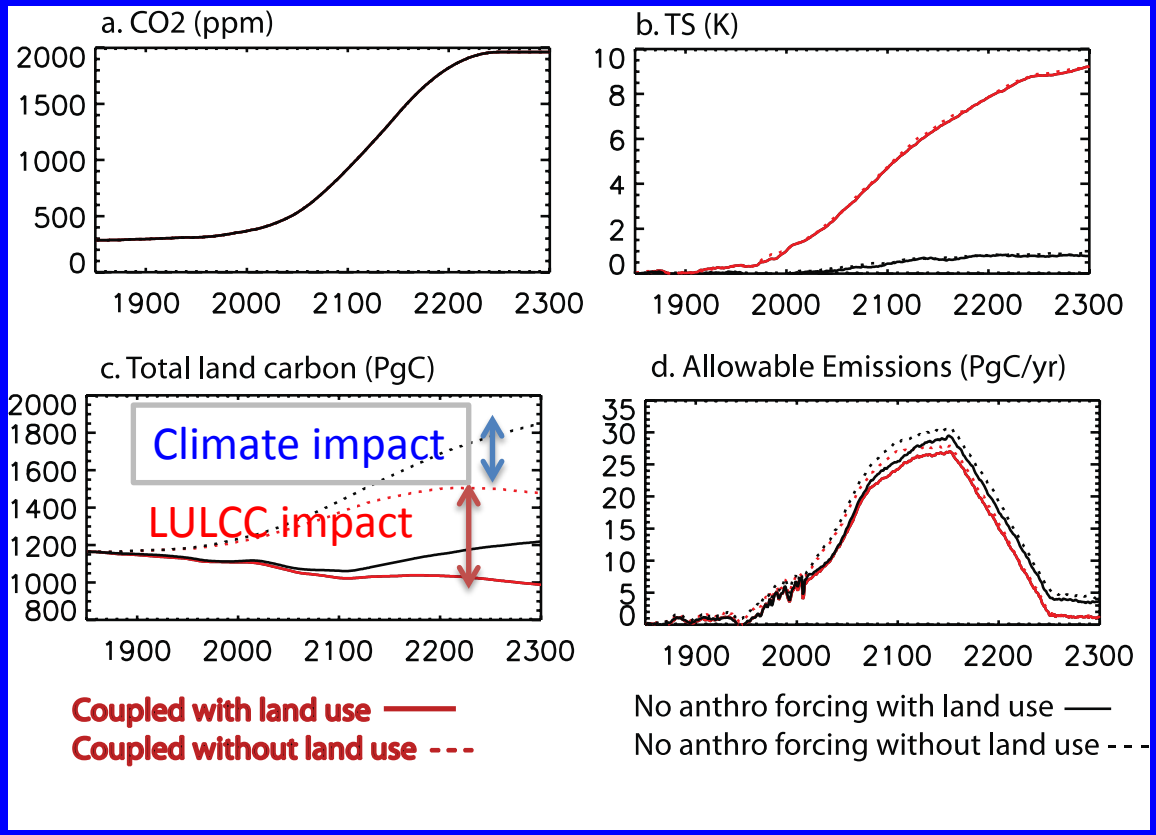
Interactions between land use change and carbon cycle feedbacks

Natalie Mahowald, James Randerson,, Keith Lindsay, Ernesto Munoz Acevedo, Scott Doney, Sarah Schlunegger, Dan Ward, David Lawrence, Peter Lawrence, Forrest Hoffman

Mahowald et al. submitted, GBC.

Funded by NSF

On long time scales what is the impact of land use onto carbon feedbacks? Use CESM runs to 2300 (RCP8.5 and ECP8.5)

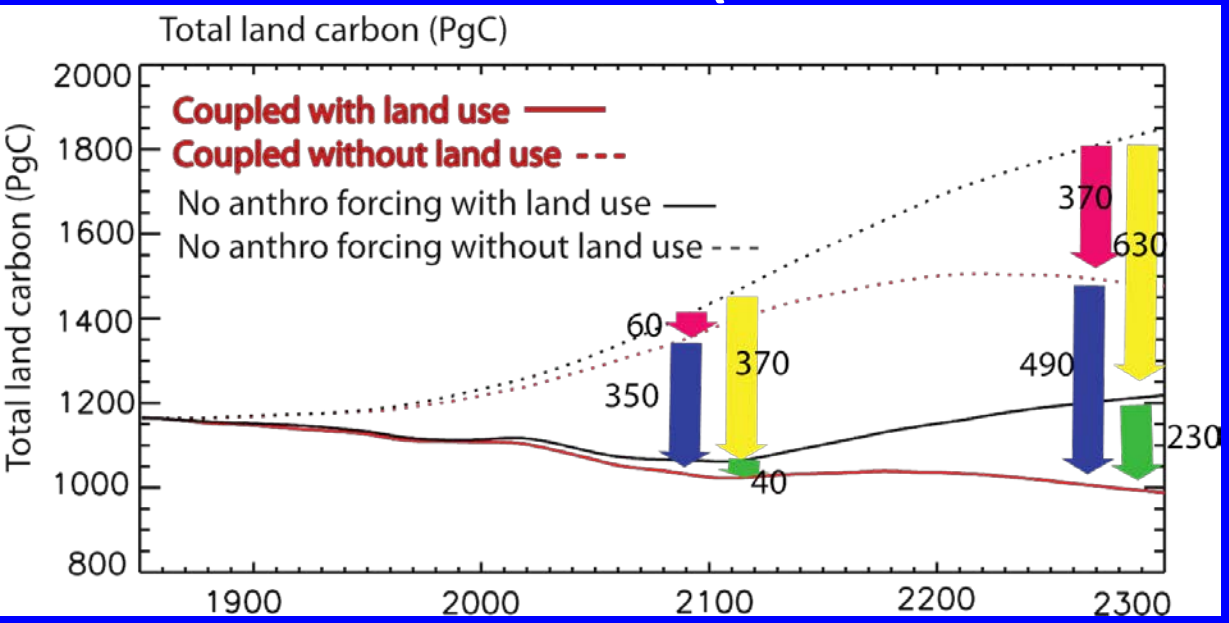


Mahowald et al., submitted.

Take CESM-BGC runs from IPCC (Lindsay et al., 2013), and extend until 2300 (Randerson et al, 2015); Meehl et al., 2012

- Here, add cases with no land use and land cover change
- LULCC changes land carbon substantially: 480PgC vs.370PgC for climate
- LULCC Significantly impacts Allowable emissions
- Increased land stocks in our model primarily due to tree pfts (calculated in pft-resolved mode).
- Not strong soil C response with time or LULCC (too weak? Levis et al., 2015; Pugh et al.,2 015)

On longer time scales? Use CESM runs to 2300 (RCP8.5 and ECP8.5)



The climate impact on land and ocean carbon has been discussed a great deal (e.g. Friedlingstein et al., 2006; Friedlingstein 2008)

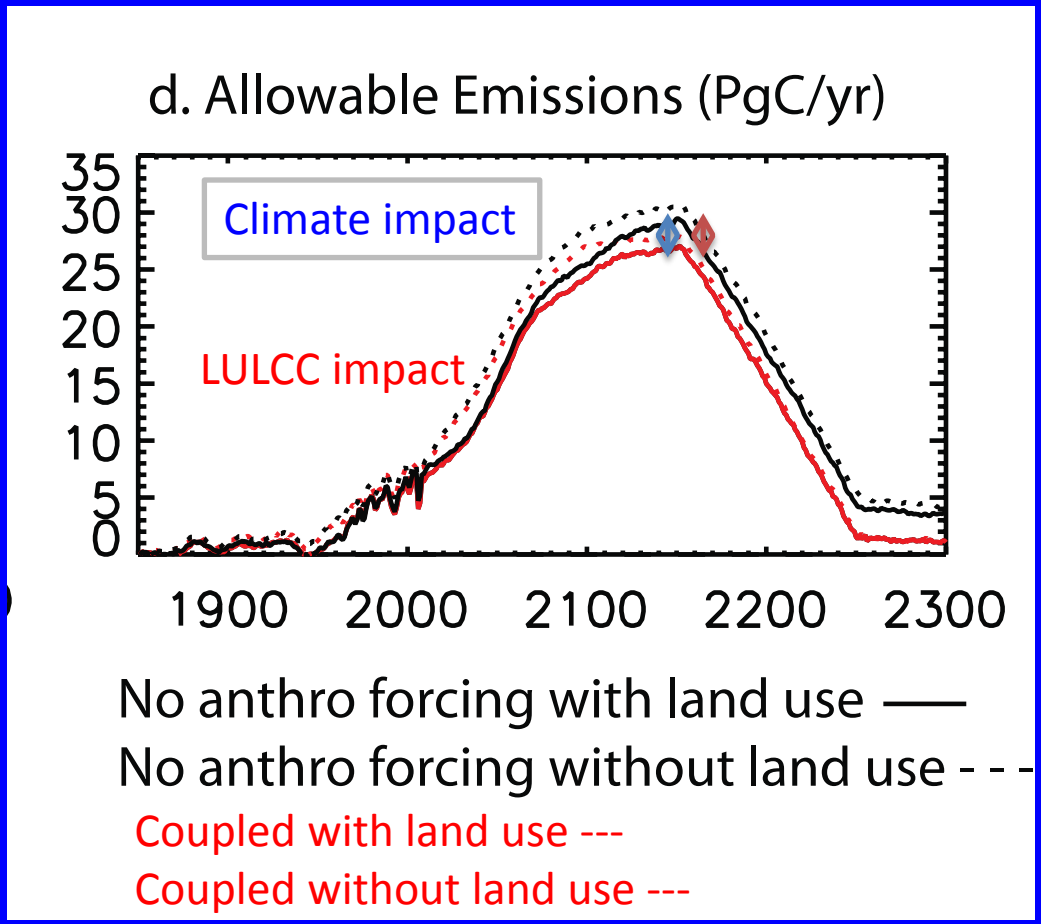
Here we focus on the LULCC impact

LULCC impact on land carbon (blue arrow: 490 PgC) larger than climate impacts (green arrow: 230PgC).

Much of the uptake of anthropogenic carbon goes into Tree plant functional types in this model (probably true?)

Mahowald et al., submitted.

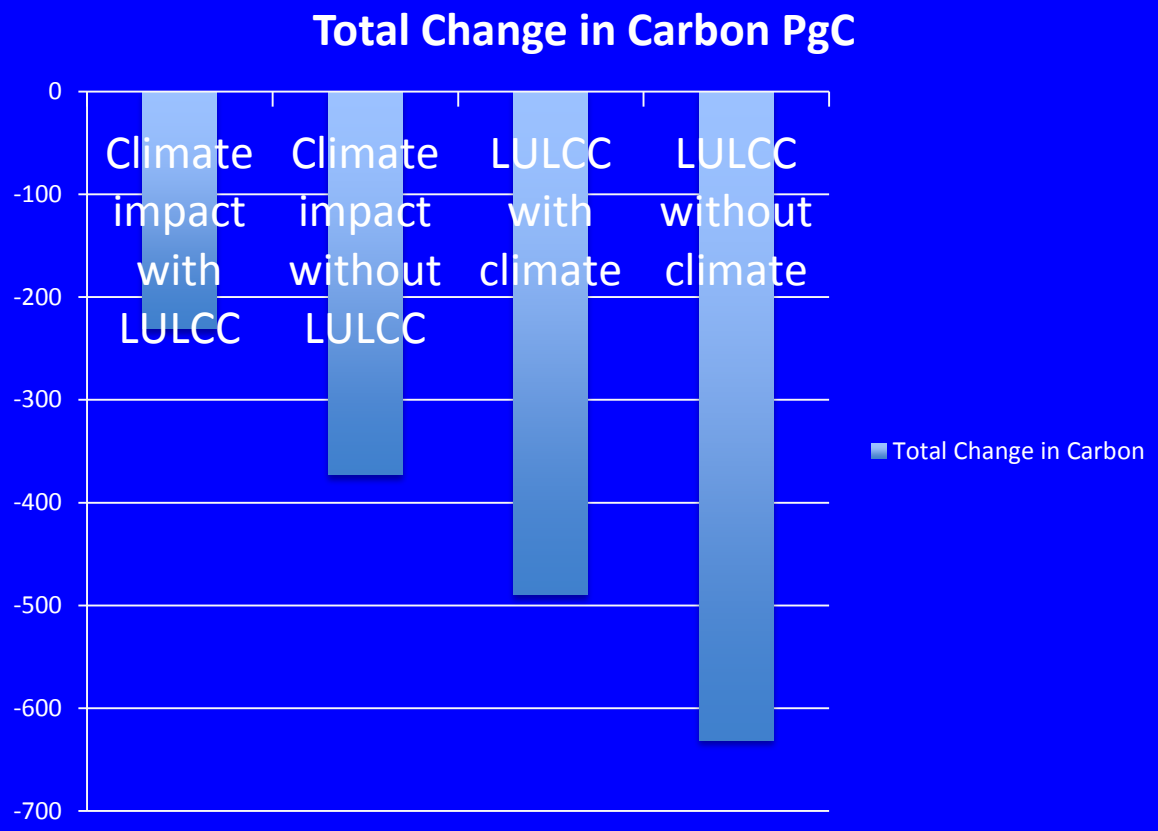
On longer time scales? Use CESM runs to 2300 (RCP8.5 and ECP8.5)



- RCP8.5,→fossil fuel emissions >>LULCC over 21st and 22nd century
- ~5 PgC/yr ~ todays emissions

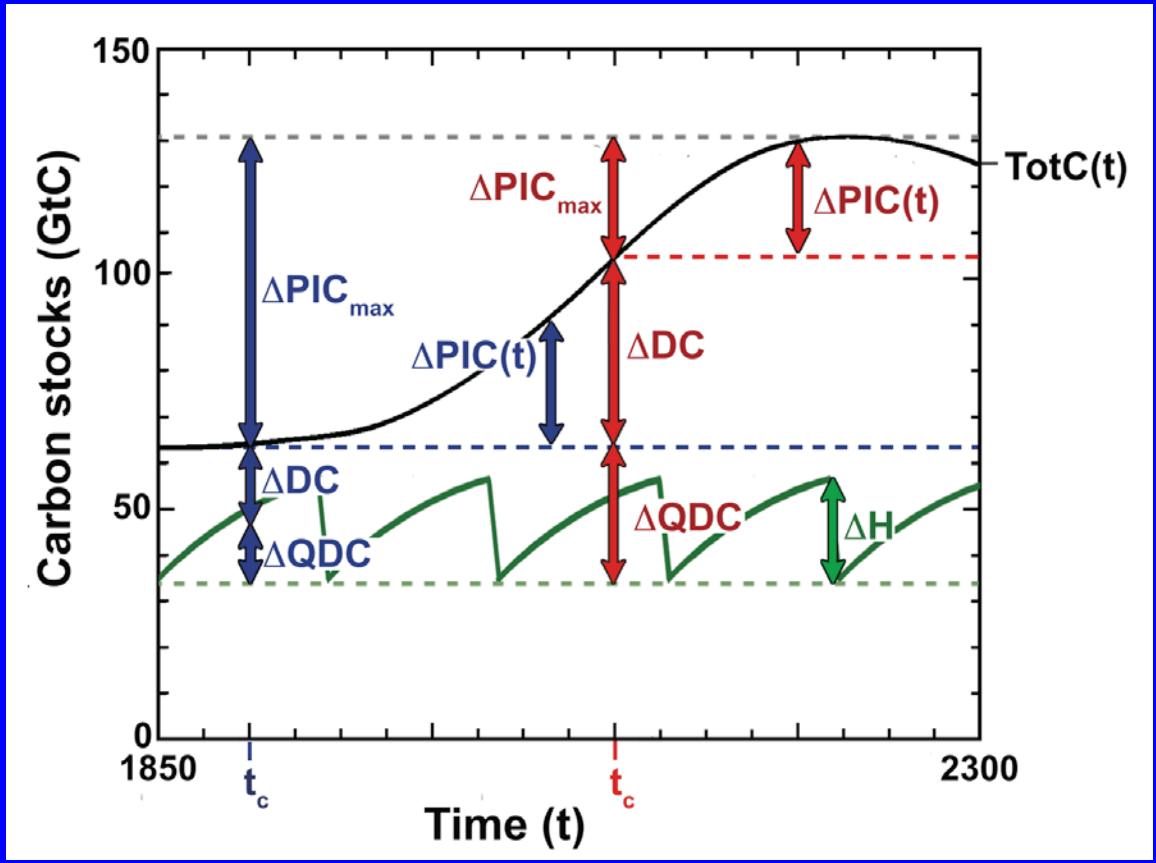
Mahowald et al. submited.

On land: LULCC impacts more important than climate (2300-1850)



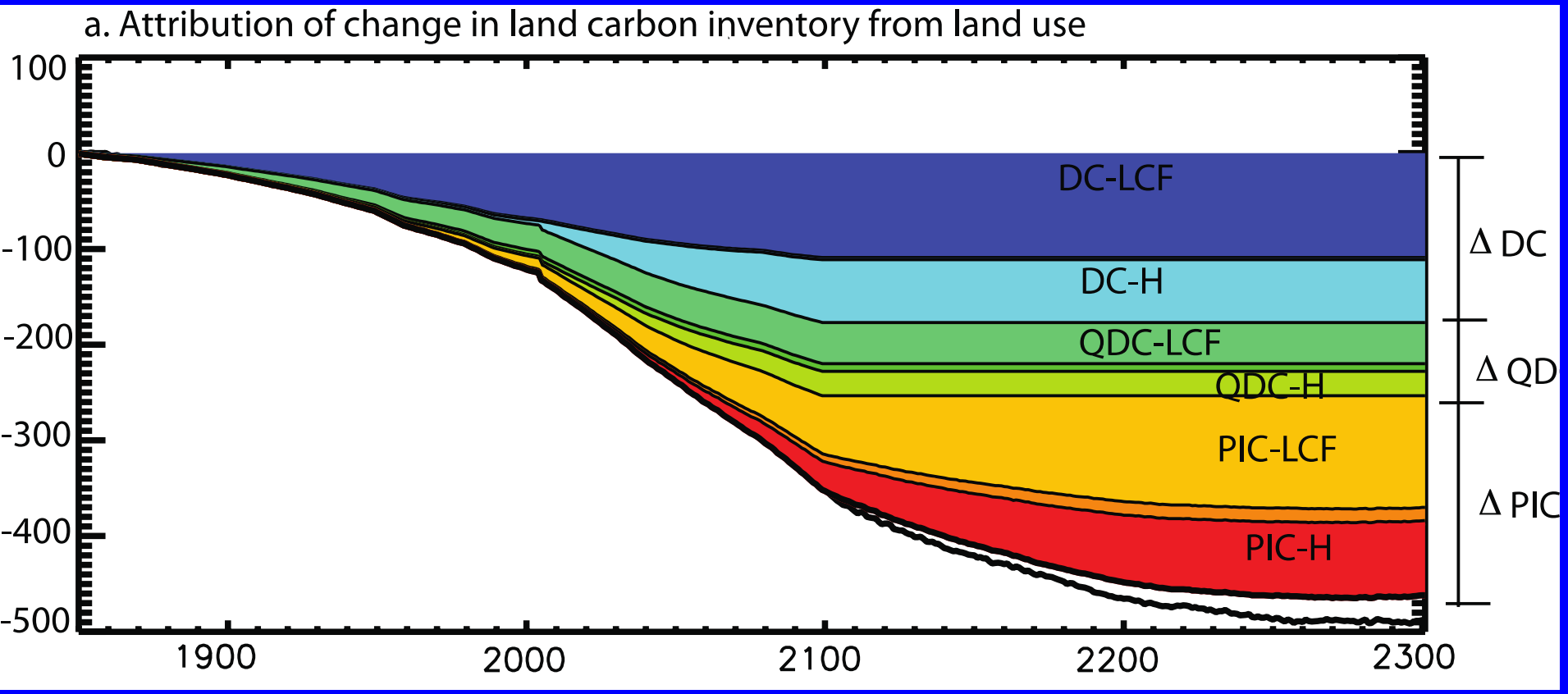
Use idea of direct and indirect carbon from land use (e.g. Gitz and Ciais, 2003; Pongatz et al 2009;2010.)

TotC (black line): natural veg



H=harvest
DC=direct carbon released at time of land use conversion
QDC=quasi direct carbon: carbon in veg killed but left on site
PIC=potential indirect carbon: future sink lost due to loss of natural vegetation
IC=indirect carbon change due to land use conversion

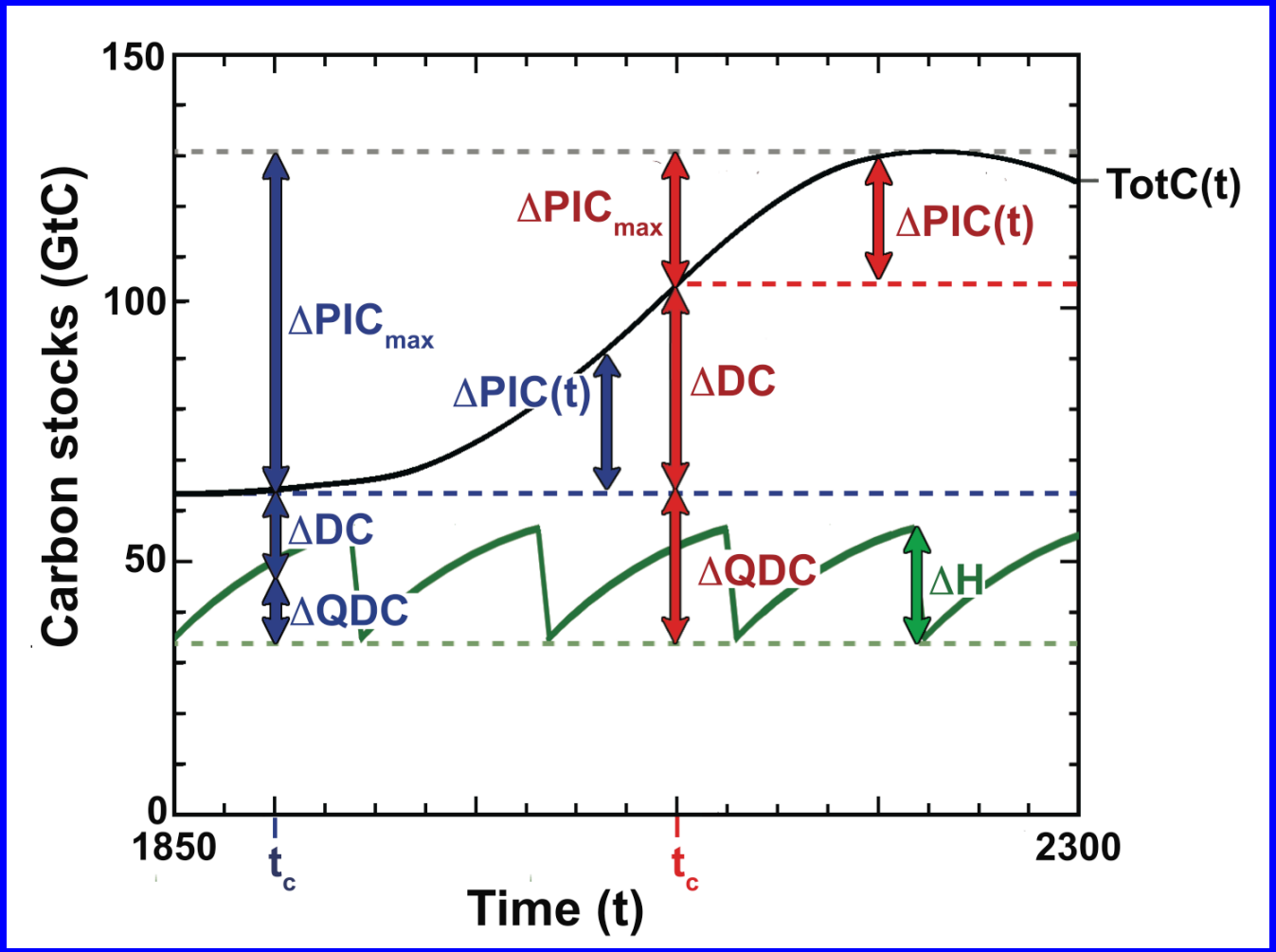
Mahowald et al., submittted.



LCF: land use conversion of forests
LCnF: land use conversion of non forests (too small to see)
H: harvesting

Can use to attribute carbon difference between runs with and without LULCC
39% DC; 17% QDC; 44% PIC➔ 61% IC
Mostly due to tree pft loss either in land use conversion (58%) or harvest (36%)

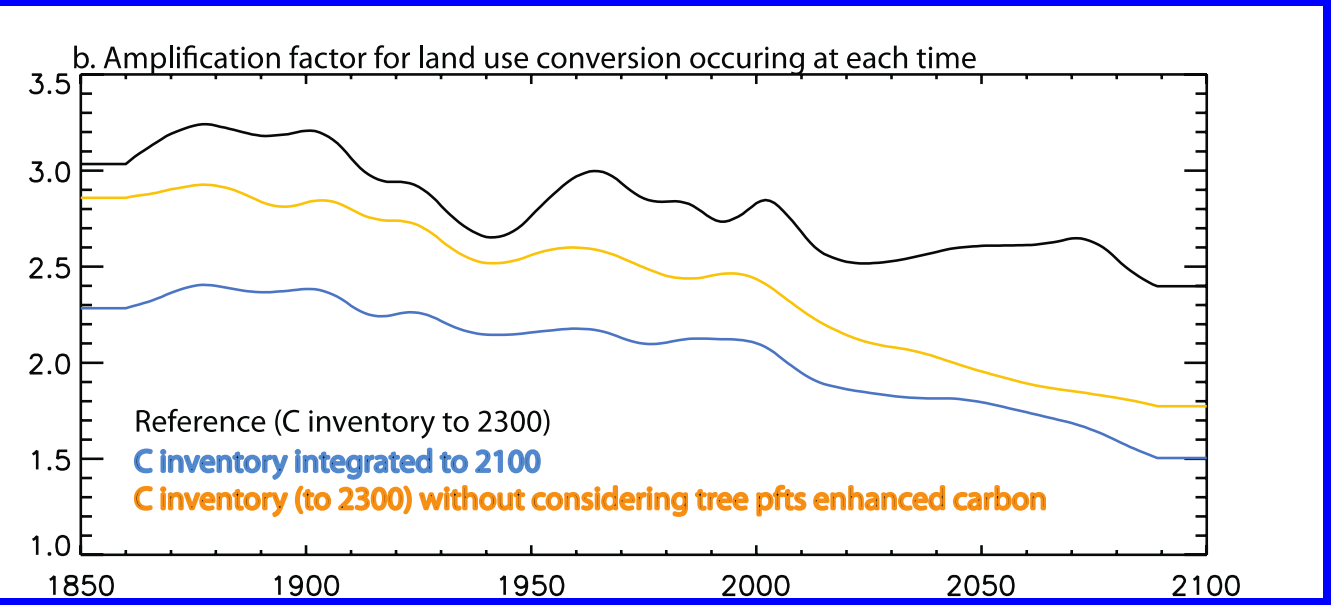
Mahowald et al., submitted.



Balance between DC and IC changes with when LULCC occurs

Blue: more IC
Red: more DC

Mahowald et al., submitted.



amplification factor evolves with time: higher at beginning, lower later

Now: Amplification factor is 2.6.

currently, emitted CO2 from LULCC →long term cause 2-3x as much RF as fossil fuel emitted CO2
(due to indirect carbon=QDC+PIC)

AF=(DC+IC)/DC (amplification factor)

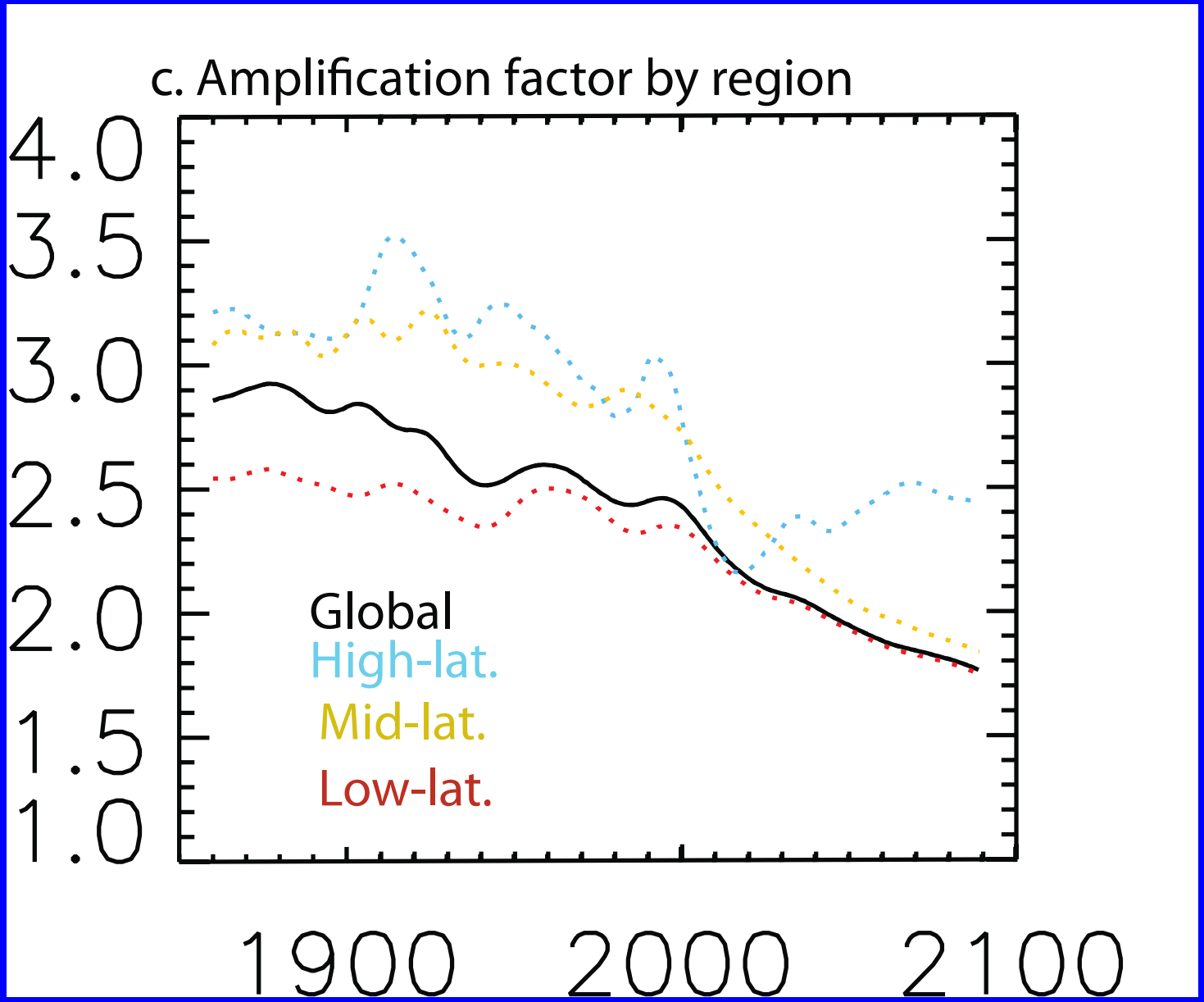
(stops at 2100 as LULCC stops at 2100 in this experiment)

Including simulations only to 2100 underestimates amplification by 35%
Not considering that tree pfts are especially important reduces amplification by 20%

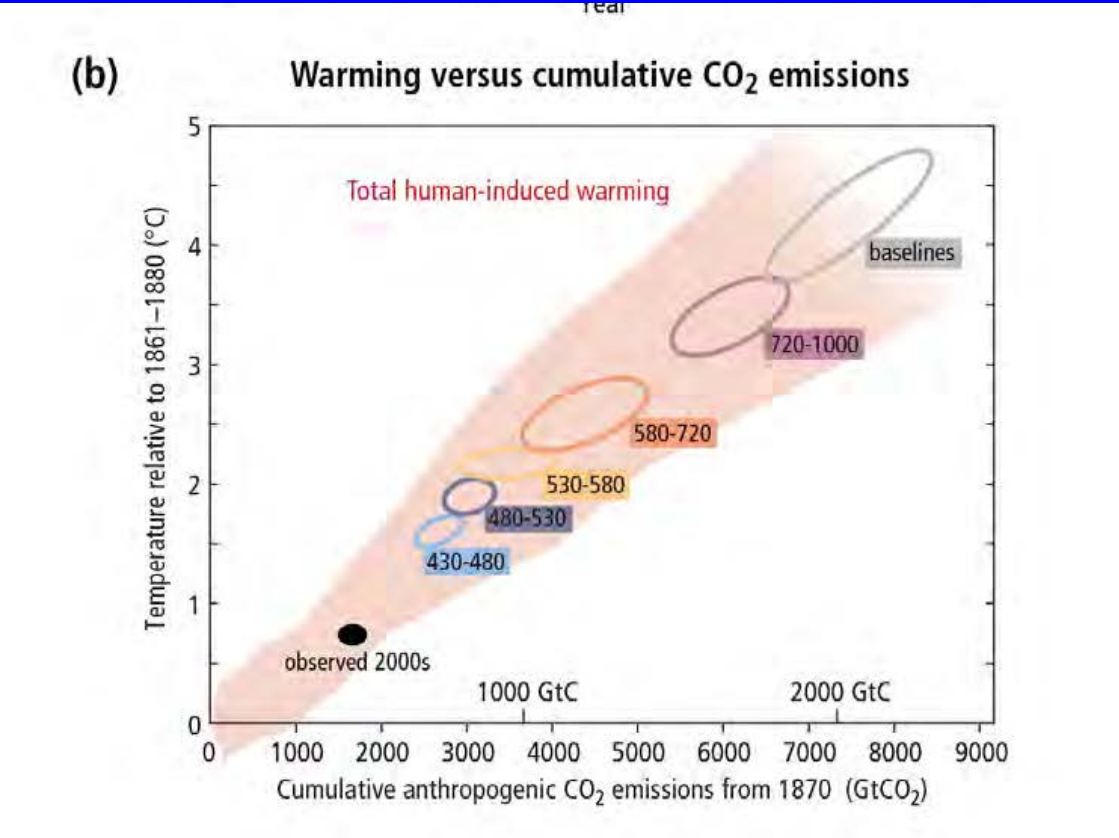
A

Mahowald et al., submitted.

Also lower with time, as more tropical deforestation occurs



Long term Implications?



To first order cumulative emissions of CO2→T
Synthesis SPM, 2014

LULCC CO2 causes > 2x as much RF as fossil fuel or other anthropogenic emissions of co2

Short term-medium term: due to co-emission of CH4, N20 and fossil fuel coemission of aerosols (Ward et al., 2014; 2015)

Long term: due to loss of sink.

Summary/conclusions

- LULCC responsible for 20% of CO2 but 40% of current RF (radiative forcing) in Ward et al., 2014
  - Likely to continue in future under different RCPs
  - RCPs optimistic about LULCC in future (lower than current rate)
- CO2 from LULCC causes 2-3x as much RF as the CO2 from fossil fuels in our set of models
  - Short-medium time scales due emissions of other GHG vs. aerosols for fossil fuels
  - Long time scales: due to loss of carbon sink
- While energy remains primary issue, deforestation as well as agriculture and pasturage should remain climate issues