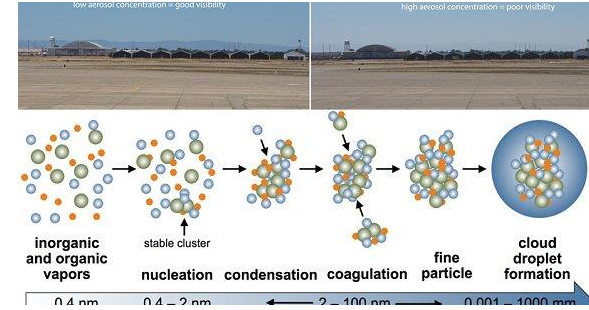
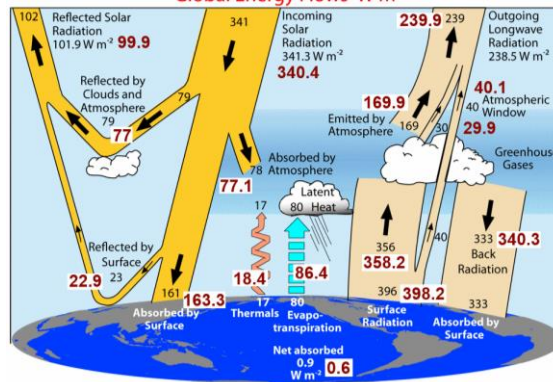
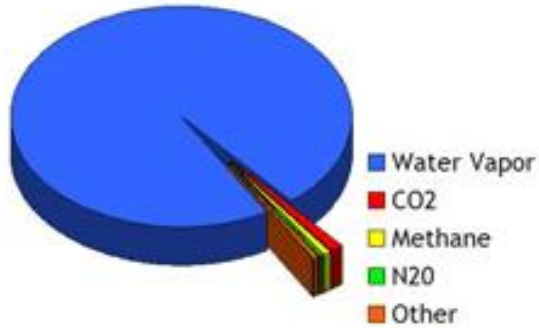


Global changes in relative humidity: connection with climate trends, humidity sources and moisture transport processes.

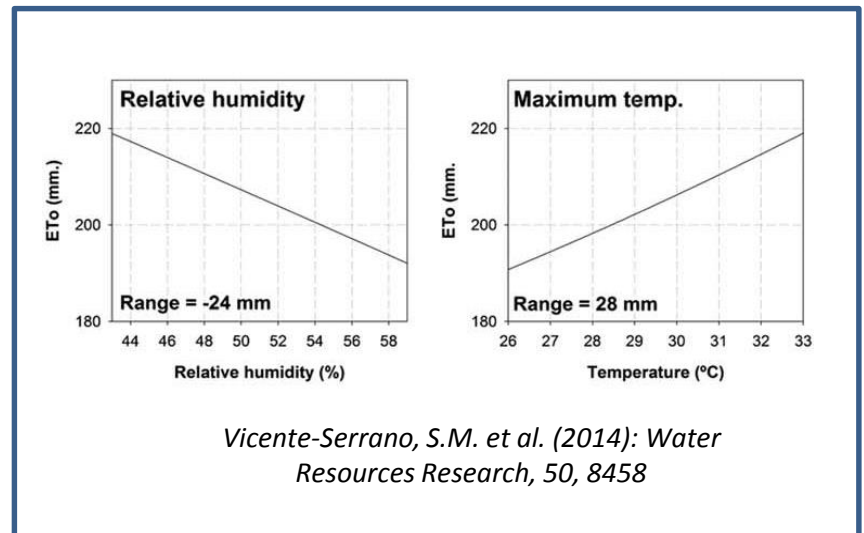
Sergio M. Vicente-Serrano¹, Raquel Nieto², Luis Gimeno², Cesar Azorin-Molina³

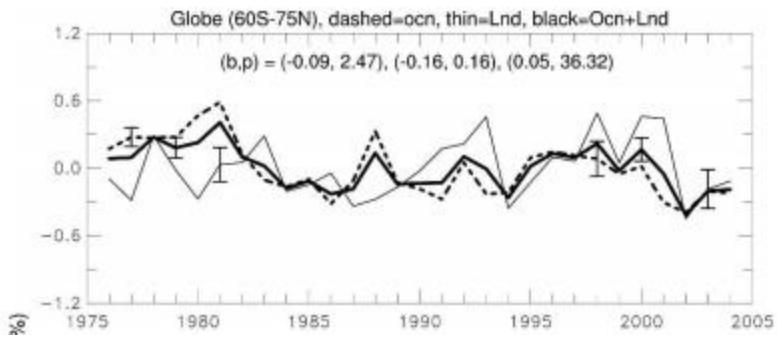
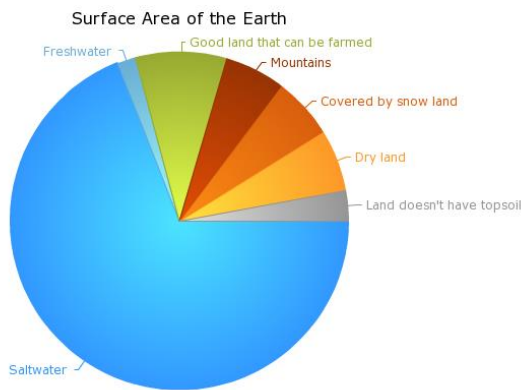
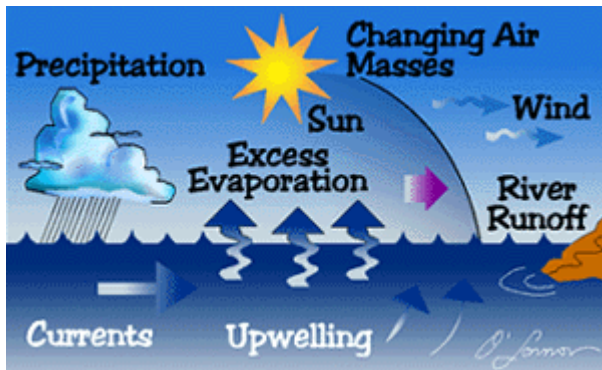
¹Instituto Pirenaico de Ecología, Consejo Superior de Investigaciones Científicas (IPE-CSIC), Zaragoza, Spain, ²Environmental Physics Laboratory, Universidade de Vigo, Ourense, Spain, ³University of Gothenburg, Gothenburg Sweden

Greenhouse Gases In The Atmosphere

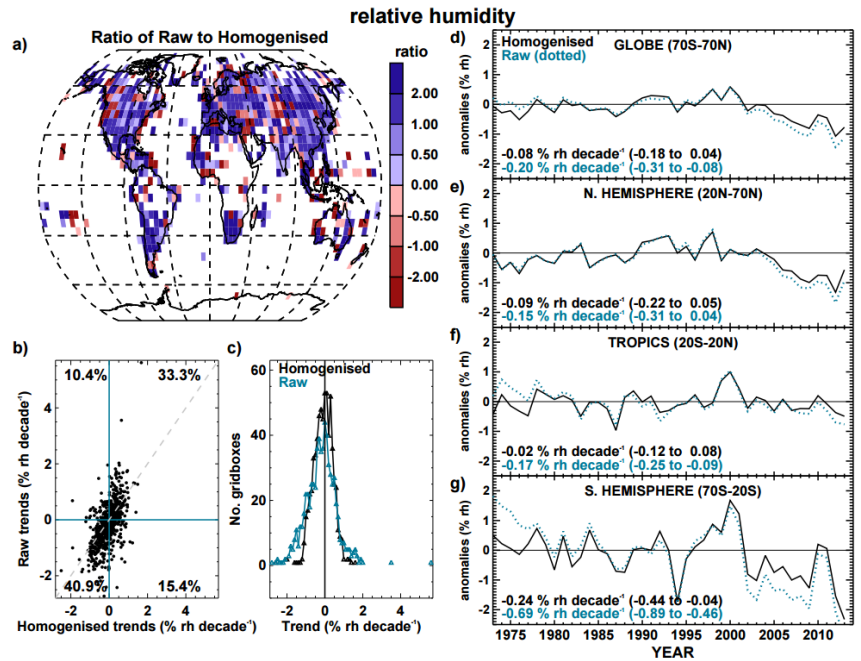


STRONG IMPORTANCE IN SEVERAL ATMOSPHERIC PROCESSES

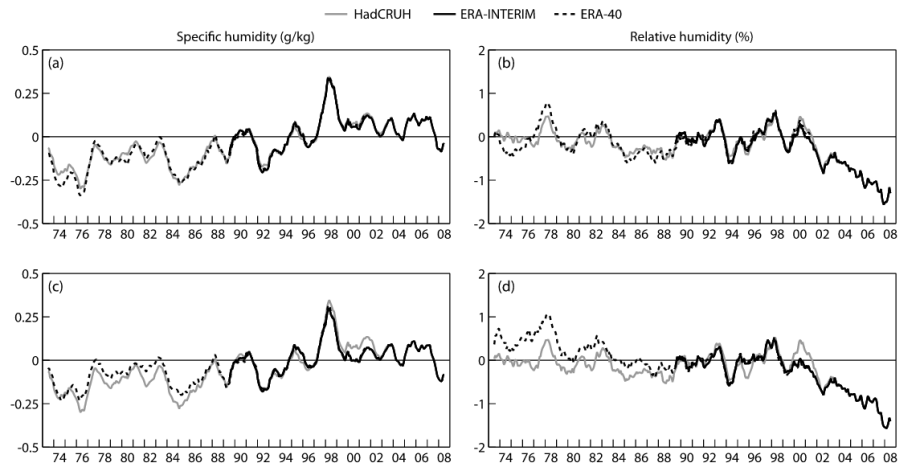




Dai, A. (2006): *J. Climate*, 19: 3589.

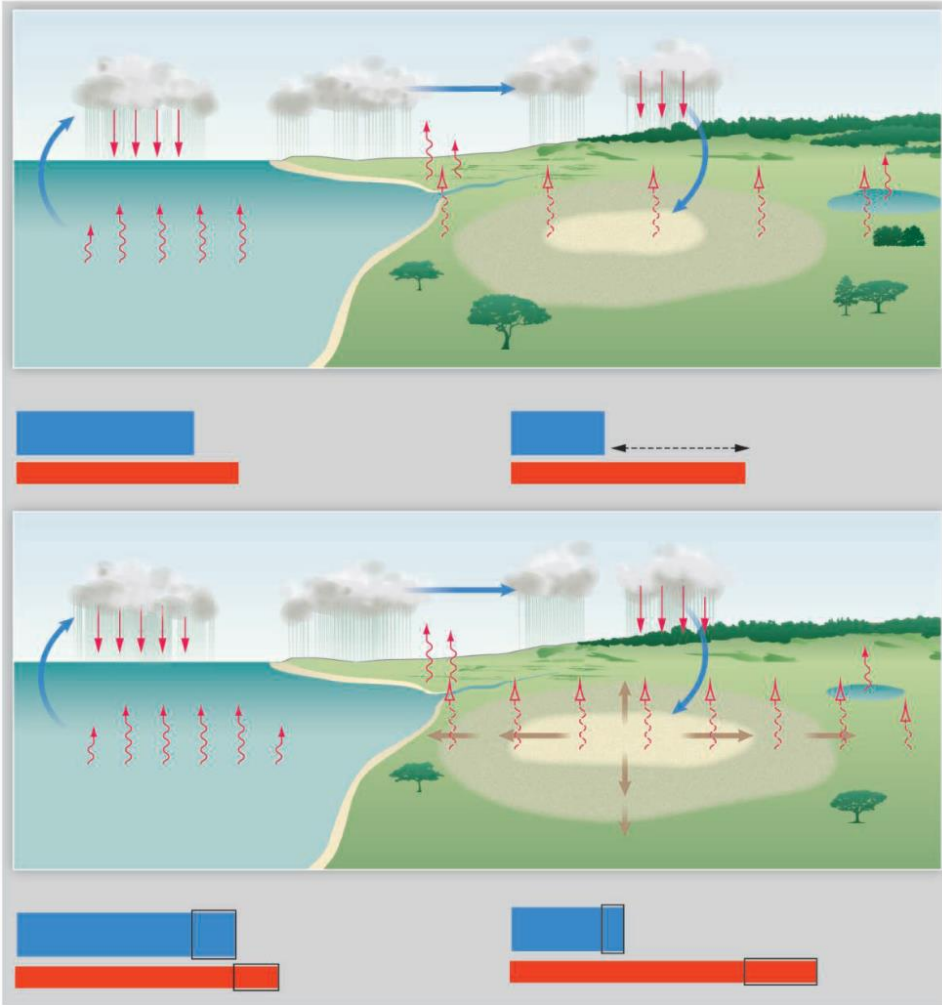


Willett, K. M., et al. (2014): *Clim. Past*, 10, 1983

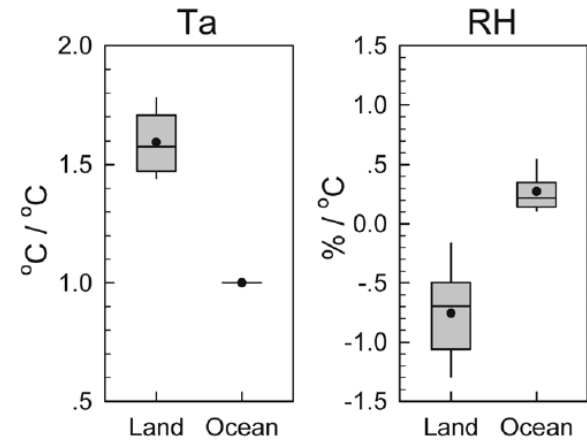


Simmons, A.J. et al (2010). *J Geophys Res Atmos* 115:D01110

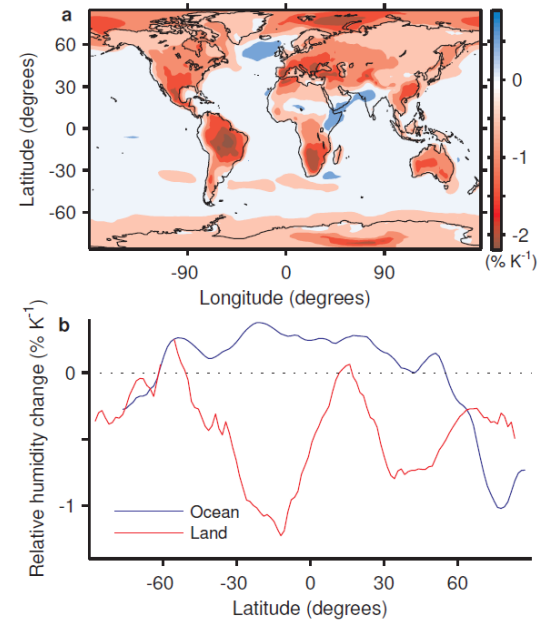
LAND-OCEAN DIFFERENCES



Sherwood and Fu (2014): *Science*, 343, 737.

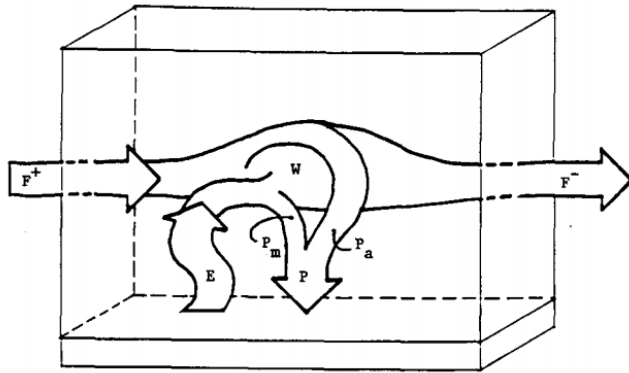


Fu, Q., and S. Feng (2014), *J. Geophys. Res. Atmos.*, 119, 7863–7875



Byrne, M., and P. O’Gorman, 2016: *J. Climate*. doi:10.1175/JCLI-D-16-0351

RECYCLING PROCESSES



Brubaker et al. (1993): Journal of Climate. 6: 1078

Continental precipitation recycling ratio ρ_c

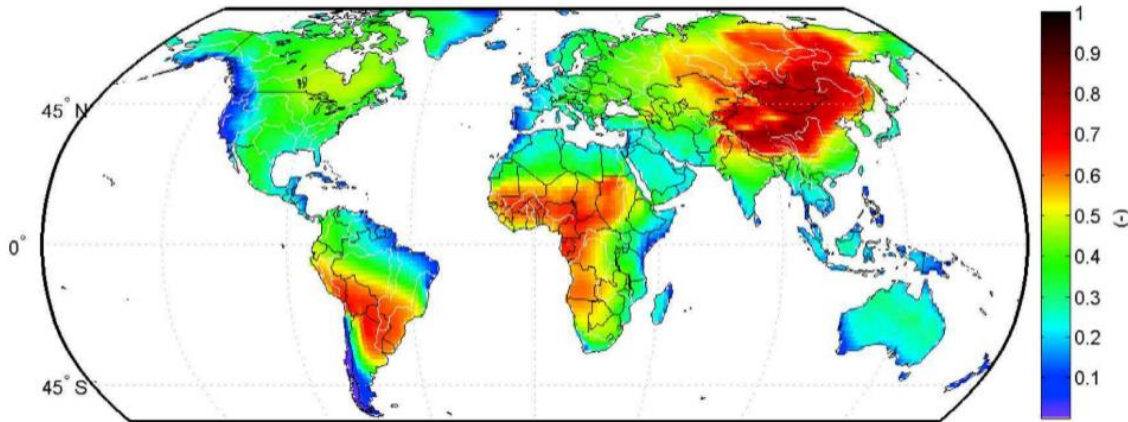
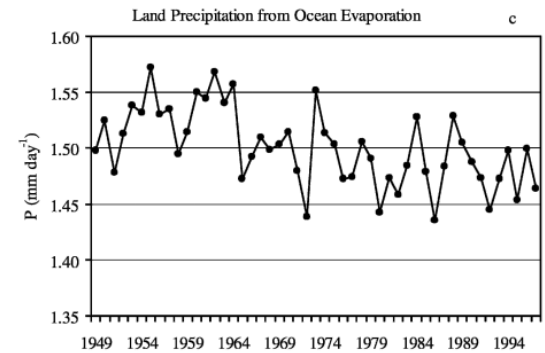
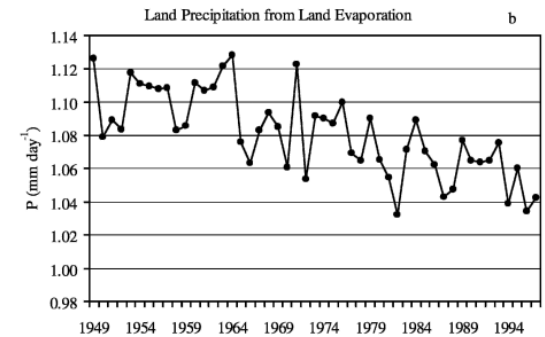


Figure 3. Average continental precipitation recycling ratio ρ_c (1999–2008).

Van der Ent et al. (2010): Water Resources Research. Vol 46, W09525



Bosilovich et al. (2005): Journal of Climate. 18: 1591

OBJECTIVES

- **TO DETERMINE SPATIAL AND SEASONAL PATTERNS OF RELATIVE HUMIDITY TRENDS**
- **TO IDENTIFY POSSIBLE DRIVERS OF RELATIVE HUMIDITY TRENDS:**
 - CLIMATE TRENDS**
 - CHANGES IN EVAPORATION IN OCEANIC HUMIDITY SOURCES**
 - CHANGES IN EVAPOTRANSPIRATION IN CONTINENTAL HUMIDITY SOURCES**

Met Office Hadley Centre observations datasets

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HadISDH - gridded global land surface humidity dataset - version 2.1.0.2015p



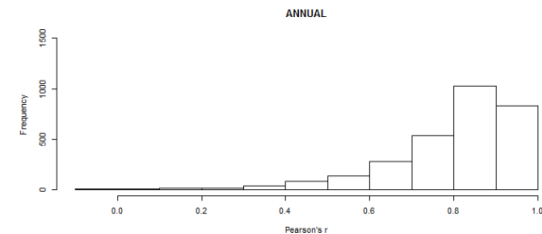
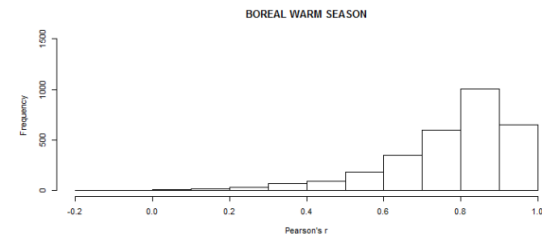
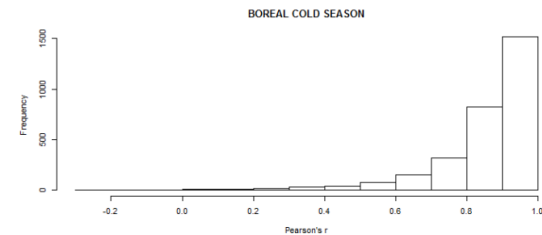
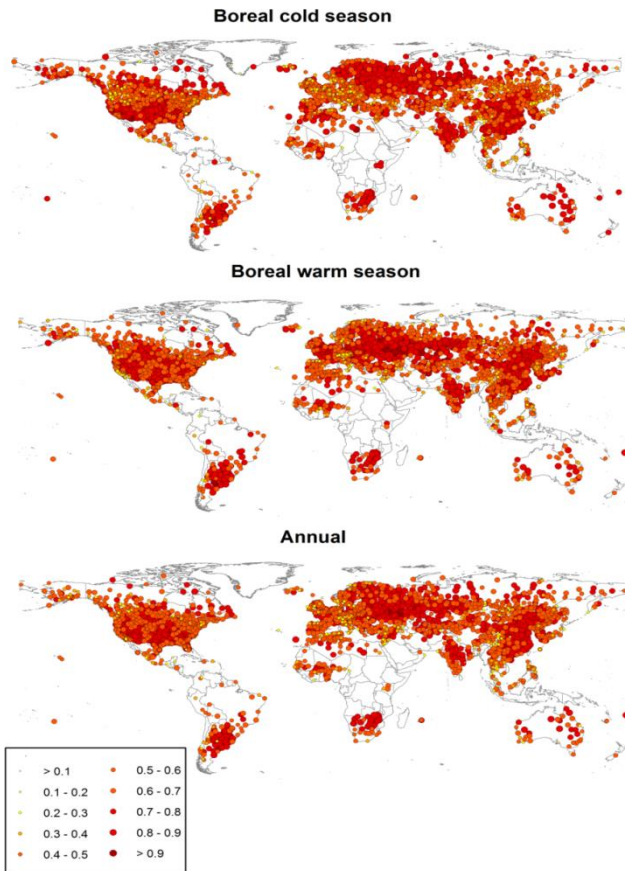
Station data: Relative humidity (3462 stations)

ECMWF

ERA-Interim

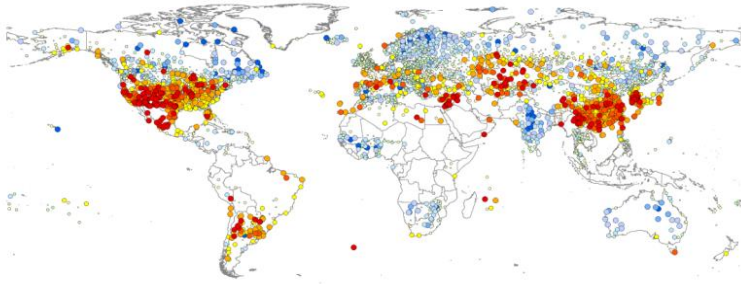


0.5° Gridded Relative humidity

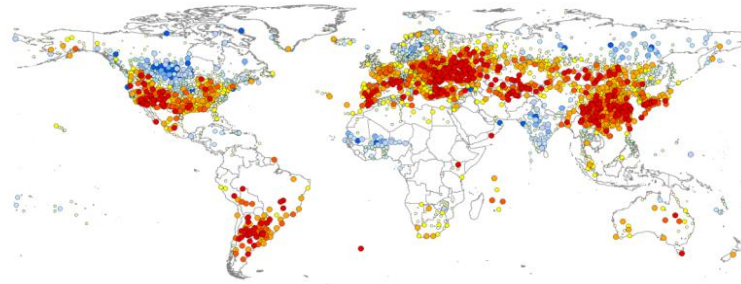


RELATIVE HUMIDITY TRENDS (1979-2014)

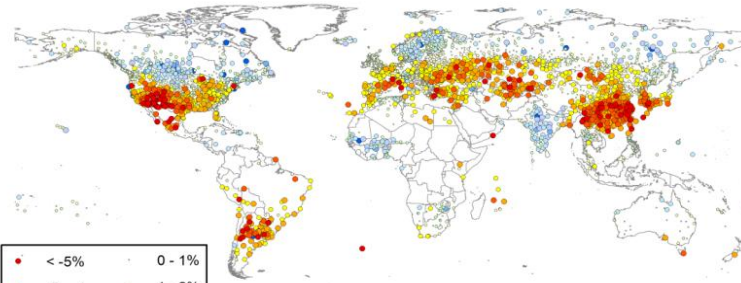
Boreal cold season



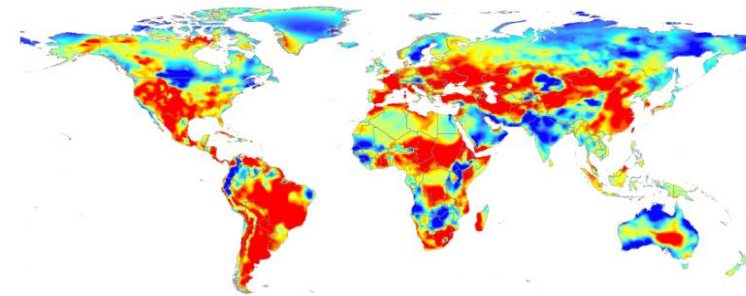
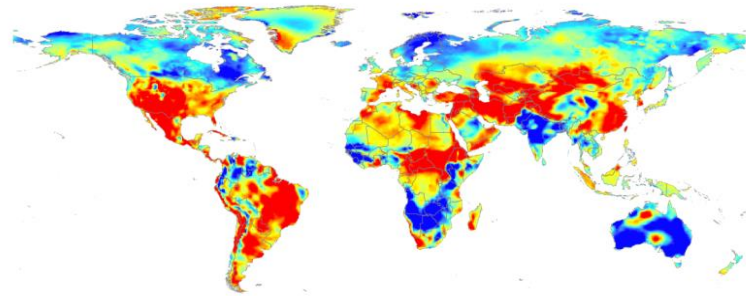
Boreal warm season



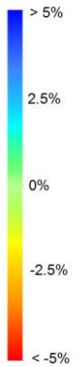
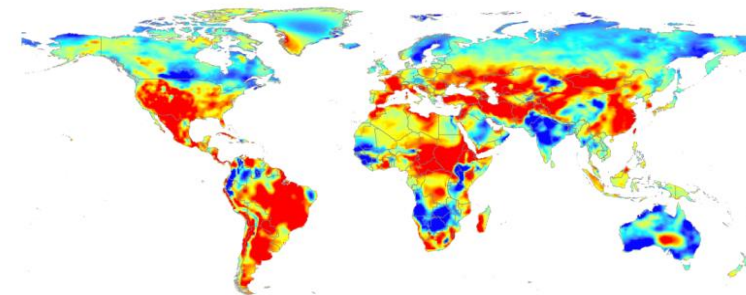
Annual



Boreal cold season

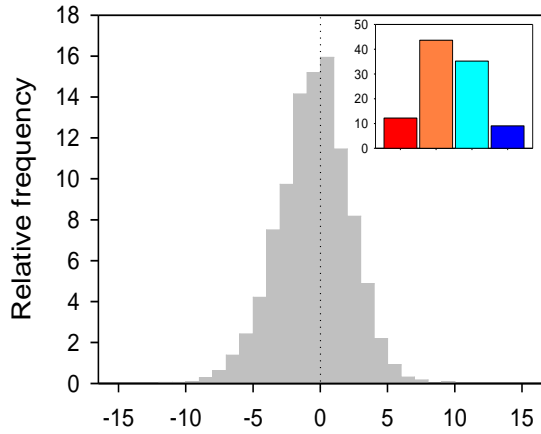


Annual

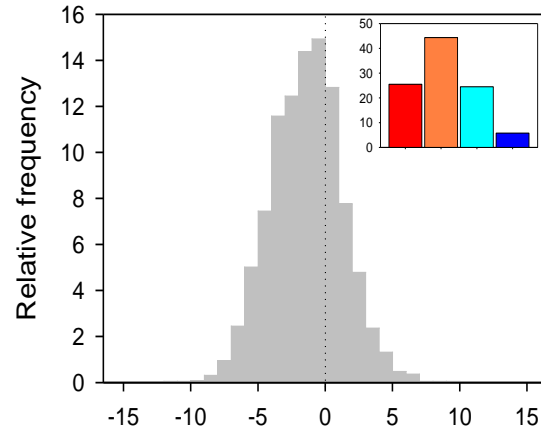


HadISDH

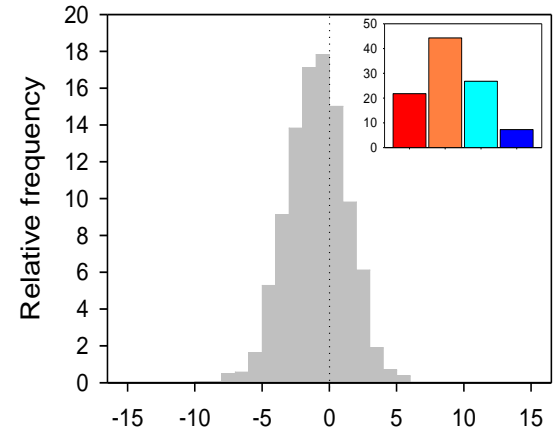
Boreal cold season



Boreal warm season

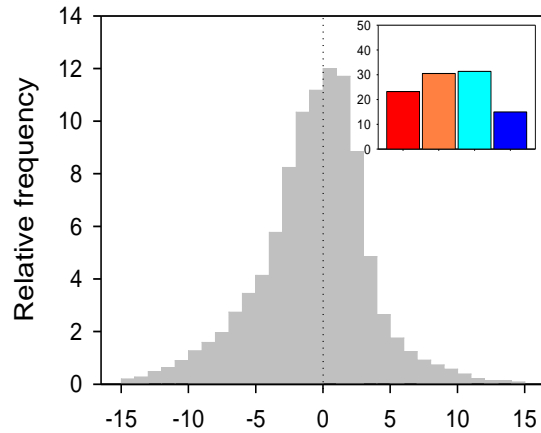


Annual

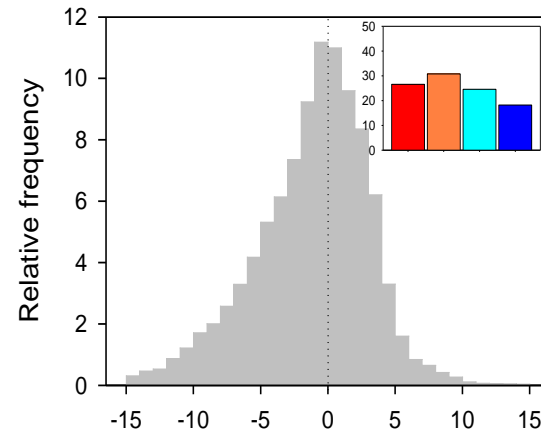


ERA-Interim

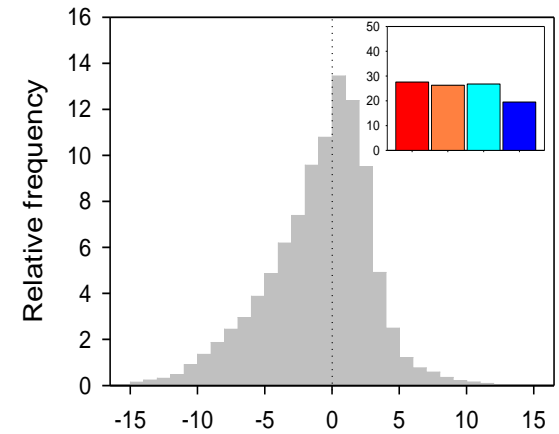
Boreal cold season

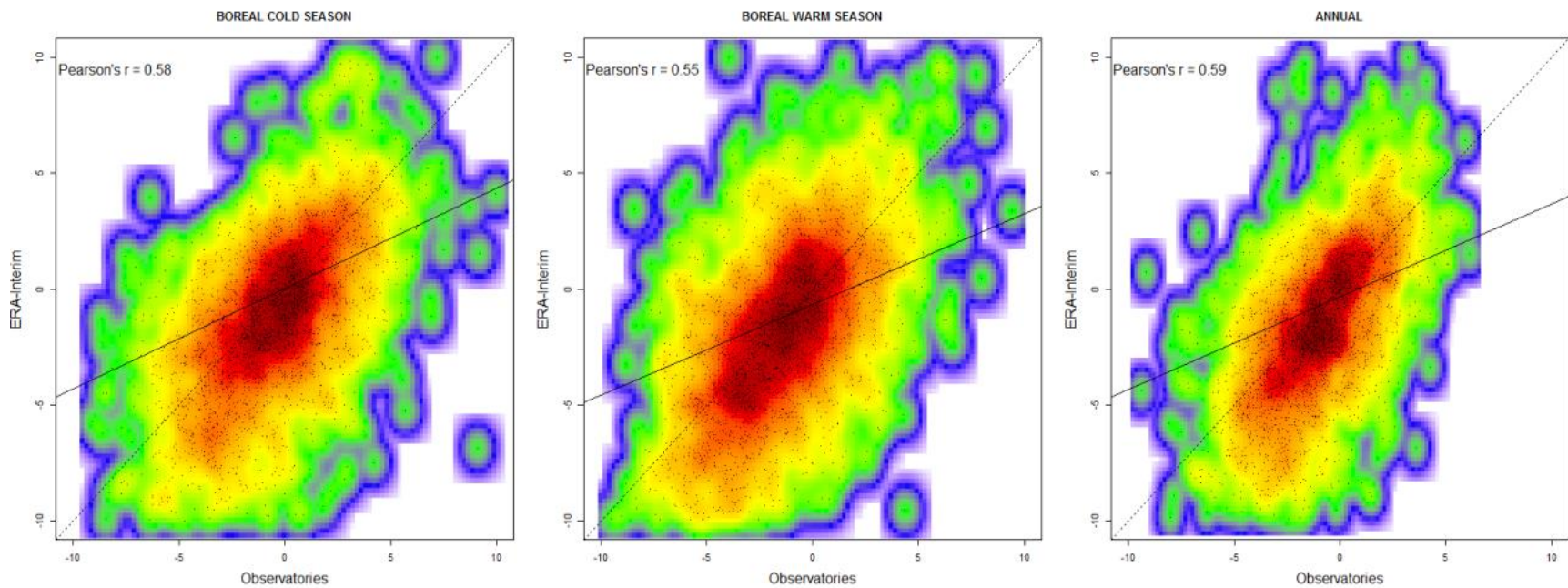


Boreal warm season

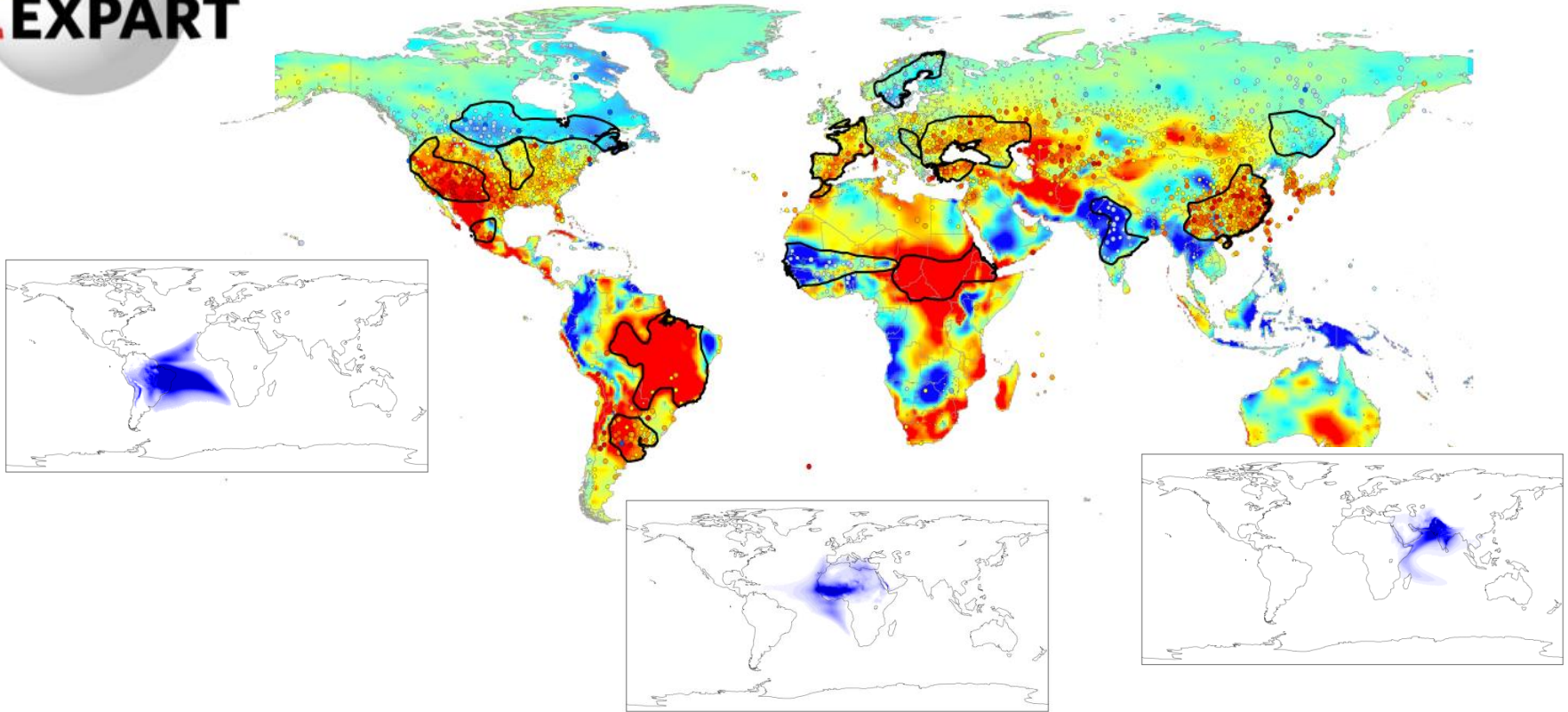


Annual





	Chi square	Sig.	C. Contingency
Boreal cold season	915.96	0.000	0.485
Boreal warm season	786.356	0.000	0.46
Annual	1080.115	0.000	0.516



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Hadley Centre SST data set (HadSST3)



5° SST



Climatic Research Unit



0.5° Precipitation and temperature



WHOI OAFlex Project

Objectively Analyzed air-sea Fluxes (OAFlex) for the Global Oceans

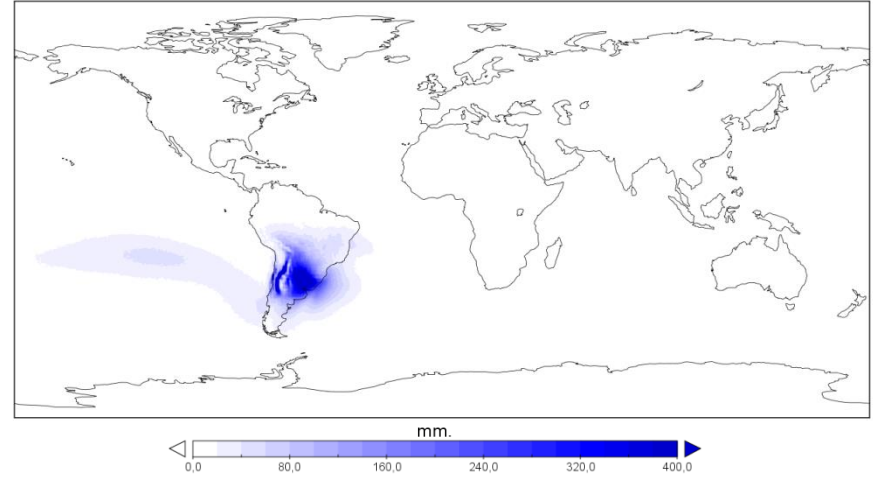
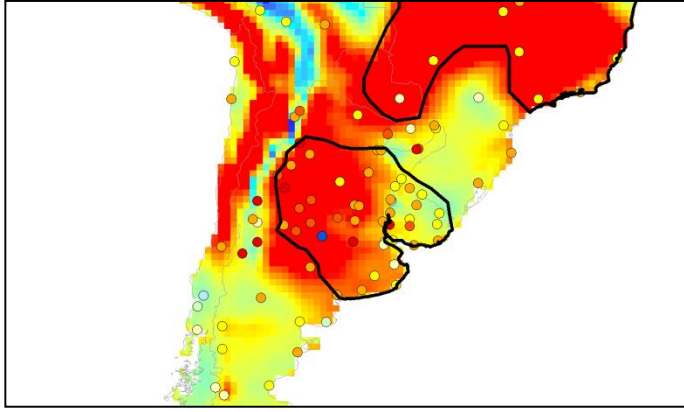


0.5° Ocean Evaporation

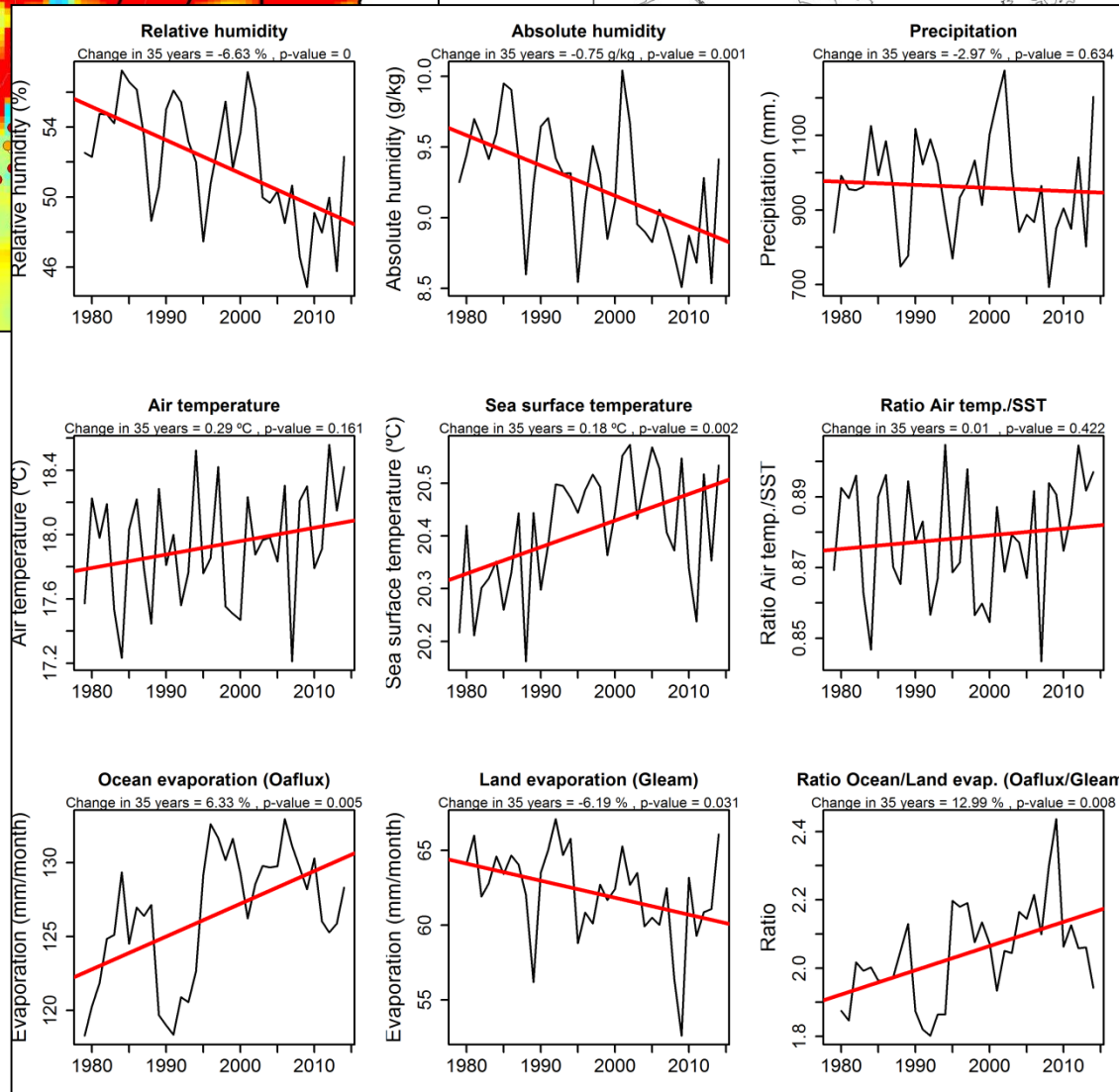
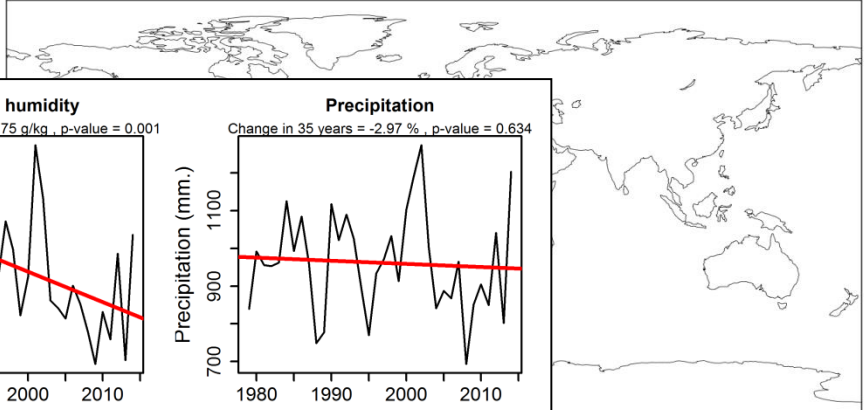
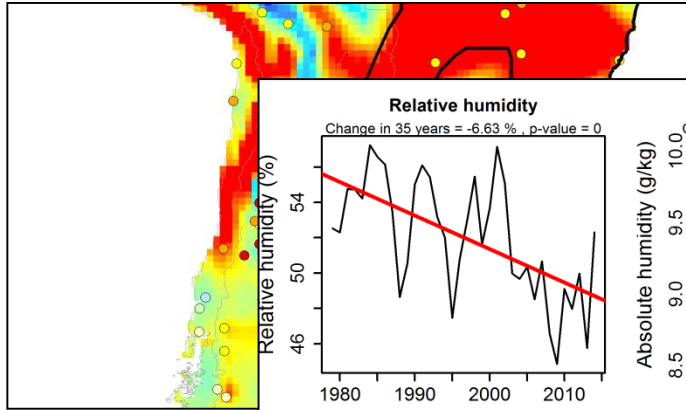


0.5° Land Evapotranspiration

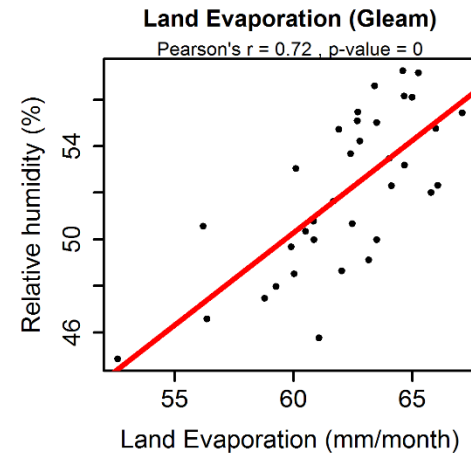
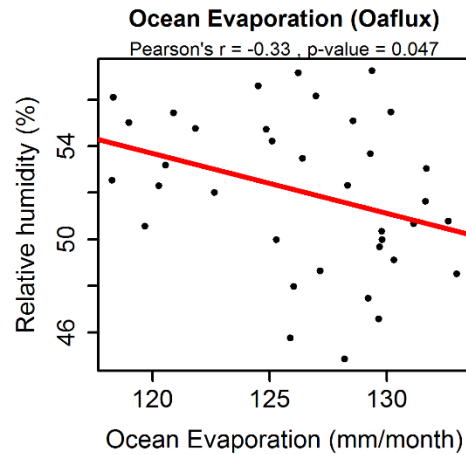
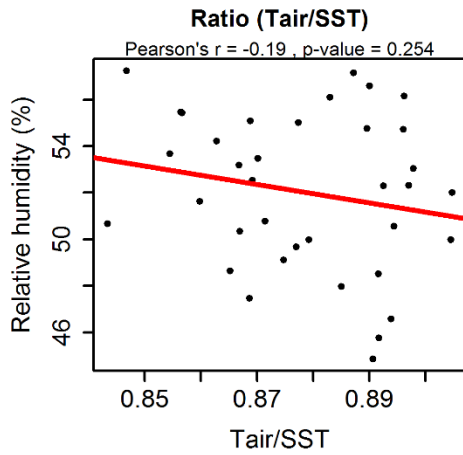
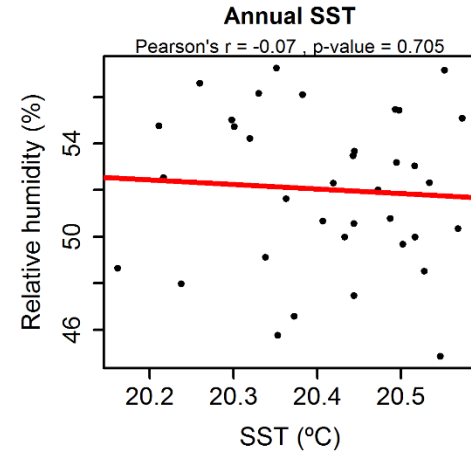
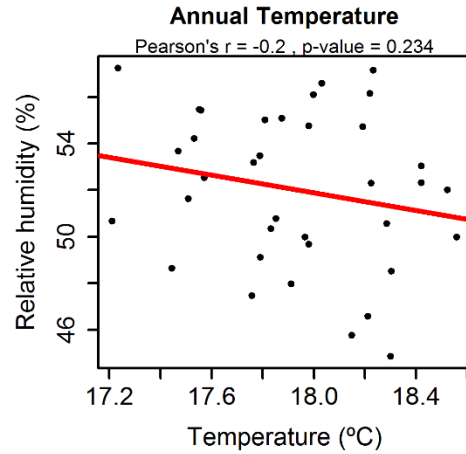
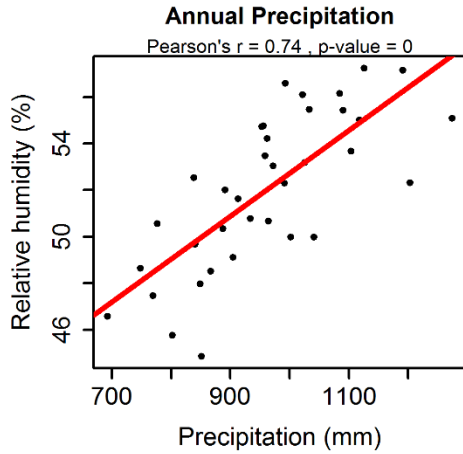
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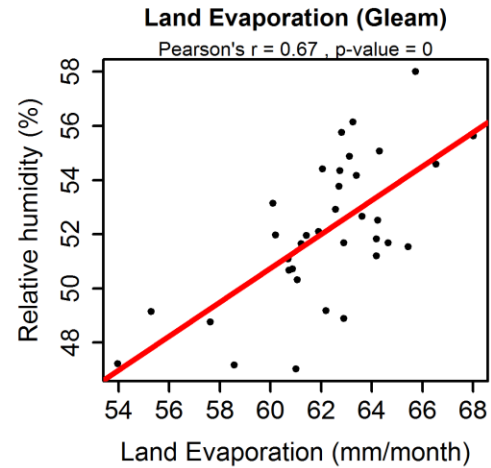
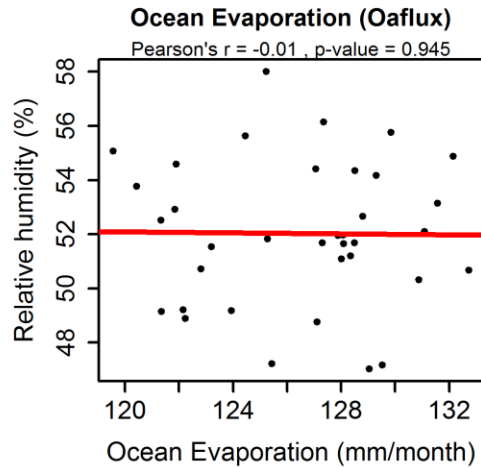
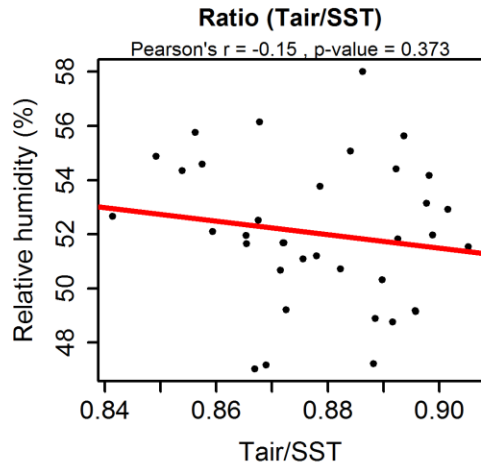
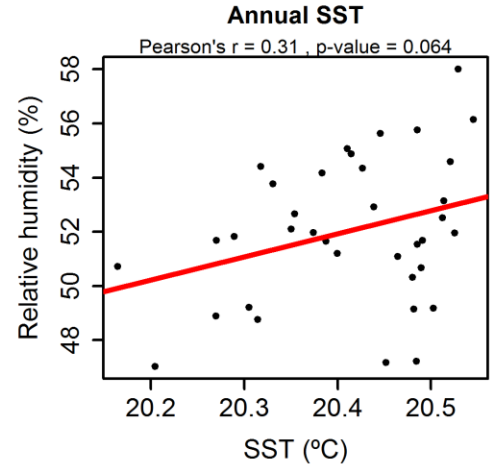
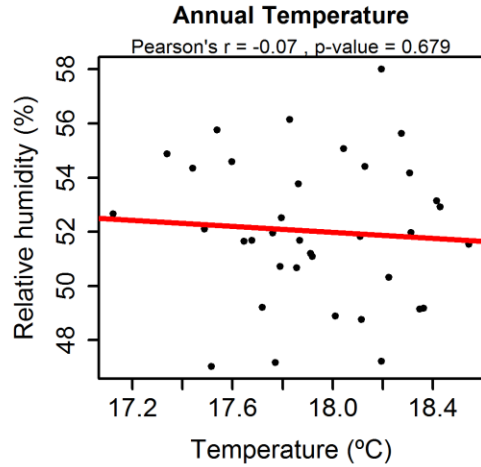
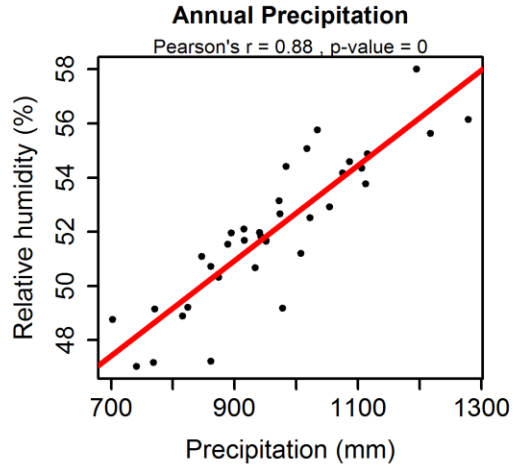
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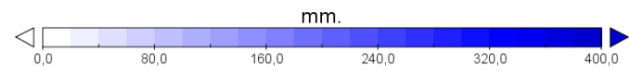
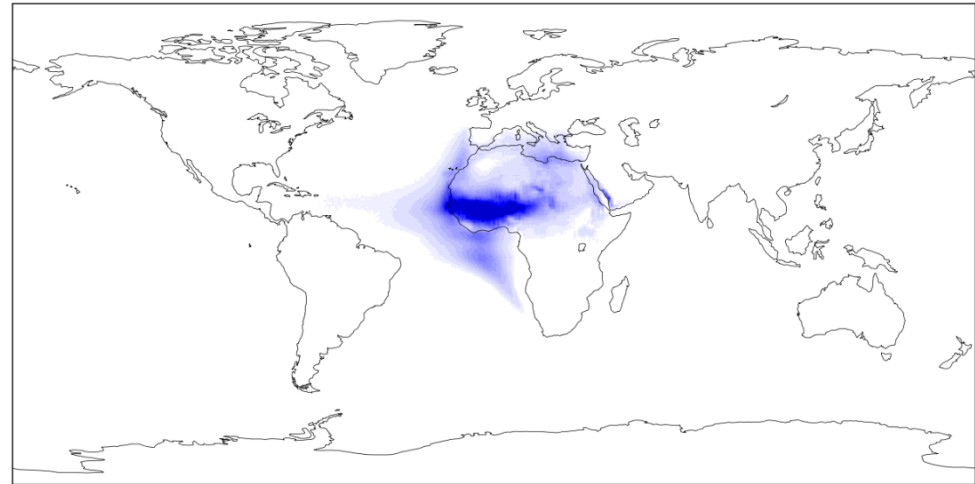
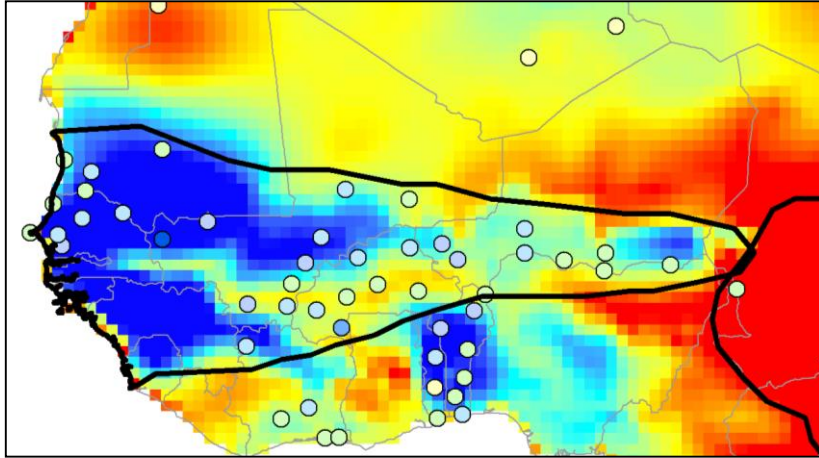
LA PLATA: OBSERVED SERIES



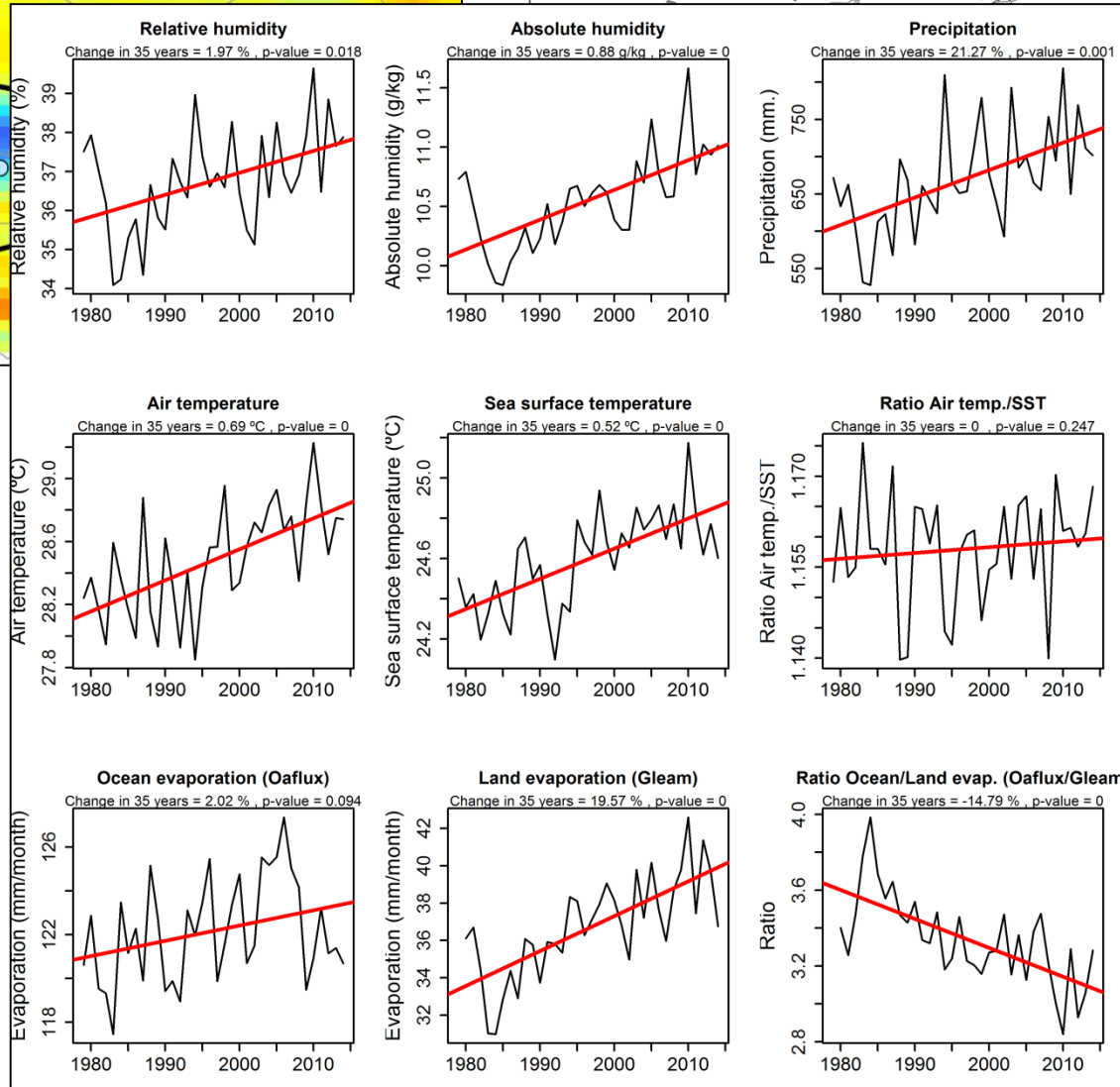
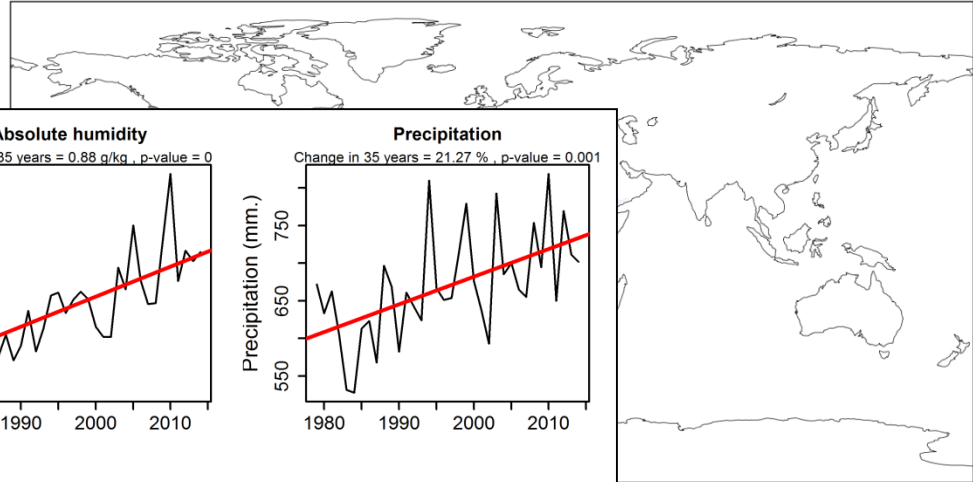
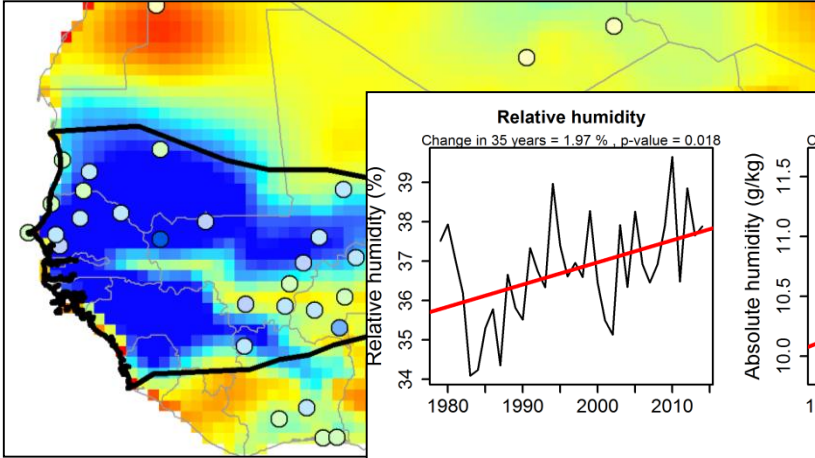
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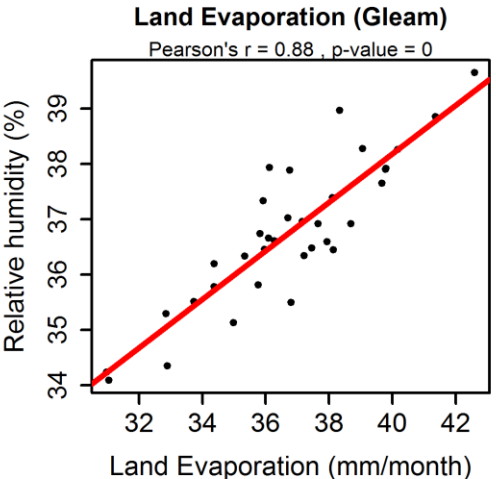
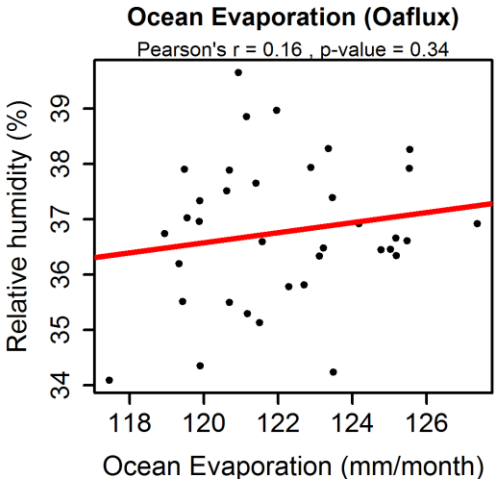
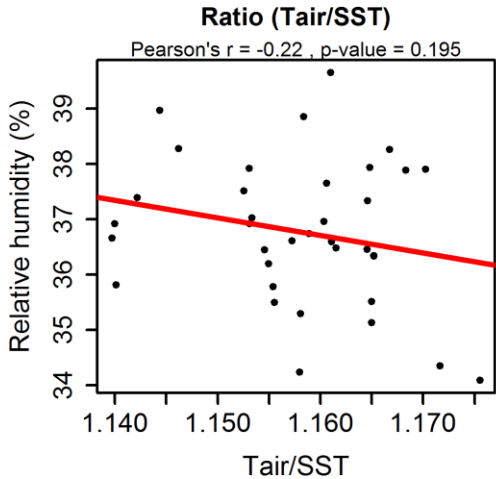
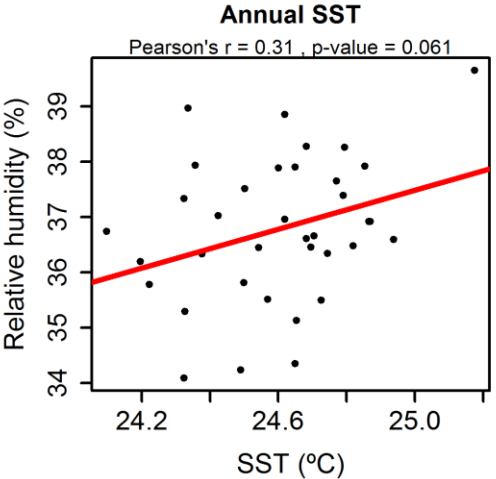
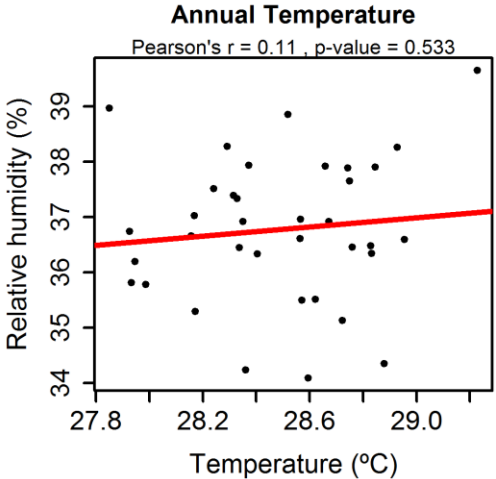
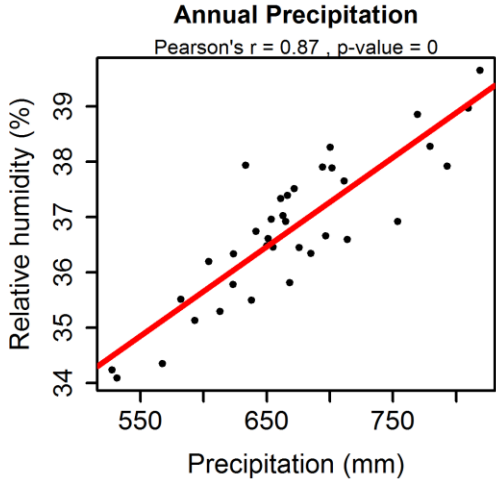
WEST SAHEL



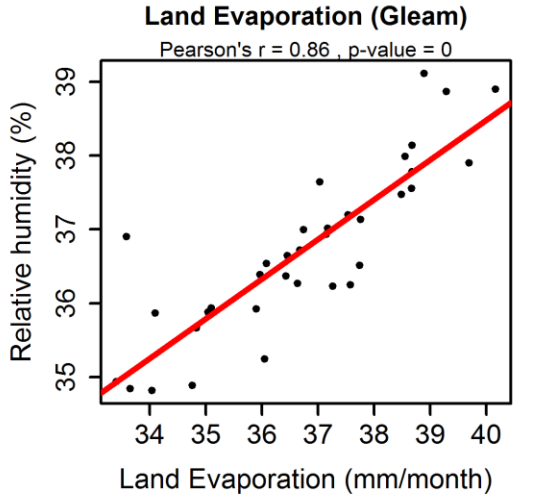
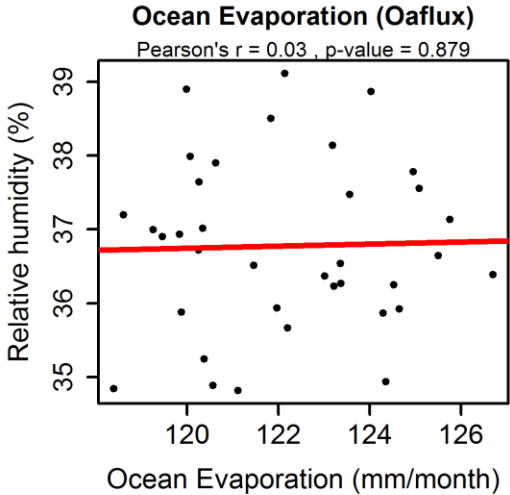
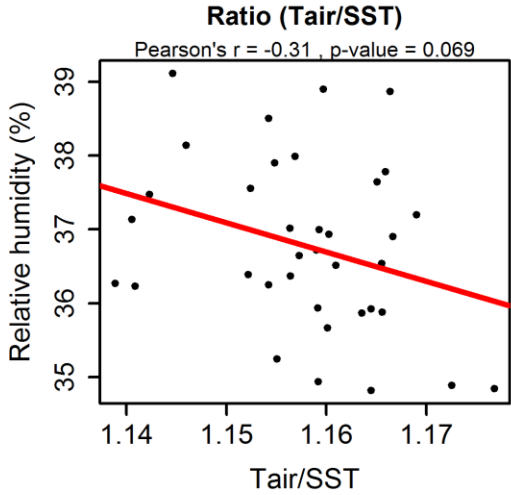
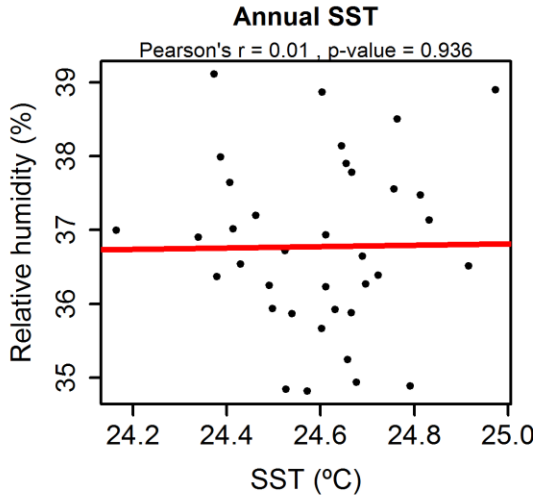
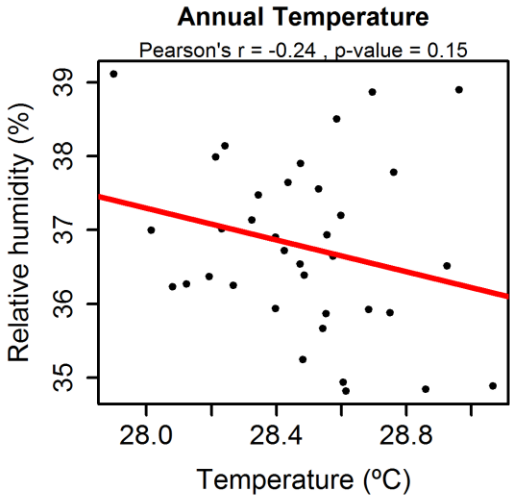
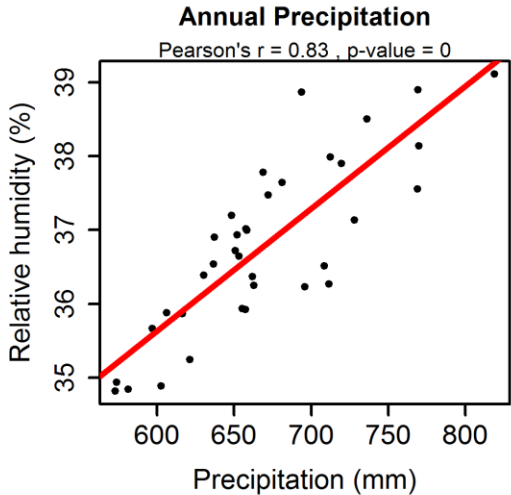
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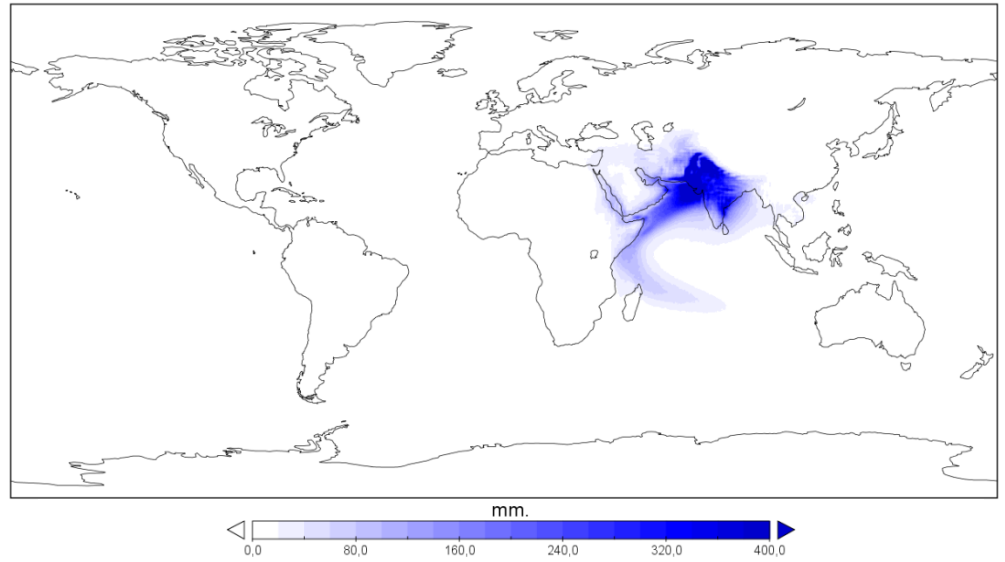
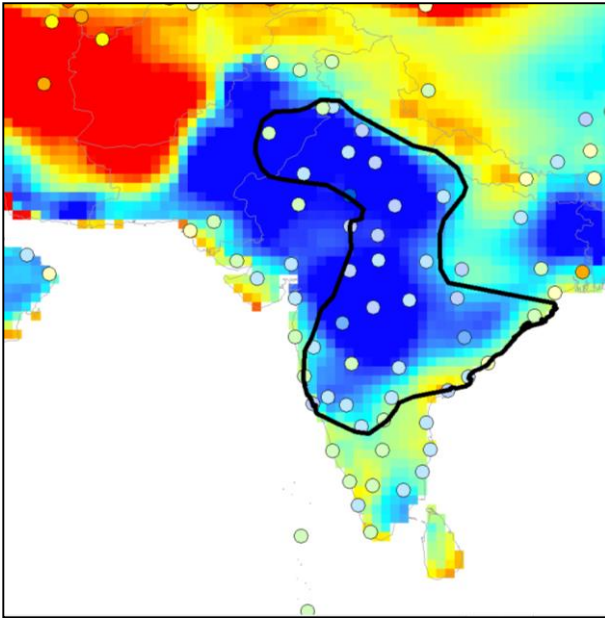
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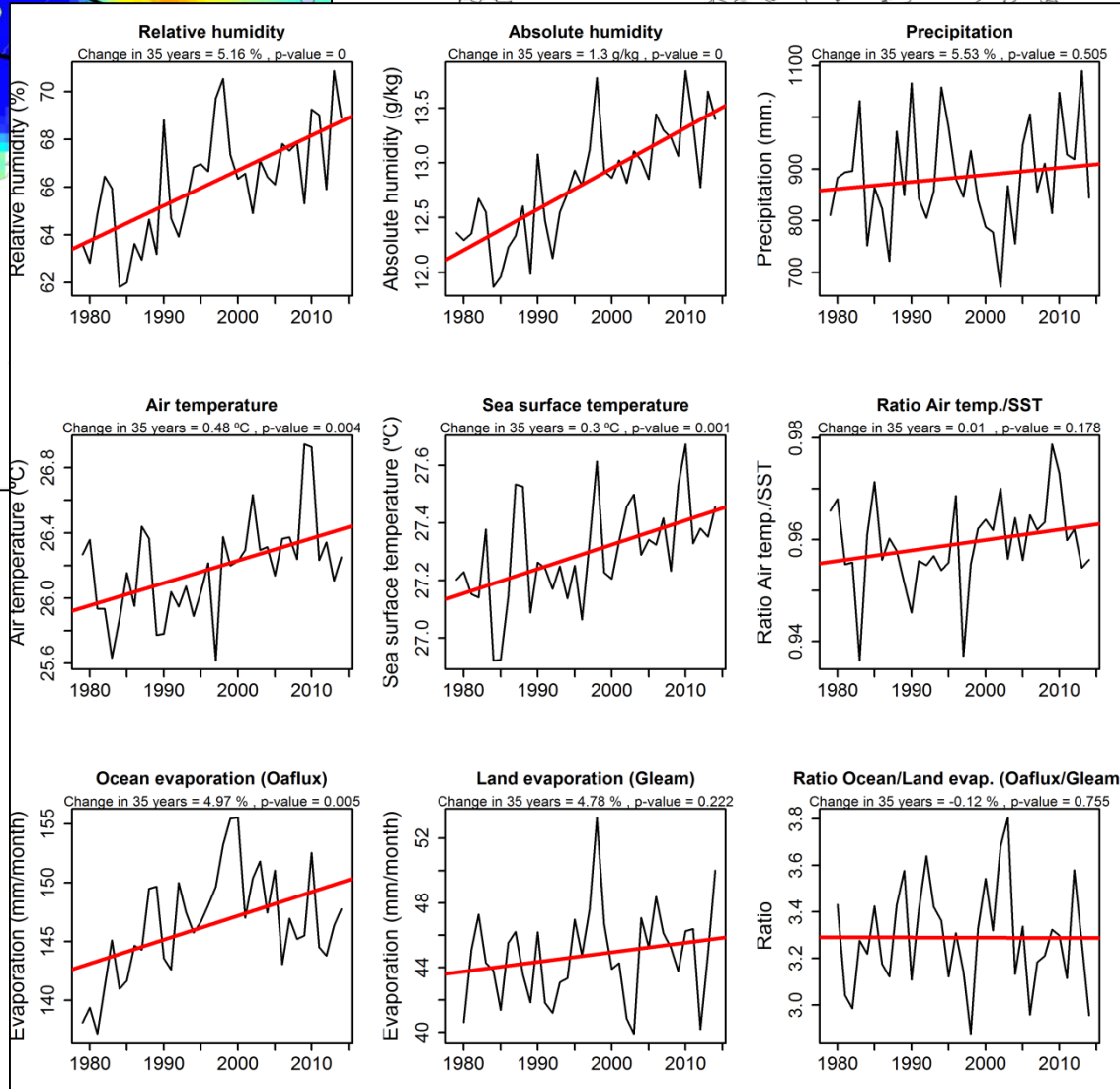
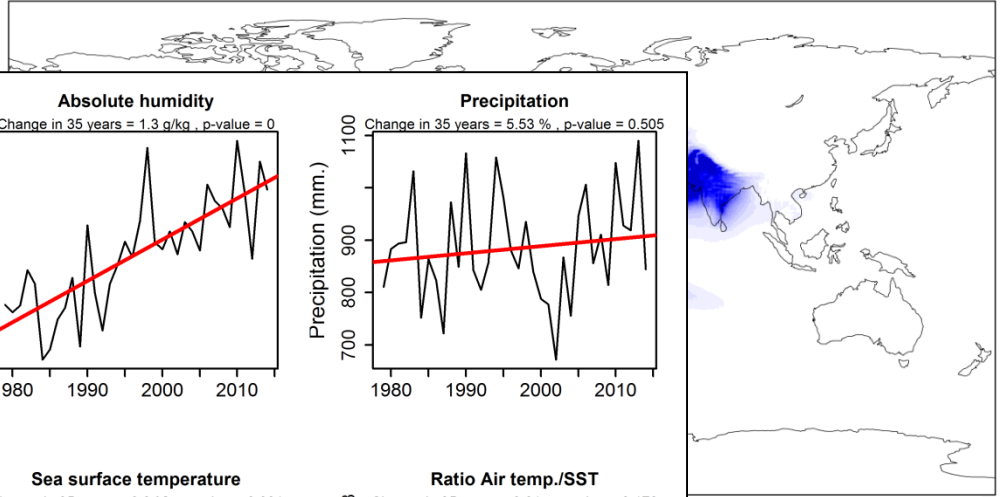
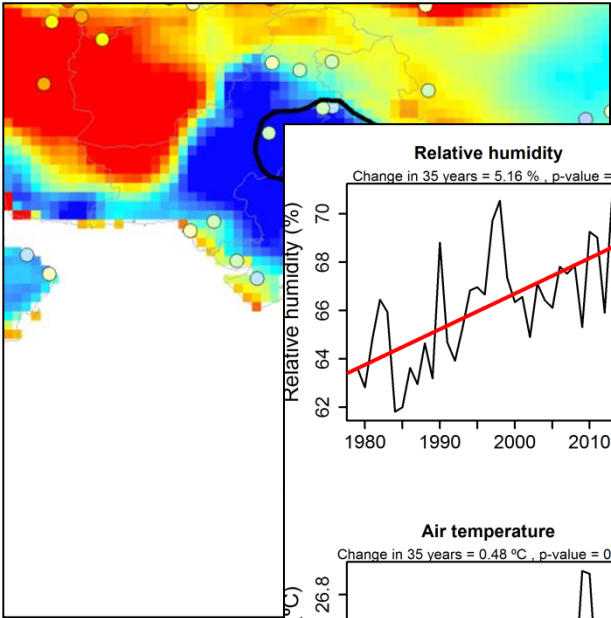
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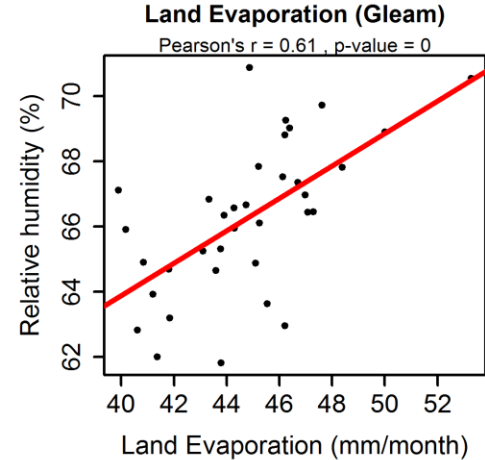
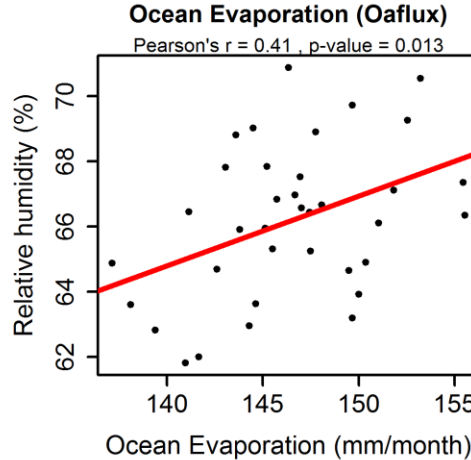
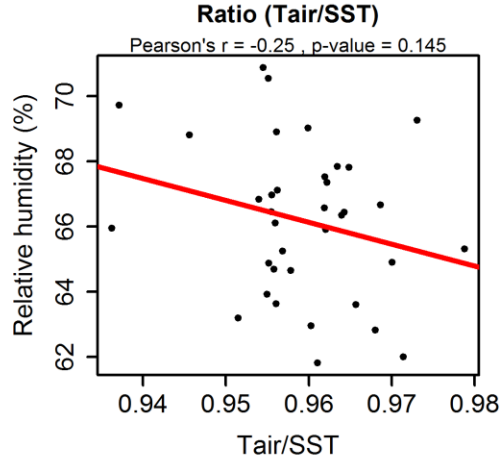
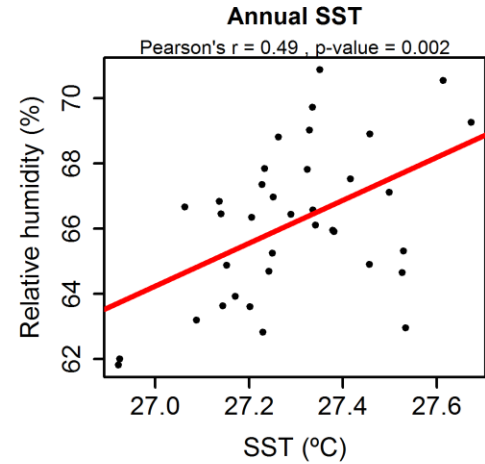
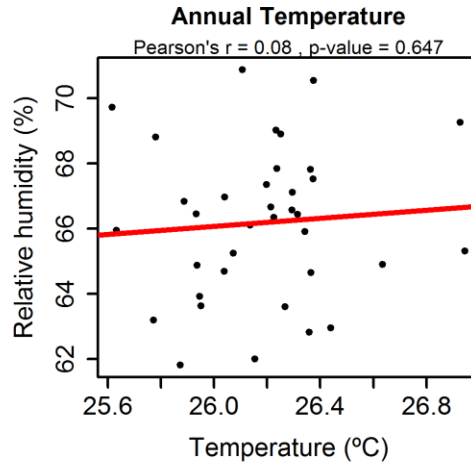
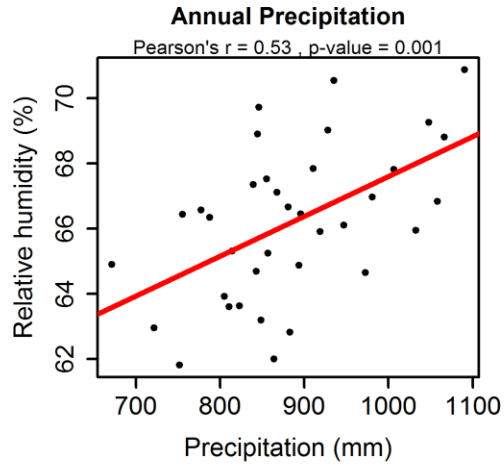
INDIA



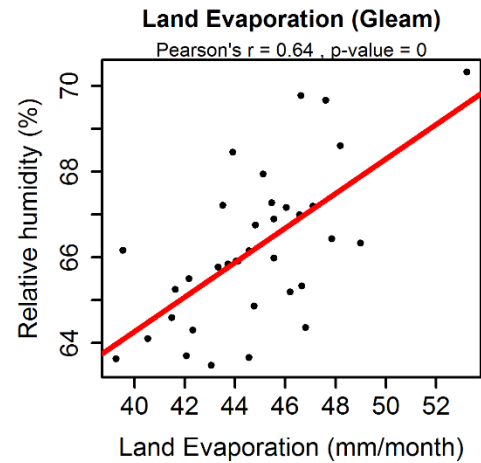
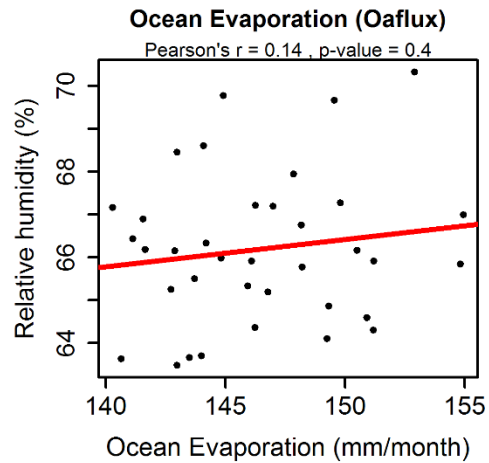
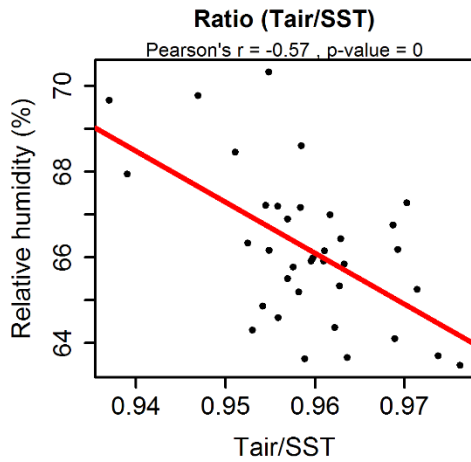
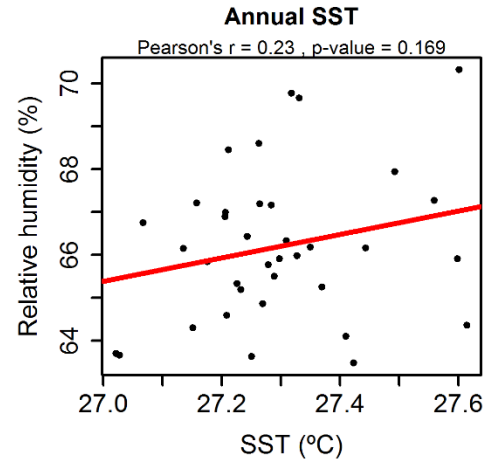
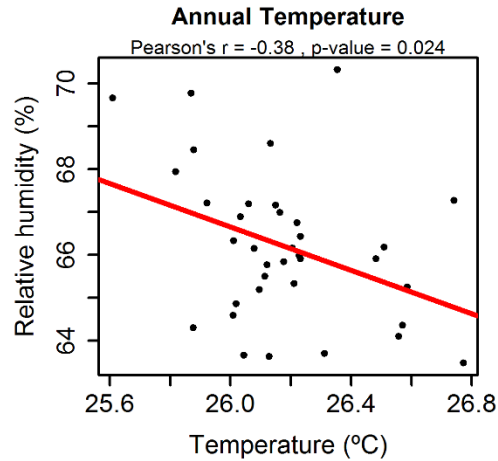
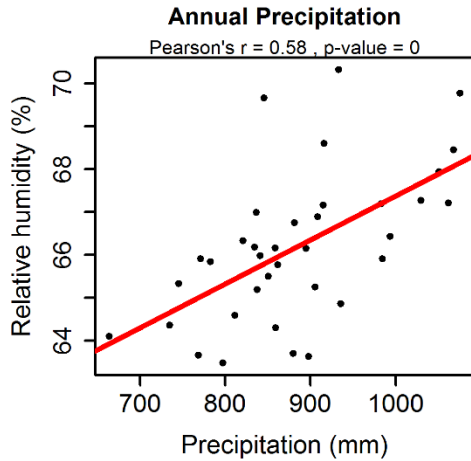
INDIA



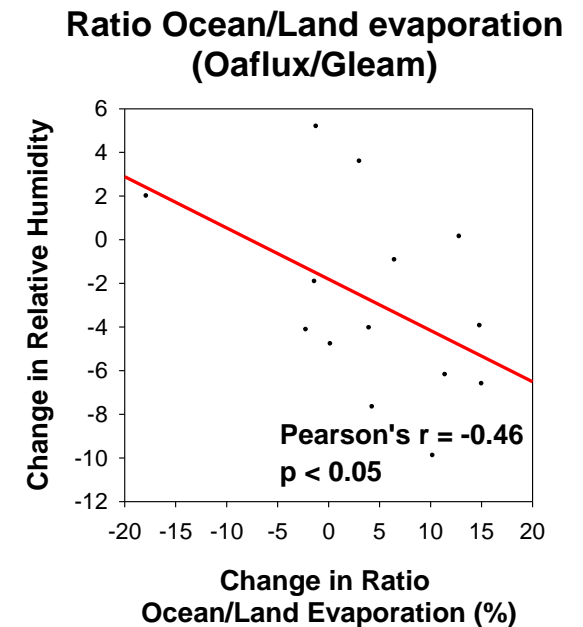
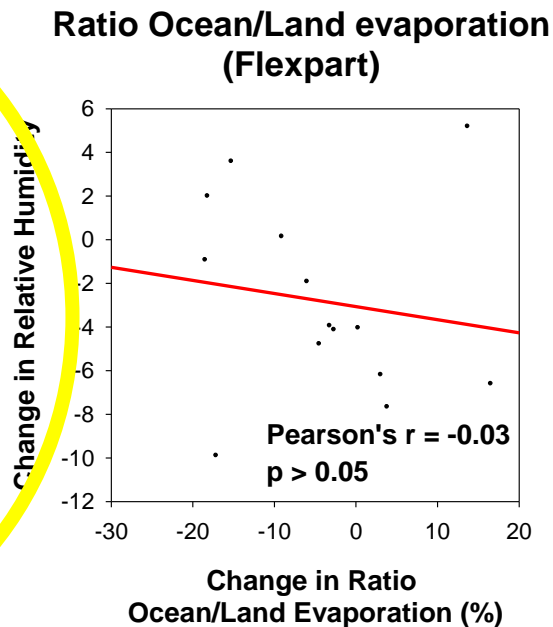
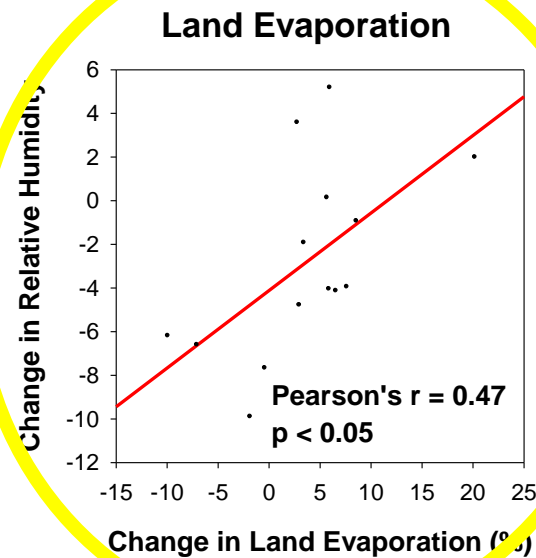
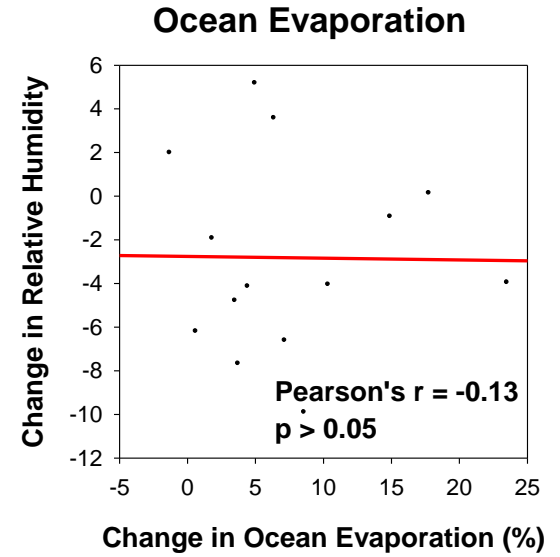
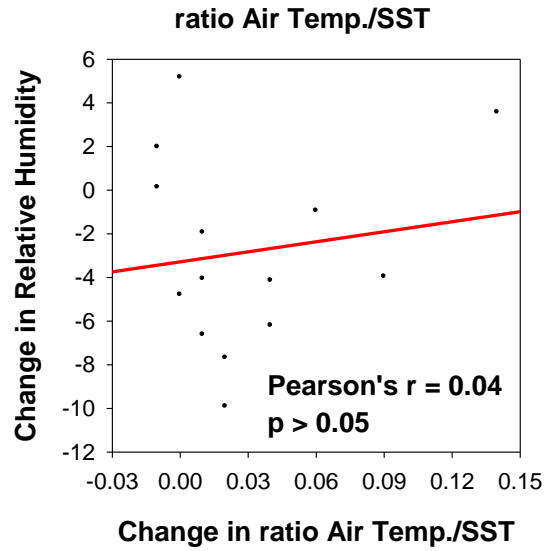
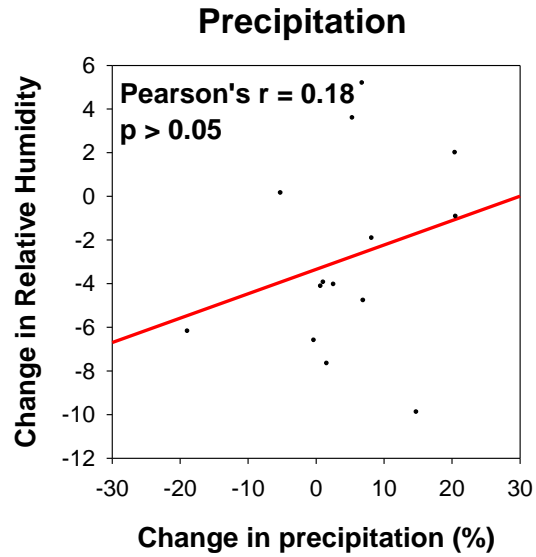
INDIA: OBSERVED SERIES



INDIA: DETRENDED SERIES

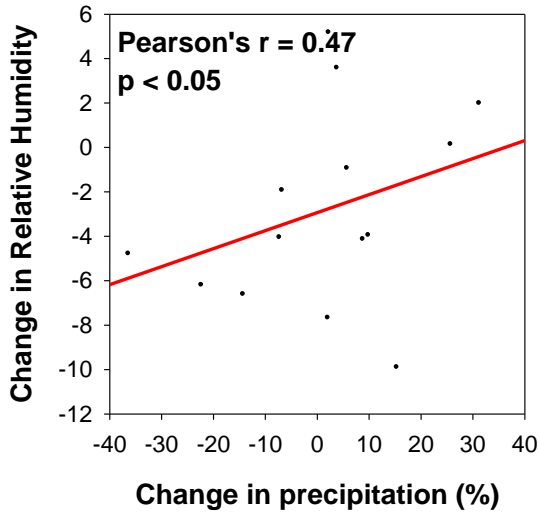


A GLOBAL SUMMARY: WARM SEASON

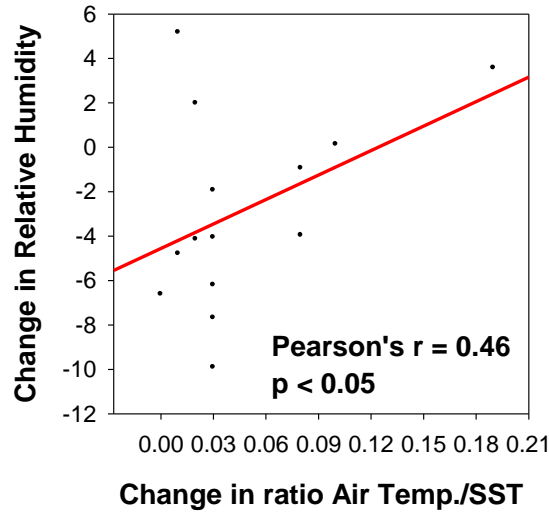


A GLOBAL SUMMARY: COLD SEASON

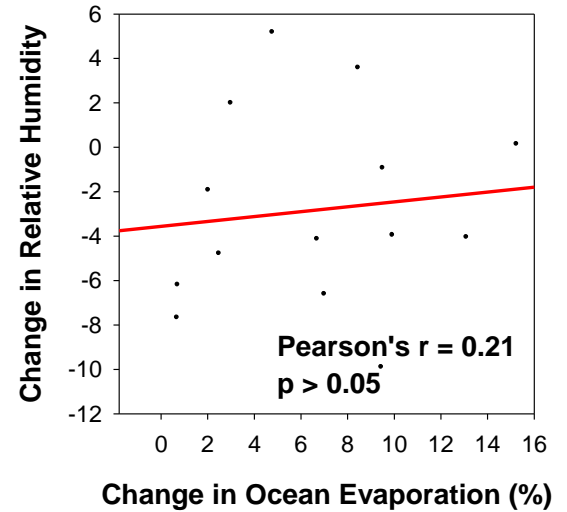
Precipitation



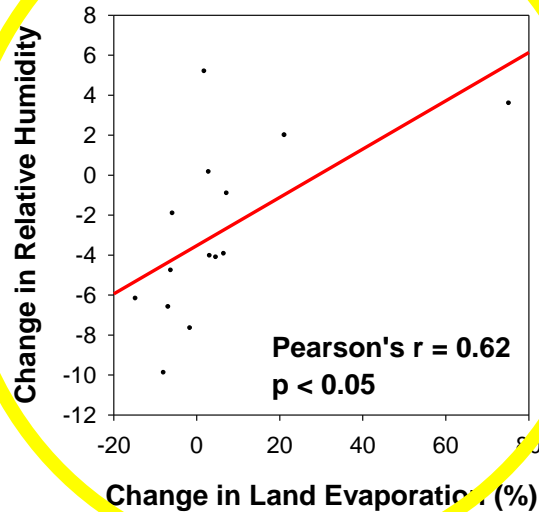
ratio Air Temp./SST



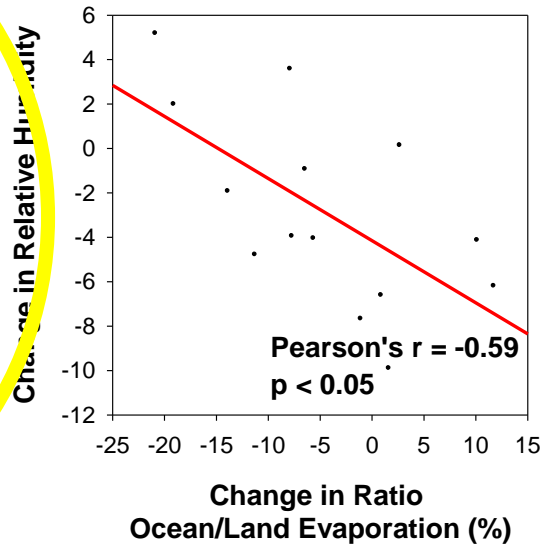
Ocean Evaporation



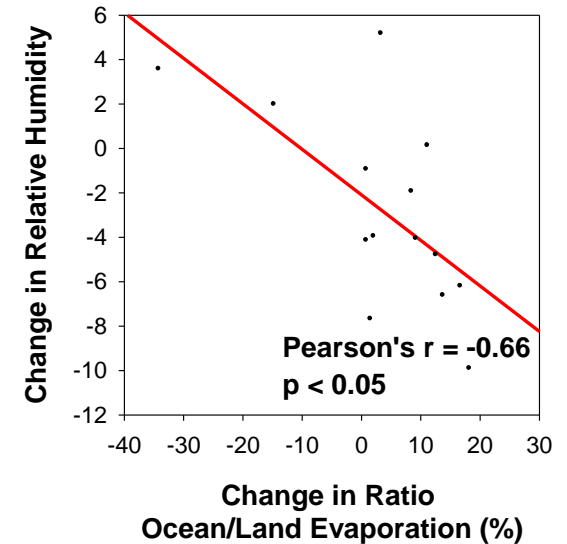
Land Evaporation



Ratio Ocean/Land evaporation (Flexpart)

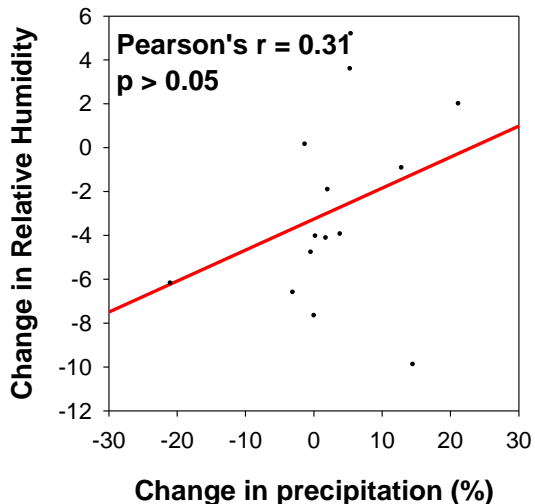


Ratio Ocean/Land evaporation (Oaflux/Gleam)

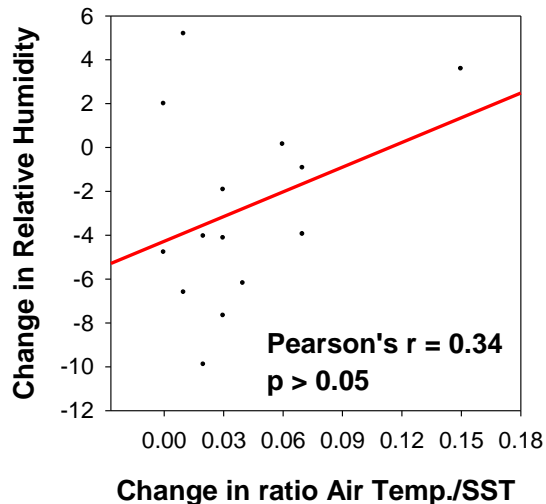


A GLOBAL SUMMARY: ANNUAL

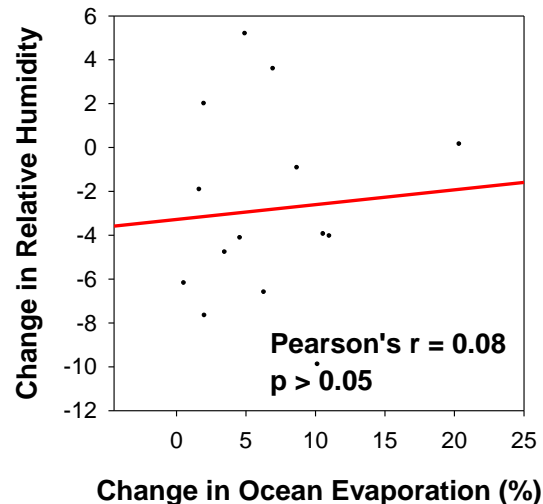
Precipitation



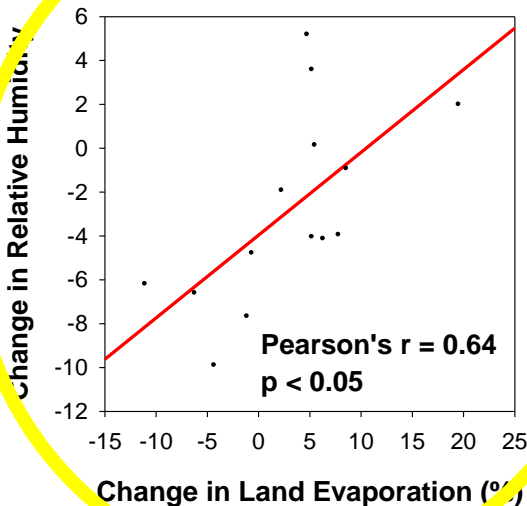
ratio Air Temp./SST



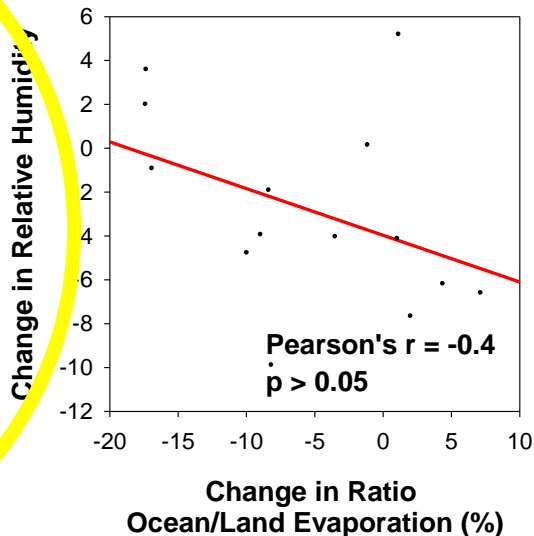
Ocean Evaporation



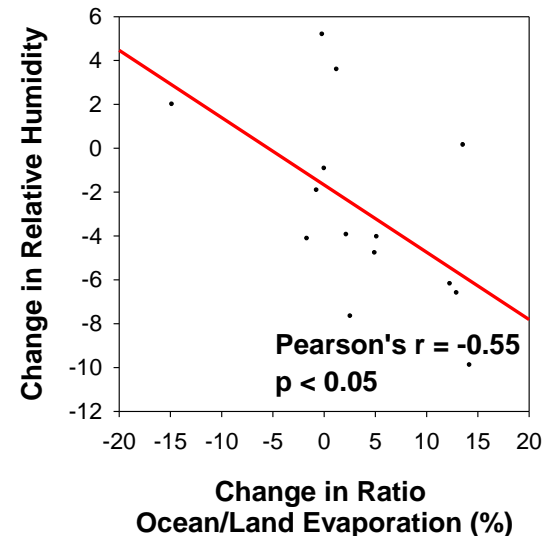
Land Evaporation

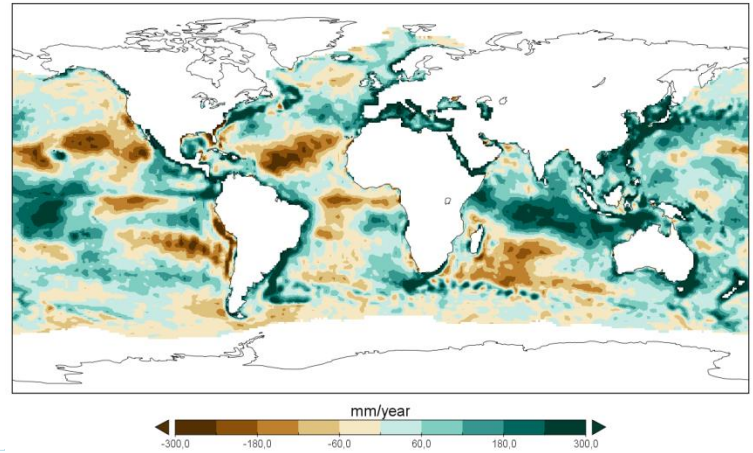
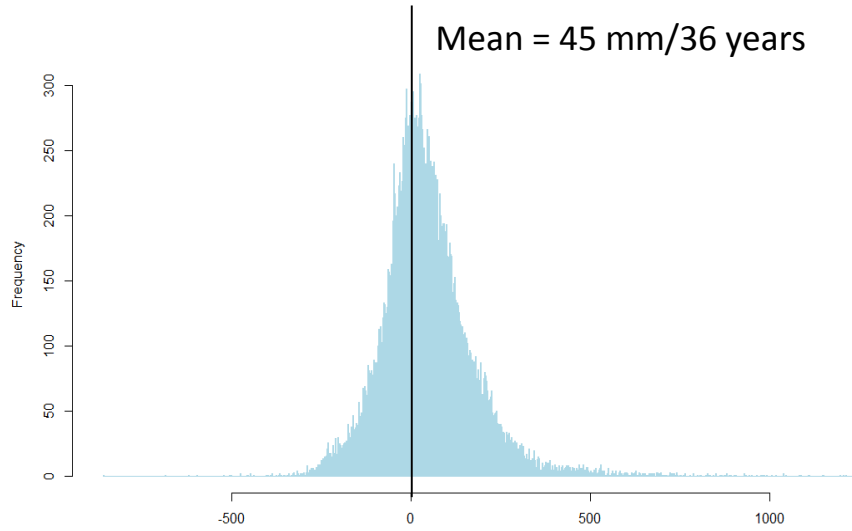


Ratio Ocean/Land evaporation (Flexpart)

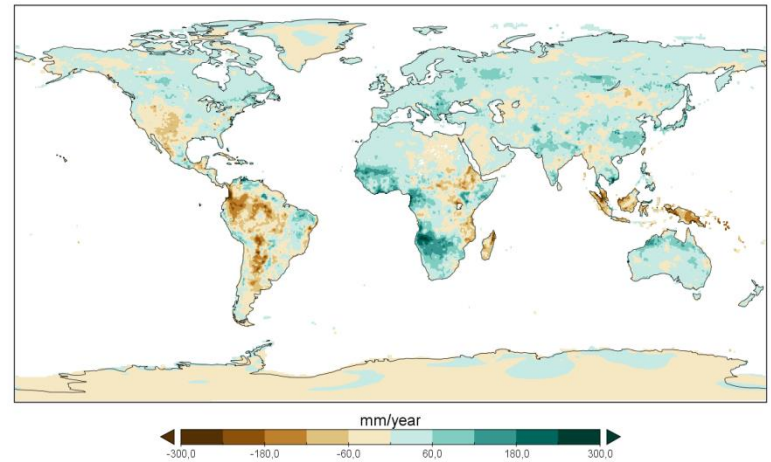
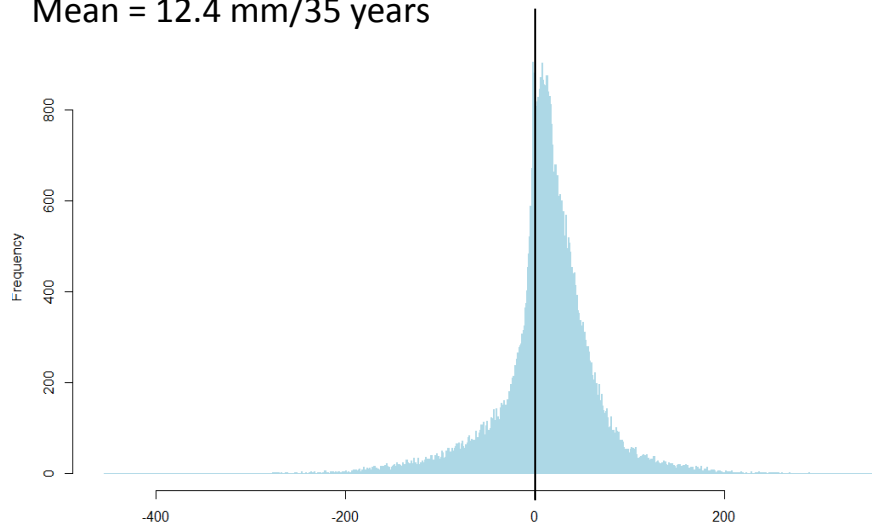


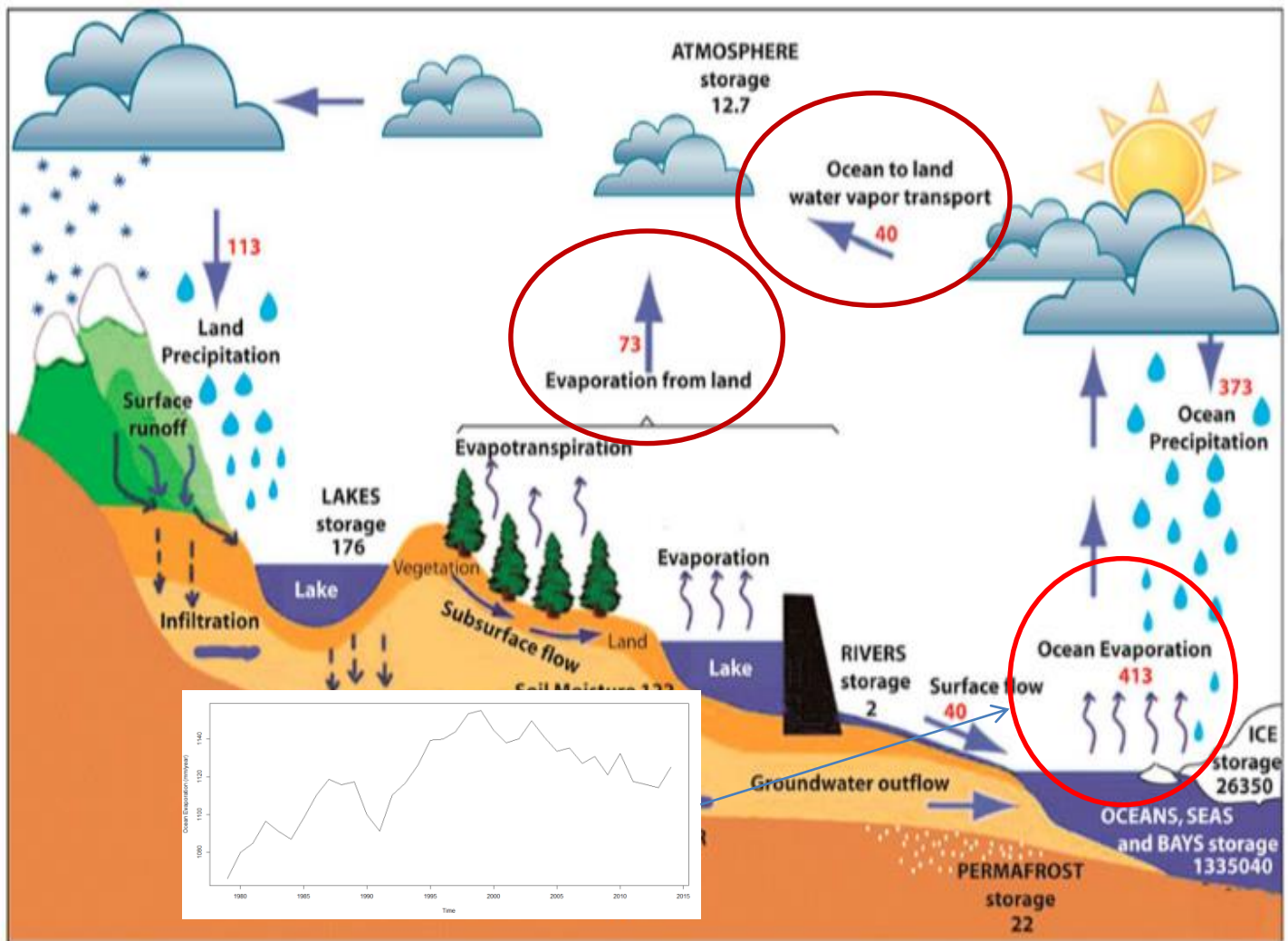
Ratio Ocean/Land evaporation (Oaflux/Gleam)





Mean = 12.4 mm/35 years

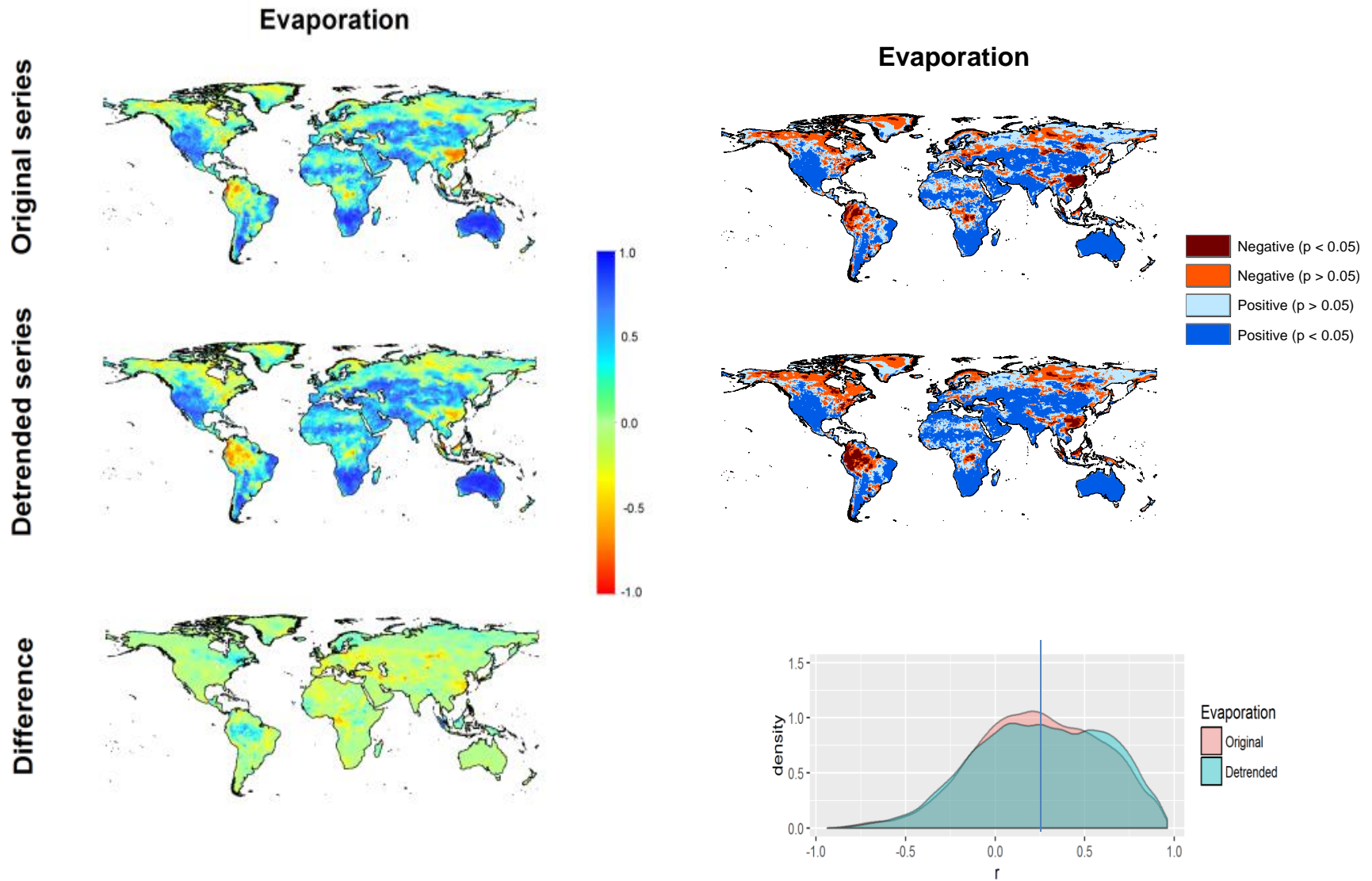




Most of the water that evaporates from the oceans (90%) is precipitated back into them. Only 10% falls as precipitation over the continents.

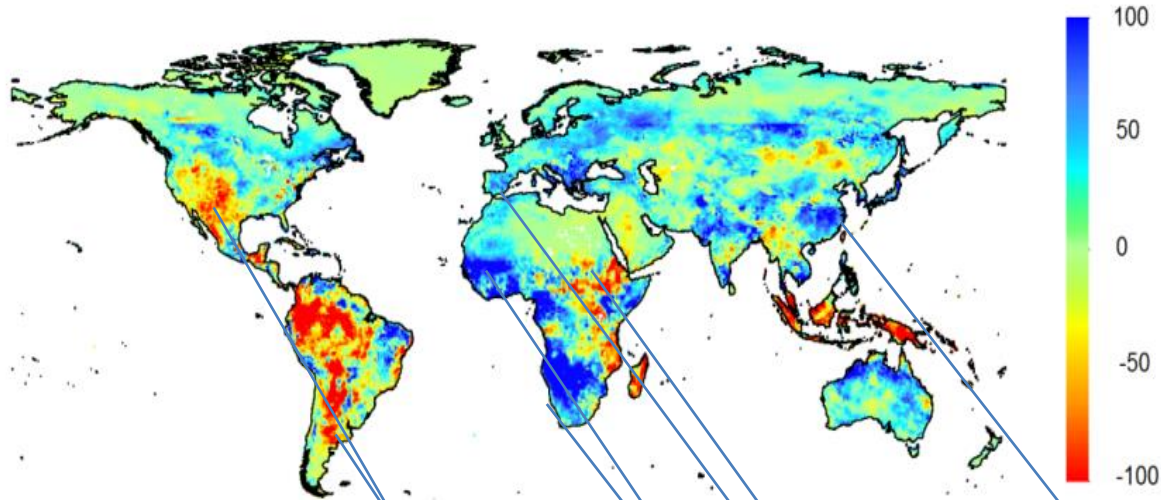
Of this precipitation, approximately **two thirds is recycled over the continents.**

CORRELATION BETWEEN ANNUAL RH AND LAND EVAPORATION

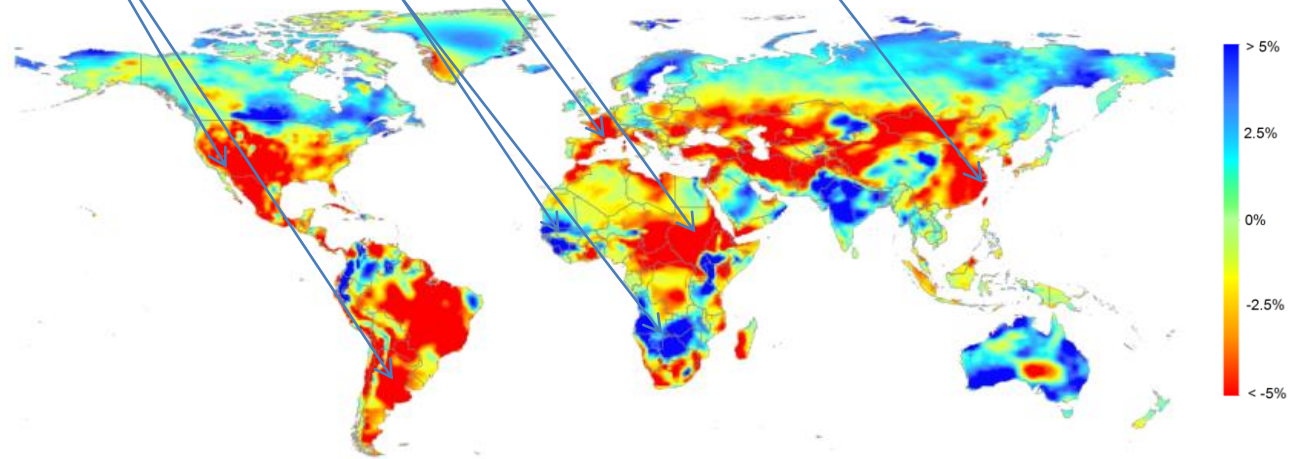


Magnitude of change in Land Evaporation

Annual Evaporation
(mm.)



Magnitude of change in Relative Humidity



CONCLUSIONS

- **HIGH SPATIAL VARIABILITY IN RELATIVE HUMIDITY TRENDS BETWEEN 1979 AND 2014**
- **GOOD AGREEMENT BETWEEN OBSERVATIONS AND ERA-INTERIM DATA**
- **HIGH SPATIAL VARIABILITY IN THE INFLUENCE OF PRECIPITATION, LAND EVAPOTRANSPIRATION AND OCEAN EVAPORATION ON RELATIVE HUMIDITY TRENDS**
- **LAND EVAPOTRANSPIRATION VARIABILITY SEEMS TO BE THE MAIN DRIVERS OF RELATIVE HUMIDITY TRENDS AT THE GLOBAL SCALE ALTHOUGH THERE ARE STRONG SPATIAL DIFFERENCES AND IN SOME AREAS OF THE WORLD THE INFLUENCE IS NOT CLEAR.**