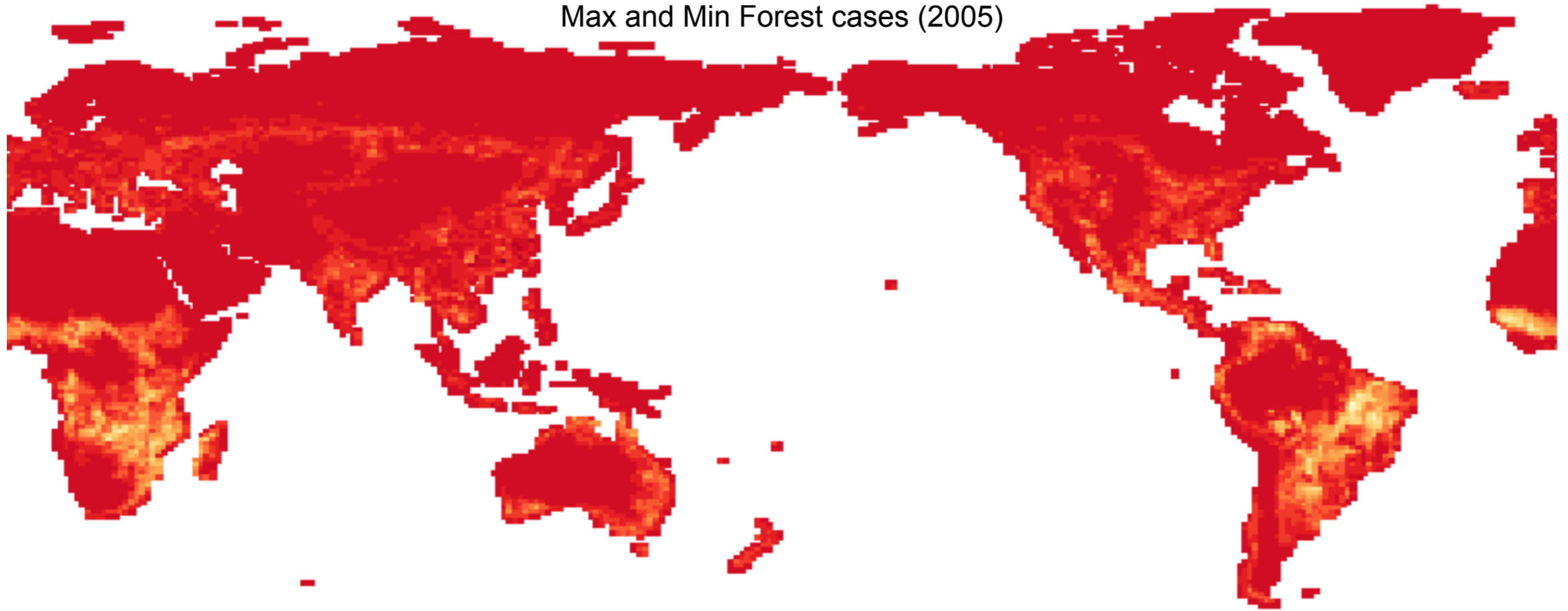


Land use/cover distribution is a primary determinant of global carbon and regional temperature projections

Difference in forest area between
Max and Min Forest cases (2005)



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Oak Ridge National Laboratory, Pacific Northwest National Laboratory, Berkeley Lab

CESM SDWG/LMWG/BGCWG meeting

5 Feb 2018



**EARTH &
ENVIRONMENTAL
SCIENCES**

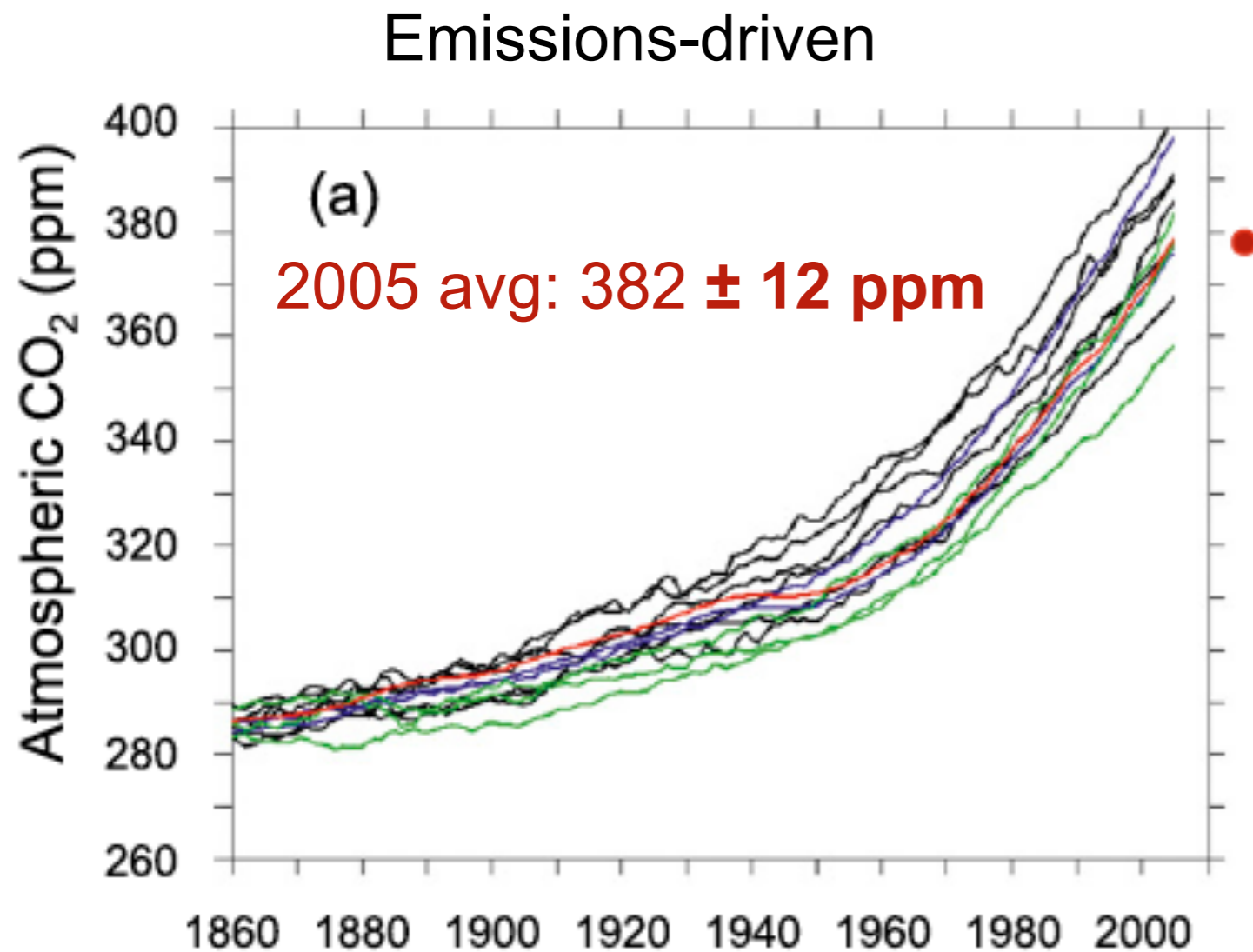
Earth Systems and Society Program



**OAK
RIDGE**
National Laboratory

**Pacific
Northwest**
NATIONAL
LABORATORY

Historical Carbon Uncertainties



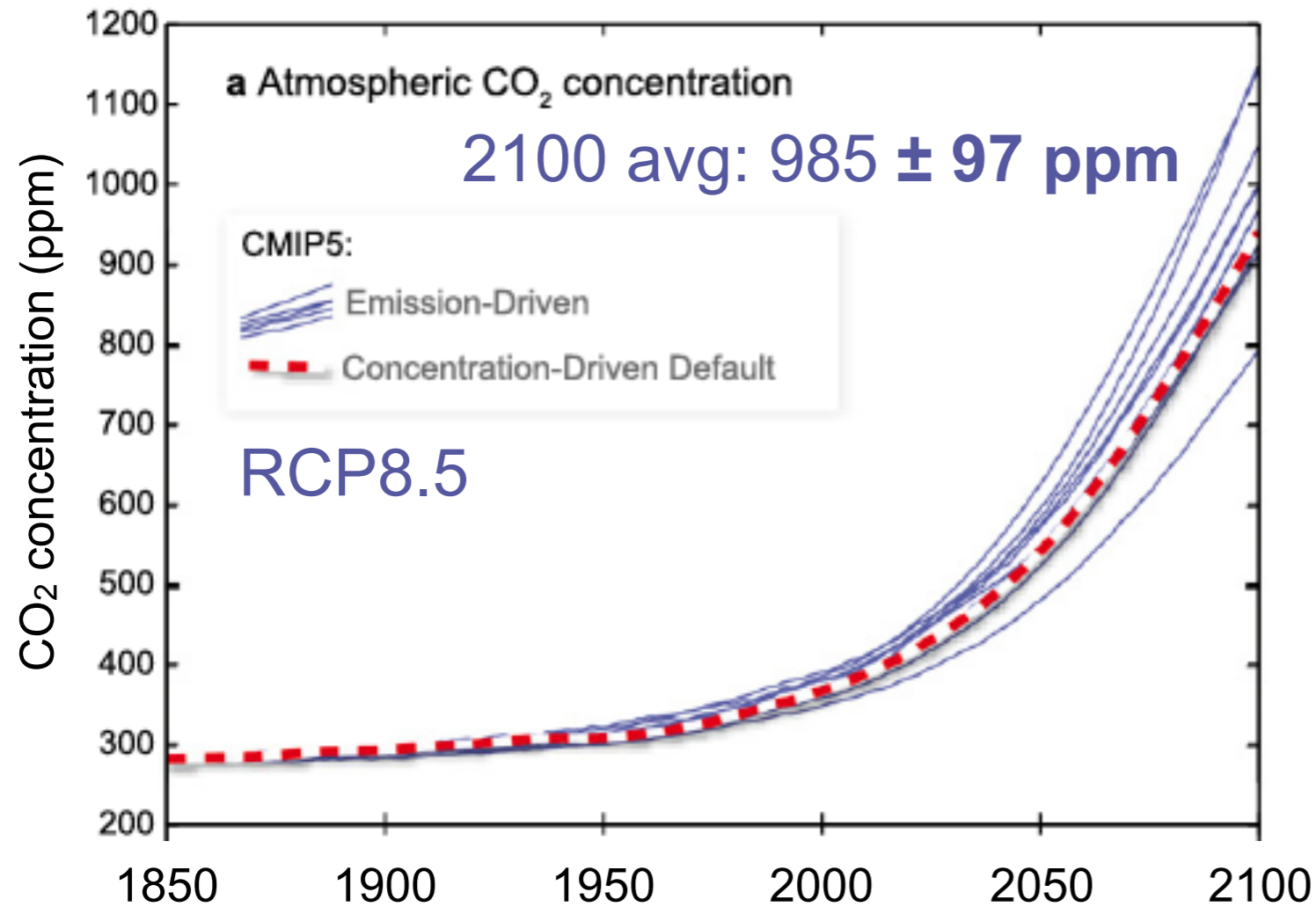
Friedlingstein et al., 2014

Model	1850-2005 NBP (PgC; + is uptake)
1	18
2	-59
3	-120
4	6.4
5	-57
6	0.8
7	-58
8	211
avg ± sd	-7.2 ± 99

Concentration-driven
Shao et al., 2013

Future Carbon Uncertainties

Emissions-driven



Friedlingstein et al., 2014

Model 2006-2100 NBP
RCP4.5 (PgC; + is uptake)

1 98

2 60

3 255

4 290

5 69

6 456

7 22

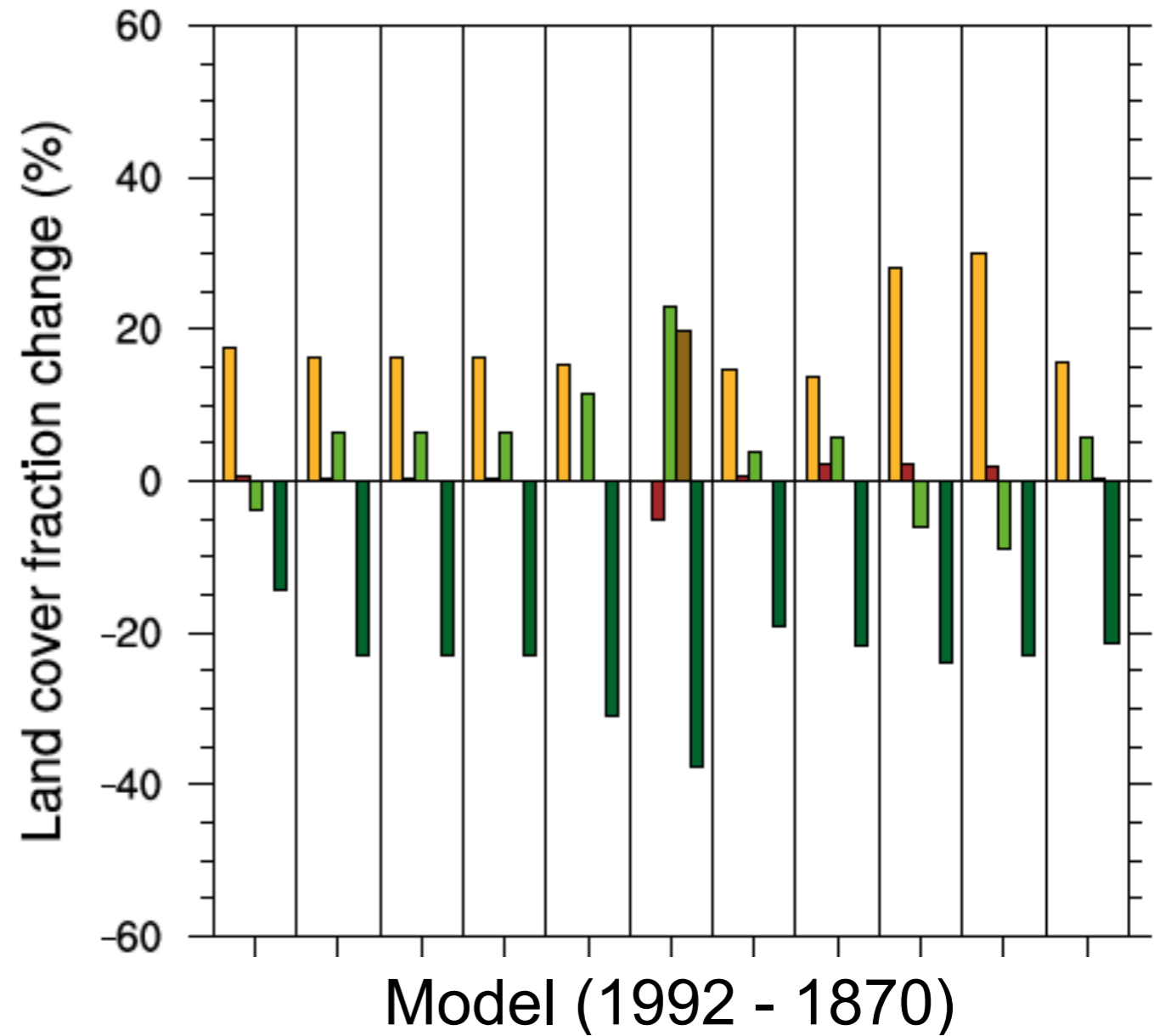
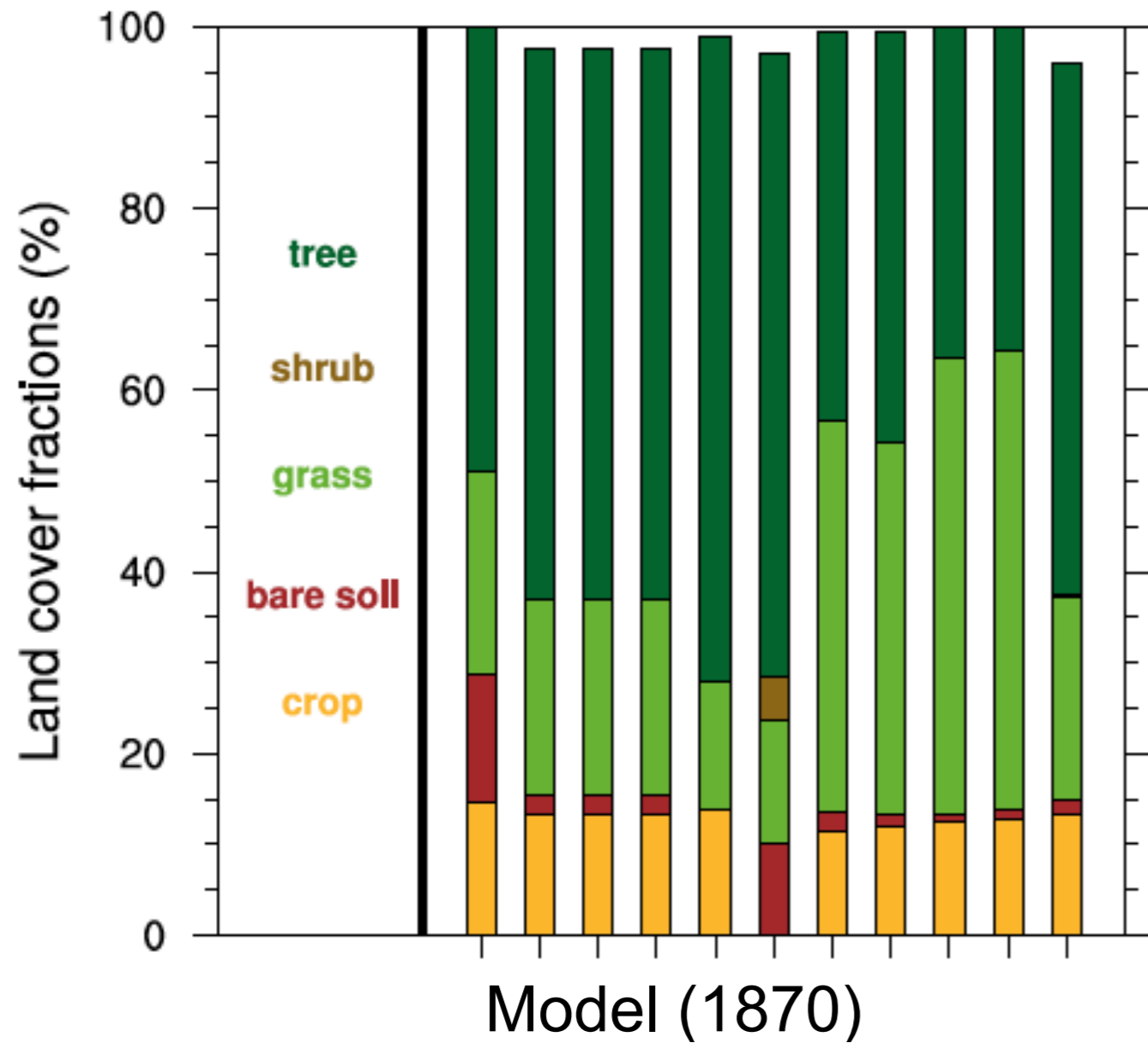
8 239

avg ± sd 186 ± 97

Concentration-driven
Shao et al., 2013

4

CMIP5 ESM land use/cover varies across models (LULC generally not reported)



North America

(Lejeune et al., 2017)

CMIP5 IAM 2005 land use/cover varies across models (M km²)

Land Type	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
Forest		41	44	39
Grassland		11	58	47
Pasture	33	33		
Shrubland		7		
Crops	16	16	14	16
Urban		0.5	1	1
Tundra		5		
Non-vegetated		14		30
Other			17	

(Masui et al., 2011; Riahi et al. 2011; Thomson et al. 2011; van Vuuren et al. 2011)

What is the contribution of initial land cover uncertainty to Global carbon and temperature projections?

Global carbon cycle uncertainty is exacerbated by initial land cover uncertainty in ESM projections

Local temperature uncertainty persists throughout simulations

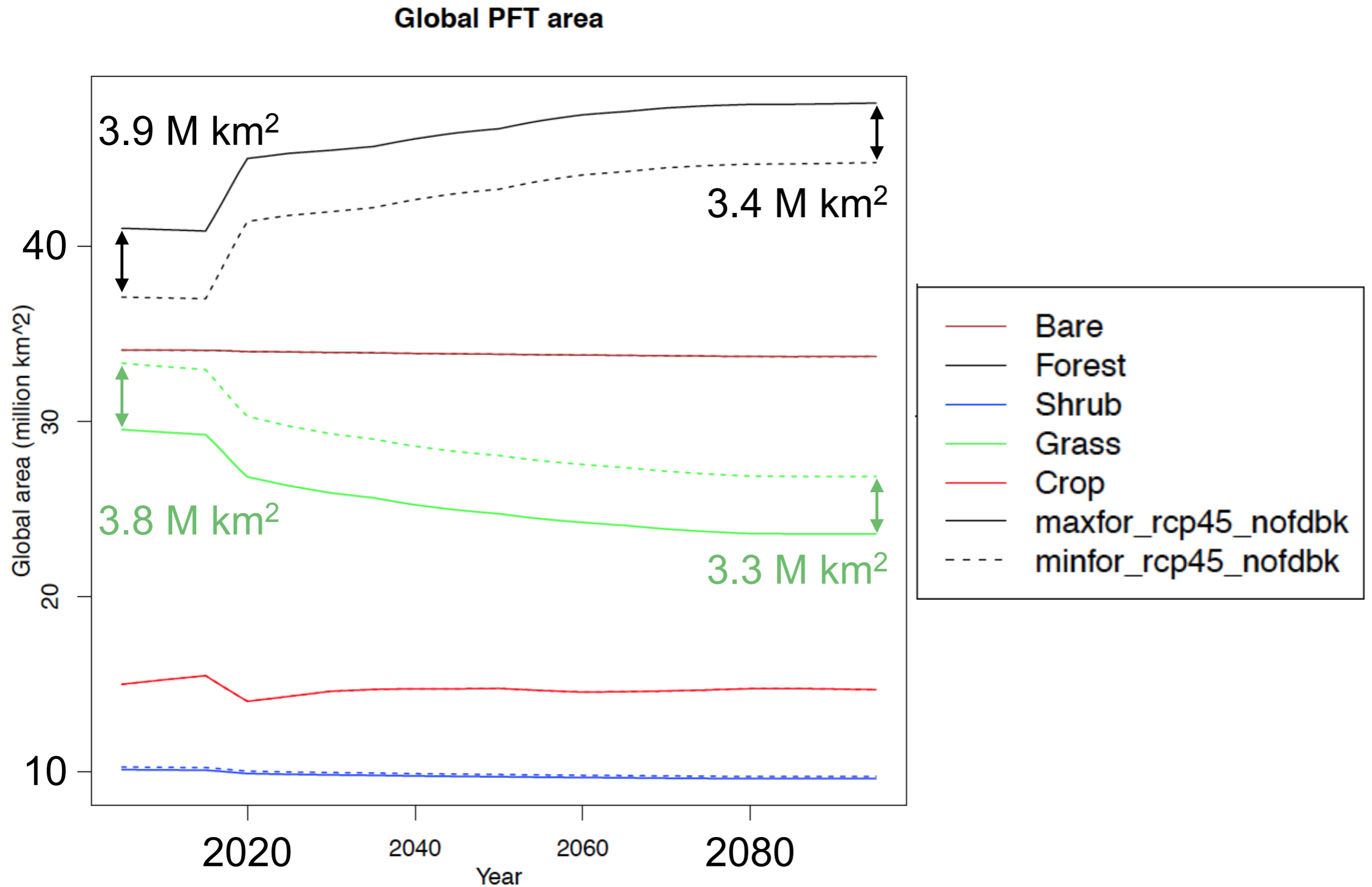
7 Atmospheric CO₂ uncertainty increases by 50% in RCP 4.5

Atmospheric CO ₂ concentration (ppmv)				
Default	Proportional	Max Forest	Min Forest	
<u>2004</u>				
392	398	397	402	
<u>2005</u>				
393	NA	398	404	
<u>2094</u>				
607	NA	608	617	

Up to 50% (6 ppmv) of 2005 C4MIP variability (+- 12 ppmv) may be explained by land cover uncertainty



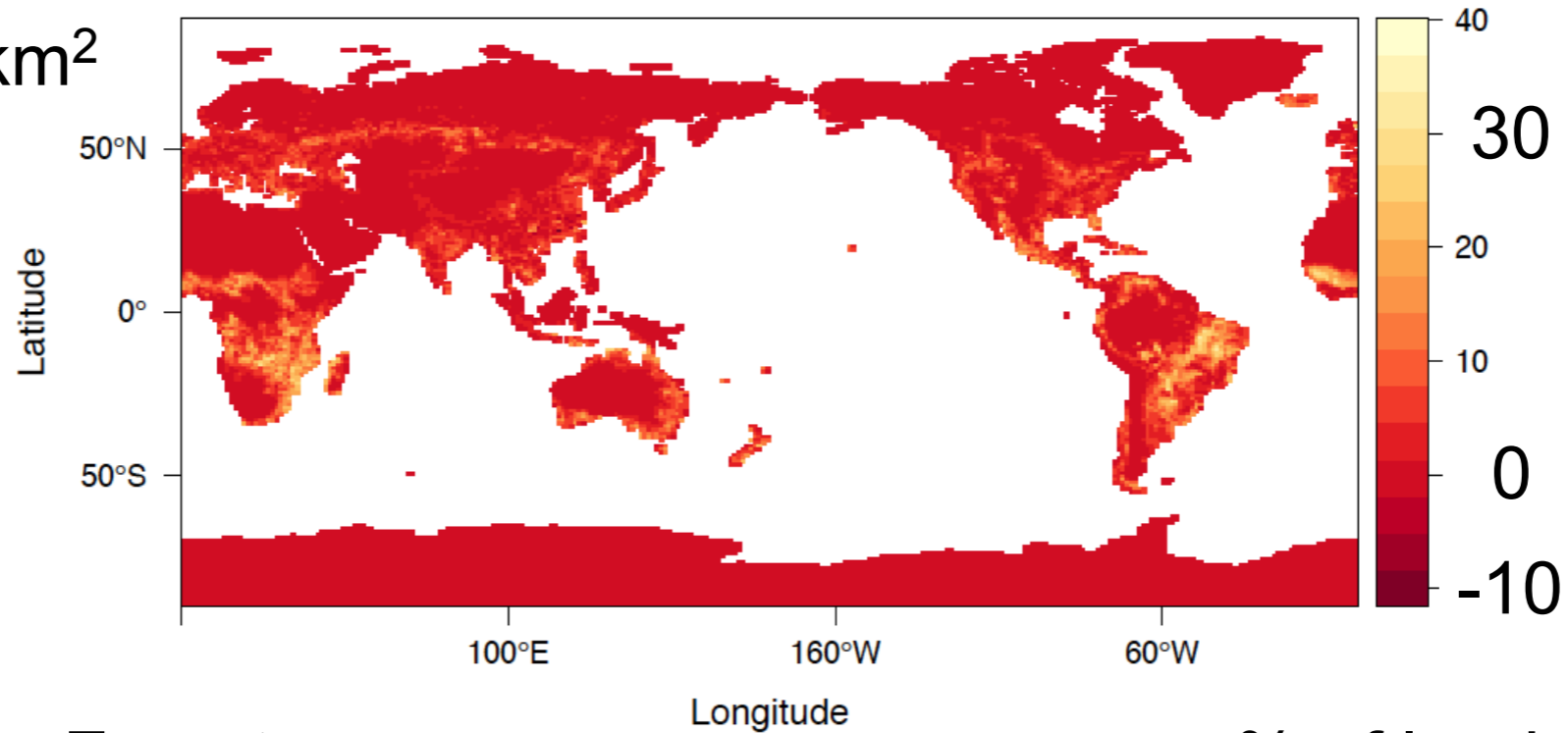
Land cover differences are maintained



Land cover differences are maintained

2005 forest area diff

Diff: 3.9 M km²

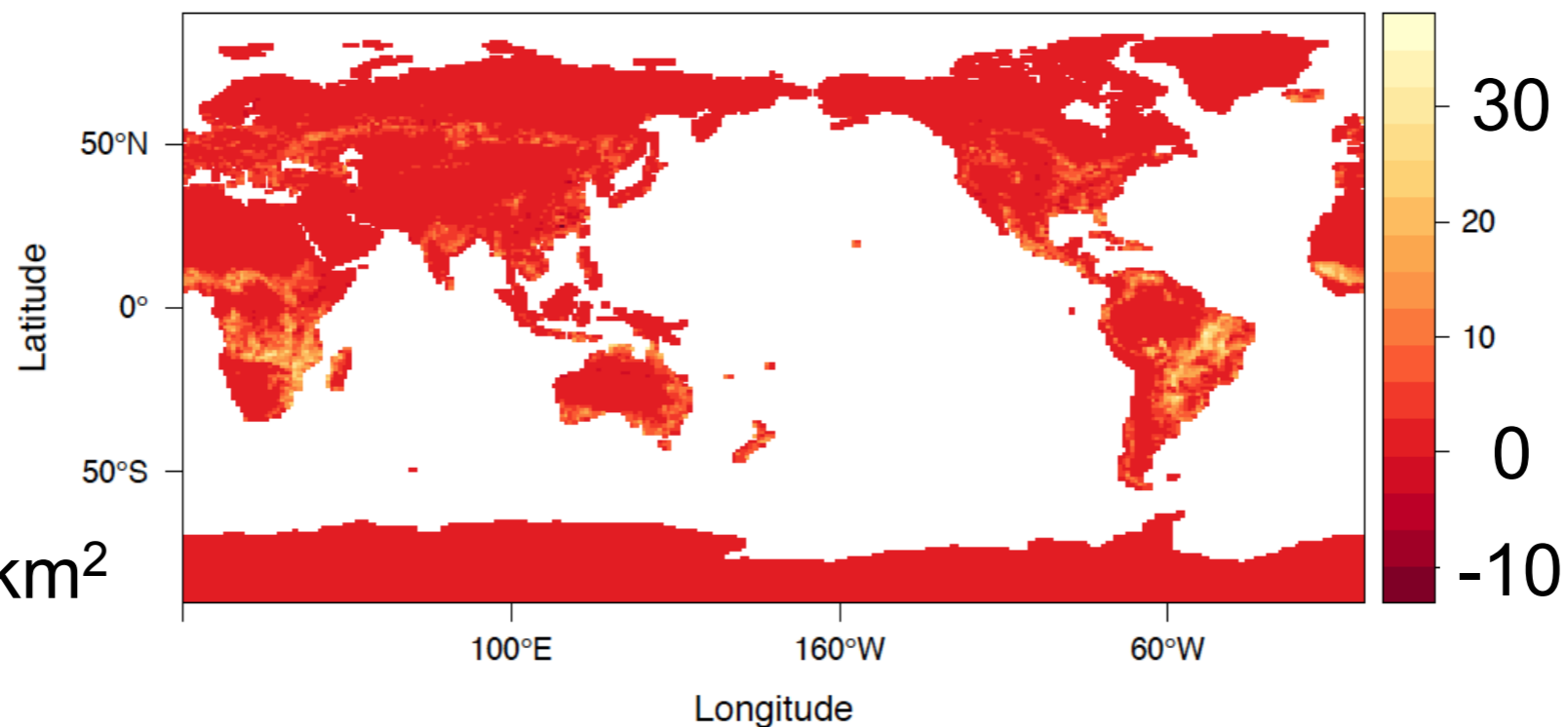


Max Forest - Min Forest

% of land area

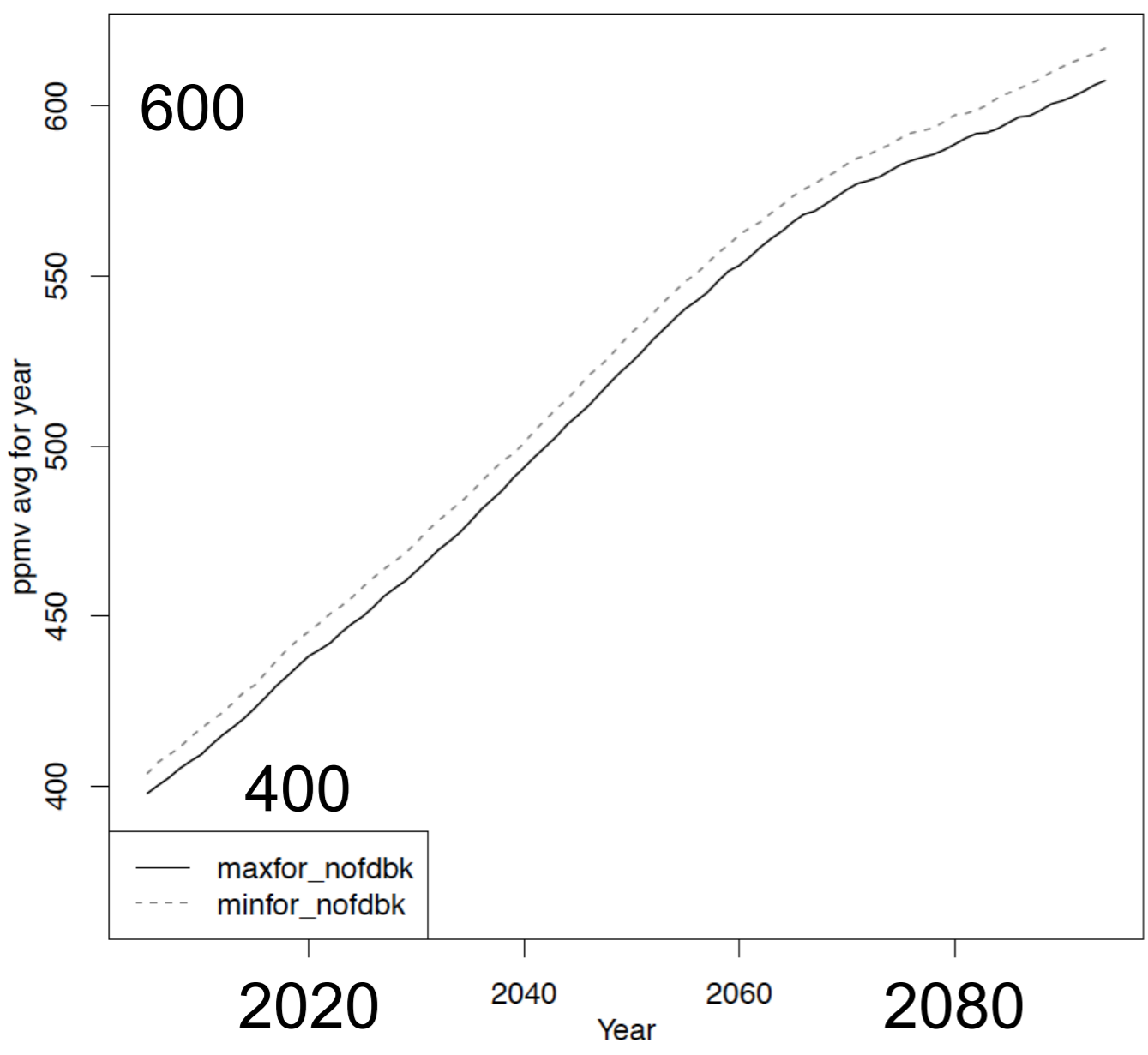
2095 forest area diff

Diff: 3.4 M km²

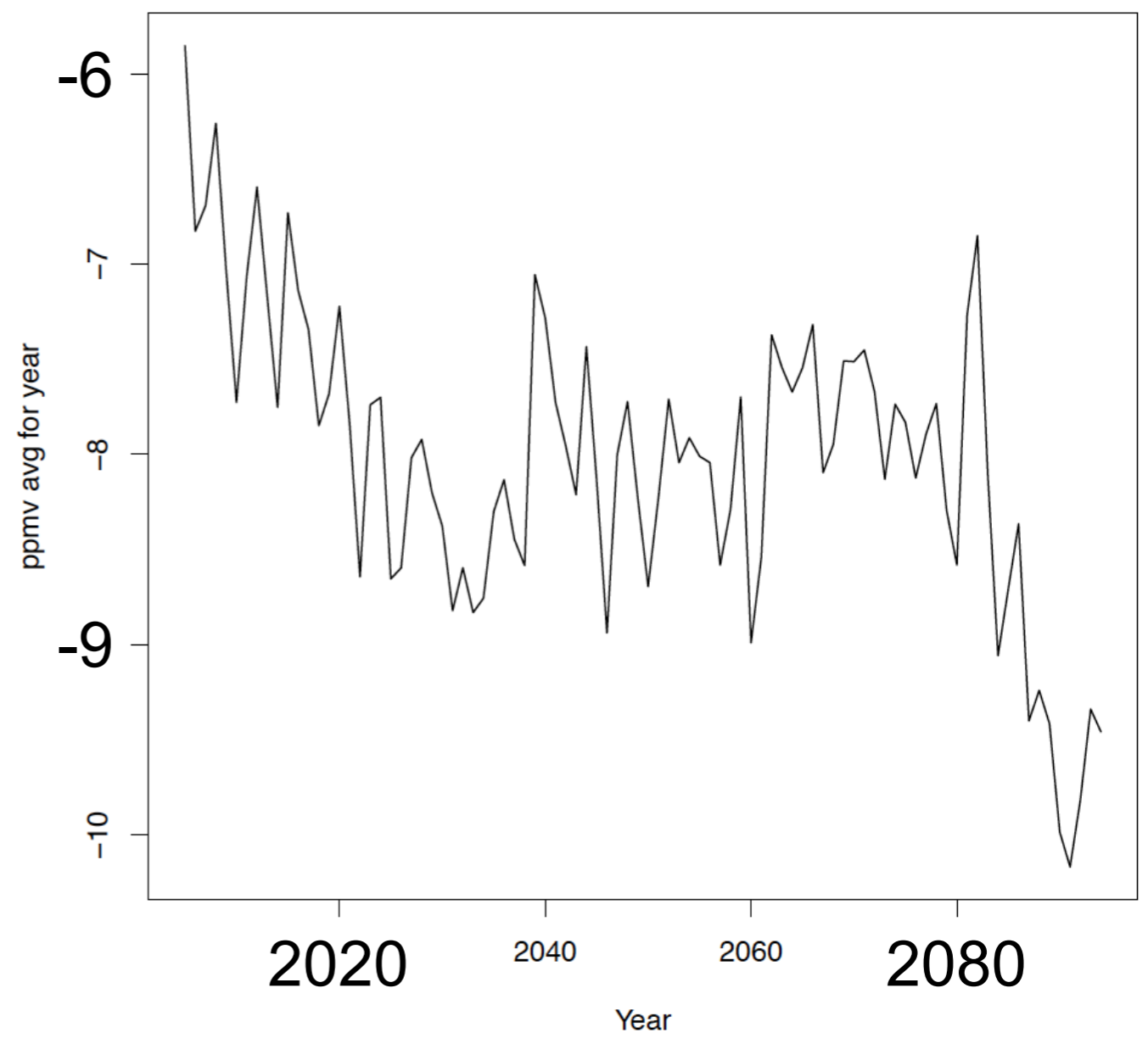


Atmospheric CO₂ uncertainty grows by ~50%

Concentration (ppmv)



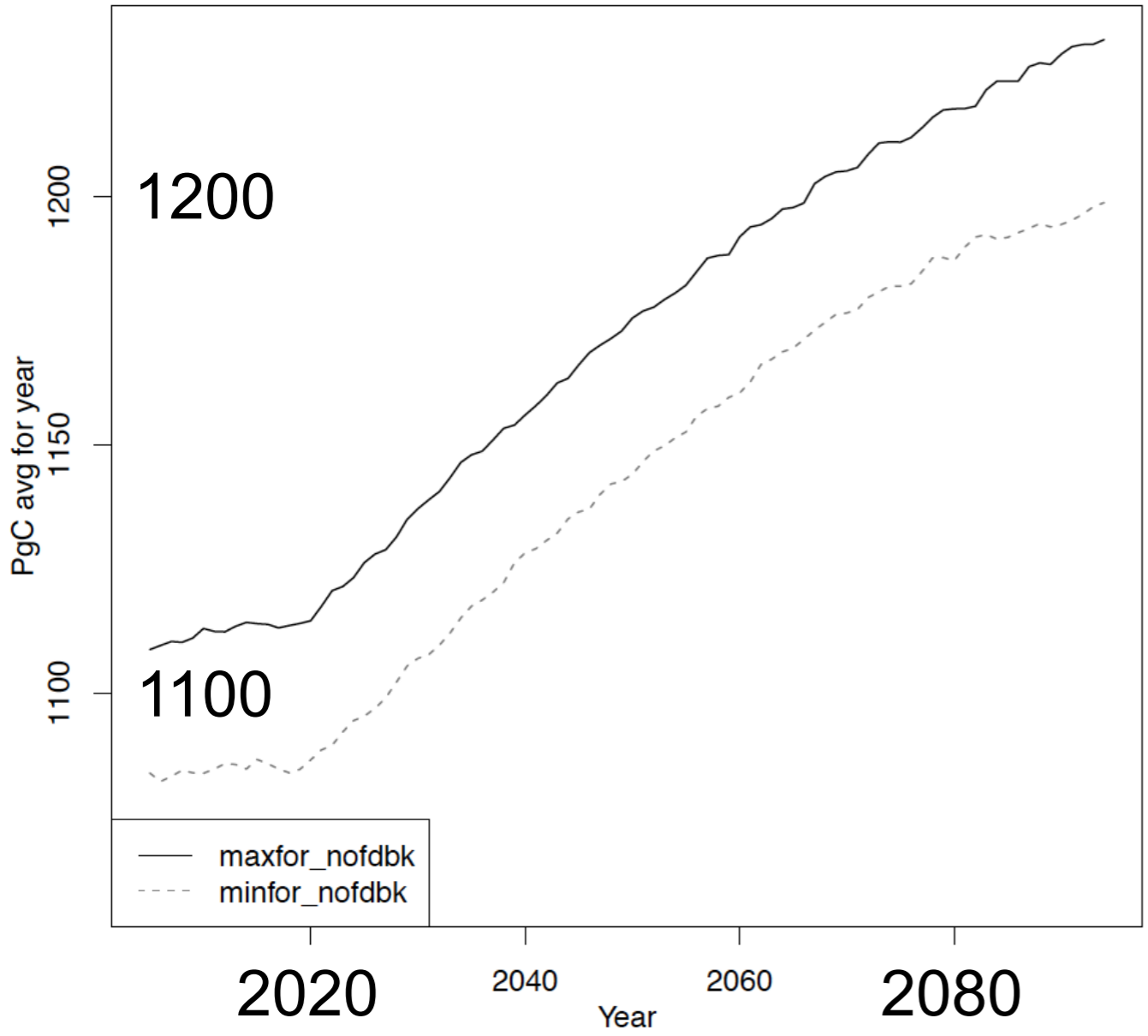
Difference (ppmv)



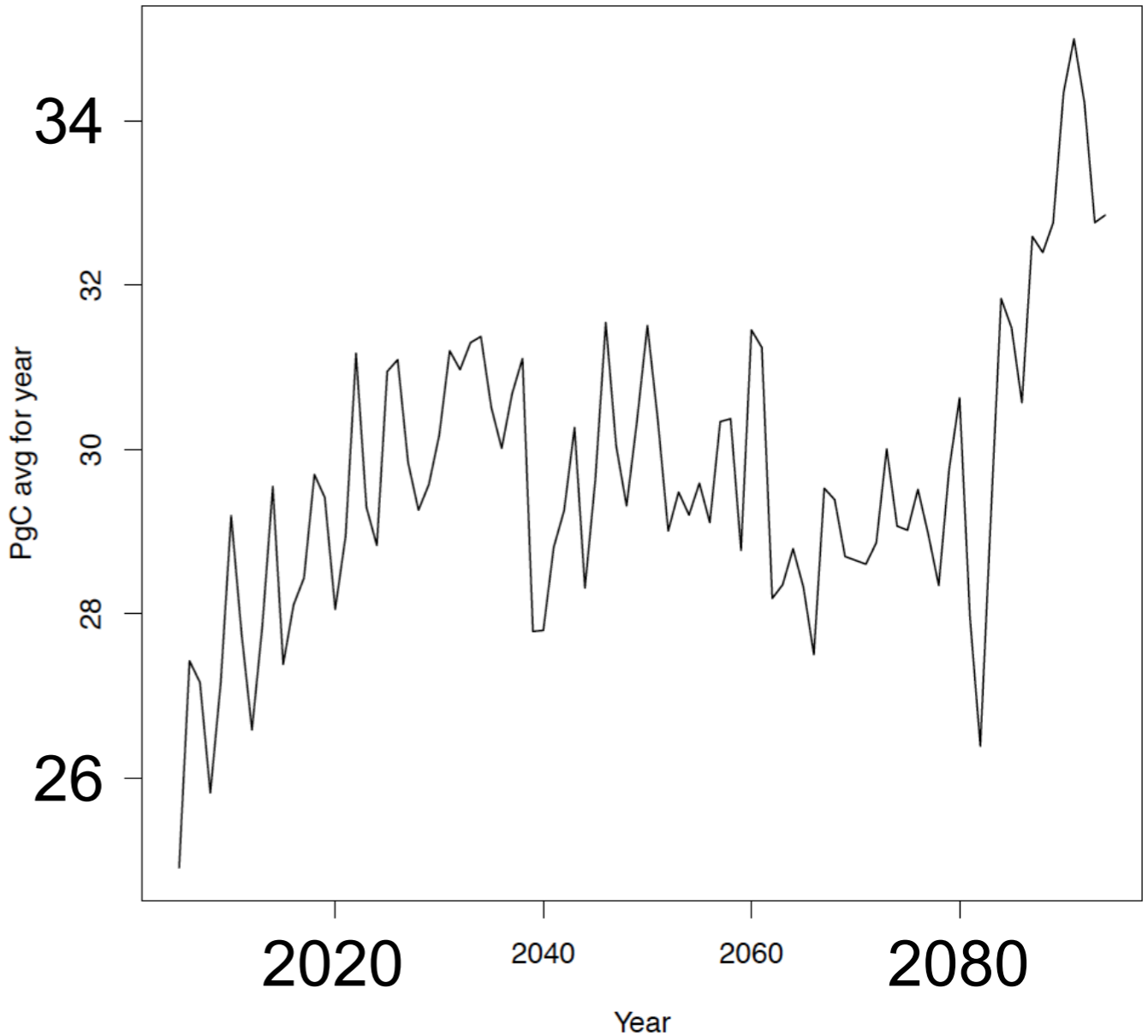
Max Forest - Min Forest

Ecosystem C uncertainty grows by ~27%

Ecosystem C (Pg C)

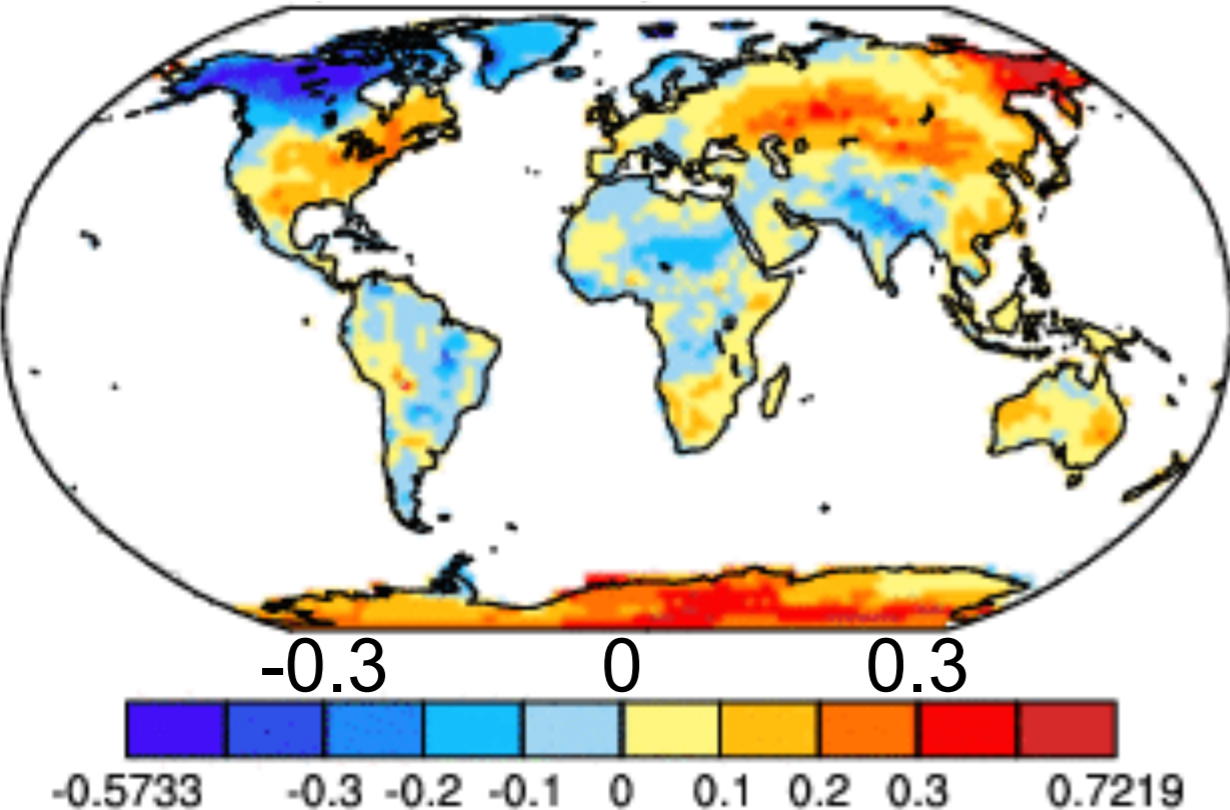


Difference (Pg C)



Max Forest - Min Forest

Persistent surface air temperature uncertainty (2005-2094 average)



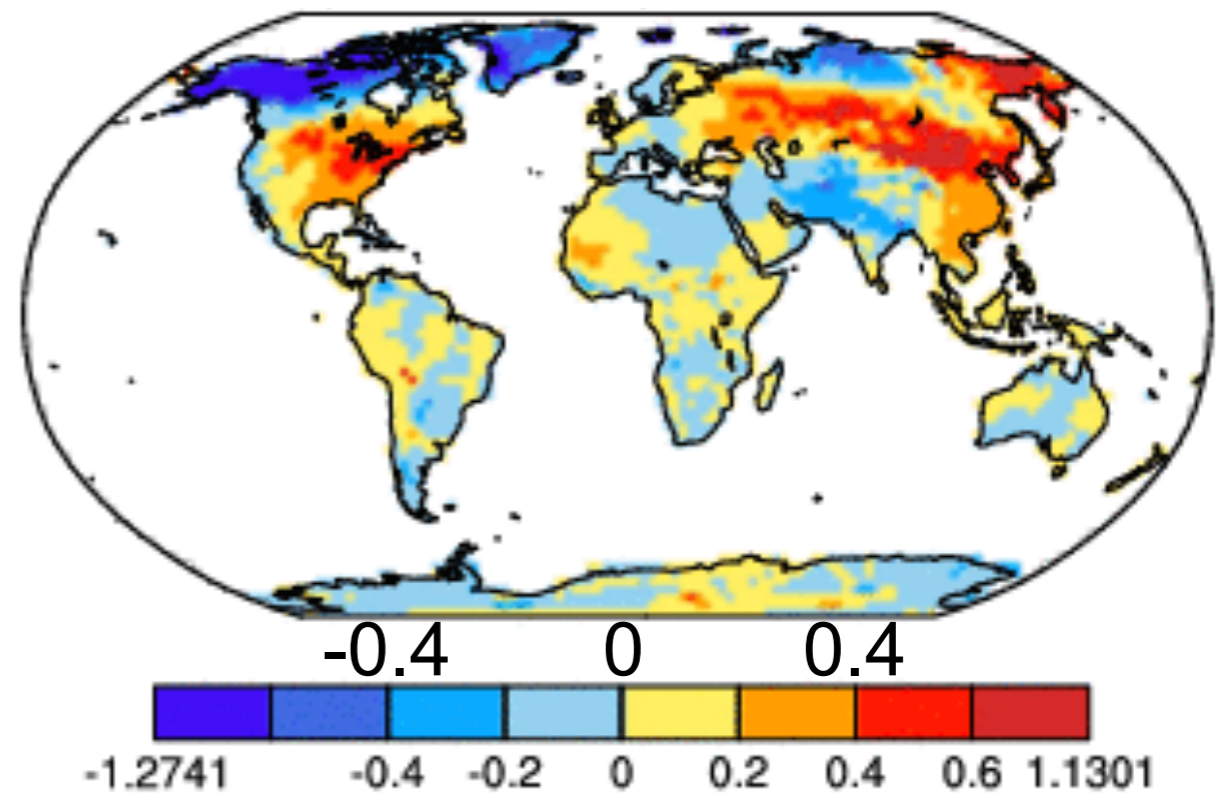
Annual

Range of local annual temperature difference:
-0.57 to 0.72 °C

Max Forest - Min Forest

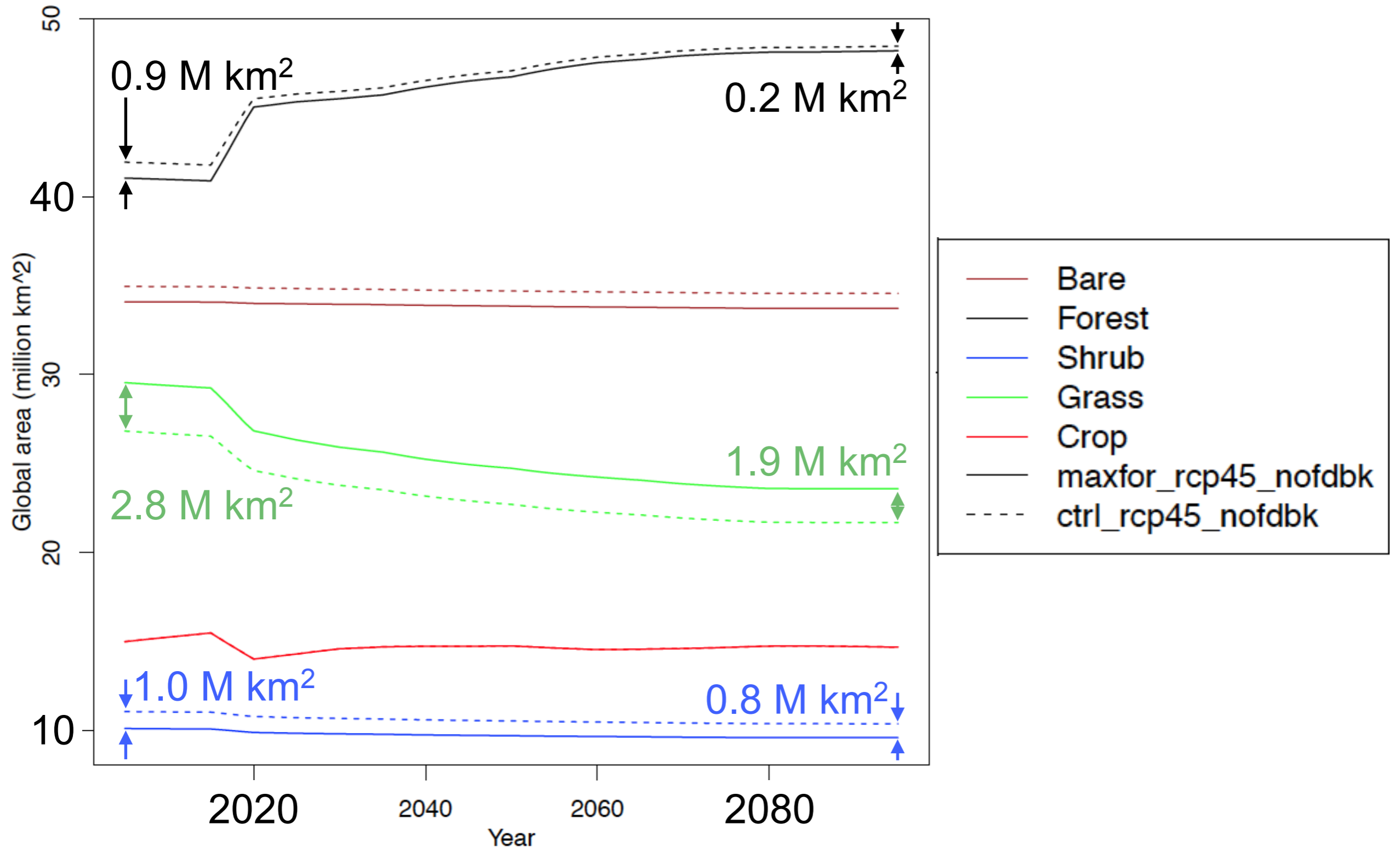
Range of local DJF temperature difference:
-1.27 to 1.13 °C

DJF



Land cover differences are reduced

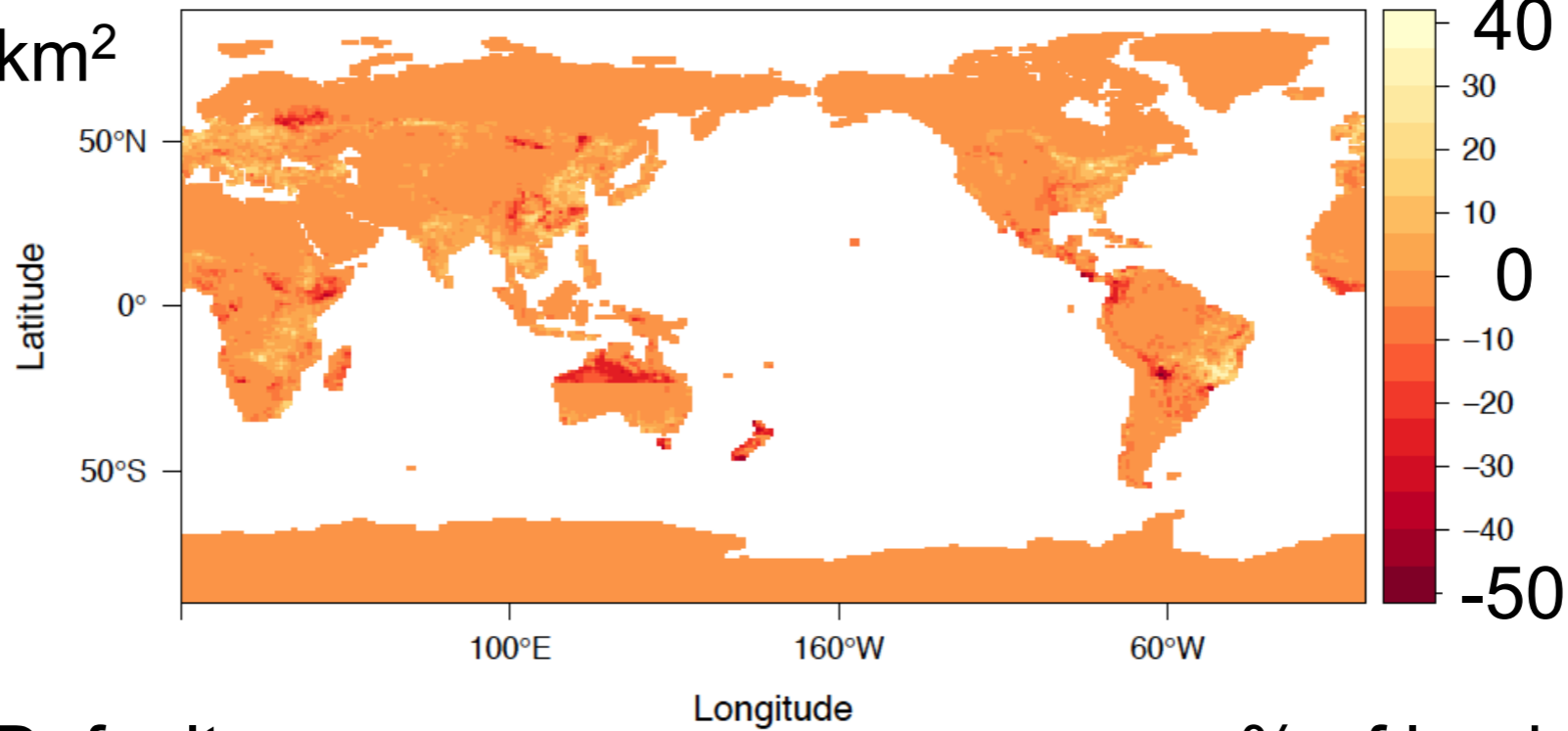
Global PFT area



Forest cover differences are reduced

2005 forest area diff

Diff: -0.9 M km²

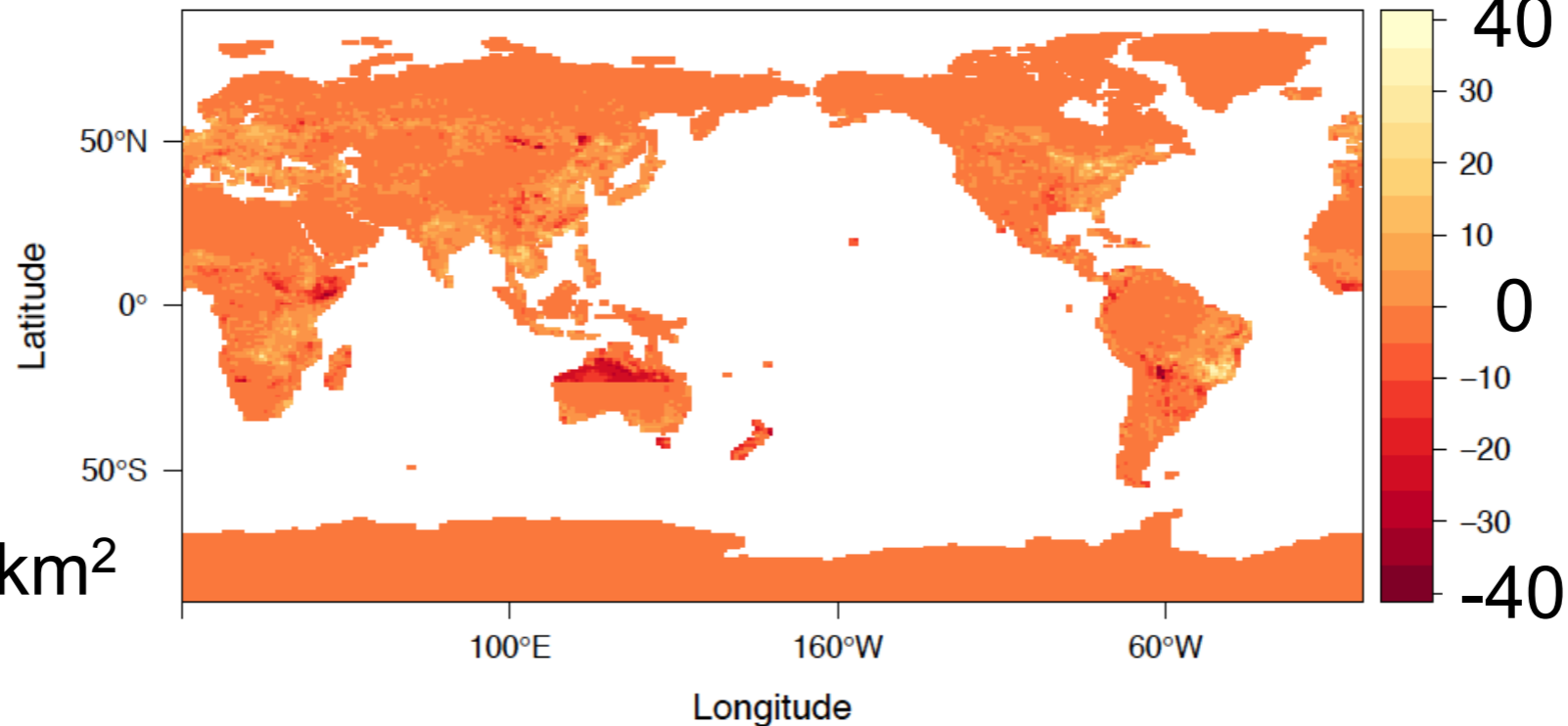


Max Forest - Default

% of land area

2095 forest area diff

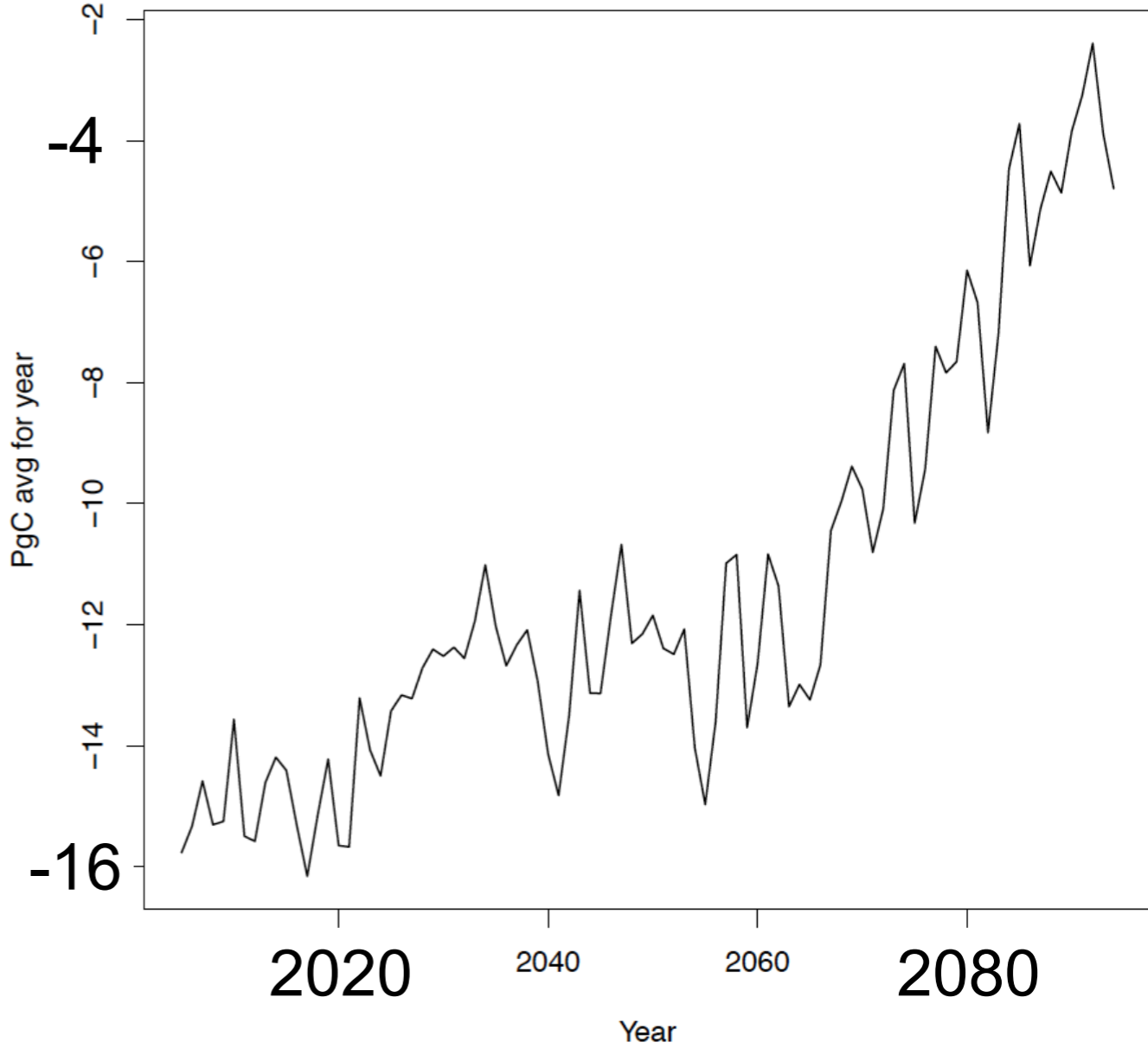
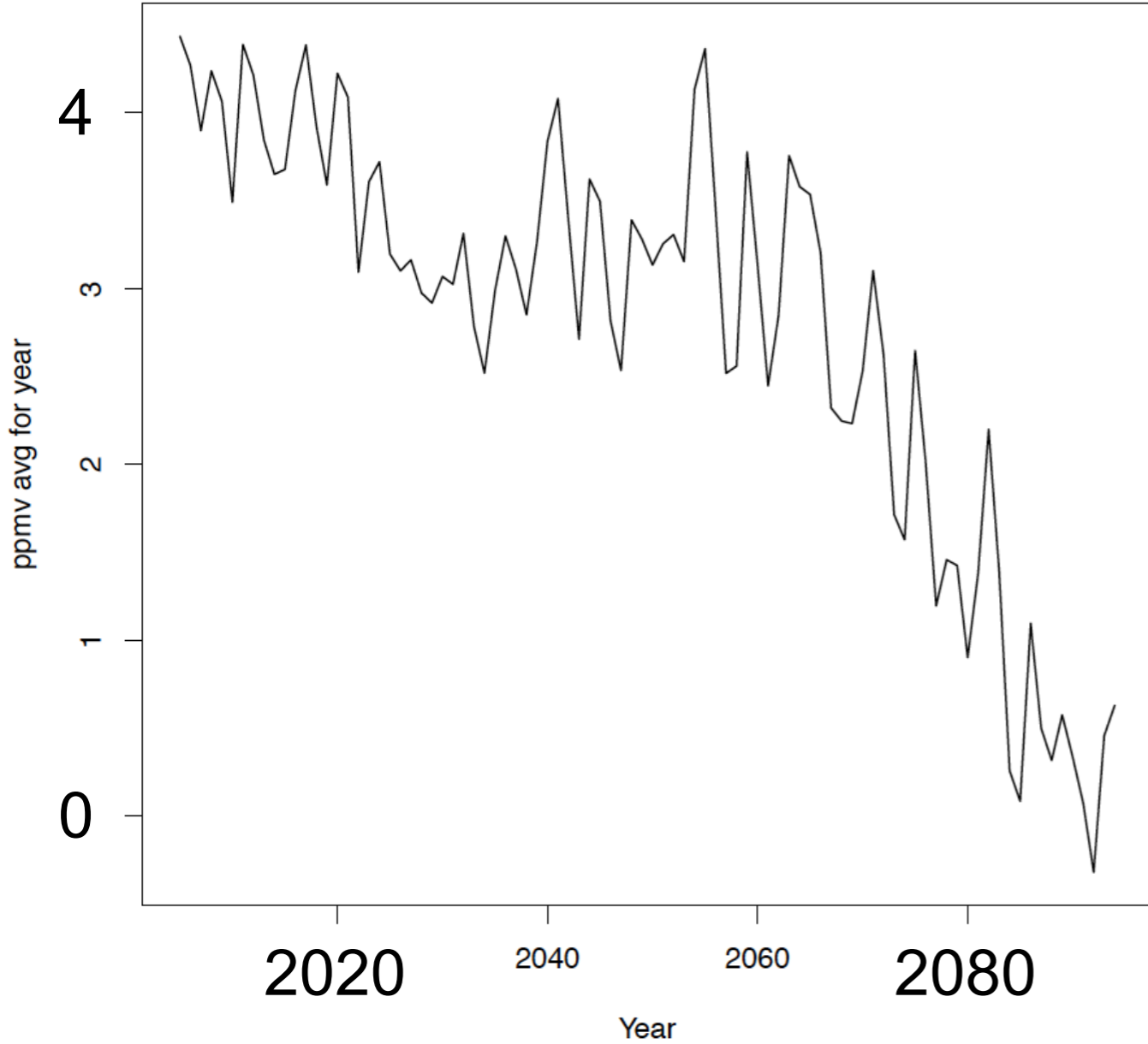
Diff: -0.2 M km²



CO₂ and Ecosystem C differences shrink for similar global forest area

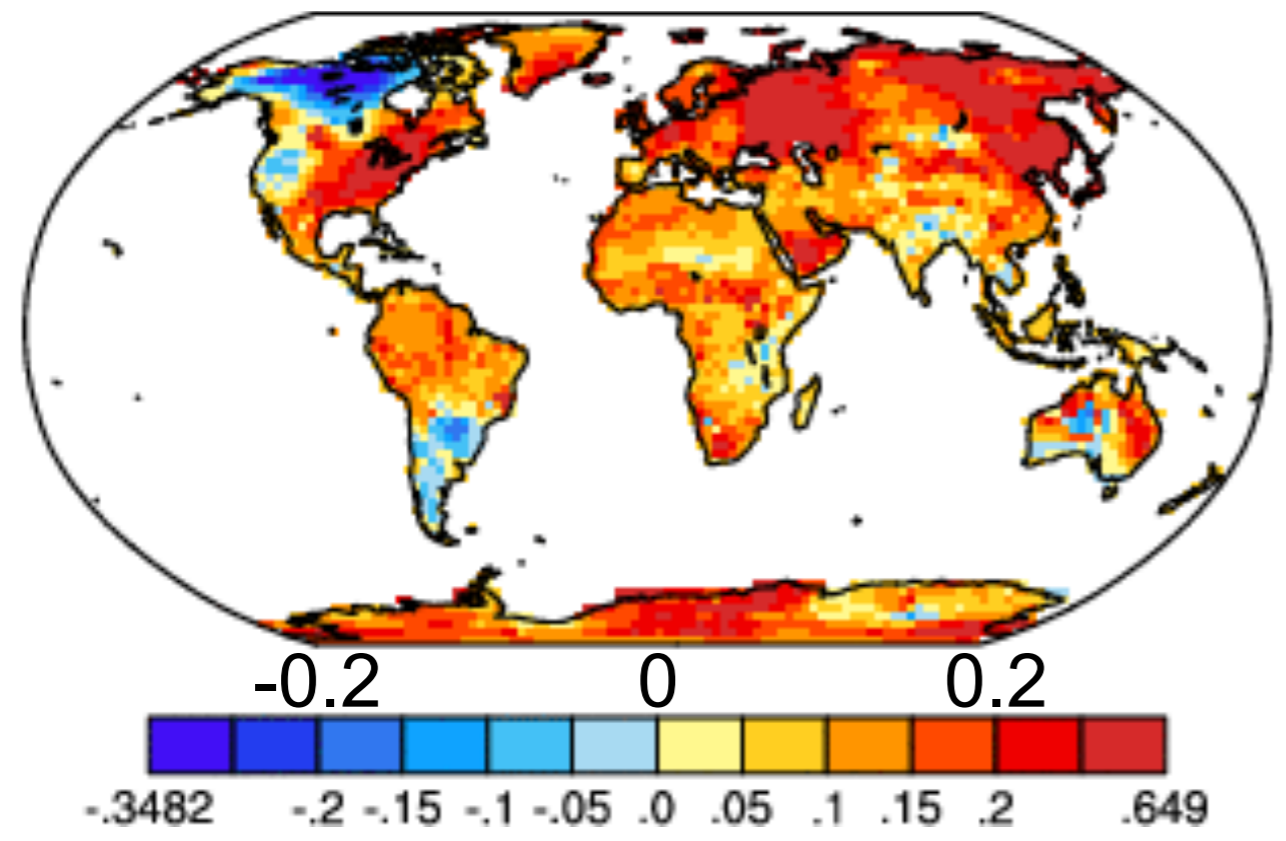
Atmospheric CO₂ difference (ppmv)

Ecosystem C difference (Pg C)



Max Forest - Default

Persistent surface air temperature uncertainty (2005-2094 average)



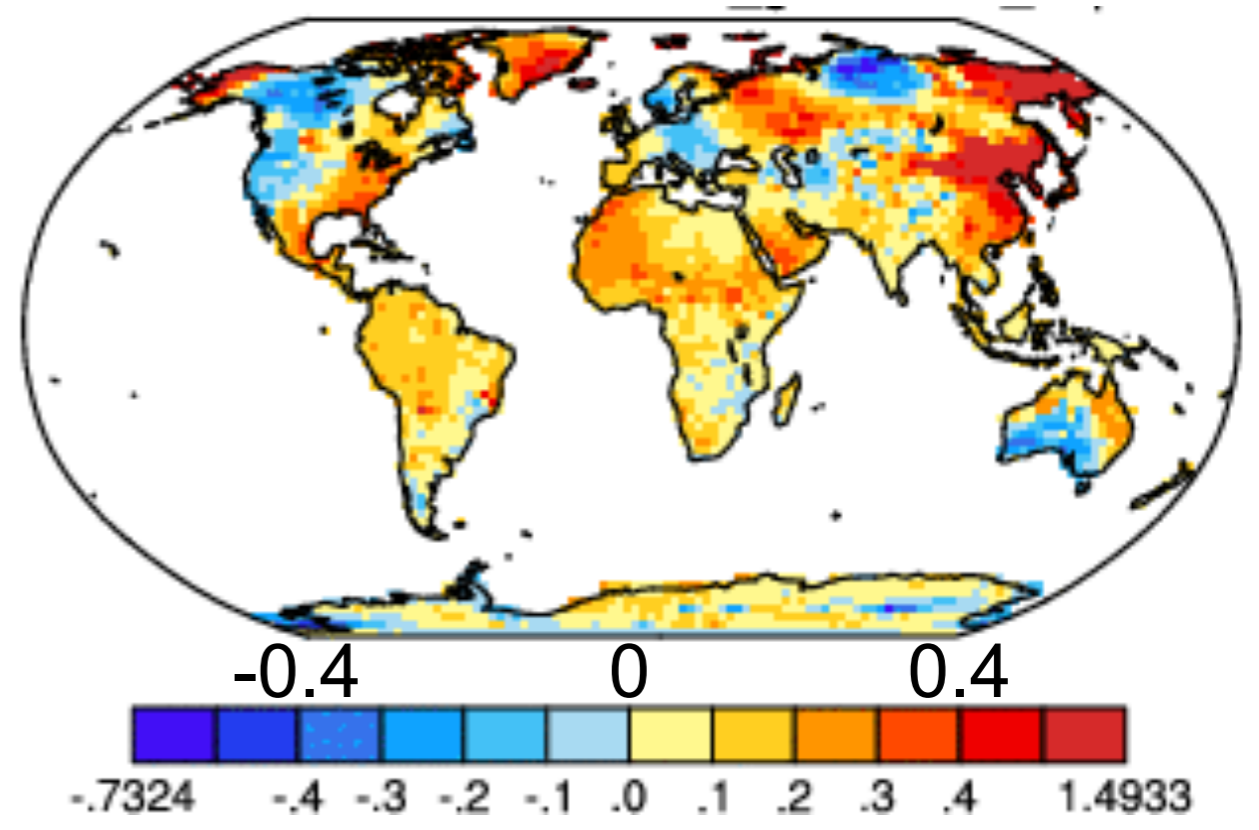
Annual

Range of local annual temperature difference:
-0.35 to 0.65 °C

Max Forest - Default

Range of local DJF temperature difference:
-0.73 to 1.49 °C

DJF



Summary

- **50% of 2005 atmospheric CO₂ projection variability may be attributable to land conversion uncertainty**
- **3.9 M km² initial forest area uncertainty (RCP 4.5)**
 - 50% increase in atmospheric CO₂ uncertainty
 - 27% increase in ecosystem C uncertainty
 - Range of temperature difference: -0.57 to 0.72
- **Smaller differences in initial forest (0.9 M km²) and shrub (1 M km²) area also generate CO₂ and C and temperature differences**
 - **Nearly eliminating forest area difference over 90 years reduces these differences**
- **Forest area difference reduction may be due to cell area saturation in higher initial forest scenarios**

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Thank you!

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