Leveraging machine learning to exploit new land satellite observations for NWP and CO2 monitoring

Sebastien Garrigues*, Patricia de Rosnay, Eulalie Boucher, Ewan Pinnington, Patrick Laloyaux, Peter Lean, Mihae Alexe, Peter Weston, Souhail Boussetta, Anna Agusti-Panareda, Christoph Rudiger

ECMWF, Reading, UK

sebastien.garrigues@ecmwf

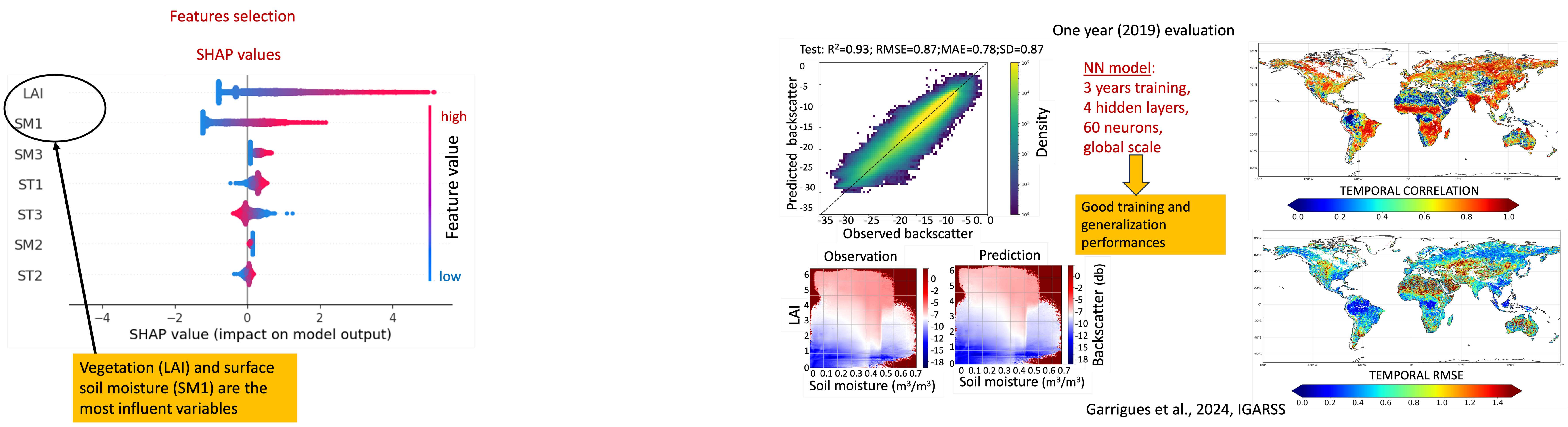
1. Introduction

- Context: machine learning (ML) methods may extract more efficiently the information content from land satellite observations compared to traditional process-based models which can be limited by the lack of accurate enough modelling of vegetation processes
- Objective: leveraging ML techniques to exploit land surface observations to improve the representation of vegetation dynamics in Numerical Weather Prediction (NWP) and C02 monitoring systems (CONCERTO project)
- Exploit ASCAT backscatter normalised at 40° , which is sensitive to both soil moisture and vegetation structure, following 2 approaches:

  1. Assimilation into the traditional physics-based Integrated Forecast System (IFS) model by implementing a ML-based observation operator in the IFS.
  2. Assimilation in the purely observation-driven system GraphDOP (Graph-Direct Observation Prediction) which learn directly from satellite radiances, surface observations and radiosondes

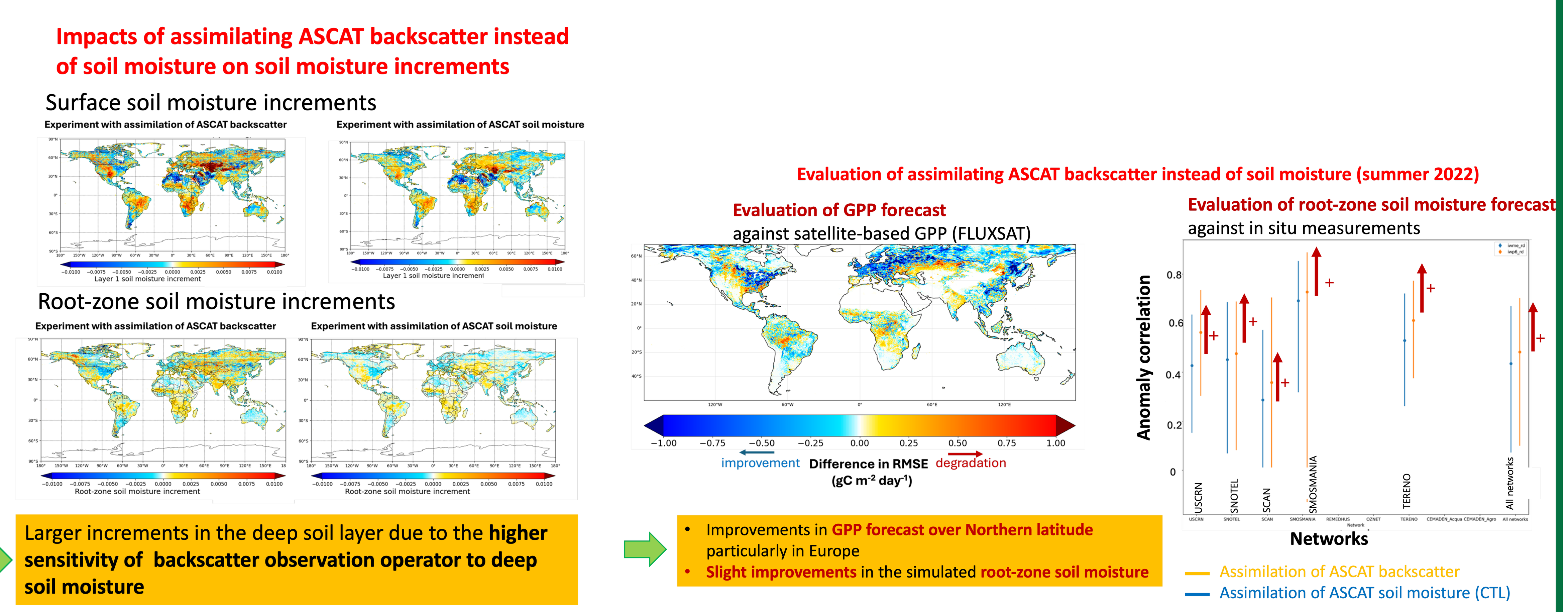
2. Deep learning observation operator for ASCAT backscatter at 40°

- Target: ASCAT backscatter at 40°, Features: ERA-5 variables: LAI, soil moisture (SM, 3 layers), soil temperature (ST, 3 layers), latitude, longitude
- ML Model: feedforward neural network (FFNN) with 4 hidden layers, 60 neurons, 3 years of training (2016-2018), one year of testing (2019), 0.25° grid.
- Results show accurate predictions of ASCAT backscatter at 40° at global scale: the backscatter pattern as a function of soil moisture and LAI is accurately reproduced by the NN.



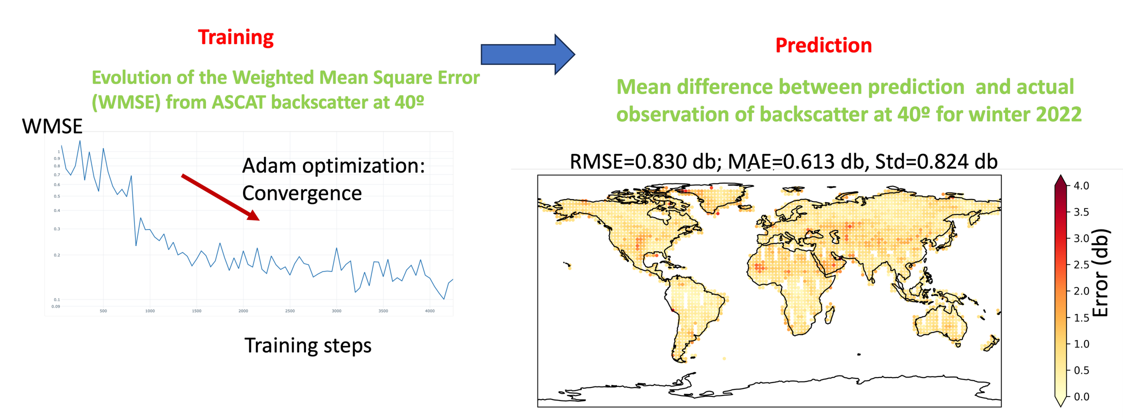
3. Assimilation into IFS

- Implementation of the FFNN-observation operator in the IFS (cycle 49r1)
- Assimilation of ASCAT backscatter at 40° instead of ASCAT soil moisture retrieval (control)



4. Assimilation into GraphDOP

- Predictors: radiosondes, ATMS, surface observations, ASCAT backscatter at 40°
- Model: Graph Neural Networks (GNN) based on an encoder-processor-encoder
- Training : 2012 to 2020; Evaluation: 2022
- Prediction of ASCAT backscatter with an error standard deviation within the product accuracy



5. Conclusions

1. Feedforward neural network observation operator provides accurate prediction of ASCAT backscatter from the IFS fields. The assimilation of ASCAT backscatter at 40° improves the simulation of the root-zone soil moisture, leading in improved GPP over Northern latitude
2. The exploitation of ASCAT backscatter at 40° in the purely data-driven GraphDOP system has potential to improve meteorological variables over land surface.

6. Acknowledgement

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