The variability of the Saharan Heat Low intensity and its impact on the West African Climate and precipitation

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Motivations

Large uncertainties of the climate models over West Africa

- predictability of wet/dry spells still poor (Sylla et al. 2012)
- uncertainties of the models for the climatological precipitation trend (Roehrig et al. 2013)

Why the models are not able to represents such trends?
→ What are the abilities of the models to represent the trend of the large scale forcings?
→ How do the models reproduce the interactions between the forcings and the precipitation?

Datasets

Variables:
- Geop@700 - Geop@925
- Temperature @850
- Wind @925
- Precipitation from GPCP

- Reanalysis
  - ERAI
  - NCEP2
- 15 CMIP5 Climate models from the AMIP exp.
  (SST imposed)
  - NCC
  - NCAR
  - CSIRO
  - MRI
  - CNRM
  - CCCma
  - MPI
  - ICHEC
  - HadGEM2
  - INM
  - IPSLA
  - GFDL180
  - BCC
  - IPSLB
  - GFDL360
The Saharan Heat Low

- Related to the warm temperature in the Saharan desert
- Dry and flat region
- In summer, large cyclonic circulation over the Sahara
- Key driver of the low level wind in West Africa
The Saharan Heat Low

At seasonal time scale

→ strongly connected to the seasonal cycle of precipitation

→ potential relationship with the monsoon jump

Lavaysse et al. 2009
The Saharan Heat Low

At intra-seasonal time scale

→ pulsation of intensity associated with wet/dry phases of precipitation in the Sahel

Lavaysse et al. 2010b
Trend in the reanalysis

CDF of the daily low level atmospheric thickness (LLAT)

Temporal evolution of the LLAT for Q10, Q90 and the median
Specific behaviour of the Sahara

Cook and Vizy. 2015
Lavaysse, Nature Climate Change 2015
Trend in the reanalysis

- Different filters used
  - $F < 25d$
  - $25d < F < 100d$ (not shown)
  - $100d < F < 365d$ (not shown)
  - $365d < F$

- No evolution in the variance of the signal

- Trend only in the low band pass filtered signal
Trend in the reanalysis

Signal debiased according to the yearly mean → no more trend

Same PDF debiased for each decade
Trend in the Climate Models

Mean and distribution of the HL intensity from GCMs

Ensemble mean of the GCMs partially succeed to represent the trend
Trend in the Climate Models

High and low band pass filtered signals of the GCMs

High band pass

Low band pass

Low band pass signal able to catch the 3 periods
Motivations & Data

Climatological trends

Impacts on the WA Climate

Conclusions

Trend in the Climate Models

Anomaly of temperature at 850hPa from ERAI and NCEP2

Same for 15 climate models
Impacts seen by the reanalysis

2D regression analysis of:
- wind @925hPa
- rainfall (GPCP, shaded)

following the HL intensity, filtered or raw.

High band pass signal

Low band pass signal
Overall impacts

**Unfiltered signal**

- **ERAI**
- **GCMs**
  - NCC
  - MRI
  - MPI
  - INM
  - BCC
  - NCAR
  - CNRM
  - IPSLA
  - IPSLB
  - ICHEC
  - CSIRO
  - CCCma
  - HadGEM2
  - GFDL_180
  - GFDL_360

For GCMs:
- Rain from the models
- Agreement on the increase of the monsoon wind
- Large discrepancies for precipitation

→ Mixture of different signals
Representation of the high frequency impacts

- **Motivations & Data**
  - Climatological trends
  - Impacts on the WA Climate
  - Conclusions

**ERAI**

Specific for the intra-seasonal pulsations

- Impact more local
- Still significant differences

**High band pass signal**

**GCMs**

- NCC
- MRI
- MPI
- INM
- BCC
- NCAR
- CNRM
- IPSLA
- IPSLB
- ICHEC
- CSIRO
- CCCma
- HadGEM2
- GFDL_180
- GFDL_360
Representation of the low frequency impacts

**ERAI**

Usefull for the climatological trend

- Connected to the correct trend of precipitation
- Not necessary same models with good skill

**Low band pass signal**

**GCMs**

NCC    MRI    MPI    INM    BCC

NCAR    CNRM    IPSLA    IPSLB    ICHEC

CSIRO    CCCma    HadGEM2    GFDL_180    GFDL_360
Conclusions:
1- Trend of the Saharan Heat Low:
Abrupt significant increase of the Saharan Heat Low intensity during the 90’s
GCM’s with SST imposed partly succeed to represent this trend (intensity lower)
2- Impacts
Different signatures of the impacts following the time-scales
Large uncertainties from the GCM’s to show these interactions.
  - different high - low frequencies
  - not sensitive to the resolution

Perspectives:
trend in GCM’s without imposed SST?
same behaviour with regional models?