GAMMA REMOTE SENSING

Max-Planck-Institut für Biogeochemie

Forest above-ground biomass estimates across three decades from spaceborne scatterometer observations

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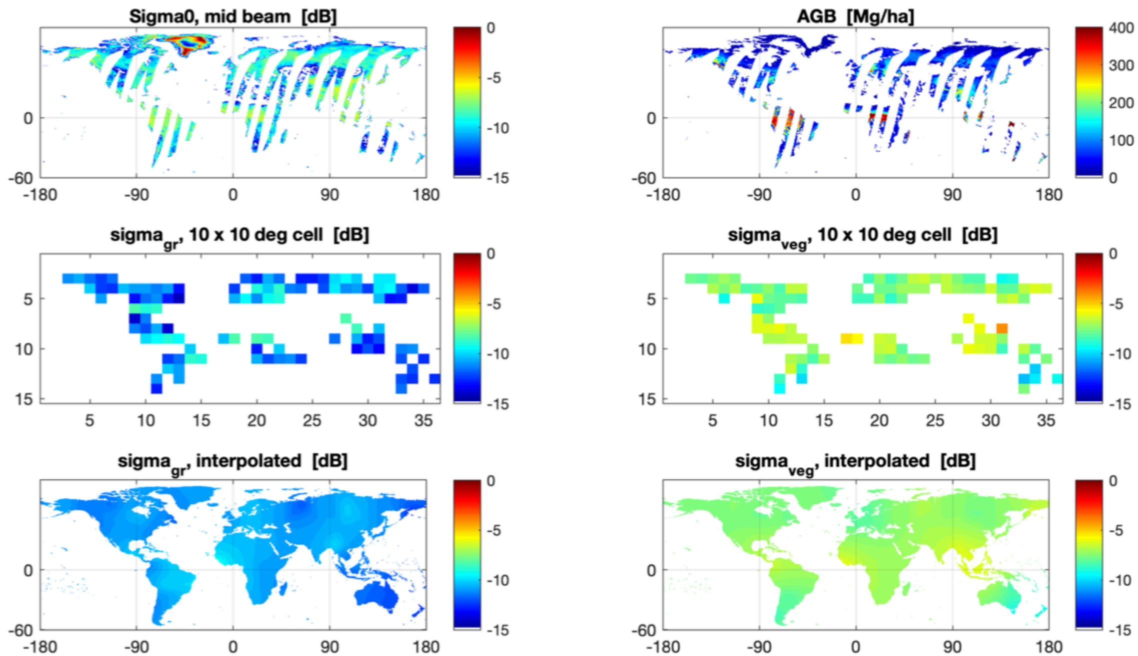
Introduction

- The large uncertainty characterizing the terrestrial carbon (C) cycle is a consequence of the sparse and irregular observations on the ground.
- In terms of observations, spaceborne remote sensing has been achieving global, repeated coverages of the Earth since the late 1970s.
- One of the longest time record of observations from space is represented by the backscattered intensity from the European Remote Sensing Wind Scatterometer (ERS WindScat) and the MetOp Advanced Scatterometer (ASCAT), both operating at C-band (wavelength of 6 cm).
- An almost unbroken time series of backscatter observations at 0.25° spatial resolution exists since 1991 and data continuity is guaranteed in the next decades.

Methodology and output

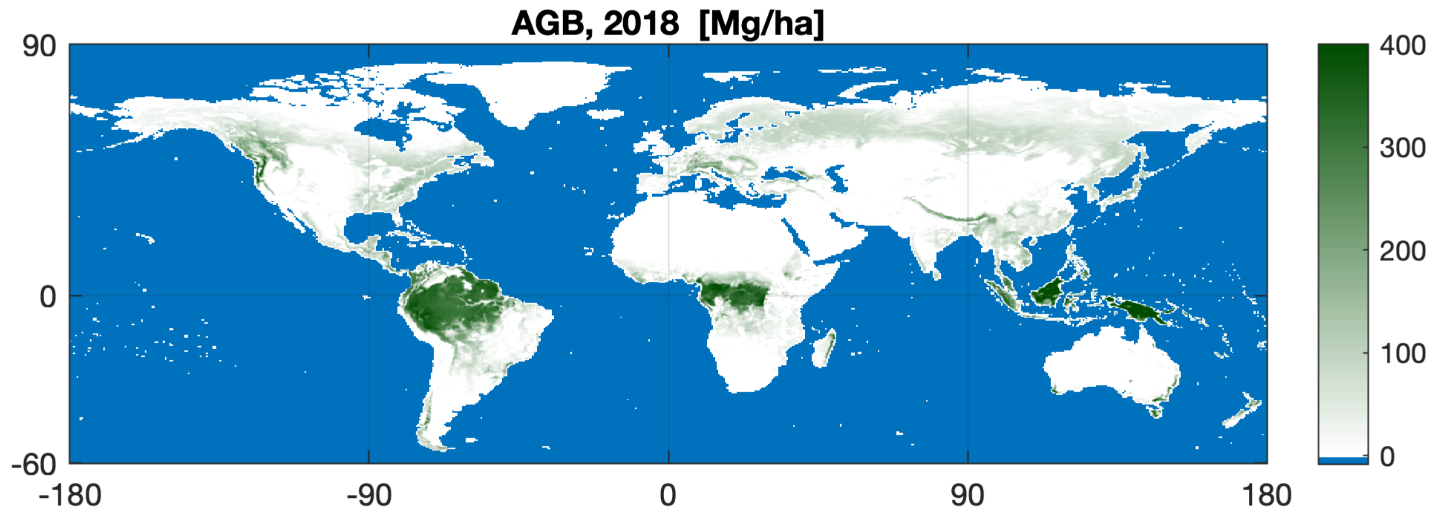
- Inversion of empirical model relating sigma0 and AGB

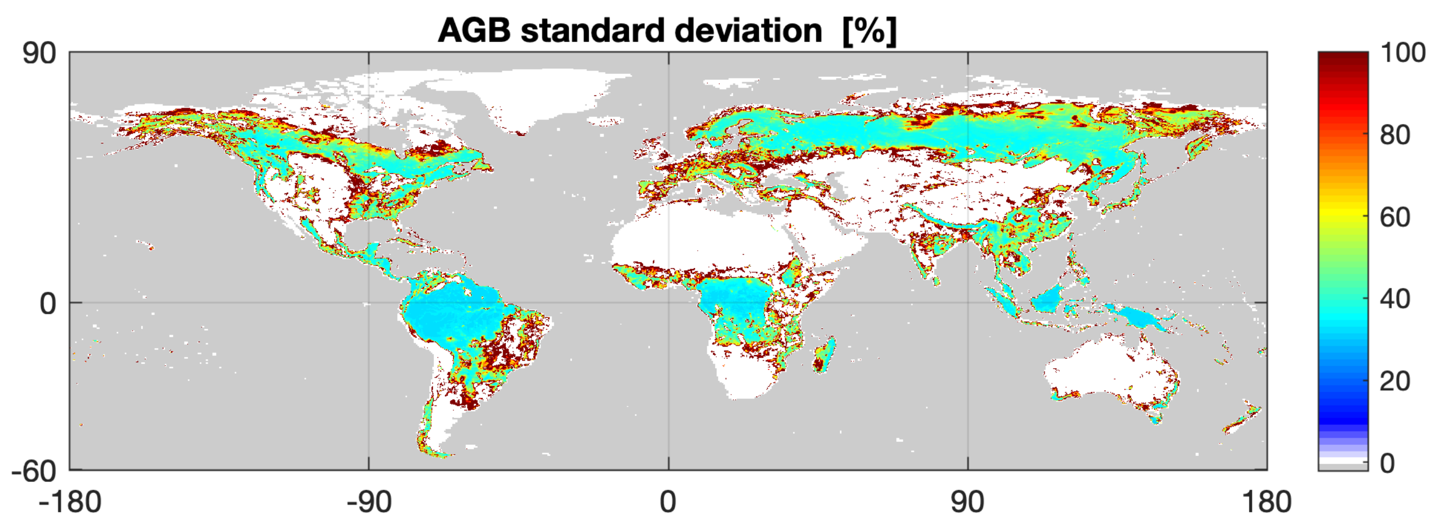


- Weighted average of daily AGB estimates to obtain a yearly estimate to increase accuracy of estimates

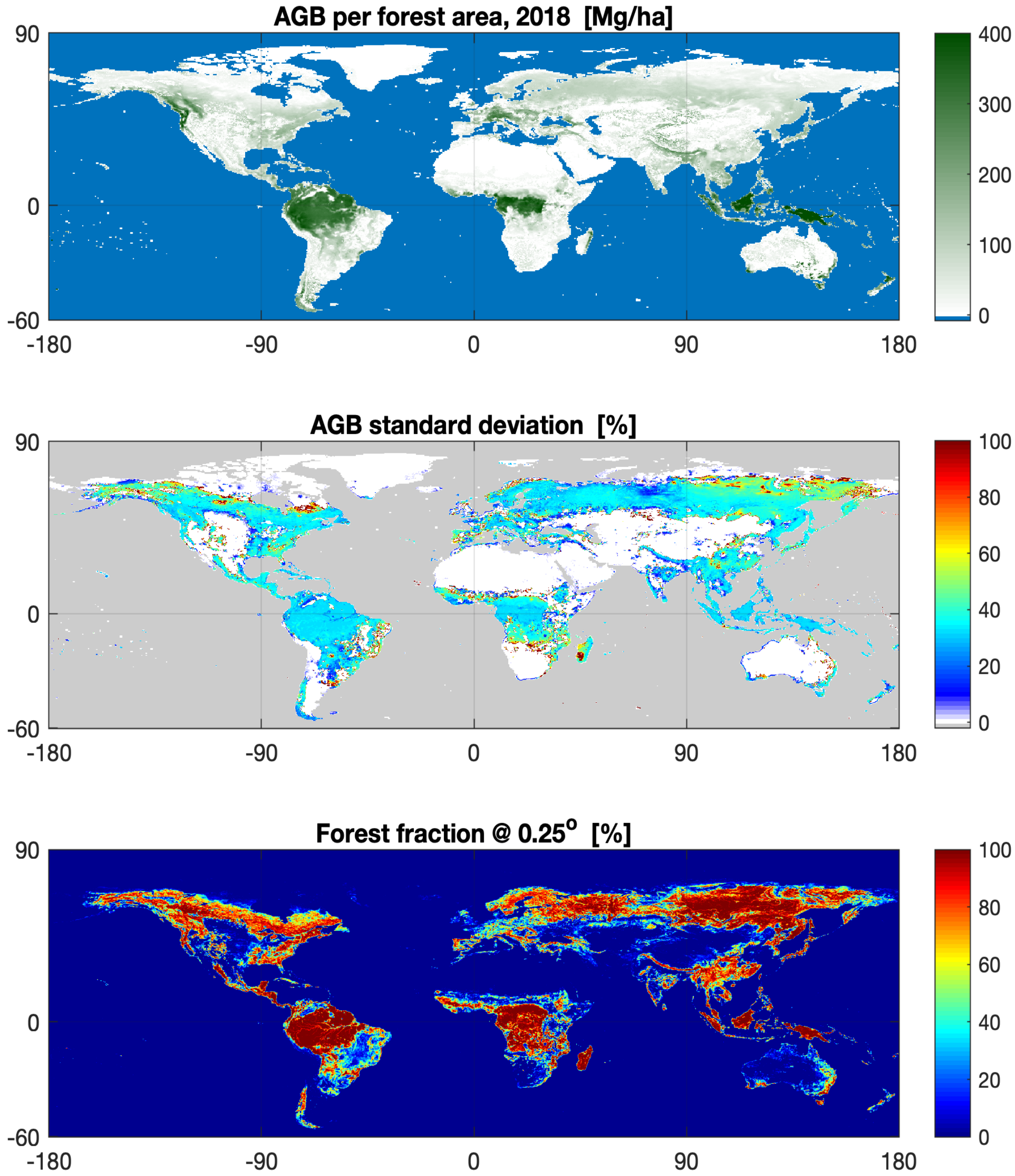
- We have now applied this approach to generate a global dataset of yearly estimates of AGB between 1992 and 2019 at 0.25° spatial resolution.

AGB estimates @ 0.25° (example for 2018)

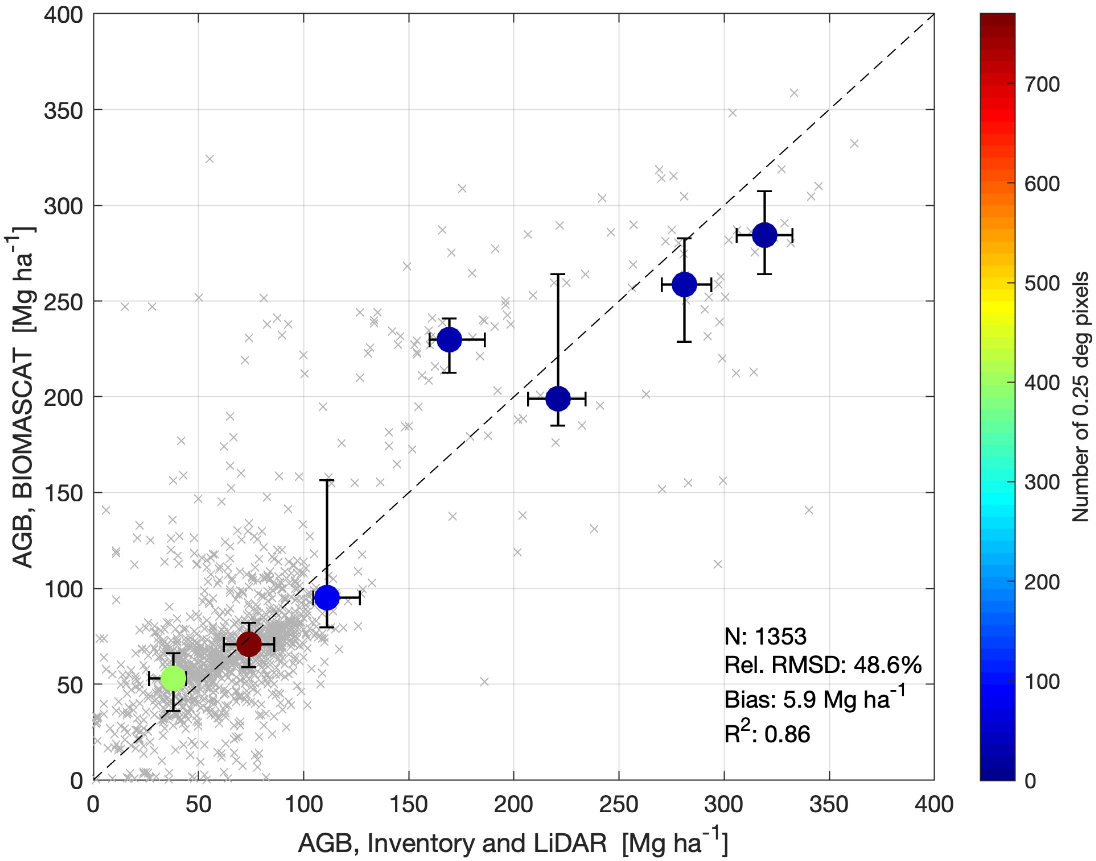




AGB estimates per forest area @ 0.25°



Validation @ 0.25°

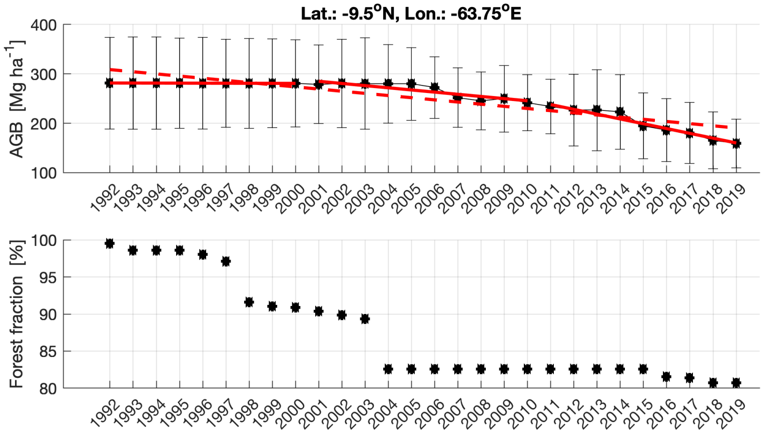


Coloured circles and bars represent the median and inter-quartile ranges of AGB for 50 Mg ha^{-1} wide bins

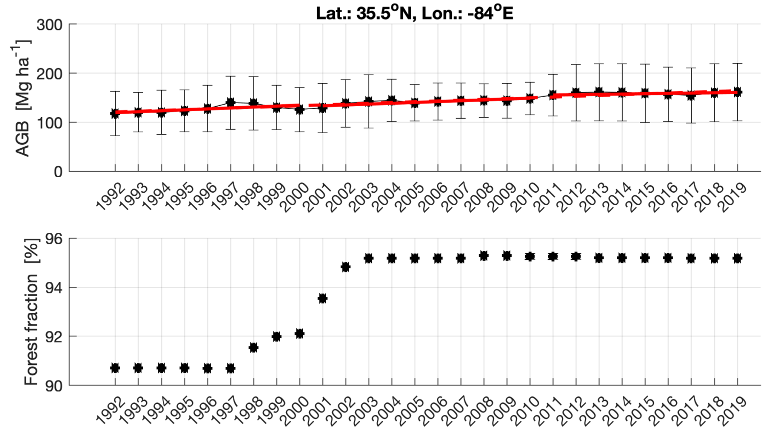
LiDAR and in situ data source: AfriSAR and TropiSAR campaigns (Labriere et al., 2018), CCI BIOMASS processing of CMS and Sustainable Landscapes data (N. Labriere and J. Chave, unpublished), CMS flights over Sonoma County (Dubayah et al., 2017) and Mexico (Urbazaev et al., 2018), Sweden forest basemap (Nilsson et al., 2017), SIBERIA-II Project region (IIASA) and Australian sites (Tanase et al., 2014)

Profiles of AGB estimates @ 0.25°

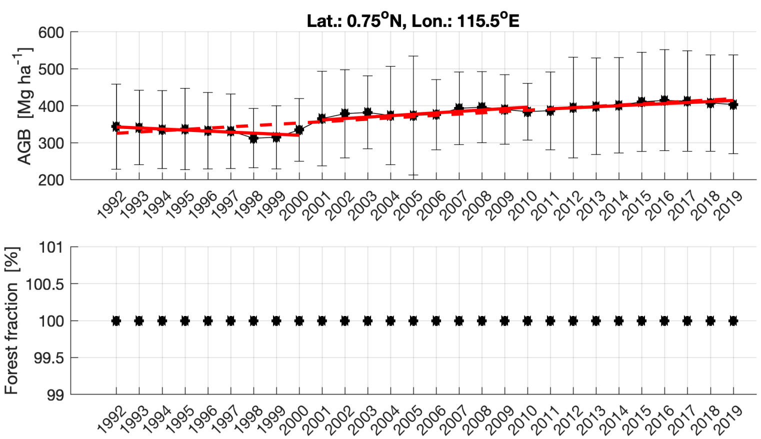
Arc of deforestation, Amazon



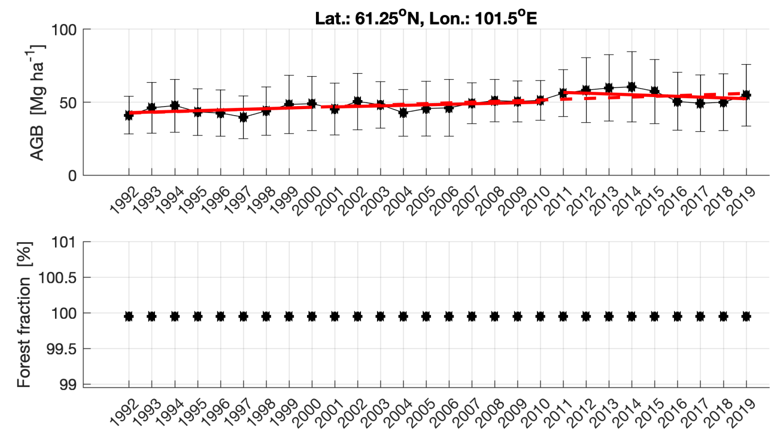
Appalachian Mountains, U.S.



Borneo, Indonesia

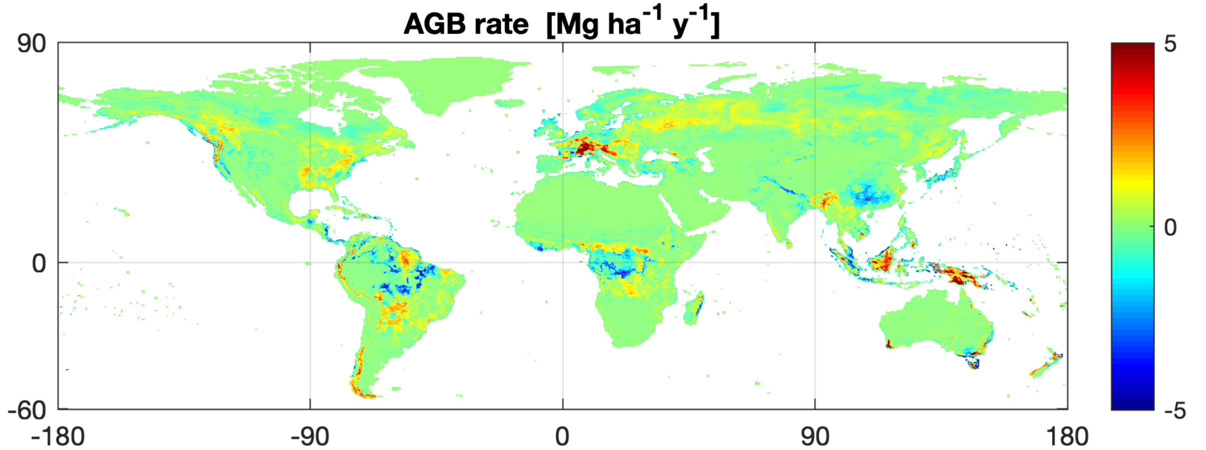


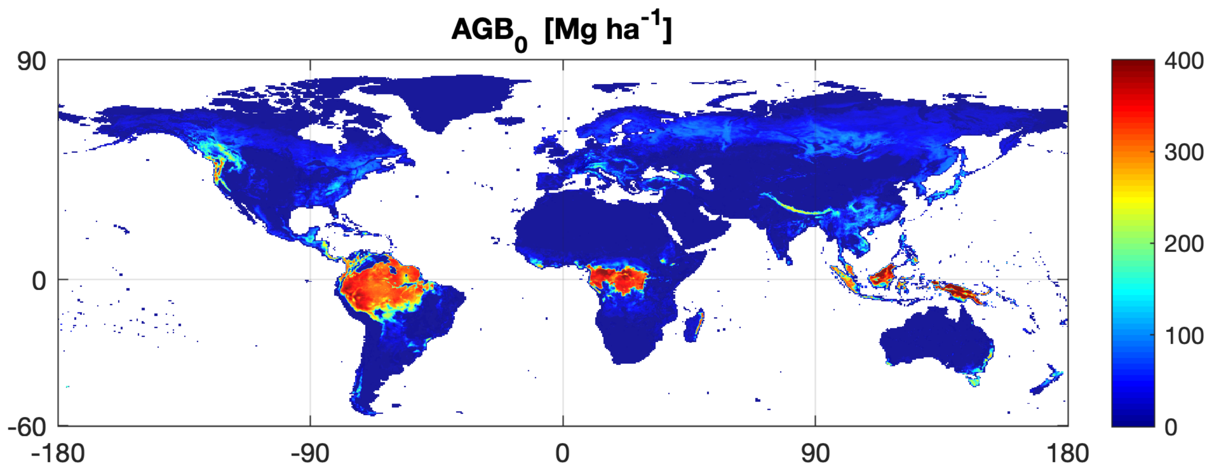
Irkutsk Oblast, Central Siberia



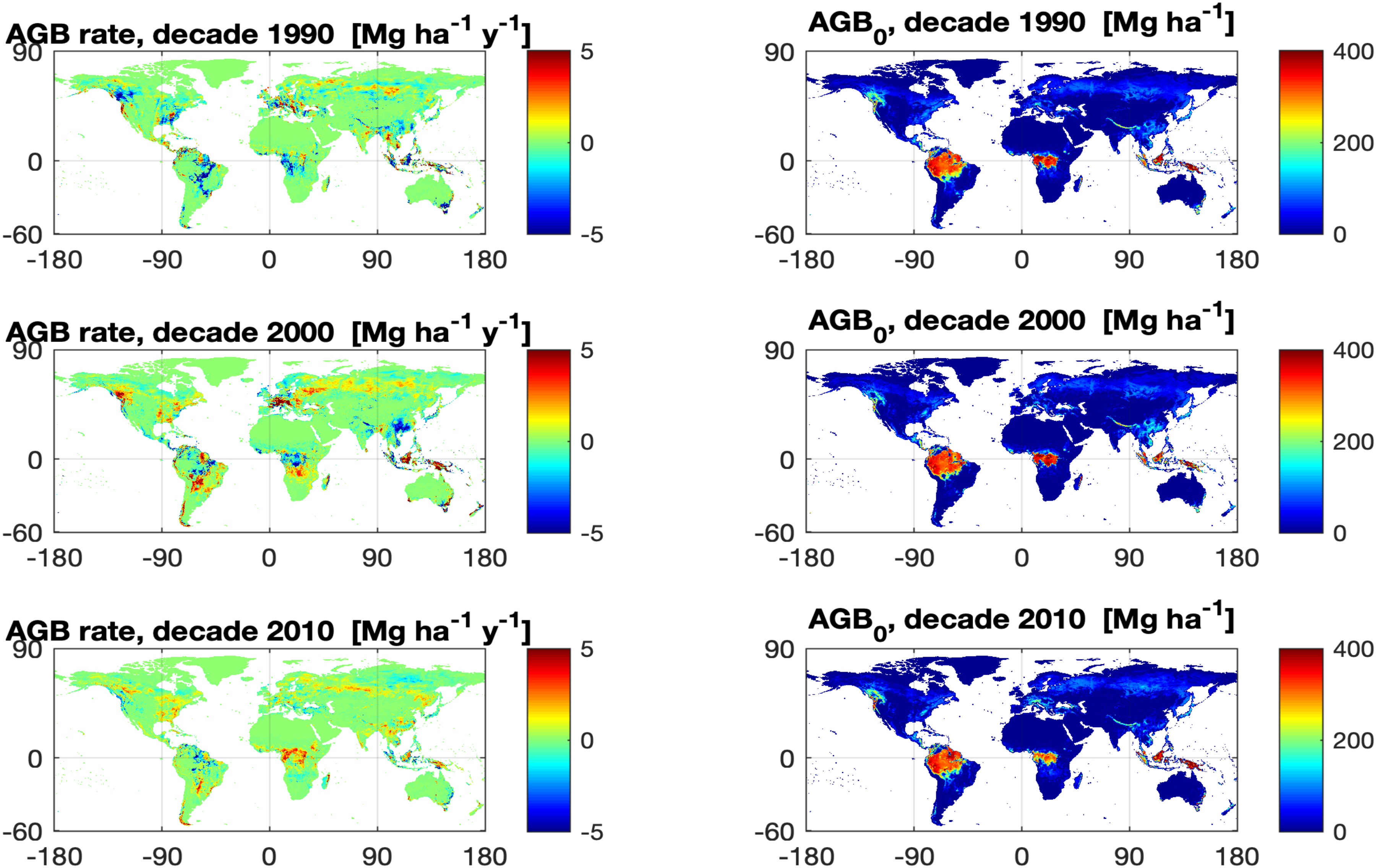
AGB trends 1992-2019

- Fitted a linear model to the time series of AGB estimates
- Images of the model slope (AGB rate) and model intercept (AGB_0) represents AGB trend and AGB level, respectively.

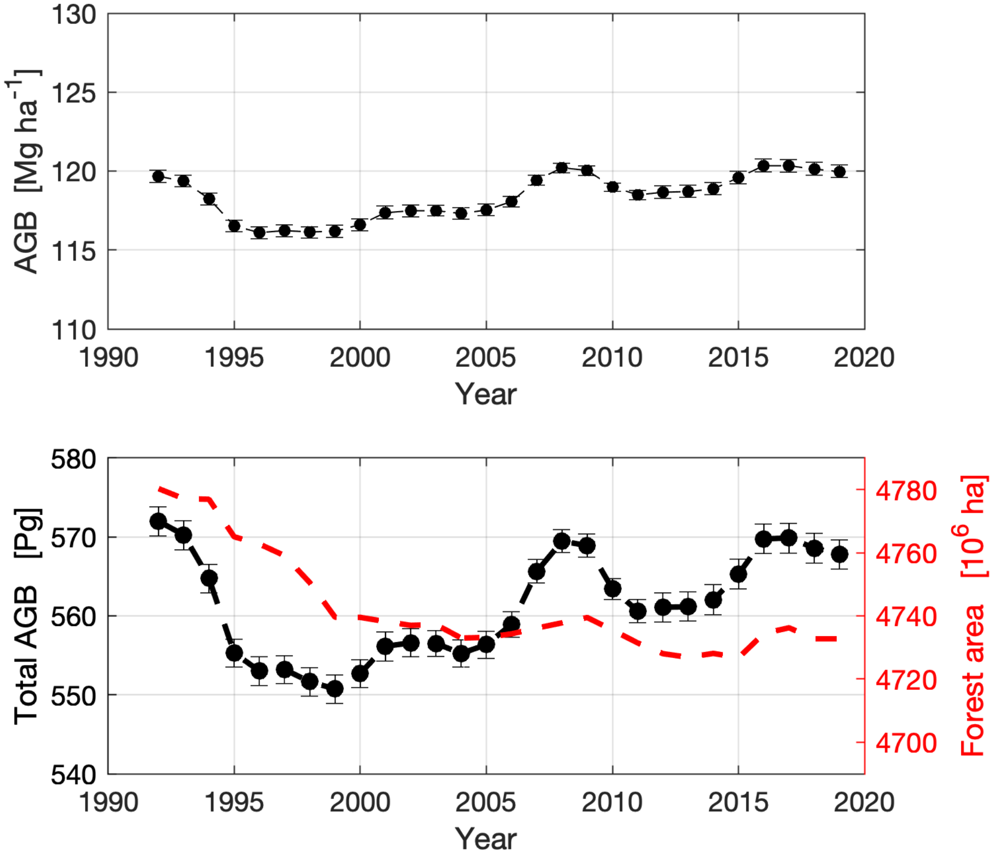




AGB trends per per decade

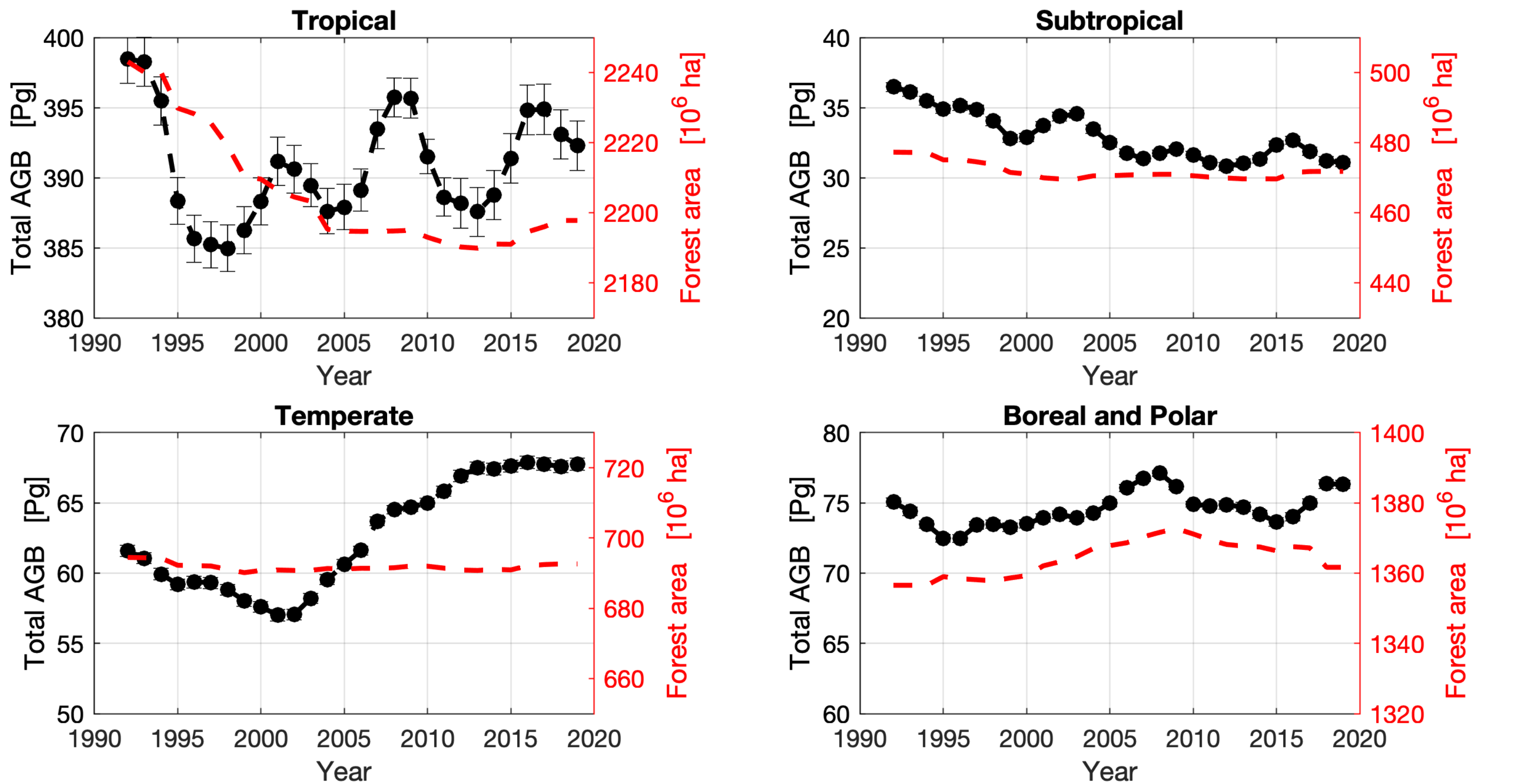


Global AGB trend (1992-2019)



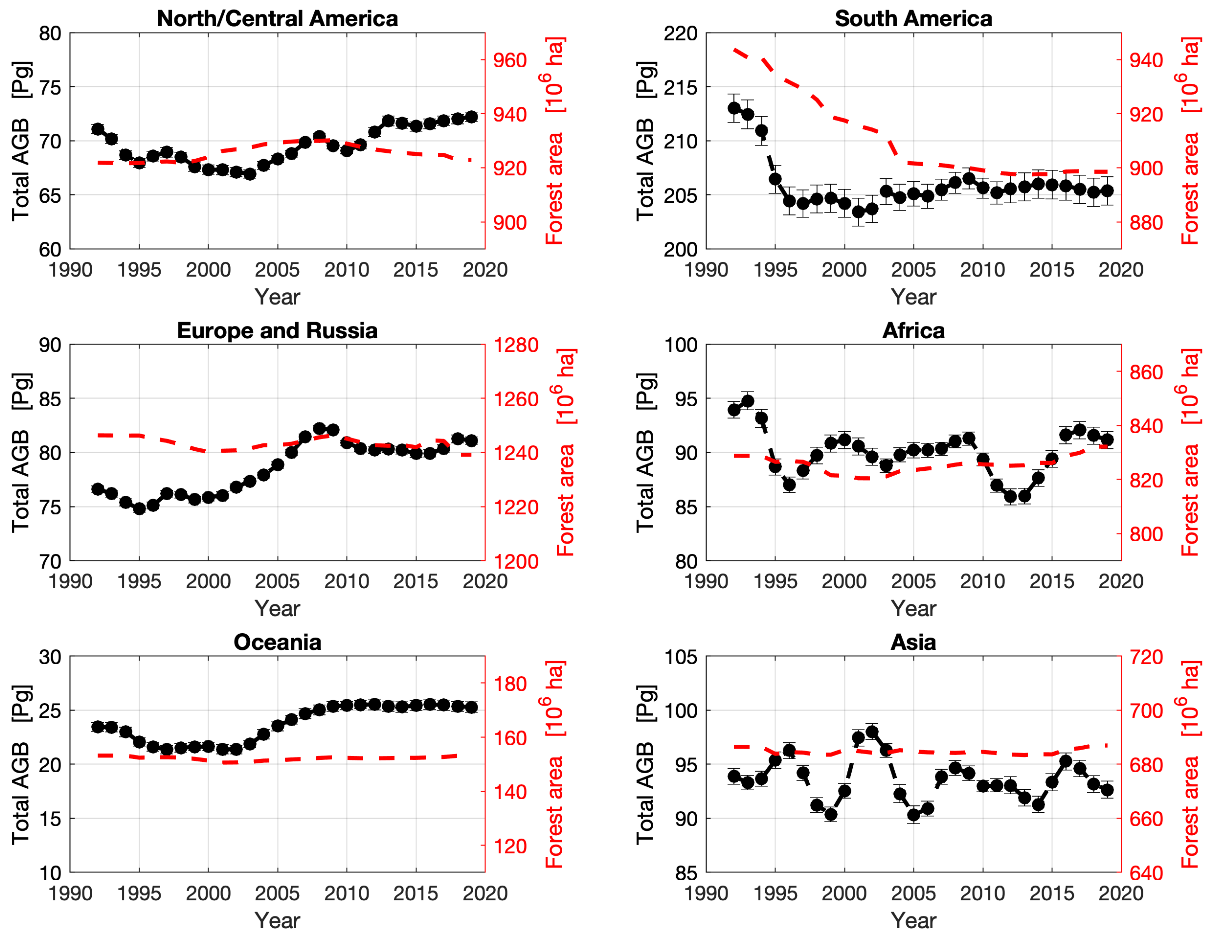
- **1990s**: total AGB loss of approximately 5% (570 Pg → 550 Pg) as a consequence of forest area loss
- **2000s**: total AGB increase (on average, 2 Pg year^{-1}). Increase interpreted as a consequence of higher AGB
- **2010s**: loss and increase of total AGB in the first halve of the decade (10 Pg). After 2015, stable total AGB at about the same level estimated at the beginning of the 1990s.

AGB trend (1992-2019) per biome



- **Tropics**: AGB gains and losses in the tropics paired with the constant decrease of forest area → net loss of total AGB of 6 Pg (-2%).
- **Subtropics**: decrease of AGB →net loss of total AGB loss of 6 Pg (- 17%)
- **Temperate**: decrease/increase of AGB → net gain of total AGB of 6 Pg (+12%)
- **Boreal**: forest area dynamics explain total AGB dynamics except for the first and the last years → net gain of AGB < 1 Pg (+ 1%)

AGB trend (1992-2019) per continent



- **South America**: almost 10 Pg, i.e. nearly 5% of the total AGB, lost in the 1990s
- **Africa**: loss of 3 Pg (larger changes in the 1990s and the 2010s)
- **Asia**: loss of 2 Pg, with changes throughout the three decades
- **North/Central America**, **Europe/Russia** and **Oceania**: increase by about 5 Pg but in different decades and with different rates

Conclusion and areas of future work

- First study demonstrating the information content of scatterometer data to estimate AGB
- Our results appear plausible but are not fully consistent with published values (Pan et al., 2011; Liu et al., 2015). Investigations needed to understand differences.
- How do these estimates reconcile with more recent studies on AGB changes at biome level and country level?
- The maps have their caveats, in particular in fragmented landscapes (e.g., Europe). Can we benefit from additional data sources to reduce uncertainties?