

SAR Coordination Working Group

Update for 2015 and Plans for 2016-18

The Polar Space Task Group (PSTG) was established under the auspices of the World Meteorological Organization. The PSTG provides coordination across Space Agencies to facilitate acquisition and distribution of fundamental satellite datasets, and to contribute to or support development of specific derived products in support of cryospheric and polar scientific research and applications. In order to assist with the collection and utilization of spaceborne synthetic aperture radar (SAR) data sets, the SAR Coordination Working Group was subsequently formed by the PSTG.

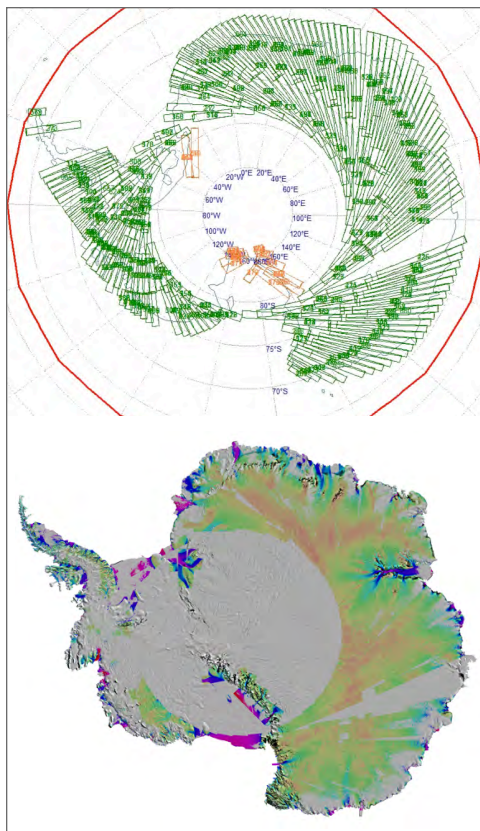
WMO / PSTG

http://www.wmo.int/pages/prog/sat/pstg_en.php

Continued SAR Data Collections with Broadened Thematic Scope

The SAR Coordination Working Group is focused on supporting polar science with the acquisition of synthetic aperture radar (SAR) data. Efforts to collect data by various space agencies are guided, in part, by thematic areas where SAR data is of particular value to scientific research. Four thematic areas have been identified: ice sheets, floating ice, permafrost and terrestrial snow.

The SAR CWG works with scientists from around the world to understand their particular polar research topics and, to the extent possible, coordinates data acquisitions to meet their SAR data requirements. Teams of scientists with expertise in the four theme areas



An ambitious plan for continued interferometric SAR data collection over Antarctica emerged as a result of coordinated space agency and science community activities. A comprehensive set of RADARSAT-2 SAR data was acquired between September and December of 2013.

Subsequent data processing and analysis led to a preliminary ice velocity map, allowing for the comparison of flow rates at regional and continental scale.

Source: MDA (top) and E. Rignot, B. Scheuchl and J. Mougnot (bottom).

HIGHLIGHT:**THEMATIC AREAS AND KEY ISSUES****Floating Ice**

- ◆ Sea ice floe size, thickness and deformation
- ◆ Sea ice motion
- ◆ Sea ice melting characterization
- ◆ Iceberg dimensions and mass
- ◆ Iceberg calving rates
- ◆ Lake ice freeze up / breakup timing and characteristics
- ◆ Lake ice thickness, concentration and snow cover
- ◆ River ice freeze up and breakup timing and characteristics
- ◆ River ice thickness and snow cover

Permafrost

- ◆ Active layer monitoring
- ◆ Permafrost lake and thermokarst dynamics
- ◆ Map and monitor Arctic coastal permafrost zones

Snow

- ◆ Wide-area wet snow characterization, also in Alpine and forested situations
- ◆ Wet snow extent
- ◆ Seasonal snow melt period
- ◆ Snow melt extent and liquid water content

Ice Sheets (including glaciers)

- ◆ Ice sheet mass balance and modelling
- ◆ Ice sheet dynamics
- ◆ Ice sheet margins (grounding line and ice front)
- ◆ Ice sheet topography
- ◆ Changing morphology (crevices, shear margins)

Science issues and data requirements have been documented and are available at http://www.wmo.int/pages/prog/sat/pstg_en.php.

have discussed and documented the key science issues that are or need to be addressed. Their work is providing the basis for data acquisition planning and coordination. The thematic areas and main issues are highlighted above.

RECENT ACHIEVEMENTS

The dialogue between space agency representatives and those of the science community have already yielded results. Since 2013 the consultation and coordination efforts have led to the acquisition of several important polar SAR data sets. Examples include the following:

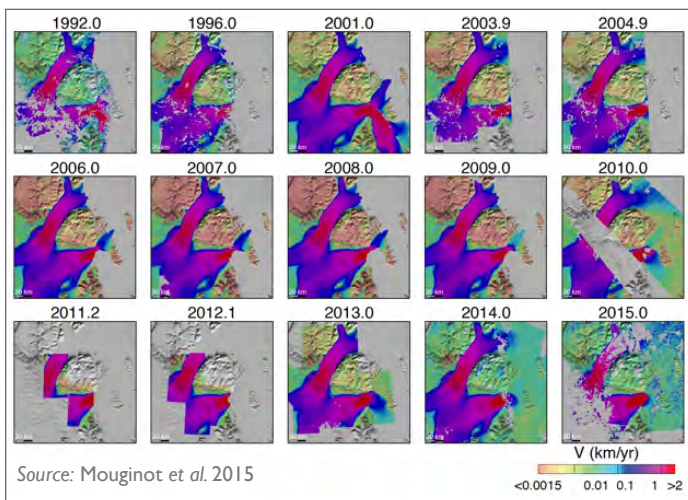
- ◆ *Select Greenland glaciers have been imaged with TerraSAR-X multiple times a year.*
- ◆ *RADARSAT-2 has acquired data of coastal Antarctica in 2013 to prevent a major data gap following the end of several satellite missions after the International Polar Year.*
- ◆ *Since 2013 RADARSAT-2 has covered central Antarctica using left-looking acquisitions over a multi-year campaign.*
- ◆ *COSMO-SkyMed has been continuously acquiring imagery at high resolution and in wide area imaging modes over the main Antarctic coastal glaciers and ice shelves.*

- ◆ *A high resolution DEM of the Antarctic is being produced from TanDEM-X data acquired in 2013 and 2014.*
- ◆ *Sentinel-1A is being used to collect data for all of Greenland and coastal Antarctica (one campaign per year) as well as for systematic acquisitions in key areas.*
- ◆ *Coverage of selected coastal regions in Antarctica and Greenland is included in the ALOS-2 PALSAR-2 basic observation scenario.*
- ◆ *Assessment of the fast retreat of Zachariæ Isstrom, including the recent decay of its ice shelf, in northeast Greenland, using time series of optical and radar satellite data.*

The PSTG coordinated data acquisition efforts have benefited from the support of the German Aerospace Centre (DLR), the Canadian Space Agency (CSA), the Italian Space Agency (ASI), the European Space Agency (ESA) and the Japanese Space Agency (JAXA), are committed to ongoing contributions to PSTG goals. Their ongoing support within the context of their own mandates will continue to enhance polar science efforts in future years.

ICE SHEETS: SCIENCE UPDATE

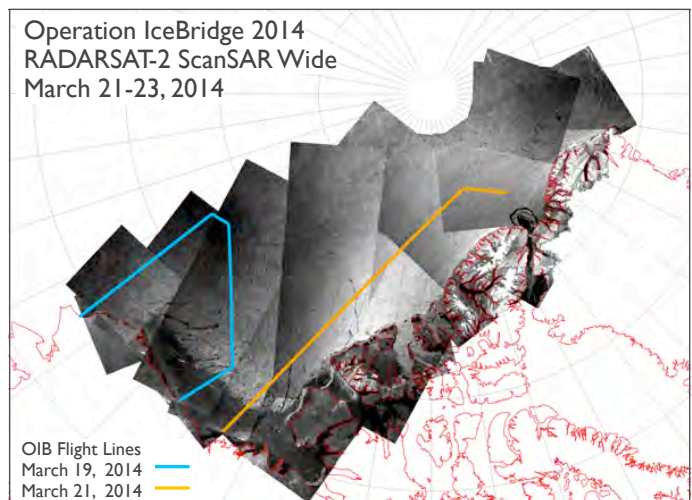
Systematic SAR acquisitions of Antarctic and Greenland ice sheets are crucial to monitor changes in mass fluxes and mass balance of the polar land ice masses. A key question is the contribution of the ice sheets to global sea level rise in response to a changing climate. The careful coordination of SAR data acquisitions through PSTG closed a looming data gap between the end of several SAR missions between 2011 and 2013 and the launch of Sentinel-1A and ALOS-2 PALSAR-2 in 2014. This was crucial to enable long time series such as the one shown below. The Sentinel-1 mission proves a game changer for ice sheet science due to the amount of data acquired as well as public access to the data. Other sensors are used to their specific strengths: RADARSAT-2 once more covers the vast region of Central Antarctica with a dedicated left looking mission. ALOS-2 PALSAR-2 acquires L-band data in key regions and TerraSAR-X, TanDEM-X and Cosmo SkyMed provide ongoing high resolution X-band data for important glaciers. The current setup provides one large-scale coverage of Greenland and Antarctica annually, and continuous monitoring of the Greenland margins and critical margins of Antarctica. Various national and international projects exploit the available SAR data for generating science products of ice sheet parameters which are available for the public.



Multi SAR sensor ice flow speed time series, 1992-2015, Zachariæ Isstrøm and Nioghalvfjærdsfjorden, Greenland (see also Highlight, p. 7)

FLOATING ICE: SCIENCE UPDATE

Through the coordinated efforts of Environment Canada, the Canadian Space Agency and the PSTG SAR Coordination Working Group, 1-3 day coverage of Western Arctic sea ice was achieved during NASA's Operation IceBridge (OIB) airborne campaign from 2013-2015. The OIB mission conducts airborne surveys of Earth's polar ice to bridge the gap between Ice, Cloud, and land Elevation Satellite (ICESat-1; 2003-2010) and ICESat-2 (2018). Of primary interest to the sea ice community are the ice thickness and snow depth on sea ice products developed through systematic surveys across the Arctic. The illustration (below) is an example of a mosaic consisting of RADARSAT-2 SAR images acquired between March 21 and 23, 2014. In total, more than 1600 SAR images were acquired; 352 images are available for 2013, 531 images for 2014, and 762 images for 2015. This extensive record of imagery over western Arctic sea ice contains a wealth of information and will be used with other satellite data to improve estimates of snow and sea ice thickness in Arctic for many years to come. Since 2015, Copernicus Sentinel-1A provides routine operational SAR coverage of sea ice and icebergs in the European Arctic and Greenland waters in support of the Copernicus Marine Environment Service and various National Ice Services.



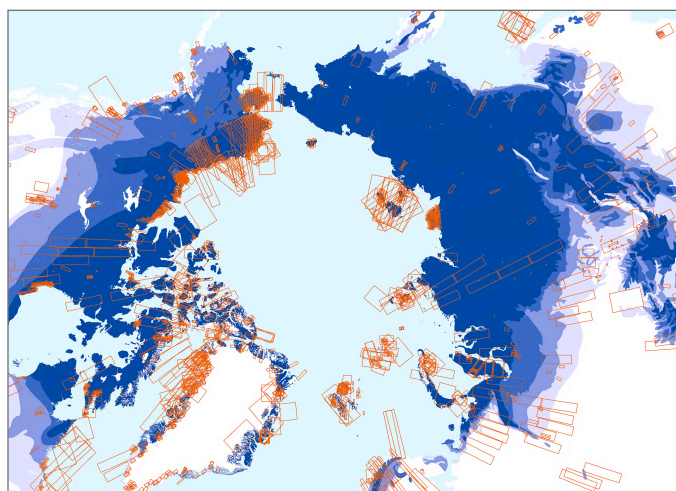
RADARSAT-2 ScanSAR wide mosaic of the Western Arctic with Operation IceBridge flight lines. (Credit: NASA, MDA)

PERMAFROST: SCIENCE UPDATE

The impact of climate change on permafrost depends on changes in temperatures, precipitation and local seasonal factors. The seasonally unfrozen (active) layer on top is expected to increase from year to year. The thickness of the active layer and evidence of related subsidence during the summer can be mapped using InSAR. Prominent surface features that are monitored with satellite data are the abundant thaw lakes. SAR can capture seasonal changes and thus contributes to the assessment of long term trends. This also applies to slope processes along sea and lake shores. During the winter, lake ice properties can be determined with radar; ground fast ice conditions in particular can reveal information about the permafrost below. SAR polarimetry supports land cover descriptions, especially wetland environments which are a source of methane. Parameters of interest for the entire Arctic and the Antarctic Peninsula include:

- ◆ *Subsidence*
- ◆ *Inundation*
- ◆ *Lake ice properties*
- ◆ *Surface structure (vegetation and snow)*
- ◆ *Erosion features*

These parameters need to be monitored by dense time series of satellite radar data. The radar measurements are usually recorded in the proximity of Arctic observatories.



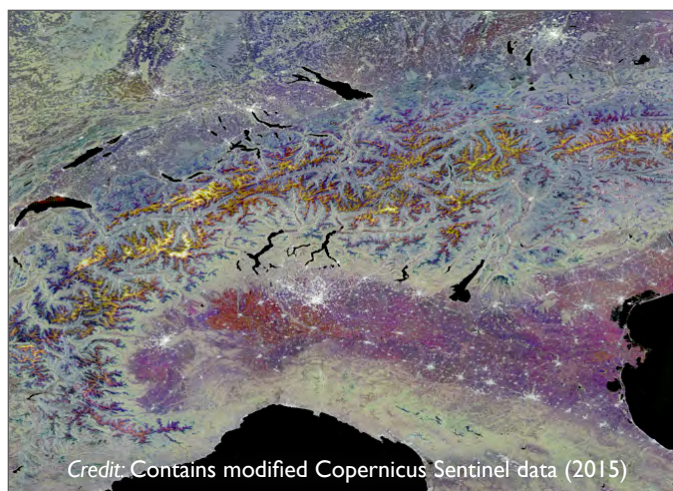
Map of TerraSAR-X data acquisitions (orange) from 2008 to 2015; permafrost areas are shown in blue. Source: ZAMG; NSIDC

WET SNOW: SCIENCE UPDATE

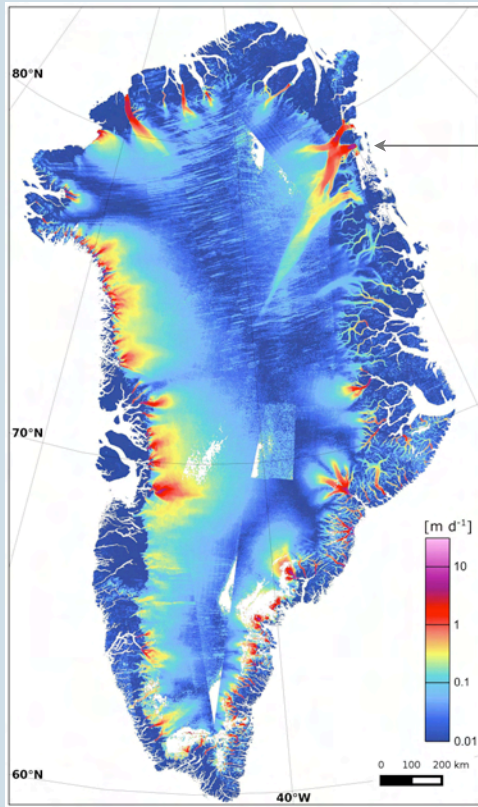
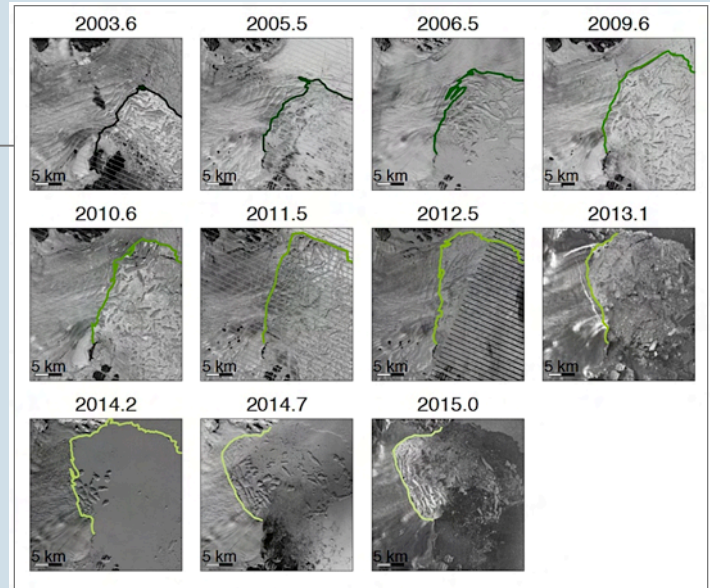
An extensive wet snow mapping exercise is in progress based on C-band backscatter time series. Scientists are combining radiometric terrain correction with composite time series of automated and seamless radar backscatter mosaics to generate regional wet snow test data sets for:

- ◆ *the Swiss Alps and the full European Alps*
- ◆ *the coastal mountains of British Columbia, Canada, and*
- ◆ *Ellesmere Island, Nunavut, Canada.*

Depending on the available temporal density of SAR data acquisitions and the DEM available, a temporal spacing between mosaics is chosen to support near-full coverage. Given that criterion, a temporal window of 16 days was employed in the European Alps, 24 days in coastal British Columbia, and 4 days for Ellesmere Island. These time series can be viewed as seamless backscatter “movies” over the full region. Alternatively, single “frames” can be overlaid as radiometrically calibrated RGB channels. The evaluation of the wet snow maps is progressing. It involves a threshold-based method and data covering the Swiss Alps processed at 10 meter resolution. An example of an RGB overlay covering the European Alps is shown below. In the mountains, the colours indicate the height progression of springtime melting; here, yellow indicates regions where melting began in late May.



The RGB snow backscatter product of Sentinel-1 SAR data: R=March 14-29; G=April 7-22; B=May 25-June 9. Source: University of Zurich

HIGHLIGHT:**ICE VELOCITY MAP,
GREENLAND, 2015****CLAVING FRONT, ZACHARIÆ
ISSTRØM, GREENLAND. 2003-15**

Credit: Mouginot et al. 2015, Science DOI: 10.1126/science.aac7111
Time series contains LANDSAT data (2003-2014), courtesy of USGS,
and COSMO-SkyMed data (2015), courtesy ASI.

Credit: Nagler et al. 2015 <http://www.mdpi.com/2072-4292/7/7/9371>
Map contains modified Copernicus Sentinel data (2015) / ENVEO / ESA

THREE YEAR PLAN, 2016-2018

The SAR Coordination Working Group has developed a three-year implementation plan spanning the period from 2015 through 2018. The main goals include:

- ◆ Identify and prioritize multi-frequency SAR acquisitions of polar regions on the basis of the needs coming from scientific and related applications communities
- ◆ Maintain constant dialogue with these communities
- ◆ Maintain constant dialogue with private sector data provider partners through the involvement of the space agency members
- ◆ Share of information on the current status of the SAR missions and the activities on polar regions
- ◆ Ensure that data are available to qualified end-users.

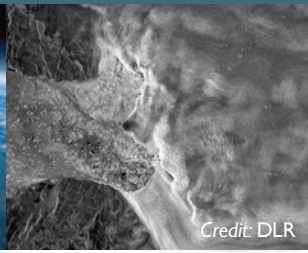
Specific objectives of the plan include:

- ◆ Collect scientific requirements and respond, through CWG member consensus and to the extent feasible based on member Agency resources
- ◆ Coordinate member agency data acquisition efforts, taking advantage of unique strengths of the various missions, with an effort to share the data acquisition load
- ◆ Strive to ensure that data collected is openly available to scientists using various mechanisms for data access
- ◆ Undertake outreach to inform broad target communities of the requirements, opportunities, data set availability and successes of SAR CWG supported polar science
- ◆ Produce a compendium of scientific requirements, acquired archive data sets, and planned future acquisitions.

The SAR CWG will review and adjust its implementation plan on an annual basis to ensure continued relevance to the science community.



Credit: ESA



Credit: DLR



PSTG SAR DATA COMPENDIUM

The SAR Coordination Working Group is currently producing a SAR data compendium, for presentation in 2016. The compendium contains a summary of comprehensive satellite radar data sets collected over polar regions during the past two decades as a result of well-planned and coordinated efforts of representatives from space agencies, international organizations and the science community. This document describes the synthetic aperture radar (SAR) data sets that have been acquired, both prior to and during the PSTG SAR CWG, and those data sets which are planned for the coming years. It mainly covers the data sets related to four priority themes identified by the Polar Space Task Group (Permafrost, Floating ice, Snow, and Ice sheets, ice caps and glaciers). The data is intended to be openly available for scientific purposes, and should lead to a wealth of new observations, analyses and conclusions. The compendium includes references and links to data portals to access data sets described in the document.

ACKNOWLEDGMENTS

The contributors for the four thematic sections, Bernd Scheuchl, Stephen Howell, Annett Bartsch and David Small wish to acknowledge ESA (Ice sheet CCI program) and NASA (MEaSURES program) (for the Ice Sheets theme); NASA and Canadian Space Agency (for the Floating Ice theme and IceBridge work); ESA DUE Permafrost, 2009-2012, European Commission (EC) FP7 PAGE21 - Changing permafrost and its global impacts in the 21st century, 2011-2015 (for the Permafrost theme); and ESA (for the Wet Snow theme).

On behalf of his SAR CWG colleagues, Yves Crevier (Canadian Space Agency, yves.crevier@canada.ca) oversaw concept and production of this brochure by Don Ball, Dennis Nazarenko and Dirk Werle.



SPACE AGENCIES INVOLVED IN THE SAR COORDINATION WORKING GROUP OF PSTG



 Canadian Space Agency Agence spatiale canadienne
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