

Avances en el desarrollo del modelo Iber+

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FLOODs 2022

Ourense: 4 y 5 de octubre

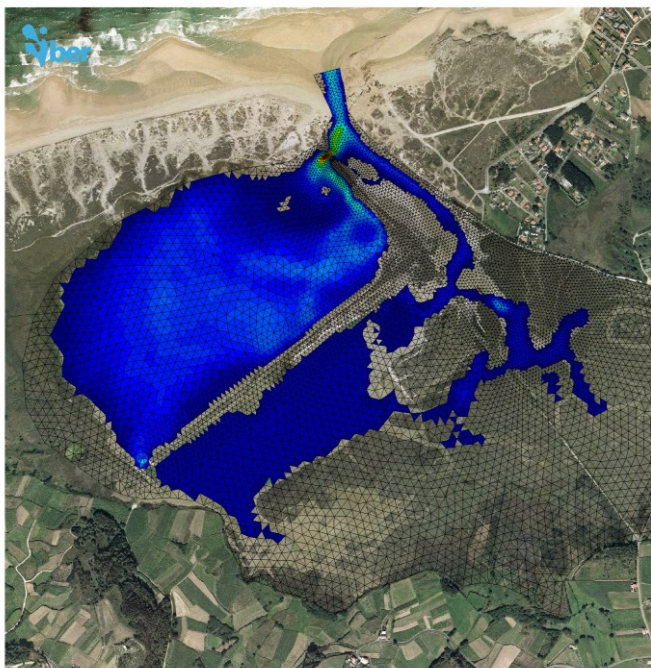


Las inundaciones, uno de los desastres naturales más peligrosos.

Se calcula que en el último siglo han causado más de 100.000 muertes y miles de millones de euros en pérdidas.



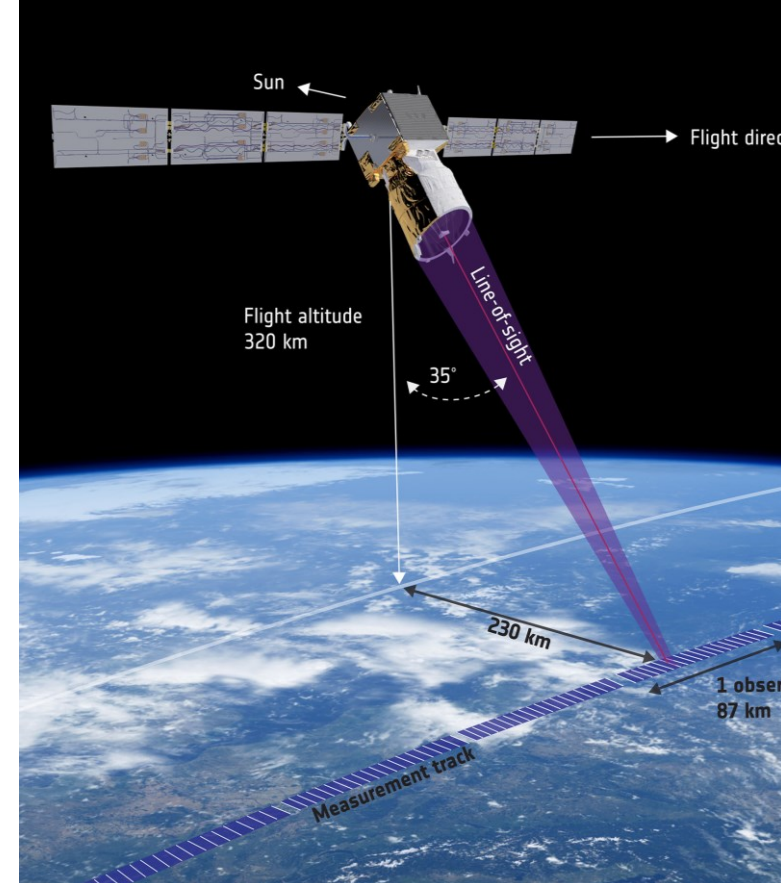
Aumentan en frecuencia y gravedad debido principalmente al cambio climático y por cambios en los usos de suelo.



ew (ESC to quit).
ew (ESC to quit).

Nodes: 8K, Elements: 16K

Render: flat



Una adecuada gestión de los recursos hídricos proporciona múltiples beneficios como protección frente a las inundaciones.

Esto requiere la obtención de datos precisos y la creación de herramientas adecuadas.

Modelado numérico

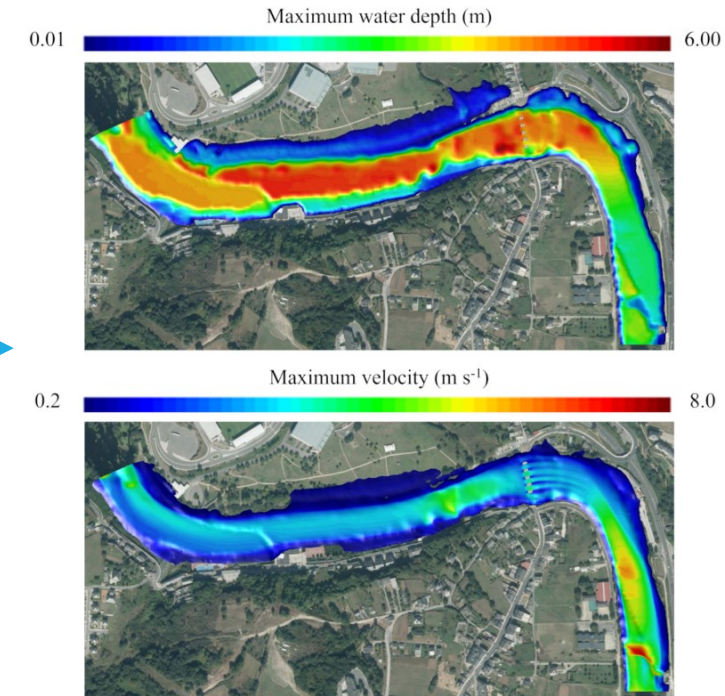
Proceso natural



Modelo numérico

```
289 #pragma omp parallel for schedule(guided)
290 for (Long nebucket = 0; nebucket < buckets.size();
291      nebucket++) { // Iterate over all buckets
292     auto sbucket = buckets[nebucket].second;
293     auto sbuckets = f.getSurroundingBuckets(buckets[nebucket].first);
294
295     for (auto spi : bucket) { // Iterate over each particle in the bucket
296         Long i = pi.id;
297
298         for (auto sb : sbuckets) { // Iterate over surrounding buckets
299             for (auto spj : *sb) { // Iterate over each particle in the bucket
300                 auto xij = ops::subtract(pi.pos, pj.pos);
301                 double mxij = ops::magnitude(xij), q = mxij / sp.h;
302
303                 if (q >= 0 && q <= 2) {
304                     double ad = 21. / (16. * M_PI * sp.h * sp.h * sp.h),
305                         e1 = (1. - (q / 2.0)),
306                         rval = colorField[pj.id] * ad * e1 * e1 * e1 * e1 *
307                             (2 * q + 1.);
308                     gradient[i][0] += rval * xij[0];
309                     gradient[i][1] += rval * xij[1];
310                     gradient[i][2] += rval * xij[2];
311                 }
312             }
313         }
314     }
```

Simulación numérica



Modelo matemático

$$\frac{\partial h}{\partial t} + \frac{\partial h U_x}{\partial x} + \frac{\partial h U_y}{\partial y} = r - i$$

$$\frac{\partial h U_x}{\partial t} + \frac{\partial}{\partial x} \left(h U_x^2 + g \frac{h^2}{2} \right) + \frac{\partial}{\partial y} (h U_x U_y) = -g h \frac{\partial Z_b}{\partial x} - \frac{\tau_{b,x}}{\rho} + \frac{\partial}{\partial x} \left(v_t h \frac{\partial U_x}{\partial x} \right) + \frac{\partial}{\partial y} \left(v_t h \frac{\partial U_x}{\partial y} \right)$$

$$\frac{\partial h U_y}{\partial t} + \frac{\partial}{\partial y} \left(h U_y^2 + g \frac{h^2}{2} \right) + \frac{\partial}{\partial x} (h U_x U_y) = -g h \frac{\partial Z_b}{\partial y} - \frac{\tau_{b,y}}{\rho} + \frac{\partial}{\partial x} \left(v_t h \frac{\partial U_y}{\partial x} \right) + \frac{\partial}{\partial y} \left(v_t h \frac{\partial U_y}{\partial y} \right)$$

Sistemas informáticos



Modelo CARPA
(E. Bladé Castellet, 2005)



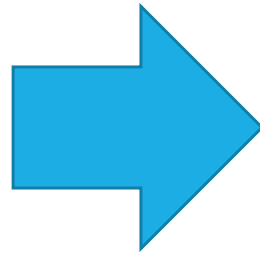
Modelo Turbillón
(L. Cea, 2005)



Pre & Post
postprocesado

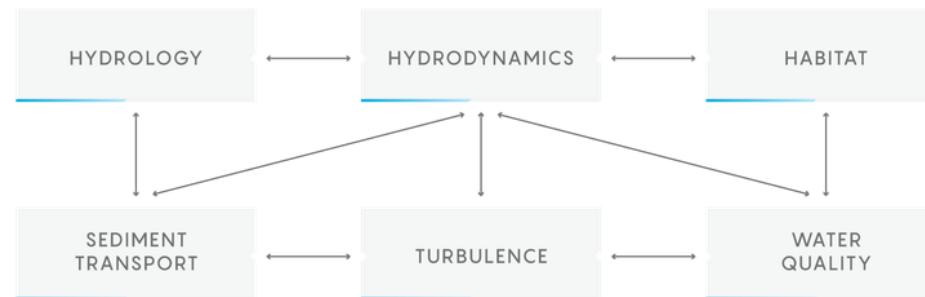


GiD
The universal, adaptative and user
friendly pre and postprocessing
system for computer analysis
in science and engineering



2D hydraulic modelling

(Bladé et al., 2014)



Modelo un modelo
hidrodinámico 2D de
aguas someras.

Orientado a simulación
de flujos de lámina libre
en cuencas de ríos y
estuarios no
estratificados.

Resuelve las ecuaciones
de St. Venant 2D
utilizando el método de
volúmenes finitos para
malllas no
estructuradas.



2D hydraulic modelling



Validado en múltiples escenarios



Misma precisión que códigos comerciales.



Computacionalmente ineficiente.



No aplicable en escenarios en tiempo real.



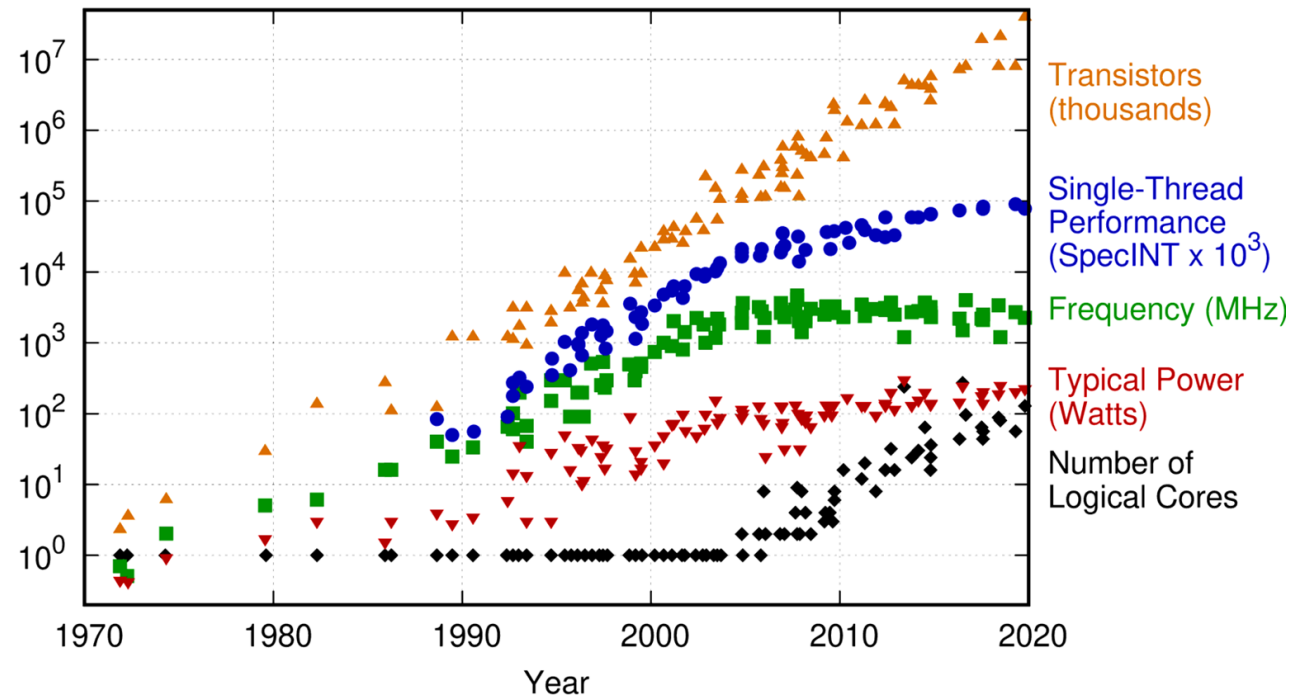
EuroHPC Leading the way in European Supercomputing

The EuroHPC Joint Undertaking is a joint initiative between the EU, European countries and private partners to develop a World Class Supercomputing Ecosystem in Europe.

Para mejorar la eficiencia se hace uso técnicas de computación de altas prestaciones, que permite emplear sistemas informáticos con una alta capacidad de procesamiento para de resolver problemas complejos.

La importancia de este tipo de tecnologías es tal que la Unión Europea reconoce la computación de altas prestaciones como una capacidad estratégica de cara a la economía y una herramienta esencial en casi todos los ámbitos de la investigación.

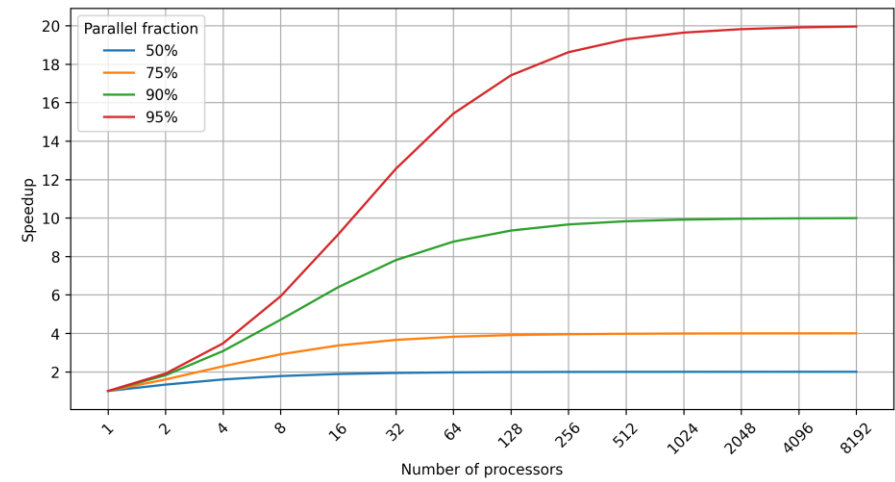
48 Years of Microprocessor Trend Data



Original data up to the year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten
 New plot and data collected for 2010-2019 by K. Rupp

Amdahl law (1967):

$$Speedup(f, n) = \frac{1}{(1 - f) + \frac{f}{n}}$$



La programación paralela es compleja y presenta dificultades añadidas a la hora de realizar un programa que funcione correctamente y sea eficiente.

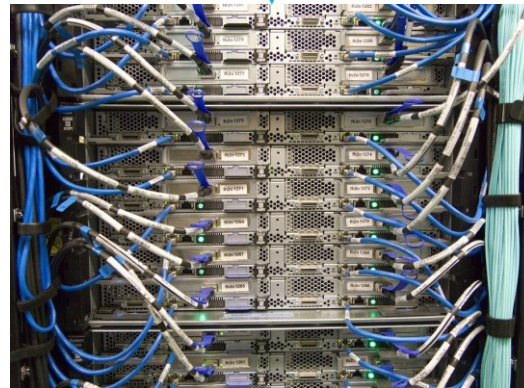
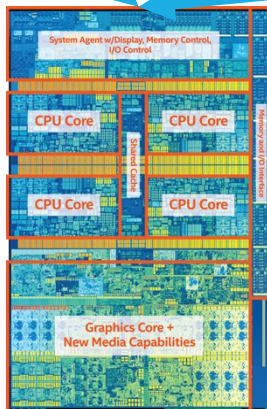
Los programas que no sean capaces de explotar el paralelismo verán limitada su aplicación.

APIs de programación paralela

OpenMP



OpenCL™



Cálculo GPGPU

General-Purpose computing on
Graphics Processing Units.

Originalmente las GPUs
estaban orientadas al
procesamiento de gráficos.

Gran número de núcleos de
procesamiento y un gran ancho
de banda de memoria.

Diseñadas ejecutar miles de
threads simultáneamente.

Ideales para procesamiento de
datos.



Home » Lists » Top500 » June 2022 » List

TOP500 LIST - JUNE 2022

R_{max} and **R_{peak}** values are in PFlop/s. For more details about other fields, check the TOP500 description.

R_{peak} values are calculated using the advertised clock rate of the CPU. For the efficiency of the systems you should take into account the Turbo CPU clock rate where it applies.

← 1-100 **101-200** 201-300 301-400 401-500 →

Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/s)	Power (kW)
1	Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,730,112	1,102.00	1,685.65	21,100
2	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.01	537.21	29,899
3	LUMI - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	1,110,144	151.90	214.35	2,942
4	Summit - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory United States	2,414,592	148.60	200.79	10,096
5	Sierra - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94.64	125.71	7,438

Home » Lists » Green500 » June 2022 » List

GREEN500 LIST - JUNE 2022

R_{max} and **R_{peak}** values are in PFlop/s. For more details about other fields, check the TOP500 description.

R_{peak} values are calculated using the advertised clock rate of the CPU. For the efficiency of the systems you should take into account the Turbo CPU clock rate where it applies.

Green500 Data

← 1-100 **101-200** 201-300 301-400 401-500 →

Rank	Rank	System	Cores	Rmax (PFlop/s)	Power (kW)	Energy Efficiency (GFlops/watts)
1	29	Frontier TDS - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	120,832	19.20	309	62.684
2	1	Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,730,112	1,102.00	21,100	52.227
3	3	LUMI - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	1,110,144	151.90	2,942	51.629
4	10	Adastr - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE Grand Equipement National de Calcul Intensif - Centre Informatique National de l'Enseignement Suprieur (GENCI-CINES) France	319,072	46.10	921	50.028
5	326	MN-3 - MN-Core Server, Xeon Platinum 8260M 24C 2.4GHz, Preferred Networks MN-Core, MN-Core DirectConnect, Preferred Networks Preferred Networks Japan	1,664	2.18	53	40.901

Article

An Accelerated Tool for Flood Modelling Based on Iber

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José Manuel Domínguez ¹  and Arno Formella ³

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Abstract: This paper presents Iber+, a new parallel code based on the numerical model Iber for two-dimensional (2D) flood inundation modelling. The new implementation, which is coded in C++ and takes advantage of the parallelization functionalities both on CPUs (central processing units) and GPUs (graphics processing units), was validated using different benchmark cases and compared, in terms of numerical output and computational efficiency, with other well-known hydraulic software packages. Depending on the complexity of the specific test case, the new parallel implementation can achieve speedups up to two orders of magnitude when compared with the standard version. The speedup is especially remarkable for the GPU parallelization that uses Nvidia CUDA (compute unified device architecture). The efficiency is as good as the one provided by some of the most popular hydraulic models. We also present the application of Iber+ to model an extreme flash flood that took place in the Spanish Pyrenees in October 2012. The new implementation was used to simulate 24 h of real time in roughly eight minutes of computing time, while the standard version needed more than 15 h. This huge improvement in computational efficiency opens up the possibility of using the code for real-time forecasting of flood events in early-warning systems, in order to help decision making under hazardous events that need a fast intervention to deploy countermeasures.

Keywords: flood; numerical simulation; shallow water equations; Iber+; benchmark; CUDA; OpenMP; finite volume

Article

IberWQ: A GPU Accelerated Tool for 2D Water Quality Modeling in Rivers and Estuaries

Orlando García-Feal ^{1,*} , Luis Cea ² , José González-Cao ¹, José Manuel Domínguez ¹  and
Moncho Gómez-Gesteira ¹

¹ Environmental Physics Laboratory (EPHYSLAB), CIM-UVIGO, Universidade de Vigo, Campus As Lagoas s/n, 32004 Ourense, Spain; jgc@uvigo.es (J.G.-C.); jmdominguez@uvigo.es (J.M.D.); mggesteira@uvigo.es (M.G.-G.)

² Environmental and Water Engineering Group, Department of Civil Engineering, Universidade da Coruña, Elviña, 15071 A Coruña, Spain; luis.cea@udc.es

* Correspondence: orlando@uvigo.es; Tel.: +34-988-387-270

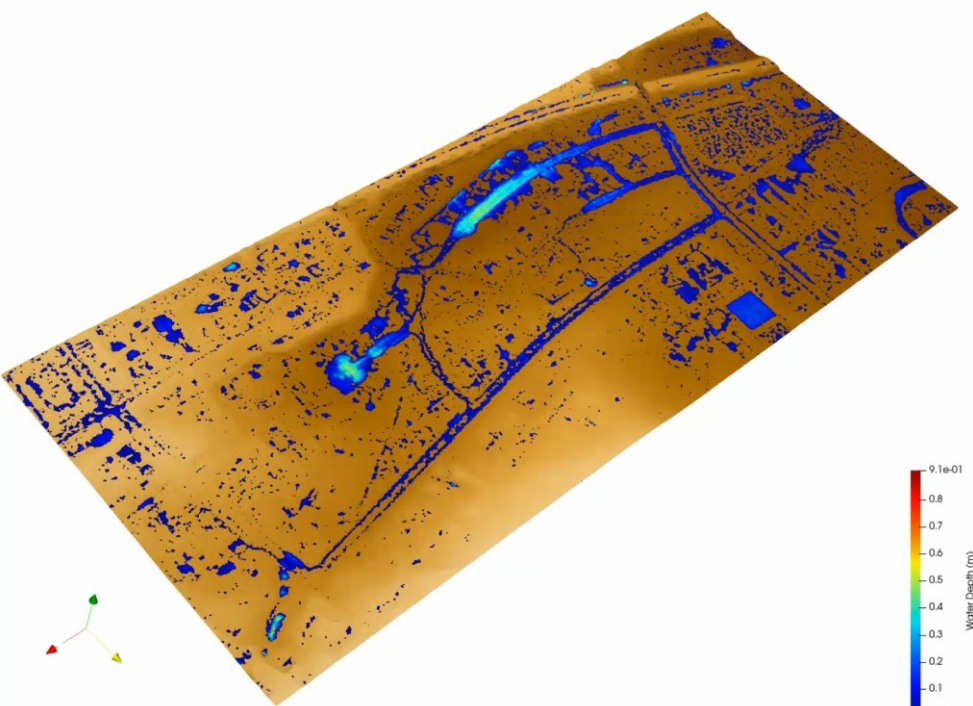
Received: 18 December 2019; Accepted: 31 January 2020; Published: 4 February 2020



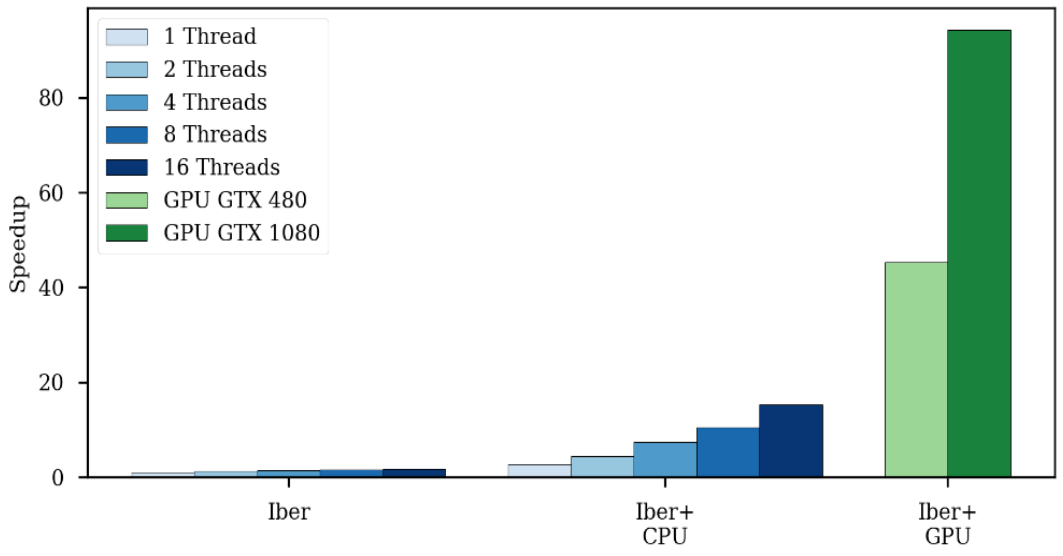
Abstract: Numerical models are useful tools to analyze water quality by computing the concentration of physical, chemical and biological parameters. The present work introduces a two-dimensional depth-averaged model that computes the most relevant and frequent parameters used to evaluate water quality. High performance computing (HPC) techniques based on graphic processing unit (GPU) parallelization have been applied to improve the efficiency of the package, providing speed-ups of two orders of magnitude in a standard PC. Several test cases were analyzed to show the capabilities and efficiency of the model to evaluate the environmental status of rivers and non-stratified estuaries. IberWQ will be freely available through the package Iber.

Keywords: computational fluid dynamics; depth-averaged modeling; water quality; environmental quality standards; high performance computing (HPC); graphic processing unit (GPU); CUDA



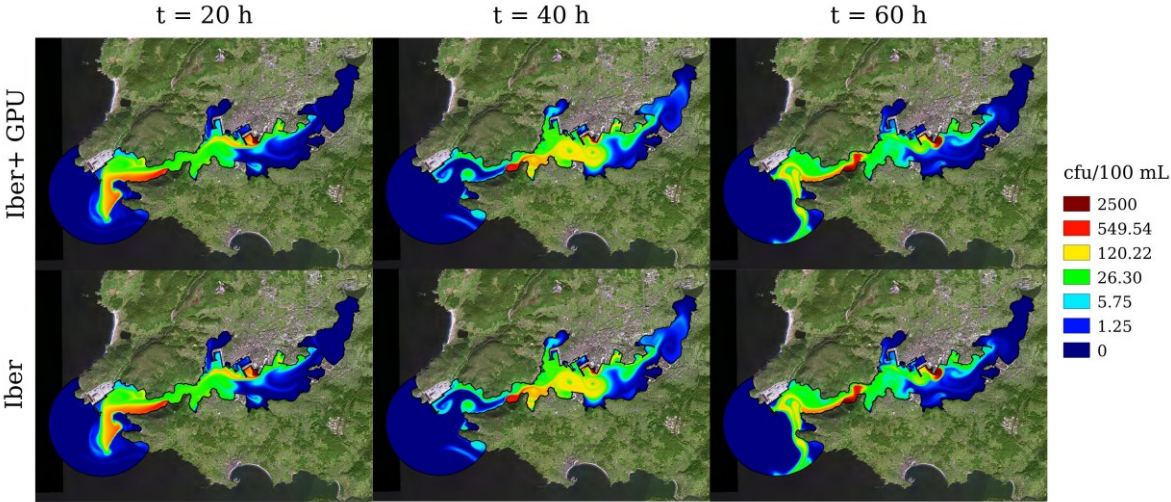
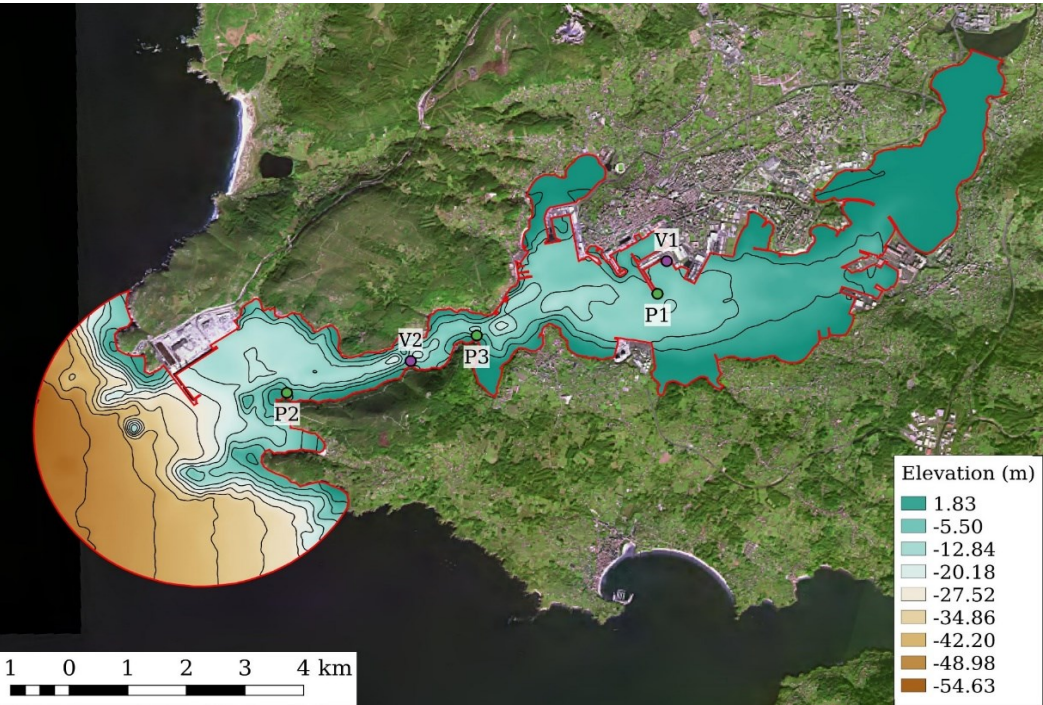


96400 elementos



Model	Hardware Configuration	Run Time (s)	Speedup vs. Iber 1 Thread
InfoWorks ICM	GPU	66	35.1
JFlow+	GPU	66	35.1
TUFLOW FV	12 Threads	410	5.7
Iber	1 Thread	2317.4	1.0
	4 Threads	1615.8	1.4
	16 Threads	1360.6	1.7
Iber+	1 Thread	850.1	2.7
	4 Threads	313.8	7.4
	16 Threads	150.9	15.4
	GPU (GTX 480)	51.1	45.4
	GPU (GTX 1080)	24.6	94.3

Simulación de calidad de aguas en la ría de Ferrol.



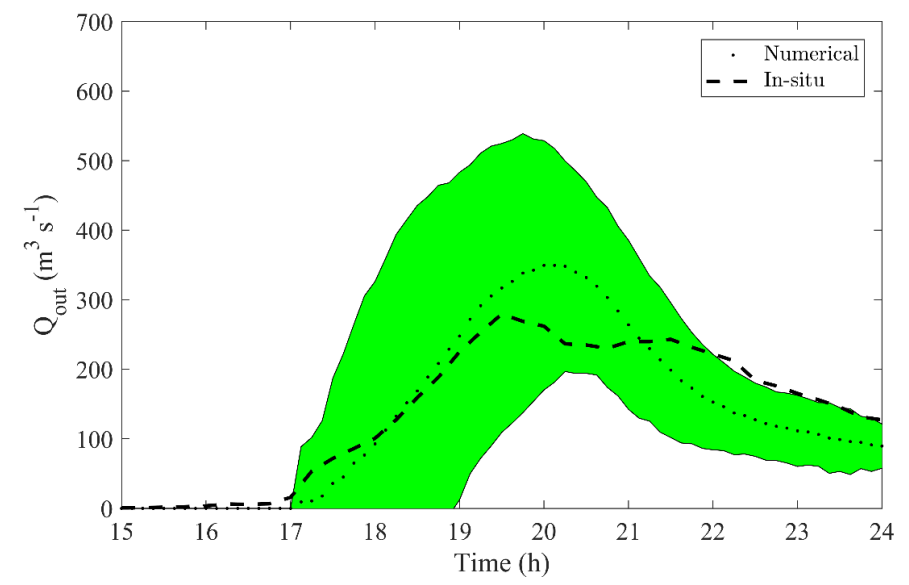
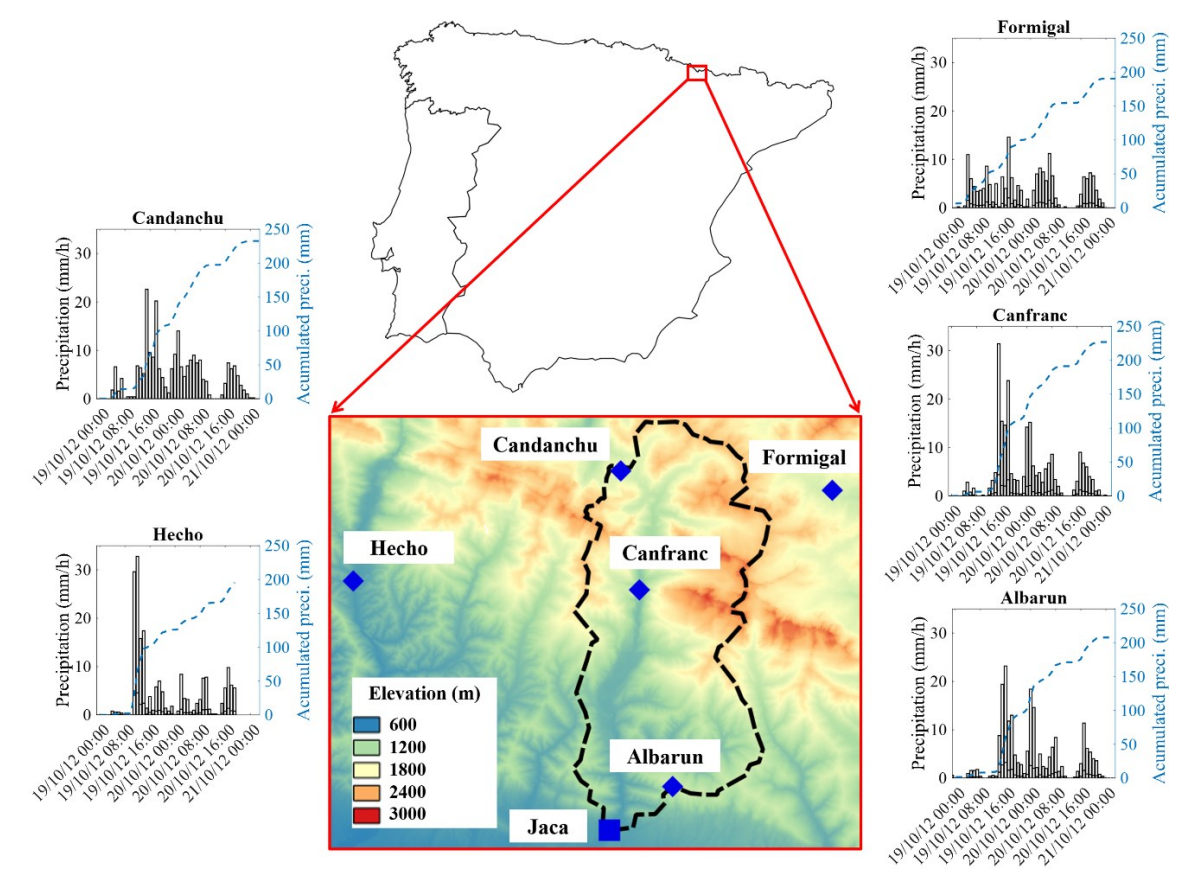
Malla de 143,993 elementos.

72h simuladas.

Se calcula concentración de E. Coli.

Model	Run Time (s)	Time per Step (ms)	Millions of Cells per Second	Speedup vs. Iber
Iber	60,545	66.8	2.2	1
Iber+ GPU	335	0.4	400.0	181

Caso de aplicación: evento de precipitación en el río Aragón



Malla de 459,000 elementos.

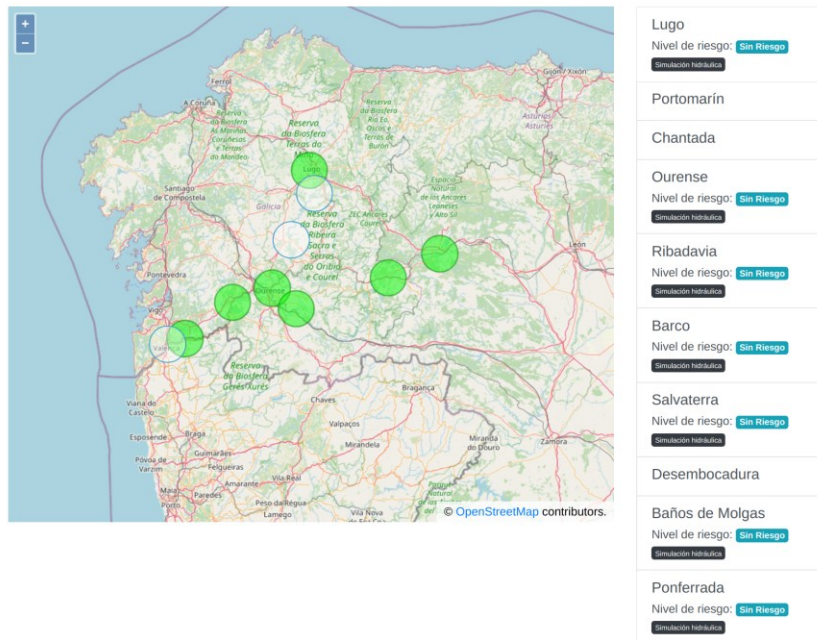
17 simulaciones: una con valores de CN y Manning de referencia. Y 16 variando estos parámetros.

El tiempo total de simulación con Iber+ es de 2h 20m.

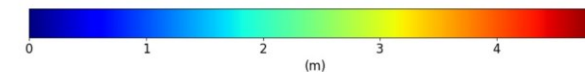
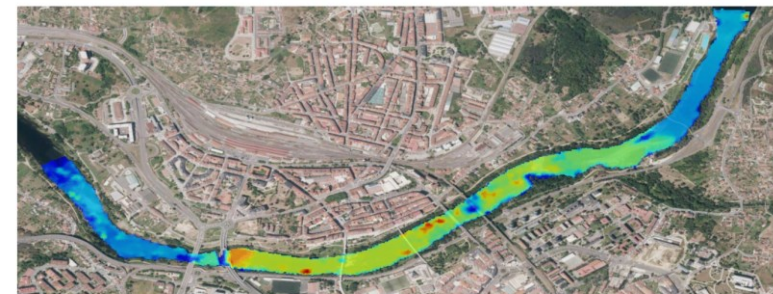
El tiempo total de simulación con Iber es de más de 10 días.



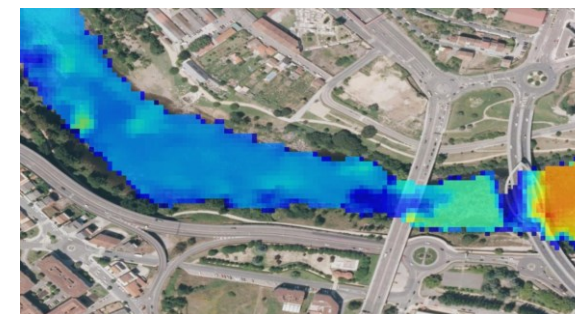
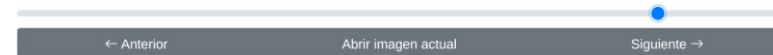
Mapa de localizaciones 2/10/2022



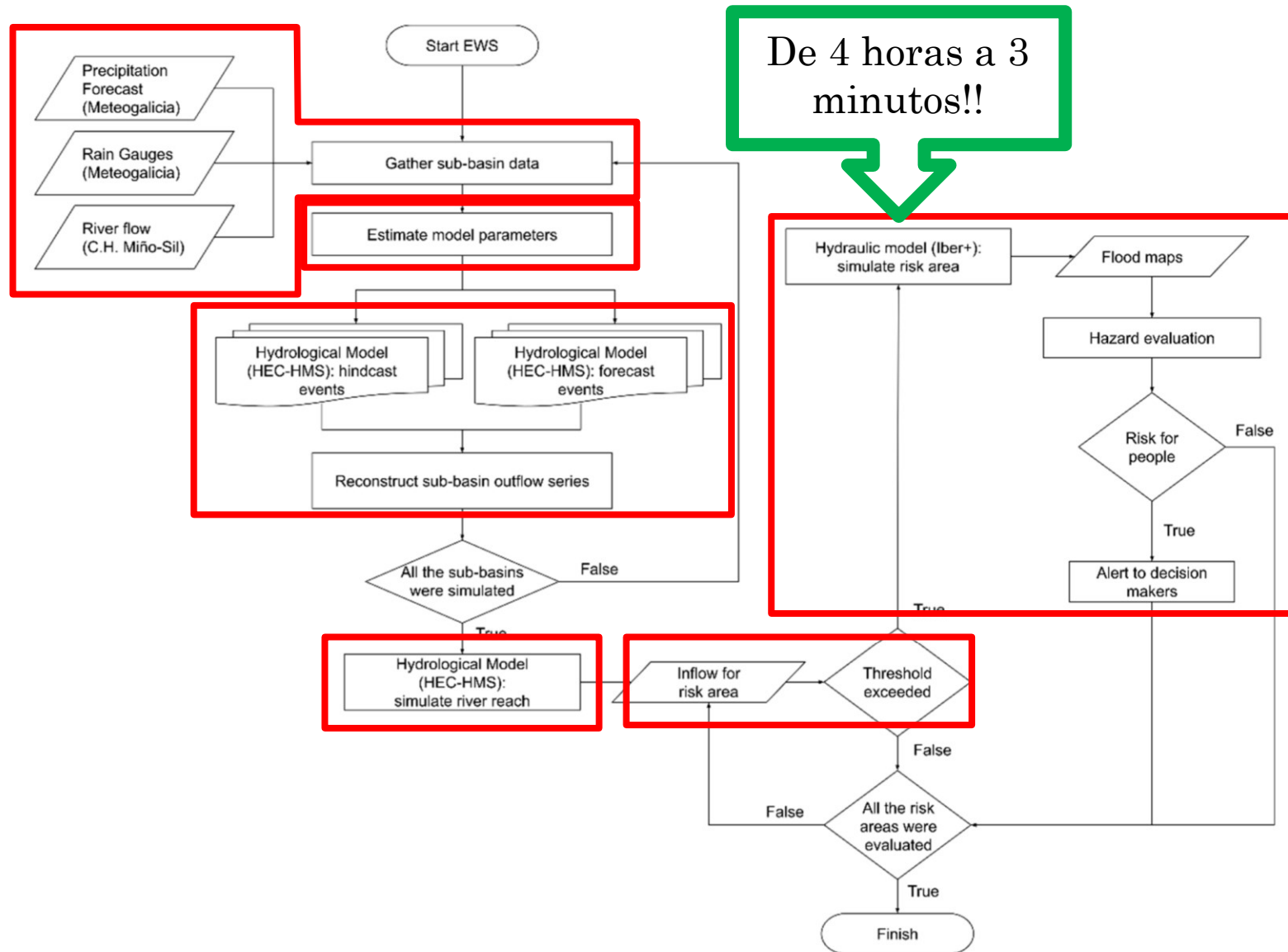
Predicción de calado a las 20:00 horas



Utiliza el selector para cambiar la imagen a visualizar.



Desarrollo de un sistema de alerta temprana de inundaciones





Iber PLUS



Hidráulica



Turbulencia



Hidrología



Calidad de aguas



Erosión de suelos



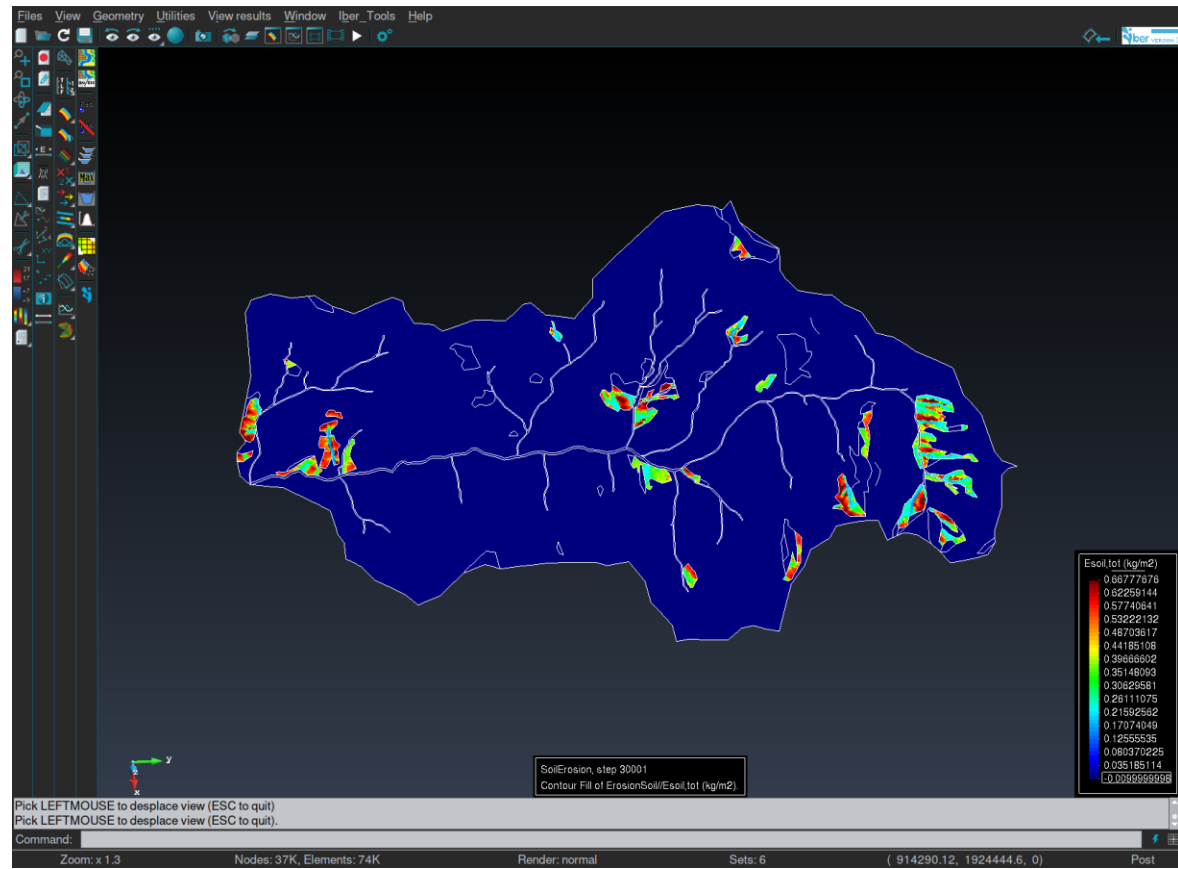
Transporte de troncos



Transporte de sedimentos



2D hydraulic modelling

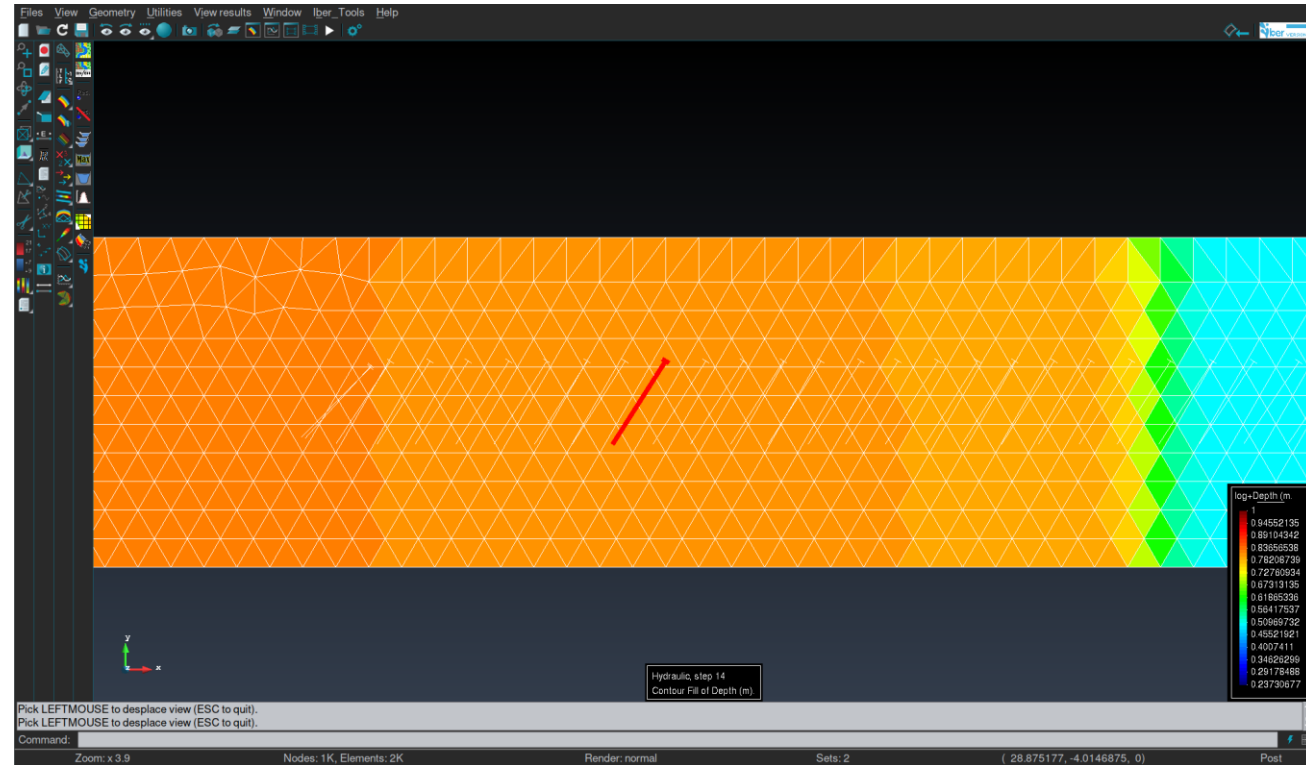


Iber 3.2

Novedades Iber+:

Implementación del módulo de erosión de suelos

Soporte para cubiertas.



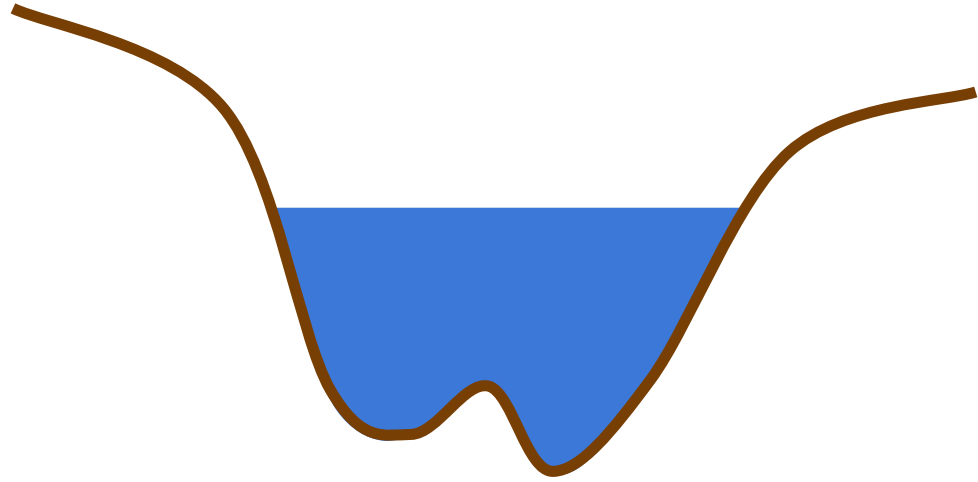
Futuros desarrollos

Módulo de transporte de troncos.

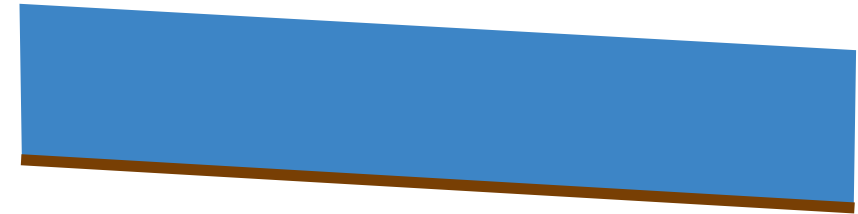
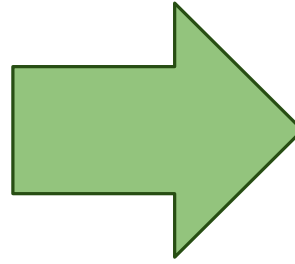
Simulaciones no deterministas.

Los estudios requieren un gran número de simulaciones.

Physical Domain



Computational Cell



Futuros desarrollos

Modelado de submalla.

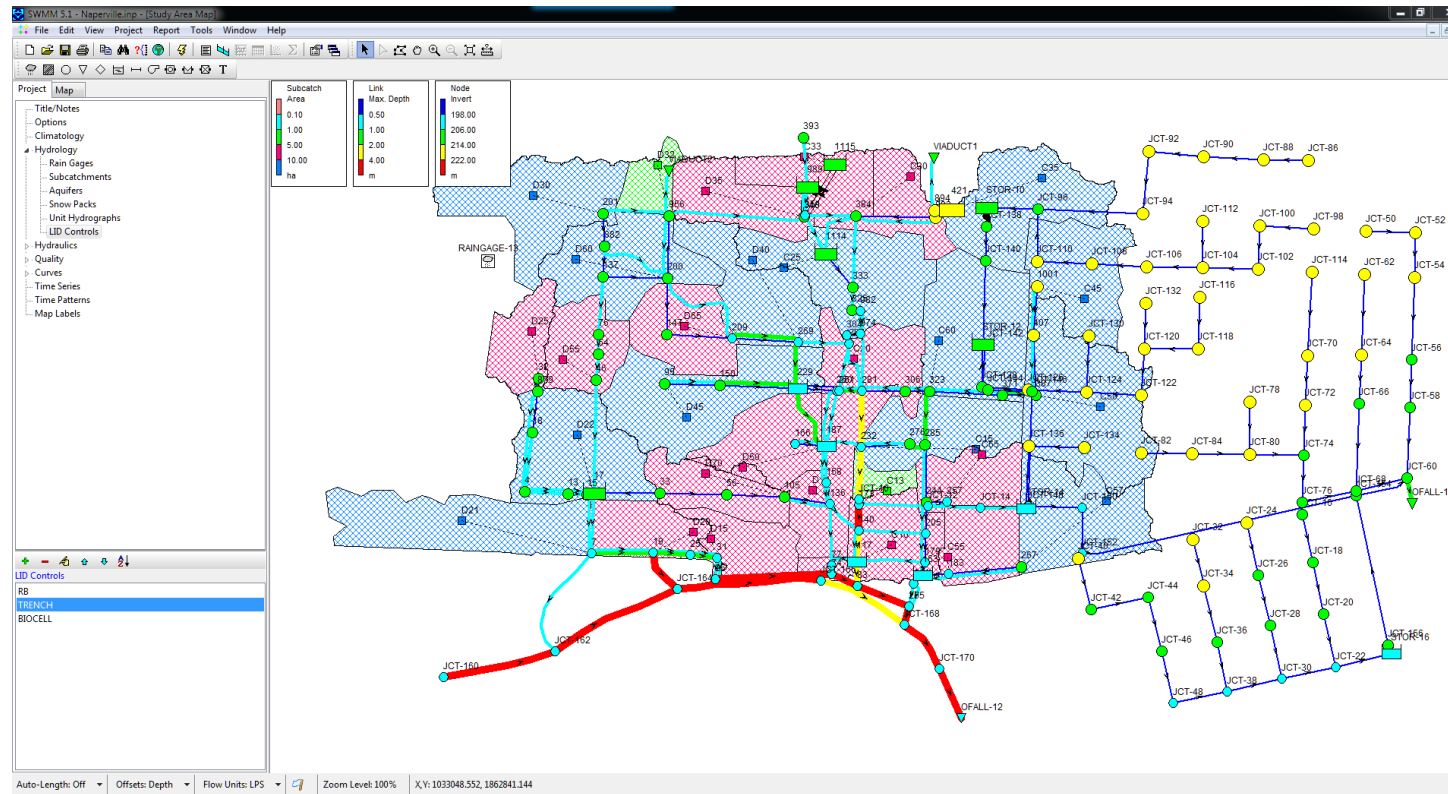
Incorpora información detallada del terreno al modelo sin incrementar la malla computacional.



Futuros desarrollos

Soporte computación distribuida.

Soporte multi-gpu.



Futuros desarrollos

Simulación de sistemas de drenaje urbano

Acoplamiento con modelo SWMM

Gracias por su atención.