Supporting Global Estimation of Past, Current and Future Vegetation Above Ground Biomass

Professor Richard Lucas & Frank Martin Seifert
UNFCCC requires systematic climate monitoring via Essential Climate Variables defined by GCOS.

ESA Climate Change Initiative

- research, development, qualification and delivery of pre-operational ECV products
- definition, sizing and demonstration of ECV processing systems
- transfer of ECV production to operational entities outside ESA e.g. C3S

Comprises
- 23 parallel ECV projects
- climate Modelling User Group
- Open Data Portal
- CCI Toolbox
- SLBC and RECCAP

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Biomass: An Essential Variable in the Earth Climate System

Plants act as a storage reservoir, absorb excess atmospheric CO$_2$ and deliver input to soil carbon pools.

Influenced by fire with fuel loads partly controlling emissions.

Highly sensitive to land use and management.

Vulnerable to climate change and disturbances. Controls biophysical climate effects.
Fate of Anthropogenic Emissions (2005-2015)

Sources

- $E_{FF} = 34.1 \pm 1.7 \text{ GtCO}_2 \text{ yr}^{-1}$ (91%)
- $E_{LUC} = 3.5 \pm 1.8 \text{ GtCO}_2 \text{ yr}^{-1}$ (9%)

Partitioning

- $G_{ATM} = 16.4 \pm 0.4 \text{ Gt CO}_2 \text{ yr}^{-1}$ (44%)
- $S_{OCEAN} = 9.7 \pm 1.8 \text{ Gt CO}_2 \text{ yr}^{-1}$ (26%)
- $S_{LAND} = 11.5 \pm 3.1 \text{ Gt CO}_2 \text{ yr}^{-1}$ (30%)

CO$_2$ sinks include response of land and ocean to elevated CO$_2$ & changes in climate and other environmental conditions

- $E_{FF} + E_{LUC} = G_{ATM} + S_{OCEAN} + S_{LAND}$
- $S_{LAND}$ - Not adequately measured
Relevance to Climate Science and Models

- Emerging relationships between biomass and climate allow process-oriented evaluations of Earth System Models.

- Provides information on carbon residence time and facilitates model initiation and validation.

- Increased recognition of biomass dynamics and influence of disturbance regimes on emissions.

- Direct retrieval of biomass changes constrain carbon budgets (e.g., as relevant to the Paris Agreement process).

Estimate of the mean residence time of a carbon atom in terrestrial ecosystems from its initial fixation by photosynthesis until its respiratory (including autotrophic respiration) or non-respiratory loss.

\[ \tau = \frac{C_{\text{total}}}{\text{Flux}} \]

\[ C_{\text{total}} = \text{kgC m}^{-2} \]

\[ \text{Flux} = \text{kgC m}^{-2} \text{ yr}^{-1} \]
Biomass & biomass change are key quantities in UN mechanisms for slowing down global warming:

- Robust and transparent reporting to the UNFCCC
- Reduction of Emissions from Deforestation and Degradation (REDD+)
- National Determined Commitments under the Paris agreement and its 5-year cycle of global stock-taking
Earth Observation Data for the Global AGB Algorithm

**GLOBAL CORE ALGORITHM**

- (C-band SAR)
- L-band SAR HH and HV
  - Canopy cover (optical)

- Segmentation

- Machine learning classification of EO data

- Assignment of LIDAR profiles and height to segments

- Classification of forest extent and structural type (inc. trees/shrubs; based on height and cover)

- Determination of C- and L-band transmissivity

- GSV and AGB maps

- Merging to generate AGB map

**In situ data**

- Algorithm refinement by biome, forest type and sensor(s)
- Existing databases
- Timely delivery
- Airborne and ground
- Validation and Uncertainty Assessment

**Biome and Forest Types (Specific improvements)**

- Tropical/subtropical closed forests
- Woodlands and savannas
- Boreal and temperate forests
- Mangroves
- Freshwater inundated forests
Observational motivation: 3 New Missions Devoted to Forest Structure and Biomass
CCI Biomass: User groups

Main target is climate and carbon cycle modellers.

Current use of biomass by modellers is limited by focus on carbon fluxes, not stocks, but key groups exploiting biomass in models are Edinburgh, LSCE (Paris) & Max Planck (Jena).

The REDD+ community has secondary priority for CCI Biomass. For them the value of biomass data (and for land management) crucially depends on:

- Resolution
- Accuracy
- IPCC acceptance
## CCI Biomass products

<table>
<thead>
<tr>
<th>Products</th>
<th>Maps of forest AGB</th>
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<tbody>
<tr>
<td></td>
<td>Maps of forest growing stock volume</td>
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<td></td>
<td>Maps of precision for both products</td>
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<td></td>
<td>Maps of AGB change between periods</td>
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<tr>
<td>Spatial Coverage</td>
<td>Global</td>
</tr>
<tr>
<td>Grid spacing</td>
<td>1 km x 1 km (target 100 m x 100 m)</td>
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<tr>
<td>Accuracy</td>
<td>Unbiased, accuracy better than existing maps</td>
</tr>
</tbody>
</table>
Epoch 2017, AGB (Mg/ha) @ 100m

Under Validation!
Linking with other ESA CCI Projects

- **land cover**
  - Inputs to land cover descriptions

- **sea level**
  - Sea level impacts on mangrove biomass

- **snow cover**
  - Impact on biomass retrieval algorithms

- **fire**
  - Fire impacts on biomass

- **soil moisture**

- **ghg**
  - Contributions to GHG emissions
CCI Biomass - Conclusions

Biomass is an Essential Climate Variable
- Considerable uncertainty at the global level
- Temporal retrieval from EO data for quantifying biomass change is problematic

CCI Biomass focuses on the above ground biomass of woody vegetation
- Using combinations of radar, optical and lidar data for retrieval.
- Refining/modify the GlobBiomass algorithm but considering other options.
- Considering influences of other environmental variables on EO data (e.g., soil moisture, water inundation)
- AGB and AGB change estimates: establishing links with other ECVs (e.g., fire, snow, soil moisture, sea level rise).

Uncertainty assessment
- Requires in situ data that are high quality (for algorithm development and validation) but also representing a wide range of environments.
- Introducing capacity to support enhancement of existing repositories and timely collection of ground data.

Links with climate science
- Benchmarking land-surface models
- Understanding carbon processes (e.g., allocation)
- Constraining regional C-budgets
- Quantifying emissions and sinks associated with the land use change and forestry sectors.

For further information visit:
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