Latin America: trading *virtual* water, carbon and biodiversity

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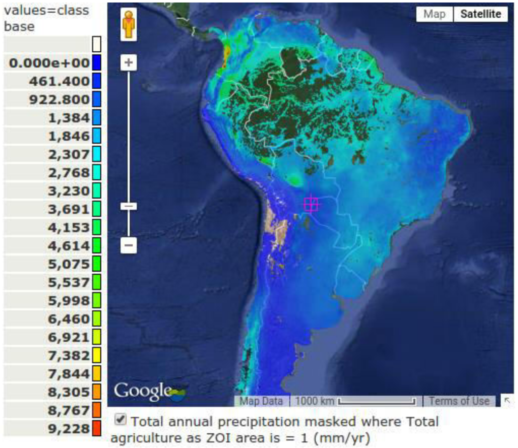
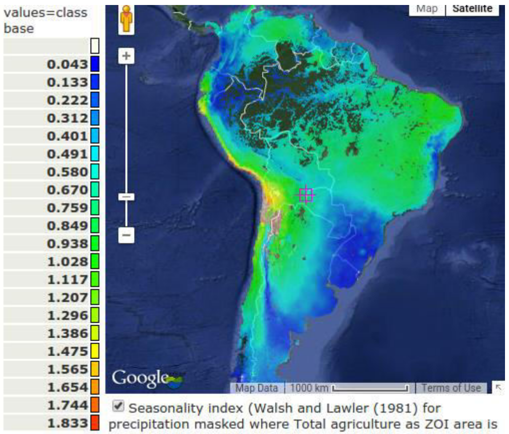
Context

- Virtual water is traded when used consumptively in production of traded product, and thus **no longer available for use downstream**.
- The agricultural land in Latin America occurs in a **mix of humid and dry lands**.
- Agriculture in **drylands** => irrigated => greater leaf area than pre-irrigation cover => greater evapotranspiration => **+ve water 'footprint' (local loss)**
- Agriculture in **humid lands** = replace tree cover with rainfed crops => less evapotranspiration => **negative water 'footprint' (local gain)**
- New agriculture in previously natural areas also 'consumes' forest carbon and biodiversity
- Embedded carbon = lost climate change mitigation potential
- Embedded biodiversity = lost opportunities for biotech and medical discovery

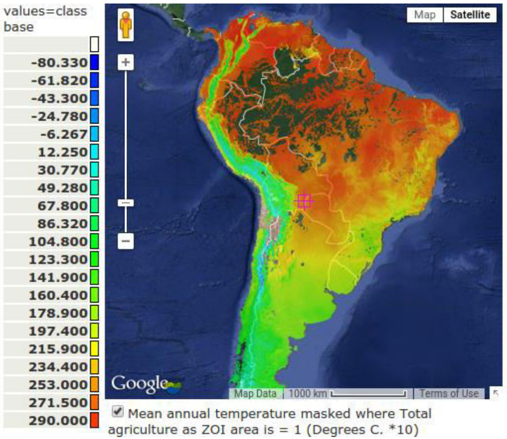
Climate of Latin American agricultural land



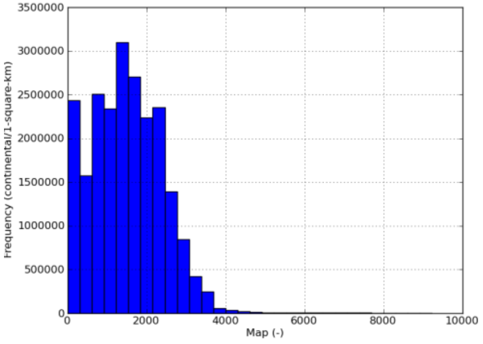
Total annual precipitation masked where Total agriculture as ZOI area is = 1 (mm/yr)

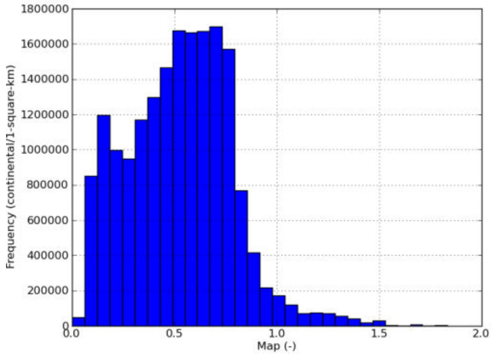


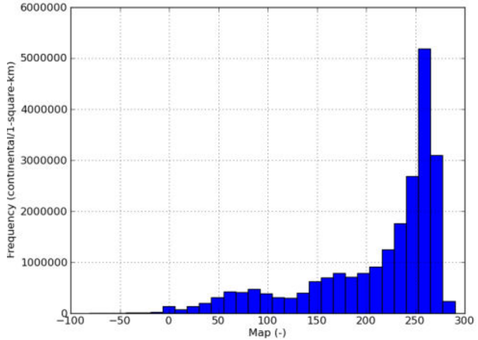
Seasonality index (Walsh and Lawler (1981) for precipitation masked where Total agriculture as ZOI area is = 1 (<0.9 to >1.20)



Mean annual temperature masked where Total agriculture as ZOI area is = 1 (Degrees C. *10)



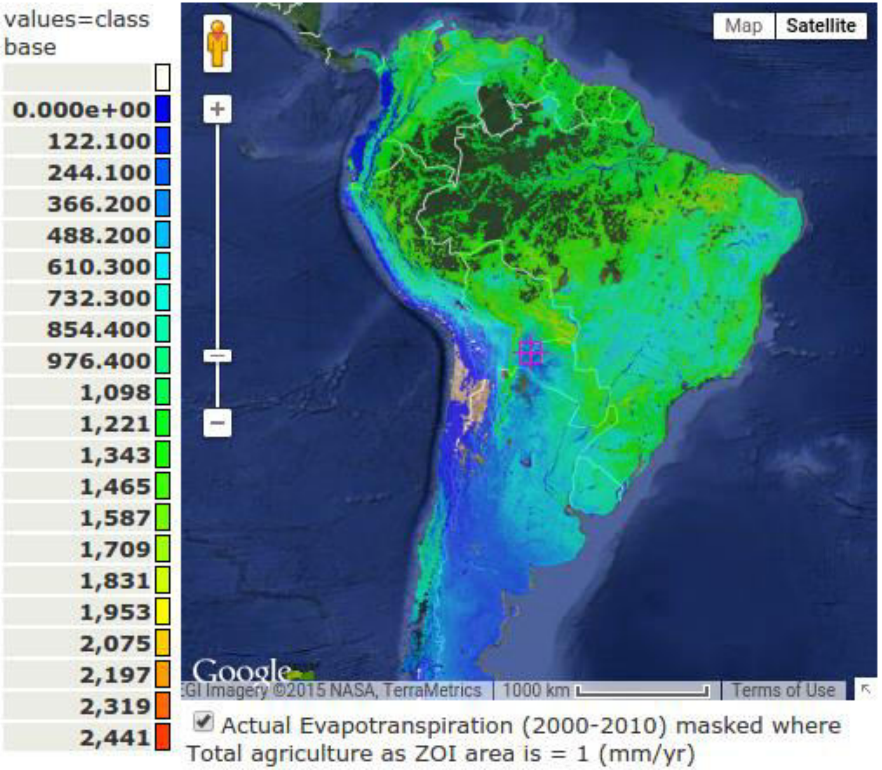


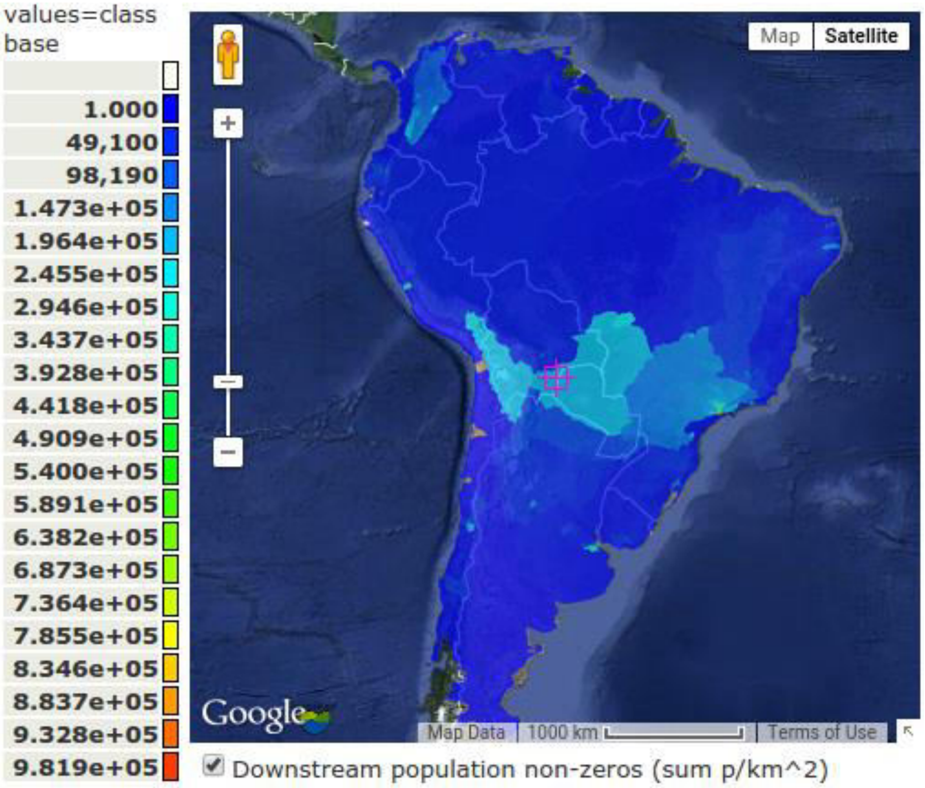


Wide variety of climate conditions on Latin-American agricultural land. Determines the ag. footprints

Precipitation distributed around 2000mm/yr, seasonality low in some places, high in others, MAT around 25℃

Latin American virtual water 'footprints'

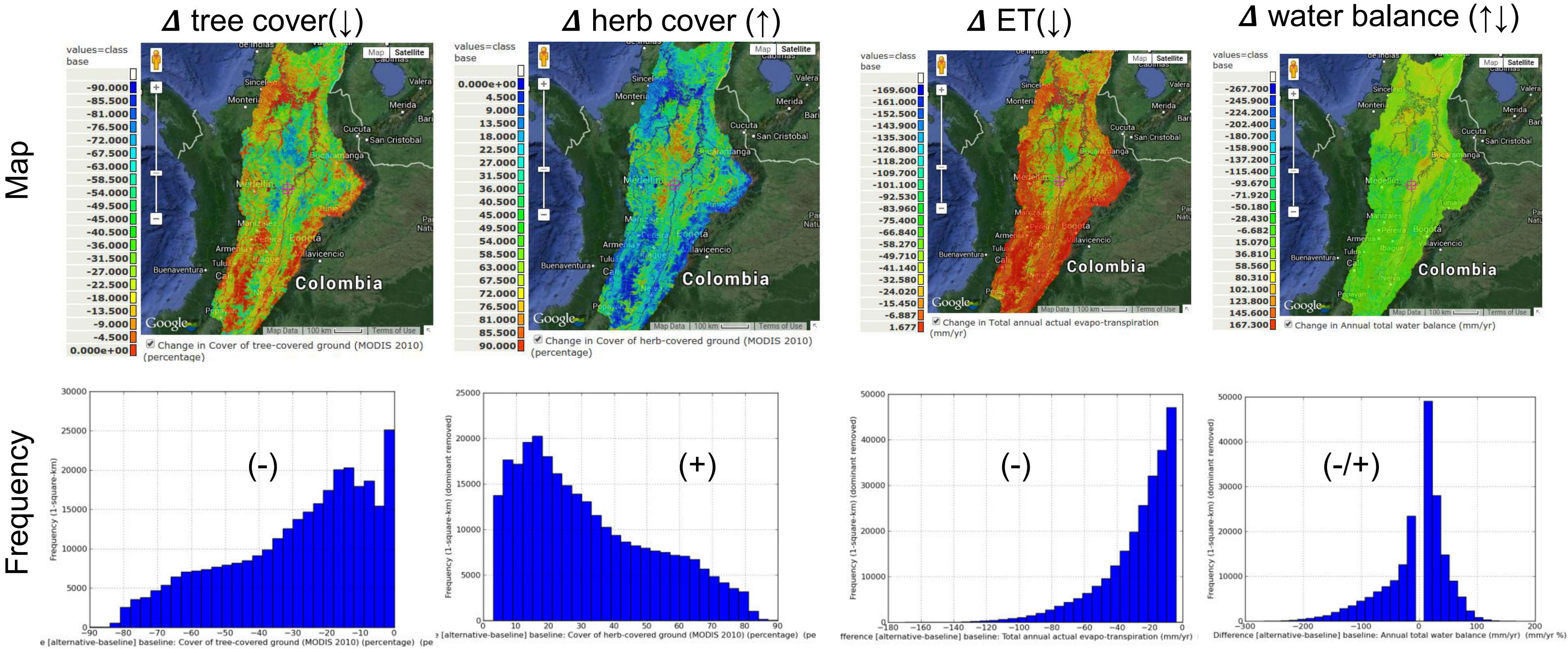




Total evapotranspiration losses over agricultural areas vary greatly according to the region, but have to be seen in the context of available rainfall

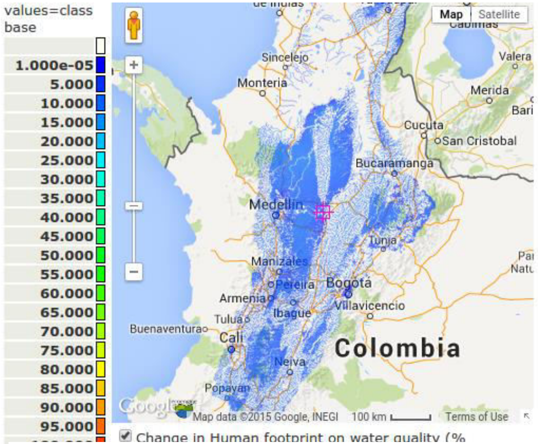
These losses are particularly important in areas with significant populations downstream who will lose as a result of irrigation or may 'gain' under rainfed conditions

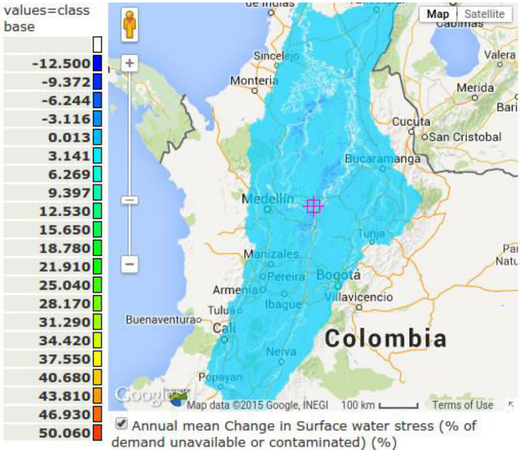
Agriculturalisation & water footprints: quantity



Agriculturalisation leads to **decreased** evapo-transpiration on formerly forested landscapes = **negative water quantity footprint** of non-irrigated crops. Water footprint only positive where agriculture leads to greater LAI than native. Agriculturalisation can lead to increases or decreases in flows downstream, **dep. on ET, fog, Infil.**

Agriculturalisation & water footprints: quality



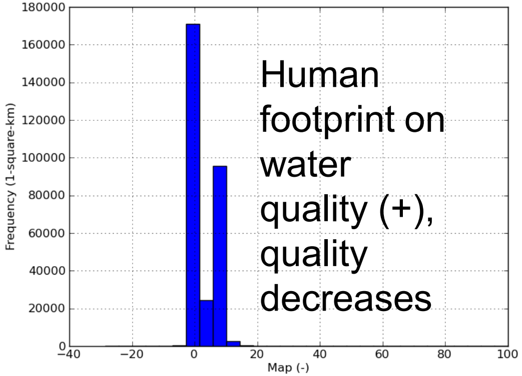


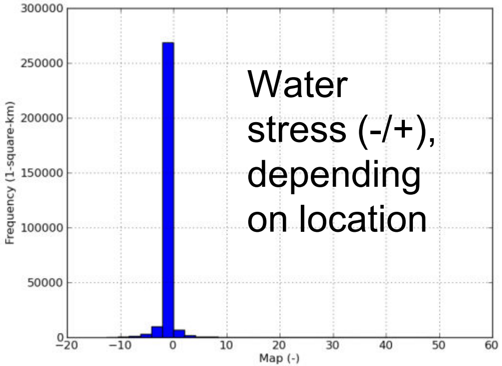
Annual mean Change in Surface water stress (% of demand unavailable or contaminated) (%):

People with decreased mean annual water stress: **374,956**

People with increased mean annual water stress: **11,873,451**

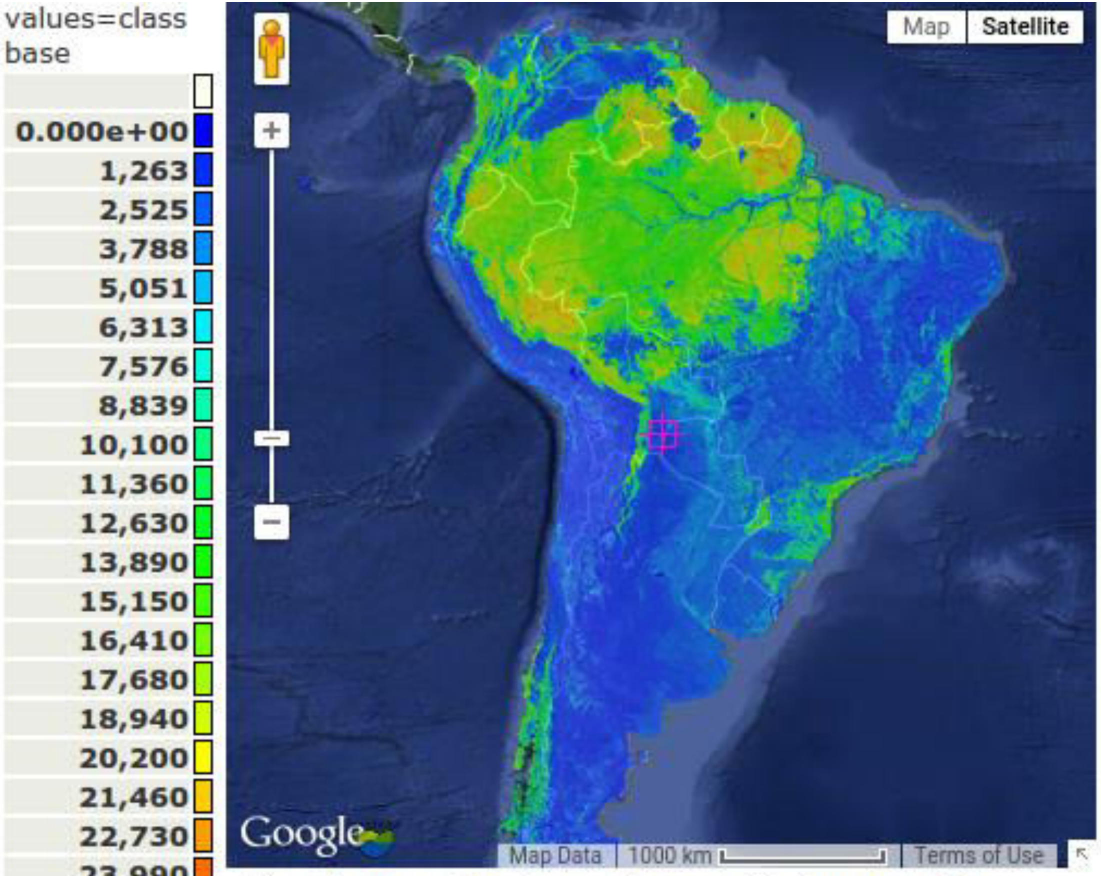
People with no change in mean annual water stress: **18,931,604**





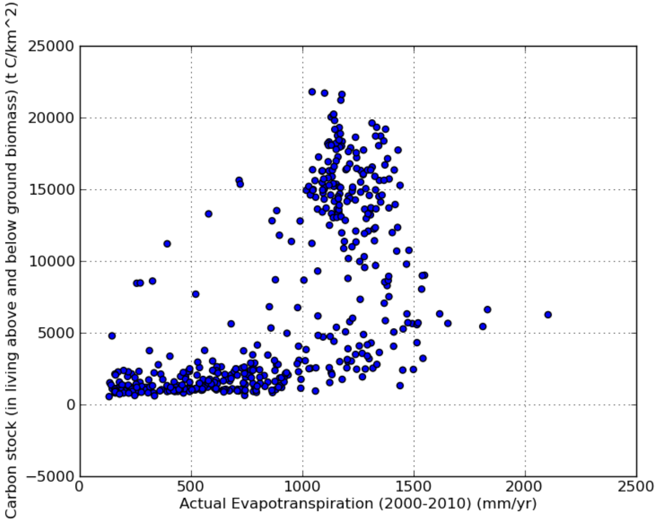
Agriculturalisation always leads to **decreased** water quality (increased human footprint).
This leads to **increases in water stress** (**% of demand unavailable or contaminated)** locally and downstream even where water quantity increases. **So water footprints of agriculture are not at all simple!**

Latin American virtual carbon ‘footprints’

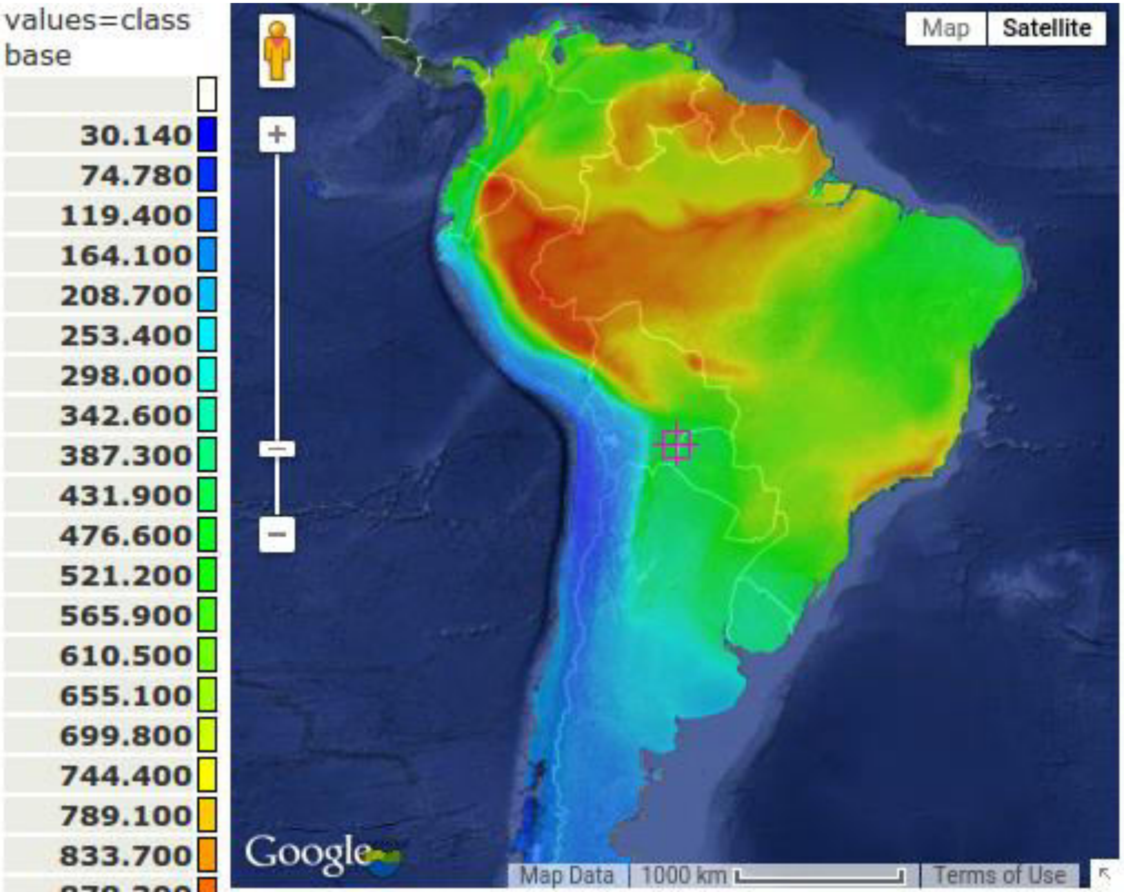


Carbon stock (in living above and below ground biomass) (t C/km^2)

- Significant variability in the carbon footprint in agricultural zones, depending on location
- In agricultural areas varies from 0 to 29,757 t/km^2, mean of 5,153 t/km^2.
- Mean of 8109 t/km^2 including non-agricultural zones.
- Strong correlation with ET

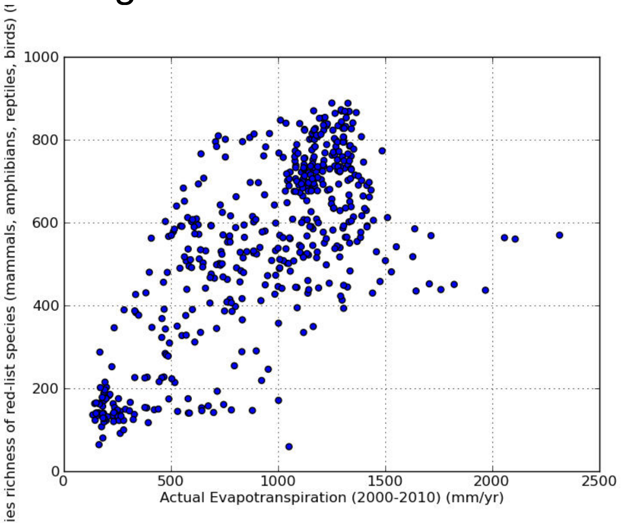


Latin American virtual biodiversity ‘footprints’



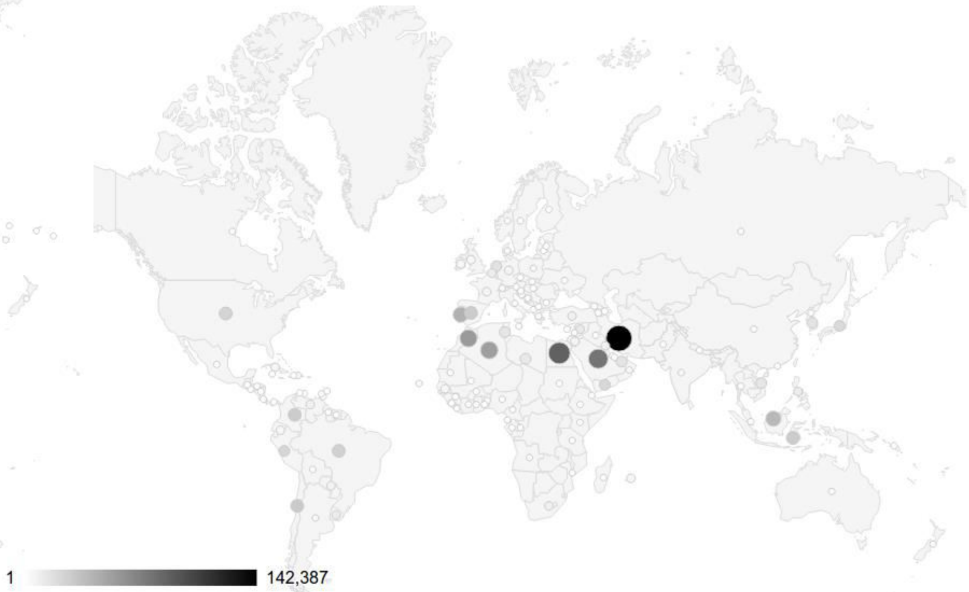
☑ Species richness of red-list species (mammals, amphibians, reptiles, birds) (taxa)

- Significant variability in the biodiversity footprint in agricultural zones, depending on location
- Sampled redlist richness in agricultural areas varies from 29 to 928 species, mean of 485.
- Mean of 626 including non-ag. zones.
- Strong correlation with ET



on Latin American water, carbon and biodiversity highly complex and location dependent

Latin America export value of food products (1000s of USD/yr)



Latin America export value of cereal grains n.e.c (1000s of USD/yr)

Conclusions

- The water quantity virtual water footprint of agriculture can be negative (local gain) as well as positive (local loss), depending on prior vegetation cover
- Water quality footprints are always positive (local loss) but quantity and quality interplay relative to demand to affect water stress such that the same agriculturalisation can lead to local water losses, local gains or no change, depending on location.
- **Water footprints are thus not simple, more sophisticated measures required**
- Neither are carbon and biodiversity footprints, since they are spatially heterogeneous and co-linear with evapotranspiration.
- Some of the most well water resourced areas are also the most environmentally sensitive