Forest Carbon Monitoring

ESA Forest Carbon Monitoring project – benchmarking of EO data, methods and estimation of uncertainty in forest inventory mapping

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Intercomparison objectives, with an overarching goal of achieving best prediction accuracies:

- Identify optimal Earth Observation data combinations for forest structural variable prediction.
- Identify best prediction method for forest variables to be further implemented on Forestry TEP within Forest Carbon Platform

Methodologies

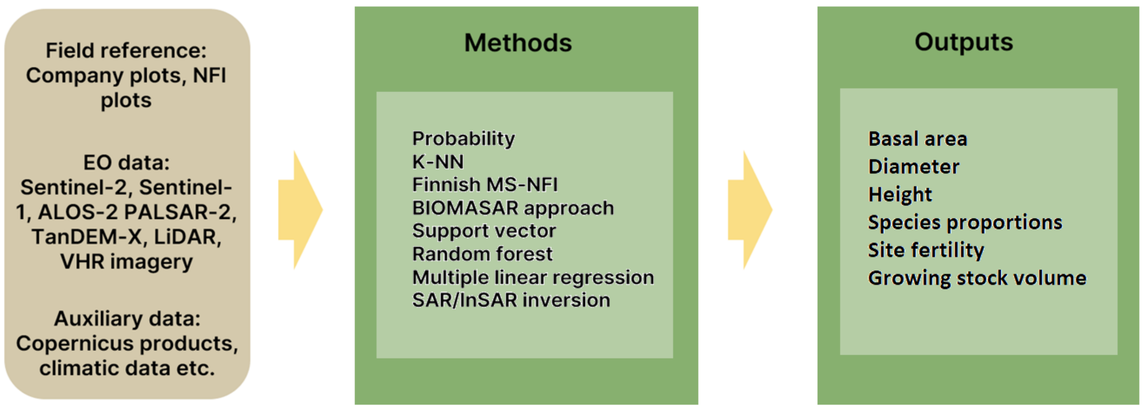


Figure 1. Main processing paths in algorithm comparison and evaluation

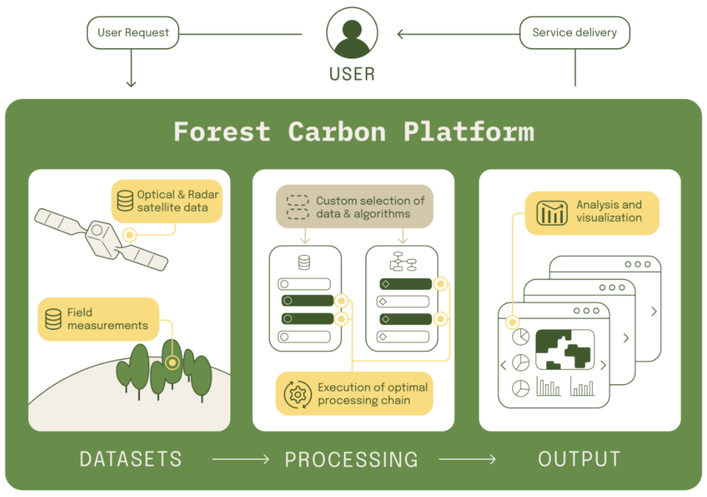
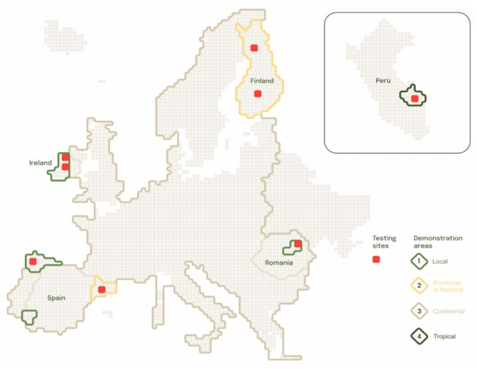


Figure 2. High level platform framework

Study/Testing sites



Testing site characteristics and field data

Testing site	Forest types	Climate and topography	Years	Field plots
1. Finland-1	Semi-natural coniferous and broadleaf	Arctic, Hilly	2018 (2019)	1004 (2018)
2. Finland-2	Semi-natural coniferous and broadleaf	Boreal, Gently undulating	2018 (2019)	1100 (2018)
3. Ireland	Mainly coniferous plantations, some broadleaf	Atlantic, Gently undulating	2018 (2019)	61 (2018)
4. Romania	Semi-natural coniferous and broadleaf	Temperate/ Continental	2019 (2020)	1400 (2019)
5. Catalonia	Semi-natural coniferous and broadleaf	Mediterranean, Hilly to Mountainous	2016 (2015) 766 (2015)	700 (2016)
6. Andalucía	Eucalypt plantations	Mediterranean, Gently undulating	2018 (2019)	76 (2018)
7. Peru	Amazonian evergreen	Tropical, Gently undulating	2018 (2019)	38 x 7 (2017-2018)

EO and reference data

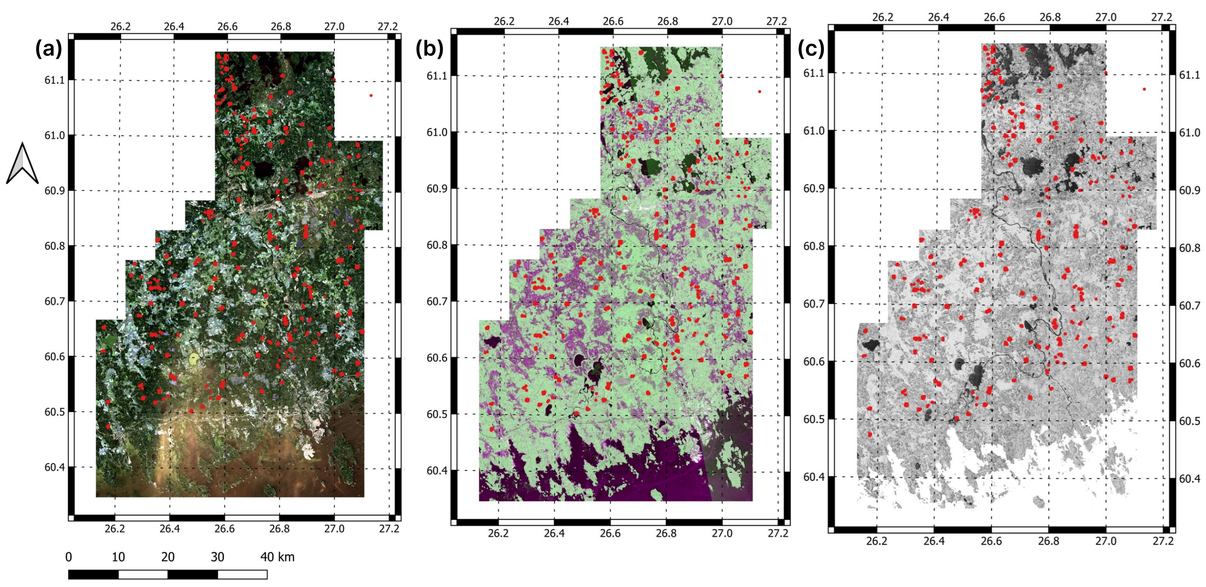


Figure 3. Example of representative datasets, Finnish test site: (a) Sentinel-2 RGB natural color composite; (b) Sentinel-1 multitemporal composite ; (c) DLR's TanDEM-X coherence magnitude

Intercomparison results

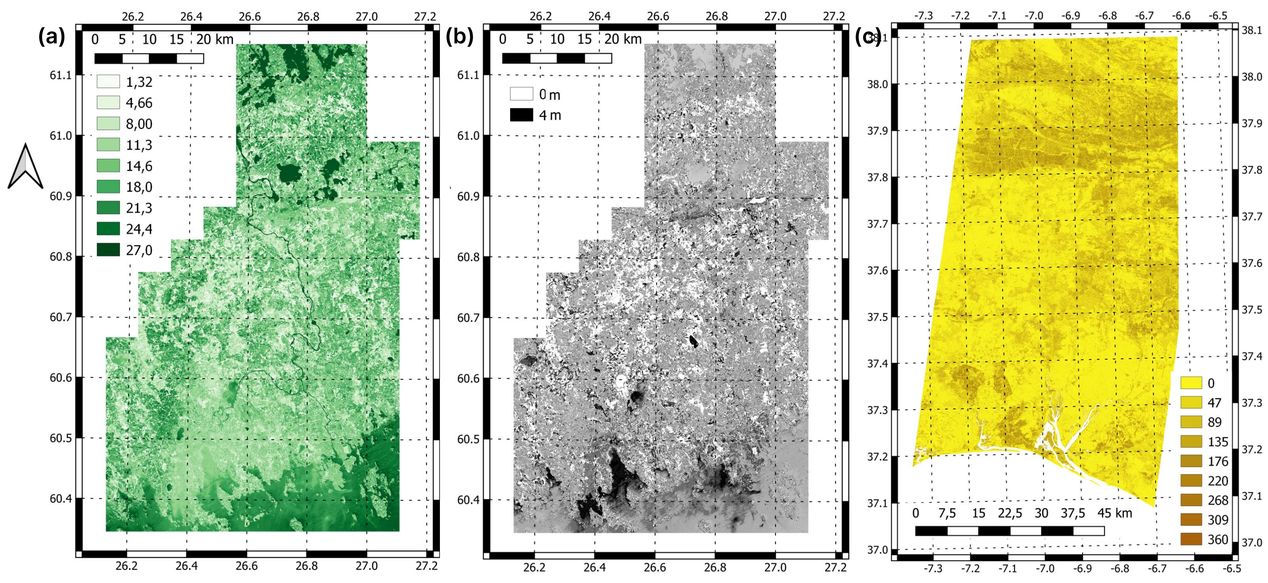


Figure 4. Examples of produced maps: (a) Tree height predictions by kNN using Sentinel-1 &Sentinel-2 data over Finland-2 site; (b) Uncertainty at mapping unit level obtained using bootstrapping approach; (c) Andalucia site growing stock volume predictions using VTT's Probability method

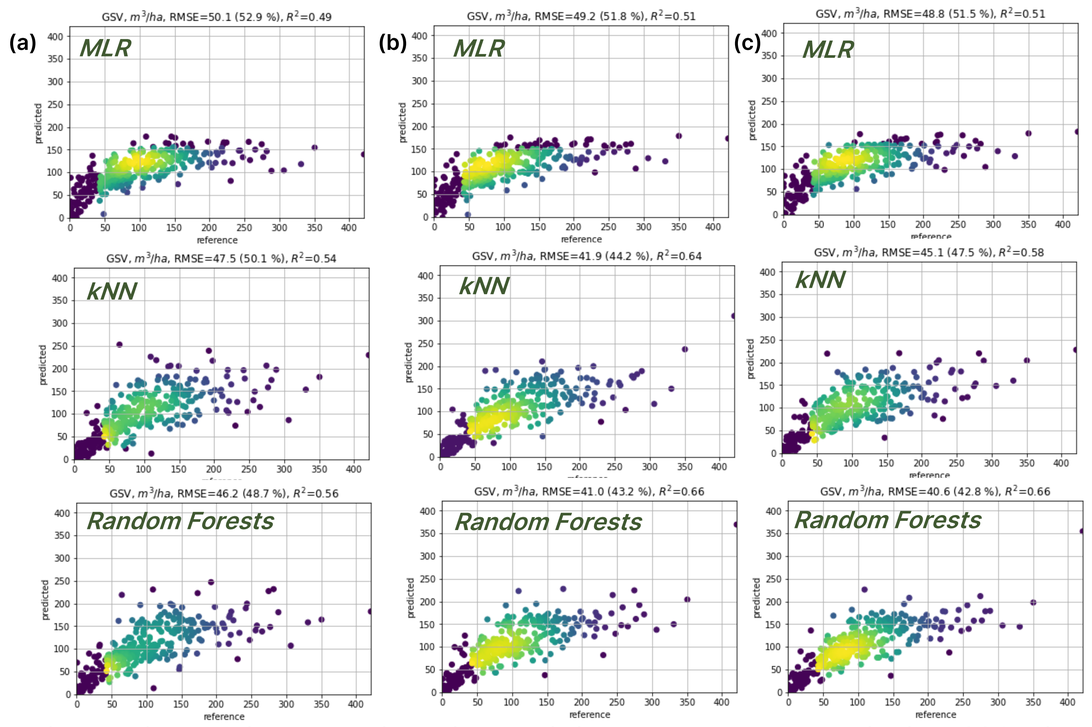
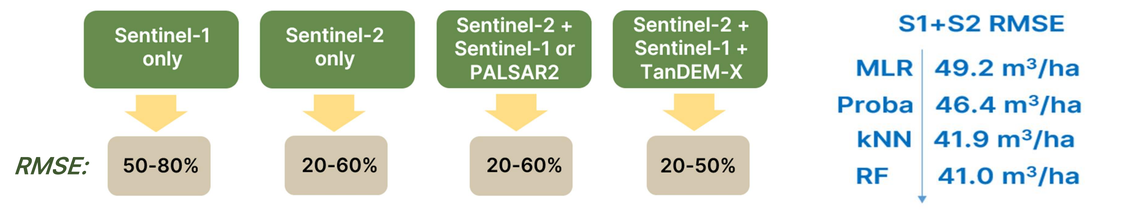


Figure 5. Finland-1 site results using various prediction methods and data combinations: (a) Sentinel-2; (b) Sentinel-2 & Sentinel-1; (c) Sentinel-2 & Sentinel-1 & PALSAR-2



Role of vertical structure

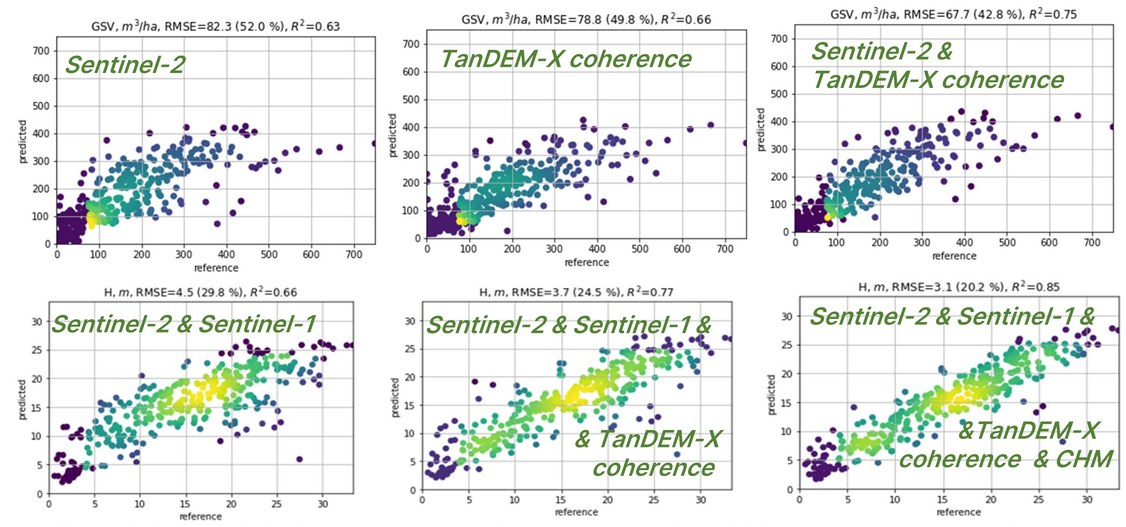


Figure 6. Finland-2 site forest variable predictions using various EO imagery: top row – growing stock volume, bottom row – forest tree height

Conclusions

- If there is representative reference data:
  - k-NN had slightly better performance than Probability.
  - Adding TanDEM-X coherence improved results significantly, even better if there is DTM were available to generate TanDEM-X canopy height model.
  - Random Forest (RF) gave the best accuracies after hyperparameter finetuning, but the method is generally limited to predicting single forest variables.
  - Multiple Linear Regression (MLR) was normally the worst performing method, however it demonstrated gradual improvement as additional EO layers are added.
- If representative field data is limited, semi-supervised VTT's Probability provided the best results.

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