

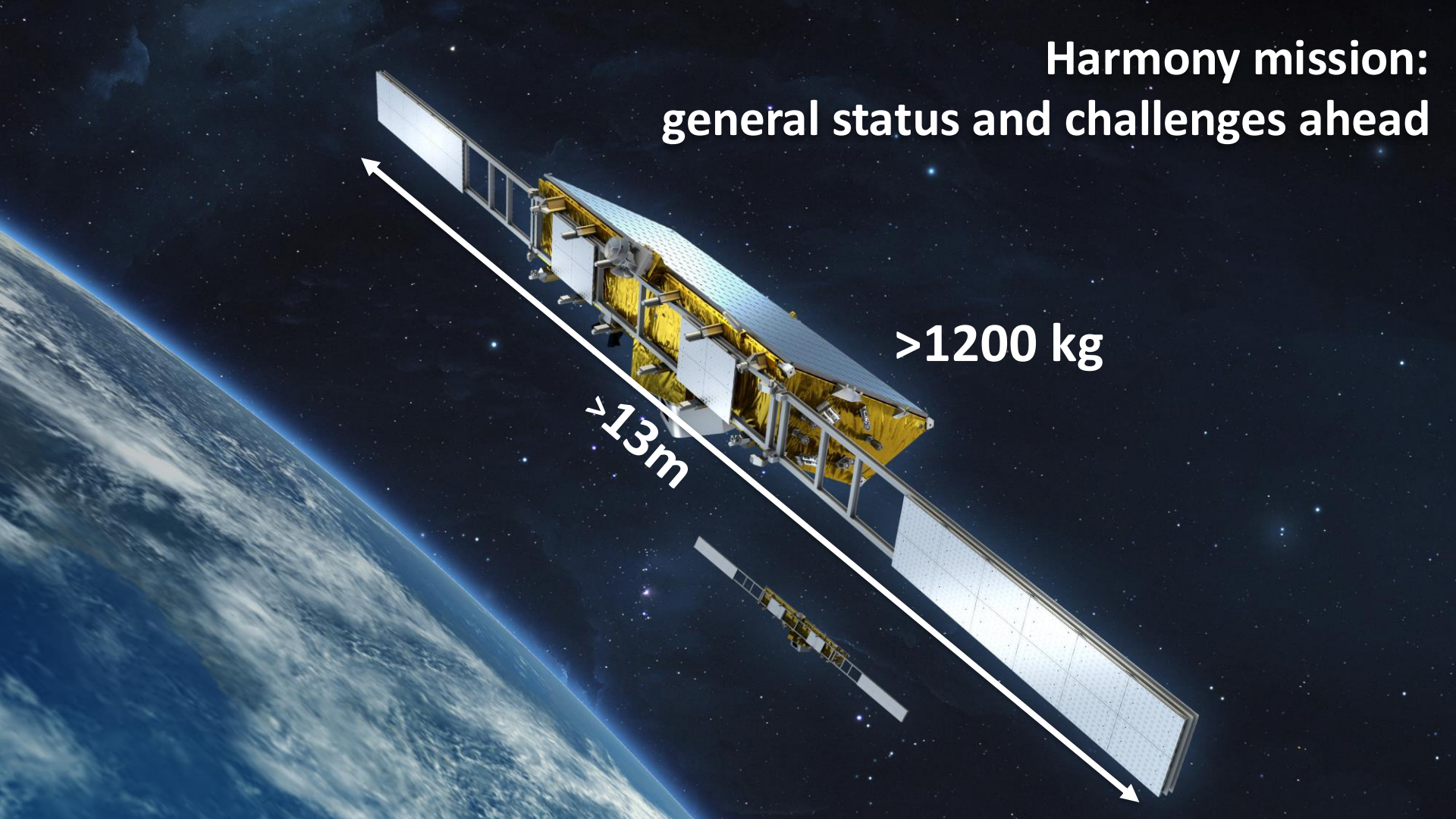
The background features a large, glowing blue globe of Earth with a network of blue lines and dots overlaid, suggesting a global data network. Three circular insets show: top-left, a glacier calving; top-right, a coastal erosion; bottom-left, a satellite view of a hurricane. The bottom of the image shows a turbulent ocean with white-capped waves.

harmony

**TO RESOLVE STRESS
IN THE EARTH SYSTEM**

Paco López-Dekker, Björn Rommen

Harmony mission: general status and challenges ahead



>1200 kg

>13m

A multi-domain “Earth System” mission



Upper oceans and ocean-atmosphere interactions



Land ice and sea ice

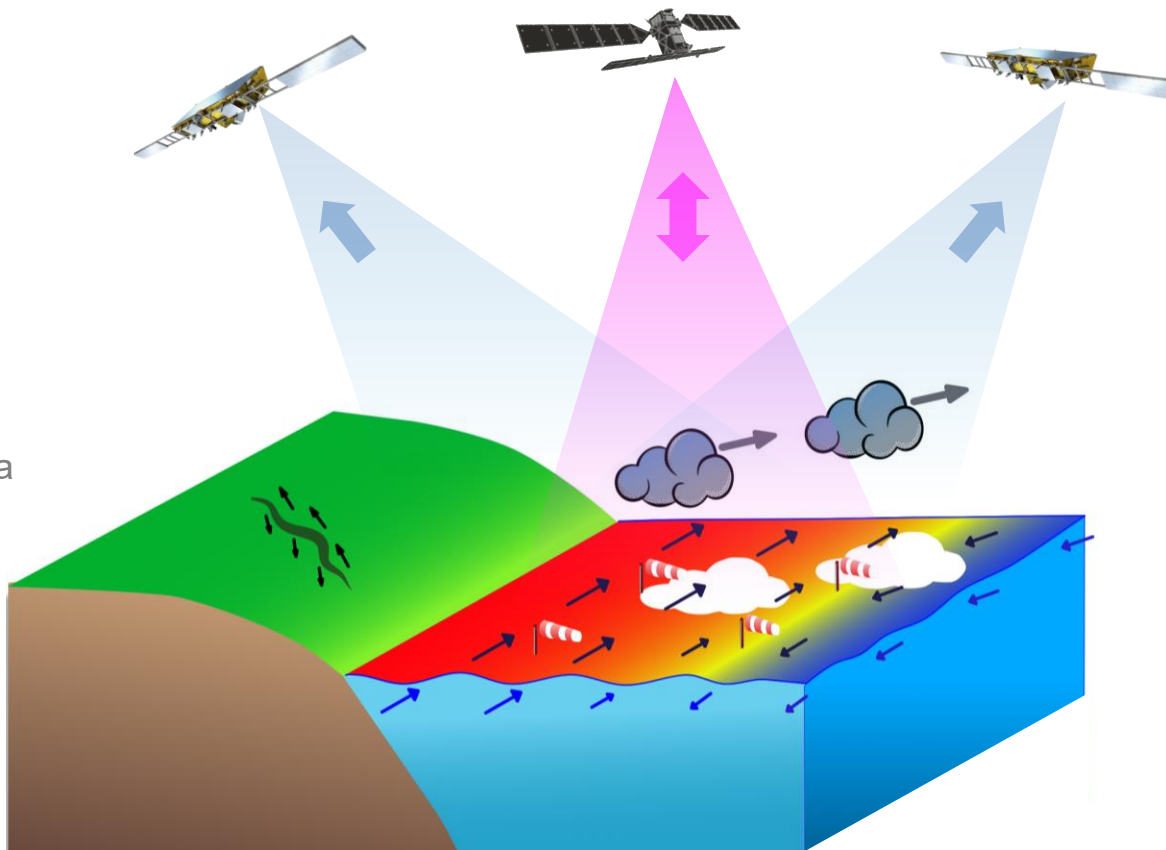


Tectonic strain and volcanic processes

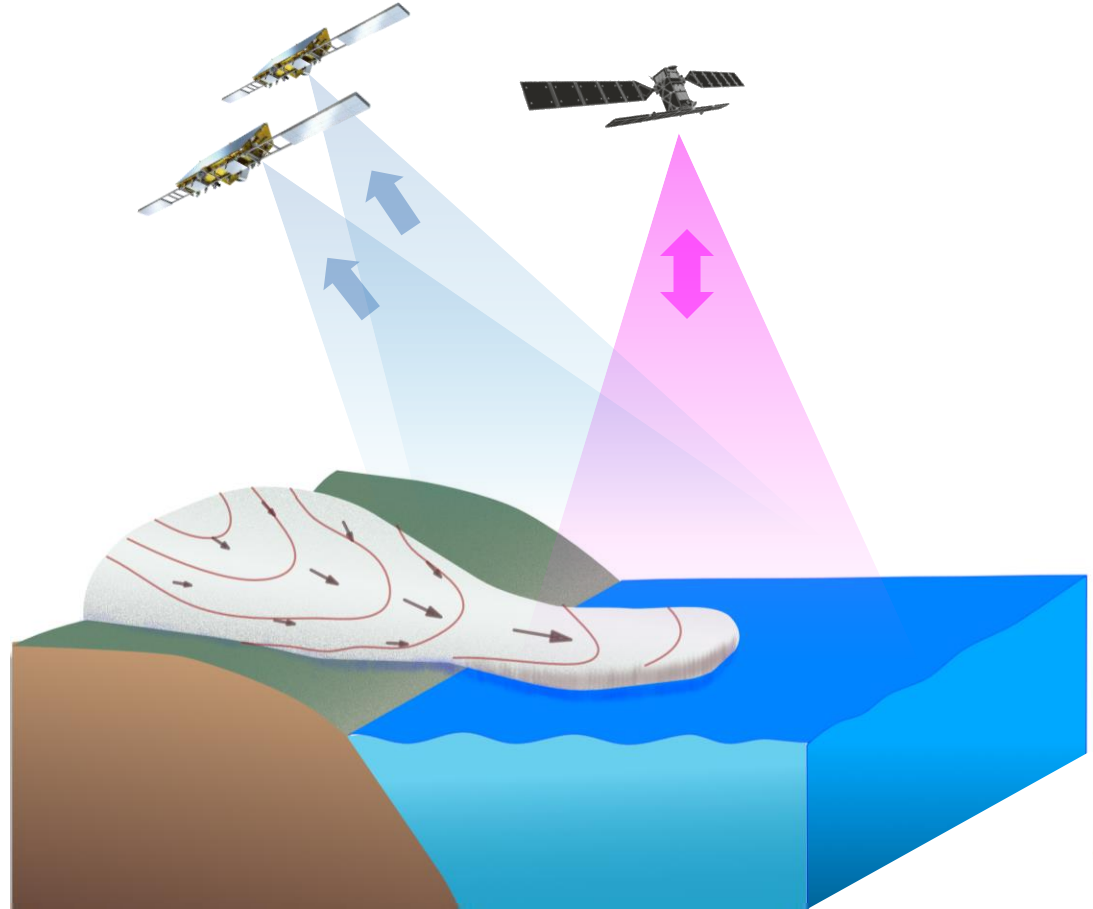
Observation concept: “stereo” phase

Line-of-sight diversity for high resolution

- **3-D surface deformation (DInSAR)**
- Ocean surface motion (Doppler)
- Surface winds (scatterometry)
- Improved directional surface wave spectra
- Sea Surface (skin) temperature
- Cloud-top motion (TIR time-lapse) and height (TIR parallax)



Observation concept: close formation phase



Single-pass cross-track interferometer

- **3-D surface deformation (as in Stereo)**
- **Surface elevation time-series**
 - Glaciers, permafrost, icebergs
 - Volcanoes
- Ocean-topography (experimental)

FRINGE-relevant product requirements

3D deformation



< 5% of velocity



< 100 x 100 m²



seasonal



Quantify multi-year average elevation change for most glaciers and ice sheet outlets, with a high spatial resolution of at least 100m, and sub-meter accuracy (OBJ-C11).



Observe 3D surface motion and deformation of glaciers and ice streams (OBJ-C22) and support of OBJ-C21



Constrain strain rate to detect variability down to 10 nanostrain per year (1mm/year/100km) (OBJ-G11)



Provide measurements of topographic change at active volcanoes with a spatial resolution of 30 x 30 m² (OBJ-G21).

Land Ice TOC



< 0.2 m/yr



< 100 x 100 m²



5 year

3D deformation



1 mm/year



100 x 100 m²



5 year

Solid Earth TOC

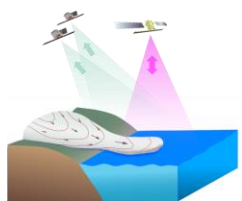


< 1 m

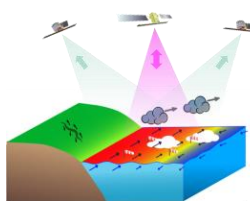


< 30 x 30 m²

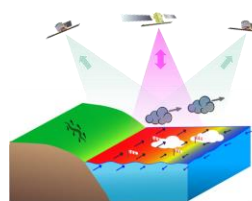
Mission Timeline



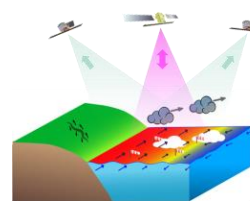
Y1



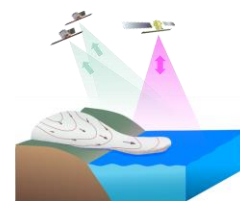
Y2



Y3



Y4



Y5

Ice Volume change

Glacier dynamics

Ice Volume change

Glacier dynamics

3-D Ice surface motion

Air-sea interactions

Atmosphere-ocean-extemes (Tropical Cyclones, Polar lows, etc)

Upper ocean dynamics

Tectonic Strain (3-D deformation)

Exp. Ocean topography

Exp. Ocean topography

Vol. change (volcanoes)

Vol. change (volcanoes)

Iceberg volume

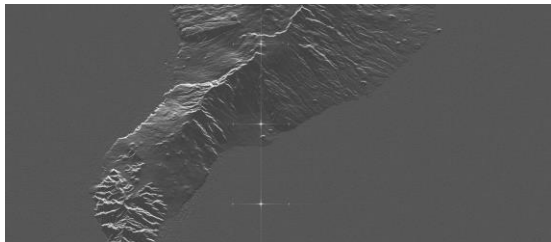
Sea-ice instantaneous motion/deformation

Iceberg motion

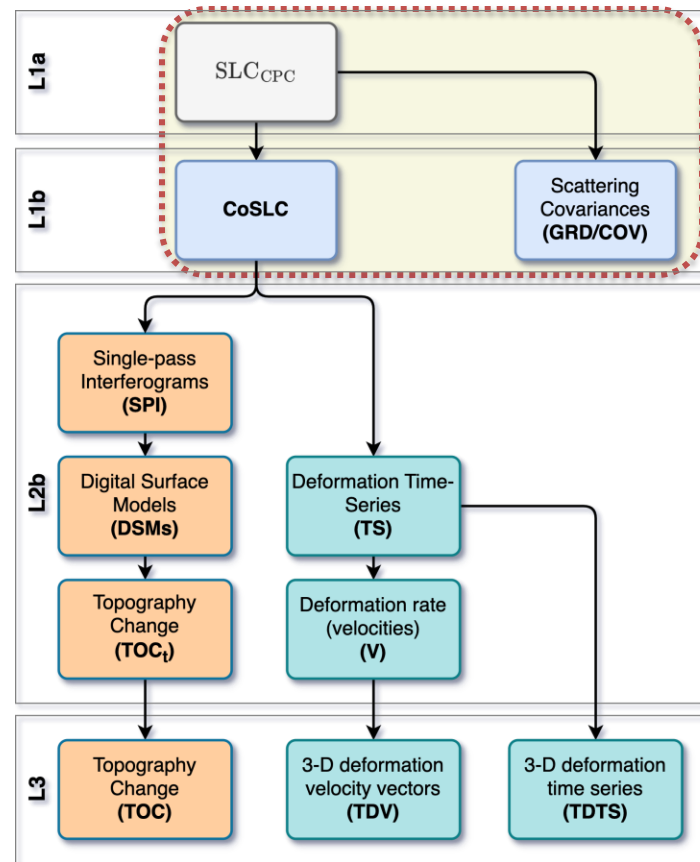
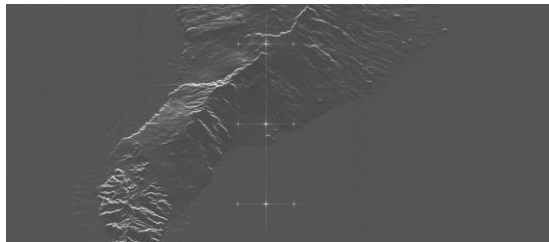
Solid-earth and land ice products: L1

- **SLC_{CPC}**: dual polarized combined phase center SLCs
- **CoSLC**: coregistered stacks
 - Single-pass InSAR pairs
 - Time-series
- **COV**: Geocoded and terrain corrected polarimetric covariance matrix.

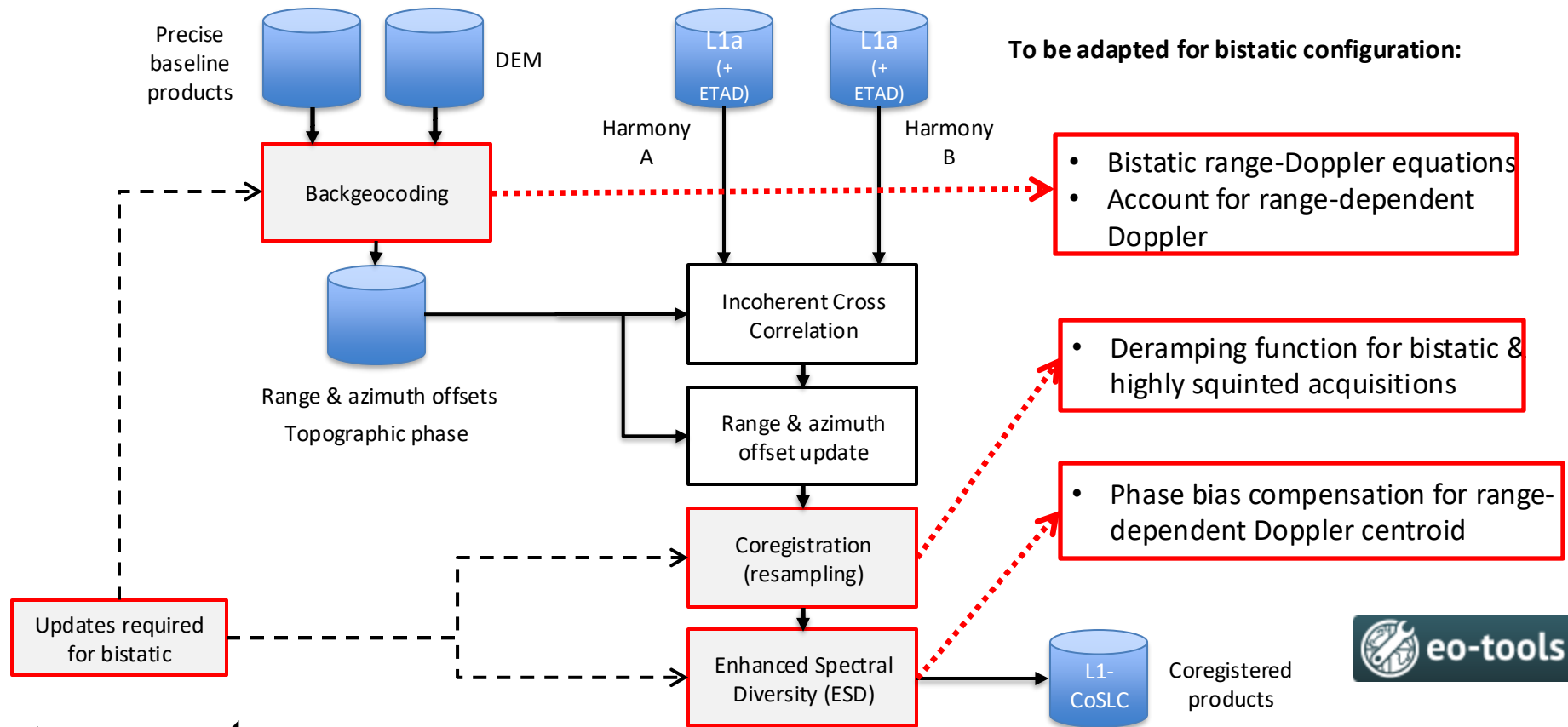
Monostatic (S1) SLC



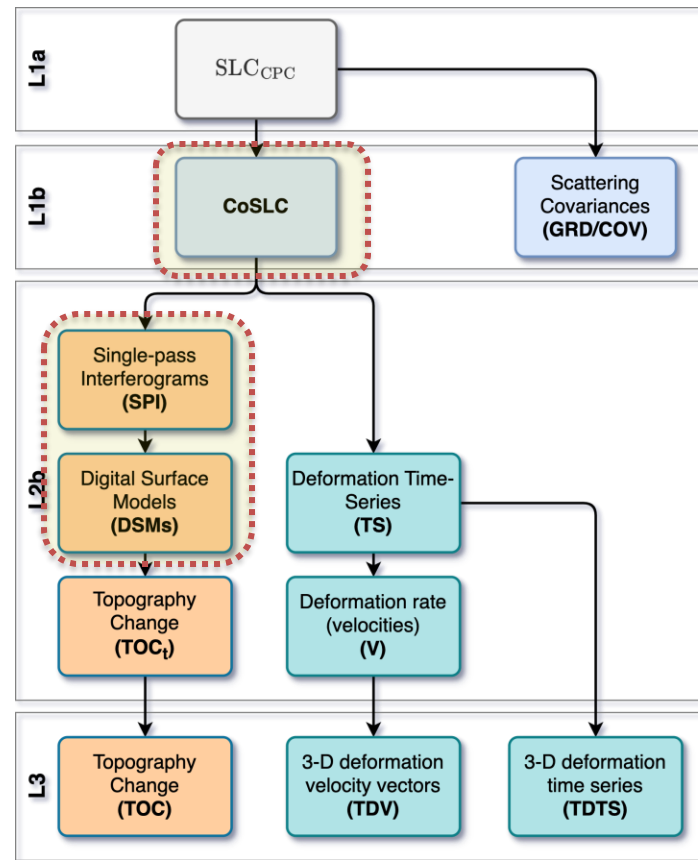
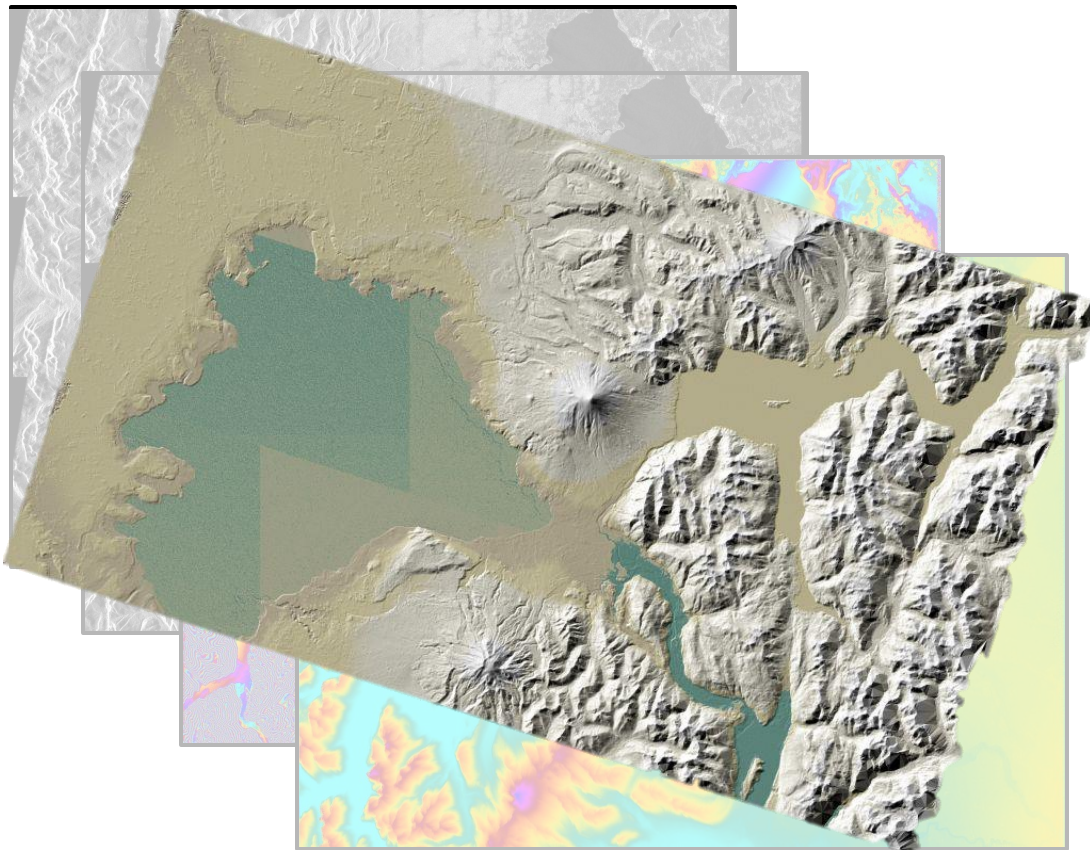
Bistatic (Harmony-A) SLC



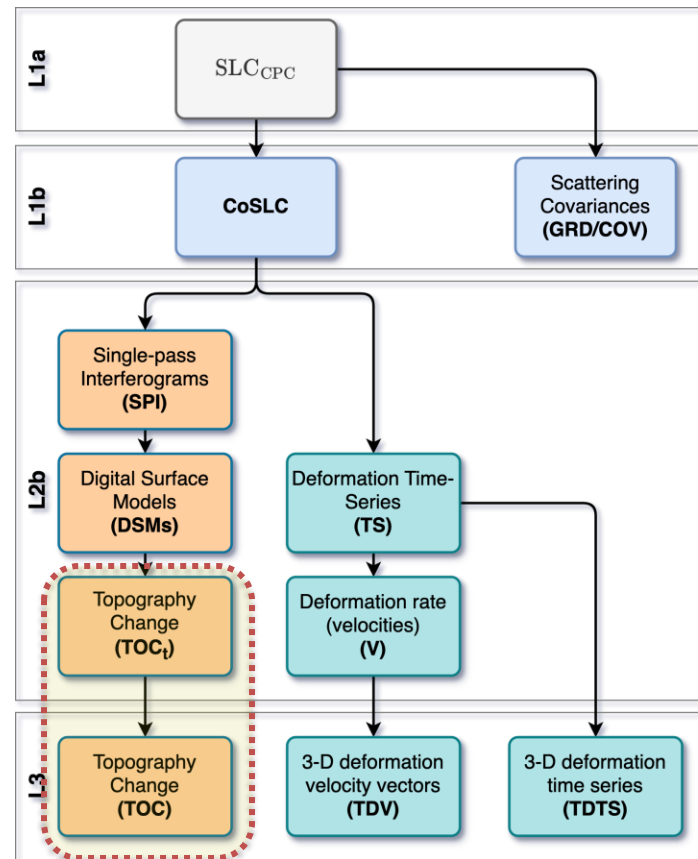
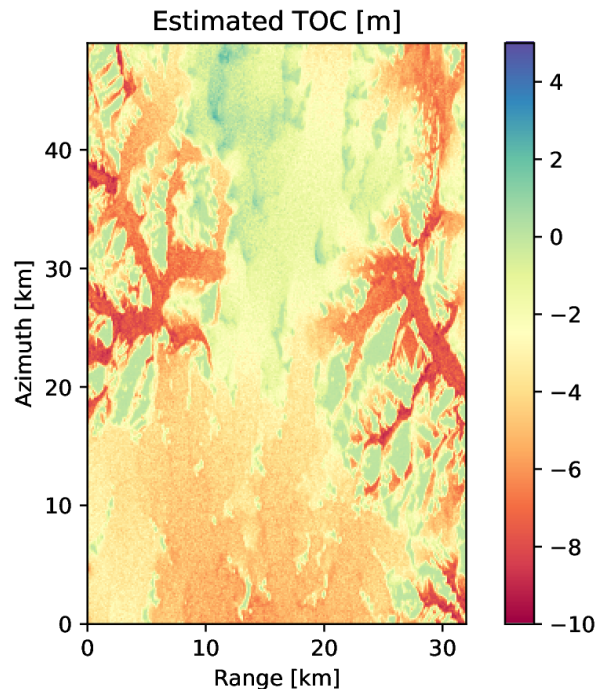
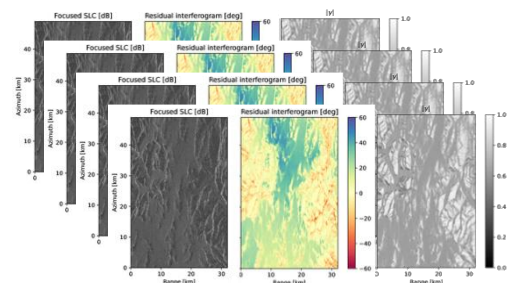
Towards bistatic coregistered SLCs



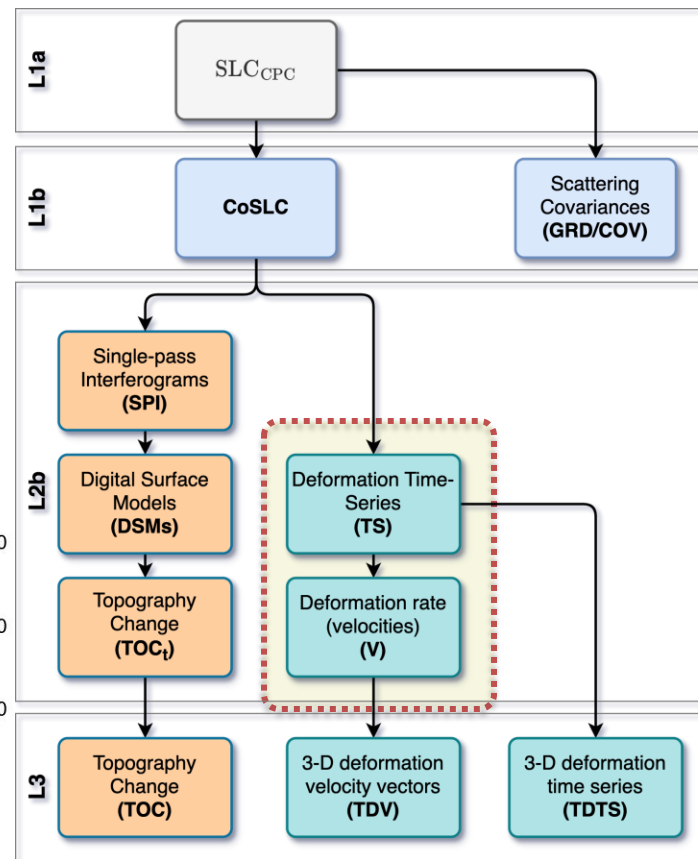
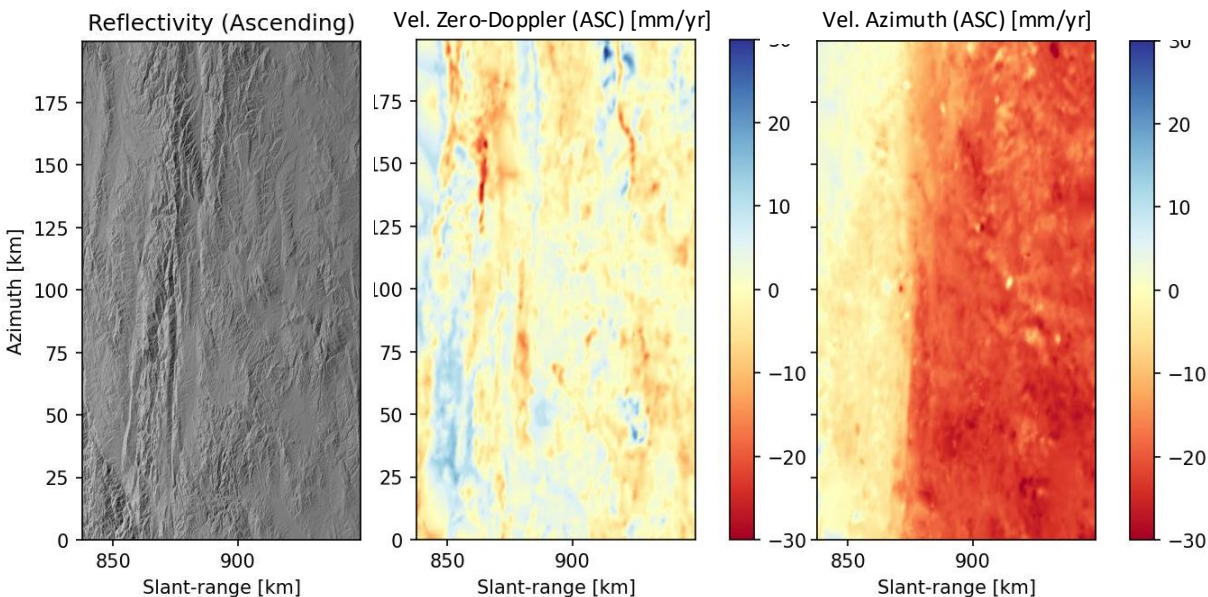
Single-pass interferograms



Topography Change (TOC)

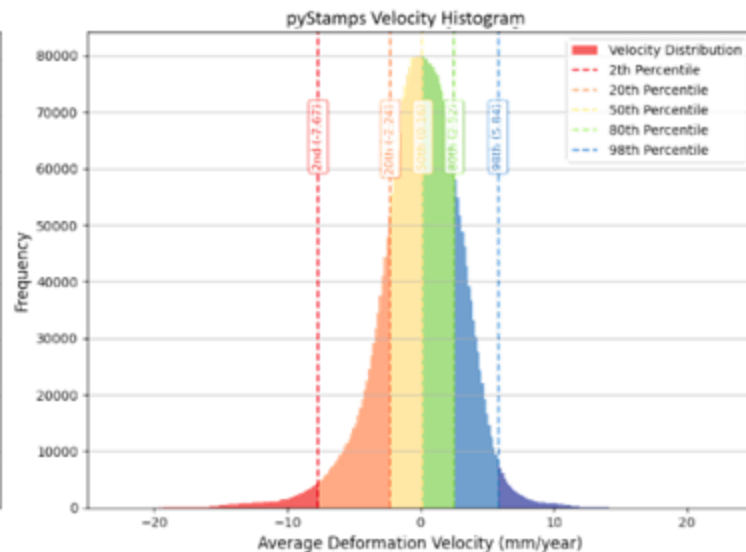
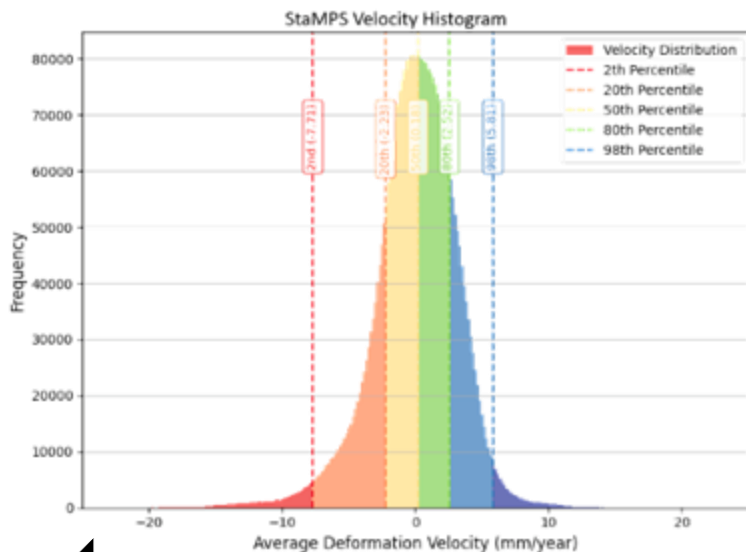


Deformation components

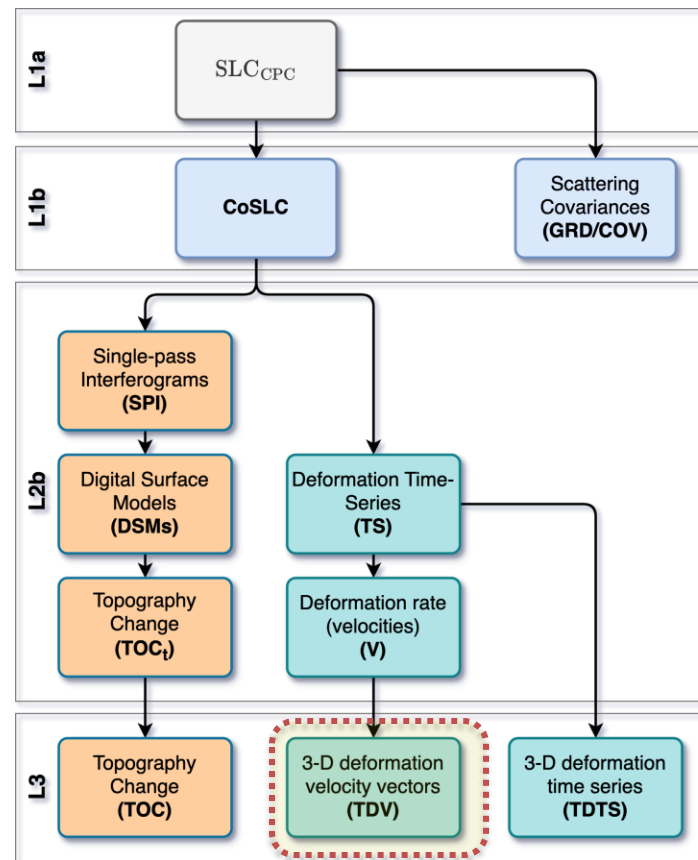
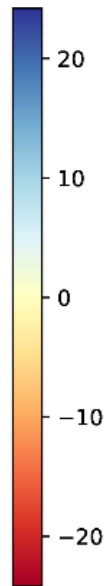
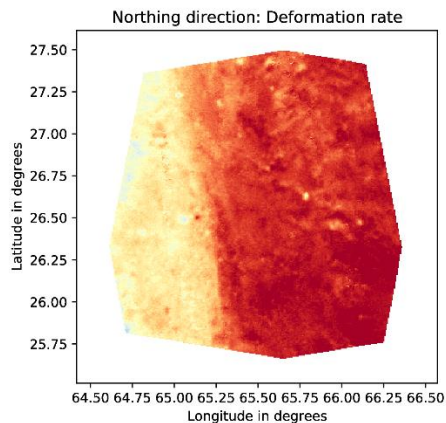
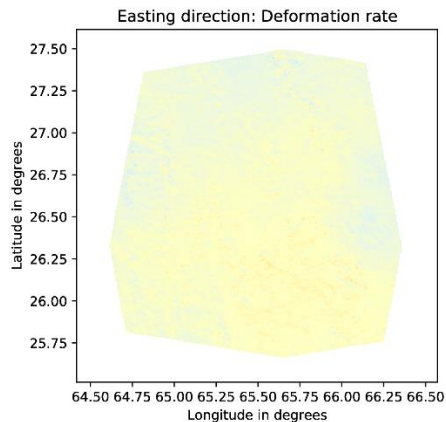
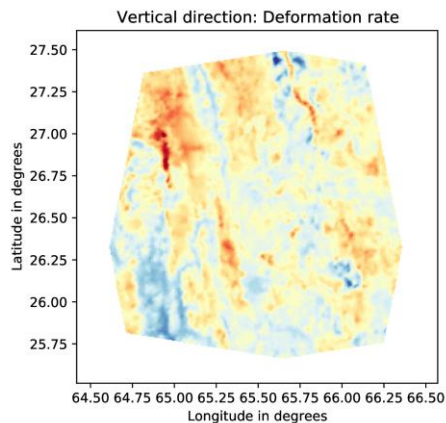


StaMPS → PyStamps

- **StaMPS** pythonisation (originally Matlab) currently implemented by KorrAI/Pi Space as **PyStamps**, under a permissive license.
- **Harmony** developments being developed by Pi Space in a new python version of the StaMPS code known as **StaMPy**.



Land Products



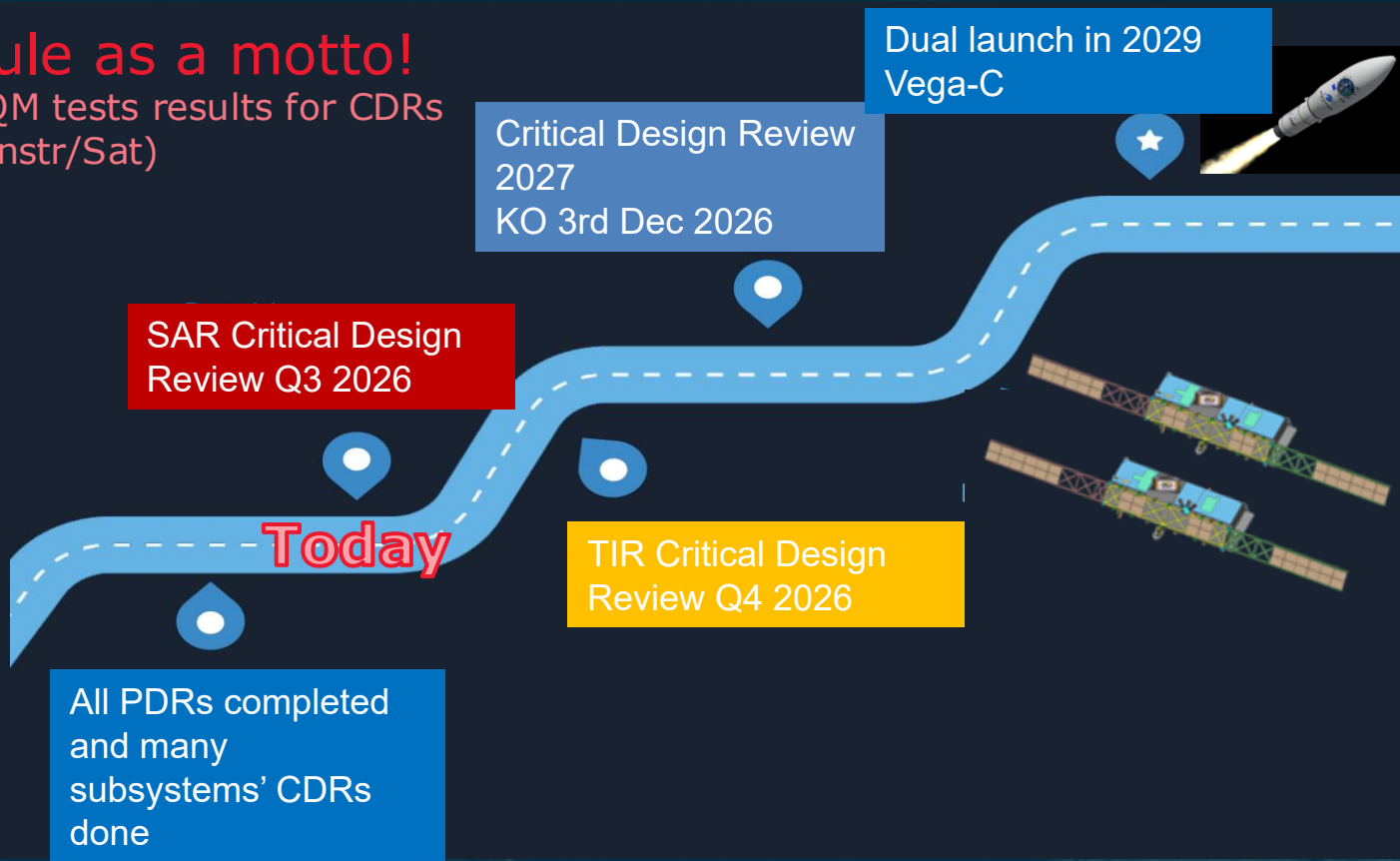
Status of science/processing activities

- E2E suite (HEEPS-Terra) continuously gaining fidelity and complexity (stay until Friday morning)
- ATBDs and prototype code
 - Time-domain + numerical $\omega - k$ algorithms in development (GAFA)
 - TDV+land: quite mature 3D-deformation + PyStamps/StaMPy
 - TDV+ice: baseline approach combining InSAR + speckle tracking
 - DEM/InSAR breadboard processor based on EO-Tools
- Validation strategy study recently started
- Development of operational processors will start after system CDR

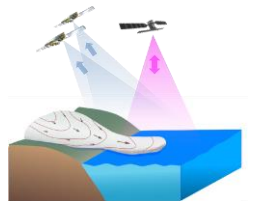
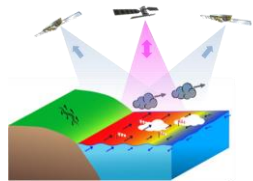
Harmony journey towards launch!

Meeting schedule as a motto!

- Availability of EM/EQM tests results for CDRs (e.g. Interfaces tests Instr/Sat)



Science outlook



Simultaneous,
 $O(1\text{ km})$ scale

SST

Cloud-top Motion

Directional roughness

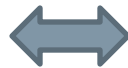
Directional Doppler

C-band = all weather

3-D repeat pass InSAR

Dense DSM time-series

Simultaneous,
 $O(50\text{m})$ scale



- Data driven ocean-atmosphere couplings and statistical characterization of vertical fluxes in ESM 2.0.
- Understanding of air-sea interactions within extremes.
- Sea-ice dynamics.
- **Global strain maps.**
- **Understand cycles of topographic change at volcanoes.**
- **Global and temporally consistent map of ice volume change (loss).**
- **Improved understanding of glacier dynamics.**

