FUTURE CLIMATE FOR AFRICA

Regional scale soil-moisture feedbacks in a convection-permitting simulation over Africa

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Met Office

IMPALA

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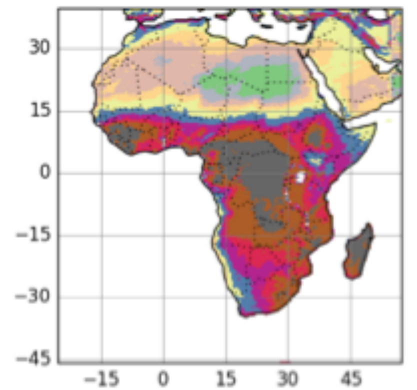
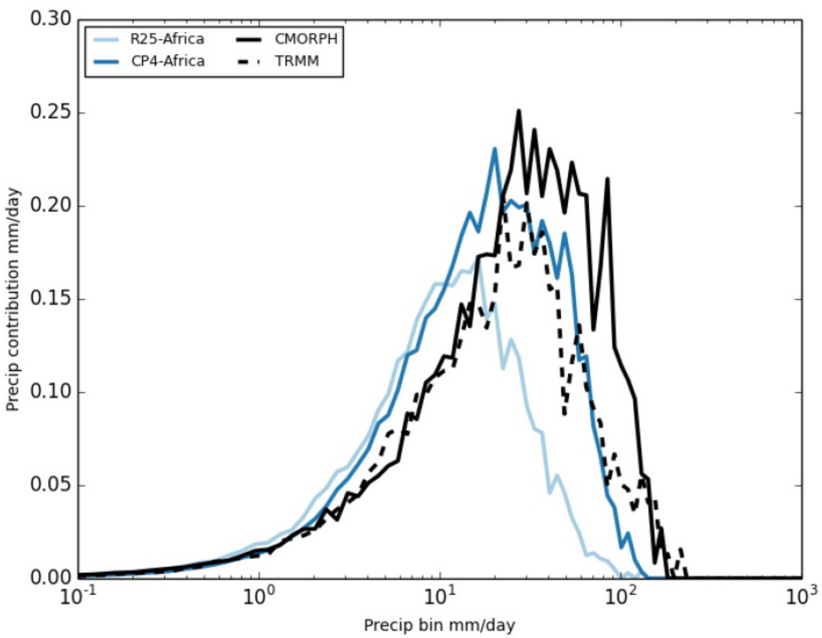
Experimental setup for CP4-Africa

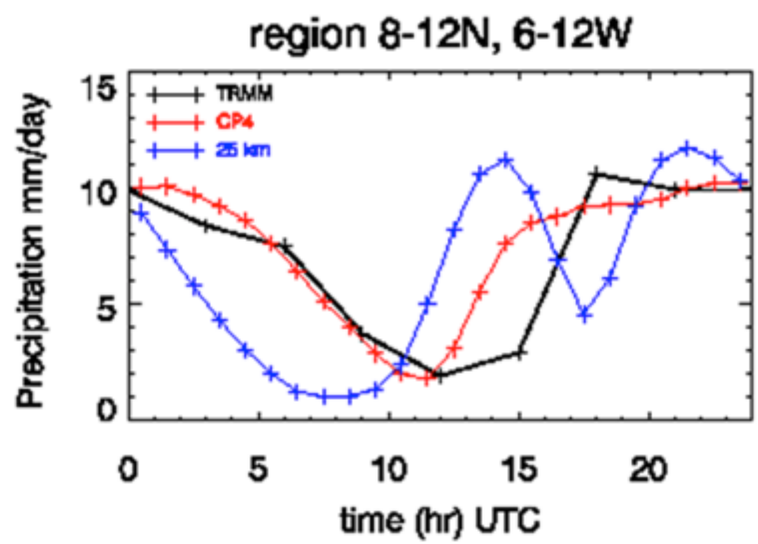
Two model experiments using the **MetUM, b**oth forced with observed SST (1997 to 2006), and forced by a common global run (25 km):

- 25 km parameterised convection (**R25**)
- 4.5 km convection permitting (**CP4**), convection switched off

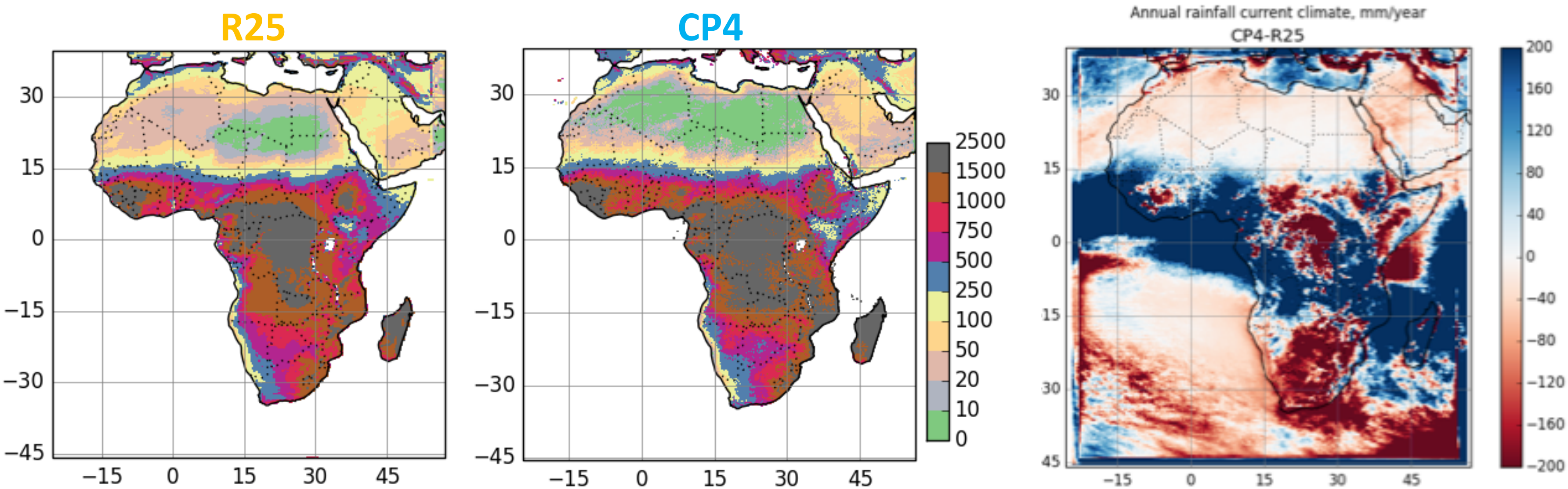


Stratton et al. J Clim, 2018





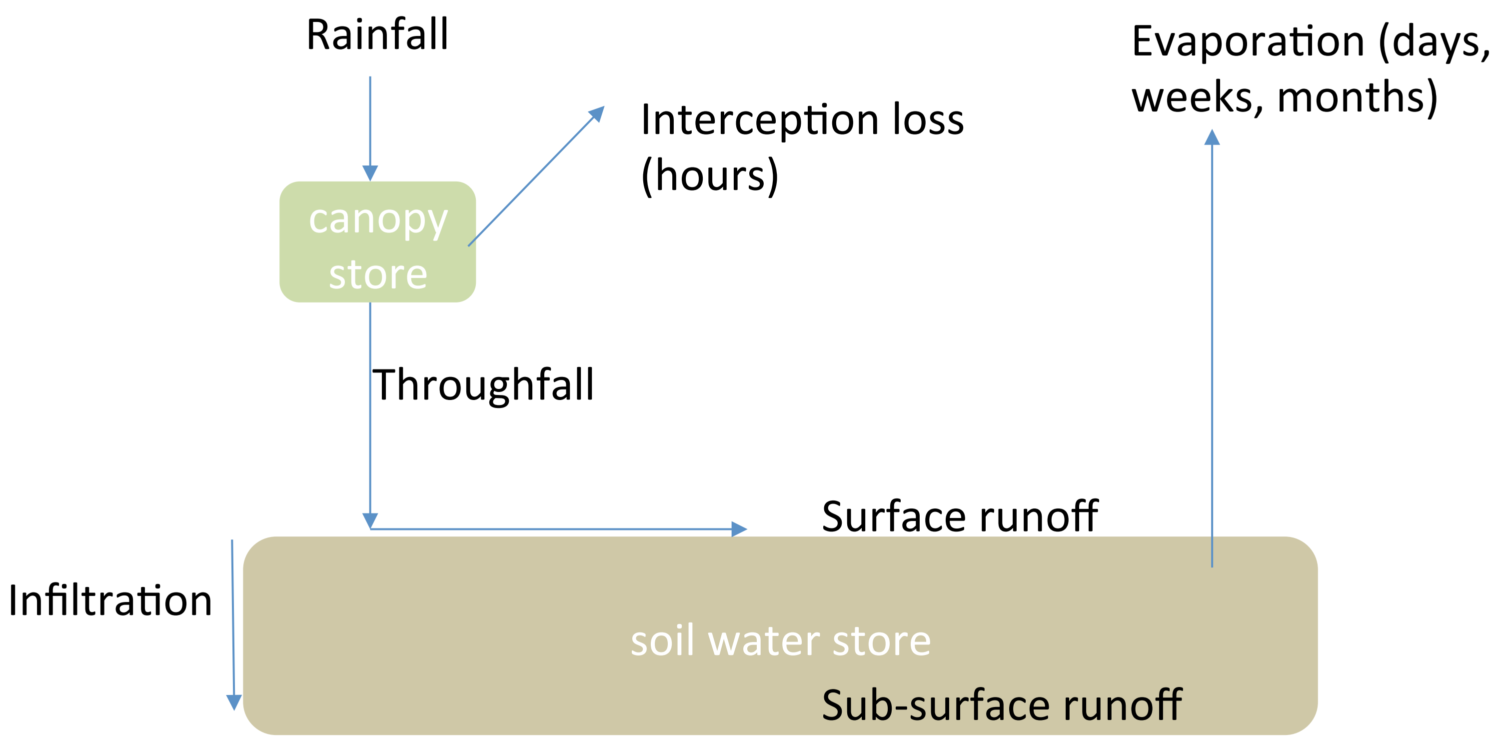
Annual rainfall



Annual rainfall over land: 611 mm/year vs. 672 mm/year

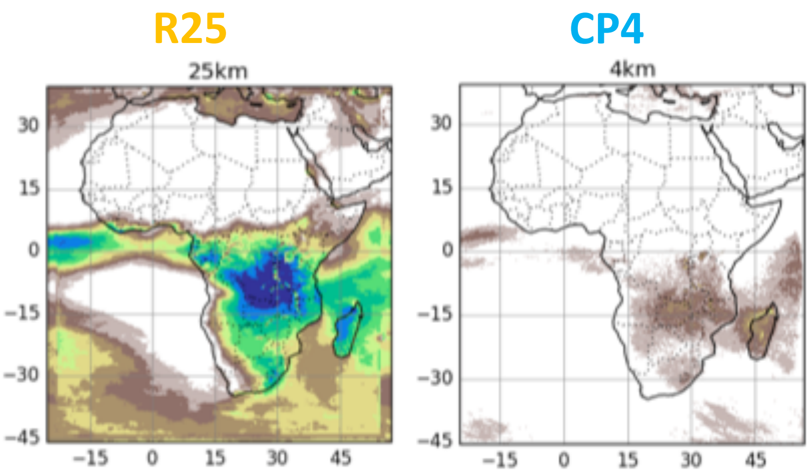
Surface water partitioning

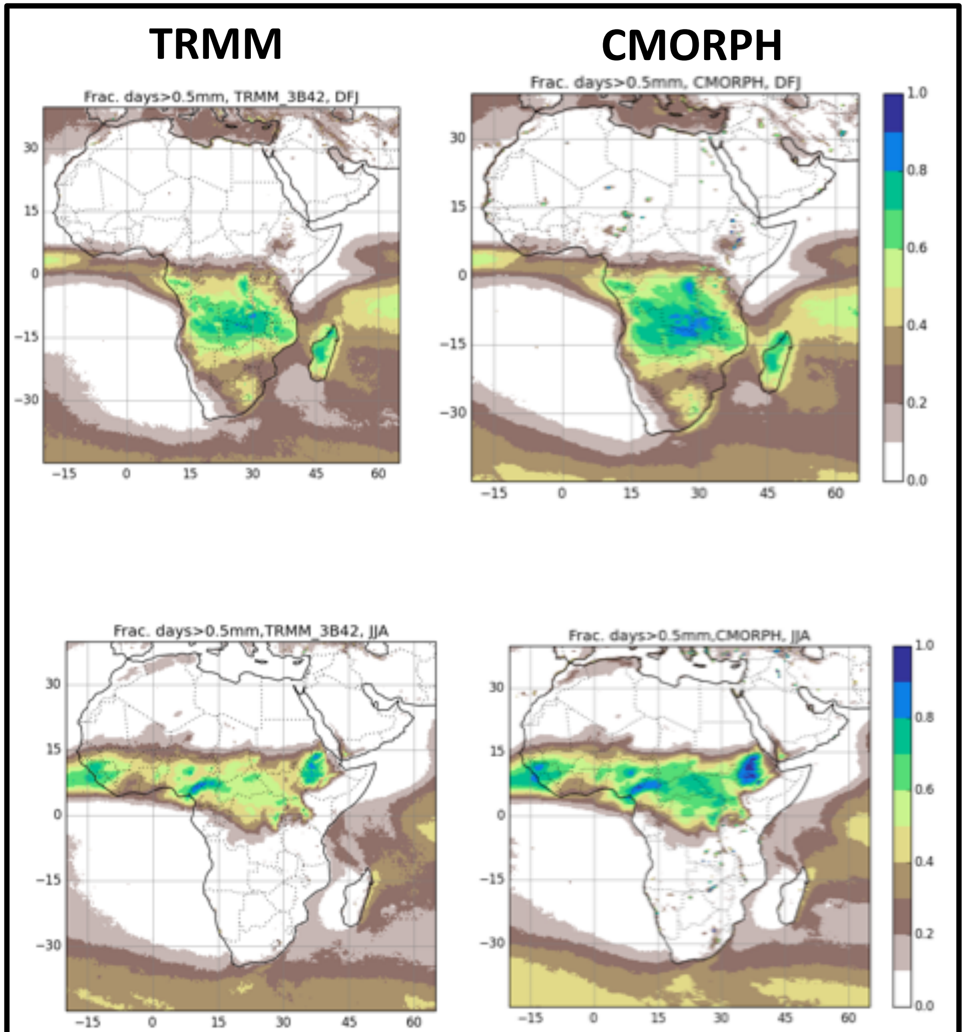
- Are surface fluxes sensitive to the whether the model is run in a parameterised or convection permitting mode?
- Changing the rainfall intensity, quantity so what is the net effect of all these changes?



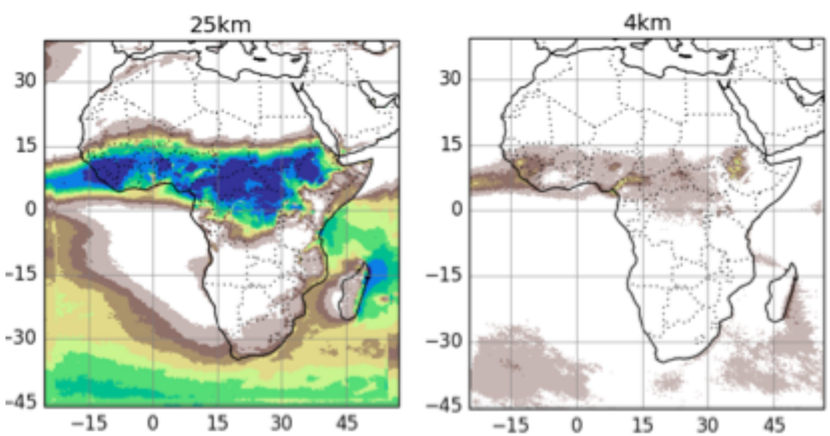
CP4: Fewer events

Fraction of days with >0.5 mm rain, **DJF**





Fraction of days with >0.5 mm rain, **JJA**



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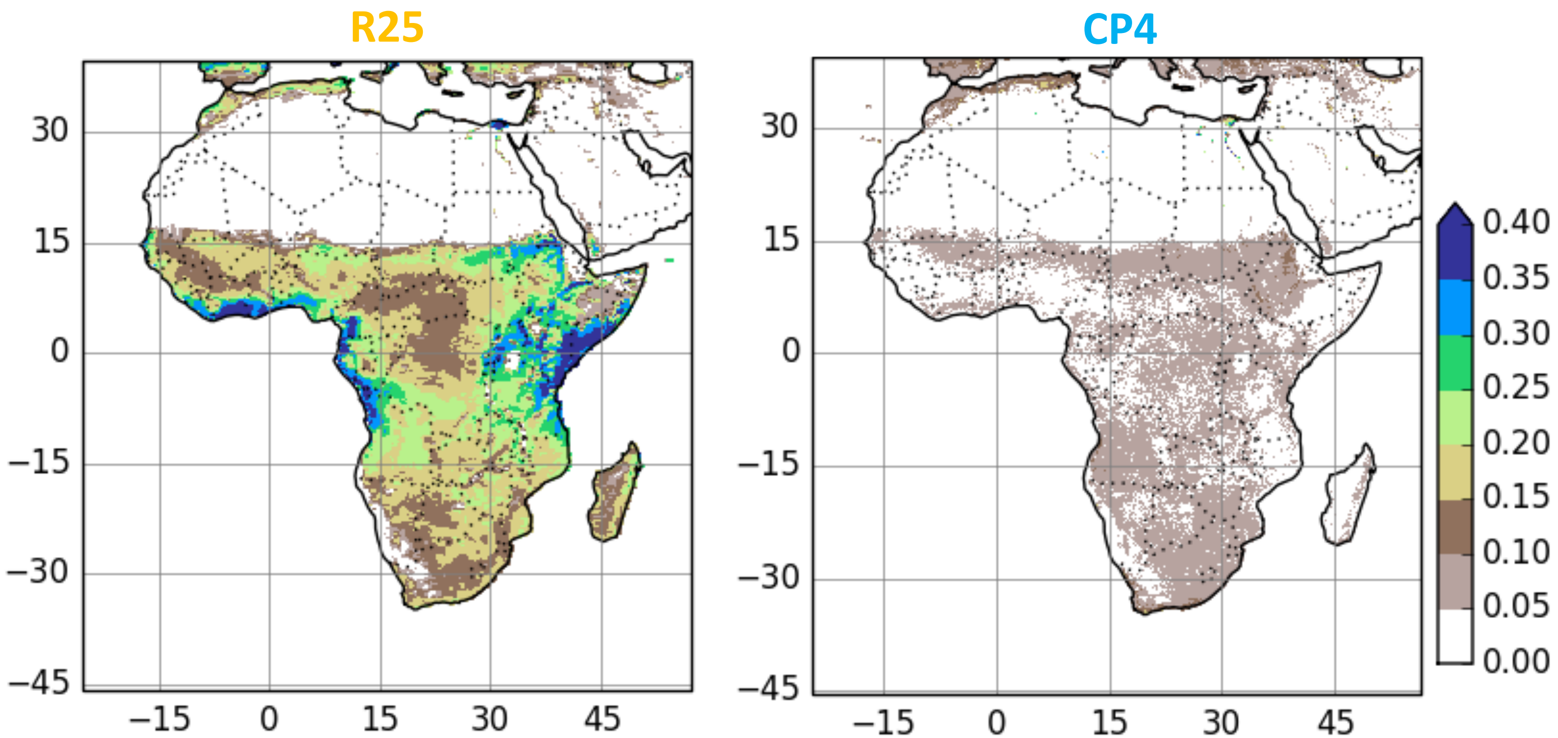
Fractional canopy interception loss

Water intercepted and returned to the atmosphere over very short timescales, Ec

Fraction of annual rainfall intercepted by the canopy (Ec/Rain)



Observations of interception loss over tropical rain forests (Amazonia) ~ 15%

Tai Park in Ivory Coast = 9.2% (Aug to Dec)

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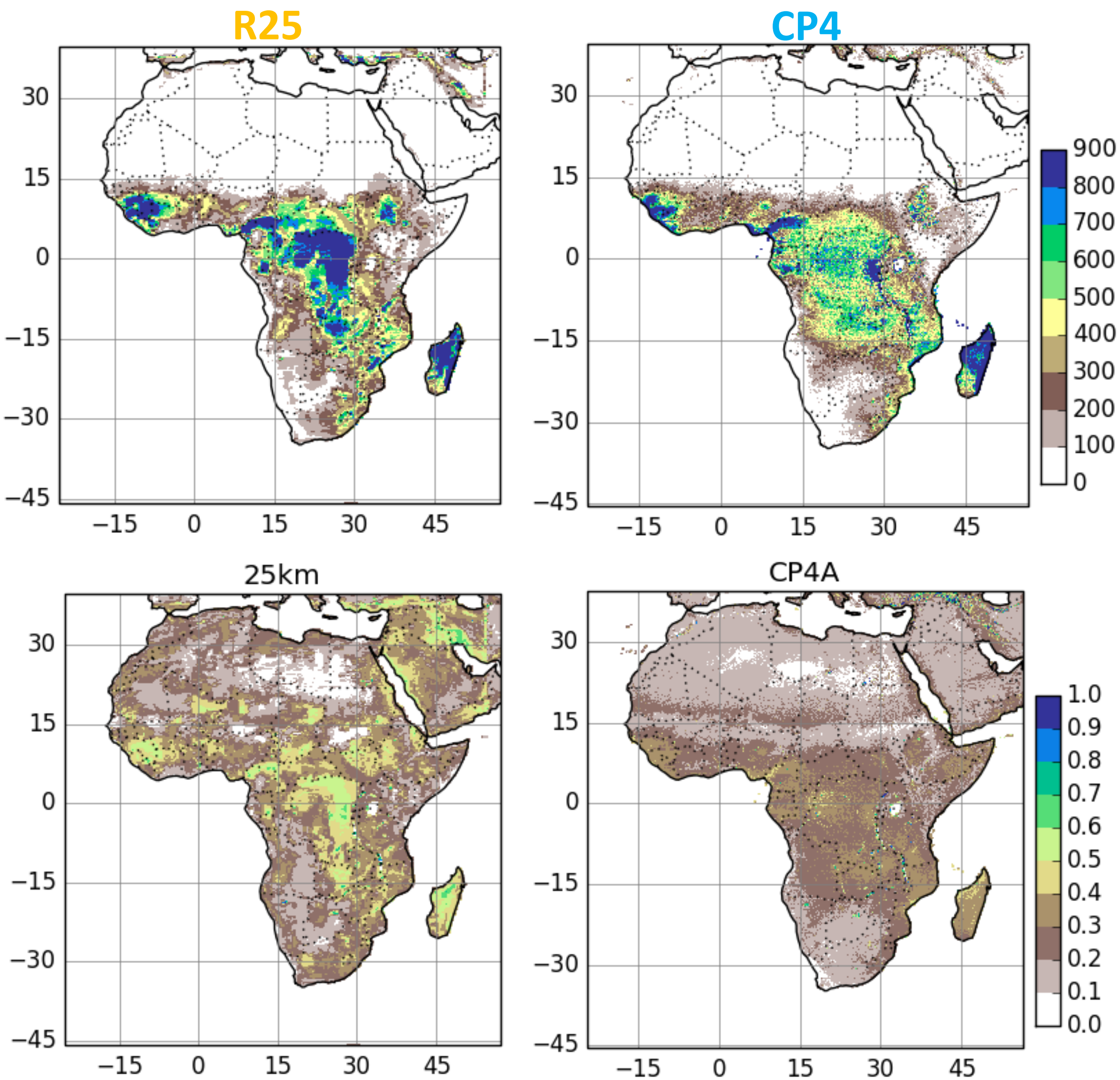
Surface runoff

Annual surface runoff, 214 mm/year, 189 mm/yr



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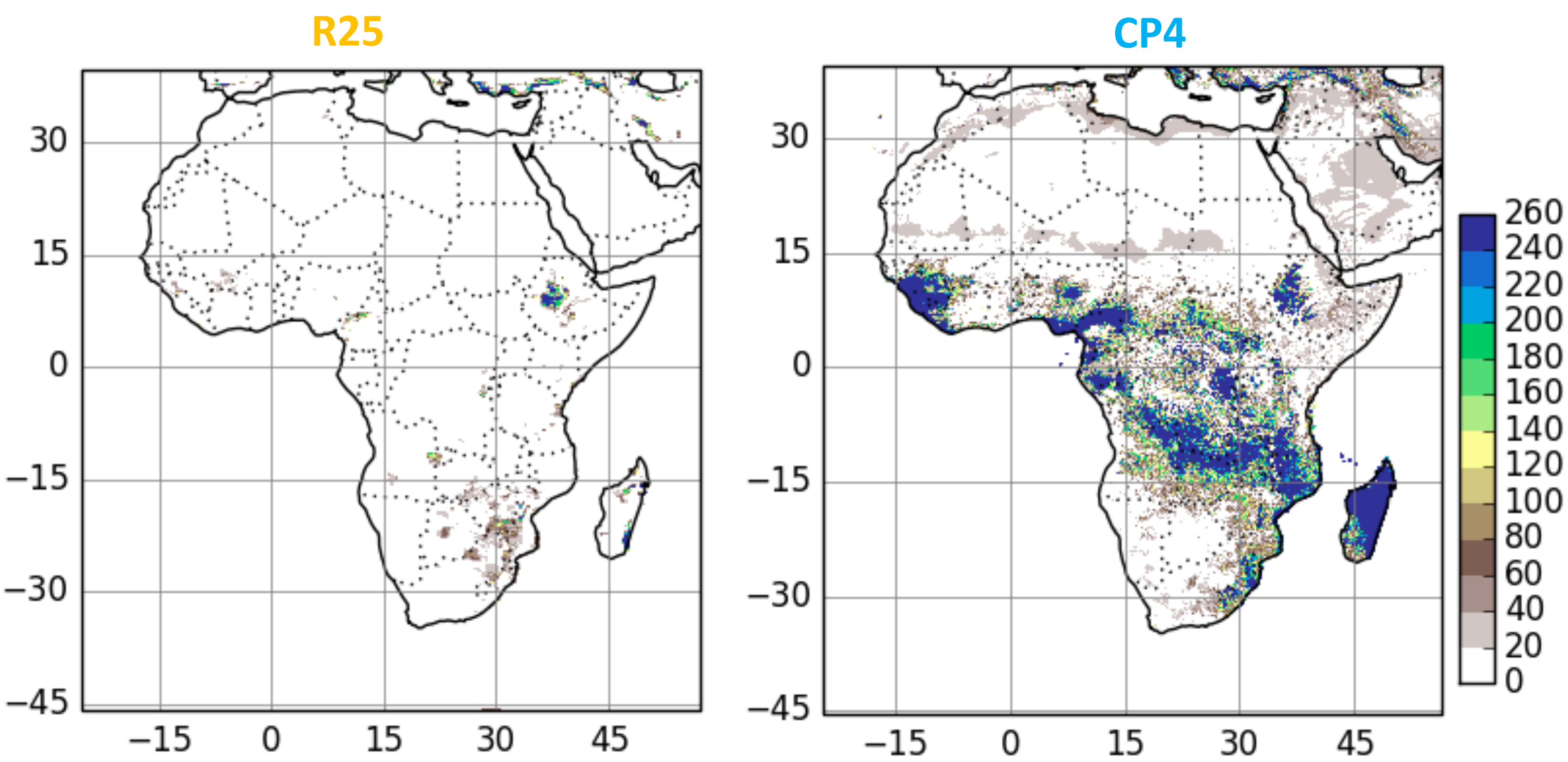
Sub-surface runoff

Annual sub-surface runoff, 6 mm/year, 79 mm/year



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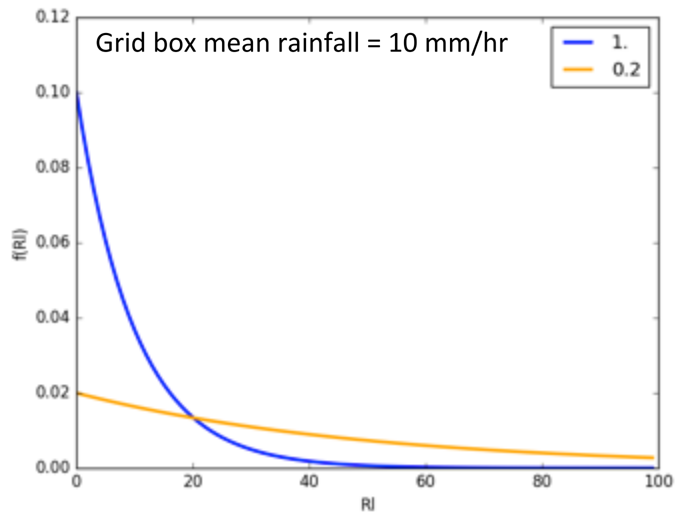
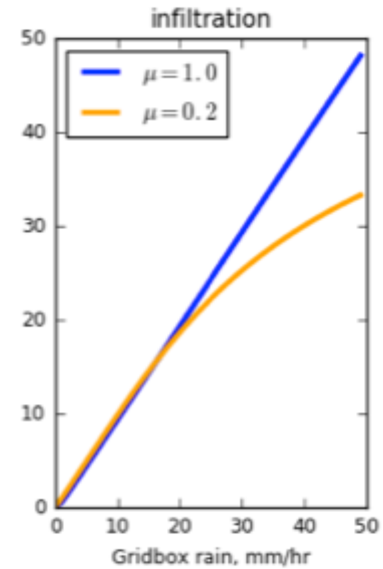
JULES sub-grid rainfall

JULES assumes a sub-grid distribution of rainfall

$$f(R_l) = (\mu/R)\exp(-\mu R_l/R)$$





Gridbox mean throughfall, Tr

$$T_f = R(1 - C/C_m)\exp(-\mu C_m/R$$

Gridbox mean infiltration excess runoff, Y

$$=\{ R C/C_m \exp(-\mu K C_m/RC) + R(1 - C/C_m)\exp(-\mu$$
$$_m/R\Delta t), \quad K\Delta t \le C R\cdot\exp(-\mu(K\Delta t + C_m - C)/R\Delta t),$$
$$\Delta t > C$$

In **coupled** mode:

R25 model -> convective rainfall; rainfall area fraction ~ 0.2.
-> large scale rainfall; 0. < rainfall area fraction < 1.

CP4 model -> large scale rain; rain area fraction = 1

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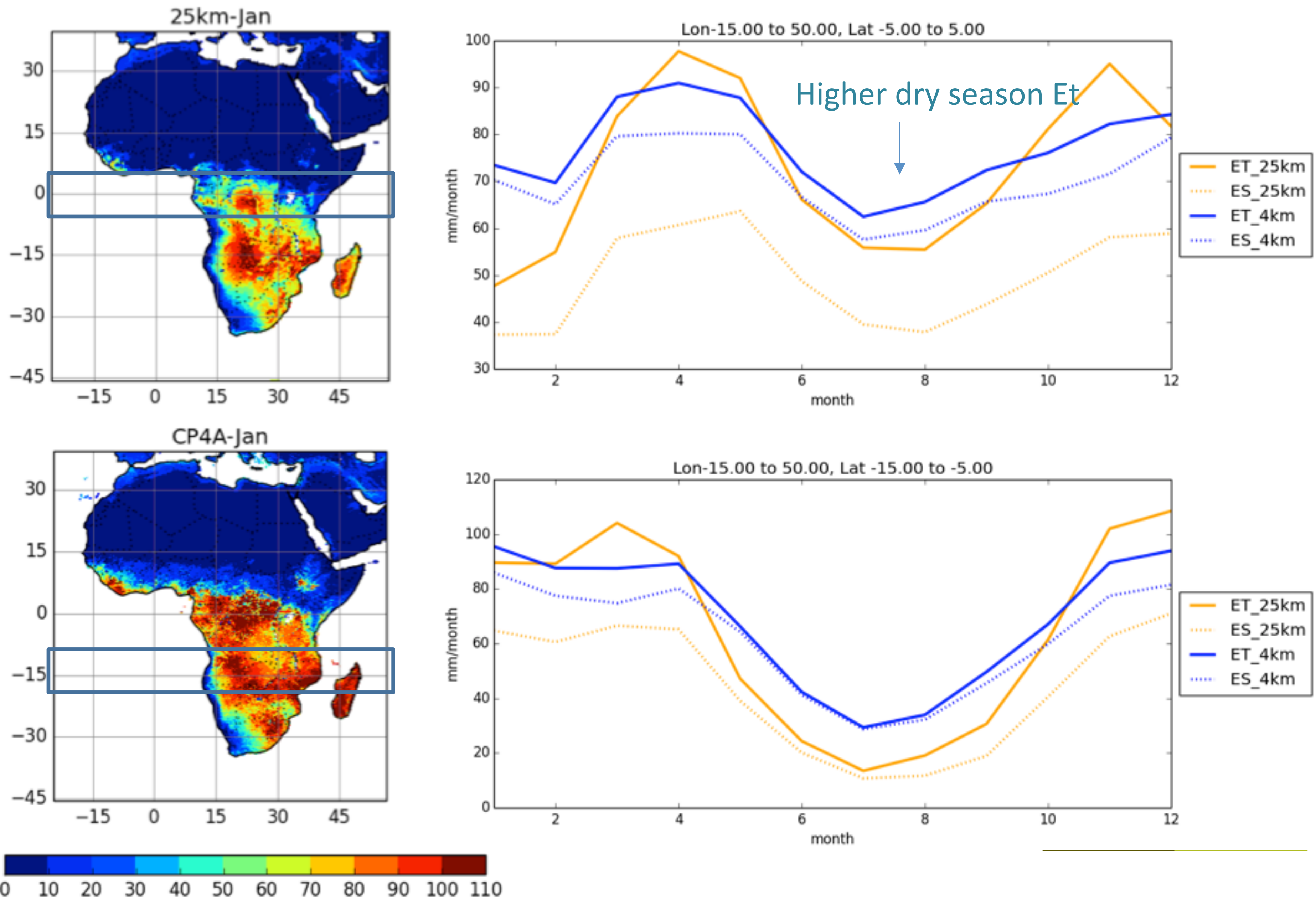
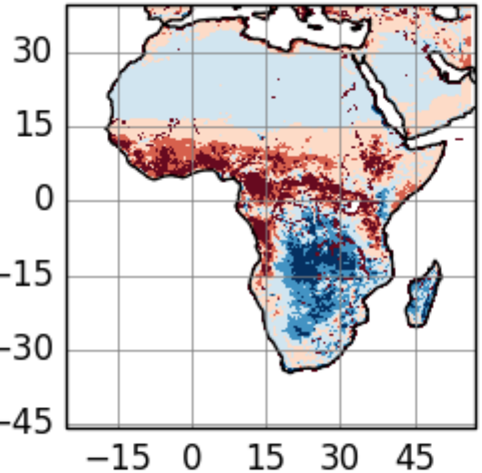
Seasonal evaporation



Fluxes: DJF

Dry season in the northern hemisphere

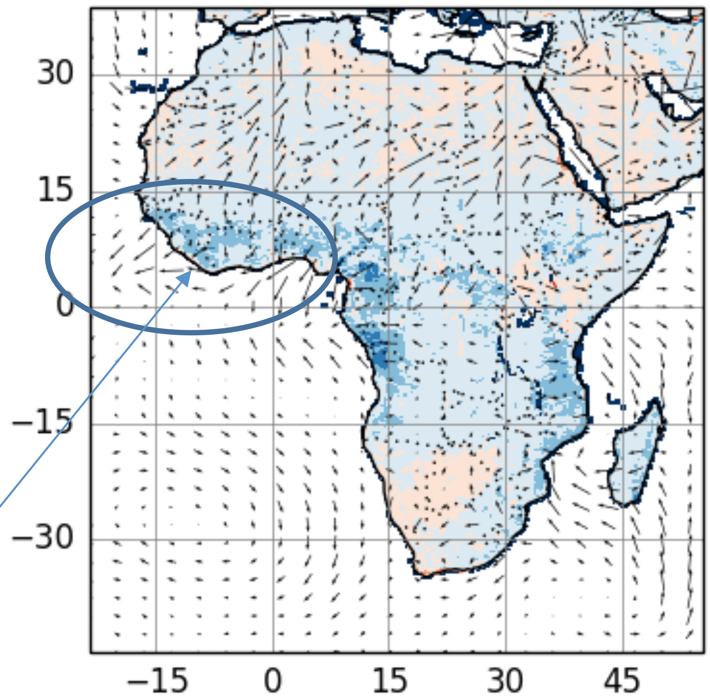
CP4 - R25



LH, Wm^{-2}

−30 −20 −10 0 10 20 30

CP4 - R25



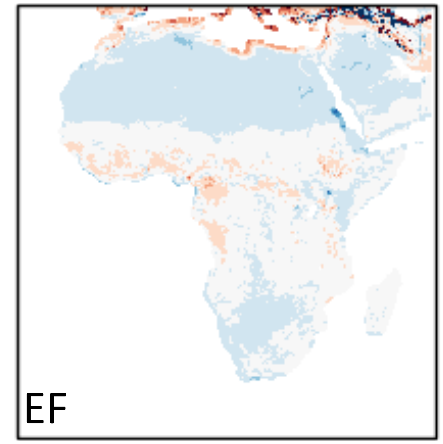
$2\frac{m}{s}$

Tair 2-3K cooler

SH, Wm^{-2}

−80 −60 −40 −20 0 20 40 60 80

CP4 - R25



−0.8 −0.4 0.0 0.4 0.8

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Summary

- Do we see a difference in the land surface response in these idealised experiments?

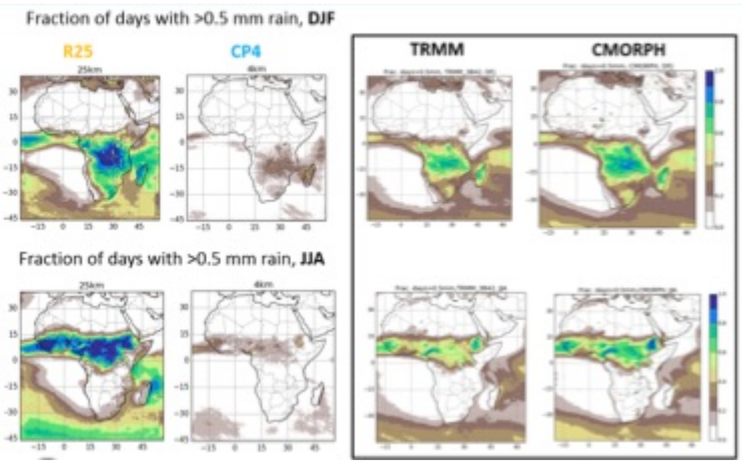
- Yes we see a large difference in canopy interception losses:
  CP4 is too low
  R25 too high along west coast and east Africa.

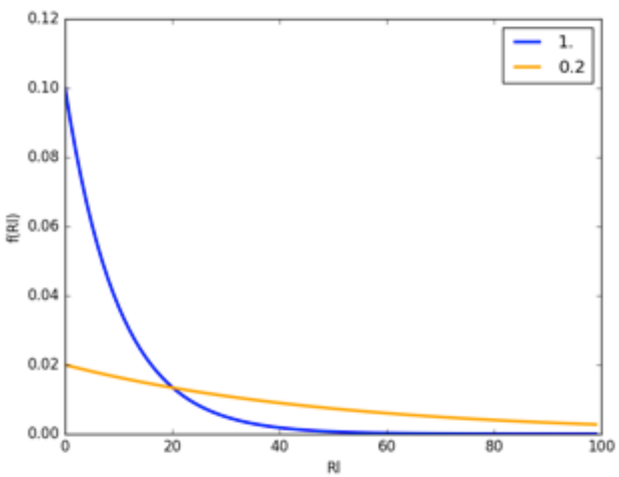
- We see an impact on dry season evaporation, both in West Africa and across central Africa with additional ~30 Wm^{-2}

- There is also a model structural effect due to the sub-grid distribution of rainfall which is something for development.

- Canopy evaporation has masked the effects of the land surface in the rainy season.

- Thank you!





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