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, developping countries)

CTOH Organisation

R&D

Open ocean fine scale	Coastal Oceans	Terrestrial Surfaces waters	Sea-Ice	Measurement Physics
R. Morrow	F. Birol	F. Frappart	S. Fleury	D. Blumstein/ F. Niño

Technical

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

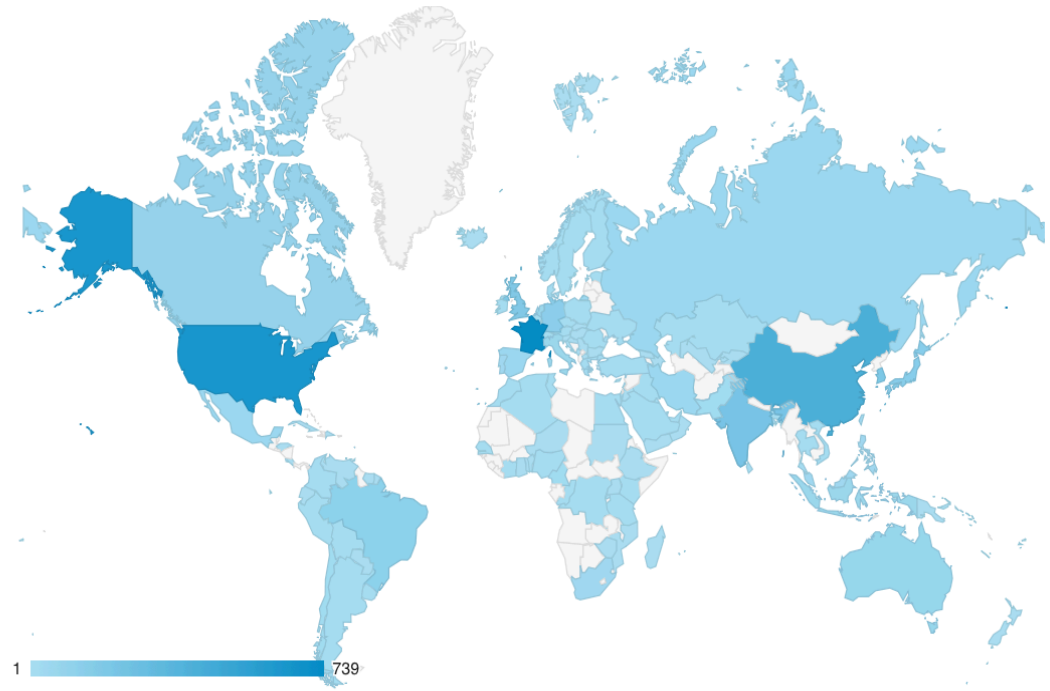
Users: 300-500 / year

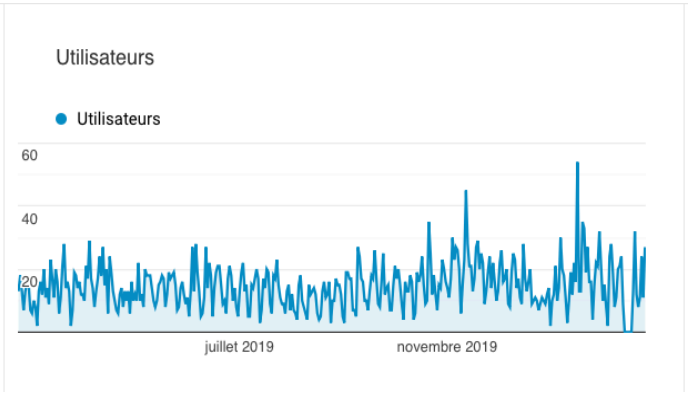
2020 : 5 researchers & 9 research engineers

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

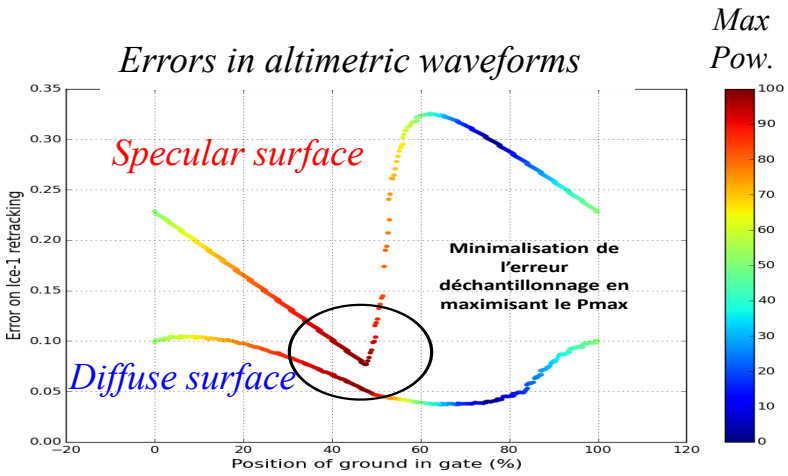
new **P**erspectives for higher **R**esolut**I**on **A**ltimetry - a **M**ulti-disciplinary approach

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

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

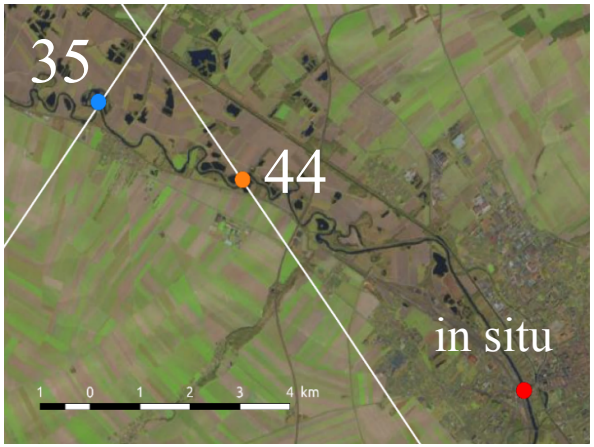
5 themes:

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



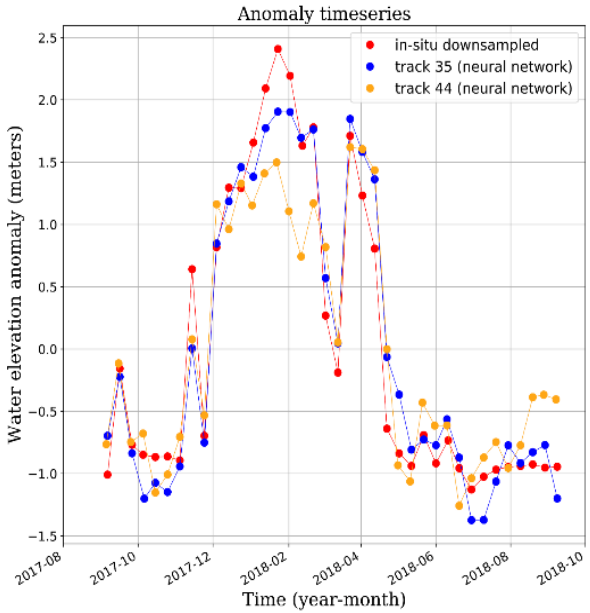
R&D Examples : Measurement Physics

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

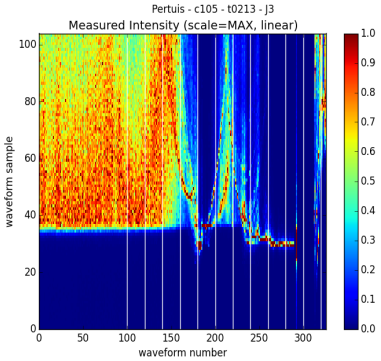


La Marne width ~50m

- 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.

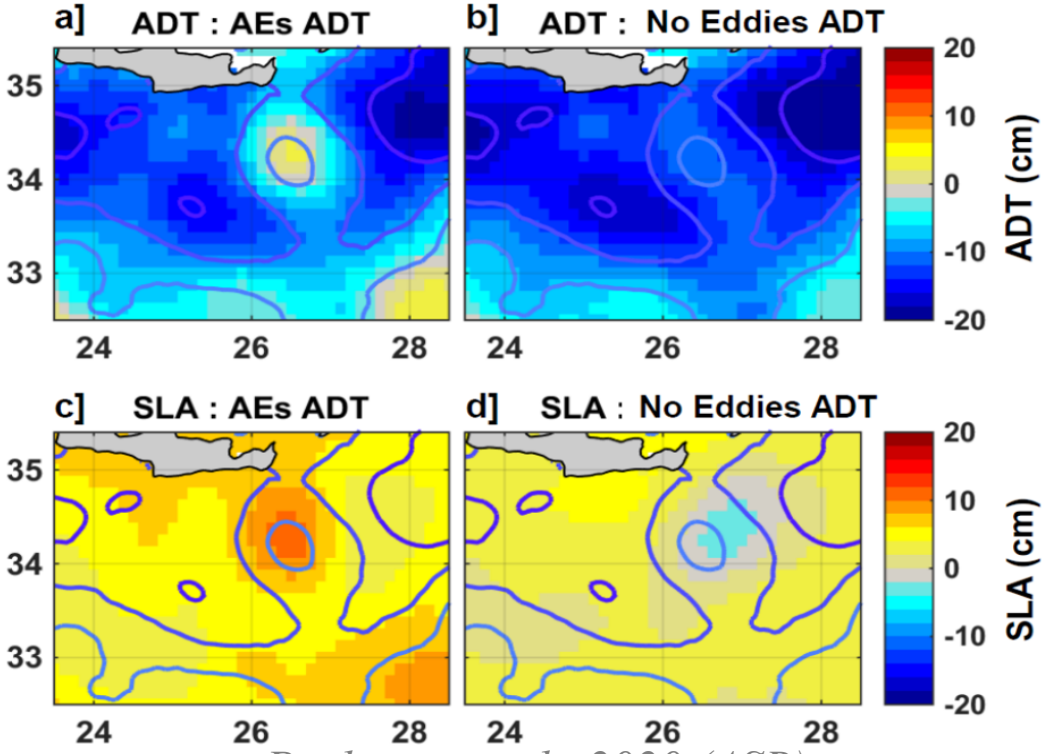
2) **Observability of ocean fronts and eddies** using gridded altimetery maps & Sentinel-3 alongtrack altimetry & tracers (SST / ocean color)

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

ADT = SLA + MDT

Example : Ierapetra Eddy Anticyclone
occurs seasonally – present in MDT (contours)
ADT maps : Ierapetra Eddy detected well with closed ADT contours
SLA maps : Ierapetra 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)

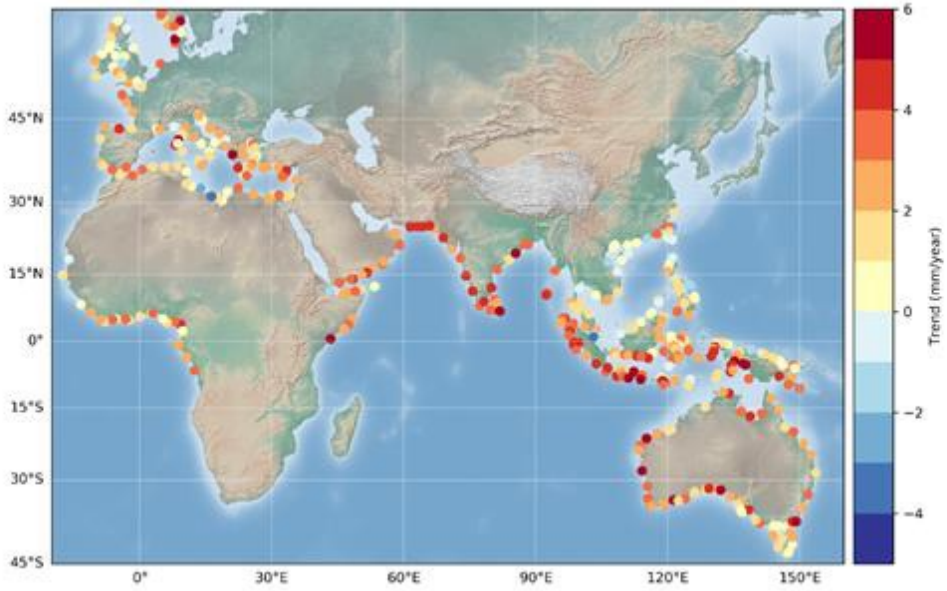
R&D Examples : Coastal Oceans

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

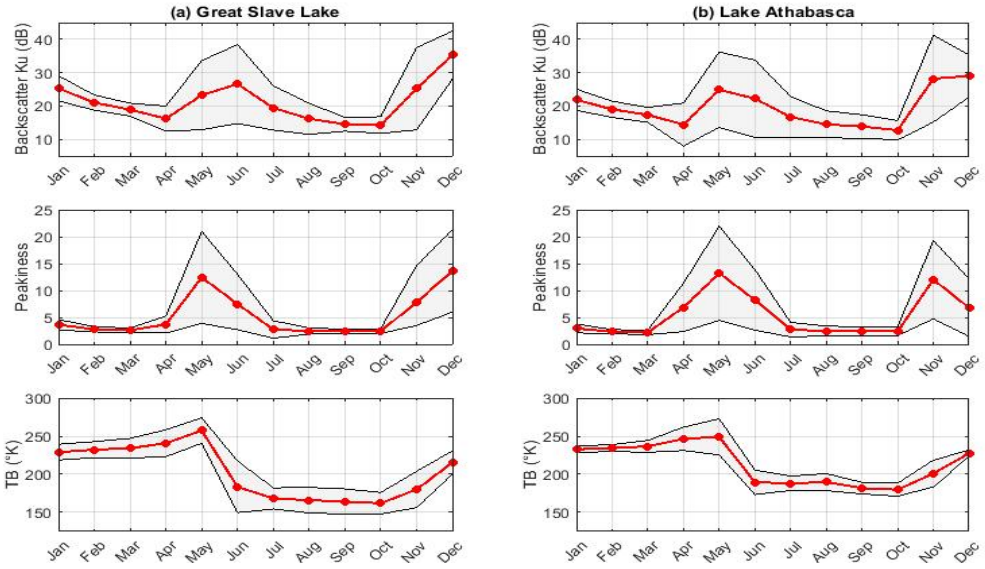
Development of new products available in 2019 (distributed via AVISO+):

- **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

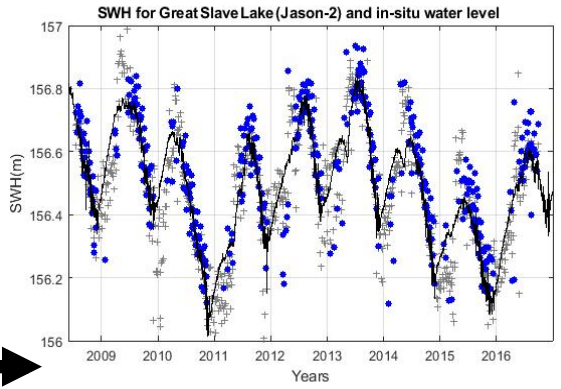
R&D Example : Terrestrial surface waters

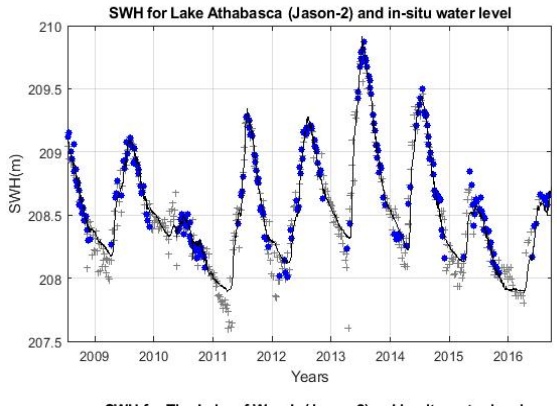
- Automatic water detection from altimetric parameters
  Arctic Lakes : Ziyad et al., Remote Sensing, 2020



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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