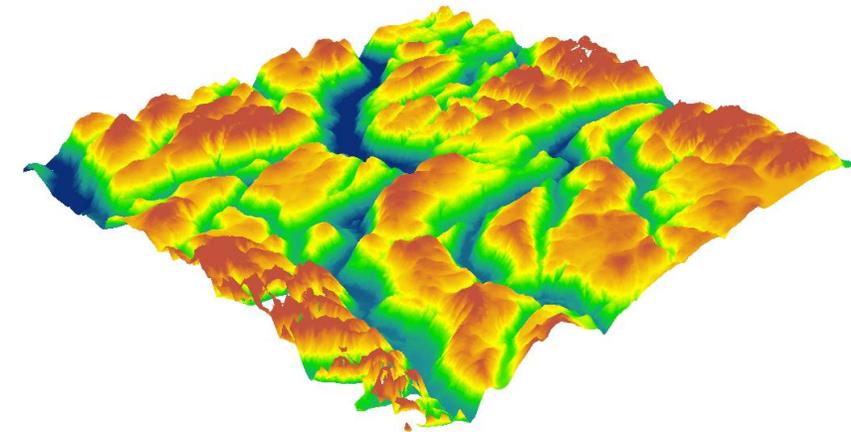
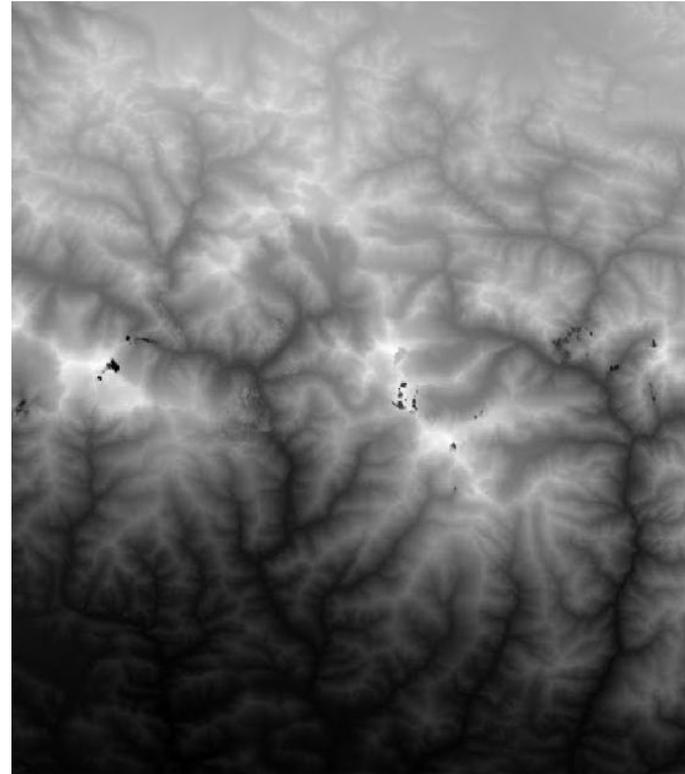
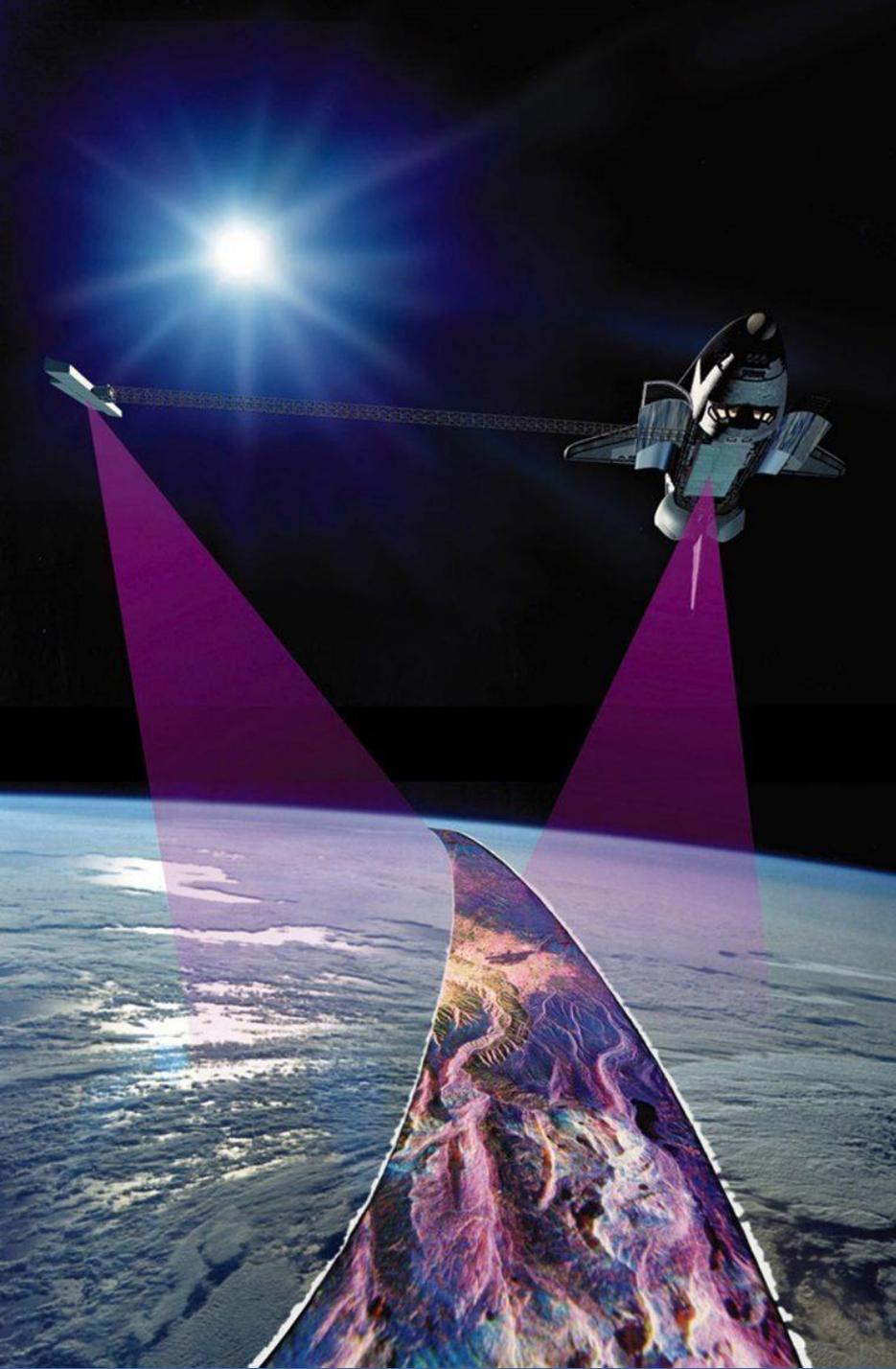




ANÁLISE COMPARATIVA  
**MODELOS DIGITAIS  
DO TERRENO**  
PARA APLICAÇÃO  
HIDROLÓGICA EM PORTUGAL

Jorge E. Matos

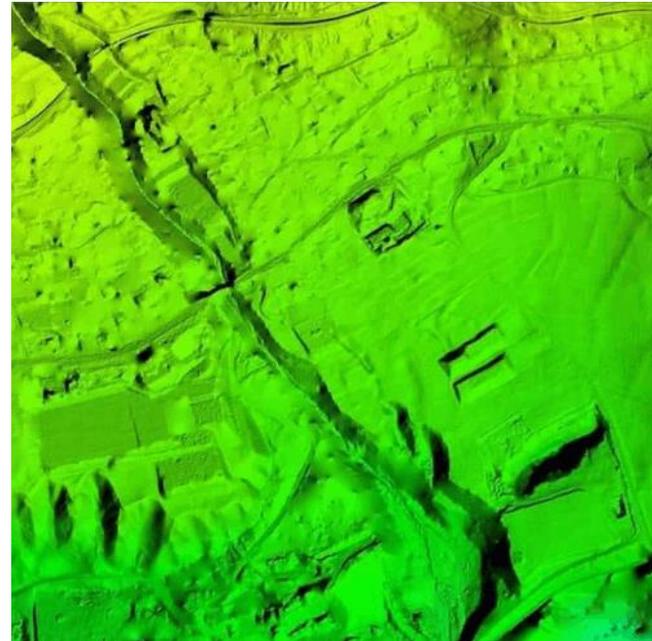
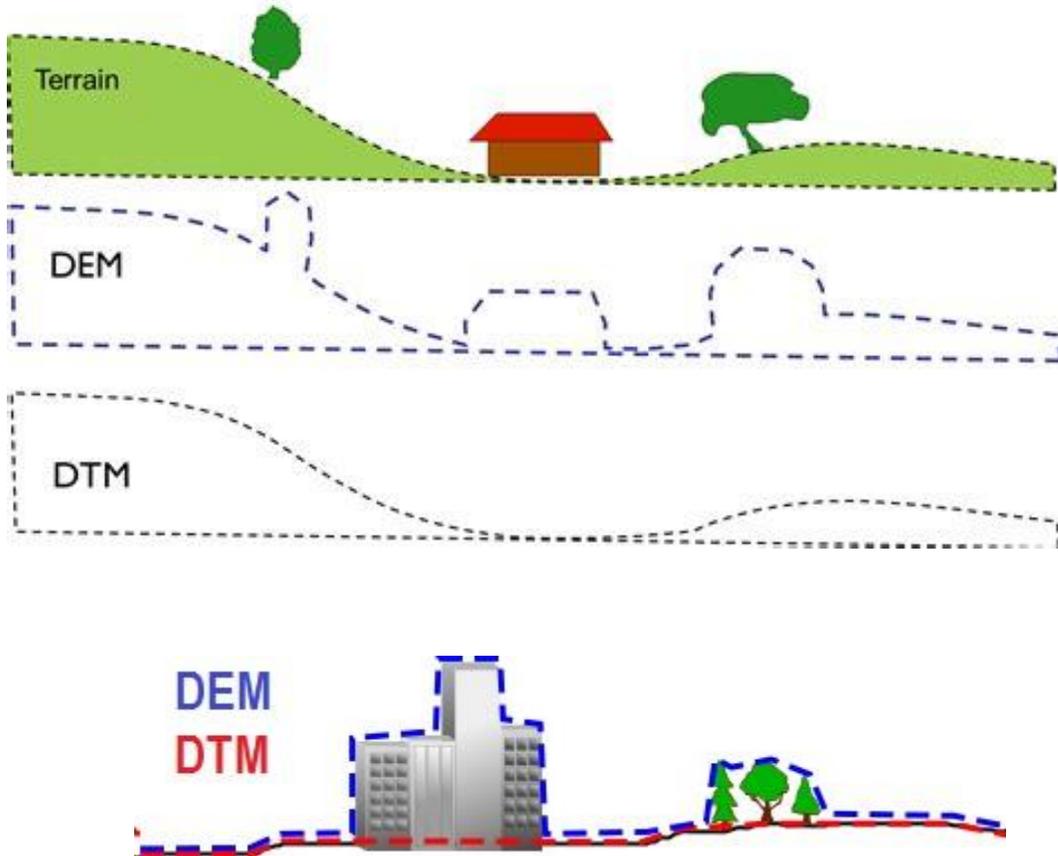
## Como se obtêm os Modelos Digitais Terrestres?



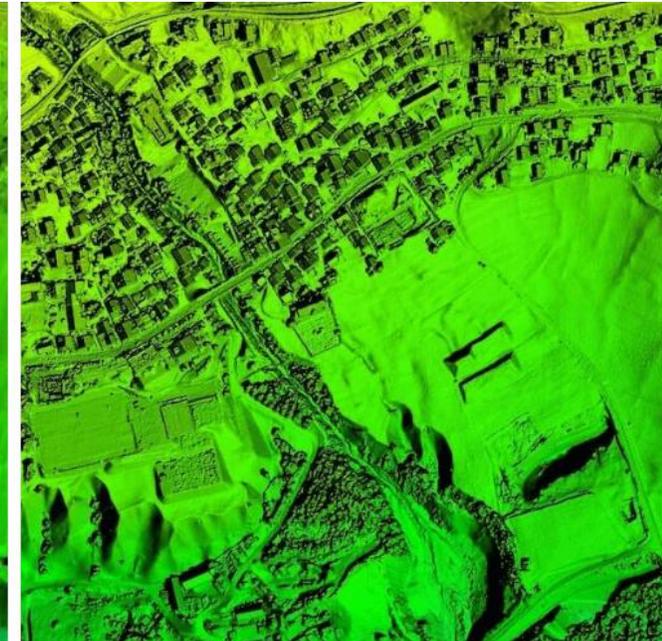
## MDE/MDT analisados

NOME	DATA	RESOLUÇÃO	PRODUTOR	PAÍS	OBS.
SRTM	2000	30 e 90 m	NASA	USA	
ASTER GDEM	2009	30 m	NASA/METI	USA/JAPÃO	
ALOS WORLD (AW3D)	2015	5 e 30 m	JAXA	JAPÃO	
COPERNICUS DEM	2019	10, 30 e 90 m	ESA/AIRBUS	ALEMANHA	
NASADEM	2020	30 m	NASA	USA	Com base em SRTM e ASTER
EU-DTM	2020	30 m	Univ. Wageningen	HOLANDA	Com base em ALOS, GLO-30 e outros
FABDEM	2021	30 m	Univ. Bristol	UK	Com base no Copernicus DEM
ALOS-PALSAR	2007	12,5 m	JAXA	JAPÃO	Com base em ALOS WORLD

# DEM vs DTM

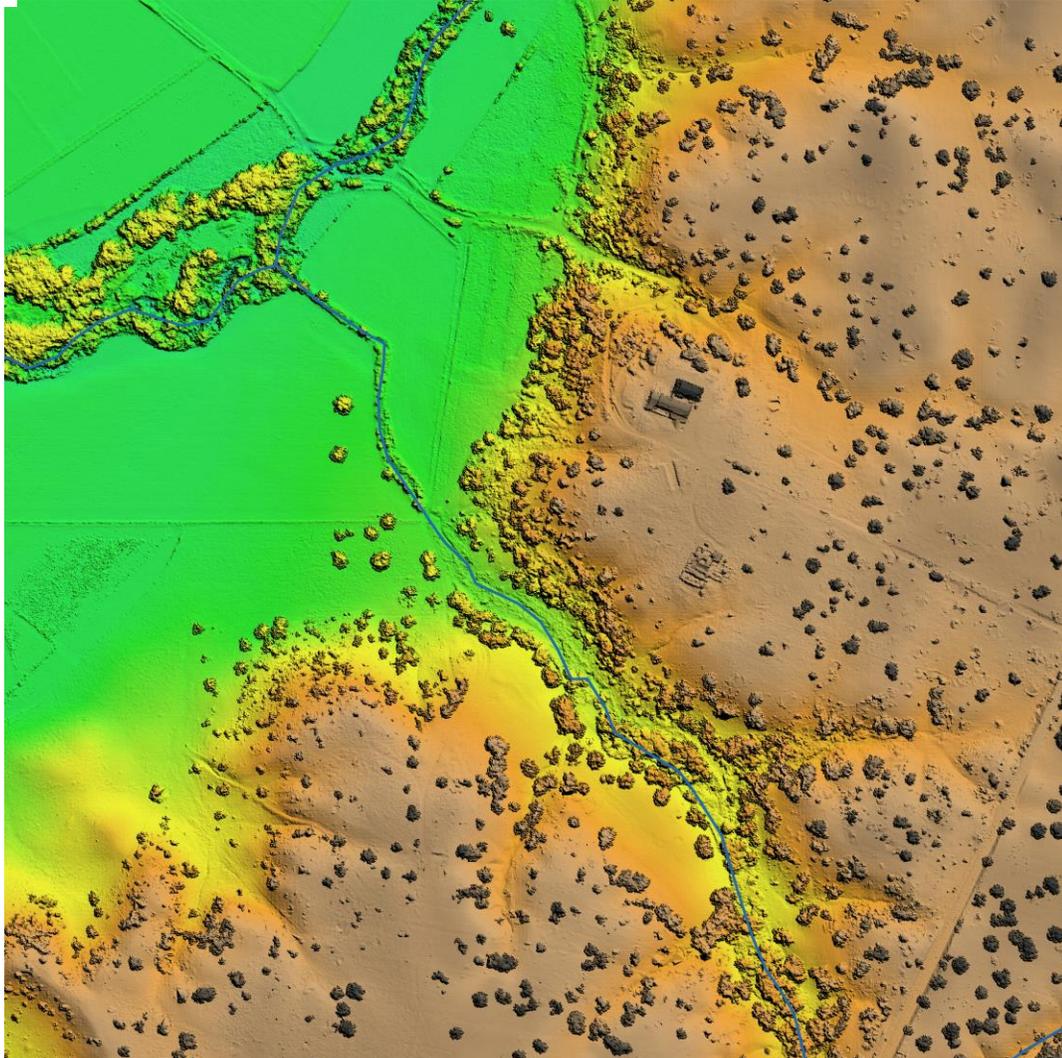


**DTM**

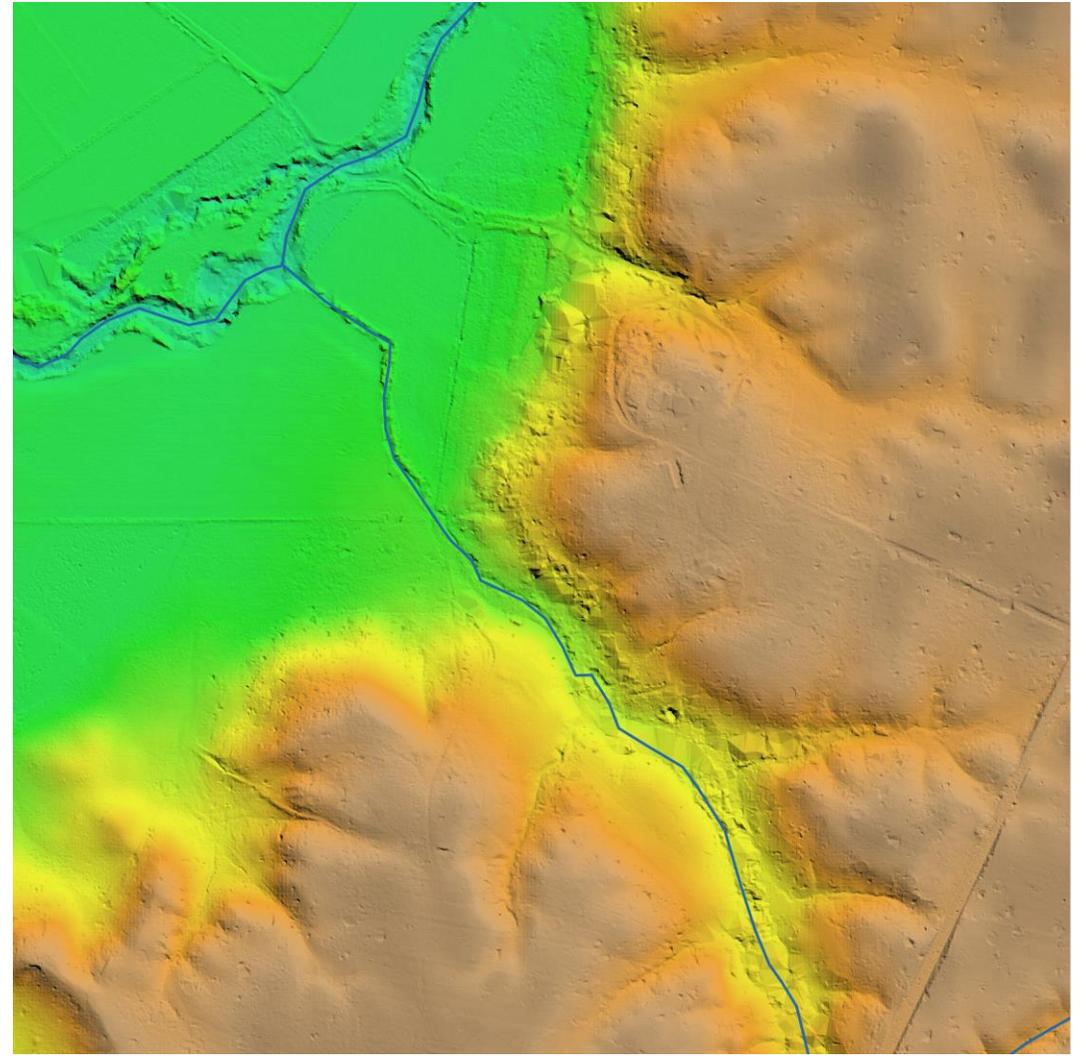


**DEM**

# MDE/DEM



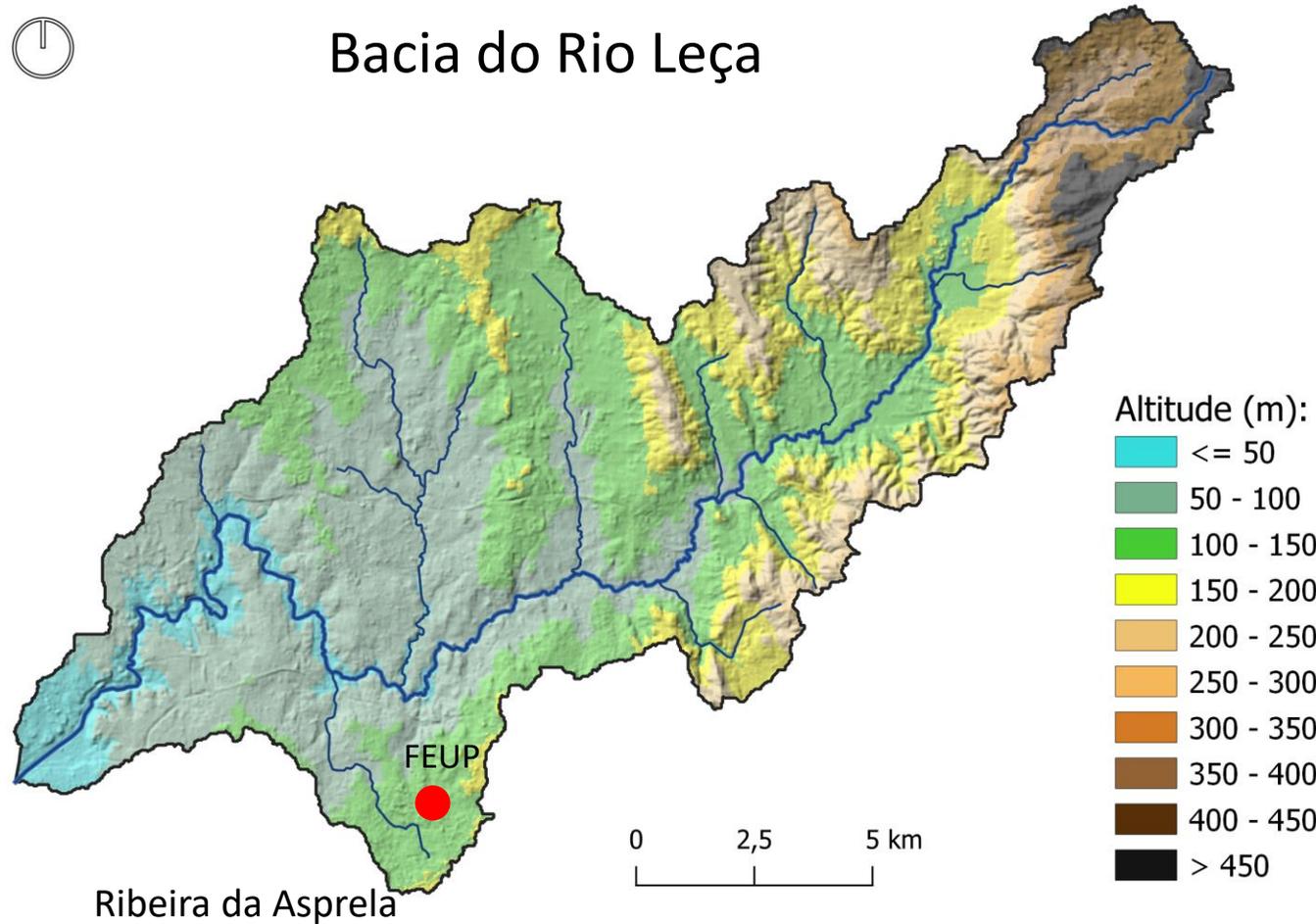
# MDT/DTM



# Bacias hidrográficas estudadas



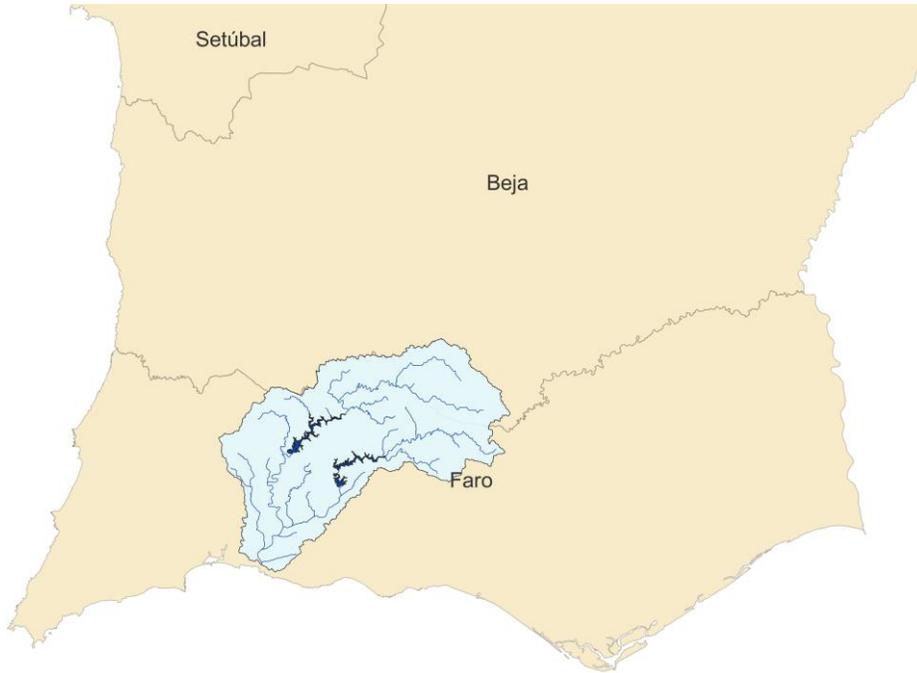
## Bacia do Rio Leça



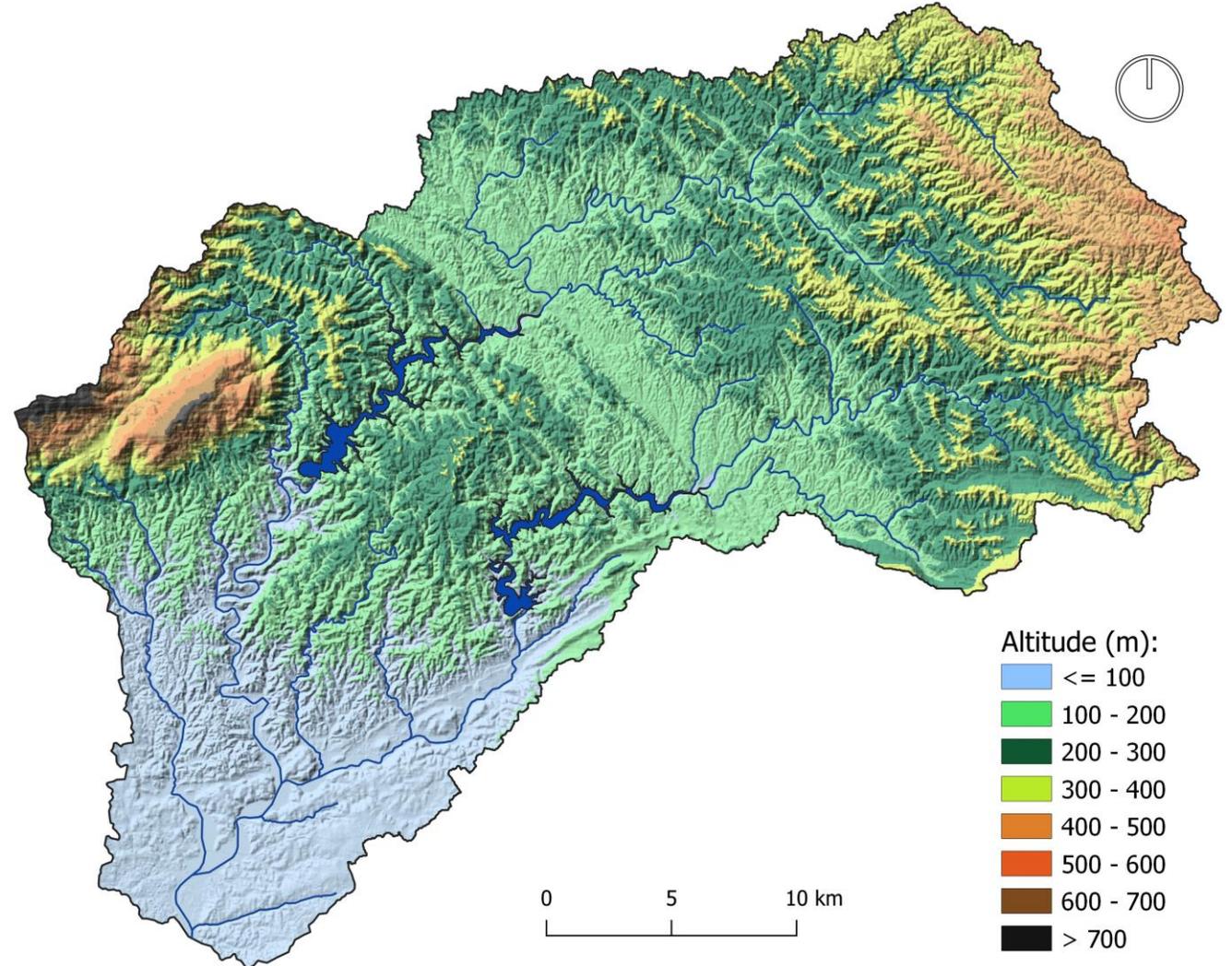
**Área: 189,19 km<sup>2</sup>**  
**Ria Leça: 48,613 km**  
**nasce a 460 m alt.**

# Bacias hidrográficas estudadas

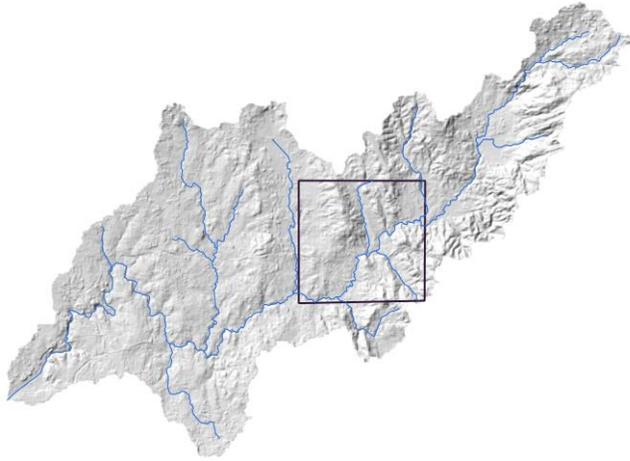
## Bacia do Rio Arade



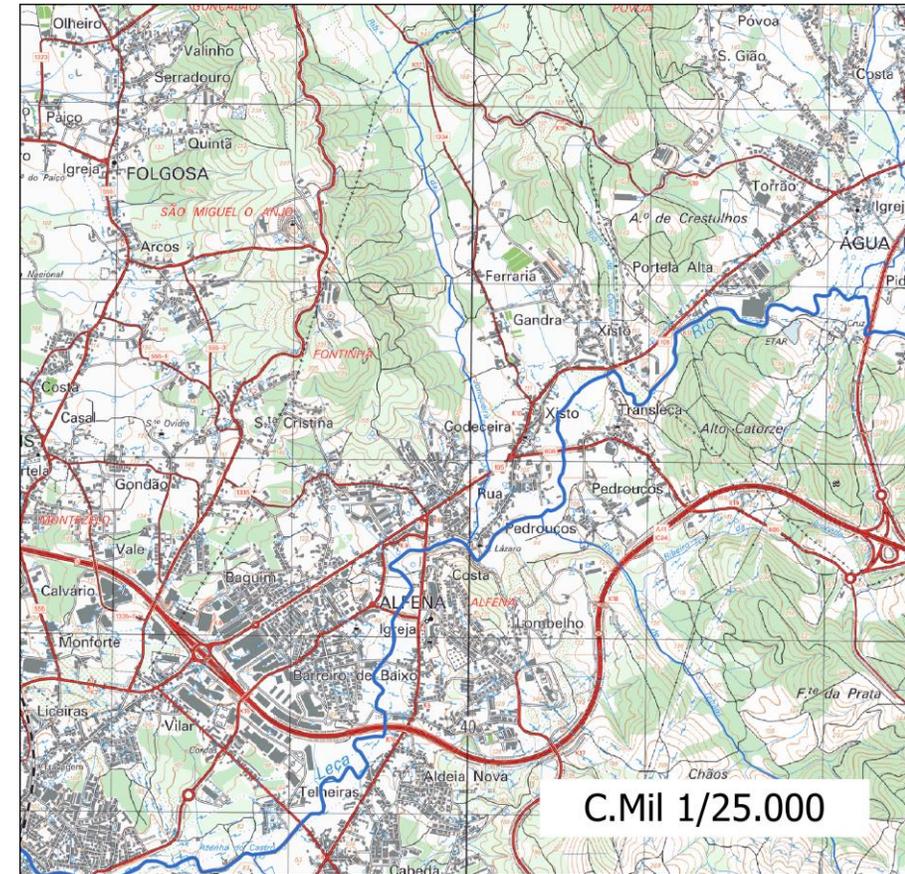
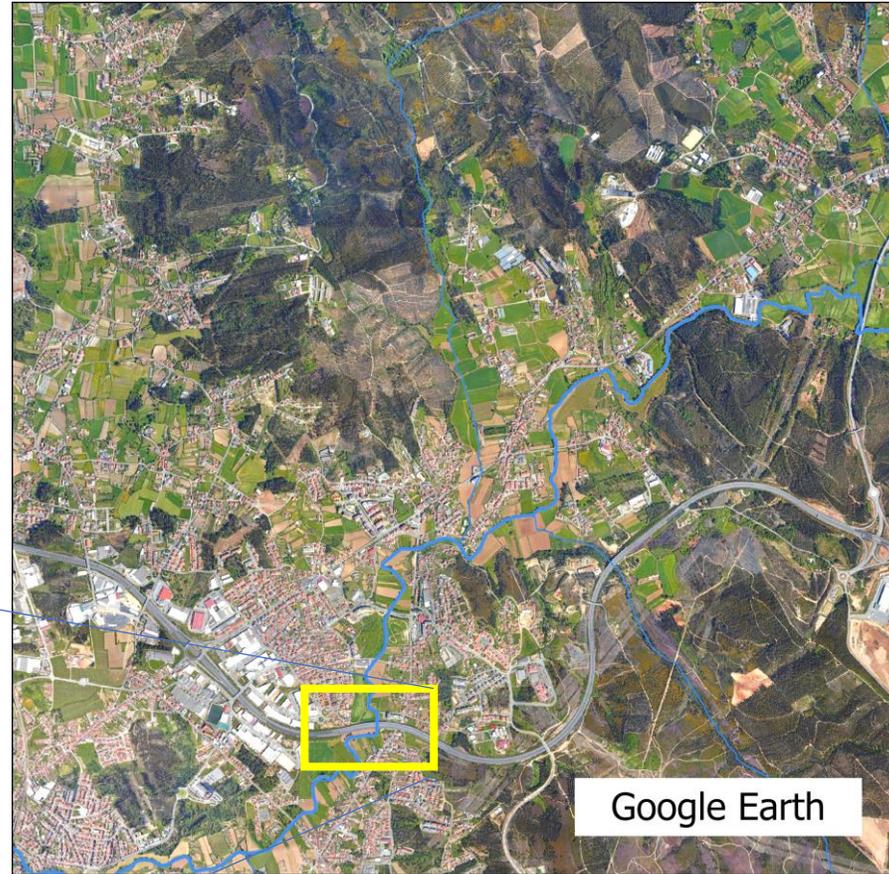
**Área: 972,24 km<sup>2</sup>**  
**Ria Arade: 72,028 km**  
**nasce a 345,5 m alt.**



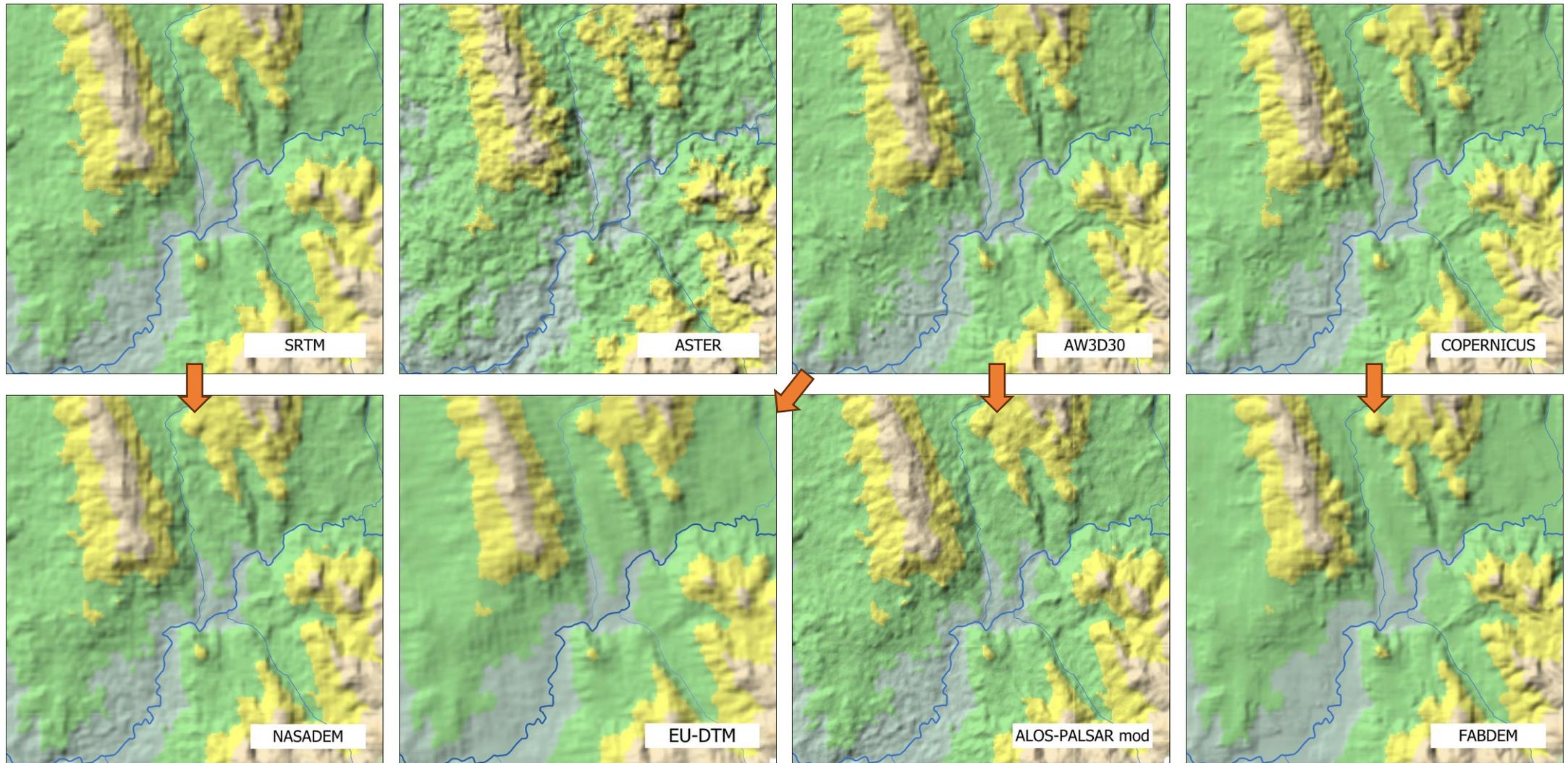
# Bacia do rio Leça



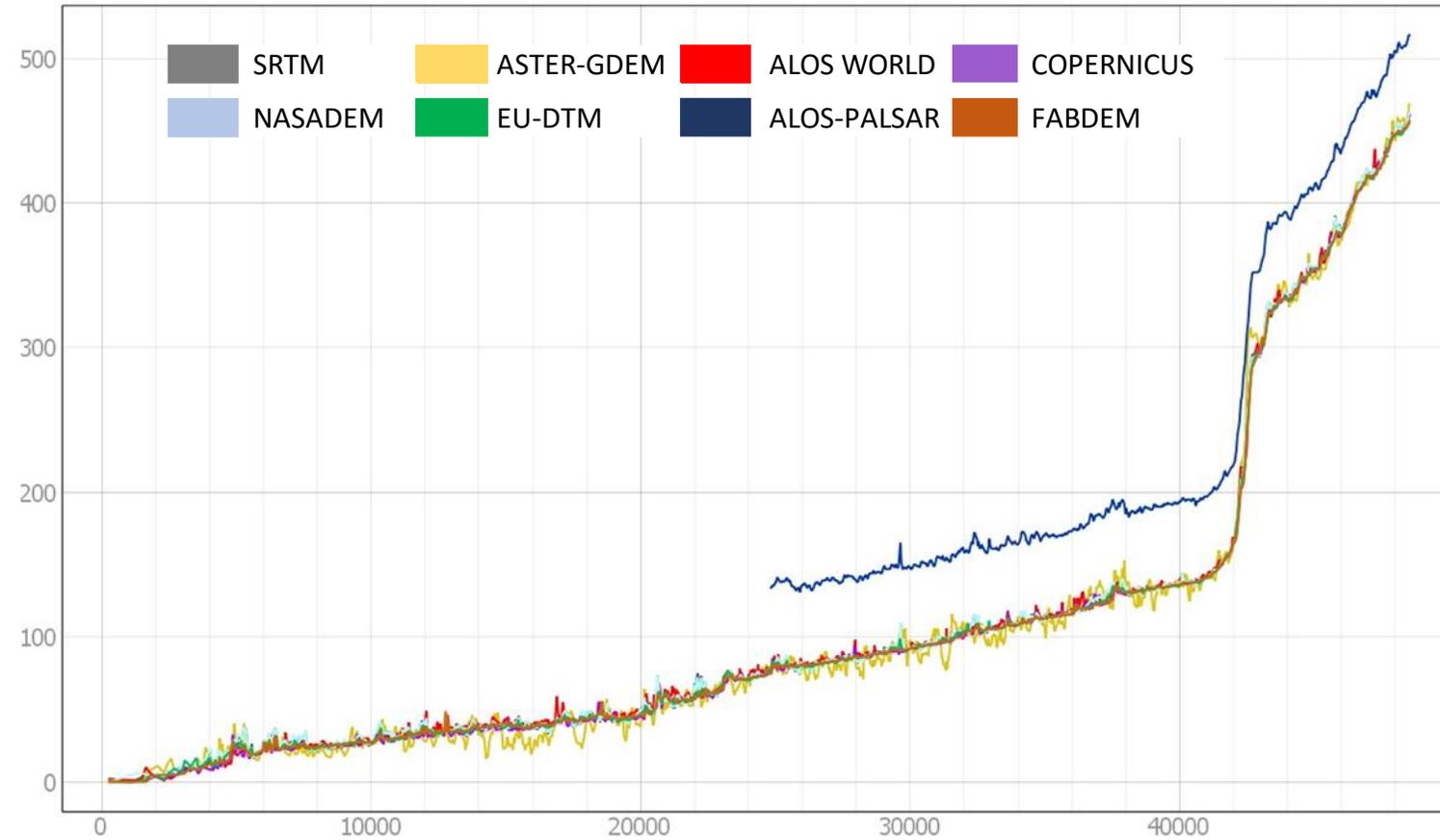
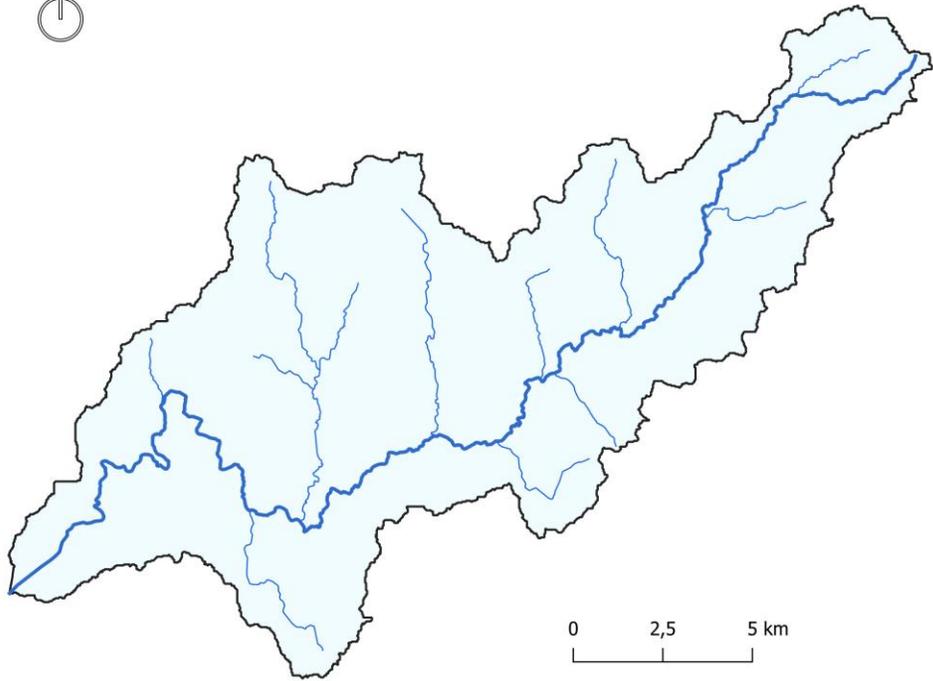
Viaduto na A41  
(650 m - 2007)



# Bacia do rio Arade – Relevo

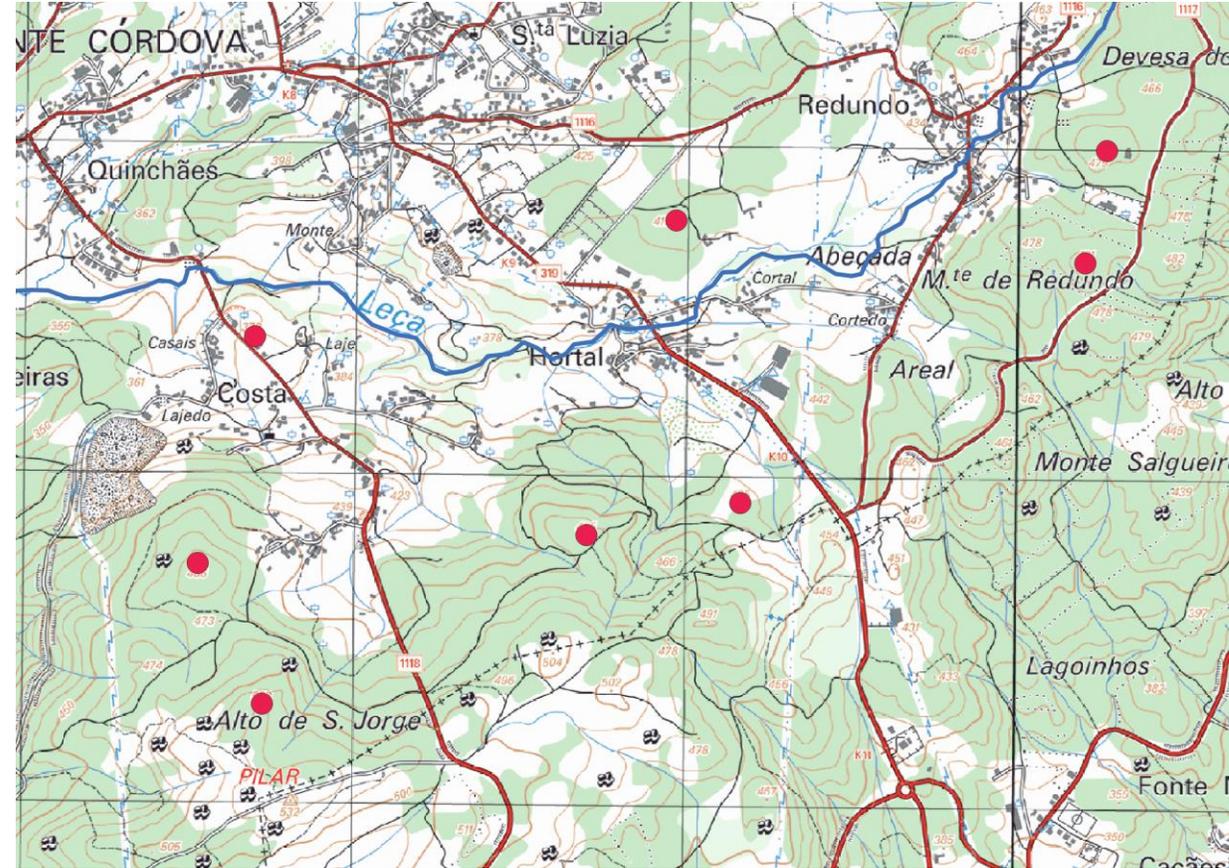
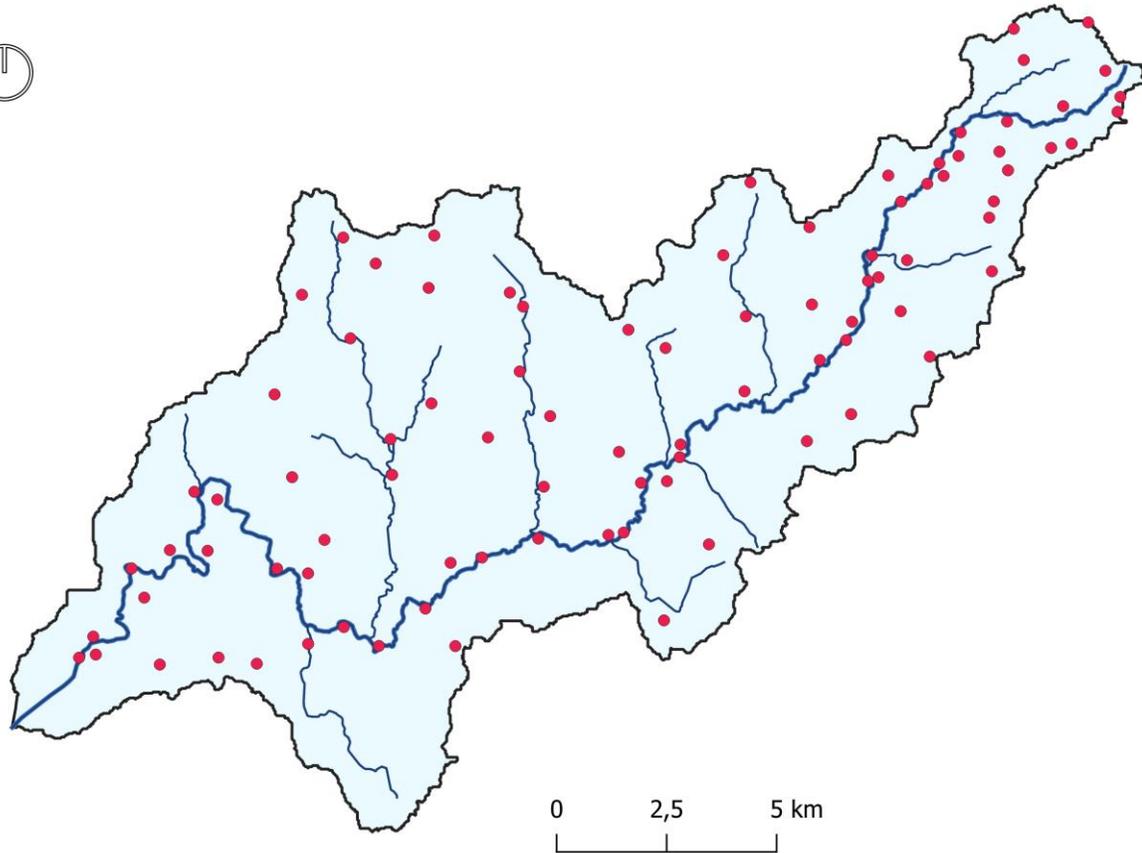


# Bacia do rio Leça

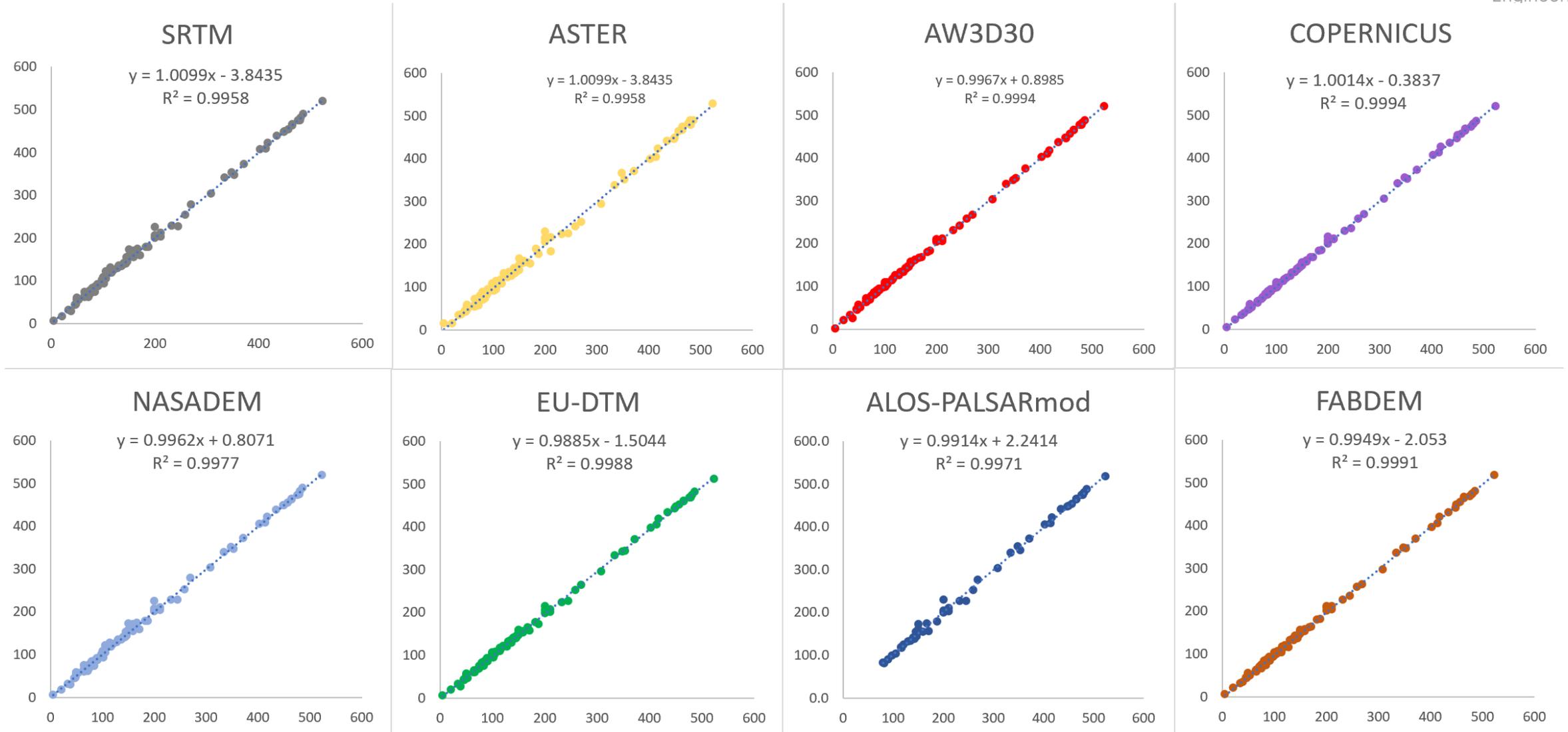


Curvas hipsométricas

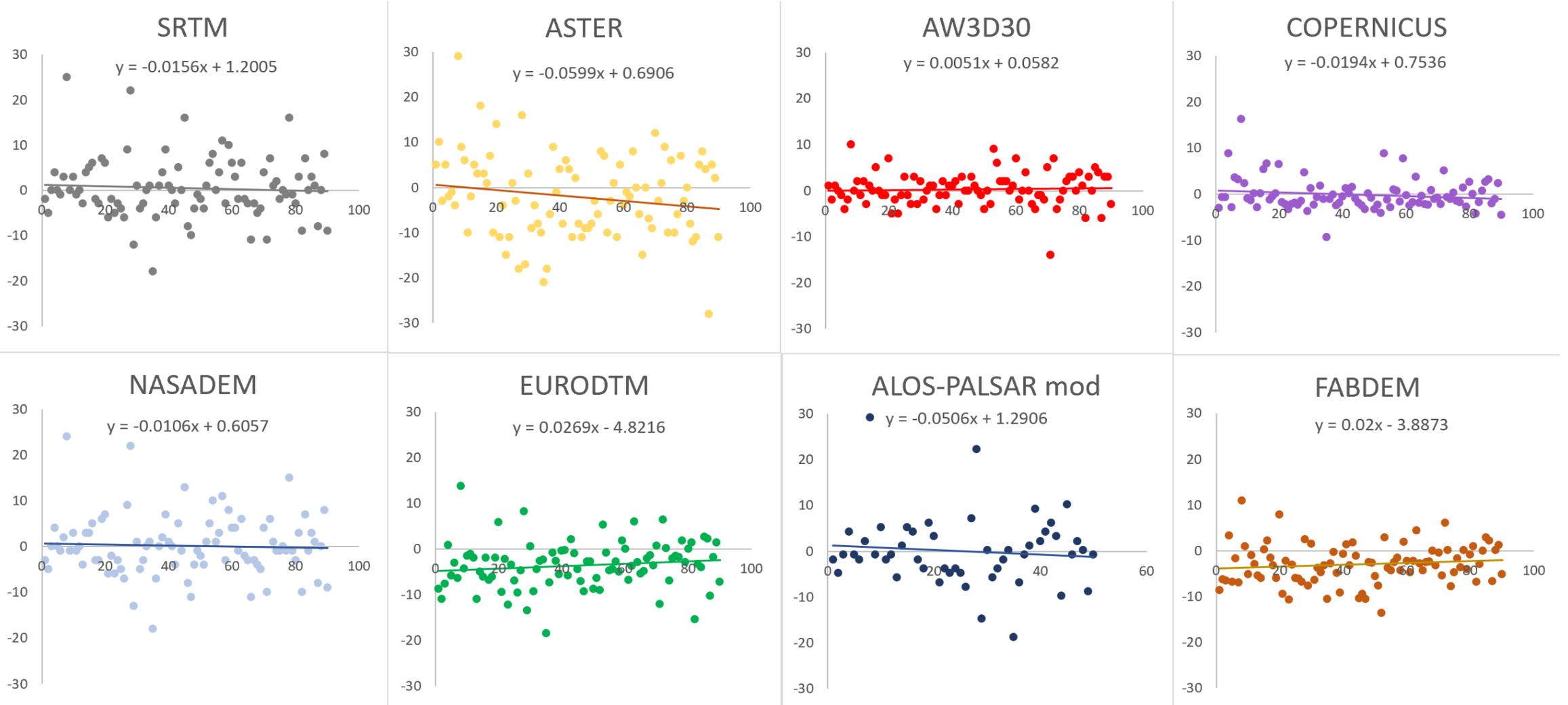
# Bacia do rio Leça – Análise pontual



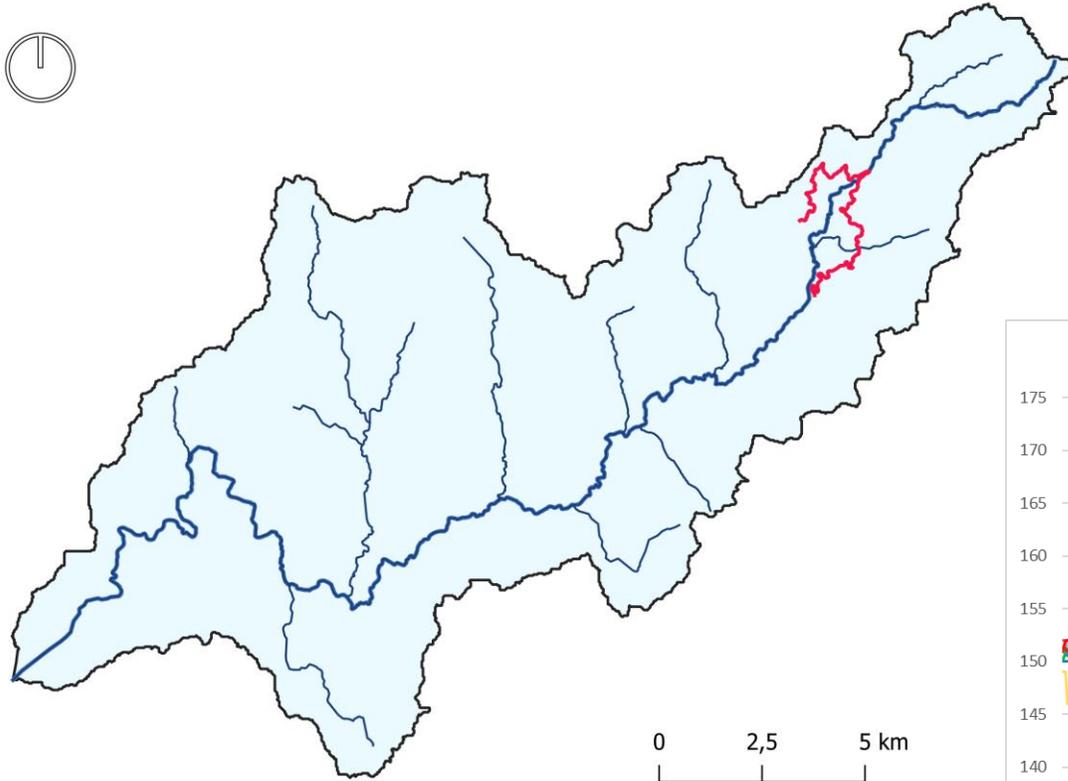
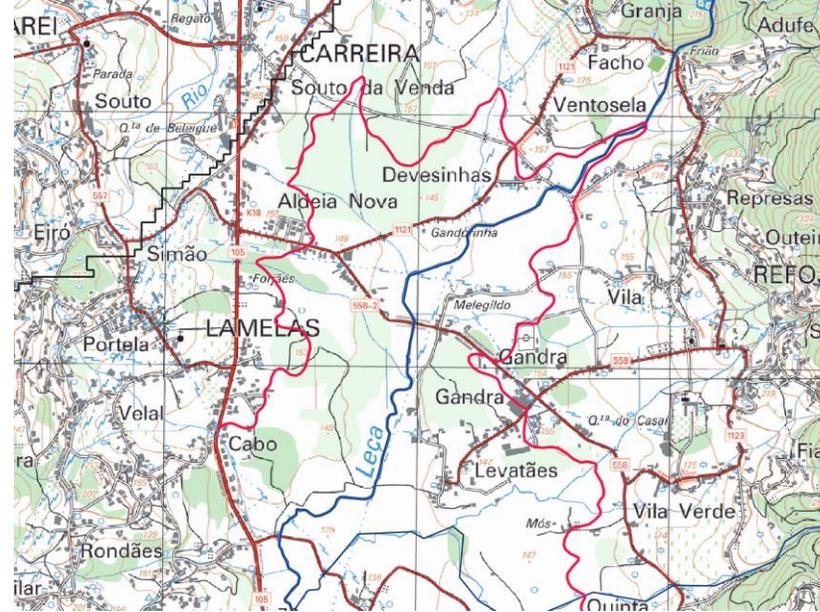
# Bacia do rio Leça – Análise pontual (correlação)



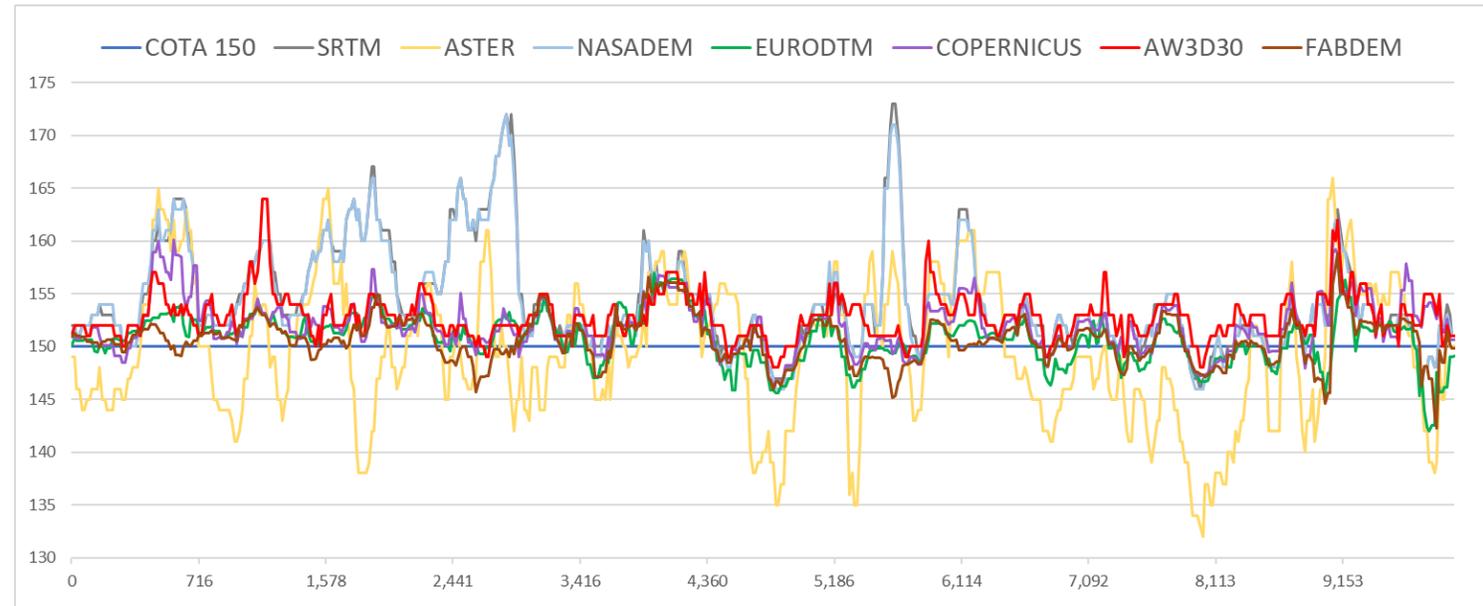
# Bacia do rio Leça – Análise pontual (diferença)



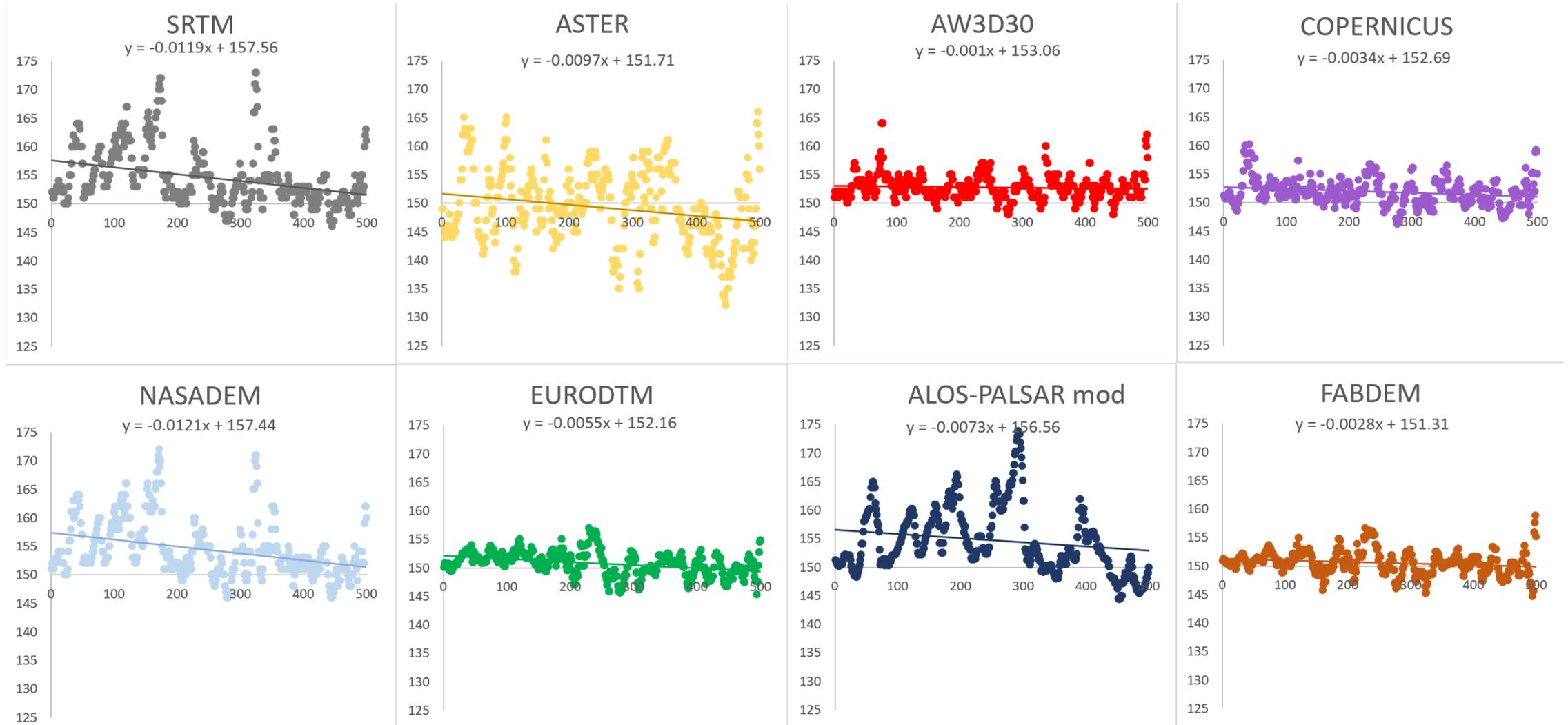
# Bacia do rio Leça - Análise linear



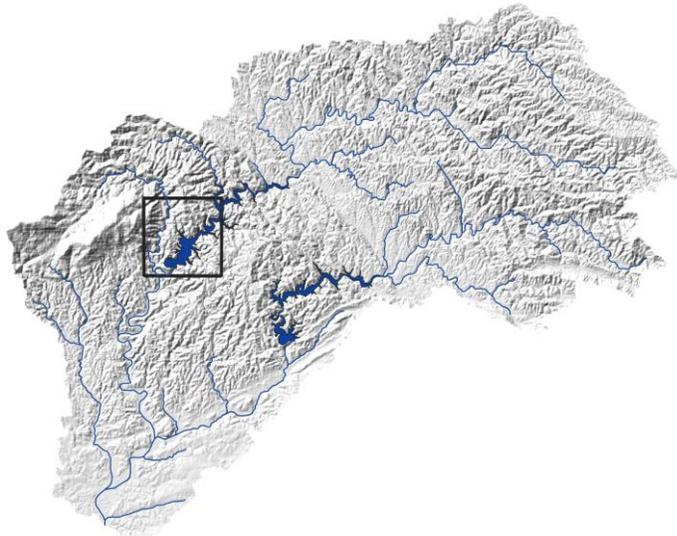
0 2,5 5 km



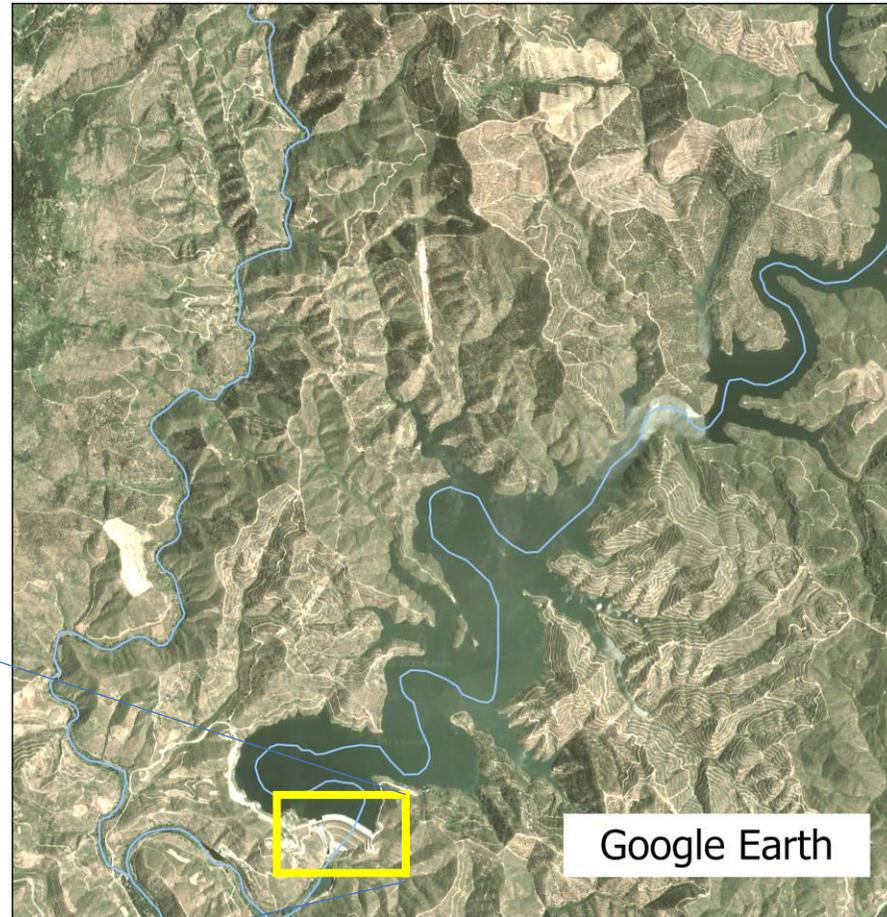
# Bacia do rio Leça - Análise linear



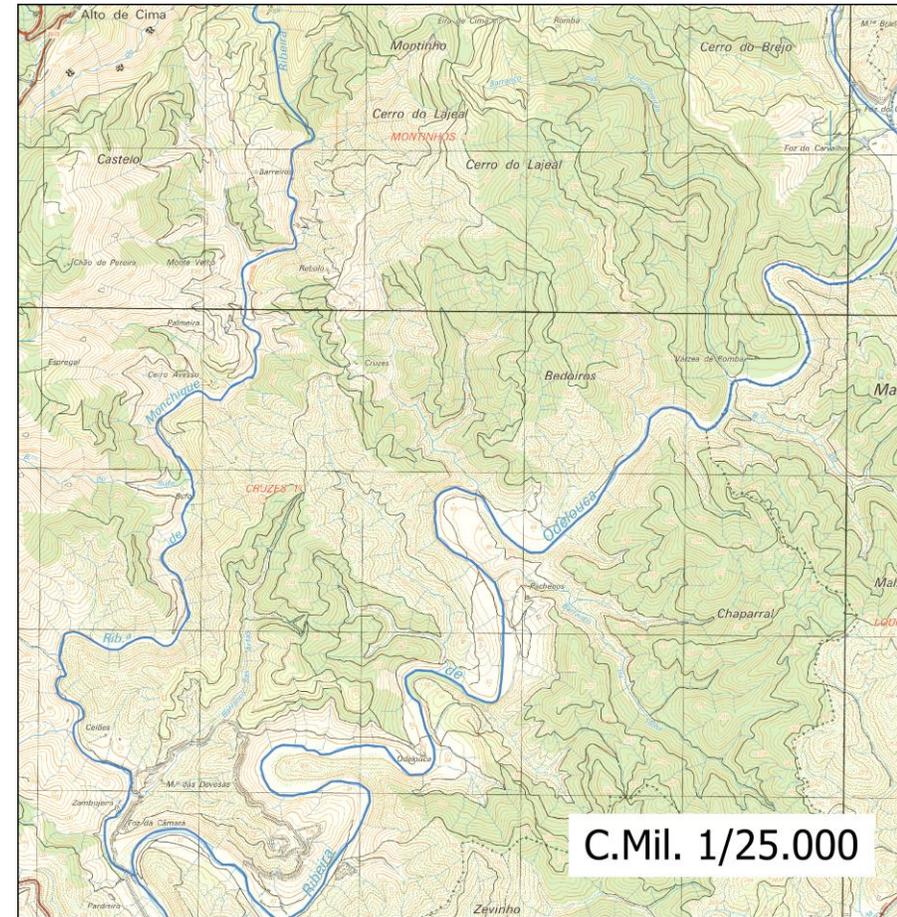
# Bacia do rio Arade – Relevo



Barragem de Odelouca  
(2009)

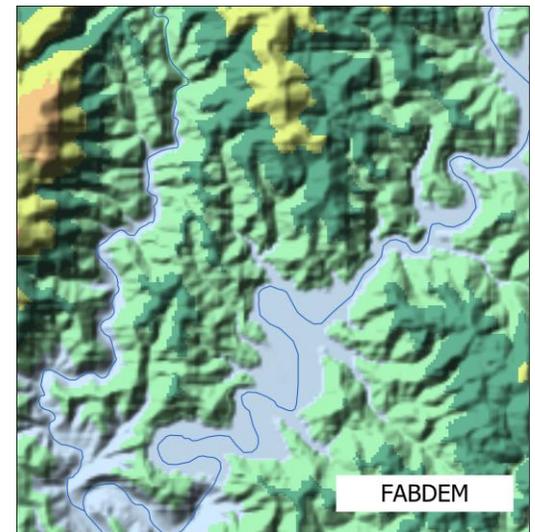
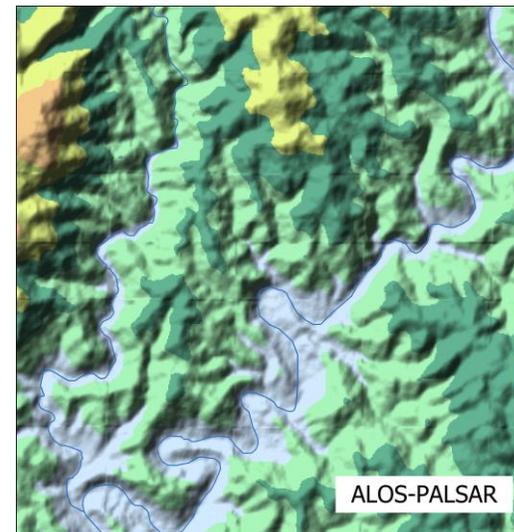
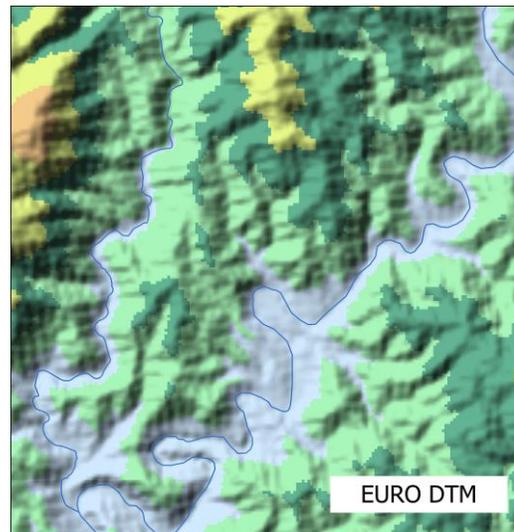
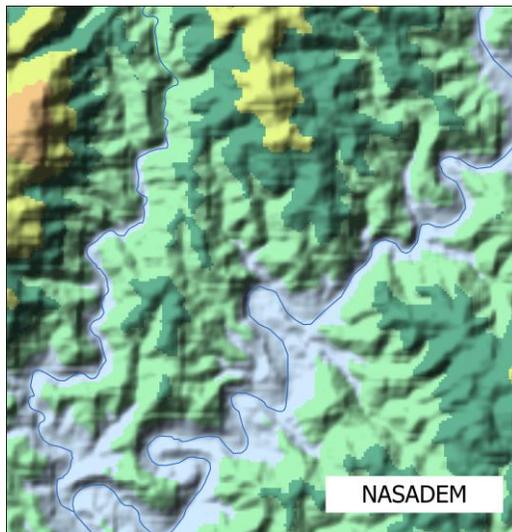
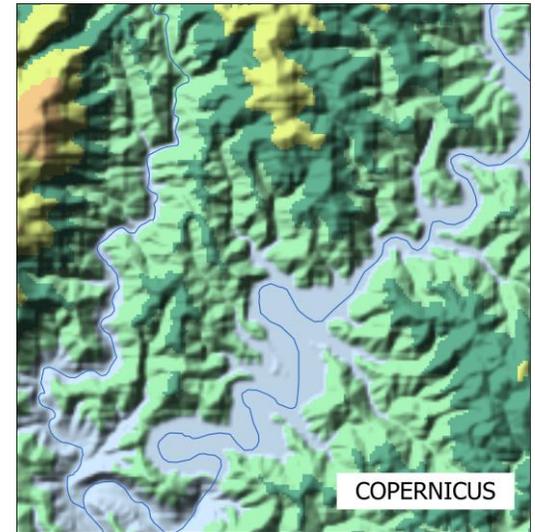
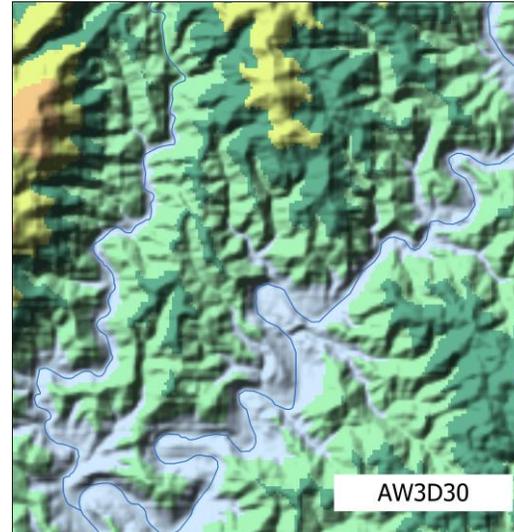
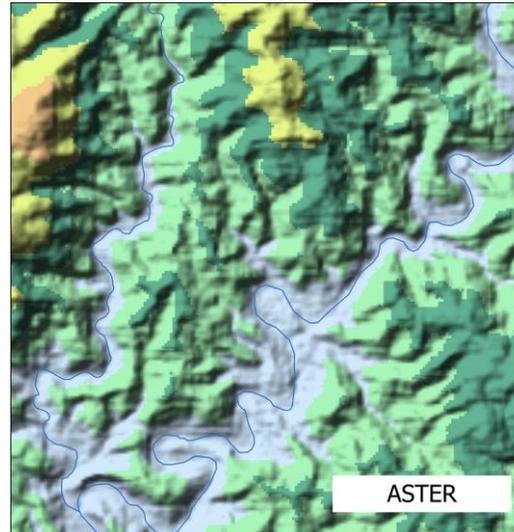
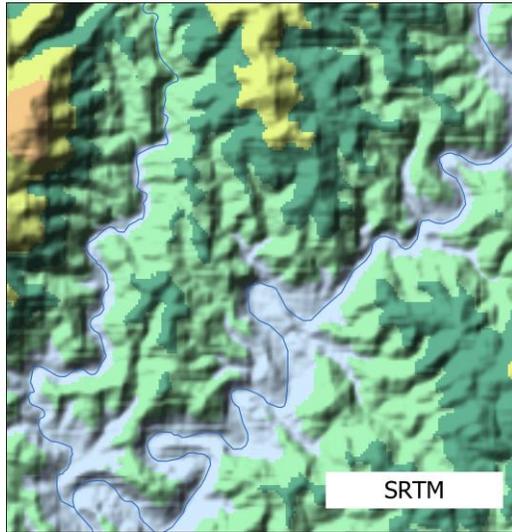


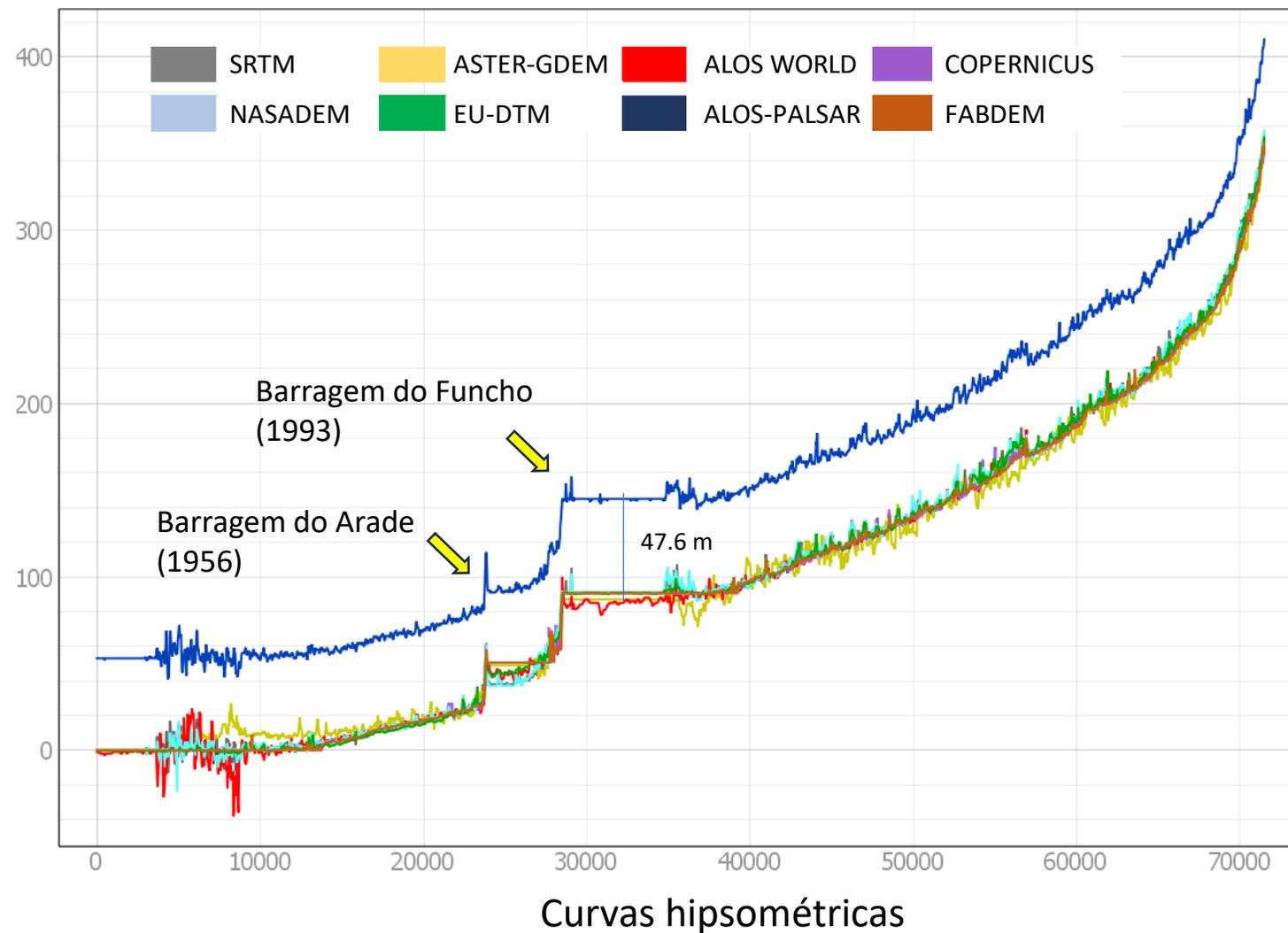
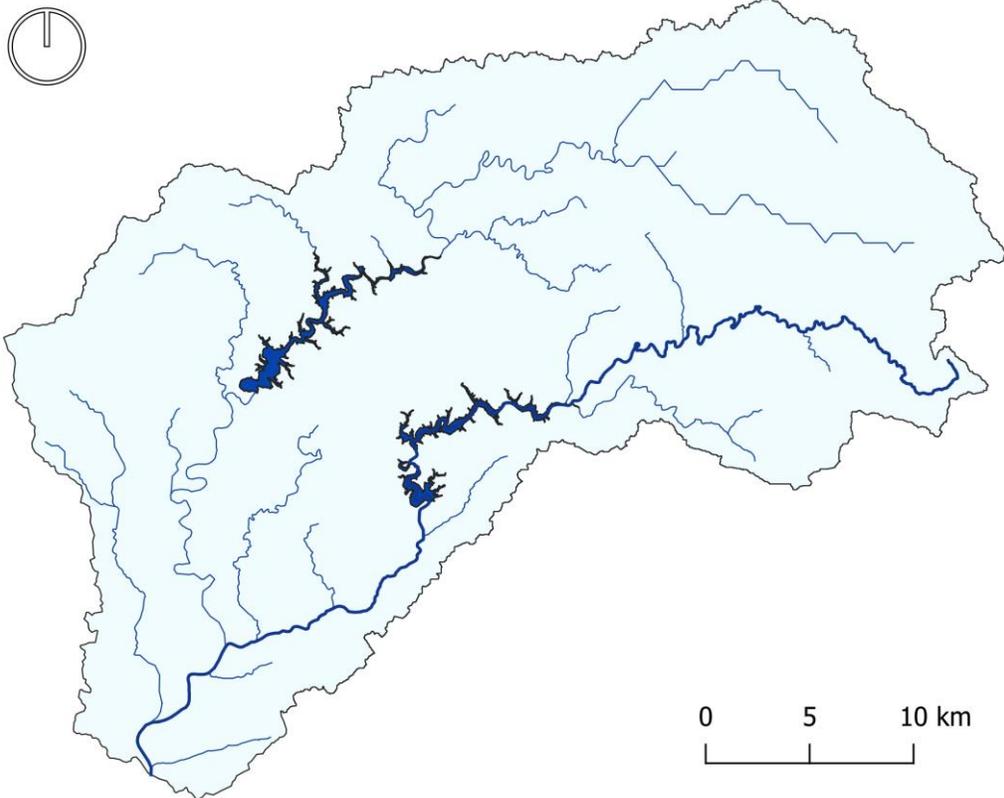
Google Earth



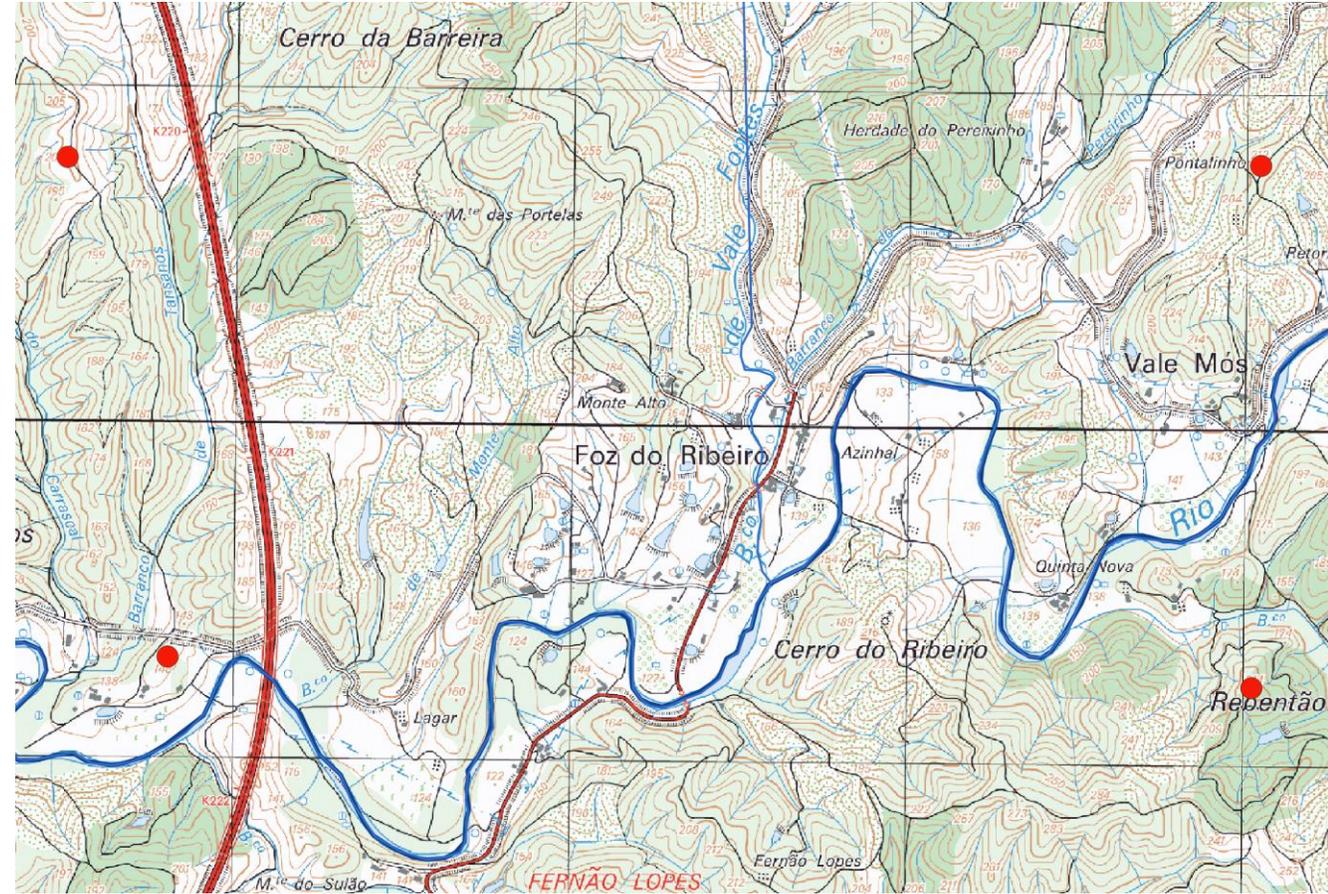
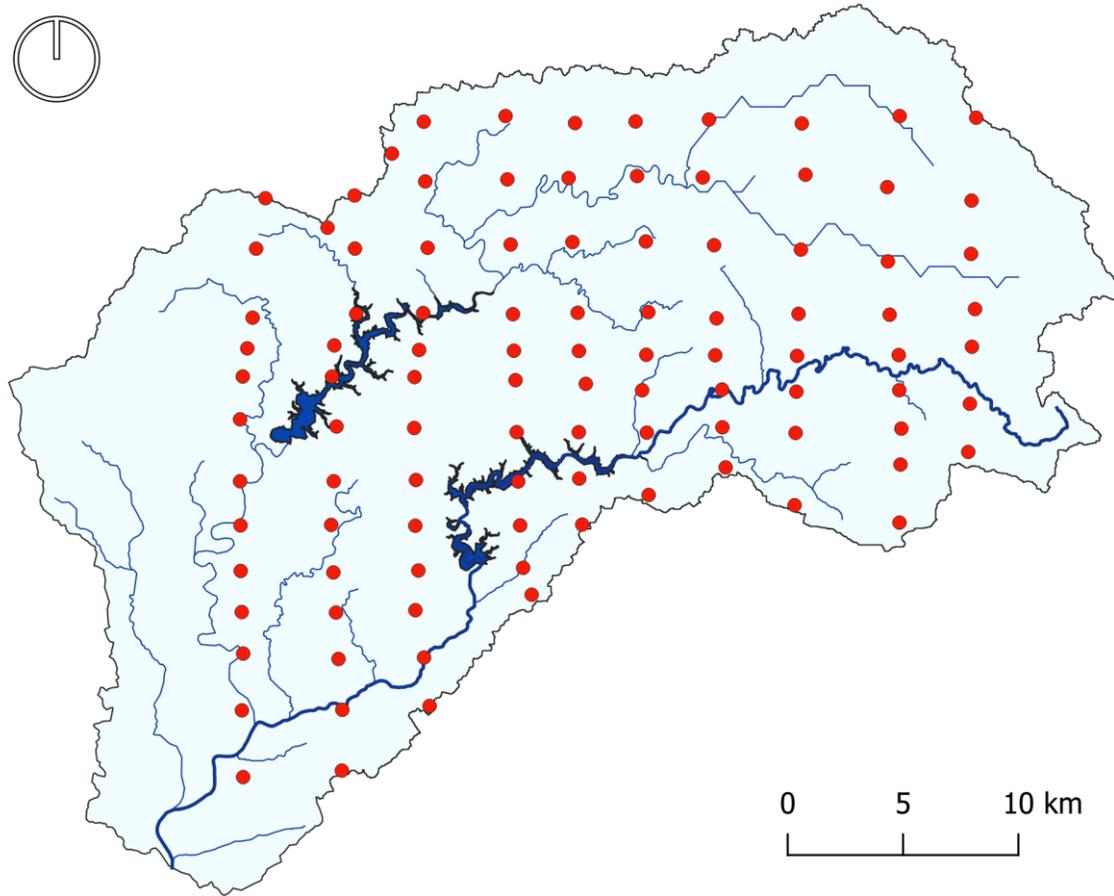
C.Mil. 1/25.000

# Bacia do rio Arade – Relevo

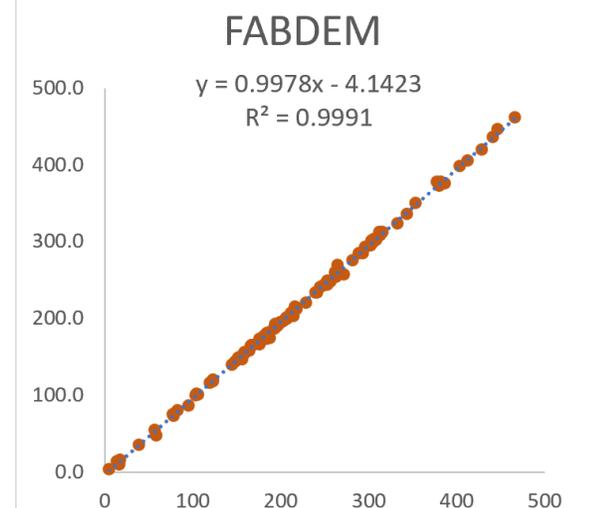
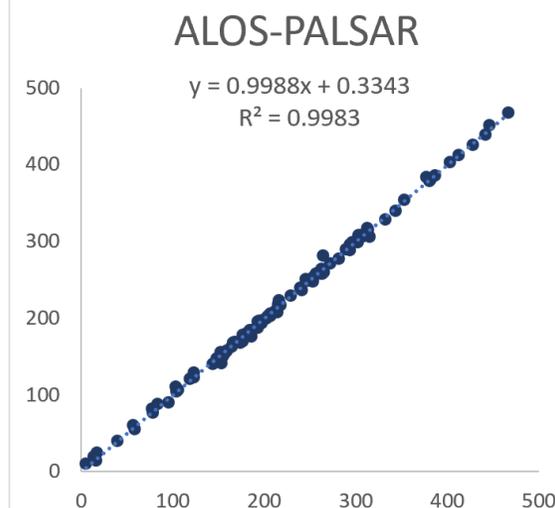
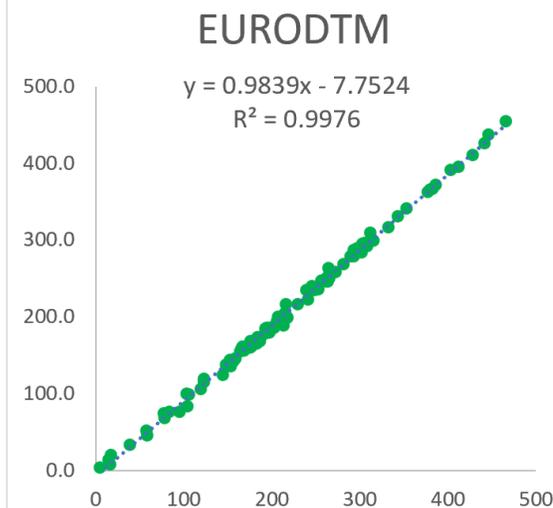
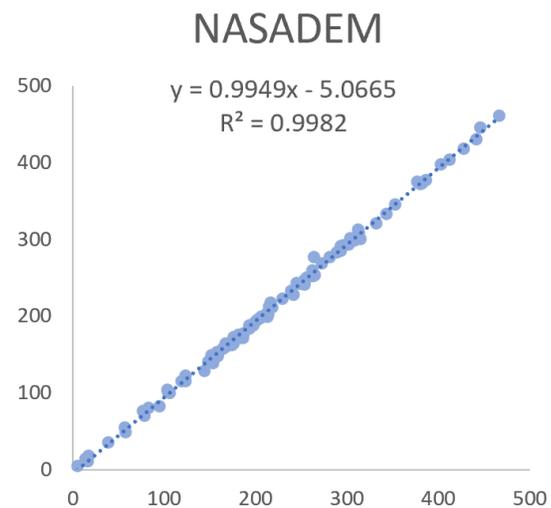
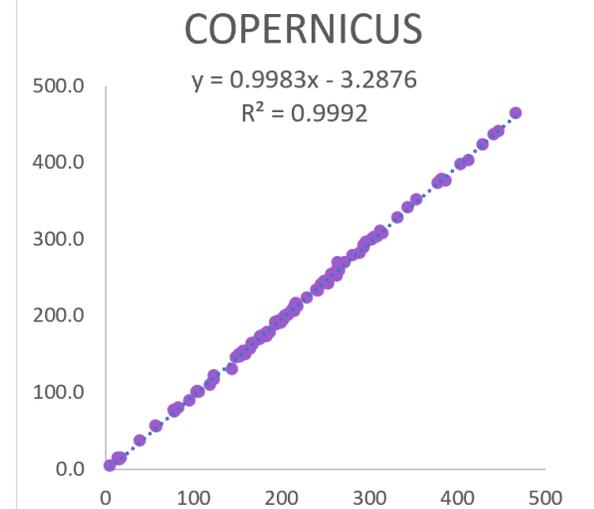
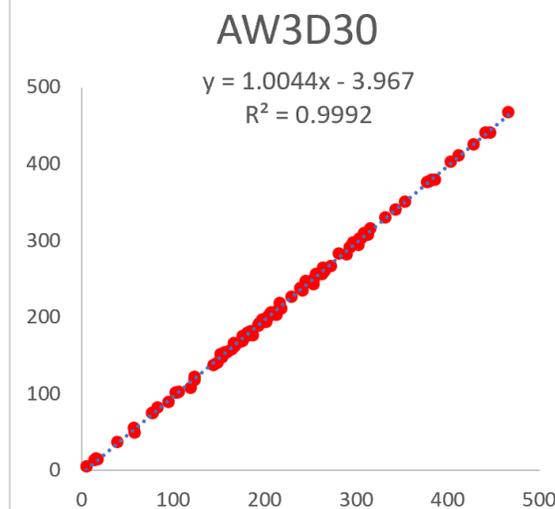
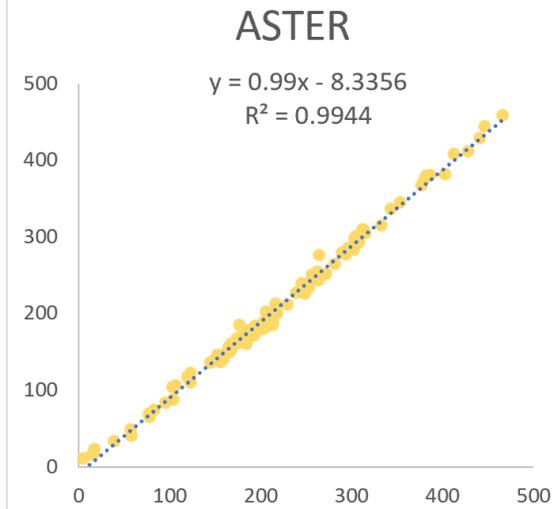
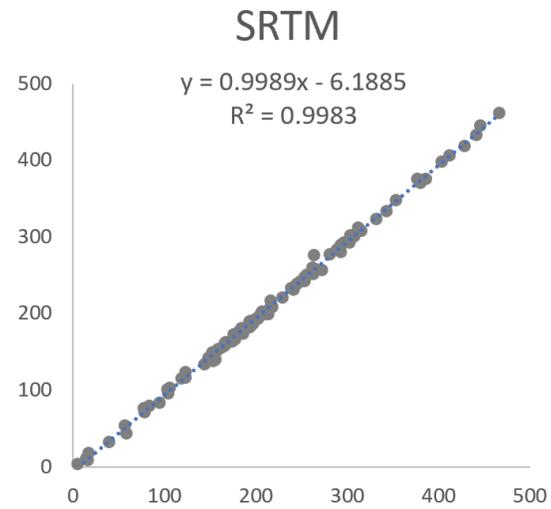




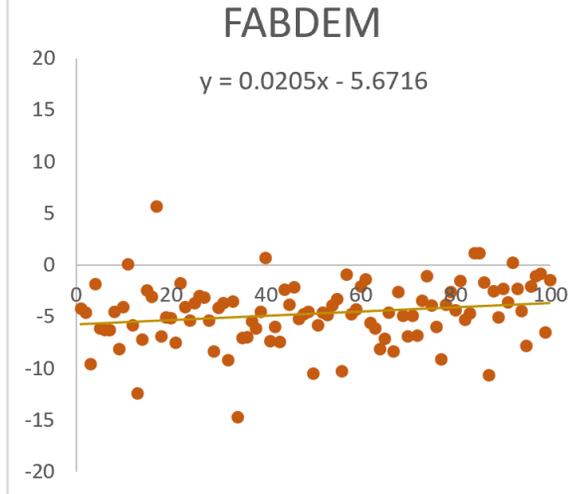
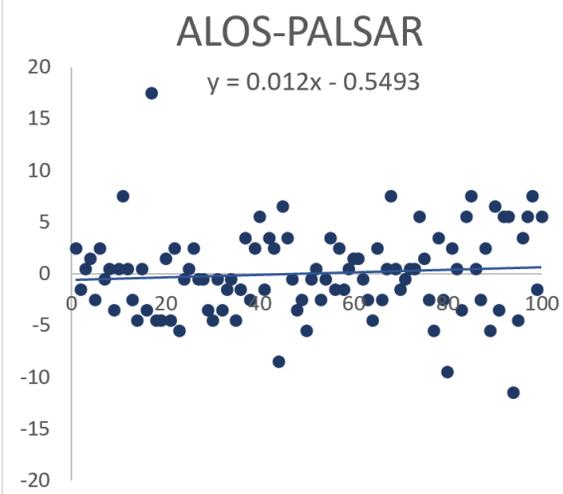
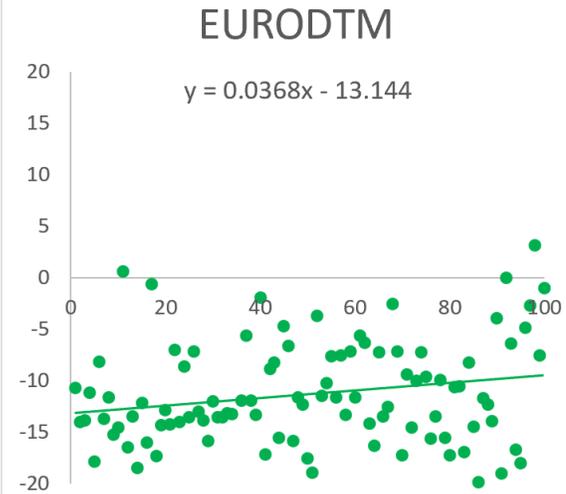
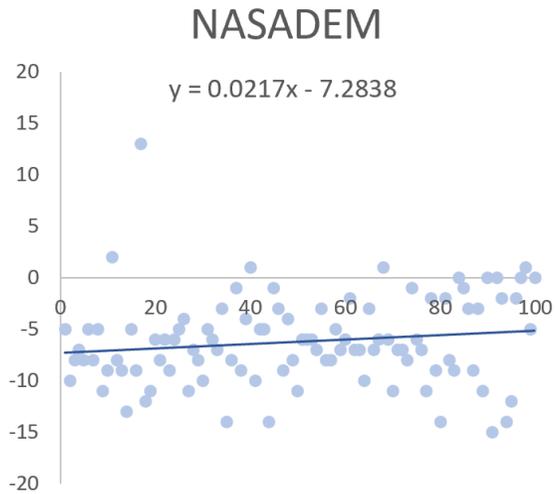
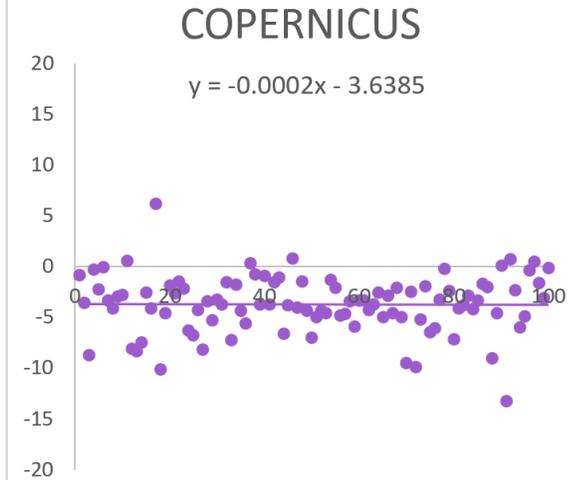
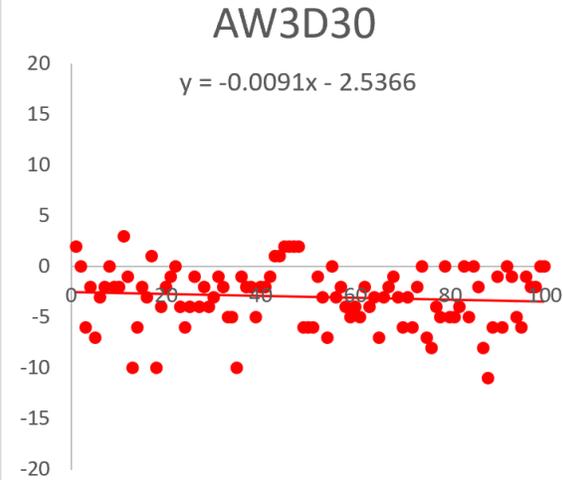
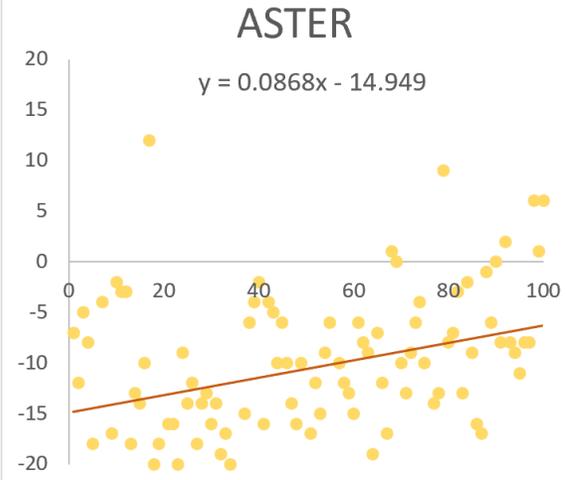
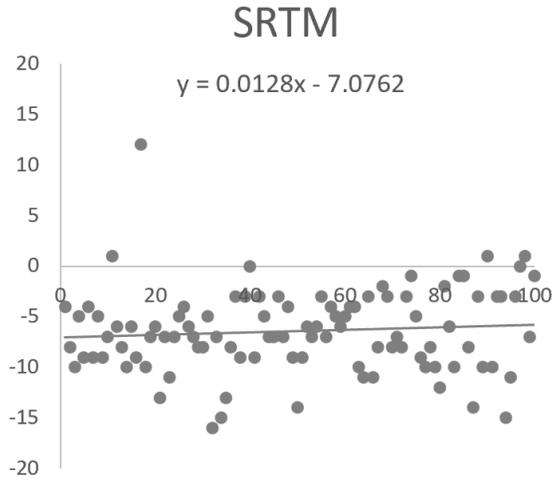
# Bacia do rio Arade – Análise pontual



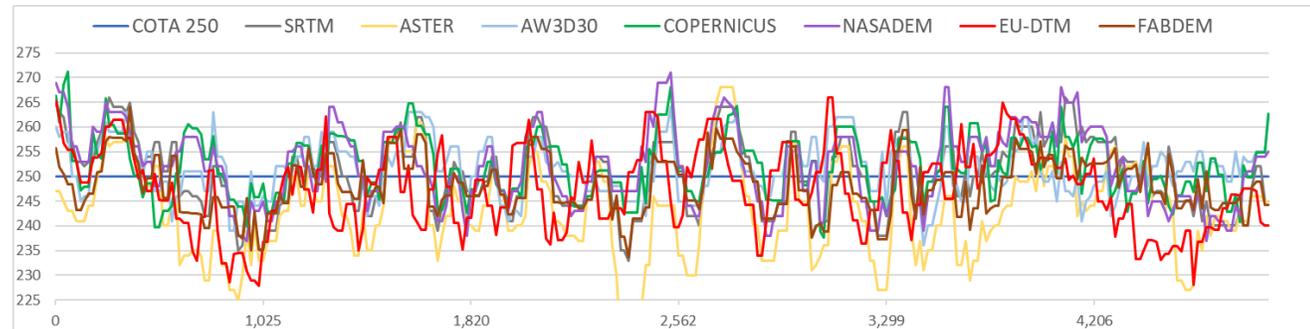
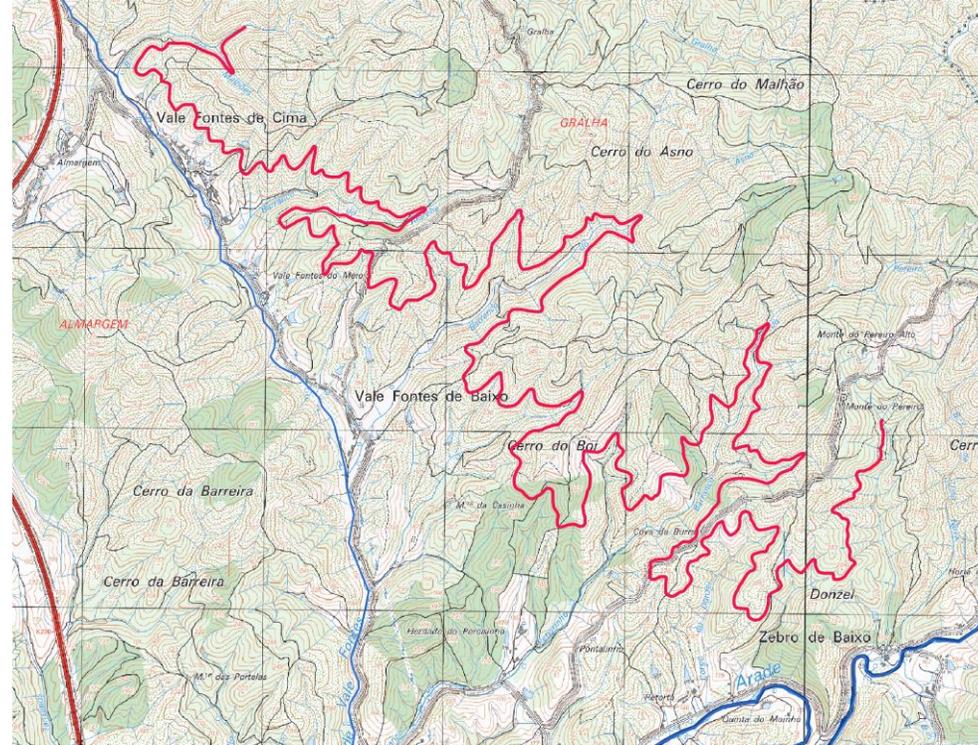
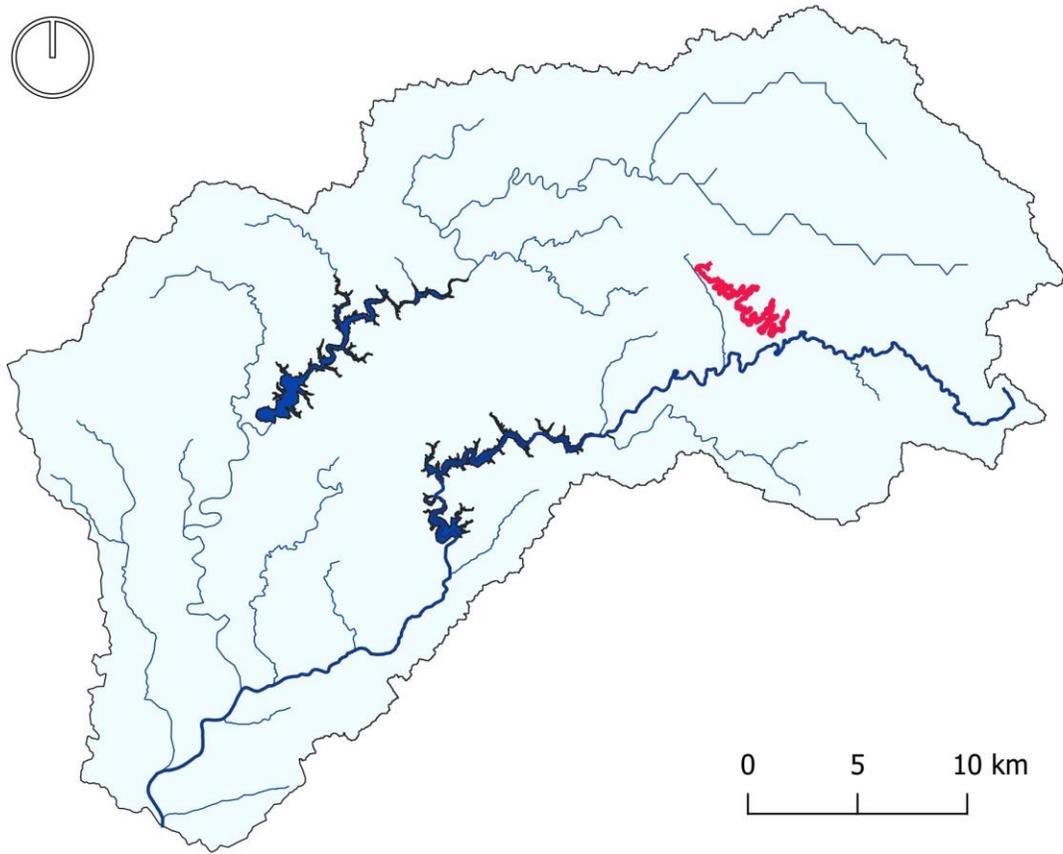
# Bacia do rio Arade – Análise pontual (correlação)



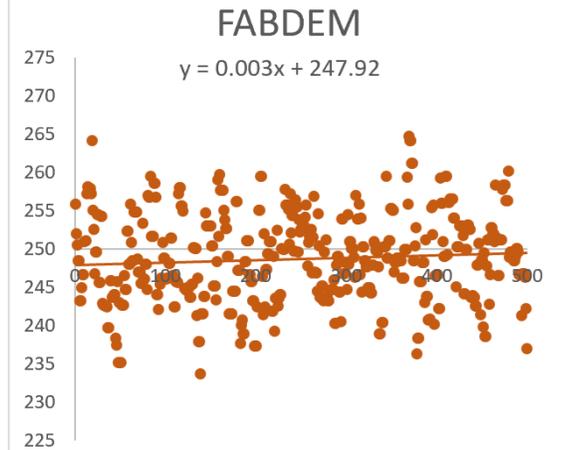
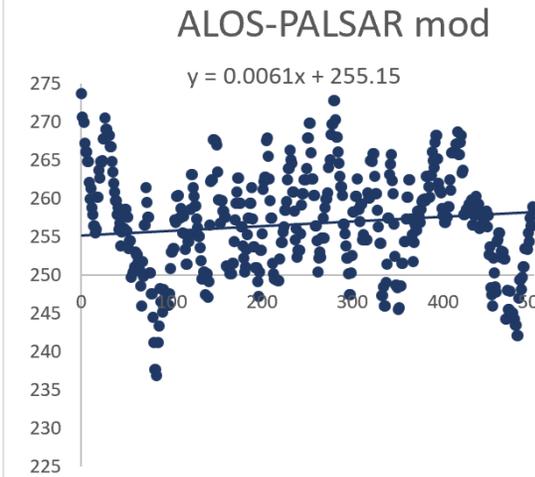
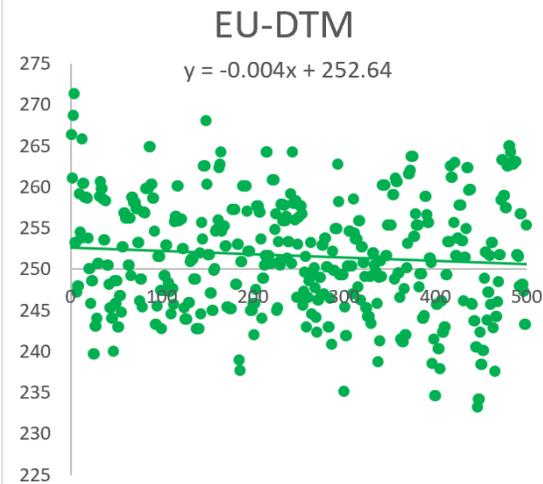
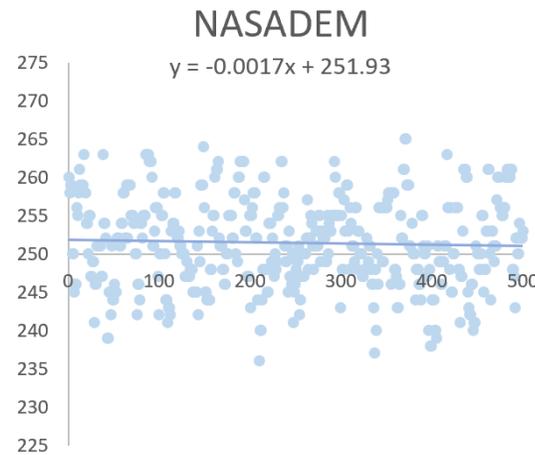
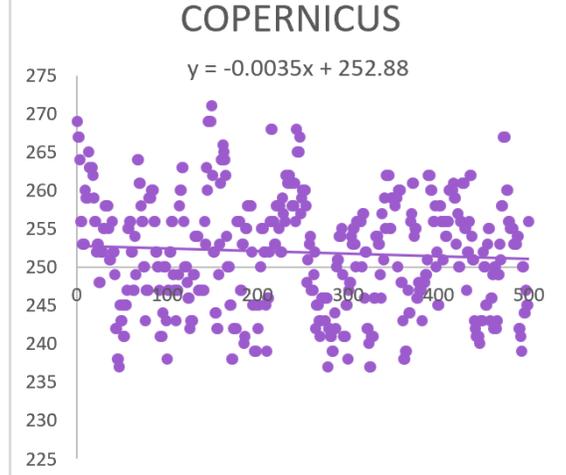
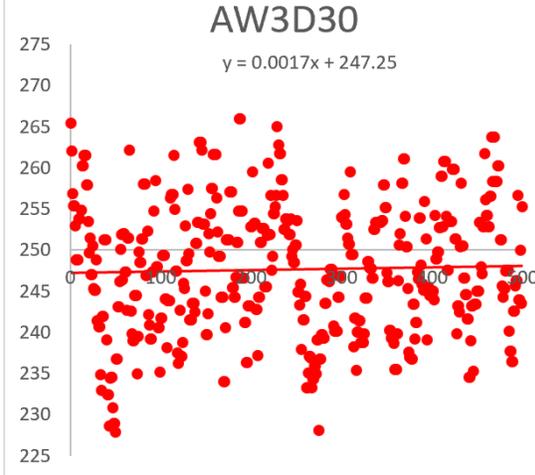
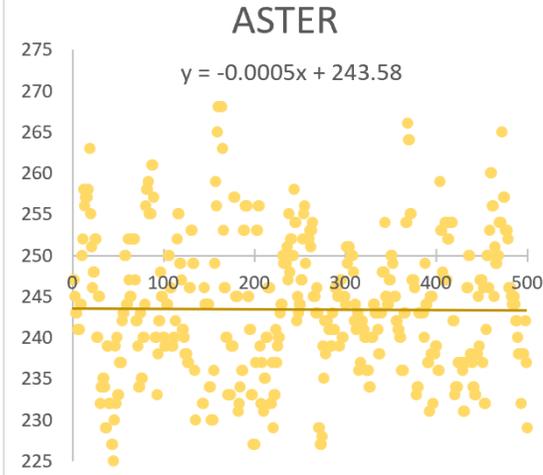
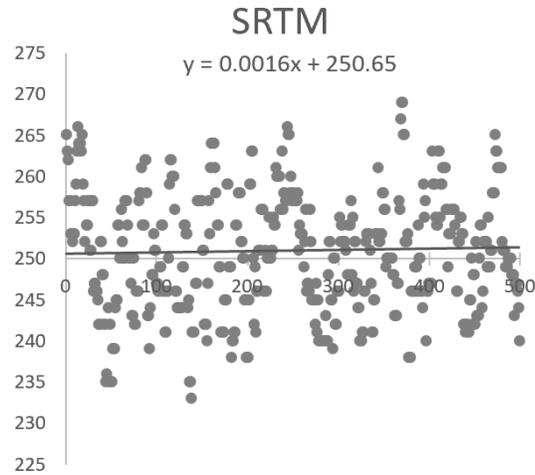
# Bacia do rio Arade – Análise pontual (diferença)



# Bacia do rio Arade – Análise linear



# Bacia do rio Arade – Análise linear (diferença)



## Resultados da comparação vertical (1D) com as cartas militares

NORTE - Rio Leça					
MDT/MDE	R <sup>2</sup>	EQM (m)		DP (m)	
		Pontos	Linha	Pontos	Linha
SRTM	0.9976	7.41	6.56	6.79	4.89
ASTER	0.9958	9.08	6.62	9.23	6.60
AW3D30	0.9994	3.48	3.56	3.53	4.82
COPERNICUS	0.9994	3.53	3.09	3.47	2.29
NASADEM	0.9977	6.60	6.39	6.66	2.39
EURODTM	0.9988	4.82	2.39	5.11	2.17
FABDEM	0.9991	4.20	2.24	4.28	2.16
ALOS-PALSAR*	0.9971	7.55	6.12	7.72	6.12

Nota\* - Depois de rebaixado 56,8 m

SUL - Rio Arade					
MDT/MDE	R <sup>2</sup>	EQM (m)		DP (m)	
		Pontos	Linha	Pontos	Linha
SRTM	0.9983	4.10	7.40	4.13	7.20
ASTER	0.9944	7.39	10.76	7.49	8.37
AW3D30	0.9992	2.86	6.11	2.91	5.91
COPERNICUS	0.9992	2.82	7.01	2.84	6.83
NASADEM	0.9982	4.25	7.30	4.3	7.02
EURODTM	0.9976	22.15	8.12	5.06	7.86
FABDEM	0.9991	2.99	5.90	3.02	5.86
ALOS-PALSAR*	0.9983	4.19	10.42	4.16	6.72

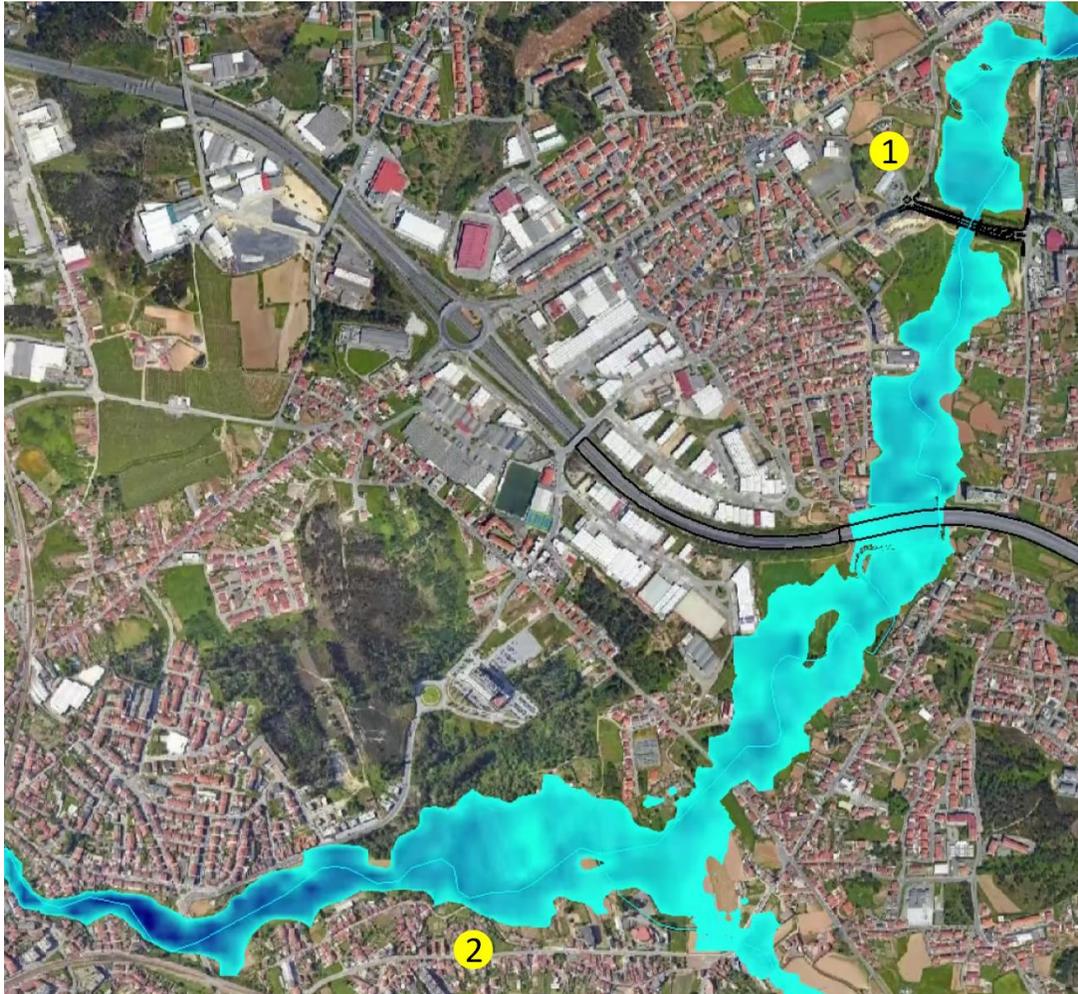
Nota\* - Depois de rebaixado 47,6 m

EQM – Erro quadrático médio

DP – Desvio padrão

# Bacia do rio Leça – Análise da área inundada

Simulação de uma inundação semelhante á de 4 de Novembro de 2023

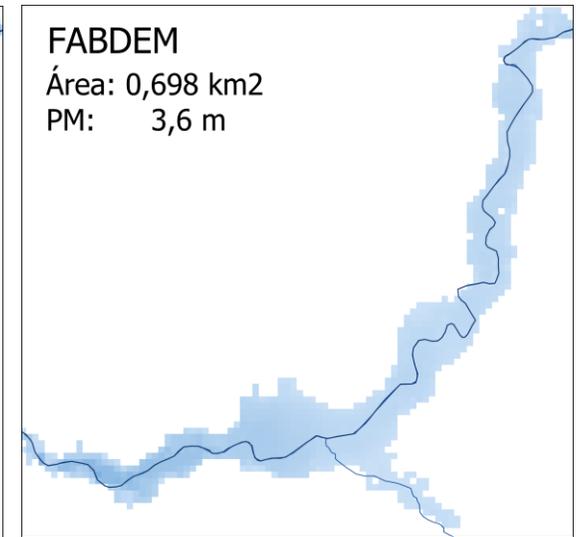
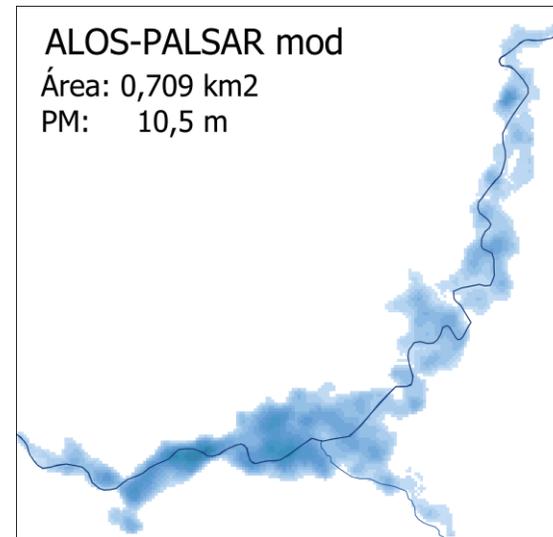
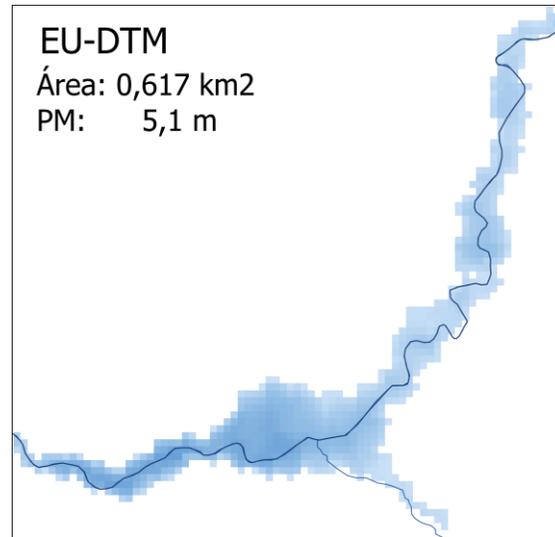
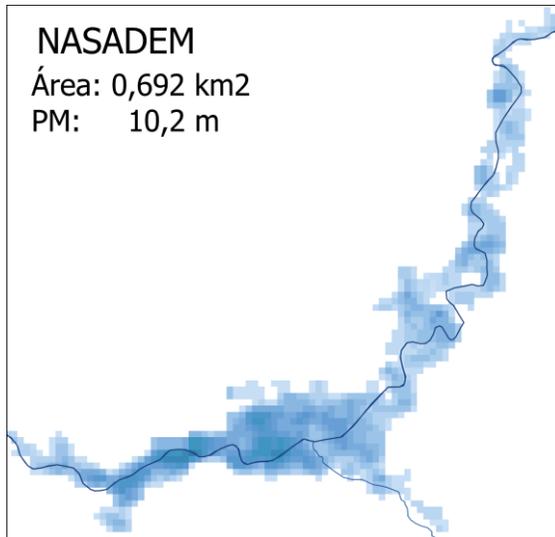
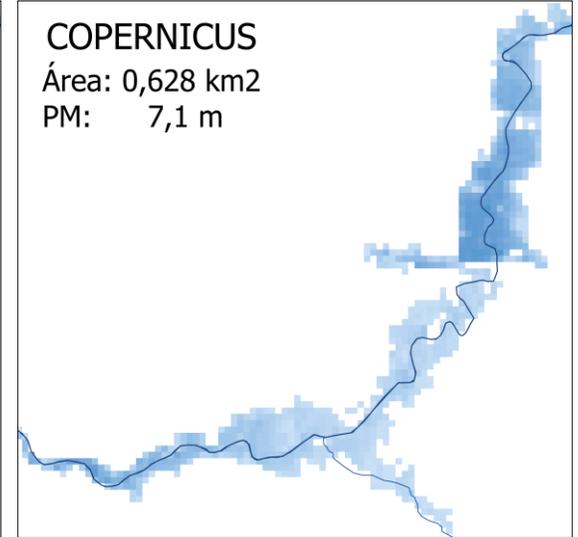
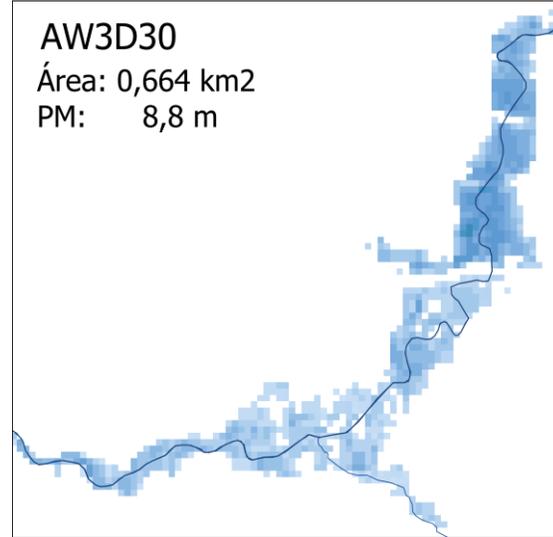
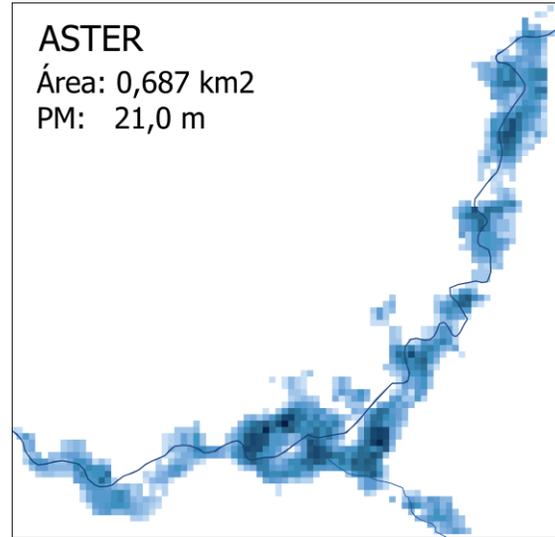
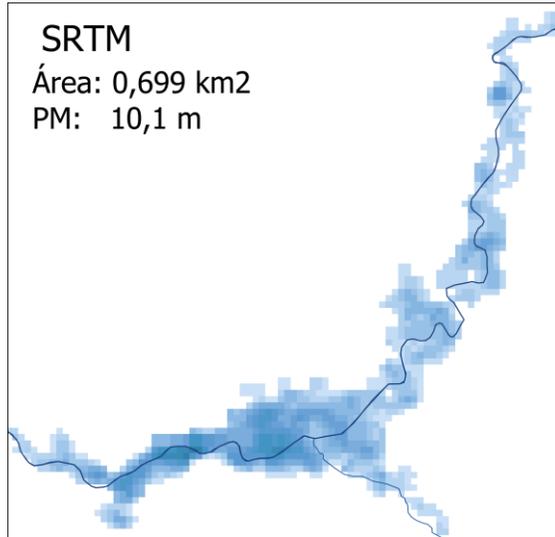


1

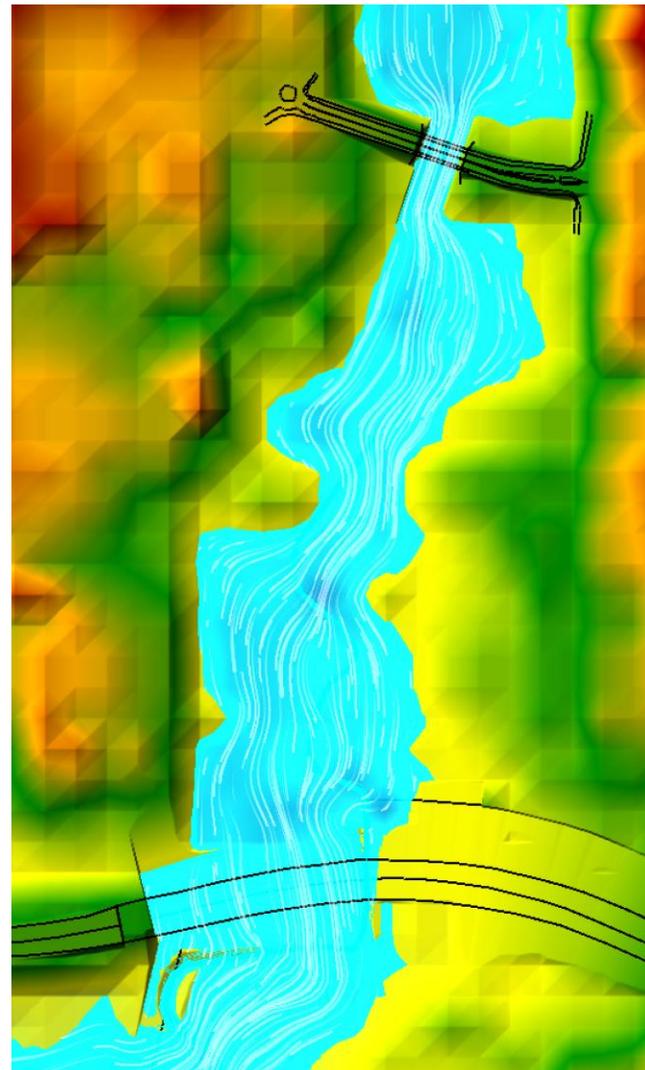
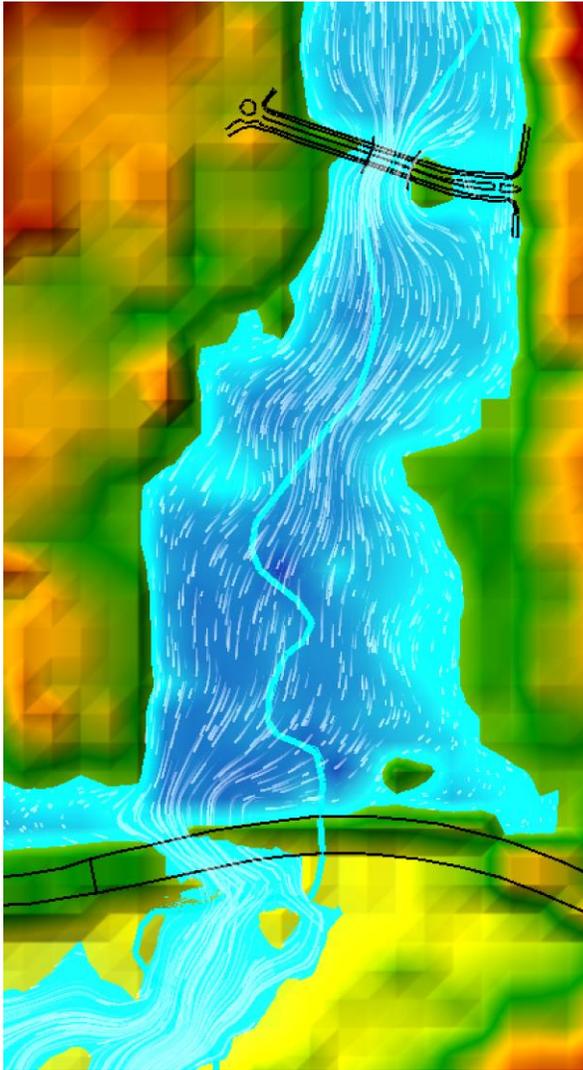


2

# Bacia do rio Leça – Análise da área inundada



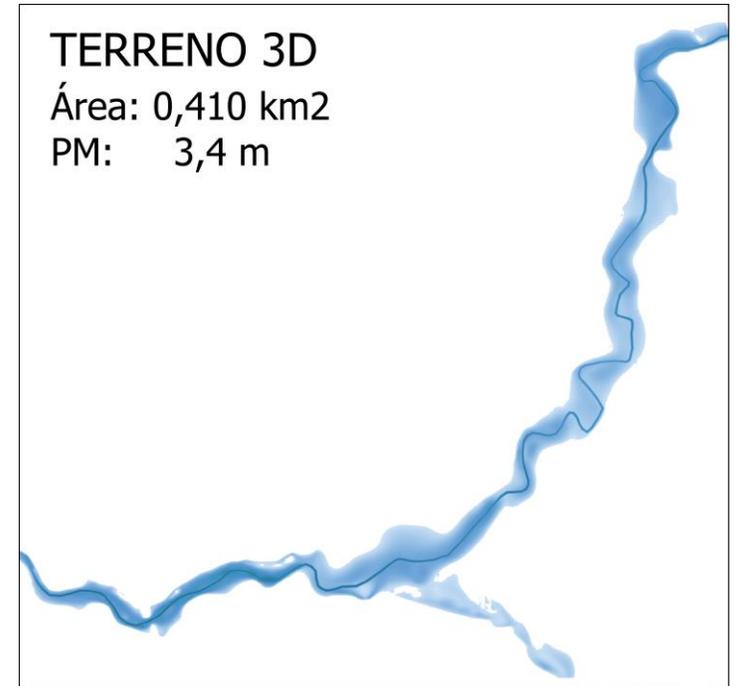
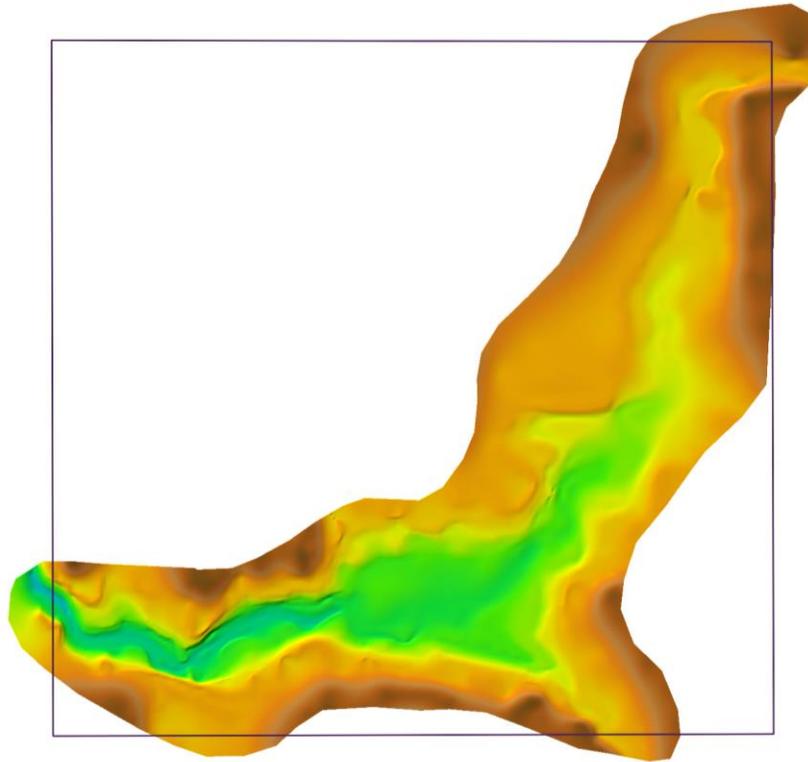
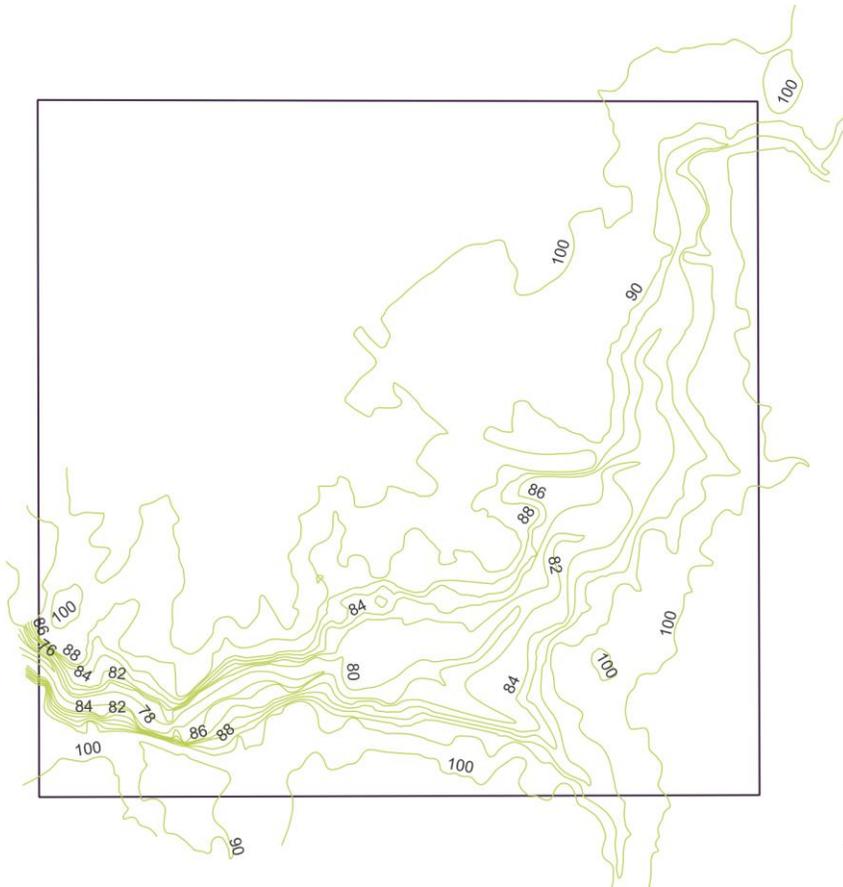
# Bacia do rio Leça – Análise da área inundada



COPERNICUS DEM



# Bacia do rio Leça – Modelação do terreno real



# Resultados Rio Leça

## Comparação com cartas militares

NORTE - Rio Leça					
MDT/MDE	R <sup>2</sup>	EQM (m)		DP (m)	
		Pontos	Linha	Pontos	Linha
SRTM	0,9976	7,41	6,56	6,79	4,89
ASTER	0,9958	9,08	6,62	9,23	6,60
AW3D30	0,9994	3,48	3,56	3,53	4,82
COPERNICUS	0,9994	3,53	3,09	3,47	2,29
NASADEM	0,9977	6,06	6,39	6,66	2,39
EURODTM	0,9988	4,82	2,39	5,11	2,17
FABDEM	0,0009	4,20	2,24	4,28	2,16
ALOS-PALSAR*	0,9971	7,55	6,12	7,72	6,12

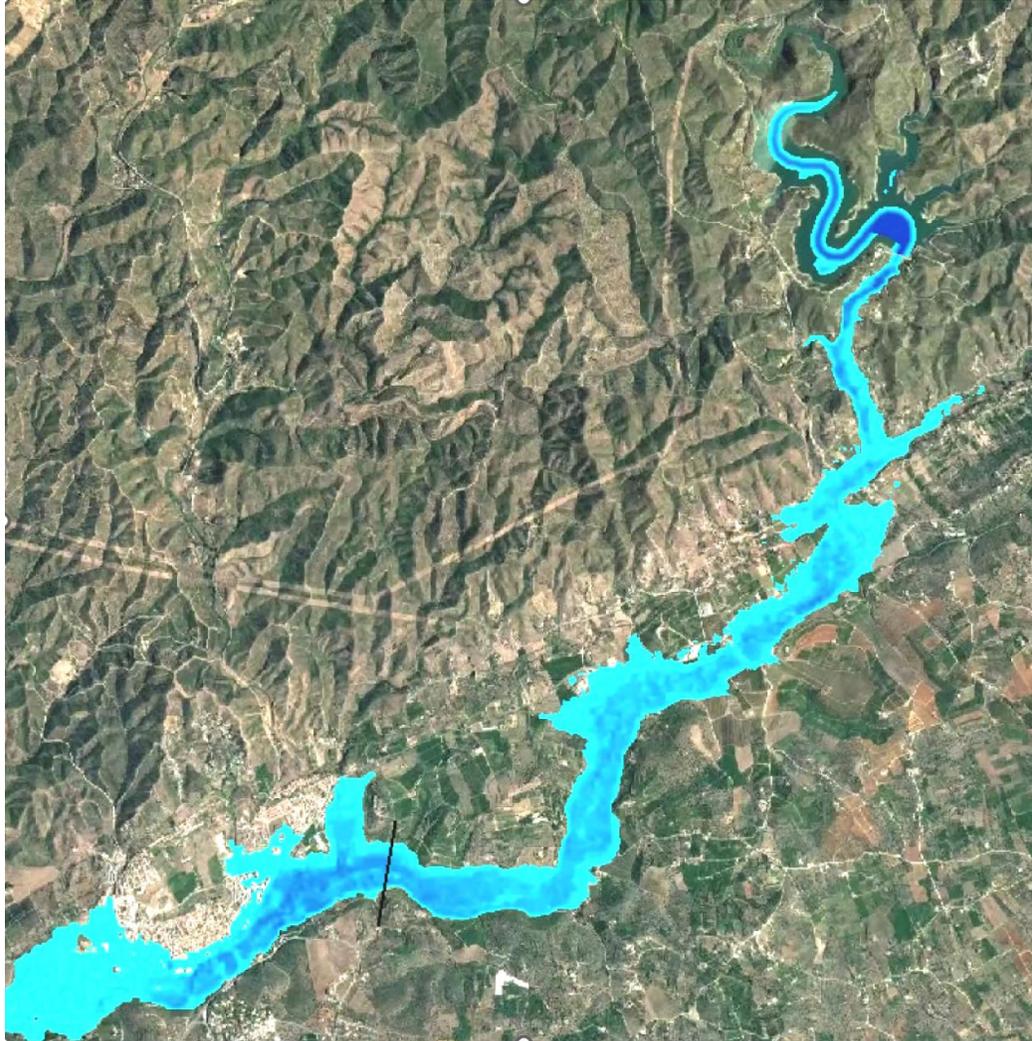
Nota\* - Depois de rebaixado 56,8 m

## Comparação de mapas de inundação

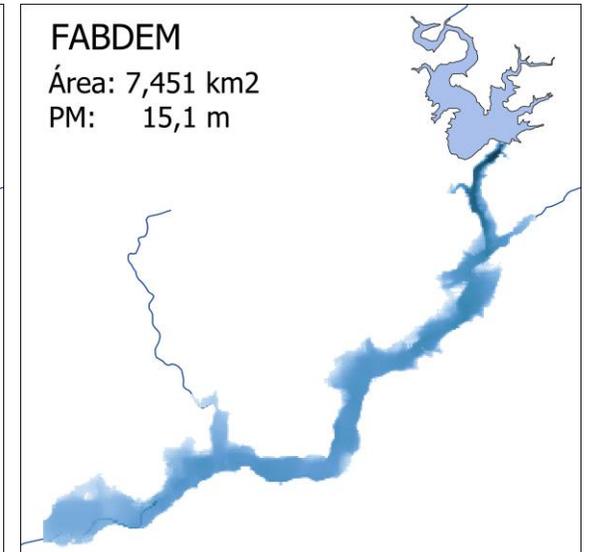
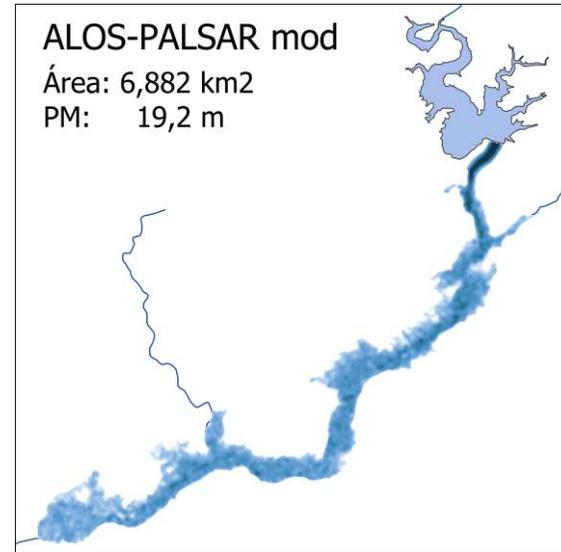
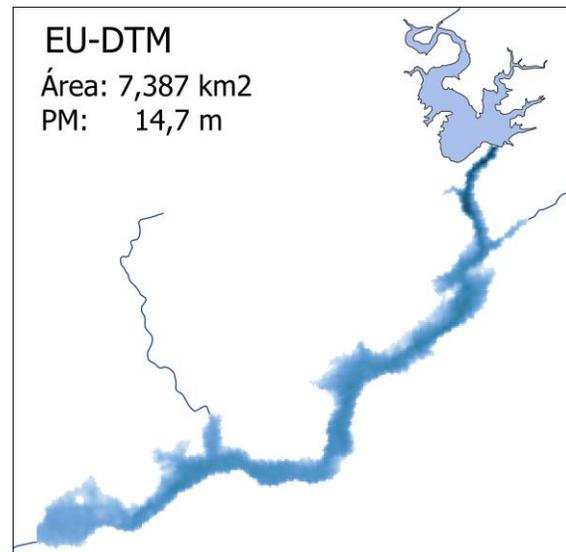
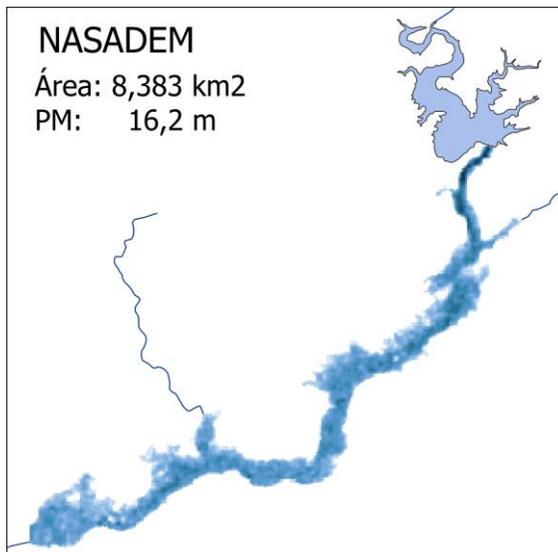
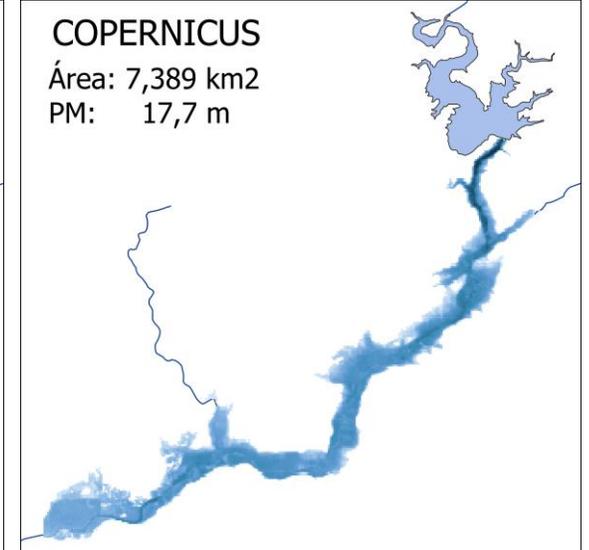
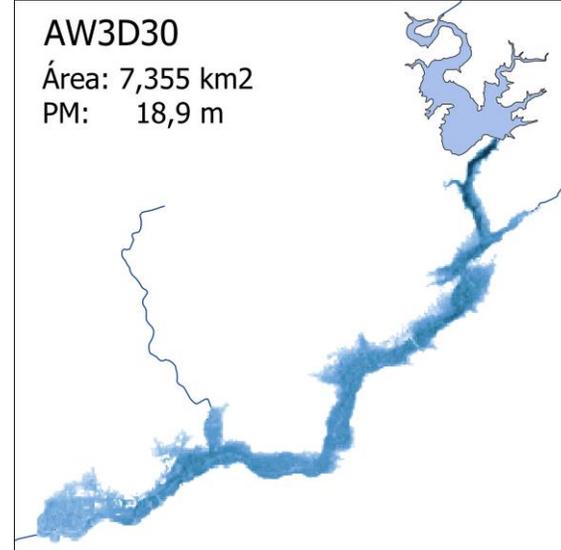
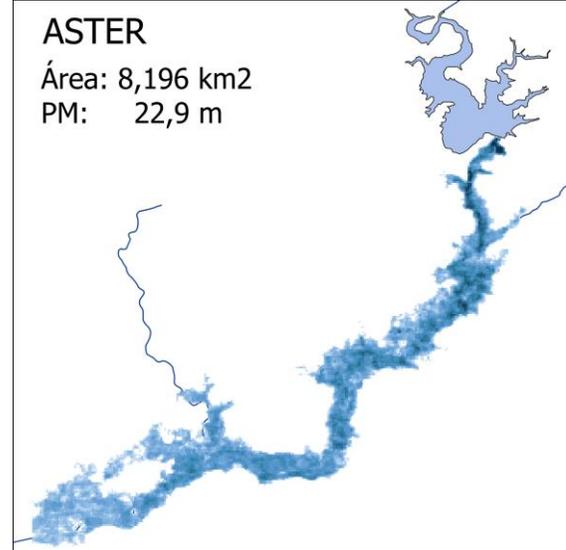
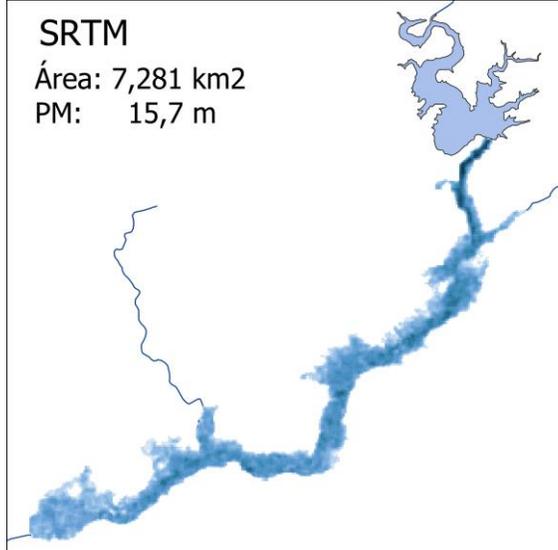
NORTE - Rio Leça						
MDT/MDE	Área Inundada (Km2)			Prof. Máx. Escoam.(m)		
	MDT	REAL	DIF.	MDT	REAL	DIF.
SRTM	0,699		0,289	10,0		6,6
ASTER	0,687		0,277	21,0		17,6
AW3D30	0,664		0,254	8,8		5,4
COPERNICUS	0,628	0,410	0,218	7,1	3,4	3,7
NASADEM	0,692		0,282	10,2		6,8
EURODTM	0,617		0,207	5,2		1,7
FABDEM	0,698		0,288	3,6		0,2
ALOS-PALSAR*	0,709		0,299	10,5		7,1

# Bacia do rio Arade – Análise da área inundada

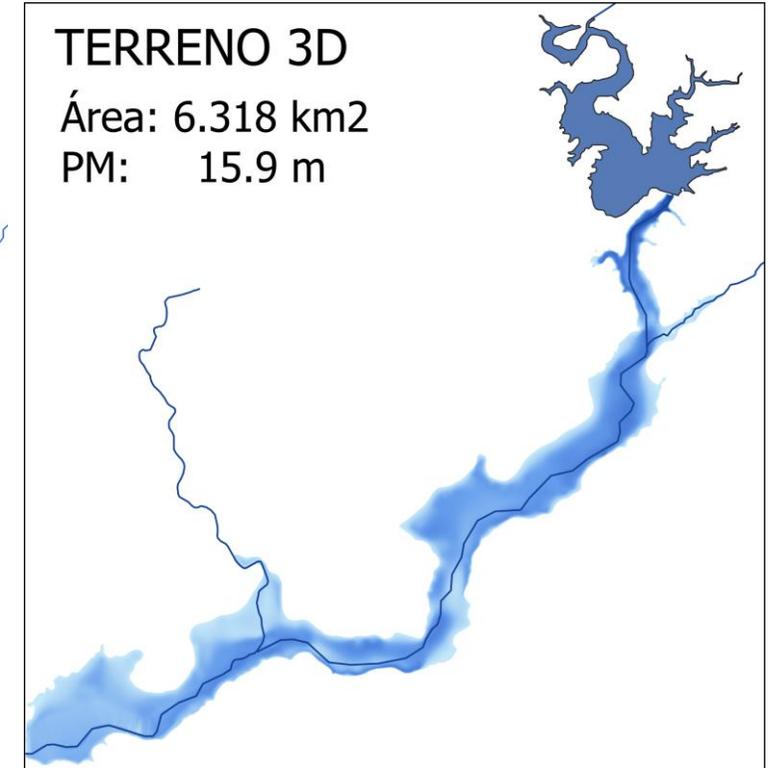
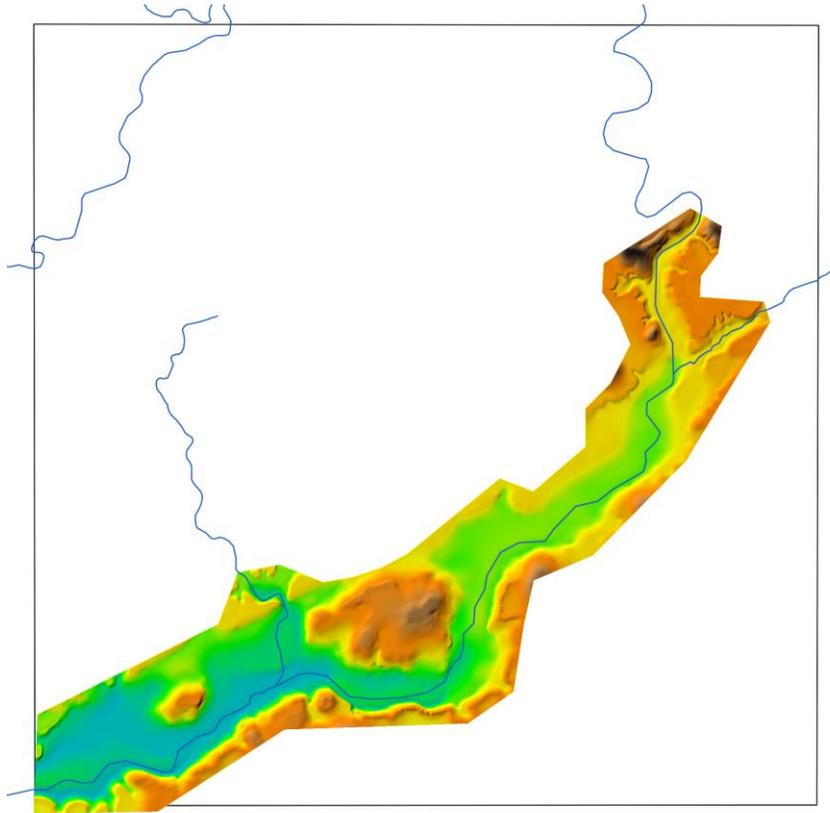
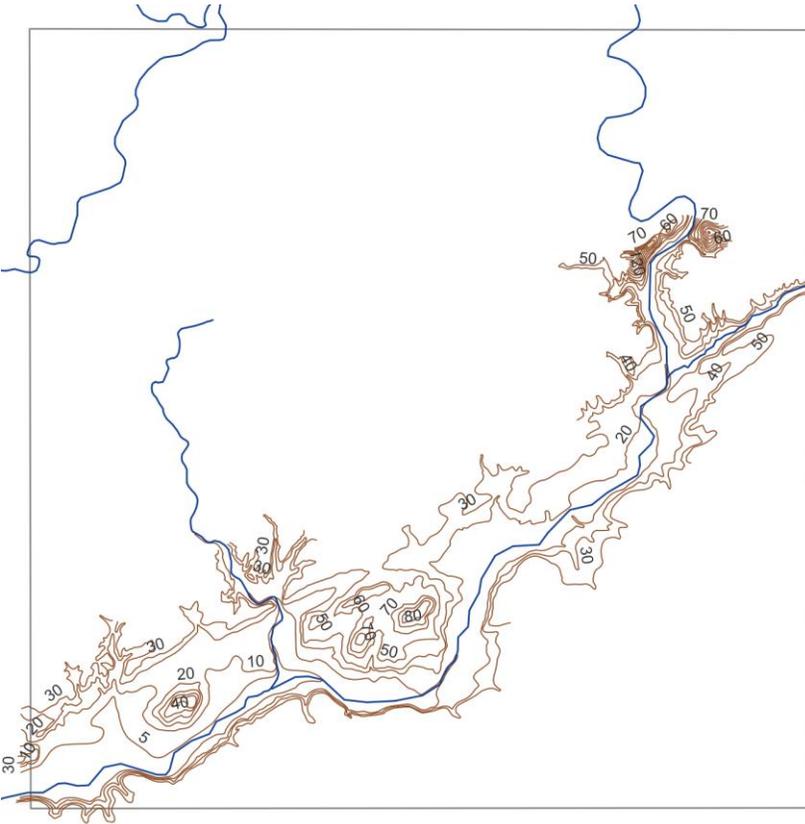
Simulação da inundação causada pelo rebentamento da barragem do Arede



# Bacia do rio Arade – Análise da área inundada



# Bacia do rio Arade – Análise da área inundada



# Resultados Rio Arade

## Comparação com cartas militares

SUL - Rio Arade					
MDT/MDE	R <sup>2</sup>	EQM (m)		DP (m)	
		Pontos	Linha	Pontos	Linha
SRTM	0,9983	4,10	7,40	4,13	7,20
ASTER	0,9944	7,39	10,76	7,49	8,37
AW3D30	0,9992	2,86	6,11	2,91	5,91
COPERNICUS	0,9992	2,82	7,01	2,84	6,83
NASADEM	0,9982	4,25	7,30	4,30	7,02
EURODTM	0,9976	22,15	8,12	5,06	7,86
FABDEM	0,9991	2,99	5,90	3,02	5,86
ALOS-PALSAR*	0,9983	4,19	10,42	4,16	6,72

Nota\* - Depois de rebaixado 47,6 m

## Comparação de mapas de inundação

SUL - Rio Arade						
MDT/MDE	Área Inundada (Km2)			Prof. Máx. Escoam.(m)		
	MDT	REAL	DIF.	MDT	REAL	DIF.
SRTM	7,281		0,963	15,7		0,2
ASTER	8,196		1,878	22,9		7,0
AW3D30	7,355		1,037	18,9		3,0
COPERNICUS	7,389	6,318	1,071	17,7	15,9	1,8
NASADEM	8,383		2,065	16,2		0,3
EURODTM	7,387		1,069	14,7		1,2
FABDEM	7,451		1,133	15,1		0,8
ALOS-PALSAR*	6,882		0,564	19,2		3,3

## CONCLUSÕES

- 1 - A modelação hidráulica tridimensional de linhas de água naturais, deve ser feita com modelos digitais do terreno com a máxima precisão, que representem, tanto quanto possível, o terreno natural.
- 2 – Os modelos digitais de grande precisão são caros, o que encarece o resultado final e sendo, por essa razão, normalmente utilizados apenas para áreas pequenas.
- 3 – Os MDT de acesso livre são uma opção viável para o modelamento de escoamentos superficiais, e tem vindo a ganhar popularidade, a partir de 2015, quando foi publicado o SRTM de 30 metros.
- 4 – O modelo pioneiro SRTM, foi ultrapassado em precisão e rigor geográfico pelos posteriores modelos ALOS WORLD e COPERNICUS e seus sub-produtos.
- 5 – O modelo FABDEM, sub-produto do COPERNICUS, parece ser o que mais se aproxima no terreno real em Portugal continental, devendo por essa razão ser, usado nos estudos de escoamento superficial.

Obrigado pela atenção.



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