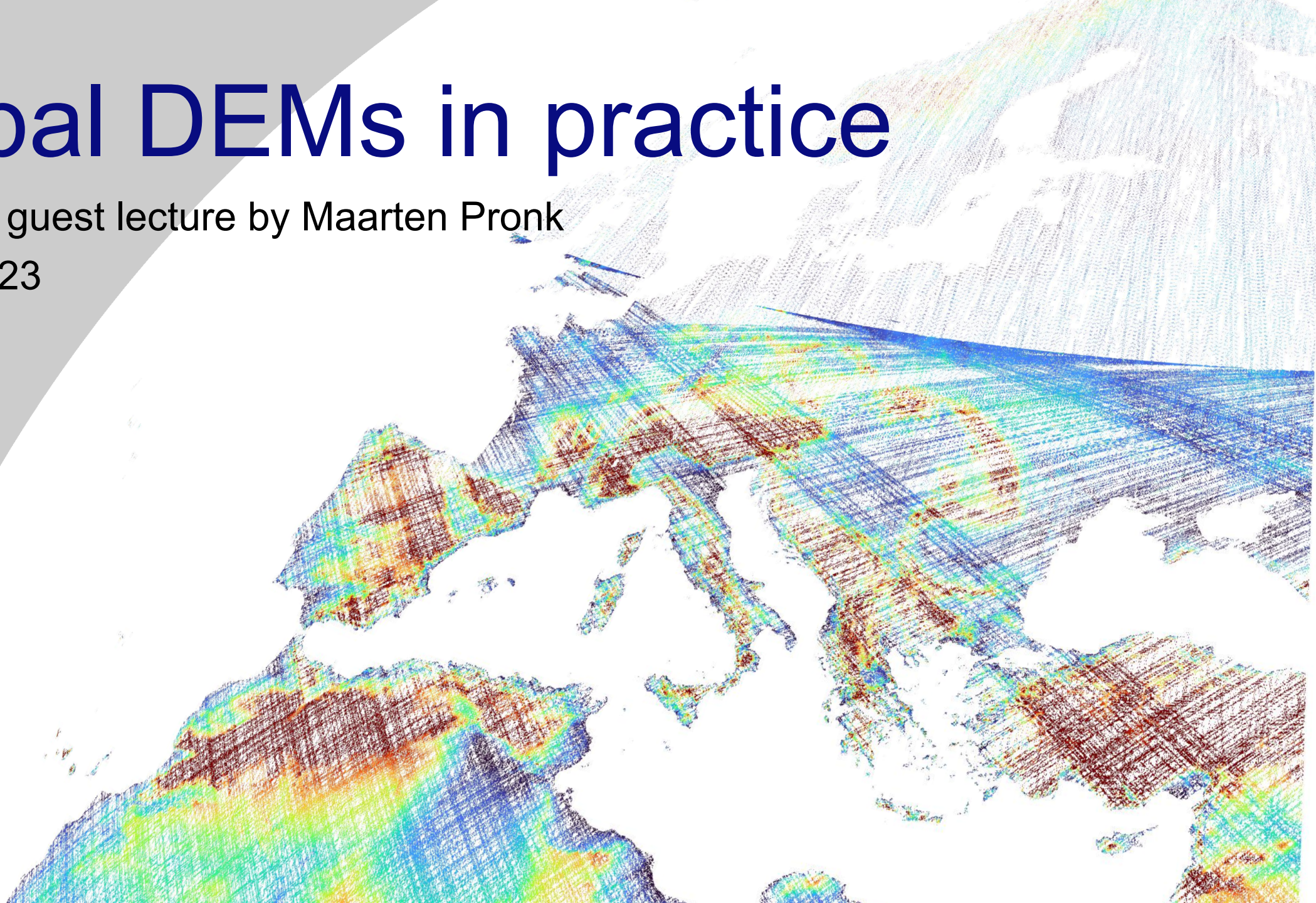# Deltares

Global DEMs in practice

GEO1015 guest lecture by Maarten Pronk

29-11-02023

Me

- Bachelor Architecture (2012)
- Master Architecture (unfinished)
- Master Geomatics (2015)

- Thesis:
  Storing Massive TINs in a DBMS: A comparison and a prototype implementation of the multistar approach

- external PhD candidate (2021-now)
- Researcher at Deltares (2015-now)

Deltares

Bouldering in Fontainebleau, France

Deltares

- independent institute for applied research in the field of water and subsurface

- non-profit

- based in Delft & Utrecht

- operates nationally & internationally
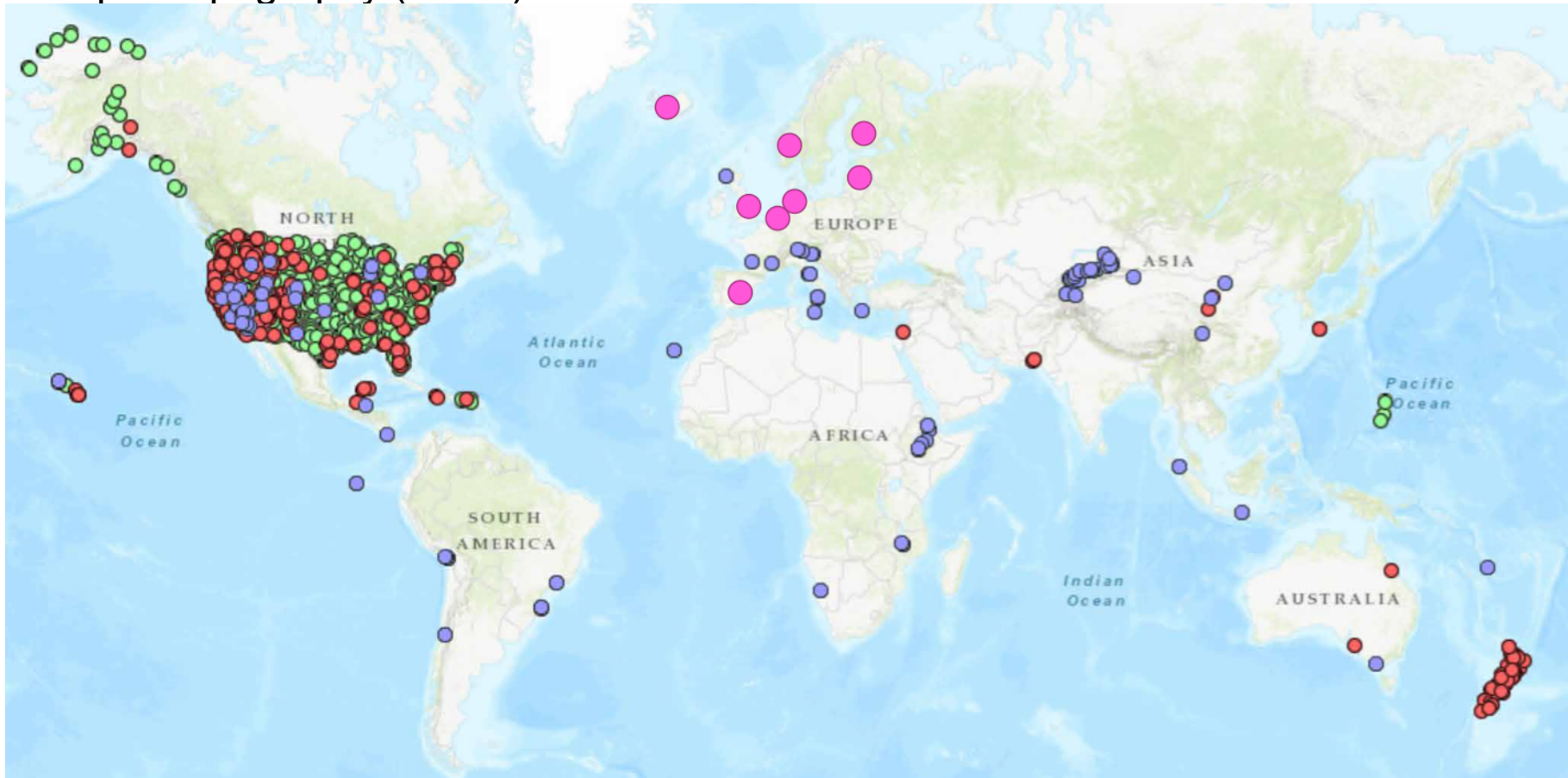
- physical facilities, labs

Deltares

Photo by Saikiran Kesari on Unsplash

Elevation data

- Flooding

- Sea level rise >

- Subsidence

- Landslides

- …

- Sea level rise will probably swallow this island in our lifetime
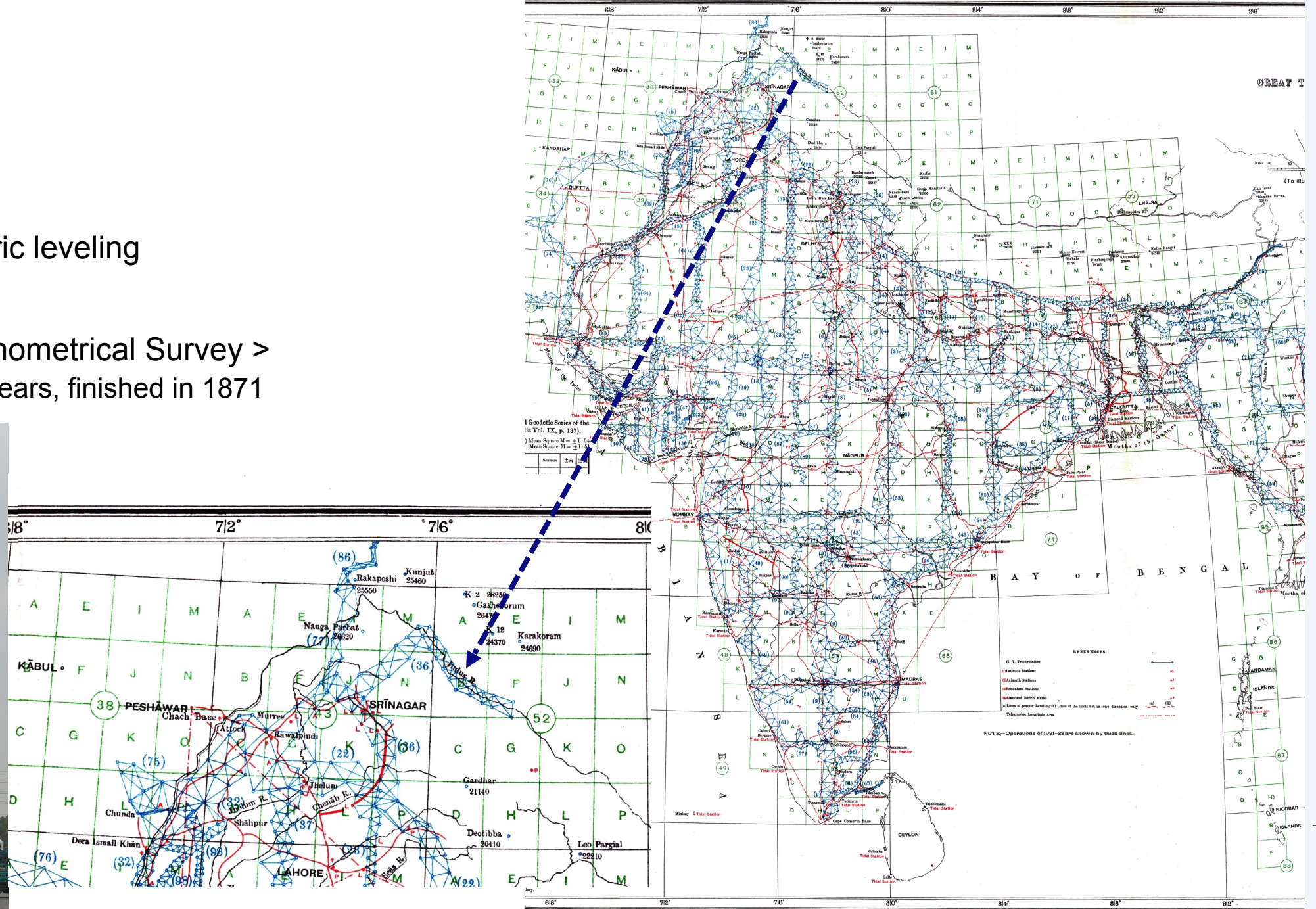
Photo by Kurt Cotoaga on Unsplash

Availability

- OpenTopography (demo)

History

- Trigonometric leveling

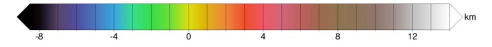- Great Trigonometrical Survey >
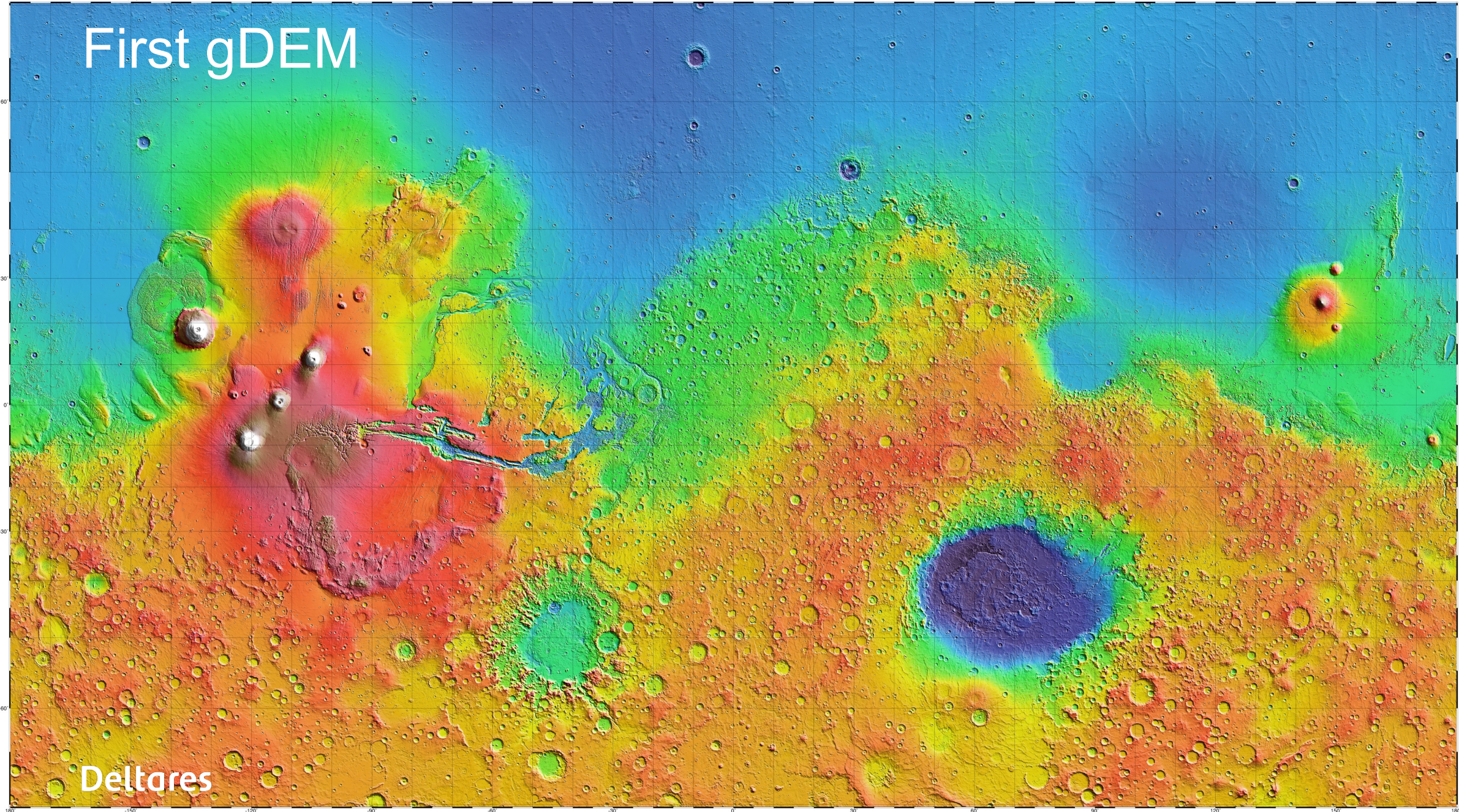 - Took 70 years, finished in 1871

History

- GPS enabled measurements

- Height of Everest in 1999 >

Deltares

First gDEM

THE TOPOGRAPHY OF MARS BY THE MARS ORBITER LASER ALTIMETER (MOLA)
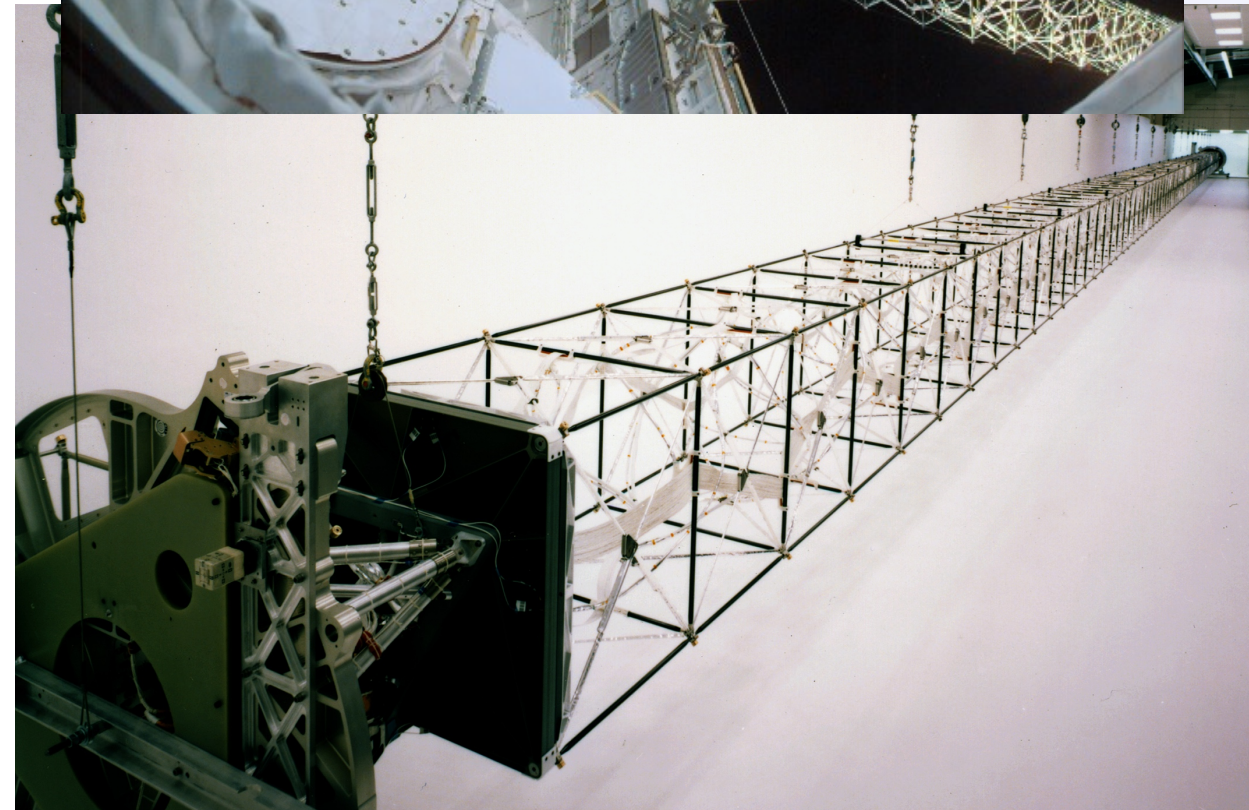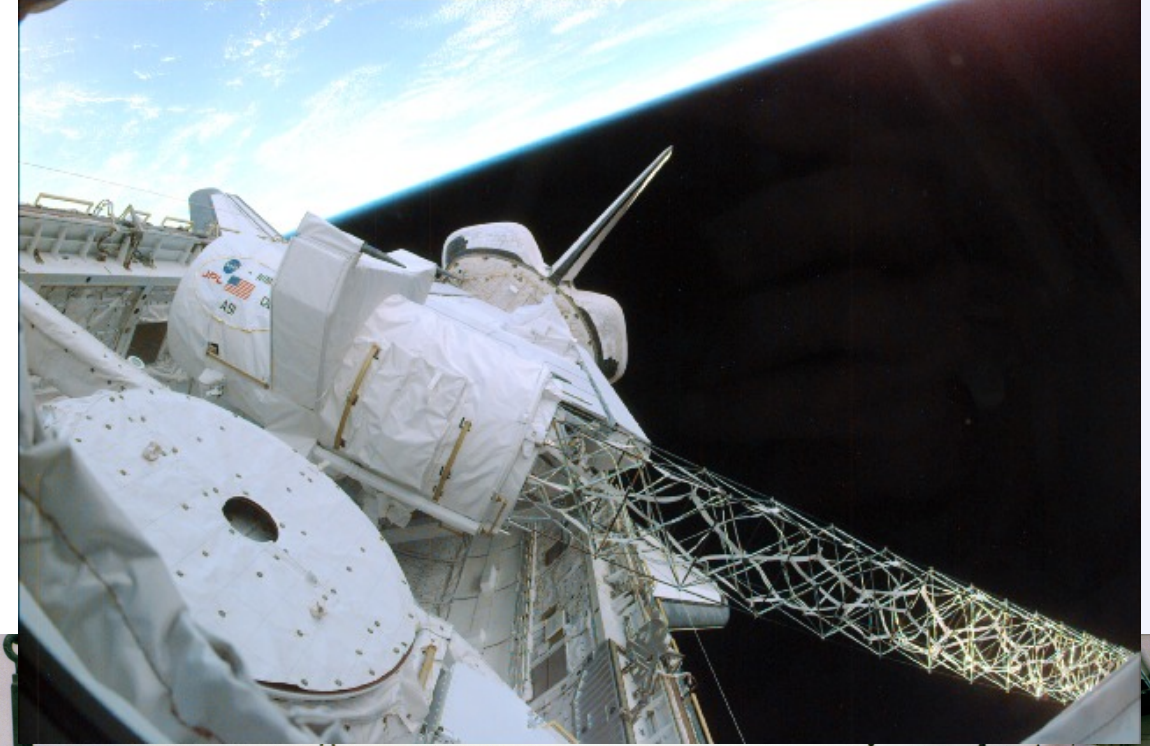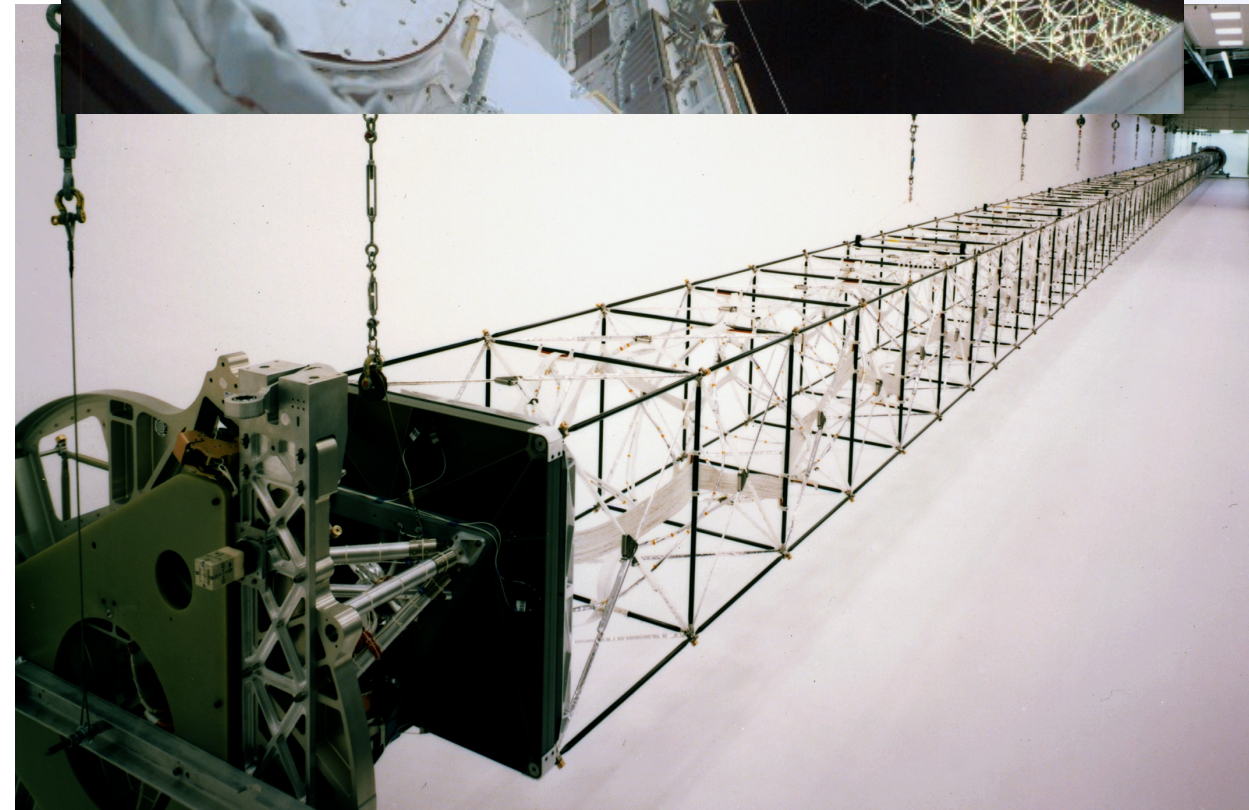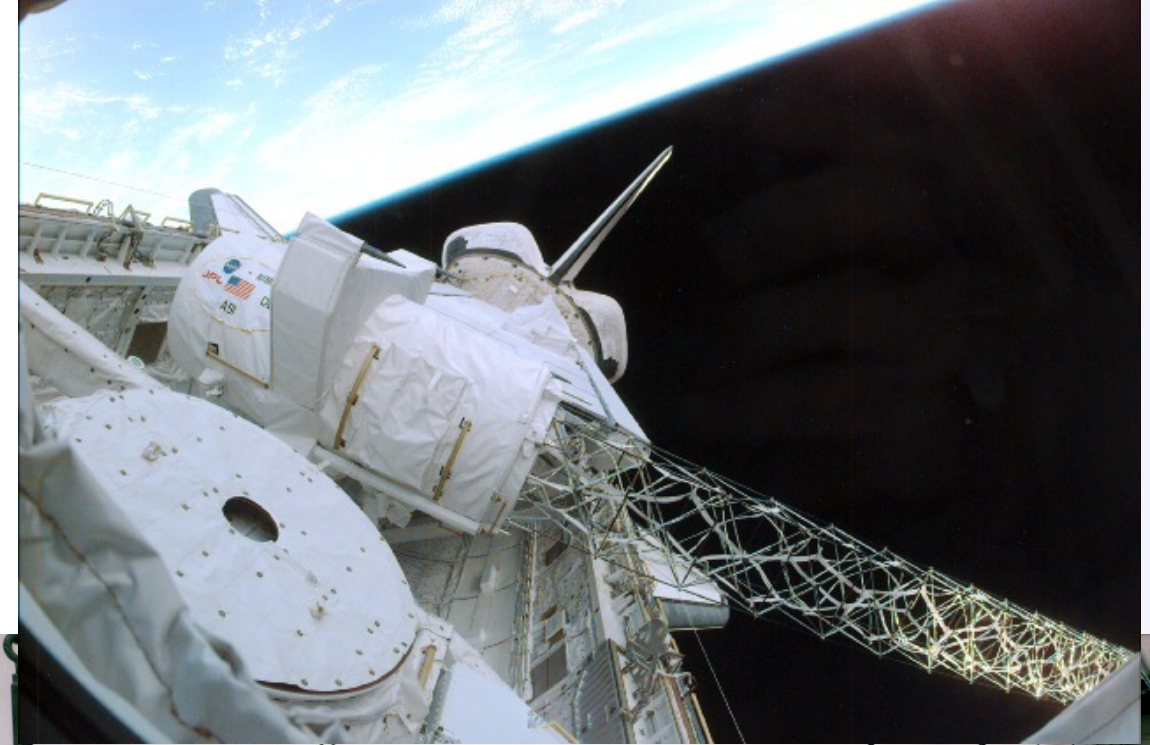
km

Deltares

SRTM

- First gDEM (earth)

- ~60S-60N latitude

- inSAR by using a second antenna on 60 m mast

Deltares

SRTM

- First gDEM (earth)

- ~60S-60N latitude
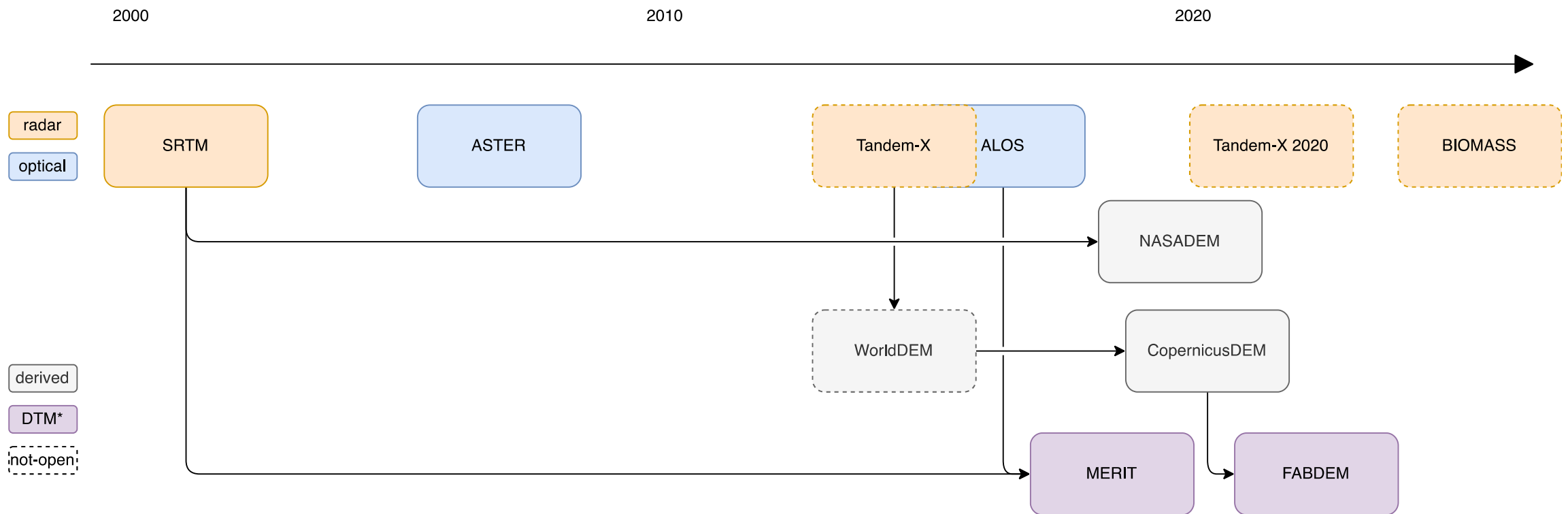

- inSAR by using a second antenna on 60 m mast

Deltares

SRTM

- First gDEM (earth)
- ~60S-60N latitude

- inSAR by using a second antenna on 60 m mast
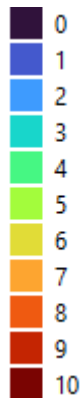

Deltares
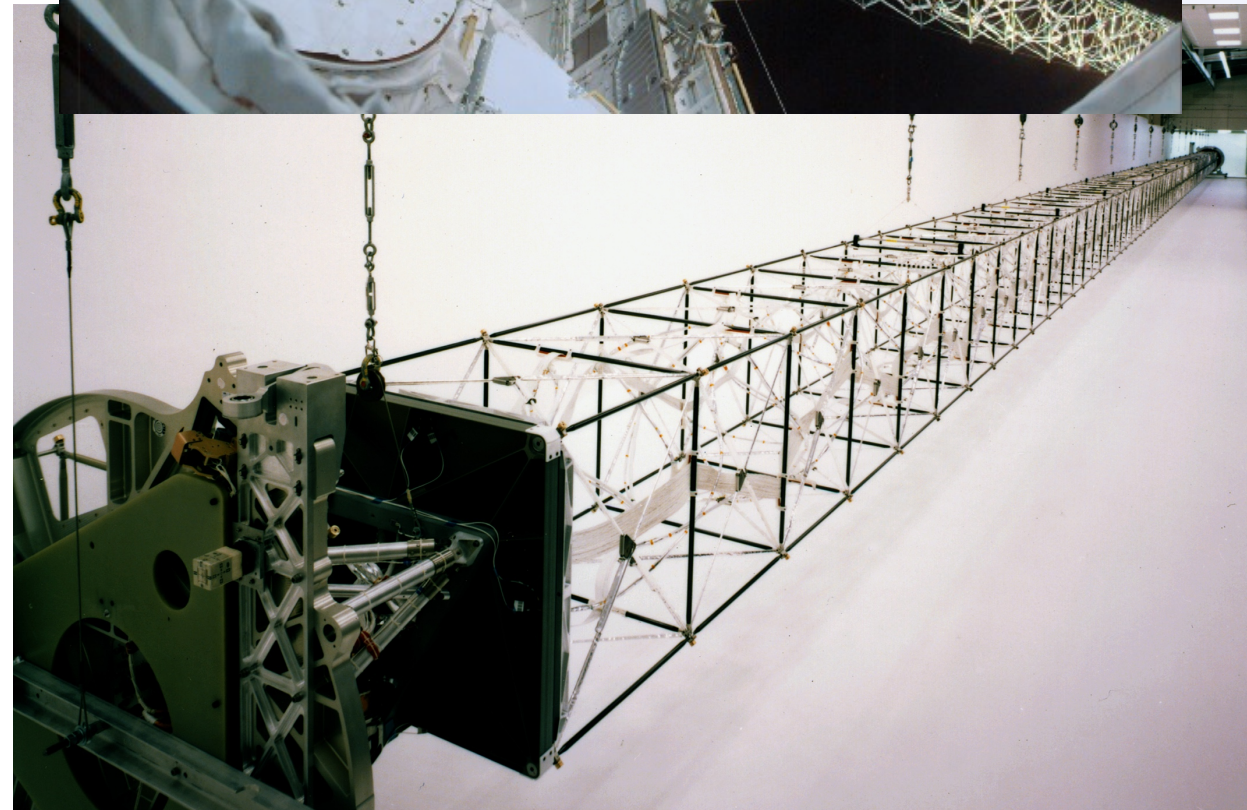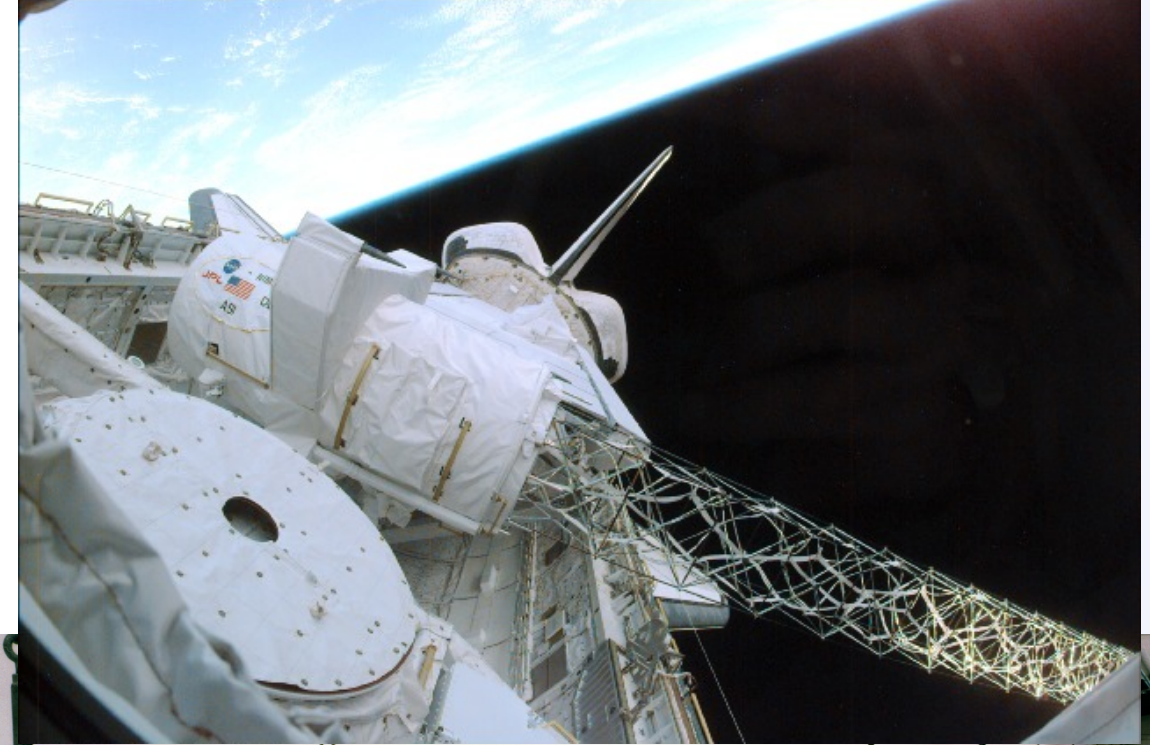
gDEMS
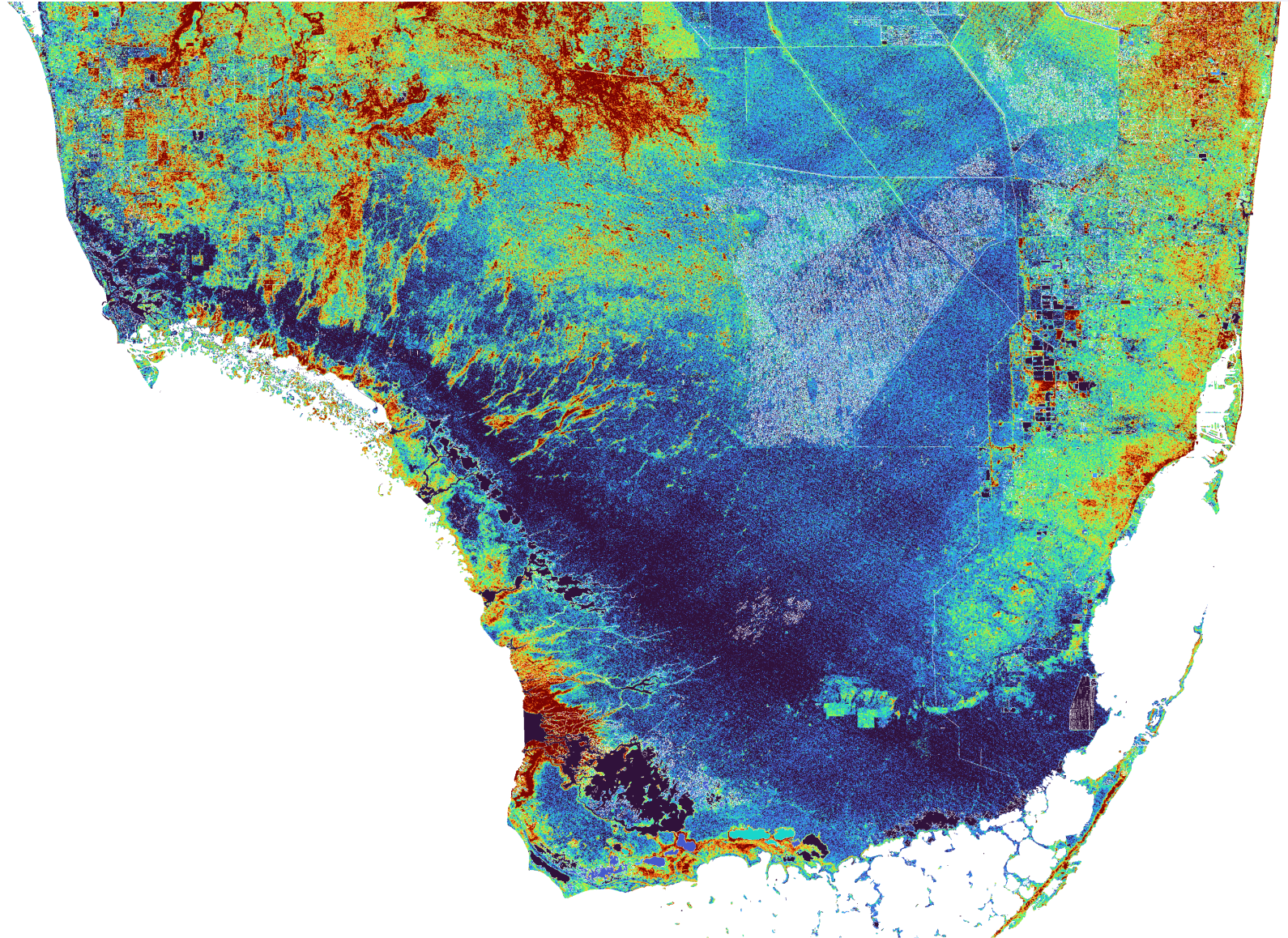
- Overview, timeline

SRTM

- First Radar
- Versions 1-3
- NASADEM (+ICESat)

- EGM96 vertical reference
- Integers (whole numbers)

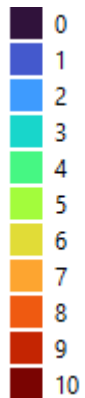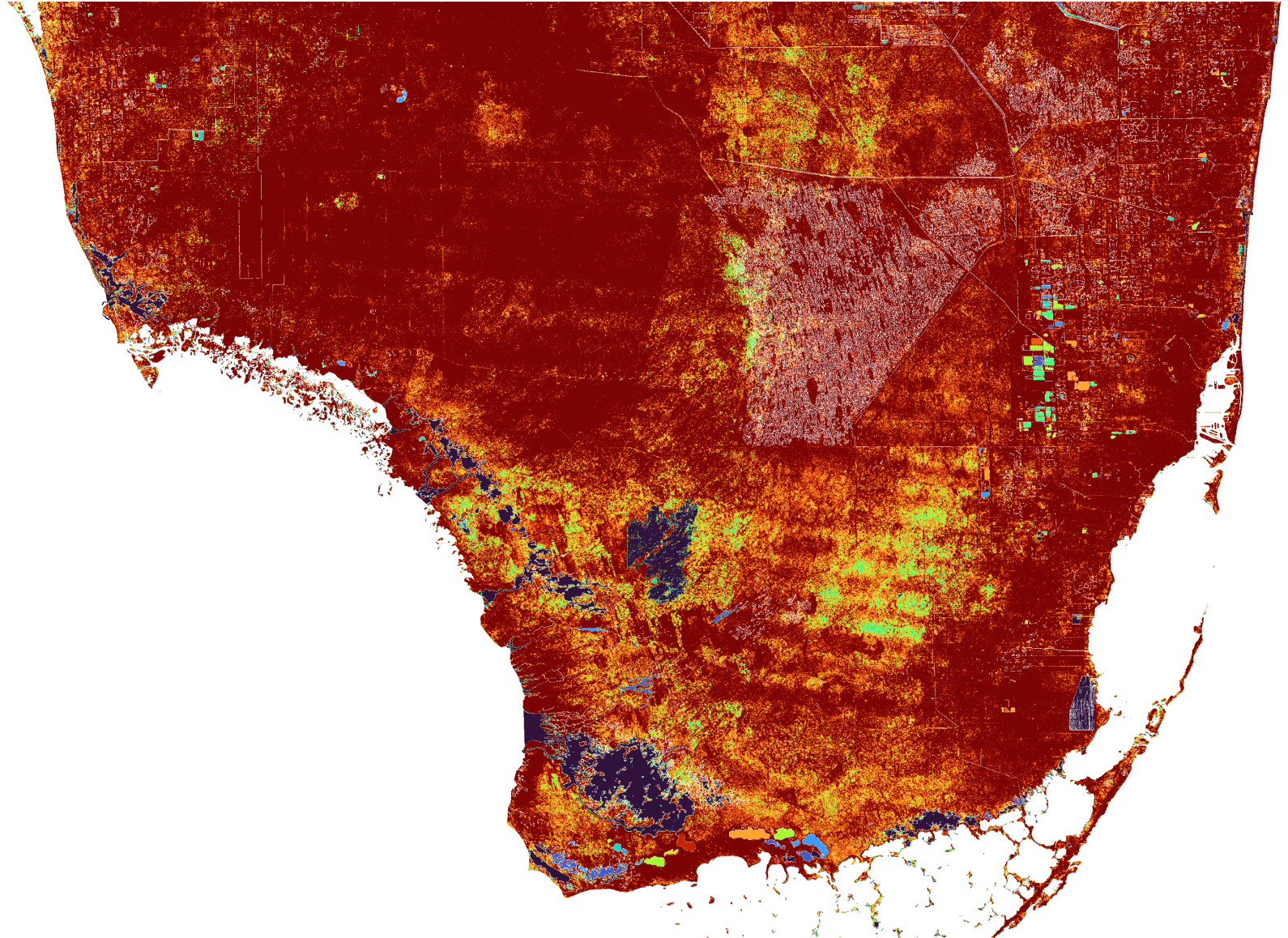- Even now, artefacts, striping.

- **DSM**

[m+ MSL]

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Deltares

ASTER GDEM

- First optical

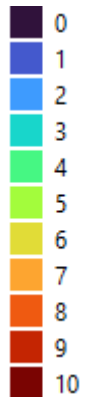- Collaboration between METI & NASA

- Integers
- Striping

[m+ MSL]

Deltares

Alos

- Optical

- Integers
- Some artefacts

- Commercial 5m version (!)

[m+ MSL]

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Deltares
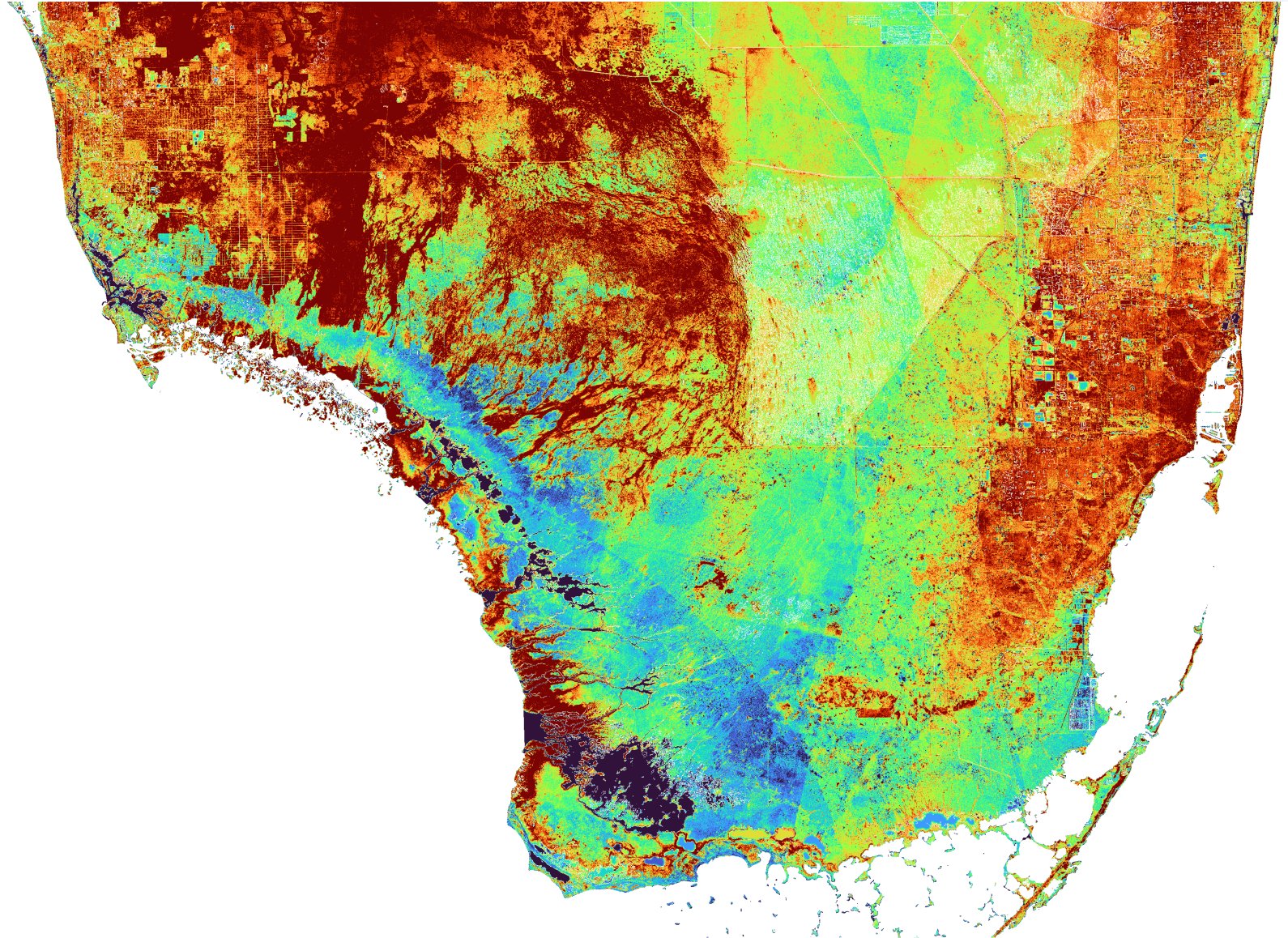
Tandem-X

- CopernicusDEM

- Based on Airbus WorldDEM bought by ESA for €200M.

- Floating point (!)

- EGM2008 vertical reference

- 12m available for Europe

- New 2020 version in the works

- Commercial 5m version (!)

Deltares
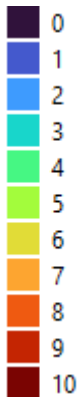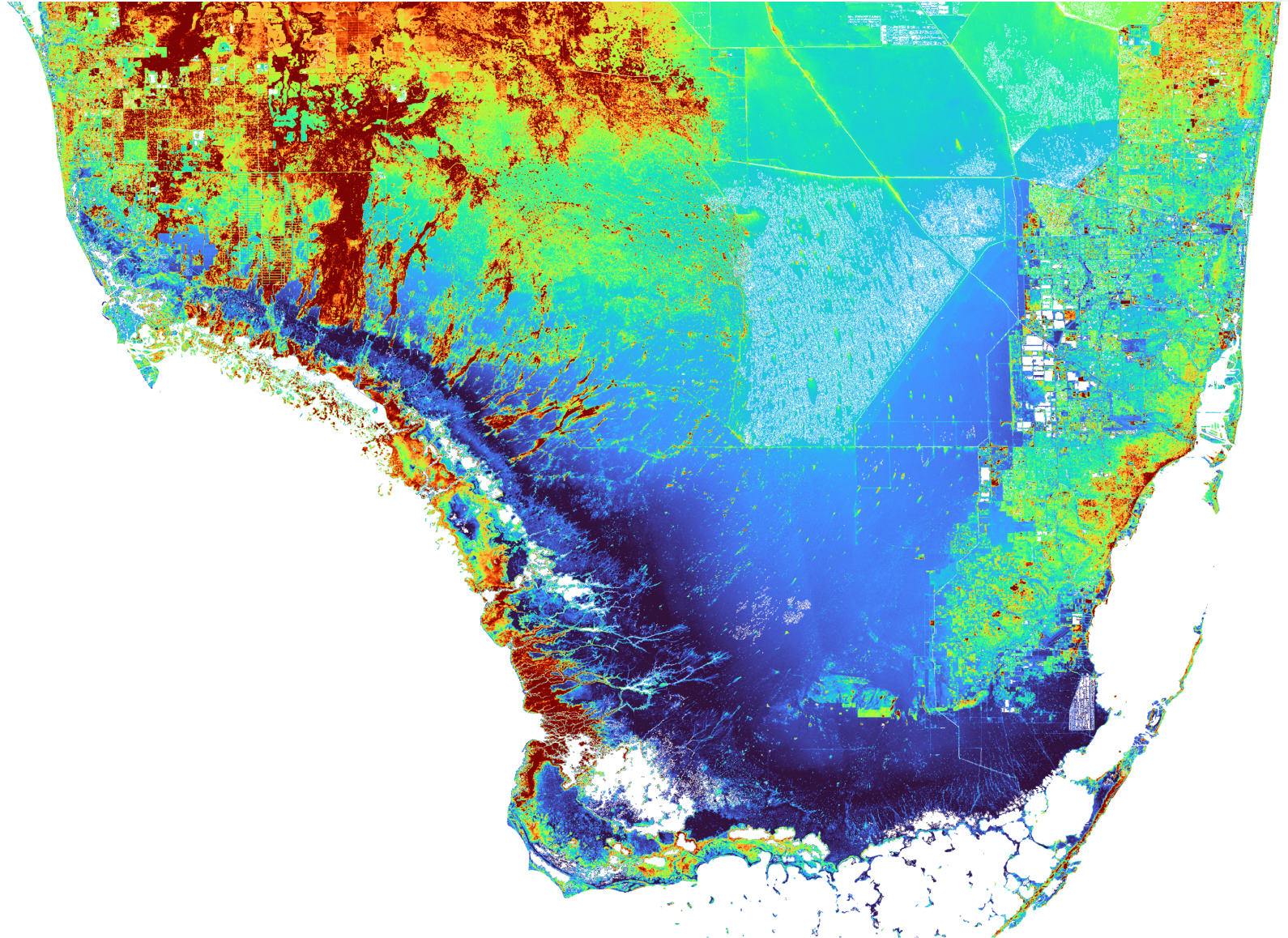
Corrected gDEMS

- Corrections for canopy, infrastructure

- Based on other data sources (optical, canopy height estimates, trained on local lidar DTM)

- Regression methods to predict surface height

- All DEMs are **wrong**, some are *useful*

Deltares

MERIT

- Multi-error improved terrain

- Improvements in both artefacts and vegetation correction

- Used in Deltares (hydro version)

[m+ MSL]

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Deltares
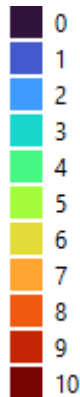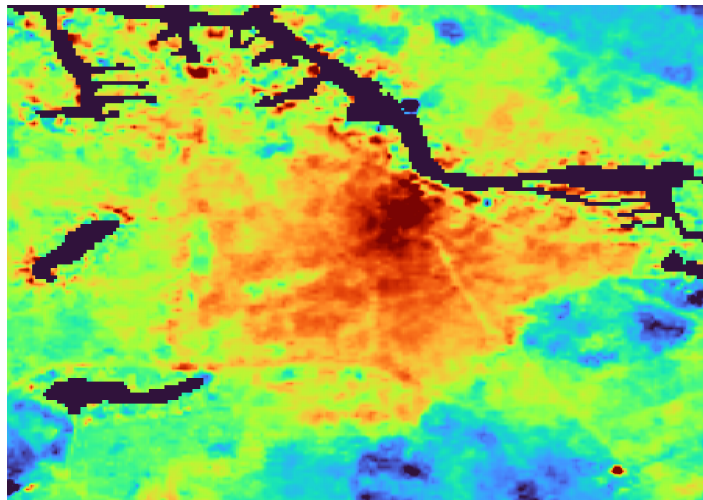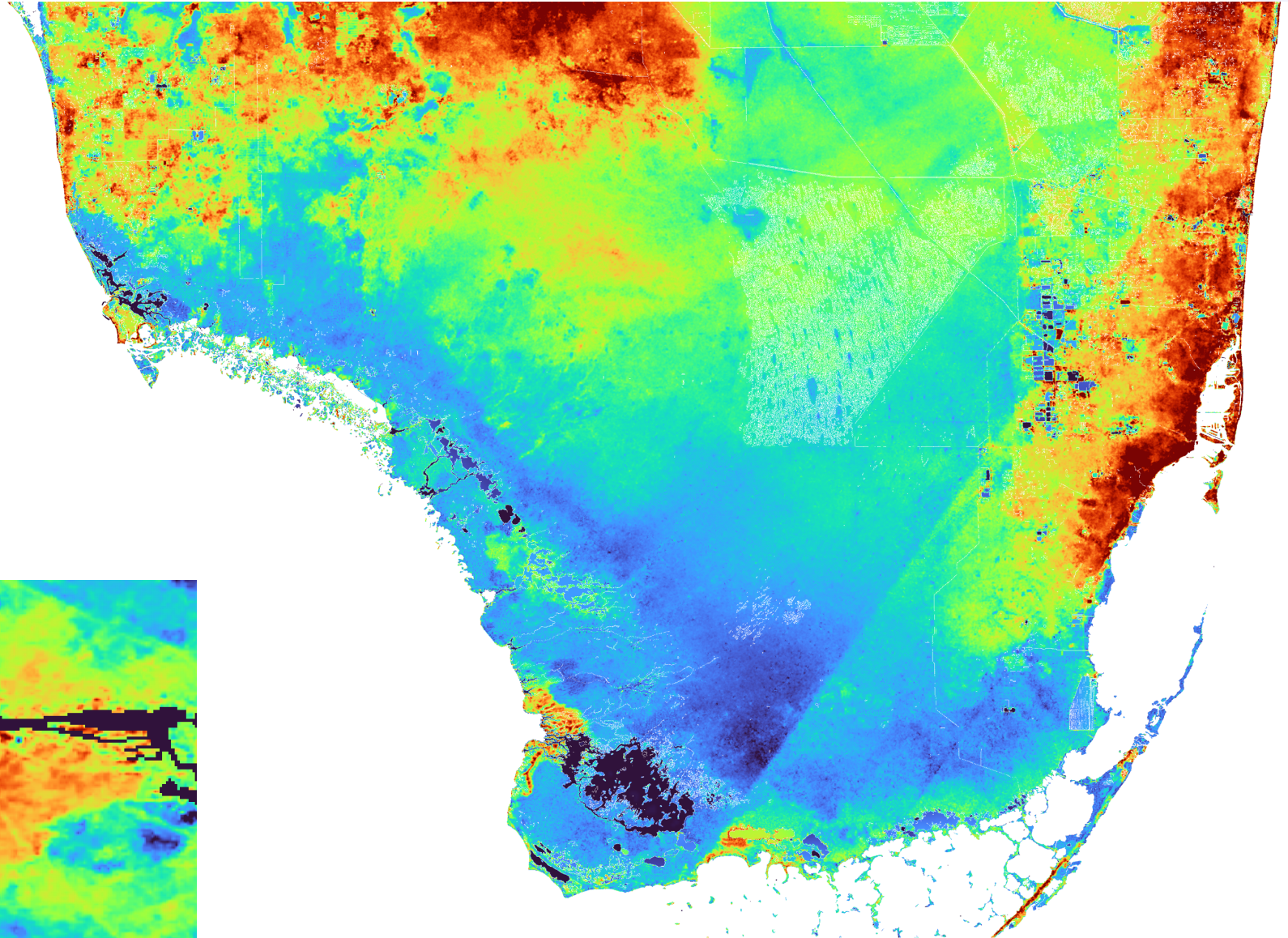
CoastalDEM

- Based on NASADEM

- Trained with LiDAR, ICESat-2

- Only coasts <120m +MSL

- Commercial

[m+ MSL]

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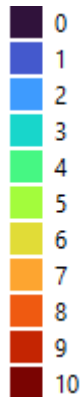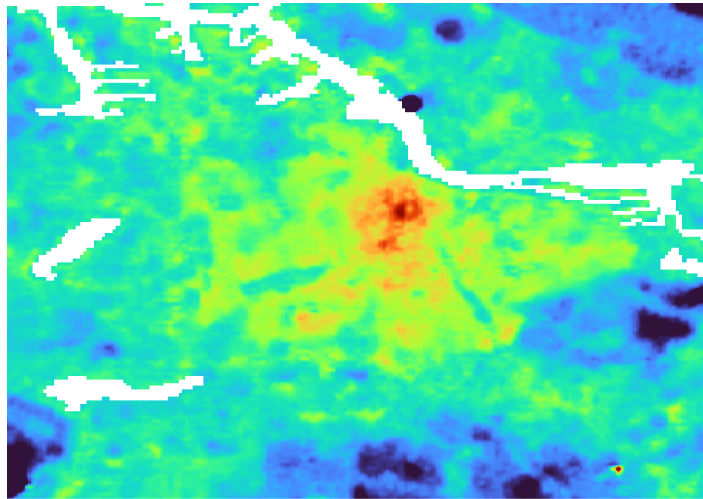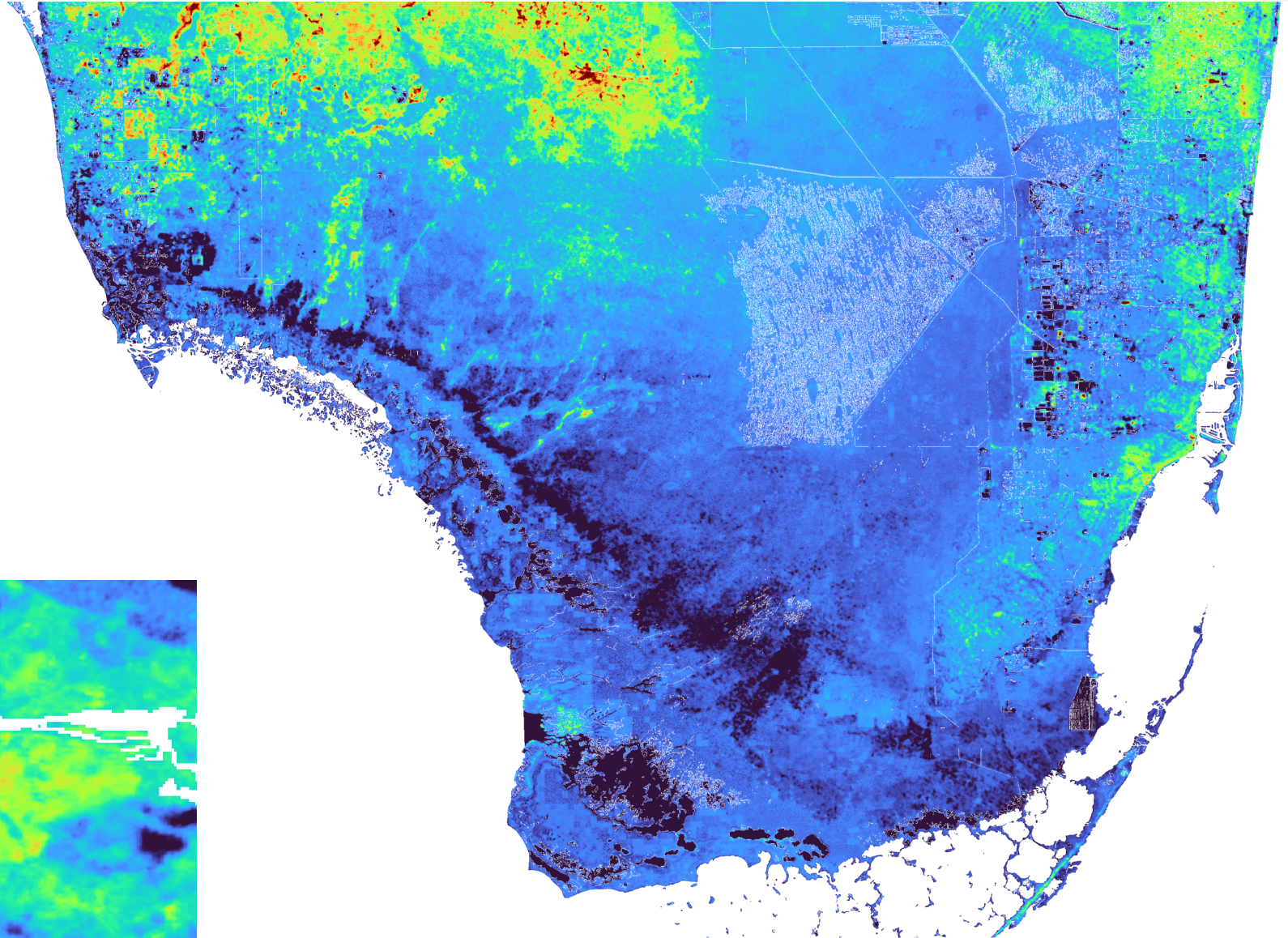
Deltares

FABDEM

- Based on CopernicusDEM
- Trained with LiDAR, ICESat-2

- Global

- Commercial

[m+ MSL]

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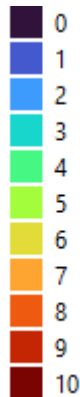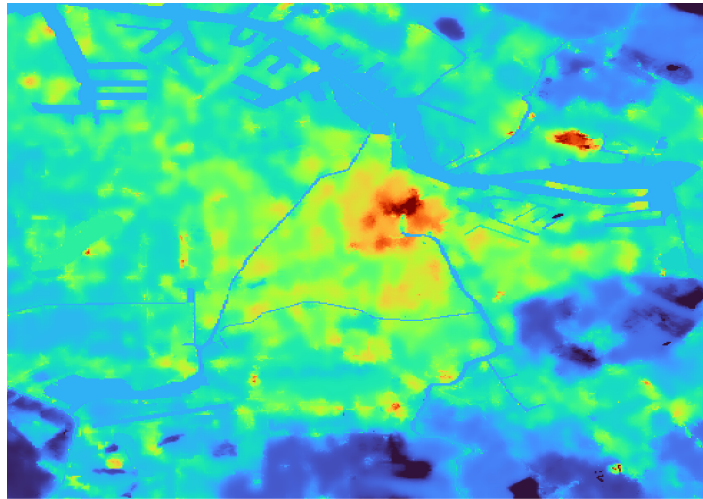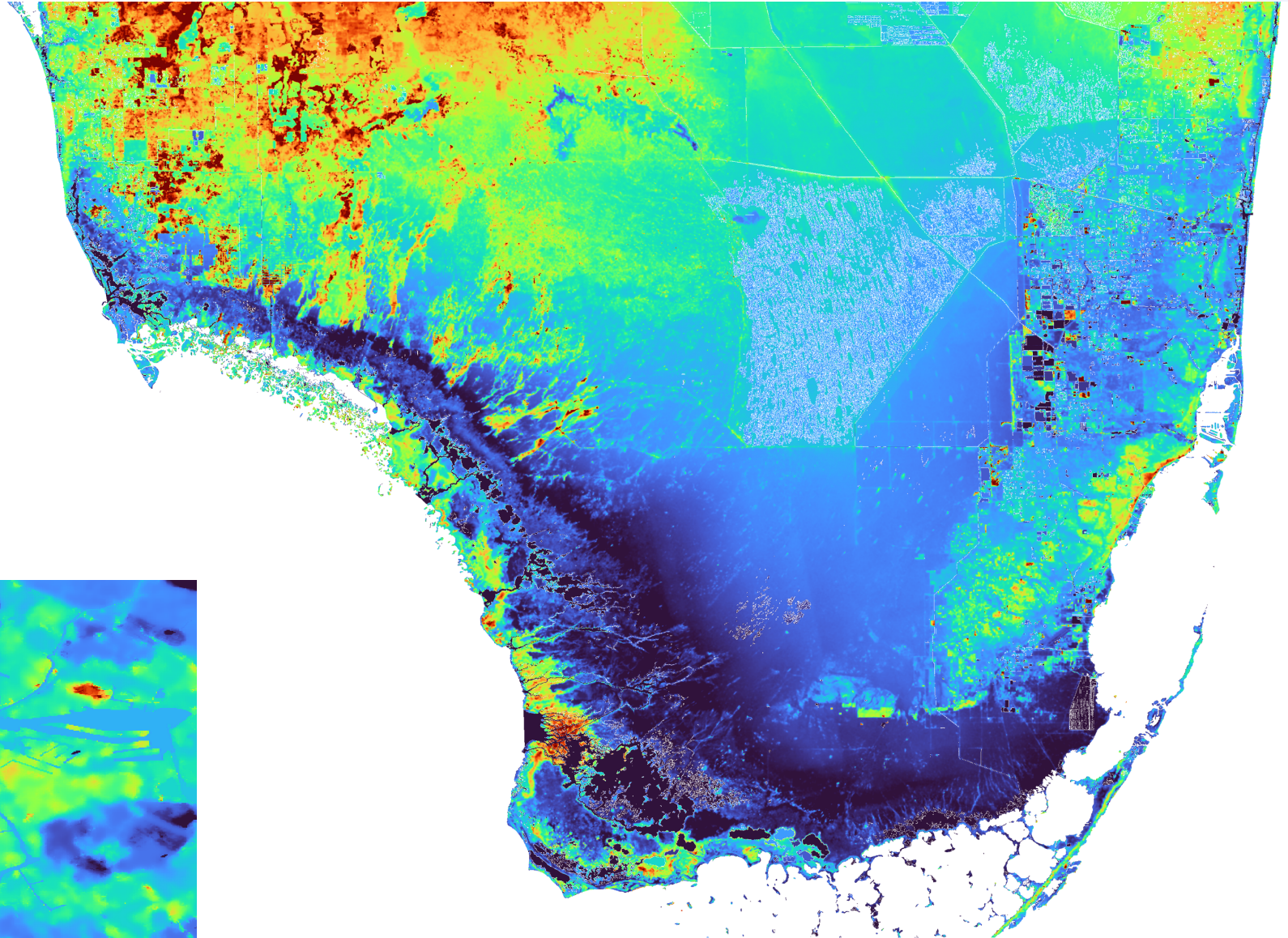
Deltares

DiliviumDEM

- Based on CopernicusDEM

- Trained with LiDAR, ICESat-2

- Coastal

- Non-commercial

- Speckle noise (roughness)
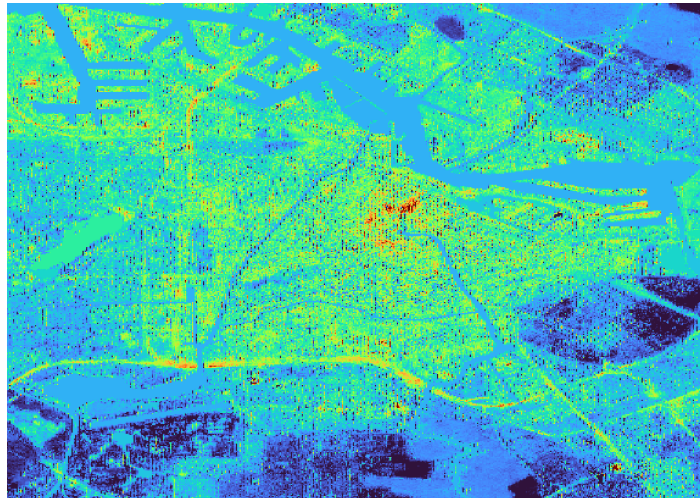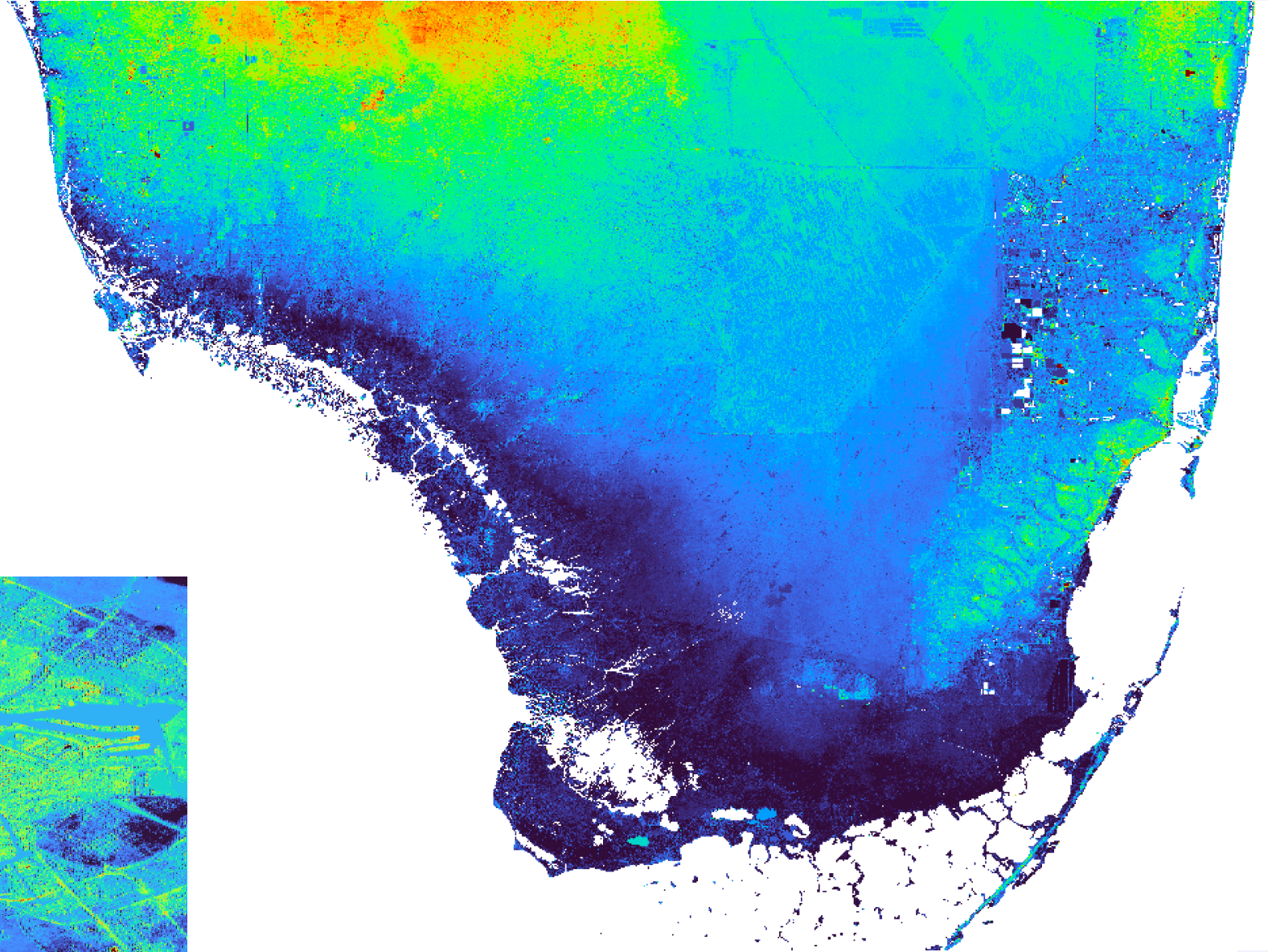
[m+ MSL]

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Deltares

DeltaDTM (ours)

- Based on CopernicusDEM

- Derived with LiDAR, ICESat-2

- Coastal

- Non-commercial

- Some stripes

[m+ MSL]

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Deltares
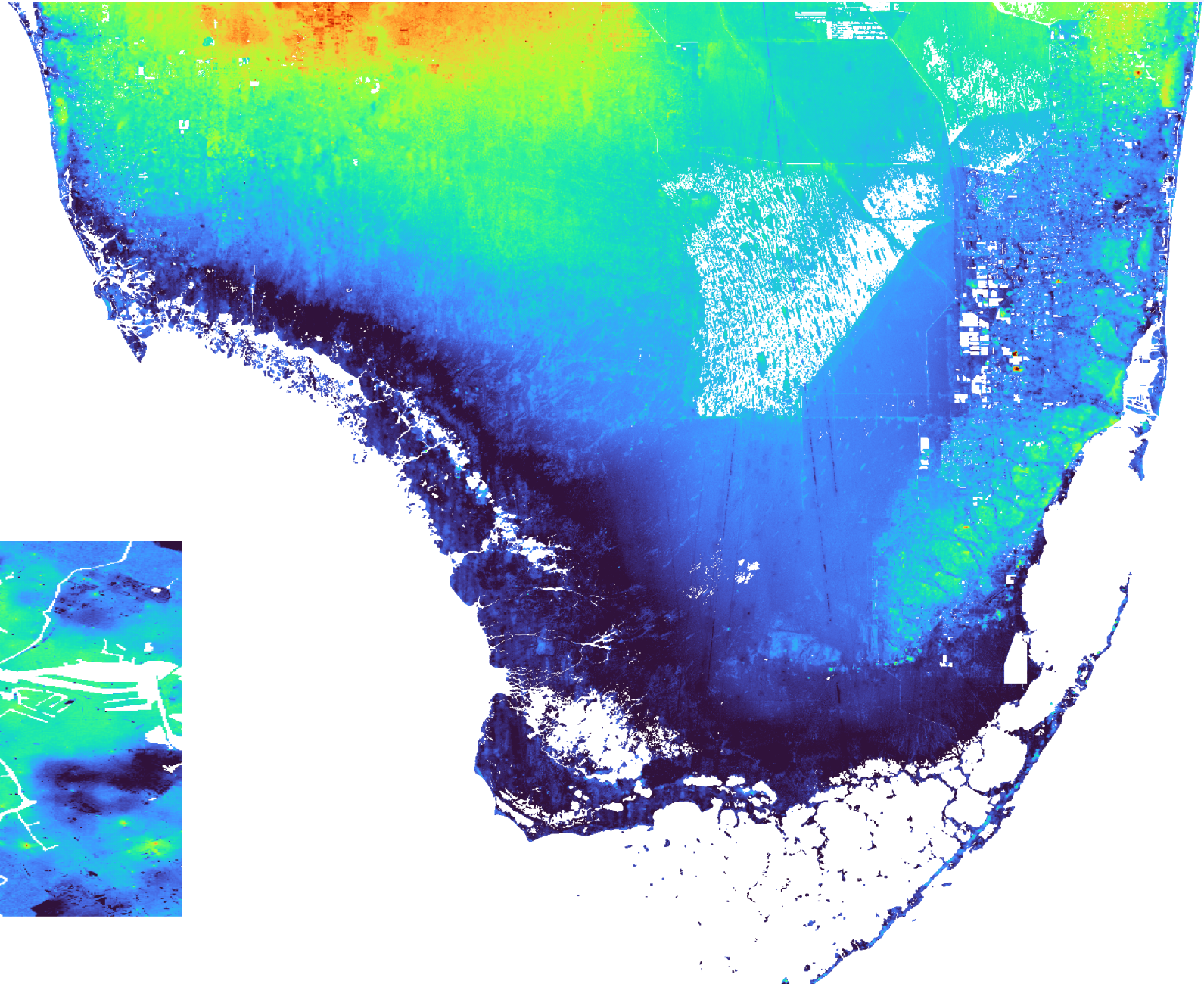
Actual DTM

- NOAA SeaLevelRise DTM (right)

- AHN4 (below)

- LiDAR based
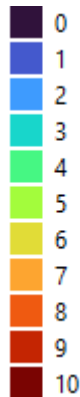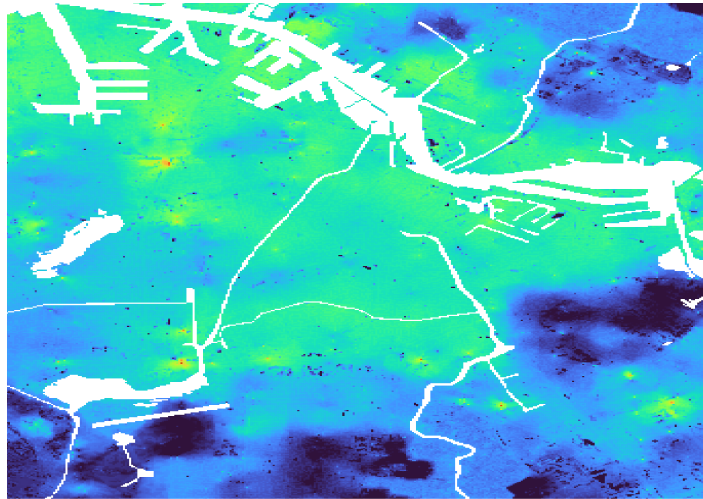

[m+ MSL]

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Deltares
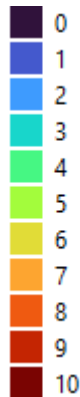
LiDAR

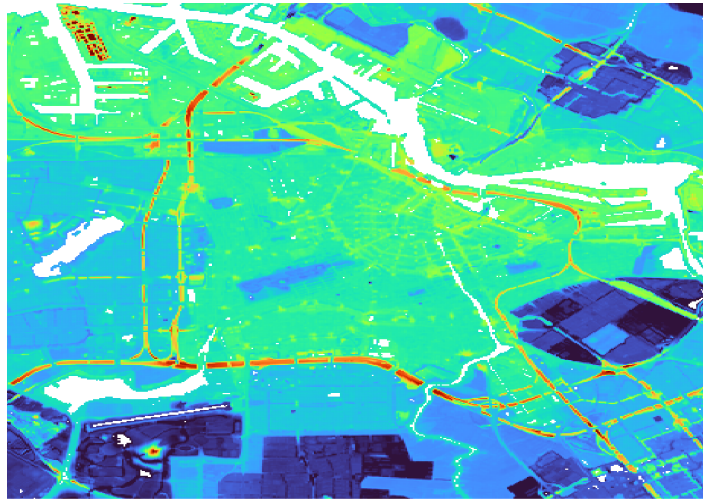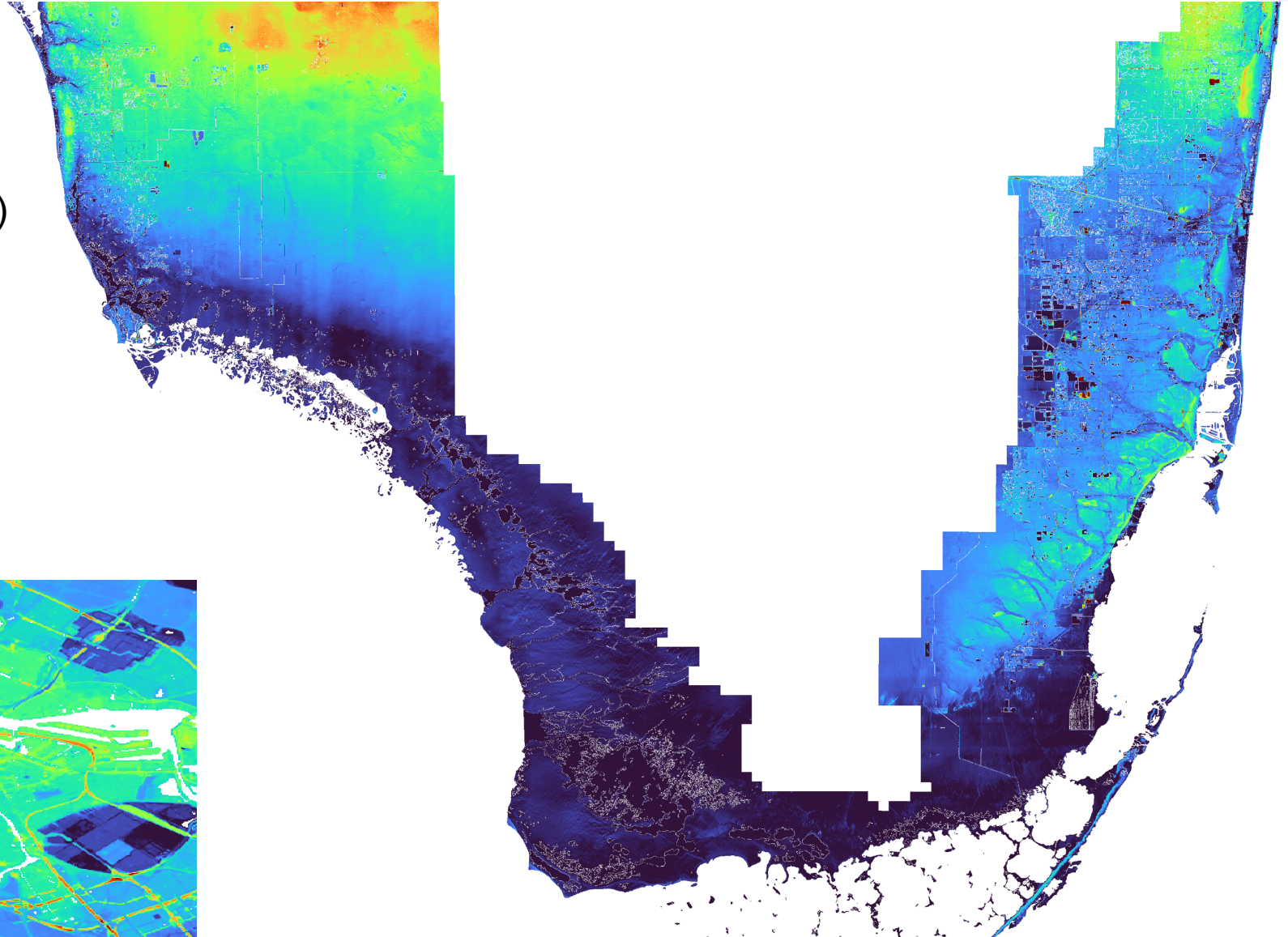|		
🏠	**Terrestial**	Buildings, archeology, cars
🎈	**Airborne**	Elevation models, canopy height, change detection
🛰	**Spaceborne** *NEW*	Elevation, distances of moons and **planet**s, star wars

LiDAR platform considerations

	Terrestial	Airborne	Spaceborne
Pointing ability	360 degrees	90 degrees	0.01 degrees
Range	~ 200m	~1 km	~500 km
Speed	0-100 km/h	100-200 km/h	5000 km/h
Area Coverage	Repeated measurements	Overlapping trajectory	NA
Footprint	mm	cm	m

Deltares

SpaceLiDAR

- ICESat-2
  - Single Photon LiDAR
  - Icesheet monitoring

- GEDI
  - Full waveform LiDAR
  - Ecosystem monitoring

ICESat-2 (92° inclination)
GEDI (51.6° inclination)

Deltares
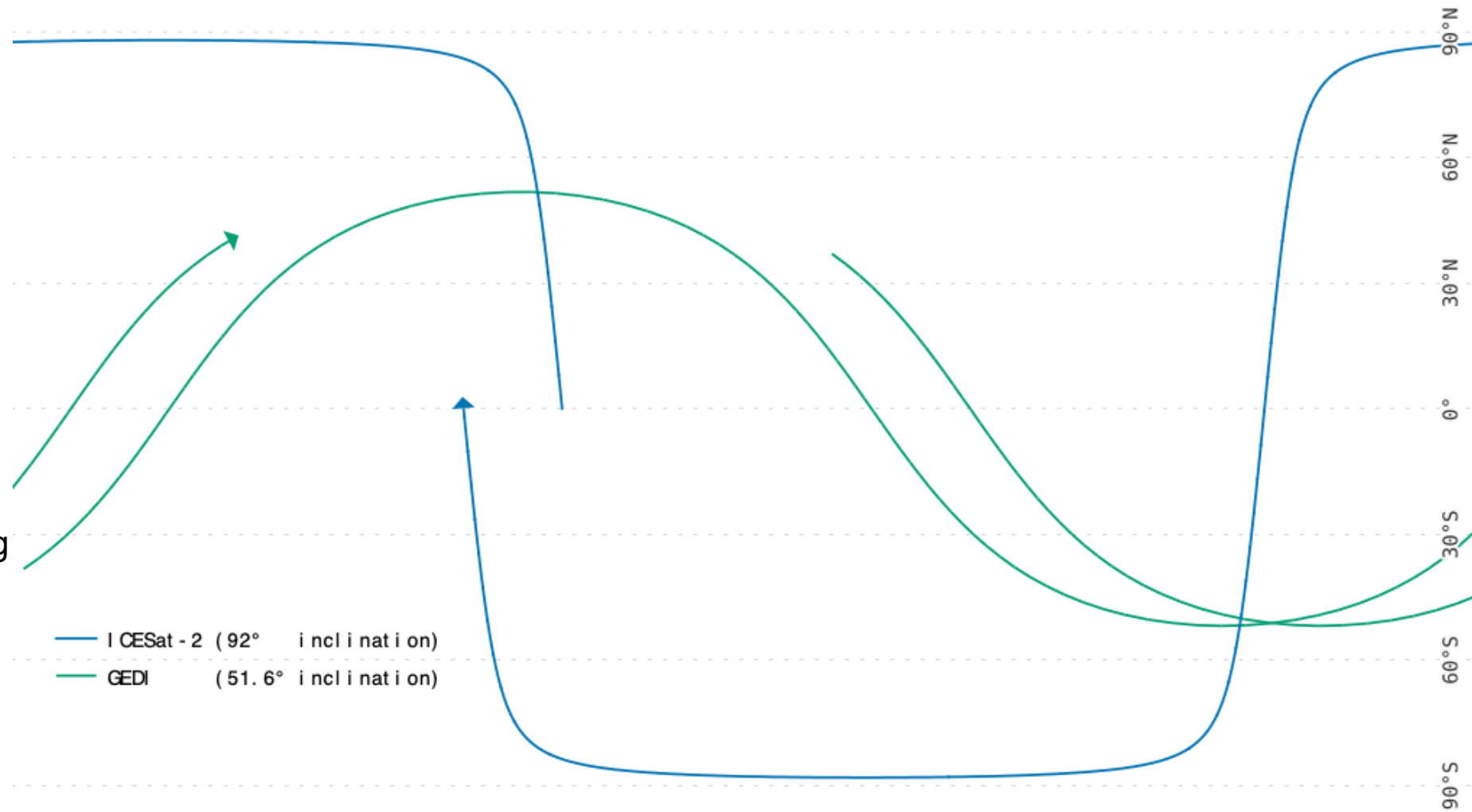
SpaceLiDAR

- **ICESat-2**
  - 6 beams (3 weak)
  - 15m footprint
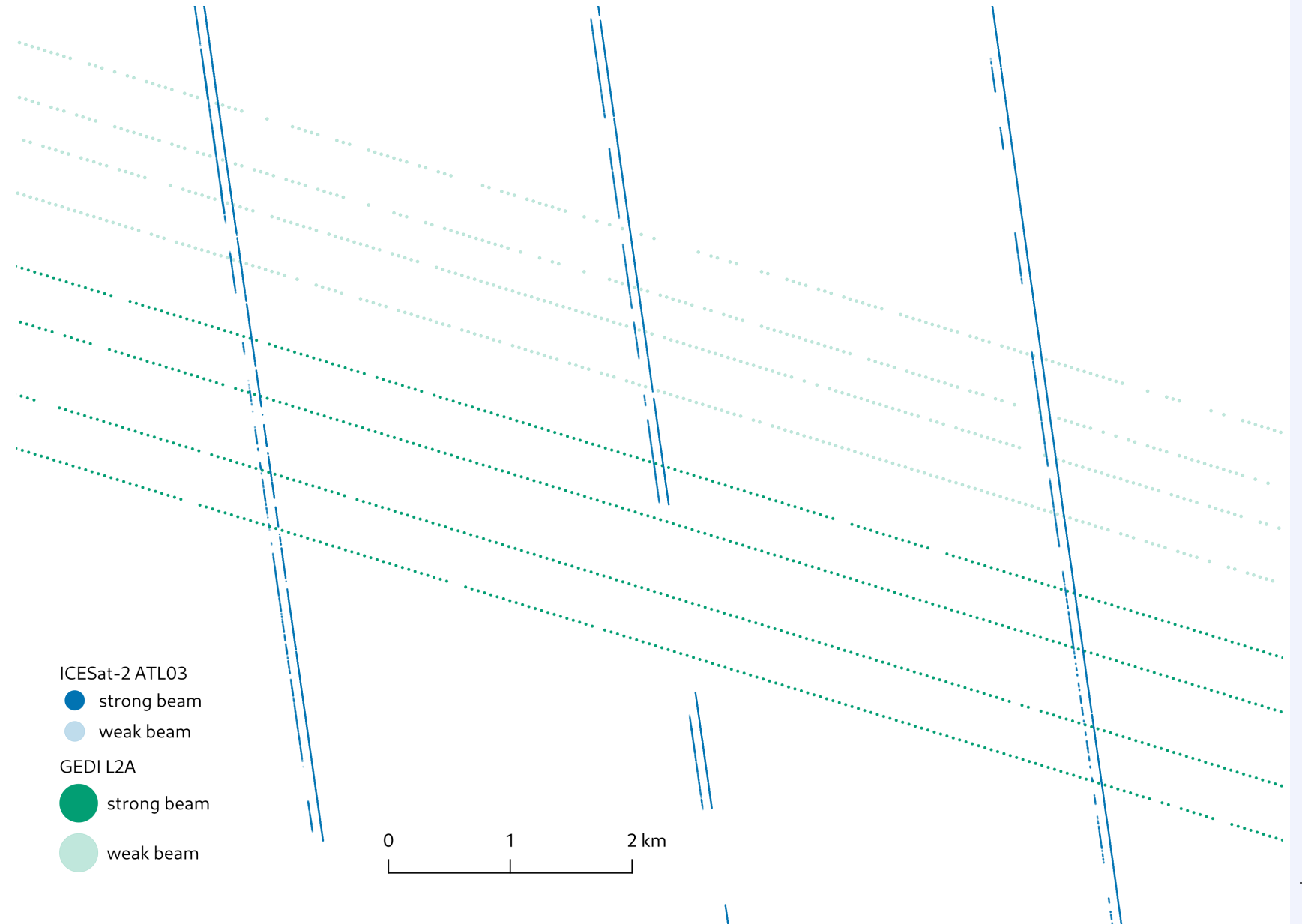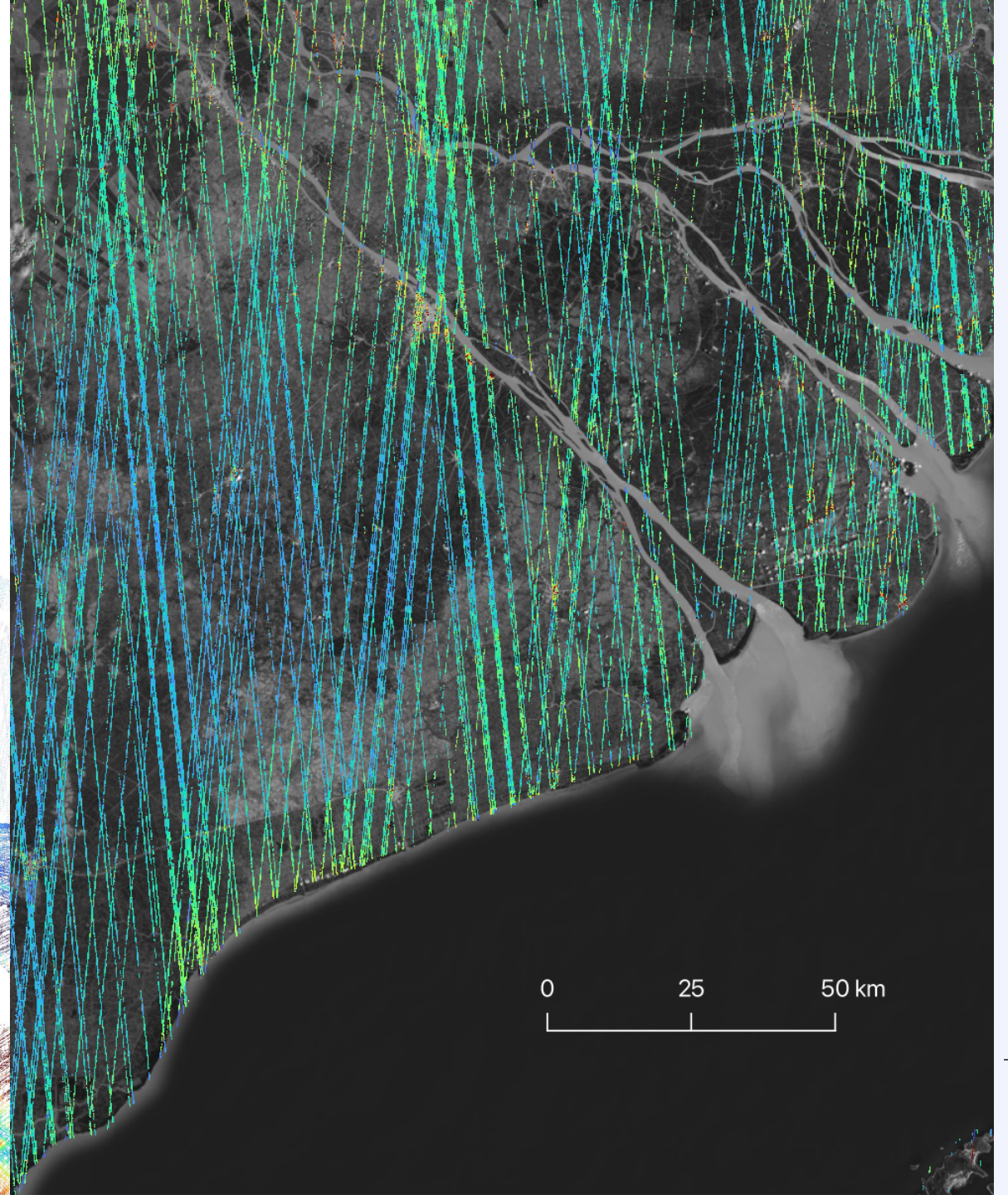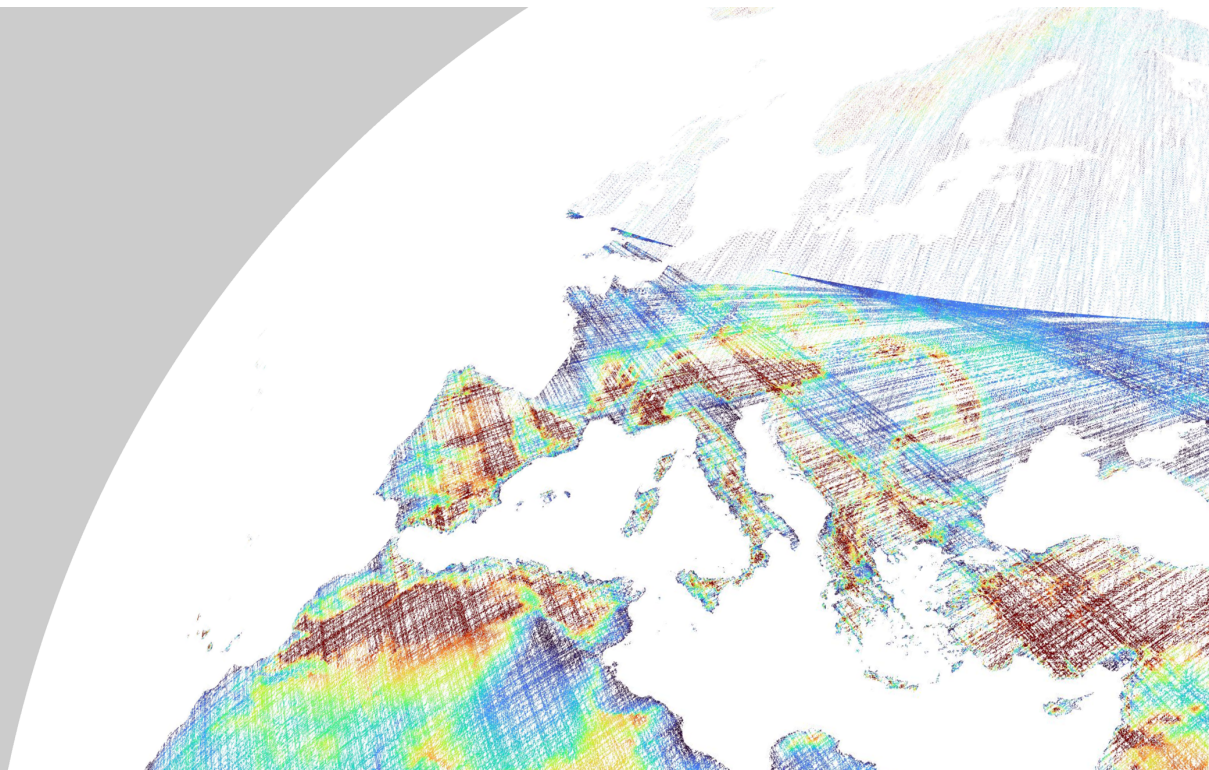 - 0.7m along track
  - < 1m accurate

- **GEDI**
  - 8 beams (4 weak)
  - 25m footprint
  - 70m along track
  - ~1m accurate

ICESat-2 ATL03
● strong beam
● weak beam

GEDI L2A
● strong beam
● weak beam

0   1   2 km

Deltares

Sparsity

- High resolution along-track

- Low resolution across-track
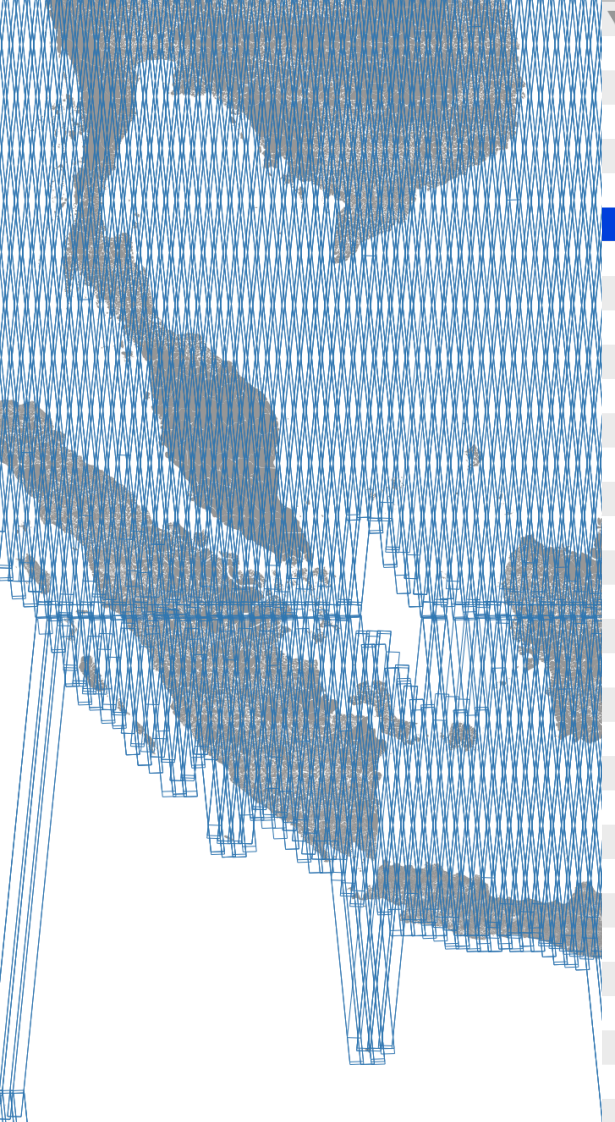
- Factor 10-100 difference

- Coverage can be lacking

Data handling

- Comes in several .h5 files (granules)
- Requires selection, download

- Elevation data requires filtering / conversion

- Aggregated ICESat-2 20TB (GEDI >40 TB)
  - Updates every 3 months
  - New versions, redownload

- OpenAltimetry webservice
- Amazon S3 access

Deltares

▼ ATL08_20181016201816_02780107_00...	SET_BY_ME
▶ ancillary_data	ancillary_d
ds_geosegments	Geosegmen
ds_metrics	Metrics
ds_surf_type	Surface Ty
▼ gt1l	gt1l
▼ land_segments	gt1l/
asr	apparent s
atlas_pa	atlas point
beam_azimuth	beam azin
beam_coelev	beam co-e
brightness_flag	brightness
▶ canopy	gt1l/land_
cloud_flag_atm	cloud flag
cloud_fold_flag	cloud foldi
delta_time	mean pass
delta_time_beg	delta time
delta_time_end	delta time
dem_flag	dem sourc
dem_h	dem heigh
dem_removal_flag	dem remo
h_dif_ref	h dif from
last_seg_extend	last segme
latitude	latitude
layer_flag	consolidate
longitude	longitude
msw_flag	multiple sc
n_seg_ph	number of
night_flag	night flag
ph_ndx_beg	photon ind
ph_removal_flag	ph remova
psf_flag	point sprea
rgt	reference t
sat_flag	saturation
segment_id_beg	begin geol
segment_id_end	end geoloc
segment_landcover	segment la
segment_snowcover	segment s
segment_watermask	segment w
sigma_across	sigma atla
sigma_along	sigma atla
sigma_atlas_land	sigma atla

SpaceLiDAR.jl

- **Julia** toolbox for ICESat-2 and GEDI data

- Builts upon existing open source geospatial packages
  - GeoArrays
  - GeoDataFrames
  - LazIO

- Pluto Notebook [demo >](demo)

Deltares

GLL_DTM

- Global Lowland LiDAR DTM

- Based on ICESat-2

- **1km** (was 5km)

- Vernimmen, Ronald, Aljosja Hooijer, and Maarten Pronk. 2020. 'New ICESat-2 Satellite LiDAR Data Allow First Global Lowland DTM Suitable for Accurate Coastal Flood Risk Assessment'. *Remote Sensing* 12 (17): 2827. https://doi.org/10/gg9dg6.

[m+ MSL]

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Deltares

Questions?

https://deltares.nl/en/
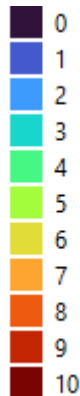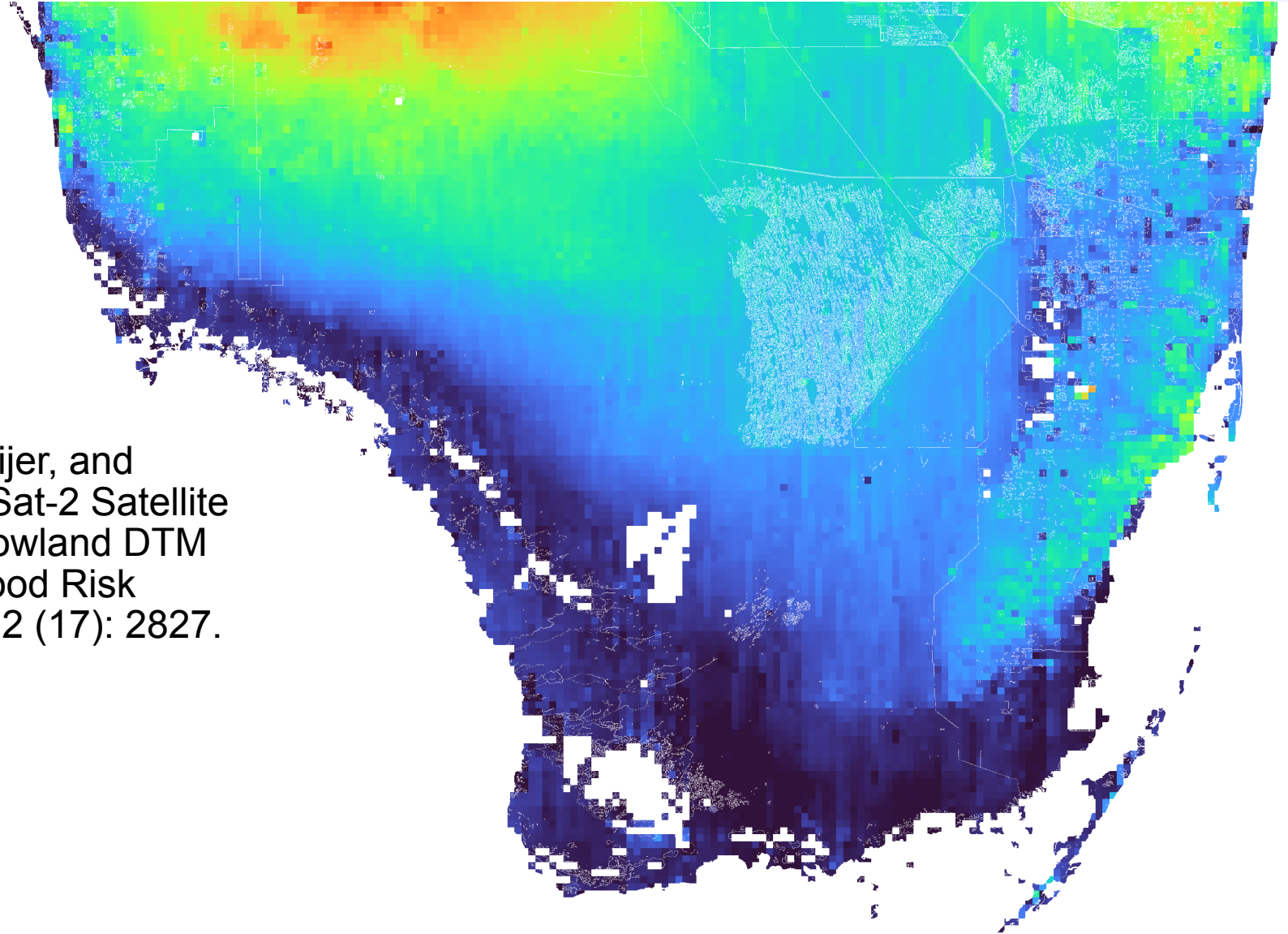
maarten.pronk@deltares.nl m.j.pronk@tudelft.nl

3vetion

@evetion

Deltares