

Land use and land cover change (LULCC) analysis for LUMIP

Elena Shevliakova

NOAA/GFDL-Princeton U CICS

On behalf of land working group

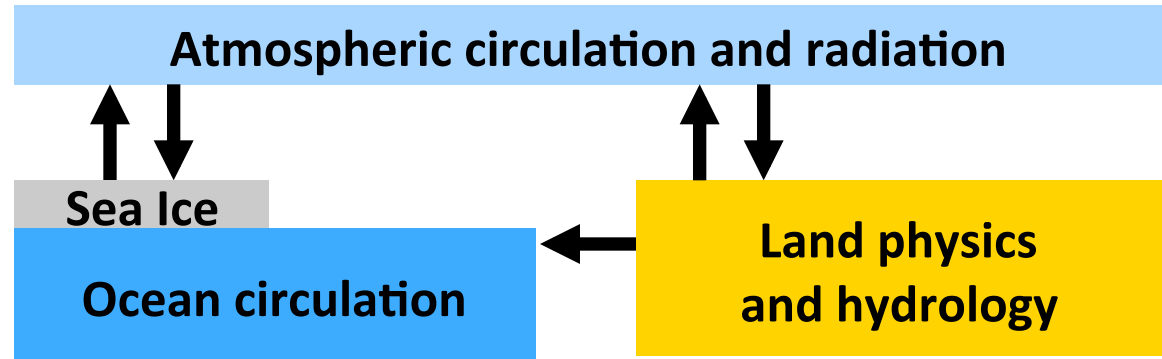
LUMIP in CMIP6

- Why do we want to report state of land by land management category?
 - Including other experiments in CMIP6
- Why do we need to add land only simulations to understand LULCC?

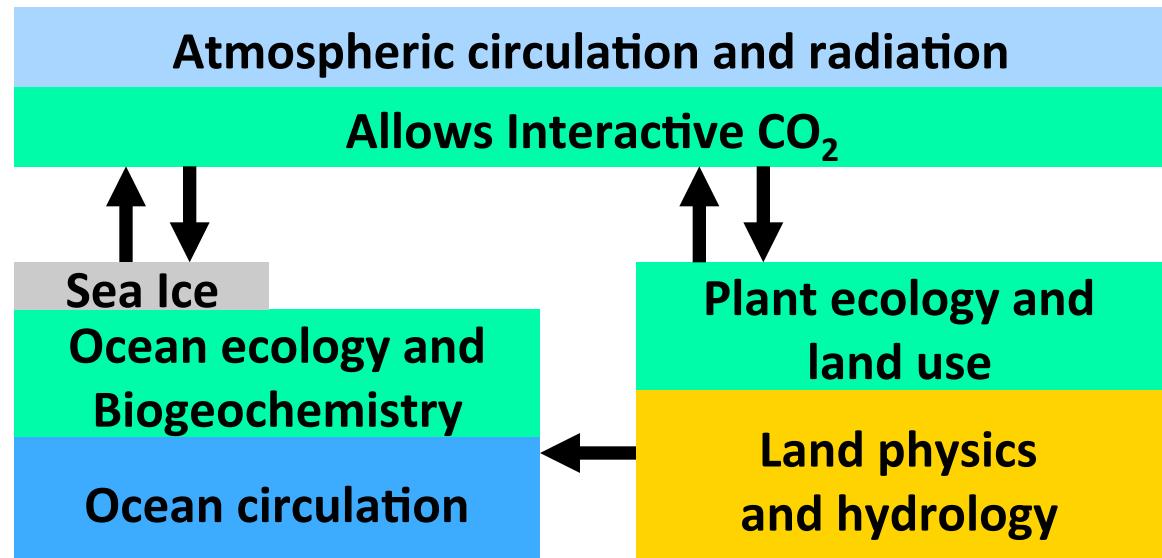
Earth System Models* close the carbon cycle

Future CMIPs ? – Nitrogen, CH₄, Fe, P, ...

Climate Model

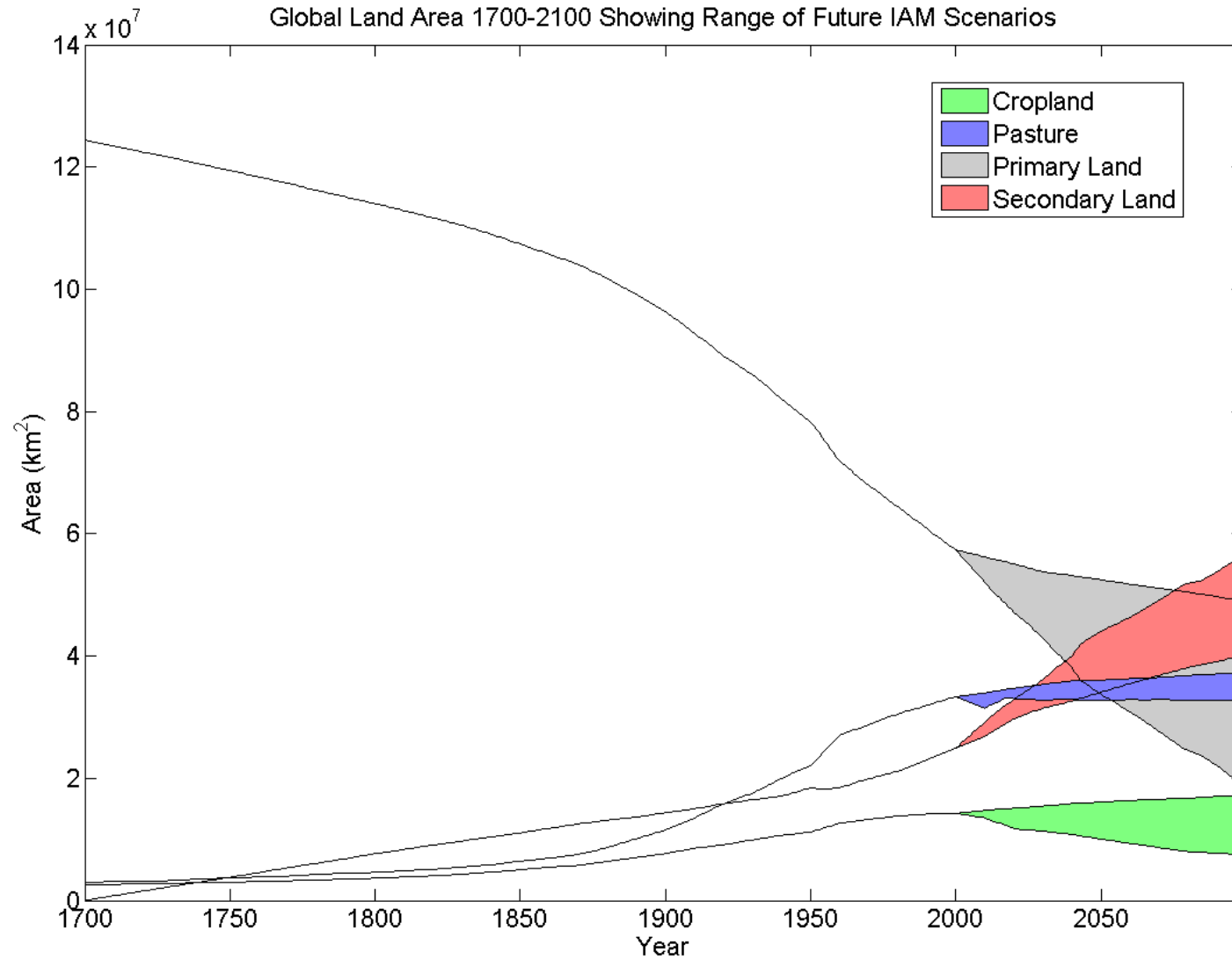


Earth System Model *



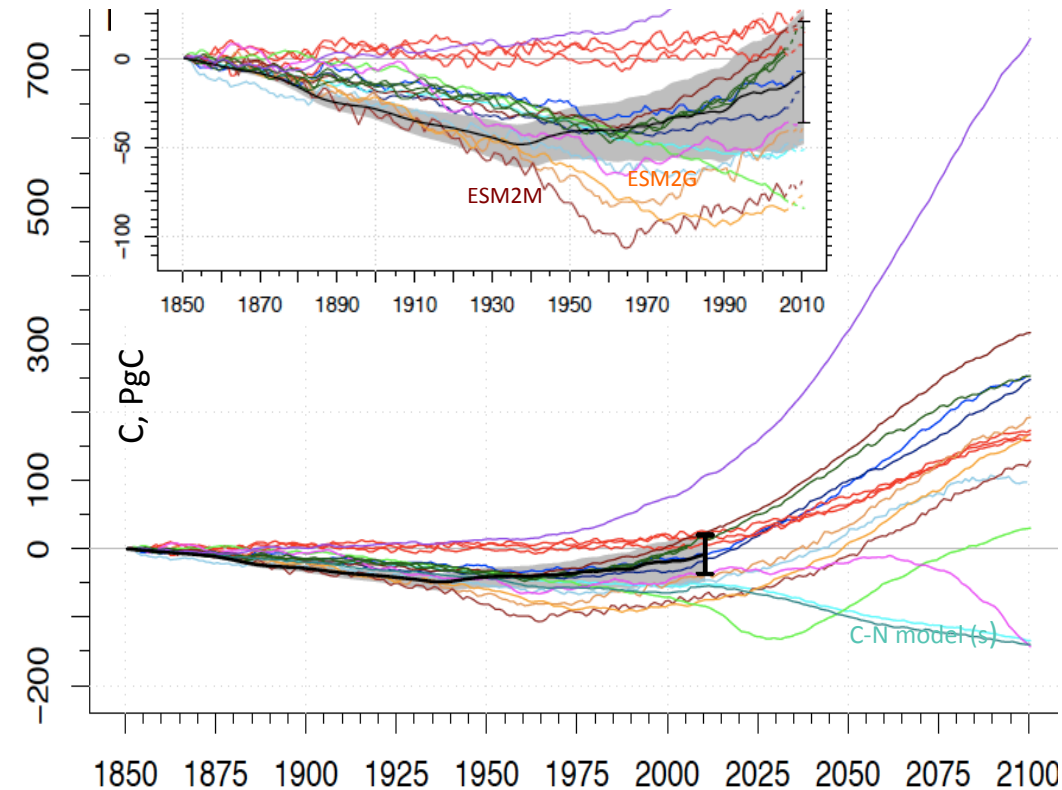
*CMIP5 definition; many other definitions of an ESM possible

Past and Future Land Use



Most CMIP5 ESMs have included LULCC

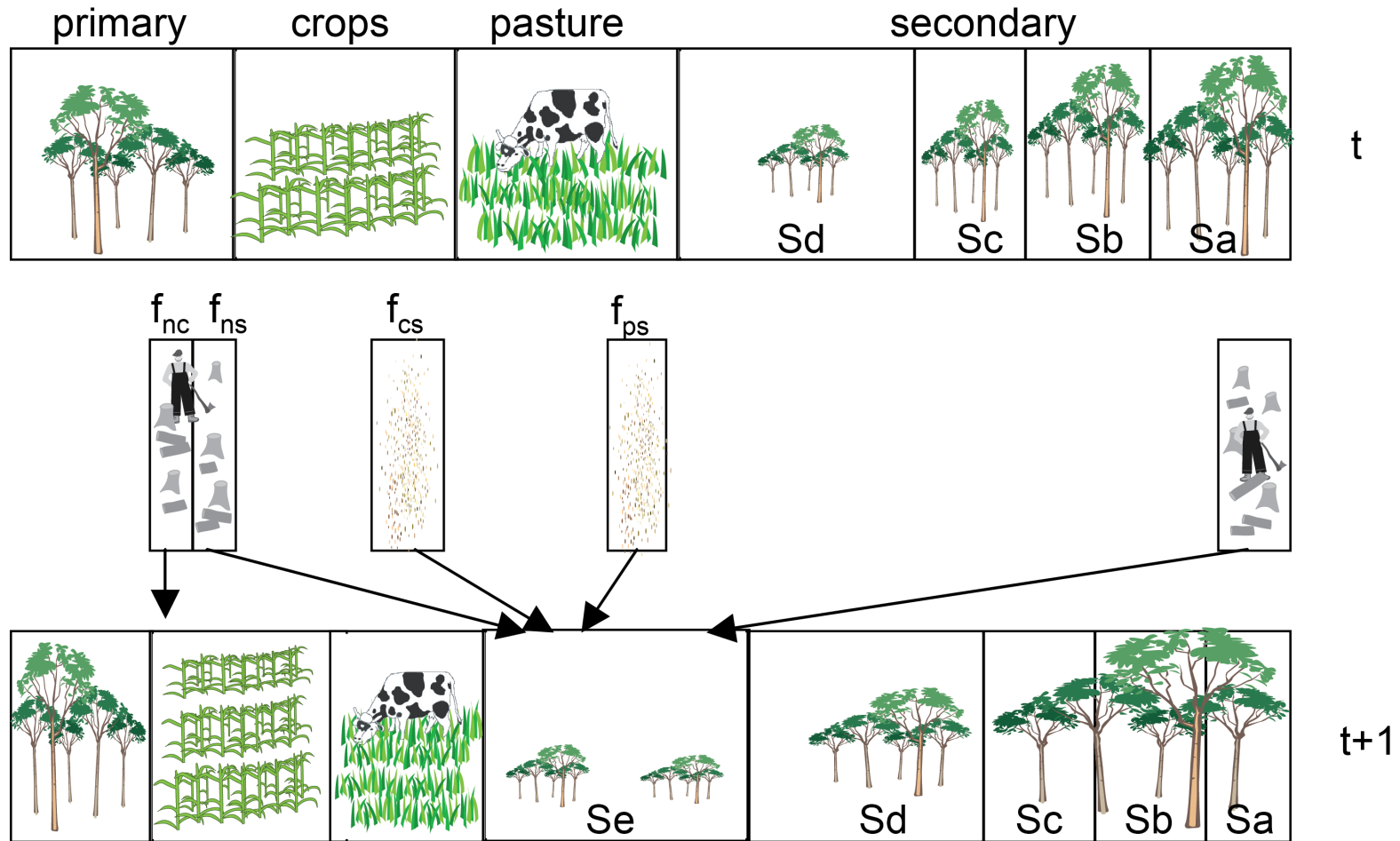
Land C Accumulation



Hoffman et al. 2013

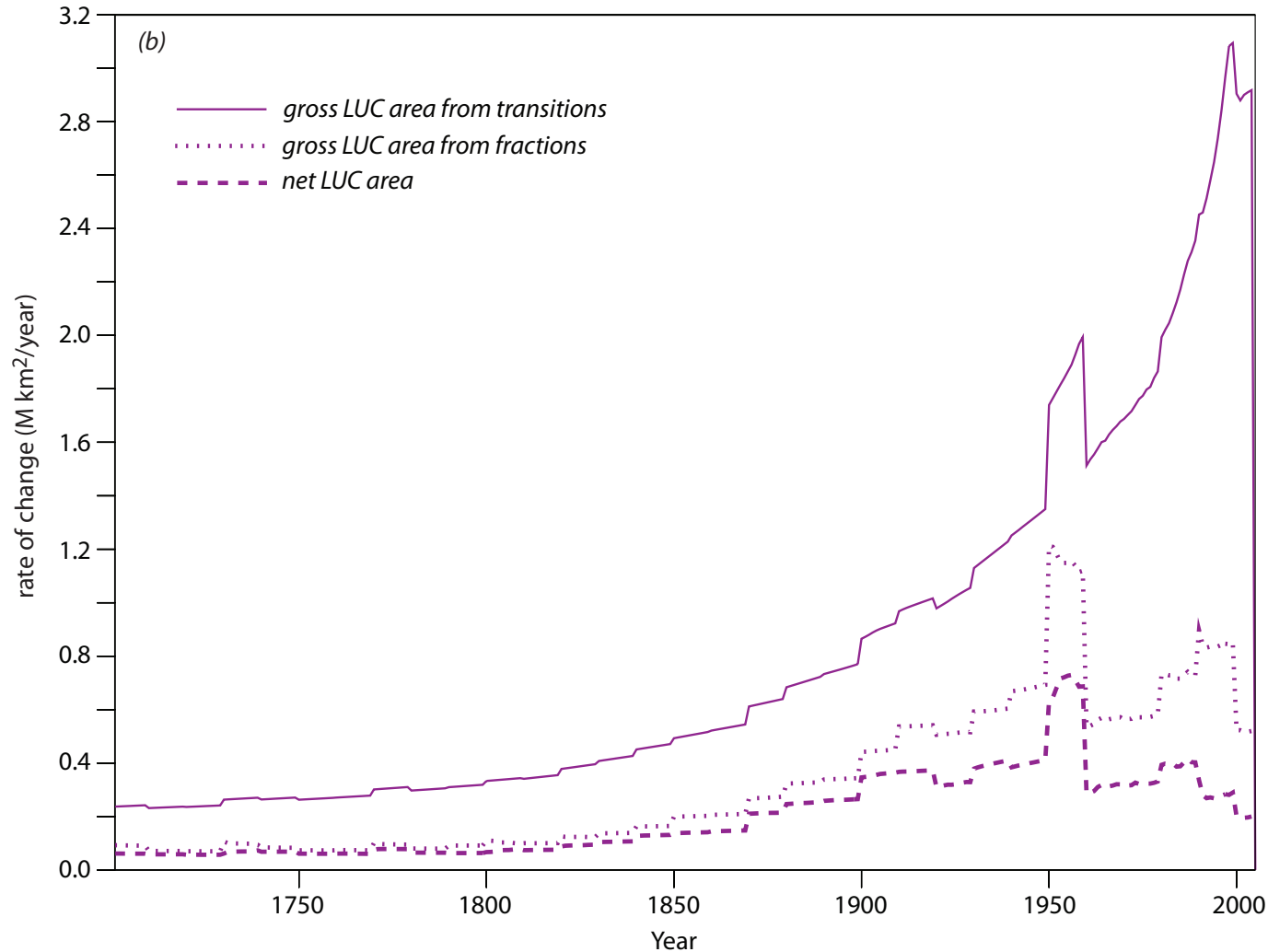
- Only 5 out of 15 ESMs used prognostic biogeography
- LULCC is different among the models
- Many ESMs capture land C source to sink transition, but timing is delayed
- Cumulative historical land C uptake in ESM2G within observational constraints.
- Large uncertainty in future land uptake
 - nutrient limitation
 - ecosystems processes
 - climate change
 - LULCC

GFDL ESM LU categories

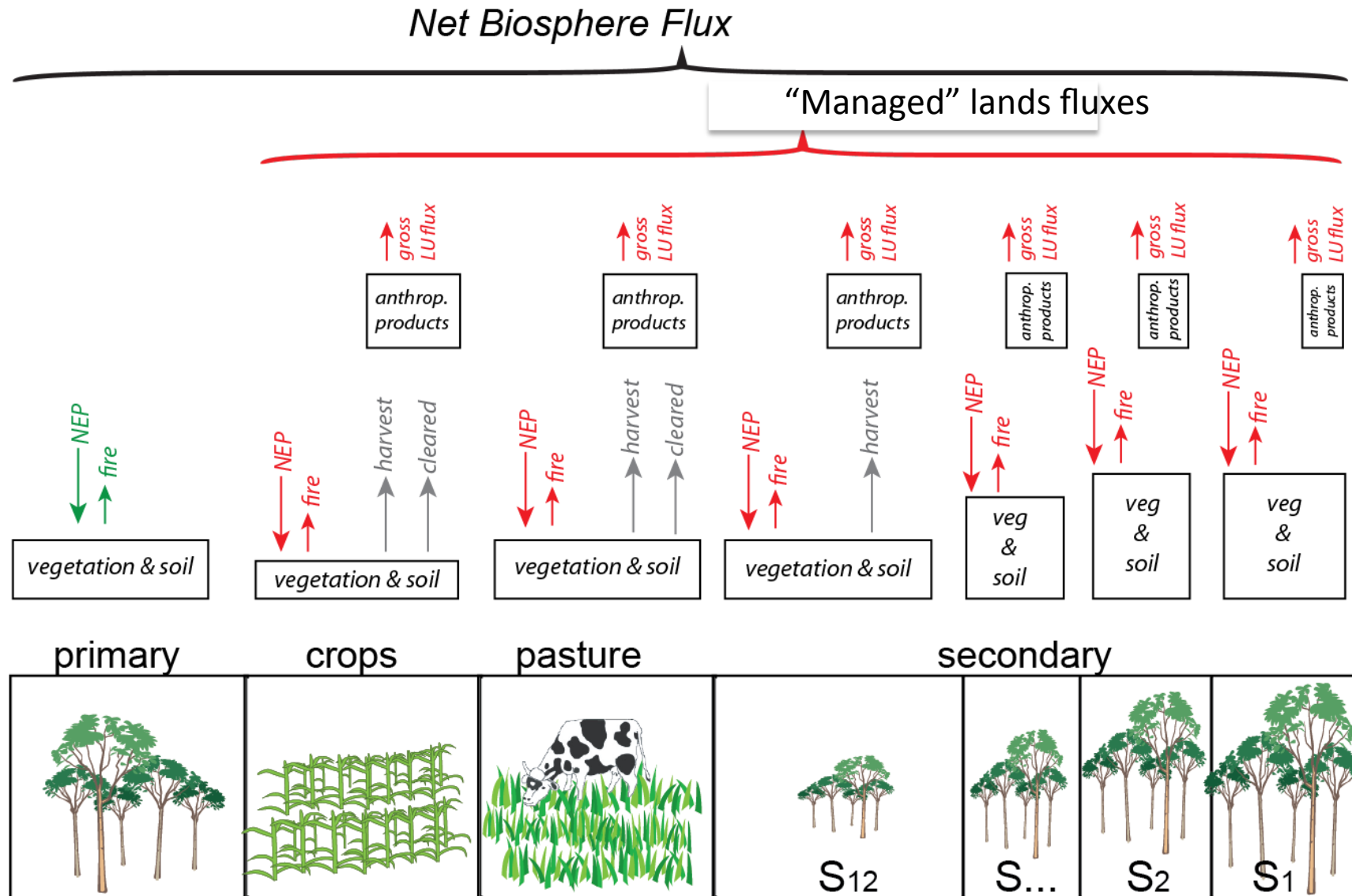


Represents both deforestation and forestry, including secondary forest re-growth

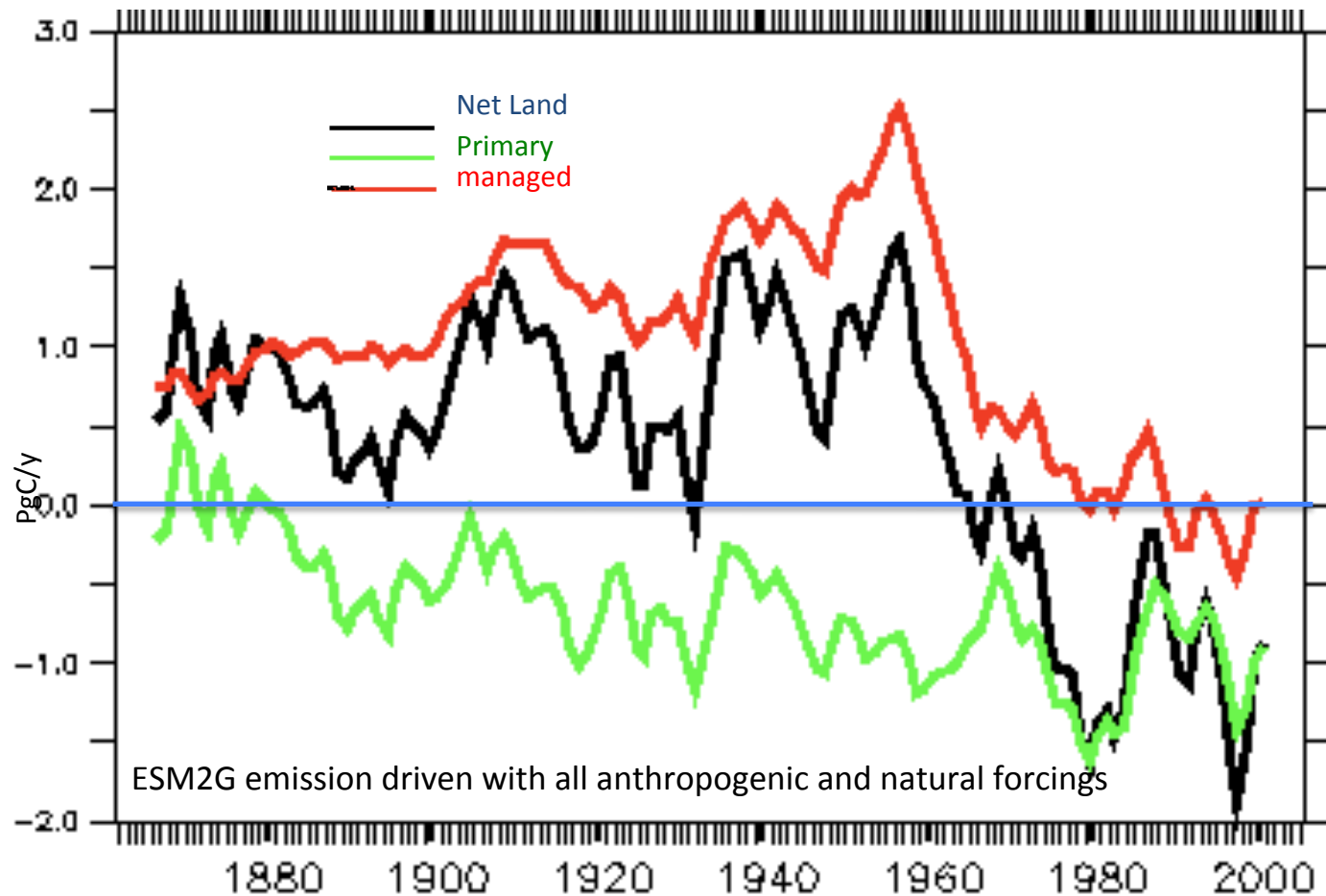
How much LULCC ? (gross vs net)



BGC cycling on primary vs “managed” lands



GFDL ESMs: Substantial Managed Lands Net Contribution of 140PgC



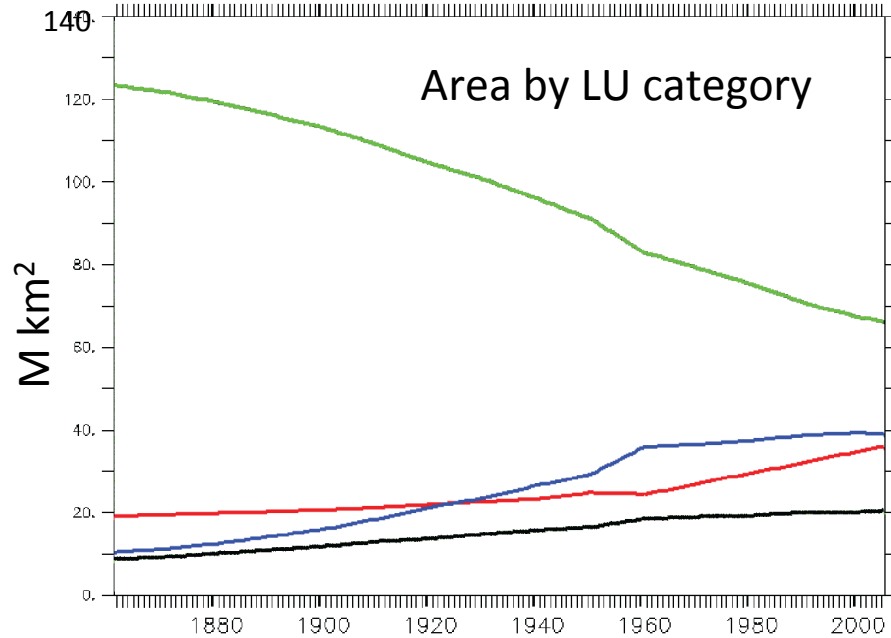
Land is a sink
from ~1970s

Managed lands
are in balance
since 1990s

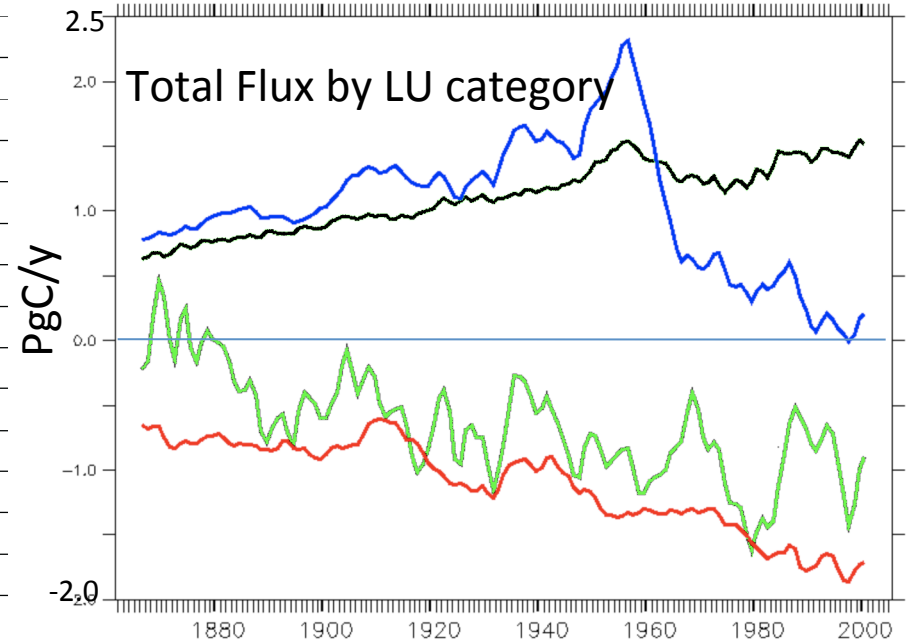
CO₂ fertilization
drives uptake on
primary lands

;

Shevliakova et al. , in prep



— Cropland
— Primary

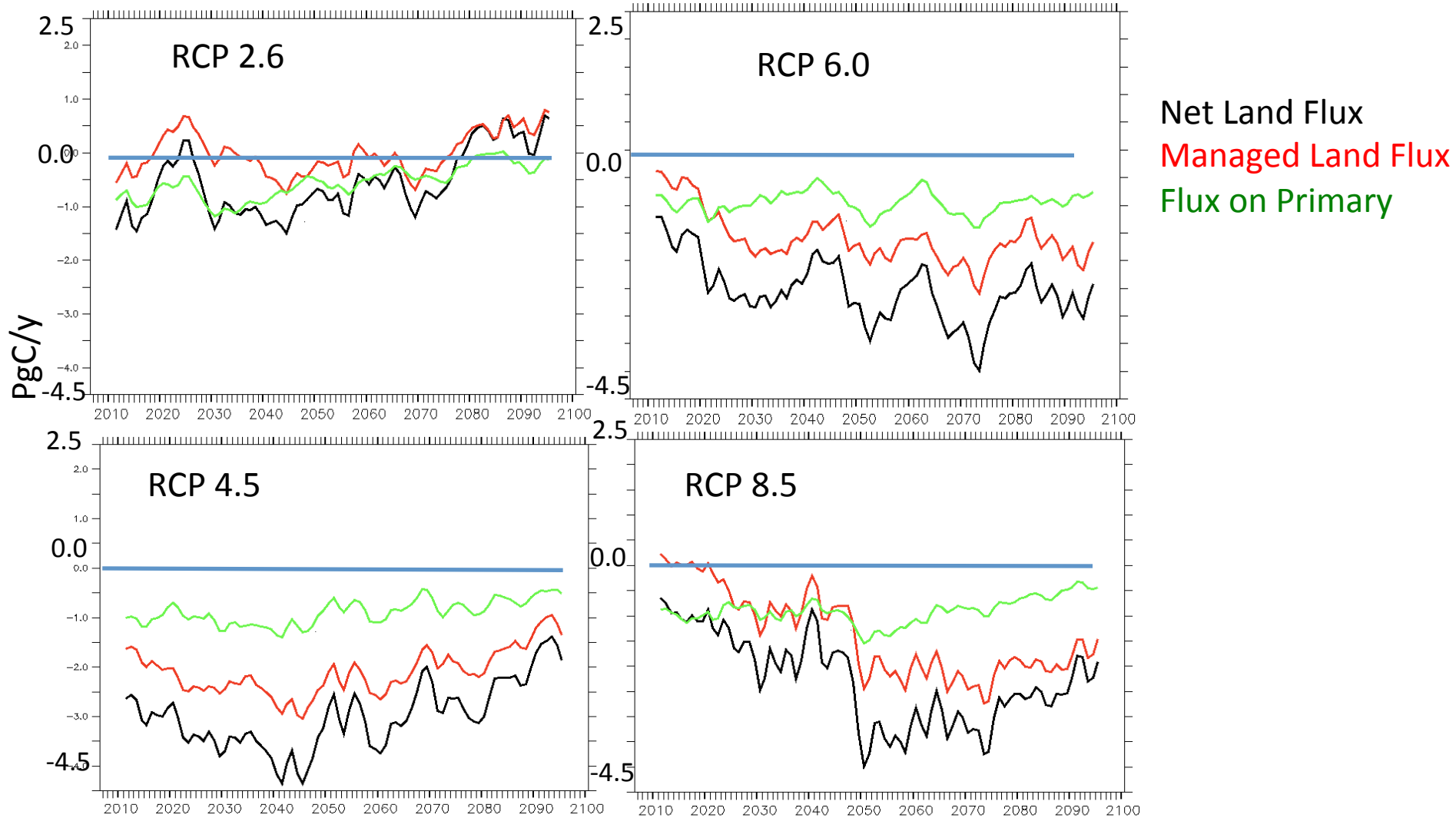


Shevliakova et al. , in prep

— Secondary
— Pastures

ESM2G emission driven experiment with all anthropogenic and natural forcings
LU scenarios in terms of transition rates between 4 different LU types

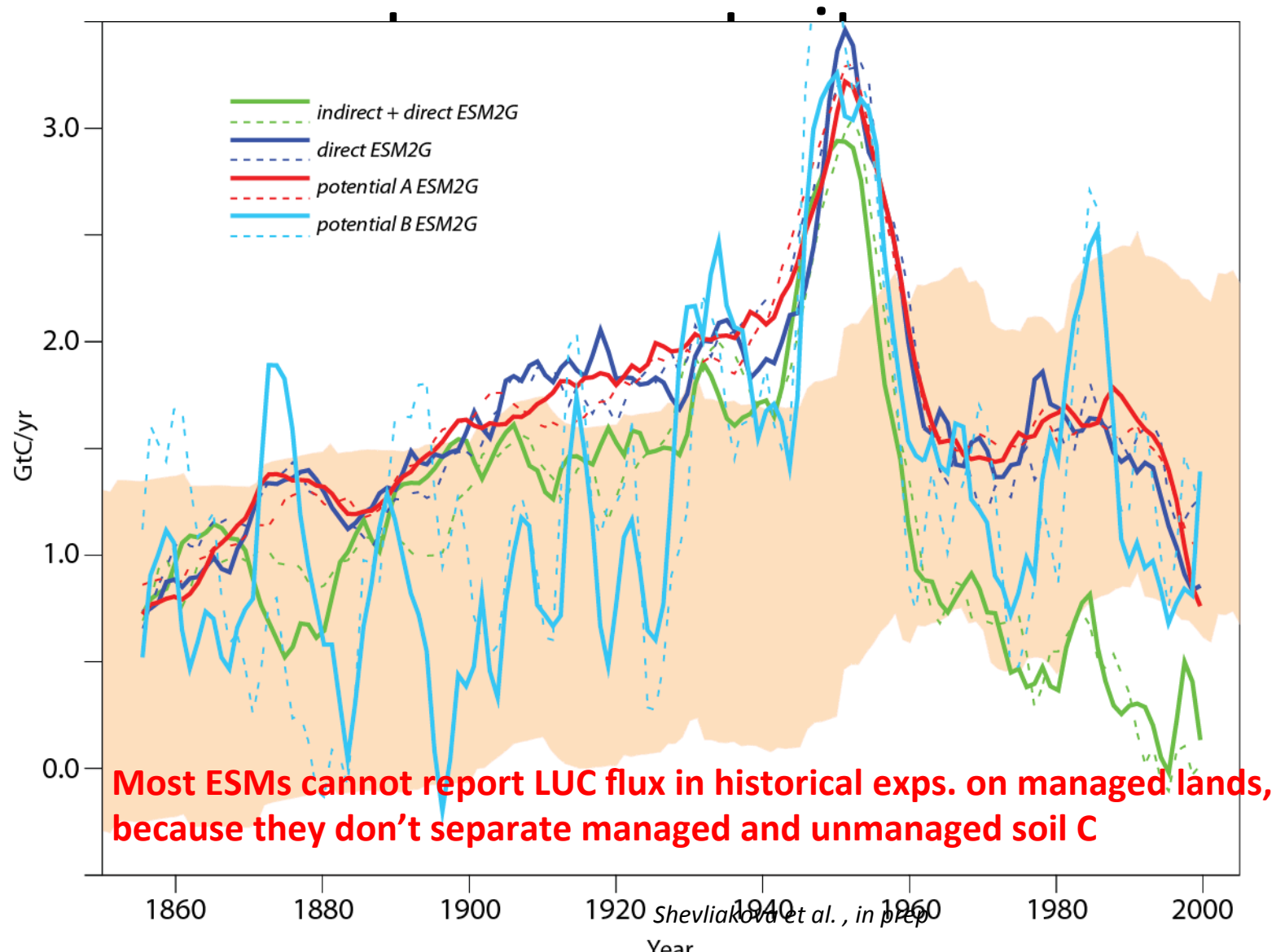
ESM2G: in 21st century Land continues to be a sink except in RCP2.6



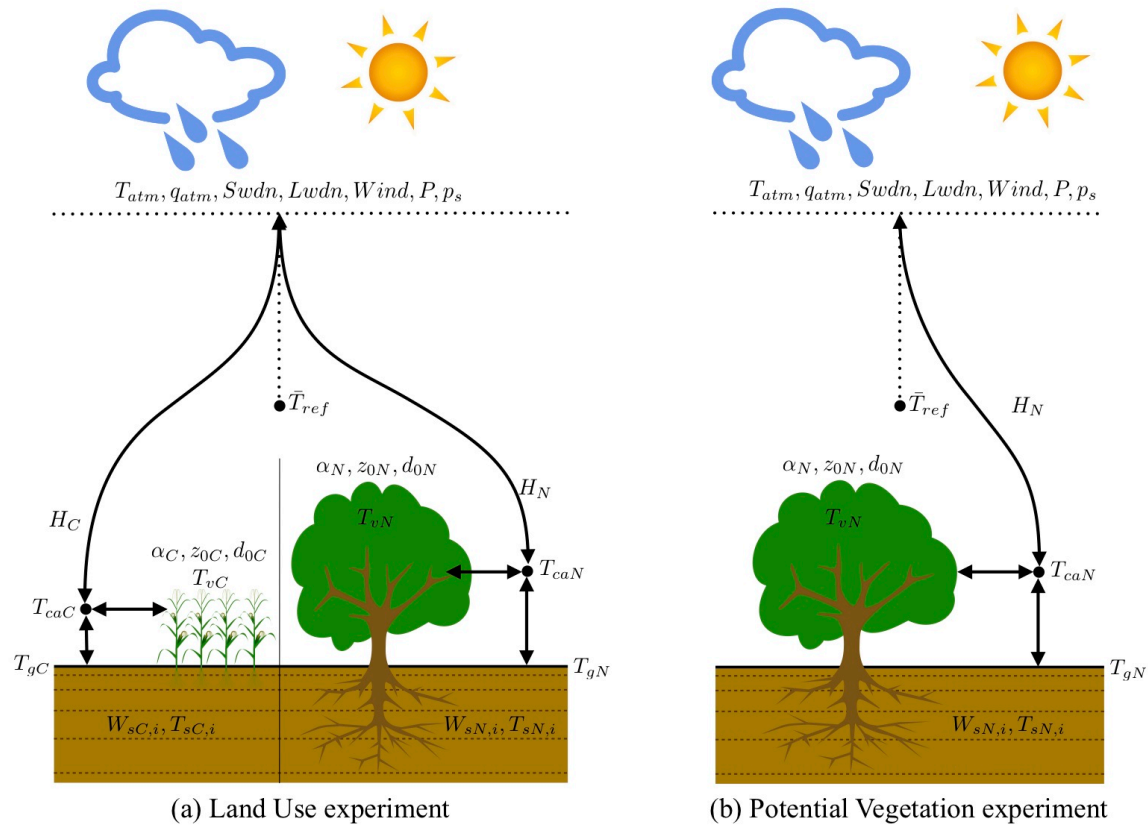
Land flux on managed lands : different methods

- **Net land flux on managed lands, bookkeeping method**
- **Net land flux on managed lands, PI (no climate change or CO₂), bookkeeping method (same transitions)**
- **ESM: historical – no LULCC**
 - the same climate forcing but different historical experiment,
 - climate variability is too large!
- **Land_only: historical – no LULCC**
 - the same climate/CO₂
 - No climate variability !

The magnitude of C flux on managed lands **DEPENDS** on the methods used

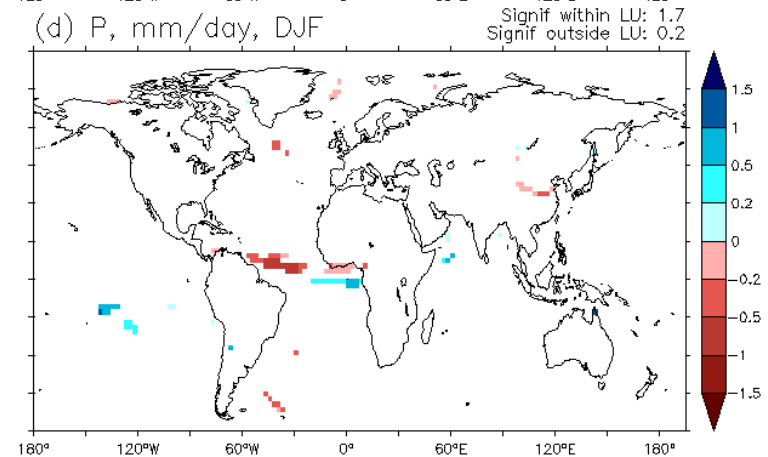
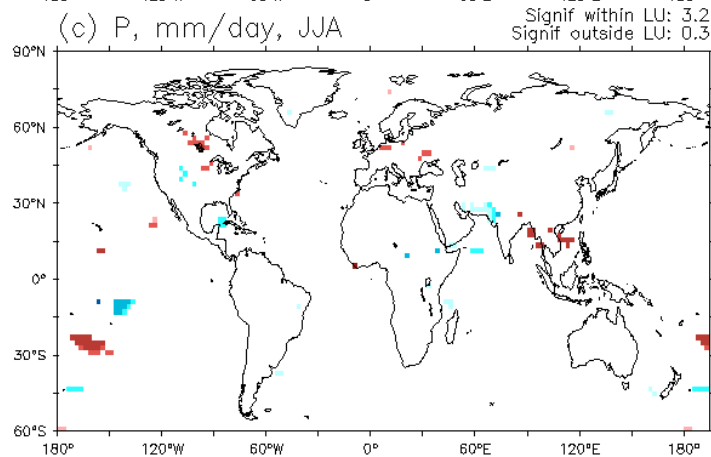
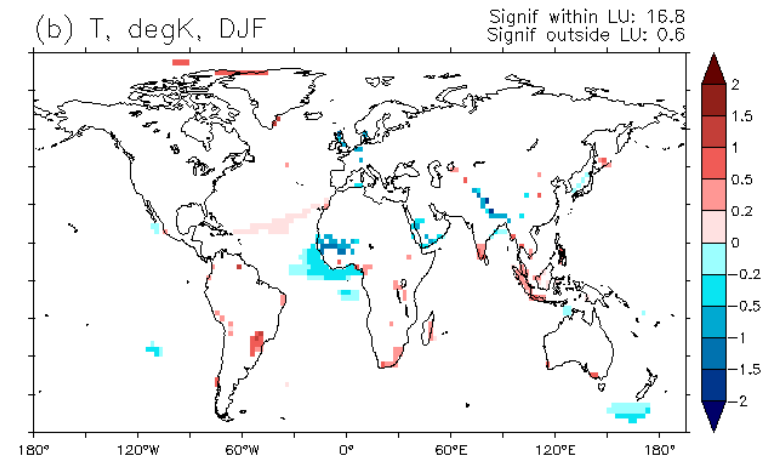
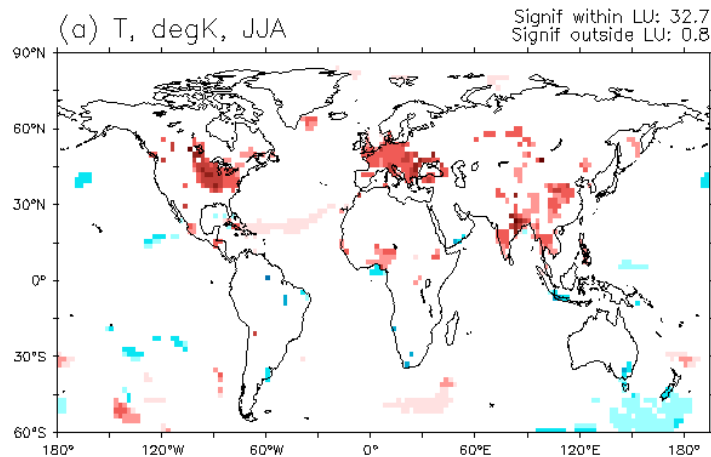


Biophysical effect of LULCC– implications of differencing ESM experiments (and climate variability)

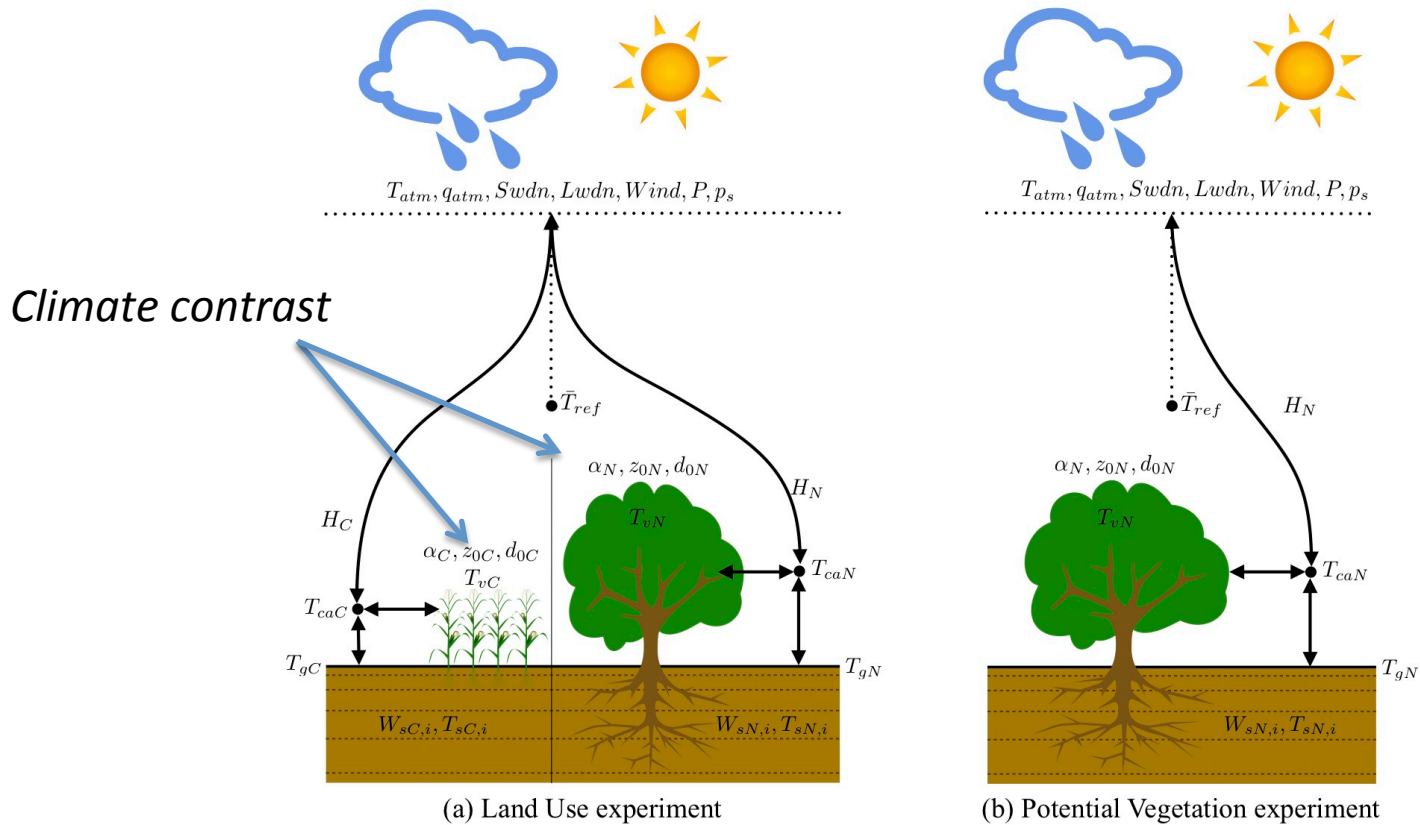


Climate variability masks LULCC biophysical signal in difference between GFDL exps

1986-2005

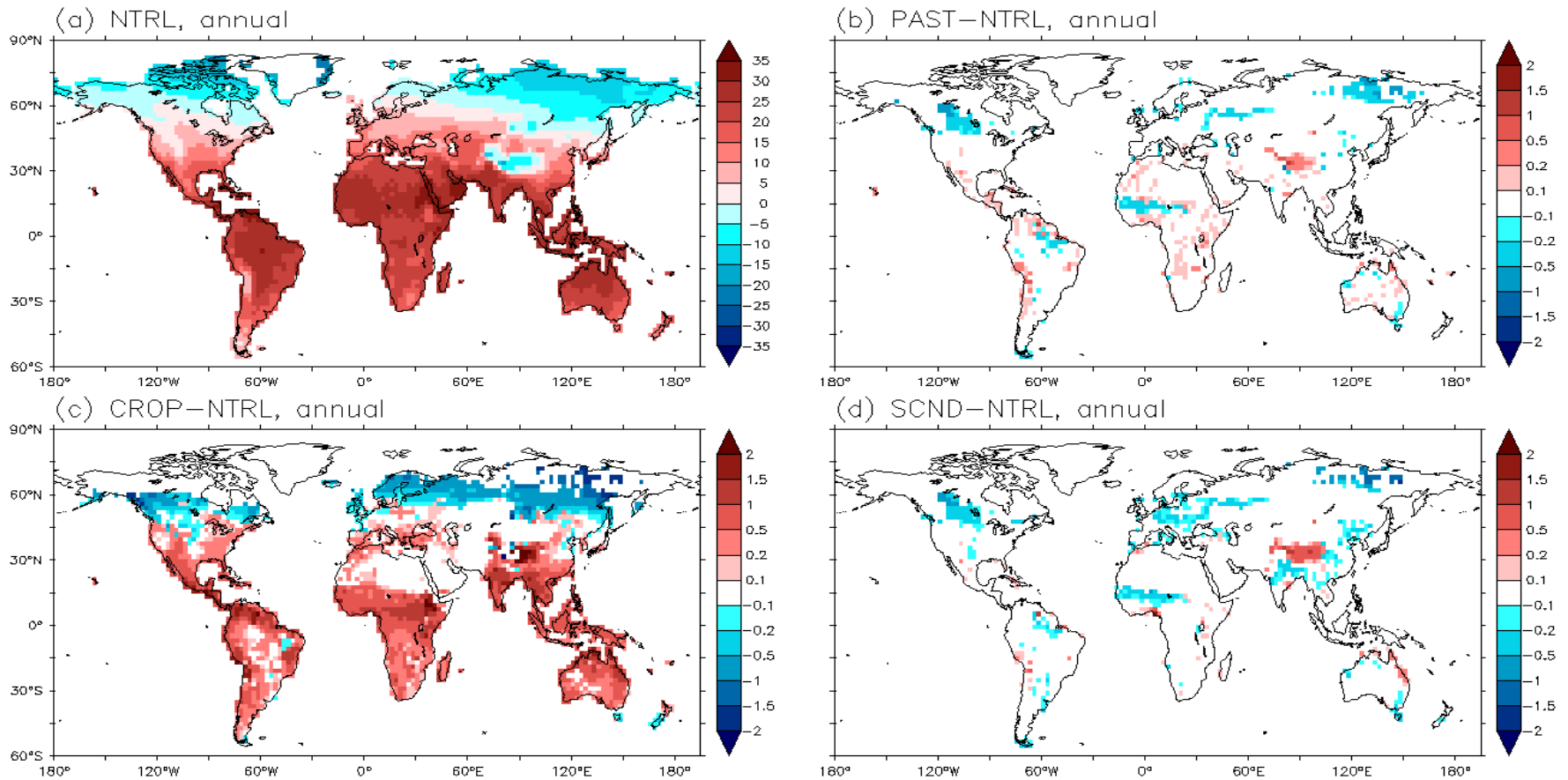


Biophysical effect of LULCC– implications of differencing ESM experiments (and climate variability)



Climate contrasts alleviate some of the issues with climate variability for LULCC

1986-2005



Malyshev et al, in prep

Summary: LUMIP for CMIP6 design

- Comprehensive LU scenarios will help to accelerate ESM developments
- New experimental design will enable new investigations
- Diagnostic by LU management (e.g. cropland, pasture, natural+ secondary, urban, lake) will help to
 - evaluate and compare land components of ESMs
 - characterize effects of LULCC on surface climate and BGC cycling
 - provide sub-grid information for impact studies
 - alleviate some issues with the ESM/AOGCM climate variability masking LULCC effects
- Land –only simulations will help to
 - evaluate land models with “best” climate reconstructions (e.g. ILAMB) or with native ESM climates
 - figure out below-ground hydrological and BGC responses to LULCC in many ESMs