

The Role of Forests within the Global Carbon Cycle: Data, Methods and Developments

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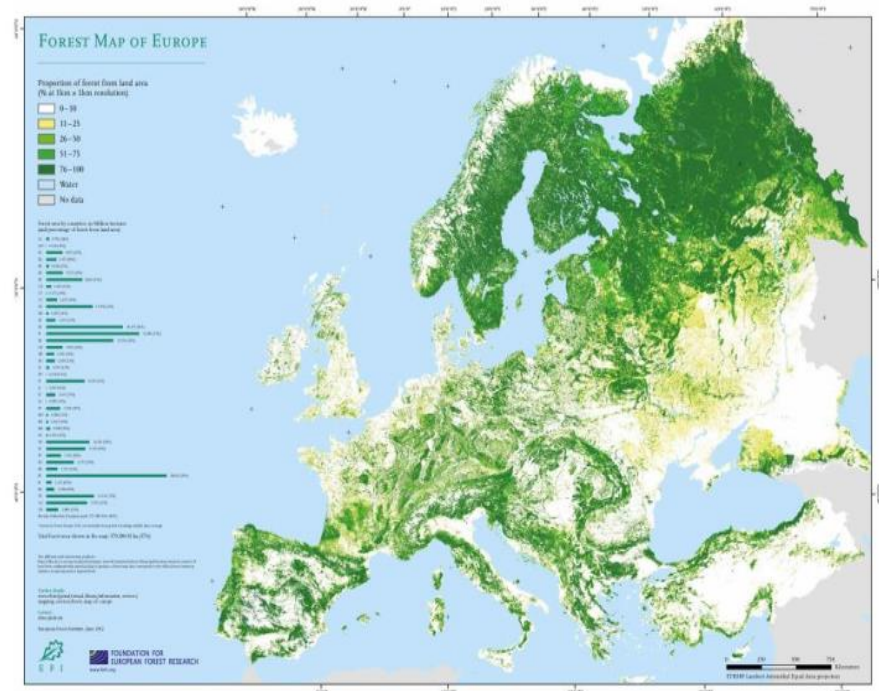
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Forests in Europe

- 38% forest cover in EU-28 (160 Mio. ha)
- 10.000 Mio. t Carbon are stored in forest biomass
- 120 Mio. t C are sequestered every year



increasing interest due to climate change, the protection of forest areas and the promotion of a bio-based "green" economy!



Climate and Forests

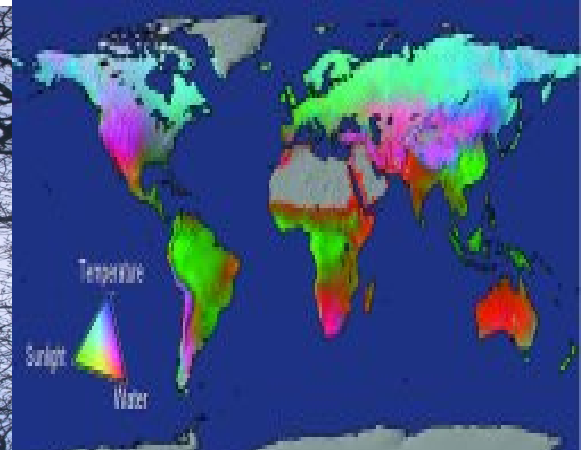
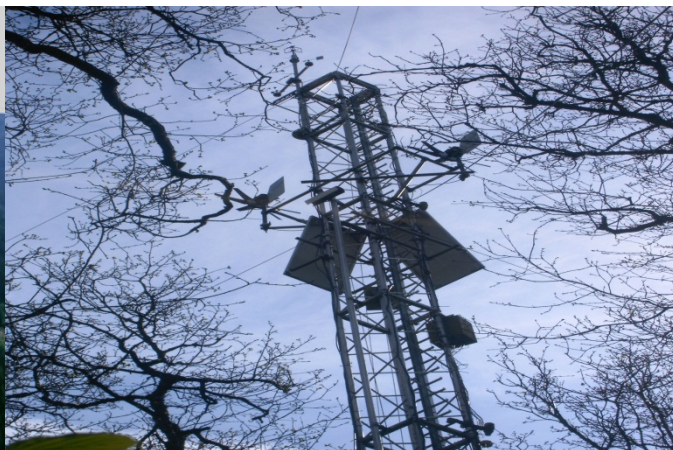


- High demand for forest ecosystem services
- Forest management versus protection
- CO₂ concentration increases
- Climate change and its unknown effects on forests
- Forests mitigate but also adapt to climatic change

The Role of Forest within the Carbon Cycle

Where do the Carbon Data come from?

- Forest inventories – measure tree volume ($V \text{ m}^3/\text{ha}$)
- Flux towers – measure flow of material
- MODIS satellite data – estimate NPP ($\text{C t}/\text{ha}$)



How do we calculate Carbon in Forests?

1. Expansion Factors or Functions

- Statistical – empirical approach
- (i) Expansion factors - convert volume into carbon
- (ii) Biomass functions - predict carbon from tree attributes (DBH and height)
- Typical procedure for forest inventory data, within tree growth models, or gap models

How do we calculate Carbon in Forests?

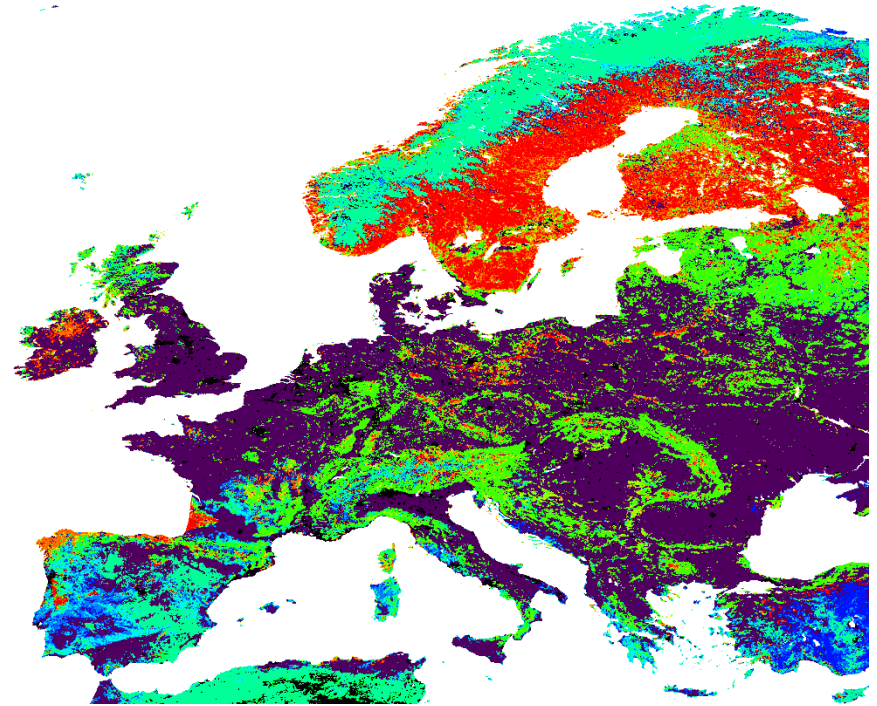
2. Explicit Carbon Cycle

- Biogeochemical-mechanistic modeling approach
- Photosynthesis routine to assess the flux dynamics (C, Water, N, and Energy Cycle) within forests
- Typical procedure in BGC-Models and MODIS
- For validation, carbon pools are converted in volume using biomass expansion factors

Assessing the forest productivity of European Forests (EU Project FORMIT)

Objectives

- Combining terrestrial forest inventory data with MODIS satellite driven estimates
- Conceptual integration of forest management

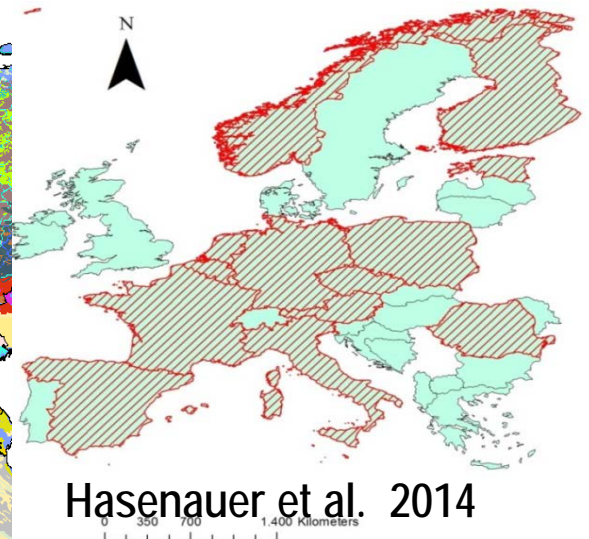
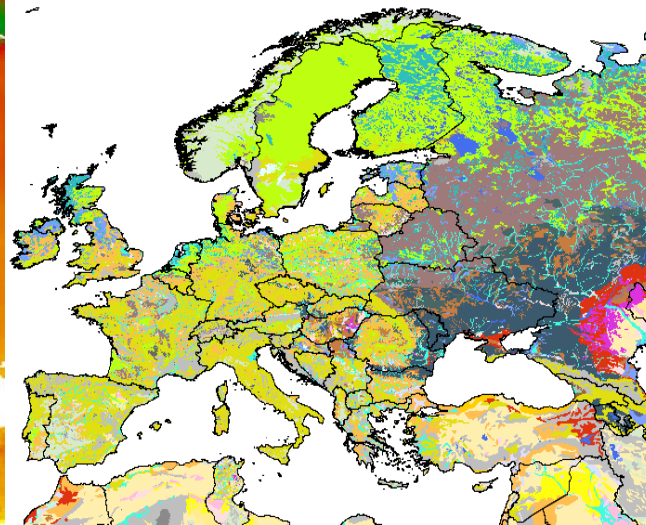
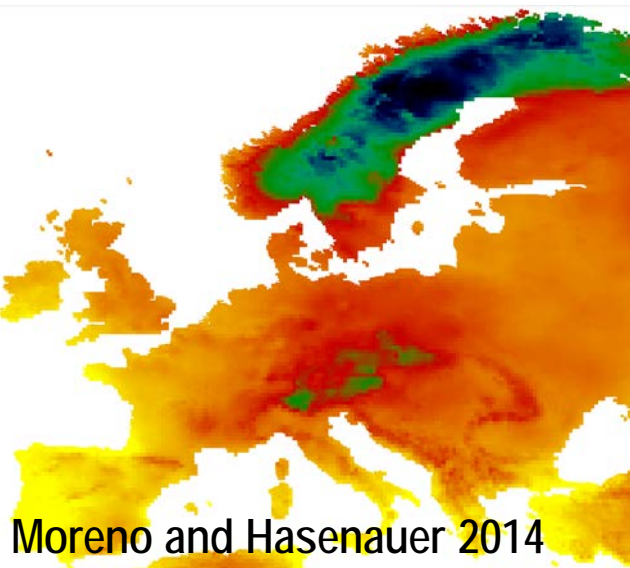


Univ.of Maryland land cover classification
MOD12 Q2 C04

Consistent Forest Productivity Information across Europe

Data and Methods

- 1 x 1 km daily weather data across Europe
- Harmonized 1 x 1 km soil data base
- Forest inventory data from 13 European countries covering > 200.000 Inventory plots



Forest and their Role within the Carbon Cycle Analysis

- Repeated tree observations of the forest inventories
 - Biomass from Expansion factors or biomass functions
 - Stand density measures to address management
- NFI NPP = carbon increment + litterfall
- Improved MOD 17 algorithm for Europe provides the satellite driven NPP data
- Mean periodical comparison of MODIS NPP with NFI NPP for the period 2000-2010

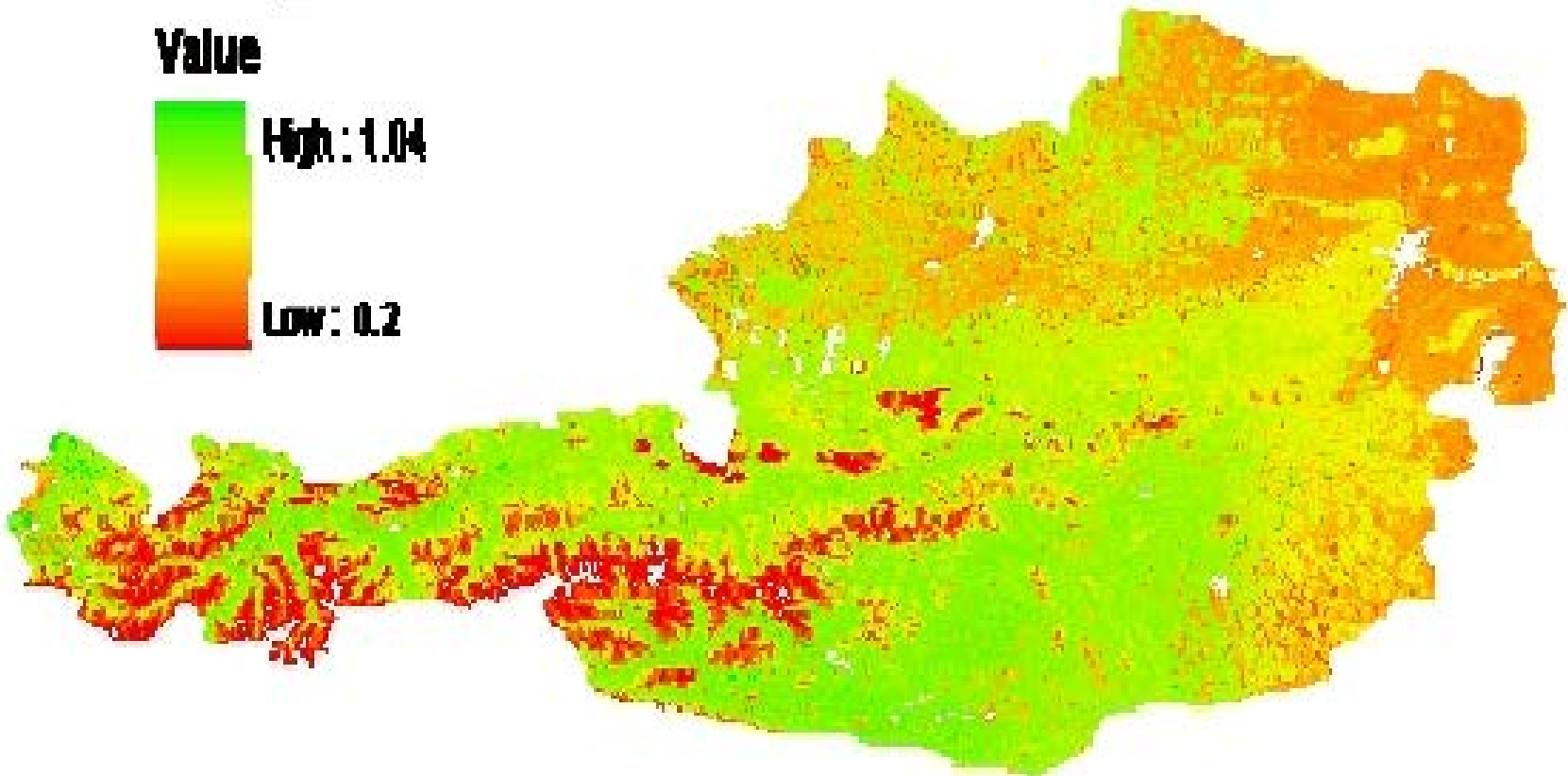
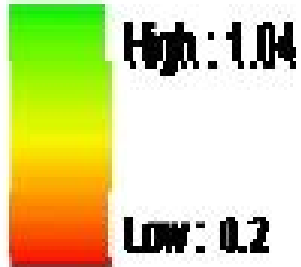
From MOD17 NPP inferable (2002-2007)

With a biomass function and tree data -
estimation of NPP

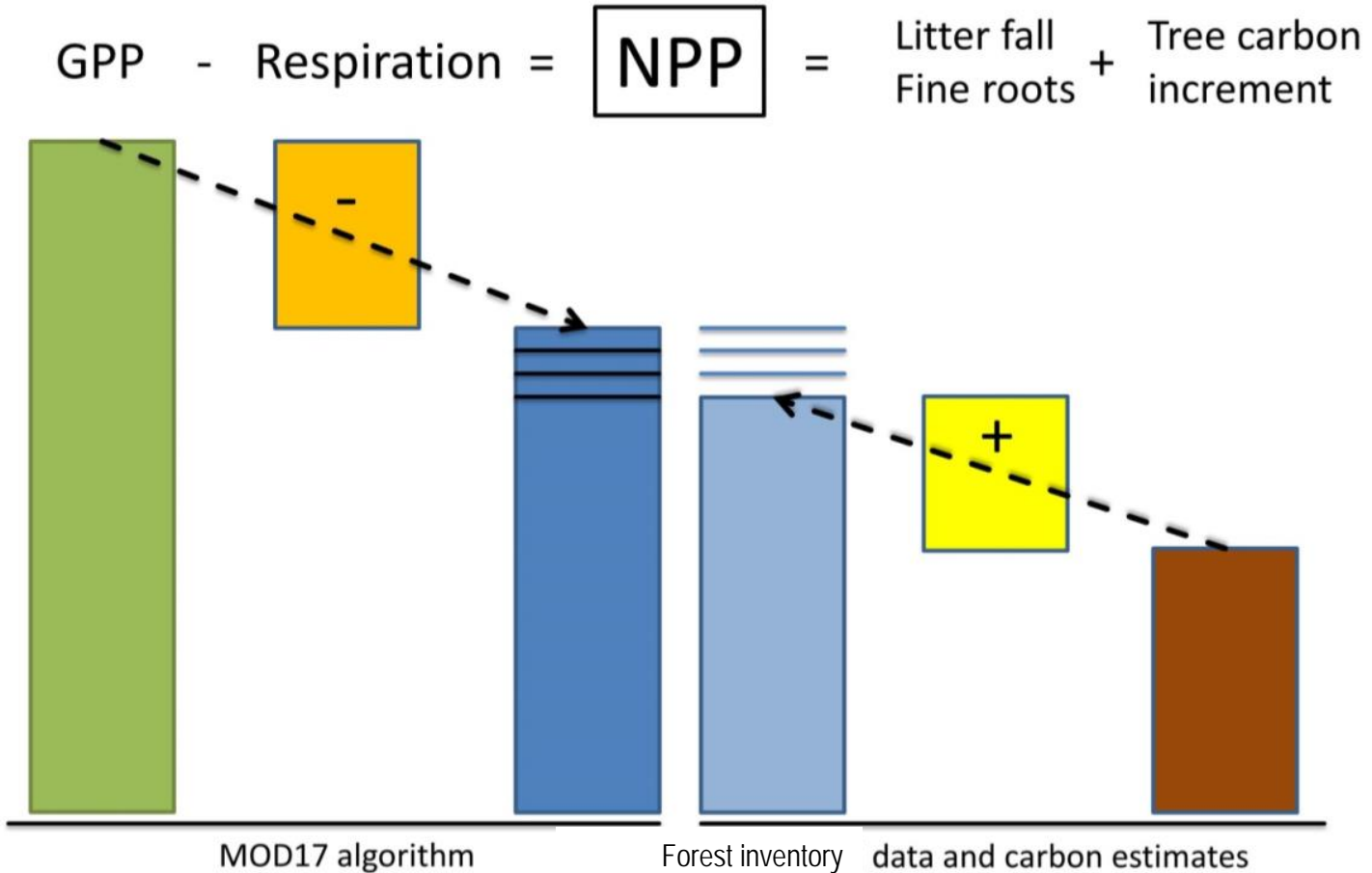
NPP kgC/m²/yr

floatto_01 dec8

Value



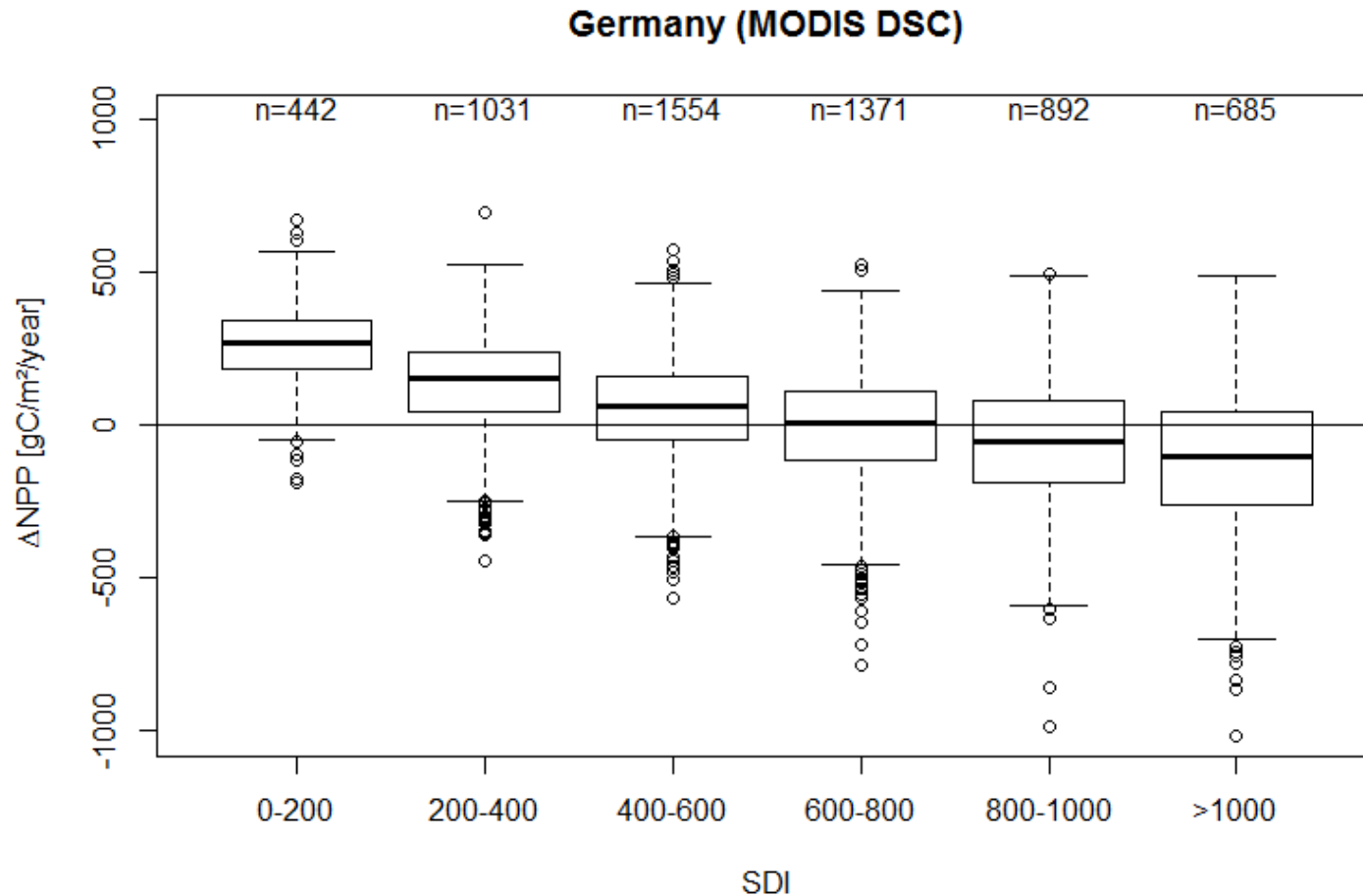
Carbon flux estimates by combining MODIS NPP & NFI data sources



Climate-sensitive light-use efficiency model using satellite data

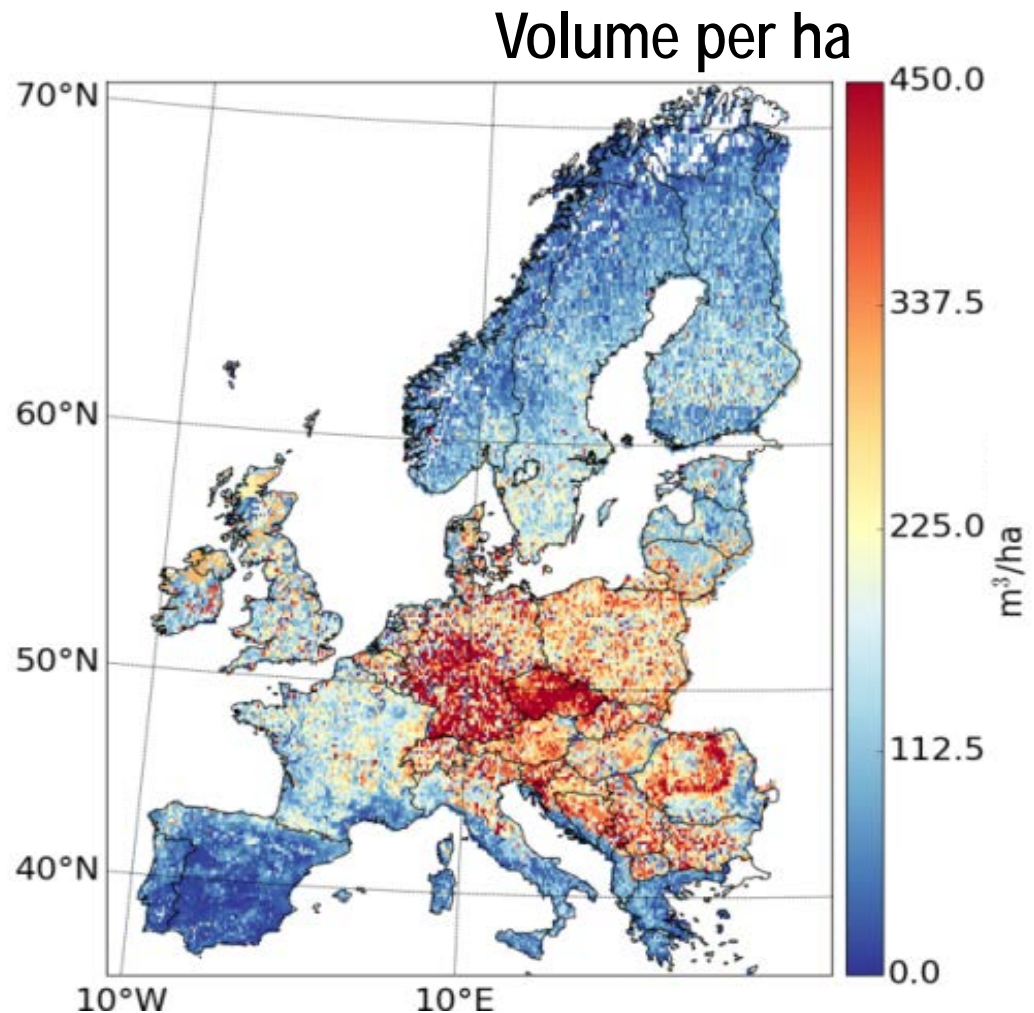
Carbon allocation using field data and biomass functions

Difference in satellite MODIS NPP and terrestrial Inventory NPP vs. Stand Density



Results - Forest Characteristics

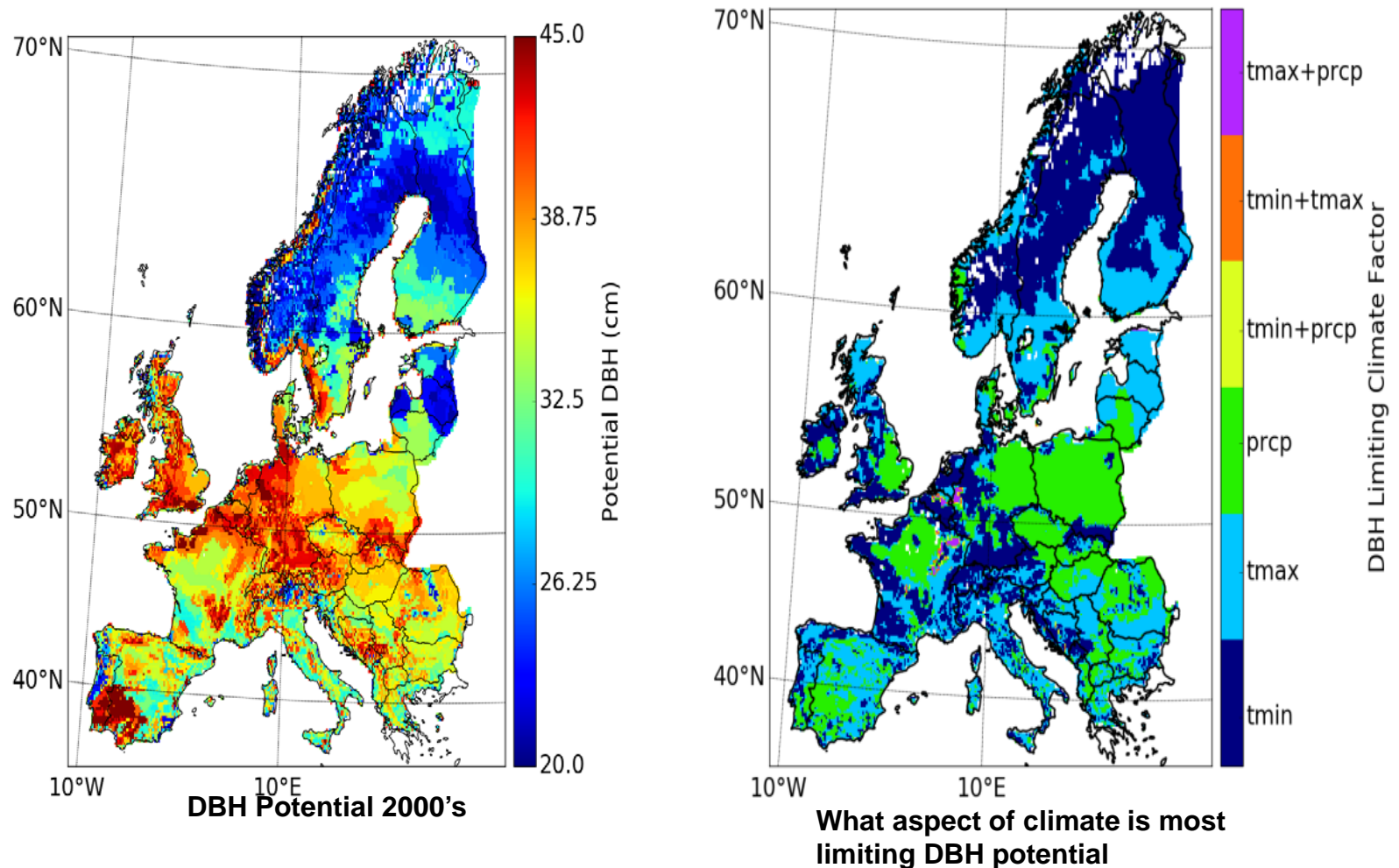
- Pan-European maps on forest carbon, volume, tree height and tree age at 0.133° resolution



Moreno, Neumann, Hasenauer 2017,
Geoscience Data Journal

Climate Limits influence the Forest Structure

Example Breast Height Diameter (DBH)



Moreno, Neumann, Hasenauer et al. 2018

The Role of Forest within the Carbon Cycle

Summary

- Forests sequester large amounts of carbon
- Exceptions are disturbances (storms, etc.)
- Forests mitigate climate effects but they are also effected by climate
- Forests are a big „energy source“
- Increase in forest area
- Increase in growing stock

Forest in Europe are sustainable



Thanks