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Satellite Technology For Assessing Global Terrestrial Carbon Stock – State Of The Art & Future

Kaupo Voormansik, CEO & Co-Founder, KappaZeta

Webinar

Tuesday, 26 September 2023

A Word From Today's Chairman

Simon Mills

Senior Associate

Z/Yen Group

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- 11:00 – 11:05   Chairman's Introduction
- 11:05 – 11:25   Keynote Presentation – Kaupo Voormansik
- 11:25 – 11:45   Question & Answer

Today's Speaker

Kaupo Voormansik

CEO & Co-Founder

KappaZeta

Outline

1. The presenter and KappaZeta team.

2. Satellite methods for assessing global carbon stock:
   - advantages,
   - the methods,
   - current and upcoming relevant satellite missions.

3. Our planned breakthrough 3D-SAR satellite mission:
   - advantages,
   - applications enabled,
   - the concept for implementation,
   - status in September 2023,
   - cooperation opportunities.

4. References.

Presenter and KappaZeta background

Kaupo Voormansik

- Co-founder and CEO of KappaZeta.
- PhD in physics (synthetic aperture radar – SAR), University of Tartu, MSc in space studies, ISU, France, MSc in Computer Science, University of Tartu.
- Visiting researcher in German Aerospace Center 2011/12 and 2014.
- Systems engineer of 1st Estonian satellite ESTCube-1, successful launch in 2013.

KappaZeta

- Earth Observation services company.
- Agriculture, forestry and defence applications.
- Synthetic aperture radar and AI technologies.
- Founded in 2015 as the spin-off of Tartu Observatory, University of Tartu.
- 16-people team (6 PhDs).
- Raised €480 000 investment in 2023.

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Satellite technology vs terrestrial and airborne/drone measurements for terrestrial carbon stock estimation

Advantages	Disadvantages
• Truly global coverage. • Frequent updates. • Price per km^2. • Uniform data quality. • Independent 3rd party validation is easier thanks to open data policy. • No local interference at data collection.	• Lower accuracy.

Terrestrial carbon stock estimation with satellite technology

Section	Assessment methods with satellite technology
Above-ground biomass	• Optical reflectance and SAR backscatter proxy methods, fitting a model that captures the empirical relation best (less accurate, but there is abundance of data). • Via direct measurement of the biomass height and volume with LiDAR or interferometric SAR (more accurate, but lack of data). • Via physical modelling – Net and Gross Primary Production (how to handle the gaps due to cloud cover?)
Roots	• Via modelling, knowing the above-ground biomass, its species, age and soil type.
Soil	• Via modelling, knowing the above-ground biomass, its species, age and soil type. • Indirect proxy methods by measuring the top layer reflectance with multispectral or hyperspectral imager (works for bare soil).
Fauna	• ??

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State of the art methods

- Achieve down to 25-30% uncertainties.

- Often use airborne/drone LiDAR as the ground reference.

- Use AI (deep learning) to capture the empirical correlations best.

- Combine multiple spaceborne data sources with auxiliary terrestrial GIS data layers.

- Take advantage of direct forest height/volume measurements with GEDI spaceborne LiDAR and/or TanDEM-X interferometric SAR.

Relevant satellite missions

Method	Current missions	Future missions
Proxy via optical reflectance	Sentinel-2, Landsat-8,-9, Planetscope	Sentinel-2NG
Proxy via SAR backscatter	Sentinel-1, ALOS-2, RADARSAT-2 and RCM,	NISAR, BIOMASS, ROSE-L, Sentinel-1NG
Direct vegetation height measurement with LiDAR	GEDI (on ISS, currently in storage), ICESat-2 ATLAS	Nuview constellation
Direct vegetation height measurement with interferometric SAR	TanDEM-X	BIOMASS, 3D-SAR
Net and Gross Primary Production modelling	MODIS, Sentinel-3 OLCI	

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KappaZeta's planned 3D-SAR satellite mission

3D-SAR

- Passive receivers to make Sentinel-1 data 3-dimensional.

- Global, comparable, accurate & affordable data set for carbon stock estimate.

- <u>Killer combination of high accuracy, reasonable price and global coverage.</u>

- All existing Sentinel-1 applications benefit from added height dimension.

- Relatively low investment ~20 MEUR.

Drawing by Taavi Torim and European Space Agency

Forest biomass with carbon stock estimate at parcel level

82.4 t/ha

103.8 t/ha

Direct physical volume measurement,
excellent combination of global coverage
and accuracy (~10% error at parcel level).

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Enabled applications and use cases

Use case	Relevance
1) **Global forest carbon stocks and biomass data** for carbon trading and climate policy making.	Fast growing market, increasing interest. Lack of accurate and transparent global data source. Single-pass across-track InSAR probably the best combination between price and accuracy.
2) **Mapping forest and agri-biomass for bio-based circular economy**.	Transition from oil- and gas-based economy to bio-materials based circular economy. Biomass is a critical resource as a fuel and raw material for the manufacturing industry.
3) Landscape passability and cover mapping for defense and rescue use.	Existing military VHR SAR systems have very limited coverage, no height and vegetation density estimate. Critical to plan defense and offense routes.
4) High resolution coastal surface current fields, bulk wave parameters and wave density spectra estimations.	Ocean model input to improve forecast accuracy (complementary to SKIM mission, for improving forecast model parametrizations). Ice dynamics in coastal zones and in marginal ice zone (MIZ) for safe winter navigation and climate adaption. Surface currents in large rivers -> flow rates in large rivers for estimating the river discharge to coastal sea.
5) Improving existing agri- and forestry applications on Sentinel-1 data.	Existing Sentinel-1 feature set is rather limited. Most of existing agricultural and forestry applications would benefit from a richer feature set SAR data. More linearly independent input features -> higher accuracy AI models -> more value for clients->EO sector growth.

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Status in September 2023

- Mission architect will join in October and mission manager in November 2023.

- Phase 0 will start late this year:
  1) user requirements and relations development,
  2) alternative mission concepts development,
  3) space hardware partners mapping and relations development.

KAPPAZETA

Contact me if you would like to:

- Team up for market analysis.

- Use our future data products.

- Invest into us in the next phase, when we start to build the satellites and its ground segment.

Thank you!

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Questions?

Photo: Indrek Sünter 2021

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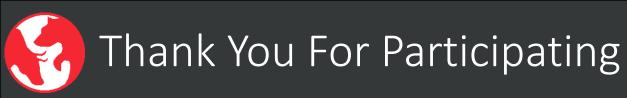
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- Thu, 28 Sept (17:30 – 20:30)   FS Club Mixer – Creating Real Business Value From AI

- Thu, 05 Oct (11:00 – 11:45)   A New Regime For Environmental Law

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