7th ICWRER

June 5-9, 2016 Kyoto, Japan

Climatic and Physical Controls on the Hydrologic Regime of Southern Brazil: the 1975-2010 Period

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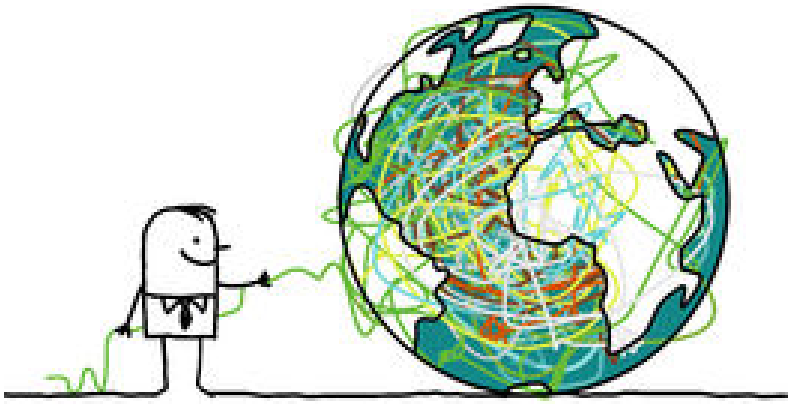
FUTURE HYDROLOGIC REGIME

- Depends on how the **climate** determines the streamflow;
- …how the **landscape** influences the **paths and storage** of water (topography, geology, soils, land use etc);
- …how **humans** interact with changes.

What deems a catchment more or less sensitive to climate change??

FUTURE HYDROLOGIC REGIME

How can we disentangle Climatic and Physical Signatures in catchment hydrology?



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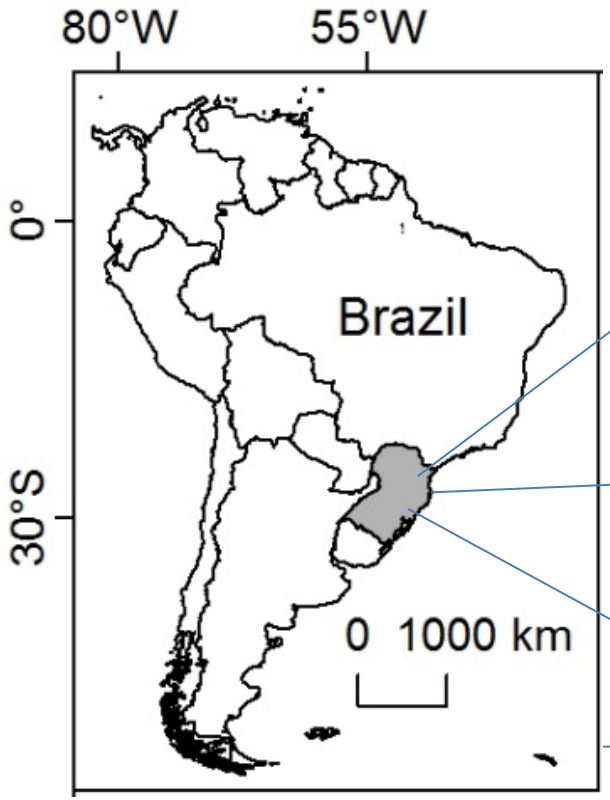
OBJECTIVES

- The objective of this study was to analyze **climatic** and **physical controls** on the **hydrologic regime** of Southern Brazil



Curitiba-PR

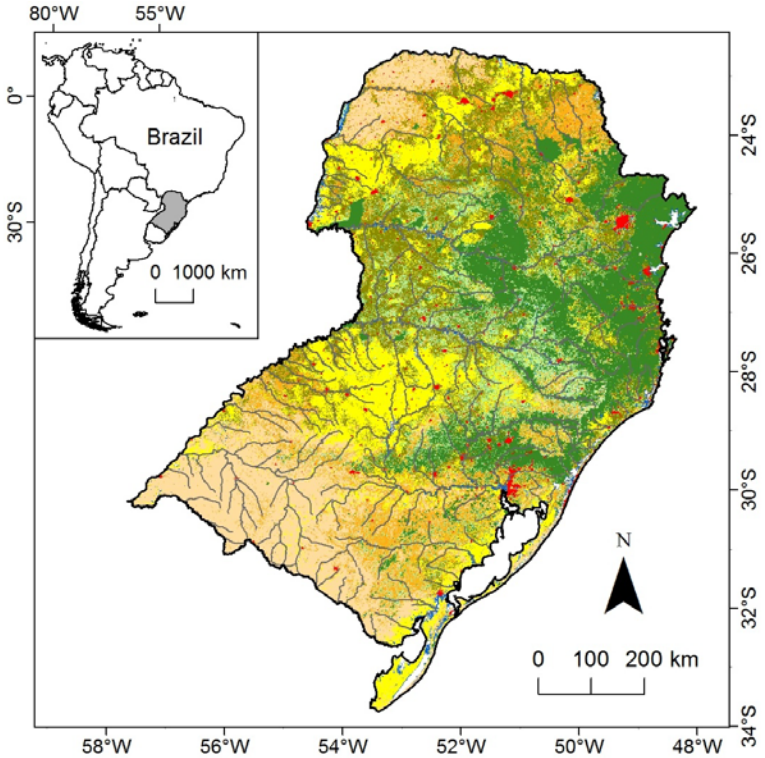
Florianopolis-SC

Porto Alegre-RS

Data and Methods

STUDY AREA

- Southern Brazil is about 1.5 times the area of Japan (~567000 km^2)
- Mostly Cropland and Atlantic Forest



Land cover type	% of total area
Evergreen Broadleaf Forest	19.8
Grassland	18.4
Croplands	17.5
Cropland/Natural Veg. Mosaic	17.0
Savannas	11.7
Woody Savannas	10.3
Urban	1.7
Permanent Wetland	1.7

*Data source: Broxton, P.D., Zeng, X., Sulla-Menashe, D., Troch, P.A., 2014a: A Global Land Cover Climatology Using MODIS Data. J. Appl. Meteor. Climatol., 53, 1593-1605. doi: http://dx.doi.org/10.1175/JAMC-D-13-0270.1

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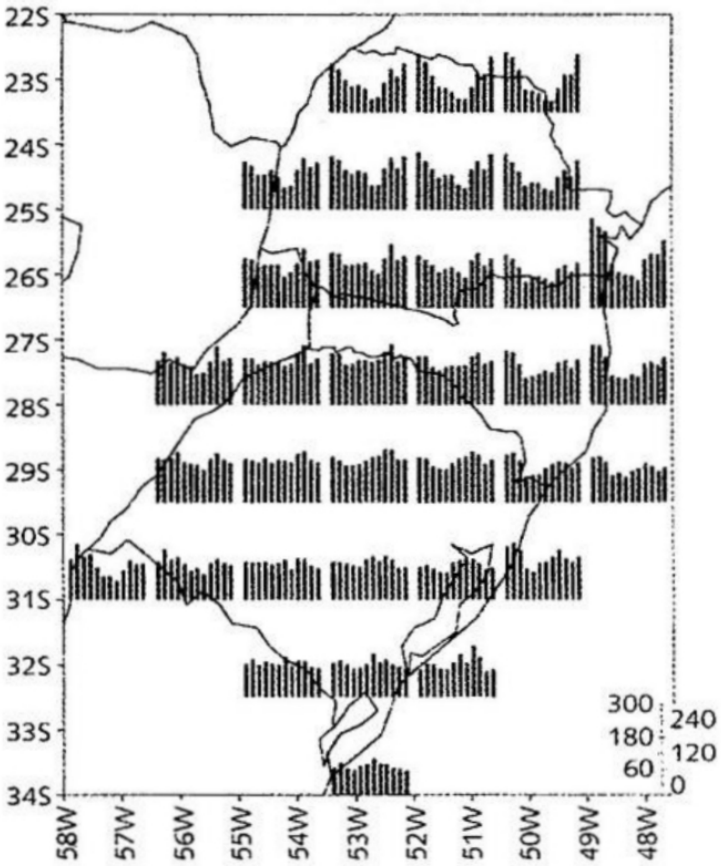
STUDY AREA

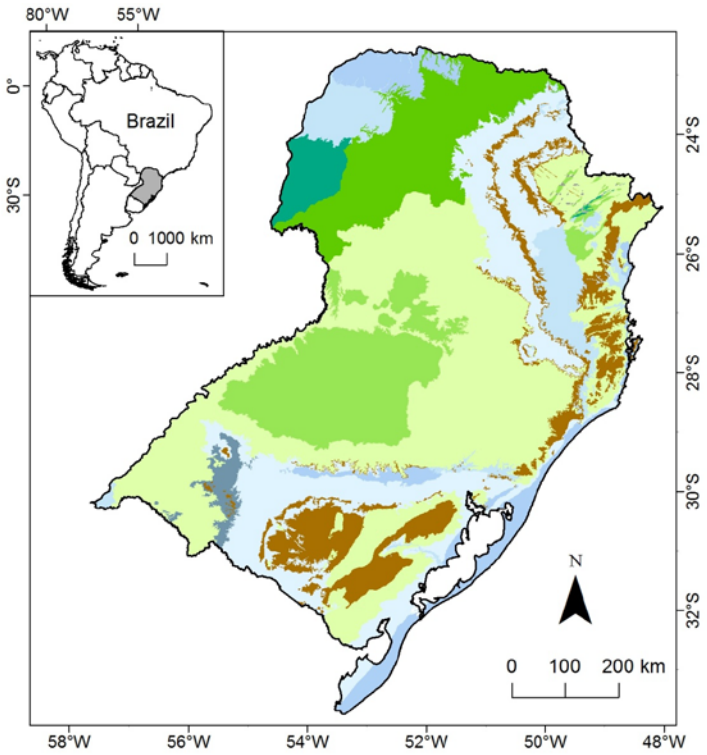
- Subtropical Cfa and Cfb
- Precipitation varies from 1200mm to 1900mm



Data source: Grimm, A.M. (2003), *The El Niño Impact on the Summer Monsoon in Brazil: Regional Processes versus Remote Influences, J. Climate, 16, 263-280.*

STUDY AREA

- Mostly Mesozoic Basalt (400m thick/green areas)
- Sedimentary – Shale and Sandstone (100-500m thick / blue areas)

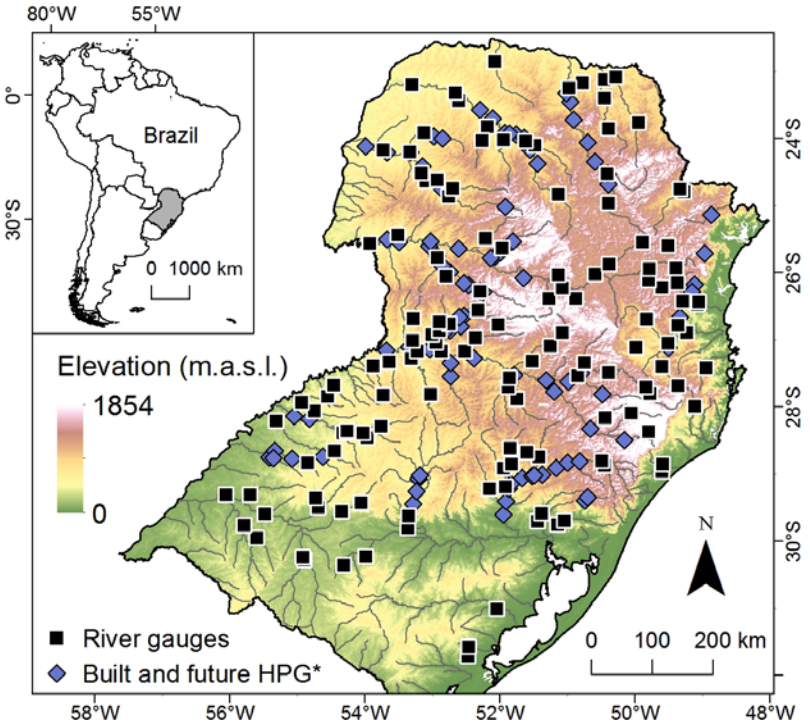


Sedimentary	Fractured	Hydraulic Conductivity (m/s)
		$\geq 10^{-4}$
		$10^{-5} \leq T < 10^{-4}$
		$10^{-6} \leq T < 10^{-5}$
		$10^{-7} \leq T < 10^{-6}$
		$10^{-8} \leq T < 10^{-7}$
		$< 10^{-8}$

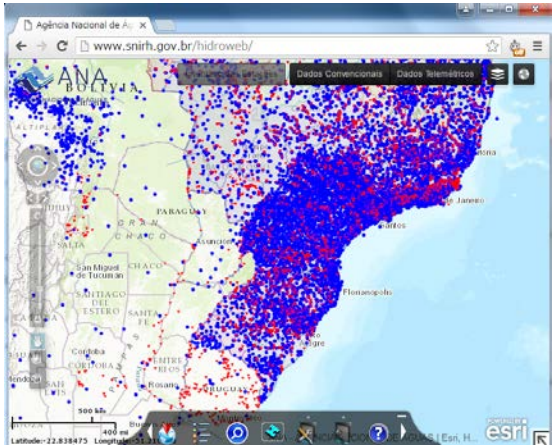
Diniz , J.A.O., Monteiro, A.B., Silva, R.C. and Paula, T.L.F. (2014), *Hydrogeologic Map of Brazil, 1:1 Million scale: Technical Note (in Portuguese), CPRM, Recife.*

PRECIP & DISCHARGE DATA

- Precipitation from 745 rain gauges
- Discharge for 138 catchments



http://www.snirh.gov.br/hidroweb/



CLIMATIC AND HYDROMETRIC INDICES

- Mann-Kendall trend analysis
- Precipitation; Flow Duration Curves; Topography

Signature	Name	Description [units]	Min. value	Max. value
Q_{MEAN}	Mean flow	Mean flow for the analysis [mm year^{-1}]	443.45	2546.6
Q_1, Q_5, Q_{95}, Q_{99}	Flow percentiles of the normalized FDC	High and low-flow exceedance of the FDC normalized by mean streamflow [-]	2.72; 1.79; 0.01; 0.01	13.45; 4.61; 0.52; 0.42
CVQ_1, CVQ_5, CVQ_{95}, CVQ_{99}	CV of flow percentiles	Coefficient of variation of inter annual values of flow percentiles [%]	15.0; 12.6; 8.99; 9.56	71.73; 32.32; 24.21; 140.9
S_{FDC}	Slope of the normalized FDC	Slope between the 33 and 66% exceedance values of the FDC normalized by mean annual streamflow (Yadav *et al*, 2007) [-]	0.95	4.62
CVQ_M	CV of mean monthly flow	Coefficient of variation of mean monthly flow for the analysis period [%]	7.82	48.3
P_{MEAN}	Mean precipitation	Mean precipitation for the analysis period [mm year^{-1}]	1418.2	2025.8
P_{INT}	Precipitation intensity of wet days	Mean precipitation intensity of days when rainfall rate $\geq$ 1 mm [mm year^{-1}]	13.4	22.16
N_{DD}	Number of dry days	Average number of days per year when rainfall rate < 1 mm [days year^{-1}]	206.23	293.38
CVP_M	CV of mean monthly precipitation	Coefficient of variation of mean monthly precipitation for the analysis period [%]	10.13	38.59
R_{QP}	Total runoff ratio	Total runoff divided by total precipitation[-]	0.31	1.37
E_{QP}	Precipitation elasticity of streamflow	Sensitivity of mean streamflow to changes in precipitation at the annual time scale [-]	0.77	2.91
Ar	Area	Catchment area [km²]	123.3	63901.8
A_{MED}	Median altitude	Median value of altitude for all catchment's grid cells [m]	105	1392
S_{MED}	Median slope	Median value of slope for all catchment's grid cells [%]	5	29
R	Relief	Elevation difference between catchment's and outlet and highest elevation [m]	176	1688

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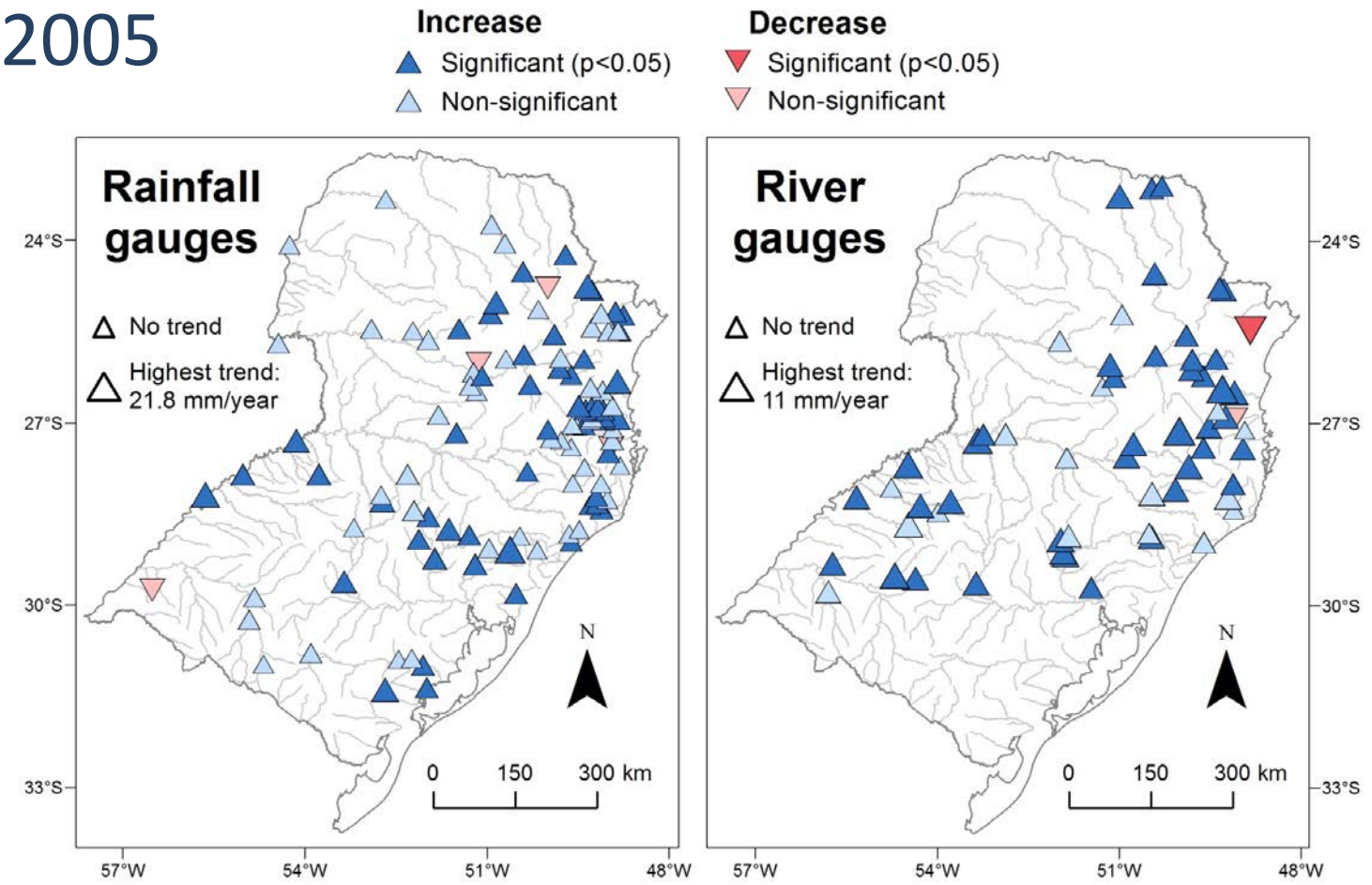
Results and Discussion

TREND ANALYSIS

MEAN ANNUAL VALUES

1951-2005



TREND ANALYSIS

MEAN ANNUAL VALUES

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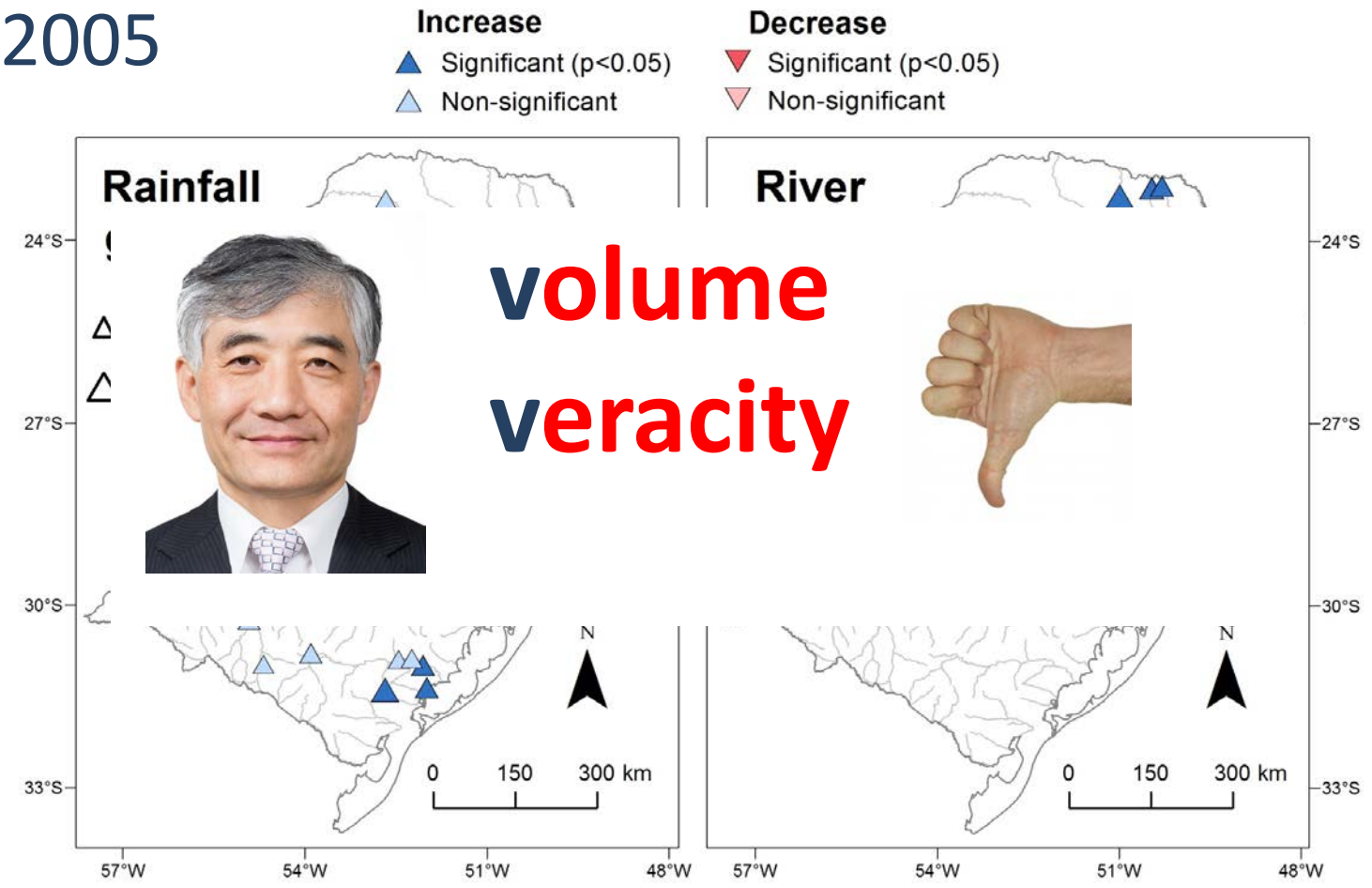
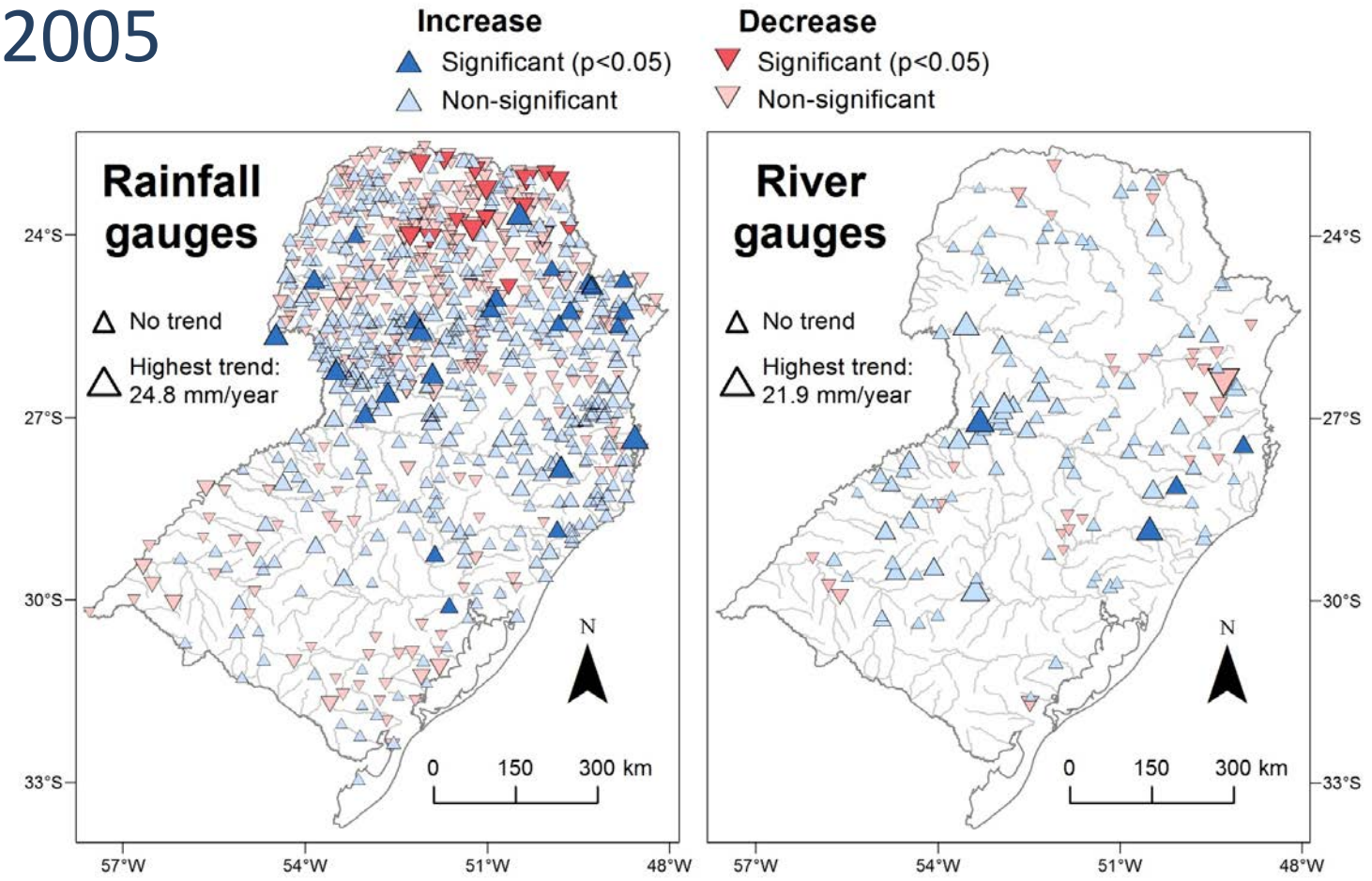


TREND ANALYSIS

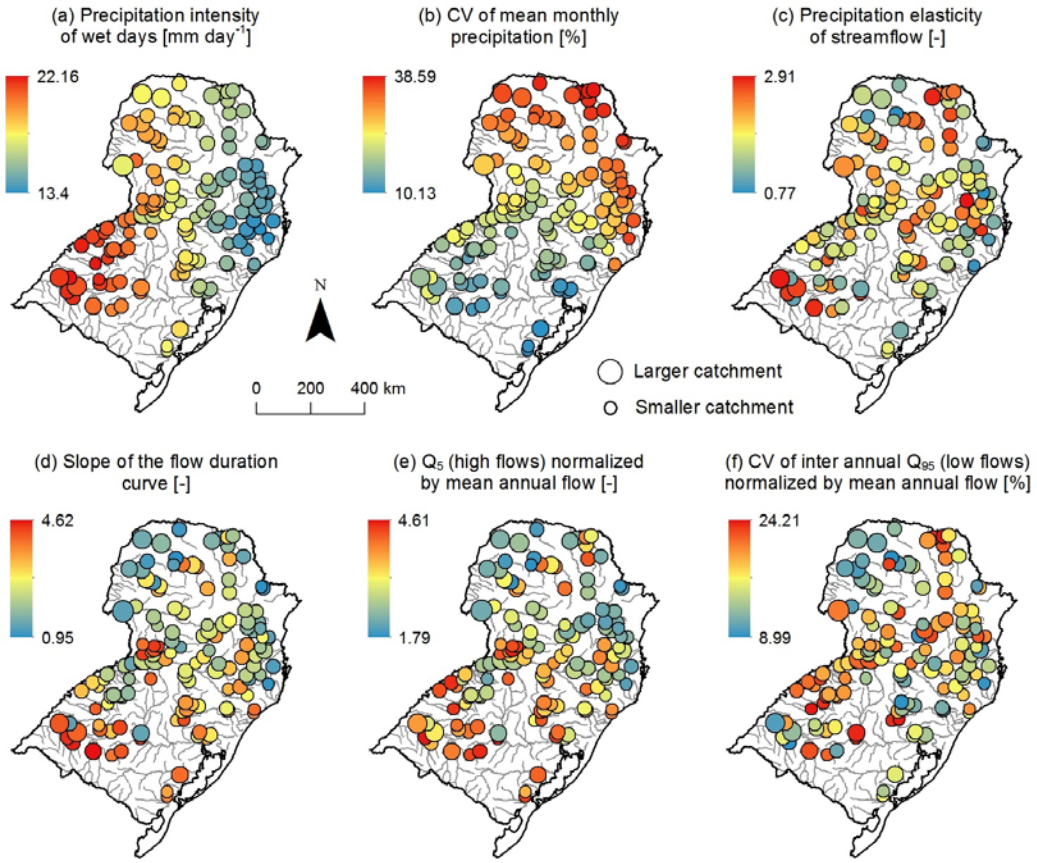
MEAN ANNUAL VALUES

1976-2005



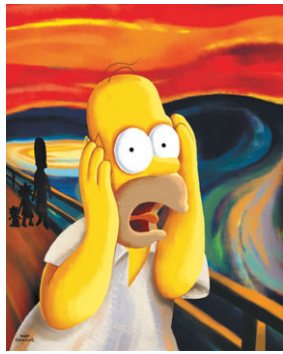
CLIMATIC AND HYDROMETRIC INDICES

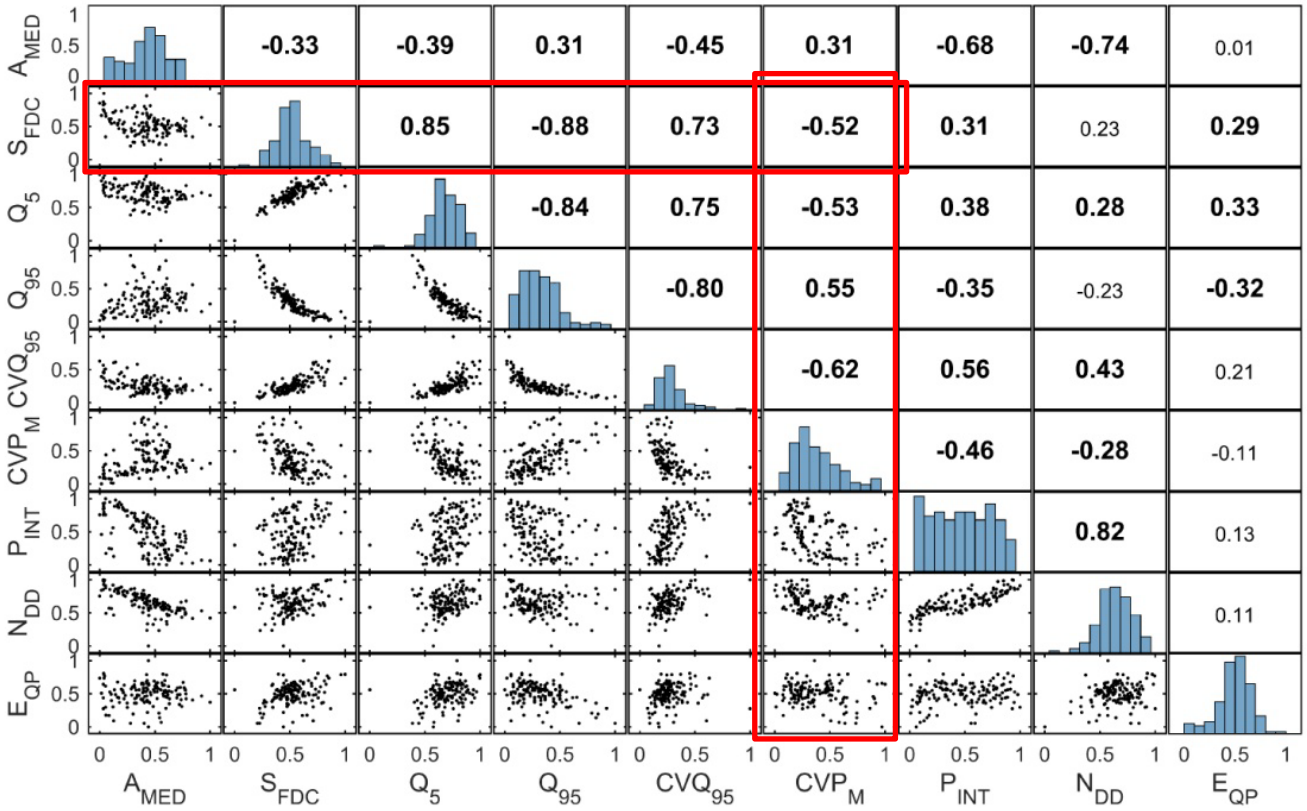
- Rainfall characteristics vary smoothly in space.
- Streamflow signatures vary abruptly.



FLOW DURATION CURVES

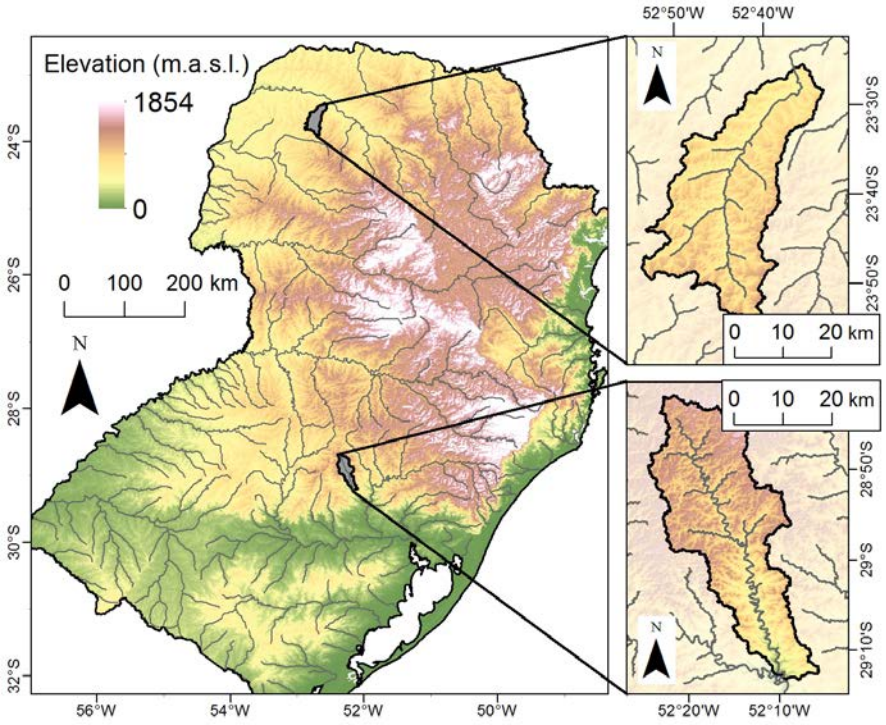
- **Inverse** relationship between S_{FDC} variability and **P**!

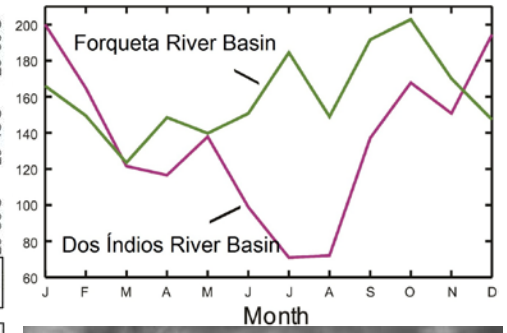


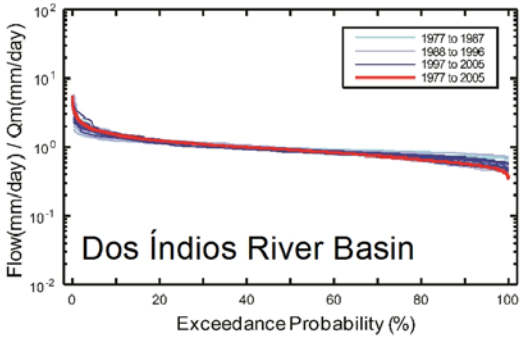


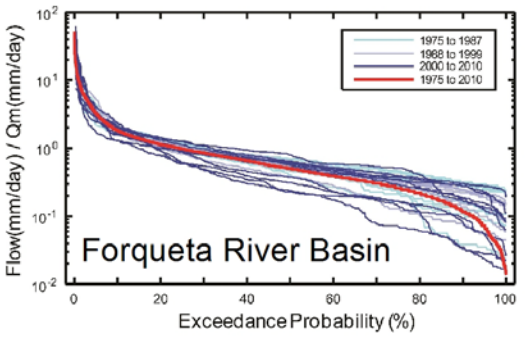
FLOW DURATION CURVES

- We cannot always infer discharge behavior from rainfall



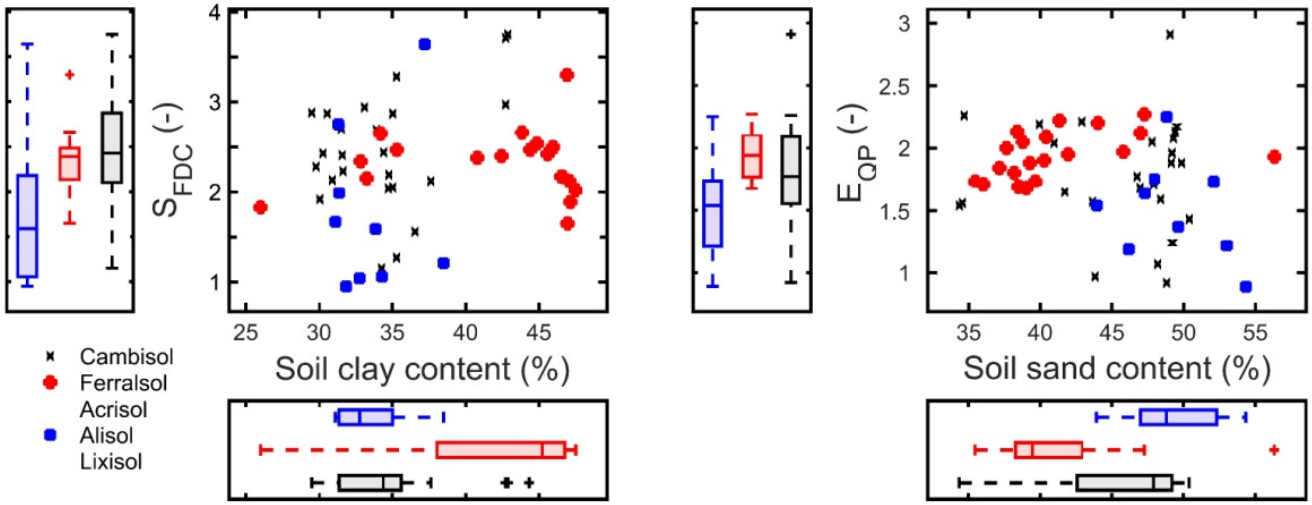


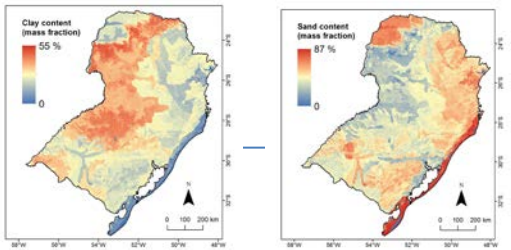




SOIL TYPES & STREAMFLOW

- For well drained **soil** it seems that S_{FDC} increases with clay content.
- In **Acrisol/Alisol** E_{QP} decreases with sand content.





Data source: ISRIC (2013). *SoilGrids: an automated system for global soil mapping. Online at http://soilgrids1km.isric.org .*

SOIL TYPES & STREAMFLOW

- For well drained **soil** it seems that S_{FDC} increases

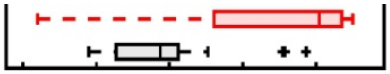
maybe…

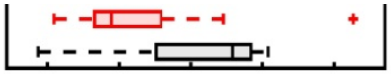
Soil is serving as a proxy for land use…

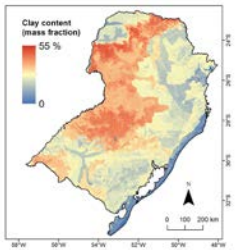
Socio-hydrology!

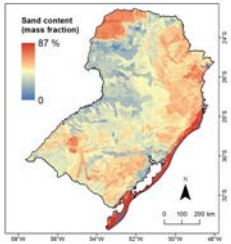
Panta Rhei
IAHS AISH
Everything Flows
Change in Hydrology and Society

Lixisol









Data source: ISRIC (2013). *SoilGrids: an automated system for global soil mapping. Online at http://soilgrids1km.isric.org .*

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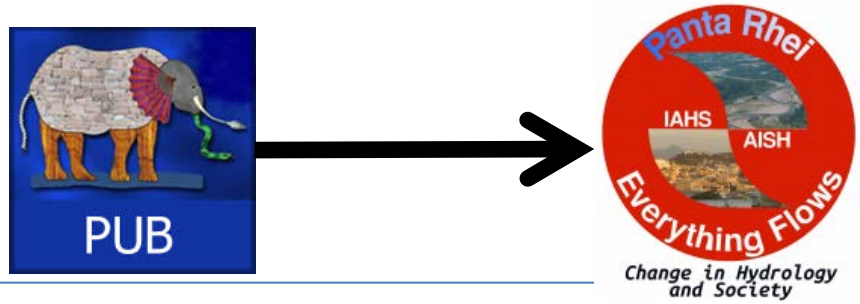
Conclusions

CONCLUSIONS

- Geologic characteristics did not show direct relation to the hydrological regimes;
- Higher precipitation elasticity of streamflow and higher slope of the FDC in higher soil clay content (proxy for land use?);
- The precipitation changes not impact streamflow regimes equally;



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Thank you very much!!

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