Characterization of diurnal cycle in relation to deep convection using a dense network of raingauge in western Dakar

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Abstract

The diurnal cycle and intra-seasonal variation of the rainfall amount, frequency and intensity, and durations are analysed using rainfall data from a dense network of 18 raingauges over Ndiaganiao in Senegal, during the 2005-2015 period. These results have important implications on the nowcasting early warning system over western Sahel and will contribute on the improvement of the parametrization of convection in the numerical weather prediction model.

Introduction

The rainy season in Senegal as in other Sahelian countries, is governed by the West African Monsoon (WAM) (Parker et al., 2005 Vischel et al., 2019). The monsoon system has a strong diurnal cycle drived by the daily migration of the Intertropical discontinuity (ITD). It variability affected the westward propogation of the mesoscale convective systems (MCSs) and local thurderstorms observed during the the afternoon hours (Lebel et al., 2003). The local thunderstorms persist late at night when the synoptic circulation is favorable to maintain the convection through African Easterly Waves to become MCSs (Lafore et al., 2017).

WAM complexity and Models challenge on diurnal cycle

An accurate representation of the diurnal cycle of convection remains an unresolved problem in climate models employing convection parameterizations, with convection systematically triggered too early in the day and precipitation maxima often phased with local noon, some 6 to 8 hours earlier than observed (Guichard et al. 2004).

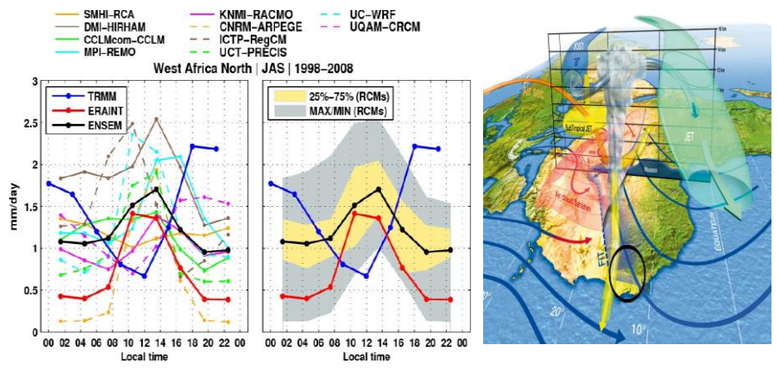
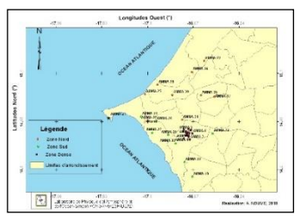


Figure 1: Mean diurnal cycle of precipitation averaged over West Africa and for the period 1998-2008. Left panel shows TRMM342B, ERA-interim, the 10 RCM ensemble mean and results from each RCM. Right panel plots in yellow shading the spread of the 50% most accurate RCMs and the full spread of the RCM results. Conceptual schema of the WAM.

Raingauge Data

Network characteristics

- Temporal resolution : Hourly
- Spatial resolution : 40 raingauges
- Availability period : 2007 - 2015



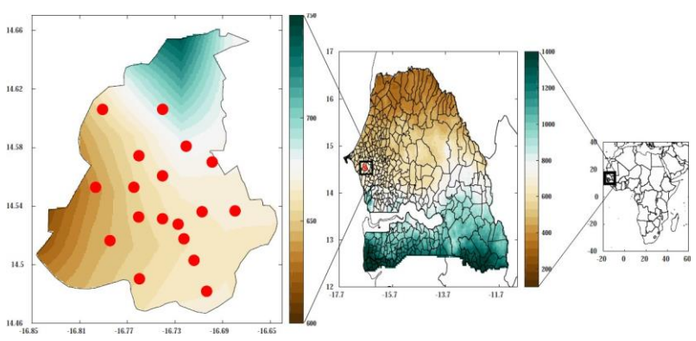


Figure 2: The red dots denote 18 raingauges of LPAOSF' high-density zone in Ndiaganiao over the peanut basin of Senegal (left panel). Location of 18 AMMA rain gauge over high-density zone in Ndiaganiao over the peanut basin of Senegal (left panel). Black box indicates the district of Ndiaganiao within Senegal (middle panel). Color shaded illustrates the average cumulative precipitation over the period 1998−2010 computed from TAMSAT (Tropical Applications of Meteorology using SATellite data and ground-based observations) daily data with 0.03° as resolution.

Methodology

1. Definition of rainy hour: More than or equal to 0.5 mm precipitation accumulated during an hour
2. Definition of Amount: The mean rate of accumulated rainfall in all observational hours
3. Definition of Frequency: The ratio of observational hours having measurable precipitation
4. Definition of Intensity: The mean rate of accumulated rainfall in rainy hours

Mean diurnal cycle

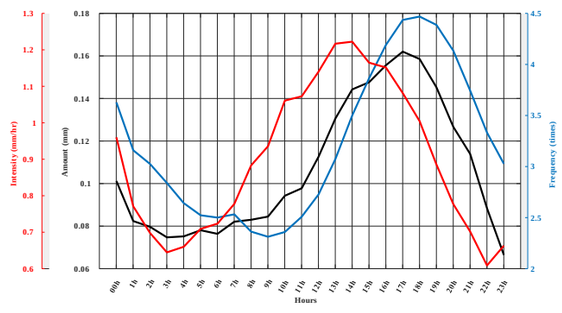


Figure 3: Diurnal variations of the precipitation amount (black line), frequency (blue line) and intensity (red line) averaged over Ndiaganiao (Senegal) during 2007–2015

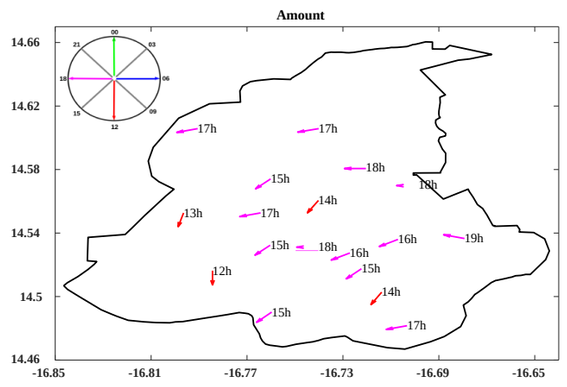


Figure 4: Spatial distributions of the peaks of diurnal cycles of the hourly precipitation amount averaged during 2007 to 2015

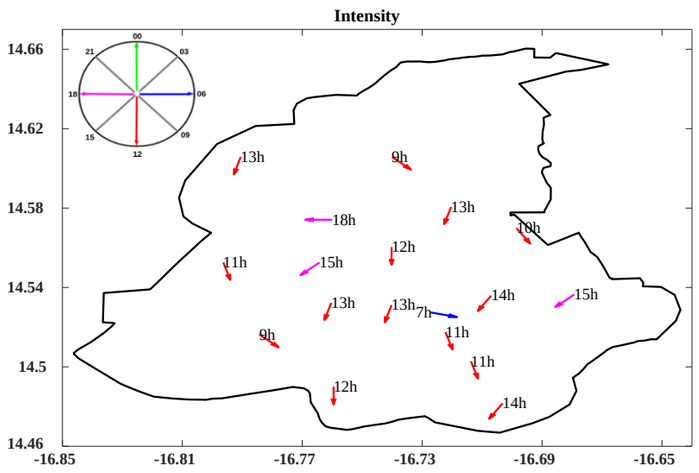


Figure 5: Spatial distributions of the peaks of diurnal cycles of the hourly precipitation intensity averaged during 2007 to 2015

Diurnal cycles of seasonal rainfall with different durations

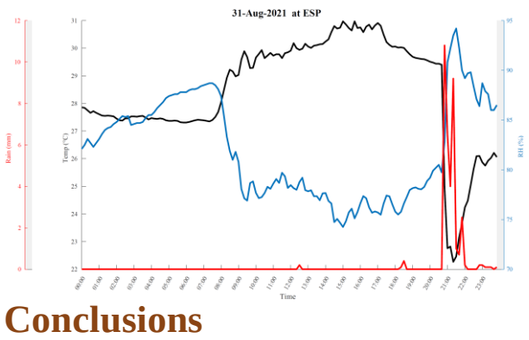
- Definition of Durations: If a dry period lasted for 1 hr or longer. The number of hours between the start and the end of an event was de

  ned as the duration.
- 30% of rain have a lifetime around 2 hours. Around 4.7% of the rain events have the longest duration of 7 hours
- 90% of rain events have a lifetime between 1 to 2 hours
- High occurrence of short duration events
- High intensity of long duration events

Figure 6: Contribution of differents rainfall durations on the seasonal rainfall amount over Ndiaganiao.

Diurnal cycle of each duration

Figure 7: Standardized diurnal cycles (by the daily mean) of the precipitation amount of the events with different durations averaged over Ndiaganiao (Senegal).



Implementation of a connected raingauge system of LPAOSF for a real-time observation of rainfall event and a better understanding of diurnal cycle

Conclusions

Our results show that a complex diurnal cycle combined with spatial variability,rainfall is observed in a small domain of raingauge network in western Senegal. Rainfall amount and average frequency peaks around 18:00 GMT. The peak of rainfall intensity appears ealier between 13:00 and 14:00 GMT compare to the rainfall amount and frequency. The distribution of the duration of rainfall events shows a high occurrence of short duration events with a higher contribution of events having a lifetime of 2 hours.

Forthcoming Research

Improvement of weather and climate forecasting models. They can also be used by forecasters as part of Nowcasting to save human lives and limit material damages created by convection.

Floods of 5 September 2021 in Dakar

References

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