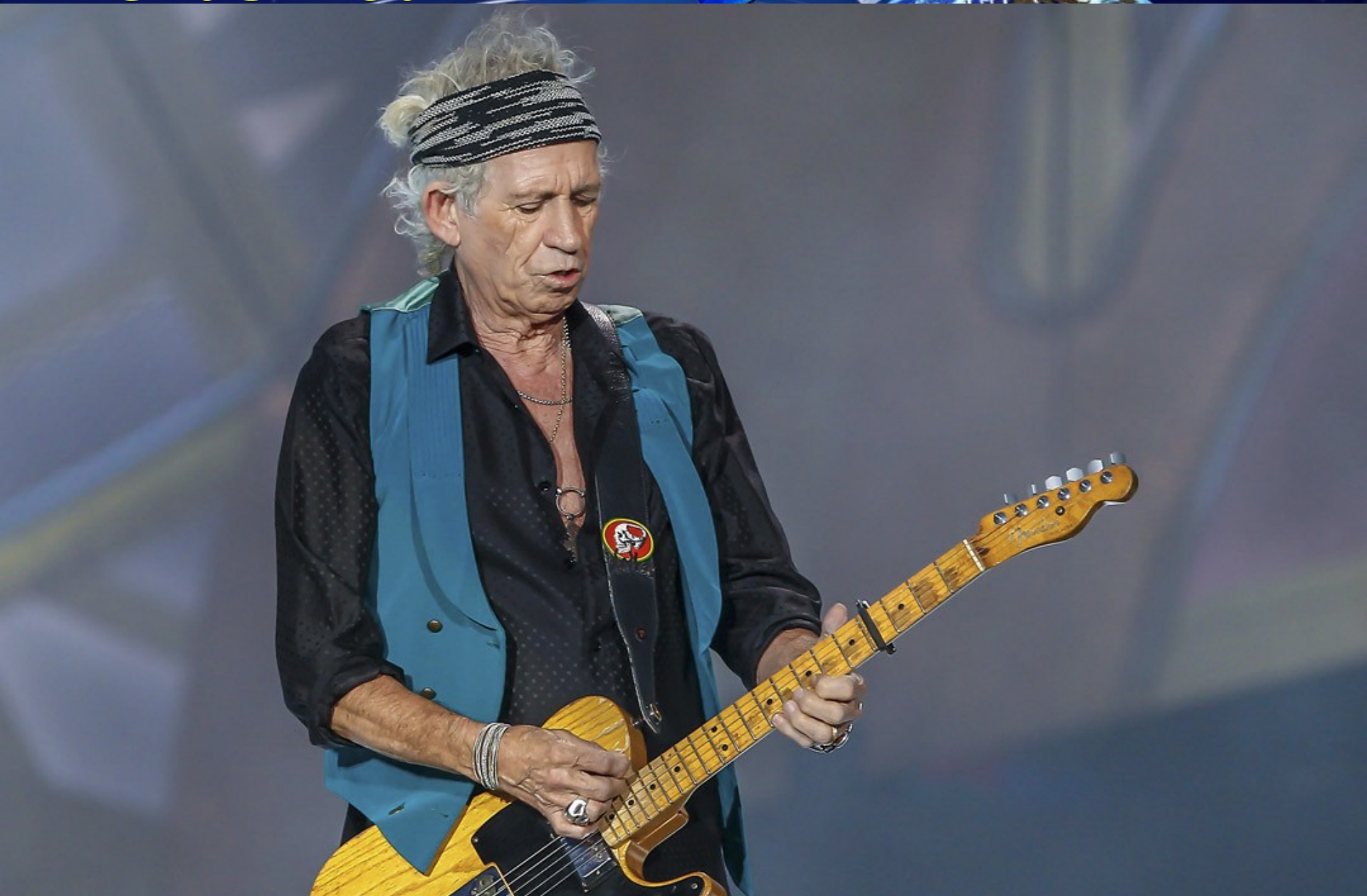
Medspiration :
from demonstration to operation, history and legacy

Jean-François Piollé, Olivier Arino, Craig Donlon, Ian Robinson, Pierre Leborgne, E.Autret, Jean Tournadre, Dave Poulter, Bruno Buonjurno-Nardelli, Steinar Eastwood, Gérard Legendre, Jacques Stum, Gilles Larnicol, Cédric Prevost, Romain De Joux, et al.

esa European Space Agency

medspiration EUROPEAN NODE FOR SEA SURFACE TEMPERATURE

This is definitely the last tour !



2003-2006
Implementation and demonstration

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GHRSST at the dawn of times (2003)

Interoperable user access via OPeNDAP, TDS WCS, FTP...

Data Provid...s / GHR...T Regional Data Assembly Centers (RDACs)

NOAA | esa | medspiration | JAXA | EUMETSAT | OSI SAF | NASA | myOcean | NEODAAS | Remote Sensing Systems | Environment Canada | Met Office | Australian Government Bureau of Meteorology | and more...

Level 2, 3 and 4 GHRSST satellite SST data in COARDS/CF-compliant netCDF with ISO 19115-2 metadata

GDAC — GHRSST Global Data Assembly Center (GDAC) — Physical Oceanography DAAC

Rolling Archive | Data Ingest | MMR System | Data Tools | Data Access | User Services

Ancillary fields filled as needed, initial FGDC metadata records appended, data provided in 30-day rolling store

LTSRF — GHRSST Long Term Stewardship and Reanalysis Facility (LTSRF) — NOAA National Oceanographic Data Center

Data Ingest | CDR Production | Aggregation | Data Access | Metadata | Perpetual Archive

Perpetual archive services, data access and aggregation, climate data records and complete ISO 19115-2 metadata

User requirements, services and feedback at all levels...

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Medspiration

- Medspiration was an ESA/Data User Element funded call launched in 2003, KO in 2004
- Kick forward GHRSST system implementation – yet a conceptual view - with the European subsystem
- improve the uptake of Envisat AATSR data by the user community. Due to complex format and content, the usage of AATSR was not yet up to his reputation as a high quality reference sensor.
- take advantage of the growing number of sea surface temperature measuring instruments with increasing operationality and timeliness, to define and implement new multi-sensor products with higher temporal and spatial resolution.

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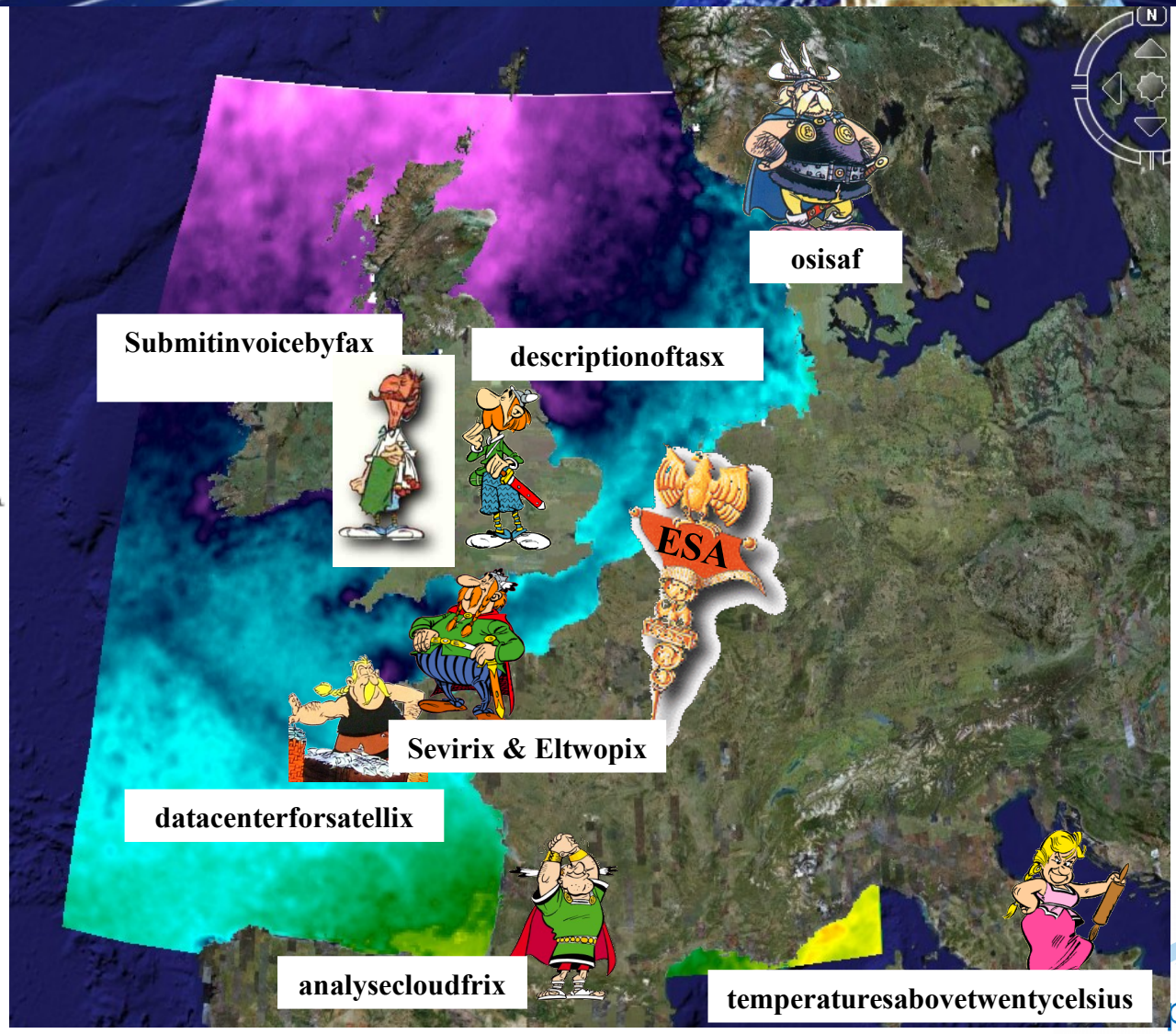
A team led by Ian Robinson



Meteorologisk institutt met.no

CLS

Southampton Oceanography Centre
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

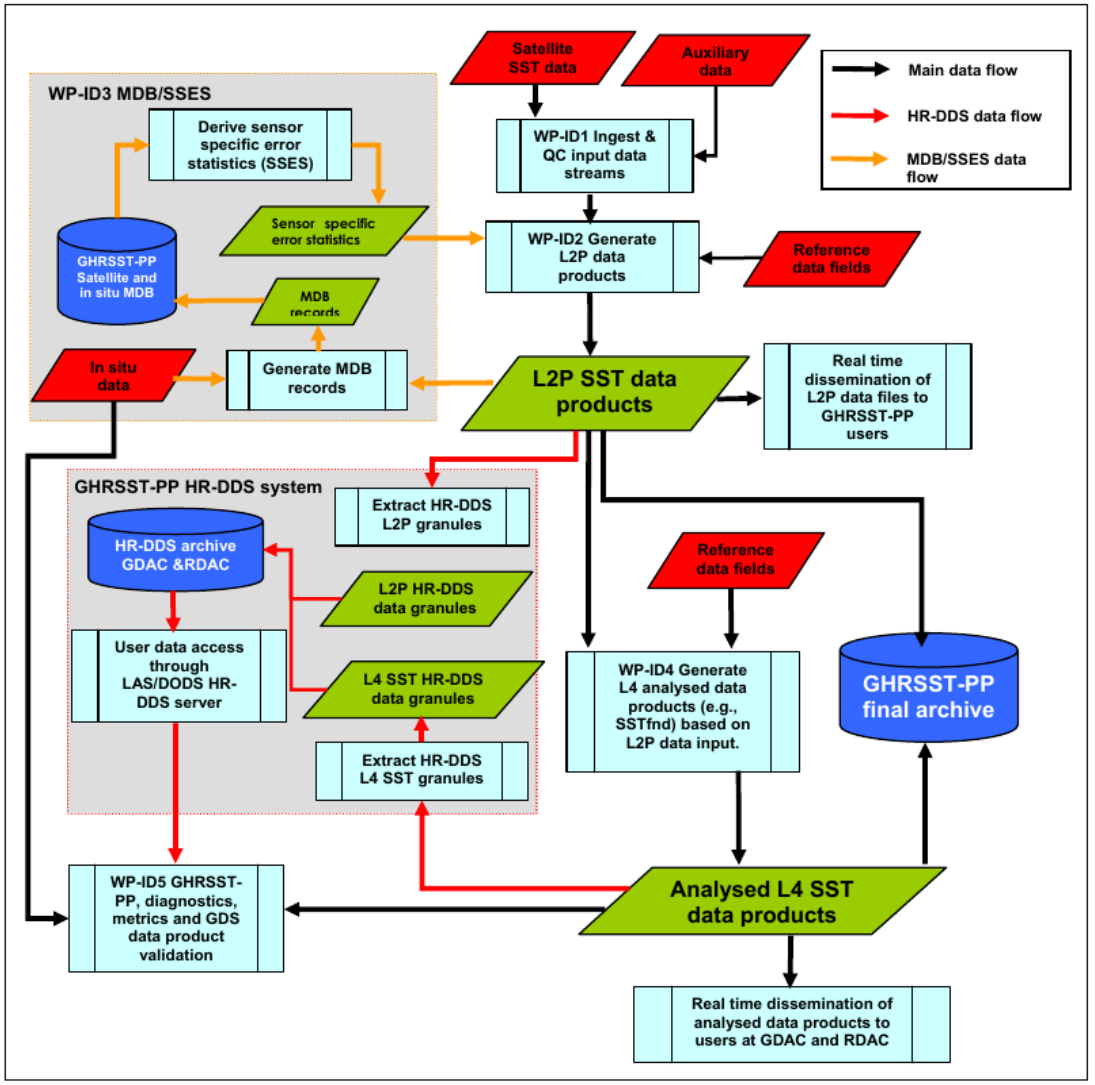
VEGA

METEO FRANCE

Ifremer

piration
EUROPEAN NODE FOR SEA SURFACE TEMPERATURE

GHRSST GDS (for senior members)



Craig completing the first GDS in time for Medspiration implementation !

Medspiration team trying to make some sense of it ...

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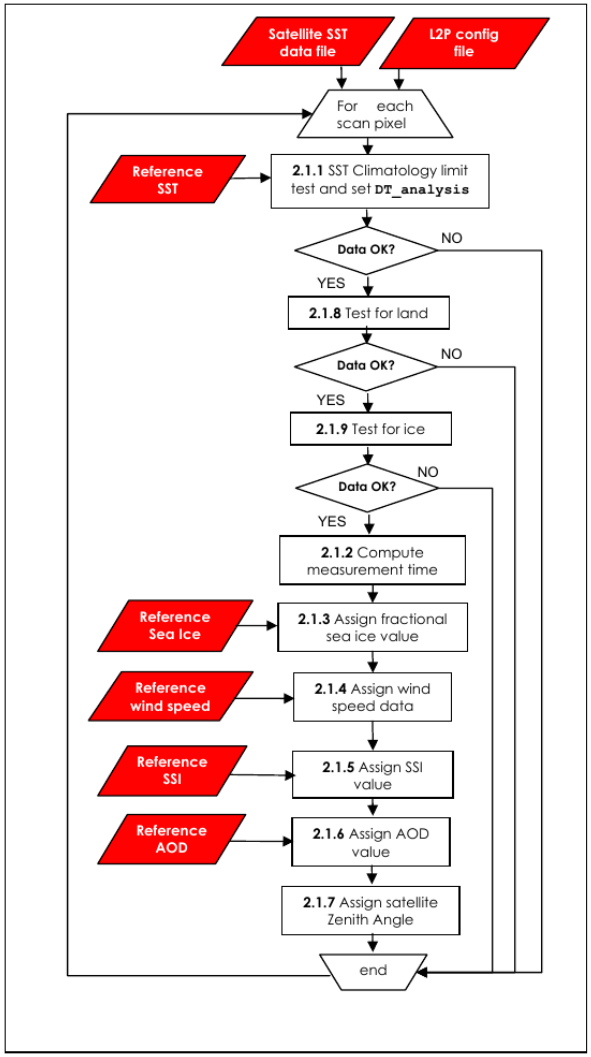
GHRSST GDS (for senior members)



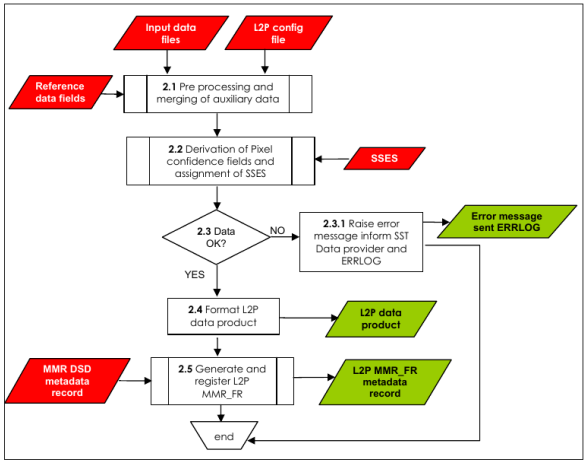
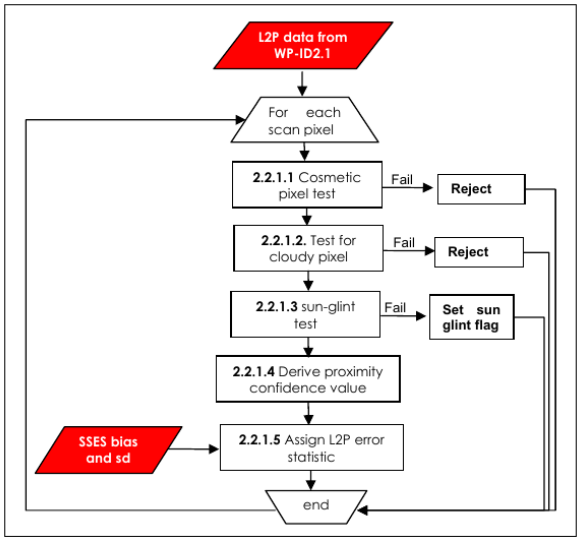
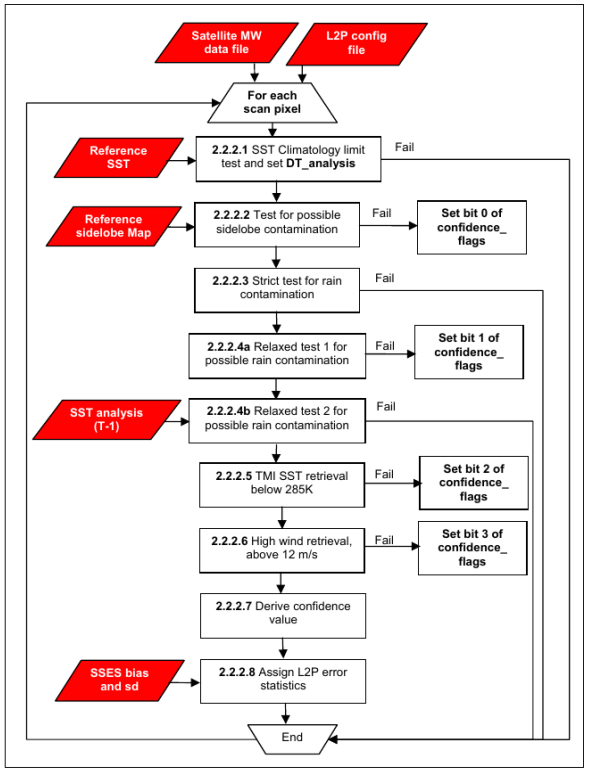


Figure 5.1 Functional breakdown of WP-ID2 identifying each major sub task.



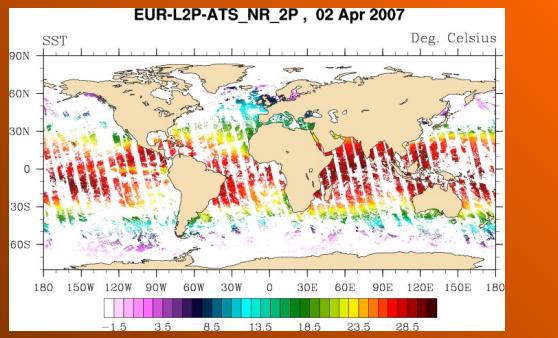


Threshold values for DT_min, (K)>			
> IPCVThres1	3 (Suspect)	3 (Suspect)	5 (Excellent)
< IPCVThres1	2 (Bad)	2 (Bad)	4 (Acceptable)
> IPCVThres2	1 (Cloudy)	2 (Bad)	4 (Acceptable)
< IPCVThres3	1 (Cloudy)	(Cloudy)	6 (Suspect, Cool skin, upwelling, riverine inputs etc.)
	IPCV_D1 (close)	IPCV_D2 (near)	> IPCV_D2 (far)	Distance from nearest cloudy pixel (km)

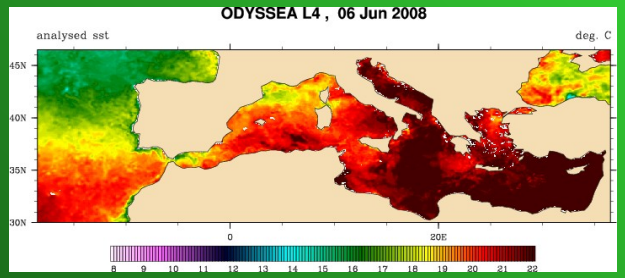
241 pages of these tiny diagrams !!!

Medspiration initial products

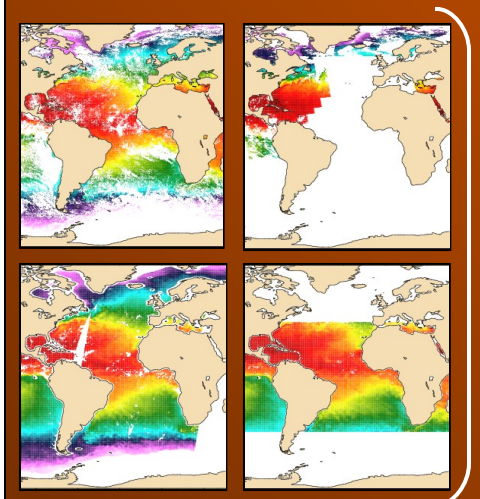
products



Direct observations (L2P)

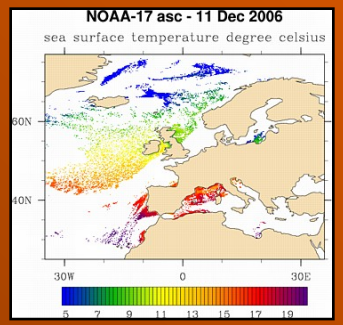


Gap free high resolution maps (L4)

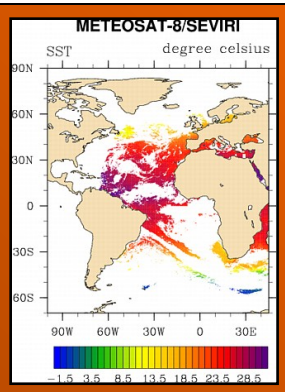


LAC NOAA17
LAC NOAA16
GAC NOAA17
GACNOAA17
AMSRE
TMI

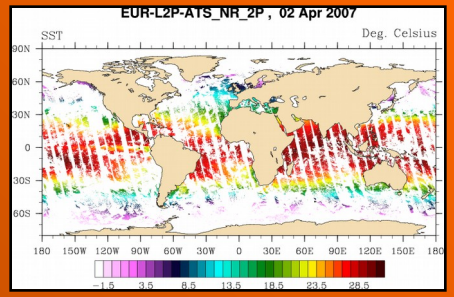
Disc. In 2006



SAF O&SI NAR for NOAA17 & NOAA18 (2km, 2 passes/day)



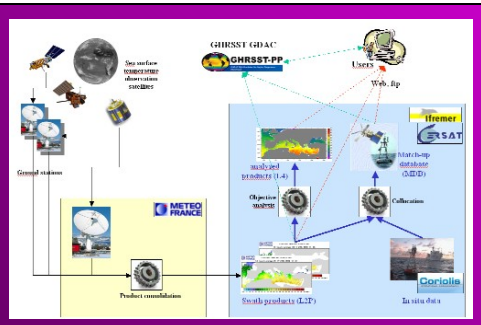
MSG/SEVIRI (10km, 3-hourly snapshots)



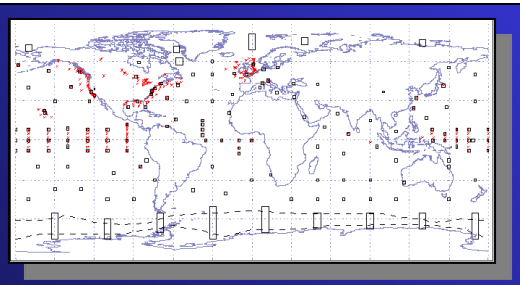
ENVISAT/AATSR (1km, 14-15 orbits/day)

ATLANTIC => GLOBAL (Dec 2005)

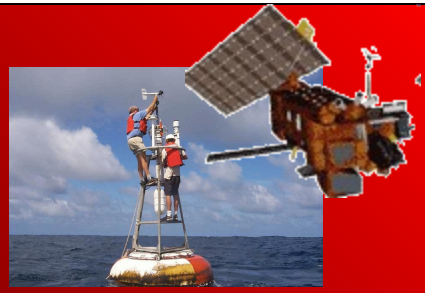
Medspiration initial framework



Real-time processing platform



High-resolution diagnostic datasets



Match-up database (MDB)

- Operation platform distributed over three production sites
  - ✓ Automated real-time processing
  - ✓ Job scheduler & sequencer
    - ➢ Chaining of processes
    - ➢ Data driven processing
    - ➢ Load balancing
  - ✓ Job monitoring
    - ➢ Alerts/warnings
  - ✓ Logging of all operations
  - ✓ Distributed message and data exchange across remote centers

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2007- 2012

Extension and transition to operational services

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Goals

- The effort in the following years was focused on two aspects:
  - ✓ transitioning the well acknowledged Medspiration products to more sustained and operational services
  - ✓ implementing specific products for well identified research projects with no operational context or framework

Transition to operational frameworks

- sustaining product and services into more long-term and operational contexts
- **single sensor L2 products** (GHRSST L2P) by **Eumetsat funded Ocean & Sea-Ice Satellite Application Facility (OSI SAF)** - Meteo-France/CMS & Ifremer
- US sensors (AVHRR, GOES, AMSRE, TMI) taken over by **other GHRSST agencies** as they progressively interface to GHRSST system
- Support by ESA in the context of a Medspiration extension of **AATSR L2P** NRT production and transfer to ESA/RAL until the end of its life time (the follow-on – SLSTR – would by natively produced by the ground segment)
- **multi-sensor L4 products** : operational oceanography projects => **Mersea**, then **MyOcean**, **MyOcean-2** and now **CMEMS**
  - ✓ North Western Shelves product
  - ✓ Med Sea taken over by CNR using a similar methodology
  - ✓ new high resolution products (L3 and L4) were implemented in order to cover new areas and needs (Baltic, Black sea, Arctic, Global)
  - ✓ Supported by same formed team working together to improving merging methodologies
  - ✓ Sustained availability of Medspiration L2P for AATSR now widely acknowledge as a reference sensor that could be used for cross sensor calibration.

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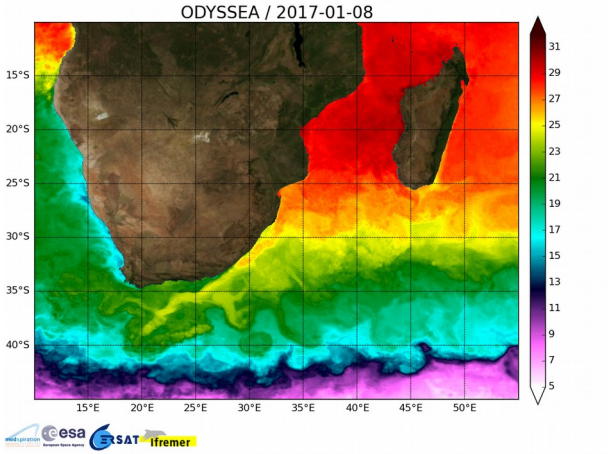
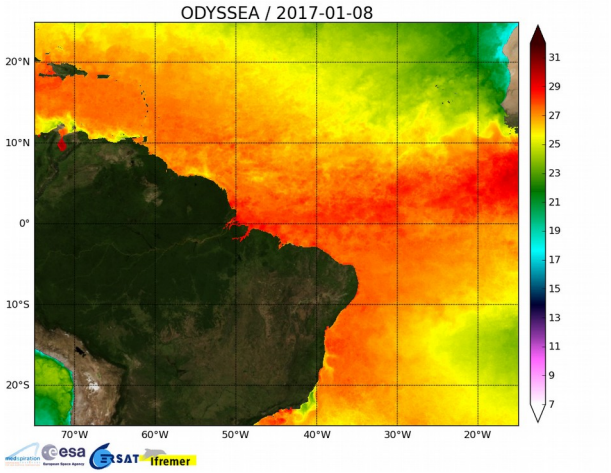
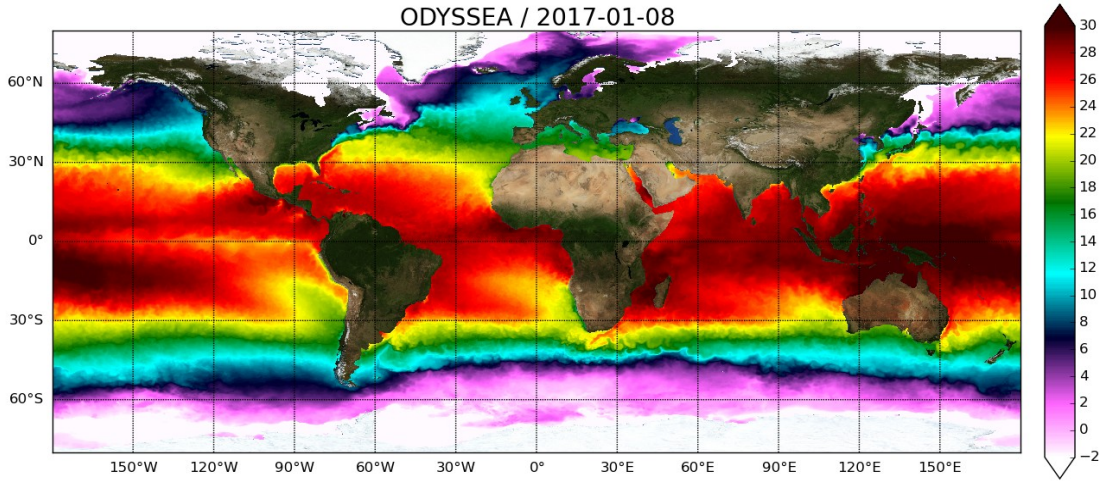
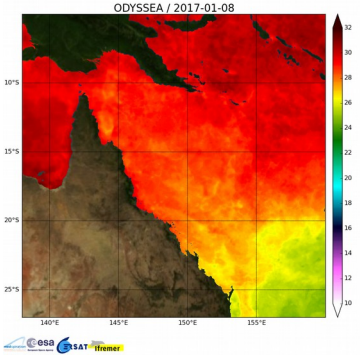
New products

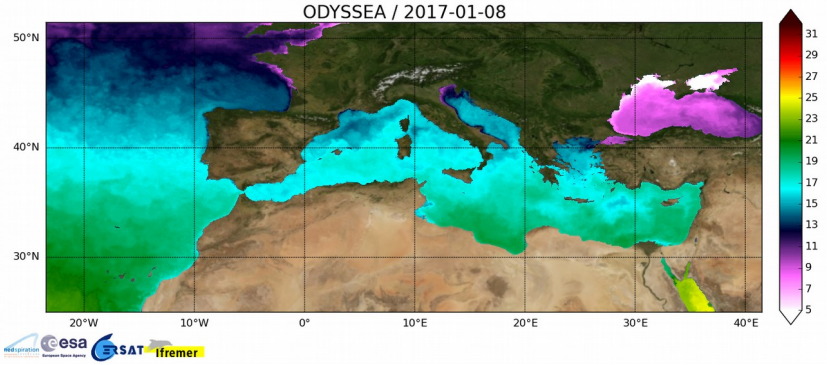






2 to 10 km res.





Support to non operational projects

- Operational oceanography limited coverage driven by NRT applications
- Medspiration project sustained to address other needs
  - ✓ new regional high resolution products occasionally produced for identified projects limited in time
  - ✓ high resolution multi-sensor daily analysis over Coco islands and Galapagos, for a ESA supported project on hammerhead shark monitoring
  - ✓ high resolution multi-sensor daily analysis over Greenland
- In that perspective, Medspiration therefore also continued to complement operational services by ensuring a link toward more research oriented applications and usages with experimental or short-lived products for specific application requirements

2012-2016

Reaching new user communities

Feedback, lessons and way forward

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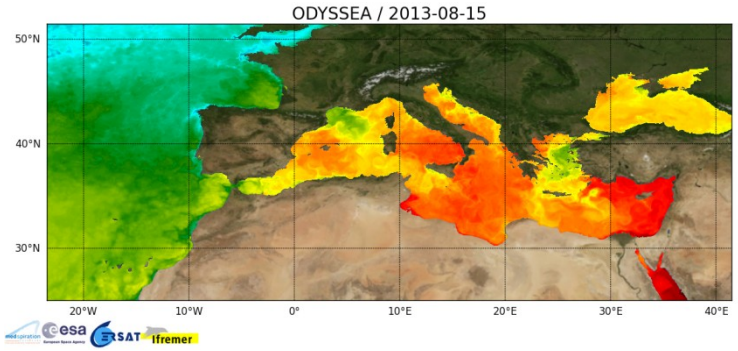
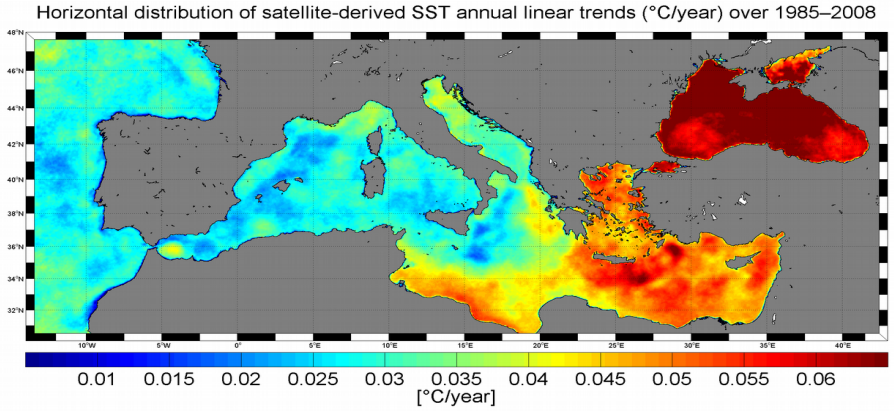
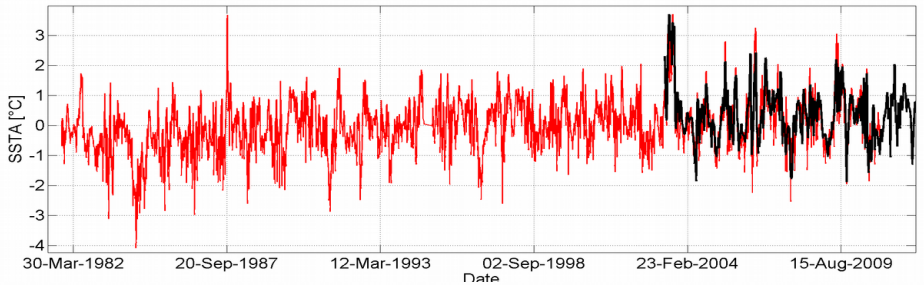
Support to Med Sea community

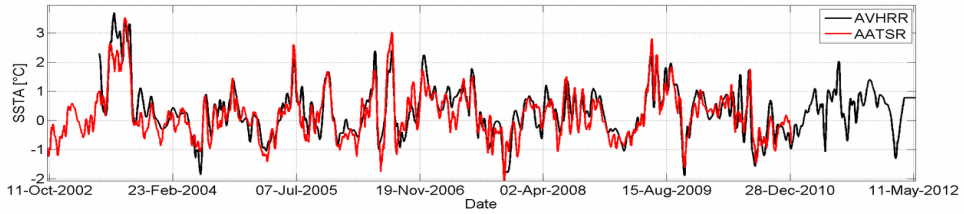
Project: Monitoring of Sea Surface Temperature evolution over the last 30 years from Satellite data around the Small Mediterannean Islands (PIMs)+ESA Medspiration



http://www.initiative-pim.org/en



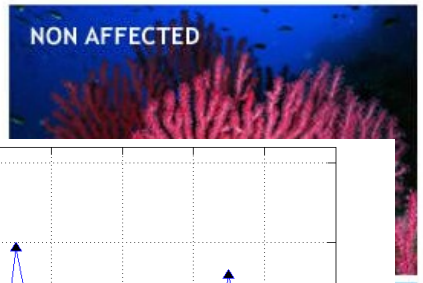


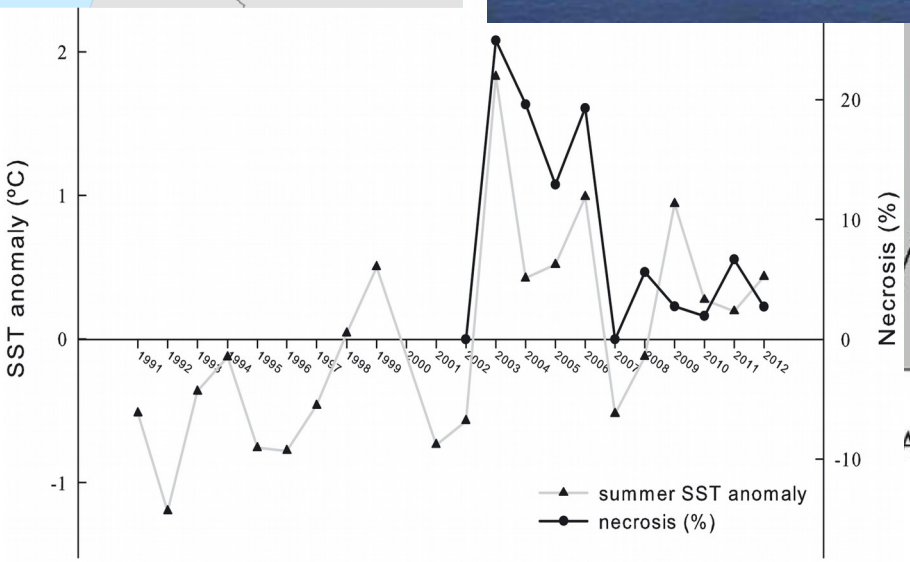


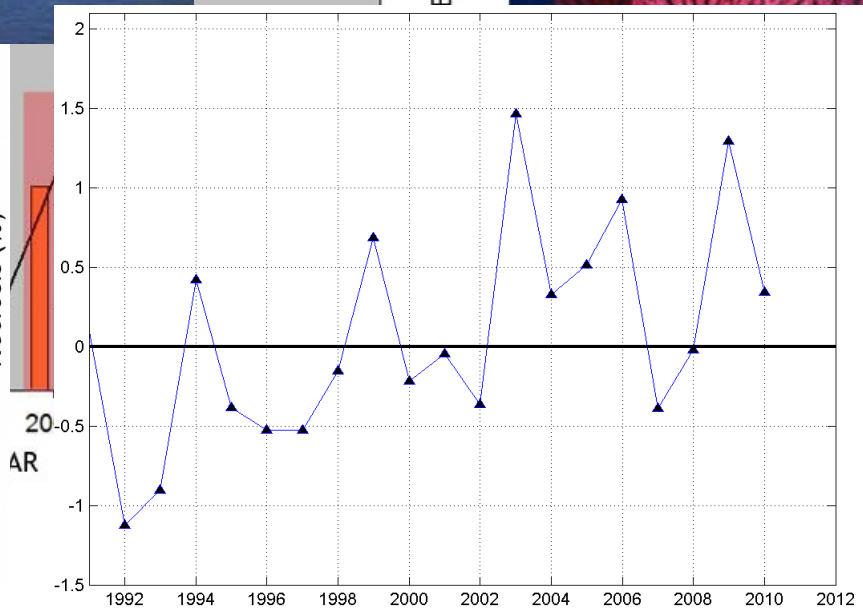
Sea Surface Warming from Satellite observations & links with Mass Mortality Events

CONDITIONS DURING MASS MORTALITY EVENTS

23ºC
25 ºC
Affected colonies
60
50







In situ

MedSpiration

FOR SEA SURFACE TEMPERATURE

How does ocean seasonality drive habitat preferences of highly mobile top predators? Part I and Part II *(Lambert et al., 2016)*

→ aerial surveys data conducted over north-western Mediterranean Sea during winter 2011–2012 and summer 2012

→ **L4 SSTs (in terms of mean, variance and gradient) are used as environmental predictors** in Generalized Additive Models (GAM) for habitats modelling for four groups of cetaceans such as striped dolphins or fin whales and three groups of seabirds such as storm petrels and Cory's Shearwaters.

Striped dolphin is one of the species studied in Lampert et al, 2016 using Medspiration SSTs as environmental preditors for habitat modelling.

Contents lists available at ScienceDirect

Deep-Sea Research II

journal homepage: www.elsevier.com/locate/dsr2

Regular article

How does ocean seasonality drive habitat preferences of highly mobile top predators? Part I: The north-western Mediterranean Sea

C. Lambert [a,*], S. Laran [b], L. David [c], G. Dorémus [b], E. Pettex [b], O. Van Canneyt [b], V. Ridoux [a,b]

[a] Centre d'Etude Biologique de Chizé, UMR 7372 CNRS - Université de La Rochelle, Institut du Littoral et de l'Environnement, 17000 La Rochelle, France
[b] Observatoire PELAGIS, UMS 3462 CNRS - Université de La Rochelle, Systèmes d'Observation pour la Conservation des Mammifères et des Oiseaux Marins, 17000 La Rochelle, France
[c] EcoOcéan Institut, 18 rue des Hospices, 34090 Montpellier, France

Regular article

How does ocean seasonality drive habitat preferences of highly mobile top predators? Part II: The eastern North-Atlantic

C. Lambert [a,*], E. Pettex [b], G. Dorémus [b], S. Laran [b], E. Stéphan [c], O. Van Canneyt [b], V. Ridoux [a,b]

[a] Centre d'Etudes Biologiques de Chizé, UMR 7372 CNRS - Université de La Rochelle, Institut du Littoral et de l'Environnement, 17000 La Rochelle, France
[b] Observatoire PELAGIS, UMS 3462 CNRS - Université de La Rochelle, Systèmes d'Observation pour la Conservation des Mammifères et des Oiseaux Marins, 17000 La Rochelle, France
[c] A.P.E.C.S. (Association pour l'Étude et la Conservation des Sélaciens), 13 rue Jean-François Tartu, BP 51151 - 29211 Brest Cedex 1 - France

The Storm Petrel is one of the seabird groups studied in Lampert et al., 2016, using SSTs from Medspiration for habitat modelling.

Ongoing work and collaborations (1):

Spatio-temporal distribution of the order Cetacea in the Azores : relationship between biotic and abiotic variables.

→ Two month research stay : L. Gonzalez from the University of Vigo

→ The goal of the thesis is to study the temporal and spatial distribution of several cetacean species in the Azores Archipelago sighed from opportunistic whale watching platforms and to link their distribution with environmental variables (SST, Chl, …). In this on-going work, SSTs from Medspiration has been used as predictors in Generalized Additive Models

Fin whale and Spotted Dolphin : two of the species studied in L. Gonzalez's PhD Thesis.

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Medspiration products : applications
Medspiration products and studies related to marine ecology

Other research activities dealing with habitats modelling using SSTs from Medspiration are presented in *Racine, 2015, Vieira, 2010 and Virgili et al., 2014*.

Habitats modelling or migrations are also studied in a global change context :

How global change relates to the invasion of European coasts by non-native marine invertebrate, the Pacific oyster *Crassostrea gigas (*Thomas et al., 2016*, Journal Of Biogeography).*

⟶ « Effects of environmental variations on C. gigas physiology and Phenology studied using a bioenergetics model based on Dynamic Energy Budget theory. The model was forced with environmental time series including in situ phytoplankton data, and satellite data of sea surface temperature and suspended particulate matter concentration. »

→ Simulation outputs were successfully validated against in situ oyster growth data.

→ Poleward expansion of the invasive species C. gigas is related to global warming and increase in phytoplankton abundance. The combination of mechanistic bioenergetics modelling with in situ and satellite environmental data is a valuable framework for ecosystem studies.

Pacific Oyster, the main oyster species farmed in Europe today : a case study in Thomas et al., 2016

***A* cascade of warming impacts brings bluefin tuna to Greenland waters (MacKenzie et al., 2014, *Global change biology*).**

Decline of cold-water fish species in the Bay of Somme (English Channel, France) in response to ocean warming (Auber et al., 2017, *Estuarine, Coastal and Shelf Science)*.

A HMM-based model to geolocate pelagic fish from high-resolution individual temperature and depth histories *(Woillez et al., 2016)*

Method to geolocate fish from data storage tags.

The authors pressent a new HMM-based model that infers pelagic fish positions from the sole use of high-resolution temperature and depth histories.

A key contribution of their framework lies in model parameter inference (diffusion coefficient and noise parameters with respect to the reference geophysical fields—satellite SST and temperatures derived from the MARS3D hydrodynamic model), which improves model robustness.

As a case study, they consider long time series of data storage tags (DSTs) deployed on European sea bass for which individual migration tracks are reconstructed for the first time

European Sea Bass

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

A HMM-based model to geolocate pelagic fish from high-resolution individual temperature and depth histories: European sea bass as a case study

Mathieu Woillez[a,*], Ronan Fablet[b], Tran-Thanh Ngo[a,c], Maxime Lalire[a,d], Pascal Lazure[e], Hélène de Pontual[a]

[a] Ifremer, Sciences et Technologies Halieutiques, CS 10070, 29280 Plouzané, France
[b] Institut Telecom/Telecom Bretagne, UMR 6285 LabSTICC, CS 83818, 29238 Brest CEDEX 3, France
[c] Université de Strasbourg, ICube UMR 7357, BP 10413, 67412 Illkirch Cedex, France
[d] CLS, Space Oceanography Division, 8-10 rue Hermes, 31520 Ramonville Saint-Agne, France
[e] Ifremer, Laboratoire de Physique Hydrodynamique et Sédimentaire, CS 10070, 29280 Plouzané, France

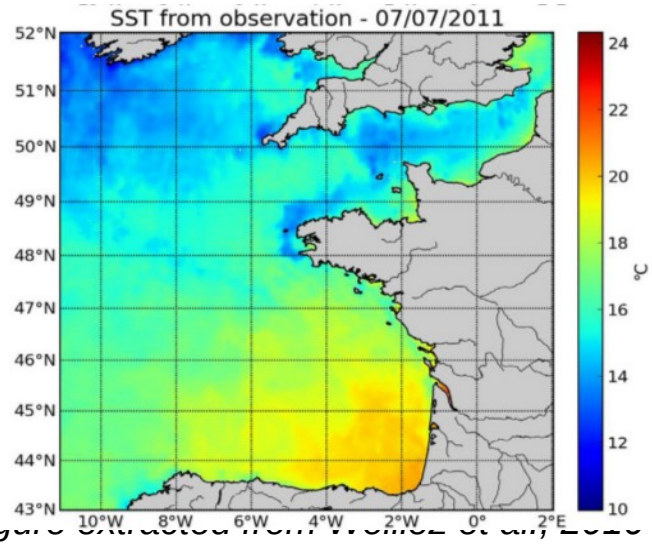
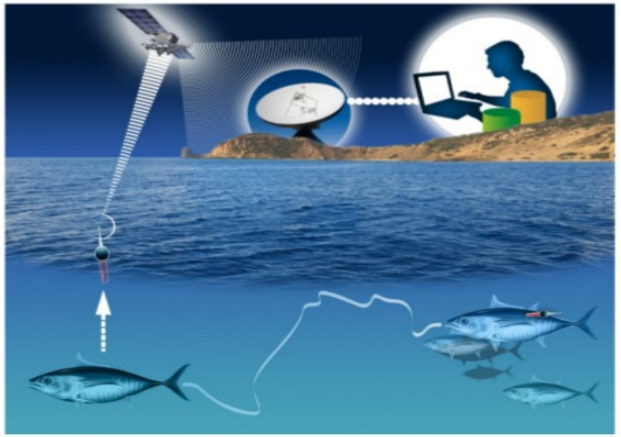


Figure extracted from Woillez et al., 2016 showing an example of the ODYSSEA/Medspi SST used in the this study.

Ongoing work and collaborations (2):



Geolocation and tracking fish (Tuna)

in the Northwestern Mediterranean (collab. Ifremer Sè

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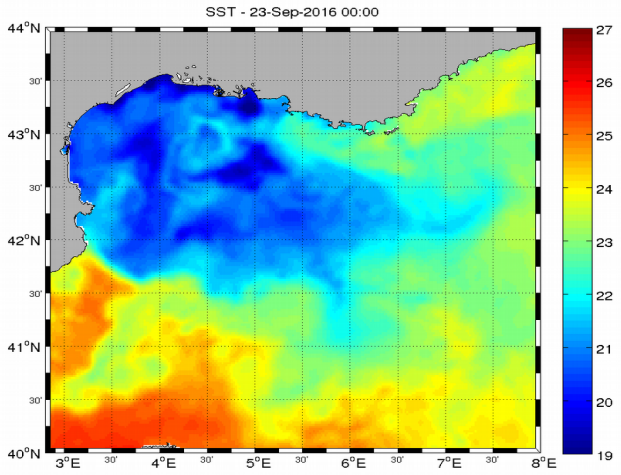
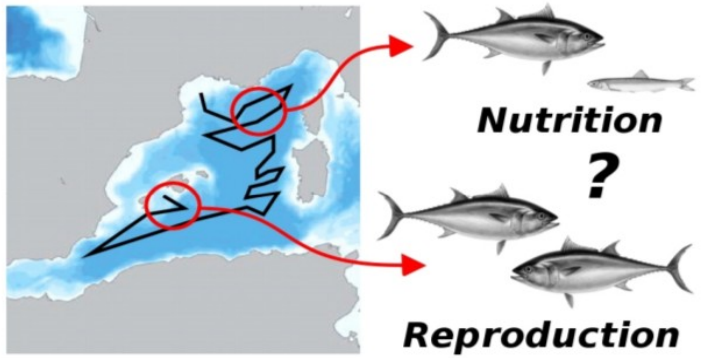




Submesoscale cyclones in the Agulhas Current (Krug et al., 2017, GRL)

In this study, Medspiration SSTs have been used to during the deployment of several gliders. Moreover, the analysis of the AC frontal variability using ODYSSEA SST observations has confirmed the increase in the meandering of the AC front south of 34°S as noted in a previous work. Figure shows some plots extracted from the publication. This figure presents the positions of the AC front estimated from ODYSSEA.

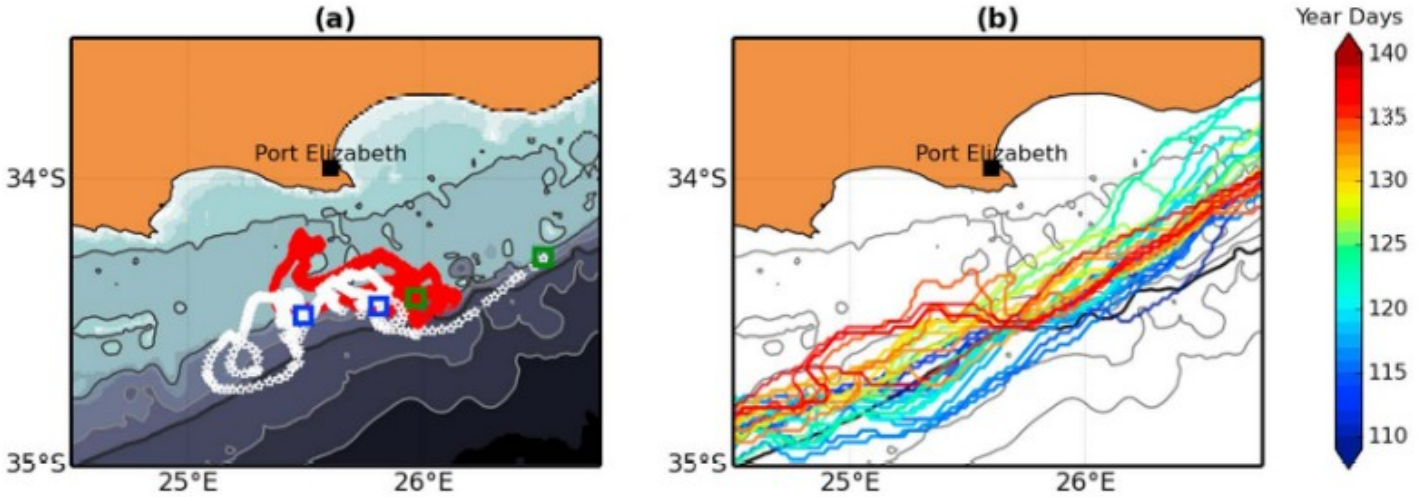
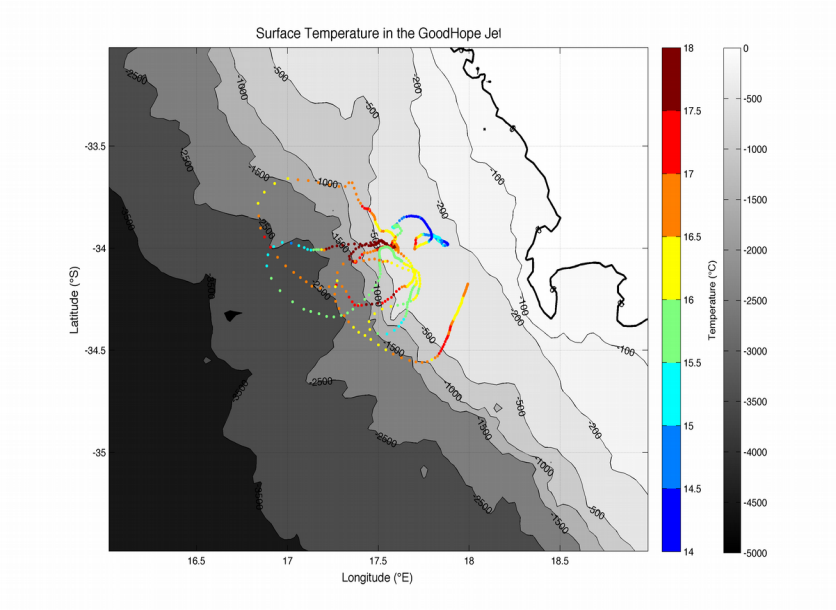
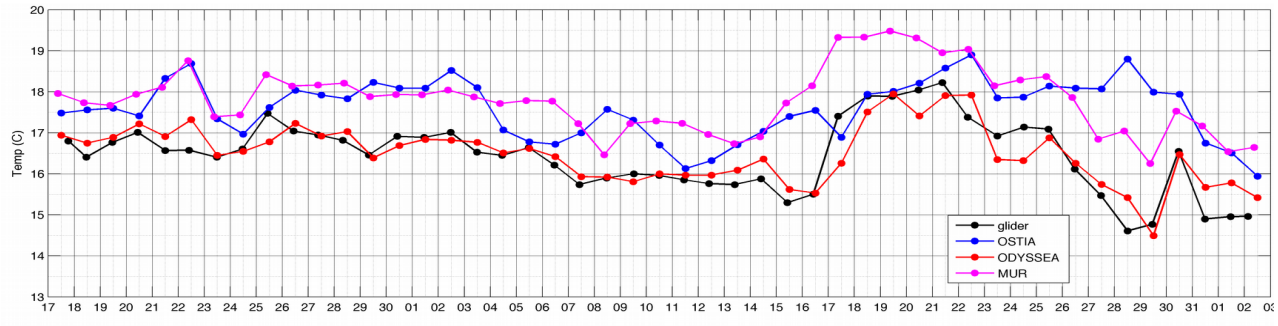


Figure 1. (a) Glider trajectories between year days 109 and 140. Deployment and recovery positions are plotted with green and blue squares, respectively. The gray color scale shows the bathymetry with darker tones toward the deeper regions and is overlaid with the 100 m, 200 m, 500 m, 1000 m (thick black line), 2000 m, and 3000 m isobath contours. (b) Location of AC inshore edge derived from the Odyssea SST between year days 109 and 140. The color bar represent days in 2015.

Figure extracted from Krug et al., 2017

Submesoscale cyclones in the Agulhas Current (Krug et al., 2017)





Comparison between satellite-derived SST products and temperature from one glider in the GoodHope jet (M. Krug)

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Thinking strings: Additional evidence for personal ornament use in the Middle Stone Age at Blombos Cave, South Africa

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Still Bay

ABSTRACT

Here we report on newly identified beads rec
and, in particular, on a cluster of 24 perforated
single beadwork. Contextual information, mo
published beads and those recently found, c
allow us to reconstruct the most probable way
reveal unexpected regularities but also var
resulting from changes in beadwork manufac
document one of the first examples of chang
symbolic material culture.

Research background

In the past decade, personal ornaments have played a central role in the debate on the origin of behavioural modernity and language (Ambrose, 1998; McBrearty and Brooks, 2000; Kuhn et al., 2001; Henshilwood and Marean, 2003; d'Errico, 2003; d'Errico et al., 2003; Wadley, 2001, 2003; Vanhaeren, 2005; Chase, 2006; Kuhn and Stiner, 2006, 2007; White, 2007; Zilhão, 2007; Botha, 2008; Klein, 2008; Henshilwood and Dubreuil, 2009; d'Errico and Vanhaeren, 2007, 2009). Beads represent a behaviour specific to humans whereby standardized items are displayed on the physical body to project symbolic meaning that can be interpreted by members of the same or other groups that share a common culture. For this reason, early instances of bead use are generally regarded as evidence for the existence of complex communication systems (Henshilwood and Dubreuil, 2009, 2011; but see; Botha, 2008; Wynn and Coolidge, 2007).

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E-mail addresses: m.vanhaeren@pacea.u-bordeaux1.fr (M. Vanhaeren), f.derrico@pace.a.u-bordeaux1.fr (F. d'Errico), karen.niekerk@ahkr.uib.no (K.L. van Niekerk), christopher.henshilwood@ahkr.uib.no (C.S. Henshilwood), rudolph.erasmus@wits.ac.za (R.M. Erasmus).

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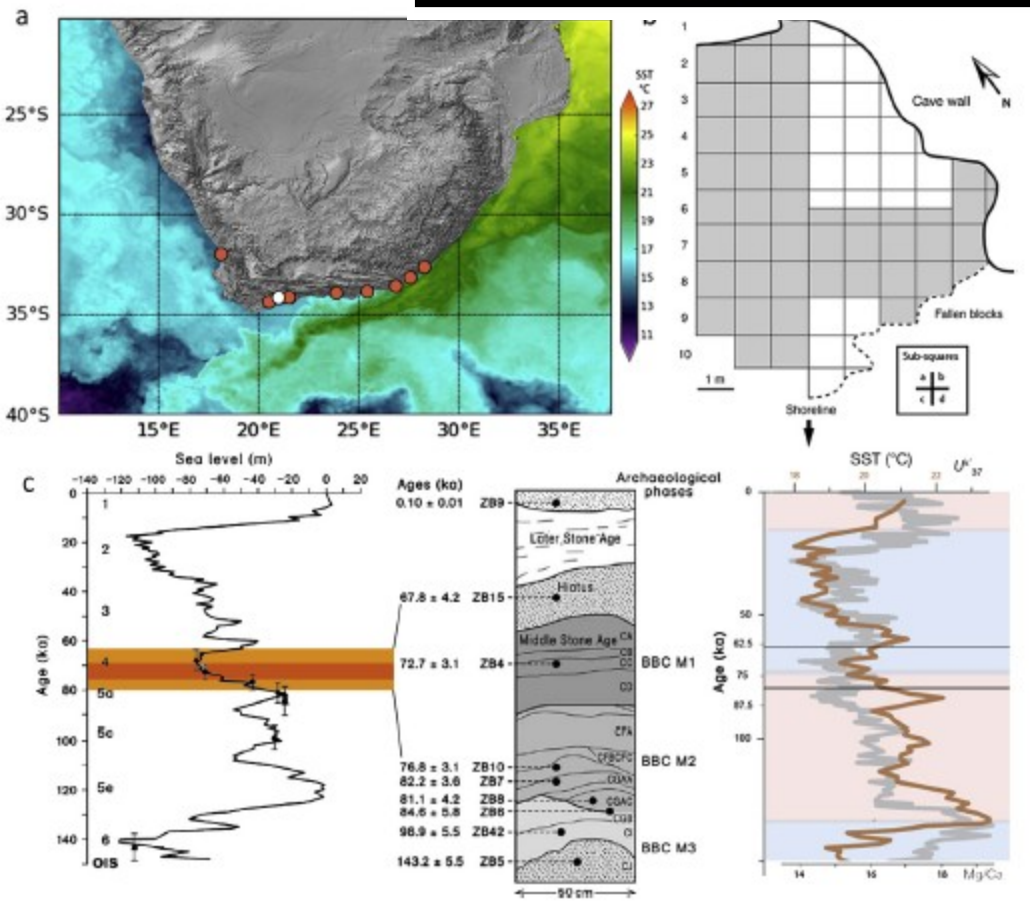
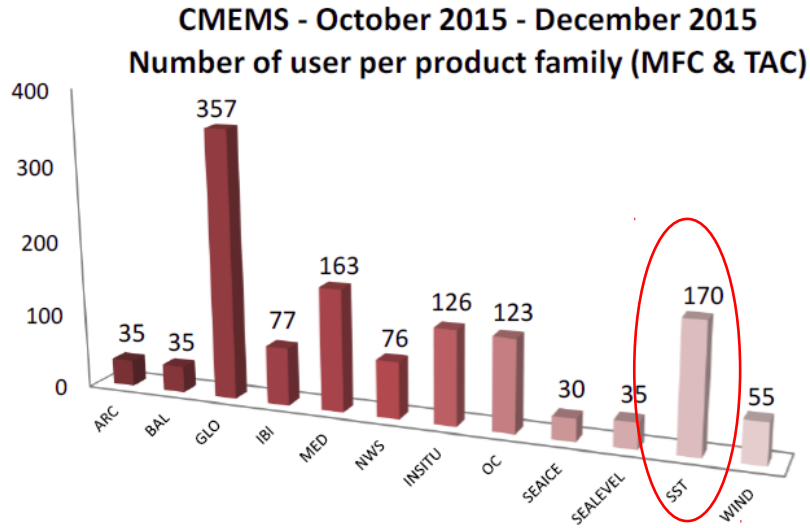
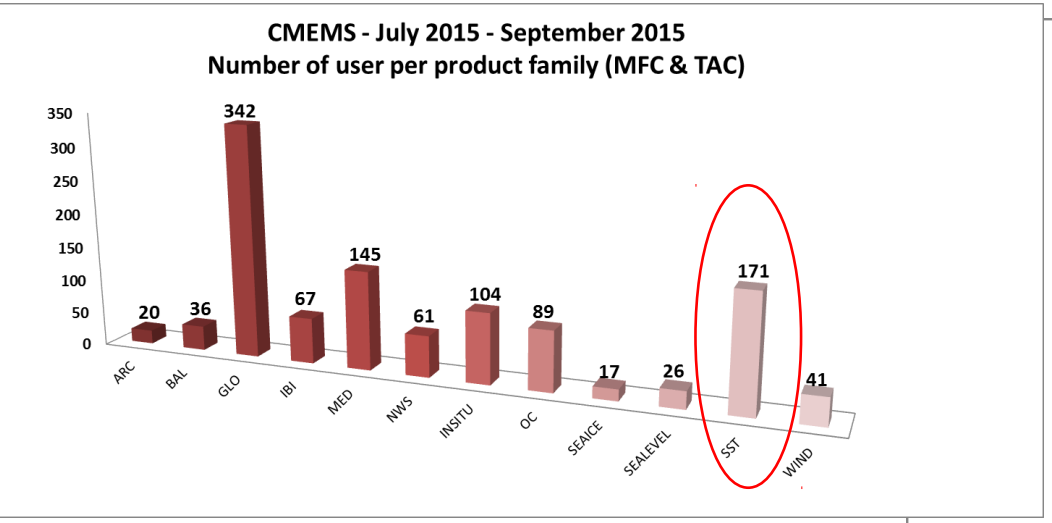
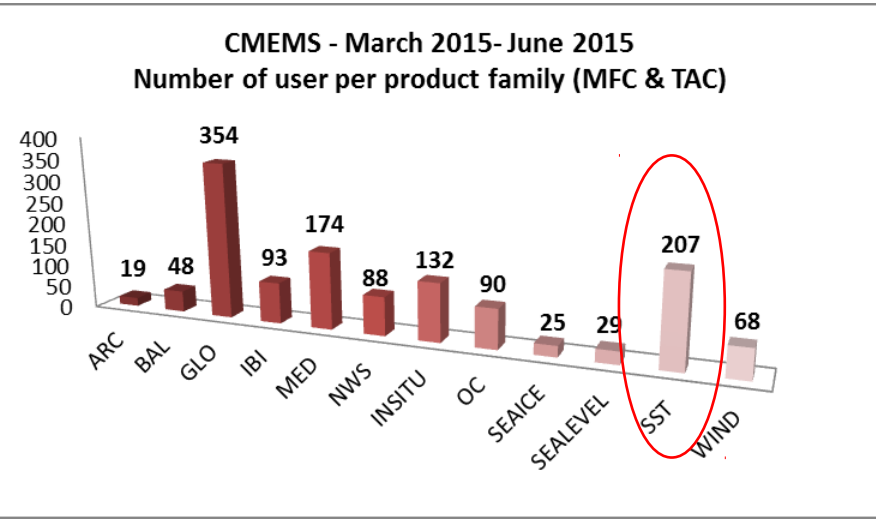


CMEMS product distribution

SST products (L3 and L4) highest requested observation products







Legacy and lessons learnt

achievements

- **first implemented and operated node of GHRSST system**, with the first initial set of L2P products produced and available within a less than 12 hours latency
- complete development of a **distributed real-time production system** in about 7 months – still used today
- **Drove extension of Coriolis** scope to ocean surface measurements from ships, drifters and moored buoys
- **First high resolution (2km) merged products** readily produced and available in less than 24 hours every day, initially over Mediterranean Sea with the later addition of North-Western shelves
- **successful transition to European operational frameworks**
- follow-on of the team build up for Medspiration as **a nucleus group in operational projects** keeping on with continuous and shared improvements of SST products and methodologies
- AATSR established as **reference sensor** for multi-sensor calibration, thanks to NRT availability of Medspiration L2P
- **support** to identified end-user projects

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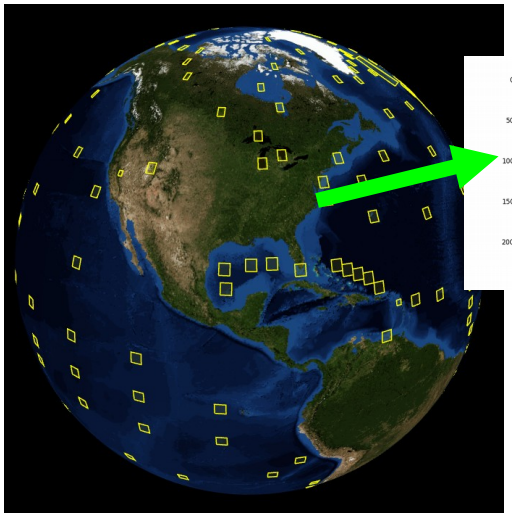
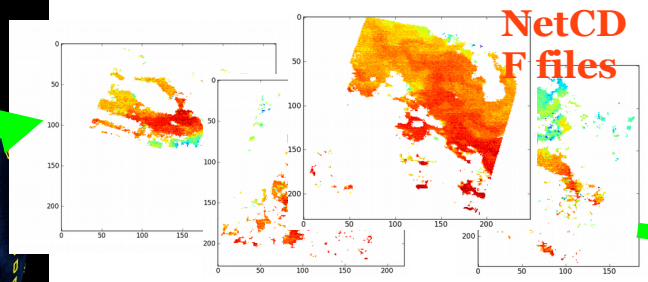
Tools and services heritage



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glob_010_v2.1
 percentage_coverage_of_site_by_miniprod:
100.0
 date_modified: 2014-04-18T10:30:21
 felyx_site_identifier: ukm005
 date_created: 2014-04-18T10:30:21
 time_coverage_start: 2013-01-01T00:00:00
 time_coverage_stop: 2013-0101T00:00:00

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 ice_presence: 0
 cloud_presence": 46.80
 day_or_night: "night"
 mean_wind_speed: 4.8388
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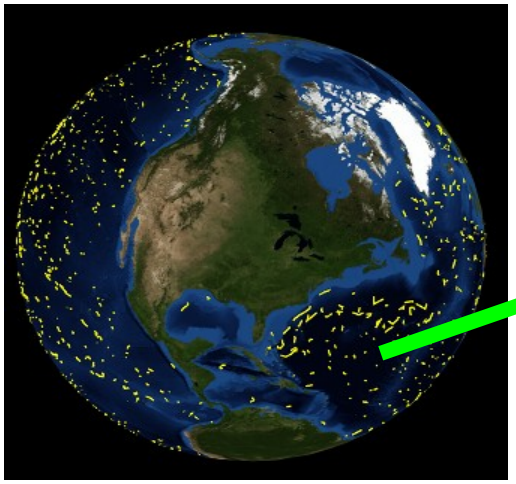

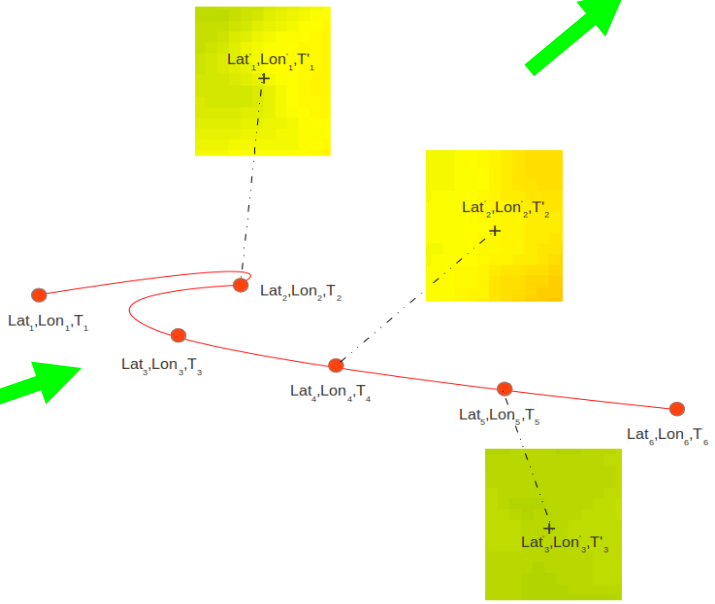

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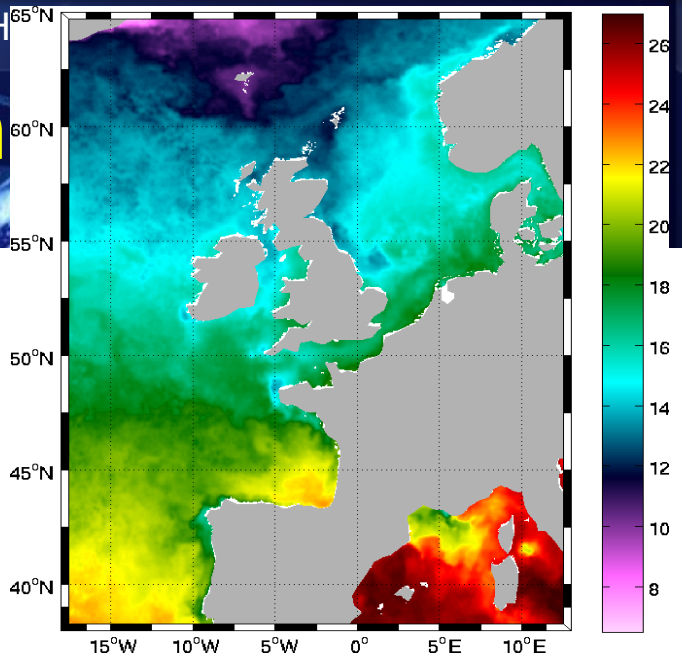
Lessons learnt : products

- L2 products still an issue for a lot of users
  - ✓ Still largely prefer L4 products
  - ✓ Can be an issue as users see « L4 » as same but just easier to user => definition, resolution, gap filling issues
- Users request both **long time series** and **updated** products
  - ✓ Short lived demonstration products of poor interest (unless specific usage with identified user)
  - ✓ Confidence issue
  - ✓ **Transition to operational frameworks help with that but also limit offer and innovation in a domain where there are still a lot of shortcomings**
- request for real-time is not the majority (more focused on « access to any day »)
- Need better « visual » assessment, interactive tools, demonstration or simplified products

Lessons learnt : users, organization

- 250 registered users, more than 50 publications identified but difficult to track down
- DOIs may help to improve citation and user tracking
- benefit in terms of publication come several years after demonstration phase, most of the research activities were published recently (2012-2017)
- Reaching out user community takes time, usually beyond 2 year demonstration phase
- Reaching out new user communities require pro-active support (mini project, use case, …) that was implemented at a later stage in Medspiration
- Do help to bring experts together and build up team cooperation that will last beyond project frame
- operational frameworks help avoiding team to disband at least in first stage when direct heritage
- Operational frameworks tend to freeze improvement and innovation : innovative or demonstration companion projects are still needed

Future product imrpovemen



- Need for long time series, good effective resolution
- Possible improvements :
  - ✓ **Temporal consistency => New REP NWS CMEMS product using a Kalman smoother (1982-2014)**
  - ✓ **Gradient field => Enhanced resolution of SST fields from gradient transformation**

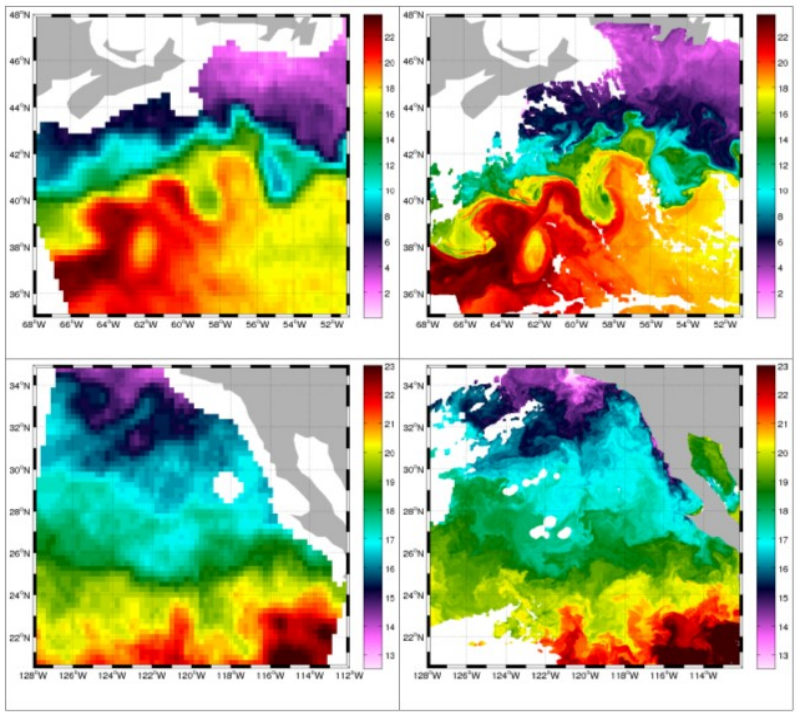
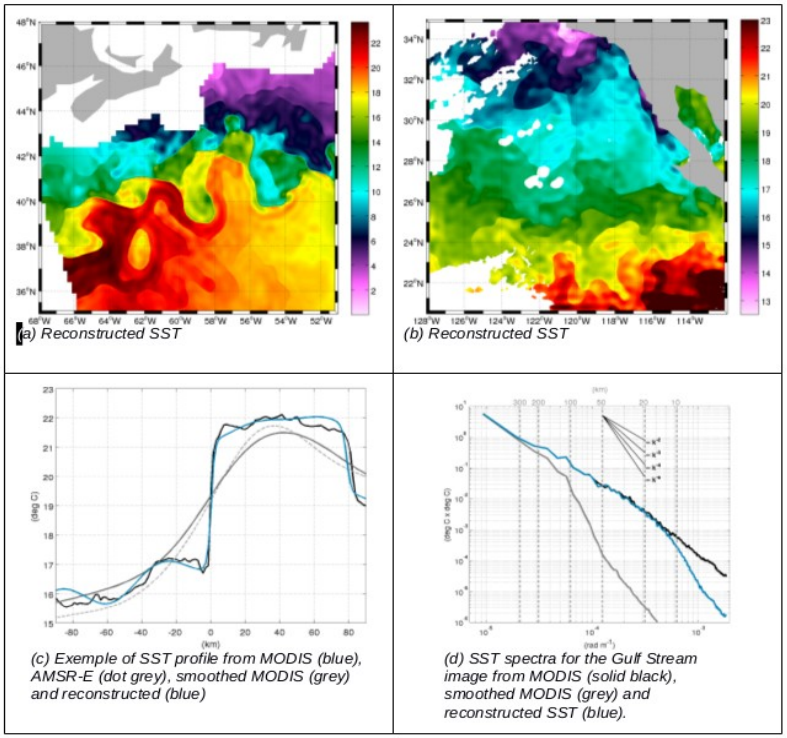


Figure 1: AMSR-E (left) and MODIS (right) SSTs on 6 May 2010 (top) and on 29 March 2010 (bottom).



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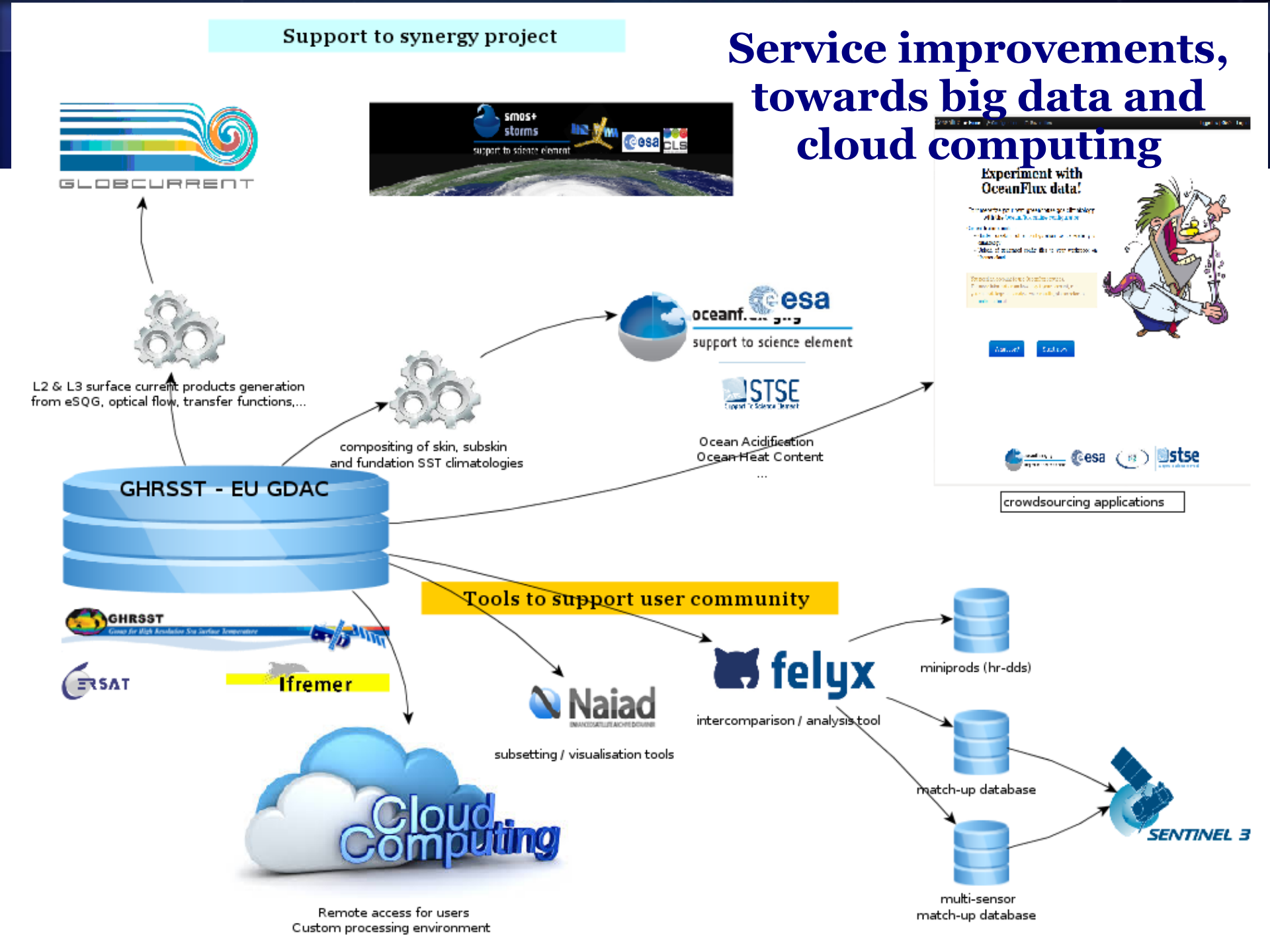
Service improvements, towards big data and cloud computing



Conclusion

- From operational perspective
  - ✓ First operating node of GHRSST network
  - ✓ Medspiration was a seed and model for European operational oceanographic RT services
    - Performance and timeliness high requirements
    - Data homogenization
    - Processing platform
    - Data quality assessment and monitoring services
- Bridged the gap to operational and sustained services
- Supported, spawned and fueled other projects (GlobWave, GlobCurrent,…)
- Will survive beyond project frame
    - Implemented software & hardware is sustained
    - **Data production is sustained on a best effort basis for regional products**

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