THEMATIC AREA 1 – SESSION SUMMARY

PolSAR & Multi-frequency applications:
*(**Backscatter intensity** and/or **polarimetric phase** the main measurements)*

Session Organizers: Ake Rosenqvist (JAXA) & Klaus Scipal (ESA)

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Thematic Area 1 Splinter

Polarimetric & multi-f applications
Thursday Sept 29; 14:45-17:45

Summary:
Friday Sept 30; 10:20 – 10:40

2023: Review paper incorporating output of this session + online survey

Time	Topic	Speaker	
14:45 – 14:55	Welcome & session objectives.	Ake Rosenqvist & Klaus Scipal	
14:55 – 15:10	**PolSAR/Multi-*f* Theme 1:** Forest, Wetlands & Biomass	Maurizio Santoro (Gamma RS)	45 min
15:10 – 15:40	Theme 1 open floor discussions	Moderators: AR & KS	
15:40 – 15:55	**PolSAR/Multi-*f* Theme 2:** Agriculture & Soil Moisture	Heather McNairn (AAFC)	45 min
15:55 – 16:25	Theme 2 open floor discussions	Moderators: AR & KS	
16:25 – 16:40	**PolSAR/Multi-*f* Theme 3**: Ocean & Sea Ice	Malin Johansson (U. Tromsø)	45 min
16:40 – 17:10	Theme 3 open floor discussions	Moderators: AR & KS	
17:10 – 17:45	**TA discussions** - Coordination across disciplines Summary & Conclusions	AR & KS	35 min

Forest

From Santoro (29 Sep 2022)

- State of the art in the 2010s :
  - Long-term and repeated observations are used to generate (semi-)operational data products (disturbance alerts, biomass maps, land cover maps)
  - The level of breakthrough of a SAR dataset in thematic mapping is directly related to its availability → multi-frequency applications are still very limited
  - Poor reliability of temporal dynamics when based on data from several sensors (e.g., biomass from JERS-1/ERS + ASAR/PALSAR-1 + Sentinel1/PALSAR-2)
  - Mapping and monitoring rely on backscatter data only.
  - Full potential of Full-pol and Pol-InSAR unexplored due to lack of consistent data

Forest, Biomass & Wetlands

SAR coordination actions in the near term (2020s)

From Santoro (29 Sep 2022)

Regardless of the application, data acquired with the same geometry and configuration required.

Users should not need extensive pre-processing extra-efforts to combine datasets, even if acquired with the same frequency (e.g., JERS-1/ALOS-1/ALOS-2/future L-band or ERS/ASAR/Sentinel-1)

Dynamic forest environments (e.g., deforestation)

- Frequent revisit → tropics well covered, extra-tropical regions are not
  - C-band SAR: coordinate Sentinel-1A and RCM to fill gaps, get S1-C launched
  - Coordinate L-band acquisitions (present and future missions)

Static forest variables (e.g., biomass)

- Repeated global observations, at least C- and L-band, every year with the same modes, over and over

Wetlands

- Repeated (~weekly) observations (L-band) to track dynamics (inundation), same mode over and over
- Multi-frequency polarimetric data to capture the diversity of vegetation forms

SAR coordination actions in the long term (2030s)

From Santoro (29 Sep 2022)

Regardless of the application, data acquired with the same geometry and configuration required.

Users should not need extensive pre-processing extra-efforts to combine datasets, even if acquired with the same frequency (e.g., JERS-1/ALOS-1/ALOS-2/future L-band or ERS/ASAR/Sentinel-1)

Requirements

- (Very) frequent revisit (to reduce seasonal noise)
- Homogeneous global coverages (with fixed sensor parameters)
- Multi-frequency data (ranging from X- to P-band)
- InSAR (non-zero baseline) and full-polarimetric for a 3-D representation of vegetation (height and density) and capture diversity
- Spatial resolution: sufficient to detail individual crowns (short frequency)

- Data policy: public free and open of critical importance
- Data provision in a few simple standardised data formats (raw, SLC, ARD)

Agriculture & Soil moisture

Agriculture – AAFC Experience

	Crops			
	Classification	Growth Stage	Condition	Tillage
RADARSAT + Sentinel-1	Ready	Demonstrated	Demonstrated	In development
C-band + one or more other frequencies	Demonstrated	Demonstrated		In development

- Limitations to move from demonstrated to ready are mostly a function of availability of consistent coverage at wide swaths at multiple frequencies
- Green: science has demonstrated capability, repeatedly (more than one site and year)
- Implementation is lagging the science; many factors but one being data availability

From McNairn (29 Sep 2022)

Agriculture & Soil moisture

Hierarchy of Importance

Time

(covers growing season & at critical development stages)

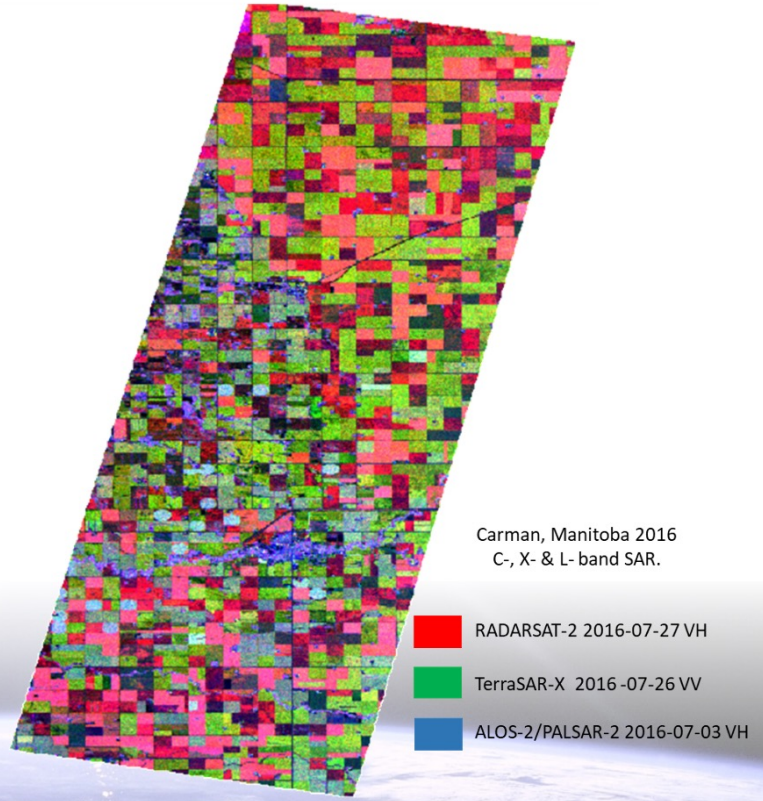
Frequency

(soils: lower is better
crops: need 2+ frequencies)

Polarization

(huge benefits with QP or CP)

Virtual Constellations



From McNairn (29 Sep 2022)

Agriculture & Soil moisture

Take Home Message - Agriculture

Research has clearly demonstrated

- Virtual constellations provide huge benefits by populating temporal data stacks, even if limited to one frequency
- Multi-frequency and multi-polarization data add critical data in particular to determine crop condition
- Multi-frequency in particular, is needed because biomass varies from crop to crop, and as crops grow (thus need differential penetration capability)

Challenges

- Require access to “consistent” wide area coverages of multi-frequency data
- Training of user communities on polarimetry

From McNairn (29 Sep 2022)

Sea Ice & Ocean applications

Near/mid-term SAR coordination

1) Preparation of multi-frequency SAR acquisitions over Arctic and Antarctic

- Publish satellite acquisition plans in advance –> data merging, planning of in-situ data campaigns
- Minimize temporal differences for different frequencies
- Continued coordination for spatial overlap at study sites

2) Aim for a **"sea ice year"** -> Pan-Arctic/Antarctic coverage

- Multi-mission coordination, e.g.
  - ALOS-4 and Sentinel-1 for Arctic
  - NISAR L- and S-band / SAOCOM and COSMO SkyMed for Antarctic
- Global baseline – to be used in future studies

3) Improved **noise compensation** algorithms applied to archived products

For Marine/Ocean Response:

- Frequent imaging, best < 1 h
- Any frequency

- Coordination with optical and near-IR benificial

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From Johansson/Dierking (29 Sep 2022)

Sea Ice & Ocean applications

Long-term goals (2030s) - Sea ice and ocean

Mission parameters

- Continuous multi-frequency SAR coverage of Arctic (e.g. S1/S1N + ROSE-L) and Antarctic (e.g. NISAR, SAOCOM, COSMO SkyMed)
- Increased downlink capacity
- Wide swath + increased spatial resolution (< 10 m) at the same time (e.g. iceberg and oil spill detection)
- SNR as high as feasible – essential for identification of thin sea ice and for marine pollution
- Coordinated combination of SAR and non-SAR data (altimeter, optical, IR)

Data / products

- Data delivery within 15 minutes – operational sea ice and marine applications
- Free sharing of different (SAR-) Sensor data
- Archive(s) combining different SAR and non-SAR sensors and in-situ data with efficient search tool(s)
- Easy-to-handle planning tool for combining data acquisitions of different satellite sensors / missions
- Integration of commercial (SAR) satellite data providers in acquisition strategies

From Johansson/Dierking (29 Sep 2022)

TA-1 PolSAR/Multi-ƒ Applications crosscutting recommendations

Foster Operational Applications

1. High potential of Full-Pol and Multifrequency data that today is still underexplored.
2. Continuity (sensor characteristics) and Homogeneity (in global coverage) are critically important for operational applications. Be boring rather than innovative.
3. Free and openly accessible products stimulate applications (preferably standardized ARD products).
4. For dynamic processes (agriculture, sea ice, …) acquire multifrequency data temporally coincident.

Foster Research and Development

1. Conduct coordinated tower and airborne campaigns collecting multi-frequency and multi-polarisation data to support studies into the information content of multidimensional SAR data.
2. Define core site (forest, agriculture, wetland, ice,…) where Agencies AND Commercial providers systematically collect SAR data and make those data openly available.
3. Support the development of Open Source toolboxes for advanced SAR processing both optimized for “operational” applications (e.g. SNAP) and as learning tools (e.g. Python notebooks).
4. There is a need for a coordinated data catalog.

SURVEY

https://esa-survey.limequery.org/654789?lang=en

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