Analysis of extreme hydrological events in the Uruguay River basin

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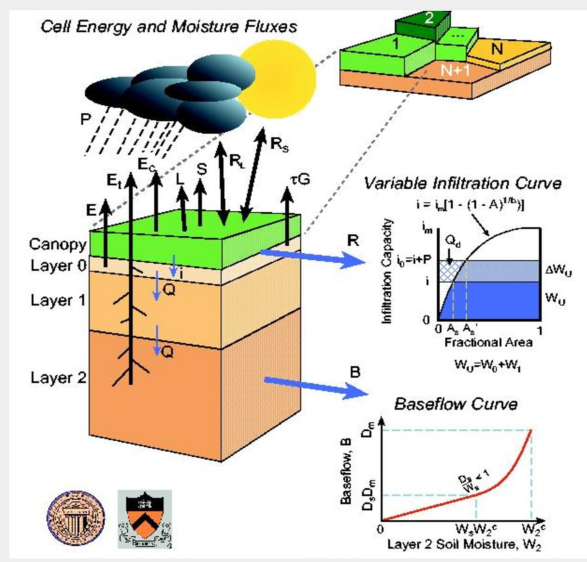
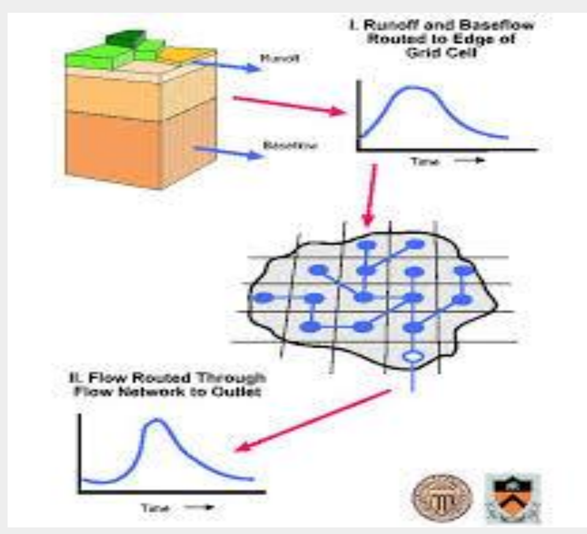
Motivation

During the periods October 2009-March 2010 and October 2015 - March 2016 several extreme precipitation events occurred in southeastern South America and impacted on the Uruguay River streamflow. Within the framework of the Flagship Pilot study in southeastern South America endorsed by CORDEX, statistical and dynamical simulations were performed for these particular periods. These extreme events are analyzed based on precipitation outputs from regional climate models (RCMs) and empirical statistical downscaling (ESD) in comparison to weather station observations within the Uruguay River basin. Model outputs and observations are also used to force the macroscale hydrological Variable Infiltration Capacity (VIC) model to study the impact on river flows.

Model overview

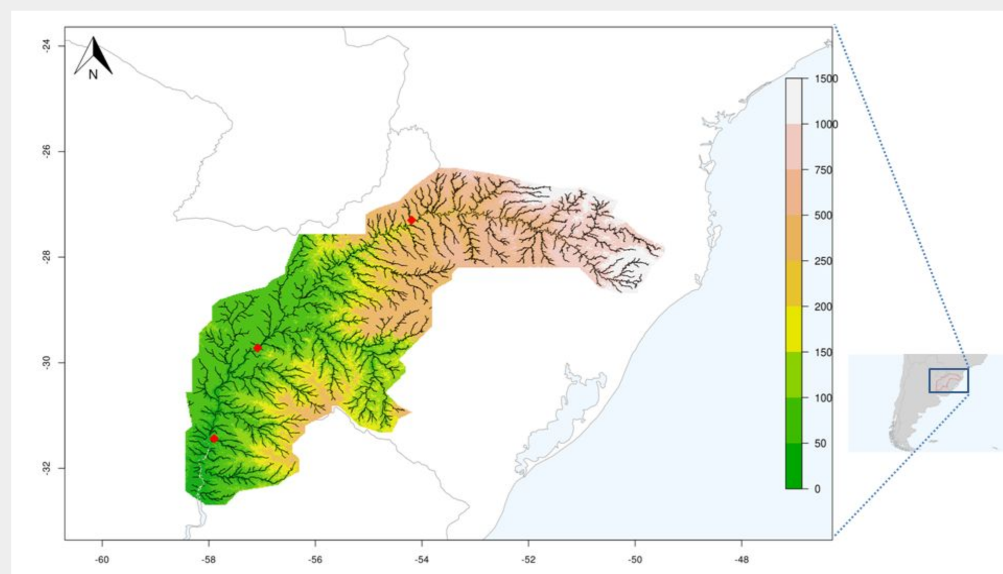
- Variable Infiltration Capacity (VIC, https://vic.readthedocs.io/en/master/), is a semi-distributed model developed at the University of Washington (Liang et al. 1994, 1996).
- 3 soil thicknesses: 10 cm (superficial), 30 cm and 100 cm (subsurface).
- Representation of different hydrological processes: interception of precipitation by vegetation, evapotranspiration, surface runoff and base flow.
- Sub-grid variability of characteristics such as vegetation type and soil moisture content.
- In a decoupled way, the VIC has a routing model based on linear transfer functions to simulate river flows (Lohmann et al., 1996, 1998; Gao et al., 2009).





Study region

- Uruguay River Basin, one of most important river of the region also with Parana and Paraguay River Basins.
- In confluence of Pelotas and Canoas Rivers.
- Length of 1800 km. Area of 365.000 km^2.
- Concordia average discharge 5299 m^3s^{-1} (period 1950-2017).



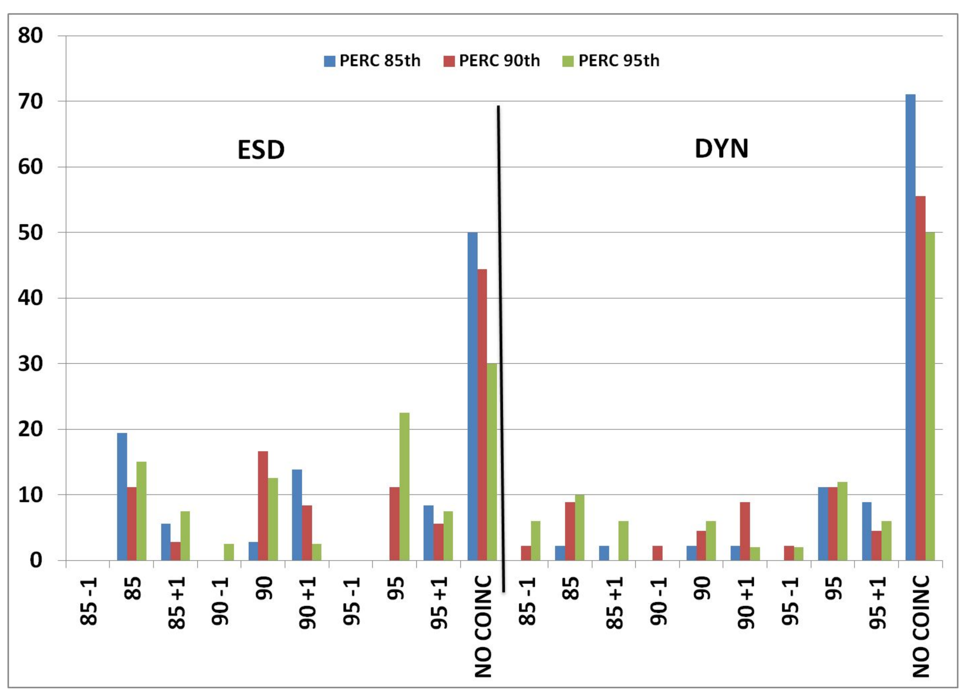
Results and Discussion

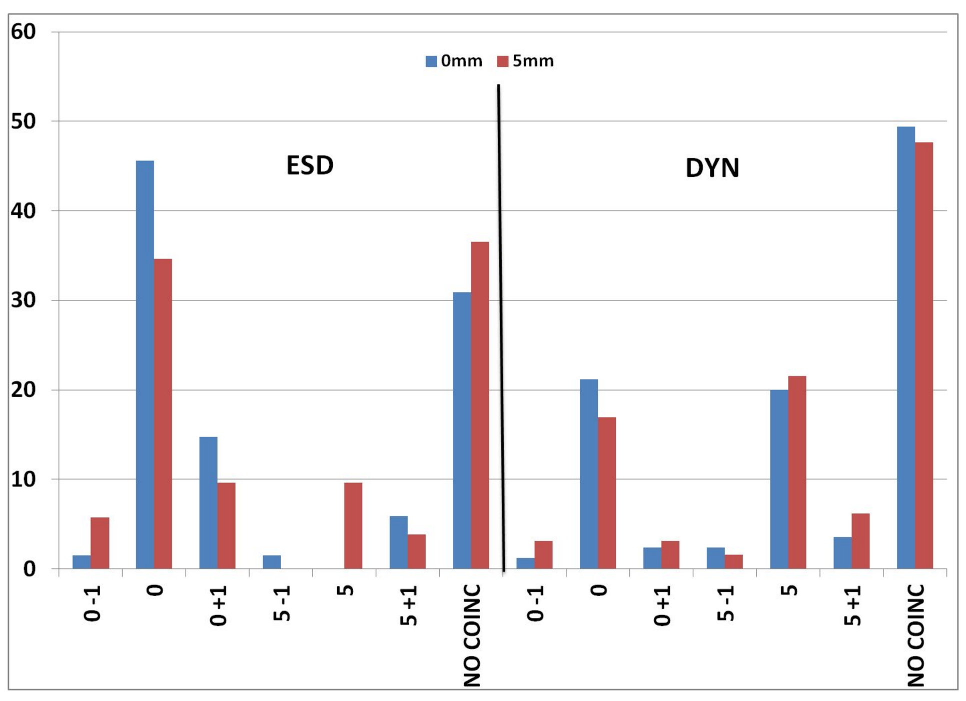
Correlations are significant between observation and model simulated streamflow though with considerable spread. The 85th, 90th and 95th percentiles are calculated to determine the wet events and the 5th, 10th and 15th percentiles for the extremely dry events for each of the models and the observed data. Results indicate differences between the percentile values from model outputs and observations, and also on the date associated with each of the selected events. There are less differences in the dates associated with the 95th percentile in wet extreme cases and in general the degree of coincidence is smaller with RCMs. Streamflow results for extremely high and low percentiles show smaller differences than precipitation.

PERCENTILES

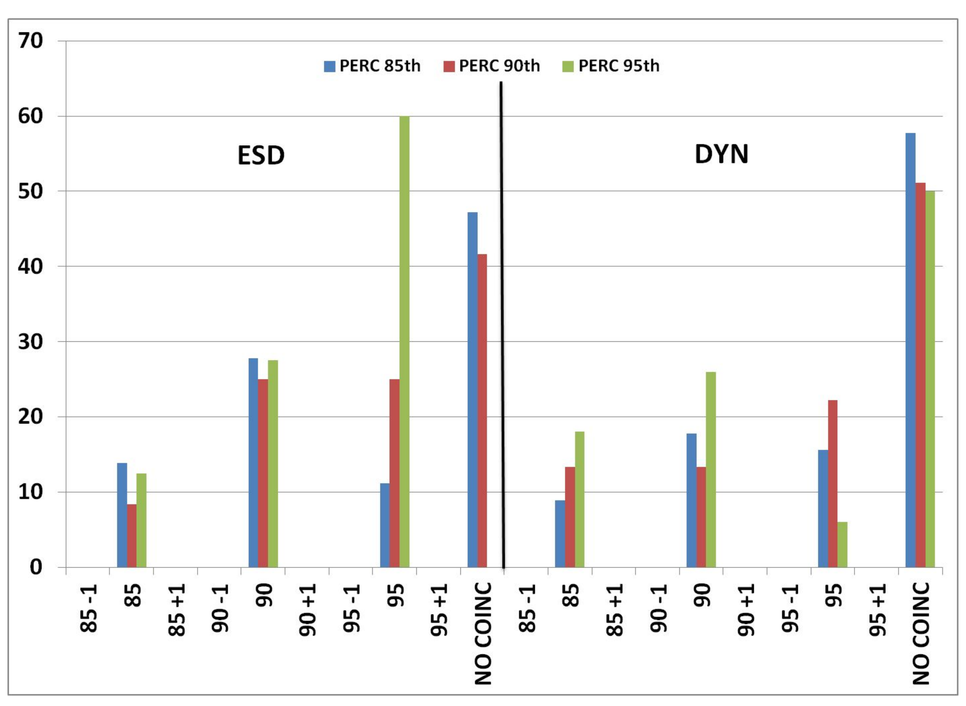
PRECIPITATION	85	90	95	5	10	15	20
AN_LS	7739.1	10435.4	13084.3	0	0	0	4.9
GLM_ST_PC	7623.3	10032.8	12628.7	0	0	1.0	23.2
GLM_WT_PC	9217.7	11663.5	15967.5	0	0	0	0
NN_L16_ST	7231.8	8993.7	12118.2	0	0	0	2.5
REGCM4-7	9221.4	12058.0	14797.1	0.2	4.2	17.0	63.0
REMO2015	7022.2	8601.6	13592.3	0.01	0.2	1.0	3.3
UCAN	4488.5	7464.0	16381.5	0	0	0	0
USP	10513.5	13304.5	21689.4	0	0.1	2.6	20.4
WRF-CIMA	5345.8	7645.5	13066.8	0	0	0	0
SMN	6617.3	10723.9	15586.2	0	0.01	2.5	28.2

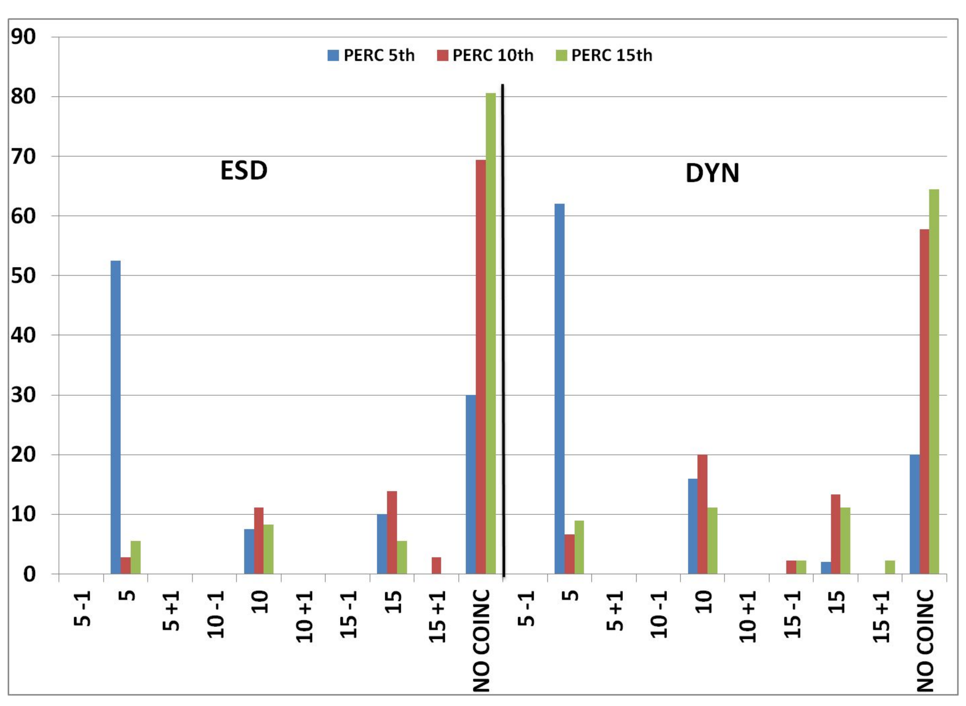
STREAMFLOW	85	90	95	5	10	15
AN_LS	10152.3	12062.0	14676.8	952.7	1411.8	1680.3
GLM_ST_PC	9276.5	10043.6	10553.0	915.0	1542.2	1709.4
GLM_WT_PC	15998.9	17577.4	22177.1	2707.5	2960.3	3387.1
NN_L16_ST	10599.3	12471.9	14972.7	1185.7	1685.7	2608.7
REGCM4-7	15236.5	17232.6	20850.6	843.7	1766.0	2386.0
REMO2015	12687.2	14785.6	15844.4	1798.3	2776.4	3616.7
UCAN	8397.6	17406.7	21987.9	39.7	80.8	165.3
USP	15827.1	16494.7	18029.4	2076.1	3885.9	5190.1
WRF-CIMA	16215.9	17874.6	20210.5	1234.4	2233.2	2854.8
SMN	10401.0	12551.5	16063.1	1679.2	2035.2	2369.4





PRECIPITATION





STREAMFLOW

Correlation between model and SMN simulated streamflow
Oct2009/Mar2010 *(Oct2015-Mar2016)*

	PELOTAS	CANOAS	IRAI	SOBERBIO	GARRU	PLIBRES	CONCOR
AN_LS	0.364* *(0.400*)*	0.066 *(0.496*)*	0.592* *(0.425*)*	0.684* *(0.285*)*	0.807* *(0.260*)*	0.852* *(0.537*)*	0.902* *(0.559*)*
GLM_ST	0.609* *(0.483*)*	0.565* *(0.403*)*	0.542* *(0.368*)*	0.403* *(0.464*)*	0.605* *(0.587*)*	0.679* *(0.692*)*	0.747* *(0.770*)*
GLM_WT	0.588* *(0.455*)*	0.775* (0.406*)	0.655* *(0.418*)*	0.494* *(0.389*)*	0.724* *(0.416*)*	0.713* *(0.605*)*	0.733* *(0.678*)*
NN_L16	0.083 *(0.550*)*	0.268* *(0.443*)*	0.389* *(0.468*)*	0.340* *(0.442*)*	0.575* *(0.533*)*	0.682* *(0.684*)*	0.772* *(0.738*)*
REGCM	0.490*	0.407*	0.532*	0.328*	0.338*	0.454*	0.547*
REMO	0.295* *(0.205*)*	0.080 *(0.341*)*	0.458* *(0.375*)*	0.436* *(0.397*)*	0.618* *(0.303*)*	0.744* *(0.289*)*	0.851* *(0.435*)*
UCAN	0.451*	0.542*	0.264*	0.225*	0.019	0.048	-0.164
USP	0.564*	0.537*	0.358*	0.440*	0.412*	0.727*	0.689*
CIMA	0.323* *(0.530*)*	0.489* *(0.432*)*	0.511* *(0.424*)*	0.451* *(0.490*)*	0.564* *(0.658*)*	0.562* *(0.688*)*	0.607* *(0.772*)*

PRECIPITATION ESD and DYN (2009-2010)