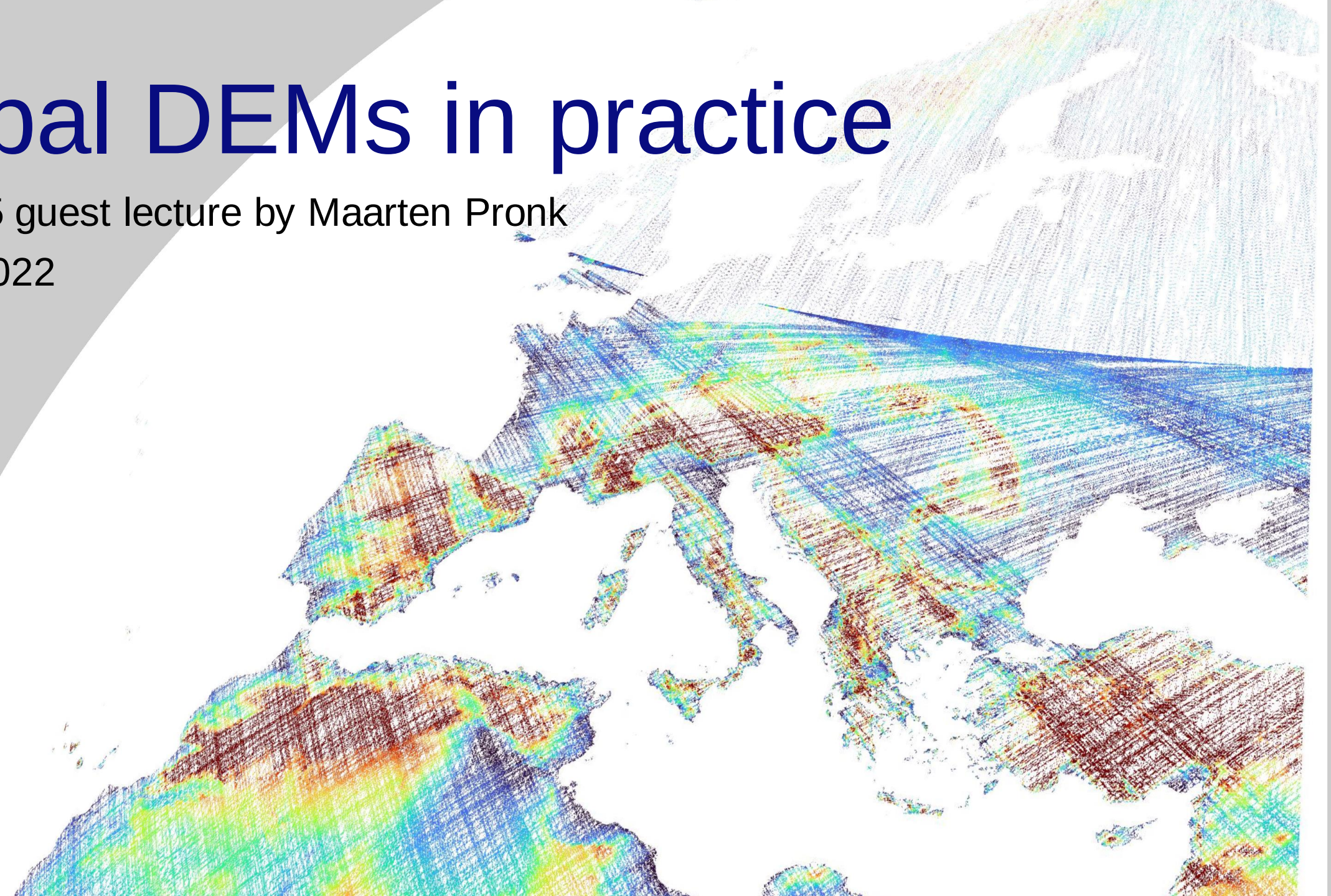
Deltares

enabling delta life

Global DEMs in practice

GEO1015 guest lecture by Maarten Pronk

16-12-02022



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)

Bouldering in Fontainebleau, France

Deltares

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

Photo by Saikiran Kesari on Unsplash

Elevation data

- Flooding
- Sea level rise >
- Subsidence
- Landslides
- …

- Sea level rise will swallow this island in our lifetime

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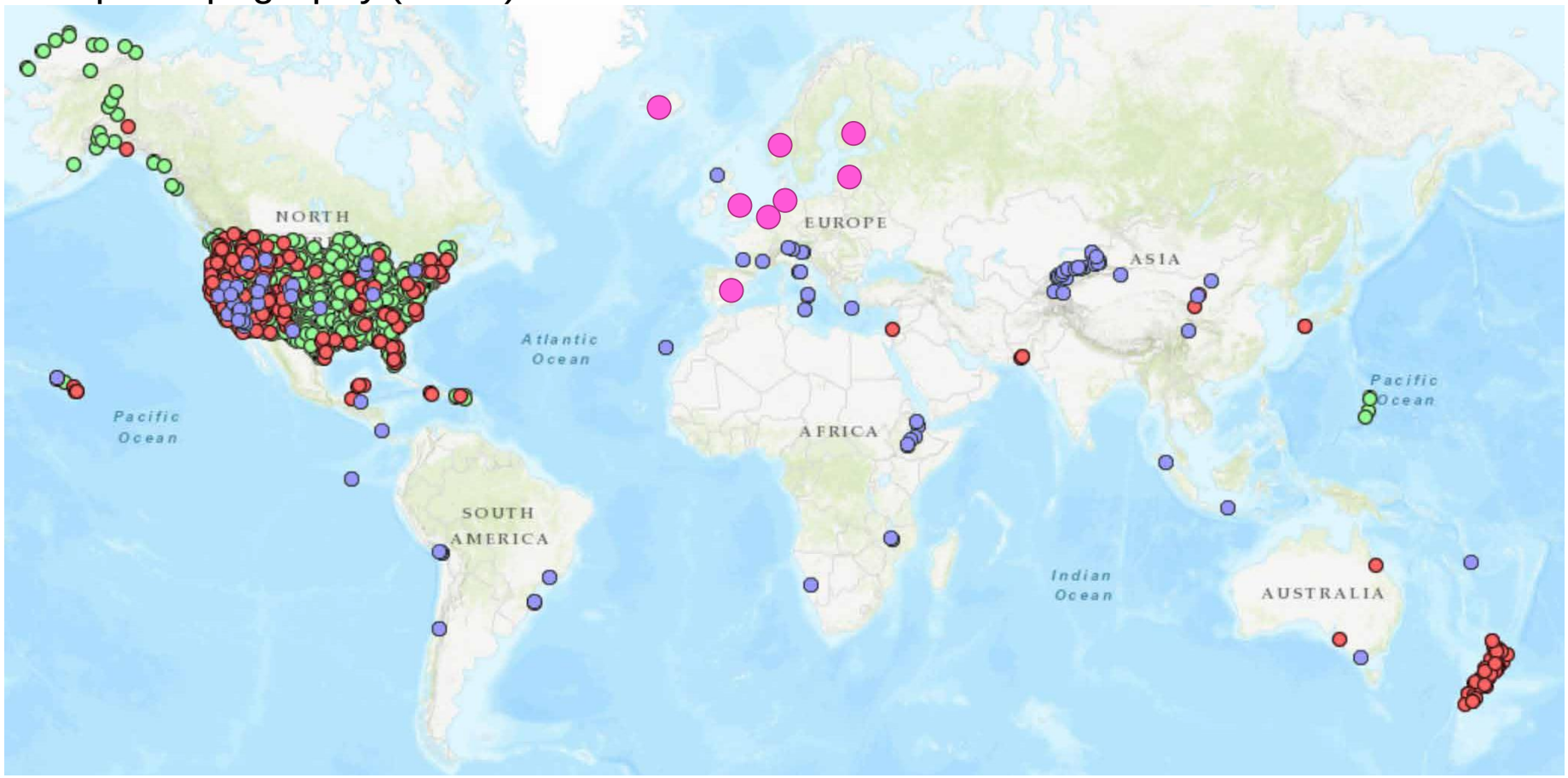
Photo by Kurt Cotoaga on Unsplash

Availability

- OpenTopography (demo)



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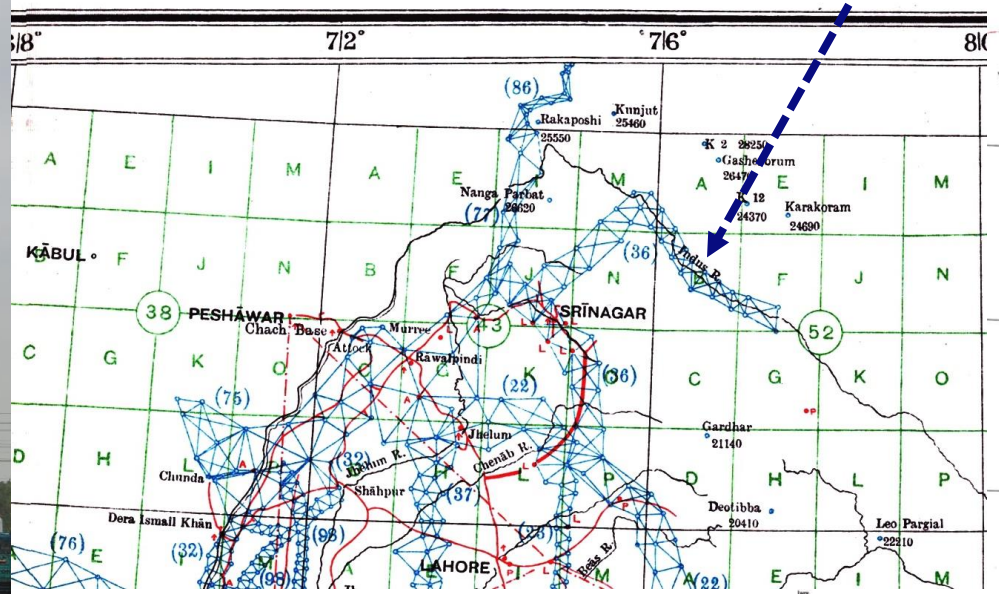
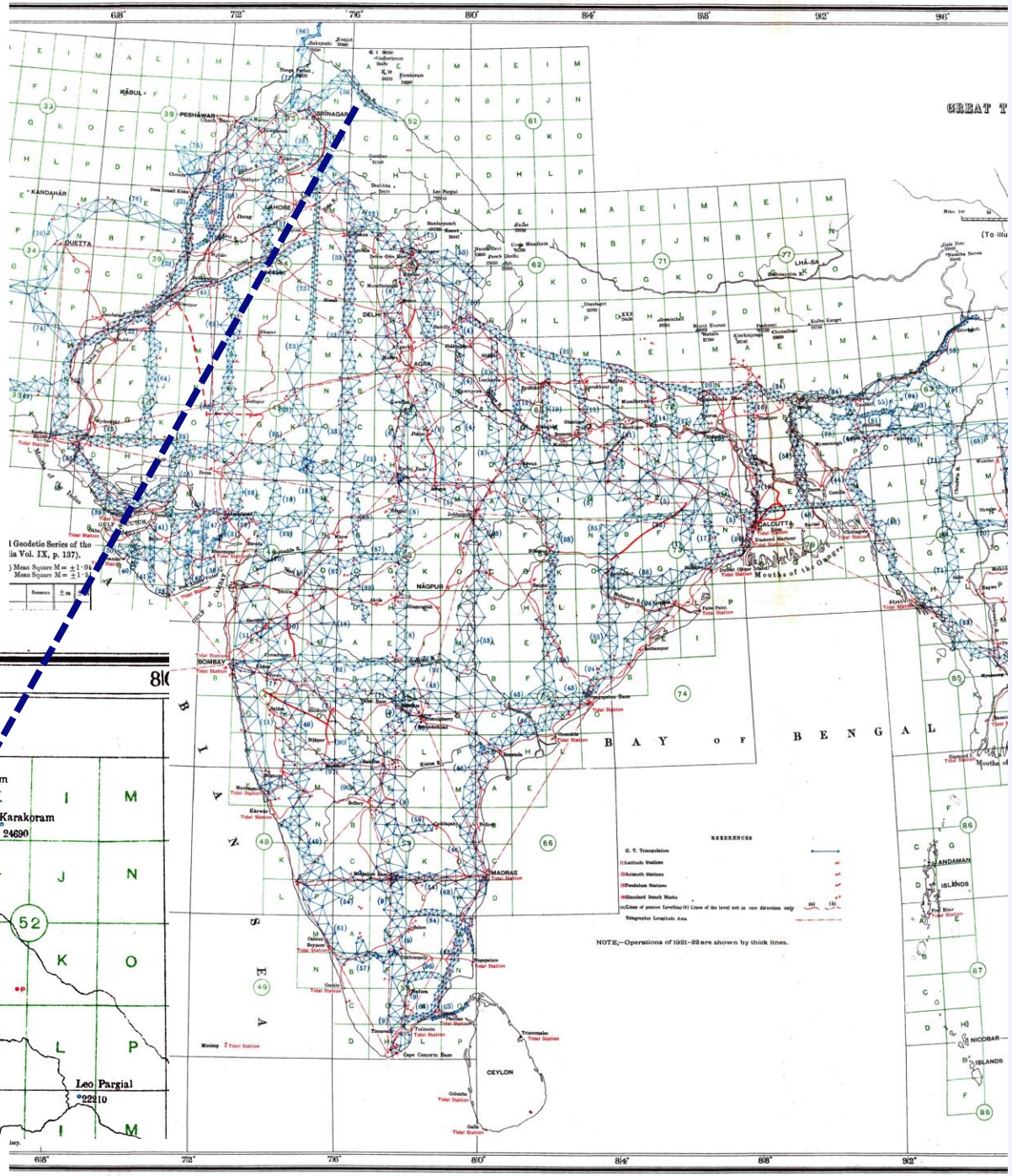
History

- Trigonometric leveling

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





History

- GPS enabled measurements
- Height of Everest in 1999 >

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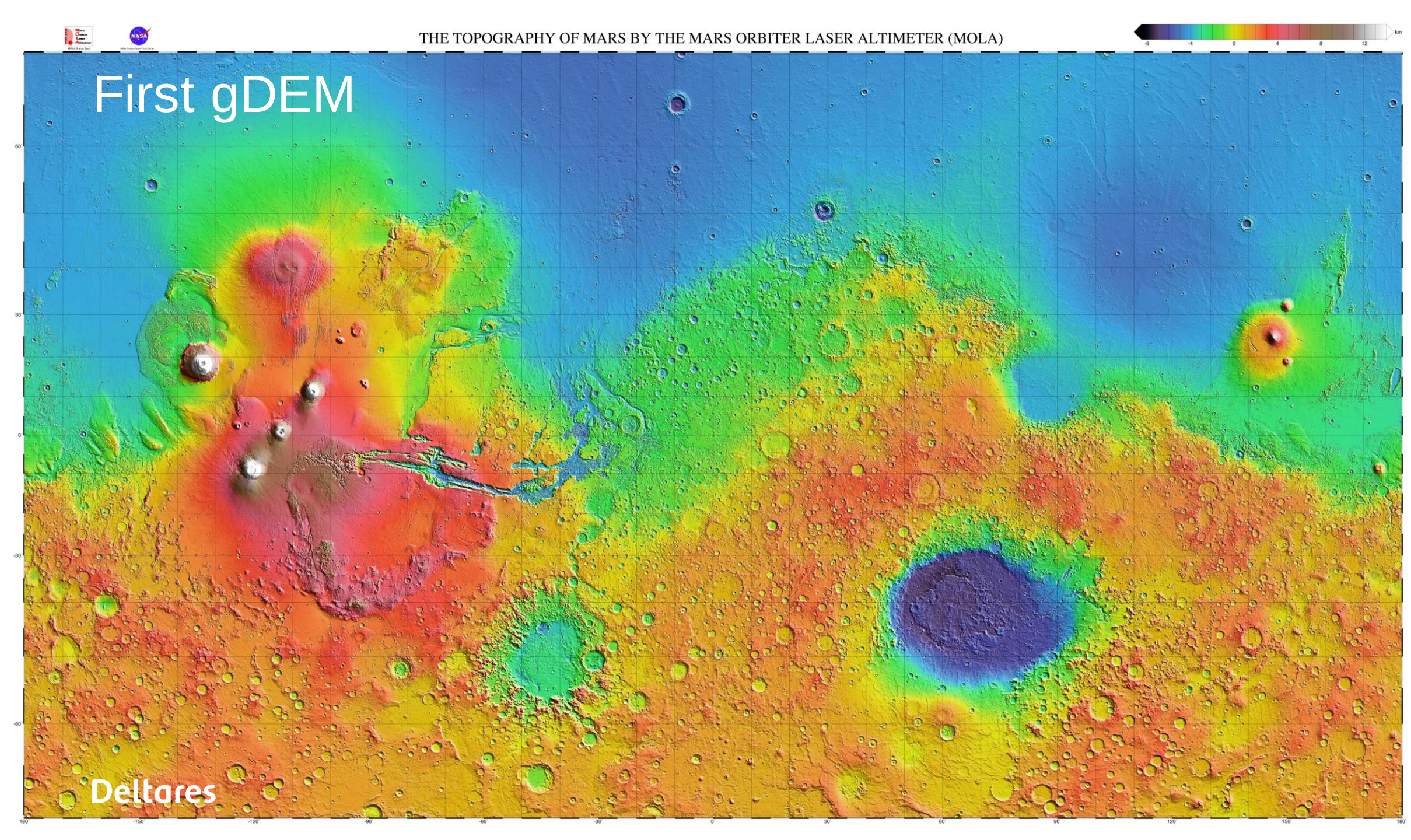
THE TOPOGRAPHY OF MARS BY THE MARS ORBITER LASER ALTIMETER (MOLA)
km
-8
-4
0
4
8
12
First gDEM
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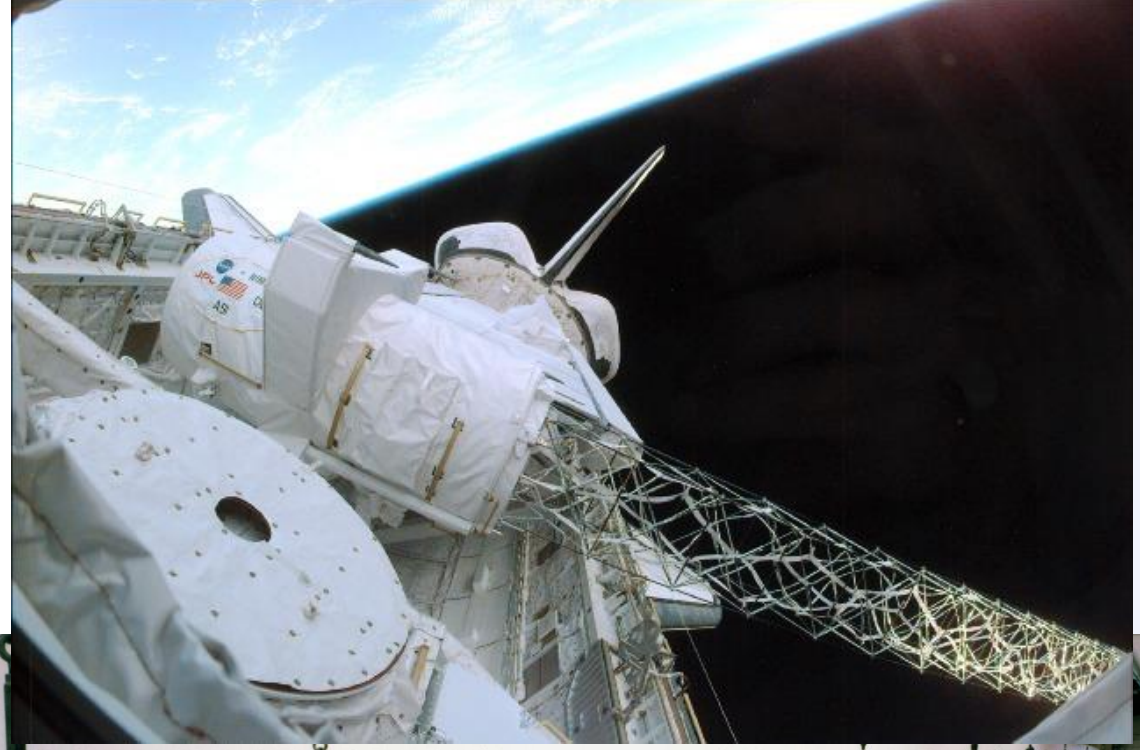
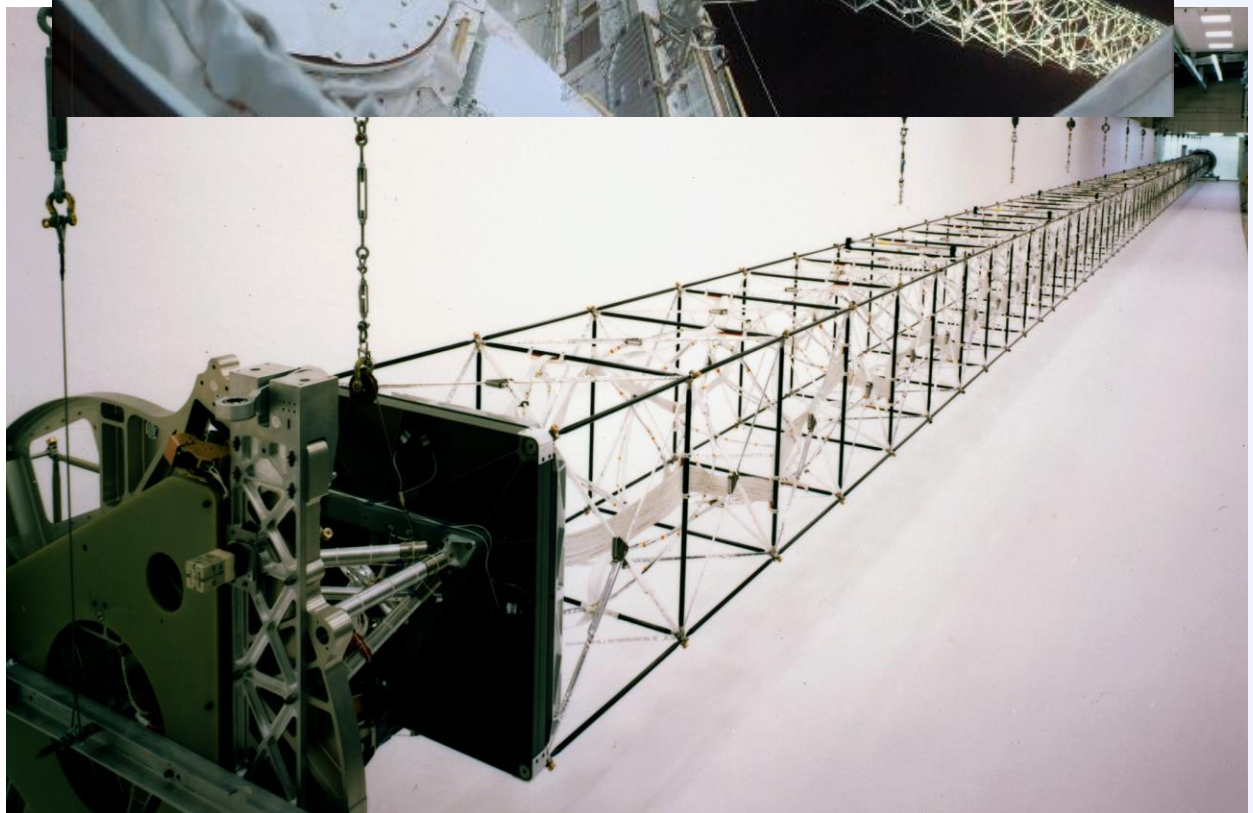
SRTM

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

- inSAR by using a second antenna on 60 m mast





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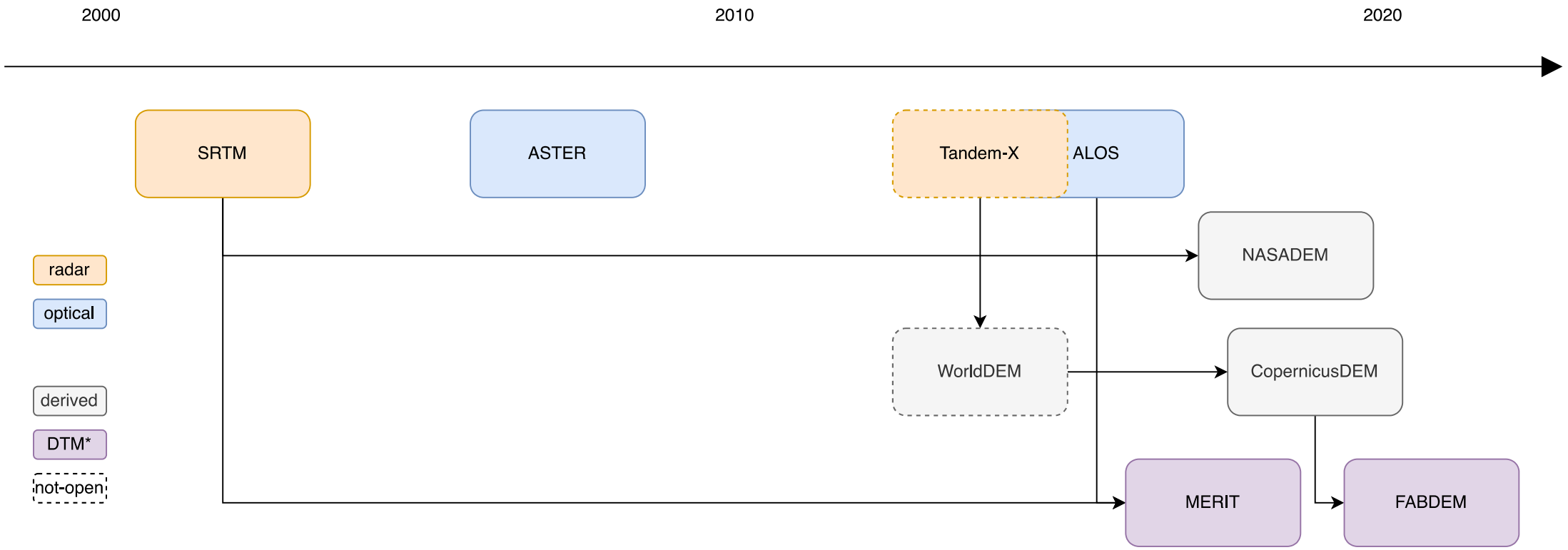
gDEMS

- Overview, timeline



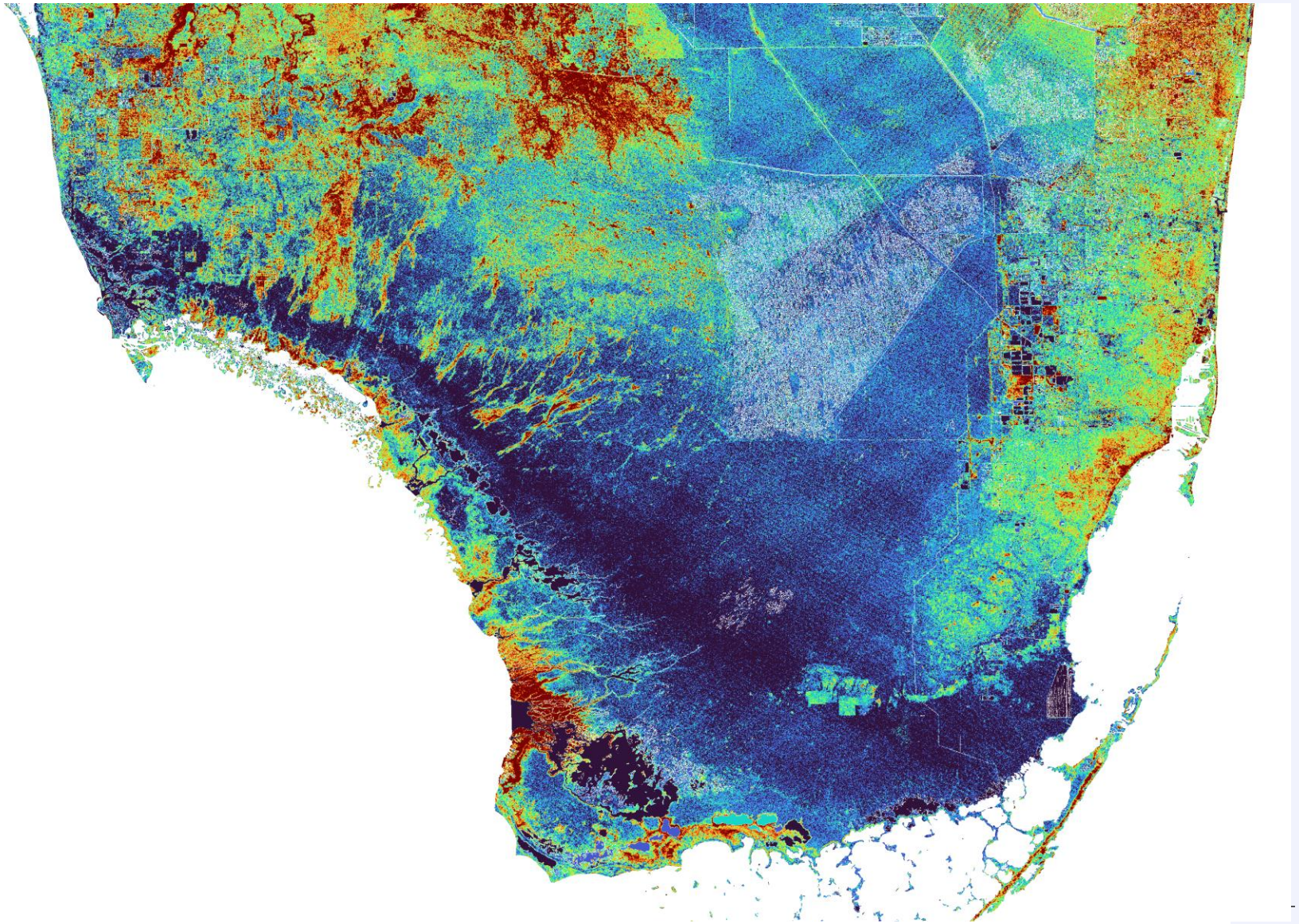
SRTM

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

- EGM96 vertical reference
- Integers (whole numbers)

- Even now, artefacts, striping.

- **DSM**



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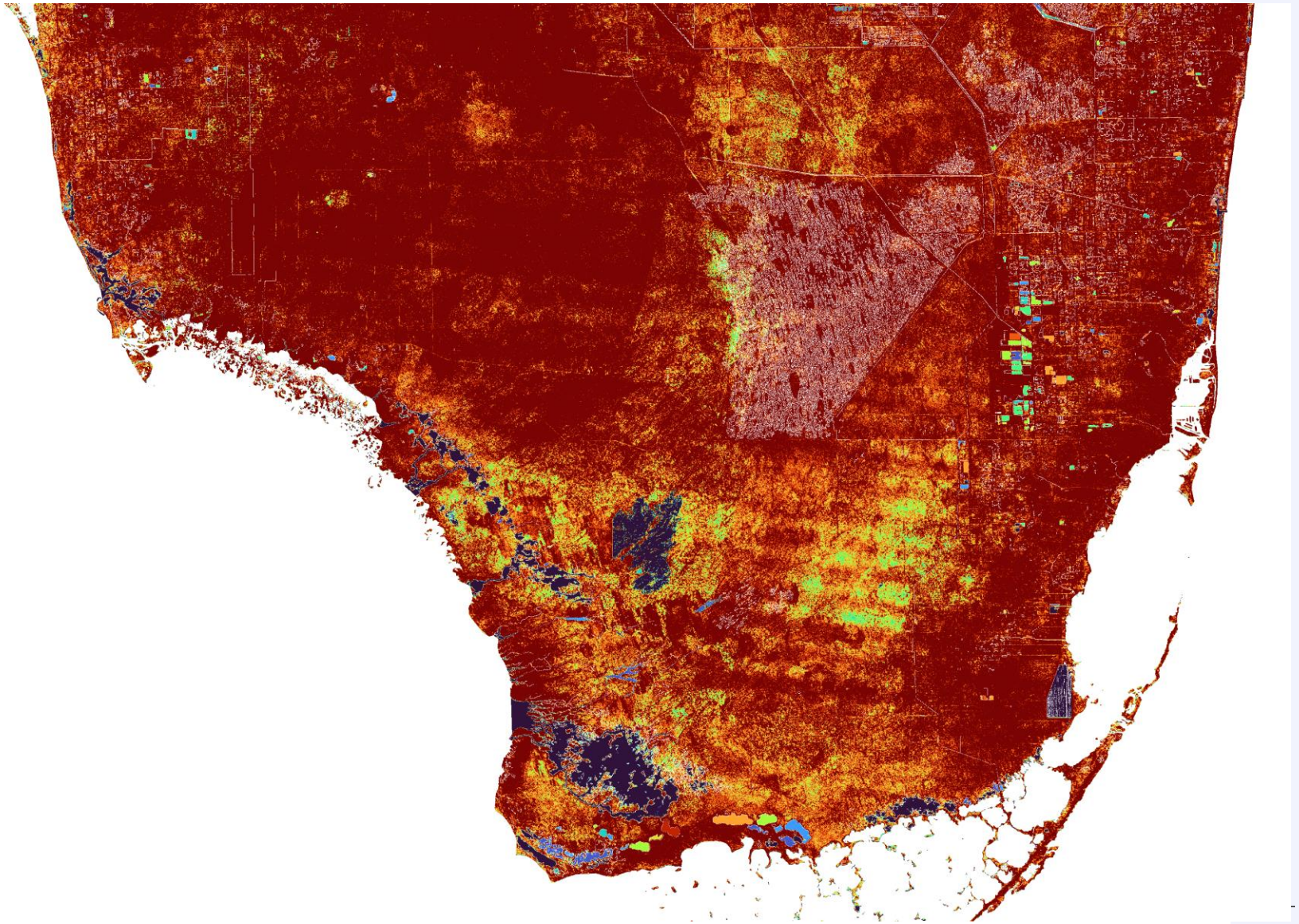
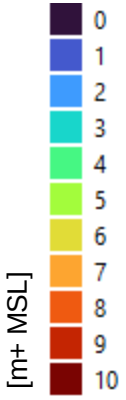
ASTER GDEM

- First optical
- Collaboration between METI & NASA
- Integers
- Striping





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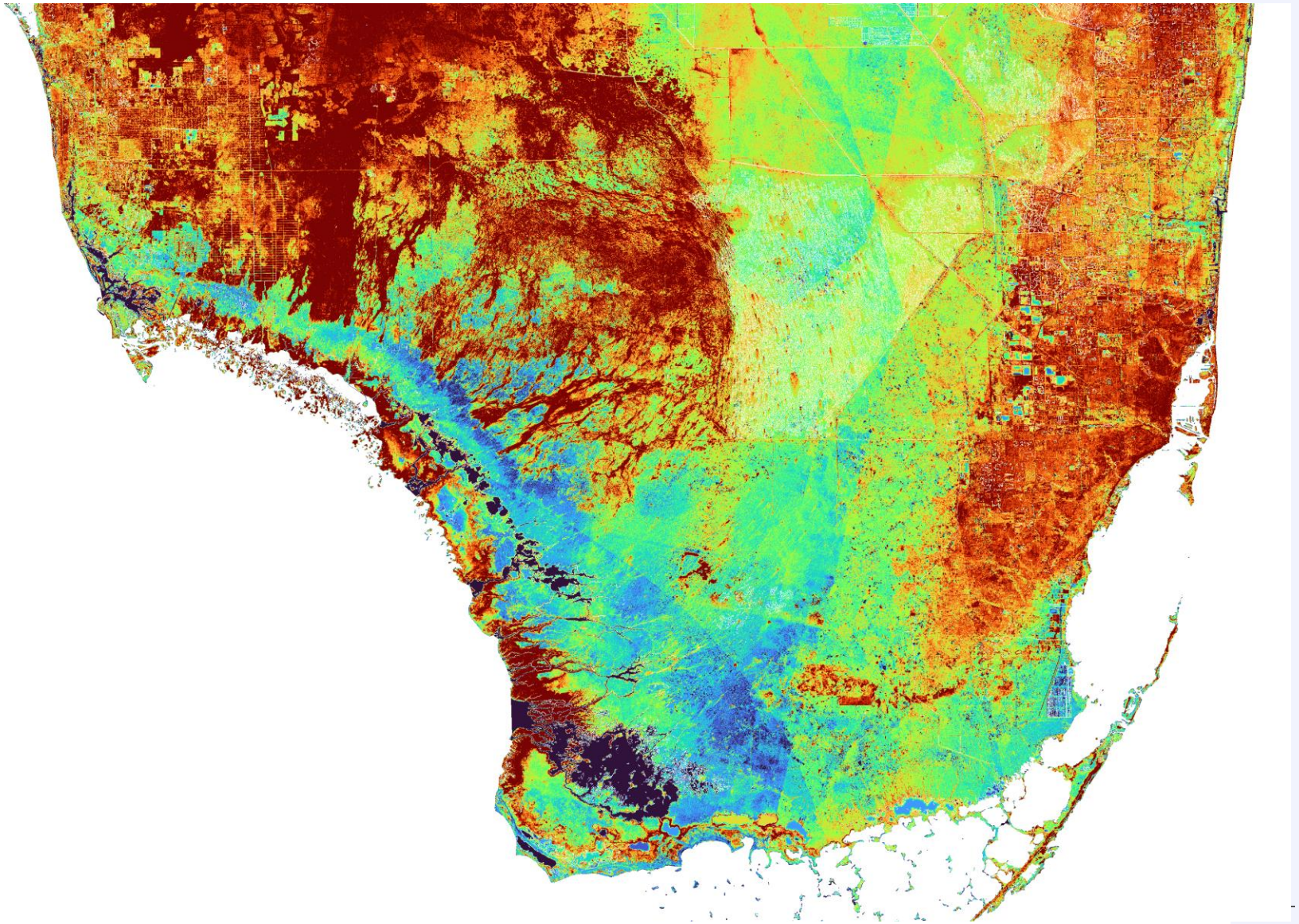
Alos

- Optical

- Integers
- Some artefacts

- Commercial 5m version (!)



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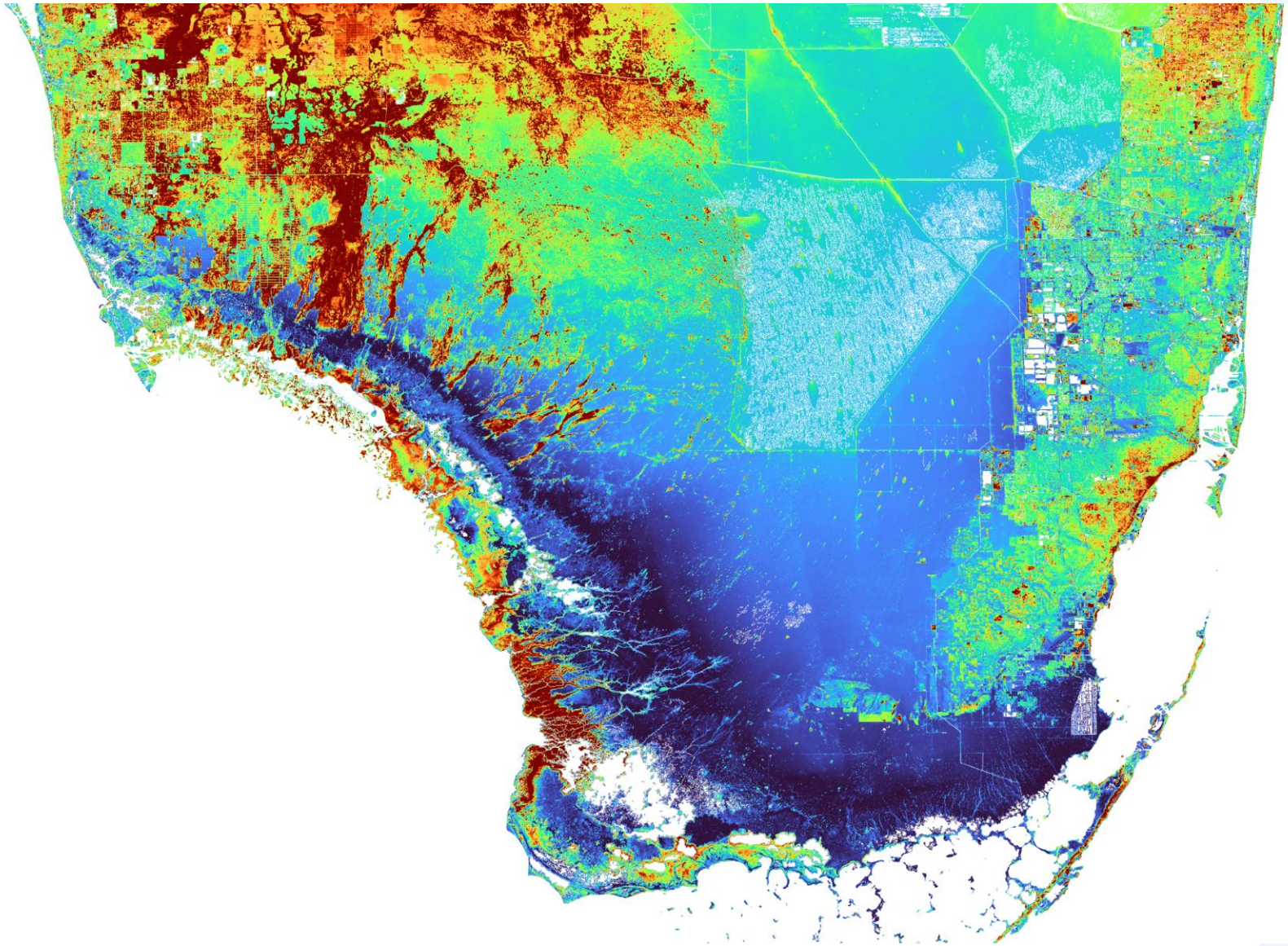
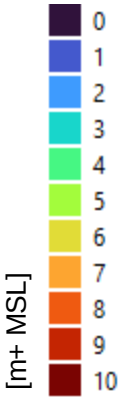
Tandem-X

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

- Floating point (!)
- EGM2008 vertical reference
- 12m available for Europe

- Commercial 5m version (!)





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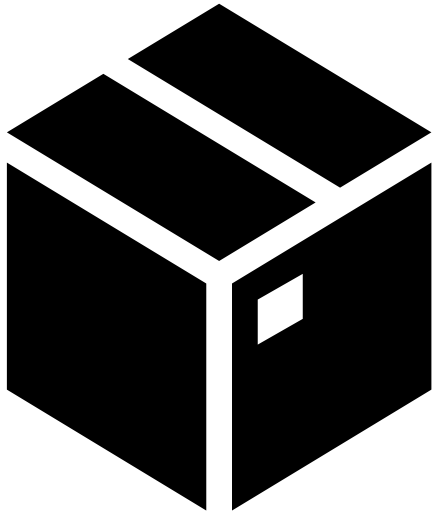
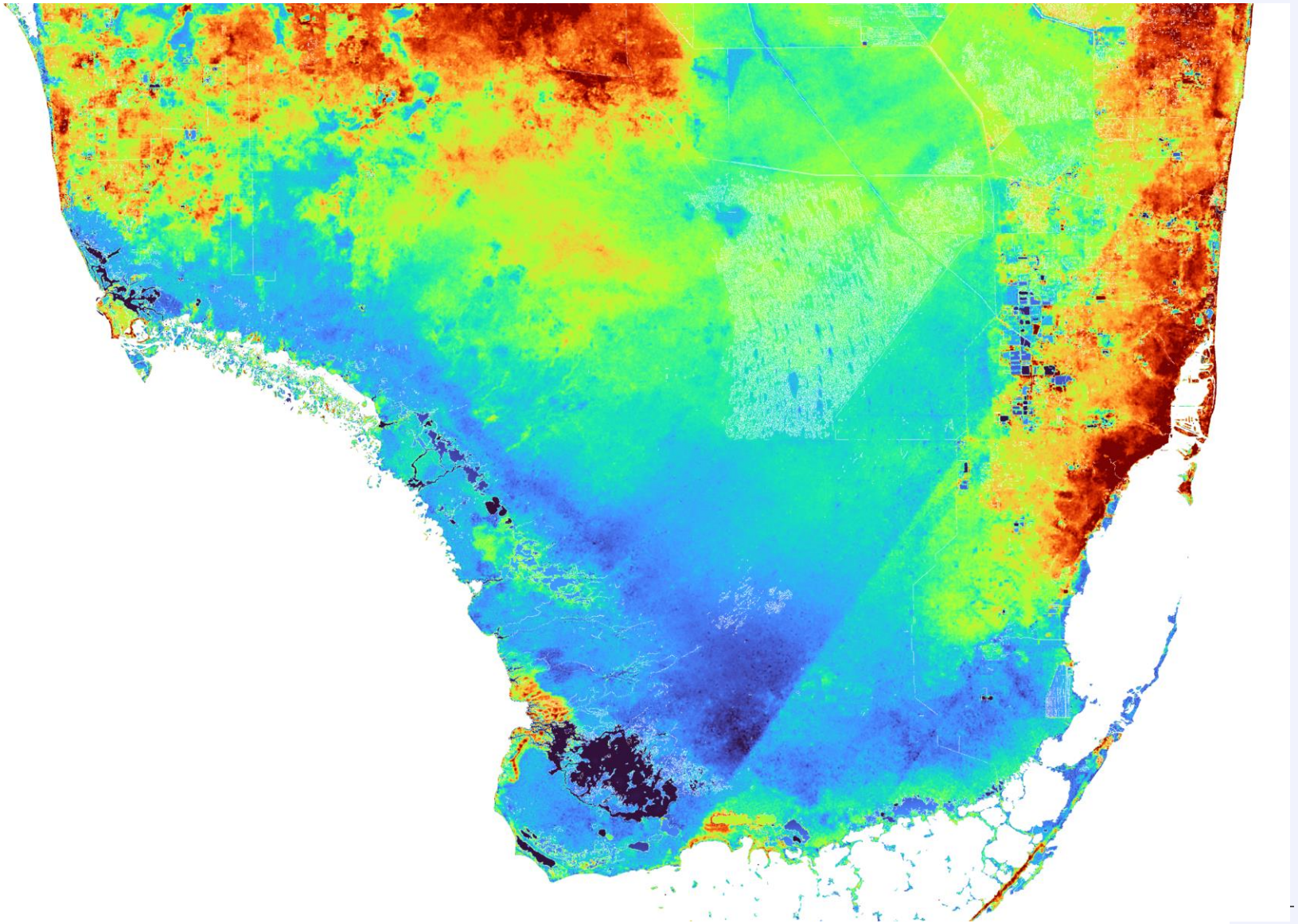
Corrected gDEMS

- Corrections for canopy, infrastructure
- Based on other data sources (optical, canopy height estimates, trained on local lidar DTM)
- Regression methods to predict surface height
- “Smudge effect”



MERIT

- Multi-error improved terrain
- Improvements
- Used in Deltares (hydro version)



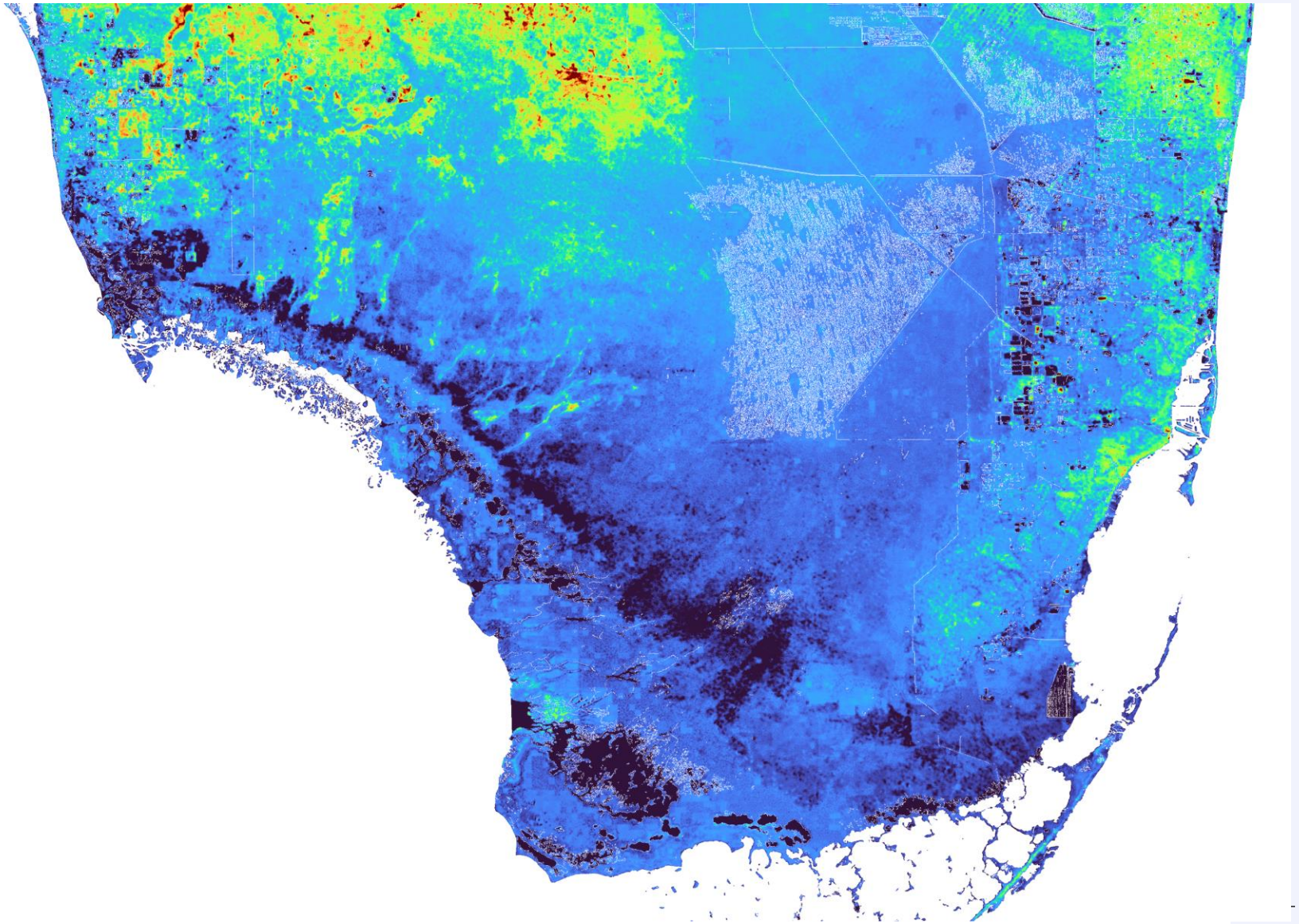
Deltares

CoastalDEM

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

- Only coasts <120m +MSL

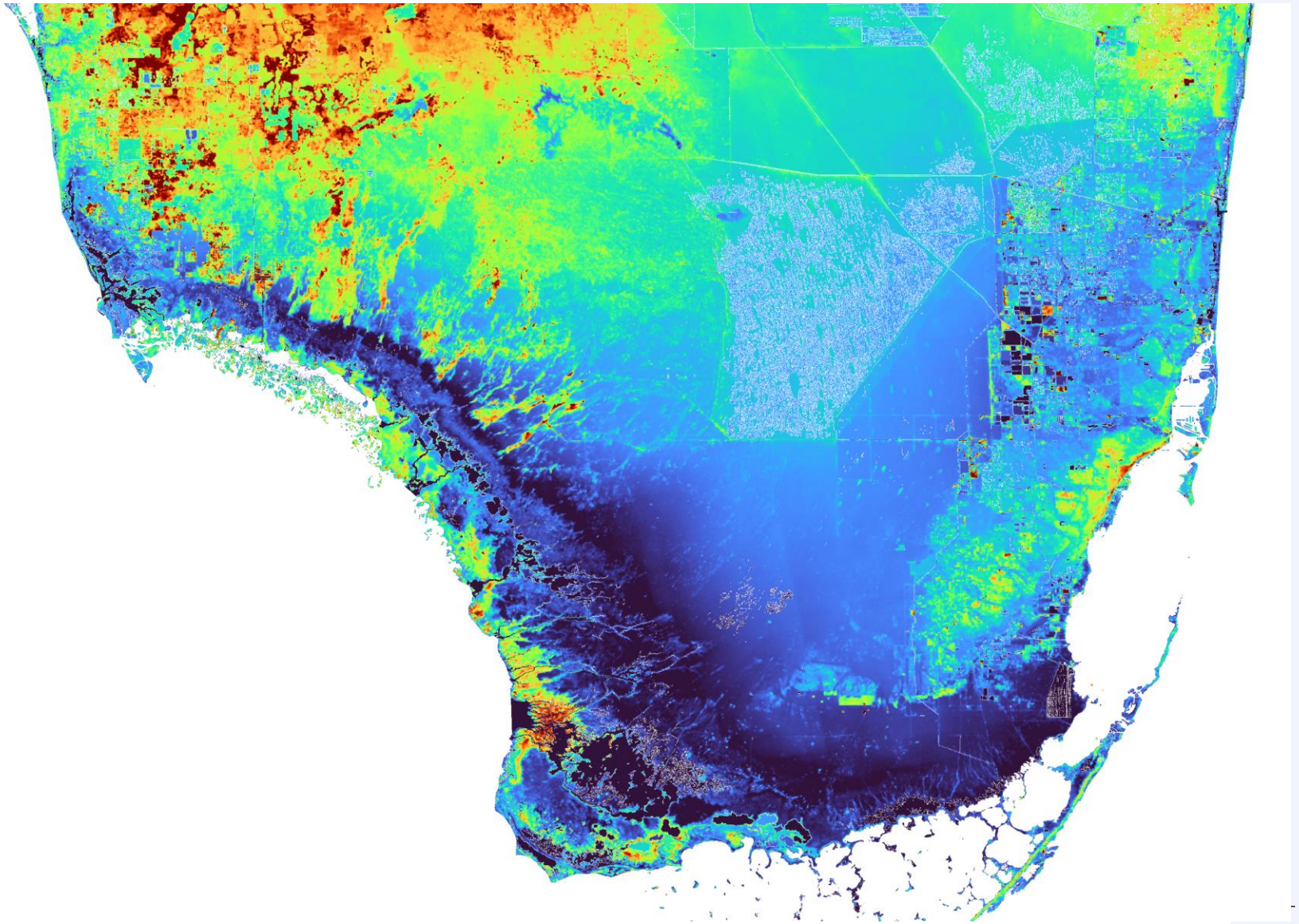
- Commercial



Deltares

FABDEM

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



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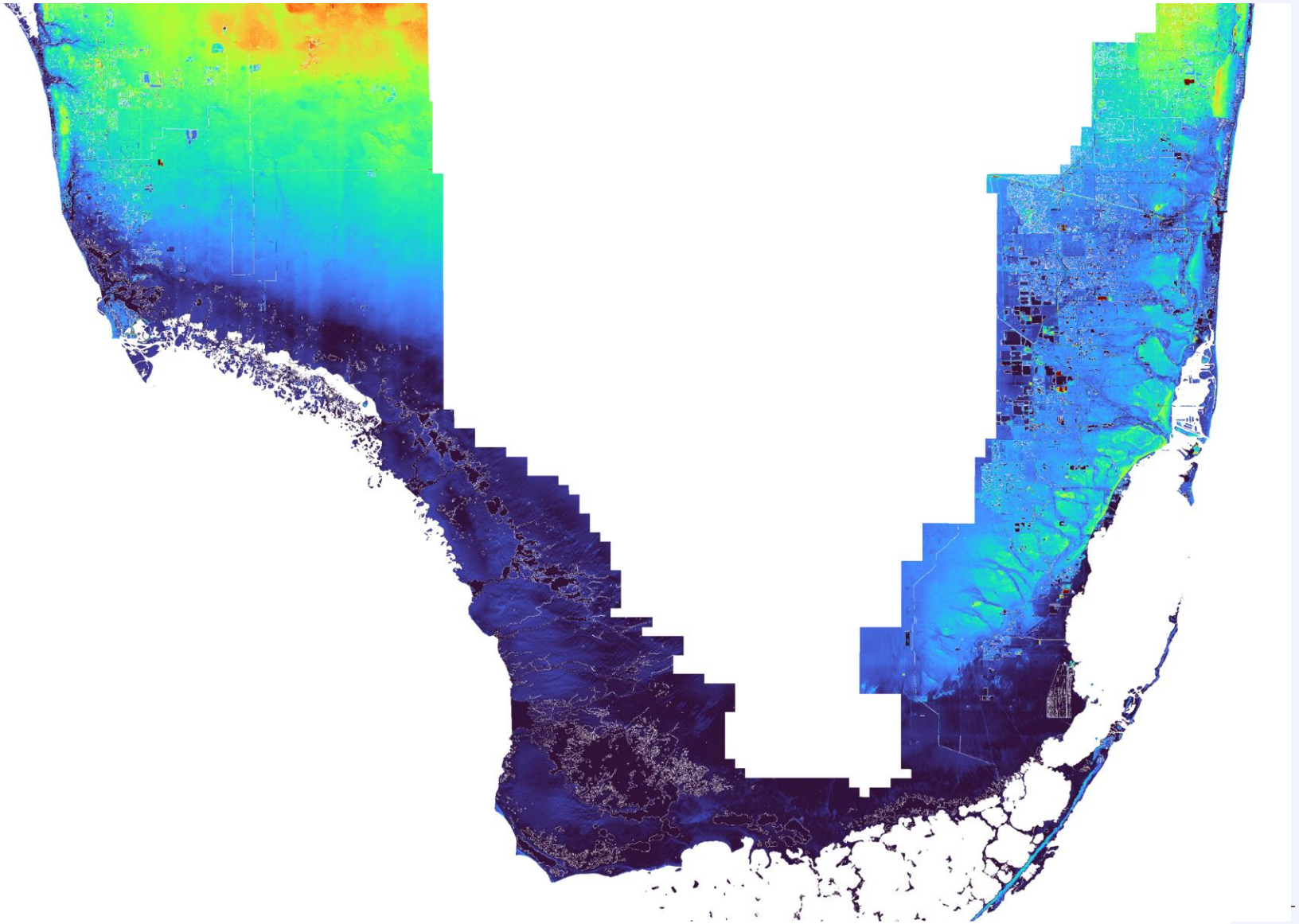
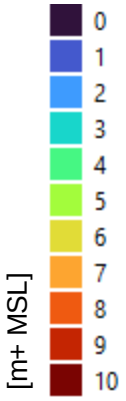
Actual DTM

- NOAA SeaLevelRise DTM
- LiDAR based





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LiDAR

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

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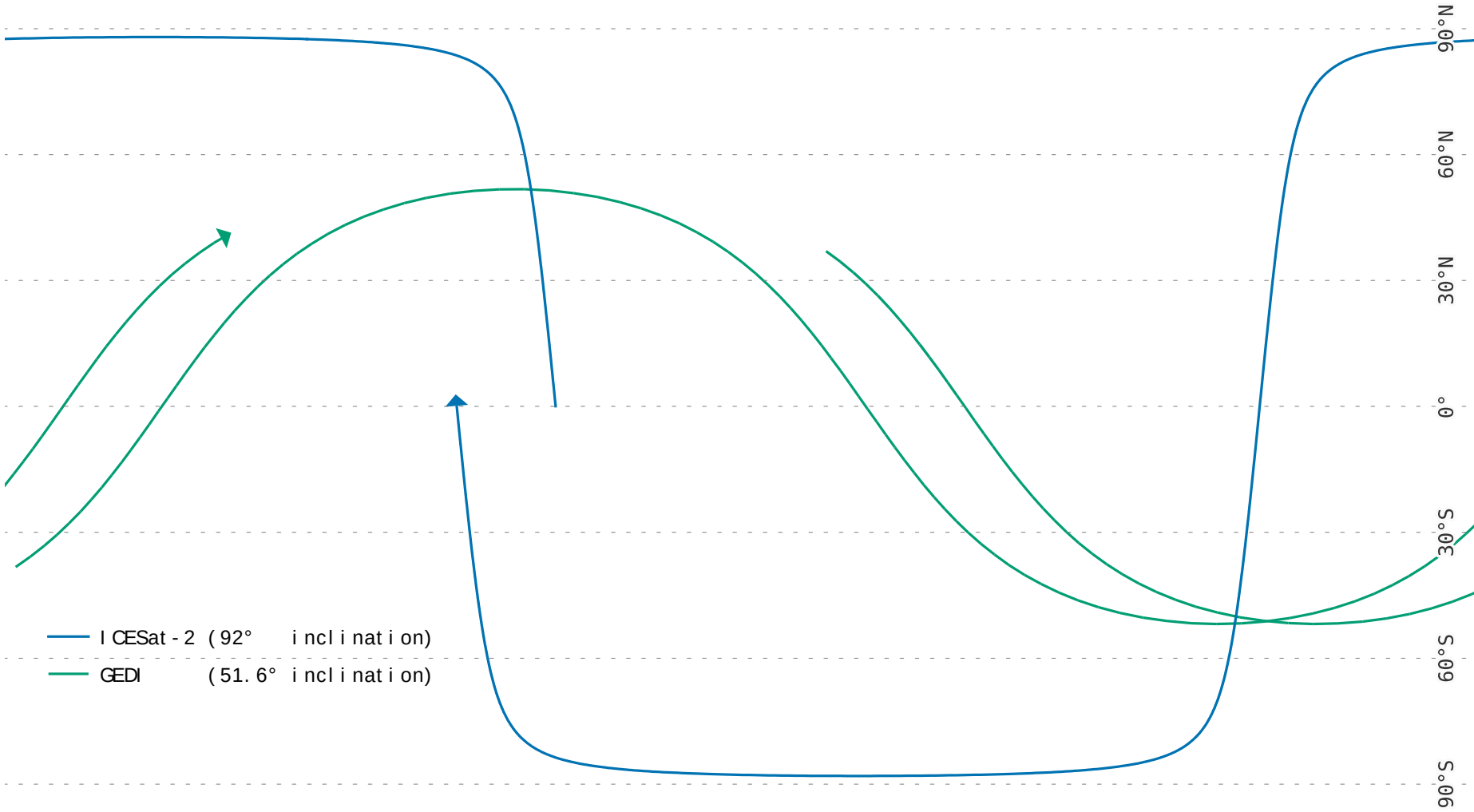
LiDAR platform considerations



	Terrestial	Airborne	Spaceborne
Pointing angle	360 degrees	90 degrees	0 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	Nope
Footprint	mm	cm	m

SpaceLiDAR

- ICESat-2
  - Single Photon LiDAR
  - Icesheet monitoring
- GEDI
  - Full waveform LiDAR
  - Ecosystem monitoring



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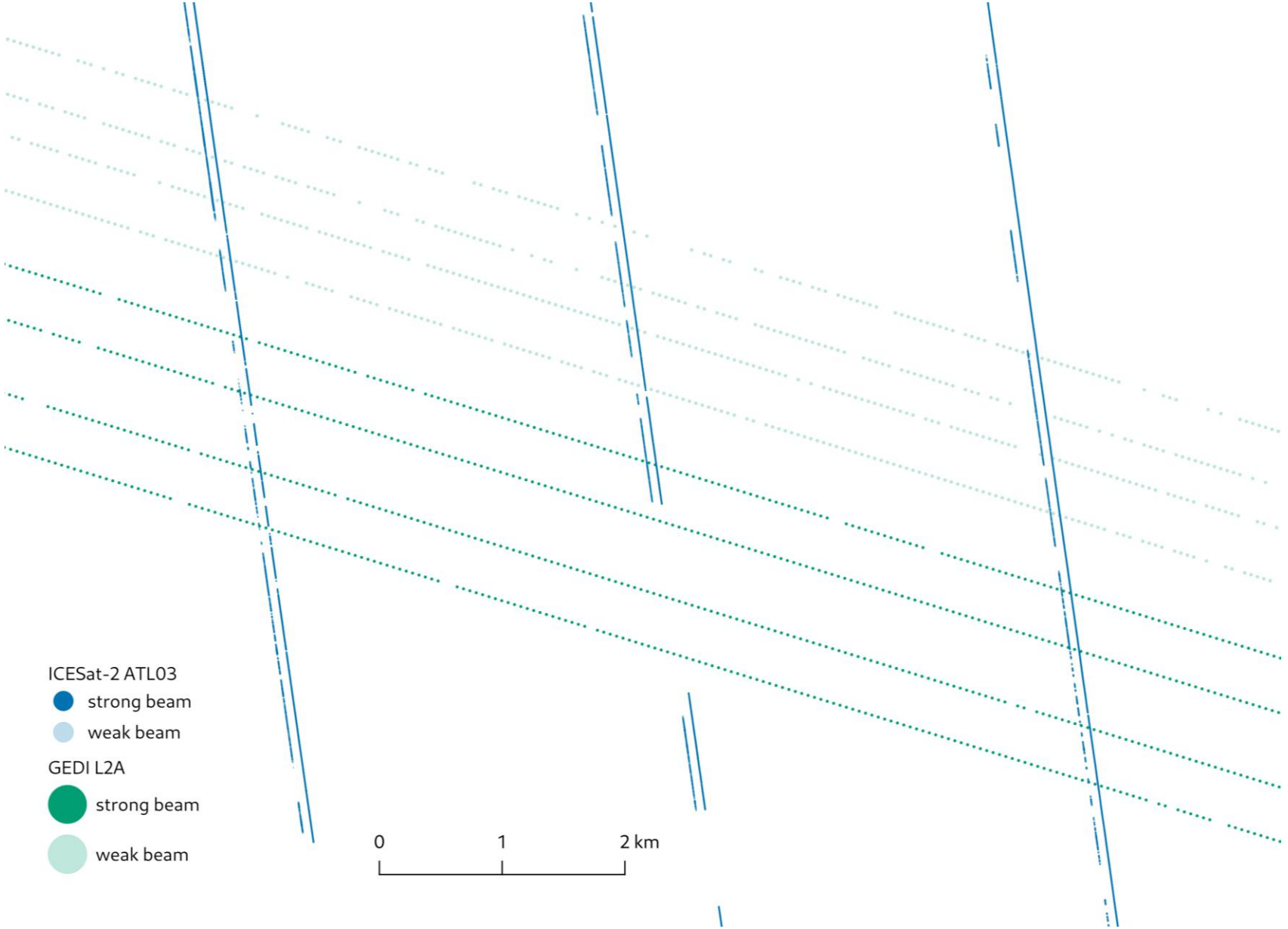
SpaceLiDAR

- 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



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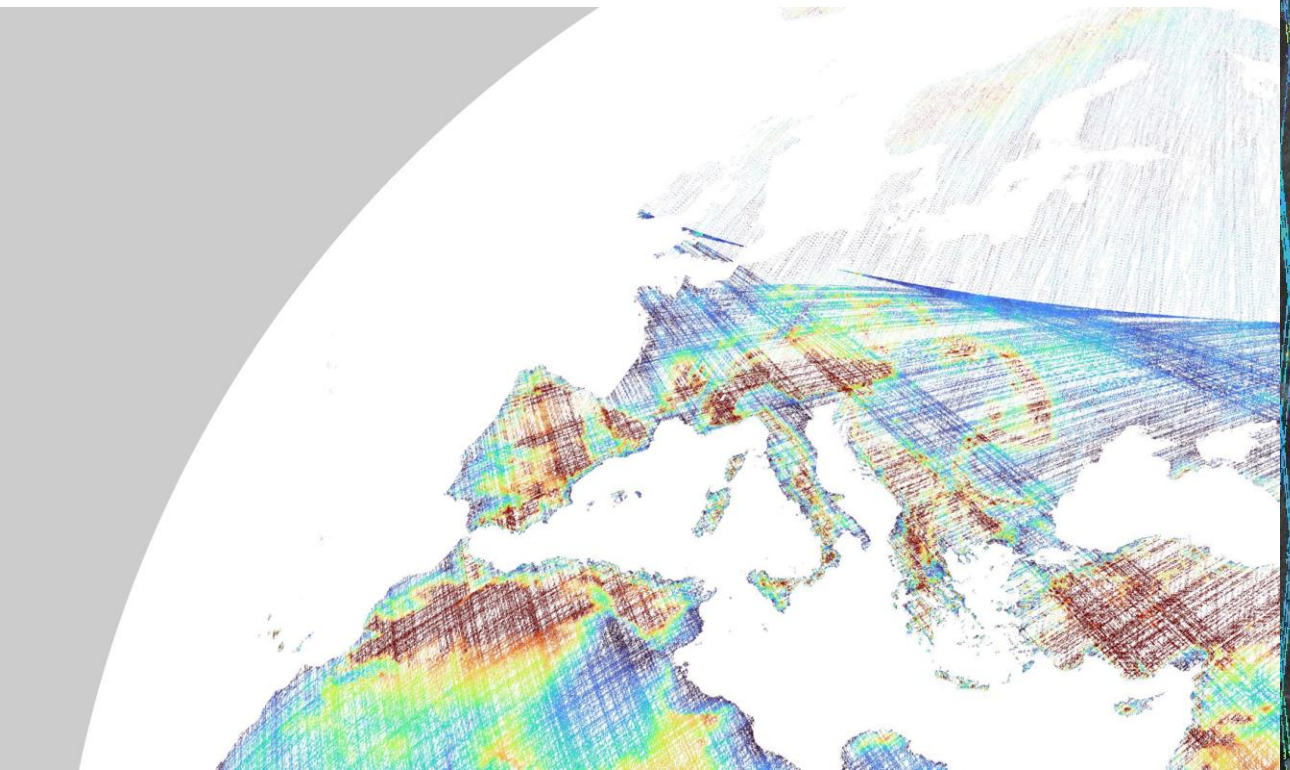
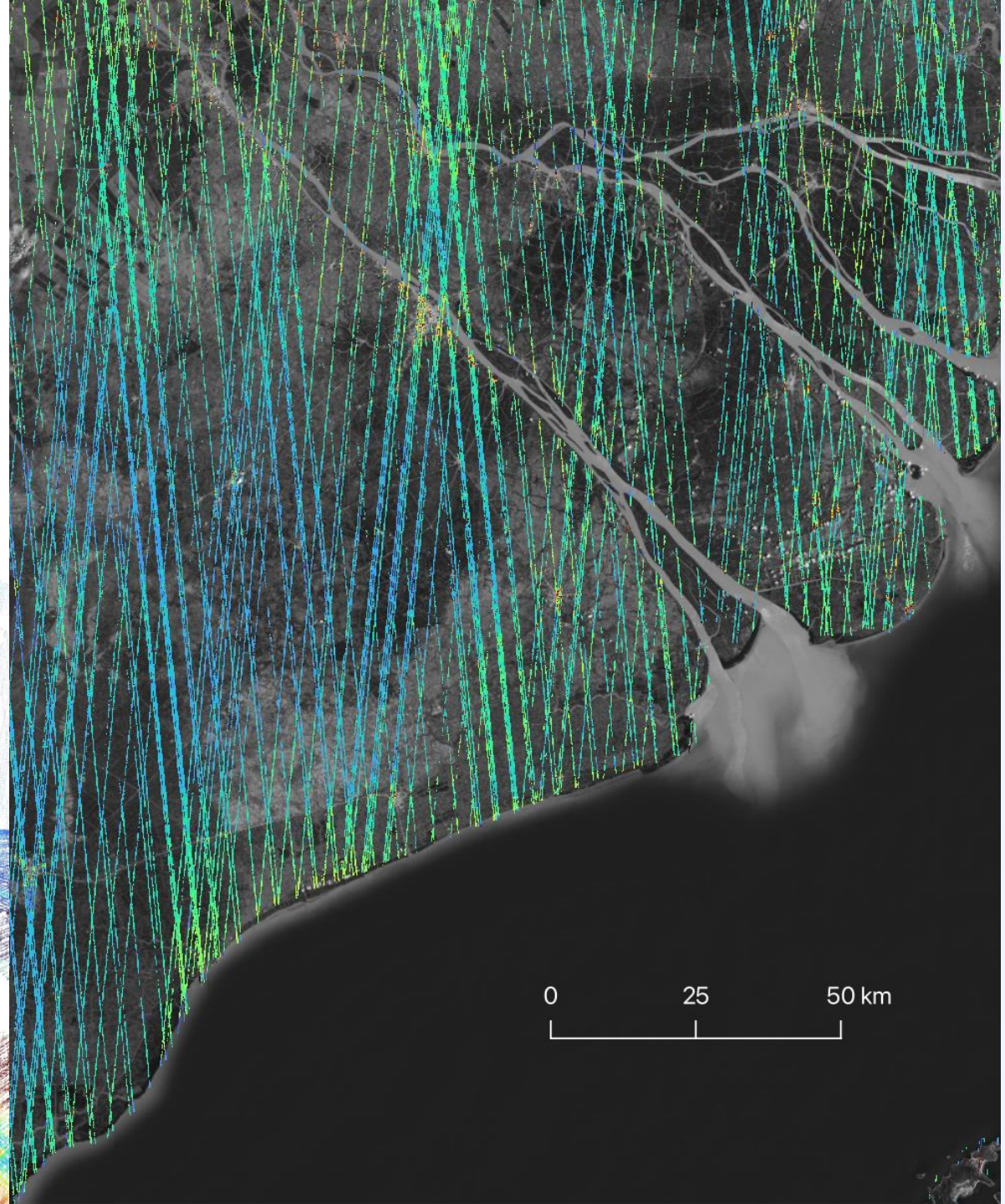
Sparsity

- High resolution along-track
- Low resolution across-track
- Factor 10-100 difference
- Coverage can be lacking





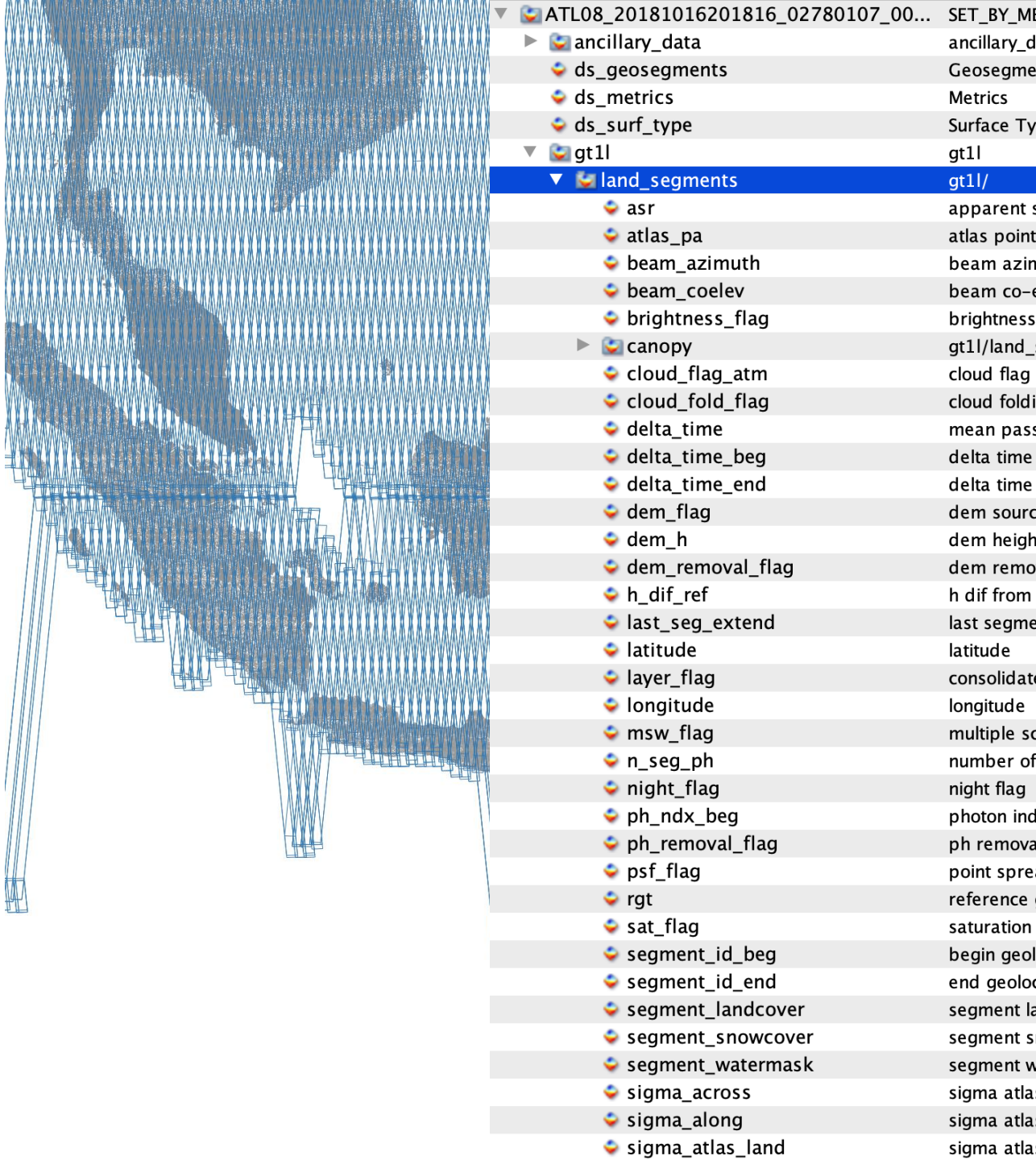
Data handling

- 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



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SpaceLiDAR.jl

- **Julia** toolbox for ICESat-2 and GEDI data
- Builts upon existing open source geospatial packages
  - GeoArrays
  - GeoDataFrames
  - LazIO
- Pluto Notebook [demo >]

```
using SpaceLiDAR ✓
```

Search

Let's find some data in Vietnam. We can define a (very rough) bounding box and search for data. This makes use of **NASA EarthData Search**.

```
vietnam = (min_x = 102.0, min_y = 8.0, max_x = 107.0, max_y = 12.0)
```

```
vietnam = (min_x = 102., min_y = 8.0, max_x = 107.0, max_y = 12.0)
```

```
granules =
[ICESat2_Granule("ATL08_20181016201816_02780107_004_01.h5", "https://n5eil01u.ecs.nsidc.c
```

```
granules = find(:ICESat2, "ATL08", vietnam, "004")
```

These datasets (granules) come in the form of HDF5 (.h5) files, with *a lot* of attributes. Downloading them requires a working NASA EarthData account configured in an `~/.netrc` file.

```
"/Users/evetion/code/SpaceLiDAR/notebooks/ATL08_20181016201816_02780107_004_01.h5"
```

```
begin
    granule = copy(granules[1])
    SpaceLiDAR.download!(granule)
end
```

Extract

Now that we have one granule locally, let's extract some data. This package is opiniated and does already apply some filters for you. It also converts dates and unnests where required.

```
using DataFrames ✓
```

```
t =
```

	x	y	z	u	t	q	phr	se
1	107.33	17.4242	NaN	3.40282f38	2018-10-16T20:21:02.123	0	0	41
2	107.33	17.4233	NaN	3.40282f38	2018-10-16T20:21:02.137	0	0	41
3	107.33	17.4224	NaN	3.40282f38	2018-10-16T20:21:02.151	0	0	41
4	107.33	17.4215	NaN	3.40282f38	2018-10-16T20:21:02.165	0	0	41

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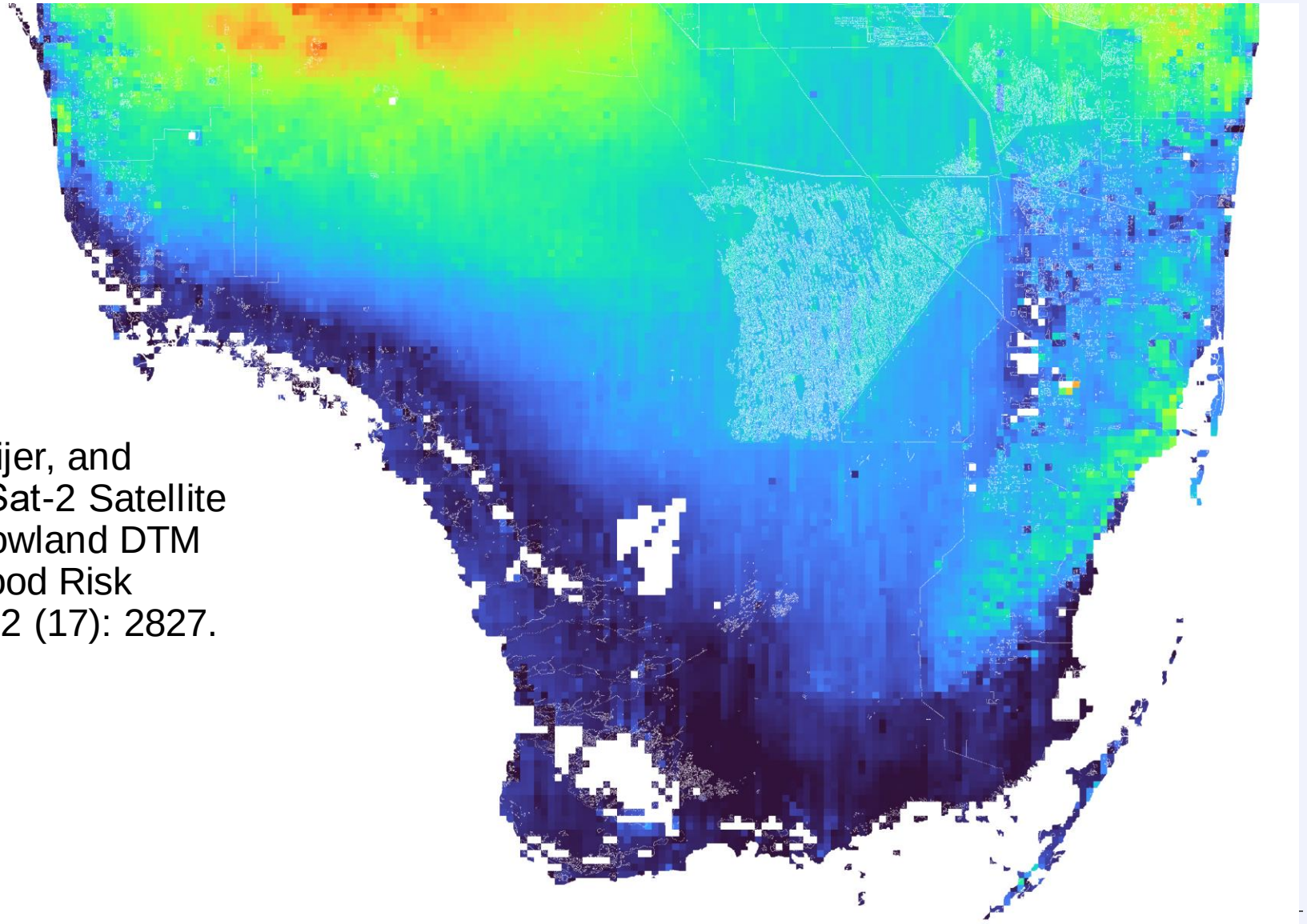
GLL_DTM

- 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.



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Questions?

https://deltares.nl/en/

3vetion

maarten.pronk@deltares.nl
m.j.pronk@tudelft.nl

@evetion