Hydrological Feedbacks in Tropical African Wetlands

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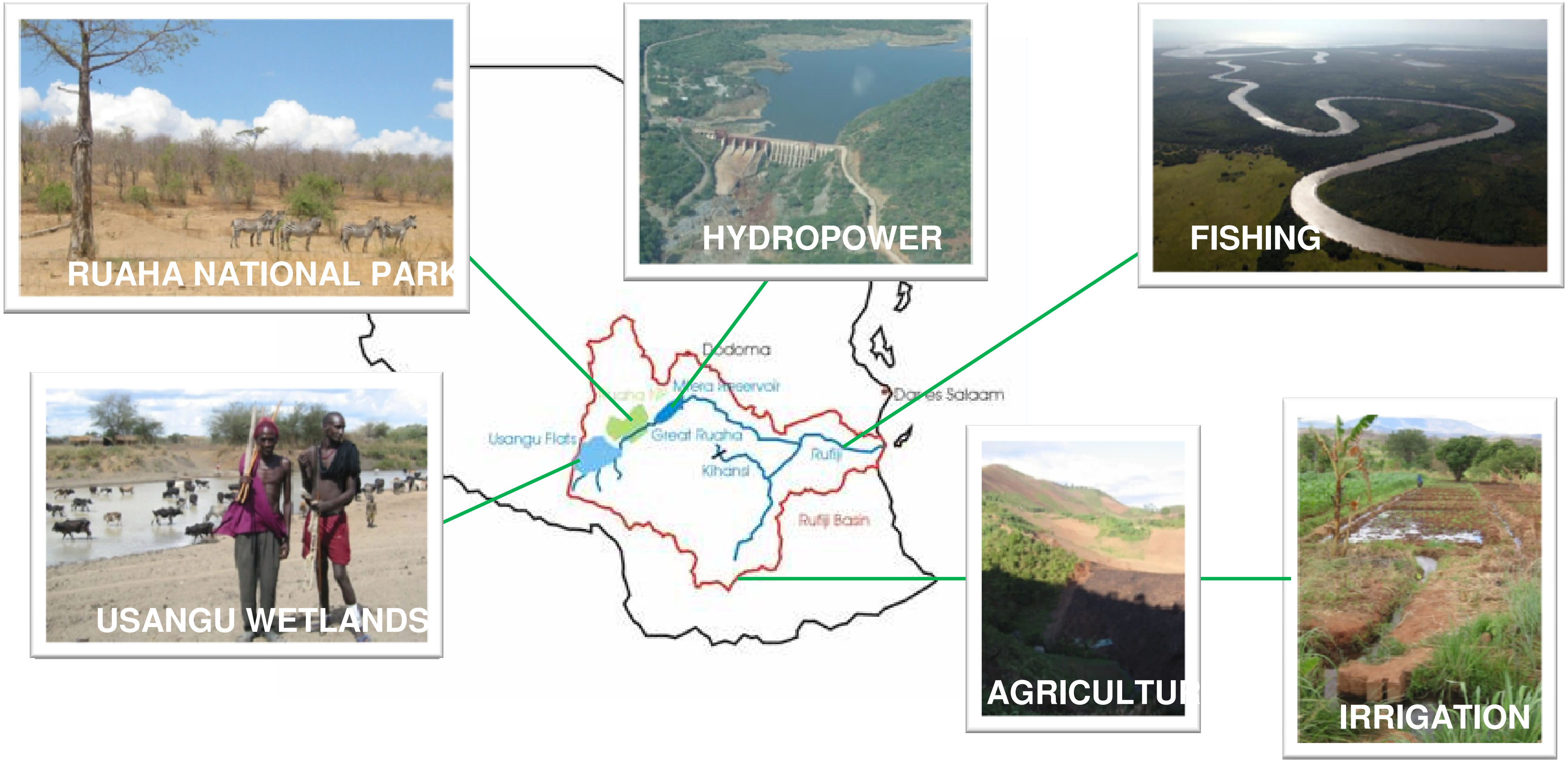
Key challenges

- **Linking across scales**: can we predict the hydrological response to climate change?
- **Representing feedbacks**: how does the land-surface govern fluxes of water, energy, and carbon?
- **Sustainable water futures**: how can policymakers balance adaptation to climate change with food security, biodiversity, and other ecosystem services?

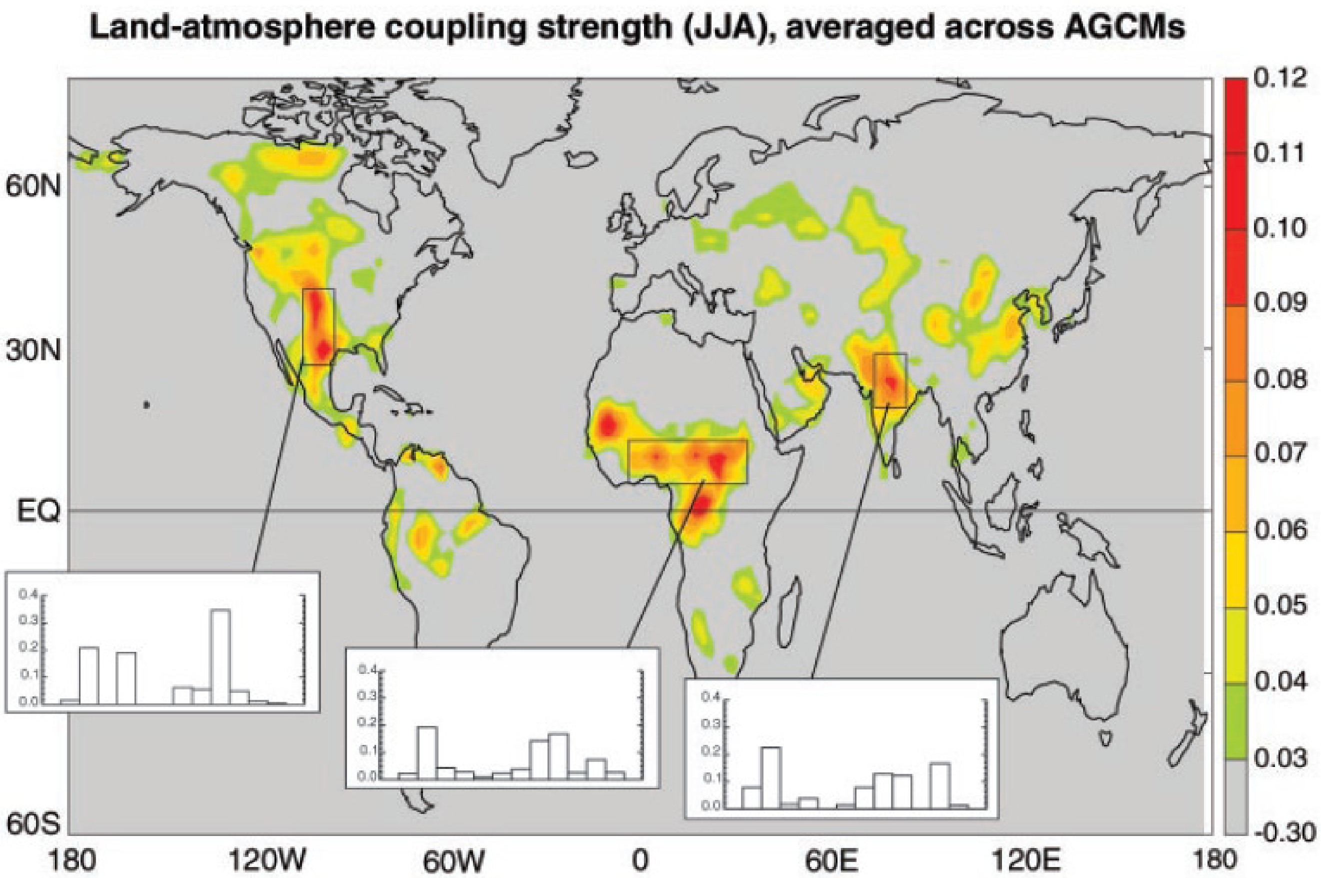
Water use and ecosystem services



- Water use in the Rafiji Basin, Tanzania.
- Upstream irrigation has dried wetlands, affected wildlife and reduced hydropower.
- Need to understand links between climate change, land use and water management

Photos: M. Acreman

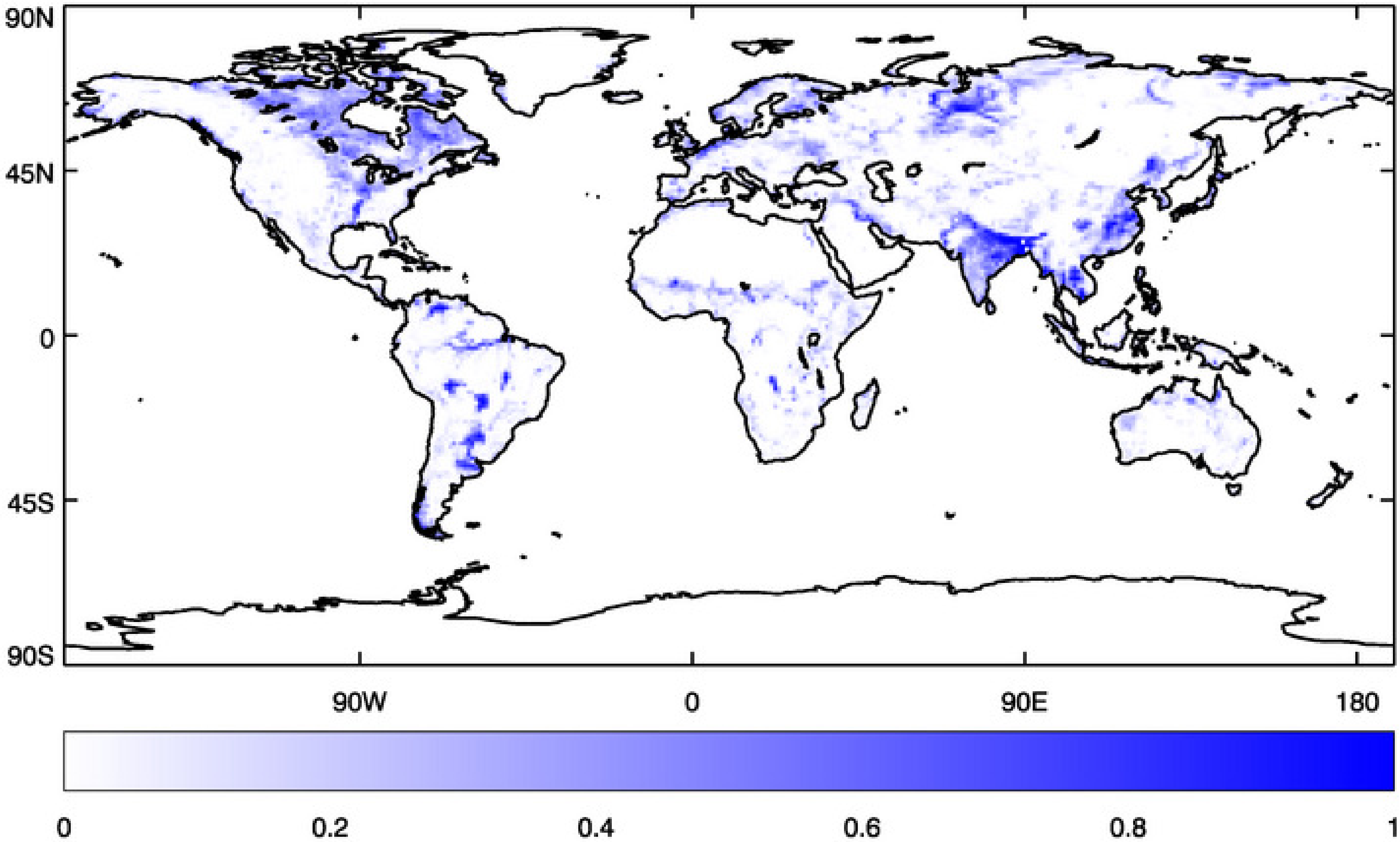
Hydrological feedbacks in the Earth system



- **Feedbacks strongest in transition zones between wet and dry climates.**
- **Need to know state of soil moisture in order to provide accurate forecasts.**
- **Changes to water management can affect regional climate.**

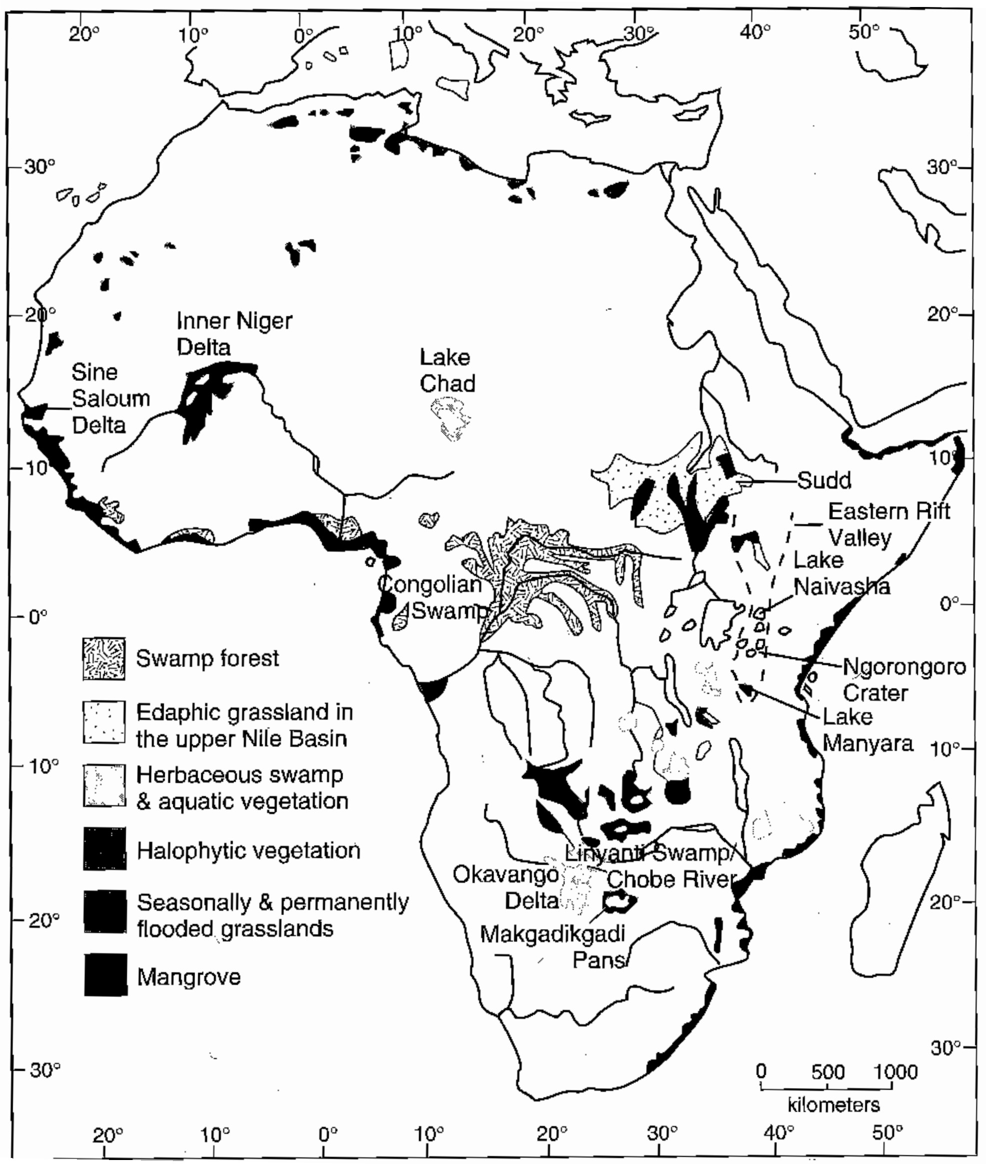
Koster *et al.*, 2004. *Science* 305:1138-1140

Maximum wetland fraction (1993-2004)



Data: Prigent *et al.*, 2008

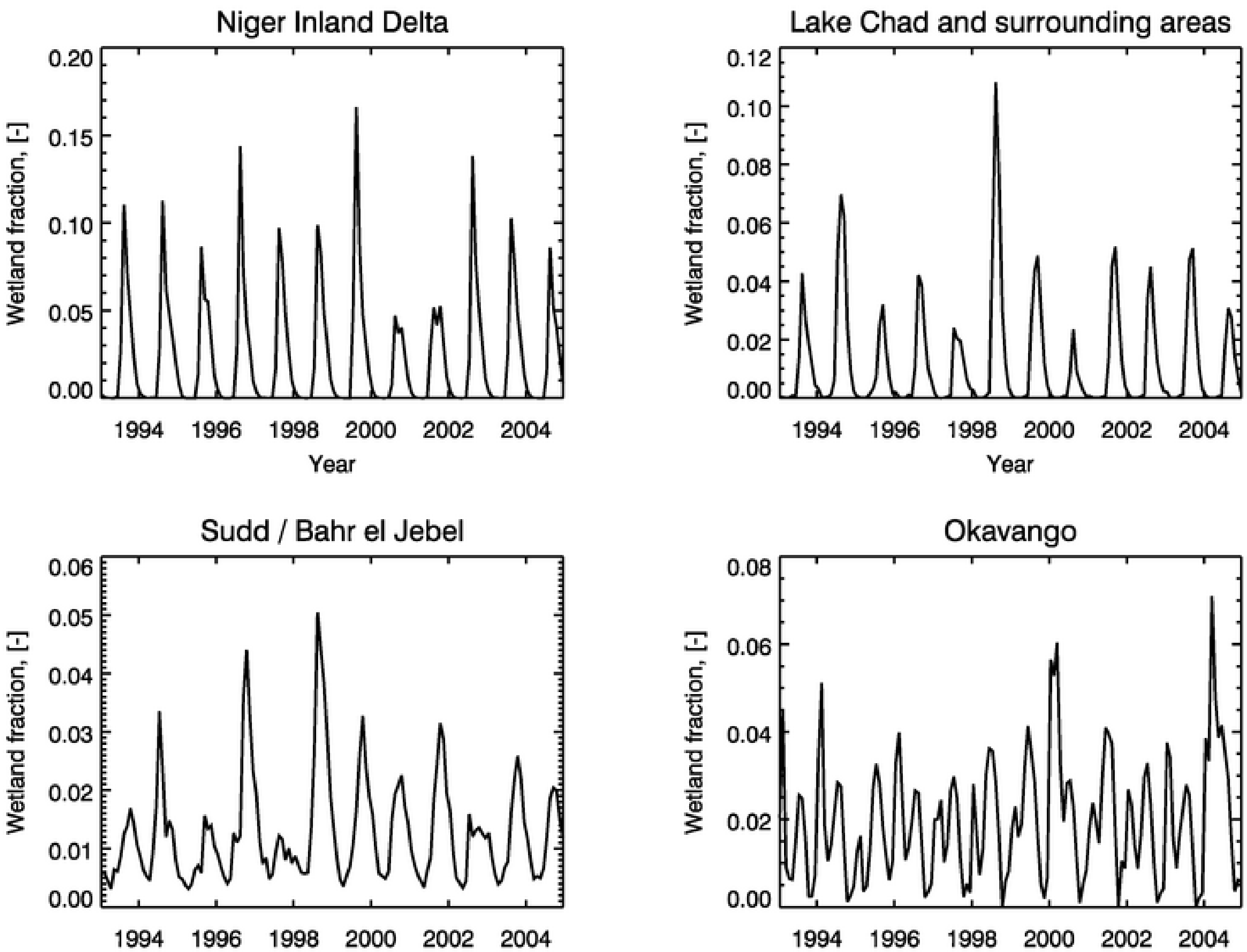
Important Wetlands in Africa



- Niger Delta
- Lake Chad
- Sudd (S. Sudan)
- Congo
- Zambezi
- Okavango

Mitch and Gosselink (2007)

Seasonal Inundation



Data: Prigent et al., 2008

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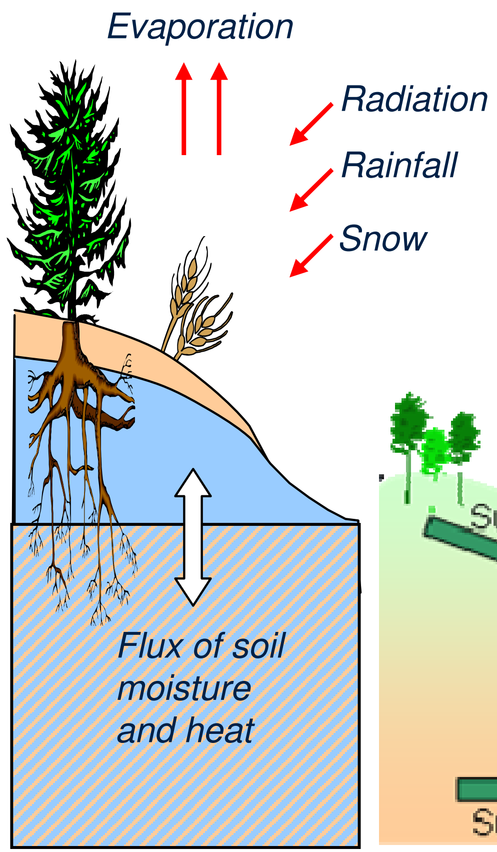
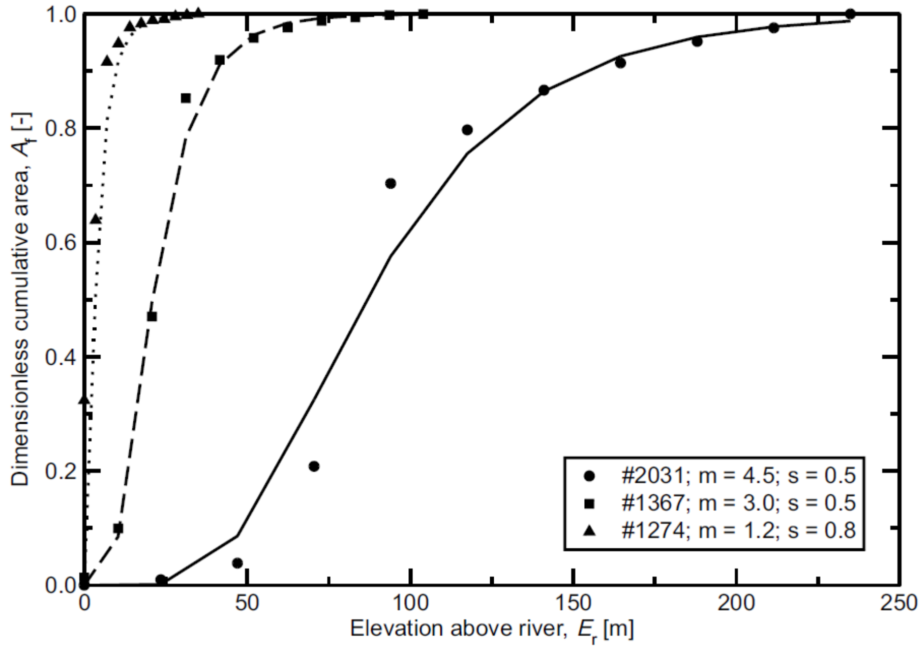
Flow routing and inundation in JULES

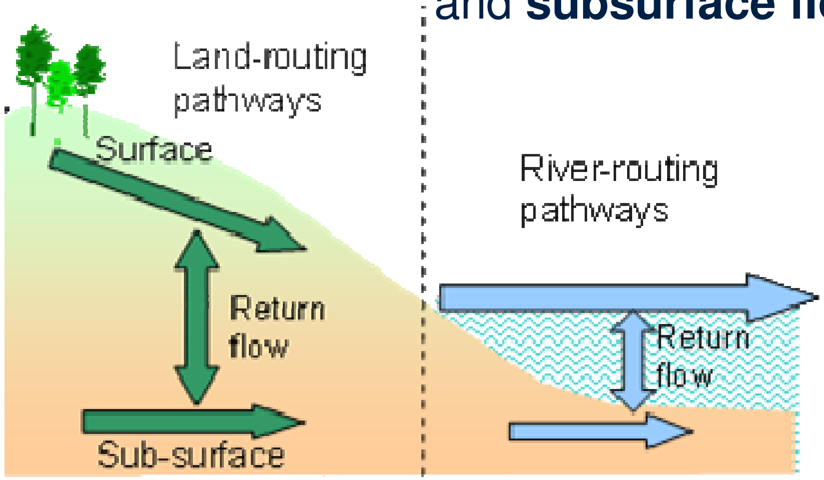
Joint UK-Land Environment Simulator (JULES) takes **temperature**, **wind speed**, **humidity**, **LW** & **SW radiation** and **precipitation** from RCM;



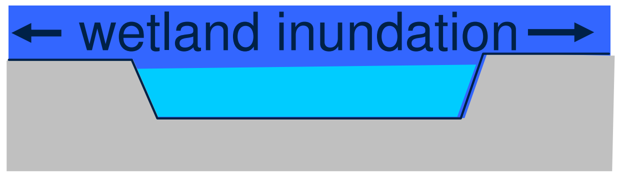
Diagnose state of **soil moisture** by using a Pareto distribution of soil moisture stores;



Convert to **surface** and **subsurface flow.**



Inundated wetland area calculated using sub-grid elevation data



Dadson *et al.*, 2010, *J. Geophys. Res.*, 115: D23114

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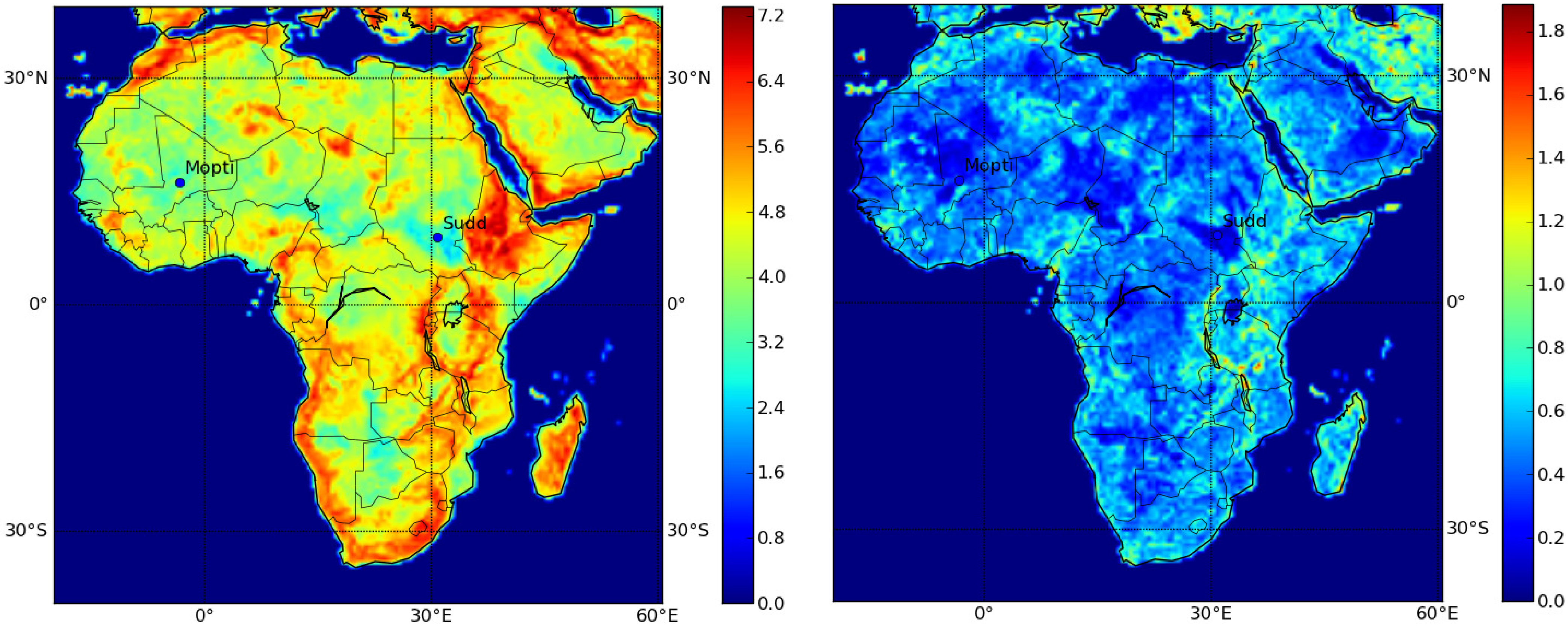
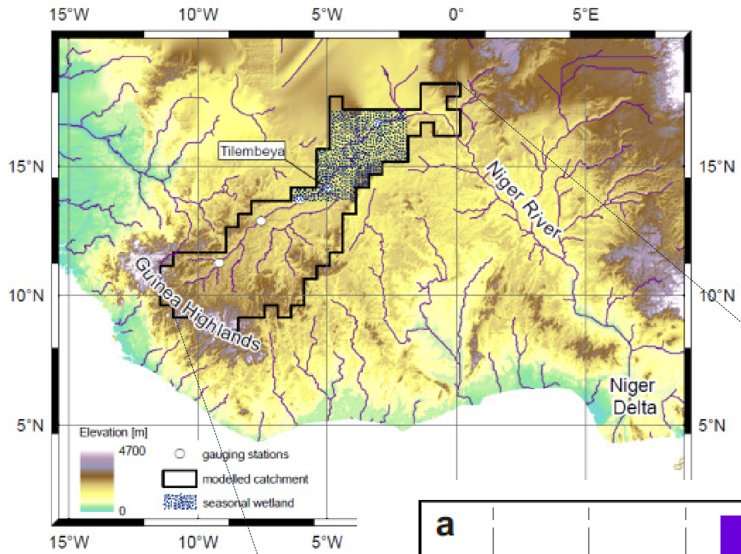
Flow routing and inundation in JULES

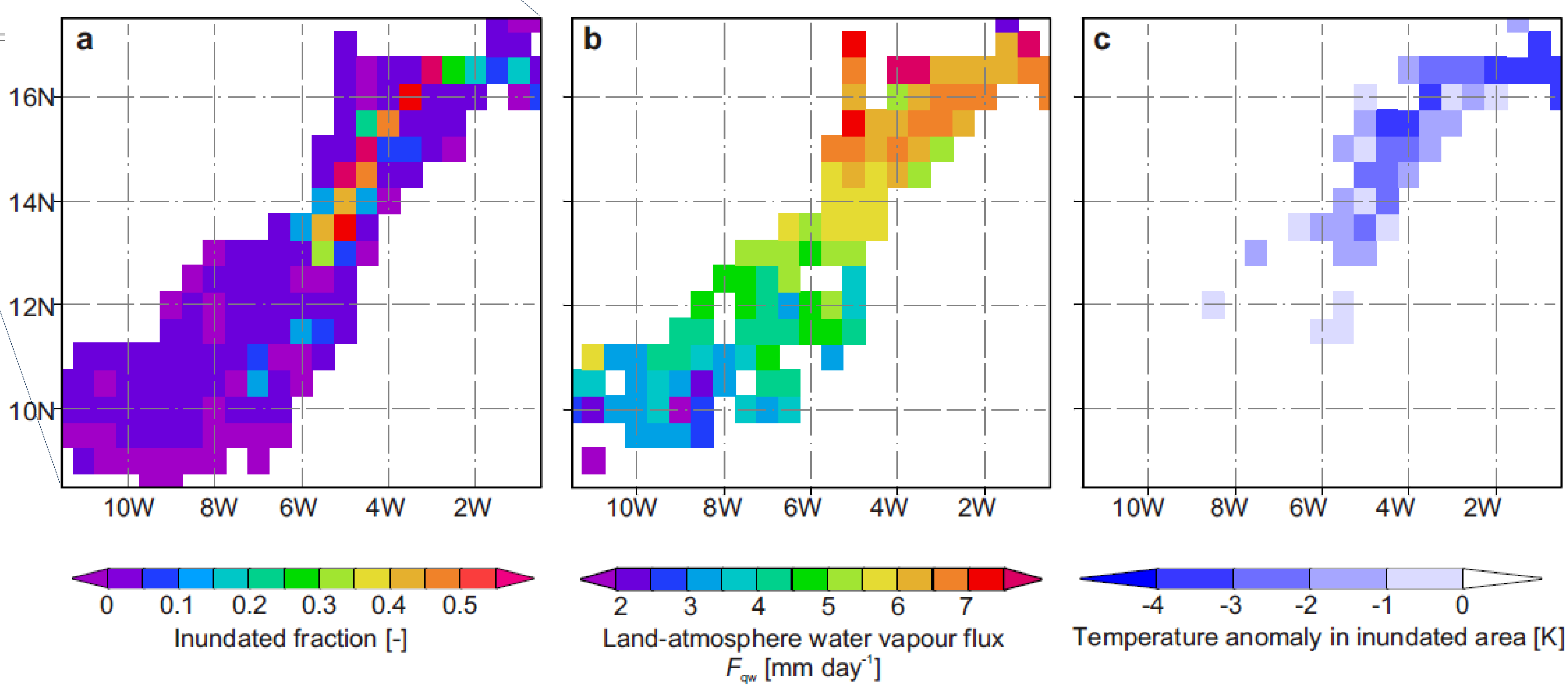


- HydroSHEDS digital topography (90 m hydrologically sound DEM)
- Used to produce inundation parameters for large-scale model

Land-atmosphere feedbacks in W. Africa



- **Niger Inland Delta, Mali;**
- **Inundation drives water vapour flux and temperature anomaly;**
- **Seasonal flooding provides up to 50% of water vapour to atmosphere.**



Dadson *et al.*, 2010, *J. Geophys. Res.*, 115: D23114

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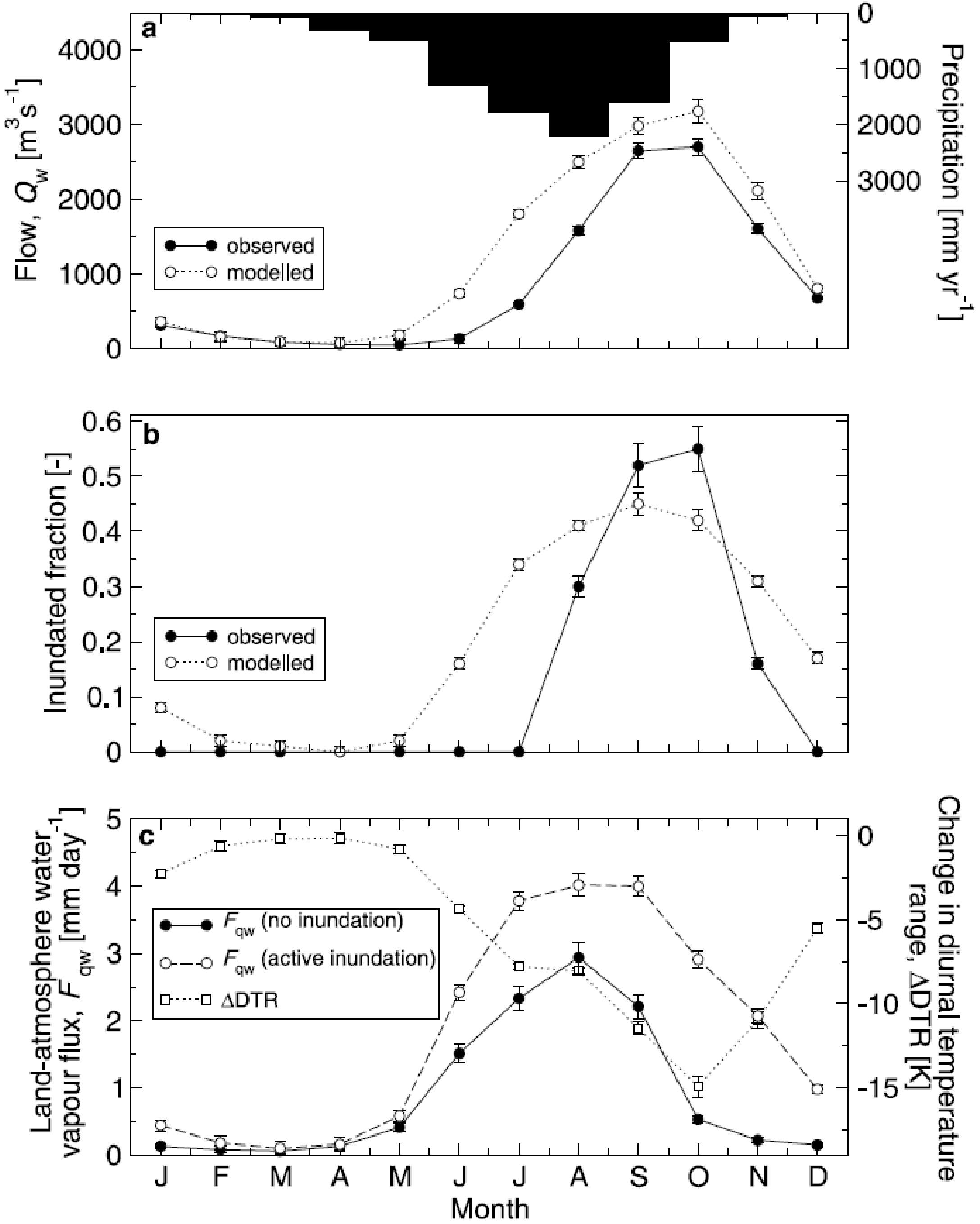
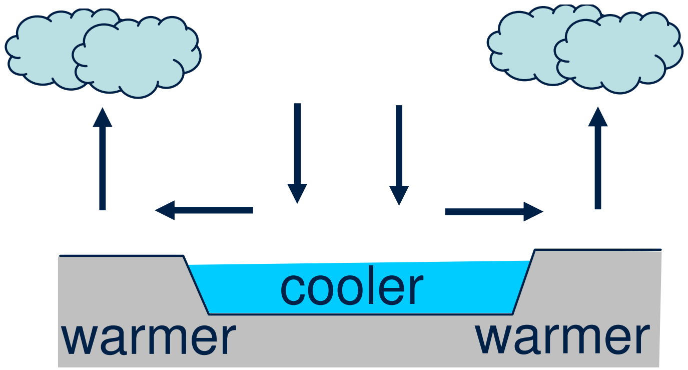
Impact of flooding on water and energy fluxes

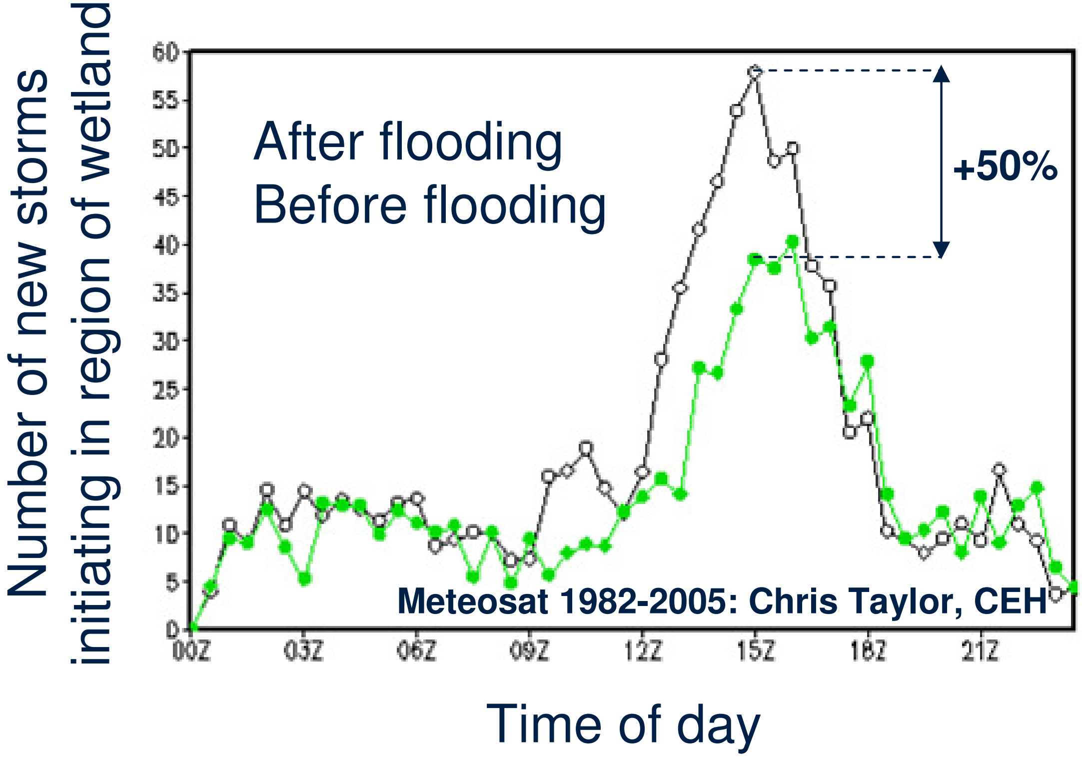


- Timing of flows accurately reproduced ($R^2 = 0.70$); ongoing work to improve groundwater in JULES
- Satellite observations show good representation of seasonal inundation pattern (passive & active microwave, near infra-red);
- Evaporation increases from 11 to 22 mm/day with inundation scheme;
- Evaporation reduces surface temperature by 5 K and diurnal temperature range by up to 15 K.

Dadson *et al.*, 2010, *J. Geophys. Res.*, 115: D23114
Prigent *et al.*, 2007, *J. Geophys. Res*, 112: D12107

Observed land-atmosphere feedback

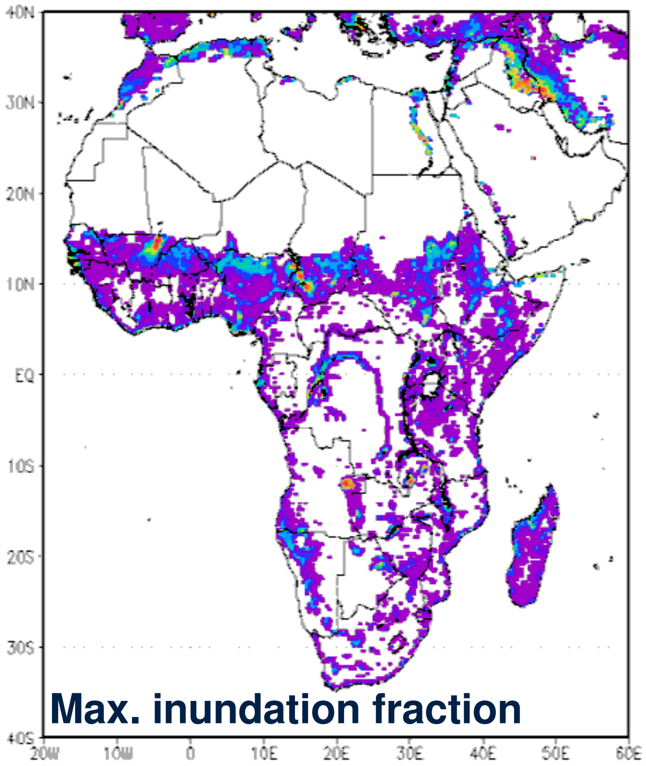


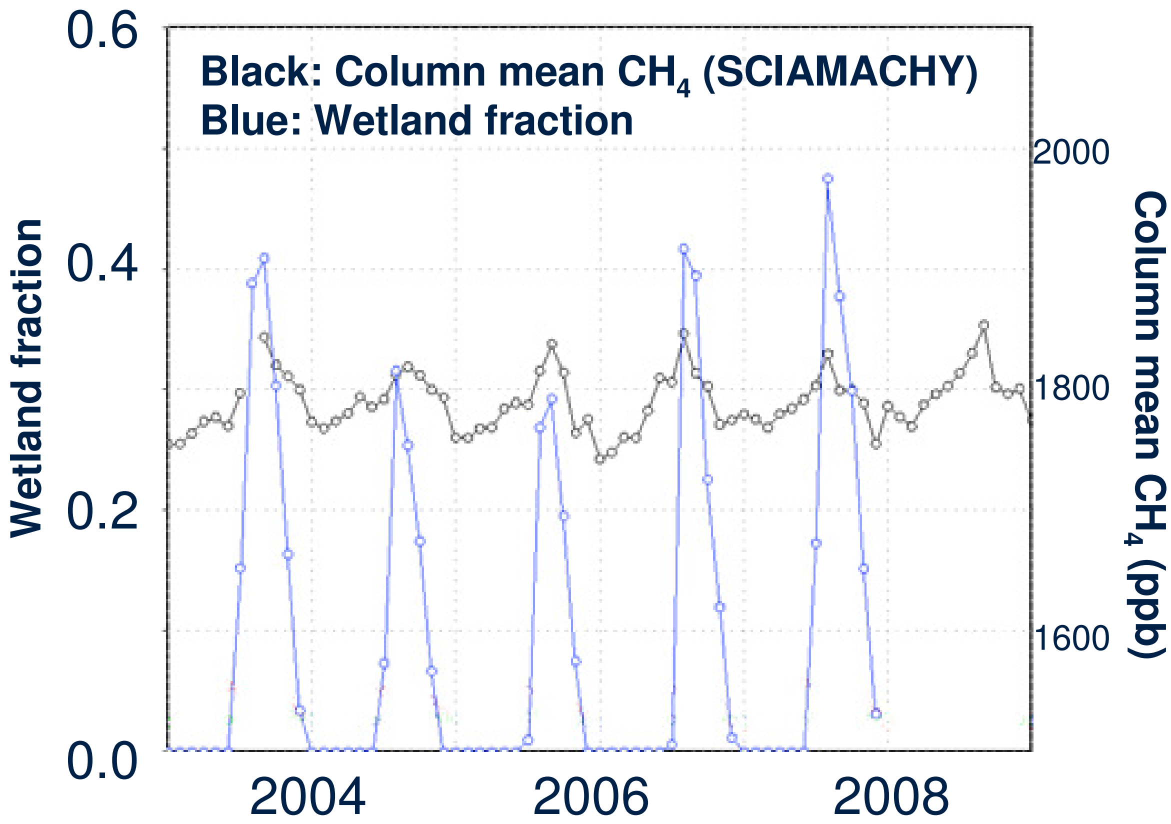


- **Development of a "wetland breeze";**
- **50% more daytime storms during floods**
- **Better land-surface modelling will improve weather forecasts in West Africa.**

Dadson *et al.*, 2010, *J. Geophys. Res.*, 115: D23114
Taylor, (2010), *Geophys. Res. Lett.*, 37, L041652

Links between the water and carbon cycles





- Methane (CH_4) is the second most important greenhouse gas after CO_2.
- Wetlands are largest natural source of CH_4, via anoxic degradation of organics.
- CH_4 fluxes from wetlands are poorly quantified (105-278 Tg yr^{-1}, 75% tropical).

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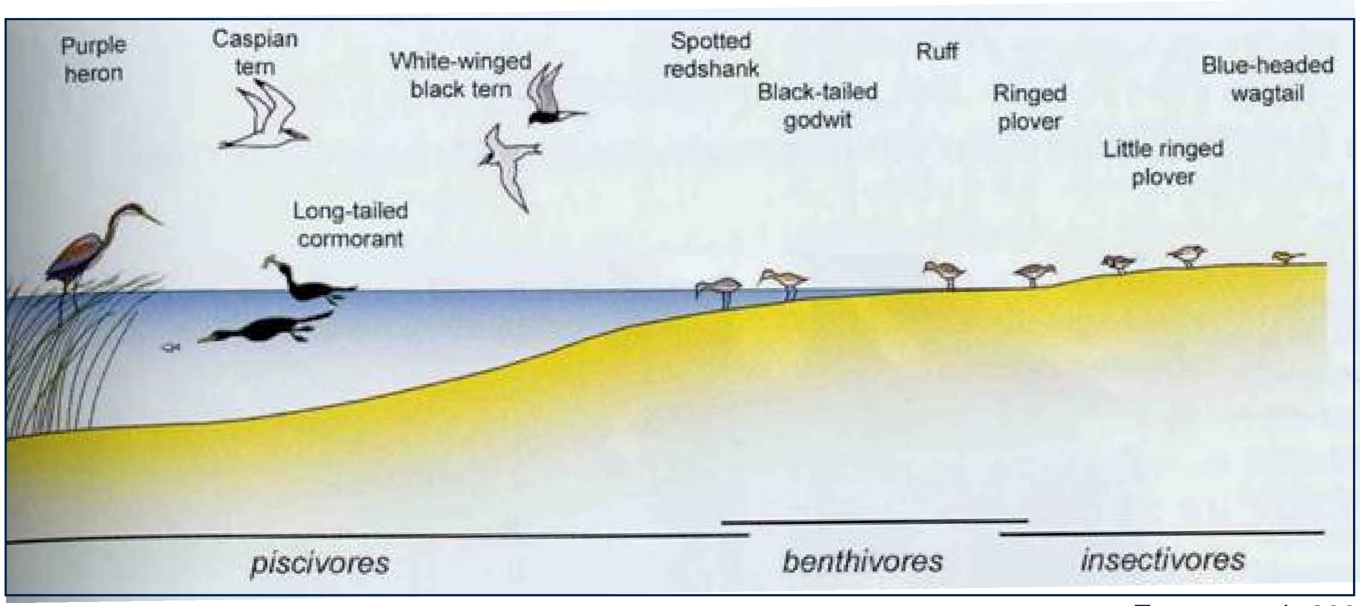
Water Resources and Ecosystem Services



Zwarts *et al.*, 2005

- **Proposed new 90 MW dam at Fomi will:**
  - reduce fish populations by up to 36%
  - disrupt complex relation between flooding and ecology (3-4 million staging waterbirds)
  - **but** increase rice production in newly-irrigated areas by 320,000 t (to meet 90% of domestic demand)
- **How can policymakers balance need for mitigation of & adaptation to climate change with food security, wetland biodiversity, and other ecosystem services?**

Q & A

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