EVALUATION OF WATER CYCLE COMPONENTS IN THE UPPER BLUE NILE BASIN BASED ON AN ENSEMBLE OF WATER RESOURCES REANALYSIS PRODUCTS

MARIKA KOUKOULA[1], EFTHYMIOS I. NIKOLOPOULOS[1], ZOI DOKOU[1], SEMU MOGES[2], AMVROSSIOS C. BAGTZOGLOU[1], EMMANOUIL, N. ANAGNOSTOU[1]

[1]Department of Civil & Environmental Engineering, University of Connecticut, [2] Addis Ababa Institute of Technology, Addis Ababa University

Abstract: Managing water resources in a sustainable manner requires at the very least an adequate characterization of hydrological fluxes (precipitation, streamflow, evapotranspiration, groundwater) and states (soil moisture) at monthly, seasonal and annual scale. In this work we present a comprehensive evaluation of water cycle components for the Upper Blue Nile basin in Ethiopia estimated from four state-of-the-art water resources reanalysis (WRR) products associated with different land surface models (LSMs), meteorological forcing and precipitation datasets. Specifically, evaluation is carried out for a dataset produced through NASA's Land Data Assimilation System (LDAS) regional (FLDAS) scale and the latest versions (tier 2) of the global WRR product of the EU Earth2observe project. Each product includes a multi-model ensemble output. The final ensemble output, considering all products, incorporates differences in forcing, model space/time resolutions and assimilation procedures used in each WRR product. Results from this analysis highlight the current strengths and limitations of available WRR datasets for analyzing the hydrological cycle and dynamics of East Africa region and provide unprecedented information for both developers and end users in similar hydroclimatic regimes.

1.Introduction

Availability of multiple global water resources reanalysis (WRR) products has provided a unique opportunity to advance understanding of terrestrial hydrologic processes at regions where in situ information is sparse or nonexistent. Africa is generally 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. Ethiopia's hydrology plays a significant international role, being the headwaters of the Blue Nile Basin, where it contributes about 86% of the total annual flow of the Nile (Sutcliffe, 1999).

The objectives of this study is to identify the most suitable combination of LSM and precipitation forcing to represent the hydrological cycle components for the Upper Blue Nile.

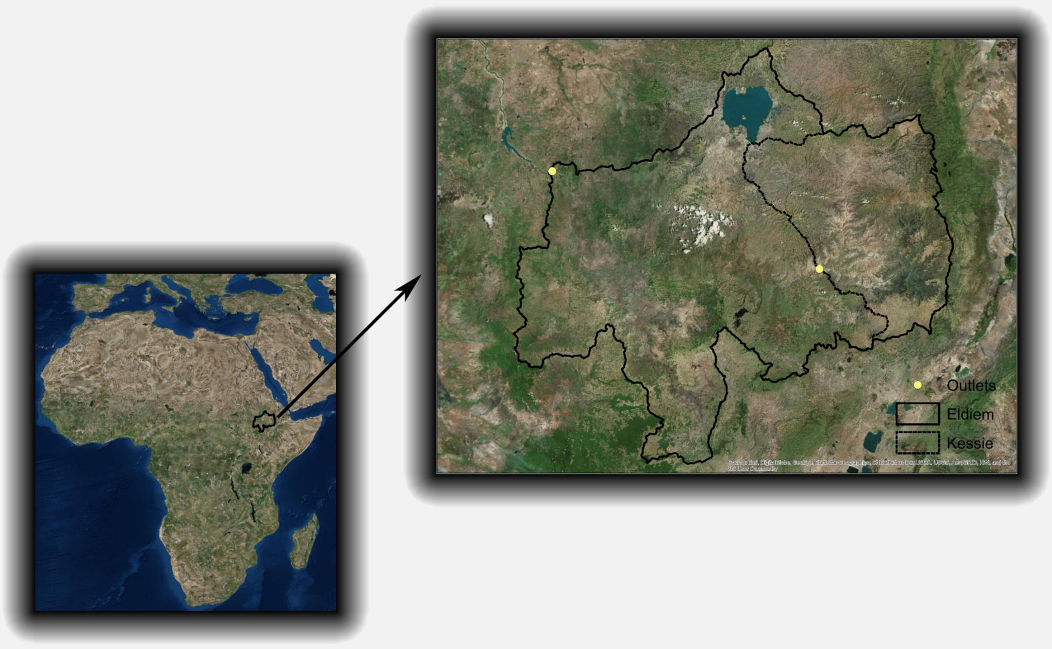
2.Methodology

- Evaluation was carried out at two basin scales, Upper Blue Nile at Eldiem (177642.9 km²) and Kessie (50418.08 km²), at monthly and annual temporal scales.
- Precipitation, evapotranspiration (ET), and streamflow were evaluated against the Ethiopian National Meteorological Agency (NMA) dekadal rainfall, remote sensing derived actual ET (Zhang et al 2016) and in-situ streamflow observations, respectively.
- For the water budget analysis 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.

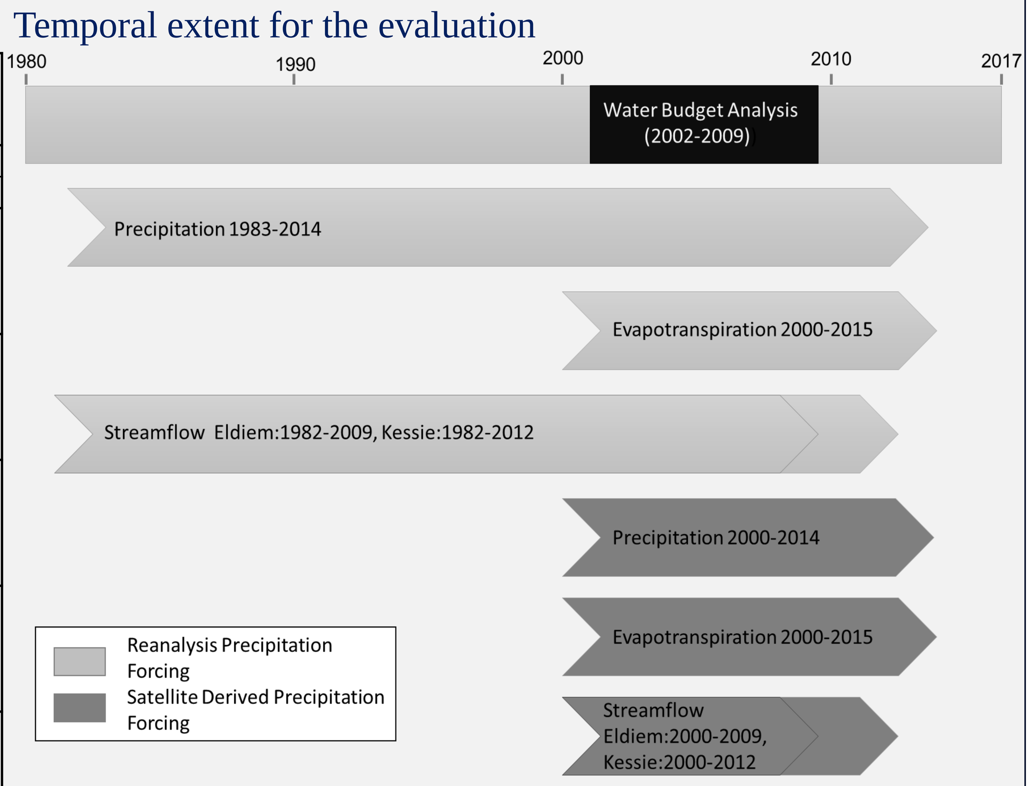
Study Area



WRR products under consideration

WRR Models	Model	Precipitation Forcing	Model Spatial Resolution
FLDAS	Noah 3.3	MERRA-2	0.1°
	VIC	MERRA-2	0.25°
Earth2Observe	HTESSEL-CaMa	ERA-Interim/RGPCC	0.25°
		TRMM	
		GSMAP	
		CMORPH	
	SURFEX-TRIP	ERA-Interim/RGPCC	0.25°
		TRMM	
		GSMAP	
		CMORPH	
	Jules	ERA-Interim/RGPCC	0.25°
		TRMM	
		GSMAP	
		CMORPH	
	LISFLOOD	ERA-Interim/RGPCC	0.25°
		TRMM	
		GSMAP	
		CMORPH	
	WaterGAP3	ERA-Interim/RGPCC	0.25°
		TRMM	
		GSMAP	
		CMORPH	
	ORCHIDEE	ERA-Interim/RGPCC	0.25°

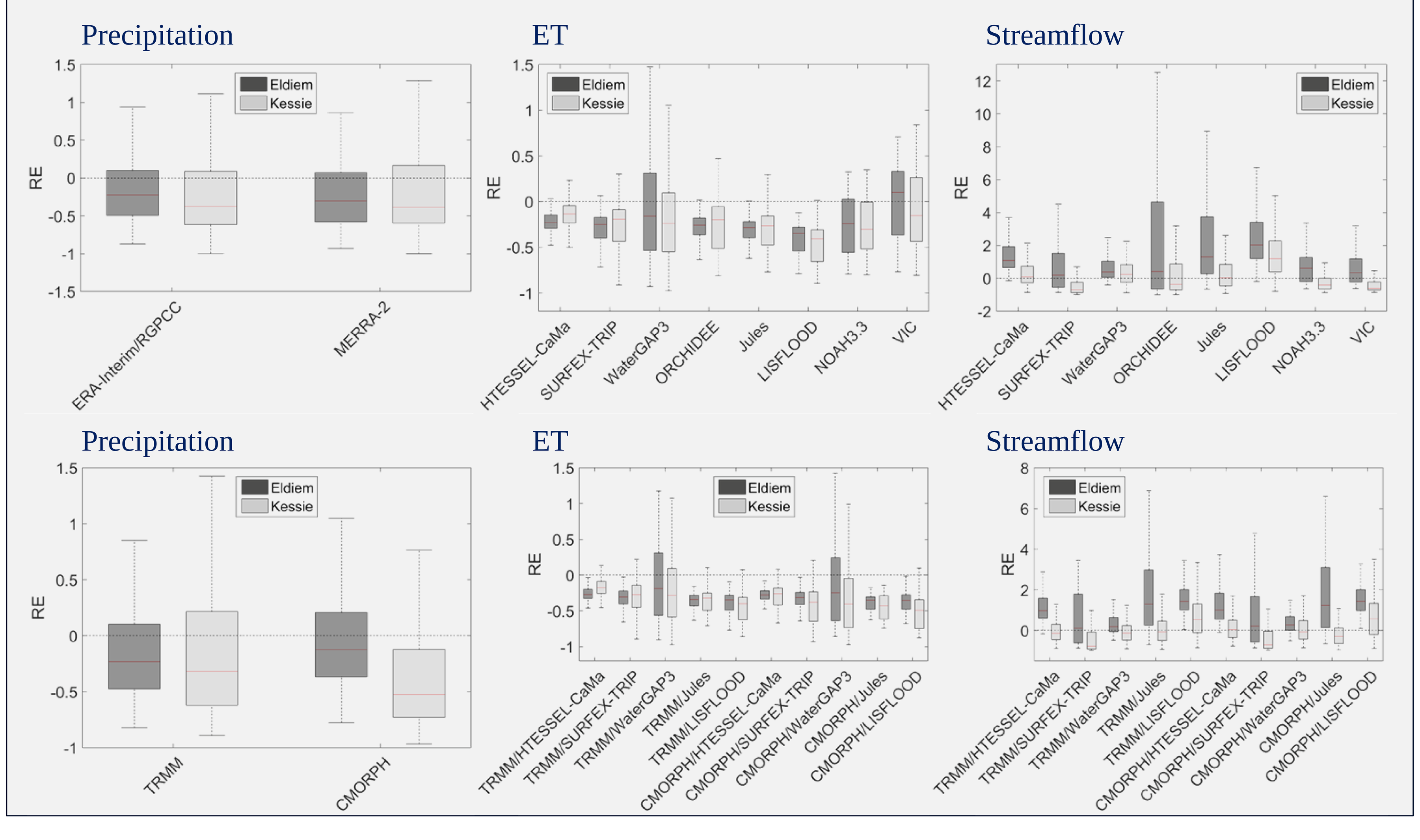
Temporal extent for the evaluation



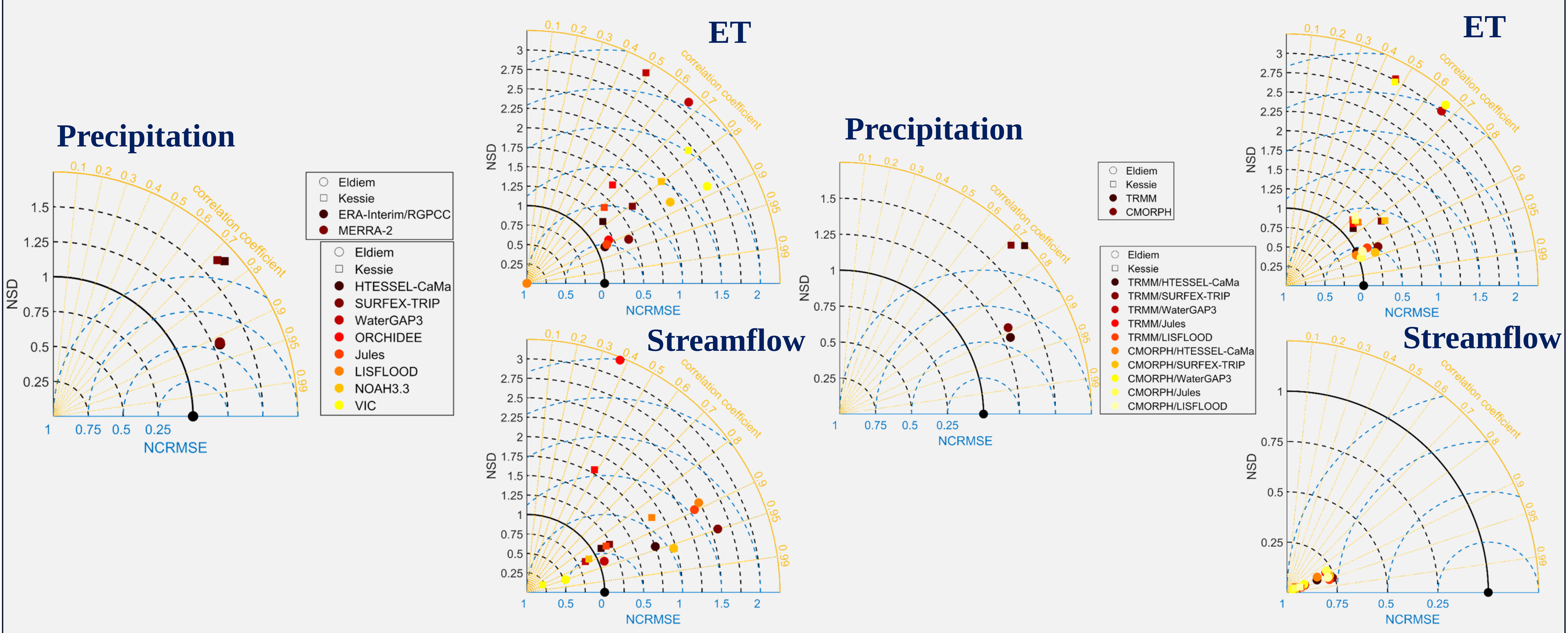
The performance of the WRR products is assessed using relative error (RE) calculated as $RE = \frac{SIM - OBS}{OBS}$, and normalized Taylor diagram.

3.Results

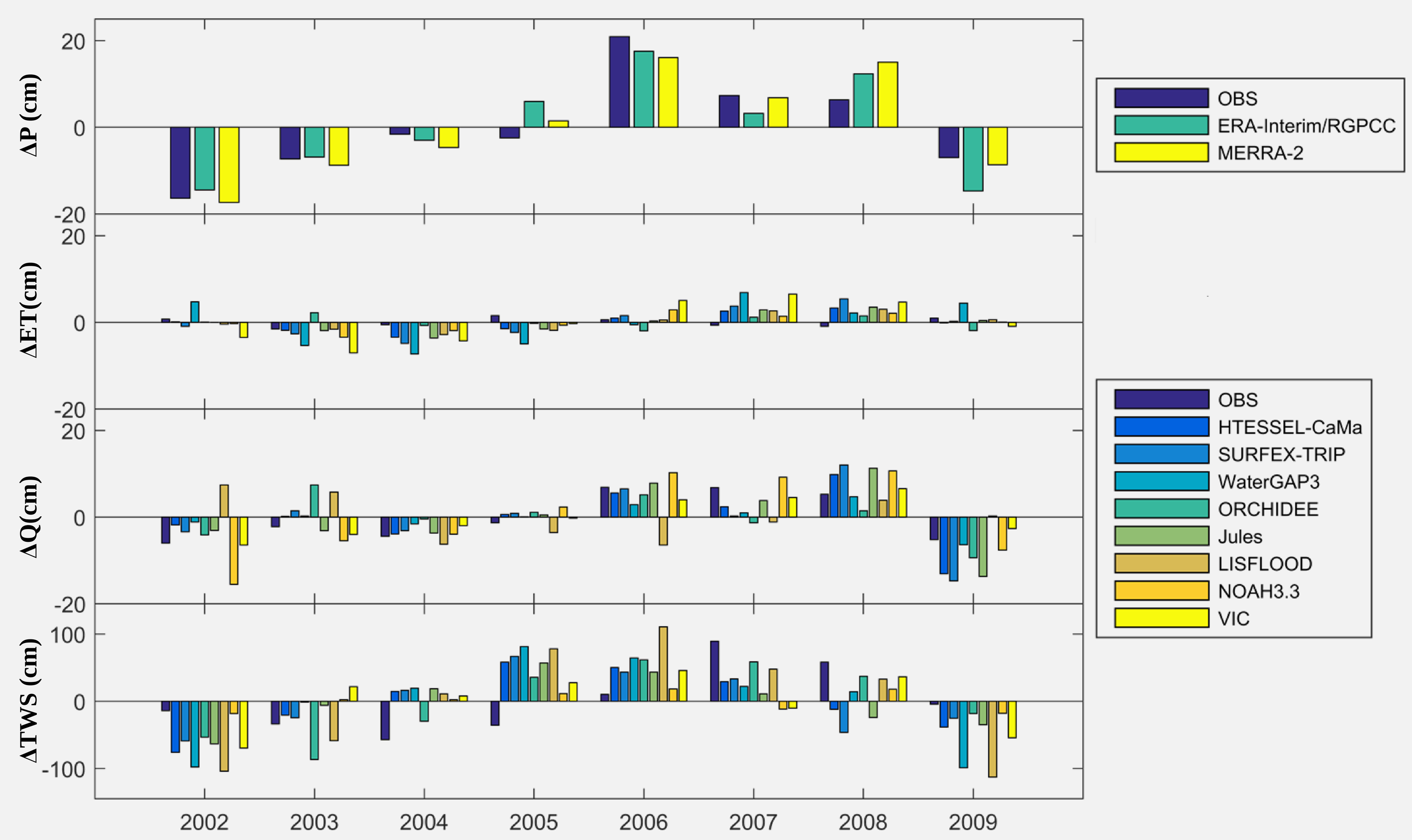
3.1 Relative Errors at Monthly Scale

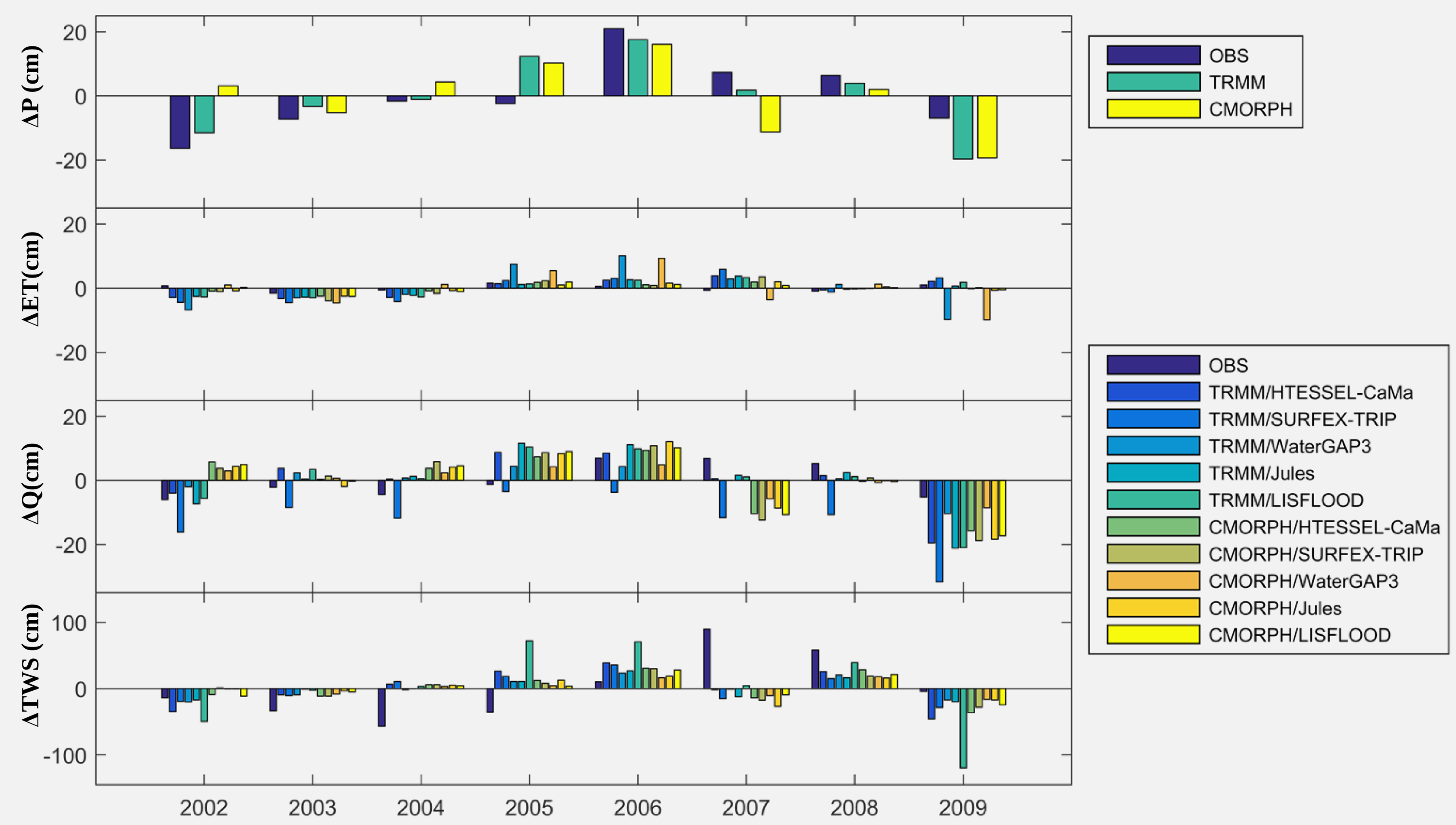


3.2 Statistical Evaluation at Monthly Scale



3.3 Water Budget Analysis





4.Conclusions

- Given the close agreement of the precipitation forcing, variations in ET and streamflow parameter across the different WRR products is attributed to differences in the LSM schemes of the various models.
- WaterGAP3 and VIC exhibited the best representation of the observed streamflow over the Upper Blue Nile.
- Water budget analysis showed strong variability of ΔTWS derived from the different WRR products, but agreement in terms of the sign.
- Precipitation seem to be the most important component in the water budget analysis for the WRR producs. Relatively high mean annual precipitation results into positive ΔTWS and vice versa.

Acknowledgements : This research was supported by the FP7 project eartH2Observe and PIRE- Water and Food Security Project.

References: Sutcliffe J, Parks Y.,1999. The Hydrology of the Nile. Technical Report International Association of Hydrological Sciences Oxfordshire, UK. Special Publication No. 5.

Zhang, K., J.S. Kimball and S.W. Running, 2015. A review of remote sensing based actual evapotranspiration estimation, WIREs WATER, 3, 834-853, doi: 10.1002/wat2.1168.