



Land Use and Land-Cover Change Consequences for Land-Surface Dynamics

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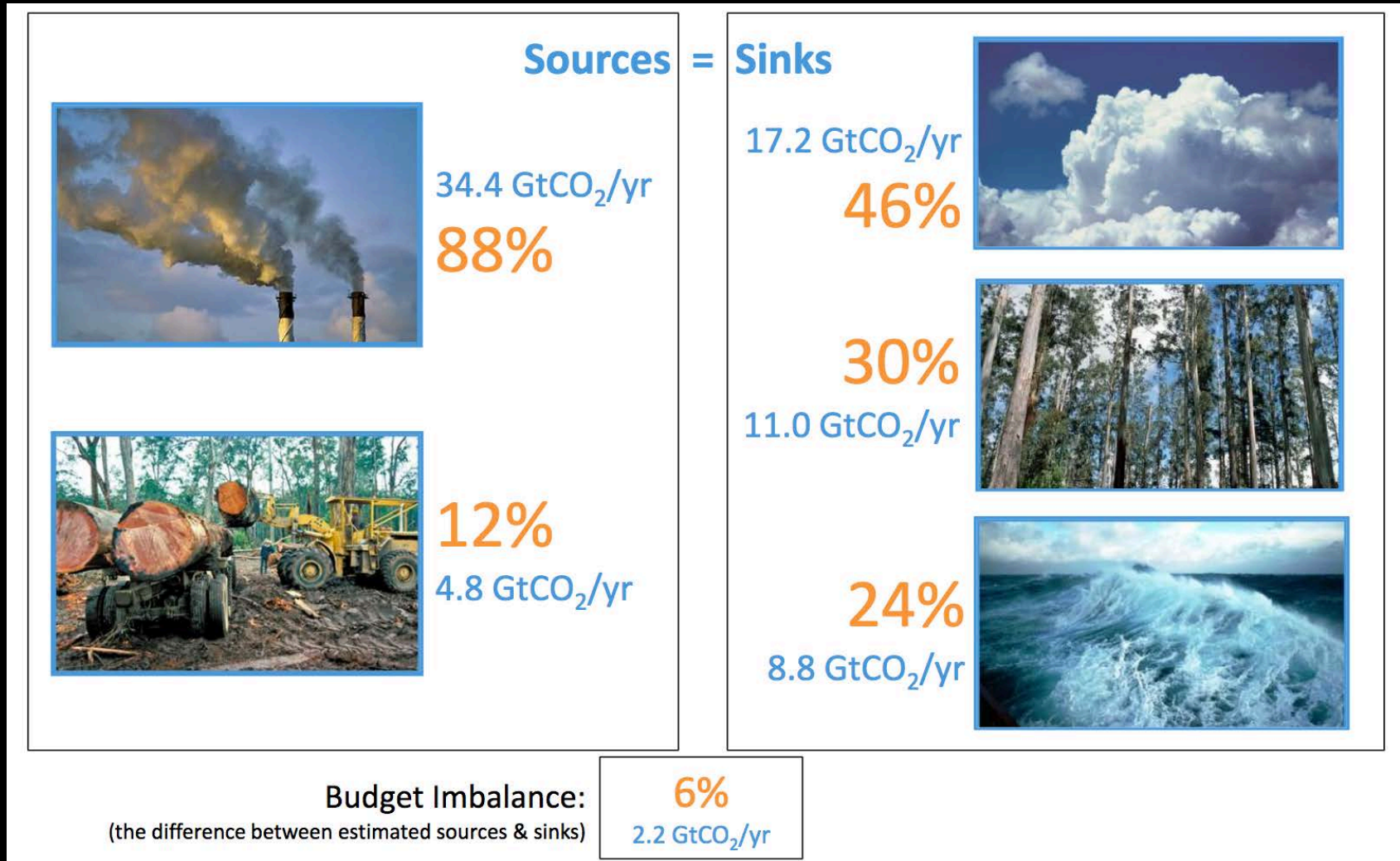
Overview of presentation

1. Role of land-use and land-cover change in the Earth system
2. Sources of uncertainty in LUC modeling
3. Integrating remote sensing of forest structure and Earth system modeling

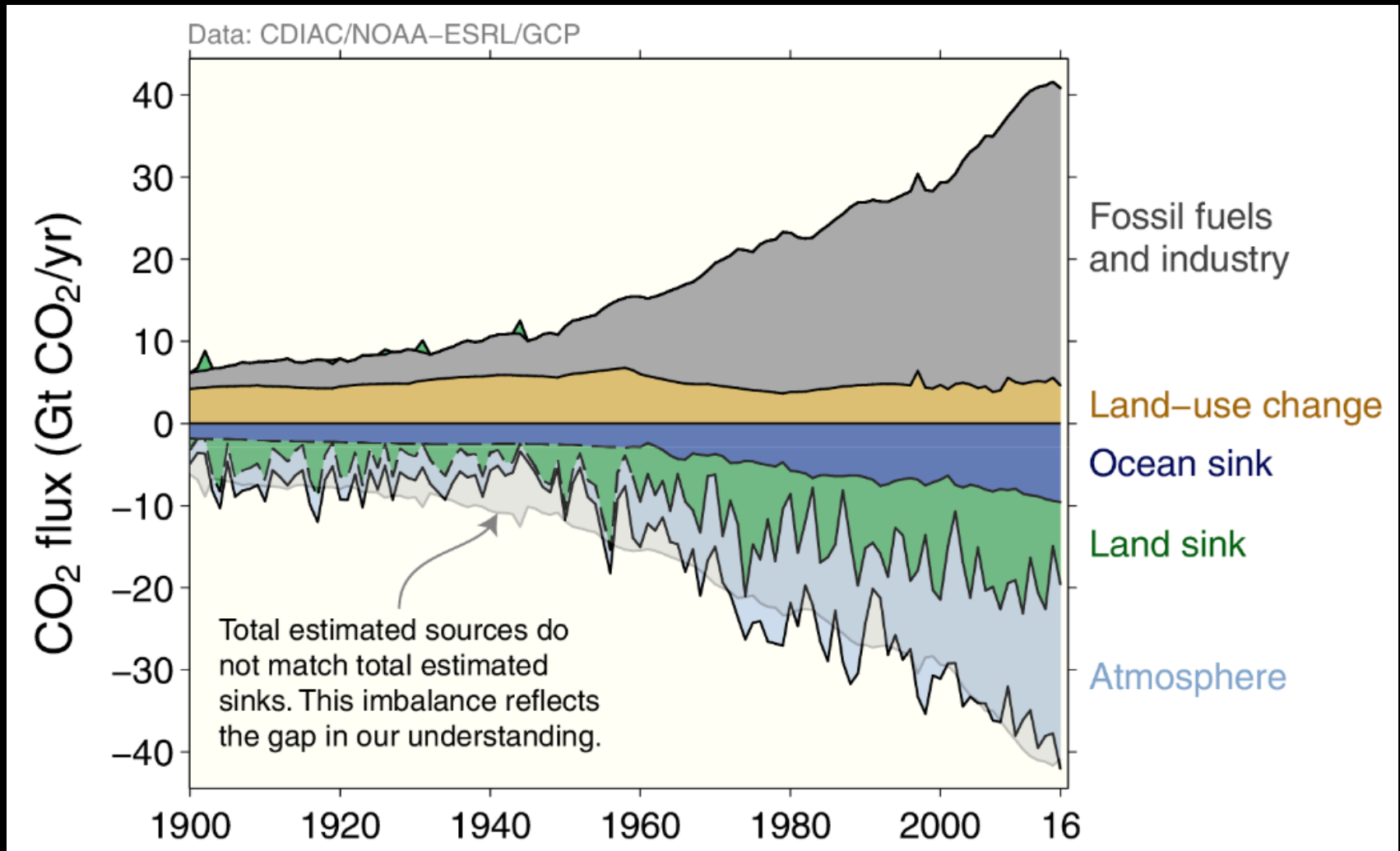
Take home message:

Sub-grid cell heterogeneity continues to be a key challenge in LUC (& disturbance) modeling

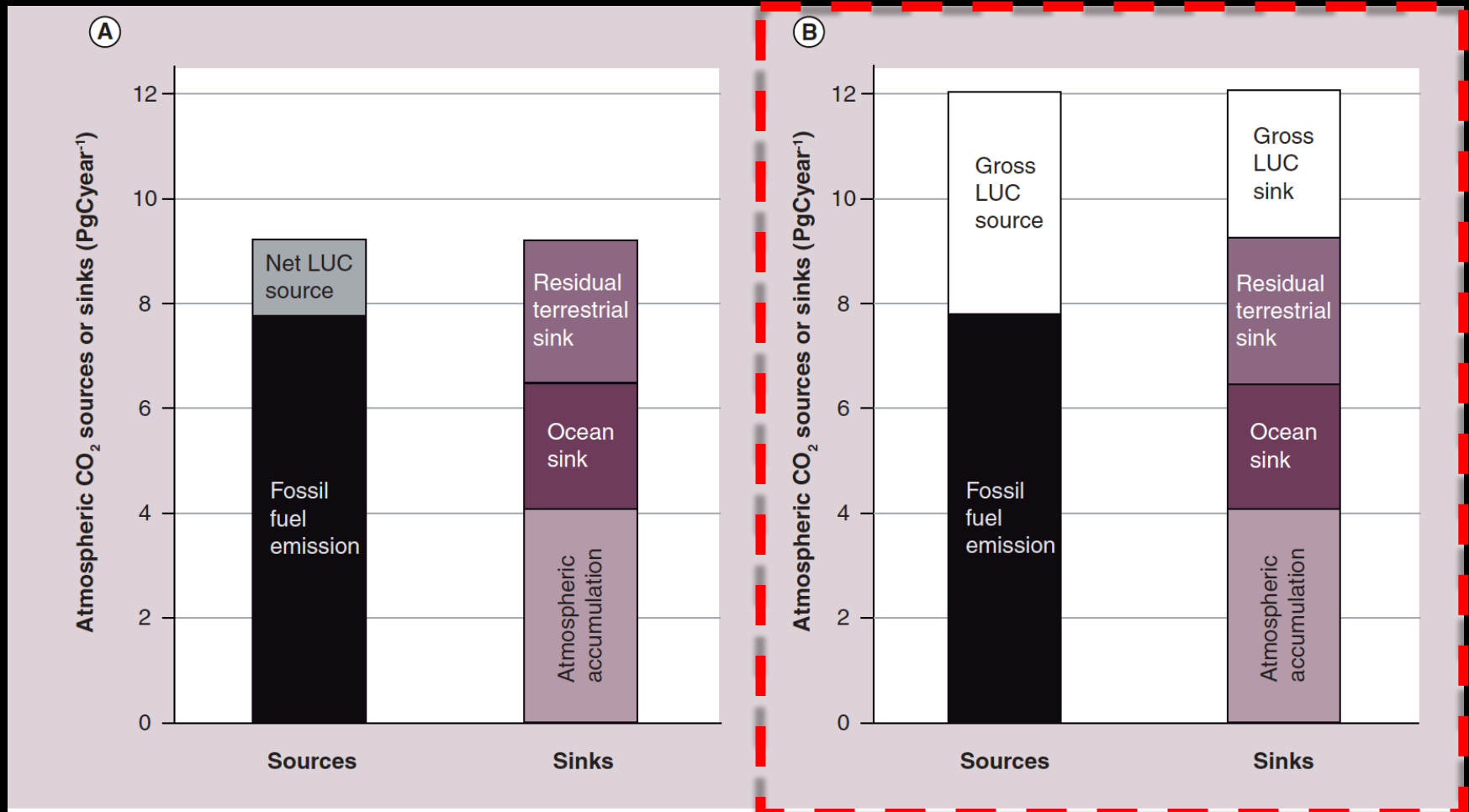
1) Land-cover and land-use change is ~10% of total CO₂ sources



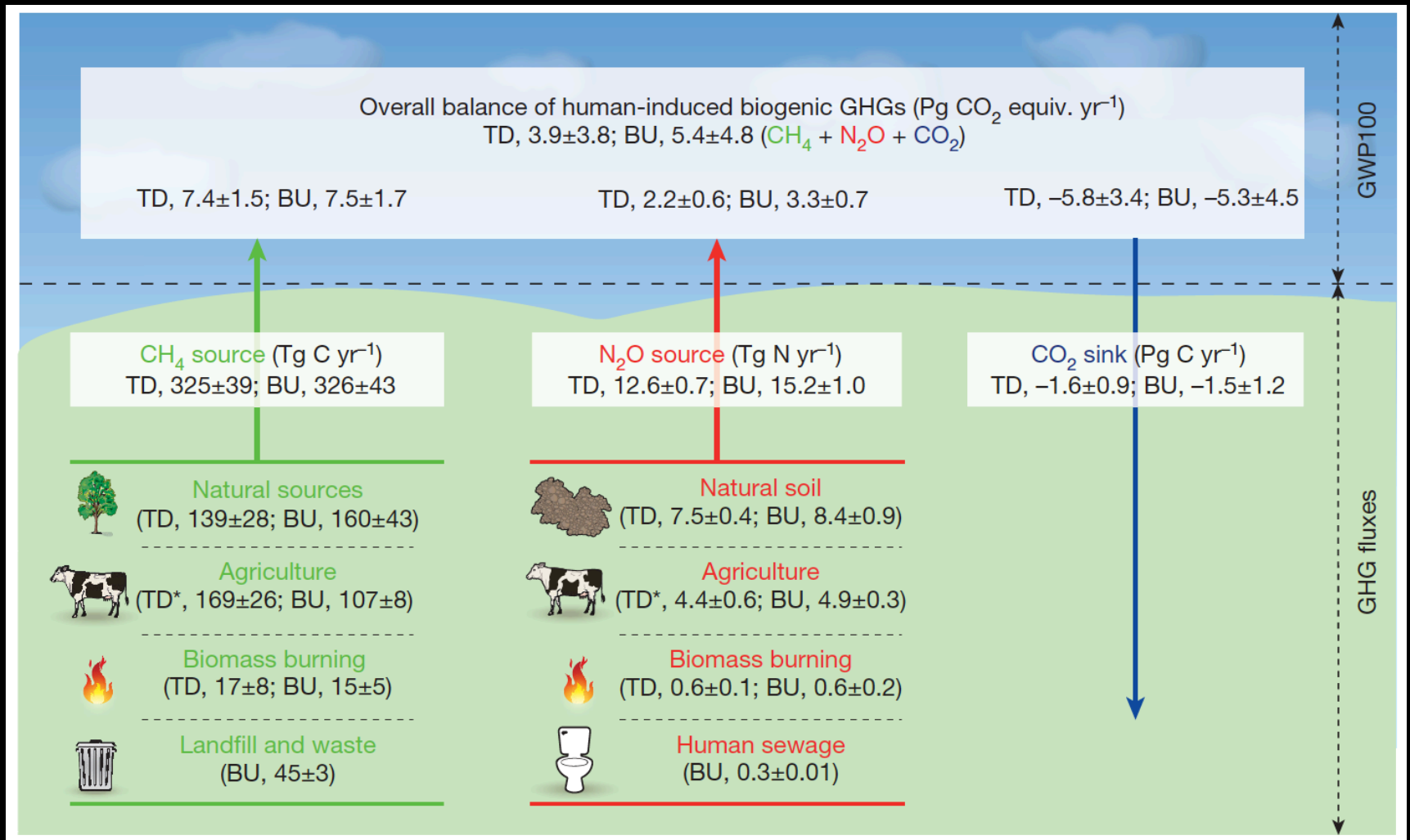
1) Land-use change (LUC) is declining contribution to total CO₂ emissions



1) Net LUC perspective masks large gross fluxes from deforestation and regrowth

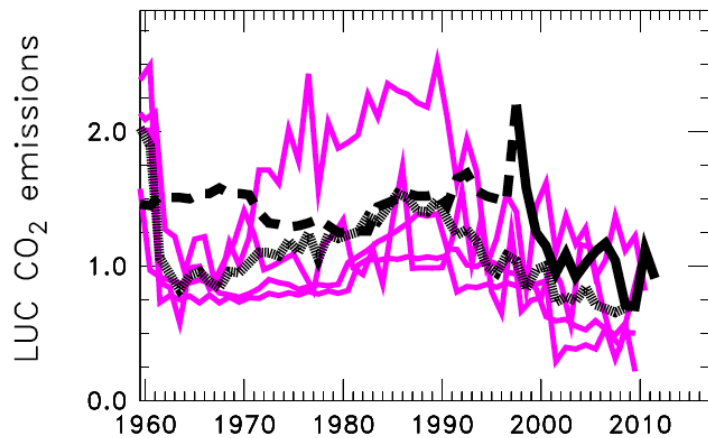


1) Non-CO₂ GHGs from land-use activities lead to positive radiative forcing

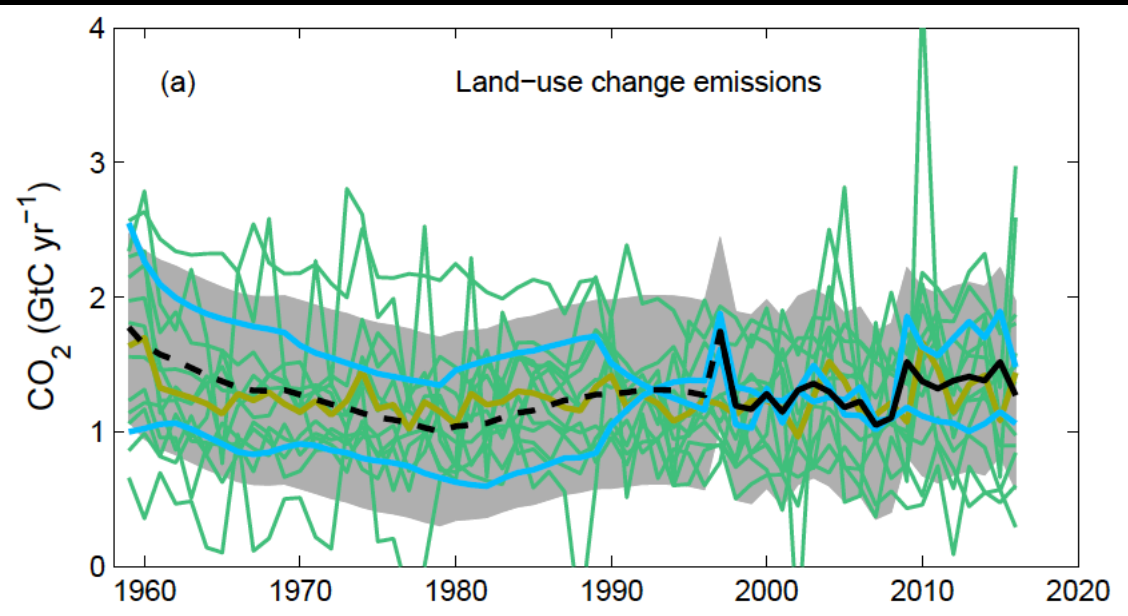


2) Uncertainties in the LUC flux is increasing over time

- Inclusion of LUC processes
- Representation of LUC processes



Le Quere et al. 2013

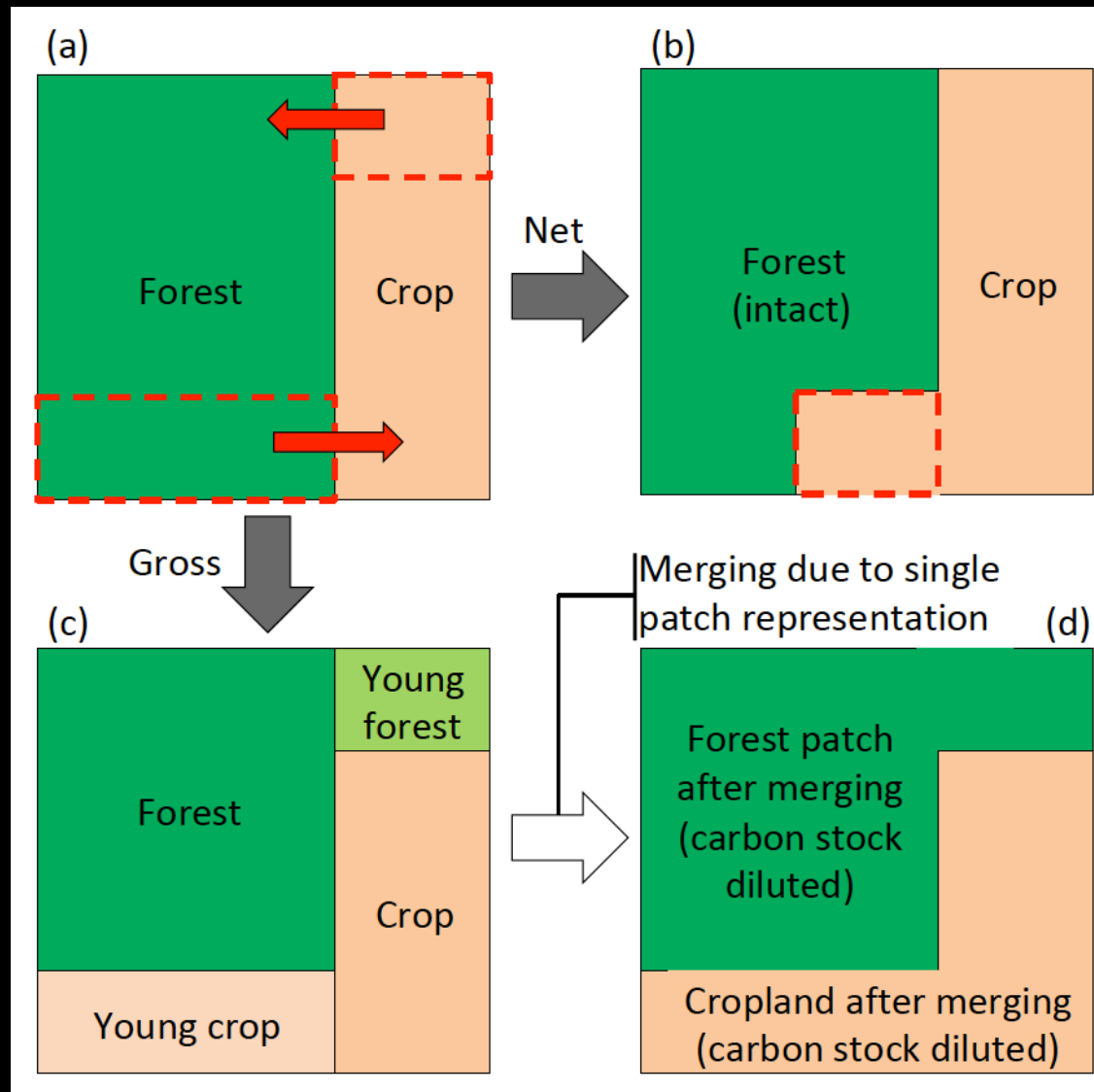


Le Quere et al. 2018

2) Inclusion of LUC processes

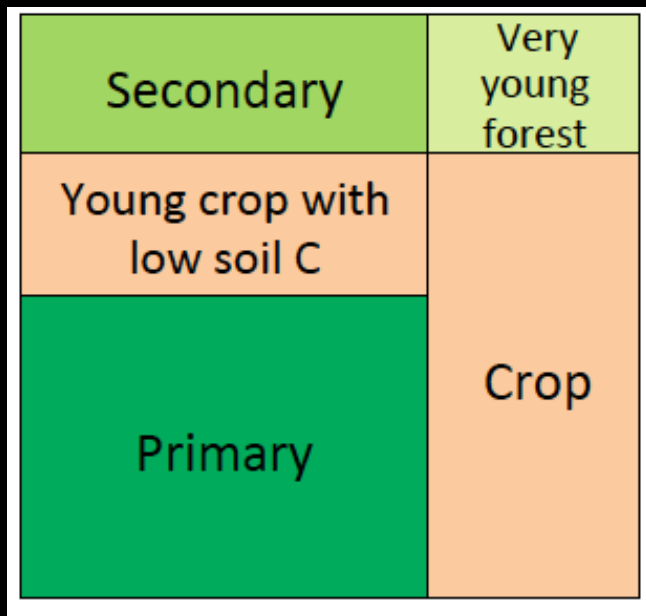
	H&N2017	BLUE	CABLE	CLASS-CTEM	CLM4.5(BGC)	DLEM	ISAM	JSBACH ^j	JULES	LPJ-GUESS ^j	LPJ	LPX-Bern	OCN	ORCHIDEE	ORCHIDEE-MIC	SDGVM	VISIT ^j
Processes relevant for E_{LUC}																	
Wood harvest and forest degradation ^a	Y	Y	Y	N	Y	Y	Y	N	N	N	N ^d	Y	Y	N	N		
Shifting cultivation/ subgrid scale transitions	N ^b	Y	Y	N	Y	N	N	N	N	N	N ^d	N	N	N	N		
Cropland harvest	Y ⁱ	Y ⁱ	N	L	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Peat fires	Y	Y	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N
Fire as a management tool	Y ⁱ	Y ⁱ	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
N fertilisation	Y ⁱ	Y ⁱ	N	N	N	Y	Y	N	N	N	Y	Y	N	N	N	N	N
Tillage	Y ⁱ	Y ⁱ	N	Y ^f	N	N	N	N	N	N	N	N	N	Y ^h	Y ^h	N	N
Irrigation	Y ⁱ	Y ⁱ	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N
Wetland drainage	Y ⁱ	Y ⁱ	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Erosion	Y ⁱ	Y ⁱ	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Southeast Asia peat drainage	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Grazing and mowing harvest	Y ⁱ	Y ⁱ	N	N	N	N	Y	N	N	Y	N	N	N	N	N	N	N
Processes relevant also for S_{LAND}																	
Fire simulation	US only	N	N	Y	Y	Y	N	Y	N	Y	Y	Y	N	N	Y	Y	Y
Climate and variability	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
CO ₂ fertilisation	N ^g	N ^g	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Carbon–nitrogen inter- actions, including N deposition	N ⁱ	N ⁱ	Y	N ^e	Y	Y	Y	N	N	Y	N	Y	Y	N ^e	N	Y ^c	N

2) Representation of LUC processes

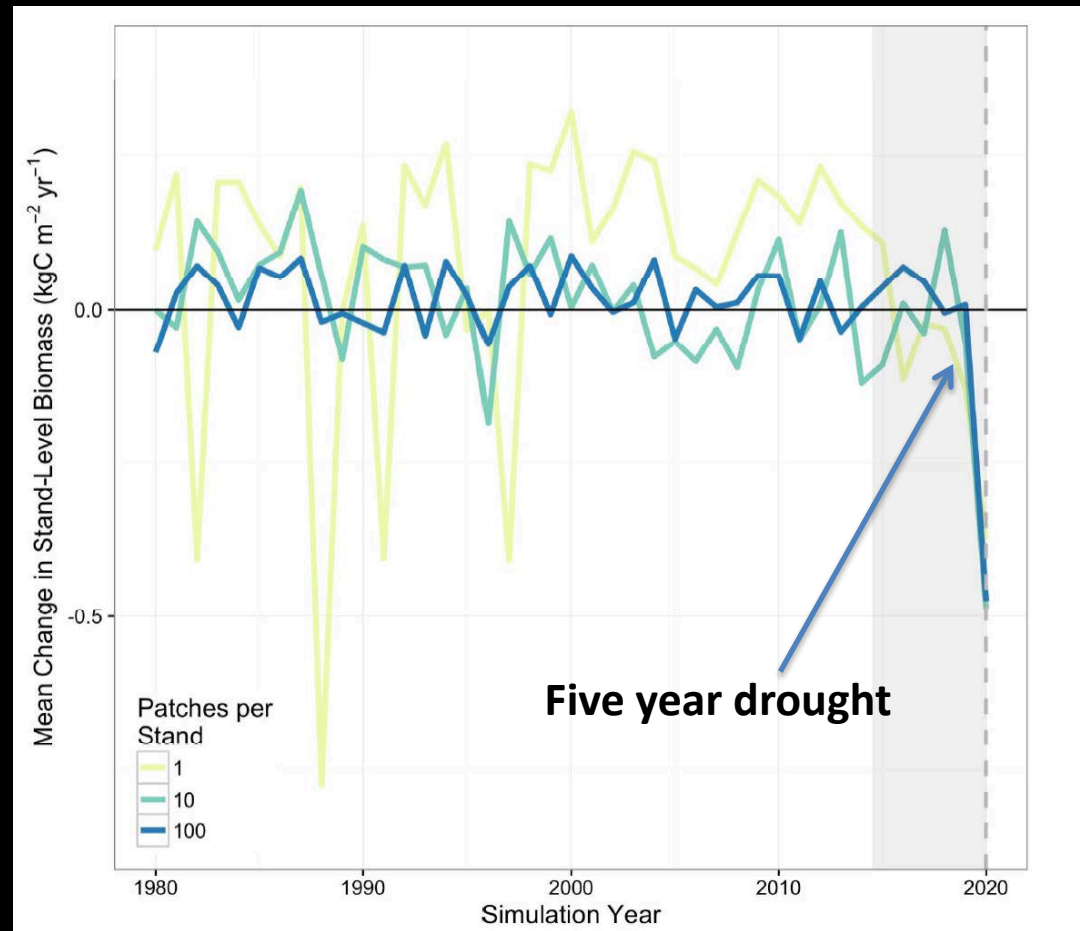


2) Representation of LUC processes

Sub-grid cell tiling of forests into primary and secondary stands, and with age classes



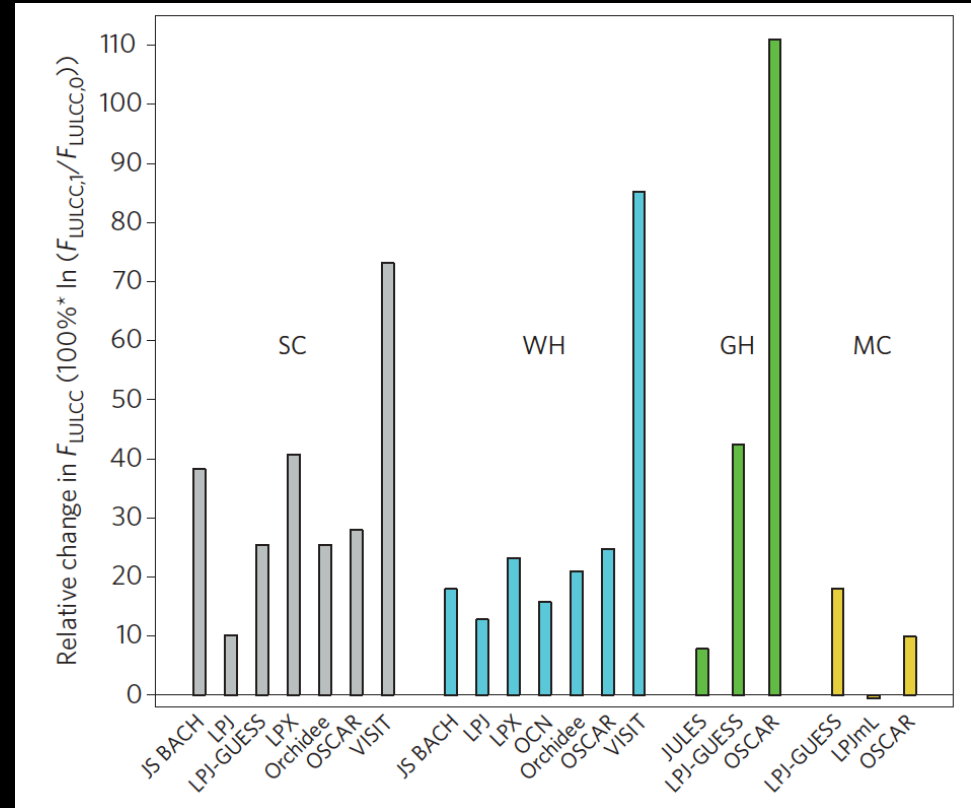
Grid cell properties are sensitive to tiling structure



2) Is the land carbon sink underestimated as sum of missing LUC sources increases?

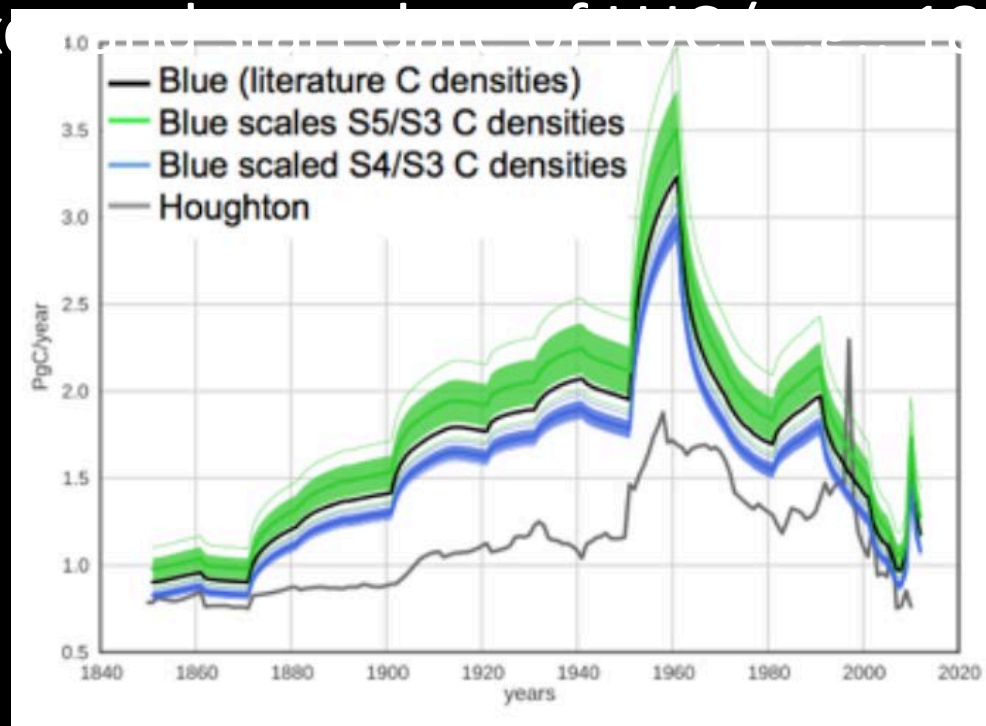
Summary of missing LUC fluxes (PgC yr⁻¹)

wood harvest	0.337
gross transitions	0.388
crop harvest	0.303
peat burning	0.033
fire as management tool	0
N fertilization	0
tillage	0.116
irrigation	0
wetland drainage	0
fire as management tool	0
erosion	0
SSEA peat drainage	0.082
grazing and mowing	
harvest	0.151



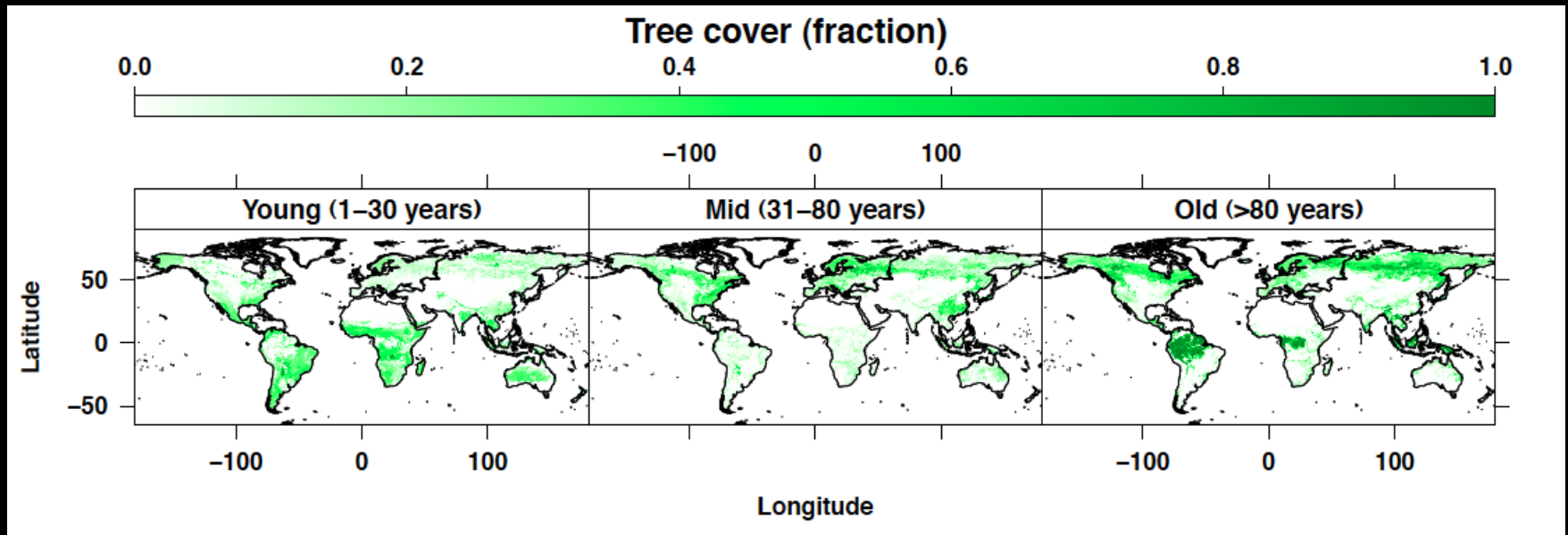
2) Towards an LUC benchmarking

- Bookkeeping models have no climate or CO₂ fertilization effect on biomass (<10% error)
- Loss of additional sink capacity ~0.3-0.5 PgC bias in DGVMs
- Legacy fluxes (e.g. from 1850 to 1950 vs 850)



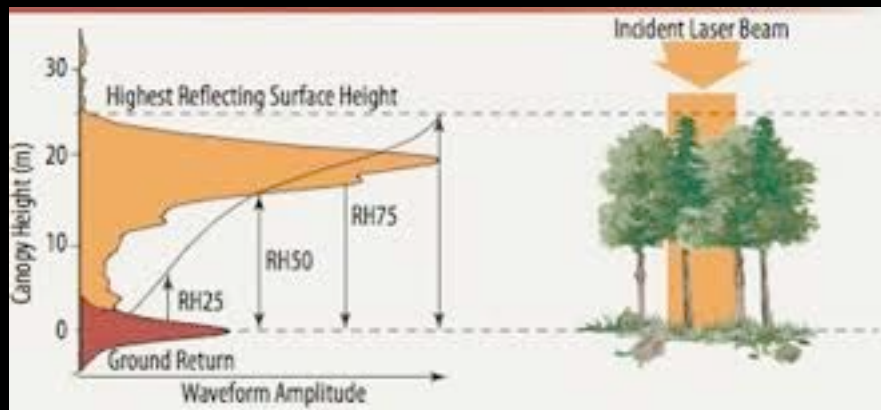
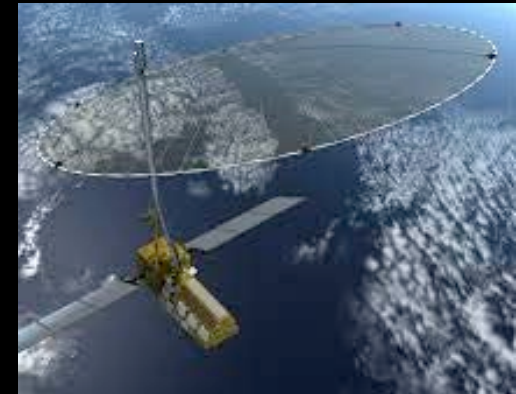
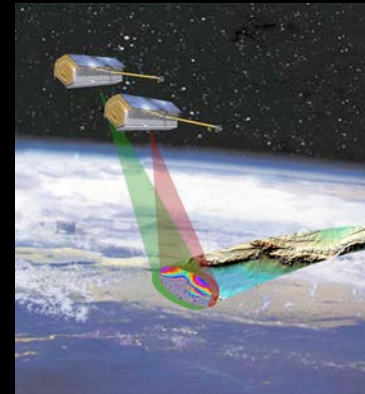
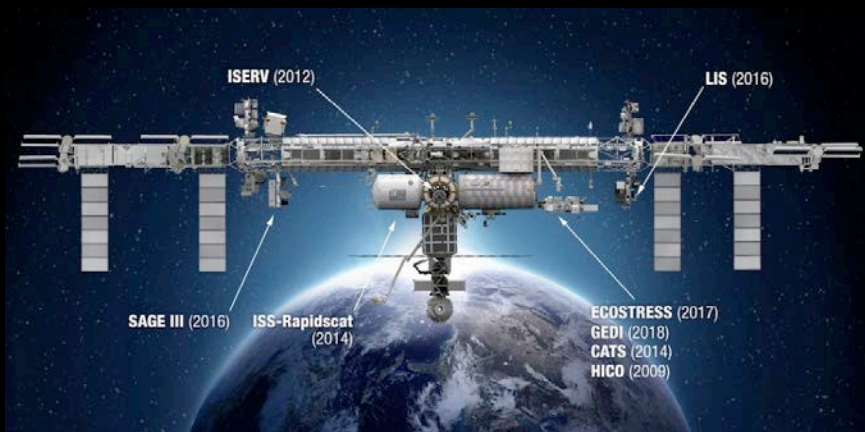
3) Remote sensing of forest structure

- Initialization opportunities for forest structure and forest age (inventory + remote sensing hybrid)



3) Remote sensing of forest structure

- Initialization, benchmarking and data assimilation opportunities for forest structure and forest age (GEDI, ICESat-2, NISAR, BIOMASS, Tandem-X)



How the trees are seen by radars?

Austrian pine

X band
 $\lambda = 3$ cm

L band
 $\lambda = 27$ cm

P band
 $\lambda = 70$ cm

VHF
 $\lambda > 3$ m

The main scatterers in a canopy are the elements having dimension of the order of the wavelength



Thank you