IMPROVING THE CAPABILITIES OF 2D SHALLOW WATER MODELS FOR HYDROLOGICAL APPLICATIONS

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DOCTORAL THESIS DEFENCE Civil Engineering Ph.D. Program

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ESCUELA TÉCNICA SUPERIO INGENIEROS DE CAMINOS, CANALES Y DI JEPTOS ESCUELA TÉCNICA SUPERIOR CANALESY PUERTOS



THESIS FORMAT

COMPENDIUM OF ARTICLES

4 articles published in JCR indexed journals





INTERNATIONAL MENTION

Predoctoral stay of 1.5 months (2021): Luxembourg Institute of Science and Technology (LIST), Luxembourg.

<u>Predoctoral stay of 3 months (2022):</u> Institut de Recherche pour le Développement (IRD), Montpellier, France.



CONTENTS

- 1. Introduction
- 2. Motivation
- 3. Objectives
- 4. Research development
 - 4.1. DTM and mesh resolution
 - 4.2. Hydraulic structures
 - 4.3. Data assimilation
- 5. Conclusions
- 6. Future research



CONTENTS

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INTRODUCTION

HYDROLOGICAL MODELS



Hydrological cycle of a river basin





Numerical model

- 2. Motivation
- 3. Objectives
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 - 4.1. DTM and mesh resolution
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- 6. Future research

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MOTIVATION

Scarcity of works that explicitly study the relationship between mesh sizes and DTM resolution, and their impact on the result.



Models limited by not being able to include the presence of reservoirs and dams in the numerical modelling.



Scarcity of experimental data and numerical simplifications to include hydrodynamic computations at basin scale.



Need of reduction in uncertainty through the application of calibration techniques

> 3-7 parameters per element



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OBJECTIVES

MAIN OBJECTIVE

To contribute to the development of the hydrological module of the Iber model.



SPECIFIC OBJECTIVES

- **Specific Objective 1 (SO1)**: To evaluate the impact of Digital Terrain Model (DTM) resolution and mesh size on the result.
- **Specific Objective 2 (SO2)**: To evaluate the suitability of the lber model in simulating anthropogenic modifications within natural catchments. To develop a dedicated reservoir module.
- Specific Objective 3 (SO3): To explore the application new calibration techniques. To develop an automatic calibration tool to provide lber modelers with flexible calibration options.



RESEARCH DEVELOPMENT

- 1. Introduction
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RESEARCH DEVELOPMENT CHAPTER 02 SO1 - DTM AND MESH RESOLUTION CHAPTER 03 SO2 - HYDRAULIC STRUCTURES ARTICLE 01 ARTICLE 02 ARTICLE 03 ARTICLE (ESCI)



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- 4. Research development
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RESEARCH DEVELOPMENT



CHAPTER 02 SO1 - DTM AND MESH RESOLUTION



DTM AND MESH RESOLUTION





CHAPTER 02 SO1 - DTM AND MESH RESOLUTION



DTM AND MESH RESOLUTION







Environmental Physics Laboratory

CHAPTER 02 SO1 - DTM AND MESH RESOLUTION



DTM AND MESH RESOLUTION

Focus on diversity among the selected basins.

CASE STUDIES

Watershed	Location	Area (km²)	Mean slope (°)	Altitude range (m.a.s.l.)	Average annual precip. (mm)	Average annual maximum daily precip. (mm)
Sada	North-western Spain	25	7	0 - 190	1300	66
Landro	North- western Spain	199	15	0 - 1033	1400	61.8
Caldo	North- western Spain	38	20	370 - 1200	1800	41
Izas	North-Eastern Spain	0.33	16	2060 - 2280	2000	36
Genil	Southern Spain	3750	7	47 - 1438	500	42.8



Elevation (m.a.s.l.)





1) SADA







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4) IZAS

CHAPTER 02 SO1 - DTM AND MESH RESOLUTION



DTM AND MESH RESOLUTION

<u>PURPOSE</u>

Does the mesh size affect the outflow hydrograph of the catchment? And the DTM resolution?

METHODOLOGY

- 7 rainfall events in 4 hydrological basins
- 9 model configurations were run for each event by combining 3 freely distributed DTMs with 3 different mesh sizes.



Izas

0 0.2 0.4 km











Watershed	Mesh size (m)	Number of elements (K)	Mesh Id.
·	10	7	Coarse
Izas	2.5	116	Medium
	1	725	Fine
	100	9	Coarse
Caldo	25	127	Medium
	10	799	Fine
	100	45	Coarse
Landro	25	733	Medium
	10	4,587	Fine
	250	119	Coarse
Genil	62.5	1,933	Medium
	25	12,075	Fine



CHAPTER 02 SOI - DTM AND MESH RESOLUTION



DTM AND MESH RESOLUTION

<u>RESULTS</u>

Result of DTM05 and fine mesh was taken as reference and compared with the observations for validation.









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CHAPTER 02 SOI - DTM AND MESH RESOLUTION

DTM AND MESH RESOLUTION

RESULTS

- Vertical accuracy is more relevant than the horizontal resolution of the DTM.
- For DTM05 and DTM25, we find good results from a mesh resolution threshold close to 25 m
- In comparison with the fine mesh, the use of the medium mesh results in a reduction of 90% on the calculation time.









HYDRAULIC STRUCTURES













HYDRAULIC STRUCTURES: FLOW OVER WEIRS





ARTICLE 02		
- \ water		MDPI
Article Modelling V	Veirs in Two-Dimensional Shallow Water	Models
Gonzalo García-Alén	* 💿, Olalla García-Fonte, Luis Cea 💿, Luis Pena and Jerónimo Puertas	
	Department of Civil Engineering, Water and Environmental Engineering Group, Univer 15071 A Contra, Spain; Gallagarcial@udc.es (0.GF.); luis.cea@udc.es (L.C.); luis.p jeronimo.puertas@udc.es (2.P.) * Correspondence: g_glores@udc.es	sidade da Coruña, Elviña, ena@udc.es (L.P.);
	Abstract: 2D models based on the shallow water equations are widely However, these models can present deficiencies in those cases in which t	used in river hydraulics. heir intrinsic hypotheses

García-Alén, G., García-Fonte, O., Cea, L., Pena, L., Puertas, J., 2021. Modelling Weirs in Two-Dimensional Shallow Water Models. Water 13. https://doi.org/10.3390/w13162152



HYDRAULIC STRUCTURES: FLOW OVER WEIRS

EXPERIMENTAL WORK









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CEAMA Value and Environmental Engineering Group	GEAMA. Water and Environmental Engineering Group
Published June 28, 2021 Version v1	Published July 11, 2020 (Version v3
VAMONOS - Flow through bridges. Experimental data. Ces.Las [®] , Wa. Gabres [®] , Garcia-Alén, Gorcas [®] , Paestas, Jennero [®] , Pens, Las [®]	VAMONOS - Open-channel flow over weirs, Experimental data. Cacta Allin, Cacta Allin, Cacta - Mark, Calar - Parts, additro - Oca, Lai - O
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nterested in experimental data for the calibration of numerical models or the analysis of empirical discharge rat

Improving the capabilities of 2D shallow water models for hydrological applications - Doctoral thesis defence





HYDRAULIC STRUCTURES: FLOW OVER WEIRS

EXPERIMENTAL WORK













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• This fee coulde information and the experimental faithing. The transition can be and the advancements are appreciations of the experimental and the advancement a	This dates' is shouldn't holp that online at the basis. I hannya, basis final this is unclease at the basis of the operation that the operation of the operati

ARTICLE 02 MDPI Modelling Weirs in Two-Dimensional Shallow Water Models Gonzalo García-Alén * 0, Olalla García-Fonte, Luis Cea 0, Luis Pena and Jerónimo Puertas Department of Civil Engineering, Water and Environmental Engineering Group, Universidade da Coruña, Elvika, 15071 A Coruña, Spain; elalla garcia1@udc.es (U.G.-F.); kin.cea@udc.es (L.C.); kin.pena@udc.es (L.P.); eronimo.puertas@udc.es(3.P.) Correspondence: g.glores@udc.es Abstract: 2D models based on the shallow water equations are widely used in river hydraulics. However, these models can present deficiencies in those cases in which their intrinsic hypotheses are not fulfilled. One of these cases is in the presence of weirs. In this work we present an experimental dataset including 194 experiments in nine different weirs. The experimental data are compared to the numerical results obtained with a 20 shallow water model in order to quark and discrepancies that exist due to the non-fulfillment of the hydrostatic pressure hypothest. The experimental dataset presented can be used for the validation of other modelling approach

31 / 58



HYDRAULIC STRUCTURES: FLOW OVER WEIRS

PURPOSE

What is the most accurate methodology for modelling flow over weirs?

Experimental tests were modelled with the software lber using two different approaches:

METHODOLOGY

• Experimental campaign based on 2 flow conditions.















• Water depth was measured in a control point (CP) and with an automatic positioner.





(1) Using a specific internal discharge equation (classic formulation).



(2) Modelling the weirs as the topography of the flume.



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HYDRAULIC STRUCTURES: FLOW OVER WEIRS

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 $Q = C_d B (Z_U - Z_W)^{1.5}$

(2) Modelling the weirs as the topography of the flume.







HYDRAULIC STRUCTURES: FLOW OVER WEIRS

RESULTS (CP POINT)











HYDRAULIC STRUCTURES: FLOW OVER WEIRS

RESULTS (AUTOMATIC POSITIONER)











HYDRAULIC STRUCTURES: FLOW THROUGH BRIDGES





36 / 58



Cea, L., Vila, G., García-Alén, G., Puertas, J. & Pena, L. (2022). Hydraulic Modeling of Bridges in Two-Dimensional Shallow Water Models. Journal of Hydraulic Engineering. 148, 6022006. https://doi.org/10.1061/JASCEHY.1943.7900.0001992

ARTICLE 02	
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Article Modelling Weir	s in Two-Dimensional Shallow Water Models
Gonzalo García-Alén * ⁰ , 0	Dialla García-Fonte, Luis Cea 🤍, Luís Pena and Jerónimo Puertas
	Department of Civil Engineering, Water and Environmental Engineering Group, Universidade da Courla, Elvika, 15071 A Courla, Spann, elaita garcial Buckes (D.G. F_{22} bisi.cost@udc.es (L.C.): bisi.pens@udc.es (L.P.): jeronina paratras@udc.es (L.P.): # Correspondence: gdpom@udc.es
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HYDRAULIC STRUCTURES: FLOW THROUGH BRIDGES

PURPOSE

What is the most accurate methodology for modelling flow through bridges?

METHODOLOGY

- Set of 32 experimental test conducted with four bridge geometries.
- Water depth was measured in a control point (CP) and with the automatic positioner.
- Four different test conditions: overtopped, fully pressurized, partially pressurized and free.

(2) the more recent extension of the two-component pressure approach (TPA) applied by Cea and López-Núñez (2021).









37 / 58

• All the experimental tests were reproduced in Iber using two different approaches to account for the deck:

(1) the commonly used internal condition for bridges (ICB)











HYDRAULIC STRUCTURES: FLOW THROUGH BRIDGES

RESULTS (CP POINT)







Improving the capabilities of 2D shallow water models for hydrological applications - Doctoral thesis defence



HYDRAULIC STRUCTURES: FLOW THROUGH BRIDGES

RESULTS (AUTOMATIC POSITIONER)





bridge







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HYDRAULIC STRUCTURES: RESERVOIRS





Ingeniería del Agua 27.1 2023	García-Alén et ol. Implementación de embalses en cálculos hidrológicos con Iber [
Implementación de embal	ses en cálculos hidrológicos con Iber
Implementation of reservoirs	in hydrological calculations with Iber
Gonzalo García-Alén [©] ª1*, Orland	do García-Feal [©] a2. ⁶ , Luis Cea [©] a3 y Jerónimo Puertas [©] a4
Universidade da Coruña, Grupo de Ingeniería del (CITEEC), Elviña, 15071, A Coruña, España.	Agua y del Medio Ambiente, Centro de Innovación Tecnolóxica en Edificación e Enxeñaria Civil
b Centro de Investigación Mariña, Universidade de E-mail: a1* g.glores@udc.es, a2,b orlando@uvig	Vigo, Environmental Physics Laboratory (CIM-EPhysLab), Campus Auga, Ourense, 32004, España o.es, a3 luis.cea@udc.es, a4 jeronimo.puertas@udc.es.
*Autor para correspondencia	
Recibido: 11/11/2022 Aceptado: 18/01/2023 Po	ublicado: 31/01/2023
Citar como: Garcia-Alén, G., Garcia-Feal, O., Cea, del agua, 27(1), 59-72. https://doi.org/10.4995/	, L., Puertas, J. 2023. Implementation of reservoirs in hydrological calculations with Iber. Ingenie Ia.2023.18750

ARTICL	E 02		
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Modelling	Weirs in Two-Dimensio	nal Shallow Water Models	
Sonzalo Garcia-A	Uén * , Olalla García-Fonte, Luis Cea , L Department of Civil Engineering, Water an 15071 A Constik, Spain; cialia,garcial@u jeronimo.puartas@udc.es.(J.P.)	uis Pena and Jerónimo Puertas nd Environmental Engineering Group, Universidade da Coruña, Elviña, do es (0.6. \mathcal{F}_{2} baix.ceal(bid.es 1, \mathcal{E}_{2} baix.genal(bid.es 1, \mathcal{P}_{2}	
	ARTICLE 03		CI
	Hydraulic Two-Dimens Luis Cea; Gabriela Vila; Gor	Modeling of Bridges in sional Shallow Water Models nzalo García-Alér; Jerónimo Puertas; and Luis Pena	
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Int	troduction a east after of due leucitative det utilez hunder o	which in turn will affect the flood extension in the whole in the reach. Especially when the terrain is relatively to advance.	

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HYDRAULIC STRUCTURES: RESERVOIRS

PURPOSE

Development of a reservoir module in Iber to include their routing effect in the numerical simulations at basin scale.

METHODOLOGY

- Numerical implementation in the Iber model: reservoirs as virtual tanks and five different outflow structures.
- Development of a graphical user interface (GUI) integrated in the Iber preprocess and postprocess interface.
- Genil river basin and the Iznájar reservoir as study case









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GUI INTEGRATED IN IBER

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HYDRAULIC STRUCTURES: RESERVOIRS

<u>RESULTS</u>

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Hydrographs calculated at the watershed outlet point (P1) and at the outlet of the Iznájar reservoir (P2):







- <u>Hypothesis 0</u>: Model without reservoir.
- <u>Hypothesis 1</u>: Initial reservoir level equals spillway crest level.



• <u>Hypothesis 2</u>: Initial reservoir level equals spillway crest level and three bottom outlets.



• Hypothesis 3: Initial reservoir level equals spillway crest level and discharge defined by a user-defined drainage curve.



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ing Weirs in Two cia-Alén * [©] , Olalla Garcia-F Department of / 19271 A Comb	D-Dimensional Shallow Water Models
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Tw Luis Cea;	Hydraulic Modeling of Bridges in o-Dimensional Shallow Water Models Gabriela Vila; Gonzalo García-Alén; Jerónimo Puertas; and Luis Pena
Abstract: The backwater methods to include the equations that are imple pressure approach, whic experimental data obtain that both methods can re less depindent on mode depthpatternsobserved Engineers.	ARTICLE (ESCI) Gerb Alter of Imperentiation endotes an advance beingers on the
Introduction	Implementación de embalses en cálculos hidrológicos con Iber Implementation of reservoirs in hydrological calculations with Iber
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	*Anar jour semigradheisi Recibilits 1212/2022 Assystatis 1202/2023 P. Addicado: 3120/20233 Char come Calcado: G. C. García Felda, O. Cau, L., Anartus, J. 2023. Implementation of reservoirs in hydrological calculations with Baer. Tigen del agene, 2713, 59–72. https://doi.org/10.4790/j.a.2023.10750



DATA ASSIMILATION







DATA ASSIMILATION





PARAMETER ESTIMATION MODEL (PEST)









water model. Journal of Hydrology. 621, 129667. https://doi.org/10.1016/j.jhydrol.2023.129667

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DATA ASSIMILATION: TEMPERED PARTICLE FILTER

PURPOSE

Development of a data assimilation technique based on the Tempered Particle Filter (TPF).

METHODOLOGY

- A total of 12 storm events.
- Joint assimilation of discharge and soil moisture data.
- Infiltration modelled with the Green & Ampt model.
- Sensitivity analysis of the parameters.
- TPF applied twice:
- (1) Using as first guess a set of random particles from their ranges of variation
- (2) Establishing the initial set of particles based on the hydrological antecedent conditions.



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neter	Range of variation in DA	
ultiplier (-)	0.5 – 5	
ım/h)	0.3 – 10	
nm)	55 – 355	\sqsubseteq
(-)	0.2 – 1	
nm)	0 - 30	-

Based on the SA results:				
Parameter	Range of variation in DA			
k_s (mm/h)	0.3 – 10			
$S_{r,0}$ (-)	0.2 – 1			
I_a (mm)	0 - 30			

lation of SMAP s	oil moisture data into a fully distributed hydrological model	
a tempered Pal	ticle Filter (TPF): the canoro basin in Spain as a test case	
onzalo García-Alén 🖽	Renaud Hostache ⁽²⁾ , Patrick Matgon ⁽²⁾ , Luis Cea ⁽⁴⁾ and Jerónimo Puertas ⁽⁵⁾	
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DATA ASSIMILATION: TEMPERED PARTICLE FILTER

<u>**RESULTS: (1) Frist application of TPF**</u>





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WORLD CONGRESS GRANADA, SPAIN 2022

Abst

19-24 June 2022

ARTICLE 04

Research papers

ARTICLE INFO

Keywords: Hydrodynamic modelling

Iber+ Flood forecasting Tempered particle fitter Shallow water equations Data assimilation

Proceedings of the 39th IAHR World

ata assimilation (DA) in physically-based hydrochytemic models is conditioned by the difference in te nd spatial scales of the observed data and the resolution of the model itself. In order to use remote and spatial scales of the observed data and the resolution of the model itself, an order data in small-scale hydrodynamic modelling, it is necessary to explore innovative DA ma a more plausible representation of the spatial, variability of the parameters and proce

present study, satellite-derived soil moisture and in situ-observed streamflow data w a high-reso- lution hydrological-hydrodynamic model based on the liber software, ur

Assimilation of SMAP soil moisture data into a fully distributed hydrological model using a Tempered Particle Filter (TPF): the Landro basin in Spain as a test case

Gonzalo García-Alén (3), Renaud Hostache (2), Patrick Matgen (3), Luis Cea (4) and Jerónimo Puertas (1)

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ABSTRACT

G. García-Alén.**, R. Hostache, L. Cea, J. Puertas *

Joint assimilation of satellite soil moisture and streamflow data for the

investidade da Coruño, Water and Environmental Engineering Group, Center for Technological Innovation in Construction and Civil Engineering (CITEEC), Computed

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DATA ASSIMILATION: TEMPERED PARTICLE FILTER

<u>RESULTS: (1) Frist application of TPF</u>





RESULTS: (2) Second application of TPF





DATA ASSIMILATION: PEST

1 Garcia-Alén et al. Simulación de inundaciones pluviales en el núcleo urbano de Sada (Galicia) con Iber y PEST 31A 2023 Linea Temática XX	
Simulación de inundaciones pluviales en el núcleo urbano de Sada (Galicia) con Ther y PEST	Ľ
García-Alén, G.a, Montalvo, C.a, Cea, L.a y Puertas, J.a	
* Universidade da Coruña, Grupo de Tegeniería del Agua y del Medio Ambiento, Centro de Innovación Tecnolóxica en Edificación e Enveñaria gibrerel/au-ce, a caños montalvolówca, es las cesalvados en el, inrovimo puertas@udc.es	
Línea temática (i) Hidrología y dinámica fluvial	
RESUMEN	
La calibración automática de modelos hidrológicos es crucial para comprender y gestionar eficazmente los recursos hidricos. En este estudio, se combina la herramienta de calibración PEST con el modelo hidrodinámico Dies tomando como caso de estudio núcleo urbano de Sada. Mediante la integración de ambos modelos ruméricos, se logra una calibración automática eficientry un análisis de sensibilidad de los parámetos. La interfaz gráfica de Der ha sido extendida para incluir la construcción de los arphinos	
de PEST desde el propio modelo de Iber, lo que simplifica el proceso de calibración. Esto permite al usuario de Iber especificar parámetros a calibrar y los valores observados para su comparación con los resultados simulados. La combinación de PES	
García-Alén G. Montalvo, C. Cea, L. & Puertas, L. (2023). Simulación de inundaciones pluviales	
na né núcleo urbano de Sada (Galicia) con Iber y PEST, in: VII Jornadas Ingeniería Del Agua (JIA). L'artagena, Spain. 18-19 October 2023.	
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PEST: Automatic calibration in fully distributed hydrological models on the 2D shallow water equations

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a Coruñ" a, Water and Environmental Engineering Group, Center for Technological Innovation in Construction and Civil Engineering (CITEEC), 6° a, 15071, A Coruñ" a, Spain

taniet P Ames Calibrating physically based hydrological models manually is time calibration tools have become prevalent in these models; however, i	e-consuming and challenging. Automatic its effective use requires not only
knowledge of the calibration procedure itself, but also understanding the study, we introduce Iber-PEST, a novel framework com certainty analysis package, PEST, with Iber, a 2D model based on the its capabilities by successfully calibrating eight storm events in northworks (mean NSE caula to 0.68). Furthermore, bas analysis the iteration of the store of	the structure of the model input an output bining the parameter estimation and up shallow water equations. We denote vestern Spain's basins, achieving the ensemble smoother include

án, G., Montalvo, C., Cea, L., & Puertas, J. (2024). Iber-Pest: Automatic Calibration in Juted Hydrological Models Based on the 2d Shallow Water Equations. Environmental & Software, 106047. <u>https://doi.org/10.1016/j.envsoft.2024.106047</u>





DATA ASSIMILATION: PEST

PURPOSE

To develop an automatic calibration tool integrated in Iber: Iber-PEST

🕽 lber PEST

METHODOLOGY

- Development of a graphical user interface (GUI) integrated in the lber preprocess and postprocess interface.
- Assimilation of water elevation in Sada and discharge in Landro.
- Calibration of four storm events in each basin.
- Infiltration modelled with the SCS-CN model (Sada) and the Green & Ampt model (Landro).
- Calibration of 4 parameters with PEST (basic capabilities) and PESTPP-IES.



: MandeoPEST_caso4







IBER-PEST FRAMEWORK





Simulación de inundaciones pluviales en el núcleo urbano de Sada (Galicia) con Iber v PEST

García-Alén, G.a. Montalvo, C.a. Cea, L.a.v Puertas, J.a.

Universidade da Coruña, Grupo de Ingeniería del Agua y del Medio Ambiente, Cantro de Innovación Tecnolóxica en Edificación e Enveilaria ITEEC, Campos de Elvíña, 15071 A Coruña, España. edivición, cataloximontalo/guduce, hai, sociaguación, es, promino, puertas@uduces



Iber-PEST: Automatic calibration in fully distributed hydrological models based on the 2D shallow water equations

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Universidade da Cend" a. Water and Environmental Engineering Group. Center for Technological Innovation in Construction and Civil Engineering (CITEEC). Compute de Divil" a. 15071, A Const" c. Spain

ARTICLE INFO	A B S T R A C T
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Keywonds: Hydrological modelling Iber+ 20-SWE PEST=+	Innovietige of the calibration procedure itself, but also understanding the structure of the model input an instance of the calibration procedure itself, but also understanding the structure of the model input and cartining analysis parkage, PEST, but them, a 20 model based on the shallow water equations. We de- tis capabilities by successfully calibrating eight storm events in northwestern Spari's basin, achieving multis finance 306 equals to 400. Whethermore, but candidation the handlow meetils watershall included multis finance 300 equals to 400. Whethermore, but candidation the handlow meetils watershall included and the store of the stor



DATA ASSIMILATION: PEST

RESULTS: PEST



Event	NSE	N° Iber runs
E1	0.99	221
E2	0.61	297
E3	0.89	267
E4	0.95	177

Landro





CONFERENCE 02



Simulación de inundaciones pluviales en el núcleo urbano de Sada (Galicia) con Iber v PEST

García-Alén, G.a. Montalvo, C.a. Cea, L.a.v Puertas, J.a.

Universidade da Coruña, Grupo de Ingeniería del Agua y del Medio Ambiente, Centro de Ennovación Tecnolóxica en Edificación e Enxelharia el (CITEEC). Carnos de Elhía, 15073. A Coruña, España. Torrello Lóna, carlos montalo degluca, mís con ejevorimo puertas @udc.es



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Event

NSE

0 88

N° Iber runs

297

172

178

169





DATA ASSIMILATION: PEST

RESULTS: PESTPP-IES

Reduction of 36.7%, 54.4%, 47.6% and 20.9% in the number of simulations required to calibrate the event E1, E2, E3 and E4, respectively.







June 2024

52 / 58

Simulación de inundaciones pluviales en el núcleo urbano de Sada (Galicia) con Iber v PEST García-Alén, G.a. Montalvo, C.a. Cea, L.a.v Puertas, J.a. Universidade da Coruña, Grupo de Ingeniería del Agua y del Medio Ambiente, Centro de Innovación Tecnolóxica en Edificación e Enxeñaria (ICITEEC), Campus de Ehrla, 15071 A Coruña, España. Intergliducies, catalus interalidudicas in Júlic Aguado en Senta Budoces PREPRINT Environmental Modelling and Software 177 (2024) 104047 La calibraci este estudi Contents lists available at ScienceDirect núcleo urbi Environmental Modelling and Software anàlisis de de PEST de Entell iournal homenage:

Garcia-Alón et al. | Simulación de inundaciones aluvisles en el núcleo urbano de Sada (Galicia) con Iber y PEST

CONFERENCE 02

Iber-PEST: Automatic calibration in fully distributed hydrological models based on the 2D shallow water equations

G. García-Alén,º C. Montalvo, L. Cea, J. Puertas

Universidate do Cenvil" a. Water and Environmental Eligineering Group. Center for Technological Innovation in Construction and Clini Eligineering (CITEEC). Compute de Dinti" a. (307), A Couvil" a. Spain

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CONCLUSIONS

- 1. Introduction
- 2. Motivation
- 3. Objectives
- 4. Research development
 - 4.1. Case studies
 - 4.1. DTM and mesh resolution
 - 4.2. Hydraulic structures
 - 4.3. Data assimilation
- 5. Conclusions
 - 6. Future research



June 2024

- 2. Motivation
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CONCLUSIONS

DTM AND MESH RESOLUTION ANALYSIS

The vertical accuracy of the DTM has a greater effect on the outflow hydrograph of the model than the horizontal resolution.

Threshold of 25 m















June 2024

- 2. Motivation
- 3. Objectives
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CONCLUSIONS

HYDRAULIC STRUCTURES

Weirs: classical formulations led to better results than the modelling as the flume topography.

Bridges: when no calibration data is available, TPA method is more accurate than the ICB approach.







<u>Reservoirs</u>: Iber can now incorporate the routing effect of reservoirs in basin-scale hydrological models.





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CONCLUSIONS

DATA ASSIMILATION

Successful application of 2 calibration techniques to reduce model uncertainty.

Hydrological parameters can be related with the antecedent conditions of the basin







lber now incorporates a dedicated tool to facilitate the calibration of basin-scale hydrological models.

> Iber PEST



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Ko Hy Line No Te Sh RES	Iber-PEST: Auto based on the 2D	matic calibration in fully distributed hydrological models shallow water equations
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Improving the capabilities of 2D shallow water models for hydrological applications - Doctoral thesis defence

1. Introduction

- 2. Motivation
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- 6. Future research

Analysis of the influence of the DTM and mesh size in depth and velocity maps

FUTURE RESEARCH



Coupling of Iber with a 3D nonhydrostatic free surface model (DualSPHysics, for example)







model calibration.

Explore new data assimilation techniques

to reduce the computational cost of



June 2024

Thank you for your attention

IMPROVING THE CAPABILITIES OF 2D SHALLOW WATER MODELS FOR HYDROLOGICAL APPLICATIONS

Gonzalo García-Alén Lores

DOCTORAL THESIS DEFENCE Civil Engineering Ph.D. Program

> Supervisors: Luis Cea Gómez Jerónimo Puertas Agudo

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