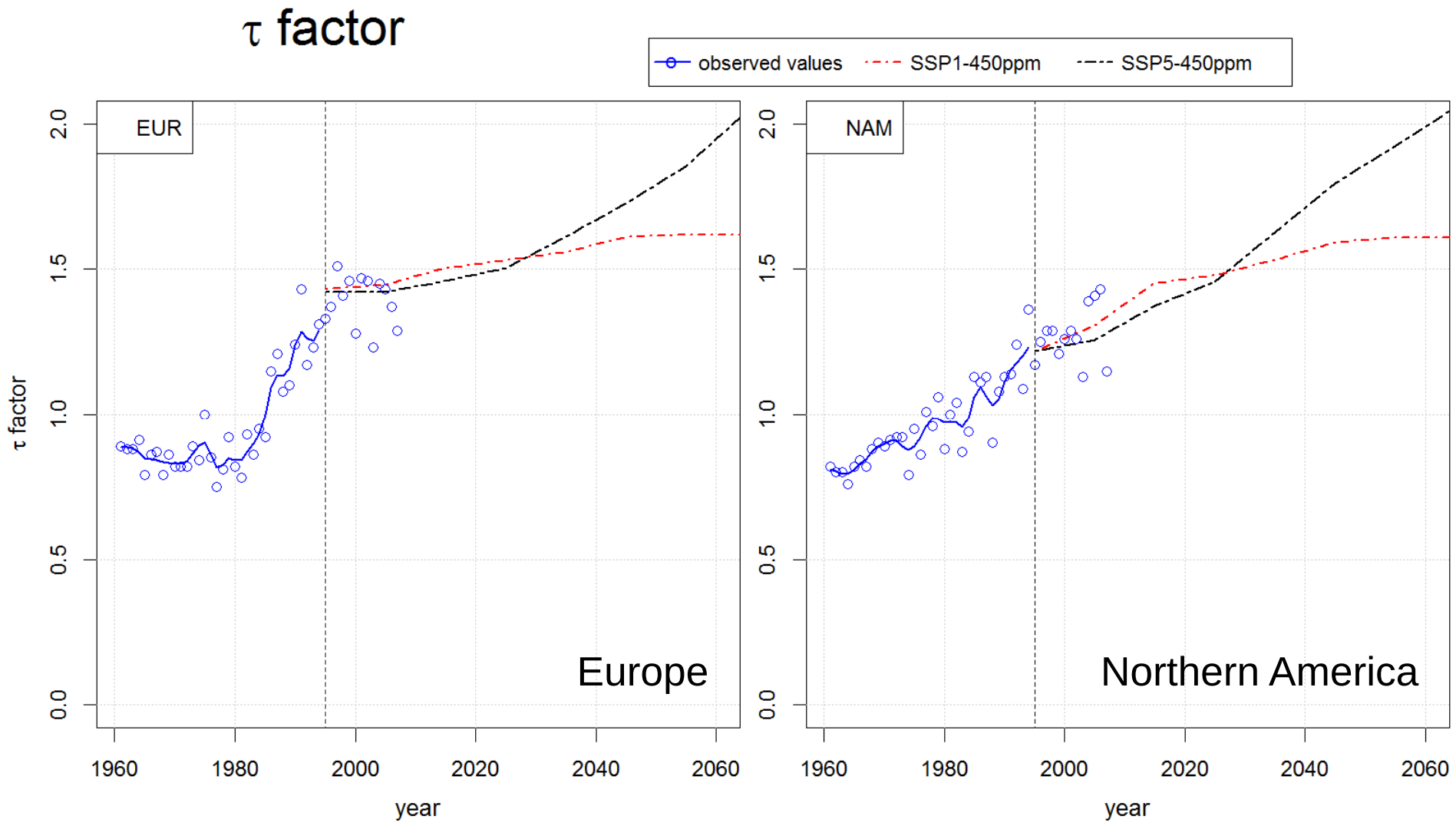
Preliminary results

Land use intensification - BAU



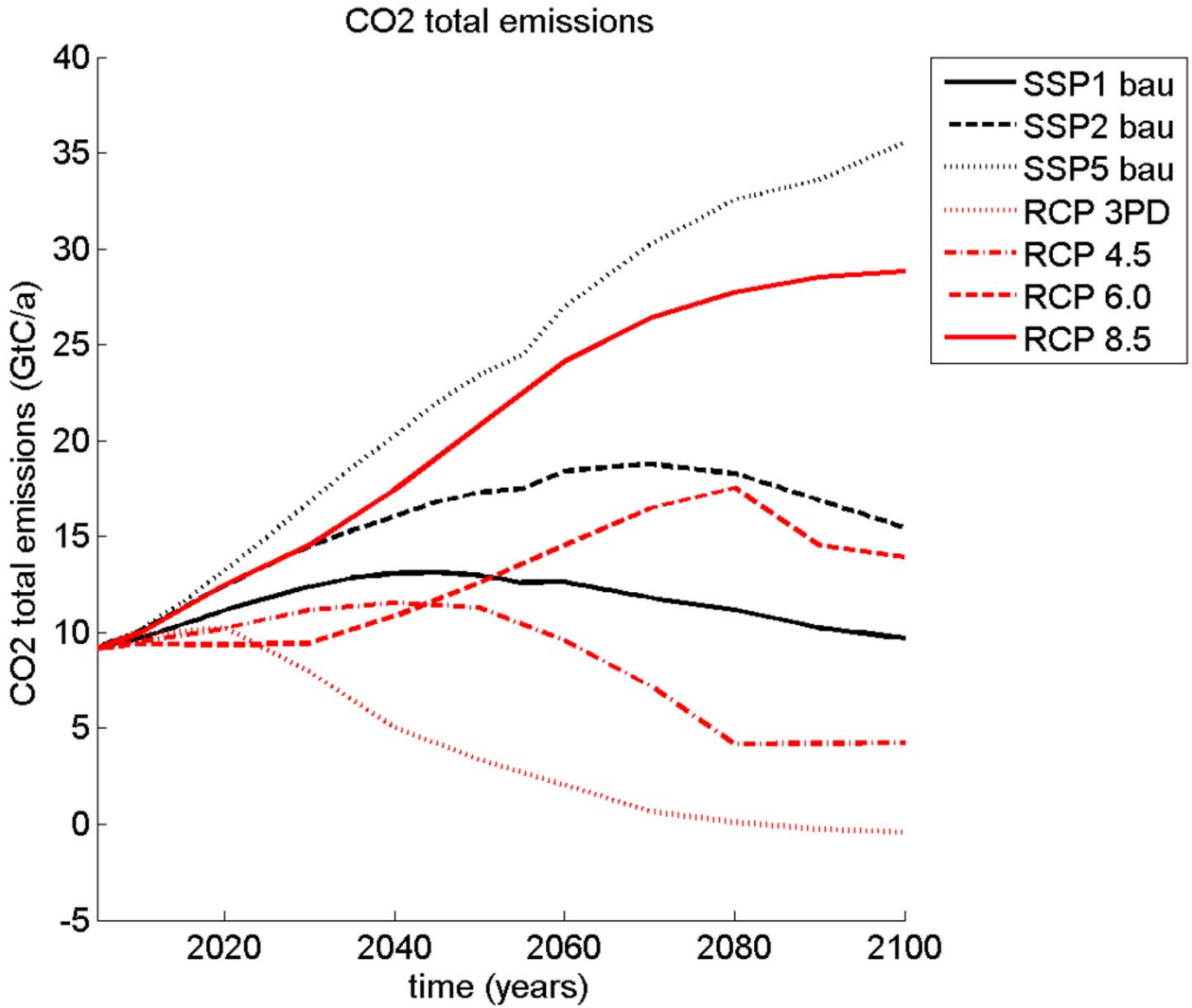
Preliminary results

Land use intensification - 450ppm



Preliminary results

CO2 emissions – ReMIND-MAgPIE SSP vs. RCP



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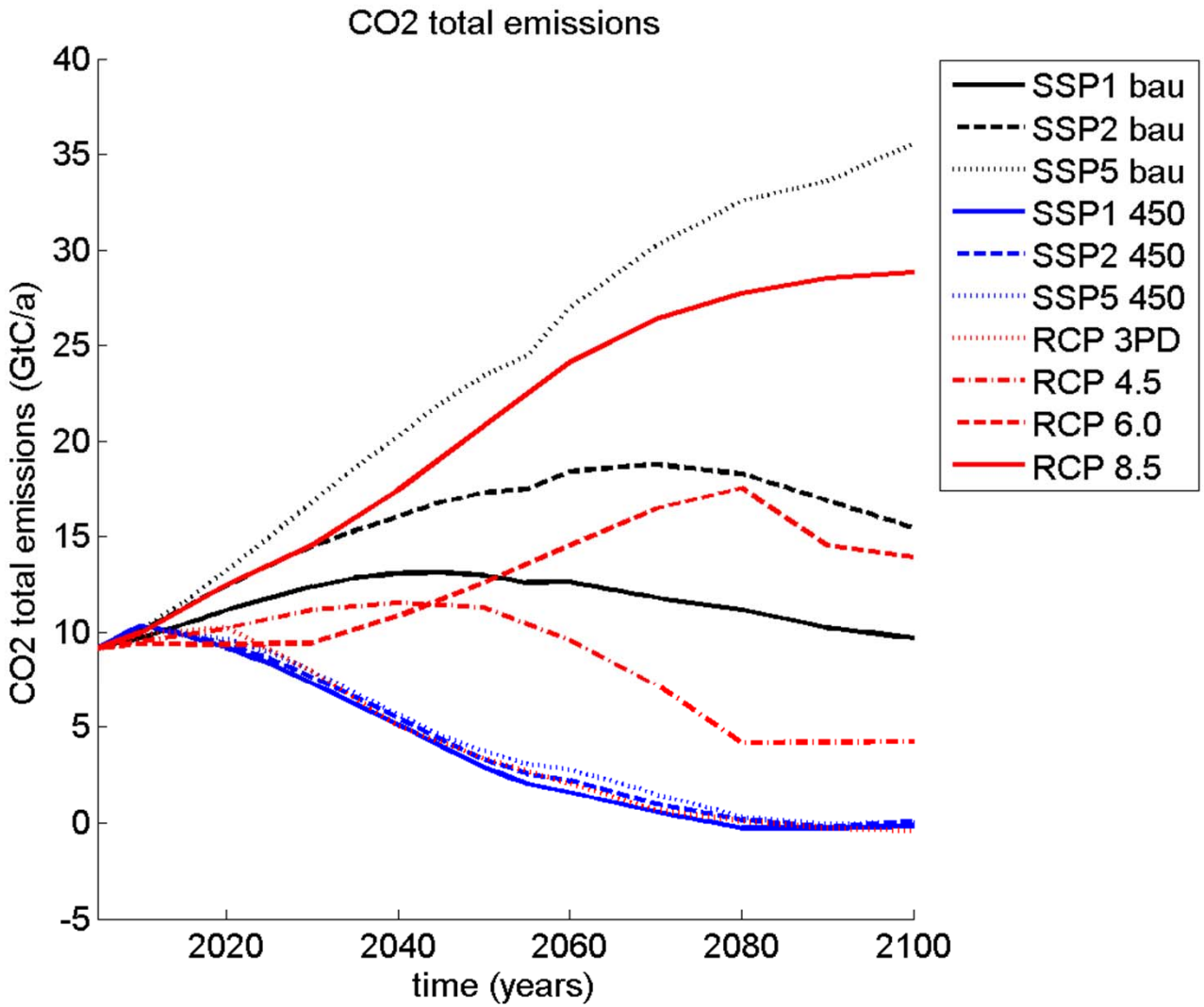
Preliminary results

CO2 emissions – Reference and 450 ppm



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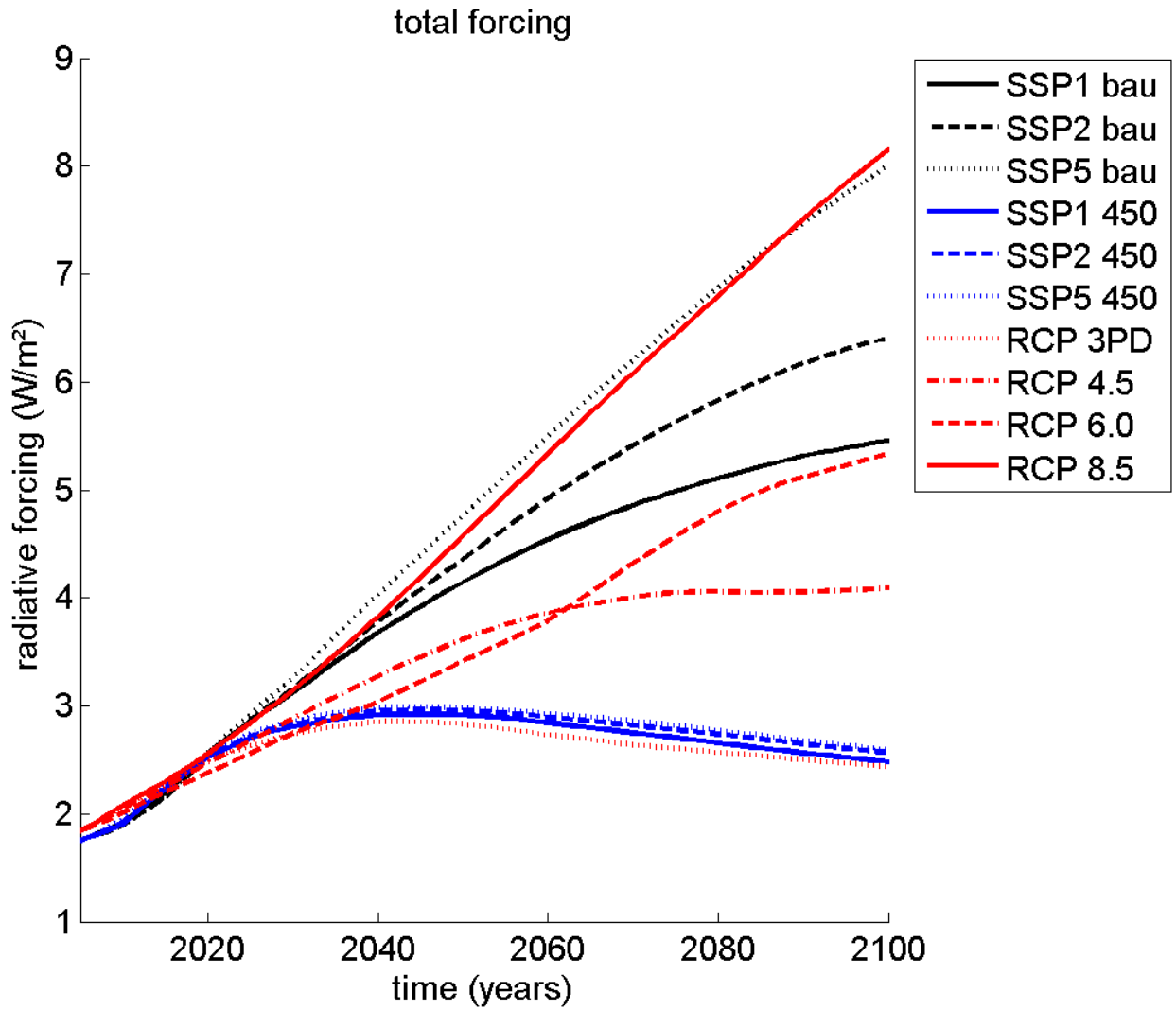
Preliminary results

Radiative forcing – ReMIND-MAgPIE SSP vs. RCP



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Conclusions

- SSP5 reference scenarios reaches RCP8.5. SSP1 is in the area of RCP6. Can it go lower? Assumptions used were already very optimistic.
- Large variation in mitigation challenges between SSP1 & 5 already under 1st best climate policy assumptions, if a variety of SSP differences beyond GDP and population is implemented
- Key assumptions impacting emissions: fossil resources, energy intensity
- Further assumptions impacting mitigation costs: renewable energy costs (mediated via food demand and forest protection in case of bioenergy)
- Effect of assumptions on capital intensity convergence, globalization of food trade, fossil fuel taxes / subsidies need to be further explored.
- Land use assumptions likely will have increased significance for high population scenarios (SSP3 & 4). Effect on food prices need to be explored (ongoing work)

Thank you

SSP TEAM AT PIK

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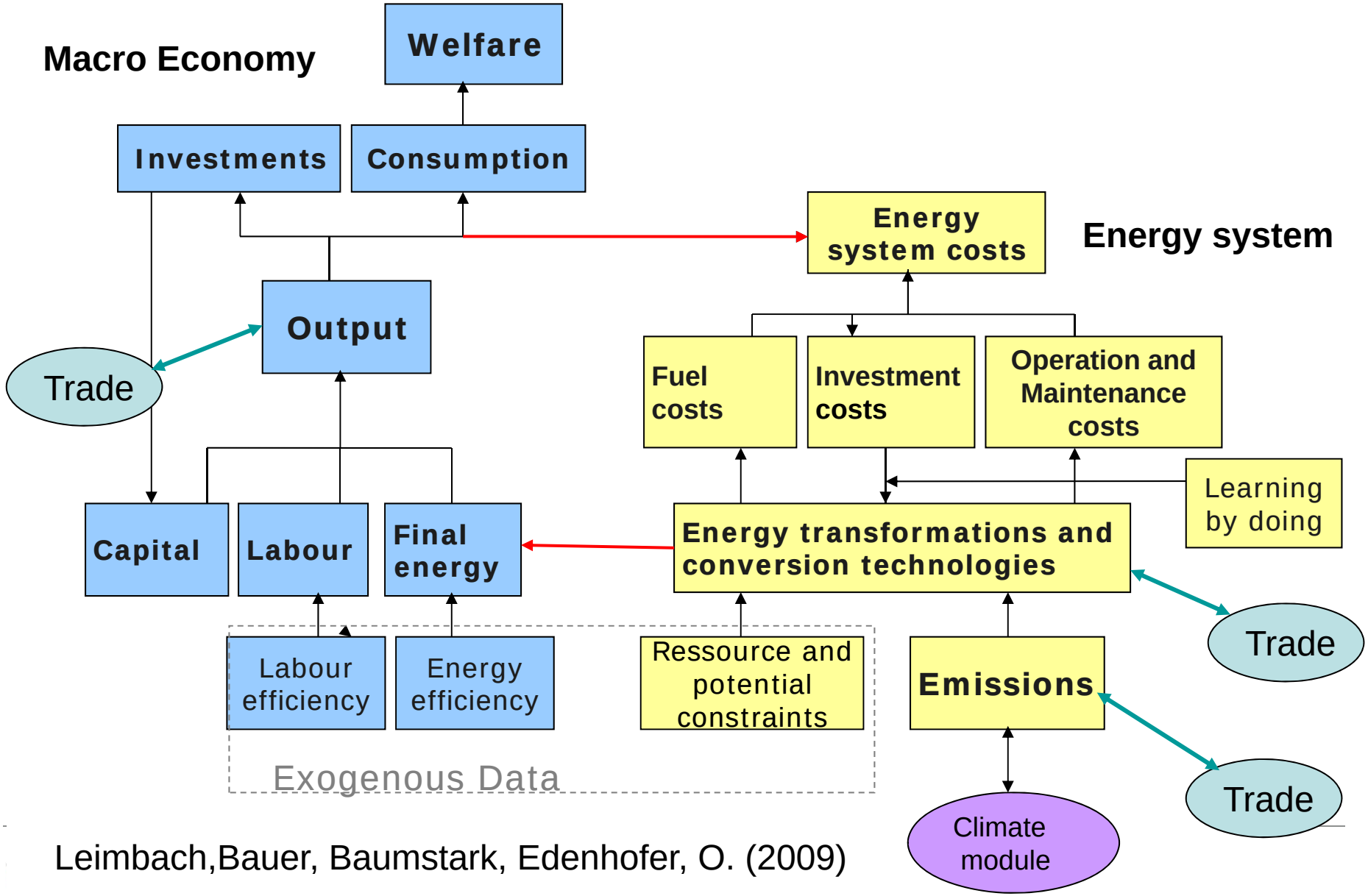
Backup Slides on Model Framework

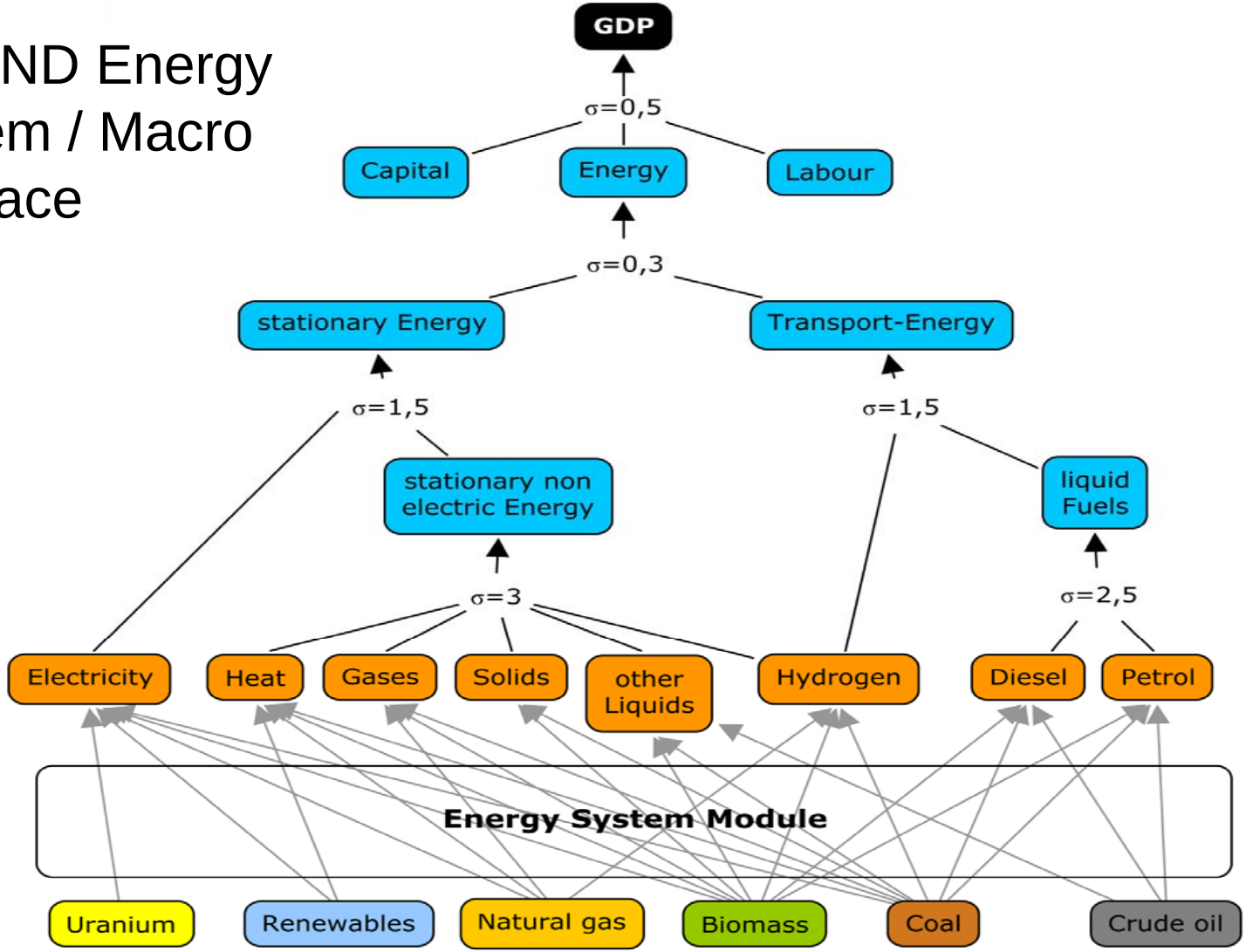
Quick introduction to the models: ReMIND



Leimbach,Bauer, Baumstark, Edenhofer, O. (2009)

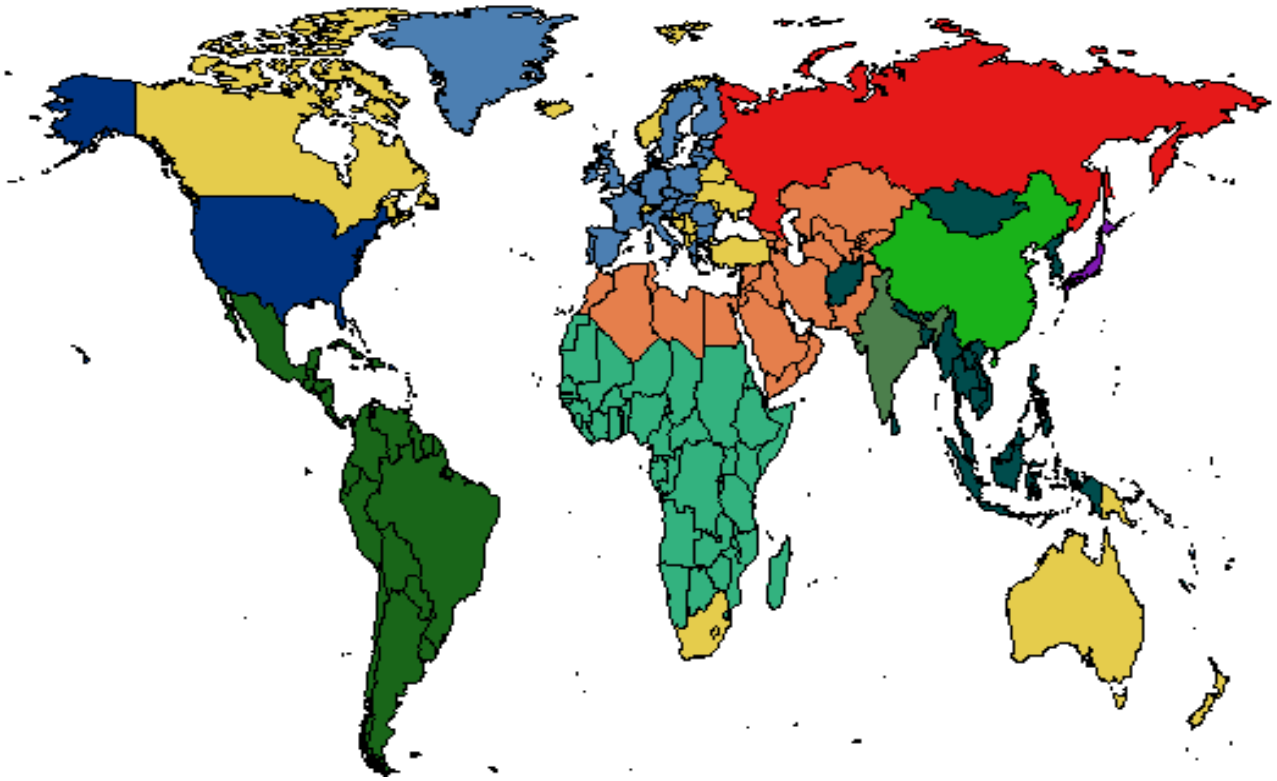
Quick introduction to the models used: ReMIND

ReMIND Energy System / Macro Interface

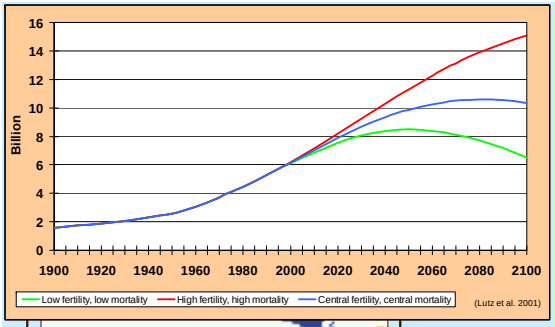


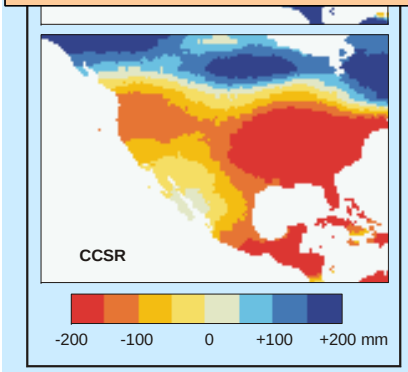
Quick introduction to the models used: ReMIND

ReMIND regions



USA - USA
EUR - EU27
JAP - Japan
CHN - China
IND - India
RUS - Russia
AFR - Sub-Saharan Africa (excl. Republic of South Africa)
MEA - Middle East, North Africa, central Asian countries
OAS - Other Asia (mostly South East Asia)
LAM - Latin America
ROW - Rest of the World (Canada, Australia, New Zealand, Republic of South Africa, Rest of Europe).





Crop yields

Land & Water constraints

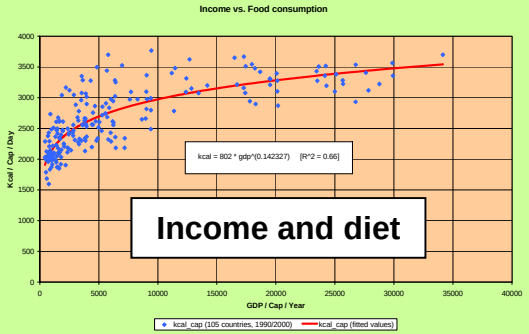
Cereals | Sugar beets | Oilseeds | Pulses | Bioenergy

LPJ (50x50 km grid)

Biophysical inputs

Lotze-Campen , Popp et al. (2008), Agricultural Economics

Demography



Income and diet

Food demand, production costs

Socioeconomic inputs

MAgPIE – a global land use optimisation model

- spatially explicit (0.5°), 10 economic regions
- 30 production activities (13 crops, livestock, irrigation, bioenergy, land conversion)
- internal feed balances, international trade
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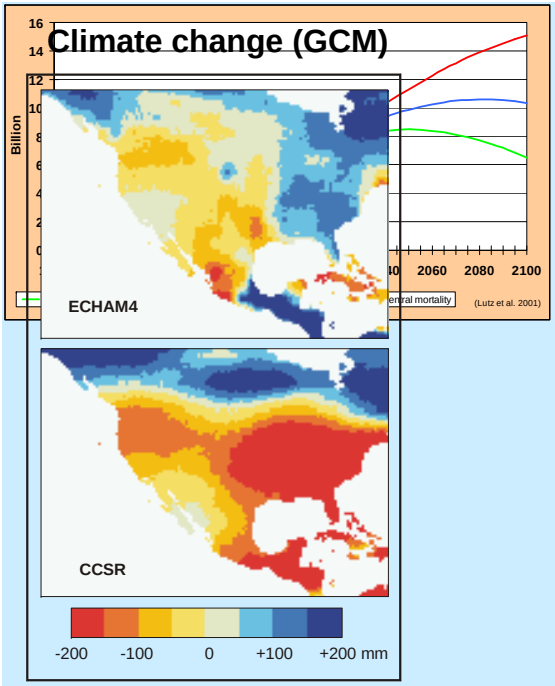
P I K



Crop yields

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Cereals

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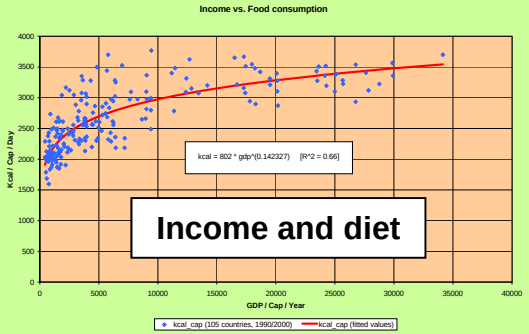
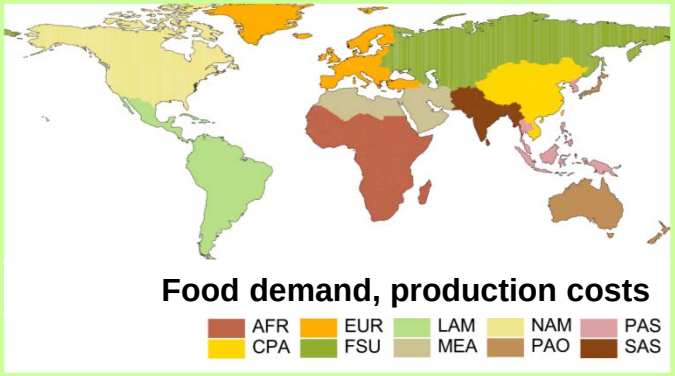
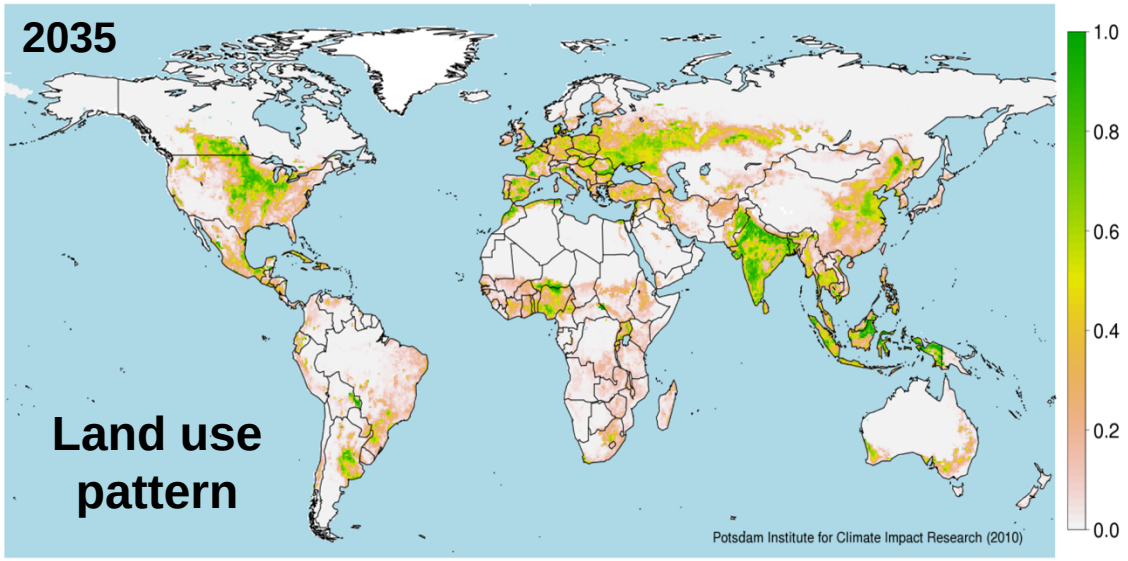
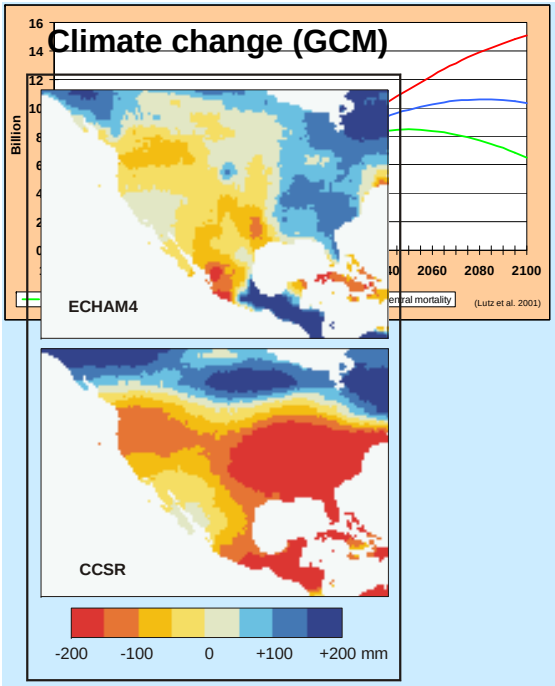


Socioeconomic inputs



Land use dynamics





Crop yields

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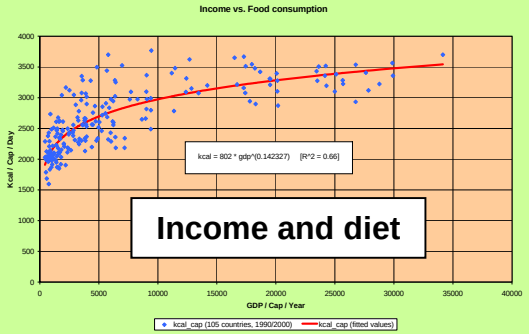
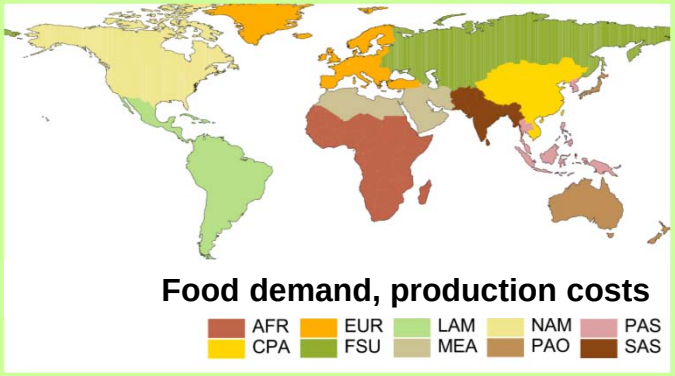
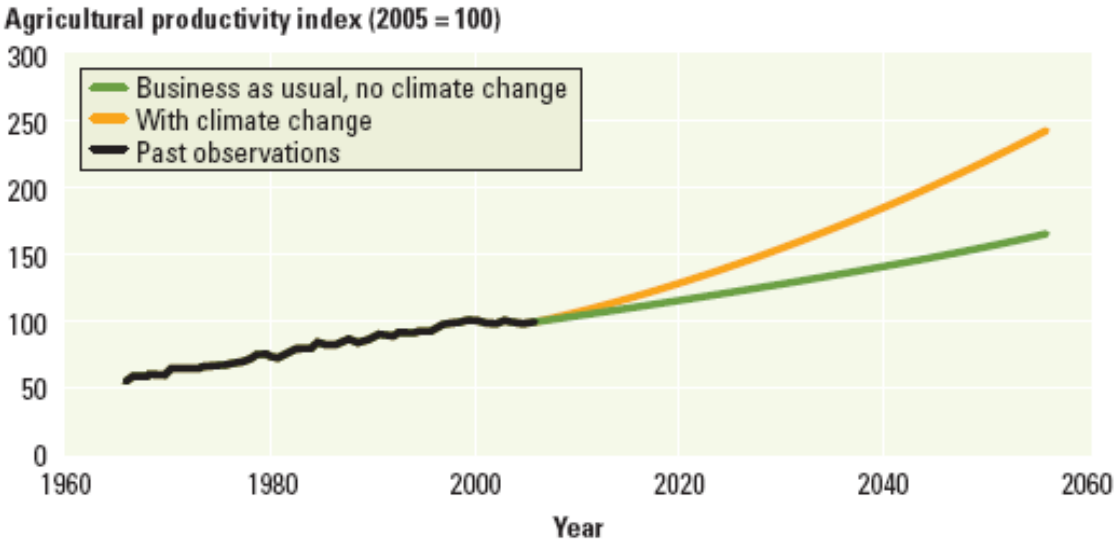


Income and diet

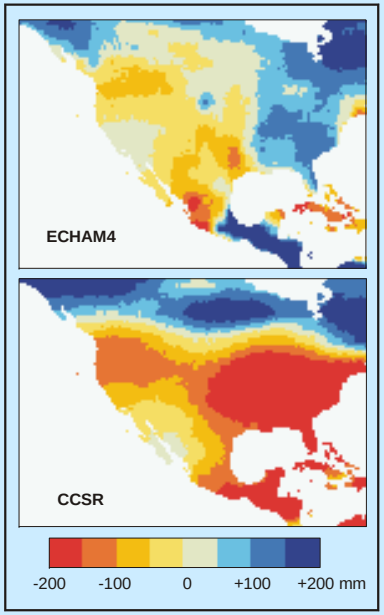
Socioeconomic inputs





Lotze-Campen and Popp, World Development Report 2010

Climate change (GCM)



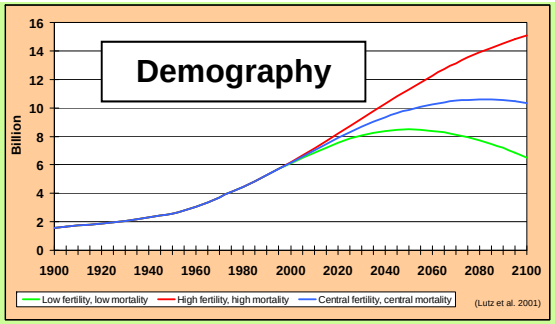
Crop yields

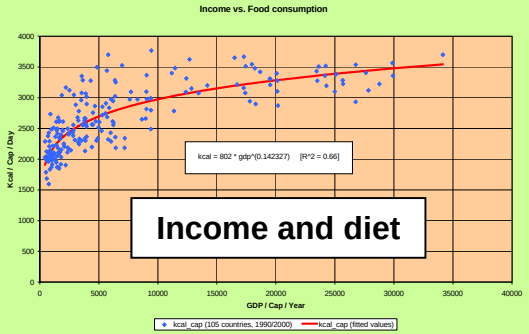
Land & Water constraints

Cereals | Sugar beets | Oilseeds | Pulses | Bioenergy

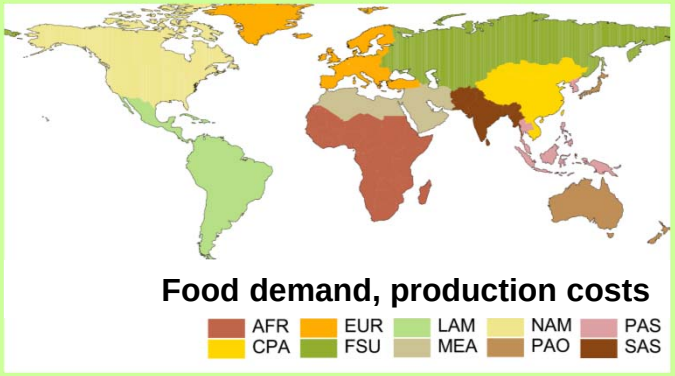
LPJ (50x50 km grid)

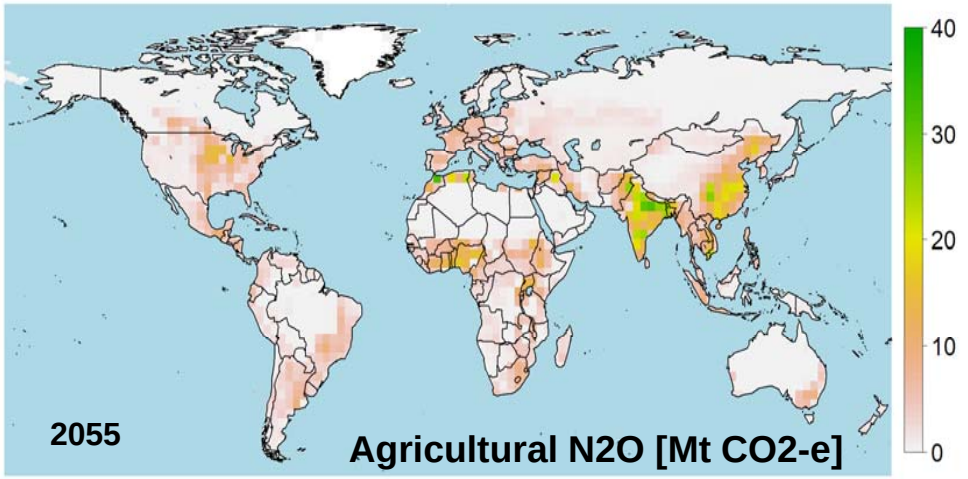
Biophysical inputs





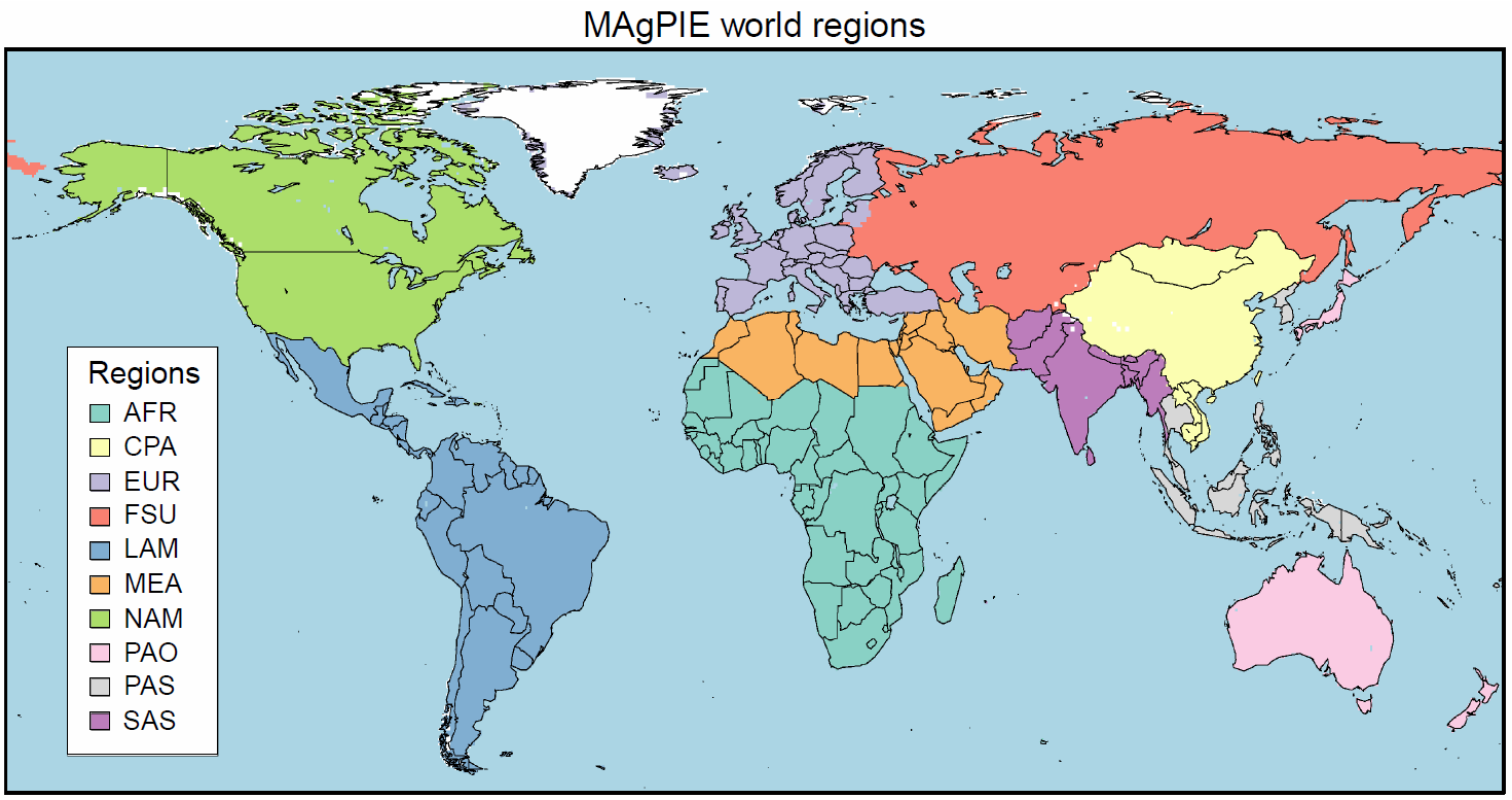
Socioeconomic inputs





Popp et al. 2010, GEC

MAgPIE world regions



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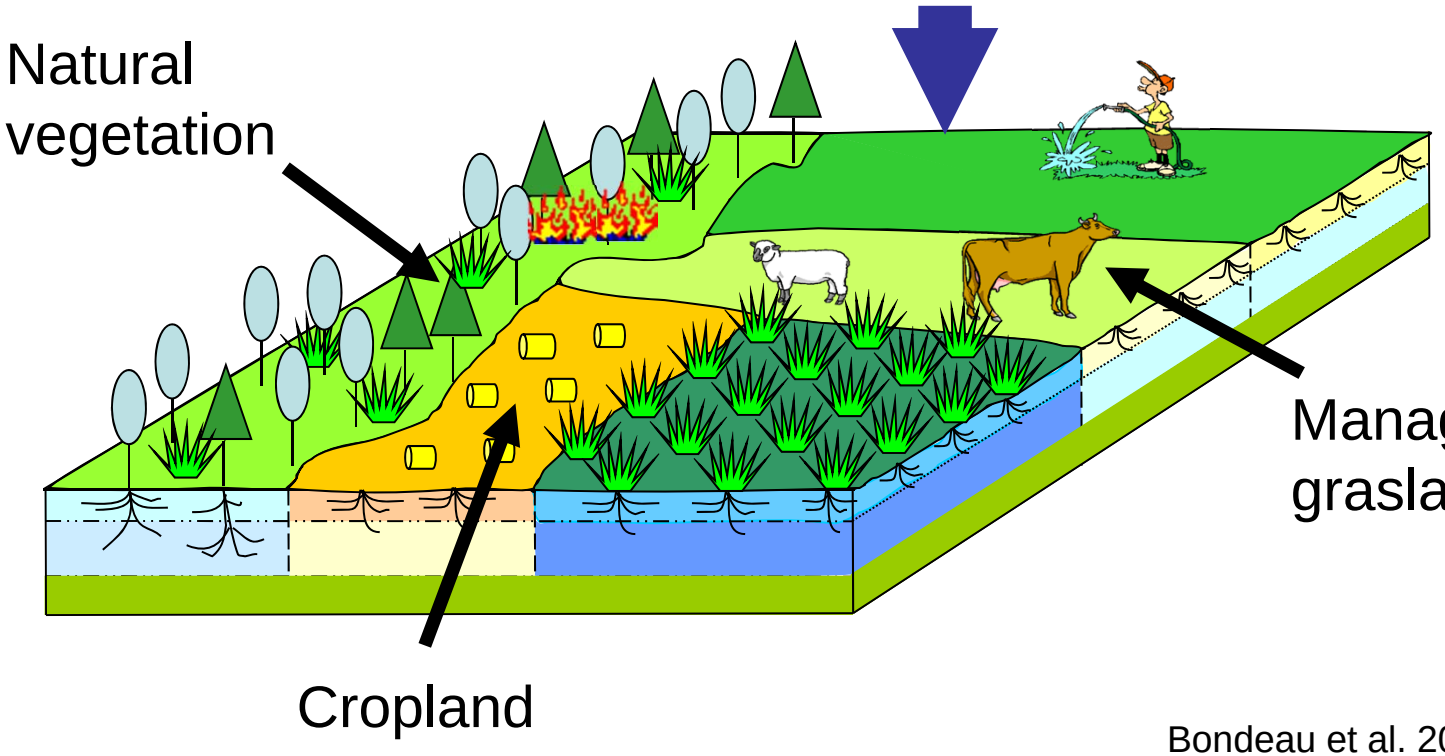
Input:
climate, CO_2, soil, land-use



Bondeau et al. 2007, GCB

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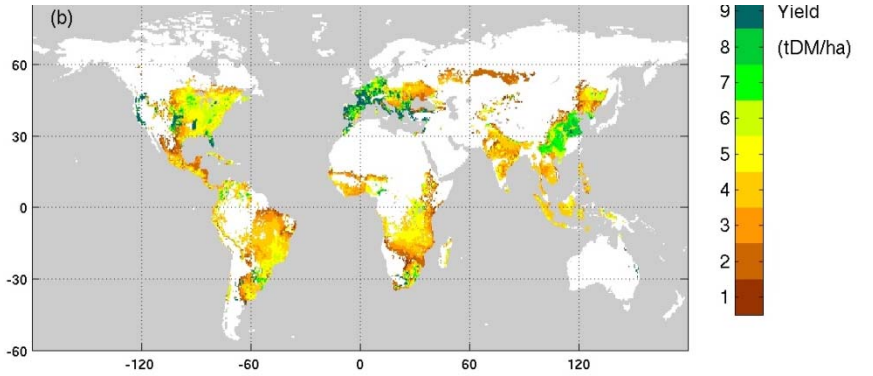
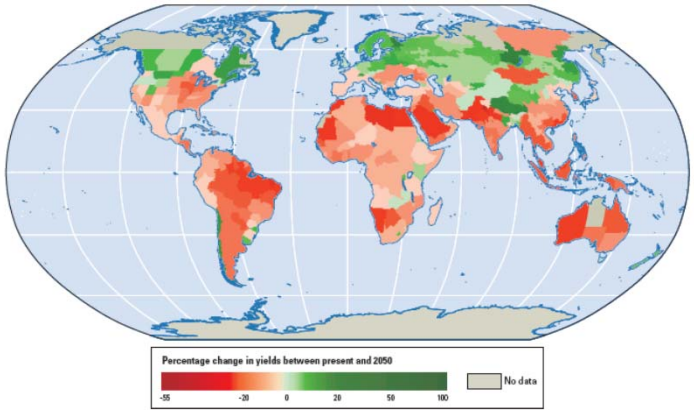
Agricultural yields

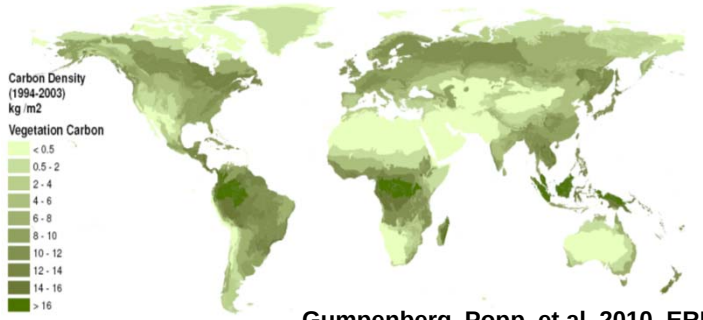


Bondeau et al. 2006, GCB



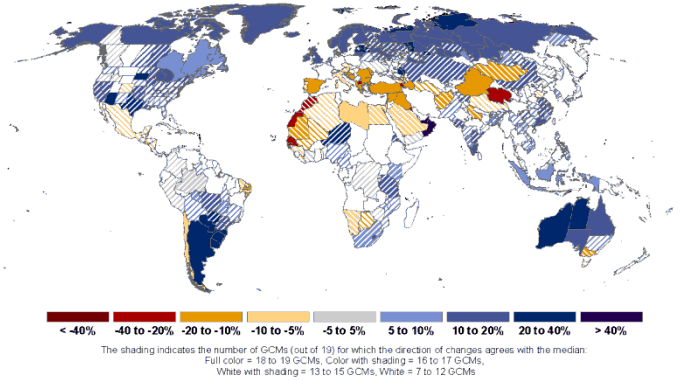
Müller, Bondeau, Popp et al. WDR 2010

Carbon content



Gumpenberg, Popp et al. 2010, ERL

Run-off



Füssel, Popp, Heinke (2010)

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