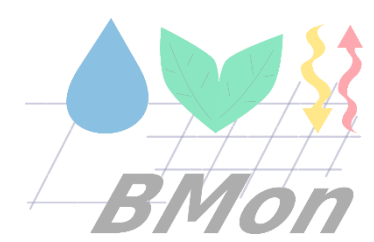


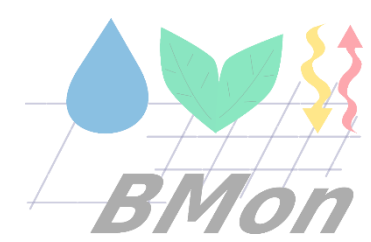
# A CLOUD-BASED SYSTEM FOR HIGH RESOLUTION SOIL MOISTURE MONITORING OVER AUSTRIA

**Mariette Vreugdenhil**, Wolfgang Wagner, Franz Schmid,  
Ingo Schnetzer, Günter Blöschl, Juraj Parajka, Jürgen Komma,  
Christian Briese, Richard Kidd, Stefan Schneider, Klaus  
Haslinger, Josef Eitzinger, Gerhard Kubu, Lukas Künzel, Lucas  
Scheiber, Friedrich Teichmann, Ammar Wahbi



## Aim of BMon

The “**best possible**” **soil moisture product** by integrating EO data with ground observations (precipitation, runoff, etc.) and ancillary data (soil maps, land cover, etc.) through model-data assimilation schemes, and **combining the skills of EO data and three models from hydrology, agronomy and meteorology** in a multi-model ensemble.



## Goals of BMon

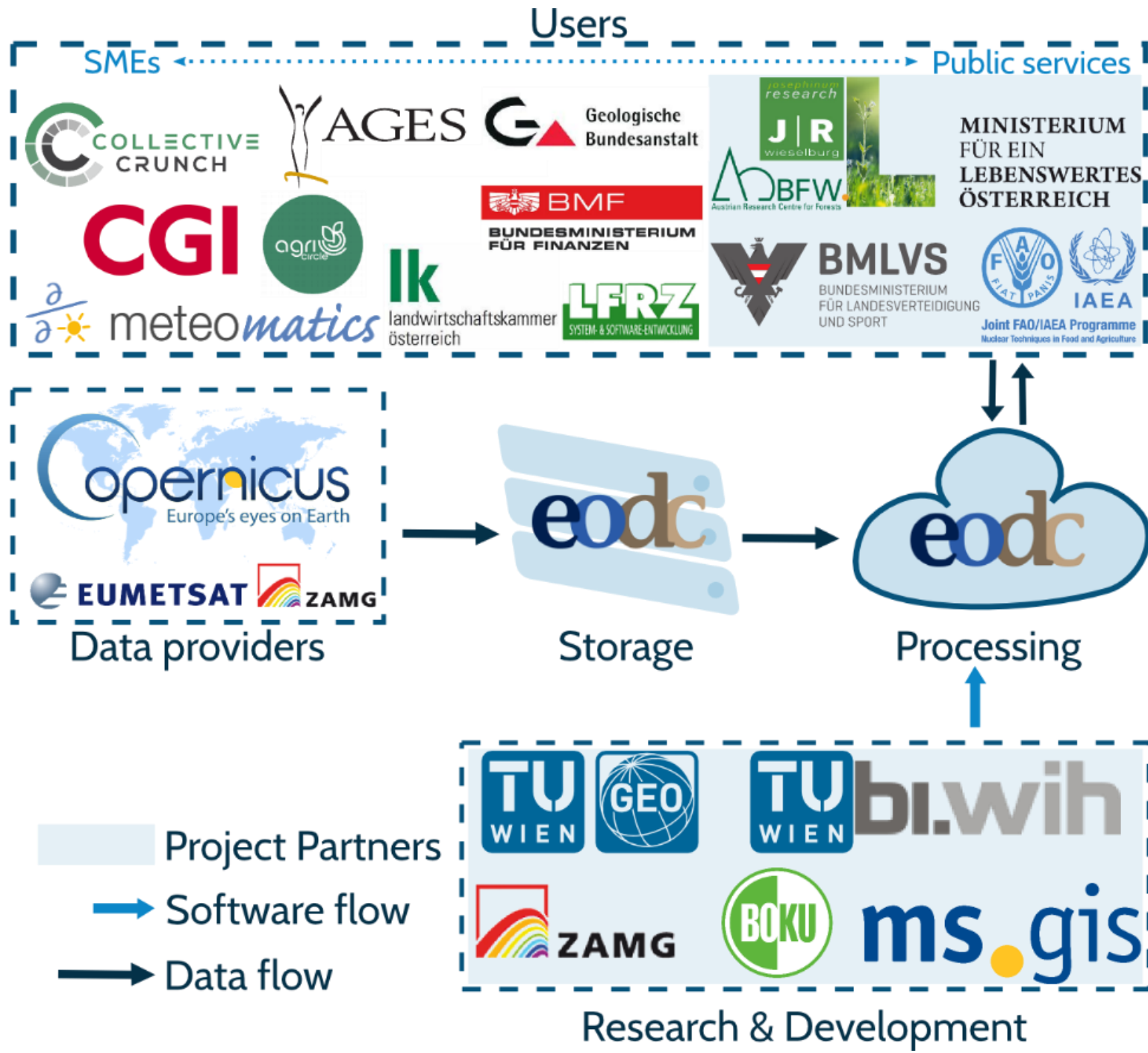
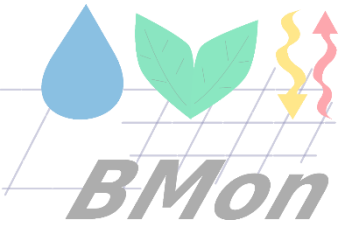
User-driven cloud-based system for real-time high-resolution soil moisture monitoring:

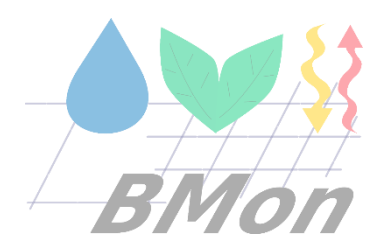
- The **soil moisture estimates are consistent with closely related variables** (rainfall, runoff, yield).
- The **spatio-temporal resolution of the soil moisture output is improved** compared to only-satellite based approaches.
- The implementation of the system on a **cloud platform** reduces operational costs by **simplifying the exchange of data and information** between the different system components.

## User benefits and integration

- Close integration of users and project partners/developers through **user requirement inquiry** in two phases and **user workshops**.
- Providing a **modular prototype**, easily extendable and adaptable for further projects/applications.
- Demonstrating platform capabilities through **test cases** (Austria and Mali) and a final user workshop.





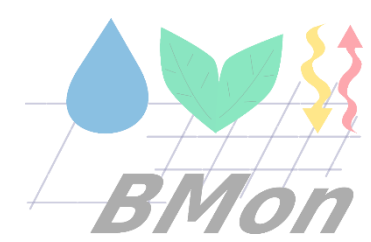


# Importance of soil moisture monitoring

## Applications of soil moisture:

- Forecasting river **runoff** and ground water replenishment
- Improving **weather forecasts**
- Preparedness for **extreme events**
- Plan **irrigation** and field management practices to optimize yields
- Anticipate **droughts** and **water demands**
- ...





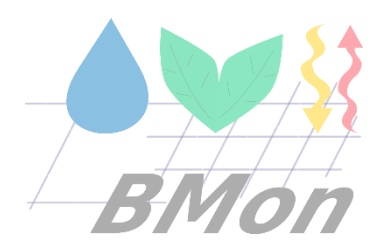
# Importance of soil moisture monitoring

## Applications of soil moisture:

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- Improving **weather forecasts**
- Preparedness for **extreme events**
- Plan **irrigation** and field management practices to optimize yields
- Anticipate **droughts** and **water demands**

Develop a **cloud-based system for near-real-time monitoring of soil moisture** conditions over Austria at high spatio-temporal sampling (twice daily at 100 m sampling)





# Soil moisture monitoring

Soil moisture is driven by processes acting at different spatial scales:

- Topography
- Land cover
- Soil
  
- Climate
- Large scale weather patterns



Zeitraum  
< Frühling > < 2018 >

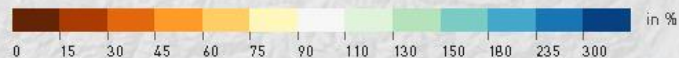
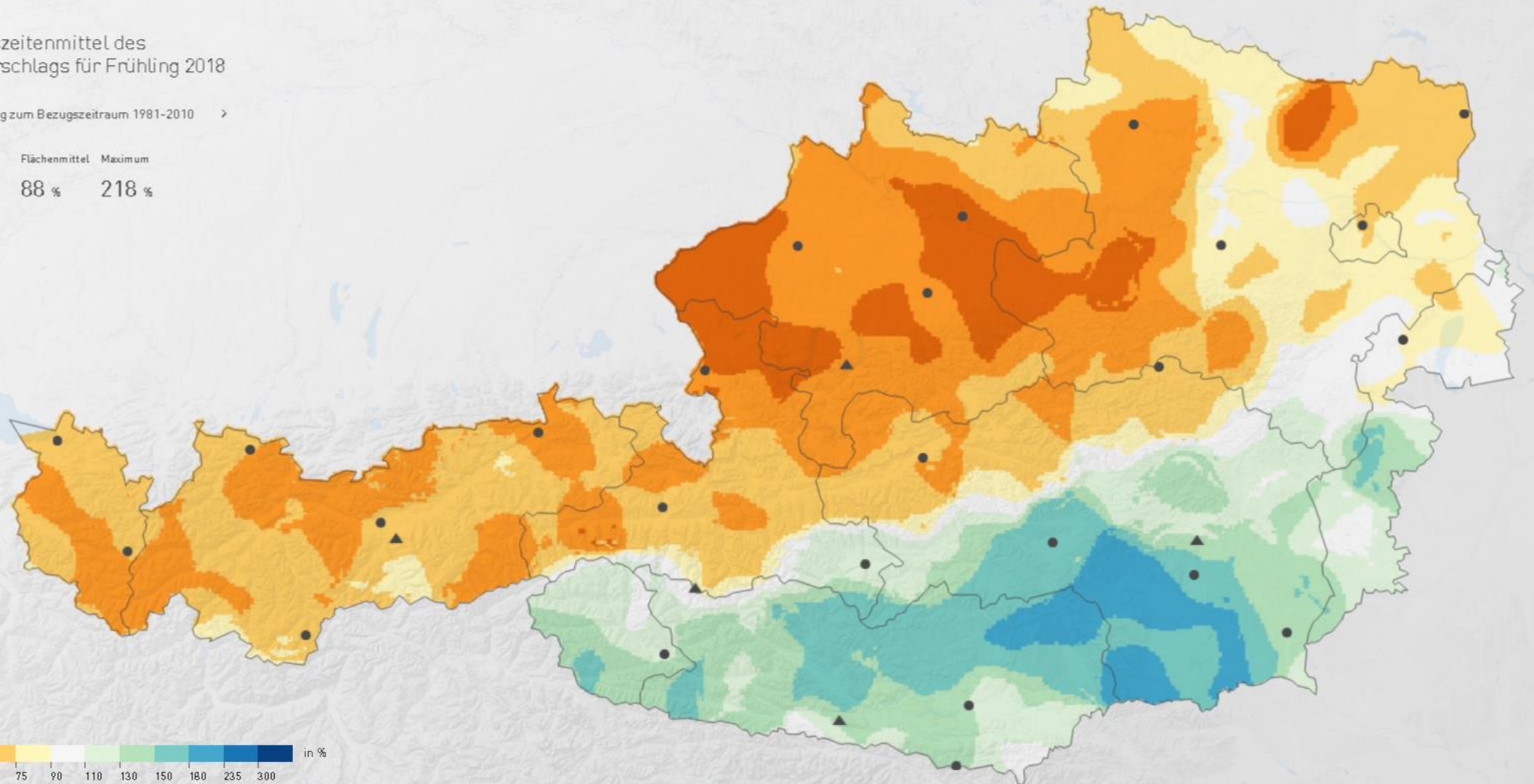
Messstation  
< Österreichweit >

LUFTTEMPERATUR NIEDERSCHLAG SONNENSCHEN BERICHTE

## Jahreszeitenmittel des Niederschlags für Frühling 2018

< Abweichung zum Bezugszeitraum 1981-2010 >

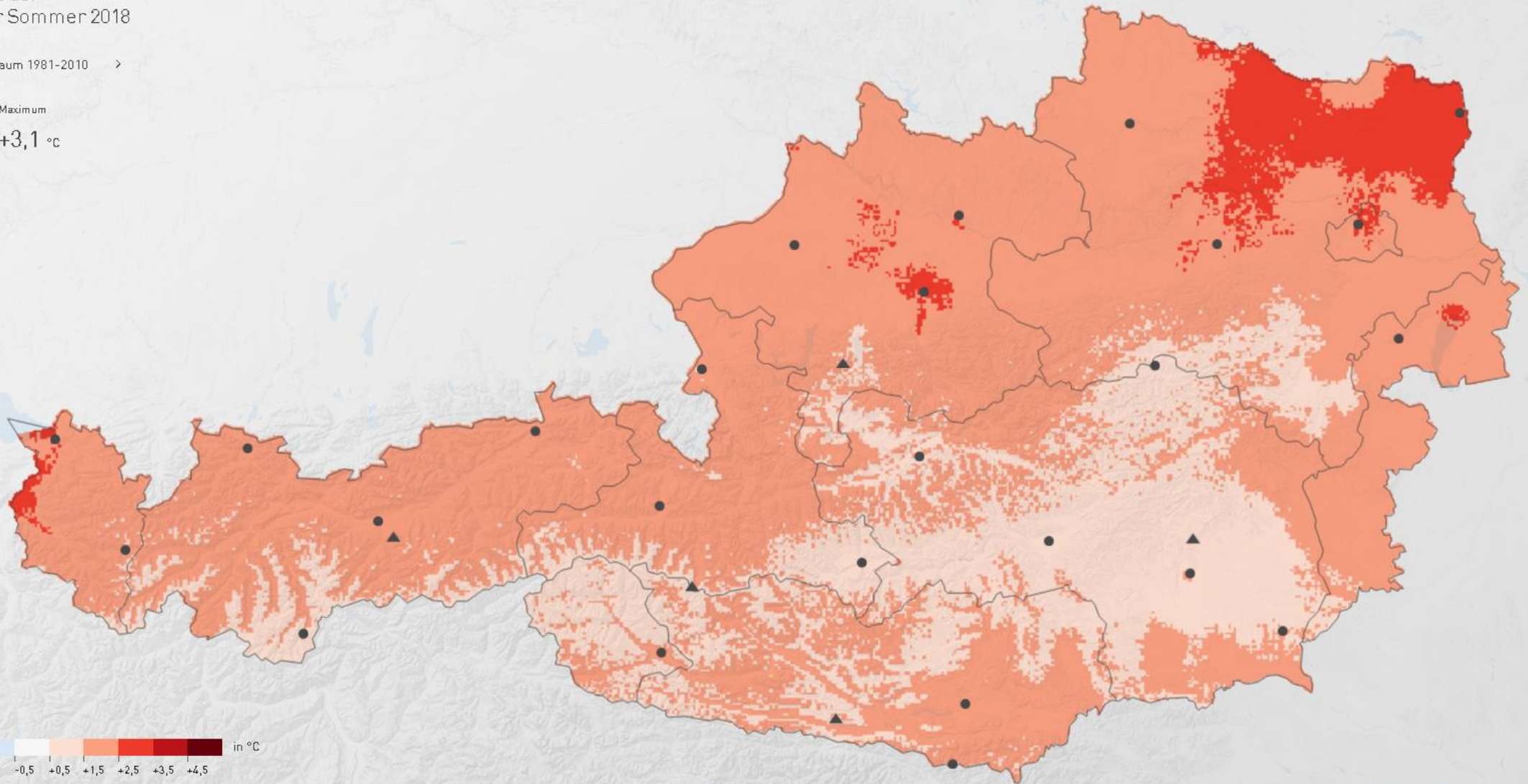
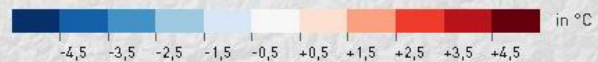
Minimum	Flächenmittel	Maximum
30 %	88 %	218 %

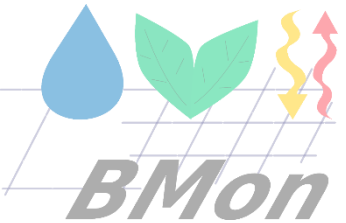


### Jahreszeitenmittel der Lufttemperatur für Sommer 2018

< Abweichung zum Bezugszeitraum 1981-2010 >

Minimum Flächenmittel Maximum  
+0,8 °C +1,9 °C +3,1 °C

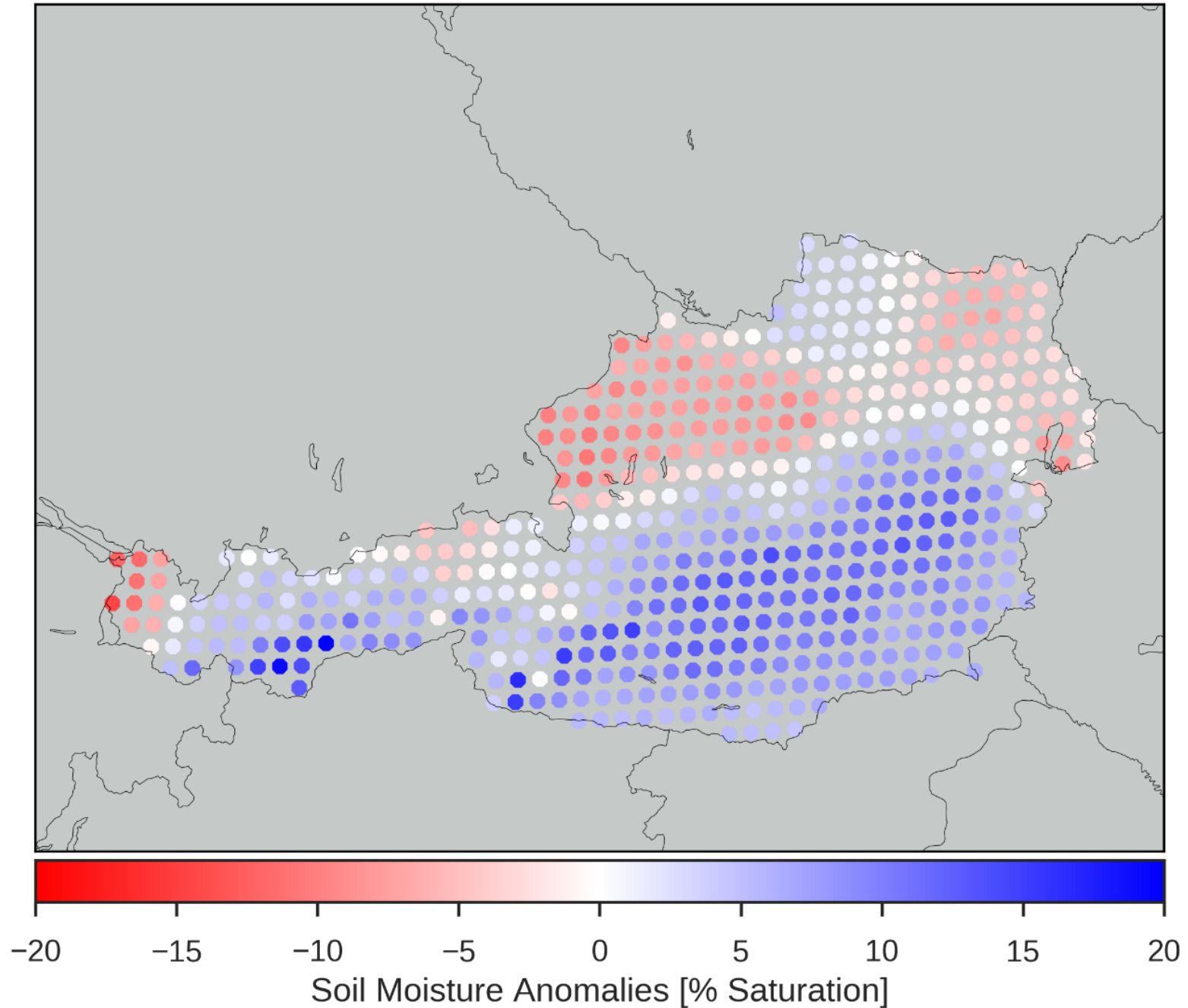


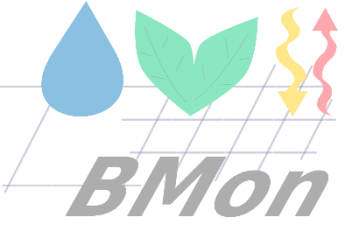


# Soil Moisture Anomaly 2018 Austria

**Soil Moisture anomalies  
April-June 2018**

ASCAT Surface Soil Moisture  
Anomaly from average 2007-  
2017





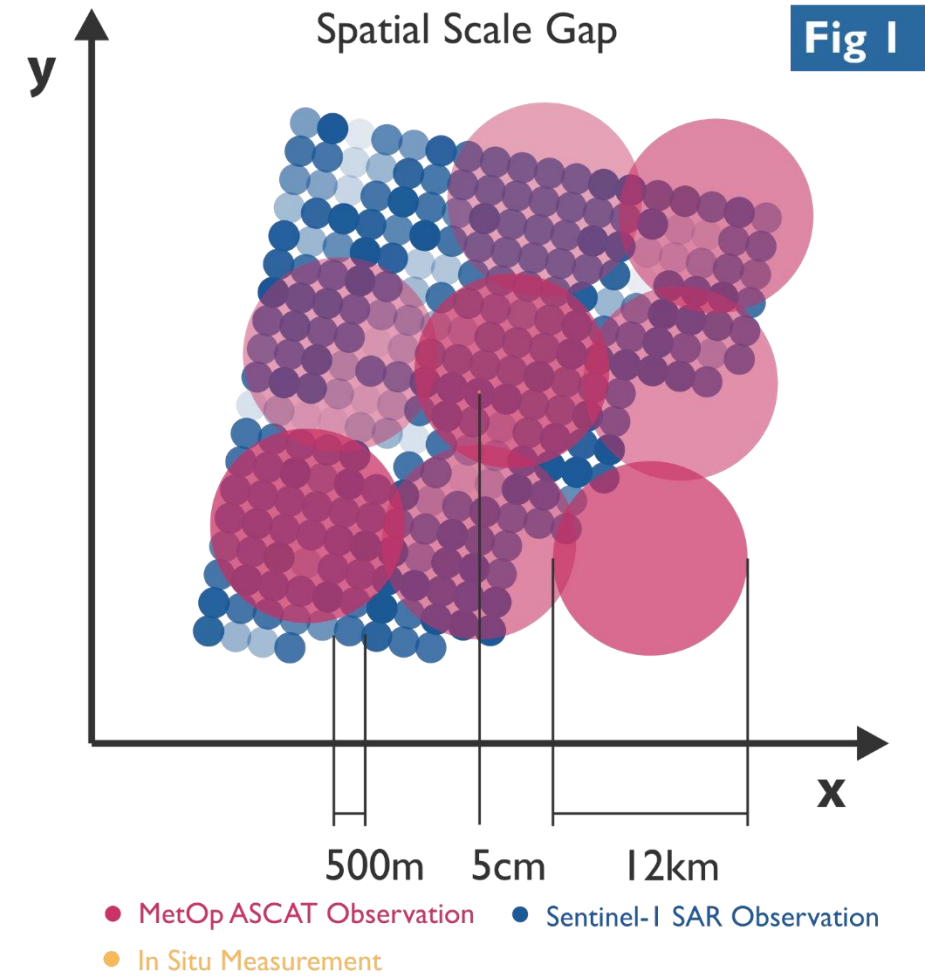
# Soil moisture monitoring

What techniques are available to capture variability in soil moisture?

Soil moisture can be estimated at different scales:

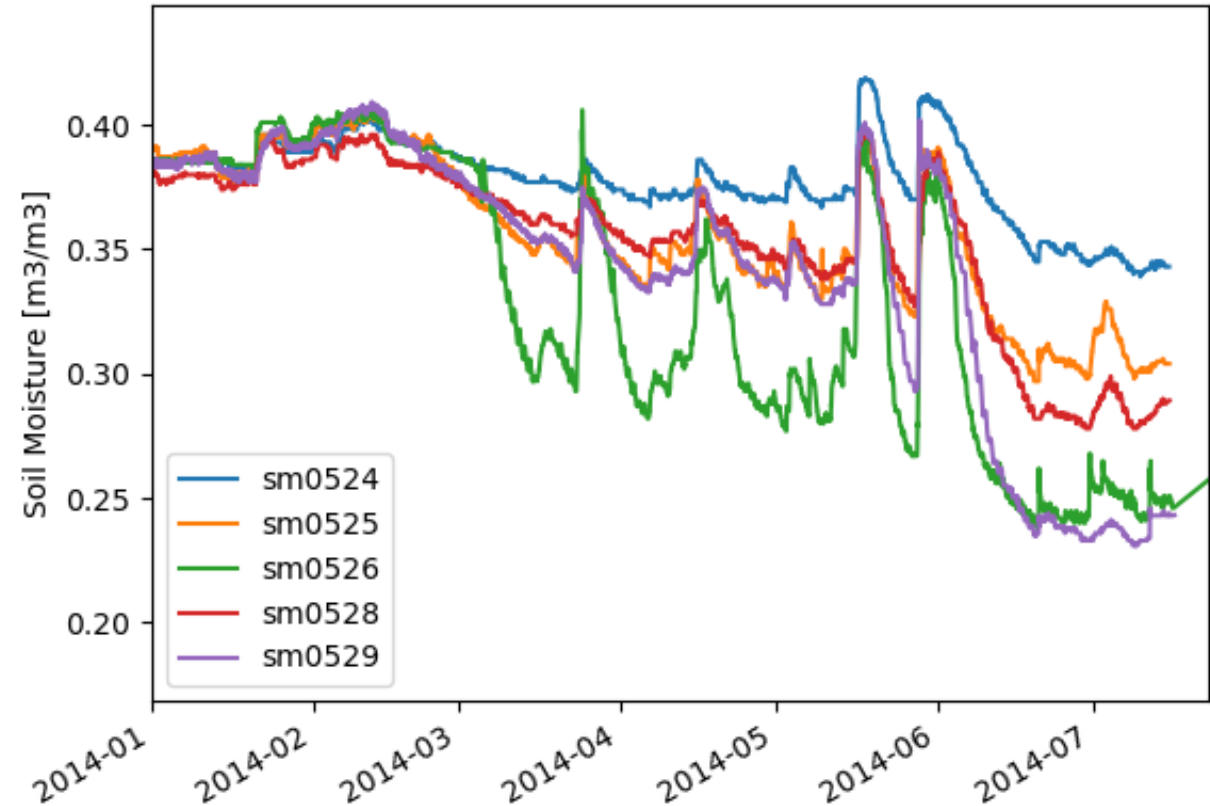
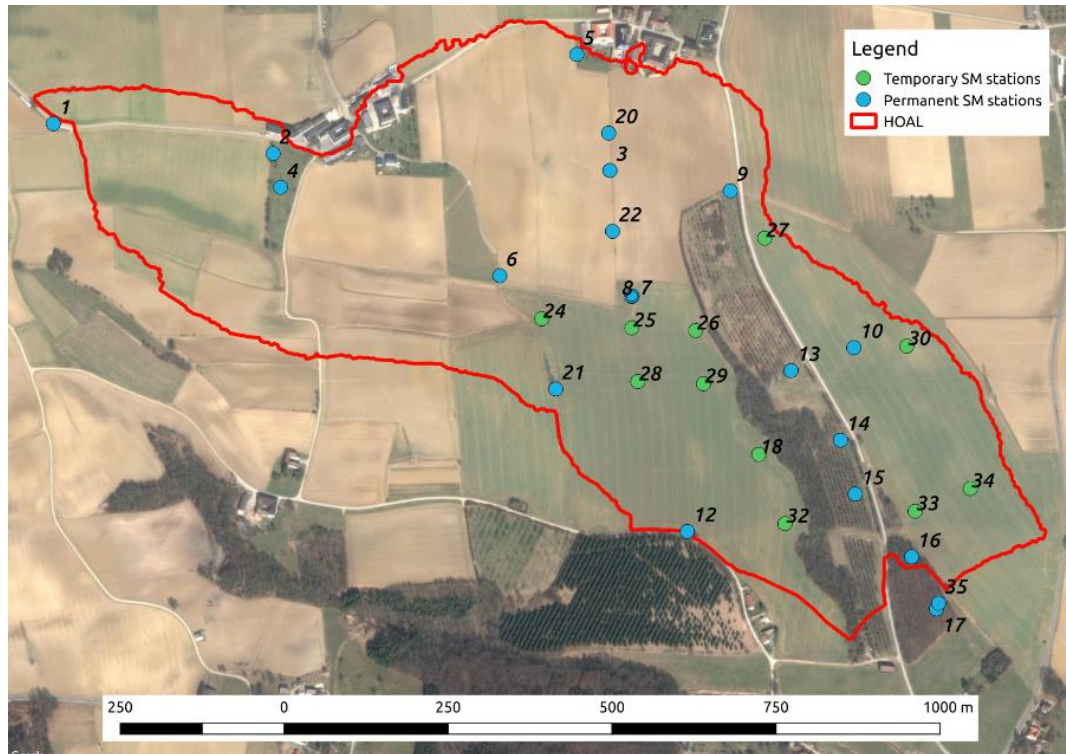
1. Remote sensing – **average over a footprint**
2. In situ – **point measurement**
3. Modelling – **different scales**

**All methods have strengths and weaknesses.**

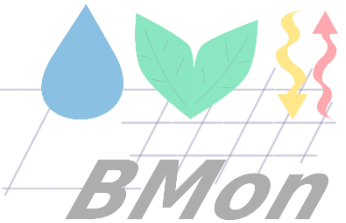


\*Figure courtesy of Bernhard Bauer-Marschallinger et al. (2015).

# In situ soil moisture monitoring



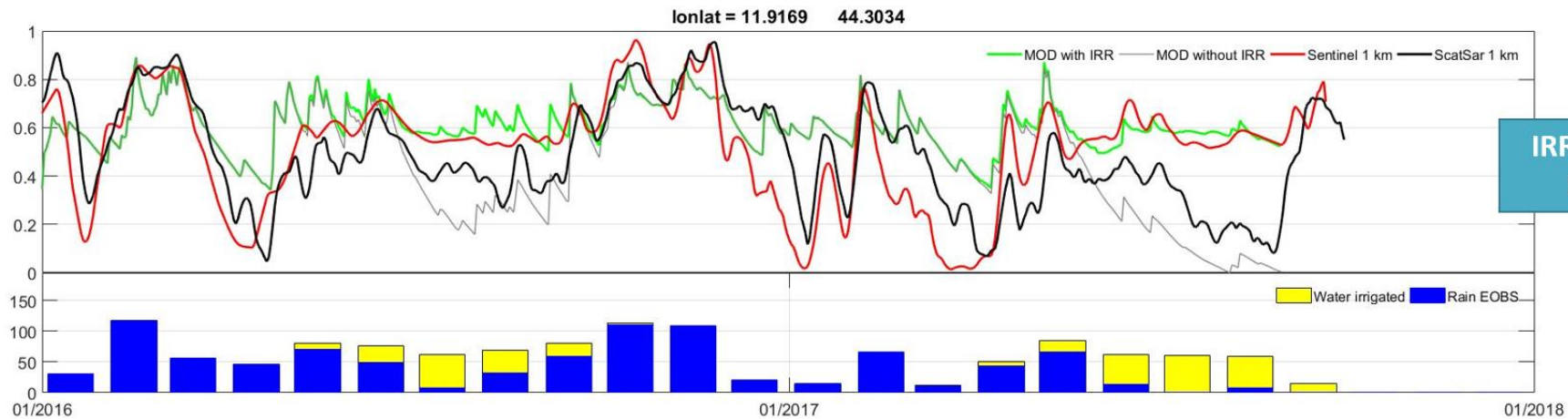
- Soil moisture can vary within one field with the same land cover.
- Too costly and time consuming.



ROMAGNA (ITALY)

# Models

Sentinel-1 (1 km)



IRRIGATED  
PIXEL



NON-IRRIGATED  
PIXEL

Models are driven by different variables and do not always capture irrigation events.



# Remote sensing

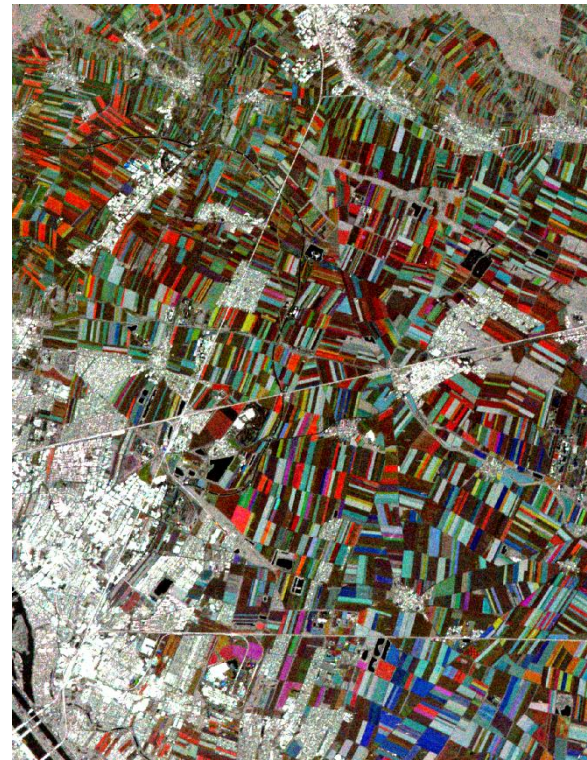


*False colour composite of Sentinel-1 VH images acquired in 2015 over Vienna and surrounding areas*

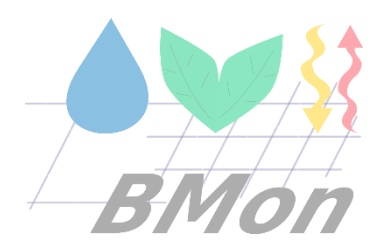
Red – June

Green – July

Blue – August



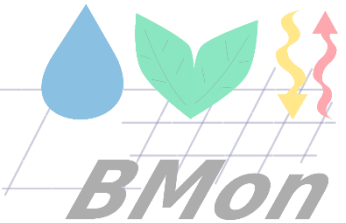
- Effect of vegetation on backscatter signal of S-I.



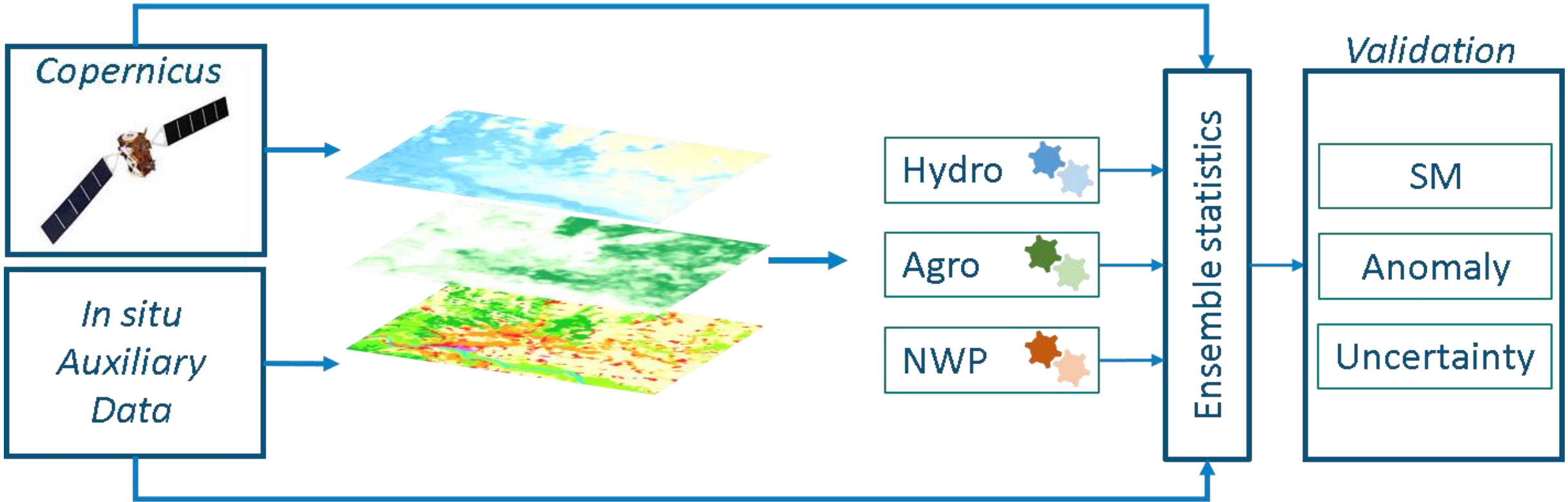
## BMon – Model-data integration

**Combining the skills of EO data and three models** from hydrology, agronomy and meteorology through **model-data integration** to obtain high resolution soil moisture estimates

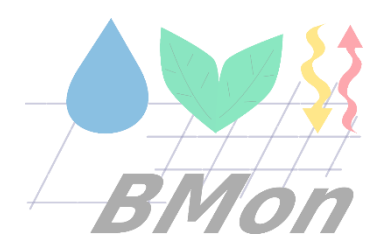




# BMon – Model-data integration



Scientific workflow of the BMon project.

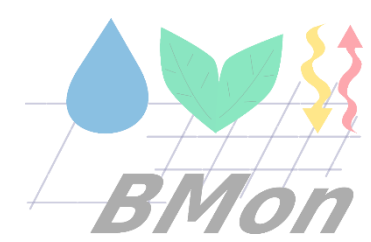


## BMon – Model-data integration

**Combining the skills of EO data and three models** from hydrology, agronomy and meteorology through **model-data integration** to obtain high resolution soil moisture estimates

Advantages of combining different methods in an ensemble:

1. Even a simple ensemble mean often outperforms a single product.
2. Opportunity to quantify uncertainty and errors of different products.
3. Improve our understanding of respective models.



## BMon – Validation

### Soil moisture data intercomparison

- **Asses the quality** of the different high-resolution soil moisture datasets, EO based, model based and integrated.
  - Using in situ soil moisture networks and innovative methods.(ms.GIS, IAEA, BMNT)
  - Focus on different regions, land cover types, elevation
- ❖ Use classic metrics (bias, RMSE,  $R^2$ ), triple collocation and signal to noise ratio to quantify the performance of the different products.
  - ❖ Learn from ASAPI4 QA4SM project

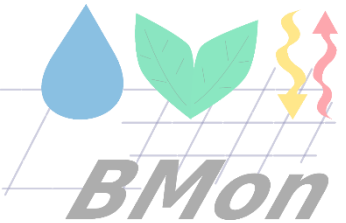
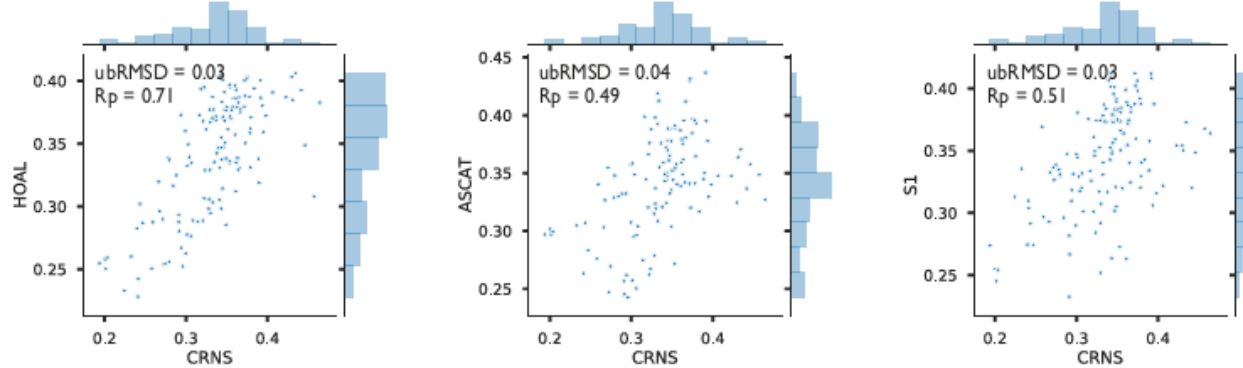


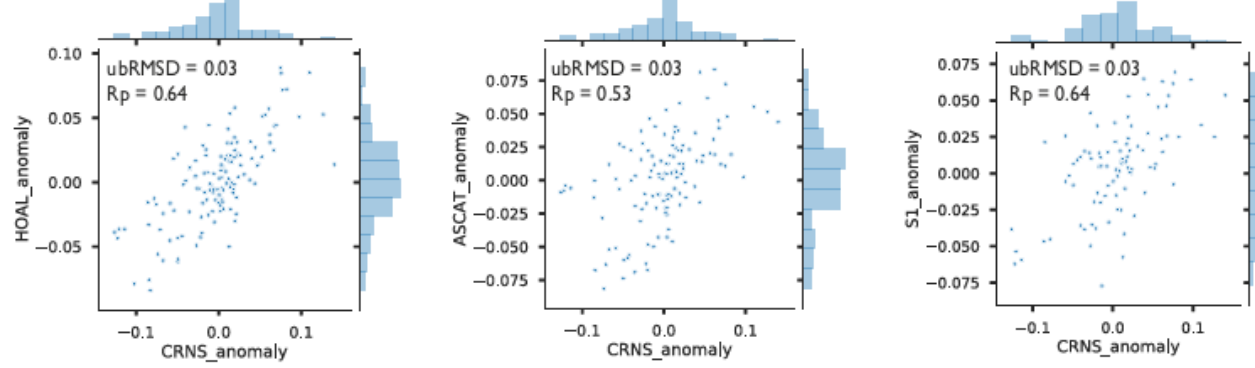
Fig 4

# Classic validation using in situ sensors

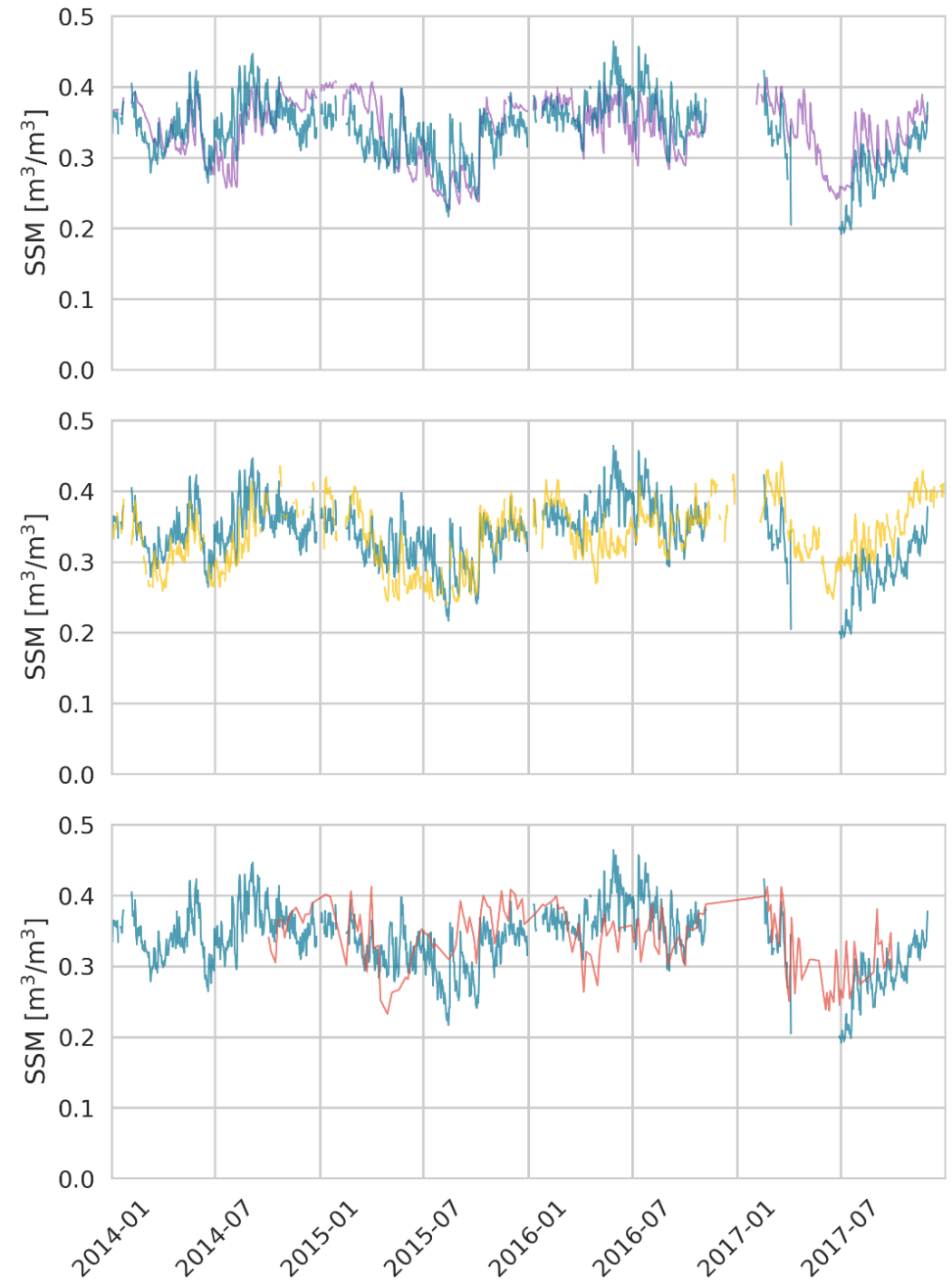
## Absolute

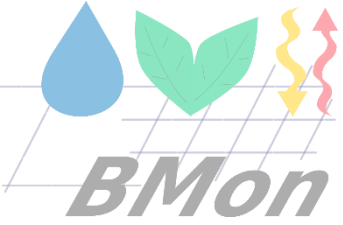


## Anomalies



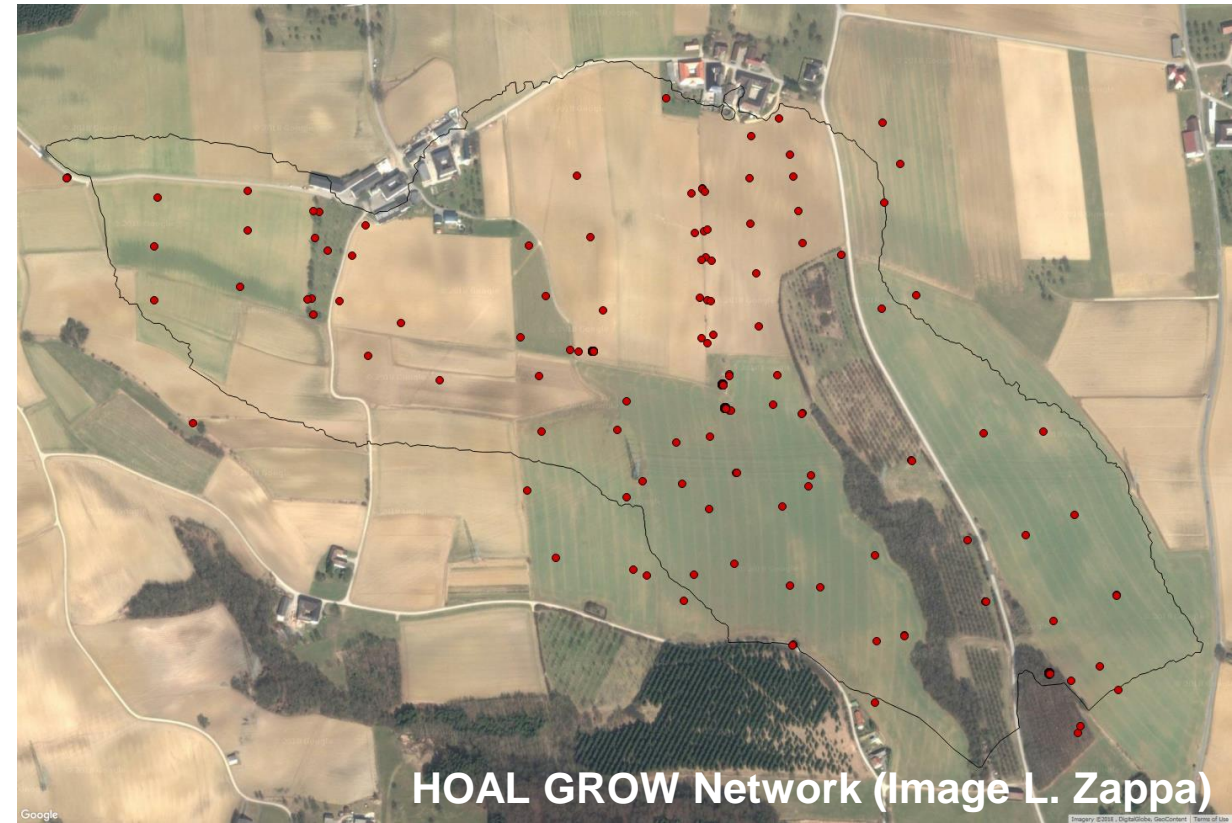
- HOAL
- CRNS
- ASCAT
- S1

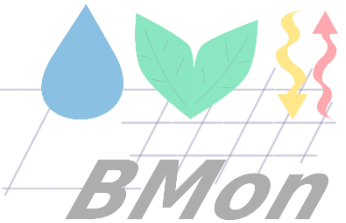




## BMon – Validation

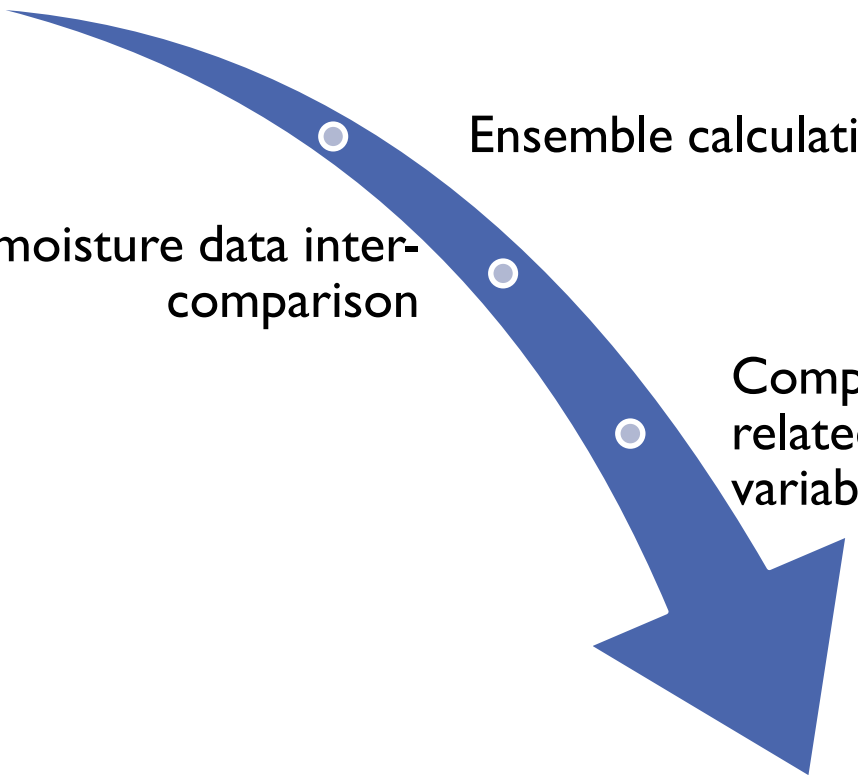
- 5-10 focus catchments will be selected for validation
  - Spread over Austria to cover different climate, land cover types and soil types
- Install in situ soil moisture sensors in focus catchments:
  - Parrot sensors – freely available via the GROW project.
    - + High spatial density
    - Data needs to be collected on site
  - Sensors connected via LORA network
    - + Automatic data transfer
    - + Sustainable solution for long-term
    - Point measurement
    - Expensive





# Summary

In situ, model and satellite datasets



Ensemble calculation

Soil moisture data inter-comparison

Comparison to related key variables

Validated optimal soil moisture product at 100m

