ESA CCI+ Phase 2 – Land

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Colocation Meeting - 26 October 2022
**Science Objectives**

**Measuring forest biomass and its changes**
- exploiting in carbon and climate models
- supporting national reporting to UNFCCC

**Production of AGB products with associated standard error:**
- With development of algorithms for change products between these epochs together with uncertainty.

AGB at 100m resolution for 2018

**CEOS-led harmonisation of multiple AGB maps**
- Open science activity on ESA/NASA Multi-mission Algorithm Analysis Platform
- Prototype presented at COP26

**User exploitation in carbon modelling**
- comparison of carbon emissions and subsequent sink due to fire in the boreal region from 1985-2020 (CCI left, Saatchi AGB middle, GFED right)

post fire sink

emissions due to fire
Land Cover

• CCI+ aims to
  – Develop a brand new PFTs time series for climate models matching new GCOS requirements
  – Integrate all existing high resolution global LC data harmonized thanks to MRLC time series
  – Enhance the awareness of MRLC users community

• Key Outcomes
  – New 29-year time series of annual Plant Functional Type (PFT) fraction maps (pixel quantification at 10-30 m describing each 300m cell) and model impact assessment
  – End-to-end uncertainty budget at pixel level (from L0 data to land class level) using S3 time series
  – Assessment of LC impact on LST in the context of urban area heat island mapping using VHR LC

 ➤ Roadmap towards harmonization of land ECVs
HR Land Cover

Main Science questions
• Understand the role of land cover spatial resolution in climate modeling and research.
• Studying LCC in key regions exposed to extreme climate conditions or characterized by significant climate changes over the last decades.
• Understanding classification variability across spatio-temporal scales.

Products:
• Generate reliable regional products at high spatial resolution.
• A static HRLC map at 10m for 2019 at subcontinental level as reference static input to the climate models.
• A time series of regional HRLC maps at 30m in the sub-regions every 5 years (2019 and 1990).
• The change information at 30 m on a yearly scale.

Use cases:
• Siberia: Impacts of CC on northern displacement of the forest-shrubs-grasslands-transition zone, fate of permafrost carbon.
• Amazon: Impacts of deforestation, fires, agricultural expansion on water and carbon cycles changes.
• Africa: Impacts of CC on drought/flood events, West Africa and Indian Monsoon dynamics, mitigation studies (e.g., Green Belt).

R&D topics:
• Design machine learning methods dealing with both nowadays large data volumes and sparse historical data.
• Guarantee temporal, seasonality and change coherence in time.
• Establish validation and intercomparison paradigms for HRLC.
• Update climate models to absorb HR products.
CCI+ aims to understand better fire trends and impacts by comparing coarse (MODIS - S3) and fine (S2) resolution burned area products. In addition, global BA algorithms are adapted to S3 SYN data and active forest from VIIRS and S3. Historical BA will be retrieved from Landsat-S2 data in three sites (coincident with HRLC CCI). Relations with land cover change (particularly deforestation and degradation). Merging of existing global BA products will be carried out to obtain a user-oriented single BA dataset. 

80% more BA than FireCCI51 (based on MODIS 250 m) 
120% more BA than NASA MCD64A1 (based on MODIS 500 m) 

<table>
<thead>
<tr>
<th>Product</th>
<th>OE [%]</th>
<th>CE [%]</th>
<th>DC [%]</th>
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<tbody>
<tr>
<td>FireCCISFD20</td>
<td>8.5</td>
<td>15.0</td>
<td>87.7</td>
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<tr>
<td>MCD64C6</td>
<td>56.5</td>
<td>21.1</td>
<td>56.0</td>
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<tr>
<td>FireCCI51</td>
<td>52.2</td>
<td>25.1</td>
<td>58.4</td>
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</tbody>
</table>

Significantly better accuracy than existing global BA products

First Burned area product from S-3 SYN data and VIIRS active fires (2019): Lizundia-Loiola et al., 2022, RSE
**Vegetation**

**Goal:** Long term, multi sensor product of FAPAR (-> plant productivity) and LAI (-> foliage density)

**Application:** for climate reanalysis, phenology, improving LSMs, study of extremes

**When:** March 2022 - Febr 2025

**Key questions**
- Less sensor dependence -> consistency
- More direct link with photosynthesis
- Temporal resolution good enough to detect anomalies, seasonal phenology?

**Cycle 1 (2022-2023)**
- Full 4-strm RT inversion versus albedo-TIP?
- Uncertainty budget from TOA -> product (error matrices)
- Inclusion of soil, snow residual cloud in inversion

**Cycles 2 & 3 (2023-2025):**
- Progressive increase in # sensors
- science application:
  - phenology
  - test use in land surface models
  - synergy with SIF and stress indicators (formaldehyde), ...

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<table>
<thead>
<tr>
<th>Name</th>
<th>Cycle</th>
<th>Resolution</th>
<th>Sensors</th>
<th>ROI</th>
<th>Period</th>
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<tbody>
<tr>
<td>TDS-1</td>
<td>1-3/23</td>
<td>1000 m</td>
<td>SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI</td>
<td>Selected sites</td>
<td>2019</td>
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<tr>
<td>CRDP-1</td>
<td>1 2/23</td>
<td>1000 m</td>
<td>SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI</td>
<td>Selected sites + transect</td>
<td>2000-2020</td>
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<td>CRDP-2</td>
<td>2 3/24</td>
<td>1000 m</td>
<td>SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI, Metop-A/B/C-AVHRR, VIIRS</td>
<td>Selected sites + transect</td>
<td>2007-2020</td>
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<tr>
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<td>2 3/34</td>
<td>300 m</td>
<td>(1) Terra/Aqua-MODIS, Envisat-MERIS (2) Terra/Aqua-MODIS, PROBA-V, Sentinel-3 OLCI</td>
<td>Selected sites + transect</td>
<td>1 year</td>
</tr>
<tr>
<td>CRDP-3</td>
<td>3 3/25</td>
<td>1000 m</td>
<td>Selected from: SPOT4/5-VGT1/2, PROBA-V, Sentinel-3 OLCI, Metop-A/B/C-AVHRR, VIIRS</td>
<td>Global (*)</td>
<td>2000-2020</td>
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<td>CRDP-4</td>
<td>3 3/25</td>
<td>300 m</td>
<td>Selected sensors from: Terra/Aqua-MODIS, Envisat-MERIS, PROBA-V, Sentinel-3 OLCI</td>
<td>Global (*)</td>
<td>2000-2020</td>
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**Potential lines (Cycles 2-3)**
Green FAPAR?
Pigments?
TROPOSIF?
At CCI+ Phase 2, we aim to respond to the needs of the climate modelling community, by: 1) providing fully model independent and gap-free data 2) improving the uncertainty estimate on SM 3) verifying the long-term trends of our products.

R&D topics in CCI+ Phase 2
- Seasonal adaptation of Triple Collocation theory (error characterisation)
- Algorithmic uncertainty characterisation
- Filtering of brightness temperature outliers in input data
- Model independency. Merging of (L-band) brightness temperature datasets in one rescaling reference
- Trends in products and agreement with reanalysis

Upcoming CCI+ Phase 2 products:
- Continued: ACTIVE, COMBINED (break-adjusted), PASSIVE (v08.1, April 2023; v09.1, April 2024)
- New: Gap-filled COMBINED (v08.1, April 2023)
- New: L-band rescaled COMBINED (v08.1, April 2023)
- New: Fully model-independent COMBINED (v09.1, April 2024)
- New: 0.1° resolution PASSIVE, ACTIVE (v09.1, April 2024)

Use Cases
- SM uncertainty from CCI SM will be used in SM assimilation in Land Surface Models
- An across scales study will be performed to assess the ability of data sets with different spatial resolutions (CCI SM 0.25°, 0.1° interpolated products, high resolutions 1 km products) to detect extreme events possibly related to climate impacts.
Main science aims in CCI+ Phase 2
- Meeting the new ECV GCOS requirements in the 2022 IP
- Improving the long-term stability of our products, particularly for our multi-sensor CDRs
- Increase interaction on cross-ECV activities, and with climate services

Upcoming CCI+ Phase 2 products:
- Extensions of existing products to end 2023 (ATSRs, SLSTRs, MODIS, SEVIRI, GOES, SSM/S & SSMIS
- Long-term time series from AVHRRs from the 1980s to present
- Global LST CDR from ATSR through to SLSTR with length of 28 years
- Time series from AMSR-E and AMSR-2 with length of over 21 years
- New products for Himawari and VIIRS

R&D topics in CCI+ Phase 2
- Intercalibration of level-1 data for CDRs
- Time difference corrections for multi-mission CDRs
- Consistency across all LST ECV Products for retrievals, uncertainties, and coefficient generation
- Developing first climate quality LST at high spatial resolution (<100m)
- Optimisation of best cloud clearing detection across new sensors
- Development of first climate IST product over sea-ice

Use Cases
- Investigate the feasibility of a satellite moderate temperature extremes data set to supplement the HadEX3 dataset
- Impact of ESA LST_cci IST products on the Arctic Copernicus Marine Service (CMEMS) SST/IST product
- Investigating the diurnal heating and cooling of cities, using LST data retrieved from high resolution IR sensors
- Comparison between LST and reanalysis ‘skin’ temperature time series

Figure: LST_cci anomalies for Aqua-MODIS compared with homogenised near-surface air temperature anomalies
Main Science questions in phase-2
Improve ECV uncertainty assessments vs new GCOS requirements
Enhance interaction with climate research / limnology / cross-ECV activities
Assess potential for Coloured Dissolved Organic Matter, Lake Volume Change, light extinction

R&D topics
Application of new methodologies for Ice Thickness and Water Level
Sentinel Lakes of Sub-Saharan African
Computing efficiency of Lake Colour processing (sustainability)

Product updates:
Expand the time series, keeping the same lakes
Condense Lake Colour variables for time series consistency
Introduce Lake Ice Thickness for a subset of lakes
Improve data access for single lakes/regions
Additional quality/confidence flags

Use cases
1) Heatwave and storm event impact on lakes
2) Water quantity in relation to water quality in a changing environment
3) Aggregate climate indicators for the global lakes dataset (link to policy)