EGU
April 2025
Vienna, Austria

Revisiting global oceanic and terrestrial moisture sources based on state-of-the-art Lagrangian transport simulations

Victoria M. H. Deman, Damián Insua-Costa, Diego G. Miralles

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H-CEL / Hydro-Climate Extremes Lab · Ghent University

GHENT UNIVERSITY

Objective

Method

Results

1. Dataset construction

Lagrangian transport model **FLEXPART v11**

(Bakels et al, 2024)

Mode	Forward
Domain	Global
Temporal resolution	3 hourly
# particles	20 million
# vertical levels	90
Period	1979–2024
Input data	ERA5 0.5°
Output format	NetCDF

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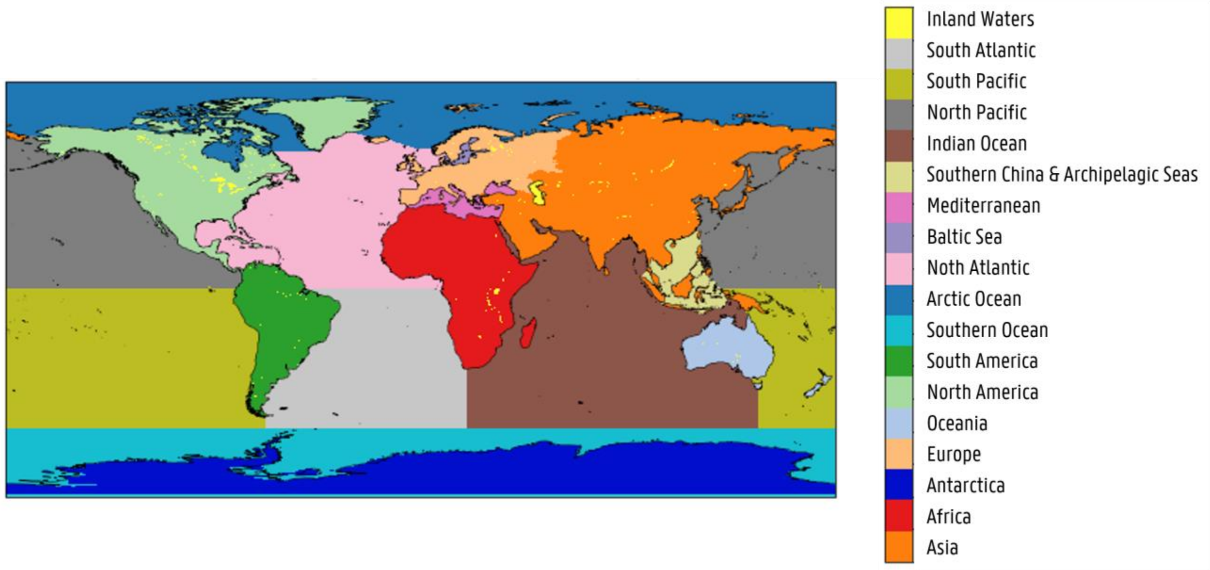
2. Split world in oceanic and terrestrial regions



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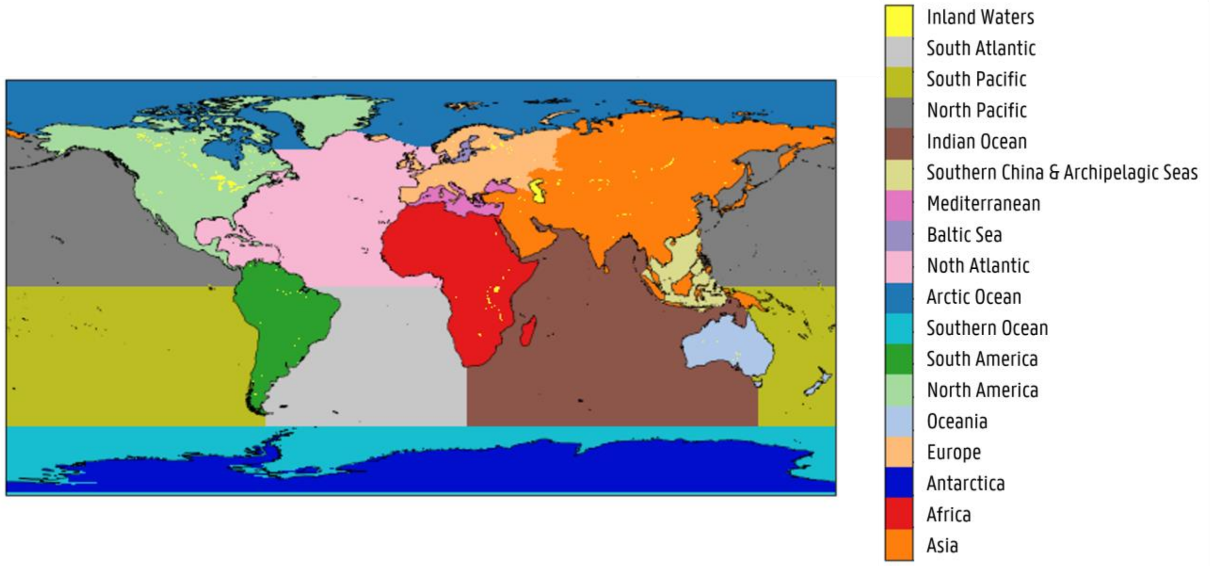

3. Determination of source–receptor relationships

Moisture tracking model **HAMSTER** (Keune et al, 2022)

- MPI parallelization
  => 6x faster + 6x less resources
- Bias correction en-route
- 30 backtracking days
- Bias corrected with ERA5

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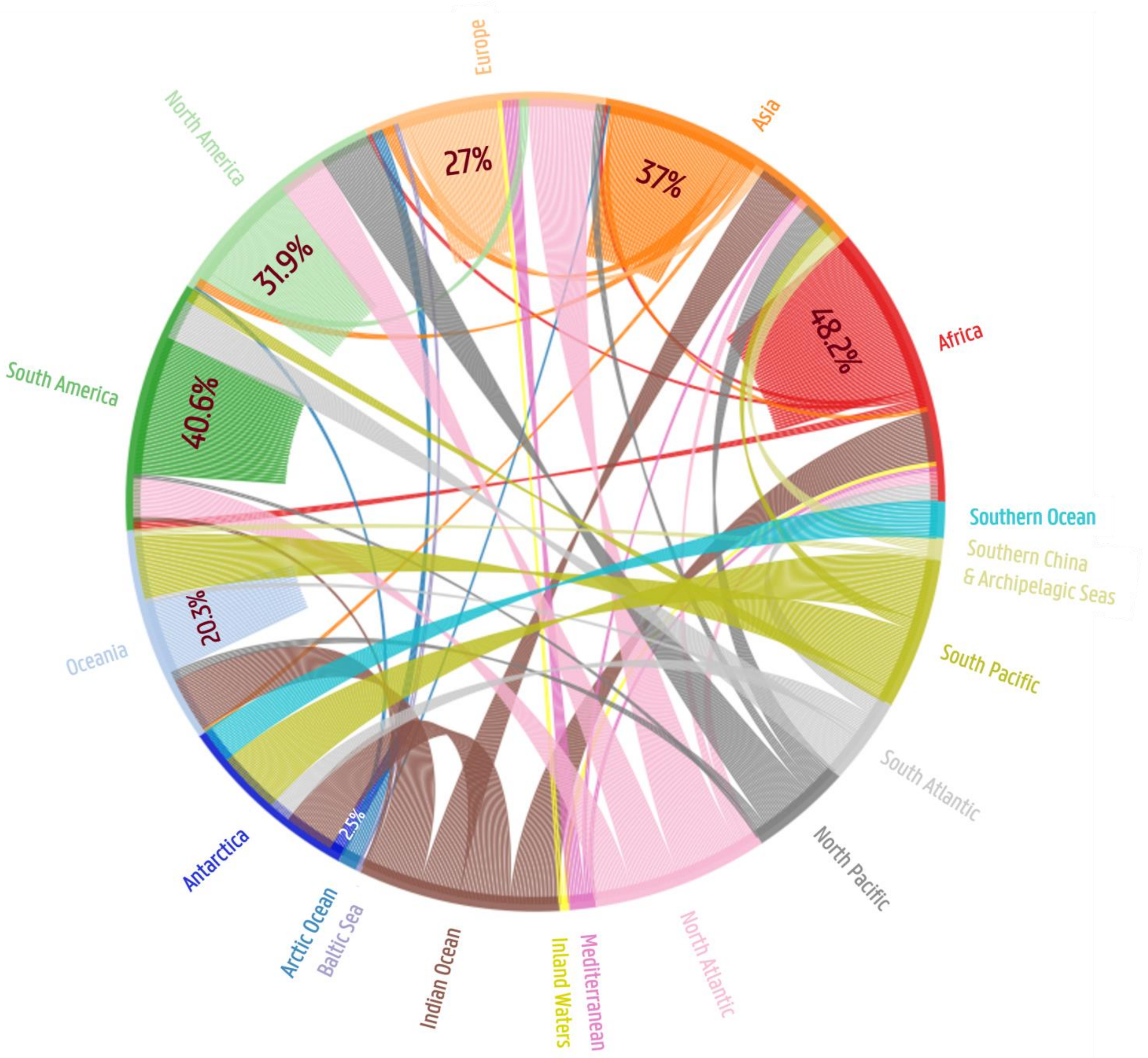

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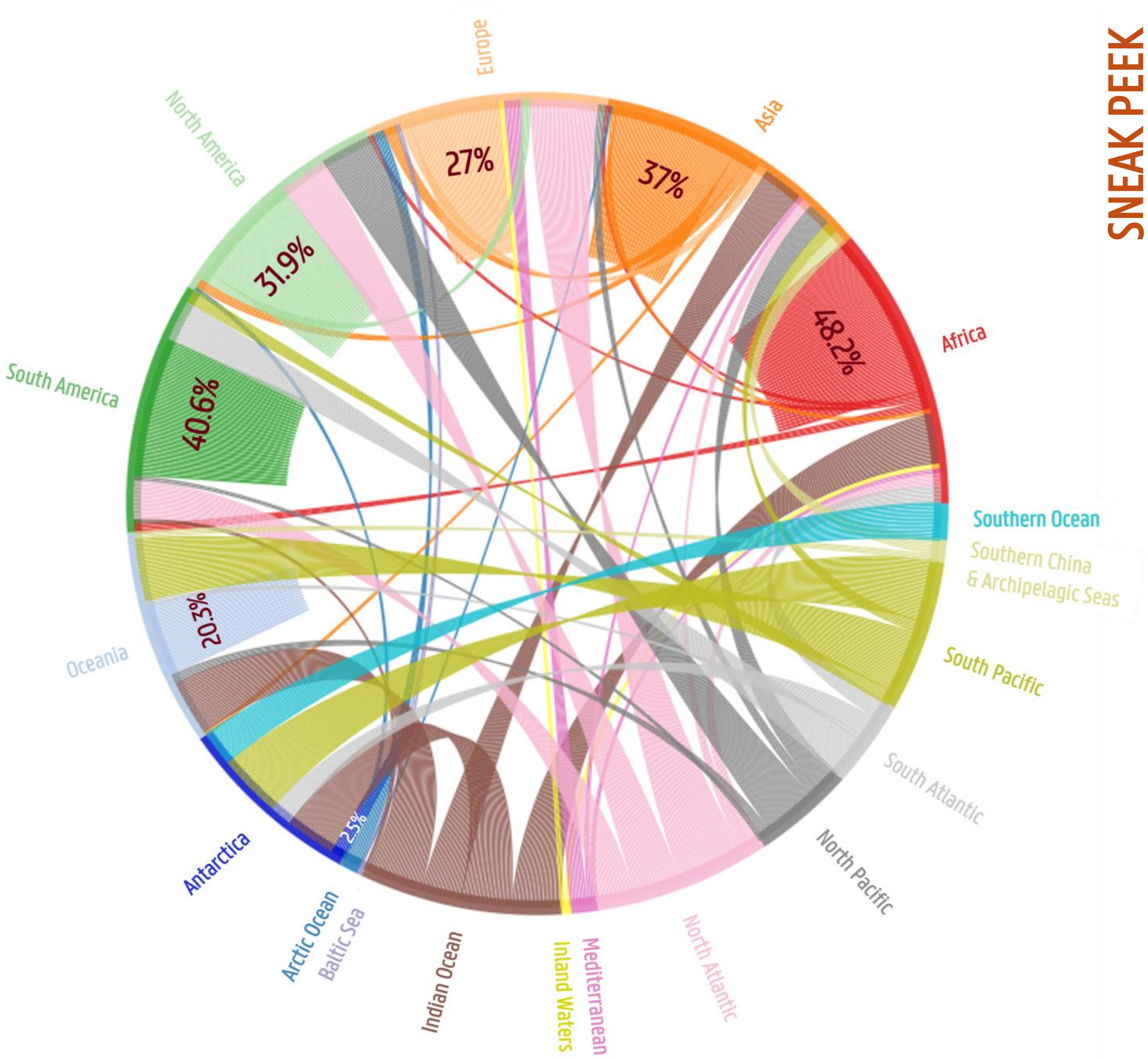
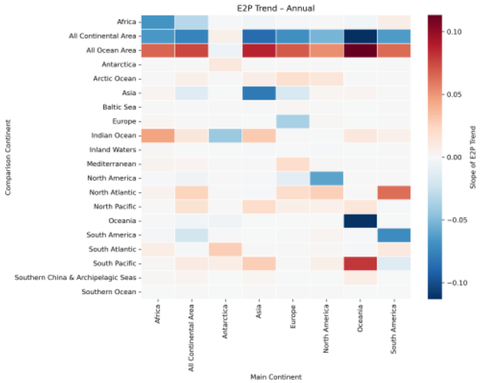
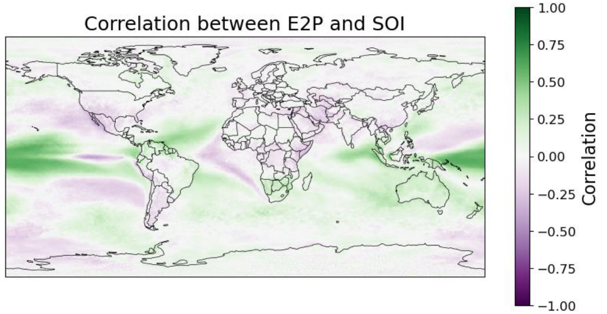


SNEAK PEEK

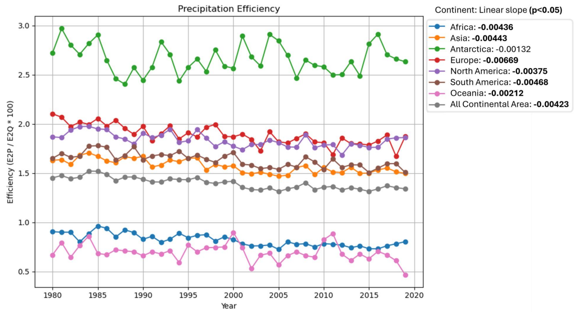
E2P Trends



Relation with El Niño/La Niña



Precipitation efficiency



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Method

- [Dataset construction]
- [Region definitions]
- [Source–receptor relationships]

Conclusion

Motivation

Results

- Climatology
- Time evolution
- Relation with SOI
- Trends
- Precipitation efficiency

Supplementary

- S1: Figures
- S2: References

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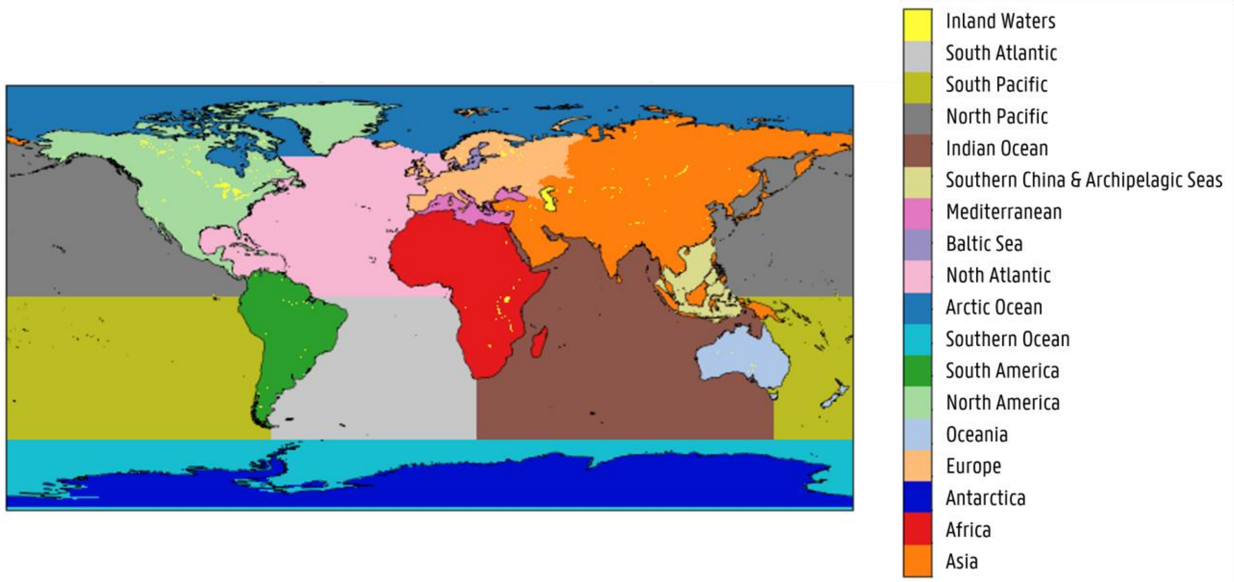

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3. Determination of source–receptor relationships

HAMSTER (Heat And MoiSture Tracking framework)

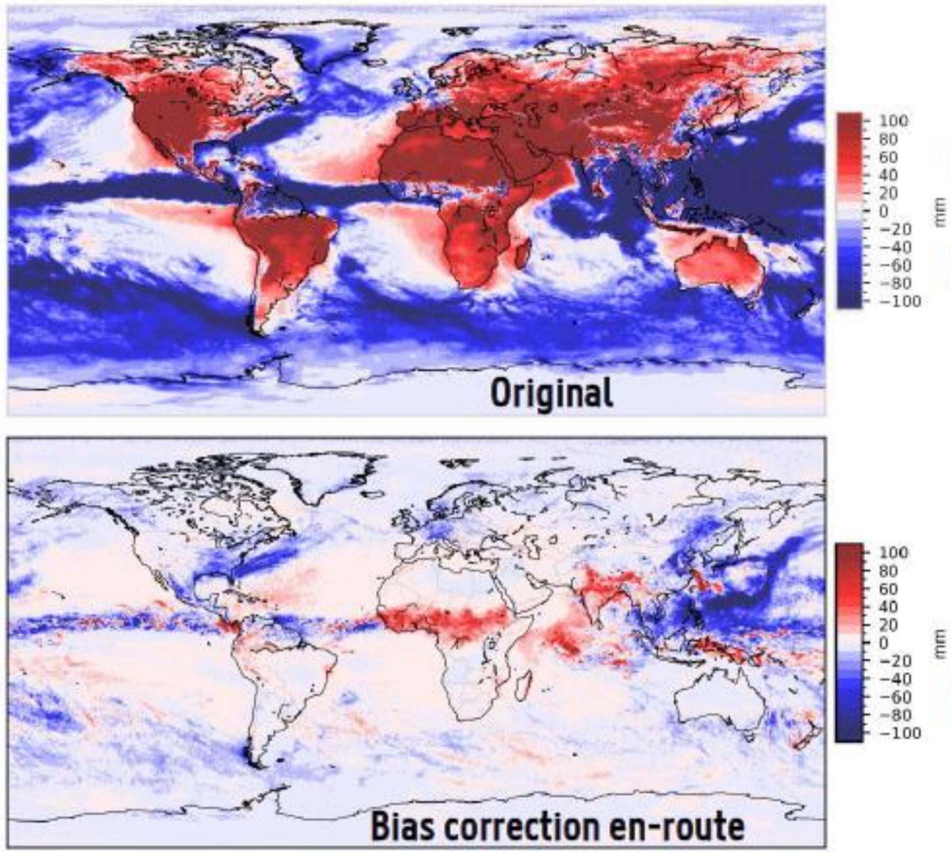
Main code updates:

- MPI parallelization
  => 6x faster + 6x less resources
- Bias correction en-route

Specifics for this study:

- 30 backtracking days
- Bias corrected with ERA5

CONSISTENCY



BIAS: -16 mm
MAE: 52 mm
RMSE: 61 mm

BIAS: -3 mm
MAE: 8 mm
RMSE: 10 mm

Note: E2P = evaporation to precipitation

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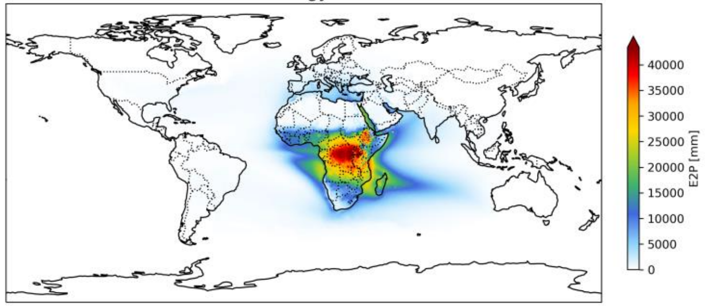
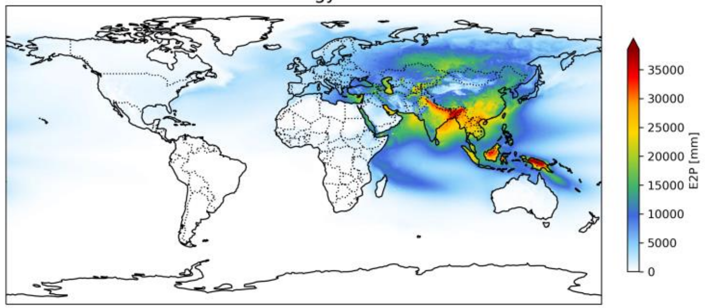
1. Climatology (1980–2019)

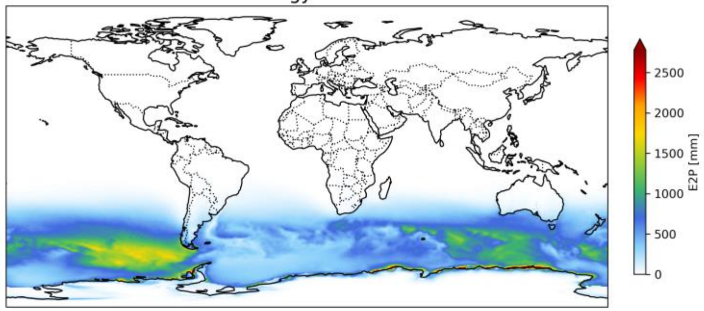
Climatology Africa



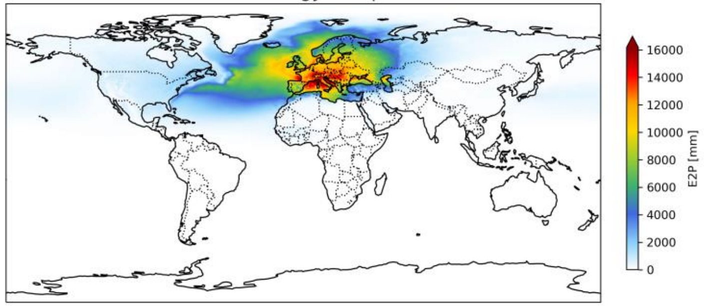
Climatology Asia



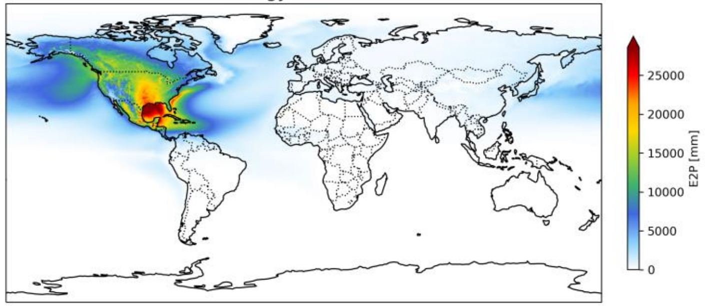
Climatology Antarctica



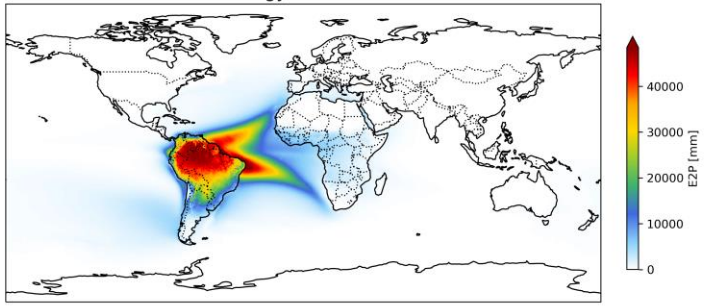
Climatology Europe



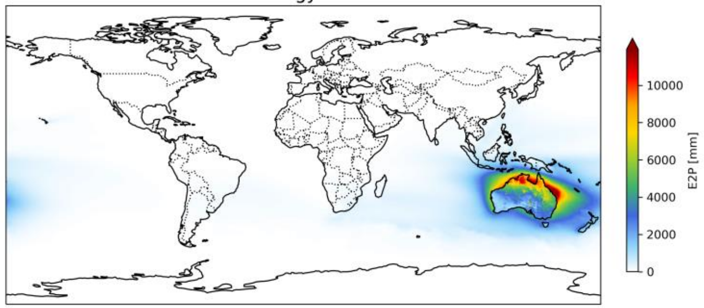
Climatology North America



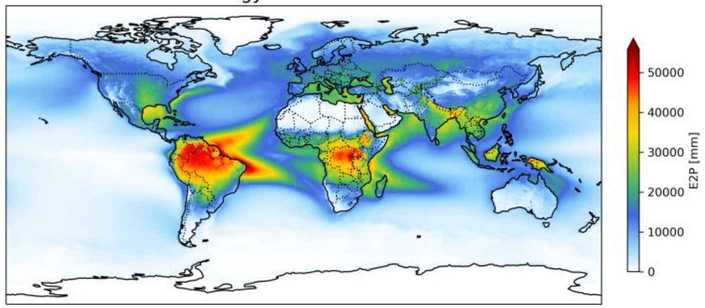
Climatology South America



Climatology Oceania



Climatology All Continental Area



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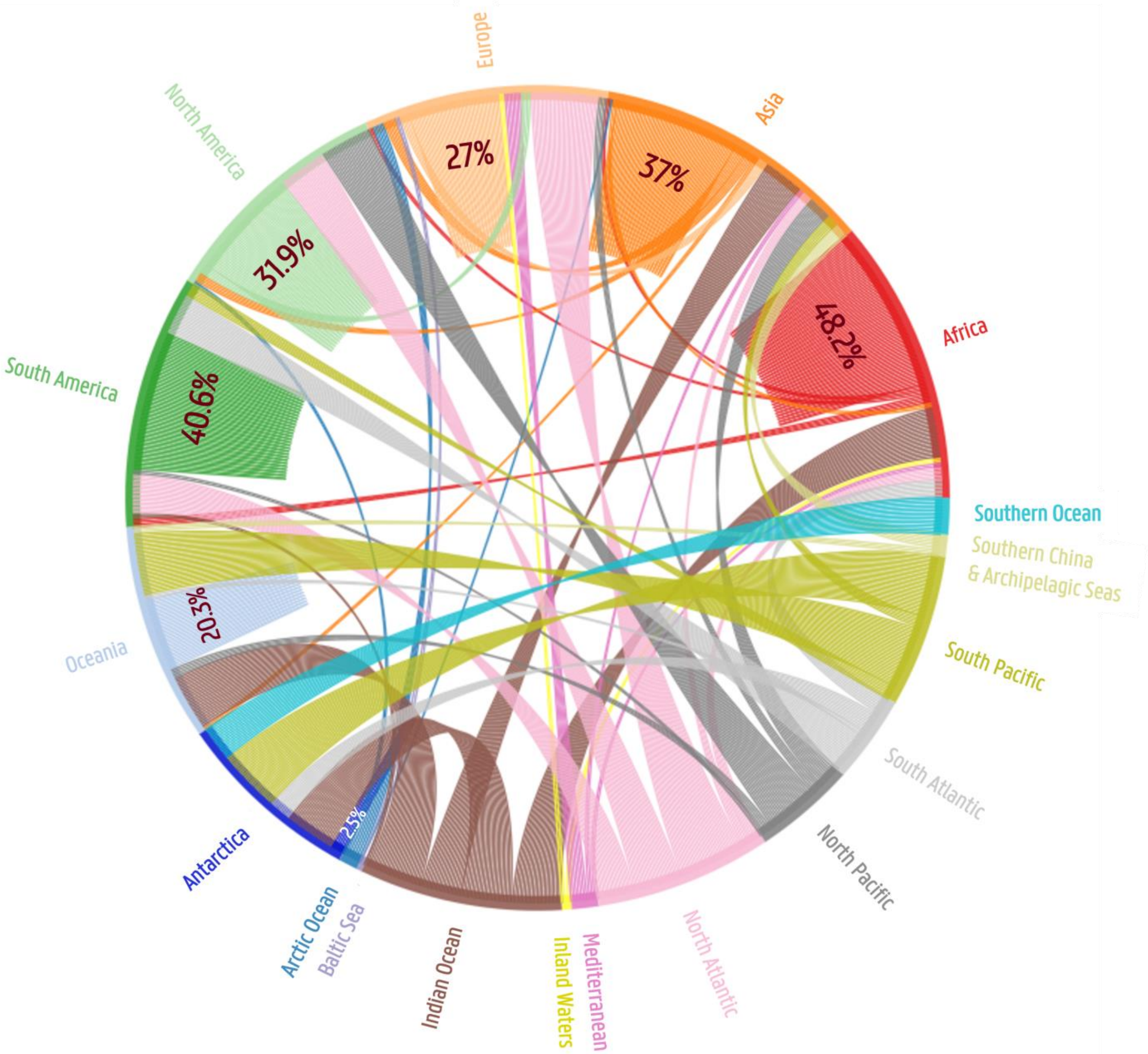

Average continental precipitation recycling: **42.6%**

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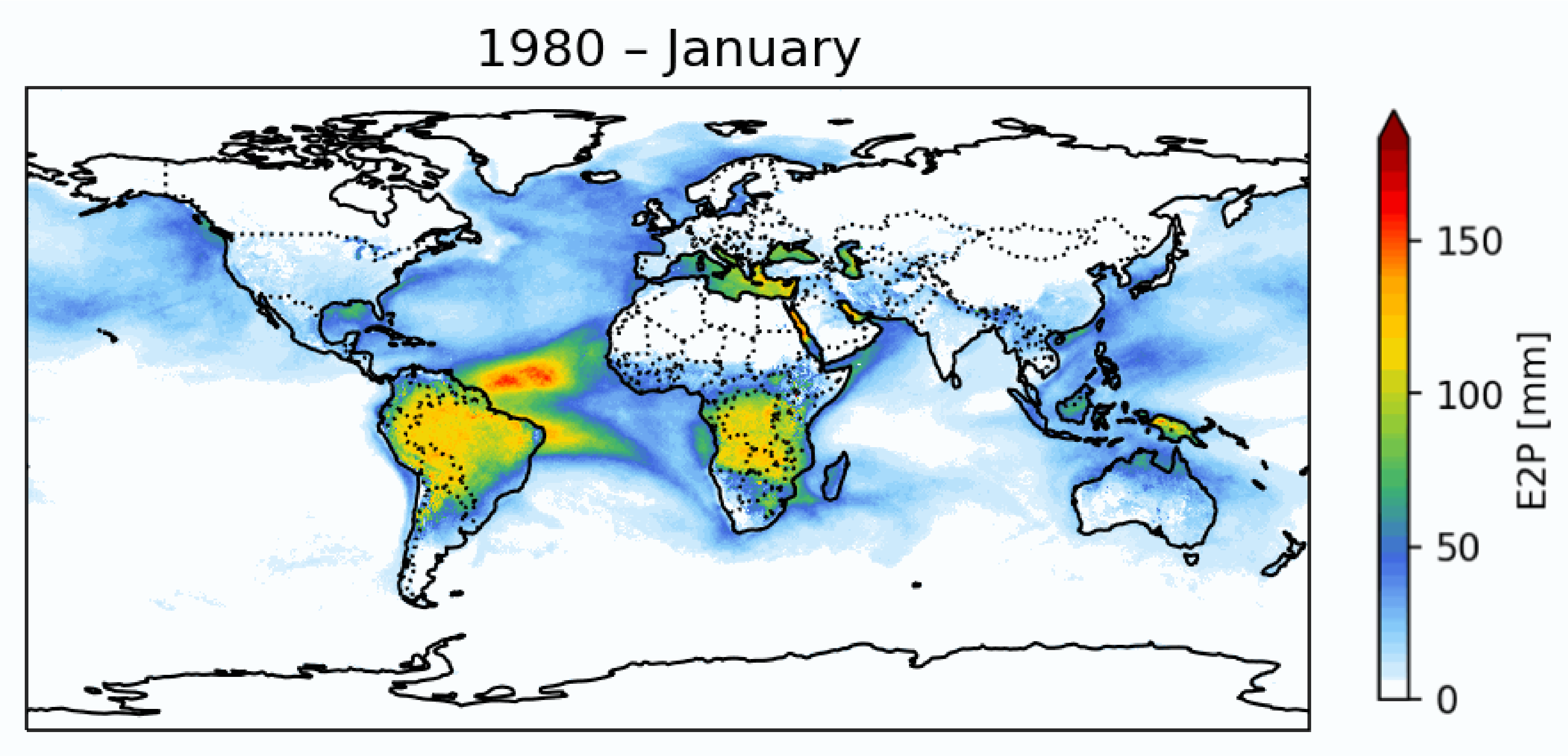
2. Time evolution



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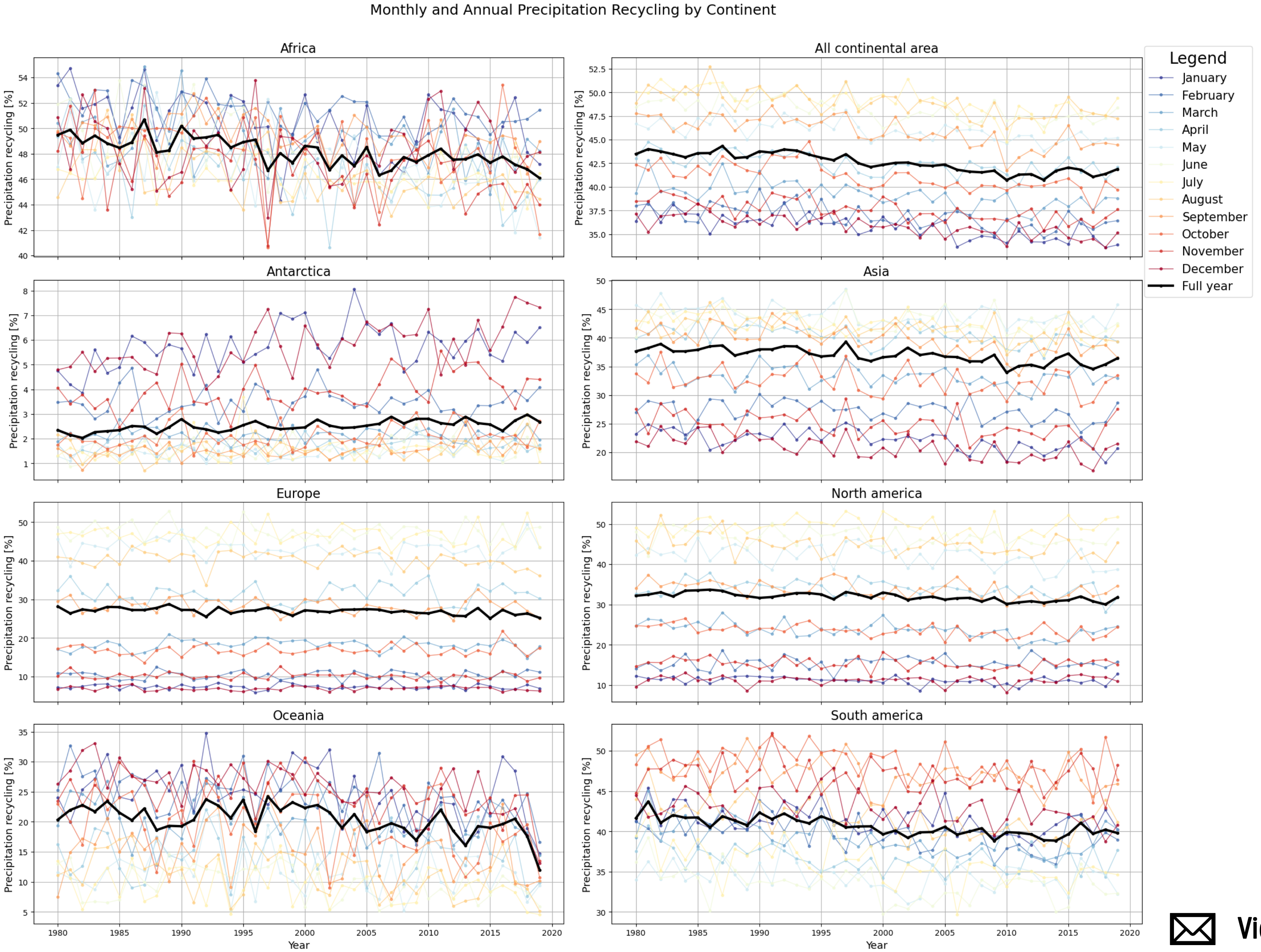

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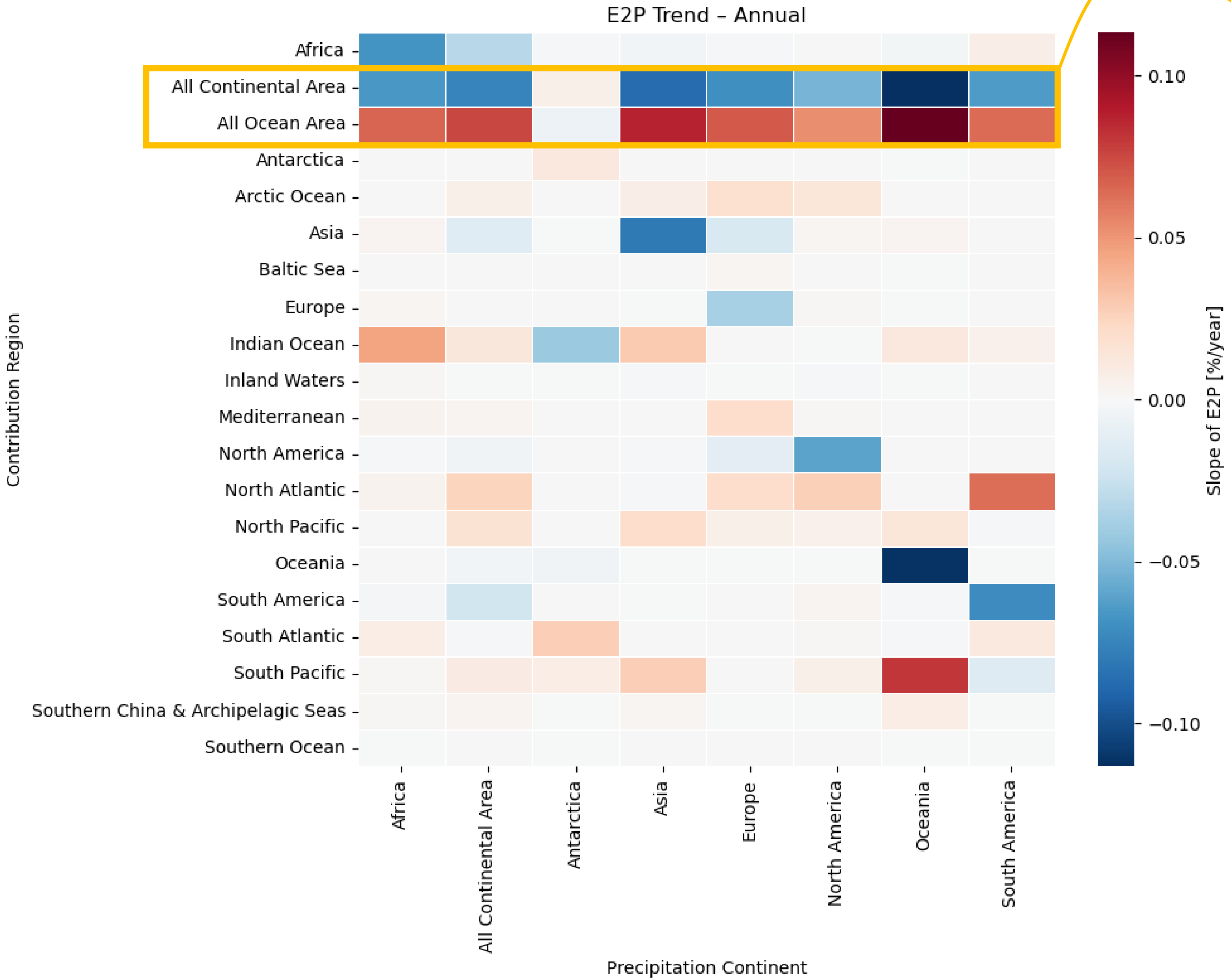
3. Trends



Significant decreases in continental contributions

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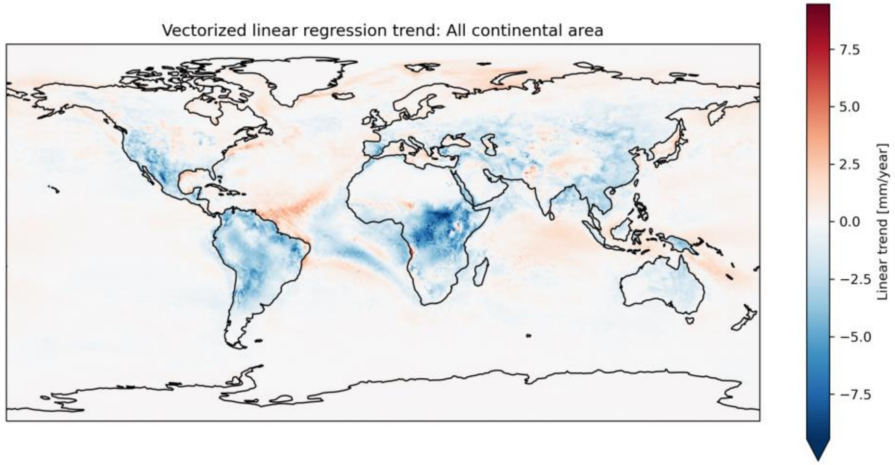
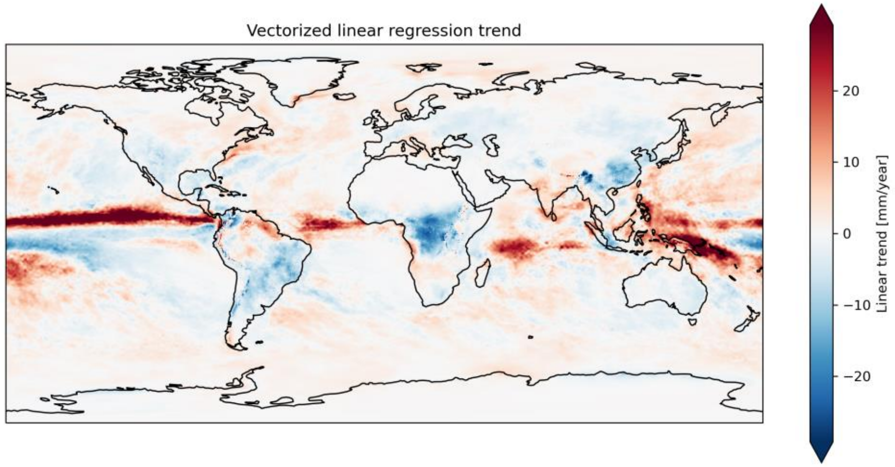
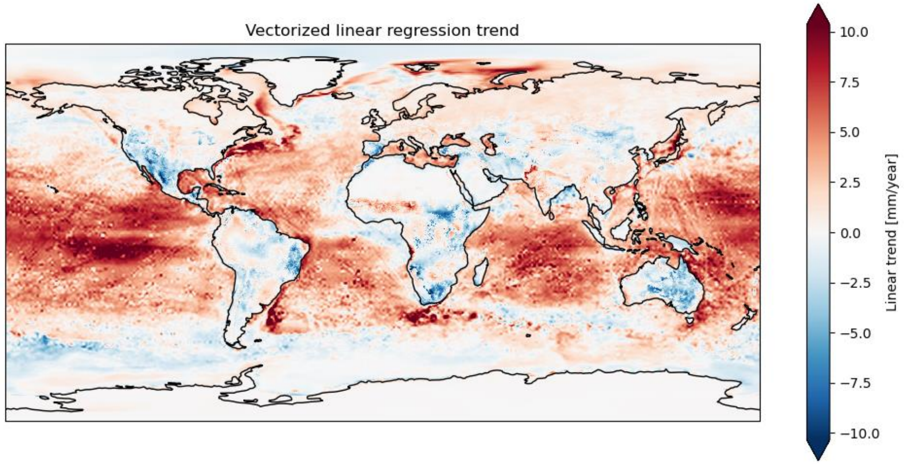
3. Trends



E2P



PRECIPITATION



EVAPORATION

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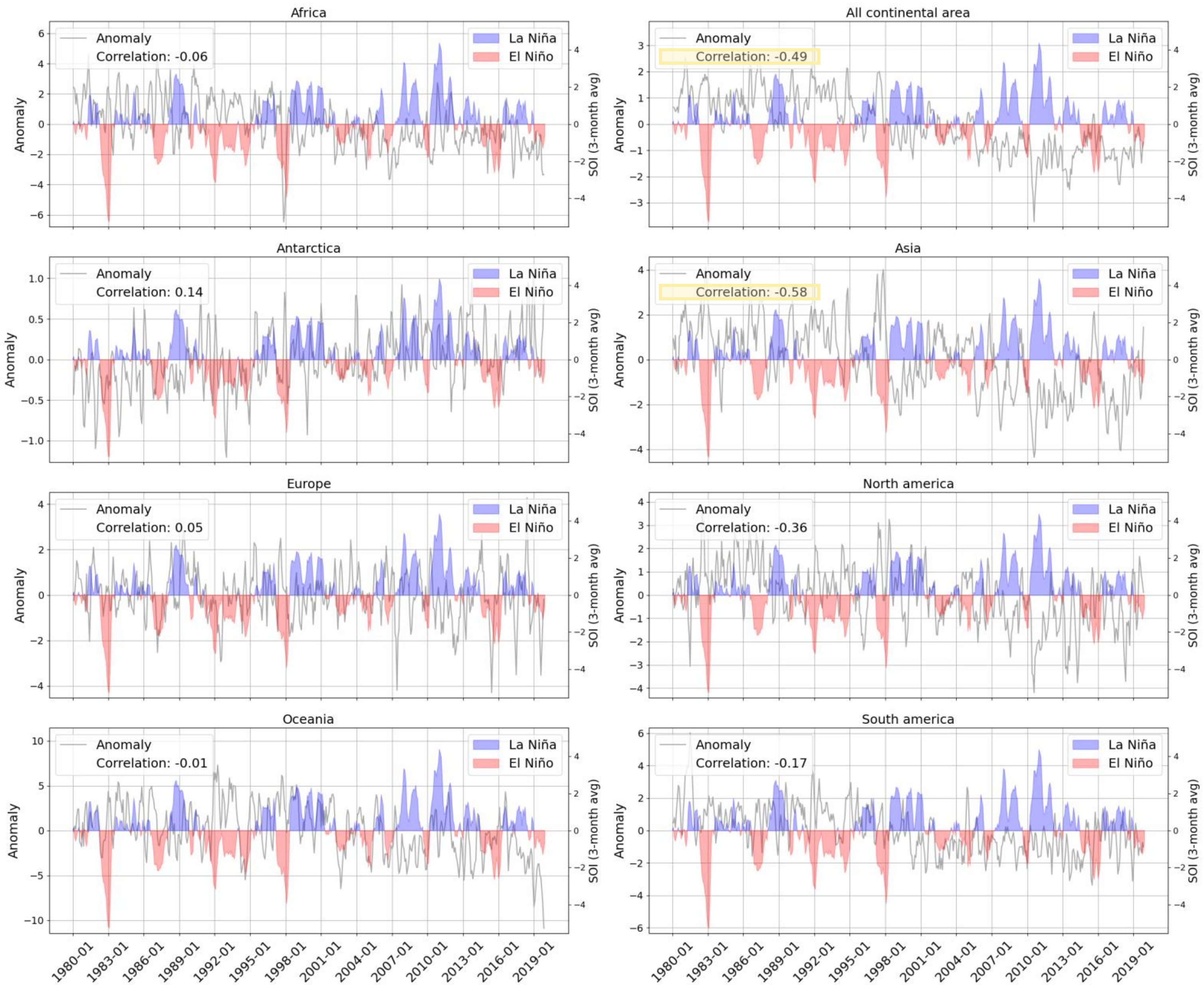
SOI: Southern Oscillation Index

4. Relation with SOI (El Niño/ La Niña)



El Niño

$\Rightarrow$ Generally hotter and wetter

$\Rightarrow$ Positive P recycling anomalies

Note: Anomalies are continent recycling anomalies [%]

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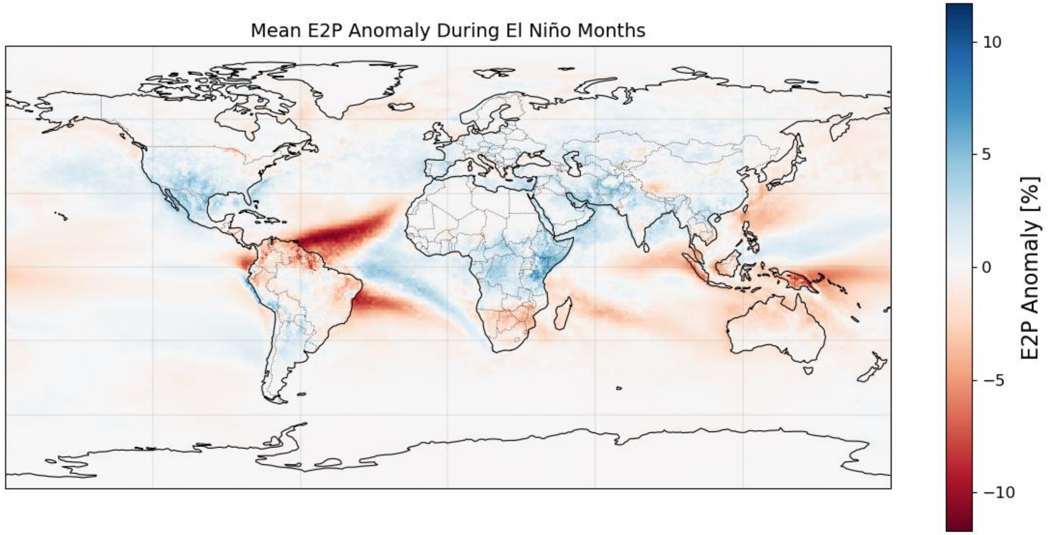
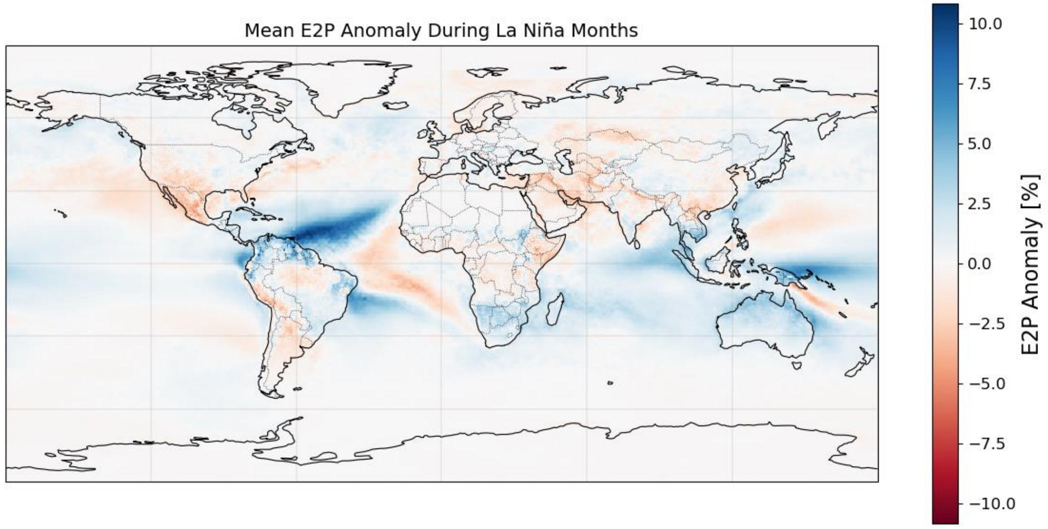
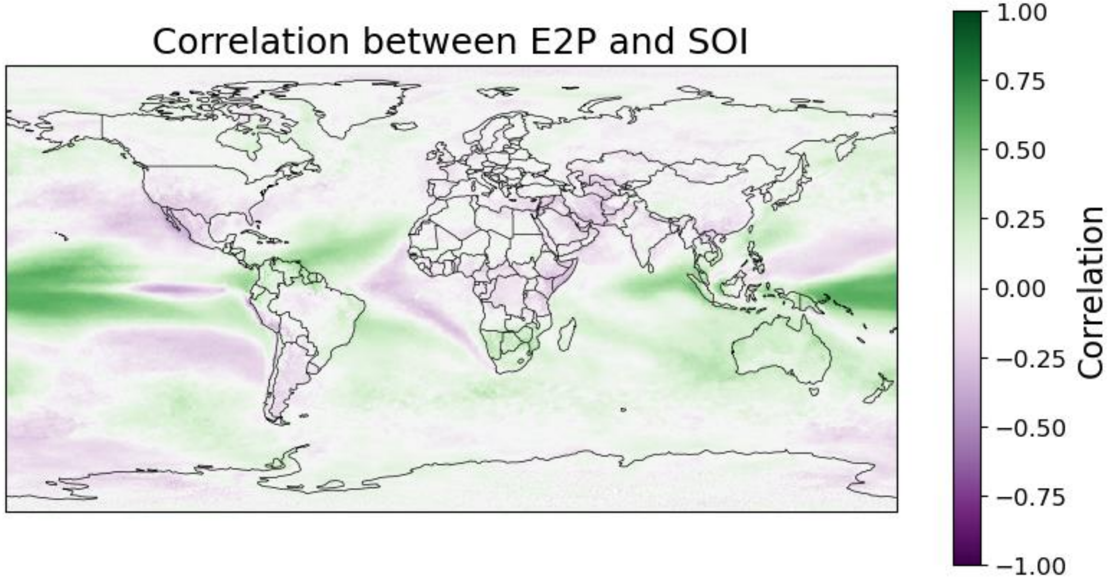
4. Relation with SOI (El Niño/ La Niña)







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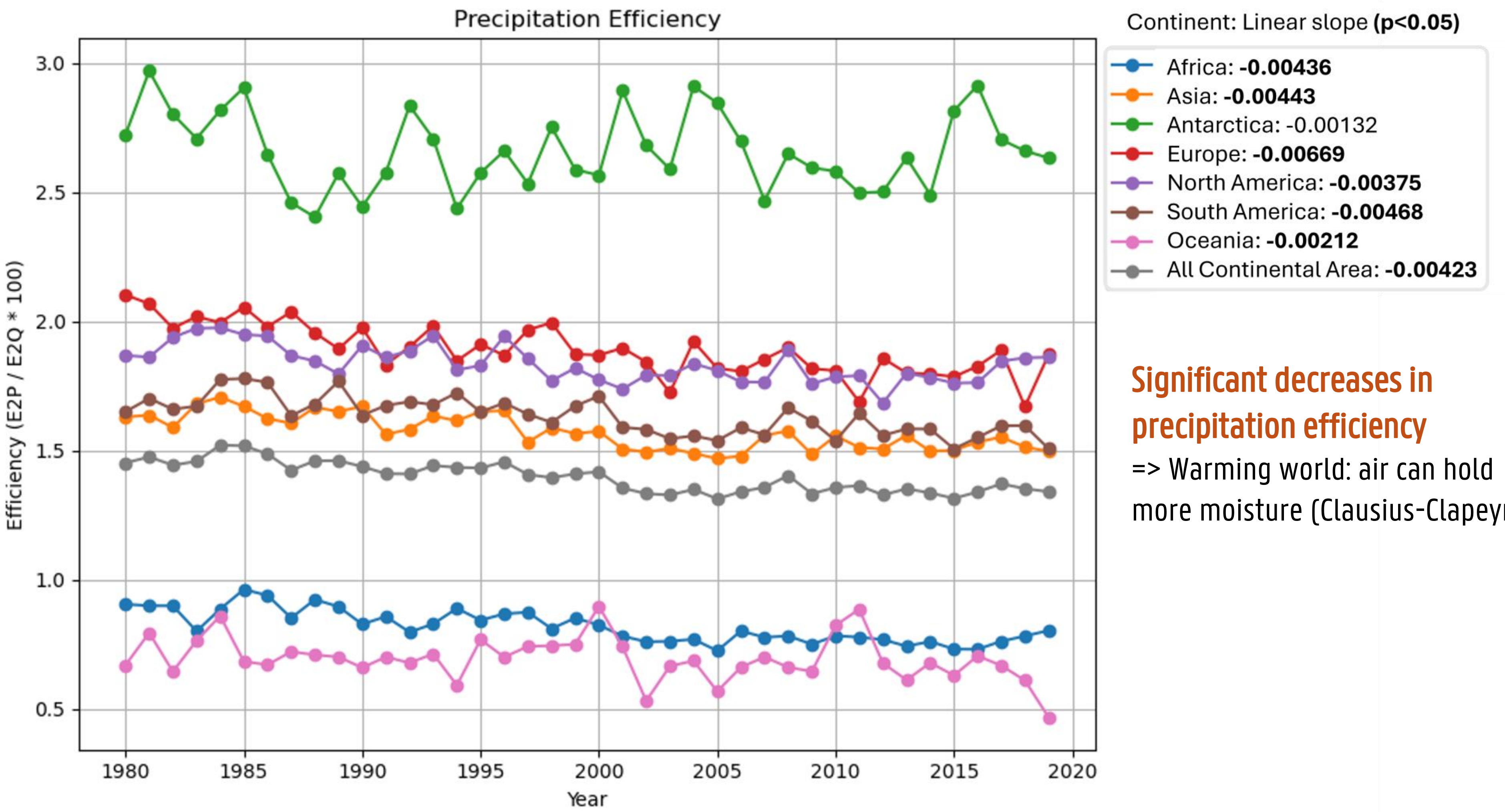
5. Precipitation efficiency



Significant decreases in precipitation efficiency

=> Warming world: air can hold more moisture (Clausius-Clapeyron)

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Conclusion and outlook

- NEW: Higher resolution + longer period than currently available
- NEW: Bias correction on route + parallelization => more realistic and efficient

=> Opportunities for future research

- Recycling ratio's similar as found in literature
- Decreasing continental recycling and precipitation trends due to global warming
- Region contribution differences e.g. Atlantic more important for moisture supply compared to Pacific
- Links with SOI e.g. during El Niño: higher continental recycling

=> To be investigated further

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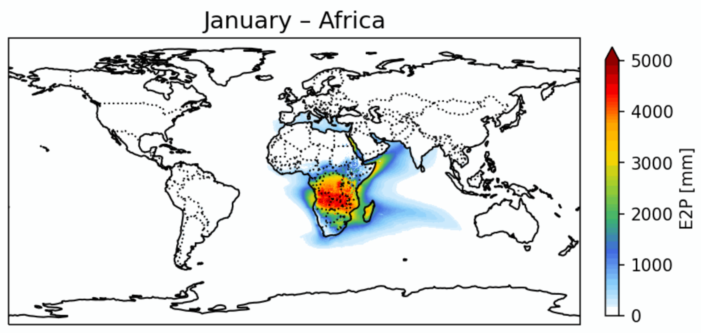
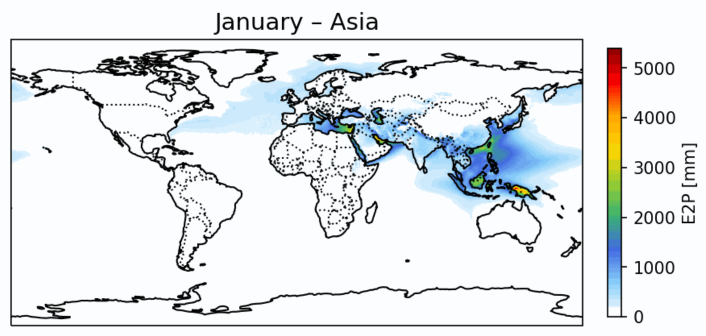
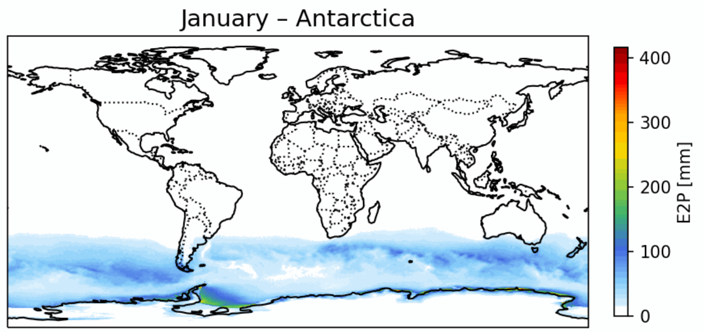
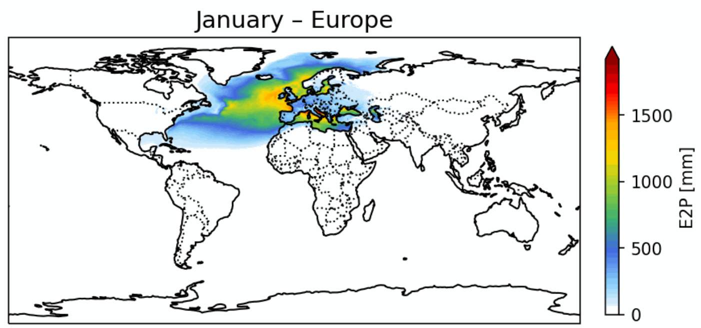
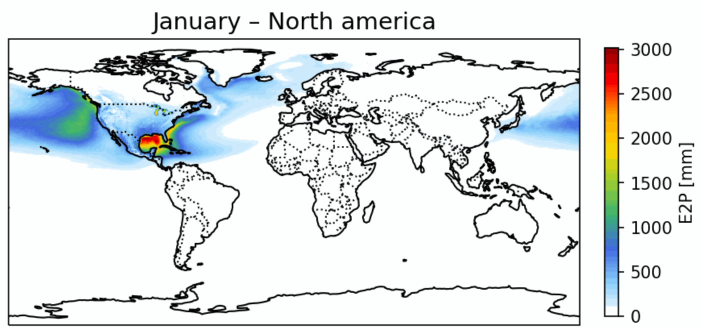
S1a. Monthly climatology (1980–2019)

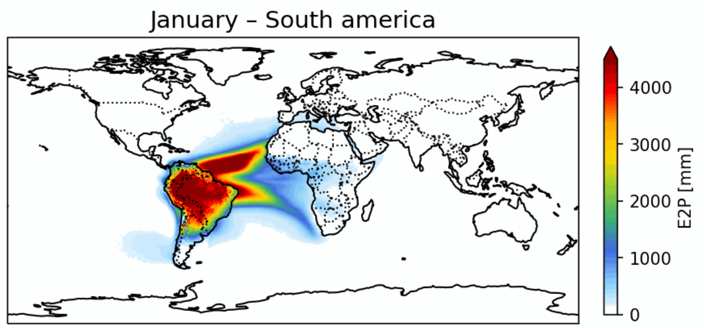


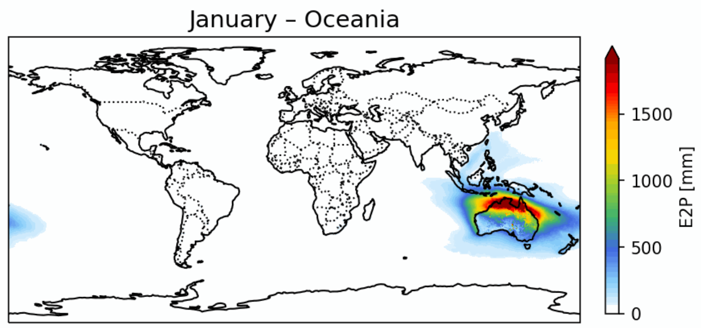


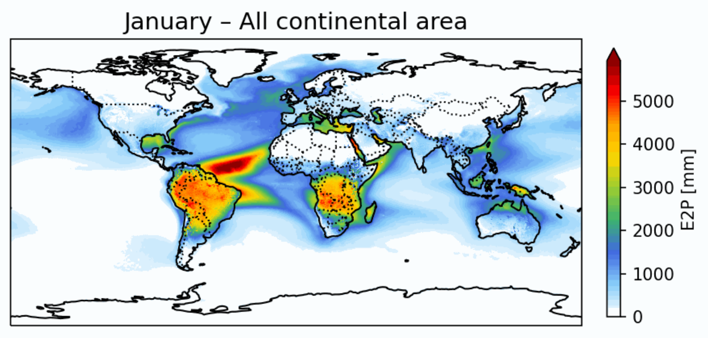












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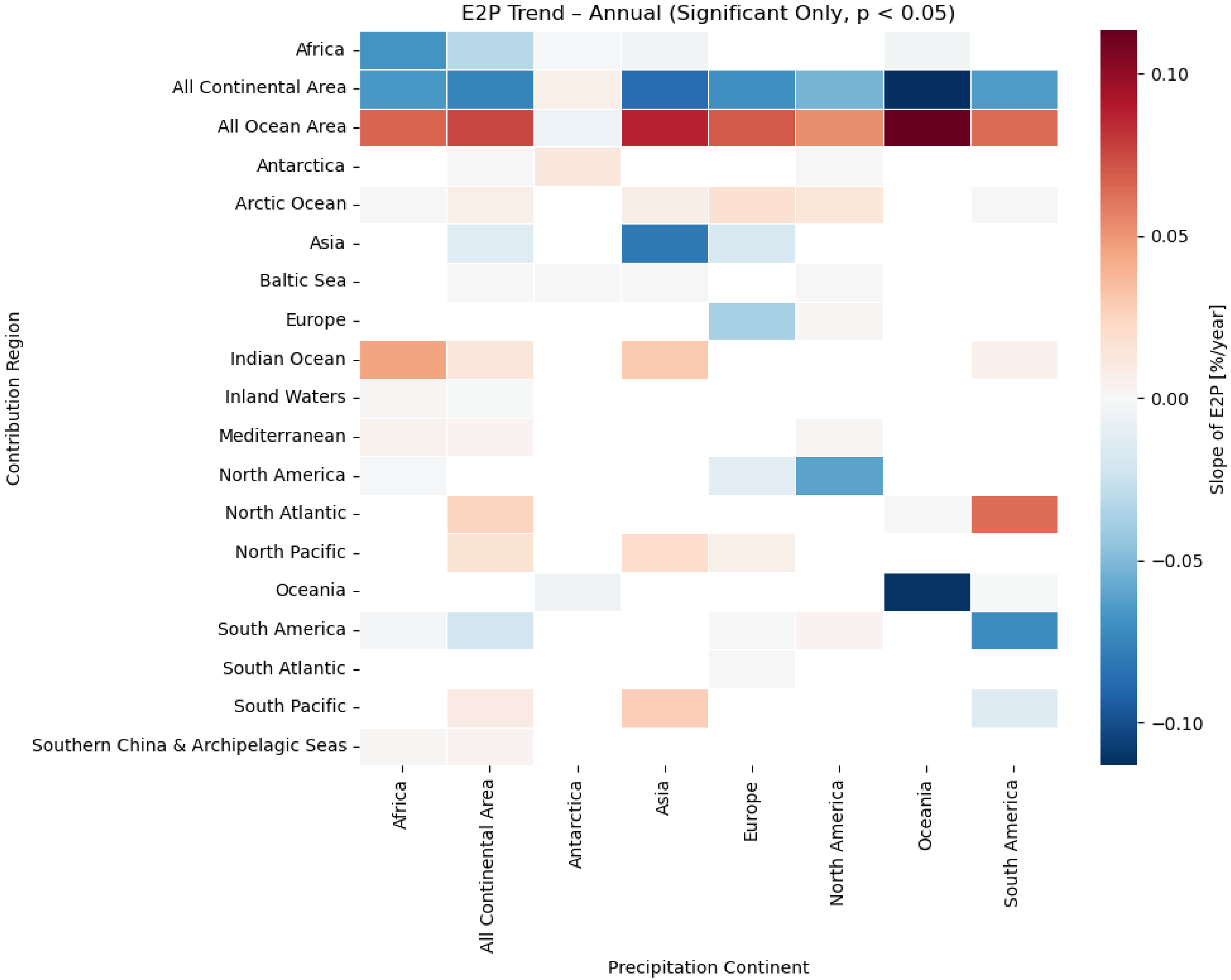
S1b. Contributions (1980–2019)

Average Annual Rainfall Contribution (Ratio Area Corrected)

E2P [%]

Comparison Continent \ Main Continent	Africa	All Continental Area	Antarctica	Asia	Europe	North America	Oceania	South America
Africa	48.2	9.9	0.2	1.2	1.8	0.5	0.5	3.8
All Continental Area	51.6	42.6	4.2	43.0	39.1	37.1	22.6	44.8
All Ocean Area	48.4	57.4	95.8	57.0	60.9	62.9	77.4	55.2
Antarctica	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0
Arctic Ocean	0.0	1.0	0.0	1.1	5.6	2.1	0.0	0.0
Asia	1.6	12.5	0.0	37.0	5.7	3.3	1.1	0.1
Baltic Sea	0.0	0.1	0.0	0.1	1.4	0.0	0.0	0.0
Europe	0.8	3.0	0.0	3.4	27.0	0.6	0.0	0.1
Indian Ocean	28.5	13.9	28.7	23.1	0.2	0.3	32.6	1.3
Inland Waters	1.1	0.8	0.0	0.9	1.4	1.0	0.1	0.3
Mediterranean	1.6	1.5	0.0	1.8	9.6	0.2	0.0	0.3
North America	0.4	5.3	0.0	1.0	4.7	31.9	0.0	0.1
North Atlantic	5.8	14.6	0.0	4.3	38.6	27.8	0.1	22.0
North Pacific	0.6	9.1	0.0	13.2	3.9	29.8	3.4	1.2
Oceania	0.1	0.9	0.7	0.4	0.0	0.0	20.3	0.1
South America	0.6	11.0	0.8	0.1	0.0	0.8	0.6	40.6
South Atlantic	10.0	8.2	11.5	0.2	0.1	0.6	1.7	22.9
South Pacific	0.6	5.6	35.7	5.7	0.0	0.9	36.5	7.1
Southern China & Archipelagic Seas	0.2	2.2	0.0	6.6	0.0	0.2	2.8	0.0
Southern Ocean	0.0	0.3	19.8	0.0	0.0	0.0	0.2	0.1

S1c. Significant trends only (other: masked)



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S2. References

Bakels, L., Tatsii, D., Tipka, A., Thompson, R., Dütsch, M., Blaschek, M., Seibert, P., Baier, K., Bucci, S., Cassiani, M., Eckhardt, S., Groot Zwaaftink, C., Henne, S., Kaufmann, P., Lechner, V., Maurer, C., Mulder, M. D., Pisso, I., Plach, A., Subramanian, R., Vojta, M., and Stohl, A.: FLEXPART version 11: improved accuracy, efficiency, and flexibility, Geosci. Model Dev., 17, 7595–7627, https://doi.org/10.5194/gmd-17-7595-2024, 2024.

Keune, J., Schumacher, D. L., and Miralles, D. G.: A unified framework to estimate the origins of atmospheric moisture and heat using Lagrangian models, Geosci. Model Dev., 15, 1875–1898, https://doi.org/10.5194/gmd-15-1875-2022, 2022.

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