

# SPACE4AGRI (S4A) project and Contextualized VGI creation by Smart App

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<http://space4agri.irea.cnr.it>

## Partners



**Funded** by CNR and Regione Lombardia within «Il Accordo Quadro»

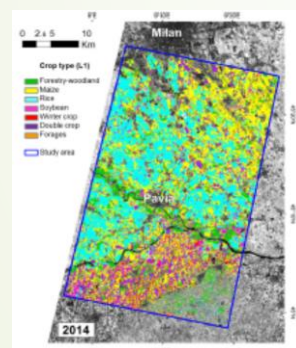
**Duration** 2 years

**Coordinator** Pietro Alessandro Brivio (IREA)

**3 domains:** EO from Space

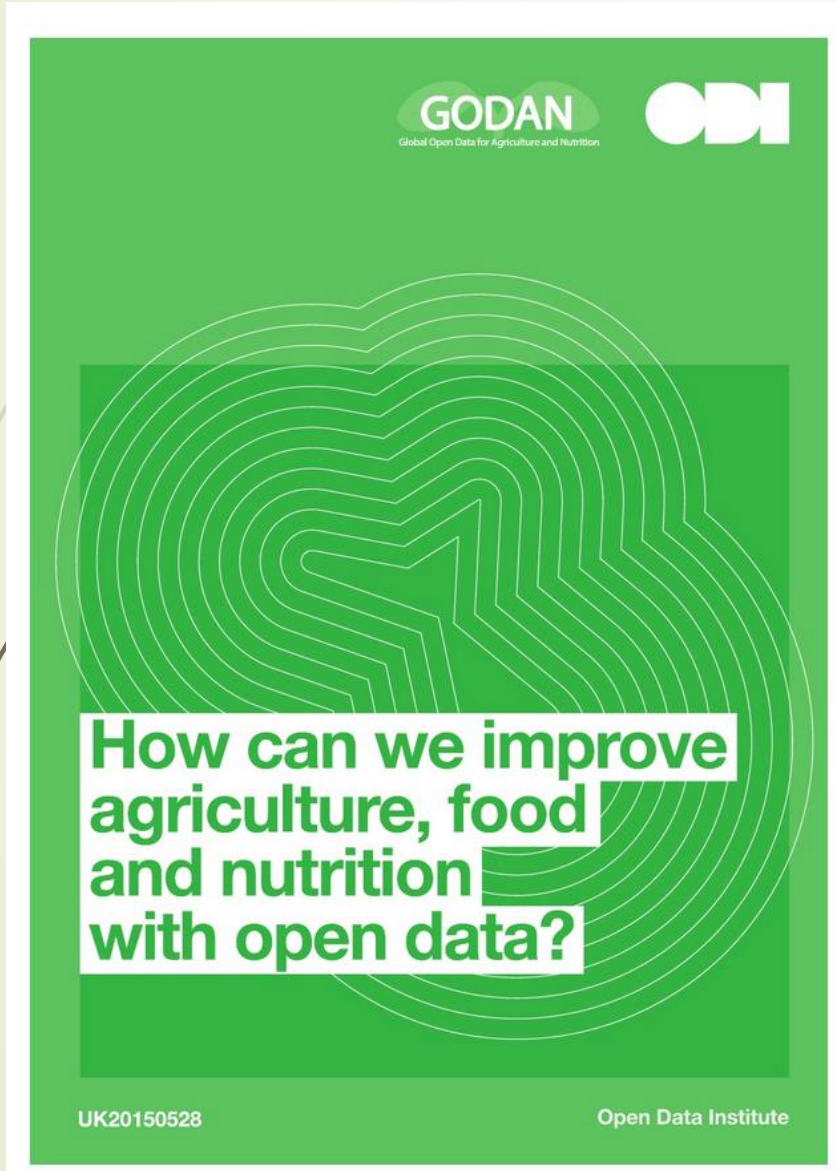
AERO

In situ ICT



**In situ ICT Working Group:** Frigerio, L., Kliment, T., Bordogna G., Brivio P.A., Boschetti M., Crema A., Stroppiana D., Sterlacchini S.

# OPEN DATA FOR AGRICULTURE CHALLENGES



- ✓ data management,
- ✓ interoperability,
- ✓ exploitation.



# Main results (*In Situ-ICT*)

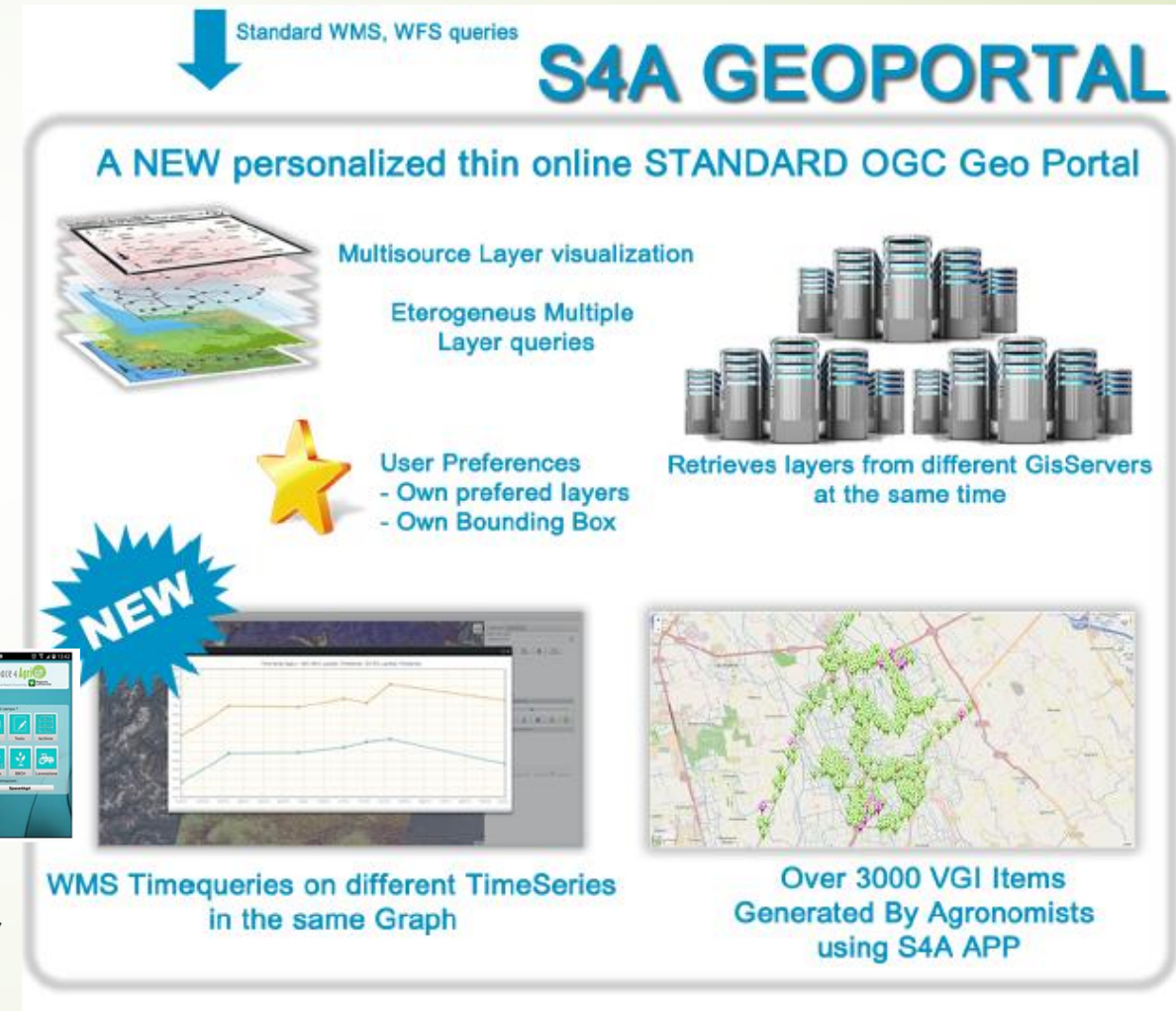


Interoperable Spatial Data Infrastructure for sharing open data

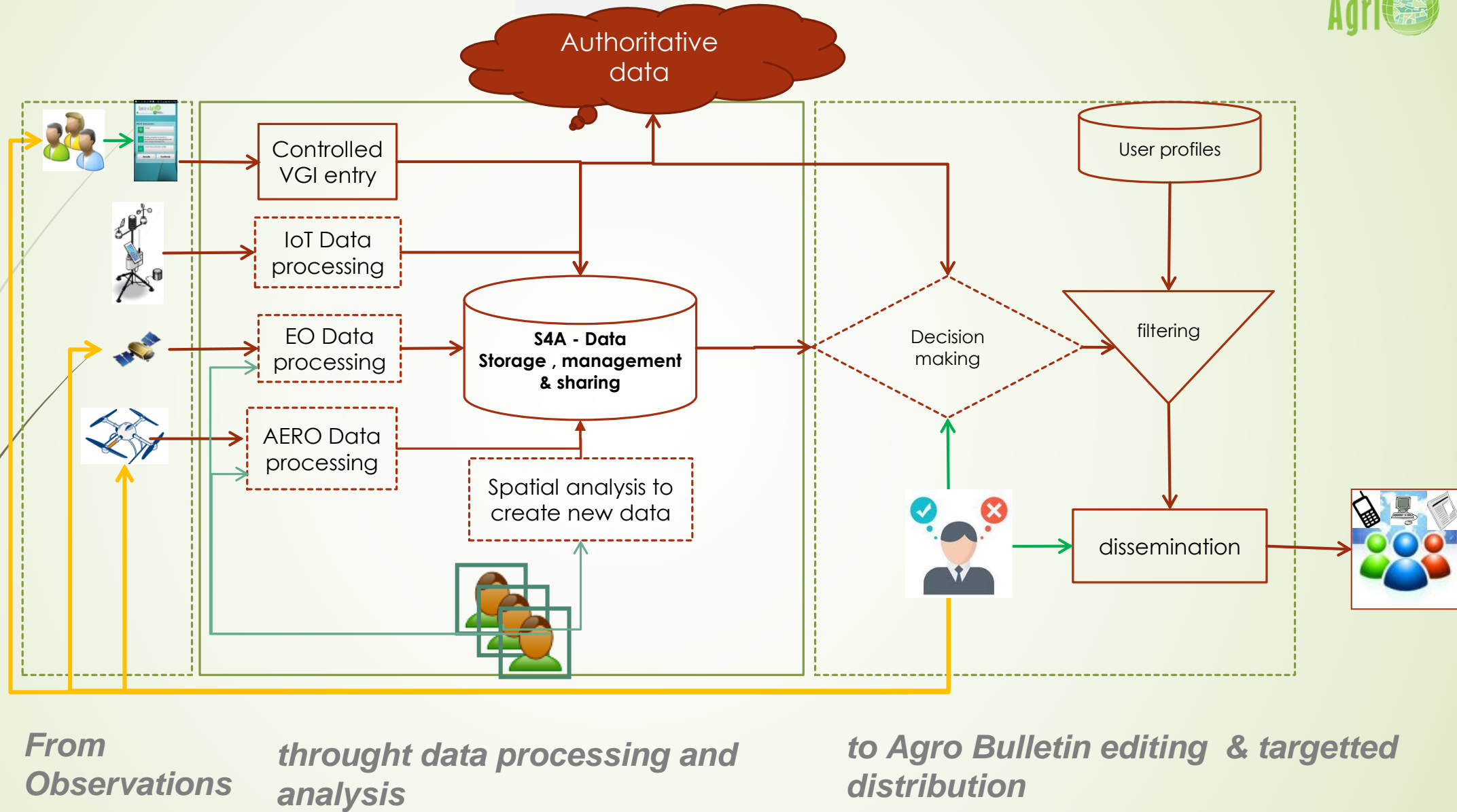
- Smart App
- Back End & Geo DB
- Crawler for EO products
- WebGIS
- GeoPortal
- GeoCatalog

Spatial data infrastructure integrating multisource heterogeneous geospatial data and time series: A study case in agriculture Bordogna, G., Kliment, T., Frigerio, Brivio P.A., Crema A., Stroppiana D., Boschetti M., Sterlacchini S., ISPRS Int. J. Geo-Inf. 2016, (5),73

“Contextualized VGI” Creation and Management to Cope with Uncertainty and Imprecision, Bordogna, G., Frigerio, L., Kliment, T., Brivio P.A., Hossard L., Manfron G., Sterlacchini S., ISPRS Int. J. Geo-Inf. 2016, 5(12), 234;



# S4A: Workflow

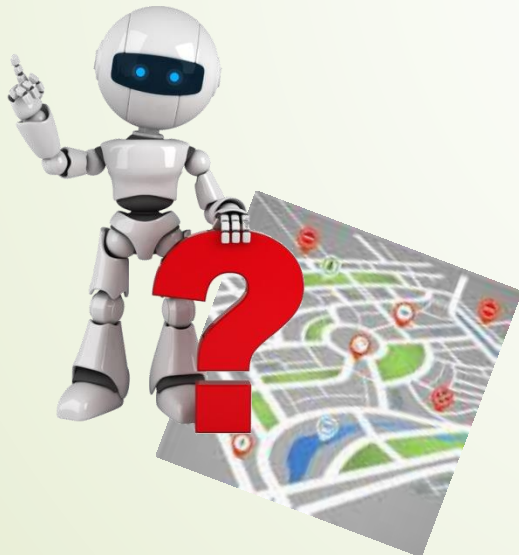
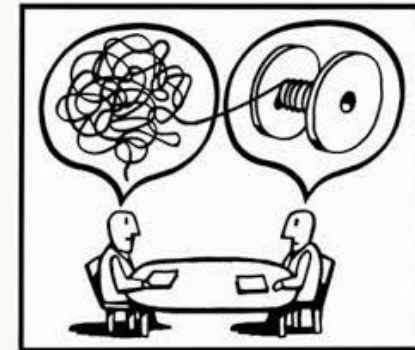


# Design Key Concepts



Syntactic interoperability

Semantic interoperability



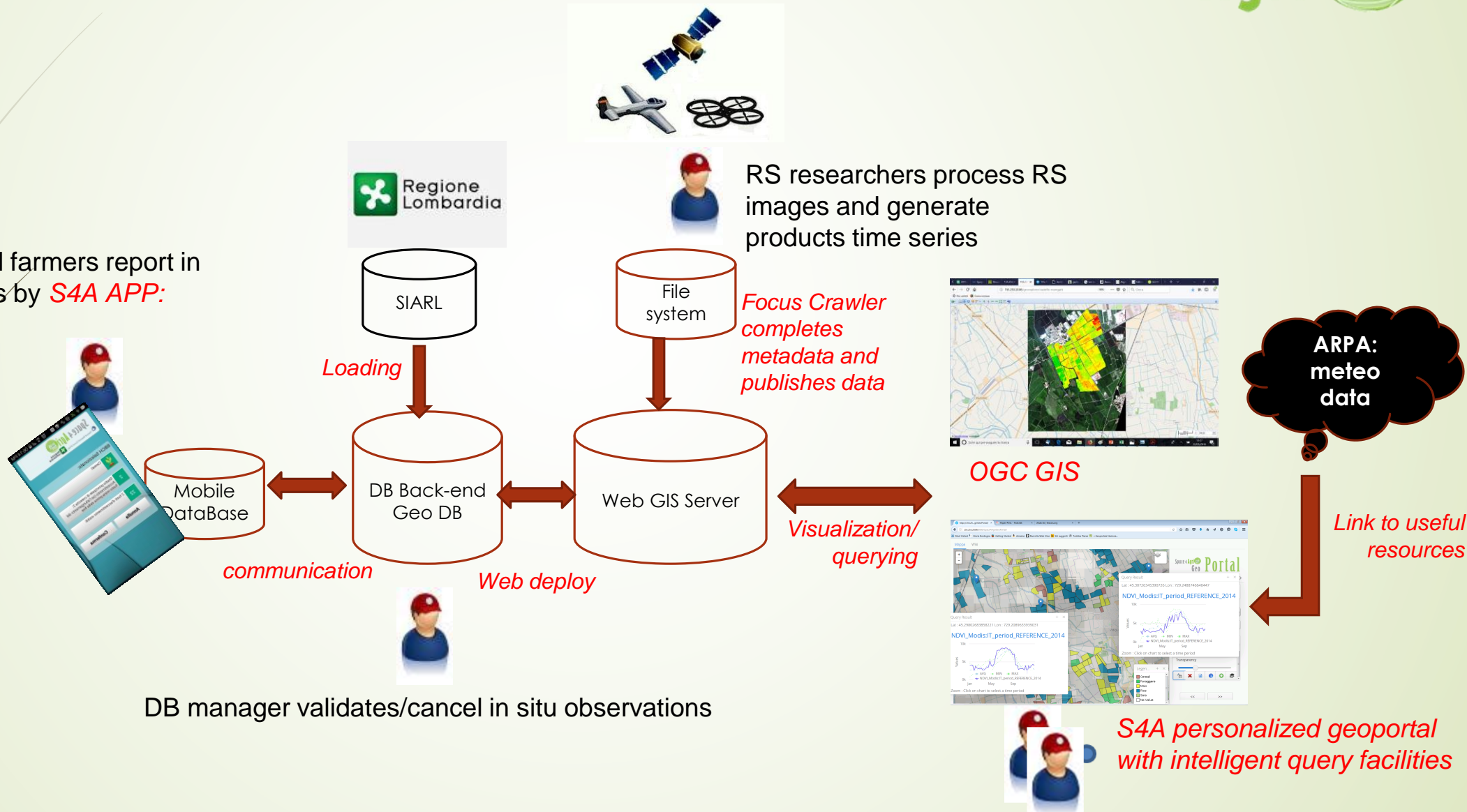
Uncertainty management



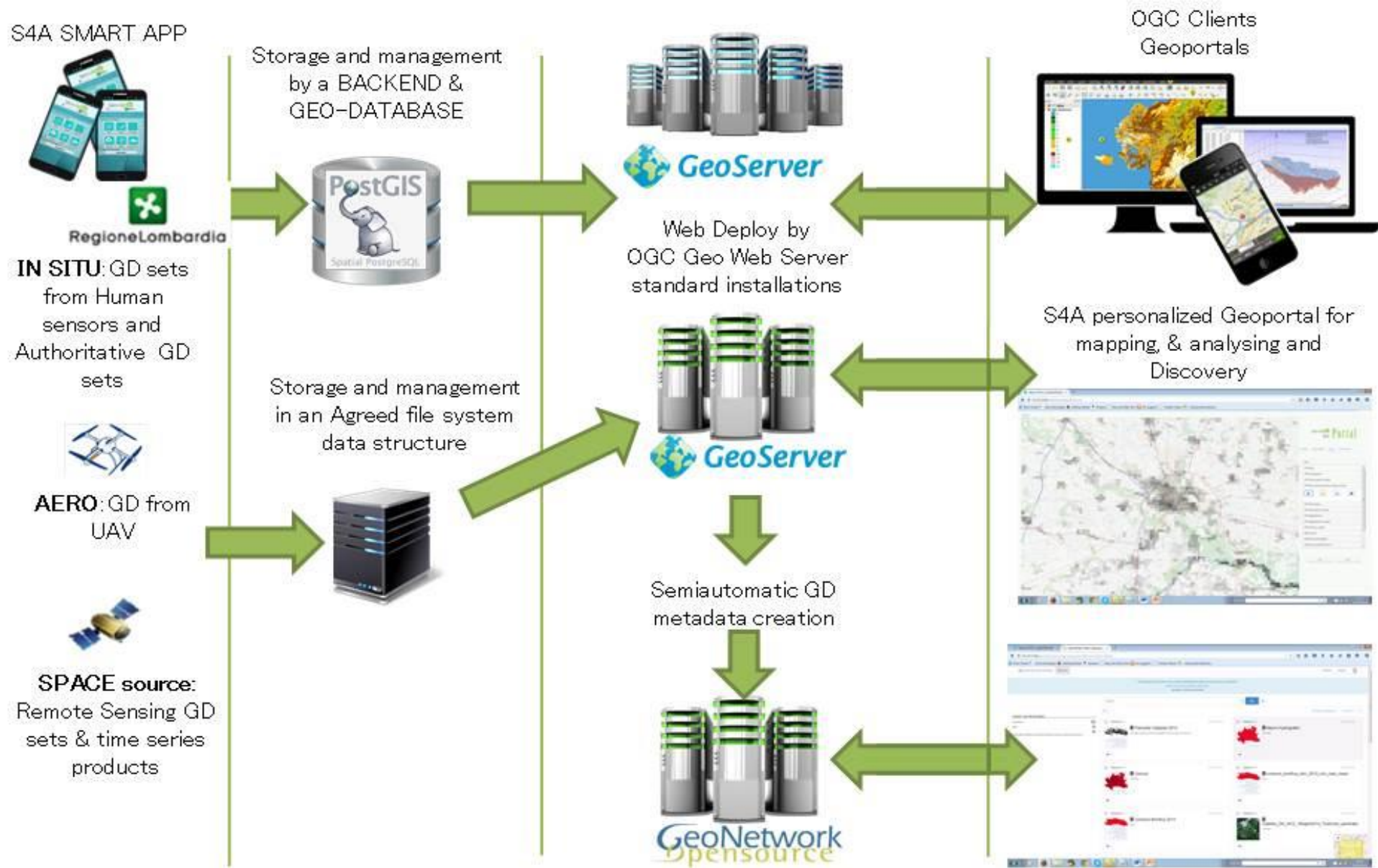
# S4A SDI: data acquisition, processing, management and sharing



Agronomers and farmers report in situ observations by **S4A APP**:



# S4A SDI : implementation

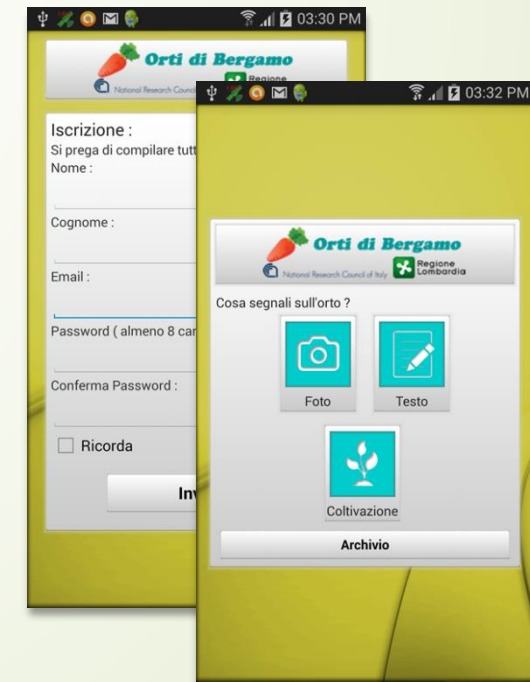
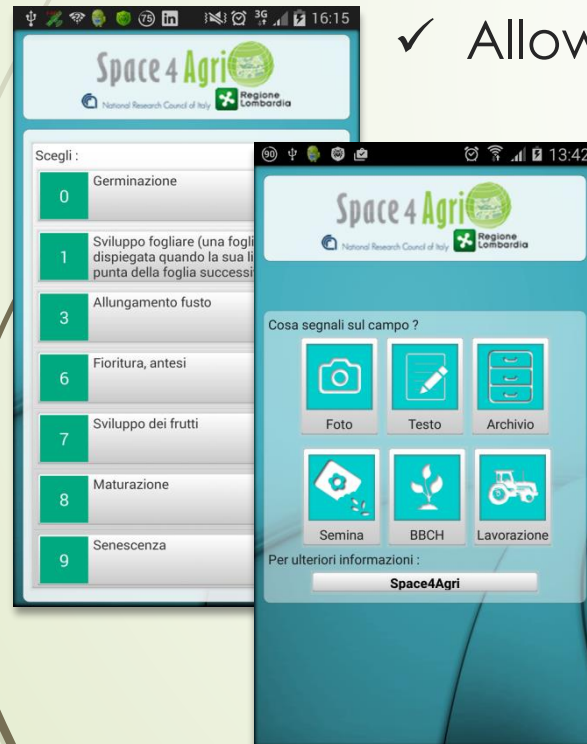




# S4A SDI: Smart APP



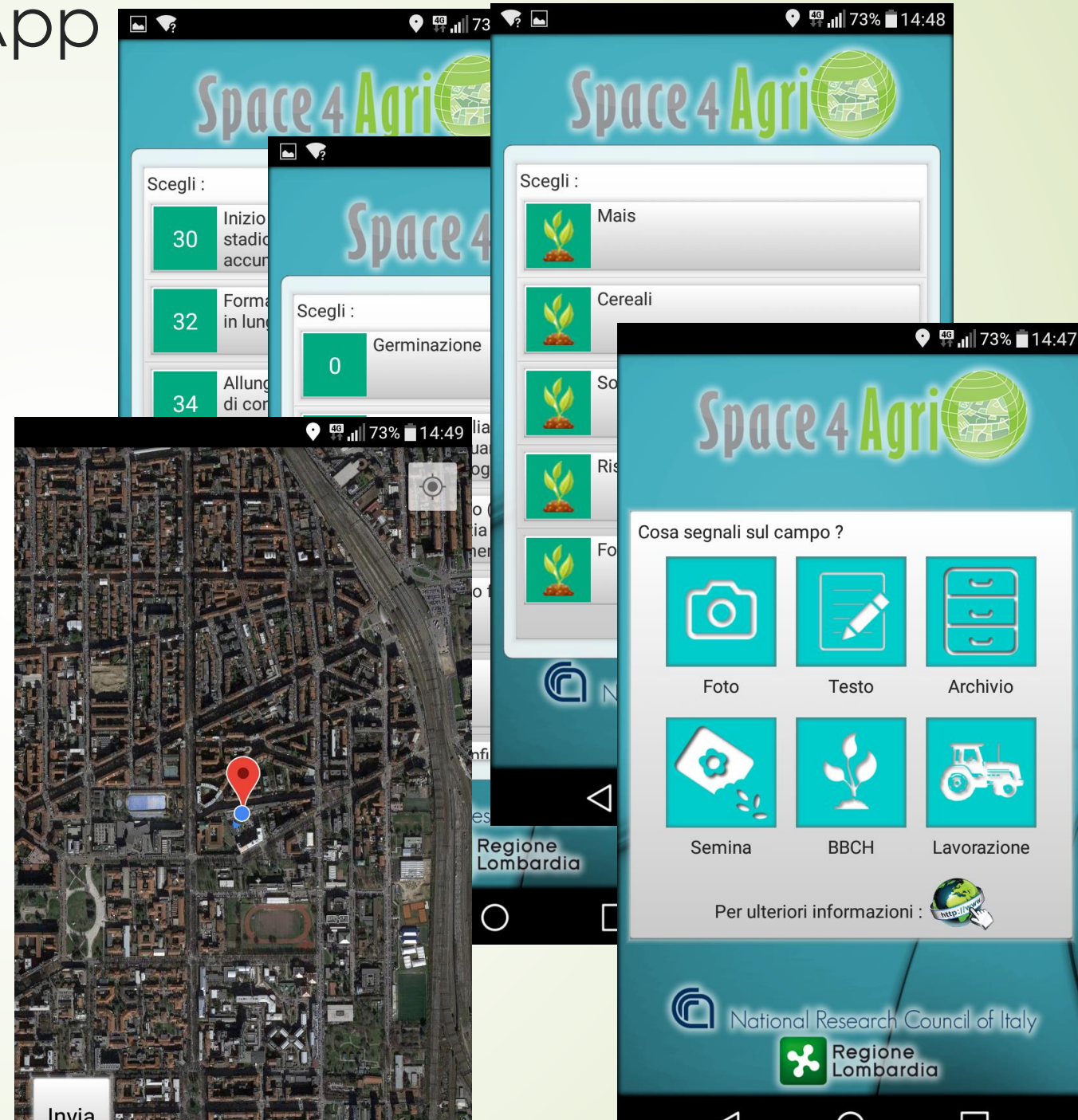
- ✓ For farmers and agronomists
- ✓ Require user's registration
- ✓ Enables the creation of controlled observations of crops
- ✓ Uses ontologies
- ✓ Verifies data consistency by applying constraints
- ✓ Allows manual repositioning of GPS coordinates
- ✓ Allows local storage and asynchronous delivery to back-end
- ✓ Allows delivery/cancellation of observations locally stored



# S4A SDI: S4A Smart App

It allows describing observations of crops, phenological stages, and field practices :

- ✓ Type of crop
- ✓ Phenological stage (2 levels of BBCH ontology)
- ✓ Seeding dates
- ✓ Field processing practices (practice ontology)
- ✓ Free text and picture





# OPEN DATA: BBCH Ontology

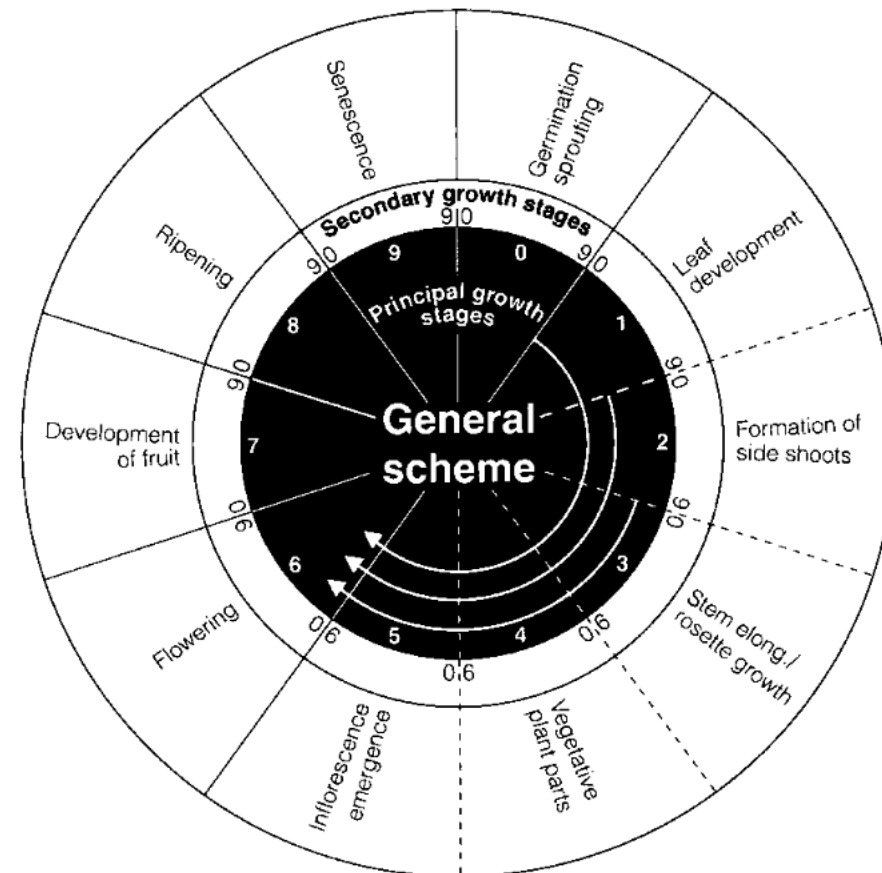
Growth stages of mono-and dicotyledonous plants:

edited by Uwe Meier (Germany), Federal Biological Research Centre for Agriculture and Forestry

**Table 1:**

Principal growth stages

Stage	Description
0	Germination / sprouting / bud development
1	Leaf development (main shoot)
2	Formation of side shoots / tillering
3	Stem elongation or rosette growth / shoot development (main shoot)
4	Development of harvestable vegetative plant parts or vegetative propagated organs / booting (main shoot)
5	Inflorescence emergence (main shoot) / heading
6	Flowering (main shoot)
7	Development of fruit
8	Ripening or maturity of fruit and seed
9	Senescence, beginning of dormancy





# BBCH Growth stages

## Cereals Witzemberger et al., 1989; Lancashire et al., 1991

### Phenological growth stages and BBCH-identification keys of cereals

(wheat = *Triticum* sp. L., barley = *Hordeum vulgare* L., oat = *Avena sativa* L., rye = *Secale cereale* L.)

Code	Description
<b>Principal growth stage 0: Germination</b>	
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle emerged from caryopsis
06	Radicle elongated, root hairs and/or side roots visible
07	Coleoptile emerged from caryopsis
09	Emergence: coleoptile penetrates soil surface (cracking stage)

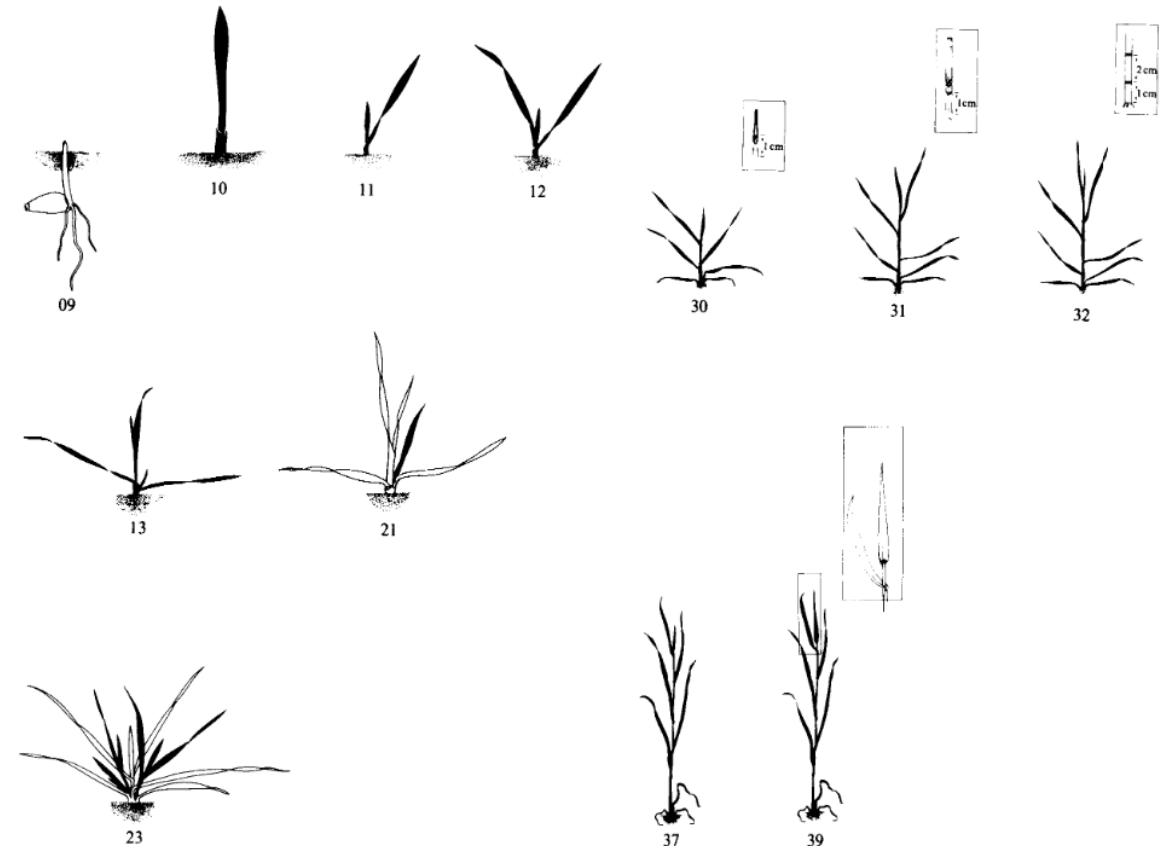
### Principal growth stage 1: Leaf development<sup>1, 2</sup>

10	First leaf through coleoptile
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded

### Principal growth stage 2: Tillering<sup>3</sup>

20	No tillers
21	Beginning of tillering: first tiller detectable
22	2 tillers detectable
23	3 tillers detectable
2 .	Stages continuous till . . .
29	End of tillering. Maximum no. of tillers detectable

## Cereals



# BBCH Ontology is loaded on the S4A APP

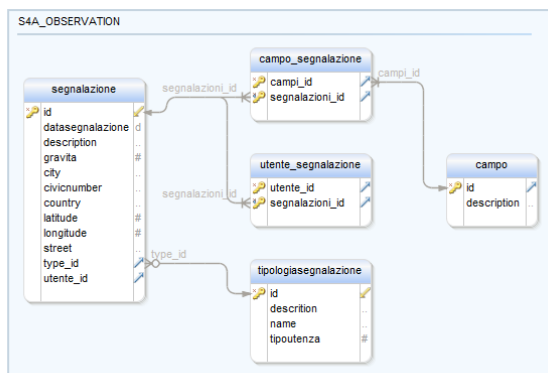
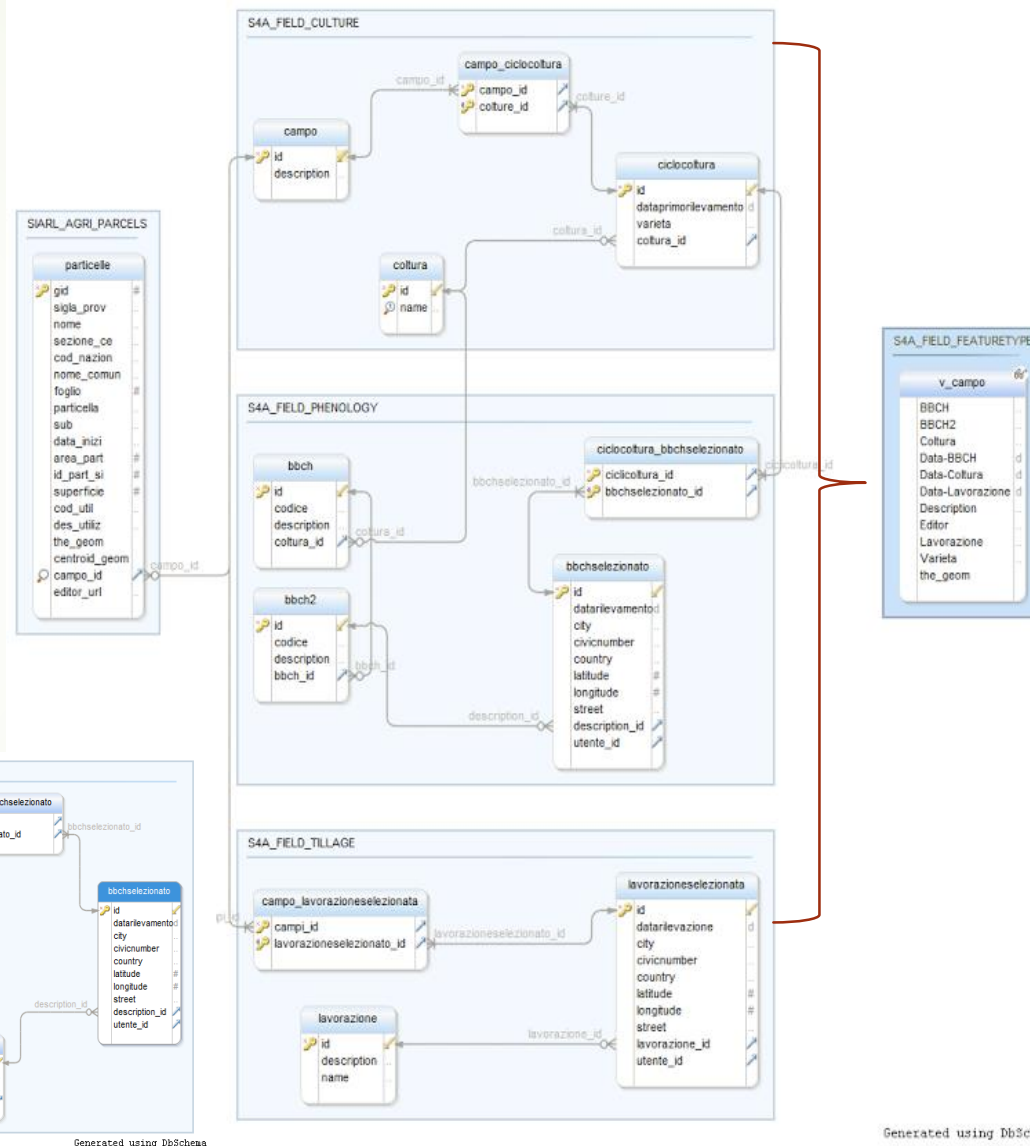
JSON   Dati non elaborati   Header

Salva   Copia   ▼ Filtra JSON

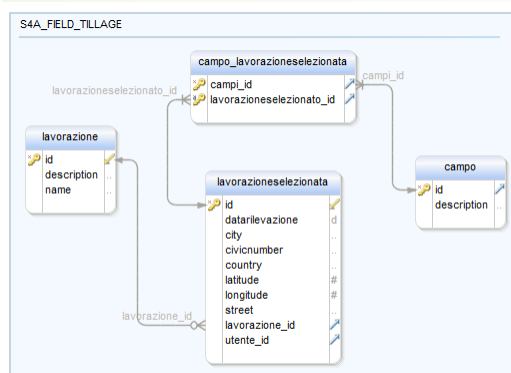
```
▼ 0:
  ▼ bbch:
    ▼ 0:
      ▼ bbch2:
        ▼ 0:
          codice:      "13"
          description:  "3 Foglie dispiegate"
          id:           "2609dfa5-dfdc-4496-85e4-b803fa86a264"
          ▶ 1:         {...}
          ▶ 2:         {...}
          ▶ 3:         {...}
          ▶ 4:         {...}
          ▶ 5:         {...}
          ▶ 6:         {...}
          ▶ 7:         {...}
          ▶ 8:         {...}
          ▶ 9:         {...}
          codice:      "1"
          ▼ description: "Sviluppo fogliare, una foglia è dispiegata quando la sua ligula o la punta della foglia successiva è visibile. Accestimento o allungamento fusto possono avvenire prima della fase 19; in questo caso continua con lo stadio 3"
          id:           "51e214ea-3f60-42c0-91f7-a337caed6b8b"
          ▶ 1:         {...}
          ▶ 2:         {...}
          ▶ 3:         {...}
          ▶ 4:         {...}
          ▶ 5:         {...}
          ▶ 6:         {...}
          name:        "Mais"
          id:           "ded7303d-0012-4419-b0b9-b99faa2e9dd4"
        ▼ 1:
          ▼ bbch:
            ▼ 0:
```

# S4A SDI: geo-database

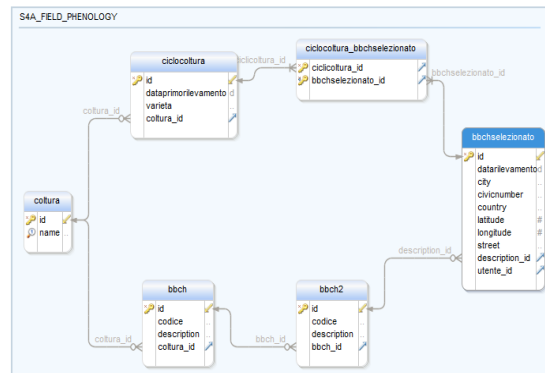
- Postgres SQL Database Management System
  - PostGIS for geometric attributes
- Georeferenced spatial objects
  - S4A\_Segnalazione (point)
  - S4A\_Lavorazione (point)
  - S4A\_Fenologia (point)
  - S4A\_Campo (polygon)



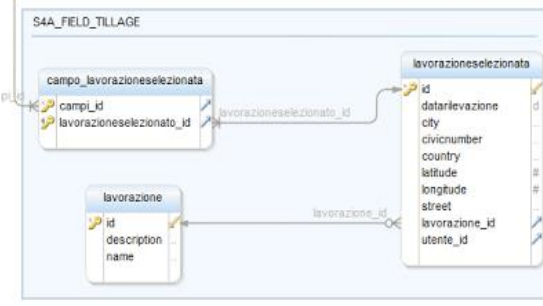
Generated using DbSchema



Generated using DbSchema



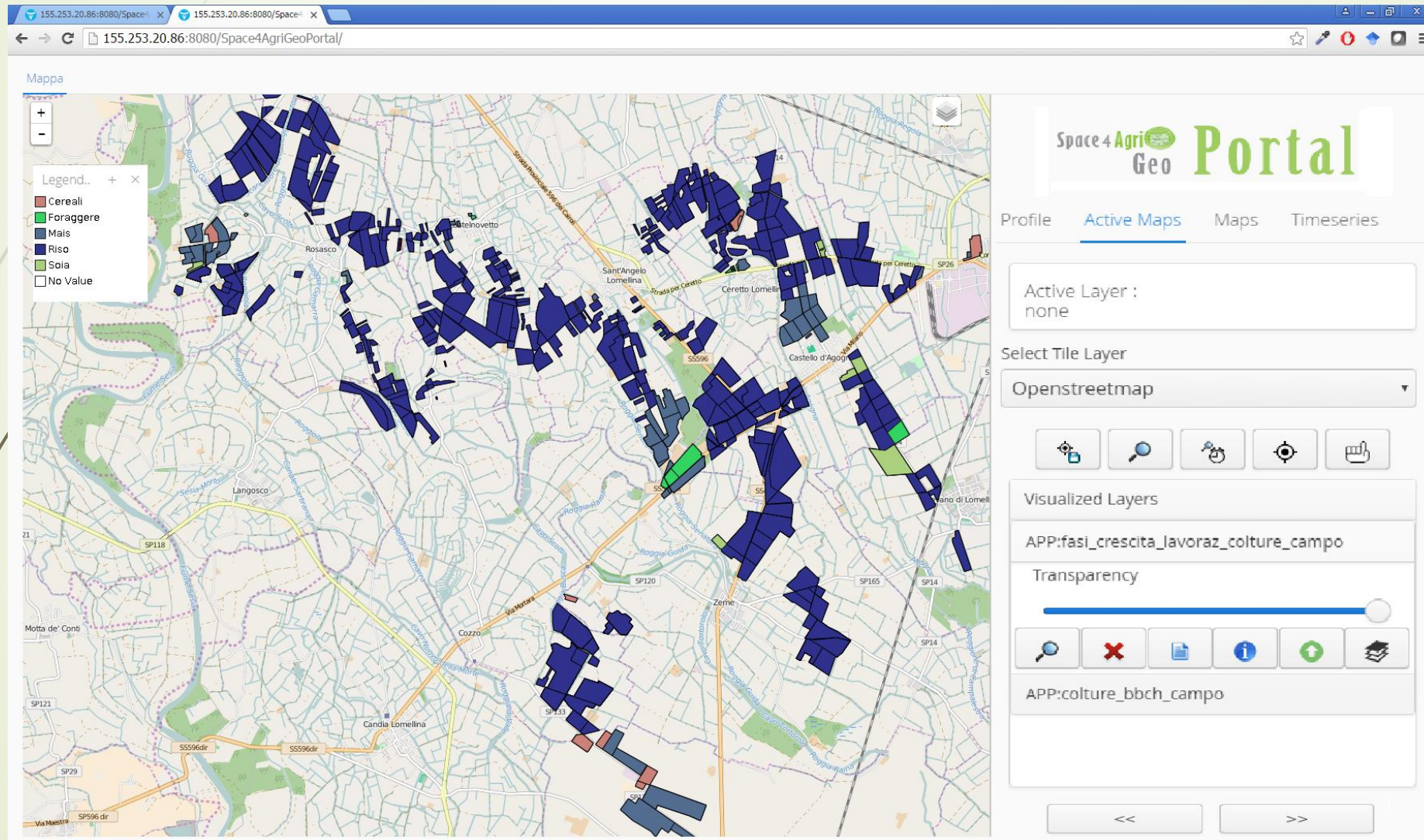
Generated using DbSchema



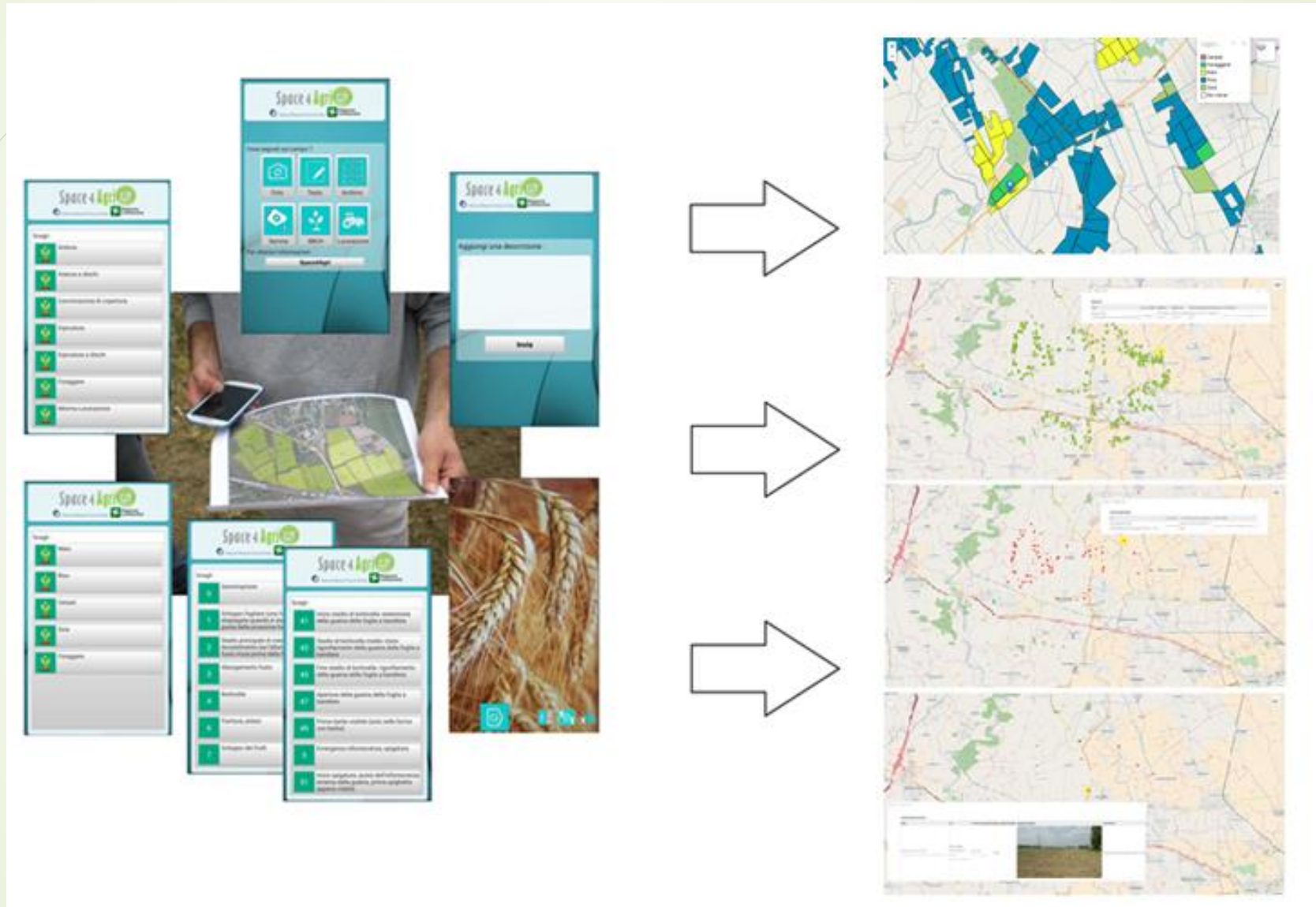
Generated using DbSchema



# S4A SDI: VGI Conflation based on Contextual Knowledge



# S4A SDI: VGI Layers Web deploy





# S4A SDI – Web GIS Server



## GeoServer



- Open source.
- Management of various formats (vector, raster) OGC standard
- OGC WMS for visualization
- OGC WFS e WCS for download and querying
- Tiling to achieve efficiency
- QGIS styling compatible

### Workspaces

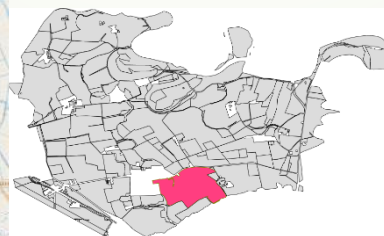
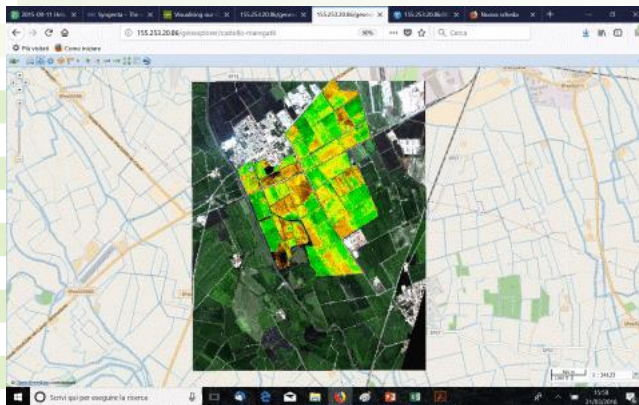
Manage GeoServer workspaces

➤ Add new workspace

➤ Remove selected workspace(s)

Results 1 to 19 (out of 19 items)

<input type="checkbox"/> Workspace Name
<input type="checkbox"/> APP
<input type="checkbox"/> ET
<input type="checkbox"/> EVI
<input type="checkbox"/> InSitu
<input type="checkbox"/> LCR
<input type="checkbox"/> LCV
<input type="checkbox"/> LS
<input type="checkbox"/> LSWI
<input type="checkbox"/> NDFI
<input type="checkbox"/> NDVI
<input type="checkbox"/> NetCDF
<input type="checkbox"/> PHENO
<input type="checkbox"/> REPORT
<input type="checkbox"/> Radar
<input type="checkbox"/> SIARL
<input type="checkbox"/> Water
<input type="checkbox"/> cp



### Layer Preview

List of all layers configured in GeoServer and provides previews in various formats for each.

Results 1 to 25 (out of 61 items)

Type	Name	Title	Common Formats
<input checked="" type="checkbox"/>	APP:bbch	BBCH della APP	OpenLayers KML GML
<input checked="" type="checkbox"/>	APP:segnalazione	Segnalazioni della APP	OpenLayers KML GML
<input checked="" type="checkbox"/>	APP:lavorazione	Lavorazione della APP	OpenLayers KML GML
<input checked="" type="checkbox"/>	EVI:EVI_20140703_194_30m_wgs84_Lombardia	EVI_20140703_194_30m_wgs84_Lombardia	OpenLayers KML
<input checked="" type="checkbox"/>	EVI:EVI	EVI	OpenLayers KML
<input checked="" type="checkbox"/>	EVI:EVI_20140804_194_30m_wgs84	EVI_20140804_194_30m_wgs84	OpenLayers KML
<input checked="" type="checkbox"/>	EVI:EVI_20140804_194_30m_wgs84_Lombardia	EVI_20140804_194_30m_wgs84_Lombardia	OpenLayers KML
<input checked="" type="checkbox"/>	EVI:EVI_20140414_194_30m_wgs84	EVI_20140414_194_30m_wgs84	OpenLayers KML
<input checked="" type="checkbox"/>	EVI:EVI_20140414_194_30m_wgs84_Lombardia	EVI_20140414_194_30m_wgs84_Lombardia	OpenLayers KML
<input checked="" type="checkbox"/>	EVI:EVI_20140703_194_30m_wgs84	EVI_20140703_194_30m_wgs84	OpenLayers KML
<input checked="" type="checkbox"/>	NDFI:NDFI_20140804_194_30m_wgs84	NDFI_20140804_194_30m_wgs84	OpenLayers KML
<input checked="" type="checkbox"/>	NDFI:NDFI_20140703_194_30m_wgs84_Lombardia	NDFI_20140703_194_30m_wgs84_Lombardia	OpenLayers KML
<input checked="" type="checkbox"/>	NDFI:NDFI_20140703_194_30m_wgs84	NDFI_20140703_194_30m_wgs84	OpenLayers KML
<input checked="" type="checkbox"/>	NDFI:NDFI_20140414_194_30m_wgs84	NDFI_20140414_194_30m_wgs84	OpenLayers KML
<input checked="" type="checkbox"/>	NDFI:NDFI_20140414_194_30m_wgs84_Lombardia	NDFI_20140414_194_30m_wgs84_Lombardia	OpenLayers KML

<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84_Lombardia	<0.20	<0.20
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84	0.20-0.30	0.20-0.25
<input checked="" type="checkbox"/> NDFI:NDFI_20140414_194_30m_wgs84	0.30-0.35	0.25-0.30
<input checked="" type="checkbox"/> NDFI:NDFI_20140414_194_30m_wgs84_Lombardia	0.35-0.40	0.30-0.35
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84	0.40-0.45	0.35-0.40
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84_Lombardia	0.45-0.50	0.40-0.45
<input checked="" type="checkbox"/> NDFI:NDFI_20140414_194_30m_wgs84	0.50-0.60	0.45-0.50
<input checked="" type="checkbox"/> NDFI:NDFI_20140414_194_30m_wgs84_Lombardia	0.60-0.70	0.50-0.55
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84	>0.70	0.55-0.60
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84_Lombardia		>0.60

<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84_Lombardia	Cereali
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84	Mais
<input checked="" type="checkbox"/> NDFI:NDFI_20140414_194_30m_wgs84	Riso
<input checked="" type="checkbox"/> NDFI:NDFI_20140414_194_30m_wgs84_Lombardia	Soia
<input checked="" type="checkbox"/> NDFI:NDFI_20140703_194_30m_wgs84	Coltura has no value

<http://155.253.20.86/geoserver/web/>



# Aided Creation of INSPIRE metadata for VGI by means of EDI metadata editor



## SEGNALAZIONE CAMPO

### About this resource

Categories	
Keywords	<ul style="list-style-type: none"><li>Copertura del suolo</li><li>Utilizzo del territorio</li><li>piano agroambientale</li><li>Agricoltura</li><li>Mappe di base</li></ul>
Language	<ul style="list-style-type: none"><li>Italiano</li></ul>
Classification	Non riservato
Legal constraints	L'accesso e la fruibilità del dato sono pubblici (access and fruition of data is open) e la responsabilità derivante dall'utilizzo del dato è a carico del fruitore
Resource constraints	Nessuna condizione applicabile
Contact	CNR IDPA
Status	Completato

### Technical information

Format	PROG
--------	------

### Metadata information

[Download metadata](#)

Contact	CNR IDPA
Metadata language	<ul style="list-style-type: none"><li>Italiano</li></ul>

### Spatial extent

### Temporal extent

Publication date  
2013-07-15

### Download and links

segnalazione\_campo  
This dataset is published in the view service [http://10.0.5.7:8000/geoserver/APP/wms?SERVICE=WMS&with:layer=segnalazione\\_campo](http://10.0.5.7:8000/geoserver/APP/wms?SERVICE=WMS&with:layer=segnalazione_campo).

(LegendURL)

### Associated resources

APP: Space4Agri Project Web Map Service - Segnalazioni della S4A APP  
La mappa delle segnalazioni, segnalazioni relative a lavorazioni di campi agricoli, segnalazioni di coltivazioni in atto e relativi stati di sviluppo...

# S4A SDI : Geocatalogue



- GeoNetwork opensource
- Standard INSPIRE metadata
- Contents indexing
- Discovery service
- Crawling and automatic metadata completion for time series
- Access to data layers served by S4A Web GIS
- Maps preview

The screenshot displays the Space4Agri Data Catalogue interface. At the top, the browser address bar shows the URL `155.253.20.86/geonetwork/srv/eng/catalog.search#/search?fast=index&_content...`. The page header includes the 'Space4Agri Data Catalogue' title, a search bar, and a 'Sign in' button. A cookie consent banner is visible below the header. The main content area shows search results for 'Meregatti farm'. On the left, there are filters for 'TYPE OF RESOURCES' (Map: 380, Static map: 380, Dataset: 31, Service: 13, Series: 11), 'INSPIRE THEMES' (Copertura del suolo: 397, Utilizzo del territorio: 15), and 'KEYWORDS' (Farming: 31). The main results area displays two map preview cards for 'Carta Uso Agricolo Suolo\_2014' and 'Carta Uso Agricolo suolo 2013', both by IREA. A small map of Europe is visible in the bottom right corner.

# S4A SDI: Geoportal for Query & Retrieval



155.253.20.86:8080/Space4AgriGeoPortal/

Most Visited Gloria Bordogna Getting Started Amazon Raccolta Web Slice Siti suggeriti Toshiba Places Geoportale Naziona...

Mappa Wiki Fenologia Scala BBCH Arpa Meteo

Legen... + x

- Cereali
- Foraggiere
- Mais
- Riso
- Soia
- No Value

Space4Agri Geo Portal

Active Maps Maps Timeserie < >

Active Layer : APP:fasi\_crescita\_lavoraz\_colture\_

Select Tile Layer MapQuest-Sat

Visualized Layers APP:fasi\_crescita\_lavoraz\_colture\_campi

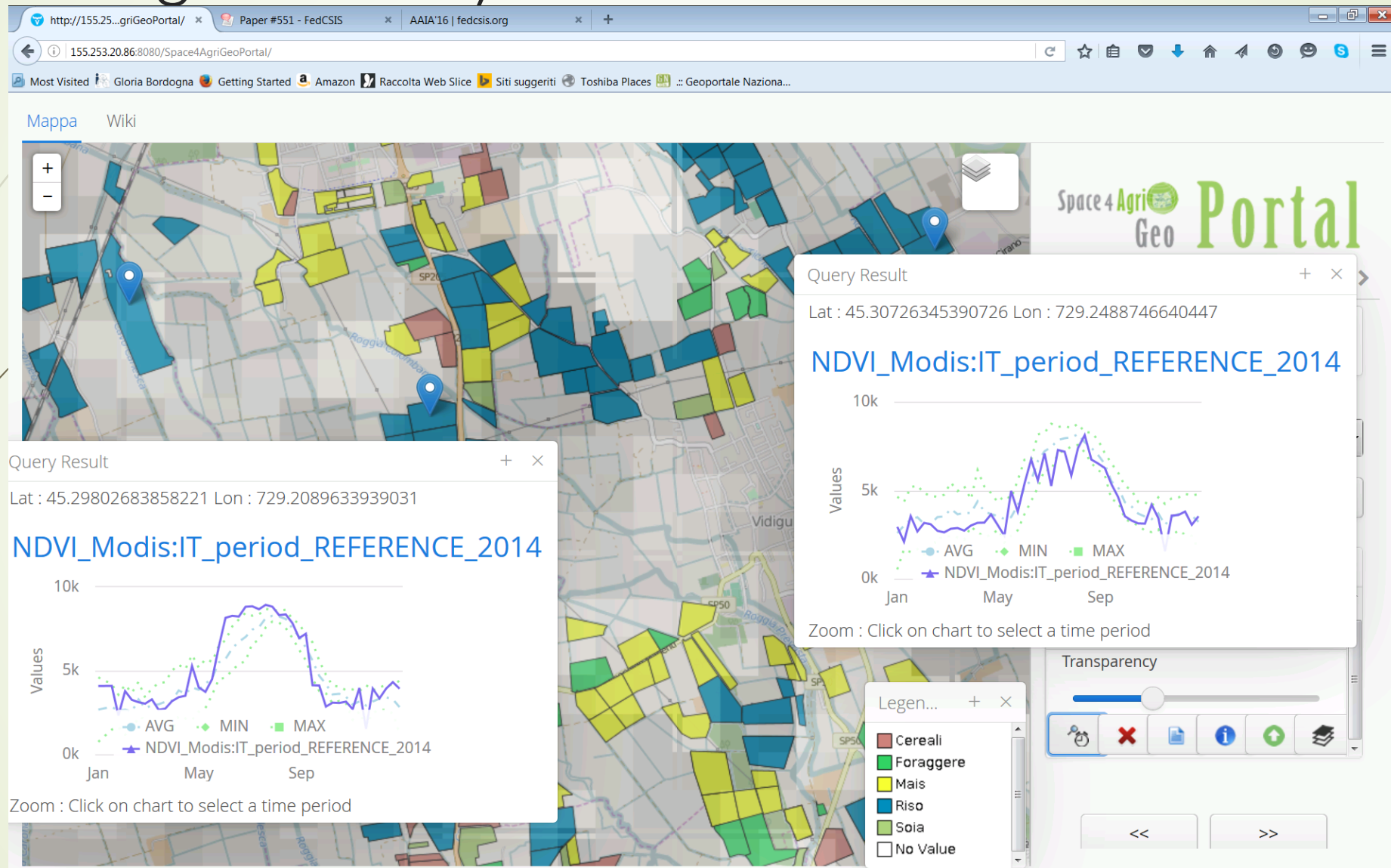
Transparency

Query Result

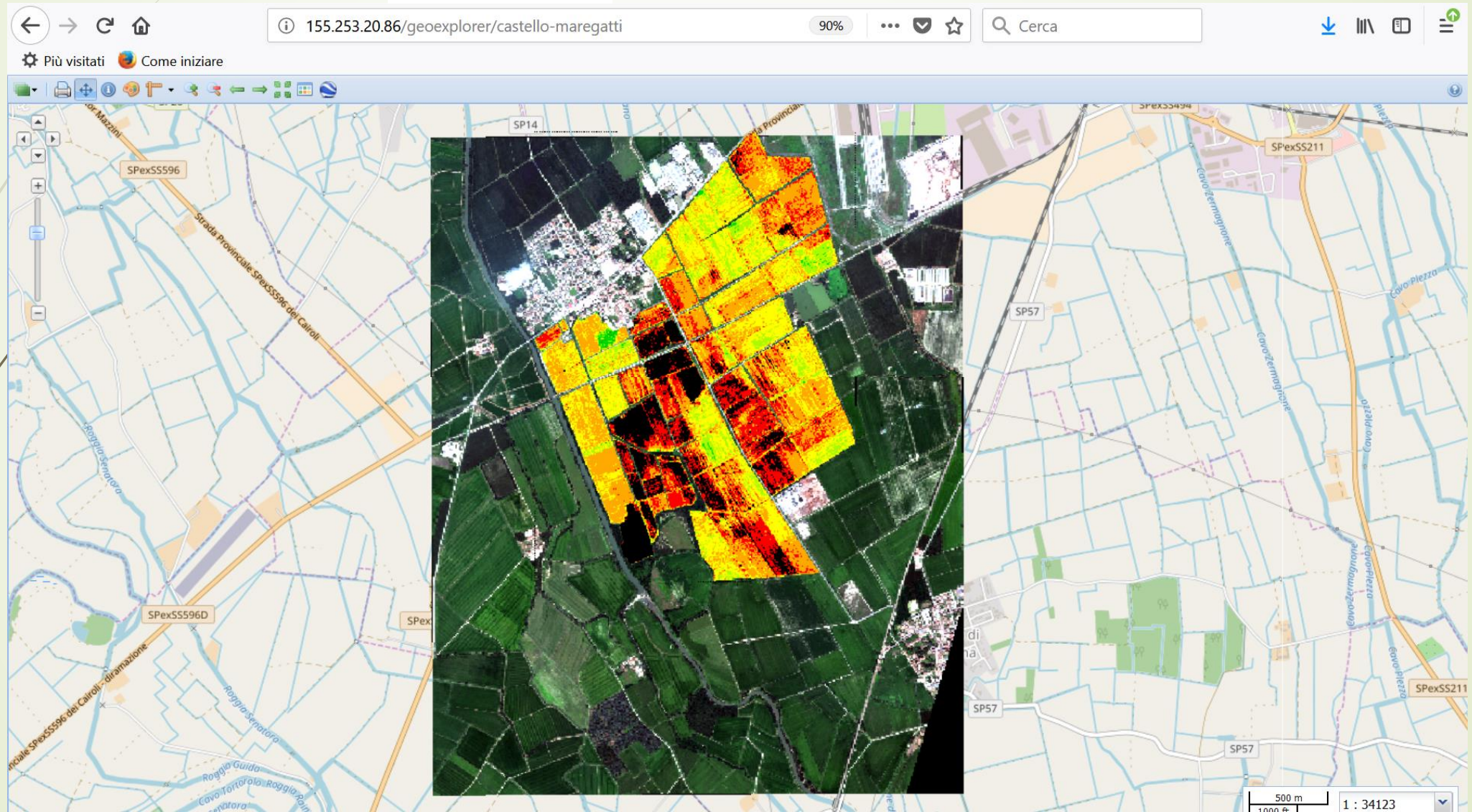
fid	ID	COLTURA	Data_di_Semina	Utente_semina	BBCH	BBCH2	Utente_BBCH	Data_BBCH	Lavorazione	Data_la
fasi_crescita_lavoraz_colture_campo.fid--37df27e3_158d2a31aa2_-6ff0	1550981	Mais			Allungamento fusto	Primo nodo identificabile	ilacazzaniga@gmail.com	May 28, 2015 2:31:23 PM		



# Complex point-Query facilities on time series and heterogeneous layers



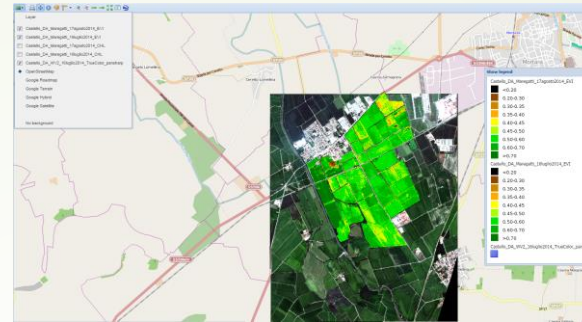
# S4A SDI : Interoperability with other geoportals (Geoexplorer)





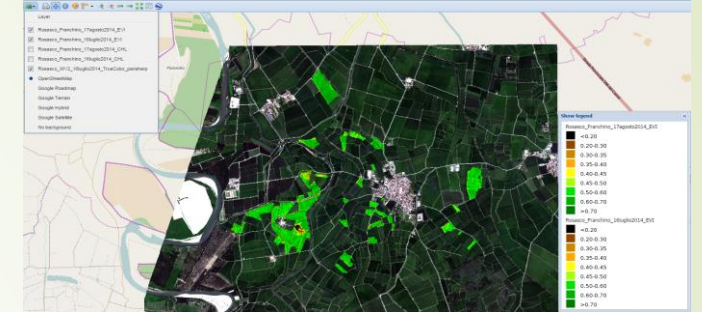
# S4A: Collaboration with stakeholders

<b>Volunteers</b>	<b>85</b>	<b>100%</b>
<b>Active Volunteers (created &gt; 10 VGI items))</b>	<b>21</b>	<b>25%</b>
<b>VGI about BBCH stages</b>	<b>2594</b>	<b>88%</b>
<b>VGI about Free text and pictures</b>	<b>370</b>	<b>13%</b>
<b>VGI about Field processing practices</b>	<b>137</b>	<b>5%</b>
<b>VGI about Seeding Dates</b>	<b>223</b>	<b>8%</b>
<b>Total VGI Items (2014)</b>	<b>2954</b>	<b>100%</b>



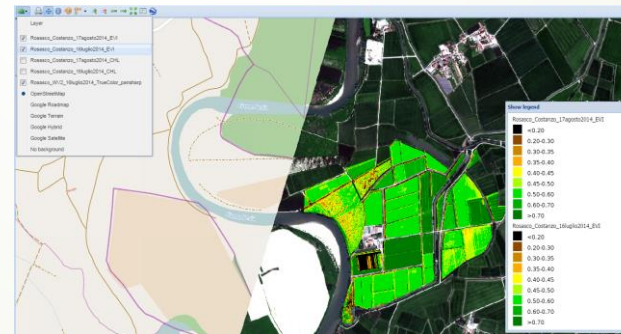
Castello – Maregatti

<http://155.253.20.86/geoexplorer/castello-maregatti>



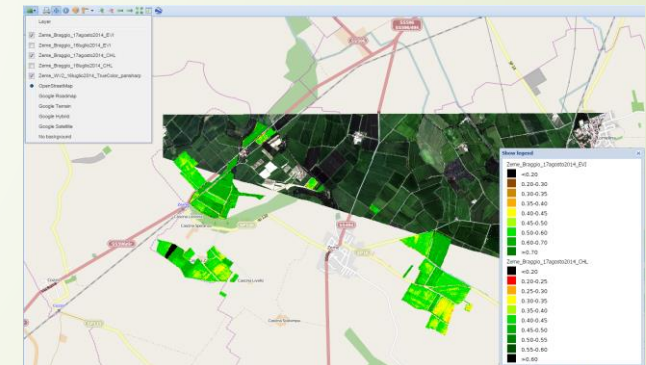
Rosasco – Franchino

<http://155.253.20.86/geoexplorer/osasco-franchino>



Rosasco – Costanzo

<http://155.253.20.86/geoexplorer/rosasco-costanzo>




Zeme – Braggio

<http://155.253.20.86/geoexplorer/zeme-braggio>



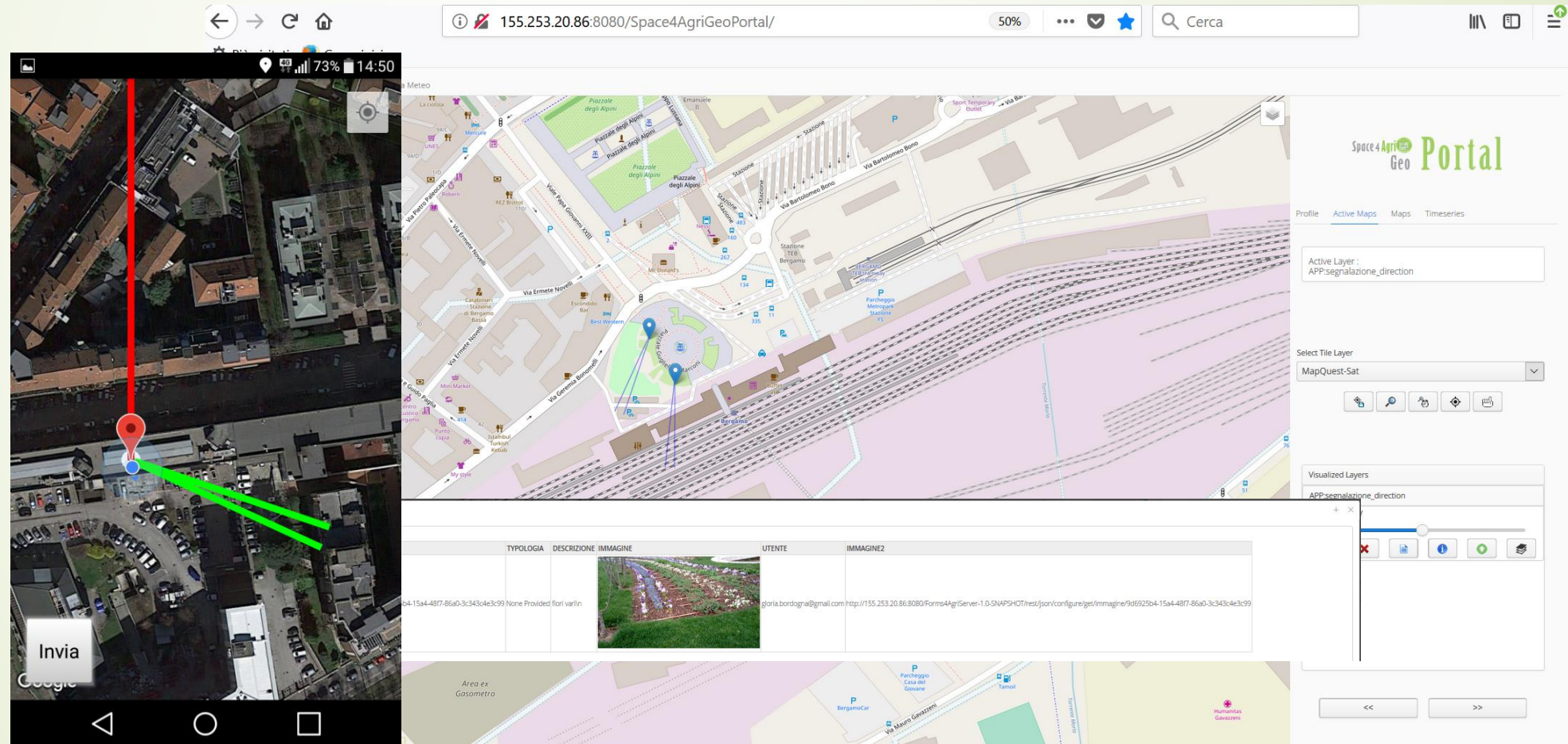
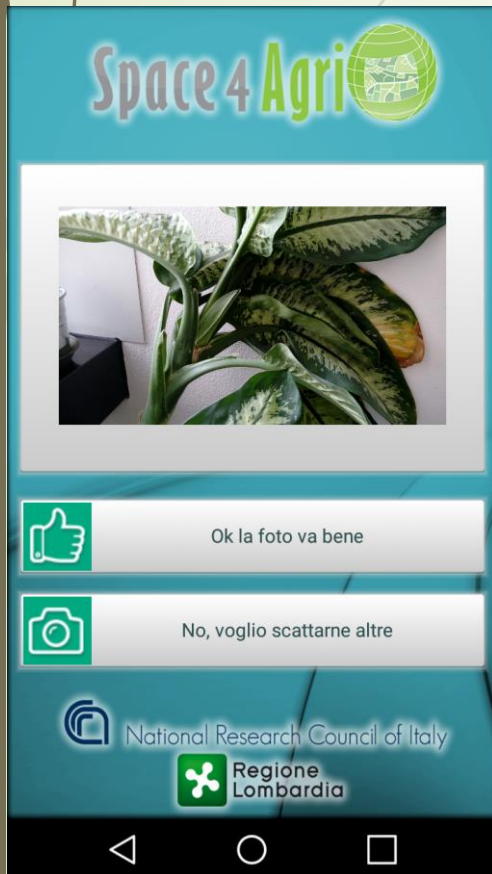
# Lesson learned: imprecision and uncertainty on VGI georeferencing

The screenshot displays the Space4Agri Geo Portal interface. The main map area shows a rural landscape with roads (D 111, D 211) and green fields. A series of red dots, representing agricultural signals, are plotted along a road. A blue location pin is also visible. A legend box in the top right corner indicates 'Legenda: APP:segnalazione'. On the right side, the 'Active Maps' panel shows 'Active Layer : APP:segnalazione' and 'Select Tile Layer : MapQuest-Sat'. Below this, the 'Visualized Layers' panel lists 'APP:segnalazione\_campo', 'APP:segnalazione', and 'Transparency' with a slider. At the bottom, a data table titled 'segnalazione' provides details for a specific signal.

fid	ID	TIPOLOGIA	DESCRIZIONE IMMAGINE	UTENTE	IMMAGINE2
segnalazione.fid--37df27e3_158d2a31aa2_5138	474d03a3-885f-4aef-9916-43108349dfc1	None Provided	lavanda 80 perc	laure.hossard@supagro.inra.fr	 <a href="http://155.25/Forms4AgriS1.0-SNAPSHC/configure/ge/474d03a3-84aef-9916-43">http://155.25/Forms4AgriS1.0-SNAPSHC/configure/ge/474d03a3-84aef-9916-43</a>

# Lesson learnt: imprecision and uncertainty on VGI georeferencing

## Disambiguation by exploiting contextual knowledge





# Lesson learnt: imprecision and uncertainty of Volunteer

- ✓ Phenological stages variability within a field
- ✓ Inadequate knowledge of the volunteer
- ✓ Limitation of observation means (sight, weather conditions, far point of view etc
- ✓ Vagueness of BBCH ontology, example :

✓ **“63 Male: beginning of pollen shedding Female: tips of stigmata visible” and**

■ **“69 End of flowering: stigmata completely dry”**

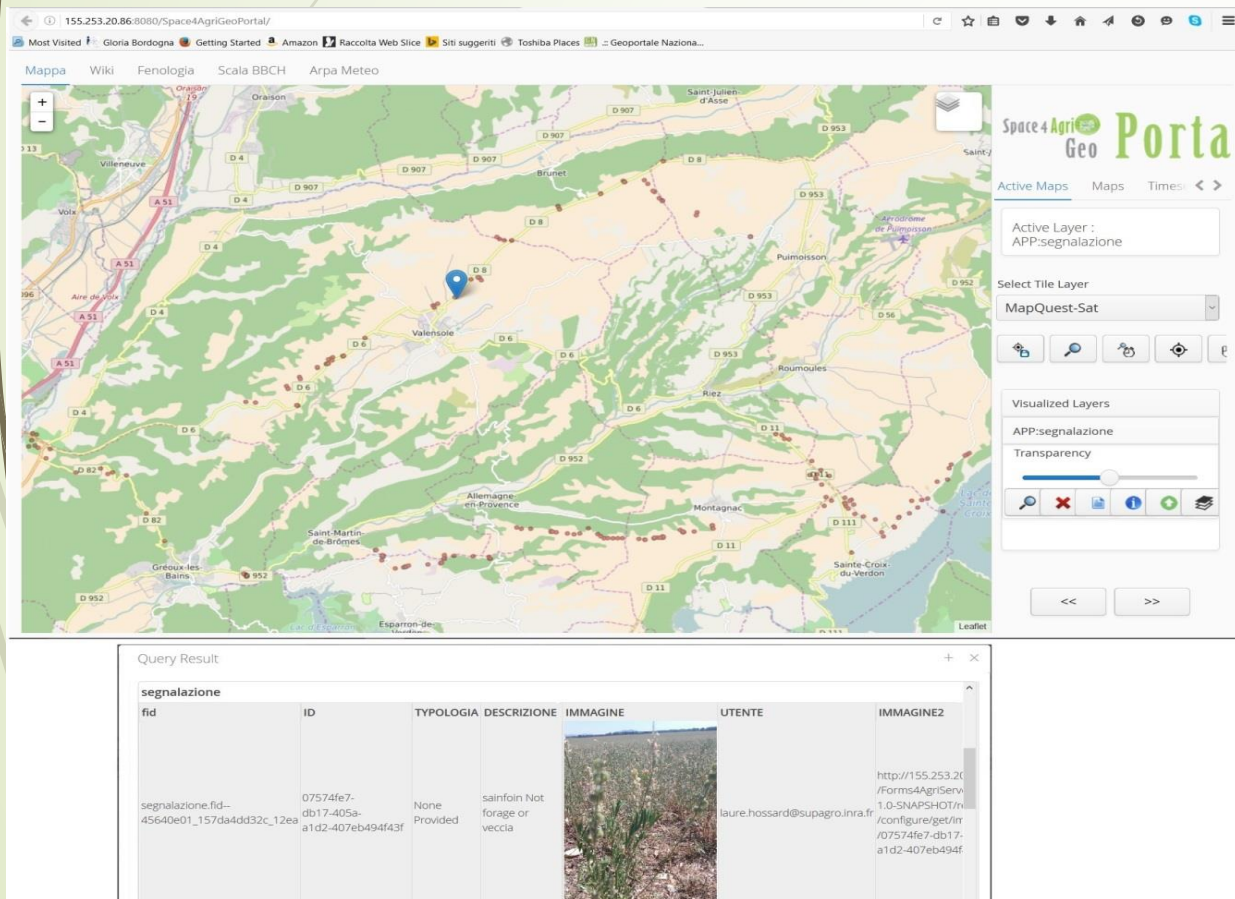
**Maize**






# Conclusion and Ongoing

- ✓ Need to represent vagueness of Knowledge and uncertainty of Volunteer;
- ✓ Need to evaluate VGI quality based on Fitness for use



The screenshot displays the Space4Agri GeoPortal interface. The top section shows a map of a rural area with various layers and a query result table. The map is titled "Space4Agri Geo Portal" and includes a search bar, a list of layers, and a "Query Result" section. The "Query Result" section shows a table with columns: segnalazione, ID, TIPOLOGIA, DESCRIZIONE, IMMAGINE, UTENTE, and IMMAGINE2. The table contains one row of data for a "segnalazione" with ID "07574fe7-d017-405a-a1d2-407eb494f3f". The "IMMAGINE" column shows a photo of a field, and the "IMMAGINE2" column shows a URL to the image.

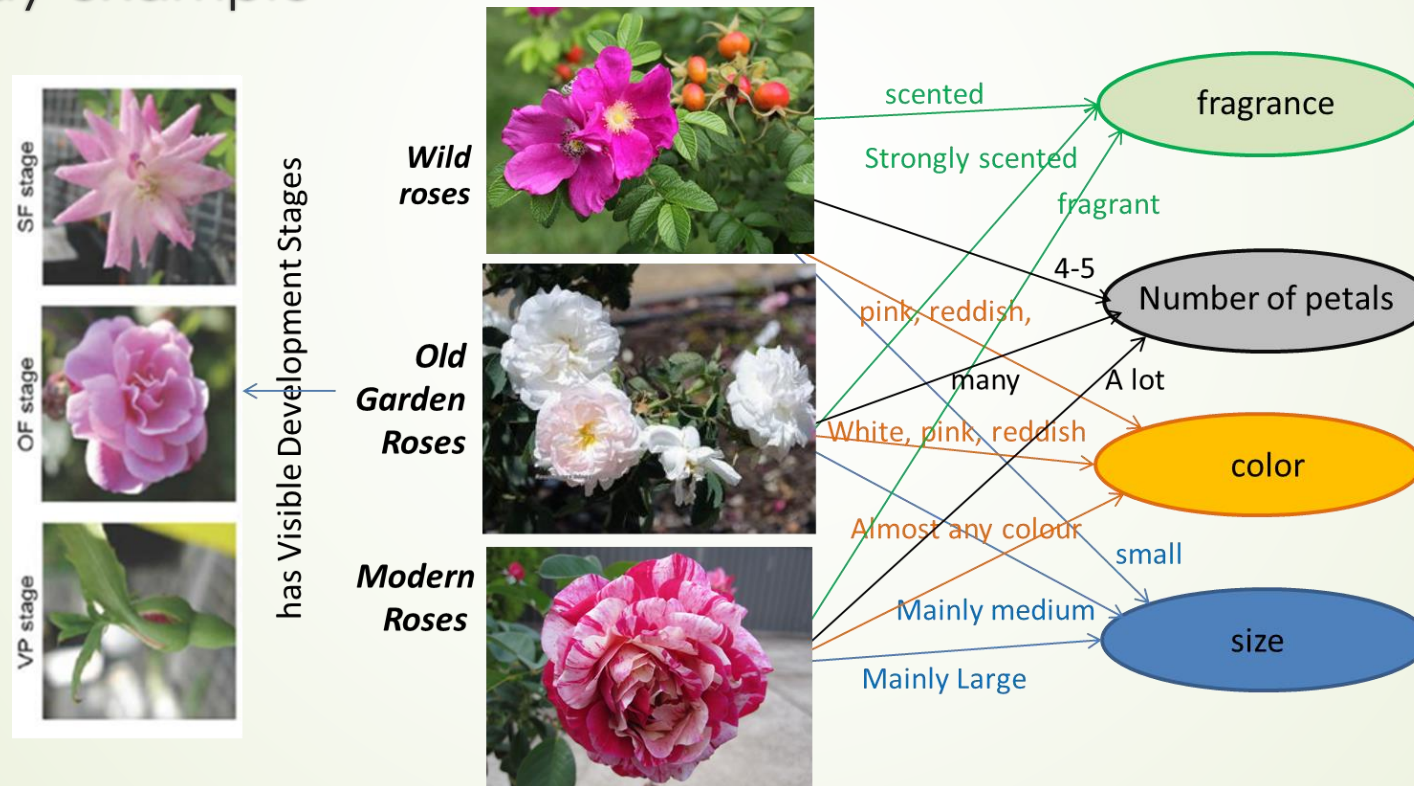
segnalazione	ID	TIPOLOGIA	DESCRIZIONE	IMMAGINE	UTENTE	IMMAGINE2
segnalazione.fid--45640e01_157da4dd32c_12ea	07574fe7-d017-405a-a1d2-407eb494f3f	None Provided	sainfoin Not forage or vecchia		laure.hossard@supagro.inra.fr	http://155.253.20/Forms4AgriServ/1.0-SNAPSHOT/in/configure/get/in/07574fe7-d017-a1d2-407eb494f

## Opportunity:

- ✓ fuzzy ontologies to create controlled VGI
- ✓ Possibilistic framework to rank the VGI items through level-based approximate reasoning on a fuzzy ontology

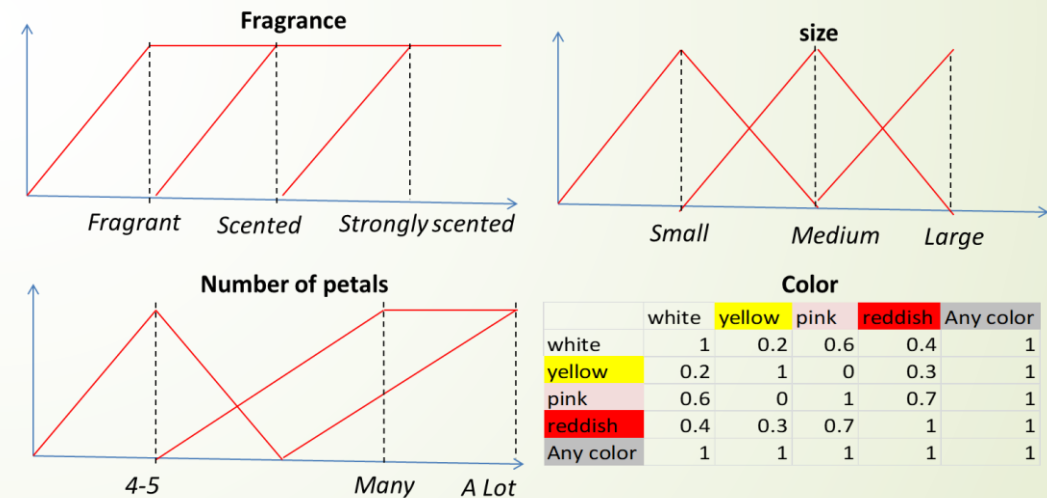
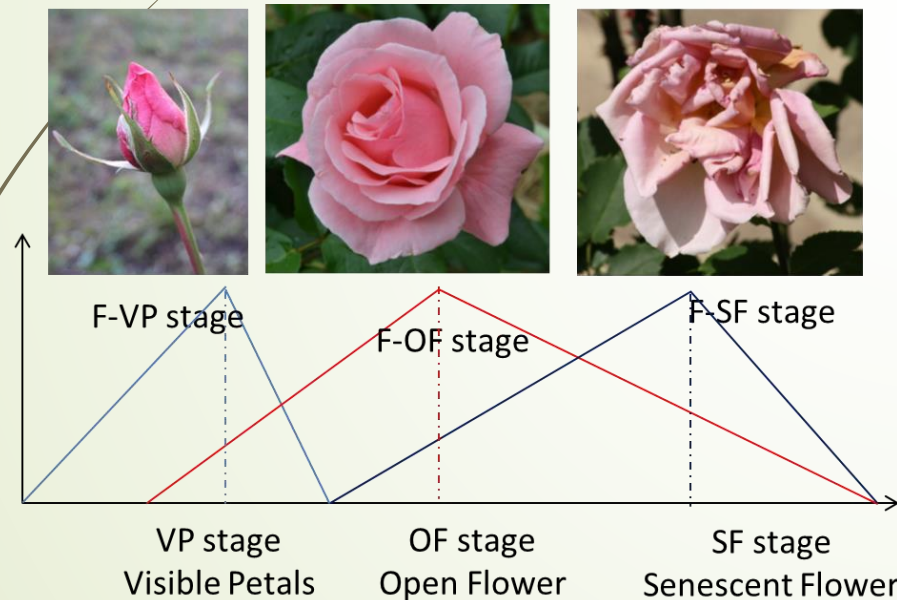
# Knowledge representation based on a Fuzzy Ontology

- Fuzzy Ontologies (Bobillo F, Straccia U., The fuzzy ontology reasoner fuzzyDL, Knowledge-Based Systems 95 (2016) 12–34.)
  - Case study example



# Knowledge representation based on a Fuzzy Ontology

- Meanings of the linguistic values defined by fuzzy sets: Fragrance, size, N. of petals, Color, Growth (Development) stages;
- the compatibility of linguistic terms can be computed





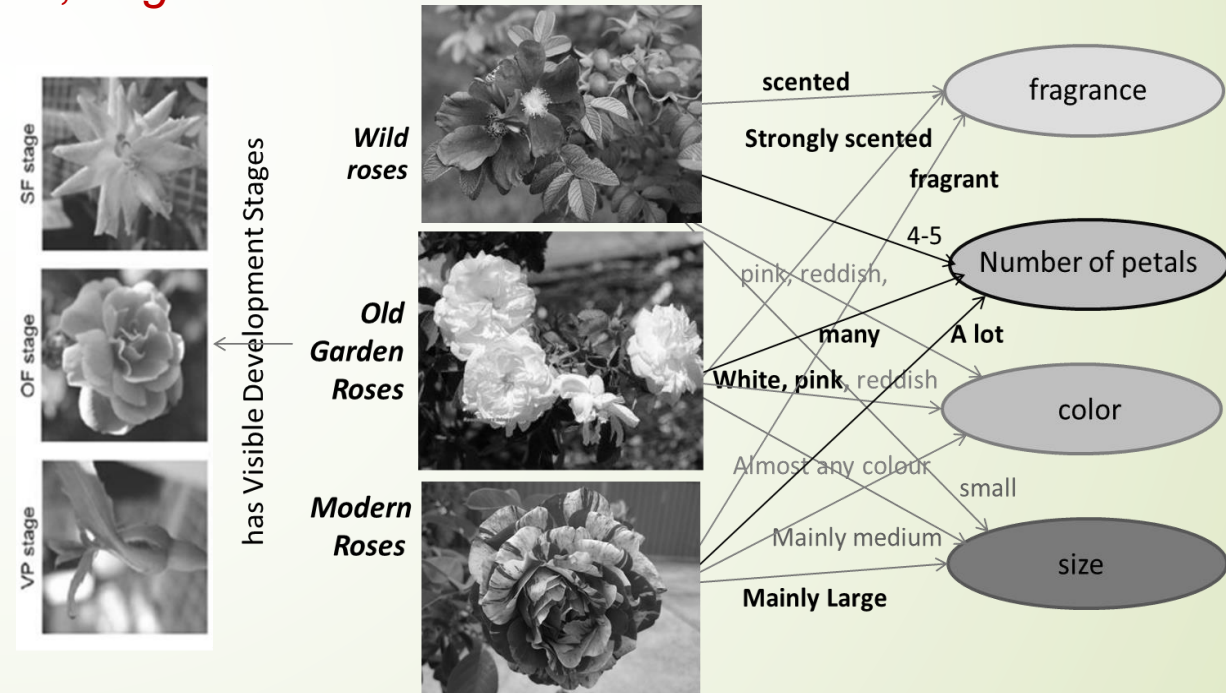
# VGI creation by exploiting a Fuzzy Ontology

- Linguistic Description of observations based on the perceived aspect of properties. Uncertainty degrees are automatically computed by applying approximate reasoning



*Fragrance : scented, strongly scented , fragrant*  
*N. petals: many , a lot*  
*Color: white, pink*  
*Size: mainly large*


Modern rose = 1     $\min(1,1,1,1)$   
Garden rose = 0.5     $\min(1,1,1,0.5)$   
Wild rose = 0     $\min(1,0.4,1,0)$





# Conclusions

We need more general tools to enable VGI creation allowing:

- ✓ ingesting a (fuzzy) ontology relevant for the application
  - ✓ creating observations by multiple selections in case of uncertainty and applying approximate reasoning to derive classifications
  - ✓ exploiting some collaborative approach for disambiguation
  - ✓ exploiting context information derived by multiple sources
- 



Thank you for your attention!

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