

Review of ESSD manuscript: *AguaTrack-ARCO-SA: A 30-year, high-resolution atmospheric moisture tracking dataset for South America*

Review summary

This manuscript presents a high-resolution atmospheric moisture-tracking dataset for South America based on WAM2layers v3 and ERA5. The combination of daily resolution, 0.25° spatial resolution, individual receptor-grid tracking, and an ARCO/Zarr data structure has clear potential for a range of hydroclimatic applications. The manuscript is generally well structured and written, and provides several useful examples of how the dataset can be used.

My main comments concern the interpretation and documentation of the diagnostic gains and losses variables and how they deal with the completeness of the tracking domain, the terminology around moisture recycling, and the treatment of uncertainties related to the ERA5 forcing. I also have several more specific suggestions regarding clarity, terminology, and presentation.

General comments

1. Insufficient description of the gains and losses variables, and missing diagnostic of spatial source completeness

The manuscript introduces four output variables in Table 2, but the descriptions of gains (“Moisture gained during the tracking”) and losses are too vague and risk to be misunderstood by users. The physical meaning of these variables is central to correctly interpreting the dataset, yet it receives only a single sentence of explanation in the Limitations section (Sect. 4.3, L310-311) and is not discussed at all in the Methods or Results sections.

My understanding from lines 308–315 is that, in backward WAM2layers tracking, the tagged precipitation at a sink is partitioned into moisture attributed to evaporation within the tracking domain, moisture entering through the domain boundaries, and a small residual or numerical loss. If so, the moisture budget may conceptually resemble

$\text{tagged_precip} \approx \sum e_track$ (summed over all in-domain source cells) + gains + small numerical residual

although the manuscript does not currently make this explicit.

If I understand the framework correctly, e_track represents the portion of tagged precipitation that can be attributed to evaporation from a specific grid cell *within* the tracking domain, whereas gains seems to represent the portion whose moisture crossed

the domain boundary during backward tracking. In the forward sense, this would correspond to moisture entering the South American tracking domain from outside its boundaries, for example from more distant parts of the Pacific or Atlantic Oceans or from north of 15°N. In that case, the total amount of externally sourced moisture would still be recorded, but its precise geographic source outside the model domain would no longer be recoverable.

This distinction is important because users may otherwise interpret `e_track` as a complete spatial attribution of all precipitation sources. I therefore recommend adding a dedicated paragraph to the Methods or Sect. 3.1 that explicitly explains how `tagged_precip`, `e_track`, gains, and losses relate to one another and how the moisture budget closes.

A second issue is that the practical importance of this limitation is not shown. It would be very useful to include a map, perhaps in the Supplement, showing the fraction of tagged precipitation that can be attributed to evaporation within the tracking domain, for example

$$\sum \frac{e_{track}}{tagged_precip}$$

or an equivalent diagnostic based on the model budget. This would immediately show where the dataset provides nearly complete spatial source attribution and where a substantial fraction of the precipitation source lies outside the domain.

Such a map would immediately convey to users where the dataset provides complete spatial attribution of moisture sources (interior Amazon, where most precipitation is recycled from in-domain terrestrial evaporation) versus where the dataset is inherently limited (coastal regions and countries like Chile, where a large fraction of precipitation originates from oceanic sources outside the domain and falls into gains). Without such a diagnostic, users have little practical basis for assessing how complete the spatial source attribution is for their region of interest. The current Limitations section explains the issue conceptually, but does not show its magnitude spatially.

2. Terminology around moisture recycling

The use of “moisture recycling” could be made more precise throughout the manuscript. In the literature, precipitation recycling and evaporation recycling are generally distinguished: precipitation recycling describes the fraction of precipitation originating from terrestrial evaporation, whereas evaporation recycling describes the fraction of terrestrial evaporation that later precipitates over land or within a specified region.

For example, at line 19 the manuscript defines continental moisture recycling as “*a continuous process by which terrestrial evapotranspiration returns to the Earth’s surface as downwind precipitation.*” This wording mixes the general concept of atmospheric moisture transport with a specific recycling metric. I suggest using more explicit terminology where possible, particularly when a precipitation-recycling quantity is actually meant.

Similarly, around line 203, “*terrestrial moisture recycling*” appears to refer specifically to the terrestrial contribution to precipitation and could therefore be described more precisely as terrestrial precipitation recycling.

The first sentence of the Abstract could also be reconsidered:

“Atmospheric moisture recycling is a key component of the hydrological cycle, linking evapotranspiration to downwind precipitation.”

The link between evapotranspiration and downwind precipitation is certainly central to the hydrological cycle, but not all downwind moisture transport is necessarily “recycling” in the stricter sense. A more general formulation around atmospheric moisture transport or source–sink connectivity may be clearer here.

3. ERA5 uncertainty and bias discussion should be expanded

The authors briefly mention that ERA5 may “*struggle to accurately resolve localized convective precipitation or extreme topographic uplift*” (Section 4.3, L298). However, ERA5 is known to have documented biases over the Amazon (overestimation of low-level convergence), over the Andes (orographic precipitation), and in the ITCZ region. These biases propagate directly into the moisture tracking. Specific references to ERA5 evaluation studies over South America are needed here and a sentence on motivation why ERA5.

Specific comments

L5: The dataset ends in 2019, leaving a 7-year gap to the present. Is there a technical reason for this, and are the authors planning to extend the dataset to more recent years? It would be useful to mention this briefly.

L9-10: The phrase “*alongside diagnostic variables for moisture gains, losses, and tagged precipitation*” is somewhat unclear because the physical meaning of these diagnostics has not yet been introduced.

L18-19 : The phrasing “*A primary behaviour of this coupling is continental moisture recycling*” reads a bit strange. Coupling is a relationship between systems, not an agent

that exhibits behaviour. The authors likely mean that continental moisture recycling is one of the primary mechanisms through which land-atmosphere coupling operates(?). I would suggest to rephrase

L25: When precipitationsheds are introduced, this is a natural place to clarify that the dataset is based on backward tracking and therefore identifies the evaporation sources of precipitation. It may also be useful to briefly acknowledge the complementary forward-tracking perspective, which addresses where evaporation subsequently precipitates.

L53-55: *“This transcontinental transport drives a remote moisture recycling effect”* reads somewhat awkwardly. I suggest avoiding “recycling” here and instead referring to remote atmospheric moisture connections or source–sink linkages.

L61: The discussion of existing datasets focuses mainly on Eulerian products. Several Lagrangian moisture-tracking datasets are also available and would be worth mentioning. The statement that existing products are constrained by fixed coarse spatial grids also does not apply in the same way to many Lagrangian approaches, so this distinction should be clearer.

L132-133: The description of the 30-day “prewarming” period is unclear. My understanding is that the model actually tracks backward for 30 days for each target period, rather than this being a conventional model spin-up. If that is correct, I suggest using terminology such as “30-day backward tracking window” or “30-day traceback period,” which would be more intuitive.

The manuscript states that this duration is sufficient to attribute more than 95% of tagged precipitation to its evaporative sources. It would be helpful to explain more clearly why 30 days was selected relative to the typical atmospheric moisture residence time.

Also, for January 1990, does the backward tracking use ERA5 forcing from December 1989? If so, this should be stated explicitly. If not, the first month of the dataset may have a shorter effective tracking window.

L165-166: *“Because Eulerian tracking requires strict numerical stability, supplementary debug files are provided in NetCDF (.nc) format.”*

has an unnecessary causal structure. The debug files are presumably provided to allow users to verify numerical stability, not because stability itself requires the files. Suggested rewrite:

“To enable users to verify tracking stability, supplementary debug files are provided in NetCDF (.nc) format.”

L220: “*Stark differences*” seems somewhat stronger than what is visible in Fig. 2. The higher-resolution dataset clearly produces a sharper boundary near the Andes, but the coarser product also shows relatively little moisture contribution west of the mountains. I suggest a more neutral wording.

Table 1 & Sect 3.4: Some countries (e.g. French Guiana, Guyana, Suriname) have a much lower TES value than WAM2layers v2, do you have any explanation for this?

Additionally, differences relative to the 3D QIBT reflect *both* resolution and methodology, yet the authors attribute all differences primarily to resolution. This interpretation should be presented more cautiously, with explicit acknowledgement that methodology is a confounding factor.

Fig. 1 and Table 3: These contain closely related information. Could they be integrated more directly, or could the text make their relationship clearer? At present they feel somewhat separated despite addressing the same comparison.

Fig. 2: The figure is described as a “*continental precipitation shed*,” so this is the precipitation coming from continental sources only? So the total cumulative contribution of 100% is only the part coming from land, right? It’s a bit unclear to me why ocean sources are excluded.

Fig. 5a: Consider using rounder values or a simpler set of ticks on the colourbar. The current values are somewhat difficult to interpret quickly.

Small question on loading the dataset: on

<https://huggingface.co/datasets/AguaTrack/AguaTrack-ARCO-SA> the following line didn’t work for me

```
store = fs.get_mapper("datasets/AguaTrack/AguaTrack-ARCO-SA/1996.zarr")
```

This line seemed to work:

```
store = fs.get_mapper("datasets/AguaTrack/AguaTrack-ARCO-SA/AguaTrack_ARCO_SA_daily/1996.zarr")
```

This could be updated

Technical comments

L8: “*providing detailed source–sink relationships at department to continental scales*” → “from departmental to continental scales”

“Department” alone does not work as an adjective here.

L18: Use an en dash: “land–atmosphere” rather than “land-atmosphere.” (similar L210 land–sea)

L24: Consider citing this moisture-tracking intercomparison paper here, particularly because the next sentence discusses moisture-tracking approaches more generally.

Benedict, I., Keune, J., Weijenborg, C., van der Ent, R., Kalverla, P., Koren, G., ... & Xu, R. (2026). Identification of Sources of Precipitation through an International Research Effort (INSPIRE): three extreme precipitation case studies. *Bulletin of the American Meteorological Society*, BAMS-D.

L29: In “*a deeply interconnected continental atmospheric network*” I suggest removing “*continental*” because the atmospheric moisture network clearly extends over the adjacent oceans as well.

L145: “*While treating ~25,000 grids as independent receptors*” → “grid cells” (more precise and consistent with usage elsewhere in the paper).

L141–142: The terminology switches from “sink” to “receptor.” I suggest using one term consistently unless there is a specific conceptual distinction between them.

Line 195/206: “3DQIBT” and “3D QIBT” are both used. Please choose one format and use it consistently throughout.

Fig 6 caption: “São Paulo”