



The Future of Altimetry of the Cryosphere

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Scientific Challenges

- Snow depth on marine/land ice - to better understand solid precipitation/freshwater balance at high latitudes
 - Variability and trends in Antarctic sea-ice thickness
 - Ice sheet instability and onset of irreversible changes (using EO+in-situ+models)
 - Information products (derived from high-lat. fundamental data records) for decision-making risk-assessments.
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- **Recommendation 1:** Continue development of dual-freq measurement capability on marine and land ice to better understand snow depth, impact on thickness retrievals, and to understand freshwater balance;
 - **Recommendation 2:** Improve capability to measure variability & trends in Antarctic sea-ice thickness;
 - **Recommendation 3:** Develop information products for climate risk assessments based on fundamental polar time-series such as ice sheet mass loss;
 - **Recommendation 4:** Improve dialogue and co-production between climate/ice/ocean modellers, EO specialists, Copernicus service providers, space agencies and policy makers.

Technical Challenges

- Dual-frequency, high bandwidth, multi-antenna, fully focused, multi-purpose SAR / interferometric Swath Altimetry
 - Intelligent open-loop tracking (with ability to refresh DEM in dynamic topography)
 - Polarisation diversity (?)
 - Radar Altimeters optimised for use on SmallSat constellations to improve time-space sampling
 - Combined altimeter/imager or radar/laser concepts
 - Optimisation of altimeter orbits and Copernicus observing system architecture to maximise multi-mission collocated sampling.
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- **Recommendation 5:** Continue progressive evolution in altimeter capabilities - ensuring enhanced continuity;
 - **Recommendation 6:** Pursue possibility of high latitude snow/ice altimetric capabilities using SmallSats;
 - **Recommendation 7:** Community to actively propose innovative new cryosphere (Explorer / other) mission ideas.

Challenge of Transition from Research to Operations

- Research and 'User' community efforts needed to transform perception of importance and priority for operations and climate action of polar altimetry in Copernicus Expansion
- Aim to secure a stable, well calibrated, operational time-series - with complementary observations such as SAR and optical imaging capabilities
- Operational Polar Altimetry needs to assure overlap / continuity of critical polar climate data records
- **Recommendation 8:** For ESA, ESSC and EU to investigate establishing a User Forum, bringing altimetry experts, ice and climate modellers, and societal decision makers together to establish and promote high-profile climate-cryosphere altimetry future priorities.
- **Recommendation 9:** Pursue systematic airborne capability for Cal/Val and airborne mapping of polar regions in conjunction with EC (see also; Sterckx et al IJRS 41, 12 4496-4511 – Towards a European Cal/Val service for Earth Observation).