ESA–MOST Dragon Cooperation

中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

The research of new ocean remote sensing data for operational application (ID: 32292)

Lead Investigators:

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26–30 June 2017 | Copenhagen, Denmark

2017年6月26-30日，丹麦 哥本哈根

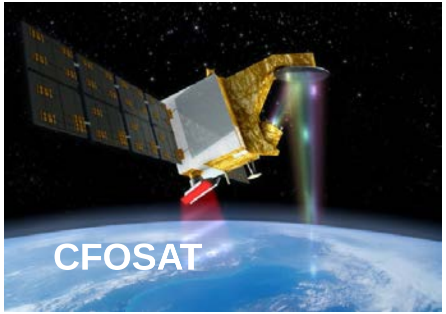
Outline

I. Introduction
II. Main results
III. Cooperation
IV. Young scientists contribution
V. Publications
VI. Next planning

I. Introduction

Objectives: employing new satellite data to improve the retrieval accuracy of marine operational application, and to make use of it for research and product development.

- Products: sea ice, SSH, SWH, currents, mesoscale eddies, and sea surface salinity
- Satellite data: Sentinel series, SMOS, CryoSat-2, CFOSAT; HY-1/2, GF series
- Global or regional applications

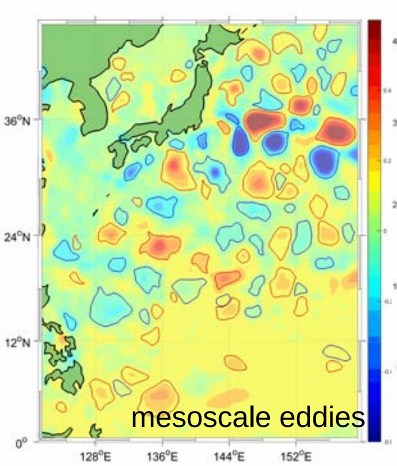


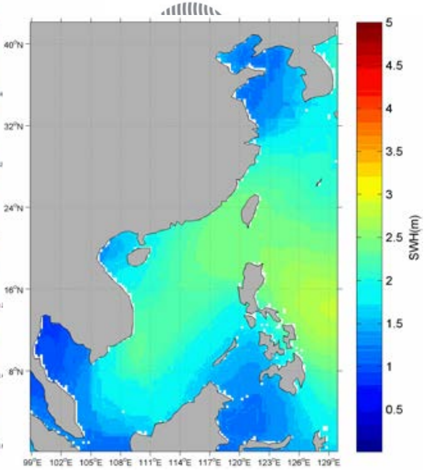
Topics

Topic 1: Techniques for sea ice parameter extraction and sea ice monitoring using new satellite data

Topic 2: Data validation and oceanic applications (SSH, SWH, currents, mesoscale eddies) of new satellite altimeters and SWIM

Topic 3: Sea surface salinity algorithm based on combined active/passive microwave imagers





Team Composition—sea ice

European Partners

- Dr. Wolfgang Dierking (PI) — Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.
- Dr. Markku Similä, Dr. Marko Mäkynen and Dr. Juha Karvonen — Finnish Meteorological Institute, Finland
- Dr. Rasmus Tonboe — Danish Meteorological Institute, Denmark

Chinese Partners

- Dr. Xi Zhang (PI) — First Institute of Oceanography
- Dr. Bin Zou and Lijian Shi — National Satellite Ocean Application Service
- Prof. Changqing Ke — Nanjing University
- Ms. Ning Wang — The North China Marine Forecasting Center
- Dr. Meijie Liu — Qingdao University

Team Composition—oceanic applications

European Partners

- Mr. Bernat Martinez (PI) — IsardSAT, Spain
- Dr. Cristina Gonzalez — Telecom Bretagne, France
- Dr. Joana Fernandes — University of Porto, Portugal

Chinese Partners

- Dr. Jungang Yang (PI) — First Institute of Oceanography
- Dr. Yongjun Jia, National Satellite Ocean Application Service
- Prof. Ping Chen, Huazhong University of Science and Technology
- Dr. Weili Wang, the North China Marine Forecasting Center

Team Composition—sea surface salinity

European Partners

- Dr. Jacqueline Boutin (PI) — LOCEAN, Sorbone Universités, France.

Chinese Partners

- Dr. Xiaobin Yin (PI) and Yingzhu Huang — National Space Science Center, Chinese Academy of Sciences
- Dr. Jin Wang and Huaisong Zhao — Qingdao University
- Dr. Qingtao Song — National Satellite Ocean Application Service

II. Main results

1. Techniques for sea ice parameter extraction and sea ice monitoring using new satellite data

① Bohai sea ice thickness and concentration retrieval by active/passive data

② Arctic sea ice types and freeboard detection by Cryosat-2 data

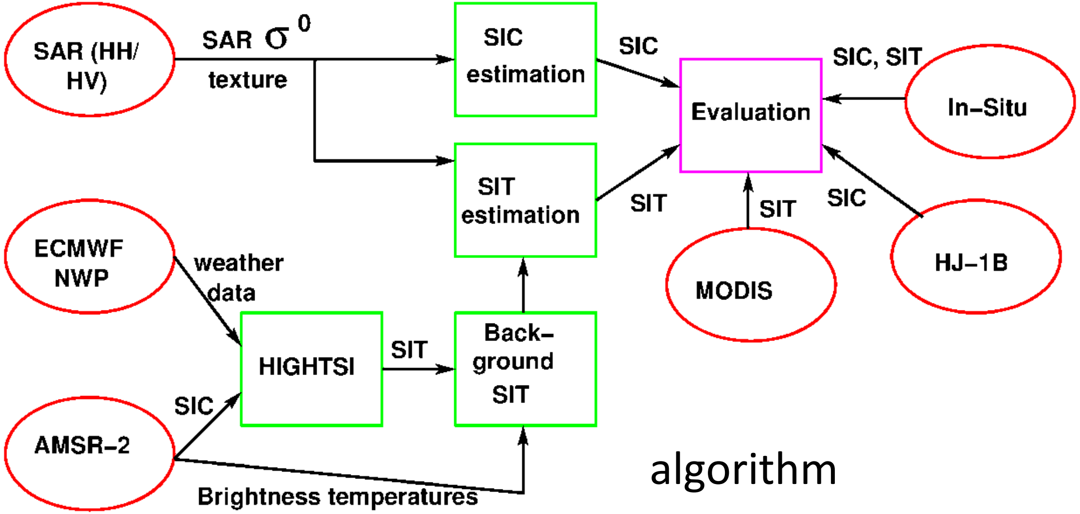
③ Sea ice surface topography retrieval by InSAR

④ Sea ice types classification by multi-frequency SAR

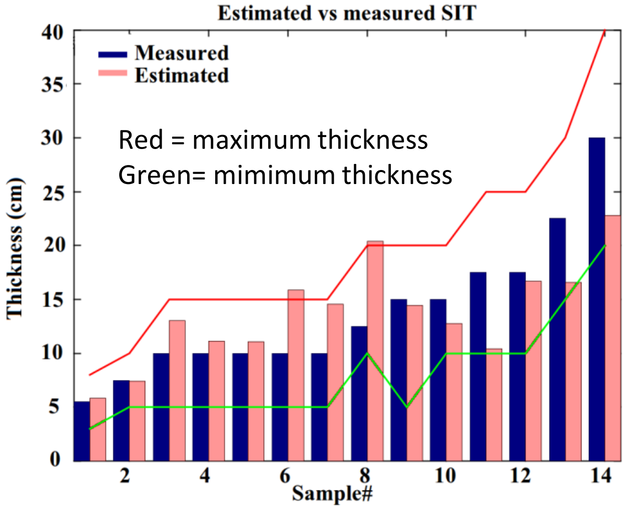
⑤ Improvement of algorithms for detecting ice drifting and deformation

① Bohai sea ice thickness and concentration retrieval

- Completed a study about sea ice thickness and sea ice concentration in the Bohai Sea in winter 2012-2013. Joint work FMI & NSOAS.
- Used instruments: RADARSAT-2, AMSR2, MODIS. In-situ data available.



algorithm



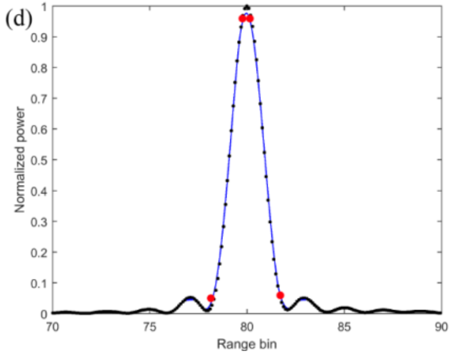
② An improve Cryosat-2 radar freeboard retrieval algorithm

- Lead waveform retracker

  Empirical threshold: different thresholds used when ice conditions and season change

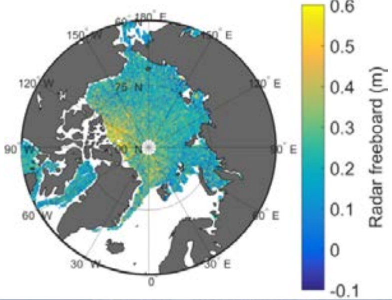
  Physical model: appropriate initial values and long computing times

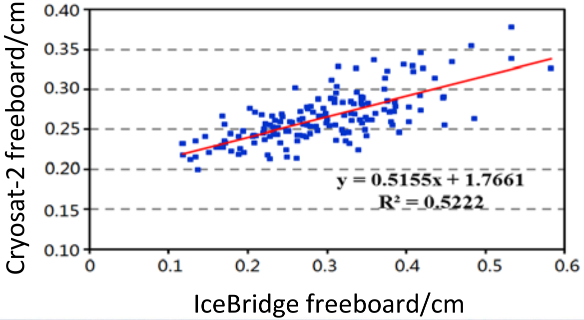
  Empirical fitting: rapid and robust
- A new empirical fitting retracker based on Bezier curve fitting is proposed for leads
- Cryosat-2 Baseline-C SAR-Mode data
- Evaluation: Compared to IceBridge freeboard data, CS-2 L2I freeboard product of mean bias is 1.80 cm, while proposed method is 1.33 cm.



Types	Retracker
leads	A new retracker based on Bezier curve fitting
sea ice	Offset Center of Gravity (OCOG)
ocean	OCOG

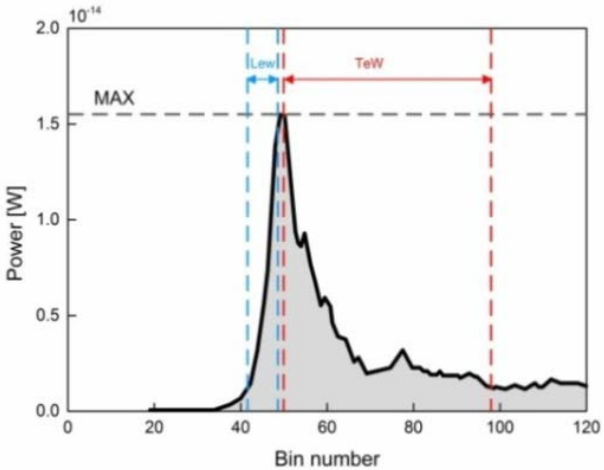
Joint work FIO, AWI & FMI





③ Sea ice type classification by CryoSAT-2 data

- Make recommendations for joint machine-learning classifier and feature selection for ice type classification.
- Cryosat-2 Baseline-C SAR-Mode data
- 6 classifiers：KNN, Bayesian, RF, SVM, BPNN, CNN
- 6 features: LeW, TeW, PP, SSD, max, sigma0
- More features may deeply understand the ice properties
- Bayesian and BPNN are best classifiers (~82%)
- Bayesian: Sigma0, SSD, TeW and LeW are most important
- BPNN: LeW, SSD, MAX are most important

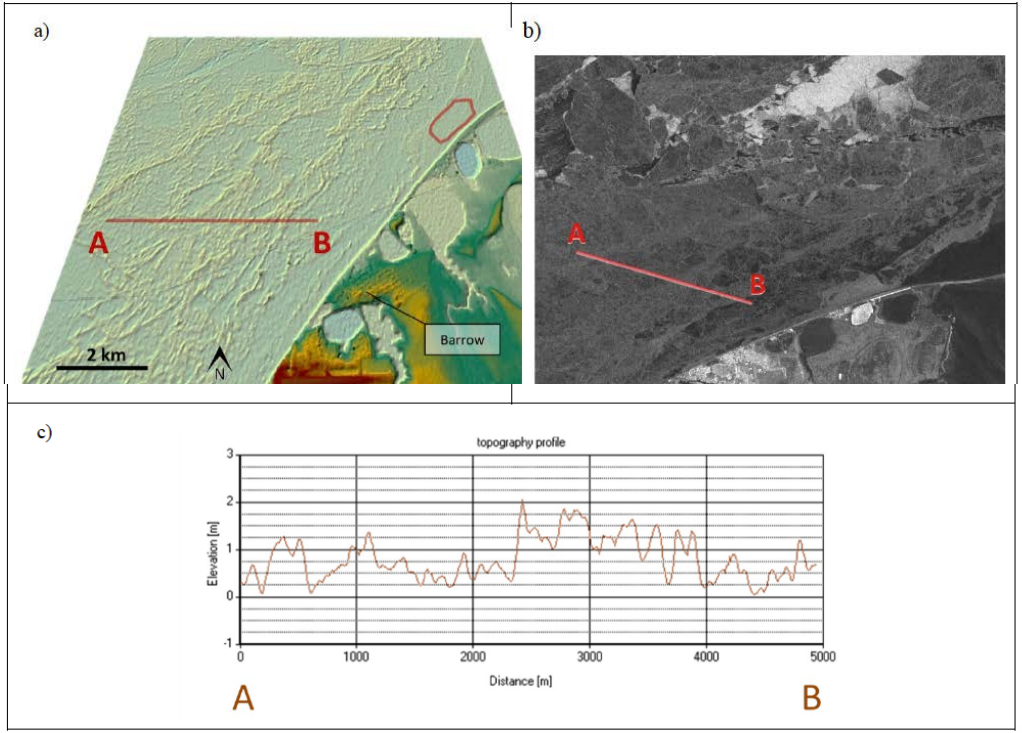


Feature	Definition
PP	$PP = P_{max} / \sum_{i=1}^{256} P_i$
LeW	The distance between 1% and 99% of the power maximum
TeW	The distance between the 99% and 1% of the power maximum
MAX	Maximum power value of the echo waveform
Sigma0	Radar backscatter coefficient
SSD	The standard deviation of power values from a set of Doppler waveforms over different incidence angles

The performance of each classifier

	KNN	NF	Bayesian	SVM	BPNN	CNN
Data Set1	0.74	0.79	0.85	0.80	0.81	0.81
Data Set2	0.76	0.81	0.80	0.81	0.82	0.81
Average	0.75	0.80	0.82	0.80	0.82	0.81

④ Sea ice surface topography retrieval by InSAR

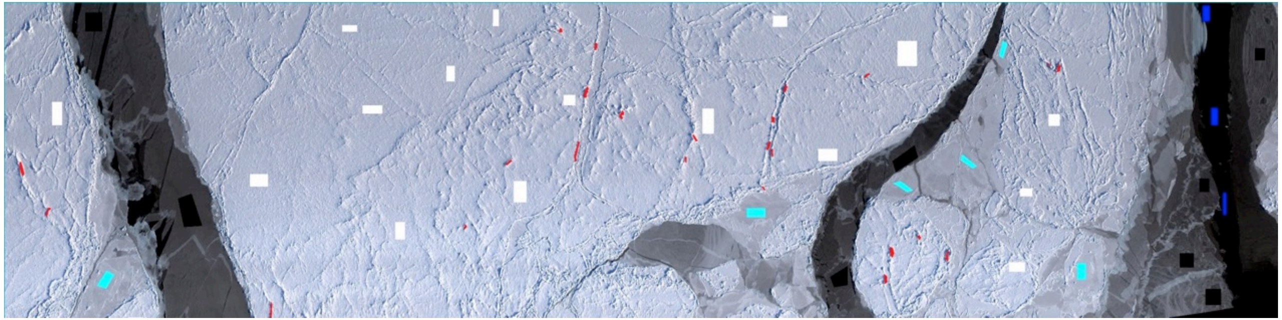


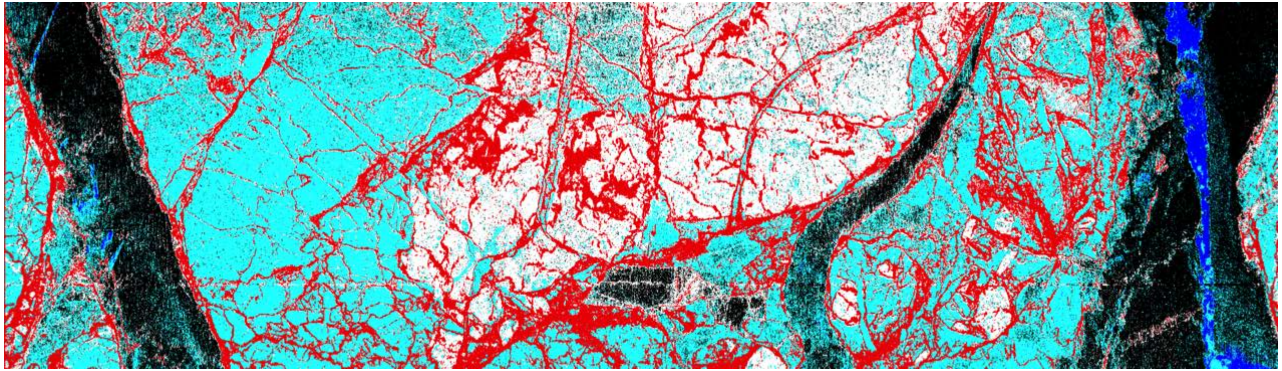
Topography of landfast ice close to Point Barrow. Data were acquired during Tandem-X Science Phase.
Baselines B_n= 1113 m, B_{at} = 138 m
Height of ambiguity 7.4 m

From Dierking et al,
The Cryosphere Discuss. 2017

Joint work AWI & UiT

⑤ Sea ice types classification by multi-frequency SAR





Comparsion airborne optical image and SAR classification, based on C-VH+C-VV +L-HH+L-VV+L-HV

Joint work AWI & UiT

cyan: grey+grey-white
black nilas
blue: OW
white: thicker snow-covered level ice
red: ridges/zones of deformation

2. Data validation and oceanic applications of new satellite altimeters

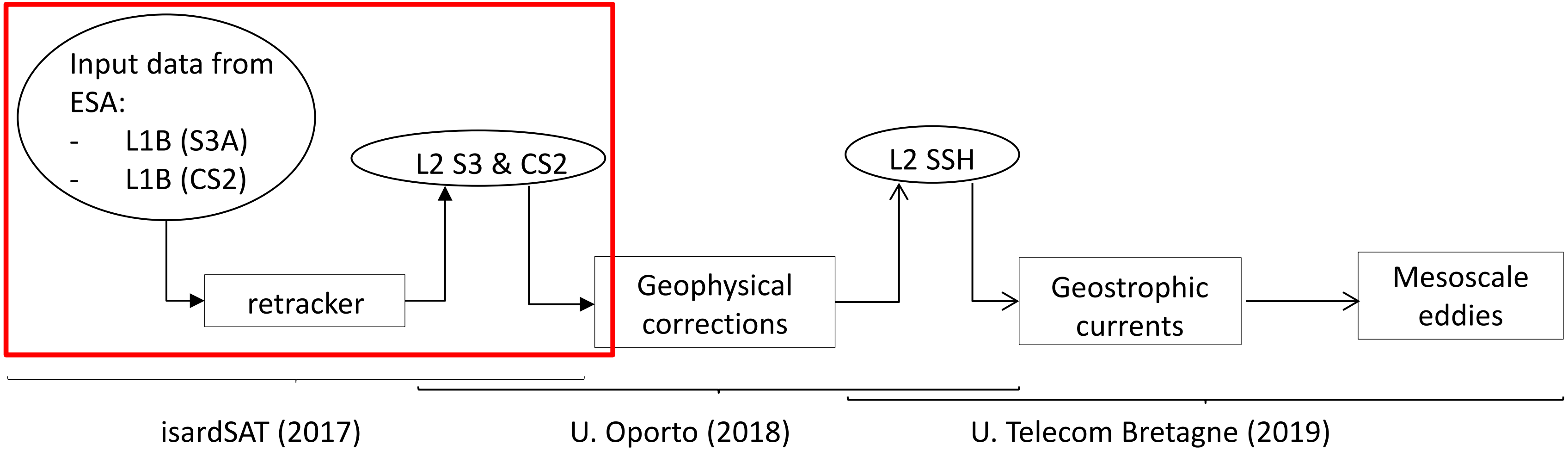
① Altimeter waveform retracker

② Data comparison between Sentinel-3 SRAL and Jason-2/3 altimeter

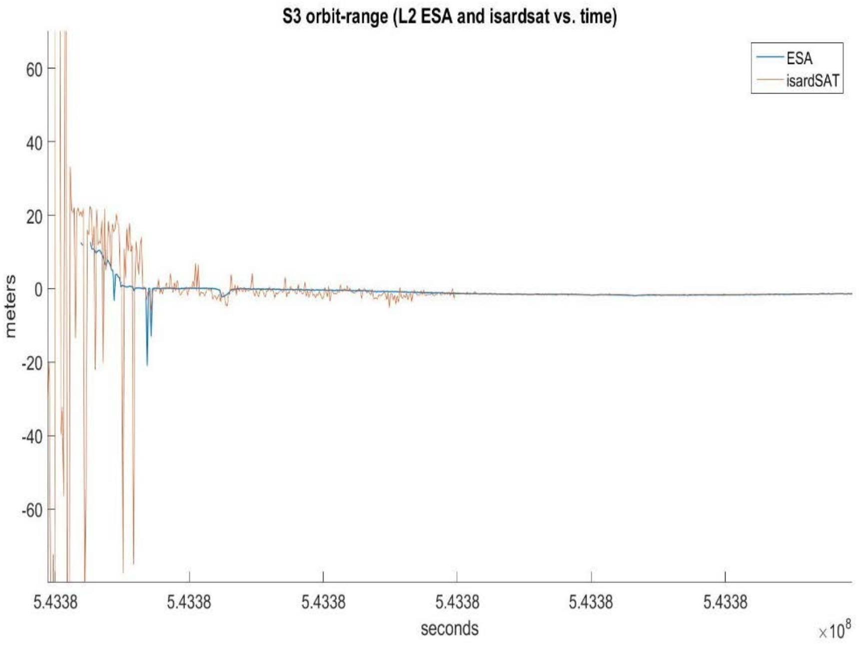
③ Data comparison between geodesic HY-2A altimeter and Jason-2/3 altimeter

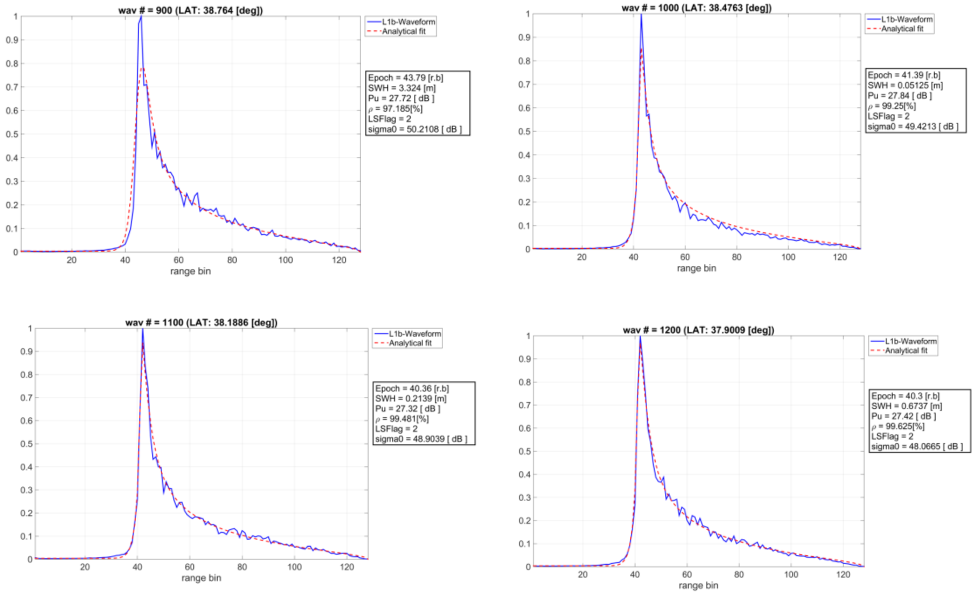
① Altimeter waveform retracker

- Data acquisition of CryoSAT-2 and Sentinel-3 L1 data for Bohai sea
- Implementation of different retrackers for coastal zones using different window types
- Comparison of new isardSAT retracked data with ESA baseline



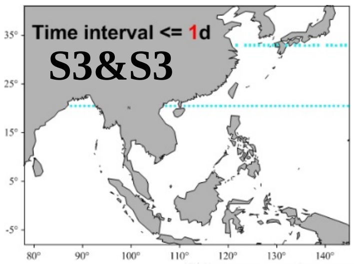
Results: Sentinel-3A L2 ESA vs. L2 isardSAT



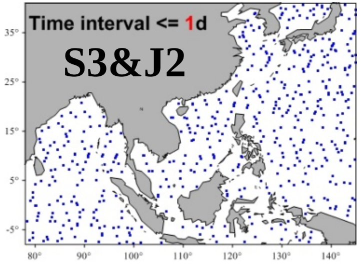


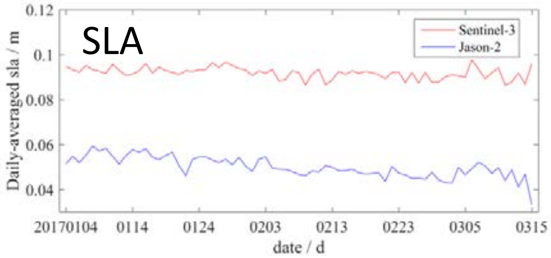
② Data comparison between Sentinel-3 SRAL and Jason-2/3 altimeter

Crossover point comparison between time difference < 1 day.

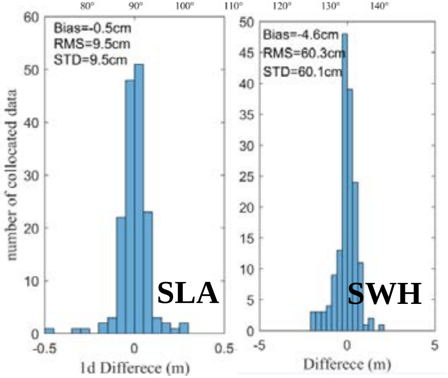


Crossover point

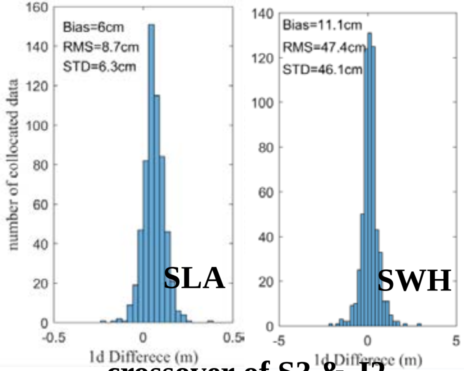




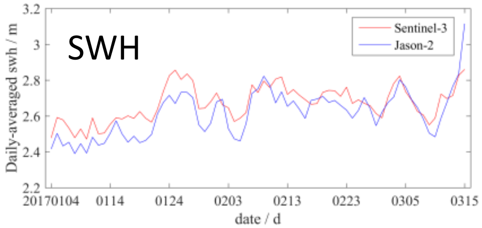
SLA systematic bias



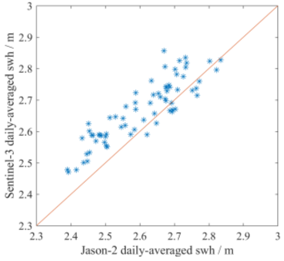
Self-crossover of S3



crossover of S3 & J2



Daily spatial average data comparison between S3 & J2

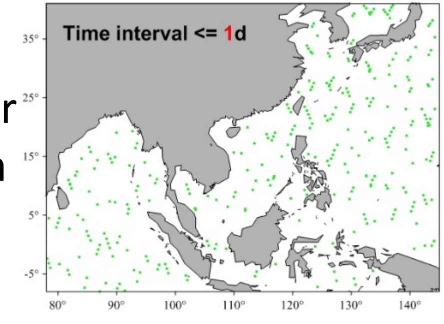


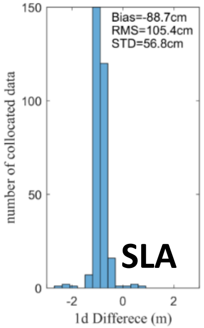
SWH of S3 is larger than J2

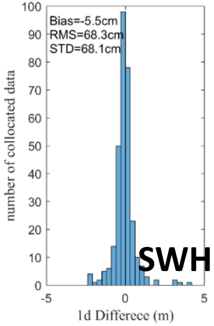
③ Data comparison between geodesic HY-2A altimeter and Jason-2/3 altimeter

Crossover point comparison between time difference < 1 day.

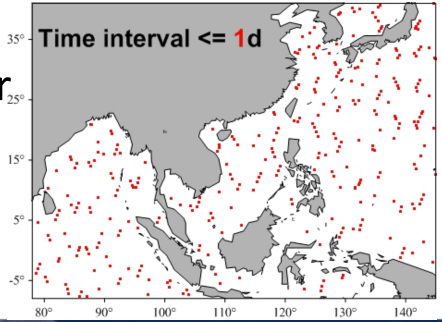
Crossover between H2 & J2

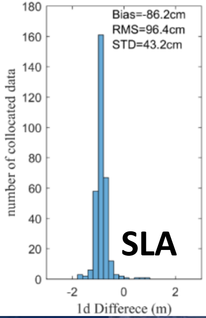


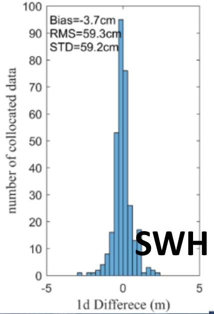




Crossover between H2 & J3







large SLA difference because of the lack of HY-2A dry tropospheric correction

3. Sea surface salinity algorithm based on combined active/passive microwave imagers

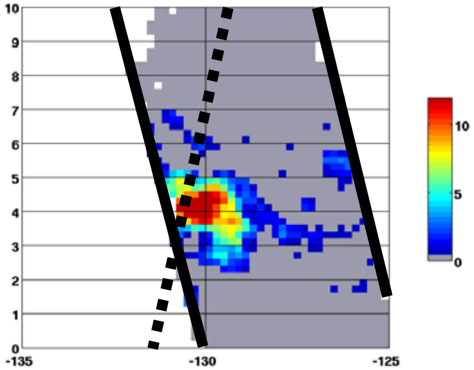
① Retrieval of rain from SMOS satellite salinity in tropical

② Correction and application of SMOS product near land

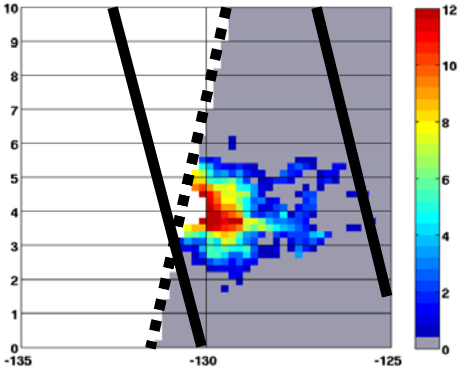
③ Sea surface salinity retrieval under rain based on CAP observations

① Retrieval of rain from SMOS satellite salinity in tropical

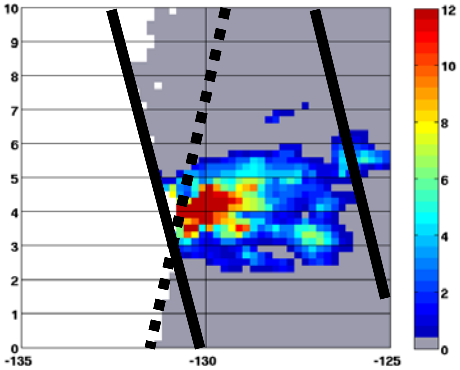
- Salinity freshening linked to rainfall events can be used to retrieve rain rate in tropical regions from satellite salinity
- We show that rain rate such retrieved is more accurate than infrared rain rate from geostationnary satellites



Example of SMOS Rain Rate



SMAP Rain Rate



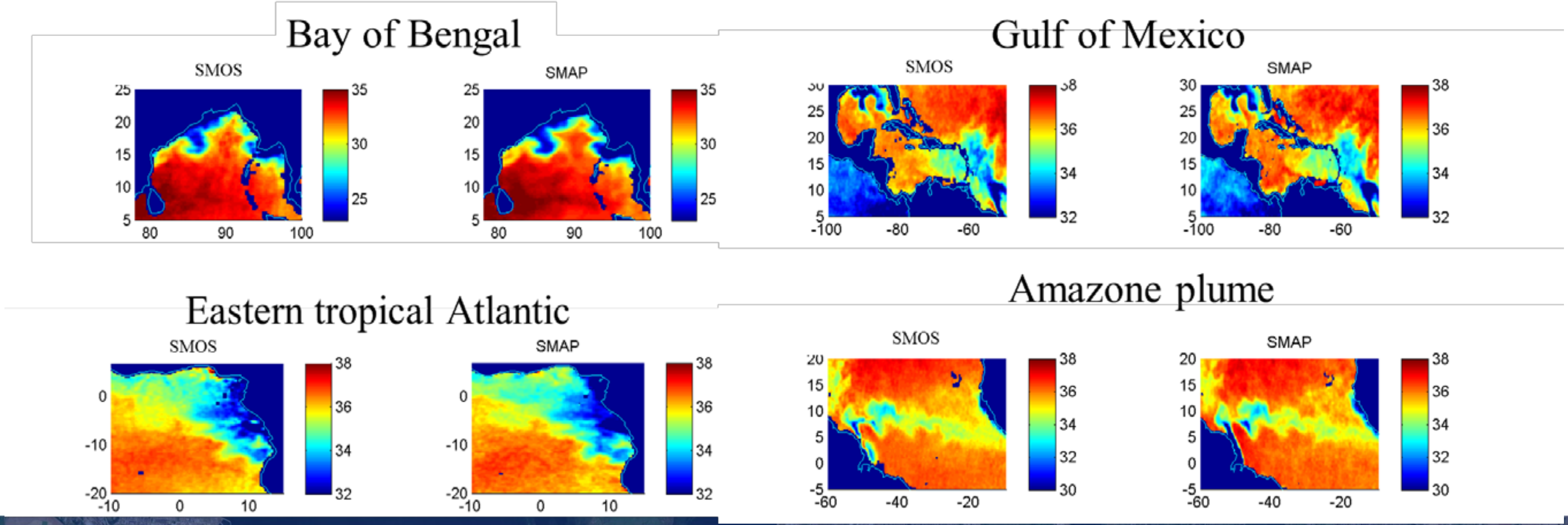
SSM/I derived Rain Rate

$t_{nearest\ MWR} - t_{SMOS} \sim -5$ min

$t_{nearest\ MWR} - t_{SMAP} \sim 5$ min

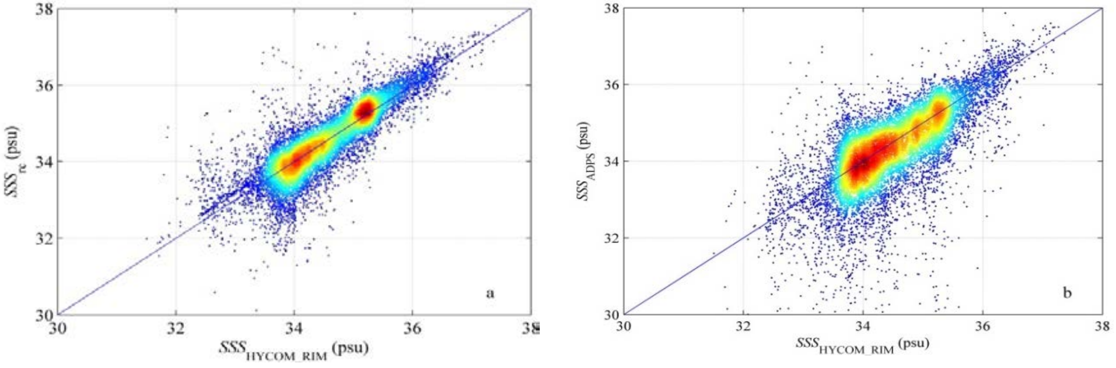
② Strategy to mitigate SMOS systematic errors in the vicinity of land areas

- Strategy to mitigate SMOS systematic errors in the vicinity of land areas
- Freshwater river plumes monitoring by SMOS and SMAP at ~50 km resolution

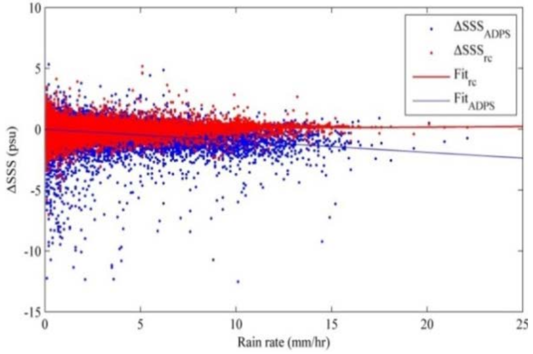


③ Sea surface salinity retrieval under rain based on CAP observations

- Strategy to separate the rain-induced freshening and roughness effect
- SSS retrieval under rain and compared with Aquarius product (ADPS)



Compare of SSS_{rc} (a) and SSS_{ADPS} (b) with HYCOM corrected by RIM



Errors of SSS_{rc}(red dots)and SSS_{ADPS} (blue dots) fit functions to rain rate. Straight lines are linear fit functions for SSS_{rc}(Fit_{rc})and SSS_{ADPS} (Fit_{ADPS}). (Fit_{rc}: y=0.01x-0.04; Fit_{ADPS}: y=-0.09x-0.01)

III. Cooperation

- The 3rd Chinese-Finnish Workshop on Sea Ice and Polar Meteorology was held 5-7 June 2017 in Helsinki. 16 Participants from China attended the seminar.
- AWI and FMI collaborate with FIO on improving retracking procedure for ice freeboard retrieval.
- FMI and NSOAS completed sea ice thickness and concentration retrieval in the Bohai Sea.
- AWI and FIO will collaborate on improving algorithms for detecting ice deformation and studying on the use of interferometric SAR for retrieval of ice surface topography.
- LOCEAN and NSSC collaborate on direct L-band model for SSS retrieval

IV. Young scientists contribution

Young Scientist: Eduard Makhoul

Research Title: Coastal Altimetry with Fully Focused SAR over Chinese seas

Expected results:

- Characterisation/evaluation of the efficient fully focused SAR processor over transponder and for Chinese Coastal areas (comparative analysis with conventional delay-Doppler processor)
- Recommendations for the development and implementation of fully focused SAR for future missions
- Fully focused SAR data sets over transponder and Chinese coastal regions
- Peer-reviewed article, International conference presentations

IV. Young scientists contribution(2)

Young Scientist: Jin Wang

Research Title: Sea surface salinity retrieval under rain based on CAP observations

Expected results:

- Radiation characteristic of rough sea surface under rainy conditions
- Sea surface salinity and wind speed retrieval by L-band observations
- Peer-reviewed article (IEEE JSTARS, minor revisions)

Young Scientist: Zhang Xudong (PhD . candidate)

Research area: internal wave detection by altimeters

Expected results: propagation speed of internal waves

Distance	Time interval	Calculated propagation speed	Theoretical propagation speed
14398 m	267 min	0.90m/s	1.26 m/s
6543 m	112 min	0.97 m/s	1.28 m/s
22226 m	247 min	1.50 m/s	1.26 m/s
22162 m		1.50 m/s	
22922 m		1.55 m/s	
5818m	56min	1.73m/s	1.87m/s
5256m		1.56m/s	
34243 m	356 min	1.60 m/s	1.50 m/s

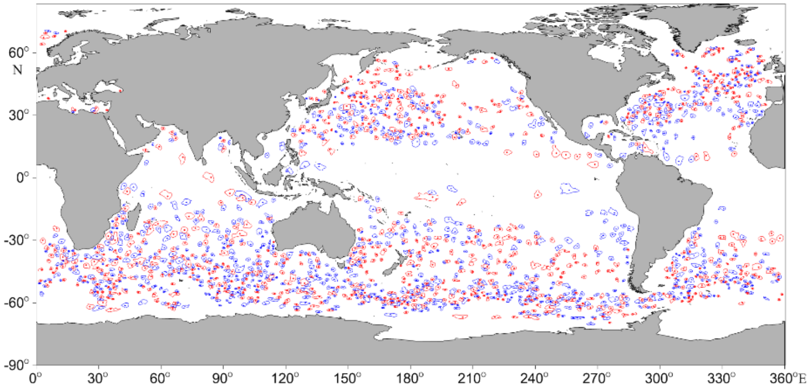
Propagation speed of internal waves derived from combined observation of Jason-2 and MODIS

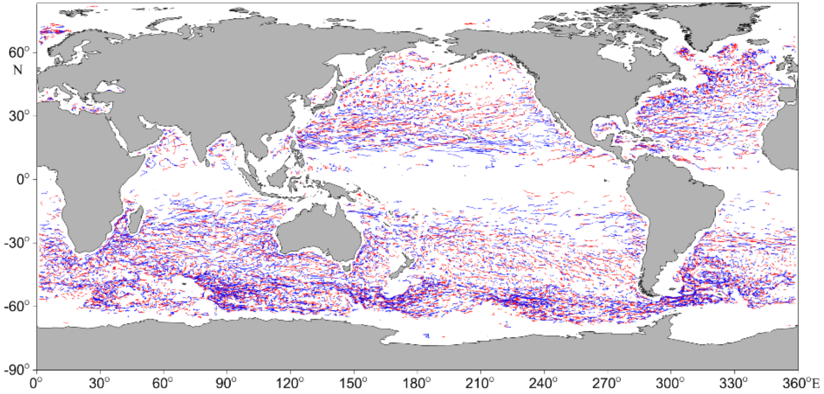
Young Scientist: Wei Cui (PhD . candidate)

Research area: mesoscale eddy detection by altimeters

Expected results:

- Distribution and movement of mesoscale eddies in the East Indian Ocean, South China Sea and Western Pacific Ocean
- Variabilities of mesoscale eddies with time





Distribution and movement of mesoscale eddies obtained by altimters data (red – warm eddy; blue – cold eddy)

V. Publications

- Hollands, T., Dierking, W. (2016), **“**Dynamics of the Terra Nova Bay Polynya: The potential of multi-sensor satellite observations”, *Remote Sensing of Environment* 187, pp. 30-48 doi:10.1016/ j.rse.2016.10.003
- Linow, S., Dierking, W. (2017), “Object-based detection of linear kinematic features in sea ice”, Remote Sens. 9(5), 493 doi:10.3390/rs9050493
- Griebel, J., Dierking W. (2017), “A method to improve high-resolution sea ice drift retrievals in the presence of deformation zones”, Remote Sens., under review (minor revisions)
- Dierking, W., Lang, O., Busche, T. (2017), “Sea ice local surface topography from single-pass interferometric InSAR measurements: a feasibility study”, The Cryosphere Discuss.
- Zeng T., L. Shi, M. Mäkynen, B. Cheng, J. Zou, and Z. Zhang, “Sea ice thickness analyses for the Bohai Sea using MODIS thermal infrared imagery”, *Acta Oceanol. Sin.*,vol. 35, no. 7, pp. 96-104, 2016.
- Karvonen J, Shi L, Cheng B, Similä M, Mäkynen M, Vihma T. Bohai Sea Ice Parameter Estimation Based on Thermodynamic Ice Model and Earth Observation Data. *Remote Sensing*. 2017; 9(3):234.
- E. Makhoul, M. Roca, C. Ray, R. Escolà, A. Garcia Mondéjar, “Evaluation of different Delay-Doppler Processor (DDP) algorithms using CryoSat-2 data over open ocean”, submitted to Advances in Space Research.

- Supply, A., J. Boutin, J.-L. Vergely, N. Martin, A. Hasson, G. Reverdin, C. Mallet, N. Viltard, Precipitation Estimates from SMOS Sea Surface Salinity, QJRMS, in revision, 2017.
- Kolodziejczyk, N., J. Boutin, J.-L. Vergely, S. Marchand, N. Martin, and G. Reverdin Mitigation of systematic errors in SMOS sea surface salinity, 2016, Remote Sensing of Environment, doi:http://dx.doi.org/10.1016/j.rse.2016.02.061.
- Boutin, J., N. Martin, N. Kolodziejczyk, and G. Reverdin, 2016, Interannual anomalies of SMOS sea surface salinity, Remote Sensing of Environment, doi:http://dx.doi.org/10.1016/j.rse.2016.02.053.
- Yin, X., J. Boutin, E. Dinnat, Q. Song, and A. Martin, 2016, Roughness and foam signature on SMOS-MIRAS brightness temperatures: A semi-theoretical approach, Remote Sensing of Environment, doi:http://dx.doi.org/10.1016/j.rse.2016.02.005.
- Boutin, J., et al. , Satellite and In Situ Salinity: Understanding Near-surface Stratification and Sub-footprint Variability, 2016, Bulletin of American Meteorological Society, 97(10), doi: 10.1175/BAMS-D-15-00032.1.
- Wang J., et al., Sea Surface Salinity Retrieval under Rain based on Aquarius Combined Active/Passive Observations, IEEE JATSRS, in revision, 2017.

VI. Next planning

Topic 1: Sea ice parameter extraction and sea ice monitoring

- FIO, AWI, and FMI will be continued to analyze a new CryoSat-2 waveform retracker algorithm.
- FMI participates in the Arctic cruises CHINARE-2017 and CHINARE-2018 by proving 4+8 snow and ice mass buoys for the validation of satellite products. The results will be analysed jointly with Chinese and European side.
- Joint effort to extend/test algorithms for sea ice drift and deformation retrieval, focusing on different satellite missions (Chinese GF-series, Sentinels), in the Bohai Sea and in the Arctic Ocean.
- Simultaneous use Chinese scatterometer HY2 and radiometer data will be used to monitor sea ice concentration in three fixed domains along the NE Passage.
- Developing and testing strategies for retrieval of sea ice topography and motion using interferometric SAR.

Topic 2: Data validation and oceanic applications of new satellite altimeters

- Validation of S3 SAR mode data retrackers over coastal areas
- Analysis and application of geophysical corrections (dry troposphere, wet troposphere and ionosphere) over coastal areas
- Mesoscale eddy detection by Sentinel-3 and HY-2A altimeter.

Topic 3: Sea surface salinity algorithm based on combined active/passive microwave imagers

- Correction for SMOS systematic errors and development of new SMOS CATDS product (LOCEAN)
- Continuation of sea surface salinity measuring (NSSC & QDU). Extend the algorithms to other satellite with CAP observation capability (such as SMAP)
- Retrieval algorithm for rain rate (LOCEAN) and wind speed (QDU & NSOAS) by L-band microwave imagers

Thanks for your attention!