FDR4LDYN: Creating Long-Term Value for Land Surface Monitoring by Preserving and Harmonizing the ERS C-Band Scatterometer Heritage

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1 Introduction

European C-band scatterometer missions provide one of the longest and most consistent satellite records for observing land surface dynamics. Starting with ERS-1 in 1991 and continuing with the currently active Metop ASCAT series, these missions offer 35+ years of global backscatter observations with stable frequency and viewing geometry. Preserving and harmonizing this heritage is essential to enable climate-scale land applications that rely on long time series. The ESA-funded *Fundamental Data Record for Land Dynamics* **(FDR4LDYN)** project addresses this need by developing an interoperable ERS scatterometer backscatter data record, designed to seamlessly integrate with ASCAT and future Metop-SG SCA missions.

2 From Heritage to Interoperability

As a first processing step, ERS-1/2 ESCAT observations were **inter-calibrated** against Metop-A ASCAT. The method uses stable tropical rainforests as natural calibration targets, as they provide temporally stable, spatially homogeneous, and nearly azimuthally isotropic backscatter. Based on quality-filtered ESCAT–ASCAT differences, incidence-angle-dependent correction polynomials were derived for the relevant viewing configurations and applied globally to reduce mission-to-mission biases. **Figure 1** shows the effect for ERS-1 ascending-orbit data over independent validation regions: after calibration, the correction function is centered much closer to zero across the incidence-angle range, indicating improved consistency with Metop-A [1].

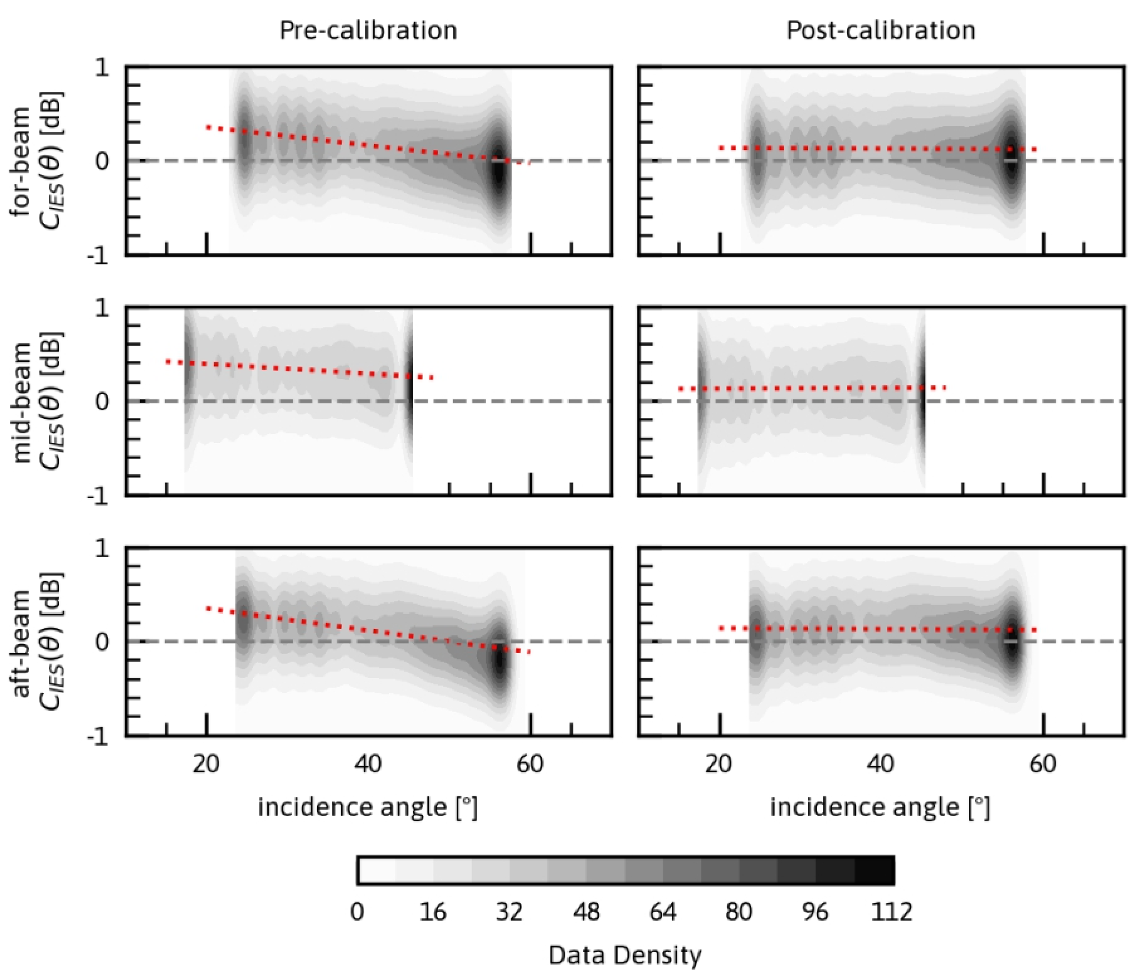

Figure 1: Inter-calibration coefficients correcting ERS-1 against Metop-A (dashed line) before (left) and after (right) correction, shown per beam (rows) over incidence angle (validation regions, ascending orbits) (taken from [1]).

As a second key processing step, we applied an updated **azimuthal correction** to reduce undesired directional viewing effects in the backscatter record. The correction is now derived yearly rather than statically, helping to retain long-term signals in the data. Additionally, in the revised approach, ascending (evening) and descending (morning) orbits are corrected separately to preserve real diurnal backscatter differences. For both ESCAT and ASCAT, the right swath is used as the common reference geometry to maximise interoperability. Following the same general principle as before, polynomial models are fitted to correct geometry-dependent backscatter biases over all incidence angles. **Figure 2** shows the effect of this correction: backscatter variability is reduced most strongly over geometrically structured surfaces such as sand dunes, ice sastrugi, and mountainous terrain.

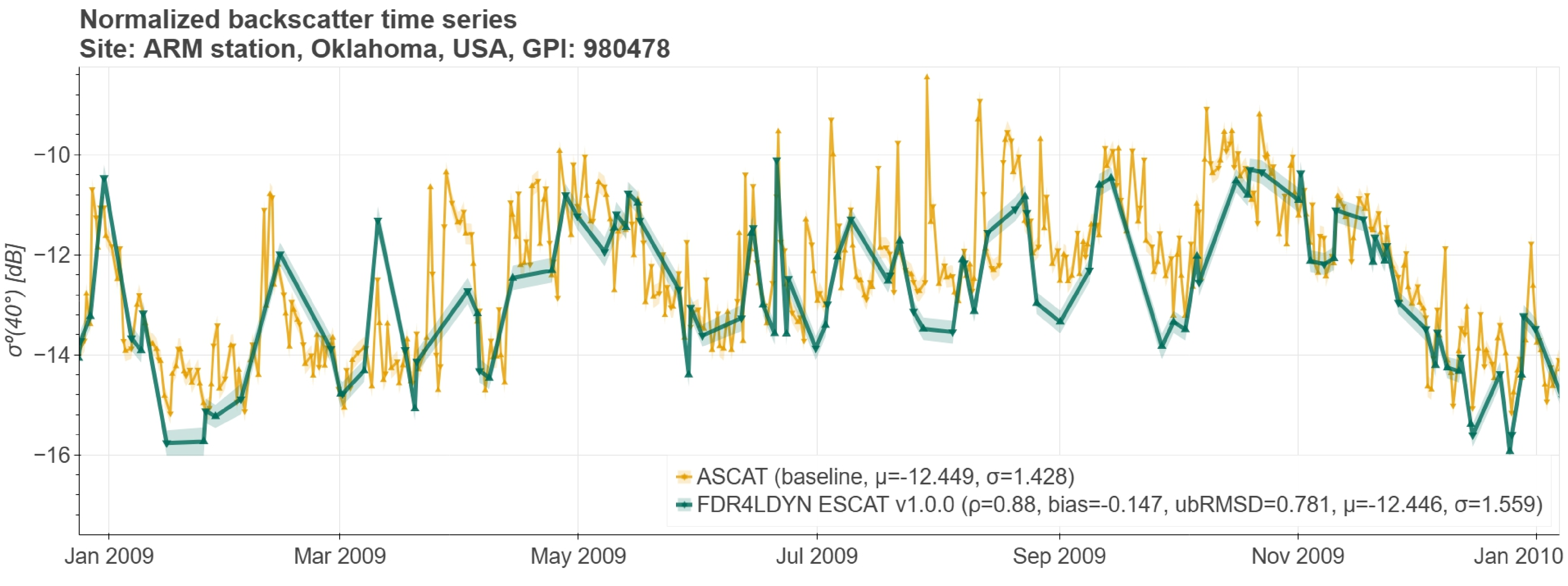

Figure 3: Comparison of normalized backscatter at 40° for one year of overlapping ASCAT (yellow) and ESCAT (green) data at the Atmospheric Radiation Measurement (ARM) site in Oklahoma, USA (36.64°N, 97.48°W).

3 Creating Value for Land Applications

The FDR4LDYN record provides normalized **backscatter** at 40°, along with **slope** and **curvature** variables describing its incidence angle dependence. **Figure 3** illustrates one year of ESCAT–ASCAT overlap: agreement is generally high, but ESCAT's sparse temporal sampling misses several short-term events. This highlights the value of ASCAT's denser temporal coverage for resolving geophysically relevant land surface dynamics.

A key use case is **surface soil moisture (SSM)** retrieval aligned with the operational EUMETSAT H SAF ASCAT SSM product, and as a step toward a future combined ERS–ASCAT–SCA SSM product. Global validation shows ERA5 correlation patterns similar to the operational ASCAT product (**Figure 4**). ISMN in-situ validation reveals lower ESCAT correlations compared to ASCAT, but still comparable behavior across all major land-cover classes (**Figure 5**).

Beyond SSM, FDR4LDYN will support studies of **vegetation** water content dynamics and plant stress [2]. The extended time series also supports the analysis of gradual backscatter trends linked to **land-cover change**, including vegetation shifts and urban expansion. Further use cases include surface water and flood monitoring, where consistent long-term backscatter observations can help characterize **inundation dynamics**. The record also extends over ice sheets and glacierized regions in Greenland and Antarctica, providing added value for **cryospheric studies**.

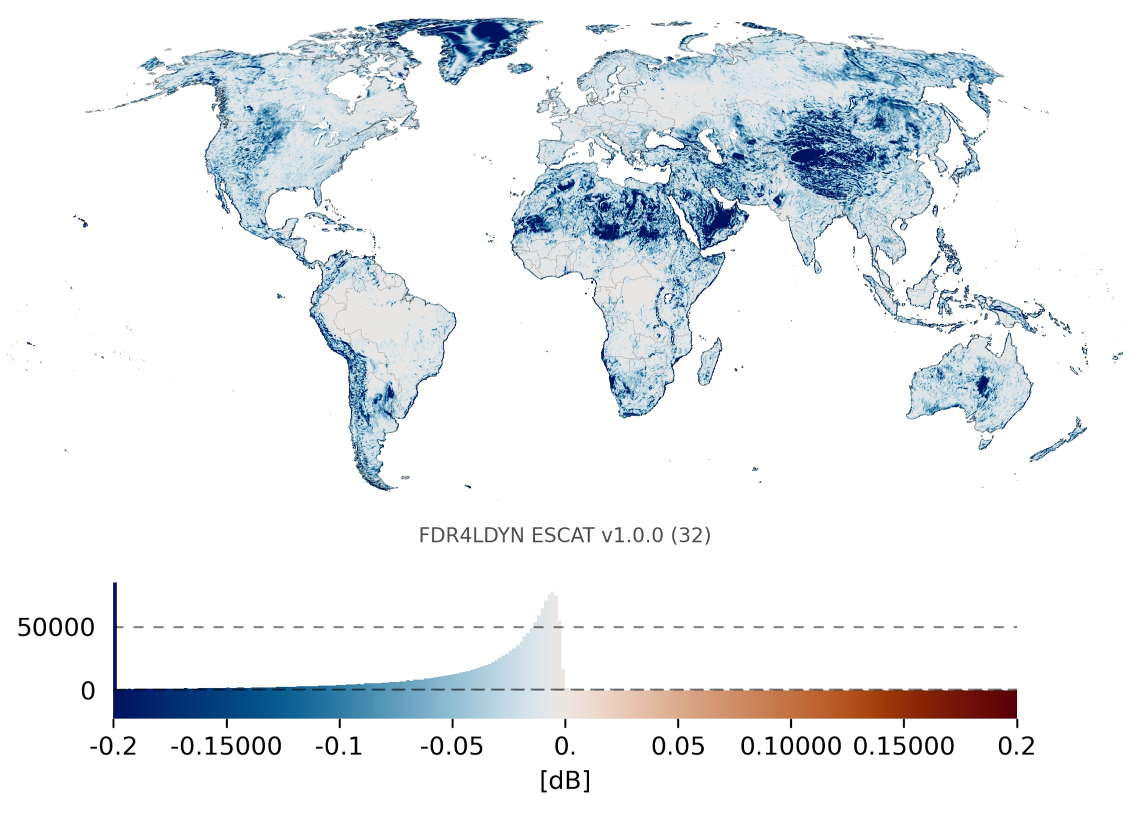

Figure 2: Change in the Estimated Standard Deviation (ESD) of backscatter after azimuthal correction. The strongest reductions occur in regions dominated by pronounced geometric structures.

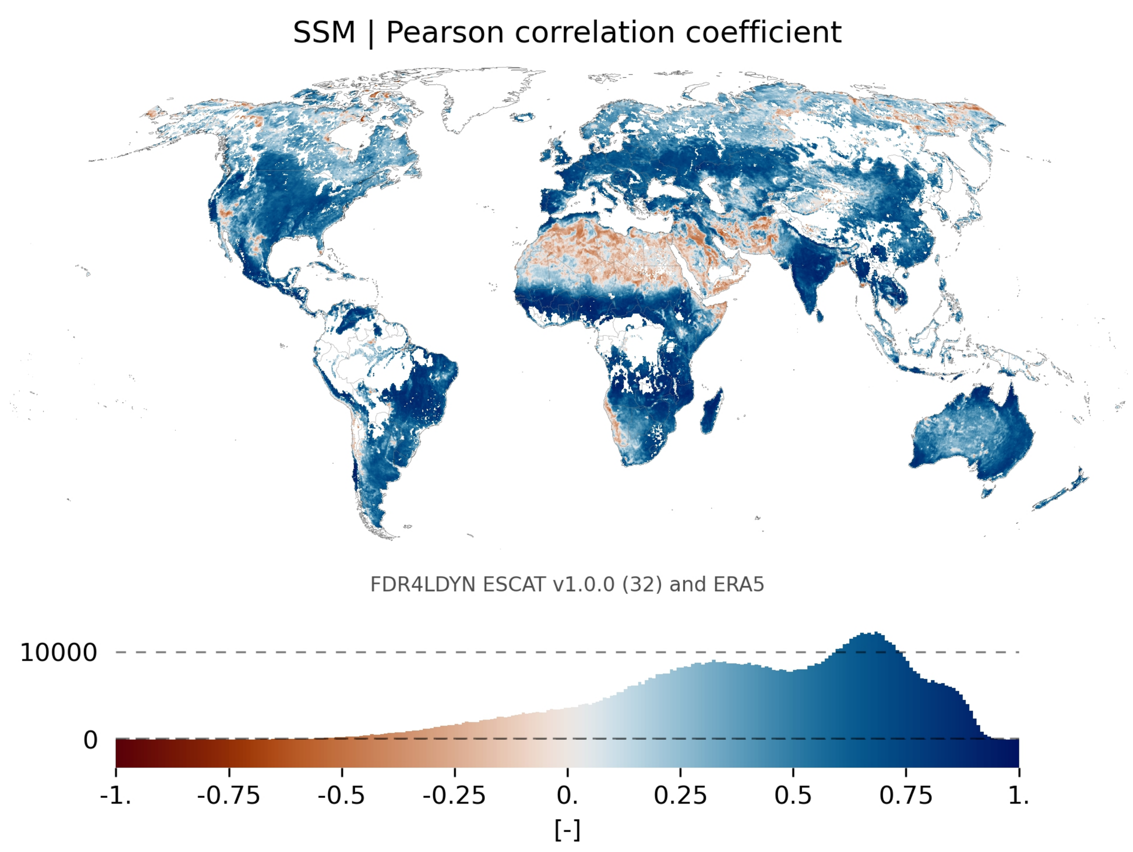

Figure 4: Spatial distribution of Pearson correlation between FDR4LDYN ESCAT-derived SSM and ERA5 SSM.

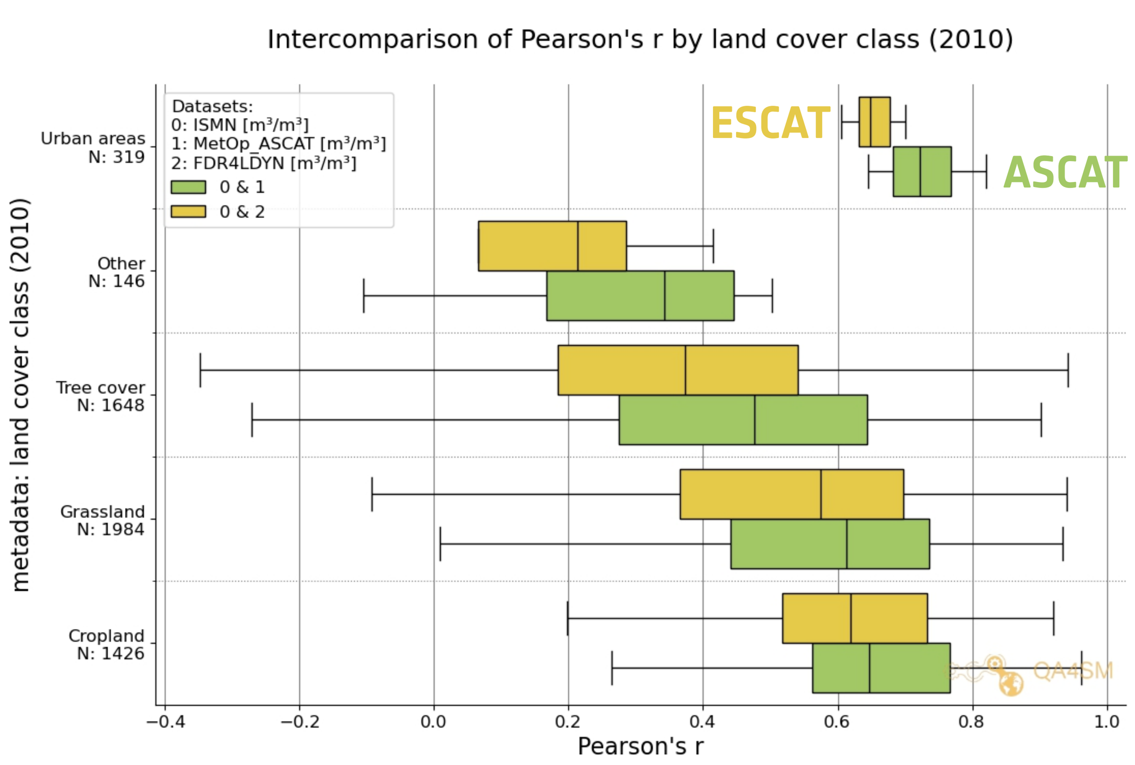

Figure 5: Pearson correlation by CCI Land Cover class for SSM validation against ISMN in-situ stations, comparing ASCAT (green) and ESCAT (yellow) (generated with the Quality Assurance Service for Satellite Soil Moisture Data: QA4SM).

4 Conclusion

By preserving ERS scatterometer heritage and translating it into a validated, interoperable data record, FDR4LDYN will provide a long-term observational backbone supporting diverse, user-driven applications in land surface and climate studies.

References

[1] C. Harrison et al. (2026): Practical Implementation and Adaptation of Rainforest-Based Inter-calibration for ESCAT-ASCAT Scatterometer Data Records, 2026 ISPRS Congress.

[2] P. Frantzen et al. (2025): Improved Estimation of Temporal Dynamics in the ASCAT Backscatter-Incidence Angle Relation Using Regularization, IEEE JSTARS. doi: 10.1109/JSTARS.2025.3572306.

Acknowledgments

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