



# CTOH altimetry products (L1 to L4) for Ocean, Ice and Continental Surfaces

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Established in 1989, the **Center for Topographic studies of the Oceans and Hydrosphere (CTOH)** is a French national observation service dedicated to satellite altimetry. The main objective of the CTOH is to develop and maintain altimetric data bases with homogeneous, up-to-date corrections for the long term monitoring of sea level, lake and river levels, and the cryosphere for climate studies. The CTOH aids scientific users in the development of new altimetric products and applications, and works in close relation with the CNES and ESA.



"In order to improve the transfer of expertise between the CTOH research service and the operational service at AVISO/CNES, a joint project has been conducted over the past years with the CNES. A common web portal for altimetry (AVISO +), based on the operational AVISO service and the research and development CTOH service is opened since February 2014 (<http://www.aviso.altimetry.fr/en/home.html>)."

## Database: L1 & L2 products

### Along-Track L1/L2 GDR Products

- Topex/Poseidon 1992-2005
- GFO 1998-2008
- ERS2 Reaper 1995-2003
- ERS2 CTOH 1995-2003
- Envisat v.2.1 2002-2012
- Jason-1, 1n and 1g v.E 2002-2013
- Jason-2 v.D 2008-now
- Jason-3 v.D 2016-now
- Saral 2013-now
- Cryosat2 ESA v.B 2010-2015 (LRM,SAR,SAR-IN)
- Cryosat2 ESA v.C 2010-now (LRM,SAR,SAR-IN)
- Cryosat2 CPP v.14 2012-2015 (LRM,SAR)
- Sentinel3A land and water 06/2016-now

### Corrections added to all GDR databases by CTOH :

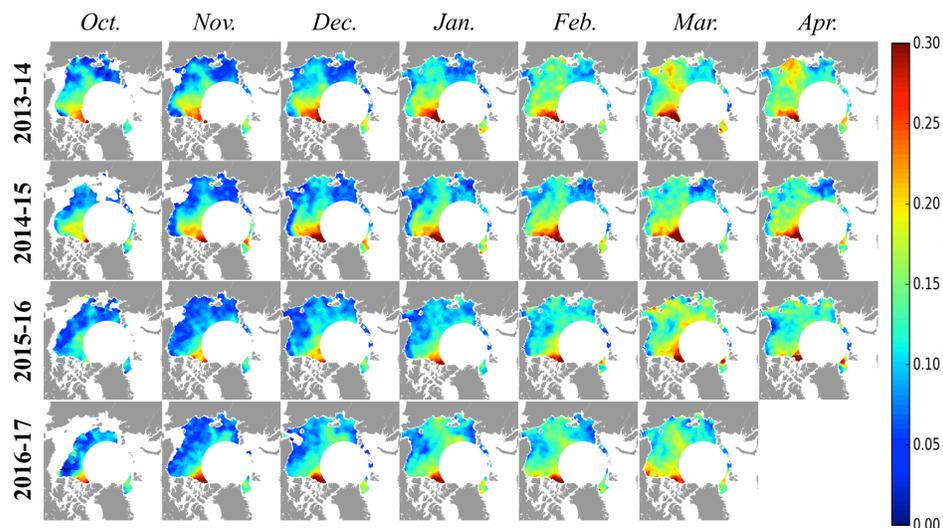
- Ionospheric correction (NIC08 and GIM)
- Wet Tropo (CLS 01, Brown 2010, GPD+)
- Tide models (FES04, GOT47, GOT48, FES14)
- Inverse barometer (ECMWF, MOG2D)
- Mean Dynamic Topo (RIO05, RIO09)
- Mean Sea Surface: (CNES\_11, CNES\_15, DTU15)
- Geoids (EGM08, GOCE10, EIGEN\_6C3, EIGEN\_6C4d)
- Bathymetry (Gridone, gebco14)
- Dist. to nearest coast (Leuliette, Stumpf, GSHHS)
- Dry Troposphere
- Doppler Slope

Both 1 Hz and 18-20-40 Hz data available over all oceanic and continental surfaces.  
All in netcdf format (except T/P and GFO).

## Snow Depth from Ka/Ku Altimetry

### Snow Depth over Arctic Sea Ice 2013-2017

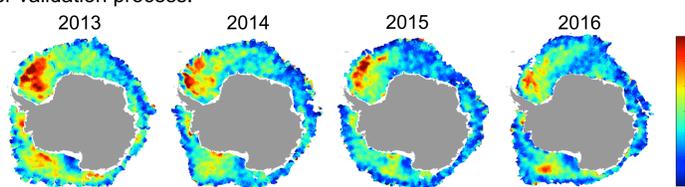
Using the bi-frequency methodology presented in [Guerreiro et al 2016] we have established the following monthly snow depth maps, covering the common flight period between Saral/AltiKa and CryoSat-2. These maps have been validated with Operation Ice Bridge airborne snow radar.



Snow depth maps for the 7 "winter" months over Arctic sea ice obtained from Ka/Ku radar altimeters on board Saral and CryoSat-2.

### Snow Depth over Austral Sea Ice 2013-2016

The same method has been applied to retrieve the snow depth over Austral sea ice. This dataset is currently under validation process.



The Arctic and Antarctic Snow Depth datasets will be provided on the CTOH website (<http://ctoh.legos.obs-mip.fr>) by the end of 2018 in NetCDF format. The resolution of the monthly maps is of 12,5 x 12,5 km<sup>2</sup>. For more information, see the poster 368 "Snow Depth on Sea Ice for 2013-2017 Arctic Winters from CryoSat-2 and SARAL Inter-Comparison".

**Reference:** Guerreiro, K., Fleury, S., Zakharova, E., Kouraev, A., Rémy, F., & Maisongrande, P. (2017). Comparison of CryoSat-2 and ENVISAT radar freeboard over Arctic sea ice: toward an improved Envisat freeboard retrieval. *The Cryosphere*, 11(5), 2059.

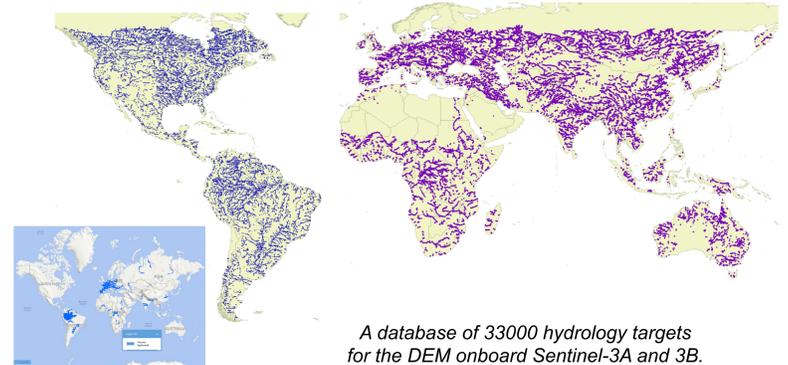
**Acknowledgments:** We thank the CNES TOSCA and the ESA CryoSeaNICE projects for their support.

### See also ...

- Mon.17h40 "Review: Progress and challenges of the DAC for altimetry over last 25 years.", L. Carrere et al.
- Tue., 08h30 "Review: How Our Understanding of Ocean Mesoscale Eddies Has Evolved over 25 Years ", R. Morrow et al.
- Tue. 14h00 "Advances in our Understanding of Coastal Processes", Carret A. et al.
- Wed 14h40 "SARAL/AltiKa: The Emblematic Ka-Band Altimetric Mission" Verron J. et al.
- Thu 16h45 "Impact of Geophysical Corrections on Altimetry Sea Level Estimations Near the Coast" F.Niño et al.

## Hydrology Targets for Sentinel-3

In the frame of the VOLODIA project a database of hydrological targets (rivers and lakes) has been produced at CTOH for the onboard DEM of Sentinel-3A and 3B. This database contains around 33000 targets for each satellite. It was delivered to CNES beginning of September for conversion in onboard tables. They will be uploaded by ESA in Sentinel-3B altimeter during the drift phase end of October.



A database of 33000 hydrology targets for the DEM onboard Sentinel-3A and 3B.

For more informations, see the Poster 111 :  
"Extending the Database of Hydrology Targets for DEM Onboard Altimeters"

## MGB modeling of the Ogooué river discharge based on altimetry data

The Ogooué river basin (ORB) is located between 9°E and 15°E, and 3°S and 2.5°N stretching about 80% of the total area of Gabon (figure 1). Due to its location crossing the Equator, the ORB receives the largest annual precipitation in Africa (1,600–2,200 mm yr<sup>-1</sup>). The ORB is drained by a dense river network, with about a river each 15 km. But the ORB underwent a drastic depletion of river monitoring stations in seventies that made it almost an ungauged basin.

In order to overcome this situation, the MGB ("Modelo de Grandes Bacias" or "Large Basins Model") was used to simulate hydrological processes of the ORB from 1999 to 2015. Upstream of the ORB, altimetry derived water levels and discharge from 3 virtual stations: SV\_272\_lwindo and SV\_272\_Ogooué using Envisat data (2002–2010), and SV\_185\_Ogooué using Jason-2 data (2008–2015) were used to calibrate the model (see Bogning et al., 2018). The last functioning gauge station, downstream of the ORB, at Lambaréné were used for the calibration of the model.

Volume error was used as performance metrics to evaluate the MGB model results in the ORB. Table 1 shows values of Nash-Sutcliffe Efficiency (NSE), NSElog and Evol obtained in the four calibration gauges as well as Figure 1 shows co-variations of both field measured and modeled discharges of the Ogooué river at Lambaréné. Model results are in good agreement with discharges at stations both upstream and downstream of the Ogooué river basin (NSE>0.56 for all gauges). Furthermore, the MGB model efficiently replicates seasonal variations of the Ogooué river discharge at Lambaréné as it can be seen in Figure 2.

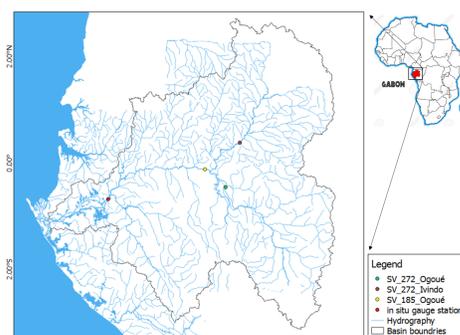


Figure 1: The Ogooué river basin (ORB) covers about 80% of the Gabon. Due to its location crossing the Equator, the ORB receives the largest annual precipitation in Africa (1,600–2,200 mm yr<sup>-1</sup>).

Calibration gauges	Longitude (°E)	Latitude (°N)	Drainage area(km <sup>2</sup> )	NSE	NSElog	Evol (%)
SV_272_lwindo	12.8135	0.5371	49115.48	0,56	0,51	-0,60
SV_272_Ogooué	12.6932	-0,8254	46142,51	0,68	0,73	0,15
SV_185_Ogooué	11,9393	-0,1083	130844,32	0,71	0,75	0,21
In situ gauge station	10,3634	0,5867	205082,57	0,75	0,80	1,21

Table 1: performance metrics of MGB modeling of the ORB

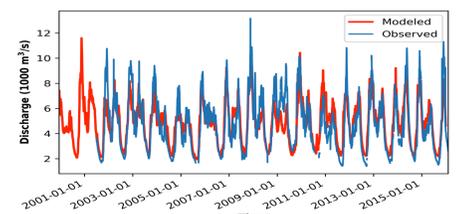


Figure 2: comparison of in situ and modeled discharges of the Ogooué river at Lambaréné

**Reference:** S. Bogning, F.Frappart, F.Blarel, F.Niño, G.Mahé, JP Bricquet, F. Seyler, et al. 2018. "Monitoring Water Levels and Discharges Using Radar Altimetry in an Ungauged River Basin: The Case of the Ogooué." *Remote Sensing* 10 (2): 350.