Summer School on Climate Impacts
Modelling for Developing Countries:
Water, Agriculture and Health

(5 September 2011)

Session II: Weather data input for impact modelling

Comparison of high-resolution satellite-based precipitation products over Africa

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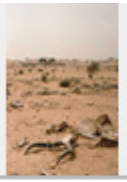
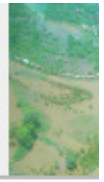
Comparison of high resolution satellite-based precipitation products over Africa





Precipitation = key steering factor of many socio-economic activities

- rainfed agriculture → nourishment
- floods → drowning
- droughts → starvation

Aim decrease socio-economic and human losses
(facilitate planning of prevention, protection and mitigation measures)

Approach development / use of impact models, e.g.
- agricultural models
- flood or drought forecast models

Dilemma model performance relies on accuracy of precipitation information

Which precipitation data should we use to feed our models?

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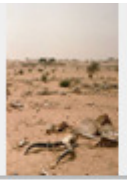
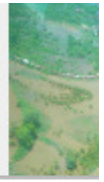




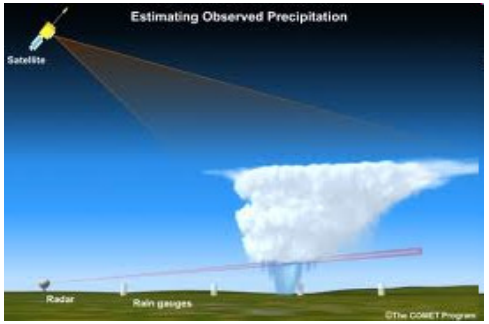
Precipitation information

traditionally rain gauge observations

- ☺ **long historical records**
- ☺ **easy format**
- ☹ **insufficient network density**
- ☹ **point data**
- ☹ **missing values**
- ☹ **questionable reliability of records**
- ☹ **delay in reporting time**
- ☹ **limited accessibility of available data**

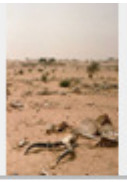
➢ Many disadvantages! Is there an alternative?

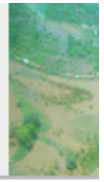
recently satellite-based rainfall estimates (SRFE)



- ☺ **quasi-global coverage**
- ☺ **high temporal and spatial resolution**
- ☺ **increasingly available**
- ☺ **accessible in near real-time**
- 😐 **complicated format**

➢ Looks more promising. But **how reliable are they**?





This presentation should give …

1) an overview about available high resolution SRFE products
2) an indication about which product is the closest to ground observations
   a) for certain areas (geographical location, climatologic conditions, topographic realities)
   b) on a pan-African scale

For whom is this PPP of interest?

1) People that need to select a precipitation data set for their application and don't know the strength and weaknesses of the individual SRFE products
2) People that use one of these SRFE products and would like to know more about them

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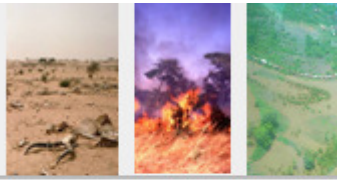
Comparison of high resolution satellite-based precipitation products over Africa



Which satellite-based rainfall estimates (SRFE) should be validated?

Basic requirements:

- **provided timely**
- **high temporal (≤ daily) and spatial (≤ 0.25°) resolution**
- **free of charge**
- **easily accessibility**
- **consistent (not many missing values)**

Product	Provider	Spatial coverage	Temporal coverage	Spatial resolution	Temporal resolution
CMORPH	NOAA-CPC	60°N-S, globally	since 06.12.2002	0.25°	3 h
ERA-interim	ECMWF	global	1989 - 2009	~ 79 km	6 h
GPROF v6	NASA	globally	Since 01.01.1998	0.25°	24 h
GSMaP-MVK	JAXA/EORC	60°N-S, globally	2003 - 2008	0.1°	1 h
PERSIANN	University of Arizona	60°N-S, globally	Since 01.03.2000	0.25°	6 h
PERSIANN-CCS	University of Arizona	50°N-S, globally	Since 01.03.2000	0.04°	0.5 h
RFE 2.0	NOAA-CPC	40°N-S, 20° W - 55°E	Since 01.01.2001	0.1°	24 h
TRMM 3B42 v6	NASA	50°N-S, globally	Since 01.01.1998	0.25°	3 h

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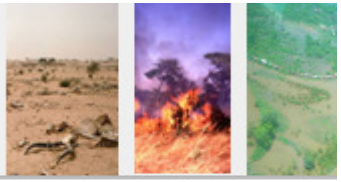


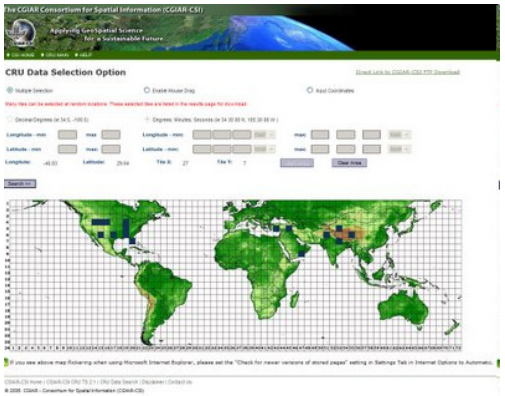
Ground truth data

rain gauge observations

- 93 national stations (GTS stations excluded)
- daily records
- data from 2000 - 2005

CRU TS 3.1

- interpolated monthly observations
- grid data (0.5°)
- released by British Atmospheric Data Centre
- publicly available: http://www.cru.uea.ac.uk



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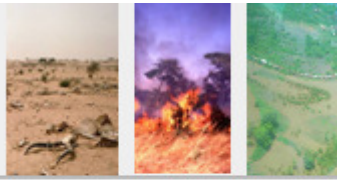
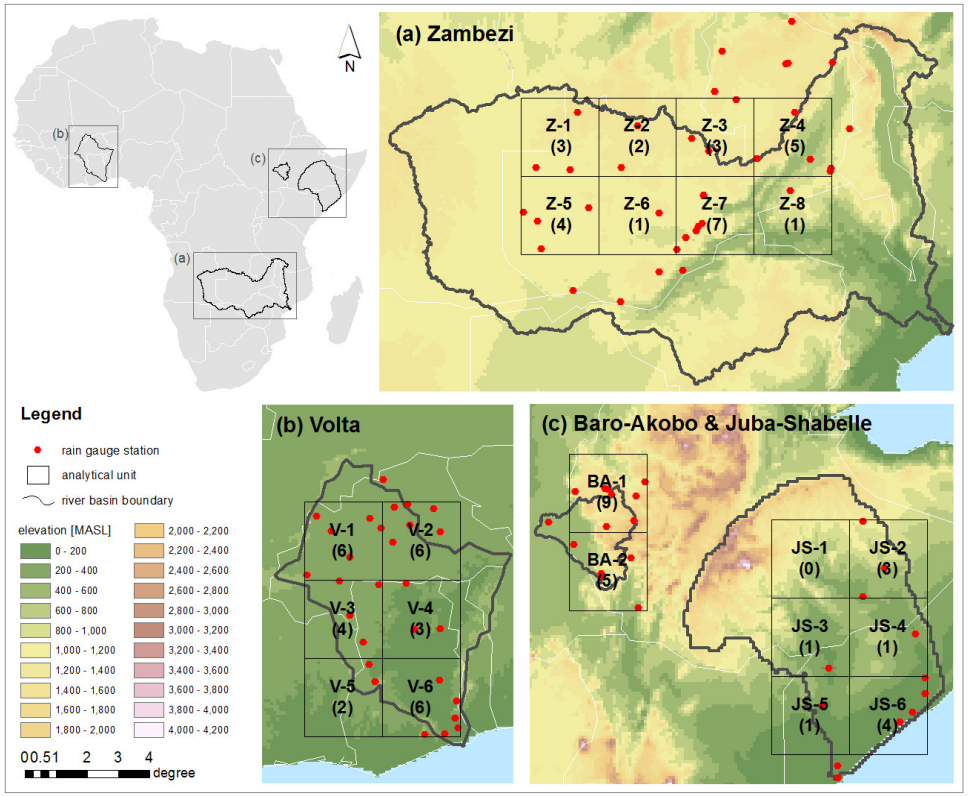


Over which areas should we validate?

Focus:
- **river-basin scale**
- **different climatologic regimes**
- **Different topographic realities**

Limitations:
- **accessibility of data**
- **amount, quality and distribution of available data**



Zambezi
- tropical wet and dry
- one rain season
- 1200 mm/a (northern part)
- 38 stations

Volta
- mostly: tropical wet and dry
- one rain season (inland), two (at coastal zone)
- 300 (north), 1200 mm/a (south)
- 29 stations

Juba-Shabelle
- mostly: semi-arid to arid
- two rain seasons
- 500 mm/a
- 12 stations

Baro-Akobo
- highland climate
- one rain season
- 1800 mm/a
- 13 stations

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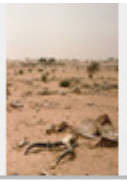

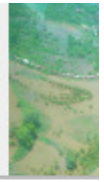

What characteristics do we want to validate?

daily	general ability	error statistic: RMSE, PBIAS, NS_{eff}, R
	distribution	QQ-plot
event based	quantity	detailed analysis of the 10 highest observed rainfall events
	timing	
monthly	general ability	box-plot statistic
	seasonality	monthly average
yearly	general ability	average sum
		monthly maximum
		Number of rainy days

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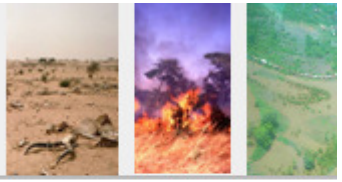
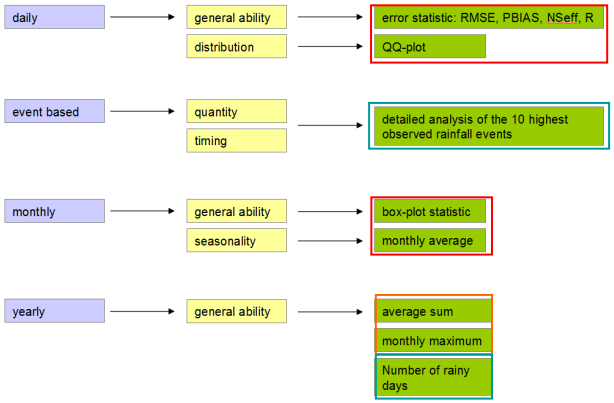


How do we want to validate them?

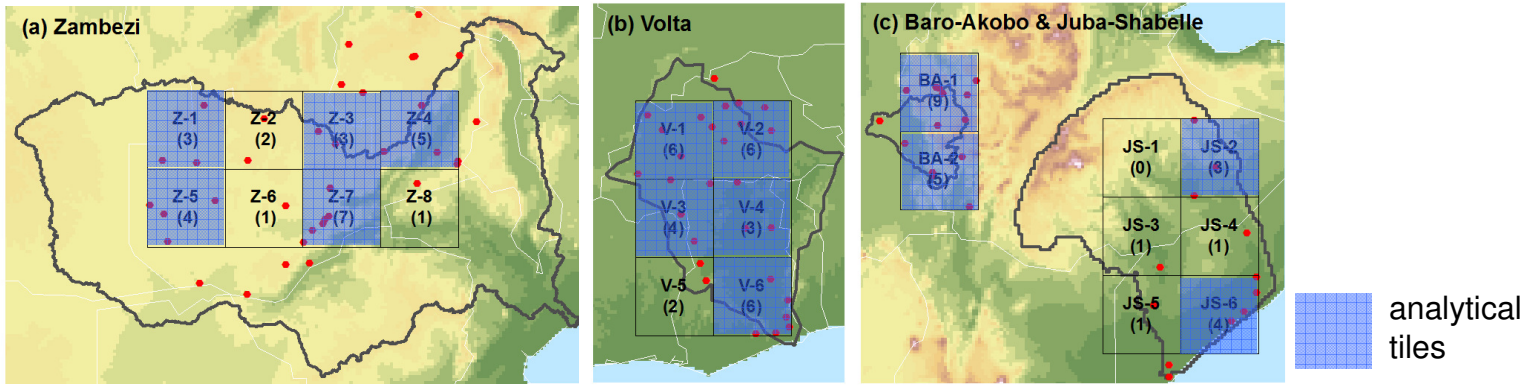


With a point-to-pixel analysis?

- If possible then not. Both have a different spatial representation, which would be derogatory to the skill of the satellite products

Solution: average-points-to-pixel analysis

- If 5 or more stations are within a 2.5 x 2.5° cell, then the error of this average observation is negligible (less then 10 %) in comparison to the bias of the SRFE



Solution: large-scale analysis with CRU

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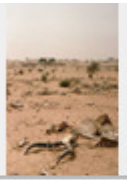

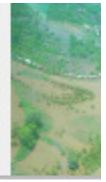

Error statistic

- first impression:
- for Zambezi and Volta RFE 2.0 and TRMM 3B42 are the best
- for JS and BA CMORPH is the best

best score

2nd best score

		Zambezi					Volta					Juba-Shabelle		Baro-Akobo	
		Z-1	Z-3	Z-4	Z-5	Z-7	V-1	V-2	V-3	V-4	V-6	JS-1	JS-3	BA-1	BA-2
MAE	ERA-interim	2.8	3.0	2.2	2.5	2.2	2.2	1.8	2.8	3.4	4.1	1.2	20.1	4.3	4.5
	GPROF	4.3	4.0	3.5	3.9	3.1	3.8	3.4	5.6	5.5	5.4	0.9	31.8	4.4	4.2
	TRMM 3B42	2.4	2.8	2.0	2.1	1.8	2.1	2.3	2.9	3.2	3.4	0.8	21.3	2.7	3.1
	PERSIANN	4.1	3.7	3.0	3.5	2.9	3.9	3.8	4.5	4.8	5.4	0.9	24.8	3.6	3.6
	RFE 2.0	2.3	2.5	1.9	2.0	1.6	1.5	1.8	2.3	2.4	2.9	0.8	23.0	2.8	3.1
	GSMaP-MKV	4.1	4.0	3.3	3.8	2.8	4.7	4.8	5.9	6.6	6.0	1.0	42.2	4.8	5.1
	CMORPH	3.2	3.2	2.3	3.1	2.3	2.7	3.2	3.9	4.1	4.6	0.7	19.5	2.5	3.4
RMSE	ERA-interim	5.3	6.8	4.8	5.6	4.4	4.9	4.2	5.0	6.8	6.6	3.0	4.5	7.4	6.9
	GPROF	8.9	8.9	8.1	8.9	7.4	10.6	10.4	13.2	12.9	11.9	3.4	5.6	7.4	7.1
	TRMM 3B42	5.0	6.6	4.5	5.5	4.3	5.1	5.3	6.0	6.8	6.8	3.1	4.6	4.8	5.3
	PERSIANN	7.6	7.8	6.6	7.7	6.5	8.6	8.3	8.9	9.4	9.6	3.1	5.0	5.9	6.0
	RFE 2.0	4.7	6.3	4.3	5.1	3.7	3.8	4.1	4.7	5.2	5.8	3.0	4.8	4.8	5.5
	GSMaP-MKV	9.8	9.7	8.7	10.3	8.3	14.4	18.3	17.2	17.6	15.6	4.9	6.5	10.4	10.5
	CMORPH	6.1	7.1	4.9	6.6	5.1	6.0	7.4	8.2	8.1	8.5	2.6	4.4	4.5	5.5
PBIAS	ERA-interim	31	-13	1	14	24	-33	-31	-6	-18	36	38	63	40	60
	GPROF	60	7	31	53	44	23	47	82	49	46	-52	-2	-8	-6
	TRMM 3B42	-2	-15	2	-15	0	4	24	4	-4	4	-33	-19	-34	-23
	PERSIANN	83	15	39	68	51	82	114	69	52	68	-45	-20	-30	-33
	RFE 2.0	6	-17	-1	-1	7	-1	17	-7	-12	-4	-25	-24	-34	-23
	GSMaP-MKV	25	-4	-13	11	20	41	78	80	36	26	-14	-66	-5	6
	CMORPH	71	20	33	56	56	49	86	85	48	59	-26	-23	6	20
NSeff	ERA-interim	0.1	0.27	0.36	0.26	0.25	0.14	0.15	0.17	0.08	-0.03	0.04	0.02	-0.49	-0.73
	GPROF	-1.57	-0.27	-0.85	-0.87	-1.14	-2.9	-4.27	-4.78	-2.31	-2.39	-0.17	-0.55	-0.52	-0.81
	TRMM 3B42	0.19	0.31	0.43	0.29	0.29	0.09	-0.36	-0.19	0.1	-0.11	0	-0.04	0.37	0.01
	PERSIANN	-0.94	-0.02	-0.25	-0.41	-0.76	-1.54	-2.34	-1.56	-0.72	-1.16	0.03	-0.18	0.04	-0.26
	RFE 2.0	0.3	0.39	0.5	0.4	0.46	0.52	0.18	0.27	0.49	0.24	-0.24	-0.2	0.33	-0.02
	GSMaP-MKV	-2.01	-0.53	-0.91	-1.12	-1.72	-5.23	-13.3	-9.34	-4.41	-4.4	-2.04	-0.87	-1.81	-2.47
	CMORPH	-0.15	0.17	0.39	0.12	-0.03	-0.08	-1.33	-1.33	-0.15	-0.6	0.13	0.14	0.47	0.05

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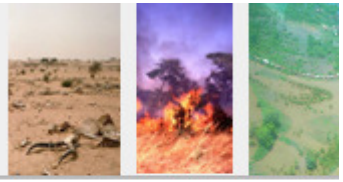
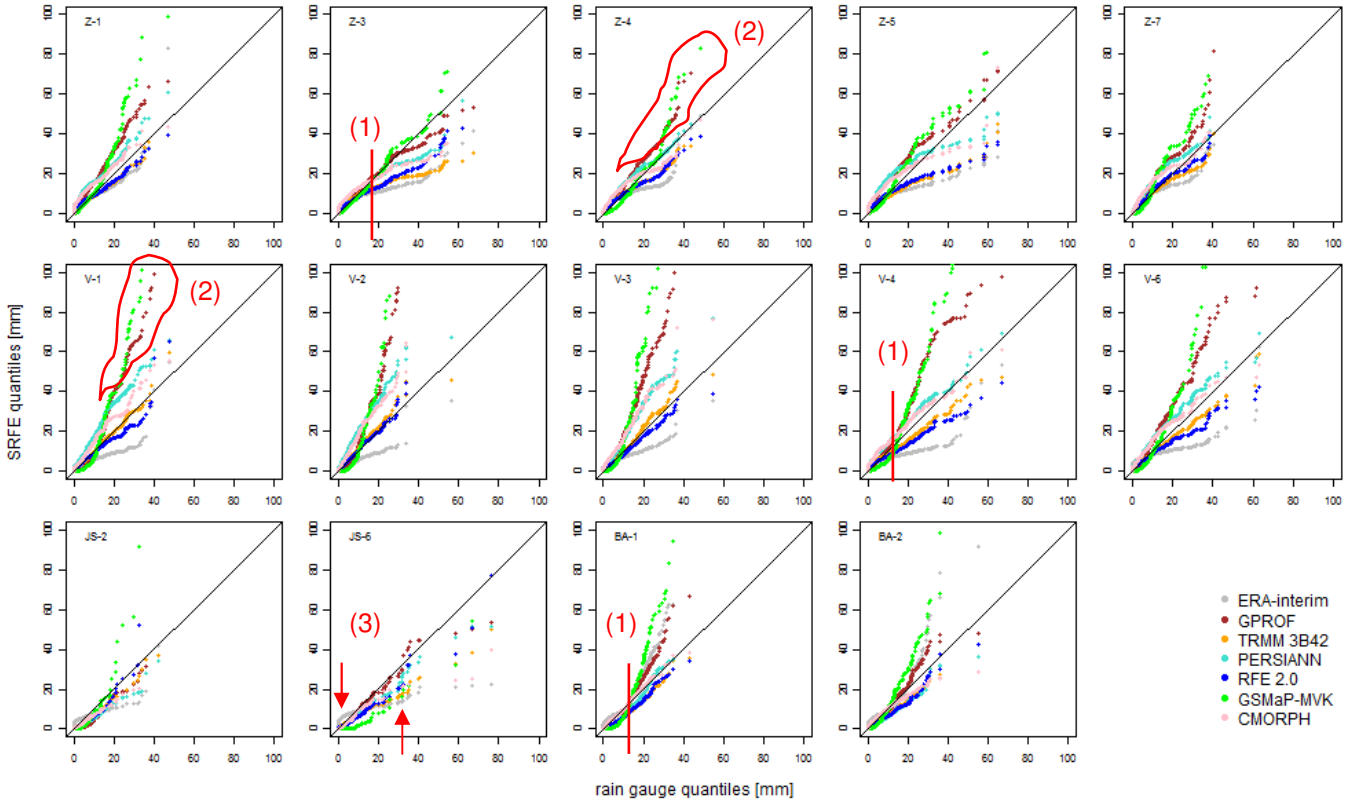


Quantile distribution



(1) a good agreement of the amount of low precipitation (< 15 mm) values

(2) increased amount of high precipitation values for GPROF and GSMaP-MVK

(3) increased amount of lower small precipitation values while shifting towards underestimation of observed precipitation for high values for ERA-interim

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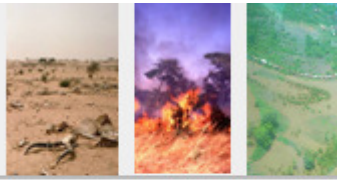
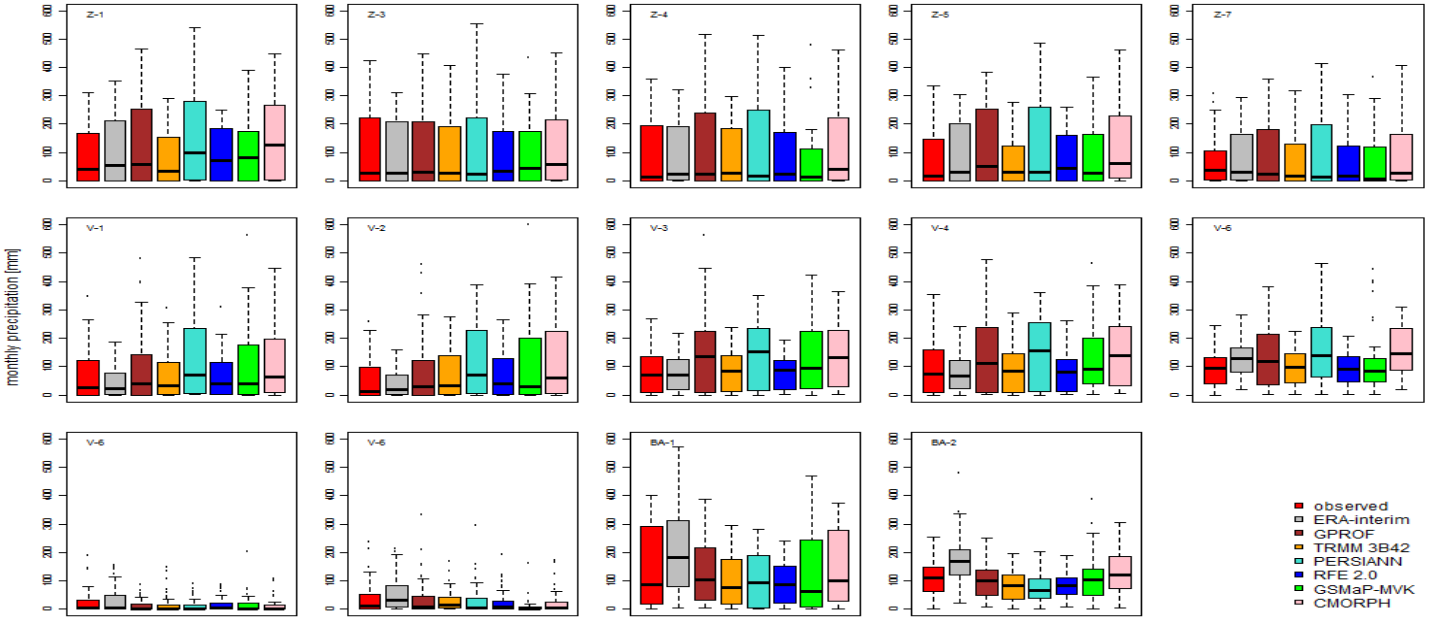


monthly box-plots



Zambezi
- large spread between the quartiles → high monthly variability
- median low → most month hold low precipitation
- positive skewness for CMORPH, PERSIANN and GPROF

Volta
- median confirms increase of precipitation from north to south
- TRMM 3B42 and PFE capture the spread well

Juba-Shabelle
- negligible differences between the SRFE
- narrow spread reflect arid conditions
- SRFE have skill in reproducing precipitation for this area on a monthly scale

Baro-Akobo
- large difference between north and south
- product-wise CMORPH seems to be most accurate

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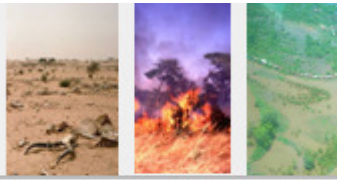
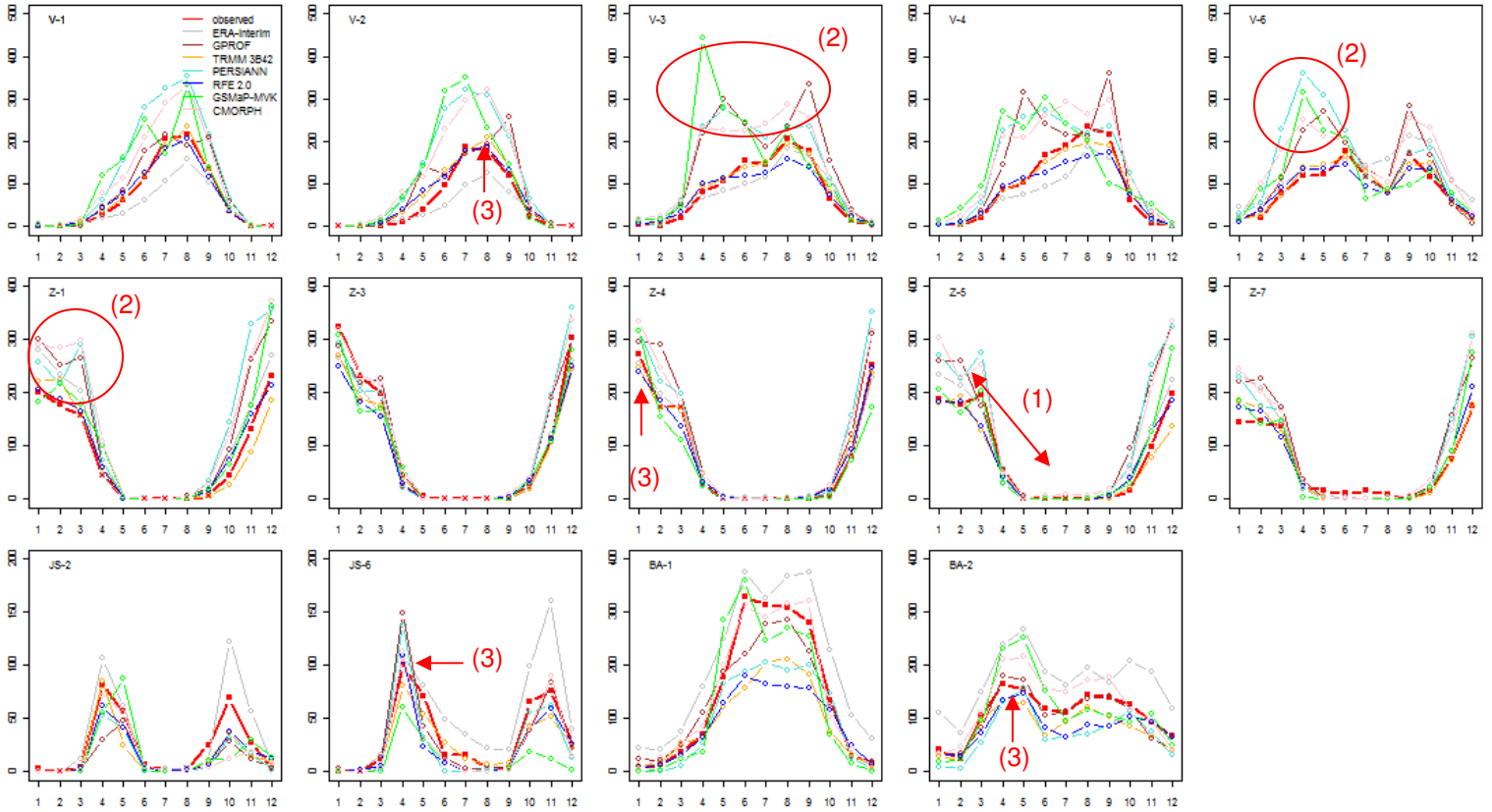


Average inter-annual variation



(1) better accuracy during the relative dry periods, large deviations during the wet months

(2) PERSIANN, CMORPH, GSMaP-MVK and GPROF stick out with large, mostly positive, deviations

(3) TRMM 3B42 and RFE 2.0 show the highest accuracy

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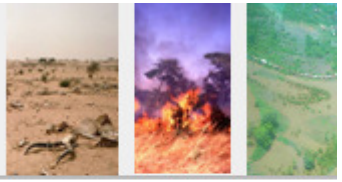
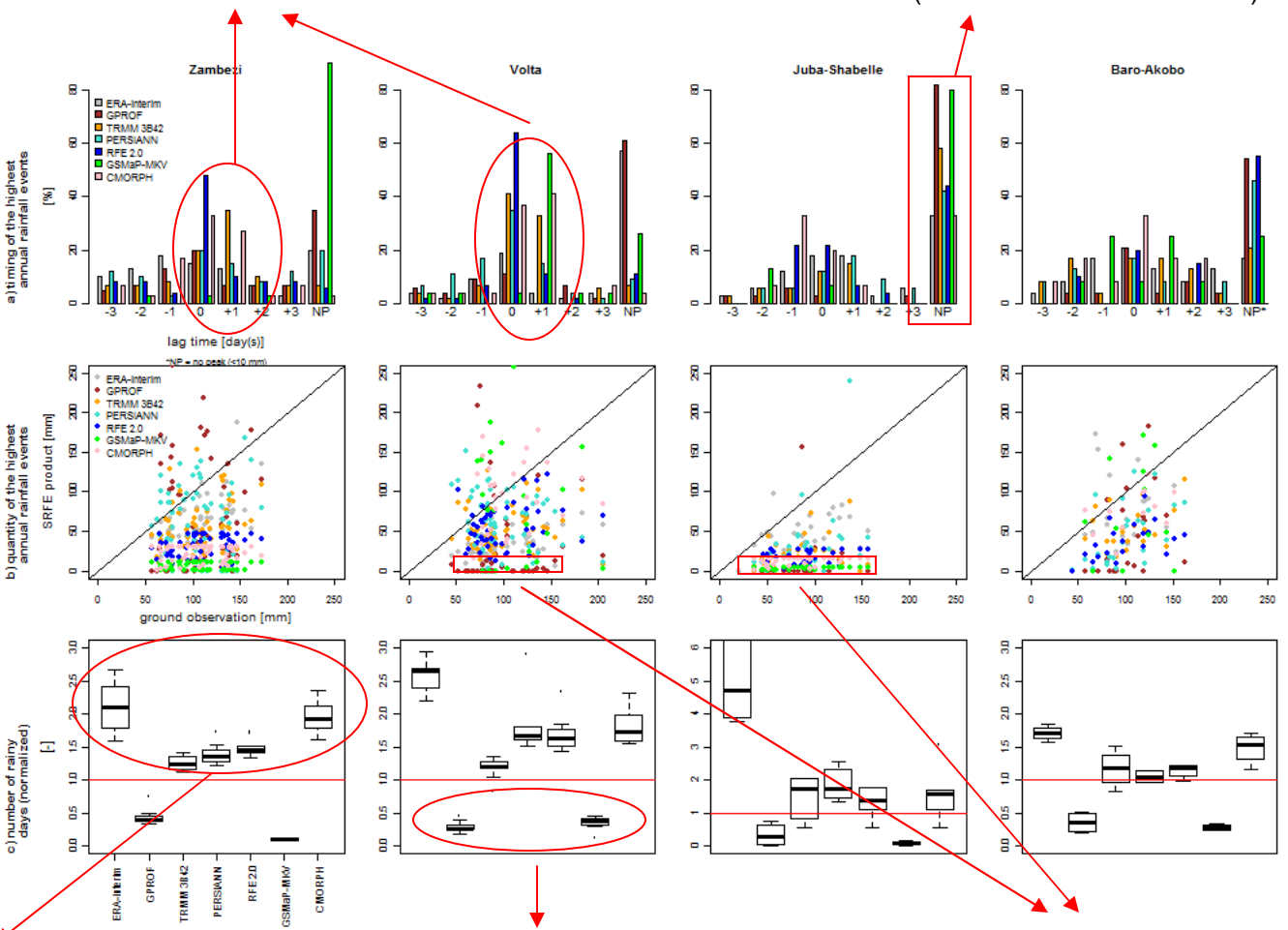


highest annual rainfall events

good temporal fit of the peak precipitation

SRFE show no peak
(less than 10 mm / event)



overestimation of
rainy days per year

underestimation of
rainy days per year

inability to reproduce the
rainfall event quantitatively

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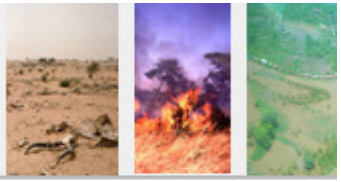
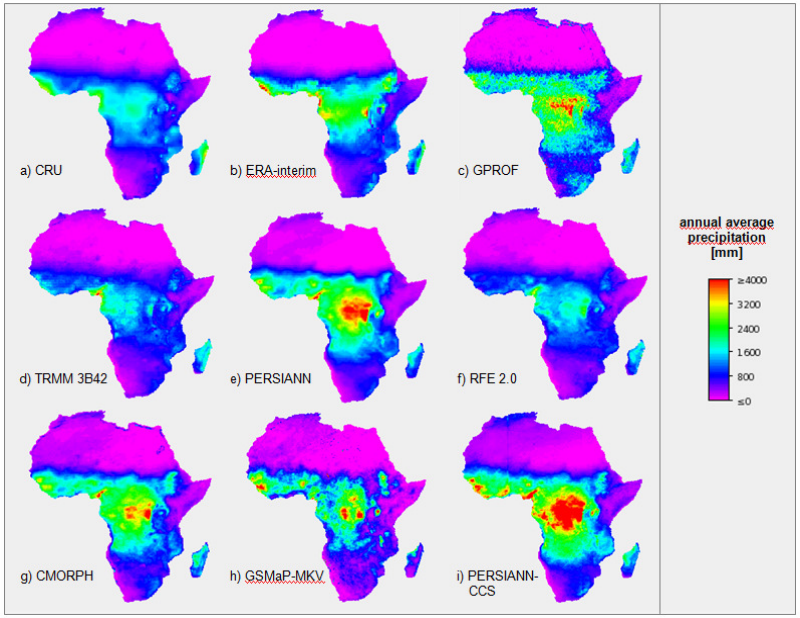
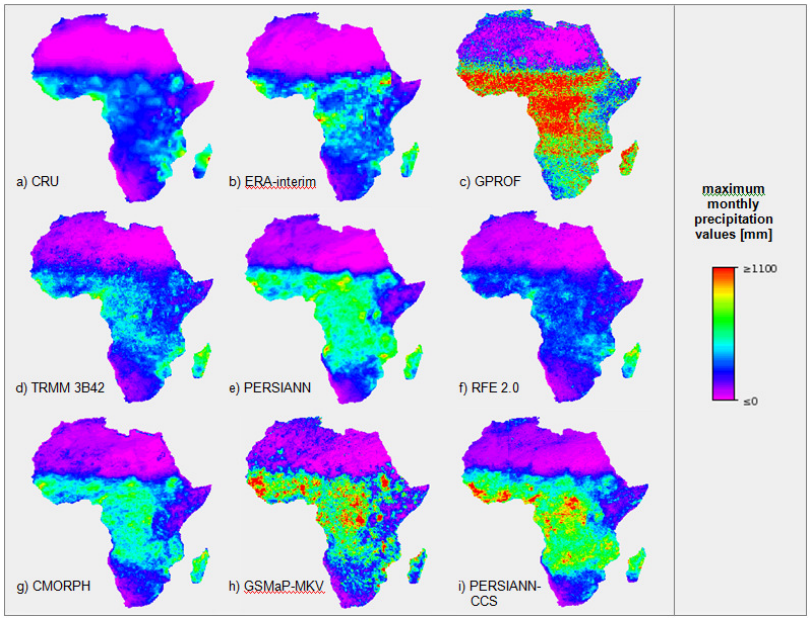


Spatial distribution





- CRU data serves as reference (gridded observation)
- significant overestimation over the tropics (PERSIANN(-CCS), CMORPH, ERA-interim)
- RFE 2.0 and TRMM 3B42 are very close to the observation
- same tendencies for maximum monthly values

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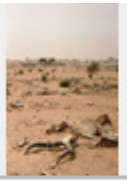
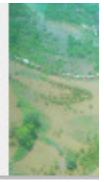




All products / in general

☺ very good reproduction of dry periods

☺ good reproduction of spatial pattern across the continent

☹ underestimate amount of heavy rainfall events

☹ largest deviations within the wet periods

Product-wise

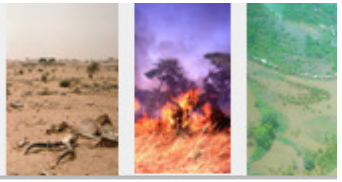
☹
- GPROF & GSMaP-MKV → daily rainfall variability wrongly reproduced: most days rain-free; low amount of rainy days hold extreme values
- PERSIANN(-CCS) → large overestimations (annual; over the tropical band)

😐
- ERA-interim → daily rainfall variability too flat (most days are rainy days, but the amount of rainfall is low: around 6-10 mm)
- CMORPH → captures rainfall over mountainous areas well; overestimation in low altitudes

☺
- RFE 2.0 & TRMM 3B42 → closest to observed (inter-annual variability, spatial distribution pattern, timing of heavy rainfall events)

Session II: Weather data input for impact modelling

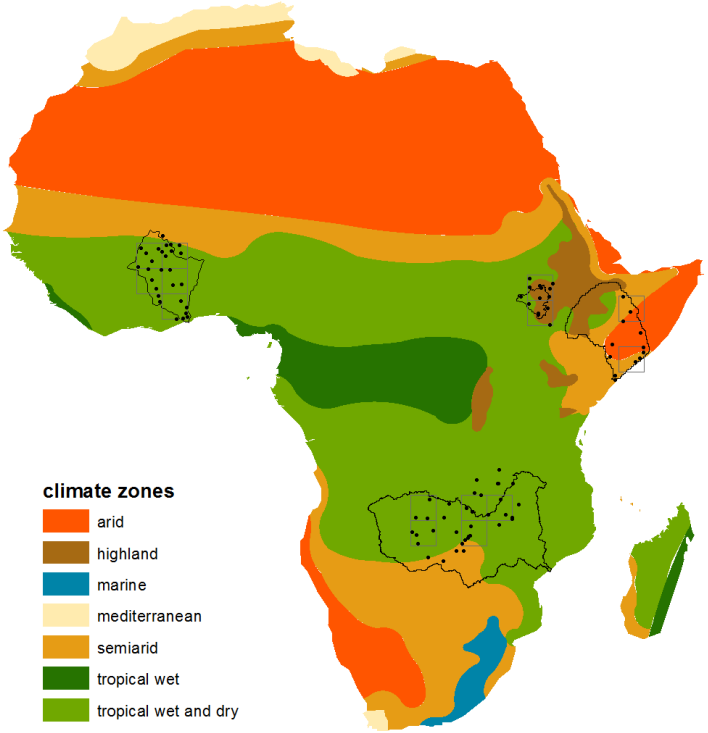
Comparison of high resolution satellite-based precipitation products over Africa



Which data set to chose…

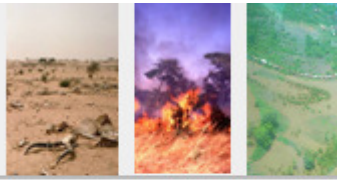
… for certain areas?

- Mountainous regions:
  - CMORPH,
  - GPROF (for monthly applications)
- Arid to semiarid zone:
  - CMORPH,
  - RFE 2.0
- Tropical wet and dry:
  - RFE 2.0,
  - TRMM 3B42
- (Tropical wet:
  - RFE 2.0,
  - TRMM 3B42)



… on a pan-African scale?

- RFE 2.0, TRMM 3B42



Thank you for your attention!