Oceanic vs continental sources of precipitation

And… what can we do we it?

Ruud van der Ent & Huub Savenije

3-5-2012

Research questions

- Where has precipitation evaporated?
- Where does evaporation go to?
- How can we use this knowledge in case of oceanic sources
- How can we use this knowledge in case of continental sources

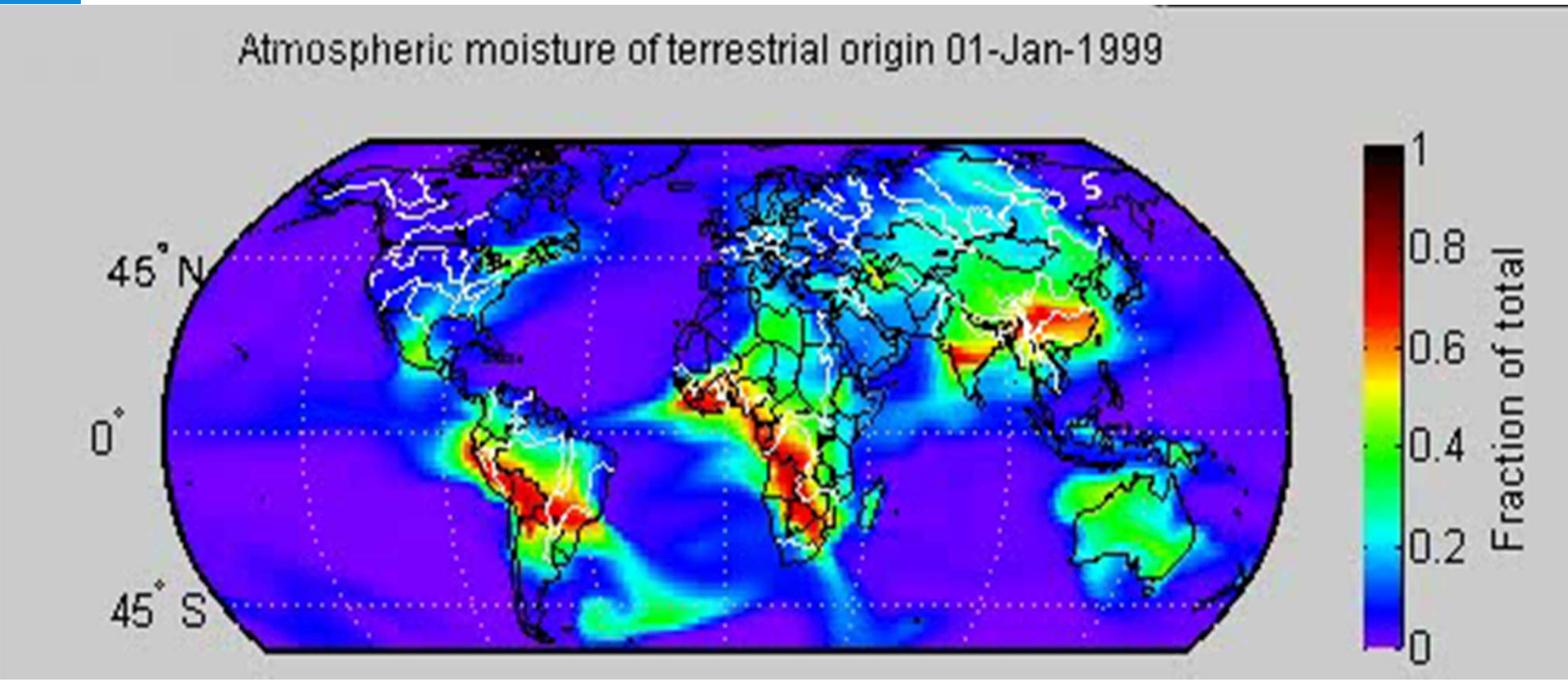
Results

- van der Ent, R. J. et al., Origin and fate of atmospheric moisture over continents, *Water Resources Research*, 2010.

- van der Ent and Savenije, Length and time scales of atmospheric moisture recycling, *Atmospheric Chemistry and Physics*, 2011.

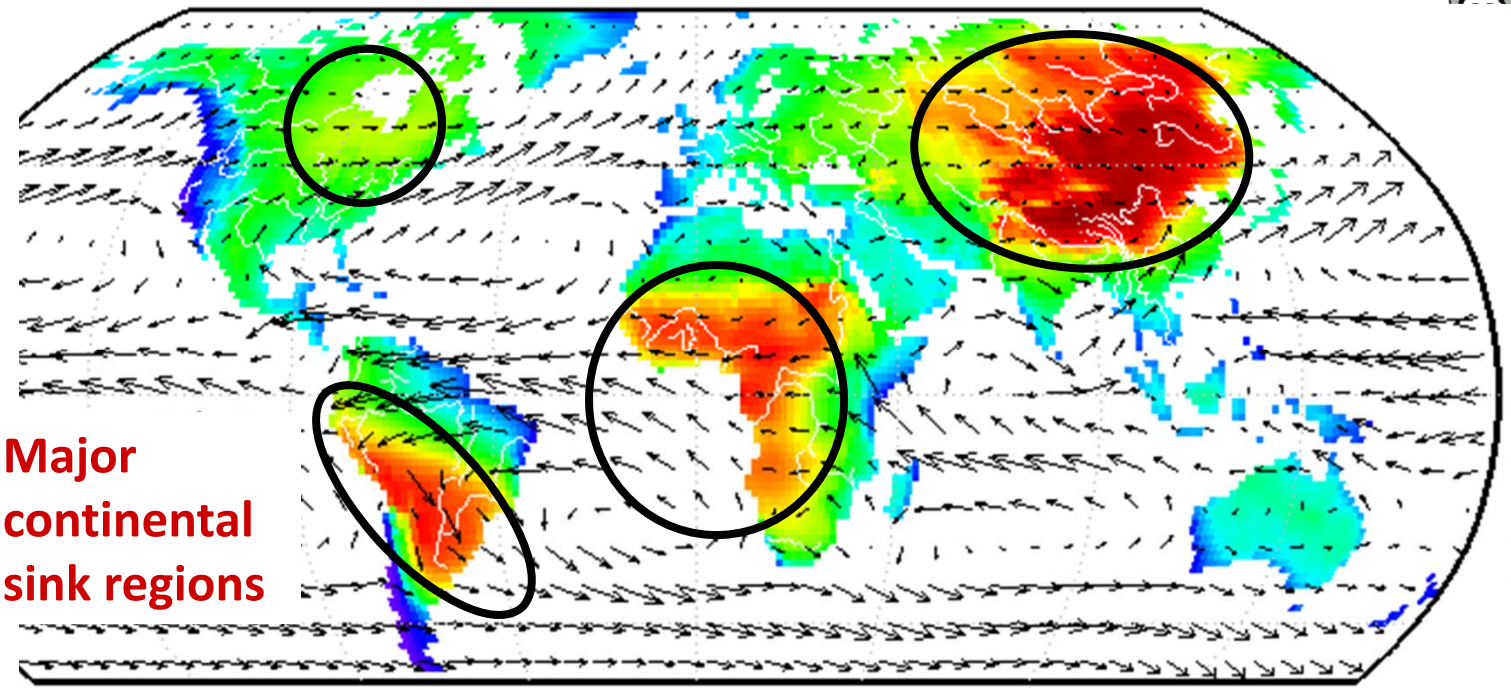
  - Water vapour tracking model
  - ERA-Interim reanalysis

Results


Atmospheric moisture of terrestrial origin 01-Jan-1999
45° N
0°
45° S
1
0.8
0.6
0.4
0.2
0
Fraction of total

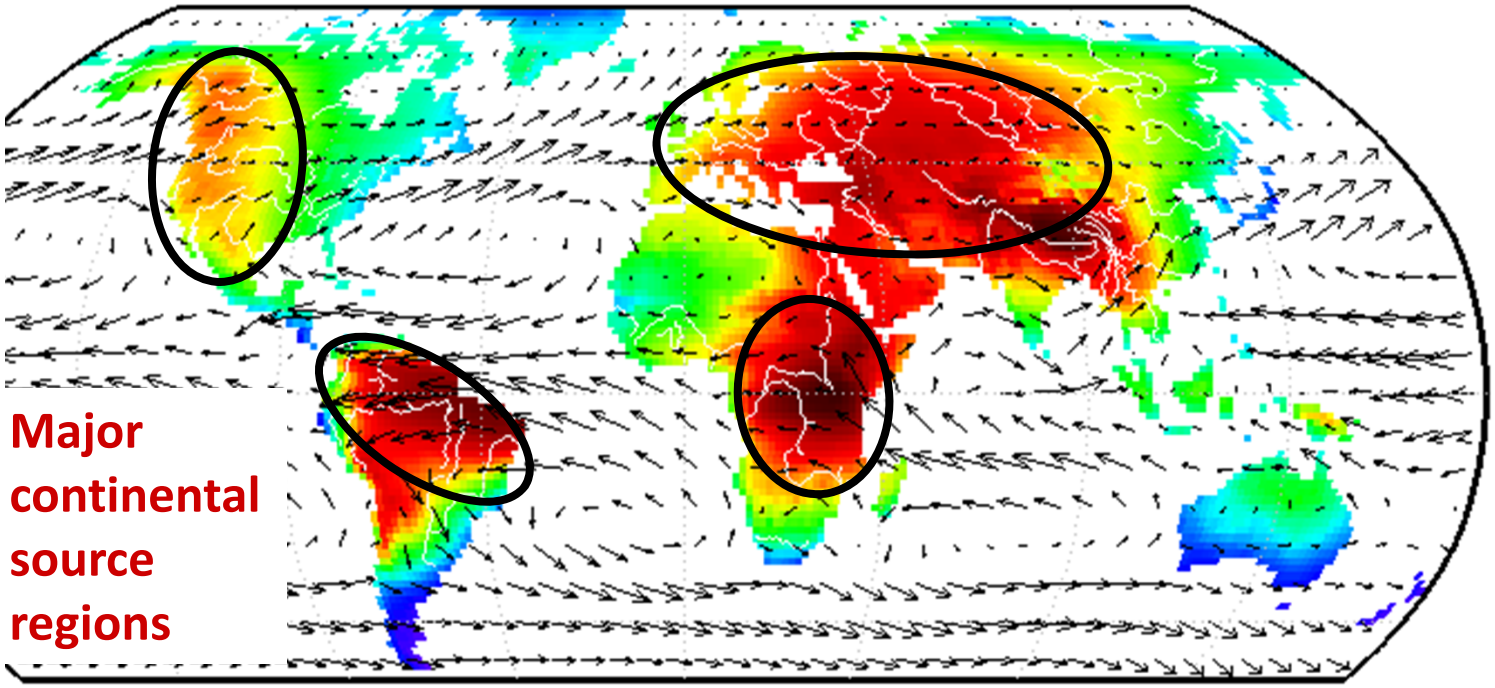
ρ_c:

Fraction of the precipitation that originates from continental evaporation

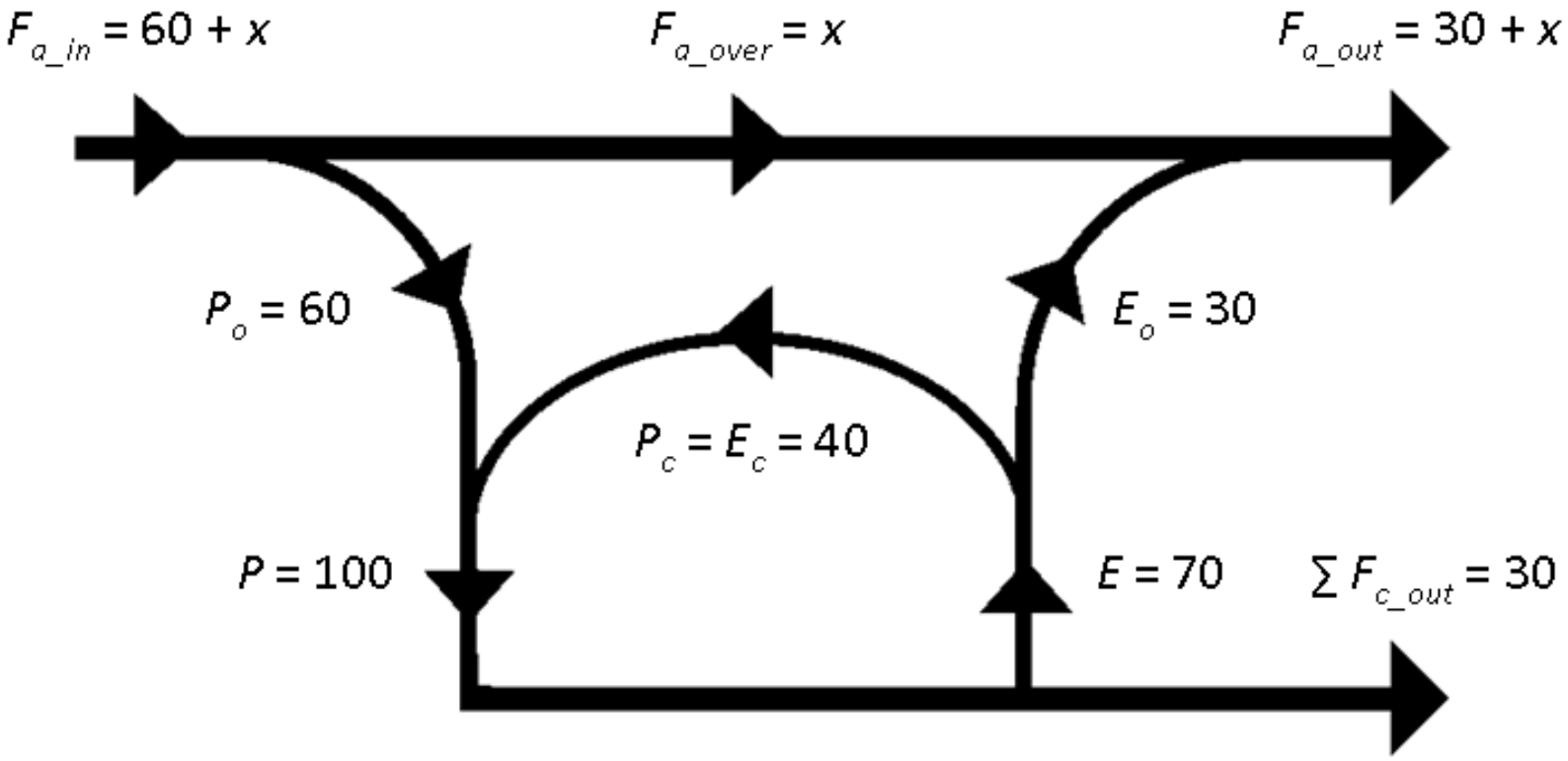


ε_c:

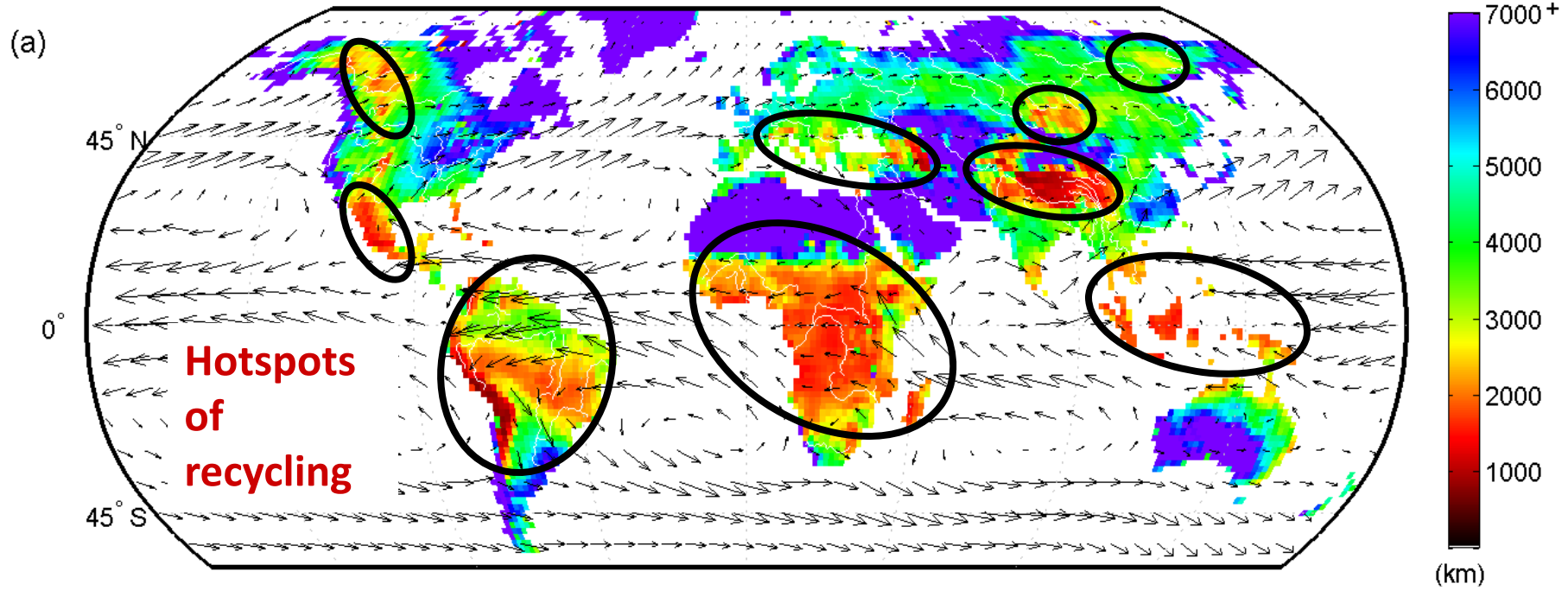
Fraction of the evaporation that returns as precipitation to any continental area



Water balance of 'the continent'



Local length scale of recycling



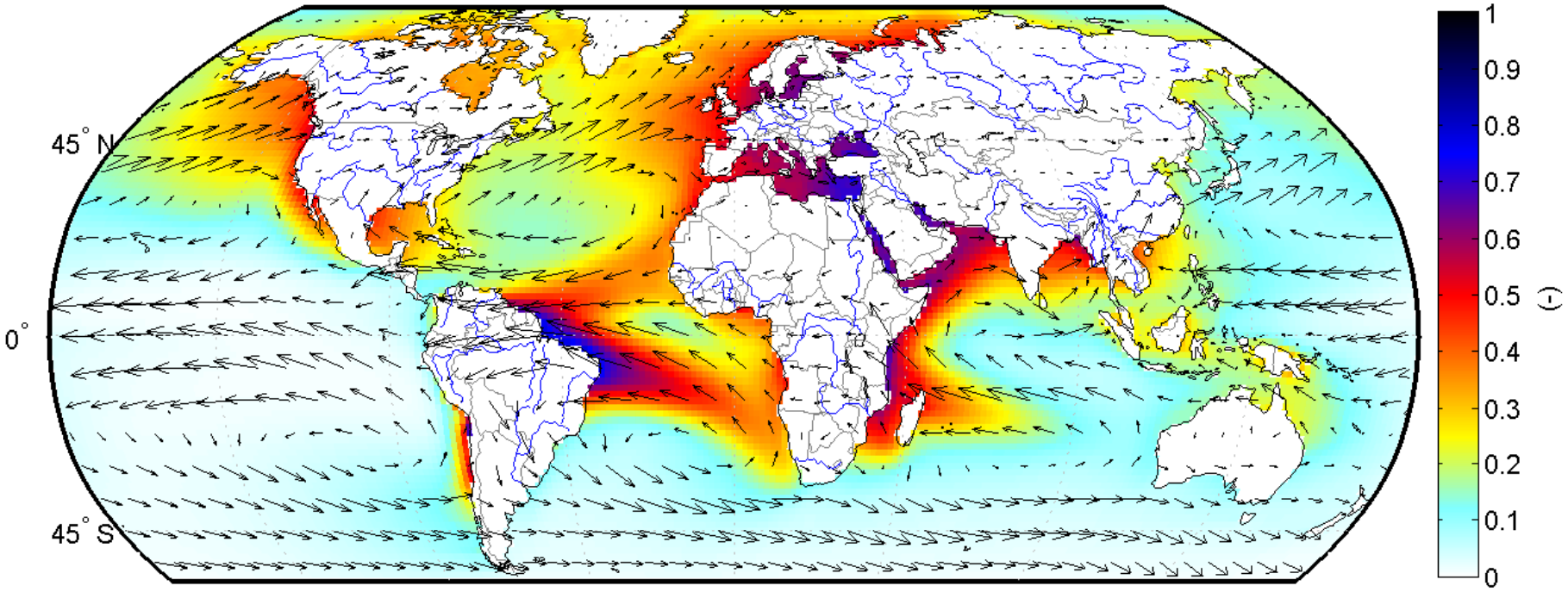
Oceanic versus continental sources

Characteristics

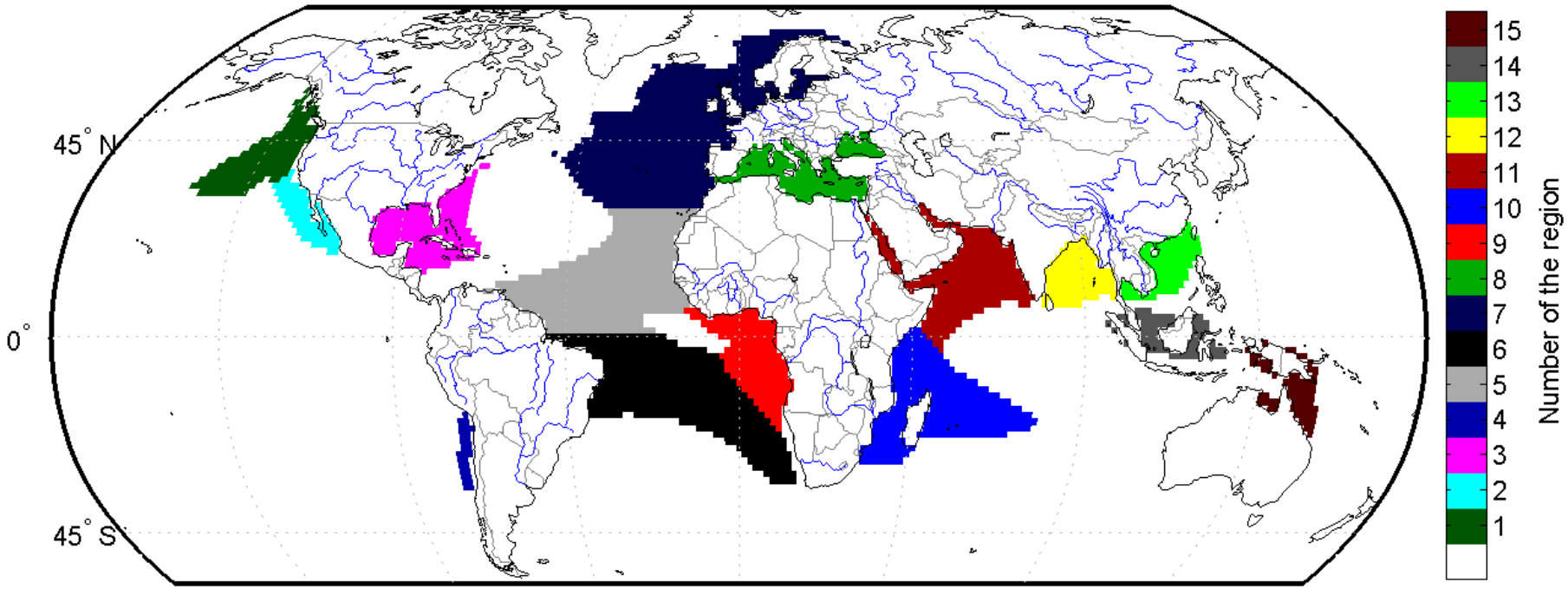
	Ocean	Continent
Evaporation	Related to sea surface temperature	Water limited or energy limited. Related to land-cover and land-use
Management timeframe	>100 years, carbon emissions	<10 years

Oceanic source regions

Fraction of oceanic evaporation that will fall on a continent

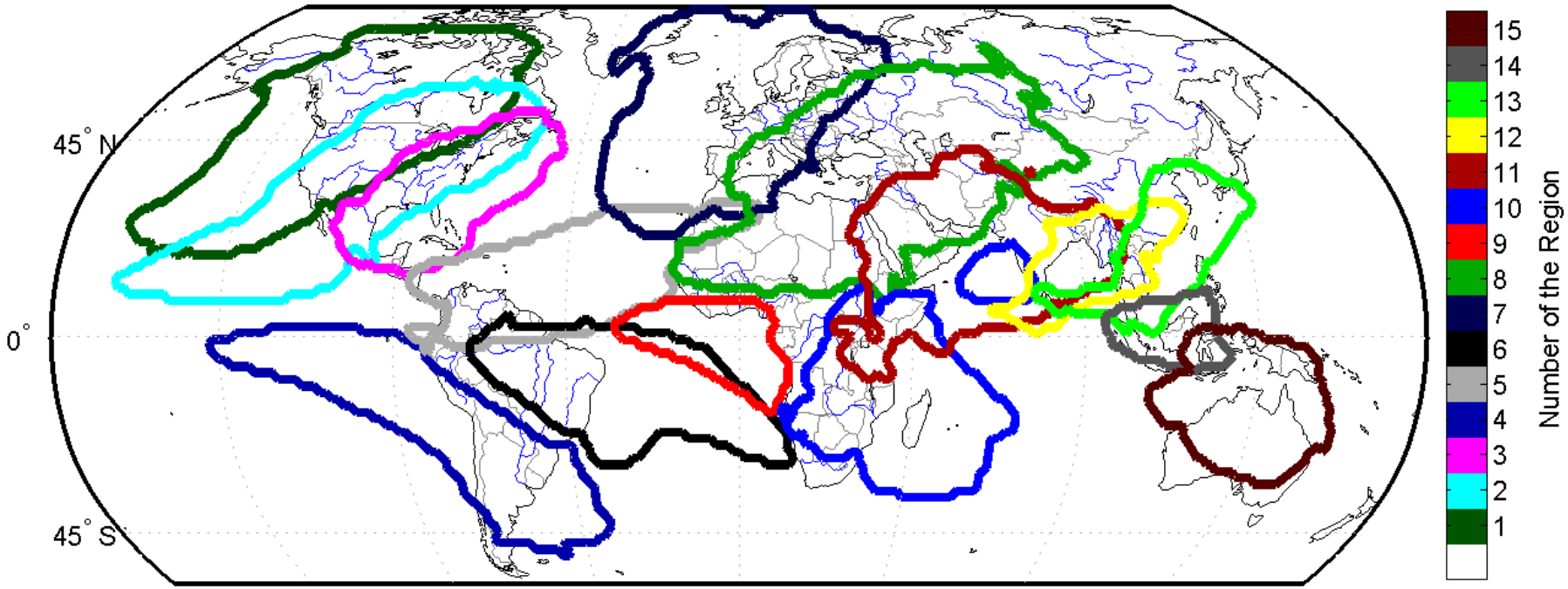


Oceanic source regions



Oceanic source regions

Boundaries enclose the area where 50% of the evaporation from the source regions ends up as precipitation

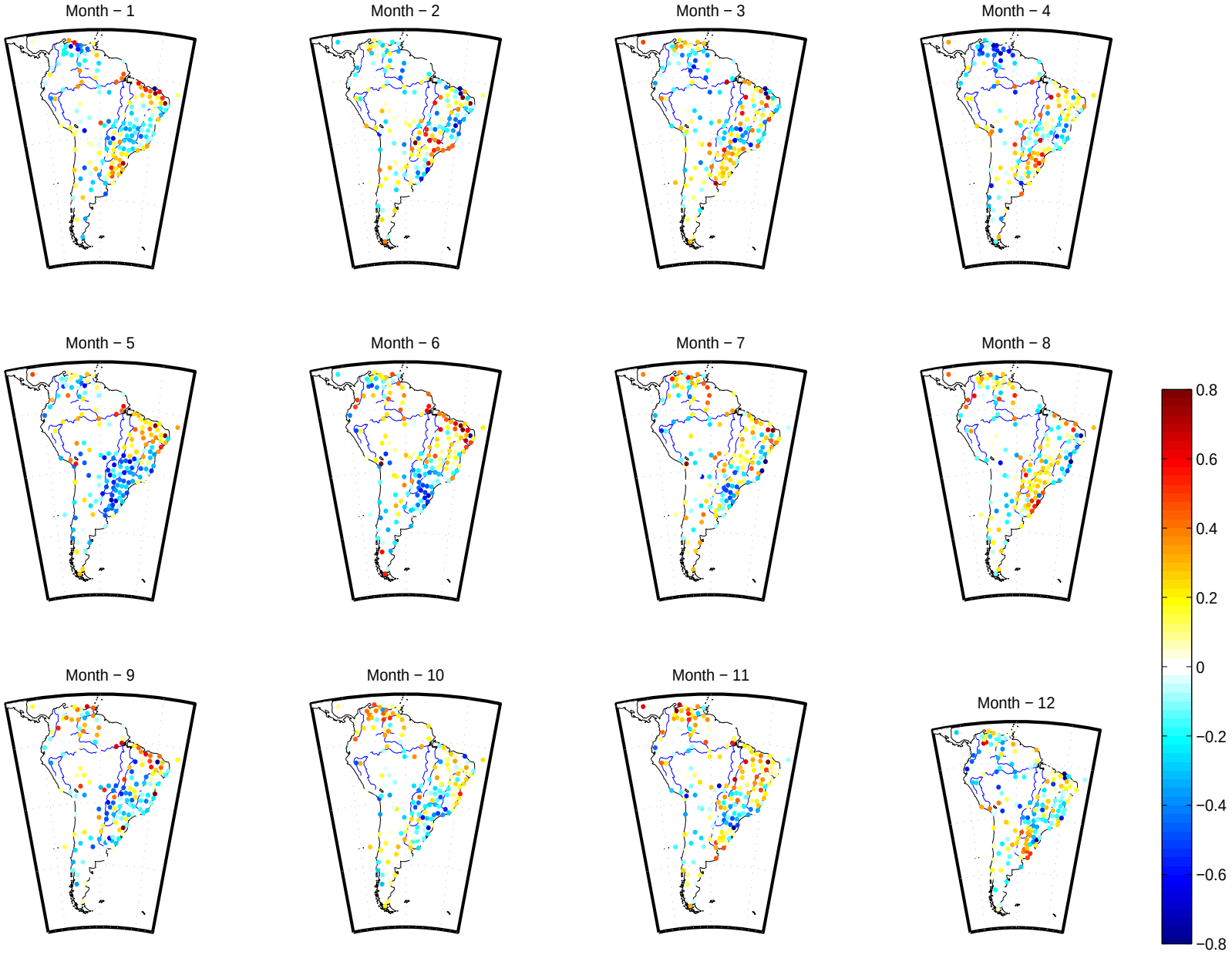


Oceanic source regions

SST related to continental precipitation?

- Observed (station data) precipitation and SST product (Pathfinder) – unpublished work

Correlation P and SST in Region 6



Oceanic source regions

SST related to continental precipitation?

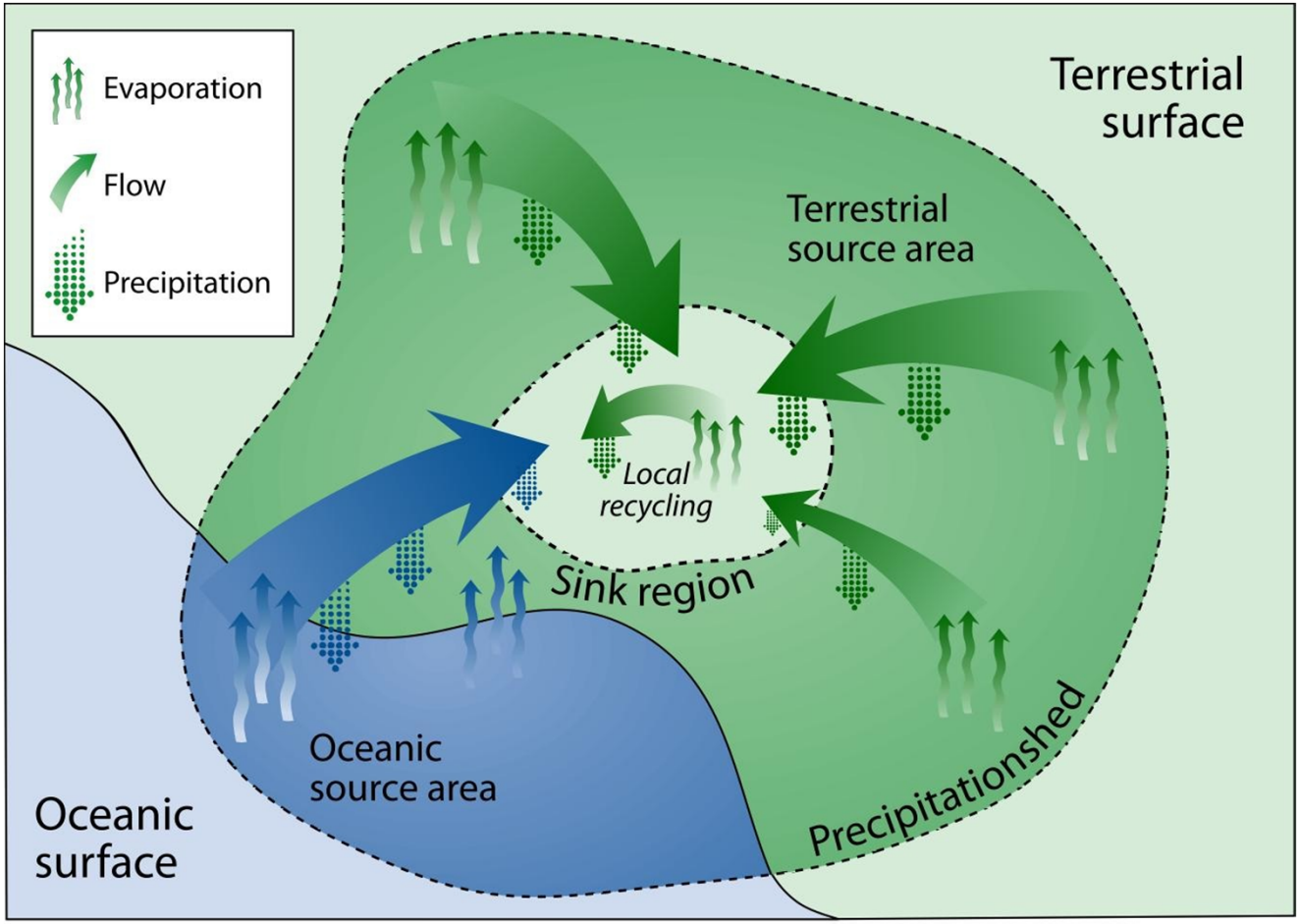
- Difficult to establish statistically significant trends for large areas
- Changed winds are (probably) a bigger driver for (coastal) precipitation than increased oceanic evaporation

Continental sources

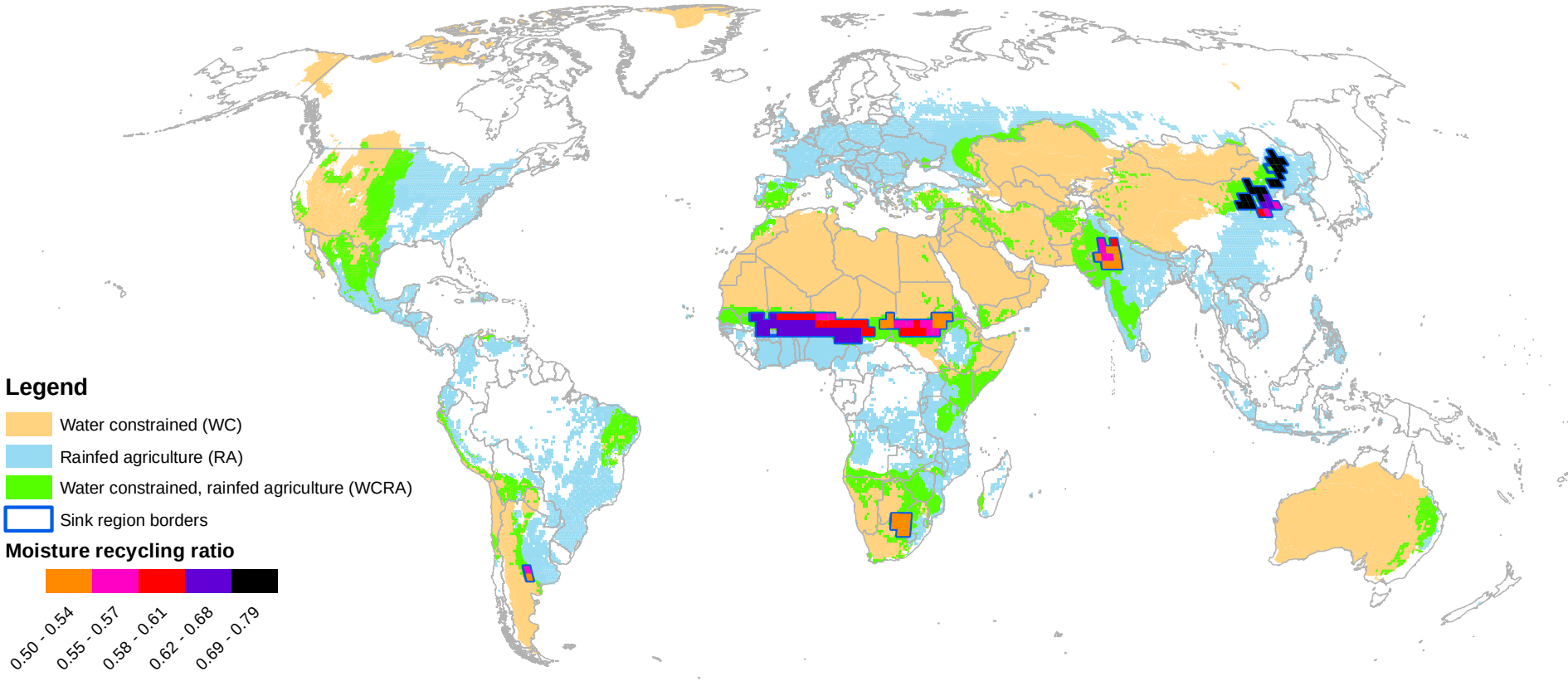
Potentially more to manage?

- Keys et al., Analyzing precipitationsheds to understand the vulnerability of rainfall dependent regions, *Biogeosciences*, 2012.

The precipitationshed



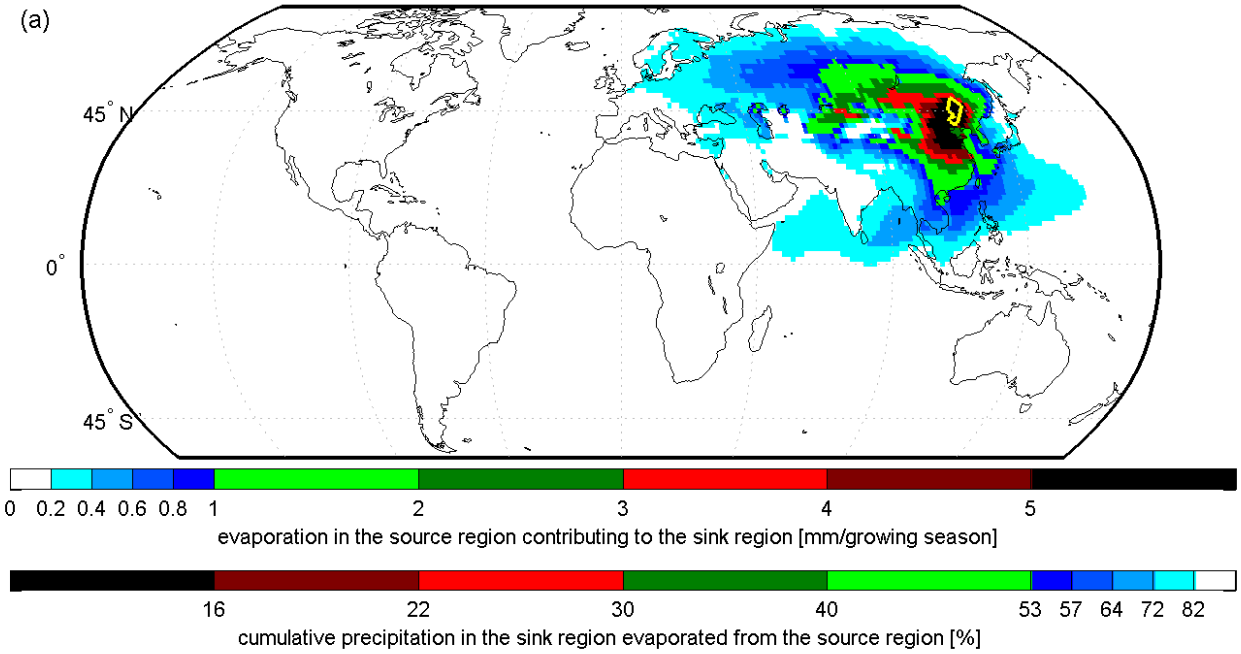
The precipitationshed

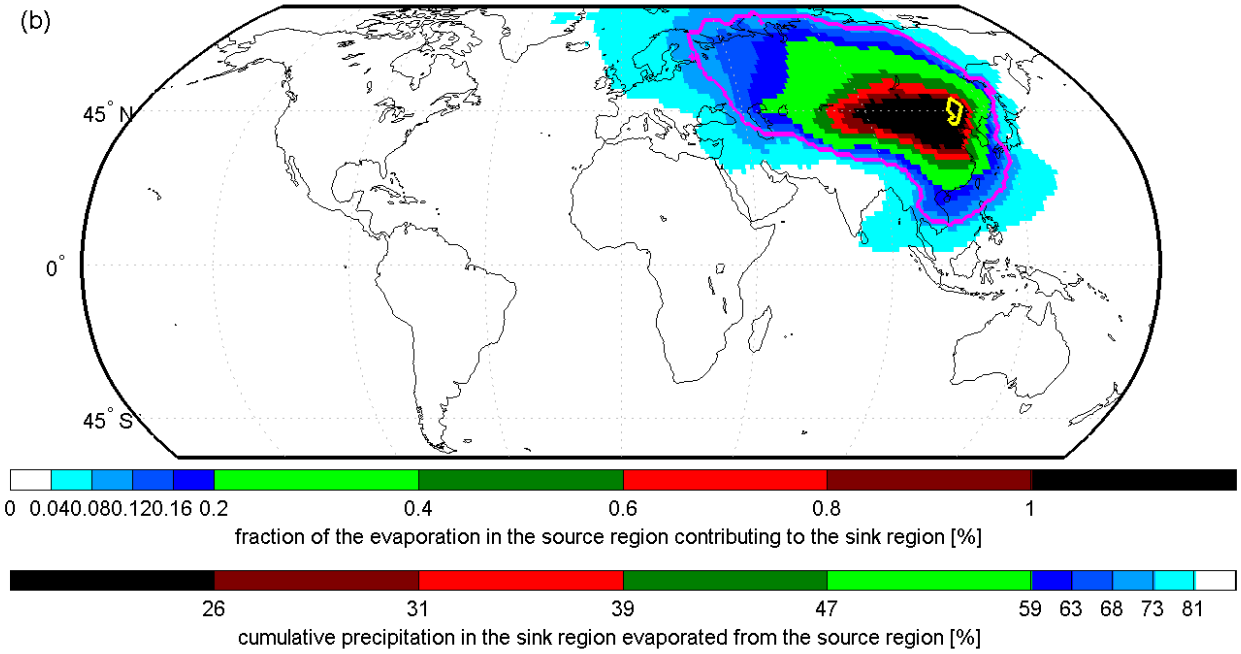


Region	Area size (10^6 km^2)	Growing season	Nations within sink region	Sum of the rainfall during the growing season (mm)	Rainfall during the growing season as a fraction of the yearly precipitation	Rainfall originating from terrestrial sources during the growing season
East China	35	May-Sep	China	419	79%	64%
North China	20	May-Sep	China	334	81%	72%
Western Sahel	137	June-Oct	Benin, Burkina Faso, Cameroon, Chad, Mali, Mauritania, Niger, Nigeria	301	93%	64%
Eastern Sahel	54	June-Oct	Chad, Eritrea, Sudan	452	93%	59%
Argentina	4.5	Nov-Mar	Argentina	583	59%	57%
Pakistan-India	30	Jul-Nov	India, Pakistan	339	78%	55%
Southern Africa	20	Dec-Apr	Botswana, South Africa	343	64%	54%

Most vulnerable regions

Northern China region

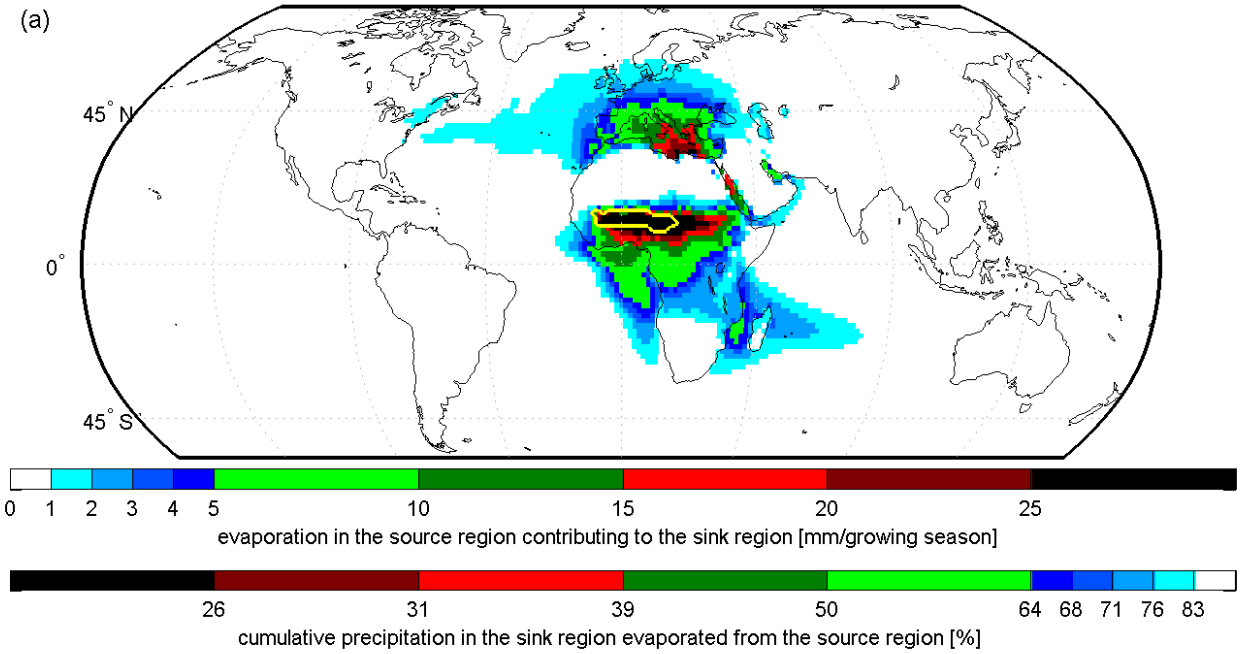


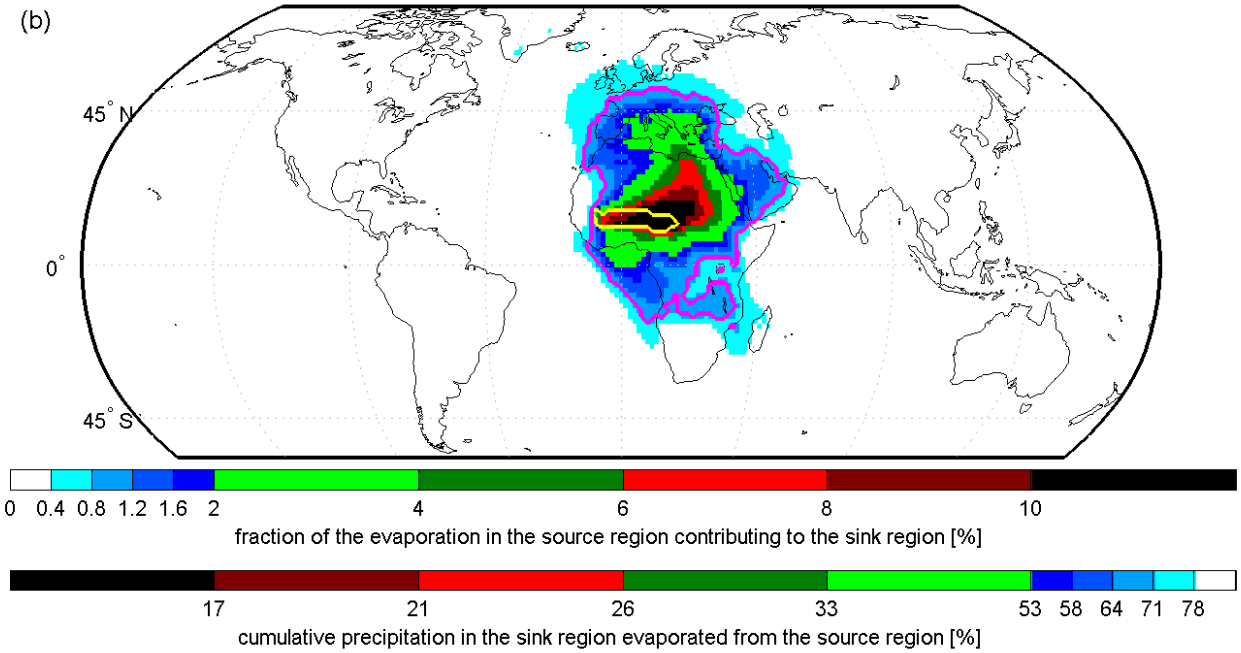


- Vulnerability:
  - High
- Threats:
  - Deforestation
  - Urbanization
  - Salinization
- Opportunities:
  - Afforestation
  - Water harvesting

Most vulnerable regions

Western Sahel region

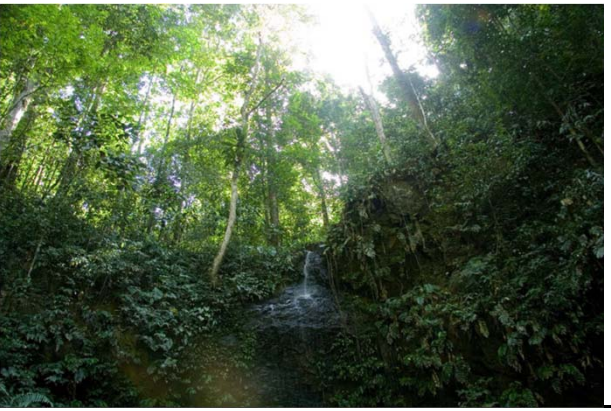


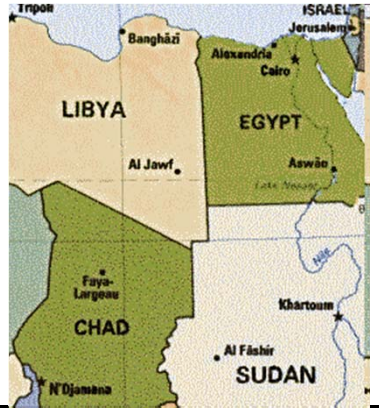


- Vulnerability:
  - Medium
- Threats:
  - Deforestation
  - Overgrazing
- Opportunities:
  - Afforestation
  - Irrigation

Take home messages

- Make use of the Precipitationshed
- We need to preserve forests and use sustainable agriculture
- Do not enhance fast drainage, but try to retain the water
- Include ‘moisture recycling’ in transboundary water management





Open questions

Some examples

- What if?
  - The whole ocean was 1° C warmer?
    - Clausius-Clayperon → 7% more rainfall per 1° C?
    - What about recycling?
    - Big difference between areas where evaporation is water limited and where evaporation is energy limited
  - We re-afforest the Sahel?
    - Can we simply increase the intensity of the hydrological cycle from east to west?
    - How much more rainfall will we get?
- We hope to further develop 'conceptual models' that can answer these questions and compare them with GCM results

Further reading

- van der Ent, R. J., H. H. G. Savenije, B. Schaefli, and S. C. Steele-Dunne (2010), Origin and fate of atmospheric moisture over continents, *Water Resour. Res.*, *46*, W09525, doi:10.1029/2010WR009127. http://www.agu.org/journals/wr/wr1009/2010WR009127/
- van der Ent, R. J., and H. H. G. Savenije (2011), Length and time scales of atmospheric moisture recycling, *Atmos. Chem. Phys.*, 11, 1853-1863, doi:10.5194/acp-11-1853-2011. http://www.atmos-chem-phys.net/11/1853/2011/acp-11-1853-2011.html
- Keys, P., R. J. van der Ent, L. Gordon, H. Hoff, R. Nikoli and H. H. G. Savenije (2012), Analyzing precipitationsheds to understand the vulnerability of rainfall dependent regions, *Biogeosci.,* 9, 733-746, 10.5194/bg-9-733-2012. http://www.biogeosciences.net/9/733/2012/bg-9-733-2012.html
- Schaefli, B., R. J. van der Ent, R. Woods, and H. H. G. Savenije (2011), An analytical model for soil-atmosphere feedback, *Hydrol. Earth Syst. Sci. Discuss., 8(5), 8315-8354.* http://www.hydrol-earth-syst-sci-discuss.net/8/8315/2011/hessd-8-8315-2011.html
- Van der Ent, R. J., A. M. J. Coenders-Gerrits, R. Nikoli and H. H. G. Savenije (2012), The importance of proper hydrology in the forest cover-water yield debate, *Glob. Change Biol.,* accepted.