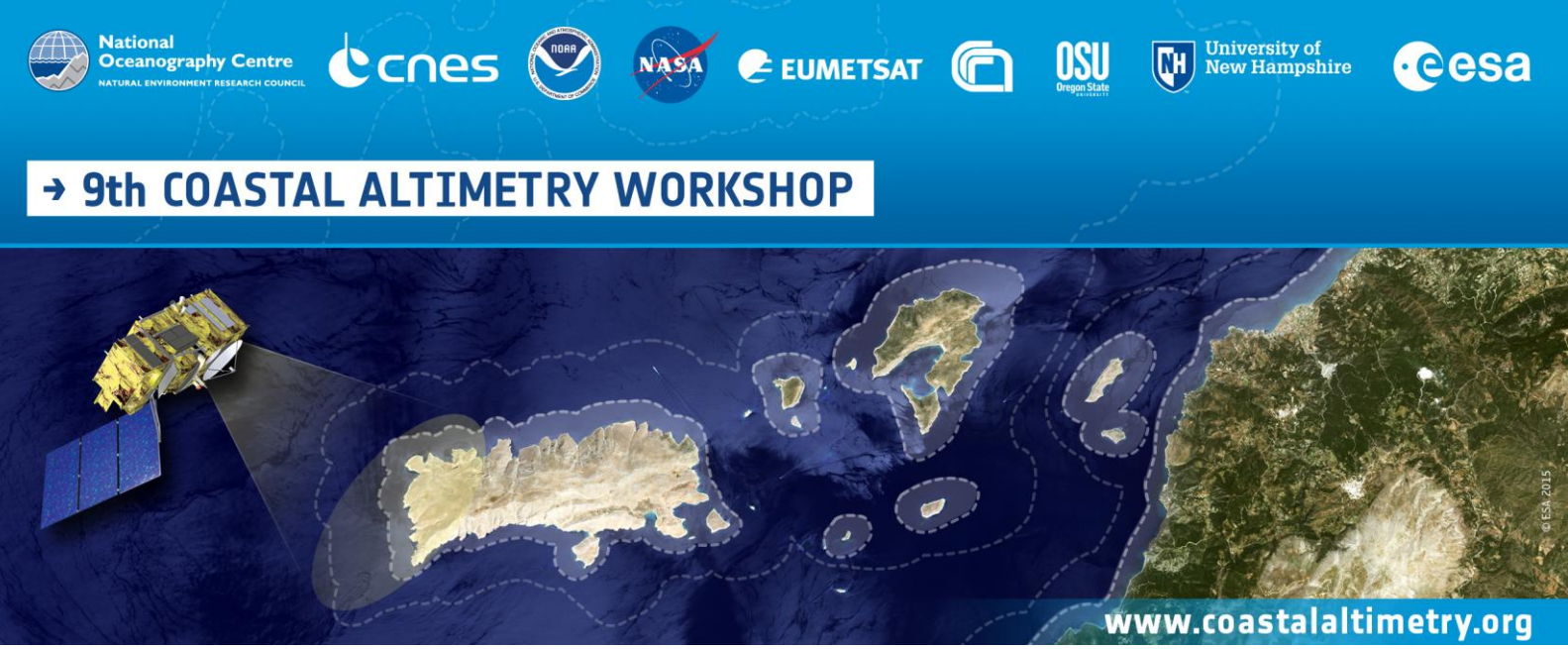

9th Coastal Altimetry Workshop

Sunday, October 18, 2015 - Monday, October 19, 2015

Hyatt Regency Hotel, Reston, Virginia (United States)

Abstract Book

Oral

Sun, Oct 18 2015, 14:00 - 14:20: Prospects for the Use of Satellite Altimetry in Coastal Regions: Remko Scharroo et al.
Sun, Oct 18 2015, 14:20 - 14:40: Simultaneous multi-waveform retracking in coastal regions : application to the NW Mediterranean Sea: Fernando Niño et al.
Sun, Oct 18 2015, 14:40 - 15:00: Coastal SAR and PLRM Altimetry in German Bight and West Baltic Sea: Salvatore Dinardo et al.
Sun, Oct 18 2015, 15:00 - 15:20: A fast convolution based SAR retracker and its performance in coastal areas: Christopher Buchhaupt et al.
Sun, Oct 18 2015, 15:20 - 15:40: SAR altimetry performance in the coastal zone: an assessment with CryoSat-2 around the UK coast: Paolo Cipollini et al.
Sun, Oct 18 2015, 16:30 - 16:50: Recent developments in the GNSS-derived Path Delay (GPD) targeting at better wet tropospheric corrections for open-ocean and coastal studies: Clara Lázaro et al.
Sun, Oct 18 2015, 16:50 - 17:10: Inter-calibrated wet path delays for eight altimetric missions – impacts on coastal sea level: M. Joana Fernandes et al.
Sun, Oct 18 2015, 17:10 - 17:30: Wet-Tropospheric Path Delay Retrievals with High Spatial Resolution over Coastal Areas and Inland Water from the High-frequency Airborne Microwave and Millimeter-wave Radiometer (HAMMR) West Coast Flight Campaign: Steven Reising et al.
Mon, Oct 19 2015, 08:30 - 08:50: Coastal improvement for MSS improvement - DTU15MSS in Antarctica: Ole Baltazar Andersen et al.
Mon, Oct 19 2015, 08:50 - 09:10: A Global Coastal Altimetry Dataset for Coastal Dynamics and Sea Level Research: Marcello Passaro et al.
Mon, Oct 19 2015, 09:10 - 09:30: Satellite altimetry data validation in San Matias Gulf, Argentina: Martin Saraceno et al.
Mon, Oct 19 2015, 09:30 - 09:50: Using SARAL/AltiKa to improve Ka-band altimeter measurements for coastal zones, hydrology and ice: status of the PEACHI project: Guillaume Valladeau et al.
Mon, Oct 19 2015, 09:50 - 10:10: Monitoring Coastal Upwelling using Altimetry: a Feasibility Study.: Madeleine Cahill et al.
Mon, Oct 19 2015, 11:00 - 11:20: The Altimetry for Regional and Coastal Ocean Models (ARCOM) pilot workshop: Claire Dufau et al.
Mon, Oct 19 2015, 11:20 - 11:40: Coastal Altimeter Data Assimilation: Matching dynamics and datum inside the 200-m isobath: John Wilkin et al.
Mon, Oct 19 2015, 11:40 - 12:00: Combining altimetry, numerical modeling and in-situ observations for the observation and the understanding of fine scale coastal processes in the Bay of Biscay: Florence Toublanc et al.
Mon, Oct 19 2015, 12:10 - 12:30: Comparing coastal and open ocean sea level variability and trend from altimetric data: Angelique Melet et al.
Mon, Oct 19 2015, 12:30 - 12:50: Fluctuation of annual sea level cycle and sea level rise acceleration in China Seas: Yongcun Cheng et al.
Mon, Oct 19 2015, 14:00 - 14:20: Coastal Connections in the Southern Benguela Current During Periods of Interleaved Data: P Ted Strub et al.
Mon, Oct 19 2015, 14:20 - 14:40: Variability of surface circulation determined from coastal altimetry over the Tunisian shelf (Central Mediterranean): FATMA JEBRI et al.
Mon, Oct 19 2015, 14:40 - 15:00: The impact of southwest Nova Scotian shelf inflow on the seasonal and inter-annual variability of freshness in the Gulf of Maine: Robust evidence from long-term altimeter observations: Hui Feng et al.
Mon, Oct 19 2015, 15:10 - 15:30: DAHITI - An Innovative Approach for Estimating Water Level Time Series over Inland Water using Multi-Mission Satellite Altimetry: Christian Schwatke et al.
Mon, Oct 19 2015, 15:30 - 15:50: The ICESat-2 Mission: Overview and Potential Applications to Coastal Altimetry: Michael Jasinski et al.

Poster

Technical issues in coastal altimetry

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TEC_002: Towed and static GPS buoys for CAL/VAL and SSH: Cédric Brachet et al.
TEC_003: Classification of altimeter Waveforms for an Improved Estimation of Water Level Time Series over Inland Water: Christian Schwatke et al.
TEC_004: Analysis of Cryosat-2 altimeter waveforms for the detection and characterization of ship targets: Jesus Gomez-Enri et al.
TEC_005: Use of satellite altimetry data in the Rio de la Plata estuary: Laura Agustina Ruiz Etcheverry et al.

Applications of coastal altimetry data

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APP_002: Regional X-TRACK altimeter products for coastal applications: updates and evolutions: Nicolas Fuller et al.
APP_003: On the Lofoten Basin and its permanent eddy: Leon Chafik et al.
APP_004: Radar Altimetry Toolbox: Albert Garcia-Mondejar et al.
APP_005: Improved satellite altimeter mapped sea level anomalies in the Mediterranean Sea: A comparison with tide gauges: Marta Marcos et al.
APP_006: Coastal sea level monitoring in the Bay of Bengal using SAR and LRM altimetry.: Gaia Piccioni et al.
APP_007: Seaweed mapping along Karachi coast using geospatial techniques: Muhammd Danish Siddiqui et al.
APP_008: Identification of potential fishing zones using geo-spatial techniques: Muhammad Abdullah et al.
APP_009: Tropical Cyclone Intensity Analysis Using Geospatial Techniques : Maha Qaisar et al.
APP_010: Passive tracer simulations of inflows into the Mid-Atlantic Bight & Gulf of Maine: Alexander Lopez et al.
APP_011: Patterns of the Loop Current System and Regions of Sea Surface Height Variability in the Eastern Gulf of Mexico Revealed by Self-Organizing Maps: Yonggang Liu et al.
APP_012: Ice, Cloud and land Elevation Satellite-2 Mission Applications: Sabrina Delgado Arias et al.
APP_013: The NASA Applied Sciences Program for the GRACE Satellite Missions: Michael Jasinski et al.
APP_014: U.S. Regional Sea Level Indices from Water Level Stations and Satellite Altimetry: Zervas Chris et al.
APP_015: Regional Altimeter Data for Brazilian Applications: Claire Dufau et al.
APP_016: Analysis of changes in coastal sea level from the new SL_cci altimetry product and tide gauge data: Francisco Mir Calafat et al.

Abstract details

The Altimetry for Regional and Coastal Ocean Models (ARCOM) pilot workshop

Claire Dufau (CLS, France) ; Wilkin John (Rutgers university, USA) ; Mourre Baptiste (SOCIB, Spain)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
Through its provision of global routine estimates of sea level, satellite altimetry is routinely used to constrain large-scale ocean models in operational centers and in research groups. The availability and potential of altimetry products are still often ignored by the regional and coastal ocean modelling community. New altimeter technologies and future missions such as SWOT (wide-swath altimetry) provide and promise an even better match to the modelers needs in coastal and shelf seas and estuaries
The existing link between the Coastal Altimetry Community and the Coastal Oceans and Shelf Seas Task Team (COSS-TT) established since several years to date has opened up opportunities to facilitate cross-fertilization of ideas. It paves the way for routine use for validation and/or assimilation of altimetry data in coastal models. To foster it, a pilot ARCOM workshop was recently organized within the 4th International Coordination Workshop of the GODAE Coastal Oceans and Shelf Seas Task Team (GOV COSS-TT). The main objectives of this workshop were:
I. Discuss the interest of sea level measurements for the regional/coastal ocean modellers
II. Present the available altimetry missions and products; discuss recent advances and projects
III. Discuss how altimetry can improve the forecast quality and enable new applications in the regional/coastal oceans
IV. Discuss how to use altimetry products in regional and coastal models for assimilation and validation
V. Establish a community of practice to advance complementary uses of coastal altimetry in regional/coastal modelling and prediction, involving the COSS community and the regional altimetry groups
This paper presents the outcome of this ARCOM pilot workshop and its perspectives.

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Coastal Altimeter Data Assimilation: Matching dynamics and datum inside the 200-m isobath

John Wilkin (Rutgers University, United States) ; Alexander López (Rutgers University, United States) ; Julia Levin (Rutgers University, United States)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
Skillful analysis and prediction of sea level variability at the coast is an important objective of applied coastal ocean modeling systems. To achieve accuracy across a broad spectrum of scales, these modeling systems strive to include the influence of all dynamic processes that impact coastal sea level: tides, wind and wave set-up, atmospheric pressure, remotely forced coastally trapped waves, and the open ocean mesoscale. When coastal sea level is predicted with respect to a recognized datum, the resulting Total Water Level Envelope has significant practical utility. In regional coastal modeling systems that assimilate or otherwise exploit coastal altimetry data, achieving an accurate Total Water Level Envelope requires some caution in the definition of sea level datum and in the choice of altimeter range corrections that are consistent with the model dynamics.

For a modeling system that encompasses the Mid-Atlantic Bight and Gulf of Maine, we present our experience reconciling the mean and variability in modeled and altimeter-observed sea level on a broad, shallow continental shelf. Two key factors are considered: (1) The influence of atmospheric pressure forcing on modeled coastal sea level and what this says about the appropriate application of the Dynamic Atmosphere Correction (DAC) to altimeter range, and (2) Choosing appropriate definitions of mean sea surface and mean dynamic topography that consistently treat the datum assumed in open boundary condition sea surface height (inherited from a basin-scale model), coastal corrected altimeter sea level anomaly, and sea level observed by tide gauges at the coast.
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Combining altimetry, numerical modeling and in-situ observations for the observation and the understanding of fine scale coastal processes in the Bay of Biscay

Florence Toublanc (LEGOS/CNRS, France) ; Nadia Ayoub (LEGOS/CNRS, France) ; Florence Birol (CTOH/LEGOS, France) ; Patrick Marsaleix (LA/CNRS, France) ; Nicolas Fuller (CTOH/LEGOS, France)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
The aim of this work is to study mesoscale processes occurring in the Bay of Biscay, using coastal altimetry products (X-TRACK, CTOH) from the Jason missions, 3D numerical modeling (SYMPHONIE code) and a wide range of in-situ datasets (tide gauges, buoys, salinity and temperature databases, ...).

The SYMPHONIE configuration is characterized by a variable horizontal resolution, from 3 km in the open sea to less than 800 m on the shelf, and less than 300 m in the Gironde estuary and the Pertuis Charentais. This approach allows the representation of different scales, without using nested grids.

The sea surface elevation signature and the geostrophic currents derived from along-track altimetry are compared and analyzed in complement to other data (SST satellite products, surface buoys, moorings) and numerical simulations. Preliminary model results show a good agreement between estimated and observed SST and SSS. Surface geostrophic currents associated with the slope currents and mesoscale eddies are also obtained numerically in the southern Bay of Biscay.

First, we analyze the SLA data close to the coast and the main corrections (tides, wet tropo, SSB). The seasonal and interannual variability of the slope currents and the shelf circulation is then more particularly investigated. Both modeling results and altimetric data are processed to produce monthly means of along-track geostrophic currents (by year and also for the longest period available). Ultimately, these products could be used by the community as diagnostic tools for their models. We investigate as well the impact of the MDT on the sea surface elevation and on the geostrophic currents.
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Comparing coastal and open ocean sea level variability and trend from altimetric data

Angelique Melet (LEGOS / CNES, France) ; Benoit Meyssignac (LEGOS / CNES, France) ; Marcellin Nonti (University of Abomey Calavi, Benin) ; Baptiste Chide (LEGOS , France) ; Florence Birol (LEGOS, France)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
Since 1993, altimetry has provided an unprecedented opportunity to study sea level variability with a quasi-global coverage. Satellite altimetry indicates that sea level has been rising fast in response to global warming, but with large regional variations. However, standard altimetric data do not allow to study sea level variability and rise close to the coast, where the socio-economic impacts of sea level rise are the greatest. Recently, along-track altimetric data have been reprocessed at LEGOS/CTOH using algorithms adapted to coastal regions to recover information in coastal zones (this reprocessed coastal product is referred to as the XTRACK dataset here).
In this study, we investigate sea level variability and trend changes from the open to the coastal ocean (from 200 to a few kilometers offshore) based on the 20-years of along-track data provided by Topex-Poséidon, Jason-1 and Jason-2. Analyses are performed over two regions (Western coast of Africa and southwest Pacific), which are vulnerable to sea level rise and contrasted. We analyse both the standard dataset distributed by AVISO and the reprocessed XTRACK dataset. We show that sea level variability is enhanced from the open to the coastal ocean over a wide range of frequencies. Sea level rise is also faster closer to the coast in the XTRACK dataset, but not in the AVISO dataset. To understand the differences between the two products, we investigate the different geophysical corrections that are applied to the altimetric data.
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Fluctuation of annual sea level cycle and sea level rise acceleration in China Seas

Yongcun Cheng (Center for Coastal Physical Oceanography, Old Dominion University, United States) ; Plag Hans-Peter (Mitigation and Adaptation Research Institute, Old Dominion University, United States) ; Ezer Tal (Center for Coastal Physical Oceanography, Old Dominion University, United States) ; Hamlington Benjamin D. (Center for Coastal Physical Oceanography, Old Dominion University, United States)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
The regional sea level variability in the China Seas is investigated based on tide gauge, satellite altimeter data and an independent oceanic general circulation model for the Earth Simulator (OFES) model outputs. It is found that atmospheric forcing significantly affects local sea level variability in Bohai Sea and the Yellow Sea and local sea level variability at Southern East China Sea is highly correlated with along-shore currents.
Particularly, the annual sea level fluctuations (i.e., inter-annual variability of the annual sea level cycle) potentially change inundation risk and the frequency and magnitude of flooding in regions with high annual sea level. Hence, the cyclostationary empirical orthogonal function (CSEOF) analysis is carried out to investigate the interannual variations of annual sea level cycle. Similar spatial distribution characteristics of annual sea level fluctuations are presented from satellite altimeter data and model outputs. The variability of annual sea level amplitude estimated from the satellite altimeter data agrees well with that from the tide gauge data, and positively (negatively) correlates with Southern Oscillation Index (Pacific Decadal Oscillation). The OFES model, however, underestimates the fluctuation of the annual cycle. After removing the annual signal, the tide gauge data shows high correlations with SOI and PDO on time scales over 8 years in Bohai Sea and East China Sea. We also investigated the sea level accelerations in China Seas with the annual sea level cycle removed. Tide gauge data in the Bohai Sea show twice sea level rise acceleration of that in the East China Sea. Both the sea level pressure and wind stress contributes to local sea level rise acceleration. EMD analysis demonstrates high correlation between residual sea level trend and SOI trend on climate cycle time scale. Moreover, there is coherent sea level variability on decadal to multi-decadal time scales in the China Seas since 1980.

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Coastal Connections in the Southern Benguela Current During Periods of Interleaved Data

P Ted Strub (Oregon State University, United States) ; Ricardo Matano (Oregon State University, USA) ; Vincent Combes (Oregon State University, United States) ; Corinne James (Oregon State University, United States) ; Juliet Hermes (University of Cape Town, South Africa) ; Charine Collins (University of Cape Town, South Africa)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
We are using the 22-year record of alongtrack altimeter data from the reference missions to analyze the circulation in the coastal region along the southern Benguela Current (30°-35°S) and its connection to the circulation over the Agulhas Bank east of Cape Agulhas (20°E). These missions provide only very coarse coverage of the region. To look in more detail at the structure of the currents, we are examining data from the two 3-year periods of interleaved tracks at the beginning of the Jason-1 and Jason-2 missions. The interleaved reference missions provide twice the coverage for these six years. We are also analyzing the gridded SLA mapped data from the interleaved periods using all altimeters during these periods, which provide the most detailed pictures of synoptically varying SLA fields. During the first period, 15 September 2002 - 15 October 2005, there are 4 altimeters in operation, providing the densest coverage in the record. The reference mission tracks are more optimally spaced for mapping during the second interleaved period, 1 February 2009 - 1 March 2012, although there are only three altimeters in operation. Results from the 6-years with more detailed fields will be compared with results from the full 22-year period, as well as the surface fields from high-resolution ocean circulation models. The goal is to more completely describe features such as the seasonal jets that form next to the coast each year.

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Variability of surface circulation determined from coastal altimetry over the Tunisian shelf (Central Mediterranean)

FATMA JEBRI (INSTM, LEGOS, MIO) ; Bruno Zakardjian (Mediterranean Institute of Oceanography (MIO), France) ; Florence Birol (Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS), France) ; Jérome Bouffard (RHEA for European Space Agency/ESRIN/EOP GMQ Section, Italy) ; Cherif Sammari (Institut National des Sciences et Technologies de la Mer (INSTM), Tunisia)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
Few studies have focused on the use of satellite altimetry to assess surface circulation in the Central Mediterranean Sea(8°E to 15°E; 31°N to 38°N). First, the relative performances of both standard and improved regional altimetric data sets are compared with tide gauge records as a reference. Then, twenty years (1993-2013) of altimeter absolute dynamic topography from TOPEX/Poseidon, Jason-1 and Jason-2 mission are used to examine the seasonal and inter-annual variability of the coastal circulation in the area. The seasonal evolution of the flow is also documented using satellite surface temperature (SST) maps. Results indicate the ability of along-track altimetry data in contributing to the description of the surface circulation and the associated variability along the Tunisian coasts. We demonstrate permanent bifurcations of Atlantic waters advected by the boundary currents. The latter are much stronger in winter when flowing from Algerian/Tunisian shelf to the Tunisian one. In the contrary, the currents are more marked in summer at the southeast of Sicily. In the Gulf of Gabes, the circulation seems unstable and generates an anticyclonic eddy visible in winter that spread AW off-shore until the Tunisian-Libyan shelf. Also, volume transport in the area is estimated empirically based on altimetry data. The seasonal variations of the transport agree fairly well with previous studies, as well as to the climatological analysis from crosstrack altimetry and SST data. Finally, we outline the dominant inter-annual variations of the estimated transport.

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The impact of southwest Nova Scotian shelf inflow on the seasonal and inter-annual variability of freshness in the Gulf of Maine: Robust evidence from long-term altimeter observations

Hui Feng (University of New Hampshire, United States) ; Doug Vandemark (University of New Hampshire, USA) ; John Wilkin (Rutgers University, USA)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:

The GoM is a semi-enclosed marginal sea in the Northwest Atlantic (NWA). Offshore shallow banks and shoals limit GoM-to-NWA water mass exchange to flows from the Scotian Shelf (SS) and two channels, the Northeast Channel (NEC) and the Great South Channel (GSC). Specifically, GoM water mass exchange occurs mainly through 1) the inflow of fresher and colder surface water via the SS shelf and the eastern NEC, 2) the deeper NWA inflow via NEC, and 3) outflow through the western NEC. Previous studies suggest that observed large, but infrequent, Gulf-wide salinity anomalies are attributed mainly to larger SSW inflow. These salinity anomalous periods can significantly impact the ecosystem and fisheries via alteration of water mass characteristics and buoyant stratification. Clarifying the controls of variability in GoM salinity has been quite difficult due largely to the absence of long-term observations of current/transport measurements in critical inflow locations. It is now possible to examine long-term salinity dynamics within the GoM over a decade-long period by combined use of US Integrated Ocean Observing System (IOOS) in situ salinity data and a decade of satellite altimeter observations.

This study uses altimetric observations in the Scotian Shelf (SS)-Gulf of Maine (GoM) system to assess variability of remote freshwater inflow and its control on GoM freshness. To do this we examine the response of the interior GoM salinity change to intermittent upstream current anomalies, at time scales of months to years, as derived from regional satellite altimeter observations from 1993 to 2014.

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DAHITI - An Innovative Approach for Estimating Water Level Time Series over Inland Water using Multi-Mission Satellite Altimetry

Christian Schwatke (DGFI-TUM, Deutschland) ; Denise Dettmering (DGFI-TUM, Germany)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
Satellite altimetry has been designed for sea level monitoring over open ocean areas. However, for some years, this technology has also been used to retrieve water levels
from lakes, reservoirs, rivers, wetlands and in general any inland water body.
In this contribution, a new approach for the estimation of inland water level time series is presented. The method is the basis for the computation of time series of rivers and lakes available through the web service ‘Database for Hydrological Time Series over Inland Water’ (DAHITI). It is based on an extended outlier rejection and a Kalman filter approach incorporating cross-calibrated multi-mission altimeter data from Envisat, ERS-2, Jason-1, Jason-2, Topex/Poseidon, and SARAL/AltiKa, including their uncertainties. The new approach yields RMS differences with respect to in situ data between 4 cm and 36 cm for lakes and 8 cm and 114 cm for rivers, respectively.
Within this presentation, the new approach will be introduced and examples for water level time series for a variety of lakes and rivers will be shown featuring different characteristics such as shape, lake extent, river width, and data coverage. A comprehensive validation is performed by comparisons with in situ gauge data and results from external inland altimeter databases.
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The ICESat-2 Mission: Overview and Potential Applications to Coastal Altimetry

Michael Jasinski (Hydrological Sciences Lab, NASA Goddard Space Flight Center, United States) ; James Morison (Applied Physics Lab, University of Washington, USA) ; Jeremy Stoll (Science Systems and Applications, Inc., NASA GSFC, USA) ; Thomas Neumann (Cryospheric Sciences Lab, NASA GSFC, USA) ; Thorsten Marcus (Cryospheric Sciences Lab, NASA GSFC, USA) ; Kelly Brunt (Morgan State Univ, NASA GSFC, USA) ; William Cook (Mesoscale Atmospheric Processes Lab, NASA GSFC, USA)

Session: Applications of coastal altimetry data
Presentation type: Oral

Abstract:
The Ice, Cloud, and Land Elevation Satellite (ICESat-2), carrying the Advanced Topographic Laser Altimeter System (ATLAS), is a National Research Council recommended mission scheduled to launch in 2017. Its primary objectives are to quantify polar ice sheet changes, estimate sea ice thickness, and enable measurements of canopy height. To complement these objectives, ATLAS data products also will include height observations over both inland water and oceans throughout the designed three-year mission life, encompassing the near shore, coastal and open ocean regions. ATLAS will employ a high repetition rate 532 nm lidar with three pairs of beams spread over 6 km, each with an approximately 14 m footprint, offering unprecedented high resolution altimetry along observed transects.

The ICESat-2 Inland Water Body Height Data Product will consist of along-track water surface height, slope, and roughness for each ATLAS strong beam, and also aspect and slope between adjacent beams. The data product will be computed globally for beams that transect an inland water body during clear to moderately clear atmospheric conditions. Water bodies will be identified primarily through the use of an “Inland Water Body Shape Mask”. In preparation for the mission, the prototype Multiple Altimeter Beam Lidar Experimental Lidar (MABEL), was built and flown during several high altitude experiments, observing a wide range of water targets. Analyses presented herein focus on several MABEL inland and near shore targets flown during 2012 to 2015 under a range of atmospheric and water conditions. Overall, the MABEL data and subsequent analyses have demonstrated the feasibility of ATLAS for providing quantifiable ICESat-2 height data products of the near shore and coastal waters.

For the open ocean, ICESAt-2 will measure Sea Surface Height (SSH) primarily for determination of Dynamic Ocean Topography (DOT=SSH-Geoid) responsible for determining surface geostrophic circulation. Also, variance and other moments in the surface height distribution will also be used to estimate significant wave height, and in turn sea state bias in the DOT.

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Prospects for the Use of Satellite Altimetry in Coastal Regions

Remko Scharroo (EUMETSAT, Deutschland) ; Hans Bonekamp (EUMETSAT, Germany) ; Christelle Ponsard (EUMETSAT, Germany) ; Carolina Nogueira Loddo (EUMETSAT, Germany)

Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Satellite altimetry is rapidly advancing during the last years. With CryoSat-2 a new era of satellite altimetry has been embarked, in which altimeters are able to measure closer to the coast, with a higher spatial resolution, and a higher precision. This all thanks to the use of the Delay Doppler technique, also known as Synthetic Aperture Radar (SAR) altimetry, or High Resolution altimetry.

The advances over the conventional altimetry, known as Low Resolution Mode (LRM) altimetry, are large. But it comes at a cost: the data streams are much larger, and a lot of the algorithms and applications are still being developed. Thanks to CryoSat-2, which has only limited coverage of the globe in SAR mode, techniques are continuously improved, accelerated, and new scientific results are produced.

Two more SAR altimeters are to be launched within the next two years: Sentinel-3A (planned launch date 31 Oct 2015) and Sentinel-3B (to be launched end 2016). They will be flying in complementary, interleaved, ground tracks, each with a repeat period of 27 days, thus creating a dense spatial sampling, which can be advantageous to coastal monitoring. In addition, both missions will be operating in SAR mode 100% of the time, thus providing high-resolution altimetry in all coastal regions up to 82º latitude. Finally, in contrast to CryoSat-2, the data production at EUMETSAT is fully operational, with Level 2 data products produced with latencies of 3 hours, 48 hours, and 60 days, with increased accuracy. Scientist will also be able to download Level 1 data to investigate the individual radar echoes and help further improve processing algorithms aimed at coastal sea level monitoring.

The Sentinel-6 mission will be developed and implemented through a partnership between the EU, ESA, EUMETSAT and NOAA. Its aim is to secure the continuity until 2030+ of critical high precision observations of ocean surface topography beyond Jason-3. NASA and CNES will be supporting partners. The mission will start with the launch of Jason-CS A in 2020, followed by Jason-CS B in 2025. These satellites will carry a new style of SAR altimeter that is able to simultaneously produce the traditional LRM and SAR measurements. That would provide the opportunity to cross-calibrate the two types of altimeter measurements to insure the continuity with the TOPEX/Jason reference series of altimeters. At the same time Sentinel-6 will allow us to learn more about the advantages and differences in geophysical retrievals between conventional and SAR altimetry.

This presentation will give an overview the upcoming Sentinel-3 and Sentinel-6 missions, their new capabilities for coastal altimetry, and the data products to be distributed by EUMETSAT.

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Simultaneous multi-waveform retracking in coastal regions : application to the NW Mediterranean Sea

Fernando Niño (CNRS/Legos, France) ; Florence Birol (UPS/Legos, France) ; Denis Blumstein (CNES/Legos, France) ; Nicolas Fuller (CNRS/Legos, France)

Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Altimetric waveforms near the coast are difficult to analyze because of the complexity of echoes returned from land and coastal waters. Most tracking algorithms are optimized for the open ocean; others try to fit the observed signal to one or more signal templates suitable for a particular setting and then estimate the altimetric range from the deduced parameters. We present new developments in which the goal is to use the reflective ground properties as the main parameters for a radar signal inversion problem over. Instead of trying to fit the waveform data to an a priori reference set of waveforms, from which one can deduce the “real” satellite-earth surface range, we try to model the observed waveform in terms of the configuration of the topography and water and their backscattering properties beneath the satellite. For this, we simultaneously fit a set of waveforms over the study region, instead of using the usual approach of optimizing each waveform individually.

The current version of the inversion algorithm uses a set of parametric generators from which several parameters can be chosen to be inverted (topography, sigma-naught, radar penetration). An iterative optimization algorithm based on evolutionary computation is applied on a realistic altimetry waveform model, obtaining suitable parameters of the generators to describe the waveforms acquired by the satellite(s) over the study area.

An application is shown for the NW Mediterranean region, and the range results compared to those of standard retracking and the PISTACH coastal data processing chain.
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Coastal SAR and PLRM Altimetry in German Bight and West Baltic Sea

Salvatore Dinardo (SERCO/ESRIN, Italia) ; Luciana Fenoglio (TU Darmstadt, Germany) ; Christopher Buchhaupt (TU Darmstadt, Germany) ; Remko Scharroo (EUMETSAT, Germany) ; Joana Fernandez (UPorto, Portugal) ; Jerome Benveniste (ESA/ESRIN, Italy) ; Matthias Becker (TU Darmstadt, Germany)

Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Unlike previous altimetric missions, the CryoSat-2 altimeter (SIRAL) features a novel Synthetic Aperture Radar (SAR) mode that allows higher resolution and more accurate altimeter-derived parameters in the coastal zone, thanks to the reduced along-track footprint. The scope of this study is a regional analysis and inter-comparison of the CryoSat-2 SAR altimeter products against in-situ data and regional model results at distances to coast smaller than 10 km. The in-situ data are from a network of tide gauges and GNSS stations. The validated geophysical altimeter parameters are the sea surface height above the ellipsoid (SSH), the significant sea wave height (SWH) and wind speed (U10), all estimated at 20 Hz.

We have carried out, from CryoSat-2 FBR (L1a) data, a Delay-Doppler processing and waveform retracking tailored specifically for coastal zone by applying Hamming Window and Zero-Padding, using an extended vertical swath window in order to minimize tracker errors and a dedicated SAMOSA-based coastal retracker (named SAMOSA+). SAMOSA+ accepts mean square slope as free parameter and the epoch's first guess fitting value is decided according to the peak in correlation between 20 consecutive waveforms (in order to reduce land off-ranging effect).

Since the highest remaining uncertainties in the altimeter parameters derived in coastal shallow waters arise from residual errors in the applied corrections we use regional ocean tide and high resolution geoid and mean sea surface models (as TPXO8 for tides, EGM 2008 or EIGEN-6C4 for the geoid and DTU13 for the mean sea surface). We also apply a regional improved wet tropospheric correction computed from the GNSS-derived Path Delay Plus (GPD+) algorithm at the University of Porto. Hence for the in-situ validation, errors in corrections are expected to contribute less then in previous analysis on sea level differences measured by altimeter and in-situ data.

In parallel with SAR measurements, in order to quantify the improvement with respect to pulse-limited altimetry, we build 20 Hz PLRM (pseudo-LRM) data from FBR and retrack them with numerical convolutional Brown-based retracker. Hence, here, PLRM is used as a proxy for real pulse-limited products (LRM), since there is no direct comparison of SAR and LRM possible otherwise. The L2 SAR ocean data products are generated and extracted from ESA-ESRIN GPOD service (named SARvatore) while the PLRM data are built and retracked by Technical University of Darmstadt (TUDa). The region of interest is the German Bight and West Baltic Sea (being a very challenging area for radar altimetry due to its complex coastal morphology and its high tide dynamics) while the time of interest is the complete the mission duration (5 years).

The analysis exploits both geometric parameters, as the distance-to-coast parameter and the sea floor bathymetry with resolution of 300 m (from the MERIS water mask and TPXO8 Atlas) and waveform quality parameters, as the misfit between the SAMOSA model waveform and the received echo, the waveform entropy (an high value of waveform entropy is an index of land contamination) and the equivalent number of Looks (ENL, a very low value of ENL is an index of heavy data dispersion and hence land contamination).

Considering the almost five year long analysis, the final objective is to verify the ability of SAR Altimetry to measure accurately in coastal zone the sea level annual cycle and the sea level trend.

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A fast convolution based SAR retracker and its performance in coastal areas

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Since the start of the Cryosat-2 mission SAR Altimetry contributes through a higher signal to noise ratio and a better along track spatial resolution to a better understanding of the oceanic processes. Unfortunately, to achieve an analytical solution for the retrieval of geophysical parameters from the radar echo, the Point Target Response (PTR) in the time/frequency domain has to be approximated by Gaussian bell-curves. This approach leads to errors in the estimated parameters, particularly in Significant Wave Height (SWH).

In an alternative method, which allows to use the correct PTR in the convolution of Delay/Doppler Altimetry waveforms, the Flat Sea Surface Response (FSSR) is calculated analytically and the convolution with the PTR and the Probability Density Function (PDF) of the sea surface is computed numerically.

In this work a close form solution without special functions and infinite sums of SAR Altimetry waveforms is developed in the frequency/time domain by calculating analytically the two-dimensional Fourier Transform of the Convolution term. The corresponding signal in the time/frequency domain can then be computed fast and easily with a two-dimensional fast inverse Fourier transform. Furthermore a Retracking algorithm is developed from this functional model.

Estimable parameters are the amplitude, epoch, SWH, sea surface mean square slope, mispointing angles, and wave skewness.

Finally the algorithm is run in the coastal area of the German Bight with different realizations of window functions. The results are validated against in-situ data and compared to against the SAR/ESRIN and PLRM/TUDa level 2 data.
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SAR altimetry performance in the coastal zone: an assessment with CryoSat-2 around the UK coast

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Coastal Altimetry is expected to benefit significantly from the advent of SAR altimetry, due to the much higher along-track resolution and the better signal to noise ratio of the SAR mode, and data from Cryosat-2 can be used to assess this expected improvement In the framework of the ESA-funded CryoSat Plus for Oceans Project (CP4O) we have carried out such an assessment, using SAR altimetry from CryoSat-2 around the UK coast from the CPP processor, courtesy of CNES, and from the ESA-ESRIN SARvatore GPOD processor.

The diagnostic that we use as a measure of the instrumental noise is the absolute value of the difference amongst consecutive 20-hz samples; over the short distance (~350m) of two consecutive samples, the contribution due to oceanographic phenomena and corrections is of the order of mm so the values observed (usually a few cm) are essentially due to the instrumental noise – and their median is an estimate of the instrument's precision.

As the SAR mode resolution cell extends across-track it is appropriate to first consider this diagnostic as a function of the across-track distance from the coast. Analysis done over one year of CPP data shows that the 20-Hz noise is flat at <6 cm up to 6 km across-track from the coast. Application of a burst-weighting window (Hamming) as done in the GPOD data can reduce this further.

In terms of distance from the closest coastline the number are even better, as when the track is orthogonal or nearly orthogonal to the coast the height estimates are reliable to 1-2 km. This is demonstrated with some data along the UK south coast and also compared to previous results in the Northern Adriatic. With GPOD data the precision is flat at 4.5 cm up to 5 km and still < 6 cm at 3 km. With some screening based on retracking misfit we can still get 4.5 cm precision at 2km but with only about 40% of points valid; and ~4.0 cm at 5 cm with 80% of points valid.

Finally we discuss the plans for extending this work in the SCOOP Project, recently approved for funding in the framework of ESA's Scientific Exploitation of Operation Missions (SEOM) Program, which will pave the way for the scientific exploitation of forthcoming Sentinel-3 SRAL data in the coastal zone.

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Recent developments in the GNSS-derived Path Delay (GPD) targeting at better wet tropospheric corrections for open-ocean and coastal studies

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
In the scope of the ESA Climate Change Initiative Sea Level (SL-cci) project, which aims at generating a long term stable sea level dataset accurate to 0.3 mm/yr, new and inter-calibrated sets of wet tropospheric correction (WTC) were generated at University of Porto U.Porto), using the GNSS-derived Path Delay Plus (GPD+) algorithm evolved from GPD. The new algorithm was applied to eight altimetry missions: TOPEX/Poseidon (TP), Jason-1 (J1), Jason-2 (J2), ERS-1 (E1), ERS-2 (E2), Envisat (EN), CryoSat-2 (C2) and SARAL/AltiKa (SA).
For each mission, the GPD methodology combines, through objective analysis, valid wet path delays (WPD) observations i) from the microwave radiometer (MWR) on board that mission, whenever they exist and ii) derived from Global Navigation Satellite Systems (GNSS) data acquired at coastal and island stations to estimate a new WTC for all invalid MWR measurements. The GPD+ has the advantage of combining also WPD observations from scanning imaging radiometers (SI-MWR) on board various remote sensing satellites, this way increasing data availability.
In the estimation process, the WPD derived from an atmospheric model, such as the European Centre for Medium-range Weather Forecasts (ECMWF) ReAnalysis (ERA) Interim or the ECMWF operational, are used as first guess and also as the GPD+ estimated WTC in the absence of WPD observations.
To achieve the requisite long term stability of the WTC datasets, the radiometers used in the GPD+ estimations require proper inter-calibration. For this purpose, all radiometers have been inter-calibrated, using the set of Special Sensor Microwave Imager (SSM/I) and Special Sensor Microwave Imager/Sounder (SSM/IS) on-board the Defense Meteorological Satellite Program (DMSP) satellite series (F10, F11, F13,F14, F16 and F17) as reference, since their stability and independent calibration are well documented. Due to the different orbits and sampling of the various satellites, the inter-calibration was performed differently for the i) NASA/CNES, ii) ESA and CNES/ISRO altimetry missions and iii) for the SI-MWR radiometers. For each radiometer, a set of three parameters (offset, scale factor and linear trend) were calculated and applied to the original WPD dataset.
These recent developments in the GPD algorithm, targeting at better wet tropospheric corrections are discussed in detail. They are shown to have contributed to the generation of new WTC products that reduce sea level anomaly variance with respect to previous non-calibrated versions (e.g., calculated using GPD) and are expected to be an added-value both for open-ocean and coastal studies.

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Inter-calibrated wet path delays for eight altimetric missions – impacts on coastal sea level

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Coastal sea level variation is of most interest due to its socio-economic impacts. Recent developments in satellite altimetry, particularly on wave retracking and on the improvement of range and geophysical corrections, such as those due to ocean tides and to the atmosphere, have allowed the inspection of the coastal ocean up to a few km from the coast.
One of the major sources of uncertainty on satellite altimetry measurements in the coastal regions is the delay induced by the water vapour content of the atmosphere in the altimeter signal or wet tropospheric correction (WTC). When using standard altimeter products at distances less than 20-40 km from the coast, depending on the mission, the user is faced with the decision whether to adopt a WTC from an atmospheric model or from the on-board microwave radiometer (MWR), contaminated by land effects.
In phase 2 of the ESA Climate Change Initiative Sea Level (SL-cci) project, wet path delays (PD) for all missions used to generate the SL essential climate variable (ECV) were derived at the University of Porto using the GNSS-derived Path Delay Plus (GPD+) methodology. A new and inter-calibrated set of WTC was generated for eight altimetric missions: TOPEX/Poseidon (TP), Jason-1 (J1), Jason-2 (J2), ERS-1 (E1), ERS-2 (E2), Envisat (EN), CryoSat-2 (C2) and SARAL/AltiKa (SA).
This paper demonstrates how this new data set improves the retrieval of the coastal sea level and illustrates the major impacts in regional coastal sea level variation.
Compared to previous GPD products, the main differences are: 1) the series is extended to 8 altimetry missions, including C2 and SA, thus allowing to fill the Envisat gap and extend the higher spatial resolution ESA satellite series until present; 2) additional data from scanning imaging radiometers on-board various remote sensing satellites have been used, improving the WTC retrieval, particularly for the most recent missions such as C2 and SA; 3) all radiometer data sets have been inter-calibrated, using the set of Special Sensor Microwave Imager (SSM/I) and Special Sensor Microwave Imager/Sounder (SSM/IS) on- board the Defense Meteorological Satellite Program (DMSP) satellite series as reference, thus ensuring the long term stability of the corrections and reducing the uncertainty in the long term sea level variation.
For most missions, the new products are shown to reduce coastal sea level anomaly variance with respect to previous non-calibrated versions and to other WTC data sets such as the AVISO Composite WTC or the ERA Interim model. Coastal improvements are also illustrated through the reduction of the RMS differences between GNSS-derived wet path delays at coastal stations and the WTC at the nearby altimeter points, function of the distance from coast. Finally, the impacts on regional sea level variation is illustrated for various regions with different WTC variability and sea level conditions, such as Indonesia and the German Bight.

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Wet-Tropospheric Path Delay Retrievals with High Spatial Resolution over Coastal Areas and Inland Water from the High-frequency Airborne Microwave and Millimeter-wave Radiometer (HAMMR) West Coast Flight Campaign

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Past and current precision ocean altimeters, including the Jason series, have nadir-viewing, co-located low-frequency 18-34 GHz microwave radiometers to correct the radar signal for wet-tropospheric path delay. Since surface footprints are substantial at these frequencies, the accuracy of wet path delay retrievals is significantly degraded within approximately 30-40 km of the world's coastlines, and retrievals are not provided over land. To improve this capability, high-frequency millimeter-wave window channels in the 90-180 GHz band may be added to achieve finer spatial resolution for a similar reflector antenna size. In May 2014, NASA and CNES administrators signed a bilateral agreement to move from feasibility studies to implementation of the Surface Water and Ocean Topography (SWOT) mission, now planned for launch in late 2020. The primary objectives of SWOT are to improve the spatial resolution of ocean surface altimetry from 200-km to 15-km spatial scales on a global basis as well as to measure global water storage in inland surface water bodies and the flow rate of rivers. Therefore, an important new science objective of SWOT is to transition satellite altimetry from the open ocean into the coastal zone and over inland water.

The addition of 90-180 GHz high-frequency millimeter-wave window-channel radiometers to current Jason-class 18-34 GHz low-frequency radiometers is expected to provide retrievals of wet-tropospheric delay in coastal areas and to enhance the potential for over-land retrievals. A preliminary study assessed the value of high-frequency radiometer data by using the Global Precipitation Measurement (GPM) Microwave Imager (GMI)'s 90 GHz channel to extrapolate the conventional low-frequency (18.7-37.0 GHz) retrieval toward the coasts. When the extrapolation distance from the last valid low-frequency retrieval is 50 km, the error from the true path delay is 10 mm, but the high-frequency extrapolation algorithm reduces the error to 4 mm, providing substantial benefits for ocean altimetry.

To address these needs, Colorado State University (CSU) and NASA/Caltech Jet Propulsion Laboratory (JPL) have designed, fabricated and demonstrated the HAMMR airborne radiometer instrument with a total of 25 channels, combining low-frequency microwave channels similar to Jason-2/3 at 18.7, 23.8 and 34.0 GHz with high-frequency, wide-band millimeter-wave window channels at 90, 130 and 168 GHz, as well as temperature and water vapor sounding channels near 118 GHz and 183 GHz, respectively.

The new airborne HAMMR instrument (1) provides calibration and validation support for the SWOT, Jason-3 and Jason-CS missions that is complementary to JPL's AirSWOT, (2) assesses wet-tropospheric path delay variability on 1-km and smaller spatial scales, and (3) provides high-frequency millimeter-wave radiometers with direct detection and internal calibration that can be integrated into future space missions, including the TEMPEST-D NASA-funded technology demonstration mission aboard a 6U CubeSat.

The HAMMR instrument was deployed on a Twin Otter aircraft for the West Coast Flight Campaign (WCFC) between November 4 and 17, 2014. During 11 of these 14 days, HAMMR successfully collected more than 53.5 hours of data under diverse atmospheric conditions, including clear sky, scattered and dense clouds, as well as over coastal ocean areas, inland water and land. HAMMR performed measurements over nearly the entire U.S. West coast from Camarillo, CA, to the Strait of Juan de Fuca, WA. Both coastal and inland water were overflown

at different times of day to measure diurnal variations in wet-path delay under a variety of atmospheric conditions, including clear sky, clouds and fog.

The HAMMR WCFC antenna temperatures were accurately calibrated and geolocated to retrieve wet-tropospheric path delay with approximately 1-mm precision and 150-m spatial resolution. Spatial spectral analysis will be performed to determine the spatial variability of wet-path delay over coastal areas after completing additional quality control and data refinements.

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Coastal improvement for MSS improvement - DTU15MSS in Antarctica

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
The MSS is a reference for numerous geophysical applications, and in particular it is crucial for the derivation of sea ice thickness in Polar regions.. In 2013 DTU Space released DTU13MSS, a global-coverage MSS which is based on a 20-year period of satellite data provided by 9 different missions.

In this work an updated version of DTU13 with respect to applying Cryosat-2 in the Antarctic region, the DTU15MSS, is presented and the specific problems related to rapid change in SAR/SARin masks in the region is highlighted. Frequently the mask changes from LRM over SAR to SARin within a few hundred km of the coast.

DTU15MSS is based on DTU13MSS and integrates four years of CryoSat-2 data. Over Antarctica, the unprecedented design of CryoSat's radar altimeter provides high-resolution observations in SAR and SARin modes which is crucial to ingest into the MSS in order to get an accurate MSS close to the coast. The surface is computed with a 2-step method which involves the correction of orbital and range errors of CryoSat data and iterative adjustment of the SAR and SAR-in data to LRM based on Stack Standard Deviation and Pulse Peakiness.

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A Global Coastal Altimetry Dataset for Coastal Dynamics and Sea Level Research

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Improvements in coastal altimetry are now bringing new possibilities to studies of coastal dynamics and coastal sea level and allow the exploitation of synergies with the other components of the coastal observing systems (gauges, buoys, mooring, HF radars, floats) and with regional models. Those improvements come from technological advances in altimeters (i.e. the SAR mode altimeter on board CryoSat-2 and soon Sentinel-3) as well as improved processing techniques (better waveform retracking and data screening) and corrections.

Our research has focused on the retracking, i.e. the on-ground processing that fits a model to the signal received by the satellite in order to increase the precision of the estimated geophysical parameters. This study will present its outcome, i.e. a new global multi-mission coastal-retracked altimetry dataset based on the ALES (Adaptive Leading-Edge Sub-waveform retracker) algorithm. ALES aims at retracking both open ocean and coastal data with the same precision, and is therefore tailored to the needs of the coastal and shelf oceanographers and modellers.

As an introduction we present the details of the algorithm and summarize its validation against in-situ measurements of tide gauges (TGs) located in the Adriatic Sea and on the Agulhas Bank. We also briefly recall the validation of the Significant Wave Height (SWH) against buoy data in the German Bight. We show a couple of example applications of the reprocessed data to sea level variability studies and coastal oceanography in the Danish Straits and in the Indonesian Sea.

We finally describe the coastal altimetry datasets deriving from the application of ALES to the entire Jason-1, Jason-2 and Envisat missions in the global coastal strip. This dataset is being made available free of charge from the Physical Oceanography Distributed Active Archive Center (PO.DAAC) at the NASA Jet Propulsion Laboratory, Pasadena, CA. http://podaac.jpl.nasa.gov. The file structure is the same as standard SGDR products, with the addition of the fields concerning the ALES retracking, i.e. range and SWH. Users are invited to integrate the new retracked fields with state-of-the-art geophysical corrections in order to maximise the impact of the improvements.

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Satellite altimetry data validation in San Matias Gulf, Argentina

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
The objective of this work is to evaluate satellite altimetry data and its corrections terms in a complex coastal environment. Satellite altimetry data are compared with data obtained from a bottom pressure recorder deployed during 22 months. The instrument is moored at 1 km from the coast in San Matias Gulf, Argentina, at only 38m from the nominal intersection of satellite tracks 52 (descending) and 189 (ascending) of Jason 2. Data obtained from the bottom pressure recorder are therefore ideal to test coastal satellite altimetry products. Correlation between the two datasets is 0.9 (95% CL) when no corrections are applied to the altimeter data, until a distance of 3 km to the coast for track 189, and 10 km for track 52. Results show that both sea bias and ionosphere corrections reduce the correlation between altimetry and in-situ data near the coast: a correlation value of 0.9 is found at a distance from the coast of 7 km (track 189) and 13 km (track 52). Tide correction also reduces the correlation between the two datasets along the tracks. Eight global models were considered, and the one with lower root sum square of the difference considering the first 11 amplitude and phase constants is FES2012 (0.84 cm). Finally two retracking algorithms were considered: a classic Brown model (MLE4) and a more recent developed method: ALES (Adaptive Leading Edge Subwaveform Retracker). Both ALES and MLE4 show similar correlation with in-situ data when applied to satellite altimetry data for distances larger than 10km from the coast, obtaining a correlation factor of 0.9 (95% CL). ALES has the ability to recover more data close to the coast, especially for the ascending track 189 (the one that has a transition from ocean to land), up to 3km from the coast. We conclude that satellite data from Jason 2 can adequately represent the sea level variability as close as 3 km from the coast depending on the position of the coast relative to the track and the correction used.

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Using SARAL/AltiKa to improve Ka-band altimeter measurements for coastal zones, hydrology and ice: status of the PEACHI project

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
With the objective to ensure the complementarity but also the continuity with the SARAL/AltiKa Level-2 products provided in the open ocean, the PEACHI (Prototype for Expertise on AltiKa for Coastal, Hydrology and Ice) project has been set up as an initiative of the French space agency, CNES. The PEACHI prototype is designed to process and fine tune enhanced algorithms dedicated to the assessment of Ka-band parameters, from the instrument processing to geophysical corrections. As a result, end users are routinely provided with the latest available altimeter corrections for scientific applications.

Complementary to the last update of SARAL/AltiKa processing software and the dissemination of the operational Level-2 products, some new or improved algorithms have been developed in the framework of the PEACHI project to better observe the open ocean and achieve SARAL secondary objectives on the study of coastal dynamics, inland waters, polar oceans, or continental and sea ice. The purpose of this work is to provide a global status of the PEACHI project and the reprocessing performed in 2015. We focus on a handful of key algorithm improvements with regard to the operational GDR (Geophysical Data Record) products: new waveform retrackers improving performances over ocean, continental and sea ice, improved 2D and new 3D sea state biases, new tide models, better altimeter wind correction, new editing process over rain and bloom areas or sea ice regions.

We would like to foster all current and prospective users to provide us with independent assessment and feedback in order to determine which parameters should be transferred into the classical GDR, or applied to other missions. Feedback would also be appreciated to define possible innovative algorithms and studies that should be added to future PEACHI versions, keeping in mind the project goal: deliver a long, rich and consistent time series of demonstrative algorithms.
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Monitoring Coastal Upwelling using Altimetry: a Feasibility Study.

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Session: Technical issues in coastal altimetry
Presentation type: Oral

Abstract:
Upwelling occurs along the Bonney Coast, in the Great Australian Bight, two or three times each summer. The region is Australia's only deep-reaching coastal upwelling system, drawing water from depths exceeding 300m and affecting up to 800 km of coastline. The upwelling sustains a rich ecosystem attracting blue whales and southern Bluefin tuna as well as supporting populations that includes fur seals, penguins and southern rock lobster.

Altimeter estimates of sea level anomaly (SLA) over the shelf are often difficult to test because the dominant time scale of shelf motion is much shorter than the repeat sampling time of altimeter tracks. Upwelling events provide an opportunity to test the coastal altimetry product PEACHI as the relative longevity (up to 10days) and spatial extent of the upwelling sea surface signal allows for repeat sampling of the same event. We compare an analysis of PEACHI SLA estimates over the shelf and slope of the Bonney Coast for the summer of 2013/2014 against estimates of surface velocity from coastal radar and patterns of sea surface temperature. PEACHI estimates of SLA confirm the upwelling patterns observed and could provide a valuable resource for monitoring and assessing upwelling events.

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Sea level variability in the Baltic Sea

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_001

Abstract:
The exploration of sea level variability from multiple satellite altimetry measurements in the Baltic Sea is yet to be performed due to the lack of reliable data, especially near the coast. By replacing the radiometer wet troposphere correction with model-based correction, the number of available altimeter measurements was increased by 96% in coastal regions. The satellite altimeter data show good agreement with monthly tide gauge data, with mean a root mean square difference (RMSD) of 3.4 cm and a mean correlation coefficient of 0.97 at 42 tide gauges in the Baltic Sea, and higher RMSD and lower correlation coefficient in the Gulf of Bothnian and the Danish Straits, respectively. Independent model reanalysis demonstrates similar performance at the sites. The collocated high-frequency tide gauge data and altimeter data demonstrate an RMSD of 8.86 cm and a bias of 6.63 cm at Stockholm, respectively.
The tide gauge sea level variations in the Baltic Sea are highly correlated with the North Atlantic oscillation (NAO) index at the decadal timescale. A decrease in the correlation coefficient of the tide gauge winter averaged sea level time series and the winter NAO index has been observed on the decadal timescale in the last decade, especially during 2003 and 2005.
Furthermore, consistent annual sea level cycle variability is captured by satellite altimetric data, tide gauge data and model outputs using the cyclostationary empirical orthogonal function method. NAO index dominates the variations of annual sea level cycle in the Baltic Sea. The correlation between annual sea level and annual air temperature variations increases since 2003.

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Regional X-TRACK altimeter products for coastal applications: updates and evolutions

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_002

Abstract:
The CTOH (Centre of Topography of the Oceans and the Hydrosphere) is an independant research service dedicated to satellite altimetry studies. One of its objectives is to optimize the completness and the accuracy of the sea surface height information derived from satellite altimetry in coastal areas. A dedicated tool, called X-TRACK, has been used since 2008 in order to process up-to-date altimeter products from Topex/Poseidon, Jason-1&2, Geosat Follow On and Envisat satellites. X-TRACK produces 1Hz along-track Sea Level Anomaly (SLA) time series over 23 coastal regions, which are available on our website (http://ctoh.legos.obs-mip.fr/products/coastal-products) and on the new AVISO+ web portal. Along-track tidal constants (including the amplitude, phase lag and error estimates for a number of tidal constituents) are also computed from the harmonic analysis of the SLA long time series.

Recently, X-TRACK code was rewritten to gain consistency and efficiency in the data processing workflow. We also revisited several aspects of the processing, as the altimetry corrections or the data editing strategy which has been significantly improved in order to obtain a better data quality for the points closest to the coast. Finally, the new finite element global tides atlas FES2014 (F. Lyard et al.) is used in place of FES2012 to remove the tidal signal. We present here our first results by comparing the new X-TRACK along track SLA with co-located tide gauges in various regions and discuss the future improvements of our products.

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On the Lofoten Basin and its permanent eddy

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_003

Abstract:
In recent years studies have identified an intense and permanent anticyclonic eddy ~600 km west of the Lofoten Islands, Norway. We show that dynamic height from altimetry is an excellent tool to document its position and strength during the past 22 years. Eddies shed from the Norwegian Atlantic Current at the coastal escarpment drift west towards this eddy and maintain its long-term stability and its substantially deep mixed layer as further suggested from hydrography. This eddy is a permanent feature and has been part of the circulation of the Nordic Seas thermohaline circulation as long as eddies have been pinched off at the escarpment, quite possibly for millennia.

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Radar Altimetry Toolbox

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_004

Abstract:
The prime objective of the SEOM (Scientific Exploitation of Operational Missions) element is to federate, support and expand the large international research community that the ERS, ENVISAT and the Envelope programmes have build up over the last 20 years for the future European operational Earth Observation missions, the Sentinels. Sentinel-3 builds directly on a proven heritage of ERS-2 and Envisat, and CryoSat-2, with a dual-frequency (Ku and C band) advanced Synthetic Aperture Radar Altimeter (SRAL) that provides measurements at a resolution of ~300m in SAR mode along track. Sentinel-3 will provide exact measurements of sea-surface height along with accurate topography measurements over sea ice, ice sheets, rivers and lakes. The first of the two Sentinels is expected to be launched in early 2015.

The current universal altimetry toolbox is BRAT (Basic Radar Altimetry Toolbox) which can read all previous and current altimetry mission's data, but it does not have the capabilities to read the upcoming Sentinel-3 L1 and L2 products.

ESA will endeavour to develop and supply this capability to support the users of the future Sentinel-3 SAR Altimetry Mission. BRAT is a collection of tools and tutorial documents designed to facilitate the processing of radar altimetry data. This project started in 2005 from the joint efforts of ESA (European Space Agency) and CNES (Centre National d'Etudes Spatiales), and it is freely available at http://earth.esa.int/brat. The tools enable users to interact with the most common altimetry data formats, the BratGUI is the front-end for the powerful command line tools that are part of the BRAT suite. BRAT can also be used in conjunction with Matlab/IDL (via reading routines) or in C/C++/Fortran via a programming API, allowing the user to obtain desired data, bypassing the data-formatting hassle. BRAT can be used simply to visualise data quickly, or to translate the data into other formats such as netCDF, ASCII text files, KML (Google Earth) and raster images (JPEG, PNG, etc.). Several kinds of computations can be done within BRAT involving combinations of data fields that the user can save for posterior reuse or using the already embedded formulas that include the standard oceanographic altimetry formulas.

The Radar Altimeter Tutorial, that contains a strong introduction to altimetry, showing its applications in different fields such as Oceanography, Cryosphere, Geodesy, Hydrology among others. Included are also "use cases", with step-by-step examples, on how to use the toolbox in the different contexts.

The new Altimetry Toolbox shall benefit from the current BRAT version. While developing the toolbox we will revamp of the Graphical User Interface and provide, among other enhancements, support for reading the upcoming S3 datasets and specific "use-cases" for SAR altimetry in order to train the users and make them aware of the great potential of SAR altimetry for coastal and inland applications. As for any open source framework, contributions from users having developed their own functions are welcome.

The first Release of the new Radar Altimetry Toolbox is expected fot mid September. It will incorporate the capability to read S3 products, the new CryoSat-2 Baseline C as well as the Jason-3.
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Improved satellite altimeter mapped sea level anomalies in the Mediterranean Sea: A comparison with tide gauges

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_005

Abstract:
The new gridded Mediterranean sea level anomaly product recently released by AVISO (DT14) is evaluated and compared with the earlier version (DT10) at which it is aimed to substitute. Differences between the two products are found along coastal regions, where the new version captures more variability (up to 10% more) and trends locally differ by up to 1 mm/yr for the altimetric period. Coastal tide gauge observations have therefore been used as the basis for quantifying changes in DT14. Correlation and variance reduction in available monthly tide gauge time series are improved in more than 80% of the selected sites by up to 0.2 and 5 cm2, respectively. This resulted in an overall higher skill to recover coastal low frequency (with periods larger than a few months) sea level signals. Results for higher/lower order percentiles were also explored and showed different performances depending on the site, although with a slight overall improvement. A comparison with tide gauges on a daily basis using wavelet analysis reveals that altimetry gridded products are not capable of recovering higher frequency (a few days) coastal sea level signals despite some advances have been achieved thanks to the daily temporal sampling of DT14.
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Coastal sea level monitoring in the Bay of Bengal using SAR and LRM altimetry.

Gaia Piccioni (Masters, Danmark) ; Salvatore Dinardo (Dr, Italy) ; Jerome Benveniste (Dr, Italy) ; Ole Andersen (DTU Space, Denmark, Denmark)

Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_006

Abstract:
A continuous monitoring of sea level is particularly necessary along the coastal zones as these areas are the most exposed to flooding and storm surges that dramatically affect local economy and society. One of the most critical coastal zone to flooding is the coast of Bangladesh. In this project the annual sea level variability in the Bay of Bengal more specific the area of Bangladesh is studied with exploiting CryoSat-2 data from SARvatore online processing toolbox. The choice of the region is justified by the objective of comparing LRM and SAR modes, which have covered the same area for different time frames: LRM from 2010 to October 2012 and SAR from October 2010 to present. This research is also an opportunity for studying SIRAL's performance above coastal areas and also to compare with independent datasets like the ESA CCI product or AVISO data sets.

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Seaweed mapping along Karachi coast using geospatial techniques

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_007

Abstract:
Seaweed is an important coastal resource that has great economic potential due to its utilization in food, cosmetics and industrial products. They also play an important role in aquaculture and fish breeding. Habitat of many sea species rely on seaweeds for their shelter and food requirements. Seaweed resources are present along Pakistan coastal areas mainly around Karachi shoreline and there exists a potential market for seaweed in the country that is yet untapped.Seaweed resources in Pakistan are still unexplored and unmapped. The main purpose of this study is to map potential seaweed locations and to identify the environmental parameter which impact on seaweed growth in coastal waters of Karachi. The environmental parameters conducive for seaweed growth will also be assessed using satellite data.
LANDSAT 8 image of 30 meters resolution, WorldView-2 images of 2 meters multispectral and 0.5 meters panchromatic and MODIS (Moderate Resolution Imaging Spectroradiometer) daily composite of Sea Surface Temperature (SST) product of 250 meters resolutions are used in this study.
Images of calculated indices of Landsat 8 were analyzed. The newly seaweed index which was developed by using spectral signatures, shows better results as compared to NDVI and FAI. FAI is a good indicator to monitor green tide and algal blooms along the coast. PCA also showed good results that clearly discriminate between water and seaweed patches. Area estimation of seaweed cover has been performed using reclassification techniques. The same methods and techniques was repeated on high resolution Worldview -2 satellite data .WorldView-2 delivers 2 meters multispectral and 0.5 meter panchromatic images. Indices such as NDVI have been applied on worldview-2 imagery and spectral indices have also been developed by using spectral signatures. Image enhancement technique PCA is applied on the same image.

WorldView-2 coastal blue and yellow bands are helpful for bathymetry studies but Landsat 8 images have advantage of having shortwave infrared (SWIR) band which is ideal for identifying Phytoplankton bloom and seaweed studies. For assessment of environmental parameters, freely available MODIS daily SST product has been acquired. The final results were verified by field survey data that showed a good agreement between ground and satellite data.

The major environmental factors affecting seaweeds are light, temperature, salinity, current and nutrient availability. The presence of seawater (or at least brackish water) and sufficient light to enable photosynthesis are the main common requirements for seaweed species to survive. All types of seaweed use sunlight, carbon dioxide and water to create food.(FAO) report stated that a location be selected where there is good water movement or a fast water turnover, just fast enough that does not spoil farms. Current speed should be between 20 to 40 meters per minute. Region should be protected from very strong wave action, current and winds. For the spatial distributions of eddies which also effect the current and the transportation of floating seaweed, satellite altimetry data such as Sea surface height (SSH) can also be used for movement of seaweed patches. Another important Parameter for transportation of seaweed rafts is Sea Surface current (SSC). For Detailed Mapping of floating seaweed resources Satellite altimetry data such as Sea surface Height, Sea surface current (SSC) and Sea surface wind parameter will provide important contribution for coastal resources mapping and monitoring system. By comparing and overlaying SSH, SSC and wind data with Sea surface temperature we can identify preferable sites for Seaweed Farming along the Pakistan coastline which has not been studied yet.

Since the macro-habitats and benthic communities around Pakistan coastline have not yet been properly mapped and defined, this study will be a blueprint for protection of marine biodiversity and habitat of many sea species which rely on seaweeds for their food and shelter. Regular monitoring and mapping is important to regulate the growth of seaweeds and their dependent species to maintain their biological associations which will eventually maintain the equilibrium among various species in the marine ecosystem. As seaweed is also important for food and cosmetics industries so it can aid at governmental level to the stakeholders to design import/export policies that can ultimately help strengthen the country’s economy. Seaweed estimations are primarily important for fisherman, policy makers, food and cosmetics companies who are the actual stakeholders for addressing food and other economically security issues of the nation. In Pakistan very few people have studied Remote Sensing data in ocean field and none of the studies have been found on coastal resources mapping using Satellite altimetry data. Such studies, if done tactfully can help to promote Pakistan coastal resources.

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Identification of potential fishing zones using geo-spatial techniques

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_008

Abstract:
Fishery resources surveys using actual sampling and data collection methods require extensive ship time and sampling time. Informative data from satellite plays a vital role in fisheries application. Satellite Remote Sensing techniques can be used to detect fish aggregation just like visual fish identification ultimately these techniques can be used to predict the potential fishing zones by measuring the parameters which affect the distribution of fishes. Remote sensing is a time saving technique to locate fishery resources along the coast.
Pakistan has a continental shelf area of 50,270 km2 and coastline length of 1,120 km. Fishery is the most important economic activity in the villages and towns along the coast, and in most of the coastal villages and settlements it is the sole source of employment and income generation. Fishing by fishermen is done on the sole basis of repeated experiments and collection of information from other fishermen. Often they are in doubt about the location of potential fishing zones. This leads to waste of time and money,The main purpose of this study was to map potential fishing grounds by identifying various environmental parameters which impact fish aggregation along the Pakistan coastline.
The primary reason of this study is the fact that the fishing communities of Pakistan's coastal regions are extremely poor and lack knowledge of the modern tools and techniques that may be incorporated to enhance their yield and thus, improve their livelihood. Using geospatial techniques in order to accurately map the potential fishing zones based on sea surface temperature (SST) and chlorophyll –a content, in conjunction with active use of GPS navigation systems can go a long way in improving the output of the fishing community.
For this study, satellite data of sea surface temperature and chlorophyll-a content product of MODISAqua 250 meters, 8 day composite was used. Secondary field survey of Fish and Agriculture Organization (FAO) in month of October was used to assist the fish catch, SST and Chlorophyll-a concentration in Exclusive economic zone (EEZ) of Pakistan, The next step was to establish a GIS database of fish catch data along with the geographical coordinates of the catch spot.
After that MODIS SST and Chlorophyll-a concentration image of October 2010 was acquired, the product was converted to tiff format and projection applied for further processing. SST and chlorophyll-a images were reclassified using reclassification technique and then SST and chlorophyll-a values were extracted which were then used to overlay on fish catch data to extract best catch. GIS techniques such as suitability analysis was performed which helped to identify the potential fishing zones in the study area.
The next step was to acquire local fishermen knowledge by using questionnaires to verify the sites identified for their fish catch potential, after verification the methodology was applied on whole year (2010) comprising of 45 images of MODIS sensor. Final potential fishing grounds maps were generated using satellite and in-situ measurements.
Once we accurately identify the fishing areas with a high catch potential, it may be possible to estimate the overall fishing resources of the study area. This study will be an outline for local fisherman and marine fisheries department this will help them to monitor real time mapping of fish aggregation in Pakistan EEZ.
Oceanic frontal regions are often concentrated to marine fauna, which can be detected from altimeter derived data. Altimetry satellite data products merged from Jason-1, Envisat, ERS-2, GFO and T/P will be used to get sea surface height and geostrophic currents which are indicate flow structures such as upwelling, Eddies. The secondary indicators such as Eddy Kinetic Energy (EKE) and sea surface height anomaly (SSHA) plays an effective role on distribution of fish. Tracking such meso-scale features by satellite remote sensing technology can provide information on ocean circulations and corresponding biotic interaction with them. Sea Surface Height Anomaly (SSHA) and Eddy Kinetic Energy (EKE), derived from geostrophic velocities to identify other possible highly productive marine systems such as eddy fields, around fishing grounds.
Fish is important for food industries and national economy. Thus this study can facilitate the government, investors and stakeholders to design export policies that can eventually help the country economically while not depleting the marine resources. Remotely sensed data can therefore prove to be an economical and time saving method of carrying out analysis for maritime fishing activities. Such studies, if used intelligently can help assure food security to the nation and promote Pakistan's coastal resources in world market.Such studies have not been studied along Pakistan coast using ocean color and satellite altimetery data. So this study could help the fishermen of Pakistan by using PFZ maps.

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Tropical Cyclone Intensity Analysis Using Geospatial Techniques

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_009

Abstract:
Cyclone is defined as the circular motion of fluid in a closed area rotating in the same direction of an earth which is characterized by strong winds counter clockwise in the northern hemisphere and vice versa in the southern hemisphere. However, the main reason for tropical cyclone is the sea surface temperature, and low pressure and high precipitation rate in nearby areas. Depending upon the wind speed cyclone can be categorized into 5 major categories I.e. category-1, 2, 3, 4 and 5. Cyclone genesis, intensity, track and landfall have to be predicted with accuracy throughout the life cycle for a better disaster management in planning the mitigation efforts to save loss of human life and property. Upon the integration of in-situ measurements and satellite observations, the study of cyclones can be done. On the contrary, in-situ measurements pose the greatest limitation on studying the temporal and spatial coverage of cyclone. So therefore, satellite observations have been a key component of cyclone monitoring and research.Optical sensors on the geostationary satellites have been the only source of information for cyclone studies for a long period of time. It is well known that visible/infrared sensors cannot provide all the information required for monitoring cyclones. The development of advanced sensor technology and the availability of a variety of satellites orbiting the earth, it has been possible to use multi-spectral, multi-sensor combination to improve the understanding of physics of the tropical cyclones for a better and accurate forecasting. Thus a combination of visible and infrared data from the geostationary satellites and active and passive microwave data from atmospheric sounders, scatterometers and altimeters has improved the cyclone prediction capability skills.The main purpose of this study is to temporally study the effects of Cyclone Nanauk an Indus Delta (Wetland) and to know the relationship established among SST, SSH, wind vectors and wind speed. For this remote sensing plays a vital role in cyclone monitoring and assessing the damage ahead of cyclone.Study area was Indus Delta forms where River Indus is entering into the Arabian Sea, Pakistan. The total area of Indus Delta is about 41,440 km² (16,000 square miles) and is approximately 210 km across where it meets the sea.The vital ecological importance of this area is its being the largest arid mangrove forests in the world, as well as homes for many birds, fish and the Indus Dolphin.Information on the location, intensity and track of the cyclones were first confirmed from Pakistan Meteorological department. Then desktop work was started with the acquisition of Landsat 8 image then pre-processing was applied, that includes stacking of bands, digitizing Indus Deltaic region and latterly sub setting of this area. Now spectral indices were applied to enhance water and vegetation. Normalized Difference Vegetative Index (NDVI) and Modified Normalized Difference Water Index (MNDWI) were calculated. Unsupervised Classification of Images was performed on land covers on the basis of their inundated and non-inundated area extent. Inundated areas were all calculated in square kilometers (km2). This work needs to be extended with the data of sea surface temperature, sea surface height, wind vectors and wind speed so that the reason of tropical cyclone Nanauk can be studied and it will play a critical role in disaster management practices. With sea surface temperature, wind vectors and wind speed, cyclones emergence time can be ascertained and sea surface height can be useful to give wave height which will assist in early warning systems of cyclones by measuring and comparing it with the normal wave height. This is how this research can play its vital role in predicting the emergence of cyclones and other sea level anomalies. Therefore, along with other remote sensing and in-situ data, prediction and the severity of cyclones in terms of intensity of given storms can be forecasted. Or in other words, with this altimetry tracking, monitoring and measurement of the ocean surface including waves, winds can help in providing near real-time estimates of wave height and storm surge at landfall.Due to the non-availability of data , damage assessment in terms of inundation of sea water in Indus Delta was done prior to analyse SST, SSH, wind speed and wind directions. If the data would be provided, this study can definitely be a milestone for Pakistan in coastal altimetry's field. Altimetry provides proper understanding of the physics of the tropical cyclones for a better and accurate forecasting. Thus, this established study can help coastal related agencies to work more efficiently in the field of research and even for the welfare of the coastal community so that the risk of cyclones can be minimized.

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Passive tracer simulations of inflows into the Mid-Atlantic Bight & Gulf of Maine

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_010

Abstract:
This project details the use of passive tracer simulations within a ROMS model of the Mid-Atlantic Bight & Gulf of Maine to examine transport pathways and time scales. The model resolution, dynamics, and forcing are configured to simulate sea level variability observable in coastal altimetry across time scales from hours to years. Model skill for sea level variability is assessed with respect to coastal tide gauges. Complementing observational studies by H. Feng and D. Vandemark regarding water exchange in to and out of the Gulf of Maine, these model experiments serve to identify the circulatory pathways of Scotian Shelf water, slope inflow through the Northeast Channel, and outflow through the Great South Channel that might drive the observed salinity anomaly patterns. The model captures the intense vertical mixing of the region due to extreme tidal variability, which is a factor in dispersal of the passive tracers. Model boundary conditions are from the Mercator-Ocean daily average analyses with bias correction to the long-term mean; mesoscale variability is retained. Bias corrections are based on T & S from regional hydrographic climatology and long-term velocity observations from moorings and drifters that together constrain a data assimilative version of the model to derive a balanced Mean Dynamic Topography and mean climatological velocity analysis.

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Patterns of the Loop Current System and Regions of Sea Surface Height Variability in the Eastern Gulf of Mexico Revealed by Self-Organizing Maps

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_011

Abstract:
The Self-Organizing Map (SOM), an unsupervised learning neural network, is employed to extract patterns evinced by the Loop Current (LC) system and to identify regions of sea surface height (SSH) variability in the eastern Gulf of Mexico from 20+ years (1993 – 2015) of Ssalto/Duacs multi-mission altimetry data. Spatial patterns are characterized as different LC extensions (retracted to extending northwestward), different stages in the process of LC eddy shedding (anticyclonic eddy separating from the LC and propagating westward), and different patterns of cyclonic rings appearing around the LC. The temporal evolutions and the frequency of occurrences of these patterns are also obtained. Regions of differing SSH variations are also identified using the SOM. Along the general axis of the LC, SSH exhibits strong variability on time scales of 3 months to 2 years, with a phenomenon of energetic intraseasonal variations. In the more peripheral regions, the SSH has a dominant seasonal variation that also projects across the coastal ocean. The lack of energetic synoptic weather induced variations in the altimetry over the shelf calls for better altimetry products for coastal applications. Nonetheless, the SOM when applied to the existing altimetry data, through its ability to identify patterns of deep ocean interactions with the shelf slope, provides a powerful tool for diagnosing coastal ocean processes.
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Ice, Cloud and land Elevation Satellite-2 Mission Applications

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_012

Abstract:
The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) is the new space-based altimeter mission being developed for a target launch in 2017. ICESat-2 will continue the multi-year observations of the Earth's surface elevation established by ICESat (2003-2009) and will advance our knowledge on ice sheet elevation change, sea ice thickness, and other key observations for ecosystem, climate, and water applications. In an effort to provide insight into the range of potential uses of ICESat-2 observations and to help communicate the value and impact of mission products, ICESat-2 has an Applications program. We define 'applications' as innovative uses of mission data products in decision-making activities for societal benefit. The Applications program provides a framework for building a broad and well-defined user community during the prelaunch phases of the mission to maximize the use of data products after launch and to foster innovative use of the mission's measurements to inform actionable decisions that are relevant and of value to society. In this presentation, we will summarize the various initiatives of the ICESat-2 Applications program and discuss prelaunch research that explores the use of ICESat-2 for coastal applications. This includes Early Adopter work on the potential use of ICESat-2 for analysis of repeat altimetry of landfast sea ice and use of ICESat-2 to compute a more precise past and current ice volume discharge.

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The NASA Applied Sciences Program for the GRACE Satellite Missions

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_013

Abstract:
The GRACE mission has been accurately mapping variations in Earth's gravity field since its launch in 2002, where the major time-varying signal is due to redistribution of water mass within the Earth system. The principal dynamics causing redistribution include changes due to surface and deep currents in the ocean, runoff and ground water storage on land masses, exchanges between ice sheets or glaciers and the ocean, and variations of mass within Earth. While the scales of the GRACE observations are coarse when compared to nearly all other remote sensing technologies, when the data are used in combination with other complementary observations such as satellite altimetry, or with terrestrial hydrology and ocean models, it offers enhanced insights on earth hydrologic processes at higher spatial and temporal resolutions. These include ice sheet and glacier mass change monitoring, drought monitoring, flood risk assessment, regional water budget analysis, quantification of groundwater depletion and non-steric sea level rise.

In response to the next GRACE Follow-on (GRACE-FO) mission, scheduled to launch in 2017, the NASA Applied Sciences Program in Water Resources has developed a formalized GRACE Applications effort to encourage incorporation of GRACE and GRACE-FO and other satellite data into Earth System models for operational uses. The overarching purpose is to discover and demonstrate innovative uses and practical benefits of GRACE science data and technology. The goal is to promote the use of satellite data by public and private organizations to help support decision-making activities and services, and to enable them to envision possible applications as a way to increase the benefits of GRACE to our nation. The purpose of this presentation is to reach out to scientists, water resources engineers and planners, and other end users who are interested in exploring applied sciences uses of GRACE data.

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U.S. Regional Sea Level Indices from Water Level Stations and Satellite Altimetry

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_014

Abstract:
Water level stations record the motion of the sea surface relative to land. If the land is undergoing vertical land motion (VLM), that motion is included in the relative sea level record. In most regions VLM is steady in time, but can be highly variable in location. Nearby stations often have different relative sea level trends, even though the absolute sea level trend and the interdecadal and interannual variations are similar for long distances along a coastline.
NOAA's Center for Operational Oceanographic Products and Services (CO-OPS) has developed regional sea level indices for coastal regions of the U.S. to represent a region's absolute sea level trend and variability without the locally-variable VLM. The U.S. coast has been divided into regions in which the interdecadal and interannual variations are highly correlated between stations. An annual average sea surface height has also been derived for each of the regions from satellite altimetry data by NOAA's Laboratory for Satellite Altimetry. The averaged altimetry data for the offshore regions are compared with the regional indices derived from coastal water level stations.
The National Climate Assessment (NCA) has proposed four global sea level rise scenarios for the 21st century. The lowest scenario is a continuation of the assumed 20th century trend of 1.7 mm/yr. The other three scenarios reach specified 2100 levels via quadratic curves, implying a constant acceleration of the global trend. Comparison of the regional indices with the NCA global sea level rise scenarios will indicate whether a region is beginning to follow a particular scenario. This information should prove to be vitally important for coastal planners over the next several decades. In FY16, CO-OPS will deliver an annually-updated web-based product to track the regional indices versus the NCA sea level rise scenarios.

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Regional Altimeter Data for Brazilian Applications

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_015

Abstract:
Through a regional altimetry project funded by the Brazilian Navy and PETROBRAS and called ATOBA, a dedicated processing of the 20 Hz data over the Brazilian Current system has been set up and HR regional altimetry products are now operationally delivered to the REMO teams in addition to more classical 1Hz regional altimeter products.Through a regional altimetry project funded by the Brazilian Navy and PETROBRAS and called ATOBA, a dedicated processing of the 20 Hz data over the Brazilian Current system has been set up and HR regional altimetry products are now operationally delivered to the REMO teams in addition to more classical 1Hz regional altimeter products.
This multi-mission level3 HR processing includes a dynamic 20 Hz data selection, tuned to take benefit of more measurements, a fitted spatial filtering based on a regional spectral analysis and 5Hz sub-sampling. It allows to retrieving more accurately the oceanic structures compared to the standard altimeter processing confirming that to reach small spatial scales, one important issue is to work with the native 20 Hz sampling of altimetry data rather than the traditional use o f 1 Hz.
Regional and coastal ocean analyses using 1Hz and 5Hz altimeter data are exhibited in this paper. The use of these altimetry data into the REMO models is also presented.

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Analysis of changes in coastal sea level from the new SL_cci altimetry product and tide gauge data

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Session: Applications of coastal altimetry data
Presentation type: Poster
Poster number: APP_016

Abstract:
The volume of the global oceans is a very sensitive indicator of climate change as it essentially reflects heat uptake by the ocean and mass addition from ice. Conversely, the link between regional sea level changes and climate change is not, in general, so straightforward because the former are the result of the interplay among different forcing mechanisms acting on a wide range of temporal and spatial scales that lead to regional changes usually differing greatly from the global mean. In addition, because the Earth's crust is also changing over time, the sea level relative to land, which is in fact the relevant quantity for coastal impacts, can change significantly as a result, even in the absence of any other forcing factors. Understanding regional and relative sea level at the coast is, therefore, crucial for improvement of future sea level change projections and thus for reaching informed decisions on coastal and adaptation planning. Here we assess the performance of the new satellite altimetry product from the Sea Level Climate Change Initiative (SL_cci) project over the period 1993-2013. We also use the new product in combination with tide gauge data to investigate relative sea level changes at a number of carefully selected tide gauge stations along the western European coast and the southeastern coast of Australia, decomposing such changes into their different long-term components, including the seasonal cycle, intra-annual and inter-annual variability, and the long-term trend. By noting that the coastal sea level from altimetry and the tide gauges only coincides if the land at the coast has no vertical motion, one can in principle derive rates of vertical land motion (VLM) at the tide gauge stations from the difference between the two types of measurements. We explore the feasibility of this approach by comparing to Global Positioning System (GPS) data where available and by conducting a realistic assessment of uncertainties. For this approach we consider the SL_cci grid element where the tide gauge is located (or closer to it). In terms of the annual cycle, we find a good agreement between the SL_cci data and the tide gauges, with differences smaller than 1.6 cm and 23 days in all cases for the amplitude and the phase offset, respectively. The correlation between the two data sets for detrended and deseasoned (and atmospherically-corrected) time series is statistically significant at all stations, with values ranging from 0.54 to 0.87. We find that large uncertainty in the trend estimates of both data sets prevents the computation of VLM rates at most stations. Finally we discuss how this investigation may be extended and possibly improved by using data specially reprocessed for the coastal environment, such as those from the ALES retracker that will be available from Phase 2 of SL_cci.

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Retrieval of coastal sea surface height from along-track continuous AltiKa data

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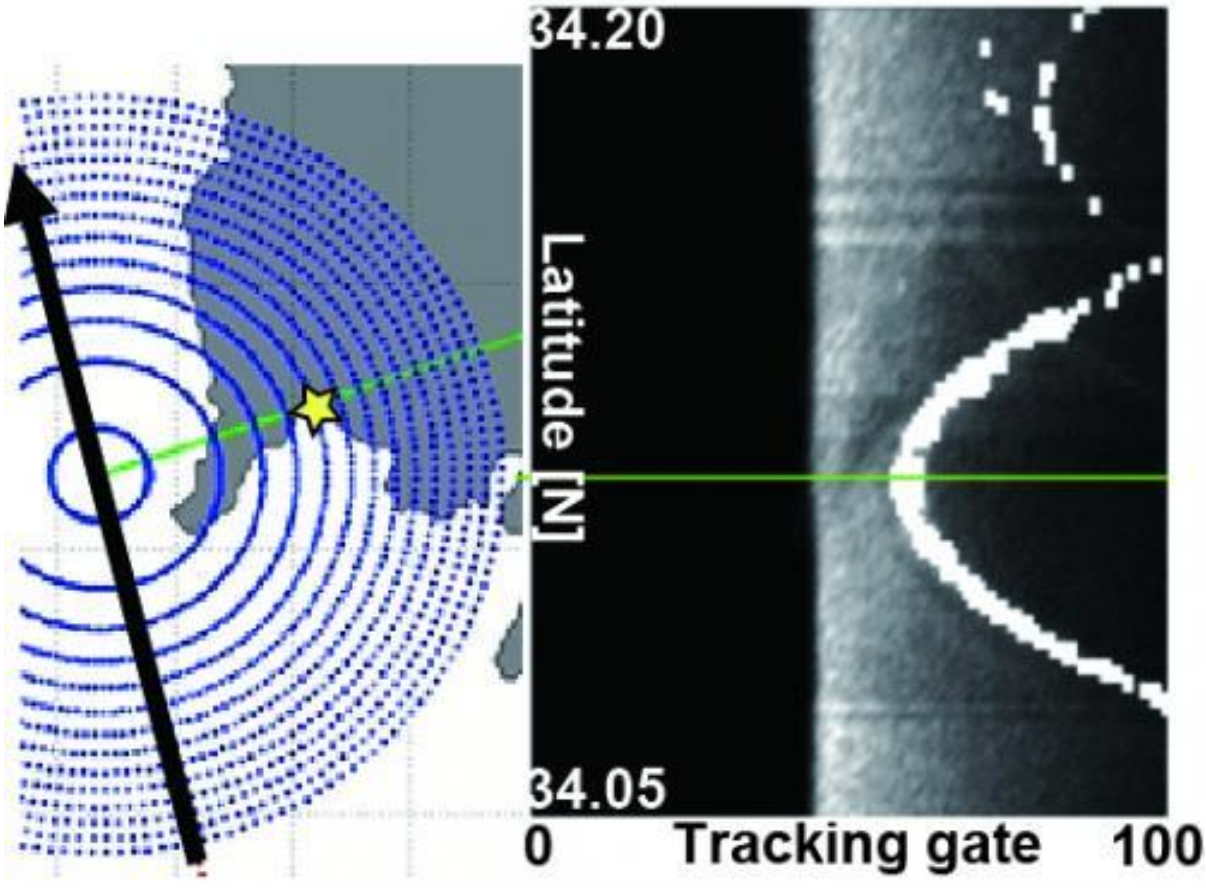
Session: Technical issues in coastal altimetry
Presentation type: Poster
Poster number: TEC_001

Abstract:
Waveforms of satellite altimeters are often contaminated in coastal areas by strong radar reflection from calm water in semi-closed bays or weak reflection from lands. Several algorithms have been proposed to retrieve the sea surface height (SSH) avoiding these contamination in a waveform, but such retrievals are independent for each single waveform and waveforms of the adjacent points have never been referred. In this study, along-track AltiKa 40 Hz data near Tsushima Island, Japan, are processed at once for each cycle to retrieve the coastal SSH accounting contamination in waveforms of the adjacent points. Since the reflection from a point source results in a parabolic shape in an echogram with latitude versus altimeter tracking gate, extremely strong echo values with parabolic shapes are first masked. For each tracking gate at each point, lost echo by land is roughly compensated based on the ratio of the land area in the altimeter's footprint ring, then the Brown model is fitted to each modified waveform. The retrieved SSH shows reasonable values with no abrupt changes along tracks.



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Towed and static GPS buoys for CAL/VAL and SSH

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Session: Technical issues in coastal altimetry
Presentation type: Poster
Poster number: TEC_002

Abstract:
The observation of the sea level variations and the ocean sea surface topography calibration is achieved thanks to a set of specific instruments developed for these missions by Technical Division of INSU (National Institute of Universe Science) in Brest (France).

We present a static and a towed GPS buoys dedicated to altimetric
satellites calibration (CAL/VAL) and absolute sea level determination (SSH).

These developments have been supported by FOAM (From Ocean to inland waters Altimetry Monitoring), a project funded by CNES that aims to perform calibration and validation of the altimetric measurement systems over both ocean and inland water. Continuous monitoring over ocean is performed in operational sites like Corsica that is equipped with tide recorders and permanent GPS stations for in situ measurements.

These systems consist of a geodetic GPS on dedicated structures for static and towed use.
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Classification of altimeter Waveforms for an Improved Estimation of Water Level Time Series over Inland Water

Christian Schwatke (DGFI-TUM, Deutschland) ; Denise Dettmering (DGFI-TUM, Germany)

Session: Technical issues in coastal altimetry
Presentation type: Poster
Poster number: TEC_003

Abstract:
The estimation of water level time series over smaller inland water is a challenging task due to the large footprint of satellite radar altimeters of up to several kilometers which may lead to a contamination of the altimeter waveform by land. Also ice coverage of lakes influences the altimeter echos and decreases the measurement accuracy. The waveform shapes vary between ocean-like shapes in the center of larger lakes and single peak waveforms for smaller rivers. There is a steady and uniform transition of the waveform shape at the water's edges.
An identification of disturbed altimeter observations can be used to reject these measurements or to apply a class-dependent handling such as the usage of special retracking algorithms in order to achieve more realistic ranges and finally an improved water level time series of the investigated inland water body.
In this poster, an approach for the classification of altimeter waveform is presented which separates different waveform shapes into different classes such as ocean-like, peaky, etc. Hereby, statistical criteria such as kurtosis, skewness, etc. are used as features. The reliability of the classification system is validated by using simulated waveforms of different shapes. In addition, altimeter waveforms from the Envisat mission (2002-2010) serve as input data for the classification. Results are presented for different lakes and rivers. In a first step, the resulting water level time series are computed by using only one single waveform class per target. A validation based on in-situ data demonstrates the impact and need of the classification.
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Analysis of Cryosat-2 altimeter waveforms for the detection and characterization of ship targets

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Session: Technical issues in coastal altimetry
Presentation type: Poster
Poster number: TEC_004

Abstract:
The detection of non-ocean scatterers over the sea surface by using pulse-limited satellite altimeters involves a series of challenging targets, such as icebergs, lighthouses and ships, which have been investigated in the literature. In particular, past works focused on the hyperbolic features observed in the thermal noise area of the received waveforms, in order to detect the presence of such non-ocean targets.
In this work, we exploit the capabilities of Cryosat-2 SIRAL instrument (operating in SAR mode) for the detection and characterization of ships. In particular, we propose a suitable metric for the discrimination of ships and investigate the possibility to estimate some geometric features of the detected vessels from the echoes returned by the altimeter.
Thus, the possibility to extract further information, in addition to the mere presence of eventual ship targets, is discussed in this work. The presented approach offers the opportunity to: i) study the compatibility between the detected target(s) and the known ship traffic, by using the Automatic Identification System (AIS) data; ii) resolve ambiguities among multiple targets, by investigating their compatibility with the estimated geometry.
Ship traffic statistics, as introduced by the recent literature, may take benefit from the method described in this work, providing a contribution to improve the overall precision of such statistics. In particular the next Sentinel-3 mission, which will be soon in operation, will provide a constellation with global SAR coverage and free accessibility to the data, with a potential enhancement to the estimation of the number and characteristics of the ships with respect to past literature approaches.

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Use of satellite altimetry data in the Rio de la Plata estuary

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Session: Technical issues in coastal altimetry
Presentation type: Poster
Poster number: TEC_005

Abstract:
The La Plata River Estuary is located in the eastern coast of South America at approximately 35ºS. This extensive and shallow region is one of the largest estuaries of the world. The estuary is formed by the confluence of the Paraná and Uruguay rivers that generate a mean discharge of about 23000 m3/sec. Previous studies have shown that the estuarine circulation is vulnerable to the river run-off and wind variability. In particular, changes in wind seem to be the main forcing of the river circulation, especially at sub-annual scales. The objective of this work is to analyze the descending pass #0964 and ascending pass # 0493 of ENVISAT RA2 (18 Hz) in this region. We evaluate the performance of each correction applied to the altimetry data. Results show that both passes are sensible to the different retrackings. ICE1 recover more data in the proximity of the coast in pass #0493 and pass #0964. We applied a criterion to remove outliers (-/+2 standard deviation) keeping the nominal position along the track with less that 20% of missing values in both passes. As a result, correlation coefficients between altimetry data and a tide gauge deployed in the study area are 0.61 (95%CL) and 0.87 (95%CL) for pass #0493 and #0964, respectively when no tide and atmospheric corrections are considered. We also analyze the dynamic atmospheric correction obtained with a global barotropic model (MOG2D: Modèle aux Ondes de Gravitè 2-Dimensions) and two regional barotropic models (HamSOM: Hamburg Shelf Ocean Model, SMARA). Results show that the global model underestimates the variability of the sea level response to pressure and wind forcing in comparison with the regional models. The ENVISAT RA2 data will be corrected by the atmospheric effect with the best model. Then we will examine the capabilities of the altimetry data to measure the sea level variability due to freshwater discharges from the main tributaries of Río de la Plata.

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