THE SCATTEROMETER INSTRUMENT COMPETENCE CENTRE (SCIRoCCo): PROJECT'S ACTIVITIES AND FIRST ACHIVEMETS

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ABSTRACT

The Scatterometer Instrument Competence Centre (SCIRoCCo, http://scirocco.sp.serco.eu) is a project established by the European Space Agency (ESA) in 2014 as an interdisciplinary cooperation of international scatterometry experts aimed at promoting the continuing exploitation of ESA's unique 20 years' worth of ERS Scatterometer data (ESCAT) at medium (25Km, 50 Km) spatial resolution, and improving the quality of available and future scatterometry data.

SCIRoCCo aims at consolidating current methodologies for Scatterometer data processing and calibration. SCIRoCCo provides ERS-1/ERS-2 sensors inter-calibration, sensor characterization and data validation.

Data analysis and processing software, academic and technical publications in support of calibration and many diverse applications and research in Land (e.g. Soil Moisture), Oceanography (Ocean Winds, Sea, Ice), Climatology are also provided through the web portal, which also serves as the entry point to SCIRoCCo's educational network, funded through Grants and aimed at fostering the next-generation scatterometry experts.

SCIRoCCo thus targets the needs of meteorological agencies, meteorological operations centers and the broader Researchers' and Users' communities for consistent and high quality Scatterometer data processing.

1. The SCIRoCCo PROJECT

1.1. Project Areas

SCIRoCCo activities cover a broad spectrum of activities, organized in five areas:

i) consolidation of scatterometry documentation, data processing and calibration, through methodologies complying with the GCOS recommendations;

ii) scientific support to the next ESA's ESCAT data reprocessing campaign;

iii) Outreach to the scatterometer user community to encourage the usage of ESCAT data, providing a single point of collection and exchange of information and knowledge on ESCAT through the web-portal: http://scirocco.sp.serco.eu/;

iv) Educational program aimed at fostering the next-generation scatterometer community. Grants, stages, and training initiatives related to scatterometer data exploitation and evolution has been set up with special consideration to proposals and activities based on scatterometry and showing innovation and cross-domain applicability (eg. Land, Oceanography...).

v) Improvement of the current processing algorithms and geophysical models through the analysis of instrument design, inclusion of inter/cross calibration amongst different instruments in the level-1 processing. Consolidation of the level 2 retrieval algorithms for soil moisture, sea surface wind vector, and sea ice characteristics. Validation and assimilation of the results.

1.2. Organization

SCIRoCCo collects experts from different entities with recognized international expertise in the scatterometer area. Current members are: the Royal Military Academy of Belgium (RMA), the Koninklijk Nederlands Meteorologisch Instituut (KNMI), the Technische Universität Wien (TU Wien), the European Centre for Medium Weather Forecast (ECMWF) and Serco spa (Italy), as prime contractor and project interface to ESA. Fig, 1 shows the project organization, the assigned tasks and the project schedule plan.

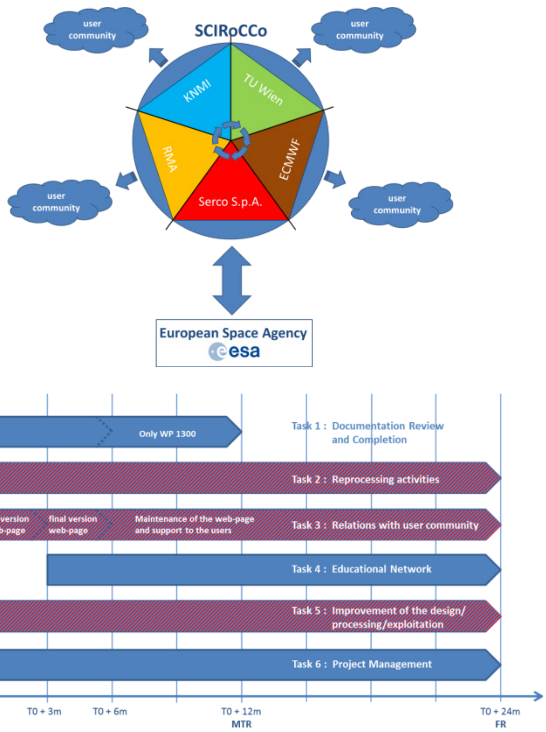

Figure 1: SCIRoCCo project organization (upper panel) and project plan (lower panel)

SCIRoCCo, started in June 2014, is funded by the European Space Agency in support of the activities of the Sensor Performance and Product Assessment and Algorithm section (EOP-GMQ), for the ERS-2 scatterometer mission during the Phase-F exploitation and for the ERS-1 scatterometer mission in the framework of the Long Term Data Preservation (LTDP) programme.

2. SCIRoCCo PROJECT RESULTS

The SCIRoCCo project is still on-going and the entire set of the final results are not yet available. Nevertheless, the most relevant project results achieved so far are reported in the next subsections focused on the main project areas.

2.1. Documentation, Outreach and Educational

SCIRoCCo’s web portal (http://scirocco.sp.serco.eu/) is the entry point to SCIRoCCo’s documentation, educational network and grants (see Fig.2). The portal provides a single point of collection and exchange of information and knowledge on ESCAT and it already includes the scatterometer glossary, educational material and grants available to European researchers.

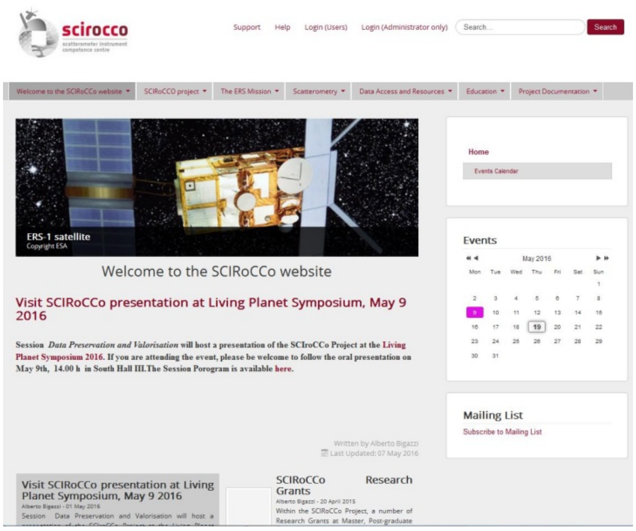

Figure 2: SCIRoCCo web-portal, home page

Several European students have been involved in the educational network within the research activities detailed in Tab. 1. For some of the grants an internship period of 3 months was performed, in order to strength cooperation inside the consortium and to develop students international research experience.

Grants research subjects	Institution
Examining the validity of ERA-Interim for tropical hurricanes over the course of time	KNMI
Neural-network based sea/ice discrimination using ERS scatterometer data	RMA
Surface State Flag (SSF) from ESCAT data	TU Wien
Daily vegetation modelling to improve the ERS ESCAT soil moisture retrieval	TU Wien
Comparison of ESCAT sea backscattering coefficients with electromagnetic models of sea surface scattering and other empirical models under challenging geophysical conditions	KNMI Serco
Comparison of satellite soil moisture products, models and on-site observation by intercomparison of ESCAT vs SMOS over the USDA Watershed in the period Jan-2010 / Jul-2011	TU Wien Serco
Comparison of satellite soil moisture products, models and on-site observation by triple / quadruple collocation including ESCAT data over H-SAF region (Europe) or "global" for ESCAT regional scenario	TU Wien Serco

Table 1: List of SCIRoCCo grants research subjects concluded or on-going

2.2. Support to ESCAT data reprocessing

As part of the support for the ESCAT mission reprocessing the SCIRoCCo project is responsible for the provision of the calibration factors and the characterization of the in-flight antenna patters and reprocessed dataset verification. The inter-sensors calibration methodology developed at RMA, for the reprocessing of the ERS-2 Scatterometer data [1], [2], [3] has been applied to compute cross-calibration coefficients between ERS-1 and ERS-2 scatterometers. The main underlying assumption of the method is that differences in measured σ_0 (sigma-nought) are due to differences in antenna gain. The cross-calibration methodology used was a two-step routine:

i) a *model bias* (β^*) is computed for a range of incidence angle and for each antenna by comparison of the measured sigma-nought and the simulated one for both scatterometers. In our case the model used is a constant sigma-nought over the Brazilian Rain forest.

ii) the *bias* (β) is computed by comparison of the *model bias* of ERS-1 scatterometer and the *model bias* of ERS-2 scatterometer

Since the inter-comparison is performed Wind Vector Cell (WVC) by WVC, the *bias* (β) is a function of incidence angle (antenna elevation angle) or the WVC (across-track node number). As nominal ESCAT products are used, the inter-comparison provides, for each antenna, 19 calibration coefficients. Herein, the *bias* (β) is equal to the difference (ERS-1 - ERS-2) and therefore the model is not taken as reference in the absolute sense. Finally, the antenna gain used in the normalization function is corrected for β and this corrected antenna pattern is used in the ESCAT data reprocessing. For the dataset before reprocessing, Fig. 3 shows the *model bias* (β^*) for both ERS-1 and ERS-2 scatterometers and the *bias* (β) for the Mid and Fore antenna. The Mid beam inter sensor *bias* (β) is about 0.2 dB. That bias translates on about 0.2 m/s for wind speed bias.

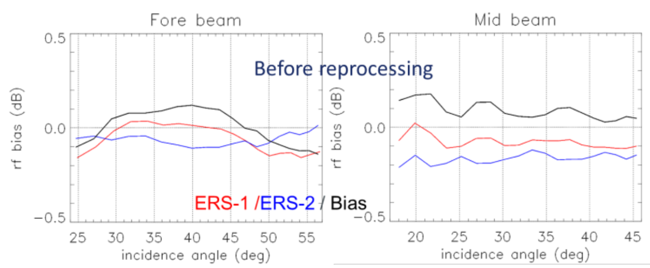

Figure 3: ERS-1 and ERS-2 model bias and inter-sensor bias over the Brazilian rain forest. Data before the reprocessing

Once corrected for the bias, the computed antenna patterns are shown in Fig. 4. In this case the antenna profiles are much more flat across the range of incidence angles and the inter sensor *bias* (β) becomes negligible within 0.03 dB.

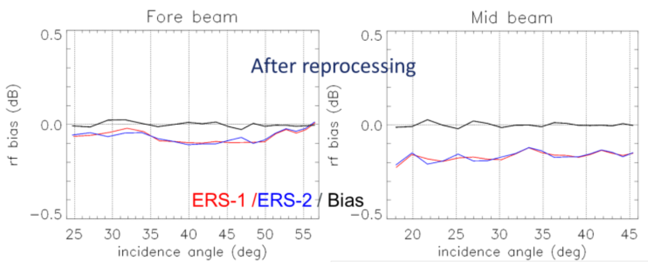

Figure 4: ERS-1 and ERS-2 model bias and inter-sensor bias over the Brazilian rain forest. Data after the reprocessing

2.3. Evolutions in calibration monitoring methodologies

A new tool for scatterometer inter-calibration, termed cone metrics, has been developed in the context of the KNMI's winds reprocessing activities for ERS-1 and ERS-2. The new method, which is based on monitoring changes in the location and shape of the surface of maximum backscatter density in the instrument measurement space (also known as "the wind cone", see Fig. 5), complements the standard NWP Ocean Calibration (NOC) method nicely. Cone metrics are independent of the ocean wind distribution, and able to deal with situations that do not satisfy the linear beam offset assumption.

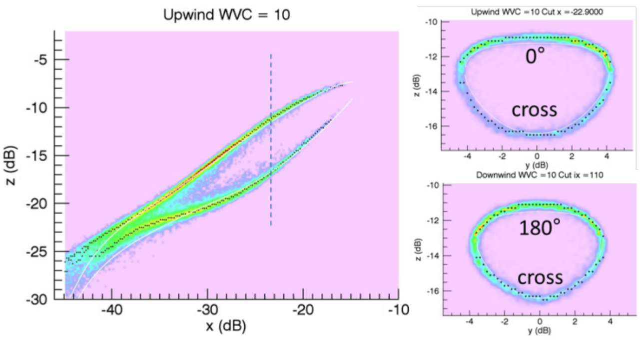

Figure 5: The surface of maximum backscatter density (black dots) defined from the 3D histogram of ASCAT backscatter triplets collected from Oct'07 to Sep'08. Four well defined surfaces are used to draw the wind cone: two for the upper and lower branches of the upwind sheath, and another two for the upper and lower branches of the downwind sheath.

Using 50Km resolution sigma-nought scatterometer data archived at KNMI (not reprocessed data set), the surfaces of maximum backscatter density (or wind cones) may be defined using different instruments over different periods. Here we will examine:

1) ASCAT over 2014
2) ERS-1 over 1995
3) ERS-2 over 1997

The relative beam offsets between records (assumed linear at this point, as in ocean calibration) may be determined by monitoring changes in the location of one cone relative to some other reference cone. Note that the reference cone is defined (yet somewhat arbitrarily) by the ASCAT data collected over Oct'07 to Sep'08, the same period over which CMOD6 was developed. The determination of relative beam offsets is carried out by minimizing the RMS difference between cones using variable fore/aft/mid beam offsets (see Fig. 6).

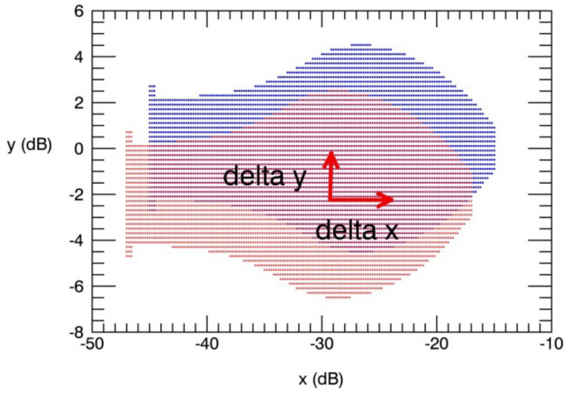

Figure 6: Minimizing the RMS difference between cones for variable fore/aft/mid beam offsets.

If the relative beam offsets are actually linear, then the cone differences will result in a manifold of flat residuals after solving for the relative cone shift (see Fig. 7). The presence of relative beam non-linearities may thus be detected by carefully monitoring the structure of the residuals, which amounts to looking for changes in cone shape (see Fig. 8).

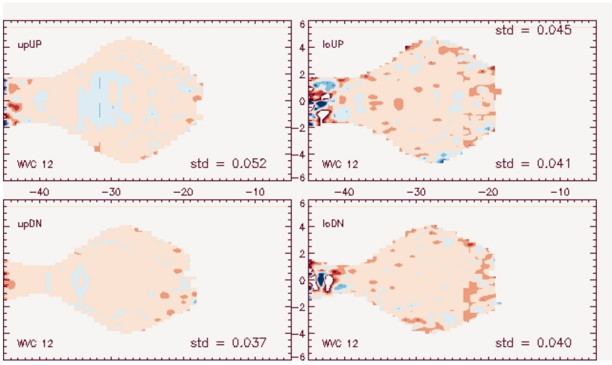

Figure 7 Cone fit residuals between the ASCAT 2014 and ASCAT reference cones (WVC12).

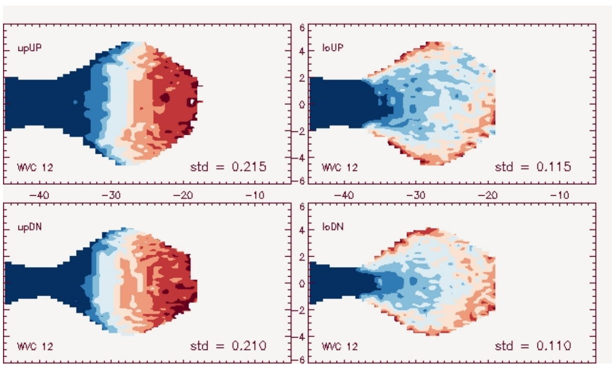

Figure 8 Cone fit residuals between the ERS2 1997 and ASCAT reference cones (WVC12).

From the limited number of comparison performed so far, we learn that the wind cone does not change its shape over the ASCAT period. This is a necessary condition for the assumption of linear beam offset to hold, and thus for the Numerical Weather Prediction (NWP) ocean calibration method to perform optimally. However, the shapes of the ERS-1 and the ERS-2 cones differ from those of the ASCAT period, implying that the ERS and ASCAT records are related nonlinearly. The magnitude of this relative change in cone shape reaches up to 0.1 dB for the ERS-1 and 0.4 dB for the ERS-2 record, clearly at variance with the ballpark requirement of 0.1 dB for backscatter stability outlined by the

Global Climate Observing System (GCOS). This motivates the need for finding appropriate nonlinear calibration curves for ERS-1 and ERS-2 data.

After a number of preliminary tests, it was found that aligning the ERS-1 and ERS-2 wind cones to the ASCAT reference seems to call for the introduction of node-dependent noisefloor corrections in the fore, aft and mid beams, such as outlined in Fig. 9

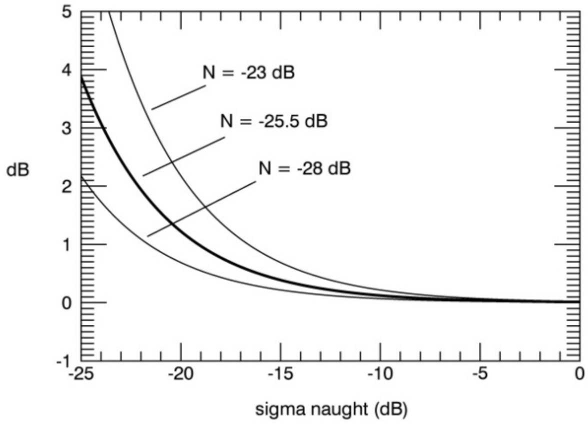

Figure 9: Sample noisefloor corrections: a small offset N in linear space translates into a nonlinear 10^[-(sigma_naught-N)/10] curve in dB space.

The noisefloor corrections, which are obtained after a recursive search for the optimal N parameter, bring the ERS-1 (Fig. 10) and ERS-2 (Fig. 11) wind cone shapes back in line with the ASCAT reference cone, and the residual RMS cone differences down to 0.05 dB, well in compliance with the GCOS requirement.

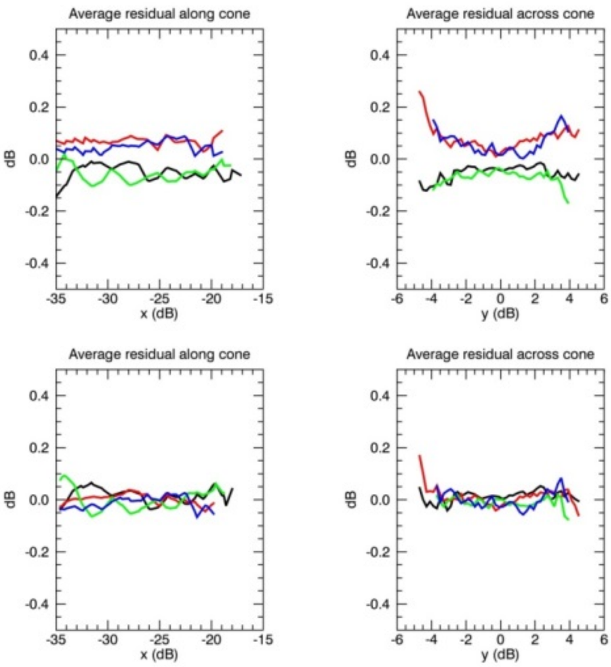

Figure 10: Cone fit residuals (WVC12) between ERS1 1995 and ASCAT reference cones: before (top panel) and after (bottom panel) noisefloor corrections.

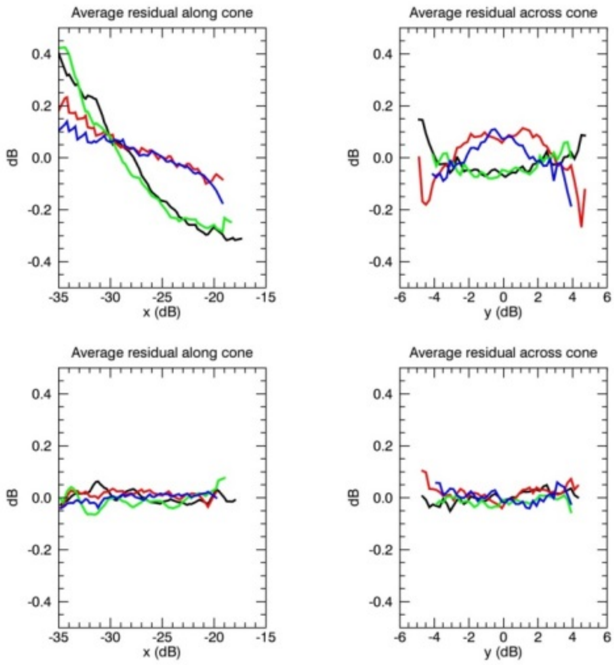

Figure 11: Cone fit residuals (WVC12) between ERS2 1997 and ASCAT reference cones: before (top panel) and after (bottom panel) noisefloor corrections.

These are preliminary results and work is currently under way in order to consolidate the noisefloor corrections in terms of its effects at the lowest sigma naught levels.

2.4. ESCAT soil moisture retrieval evolution

The TU-Wien soil moisture algorithm is a physically motivated change detection approach implemented in a software called the WAter Retrieval Package (WARP) [4]. Since the first release of global soil moisture observations from ESCAT in 2002, algorithmic updates and improvements have been implemented into WARP. In view of the SCIRoCCo project, latest algorithmic changes, previously specially tailored to ASCAT on-board Metop-A/B, have been adopted to extent the soil moisture retrieval capabilities also to ESCAT. As a consequence, WARP was implemented from scratch in Python taking advantage of this community drive programming language and external packages. Achieved algorithmic improvements in WARP with reference to the latest released ESCAT soil moisture product in 2002 can be summarized as follows:

1. Error modelling for soil moisture retrievals through error propagation
2. Updates in dry- and wet-reference calculation
3. Improved wet-correction in arid regions
4. Implementation of freeze/thaw thresholds and surface state flag estimation
5. Sensor intra- and inter-calibration methods
6. Complete ESCAT and ASCAT processing capabilities
7. NetCDF output products compliant to CF-conventions

Soil moisture products from ESCAT have been re-processed resulting in a Swath-Grid and a Time-Series product to cover the wide range of applications, by making use of this up-to-date soil moisture processor. The Swath-Grid product is aimed for NWP centers in support to NWP re-analysis and climate monitoring activities. For research and climate change studies a Time-Series product is disseminated on a discrete global earth grid. Both soil moisture products are available at two different spatial resolutions with a sampling of 12.5 and 25 km, and will be disseminated in NetCDF following the CF-conventions.

3. CONCLUSION AND FUTURE WORK

ESA's ESCAT legacy data provide a unique source of C-band backscattering measurements of the Earth's surface, with medium spatial resolution (25 and 50 km) and a wide (20 years) temporal coverage, making it an invaluable source of measurements. SCIRoCCo has developed a general activity framework based on synergistic approach among different expert laboratories, industry and educational network in order to preserve knowledge and to improve the quality of the ESCAT dataset. Current scatterometer mission can also benefit from some of the methodologies developed by the project. Future project work is focused on the assessment of the ESCAT reprocessed dataset with data assimilation into the ECMWF IFS 4D-var system, conversion of the ESCAT reprocessed dataset into NetCDF format to facilitate data usage. Further develop the SCIRoCCo's concept fostering opportunities in the frameworks:

i) ESA "LTDP+" (Long Term Data Preservation+) program which will be presented at the ESA Council at Ministerial level in late 2016, for the preservation, discovery, access and valorization of all ESA past EO data holdings including among others the ERS missions.

ii) Metop Second Generation (EUMETSAT) to support sensor calibration, algorithms improvements and data performances monitoring based on the SCIRoCCo expertise from ERS-SCAT and ASCAT sensors.

4. REFERENCES

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