Product Specification and Algorithm Theoretical Base Document Wood provision service account

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Submitted by

vito remote sensing	bc3	Ecounting	University of Patras

In collaboration with

Statistisk sentralbyrå Statistics Norway	cbs	ile Institute of Landscape Ecology Slovak Academy of Sciences	University of Patras	Istat Istituto Nazionale di Statistica; ISPRA
Norway	*Netherlands*	*Slovakia*	*Greece*	*Italy*

DOCUMENT RELEASE SHEET

Role	Name
Book Captain	Dr. Marcel Buchhorn (VITO)
Approval (consortium)	Bruno Smets (VITO)
Approval (ESA)	Marc Paganini (ESA)
Contributing Authors	Bruno Smets (VITO)
Distribution	Giuseppe Ottavianelli (ESA)
	Early Adopters
	Project Team

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1. Introduction

1.1 Report objectives and approach

The objective of this report is to detail the technical requirements of the selected accounting pilot demonstrators for the PEOPLE-EA project, and hence covers the results of tasks in WP2.1 and WP2.2.

The report first describes the technical specification of the platform, whereafter for each demonstrator account is described:

- the technical specification (e.g., selection of condition indicators and reference levels)
- an overview of potential algorithms to be evaluated during an agile iterative co-design round-robin benchmarking
- test areas and input datasets necessary to perform the round-robin benchmarking
- results of the benchmarking, and justification of the selected algorithm

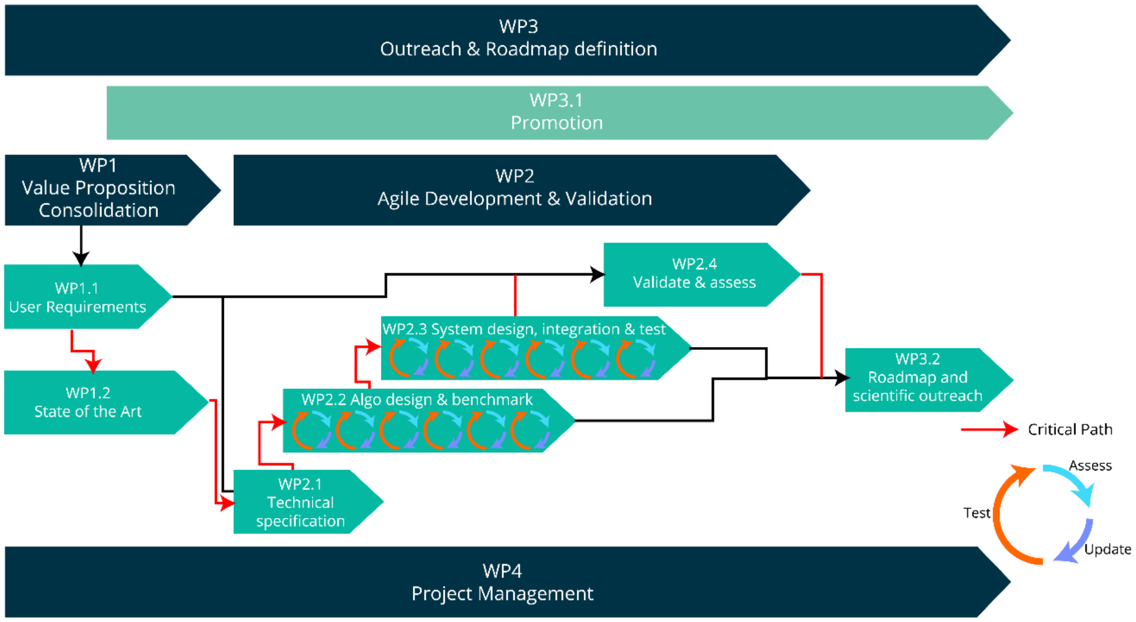

Figure 1: Overview of WP2 agile iterative co-design development cycle

1.2 Scope of work

Table 1 shows the selected pilot demonstrators, and the Early Adopters (countries) where a test-site will be selected to perform the round-robin benchmarking as a co-design activity.

Table 1: Overview of ecosystem account pilot demonstrators

Account	Country	Details / Indicator	Year	Round-robin
Service – Wood provision	Greece		2018 - 2022	
	Italy		2019 - 2021	
	Norway		2021	
	Slovakia		2015-2022	X

Note that the workflow developed is still experimental and not operational, since it is considered to have reach TRL[1] Level-3. This level declares the technology is an experimental proof of concept (in this context the demonstrations) and requires further R&D work as well as being made compliant to the European Statistics Code of Practice (CoP) before being used for official statistical reporting.

1.3 About ecosystem service accounts

Within the UN System of Environmental Economic Accounting (UN-SEEA), **ecosystem services** flow **accounts** record the supply of ecosystem services by ecosystem assets and the use of those services by economic units, including households. They can be expressed in physical or monetary terms. Monetary service accounts are however out of the scope of the project.

[1] TRL defines the Technology Readiness Level ranging from 1 (basic principles observed) up to 9 (actual system proven in operational environment).

2. Wood provision service account

2.1 The accounts and definition

The SEEA EA includes accounting for the wood provision service. In SEEA EA, provisioning services are recorded in both cultivated and uncultivated contexts (SEEA EA A1.28).

The accounts generated in the PEOPLE-EA project will be compliant with the EUROSTAT guidance note for the wood provision ecosystem service (ENV_EA_TF, 2024). There it is stated:
"Wood provision is defined as '*the ecosystem contributions to the growth of trees and other woody biomass'* (proposed amendment of Regulation (EU) 691/2011). The proposed legal text furthermore specified that it *'shall be reported as net increment as defined in Annex VII [i.e., the proposed Forest accounts legal module] in thousand m^3 overbark'.* The proposed Forest accounts legal module defines net increment as follows: *'Net annual increment of timber is defined as the average annual volume growth of live trees, calculated from the stock of live trees (growing stock) available at the start of the year less the average annual mortality.' "*

Further it is stated that the net increment in cultivated forests for wood (approximated as FAWS – Forest Available for Wood supply) is an economic product of the forestry industry (NACE A02.1). It is this product that ecosystems contribute to, hence the proposed legal module uses the net annual increment as the best indicator of service flow.

Therefore, the wood provision (WP) account generated in context of the PEOPLE-EA project will be reported as net annual increment (NAI) measured as volume timber given in cubic meter overbark per year.

2.2 Current INCA methodology

For the wood provision ecosystem service, INCA calculates the actual flow per reporting region. The flow in physical units is based on the net annual increment of timber in forests available for wood supply, and removals from forests not available for wood supply. The standard source of this input data is the Eurostat dataset 'Volume of timber overbark (source: EFA questionnaire)'.

The wood provision service is defined as the ecological contribution to the production of timber that can be harvested and used as a raw material. In terms of the ecological process, we need to refer to natural growth of a biotic resource; this in turn implies that the service flow for accounting purposes is the net annual increment (NAI) of standing timber in forests that is available for wood supply.
The method for wood provision accounting follows the EU INCA account model, as shown in Figure 2. More details can be found in Vallecillo et al. [2019] and LaNotte et al.[2021].

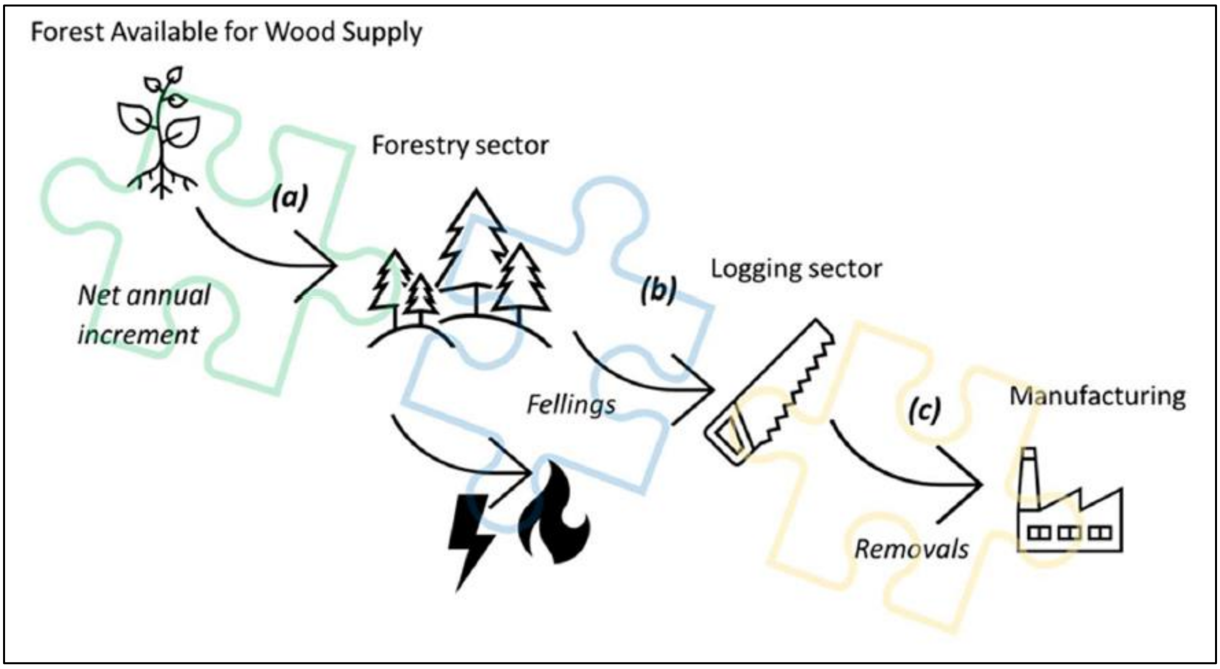

Figure 2: Service flows along the chain of timber management, extraction and transformation (from [LaNotte et al., 2021])

The INCA tool calculates the actual flow per member state based on the tabular inputs. To generate maps, the total flow per member state is then spatially distributed based on the ecosystem extent map, a spatial proxy and the proxy weight as follows:

- Multiply spatial proxy and proxy weight maps to obtain the relative contribution from each pixel.
- Using the ecosystem type map, set contributions from pixels outside of 'Forest and woodland' ecosystems to 0.
- Per reporting area, transform the relative contributions into weights, by dividing the contribution from each pixel by the sum of the relative contributions from all pixels in the same member state.
- Multiply the weight for each pixel by the total actual flow of the region.

The INCA methodology therefore:

- Is currently based solely on existing statistics and on the national LULUCF reporting.
- Is a top-down approach.
- Uses Earth Observation (EO) data (detailed in the Copernicus DMP) only as a proxy to spatially redistribute the forest net annual increment at NUTS-0 level. Therefore, the geospatial error of the generated map can be quite high depending on forest type, management practices, and growth area.
- a geo-location of the statistics at low resolution (NUTS-0 level) coming from the national LULUCF statistics; and
- EO datasets are not directly used for the account generation.

2.3 Possibilities to utilize EO data in WP accounting

Compared to the currently implemented top-down approach, WP accounts based on EO data will use a bottom-up-approach, which gives detailed spatial information.
To be compliant with the EU Guidance Note definition, several bottlenecks in a bottom-up calculation must be resolved:

- Where are managed forest areas (areas for Forest Available for Wood Supply (FAWS) – cultivated areas) and restricted areas (Forest Not Available for Wood Supply (FNAWS) – non-cultivated forests) versus OWL-AWS (Other Wooded Land Available for Wood Supply) and OWL-NAWS (Other Wooded Land Not Available for Wood Supply) areas located?
- For measuring/estimating of net annual increment (NAI) of timber in thousand m^3 overbark via EO:
    - Can we measure it directly or do we have only proxies available as EO data products?
    - Is the uncertainty of EO datasets known, and is the magnitude problematic?
    - Vertical structure description via EO needs the combination of several RS sources (e.g., radar and optical).
- The reporting unit for the wood provisioning service is defined as the NAI of timber and measured as the “stock of live trees (growing stock) available at the start of the year LESS the average annual mortality”. However, EO measures variables at a certain point of time or over a certain time period, thus forest disturbances and removals are directly incorporated into the measurements after their appearance. How to retrieve therefore a consistent EO based map showing only the results for areas with natural mortality?
- How should timber from non-wood forest (OWL-AWS & OWL-NAWS, which is mainly Heathland & Shrub, Settlement & other artificial areas as well as cropland) be measured? By GN definition, timber volume of these areas is only incorporated into the calculation when it is harvested, and so NAI is not used in the statistics.
- Detection of Harvest areas (production areas) can be done via change detection, but not all types of Harvest areas will be detected correctly, e.g. to detect selective logging practices is still challenging. This can lead to the underestimation of harvest areas, and therefore harvest-associated removals, and in the overestimation of the living tree area.

How to overcome such bottlenecks:

- Usage of existing and validated EO data products to get the location of live trees at the beginning of the year over all ecosystem types (ET) (Copernicus HRL layers, tree detection algorithms, high resolution landcover maps like WorldCover).
- Usage of EO data products / models to detect tree loss in the year for each mortality type
    - e.g. Hansen forest loss gives an indication of where total tree loss per pixel occurred,
    - change map of Copernicus HRL layers plus identification of which tree areas were removed through harvest etc.
- Datasets like Gross Dry Matter Productivity (GDMP), Dry Matter Productivity (DMP) or Net Primary Productivity (NPP) are a good proxy for wood production, but a reliable conversion to volume timber overbark is needed.
- Usage of EO products estimating the standing biomass (e.g. ESA CCI biomass, ESA forest carbon monitoring) could be used to directly estimate the NAI, but the issue would remain that harvested trees are also removed in these products, and the measures of uncertainty in the change product between two years must be reliable.

2.4 Proposed improved method utilizing EO data/products

Experimental approach to generate Wood Provisioning accounts

Note! These products are prototype outputs only, not to be used for any official or operational monitoring or reporting.

The products are provided publicly for research and evaluation purposes.

2.4.1 Objective for generating WP service accounts in context of the PEOPLE-EA project

Since PEOPLE-EA is an exploratory project, we want to test the extent to which WP service accounts can be generated by using EO data/products. Therefore, we focus on the following points:

- Generation of a spatial map of the living trees at end of the accounting year following the GN definition (stock of live trees available at the start of the year less the average annual mortality) at a spatial resolution of 20m;
- Generation of a spatial map of forest available for wood supply (FAWS) to identify the merchantable forest areas;
- Estimation of the NAI in m^3 timber overbark for the FAWS of the living tree maps;
- The test account will be generated as annual account for the year 2021.

2.4.2 Generation of living tree map for the end of the accounting period

Since EO datasets are measurements at a certain point in time, EO products (e.g. standing volume, AGB, tree cover fraction, land cover maps) are mainly generated for the end of a temporal aggregation period (e.g. 10-daily, monthly, annual) or represent the average of a longer time period (e.g. annual land cover maps). This combination of several EO datasets timesteps into an aggregation always means that all direct changes on the ground are incorporated.
This characteristic produces some challenges in the generation of a living tree map following the GN definition: "stock of live trees (growing stock) available at the start of the year LESS the average annual mortality". The main challenge is to identify tree areas of loss over the year and attribute them as natural or non-natural (e.g. harvest, fire, other disturbances). All non-natural loss areas are marked so that in the NAI calculation it can be accounted for.

As a starting point we used the High Resolution Layers (HRL) of the Copernicus service since these products are well documented and validated (https://land.copernicus.eu/en). In detail we used the Copernicus High Resolution Layer Tree Cover Density (TCD) product for the year 2018 as a starting point for the WP 2021 account (Copernicus, 2020). Please note: the Copernicus HRL TCD dataset for the year 2021 is not available and planned to be rolled out by end of the year 2024. The Global Forest Change dataset (Hansen et al., 2013), in detail the tree loss of the years 2018, 2019 and 2020, was used to mask out areas of tree loss between 2018 and end of 2020. Next, we applied the FAO definition of forest and removed areas with a tree cover density under 10% and minimum area of 0.5 ha (FAO, 2020). Output is a map at 20m spatial resolution showing the stock of live trees available at the start of the accounting period 2021. Please note: the forest gains between 2018 and 2021 are not incorporated since no current dataset is available to identify them.

Next, the Global Forest Change tree loss product for the year 2021 (Hansen et al., 2013) showing areas of full loss and national tree loss datasets (e.g. harvest maps of the year 2021, disturbance maps for the year 2021, fire maps, …) were combined into a forest loss mask (full loss and partial pixel loss) for the year 2021.

This mask was then split into natural and non-natural disturbance by usage of a global annual fire map (Tyukavina et al., 2022), national fire maps, national harvest maps, and national disturbance maps filtered to non-natural mortality causes. Output are two masks: tree loss by natural causes for the year 2021 and tree loss by non-natural causes for the year 2021. Applying the mask of tree loss by natural causes for the year 2021 on the map of the stock of live trees at the start of the accounting period 2021 generates the map of the stock of the living trees for the end of the accounting period 2021.

2.4.3 Generation of FAWS map

The definition of FAWS is quite different in the EU countries, but there are several attempts to generate a harmonized definition and maps for Europe (Alberdi et al., 2016; Alberdi et al., 2020). Unfortunately, these generated maps are only available in a coarse resolution or as aggregates by NUTS regions for statistical purposes. Therefore, we used the spatial FAWS map for the year 2020 produced by the JRC (Avitabile, Valerio, 2022). This map at a spatial resolution of 100m shows the forest areas which can be used for wood supply by taking into account altitude, slope, distance to roads, protected areas, and unproductive forests restrictions. We assume that the areas for the year 2020 are still valid for the year 2021.

Please note that the JRC FAWS map covers only the EU-27 region currently. For the account generation of Norway, the national approach was used by masking out all forest regions with a bonitet smaller than 6 (see Figure 3).

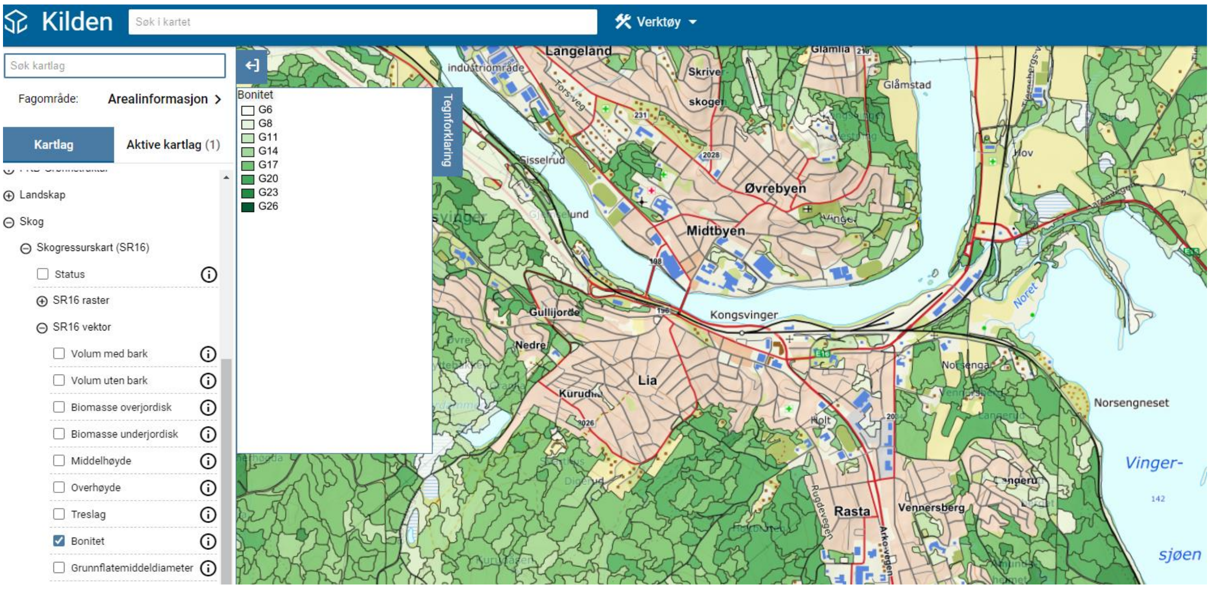

Figure 3: Screenshot of the Norway portal from which the bonitet was extracted to generate the Norway FAWS map. https://kilden.nibio.no/?topic=arealinformasjon&zoom=9&x=6675415.73&y=334810.97&bgLayer=farger&layers=skogressurs_srvbonitet&layers_opacity=0.75&layers_visibility=true

2.4.4 Estimation of NAI for FAWS areas

Since a direct EO data product measuring the NAI is not available, we tried several methods to derive an estimate of the annual NAI from other EO products:

- Usage of the annual change in biomass data products e.g., ESA CCI biomass, ESA forest carbon monitoring,
- Development of a tree increment model based on Gross Dry Matter Productivity (GDMP) data.

Following a detailed plausibility check (see Smets et al., 2024, section 2.4) of existing EO based biomass data products, we decided to develop a prototype model to convert annual Gross Dry Matter Productivity GDMP extracted from EO data products to tree net annual increment (NAI).

The exploratory model consists of the following steps:

- Generation of annual Gross Dry Matter Productivity (GDMP) product for living tree areas.
- Conversion to annual Dry Matter Productivity (DMP) product.
- Split of calculation in hardwood, softwood and mixed wood areas.
- Calculation of the total green biomass increment (TGBI).
- Calculation of Net Annual Increment (NAI).
- Adjustment for areas with less than 100% tree cover fraction.

Generation of annual GDMP product for living tree area

The main input dataset of the model is the Copernicus Gross Dry Matter Productivity (GDMP) product. 10-days estimates are available in near real time at global scale in the spatial resolution of about 300 m from January 2014 to June 2020 based upon PROBA-V data with version 1.0 and from July 2020 onwards based on Sentinel-3/OLCI data with version 1.1.

The GDMP is calculated by usage of a Light Use Efficiency model by Monteith (1972) driven by meteorology data (radiation and temperature), land cover information, FAPAR and a number of other factors.

A more detailed explanation of the algorithm can be found here: https://land.copernicus.eu/en/technical-library/algorithm-theoretical-basis-document-dry-and-gross-dry-matter-productivity-version-1/@@download/file ; https://land.copernicus.eu/en/technical-library/algorithm-theoretical-basis-document-dmp-gdmp-npp-gpp-version-1/@@download/file

A detailed validation of the Copernicus GDMP dataset can be found here: https://land.copernicus.eu/en/technical-library/quality-assessment-report-dry-and-gross-dry-matter-productivity-version-1-1/@@download/file ; https://land.copernicus.eu/en/technical-library/quality-assessment-report-dry-and-gross-dry-matter-productivity-version-1-1/@@download/file

The Copernicus GDMP is delivered as 10-daily raster datasets in the unit of kg DM/ha/day. Therefore, in a first processing step each GDMP raster dataset is multiplied with the number of days based on the time difference between the start and end day of each 10-day interval. In a second step, all 36 raster datasets representing a year are summed up and divided by 1000 to get the unit of “tons of dry matter (DM) per ha per year”. Since the original dataset comes in a spatial resolution of 300m, the dataset is resampled to a spatial resolution of 20m using a bilinear filter. A last pre-processing step is the conversion from a relative to an absolute unit by dividing the GDMP by 25 to come to the working unit of “tons DM per year per pixel”.

Since the GDMP is modelled in 10-day intervals and therefore incorporate changes on the ground (e.g., fire, harvest, storm events) in real-time, the GDMP for the living tree area has to be modelled by combining the annual GDMP of the current year with extrapolations of the GDMP of the previous year. Overall, the following cases have to be taken into account:

- Non-disturbed pixels in current year: direct usage of annual GDMP of current year.
- Partially or full disturbed pixels: the annual GDMP of the previous years is extrapolated to the current year by multiplying it with the regional correction factor.

Full disturbed pixels are retrieved from the mask of tree loss by non-natural causes generated in chapter 2.4.2. Partially disturbed pixels due to selective logging or partial burns are currently not considered in the exploratory method. The GDMP regional correction factor to extrapolate the GDMP of the previous year to the current year is generated via a window approach. Therefore, for each raster window (spatial area) the median of the annual GDMP of the current year is divided by the median of the annual GDMP of the previous year.

The final product is a GDMP raster dataset masked to all living tree areas for the annual accounting period in the absolute unit "tons DM per year per pixel".

Conversion to annual Dry Matter Productivity (DMP) product

The Dry Matter Productivity (DMP) and Gross Dry Matter Productivity (GDMP) are two components expressing components of Primary Production of ecosystems related to the creation of new organic matter by vegetation. GDMP is the total amount of dry matter "fixed" by land plants per unit time through photosynthesis (atmospheric CO2 into organic compounds). A substantial fraction of GDMP supports plant autotrophic respiration, with the remainder allocated to the Dry Matter Productivity (DMP) of plant structural biomass in stems, leaves, and fruit (Gough, et al., 2011; GDMP ATBD, 2020). The standard conversion of GDMP to DMP in the Copernicus services is the usage of a fixed conversion factor of 0.5 for all ecosystem types (GDMP ATBD, 2020). Since the conversion factor in forest ecosystems highly depends on tree species, age class and underlying restriction or management practices, the plant autotrophic respiration factor in forest ecosystem is closer to 0.464 +- 0.127 (Tang et al., 2019).

Since the exploratory model is not using tree species and tree class distribution maps, we decided to use a GDMP to DMP conversion factor of 0.464.

Split of calculation in hardwood, softwood and mixed wood areas

To transfer the DMP into biomass volumes increments and finally into NAI is highly tree type and age-class specific as well as depending on several abiotic factors which can be combined in the term bonitet. To keep the exploratory model simple, we decide to group the trees into three categories for further calculations: hardwood, softwood and mixed wood. Where hardwood refers mainly to deciduous tree species, softwood includes most of the coniferous tree species. All further calculations and used parameters are therefore split into these three categories and the results are combined in the final products.

We use the Copernicus High Resolution Layer Dominant Leaf Type (HRL DLT) product which identifies and tracks changes in the dominant leaf type of all European tree cover as the main data source to categorize the living tree area into hardwood, softwood and mixed-wood. For the 2021 account we used the latest available dataset of the HRL DLT of the year 2018 and assume that the changes in the DLT between 2018 and 2021 are negligible.

The details of the dataset can be found here: https://land.copernicus.eu/en/products/high-resolution-layer-dominant-leaf-type. The quality of the dataset is assessed in the following report: https://land.copernicus.eu/en/technical-library/hrl-forest-2015-validation-report/@@download/file

Calculation of the total green biomass increment (TGBI)

The dry matter productivity can be converted into tree biomass volume by using the tree species' specific wood density (sometimes also referred to as basic specific gravity). The wood density is defined as mass per unit volume and has the SI unit g/cm^3 or kg/m^3 and is an absolute quantity. Wood density measures the amount of actual wood material in a unit volume of wood.

Therefore, the ratio between an oven-dry mass of wood (that is, the lightest it will ever get) divided by the green volume of the wood (when it is freshly cut and has its largest possible water volume) is measured to find its moisture content. The density of wood differs depending on tree species and tree growth environment. Even the parts of the tree have different densities: branches usually have a lower wood density compared to the trunk. Please note that, for simplification reasons, the model currently only uses one wood density factor per tree species.

In the exploratory WP model, the DMP of a pixel given in the unit "tons DM" is divided by the national adjusted wood density factor for hardwood, softwood or mixed forest. Since the DMP represents the annual productivity, this results in the generation of the tree green biomass volume increment in the unit "m^3 per year per pixel". Moreover, since the GDMP and DMP both represent the above- and belowground part of plants, TGBI can be seen as total annual green biomass increment representing the roots, trunk, branches and foliage increment of the tree over the year.

To generate the national adjusted wood density factors for softwood, hardwood and mixed forest, we use national tree species distributions information and a wood density database listing basic specific gravity values of trees, searchable by region, common or binomial name (Spikevm, 2024). In case no national tree species distributions are available or the overviews are outdated, we use the mean wood density for hardwood and softwood in boreal and temperate forests extracted from the Global Wood Density Database by Thurner et al. (2014) (see Figure 4).

Forest leaf type	Broadleaf	Needleleaf deciduous	Needleleaf evergreen
Mean wood density (g cm^{-3})	0.570	0.464	0.411
Standard deviation of wood density (g cm^{-3})	0.150	0.057	0.066

Figure 4: Mean wood density for hardwood and softwood in boreal and temperate forests extracted from the Global Wood Density Database by Thurner et al. (2014)

Calculation of Net Annual Increment (NAI)

Since the TGBI represents the total green biomass increment, we have to remove all non-merchant tree parts proportionally to get the NAI definition of the wood provision service. Several databases and literature exist which describe functions of the total tree biomass (above ground + below ground) to the merchantable useable part which is mainly the stem and branches above a certain diameter (see Figure 5).

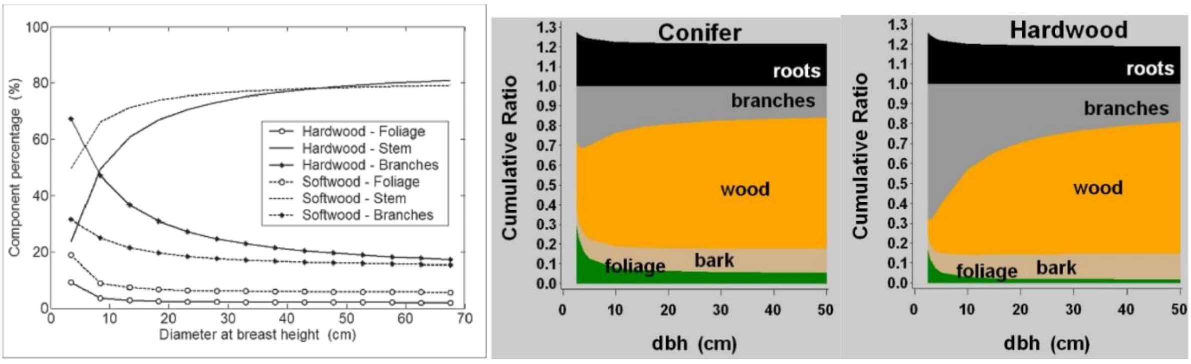

Figure 5: Examples for merchantable percentages functions of tree biomass stocks to calculate merchantable biomass volumes. Left) only for AGB by Della Vecchia et al. (2008); right) for total tree biomass by Jenkins et al. (2003)

Unfortunately, these tree and age-class (plus management practice) dependant conversion factors are only valid for the biomass stock and not for the searched annual increment. Why is that the case? For example: the foliage of a young hardwood tree can be up to 10% of its total biomass volume. But this volume must be generated anew every year and therefore can correspond to up to ~50% of the annual total green biomass increment volume. This significantly reduces the remaining biomass volume to be accounted to the annual growth of roots, stem and branches.

Therefore, we must apply an extra adjustment factor (called increment correction factor) to the existing merchantable percentage factors stated in the literature and databases. Since there are currently no studies available for this adjustment factor, we estimated this factor to be 50% of the TGBI. Please note that we roughly estimated this factor using common NAI values of hardwood and softwood tree species and checked these against their annual total biomass stock change reduced by average merchantable percentages to retrieve the merchant timber volume. Nevertheless, since the merchantable percentages, total biomass and NAI of tree species are age-class and management practice dependent, we can only give a rough estimate of the additional correction factor. A more detailed study is needed to generate correction factor as a function of tree species, age class and management practices or bonitet.

Multiplying the TGBI with the merchantable increment percentage (merchantable percentage * increment correction factor) results in the calculation of the NAI given in m^3 overbark.

<u>Adjustment for areas with less than 100% tree cover fraction</u>

Since the GDMP expresses the primary productivity of the full area (here a 10x10 m raster pixel), we must account for areas not covered by trees, or better: raster pixels with a tree cover fraction (TCF) less than 100% that have a reduced forest NAI. This adjustment is quite challenging since we do not always have the information of the understory vegetation or the other mixed-in ET classes. For simplification reasons we implemented the following NAI reduction scheme per pixel:

- Pixel TCF >= 50%: we account 100% of the calculated NAI to the tree.
- Pixel TCF 36 – 50%: we account 75% of the calculated NAI to the tree.
- Pixel TCF 23 – 36 %: we account 50% of the calculated NAI to the tree.
- Pixel TCF 10 – 23%: we account 25% of the calculated NAI to the tree; and
- Pixel TCF < 10%: we account 0% of the calculated NAI since by definition this pixel is not forest.

Overall formulas

Combining all modelling steps into formulas:

NAI [m3 overbark\pixel\year] = ($NAI_{hardwood}$ [m^3 overbark\pixel\year] + $NAI_{softwood}$ [m^3 overbark\pixel\year] + $NAI_{mixedwood}$ [m^3 overbark\pixel\year]) * $c_{reduction\_TCF}$

Since the modelling steps for hardwood, softwood and mixed forest are only differing by the specific adjustment factors, only the formulas for hardwood will be shown:

$NAI_{hardwood}$ [m3 overbark\pixel\year] = $TGBI_{hardwood}$ [m^3\pixel\year] * $c_{merchantable\_increment\_percentage\_HW}$ = $TGBI_{hardwood}$ [m^3\pixel\year] * $c_{merchantable\_percentage\_HW}$ * $c_{increment\_correction\_factor\_HW}$

$TGBI_{hardwood}$ [m^3\pixel\year] = DMP [ton\pixel\year] * (1 / $c_{wood\_density\_HW}$ [t\m^3])

DMP [ton\pixel\year] = GDMP [kg DM\ha\year] * $c_{ha\_2\_pixel\_area}$ * $c_{kg\_2\_ton}$ [t\kg] * $c_{plant\_autotrophic\_respiration}$

GDMP [kg DM\ha\year] = annual ∑GDMP [kg DM\ha\day]

2.4.5 Compilation of national parameters

The parameters for wood density and merchantable percentage were adjusted on national basis using existing tree species distribution statistics as close to the year 2021 as possible:

- SK: Report on the forest sector of the Slovak Republic 2020 – Green Report (Moravčík et al., 2021)
- NO: NIBIO webpage (https://landsskog.nibio.no/)
- IT: ITALIAN FORESTS - Selected results of the third National Forest Inventory INFC2015 (De Laurentis et al., 2021)
- GR: Results of the first national Forest Inventory conducted in 1963 and officially published in 1992 (National Inventory of Greece, 1992)

The merchantable percentage was estimated using the publication of Jenkins et al. (2003) by estimating the average age-class and breast hight diameter for hardwood and softwood on national level.

Please Note: In the current model these national parameters are estimates and would need an in-depth analysis of the national forest inventories to be more concretised. Moreover, generating the model as tree-species specific would make the estimation of the wood density and merchantable percentage more precise.

Slovakia

Table 2: Tree species distribution in Slovakia 2020 (main tree species)

Main tree species	%	Wood density [t/m3]	Merchantable percentage [%]
Picea abies	22	0.370	0.4 - 0.63
Pinus sylvestris	7	0.422	0.4 – 0.6
Fagus sylvatica	35	0.58548	0.5-0.63
Quercus robur	11	0.56	0.5-0.63

Table 3: National wood density and merchantable percentage used to generate the average model trees in Slovakia for the year 2021

Forest type	% on country	Tree species	Wood density [t/m3]	Merchantable percentage [%]
softwood	36	60% spruce; 40% other needle	0.411	0.45
hardwood	64	55% beech; 16% oak; 29% other	0.57274	0.6
mixed		50% softwood; 50% hardwood	0.49187	0.525

Norway

Table 4: Tree species distribution in Norway 2021 (main tree species)

Main tree species	%	Wood density [t/m3]	Merchantable percentage [%]
Pinus sylvestris	29	0.422	0.4 – 0.6
Picea abies	28	0.370	0.4-0.63
***Betula* sp.**	42	0.525	0.5-0.63

Table 5: National wood density and merchantable percentage used to generate the average model trees in Norway for the year 2021

Forest type	% on country	Tree species	Wood density [t/m3]	Merchantable percentage [%]
softwood	48	50% spruce; 50% pine	0.396	0.45
hardwood	35	100% birch	0.525	0.55
mixed	17	50% softwood; 50% hardwood	0.461	0.5

Italy

Table 6: Tree species distribution in Italy 2015 (main tree species)

Main tree species	%	Wood density [t/m3]	Merchantable percentage [%]
Fagus sylvatica	11.76	0.58548	0.5-0.63
Temperate oaks	12.86	0.56	???
Mediterranean oaks	11.83	0.7305	???
chestnut	8.69	0.5	???
Hornbeam & hophornbeam	9.59	0.7363	???
Other coniferous	8.64	0.45217	???
Picea abies	6.55	0.370	0.4 - 0.63
Larix decidua	4.39	0.47355	???
Holm oak	7.18	0.82	???
Other non-coniferous	18.5	0.55652	???

Table 7: National wood density and merchantable percentage used to generate the average model trees in Italy for the year 2021

Forest type	% on country	Tree species	Wood density [t/m3]	Merchantable percentage [%]
softwood	13	Spruce, *Larix*, et al.	0.429476	0.35*
hardwood	68	See list	0.625768	0.35*
mixed	19	50% softwood; 50% hardwood	0.527622	0.35*

* Since there are nearly no articles for Mediterranean areas available, we used also the forest inventory statistics to estimate the merchantable percentage.

<u>Greece</u>

Table 8: Tree species distribution in Greece 1963 (main tree species)

Main tree species	% *	Wood density [t/m3]	Merchantable percentage [%]
Fir (*Abies*)	16.17	0.35301	0.4 - 0.63
Pine (*Pinus halepensis, Pinus brutia*)	16.9	0.46	???
Other coniferous (Black pine, Scots pine)	9	0.45217	0.4 – 0.6
Beech (*Fagus*)	10	0.58548	0.5-0.63
Oak (*Quercus coccifera, Quercus ilex)*	43.8	0.82	0.5-0.63
Other broadleaf (*Ceratonia siliqua, Pistacia lentiscus, Olea europaea, Arbutus* sp., *Quercus coccifera, Quercus ilex, Erica* sp.)	4	0.55652	???

* Detailed tree species composition was not available for the authors from the National Inventory of Greece (1992). There we used an external source which validity is not clear: https://ypef.weebly.com/greece.html

Table 9: National wood density and merchantable percentage used to generate the average model trees in Greece for the year 2021

Forest type	% on country	Tree species	Wood density [t/m3]	Merchantable percentage [%]
softwood	48	See list	0.417202	0.45
hardwood	35	See list	0.761192	0.25
mixed	17	50% softwood; 50% hardwood	0.589197	0.35

2.4.6 Final overview of the used datasets and factors

Table 10: Universal EO datasets and GIS products

Dataset name	Source	DOI manual	Resolution	Notes
HRL forest TCD	Copernicus	https://land.copernicus.eu/en/technical-library/hrl-forest-2018/@@download/file	10m	Only for year 2018, tree cover fractions
HRL forest DLT	Copernicus	https://land.copernicus.eu/en/technical-library/hrl-forest-2018/@@download/file	10m	Only for year 2018, only separates the dominant leave type into needle-leave and broad-leave
GDMP	Copernicus	https://land.copernicus.eu/en/technical-library/product-user-manual-soil-water-index-version-3/@@download/file	300m	10-daily product; Products for end of year 2020 and 2021 has to be calculated via preprocessing script
Global Forest Change forest loss	University of Maryland	http://www.sciencemag.org/content/342/6160/850	30m	https://storage.googleapis.com/earthenginepartners-hansen/GFC-2022-v1.10/download.html
Global forest loss due to fire	GLAD	https://glad.umd.edu/users/Alexandra/Fire_GFL_data/frsen-03-825190.pdf	30m	Add on to Hansen – split into loss by fire or other disturbance
EU FAWS	JRC	https://data.jrc.ec.europa.eu/dataset/768d2620-1619-4953-8c7d-42511a43ff8a?locale=ro	100m	FAWS for 2020 (the forest areas which can be used for wood supply by taking into account: altitude, slope, distance to roads, protected areas, unproductive forests) - technical potential to use net increment

Table 11: National used datasets

Dataset name	Source	Resolution	Notes
SK harvested areas	SK national forest service	Vector 1ha MMU	Vector file where forest was harvested as well as the reason for it (wind, management, etc) --> official wood production; has to be rasterized
SK disturbance areas	SK national forest service	Vector 1ha MMU	Vector file where forest was disturbed --> but no wood produced (stays as deadwood or other); has to be rasterized
NO bonitet, harvest areas, disturbance	NO SR-16 dataset		https://kartkatalog.geonorge.no/metadata/sr16-skogressurskart-16x16-meter-raster/5de45872-f534-4e97-840e-3cfd8db04398
GR managed forest areas	Vector file		By email

Table 12: Universal constants

Name	Value	Note
forest_threshold	10	Only areas >= 10% cover fraction of forest in the HRL TCD layer are used as "forest area"
Plant autotrophic respiration	0.464	Conversion from GDMP to DMP for forest areas (better than the normal 0.5 value used)
Kg_2_tonnes	0.001	Conversion from kg DM/year to tonnes DM/year
Ha_2_pixel	0.04	In 20m resolution one pixel represent 400m2 → the values per ha have to be divided by 25
NAI_reduction	36 < TCD < 50 → 0.75 23 < TCD < 36 → 0.5 10 < TCD < 23 → 0.25	Reduction factor of the DMP depending on the TCD % → the lower the tree cover fraction, the more the DMP will come from non-tree species
Increment correction factor	0.5	Adjustment factor for merchantable percentage to be applied for stock biomass to annual biomass increment

Table 13: National conversion factors

Name	Value	Note
SK_wood_density	Hardwood: 0.57274 Softwood: 0.411 Mixed: 0.49187	Conversion factor from DMP to total green biomass increment (TGBI) in tonnes; modelled for the average SK hardwood and softwood tree using the SK statistics for tree species distribution, age class distribution and abiotic factors
SK_merchantable	Hardwood: 0.6 Softwood: 0.45 Mixed: 0.525	Conversion factor to extract merchantable wood part from full tree biomass increment (TGBI); modelled for the average SK hardwood and softwood tree using the SK statistics for tree species distribution, age-class distribution and abiotic factors
NO_wood_density	Hardwood: 0.525 Softwood: 0.396 Mixed: 0.461	Conversion factor from DMP to total green biomass increment (TGBI) in tonnes; modelled for the average NO hardwood and softwood tree using the NO statistics for tree species distribution, age class distribution and abiotic factors
NO_merchantable	Hardwood: 0.55 Softwood: 0.45 Mixed: 0.5	Conversion factor to extract merchantable wood part from full tree biomass increment (TGBI); modelled for the average NO hardwood and softwood tree using the NO statistics for tree species distribution, age class distribution and abiotic factors
IT_wood_density	Hardwood: 0.625768 Softwood: 0.429476 Mixed: 0.527622	Conversion factor from DMP to total green biomass increment (TGBI) in tonnes; modelled for the average IT hardwood and softwood tree using the IT statistics for tree species distribution, age class distribution and abiotic factors
IT_merchantable	Hardwood: 0.35 Softwood: 0.35 Mixed: 0.35	Conversion factor to extract merchantable wood part from full tree biomass increment (TGBI); modelled for the average IT hardwood and softwood tree using the IT statistics for tree species distribution, age class distribution and abiotic factors
GR_wood_density	Hardwood: 0.761192 Softwood: 0.417202 Mixed: 0.589197	Conversion factor from DMP to total green biomass increment (TGBI) in tonnes; modelled for the average GR hardwood and softwood tree using the GR statistics for tree species distribution, age class distribution and abiotic factors
GR_merchantable	Hardwood: 0.25 Softwood: 0.45 Mixed: 0.35	Conversion factor to extract merchantable wood part from full tree biomass increment (TGBI); modelled for the average GR hardwood and softwood tree using the GR statistics for tree species distribution, age-class distribution and abiotic factors

2.5 Results

The WP accounts presented here are only presented for FAWS areas (Forest Areas for Wood Supply) and the NAI is given in m^3 timber overbark. The results are only illustrated for the example of Slovakia used in the round-robin exercise.

2.5.1 Account for the year 2021 using INCA method

Presented here are the results of a purely statistical approach based on a top-down methodology and LULUCF statistics generated using the INCA tool version 2.1. The results are for NUTS-0 and NUTS-2 NAI 2021 for FAWS areas in $1000m^3$ overbark.

Table 14: Wood provision account for the year 2021 of the FAWS in SK – supply. Calculated with the INCA tool 2.1 following the INCA methodology.

FAWS code	FAWS	Total wood volume in $1000m^3$ overbark	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)
SK		12.731	-	-	-	12.731	-	-	-	-	-	-	-	-
SK01	Bratislavský kraj	370	-	-	-	370	-	-	-	-	-	-	-	-
SK02	Západné Slovensko	3.335	-	-	-	3.335	-	-	-	-	-	-	-	-
SK03	Stredné Slovensko	5.908	-	-	-	5.908	-	-	-	-	-	-	-	-
SK04	Východné Slovensko	3.118	-	-	-	3.118	-	-	-	-	-	-	-	-

Table 15: Wood provision account for the year 2021 of the FAWS in SK – use. Calculated with the INCA tool 2.1 following the INCA methodology.

FAWS code	FAWS	Total wood volume in $1000m^3$ overbark	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports
SK		12.731	12.731	-	-	-	-
SK01	Bratislavský kraj	370	370	-	-	-	-
SK02	Západné Slovensko	3.335	3.335	-	-	-	-
SK03	Stredné Slovensko	5.908	5.908	-	-	-	-
SK04	Východné Slovensko	3.118	3.118	-	-	-	-

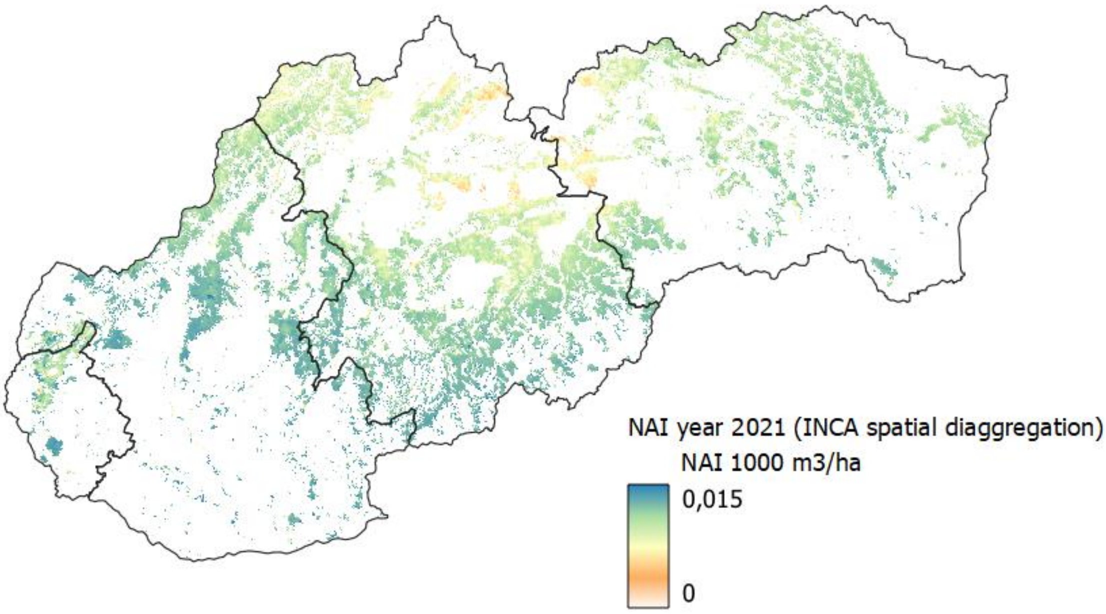

Figure 6: Wood provision account for the year 2021 of the FAWS in SK – supply. Calculated with the INCA tool 2.1 following the INCA methodology and spatial disaggregated using the Copernicus DMP as proxy.

The WP account generated with the INCA methodology results in an average 10.86 m^3/ha NAI for all FAWS areas in Slovakia (official numbers from the forest inventory: 6.22 m^3/ha). This high NAI is mainly generated by the low FAWS area in Slovakia used in the INCA tool (1.17 million ha compared to officially reports FASW of 1.8 million ha).

2.5.2 Account for the year 2021 using the experimental RS method

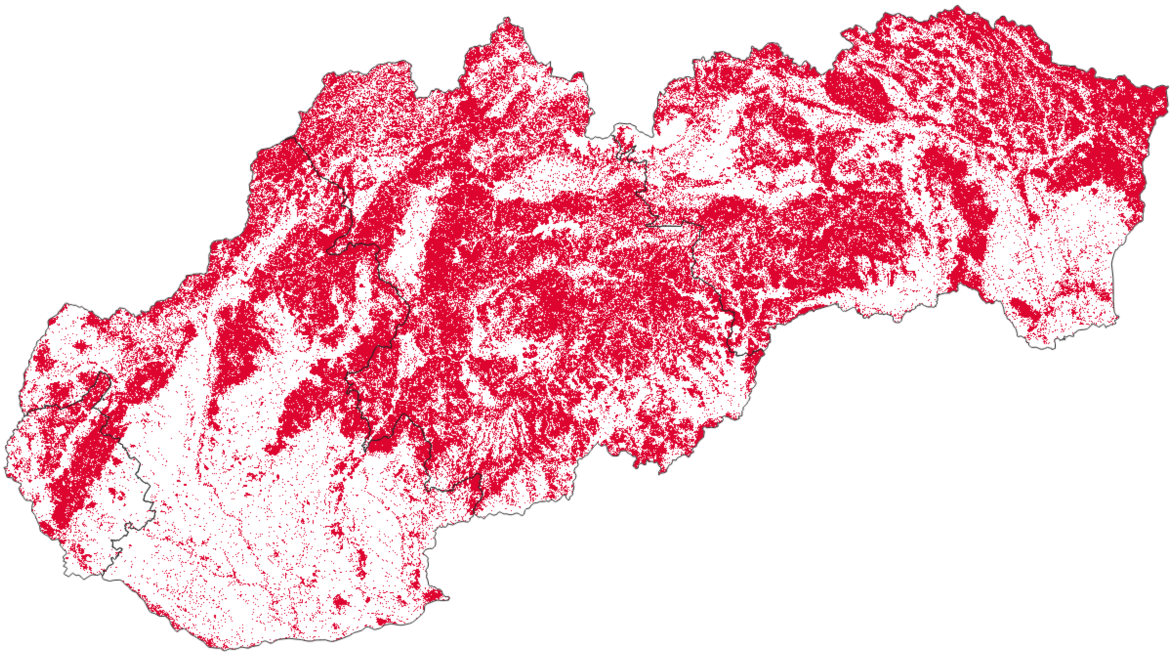

Figure 7: Mask of the areas of living trees for the year 2021 in Slovakia following the EU GN definition.

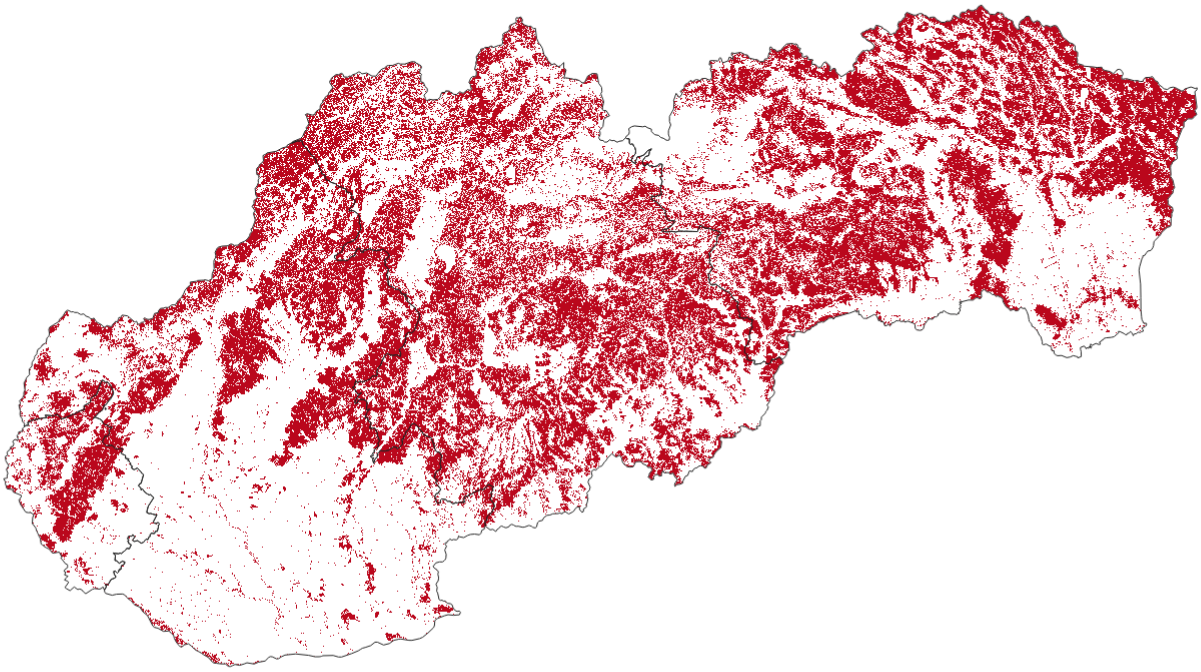

Figure 8: Area of living trees in 2021 masked to the FAWS areas in Slovakia. Overall area: 1,803,172 ha.

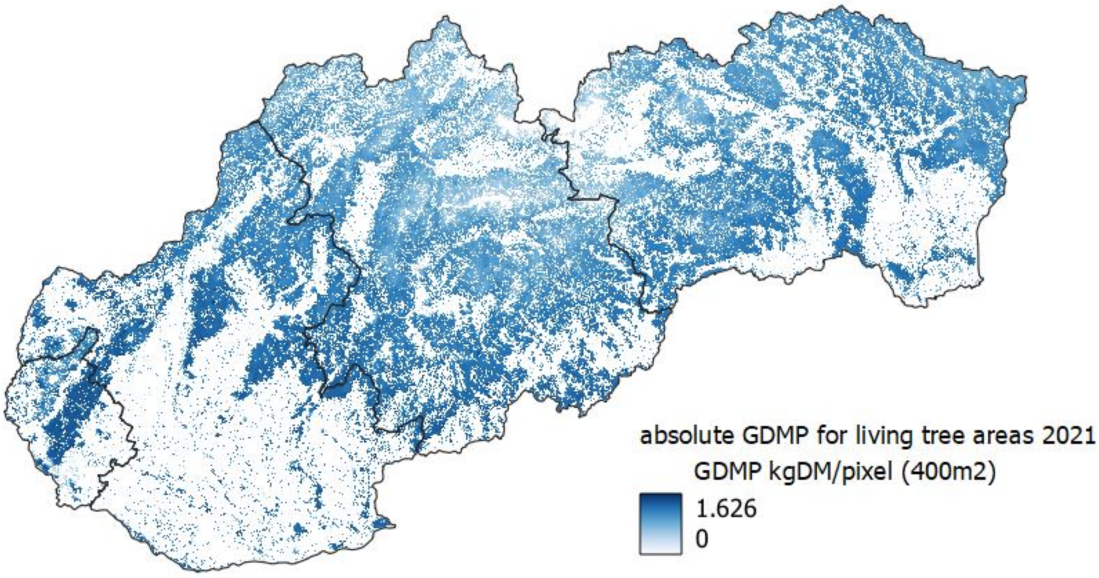

Figure 9: Absolute GDMP of all living trees in 2021 for Slovakia.

Results for NUTS-0 and NUTS-2 NAI 2021 for FAWS areas in 1000m^3 overbark.

Table 16: Wood provision account for the year 2021 of the FAWS in SK – supply. Calculated with the experimental EO methodology.

FAWS code	FAWS	Total wood volume in 1000m³ overbark	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)
SK		12.726	-	-	-	12.726	-	-	-	-	-	-	-	-
SK01	Bratislavský kraj	556	-	-	-	556	-	-	-	-	-	-	-	-
SK02	Západné Slovensko	2.811	-	-	-	2.811	-	-	-	-	-	-	-	-
SK03	Stredné Slovensko	4.791	-	-	-	4.791	-	-	-	-	-	-	-	-
SK04	Východné Slovensko	4.568	-	-	-	4.568	-	-	-	-	-	-	-	-

Table 17: Wood provision Account for the year 2021 of the FAWS in SK – use. Calculated with the experimental EO methodology.

FAWS code	FAWS	Total wood volume in 1000m³ overbark	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports
SK		12.726	12.726	-	-	-	-
SK01	Bratislavský kraj	556	556	-	-	-	-
SK02	Západné Slovensko	2.811	2.811	-	-	-	-
SK03	Stredné Slovensko	4.791	4.791	-	-	-	-
SK04	Východné Slovensko	4.568	4.568	-	-	-	-

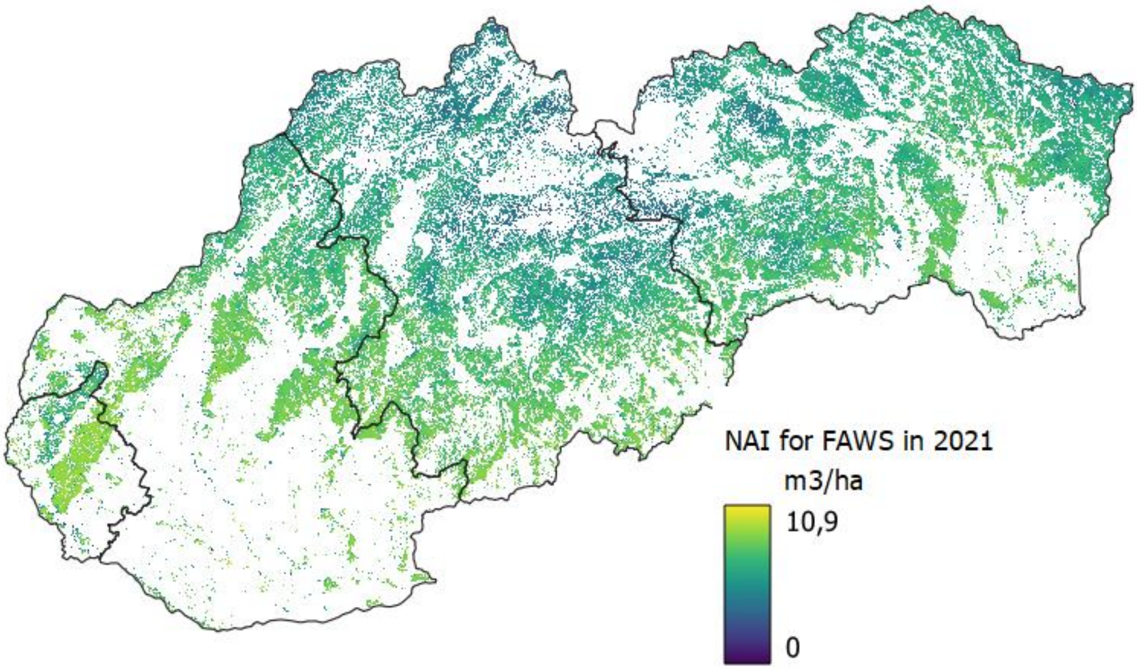

Figure 10: Wood provision account for the year 2021 of the FAWS in SK – supply. This map is a direct result of the bottom-up approach using the PEOPLE-EA experimental EO approach.

The WP account generated with the experimental EO methodology results in an average 7.05 m3/ha NAI for all FAWS areas in Slovakia (official numbers from the forest inventory: 6.22 m3/ha). The FAWS area in Slovakia calculated is ~1.8 million ha (compared to official reports FASW of 1.8 million ha).

2.6 Short comparison INCA method vs. RS method

Since the INCA method is using the official reported NAI numbers of the country, a short comparison between the accounts is possible:

- The spatial map of the experimental EO approach shows more reliable spatial distribution of the NAI compared to the INCA map.
- The overall national NAI numbers match quite well, but the distribution on NUTS-2 level shows significant differences.

INCA - Official statistic

		total	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)
SK		12.731	-	-	-	12.731	-	-	-	-	-	-	-	-
SK01	Bratislavský kraj	370	-	-	-	370	-	-	-	-	-	-	-	-
SK02	Západné Slovensko	3.335	-	-	-	3.335	-	-	-	-	-	-	-	-
SK03	Stredné Slovensko	5.908	-	-	-	5.908	-	-	-	-	-	-	-	-
SK04	Východné Slovensko	3.118	-	-	-	3.118	-	-	-	-	-	-	-	-

NAI 2021 in FAWS in 1000 m3 overbark

PEOPLE-EA

		total	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grassland)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (offshore coastal shelf and open ocean)
SK		12.726	-	-	-	12.726	-	-	-	-	-	-	-	-
SK01	Bratislavský kraj	556	-	-	-	556	-	-	-	-	-	-	-	-
SK02	Západné Slovensko	2.811	-	-	-	2.811	-	-	-	-	-	-	-	-
SK03	Stredné Slovensko	4.791	-	-	-	4.791	-	-	-	-	-	-	-	-
SK04	Východné Slovensko	4.568	-	-	-	4.568	-	-	-	-	-	-	-	-

2.7 Limitations

The following limitations of the experimental EO approach have been identified. Please note that this list is not exhaustive.

- Area of forest excl. natural mortality (area of living trees)
  - HRL tree cover layer is from 2018 at a resolution of 10m --> not directly corresponding to forest definition of MMU 0.5ha and 5m height plus minimum 10% tree cover --> dataset was resampled to 20m with average filter.
  - The Hansen tree loss layer is only available at30m resolution.
  - Uncertainty of Hansen loss product is not known (we use the loss of years 2018, 2019, and 2020 to determine the living trees at beginning of 2021 PLUS the tree loss of 2021 to determine the natural mortality).
  - Hansen only gives full lost pixels --> no information about partial disturbance of pixels.
  - Split of disturbance into the natural mortality, non-natural disturbance and harvest components is highly experimental and has a high risk of miss-classification.
  - Usage of SK national vector datasets of harvested and disturbed areas – not clear if that is a complete dataset.
- GDMP of living trees in 2021
  - No high resolution GDMP or NPP product for EU available at the moment --> EVOLAND project will generate one within the next years.
  - Copernicus GDMP 300m product was resampled to 20m with bilinear filter --> this can lead to substantial errors in heterogeneous areas or areas with highly changing tree cover percentages --> error margin is unknown for GDMP in heterogeneous land cover areas!
  - In areas with disturbance in 2021 (Hansen loss which is not natural + SK national harvest and disturbance maps) we used the GDMP 2020 extrapolated to 2021. The conversion factor is based on full SK GDMP comparison between 2020 and 2021. This correction factor should be more tree species or area specific.
  - The GDMP product of Copernicus is optimized in forest areas to
    LUEs categories representing different forest types, but those are broad categories and not Slovakian tree species specific --> error margin
    (see https://land.copernicus.eu/global/sites/cgls.vito.be/files/products/CGLOPS1_ATBD_DMP-NPP300m-V1.1_I1.30.pdf).

- GDMP conversion to volume timber overbark
    - Conversion of GDMP to DMP --> the carbon use efficiency (autotrophic respiration) is tree species and age class specific plus is influenced by other abiotic and biotic restrictions --> Copernicus uses a fixed factor of 0.5 (see https://land.copernicus.eu/global/sites/cgls.vito.be/files/products/CGLOPS1_ATBD_DMP-NPP300m-V1.1_I1.30.pdf).
    - We decided to optimize the CUE to forests --> CUE = 0.464 +- 0.127 (see https://bg.copernicus.org/preprints/bg-2019-37/bg-2019-37.pdf).
    - DMP-to-tree biomass conversion uses the density factor (specific gravity) which is tree specific and age class specific and even internal wood type specific (sapwood versus kernwood) --> we used the SK tree species distribution to generate weighted averages for hardwood, softwood and mixed wood specific for SK --> the ranges are quite high in these conversion factors and therefore the uncertainty is quite high.
    - Tree biomass-to-green ton conversion: the "merchantable to total biomass factor" is tree specific --> we used average factors for hardwood, softwood and mixed wood --> unknown uncertainty --> we assumed an average DBH (diameter-at-breast-height) of 40cm for softwood in SK and an average DBH of 50cm in hardwood.
    - The reduction of DMP in pixels without 100% tree cover is based on the assumption of forest understory growth – the lower the TCD, the more understory and the less DMP belongs to the tree --> full assumptions for the values and a full study are needed to calculate correct reduction factors.
- FAWS areas
    - We use the JRC map for FAWS areas based on DEM slope, protected areas... (see https://data.jrc.ec.europa.eu/dataset/768d2620-1619-4953-8c7d-42511a43ff8a) --> the uncertainty of these areas is unknown.
- This approach does not use sophisticated forest harvest and mobilization models like EFISCEN-Space.

2.8 Roadmap

The following points would be valuable to improve the experimental model:

- Annual cover fractions maps of annual Copernicus HRL TCD will be available starting in 2025.
- Tree loss map at HR (10m).
- High resolution GDMP/NPP products.
- High resolution tree species maps.
- High resolution tree age class maps.
- High resolution tree height product or bonitet maps.
- High resolution disturbance mapping --> by disturbance categories.
- Optimization of the merchantable percentage by incorporation of the JRC allometric biomass and carbon factors database (https://iforest.sisef.org/contents/?id=ifor0463-0010107).

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Annex 1. Production datasets

Country	Validation of:	Dataset	Source
Slovakia	Extent	Ecosystem map (EUNIS)	Dataset which identifies individual ecosystems and their spatial distribution, status, and selected properties. The impetus for producing this map is the need of various stakeholders, especially nature protection bodies, forestry management, agricultural management, and public administration, for better data on the distribution of ecosystems. The methodology mostly involves using GIS analytical tools to combine datasets on nature protection, forestry, and agriculture which list attributes related to habitat identification.
Slovakia	Forest & woodland condition	National Forest Inventory	Data from the National Forest Centre on the spatial distribution of forest ecosystems. Spatial dataset covering 96% of Slovak forests (except for military forests and areas not defined as forest stand) with attributes defining age, tree composition, habitat identification, etc.
Slovakia	Forest & woodland condition	High Nature value Forests	Data from the National Forest Centre on the spatial distribution of forest ecosystems. Spatial dataset covering 96% of Slovak forests (except for military forests and areas not defined as forest stand) with attributes defining age, tree composition, habitat identification, etc. For identification of high nature value forest areas one specific parameter from data set will be used - naturalness of forest, which is calculated based on the tree composition of individual forest stands.
Slovakia	Global Climate Regulation	Geodatabase National pilot Ecosystem Services Assessment	Spatial national dataset prepared based on national ecosystem map, considering actual conservation status of habitats. ES is assessed based on allocated matrix values, where certain ecosystem types provide specific level of global climate regulation.
Greece	Extent	Ecosystem map (MAES level 3)	LIFE-IP 4 NATURA dataset
Greece	Forest & woodland condition	MAES_GR field protocols	LIFE-IP 4 NATURA dataset / Field survey plots at Woodland and forests
Greece	Extent	Natura 2000 habitat type map 1:5000	Ministry of Environment and Energy
Greece	Forest & woodland condition	Field survey of the plots on Habitat Directive monitoring projects	Ministry of Environment and Energy
Greece	Near Shore tourism recreation service	Blue flag beaches database for Greece / Photointerpretation of ortho-photo imagery	https://www.blueflag.global/ Hellenic Cadastre ortho imagery
Norway	Extent	SAT-SKOG dataset; Landsat-5 and Landsat-7	https://kart8.nibio.no/nedlasting/dashboard or https://www.nibio.no/tjenester/wms-tjenester/wms-tjeneste-sat-skog
Norway	Extent - Urban	Land use 2021 Geonorge – KartKatalog Urban settlements	https://kartkatalog.geonorge.no/metadata/land-use/a965a979-c12a-4b26-90a0-f09de47dbecd LiDAR-data https://hoydedata.no/LaserInnsyn2/ https://kartkatalog.geonorge.no/metadata/tettsteder/173f4a15-dead-4f82-b92e-f37396b72cea

Country	Validation of:	Dataset	Source
Norway	Forest & woodland condition	SR16	https://kartkatalog.geonorge.no/metadata/sr16-skogressurskart-16x16-meter/7df9ef08-faf2-4ad3-9ae2-49905f5ea808 Provides an overview of the distribution and characteristics of the country's forest resources. SR16 is divided into SR16R which is a raster map and SR16V which is a vector map LiDAR-data https://hoydedata.no/LaserInnsyn2/
Norway	Forest & woodland condition	'Naturebase'	'Naturebase' contains information on vegetation for selected regions. The Norwegian Environment Agency: https://geocortex01.miljodirektoratet.no/Html5Viewer/?viewer=naturbase
Netherlands	Coastal condition	National ecosystem extent map; national annual 30cm resolution aerial photographs	https://www.cbs.nl/en-gb/society/nature-and-environment/natural-capital/themas/ecosystem-types
Netherlands	Global Climate Regulation	National Forest Inventory	https://www.wur.nl/en/research-results/research-institutes/environmental-research/projects/dutch-forest-inventory.htm
Netherlands	Global Climate Regulation	CO2 Flux towers: national flux towers measurement program	https://www.wur.nl/en/project/National-research-program-on-greenhouse-gas-emissions-from-peat-meadows.htm Field data from measurement station 'Zegveld'. Dataset has been obtained.
Italy	Artificial impervious area cover in coastal zone	SNPA soil consumption map (2006-2021) raster (10m resolution) and photo-interpreted changes at very high resolution (<1m)	Available for the whole of Italy https://groupware.sinanet.isprambiente.it/uso-copertura-e-consumo-di-suolo/library/consumo-di-suolo
Italy	Global climate regulation	Soil organic carbon and soil data	In situ measures in the Veneto Region by the Regional Environmental Agency including soil moisture, texture, lithochromy
Italy	Global climate regulation	Datasets of forest carbon stock	Datasets of in situ measures by project LIFE CO2PES&PEF (https://lifeco2pefandpes.eu/) (to be confirmed)
Italy	Wood provisioning	Italian Land Use Inventory	Datasets 1990–2018 available upon request, comprising several thousands of photo-interpreted stratified samples (5000m2) distinguishing forest types (http://www.sisef.it/forest@/contents/?id=0696-009). General availability over Italy, with focus in Emilia-Romagna Region
Italy	Wood provisioning	Datasets of forest growth from research projects	Datasets 1988–2020 available upon request, comprising 4000 photo-interpreted samples over Italy (Cavalli et al. 2022 https://iforest.sisef.org/abstract/?id=ifor4043-015)
Italy	Wood provisioning	Database about growing stock	Several plots all over Italy measuring volume of growing stock by plot (cubic meters per hectare) http://crea.g3wsuite.it/en/map/consistenza-e-accrescimento/qdjango/27/
Italy	Wood provisioning	Database about wood provision types	Data by ISTAT from 2001 to 2015 (http://agri.istat.it/sag_is_pdwout/jsp/NewDownload.jsp?id=7A Tavola F01B - Utilizzazioni legnose forestali per Assortimento)

Country	Validation of:	Dataset	Source
Italy	Wood provisioning	Database of forest wildfires by Arma dei Carabinieri - Comando Unità per la Tutela Forestale, Ambientale e Agroalimentare	Database available upon request for most Italian Regions for several years from 2008 to 2021, containing vectors of wildfire extent at very high resolution.
Italy	Wood provisioning	Datasets of forest disturbances from research projects	Datasets 2012–2020 available upon request (De Fioravante et al. 2022 https://www.mdpi.com/2073-445X/11/1/35) 10m spatial resolution
Italy	Wood provisioning	Possible photointerpretation of very high resolution images	Photointerpretation to be performed using very high resolution images for a limited number of stratified samples (e.g., 250 samples per strata) depending on the characteristics of the products (temporal and spatial resolution)