Supporting information for "Constraining and Characterizing the size of Atmospheric Rivers: A perspective independent from the detection algorithm".

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Introduction

In Text S1 to S2 and Figures S1 to S3, we present the sensitivity analysis of three of our AR size estimation methods: Statistical Overlapping of IVT With the Background Field PDF (SO), K-S Statistics Between AR Composite and the Background CDF (KS), and Lagrangian tracers method (LT).

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For reference, Table S1 shows the labels in Figure 1 from the main text to the respective ARTMIP detection and tracking algorithm used to calculate the AR areas.

Text S1. Sensitivity analysis: BG and SO methods.

We calculate a sensitivity test for the Statistical overlapping of AR composite conditional probability distribution of IVT given the distance to the AR center and the PDF of the background IVT field (SO), and the comparison of the IVT cumulative distribution function (CDF) of AR composite with the CDF of the background IVT field (BG) method.

For the SO method, we vary the overlapping PDF intersection value to define the AR composite size: the background IVT PDF value σ^- from 0.05 to 0.5, and the conditional probability distribution (CPD) value of the AR IVT composite σ^+ from 0.95 to 0.5. The values used to calculate the results shown in the main text are σ^-=0.16 and σ^+=0.84.

For the BG method, we test the sensitivity of the one-tailed Kolmogorov–Smirnov test by varying the p-value used to estimate the size of the AR composite, from $p = 0.80$ to $p = 0.99$.

Figures S1(a-b) and S1(c-d) show the results of these sensitivity tests for the Northwest (WP) and Northeast Pacific (EP) ARs at 50% life cycle. Similar results 25% and 75% of the AR life cycle.

It is important to notice that the dependence on the free parameters for the SO and BG methods is as expected. SO dimensions and areas should increase as σ^- decreases and σ^+ increases (so the AR becomes “indistinguishable ” from the background). This is shown in Figure S1(a-b). Moreover, in the BG method areas should decrease as p increases (a more stringent condition), as Figure S1(c-d) shows.

Text S2. Lagrangian tracers method (LT) sensitivity analysis

We explore the sensitivity the LT method to the stochastic component and the scaling of the horizontal-velocity used for the velocity used for tracer advection. We calculate the trajectory of the tracers using a modification of Equation (10) from the main text of this work

$$dx_i = (u_i + \alpha\sqrt{2}\overline{u}_i\, w_i)\, dt, \tag{1}$$

where we use the parameter α to modify the magnitude of the scaling velocity, from 1/8 times $\sqrt{2}\overline{u}_i$ to 4 times $\sqrt{2}\overline{u}_i$ ($\alpha = 1$ represents the value used to calculate the results shown in the main text of this work).

Additionally, we vary the PDF threshold value used to define the AR area from $p = 0.4$ to $p = 0.93$, where $p = 0.68$ represents the value used to estimate the AR area for the results of this work.

Figure S2 shows the sensitivity test results for WP and EP AR composites at 50% life cycle. Similar results 25% and 75% of the AR life cycle.

Results for the LT sensitivity test are as expected. Increasing p should decrease the area for a given value of alpha, as shown in Figure S2. The increase in area for a given p value is certainly plausible – in the limit of $\alpha \to \infty$, the sample points from the AR should insteadly spread over the whole globe after the first time step, thereby maximizing the area.

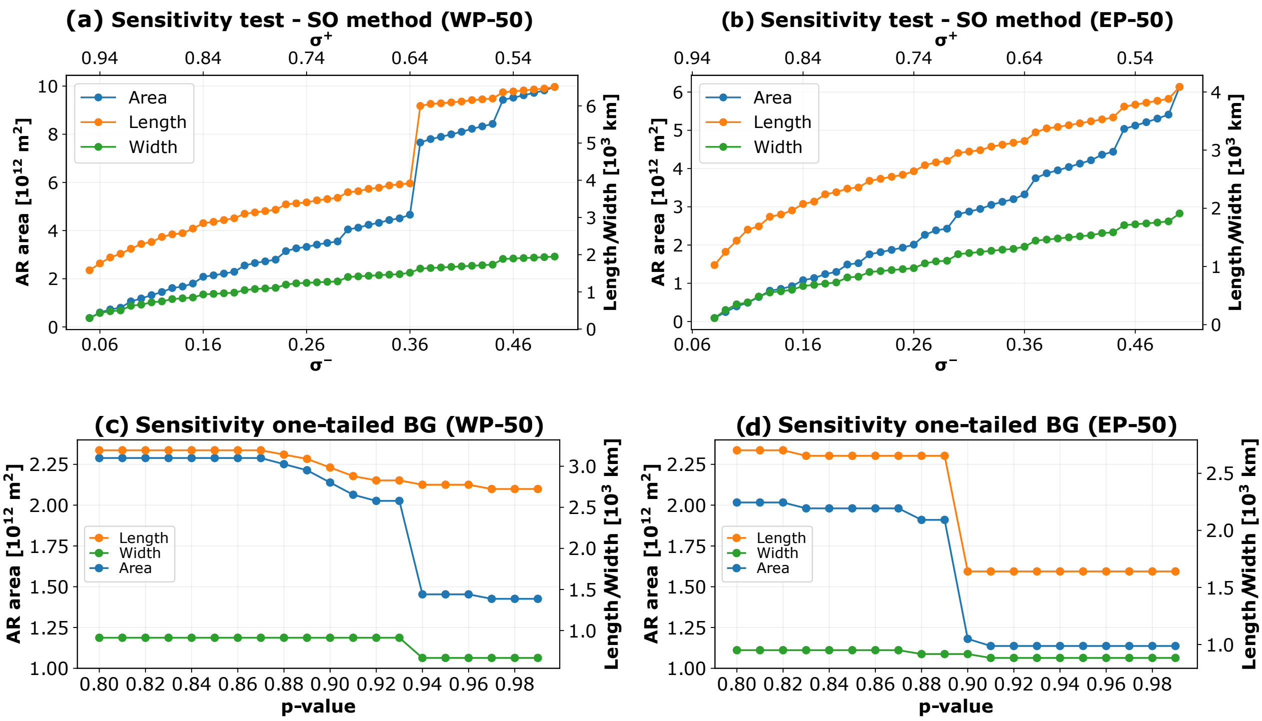

Figure S1. WP (a) and EP (b) sensitivity background for the one-tailed KS-test method (BG). AR area is shown in blue (left vertical axis). AR length and width are shown in orange and green, respectively (right vertical axis). p is the statistical significance level for the one-tailed KS-test. The results presented in the main text of this work are generated using $p = 0.95$. WP (c) and EP (d) sensitivity test for the statistical overlapping method (SO). σ^- and σ^+, are the PDF value of the IVT background and the CPD value of the IVT composite with distance, respectively. AR area is shown in blue (left vertical axis). AR length and width are shown in orange and green, respectively (right vertical axis). The results presented in the main text of this work are generated using $\sigma^- = 0.16$ and $\sigma^+ = 0.84$.

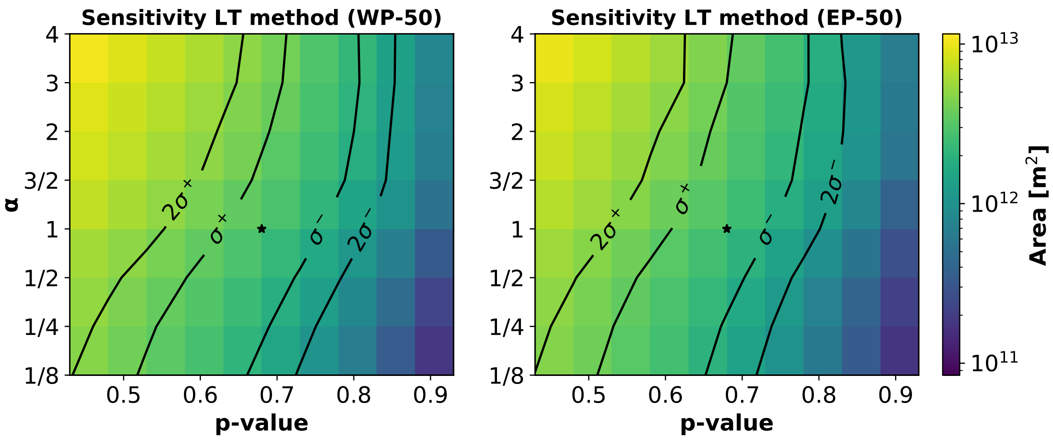

Figure S2. Sensitivity test for the Lagrangian tracers method (LT). Colored contours show AR area, α is the multiplication factor of the scaling velocity $\sqrt{2\overline{u}_i}$ from equation (1), and p-value is the final tracer position PDF value at which we define the AR size. Black contours represent -2, -1, 1, and 2 standard deviations of the AR area calculated using the LT method (from main text Figure 1). The black star represents $\alpha = 1.0$ and $p = 0.68$, which are the values used to calculate the main work results.

Table S1. List of ARTMIP algorithms used to generate Figure 1.

Label	Algorithm name
01	Lavers
02	PNNL_AR_detection_ALG#2_v1
03	wille_IWV
04	Brands_v3
05	Tempest_T2CNTL
06	CASCADE_IVT
07	tempest_ivt250
08	tempest_ivt700
09	tempest_ivt500
10	CASCADE_IWV
11	Payne_Magnusdottir
12	wille_vIVT
13	Gershunovetal2017_v1
14	PNNL_AR_detection_ALG#1_v1
15	Reid500
16	Mundhenk_v3
17	Guan_Waliser_v2
18	TDA_ML
19	Walton_v1
20	SAIL_v1
21	Rutz
22	Lora_v2
23	Reid250
24	PanLu
25	Viale_SAmerica
26	Goldenson_v1-1
27	cascade_bard_v1
28	ARCONNECT