Soil Classification Techniques in Local Areas Based on Satellite Data

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Soil related scenarios

- General scenario:
  - A farmer wants to obtain the best results and he wants to know if the soil is good and properly for the desired agricultural crop (wheat, corn, sunflower, etc.)
- Specific scenario.
  - Continuous updating of information on the soil composition in Transylvania area
  - Sensor stations (10 units) - supervised manually by the human operators
  - “black holes” - areas with no any specifications for soil and climate changes which affects the structure of soil
  - Soil degradation by intensive exploitation - dynamical and continuum process

Main requirements

- Efficient technical management in agriculture
- Good, reach and accurate information on the soil
- Up-to-date and high-resolution soil information
- Direct access to this information in a flexible and simple manner
- Pedology and agriculture specialists, farmers, soil monitoring and land management organizations, pedology maps developers, Earth Observation and Earth Science oriented software development companies, sustainable development, and universities

Soil characteristics

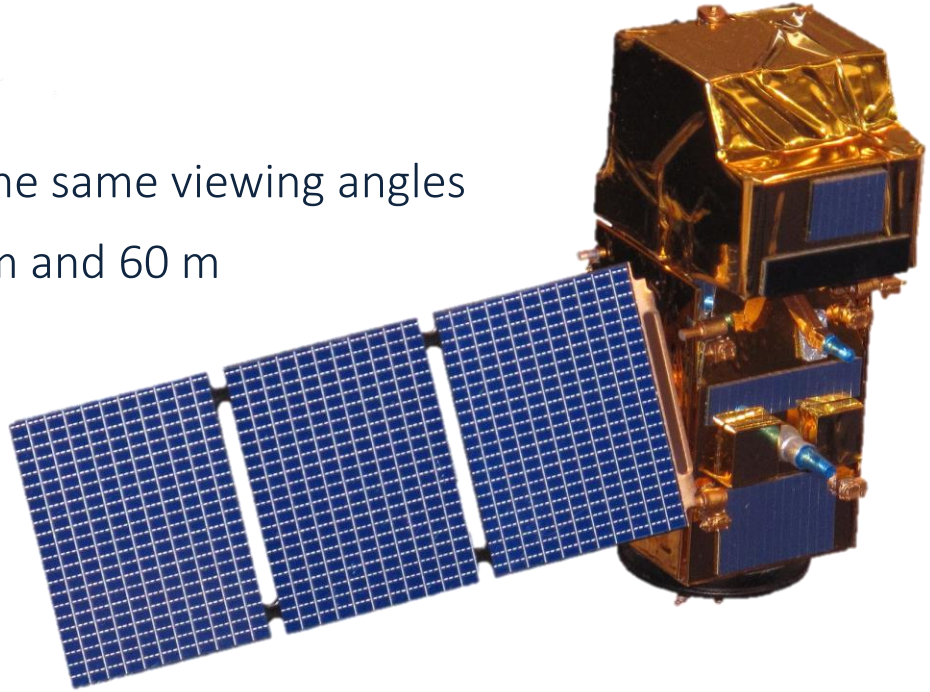
- *Organic Content* - plants and animals add organic matter (humus)
- *Mineral content* - different particles of rocks (i.e. sand, silt and clay), and minerals (i.e. calcium, potassium, phosphorous, nitrates)
- *Water and air* - vast interconnecting cavities or holes giving the soil porosity
- *Soil Texture* - mixture of particles (fine –sand, very fine – silt, extra fine - clay).
- *Soil reaction or soil pH* - measure of the acidity and alkalinity in soils.

Soil classification

- Romanian System of Soil Classification (1969)
- FAO – UNESCO, World Reference Base for Soil Resources
- Romanian Soil Taxonomy System (SRTS, 2003), by Research Institute for Soil Science (ICPA)
  - 3 higher level taxonomic soil units: class, type and subtype
  - 4 lower-level taxonomic soil units: variety, family, species and variant
  - classification is based on samples taken from the ground
  - pedologist makes soil maps used by agronomists to establish crop plans

Sentinel-2 data

- Provided by Sentinel-2 satellites as part of the Copernicus Programme
- Characteristics:
  - Revisiting every 5 days under the same viewing angles
  - Spatial resolution of 10 m, 20 m and 60 m
  - Multi-spectral data (13 bands)
  - Free and open data policy
- Examples of applications:
  - Monitoring land cover changes
  - Agricultural crop monitoring
  - Observation of coastal zones
  - Glacier monitoring, ice extent mapping, snow cover monitoring
  - Flood mapping & management

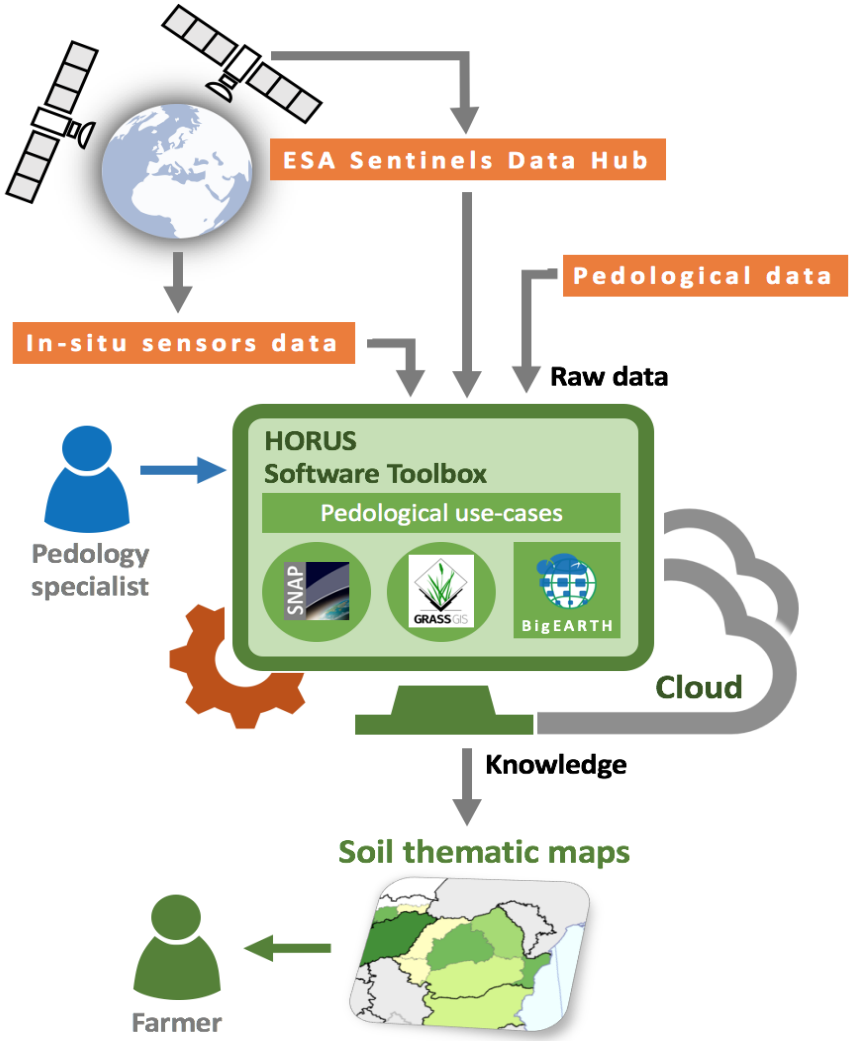


esa
European Space Agency

Sentinel-2 data processing

- Issues:
  - High volume of data
  - High computational resources
  - Satellite data processing and interpretation is very particular to each area, time, season, and context
- Proposed solution:
  - Spectroscopic analysis to infer soil genesis and soil classification
  - Parallel and distributed execution over the cloud
  - Processing data series
  - Remote execution (multiple Virtual Machines, cloud)
  - Interactive applications

Satellite data to pedology



HORUS Project

- Software Toolbox for Pedological Monitoring of Transylvanian Area based on Sentinel-2 Data
- Funded by the Romanian Space Agency (ROSA), member of ESA
- Contract 184/2017, 2017-2019
- Partners:
  - Technical University of Cluj-Napoca (UTCN)
  - University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca (USAMV)

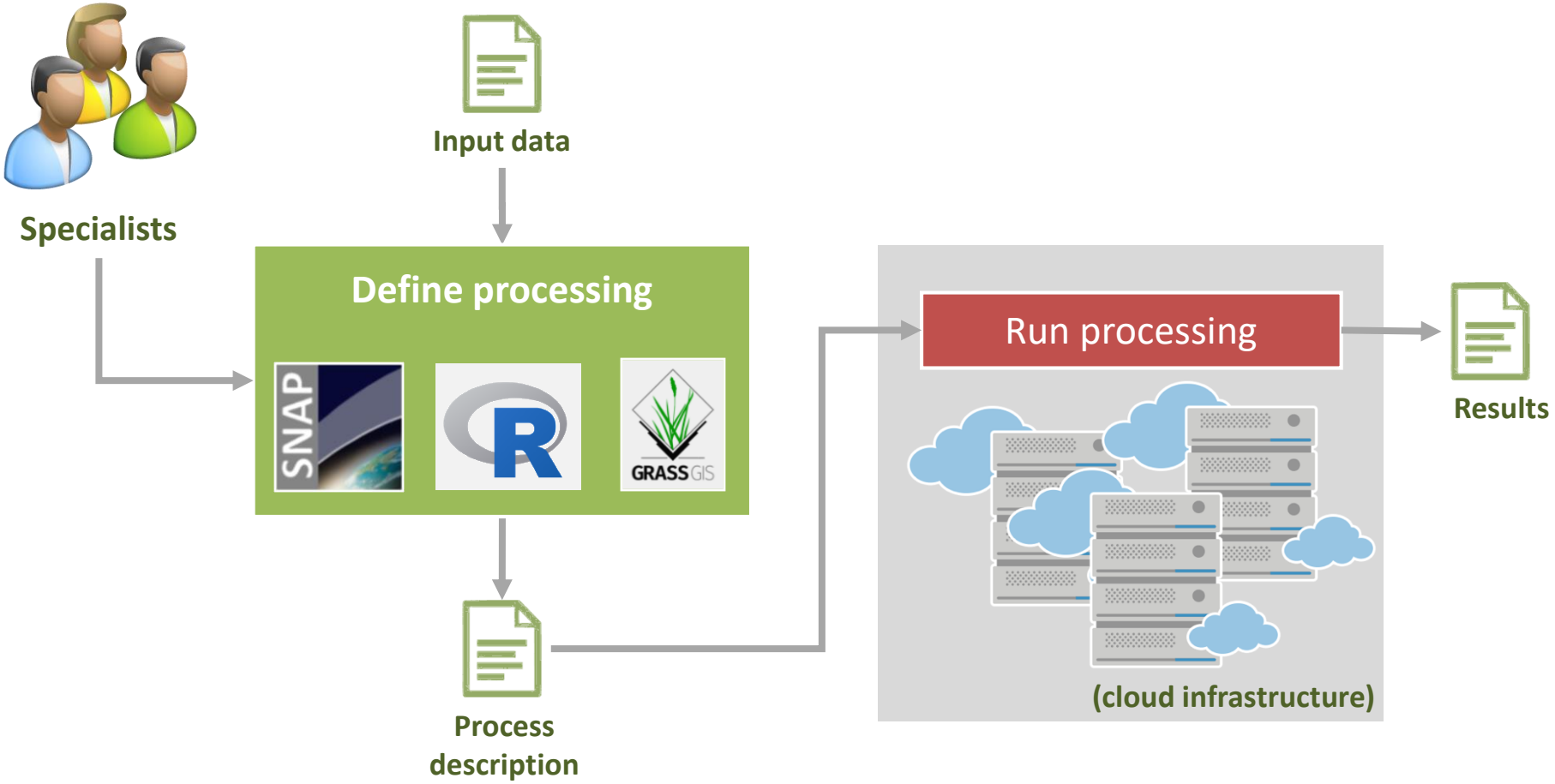
Main objectives

- Development of software platform and tools for pedology studies in Transylvania area, based on Sentinel-2 data
- Flexible description and adaptive high performance computation of spatial big data
- Building a community for sustainable development

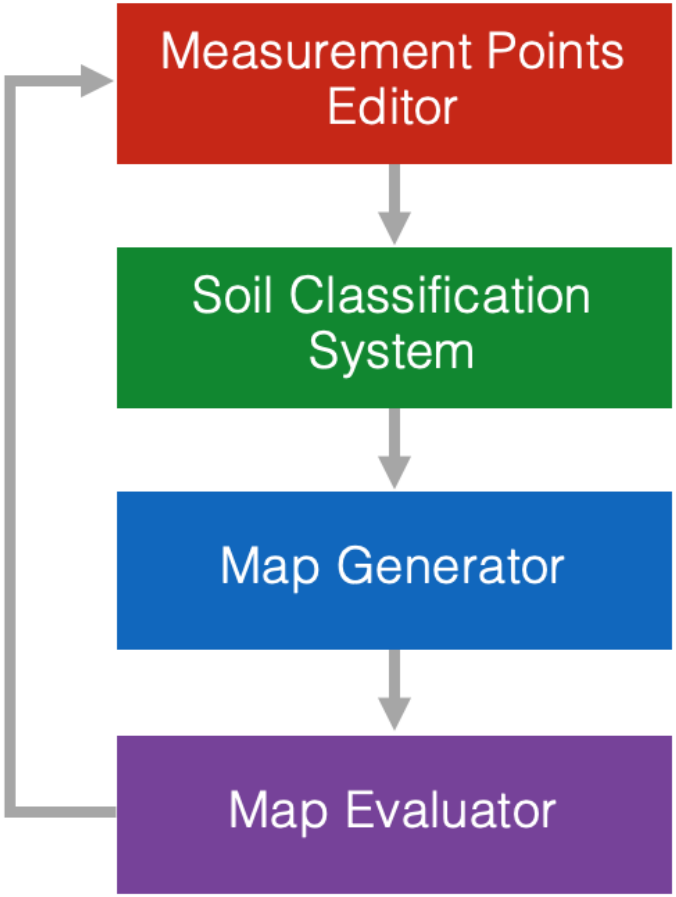
Satellite data computation

- The specialists provide the characteristics of the measured soil positions
- Calibrate the satellite data computation to fit the measurements in the field
    a. Analytical definition of the computation
    b. Machine learning based computation techniques
- Extend the computation approach to neighbor areas
- Check and adjust the computation approach to another area

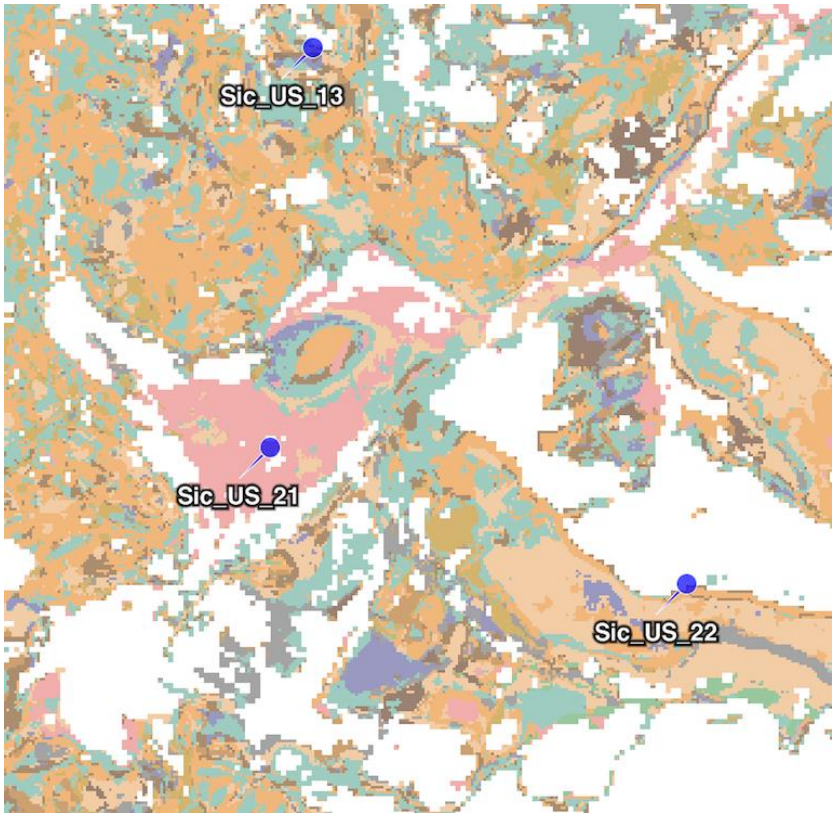
Distributed execution



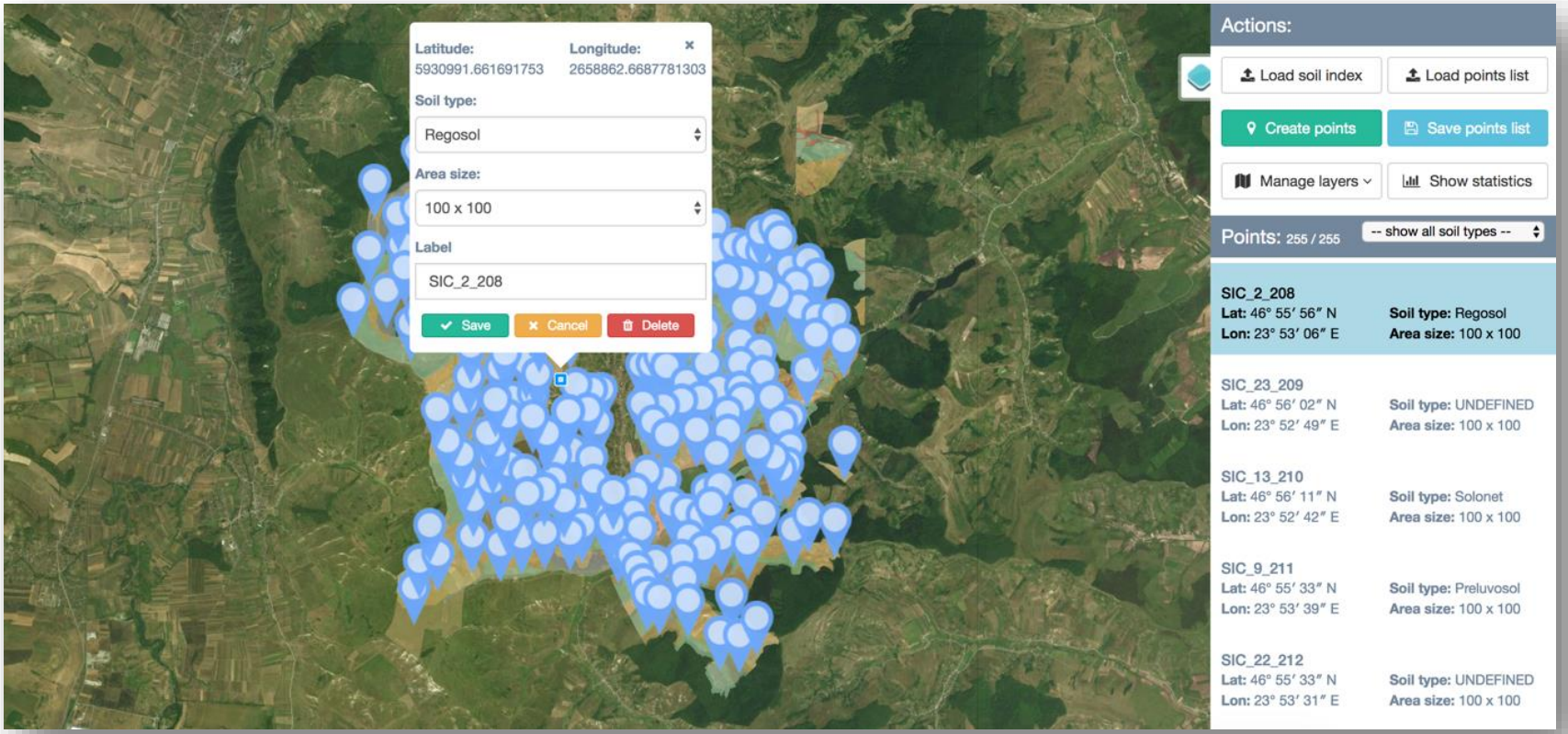
Horus application



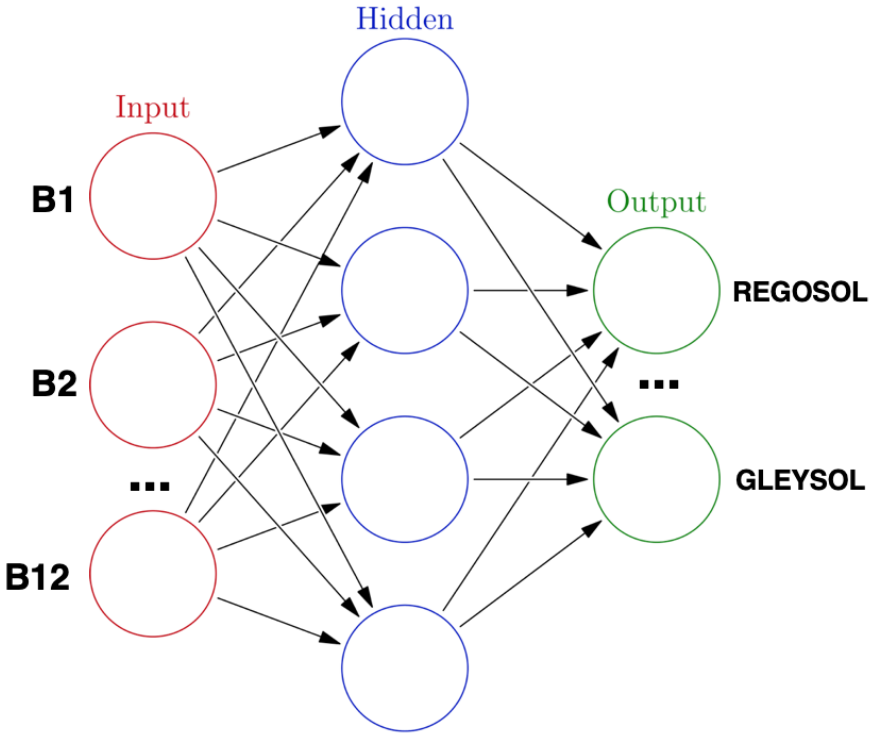
Pedological maps



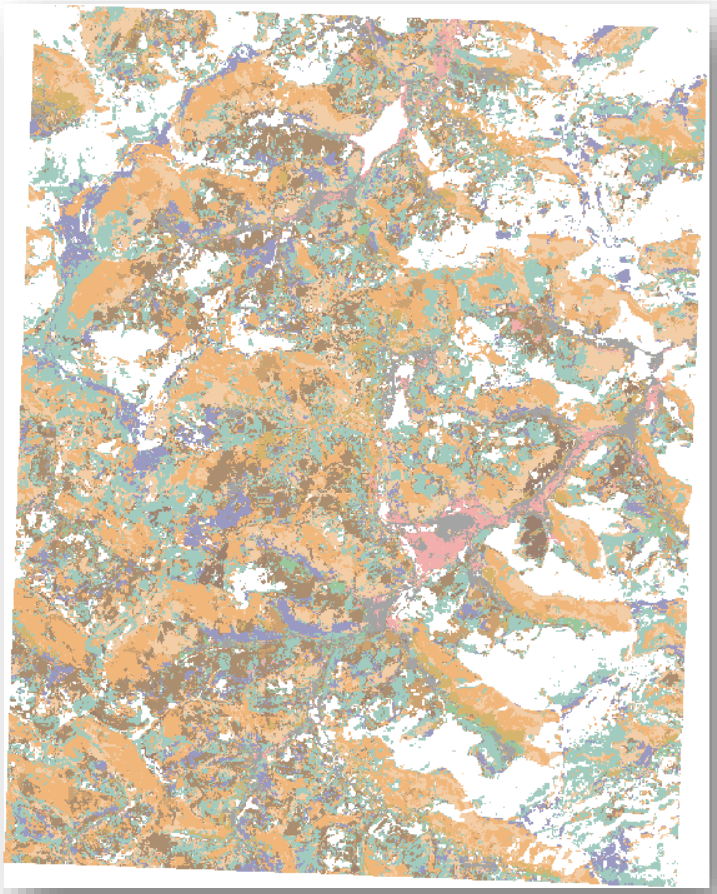
Measurement points

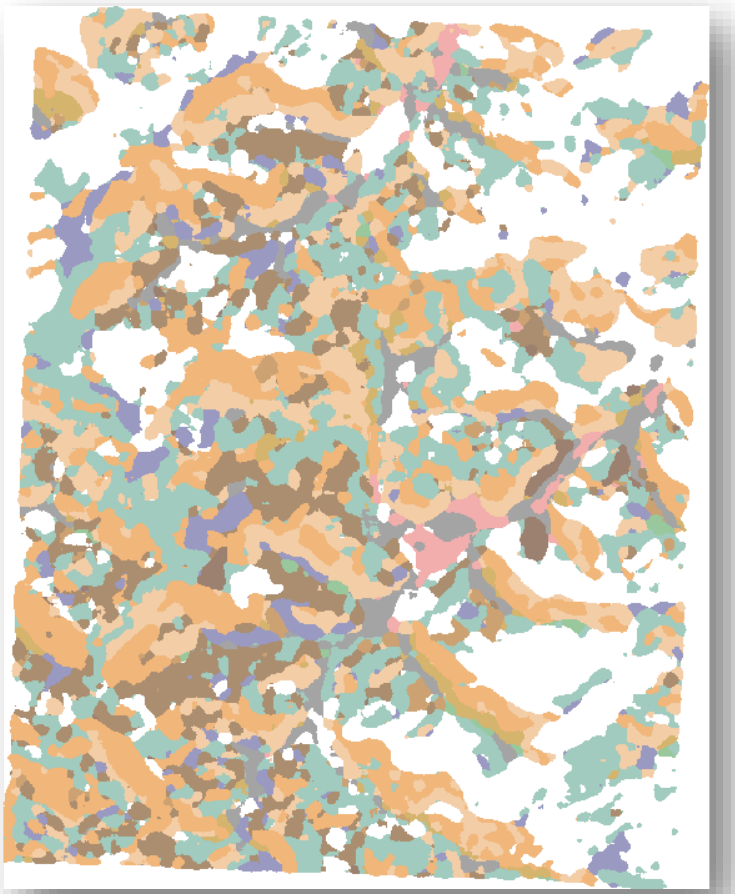


Soil classification system

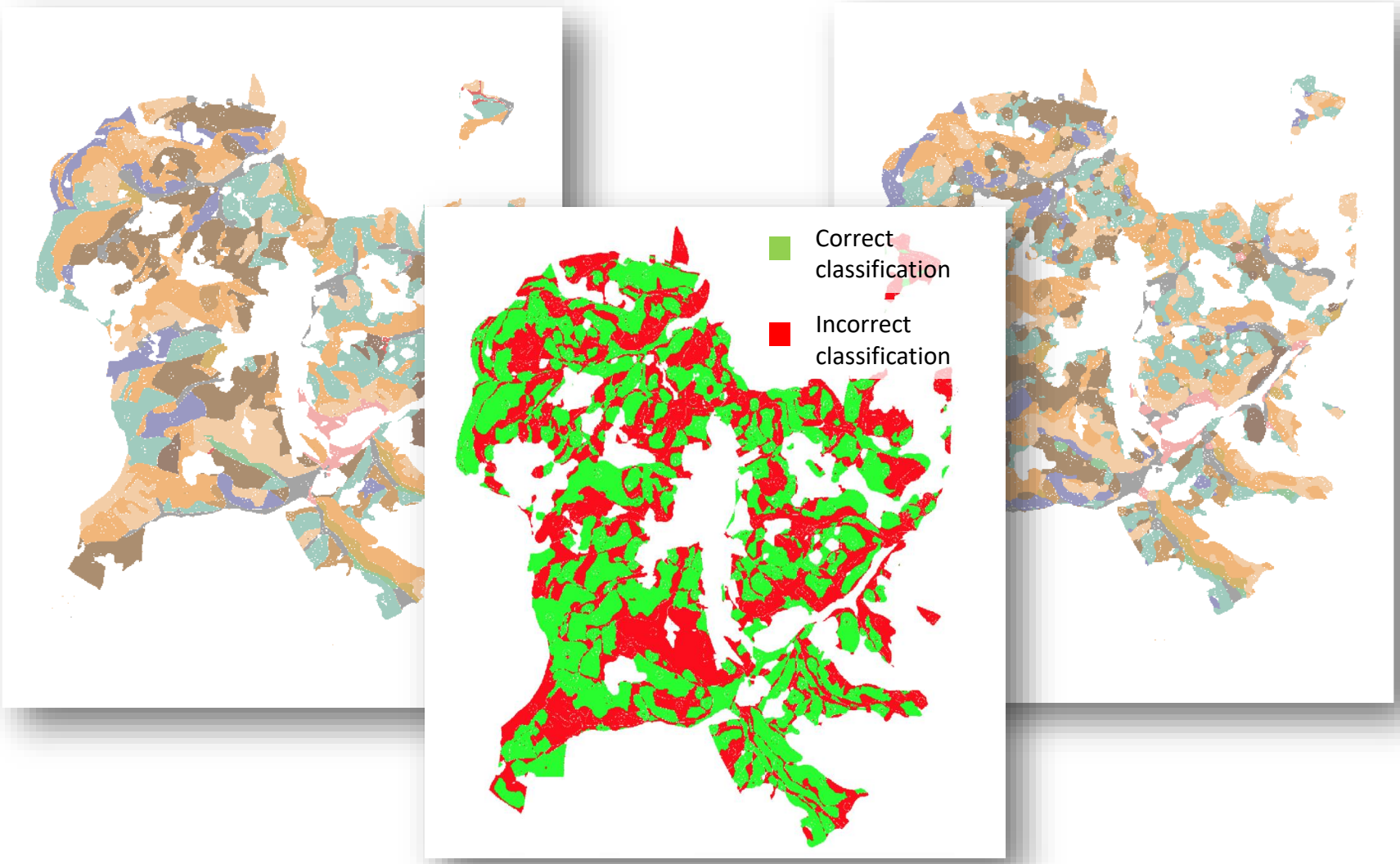


Generated maps





Mapping assessment



Conclusions

- Soil classification is a complex process based on the field observation and analysis
- Soil classification process is different for various countries and regions
- Not all soil parameters can be mapped onto the satellite data
- Satellite data computation needs local calibration based on particular context
- Classification criteria are indirectly inferred from the computed parameters
- Real time computation requires high performance computation resources

Many thanks for your attention!

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