The TanDEM-X DEM Change Maps Product And Their Application

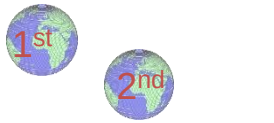
Marie Lachaise, Barbara Schweisshelm, Carolina Gonzalez, Paola Rizzoli, Manfred Zink (DLR)

Fringe 2023

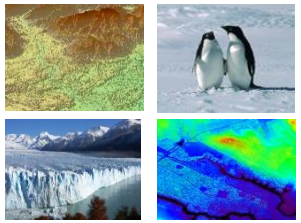
DLR

TanDEM-X Acquisitions and Products

2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024

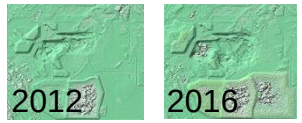


(first global) TanDEM-X DEM

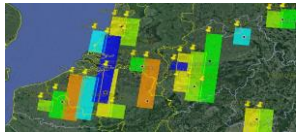


Science Phase

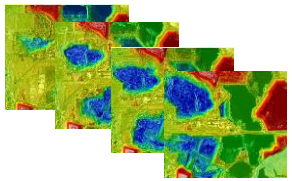
High-Resolution DEMs



TanDEM-X DEM 2020 (second global TanDEM-X DEM)



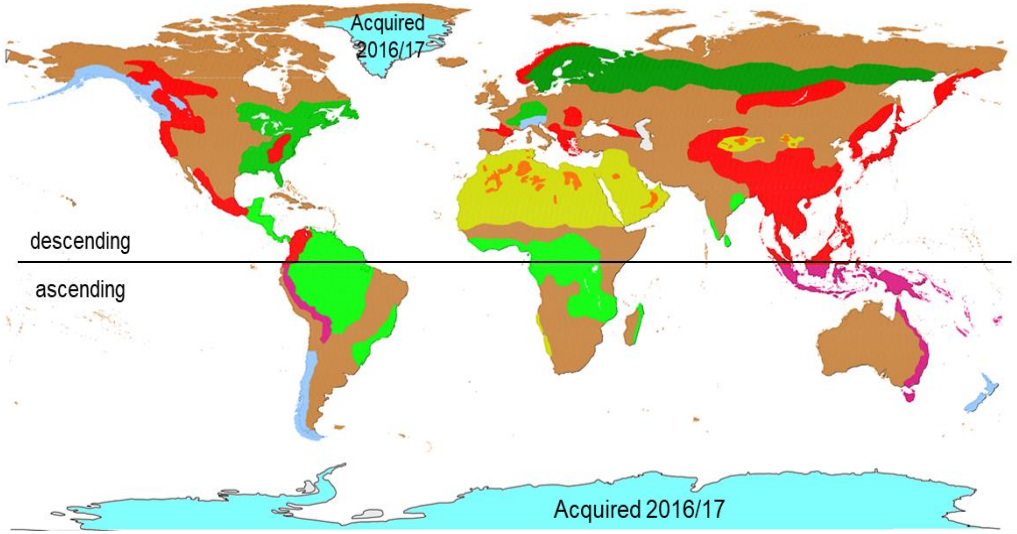
Scientific Phase 20-22



TanDEM-X 4D Phase (Temporal DEM Updates)

Third global TanDEM-X DEM acquisition phase

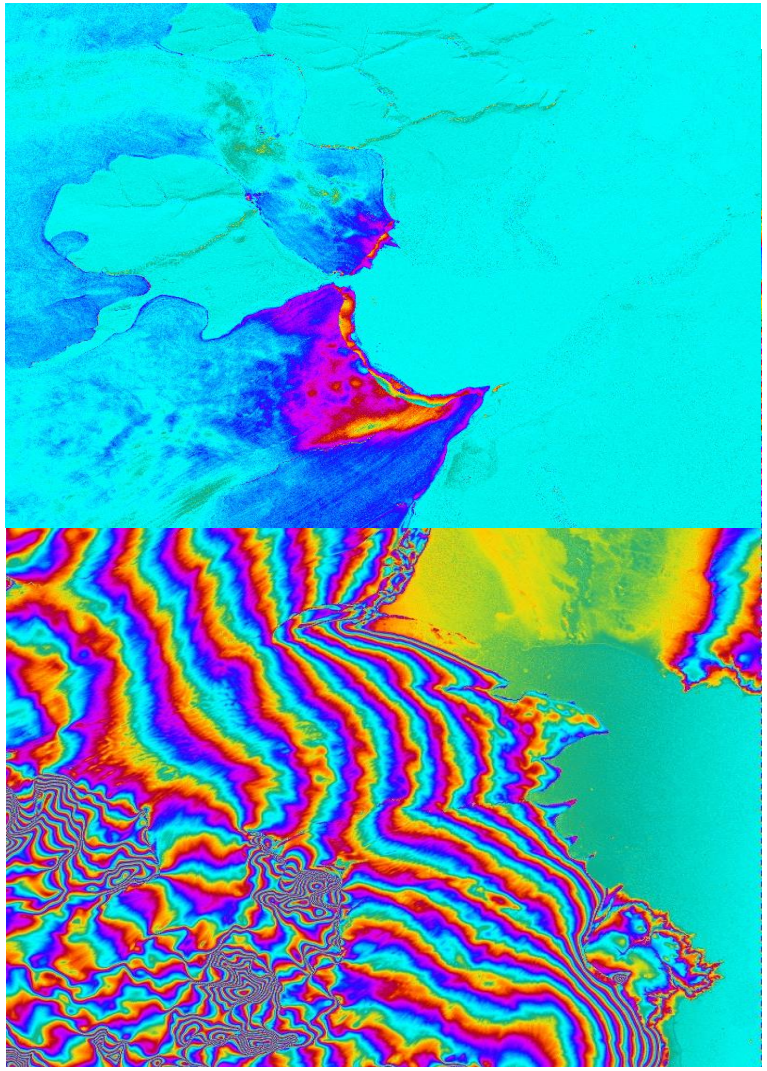
- **only one global coverage for most of the landmass**
  - From late 2016 until mid 2020 (+gaps filling till 2022)
  - Acquisition parameters depend on dominant land classes / types
- **Goal**: new independent global DEM TanDEM-X DEM 2020 with similar absolute and relative accuracies to first TanDEM-X DEM.

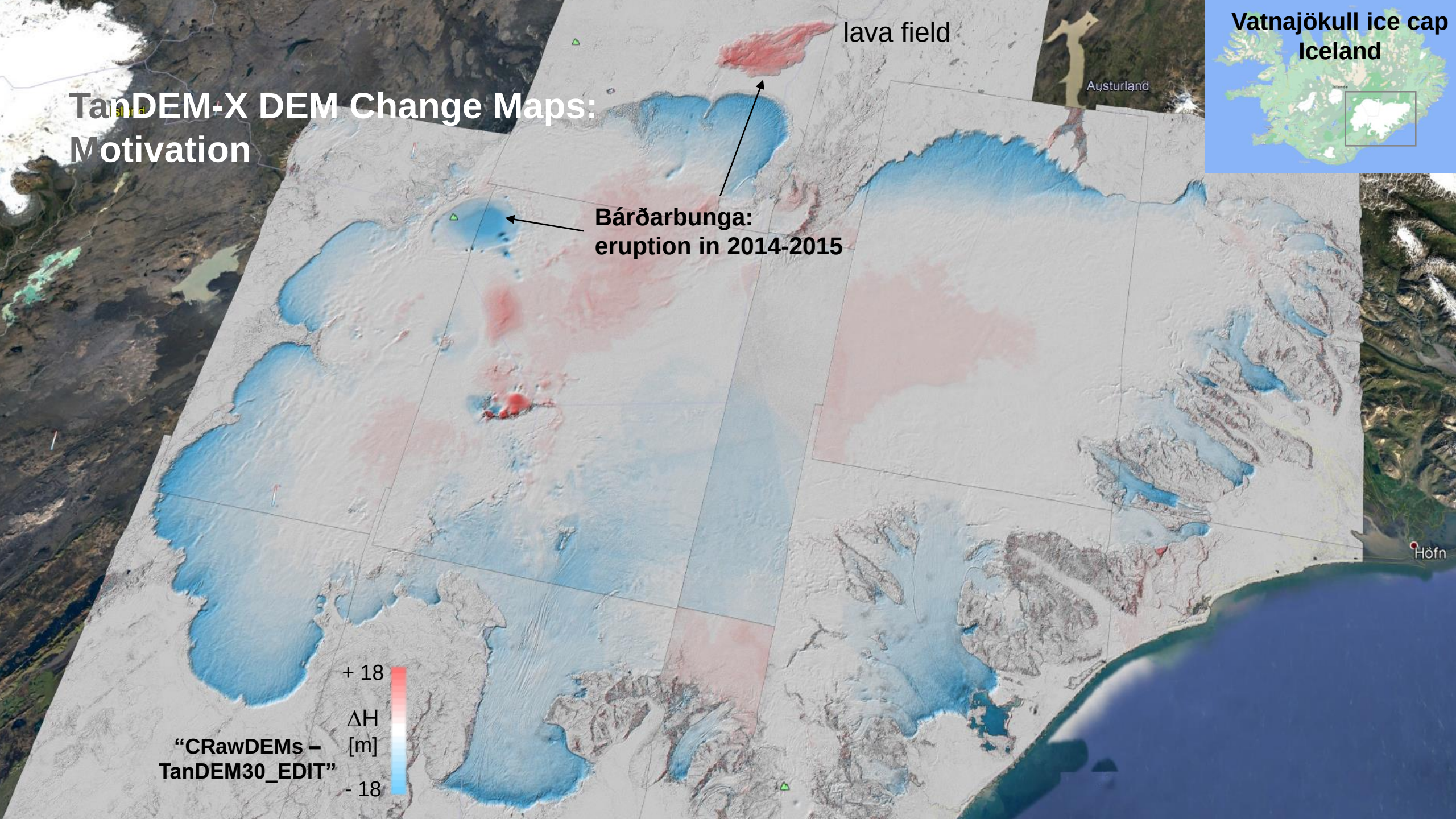


Region	Coverages	Season	Height of Ambiguity	Incidence Angle Range	Expected Relative Height Error
Mountains with forest	2	Local summer	55 m – 75 m (1st) 45 m – 53 m (2nd)	27 – 49 deg	2 m – 4 m
Glaciers	2	Local winter	55 m – 75 m (1st) 45 m – 53 m (2nd)	29 – 47 deg	2 m – 3 m
Tropical forest	1	Year round	50 m – 60 m	27 – 49 deg	2.5 m – 4.5 m
Temperate and boreal forest	1	Local summer	50 m – 55 m	27 – 49 deg	2.5 m – 4 m
Deserts with mountains	2	Year round	55 m – 75 m (1st) 45 m – 55 m (2nd)	27 – 49 deg	3 m – 7 m
Deserts	1	Year round	23 m – 45 m	14 – 38 deg	2.5 m – 5 m
Rest of the world	1	Year round	35 m – 45 m	27 – 49 deg	1 m – 2. 5 m

InSAR processing strategy: Change Raw DEMs generation

- Usage of **reference DEM** to ease phase unwrapping:
  - TanDEM30_EDIT
  - TanDEMPolar12 (ATA, GRL)
- Delta-phase (also called differential phase e.g. in PSI)
- Better filtering (depending on the scene content)
- Pre-calibratrion




TanDEM-X DEM Change Maps:
Motivation
lava field
Austurland
Vatnajökull ice cap
Iceland
Bárðarbunga:
eruption in 2014-2015
Höfn
+ 18
ΔH
[m]
- 18
"CRawDEMs –
TanDEM30_EDIT"

TanDEM-X DEM Change Maps: Product Characteristics

- DEM changes between the Change Raw DEMs and TanDEM30_EDIT (edited first global TanDEM-X DEM)

- Available layers:
  - 2 DEM Change Maps with date layers:
    - first and last DEM changes
  - 2 Change Indication Masks
  - 2 Height Accuracy Indicators
- Also available:
  - Edited TanDEM-X DEM: edited version of the first global DEM
  - DEM Editing Mask
  - HEM (Height Error Map)
  - Land Cover Map

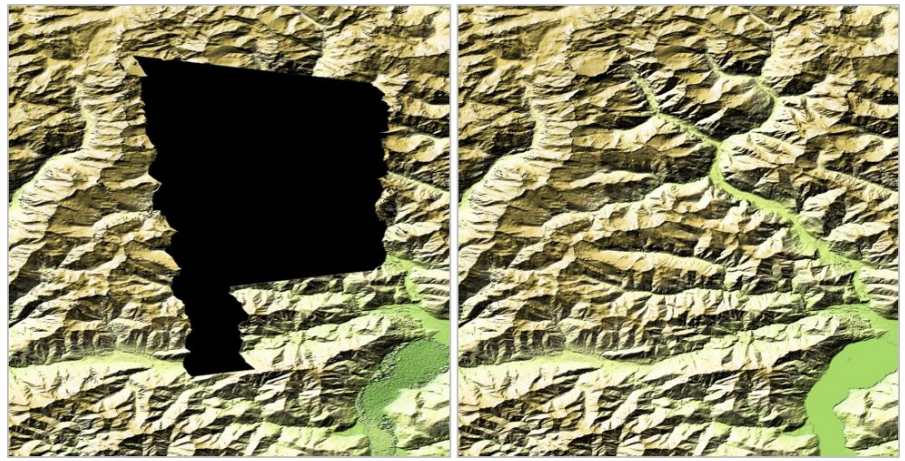
- **Freely available from mid October on in 30m posting** on geoservice.dlr.de

Edited TanDEM-X DEM 30m

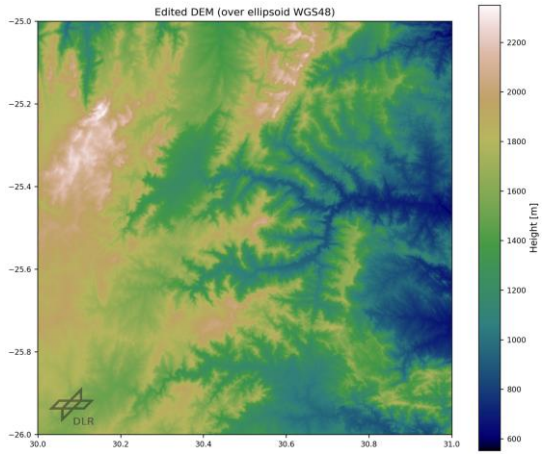
- Holes are filled by means of external reference and water is flattened by a fully automatic process
- Available layers:
  - Edited DEMs (EDEM) in WGS84 (TanDEM-X DEM like) & EGM (Copernicus
  - Height Error Map
  - Editing Mask
  - Land Cover Map indicating water and forest

original TanDEM-X DEM

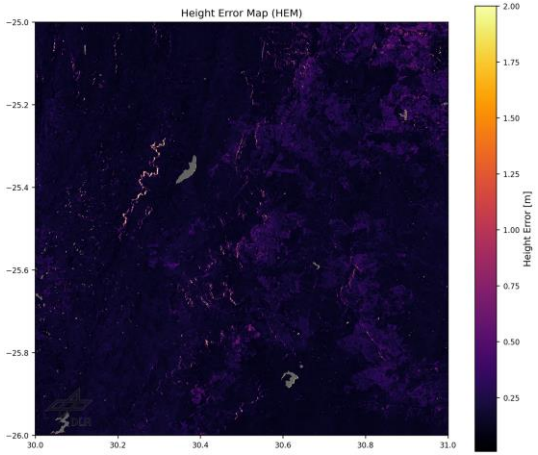
edited TanDEM-X DEM



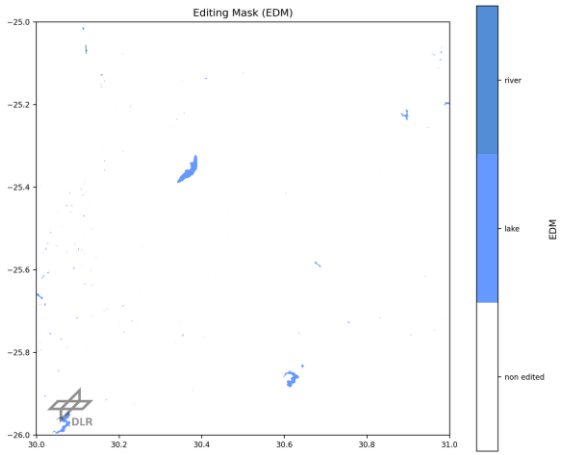
EDEM (WGS84 &EGM)



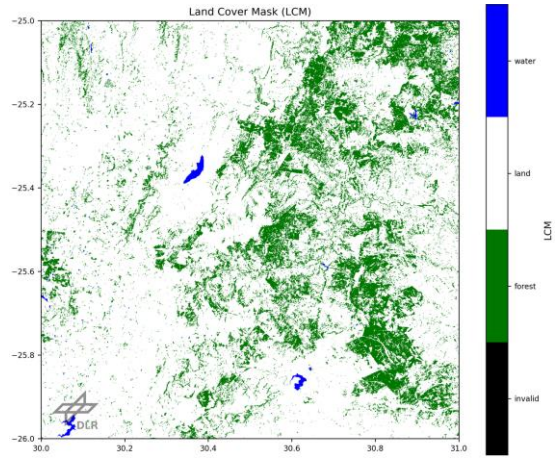
Height Error Map



Editing Mask



Land Cover Map



TanDEM-X DEM Change Maps: Available Layers

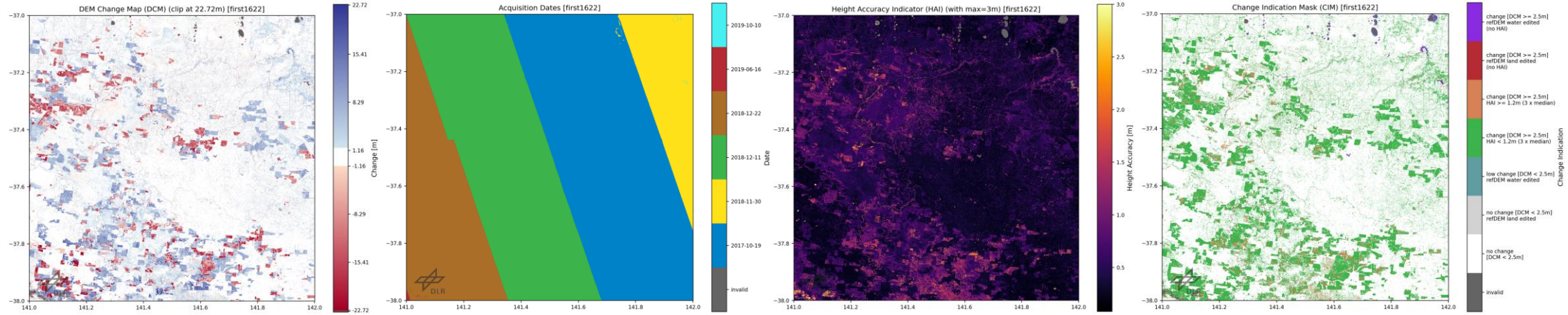
DEM Change Maps

DATEs

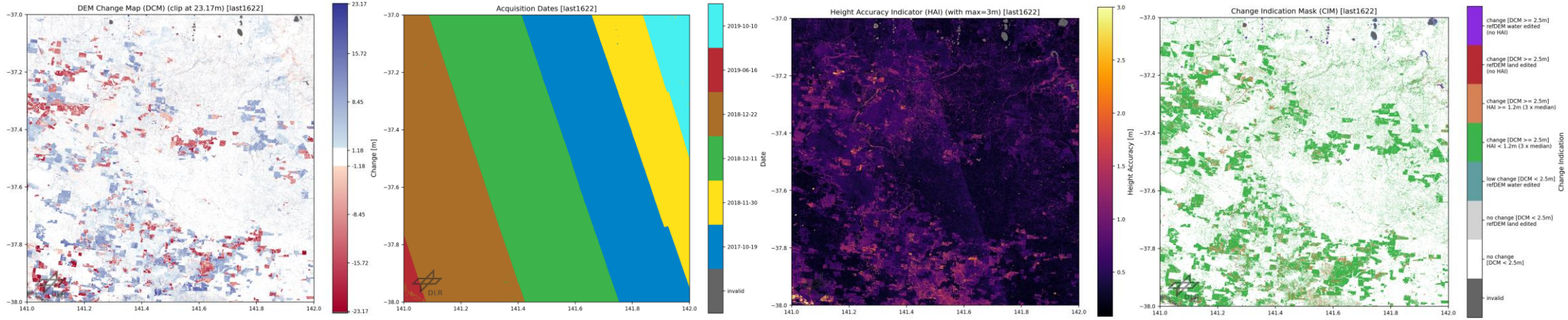
Height Accuracy Indicator

Change Indication Mask

1st DCM: oldest changes within 2016-2022



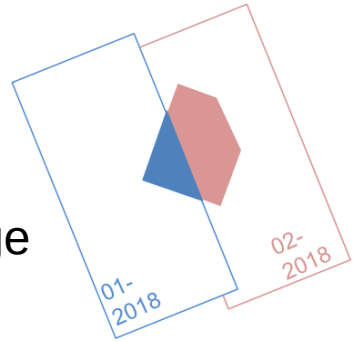
2nd DCM: newest changes within 2016-2022

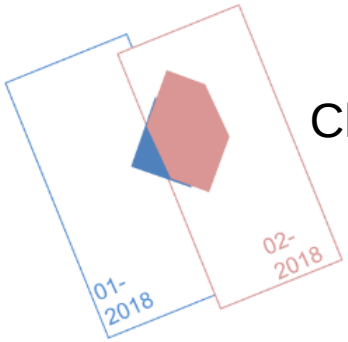


TanDEM-X DEM Change Maps: First and Last Change Maps

- 2 Change Maps generated:
  - first DEM change: change from the oldest pixel within the new dataset
  - last DEM change: change from the newest pixel used

First Change



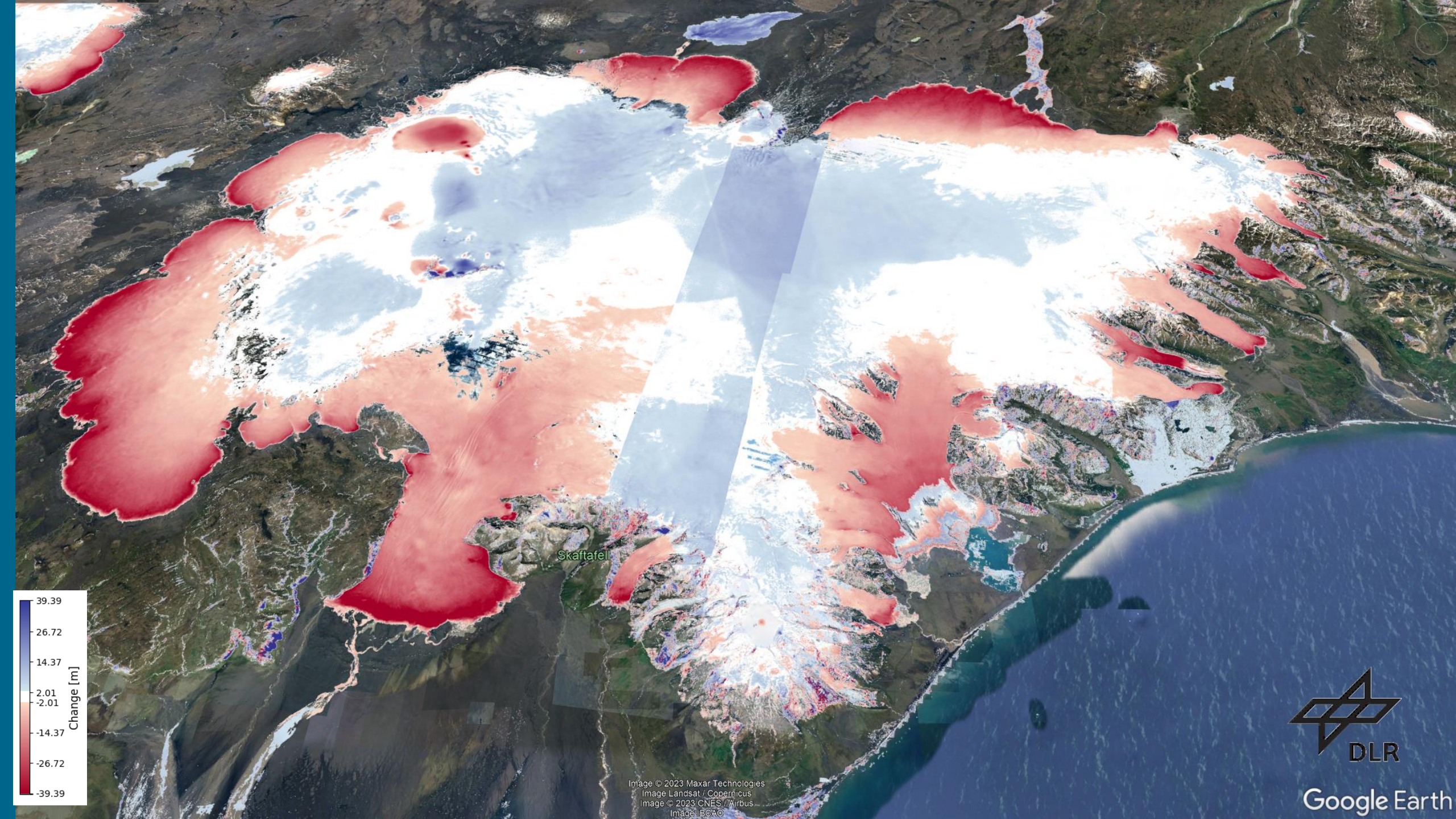


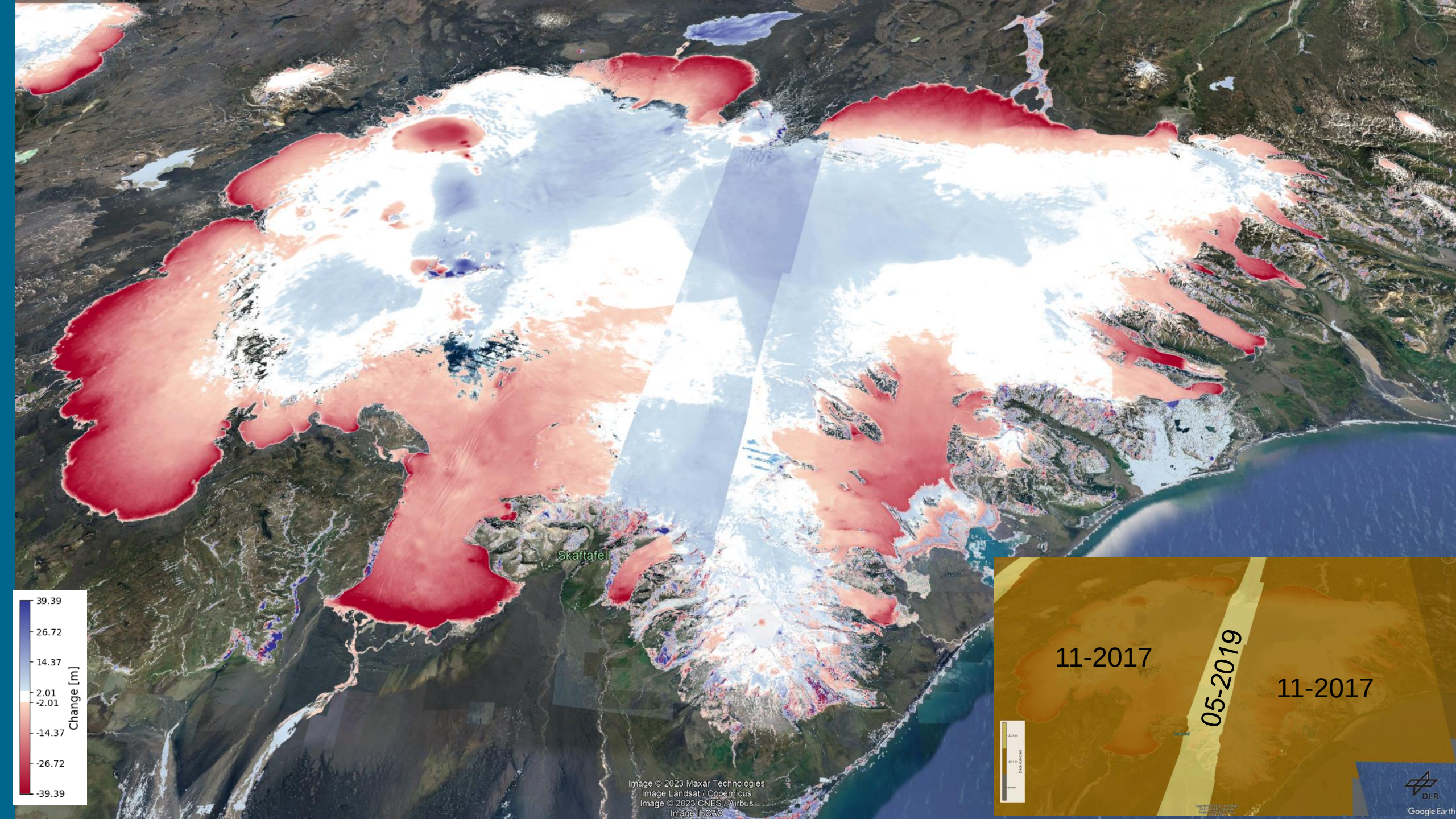
Last Change

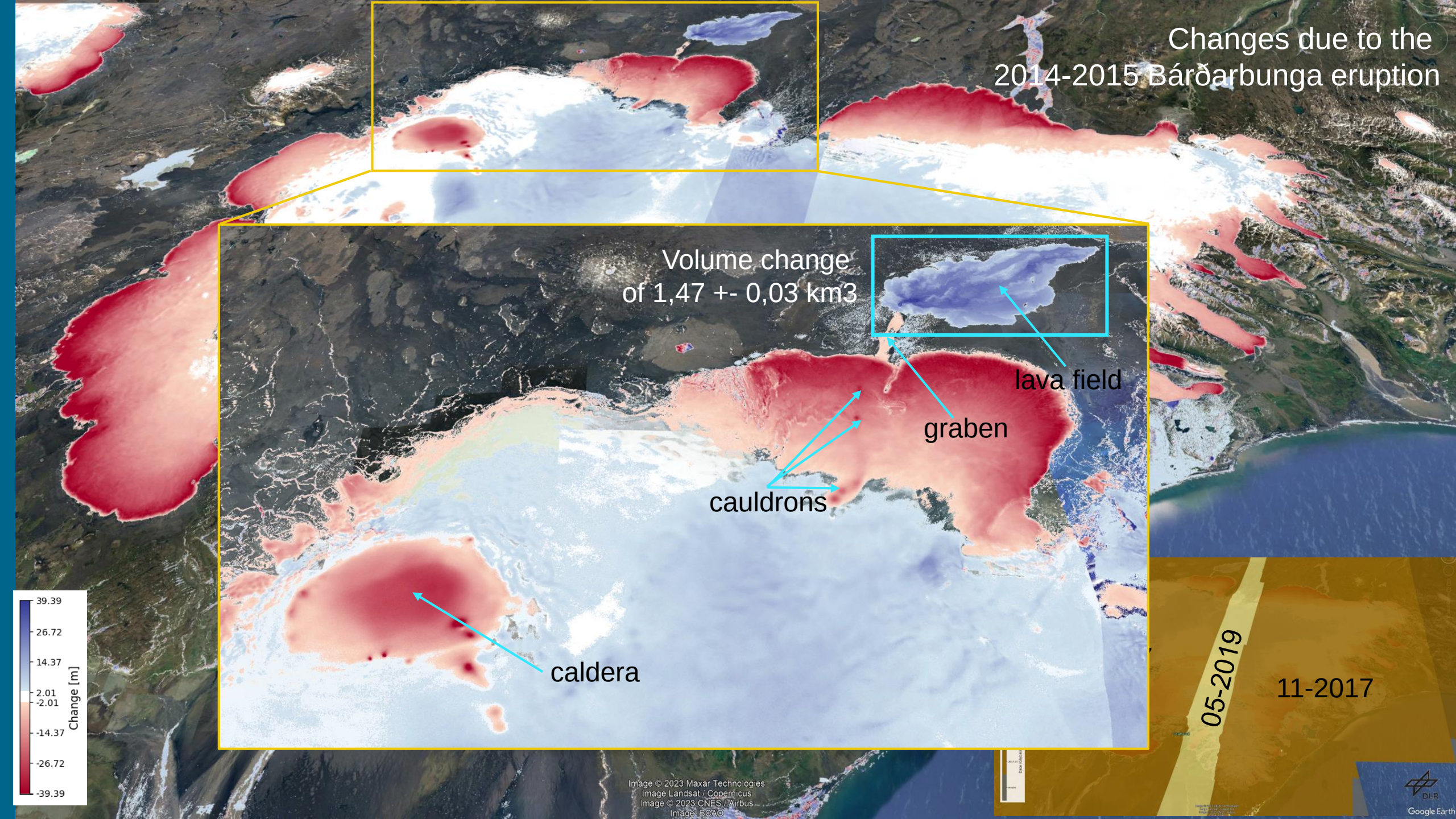
- Jumps between datatakes separated by several months are possible when large scale terrain changes occurred

- **WARNING**:
  - the elevation change measured in the DEM change maps corresponds to a topographic change with respect to the global TanDEM-X DEM
  - **but** it does not correspond to a physical height change of the same magnitude.
    - the reference TanDEM-X DEM is an average of different images, possibly acquired over a period of several years.

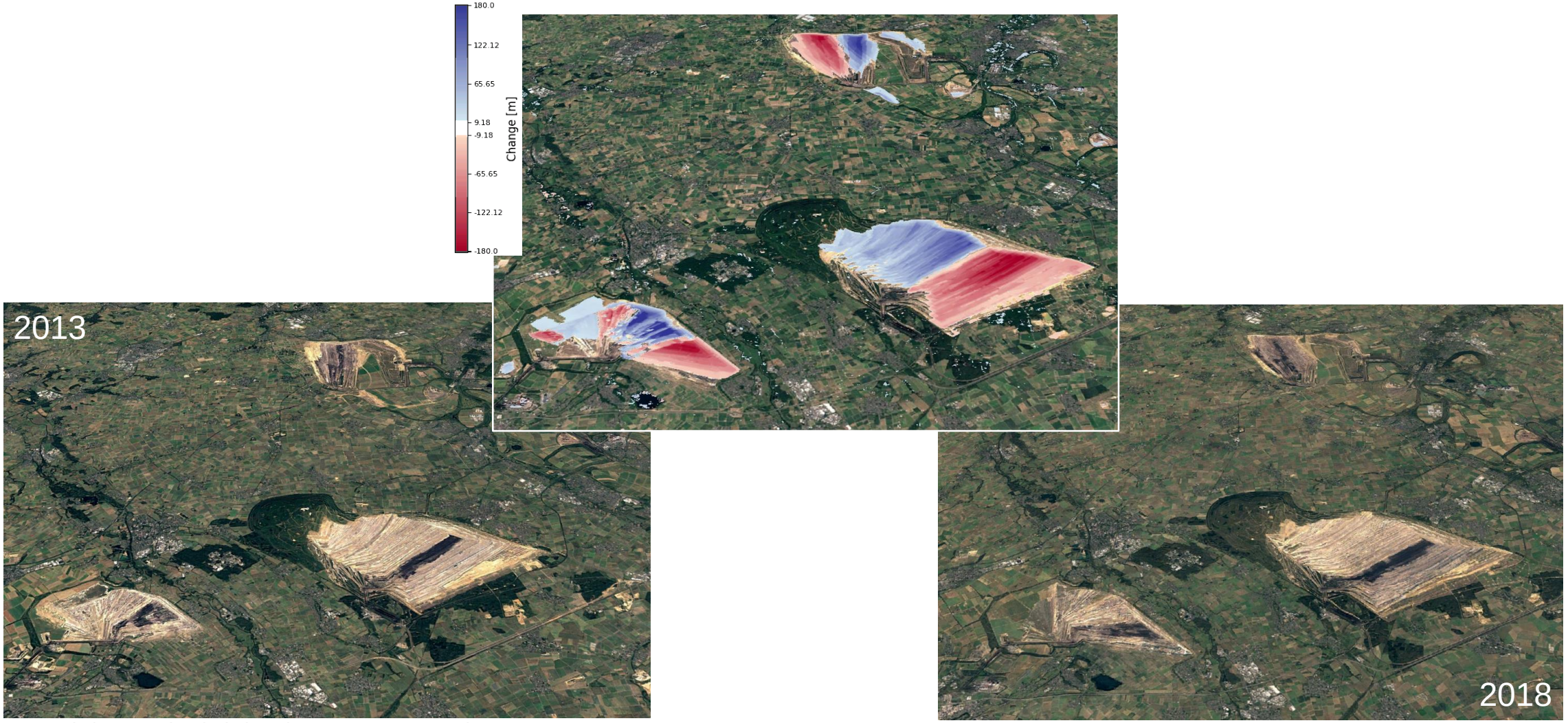
    ➔ Especially important over vegetated and snow-covered regions.


39.39
26.72
14.37
2.01
-2.01
-14.37
-26.72
-39.39
Change [m]
Skaftafell
Image © 2023 Maxar Technologies
Image Landsat / Copernicus
Image © 2023 CNES / Airbus
Image IBCAO
DLR
Google Earth


39.39
26.72
14.37
2.01
-2.01
-14.37
-26.72
-39.39
Change [m]
Skaftafell
11-2017
05-2019
11-2017
Image © 2023 Maxar Technologies
Image Landsat / Copernicus
Image © 2023 CNES / Airbus
Image IBCAO
DLR
Google Earth

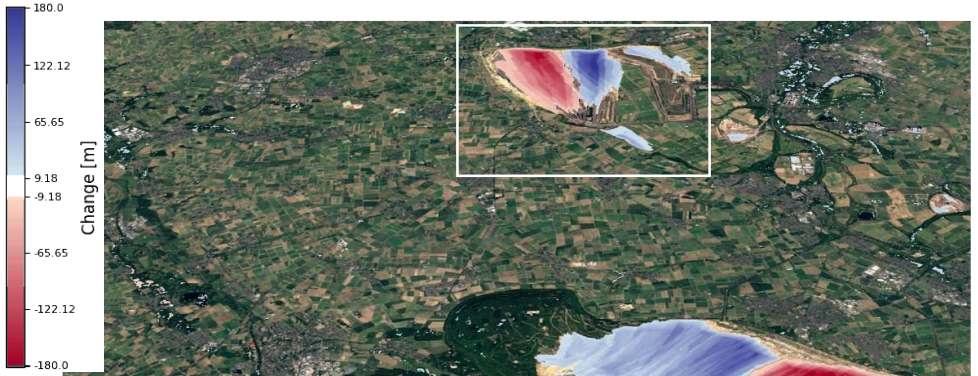

Changes due to the
2014-2015 Bárðarbunga eruption
Volume change
of 1,47 +- 0,03 km3
lava field
graben
cauldrons
caldera
39.39
26.72
14.37
2.01
-2.01
-14.37
-26.72
-39.39
Change [m]
05-2019
11-2017
Image © 2023 Maxar Technologies
Image Landsat / Copernicus
Image © 2023 CNES / Airbus
Image IBCAO
DLR
Google Earth

Hambach and Garzweiler Mines in Germany,



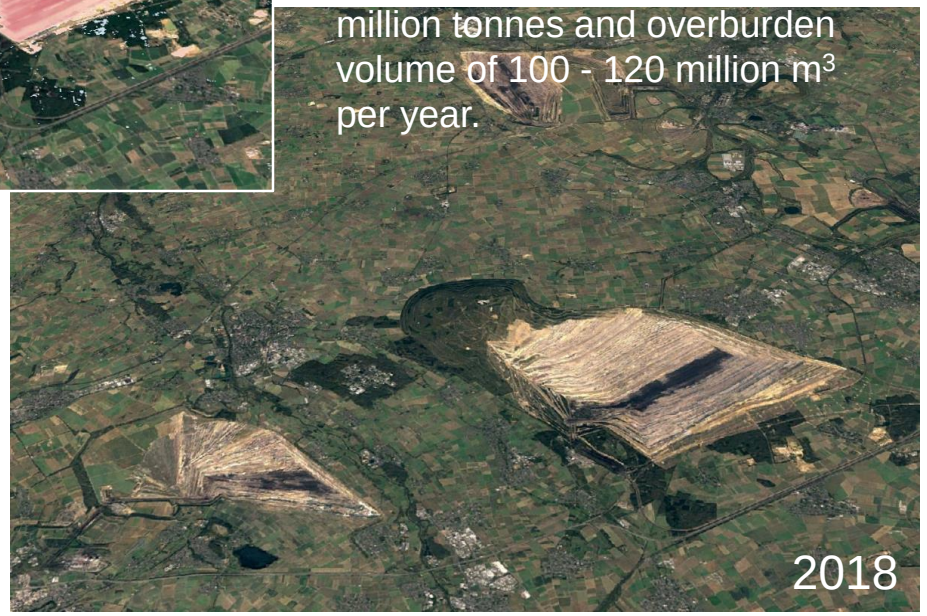
M. Lachaise, B. Schweisshelm, The TanDEM-X DEM Change Maps, Fringe 2023

Hambach and Garzweiler Mines in Germany,

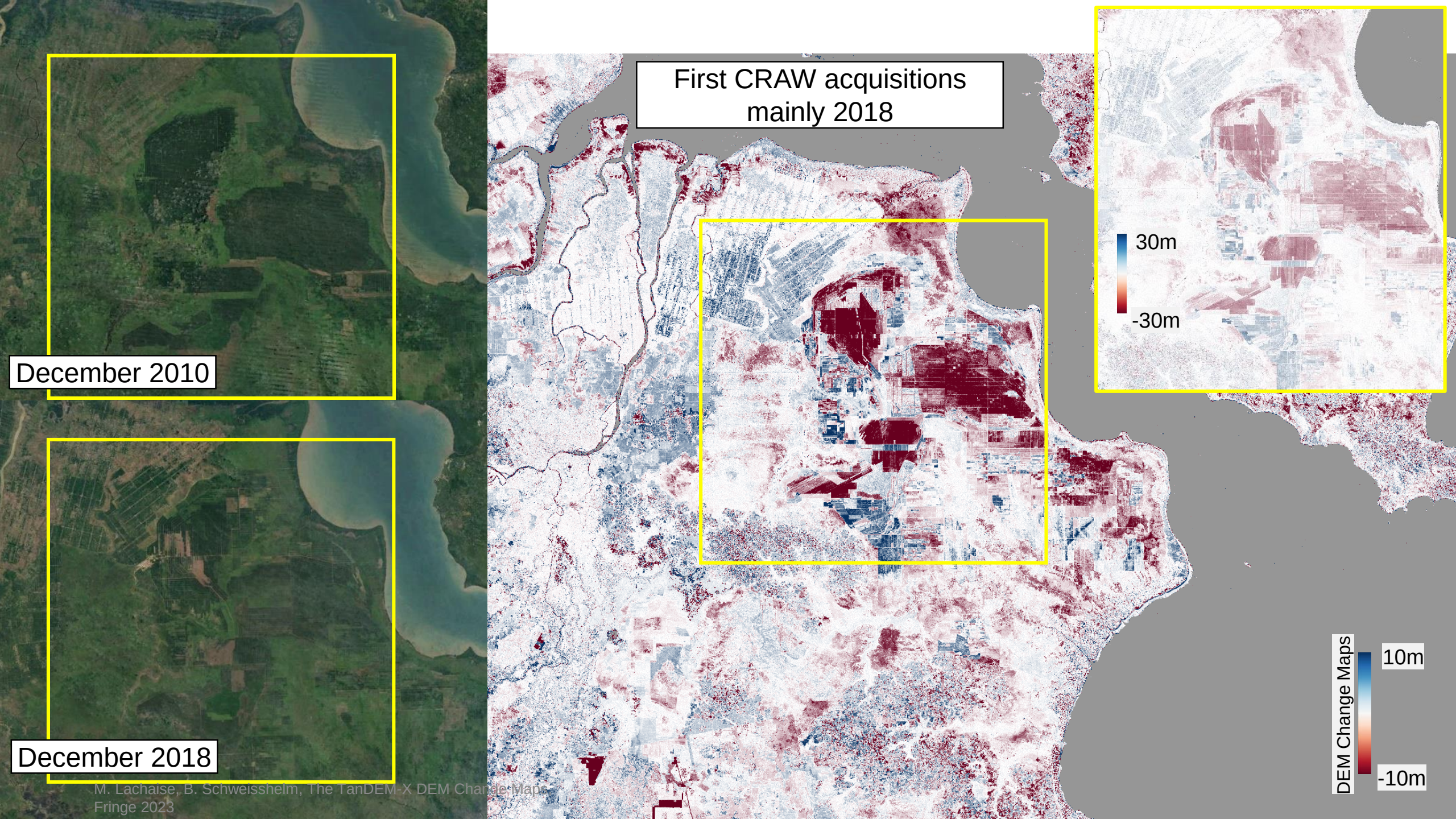


Excavation volume (in red) = mined lignite and the overburden volume = -490 ± 6 Mio. m^3

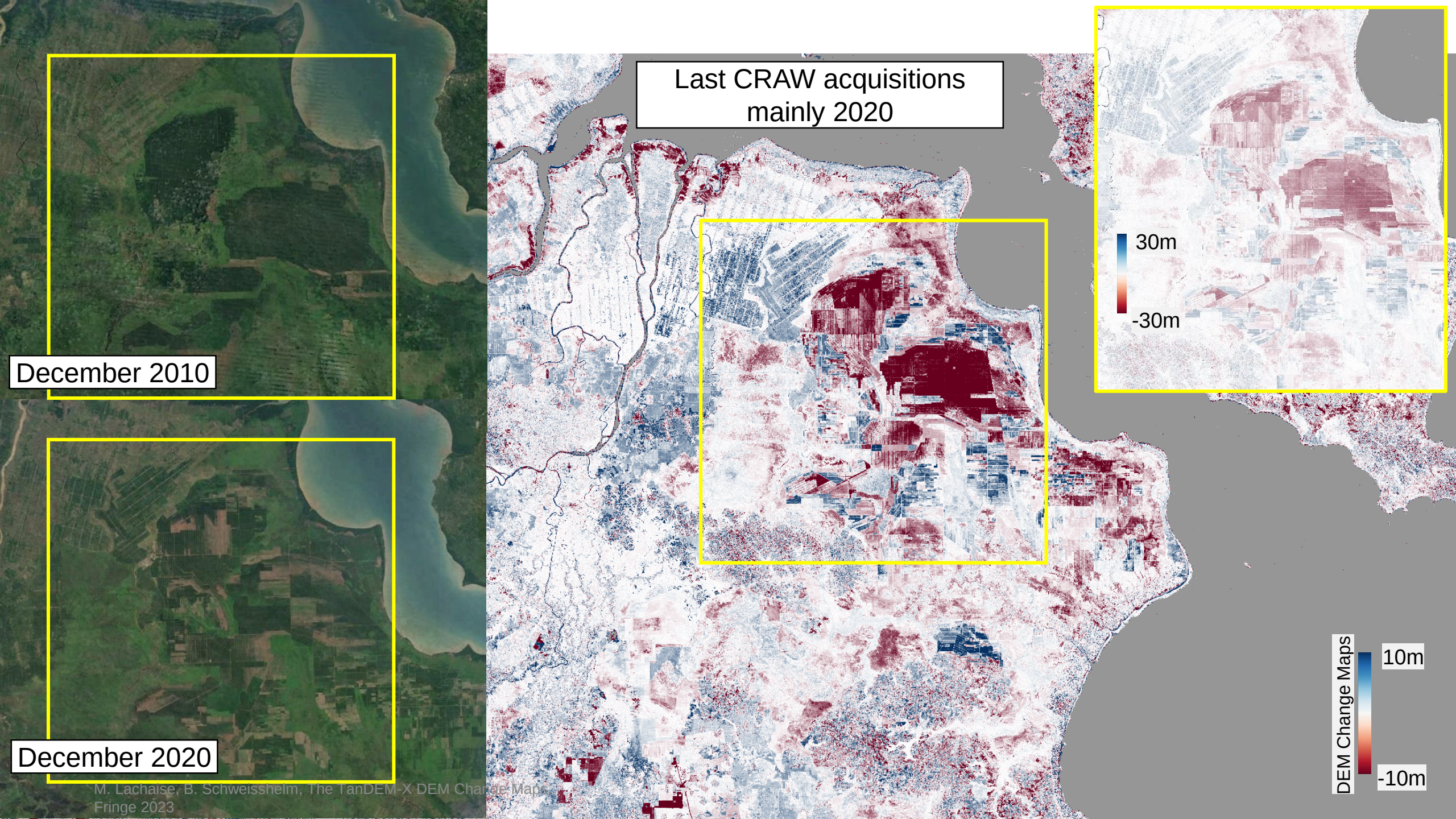
=> Energy supply company RWE indicated coal production of 30 million tonnes and overburden volume of 100 - 120 million m^3 per year.



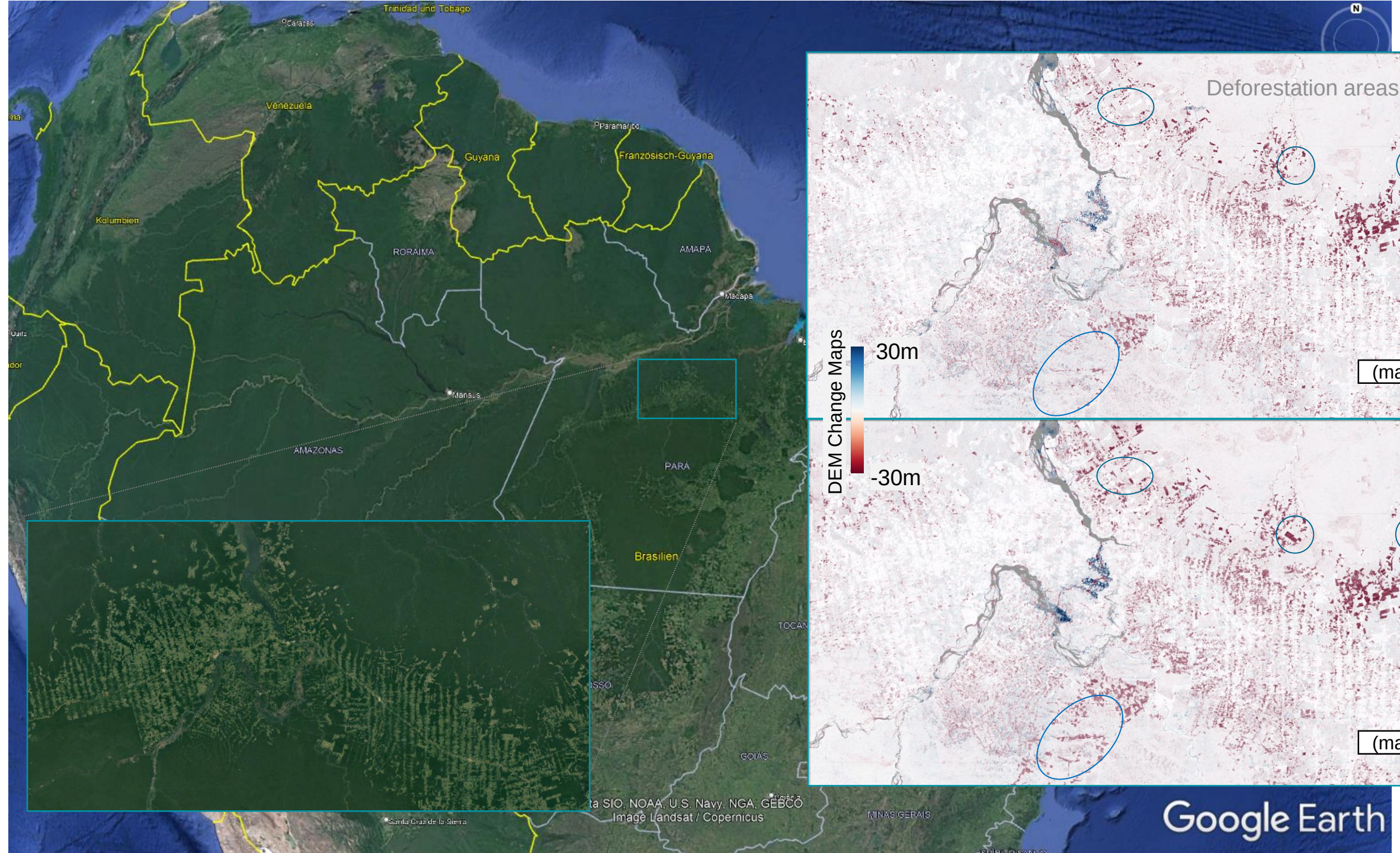
M. Lachaise, B. Schweisshelm, The TanDEM-X DEM Change Maps, Fringe 2023

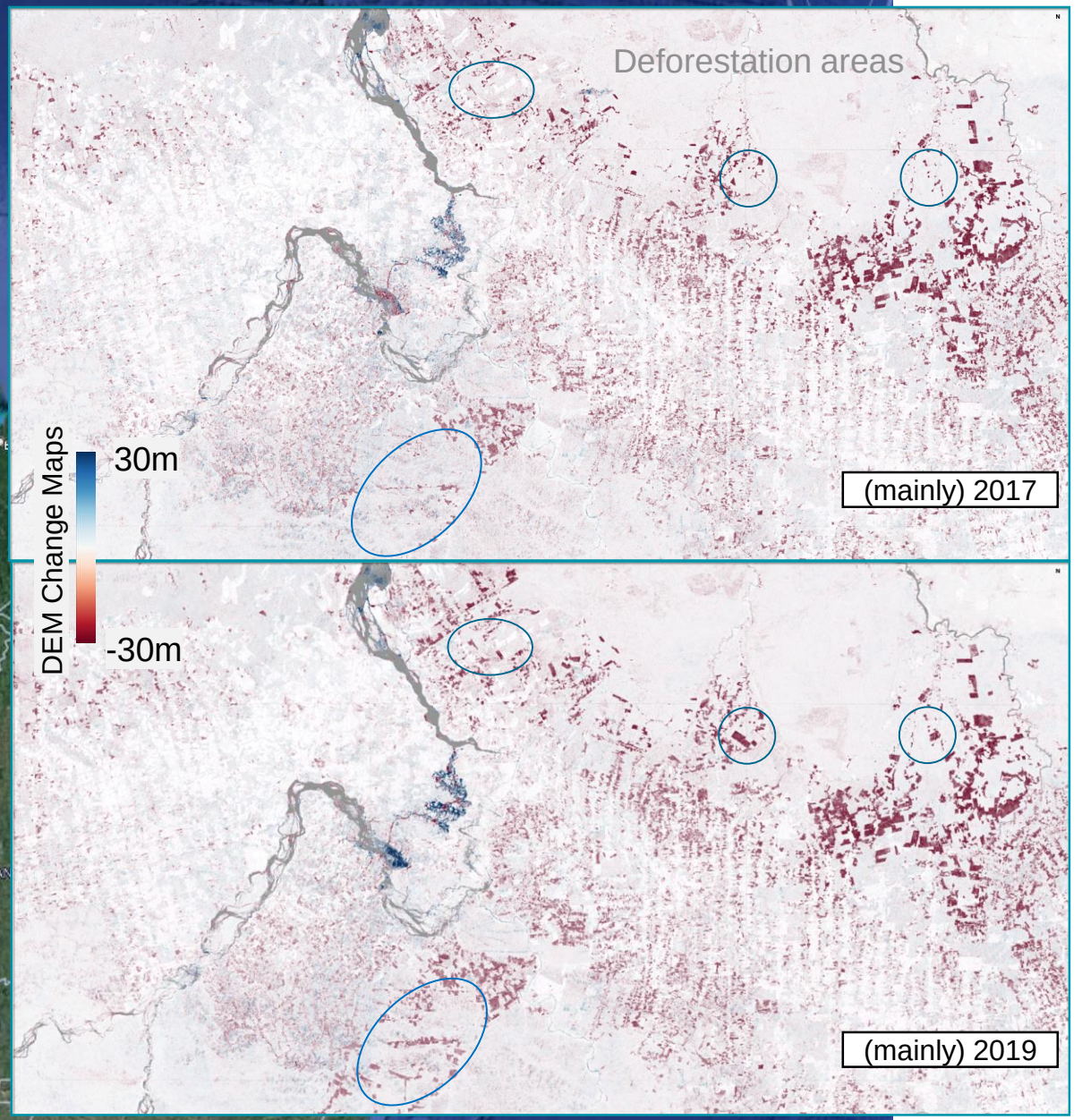


M. Lachaise, B. Schweisshelm, The TanDEM-X DEM Change Maps
Fringe 2023



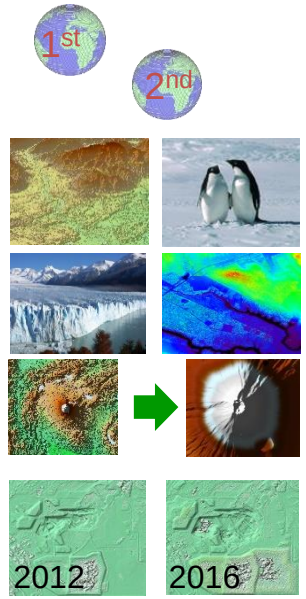
M. Lachaise, B. Schweisshelm, The TanDEM-X DEM Change Maps
Fringe 2023


Trinidad und Tobago
Caracas
Venezuela
Paramaribo
Guyana
Französisch-Guyana
Kolumbien
RORAIMA
AMAPÁ
Macapa
Manaus
AMAZONAS
PARÁ
Brasilien
TOCAN
GOIÁS
MINAS GERAIS
Santa Cruz de la Sierra
ta SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Google Earth


Deforestation areas
DEM Change Maps
30m
-30m
(mainly) 2017
(mainly) 2019

Further developments: DEM Change Map stacks

2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024



(first global) TanDEM-X DEM

Science Phase

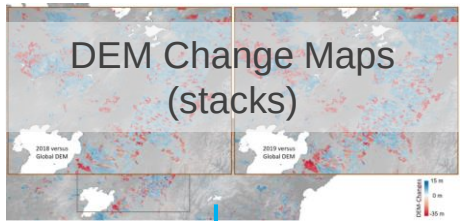
High-Resolution DEMs

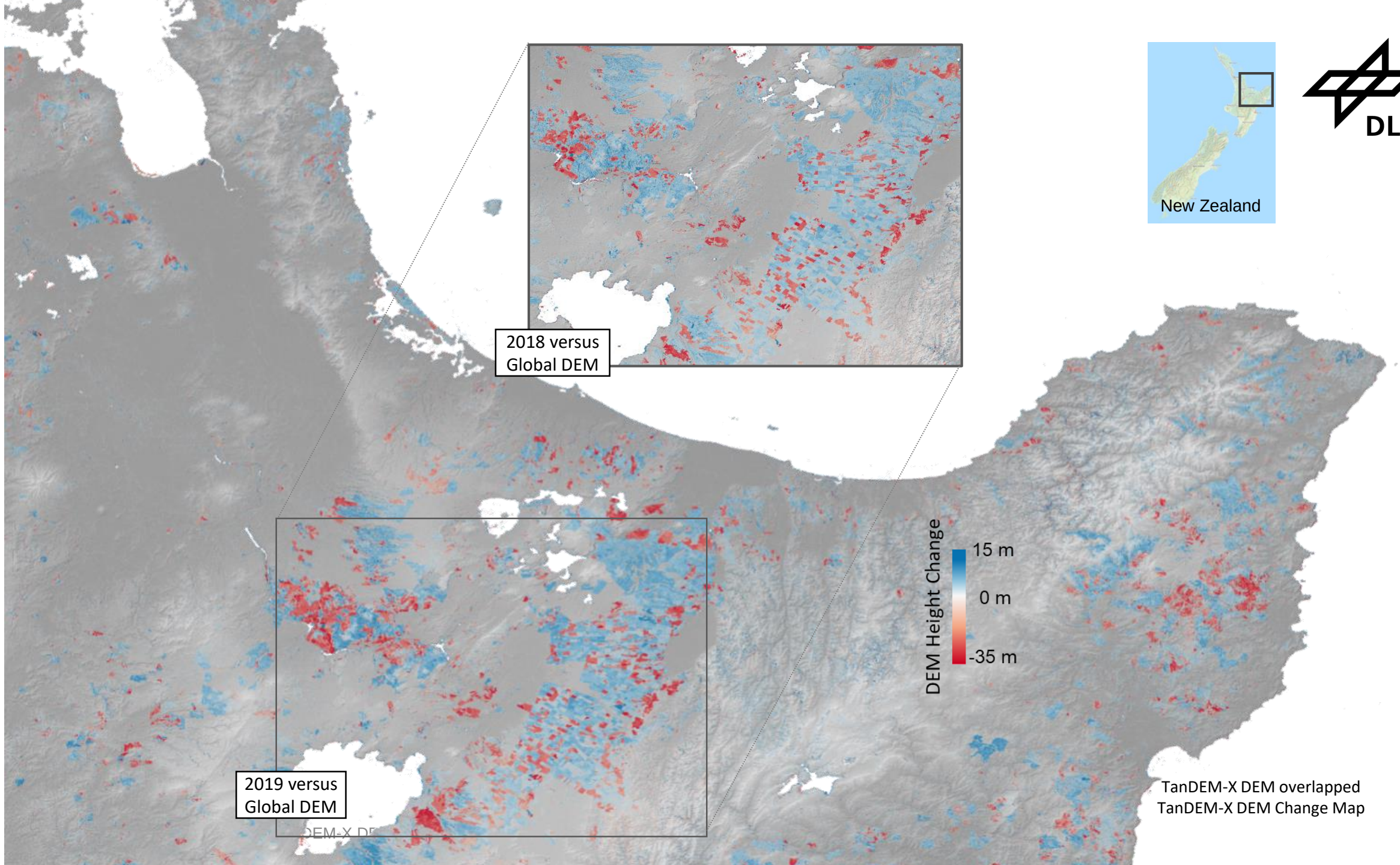
TanDEM-X DEM 2020 (second global TanDEM-X DEM)

Scientific Phase 20-22

TanDEM-X 4D Phase (Temporal DEM Updates)

Changes between temporal DEMs, number of maps and coverage completeness in stacks will depend on data availability for that location




2018 versus
Global DEM
2019 versus
Global DEM
New Zealand
DEM Height Change
15 m
0 m
-35 m
TanDEM-X DEM overlapped
TanDEM-X DEM Change Map