

French Observation Service : CTOH

Centre de Topographie des Océans et l'Hydrosphère

LEGOS, Toulouse, France

ctoh.legos.obs-mip.fr

Expertise in Satellite Altimetry since 1989

Objectives of the service:

Maintenance of a long term, multi-agency **altimetry databases** (L1 and L2), as homogeneous as possible.

Research & Development on new altimetry applications (coastal areas, lakes, rivers, floodplains, cryosphere, sea ice, fine scale open oceans...)

Develop, manage and distribute **new products** (with AVISO+ and THEIA)

Ensure the transfer of skills and **expertise to the operational centers** (CNES, ESA), providing support for new mission development

User support for data and products, and **altimetric training** (students, researchers, developing countries)



CTOH Organisation

R&D

Open ocean
fine scale

R. Morrow

Coastal
Oceans

F. Birol

Terrestrial
Surfaces waters

F. Frappart

Sea-Ice

S. Fleury

Measurement
Physics

**D. Blumstein/
F. Niño**

CTOH Databases & products

- 11 altimetric missions (L1 to L4) : ~ 92 To
- derived products (open ocean, coastal oceans, hydrology, sea-ice)
- new algorithms (Cal/Val, processing, analysis)
- user support service
- web site (visualisation & extractions)

Expertise, algos,
products

AVISO+

Operational service

Expertise

**CNES, ESA
Copernicus**

Expertise, products, training

Users: 300-500 / year

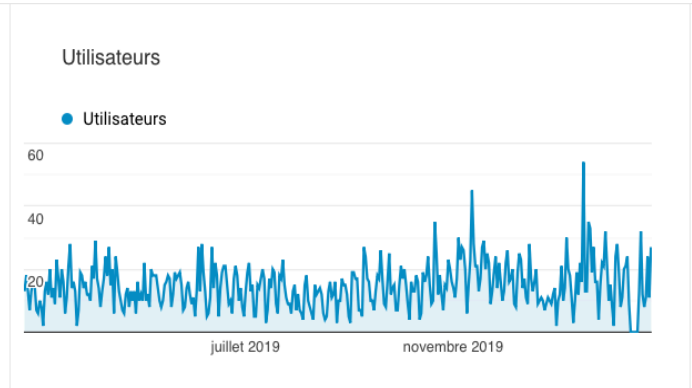
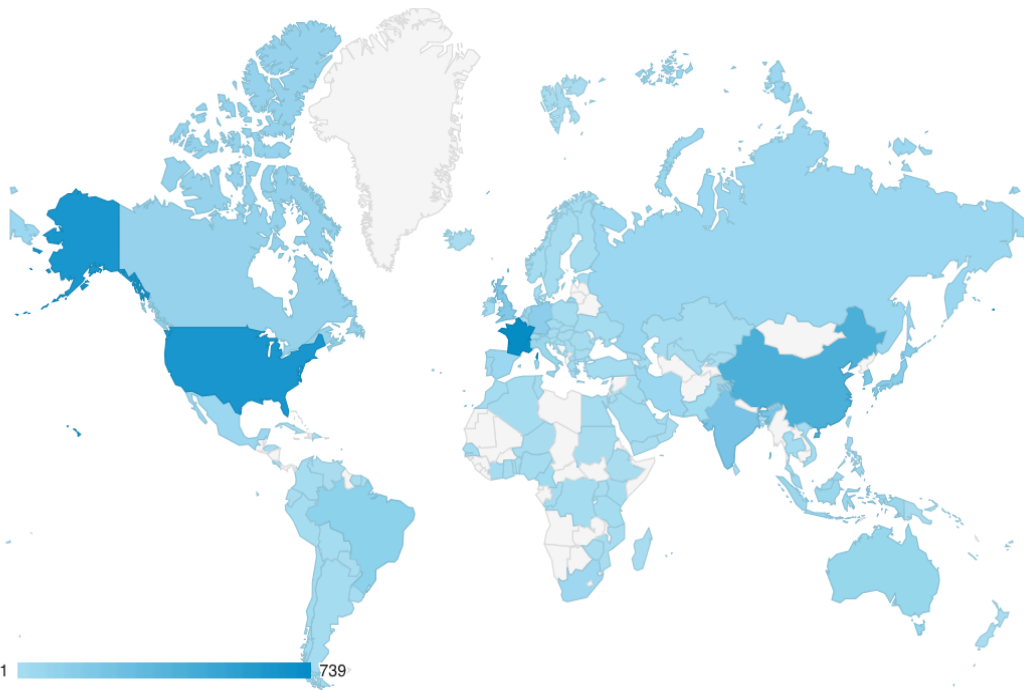
2020 : 5 researchers &
9 research engineers

Technical

Data and Product distribution in 2019

via CTOH & AVISO+ websites

Consultation CTOH website



4000 users annually
(4114 from Feb 2019 & Feb 2020)

Distribution of data & products : > 500

- 210 CTOH data/product requests handled offline
- 242 online extractions
- > 60 requests via AVISO+



OSTST CTOH R&D Projects : PRIAM

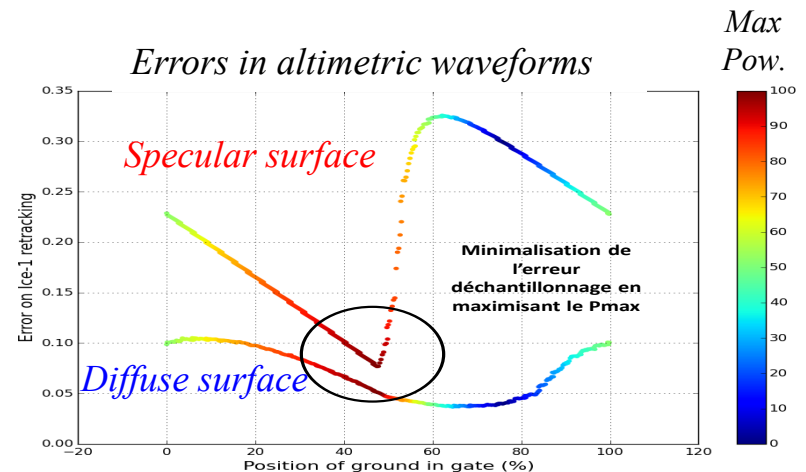
new Perspectives for higher Resolution Altimetry - a
Multi-disciplinary approach

F. Birol, D. Blumstein, S. Fleury, F. Frappart, R. Morrow, F. Niño, F. Blarel

- ❑ A multi-thematic approach to mutualise effort, tools and altimetric expertise over different surfaces
- ❑ Continuity in expertise, from altimetric measurement physics to scientific applications, including processing & developing demonstration products.

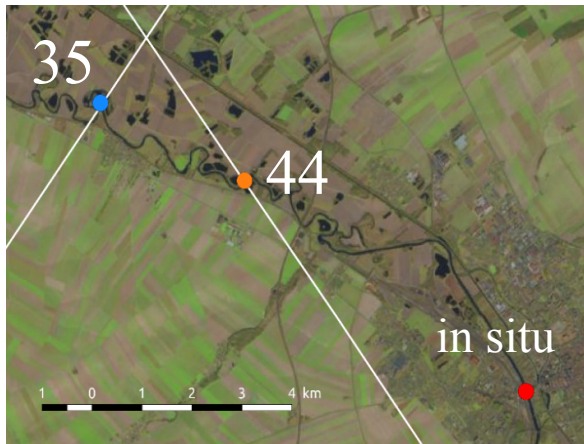
5 themes:

- Waveform analysis
- Coastal ocean dynamics
- Fine-scale interior dynamics
- Sea ice
- Land surface



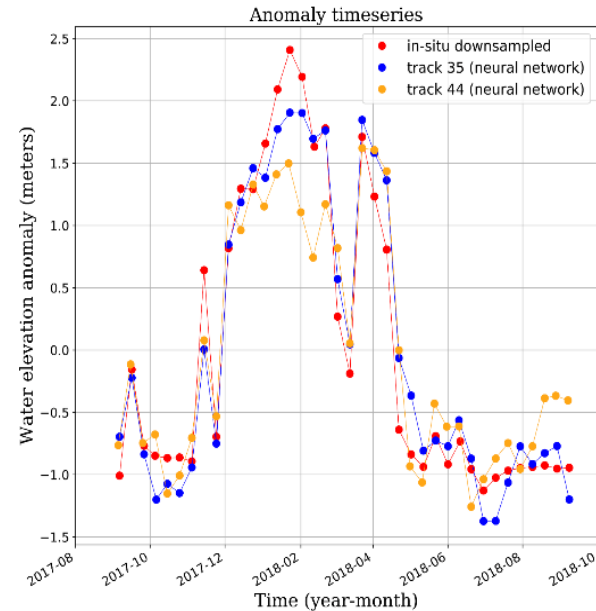
R&D Examples : Measurement Physics

- 1) Preparation studies for the **future SMASH mission** (multiple altimeters for Hydrology)
- 2) **Deep Learning** for the conversion of altimetry measurements into water level, mainly for continental hydrology

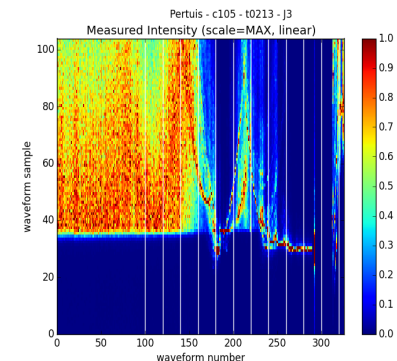


La Marne width ~50m

- tr 44/insitu : corr. 0.955, RMSE 32 cm
- tr 35/insitu : corr. 0.884, RMSE 44 cm
- tr44/tr35 : 0.889, RMSE 49 cm



- 3) Study of waveforms in the Pertuis Charentais
Collaboration with the Triskell group of La Rochelle. Study of the location of the source of hyperboles on radargrams (presence of saltflats on the island of Ré).



R&D Examples : Fine scale open ocean

- 1) Study on the **altimetric signal and errors at short wavelengths** (10-100 km) based on spectral analyses of different altimetry missions (J2, Saral, S3) (*Vergara et al., 2019 JGR*); and the impact of internal tides and the IGW energy cascade on spectra.
- 2) **Observability of ocean fronts and eddies** using gridded altimetry maps & Sentinel-3 alongtrack altimetry & tracers (SST / ocean color)

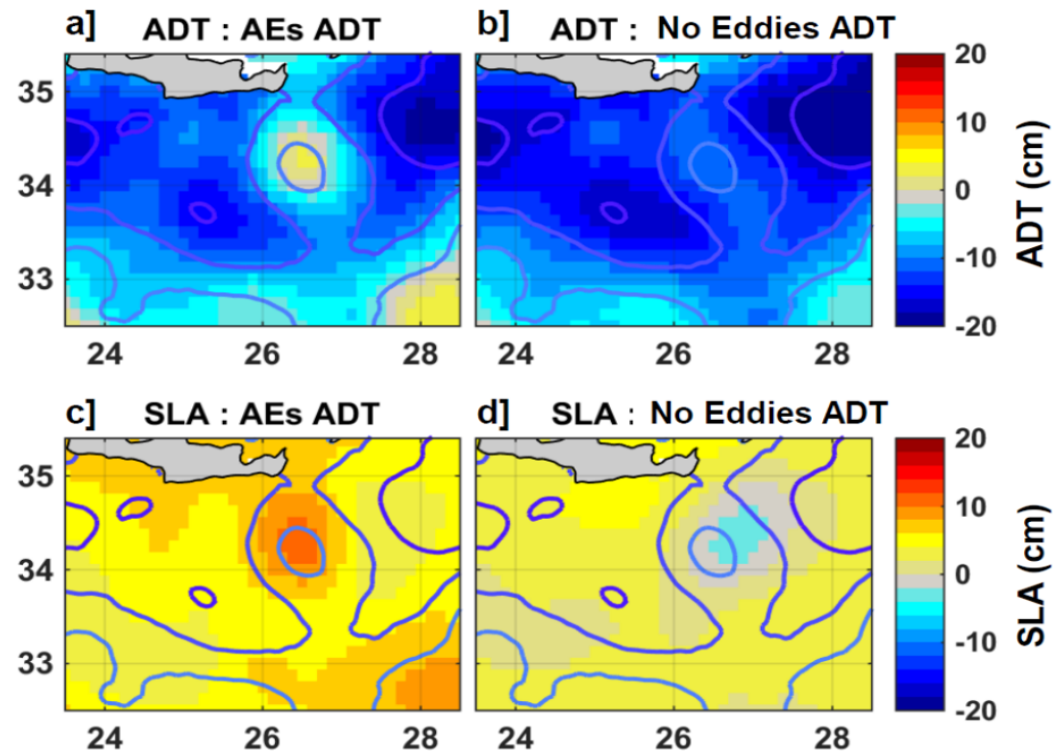
3) Eddy tracking techniques :
advantages of using SLA vs ADT
maps for eddy detection & tracking
 $ADT = SLA + MDT$

Example : Irapetra Eddy Anticyclone
occurs seasonally – present in MDT
(contours)

ADT maps : Irapetra Eddy detected well
with closed ADT contours

SLA maps : Irapetra A/C eddies have
increased SLA, but periods with NO eddies
show a false cyclonic eddy.

=> Eddy tracking with ADT is better in
regions with mesoscale structures in MDT



Pegliasco et al., 2020 (ASR)

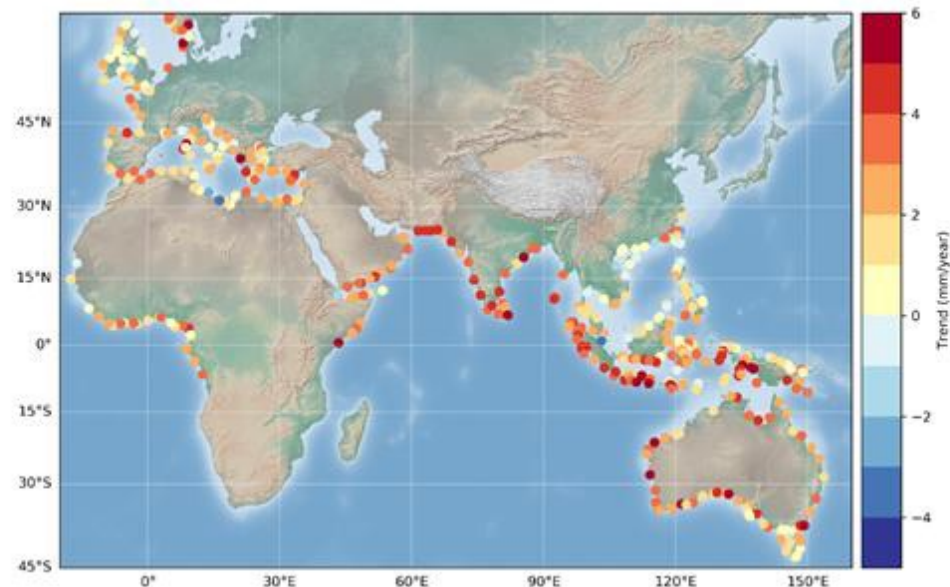


R&D Examples : Coastal Oceans

- 1) Studies on the circulation and volume transport over the Tunisian shelf combining coastal altimetry and in-situ data (Jebri et al., JGR, 2016; Jebri et al., JGR, 2017)
- 2) Identify the SSH signature of regional ocean processes, via analyses of (SSH, currents) from coastal altimetry products (X-TRACK-J2 & SARAL in 1hz & 20-40hz), gliders, ADCP, HFradars & a HR model (1km) (Carret et al., Ocean Science, 2019)
- 3) Development, validation and distribution (on ESA portal) of the new X-TRACK/ALES coastal sea level product (CCI+ project)**

- 16-year-long (June 2002 - May 2018) 20-Hz, along-track SLA time series
- 6 regions (today): Northeast Atlantic, Mediterranean Sea, West Africa, North Indian Ocean, Southeast Asia and Australia.
- extend the spatial coverage of sea level altimetry data ~3.5 km in the land direction, when compared to the X-TRACK 1-Hz dataset.
- reach a distance of 1.2-4 km to the coast when combining measurements from Jason-1 to Jason-3.

Marti et al., ASR, 2019; Gouzenes et al., Ocean Science, 2020; The SL_CCI+ coastal sea level team, Scientific Data, 2020; Birol et al., ASR, 2020.



Coastal sea level trends (mm/yr) at the first valid altimetry point from the coast in X-TRACK/ALES product – from The SL_cci+ coastal sea level team, Scientific Data (Nature), 2020



R&D Examples : Sea Ice

Development of new products available in 2019 (distributed via AVISO+):

- **Sea-ice freeboard heights** from multi-mission Envisat+CryoSat2 - 2002-2019
 - ✓ Arctique + Antarctique
- **Snow depth** Saral(Ka)/CryoSat-2(Ku) - 2013-2019
 - ✓ Arctique + Antarctique
- **1st product of Sea-ice thickness 100% by altimetry** 2013-2019
 - ✓ Arctique + Antarctique
- **Sea-ice freeboard & SLA** in Arctic with the SAMOSA+ physical retracker

Laforge et al., ASR, 2020

AVISO+
Satellite Altimetry Data

Altimetry data for sea-ice thickness depth over Arctic and Antarctica

CTOH, Sara Fleury, Florent Garnier

Sea Ice Thickness (SIT)

SIT from Altimetry
Sea Ice Thickness measurement using Satellite Altimetry

Measurements
The sea ice and its snow coverage has important effects on the global climate because of its albedo, which reject back the solar radiations and limit the water heating, water and the atmosphere. The melting and freezing processes also modify the thermohaline circulations, and the sea ice thickness and the snow depth impact the print. The only technical to measure the sea ice thickness at ocean scale is based on satellite altimetry (see below). Some other satellite instruments allow to estimate this surface temperature and salinity (SMOS).

Measurements Principles
The principle is simple: it consists in measuring the height of the ice floes and the height of the water within the surrounding fractures of the ice (the leads and the polynyas). The sea ice and its snow coverage has important effects on the global climate because of its albedo, which reject back the solar radiations and limit the water heating, water and the atmosphere. The melting and freezing processes also modify the thermohaline circulations, and the sea ice thickness and the snow depth impact the print. The only technical to measure the sea ice thickness at ocean scale is based on satellite altimetry (see below). Some other satellite instruments allow to estimate this surface temperature and salinity (SMOS).

Available Products
For now 3 products are available for the North Hemisphere (NH):

Product	Satellite/Altimeter	Covered Region	Covered Period	DOI
SIT NH ENV	Envisat/RA2	Arctic 65°N + lat + 81.5°N	2002-2012	10.8086/CTOH_SIT_NH_ENV_2017_01
SIT NH C2	CryoSat-2/SARAL	Arctic 65°N + lat + 86°N	2010-2017	10.8086/CTOH_SIT_NH_C2_2017_01
SIT NH ENV C2	Envisat + CryoSat-2	Arctic 65°N + lat + 81.5°N	2002-2017	10.8086/CTOH_SIT_NH_ENV_C2_2017_01

Accès aux données

Accueil / Accès aux données / Accès direct au catalogue

Export **Retour**

Arctic Sea Ice Thickness

Aperçu **Complet**

Résumé
Sea Ice Thickness (only from October to April), observed from Envisat and CryoSat-2 altimetric satellite. The bias between the two missions have been corrected to provide a continuous Sea Ice Thickness all along the period. Monthly maps on stereographic projection.

Date(s)
2017-11-17 - Publication

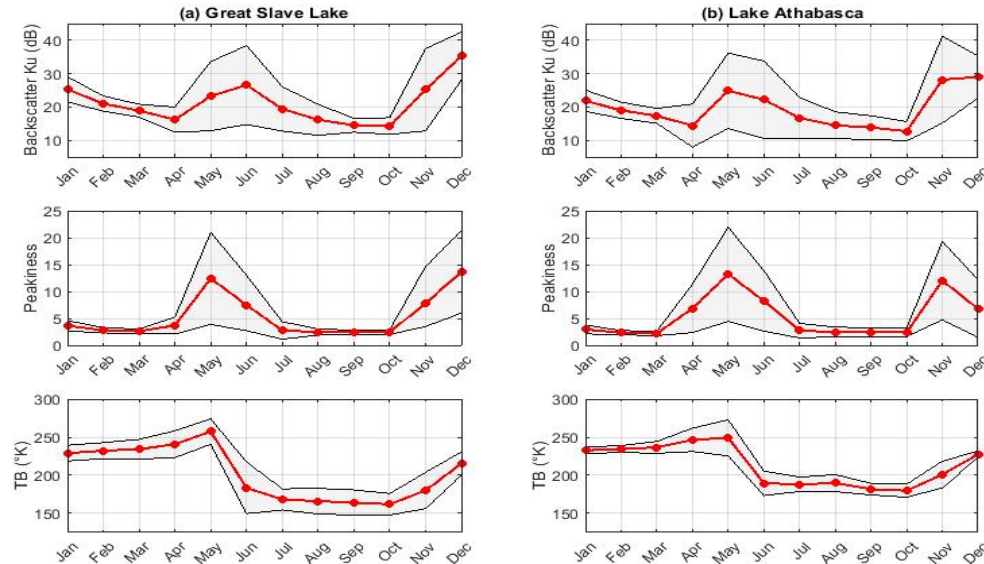
Contacts
CTOH, Sara Fleury

Mots-clés
freeboard, snow depth, density, sea ice thickness
CryoSat-2/Trouse
/Physique de l'Océan/Glace de mer
/Télédétection
Télédétection

Généalogie
Guemter, K., Fleury, S., Zakharova, E., Rémy, F., Kourav, A. (2016). Potential for estimation of snow depth on Arctic sea ice from CryoSat-2 and SARAL/AltiKa missions. In Remote Sensing of Environment, 186, 339-349.
Comparison of CryoSat-2 and ENVISAT radar freeboard over Arctic sea-ice: Toward an improved Envisat freeboard retrieval. K. Guemter, S. Fleury, E. Zakharova, A. Kourav, F. Rémy, P. Massonnet. The Cryosphere, 11, 2009-2013, 2017, <https://doi.org/10.5194/tc-11-2009-2017>

R&D Example : Terrestrial surface waters

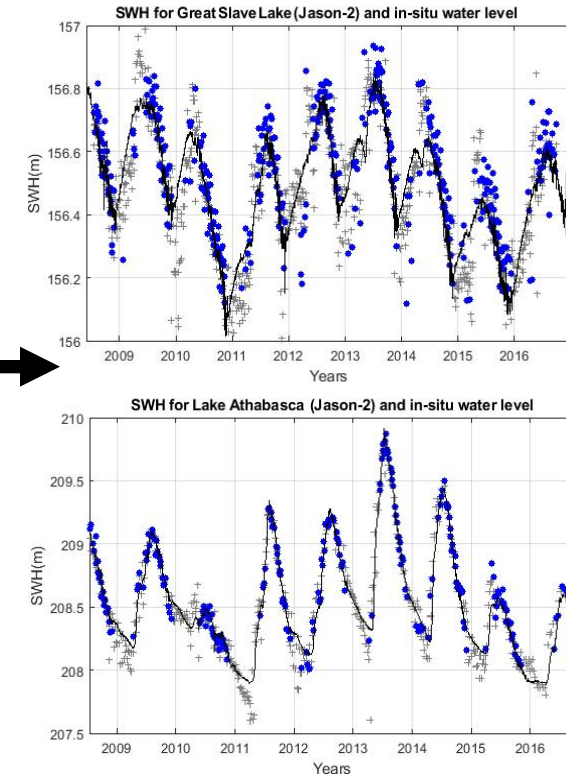
- Automatic water detection from altimetric parameters
Arctic Lakes : Ziyad et al., Remote Sensing, 2020



k-means



σ_0 , PP, TB



Frappart et al., IJAEOG, soumis

Different unsupervised classifications tested. Best results with k-means. Automatic generation of Virtual Stations for different water classes.



Name	Status
Allain Damien	CDI (AT CNES) – tide products
Birol Florence	CNAP, Physicienne Science Lead of CTOH & coastal studies
Blarel Fabien	IE CNRS – hydrology products. Data base, validation.
Blumstein Denis	Ing. CNES – Lead measurement physics studies – hydrology applications
Fleury Sara	IR CNRS Lead of sea-ice studies. Previous data base lead.
Frappart Frédéric	CNAP, Physicien adjoint Lead of Hydrology studies, and data base
Leger, Fabien	IE CNRS – coastal products and user service
Morrow Rosemary	CNAP, Physicienne Lead – fine-scale ocean studies SWOT Ocean Lead CNES
Niño Fernando	IR IRD – Technical Lead of CTOH. Algorithms in hydrology & coastal studies
Laforge, Antoine	CDD 2017-2019 (ESA) Sea-ice products
Guerreiro, Kevin	CDD 2017-2018 (CNES) Sea-ice products
Vergara, Oscar	CDI CLS/CNES Fine-scale ocean products
Garnier Florent	CDD 2018+ (CNES & ESA) Sea-Ice products
Lasson Léa	CDI (AT, CNES) Algorithms and hydrology

French Altimetric Data Service CTOH

Over 4 years: 2016-2019

- 25 team publications, 100 user publications
- (Co) Direction of 12 PhD theses
- Providing data products to AVISO+, ODATIS, THEIA
- Altimetric training for students, PostDocs and researchers
- Expertise for CNES & ESA, for present altimetric missions, and for future missions S-6, SWOT, WiSA, SMASH, CRISTAL, ...
- Financial support from CNES, INSU/CNRS, IRD, University Toulouse III via the Observatoire Midi-Pyrénées

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