



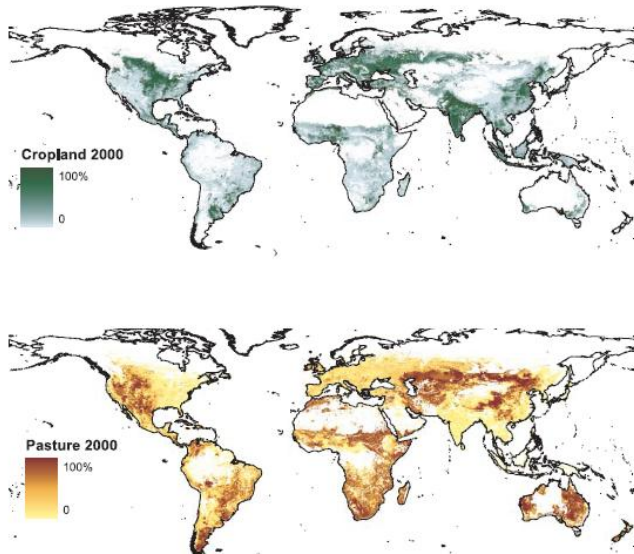
# **Land use radiative impact on temperature and precipitation response in the Eurasian regions**

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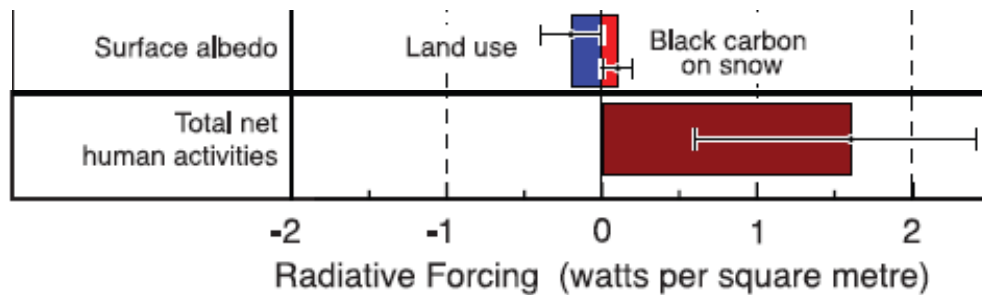
EGU General Assembly 2010

# Motivation



adopted from [Ramankutty et al., 2008]

Around year 2000, about  $\frac{1}{3}$  of the ice-free land surface is covered by crops or pastures [Ramankutty et al., 2008]. Land cover transformations affect surface albedo (direct effect due to albedo differences between different vegetation types + snow masking effect), transpiration, surface roughness, etc.



adopted from IPCC AR4

According to IPCC AR4, land use leads to the shortwave radiative forcing  $-0.2 \pm 0.2 \text{ W/m}^2$  which, in general, not a negligibly small part of the total anthropogenic radiative forcing  $\sim 1.6 \text{ W/m}^2$  (from  $0.6 \text{ W/m}^2$  to  $2.4 \text{ W/m}^2$ ).

# IAP RAS CM

*Resolution:* 4.5°\*6°, L8 – atmosphere, L4 – ocean, L1 –land;  $\Delta t = 5$  days

*Atmosphere:* 3D quasi-geostrophic large-scale dynamics. Synoptic-scale dynamics is parametrised as Gaussian ensembles. In any atmospheric layer, temperature depends linearly on height. Fully interactive hydrological cycle.

*Ocean:* Prognostic equation for sea surface temperature (SST). Geostrophic large-scale dynamics. Universal vertical profiles in any oceanic layer. Oceanic salinity is prescribed. Interactive, globally averaged oceanic carbon cycle.

*Sea ice:* Diagnostic, based on the local SST

*Vegetation:* Spatial distribution of ecozones is prescribed. Fully interactive, globally averaged terrestrial carbon cycle. Interactive CH<sub>4</sub> emissions from natural wetlands.

*Turnaround time:* ~ 6 sec per model year (Intel Core Quad 2.2 GHz)

# Land surface albedo

## Direct effect:

Surface albedo depends on vegetation type (natural/agricultural; for natural vegetation albedo is biome-dependent).

## Snow masking:

Forested vegetation may partly mask snow. In the IAP RAS CM, in the presence of snow, surface albedo for forested biomes is prescribed to be equal to bare trees rather than the snow albedo.

# Simulations

Duration: 1500-2100

**SRES<sub>yyy</sub>** (*yyy* = B1, A1B, A2):

- historical + Special Report on Emission Scenarios anthropogenic CO<sub>2</sub> and CH<sub>4</sub> emissions;
- historical + SRES atmospheric concentrations of N<sub>2</sub>O, CFC-11, CFC-12 (BernCC), and tropospheric sulphates (MOZART 2.0);
- historical variations of stratospheric aerosol loading and total solar irradiance;

**LUH<sub>zzz</sub>** (*zzz* = MiniCAM, AIM, IMAGE, MESSAGE):

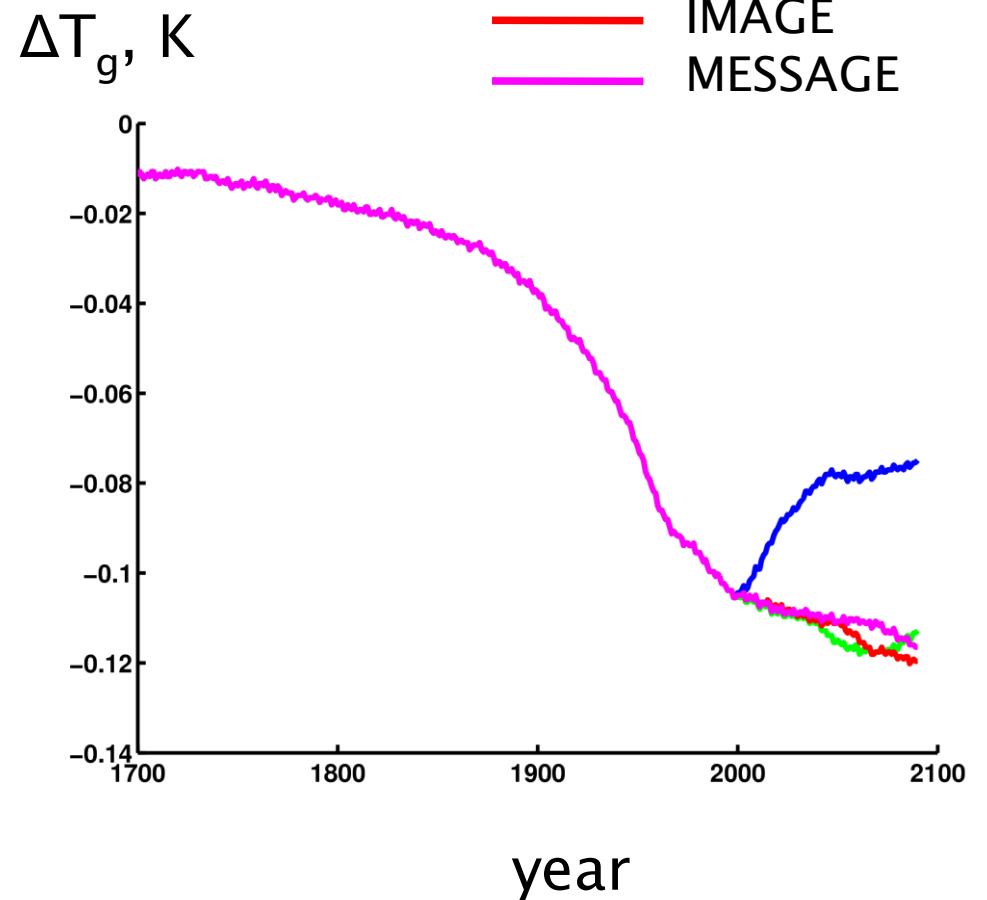
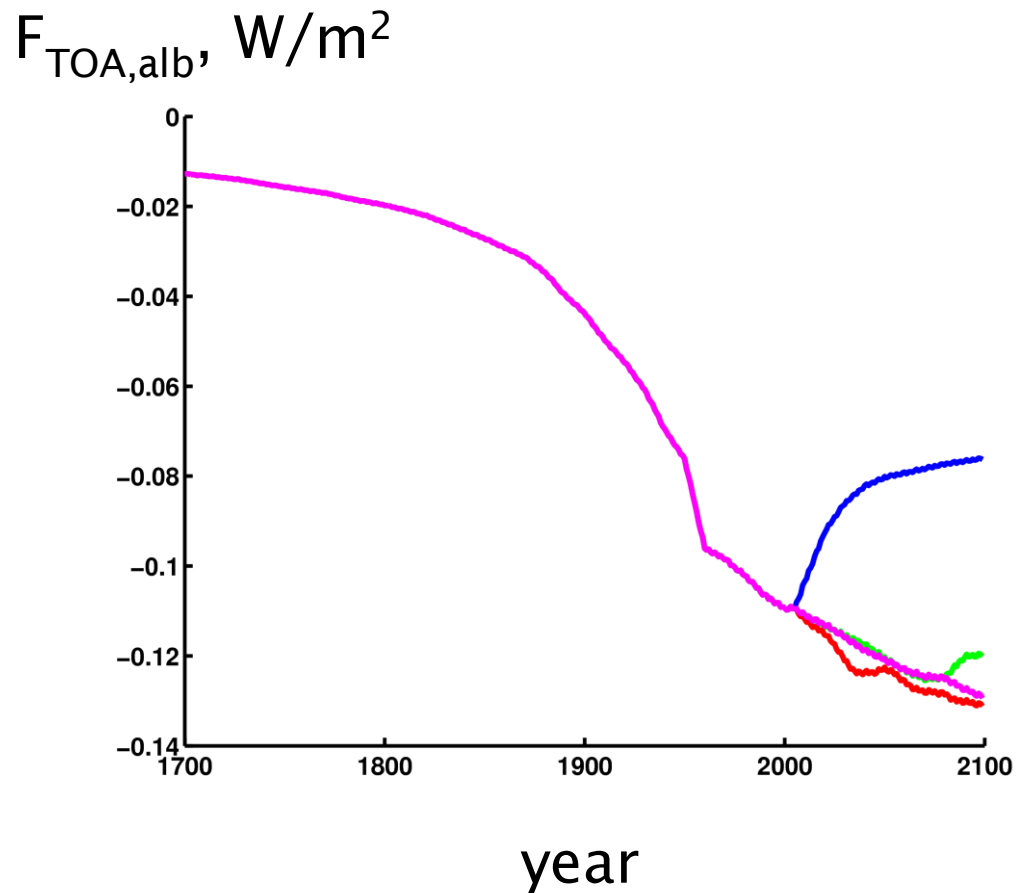
- historical (HYDE 3.1)+Land Use Harmonization extent of crops and pastures;

**SRES<sub>yyy</sub>-LUH<sub>zzz</sub>**: SRES<sub>yyy</sub> + LUH<sub>zzz</sub>;

For every simulation, 3 realisations are constructed with different initial conditions selected from the preanthropogenic simulation. Only ensemble means are studied.

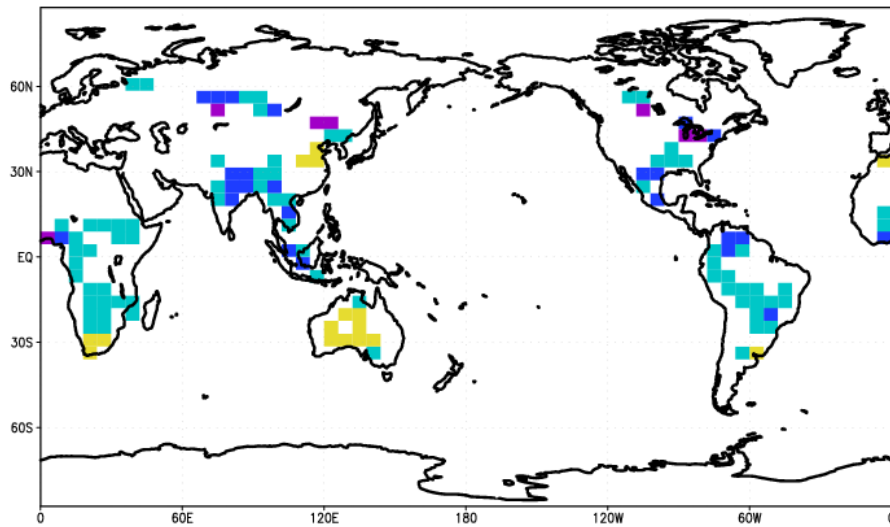
# Top-of-the atmosphere instantaneous radiative forcing due to land use and climate response in LU-only simulations

- MiniCAM
- AIM
- IMAGE
- MESSAGE

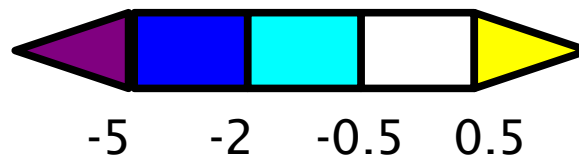
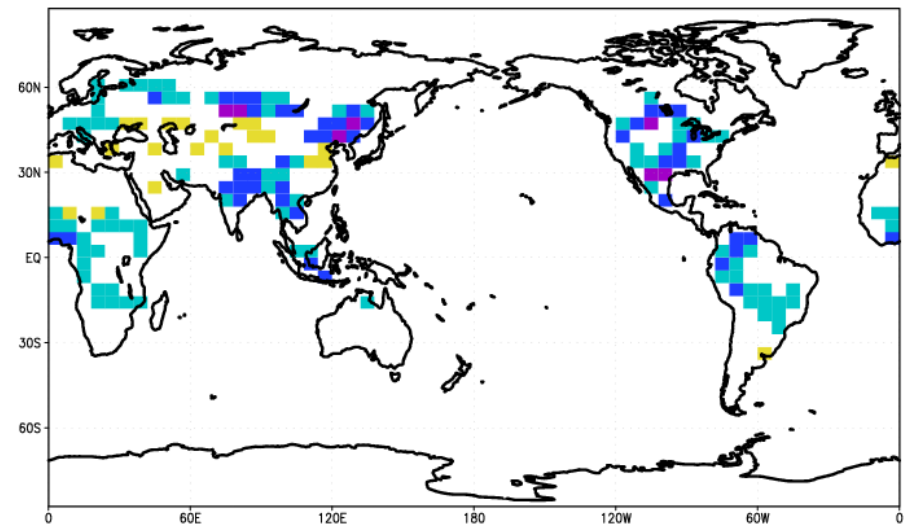


# Top-of-the atmosphere instantaneous radiative forcing [W/m<sup>2</sup>] due to land use: 1990-2000 relative to preanthropogenic state

January

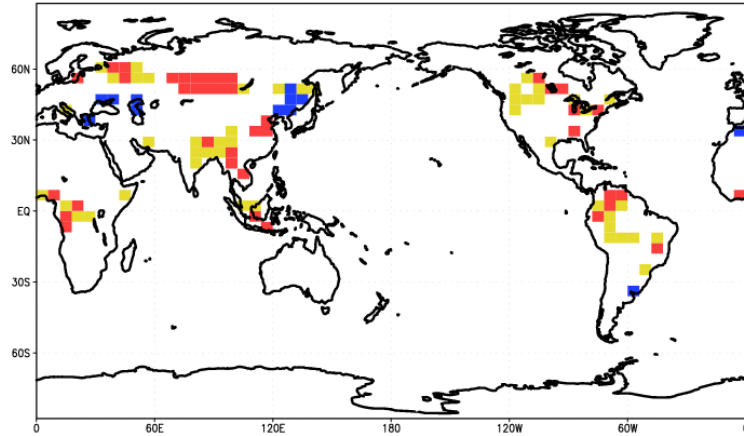


July

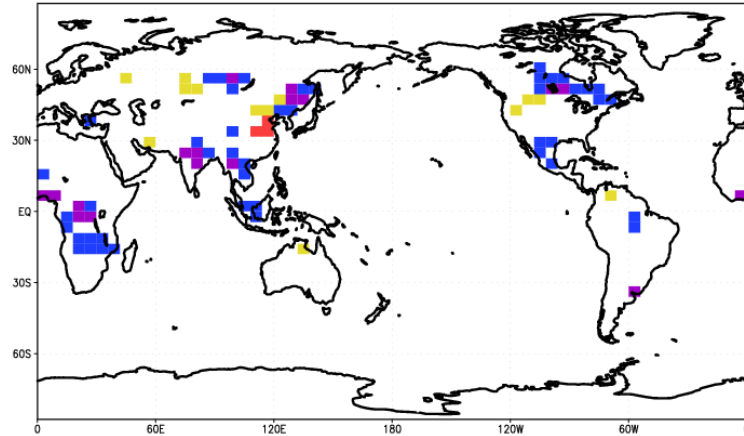


# Top-of-the atmosphere instantaneous radiative forcing [W/m<sup>2</sup>] due to land use: 2090-2100 relative to 1990-2000, July

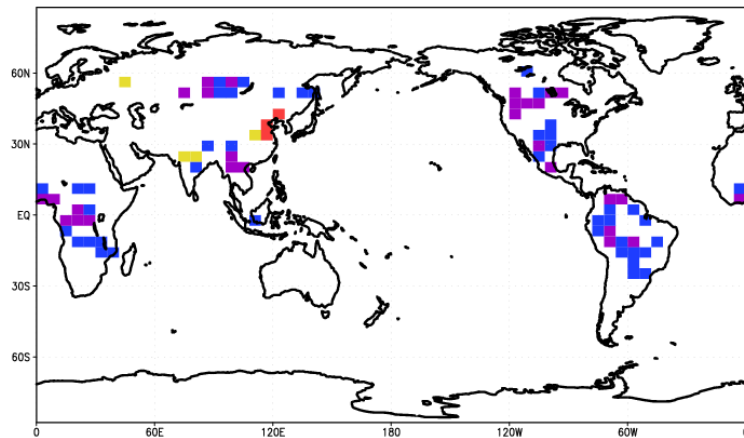
MiniCAM



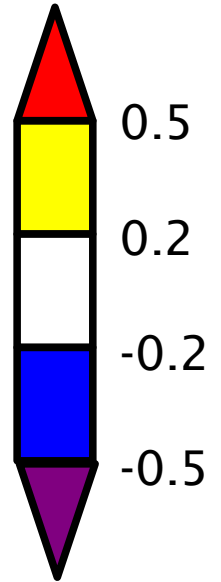
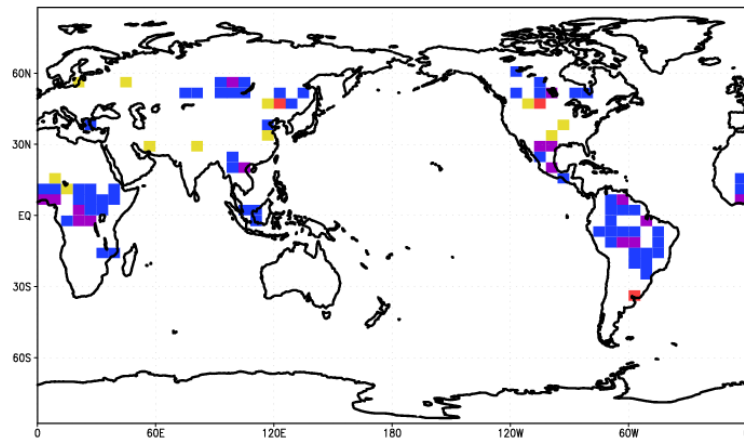
AIM



IMAGE

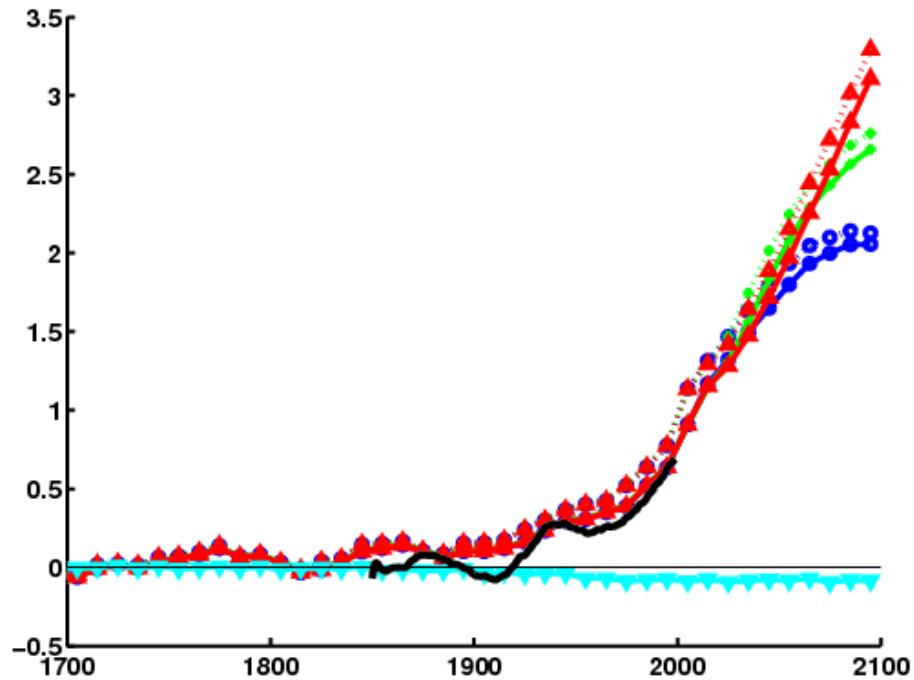


MESSAGE



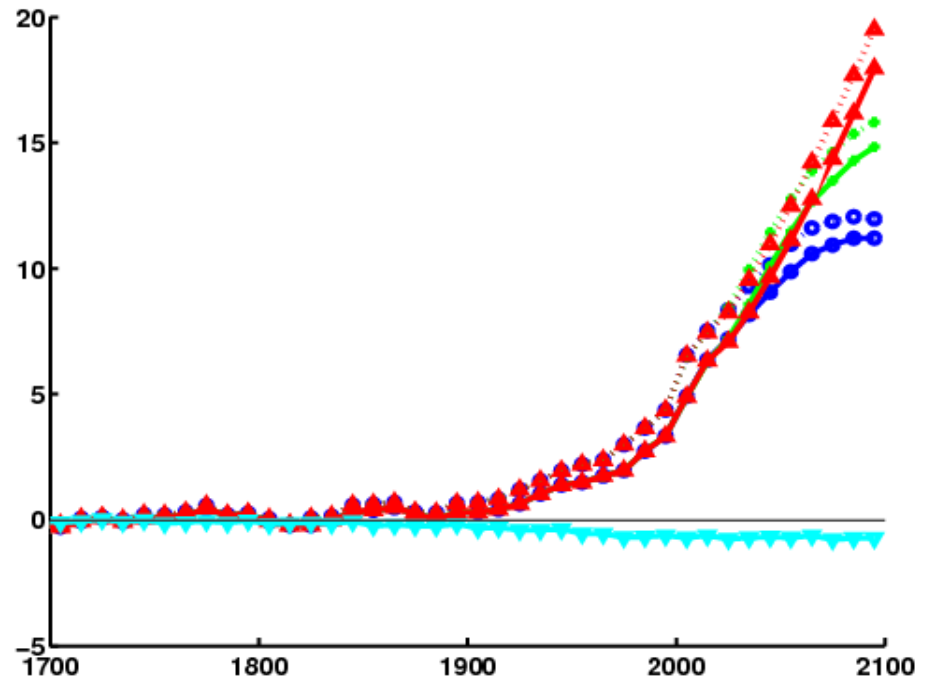
# Global annual mean response averaged over all LUH scenarios

$\Delta T_g$ , K

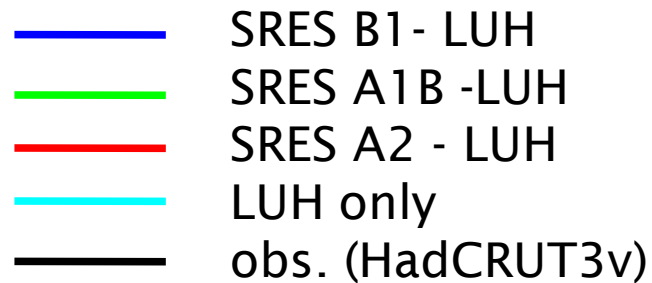


year

$\Delta P_g$ , mm/yr

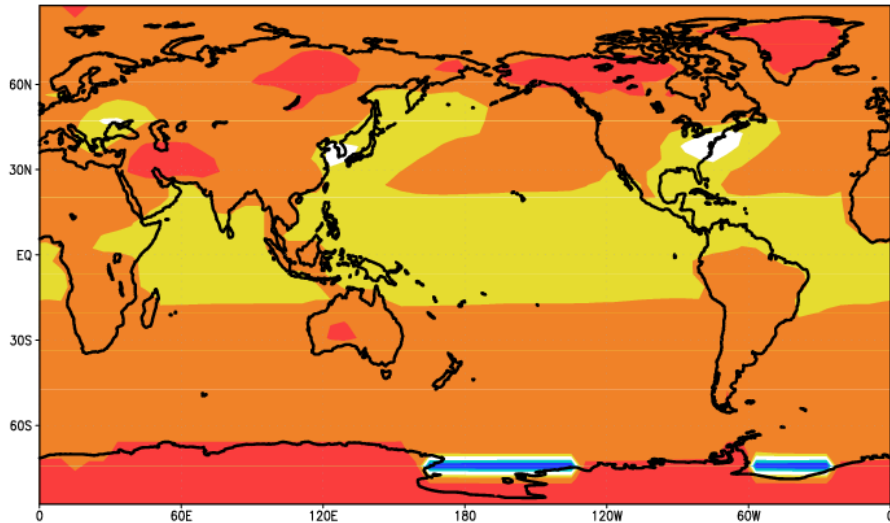


year

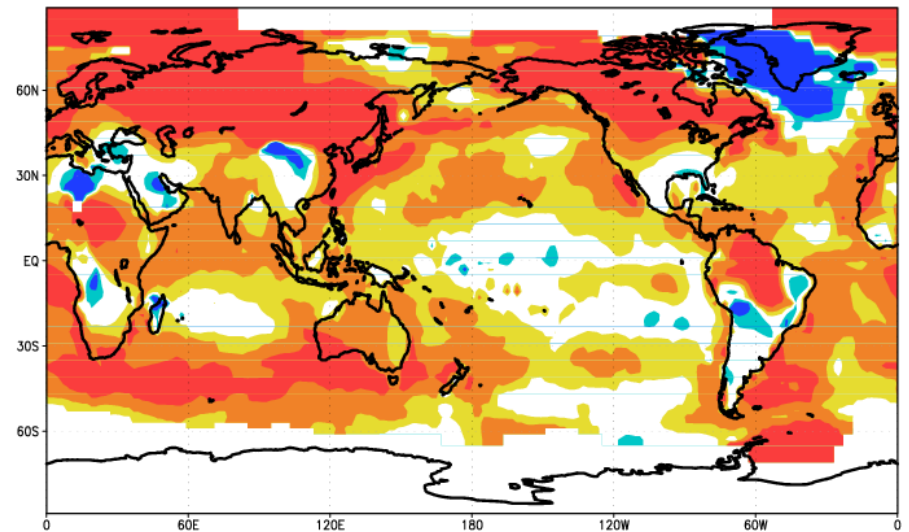


# 20th century surface air temperature change [K]

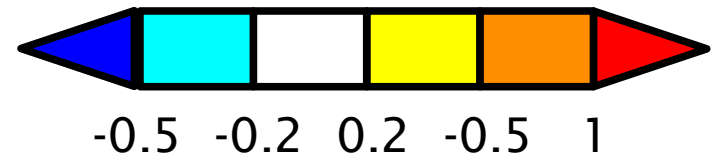
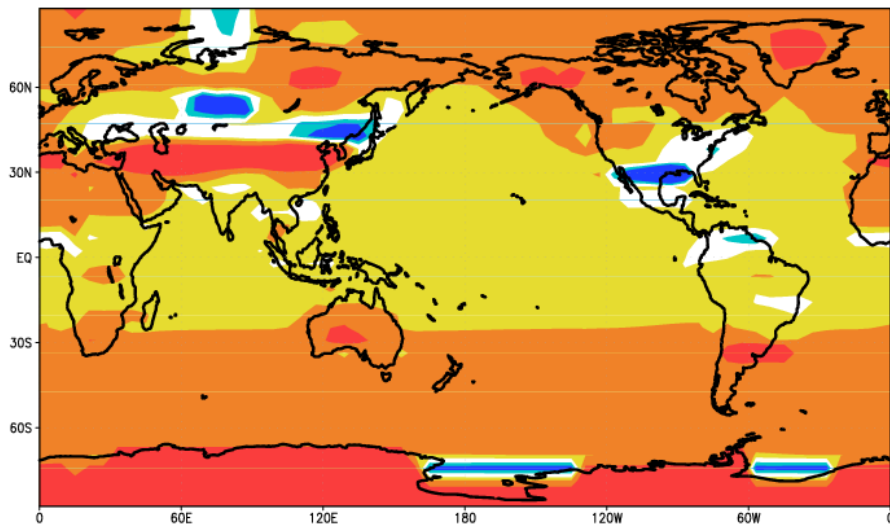
SRES



observed  
(GISS analysis data)

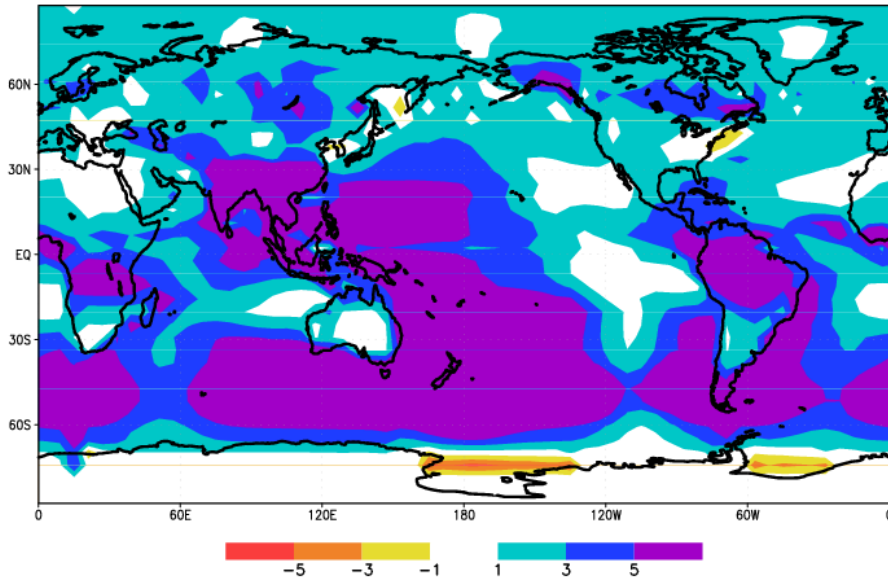


SRES-LUH

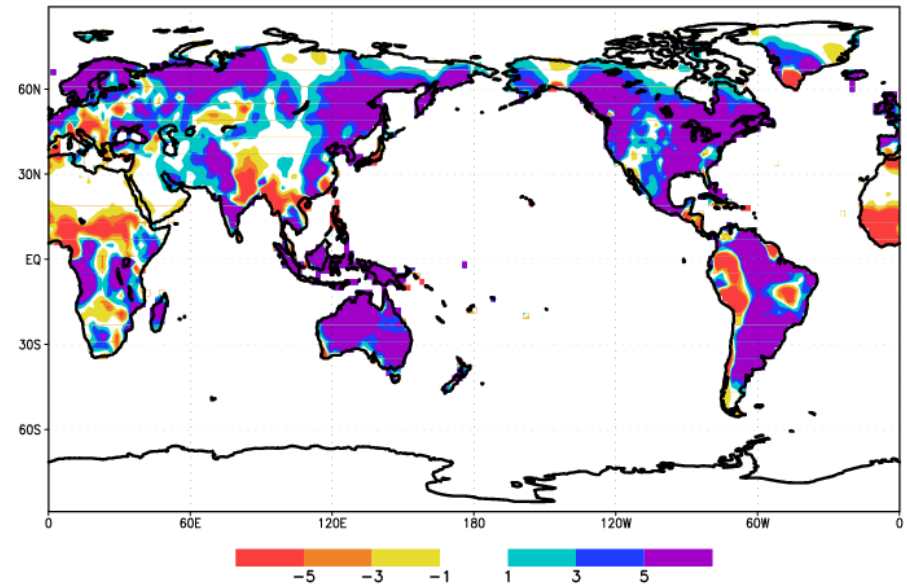


# 20th century annual precipitation change [cm]

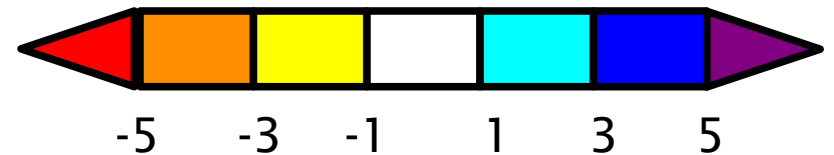
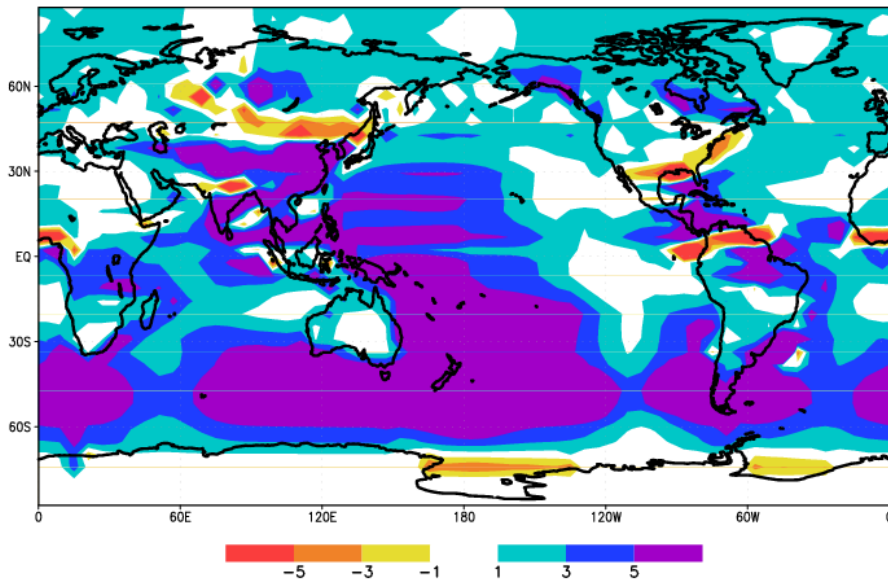
SRES



observed  
(UEA CRU analysis data)

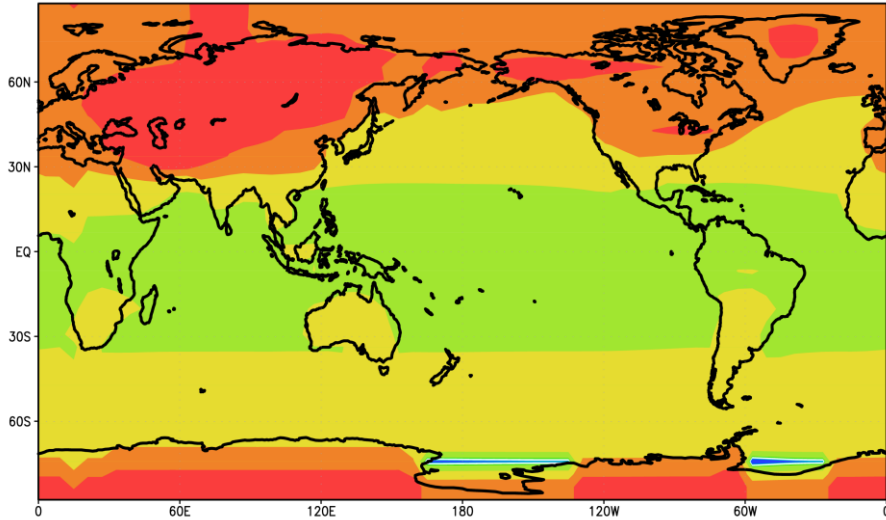


SRES-LUH

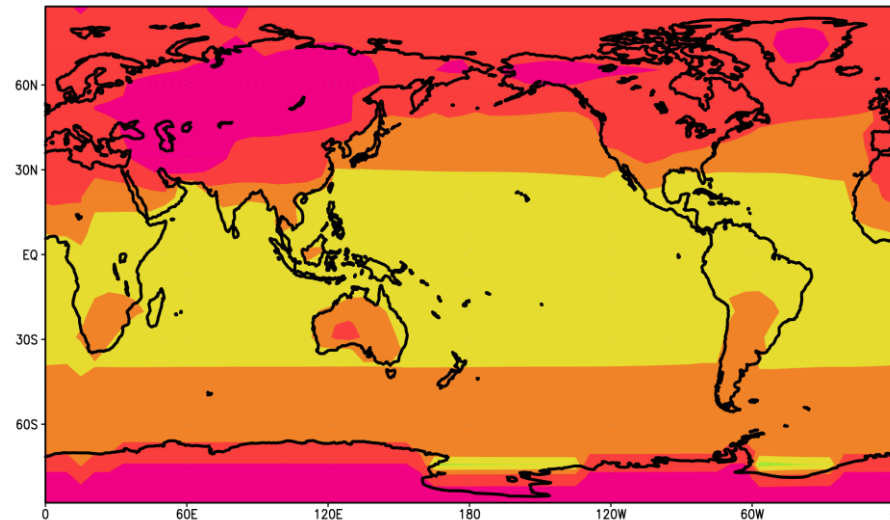


# 21st century surface air temperature change [K]

SRES B1  
(averaged over LUH scenarios)

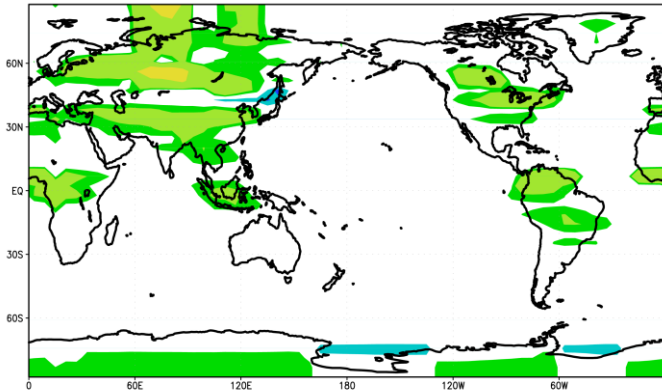


SRES A2  
(averaged over LUH scenarios)

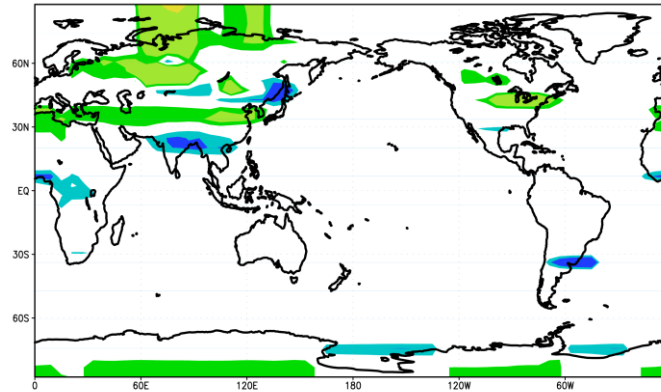


land use radiative impact averaged over SRES scenarios

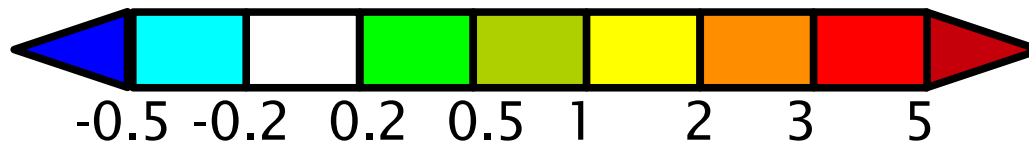
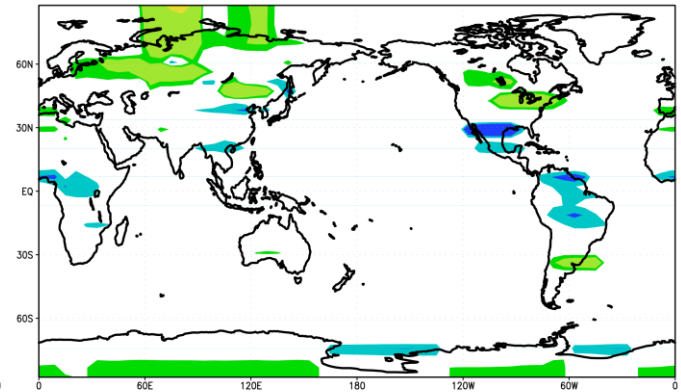
MiniCAM



AIM



MESSAGE



# Conclusions

- Radiative impact of land use is important for the observed decrease of temperature and precipitation in regions of intensive contemporary extension of agriculture. Globally, albedo change due to land use may account for 0.03 K of cooling in the 18-19th centuries. In addition, land use slows down the 20th century warming by  $\sim 0.07$  K.
- In the 21st century the radiative impact of land use activity under the LUH scenarios is, at least, smaller by one order of magnitude than the warming projected under the SRES anthropogenic scenarios.