POLinSAR 2007 Session Summaries and Recommendations

The POLinSAR 2007 Session Summaries have been prepared by the session chairpersons based on the round-table discussions, and are grouped in the following session-order:

- ALOS PALSAR First results
- Advances in POLSAR and Pol-InSAR
- Applications: Forestry
- Applications: Land-Agriculture
- Applications: Other
- Compact Polarimetry
- Polarimetry and Persistent Scatterer Interferometry (PSI)
- Theoretical Studies

ALOS PALSAR First results - Session

Chaired by M. Shimada and A. Moreira.

Presentations in the session

Initial Polarimetric Calibration of PALSAR (M. Shimada)

- Stability and accuracy of the Polarimetric Calibration using the Rio Branco sites, etc.

First Results of the ALOS PALSAR verification processor (P. Pasquali)

- Evaluation of the Polarimetric data etc., ready for SCANSAR InSAR.

The Dual Polarization H/a Decomposition: a PALSAR Case study (S. Cloude)

- Highly utilization of H/a for FBD in forest monitoring.

ALOS-PalSAR Pol-InSAR Data Analysis: First results (K. Papathanassiou)

- First results of the tree height estimation were discussed.

First Polarimetric and Interferometric Results from ALOS-PalSAR(L. Marotti)

- Temporal stability of coherent scatterers has been evaluated.

Answers to Seed Questions

1) The ALOS/PALSAR commissioning phase has been completed, including the polarimetric calibration. How well does the calibration fulfil the user requirements for Pol-SAR and Pol-InSAR applications?

- The calibration of the PALSAR sensor shows excellent results which can be summarized as follows
  - Amplitude standard deviation: < 0.2 dB
  - |HH-VV| phase < 0.35 deg.
  - Cross talk: between -25 and -30 dB
  - NESZ: - 28 dB
  - HH-VV imbalance < 0.02 dB
  - Geolocation accuracy: ca. 11 m (one pixel)

- The above values fulfil the user requirements for Pol-SAR applications. For Pol-InSAR applications it is however required that the satellite orbit is kept within the specified tube of 500 m (vertical) times 2.5 km (horizontal). This would allow achieving baseline values of ca. 1 km which are well suited for Pol-InSAR applications.

2) The use of dual-pol mode relaxes the SAR systems constraints caused by the increase of the PRF. Which applications require the use of fully polarimetric data? What is the recommendation for future SAR systems?

- In general it can be stated that a fully polarimetric system is preferred for urban areas, soil moisture retrieval (with vegetation cover), forest

structure, high biomass values (beyond the saturation level with amplitude based retrieval) etc. The use of quad pol systems allows also the determination of the Faraday rotation directly.

- The trade-off between the use of a dual-polarized and quad-polarized system is not trivial and has to be defined for each specific application. In some cases a dual polarized system is preferred (spite of reduced retrieval performance) due to the larger swath width and possibility to have larger incident angles.

- It is recommended to generate a handbook summarizing the trade-off of dual x quad-pol systems for each specific application. This handbook should be updated every year as new results of studies and publications become available.

- The conclusions of the session "compact polarimetry" are also relevant for the design of future SAR systems.

3) Based on the current operation plan, the incident angle is almost fixed to 21.5 degrees, and it is possible to select only between 9.9 degrees and 26 degrees. For the time of the future operation plan setting (probable 3 years after), which application needs smaller and larger off-nadir angles?

- The answer to the previous question can be adopted for this question. Following comments can be added:

    - Dual-pol mode allows the use of larger incident angles (due to less ambiguity constraints).

    - Less knowledge is available concerning the use of polarimetric systems with very steep incident angles (e.g. 10 deg.)

    - For geological applications the use of dual-pol and larger incident angles is preferred (instead of lower incident angles and quad-pol).

- The trade-off between a dual-polarized and quad-polarized system as a function of the incident angle should be further investigated for each specific application (see recommendation for generating a handbook with the trade-off analysis).

Further discussion points/recommendations of this session:

- There is a strong requirement from the Pol-InSAR community for the acquisition of fully polarimetric data of a few specific test sites during the operational phase of PALSAR (as it has been the case during the commissioning phase). The acquisition should be made for every orbit cycle (46 days) in order to allow the further development of Pol-InSAR applications. The selection of a few specific test sites should be done in such a way that the operational data acquisition of ALOS is not affected.

- The processed data from ESA's verification processor has a Doppler zero geometry while JAXA's processor delivers the image data with the geometry related to the Doppler centroid of the particular data set. Users should be aware of this fact and different implementations of the geocoding software are required for each case. This is not seen as a problem since each processor implementation has its own geocoding capability.

- The geolocation accuracy of the ESA verification processor and JAXA's processor show similar results so that both processing strategies are valid. Again, users must be aware of the difference of the geometry in the processed data before the geocoding.

Advances in POL-SAR and Pol-InSAR - Session

Chaired by K. Papathanassiou and E. Pottier.

Answers to Seed Questions

1) Is there any demonstrated benefit of multi-baseline Pol-InSAR (e.g. improved classification, more stable parameter estimation, tomography etc.)? What are the prospects for spaceborne MB (ALOS-2, Tandem-X etc.) and do they match the requirements of the algorithms?

- Multi-baseline implementations in a repeat pass scenario are of interest for evaluating the change of polarimetric signature of distributed and point-like scatterers in time.

- The lack of appropriate (temporal) data sets makes an (accurate) evaluation of their impact at this time difficult. However, it was recognised that the time component can be essential for several applications ranging from classification, to …

- Multi-baseline implementations in a single (or quasi single) pass scenario are essential for structure recovery of temporal unstable volumes (as forest).

2) ALOS-PalSAR is the first fully polarimetric space-borne sensor that will provide polarimetric data in a systematic way.

- What are the potential polarimetric (PolSAR) applications that can be validated and established with that data? Are the associated experiments and data secured?
- What are the potential Pol-InSAR applications that can be demonstrated and established with it? Are the associated experiments and data secured?
- Is the polarimetric SAR community prepared to face in a systematic way this unique opportunity?

    - The systematic acquisition of Quad-pol data from ALOS-PalSAR (if possible every 46 days) over a number of selected test sites (representative for each application) is a high priority request and strongly recommended.

3) What are the potential new applications that can be demonstrated / validated on the basis of multi-temporal polarimetric data sets as provided by ALOS-PalSAR.

    - See Question 1

4) With ALOS on the sky and RadarSAT-2 and TerraSAR-X on the horizon, a multi-frequency observation scenario will be feasible at least for a set of experimental observations. What are the potential applications that can be demonstrated / validated on the basis of multi-frequency polarimetric datasets?

- There are a number of important applications (in agriculture, forestry, ice, geology, sub-surface …) that will highly benefit from the availability of Multi-frequency Quad-pol data. Towards the development of the appropriate R+D the establishment of common test sites for all actual and near-future sensors (ALOS-PalSAR, TerraSAR-X, RadarSAR-2) is recommended and has to be initiated / coordinated.

- JAXA Constraints: Common super-test site located in the Pacific Ocean could be a good compromise (Fiji islands?)

Applications: Forestry – Session

Chaired by C. Erxue and P. Dubois-Fernandez.

Summary of the Session

- Ground-base, airborne, spaceborne radar
- POL-SAR, Pol-InSAR and modelling
- All tools needed to characterize the vegetation
- Pol-InSAR at P band
    - Height inversion
    - Compact Pol-InSAR results
- INSAR ground base radar
    - Susceptibility to wind effect
    - Measurements of attenuation effect & comparison to a wind-motion model
- Mr Raimadoya presented a POL-SAR analysis over tropical area
    - Benefit of POL-SAR acquisitions for forest type discrimination
    - Use of POLSARPRO…
- Vertical structure of the vegetation
    - More ecologically correct model
    - How to compute the behaviour of backscatter and frequency dependency
- Analysis of the Indrex campaign P L and X band
    - Good consistency between P and L
    - Demonstration of POLINSAR at X band

Discussions around the Seed Questions

- ALOS PALSAR and forestry…
    - Very impressive calibration assessment results
    - Enthusiastic user community
        - More data, more coverage, more often
- Forest and frequency
    - Results ranging from X to P band
    - The important parameters:
        - Penetration, temporal decorrelation, resolution, sensitivity
    - Tandem-x will allow the exploration of the X band for forestry
- Techniques for forestry…
    - Let's have them work together…
- PolInSAR and LIDAR or ….
    - Complementary measures
    - Could combine InSAR at different frequencies
    - LIDAR (scattered points with profile measurements…compared to a continuous map)
- Forest parameters
    - Biomass or heights: both are identified as interesting parameters
    - Height takes its full measning when basal area info is available
    - Provide the product data as close as possible to the measurements

Recommendations to ESA

- Validation of the compact Pol-InSAR on other datasets at P and L band over hilly terrain
- Support the request for more quad-pol PALSAR data from EU users to JAXA.
- Identify and construct several international forest super test sites.
- A consistent SAR mission design is recommended enabling continuous observations

Applications: Land-Agriculture – Session

Chaired by L. Ferro-Famil and P. Lombardo.

Comments and Recommendations based on the Seed Questions

1) Which major modifications would be required to export forest volume parameter estimation procedures based on Pol-InSAR coherence models to the case of agricultural crops?

Comments:

- Existing Pol-InSAR volume scattering model, developed in the frame of forest studies at L band, should naturally adapt to agricultural crop analysis, provided that a higher frequency band (C- or X-band) is used.

Recommendation:

- The need for modifications is not clear yet and should be tested.

2) C-band Pol-SAR data have been widely used for crop monitoring. Are X-band (Single pass) Pol-InSAR acquisitions well adapted to agricultural volume analysis or should C-band data be preferred?

Comments:

- For PolSAR surface parameter estimation techniques, volume response may cause severe biases and must be taken into account, or reduced using a lower frequency (L-band).
- In general, Pol-InSAR techniques require higher carrier frequencies (C- or X-band) to analyze a media volumetric response and aim to separate it from the ground information.
- For forest the addition of the InSAR allows to separate out contribution from the surface and estimate vegetation height. In agricultural areas, the objective might be the reverse.

Recommendation:

- The need for Pol-InSAR still needs to be proved in terms of usefulness and improvements w.r.t. PolSAR (AgriSAR, Aquiferex projects) in both Airborne and Spaceborne configurations.

3) Do the outputs of current PolSAR/Pol-InSAR processing techniques meet end-user needs in terms of usefulness and accuracy?

Comments:

- PolSAR techniques have been developed for years and are much more mature than Pol-InSAR ones. Benefits from Pol-InSAR in this domain still have to be demonstrated.
- The accuracy of parameter retrieval techniques is still variable and may not satisfy potential end-users.
- Some of the current Pol-InSAR/PolSAR outputs (biomass/roughness) may not be useful to the agricultural community.

Recommendation:

- End-user requirements do not seem to be well known. Clear need to steer analysis techniques towards the estimation of useful information over areas of interest.

4) Classification techniques using the whole PolSAR/Pol-InSAR information segment pixels according their global scattering behaviour. In order to provide more specific results, would it be preferable to limit the input information to some indicators, highly linked to physical parameters (humidity, roughness, density …)?

Comments:

- Classification of agricultural scenes has reached an interesting state of maturity. Acquisition conditions and modes may still have an important influence on results accuracy and relevance.

Recommendation:

- We need to concentrate on classification strategies that also take into account the influence of perturbing factors (angle of incidence, view direction …) and reduce their effects.

Applications: Other - Session

Chaired by C. Lopez-Martinez & P. Pasquali

Session Presentations

1. Multi-frequency PolInSAR signatures of a subpolar glacier (Jayanti Sharma (DLR - Microwaves and Radar Institute))

2. Inversion of surface parameters from NASA/JPL AIRSAR polarimetric SAR data (Sang-Eun Park (Seoul National University))

3. DTM Extraction Beneath Canopy Using L- and P-Band Data from INDREX-II: Preliminary Results (Bryan Mercer (Intermap Technologies Corp.))

4. An Overview of the PolSARpro v2.0 Software. The Educational Toolbox for Polarimetric and Interferometric Polarimetric SAR Data Processing (Eric Pottier (I.E.T.R UMR CNRS 6164 - University of Rennes 1))

5. Implementation of repeat-pass SAR interferometry for search of earthquake precursory land-cover deformation; and how Infrasonic Imaging and HF-OTHR Technology can be implemented for detecting the On-set of and real-time spreading of Tsunamis (Wolfgang-Martin Boerner (University of Illinois at Chicago))

Answers to Seed Questions

1) Which is the current state of the art on retrieving physical information form snow or ice covered regions? Is this retrieval affected by environmental conditions? Are multi-frequency techniques necessary to retrieve reliable information?

- Forest seems to be the most developed application of PolSAR and Pol-InSAR data. Nevertheless, the study of ice covered regions is not at the same level of development. As indicated by A. Freeman, the fist task would be to determine which parameters we need to pay attention to. He proposed three: Snow accumulation, Ice thickness and snow velocity/movement.
- Recommendation: Define products to be retrieved in the case of snow/ice covered areas
- There exists an agreement in the community that multi-frequency systems are one way to go in the analysis and characterization of these areas. Scattering from ice/snow covered regions contains an important component due to volume scattering; therefore low frequencies seem to be the best option. In order to study the volumetric structure of the ice/snow, polarimetry seems to offer also encouraging results. Using the PCT (Polarimetric Coherence Tomography), J. Sharma presented results concerning volumetric structure of the ice/snow layer.

- M. Bernier indicated also the importance of polarimetry when differentiating different types of sea ice. She also raised the important necessity to study land ice.

2) The analysis of polar, sub-polar and snow covered areas is critical since they are perhaps the first Earth environments affected by the greenhouse effect. Could all these regions be analyzed using the same approaches and scattering models? or their study should be considered separately?

- J. Sharma and others indicated that the different types of snow and ice covered environments must be considered separated differently due to the differences in their internal structure.
- Recommendation: Particularization of scattering models for ice/snow covered regions
- E. Trouve raised the point that Temperate Glaciers are an important environment to play attention to since they may be employed as local indicators about the global warming effect.

3) The technique reported by B. Mercer and Q. Zhang has considered Pol-InSAR data from densely vegetated areas. It would be possible to use the same approach in areas with different morphology, as for instance, the Mediterranean forest characterized by being less vegetated?

- B. Mercer indicated that the proposed method also works in other environments, but in these cases attention should be paid to the accuracy with which the different parameters are retrieved in these environments.
- Recommendation: Consider accuracy aspects on the retrieved parameters
- He also indicated that the optimum solution would be a single-pass system to avoid the problems of temporal decorrelation. The system should operate in L-band. He also commented that a P-band system presents the problem of low bandwidth with the consequent lost of spatial details.

4) Considering both, the important implications an earthquake prediction system based on multi-channel SAR data would have on the society and the current state of this technology, without neglecting its complexity, which could be done nowadays, from a realistic point of view, in terms of earthquake prediction?

- W. Martin Boerner recommended the exploitation of all the electromagnetic spectrum.
- Recommendation: One option could be data fusion techniques?

5) Nowadays, most of the applications of multi-channel SAR data (InSAR, PolSAR, Pol-InSAR, etc…) are still on a research stage. Taking into account that the next generation of spaceborne SAR system present fully polarimetric capabilities, how ready are we in terms of theory (modelling and understanding of mechanism), algorithms, signal processing techniques and tools to deliver fully operational applications to the industry and in general to the society?

6) Long term polarimetric spaceborne SAR missions will open the door to consider time as a new axis of information. Which is the current state of the art on the use of this new source of information for PolSAR and Pol-InSAR applications?

- The main problem considering the temporal axis is the effect of temporal decorrelation. This source of decorrelation represents a drawback in Pol-InSAR applications. Nevertheless, even in the presence of this decorrelation source, results may be obtained. H. Rott indicated this possibility in the case of snow covered areas.

Comment on POLSARPRO Software

The availability of POLSARPRO SW is one of the main contributions of the POLinSAR conferences series. The SW has a double contribution: scientific development & education. **All singing, all dancing situation!!!!**

Compact Polarimetry – Session

Chaired by A. Freeman and J.-C. Souyris.

Session Presentations

Session dedicated to compact polarimetry architectures – 4 presentations

- 3 presentations: comparisons between FP and CP architectures @ P,L,X bands by applying reconstruction algorithms. Promising results in each case
- Sensitivity study to azimuth symmetry assumption FP reconstruction algorithm compromised for urban environment
- CP permits to apply polarisation synthesis on receive
- Comparisons between CP and FP in the framework of multi-freq. AIRSAR data classification using SVM techniques. CP acquisition deteriorates the classification results by about 3%.

Assessment of CP system aspects

- CP assets : PRF & Swath maintained allowing acquisitions @ high inc. angles
- Assessment of P band , when circular pol. transmitted – expected to critically reduce ionospheric effects
- Demonstration of the added-value of a circular pol. transmission: invariance conditions & unbiased polarimetric analysis from Stokes parameters
- Appropriately configured CP designs can minimize the need for gain changes due to backscatter differential, as compared with conventional dual-pol, e.g. HH, HV
- Description of a CP design compliant with a lunar mission for frozen ice deposits analysis.
- Demonstration that CP modes can be calibrated from raw data

General Issues

- The effect of terrain slope on CP signals must be carefully assessed
- Faraday effects: it seems that some CP options (circular pol. transmission) would tolerate Faraday rotation to up to 10-15°. Issue of 1st concern as P band is a good candidate for CP
- Comparison between CP and FP must include both POLSAR & POL-INSAR aspects

Technological Challenges

- Antenna trade-offs must be investigated
- Technologically speaking, the design of a quad-pol mode and of a CP mode are compatible : CP can be easily integrated on FP architectures

Applications

- Earth observation : “working point” should be identified in the framework of biomass – vegetation applications (P band) – assumptions for FP reconstruction usually verified
- Referring to the earlier presentation of P. Dubois-Fernandez, it seems that switching from FP to CP has minimal effect on forest height estimations using Pol-InSAR, at least for the Landes forest test site.
- Ice applications : geophysical parameters not known precisely. Relations with POL-INSAR parameters to be established first
- Surface-Subsurface scattering @ large incidence angles appear to be compliant with CP : need more investigation

Polarimetry and Persistent Scatterer Interferometry (PSI) – Session

Chaired by K. Raney and F. Rocca.

Summary of the Session Presentations

In the first presentation, results from the Technical University of Catalonia were presented using ground based X band polarimetric radar. The goal of the observations was the monitoring of the subsidence due to mining in a village surrounded by a salt mine in Catalonia.

- A 6 months survey with repeated monitoring several times a day for six hours, every month, was carried out and very interesting results were presented, consistent also with previous results obtained from ERS data.
- Indeed the polarimetric characteristics of some stable scatterers appeared to change at given times, but the different polarimetric channels indicated very similar subsidence.

In the second presentation from Tohoku University in Japan, the effect of the orientation angle of the scatterer on the polarimetric signature was discussed.

- Based on airborne JAXA L-band and NICT X-band Pi-SAR data, experimental results were presented, over a site comprising gentle hills in a suburban area of the city of Sendai. Indeed, the orientation angle appeared to have different impact on the signal.
- In particular L band was more sensitive to main walls orientations compared to X band and X band appeared more sensitive to the random surface of the imaged objects.

A third paper, presented by Schneider and Papathanassiou from DLR, discussed alternate ways to describe the orientation of a complex scatterer as derived from its polarimetric response.

- While the orientation angle is dependent on the description technique chosen, its change with the rotation of the scatterers is not, so that the polarimetric technique can be used to detect objects rotations.
- Symmetric and asymmetric scatterers were identified in data acquired using DLR's E-SAR L-band airborne system over Berlin and Dresden.
- Indeed, polarimetry allowed the identification of many more coherent scatterers with respect to conventional techniques.

The fourth paper, from Norut IT and the University of Tromsø in Norway, discussed the application of polarimetry to the retrieval of scatterers in natural scenes in fjords in Norway, to be able to predict landslides that are known for causing small but very dangerous tsunamis.

- The rocky scatterers have different polarimetric characteristics, and many coherent scatterers were detected from L band airplane EMISAR data. Further analyses will be carried out to verify their temporal stability.

Answers to the Seed Questions

1) In which ways the polarimetric information increases the detectability and the utility of the PS?

- This first seed question aimed at identifying the synergy between polarimetry and PS interferometry. Indeed the polarimetric characteristics are very useful for the identification of coherent scatterers, i.e. scatterers that have a very uniform response across angles so that a stable temporal behaviour can well be expected. However, long surveys will be needed to assess this synergy.

2) Is the Faraday rotation detectable and is it possible to find countermeasures, using Persistent Scatterers?

- A general discussion on the effects of the Faraday rotation was then opened and further analyses will be welcome: it appears that the temporal stability of the scatterers could be of use to counterbalance its effects.
- Polarimetric returns from a rotational – invariant PS could be analyzed to measure the 2 way Faraday rotation, and then used to assess methods to compensate scattering matrix data from Faraday rotation.

3) In order to maximize the number of PS, which is the optimum balance between resolution and polarimetric information? And is the number of PS a reasonable figure of merit, or do we have a better one, in the polarimetric case?

4) Apart calibrating the gain and the antenna directivity, could we use the PS to calibrate the polarimetric matrix of the system too?

- The utility of compact polarimetry schemes for PS analyses was also underlined, as the temporal stability to be expected for those targets allows a multi pass polarimetric analysis along with the geometrical one.
- There was a general consensus on the utility of the evaluation of the persisting polarimetric characteristics of the scatterers, even if with compact schemes.

Theoretical Studies – Session

Chaired by S. Cloude and I. Hajnsek.

Comments to Seed Questions

1) Surface and Subsurface Scattering Theory: One key motivation for using radar polarimetry is the ability to employ ratios for robust surface parameter estimation, primarily the decoupling of surface roughness and moisture/salinity in a single pass sensor. What is the current status of the estimated accuracy and market impact of near and deep surface retrieval algorithms?

2) Are the requirements of SP algorithms compatible with existing sensor geometries, for example: a) Quad vs. Dual-Pol, b) those that use cross polarisation vs. copolar ratios c) high angle of incidence requirements for dynamic range and d) spatial resolution requirements vs. bandwidth restrictions of low frequency sensors)? Is there any mismatch between planned sensor deployments and requirements of scattering models?

Comments:

- There is a need to extend surface scattering models from single to multi-layer to correctly account for polarimetric phase shifts
- HHVV Phase and Coherence are important in surface as well as in urban and forest applications, especially at large angles of incidence, hence supporting the concept of compact-polarisation (e.g. mixed circular/linear polarisation) for combined coverage and good parameter estimation at large angles

Recommendations:

- Support further studies for coherent polarimetric multilayer subsurface/soil moisture modelling
- High incidence angle dual-pol modes should be investigated for subsurface studies (using existing sensors such as ALOS/PALSAR)
- Need further investigation of the potential advantage of using various compact-polarimetry modes for subsurface parameter estimation

3) Vegetation Scattering: Most quantitative inversion algorithms for vegetation parameter estimation employing polarimetric interferometry require a dominance of volume over temporal and environmental effects. What are the prospects for space borne single pass polinsar systems and can theory help inform the potential new products and increased accuracies achievable using such systems. Is there a preference for standard or ping-pong interferometry for vegetation applications?

4) Multidimensional Filtering: are the current filters we use adequate for quantitative inversion, especially for algorithms employing coherence optimisation and eigenvalue analyses? In particular what is the effect of coherence bias on algorithm inversion accuracies and are there better techniques we could use to remove bias, reduce speckle effects and improve retrievals in multi-parameter surface and vegetation polinsar applications?

Comments:

- Single pass interferometer designs are well suited to vegetation parameter retrieval, but care is required over choice of single versus dual transmitter configurations for best retrieval performance.
- While vector spatial filters for POLSAR are now quite mature, a full and complete approach to multitemporal filtering is currently missing from radar polarimetry.

Recommendations:

- Future constellations should have a dual-transmit mode in order to simplify vegetation modelling/inversion scenarios
- Inversion constraints should be considered in design process of future active/passive satellite constellations
- Further studies are required to incorporate the multi-temporal dimension in polarimetry filtering approaches (PolSAR)

5) Bistatic Polarimetry Theory: Does the use of bi-static polarimetry offer new products or better accuracy in surface and volume scattering applications? In particular does it allow better estimation of vegetation biomass and surface moisture/roughness? What is the importance of the HV-VH channel in bi-static polarimetry and how do we calibrate such new information channels if reciprocity can no longer be used?

6) Optimisation Algorithms: there are now many forms of optimisation used in radar polarimetry and polinsar. Can these be used for practical product development or are they more useful in the algorithm development/research phase. If so, given their increased complexity, what software tools are available to implement these ‘optimum’ processing strategies in the application sector?

Comments:

- Experimental bi-static polarimetric data are missing for quantitative model validations
- Bistatic modelling should be presented in terms of decomposition parameters
- A link between optimisation algorithms and parameter retrieval need to established

Recommendations:

- Recommend acquisition of Pol-InSAR bi-static airborne data within a campaign to support future bi-static algorithm developments