UNCERTAINTY IN THE ESTIMATION OF WATER BUDGET FROM REANALYSIS PRODUCTS: EVALUATION IN UPPER BLUE NILE RIVER BASIN

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- Study Description
- Introduction
- Methodology
- Results
- Conclusions

UCONN

Study Description

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Motivation

Objective

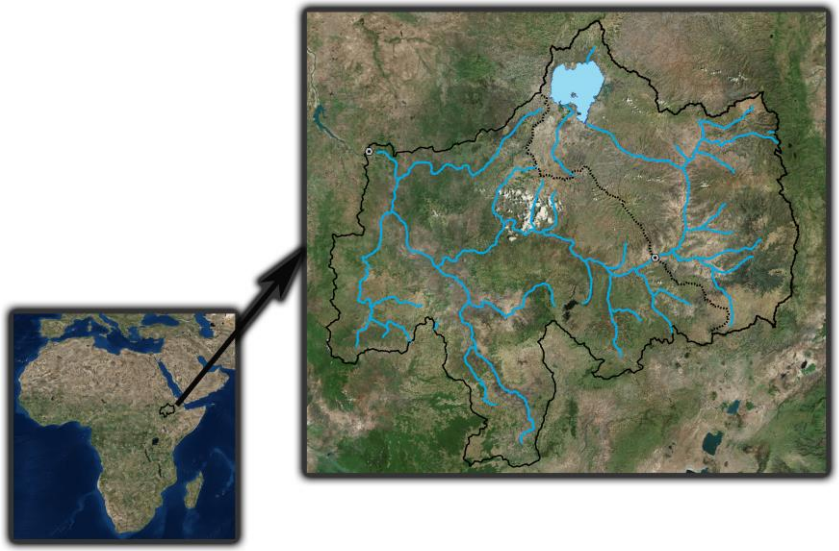
Motivation

- Water and Food are the main human security components of sub-Sahara African communities.
- Addressing these insecurities requires sustainable water resources management.
- Insufficient understanding of the hydrologic cycle due to limited in situ observations.
- Global Water Resources Reanalysis (WRR) products provide a unique opportunity to bridge this knowledge gap.
- Uncertainty characterization of WRR products is needed.

Objective

- Evaluate uncertainty in the estimation of water cycle components from WRR products.

WRR Models	Model	Precipitation Forcing	Model Spatial Resolution
FLDAS	Noah 3.3	MERRA-2	0.1˚
	VIC	MERRA-2	0.25˚
Earth2Observe	HTESSEL-CaMa	MSWEP	0.25˚
		TRMM	
		CMORPH	
	SURFEX-TRIP	MSWEP	0.25˚
		TRMM	
		CMORPH	
	Jules	MSWEP	0.25˚
		TRMM	
		CMORPH	
	LISFLOOD	MSWEP	0.25˚
		TRMM	
		CMORPH	
	WaterGAP3	MSWEP	0.25˚
		TRMM	
		CMORPH	
	ORCHIDEE	MSWEP	0.25˚



Introduction

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- Africa is characterized by sparse hydrologic observations while at the same time there is need for efficiently managing water resources to enhance food and water security in the area.
- Water resources reanalysis (WRR) products provide a unique opportunity to advance understanding of hydrologic processes at regions where in situ information is sparse or nonexistent.
- However, these products are also associated with uncertainty related to the forcing dataset and modeling schemes involved.
- The **main objective** of this study is to evaluate uncertainty and identify the most suitable combination of Land Surface Model (LSM) and precipitation forcing to represent the dynamics of water cycle components in the Upper Blue Nile basin.

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Methodology

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Study Area

Data

- **Evaluation:** We calculated the Relative Error as follow:

$$RE = \frac{SIM - OBS}{OBS}$$

and produced normalized Taylor diagrams

- **WBA**: The terrestrial water storage estimates were calculated using the equation adapted for watersheds:

$$TWS = \int P(t) - ET(t) - Q(t)dt$$

and it was evaluated against the NASA Gravity Recovery and Climate Experiment (GRACE) product.

- **Temporal scale**: Monthly for the evaluation and annual for the Water Budget Analysis (WBA)

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- Upper Blue Nile basin's hydrology plays a significant international role, being the headwaters of the Blue Nile Basin, where it contributes about 60% of the total annual flow of the Nile
- **Spatial scale**: Eldiem (177642.9 km²) and Kessie (50418.08 km²)

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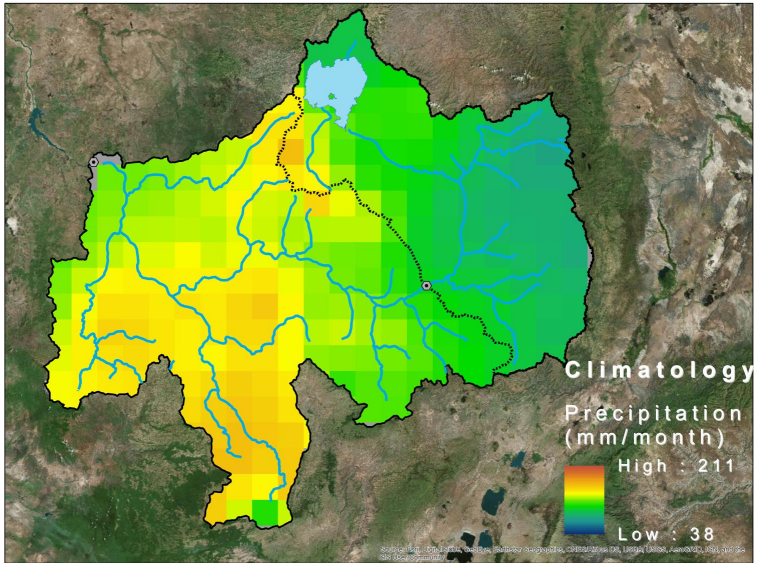
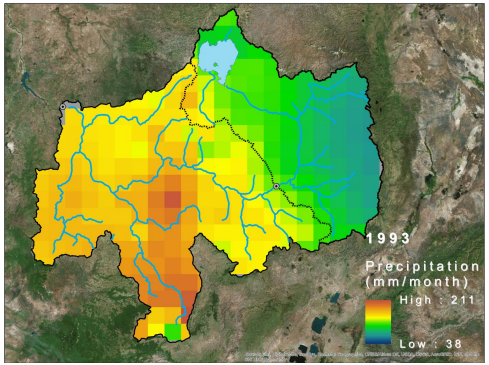
BACK

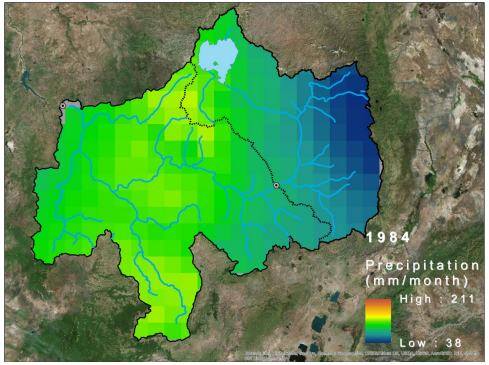
10 Years Climatology (1984 – 2013)

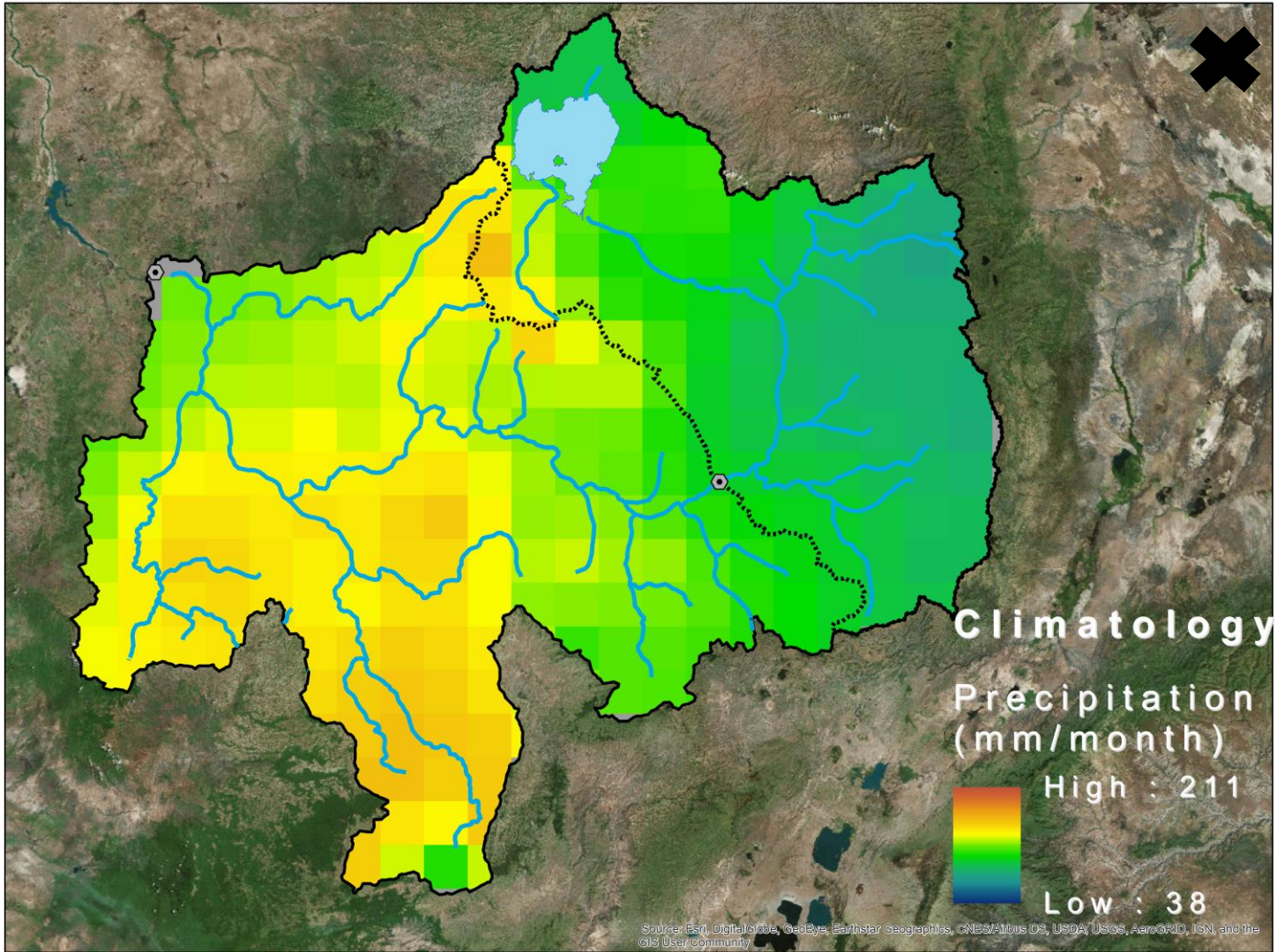


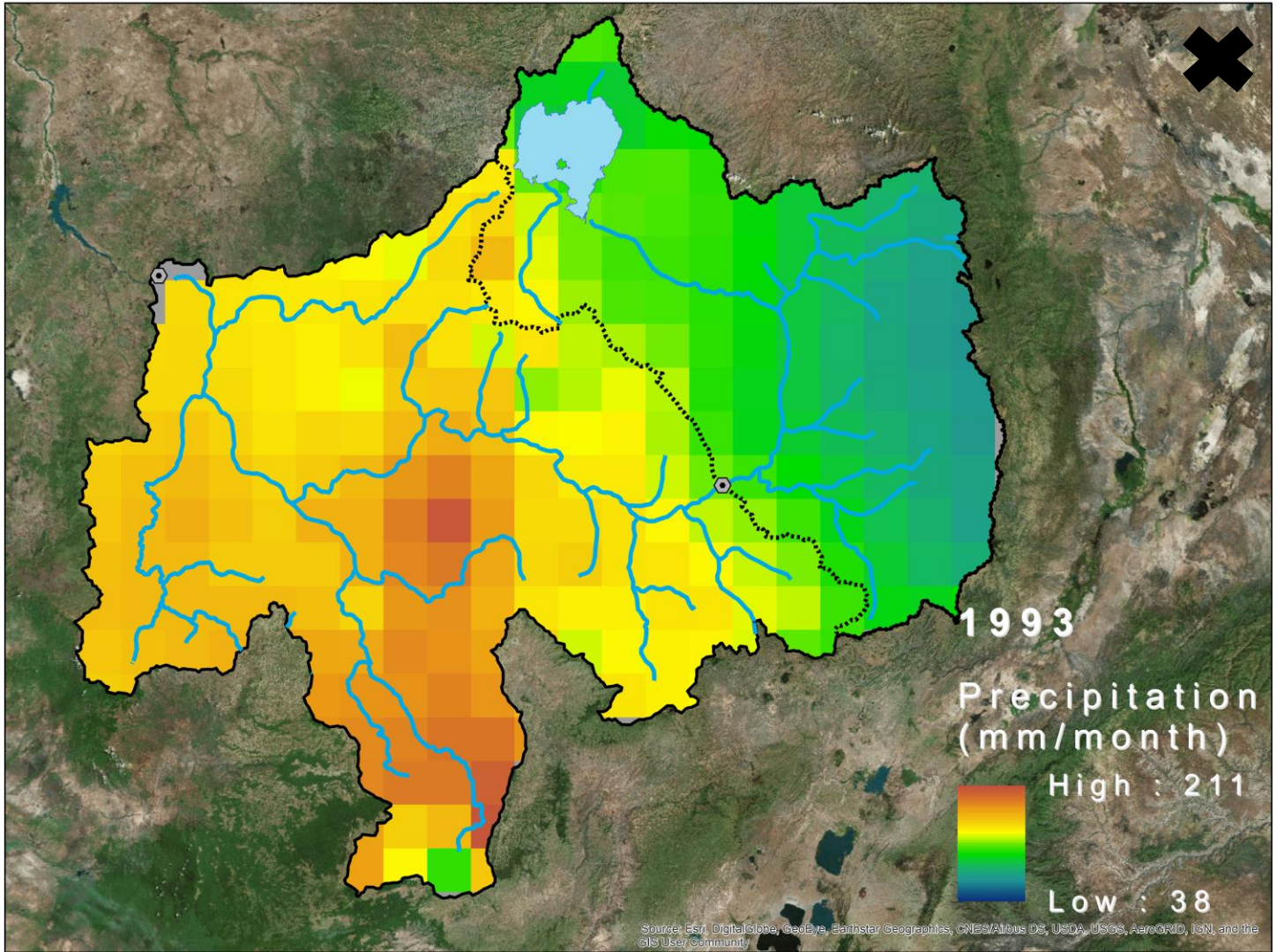
Wettest Year

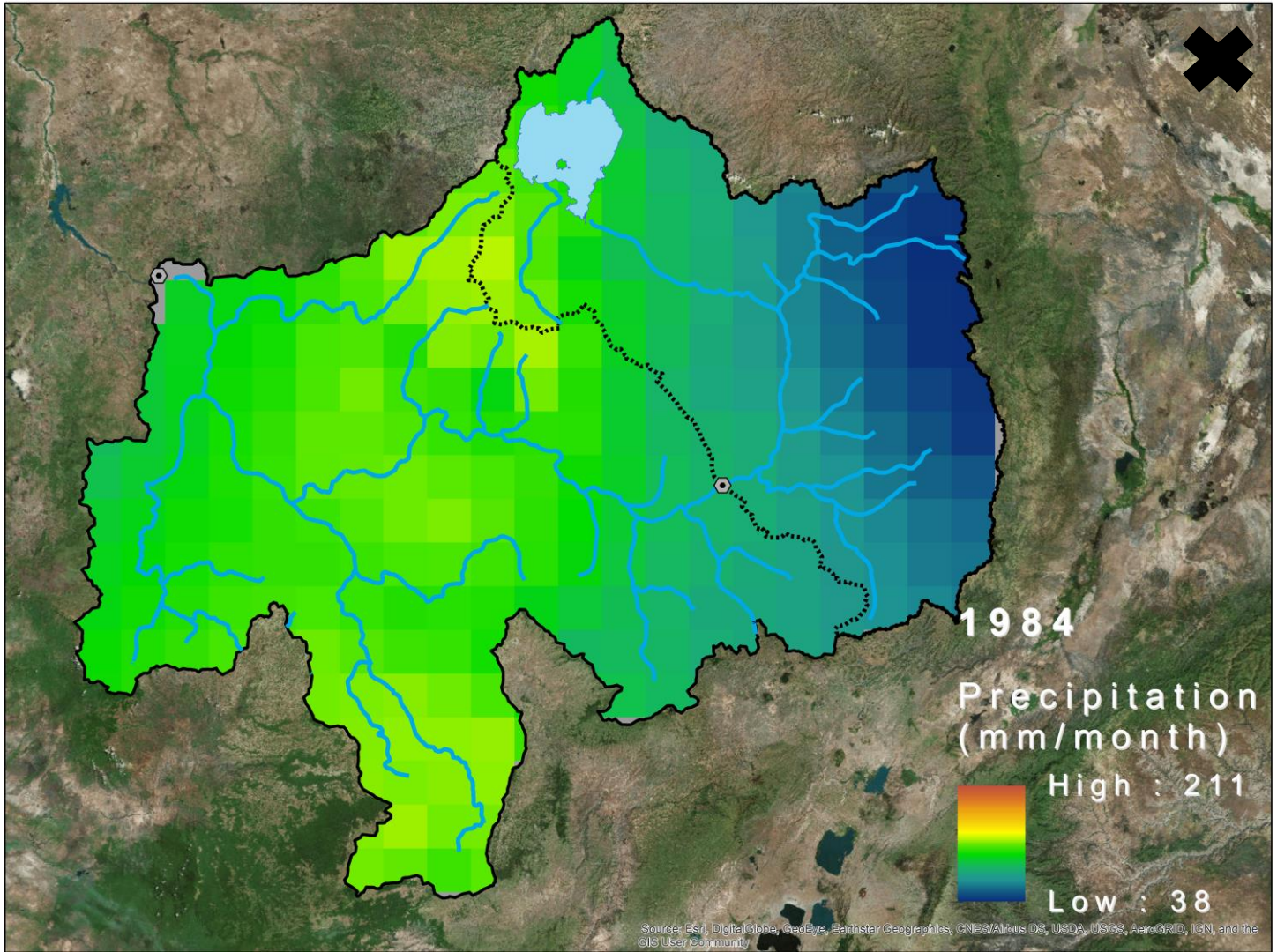


Driest Year




Climatology
Precipitation
(mm/month)
High : 211
Low : 38
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


1993
Precipitation
(mm/month)
High : 211
Low : 38
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


1984
Precipitation
(mm/month)
High : 211
Low : 38
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Data

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- **Reference data**: Daily precipitation from rain gauges measurements, remote sensing derived actual ET (Zhang et al 2016) and in-situ streamflow observations

WRR products under consideration

WRR Models	Model	Precipitation Forcing	Model Spatial Resolution
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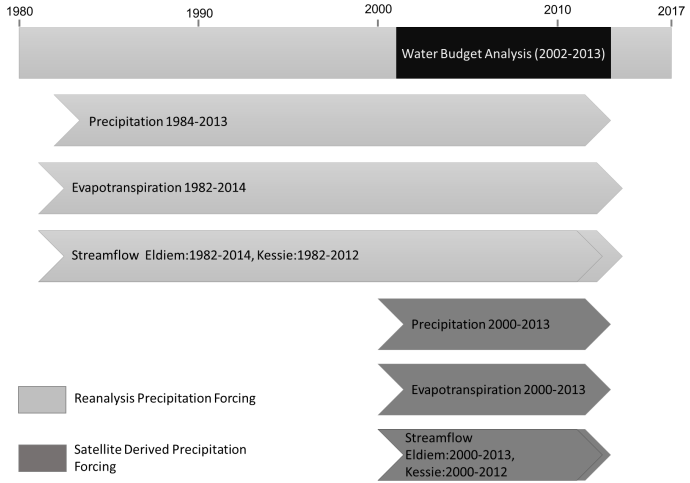
Earth2Observe	HTESSEL-CaMa	MSWEP	0.25˚
		TRMM	
		CMORPH	
	SURFEX-TRIP	MSWEP	0.25˚
		TRMM	
		CMORPH	
	Jules	MSWEP	0.25˚
		TRMM	
		CMORPH	
	LISFLOOD	MSWEP	0.25˚
		TRMM	
		CMORPH	
	WaterGAP3	MSWEP	0.25˚
		TRMM	
		CMORPH	
	ORCHIDEE	MSWEP	0.25˚

Temporal extent for the evaluation



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WRR Models	Model	Precipitation Forcing	Model Spatial Resolution
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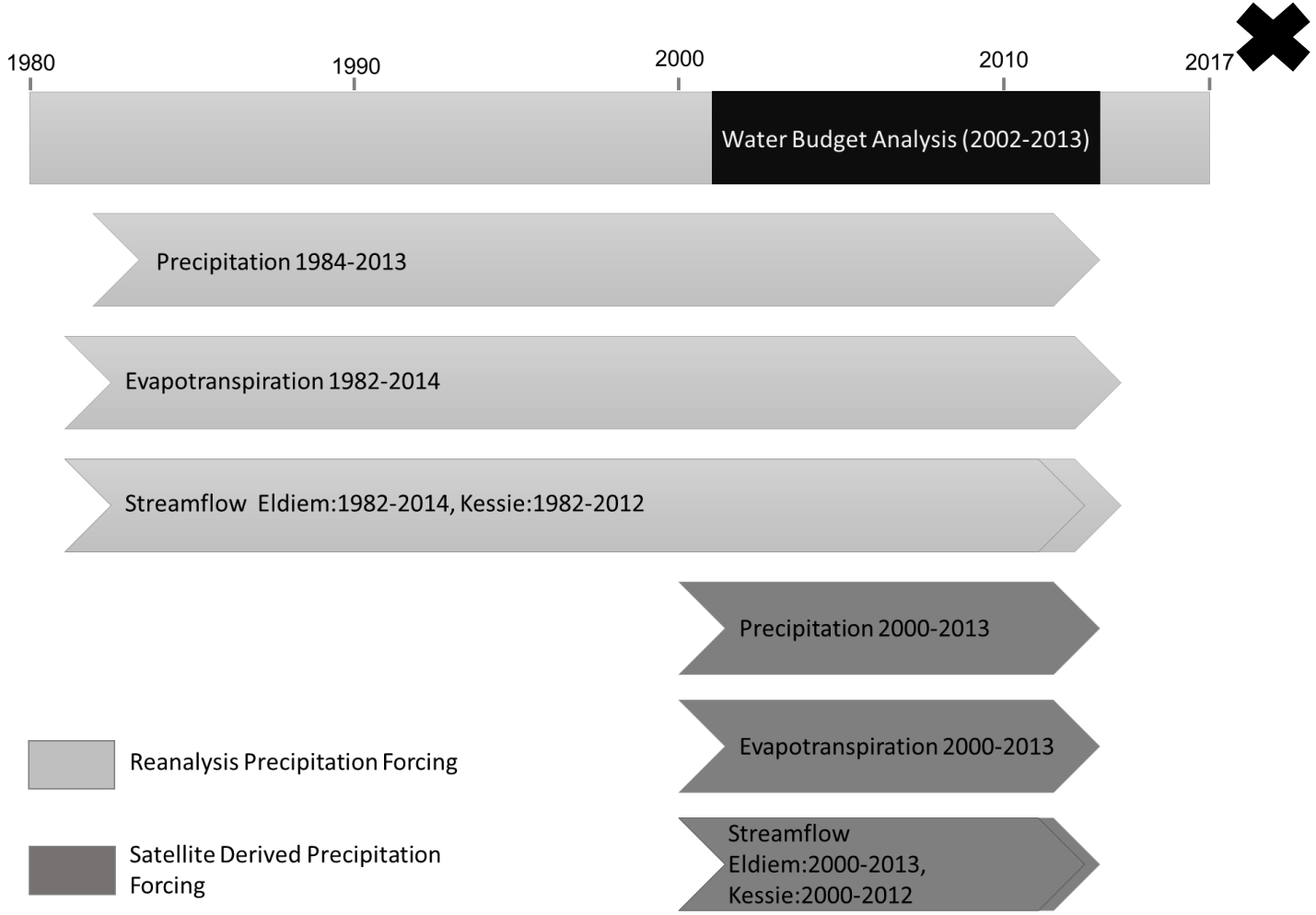
		TRMM	
		CMORPH	
	Jules	MSWEP	0.25˚
		TRMM	
		CMORPH	
	LISFLOOD	MSWEP	0.25˚
		TRMM	
		CMORPH	
	WaterGAP3	MSWEP	0.25˚
		TRMM	
		CMORPH	
	ORCHIDEE	MSWEP	0.25˚


1980
1990
2000
2010
2017
Water Budget Analysis (2002-2013)
Precipitation 1984-2013
Evapotranspiration 1982-2014
Streamflow Eldiem:1982-2014, Kessie:1982-2012
Precipitation 2000-2013
Evapotranspiration 2000-2013
Streamflow Eldiem:2000-2013, Kessie:2000-2012
Reanalysis Precipitation Forcing
Satellite Derived Precipitation Forcing

Results

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- Statistical Evaluation
- Water Budget Analysis

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Relative Errors

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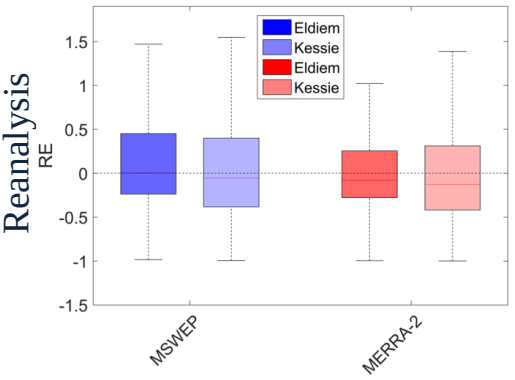
Precipitation

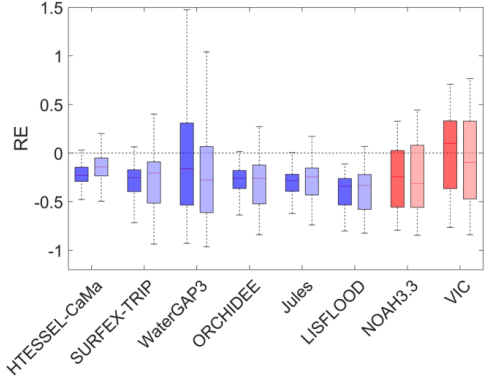
ET

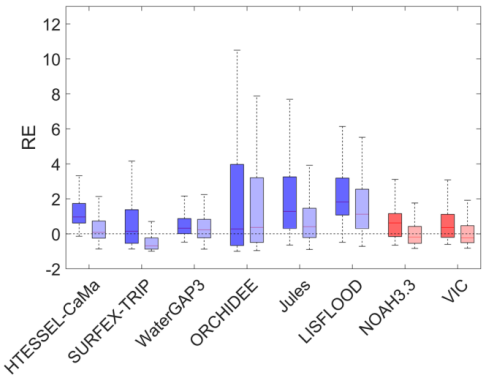
Streamflow

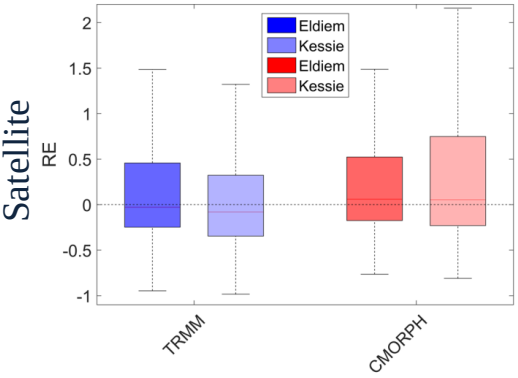
Reanalysis

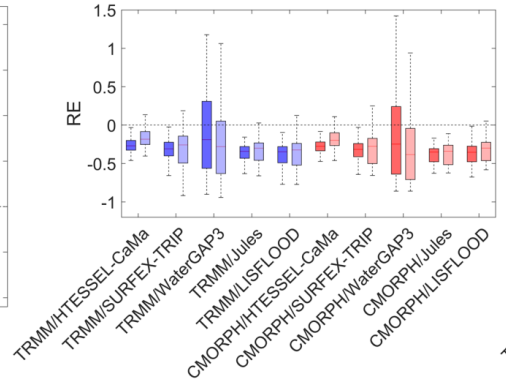
Satellite

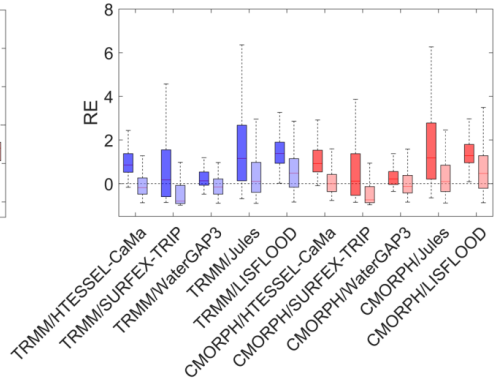












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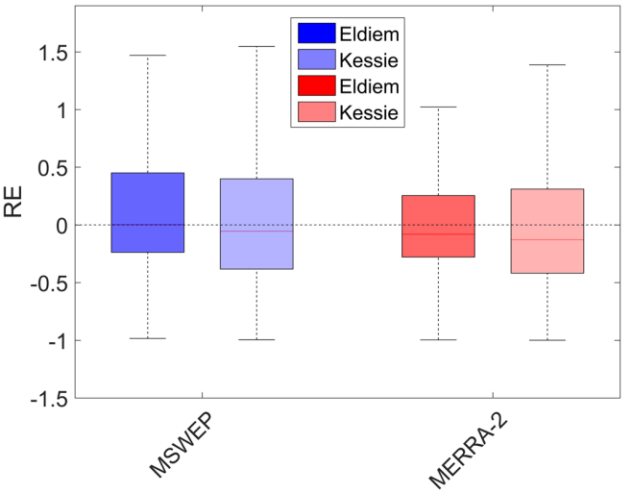
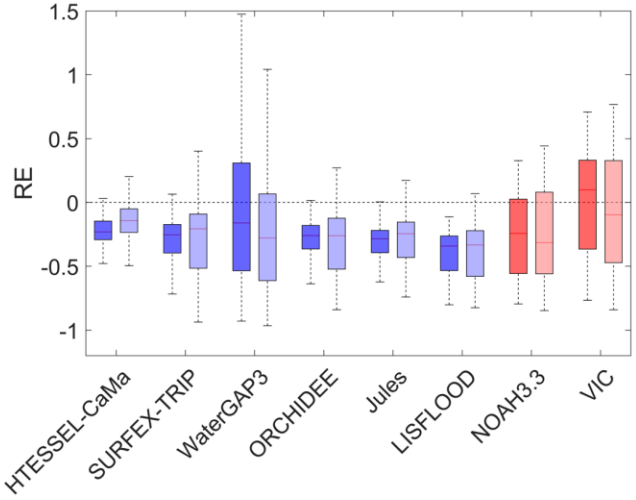
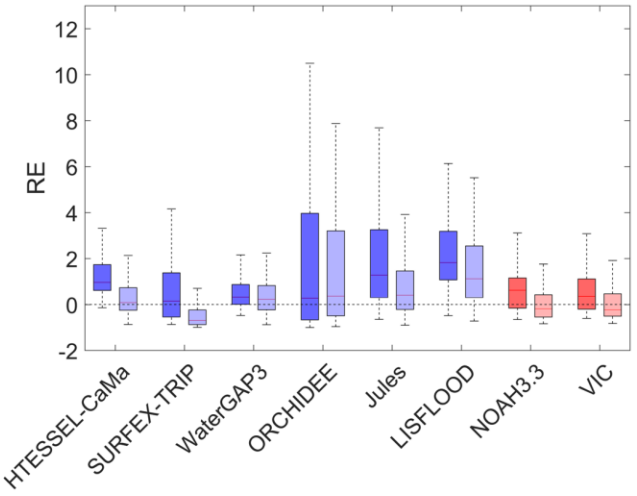
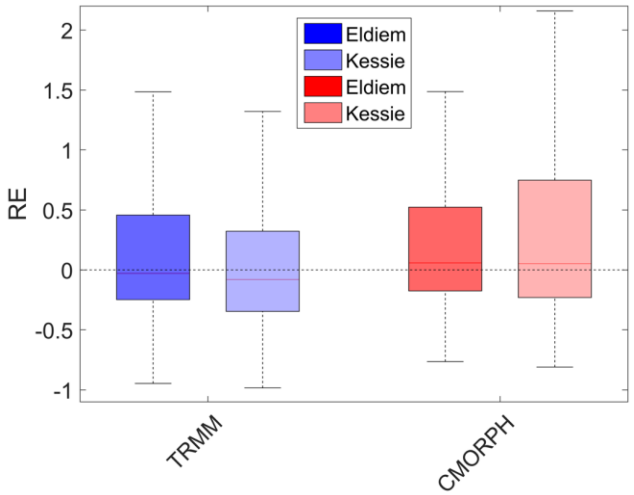
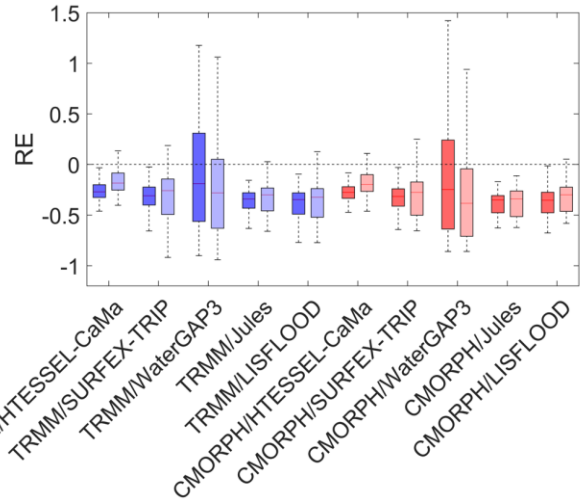
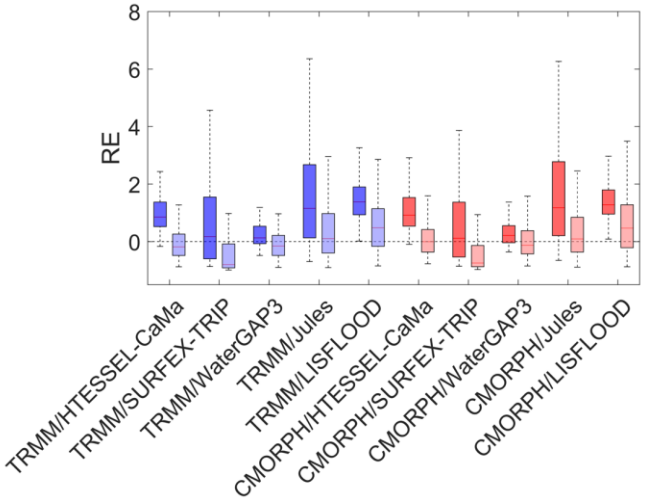

Eldiem
Kessie
Eldiem
Kessie
RE
1.5
1
0.5
0
-0.5
-1
-1.5
MSWEP
MERRA-2


RE
1.5
1
0.5
0
-0.5
-1
HTESSEL-CaMa
SURFEX-TRIP
WaterGAP3
ORCHIDEE
Jules
LISFLOOD
NOAH3.3
VIC


RE
12
10
8
6
4
2
0
-2
HTESSEL-CaMa
SURFEX-TRIP
WaterGAP3
ORCHIDEE
Jules
LISFLOOD
NOAH3.3
VIC


Eldiem
Kessie
Eldiem
Kessie
RE
2
1.5
1
0.5
0
-0.5
-1
TRMM
CMORPH


RE
1.5
1
0.5
0
-0.5
-1
TRMM/HTESSEL-CaMa
TRMM/SURFEX-TRIP
TRMM/WaterGAP3
TRMM/Jules
TRMM/LISFLOOD
CMORPH/HTESSEL-CaMa
CMORPH/SURFEX-TRIP
CMORPH/WaterGAP3
CMORPH/Jules
CMORPH/LISFLOOD


RE
8
6
4
2
0
TRMM/HTESSEL-CaMa
TRMM/SURFEX-TRIP
TRMM/WaterGAP3
TRMM/Jules
TRMM/LISFLOOD
CMORPH/HTESSEL-CaMa
CMORPH/SURFEX-TRIP
CMORPH/WaterGAP3
CMORPH/Jules
CMORPH/LISFLOOD

Statistical Evaluation

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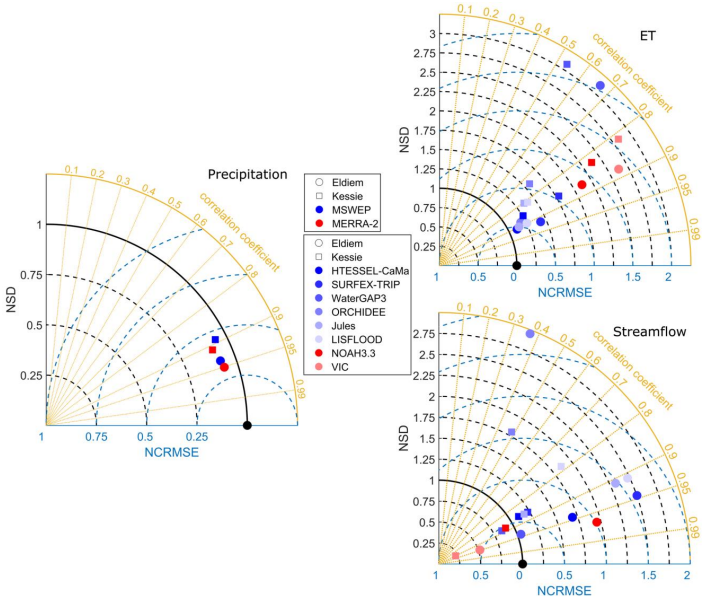
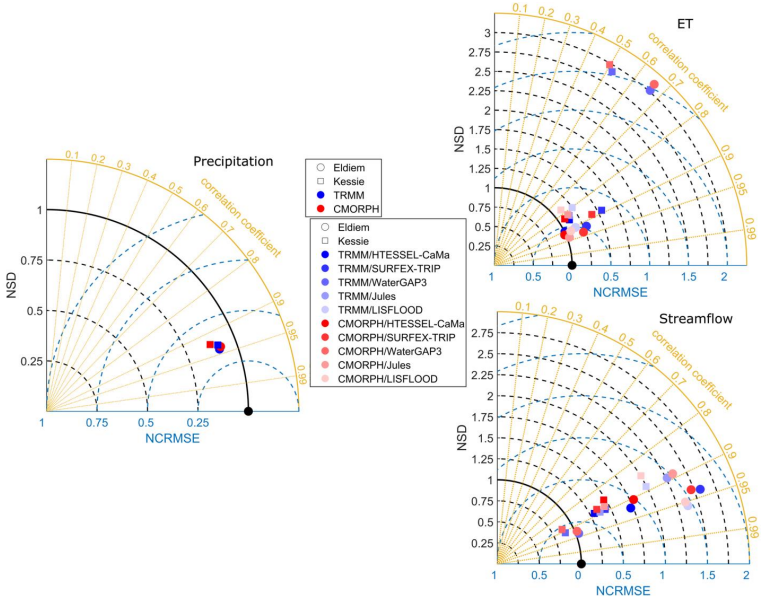
Reanalysis



Satellite



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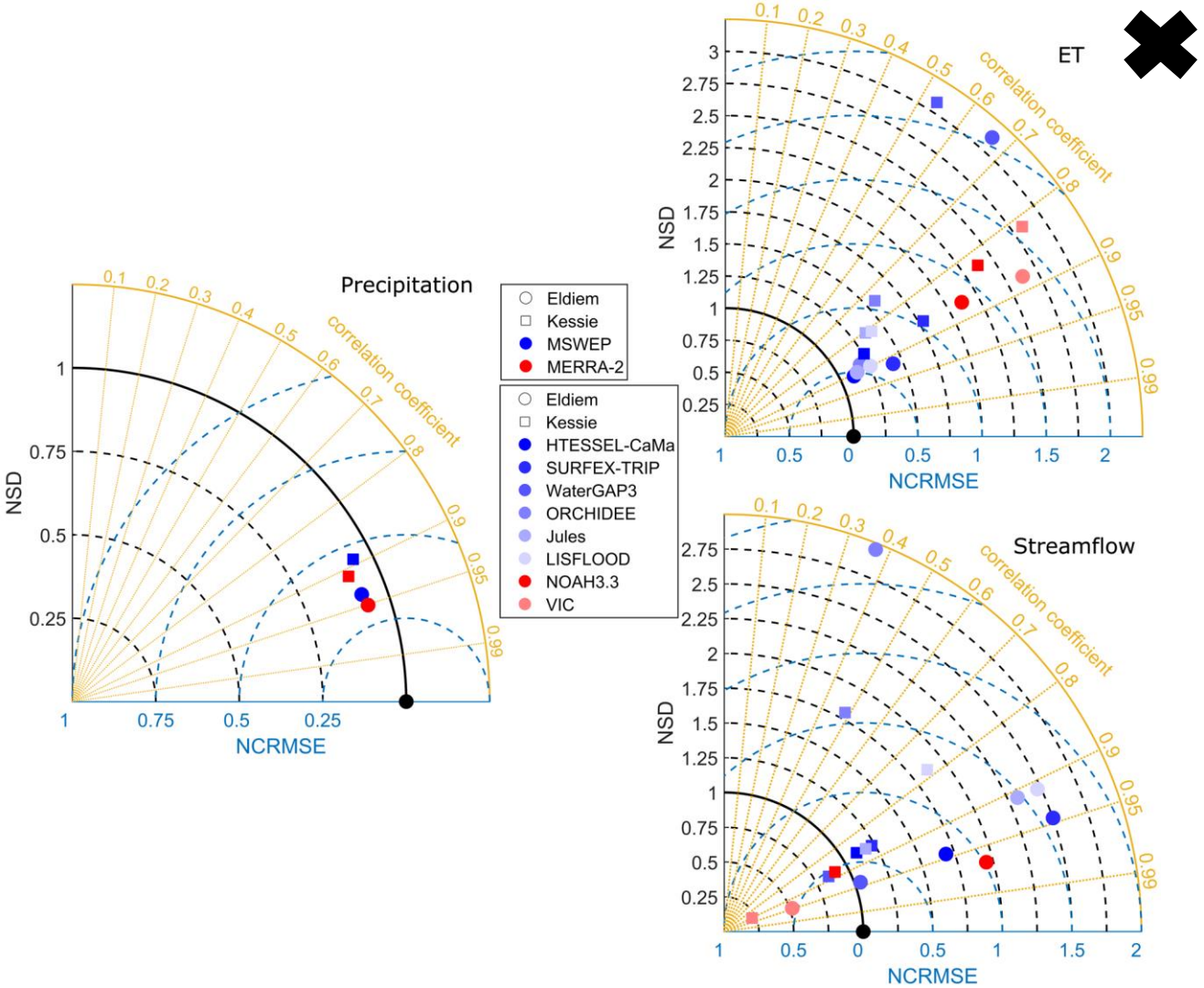
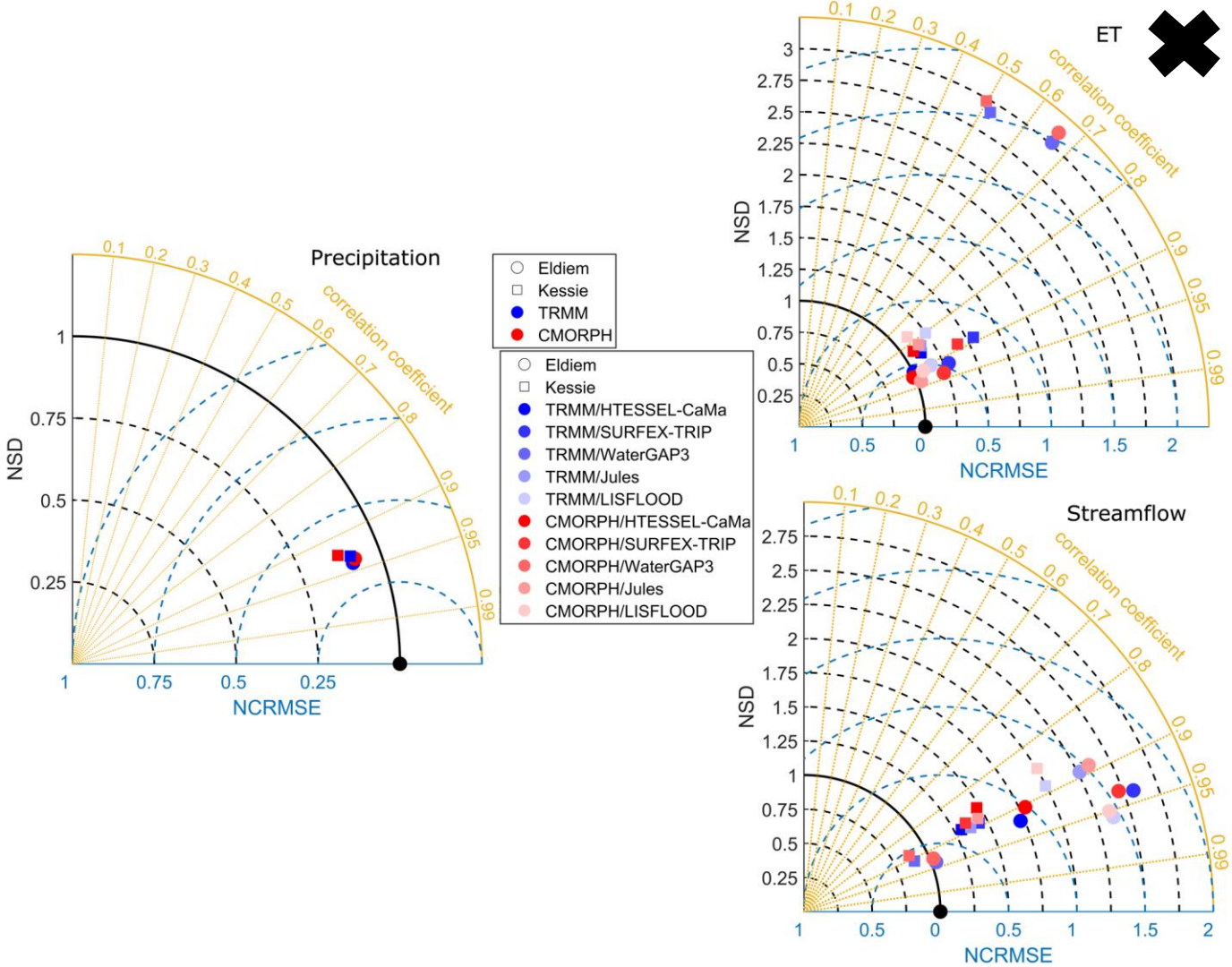

Precipitation
ET
Streamflow
correlation coefficient
NSD
NCRMSE
Eldiem
Kessie
MSWEP
MERRA-2
HTESSEL-CaMa
SURFEX-TRIP
WaterGAP3
ORCHIDEE
Jules
LISFLOOD
NOAH3.3
VIC


Precipitation
ET
Streamflow
NSD
NCRMSE
correlation coefficient
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0.95
0.99
Eldiem
Kessie
TRMM
CMORPH
TRMM/HTESSEL-CaMa
TRMM/SURFEX-TRIP
TRMM/WaterGAP3
TRMM/Jules
TRMM/LISFLOOD
CMORPH/HTESSEL-CaMa
CMORPH/SURFEX-TRIP
CMORPH/WaterGAP3
CMORPH/Jules
CMORPH/LISFLOOD

Water Budget Analysis

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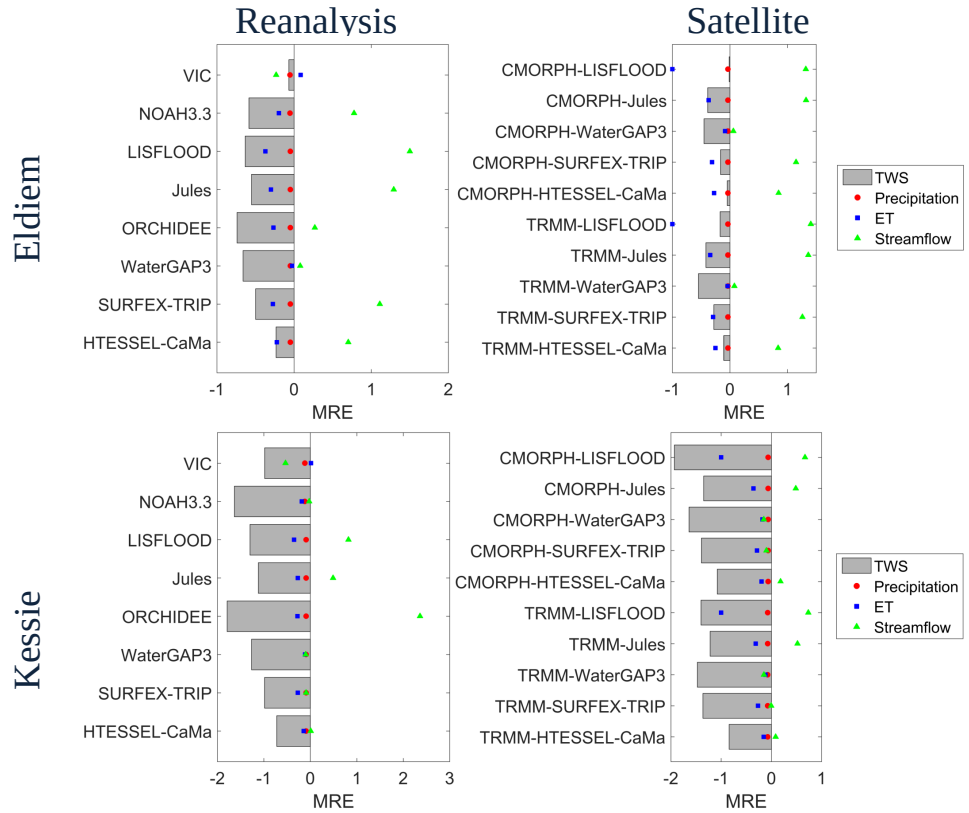

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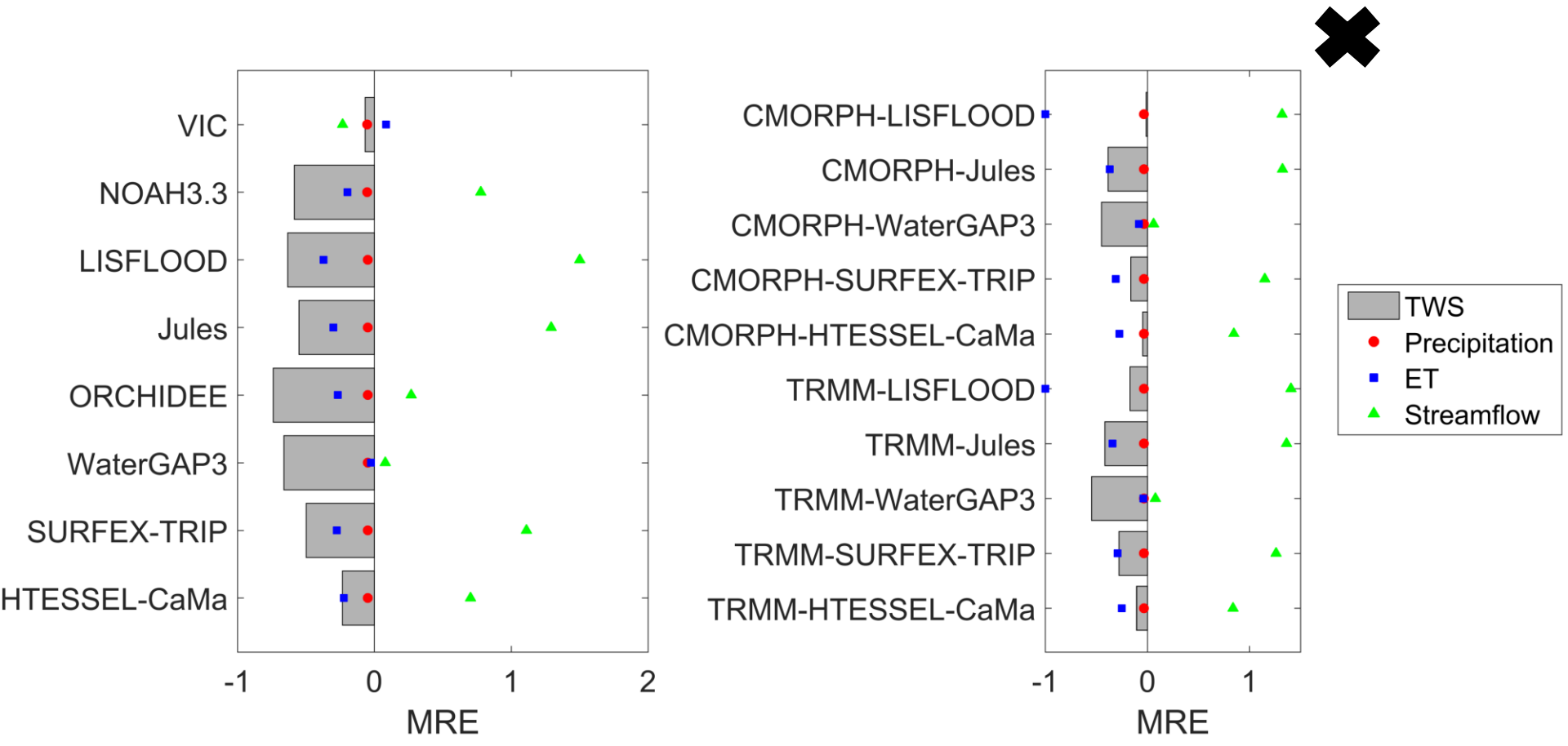
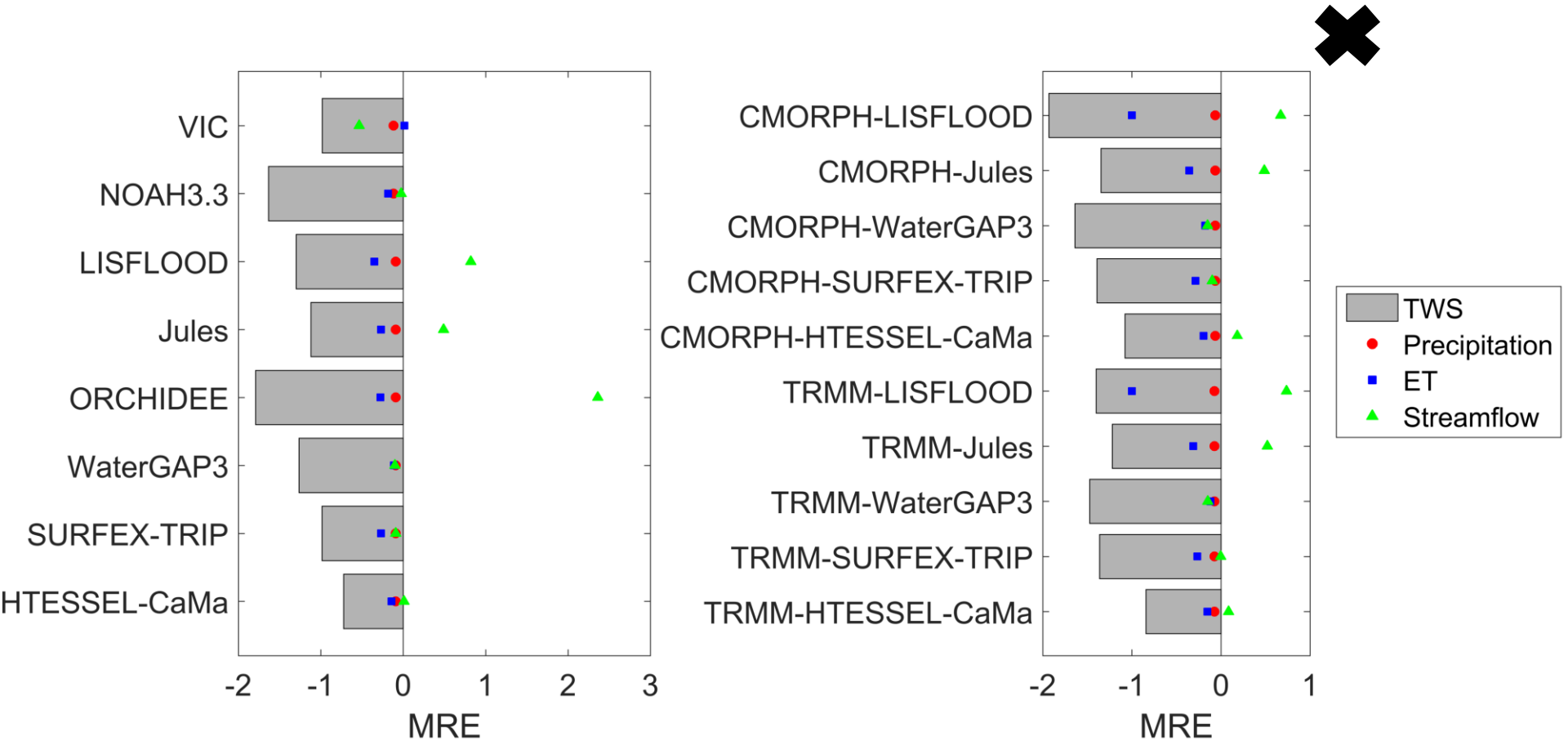

VIC
NOAH3.3
LISFLOOD
Jules
ORCHIDEE
WaterGAP3
SURFEX-TRIP
HTESSEL-CaMa
-1
0
1
2
MRE
CMORPH-LISFLOOD
CMORPH-Jules
CMORPH-WaterGAP3
CMORPH-SURFEX-TRIP
CMORPH-HTESSEL-CaMa
TRMM-LISFLOOD
TRMM-Jules
TRMM-WaterGAP3
TRMM-SURFEX-TRIP
TRMM-HTESSEL-CaMa
-1
0
1
MRE
TWS
Precipitation
ET
Streamflow


VIC
NOAH3.3
LISFLOOD
Jules
ORCHIDEE
WaterGAP3
SURFEX-TRIP
HTESSEL-CaMa
-2
-1
0
1
2
3
MRE
CMORPH-LISFLOOD
CMORPH-Jules
CMORPH-WaterGAP3
CMORPH-SURFEX-TRIP
CMORPH-HTESSEL-CaMa
TRMM-LISFLOOD
TRMM-Jules
TRMM-WaterGAP3
TRMM-SURFEX-TRIP
TRMM-HTESSEL-CaMa
-2
-1
0
1
MRE
TWS
Precipitation
ET
Streamflow

Conclusions

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- Given the close agreement of the precipitation forcing, variations in ET and streamflow parameter across the different WRR products are attributed to differences in the LSM schemes of the various models.
- WaterGAP3 (forced with the MSWEP precipitation dataset) exhibited the best representation of the observed streamflow over the Upper Blue Nile and HTESSEL-CaMa achieved the best performance in terms of ET.
- The high MRE of TWS might be partly attributed to the fact that in our TWS estimation, we didn't take into account the slower procedures like soil moisture and ground water changes which affect the TWS.
- VIC and HTESSEL exhibited the best representation of TWS changes in both basins.
- Satellite driven WRR exhibited lower MRE of TWS compared to the reanalysis precipitation forced products

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