Supplementary Material

Improved Process Representation in the Simulation of the Hydrology of a Meso-Scale Semi-Arid Catchment

S1. Model Input

Precipitation

The station data from several sources was assessed for completeness and consistency. SAWS, Lynch database, SASRI, ICMA and DWA data were checked. SAWS was found more consistent and used. SASRI data was used to complement - especially where gaps existed on SAWS records. Linear regression was used to infill stations with the most correlated neighbouring station data.

We also looked at remote sensing data for rainfall. CHIRPS, CMORPH and TRMM daily data was obtained. The data was aggregated to monthly and annual totals for comparison with station data and Mean Annual Precipitation map. Due to coarse resolution of the CMORPH and TRMM only the CHIRPS dataset was for model input.

Evaporation

We looked at evaporation data from the ground weather stations of SASRI. We also looked at the remote sensing products ALEXI, CMRSET and SSEBop. These products had different temporal and spatial resolutions. Table 1 shows an overview of remote sensing products analysed.

Table S1. Overview of Remote sensing products used.

	Product	Spatial resolution	Temporal resolution	Period covered	Source/Literature
Precipitation	CHIRPS	0.05x0.05 degrees	Daily	2000/01/01 – 2013/12/31	[1]
	CMORPH	0.25x0.25 degrees	Daily	2000/01/01 – 2013/12/32	
	TRMM	0.25x0.25 degrees	Daily	2000/01/01 – 2013/12/33	
Evaporation	ALEXI	0.05x0.05 degrees	Weekly	2003/01/01 – 2013/12/24	[2];[3]
	CMRSET	0.05x0.05 degrees	Monthly	2000/01/01 – 2012/12/01	[4]
	SSEBop	0.0083x0.0083 degrees (90x90m)	Monthly	2003/01/01 – 2013/12/01	[5];[6]

Soil data

Different sources of soil data are available for modelling in South Africa, and Southern Africa. Paterson, et al. [7] provides a comprehensive review of history and development of soil information in South Africa. An overview of different soil data and soil derived parameter sources are listed on Table 2.

Table S2. Soil data sources and products available.

Database	Source	Scale	Grid/polygon	Coverage	Reference
Land types of South Africa	ARC-ISCW, AGIS	1:250 000	Polygons	National (SA)	[8]
Harmonized World Soil Database	FAO	1:5 000 000	30 arc-second	World	[9]

Atlas ACRU (derived from Land types)	Atlas	1:250 000	Polygons	National (SA)	[10]
SOTERSAF	ISRIC	1:1 000 000	Polygons	Southern Africa	[11]
Soil Grids 1km	ISRIC	1:1 000 000	1km grid	World	[12]
Soil Grids 250m	AfSIS/ISRIC	1:250 000	250m grid	Africa	[13]

ARC-ISCW – Agricultural Research Council - Institute for Soil, Climate and Water
AGIS – Agricultural Geo-referenced Information System
FAO – Food and Agriculture Organization
ISRIC – World Soil Information.

Land type survey of South Africa [8] is the most commonly used in South Africa. It divides South Africa into a number of unique mapping units, or land types, each with a unique combination of soil pattern, macroclimate and terrain form. The extensive survey was conducted at 1:250,000 scale. However, the derivation of hydrological parameters from the database is not straightforward, and different hydrological models have used different approaches.

The South African atlas of climatology and agro-hydrology [10] database contains soil data derived from the land types of South Africa [8]. Schulze [14] and Schulze, et al. [10] derived relevant hydrological parameters from the soil data using AUTOSOILS decision support tool [15].

The PITMAN model made a simplification of the land types using their lithology and soil texture, and has also derived typical hydrological parameters from the same database.

The soil and terrain database for South Africa (SOTERSAF) was also derived from the land types using SOTER methodology [11], in order to harmonize it to the rest of Southern Africa and with world standards. This database was compiled by ISRIC - World Soil Information under the framework of the Land Degradation Assessment in Drylands (LADA, GLADA) program. The initial dataset was compiled by the Institute of Soil, Climate and Water (ISCW), Pretoria, at scale 1:1,000,000, which means some details and information, was aggregated.

The Soil Grids initiative [12], also lead by ISRIC, aims at further standardizing soil data and soil derived parameters, for application in agricultural and hydrological models and products. Initially, the Soil Grids 1km was developed, and now more refined Soil Grids 250m [13,16] is also available.

In this research we tested the different sources of soil data in a hydrological model, to see whether recent developments in the provision of soil data, particularly the Soil Grids 250m dataset (Figure 2 and Table 1), improve hydrological simulations. This is particularly relevant for trans-boundary river basins, such as the Incomati River basin, given that the available soil data is derived from three different countries databases, which are not harmonized. Therefore, Soil Grids could provide a consistent input data set to model the entire trans-boundary basin.

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S2. Results of the Selected Four Stream Model Runs

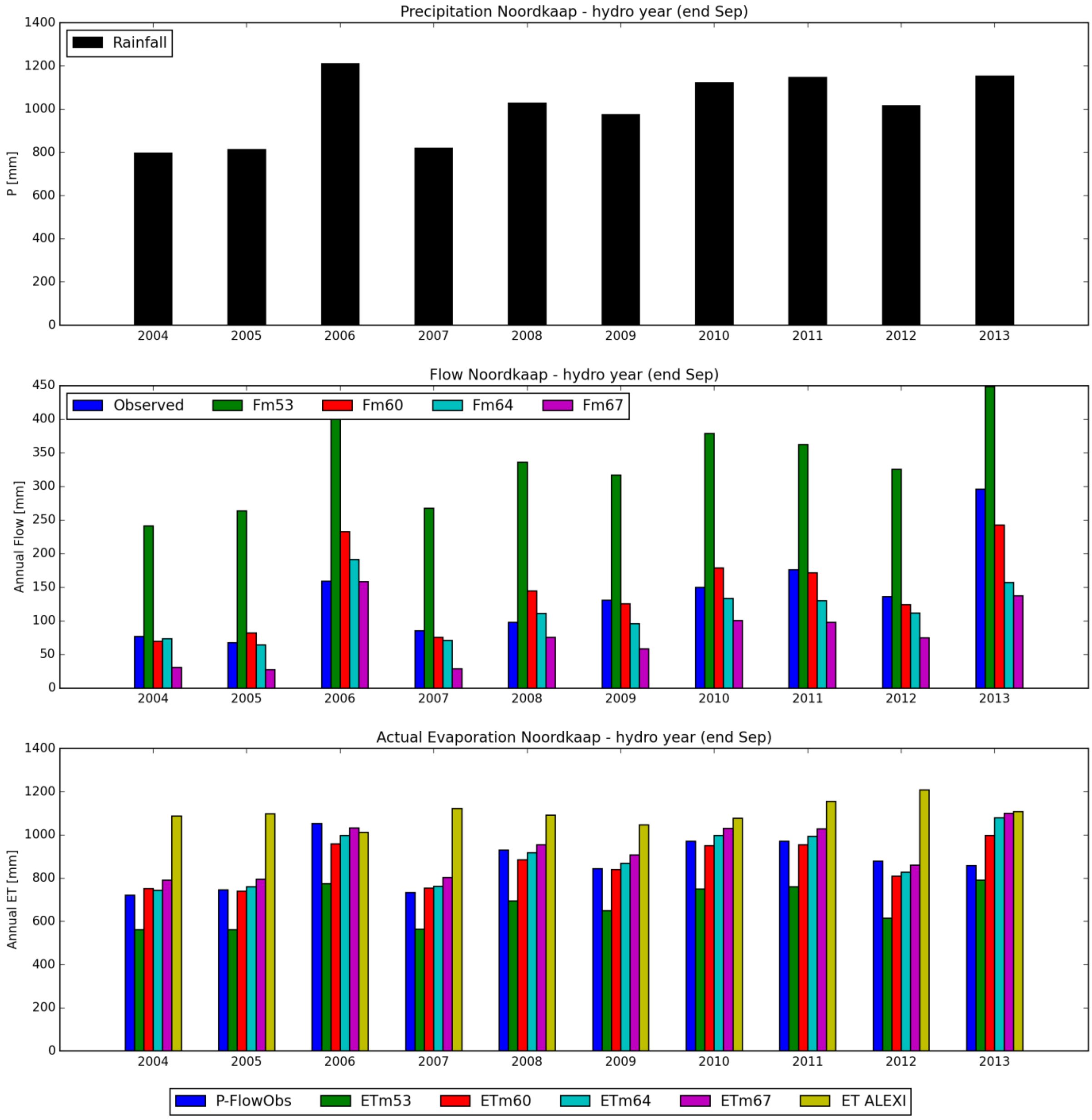


Figure S1. Annual Water Balance of the Noordkaap catchment. The subscripts of flow and evaporation refer to model simulations presented in the main text.

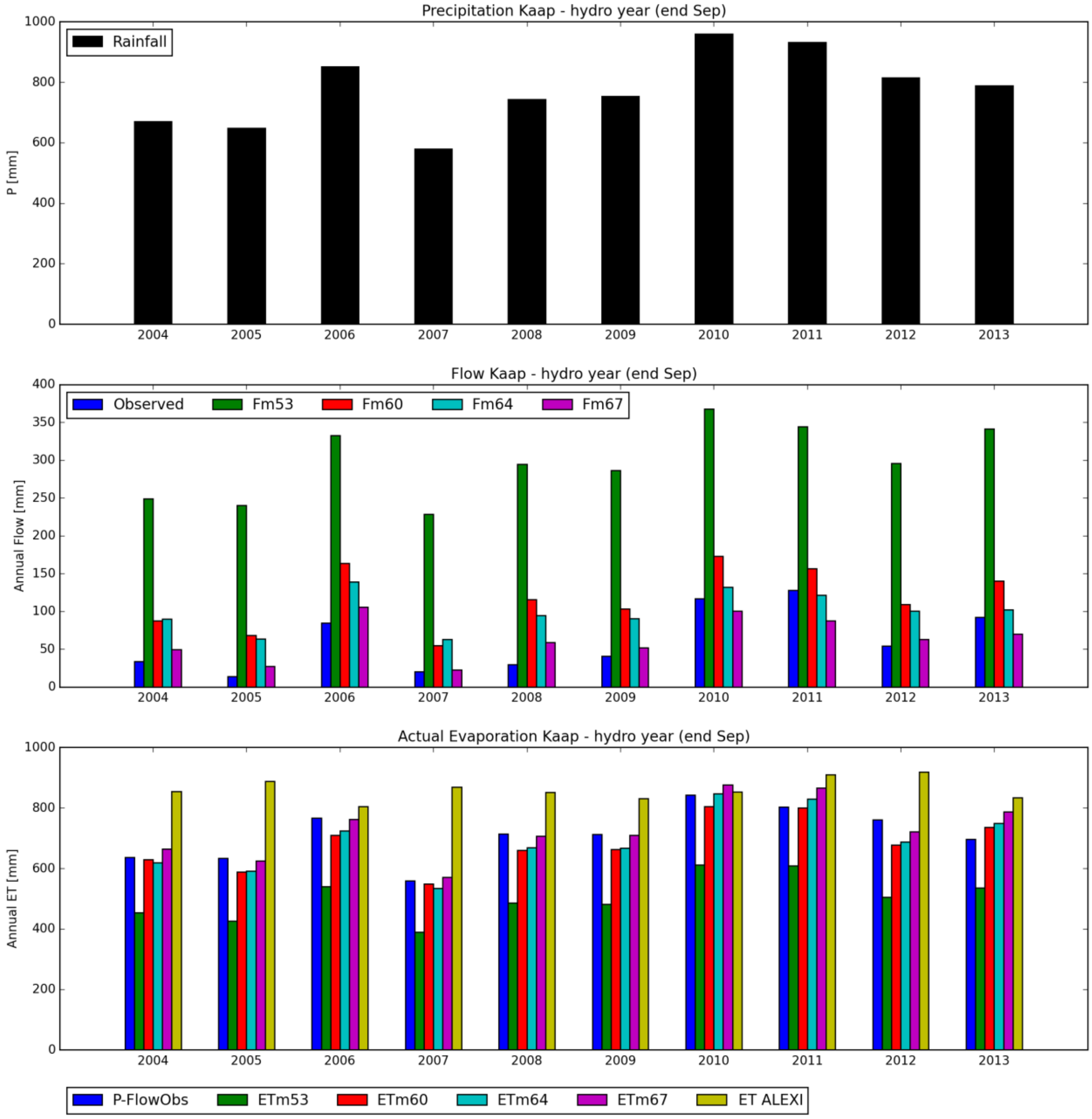
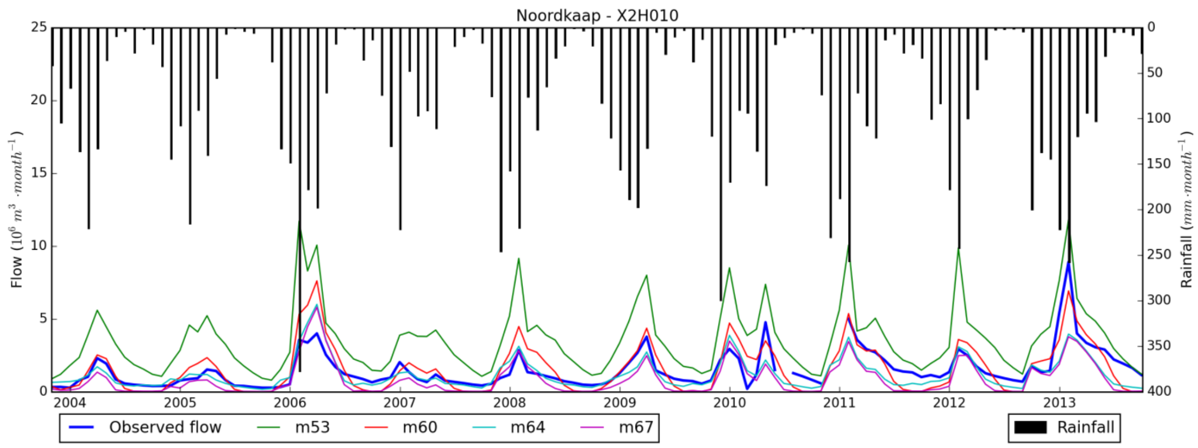


Figure S2. Water balance for the Kaap catchment.



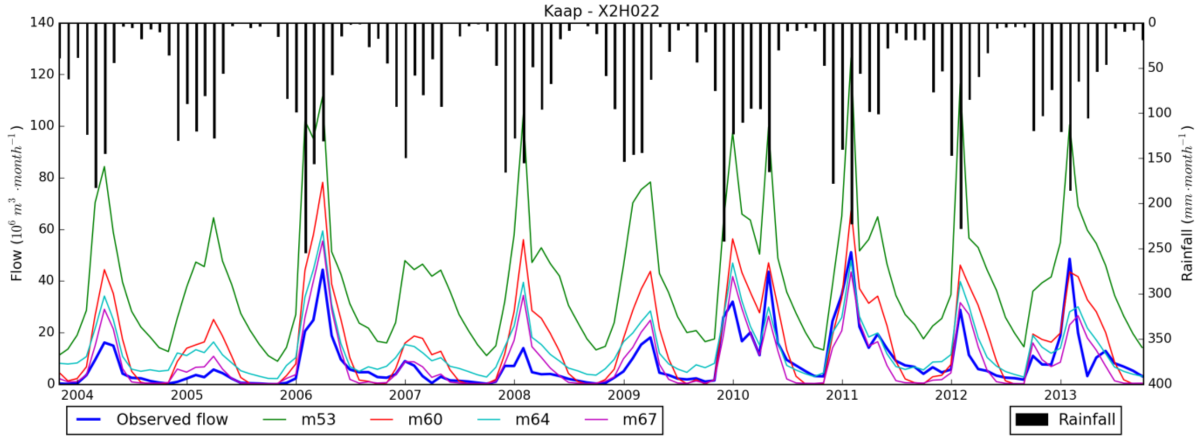


Figure S3. Hydrographs for the Noordkaap (top) and Kaap (bottom) catchments.

S3. Comparison of STREAM and HBV results

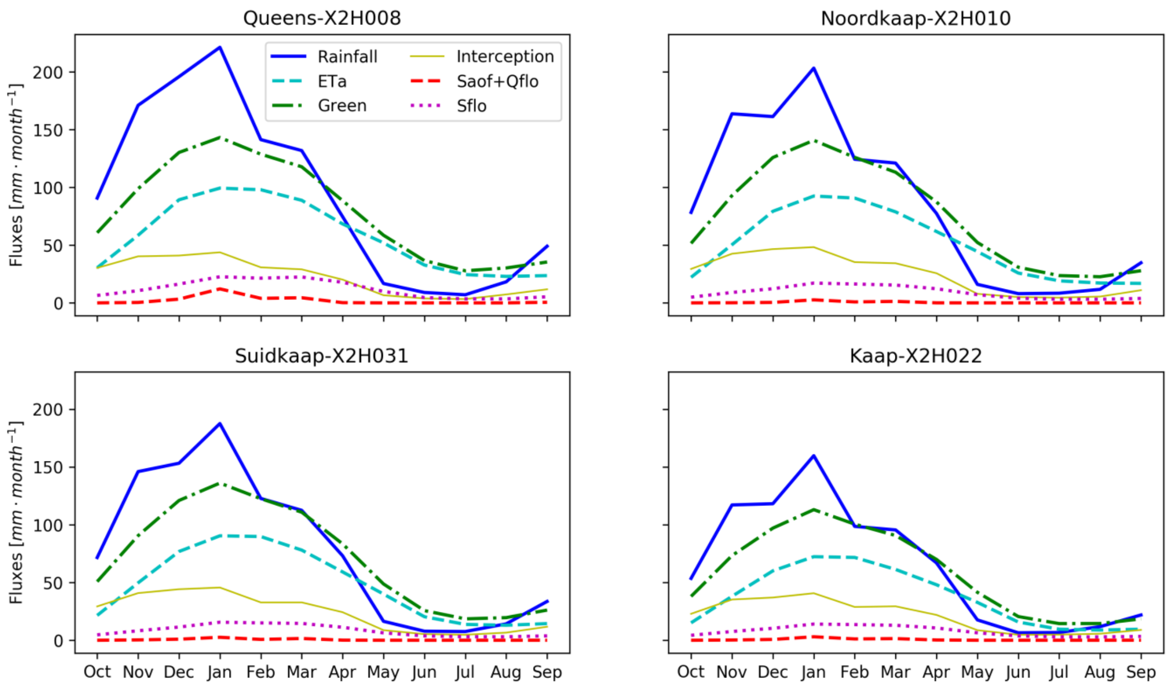


Figure S4. Mean monthly water balance and flow components for the four catchments, using results of run 64. Eta is actual evaporation, Green is the total evaporation (including interception), Saof is saturated overland flow, Qflo is quickflow component and Sflo is the slow flow (or baseflow) component.

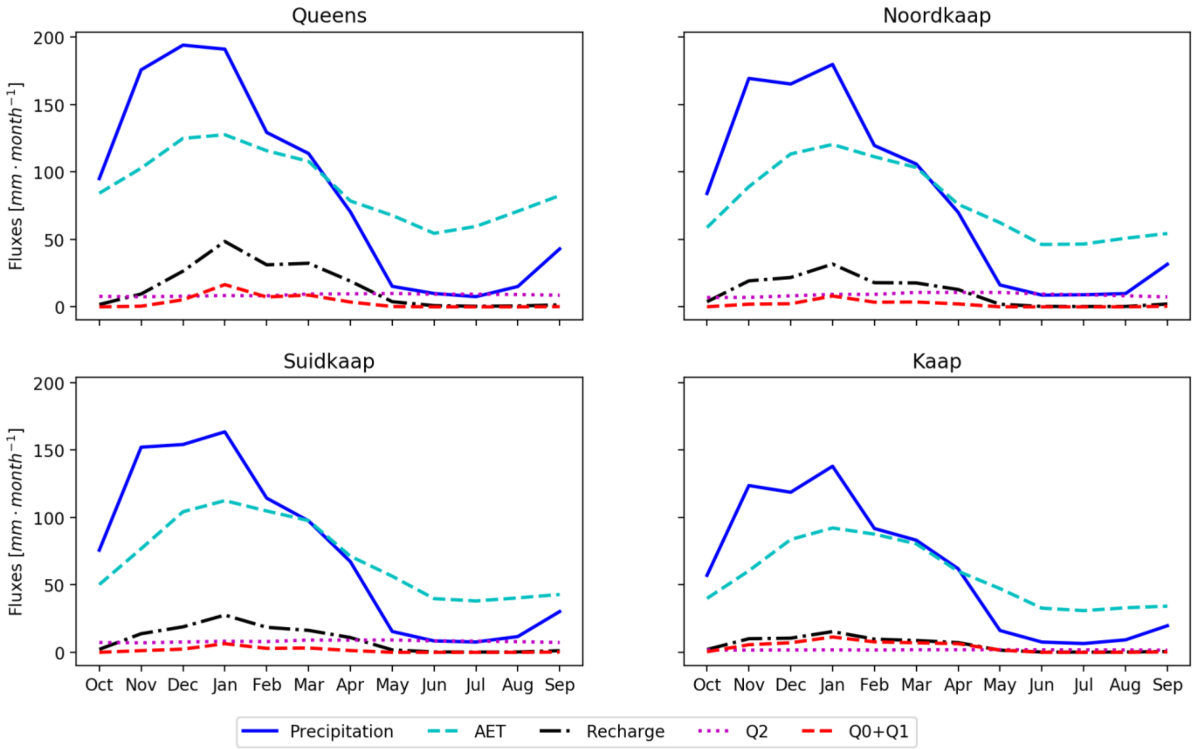


Figure S5. Average water balance of HBV model results. AET stands for actual evaporation and Q0, Q1 and Q2 are the flow components, fastest to slowest.

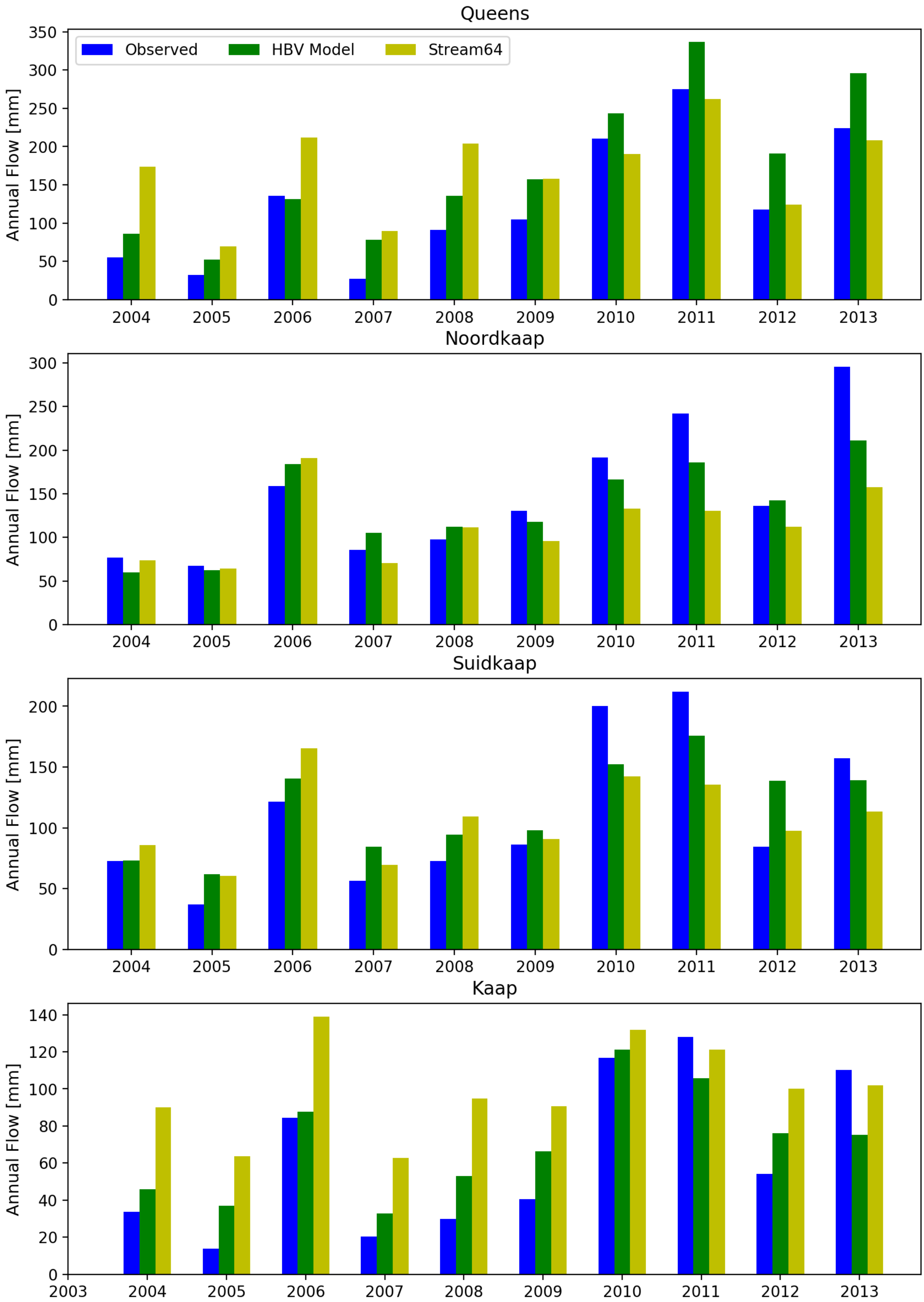


Figure S6. Comparison of annual flows observed and simulated by HBV and Stream (run64) models.

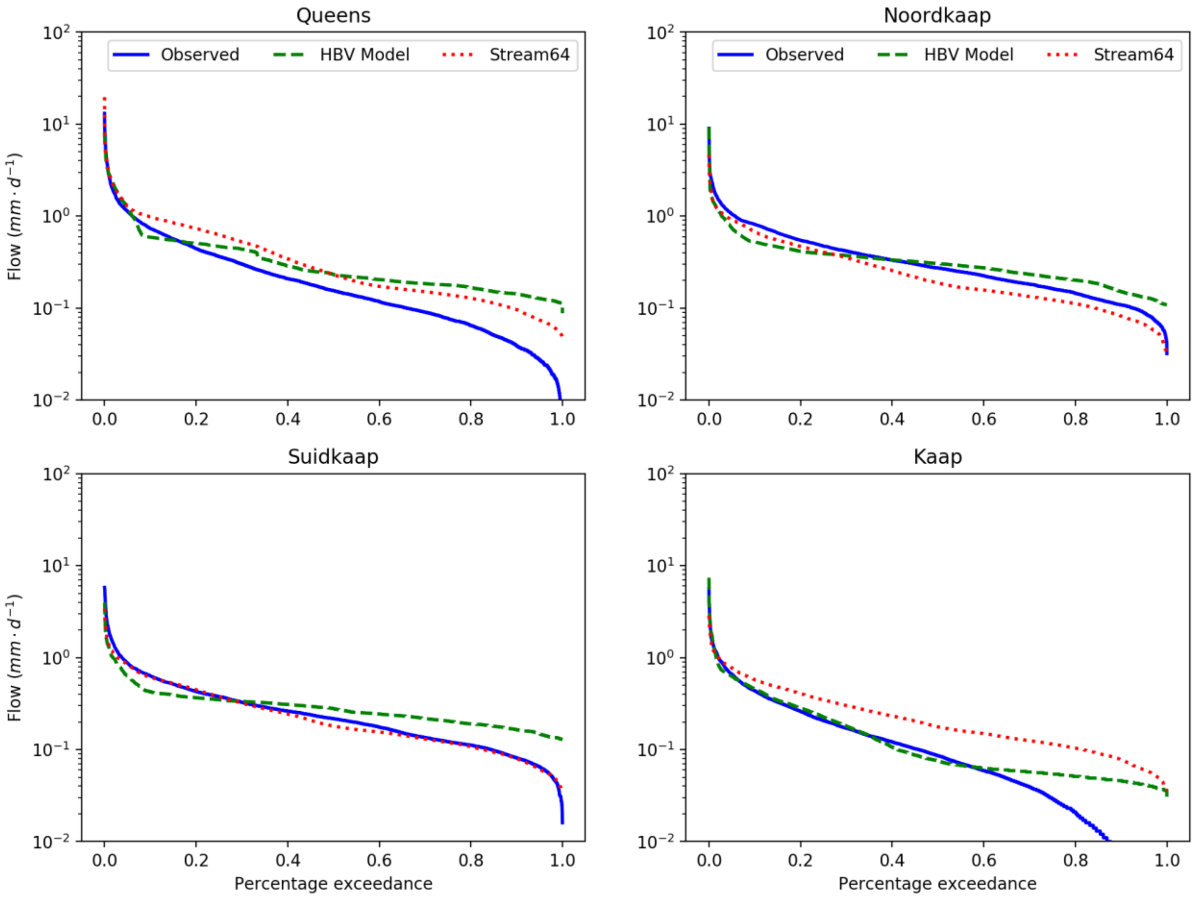


Figure S7. Comparison of FDCs from observed flow and HBV and Stream run 64 modelled flows.