September 8, 2022

NKG National Report Denmark

Global Reference Fields

Trademark: ***Global reference fields (updated, improved)***

- DTU21GRA global marine free-air gravity field (NGA->EGM2022)
- DTU21MSS Vertical Offshore Reference fields (Ref: S3A/B, I2)
- DTU19MDT & Geostrophic circulation field (ESA)

New global reference fields

DTU Global VLM model (GIA+PDIL)

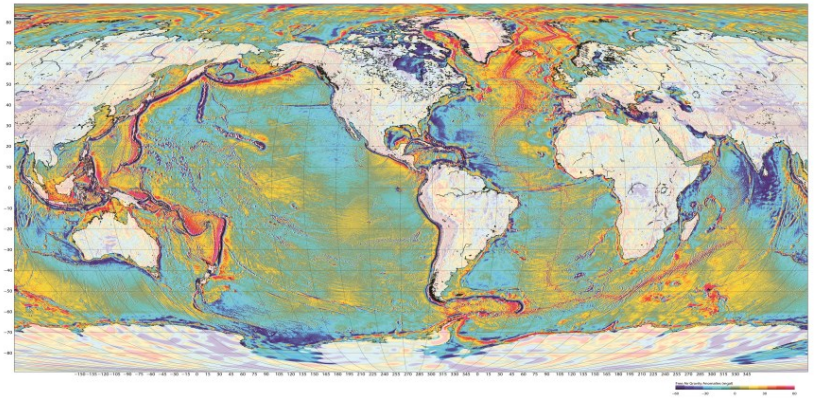
DTU21LAT for Offshore operations

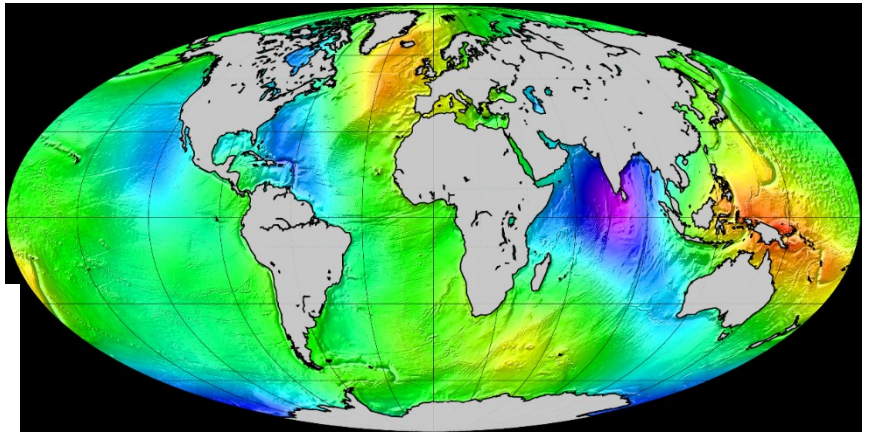
Requires extensive research on e.g.,

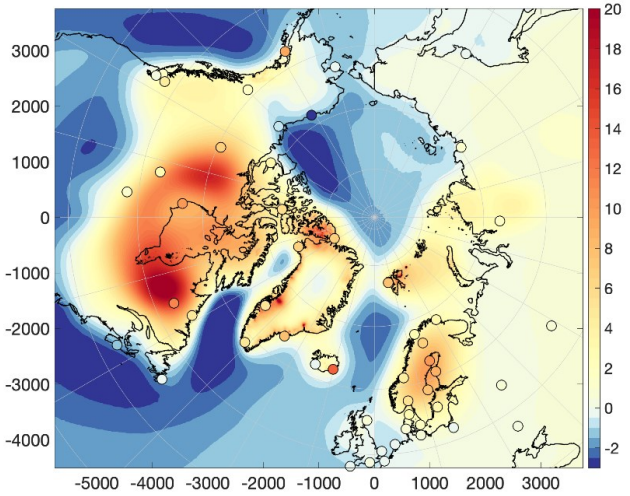
Total 20 Hz 2-pass re-tracking

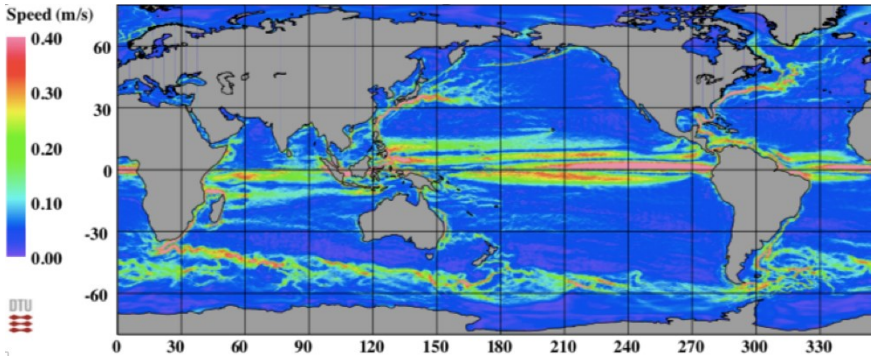
New high res 2Hz altimetry (10 km WL)

SAMOSA+ physical retracing (Cryosat-



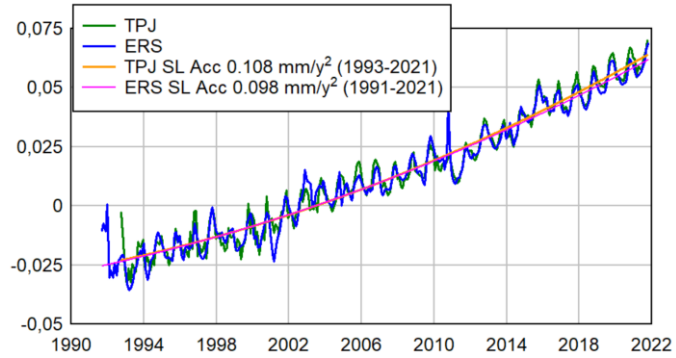


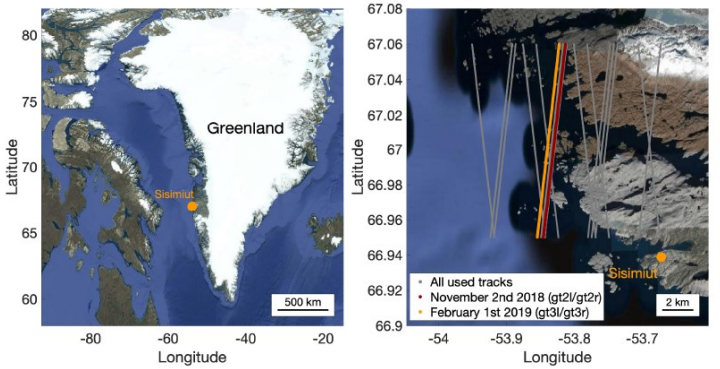


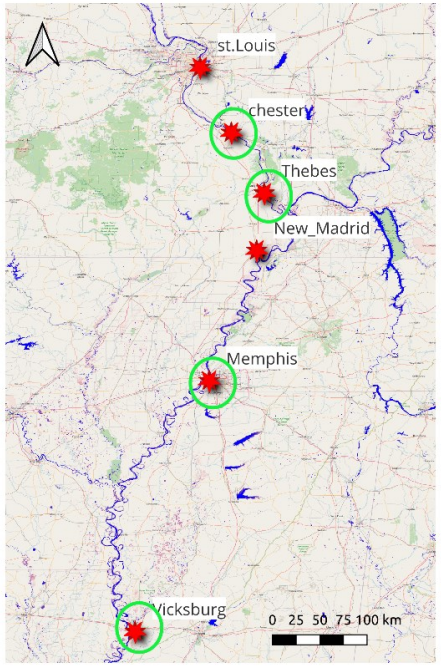


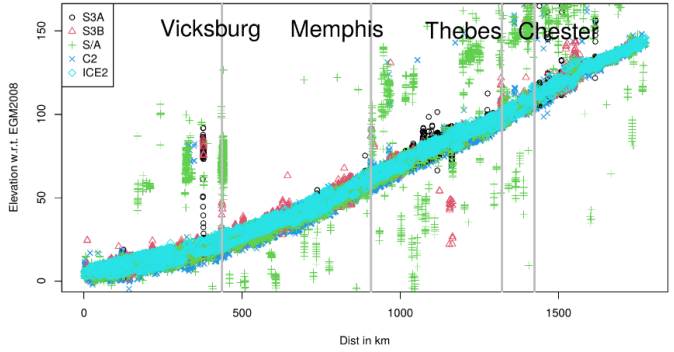
Main achievements, hydrosphere

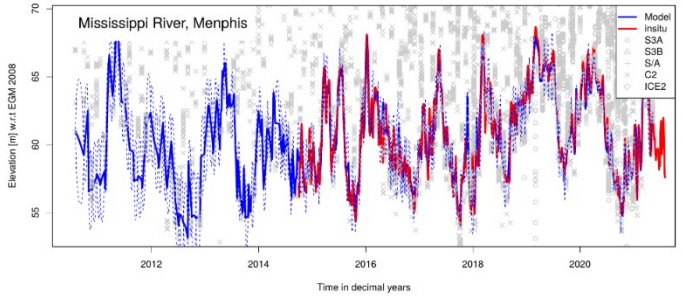
- Contribution to the Arctic observation system (EU funded H2020 INTAROS).
- Consolidating ongoing **sea level acceleration** with ESA satellites
- 30-year Arctic sea level record for enhanced Polar ocean oceanography (ESA funded)
- Coastal water monitoring with high resolution altimetry (S3A/B) (ESA)
- Coastal and river bathymetry with laser and radar (I2 + C2 FF SAR) (Danida+ESA)
- Multi-mission **inland water modelling** (water ressources) (ESA)

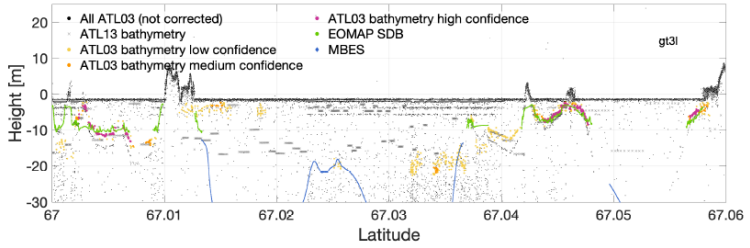


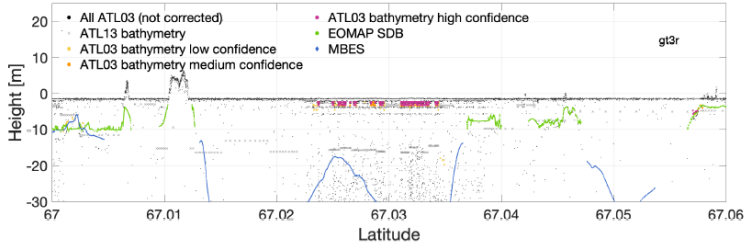


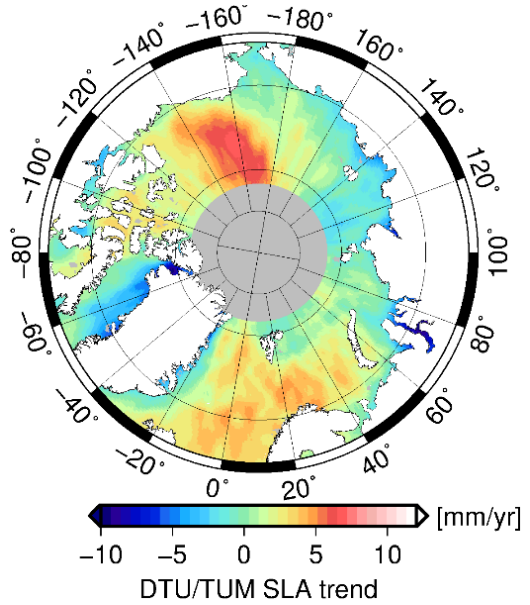








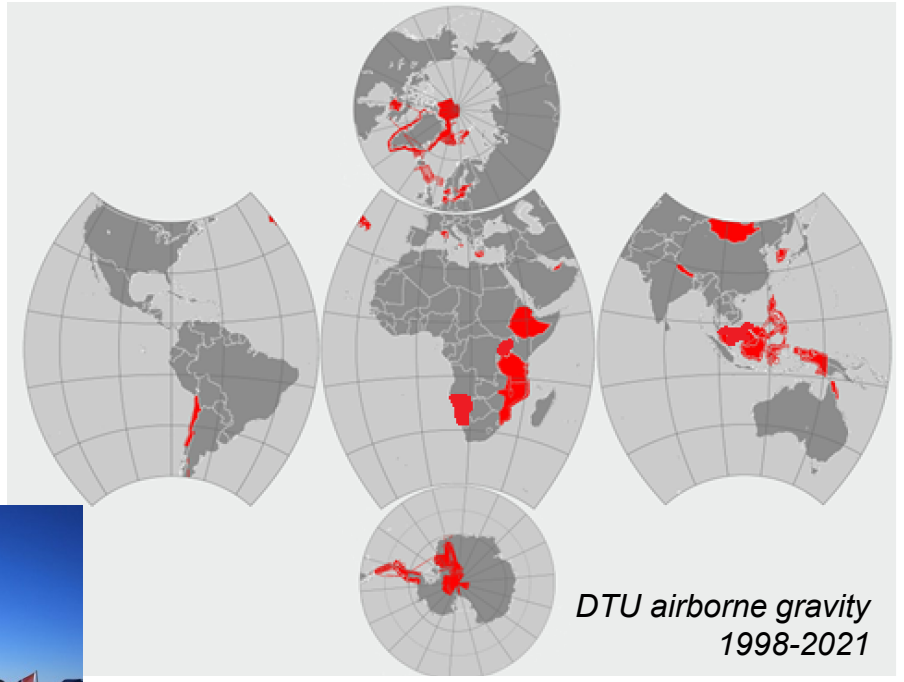




Gravity Field | Recent Activities

Maintaining geodetic infrastructure in Denmark, Greenland, Nordic and Baltic (SDFI)

- Terrestrial, marine and airborne gravity campaigns
- Gravity field modelling, Geoid computation, Gravity database, etc.



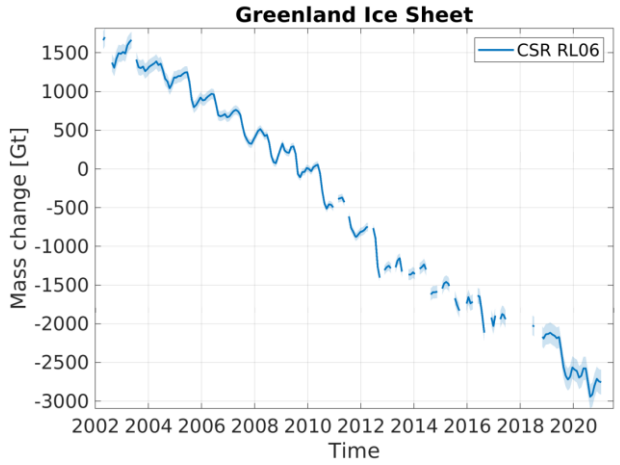
DTU airborne gravity 1998-2021

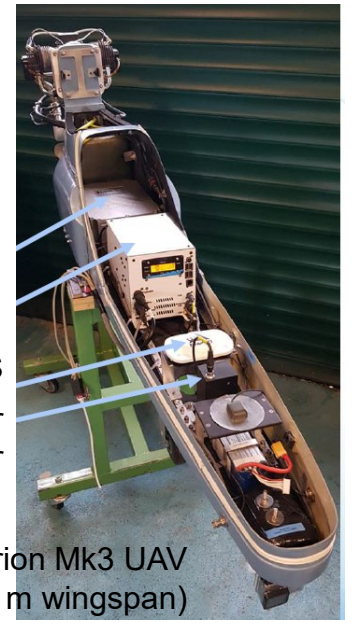
International Airborne Gravity Surveys (NGA)

- International infrastructure + teaching (GRAVSOFT)
- Support global model EGM2020

Research and Development

- 1st **cold atom gravity flight** with ONERA (Iceland 2017 and France 2019)
- UAV in polar regions (self-owned Penguin-B)
- 1st fixed-wing UAV gravity flight with UAVE (Wales, 2020)
- Close cooperation with iMAR navigation to develop strapdown gravimetry (testing prototype hardware)





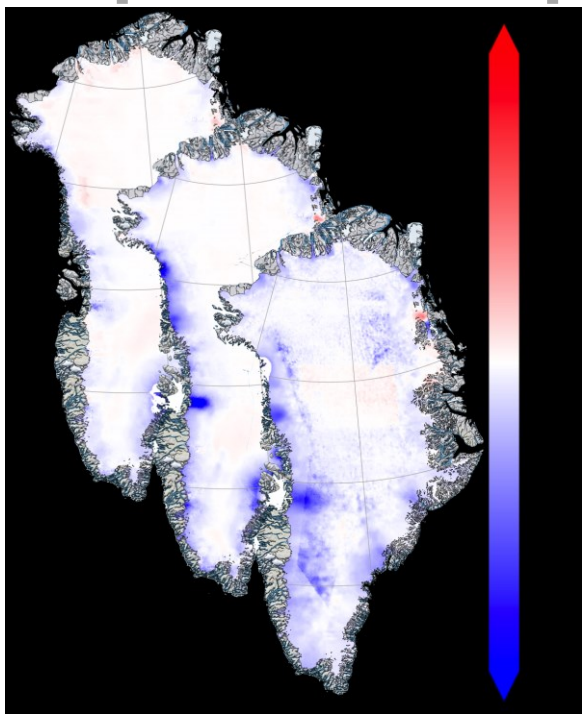
Prion Mk3 UAV
(3 m long, 4 m wingspan)

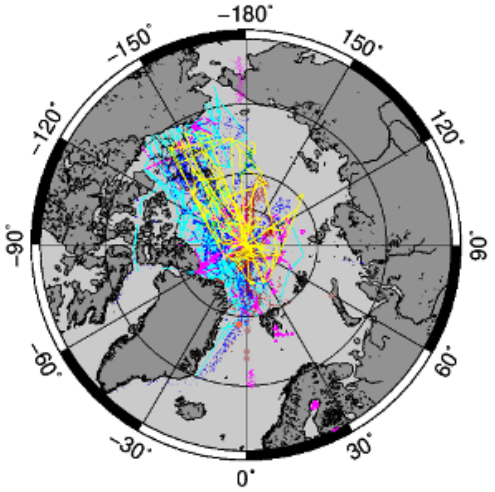
Main achievements | Cryosphere Group

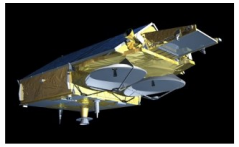
- **Essential climate variables of ice sheet**
  Elevation changes, mass changes, Copernicus Climate Change Service.

- **Essential climate variables of sea ice**
  Sea ice thickness, validation, ESA's Climate change initiative.

- **Arctic Airborne Campaigns**
  Planning, logistics, data processing, validation of satellite data.

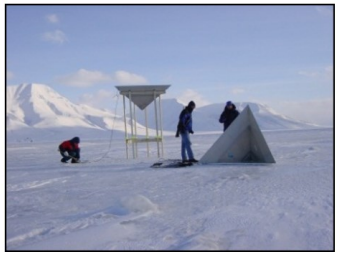






Global

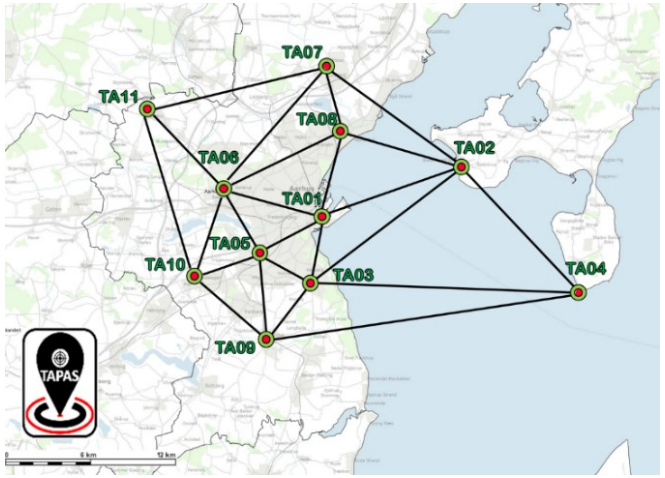
Regional

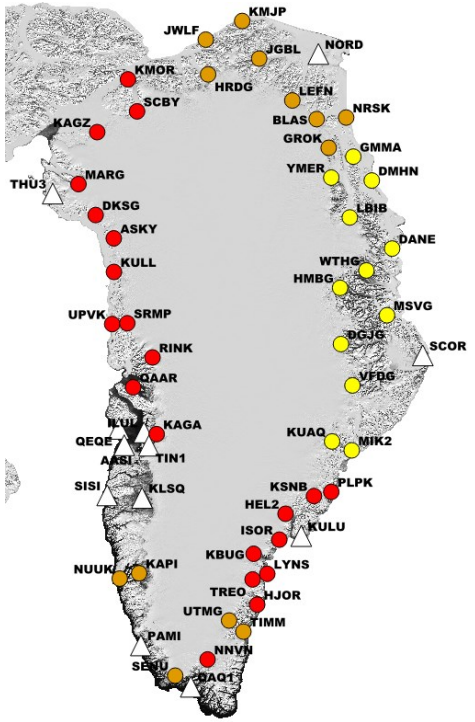


Local

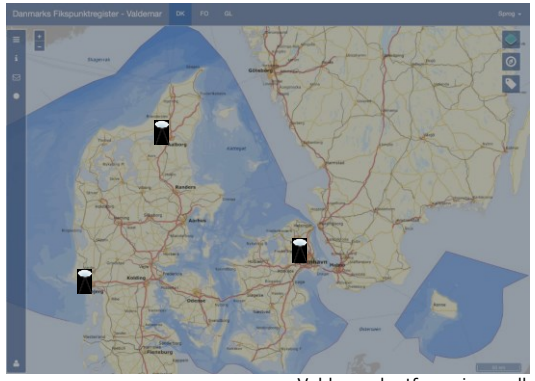
Foundation and development GNSS

- **New professor Lars Stenseng**
- **TAPAS** (SDFE)
  - Prepare for 5G
  - Real-time QC monitoring
  - Jamming analysis
  - Robust positioning
- **GNET** (SDFE)
  - Data reprocessed & database consolidated
  - (Near) real-time monitoring and QC
  - Real-





Foundation and development GNSS



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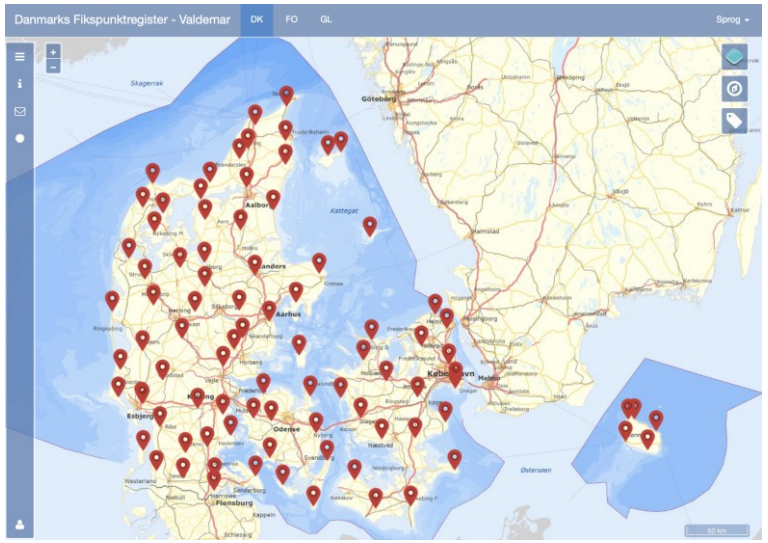
- **DANGO** (ESA)
  - Reference frame transformation
  - National geodata to/from GTRF
  - Galileo HAS QC
  - High bandwidth, low latency



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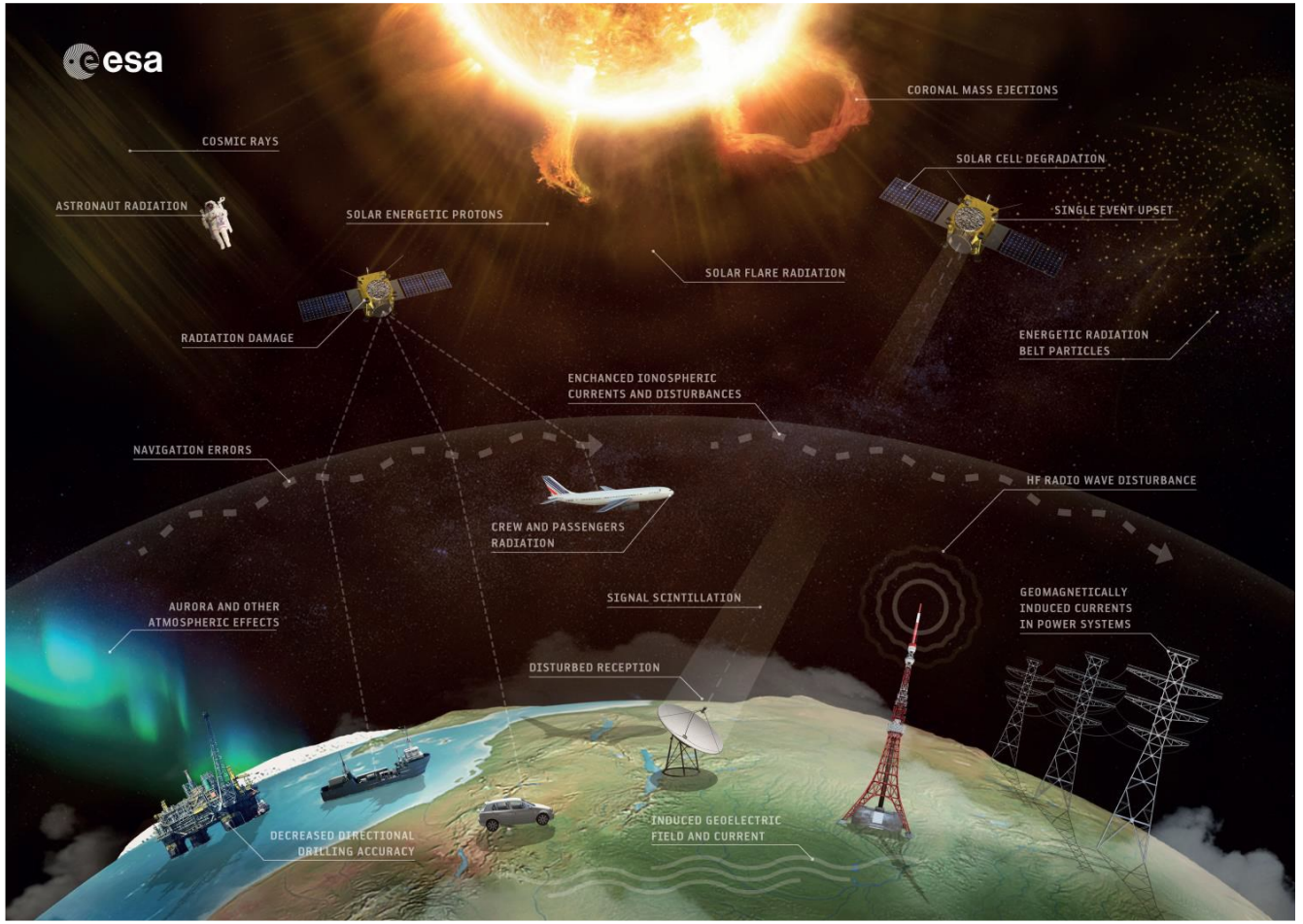
- **SWADO** (FMI)
  - Establish GNSS network
  - Ionosphere observation
  - Analysis of scintillation data
  - Coupling to geomagnetic observations

Space Weather & Space Situational Awareness

The SWADO project – forecasting!

Space Weather can cause:

- Severe disturbance on GNSS signals
- Severe disturbance of HF communication
- Induced currents in power systems
- Damage to satellites
- Decreased accuracy in directional drilling
- Corrosion in metal pipes
- Increased radiation in flights



https://www.esa.int/ESA_Multimedia/Images/2018/01/Space_weather_effects

Research fields Geodynamics

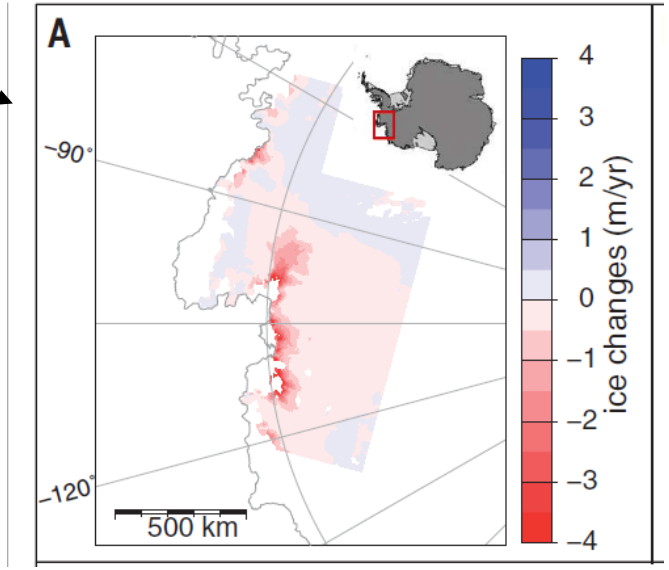
- Modelling and observing: **Solid earth dynamics**
  Cryosphere changes

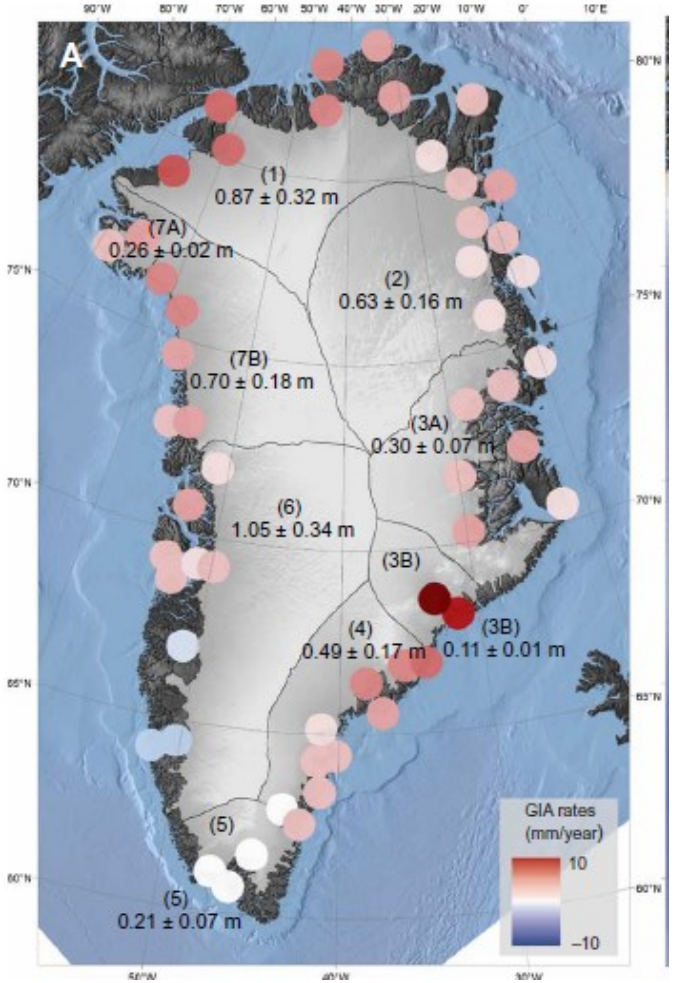
Solid earth: New **GIA model** in high impact journals:

Science Advances (Khan et al., 2016)
Science (Barletta et al., 2018)
2 x PNAS

Key data? GNSS data

2 new PhDs from 1 dec:
We know exactly what to improve/model
New 3D GIA model in 2022-24
6-8 paper





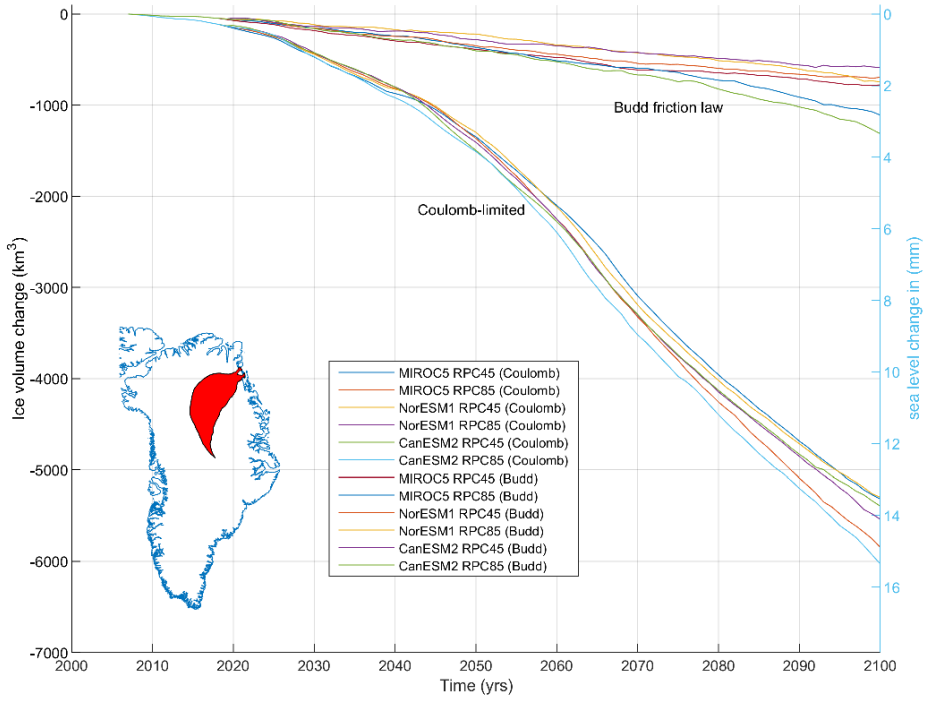
Research fields

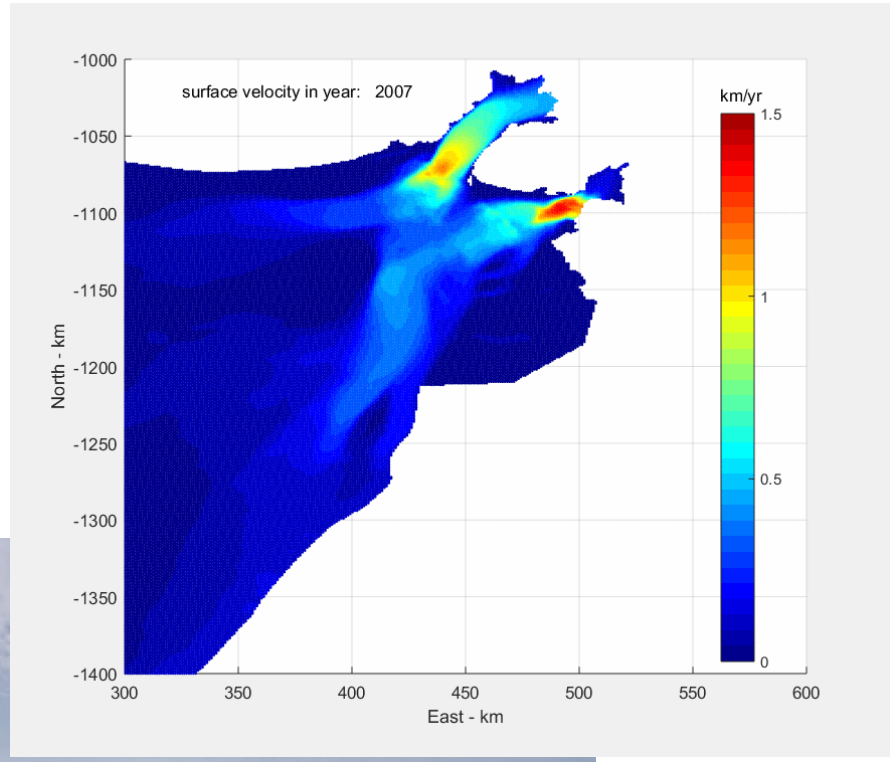
- Modelling and observing: Solid earth dynamics

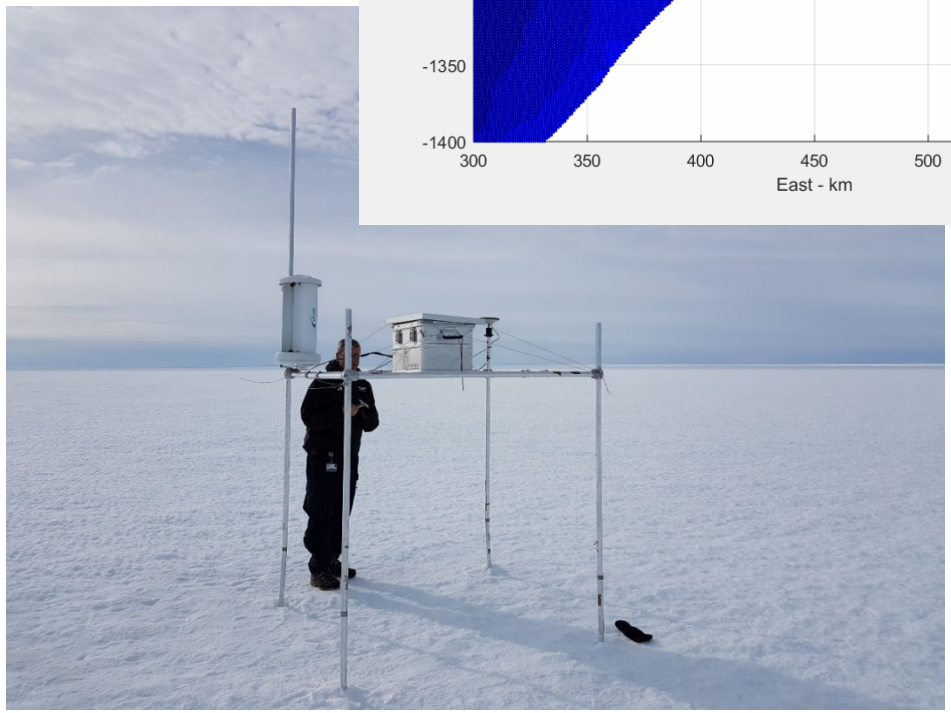
Cryosphere changes

Khan et al 2022 (*science*)

Key data GNSS on ice sheet







Research based advice & collaboration with SDFI

- Developing the 5 mm geoid
- Maintaining and develop MSL and gravity reference surfaces
- Uplift, gravity, ice melting, change in sea level
- Real-time dynamic positioning
- Robust positioning in urban areas using GNSS to support autonomy and mobility
- New height network using GNSS
- inSAR surface dynamics
- GR96 maintenance (Greenland)
- Tide gauge network

Photo: Lars Stenseng

Climate and Green Transition

- DTU Space contributes developing solutions for autonomy, mobility and smart cities exploring GNSS and sensor fusion.
- The long time series on key climate variable within hydro and cryosphere, land motion and gravity fields are important. These are published and utilized by the international community and contributes to the IPCC reporting.

Education

- **Earth and Space Physics and Engineering** (ESPE) are successful and well attended
- Summer 2022, 48 students started on the BSc program and more than 50 were admitted on the MSc
- **Core geodesy topics** are addressed in the dedicated study line “Mapping and Navigation” including satellite geodesy, physical geodesy, GNSS, Earth Observation for monitoring changes
- Associated topics: GIS, remote sensing, mapping and land surveying.
- The ESPE MSc program attracts a relative high number of international students from the DTU partner universities.

EARTH AND SPACE PHYSICS AND ENGINEERING

STUDY LINES
- Earth and Planetary Physics
- Earth Observation
- Mapping and Navigation
- Space Research
- Space Systems Engineering

JOINT INTERNATIONAL PROGRAMMES
- Cold Climate Engineering (N5T)
- Space and Geodesy (TUM)

ADMISSION
- With a bachelor from Denmark
- With a bachelor from outside of Denmark

Thank you very much for your attention!