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The influence of groundwater depth on the moisture recycling system in the Amazon rainforest following agriculture land-use change

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Moisture Recycling

- Moisture recycling is the return of moisture to the atmosphere due to evapotranspiration which can then precipitate out locally or further downstream
- Up to 70% of the rainfall in the Amazon has been recycled
- The provision of rainfall outside the Amazon is a key ecosystem service for agriculture, hydropower generation and drinking water.

Fig.1 Amazon moisture recycling system (blue arrows) representing both internal recycling of moisture and transport downstream
Grey arrows represent dominant wind direction driving moisture transport.

Land-Use Change

- Land-use change from forest to pasture or soybean results in lower interception, transpiration and atmospheric moisture (Fig.2) with higher runoff.
- Reduced moisture from the moisture recycling system will ultimately reduce rainfall downstream.

Agricultural Expansion Paradox:
No win situation: Efforts to increase the supply of agricultural products in the Amazon may in turn result in lower yields in other regions, south of the Amazon, due to decreased in atmospheric moisture supply

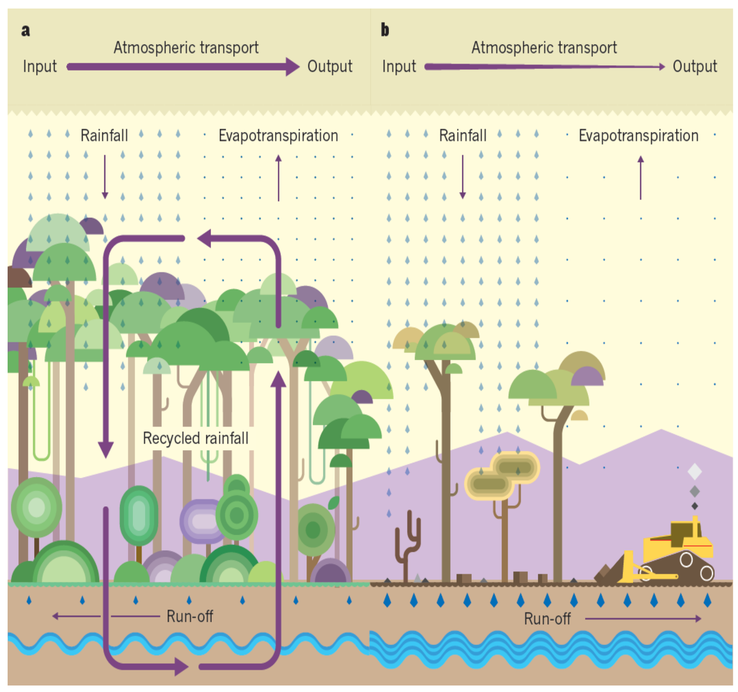


Fig.2 Moisture recycling
a) Primary forest with well functioning moisture recycling
b) Land-use change scenario with lower levels of evapotranspiration and atmospheric transport and increased runoff source - Aragão., 2012

Research Objectives

To determine whether the inclusion of different agricultural land-use classification will improve moisture recycling models, focusing on the seasonality of evapotranspiration fluxes.

To determine the importance groundwater depth on agricultural productivity and whether areas of shallow groundwater are less detrimental to the moisture recycling systems than agricultural areas over deep groundwater.

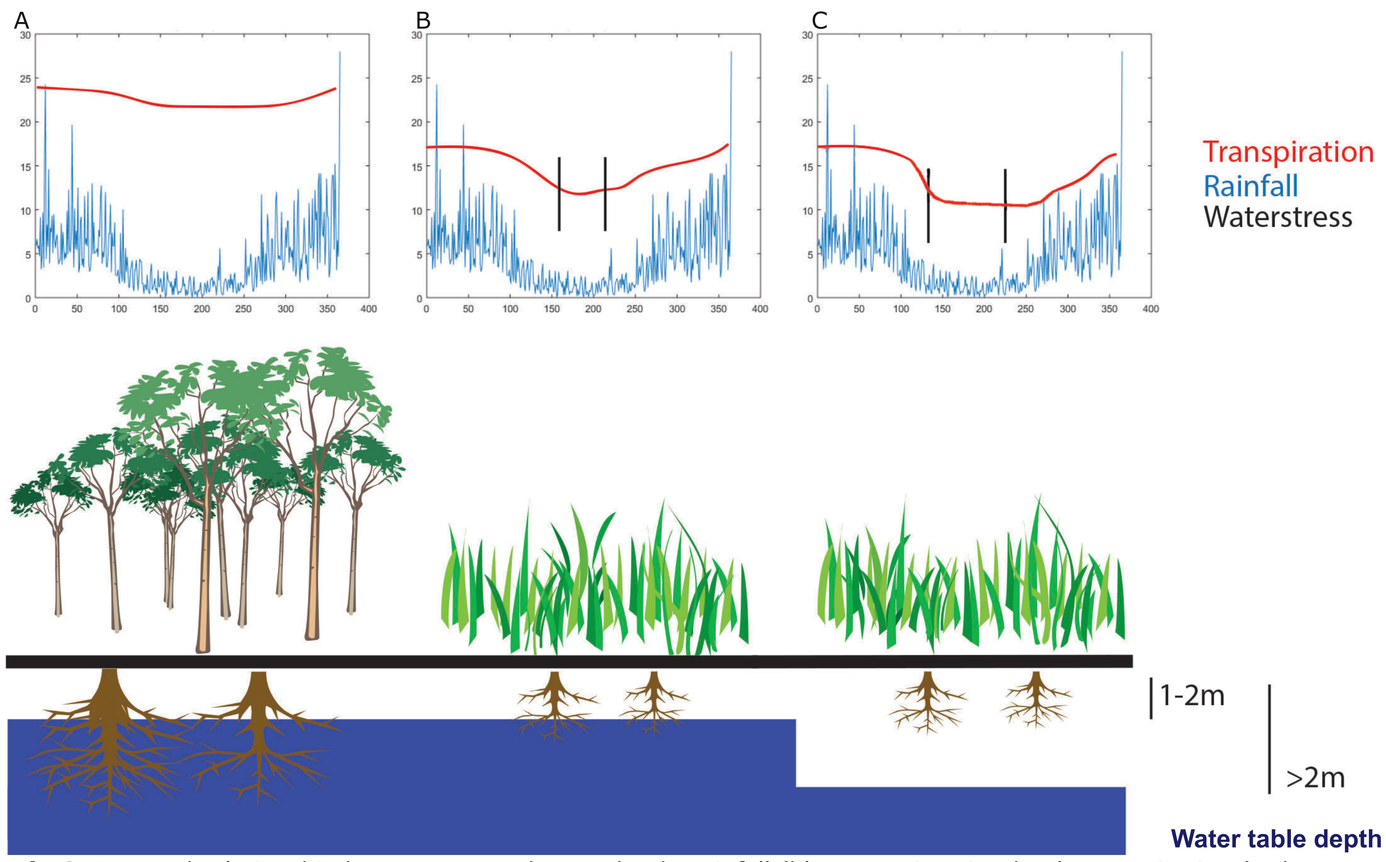


Fig.3 Proposed relationship between groundwater depth, rainfall (blue; ERA-interim data), transpiration (red; theoretical range based on early observations) and dry season length.
A)**Primary forest** maintains high evapotranspiration throughout the dry season, due to the deep rooting depth of forest. This has also been shown in areas of **deep groundwater**.
B) **Rangeland** showing a delayed reduction in transpiration at the start of the dry season.
C) Rangeland over deeper groundwater, responding directly to lower rainfall levels resulting in a longer dry season

Agricultural Land-Cover
Moisture recycling models
- Do not use different agricultural land-cover;
- Simplify the situation to areas of forest cover and forest loss.

However, rangeland and crop systems differ greatly in **seasonality** especially in single cropping systems which are still common in the region.

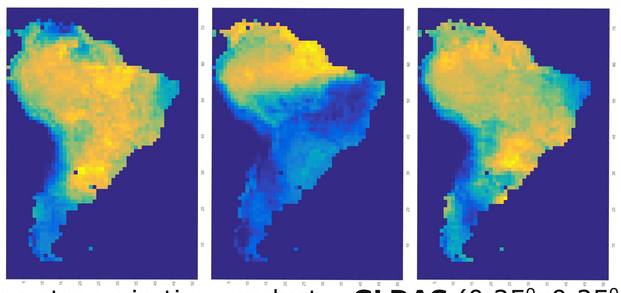
Groundwater
Dry season:
Forest do not suffer from water stress;
- Due to access of groundwater storage by deep roots forest continues to transpire moisture to the atmosphere.

The interaction between agricultural vegetation and groundwater in this region is poorly understood.

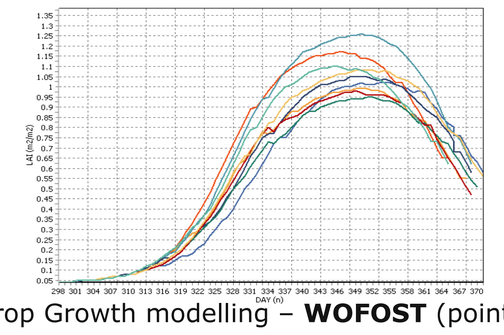
Methods

Develop a moisture recycling model for agricultural regions using a combination of crop model and remote sensing observations

Remote sensing – **MODIS** (500m x 500m)



Evapotranspiration product – **GLDAS** (0.25^0x0.25^0)



Crop Growth modelling – **WOFOST** (point model)

References:
Aragão, L. E. O. C. (2012). Environmental science: The rainforest's water pump. *Nature*, 8–9. https://doi.org/10.1038/nature11485
Oliveira, L. J. C., Costa, M. H., Soares-Filho, B. S., & Coe, M. T. (2013). Large-scale expansion of agriculture in Amazonia may be a no-win scenario. *Environmental Research Letters*, *8*(2), 24021. https://doi.org/10.1088/1748-9326/8/2/024021
Spera, S. A., Galford, G. L., Coe, M. T., Macedo, M. N., & Mustard, J. F. (2016). Land-use change affects water recycling in Brazil's last agricultural frontier. *Global Change Biology*, *22*(10), 3405–3413. https://doi.org/10.1111/gcb.13298
van der Ent, R. J., & Savenije, H. H. G. (2011). Length and time scales of atmospheric moisture recycling. *Atmospheric Chemistry and Physics*, *11*(5), 1853–1863. https://doi.org/10.5194/acp-11-1853-2011
Zemp, D. C., Schleussner, C.-F., Barbosa, H. M. J., van der Ent, R. J., Donges, J. F., Heinke, J., … Rammig, A. (2014). On the importance of cascading moisture recycling in South America. *Atmospheric Chemistry and Physics*, *14*(23), 13337–13359. https://doi.org/10.5194/acp-14-13337-2014