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DOCUMENT

SEASAR2012: sessions summaries, seed questions discussion and recommendations

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Reference	**EOP-SER/RP/085-12/YLD**
Issue	**1**
Revision	**1**
Date of Issue	**6/12/2012**
Status	**Approved/Applicable**
Document Type	**RP**
Distribution	

European Space Agency
Agence spatiale européenne

APPROVAL

Title	
Issue 1	**Revision** 1
Author	**Date** 6/12/2012
Approved by	**Date**

CHANGE LOG

Reason for change	Issue	Revision	Date

CHANGE RECORD

Issue 1	Revision 1		
Reason for change	**Date**	**Pages**	**Paragraph(s)**

Table of contents:

1 INTRODUCTION

This document gathers together the sessions summaries with seed questions discussion and recommendations of the SEASAR 2012 workshop (https://earth.esa.int/web/guest/seasar-2012/workshop-programme), the 4th SAR oceanography workshop, jointly organised by the European Space Agency and the Norwegian Space Centre and hosted in Tromsø, Norway, from 18 to 22 June 2012.

2 FUTURE SAR MISSIONS (SENTINEL-1, RADARSAT CONSTELLATION MISSION, ETC.) SESSION - PREPARED BY P.E. SKRØVSETH & P.POTIN

2.1 Overview about SAR Missions

SAR missions	Principal Owner	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
C-Band SAR															
Envisat (ASAR)	ESA	In orbit													
Sentinel-1 A	ESA			Approved	Approved	Approved	Approved	Approved	Approved	Approved					
Sentinel-1 B	ESA					Approved	Approved	Approved	Approved	Approved	Approved	Approved			
Sentinel-1 C, ...	ESA										Planned	Planned	Planned	Planned	Planned
Radarsat-1	CSA	In orbit	In orbit	In orbit	In orbit										
Radarsat-2	CSA	In orbit	In orbit	In orbit	In orbit										
RCM-1,2,3	CSA					Approved	Approved	Approved	Approved	Approved	Approved	Approved	Approved	Approved	
X-Band SAR															
TerraSAR-X	DLR	In orbit	In orbit												
TerraSAR-X/2	Astrium					Planned	Planned	Planned	Planned	Planned	Planned	Planned			
TanDEM-X	DLR	In orbit	In orbit	In orbit	In orbit										
HRWS	DLR								Planned	Planned	Planned	Planned	Planned	Planned	
Cosmo-Skymed-1,2,3	ASI	In orbit	In orbit	In orbit	In orbit										
Cosmo-Skymed-4	ASI	In orbit	In orbit	In orbit	In orbit	In orbit	In orbit								
Cosmo-Skymed 2nd gen A,B	ASI				Planned	Planned	Planned	Planned	Planned	Planned	Planned	Planned			
SeoSAR/PAZ	CDTI		Approved	Approved	Approved	Approved	Approved								
SeoSAR/PAZ-2	CDTI						Planned	Planned	Planned	Planned	Planned				
Kompsat-5	KARI		Approved	Approved	Approved	Approved	Approved								
L-Band SAR															
ALOS-2	JAXA			Approved	Approved	Approved	Approved	Approved							
SAOCOM-1A,1B	CONAE				Approved	Approved	Approved	Approved	Approved						
S-Band SAR															
HJ-1C	CRESDA, CAST, NRSCC		Approved	Approved											
NovaSAR-S 1,2,3	UKSA				Planned	Planned	Planned	Planned	Planned	Planned	Planned				

In orbit
Approved
Planned

2.2 Seed questions n.1&n.2 and recommendations

Seed question 1: considering the current SAR missions and the planned ones (in various bands: C, X, L, etc.), is there a need to plan additional missions relevant to the SeaSAR thematic areas ?

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Seed question 2: If so, where are the gaps ? which are the requirements (band, revisit, resolution, modes / swath / polarisation, products, performance, etc.) ? For which applications and scientific exploitation ?

Recommendations on seed questions 1 & 2:

- In addition to the set up of missions based on constellations, it is strongly encouraged to "combine" the operations of different systems. Any initiative in this direction should be supported

- For technical reasons (satellite power sizing mainly), most new SAR missions have a dawn-dusk orbit and therefore a similar Local Solar Time (eg 18:00 ascending node crossing), leading to some gaps during the day. This has impact on the marine surveillance type of services. In addition, synergies between SAR and other missions having a different LST (eg optical, scatterometer) is made more difficult. → Ideally , space agencies in relevant forum (eg CEOS) should better coordinate the mission design of future SAR systems in that respect

- Daily observation of the whole globe (ie incl. low latitudes) with various SAR systems should ideally be achieved on the long term.

2.3 Seed questions n.3&n.4 and recommendations

Seed question 3: What complementarity in the operational use of the current / future missions (planning, observations, etc.) could be improved to allow better data exploitation ?

Seed question 4: Are the data policies of the current and future missions satisfactory ? Which improvement would be required ?

Recommendations on seed questions 3 & 4:

- Better coordination on the observations between satellite owners is seen as challenging, but would bring strong benefits for both operational services and science

- Sentinel-1 (and Sentinels in general) is designed as an operational mission, however will be much beneficial for science; therefore science requirements should also be taken into account in the mission operations. Science is key for "qualifying" the operational services and for their advances

- SAR commercial missions should give access to archived data at much better price conditions, at least for scientific studies. High cost of archived data is preventing their exploitation

- ESA should support science related activities in the Sentinel data exploitation

2.4 Seed questions n.5 and recommendations

Seed question 5: What are the recommendations from the SAR marine communities on the ERS and Envisat access to archived data (e.g. systematic processing of all archived data at medium resolution...) ?
Which are the priorities ?

Recommendations on seed question 5:

- Access to archived SAR data should consider possible synergies between other sensors, e.g. optical (SST, ocean color, etc.)

- From session "Ocean current retrievals and applications":
  ESA to reprocess the ASAR wide swath products including the Doppler centroid (for the period 2002-2007 to improve currents related application / studies)

  → areas of interest for reprocessing should be clarified

2.5 Reply to a relevant SEASAR 2010 recommendation

2010 Recommendation*: "Many applications rely on more than a single SAR mission. It was noted that space agencies like ESA could play a role in coordinating access to the different SAR missions. (It was mentioned that in Europe in the framework of GMES, ESA has been mandated by its Member States and the European Commission to perform this data access coordination task)."*

Reply in 2012:

➔ *As part of the GMES data access activities, ESA, on behalf of the European Commission (GMES budget), has coordinated since 2009 the access to SAR data for the MyOcean operational sea-ice monitoring services (Envisat, Radarsat, Terrasar-X, Cosmo-Skymed)*

➔ *cooperation to support international activities has been made among the space agencies (example of the International Polar Year), setting up complementary observations (e.g. sharing of Arctic / Antarctica coverage)*

➔ *ESA and CSA plan to coordinate the observation plans of Sentinel-1 and RCM for the benefit of the users*

3 METHODOLOGY AND TECHNIQUES SESSION – PREPARED BY F. COLLARD & L. AOUF

3.1 Summary of the session

The methodology and techniques session had 5 presentations.

1. The session starts by a relevant presentation indicating the need of a new inversion taking into account the dependency between wind, waves and currents. The authors shows in the introduction that retrieving separately waves, wind and currents has individual errors. After that the authors insist on the fact that wind field contains current information (cross section modified by presence of surface currents). Two other key points are also mentioned. The first one is the dependency of the cross section on the sea state growth, and the second one is the dependency of the surface current on the sea state correction which actually comes from the ECMWF winds. The authors propose some solutions to implement a combined wind, waves and currents inversion, for example they suggest the best resolution (it could be 5 km) for such task. Finally The authors indicate that the first step to a combined retrieval is to start by deriving consistent semi empirical models based on ENVISAT archive (obtained from pieces of physical (RIM,DOPRIM) or empirical models(CMOD,CDOP).

2. The second presentation shows a description of the project NEREIDS which is a development of operational maritime surveillance concept. The principle is based on getting the input of information rapidly and spread it efficiently to the authorities for making decision. The project is just in beginning phase and involved many teams in Europe. The validation phase of this concept is planned to affect three major areas of interest.

3. The third presentation shows how useful can be the use of SAR images to detect atmospheric and oceanic processes. The authors implemented an automated procedure to identify SST fronts by using radarsat-2 images. The accuracy of the system is about 80 % and the author is confident to improve to 100 %. The operational use of this system is in progress and could be very helpful for METOC esquimalt on the Canadian west coast. Some perspectives has been mentioned by the authors, for example the use of auto associative artificial neural network for contextual information in a purely automated system.

4. The fourth presentation show the use of high resolution images from terraSAR-X in order to map underwater topography and height of individual breaking waves in very coastal area. An application has been done in the Australian Rottnest island. The validation of the method opens room of improvements.

5. The fifth presentation gives the way to go further in analyzing some processes such SST fronts with a muti-approach of using satellite data. A very interesting slide of the wind speed anomaly from SAR and the SST and range doppler velocity (SAR) has been presented in the area of Agulhas. The author show the challenge of using ASAR 2D products to understand some fine scale dynamics processes which are very active vertically and act relatively deep.

3.2 Seed questions

1. What are the developments on using conjointly the wind, wave, doppler centroid shift data ? in order to improve processes such as fronts, polar lows, hurricanes etc

2. What can we do on understanding the wind/wave couplings near the genarating areas ? And also in wind sea developments in presence of swell systems ?
 →complementary use of SAR to other wind information from other satellites ?

3. What are the improvements of using the bi-polarisation or full (HH,VV,HV) ?

4. What new parameter can be implemented in the new ASAR WM (20x20) ?
 for example the modulation of amplitude in groups (BFI index for freak waves) ?

3.3 Recommendations

The main message comes out from this session is:

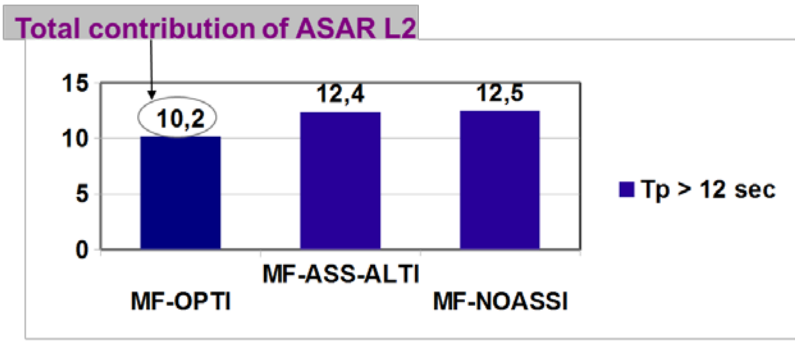
Firstly the need of implementing a combined wind, waves and current retrieval to separate the contributions of these three quantities in the SAR signal. This must be based on consistent models for NRCS and Doppler in both polarization. Research effort is highly needed to develop both consistent semi-empirical model and new statistical parameters to progress towards the consistent and combined retrieval.

Secondly, the relevance of using synergetic data from other sensors and merging methods in order to understand several physical processes at the ocean surface including 3D upper ocean dynamics is demonstrated and needs to be further developped with the help of new tools and methods. The use of doppler shift for both wind and current retrieval is in progress and further analysis and validation campaign is required to drive a larger interest in particular for the ocean modelers.

4 WAVE MODE PROCESSING ALGORITHMS, PRODUCT VALIDATION AND ASSIMILATION SESSION – PREPARED BY F. COLLARD & R. ROMEISER

4.1 Summary and recommendations

→ The contribution of ASAR in the assimilation is clearly showed for the peak period Tp>12 sec : only the use of ASAR improves the analyses by more than 20%



→ The contribution of ASAR in the assimilation improves the significant wave height by 10% (reference to altimeters)

→ In case of high seas (hurricanes) the assimilation induces a better forecast than the model without assimilation

→ Swell tracking based on wave mode observation and storm source detection has been validated using in-situ buoy waverider and seismic noise record analysis.

→ Synthetic swell field is being developed together with sea state model developers

- improve SAR data assimilation impact on sea state model
- Enable independent swell hind casting and short term forecasting

→ Research efforts still needed to properly synthetise swell field in the lee of islands and archipelagos

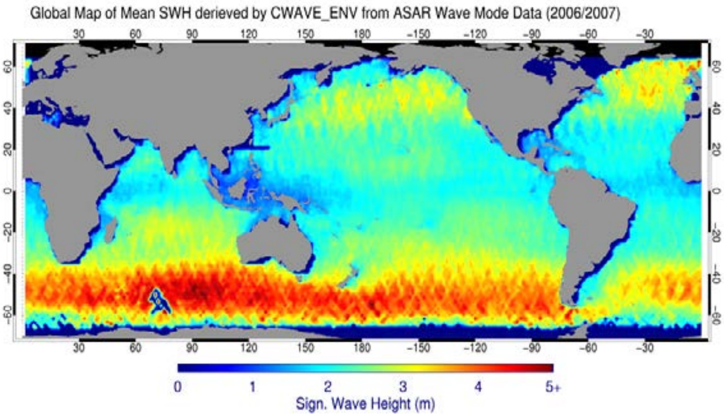
→ The parametric model CWAVE yields SWH with 20 % scatter against buoy Hs Accuracy is comparable to radar altimeter measurement (13% scatter at crossover).

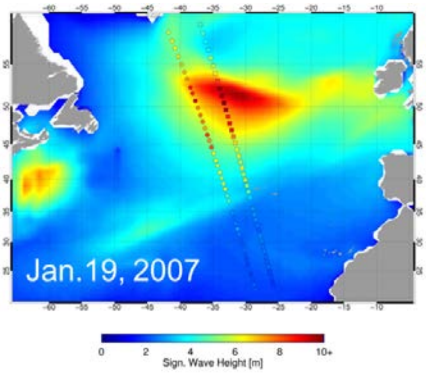
→ Forecast SWH of DWD GSM wave model is in **good agreement** with measurements of both satellites over the globe.

Significant difference to, e.g., DWD model is exhibited for SWH > 6m

→ NRT application for model assimilation for Sentinel

→ SAR wave mode data are available since 1991 and will be acquired continuously for the upcoming Sentinel-1 (2013), long term time series for trends analysis





4.2 Seed questions and discussion

Question 1: are the sea state model assimilation scheme developed so far well suited for sparse observations in space and time ?

Discussion: Yes, for the direct assimilation of along track data. Maybe not for the assimilation of synthetic swell fields.

Question 2: Shall a swell model be developed specifically to make the best use of swell observations from SAR ?

Discussion: a question to be transfered to the wave modeling community

Question 3: Is there a need for a european/international wave spectra assimilation working group that would make the best out of all scattered experience

Question 4: Which aspect of wave modelling could be validated using SAR wave spectra (spatial variation, refraction/diffraction in current, dissipation ...)

5 WAVE RETRIEVALS AND APPLICATIONS SESSION – PREPARED BY H. JOHNSEN & F. OCAMPO-TORRES

5.1 Summary

The session had 7 presentations.

1. GlobWave:

- ✓ The concept and functionality of GlobWave was presented.
- ✓ GlobWave is an online database system with tools for accessing global wave data from various sources.
- ✓ After the project period, GlobWave will be operated by Ifremer

2. S-1 Wave Processing:

- ✓ Baseline processing based on ASAR WM and Soprano achievements
- ✓ Some extension is included to improve and ease the use of data
- ✓ Improvements of MTF undertaken using large amount of ASAR WSS and WW3 data.
- ✓ No wave processing for TOPS yet.

3. Waves from ScanSAR under Tropical Cyclones

- ✓ A semi-emphirical method for waveheight retrieval was applied to ScanSAR data
- ✓ Method based on using NRCS and detected peak wave direction
- ✓ Interpolation used in areas with no visible wave
- ✓ Future plans is to extend the method to X-band

4. Sea-state from TerraSAR-X

- ✓ Coastal wave application of TSX was demonstrated
- ✓ Sea state variability in coastal areas. Importance of high-resolution SAR was emphisized
- ✓ Main wave parameters were compared to in-situ data, as well as to wave models

5. Ocean waves information from X-band

- ✓ Various aspects of surface wave imaging at x-band were studied
- ✓ Image formation under various coastal wind/wave situations were studied
- ✓ It was shown the importance of modulation effects for the swell imaging
- ✓ A challenge is to predict this behaviour

6. Swell Emulation in Coastal Zone

- ✓ Utilization of SAR achive to better assess and predict the coastal, near shore swell wave parameters
- ✓ Methodology of swell emulation was described, and results validated against wave rider and costal wave models
- ✓ Access to full SAR archive is mandatory to fully exploit the potential

7. Combined model and SAR for mapping of wave power potential

- ✓ A system for mapping wave power potential in Europe was describe based on model and SAR data
- ✓ 10 years perspective
- ✓ Data base of high-resolution atmospheric and wave parameters.
- ✓ Satellite data are useful for model optimization and evaluation

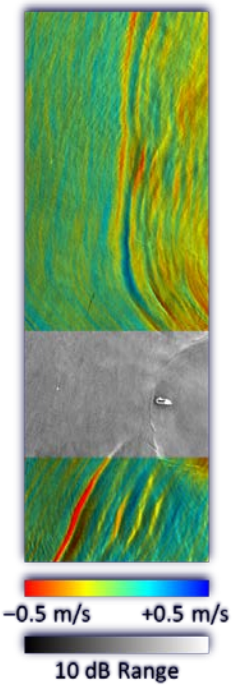
5.2 Seed questions

1. Wave retrievals from TOPS data - what are the R&D challenges?
2. What are the status on the availability of TOPS test data from TSX and/or Radarsat-2?
3. How can we boost the applicability of SAR data for shelf/coastal wave applications?
4. Are there any specific aspects on the SAR modulation transfer function that requires new theoretical development?

6 INTERNAL WAVES SESSION – PREPARED BY W. ALPERS & J. DA SILVA

6.1 Summary

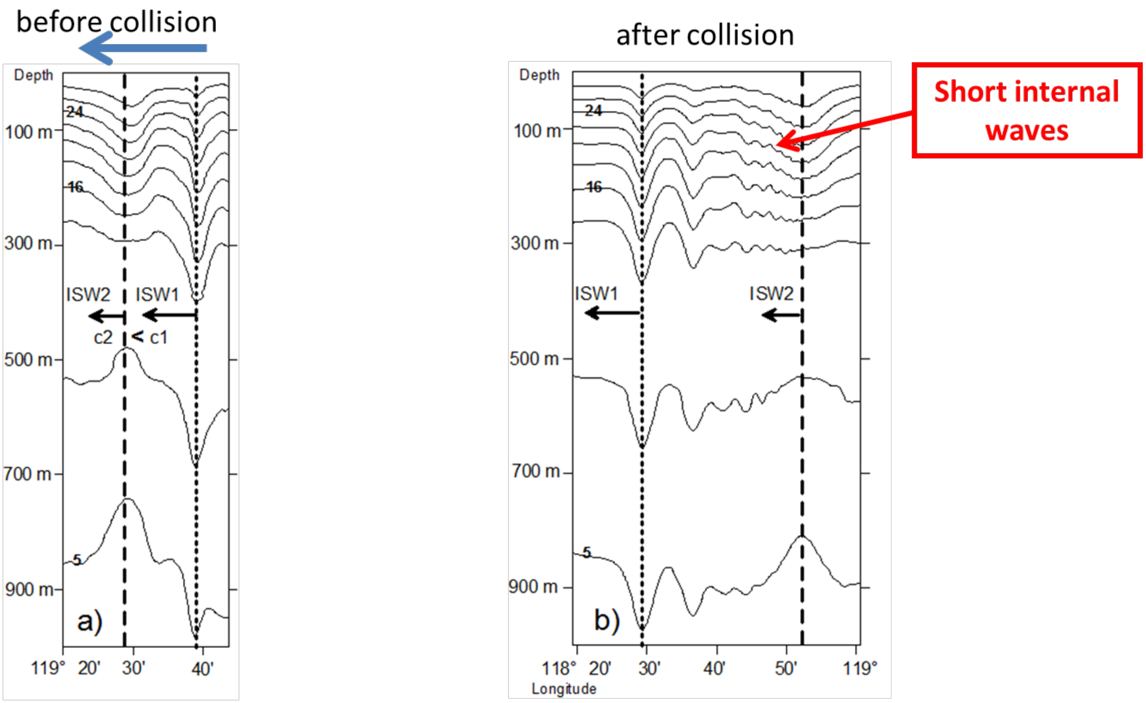
6.1.1 Along-Track InSAR Imaging of Internal Waves



- TerraSAR-X ATI can resolve surface current variations over internal waves
- Numerical ATI model can reproduce Doppler signatures with realistic input current fields.
- Tends to underestimate intensity signatures.
- Doppler signatures more robust with respect to wind & relaxation rate uncertainties.
- **Use of ATI will permit more straightforward and more accurate estimates of internal wave parameters and stratification (**

6.1.2 On the origin of short internal waves trailing strong internal solitary waves observed on spaceborne SAR images acquired over the northern South China Sea

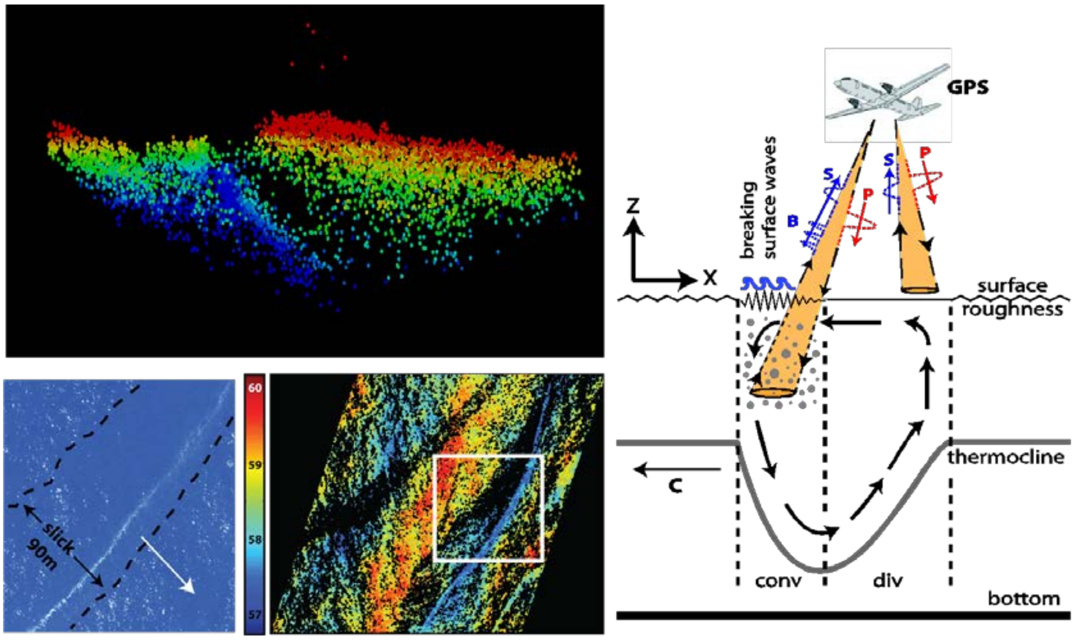
- Short internal waves following a strong first mode internal solitary wave are observed in the northern South China Sea in two distinct areas: one close to the Luzon Strait and the other further away.
- Their generation is linked to the presence of second mode internal waves.
- The short internal waves ride on the second mode internal solitary waves
- **They are long lived and become visible on SAR images because they are associated with large gradients in the surface current.**



Simulated depth profile of temperature as a function of longitude for the upper 1000 m showing the generation of short internal waves in the far-field at two different times. Panel a: t=4.125 M2 tidal periods, before the collision and panel b: t= 5 M2 tidal periods, after the collision. The dashed and dotted lines mark the center of the second and the first mode ISW, respectively.

6.1.3 Airborne and SAR Sinergy reveals the 3D structure of air bubble entrainment in internal waves and fronts

- Imaging (near-IR) LiDAR detects IW slicks & subsurface bubble layer (2 m deep)
- Thermal IR signatures of IWs have been observed off Portugal
- Surface circular structures denominated "boils" are detected with thermal-IR, having "cold" skin SST some 0.3 - 0.4 ◦C below average field
- Large "Boils" may be a result of extraordinary-large-amplitude IWs due to resonant Wave-Wave interaction (common features off Portugal with 70 m amplitude)



6.2 Seed questions

1. What are the new theoretical advances and numerical modelling results of Internal Solitary Waves that can be validated with SAR; and what do we need to do in the next few years, in the frame of the Sentinel mission

2. Is it reasonable to expect characterization of ISWs currents with new emerging methods?

3. Can we highlight the key role of SAR observations of internal waves as a prerequisite for development of cost effective solutions to industry (e.g. offshore oil and gas companies);

4. Is it possible to extract quantitative information on internal wave parameters from the modulation of the normalized radar cross section?

5. What information on internal wave parameters can be achieved by using Doppler shifts obtained from along-track interferometric SARs or from conventional SARs?

6. What are the dominant factors determining the strength of internal solitary waves in the South China Sea?

7. Are second mode internal waves a common or a rare phenomenon in the World's ocean? Are they frequently encountered in the South China Sea?

7 OCEAN CURRENT RETRIEVALS AND APPLICATIONS SESSION – PREPARED BY J. A. JOHANNESSEN & B. HOLT

7.1 Session Summary

- The range Doppler surface velocity retrieval method has emerged to a robust level. In areas of strong current such as the Agulhas Current and the Gulf Stream individual Doppler velocity field are quite distinct with an accuracy of about 5 Hz (e.g. 20 cm/s) at a spatial resolution of 5-10 km.

7.1.1 Two Collard papers

- Averaging over repeat acquisitions (ranging from 20 to > 100 individual acquisitions) reveal strong and persistent evidence of the mean surface velocity field at a spatial resolution of 10 - 20 km and accuracy of 2-5 cm/s. It agrees remarkably well with other independent estimates (surface drifter data, altimetry, etc..) It can also be used in combination with the GOCE MDT to improve the resolution in areas of strong topographically steered surface currents.

7.1.2 Hansen paper

- The range Doppler anomaly processor developed and implemented for Sentinel-1 seems to be superior to the processor currently used for Envisat ASAR. It is therefore recommended that the entire ASAR single look complex wide swath data archive be consistently reprocessed with the new processor. This should also include the data from 2002-2007 which at present has not been processed at all.

7.1.3 Johnsen paper

- Sensor synergy is the only viable approach for advancing the understanding of the dynamics at the mesoscale-to-submesoscale. Methods are now emerging for quantitative interpretation of the 2D surface expression in the context of the upper layer 3E dynamics. *(see also in the Appendix, the draft letter on data reprocessing by Collard and Johannessen)*

7.1.4 Johannessen and Collard papers

- Dedicated field campaign is highly needed and should be undertaken in the context of prelaunch/launch of Sentinel-1 in October 2013.

7.1.5 From seed questions

- Encouraging results have been determined regarding the presence, extent,and dynamics of submesoscale eddies in the inner seas and California and should be continued in the context of understanding upper ocean dynamicsand energy scaling.

7.1.6 Karimova and Holt presentations

- Radarsat 2 recommendation - request access to Radarsat 2 in lieu of Envisat failure, particularly over selected supersites.

7.1.7 Appendix: Draft letter on data reprocessing by Collard and Johannessen

- Encourage availability of Announcement of Opportunity for requesting additional imagery from Sentinel-1 to examine new science concepts, support ocean field campaigns, and so on. One concept is make use of background mission modes and to limit requests to additional acquisitions using a pre-determined mode.

7.2 Seed questions

1. What is needed or missing in order to extend the derivation of surface current retrievals from SAR?

   - consistent partitioning of the wind-wave-current signatures

   - vector currents

   - SAR modeling (RIM, DOPRIM, CDOP,.....), including with multi-sensors

   - comparisons with other satellite data (e.g. SSH, SST, sunglint,...)

2. Where are the supersites that need to be developed for Sentinel-1 and now Radarsat2 potentially and how should this be accomplished?

   - Agulhas

   - Gulf Stream, Loop current

- Norwegian-North Atlantic Current
- North Brazilian
- Kuroshio
- California/US West Coast
- other

3. Will inversion from SAR images to wind-wave-current products be possible?

8 SHIP DETECTION SESSION – PREPARED BY G. CAMPBELL & P. W. VACHON

8.1 Session summary

8.1.1 Presentations

7 presentations covering a range of issues and demonstrating major developments and new capabilities:

- Polarimetric techniques for vessel detection
- New detection & characterisation techniques (e.g. ATI/GMTI, RCS-based ship length characterization and false alarm rate reduction)
- Fusion of SAR and transponder data (AIS)
- Examples of operational or close to operational services and systems
- Clutter characterisation to support enhanced detection of vessels (at different wavelengths), including also airborne data

8.1.2 Highlights from presentations:

- Operational adoption of R-2 by Canadian Forces (but it has taken time!)
- Maturation of polarimetric techniques
- CFAR is still widely used although new techniques are being actively investigated
- Availability of additional operating frequencies brings new development requirements and new scope for improved detection (including wakes)

8.1.3 Major elements identified:

- **New observing modes lead to improved surveillance performance**:
  - RADARSAT-2 Maritime Satellite Surveillance Radar modes
  - TerraSAR-X/Tandem-X formation flying for MTI
- **Polarimetry**:

- Local estimation of polarimetric response of sea surface
- Reduction of false alarms (ghosts, ambiguities)
- Potential for detection of smaller vessels

– **Fusion of SAR and AIS**:

- AIS increasingly accepted as operational surveillance tool (not just collision avoidance)
- Utility and impact of fusion of AIS and EO based vessel detection repeatedly demonstrated

– **Operational integration of SAR-based vessel detection into RMP**:

- On-going in Canada and strong interest in Europe
- Users not happy about gap between successive acquisitions but appear to put up with the situation since non-emitting targets are addressed

– **Clutter characterisation**

8.1.4 Current Status

– **New sensors and new techniques**

- Polarimetry clearly has significant potential but do not forget simple fast NRT detection and tracking (hence CFAR-based approach will continue to be used)
- Operating frequencies – no real systematic preference and depends on nature of target of interest – multiple frequencies would improve performance
- Operating mode for Sentinel-1 over marine areas – support polarimetric analysis

– **Satellites and UAVs**:

- Satellite-based maritime surveillance is complementary to current UAV developments
- There is considerable scope for integrated surveillance over different platform types to generate benefit to the operational user community

– **Users:**

- Want simple straightforward stuff

- Always less experienced than we expect
- Delivery times are of critical importance

– **Clutter suppression**:

- Systematic advances demonstrated
- Required for detection and tracking of small, non-cooperative vessels

8.1.5 Challenges to be addressed:

– Role/availability of polarimetry and compact polarimetry

– Acquisition conflict reduction (ship detection, oil spill, etc.)

– Sub-aperture analysis – has the benefit been clearly demonstrated?

– Better use of constellations

– Correlation for MTI approach when target changes direction/orientation

– Characterization of vessel detection performance in terms that operational users can understand

– Wider swath modes of RADARSAT-2 clearly generate positive impact – how is this experience built into other missions?

– Fusion of different data sets:

- At data level this is more an interoperability and integration issue
- However, fusion of different information streams for complex assessments remains difficult

8.1.6 Issues not addressed since SeaSAR 2010:

– Morning-afternoon data gap

– How to integrate SAR detected wakes into the RMP

– Reference data sets and systematic validation campaigns

8.1.7 Longer term

Drafting of white paper:
We will email you next week with an outline structure for comments

If you do not hear anything and would like to be involved please send me an email:

Gordon.campbell@esa.int

8.2 Seed questions

1. New methods and techniques for vessel detection

- ✓ What level of maturity should we consider for current developments in vessel detection (eg MTI, polrimetry etc) and what are the main developments now required
- ✓ What are the alternative developments (eg Do we really need nice imagery as the basis for vessel detection or should we be looking at alternative processing of the radar data?)
- ✓ Are we at an acceptable point with respect to current systems (eg clutter characterisation etc)

2. New sensor developments:

- ✓ What are the on-going developments of primary interest to this community and what issues need to be resolved (eg HRWS SAR, P-band SAR, high frequency SAR, more polarimetric SAR)
- ✓ There are two national missions proposing common acquisition of SAR imagery and AIS messages on the same platform– is this sufficient and if not, what alternatives would this community propose?

3. Operational requirements and issues

- ✓ Orbit configurations and associated limitations – SAR missions are increasingly confined to a limited time window for overpasses – is this acceptable and if not, what does this community recommend?
- ✓ Detection of small non-cooperative, non-metallic targets – this remains an issue for users so what should the development activities be focussing on over the next 2 years
- ✓ Detection of anomalous behaviour – this is of increased importance for users but there is only limited activity on this issue. What can the development community offer and how can activities be structured?

- ✓ Does the proposed operations approach for Sentinel 1 satisfy user requirements for data (considering that data from national missions will be available). If not, what alternatives are proposed from this community?

- ✓ Can we explain vessel detection performance levels in an acceptable way to users at present and if not, what else do we need to do? Are these activities already addressed and if so, where?

4. Cooperation and capacity building

- ✓ How can initiatives such as C-SIGMA be better utilised? There is nothing under frameworks such as GEO for vessel detection – is this an issue that needs to be addressed?

- ✓ What other cooperation is required (scope, partners, support from ESA)

5. Data policy:

- ✓ Most of the data required for vessel detection is from commercial operators who require a return on investment made in the data collection systems. However current commercial prices do not appear to foster operational exploitation – what does the development community recommend to address these issues?

6. Parallel developments:

- ✓ There is strong interest among the user communities in alternative technologies such as aerostats, UAVs etc – is there still room for satellite based techniques in the longer term? If so, what is the vision from this community as to how these different technologies could be effectively integrated?

9 OIL SPILL DETECTION SESSION – PREPARED BY C. BREKKE & V. KUDRYAVTSEV

9.1 Summary session with recommendations

Compact polarimetry:

- Found useful to suppress of low wind field (look-alikes).

PolSAR:

- Potential discrimination of various slick types (monomolecular slicks, crude oil, emulsion)
- Internal zoning related to thickness? In-situ measurements needed. We need to know more about the characteristics of the slicks.

L-band:

- Low noise floor. Possible to use both cross-pol and co-pol.

C-band:

- Higher noise floor. Signal in cross-pol fluctuating about the noise floor, less useful for oilspill detection/characterization.

Discrimination between oil and look-alikes:

- Analysis of polarisation ratio (intensity) HH/VV.
- Bragg waves are dampened with oil slicks, but longer surface waves are not dampened and their contribution to radar return comes from their wave braking. Hence, oil slicks appear bright in polarisation ratio (HH/VV) .
- PR=(braggHH+ WB)/(braggVV + WB)->1 (slick bright)
- PD=(braggVV +WB)-(braggHH +WB) = (braggVV-braggHH) (slick dark)
- This gives a possibility to discriminate between oil slicks and look-alikes.

C-band vs. X-band:

- Question raised: Should we still continue with C-band or go towards X-band?

9.2 Seed questions

1. SeaSAR 2010: "There is a strong need for improvement in distinguishing slicks from look-alikes". In 2012: What is the current status on new techniques based on multi-polarisation SAR/PolSAR for oil spill versus look-alike discrimination?

2. What is the current status on new techniques based on multi-polarisation SAR/PolSAR for characterization (thickness etc) of oil spills?

3. Can multi-polarisation SAR/PolSAR be used for man-made oil spill versus natural oil seep discrimination?

4. There is an increasing interest in remote sensing of oil in sea ice. How far can we get with current SAR/PolSAR techniques? What types of sensors do we need?

5. How far have we got on evaluating X-band for oil spill applications? How is the performance of X-band versus C-band for oil spill applications?

6. In an oil spill application context, what is the suitability of upcoming missions such as Sentinel?

7. What should future SAR sensors look like to improve the oil spill capacity?

10 OCEAN WIND RETRIEVALS AND APPLICATIONS SESSION – PREPARED BY J. HORSTMANN & K.-F. DAGESTAD

10.1 Session presentations

1. Operational system at NOAA NESDIS
2. SAR wind retrieval with respect to Tropical Cyclones
3. Wind retrieval using X-band radar data
4. Wind speed ambiguity removal in Tropical Cyclones and wind speed retrieval utilizing cross pol
5. Organized multi-km surface stress convergence lines in tropical cyclone surface wind retrievals
6. Polar lows and ocean wind profiles
7. Dual polarized SAR imaging of ocean surface features
8. Normalized radar cross sections and sea surface wind
9. High resolution wind fields over the Black Sea

10.2 Seed questions and discussion

1. **What are the remaining issues concerning SAR level 1 data?**
    - Scalloping
    - Noise floor
    - Beam seams
    - Radiometric calibration
2. **What uncertainty estimates are useful to add to the SAR wind products?**
    - Flagging of rain ice etc.
    - Identification of fronts etc.
    - Estimation of uncertainties

3. **What is the best suited wave length and polarization for wind retrieval (tower based SCATs)?**
    - C-band
    - X-band (rain contamination)
    - L-band (less saturation?)
4. **Is useful information discarded by spatial averaging of the small scale NRCS variability?**
    - Turbulence
    - MABL depth
5. **Is it realistic that empirical GMFs can be replaced by physical algorithms? What is needed?**
6. **What are the expectations regarding use of Doppler information for Sentinel-1? Is everyone prepared?**
    - Merging Doppler and the classical wind retrieval
    - Merging Doppler and atmospheric modeling
    - Investigate wind, current and wave retrieval as a whole
7. **What scientific questions do remain with respect to SAR wind retrieval**
    - Relation streaks to wind
    - Fetch dependencies of wind speed retrieval
8. **What are the main applications for SAR wind field retrievals and what is the best suited product for the users?**

11 SEA ICE RETRIEVALS AND APPLICATIONS SESSION – PREPARED BY T. ELTOFT & W. DIERKING

11.1 Session summary

11.1.1 Some statistics

- Announced: 7 presentations, 6 posters (presented 6+4)
- Sea ice classification: 2 talks, 3 posters
- Sea ice concentration: 1 talk, 1 poster
- Sea ice drift: 1 talk
- Signature simulation: 1 talk
- Validation/Combining different data sources: 2 posters
- Icebergs: 2 talks

11.2 From presentations/posters

- Operational sea ice monitoring: Use of dual-polarization ScanSAR data (HH+HV) for classification is prepared, ice type separation by training a NN was linked to analyses provided by operational ice service.
- Research on classification: Statistical methods, polarimetric decomposition, textural analysis were investigated using dual-pol or quad-pol data, partly in combination. Some emphasis was on devising a robust segmentation scheme. Texture parameters were analyzed in detail, showing potential for improving classification.
- Validation: The importance of field work on sea ice including ground-based and airborne measurements together with satellite data acquisitions was demonstrated in conjunction with the development of algorithms for segmentation, classification, ice tracking, and estimation of sea ice thickness.
- A successful test was carried out to supplement ice charts by automatically generated analysis for separating open water and sea ice.
- A data assimilation scheme for sea ice analysis was presented, making use of various signature, texture, and statistical parameters, considering the incidence angle

sensitivity and paying attention to the statistical independence of the selected parameters.

- A method for the estimation of ice motion in pack ice was introduced, based on phase correlation, considering possible rotational movements. The method was successfully tested in comparison to a drift buoy. In the marginal ice zone segmentation and feature tracking were assessed a better approach.
- Iceberg detection was tested using polarimetric parameters. Problems of overlaps between sea ice and iceberg signatures remained. Polarimetry is useful for analysis of scattering mechanisms and e.m. wave propagation in icebergs.
- The usefulness of combining altimeter data, SAR data, and drift models for iceberg detection and tracking was demonstrated.

11.3 From round-table discussion

- An analysis of the benefits of compact polarimetry for sea ice classification was missing.
- For estimating ice drift, an analysis of the Doppler signal has to be carried out. Also detailed local studies are regarded useful for improving our knowledge on sea ice deformation and mechanics.
- Comparison of different classification algorithms on different ice regimes was suggested. The test of classification schemes needs to include the consideration of seasonal changes and environmental conditions
- The consideration of the "history" (temporal evolution) of an ice field is essential for operational sea ice charting. Information on the ice drift is hence regarded useful.
- The combination of different measurement technologies with SAR imaging is essential, e. g. for improving our knowledge about atmospheric and oceanographic drag.
- The analysis of ocean wave propagation into the ice becomes more important in view of the decreasing ice extent in the Arctic.
- The use of satellite constellations for ice tracking should be investigated.
- There should be increased emphasis on monitoring sea ice during the melt season
- There is some interest in comparing images with different spatial resolutions (up-scaling /down-scaling), and to study its affects on classification and parameter retrieval.

11.4 Seed questions

1. Have there been any recent improvements in the algorithms for the classification of sea ice? Which input is required for those algorithms (SAR frequencies, polarizations, spatial resolution...)?
2. Does sea ice classification gain from fully polarimetric radar measurements (considering, e. g., the additional work load in daily operational sea ice mapping)? Which radar frequencies are most useful for sea ice monitoring?
3. What are the best possibilities/strategies to combine recent and upcoming different satellite SAR systems to improve sea ice monitoring?
4. What is the status of sea ice velocity field monitoring?
5. What is the status of iceberg monitoring?
6. Was there any progress in blending of SAR sea ice data with other remote sensing observations?
7. Plans for field work to support cross-validation of sea ice observations from satellites and airplanes, covering the time period 2012-1014?
8. What is the status of combining sea ice modelling and observations on spatial scales typical for SAR systems?
9. Is there any possibility to get information about sea ice surface properties such as snow coverage, melt pond coverage, or roughness structure?
10. Which are the most important scientific questions that need to be addressed in the near future? Where are the key regions? Which additional measurements should be carried out besides SAR imaging?

12 APPENDIX: DRAFT LETTER ON DATA (RE)PROCESSING BY F.COLLARD AND J. A. JOHANNESSEN

12.1 Recommendation for Radarsat 2 scansar data

At the SEASAR2012: The 4th International Workshop on Advances in SAR Oceanography in Tromsø, Norway from 18-22 June 2012 the implications of the failure of the Envisat mission and the requirements of the Radarsat 2 data for the research and development work in the SAR ocean community at large was addressed by the participants.

1) It was agreed that the possibility to have regular access to the Radarsat 2 data for research and development from selected regions would be very timely in the interim period up to launch of Sentinel 1 in October 2013.

2) Selected regions for systematic monitoring are Gulf stream near Cape Haterras, Agulhas current and north brazilian current. Selected regions for dedicate support to field campaign are coastal waters of Northern Norway and gulf of Lion in the Mediterranean sea.

3) It would be highly needed to estimate the high-resolution Doppler anomaly information therefore implying access to unfiltered single-look complex scansar products. Alternatively such Doppler anomaly products could be provided as part of the detected Level 1 data.

4) In this period it is also expected that there will be field campaigns (e.g. drone campaign off the coast of Northern Norway; Airswot campaign in the Mediterranean Sea in 2013/2014) that would require dedicated SAR acquisitions with high-resolution Doppler anomaly information.

12.2 Recommendation for Envisat ASAR reprocessing

At the SEASAR2012: The 4th International Workshop on Advances in SAR Oceanography in Tromsø, Norway from 18-22 June 2012 the requirements of ENVISAT ASAR for research and development work in the SAR ocean community at large was addressed by the participants.

1) In recognition of the new achievements that were presented at the workshop in view of processing methods it became obvious that a comprehensive reprocessing of the archived ASAR wide swath data (SLC+medium resolution detected) from 2002 to 2012 is timely and highly needed.

2) The main motivation for this recommendation are:

    a. the need for noise removal and best antenna pattern correction because of their strong impact on the quality of the wind field retrievals.

b. Impact of a new high resolution accurate Doppler anomaly processor (developed for Sentinel-1 Level 2 ocean product) on the quality of retrieved adial surface velocity estimation.

c. No existence of range Doppler anomaly products in the period from 2002 to 2007.

d. Need to implement consistent Level 1 processor software version across the entire ASAR data archive for accurate geophysical model function (GMF) derivation and subsequent optimal and consistent wind retrieval quality.

e. Securing that the community will be well prepared and ready to undertake research and development of the Sentinel 1 SAR data.

3) The output reprocessed SLC products must follow the characteristics of internal SLC developed for Sentinel1 Level2 processor so that the sentinel1 Level2 RVL processor can be used to produce the proper Doppler anomaly product.

12.3 Recommendation for Radarsat 2 TOPS data

At the SEASAR2012: The 4th International Workshop on Advances in SAR Oceanography in Tromsø, Norway from 18-22 June 2012 the requirements of the Radarsat 2 TOPS data for the research and development work in the SAR ocean community at large was addressed by the participants.

1. In recognition of the lack of preparedness of the ocean community to cope with the upcomming Sentinel1 TOPS data for wave and surface current retrieval, it was mentionned that ESA entered in discussions to request Radarsat2 acquisitions in TOPS mode for marine applications.

2. It was agreed that the optimal TOPS mode and intrument settings suited for marine applications simulated with radarsat2 should have the following characteristics :

    1. should mimic acquisition mode EWS

    2. similar resolution in range and azimuth to EWS (within 20%)

    3. similar range of incidence angles (within 20%)

    4. minimum overlap from burst to burst in the azimuth direction of 2km in near range.

    5. interburst time (in a given subswath) similar to EWS (within 20%)

    6. NESZ not worse than for EWS (within 20%)

3. Acquisitions should be preferably be both over open ocean area dominated by swell like north east atlantic (except north sea) and strong current region such as Agulhas current in south African waters.