

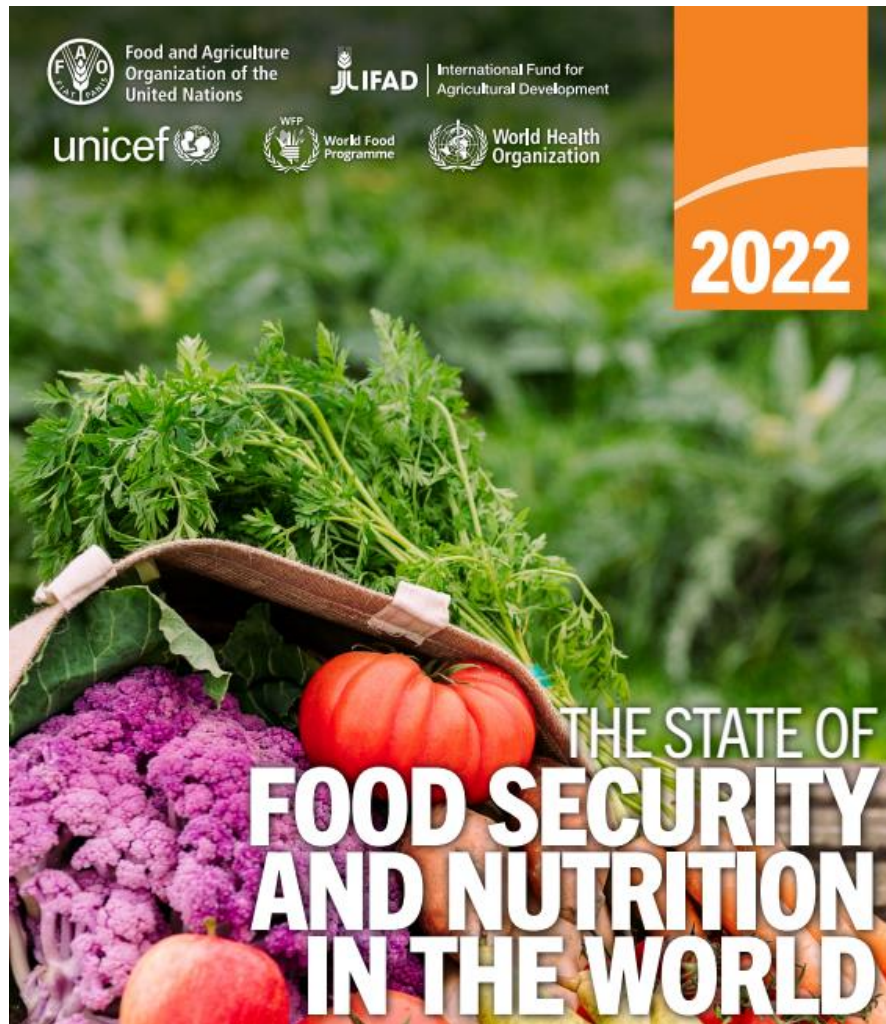
# Improved crop monitoring by removing clouds from Sentinel-2 time series

Kristof Van Tricht



# The food security challenge

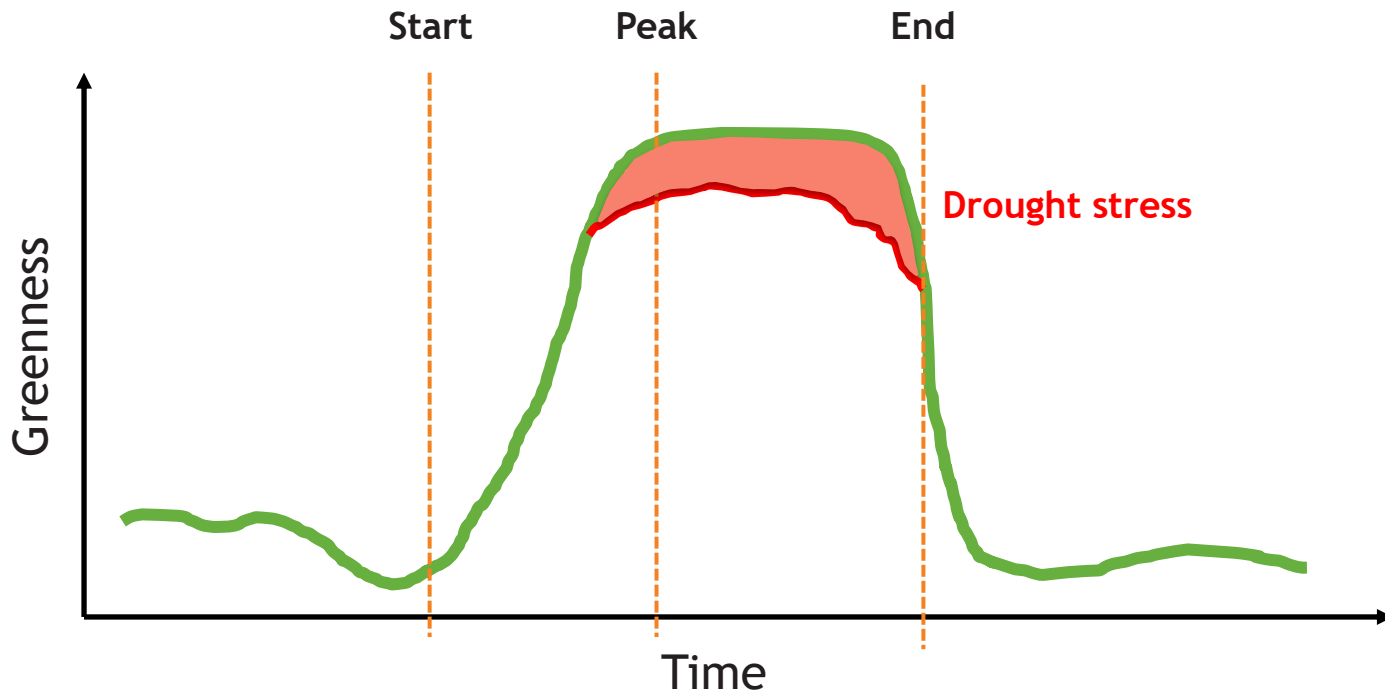
- 670 million people will still be facing hunger in 2030 - 8 percent of the world population (FAO, 2022)
- Agricultural expansion vs. intensification (Zabel et al., 2019)
- Closing the yield gap (Lobell et al., 2009)





# “Greenness” measured from space

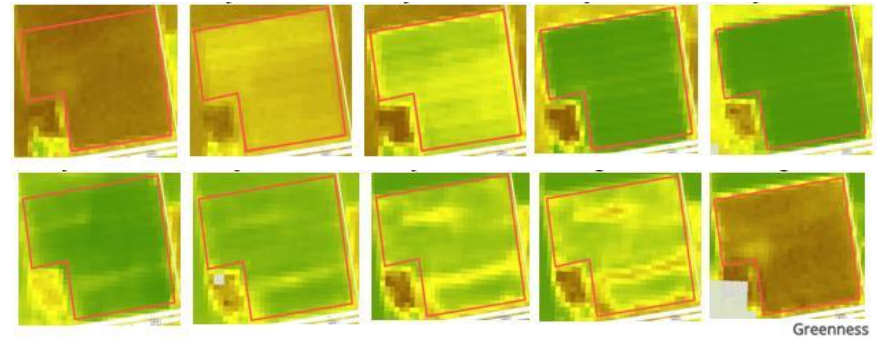
Monitoring can help closing the yield gap



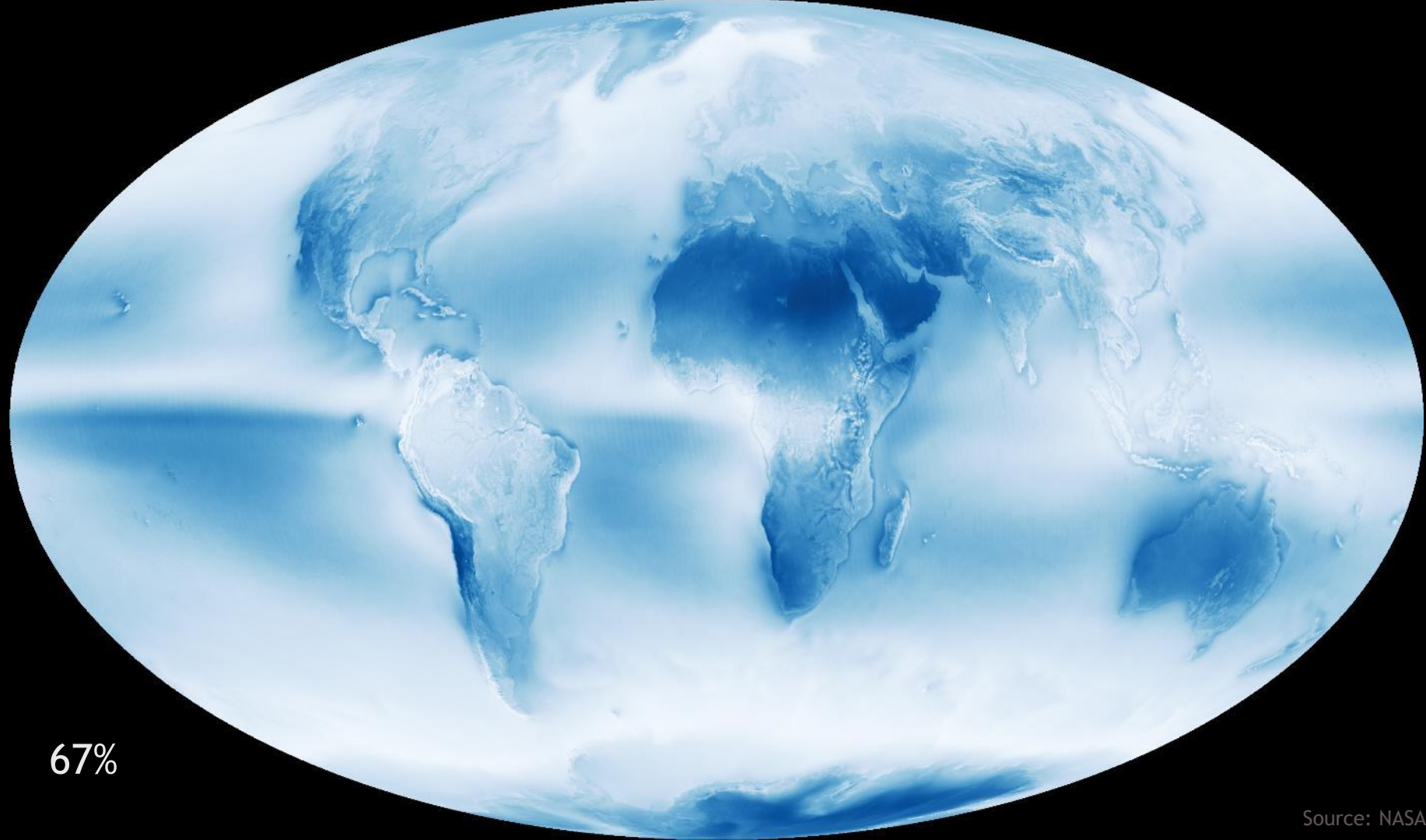


# “Greenness” measured from space

Monitoring can help closing the yield gap



<https://watchitgrow.be/>

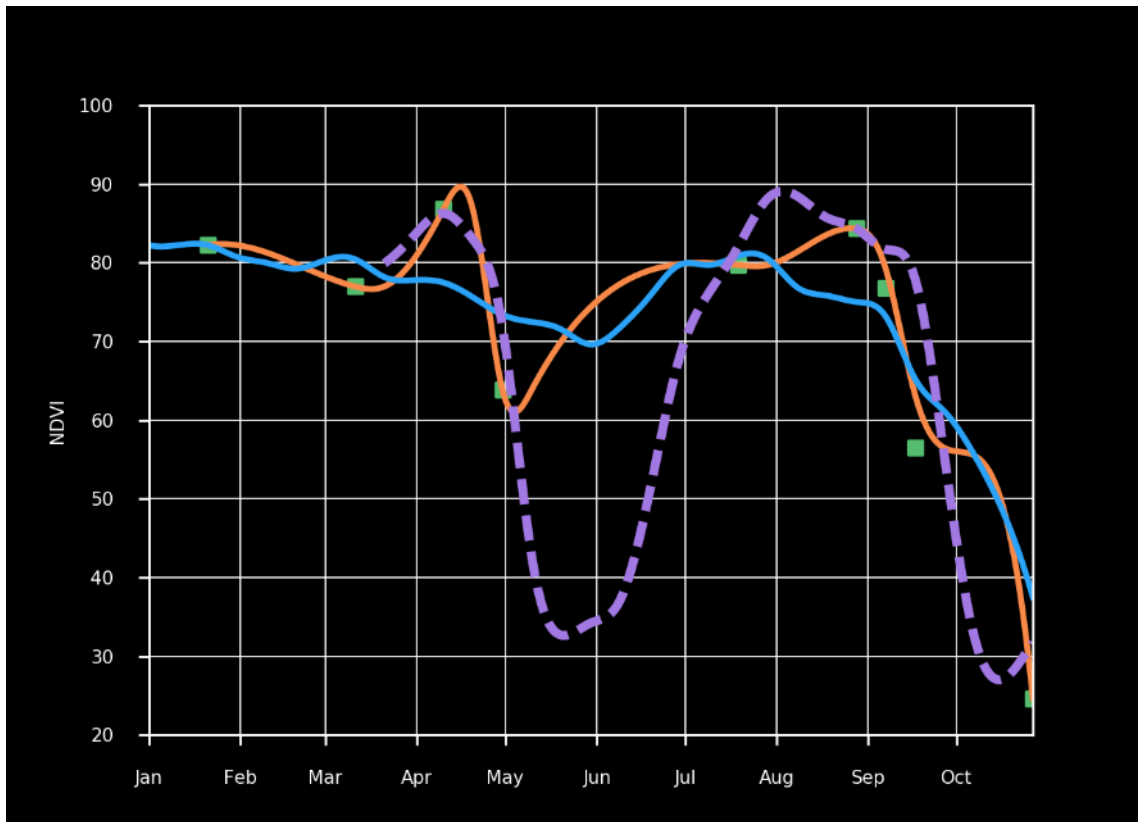


67%

Source: NASA



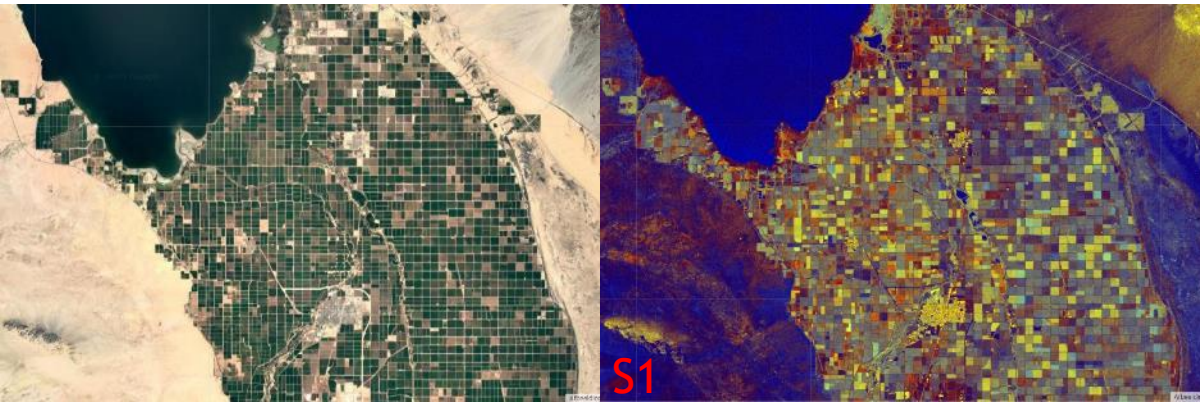
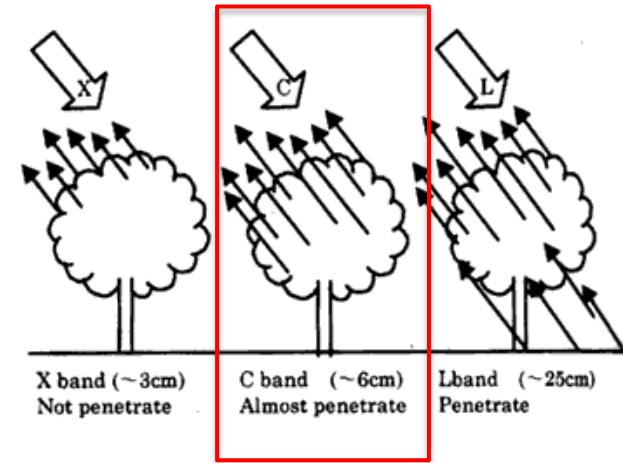
# The cloud problem

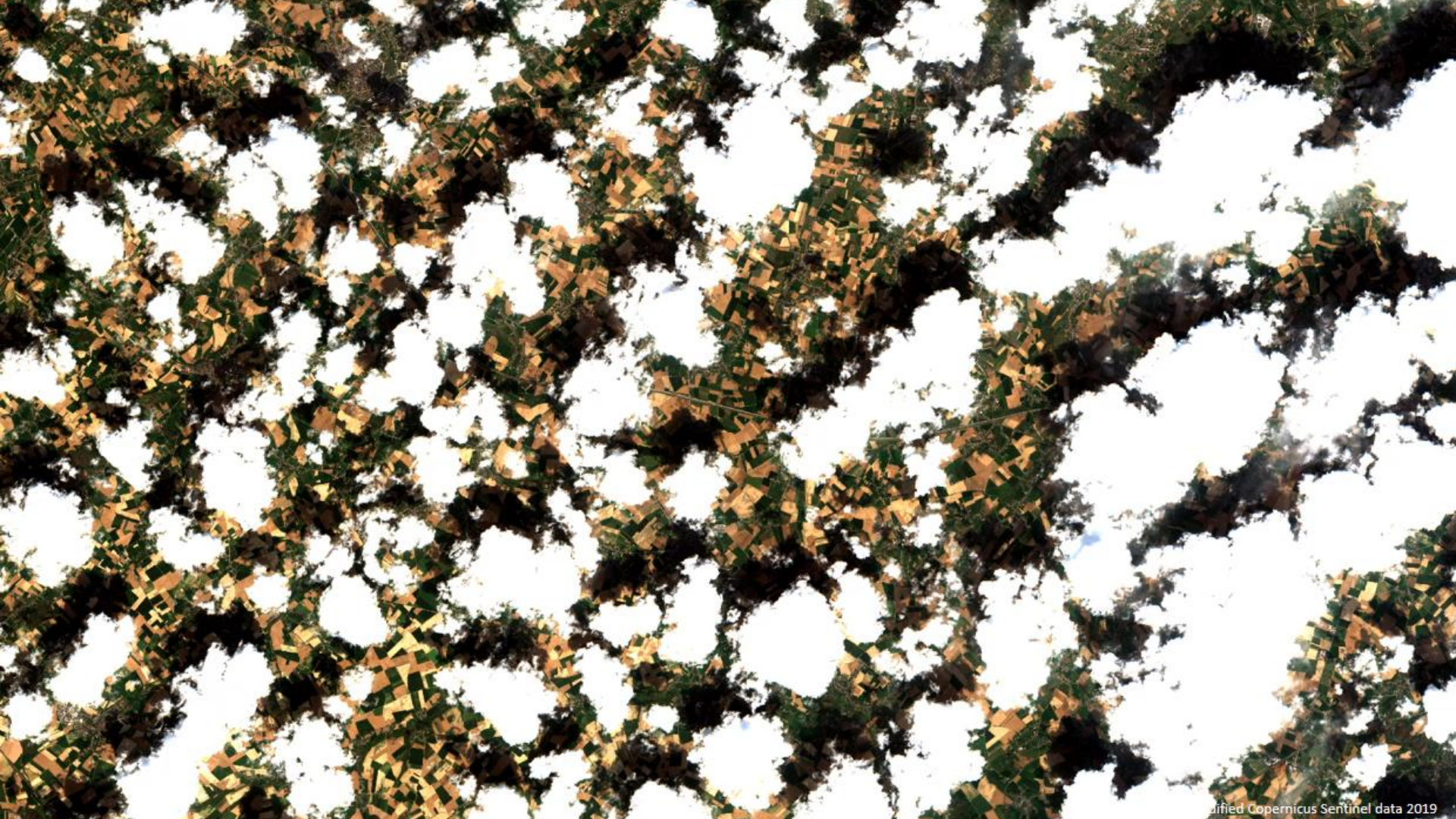




# Sentinel-1: SAR

- **Active sensor**, penetrating through clouds
- C-band radar ( $\lambda = 5.5$  cm), dual-polarization
- 6-day revisit, coverage in Europe every  $\sim 2$  days  
*(before the failure of Sentinel-1b)*
- Down to **10 m** pixel spacing
- Return signal is the result of complex interactions



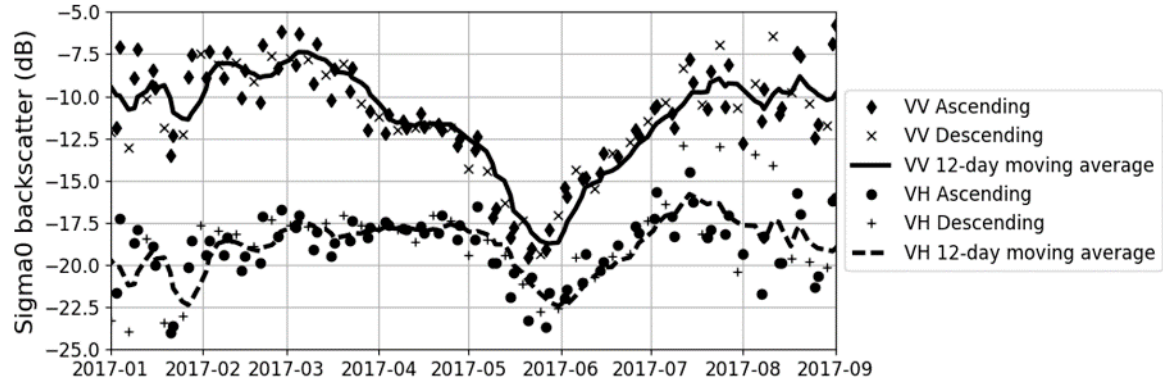
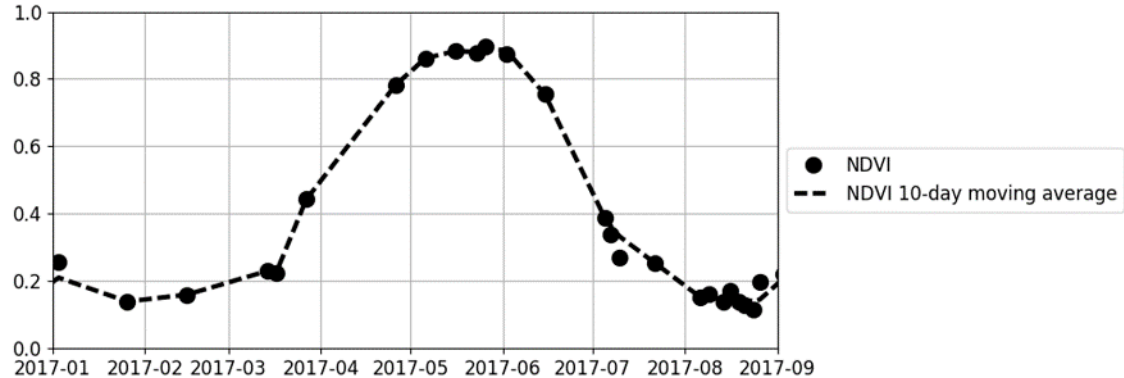






# Sentinel-1: Backscatter signatures

- Very diverse factors influence SAR backscatter
  - Crop type
  - Crop status
  - Soil conditions
  - Row orientation
  - ...
- Complex **non-unique** translation of backscatter signatures to crop status
- Opportunities for **machine learning techniques**

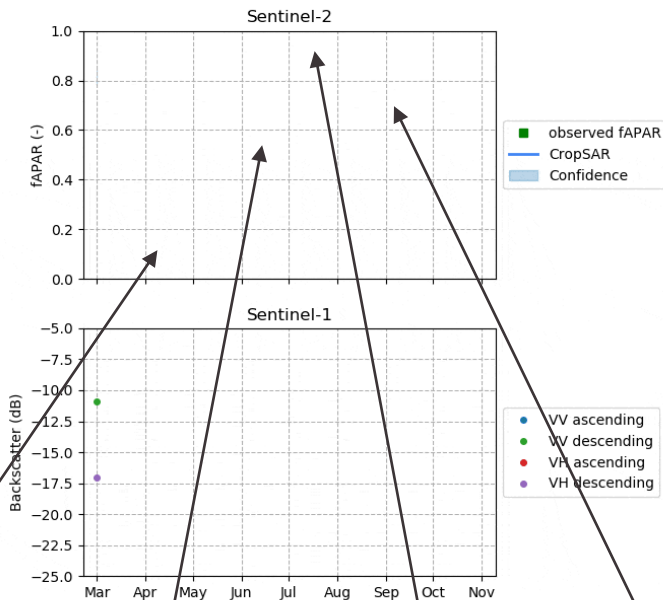




# CropSAR: S1-S2 fusion at the biopar product level

Sentinel-2  
interrupted

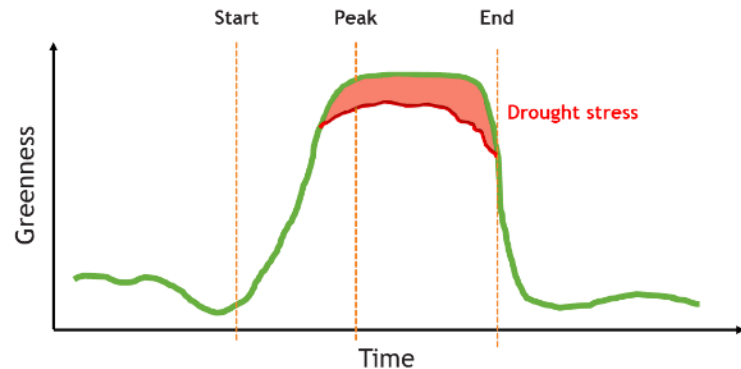
Sentinel-1  
uninterrupted



No  
Sentinel-2  
image

No  
Sentinel-2  
image

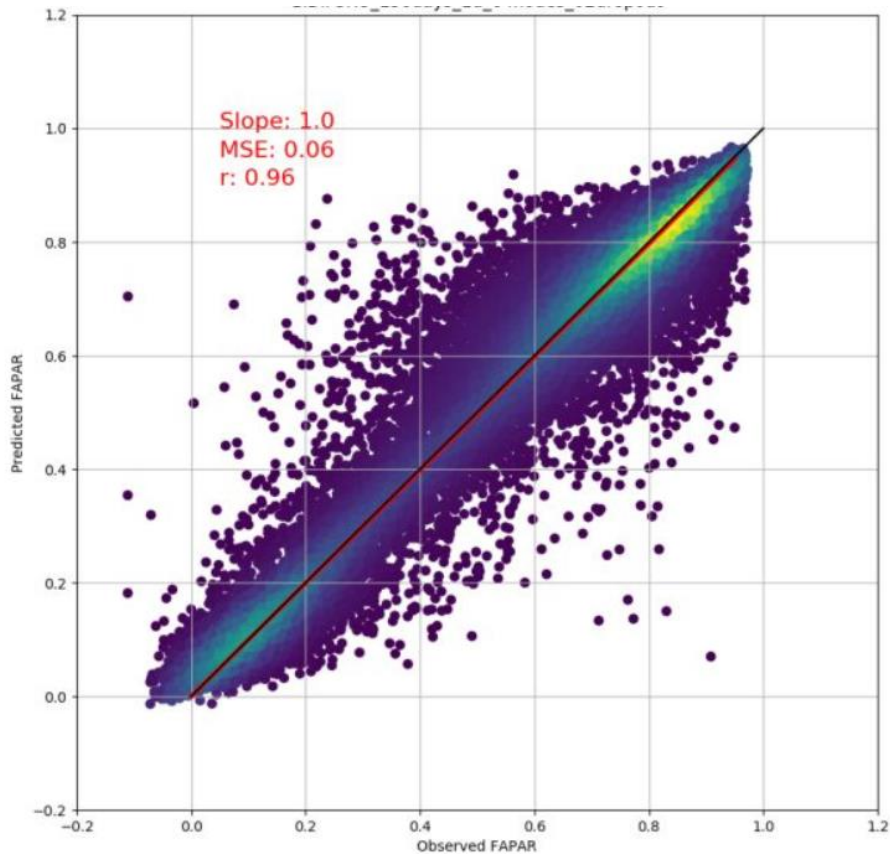
AI for multi-sensor  
solutions



Based on recurrent neural network



# A validated approach on time series



<https://cropsar.vito.be>

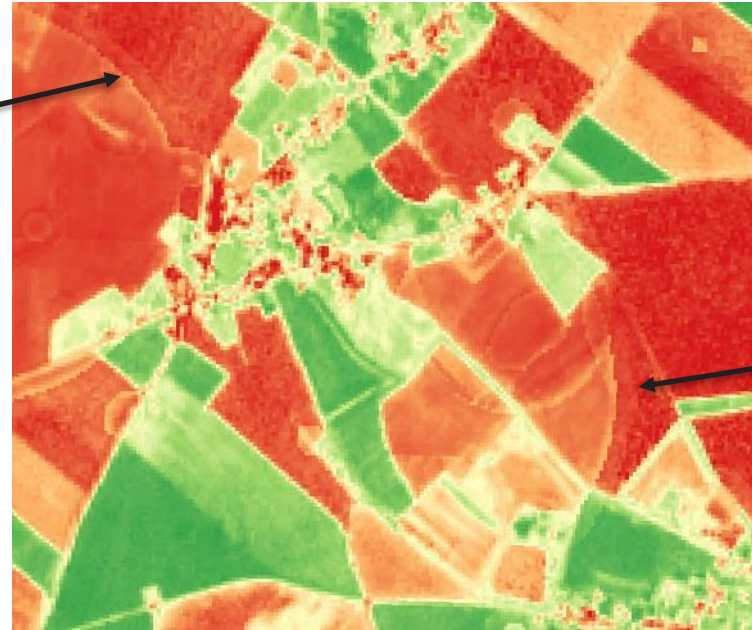




## Towards image level

Requires a completely different approach

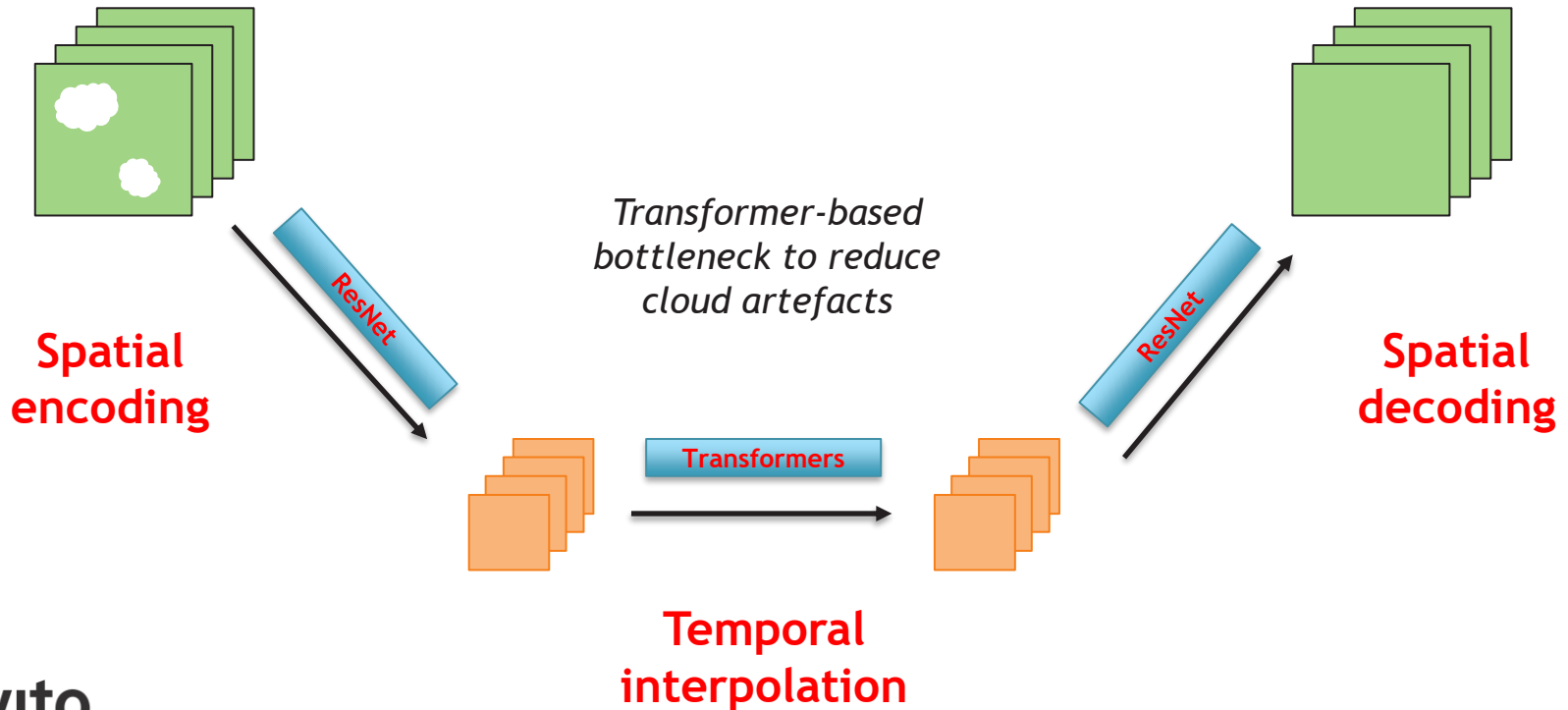
- Pixel signals are noisier than field averages
- Spatial artefacts are a real risk
- Computational efficiency matters





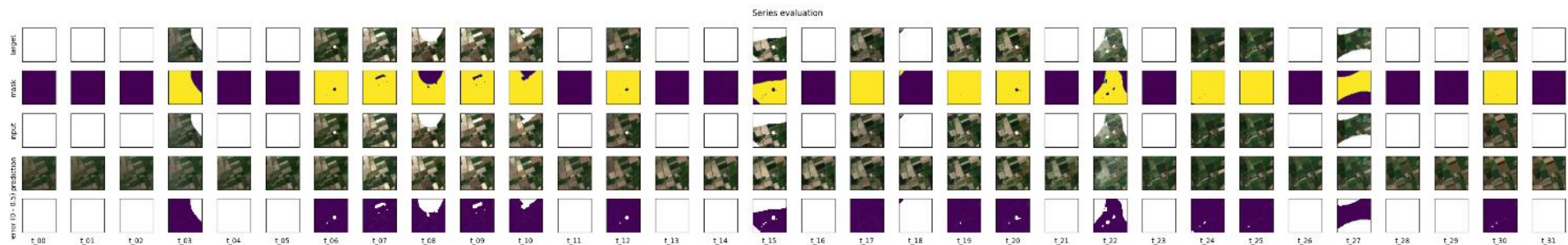
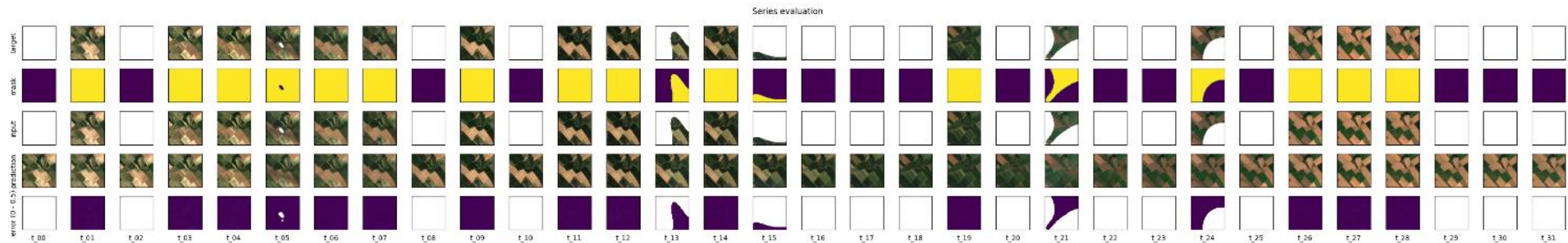
# Towards image level

Conceptual architecture overview





# Image-based CropSAR training

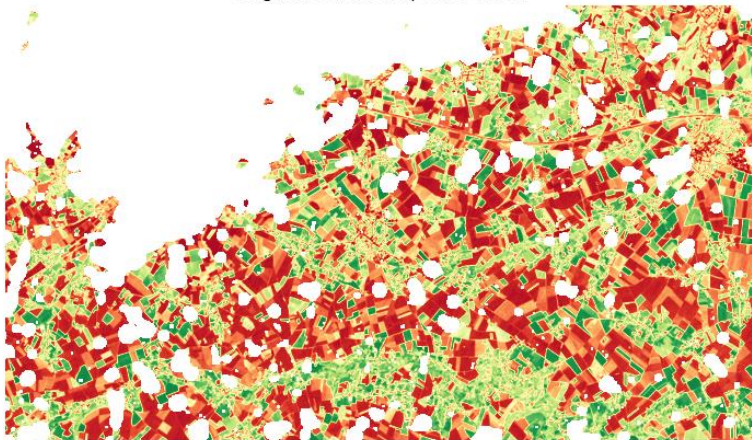




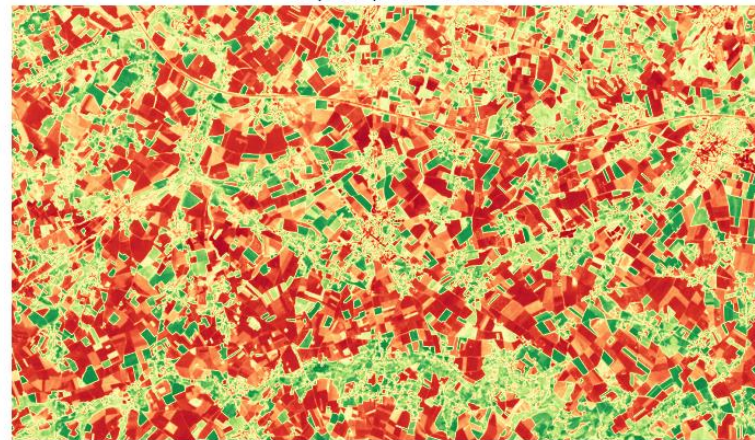
# Results: a comparison

1 year of  
5-day NDVI

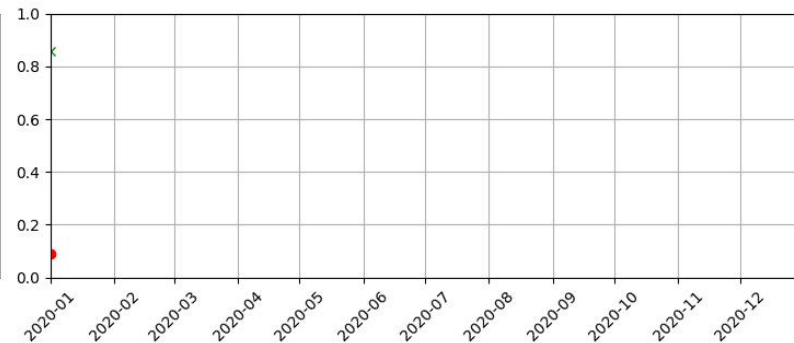
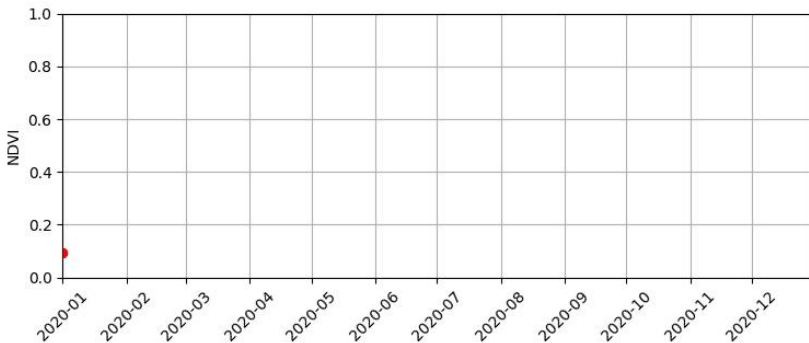
Original Sentinel-2 | 2020-01-01



CropSAR | 2020-01-01



Two example  
NDVI time  
series





# RGB as additional input and optional output

Original

CropSAR



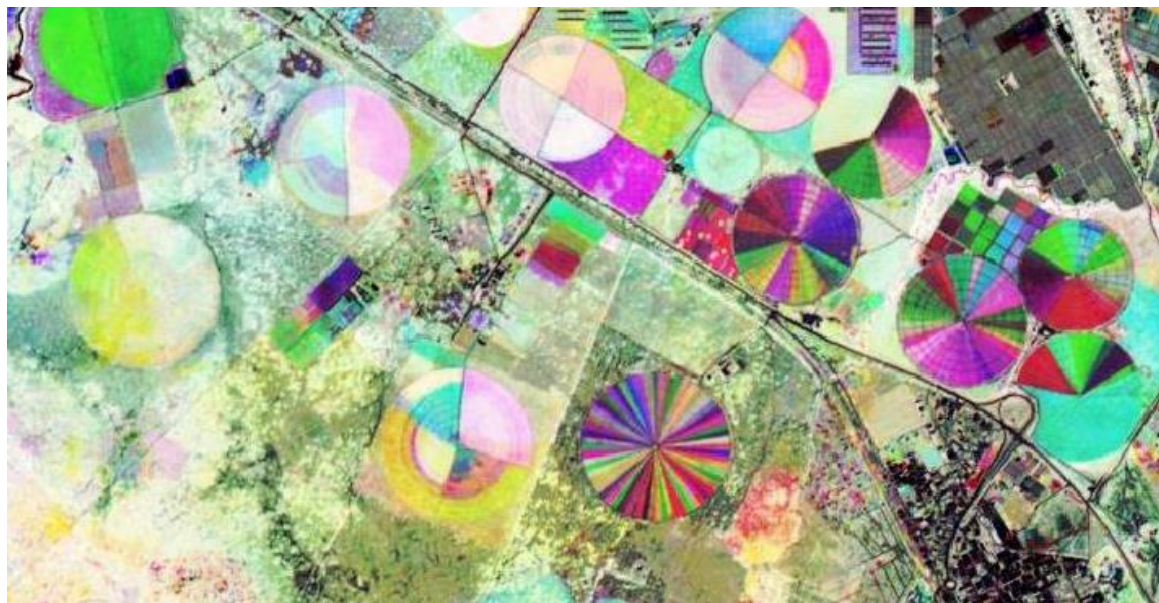




## Initial tests in challenging region

### 5-day NDVI L3 cube

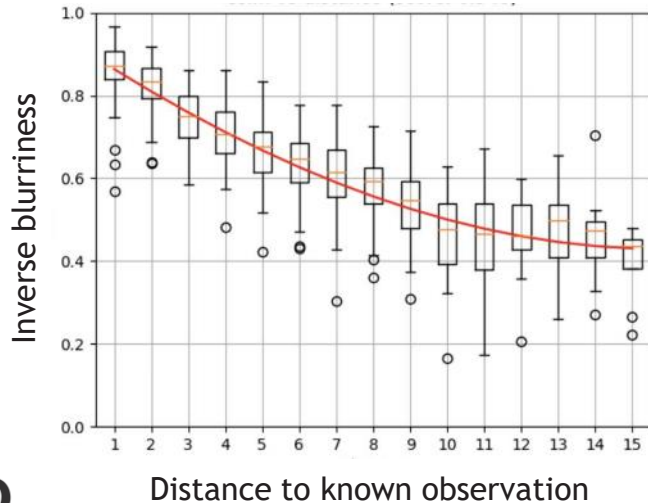
First successful tests on  
Tanzania with OpenEO





## Known issues

- While transformer bottleneck gets rid of artefacts, the lack of spatial skip connections causes **blurriness**
- Unmasked input **noise** is often faithfully **reproduced**



Original



CropSAR

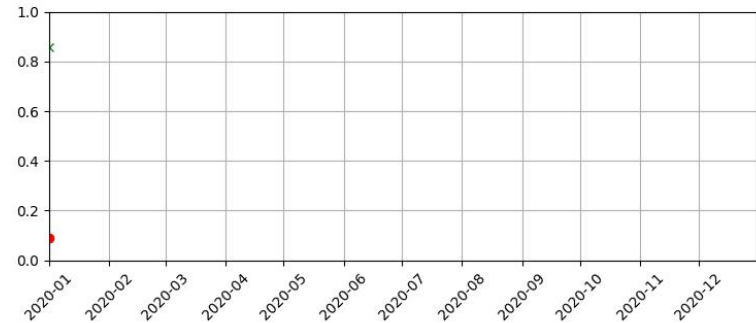
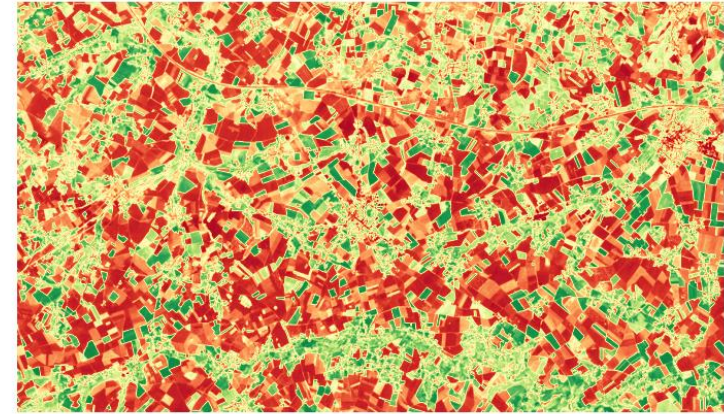




# Conclusions and next steps

- Workflow **scalability** needs to be considered from design phase
- **Transformers** bottleneck has powerful inpainting skills
- **Blurriness** and **noise reconstruction** are known issues
- Non-uniqueness of backscatter signature requires **multi-modal** approach

CropSAR | 2020-01-01



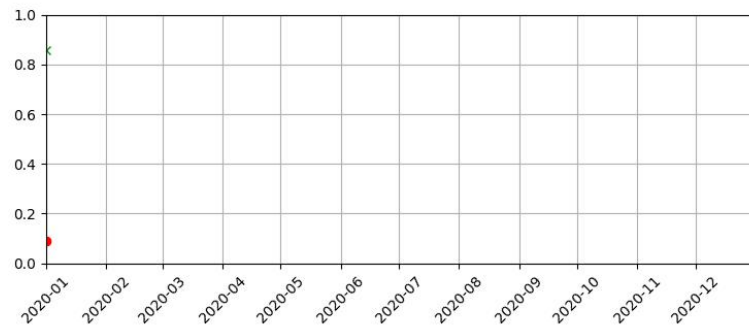
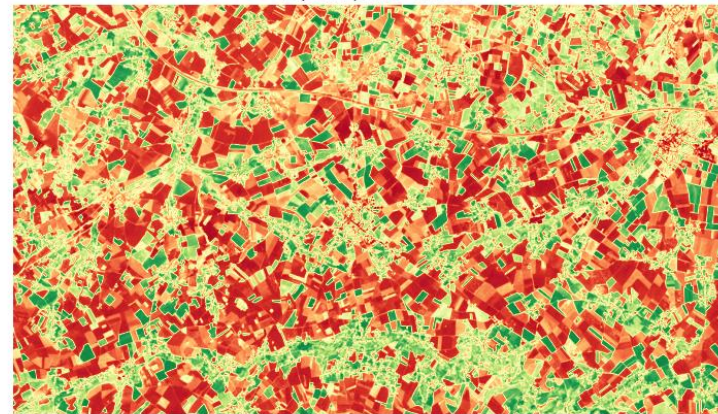


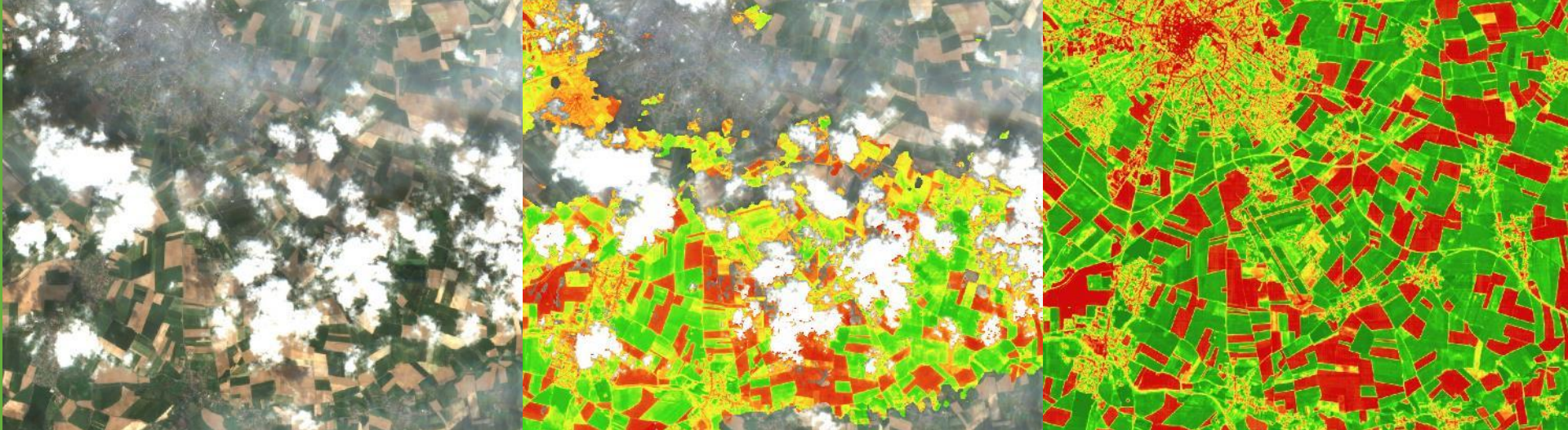
# Conclusions and next steps

- Potential of **refinement network** or **GAN** training to resolve blurriness
- Additional **validation** efforts required with specific emphasis on **NRT** applications
- Added value assessment for **downstream applications**
- Extensive testing of **OpenEO CropSAR** process



CropSAR | 2020-01-01





Thank you

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 [@K\\_VanTricht](https://twitter.com/K_VanTricht)