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Forest-Savanna Transitions in West-Africa: The climatic imprint of bimodal distributions in vegetation cover

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Introduction

- Land-atmosphere feedbacks can generate sudden shift in the vegetation state.
- Bimodal distributions of woody cover with mean annual precipitation provide evidence that alternative stable states may exist 1,2.
- Understanding clearly the climate conditions behind this bimodality is important to predict crucial transitions due to climate change



Figure 2 Observed bimodality in Woody Cover per gridcell Bimodality of S-F(Savanna-Forest) and G-S (Grass-Savanna) only observed at boundaries. Bimodality criterion with Integrated Completed likelyhood



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Results from Satellite (Modis) data³

- Bimodality also found with Mean Annual Radiation (Fig.1)
- Cell by cell analyses show only bimodality at boundaries between grassland-savanna and savanna-forest (Fig.2)
- Best prediction of Land Cover is with a combination of Mean Annual Precip, dry season length, and seasonality (Fig. 3)

• Figure 1 a) Map of Woody Cover (W) and b. above ground biomass (B). c,d,e Histograms of W, B and mean annual radiation



Figure 3 Prediction Land-cover

- a. Prediction only with mean annual Precipitation (P)
- b. Prediction with P and length dry season (LD)
- c. Prediction with P, LD, Entropy monthly precip
- d-f. Difference between 3c and 1a
 - F, S, G are resp Forest, Savanna and Grass. s means stable, b means bistable.

How do global models represent savannas?⁴

- model

Extent Coupled/offline Type Vegetation Length Run Resolution Grass-Fire-Feedback Results Water limitation 🎽

(a)

- References

• Three Dynamic-Global Vegetetation Models are used to model savanna-forest systems

• Ecological theory: grass-fire feedback is able to simulate bimodality

• Tree-grass fire feedback are differently included in the

Conclusions

- Bimodality is not observed in current data of woody cover and biomass per grid cell
- Bimodality found with precipitation, radiation and other forcings due to strong correlation between forcing data
- Seasonality is important to predict bimodality
- A bimodal systems can be bistable due to the mechanisms at play: Tree-Grass fire feedback and seasonality are important



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mean annual rainfall (mm y⁻¹)

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	aDGVM
	Mainly tropical
	Only off line
	Individual based
	CRU
	1.0°
	Positive
	Yes
e grass	Grasses better competitors via seedlings
	No
3000	l l l l l l l l l l l l l l l l l l l

Figure 4 Model results of JSBach, LPJ-Guess, aDGVM. All models show water-limitation. Due to negative grassfire feedbacks, only aDGVM show bistability.

Figure 5 Positve grass-fire feedback (a) explaining observed bimodality in Modis tree cover data (b).