

INTRODUCTION

Does global warming affect the hydrological cycle?

1 Clausius–Clapeyron

The atmosphere holds ~7% more water vapor for every °C of warming (at constant relative humidity).

2 Global intensification

An increase in the frequency and intensity of extreme events was observed.

3 Regional heterogeneity

The rol of atmospheric dynamics

OBJECTIVE

To analyze the changes and trends in the atmospheric hydrological cycle and its components over South America (1980–2025).

DATA AND METHODS

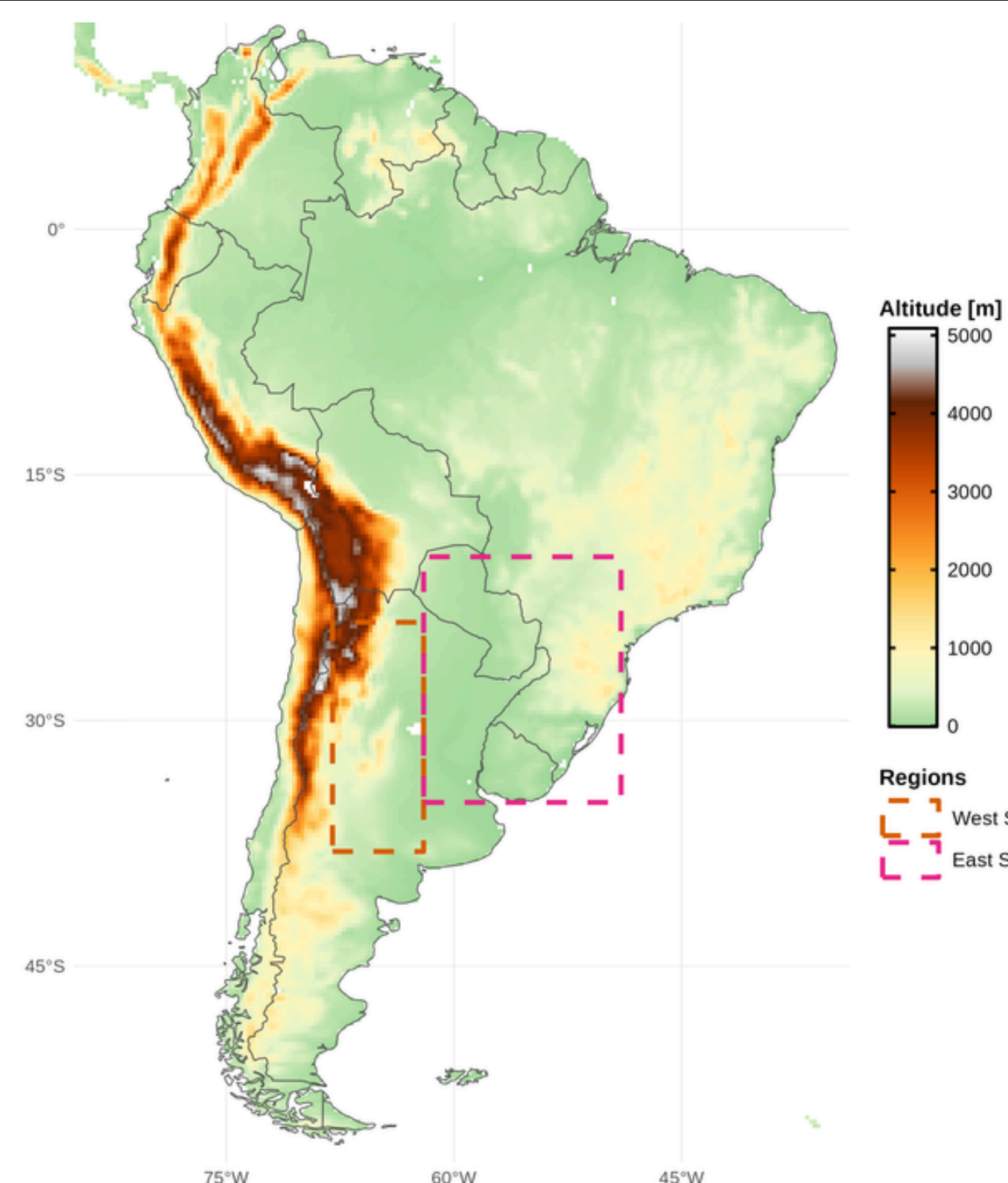
Atmospheric branch of the hydrological cycle

$$\frac{\partial W}{\partial t} = ET - P - VIMD \quad (\text{long time scales})$$

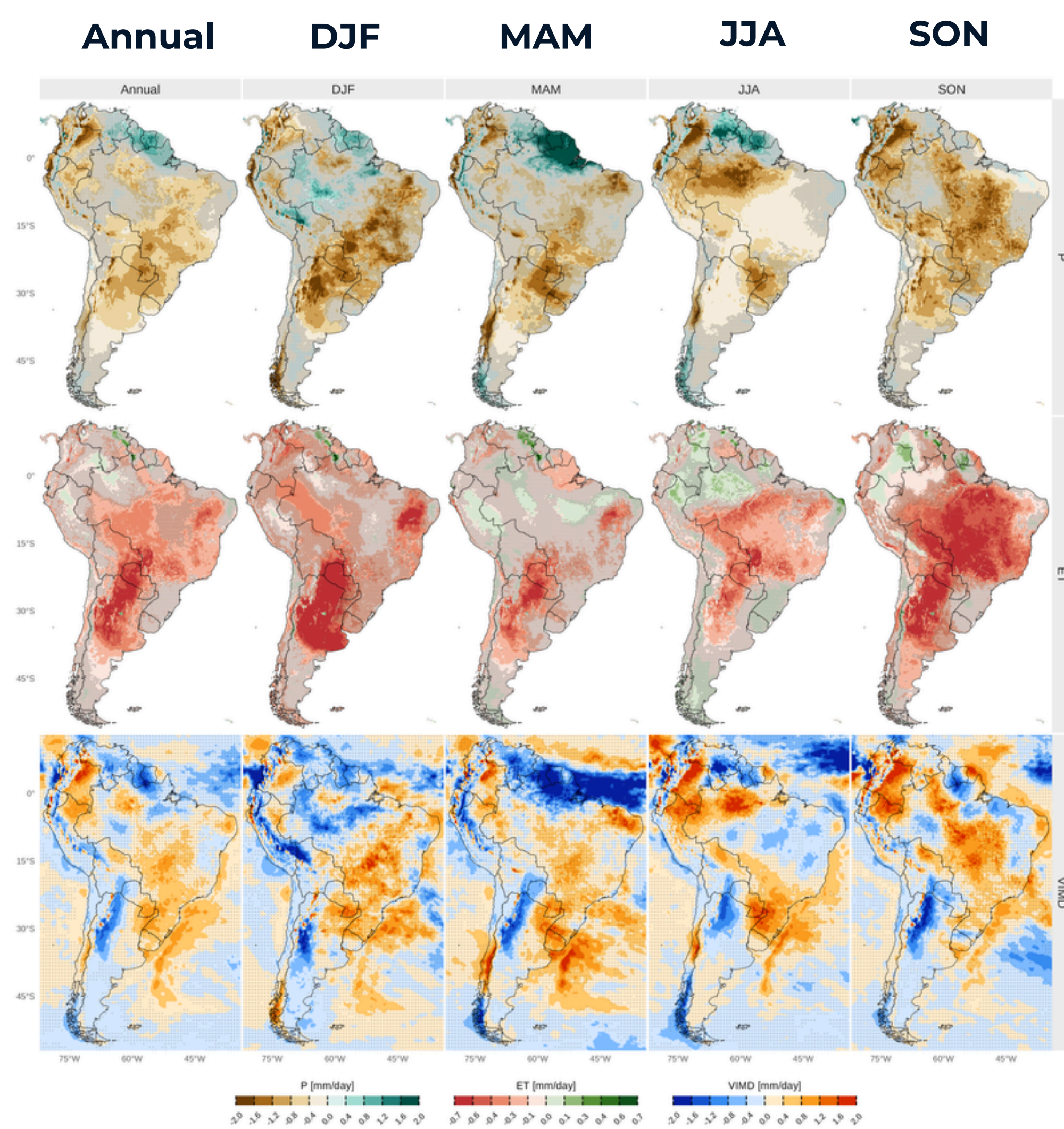
$$P = ET - VIMD$$

- Data from ERA5-Land (precipitation and evapotranspiration) and ERA5 (vertically integrated moisture divergence flux).
- Annual and seasonal mean changes (2003–2025 vs. 1980–2002; Mann–Whitney test) and Theil–Sen linear trends (Mann–Kendall test), evaluated at $p < 0.1$.

SOUTH AMERICAN DOMAIN AND SUBREGIONS (SESA WEST AND EAST)

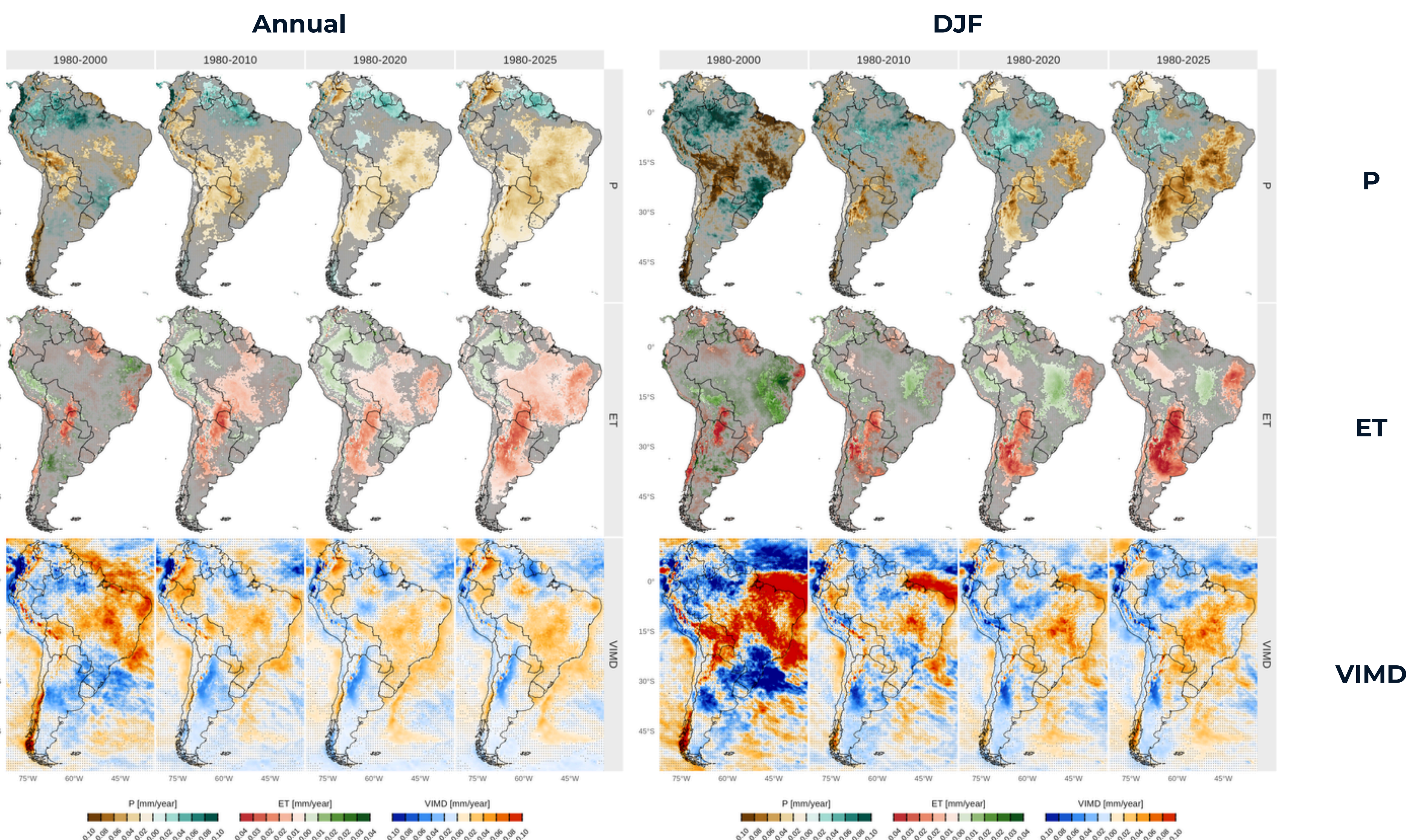


CHANGES



Non-significant trends are hatched.

LINEAR TRENDS

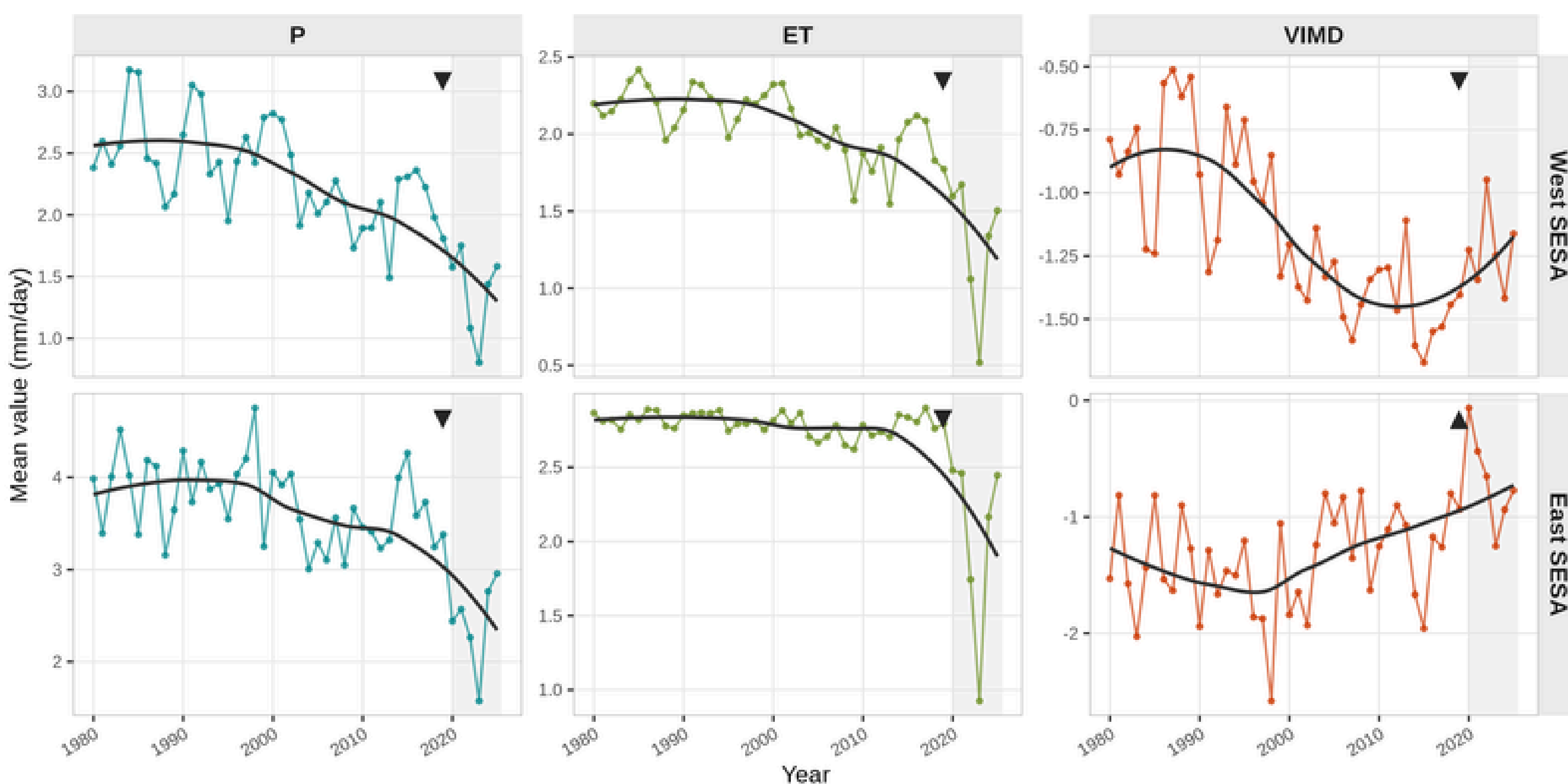


The December–January–February (DJF) and September–October–November (SON) periods best reflect both annual changes and overall trends (not shown).

WHAT HAPPENED IN THE SESA REGIONS? (ANNUAL)

Time series by region, with LOESS-fitted curves. Significant trends are marked with triangles pointing up (positive) or down (negative).

We observe a decreasing trend in both P and ET time series across both regions, with marked drying in the post-2020 years, where VIMD aligned with values associated with stronger moisture divergence.



CONCLUSIONS

- Inclusion of the recent period:** post-2020 dry conditions strongly influence the calculation of trends across a large part of South America.
- Precipitation and evapotranspiration:** consistent spatial patterns between P and ET, particularly in DJF and SON.
- Moisture flux divergence:** VIMD changes and trends generally coincided with regions of lower precipitation, suggesting a role for atmospheric dynamics.

BIBLIOGRAPHY

- Huntington, T.G. 2010. Climate warming-induced intensification of the hydrologic cycle: an assessment of the published record and potential impacts on agriculture. En: Sparks, D.L. (Ed.). Advances in Agronomy. Elsevier. Amsterdam, Netherlands. 1–53 pp.
- Llopart, M.; Domingues, L.M.; Chou, S.C.; da Rocha, R.P.; Reboita, M.S.; Cuadra, S.V.; et al. 2021. Assessing changes in the atmospheric water budget as drivers for precipitation change over two CORDEX-CORE domains. Climate Dynamics 57(5): 1615–1628.
- Skirris, N.; Zika, J.D.; Nurser, A.J.G.; Josey, S.A.; Marsh, R. 2016. Global water cycle amplifying at less than the Clausius–Clapeyron rate. Scientific Reports 6(1): 38752.
- Tsonis, A.A. 2002. An Introduction to Atmospheric Thermodynamics. Cambridge University Press. Cambridge, United Kingdom. 336 p.

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