Reply to the issue in Australia

Dear Dr. Jorge Luis Peña-Arancibia, Dr. Zaved Khan, and Dr. Dalei Hao,

We would like first to express our sincere gratitude for your interest in the GIMMS LAI4g product and your kind report on the issue in Australia. Based on the report, we have carefully inspected the issue and found that the causation could be the invalid data value (fill value: 65535) in the dataset. We recommend properly handling the value in the analysis. We hope our clarification could address the concern and enhance the confidence in GIMMS LAI4g from the community. In the meantime, we enthusiastically welcome future feedback from researchers of all backgrounds.

Although the clarification on the issue does not affect the latest version of GIMMS LAI4g (v1.2), we do make modifications to our manuscript entitled "Spatiotemporally consistent global dataset of the GIMMS Leaf Area Index (GIMMS LAI4g) from 1982 to 2020" (essd-2023-68). Below, we reply to the report as a regular reply letter. Changes in the revised manuscript have been marked in red.

Sincerely yours,

Zaichun Zhu, Ph. D. (on behalf of the author team)

School of Urban Planning and Design

Peking University

Tel: 86 185 0042 6608

Email: zhu.zaichun@pku.edu.cn

[Comment 1] *First of all, we would like to commend Cao et al. (2023) for developing a long-term Leaf Area Index (LAI product) which is an important contribution to earth sciences scientific research. While investigating LAI dynamics over the Australian continent at the catchment scale (BoM, 2022), we noticed some unusual LAI values in Alpine catchments (southeast Australia) in the early 1990s. We would like to showcase these issues to Cao et al. (2023), noting that we have not tried to systematically evaluate errors in GIMMS LAI4g and the findings came from our investigations into catchment non-stationarity, for which vegetation plays a key role (Fowler et al., 2022; Gardiya Weligamage et al., 2023). Therefore, we do not investigate this issue in detail and have only scratched the surface about occurrence and speculate about the causes of the issues. We leave the authors to further verify if the issues occur in other continents and other years.*

[Response 1] We thank the research team in CSIRO again for providing a detailed report, which excellently describes the issue and the concerns on the GIMMS LAI4g product. The report has explicitly guided us to examine the data in Australia (and across the globe) and to repeat the issue that the team has met. In the following response, we will point out that, **the causation of the issue is likely the inclusion of invalid or fill value of 65535 in the analysis.** The fill value is assigned when the algorithm fails to provide a biophysically meaningful estimate (e.g., negative LAI) which generally occurs in non-vegetation pixels such as snow-cover regions or intermittent lakes. The solution to this issue could be using the latest version of GIMMS LAI4g and properly handling the fill value in the analysis. The use of 65535 as the fill value has been stated in the data repository as well as the Readme file. However, we now include it in the manuscript.

The following changes are made in the revised manuscript:

- Data availability:

"Before applying the GIMMS LAI4g product, we highly recommend users to read the Readme file in the repository and to properly handle the fill value and the quality control flag in the dataset." (Page 31, Lines 630-632)

- Acknowledgments:

"We also thank Dr. Jorge Luis Peña-Arancibia and Dr. Zaved Khan from CSIRO for bringing up issues in southeast Australia during the preprint posting of the manuscript." (Page 31, Line 649-650)

[Comment 2] *Alpine catchments in Australia generally have snow cover during the austral winter months (June to August). The example in Figure 1 showcases this issue for catchment ID 221201, located in the Alpine area, LAI values during the early 1990s seem unusually high.*

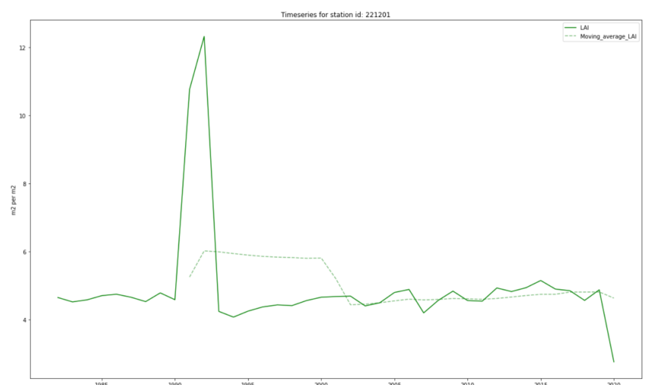


Figure 1 Annual-averaged Leaf Area Index from GIMMS LAI4g (green solid line, and green dashed line showing a 10-year moving average) LAI for catchment ID 221201. Note the high LAI catchment averaged values in the early 1990s.

[Response 2] As the BoM (2022) only provides a point location (149.200°E, 37.373°S) of Catchment 221201, we first manually delineate the boundary based on the map (Figure R1).

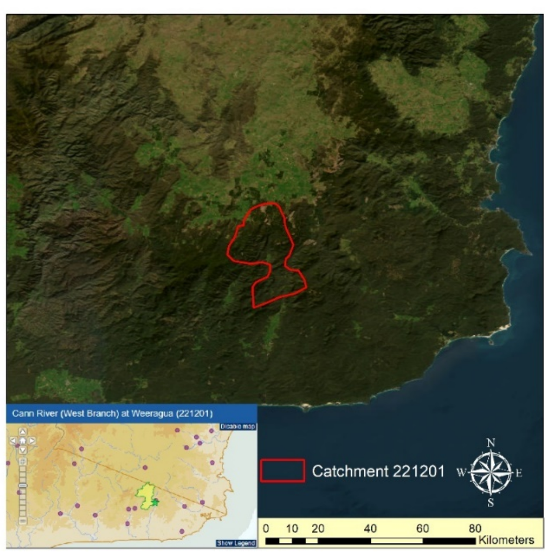
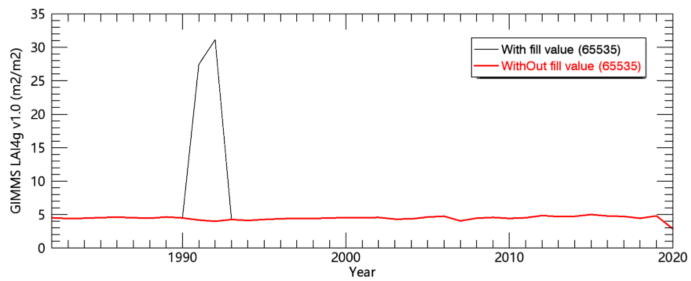
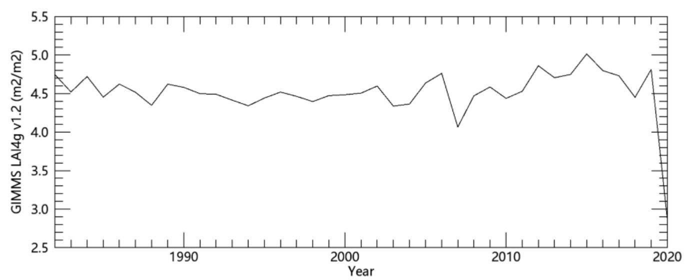


Figure R1. The location of Catchment 221201. The boundary of the catchment is manually delineated by the coordinate (149.200°E, 37.373°S) provided by BoM (2022), as seen in the subfigure of the left-bottom corner.

Despite the possible spatial mismatch, our delineation basically repeats the unusually high GIMMS LAI values for 1991 and 1992 in product version 1.0 (Figure R2a, the black line). However, when the fill value (65535) is ignored in the averaging operation, unusually high LAI values disappear (Figure R2a, the red line). The high values are not observed in the latest product version of 1.2 (Figure R2b). It should be noted that we used a substitute BPNN model in the latest GIMMS LAI4g product for winter for ENF, which has provided better LAI estimation.



(a)



(b)

Figure R2. Annual averaged LAI values from GIMMS LAI4g in the version of 1.0 (a) and 1.2 (b) in the Catchment 221201. In (a), averages were calculated from all values (black line) or values excluding the fill value of 65535 (red line).

In Figure R3, we showcase the existence of the fill value (65535) within Catchment 221201 in the first half of July 1991. Thus, we strongly recommend using the latest version of GIMMS LAI4g (v1.2) and properly processing the fill value in the analysis.

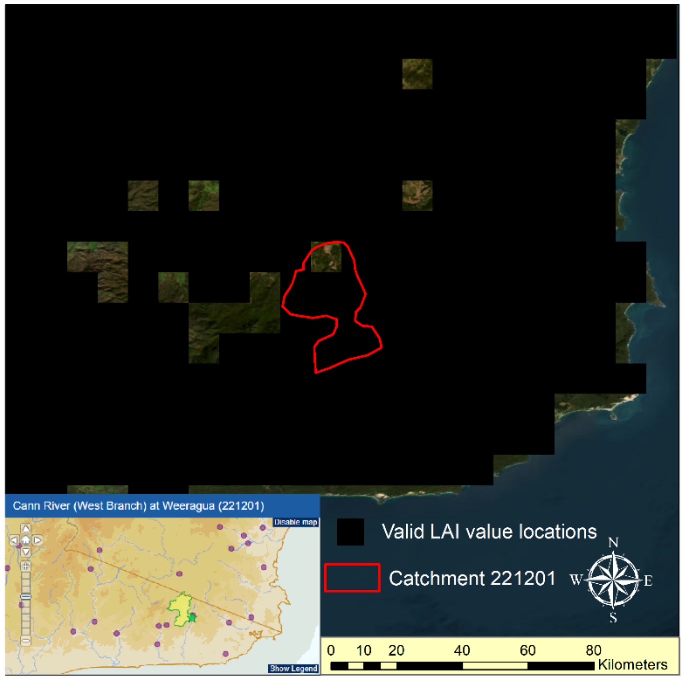


Figure R3. An example of the existent fill value (65535) within Catchment 221201 in July 1991.

[Comment 3] *The unusually high LAI values, averaged at the annual frequency are widespread and include intermittent lakes, see Figure 2 for 1992.*

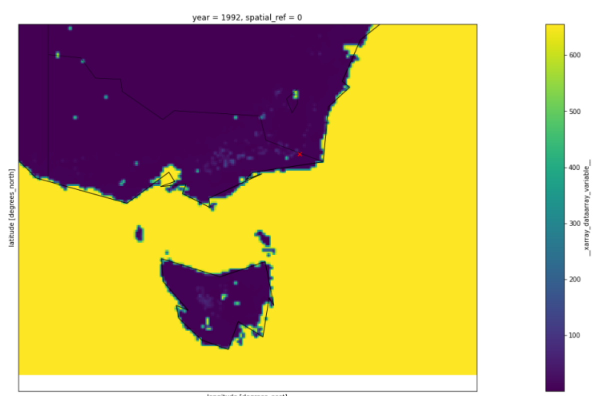


Figure 2 Annual-averaged pixel LAI for southeast Australia, the colour ramp units are in m^2/m^2.

[Response 3] For the abovementioned reason, unusually high LAI averages could exist whenever the algorithm could not retrieve a meaningful LAI estimate over a particular time or region (including intermittent lakes). This is not limited to the old version (v1.0) of GIMMS LAI4g but also to the latest version (v1.2). In terms of version 1.0, Figure R4 shows the annual-averaged LAI map for southeast Australia in 1992 before (a) and after (b) removing the fill value (65535). Unusually high LAI averages are marked by those > 7 m^2/m^2 (red), as 7 m^2/m^2 has been set as the LAI up limit in the GIMMS LAI4g. The black pixels beside the sea in Figure R4 mark permanent non-vegetation regions such as lakes.

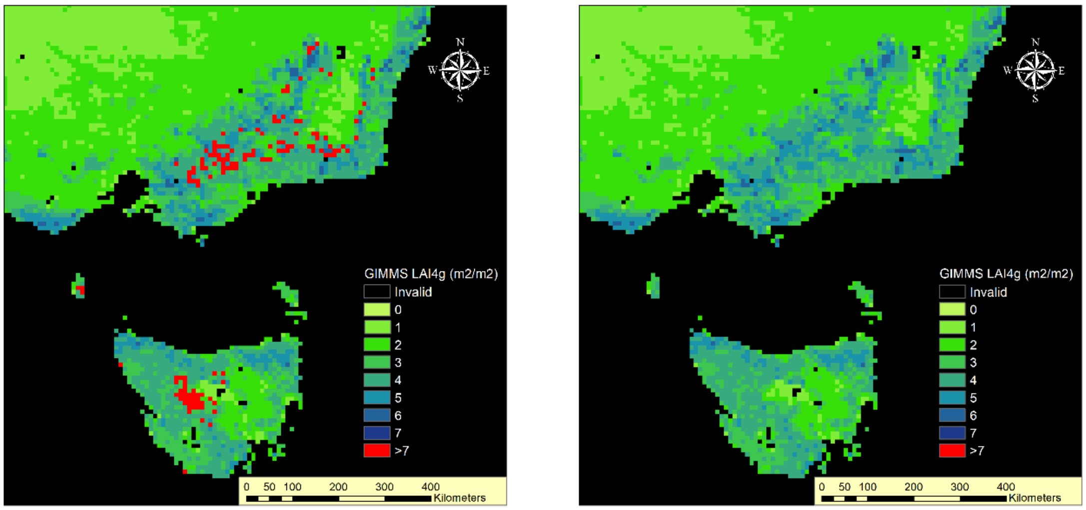


Figure R4. Annual-averaged LAI from GIMMS LAI4g (V1.0) for southeast Australia before (a) and after (b) removing the fill value (65535).

[Comment 4] *We further assessed this by obtaining average continental values during August (when snow cover is generally at its largest extent) of 1991 and 1992, and masking all pixels with LAI values >50, see Figure 3. Besides Alpine areas with snow cover, the unusually high values are evident in intermittent dry lakes as well.*

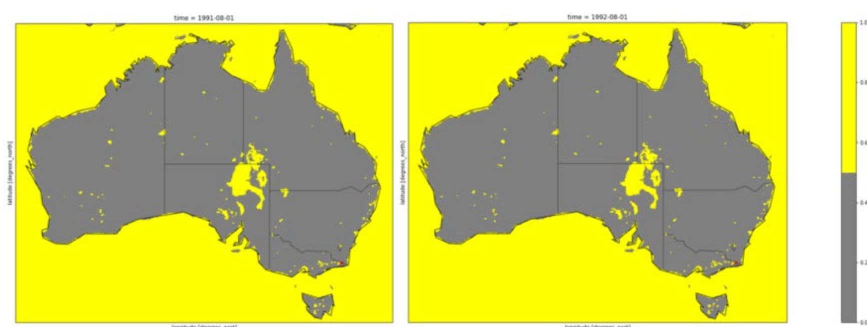


Figure 3 August-averaged pixel LAI for Australia, LAI values above 50 are shown in in yellow. Red dot in the southeast denotes a pixel used to assess the entire timeseries.

We picked one yellow-masked pixel in the Alpine area to assess this issue in years other than 1991 and 1992. Figure 4 suggest that the issue is not present in other years.

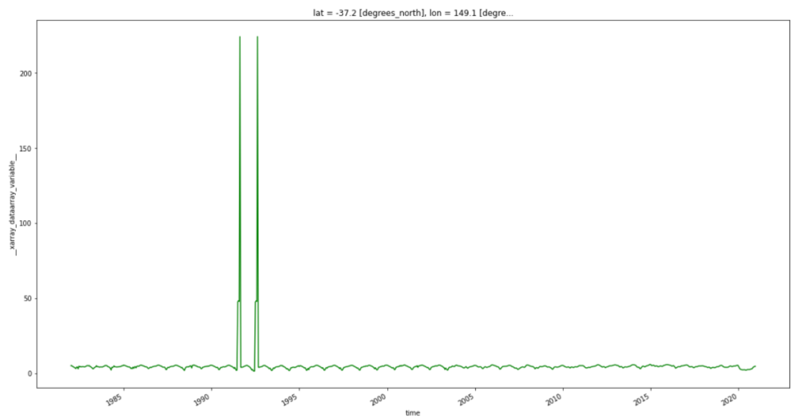
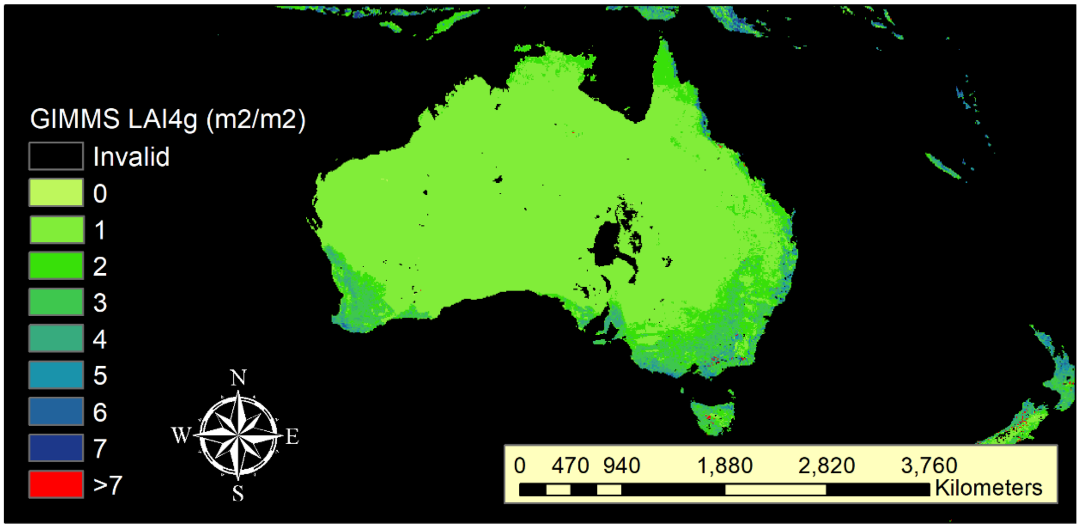


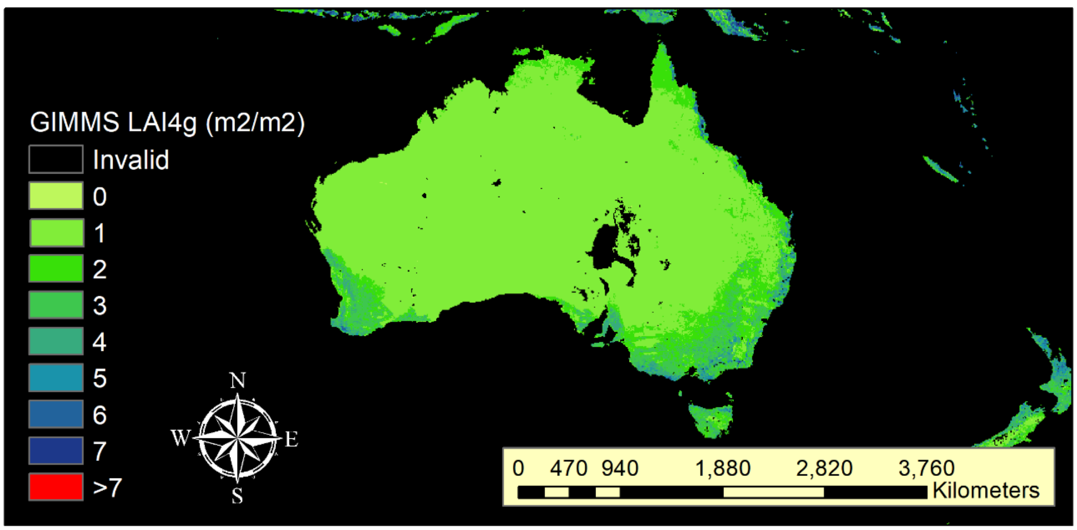
Figure 4 Monthly pixel LAI for red pixel in Figure 3, Y-axis units are in m^2/m^2.

The limited investigation of high LAI values in 1991 and 1992 suggest that this is limited to landscapes with high reflectance (snow, dry lake beds) and that filtering these values as for other years is a suitable solution.

[Response 4] We also map the LAI variation in August 1991 (GIMMS LAI4g version 1.0) for Australia (Figure R5). Similar to Figure R4, LAI values > 7 m^2/m^2 at vegetation locations are marked by red. Those unusually high LAI values are mainly distributed in southeast Australia (Figure R5a). They could be easily removed by excluding the fill value (65535) (Figure R5b). In August 1992, similar patterns were found (not shown here).



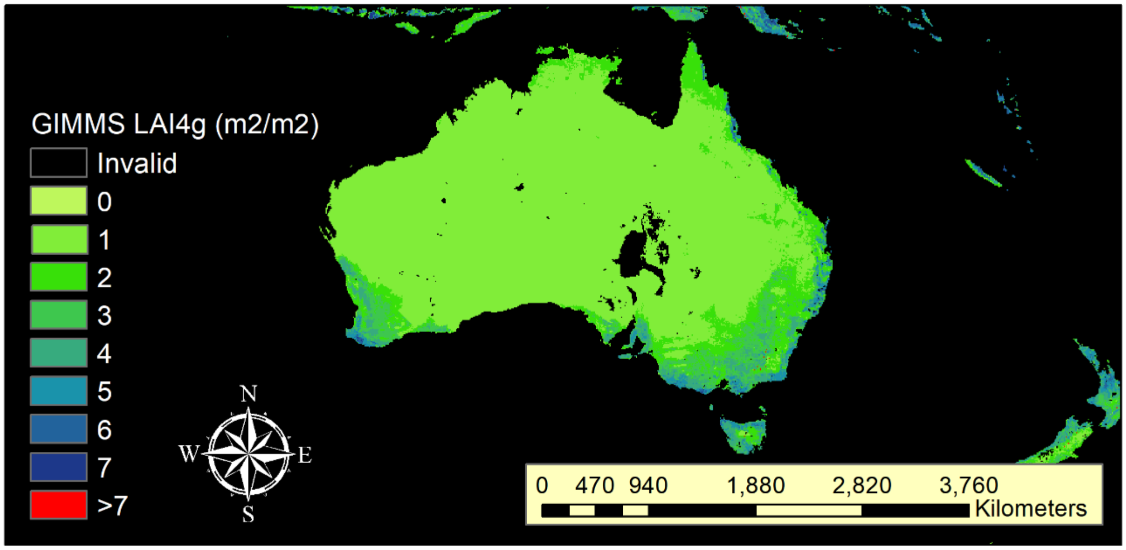
(a)



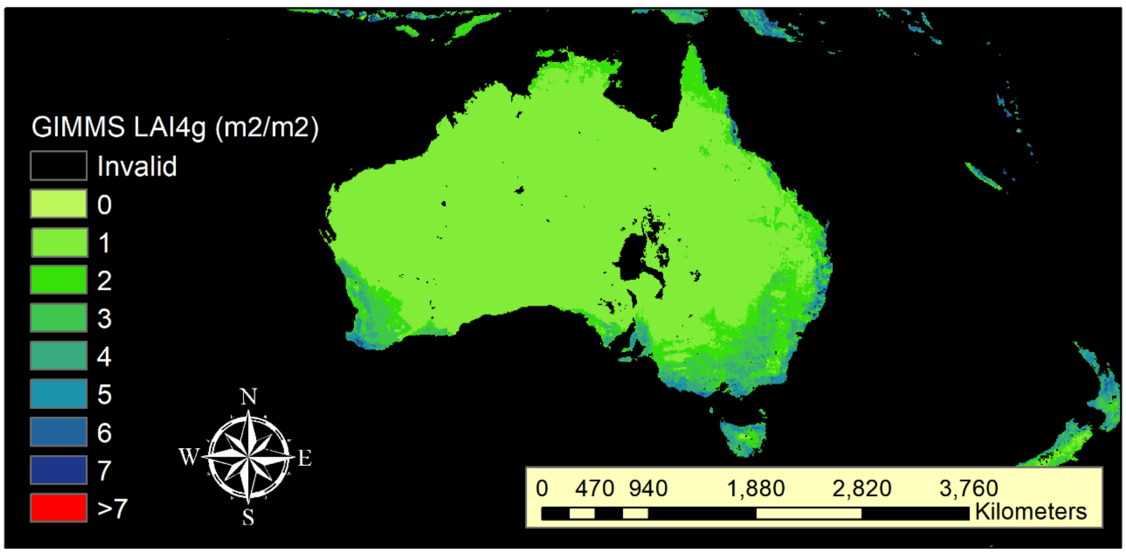
(b)

Figure R5. August-averaged LAI in 1991 from GIMMS LAI4g (V1.0) for Australia before (a) and after (b) removing the fill value (65535).

The unusually high LAI values are rare in the latest version of GIMMS LAI4g (v1.2), though still exist (Figure R6a), and they could also be removed (Figure R6b).



(a)



(b)

Figure R6. August-averaged LAI in 1991 from GIMMS LAI4g (V1.2) for Australia before (a) and after (b) removing the fill value (65535).

Although the unusually high LAI values were found primarily in 1991 and 1992 for the case of this report, they could exist in other regions and other years if the fill value (65535) is not properly processed. We hope the community can understand our rationale for replacing invalid LAI values with the fill value (65535), which has been a common practice in remote sensing-based data products (e.g., MODIS LAI). As suggested by the research team in CSIRO, we recommend other users to properly handle the fill value as well as the quality control flag in the data analysis.

References:

BoM, 2022. Hydrologic Reference Stations, Bureau of Meteorology. http://www.bom.gov.au/water/hrs/, last access: July 2022.