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DEPARTMENT OF LAND SURVEYING AND GEO-INFORMATICS
土地測量及地理資訊學系

Spatio-temporal Analysis of Changes in Rainfall Regime in the Sudano Sahelian Zone of Nigeria

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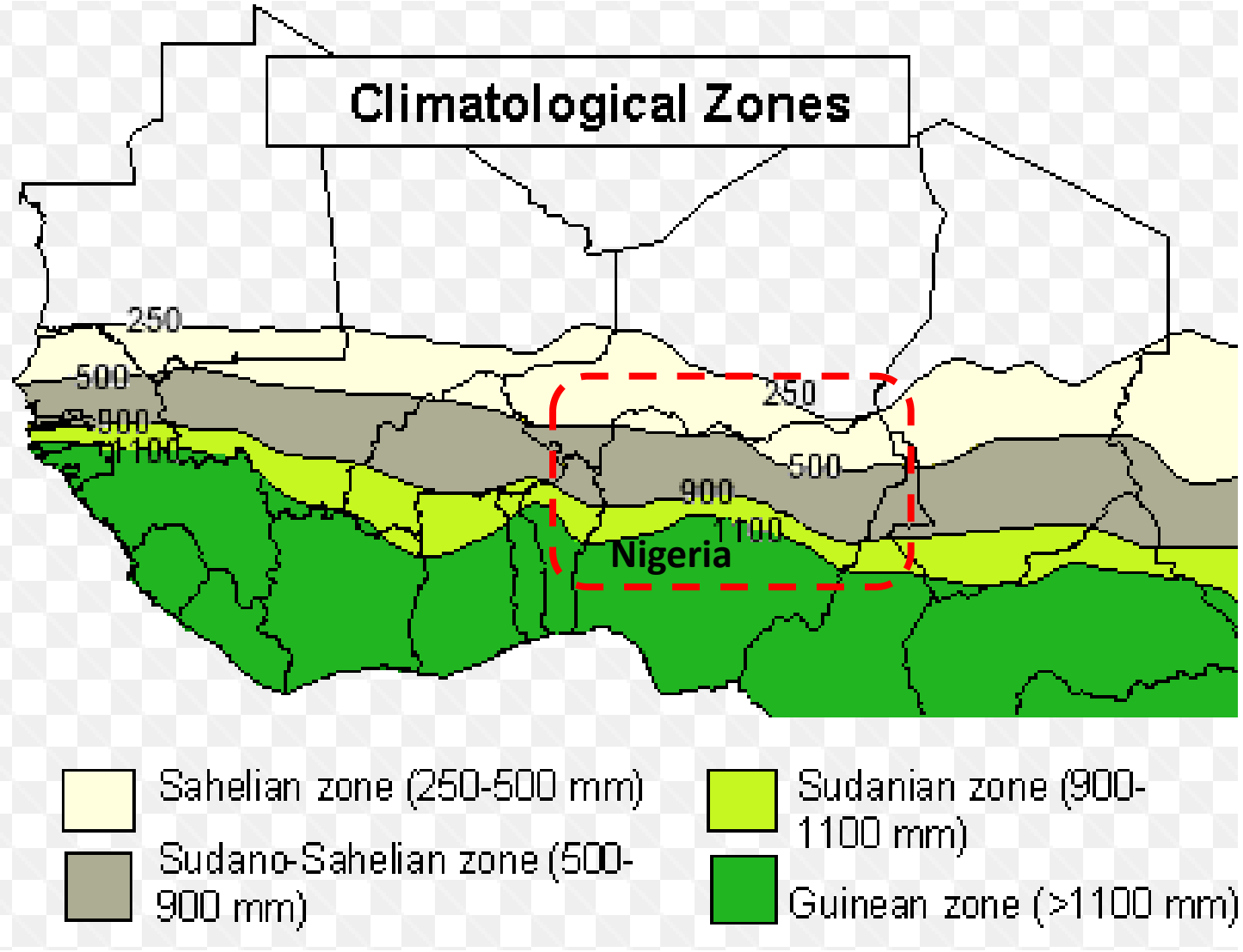
Introduction

- Climate Change
- Sub-Saharan West Africa- hardest-hit regions (IPCC, 2014)
- Due to its marginal climate and high Population
- Largest semi-arid regions in the world
- Rainfed agriculture & livestock farming are the primary source of livelihoods
- High intra-annual and inter-annual rainfall variability
- Affecting water resources and food security
- Severe droughts during the 1970-1980s
- 30% decline in rainfall between 1960-1990
- 1972-1974 and 1983-1985 are well known droughts years

Agro-Climatic Zones of West Africa



[Source: FAO]

Introduction

- Nigeria 7th most populous country
- Previous studies report great spatial variation in rainfall amounts and trends (Buba, 2010; Mortimore, 2000; Tomlinson, 2010),
- Rainfall in Northern Nigeria formed by convective clouds (vary over a few tens of km)
- Spatial distribution of rain gauges is very sparse
- Satellite based rainfall estimates are alternative to sparse gauge based rainfall

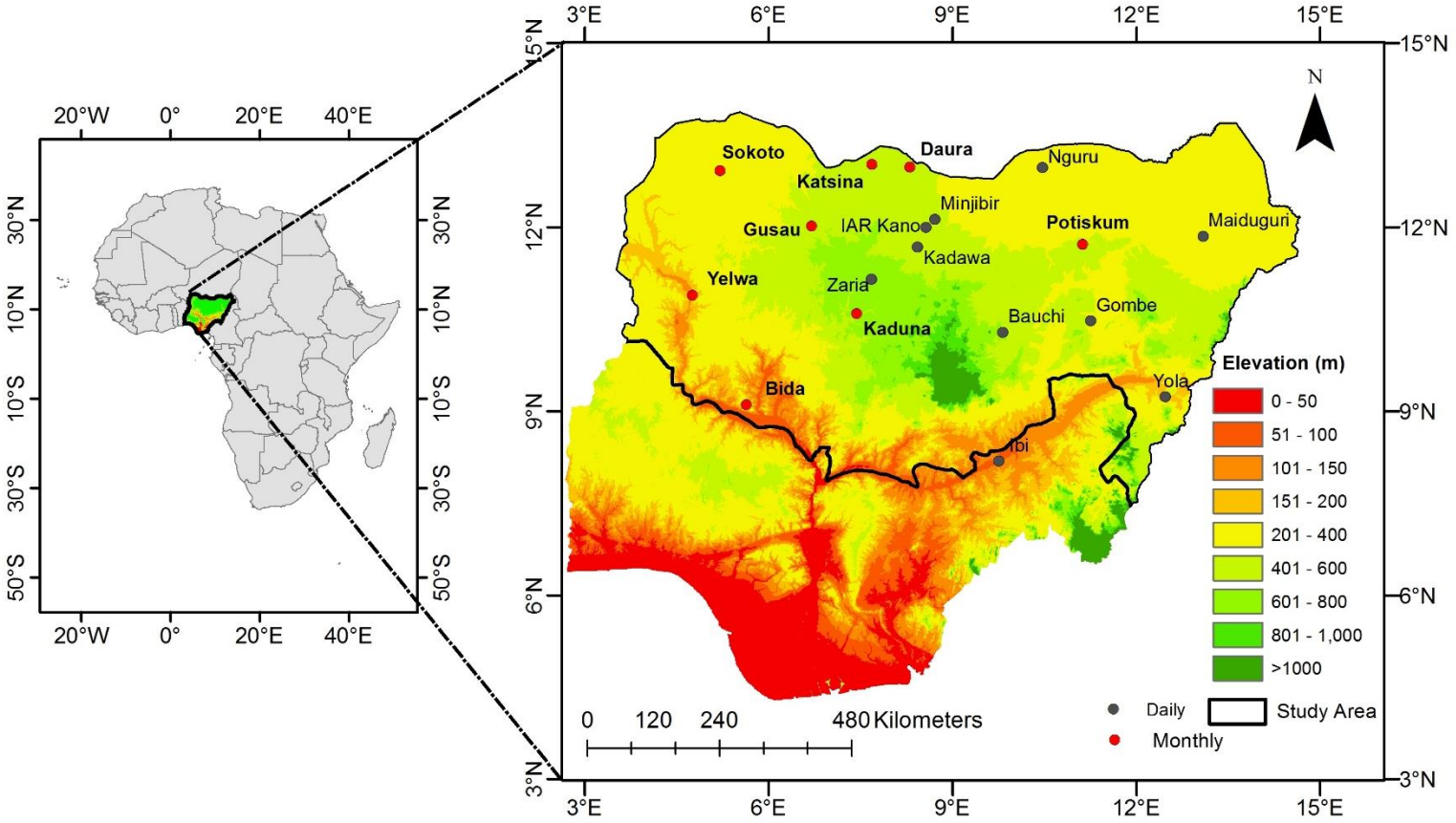
Rainfall Variables Specific to Crop Production

- Water availability and timing of rainfall events are key factors for the agricultural crop production
- None detailed study for different rainfall variables specific to crop production
- To better characterize changes in rainfall regime we used seasonal rainfall variables based on daily rainfall data
- Onset, Cessation, Length, Seasonal rainfall amount, Number of rainy days of different intensity, number and mean length of dry spells in a rainy season

Research Objectives

- Evaluation of satellite-based rainfall datasets relative to ground stations at daily, dekadal (10 days), monthly and annual time scales
- To evaluate satellite rainfall products for retrieval of seasonal rainfall variables
- To analyse temporal trends over a 30-year period (1984-2013)

Description of Study Area



Materials & Methods

Satellite Rainfall Products

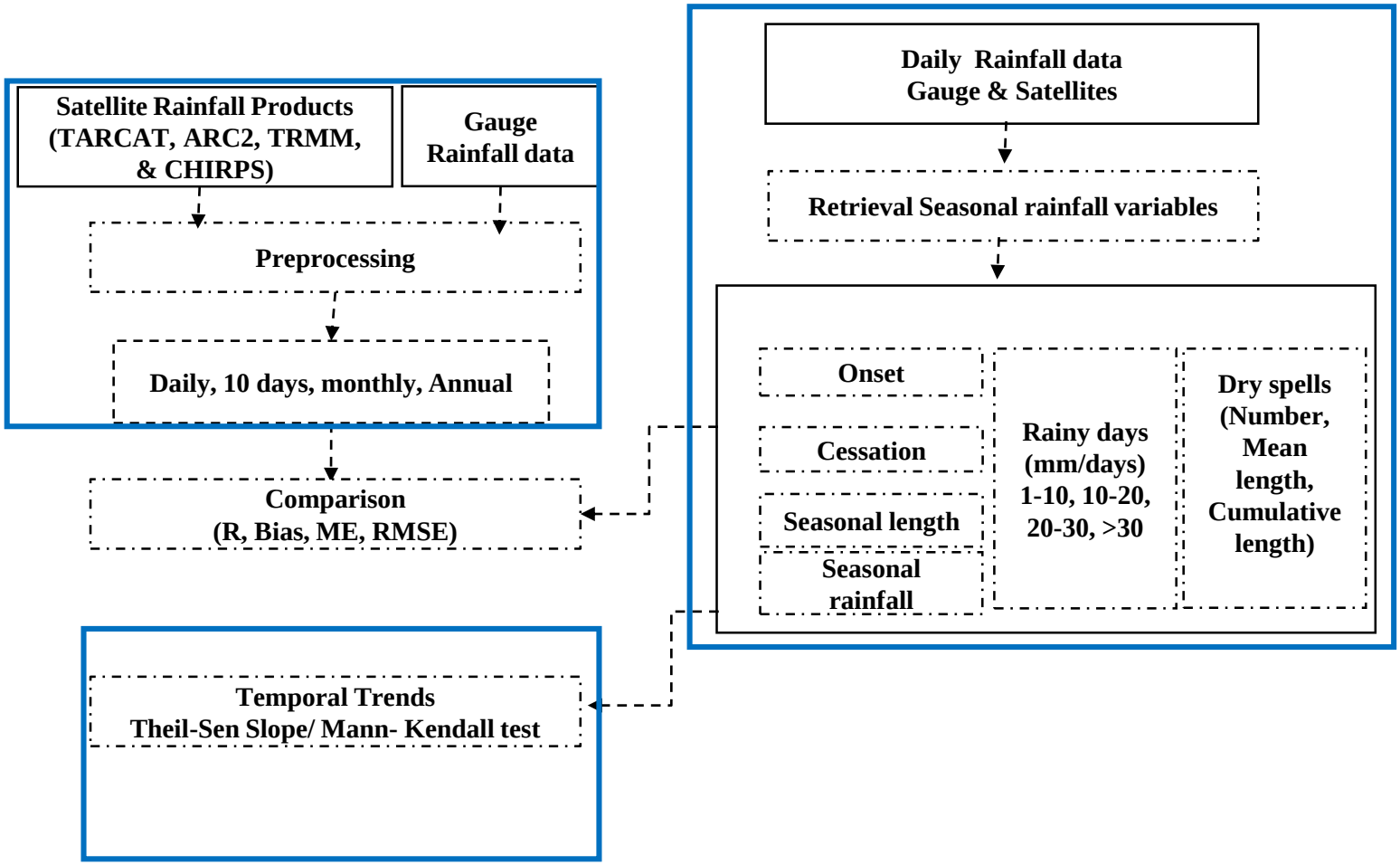
Satellite rainfall products	Temporal coverage	Data Input	Spatial Coverage	Spatial resolution	Temporal resolution
TARCAT Version 2.02	1983-2015	TIR, gauge	Africa	0.0375° (~4 km)	Daily
CHIRPS Version 2.01	1981-2015	TIR, gauge	Global	0.05° (~5 km)	Daily
ARC Version 2	1983-2015	TIR, gauge, TMPA 3B42 v7	Africa	0.1° (~10 km)	Daily
TRMM Multi-satellite Precipitation Analysis version 7 (TMPA 3B42 v7)	1998-2014	TIR, VIS, TMI, PR, gauge	Global	0.25° (~25 km)	Daily

Summary of Rainfall variables

Rainfall Variable	Definition
Onset of Rainy Season	**First occurrence of ≥ 20 mm cumulative rainfall with 7 days after May 1, Followed by at least 20 mm rainfall in next 20 days to avoid "false start"**
Cessation of Rainy Season	**Occurrence of 20 consecutive days with cumulative rainfall less than 10 mm after September 1**
Length of Rainy Season	No. of days between the Onset and the Cessation of rainy season
Season Rainfall Amount	Rainfall amount during the rainy season
Total No. of Rainy days	No. of rainy days (rainfall amount ≥ 1 mm/day) b/w onset and cessation
No. of Rainy days with 1-10, 10-20, 20-30, >30 mm Rainfall	No. of rainy days of different rainfall intensity during rainy season
No. and mean length of dry Spells	Dry spell is defined as rainfall below 1 mm in at least seven consecutive days

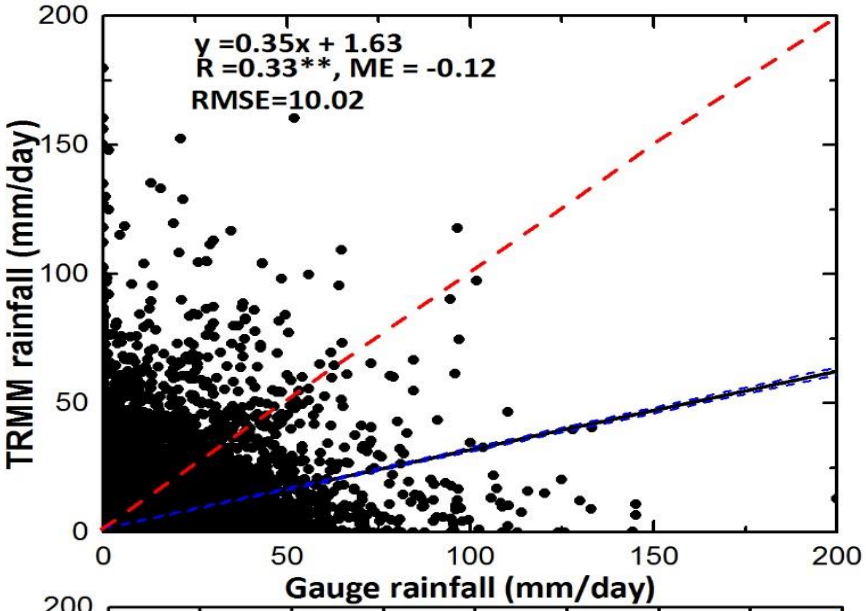
(Zhang, et al., 2017)

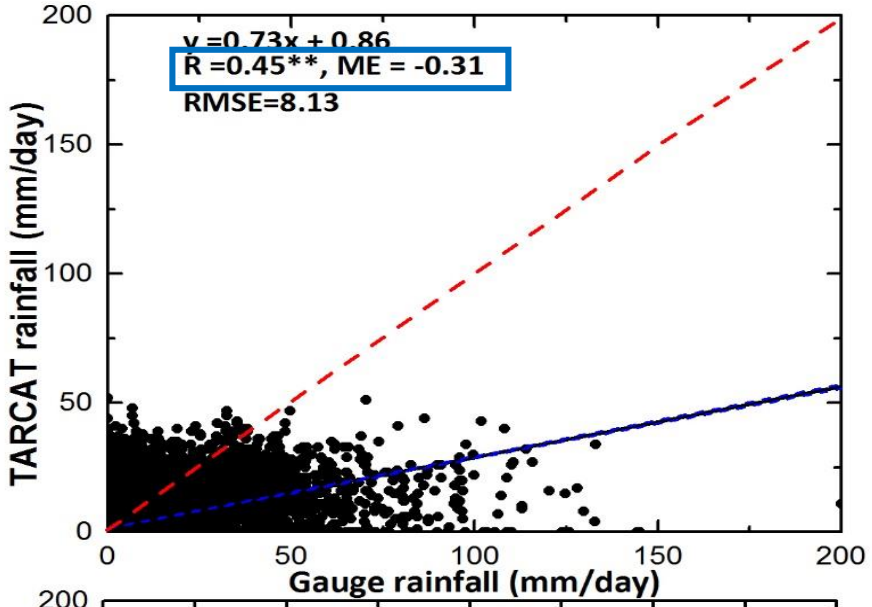
Methodology

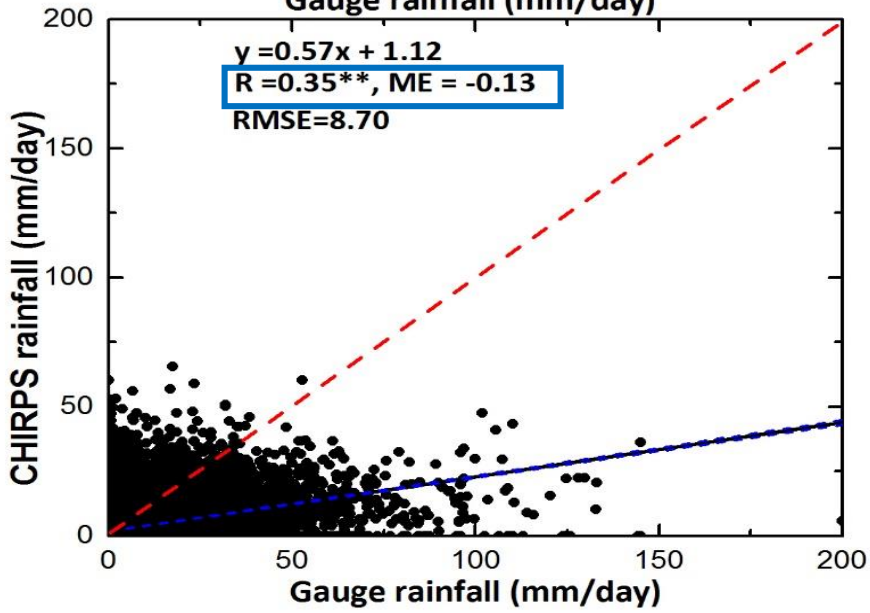


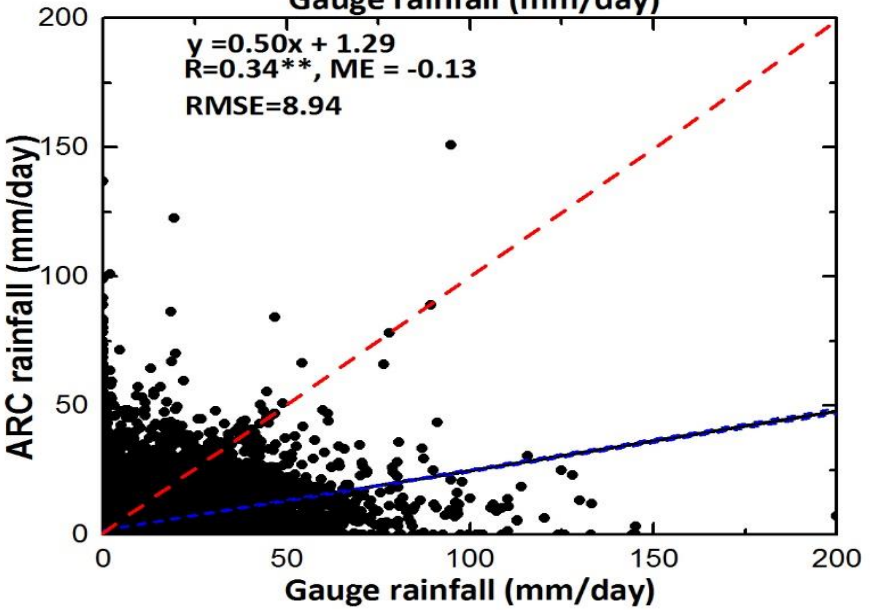
Results & Discussions

Daily Rainfall Comparison

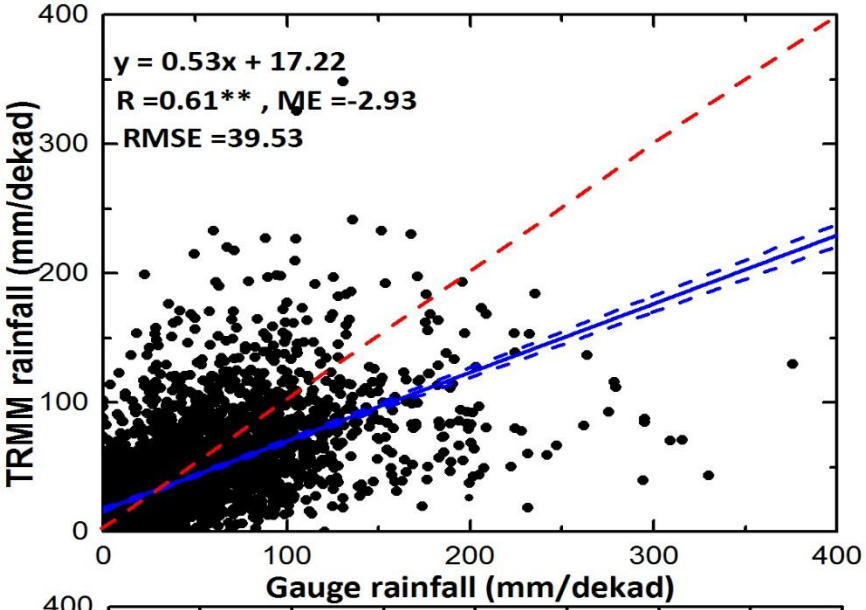


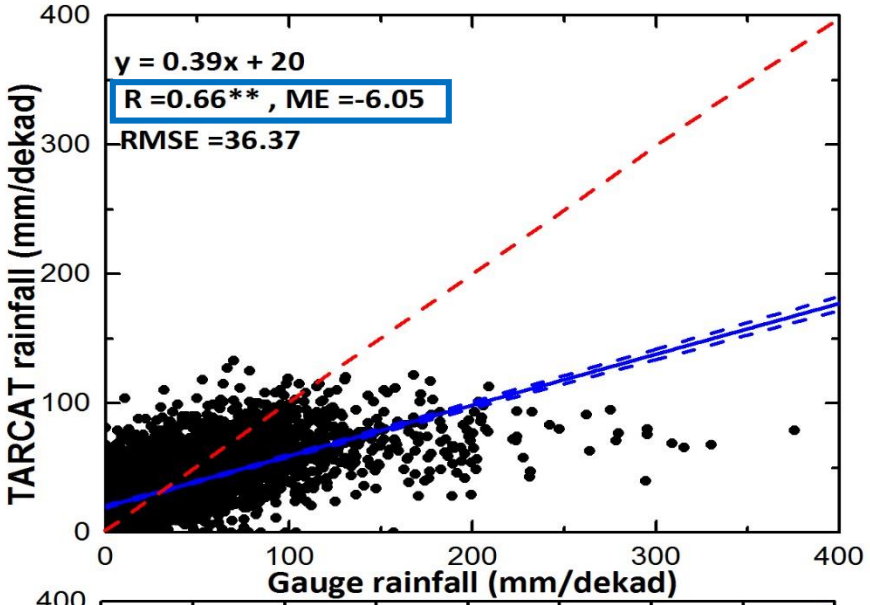


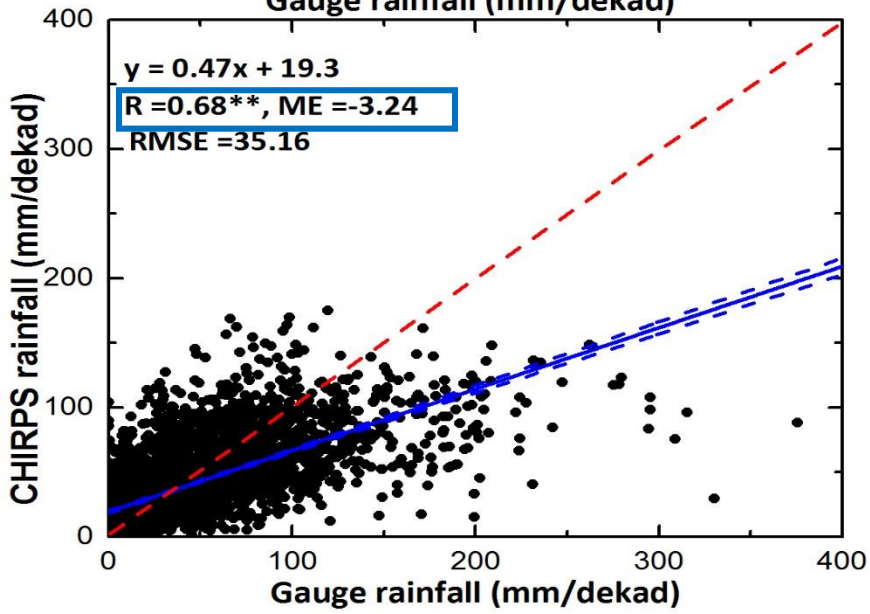


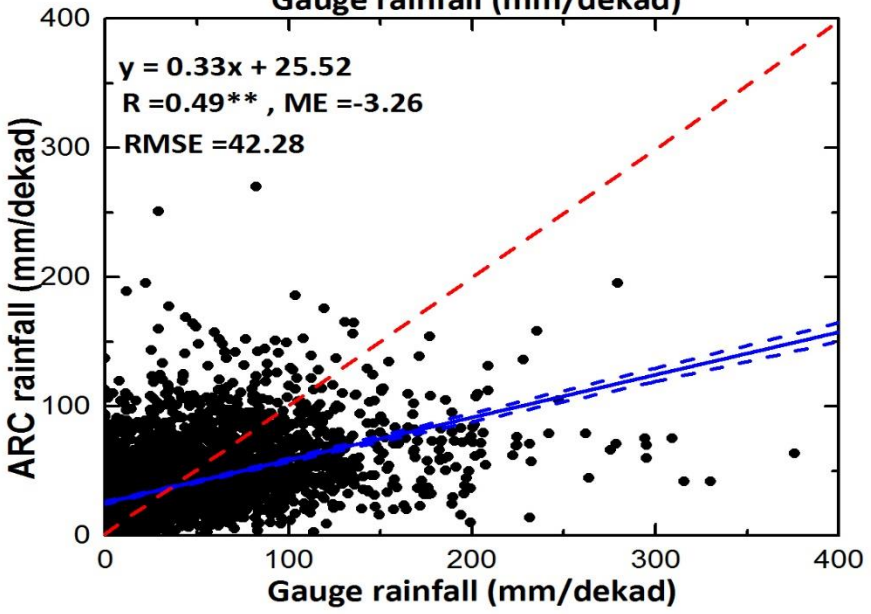


Dekadal (10 days) Rainfall Comparison

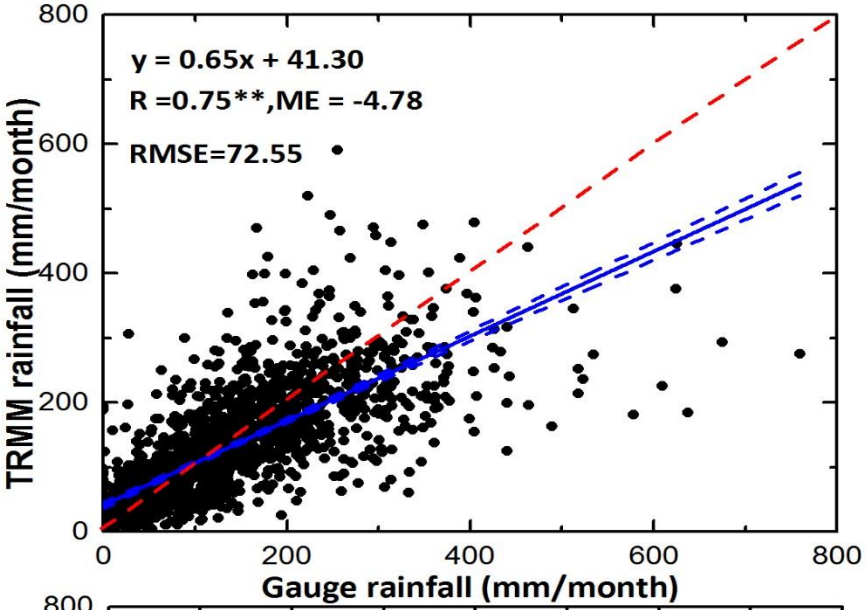


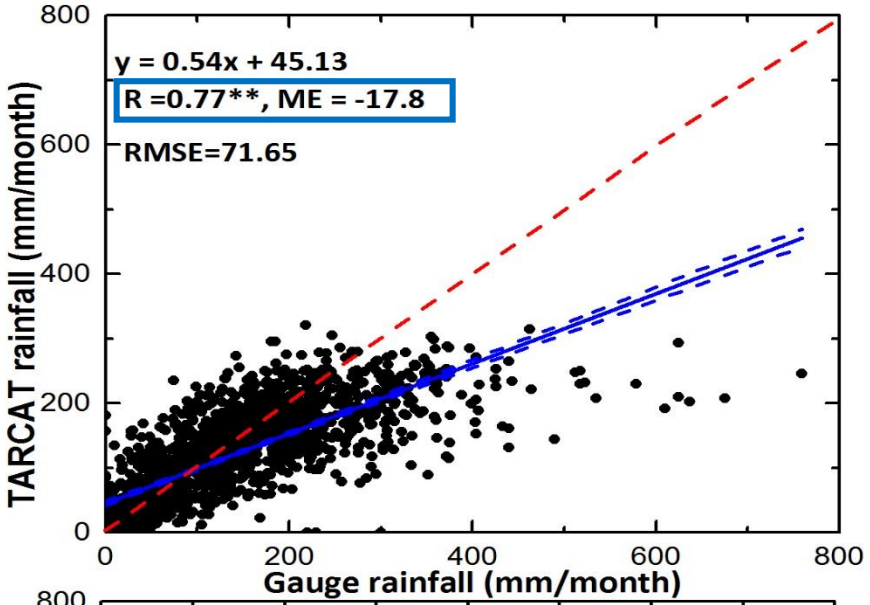


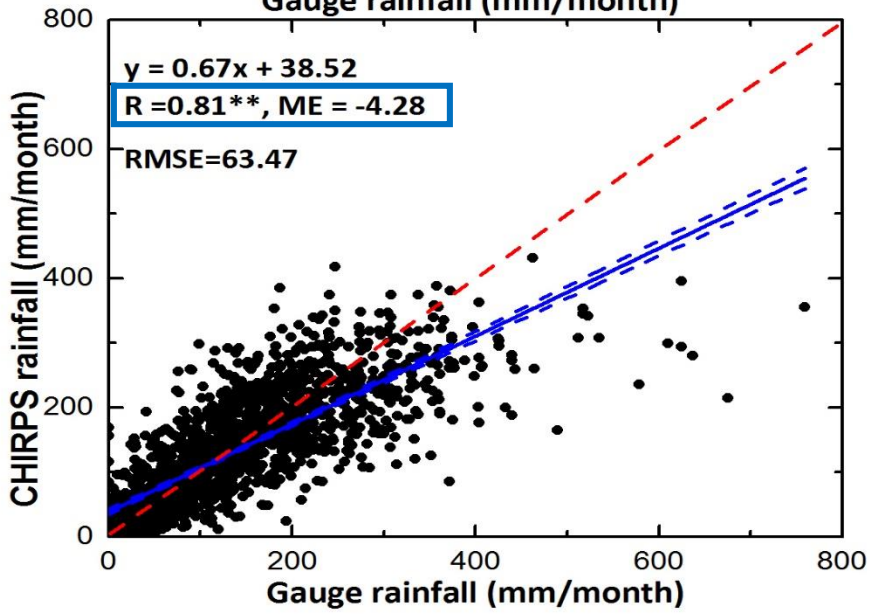


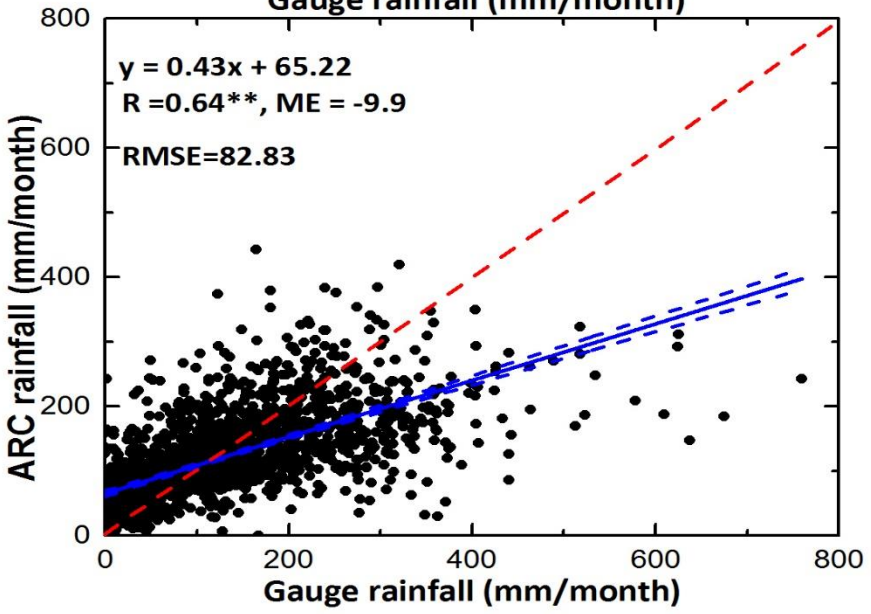


Monthly Rainfall Comparison





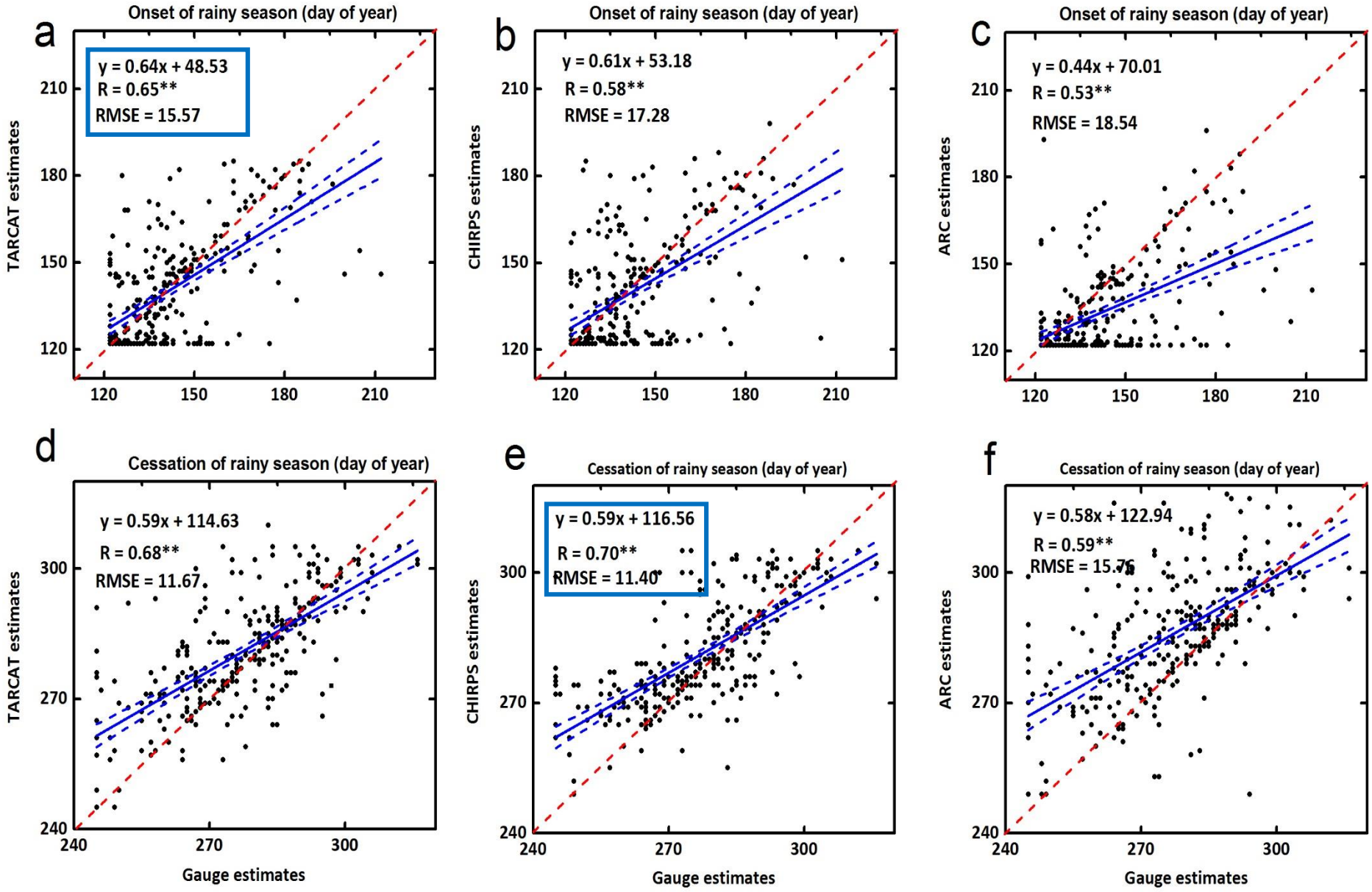




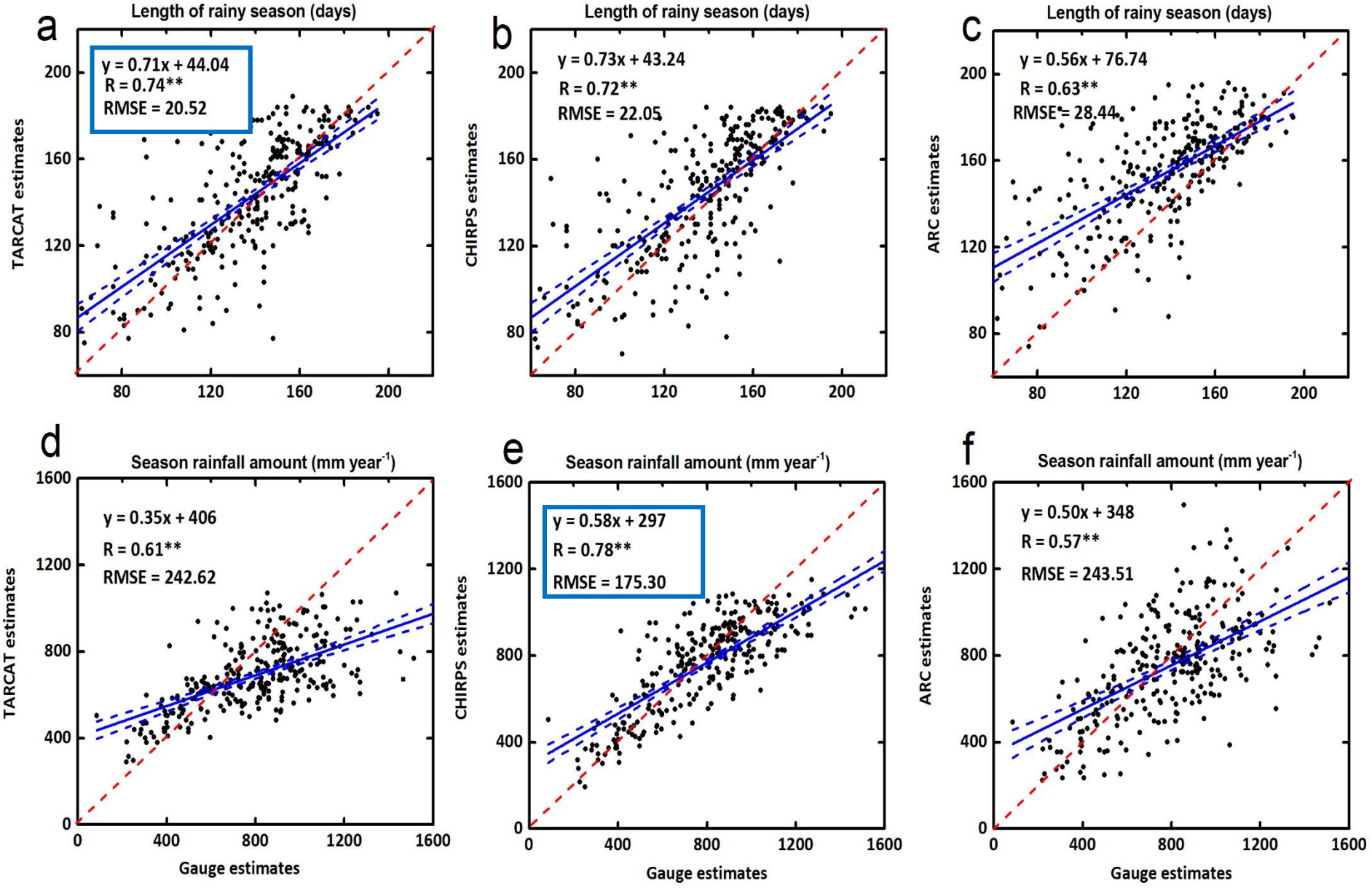
Annual (seasonal) Rainfall Comparison

	TRMM	TARCAT	CHIRPS	ARC
Correlation (R)	0.75**	0.69**	0.79**	0.62**
Bias	0.97	0.84	0.97	0.93
Mean Error (mm/season)	-29.7	-141.3	-27.387	-58.7
RMSE (mm/season)	214.3	273.9	196.6	264.4

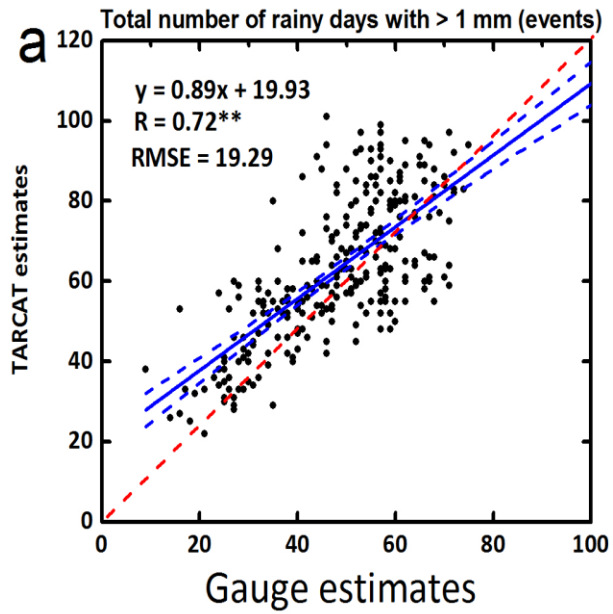
Onset and Cessation of Rainy Season

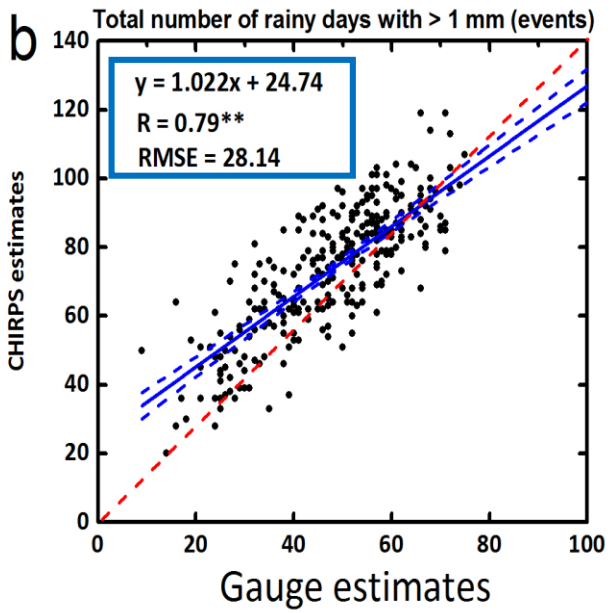


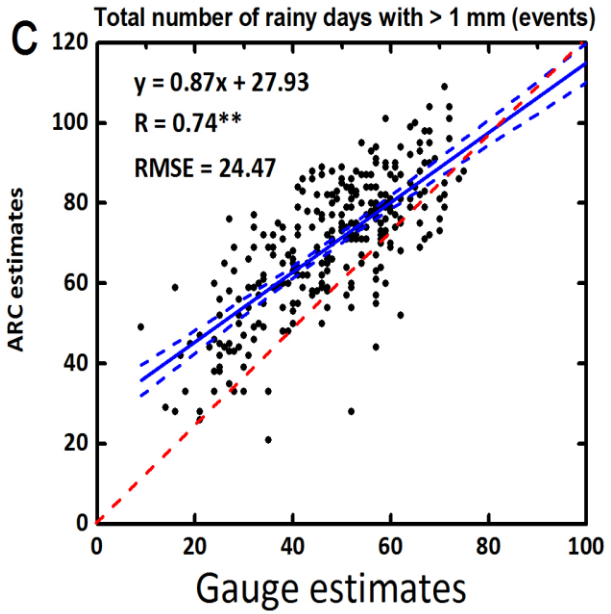
Length and Season Rainfall amount



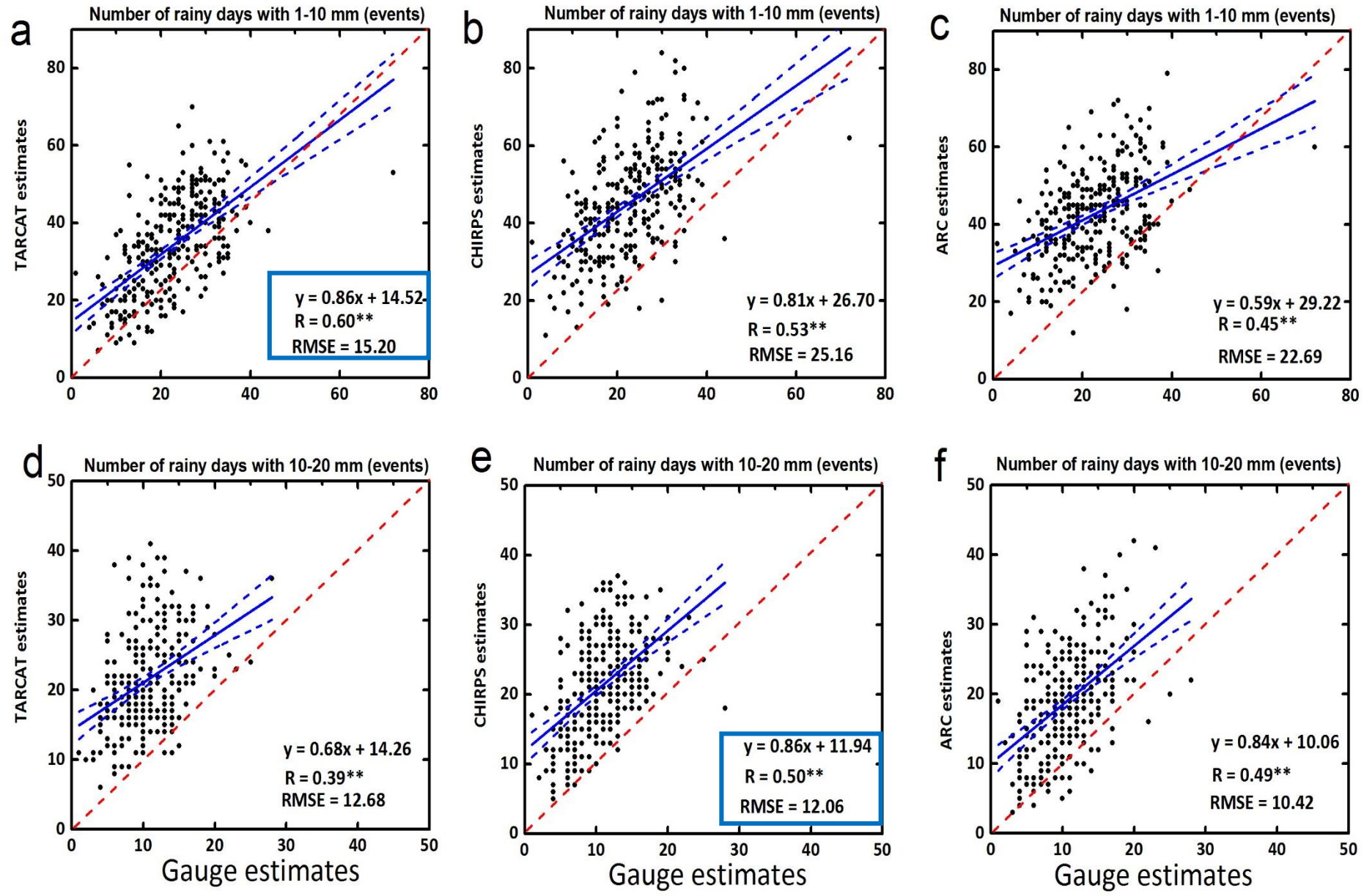
Total Number of Rainy Days with ≥1 mm Rain



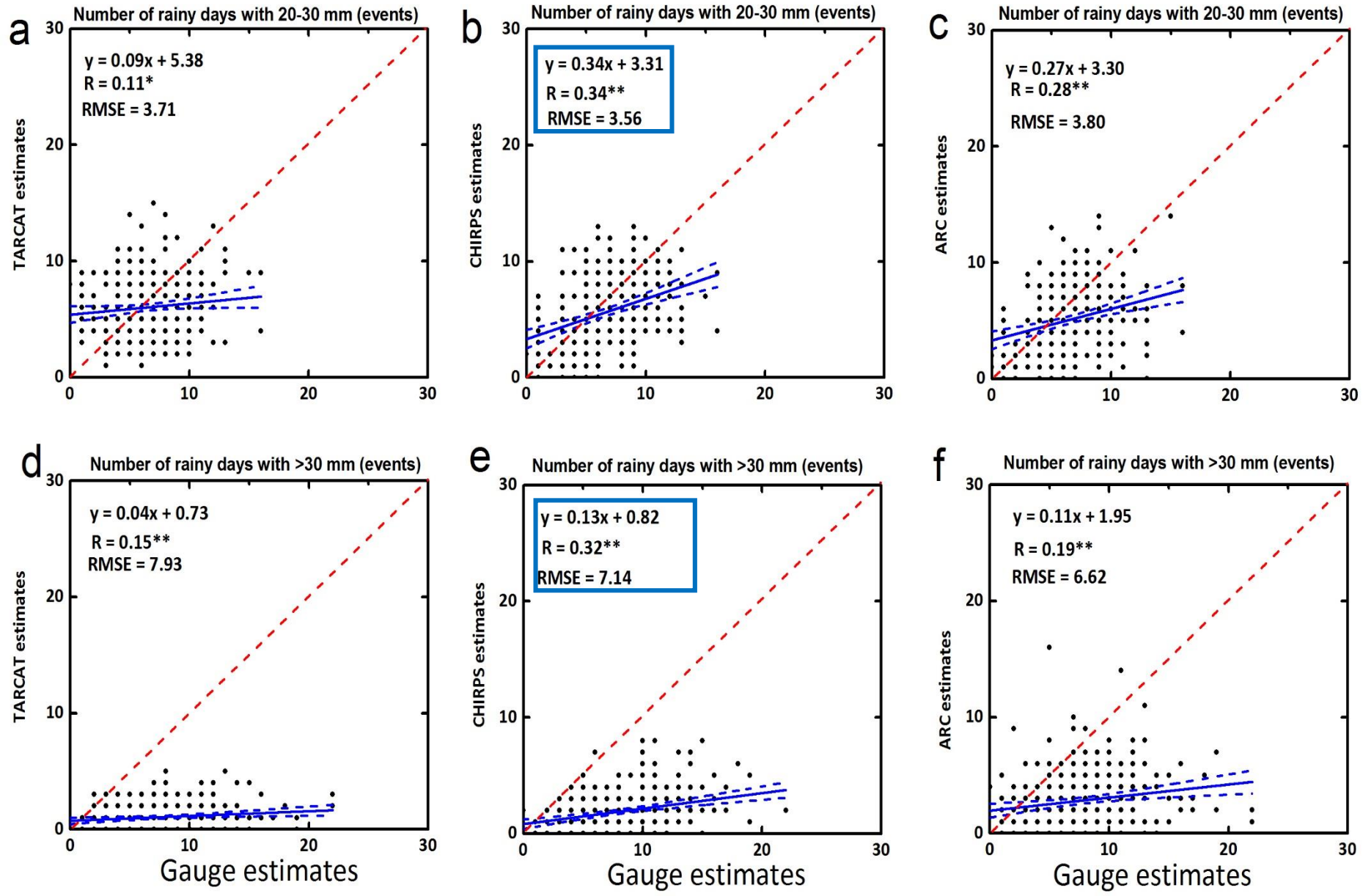




Rainy Days with 1-10 and 10-20 mm Rain



Rainy Days with 20-30 and >30 mm Rain



Temporal trends for Gauge rainfall variables (1984-2013)

Season rainfall variables	Gauge- trends
Onset of Rainy Season (day of year)	-0.18
Cessation of Rainy Season (day of year)	0.44*
Length of Rainy Season (days)	0.53*
Season rainfall amount (mm year^{-1})	8.2**
Total no. of rainy days with > 1mm (days)	0.18+
No. of rainy days with 1-10 mm (days)	0
No. of rainy days with 10-20 mm (days)	0.02
No. of rainy days with 20-30 mm (days)	0.02
No. of rainy days > 30 mm (days)	0.11**
Cumulative dry days	0.21
Length of Dry Spell (days event^{-1})	0.03
Number of Dry Spells (events year^{-1})	0.002

Statistically significant levels (+=p≤0.1, * =p≤ 0.05; ** =p≤ 0.01; *** =p ≤ 0.001)

Temporal trends for Monthly Rainfall (1984-2013)

Months	March	April	May	June	July	August	September	October
Trend Slope	-0.08**	-0.06	-0.07	0.74**	0.78	2.22**	1.40+	1.05**
Contribution to annual rainfall (%)	0.37	2.28	7.90	13.46	23.36	30.25	18.24	4.10

Conclusions

Conclusions

- CHIRPS shows relatively best results for Northern Nigeria followed by TARCAT
- Recovery in rainfall is mainly related to
  - Increase in total number of rainy days
  - Later Cessation of rainy season
  - Good implications for Sorghum crop
  - A higher number of extreme rainfall events
- Not related to
  - Earlier onset of rains nor
  - Reduction in number of dry spells

Acknowledgments

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- RGC Hong Kong (PhD Fellowship)
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- People and stakeholder of Nigeria

Thank You