

Vegetation water-use efficiency indicators in water-limited ecosystems

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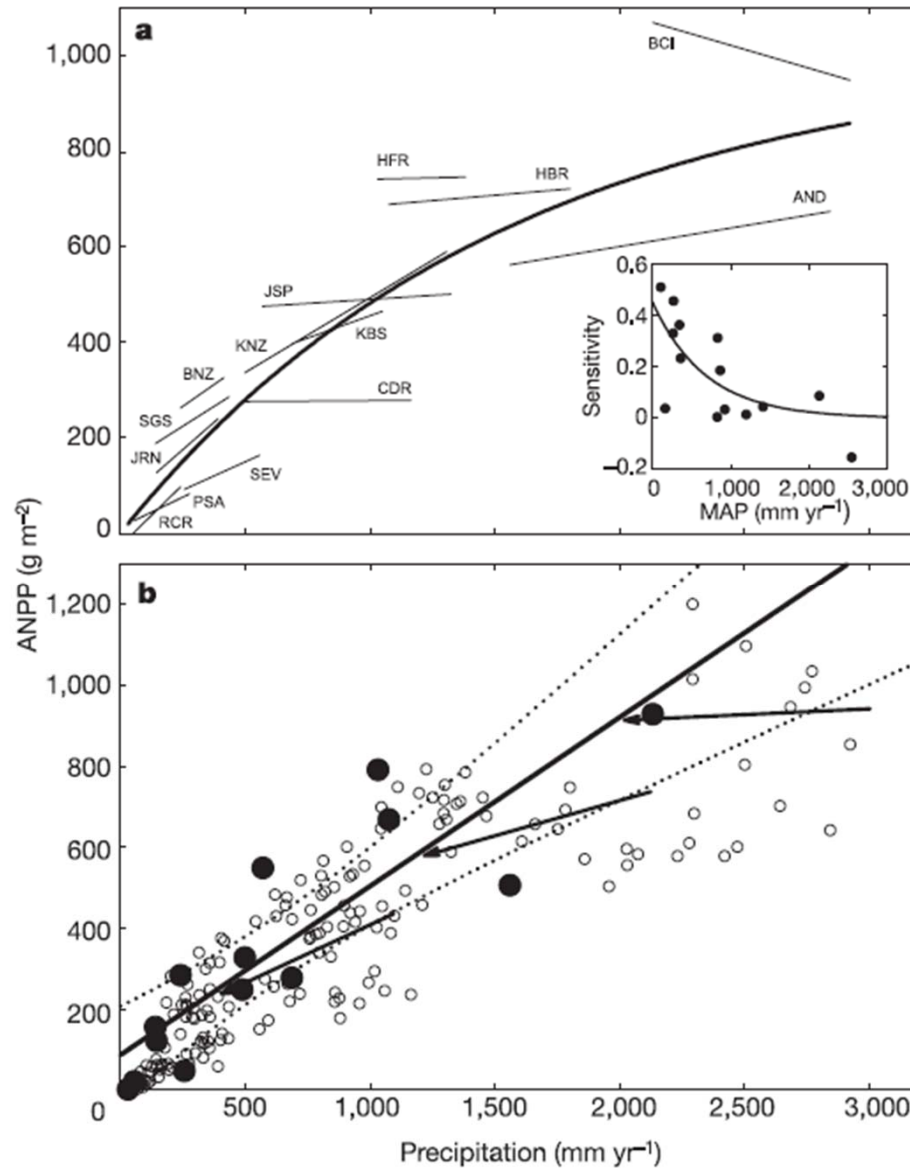
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Previous work



Huxman et al. ,2004

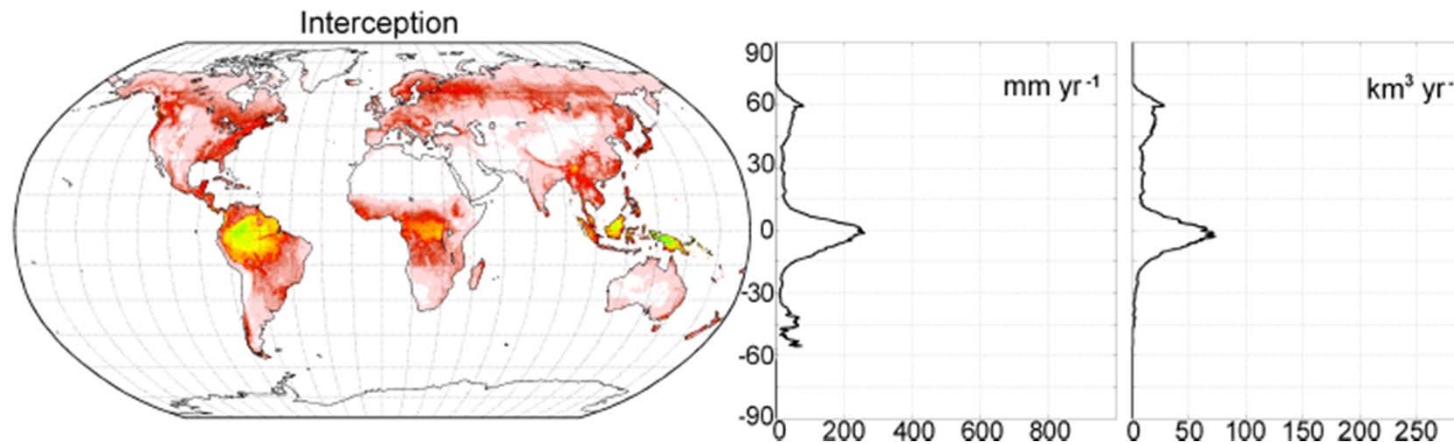
- NPP as an exponential function of MAP
- RUE is **low** in wet environments
- RUE is **high** in dry environments

- RUE converges across all the ecosystems during dry years

Hypothesis and research questions

$$RUE = \frac{NPP}{R}$$

- Not all the rainfall will be used by vegetation
- About 6800 km³/Yr of water are never used by ecosystems



Miralles et al. ,2011

RUE underestimates carbon-water interactions

$$SMUE = \frac{NPP}{SWC}$$

What is the behavior of other WUE indicators in water-limited ecosystems?

$$WUE = \frac{NPP}{ET} \quad (\text{Climate-driven})$$

$$TUE = \frac{NPP}{T} \quad (\text{CO}_2\text{-driven})$$

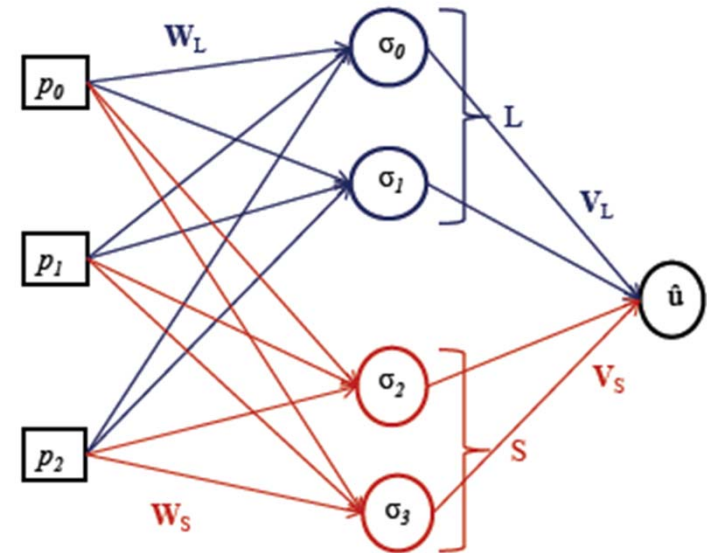
Richard's Equation

$$\frac{\partial \theta}{\partial t} = \frac{\partial}{\partial z} \left[K(\psi) \left(\frac{\partial \psi}{\partial z} + 1 \right) \right] - S(\psi(t, z))$$

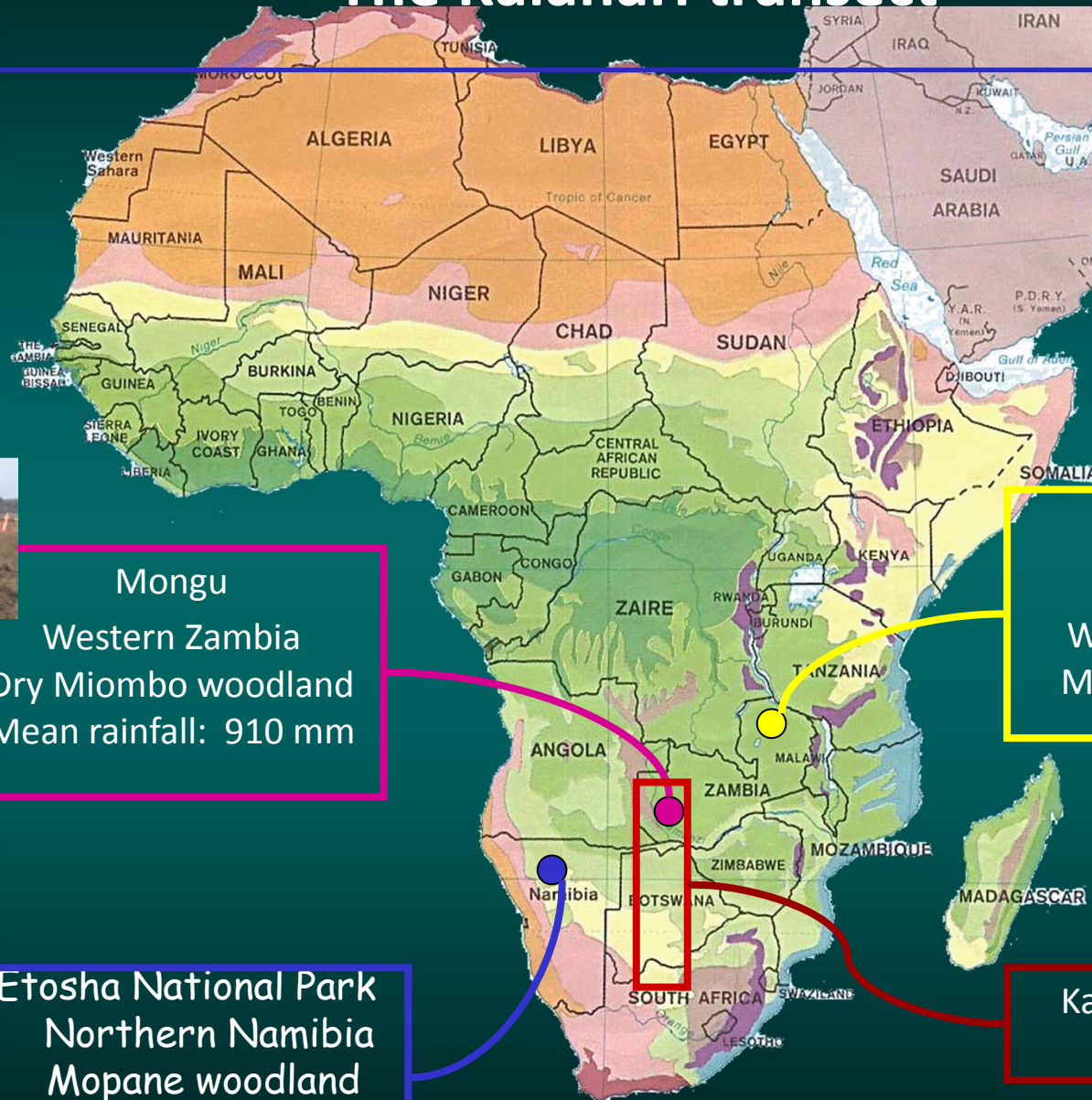
$$\theta(\psi) = \theta_r + \frac{\theta_s - \theta_r}{(1 + |\alpha\psi|^n)^m} \quad (\text{van Genuchten})$$

$$S = \gamma(\psi) S_m(z)$$

$$q = K \left(\frac{\partial \psi}{\partial z} + 1 \right) \quad \text{BC: Darcy's Law}$$



The Kalahari transect



Mongu
Western Zambia
Dry Miombo woodland
Mean rainfall: 910 mm

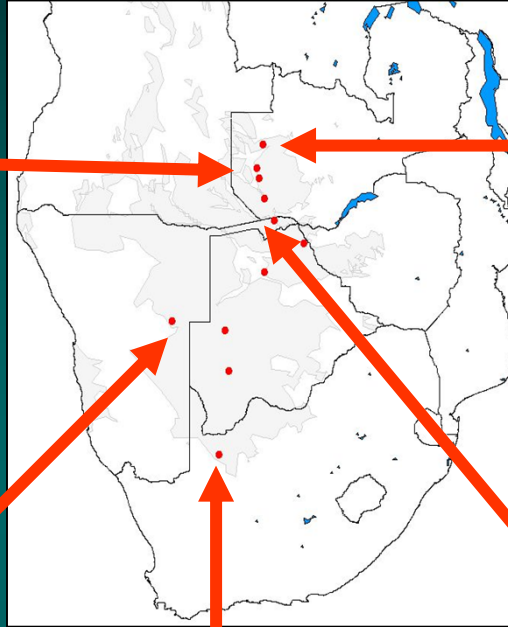
Kasama
Northern Zambia
Wet miombo woodland
Mean Rainfall: 1300 mm



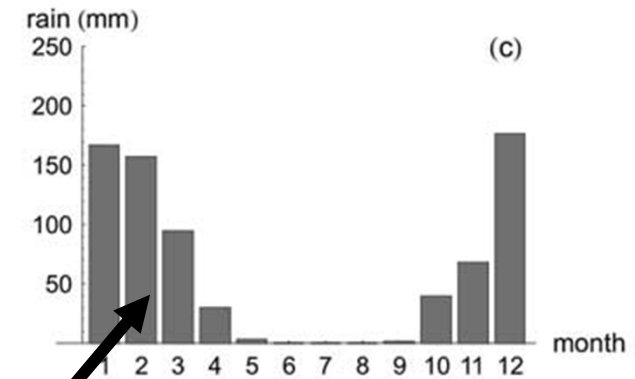
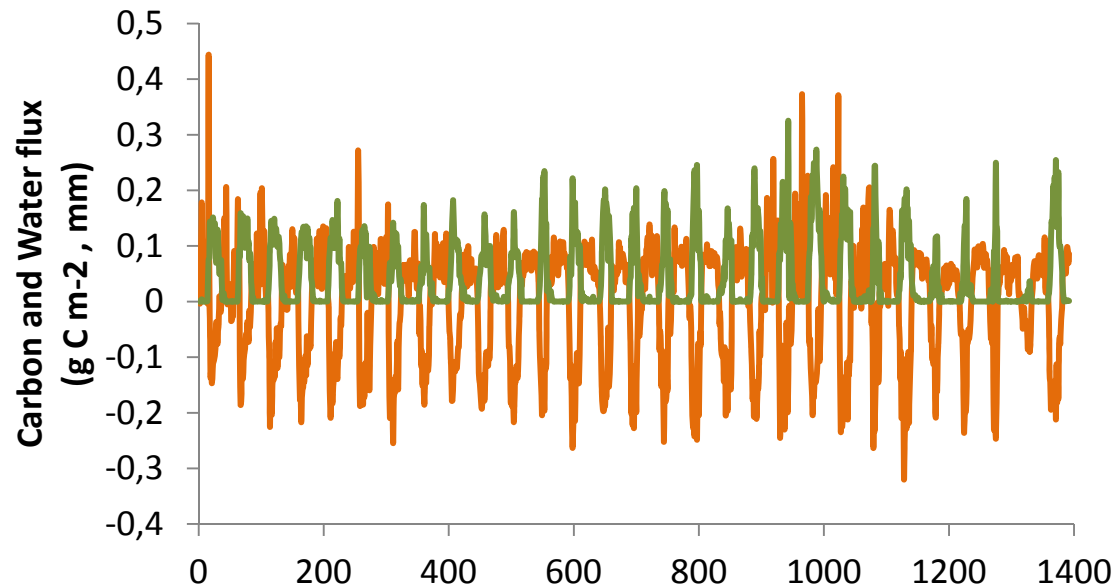
Etosha National Park
Northern Namibia
Mopane woodland
Rainfall range 300 - 450 mm

Kalahari Transect
experiment

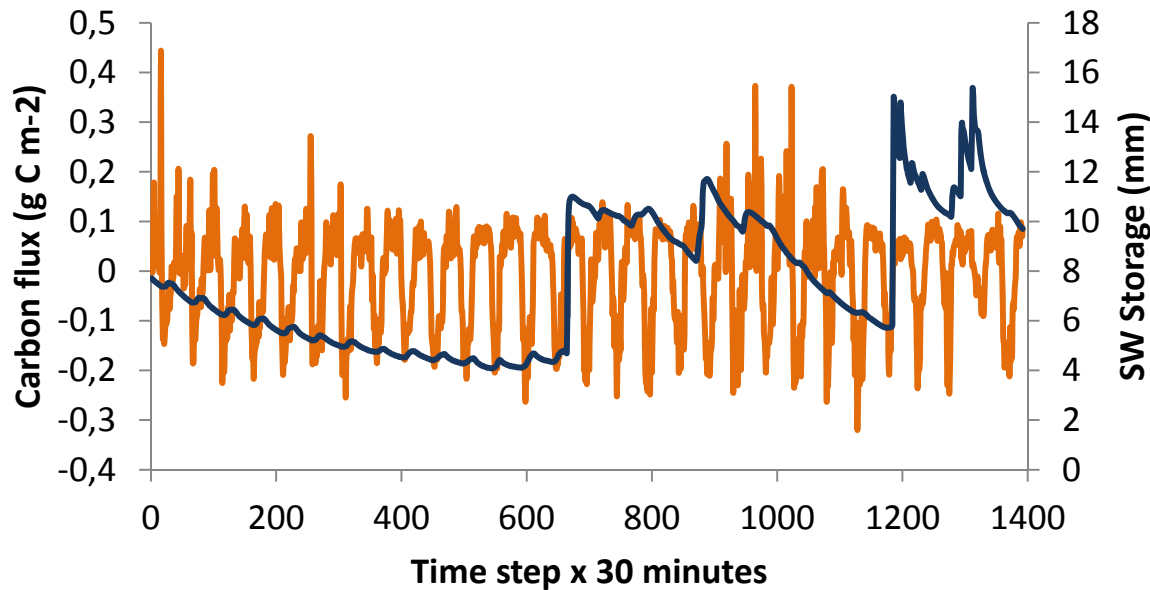
Vegetation Patterns on the Kalahari Transect



Preliminary results (rainfall season)



Porporato et al., 2003



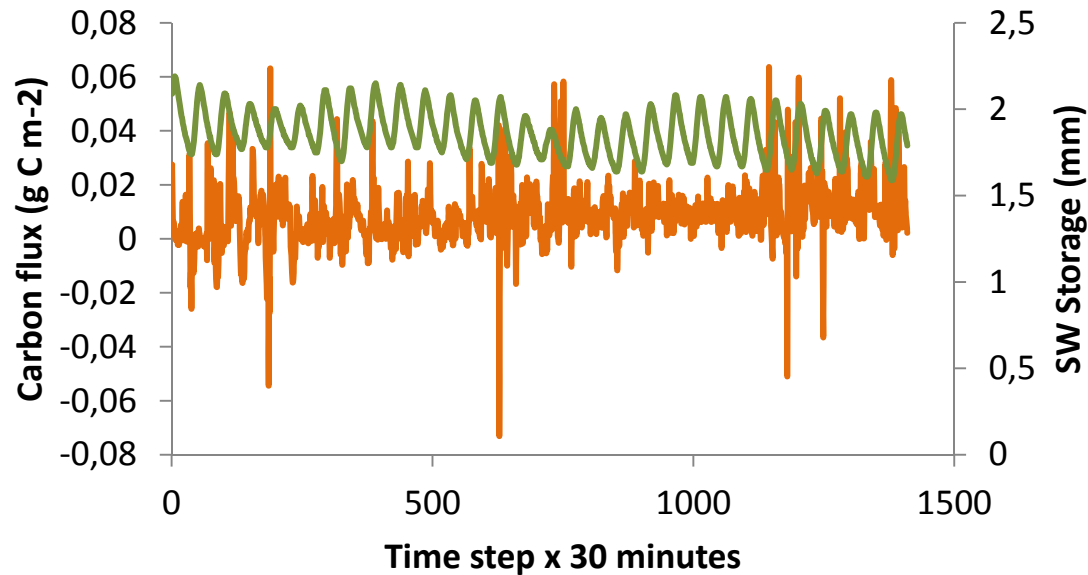
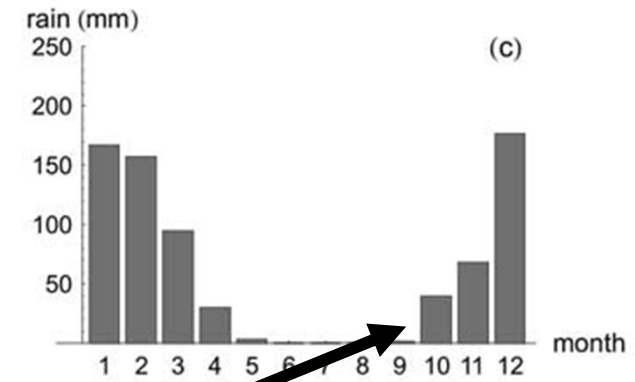
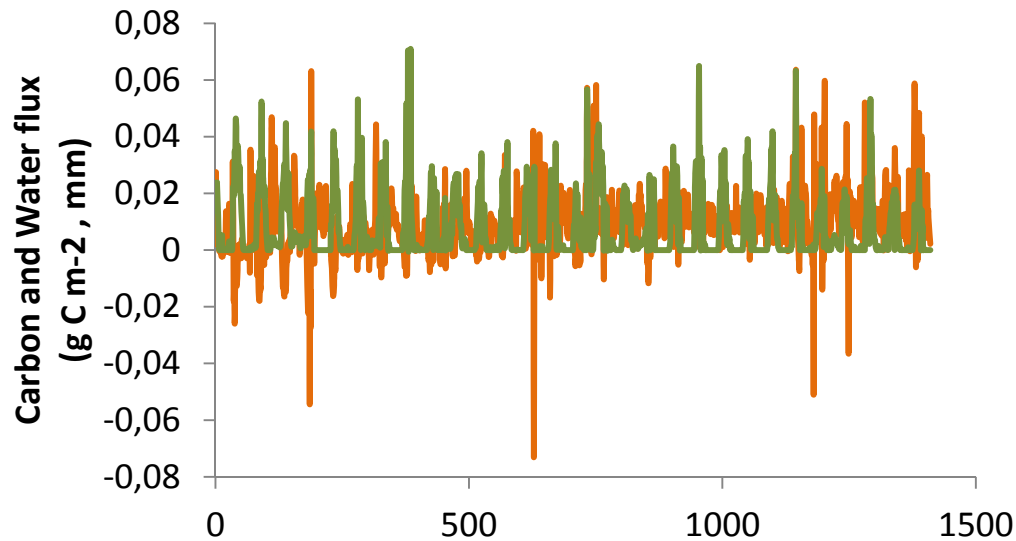
$$\text{RUE} = 24 \text{ g C m}^{-2} (\text{mm H}_2\text{O})^{-1}$$

$$\text{WUE} = 1.13 \text{ g C m}^{-2} (\text{mm H}_2\text{O})^{-1}$$

$$\text{SMUE} = 0.12 \text{ g C m}^{-2} (\text{mm H}_2\text{O})^{-1}$$

$$\text{SMUE} = 6.5 \text{ g C m}^{-2} (\text{mm H}_2\text{O})^{-1}$$

Preliminary results (dry season)



**Negative values
= Carbon Source**

Future work: root dynamics and optimal depth e.g. The Horton Index (H) [Troch et al., 2009]

H=Vaporisation/Wetting

Wet season

H = 7.32 (10cm soil)

H= 0.31 (150cm soil)

Soil texture



Coarse



Fine

Rainstorm properties



Short duration/frequent



Long duration/sparse

Climate



Wet/cool



Temperate

Rainfall occurrence



Mainly in winter



Evenly distributed

Dry season

H = 5.7 (10cm soil)

H = 0.1 (150cm soil)

Thank you!
Grazie!