We thank the referees for their valuable comments. Please find below our point-by-point responses to the comments (in italics).

Reply to RC1: 'Comment on essd-2025-537', Filippo Giannetti, 20 Feb 2026

General Comments

This manuscript presents OpenSat4Weather, an openly accessible dataset of Ku-band Satellite Microwave Link (SML) measurements for opportunistic precipitation monitoring. The dataset includes 1-minute received signal level (RSL) time series, taken in southeastern France from 215 SML stations from August to December 2022, together with co-located 6-minute rain gauge observations, radar-based rainfall estimates projected along each SML path, and ERA5-derived hourly 0°C isotherm heights. The data are arranged in NetCDF format and are compliant with OpenSense conventions.

The release of a large SML dataset fills a gap in the community, as no other open SML datasets are available. The manuscript provides a clear description of instrumentation, preprocessing, metadata structure, and known signal disturbances. In terms of relevance, documentation, and openness, the dataset meets the core expectations of ESSD.

The manuscript is generally well written and is suitable for publication after minor changes.

Specific comments

1. *Include a short discussion of representativeness and limitations of the covered period (August–December 2022), since it does not represent a full annual cycle.*

Reply: We agree that longer observation periods are generally preferable for open datasets. However, we believe that the provided period is sufficient to evaluate many aspects of SML research. It includes both convective and stratiform events during the summer, as well as stratiform and snowfall events during the winter months. Therefore, the dataset can already be used, for example, to develop processing methods for SML retrieval, test merging methods with radar data, or support hydrometeorological applications. Having said that, it is known that the precipitation regime in Southern France is characterized by a pronounced seasonal cycle, therefore the precipitation events in the five month OpenSat4Weather dataset are not representative of a typical yearly cycle. However, the dataset includes all the autumn months, which are historically the wettest season in Southern France [1].

To provide information about the occurrence of meteorological phenomena, in particular precipitation, in Southern France during the period for which SML data are available, we checked Meteo France climatologic reports, which are available at https://meteofrance.fr/actualite/publications/les-publications-de-meteo-france. In the revised manuscript, we will include the following statements: In 2022, temperatures were above normal across most of France, contributing to record-breaking drought conditions that persisted until mid-November in Southern France (in particular, in Occitanie). Precipitation, including snowfall, remained below average, and Southern France did not experience any major storms or significant Mediterranean episodes during this period.

Nevertheless, several severe convective events were recorded, notably on 16–17 August (including episodes of hail), as well as on 6–7, 13–14, and 23–24 September.

[1] Mimeau, L., Tramblay, Y., Brocca, L., Massari, C., Camici, S., and Finaud-Guyot, P.: Modeling the response of soil moisture to climate variability in the Mediterranean region, Hydrol. Earth Syst. Sci., 25, 653–669, https://doi.org/10.5194/hess-25-653-2021, 2021.

2. *Provide clarification about temporal alignment between 1-minute SML data and 5-minute radar data.*

Reply: The provider of radar data (Meteo France) confirmed that the time stamp of radar data is the end time of radar scanning, that is, the end time of each 5-min time slot. The same holds for the rain gauge data (6-min integration time). In the revised version (Secs. 2.2 and 2.3), we will clarify this aspect.

3. *Provide quantitative assessment of the frequency occurrence of disturbances (temperature effects, wet antenna, saturation, misalignment)*.

Reply: We provided a picture of SML data availability in Figure 3 and a few examples of the effect of disturbances on the received signal level (temperature effects in Figure 12, wet antenna, saturation, cable disconnection, and antenna misalignment in Figure 13, respectively). On the other hand, providing a quantitative assessment of the occurrence of the disturbances requires a comprehensive data quality check, including algorithms for automatic detection of all those anomalous patterns. Moreover, in the case of wet antenna effect, it would be necessary to implement a processing chain for rainfall identification. We believe that such quantitative analysis goes beyond the scope of the paper. To help the potential users of our dataset in better understanding these disturbances, we will include in Section 5 of the revised manuscript: 1) a reference to the open SW package available on github and developed by the OpenSense COST action community for processing data from opportunistic rainfall sensors (see https://github.com/OpenSenseAction/OPENSENSE_sandbox), and 2) references to relevant papers that survey the disturbances affecting SML data and discuss approaches for addressing them.

4. *Line 105. Add some relevant reference about the presence of the melting layer and its effects on microwave satellite signals.*

Reply: The melting layer is the portion of the atmospheric path where ice particles melt into raindrops. During stratiform events, the melting layer extends up to several hundred meters below the zero-degree isotherm and can significantly contribute to signal attenuation across Earth-Satellite paths as well as to other effects such as depolarization. A straightforward approach to account for the presence of the melting layer is to include an additional attenuation term analogous to that in Equation (1) of our paper, which depends on both the rainfall intensity and the thickness of the melting layer, although with coefficients that differ from the ones in rain [1][2]. Alternatively, the length of the rainy path is adjusted to incorporate the melting layer contribution [3]. The aforementioned techniques can be applied to retrieve the rainfall rate in real-time from signal attenuation. During convective events, the effect of the melting layer is more challenging to model accurately, as updrafts (or conversely, downdrafts) are more likely to transport liquid particles (or conversely, solid particles) to varying heights (see for instance [4]).

[1] Matrosov, S. Assessment of Radar Signal Attenuation Caused by the Melting Hydrometeor Layer. IEEE Trans. Geosci. Remote Sens. 2008, 46, 1039–1047.

[2] Giannetti, F.; Moretti, M.; Reggiannini, R.; Vaccaro, A. The NEFOCAST System for Detection and Estimation of Rainfall Fields by the Opportunistic Use of Broadcast Satellite Signals. IEEE Aerosp. Electron. Syst. Mag. 2019, 34, 16–27.

[3] Xian, M.; Liu, X.; Gao, T. An Improvement to Precipitation Inversion Model Using Oblique Earth-Space Link Based on the Melting Layer Attenuation. IEEE Trans. Geosci. Remote Sens. 2021, 59, 6451–6465.

[4] Giannetti et al. (2017). Real-time rain rate evaluation via satellite downlink signal attenuation measurement. Sensors, 17(8), 1864

We will add the above discussion and the pertinent references in Section 3.1 of the manuscript. In response to Comment 3 of RC2, we will also adjust the text in Section 3.1 to highlight the difference between statistical models of path attenuation and models that can be applied over the time series. The models listed above are those suggested for real-time estimation of the rainfall intensity from SML data.

5. *Lines 130-132. Do anomalous values include also sun transits behind the satellites?*

Reply: The sun transit effect has not been included in the examples shown in Figures 12 and 13. When the sun passes behind the satellite, the signal rises and then falls in a sinusoidal pattern over a few tens of minutes. This pattern repeats for several days, with its intensity gradually increasing and then decreasing, and it is observed twice a year during clear weather. However, this effect has minimal impact on rain detection for two reasons:1) it is observed only during clear sky conditions, and 2) it produces a signal increase followed by a decrease, which is the opposite of the variation associated with rain. Therefore, it can be readily identified and filtered out. In the revised version of the manuscript (Section 5), we will mention the sun transit effect.

Technical corrections

Conclusions. Line 389. Correct the sensor number in "RSL data for 251 SML sensors".
Reply: Done

Correct the following typos: line 387 "convectional"; line 249 "hisotherm".
Reply: Done

Reply to RC2: 'Comment on essd-2025-537', Anonymous Referee #2, 13 Mar 2026

The manuscript by Nebuloni et al. introduces a dataset of Satellite Microwave Link (SML) measurements for opportunistic precipitation monitoring. The 1-minute received signal level time series, collected in late summer and fall 2022 from 215 SML stations (August–

December 2022), are freely available. This is an important aspect, since in many cases opportunistic signals usable for precipitation measurements are not accessible. The dataset is complemented by ancillary data such as ERA5 0°C isothermal height, and reference data such as nearby rain-gauge measurements and radar-based specific attenuation (SPE) along SML paths. The data are openly accessible through Zenodo and are compliant with FAIR principles. Overall, the dataset is quite unique and well described, and some advice is provided to potential users who wish to work with it. The manuscript looks good but could be improved with some minor changes. Below are my suggestions.

1. *Licensing. According to Zenodo, the license is CC BY 4.0, whereas the manuscript reports CC SA 4.0. Furthermore, the "copyright statement" at page 1 does not appear to be fully compliant with these licenses. The authors listed in the Zenodo record also need to be acknowledged.*

Reply: We confirm the license is CC BY 4.0. The first statement in Section 7 (Data availability) of the revised manuscript will be changed into the following form: "The OpenSat4Weather dataset is openly available at https://doi.org/10.5281/zenodo.16530166 (Nebuloni et al., 2025), under the Creative Commons Attribution 4.0 International Public License (CC BY 4.0) . "

Furthermore, we will delete the copyright statement on p. 1 of the manuscript ("The SML dataset described in this paper was provided by Sereno / HD Rain. The data remain the intellectual property of Sereno / HD Rain and are made available for academic use within the scope of this publication and the COST project Opensense"). We checked the definition of CC BY 4.0 and we agree that this statement is not compatible with it, as the owners are not allowed to restrict the usage of data licensed with CC BY 4.0.

Finally, the authors listed in the Zenodo record are the same as those of this manuscript. For this reason, they were not explicitly acknowledged. However, we will revise the last statement in the acknowledgments section to include a mention of the authors of the Zenodo record.

2. *While the number of terminals is quite high, the time period covered is limited. Could the authors describe the types of precipitation phenomena included (stratiform/convective rain, snow, hail), especially considering that winter and spring are not represented?*

Reply: we received a similar comment from RC1. Please refer to our response to Specific Comment 1 of RC1 for further details.

3. *The discussion of methods for determining rain height is important. However, the uncertainty due to attenuation in the melting layer seems to be neglected, or at least delegated to statistical models. These models are suitable for designing communication links but are more limited when the goal is to provide real-time precipitation measurements with a time resolution comparable to that of rain*

gauges. It is not clear to me what is suggested to cope with melting layer attenuation.

Reply: we received a similar comment from RC1. Please refer to our response to Specific Comment 4 of RC1 for further details.

4. *As pointed out, many SML retrieval models assume rainfall intensity to be vertically constant below the melting layer. In convective situations, this assumption does not hold, and SML rain quantification becomes more challenging. Moreover, SMLs may pass through regions where rain is mixed with graupel or small hail, for which the coefficients in relation (1) are uncertain. Could the authors provide, within the dataset, a classification (e.g., convective vs. stratiform) for each measurement minute (or longer time intervals)?*

Reply: To our knowledge, no operational or reference product provides a robust convective–stratiform classification at the temporal and spatial resolution of the SML measurements used here. Although several separation algorithms exist (e.g., radar-based methods using reflectivity texture, bright-band detection, or Steiner-type approaches, see for instance [1] and [2]), their results depend strongly on the chosen method, thresholds, and input data, and different schemes may classify the same event differently. Deriving such a classification would therefore introduce additional assumptions and uncertainties, particularly in complex situations such as mixed-phase precipitation or embedded convection. Providing a single classification within the dataset could thus suggest a level of certainty that is not warranted. For this reason, we did not include a predefined convective/stratiform classification.

[1] Anagnostou, E.N., A convective/stratiform precipitation classification algorithm for volume scanning weather radar observations. Met. Apps, 2004, Vol. 11, p. 291-300.

[2] Steiner, M., and Smith, J. A., Convective versus stratiform rainfall: An ice-microphysical and kinematic conceptual model." Atmospheric Research, 1998, Vol. 47, p. 317-326.

5. *Radar data (Sections 2.3, 3.2). My understanding is that Panthere radar data represent gridded surface rainfall intensities. Therefore, the radar rain reference obtained by averaging along the link path implicitly assumes rainfall uniformity up to the rain height. If this interpretation is correct, please clarify it in the manuscript.*

Reply: Panthere data provide estimates of surface rainfall intensity derived from the combination of multiple radar scans at different elevation angles. Radar scans are inherently measurements collected aloft, the sampling height increasing with the distance to the radar. Therefore, although Panthere data (as other radar products) are intended to represent rainfall at ground, the actual radar measurements are typically taken at altitudes ranging from a few hundred meters to several kilometers above ground. Despite this limitation, we think that Panthere data are a valuable additional source of information to rain gauge observations, which are ground-based but have limited spatial representativeness.

6. *Lines 169–170. It seems that the melting-layer height corresponds to the bottom of the melting layer, i.e., what is called rain height somewhere else in the manuscript. Please clarify the text.*

Reply: we agree the statement is ambiguous. In the revised version, we will change the statement into: “The above variable represents the height (in meters above sea level) where the temperature of the air reaches 0°C. This, in turn, is crucial for identifying the melting layer, that is, the height interval where solid particles melt into raindrops, as shown in Section 3.1.”