Moisture recycling in five different regions with **Mediterranean climates** around the world

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Extreme weather is projected to intensify in regions with a Mediterranean climate due to global change

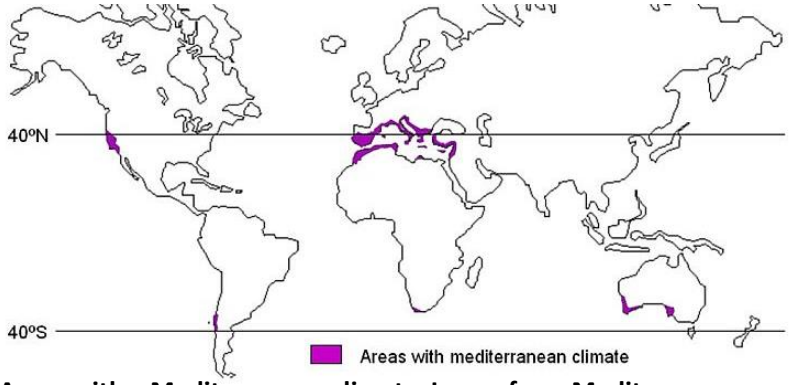
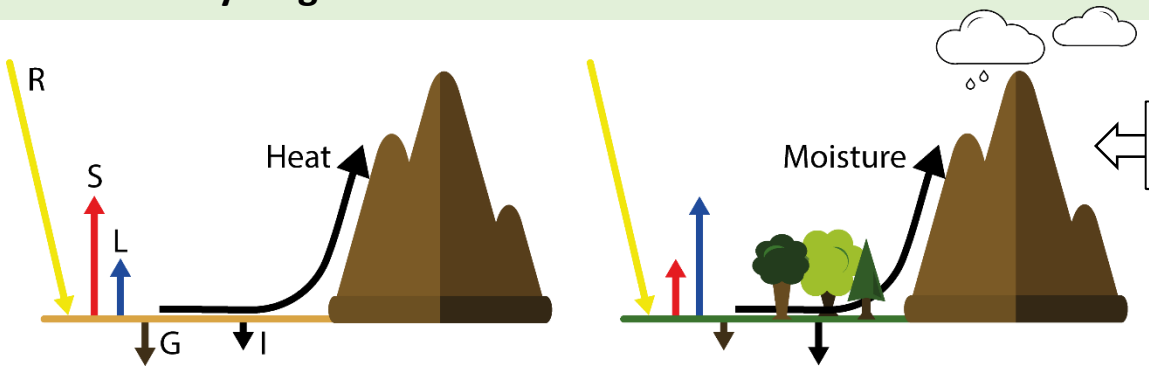


Figure 1. Areas with a Mediterranean climate. Image from Mediterranean garden society.

Hypothesis: Boost water cycle with regreening in areas with high **moisture recycling**



R = Incoming radiation, S = Sensible heat flux,
L = Latent heat flux, G = Ground flux, I = infiltration

Goal: Use moisture recycling in 5 Mediterranean regions to **predict impact of regreening**

Methods
Data: *High-resolution global atmospheric moisture connections*

There is spatio-temporal variation in land recycling of evaporated moisture

Table 1. Yearly average of land recycling ratio for 5 Mediterranean regions.

Location	Recycling ratio [-]
Australia	0.1 – 0.4
Mediterranean basin	**0.7 – 1**
North America	**0.6 – 0.9**
South Africa	0.1 – 0.4
South America	0.4 – 0.7

Figure 2. Hypothesized mechanism through which more moisture will become available.

1. Higher land recycling ratio (LRR) in Northern Hemisphere
2. Wind pattern and continental area and orientation affect LRR
3. Absolute land recycling influenced by land cover

Regreening is expected to mitigate the intensification of extreme weather more strongly in the Northern Hemisphere than in the Southern Hemisphere

Motivation

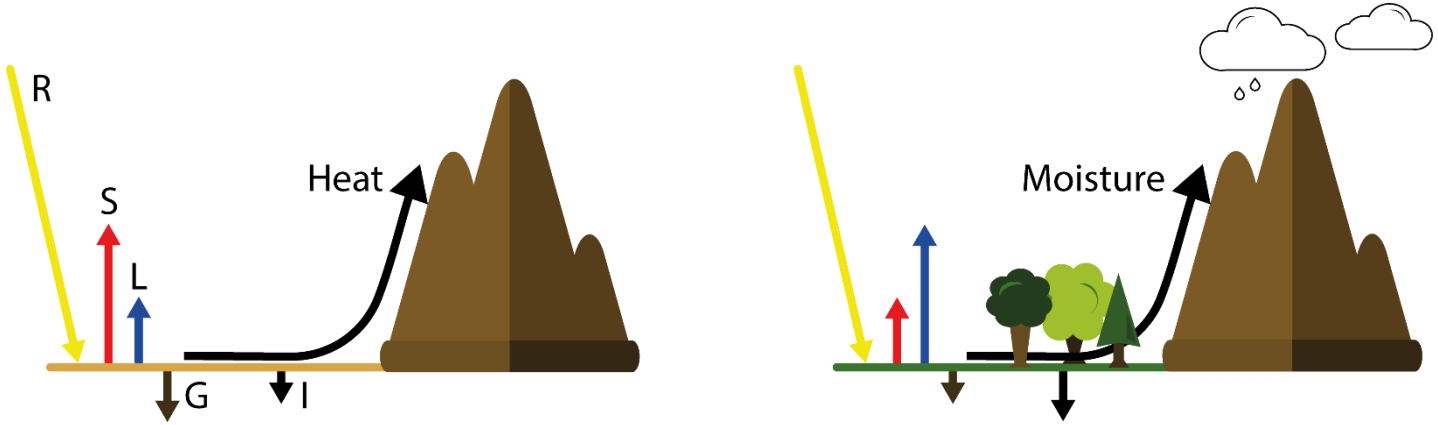
- Climate change and intense land use practices intensify extreme weather [1,2]
- Risks of extreme weather are projected to increase for regions with a Mediterranean climate [3,4,5]

- Can we reduce the intensification of climate extremes with land cover change?

Land cover change to mitigate intensification of extreme weather

Vegetation enhances:
- Deep soil moisture availability [6]
- Infiltration of rain water

In areas where soil moisture is limited evaporation will be enhanced, which will enhance precipitation (non) locally [7]



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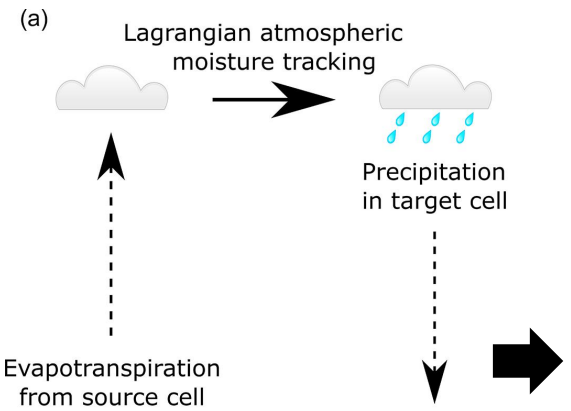
High-resolution global atmospheric moisture connections

- Monthly multi-year averages (2008-2017)
- From evaporation source to target location
- Spatial resolution of 0.5x0.5° grid size

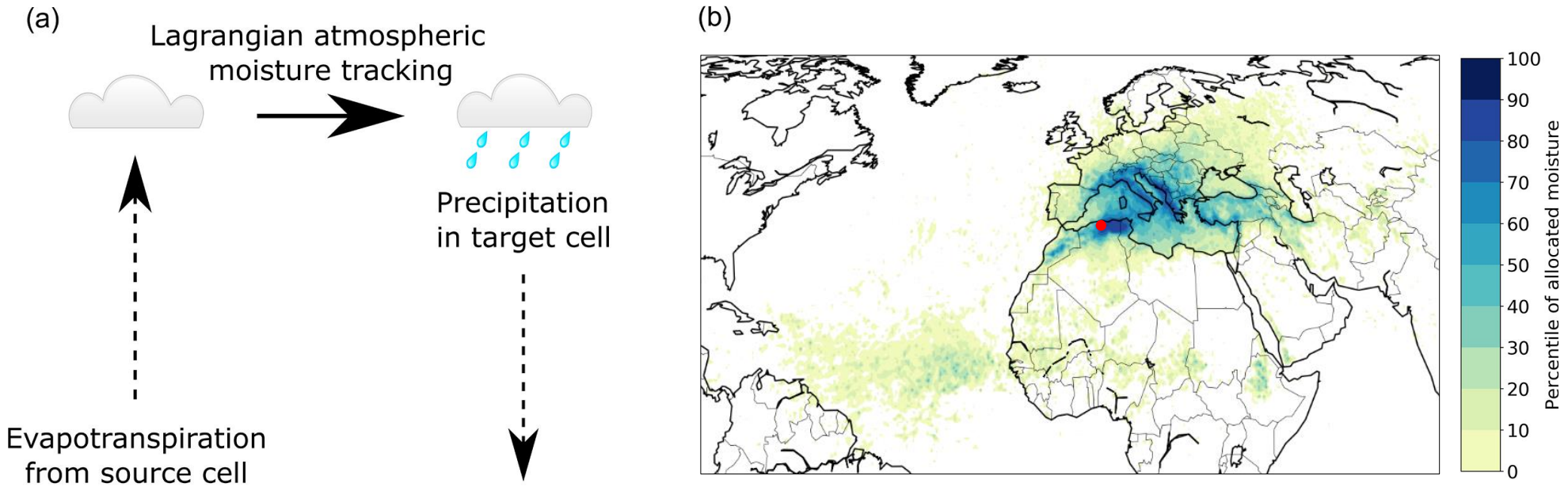
- Generated with UTrack (Lagrangian moisture tracking model)
  - Input 0.25x0.25° resolution
  - Forward and backward moisture tracking

- Land recycling
  - Evaporation recycling over land (forward)
  - Precipitation recycling over land (backward)



Tuinenburg, Obbe A., Jolanda JE Theeuwen, and Arie Staal. "High-resolution global atmospheric moisture connections from evaporation to precipitation." *Earth System Science Data* 12.4 (2020): 3177-3188.

UTrack atmospheric moisture



a) Schematic of a moisture connection which is calculated with the Lagrangian atmospheric moisture tracking model UTrack
b) Evaporationshed, footprint of precipitation for evaporated water from the source grid (below red dot)

Evaporationshed from each source grid is used to determine moisture recycling in this study ➡

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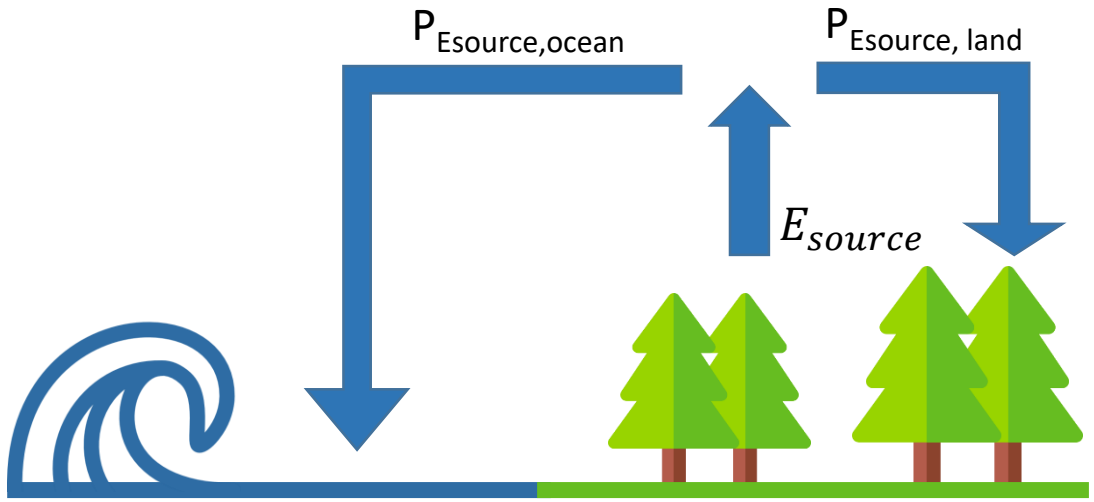
Moisture recycling over land

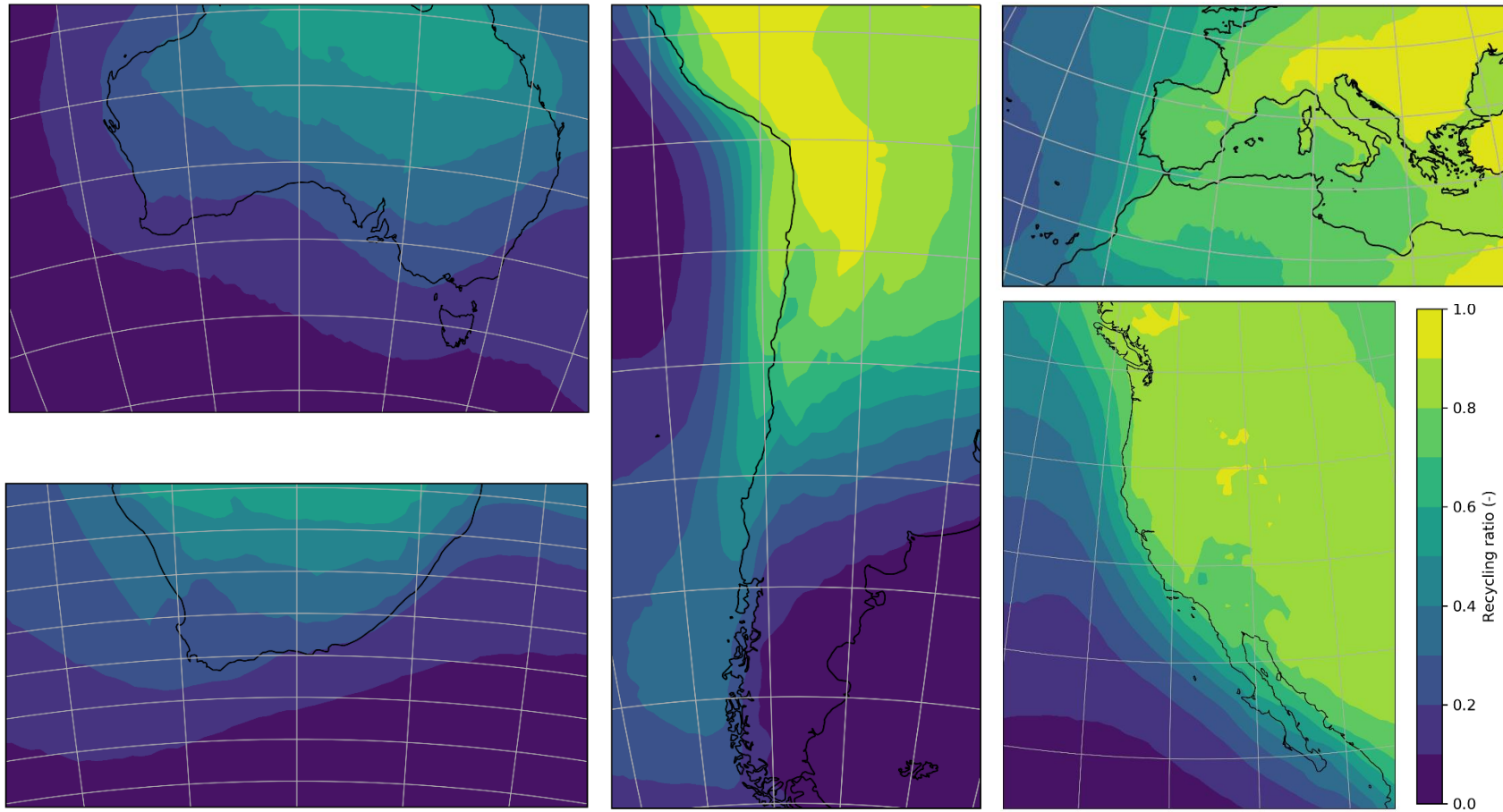
$$Land\ recycling\ ratio_{source} = \frac{P_{Esource,land}}{P_{Esource,land} + P_{Esource,ocean}}$$

$$Absolute\ land\ recycling_{source} = Land\ recycling\ ratio_{source} \cdot E_{source}$$



Land recycling ratio of evaporated moisture

Data: Multi-yearly averages (2008-2017) of land recycling ratio of evaporated moisture from UTrack dataset



Influence of landscape characteristics

- orography
- distance to coast

To predict land recycling ratio we need to understand how landscape characteristics influence moisture recycling

Spatio-temporal variation of Land recycling ratio

Range of yearly averaged land recycling ratio within each Mediterranean area

Location	Recycling ratio [-]
Australia	0.1 – 0.4
Mediterranean basin	**0.7 – 1**
North America	**0.6 – 0.9**
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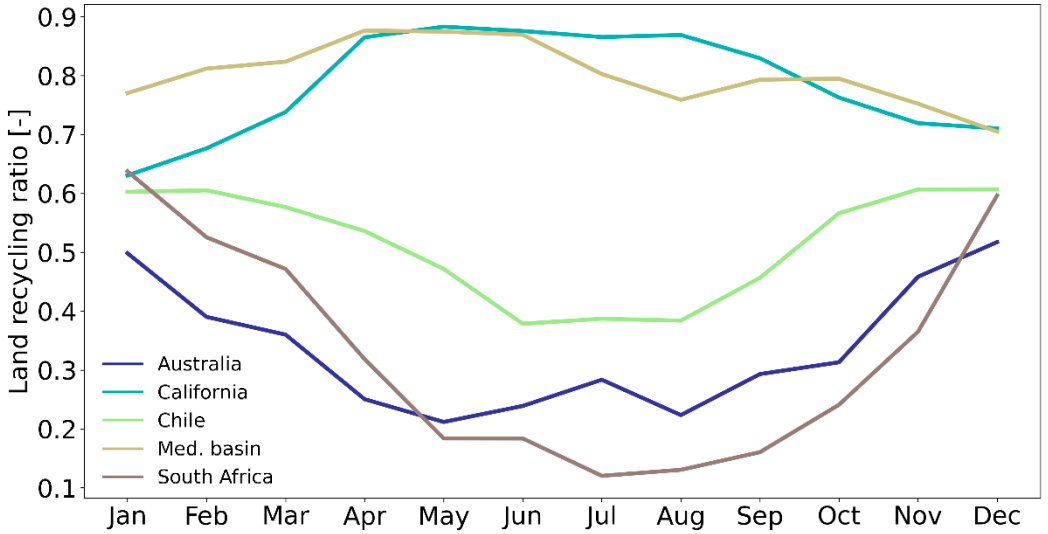
South America	0.4 – 0.7

Climatological spatial average of land recycling ratio for each Mediterranean area



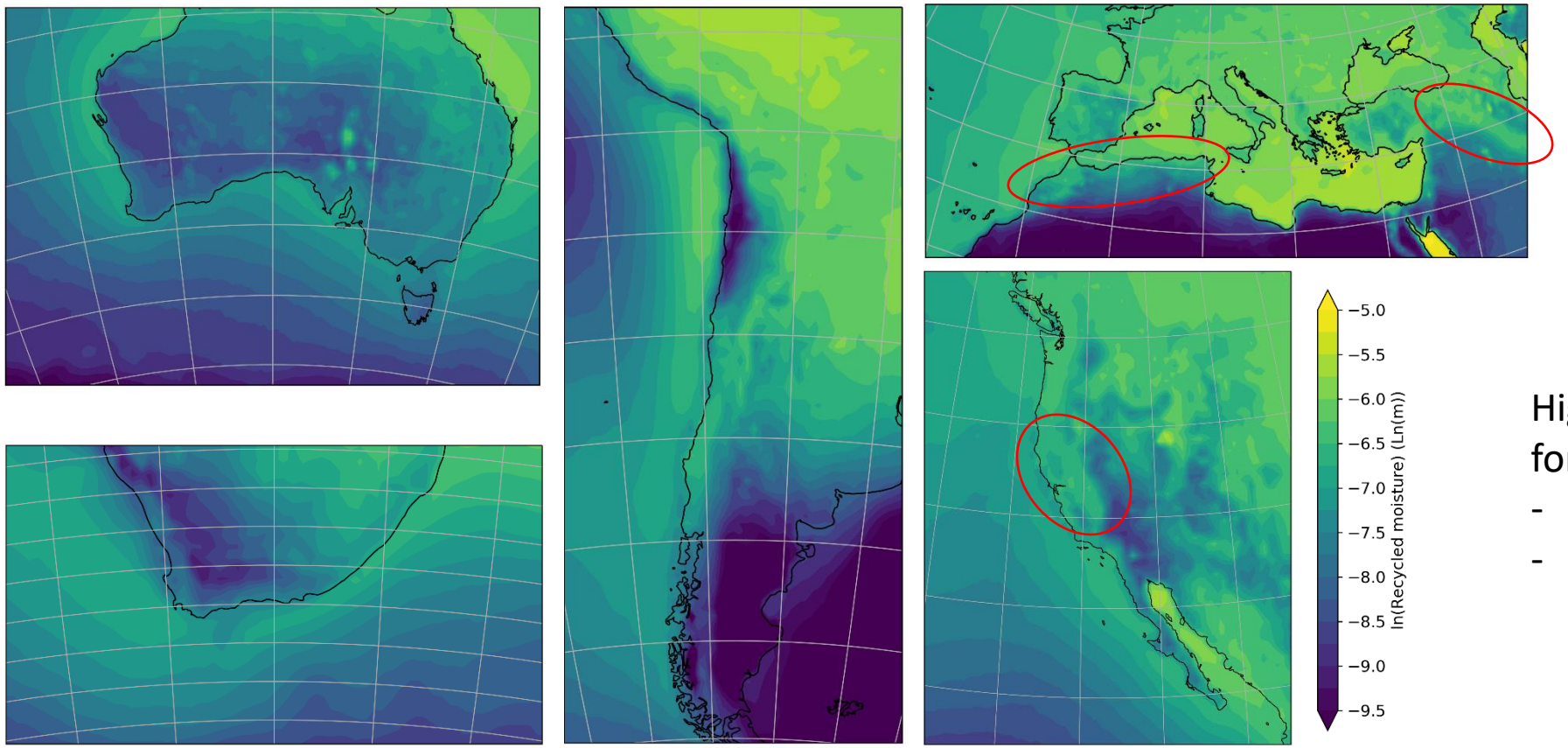
Highest land recycling ratios (LRR) are found on the Northern Hemisphere
Larger continental area:
→ Larger distance to coast
→ Weaker wind pattern

Southern Hemisphere strongly influenced by ocean

Throughout the year, on average, LRR is largest over the Northern Hemisphere

Highest values of LRR are found in spring and summer

Absolute land recycling of evaporated moisture



Higher absolute land recycling for areas with land cover type:

- agriculture
- vegetation

Conclusions

- Land recycling ratio (LRR) is higher on the Northern Hemisphere than on the Southern Hemisphere.
- LRR is affected by landscape characteristics
  - Orography, distance to coast
- Absolute land recycling is affected by land cover

→We expect LRR to remain similar after land cover changes

→more research is needed to confirm

→ Absolute land recycling is enhanced with an increase in vegetation

➔ Boost for the local water cycle

For more information

References

References

1. Rasmijn, L. M., et al. "Future equivalent of 2010 Russian heatwave intensified by weakening soil moisture constraints." *Nature Climate Change* 8.5 (2018): 381-385.
2. Teuling, Adriaan J. "A hot future for European droughts." *Nature Climate Change* 8.5 (2018): 364-365.
3. Samaniego, Luis, et al. "Anthropogenic warming exacerbates European soil moisture droughts." *Nature Climate Change* 8.5 (2018): 421-426.
4. Abiodun, Babatunde J., et al. "Future projection of droughts over major river basins in Southern Africa at specific global warming levels." *Theoretical and Applied Climatology* 137.3 (2019): 1785-1799.
5. Lu, Junyu, Gregory J. Carbone, and John M. Grego. "Uncertainty and hotspots in 21st century projections of agricultural drought from CMIP5 models." *Scientific reports* 9.1 (2019): 1-12.
6. Tang, Bingzhe, et al. "Variations in soil infiltration capacity after vegetation restoration in the hilly and gully regions of the Loess Plateau, China." *Journal of Soils and Sediments* 19.3 (2019): 1456-1466.
7. Seneviratne, Sonia I., et al. "Investigating soil moisture–climate interactions in a changing climate: A review." *Earth-Science Reviews* 99.3-4 (2010): 125-161.
8. Tuinenburg, Obbe A., Jolanda JE Theeuwen, and Arie Staal. "High-resolution global atmospheric moisture connections from evaporation to precipitation." *Earth System Science Data* 12.4 (2020): 3177-3188.

For more information

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References