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Dynamics-aerosol-chemistry-cloud interactions in West Africa

Deficiencies in seasonal rainfall simulated by CMIP5 climate models

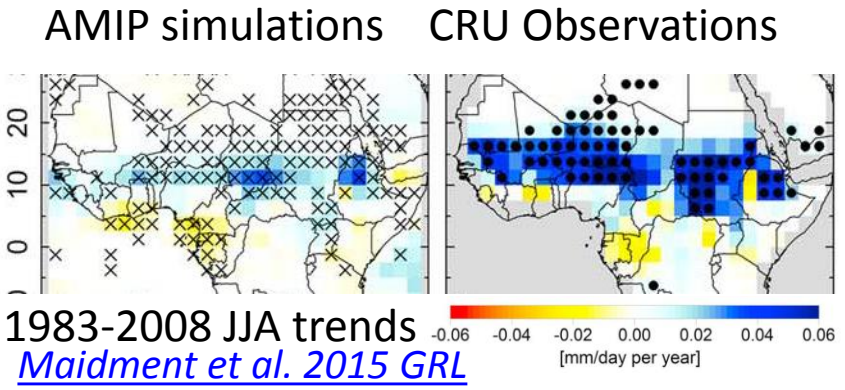
Richard Allan | University of Reading | Karlsruhe Oct 17

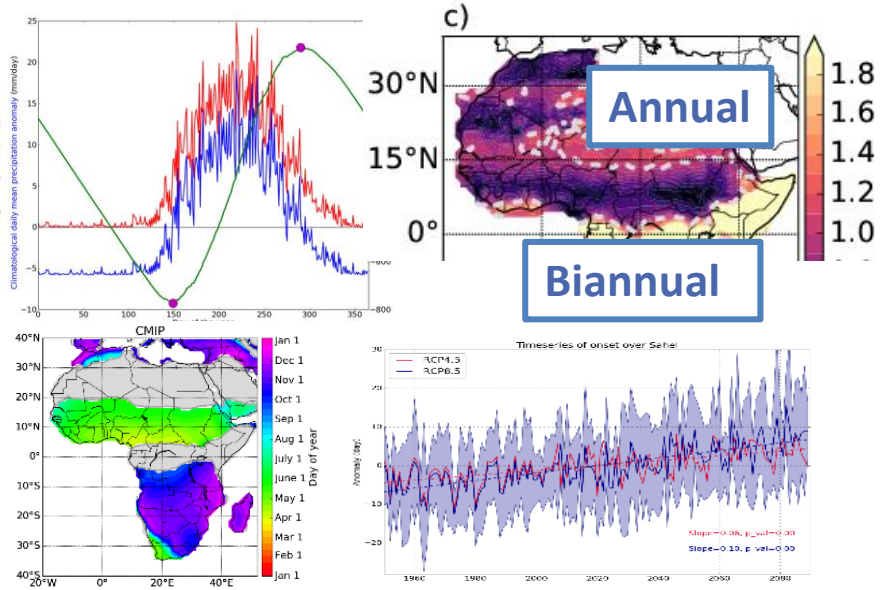
PhD work by Caroline Dunning with co-supervisor Emily Black (University of Reading)

Scenario DOCTORAL TRAINING PARTNERSHIP | NERC SCIENCE OF THE ENVIRONMENT | University of Reading | National Centre for Earth Observation NATURAL ENVIRONMENT RESEARCH COUNCIL

Introduction

- Contrasting Africa rainfall trends →
- Is timing of seasonal rains captured by models and what are the projections?
- Impact relevance e.g. Adejuwon and Odekunle (2006) J. Clim; Caminade et al. (2014) PNAS
- Method to diagnose onset & cessation using harmonic analysis + cumulative rainfall (Liebmann et al. 2012 J. Clim.; Dunning *et al.* 2016 JGR)
- Evaluation of CMIP5 simulations (Dunning *et al.* 2017 ERL) and evaluation of future projections in seasonality of rainfall





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CMIP5 simulated rainfall

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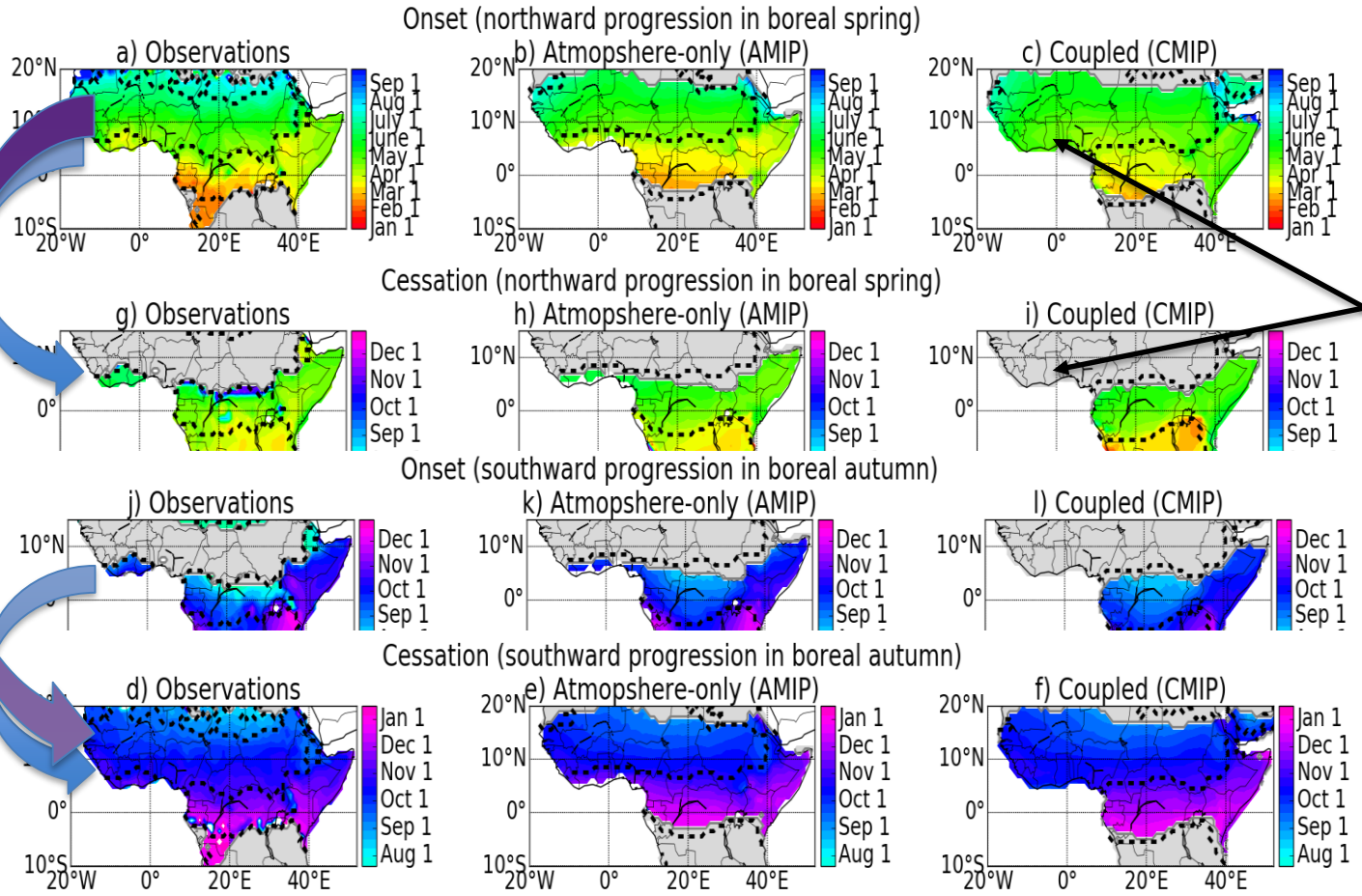

Coherent seasonal progression of wet season

Coupled models don't capture biannual regime (Ghana, Cote d'Ivoire)

Dunning *et al.* 2017 ERL

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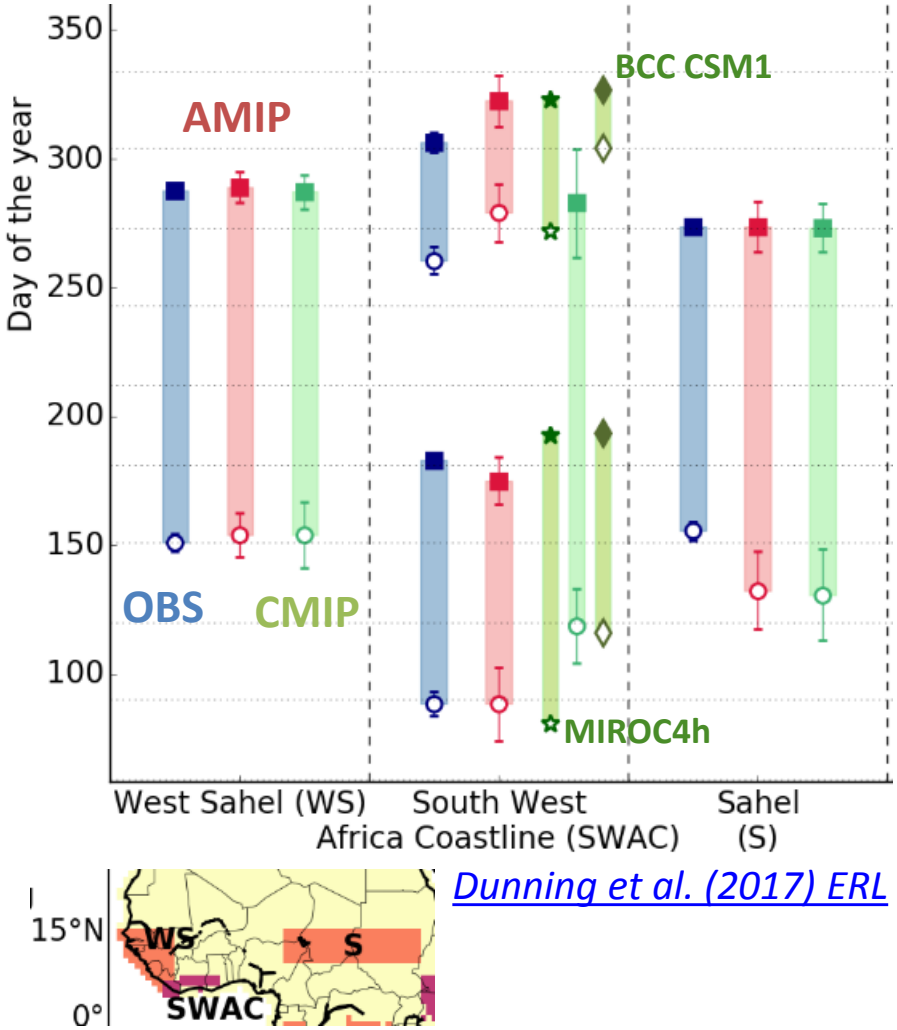
CMIP5 simulated timings



Dunning et al. (2017) ERL

- Coastal southern west Africa: late 2nd rains in models simulations
- Most coupled simulations fail to capture biannual regime
  - Except MIROC4h, BCC CSM1
  - Links to ITCZ bias e.g. Monerie et al., 2017 *Clim. Dyn*; Roehrig et al. (2013) *J Clim*; Nnamchi et al. (2015) *Nature Comms*
- Early onset in Sahel (also issues with ERA Interim depiction e.g. Hill *et al.* 2016 *JGR*)

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Deficient CMIP5 bi-annual regime

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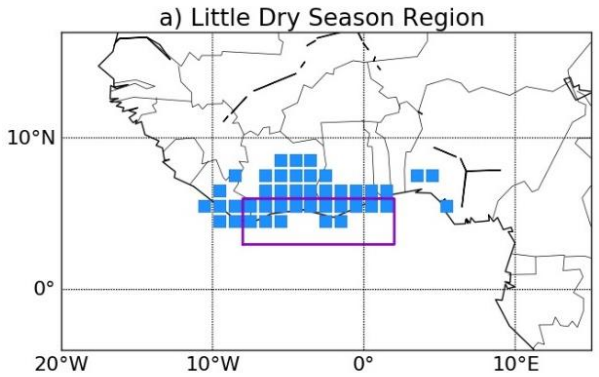
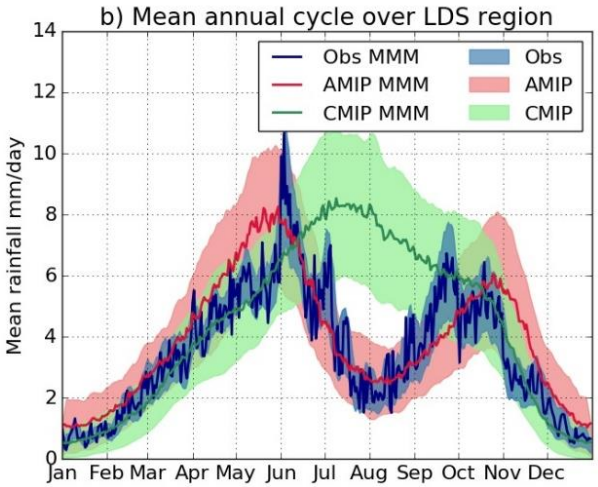


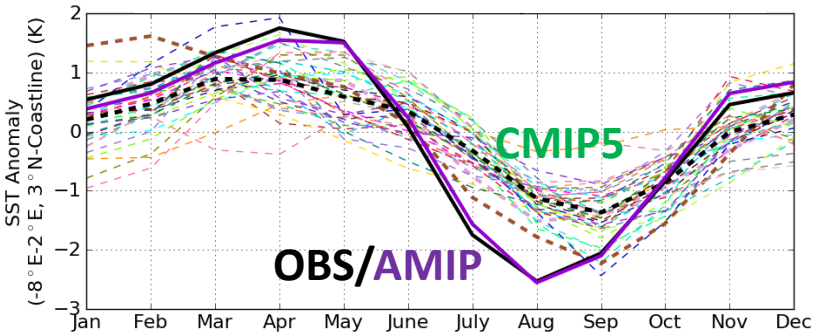


A small region on the southern west African Coastline exhibits a biannual rainfall regime; two wet seasons are separated by the Little Dry Season/August break e.g. Chineke et al. (2010) Clim. Ch.

Atmosphere-only simulations capture seasonal cycle, **coupled simulations** don't

May relate to errors in the Gulf of Guinea sea surface temperature (SST) & deficient representation of SST/rainfall relationship: See also Okumura & Xie (2004) J. Clim., Cabos et al. (2017) Clim. Dyn.

SST seasonal cycle



Dunning *et al.* 2017 ERL

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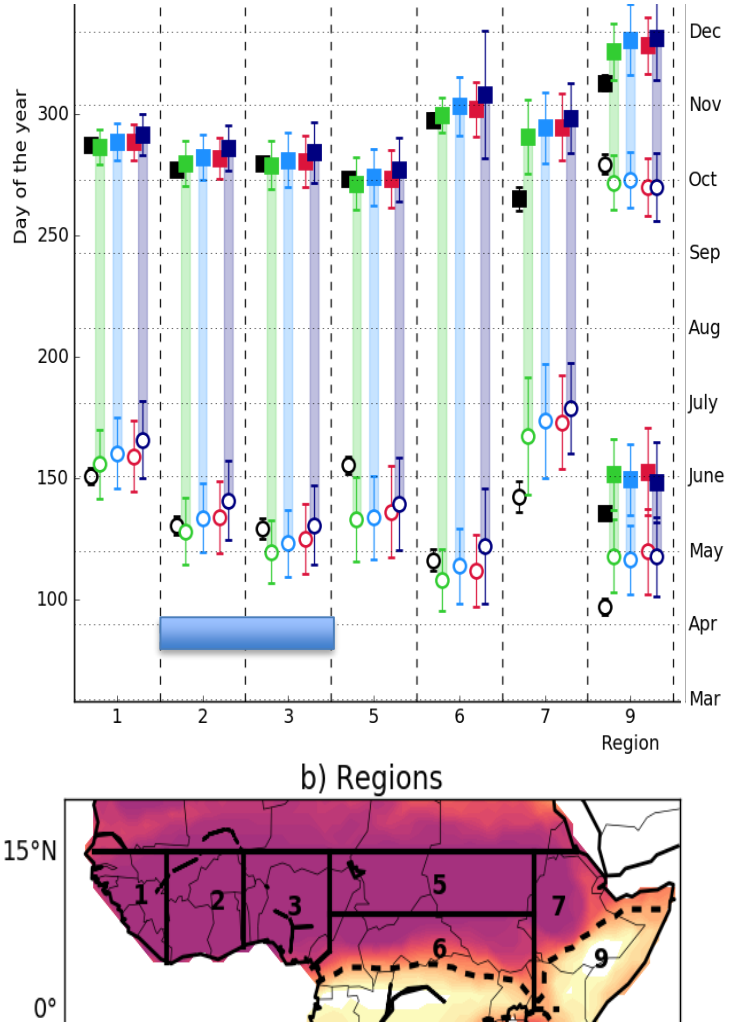
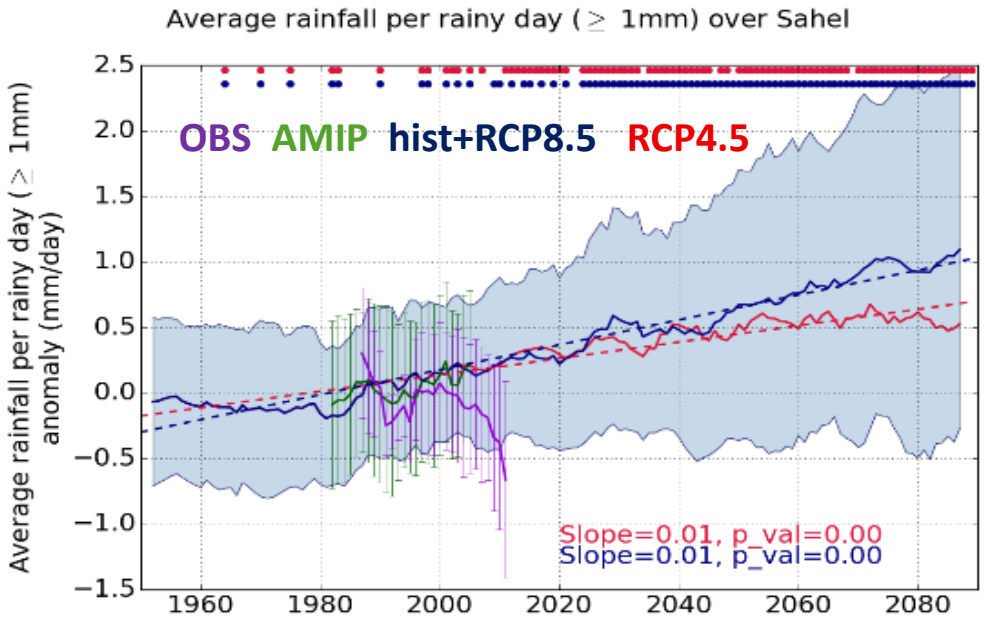
Projections in onset/cessation



- Projected future increase in rain per wet day over west Africa (below)
- Projected onset/cessation dates over southern west Africa (left)



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Current & Projected Change in Onset

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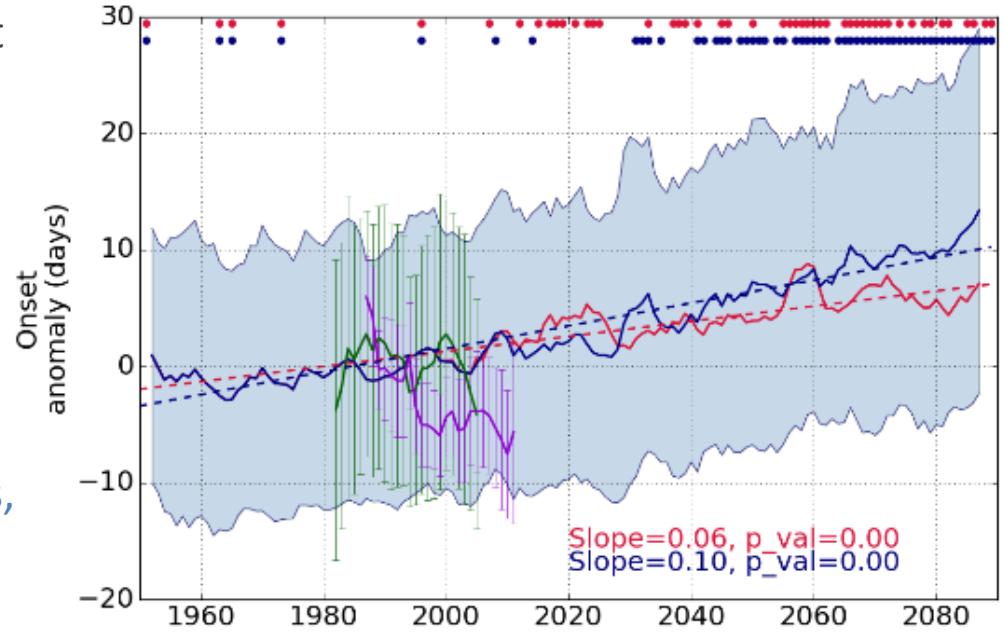
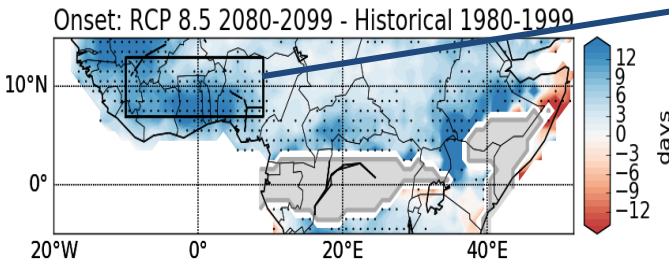
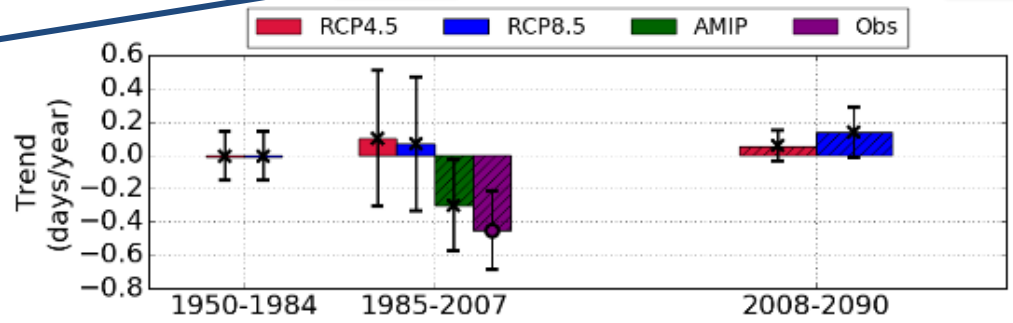
- Later onset projected over west Africa (RCP8.5 ~1 day/decade)
- Projected change in cessation date not significant
- Observed trends for earlier onset: internal variability/ dataset inhomogeneity?
- Changes in total seasonal rain not significant: fewer rainy days, more rainfall/rainy day.







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Conclusions

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- **Methodology:** identify onset/cessation of one/two wet seasons across Africa using harmonics and cumulative rainfall (Dunning et al. 2016 JGR)
- **AMIP/CMIP representation of the seasonal cycle:**
  - Atmosphere-only and coupled simulations capture gross observed patterns of seasonal progression/timing
  - **Coupled simulations fail to capture the biannual regime** over coastal West Africa; seasonal SST bias implicated (Dunning *et al.* 2017 ERL)
- **Future projections:**
  - Projected **later onset, shorter wet season** over **parts of west Africa**
  - Ongoing investigation: Sahara heat low, ITCZ width, Angola low, South Atlantic Anticyclone e.g. Cabos et al. (2017) Clim. Dyn.?
  - How is current & future monsoon progression modulated by cloud-radiation-circulation interactions? Are cloud-precipitation biases linked e.g. Hannack et al. (2017) J. Clim

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