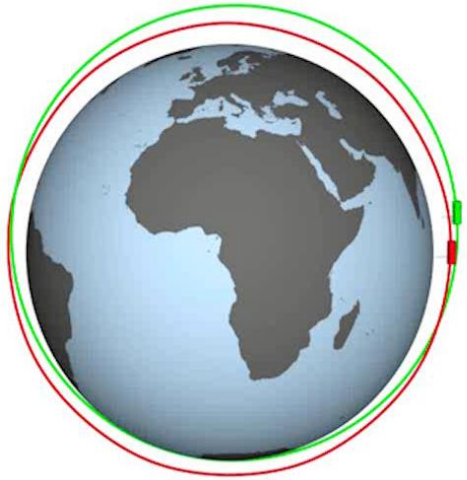
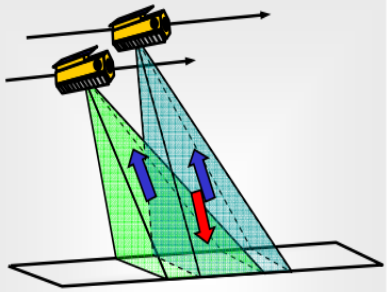
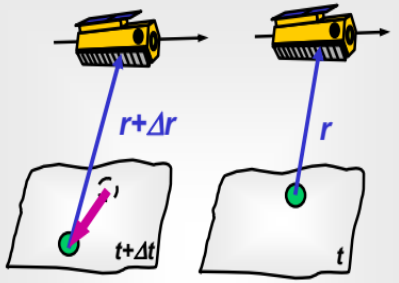
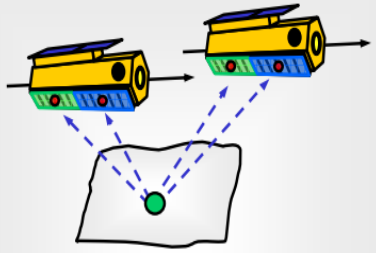
The TanDEM-X 4D Phase – Input for a Potential Future Update of the Copernicus DEM

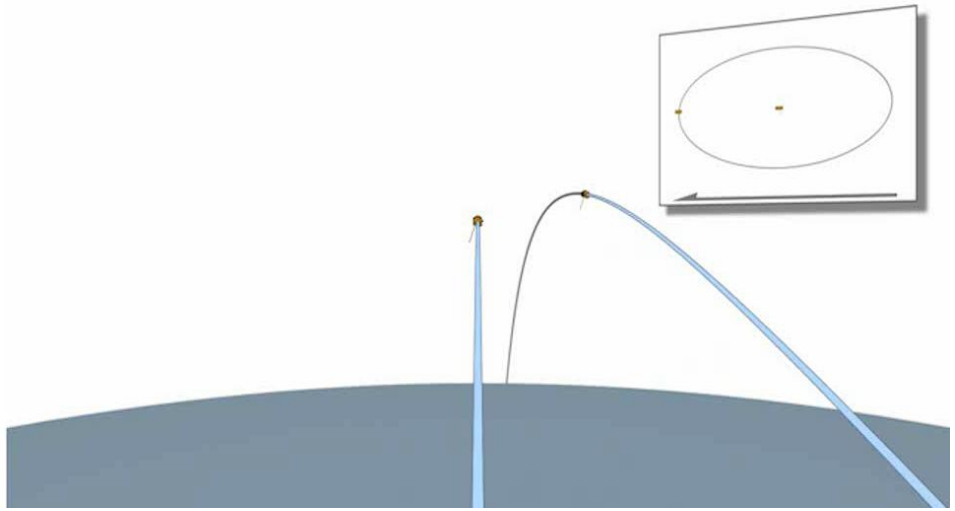
Markus Bachmann, Maximilian Schandri, Thomas Kraus, Allan Bojarski, Johannes Böer, Manfred Zink & TanDEM-X Ground Segment Team

TanDEM-X Mission

- Two X-band satellites
- In orbit since 2007 and 2010
- Primary goal:
  Global, consistent, highly accurate
  Digital Elevation Model



Cross-Track Interferometry	Along-Track Interferometry	New Techniques
		
→ **Digital Elevation Models** → **Spatial Coherence** (forest, ...)	→ **Large Scale Velocity Fields** (ocean currents, ice drift, ...)	→ **4 Phase Center MTI** (traffic, ...) → **PolInSAR** (vegetation height, ...)



Review of the Current Phases

Commissioning Phase: Calibration and operationalization

1st Global Coverage

- Small baseline (~200 m), Height of Ambiguity ~ 50 m

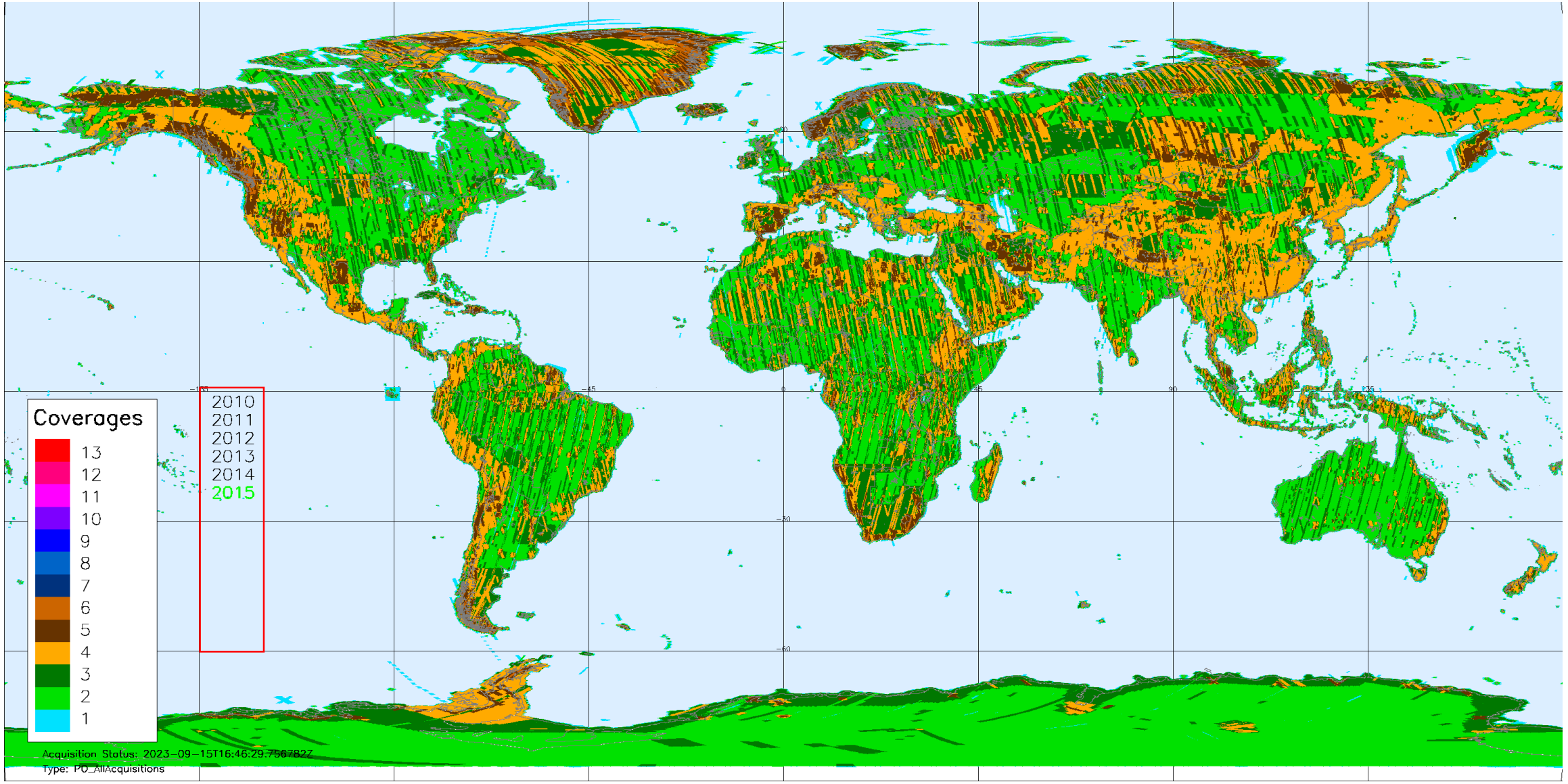
2nd Global Coverage

- Increased baseline (~300 m), Height of Ambiguity ~ 35 m
- In combination: Dual-baseline phase unwrapping + Improved height accuracy

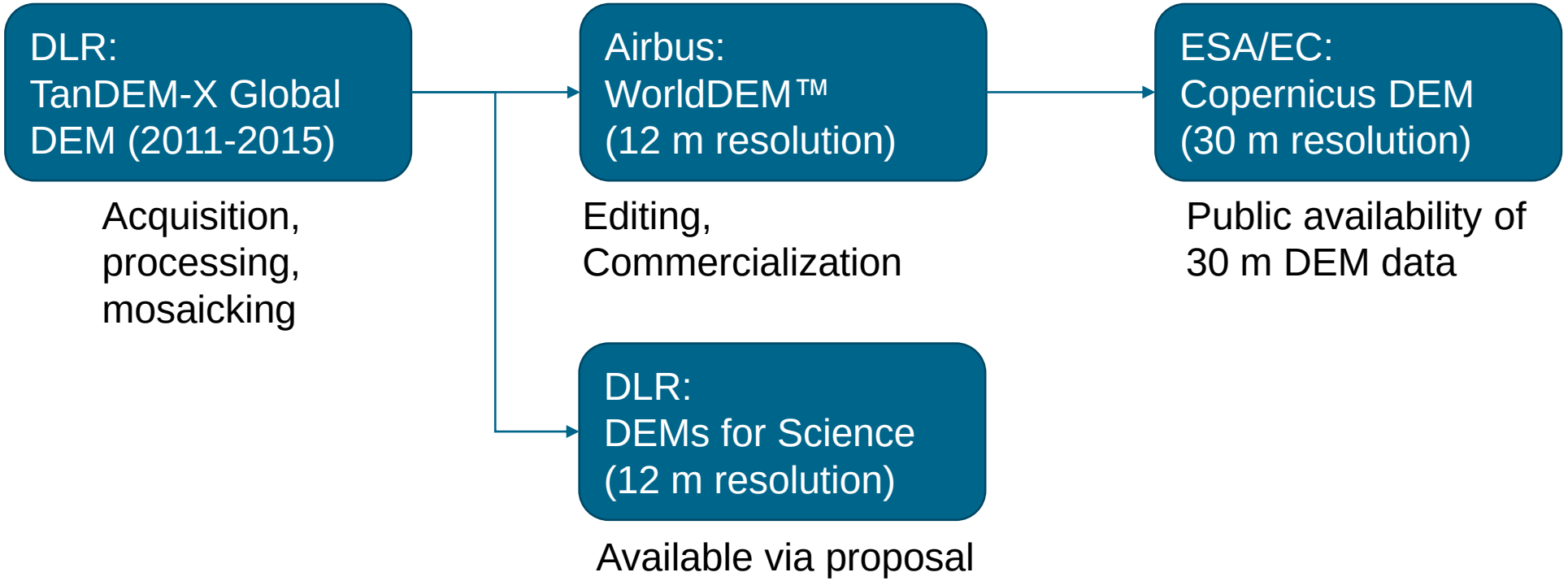
3rd Year Acquisitions

- Different viewing geometry to account for shadow & layover
- Antarctica, Deserts

Overview on the Amount of Coverages



Copernicus DEM Workflow



Review of the Current Phases

2010	2011	2012	2013-2015	2015/2016	2017-2020	2020-2022	2022-2028

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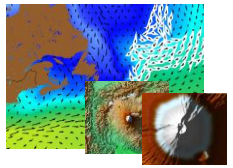
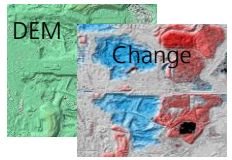


Science Phase

- Exploitation of the scientific potentials of the mission
- Acquisitions with special formations and of High Resolution DEMs

TanDEM-X DEM 2020

- Acquisitions and production of a second global DEM
- Additional DEM Change Maps with differences between 2010-2014 and 2017-2020



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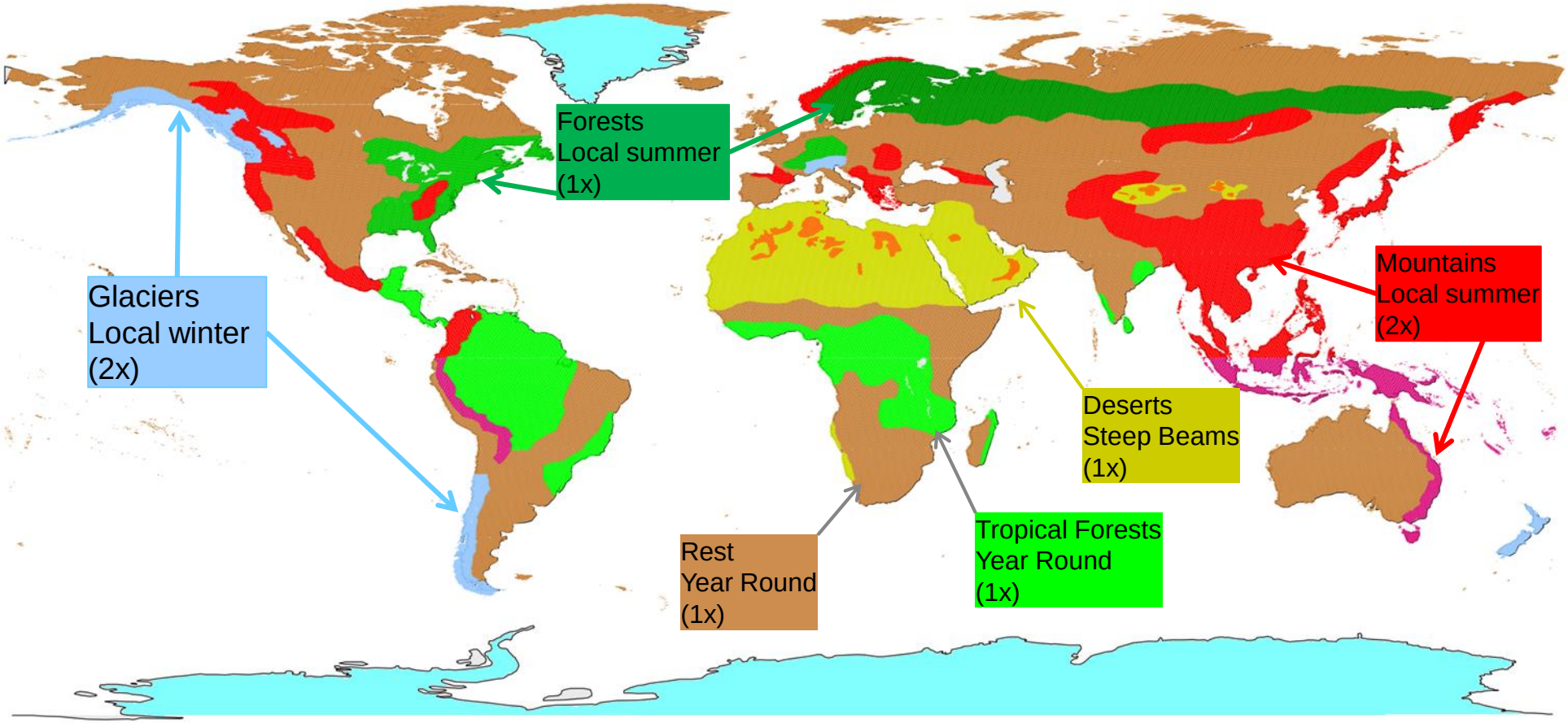
TanDEM-X DEM 2020

- Exploiting all our Global DEM experience
- Optimized DEM coverage



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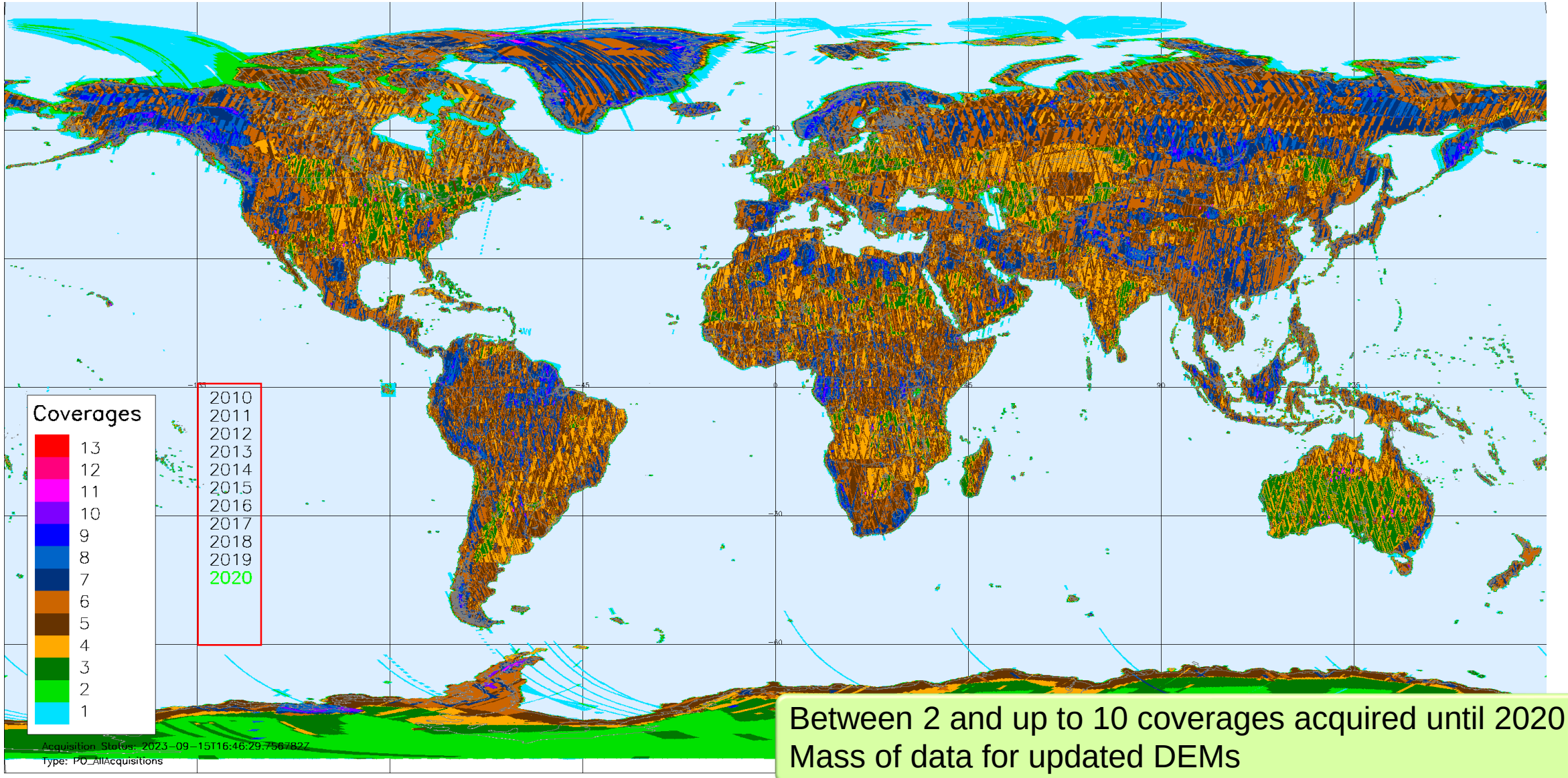
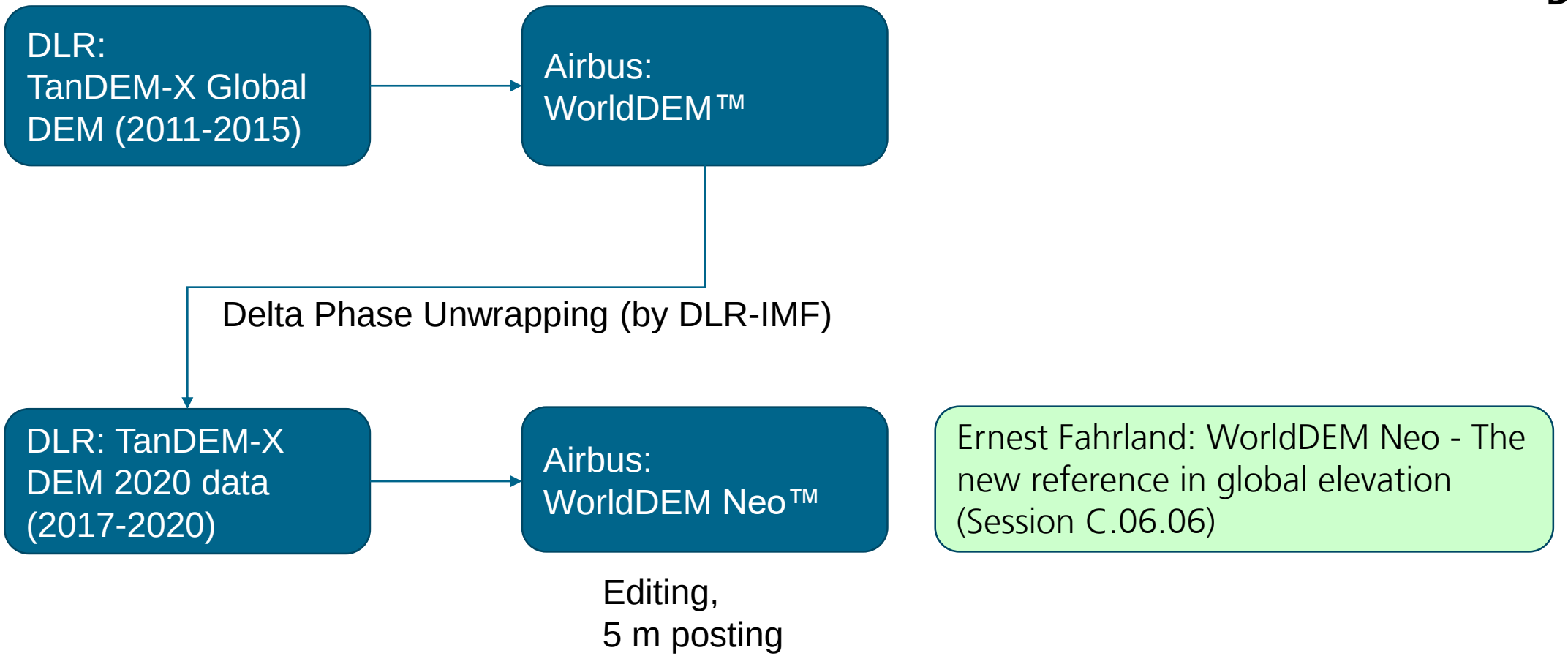
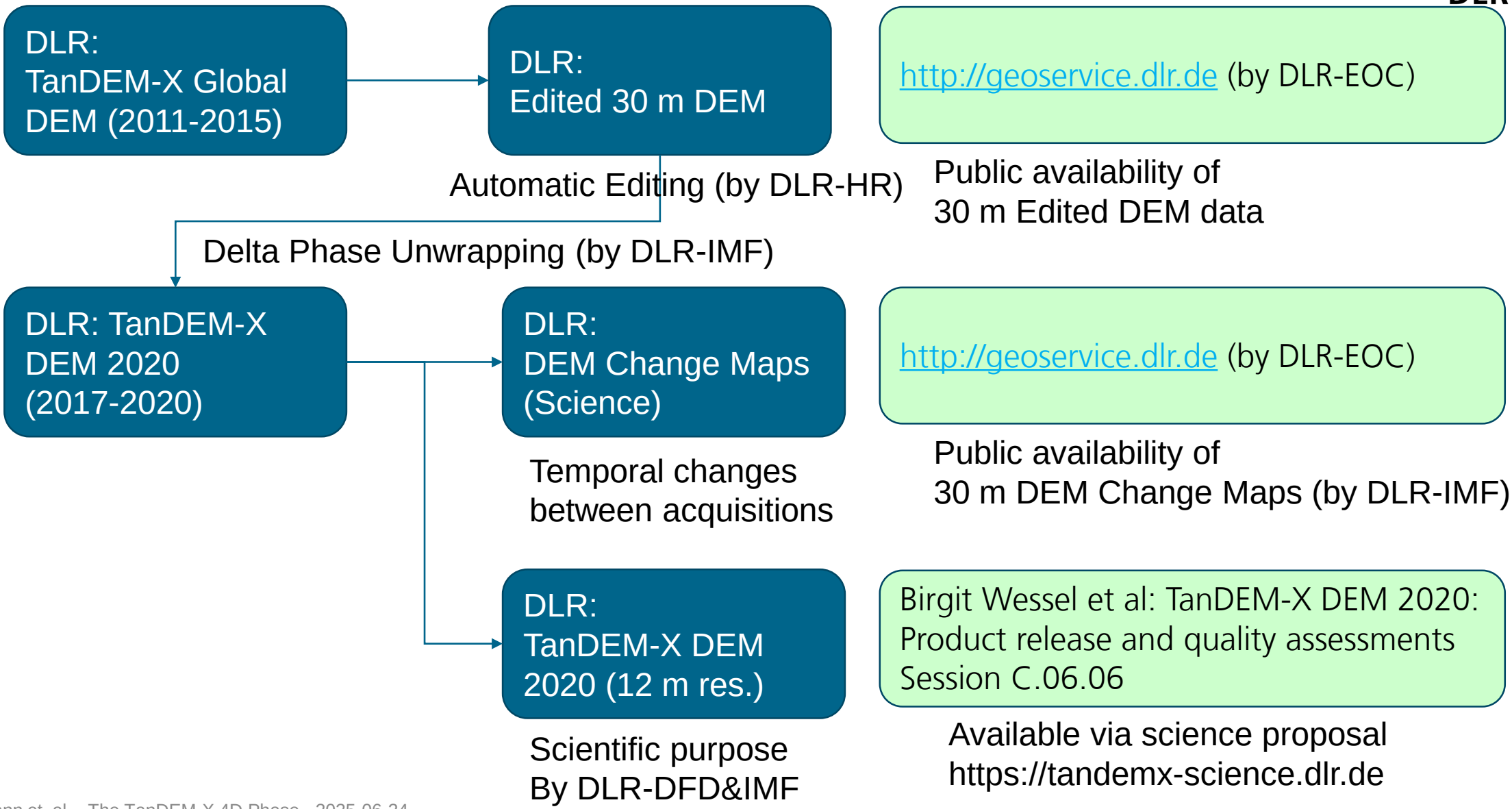


Between 2 and up to 10 coverages acquired until 2020
Mass of data for updated DEMs

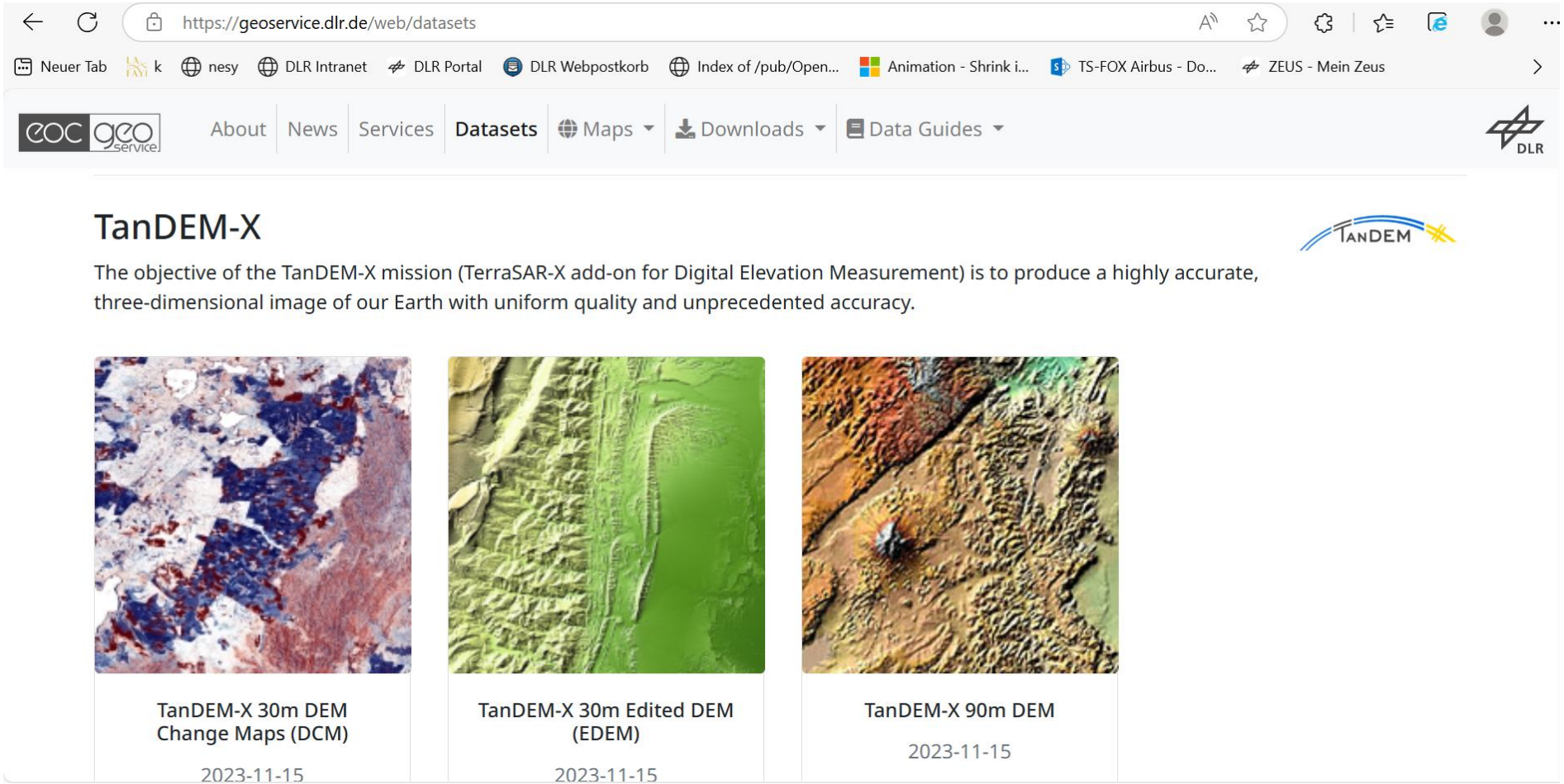
TanDEM-X DEM 2020



TanDEM-X DEM 2020



TanDEM-X DEM 2020 – Edited DEM and DEM Change Maps



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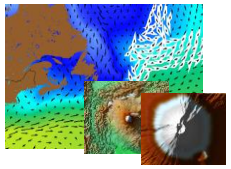

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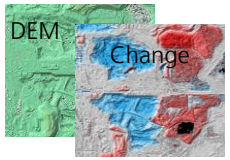
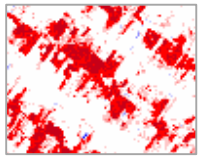


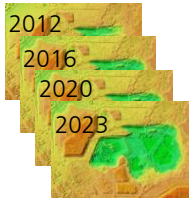


Science Phase 2020-2022

- Scientific acquisitions, Main areas of interest: forests, glaciers/permafrost, urban areas

TanDEM-X 4D Phase

- Continuous monitoring of topographic changes on Earth, prioritized areas: forest, glaciers, areas with large height changes
- Generation of DEM Change Maps Time Series



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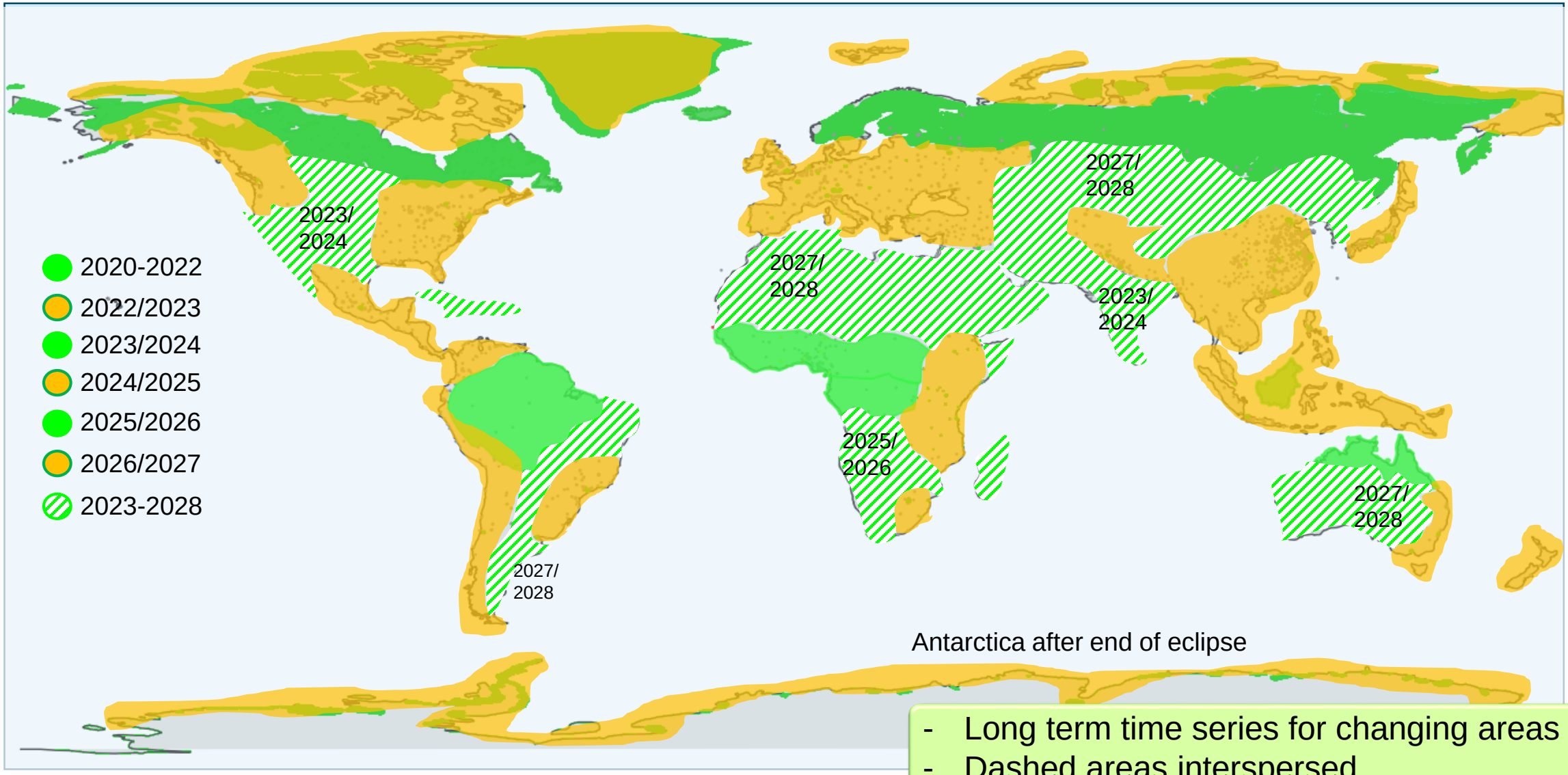
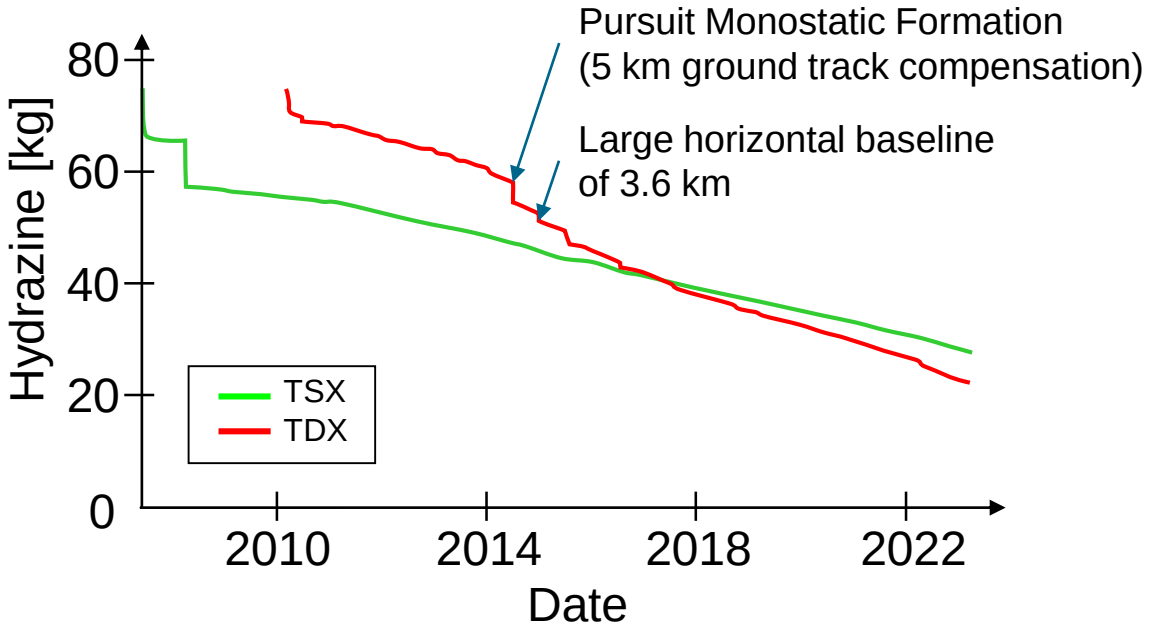
TanDEM-X 4D Phase – Original Plan

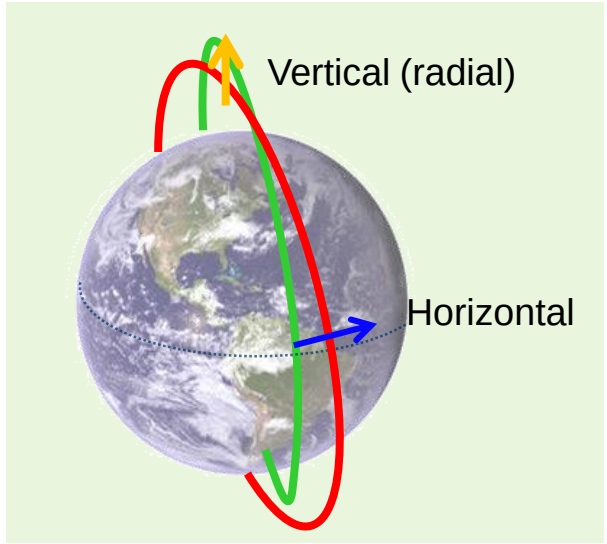
- Acquire areas with large height changes regularly and residual areas once

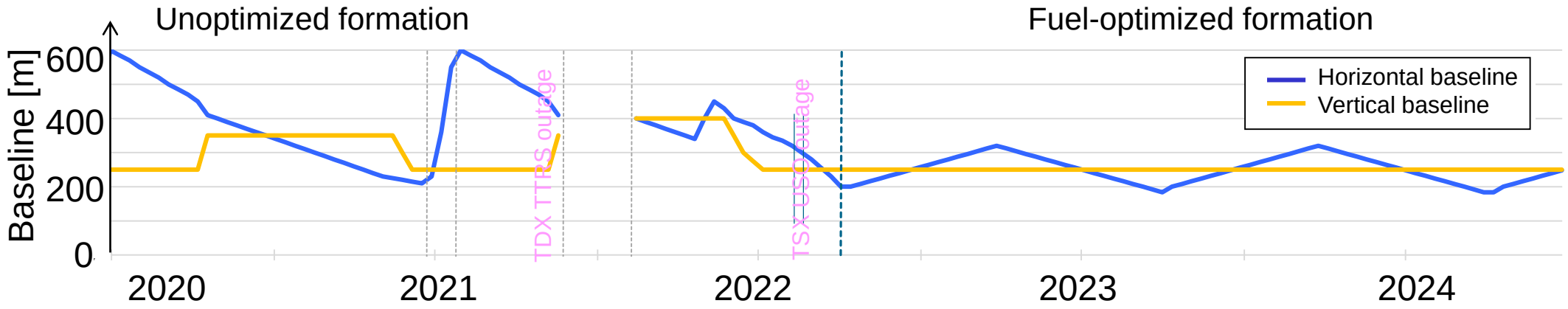


- Long term time series for changing areas
- Dashed areas interspersed

TanDEM-X 4D Phase – Formation



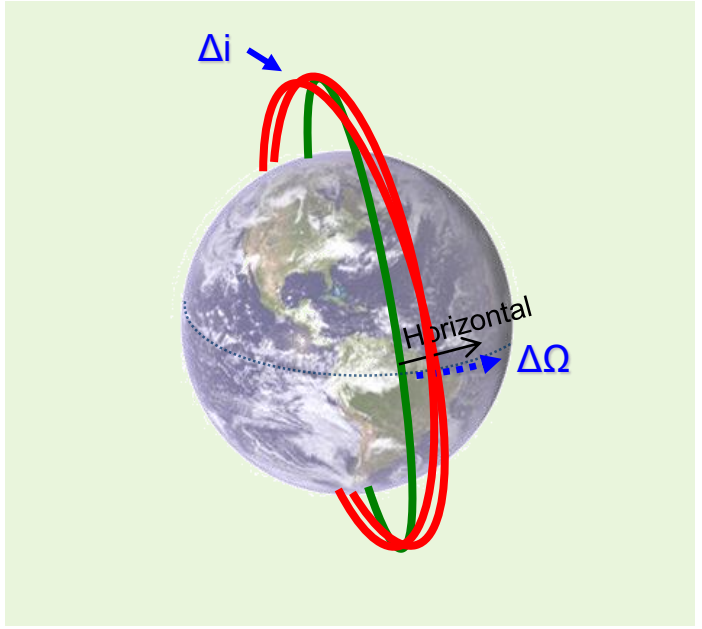




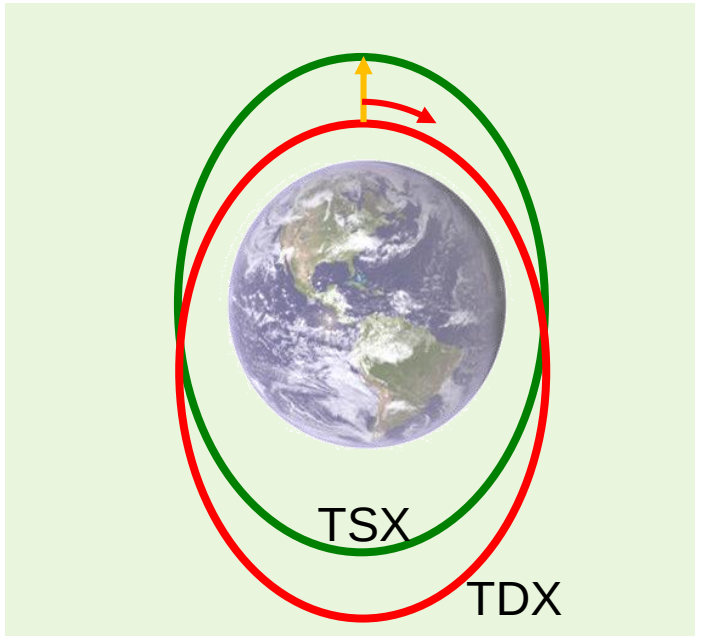
TanDEM-X 4D Phase – Formation

Resources: Fuel Saving Formation

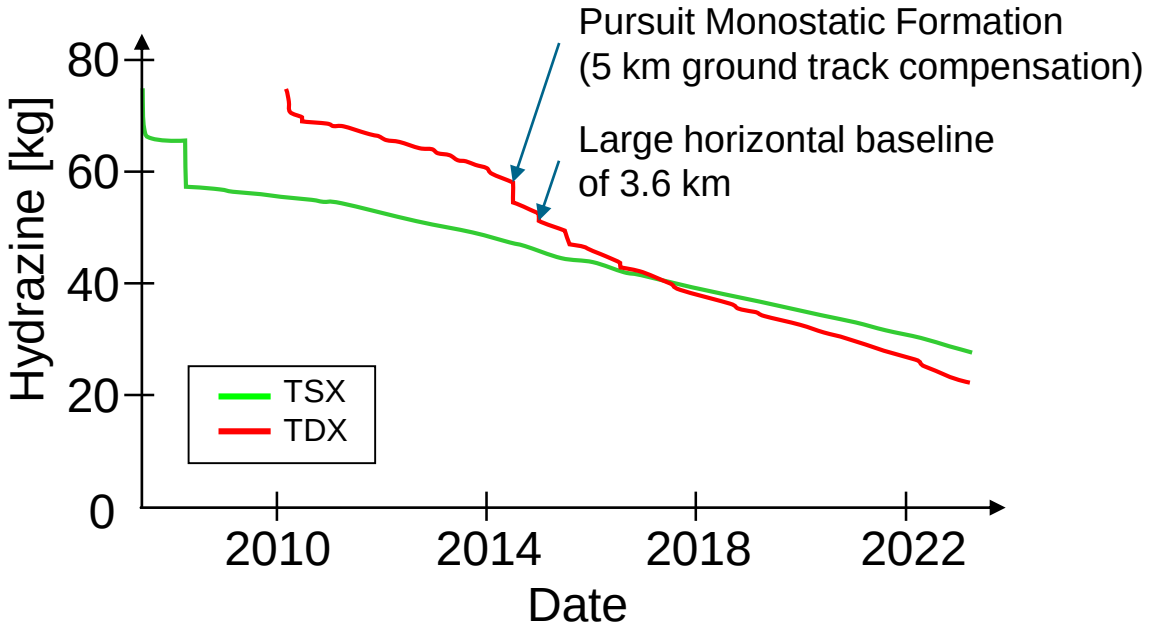
- Horizontal Baseline:
  - Instant change in horizonal baselines
    - out of plane maneuvers required
  - Optimized: Delta inclination
    - Drift of the baseline

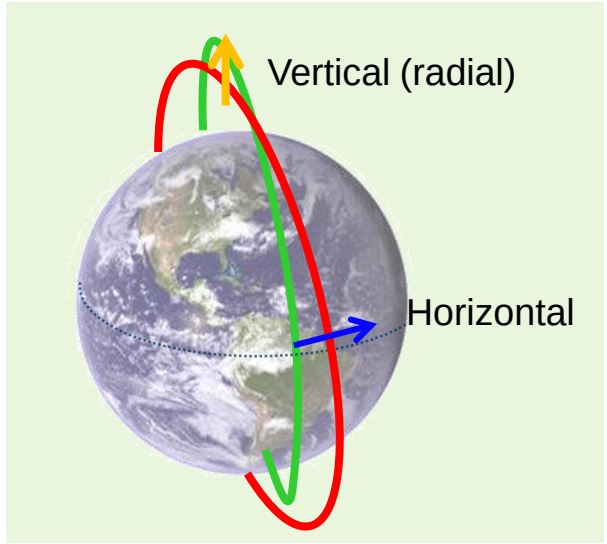


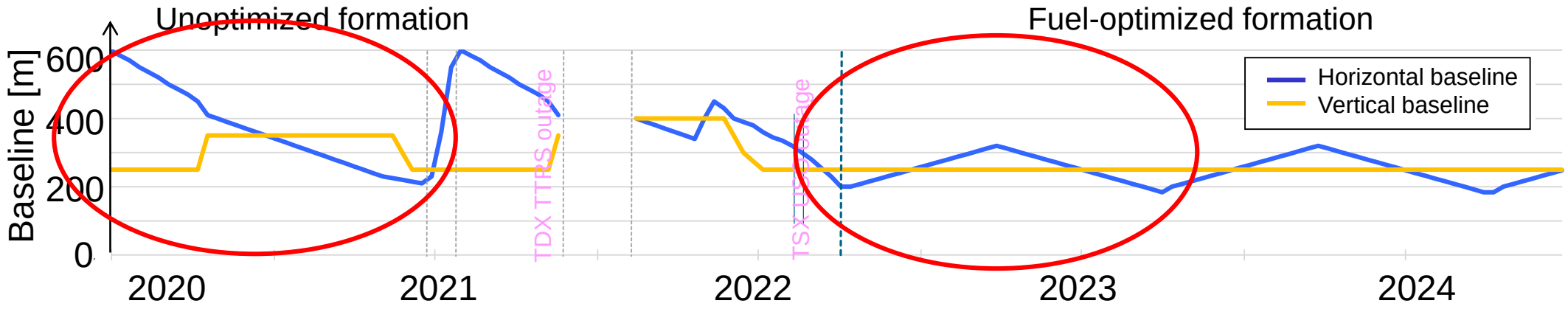
- Vertical Baseline:
  - Compensation of the eccentricity vector drift
  - Daily in-plane maneuvers
- Atmospheric drag compensation:
  - Also daily in-plane maneuvers
  - High solar activity → vertical maintenance for free



TanDEM-X 4D Phase – Formation

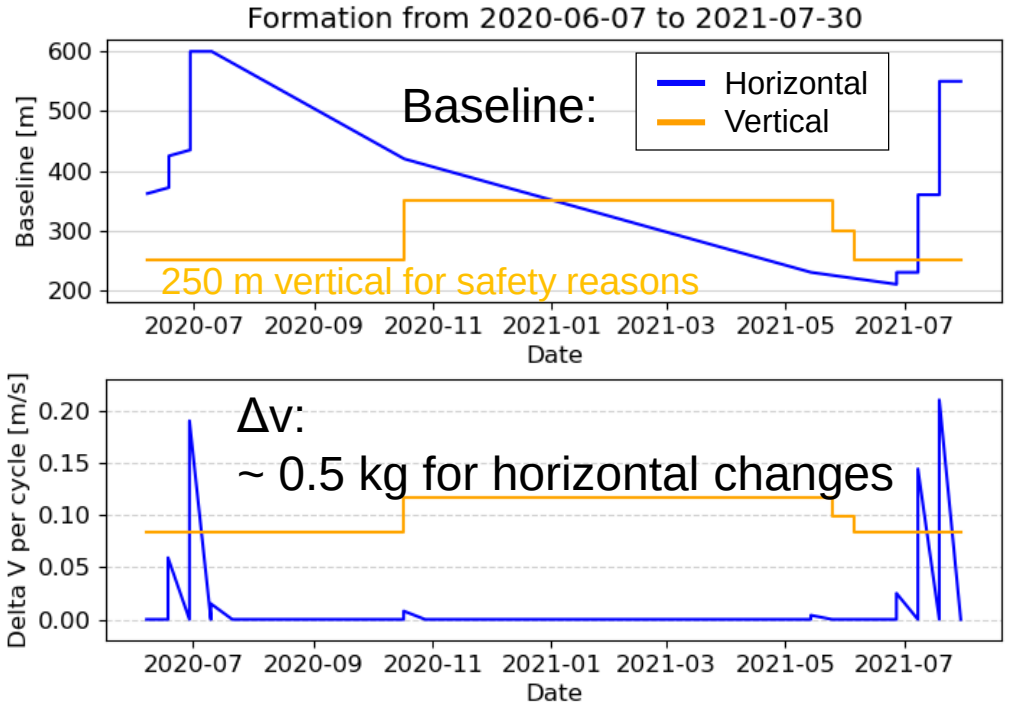




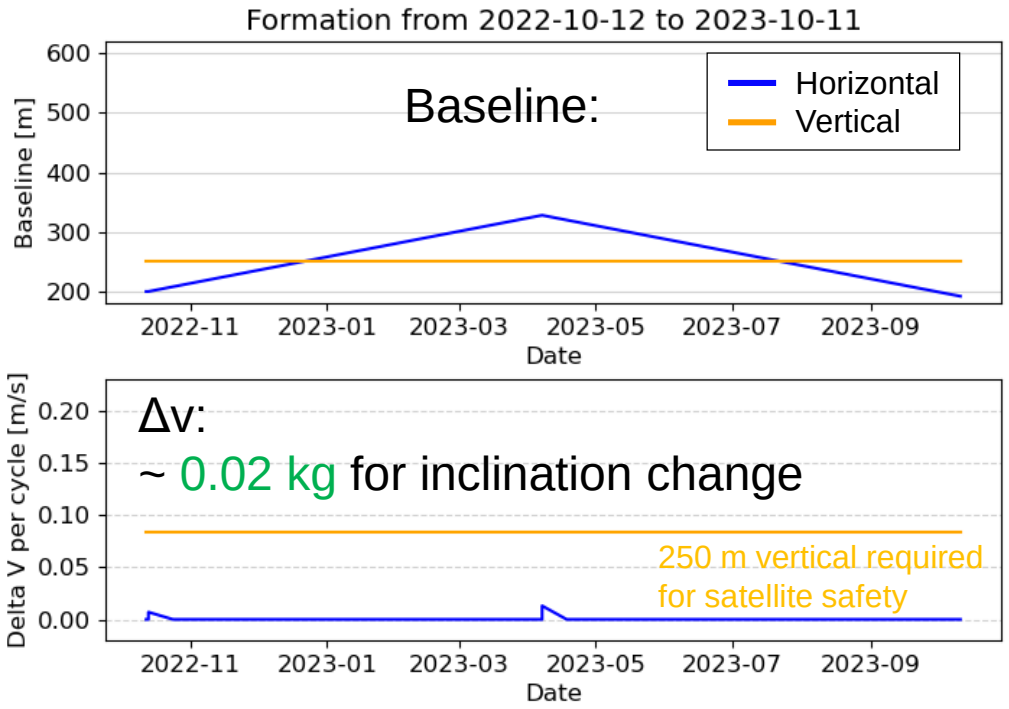


Resources: Fuel-Saving Formation

Science Phase (2020-2022)



4D Phase (now)



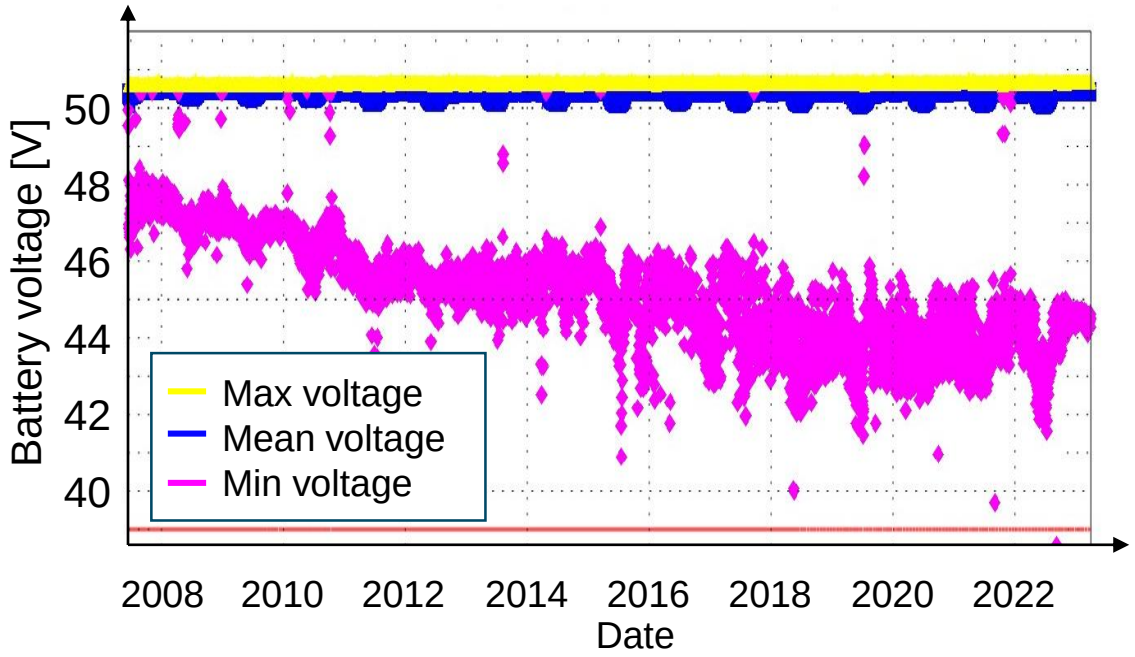
Horizontal baseline: drift of the horizontal baseline caused by small difference in orbit inclination

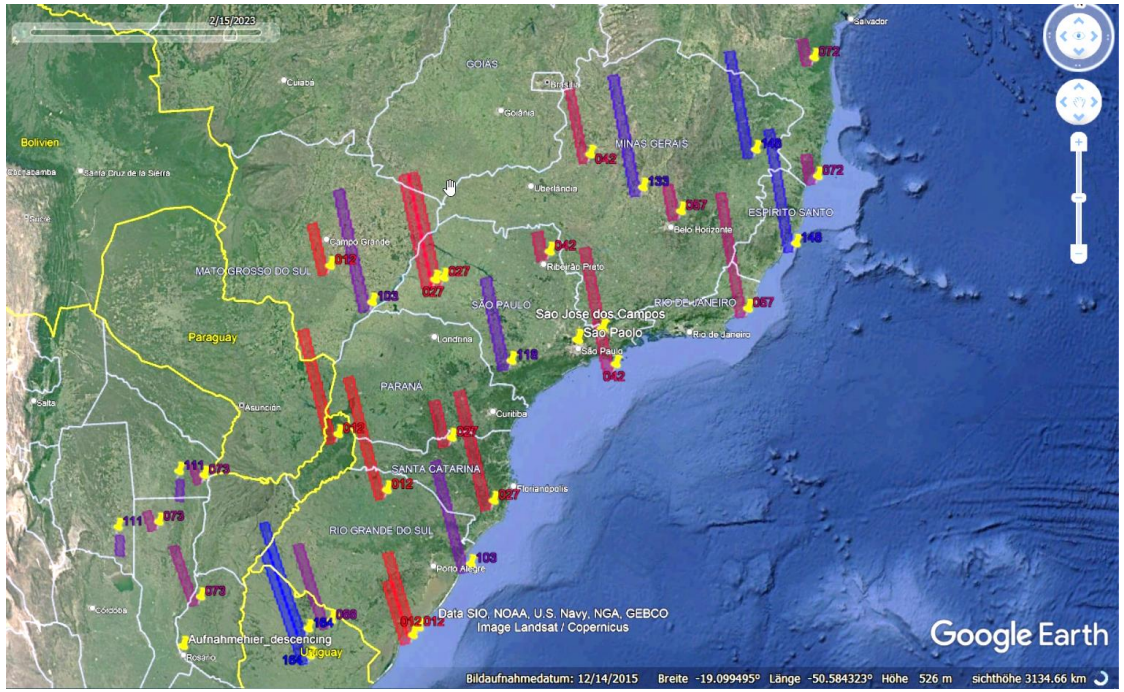
Consequence: Slight degradation of the relative height accuracy near the equator (for far beams)

- Effective orbit maintenance concept by Flight Dynamics
- Fuel-optimized formation for a long satellite life time
- No additional fuel-cost for formation keeping

TanDEM-X 4D Phase – Battery Preservation

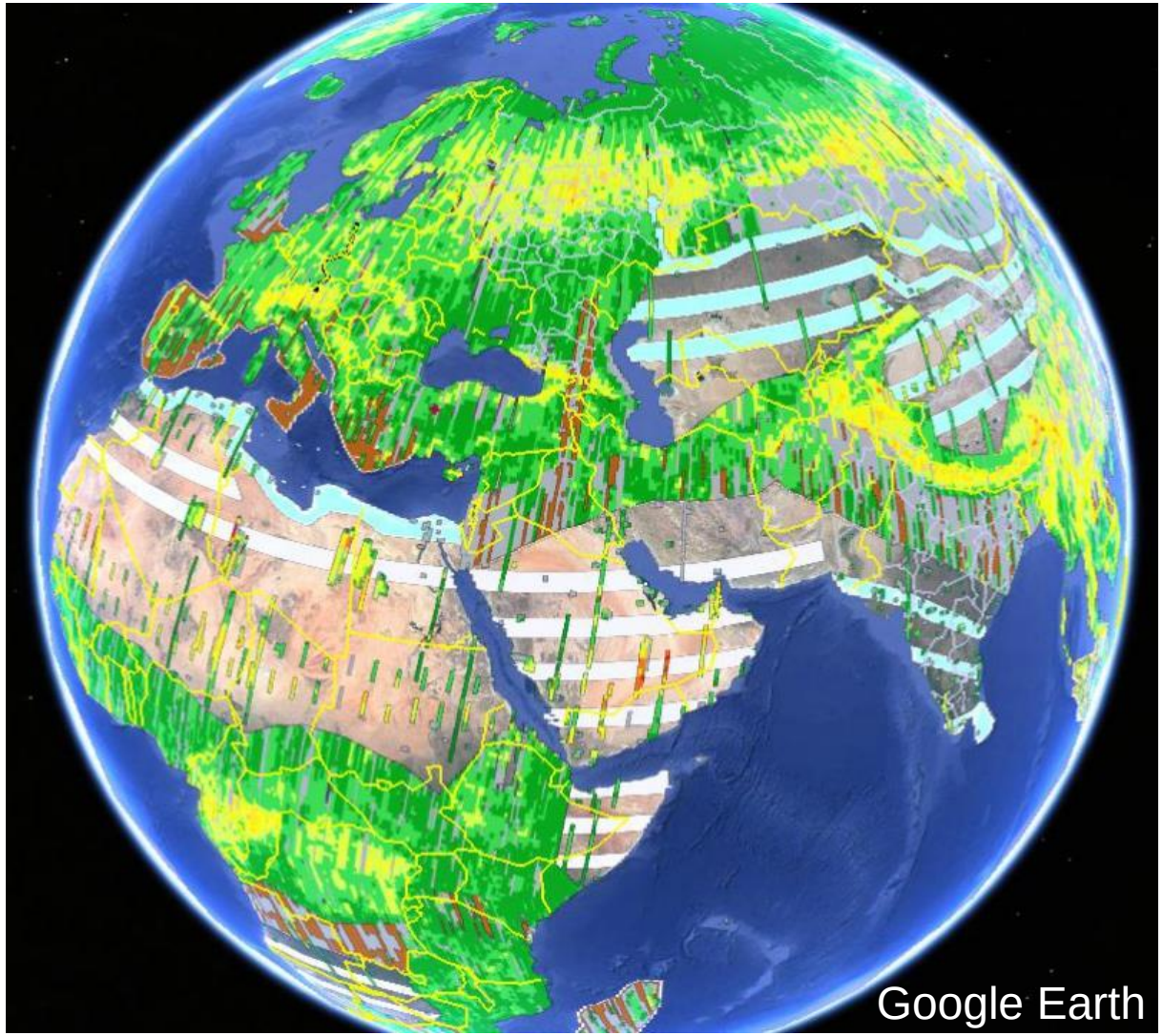
- “Diffusion Rate Limitation”:
  → Maximal data take duration limit and gliding window
  → more complex planning
- Average acquisition duration remains!

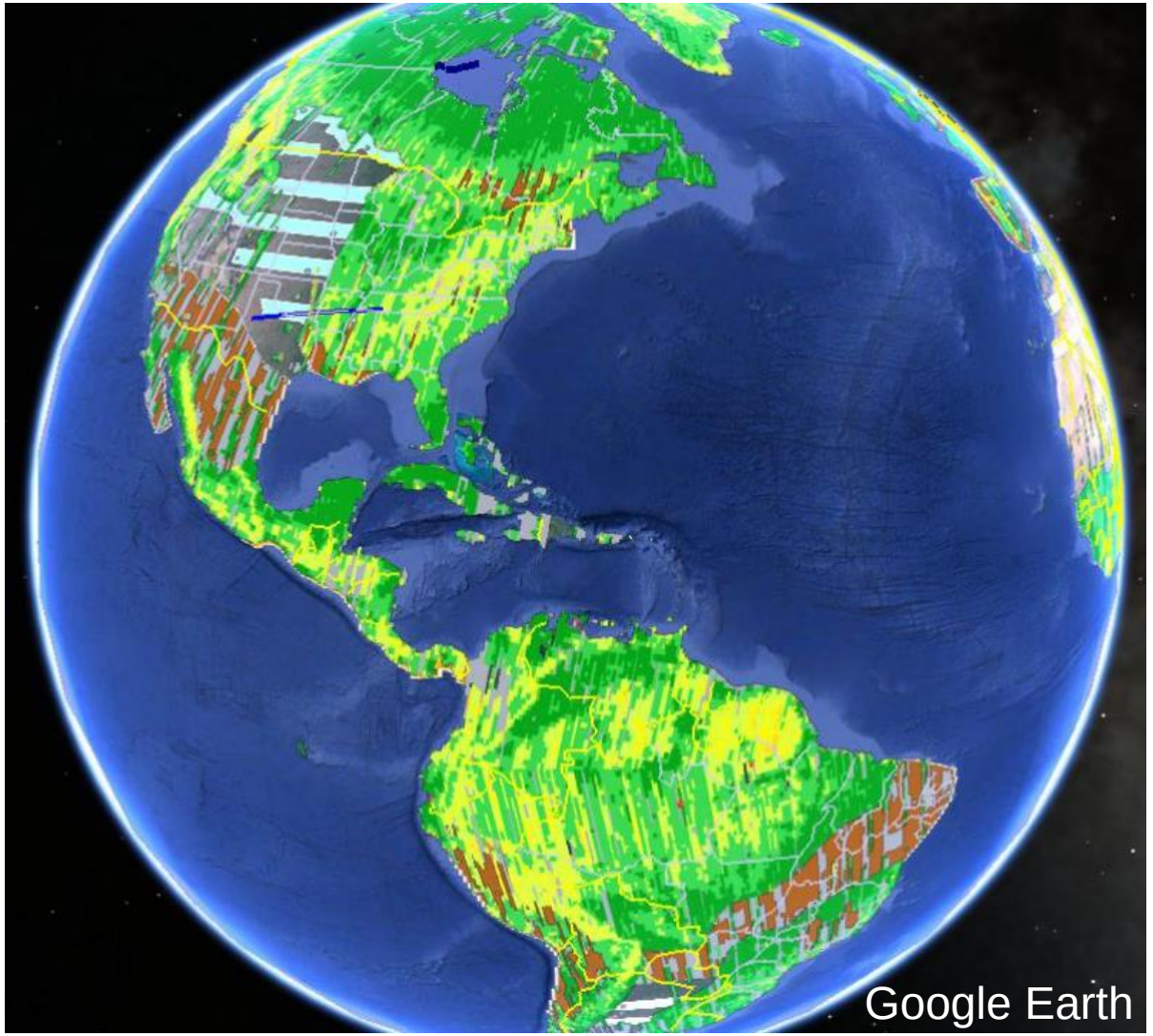




Battery is degrading
→ measures to prolong its life time

TanDEM-X 4D Phase – “Zebra-Crossing-Phase“





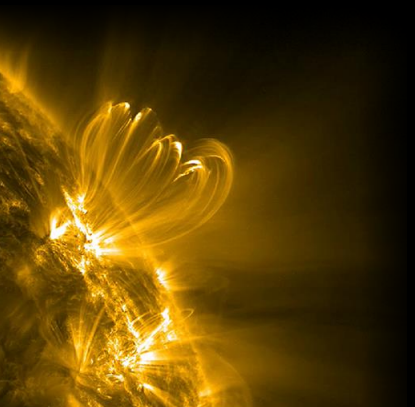
TanDEM-X 4D Phase – Conclusion

- TanDEM-X mission is successfully acquiring DEM data since 2010
- Global DEM (2011-2015): Airbus WorldDEM™ is the basis for the Copernicus DEM

- Second global coverage acquired between 2017 and 2020
- TanDEM-X 4D Phase since 2021 and aiming to complete a third global coverage
- Processed into DEM Change Maps and the Airbus WorldDEM Neo™

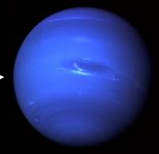
- Scientific community would benefit from an updated, higher resolved Copernicus DEM

Orbit 100.000 for TerraSAR-X on 2025-06-26



4.300.000.000 km

Neptune



Vienna in High Resolution

Thank you for your attention!