



SCIENCE AND
EDUCATION **FOR**
SUSTAINABLE
LIFE

Sward yield estimation by satellite data

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Satellite remote sensing

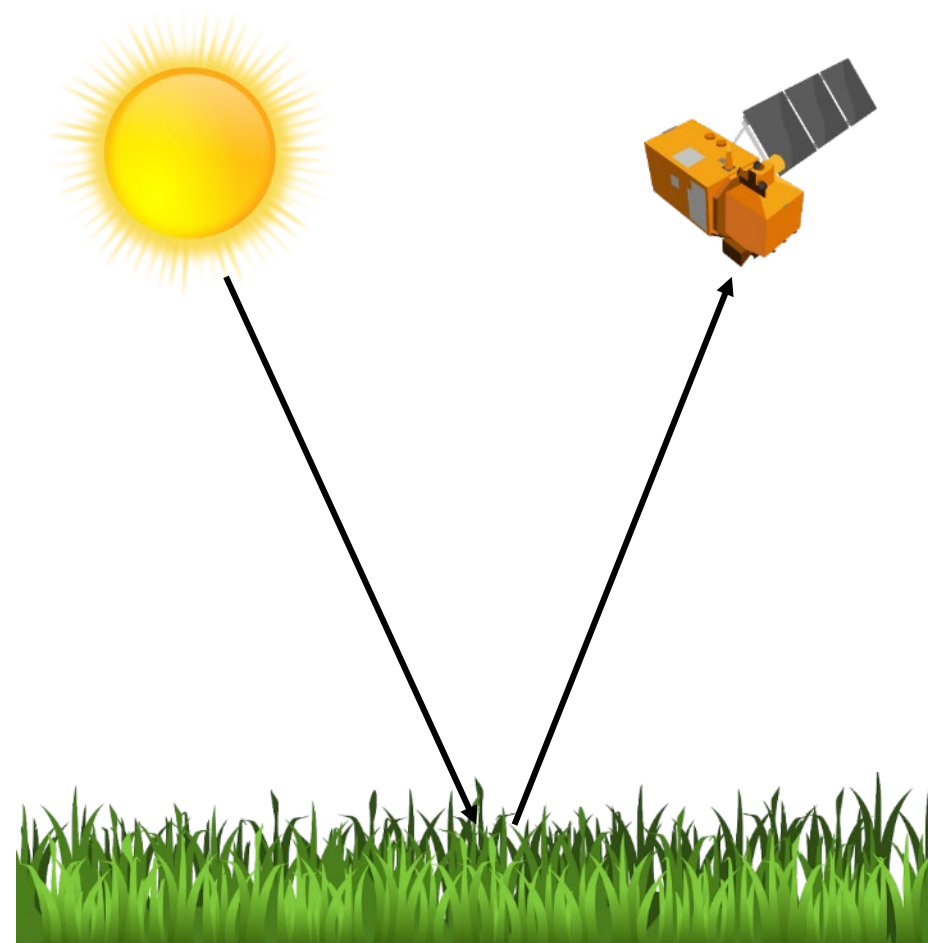
- Sensors mounted on spaceborne platforms
- Large spatial extent
- Typical spatial resolution in the metric range
- Some satellites provide open-access data
- Managed by NASA/ESA
- Transferability to operational farming support systems



Image ESA

Satellite remote sensing

- Measuring reflected light
- Reflected light carries information about the reflecting object
- Canopy chlorophyll content
- Leaf area index
- Canopy water content
- etc...



Data collection - samples

- 3-4 samples per satellite pixel
- GPS coordinates registered (<20 cm)
- Dry matter content determination (60°C, 48 hours)
- Dry matter yield per sample
- Averaged to represent the “pixel yield”
- 53 samples so far...



Satellite data – Sentinel-2

- Open-access imagery
- ESA managed
- Passive sensor
- Visible/NIR/SWIR spectral range
- Multispectral sensor (13 bands)
- Sentinel-2 A and B



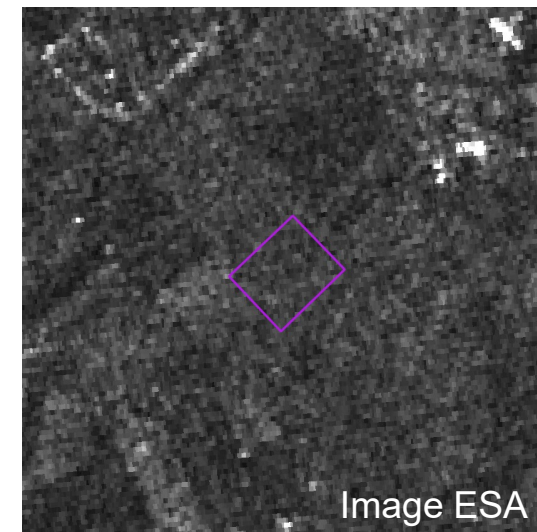
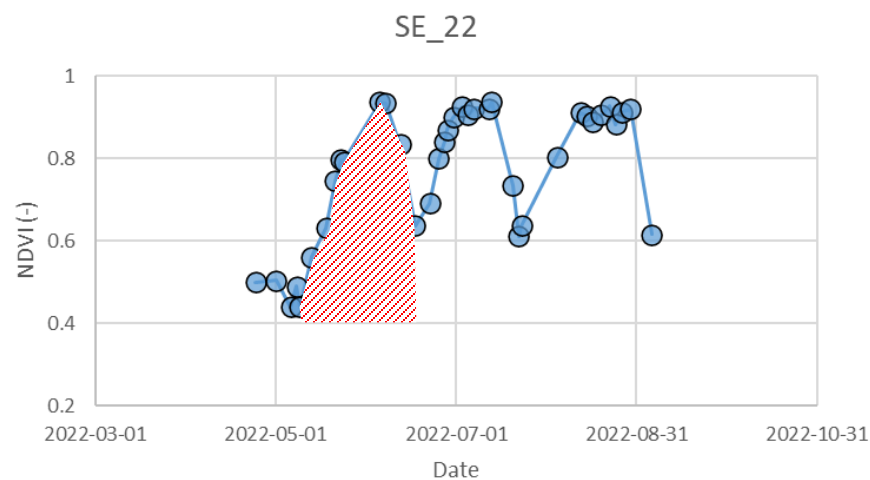
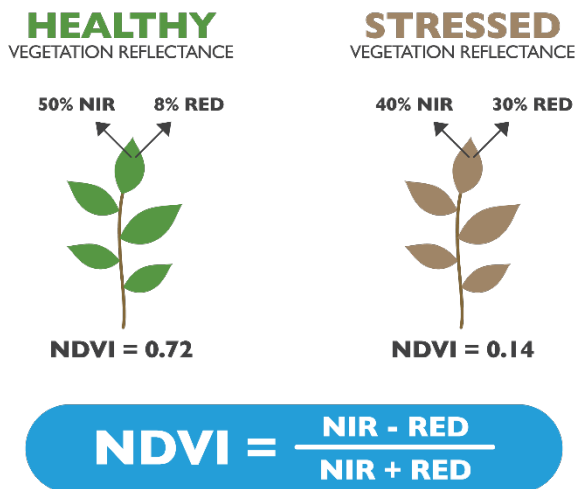
Satellite data – Sentinel-1

- Open-access imagery
- ESA managed
- Active sensor (can be used at night)
- Microwaves (can see through clouds)
- Sentinel-1 A and B
- Sentinel-1 B prematurely ended in December 2021
- Sentinel-1 C to be launched in the second quarter of 2023



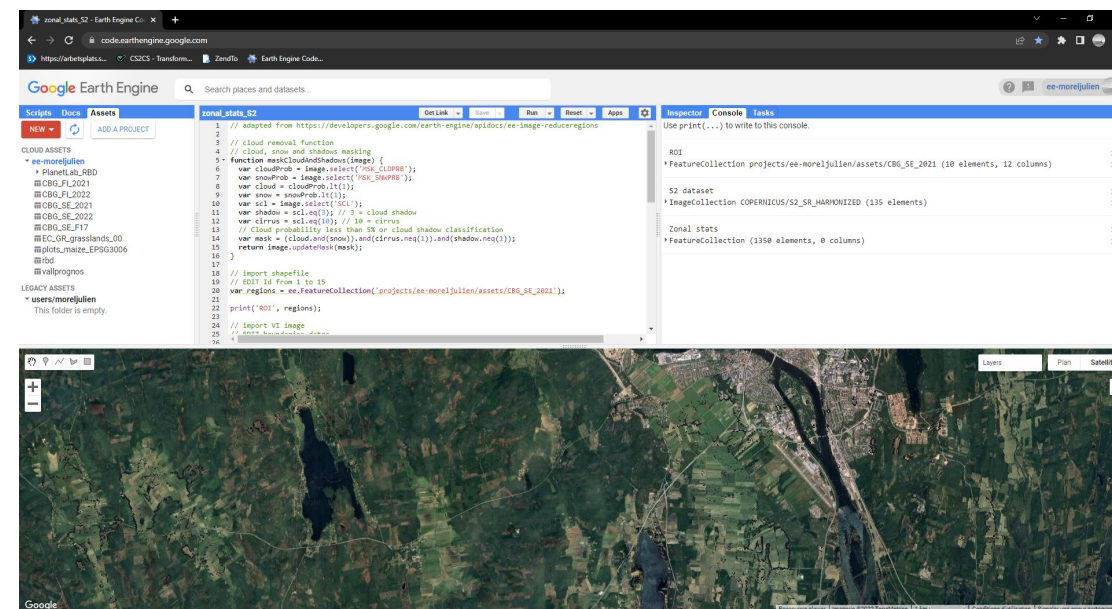
Satellite data processing

- Sentinel-2: vegetation indices, time-integrated vegetation indices, machine learning
- Sentinel-1: time-integrated backscatter



Satellite data access

- Accessed from Google Earth Engine
- javascript coded
- Cloud computing
- Continuously updated with new data



Workflow



Sample dataset

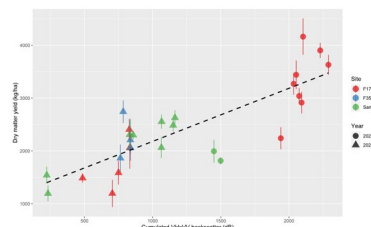
GPS coordinates

Extracting spectral values

Satellite dataset

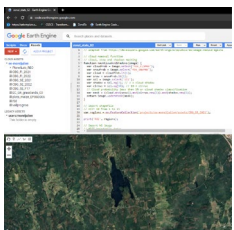
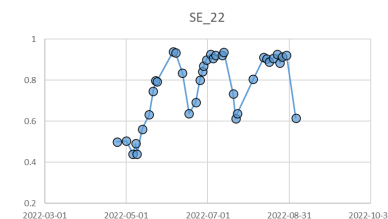
Dry matter yields

Regression models



Performance metrics

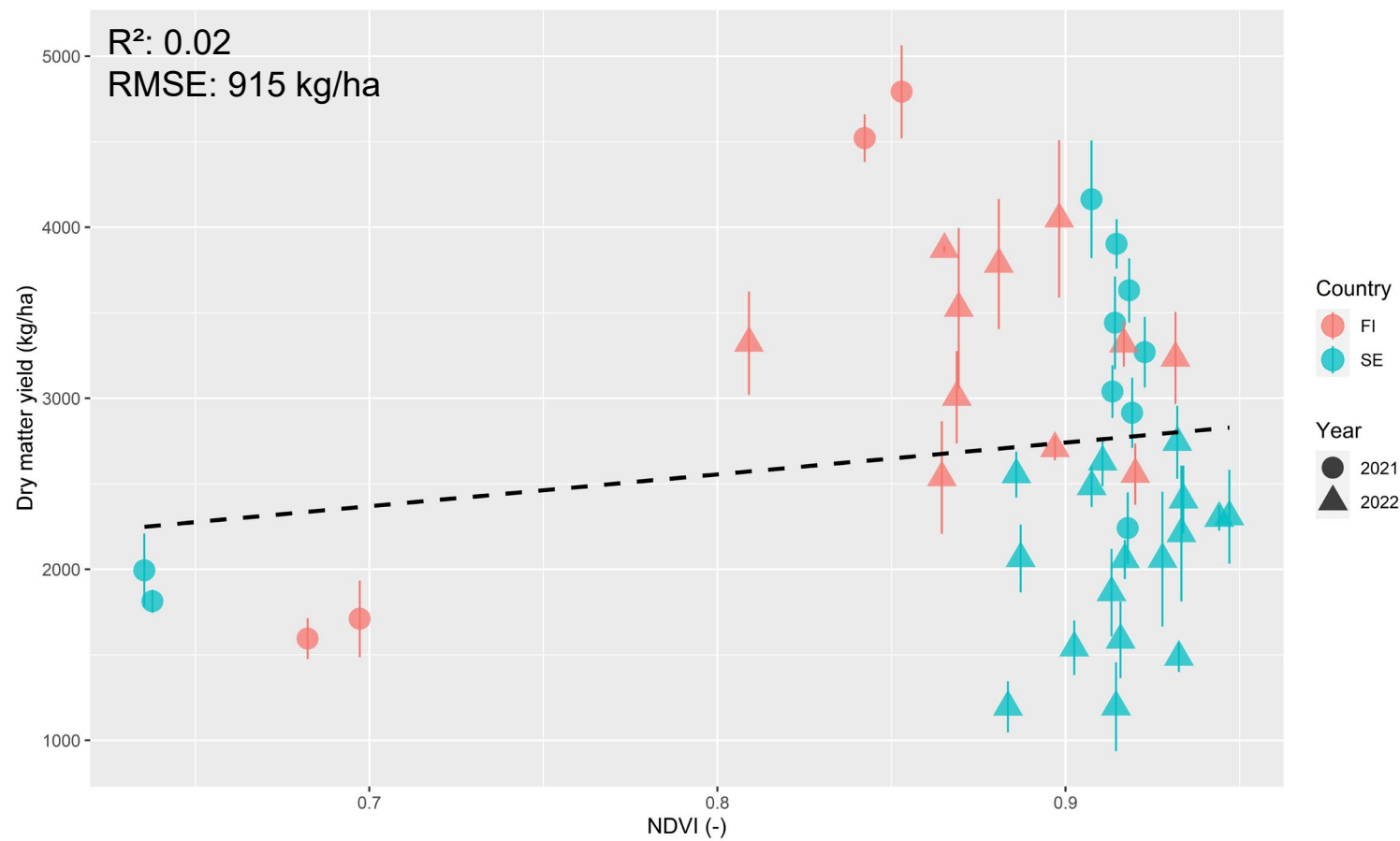
VI/Time integrated VI/ML (Sentinel-2)
Time integrated backscatter (Sentinel-1)





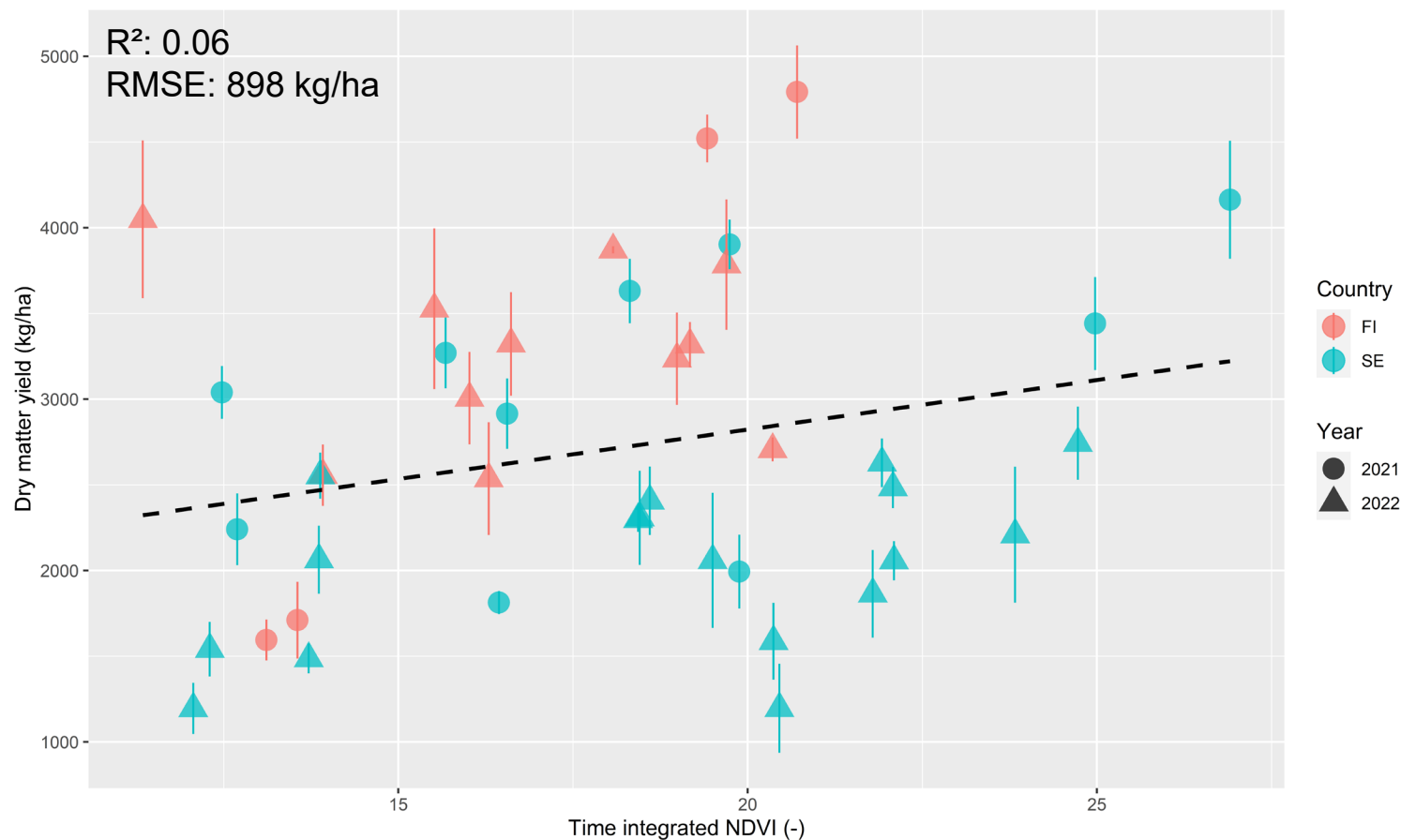


Sentinel-2, NDVI



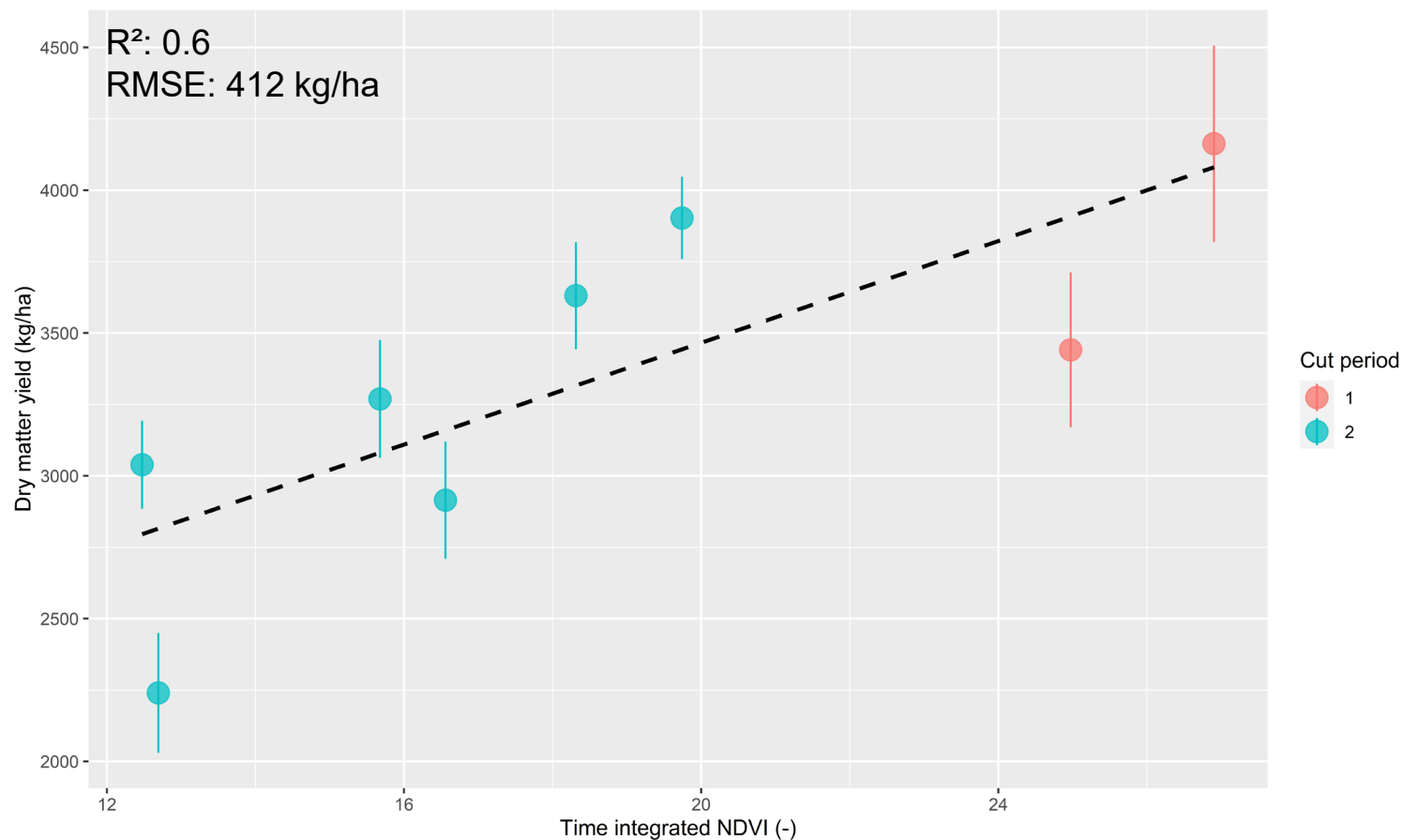


Sentinel-2, time-integrated NDVI



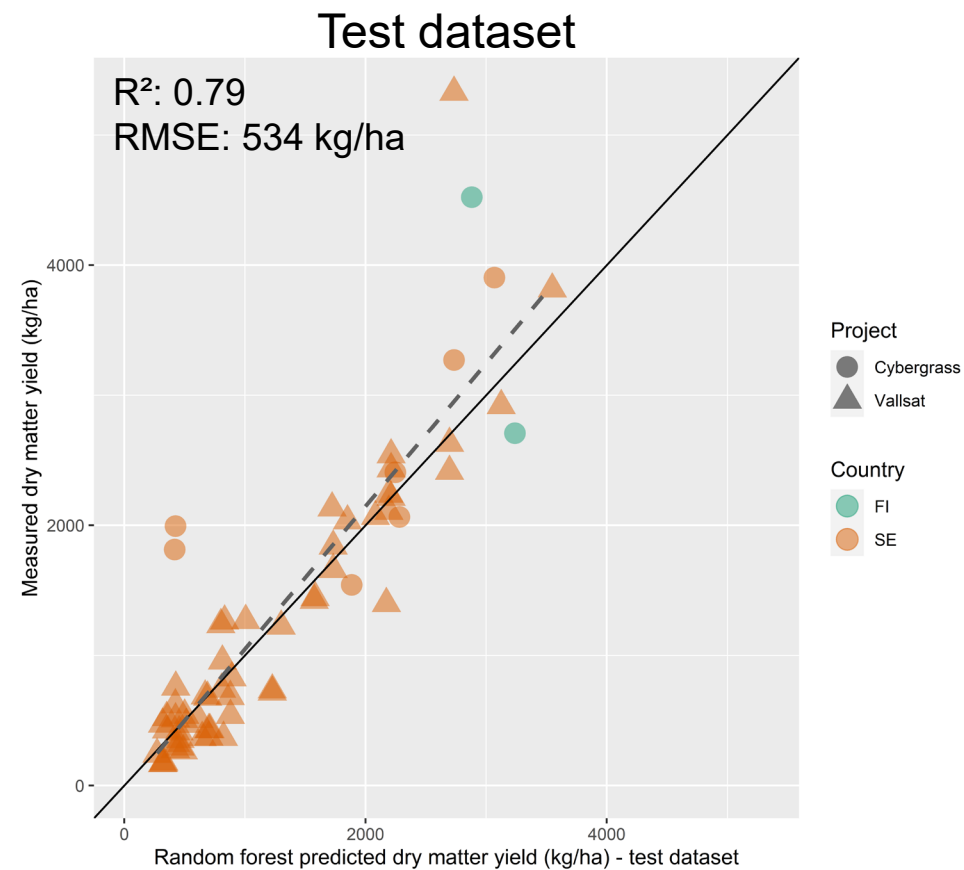
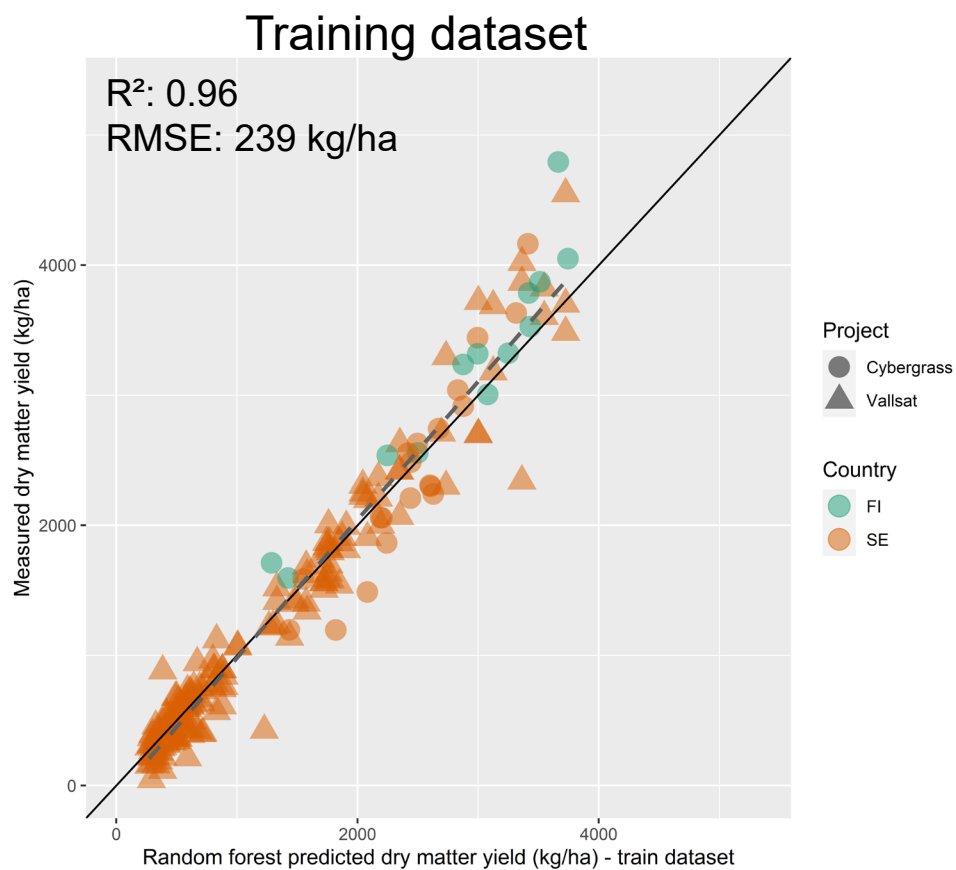


Sentinel-2, time-integrated NDVI (F17 2021, SE)

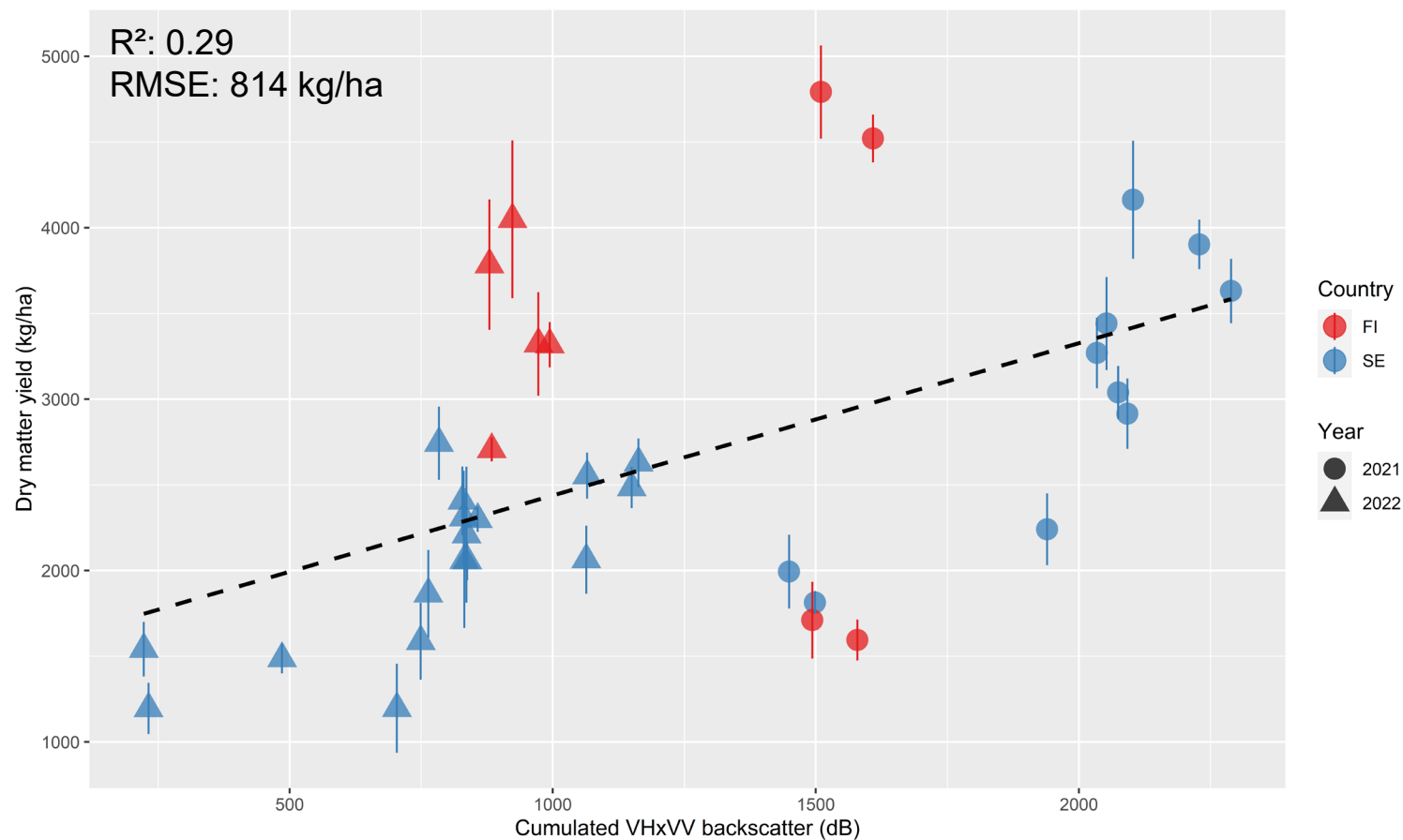




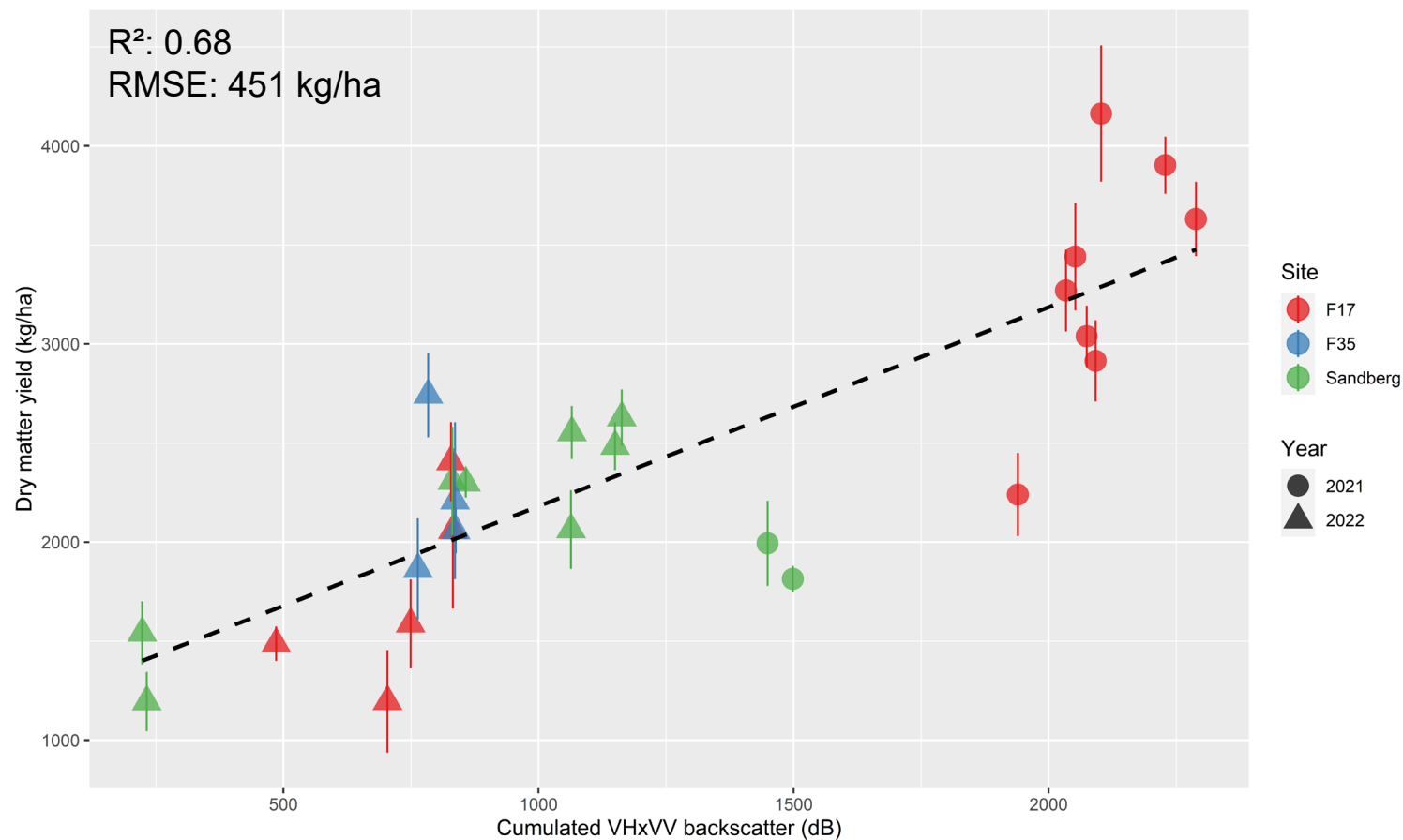
Sentinel-2 (Random Forest)



Sentinel-1, all data



Sentinel-1, Swedish data only



Summary of results

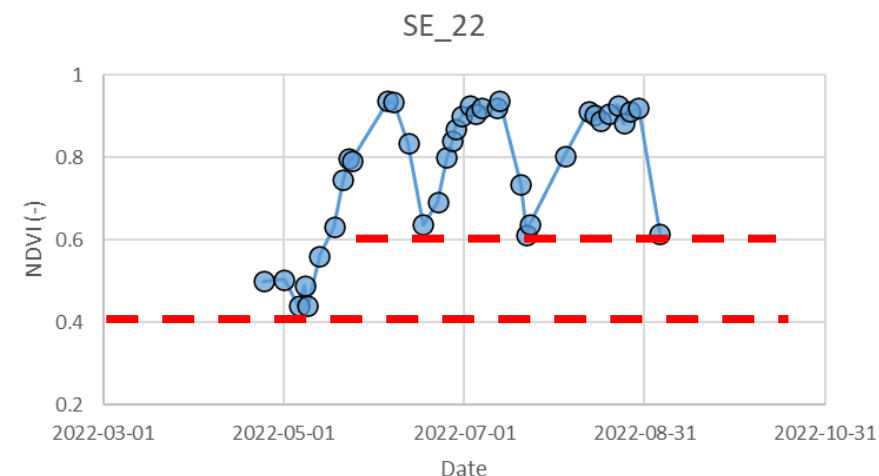
Variable	Model	R ²	Dataset	RMSE (kg/ha)
Vegetation indices	Linear regression	0.02	All	915
Time-integrated vegetation indices	Linear regression	0.06	All	898
Time-integrated vegetation indices	Linear regression	0.6	F17 2021 (SE)	412
Sentinel-2 spectral bands	Random forest	0.79	All + Vallsat	534
Time-integrated Sentinel-1 signal	Linear regression	0.29	All	814
Time-integrated Sentinel-1 signal	Linear regression	0.68	SE	451

Summary of results

- Vegetation indices: poor performances (saturation effect)
- Time integrated VIs: potentially strongly field-dependant, limitation for operational transfer
- Random forest machine learning: very good results, but limited transferability
- Time integrated radar signal: medium quality results but interesting prospects

Next steps

- Quadrats- vs strips-estimated dry matter yield
- Refining hypotheses for time integration of signal (when to start the integration? what is a good baseline value? etc.)
- Sentinel-1: effect of the angle of acquisition?
- Combining Sentinel-1 and Sentinel-2
- More data!



CONTACTS

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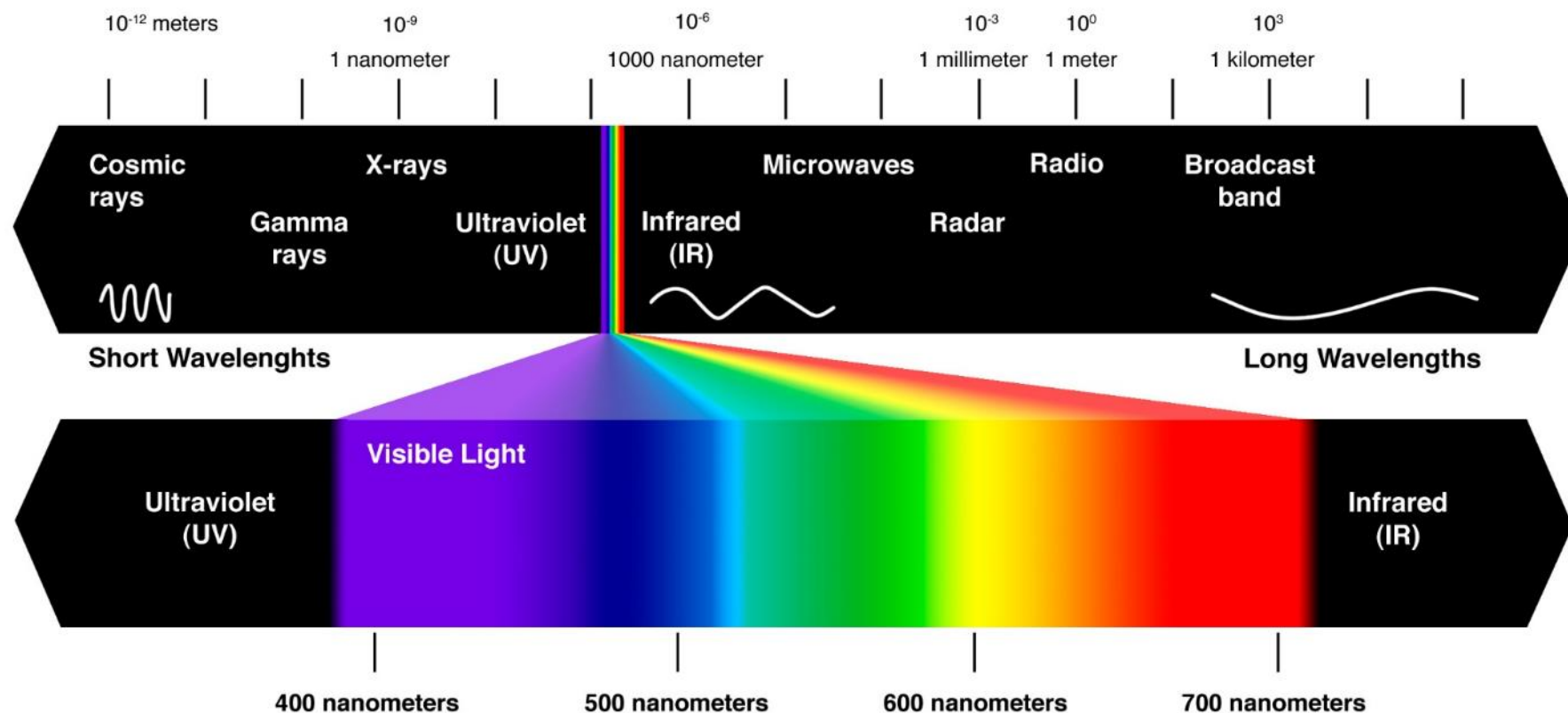
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Light spectrum



4. Results – Neutral detergent fiber

