



東京大学
生産技術研究所
Institute of Industrial Science,
The University of Tokyo

Importance of baseline **topography and hydrography data** for hydrodynamic modeling

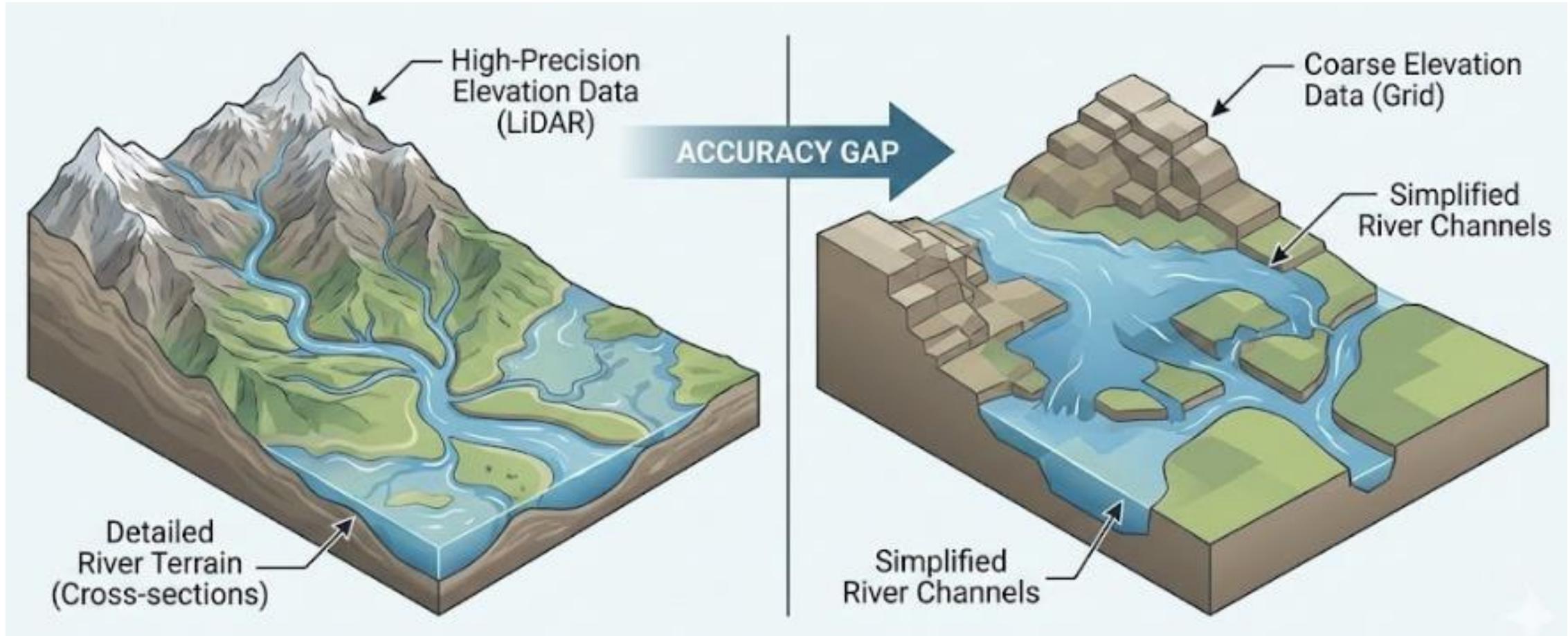
Dai YAMAZAKI

Institute of Industrial Science
The University of Tokyo

yamadai@iis.u-tokyo.ac.jp

<https://global-hydrodynamics.github.io>

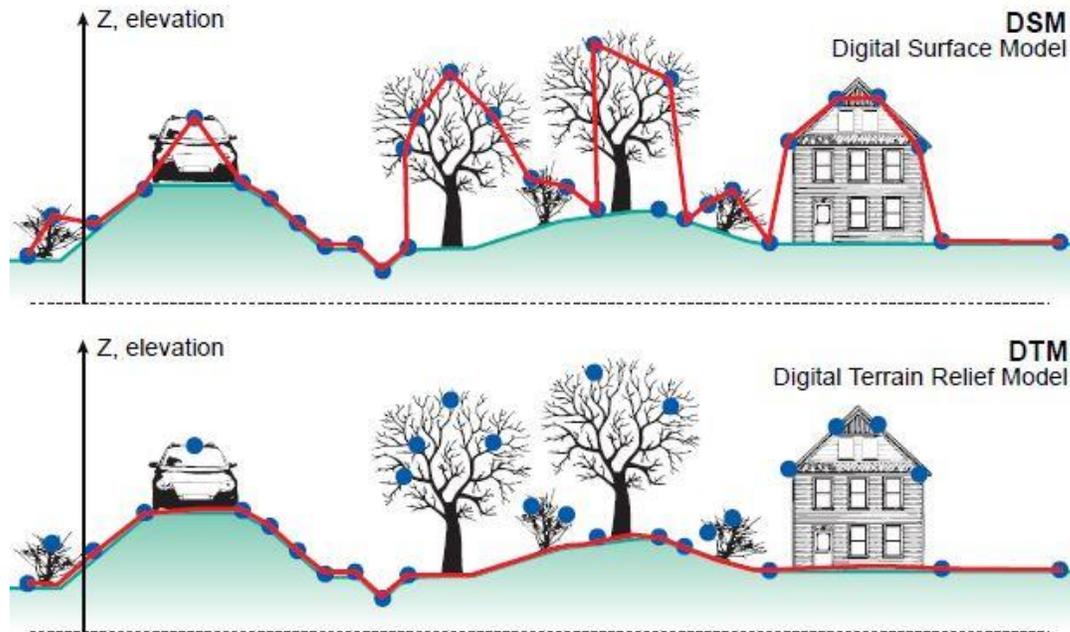
Water flows from high to low



→ High accuracy topography/hydrography datasets are key for river flood modelling

Satellite topography data has errors.

Even in the fundamental elevation data (DEM), many error exist. Precise surface water dynamics simulation cannot be achieved if we use satellite elevation data without appropriate corrections.



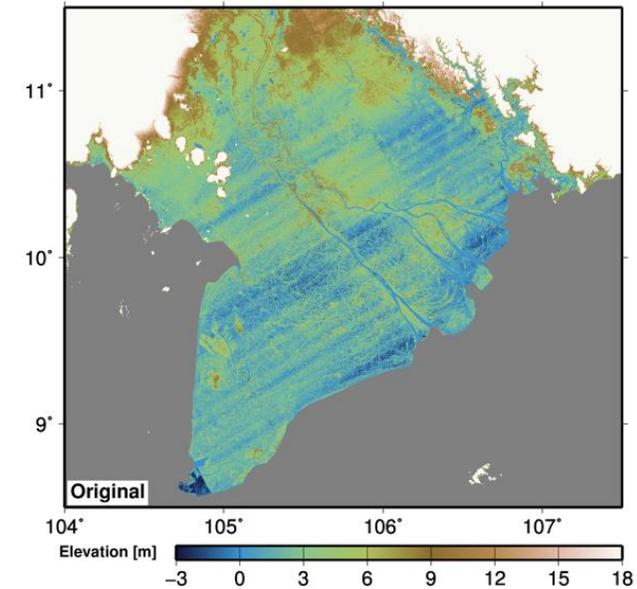
←
Ground surface objects causes positive bias in spaceborne DEMs

→
Example of noises (speckle, stripe) in satellite DEMs.

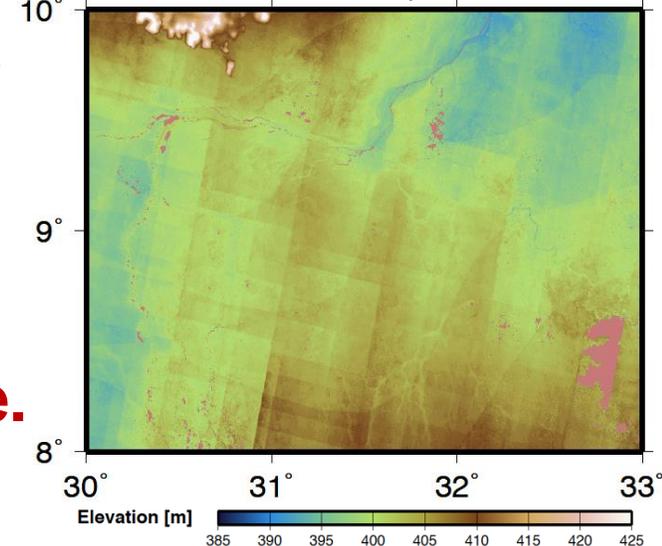
<http://www.charim.net/datamanagement/32>

We applied **multi-component error removal on global scale.**

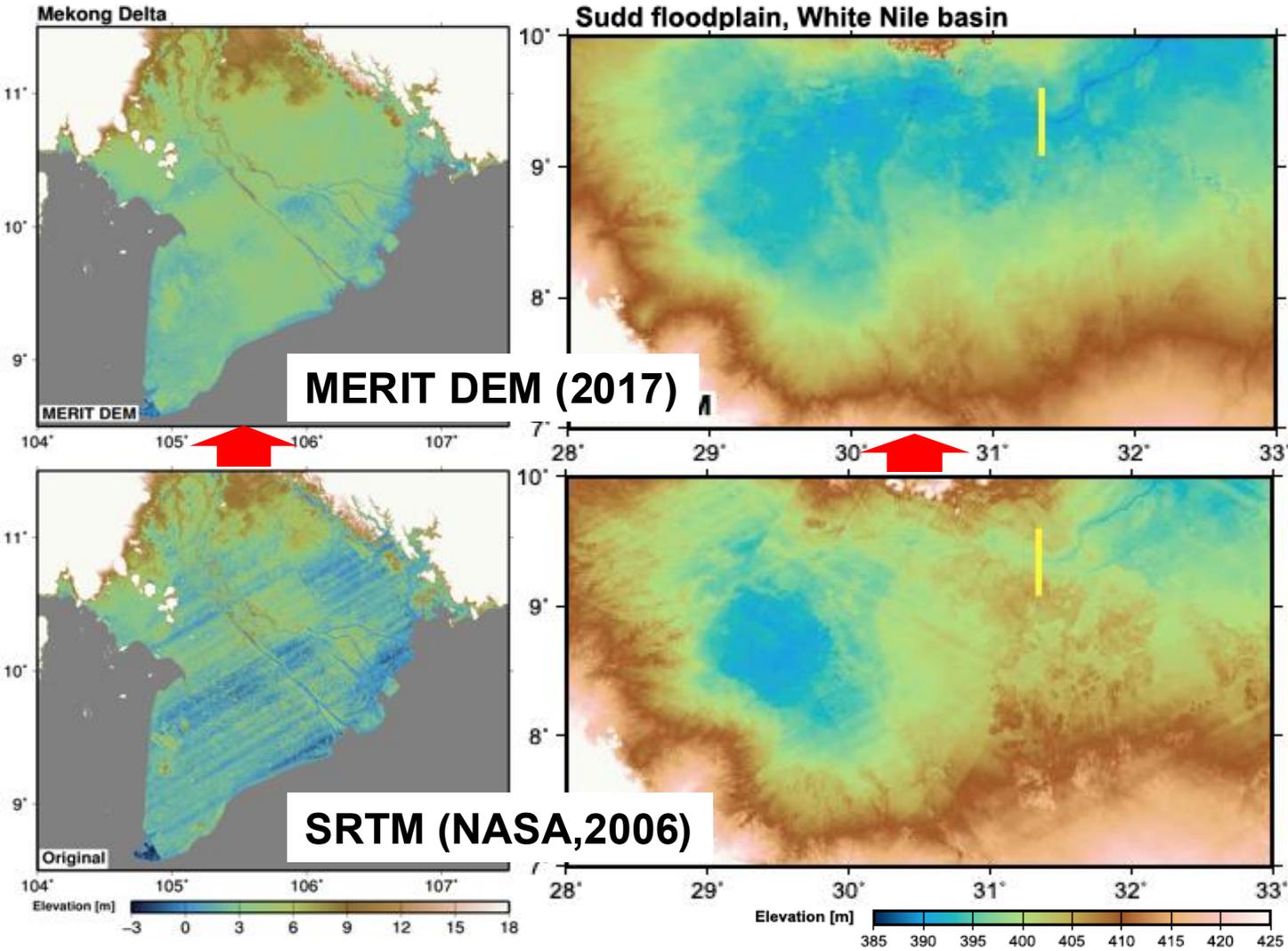
SRTM Mekong Delta



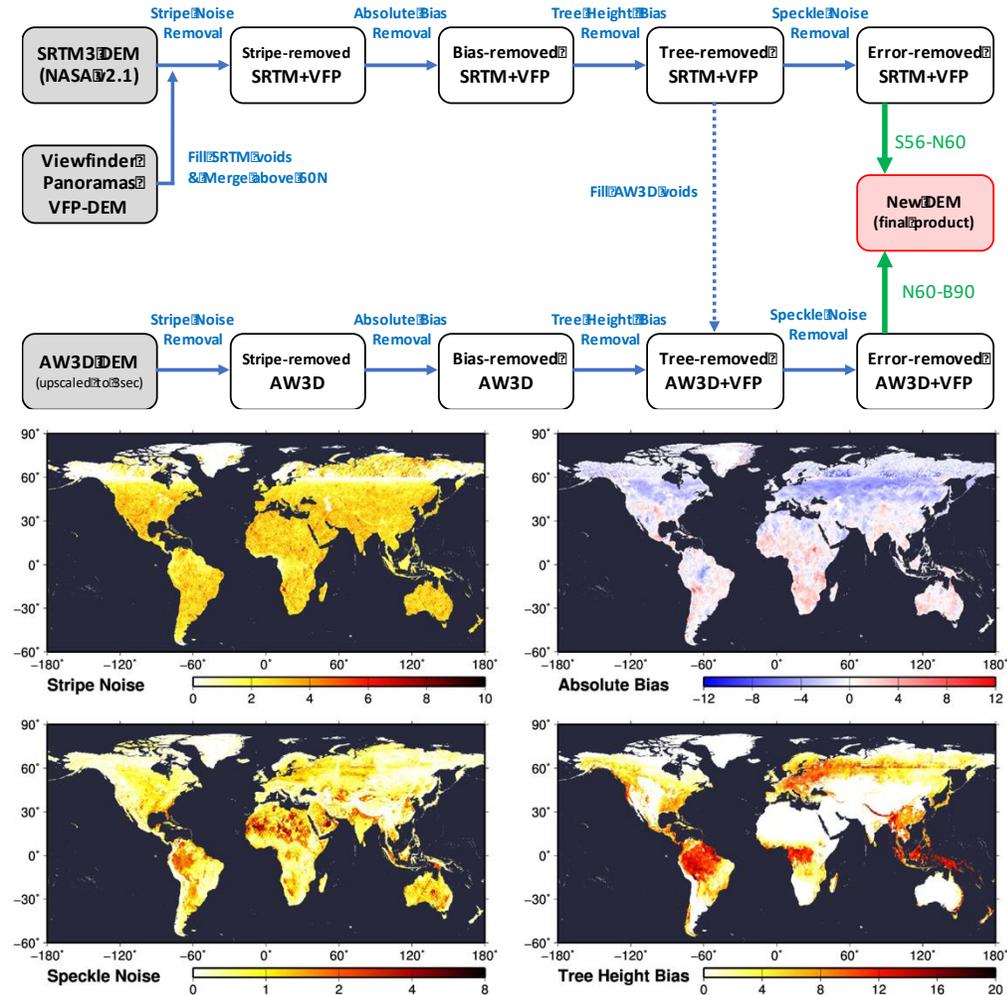
AW3D Sudd Floodplain in Nile



MERIT DEM: Global multi-error removed topography data



4-step error removal from spaceborne DEMs
Speckle Noise/Stripe Noise/Absolute Bias/Tree Bias



Highest-ever vertical accuracy as a freely-available global DEM.

Detailed description available in [Yamazaki et al., 2017].

Data available online:

http://hydro.iis.u-tokyo.ac.jp/~yamadai/MERIT_DEM/

FABDEM: Forest and Urban bias removed DEM

Based on Copernicus DEM (GLO-30), providing global 30 m resolution topography.

Uses machine-learning (random forest) to remove vegetation and building height biases, generating a global bare-earth DEM.

Significantly improves vertical accuracy over COPDEM30 and MERIT, especially in urban areas, forests, and floodplains, as validated against LiDAR and ICESat-2.

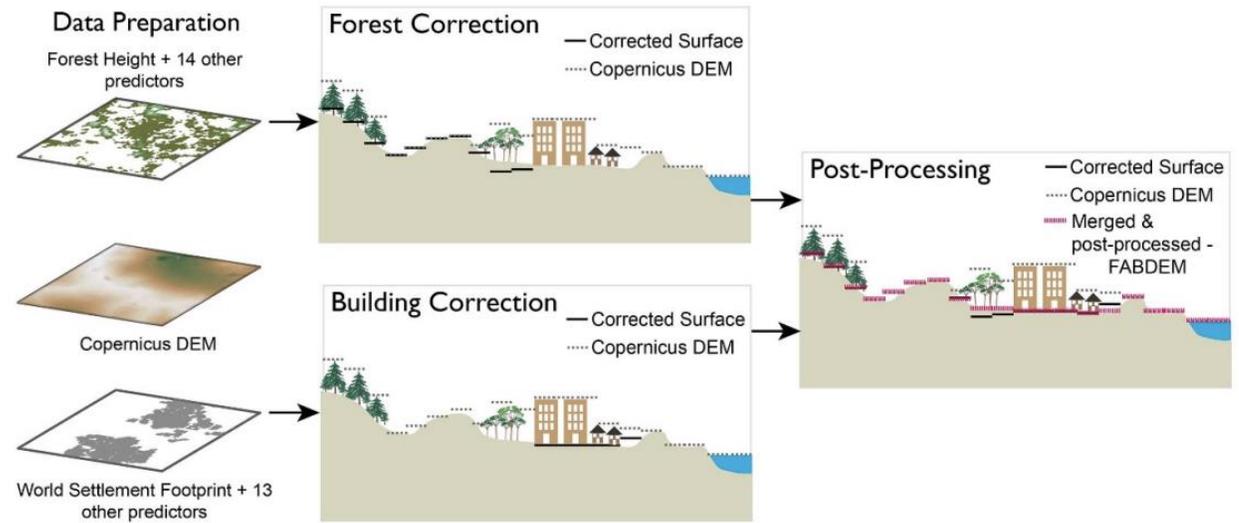
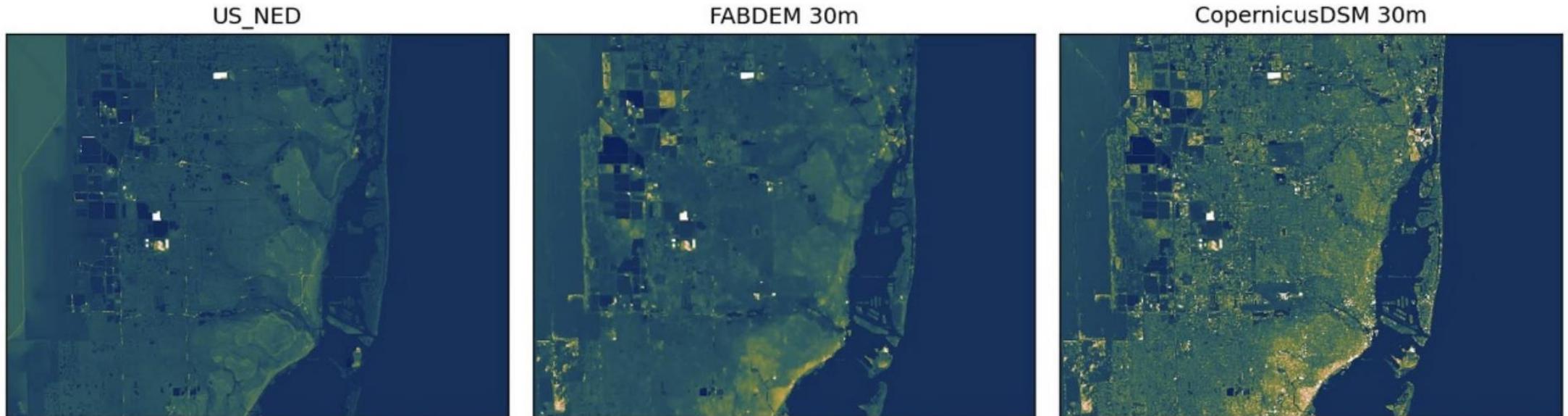


Figure 1. Schematic of the workflow to create FABDEM. Data preparation is followed by the forest and building corrections, before merging the corrected surfaces and post-processing.

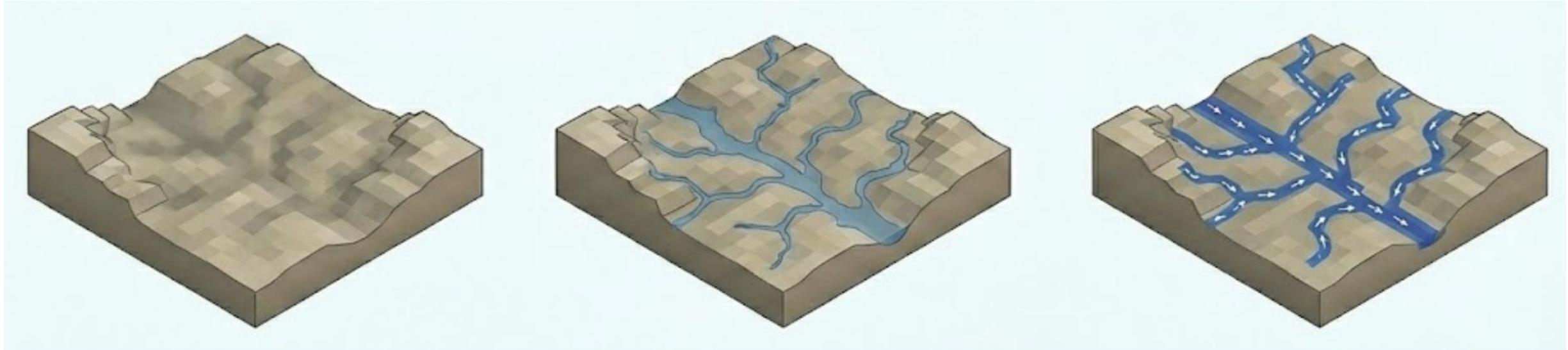


Hydrography Data: another important input for river flood models.

Satellite DEMs are typically too coarse to resolve river channels

River locations should be given by external water body map

River topography (hydrography) by combining DEM and water maps



Hydrography = raster river topography data, consistent to DEM.

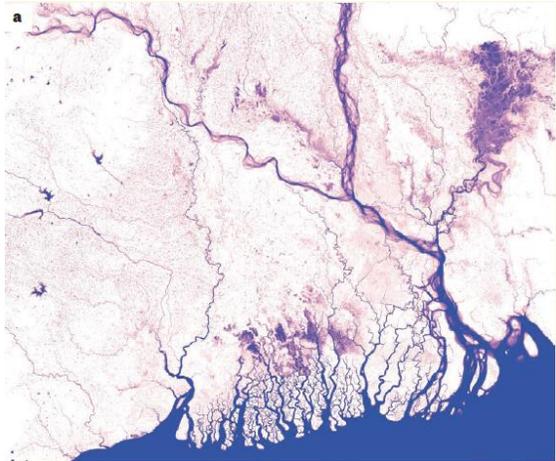
Typically contains multiple datasets

- Flow Direction, Flow accumulation
- (optional) Hydrologically adjusted DEM, River width, river cross-section shape

MERIT Hydro: hydrography based on MERIT DEM & latest geodata

Large-scale river models require “hydrography map” (fine resolution river network, surface direction).
 USGS HydroSHEDS was previous standard, but accuracy was limited due to errors in original DEM.

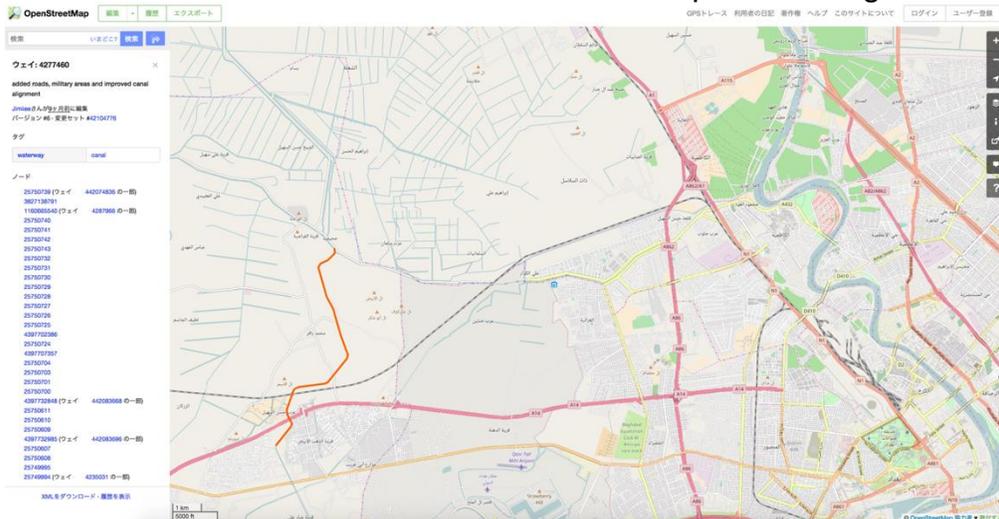
→ **We constructed high-accuracy hydrography using MERIT DEM and other latest geodata.**



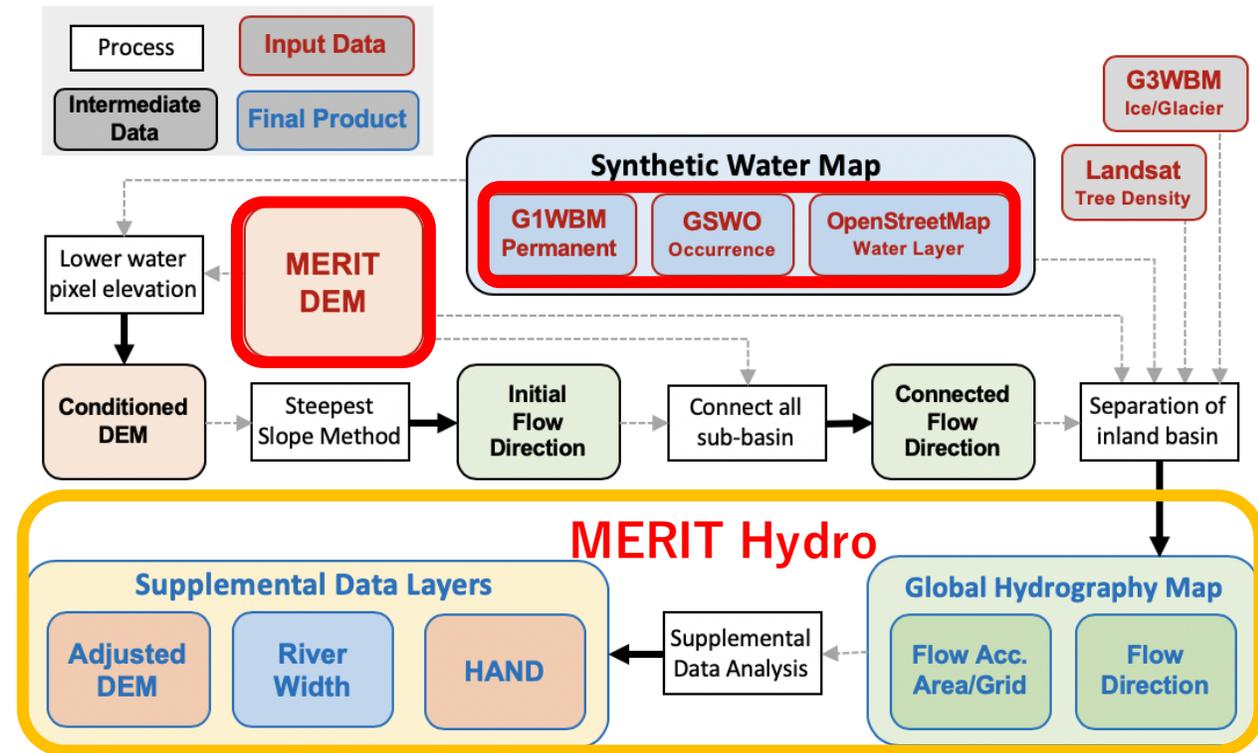
Water occurrence over 30years (Ganges delta)

←
Global Landsat analysis:
 GSWO: >3M image analysis on Earth Engine
 [Pekel et al., 2016, Nature]

↓
Trend toward “Open Data”:
 OpenStreetMap:
 Cloud platform for global map editing



Canal networks around Bagdad.
 [OpenStreetMap: www.openstreetmap.org]

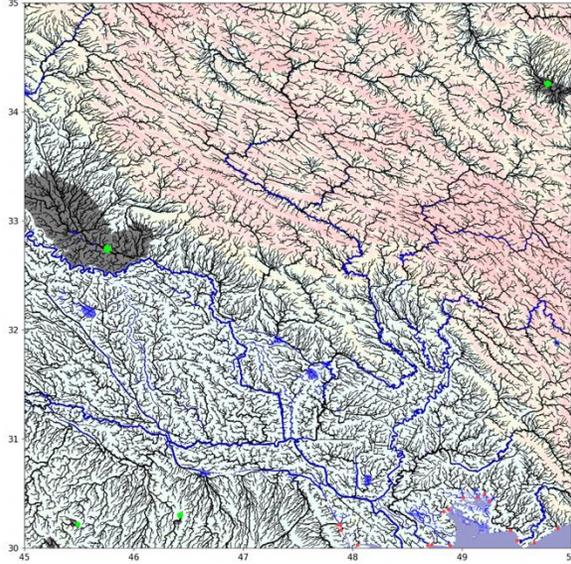


Schematic Procedure: (~30,000 line Fortran90 code)

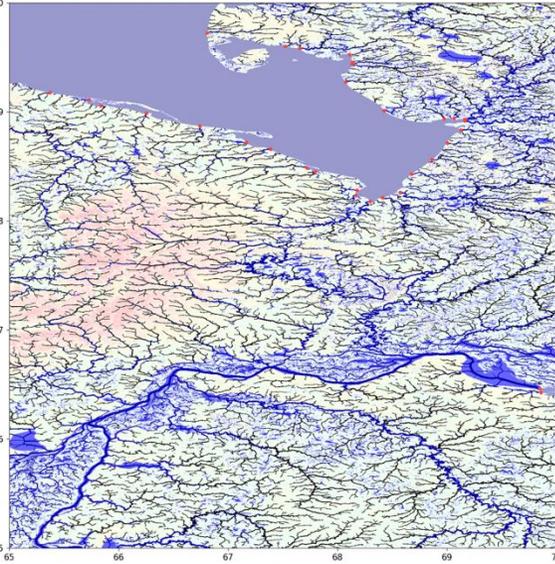
Detailed description available in [Yamazaki et al., 2019].

MERIT Hydro: hydrography based on MERIT DEM & latest geodata

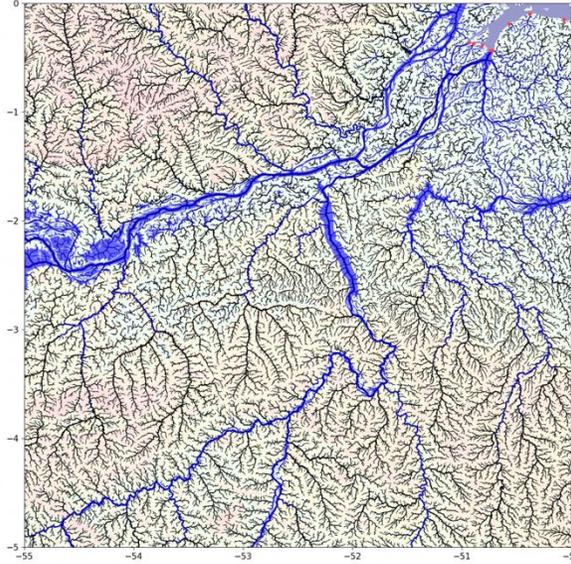
Tigris–Euphrates River



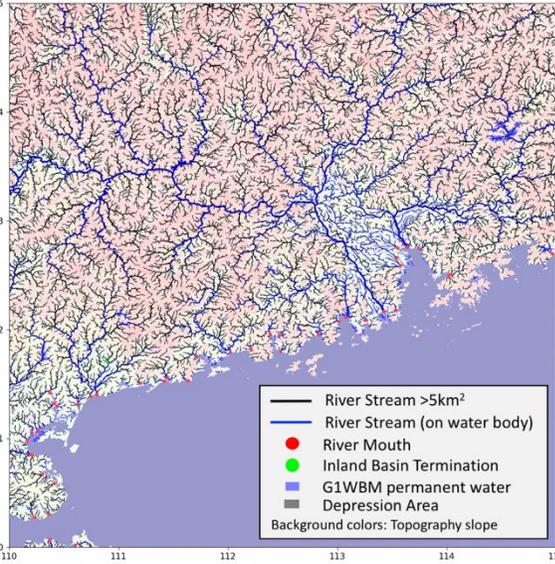
Ob River



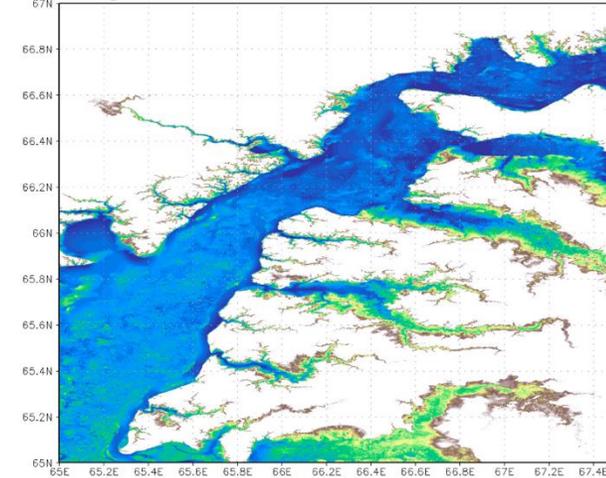
Amazon River



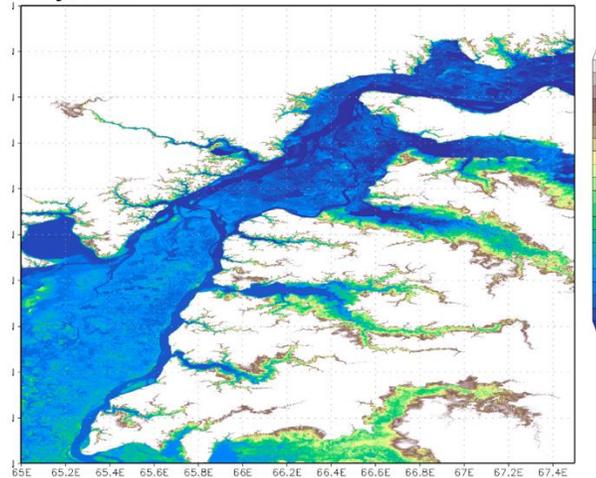
Pearl River



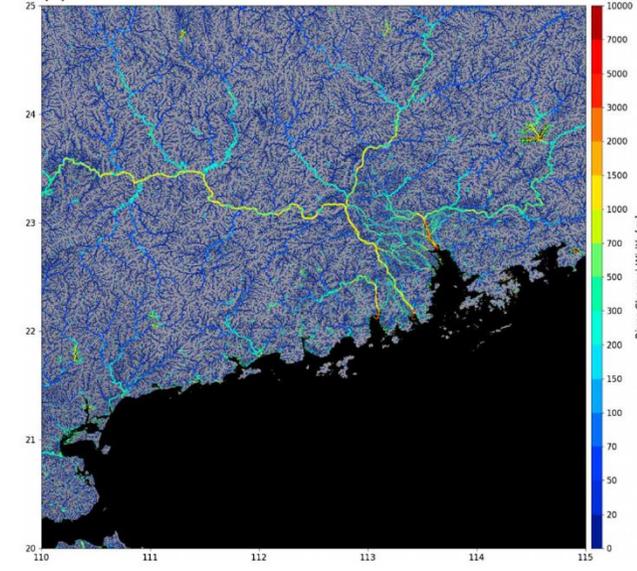
Original MERIT DEM



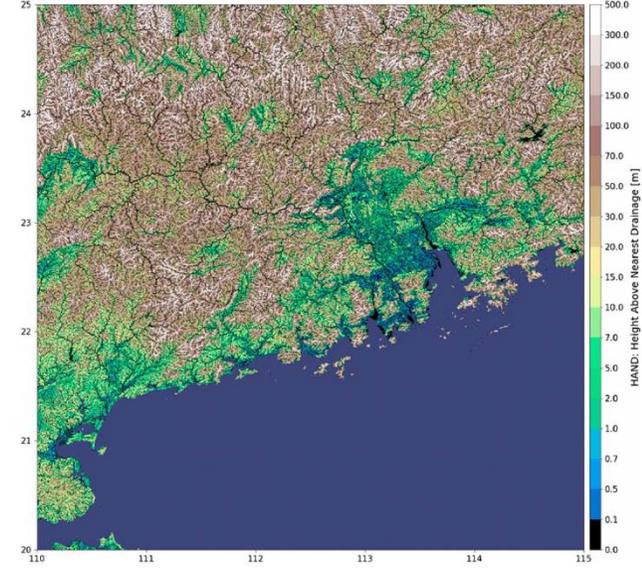
Adjusted DEM



(a) River Channel Width: Pearl River Basin



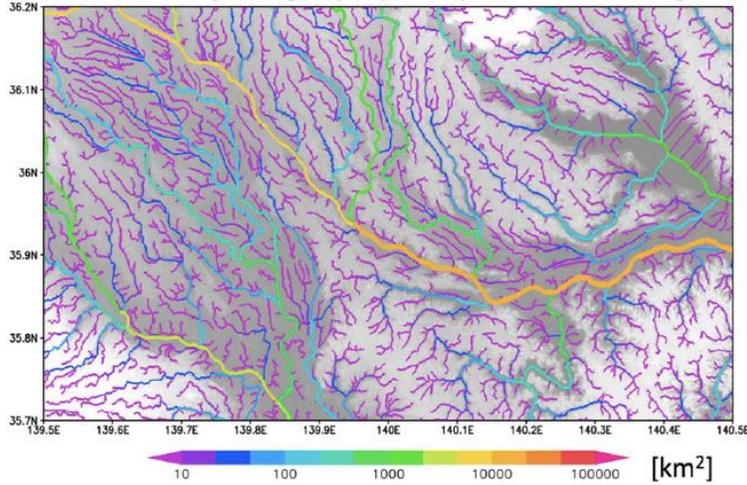
(b) HAND: Pearl River Basin



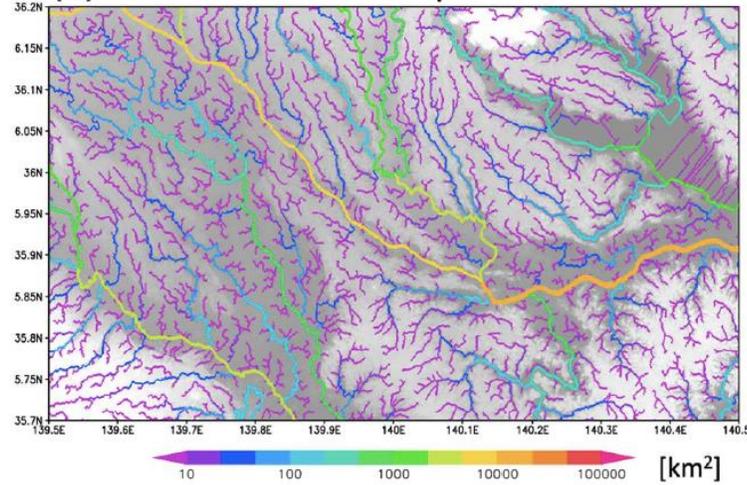
Accurate river network map + supplement topography layers are created, with global coverage.

MERIT Hydro: hydrography based on MERIT DEM & latest geodata

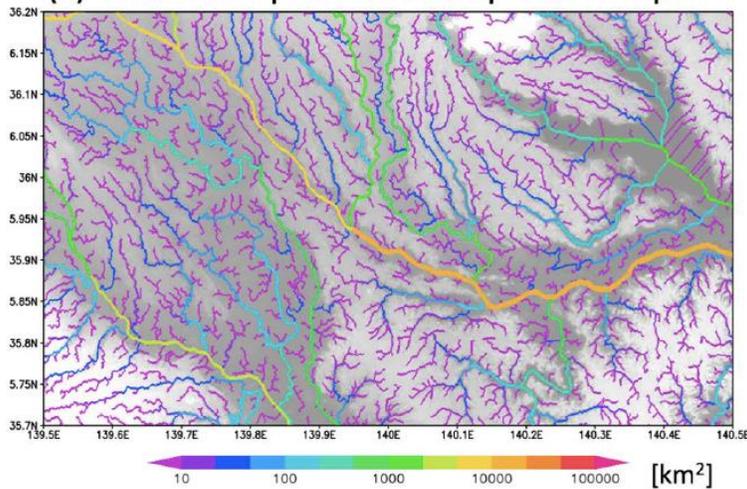
(a) **MERIT Hydro** (with full input)



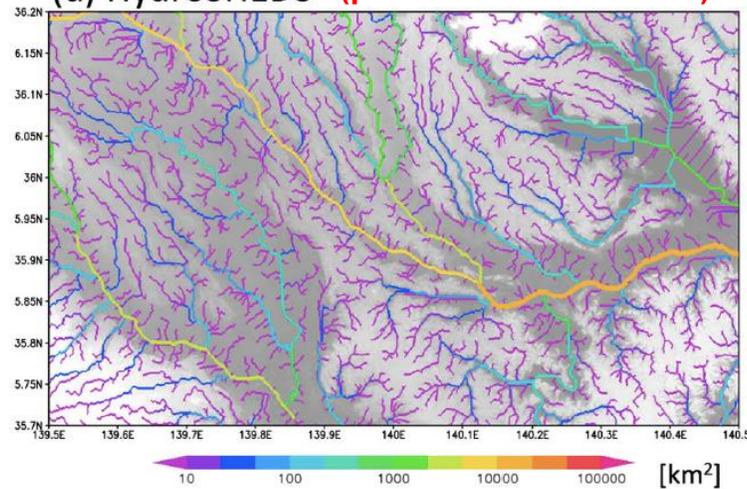
(b) Without all water input



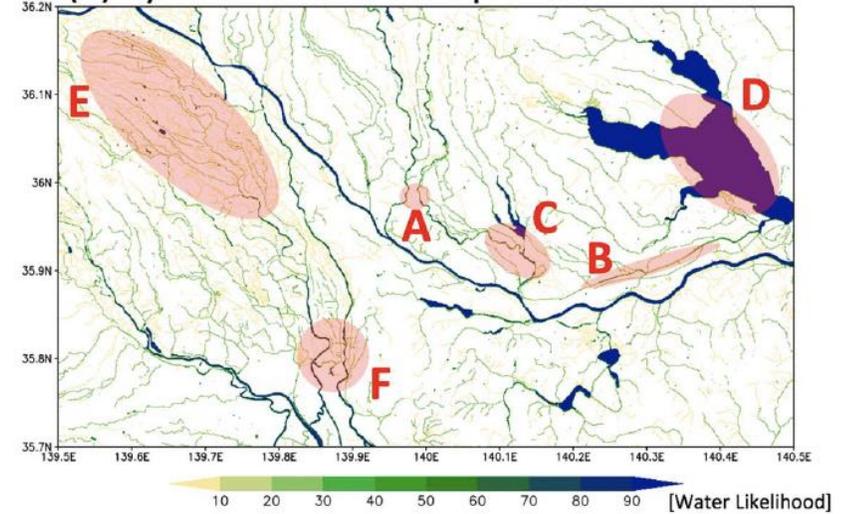
(c) Without OpenStreetMap water input



(d) HydroSHEDS (previous standard data)



(e) Synthetic Water Map & Noted Difference

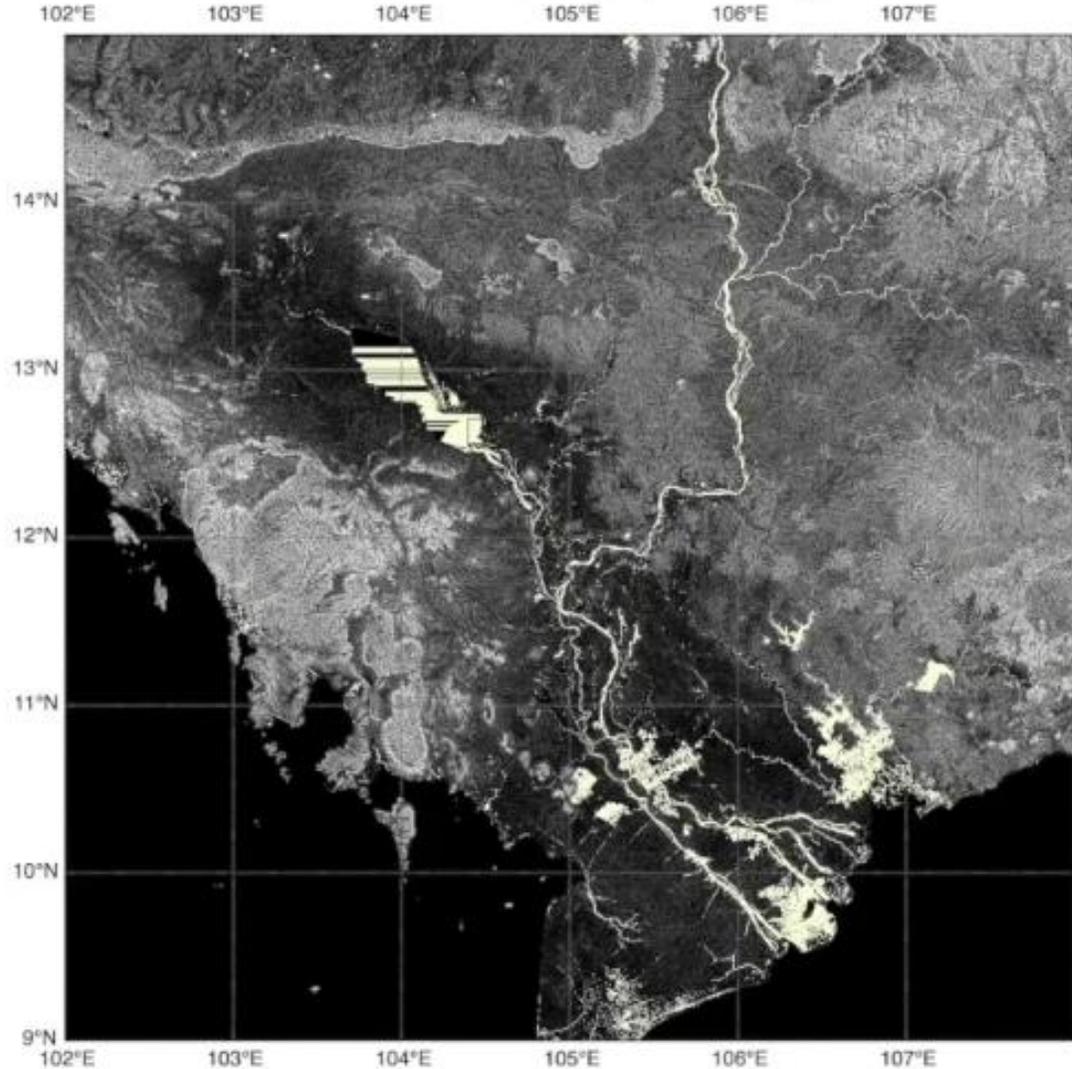


- A: Two rivers merged without water input
- B: Small stream not represented without water input
- C: Channel meandering not represented in HydroSHEDS
- D: Flow line not follows lake center without water input
- E: Artificial canals not represented without OpenStreetMap
- F: River network is not correct without water input

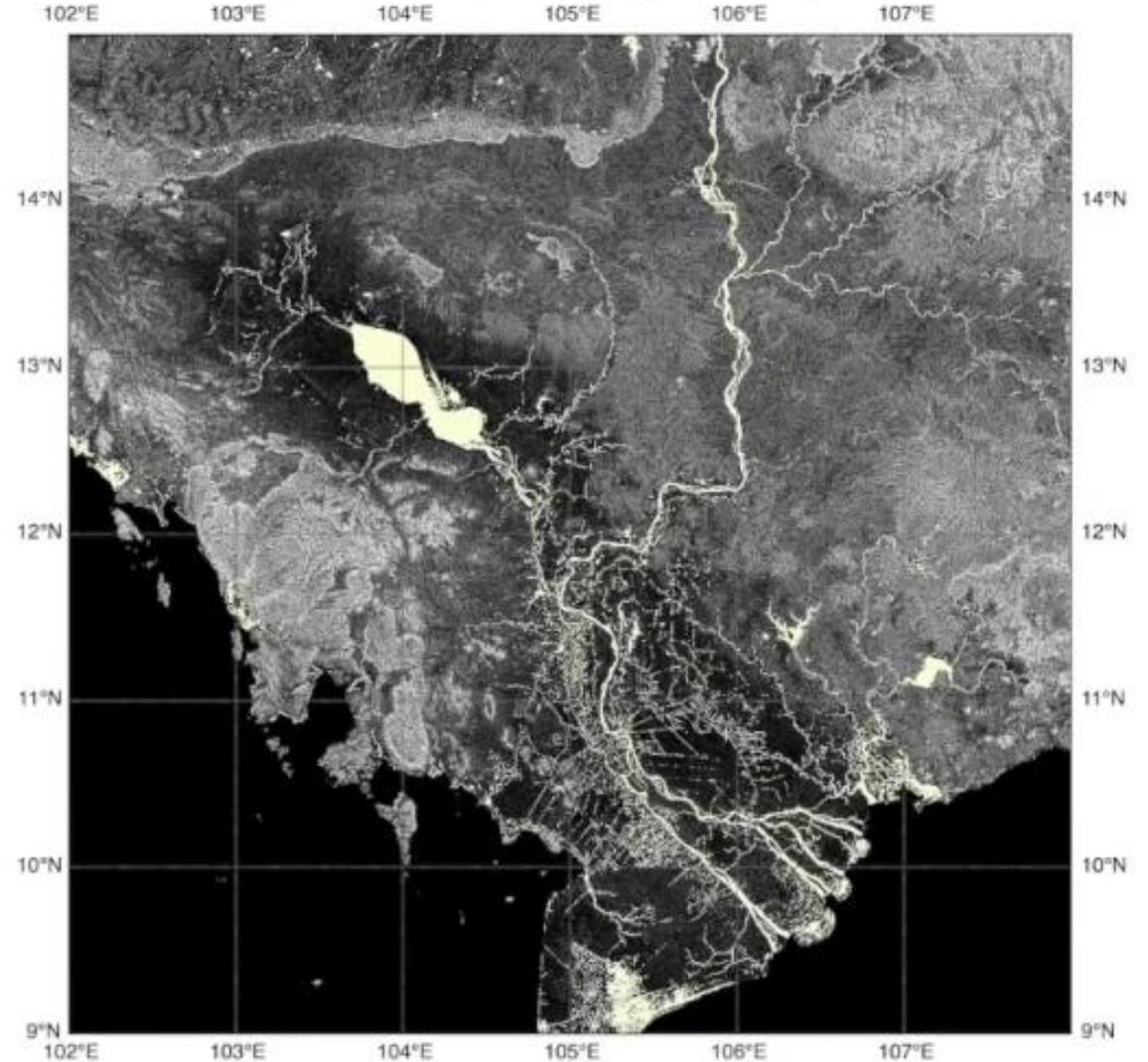
More precise river networks can be represented in global hydrography map, by using the latest DEM, satellite and cloud-sourced water maps, (+ advanced algorithms)

Improved topography leads to accurate flood simulation!

[Old] SRTM + HydroSHEDS



[New] MERIT DEM + MERIT Hydro



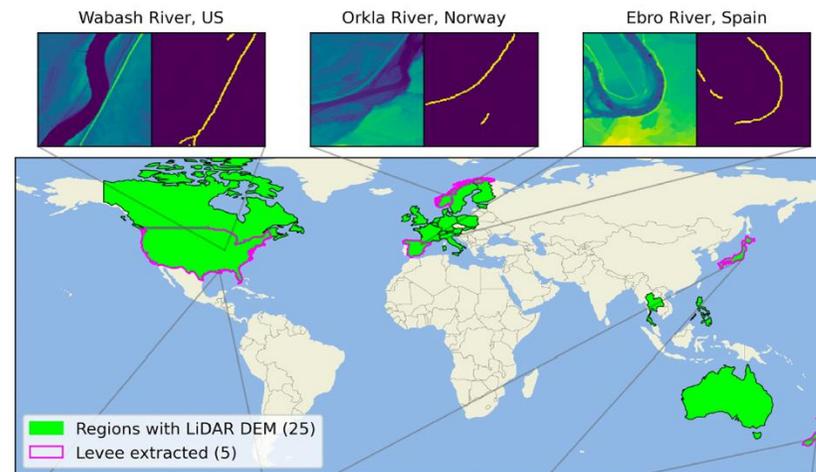
Now **MERIT DEM/Hydro** is integrated to Global River Model **CaMa-Flood version 4. (released in Mar 2021)**

Challenges:

Topography (DEM)

Accuracy, resolution, and global coverage are still insufficient for river and floodplain modeling.

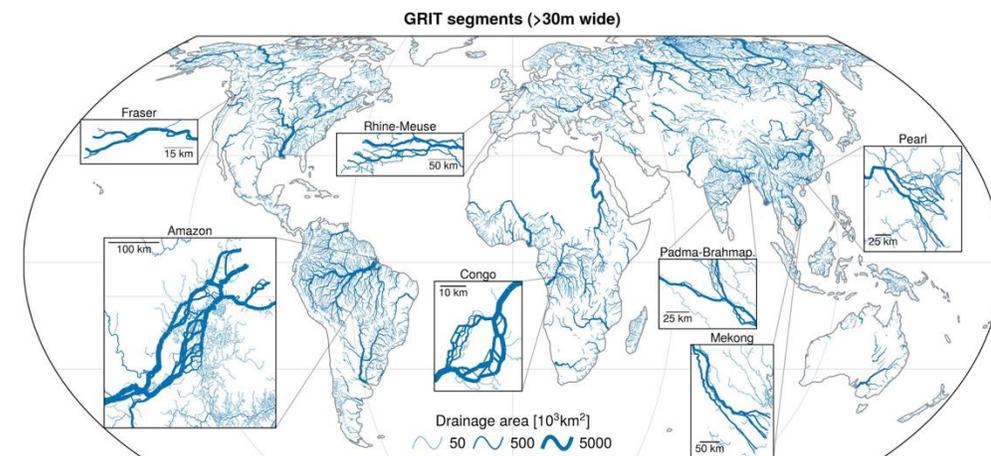
- LiDAR provides high accuracy but only limited spatial coverage, making global applications difficult.
- Satellite DEMs cannot resolve key features such as levees and embankments
- Current DEM fail to capture micro-topography critical for flood inundation and wetland ecosystems.



Khanh et al. 2025, GRL

Hydrography

- Development and continuous updating of hydrography data are highly labor-intensive at the global scale.
- River channel cross-section data are largely missing, limiting physically realistic flow representation.
- River network topology still contains errors, including incorrect bifurcations and channel connectivity.



Wortmann et al., 2025, GRIT