Remote Sensing as Data Source for a Generalized Micrometeorological Simulation and its Application in the Context of a Coastal River Basin Restoration.

25

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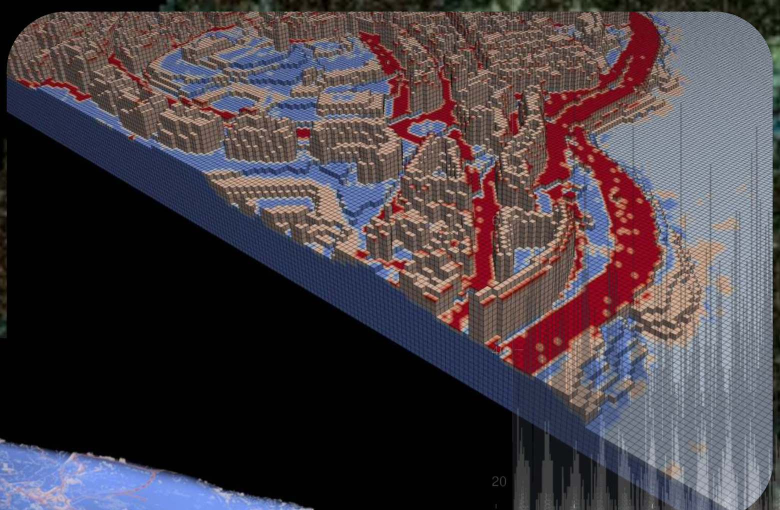
UMC (Urban MicroClimate) is a modular demostrative set of tools that aims at eventually evaluating thermal comfort indices for pedestrians in urban spaces with a very high resolution (typically 4-8 m) and accuracy as part o an ongoing Degree Thesis in urban planning.

It features a fully volumetric model that can be ran in multiple modes. Several parameterization schemes were adapted/ developed to overcome the absence of local data.



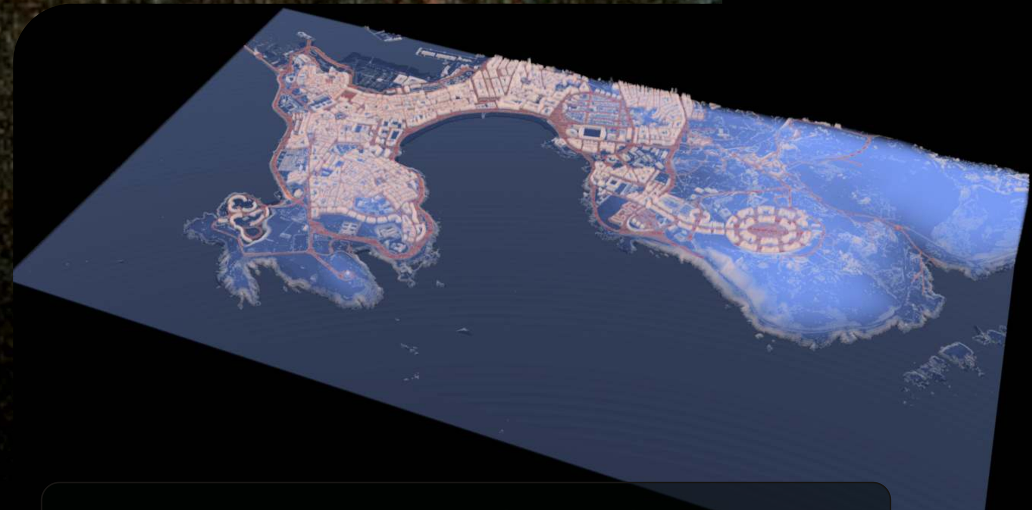


Fig. 1 Reconstruction and classification of the domain.

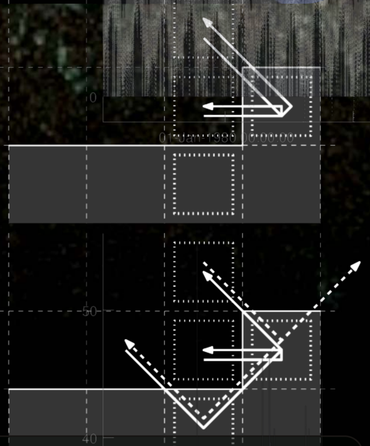


Fig. 2 No-slip condition schematic.

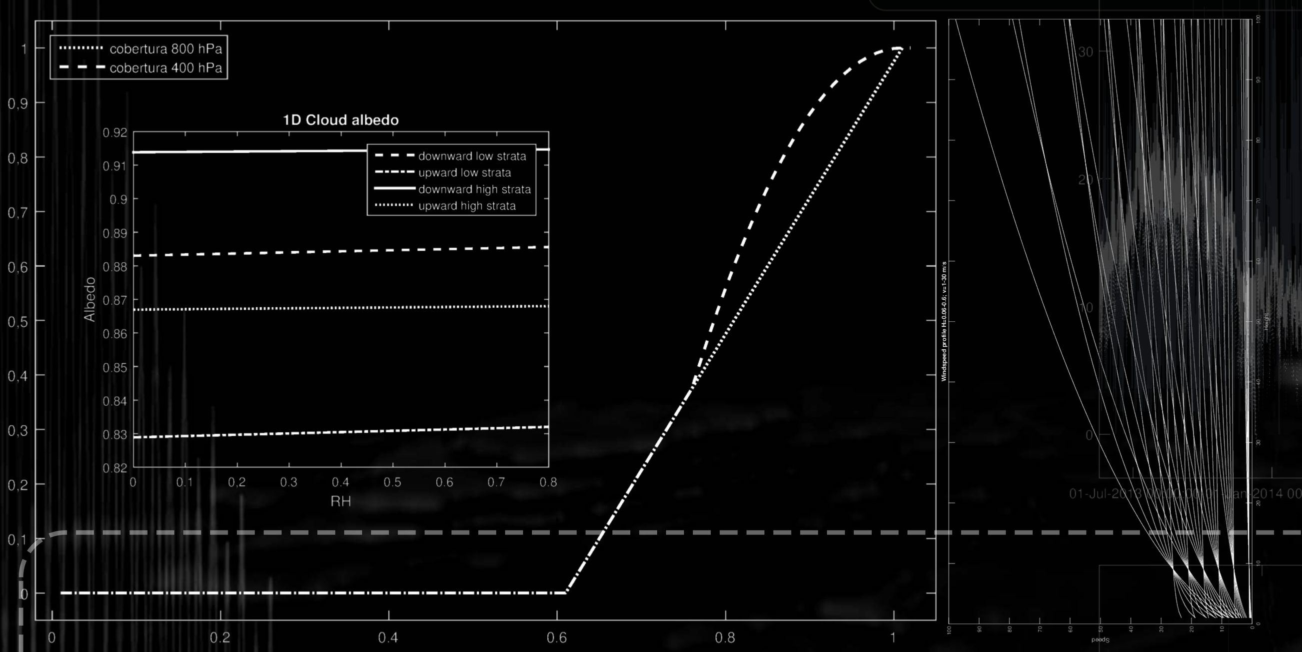


Fig. 3 Schemes of parameterization (cloud cover, cloud albedo, wind velocity at the boundary)

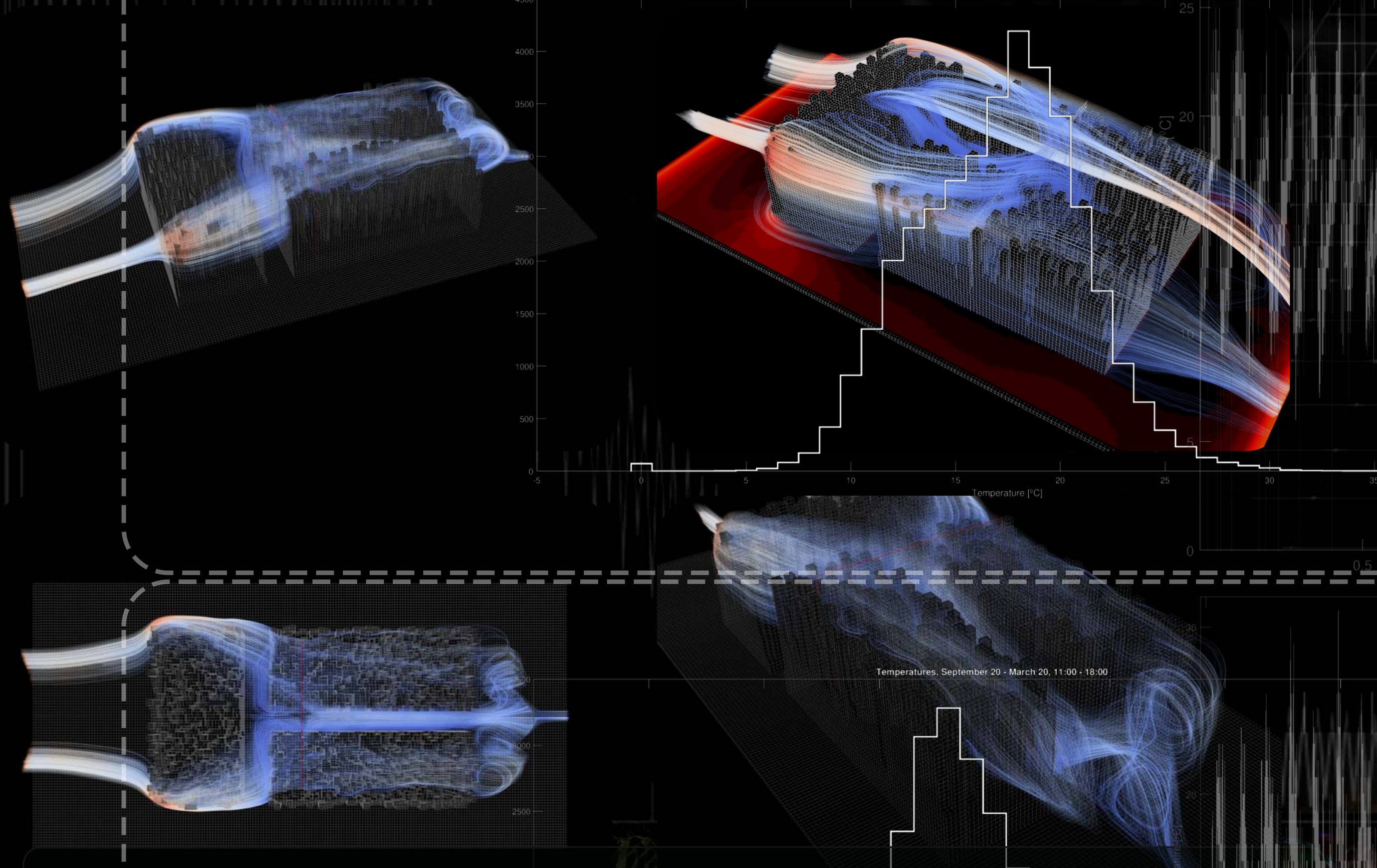


Fig 4. Test case of LBM wind flow model. Reynolds number was chosen to force convergence.

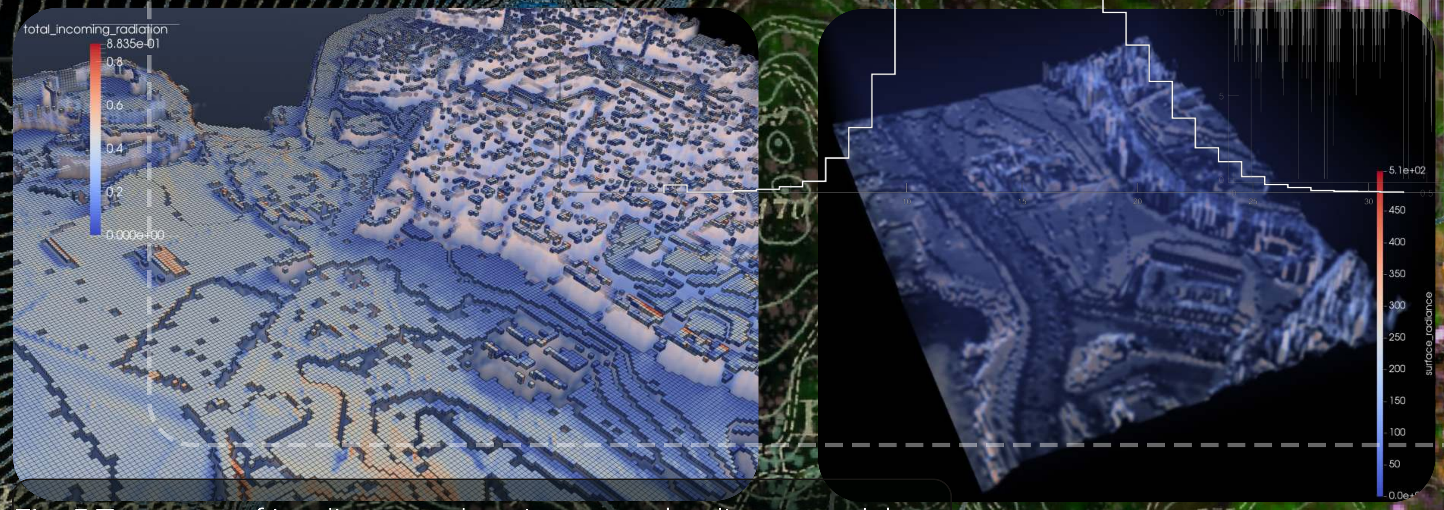


Fig. 5 Test case of irradiance and environmental radiance models.

Energy transfer models were developed including, among others, atmospheric optics, soil-atmosphere exchange, outgoing longwave radiation (with corresponding cloud cover downward albedo), environmental radiative heat transfers and a wind flow model based in Lattice-Boltzmann Method.

The proposed method, instead of solving the Navier-Stokes equation, explicitly evaluates a truncated expansion of Boltzmann equation in terms of a local fluid density that relaxes, at each iteration, towards a maxwellian distribution, reaching adjacent cells. Macroscopic variables (velocity and density) are recovered from this fictitious particle dynamics. Implementation of buoyancy and heat transfer through an equation of state is straightforward.

Boundary conditions were carefully taylored to enable buoyancy on the top of the domain, wind velocity gradient (parameterized with Hellman's exponent), along with no-slip boundary conditions and drag (parameterized with roughness) to mitigate the underestimation of windspeed in the boundary layer and a wind flow model in canopies and 'porous' materials (still incomplete).

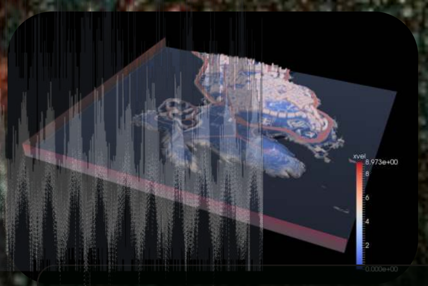
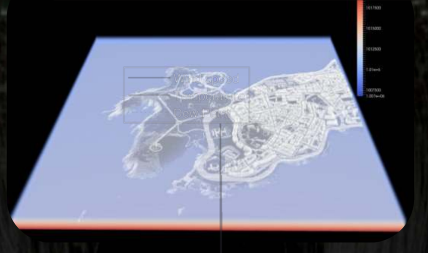
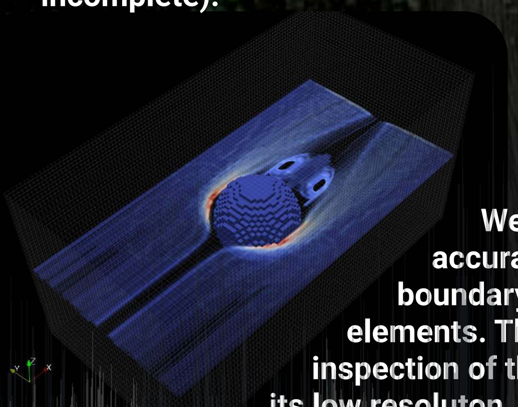


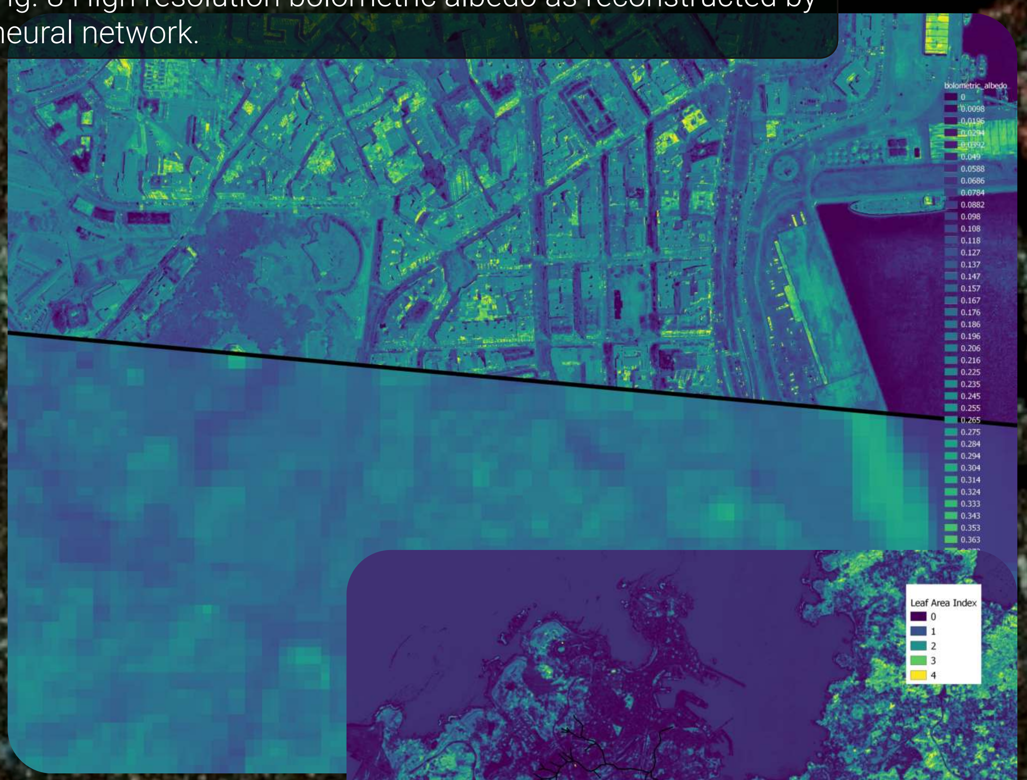
Fig. 10 Boundary conditions for wind speed and pressure.





We try to ensure an accurate evaluation of the boundary layer in the interface elements. This is relevant by inspection of the example, in spite of its low resoluton.

Fig. 8 High resolution bolometric albedo as reconstructed by neural network.



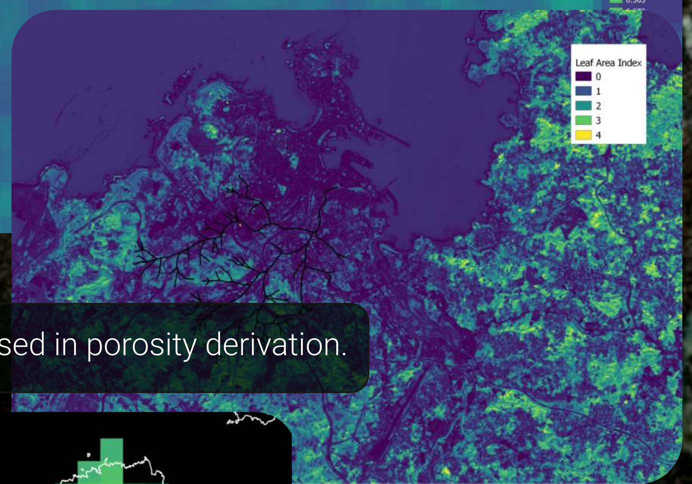


Fig. 9 Leaf area index used in porosity derivation.

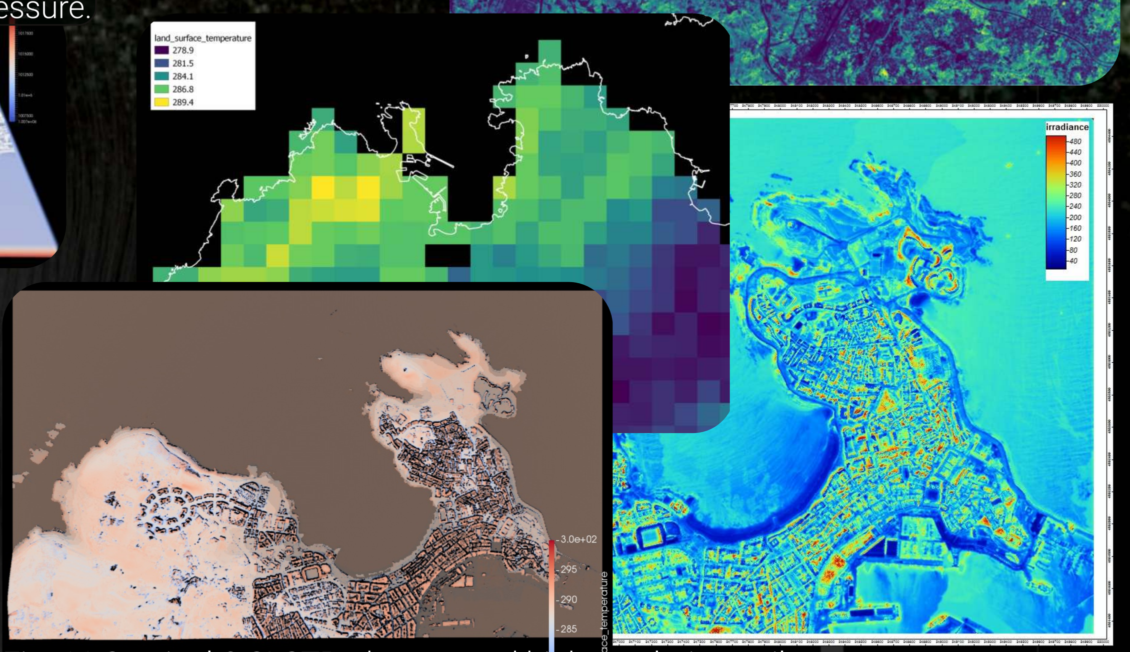


Fig. 11 Sentinel-3 SLSTR dataset and high resolution soil temperature and irradiance models.

We provide some examples of how, in this context, some critical parameters were derived from satellite data provided by Copernicus Programme.

	Local datasets	Satellite data
High availability		✔
High resolution	✔	

A neural network was trained with spectral albedos derived from Sentinel-2 MSI instrument and RGB aerial imagery, along with some morphological features and a set of descriptors developed mainly to classify vegetation in a side project. Then the neural network reconstructed the spectral albedos (fig. 8) of the RGB image with an accuracy around 91% for bolometric one (that we use in some radiance models).

Wind flow model in canopies requires the three-dimensional distribution of biomass. This could not be acquired from low resolution LiDAR, so an approximate parameterization was derived from Leaf Area Index (fig. 9) and Digital Elevation Model instead.

Coupling of soil temperature and heat exchange with atmosphere (soil makes use of a simple 1-dimensional model) is suitable for near real-time evaluation (dynamical or steady state mode). At this stage a mean temperature beyond a depth of 3 m is used as boundary condition. We consider using the SENTINEL-3 Land Surface temperature product for calibration (fig. 11).

A pocket-sized weather station prototype featuring satnav, thermometer, an hemispherical thermopile and hot wire anemometer was built for validation. Some data is shown in figures 12 and 13. Data collection for evaluation in real time is considered.

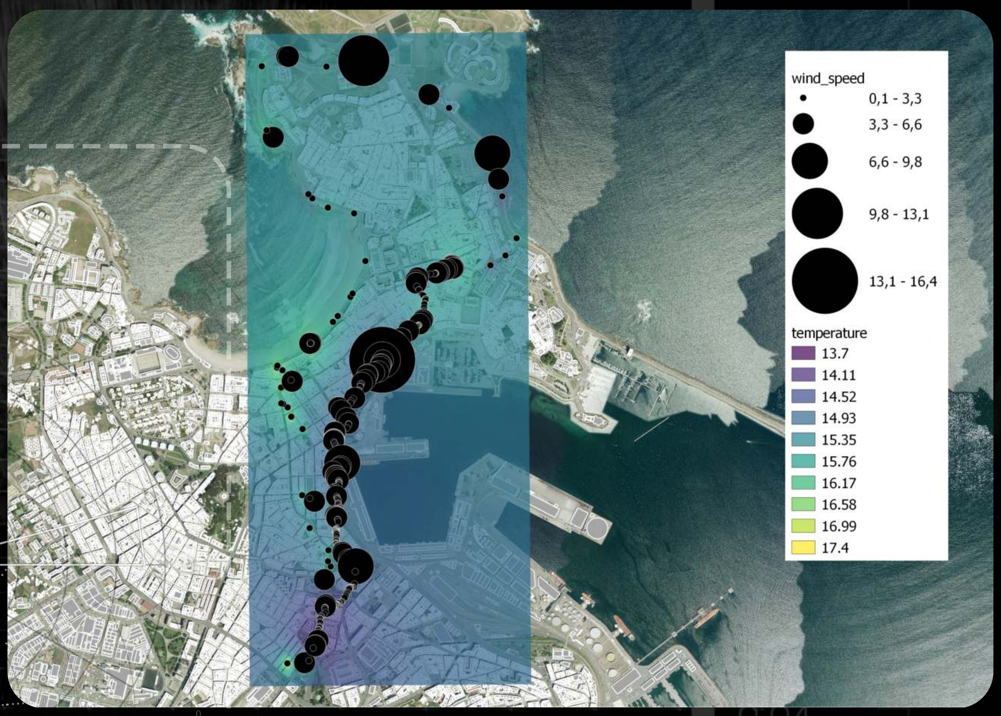


Fig. 12 and 13 Data gathered from portable station.

Monelos River was, in many senses, a source of life in the small coastal city of A Coruña (Spain). In the second half of the 20th century an important urbanization process took place. This phenomenon along with the scarcity of the stream flow, the decline of traditional water cultures and uses, such as fishing and hand washing clothes, and the past absence of water regulations, has resulted in the encroachment on the floodplain and its subsequent channelizing and piping into the sewer system.

The main objective of this project and its linked PhD Thesis is the integral recovery of the river basin and the identification of specific sections in which efficient restoration actions can be carried out within the current regulation framework.

The river as such does not exist anymore, but we can recover the extent of its drainage basin from phenological differences. Plants still express the behavior of typical riparian vegetation. This is relevant by inspection of the variance through time for the Normalized Difference Water Index in areas with vegetation obtained from Sentinel-2 MSI instrument (Fig. 6). Fig. 7 shows variance of backscattering (related to water content) derived from Sentinel-1 C-SAR. Urban areas are rich in scatterers and prone to clutter. The low signal to noise ratio and small size of the basin render this data unusable without further processing.

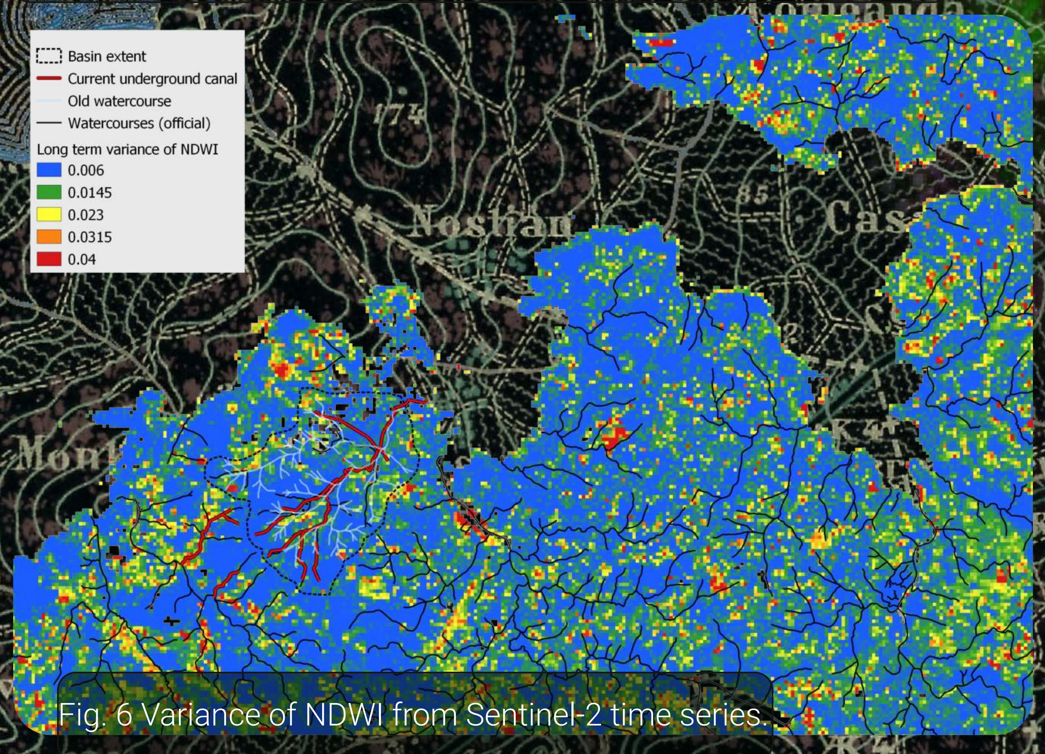


Fig. 6 Variance of NDWI from Sentinel-2 time series.

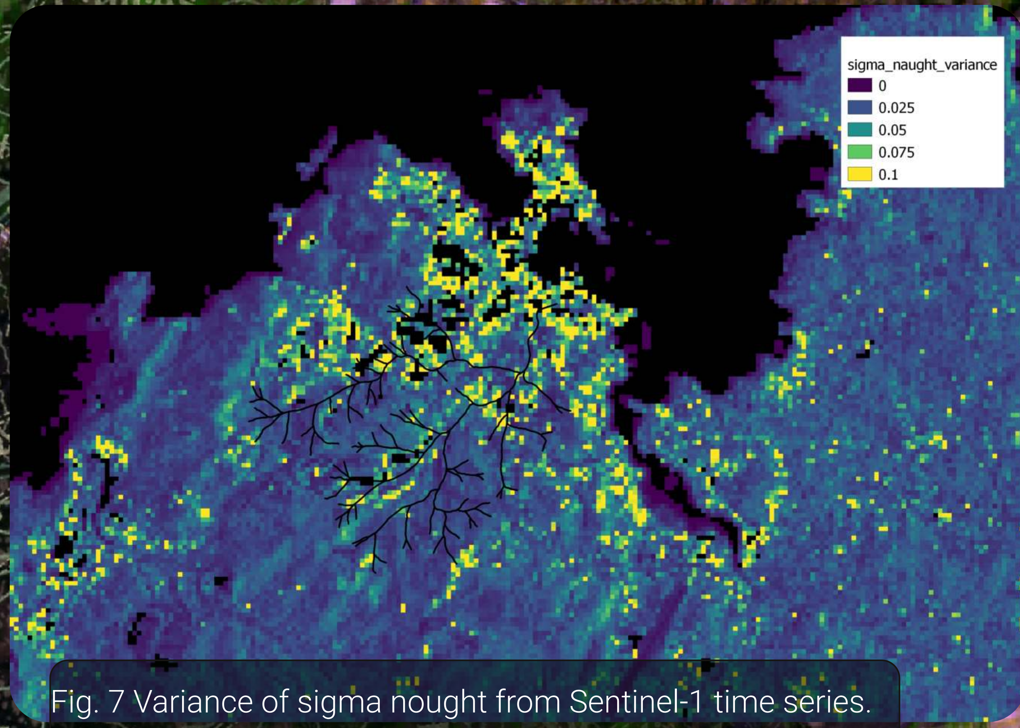


Fig. 7 Variance of sigma nought from Sentinel-1 time series.

We expect to include other possibilities such as:

- Tracking of air pollution sources
- Sound propagation
- Wildfire propagation
- Evaluation of flight conditions
- Anemochoria and seed dispersal of invasive species
- ...

Parts of this work heavily rely on Python, GNU Octave, Scilab, Julia Language, GDAL, VTK and Paraview, Orfeo Toolbox, SAGA GIS, QGIS and the Science Toolbox Exploitation Platform. It contains modified Copernicus data. LiDAR-PNOA cedido por © Instituto Geográfico Nacional. It contains data belonging to © OpenStreetMap contributors. It includes elements from the ongoing degree thesis «Climate variability at Corunna waterfront. Implications for design and user comfort».

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