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Ground-Based Atmospheric Measurements at the Onsala Space Observatory (Sweden): Data & Trends (2009–2025)

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Reply to the comments of the two referees

First of all, many thanks to the two reviewers for the time devoted to read this manuscript, for help and interesting comments. Below, we provide point-by-point responses (in blue). All changes and clarifications have been incorporated into the revised manuscript.

1 REFEREE #1 (RC1)

The authors are clear that the intention of the paper is to introduce the observations and the site, not the presented analysis of the data. However the presentation of the data reviles insights in interpretations of the description and is thus useful. To be a useful article there are some details about the observations that must be added. For example the placement of the sensors, the resolution of the sensor and how certain variables are defined. The presented analysis and interpretation is a bit trivial, but showcases the data set. I would recommend the article for publication if they clarify it.
We thank the reviewer for this constructive comment. We agree that, for a data paper to be fully useful, a detailed description of the observations is essential. We have therefore expanded the *Instrumentation* section (Sec.2.2) and Table 1 to explicitly describe sensor placement, measurement heights, resolution, and the precise definition of key variables (e.g. wind gust, rain rate, cloud cover). These additions improve the clarity and reusability of the dataset while remaining consistent with the descriptive scope of the paper.

Specific comments:

(i) Figure 1 gives an overview of the location of the instrument mast, but the picture is almost not showing the tower. I would highly recommend a better picture of it. In the text, at line 68, it is referred to as a ”concrete tower”.
We replaced Figure 1 with a close-up view of the instrumented mast and removed the word “concrete” in the revised manuscript (see revised Fig.1).

(ii) Line 68: Has the sensor been the same for the whole measuring period? It is relevant for the humidity observations where capacitive sensors are known to drift in RHmax value with time.
The Vaisala WXT520 remained installed at the same location for the full record (Aug 2009–Apr 2025). Instrument maintenance logs do not report sensor replacements during this period; sensor drift cannot be fully excluded and this is now mentioned/discussed in the revised manuscript (see Section 5).

(iii) How is the sensor placed on the tower. I cant tell from the picture. Is it placed on top of the tower or on the side on a boom (in htet case in wich direction?)?
The Vaisala WXT520 sensors are mounted at the top of the instrumented mast ($\sim$16.1 m a.s.l.; see Table 1). The modified Figure 1 shows the sensor location. This information has also been added to the revised manuscript (Section 2.2).

(iv) Line 70: It is unclear if wind (speed and direction) is measured with the Vaisala weather transmitter WXT520 or with an additional separate sensor. It is also not clear how the Vaisala weather transmitter WXT520 is mounted on the tower.
Wind speed and direction are measured by the Vaisala WXT520’s ultrasonic sensor (WINDCAP®) that determines wind speed and direction from the transit time differences of ultrasonic pulses transmitted between multiple transducers. This information has been

added to the revised text (Section 2.2). The Vaisala transmitter (including the wind sensor) is mounted at the top of the mast (see modified Fig.1 and Sec.2.2).

(v) Table 1: It is unclear if the observations are made at 16.1 m above sea level, or at 16.1 meter on the tower. Or is the base of the tower located at sea level?
The elevations in Table 1 are given in meters above sea level (a.s.l.). This includes the observation height on the mast (e.g., 16.1 m a.s.l. for the Vaisala WXT520). We have clarified the text and the table to avoid any confusion.

(vi) Rain rate (RR [mm/h]): According to the text rain rate is based on minute observations (line 73 and 168). Explain how this is done. Is it the maximum minute value that is used or ..?
Rain24: Accumulated precipitation during 24 can within meteorological data either be 00-24 or morning to morning (06-06 UTC).
The rain rate (RR) is provided at 1-minute resolution by the RAINCAP® impact sensor. For each minute, RR represents the estimated rainfall in mm/h according to the manufacturer's algorithm; it is not the maximum instantaneous value but a minute-averaged estimate. Hourly (R1h) and 24-hour (R24h) accumulations are obtained by summing the incremental minute values over the corresponding periods. For R24h, we use the 06:00–06:00 local (morning-to-morning) convention. These clarifications have been added to the revised manuscript (see Sec. 2.2).

(vii) The resolution of the sensors are missing in the table.
We thank the reviewer for this suggestion, which is very helpful. Sensor resolutions have now been added to Table 1 as requested.

(viii) In which direction is the pyranometer mounted on the tower? If it is mounted on the tower it must be shaded by the tower part of the days.
We thank the reviewer for pointing this out. The pyranometer is installed on the ground at 12 m a.s.l., not on the tower, and is therefore not shaded. We have clarified both Figure 1 and the text to prevent any misunderstanding.

(ix) Line 79-80: How are clear and cloudy pixels defined?
Cloudy and clear-sky pixels were identified using the FindCloudsTrinity (FCT) algorithm applied to ASI-16 sky camera images (Schreder CMS, 2025a,b). The method is based on color ratio analysis, in particular the Blue/Red and Blue/Green (BRBG) ratios computed from the RGB channels, which allows discrimination between clouds, haze, and clear sky. Pixels are classified as cloudy or clear-sky using the BRBG-based cloud index, resulting in a binary cloud mask. Cloud cover is then calculated as the fraction of pixels classified as cloudy within each image. This approach has been widely used and validated in previous studies based on sky camera observations for cloud and irradiance analysis (e.g. Song et al., 2023; Nevins and Apell, 2021; Long et al., 2006; Sabburg and Long, 2004). This clarification and the corresponding references have been added to the revised manuscript.

(x) Line 84: Here is the additional pyranometer placed. The height is given but not the location (on the mast or on a separate structure)? Line 102: It is unclear which pyranometer the text is referring to.
Line 235: Specify from from which sensor the data comes from (you write that there are two pyranometers).
We thank the reviewer for highlighting this ambiguity. Only one pyranometer is used in this study, and the text has been revised to avoid any confusion. Its location and height are now clearly indicated in Table 1 and Fig. 1.

(xi) Line 136: I am curious about the very few days of fog in the RH data. Since OSO is located in a costal region I would expect to see at least some occurrence of foggy days. I agree that the drift in RH value is low for most of the time period, but from 2020 it is increasing by about 2% per year. Has the sensor been replaced or recalibrated during the time period?
Line 274: Could the shape of the cure be due to drifting in RHmax value?
We thank the reviewer for raising this important point. According to maintenance logs, no explicit sensor replacement or recalibration for the Vaisala WXT520 transmitter was performed during 2009–2025; therefore, an instrumental drift cannot be fully excluded. It is also worth noting that very few foggy days are observed at OSO overall, consistent with the reported relative humidity data. These points have been clarified and discussed in the revised manuscript (Section 5).

(xii) Figure 2: Is a) showing daily or hourly observations? It is not mentioned in the text. c) What pressure value is plotted? Observed value (at what height above sea level) or as sea level. This might be clearer if table 1 is updated.
Figure 2(a) shows temperature and humidity at 1-minute resolution, while panel (c) displays a 1-minute resolution time series of

observed pressure at 16.1 m a.s.l., including monthly means (black dots). The figure caption and Table 1 have been clarified to make this explicit, and the text in Section 4 has also been updated.

(xiii) Line 170: Measurable precipitation needs to be defined. Common resolution of precipitation observations is about 0.1 mm. It thus sounds odd that the measurable precipitation needs to be at least 1 mm/day. Please clarify.
In this study, the term "measurable precipitation" is not used in the sense of the instrumental detection limit, but rather to denote days with an appreciable (non-negligible) amount of precipitation contributing meaningfully to the daily total. The threshold of R24h $\geq$ 1 mm was therefore chosen to identify days that can reasonably be considered as precipitation days at the daily scale, excluding very small amounts that may be detected by the instrument but do not represent a clearly wet day. This choice is consistent with the focus on daily precipitation occurrence and characteristics, rather than on the sensor resolution itself. The definition has been clarified accordingly in the revised manuscript.

(xiv) Line 199: If the clouds promote vertical mixing, how can the conditions lead to stable temperature profiles? It more sounds like you have unstable or near neutral (windy) conditions.
Thank you for this comment. We have clarified the sentence: we meant that marine WSW winds enhance vertical mixing in the lower atmosphere, while prevailing anticyclonic ENE conditions maintain a thermal inversion aloft. The text has been revised for clarity.

(xv) Figure 4: What is plotted in the figure? Hourly average wind speed values or daily values?
For Fig. 4, wind speed and wind direction measurements at 1-minute resolution are used to produce the wind roses and histograms. For the seasonal wind roses, the data are divided into four categories (seasons) based on the measurement date (see text for details).

(xvi) You need to define your wind gust. Max value under what time period. Its also relevant to know the frequency of the measurement.
Wind gusts are defined as the maximum wind speed measured over the internal short averaging interval of 3 seconds, as reported by the WXT520 sensor, following the manufacturer's specifications. Wind speed and gust values are recorded at a temporal resolution of 1 minute. These definitions and the measurement frequency have been added to Section 2.2 of the revised manuscript.

(xvii) Figure 5: What values are plotted? Daily average values, hourly average values or ..?
For Fig. 5, the upper panel shows solar irradiance measured by the pyranometer at 1-minute resolution. The lower panel shows 3D scatter plots combining solar irradiance with cloud cover estimated from the sky camera. For these 3D scatter plots, irradiance values corresponding to the exact dates and times of available sky camera observations are used (i.e., every 15 minutes).
This information has been clarified in the descriptive text and in the figure caption.

(xviii) Line 261: Is the "." supposed to show that the values a multiplied by each other?
Thank you for noticing this typographical error. We corrected it ($°C.yr^{-1} \rightarrow °C\,yr^{-1}$).

(xix) Line 289: It difficult to talk about trends when you at the same time show that they are not significant!
We agree that the original wording could be interpreted as suggesting trends despite the lack of statistical significance. We have therefore revised the text to adopt a more descriptive formulation and to avoid any implication of significant trends. The revised text now explicitly states that only small, non-significant variations are observed in the frequency of precipitation days.

(xx) Line 318: I suggest you specify the observation height. Common meteorological data are from 1,5 or 10 m. So important to be clear about the heights here!
Thank you for this helpful suggestion. We have added a clear statement in the Instrumentation section and in Table 1 indicating the observation heights (16.1 m a.s.l. for the Vaisala WXT520 meteorological station, 12 m a.s.l. for the pyranometer, and 3 m a.s.l. for the sky camera), and we have reiterated these heights in the conclusion of the revised manuscript (Sec. 6).

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