soil moisture cci

climate change initiative

European Space Agency

Evaluation of a global soil moisture product by means of finer spatial resolution SAR data and ground measurements over Europe

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CMRC

UCC

University College Cork, Ireland

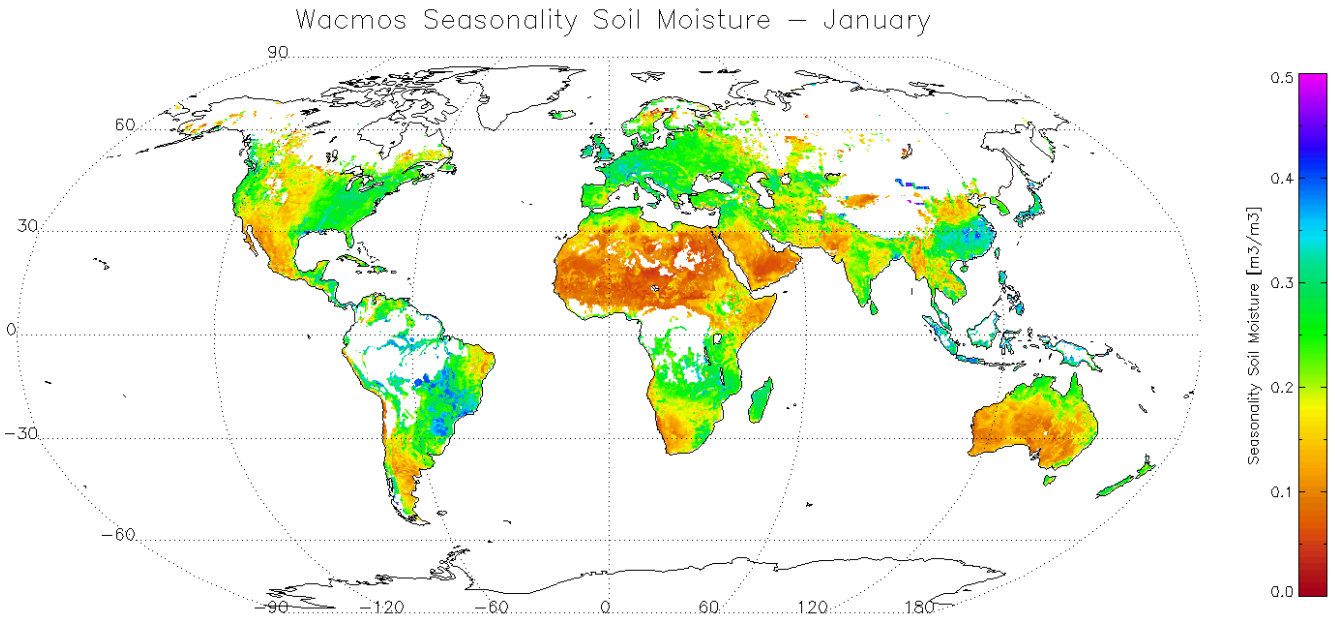
Coláiste na hOllscoile Corcaigh

Satellite soil moisture validation & application workshop

Amsterdam, the Netherlands, 10-11 July 2014

ECV SM Global Product

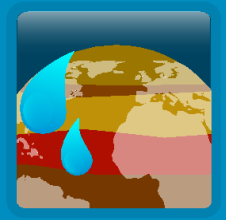
Soil Moisture retrieved by merging active and passive ECV data



Spatial resolution: 0.25x0.25 degrees

Temporal resolution: 1 day (best case)

Data availability refers to the period 1978-2013



OBJECTIVE

Soil Moisture= *f* (soil texture, topography, land cover, weather conditions)

Temporal and Spatial SM variability!

Difficulty of low spatial resolution SM ECV products to describe the phenomenon

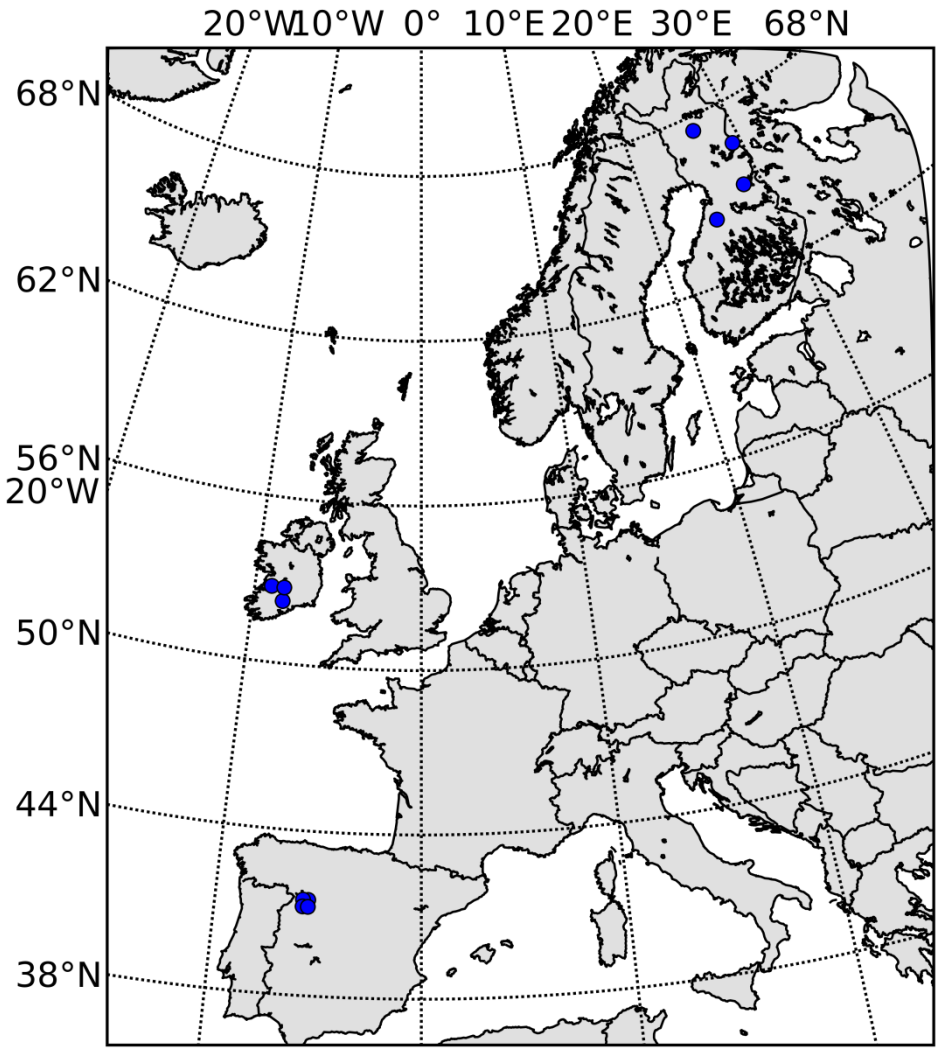
ENVISAT Advanced Synthetic Aperture Radar (ASAR)

Information of short-term, seasonal and long-term variations in surface soil moisture at **higher spatial resolution** (150 m)

OBJECTIVES

- **Improve understanding of the temporal variability of the difference between soil moisture values derived from ASAR and ECV data.**
- **Better understanding of the main factors affecting the SM spatial variability and the ECV SM values.**

Study Sites



Finland – 4 sites

- Boreal forests
- Open and forested bogs
- Tundra highlands

Ireland – 3 sites

- Permanent pastures

Spain [Duero Basin] – 4 sites

- Crop fields
- Forest
- Shrublands
- Grasslands

Methodology

ASAR WS SM

ECV SM [m^3m^{-3}]

Identification of the ECV pixel including the in situ stations

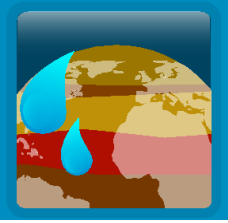
Land Cover Map

Masked out pixels over no or densely vegetated areas

Correlation Map

Masked out pixels:
$R^2(\sigma^0_{(1kmx1km)}, \sigma^0_{(25kmx25km)})<0.3$

Methodology



ASAR WS SM and BS

ECV SM [m^3m^{-3}]

Identification of the ECV pixel including the in situ stations

Land Cover Map

Collection of masked ASAR WS time series in the ECV pixel size

N_m : number of pixel after masking

Correlation Map

Comparison

- Correlation
- ubRMSD

Selection of the ASAR WS acquisitions according with the ECV size pixel coverage :

$N_{pixel}(t) \geq 50\% N_m$

Mean ASAR WS SM values into the ECV size pixels

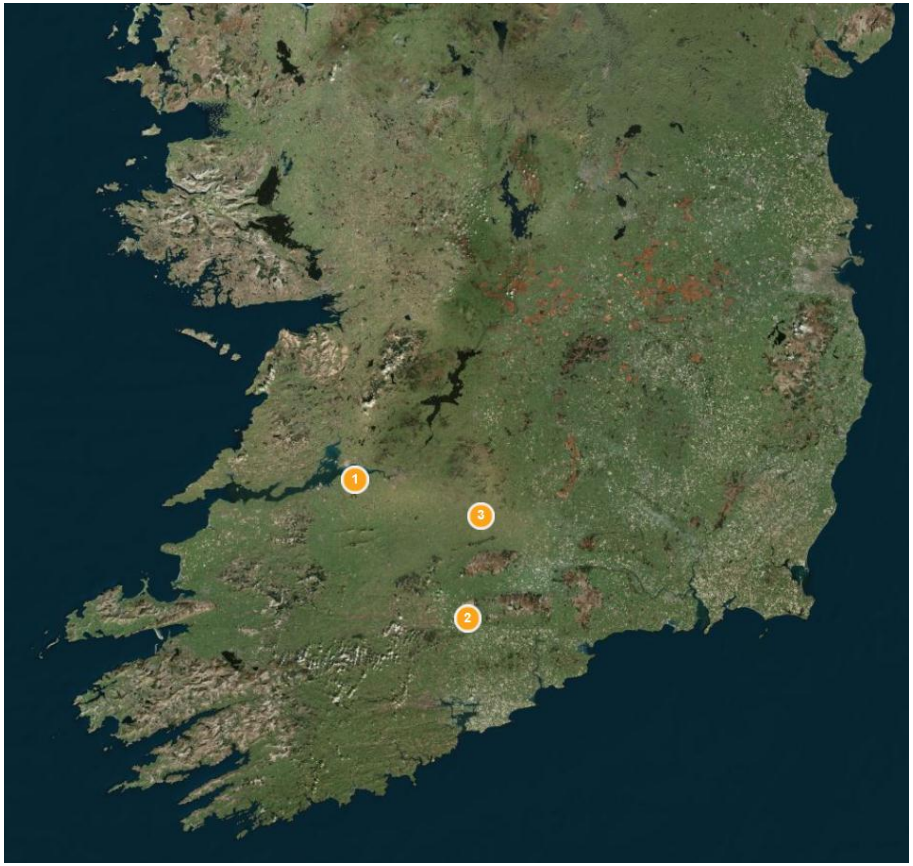
In Situ SM [m^3m^{-3}]

Ireland - Study Sites

1 - Pallaskenry

2 - Kilworth

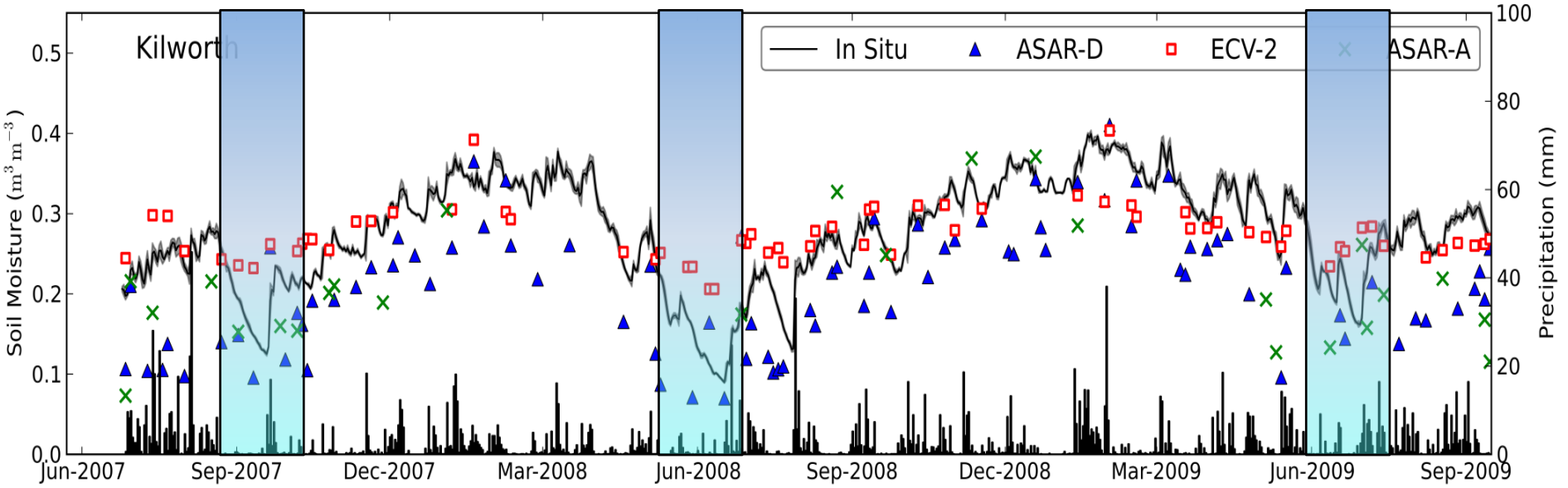
3 - Solohead



Source: Bing

Cropland/Grassland mosaic

Temporal evolution of ASAR, ECV and In Situ Soil Moisture

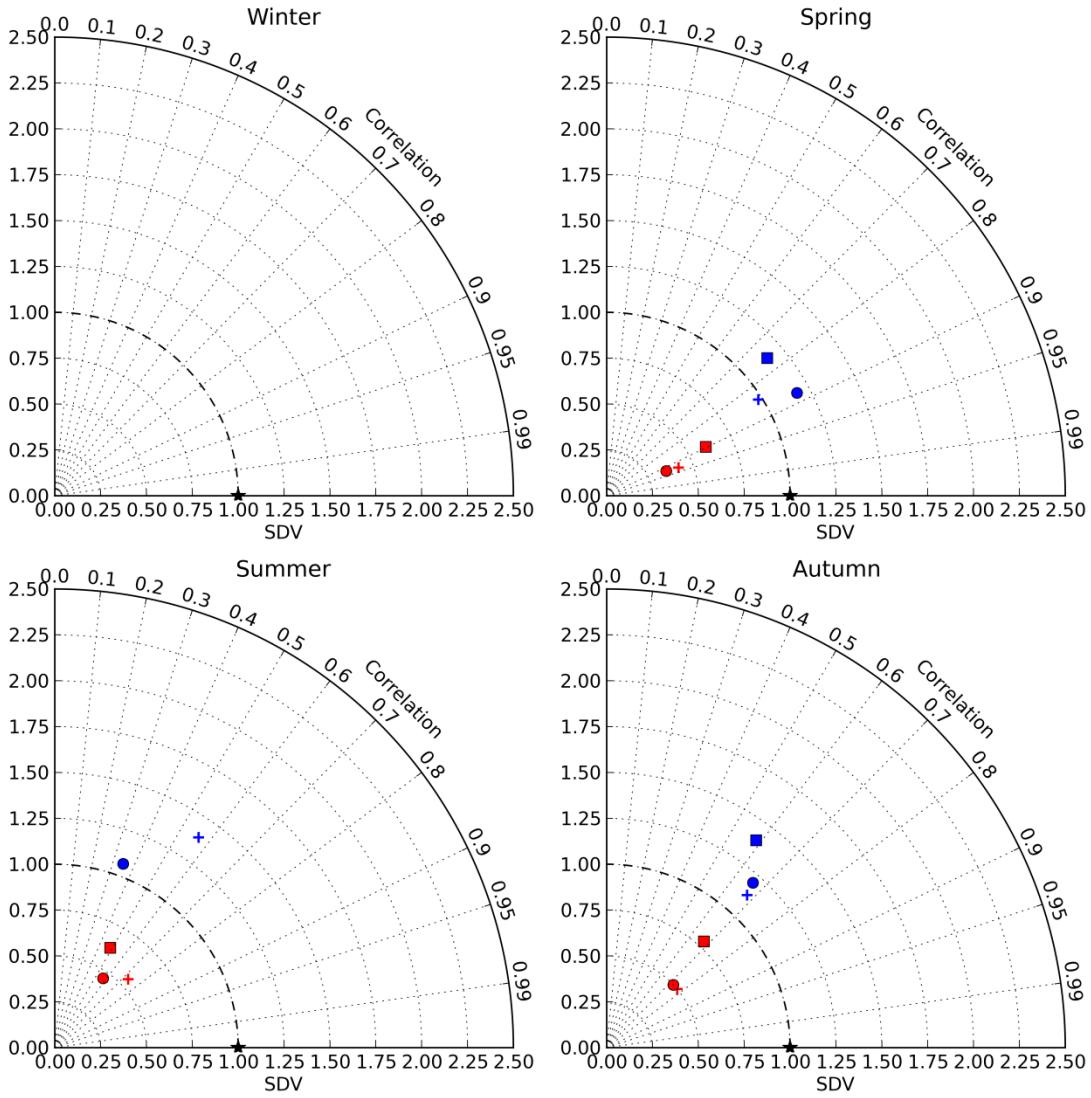


ASCAT

N=69	R	ubRMSD (m^3m^{-3})
ASAR vs ECV	0.82	0.051
ASAR vs In Situ	0.77	0.048
ECV vs In Situ	0.75	0.044

- ✓ Very good temporal correlation, low error
- X Overestimation of ECV SM in the driest conditions
- ■ General consistency between all the sites

Seasonal Analysis - Ireland



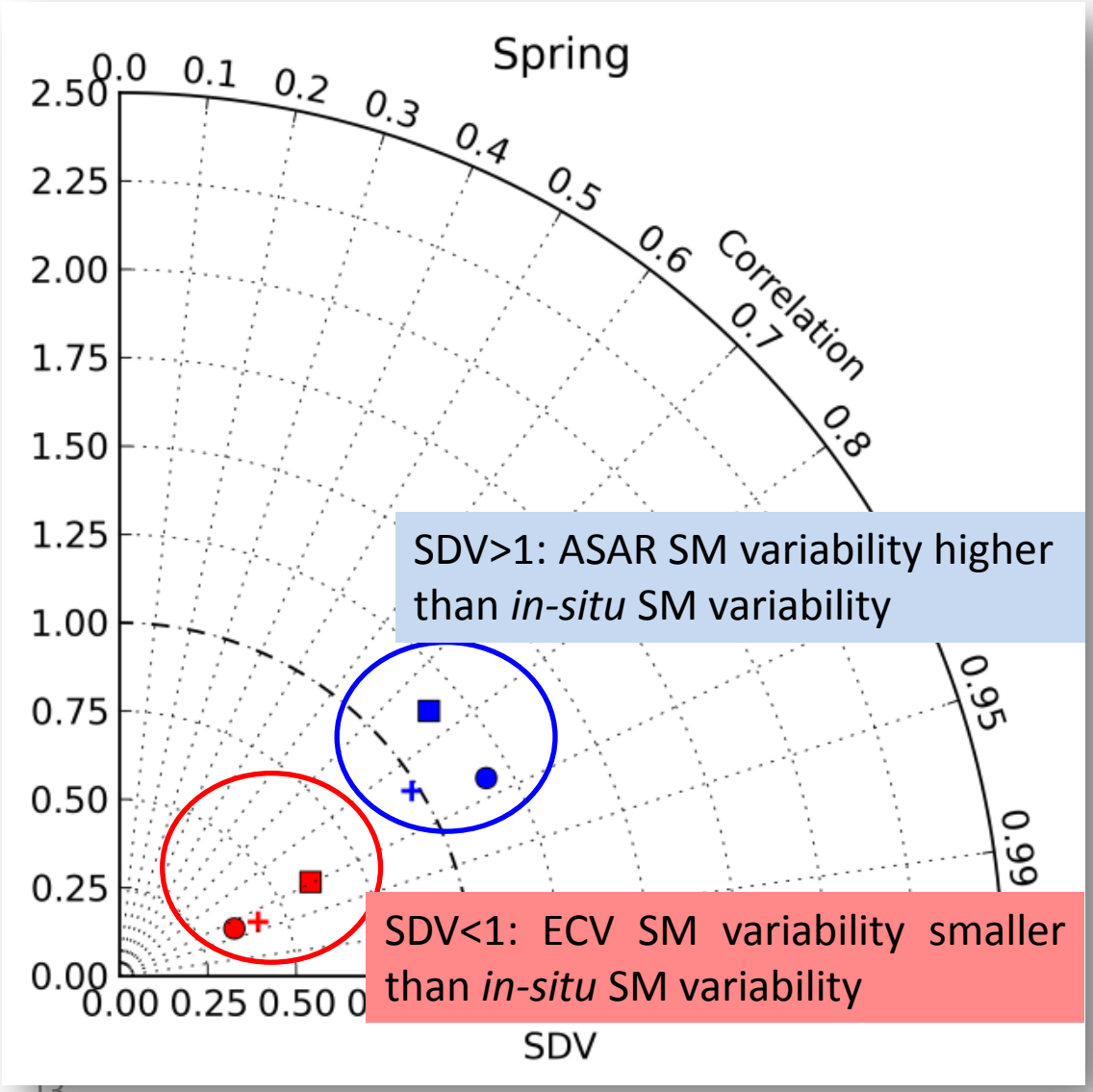
$$SDV = \frac{\sigma_{SM}}{\sigma_{in\ Situ}}$$

- Higher R, lower SDV in **Spring**
- No values p < 0.05 in **Winter**

ASAR
ECV-2

- ★ In Situ
- ● Kilworth ECV
- ● Kilworth ASAR
- ■ Pallaskenry ECV
- ■ Pallaskenry ASAR
- \+ Solohead ECV
- \+ Solohead ASAR

Seasonal Analysis - Ireland



$$SDV = \frac{\sigma_{SM}}{\sigma_{in\ Situ}}$$

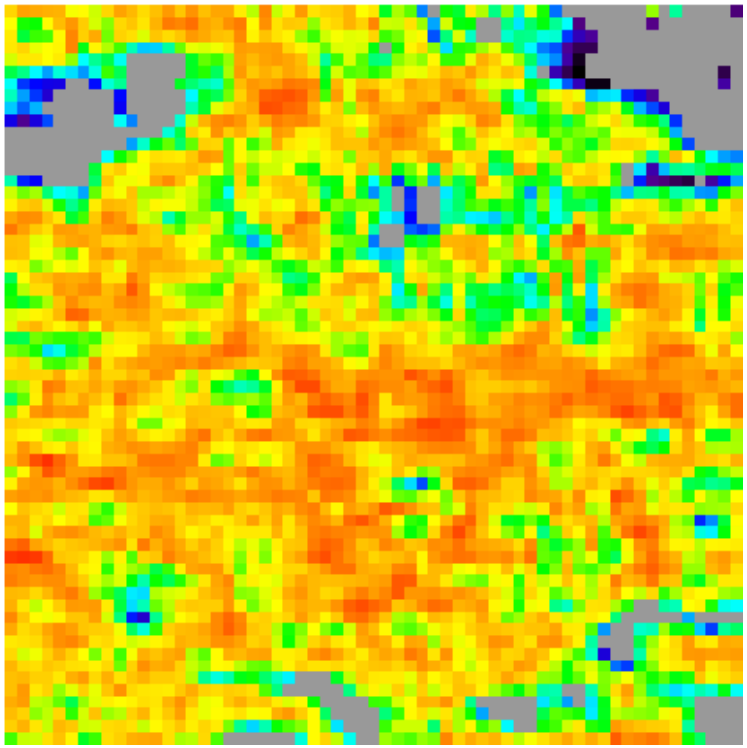
- Higher R, lower SDV in **Spring**
- No values p < 0.05 in **Winter**

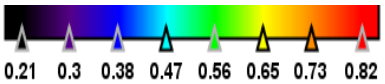
ASAR
ECV-2

- ★ In Situ
- ● Kilworth ECV
- ● Kilworth ASAR
- ■ Pallaskenry ECV
- ■ Pallaskenry ASAR
- \+ Solohead ECV
- \+ Solohead ASAR

IRELAND- Spatial analysis

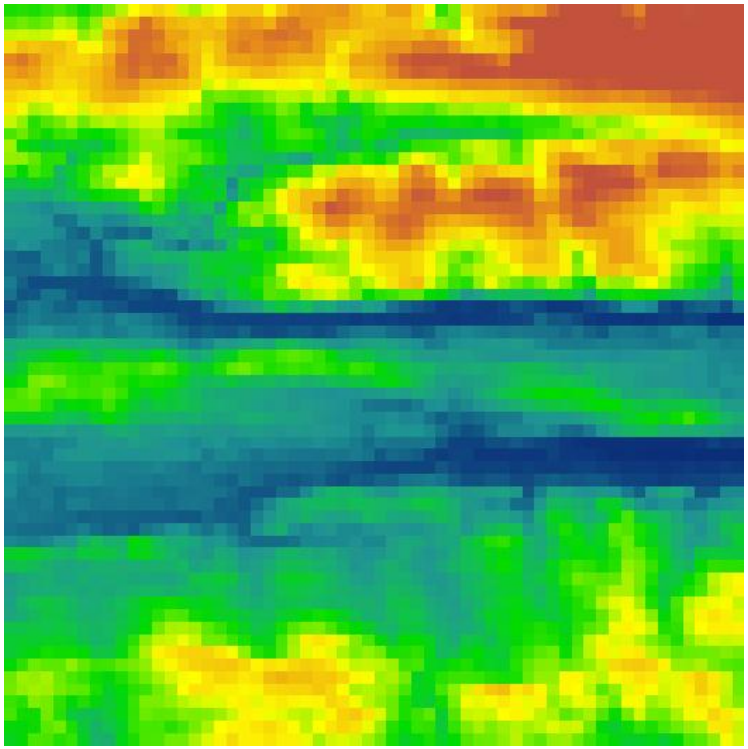
KILWORTH- R: ASAR vs ECV SM

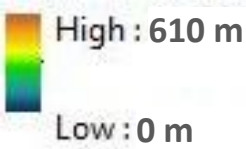




R

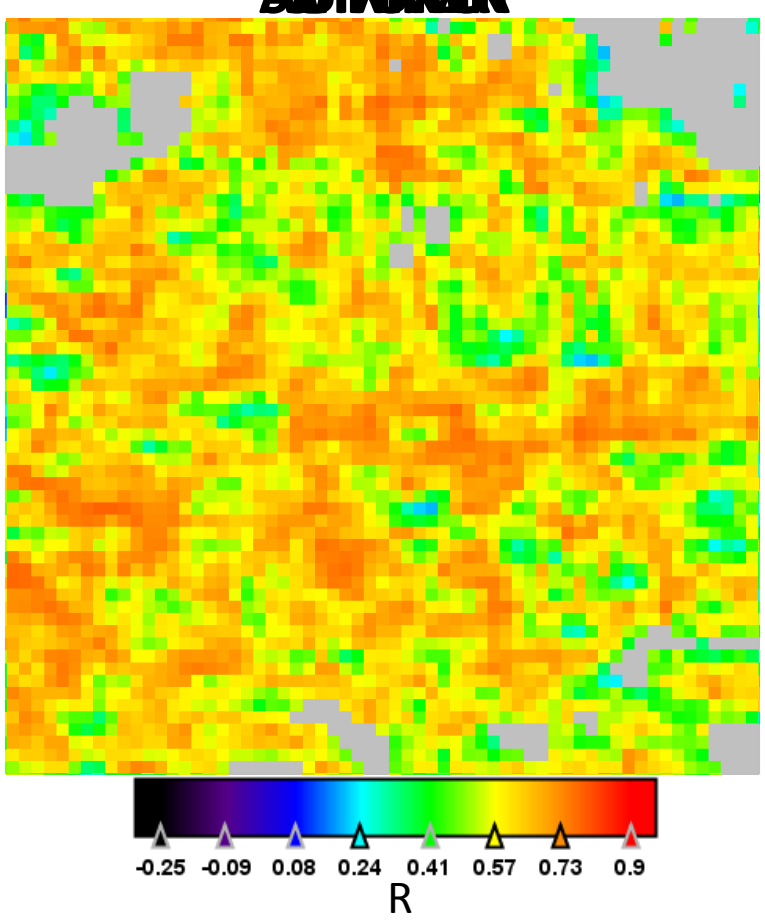
KILWORTH- DEM



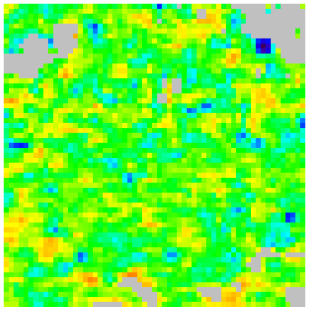


High correlation patterns mainly corresponding to low altitude areas characterized by mineral alluvium soil.

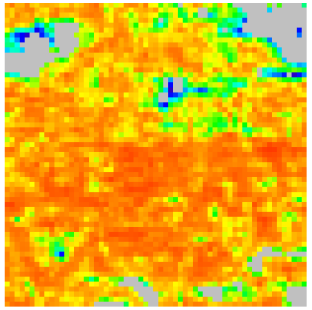
IRELAND (KILWORTH)- Seasonal Spatial analysis



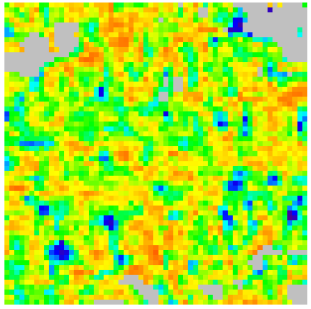
WINTER



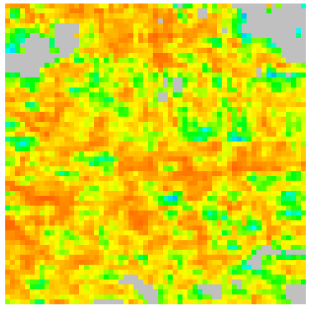
SPRING



SUMMER



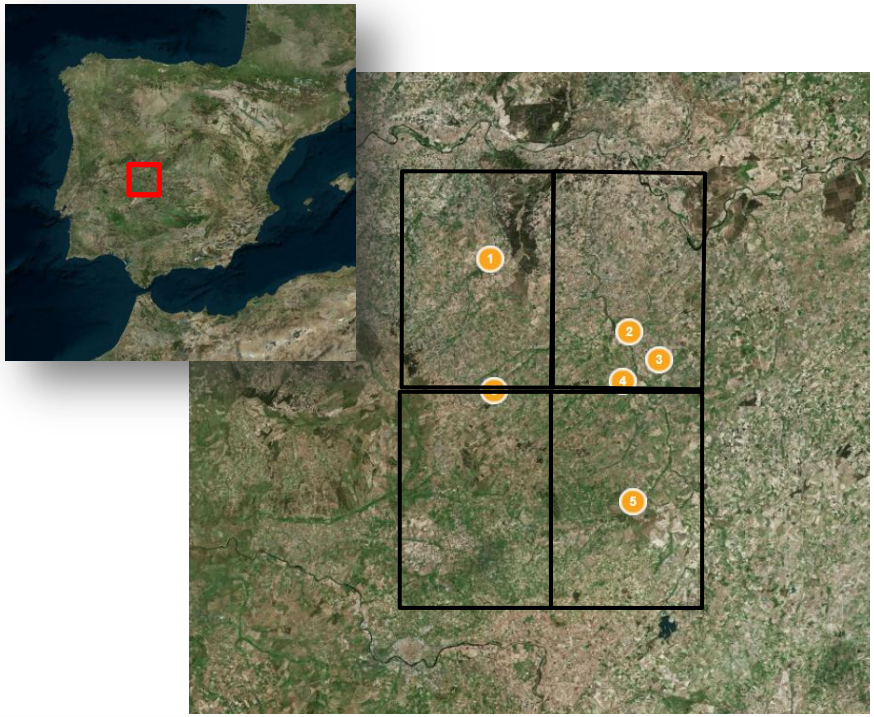
AUTUMN



- Periodical variability of spatial correlation (R= 0.4-0.9)
- Lowest and quite homogenous R values in **WINTER**
- Highest and quite homogeneous R values in **SPRING**

Spain - Study Sites

REMEDHUS Network - Spain



Source: Bing

ECV A

- 3 stations Dryland Cropland and Pasture
- 2 stations Cropland/Woodland mosaic
- 6 stations Shrubland

ECV B

- 1 station Shrubland

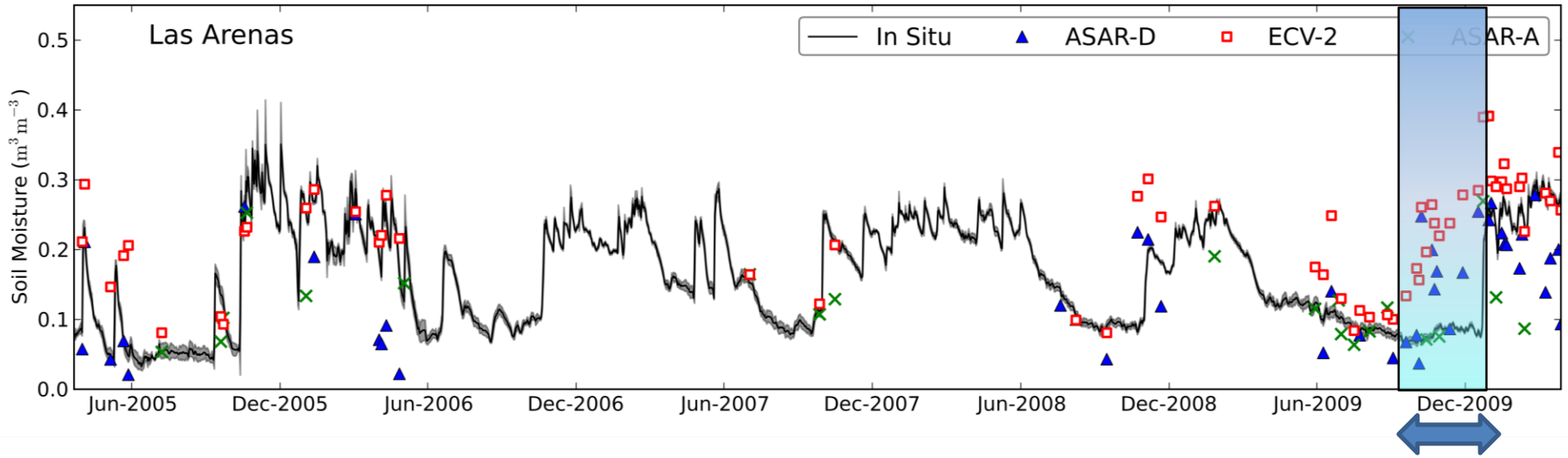
ECV D

- 1 station Dryland Cropland and Pasture

ECV E

- 2 stations Dryland Cropland and Pasture
- 2 station Cropland/ Woodland mosaic

Temporal evolution of ASAR, ECV and In Situ Soil Moisture - ECV B-



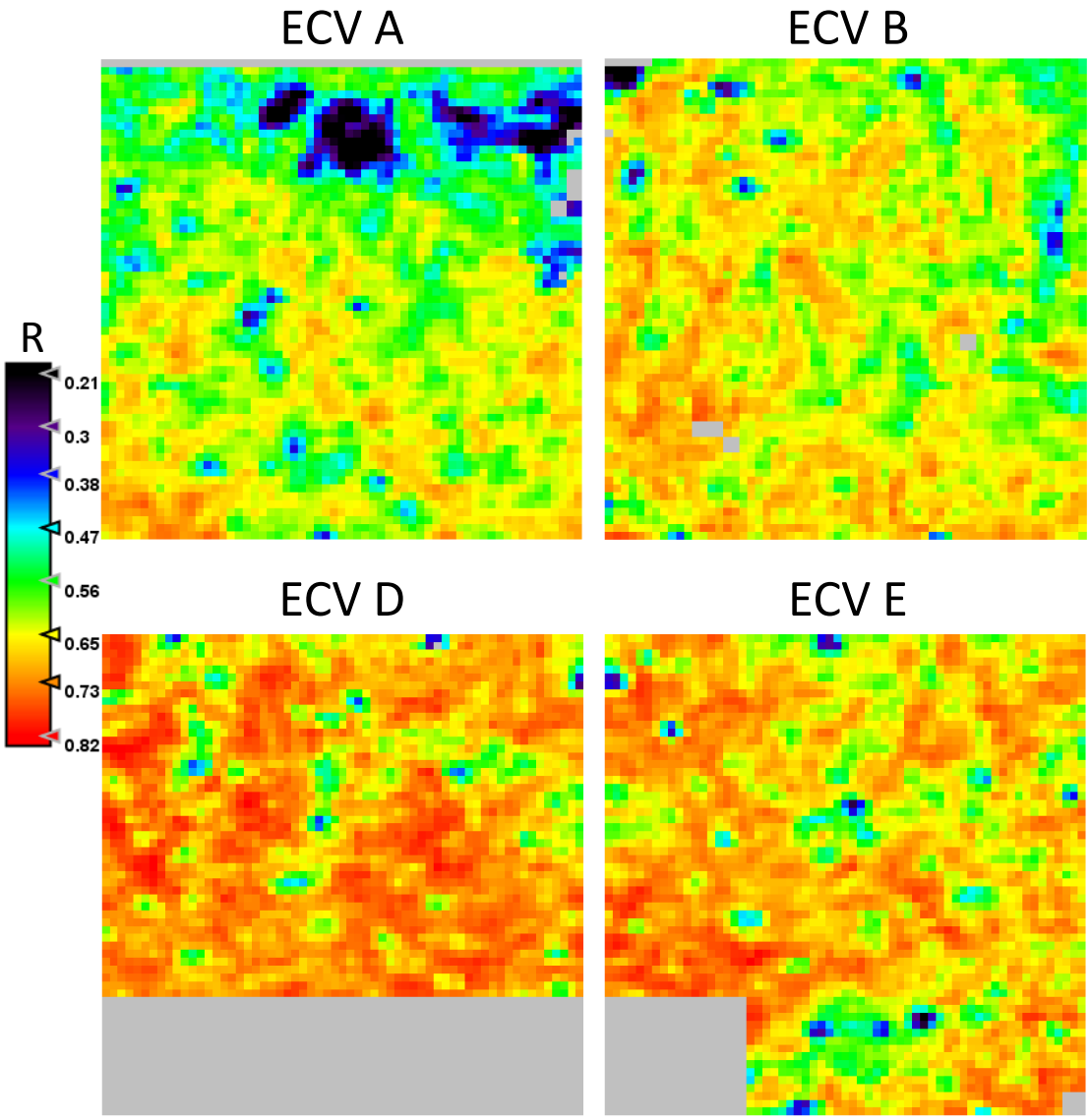
N=60	R	ubRMSD (m^3m^{-3})
ASAR vs ECV	0.72	0.057
ASAR vs In Situ	0.56	0.073
ECV vs In Situ	0.62	0.069

✓ Very good temporal correlation, low error

X Anomalous overestimation of ECV SM in the dry conditions [Oct 2009 - Dec 2009]

■ General consistency between all the sites

SPAIN- Spatial analysis

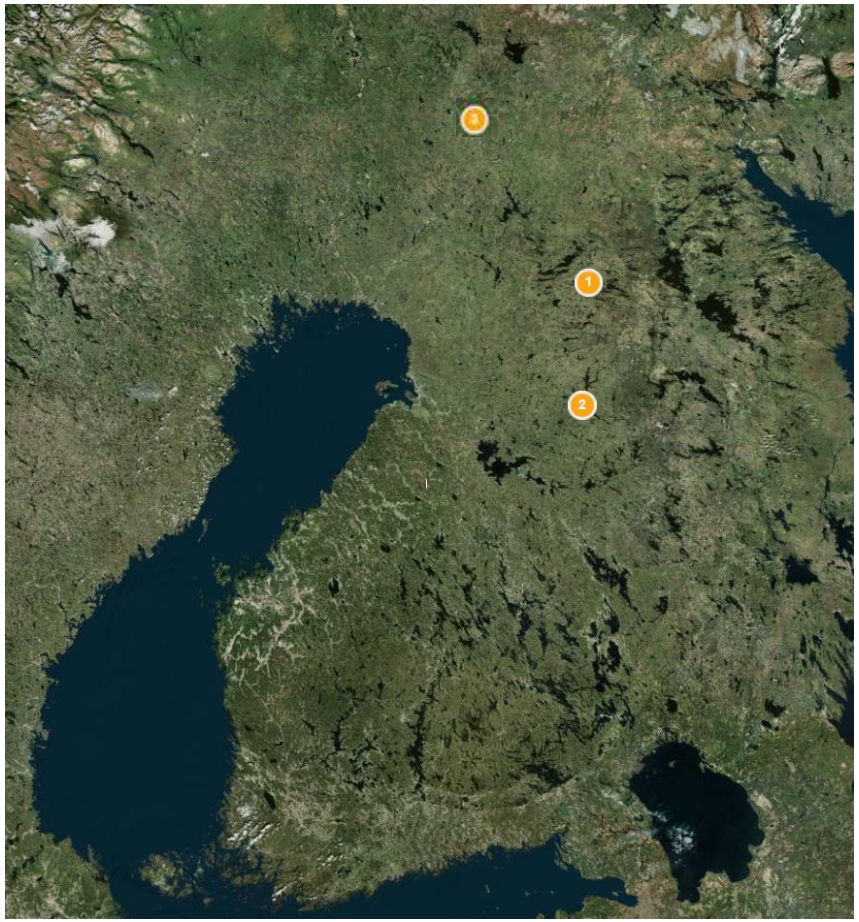


- Quite large homogenous patterns (R=0.5-0.6)
- High correlation patterns (R > 0.7)

Finland – Study Sites

Geological Survey of Finland (GTK)

- **[1] Kuusamo**
  Evergreen forest (~95%)
- **[2] Suomussalmi**
  Evergreen forest (~83%)
  Mixed forest (~8%)

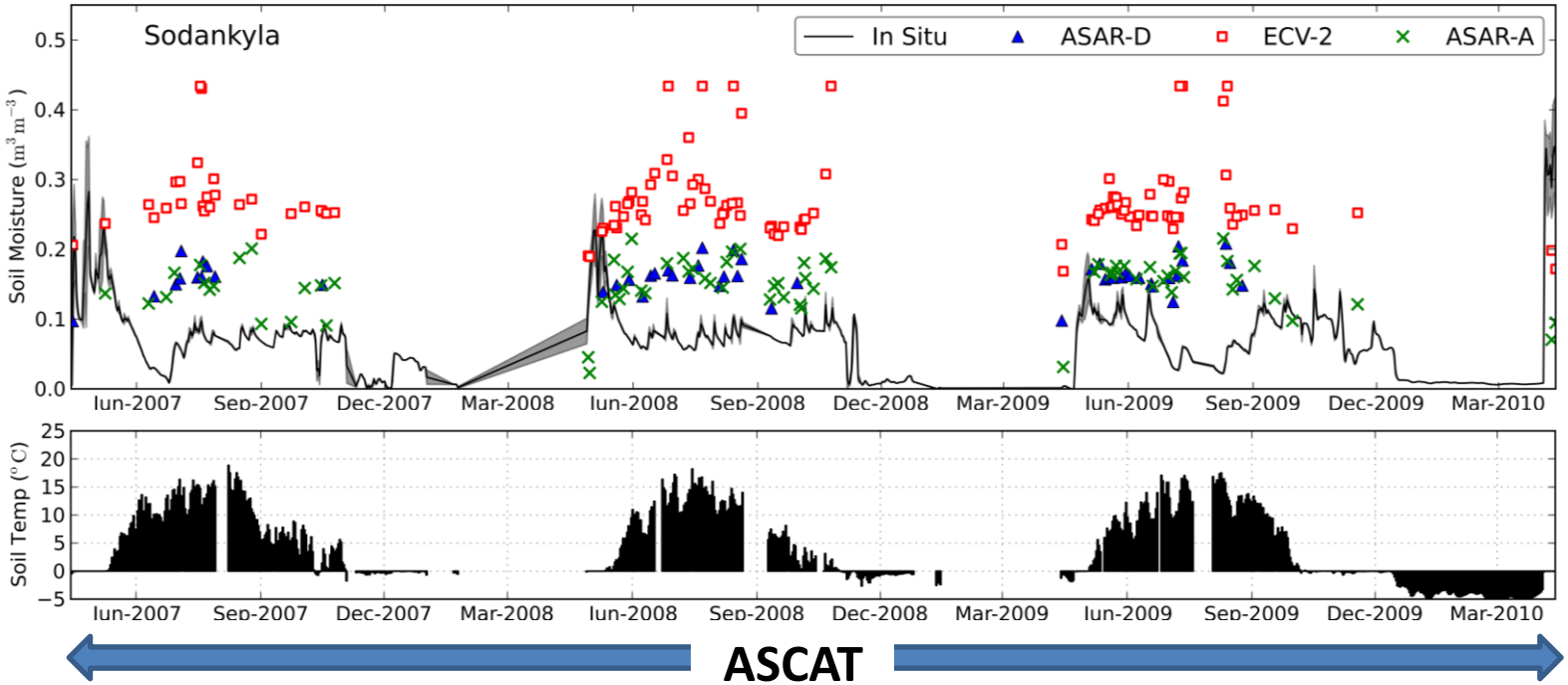


Source: Bing

Finnish Meteorological Institute (FMI)

- **[3] Sodankyla**
  Evergreen forest (~88%)
  Mixed forest (~12%)

Temporal evolution of ASAR, ECV, and In Situ Soil Moisture



N=121	R	ubRMSD (m^3m^{-3})
ASAR vs ECV	0.55	0.047
ASAR vs In Situ	-0.23	0.062
ECV vs In Situ	-0.18	0.079

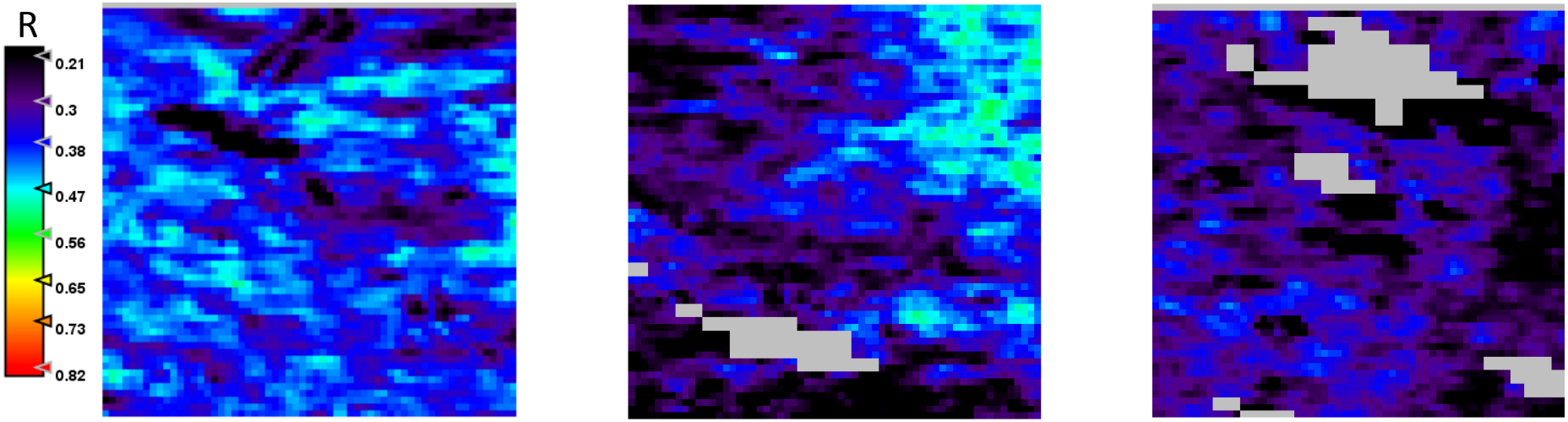
- X Low temporal correlation, quite low error
- X Overestimation of ASAR and ECV SM
- General consistency between all the sites

FINLAND – Spatial Analysis

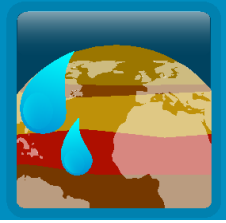
SODANKYLA

KUUSAMO

SUOMUSSALMI



- Presence of low (R= 0.3-0.4) and very low correlation (R < 0.2) patterns
- R_{max} = 0.5
- Little variations of R over the whole ECV pixel



Key Outcomes

✓ **High Correlation between ASAR and ECV SM**

Ireland[(*)]: R= 0.79-0.82, **Spain**: R= 0.65-0.77

✓ **Quite low unbiased RMSD**

Ireland[(*)]: ubRMSD= 0.05-0.06, **Spain**: ubRMSD= 0.05-0.08,
Finland: ubRMSD= 0.03-0.05

✓ **Good agreement between satellite SM time series and ground measurements (Confidence in the use of ECV and ASAR SM products)**

Ireland[(*)]: R= 0.64–0.80, **Spain** R= 0.71–0.90

✓ **Based on ASAR analysis the ECV product represents SM conditions quite well**[(*)]

(*) C. Pratola, B. Barrett, G. Kiely, E. Dwyer, "Evaluation of a global soil moisture product from finer spatial resolution SAR data and ground measurements in Irish sites", submitted to *Remote Sensing*, 2014 (under revision)

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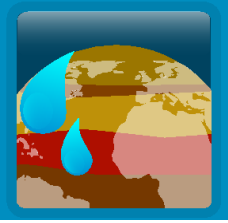

Key Outcomes

✗ **Lower Correlation** (R= 0.33-0.55) **between ASAR and ECV SM in the Finnish sites**

[likely due to the unsuitability of the change detection algorithm for latitudes larger than 60°, as well as the forest coverage].

✗ The capability of the ECV product in capturing the **driest conditions** should be improved.

(*) C. Pratola, B. Barrett, G. Kiely, E. Dwyer, "Evaluation of a global soil moisture product from finer spatial resolution SAR data and ground measurements in Irish sites", submitted to *Remote Sensing*, 2014 (under revision)

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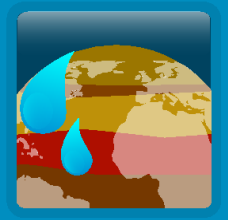

Future work

- To consider the seasonal effect for the estimation of the parameters(**) used in the change detection algorithm.
- To adapt the change detection algorithm to latitudes higher than 60°.
- To analyse the soil moisture behaviour in a forest free area at high latitude (e.g. Finnish latitudes).
- To address a land cover (and spatial) based analysis in more heterogeneous areas.
- To use *Sentinels* data for the quality assessment of the new and updated ECV SM product

(**) J. Van Doninck, J. Peters, H. Lievens, B. De Baets, and N. E. C. Verhoest, "Accounting for seasonality in a soil moisture change detection algorithm for ASAR Wide Swath time series", *Hydrology and Earth System Sciences, vol.* 16, pp. 773–786, 2012

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