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D3200 Data Set User Manual

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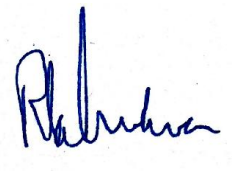
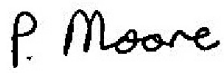
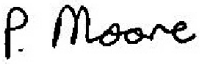
Author: Rob Balmbra

Signature: 

Author: Philip Moore

Signature: 

Authorised by: Philip Moore

Signature: 

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Abstract

This report presents a Data Set User Manual. This is part of WP3000 which is to create a repository of relevant datasets for use in the Land and Inland Water applications theme. D3100 contains the corresponding dataset. This document will be updated as CRUCIAL evolves.

This present document outlines the following key data sets:

- Cryosat -2 LRM data
- Cryostat-2 SAR L1B data
- Cryostat-2 SAR L1A data
- Cryostat-2 SARin L1A data
- Geophysical correction data
- ACE2 and other GDEM data
- Jason-2 validation data
- River mask data
- In-situ river and lake data

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1. Introduction

1.1 Scope

Cryosat-2 was launched on 8 April 2010. It follow on from previous ESA earth orbiting satellite radar altimeters (e.g. ERS2 and ENVISAT) that have been used for land surface applications including mapping (Berry et al, 2010; Smith & Berry 2011) and measurement of river and lake systems (Berry et al. 2009; Wheeler et al., 2010). Cryosat-2's primary instrument is SIRAL (SAR / Interferometric Radar Altimeter), which uses radar to determine and monitor the spacecraft's altitude. Although Cryosat-2 primary aim is to measure sea ice and ice sheets it can provide valuable data over the rest of the earth surface. SIRAL operates in one of three modes, depending on where (above the Earth's surface) CryoSat-2 is flying. The three modes are: the conventional altimeter mode or Low resolution Mode (LRM), Synthetic Aperture Radar(SAR) and Interferometric Synthetic Aperture Radar(SARIN). CryoSat-2's has a low-earth orbit and is not Sun-synchronous, it has a period of 100 minutes. The Cryosat-2 mission is the first to operate a SAR mode Altimeter.

This study is investigating innovative land and water applications from Cryosat-2 with a forward-look component to the future Sentinel-3 mission. As such it is important to bring all the relevant datasets for use in the Land and Inland Water applications theme together into a single repository and to define the data needed within CRUCIAL to develop and validate the new algorithms and products. This is the aim of WP3000. This deliverable D3200 presents a Data Set User Manual, D3100 contains the corresponding dataset. Data sets include CryoSat-2 data, auxiliary data, in-situ data and other EO satellites data. This document will be updated as CRUCIAL evolves.

1.2 Abbreviations and Acronyms

Abbreviation	Meaning
ACE2	Altimeter corrected elevations 2 (digital elevation model)
CRUCIAL	CRyosat2 sUCcess over Inland water And Land
DTU	Danish Technical University
EO	Earth Observatory
ERS2	European Remote Sensing satellite 2
ENVISAT	Environmental Satellite
ESA	European Space Agency
FBR	Full Bit Rate
GDEMS	Global Digital Elevation models
L1A	Level 1A
L1B	Level 1B
LRM	Low Resolution Mode
JASON-2	US/French Altimeter Satellite
NCL	Newcastle University
RA	Radar Altimeter
SAR	Synthetic Aperture Radar mode of Cryosat-2 SIRAL
SARIN	Interferometric Synthetic Aperture Radar mode of Cryosat-2 SIRAL
Sentinel-3	ESA Earth Observation satellite mission
SIRAL	SAR Interferometric Radar Altimeter

1.3 References

Berry, P.A.M., Wheeler, J., & Smith, R.G., (2009). Inland Water Monitoring from Multi-mission Satellite Radar Altimetry - Current Status and Future capability. The Proceedings of the Earth Observation and Water Cycle Science; 18th-20th November, ESA ESRIN, Frascati, Italy; ISBN 978-92-9221-238-4.

Berry, P.A.M., Smith, R.G., Witheridge, S. & Wheeler, J., (2010). Global Inland water monitoring from Satellite Radar Altimetry - a glimpse into the future. Proceedings of the ESA Living Planet Symposium, Bergen, Norway, 27th June - 2nd July.

Smith R.G. & Berry, P.A.M., (2011). Evaluation of the differences between the SRTM and Satellite Radar Altimetry height measurements and the approach taken for the ACE2 GDEM in areas of large disagreement, Journal of Environmental Monitoring, 2011, 13, 1646 – 1652

Wheeler,J. , Berry, P.A.M., Smith, R.G., & Benveniste, J., (2010). The ESA Near-Real-Time River & Lake Processor. ESA Living Planet Symposium, Bergen, Norway, 27th June - 2nd July.

2. Cryosat-2 data

In this section, a general overview of the different Cryosat-2 data sets to be used is this work is given. River masks derived as part of the ESA/ESRIN "Rivers and Lakes" contract are being reassessed for accuracy and compared against enhanced masks based on the rivers embedded within the gmt software. Within subsequent tables data is denoted as Input or Output; the former is data downloaded from other sites etc while Output denotes a valued added product derived within the CRUCIAL project.

2.1 Cryosat-2 LRM data

Altimetric heights in LRM mode will be used over certain inland water targets. The data utilized will be regional to cover areas in LRM mode specified in Table 1, particularly lakes Tana and Malawi) and the Mekong. Cryosat-2 LRM data is down-loaded to Newcastle and stored on our Raid Server but is not available in the repository. As shown in Table 1 LRM data is L1B.

2.2 Cryosat-2 SAR Level 1B data

CRUCIAL, with an objective to derive heights from Cryosat-2 SAR data over inland waters, first utilises the L1B (Kiruna) data product that contains parameters computed at level-1 (range, sigma_0 scaling factor and waveforms) with all instrumental corrections applied. L1B data products will be used with improved retrackers adapted to SAR waveforms. The data utilized will be regional to cover areas in SAR mode specified in Table 1. Cryosat-2 SAR L1B data is down-loaded to Newcastle and stored on our Raid Server but is not available in the repository.

2.3 Cryosat-2 SAR FBR (L1A) data

SAR L1A FBR data will be processed to derive data at high temporal sampling as required for inland water studies. The data utilized will be regional to cover areas in SAR mode with emphasis on the Amazon. SAR L1A data has not been downloaded except for two passes (one oceanic, one over the Amazon) used for preliminary analysis. SAR L1A data will need to be requested in the near future and stored on our Raid Server but will not be available in the repository.

2.4 Cryosat-2 SAR-in FBR (L1A) data

Some analysis of SARin data will be undertaken. It is expected that the SAR-in data will be over the Amazon. No SAR-in L1A data has been downloaded or requested. It is not intended at this stage to utilize L1B or L2 data.

Table 1 Cryosat-2 data sets

Theme	Product	Input (i) or Output (o)	Responsible	Data Producer	Area	Time Period	Time Frame	Supporting URLs
River Masks		Input Output	NCL	DMU NCL	Amazon, Mekong, Brahmaputra, + others Selected Locations	N/A	N/A	http://gmt.soest.hawaii.edu/
Inland water heights	SAR L1B	I/O	NCL	ESA	Amazon Basin	CS2 mission	1 yr?	http://www.esa.int/ESA
	SAR L1B	I/O	NCL	ESA	Mekong	CS2 mission	1 yr?	
	SAR L1B	I/O	NCL	ESA	Brahmaputra	CS2 mission	2 yr?	
	SAR L1B	I/O	NCL	ESA	Zambesi	CS2 mission	1 mth?	
	LRM L1B	I/O	NCL	ESA	Mekong + others	CS2 mission	1 yr?	
	SAR FBR	I/O	NCL	ESA	Amazon + Mekong	CS2 mission	Snapshot of seasonal cycle?	
	SARin FBR	I/O	NCL	ESA	Amazon	CS2 mission	Max/min of seasonal cycle?	

Note: Cryosat-2 L1B data is not stored in the repository. I/O denotes input of altimetric waveform data and output of inland water height.

3 Geophysical Corrections

Table 2 Geophysical Corrections

Product	Responsible	Input or Output	Data Producer	Data Set	Supporting URLs + comments
Orbit		Input	(on data records)		DORIS precise orbit
Dry Tropo		Input	Meteo France ECMWF atmos pressure files (on data records)		
Wet Tropo (1)		Input	Meteo France ECMWF model (on data records)		
Wet Tropo (2)	NCL	Output	Newcastle (GPS based total zenith delay)	GPS RINEX	http://www.ibge.gov.br/home/geociencias/geodesia/rbmc/rbmc_est.php
Wet Tropo (3)	NCL	Output	Newcastle	MODIS	http://modis.gsfc.nasa.gov/
Wet Tropo (4)		Input	University of Porto		*http://www.coastalt.eu/files/konstanzworkshop14/poster/p13_Poster8CAWS_EkoYH_23-24_Oct_2014.pdf*
Iono		Input	GIM (on data records)		
Solid Earth tides		Input	(on data records)		Standard software also available
Geoid	NCL	Output	NGA	EGM2008	http://earth-info.nga.mil/GandG/wgs84/gravitymod/egm2008/

The wet tropospheric correction applied to inland water heights over the Amazon Basin will be derived from three independent approaches. These include the ECMWF Numerical Weather Prediction Model (the default correction), GPS derived wet tropospheric corrections from sites across the Amazon using either the GIPSY-OASIS or Bernese GNSS geodetic software packages and, when available, MODIS based water vapour. Consideration will also be given to the University of Porto corrections if available over the areas under consideration.

At Sept 2014 no analysis of the wet tropospheric correction has as yet been undertaken. Further, data is not included in the depository as all is 3rd party and subject to conditions of usage.

Inland water heights will be referenced to the WGS84 reference ellipsoid as realized by the ITRF2008 reference frame of the DORIS station coordinates. Orthometric heights (i.e. heights above mean sea-level) are derived by subtracting the geoid reference to the same ellipsoid from the ellipsoidal inland water heights. The geoid model applied is EGM2008. For convenience the data depository contains the required EGM2008 data sets, FORTRAN code to output the heights based on scattered lat/lon input through INPUT.DAT. A simple program getgrid.f is also in the depository for deriving the input file on a 1' by 1' lat/lon grid. Note that the rectangular box is hardcoded and will need editing for other areas.

4 Land Surface Topography

4.1 ACE2 and other Global Digital Elevation Models (GDEMs)

GDEMs are required to estimate river slopes. Data is 3rd party.

Product	Responsible	Data Producer	Data Set	Supporting URLs
GDEMS	NCL	DMU	ACE2	http://tethys.eaprs.cse.dmu.ac.uk/ACE2/docs/ACE2_userguide.pdf
	NCL	JPL	ASTER	http://asterweb.jpl.nasa.gov/gdem.asp
	NCL	Curtin University	Earth2012	http://geodesy.curtin.edu.au/research/models/Earth2012/
	NCL DTU	JPL	SRTM	http://www2.jpl.nasa.gov/srtm/

5 Validation Data

Product	Responsible	Data Producer	Area	Time Period	Supporting URLs
Jason2 Waveforms and virtual stage data	NCL	Newcastle LEGOS USDA	Amazon Lake Tana Lake Malawi	To overlap Cryosat2 data	http://tethys.eaprs.cse.dmu.ac.uk/RiverLake/shared/main http://www.legos.obs-mip.fr/soa/hydrologie/hydroweb/ http://www.pecad.fas.usda.gov/cropexplorer/global_reservoir/Default.aspx
ERS2/ENVISAT Waveforms and virtual stage data	NCL DTU	ESA River and Lakes	Zambezi Brahmaputra Amazon Mekong + others		http://tethys.eaprs.cse.dmu.ac.uk/RiverLake/shared/main
River gauge (height + discharge)	NCL	MRC ORE HYBAM	Mekong Amazon	2010-2013	http://portal.mrcmekong.org/ http://www.ore-hybam.org/index.php/eng/Data/Station-Access-Maps/TSS-reference-network
	DTU	GRDC DWA	Zambesi	Before 2009	http://www.bafg.de/GRDC/EN/01_GRDC/13_dtbse/database_node.html
River gauge (height, ADCPt + discharge), Mask, historical altimetry	DTU	Various	Brahmaputra	Before 2009	See section 5.2
River gauge ADCP	NCL	ORE HYBAM	Amazon	2000-2011	http://www.ore-hybam.org/index.php/eng/Data/Station-Access-Maps/TSS-reference-network
	DTU	DWA	Zambesi		See section 5.2

EO data (Precipitation etc)	DTU		Brahmaputra; Zambezi		http://trmm.gsfc.nasa.gov/

Newcastle has archives of ENVISAT and Jason-2 waveform data for cross-calibration against Cryosat-2 heights. Due to the size the data is not stored in the repository.

5.1 Mekong

For the Mekong river in-situ water level data is available to validate Cryosat-2 data. Currently hourly in-situ data has been obtained for both Nakhon Phanom and Vientiane for the period from 10/8/2010 to 20/11/2012 (Figure 1). These show the typical annual cycle in the Mekong with low flows and water levels during the dry season (November – May) and high flows and water levels in the wet season (June - October). Due to data restrictions this data is available only to NCL CRUCIAL consortium members. The data for the rest of 2012 and most of 2013 is still not available but will be available for download within the next six months.

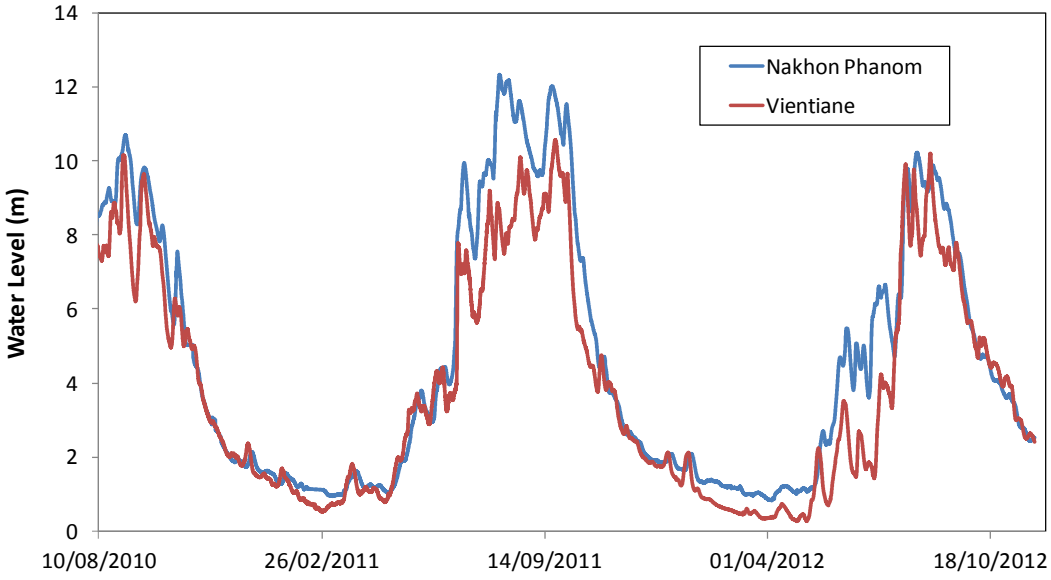

Figure 1 Measured in-situ water level data for Nakhon Phanom and Vientiane on the Mekong river.

Figure 2 and 3 show the in-situ stage and discharge for the gauge at Odipos on the Amazon River. This shows the data from 1/1/2009 to 1/1/2014. The annual variation between the wet and the dry seasons is clearly visible.

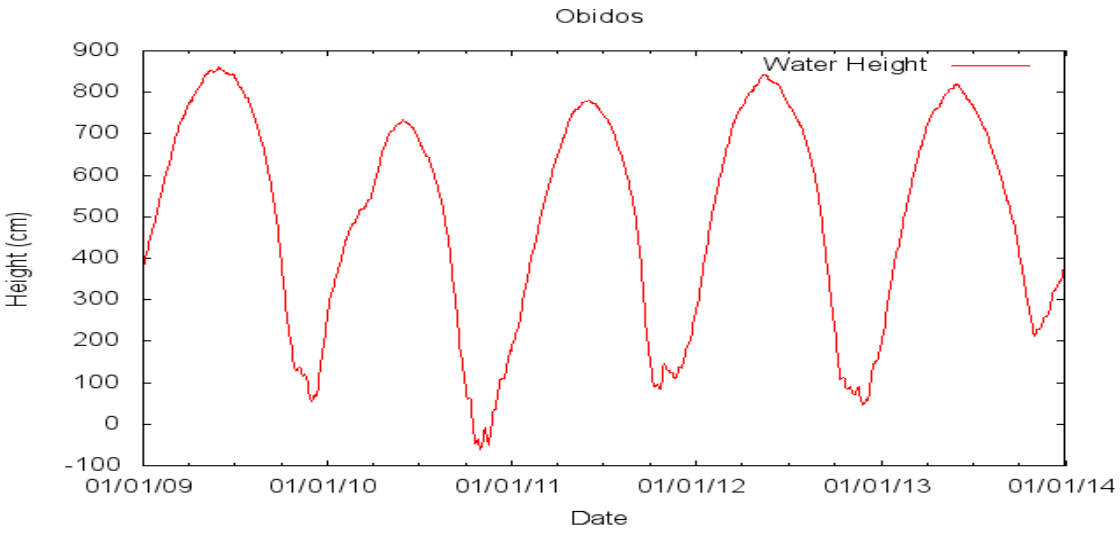

Figure 2 Stage (water height) at Obidos on the Amazonas

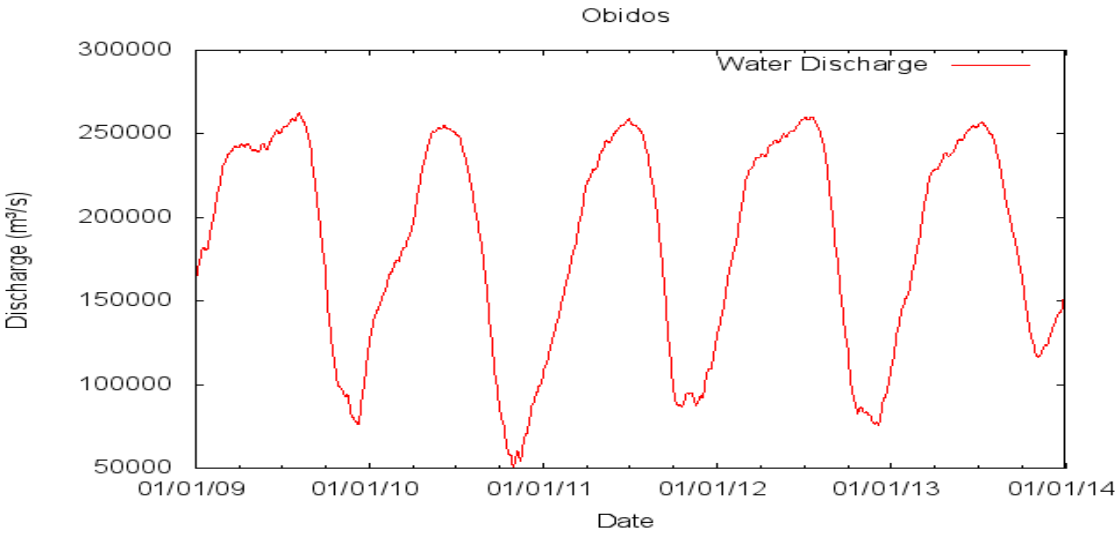

Figure 3 Discharge at Obidos on the Amazonas

5.2 Brahmaputra Data

DTU has access to Brahmaputra data that has been placed in the CRUCIAL WP3000 repository

NOTE: Further data on the Brahmaputra is available, but usually not accessible to the public. For example DTU Environment/DHI have access to some in-situ cross section profiles of the Brahmaputra in the Assam valley. Historical discharge data at Bahadurabad (daily from 1956 - 2000) can be found at http://cfab.eas.gatech.edu/Raingage/Q_Bahadurabad.txt.

Under the altimetry subdirectory for the Brahmaputra the depository holhs

- Satellite altimetry data from the River & Lake project:
- .shp file for locations of virtual stations
- .rlh files for actual timeseries
- .mat file with data of actual timeseries

River masks are stored under ./AssamValley_RiverMask

- River masks for the Brahmaputra, Assam valley as GeoTIFF. WGS 1984. Based on Landsat 8 NDVI 32-day composites imagery. Water is defined where NDVI < 0. Resolution: 30 metres
- brah1314_12.zip: Areas are marked as water that are covered with water in 12 out of 12 "months" (32-day composites) from April 2013 to March 2014
- brah1314_8.zip: Areas are marked as water that are covered with water in at least 8 out of 12 "months" (32-day composites) from April 2013 to March 2014
- ./GIS /BrahmaBasinRivers_l .shp file (polyline) with river lines, derived from SRTM.

Brahmaputra and some tributaries (WGS 1984)

- . /SRTM SRTM version 4.1 data. GeoTIFF, WGS 1984.

Discharge and rating curve

- ./insitu /Bahadurbad Bahadurabad.xlsx: Discharge data at Bahadurabad (3-hourly from 2002 to 2007), from Bangladesh Water Development Board (BWDB)
- /Bahadurabad_RatingCurves RatingCurves_Brahma.xlsx: Rating curves for Bahadurabad, based on Mirza, 2003. The article can be found in the same folder /Bahadurabad_CFAN
- Monsoon season discharge data at Bahadurabad, from 2004 to 2010. BrahmaputraRT_TechnicalReport.pdf: Report describes the extraction of data. See p. 2 for details. Q_Bahadurabad2004-2010.mat: The respective data.
    - Qnew and Tnew: only data extracted as described in the report, p. 2.
    - Qnew_withbase and Tnew_withbase: same data, with baseflow added from average values from 1950-2000 (as described in the report p. 11)
- /SAF_Tibet Discharge data at Nuxia and Nugesha, at the Brahmaputra in Tibet. 12-hourly values for the monsoon seasons 2005 to 2007. From the SAF Flood Information System: http://southasianfloods.icimod.org/saf/reports/ Including .shp file for stations locations

6. Summary

This report presents a Data Set User Manual for accomplish the repository of relevant datasets for use in the Land and Inland Water applications theme. D3100 contains the corresponding dataset. This document will be updated as CRUCIAL evolves and derivatives of 3rd party data added if appropriate.