

CAN OPTICAL SENSORS BE A REFERENCE FOR SATELLITE MEASUREMENTS OF SOIL MOISTURE?

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1. Introduction

Water content and temperature of soil are fundamental factors affecting the process of water and energy exchange on the Earth's surface. They play a key role in shaping weather and climate, moreover, the World Meteorological Organisation (WMO) defines soil moisture as one of the ECVs (Essential Climate Variables) and recognizes the need for improved measurements in this sector. However, measuring soil moisture is a metrological challenge, for example due to the non-obvious transition between large scale, continuous measurements (from satellites, drones, towers) and the reference, in-situ point measurements. A kind of "bridge" between point- and large scales is the medium scale ELBARA radiometer (The European Space Agency L-band Microwave Radiometer), which, like the SMOS (Soil Moisture and Ocean Salinity) or SMAP (Soil Moisture Active Passive) satellites, measures the brightness temperature (BT) of the soil. It depends on factors such as physical temperature, vegetation cover, surface roughness and soil moisture, of which the first and last mentioned factors are the most important. In the presented work, we focused on ground (soil) temperature assessments. A classical methods for measuring soil surface temperature, i.e. thermometers and thermocouples, may cause electromagnetic interference, which has a very strong impact on the measurements of the very subtle quantity, such as brightness temperature. Therefore, we decided to use an optic quasi-distributed temperature sensor for ground temperature measurement. The fibre optic sensor is based on light transmission, so in theory, it does not generate electromagnetic interference. In the presented research we investigated whether the optical sensors and the measuring equipment (interrogator) connected to them actually do not cause any interference in the brightness temperature measured by ELBARA.

2. Materials, methods, experimental design

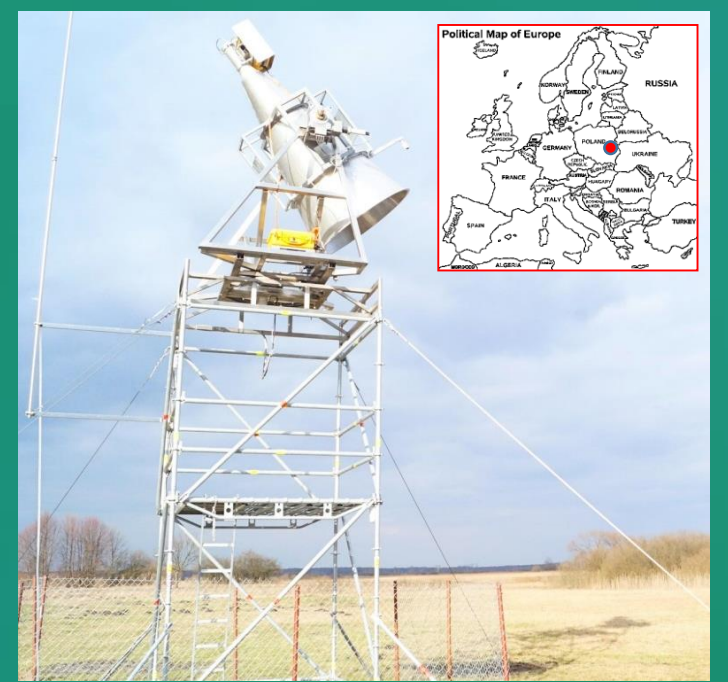
SMOS – Soil Moisture Ocean Salinity

- Launched Nov 2009
- Primary objectives:
 - Soil Moisture
 - Ocean Salinity
- 40x40 km pixel area
- Payload: MIRAS – Microwave Imaging Radiometer using L-Band ($f=1.4\text{GHz}$, $\lambda=21\text{cm}$).



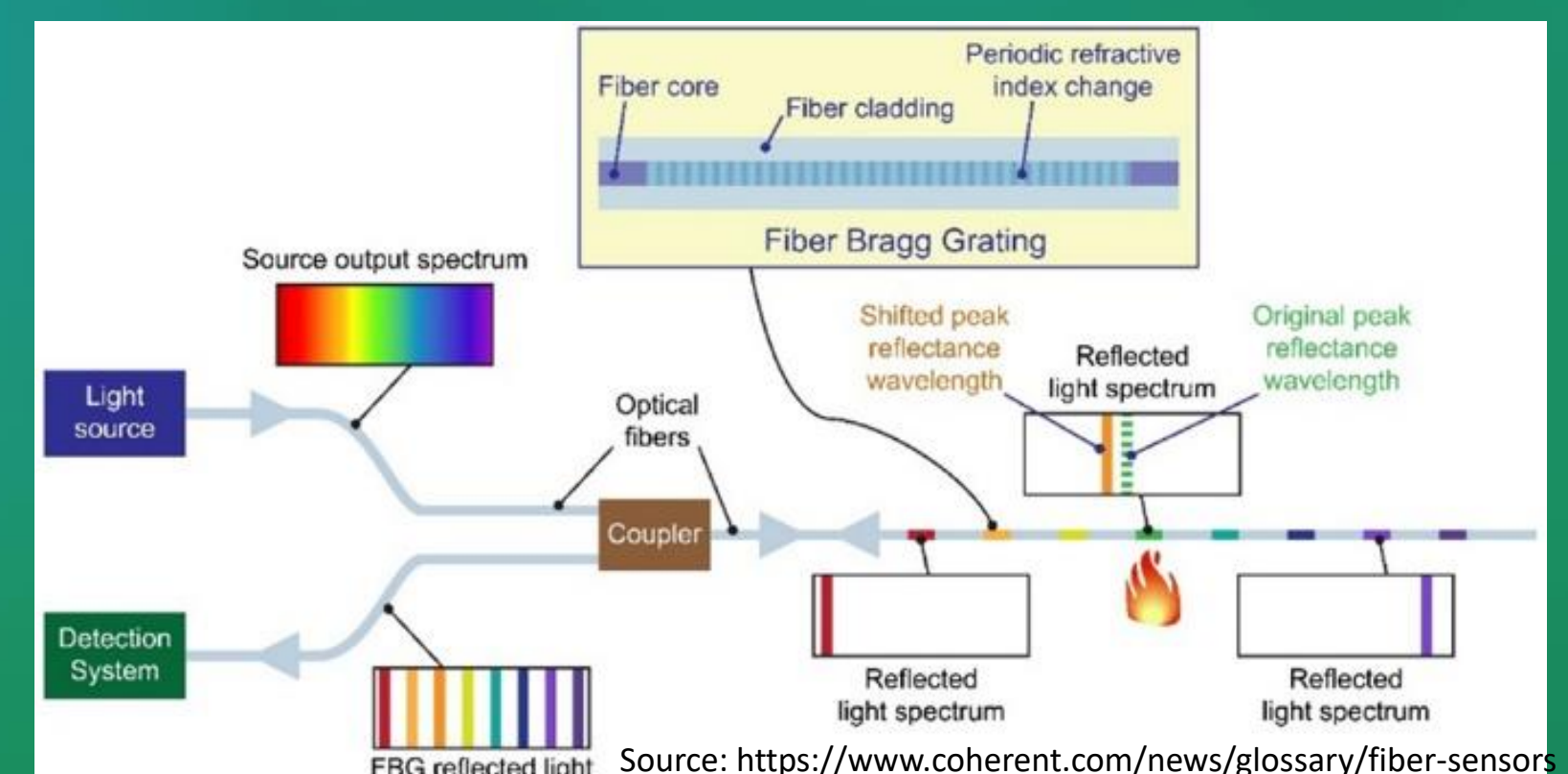
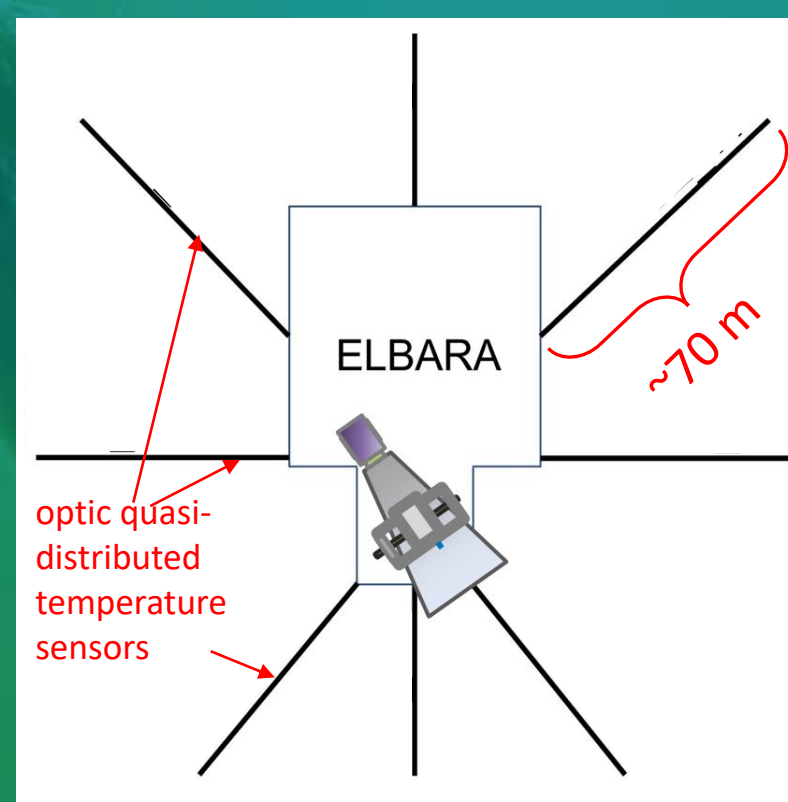
ELBARA – ESA (European Space Agency) L-band Radiometer

- ESA owned reference instrument for SMOS calibration/validation purposes mounted on 6-m tower
- on Bubnow test site in Poland
- 3x3 m average footprint area
- Dual pol (H, V) L-band radiometer

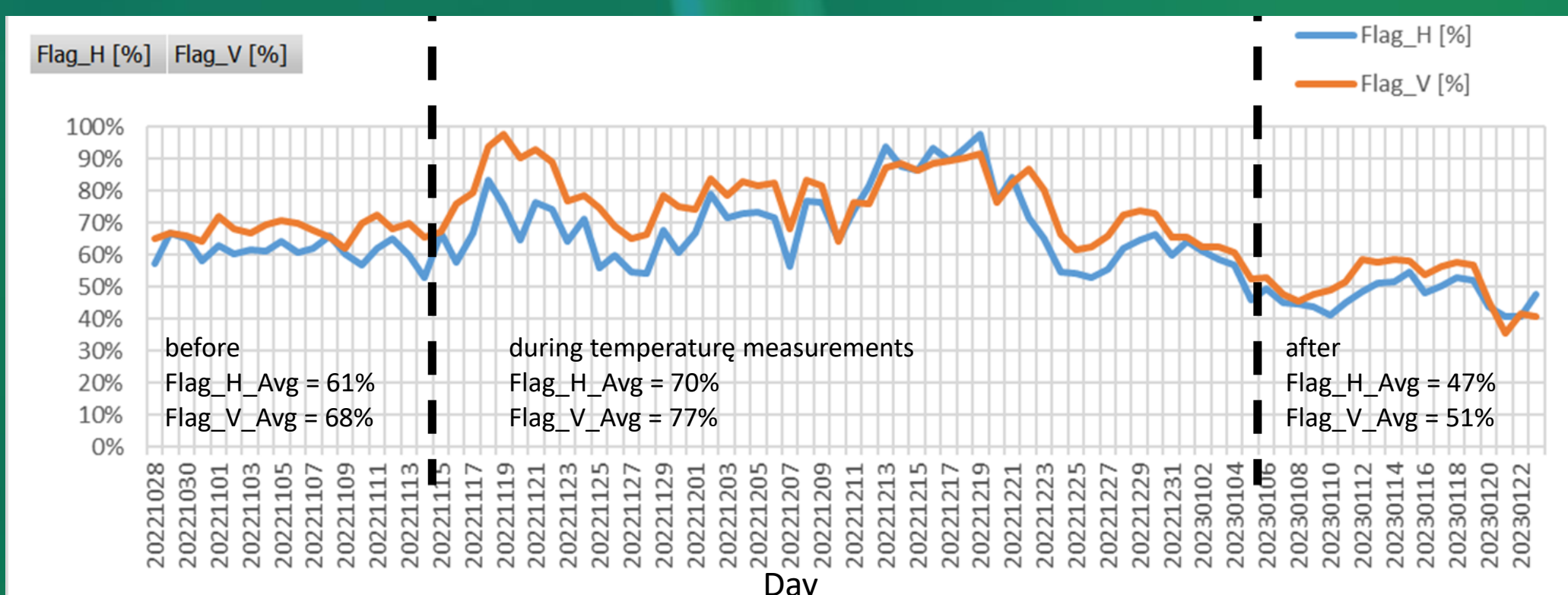


Optic quasi-distributed temperature sensors

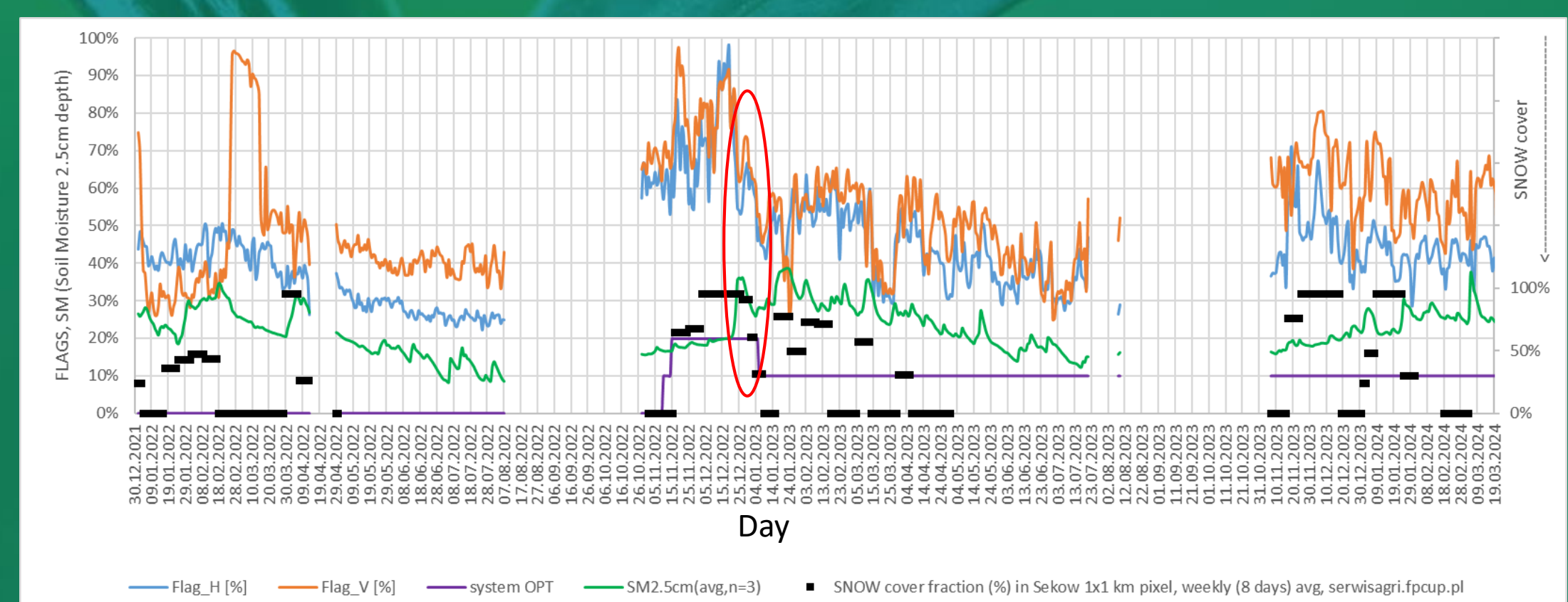
- optical fibres used as temperature sensors, each along the single optical fibre might serve as a sensing point that can be separately addressed, resulting in a continuum of thousands of data points
- does not generate electromagnetic interference of brightness temperature measurement
- about 70 m long, arranged radially in the surface layer of the soil around ELBARA



3. Results



The influence of fibre optics and interrogator (percentage of flagged BT measurements)



The influence of surface soil moisture and snow cover (percentage of flagged BT measurements)

4. Conclusions

The research revealed that the influence of optical **quasi-distributed temperature sensors** is small and does not significantly interfere with the brightness temperature measurements, however, not obvious, because mixed with the environmental impact. It provides a basis for using this technique on a larger spatial scale (even up to kilometers), e.g. as a reference measurement of surface temperature for satellite radiometers.

5. Acknowledgements

This research was partially funded:

- 1) in the framework of the 21GRD08 SoMMet project (2022–2025). The project 21GRD08 SoMMet has received funding from the European Partnership on Metrology, co-financed by the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.
- 2) by European funds under the European Regional Development Fund and The National Centre for Research and Development: 'Autonomous system of fibre optic quasi-distributed temperature sensor for ground temperature measurement' (SPILOD), Grant/Award Number: POIR.04.01.01-00-0031/19-00



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