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

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Experimental setup for CP4-Africa

Two model experiments using the **MetUM**, both 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 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**

**R25**

**CP4**

**TRMM**

**CMORPH**

Fraction of days with >0.5 mm rain, **JJA**
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)
Surface runoff

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

R25

CP4

25km

CP4A
Sub-surface runoff

Annual sub-surface runoff, 6 mm/year, 79 mm/year
JULES sub-grid rainfall

JULES assumes a sub-grid distribution of rainfall

\[ f(R_{\downarrow l}) = (\mu/R) \exp(-\mu R_{\downarrow l}/R) \]

Gridbox mean throughfall, \( T_{\downarrow f} = R(1 - C/C_{\downarrow m}) \exp(-\mu C_{\downarrow m}/R) \)

Gridbox mean infiltration excess runoff, \( Y \)

\[ Y = \{ R C/C_{\downarrow m} \exp(-\mu K C_{\downarrow m}/RC) + R(1 - C/C_{\downarrow m}) \exp(-\mu C_{\downarrow m}/R \Delta t), \ K \Delta t \leq C R \exp(-\mu(K \Delta t + C_{\downarrow m} - C)/R \Delta t), \ \Delta t > C \}

In **coupled** mode:

**R25** model -> convective rainfall; rainfall area fraction \( \sim 0.2 \).
- large scale rainfall; 0. < rainfall area fraction < 1.

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

Higher dry season Et
Fluxes: DJF

Dry season in the northern hemisphere

LH, Wm\(^{-2}\)

T\(_{air}\) 2-3K cooler

SH, Wm\(^{-2}\)
• 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!