EGU General Assembly 2020

High-resolution mapping of lake and floodplain topography from space

Alice Fassoni-Andrade,

Rodrigo Paiva, Claudio Barbosa, Evlyn Novo, Conrado Rudorff and Ayan Fleischmann

doi.org/10.5194/egusphere-egu2020-142

Large Scale Hydrology
https://www.ufrgs.br/lsh/
Institute of Hydraulic Research
Federal University of Rio Grande do Sul
Porto Alegre, Brazil
alice.fassoni@gmail.com

UFRGS
UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

HGE
Hidrologia de Grande Escala

INTRODUCTION

TOPOGRAPHY OF LAKES is a **key information** for hydrological, ecological and geomorphological studies.
It can be estimated using **altimetry data** and **flood extent** images.

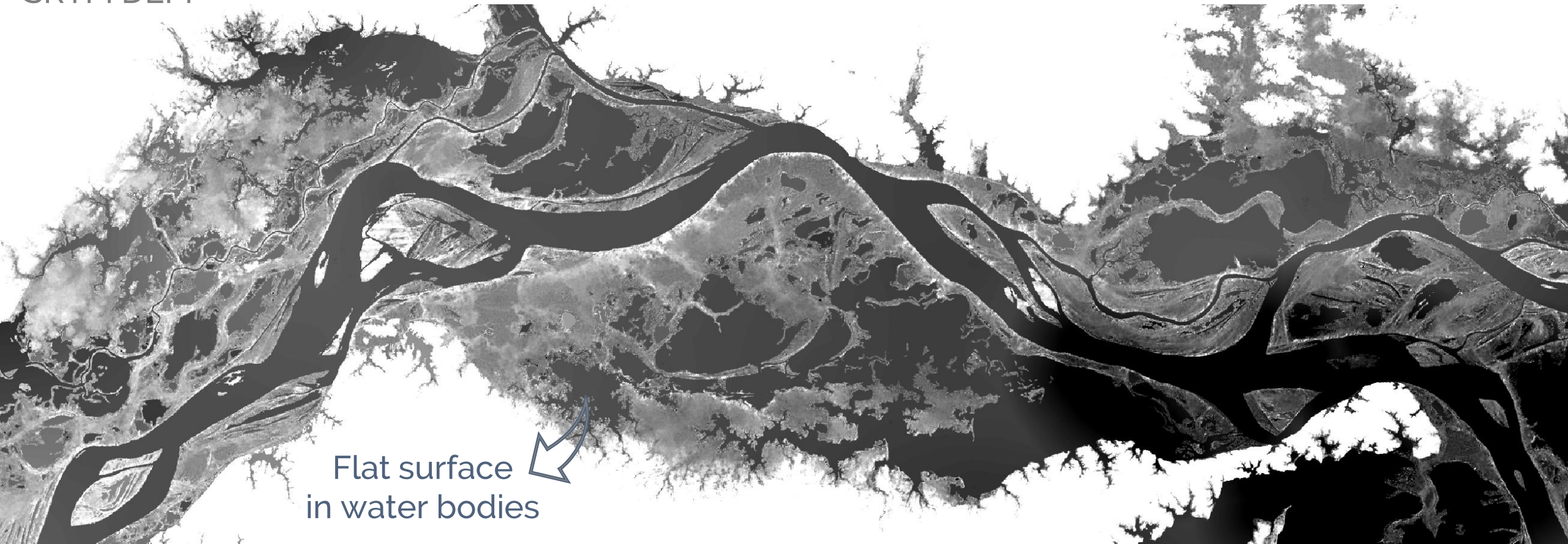
PREVIOUS STUDIES:
Delimitation of the shorelines (isobath) of lakes over time.

LIMITATIONS in areas with many lakes, such as floodplain lakes:
This delimitation have **high processing costs**, in addition to inherent **difficulties** due to connections among lakes.

INTRODUCTION

There is no systematic topography mapping of lakes and channels in large and complex floodplains using remote sensing data

SRTM DEM



OBJECTIVE

1

We present a systematic method for estimation of near shore topography for water bodies based on a flood frequency map and time series of water levels.

2

Test cases are performed for two lakes and 12 reservoirs, and in the central Amazon floodplain.

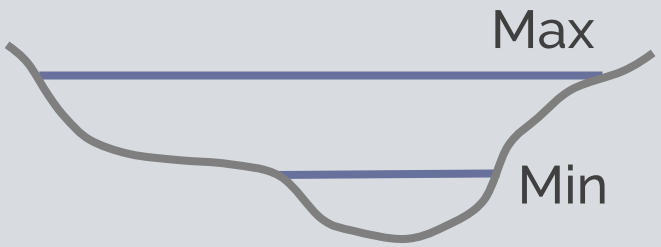
OBJECTIVE

1

Pixel by pixel

We present a systematic method for estimation of near shore topography for water bodies based on a flood frequency map and time series of water levels.

Above the lowest observed water surface elevation



2

Test cases are performed for two lakes and 12 reservoirs, and in the central Amazon floodplain.

FLOOD FREQUENCY-BASED METHOD

How the method works?

1

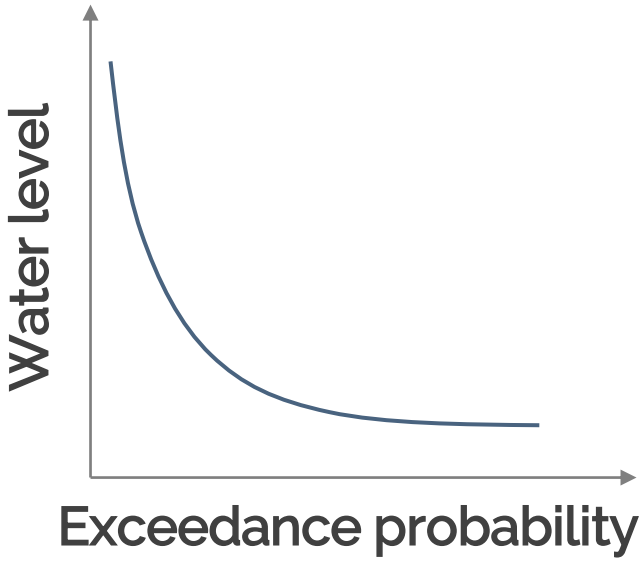
Flood frequency map

0	25	50
0	50	75
25	75	75

From flood extent maps

2

Water level duration curve



INPUT

FLOOD FREQUENCY-BASED METHOD

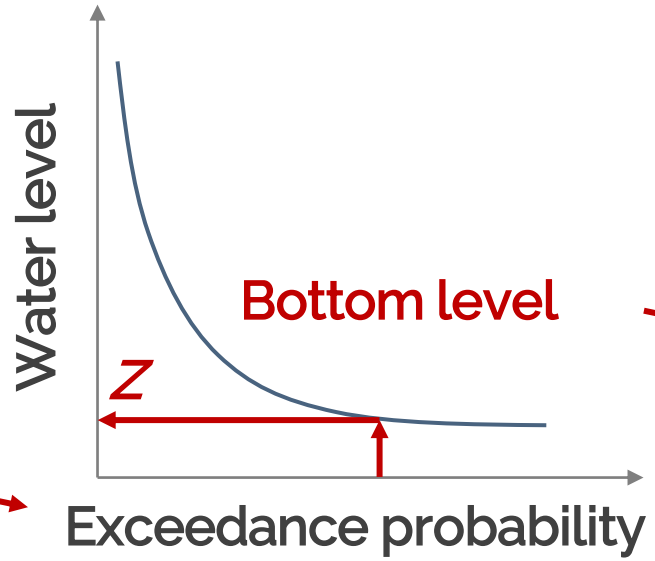
It consider the equivalence between **flood frequency** and water level **exceedance probability**

1

Flood frequency map

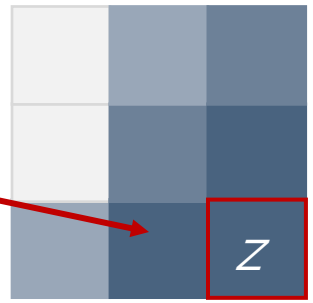
0	25	50
0	50	75
25	75	75

2



3

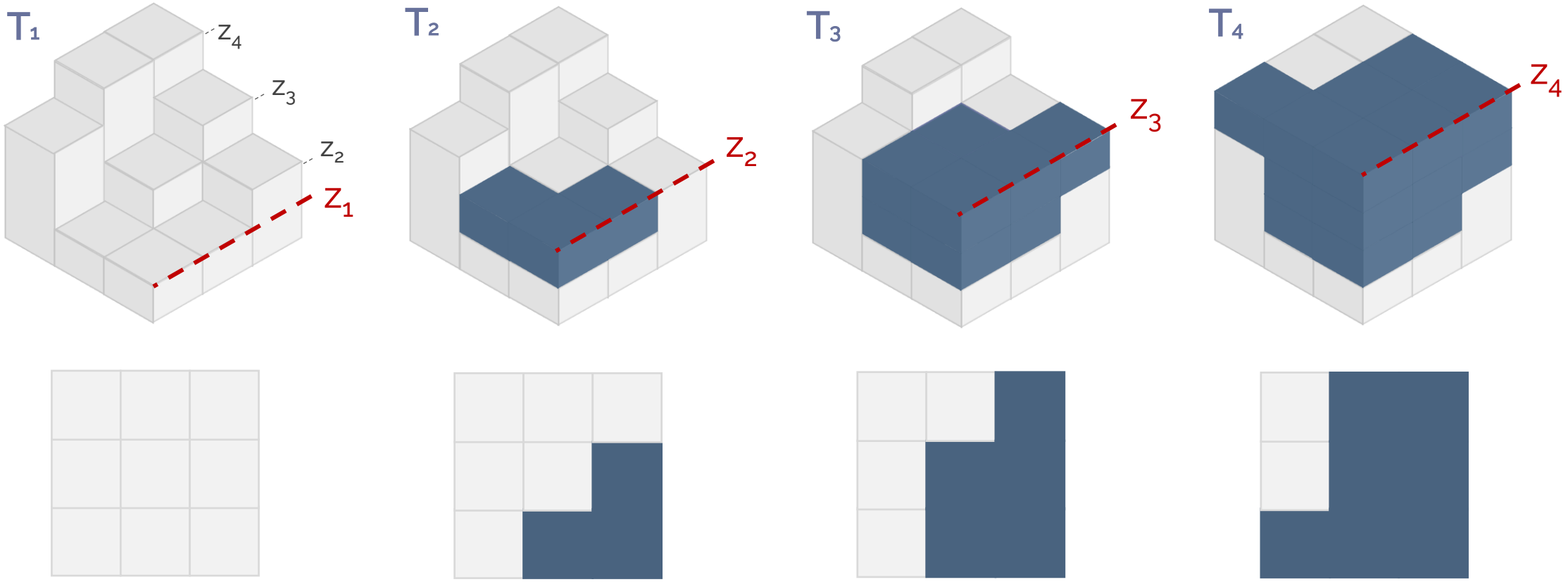
Topography map



OUTPUT

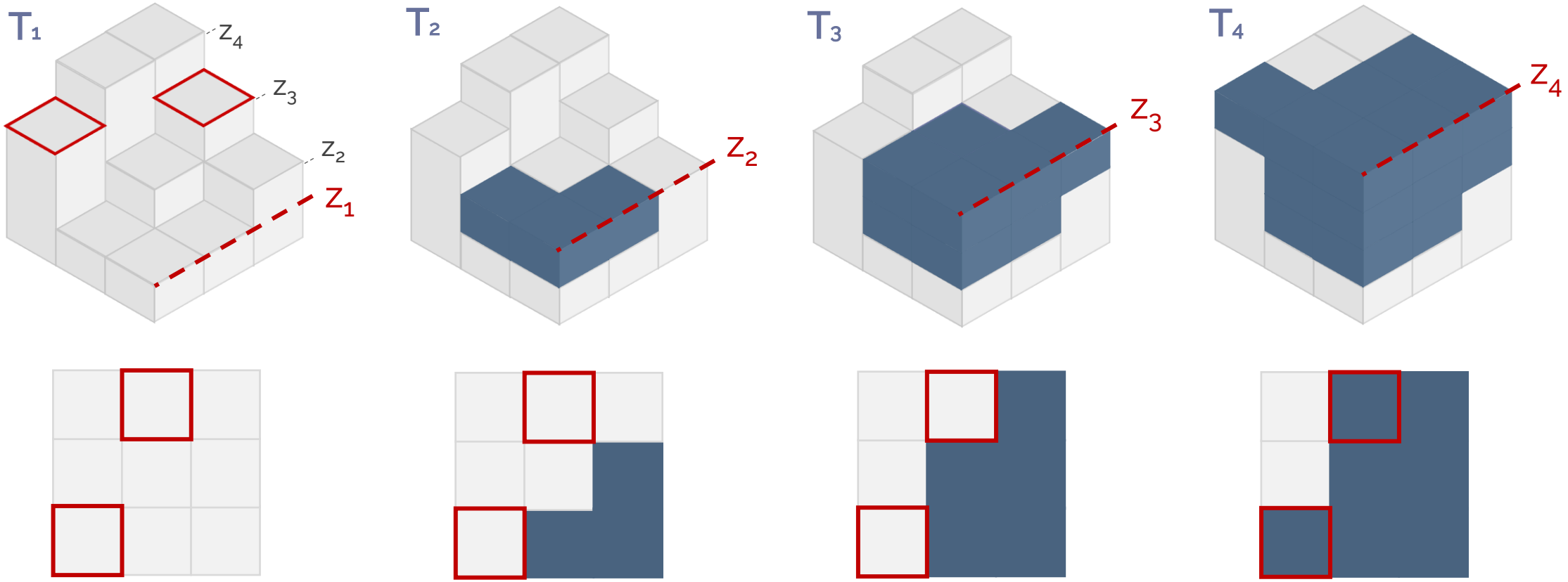
EXAMPLE

DEM with defined bottom level (z_1 to z_4);
Water surface increases each time step (T_1 to T_4).



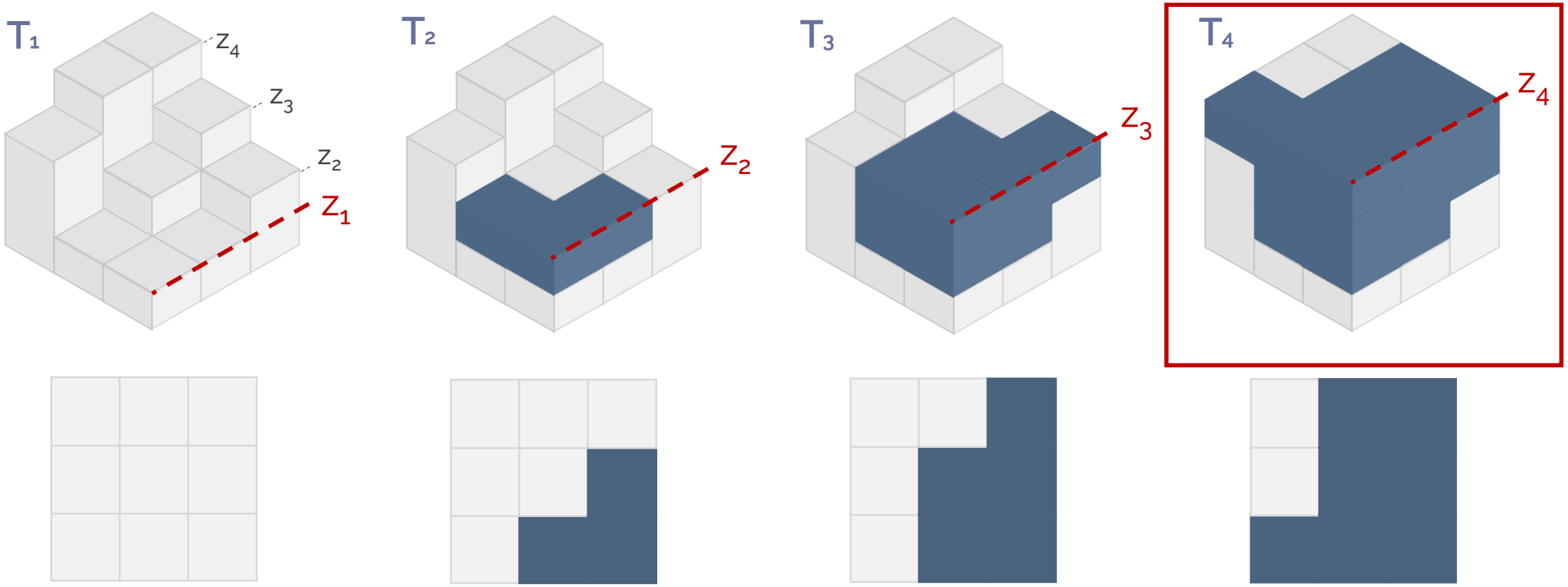
EXAMPLE

Flood frequency for pixels with bottom level z_3 is 25% of the time



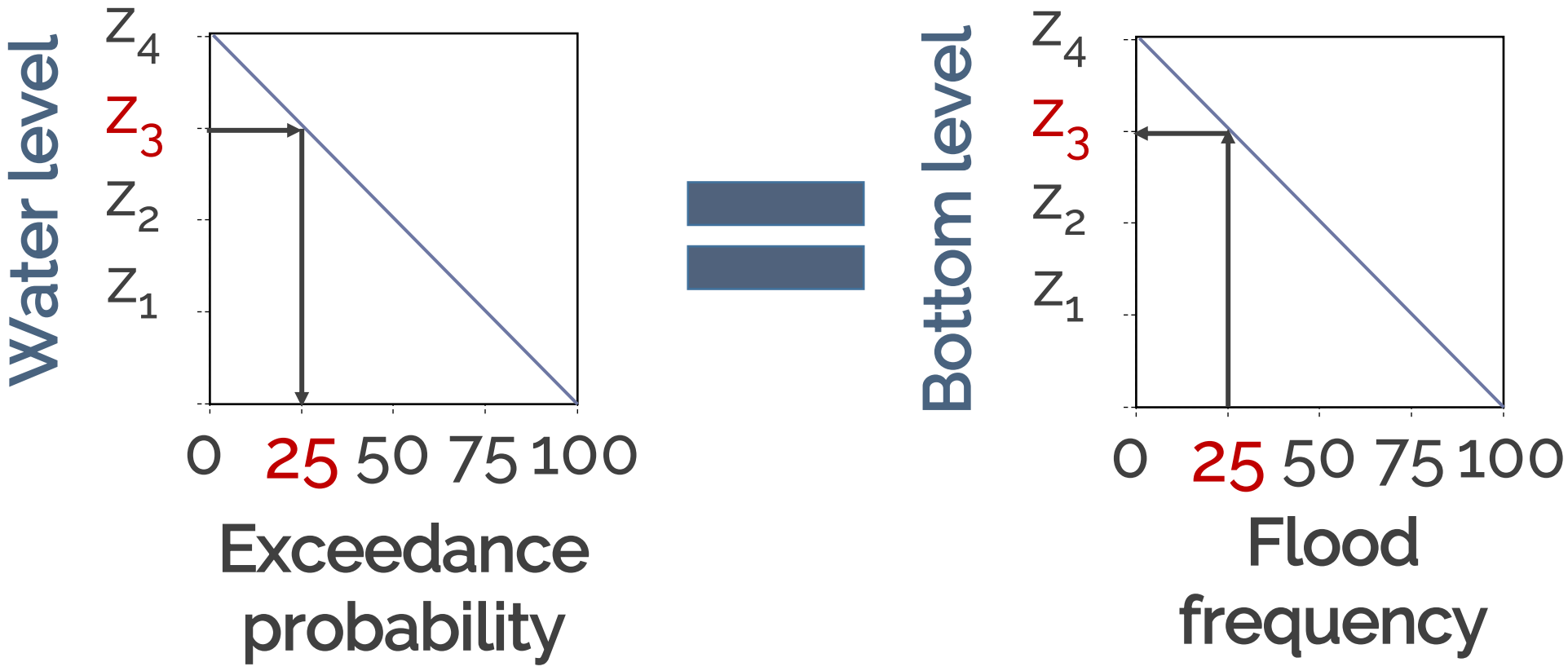
EXAMPLE

Probability that the water level exceeds z_3 is 25% of the time



EXAMPLE

Therefore: equivalence between **flood frequency** and **water level exceedance probability** at a given area

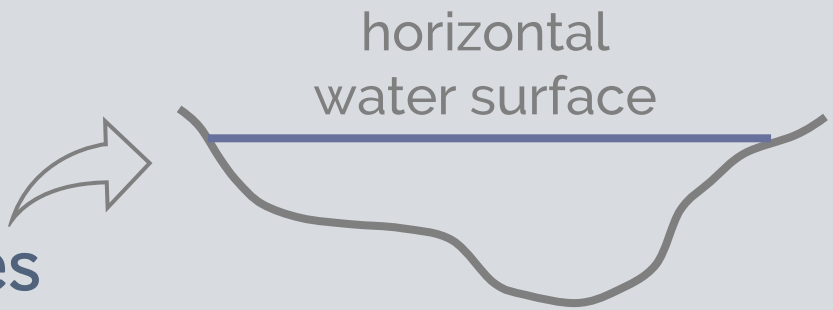


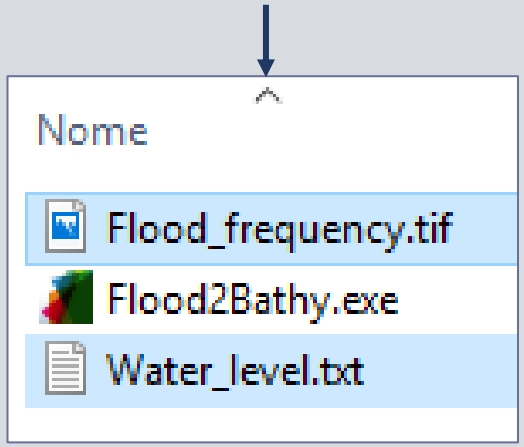
Flood2Topo app

converts water levels and Landsat based flood frequency into water body topography

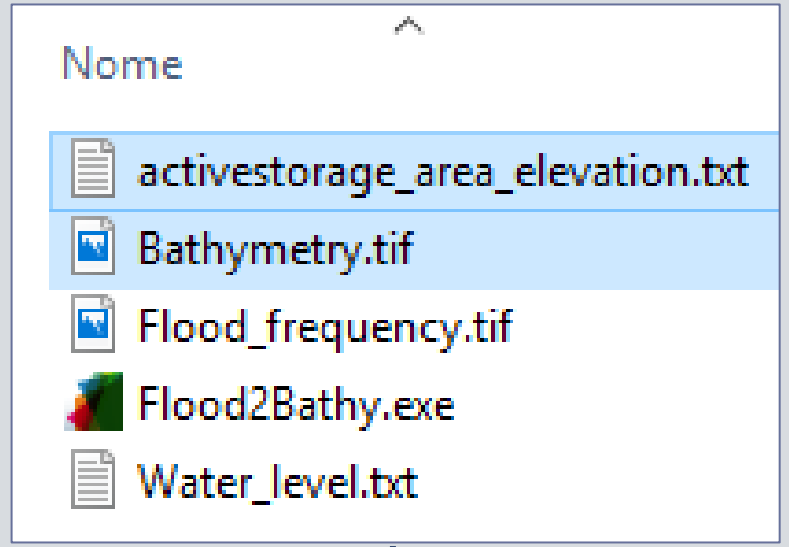
REQUEST:
alice.fassoni@gmail.com

INPUT:
1. One water level time series
2. Flood frequency map





Flood frequency map from JRC Global Surface Water Monthly Water History v1.0 Pekel et al. 2016

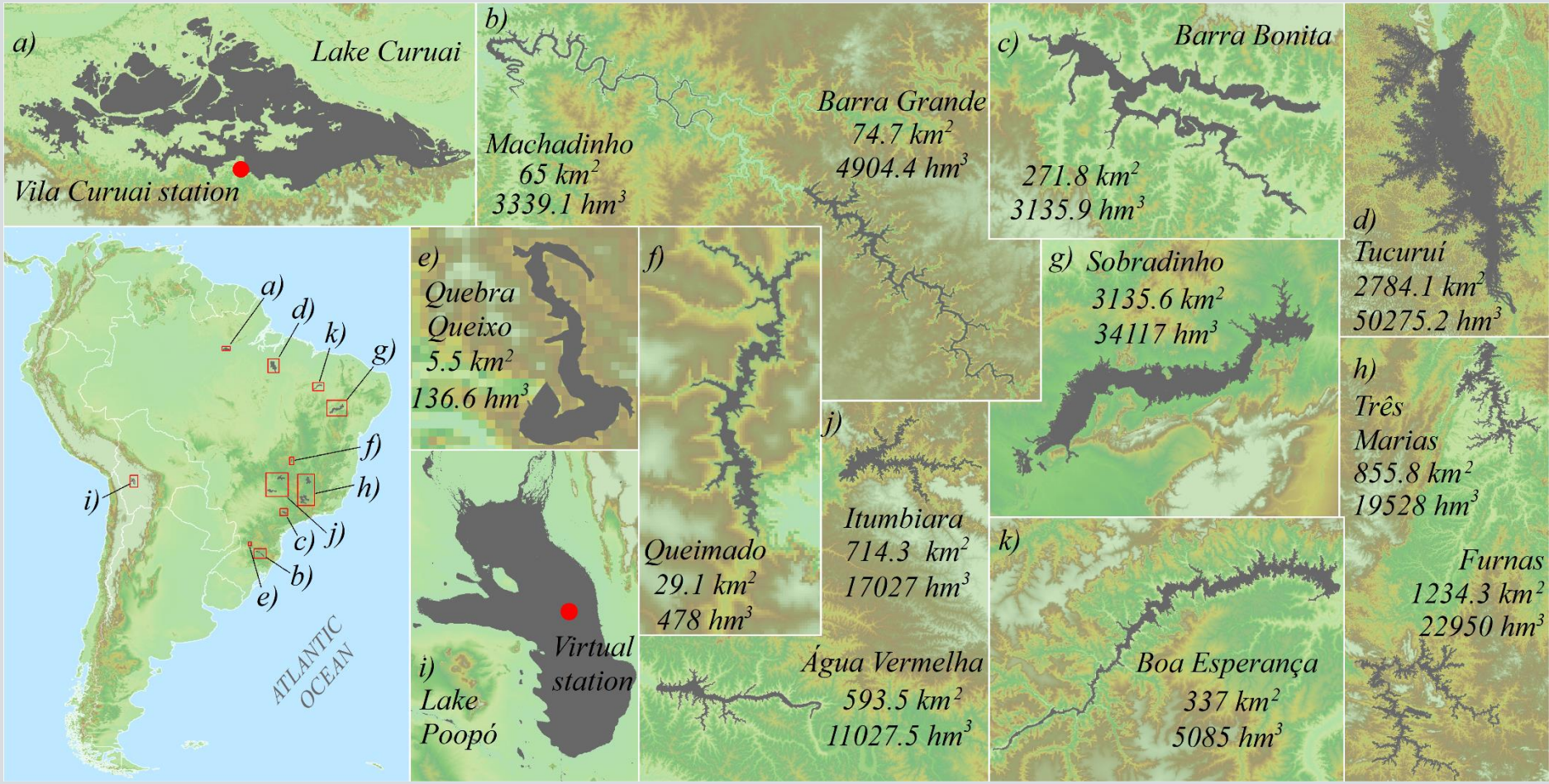


OUTPUT:
1. Topography map
2. Active storage-area-elevation relationships

APPLICATION IN LAKES

3D topography:
Lake Poopó
Lake Curuai

Level-area-active volume:
12 Reservoirs



APPLICATION IN LAKES

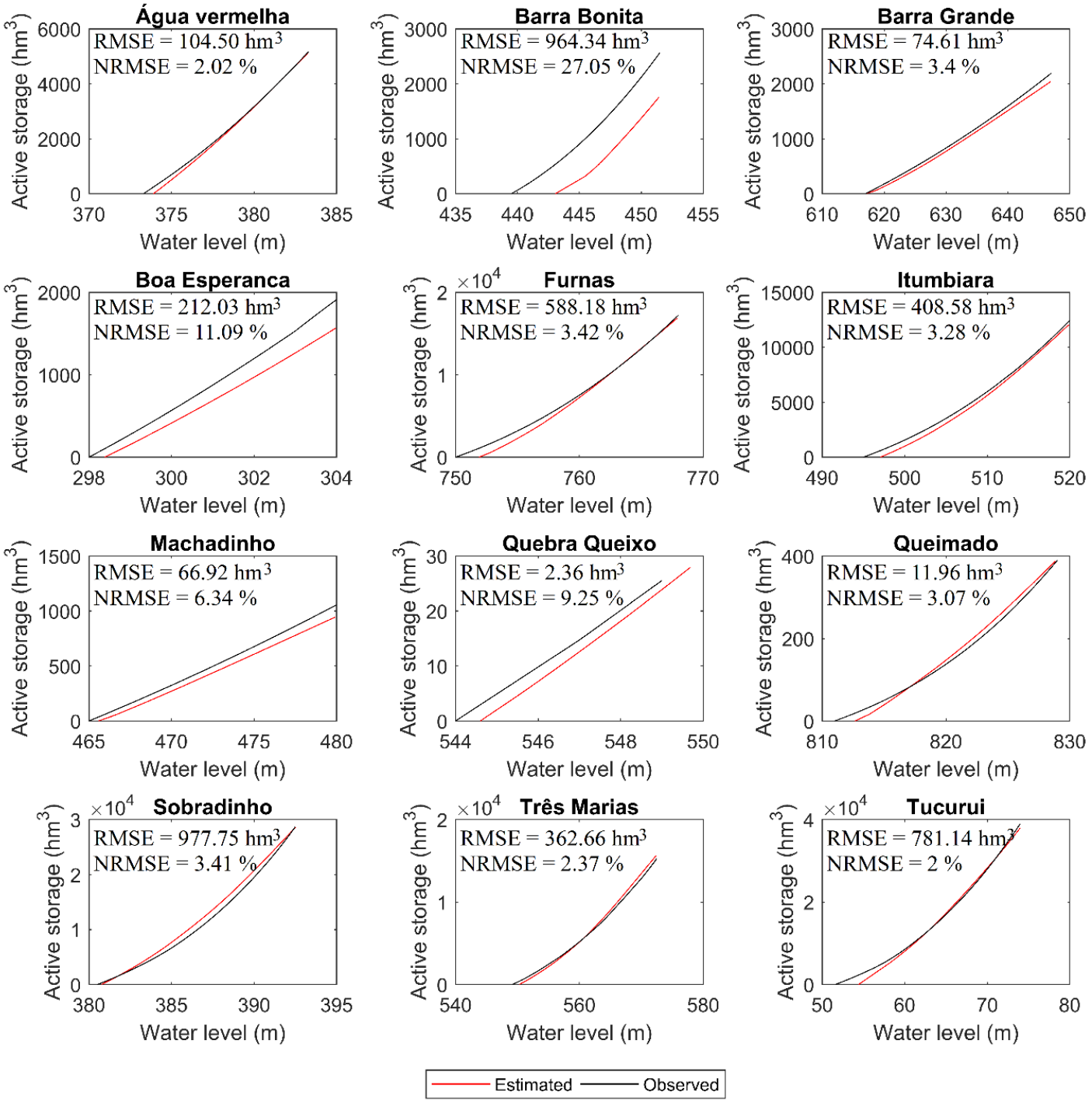
Bottom level Poopó/Curuai lakes:

Bias = 5.68/60 cm
RMSD = 18.5/146 cm
R^2 = 0.93/0.36

Active storage 12 Reservoirs:

NRMSD = 2% to 11% for 11 reservoirs.
Average of 6.39%

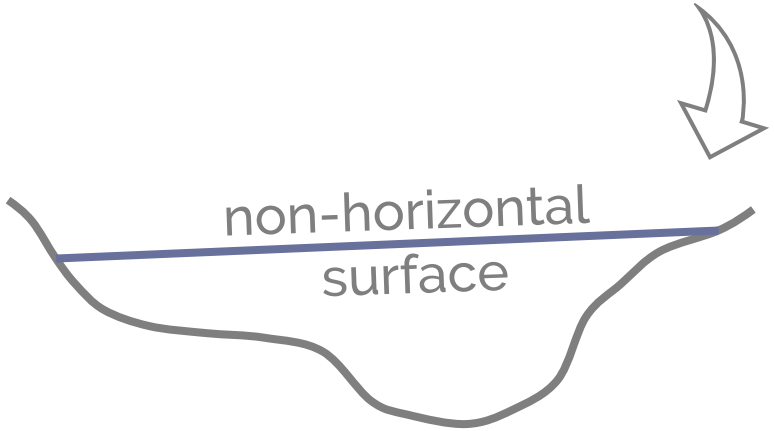
Reservoirs.
Low errors

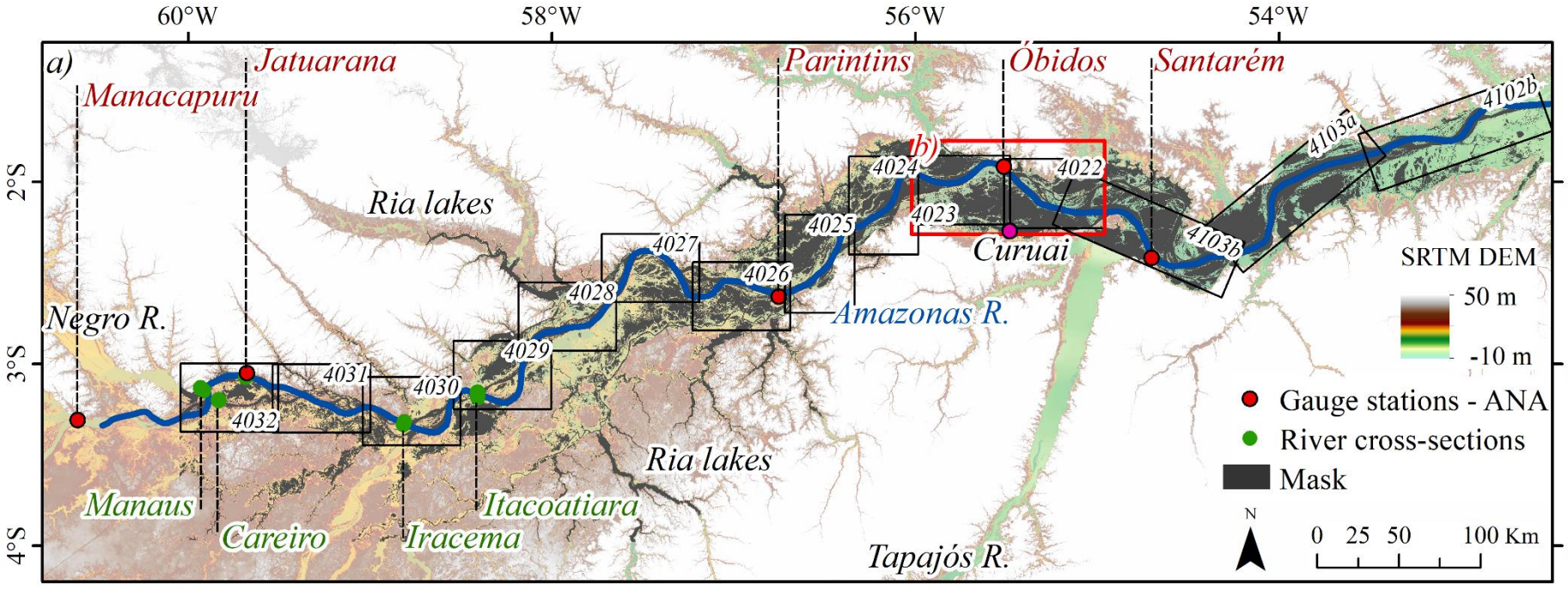


APPLICATION IN THE AMAZON FLOODPLAIN

Application using a time series of water level for each floodplain pixel, i.e. the water surface elevation is variable in the area.

Water level in the floodplain estimated by interpolation of the water level along the Amazon River





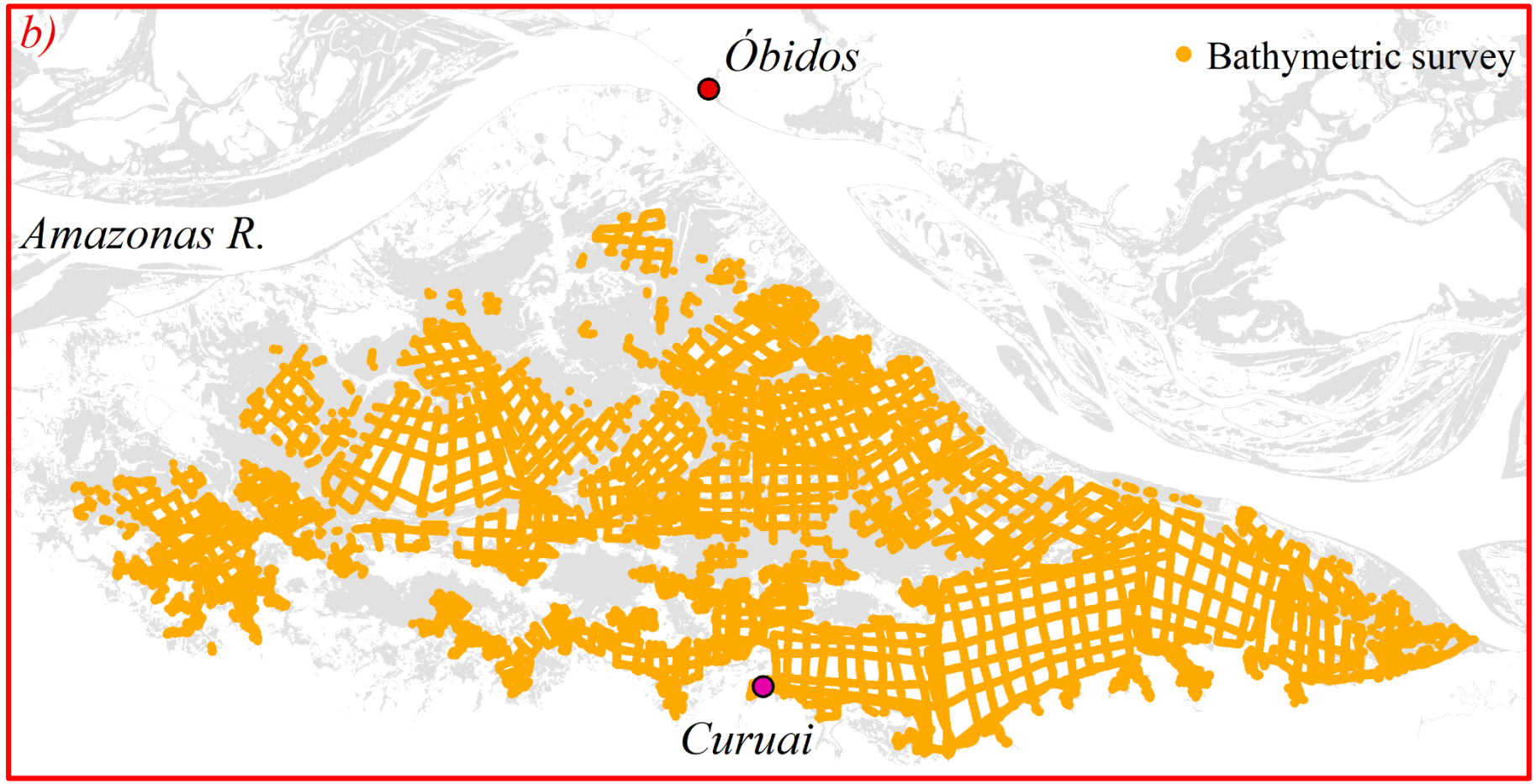
~1100 km extension of the Amazon River

VALIDATION

1 Altimetry in the Amazon river and floodplain;

2 Cross-sections in the Amazon river;

3 **Bathymetric survey in the Curuai floodplain.**



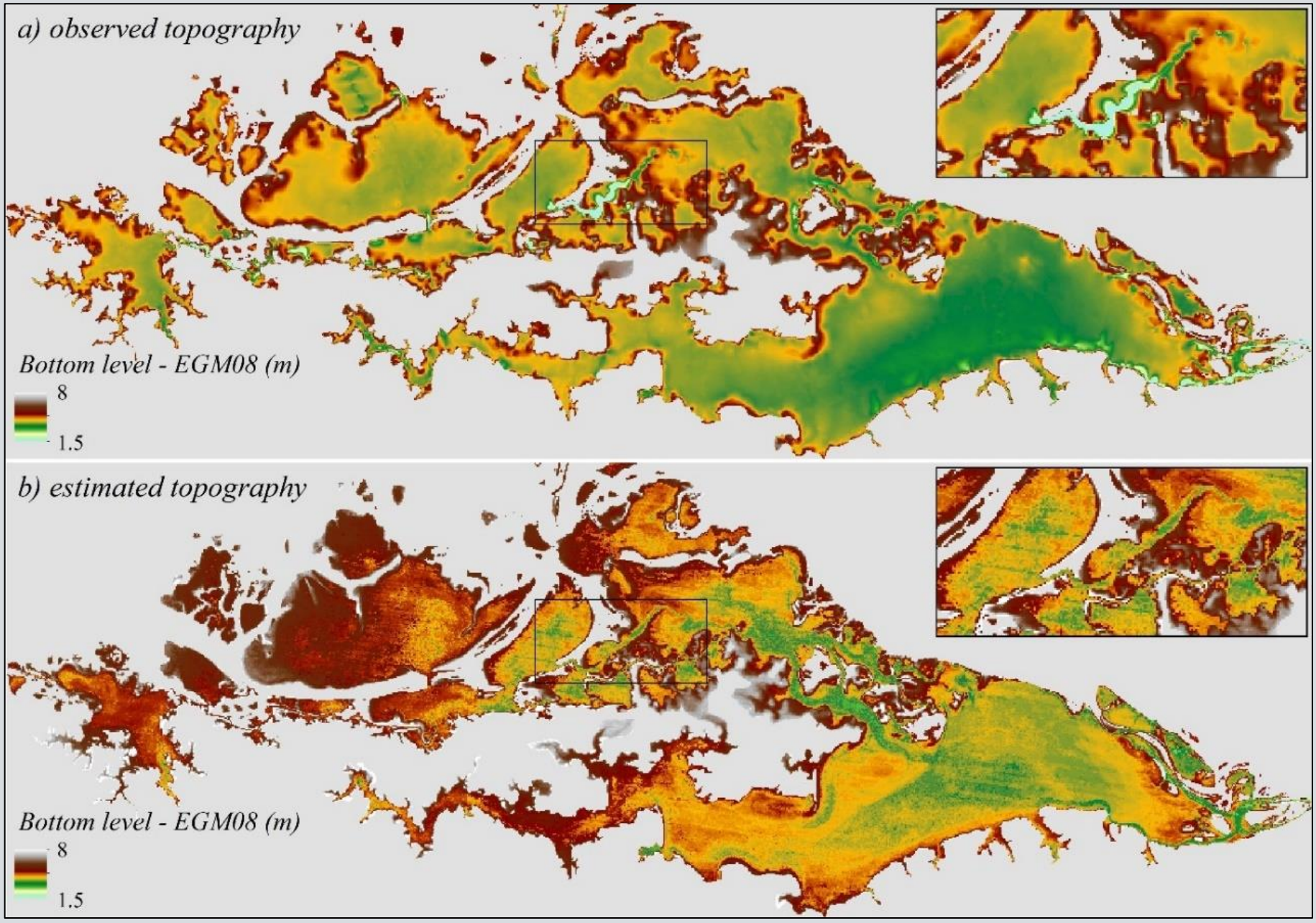
Bathymetric survey:
Barbosa, 2005
Rudorff et al., 2014

RESULTS
Curuai floodplain

Bottom level:
Bias = 0.79 m
RMSE = 1.30 m
Pearson's correlation coefficient of 0.73

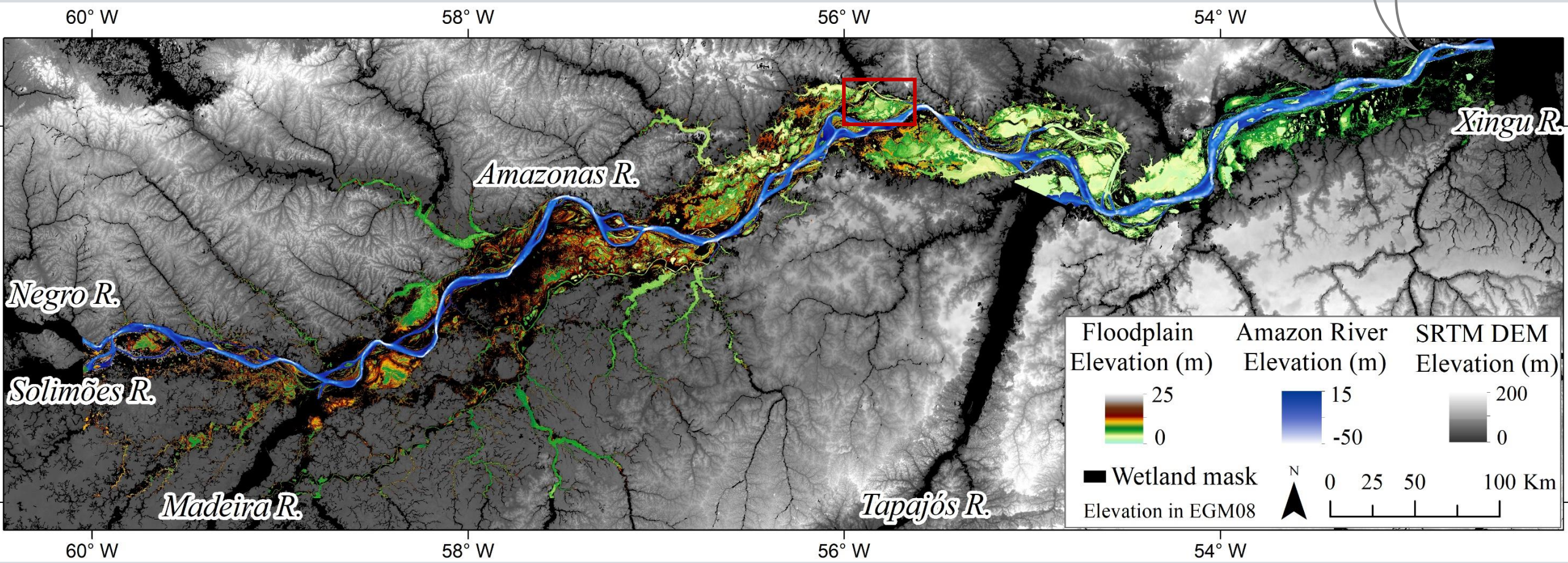
Accurate representation of spatial patterns

Improved accuracy using distributed water level in the floodplain



AMAZON FLOODPLAIN

River bathymetry obtained from nautical charts; RMSE of 7.5 m

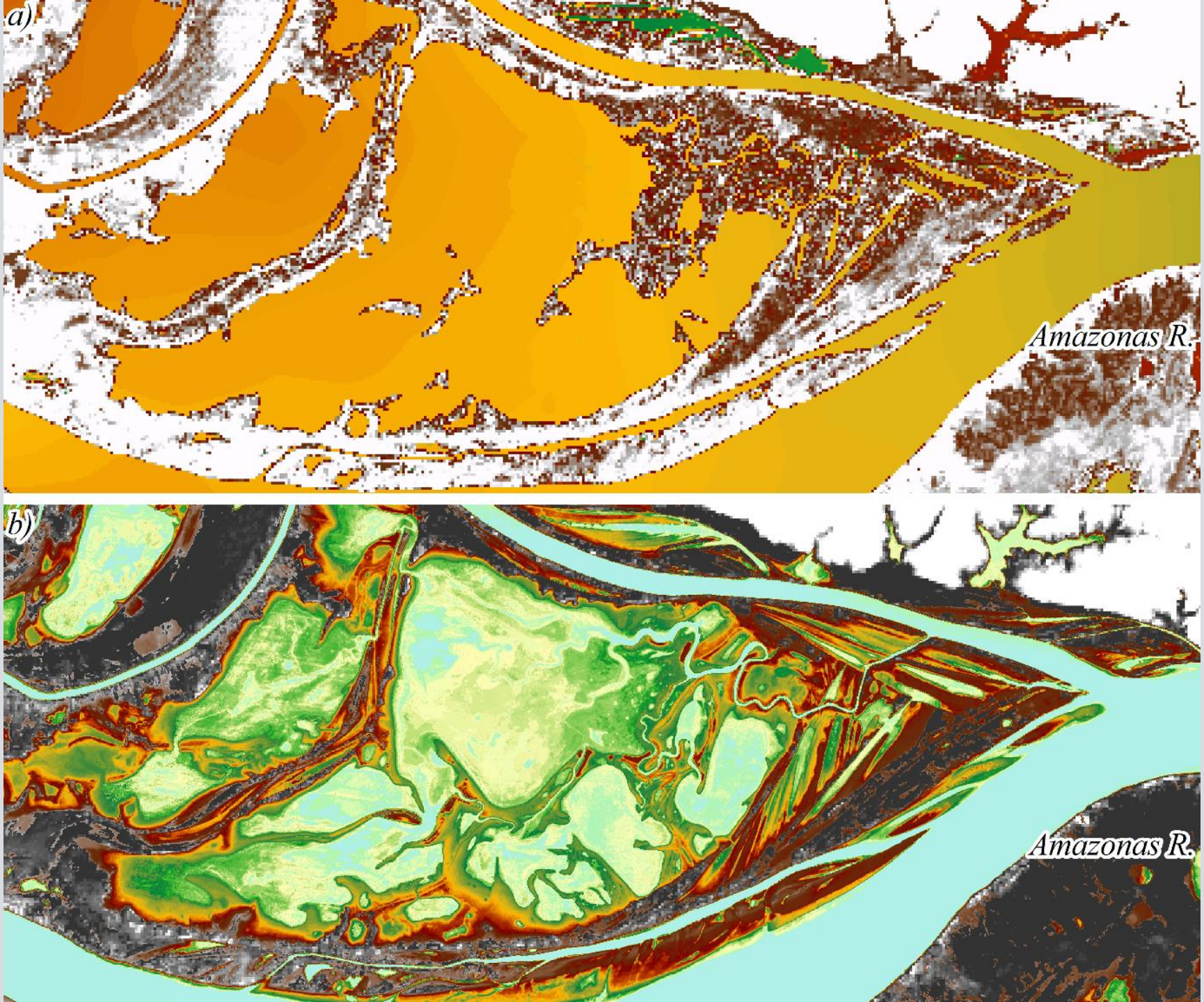


AMAZON FLOODPLAIN

SRTM x Observed:
RMSE of 3.55
Pearson's coefficient of 0.22

Improvements relative to the SRTM DEM

Estimated x Observed:
RMSE of 1.30
Pearson's coefficient of 0.73



CONCLUSIONS

0.18 to 1.4 m errors on lake bottom level and <11% error for reservoir active storage

A flood frequency-based method was proposed and validated for estimating the topography and active volume of water bodies.

The method can be applied to any area seasonally flooded: it is applicable in 35.8 % (86%) of the global water surface area mapped by occurrence map from GSW dataset, when considering the number of pixels with occurrence between 0 and 95% (99%) over 35 years.

Topographic mapping of the central Amazon floodplain can be used in hydrodynamic simulation and ecological and geomorphological studies.

REQUEST:

alice.fassoni@gmail.com

Thank you!

alice.fassoni@gmail.com

Lake topography and active storage from satellite observations of flood frequency. FASSONI-ANDRADE, Alice; PAIVA, Rodrigo; FLEISCHMANN, Ayan. *Water Resources Research* (UNDER REVIEW).

High-resolution mapping of floodplain topography from space: a case study in the Amazon. FASSONI-ANDRADE, Alice; PAIVA, Rodrigo; RUDORFF, Conrado; BARBOSA, Claudio; NOVO, Evlyn. *Remote Sensing of Environment* (UNDER REVIEW).