LAND ICE RETRIEVAL FROM CRISTAL: DESIGN, DEVELOPMENT AND VALIDATION

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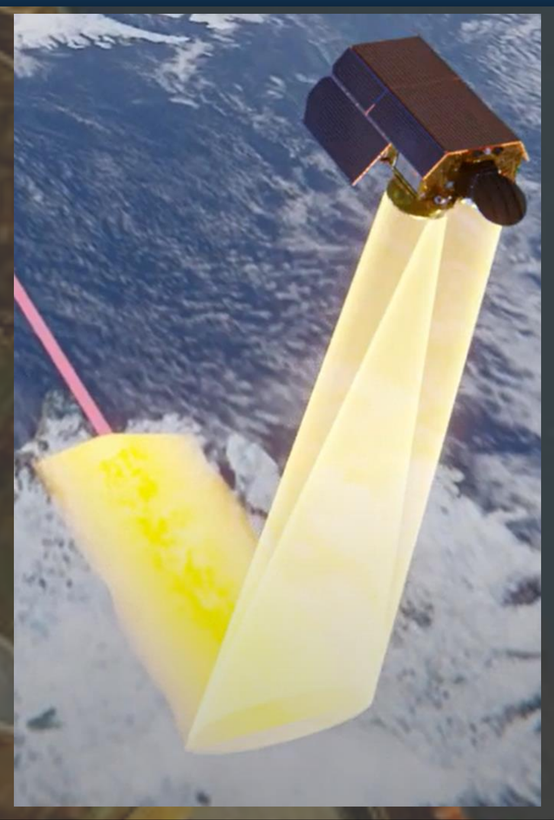
→ CRISTAL

Objectives: Monitor sea ice, icebergs, land ice, glaciers (primary), but also ocean, coasts and all inland waters

- High inclination mission (92 deg), continues the legacy of CryoSat-2, with improved performance
- Dual-frequency Ku/Ka SAR altimeter, Ku is interferometric
- Improved bandwidth: 500 MHz in both Ku and Ka
- Improved interferometric measurements with 50% improvement on elevation error
- Higher precision monitoring of icebergs, ice lead discrimination etc. with very high along-track resolution (up to 0.5m with fully-focused SAR processing)
- Addition of Passive Microwave Radiometer for wet troposphere correction (secondary mission objective) and potential contribution to ice and snow classification (primary mission objective)
- SARin over all ice surfaces
- Open burst over sea ice and icebergs: improved azimuth (along-track) resolution & range precision
- Flexible open loop/closed loop tracking everywhere
- AMR-CR radiometer with HRMR for oceanography, coastal altimetry, ice classification, snow parameters



Status: system PDR successfully completed early 2022 – Now in Phase C
On track for CRISTAL-A launch in 2027
(CRISTAL-B at some point in next decade)

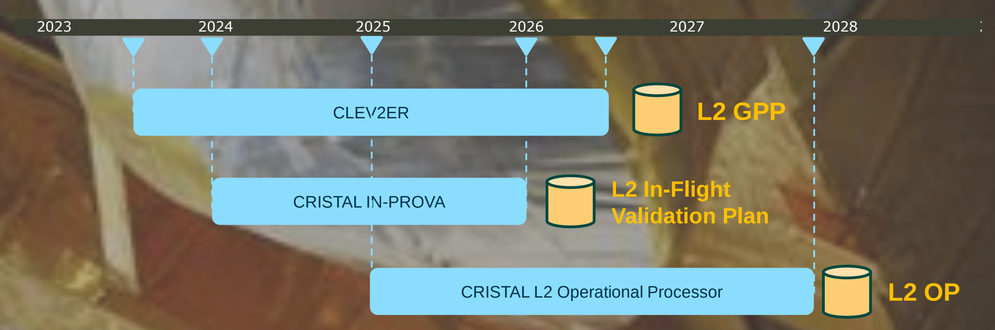
→ CRISTAL: land ice requirements

- CRISTAL shall be capable of retrieving surface elevation and surface elevation change over ice sheets, glaciers and ice caps.
- CRISTAL shall be capable of delivering surface elevation with a monthly temporal sampling and with an along-track resolution of at least 100 m.
- CRISTAL shall be capable of delivering a single-shot surface elevation with an uncertainty of 0.5 m over low slope terrain (<0.2 degrees) and 2.0 m over high slope terrain (0.2-1.5 degrees).
- CRISTAL altimeter shall as a minimum be able to track ice surfaces/glaciers with slopes up to 1.5°
- CRISTAL shall deliver Level-2 products with surface elevation measurements
  - from both POCA and Swath Processing
  - from both Ku and Ka-band

→ ESA CRISTAL Level-2 development approach

The CRISTAL Level-2 products and algorithms are planned to be provisioned and validated prior to launch with the following approach

1. A Level-2 ground processor prototype (L2 GPP) will be designed and developed in a first stage
2. The Level-2 operational processor will be developed in a second stage
3. In-Flight validation plan will be prepared to define methods and protocols for the validation of the CRISTAL Level-2 products versus Fiducial Refence Measurements (FRM)



→ CLEV2ER Land Ice and Inland Water

CRISTAL LEVel-2 procEssor prototype and R&D (CLEV2ER) is the project that is aimed at

- define a first version of the Level-2 product format for CRISTAL over the Land Ice and Inland Water domains
- develop CRISTAL Level-2 Ground processor prototype
- carry on R&D activities to support the definition and implementation of the most advanced geophysical retrieval algorithms for land ice and inland water

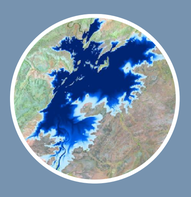
CLEV²ER

To define a first version of the Level-2 product format for CRISTAL, including fully traceable uncertainty

To carry on R&D activities to support the definition and implementation of the most advanced geophysical retrieval algorithms

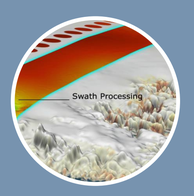
To adapt and implement geophysical retrieval algorithms in order to develop CRISTAL Level-2 Ground processor prototype

To provide a set of CRISTAL Level-2 product cases to be distributed to the Community

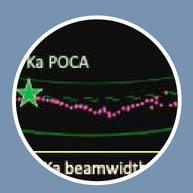


Verification of the capability to estimate water body extent using FFSAR and water height using swath processing

Algorithm development for the retrieval of penetration depth from dual band altimetry

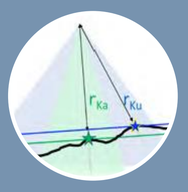


Assessment of the limitations and applications of combining FFSAR and swath processing

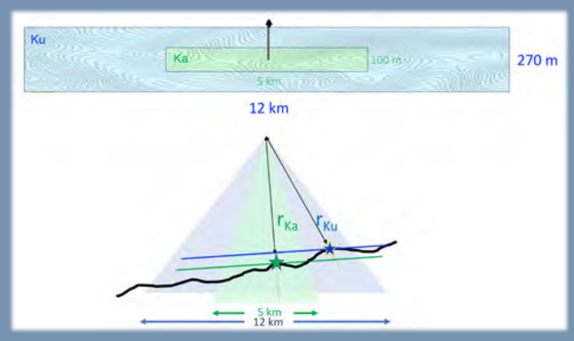


Optimisation of Ka-band slope correction algorithms

Lake ice thickness retrieval [2]



Assessment of the divergence of Ku and Ka POCA's over ice sheet surfaces [1]



(1) STATE OF THE ART IN MULTI-BAND ALTIMETRY OF THE CRYOSPHERE REPORT OF THE DUAL-CRYO WORKSHOP 13–14 JANUARY 2021, ESA-EOPSM-CPTM-RP-4038
(2) A. Mangilli, P. Thibaut, C. R. Duguay and J. Murfitt, "A New Approach for the Estimation of Lake Ice Thickness From Conventional Radar Altimetry," in IEEE Transactions on Geoscience and Remote Sensing, vol. 60, pp. 1-15, 2022, Art no. 4305515, doi: 10.1109/TGRS.2022.3186253.