

SAOCOM-CS Mission and ESA Campaigns

→ 4th ADVANCED COURSE ON RADAR POLARIMETRY

30 January – 2 February 2017 | ESA-ESRIN | Frascati (Rome), Italy

Malcolm Davidson

malcolm.davidson@esa.int

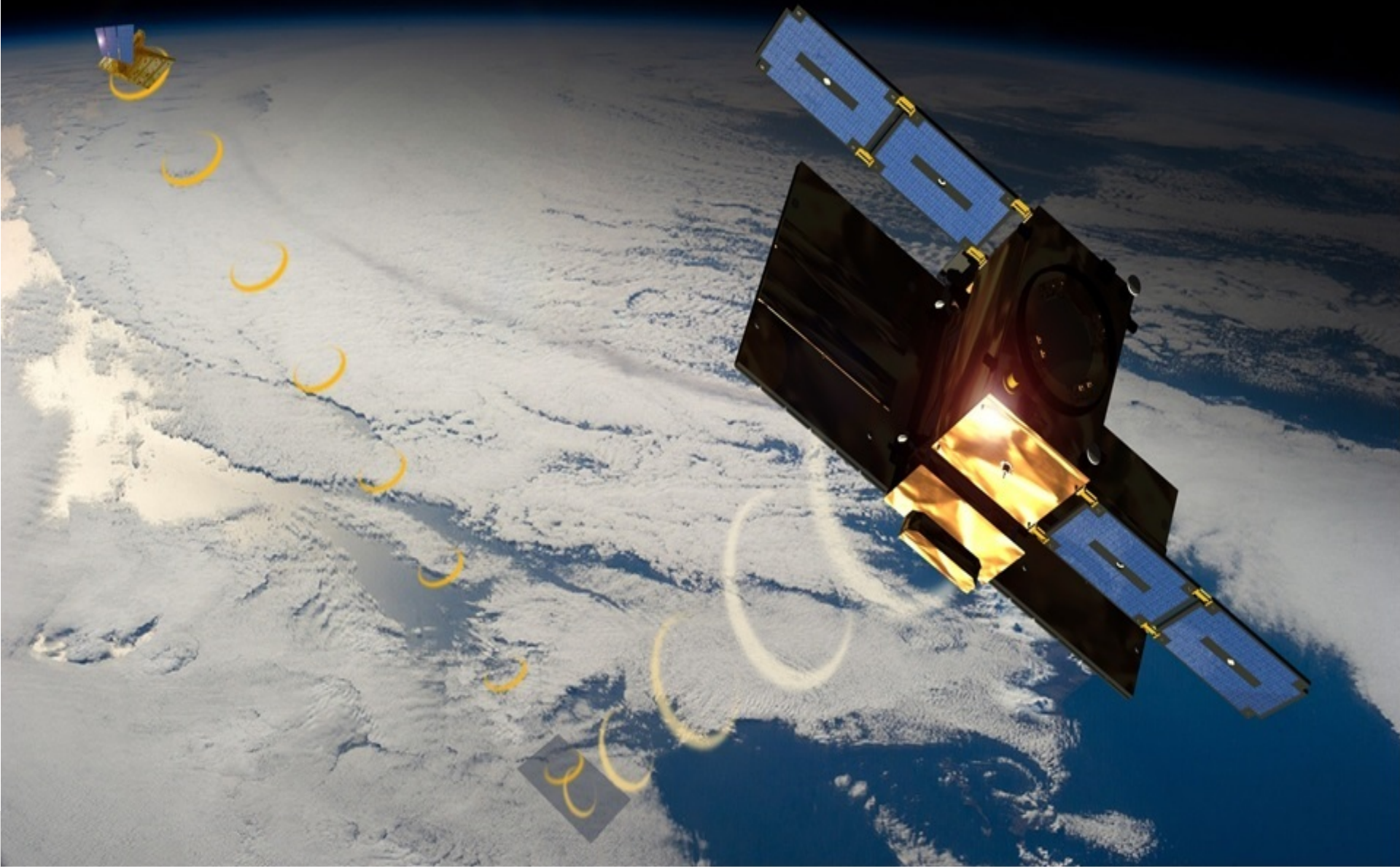
Objectives of presentation

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- Introduce a new type of ESA SAR mission with Polarimetric, Interferometric and **Bistatic** measurement capabilities
 - Use SAOCOM-CS as example for such mission
 - Other missions concepts with bistatic capabilities
 - SESAME (ESA Earth Explorer 9 proposal)
 - Tandem-L (DLR)
- Present ESA airborne SAR campaigns which provide a useful source of data for
 - Testing and exploring missions that are not yet built or in orbit (glimpse of the future)
 - New science development
 - SAR training

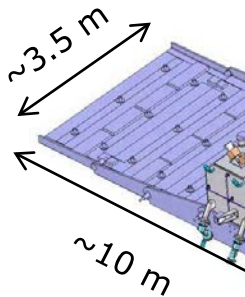
- SAOCOM Companion Satellite Mission (as example of bistatic polarimetric mission)
 - Background
 - Mission Capabilities
 - Mission Science
- ESA airborne campaigns
 - Background and objectives of campaigns
 - Example SAR campaigns
 - Access to Data

SAOCOM-CS Mission



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- The Argentinian Space Agency CONAE - with contributions from ASI - is developing an L-band SAR mission
 - 2 satellites SAOCOM-1A/1B flying in constellation with COSMO-SkyMed (forming together the SIASGE L+X-band SAR system)
 - ✓ 619.6 km altitude, incidence angle range $17.5^{\circ} - 50^{\circ}$
 - ✓ L-band SAR at 1275 MHz, bandwidth up to 50 MHz
 - ✓ peak RF transmit power 3.1 kW
 - ✓ antenna dimensions 10 m x 3.5 m
 - ✓ fully polarimetric, interferometric capabilities
 - ✓ multiple modes (Strip, TOPS)
 - In 2013, CONAE offered ESA to launch a small satellite together with SAOCOM 1B
 - ESA, together with European experts and CONAE have assessed the feasibility to fly a passive add-on satellite in formation with SAOCOM to enhance the science return (condition for cooperation from CONAE)
- 

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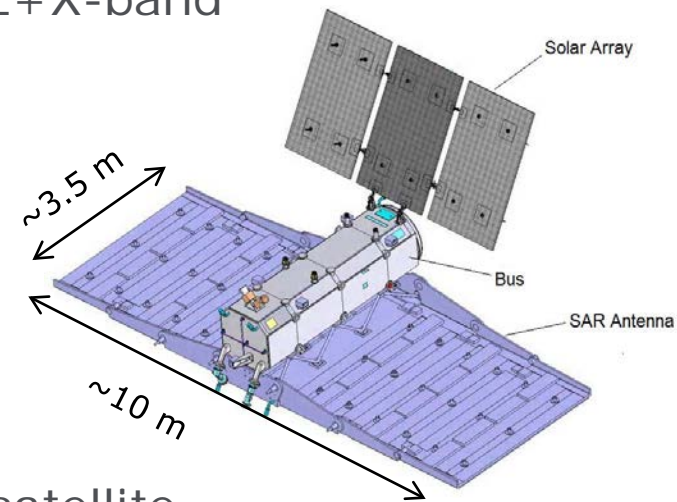
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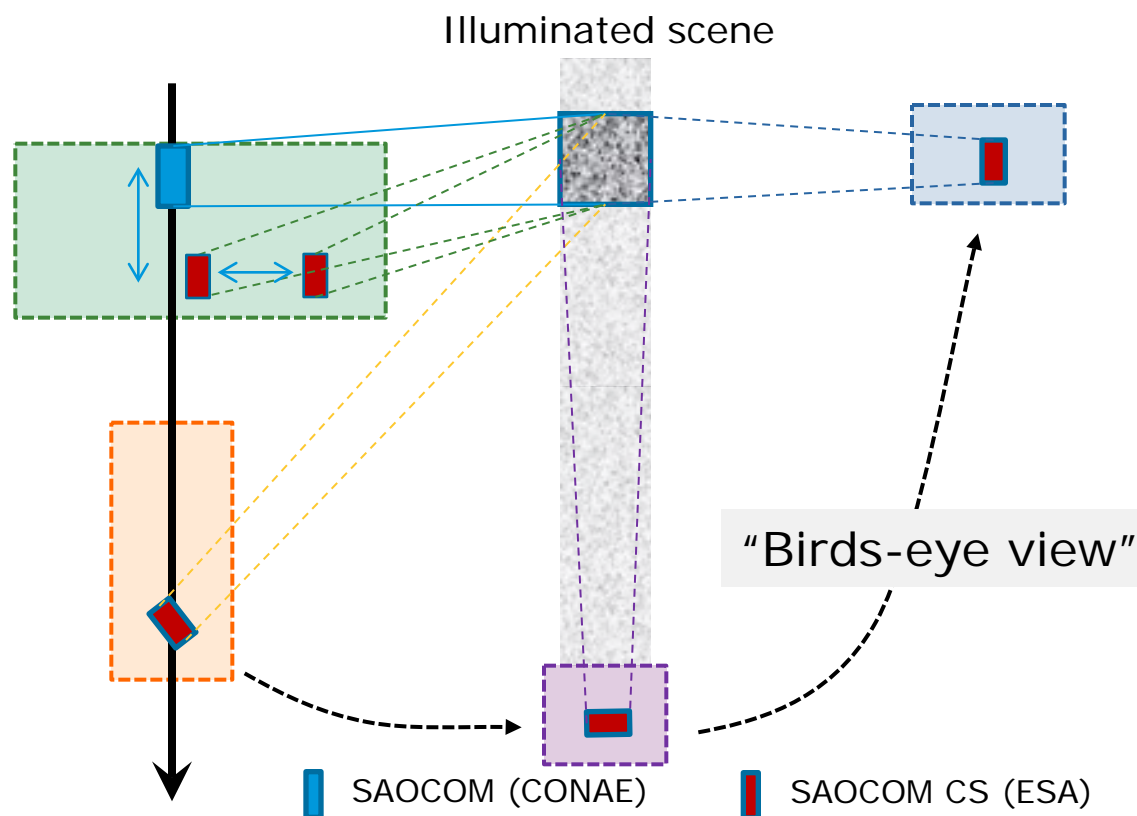
- ## Tomographic phase

- ## Bistatic 1, Bistatic 2

- ✓ AT baseline < 250 km
- ✓ Small XT baseline (phase 1)
- ✓ Large XT baseline (phase 2)
- ✓ Duration ~2 years

Specular phase

- ✓ **Experimental**
- ✓ **Short duration**



Science objectives

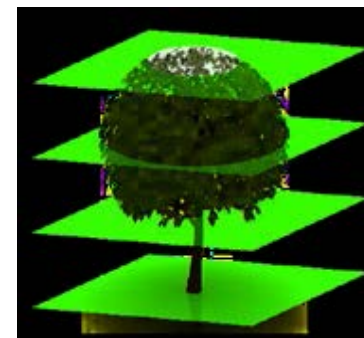
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Tomographic Configuration

Boreal forest structure (mission science driver)

Tropical forest structure (experiment)

Ice subsurface feature mapping (experiment)



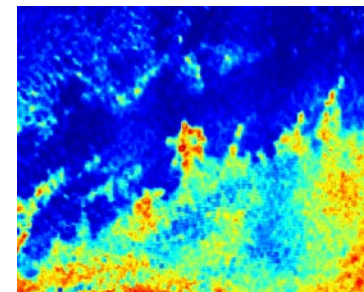
Bistatic interferometry and radar signatures

Dense persistent scatterers (PS) for urban environments (demonstration)

Bistatic interferometry for surface motion and land cover properties (demonstration)

Soil moisture (experiment)

Desert subsurface mapping (experiment)



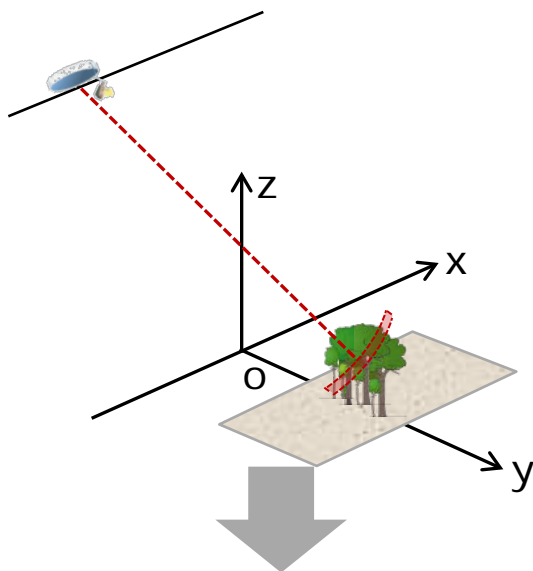
Specular configuration

Soil moisture (experiment)

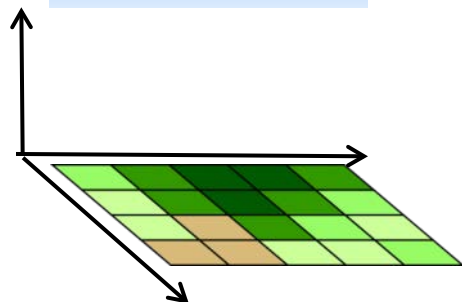
PolSAR to TomoSAR

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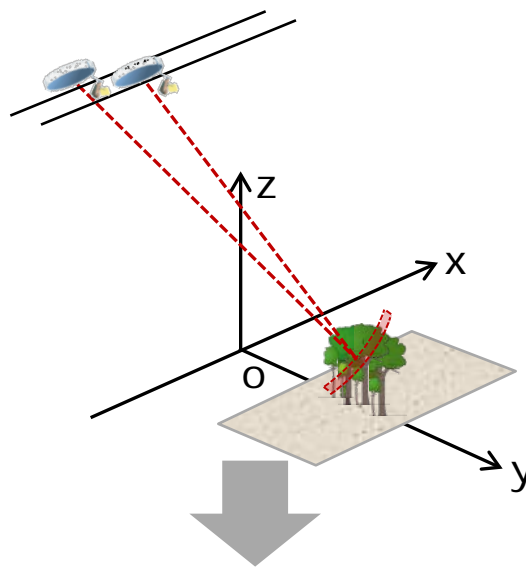
PolSAR
(SAR Polarimetry)



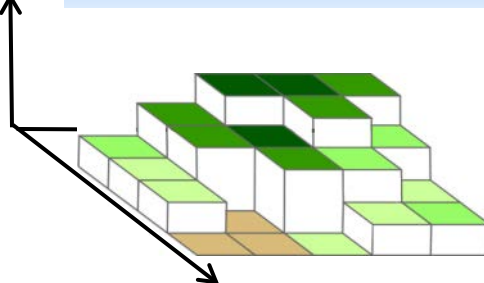
SAOCOM only



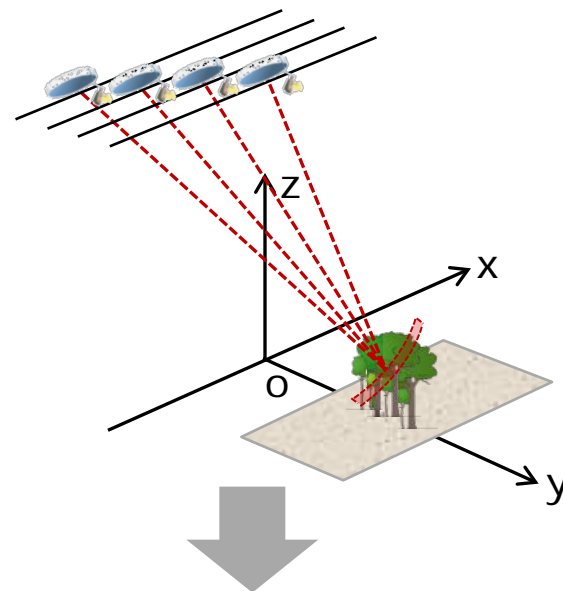
PolInSAR
(Polarimetric SAR Interferometry)



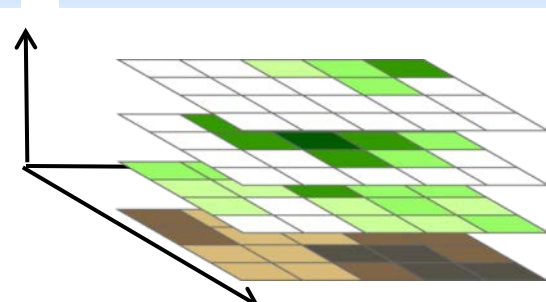
Height SAOCOM+CS (1 pass)



Tomo SAR
(SAR Tomography)

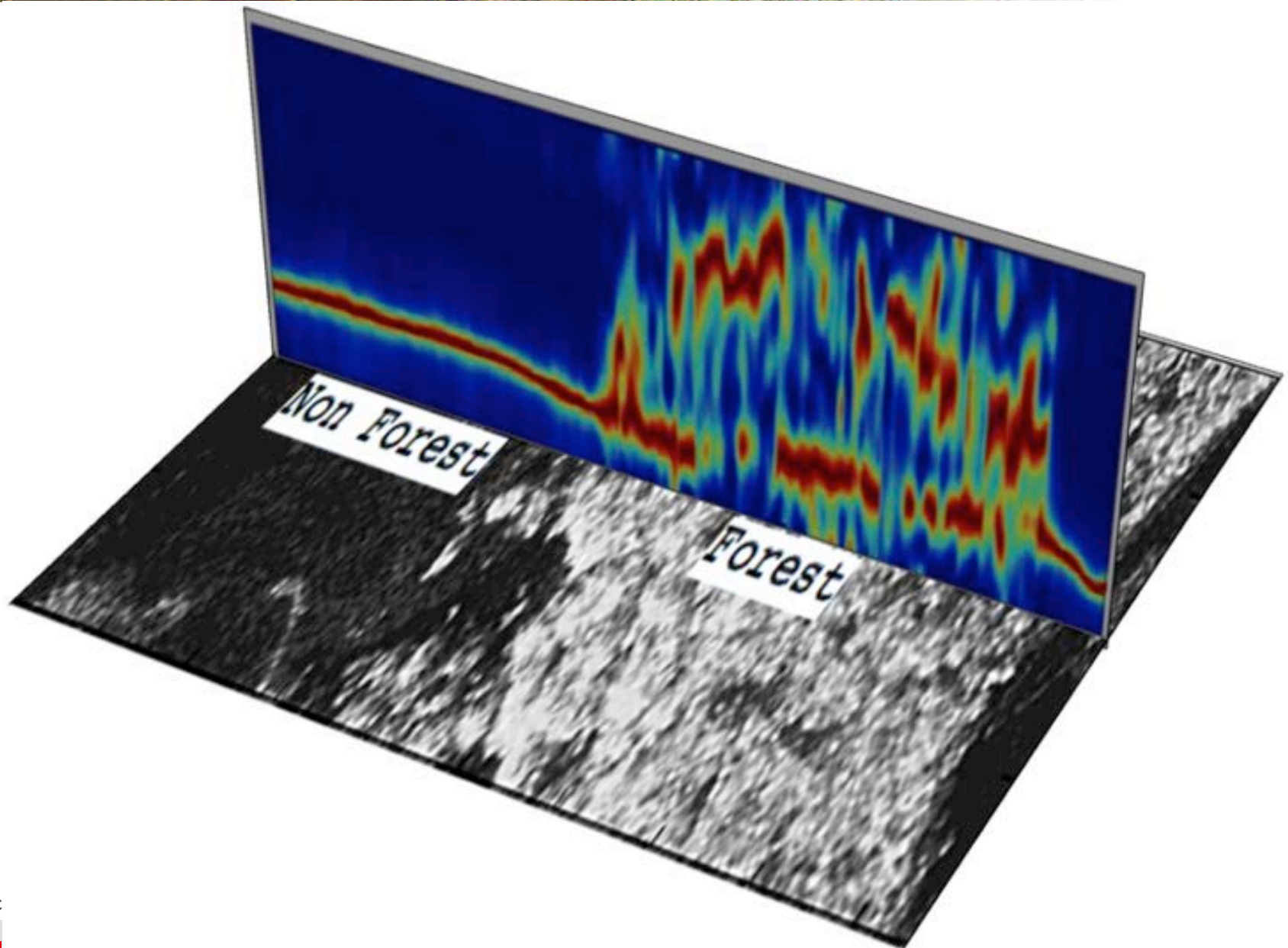


SAOCOM+CS (>1 passes)



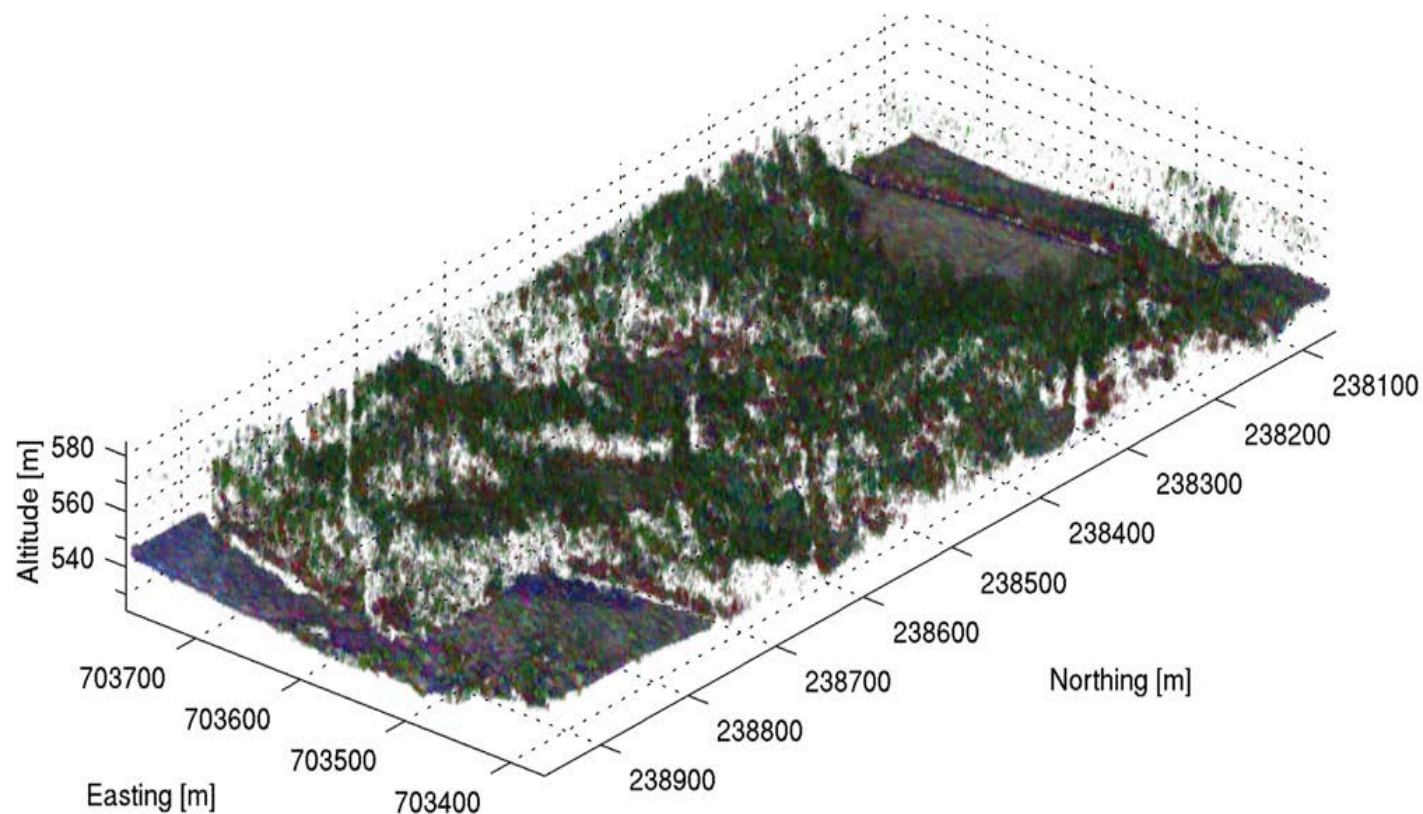
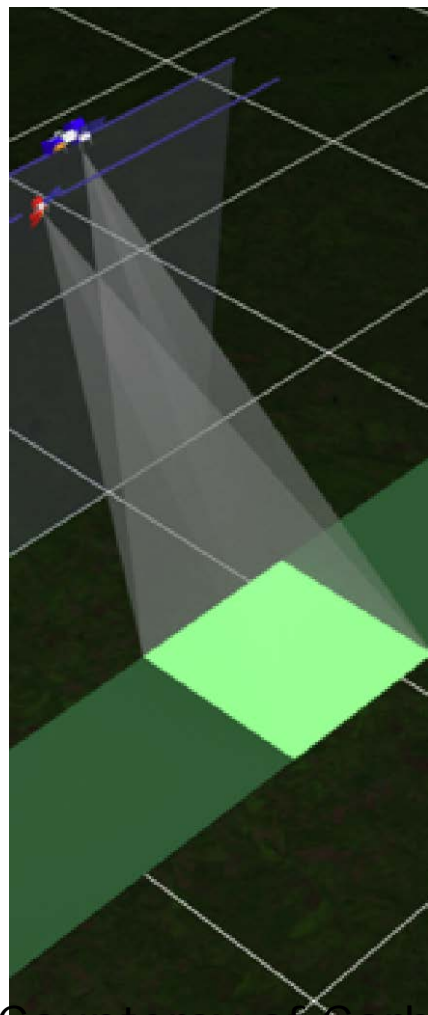
TomoSAR vs conventional 2D SAR imaging

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Example forest structure product based on tomography

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(Frey & Meier, 2011)

Countersy of Carbomap UK

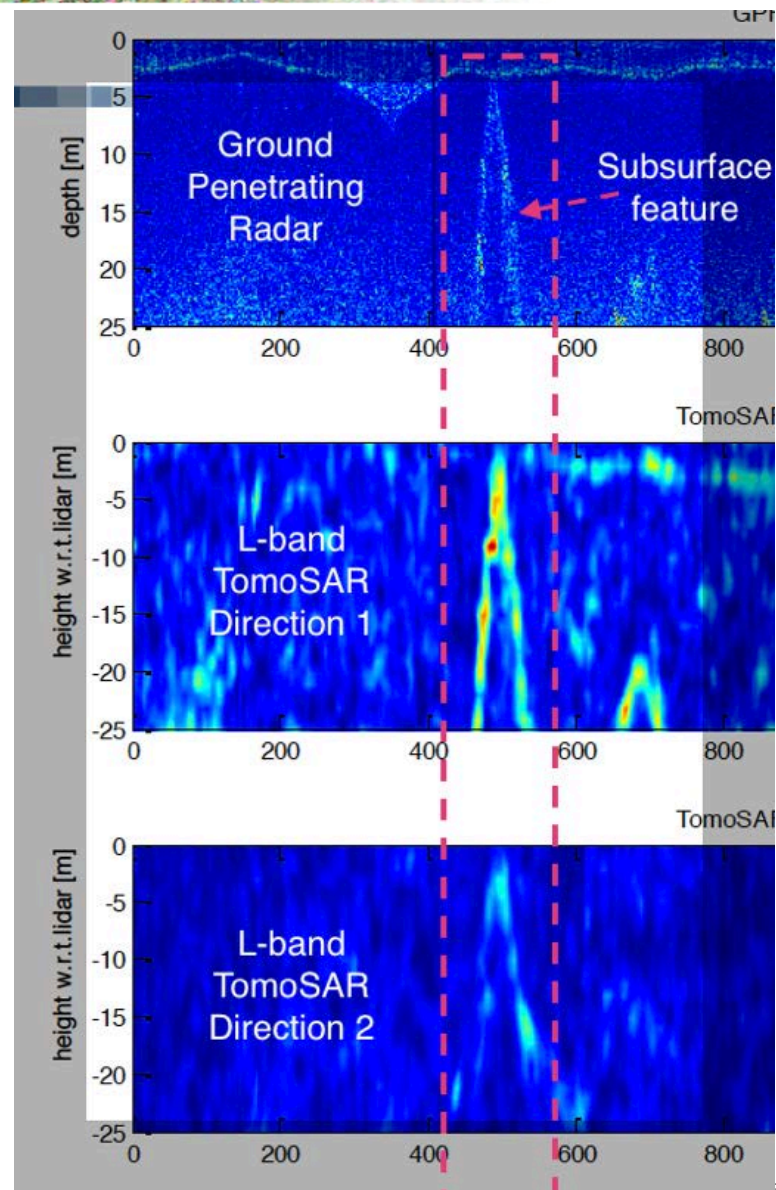
Example ice subsurface product

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Mittelbergfehrner, Austria



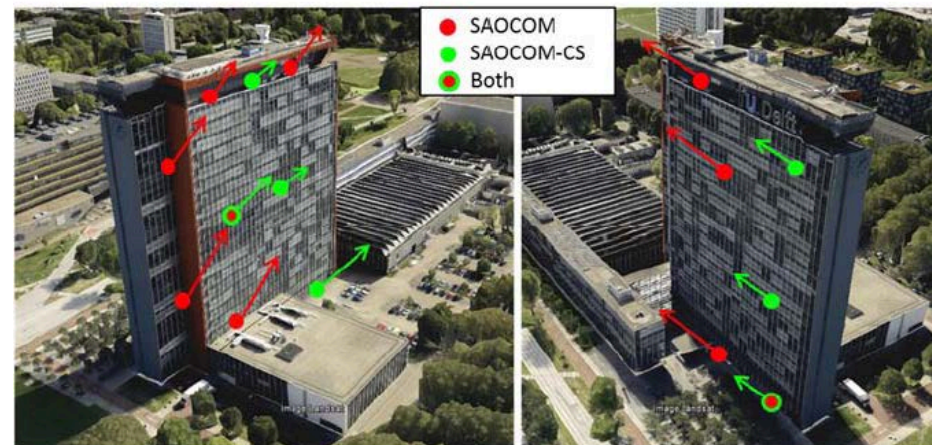
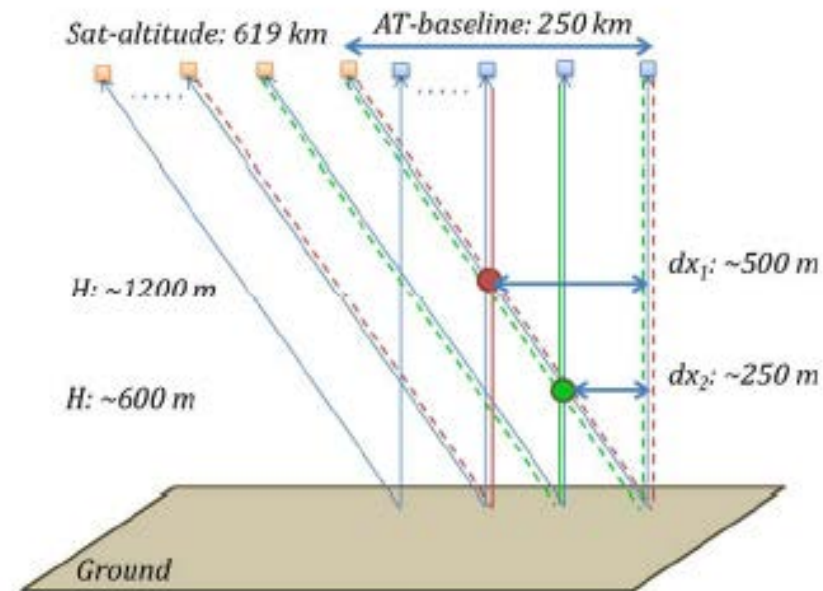
Tabaldini (POLIMI)
Nagler (ENVEO)



Example bistatic along-track application

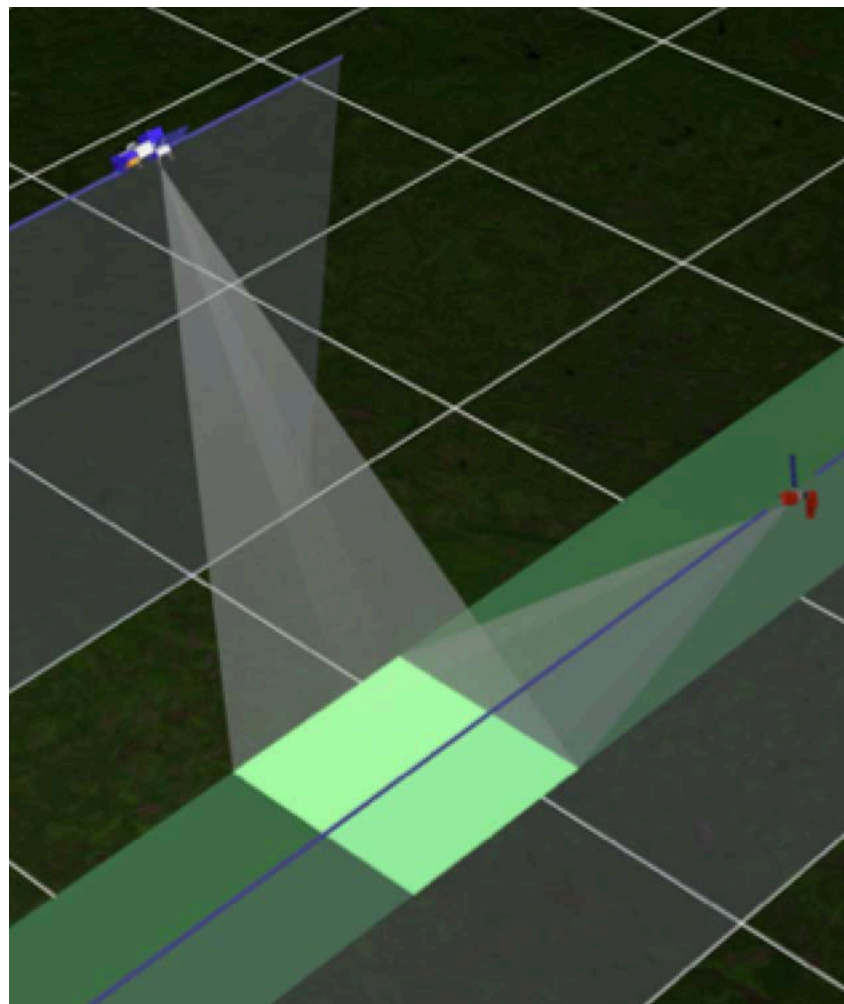
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- Urban interferometric applications based on persistent scatterers
- Phase-changes in PSs are related to movement of buildings and ground beneath (e.g. subsidence)
- Bistatic measurements improve density of PSs and urban motion estimates because:
 - Remove spatial saturation due to dihedral & trihedral scatterers
 - Allow identification of additional PS sources (i.e. fill in gaps)

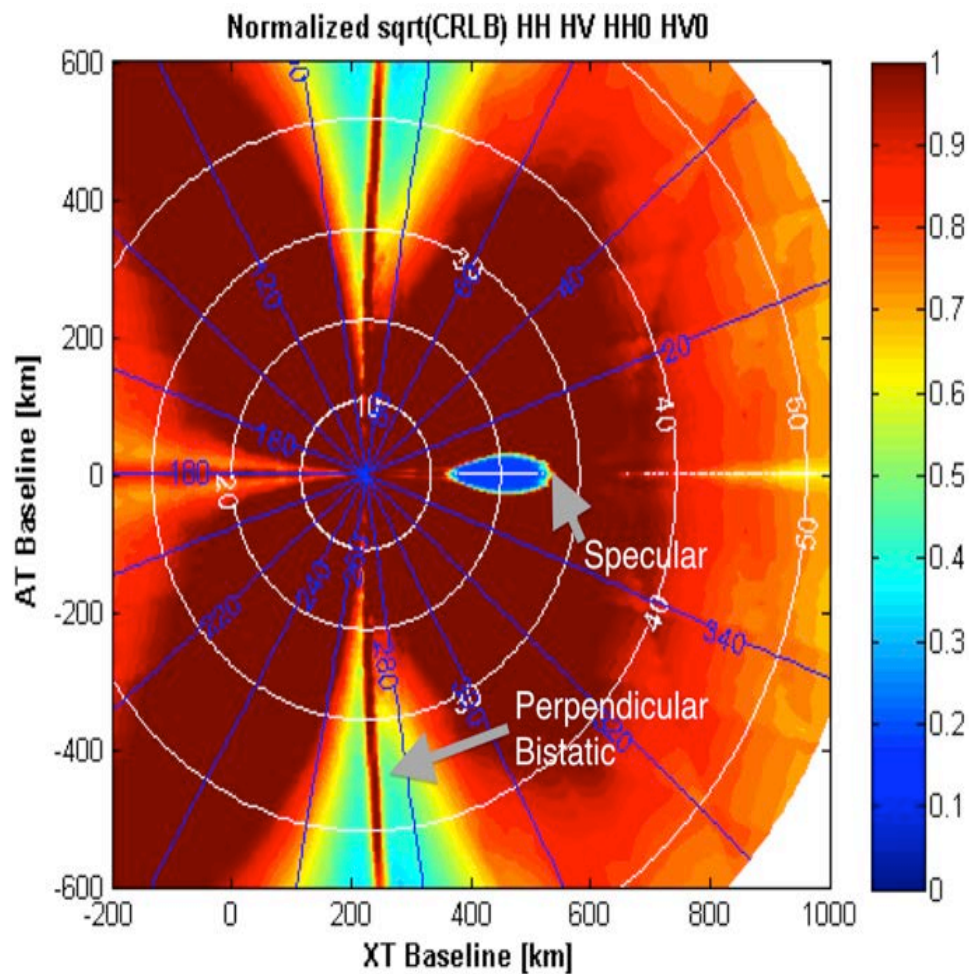


Example specular product

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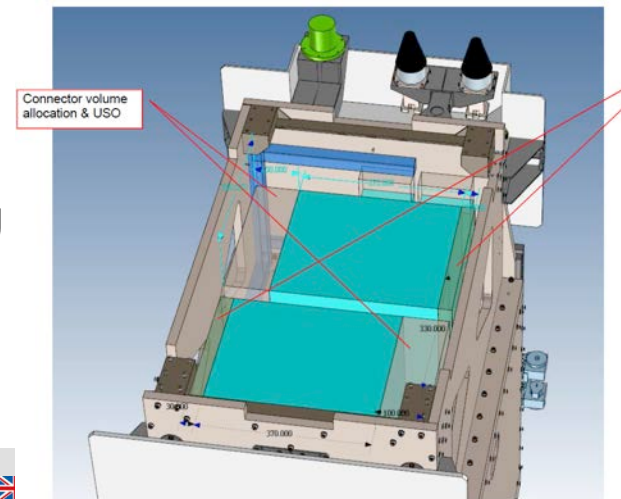
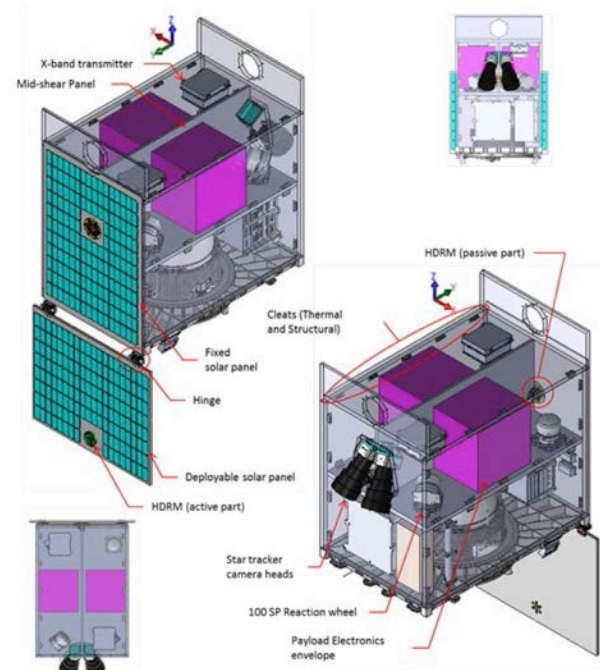


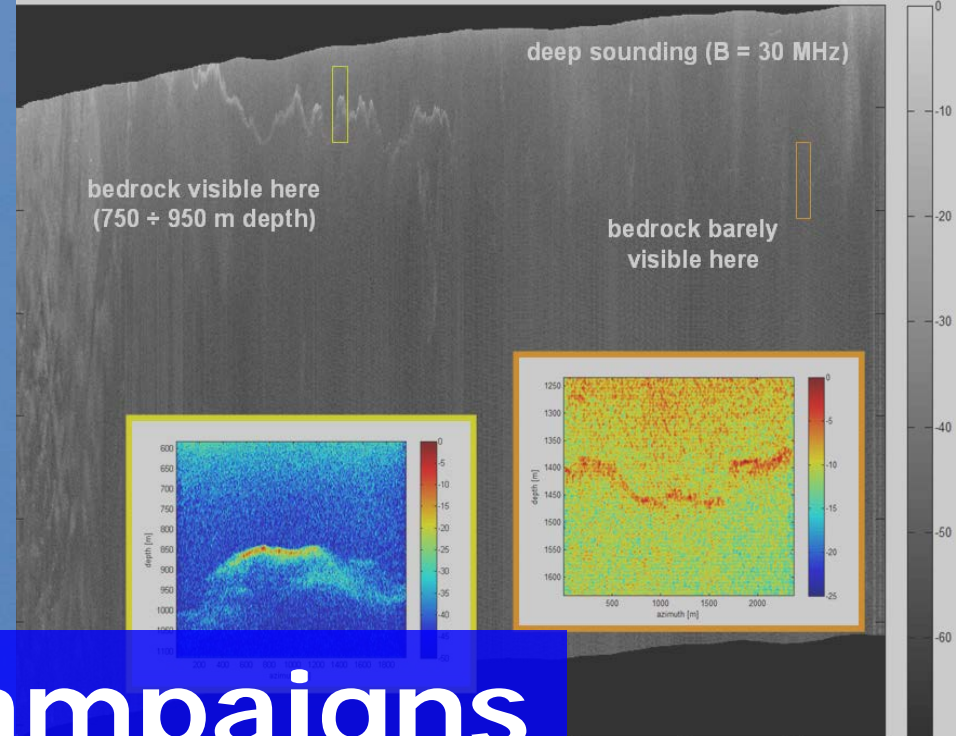
N. Pierdicca

Mission Implementation

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- SAOCOM-CS mission characteristics
 - ✓ 5m resolution/6 minutes of operation per orbit
 - ✓ 3 x 1m antenna
 - ✓ Formation flying with 3 main geometries (tomographic, bistatic and specular)
 - ✓ 400kg wet mass
 - ✓ Launch as co-passenger on Falcon-9
- Ground Segment
 - Mission Control Centre (core of flight operations segment)
 - Two X-band ground stations for science data downlink
 - A (distributed) PDGS for science data processing
- Short development schedule (ready for launch by 2nd half 2019)





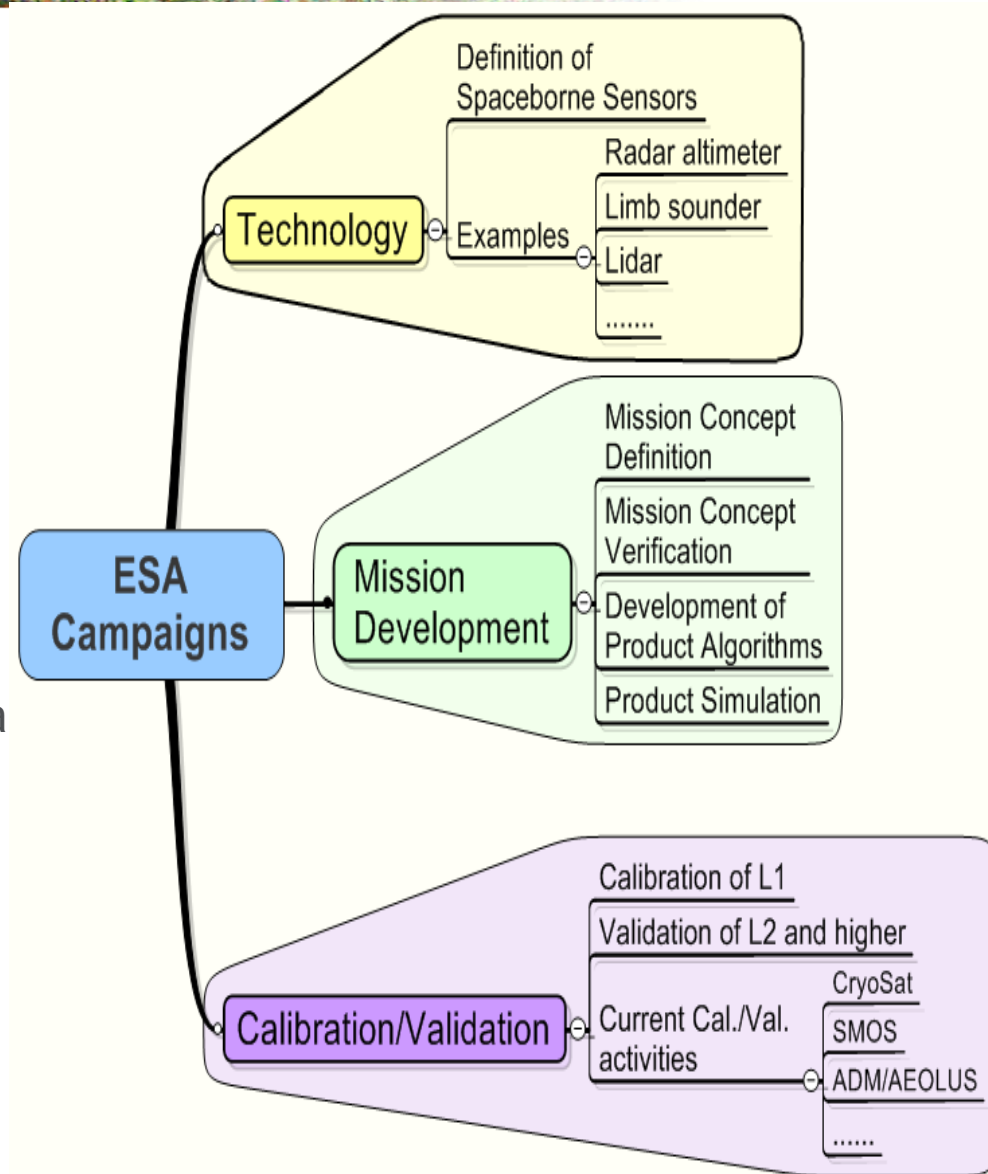
ESA Campaigns



European Space Agency Earth Observation Campaigns

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- Programme started in 1981
 - 120+ campaigns as of 2016
 - 6-10 campaigns/year
- Strategic objectives:
 - 1) Support to EO satellite missions
 - 2) Improved access to airborne instrumentation
 - 3) Partnerships with national and international organisation
- Campaign activities address three main areas: technology, mission development and calibration/validation



ESA airborne SAR campaigns - overview

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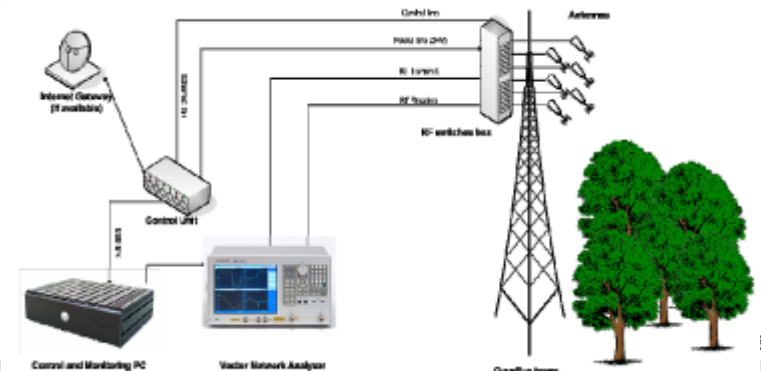
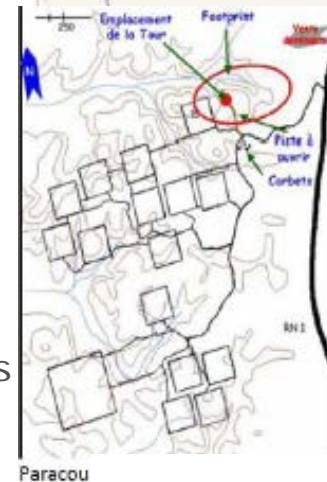
1. ESA radar airborne campaign activities **address needs of ESA SAR missions**

1. Mission design and implementation
2. Mission science

2. Main campaign datasets to date

- a. Indonesian Radar Experiment** in Borneo in 2004 (with DLR)
- b. BioSAR-1, -2 and -3** over boreal forests in Sweden (DLR, ONERA)
- c. TropiSAR** 2009 over tropical forest in French Guyana (ONERA)
- d. AlpTomoSAR** over Austrian glacier (MetaSensing)
- e. TropiScat** scatterometer measurements in French Guyana (CESBIO, ONERA, POLIMI)
- f. AfriSAR** 2015/2016 in Gabon (DLR, ONERA, NASA)
- g. AfriScat** 2014-2016 in Ghana

3. Campaign datasets generally include well-documented airborne and ancillary data (e.g. lidar, ground biomass estimates, tree height data)



Example Campaign: AfriSAR

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Objectives

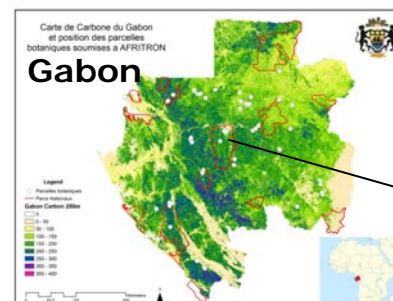
- a. Extend results from the previous TropiSAR campaign in French Guiana to an African tropical rain forest with different structure and environmental conditions
- b. Provide feedback on Biomass mission operations and Level-2 product quality
- c. Assess changes in P-band signal as a function of time over same sites

Campaign details

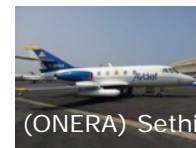
- a. Collaboration with DLR (DE), ONERA/CNES (FR) and NASA
- b. Several test Sites in Gabon
- c. Two flight campaigns: July 2015 (ONERA) and Feb 2016 (DLR)

First results

- a. First Mosaic over La Lopé
- b. First forest height tomograms demonstrate that TomoSAR potential for African Tropical forests



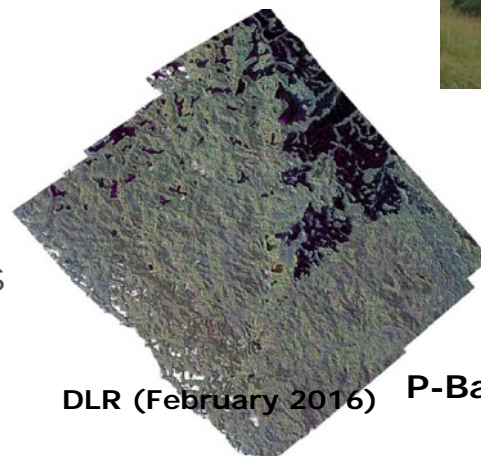
(DLR) F-SAR



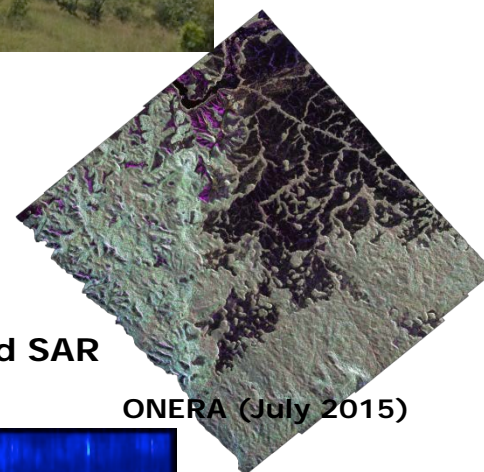
(ONERA) Sethi



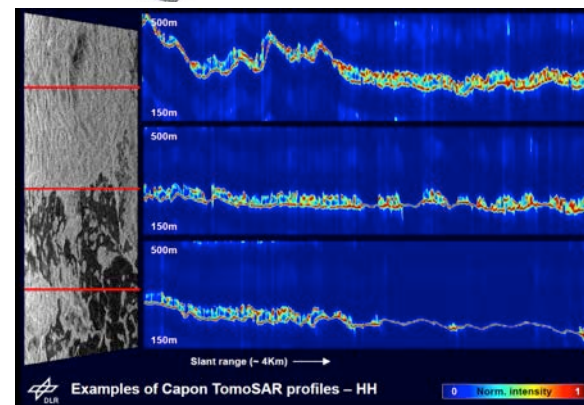
La Lopé



DLR (February 2016)



ONERA (July 2015)



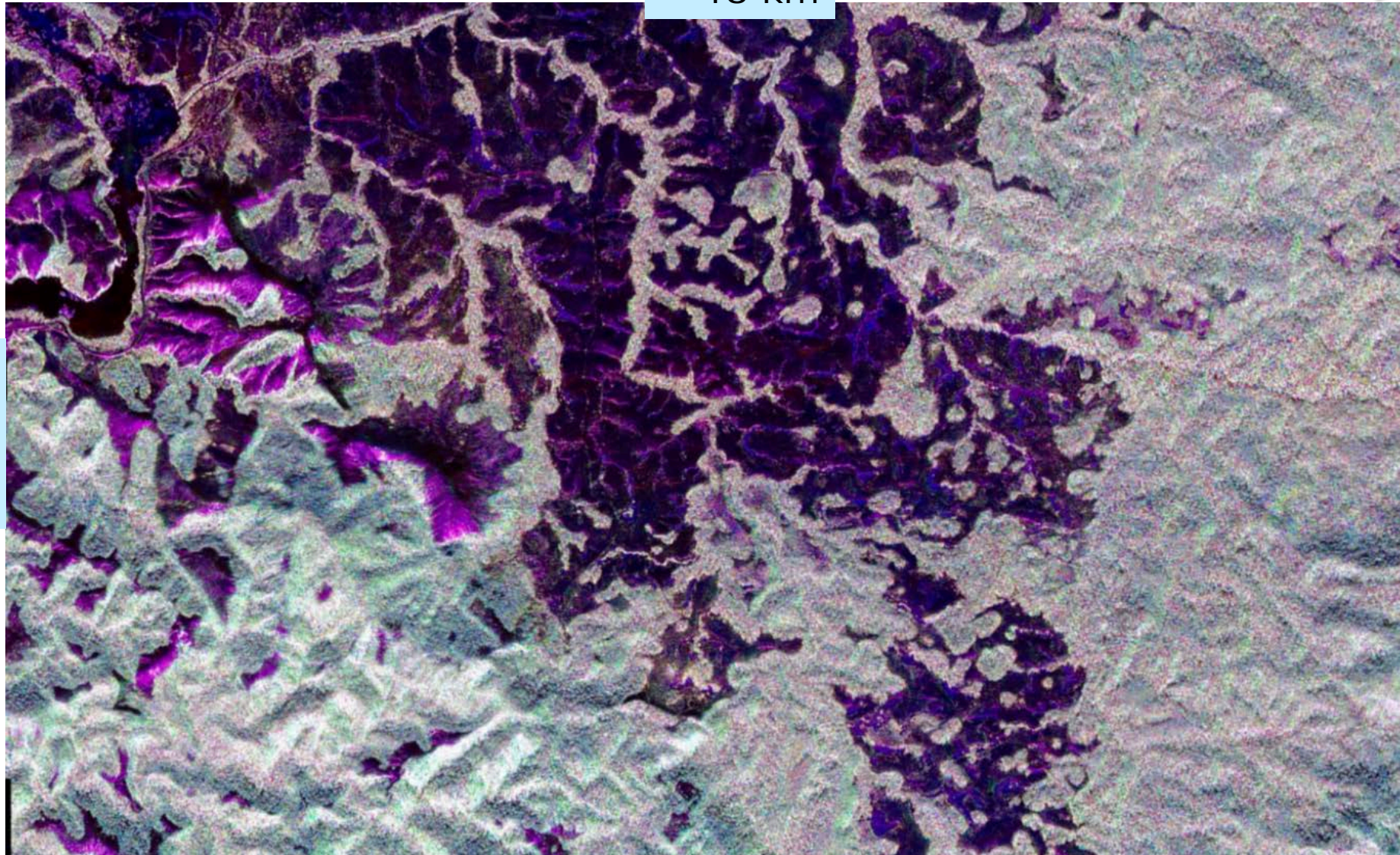
Examples of Capon TomoSAR profiles - HH

Lope National Park Mosaic

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~ 18 km

~ 12 km

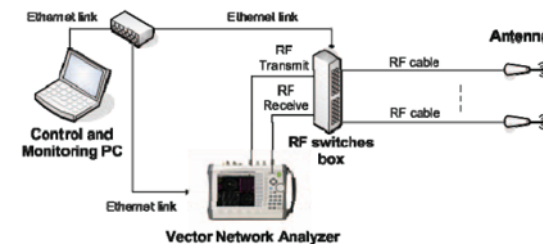


Objectives

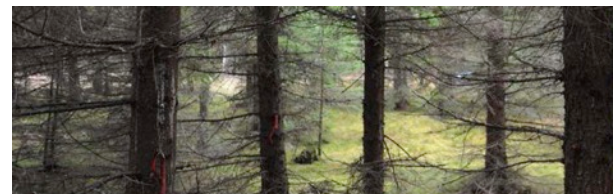
- a. Hyper-temporal polarimetric, tomographic radar measurements at P-, L- and C-band over hemi-boreal site
- b. Provide fundamental information of radar scattering mechanisms
- c. Data to support mission design (e.g. decorrelation times) and algorithm development for Biomass, SAOCOM-CS and C-band companion concept missions

Experiment details

- a. Prime: Chalmers University (SE)
- b. Tower based in Remningstorp forest in Sweden
- c. First acquisitions expected by October 2016 (P- and L-band) and April 2017 (C-band)



New 50-m tower



How to access ESA campaign data ?

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- ESA campaign data available to interested PIs
 - Formatted and documented datasets
 - Data Inventory
 - Final report with full description of campaign activity and analyses
- Final report accessible directly through web
- Access to datasets provided through Category 1 mechanism (short proposal incl. identification of desired datasets)
- Currently **71** campaign datasets available

<https://earth.esa.int/web/guest/campaigns>

esa Earth Online

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ESA Earth Observation Campaigns Data

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ESA Earth Observation Campaigns Data

- The datasets resulting from ESA airborne campaigns, available on Internet or media, can be accessed by submitting a request on the [ESA EO Campaigns data](#) section of the PI Community
- For additional information, please contact the [Earth Observation Helpdesk Team](#)

Campaign (with link to final report PDF)	Year	Geographic site(s)	Field of application	Data availability	Data Size (in Gb)	Workshop Proceedings
AirScatterGNSS	2015	Gulf of Finland	Scatterometer wind data	online	35.3 Mb	
CHARADMexp	2014	Finokalia, Crete	Lidar ground measurements of marine and marine-dust aerosols	online	8.1 Gb	
AlpTomoExp	2014	Mittelbergfemer, Austrian Alps, Austria	Airborne L-Band SAR Data together with ground-based in-situ and GPR data	on media	100 Gb	
DOMEX-3	2014	Antarctica, DOME-C	Tower based L-Band radiometric measurements and in-situ snow temperatures	on media	29.5 Mb	
CryoVEx ASIRAS	2014	Arctic	Sea-Land ice radar altimetry and laser scanner	on media	148 Gb	
CryoVEx AEM	2014	Beaufort Sea, Arctic Ocean north of Canada and Greenland	Airborne EM-bird, ground measurements	online	< 1 Gb (575.3 Mb)	
SMOSice	2014	Barents Sea, SE Svalbard	Airborne L-Band radiometer data, ALS, EM-bird, surface temperature and radiation	online	75.3	
FLEX-US	2013	Forest sites, N. Carolina	Airborne hyperspectral data and ground-based in-situ	on media	6 TB	
DOMEX-3	2013	DOME C, Antarctica	Tower based L-Band radiometric measurements and in-situ snow temperatures	online	44 Mb	
SEN2EXP	2013	Mulhouse (France)	Forested area in support to Sentinel-2 mission	on media	More than 50Gb	
DOMEcair (GOCE)	2013	DOME C, Antarctica	Airborne gravity data	on media	More than 50Gb	
DOMEcair (SMOS)	2013	DOME C, Antarctica	Airborne L-Band radiometer data	online	0.12	

Missions

- Missions Home
- ESA EO Missions
- ESA Future Missions
- 3rd Party Missions
- ESA Earth Observation Campaigns Data
- ESA/EUMETSAT
- ESA Mission Continuity
- ESA Mission News
- ESA User Services News
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- ESA Campaigns

Latest Mission News

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- Aladin wind probe ready for Aeolus
- SMOS tracks Pacific fresh water pools
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ESA Mission Continuity

1960 - 2020

Conclusions

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- SAOCOM-CS a small satellite SAR mission with highly innovative measurements from space (example of R & D satellite)
 - Bistatic single-pass measurements brings new information and future applications
 - Feability of bistatic SAR missions concepts currently being studied
- ESA has organised a number of airborne SAR campaigns in past 15 years in support of spaceborne missions (BIOMASS, SAOCOM-CS, TerraSAR-L, Sentinel-1)
- Airborne SAR datasets available to the science community via campaign database
 - Short registration procedure (10 – 15min max)