

Integrating multimodal satellite data, field photos, and
AI to go beyond traditional mapping



CLAUDIA PARIS

Google Earth Timelapse

Obispo Santistevan, Bolivia

1984

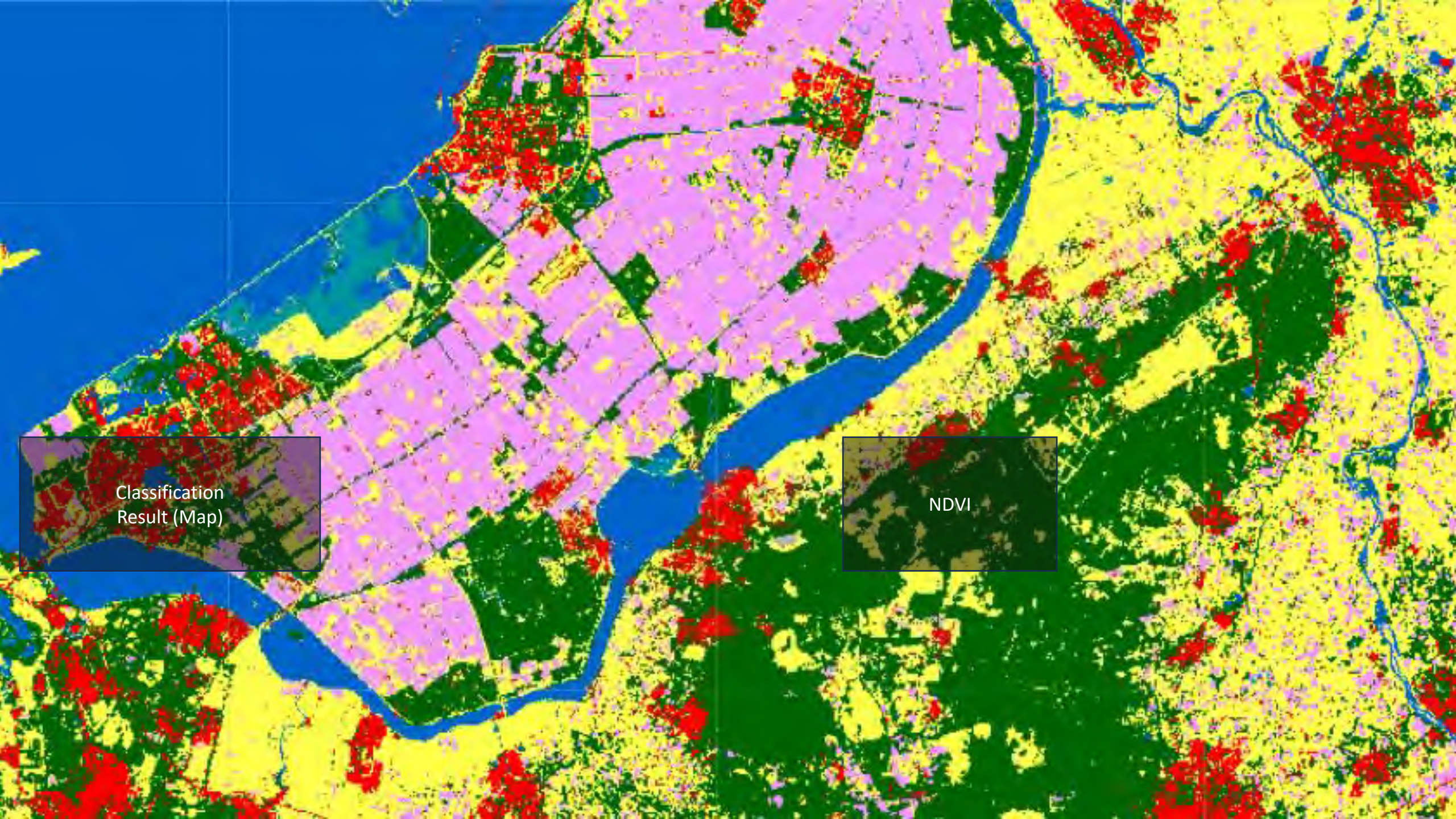


Google Earth Timelapse
Al Khiran, Kuwait
1984



Google Earth Timelapse
Chongqing, China
1984





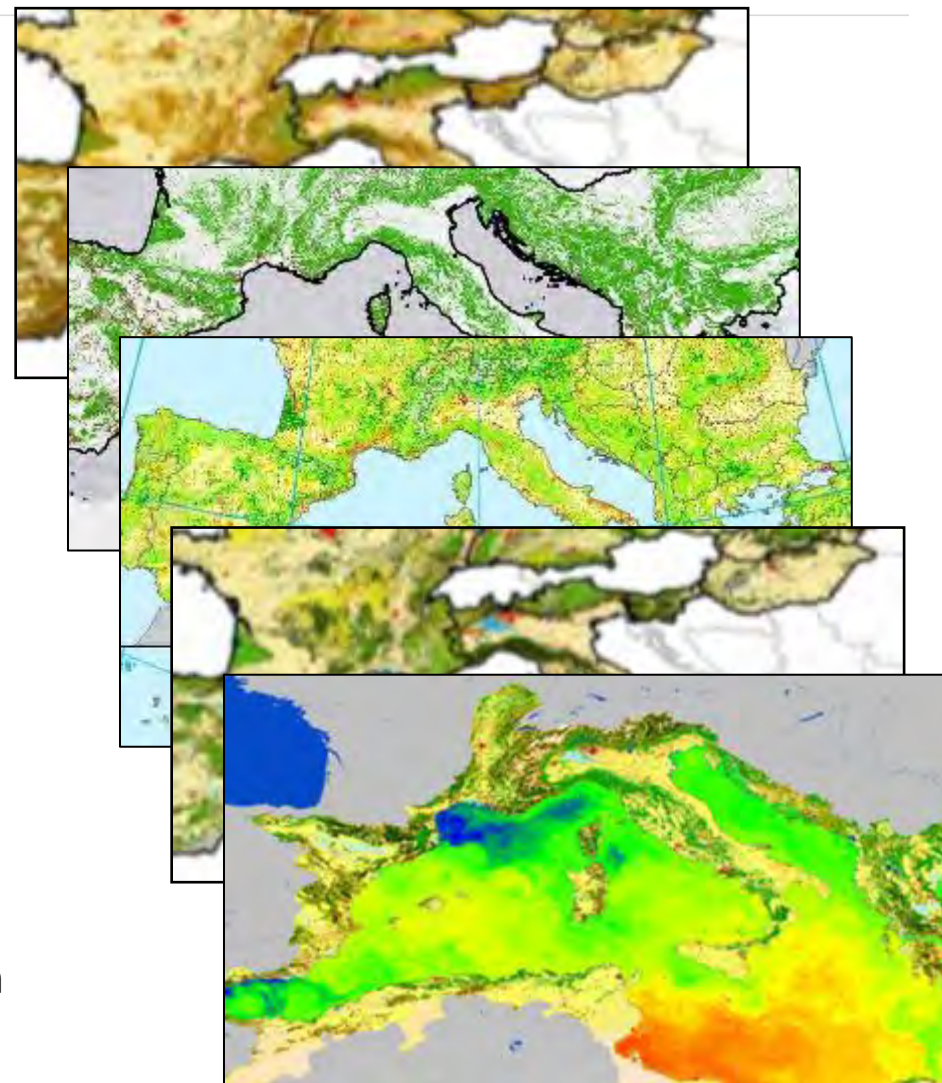
Classification
Result (Map)

NDVI

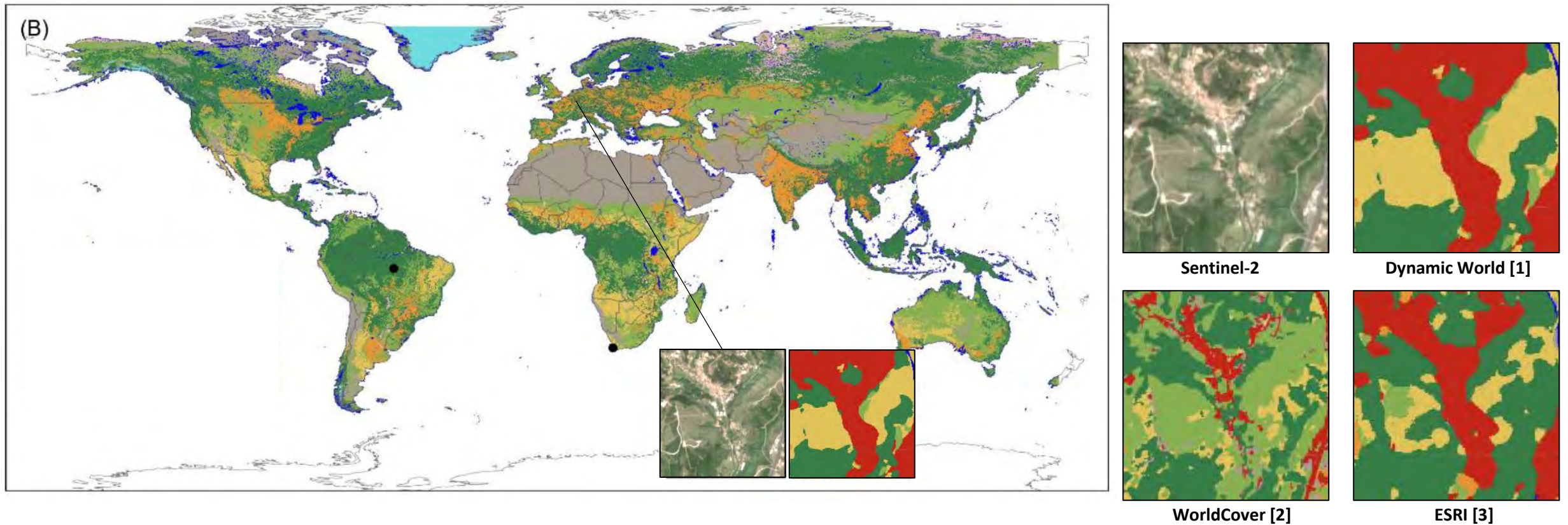
Global Land Cover Maps

Maps Available	Year	Spatial Res.	Coverage
IGBP-DISCover	1993	1 km	Global
University of Maryland land cover	1998	1 km	Global
ECOCLIMATE II	2007	1 km	Global
GlobCover	2010	300 m	Global
GlobeLand30	2010	30 m	Global
MODIS GLC	2012	500 m	Global
GLC-SHARE 2014 (old GLC-2000)	2014	1 km	Global
Copernicus Global Land Cover Map	2015	100 m	Global
ESA CCI Land cover Map	2015	300 m	Global
Corine Land Cover (CLC) Map	2018	100 m	Europe
ESA WorldCover	2020	10 m	Global
Dynamic World	2022	10 m	Global
ESRI	2022	10 m	Global

High
Resolution



High Resolution Global Land Cover Maps



- [1] Brown, C. F., Brumby, S. P., Guzder-Williams, B., Birch, T., Hyde, S. B., Mazzariello, J., Czerwinski, W., Pasquarella, V. J., Haertel, R., Ilyushchenko, S., et al., "Dynamic world, near real-time global 10 m land use land cover mapping," *Scientific Data* 9(1), 251 (2022).
- [2] Karra, K., Kontgis, C., Statman-Weil, Z., Mazzariello, J. C., Mathis, M., and Brumby, S. P., "Global land use/land cover with sentinel 2 and deep learning," in [2021 IEEE international geoscience and remote sensing symposium IGARSS], 4704–4707, IEEE (2021).
- [3] Venter, Z. S., Barton, D. N., Chakraborty, T., Simensen, T., and Singh, G., "Global 10 m land use land cover datasets: A comparison of dynamic world, world cover and esri land cover," *Remote Sensing* 14(16), 4101 (2022).

Geo-Foundation Models

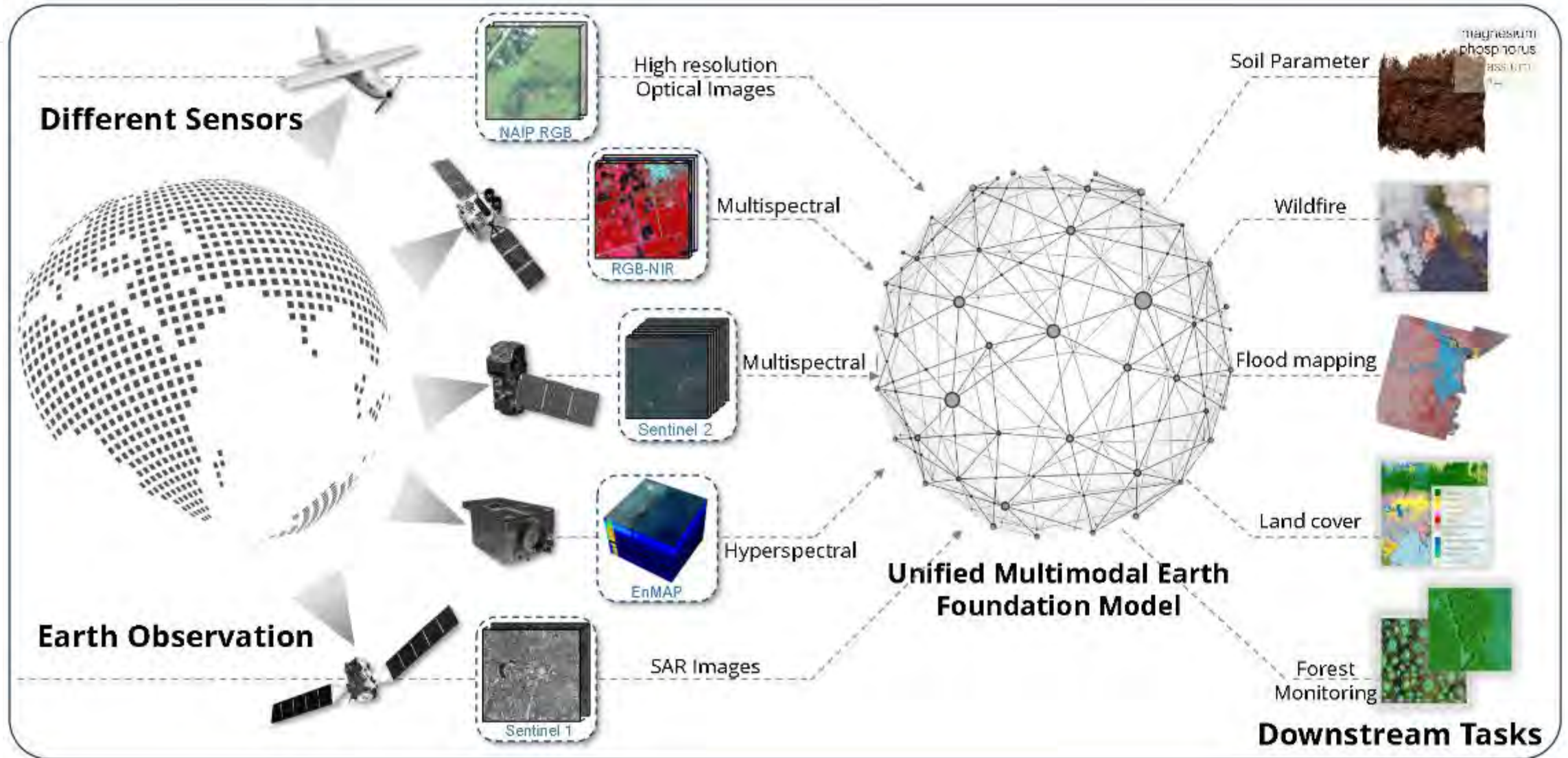


Image credit: Xiong, Z., Wang, Y., Zhang, F., Stewart, A.J., Hanna, J., Borth, D., Papoutsis, I., Saux, B.L., Camps-Valls, G., & Zhu, X.X. (2024). Neural Plasticity-Inspired Foundation Model for Observing the Earth Crossing Modalities. *ArXiv*, abs/2403.15356.



2021

● Annual cropland

Annual

● Winter cereals

Winter

● Spring cereals

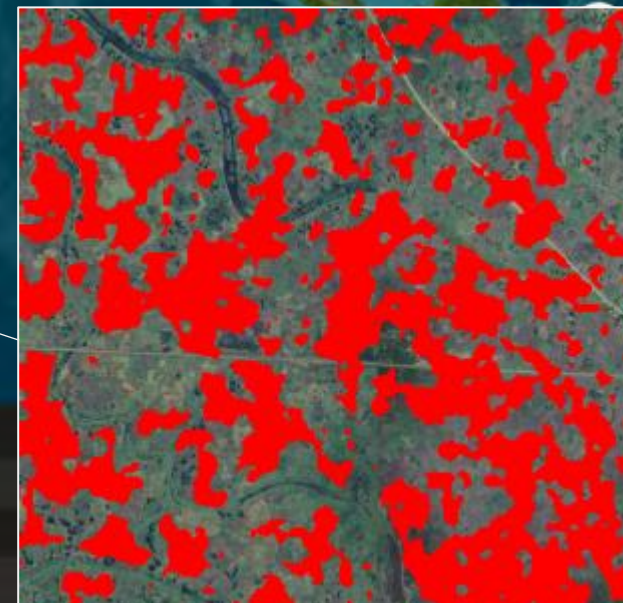
Summer1

Annual cropland
Annual - 2021



Netherlands

Mozambique



Look at | Background map: Esri, USGS, Esri, Garmin, FAO, Esri, Garmin, FAO, Esri, Garmin, FAO

1,000 km

2021

Annual cropland

Annual

Winter cereals

Winter

Spring cereals

Summer1

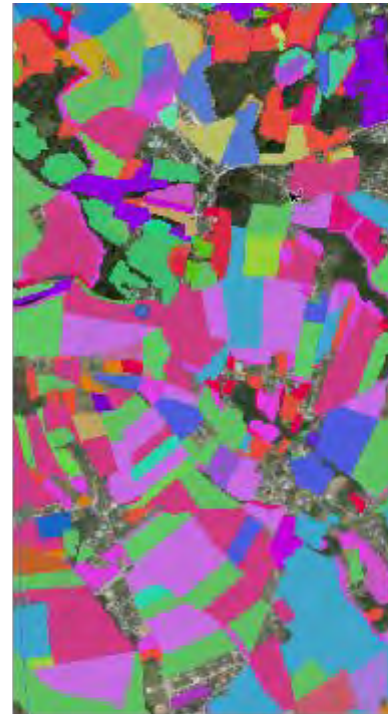
Geospatial Reference Data: Aging fast!

In-situ measurements

- ✓ Based on *field observations*.
- ✓ Constrained by *lack of access* to remote areas.
- ✓ Extremely *costly* and *time consuming*.

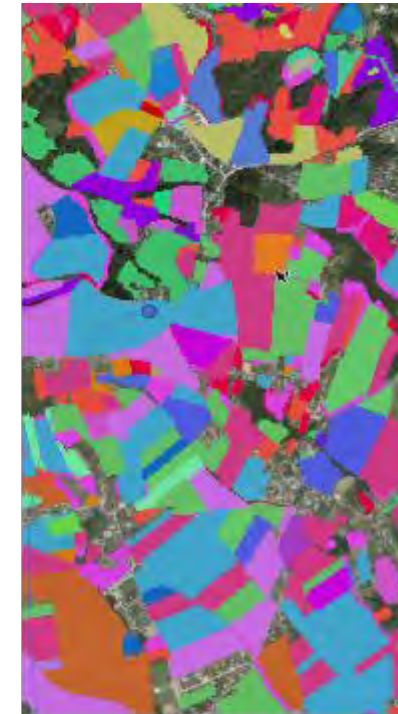


HR image



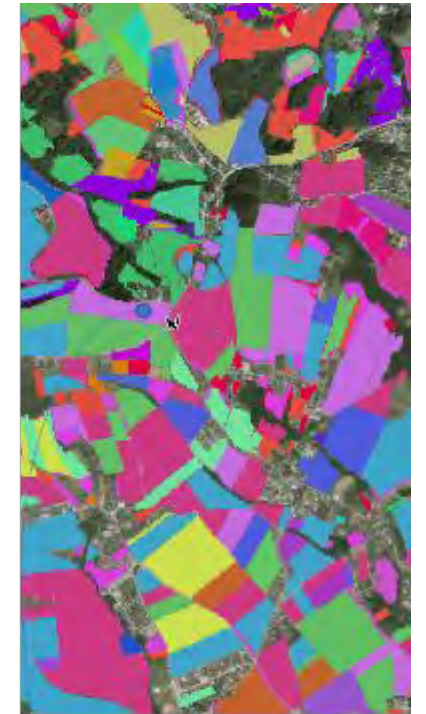
2018

Winter Wheat



2019

Maize



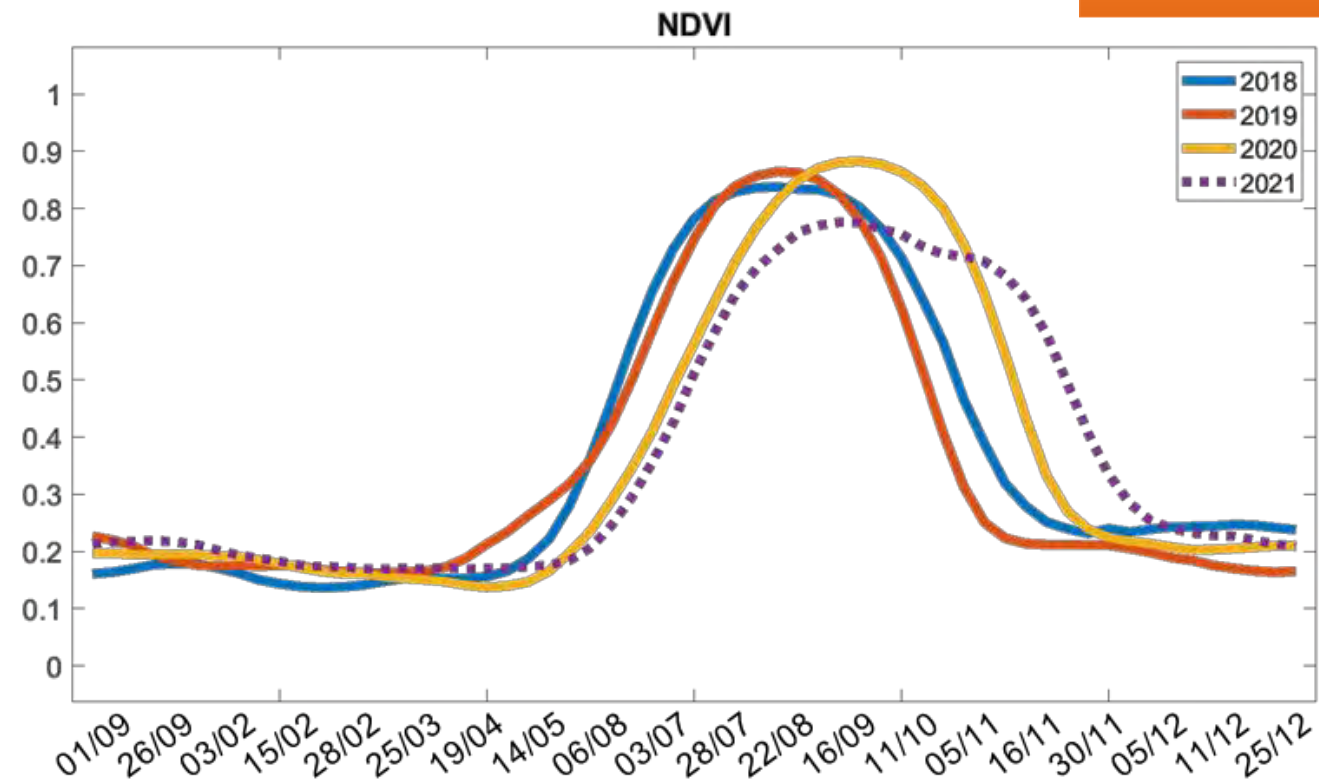
2020

Winter Barley

Geospatial labeled data: generalization problem!



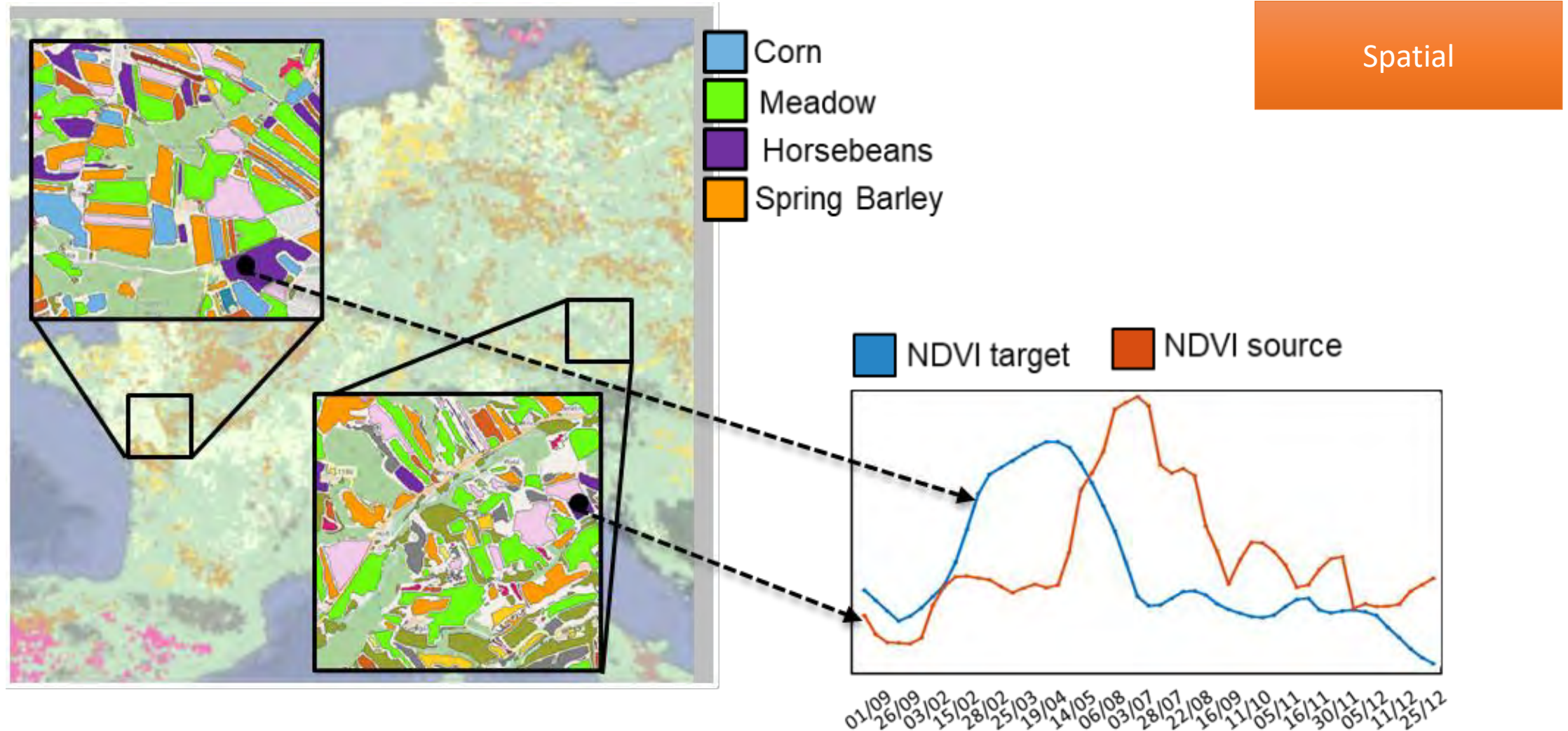
HR image



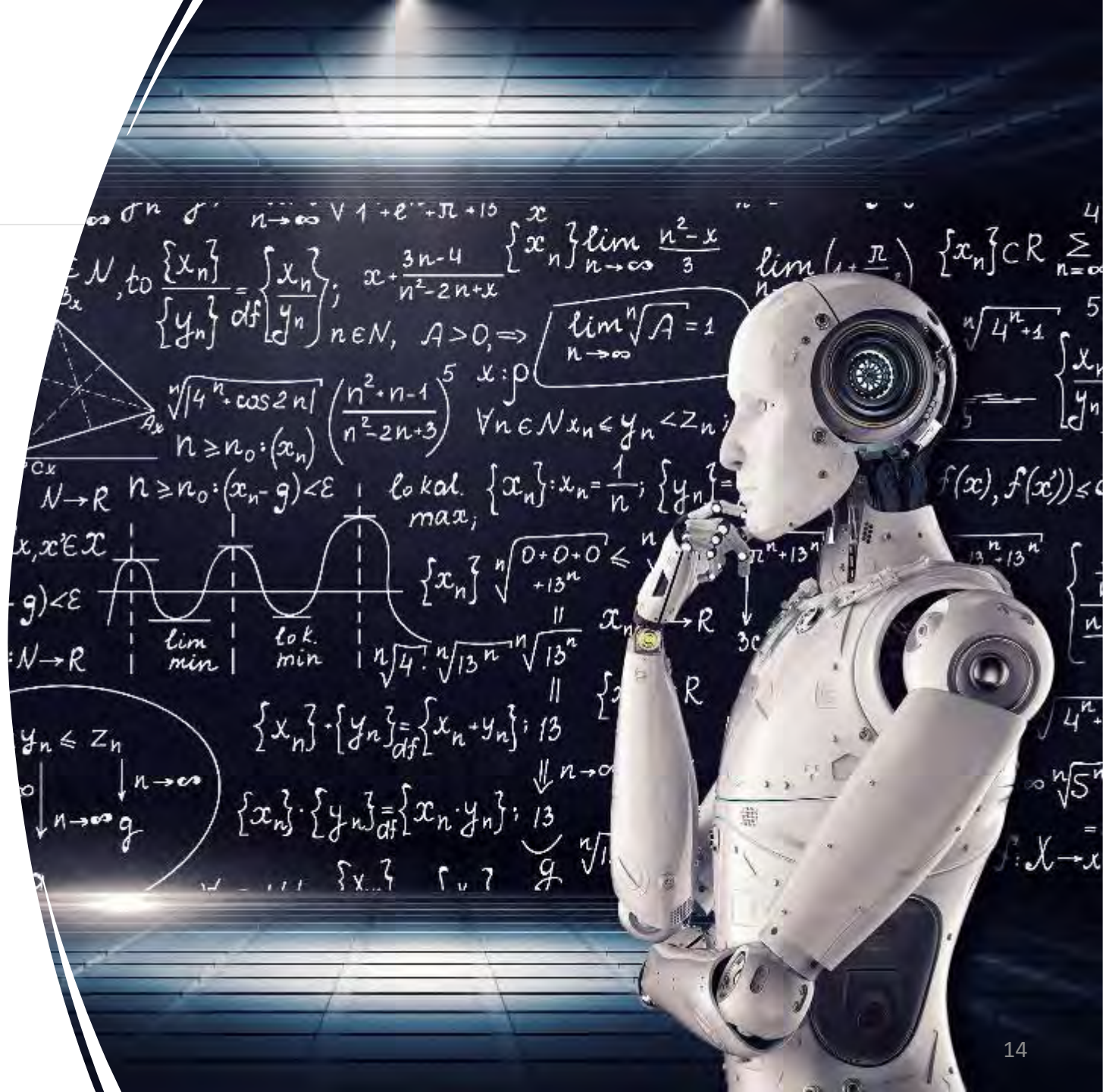
variability in climate and cultivars (same crop)

Temporal

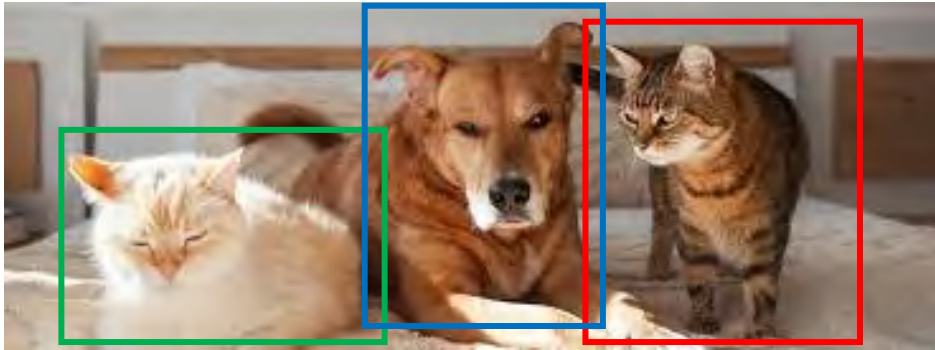
Geospatial labeled data: generalization problem!



Big Satellite Data vs Limited Labeled Data



Reference data: CV community



Where are the animals in this image?

Which pixels belong to which animal?



Is this a dog?



Geospatial labeled data: Complex Semantic



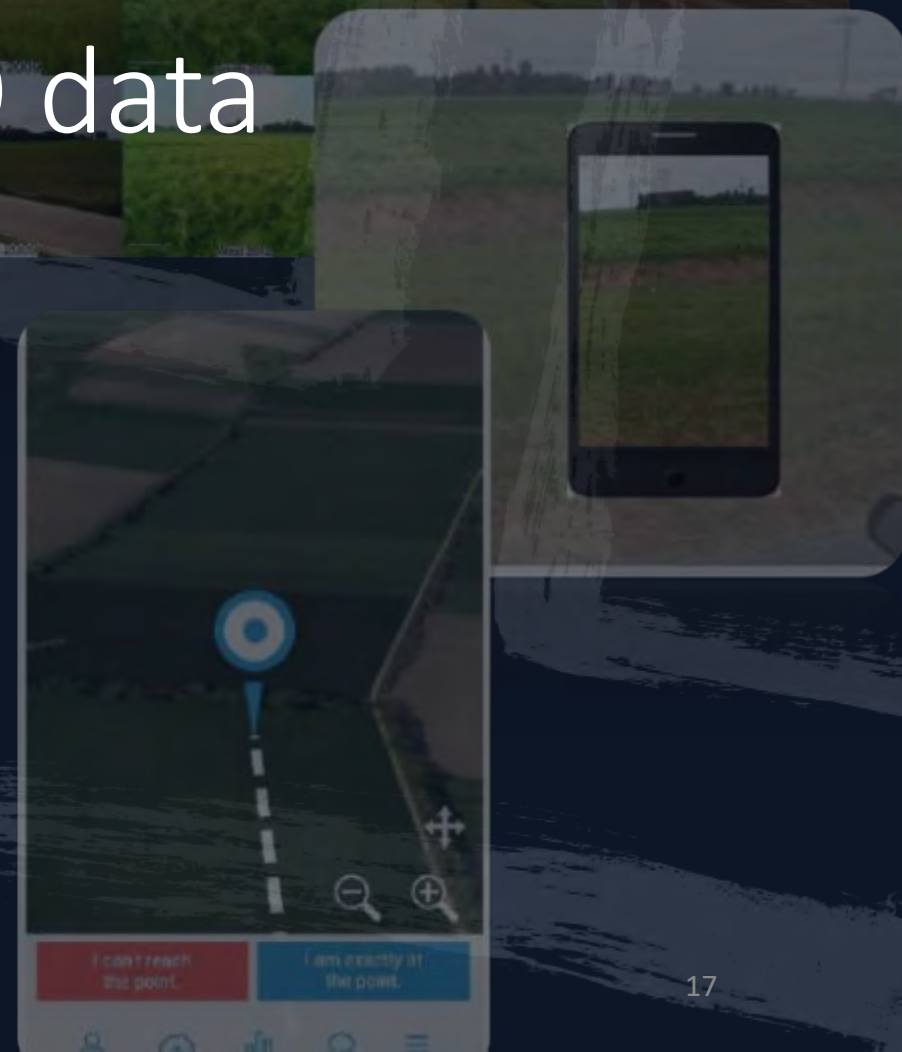
What is the biodiversity of this landscape?



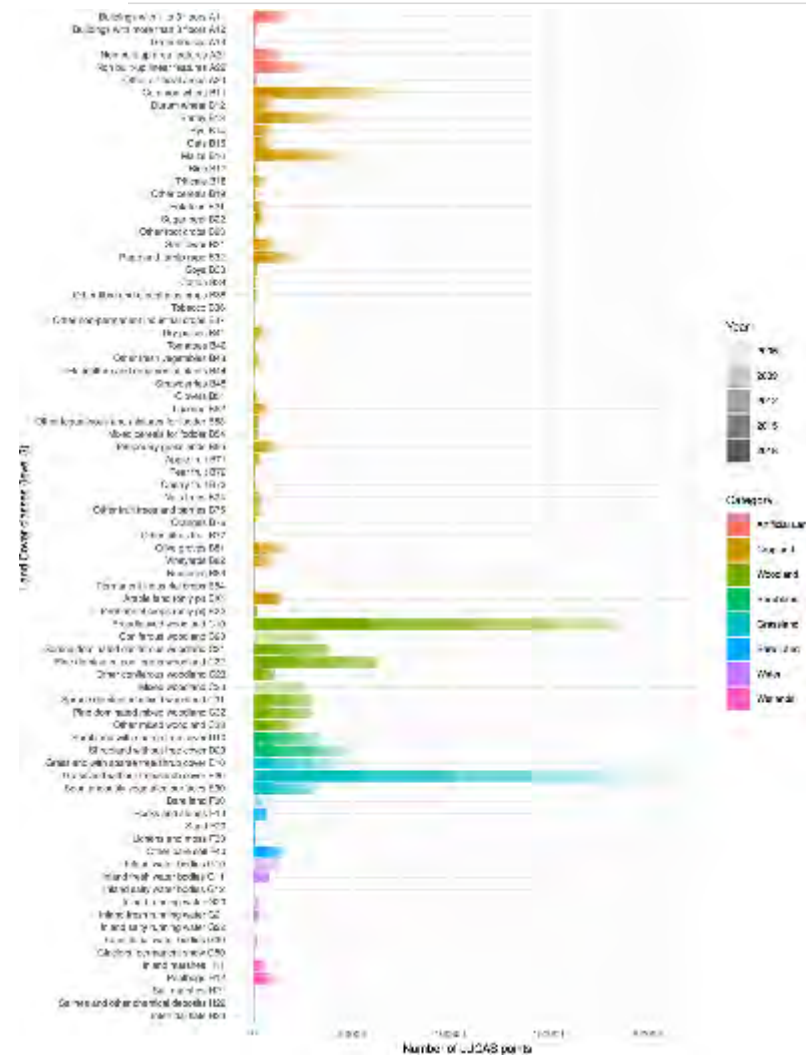
Which crops are present in the scene?

Multimodal Data...

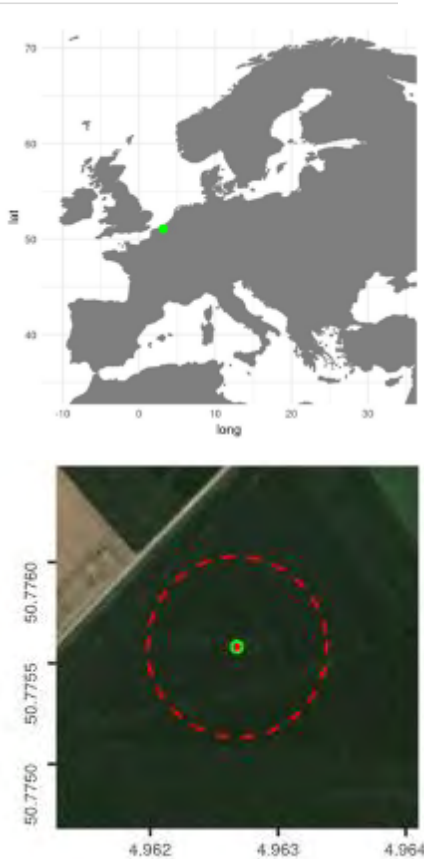
.... for getting insight on EO data



In-situ Measurements: LUCAS database



Year	2006	2009	2012	2015	2018
Land Cover	Wheat	Barley	Barley	Wheat	Wheat



Land Use/Cover Area frame statistical Survey

Multimodal Perspective



East



South



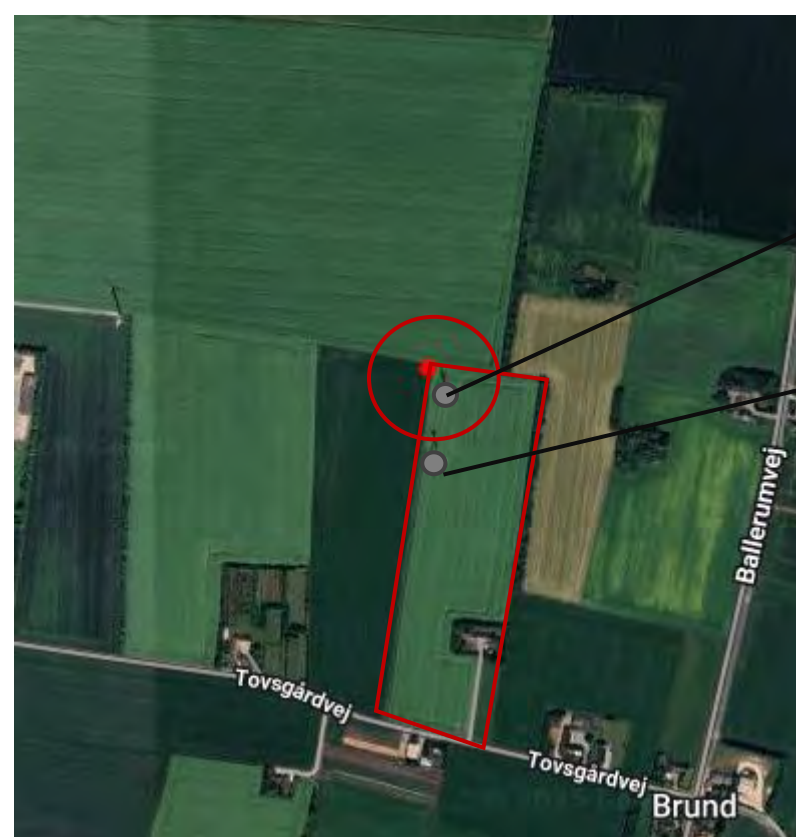
North



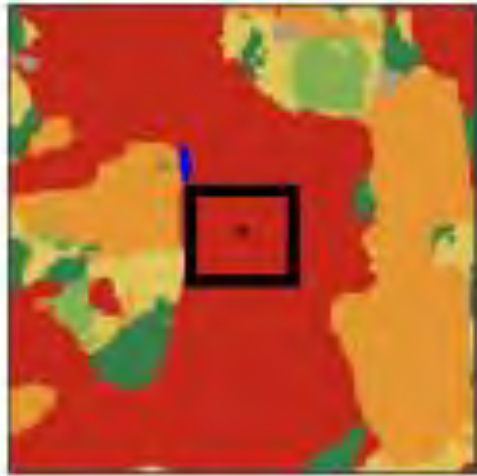
West



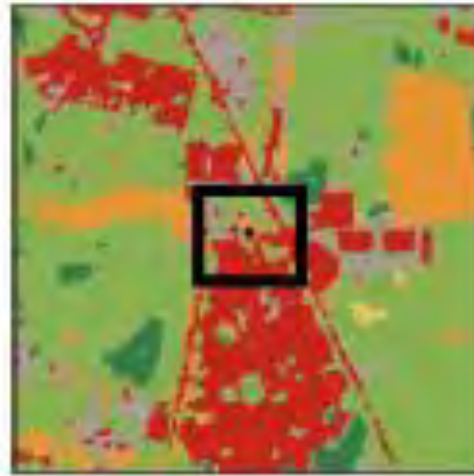
Point



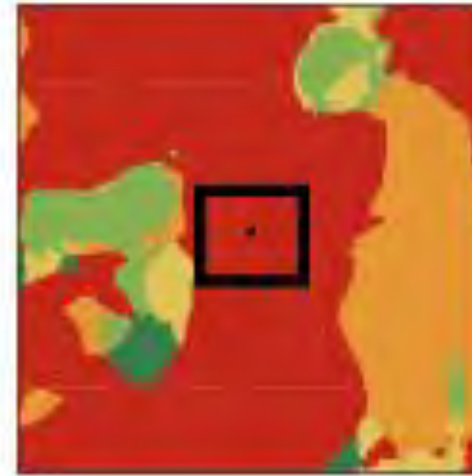
Multimodality: Geospatial Reference Data



Dynamic World



WorldCover



ESRI

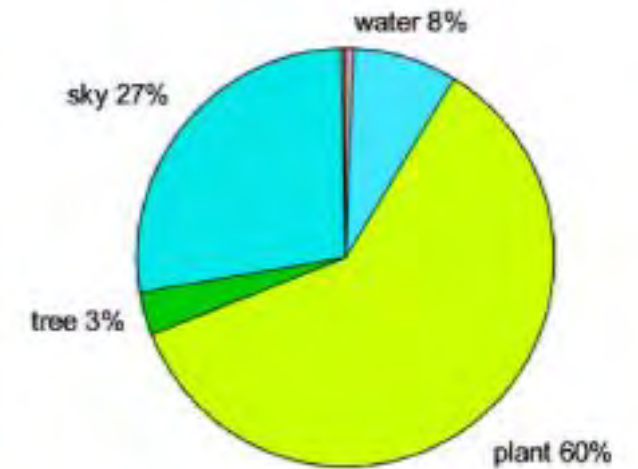


Sentinel-2



**Surveyed
Land Cover:
Water**

Multimodality: Geospatial Reference Data



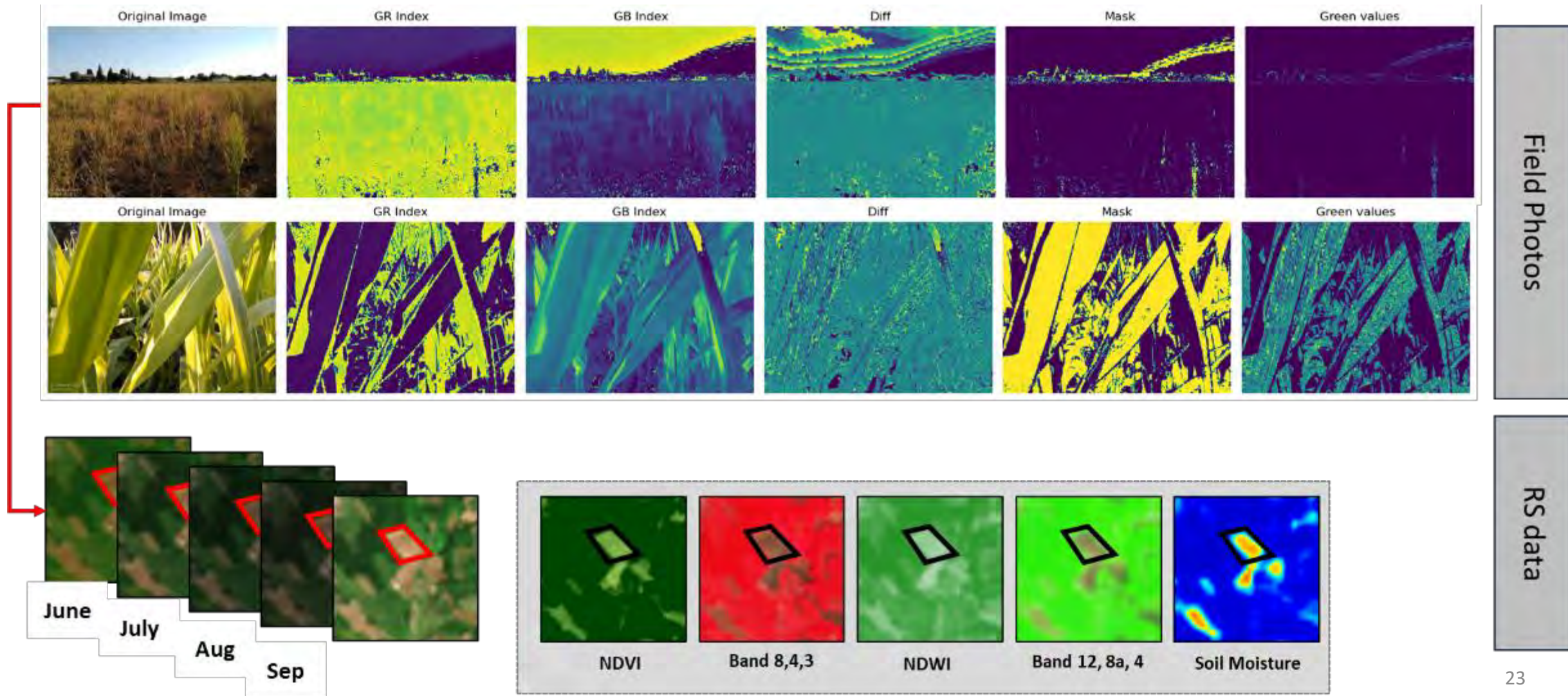
Multimodality: Geospatial Reference Data



Paris, C., Martinez-Sanchez, L., van der Velde, M., Sharma, S., Sedona, R., & Cavallaro, G. (2023, October). Accuracy assessment of land-use-land-cover maps: the semantic gap between in situ and satellite data. In *Image and Signal Processing for Remote Sensing XXIX* (Vol. 12733, pp. 187-200). SPIE.

IVFEO 28/11/2024

Multimodal Perspective

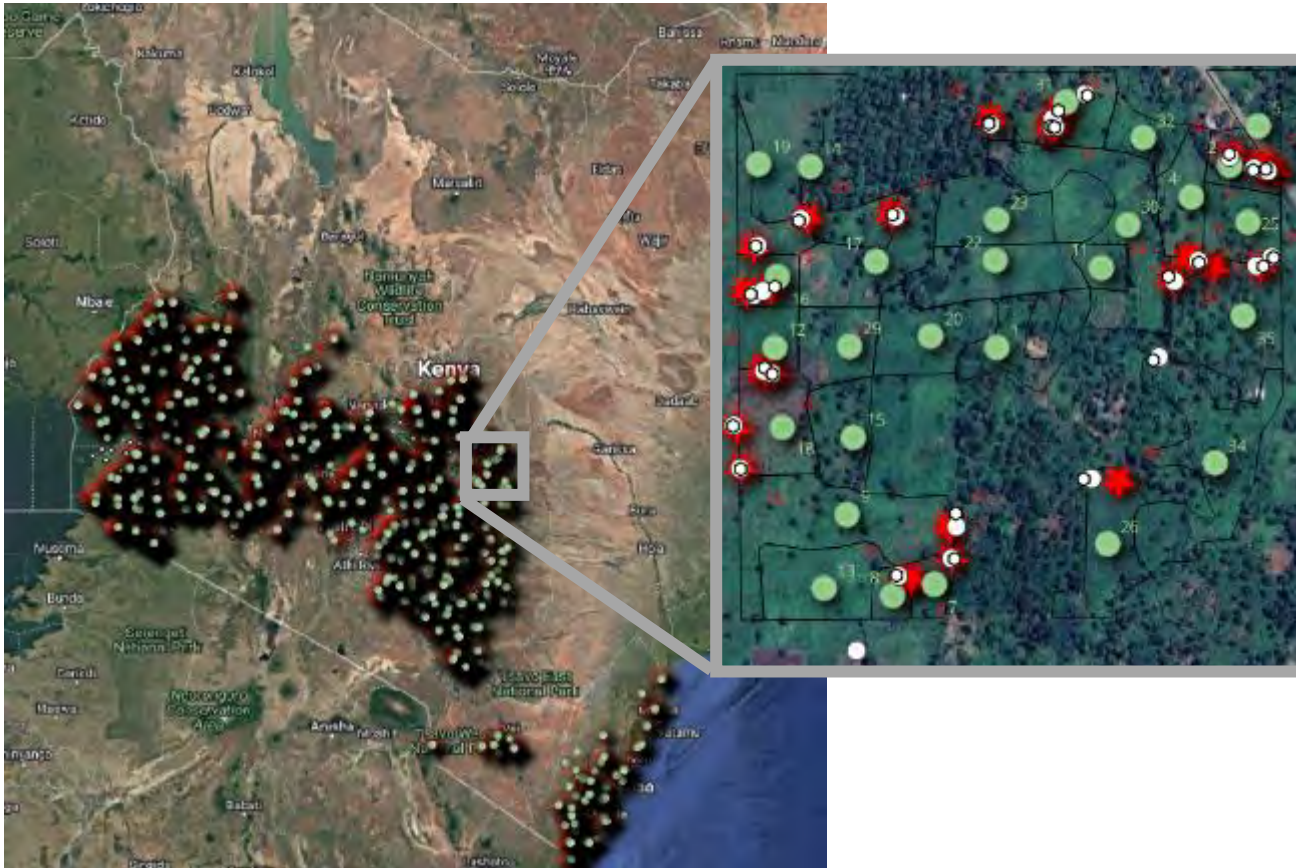


Field Photos

RS data

Field Data Collection Protocol

Copernicus4GEOGLAM: Field data collection in Kenya



Multi-country Field Photo Dataset

- Kenya (2021, 2023)
- Tanzania (2021–2023)
- Uganda (2021–2022)
- Mozambique (2025)
- Zambia (planned, 2026)

Field Data Collection Protocol



Maize crop in Mozambique

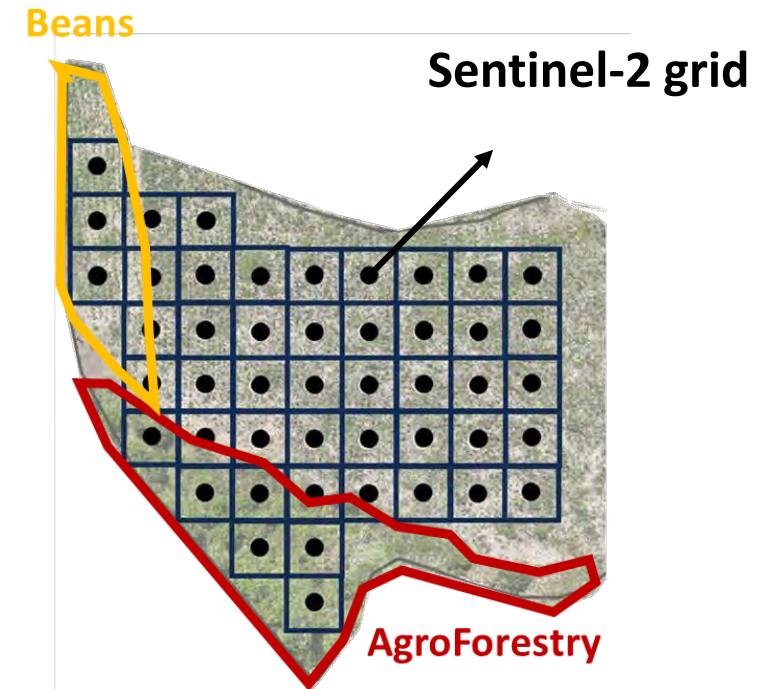


Maize crop in Portugal

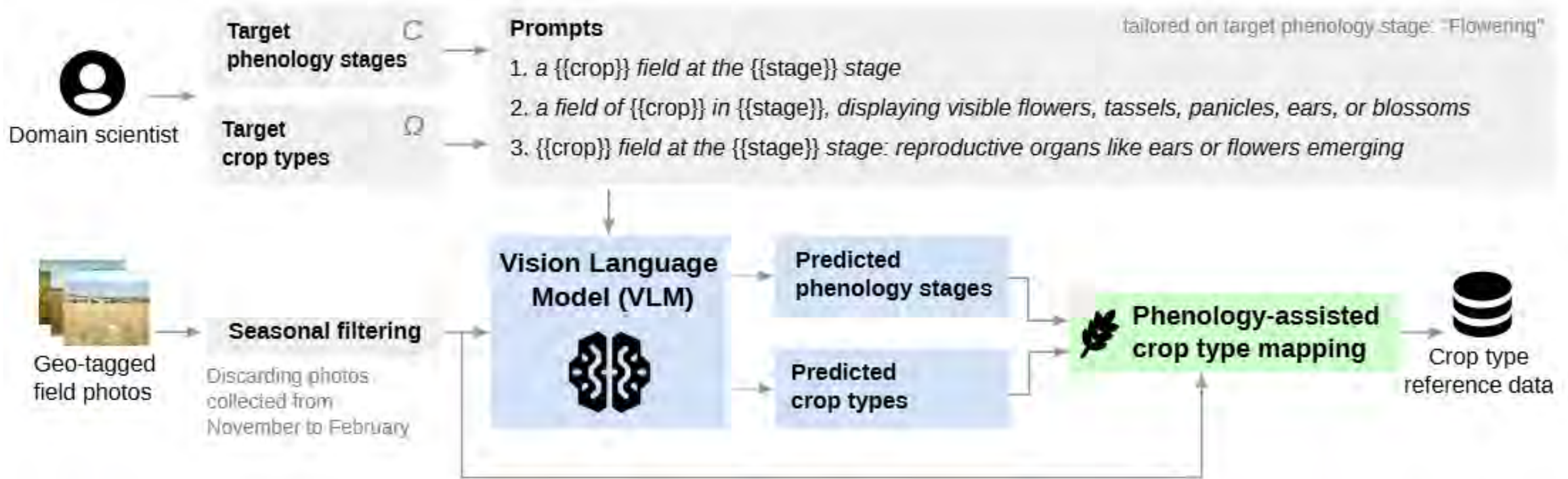
Field Data Collection Protocol



Crop associated with
“Corn and Beans”



VLM to bridge the Semantic gap



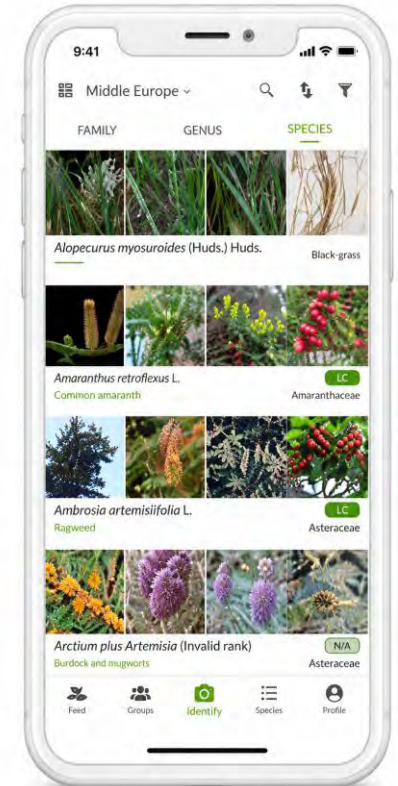
Geo-Tagged Crowdsourced Pictures



<https://plantnet.org/>



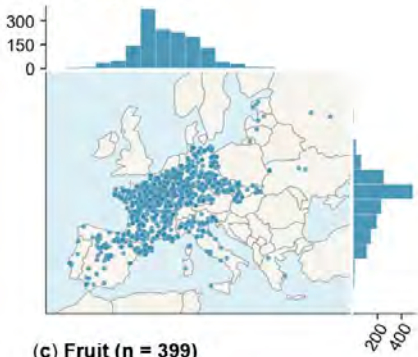
A, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community



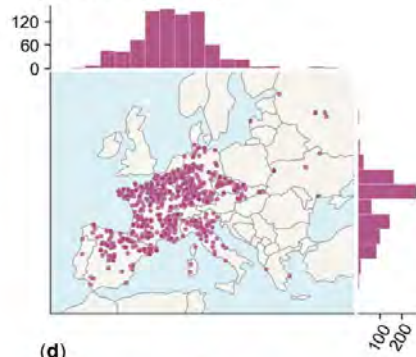
Geo-Tagged Crowdsourced Pictures



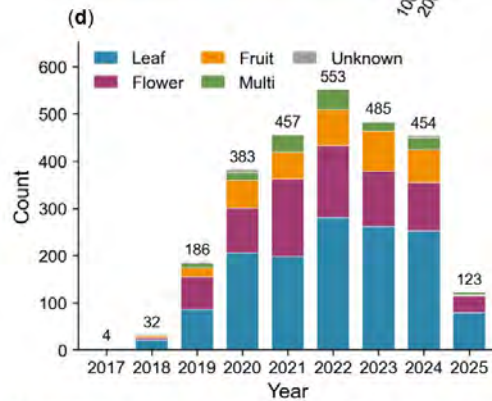
(a) Leaf (n = 1538)



(b) Flower (n = 888)



(c) Fruit (n = 399)



(e) Leaves



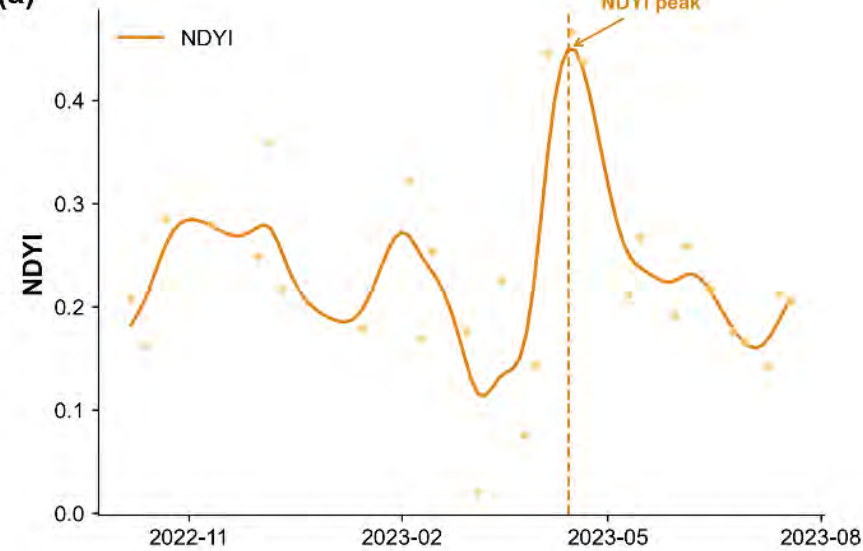
(f) Flowers



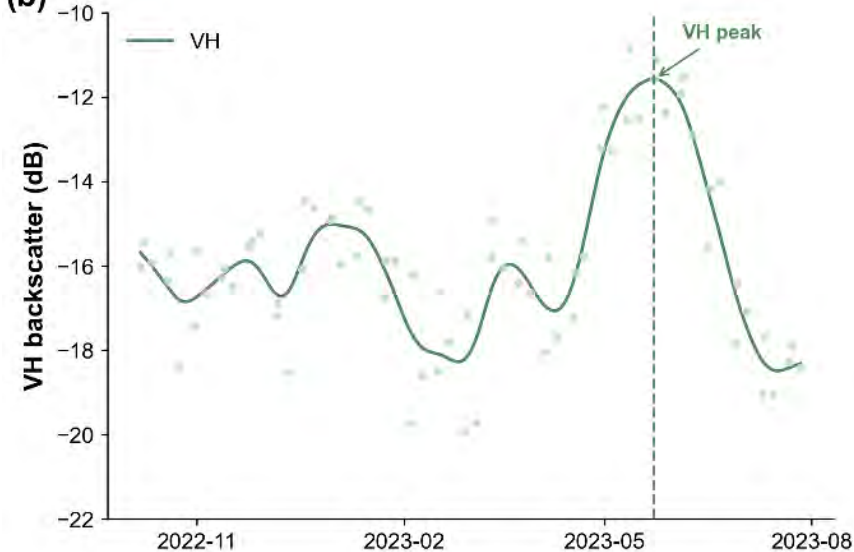
(g) Fruits



(a)



(b)

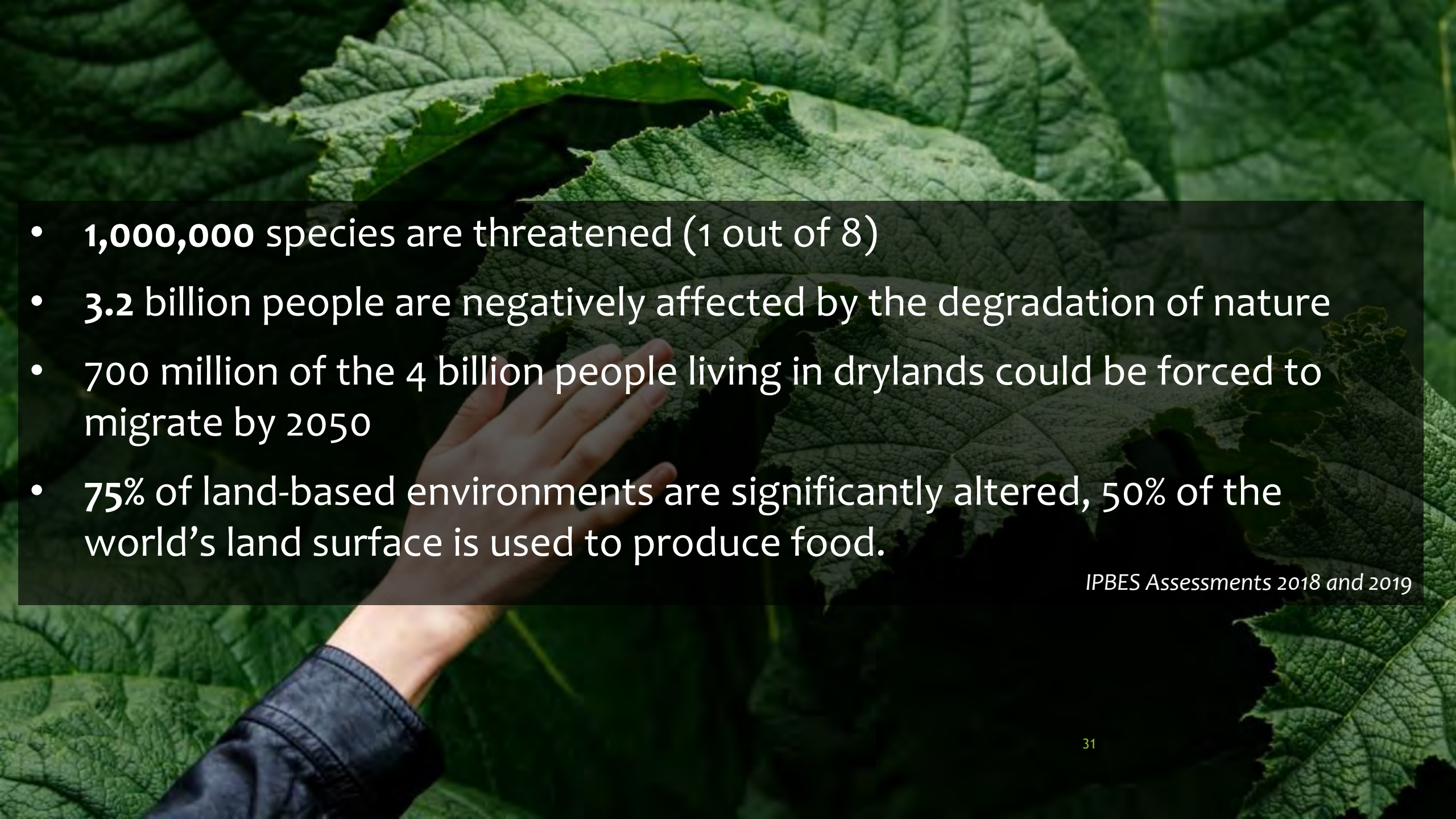




Beyond traditional
mapping...

...to better understand
and model the
complexity of our
planet



- 
- A close-up photograph of a large, vibrant green leaf with prominent veins. A person's hand, wearing a dark blue jacket sleeve, is gently touching the leaf. A semi-transparent dark grey rectangular box is overlaid on the right side of the image, containing a bulleted list of statistics in white text.
- **1,000,000** species are threatened (1 out of 8)
 - **3.2 billion** people are negatively affected by the degradation of nature
 - **700 million** of the **4 billion** people living in drylands could be forced to migrate by 2050
 - **75%** of land-based environments are significantly altered, **50%** of the world's land surface is used to produce food.

IPBES Assessments 2018 and 2019

- 
- Our impact on the environment is immense
 - ...so is our dependence on a healthy environment.
 - We are fast approaching several tipping points
 - Without proper management, these environments & the natural resources they provide will be depleted & degraded, sometimes irreversibly

Crowd-sourced field photo series to evaluate remote sensing indicators of drought in east African rangelands



North



East

Latitude: 1.0774684

Longitude: 37.272341

Date & Time: 08-03-2024 11:15:11



South

Latitude: 1.0774628

Longitude: 37.272334

Date & Time: 08-03-2024 12:12:56



West

Latitude: 1.0774534

Longitude: 37.272333

Date & Time: 08-03-2024 12:13:03

 Non-photosyn. veg.



 Bare Soil



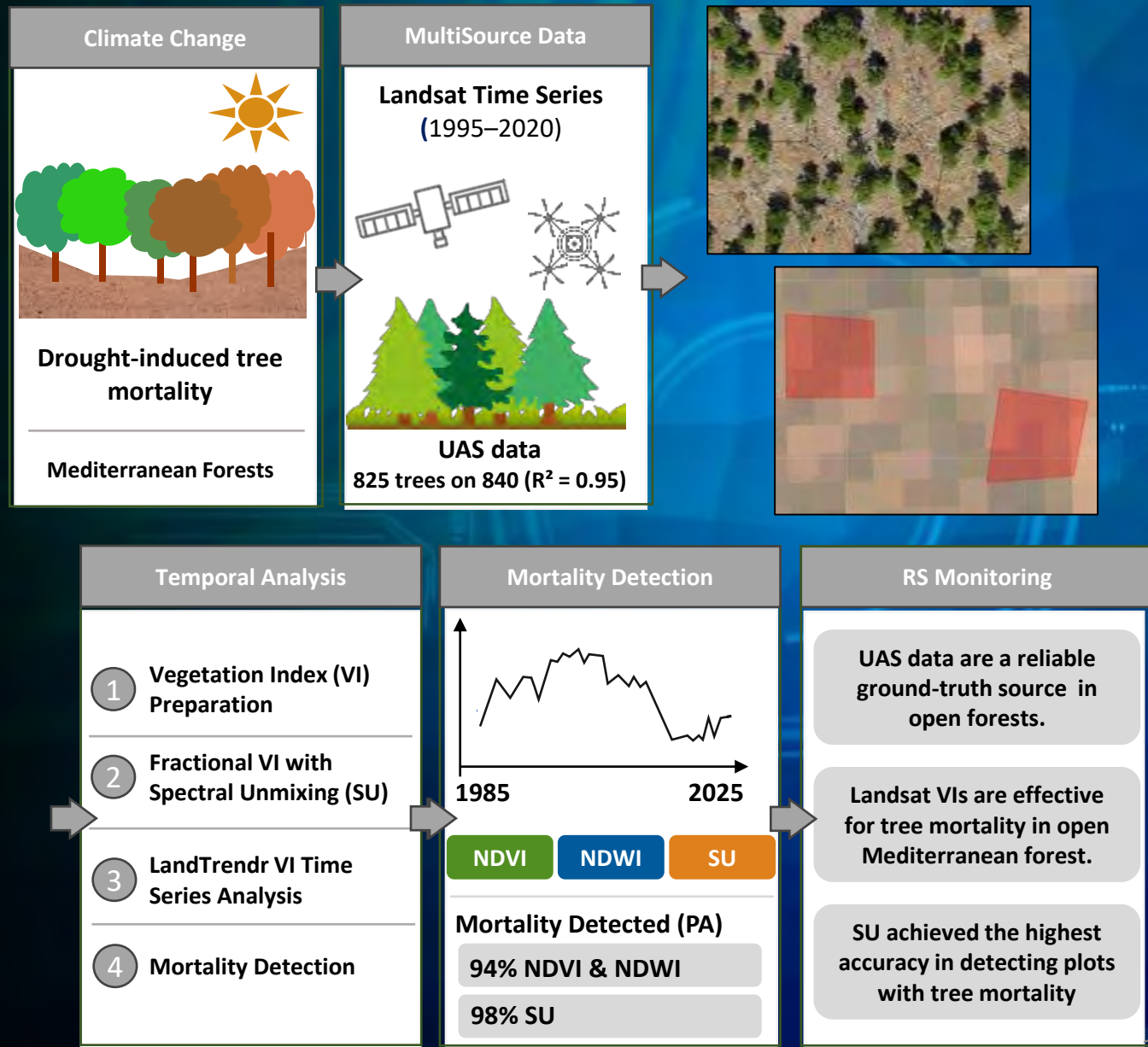
 Green Vegetation



RANGE - Resilient Approaches in Natural ranGeland Ecosystems funded by Dutch Embassy in Kenya [2024-ongoing] (Participant to Scientific and Capacity Building Activities).

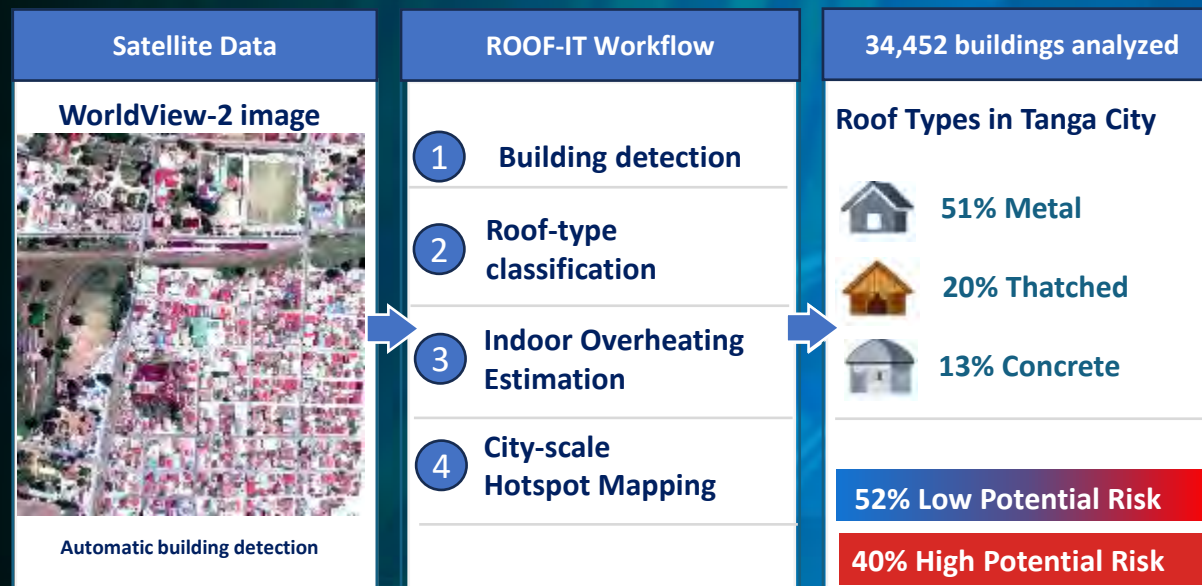
Drought-induced tree mortality in open Mediterranean forests

A. Raunak, M. Huesca, P. Nyktas, **C. Paris**,
“Assessing drought-induced tree mortality in open Mediterranean forests integrating Landsat time series, spectral unmixing, and UAS validation,” in Forest Remote Sensing, 2026



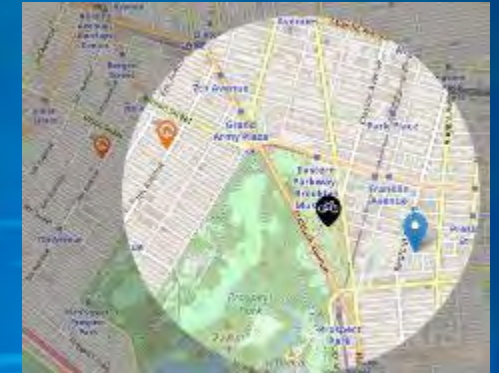
Roof-based Indoor Temperature for Mapping Indoor Overheating Potential

T. Chigovanyika, **C. Paris**, E. Hendriks, C. P. Marghidan, J. I. Blanford¹, “The ROOF-based Indoor Temperature framework: A city-scale, geospatial analysis of building overheating potential”, submitted to Building of Environment



11/11/2011

Food Gravity The project aims at understanding food flows using classic Gravity model and explainable Artificial Intelligence techniques. ITC innovation research project [2023-2024]: (co-PI)



Permanent



Urban



Future vision



Paradigm shift:

maps as intelligent, adaptive
systems driven by real-time data,
sensors, and AI...



Human-centered, trustworthy
GeoAI for better decisions



Collaborative & interdisciplinary approach



How EO and GIS data can tackle Planetary Health challenges ?



Stakeholder Workshops: Digital Transformation in Agriculture

The workshops aimed to facilitate a high-level discourse among policymakers, researchers, and industry leaders on the integration of **cutting-edge digital methodologies** into **Cambodia's** and **Vietnam's** agricultural frameworks.



Food and Agriculture
Organization of the
United Nations





AI'm Not Your Enemy...



or **Am I?**



How can be a
part of this
c h a n g e ?

We have two options:



be **OVERWHELMED** by the change

OR

DRIVE our change



E.L.I.Z.A. Talking

Welcome to

```
EEEEEE LL      IIII ZZZZZZZZ AAAAAA
EE      LL      II      ZZ  AA  AA
EEEEEE LL      II      ZZZ  AAAAAAA
EE      LL      II      ZZ  AA  AA
EEEEEE LLLLLL IIII ZZZZZZZZ AA  AA
```

ELIZA is a mock (Rogerian) psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation ('elizabot.js') by Norbert Landsteiner 2005.
Graphics and real-time text to speech integration added in 2013.

**** Type or click the microphone-button below for voice input. ****

VOICE SETUP

Please choose an accent to be used by ELIZA (speech output):

- [1] English - US
- [2] English - EN

>



VOX



digital VT100

digivox



**“The measure of
intelligence is the
ability to change”**

A. Einstein



Use resources that
machines don't have:

REMAIN HUMAN



Acknowledgements

Rocco Sedona, Adel Abbas, Stefano Maurogiovanni,
Gabriele Cavallaro, Valerio Marsocci, Surbhi Sharma,
Lorenzo Bruzzone, Anton Vrieling, Rolf de By,
Dino Ienco, Cassio Dantas, Raffaele Gaetano,
Michele Linardi, Andy Nelson, Laura
Martinez-Sanchez, Marijn van der
Velde...



