Improving coastal flood modelling.

強靭性 革新 伝統

UNDERSTANDING RISK GLOBAL FORUM 2024

TRADITION • INNOVATION • RESILIENCE

Speakers:

Anne-Laure Beck,

ARGANS Ltd Technical Manager

https://coastalerosion.co.uk

Logos:

ARGANS

WACA West Africa Coastal Areas Management Program

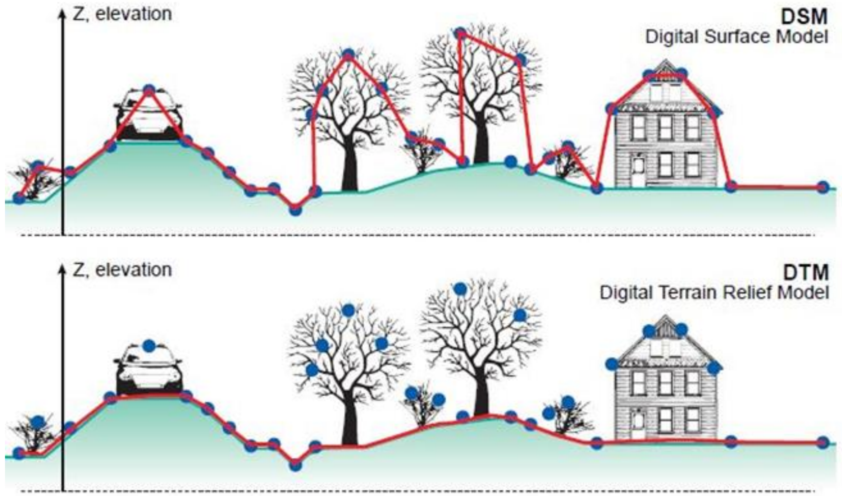
Presentation of products delivered for Accra's site

1. Calibrated Digital Terrain Modelling using GEDI/ICESAT-2 missions including heights and density of features
2. Backshore Classification
3. Flow drag coefficient map and channeling element
4. Inundation model maps :
   a) Improved flood model : bathtub approach based on DTM low point water accumulation
   b) Inverse watershed model : model based on slope angle and land occupation rugosity

Specifics of Accra’s area :

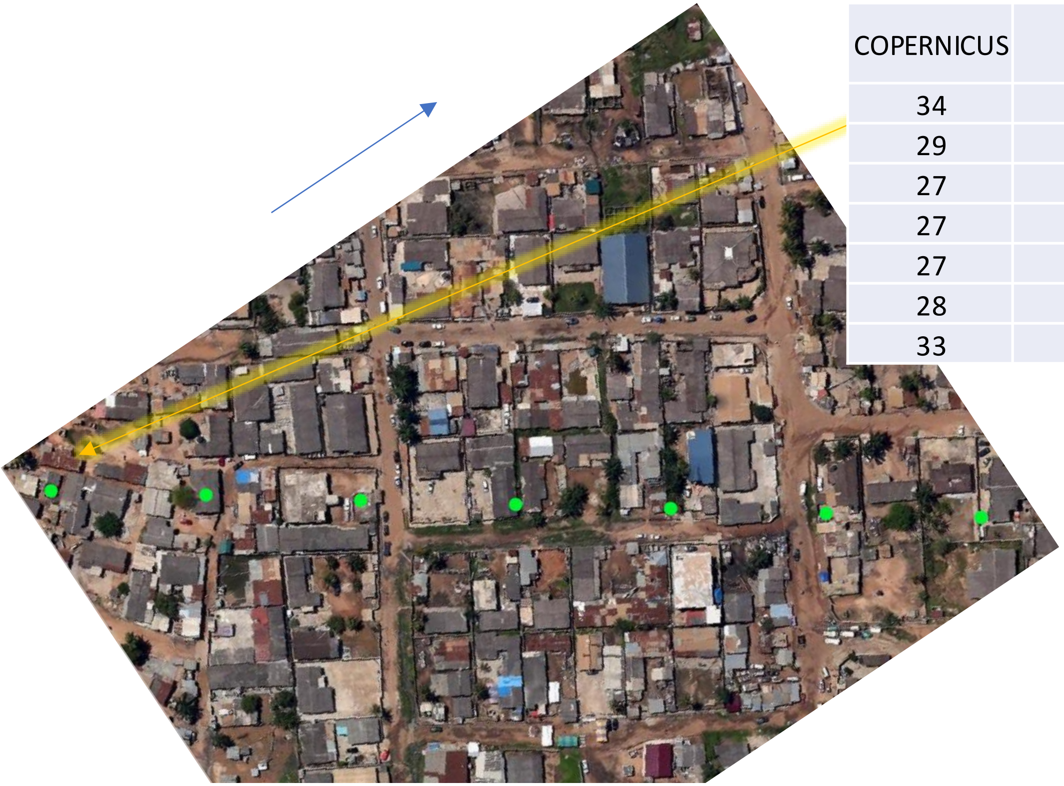
- Strong Coastal erosion
- Few risk of hurricane (Ghana is located 7.94 degrees north of the equator)
- But monsoon with flood risks

To estimate the risk, an accurate DTM is mandatory

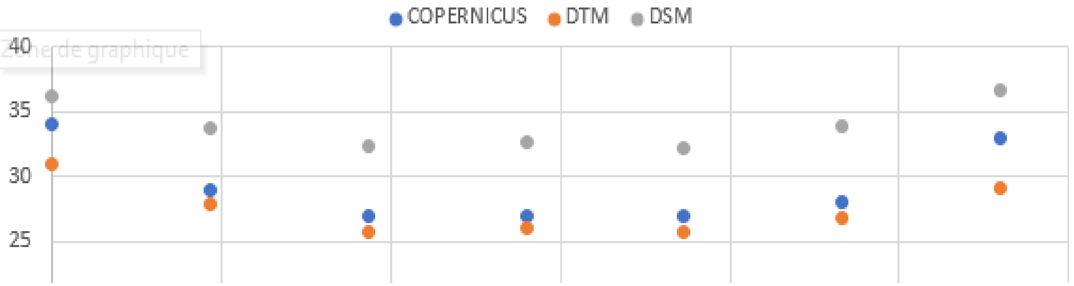


Product location

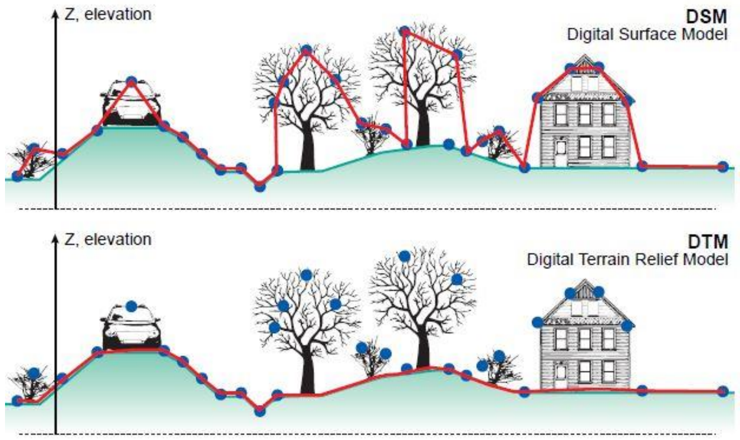
Why a Copernicus DEM improvement ? Example with Gedi data



COPERNICUS	DTM	DSM
34	30,9	36,2
29	27,8	33,7
27	25,8	32,3
27	26,0	32,6
27	25,7	32,2
28	26,8	33,9
33	29,2	36,6

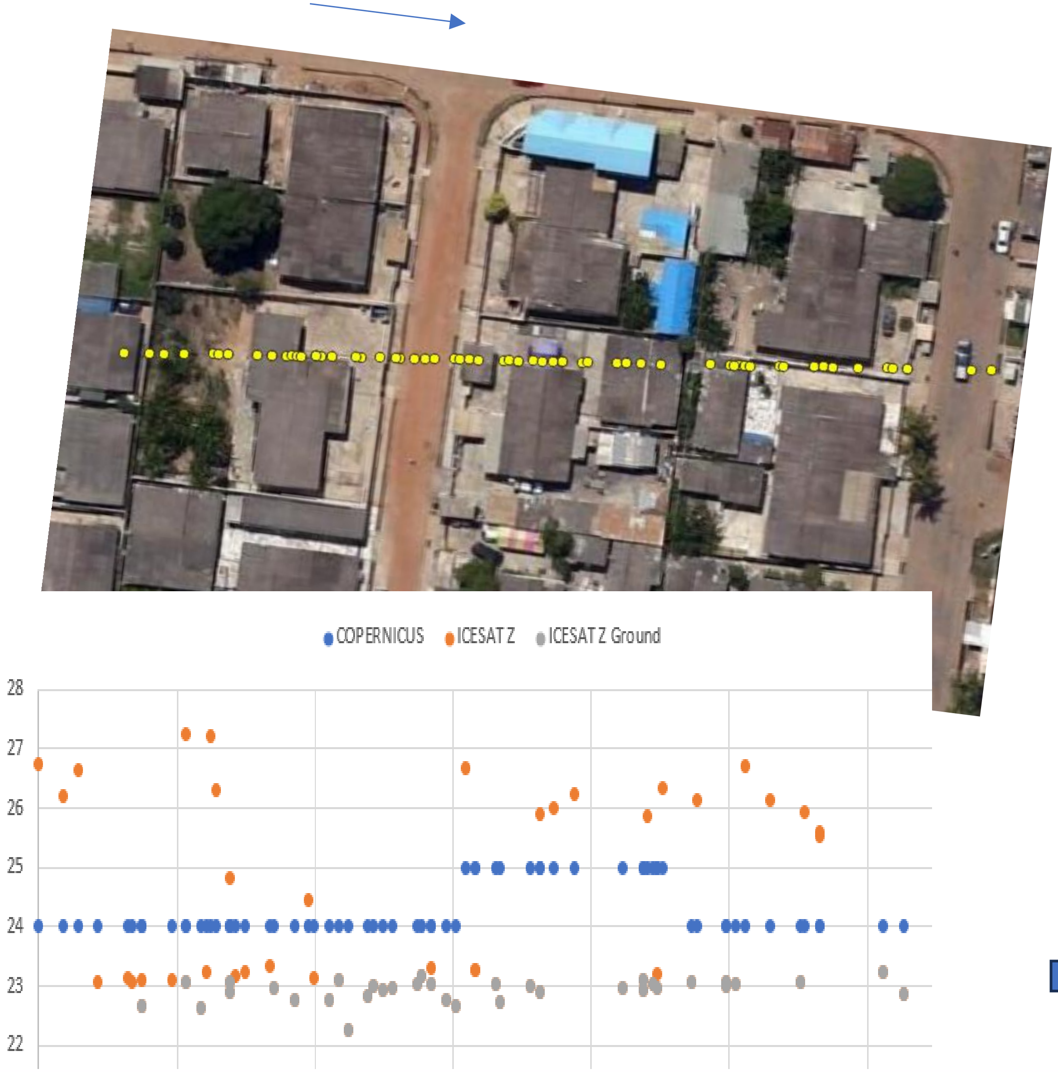


Copernicus DEM is a DSM but :
It appears that Copernicus DEM is not really a true DSM as it provides +/- the average value between the DST and the DTM.



For flood modelling, minimise the gaps is mandatory.

Why a Copernicus DEM improvement ? Example with Icesat2 data



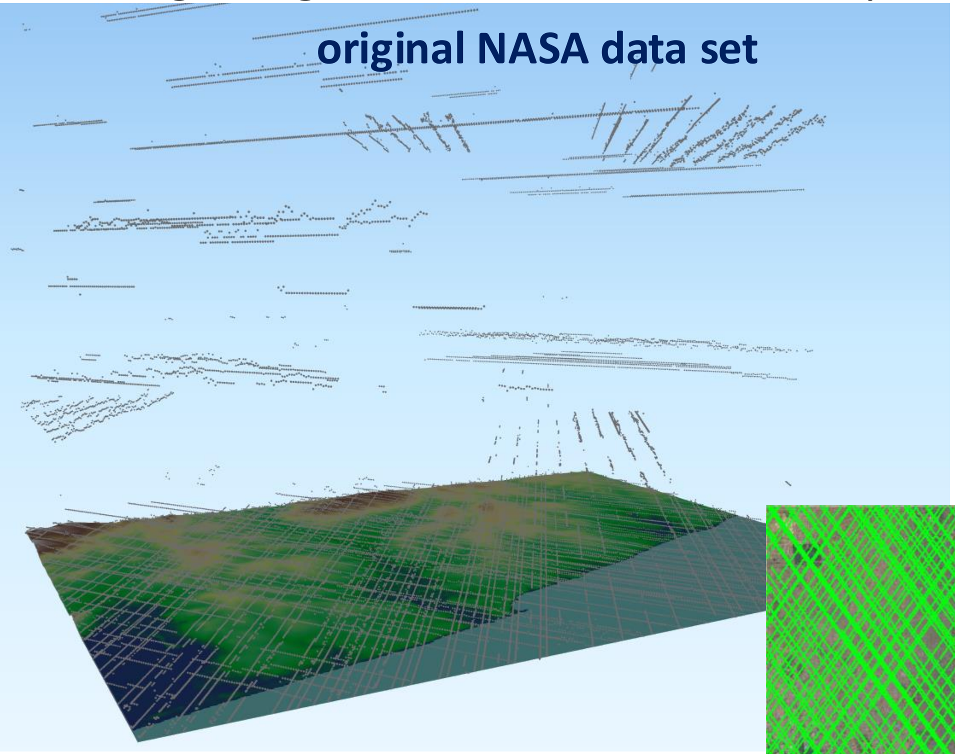
For flood modelling, we have to derived a DTM for the Copernicus DEM in case of absence of relevant DTM.

The preprocessing of ICESAT2 data consists in the separation of canopy and ground information from the footprint

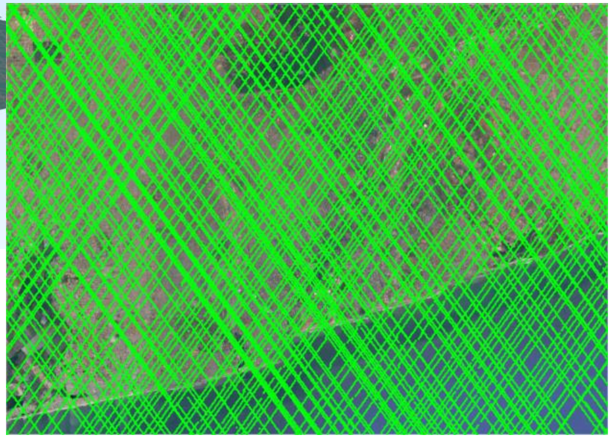
ICESAT2 data confirms that Copernicus DEM is not enough accurate vertically.

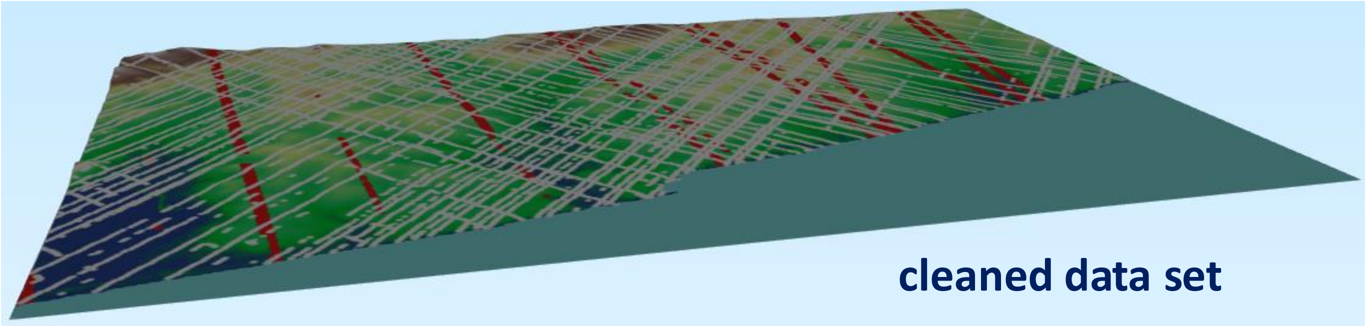
Improved DTM using GEDI/ICESAT-2 : preprocessing

GEDI: getting rid of outliers in the *L2A* products

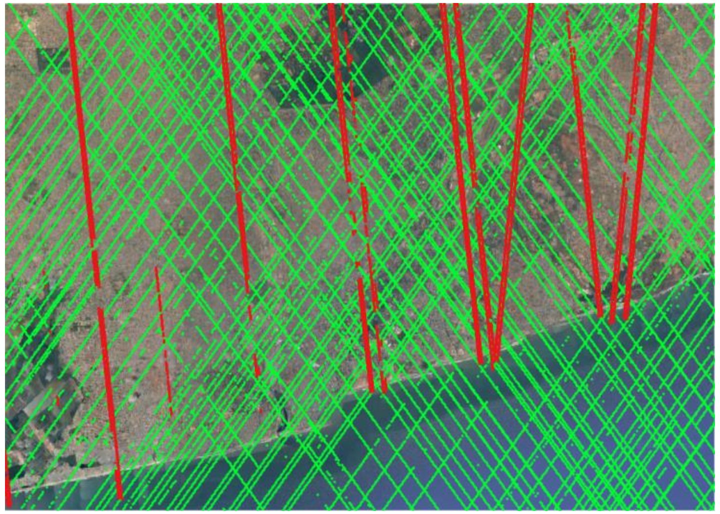


vertical exaggeration : x2





Used data from GEDI+ICESAT2 missions



Improved DTM using GEDI/ICESAT-2 : preprocessing

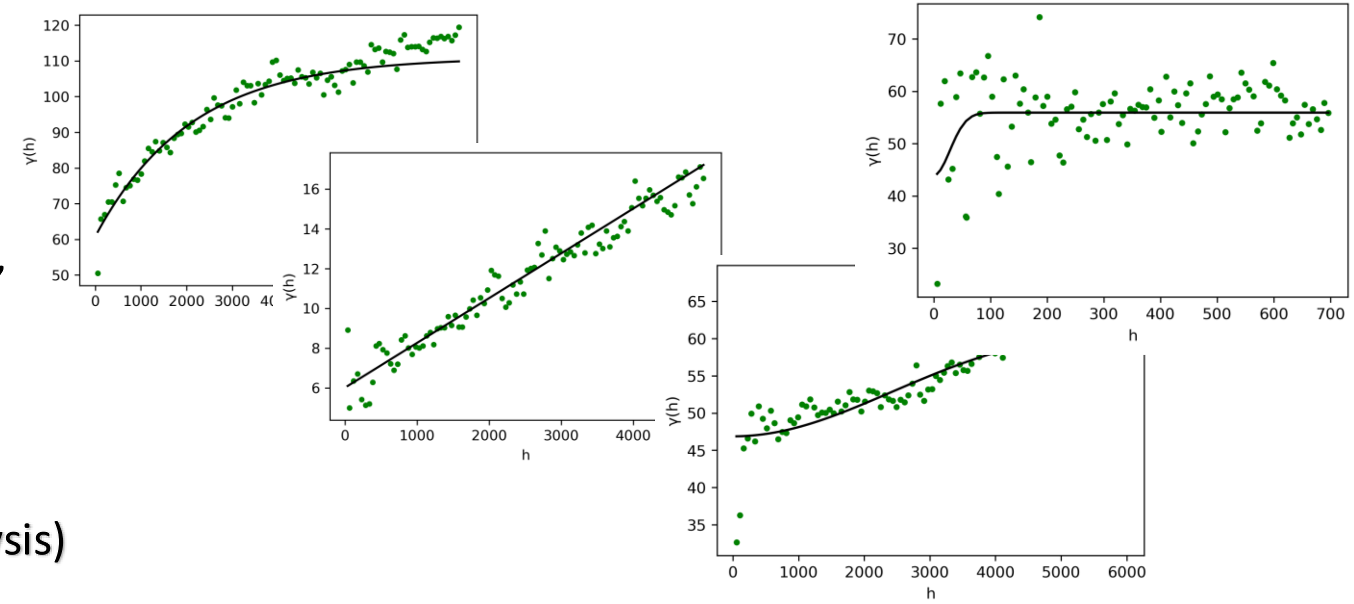
Gridding the GEDI L2A cleaned product / assessing the **geo-statistics** properties

- Design of the <u>variogram</u> model,

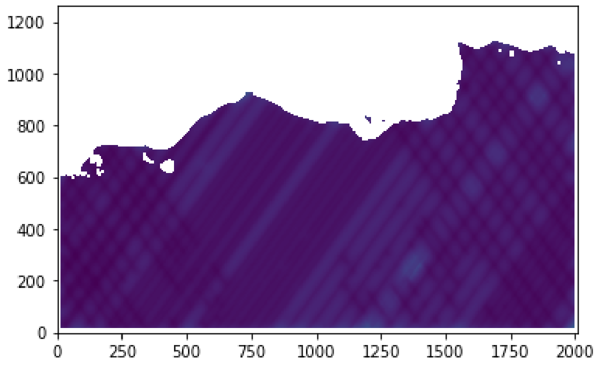
  adapting the input parameters (distance, …) to match the confidence index;

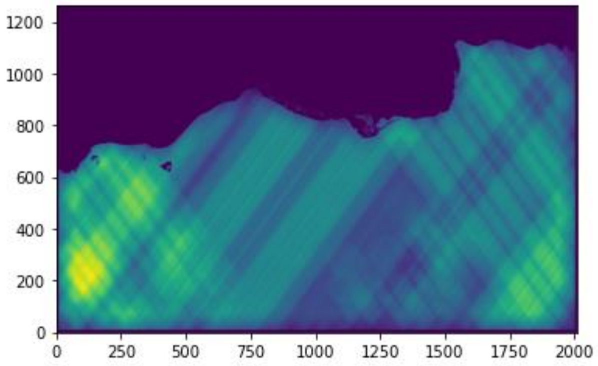
  either gaussian, or exponential, spherical, linear, power, hole-effect…

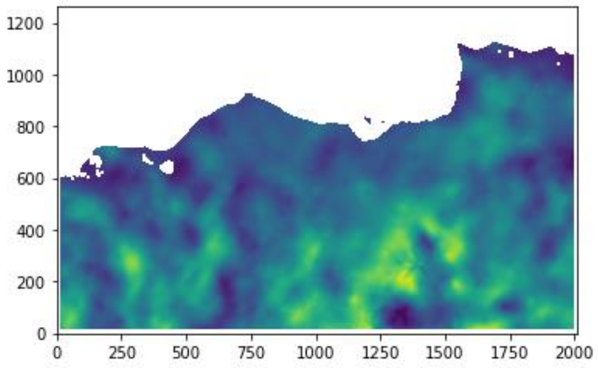
- Size of the area where a fitted <u>variogram</u> model applies



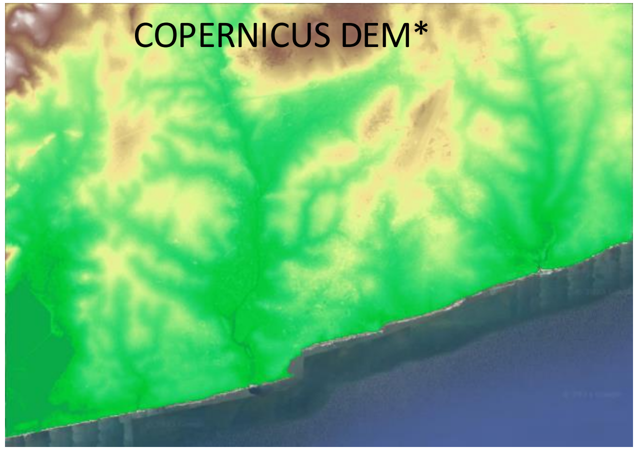
Example of gridding by kriging (~ objective analysis)



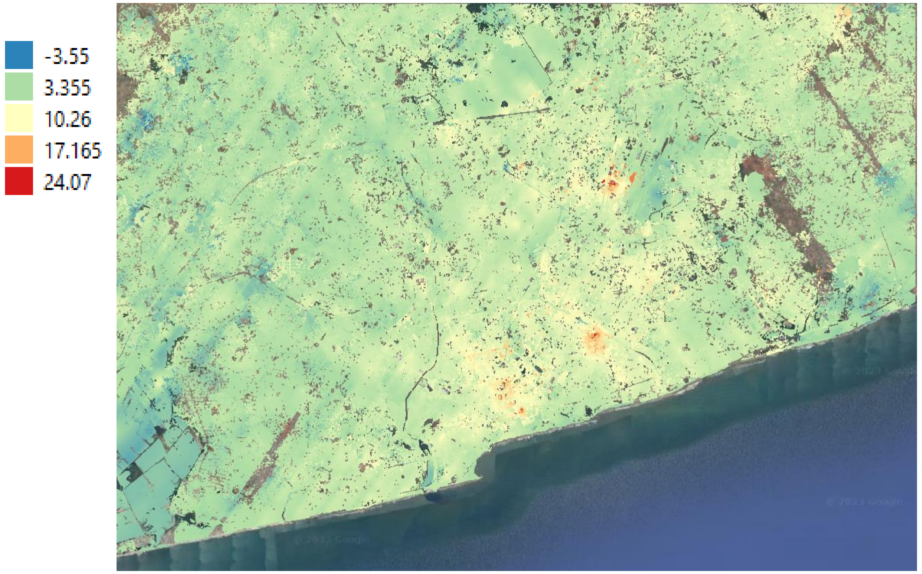


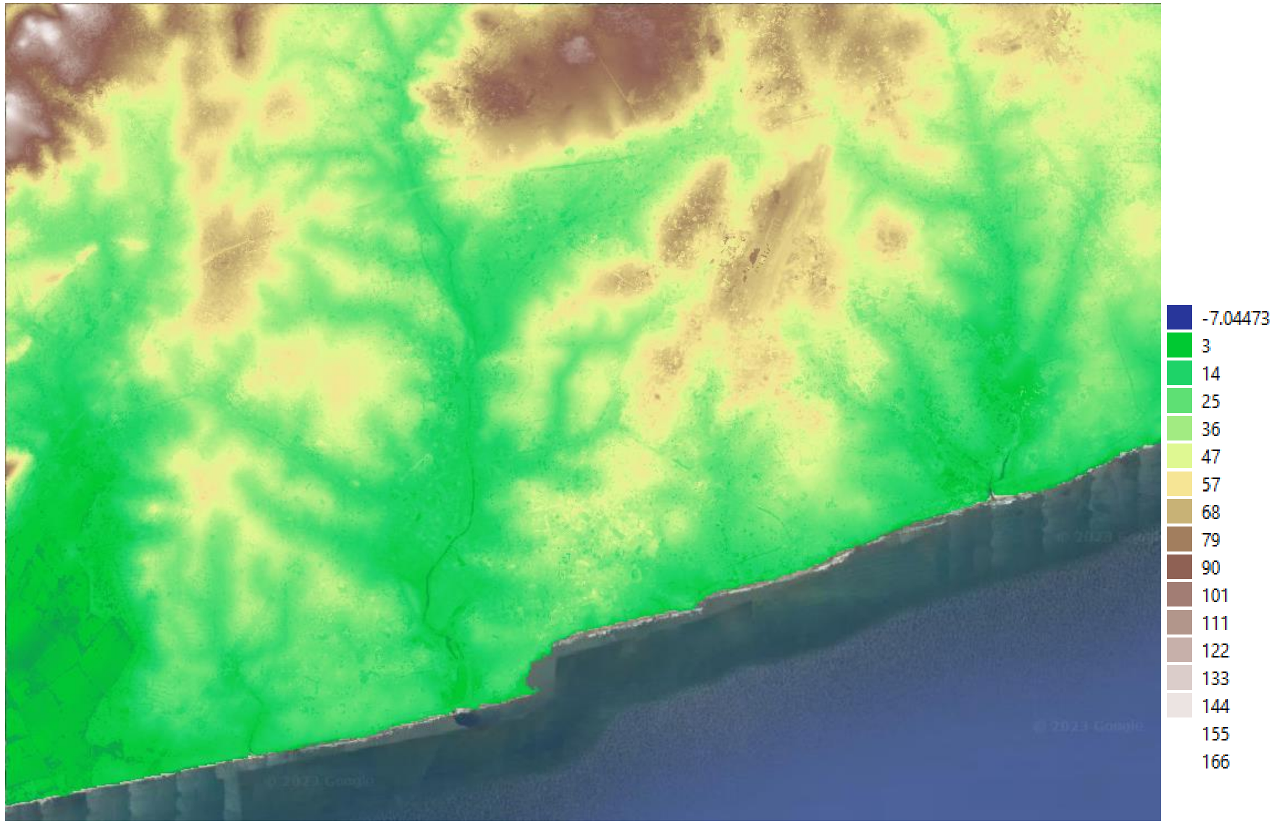


Improved DSM from Copernicus DEM

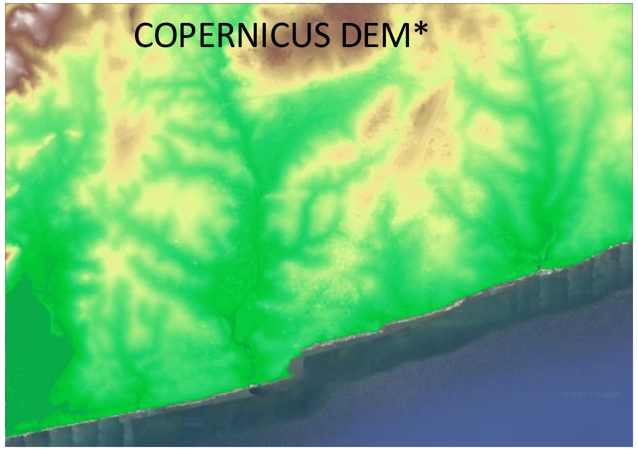


correction to apply to obtain a corrected DSM (in m)

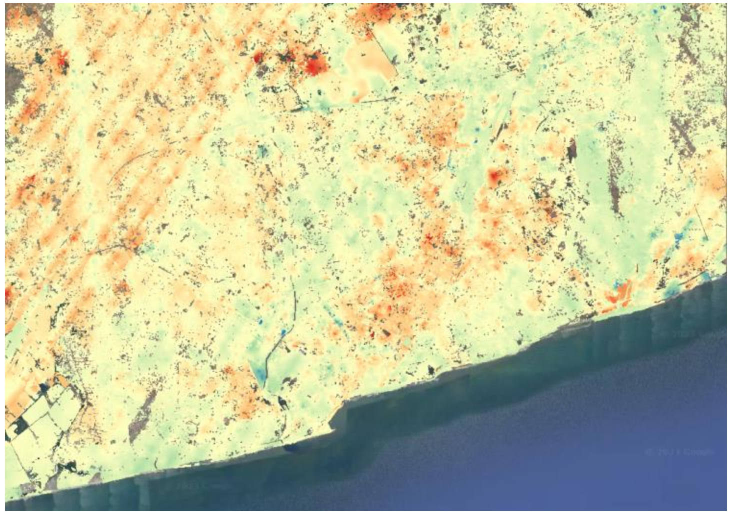


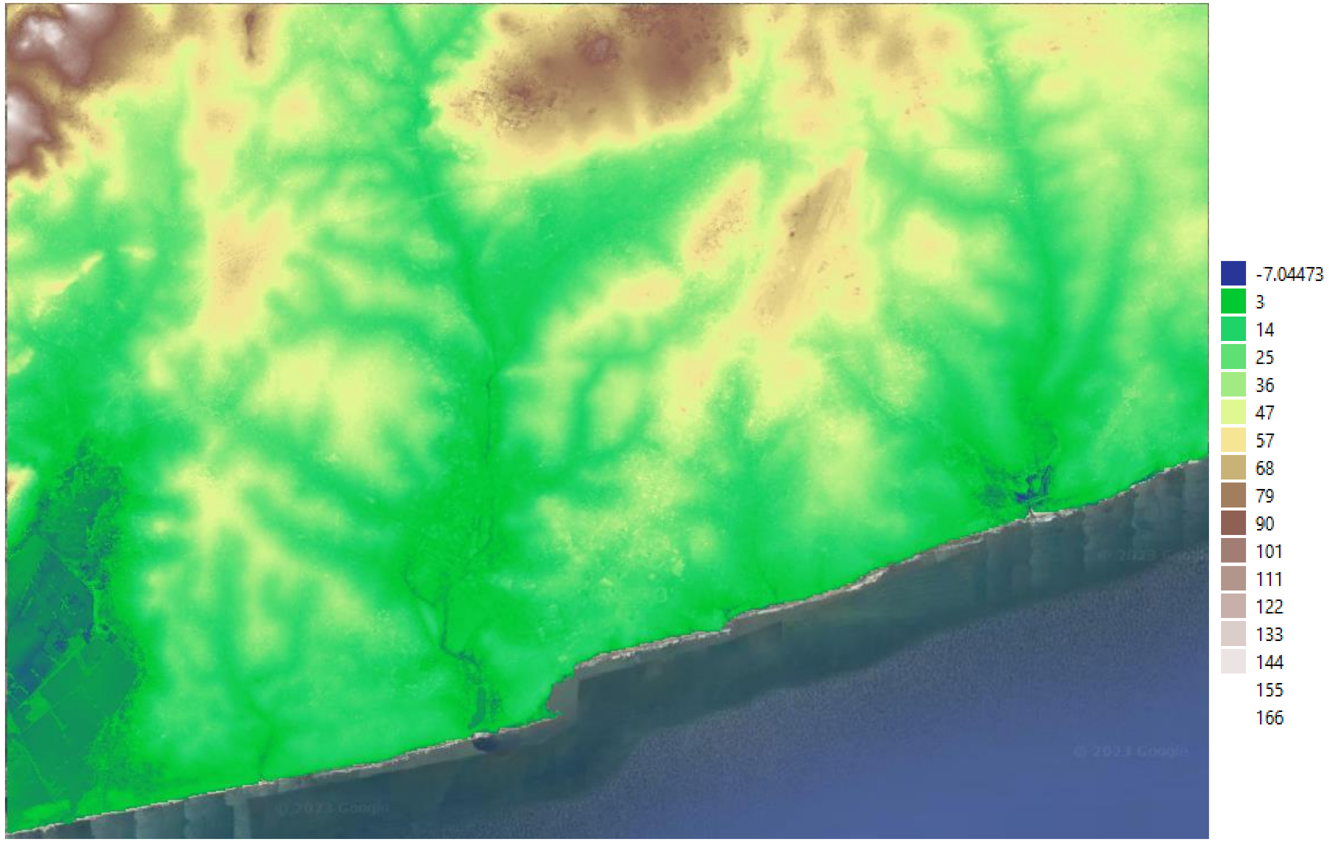


DTM generated with GEDI Mean low Return Values, Icesat2/Atlas3 data and Copernicus DEM



correction to apply to obtain a corrected DTM (in m)



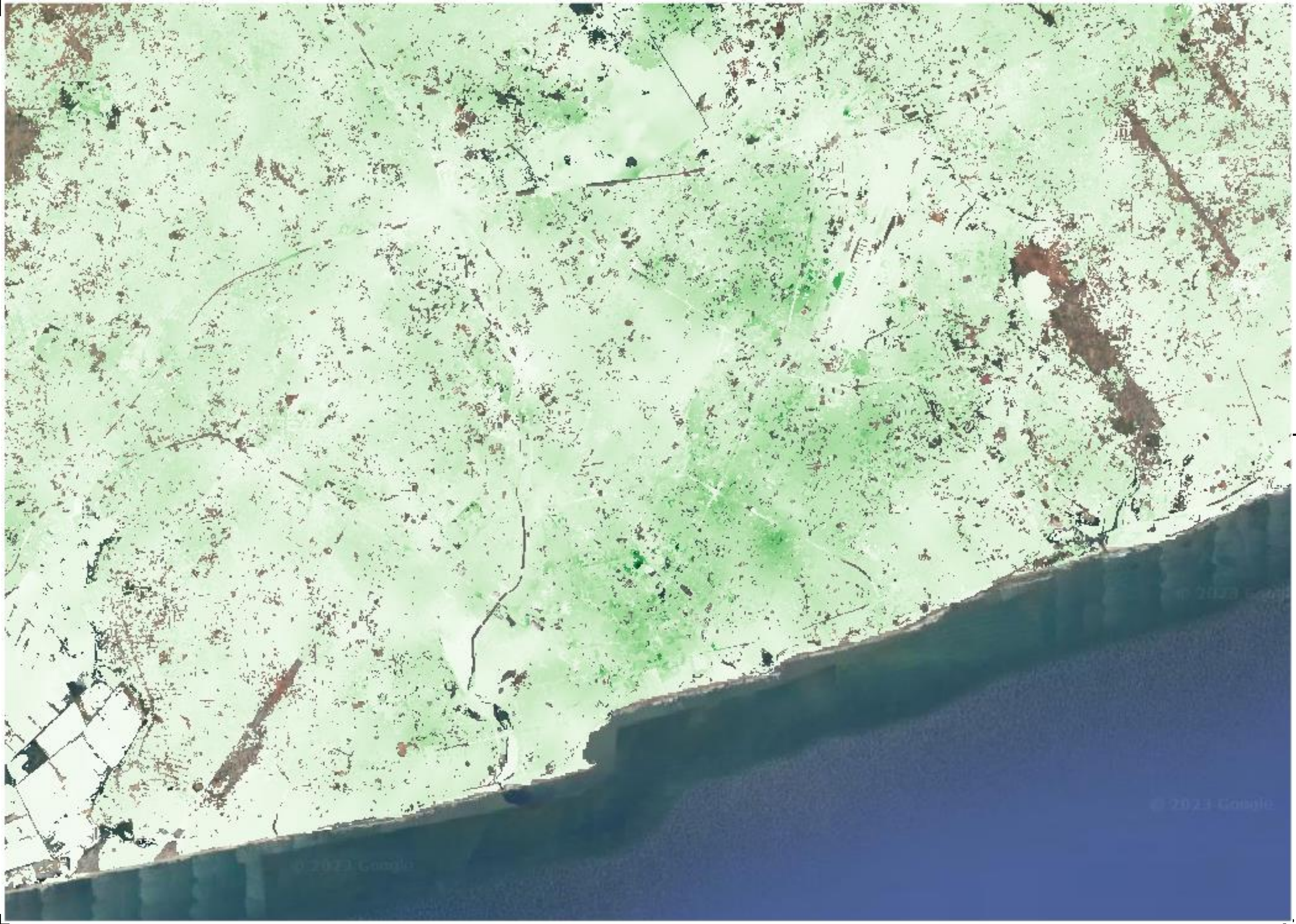


Feature height map

Features’ heights from GEDI Data*

-0,29E ; 5,64N

-0,29E ; 5,64N



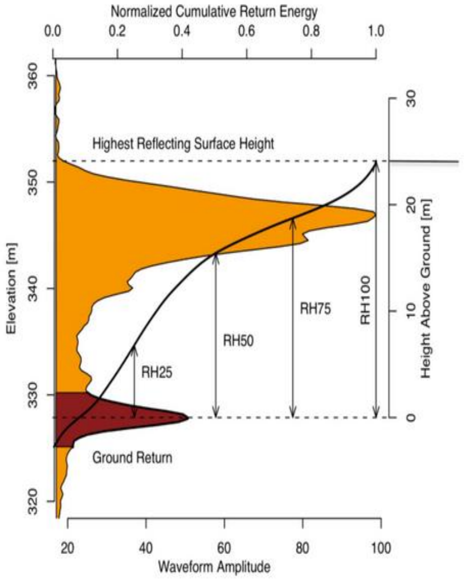
-0,29E ; 5,51N

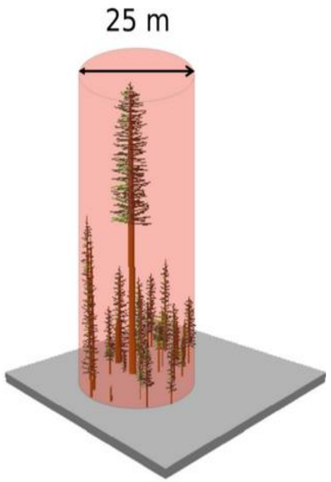
-0,11E ; 5,51N

Highest return

Low return

Lowest return



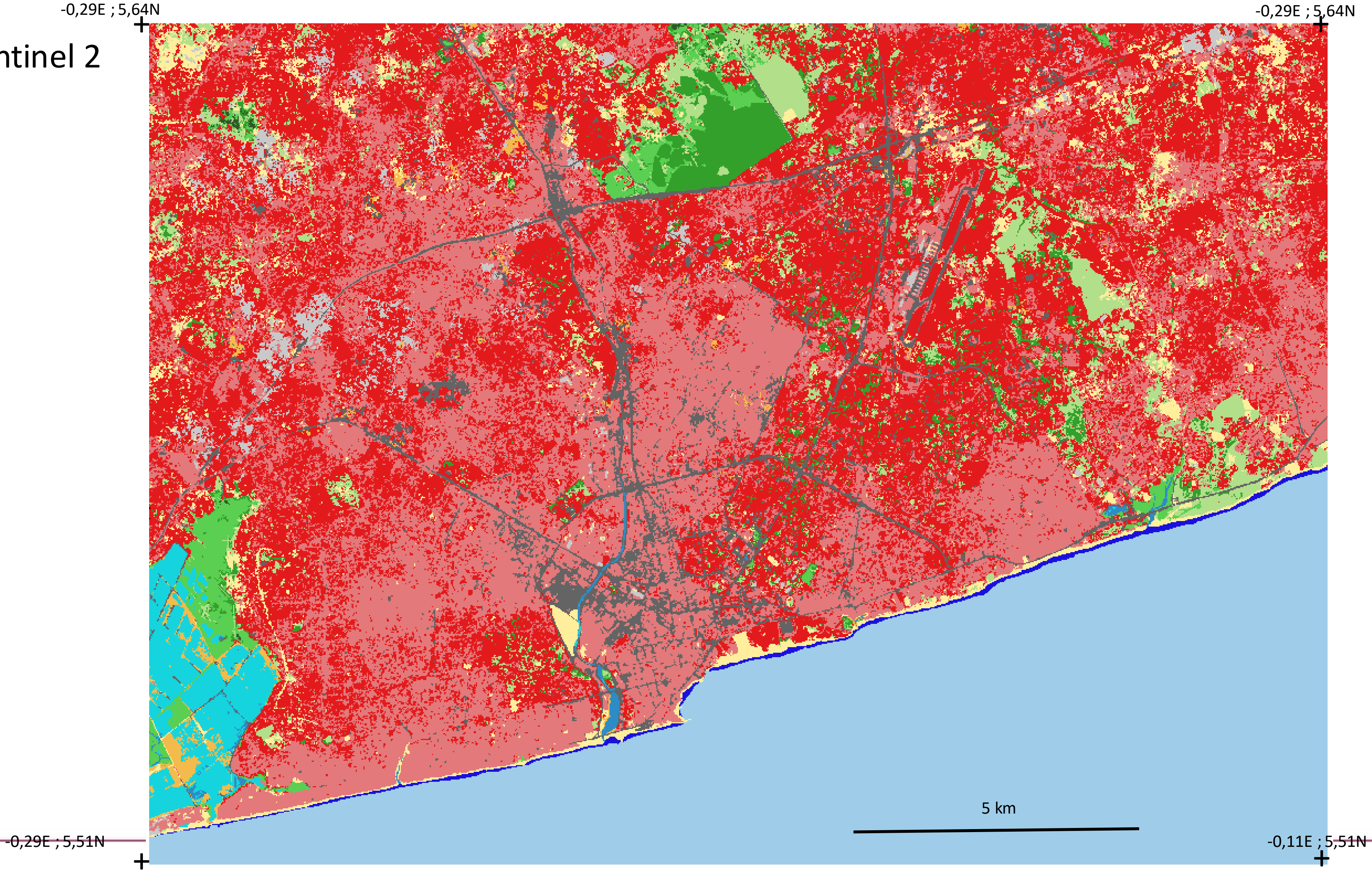


Limitation of DEM/DTM for flood modelling: Bridge

Z exaggeration : 3
Cover: Google

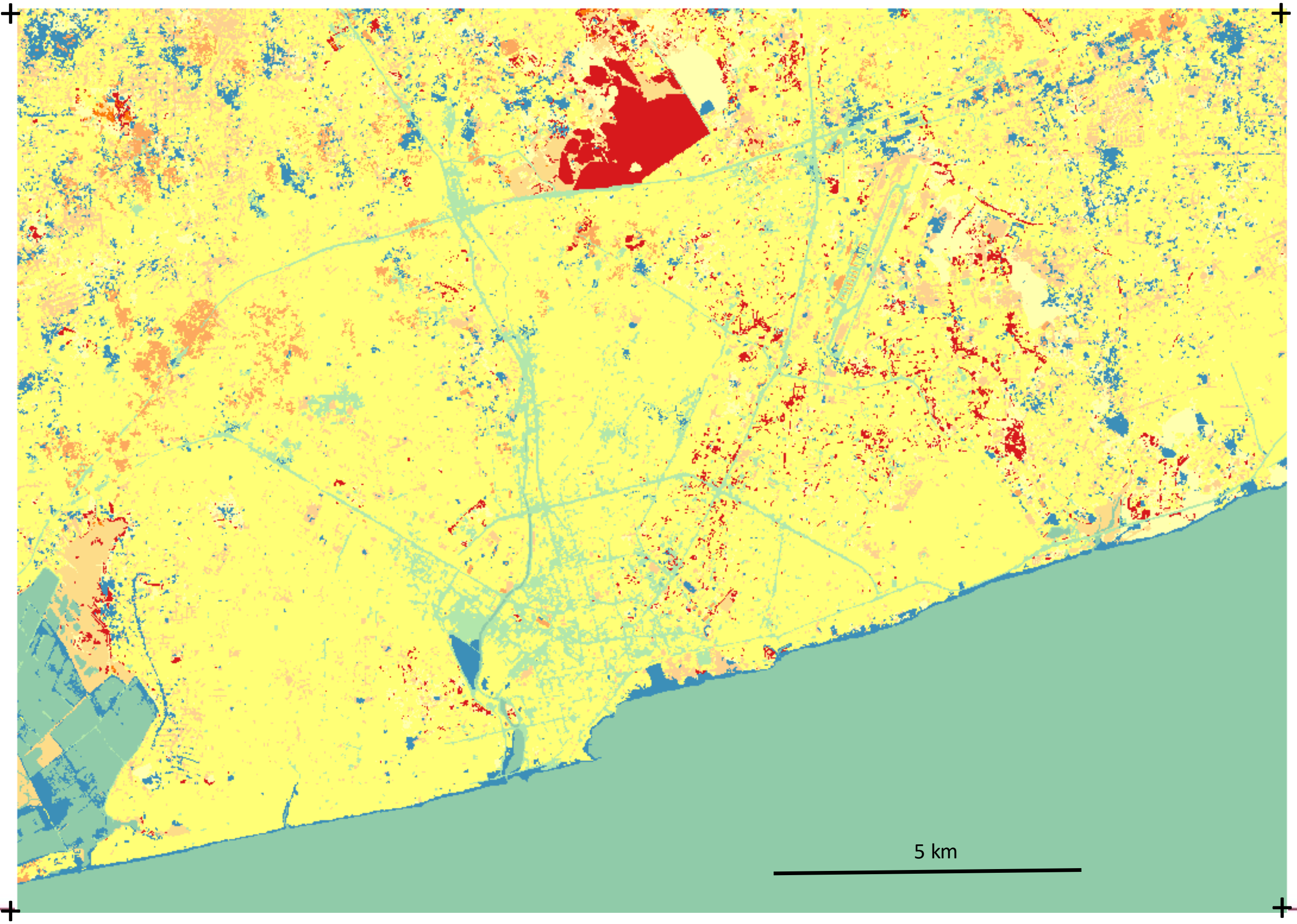
Backshore Classification

based on 1 year of Sentinel 2 data (1 tile)



Flow drag coefficient

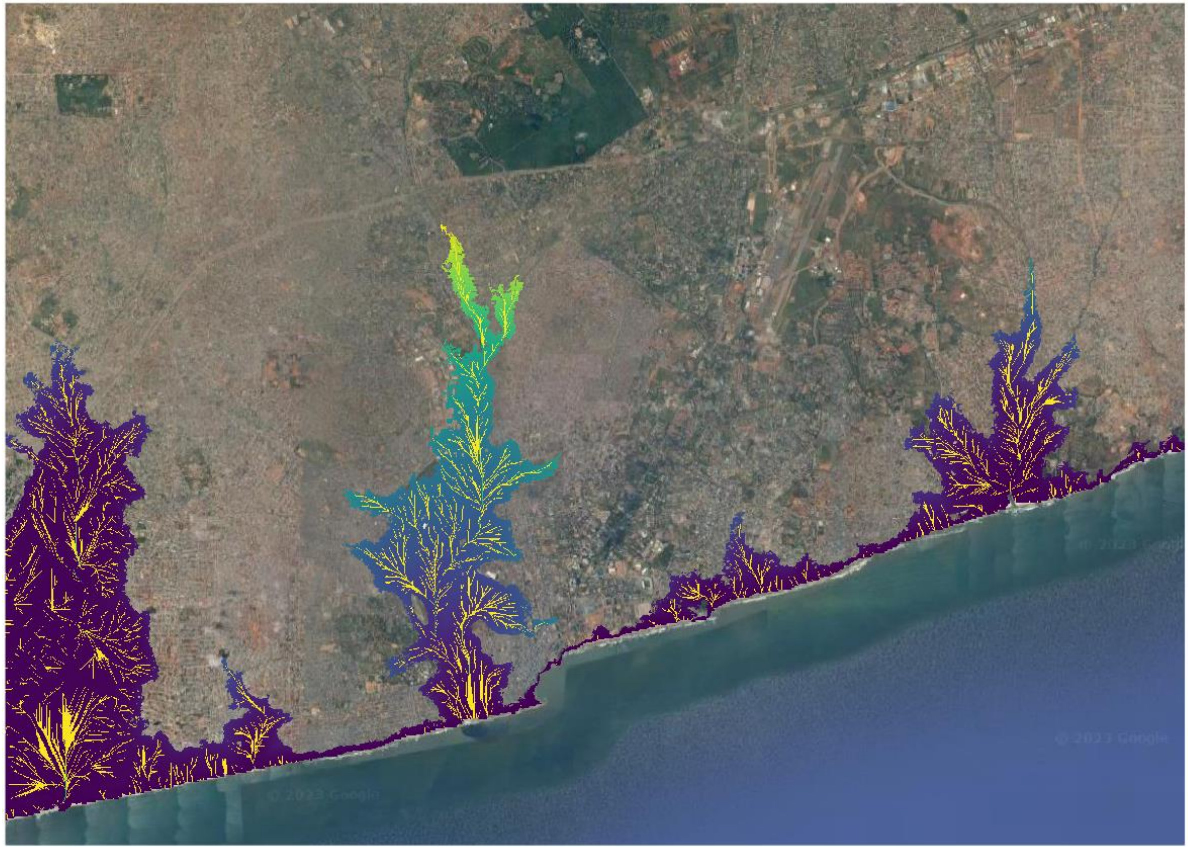
based on the backshore classification and adjusted Manning's coefficients



LU/CL	Manning's coefficients Value Range	Description	Selected coefficient
Industrial	0.12-0.20	Developed High intensity. Impervious surface 80% -100%	0.2
Infrastructure	0.08-0.16	Developed Medium intensity. Impervious surface 50% -79%	0.08
Urban	0.12-0.20	Developed High intensity. Impervious surface 80% -100%	0.12
House	0.12-0.20	Developed High intensity. Impervious surface 80% -100%	0.16
Baresoils	0.023-0.03	Barren land (Rock/Sand/Clay). Vegetation <15 %	0.015*
Mudflat	0.023-0.03	Barren land (Rock/Sand/Clay). Vegetation <15 %	0.015*
Grassland	Grassland : 0.025-0.05 Shrub : 0.07-0.16	Grassland = Vegetation >80% In that ROI, assimilated to Shrub	0.1
Tree cover	0.08-0.2	Mixed forest	0.4*
Mangrove	0.08-0.16	Evergreen forest	0.32*
Tidal		N/A	0.001
Reef		N/A	0.001
Water	0.025-0.05	Open water	0.025

Channeling elements

based on the Calibrated DTM using a cost-raster method and path distance tool



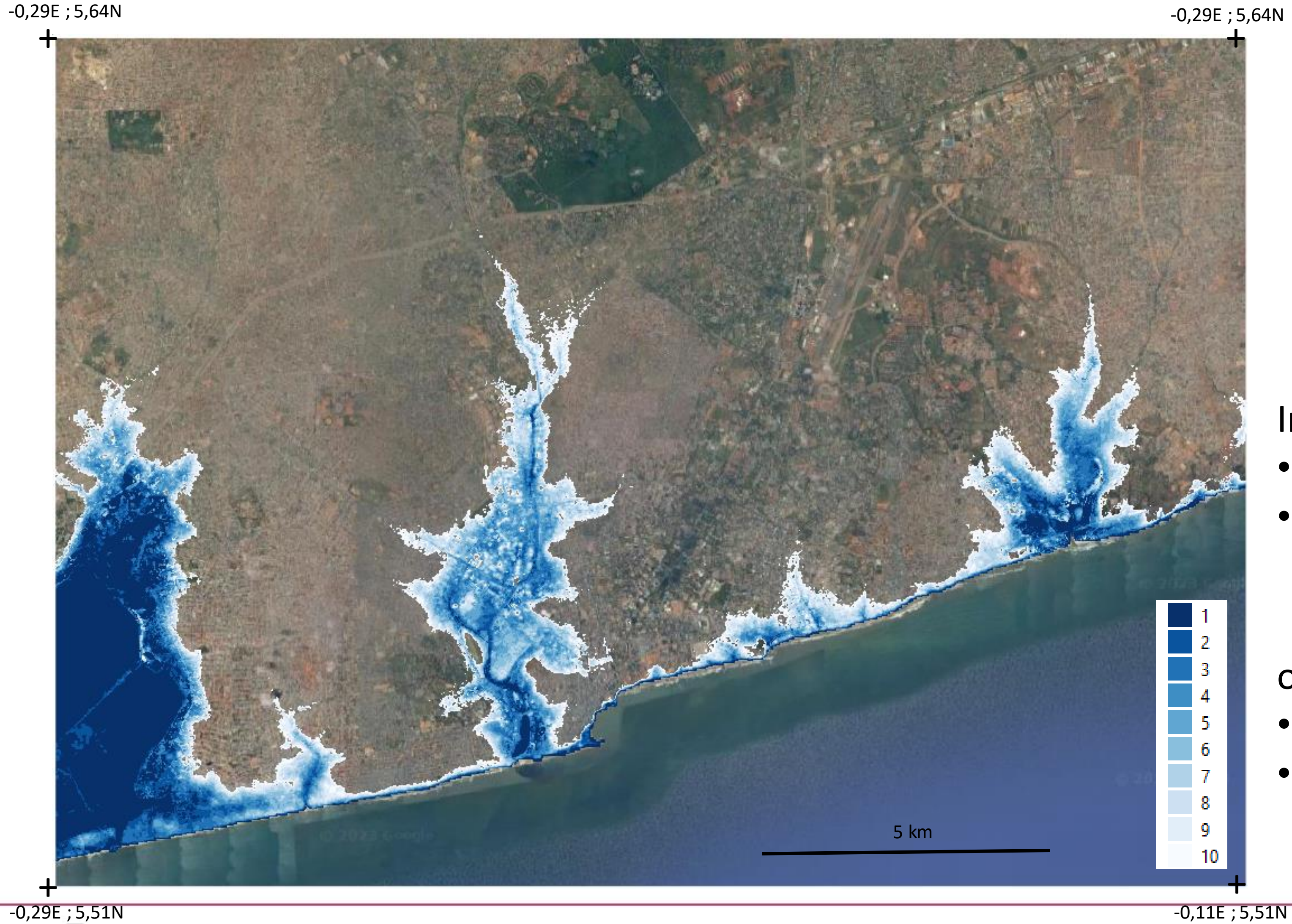
Channeling elements and cumulative cost information

Input parameters:

- Coastline as the water source
- A cost-raster where the cost of
  - perpendicular travel cost = 10
  - diagonal travel cost = 14,1
- A digital elevation model (DTM) to account for the effect of declining/ inclining slopes on flow

Inundation model maps : bathtub approach

Map of water extent, in case of Sea Level Rise, based on the Calibrated DTM



* Equivalent to ~ a water income of 1m^3/s during 1hour

Input parameters:

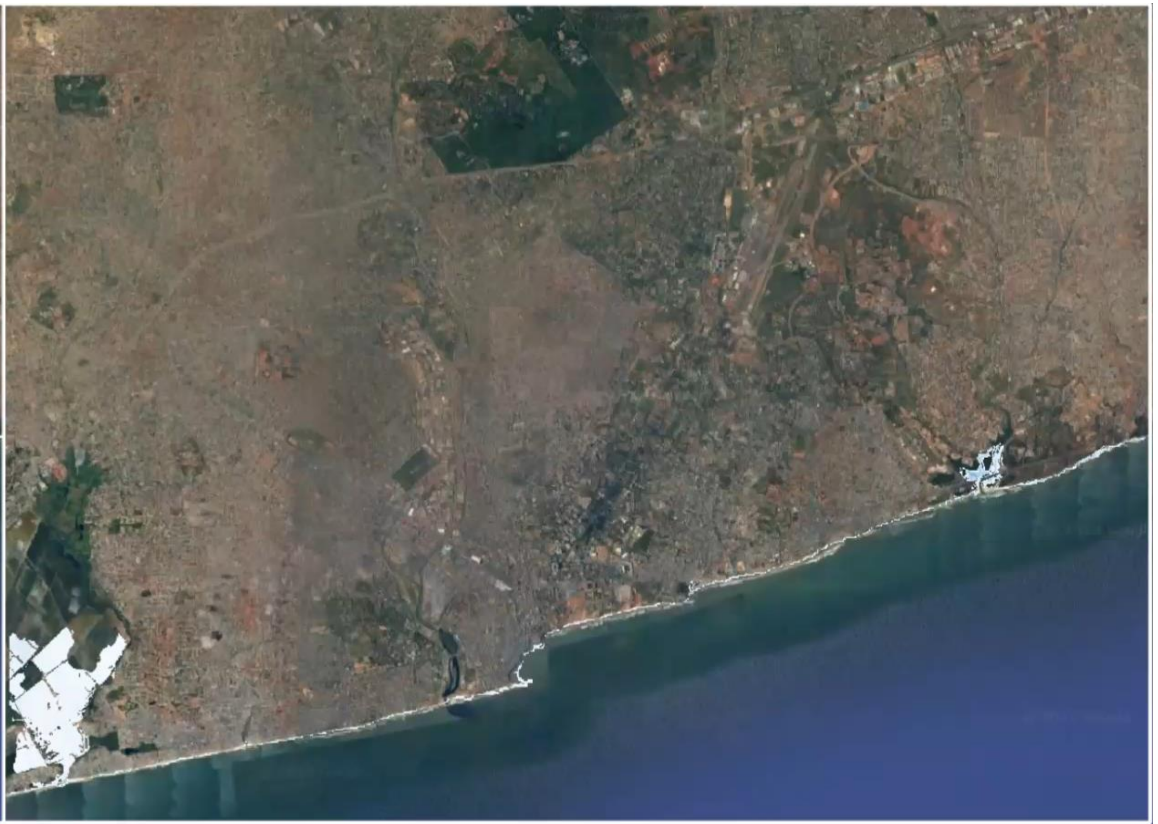
- A digital elevation model (DTM)
- Sea level rise from 1m to 10m*

outputs :

- Map of water extent from 1m to 10 m SLR
- 10 maps of water depth (one for each scenario of SLR)

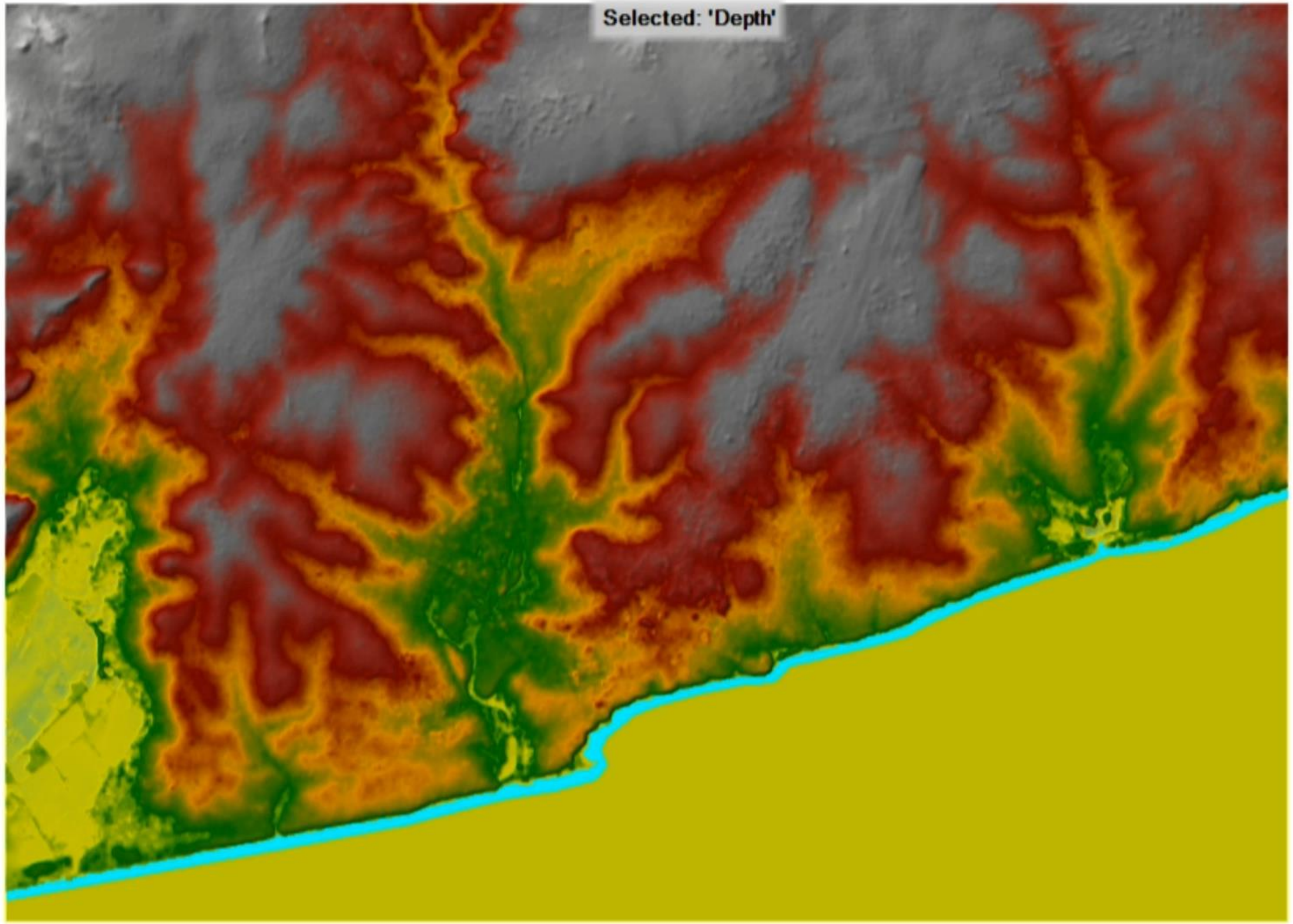
Inundation model maps : bathtub approach

Static bathtub



Quasi-static bathtub processed
With HEC-RAS

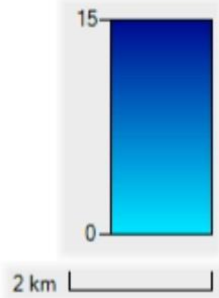
Inundation model maps : bathtub approach



Modelling using HEC-RAS software

Flow Hydrographe

Input : 0,3m^3/s
Time : 3h



Inverse watershed model

-0,29E ; 5,64N

-0,29E ; 5,51N

-0,11E ; 5,51N

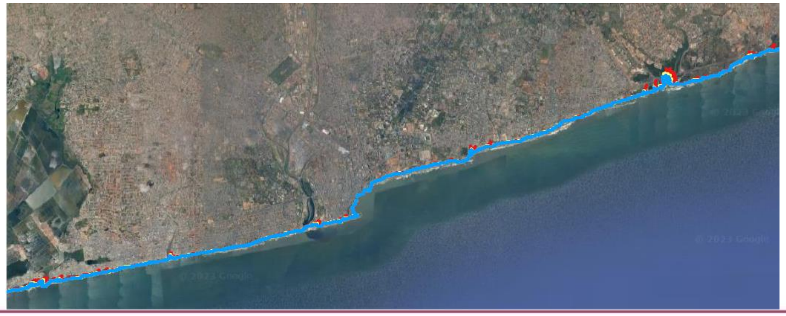
Areas with potential risk: estuaries, river's mouths

Input parameters:

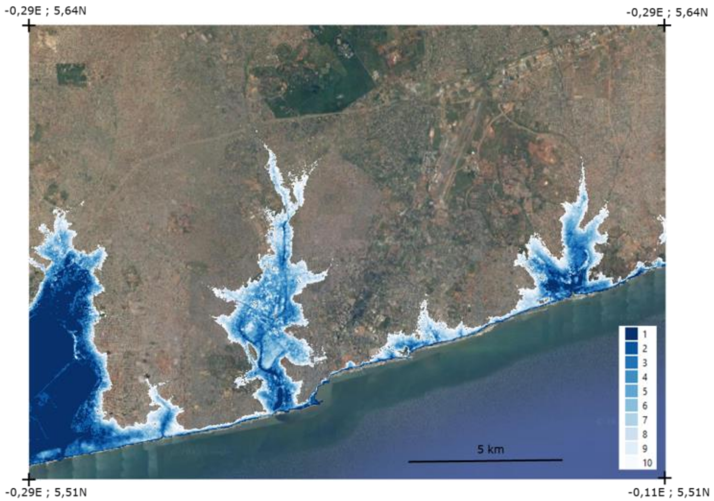
- A digital elevation model (DTM)
- a drag coefficient map
- Flow speed and direction

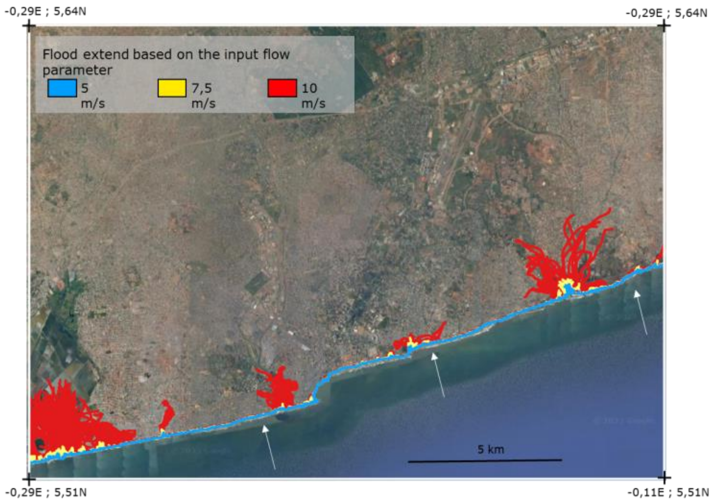
output : Vector point file in SHP format

Simulations performed for 3 speeds and 4 origins



Bathtub approach vs Inverse watershed model





Bathtub approach	Inverse watershed model
Long term event (3h)	Short term event (10mn)
Static/quasi static modelling	Dynamic modelling
No speed reduction	Speed reduction due to slope angle (gravity) and to ground frictions
GIS or St Venant Equation models	Refraction action
Storm surge & any slow sea level rise	Storm surge waves

強靭性 革新 伝統

TRADITION • INNOVATION • RESILIENCE

Thank you !

https://argans.co.uk

Logos: