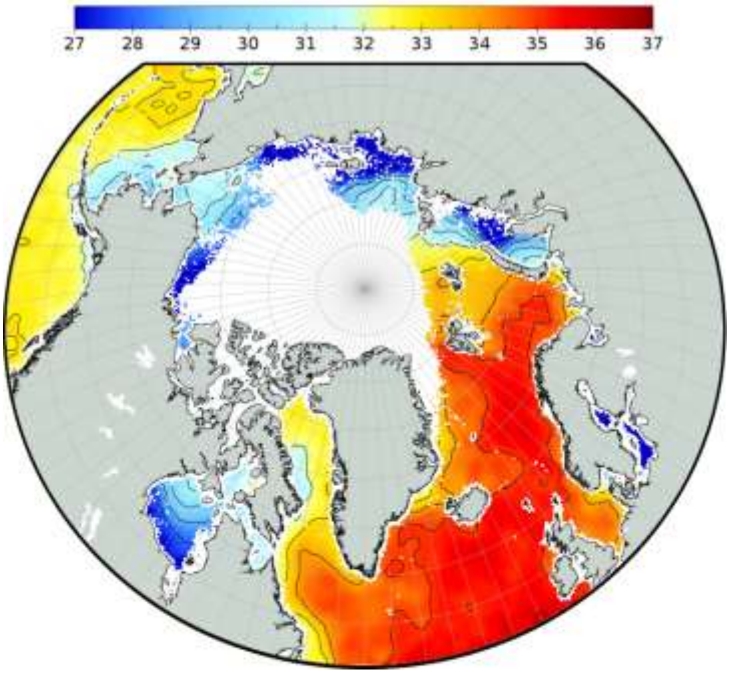
Arctic+ Salinity

Response to ITT AO/1-9158/18/I-BG



Detailed Proposal

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Arctic+ Salinity

ITT AO/1-9158/18/I-BG

Proposal

This is a proposal by

ARGANS LTD, United Kingdom

With sub-contractors:

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Acronyms

AD	Applicable document
ADB	Actions database
AMOC	Atlantic Meridional Overturning Circulation
ATBD	Algorithm theoretical basis documents
BRO	Brochure
CliC	Climate and Cryosphere
DIR	Directory
DS	Dataset availability
DS-UM	Dataset user manual
DVP	Development and validation plan
EC RTD	European Commission Directorate General for Research and Innovation
EDS	Experimental dataset
EMI	Electromagnetic Interference
EO	Earth Observation
EOEP	Earth Observation Envelope Program
ESA	European Space Agency
FR	Final review
FWF	Freshwater fluxes
GCOS	Global Climate Observing System
IAR	Impact assessment report
ITT	Invitation to tender
IPP	Year of Polar Prediction
KO	Kick-off
MR	Monthly report
MTR	Mid-term review
MV-TN	Modelling and validation technical note
NDVI	Normalized Difference Vegetation Index
PAR	Preliminary analysis report
PGICs	Peripheral glaciers and ice caps
PM	Progress meeting
PMP	Project management plan
RD	Reference document
RB	Requirements baseline
SAR	Synthetic Aperture Radar
SIAR	Scientific and impact assessment report
SMOS	Soil Moisture and Ocean Salinity
SoW	Statement of work
SR	Scientific roadmap
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
TDP	Technical data package

TDS	Training Data Set
TN	Technical note
VIR	Validation and intercomparison report
VR	Validation report
WCRP	World Climate Research Programme
WP	Work package
WS	Workshop minutes
WWRP	World Weather Research Programme

1 Scientific Part

1.1 Scientific Requirements and Objectives

Addresses requirements: SOW-2.1.1

1.1.1 Understanding of the scientific challenges and project requirements

In recent years, the Arctic Ocean has been under significant transformation as shown by numerous in situ and remote sensing measurements. The temperature of the upper layer of the Arctic Ocean has been increasing and more solar heat has been absorbed by the increasing ice-free areas [Serreze et al., 2007; Haas et al., 2008; Comiso, 2012]. The latest observational and modelling studies have documented changes in the upper Arctic Ocean hydrography [Haine et al., 2015]. In particular, an increase of liquid freshwater content over both the Canadian Basin and the central Arctic Ocean has been observed. This increase of freshwater has been linked to an intensification in the large-scale anticyclonic winds and to sea level pressure changes [Zhang et al., 2016]. An increased Bering Strait freshwater import to the Arctic Ocean, a decreased Davis Strait export, and the enhanced net sea ice melt could as well have played an important role in the observed freshwater trend [Rabe et al., 2014]. The importance to monitor changes in the Arctic freshwater system and its exchange with subarctic oceans has been widely recognized by the scientific communities [Prowse et al., 2015, Carmack et al 2016]. Among the key observable variables, ocean salinity plays a critical role of linking the freshwater components in atmospheric, terrestrial and cryospheric water cycles through ocean circulations [Wijffels et al. 1992, Durack et al., 2015].

Furthermore, rivers are the most important sources of freshwater – comparable to the sum of freshwater from the Pacific Ocean and precipitation-minus-evaporation – and stratify the upper Arctic Ocean, so that changes in the river runoff could have a strong impact on the Arctic system. [Nummelin et al. 2015, Carmack et al. 2016] It is also well known that an increment of the global mean annual temperature will produce an increase in the discharge of Arctic rivers [Peterson et al., 2002; Mulligan et al., 2010]. As seen in the 2015 update of the Arctic Report Card the combined discharge of the eight largest Arctic rivers was 10% greater in 2014 than their average discharge during the 1980-1989 period [NOAA, 2015]. However, the precise impact of an increase of the Arctic freshwater runoff remains unknown due to the lack of salinity measurements in the Arctic. Therefore, improving the observations of high latitude SSS will help to improve both the models and the forecasts of the changes taking place in such a critical region.

The acquisition of continuous series of salinity at high latitudes is a difficult task, as the Arctic is a very remote region with extreme weather conditions and sea ice forces strong enough to destroy the in situ infrastructure (like Argo floats, moorings or gliders). The number of in situ surface salinity measurements are therefore very scarce, and especially inside the Arctic Ocean making the validation of any satellite products a difficult task. Figure 1 shows the number of historical observations used in the generation of the World Ocean Atlas 2013 (WOA2013), [Zweng et al. 2013]. Notice that besides being very scarce, the geographical distribution of the observations is very inhomogeneous.

The use of L-band radiometry, and specially the SMOS mission, to fill the observational salinity gap at high latitudes, plays a key role to better determine and monitor the observed changes on the freshwater fluxes.

The SMOS standard SSS retrieval algorithm [Font et al., 2008; Mecklenburg et al., 2009; Kerr et al., 2010], as well as the algorithms used for SSS retrieval from Aquarius and SMAP data [Yueh et al. 2013, Yueh et al. 2014, Tang et al. 2013 and Tang et al 2015], provide in general good estimates of SSS in waters the open ocean and within the tropical and mid latitudes. However, SSS retrievals from the current operating L-band satellites still an on-going challenge due to the signal to noise ratio over those regions.

Some works assessed the quality of SMOS and Aquarius SSS products at high latitudes. Köhler et al., 2015 performed a comparison of previous versions of SMOS and Aquarius products with in situ measurements and models in the north Atlantic region, but they did not perform any comparison inside the Arctic Basin. Garcia-Eidell et al., 2017 carried out a comparison of that SMOS SSS maps and three other SSS products derived from Aquarius against thermosalinograph vessel transects and the CORA5.0 collection of in situ data [Cabanes et al., 2016]. The results showed that all the products attain reasonable quality in the Arctic Ocean, and especially SMOS derived products showed to be of great benefit for observing SSS in those regions.

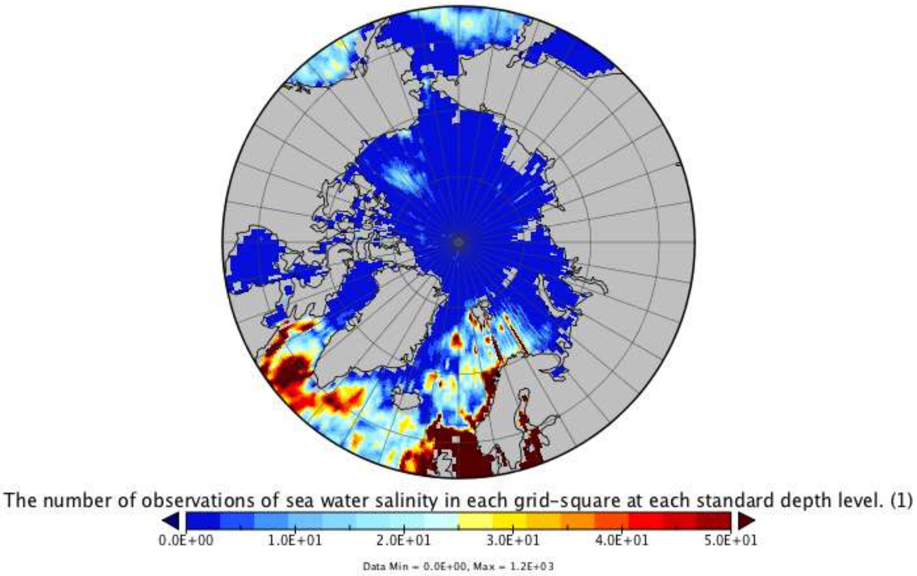

Figure 1: Number of observations per 1° at 10m depth for the period 2005-2012 (WOA 2013 [Zweng et al. 2013])

The objectives of this proposal are:

1. *Develop a new algorithm and novel approaches with the aim of* ***producing the best quality SSS product of the Arctic region of well-characterized accuracy. SMOS and SMAP data will be combined*** *with the aim to improve the radiometric accuracy and the characterization of the product biases and stability. Due to the already mentioned particular issues at high latitudes, devoted algorithm development and specific quality control analyses is required.*

2. ***Generate a long term salinity dataset*** *from 2011 up to date to be publicly offered to the scientific community, and in particular will be shared with ArcFlux team to explore synergies.*

3. ***The observed dynamics and its link with Arctic processes****, as for example freshwater flows, E-P, ocean circulation will be studied.*

4. ***Assess the relation between the dynamics of SMOS salinity with*** *land* ***freshwater fluxes*** *(Greenland and glacier flows) and ocean freshwater fluxes (rivers and E-P) using model outputs. This has the objective to quantify the freshwater fluxes with SSS products.*

5. *Assess the* ***impact*** *of the* ***new data in a data assimilation system*** *(the TOPAZ4 system, both in forecast and reanalysis mode) with the idea that if an improvement is demonstrated the assimilation of SMOS & SMAP products on TOPAZ will become the new Arctic reanalysis and forecast products on the CMEMS portal.*

6. ***Roadmap description** of future work to better characterize the Freshwater fluxes for the Arctic regions. The output of this project will be of great benefit for the on-going ESA Sea Surface Salinity Climate Change Initiative project, which was approved last February 2018. Moreover, close collaboration with Artic+ ArcFlux, Arctic+ Ice and Arctic+ Snow teams is expected (see Annexe 5, Letters of Support from ARCFLUX and IsardSAT).*

1.1.2 Discussion of scientific problem areas

Changes in the ocean circulation in the Arctic and sub-polar regions have been observed, especially on North Atlantic. Moreover, the higher rate of melting of the Greenland Ice Sheet and the Canadian Arctic has produces a change on the freshwater fluxes. This changes on the freshwater balances in the Arctic can have an impact on the clime system at global scale.

L-band radiometry plays a key role on retrieving SSS but, presents serious problems at high latitudes, due to several factors. Some of those problems are general for retrieving SSS at any latitude, but some others are produce for performing the acquisitions on cold waters.

The main scientific and technical problems to derive the satellite salinity product at high latitudes with good accuracy are listed below:

- **Low sensitivity of TB to salinity at cold waters**: Although the L-band frequency offers almost the maximum sensitivity of the brightness temperature to SSS variations, this is rather low (Zine et al., 2008). In cold waters, the sensitivity of the TB to salinity decreases rapidly (Swift and McIntosh (1983)). As shown in Yueh et al. (2001), such sensitivity drops from 0.5 K/psu to 0.3 K/psu, when SST decreases from 15 C to 5 C. Therefore, the errors of the SSS at cold waters are larger than at temperate oceans.
- **Land-sea contamination (LSC) and ice–sea (ISC) contamination**: The presence of a sharp discontinuity in brightness temperature due to the transition between sea and land or between sea and sea ice induces a contamination of the signal which is especially important (both in amplitude and spatial range) in the case of SMOS although it is also present in SMAP and in its predecessor, Aquarius. This type of contamination has an impact on the ocean observations very far from the coast and the ice.
- **A seasonal biases affecting the SMOS**: this bias is described in Martín-Neira et al., 2016, and produce an effect on the measured TBs. In the official SMOS product, this was partly mitigated with the use of the OTT (Ocean Target Transformation). This is almost unnoticeable in the SMAP TBs.

1.1.3 Detailed description of the scientific solution proposed

To produce a SSS pan-Arctic product with high accuracy and to reduce the problems described in section 1.1.2, we propose the following algorithms:

- A study to identify which of three different dielectric constant models (Klein and Swift, Meissner and Wentz, and George Washington University) is more appropriate for cold oceans will be assessed. These models and analysis is explained in detail in WP310 description. Therefore, the use of the optimal model would r**educe the bias** which might be large **due to the low sensitivity of TB to the salinity at low temperatures**.
- The use the novel approach called **Debiased non-bayesian algorithm,** which is explained in detail in the WP100, is described in Olmedo et al. This methodology permits to **reduce the land sea**

contamination considerably. Moreover, the SSS accuracy improves when using these algorithms instead of the standard salinity retrieval methodology (Zine et al. 2008). However, this algorithm cannot correct for the sea -ice contamination, since this sea ice edge is moving with time.

- **A time-dependent bias correction** is needed in order to mitigate the effect of **seasonal biases** on the TBs. The time-dependent bias correction proposed in here is the one presented in [Olmedo et al, 2017] which will be adapted for Arctic region processing. No OTT is being used in this methodology.

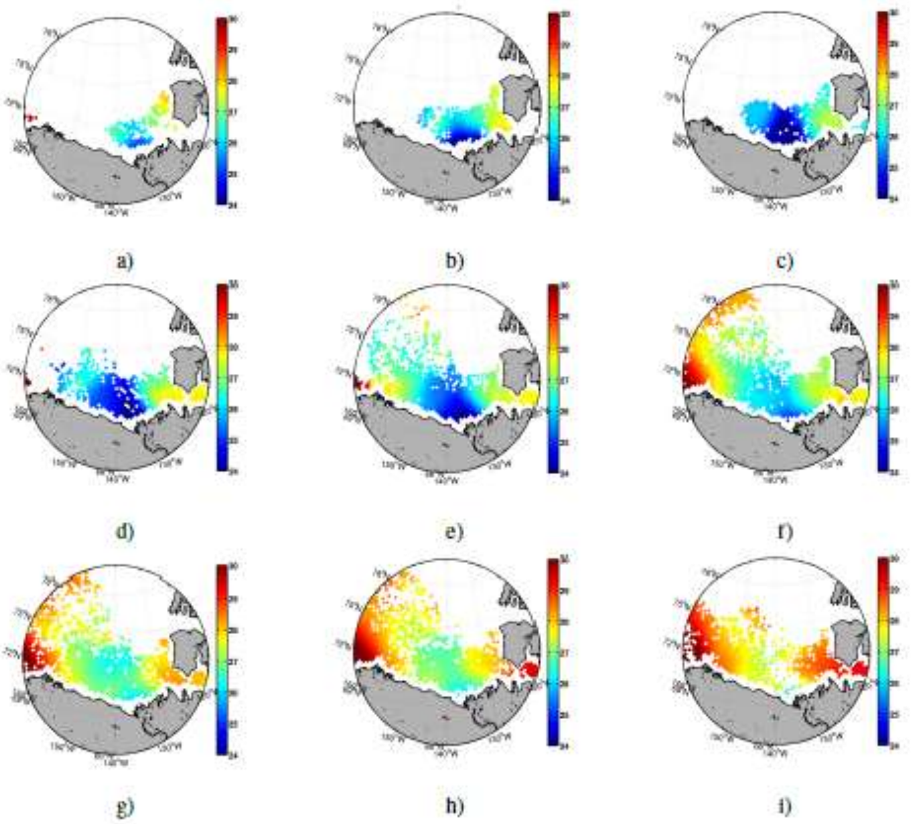

Figure 2: Debiased non-Bayesian advanced SMOS SSS 9-day maps at high latitudes distributed by BEC. The plots show the freshwater evolution close to the mouth of the Mackenzie river for June to October 2012: From a) to f): 15-24th June: 1-10th July; 15-24th July;1-10th August; 15-24th August; 1-10th September; 15-24 September; 1-10 October; 15-24 October.

1.2 Potential problem areas

1.2.1 Identification of the main scientific and technical problems or problem areas likely to be encountered in performing the activity

Some of the problems we might face during the execution of the work are listed below:

- One of the main limitations in the Arctic dataset is the **lack of a large in situ dataset** to perform a solid validation, especially in areas of largest SSS anomalies (river estuaries, coastal zones). This is especially important on the Russian basin since very few data from the acquired by Russian teams are public.

- The **sea-ice contamination** produces a TB variation nearby the ice edge which is produce by the Gibbs effect. For the moment not techniques have been described to reduce this effect. During this work, some techniques will be assessed but not sure of the exit of the result.

- **Radio Frequency Interferences (RFI):** The eventual presence of RFI can harm or even render useless the data in the Arctic Seas, even if the emitter is very far away especially in the case of SMOS due to its interferometric character [Martín-Neira et al. 2016]. The usual strategy to reduce the amplitude of the artefacts induced by such external perturbations (ripples and other Gibbs-like effects) is to apply a Blackman window to the Fourier components of the brightness temperature.

1.2.2 Proposed solutions to the problems identified

The table below details the potential problem and the response strategy foreseen at this stage.

Table 1: Identified problems and associated response strategy

Description	**Response Strategy**
Insufficient validation data, especially in areas of largest anomalies	We will use as many data as possible, combining the in situ measurements from ARGO floats, measurements from thermo-salinographs and CTD acquired during several transects and campaigns in the region, fixed buoys measurements, etc. However, public data in the **Russian bassin** is very scarce, so the quality assessment on that region will be not very reliable. A comparison with the output of numerical models (TOPAZ) will be assessed, especially on the region where no in situ data is available.
Remaining systematic errors: ice/sea contamination	The debiased non-Bayesian retrieval algorithm permits to reduce the land-sea contamination but not the ice-sea contamination, since the sea ice edge is moving this time. The methodology to reduce it will be examined here.
Effect of the satellite falling under the Earth's eclipse zone	Some studies are now being carried on by ESA staff members and ESL team analysing the Tp7 drift. No specific intervention on this topic is planned up to now in this proposal. But if needed, we could try to use the methodology proposed by the ESA ESL L1.
Eventual presence of RFI in the future	RFI is not a main problem in the Arctic region. During the beginning of the mission few RFI were detected in the North Atlantic and Canada. In 2012 an antenna located in Greenland was turned off. Not special intervention is planned on this topic, but if during the work large RFI are detected some techniques developed at BEC could be used to reduce it. One of the methods is the Nodal Sampling technique (Gonzalez-Gambau et al., 2017). Recently, a new method to reduce and detect the RFI main lobe, based in band-pass filtering the TB images, has been developed also at BEC (Martinez et al. 2018). Our staff has also contributed to develop techniques devoted to detect the RFI sources (Huyk et al., 2017).

SMAP/SMOS spatial coverage discrepancies.	The level 4 algorithm used to create maps from SMOS and SMAP data will be designed to deal with different coverages between both sources without introduce jumps in the resulting SSS maps. A technique that can be used is to compute the salinity gradient provided by both sources and apply a weighted average depending of the distance to the region that is only covered by one of them. A flag field could indicate the region in which only one of the sources is present. The spatial integration of this reconstructed gradient field should provide a continuous salinity map.

1.2.3 Proposed trade-off analyses and identification of possible limitations or non-compliances

1. One of the main limitations in the Arctic dataset is the lack of a large in situ unified in situ dataset to perform a solid validation. We will use as many data as possible, combining the in measurements from ARGO floats, measurements from thermo-salinometers and CTD acquired during several transects and campaigns in the region, fixed buoys measurements, etc. However, public data in the Russian basin is very scarce, so the quality assessment on that region will be not very reliable.
2. The sea-ice contamination produces a TB variation nearby the ice edge, which is produce by the Gibbs, effect and is not physically true. At the moment of writing this proposal there was not a methodology designed to reduce such frequency contamination. Hence there will an assessment of all the methodology developed within this project aiming to reduce the effect of the sea-ice contamination. However, at this stage it is not possible to determine the level of improvement of the resulting SSS product.
3. Effect of the satellite falling under the Earth's eclipse zone. Specific methodology to correct the decrease of the physical temperature of the receiver reduce is under study in the ESA ESL. This is out of scope of this proposal.

1.3 Programme of work

1.3.1 Proposed Work Logic and scientific approach

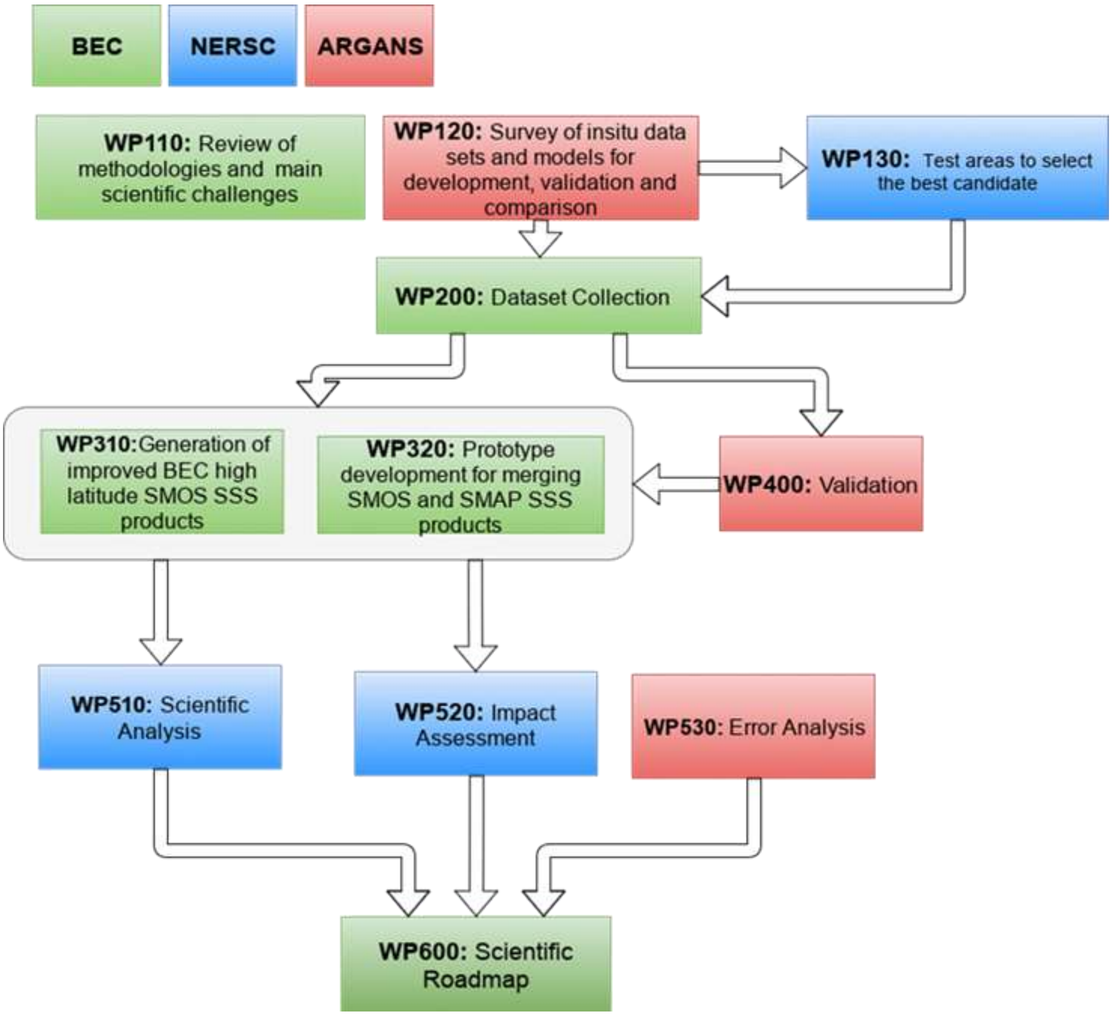

Figure 3 Workflow showing the logic of task development contained in each work package within the Arctic+ Salinity project

1.3.2 Contents of proposed work

Addresses requirements: SOW-3

1.3.2.1 Detailed description of Tasks 1 to 5

Task 1: Scientific Requirement Consolidation (WP100)

Addresses requirements: SOW-3 Task 1

The main freshwater inputs to the Arctic are according to Carmack et al. (2016) river runoffs (about 4.000 km^3/yr); net precipitation (about 2.000 km^3/yr) and other low salinity water input through Bering Strait (about 2.500 km^3/yr). Although these sources are modulated by the freeze/melt cycle of sea ice and its motions, the variations of freshwater inputs will be visible as variations of regional sea surface salinity content. As stated in the introduction of this proposal, in situ observation in region are scarce and especially those measuring the salinity content at these latitudes. Therefore, continuous SSS satellite observation may be especially relevant to close the salinity budget in the Arctic region.

With the purpose of contributing to the studies of freshwater fluxes in the Arctic, the Arctic+ Salinity project established close relationships with the already existing Arctic expert community including the ArcFlux team, which is an ongoing ESA-funded project (arcflux.eu). As there is a clear common scientific interest between our project Arctic+ Salinity and Arctic+ ArcFlux there is an existing intention of active support between both scientific communities (see Annexe 5: ARCFLUX supporting letter).

The scientific requirement consolidation will include a review of existing methodologies (WP110) and a survey of all the available in situ observations (WP120) to measure the saltiness of the ocean in the Arctic.

WP110: Review of methodologies and main scientific challenges

The use of remote sensing platforms to fill the salinity observational gap at high latitudes has a great potential. However, they also have some limitations: the sensitivity of the L-band measurements at salinity changes decrease drastically with colder oceans. This lower sensitivity should be added to other limitations that has to face the SSS retrieval which is, indeed, common for all latitudes: land-sea contamination and RFI, earth eclipse over the SMOS sensor, model function, among others as explained before.

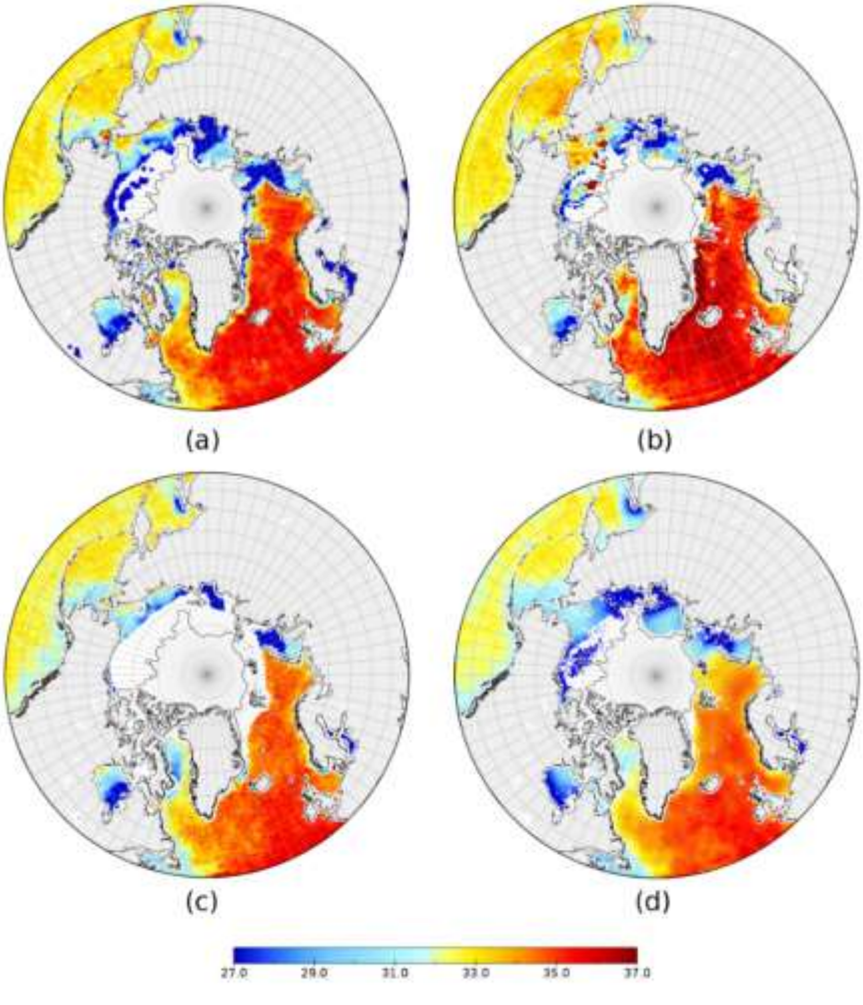

Figure 4: Arctic salinity according to 8-days maps from SMAP (left) and 9-days maps from SMOS (right). (a) Global SMAP JPL v4.0. (b) Global SMOS debiased Locean v2.1. (c) Global SMAP REMSS v2.0 (d) Arctic SMOS product proposed

by BEC using the current debiased non-bayesian algorithm. Maps are centred at September 7, 2015. Black line around the pole indicates an ice fraction of 0.5 according OSTIA.

Global SMAP/SMOS SSS products

Currently, most of the SMOS and SMAP SSS maps available for the Arctic are subsets of the global ones. Different teams are producing global L3 SSS datasets from SMOS and SMAP measures:

- Jet Propulsion Laboratory (JPL) produces global SMAP SSS product version 4.0 (smap.jpl.nasa.gov). JPL dataset is available via PODAAC website (Physical Oceanography Distributed Active Archive Center podaac.jpl.nasa.gov).
- LOCEAN produces the new version 2.1 of its debiased SSS maps departing from operational L2 processor of SMOS (www.locean-ipsl.upmc.fr/smos). This dataset is distributed by the "Centre Aval de Traitement des Données SMOS" (CATDS www.catds.fr)
- Remote Sensing Systems (REMSS) currently produces version 2.0 of its global SMAP SSS product (www.remss.com). This dataset is available from the REMSS website. It is expected that they will distribute a new version of this product this summer.

Arctic details of these global products are shown in Figure 4 (Plots (a) to (c), respectively).).

In order to retrieve the sea surface salinity from the brightness temperature measured by the satellites, it is necessary to introduce a sea water dielectric model through the known as flat sea emission model. Several dielectric constant models are proposed in the literature and the adopted models are different in the operational processing of SMOS and SMAP data. The operational processing chain of the SMOS data uses Klein and Swift model (K&S) [Klein and Swift, 1977] whereas SMAP data (and Aquarius data) is processed using the Meissner and Wentz model (M&W) [Meissner and Wentz, 2004]. The largest difference between both models takes place in cold waters. However, it is still unclear which model is most suitable for the retrieval of the salinity at high latitudes. This is especially important at cold waters since the sensitivity is lower and is where the maximum difference is observed.

Specific Arctic SMOS SSS products

The Barcelona Expert Centre (BEC, bec.icm.csic.es, part of the ICM-CSIC group) is currently distributing version 1.0 of its Debiased non-Bayesian Advanced product for Arctic through its distribution and visualization data service (http://bec.icm.csic.es/ocean-experimental-dataset-high-latitude-and-arctic-sss/). This newly released BEC product especially designed to target Artic region is the only one on its kind. Figure 3 shows the processing algorithm diagram. Currently available SMOS SSS product at high latitudes covers three years (2011-2013) of the SMOS mission. Figure 4 (plot (d)) shows a 9-days map of this product.

The computation this product is based on the debiased non-Bayesian algorithm introduced in [Olmedo et al. 2017] and it is executed at the SMOS L1B Brightness Temperatures (TB) provided ESA. The galactic [Tenerelli et al. 2008], sun glint [Reul et al. 2007] and roughness [Guimbard et al. 2012] contributions are corrected using auxiliary information provided by ECMWF [Sabater and De Rosnay, 2010] similarly to what is done in the official ESA SMOS L2 SSS products. The dielectric constant model proposed by Meissner and Wentz (M&W).

The TB measurements are geo-referenced using a 25-km resolution Equal-Area Scalable Earth (EASE) North Pole grid [Brodzik and Knowles 2002], and maps are pan Arctic from 50ºN up to the north pole.

[Olmedo et al. 2017] introduce important changes with respect to the standard processing (see [Zine et al. 2008 and Gabarro et al. 2009]) used in the ESA SMOS L2OS processor:

a) **Debiased non-bayesian algorithm:**

- Individual retrievals: the retrieval follows a non-Bayesian scheme, which means that for each SMOS TB a single value of SSS (single-SSS) is retrieved.
- Characterization of the systematic errors: All the SSS retrieved under the same acquisition conditions, i.e. the same location (grid point), incidence and azimuth angles and satellite flight direction (ascending/descending) are accumulated in a SSS distribution. The systematic errors have been estimated by computing the central estimator (the mode) of the corresponding SSS distributions. No Ocean Target Transformation (OTT) is applied since the systematic errors are already accounted for with the new methodology.
- Filtering criteria: The statistical properties of the above SSS distributions are also used for filtering poor quality measurements.
- Computation of SMOS anomalies: SMOS debiased SSS-anomalies are computed by subtracting the corresponding SMOS-based climatology value to each single-SSS data, therefore removing local biases, especially those produced by LSC, ISC and permanent RFI.
- Computation of absolute SSS: The absolute SSS is then generated by adding an annual SSS reference. The WOA2013 SSS annual climatology has been considered here.

b) **Objectively analysed maps:** Objectively analysed 9-day 25-km resolution SSS maps are generated daily. The correlation radii used are the same as the ones used for the climatology WOA2013.

c) **Time-dependent bias correction**: Finally, an additional time-dependent bias correction is needed in order to mitigate the effect of seasonal biases ([Martín-Neira et al., 2016]). The time-dependent bias correction proposed in [Olmedo et al, 2017] will be adapted for Arctic region processing.

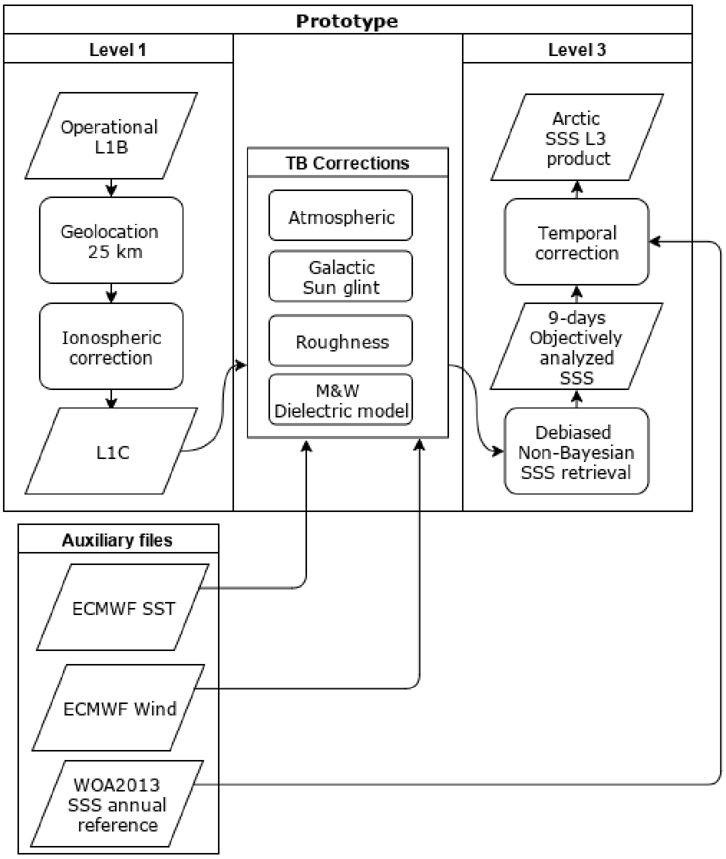

Figure 5: BEC processing algorithm diagram to produce the SSS high latitudes dataset which are freely distributed at BEC website.

Even a great improvement is obtained by using this methodology, this dataset has still some limitations and there is still room for improvements which will be studied in WP310.

WP120: Survey of in situ data sets and models for development, validation and comparison

For development and validation purpose, this project will use a broad number range of in situ datasets including ARGO floats, Eulerian and Lagrangian buoys, and ship based measurements (e.g. TSG, CTDs, etc.). However, as explained above, the measurements are scarce and they are not homogeneously distributed, i.e. neither in space nor in time. This is especially important in the Russian Basin, since few in situ data are publicly available.

To minimise the risk of low the foreseen low in situ observations (see WP400), the Artic+ Salinity project strategic plan include an insightful comparison of the new developed SSS satellite products against TOPAZ, that is a state of art Arctic ocean model developed by NERSC.

Along the course of the Artic+ Salinity project might be possible that the amount of in situ observations may change (i.e. exchange of information with both CCI+SSS and PiMEP projects may provide new insights on in situ data collections). Therefore, following there is a list of the already available in situ observations, but this might vary upon future availability new dataset:

- **Filtered Argo floats** data close to surface (less than 10m depth). ICM-CSIC maintains a local mirror of the Argo floats database [Argo, 2000] that is refreshed twice a day. Nevertheless, delayed Argo data is very sparse in Arctic as can be inferred from Figure 4 (right).
- **CTD and TSG data from the CMEMS** In Situ TAC (Including Norwegian monitoring cruises in the Barents Sea). See figure 6 centre. http://marine.copernicus.eu

  TARA expedition dataset: during the spring and summer 2013 the TARA ship traversed both the Northeast and Northwest passages in a single season to research plankton biodiversity in the Arctic and other parameters of the ocean. The schooner had a thermo-salinograph system permanently measuring while circumnavigating the Arctic Ocean (see figure 6 left). So validated salinity measurements inside the Arctic Ocean are available during several months from 2013 thanks to this campaign. https://oceans.taraexpeditions.org/en/media-library/photos/2013-tara-oceans-polar-circle/
- **Oceans Melting Greenland (OMG)** from NASA-JPL: has the objective to improve the estimates of sea level rise. Over a five-year (starting in 2016) campaign, OMG will observe changing water temperatures on the continental shelf surrounding Greenland, and how marine glaciers react to the presence of warm, saline Atlantic Water. Each year in the summer they will deploy 250 expendable temperature and salinity probes along the continental shelf. This data is public in the webpage and will be very useful for validation in the Greenland region. https://omg.jpl.nasa.gov/portal
- **Cargo ship data** from a Voluntary Observing Ship Nuka Arctica from Bergen to Baffin Bay (http://nuka.uib.no) available at LEGOS on http://sss.sedoo.fr, also likely within the CMEMS INS TAC data.
- **The UDASH data from AWI** (https://doi.pangaea.de/10.1594/PANGAEA.872931)

In the webpage of the project there will be the link of all these datasets collections.

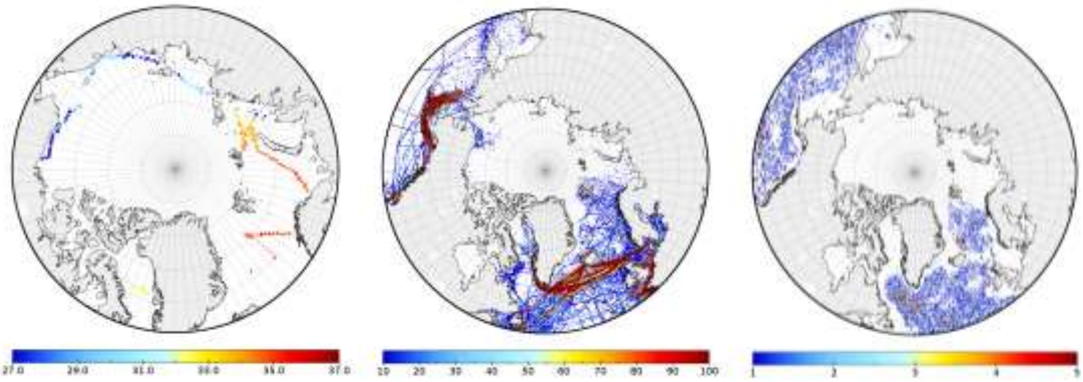

Figure 6 Left: TARA expedition SSS dataset. Centre: Number of in-situ measures provided by Copernicus Marine Environment Monitoring Service (CMEMS). Right: Number of measures provided by delayed ARGO profilers. Data contained in the centre and right figures are grouped in a 0.25°x0.25° grid and comprise the whole period 2011-2017.

WP130: Test areas to select the best candidate

Test areas are regions well characterised with abundant in situ measurements, which will be used for development and validation of the prototype optimal products.

The test areas should be selected covering a wide area of representative situations: North Atlantic for the changes observed in the AMOC; main river discharge regions with large salinity variability; regions with large sea ice melting as Laptev or Siberian seas; regions with great land ice melting close to Greenland, among others.

In order to get a robust statistical analysis, the selection of test areas is constrained upon the availability of sufficient in situ observations. This task will build up on the work done by the ArcFlux project, which already identified two test regions (i.e. Greenland and Austfonna) for land ice discharge and three test regions for river outflow near the mouth of the main Arctic rivers (i.e. Lena, Yukon, Mackenzie, Yenisey, Kolyma and Ob' rivers).

Task 2: Dataset collection (WP200)

Addresses requirements: SOW-3 Task 2

Dataset collection will be divided in three groups:

- Ancillary data used to produce the proposed SSS Arctic product.
- TOPAZ4 model for Arctic SSS dataset for visual checks.
- In-situ data suitable to be used as validation dataset: data from moorings, TSGs transects, CTD, TARA campaign and OMG.

The format used to distribute the data will be NetCDF-4 using Climate and Forecast conventions CF-1.7. All data will be provided in the same grid and spatial resolution as the product (EASE-Grid 2.0 azimuthal projection at 25 km).

Ancillary data used to produce the SSS product will be composed by ice mask, wind speed and sea surface temperature. These ancillary fields are constantly provided to BEC as an Expert Support Laboratory (ESL) for SMOS L2 Ocean Salinity and it will be interpolated to the same temporal and spatial resolution as the product. The data is provided in the SMOS original grid (ISEA 4H9) for every satellite orbit and will be included in the SSS EASE-Grid 2.0 and 9-days maps. A user requirement survey will be performed to determine if any other grid is preferred for Arctic mapping. TOPAZ4 SSS model for Arctic is a dataset to be used for sanity checks of the final product (which should not be dependent on one ocean model or another) It is currently distributed by CMEMS using a spatial resolution of 12.5km and daily-mean temporal resolution (see further description in WP500). It will be interpolated and distributed in the same spatial and temporal resolution of the final SSS product.

In situ data will be also distributed for validation purposes. According to [Peralta-Ferriz and Woodgate, 2015], the Arctic mixed layer depth varies strongly seasonally. Also it changes among the different basins and seas. Nevertheless, it seems that a cut-off depth for in-situ measures about 10 m should be good enough as representative of the mixed layer salinity value except for regions covered by seasonal ice melt. Therefore, in situ data provided by moorings, TSG and CTD will be considered above this depth.

Quality control should be applied to these in situ datasets before to distribute them. In the case of Argo profilers no measurements shallower than 5 m are used because their Conductivity, Temperature and Depth (CTD) probes stop pumping water above this depth. Profiles from BioArgo (i.e. newly deployed Argo floats equipped with new biometric sensors as from the newly approved Norwegian NorArgo infrastructure) and those included in the greylist (i.e. list of floats which may have problems with one or more sensors) will be discarded. Additional quality control filters will be used as the use of World Ocean Atlas (WOA) 2013 as an indicator; only profiles having a temperature close to surface between −2.5 and 20 °C and a salinity between 2 and 36 PSU will be used.

After the quality control is applied, the different in-situ datasets will be distributed, as the rest of the datasets, in the same spatial and temporal resolution as the final product including their own associated error.

All these datasets will be distributed using a THREDDS Data Server (TDS). THREDDS (https://www.unidata.ucar.edu/software/thredds/current/tds/) is a web server that provides metadata and data access for scientific datasets, using OPeNDAP, OGC WMS and WCS, HTTP, and other remote data access protocols. The TDS is developed and supported by Unidata, a division of the University Corporation for Atmospheric Research (UCAR), and is sponsored by the National Science Foundation. NcWMS [Blower et al, 2013] is a Web Map Service (WMS) intended to serve multidimensional gridded environmental data. ncWMS can read the NetCDF format with the Climate and Forecast conventions. This WMS has been widely adopted within the environmental data community (even it has been included as a default WMS in TDS) and will be used to show ancillary and final products in a similar way in which it is used currently by BEC (ICM-CSIC) (http://bec.icm.csic.es/ncWMS).

Task 3a: Development (WP300)

Addresses requirements: SOW-3 Task 3

WP310: Generation of improved ICM-CSIC high latitude SMOS SSS products

The currently available SMOS SSS product at high latitudes (freely available at http://bec.icm.csic.es/ocean-experimental-dataset-high-latitude-and-arctic-sss/) covers three years (2011-2013) of the SMOS mission. In this WP, we will extend this period to the full period of SMOS with and some improvements will be tested. The general Arctic+ Salinity improvements in the algorithm development include:

- **New product grid:** In the previous version the TB measurements are geo-referenced using a 25-km resolution Equal-Area Scalable Earth (EASE) North pole grid [Brodzik and Knowles 2002], with maps being pan-Arctic from 50˚ N up to the north pole. A survey to assess the most convenient grid will be done. However, for the moment, we assume the grid will be updated to the new version (EASE-Grid 2.0) [Brodzik and Knowles 2002] in order to minimize the spatial interpolations in the generation of the merged product.

- **To assess the best dielectric constant model on low temperature waters**: The dielectric constant model proposed by Meissner and Wentz (M&W) [Meissner and Wentz, 2004] is used nowadays, instead of the model defined by Klein and Swift (K&S) [Klein and Swift, 1977] which is used in the official SMOS Ocean Salinity Level 2 product. According to [Dinnat et al. 2014], the differences between M&W and K&S are small at low and mid latitudes, but they increase at high latitudes, i.e., cold waters. They conclude that for very cold waters (below 3°C), the salinity derived using M&W is significantly closer to in situ float measurements than those derived using K&S. Also note that the operational SMAP SSS products use M&W. Recently Zhou et al., from George Washington University [Zhou et al. 2017] have developed a new dielectric model (ZGW) focused on L-band. This model has been computed using a temperature range between 0°C and 35°C and salinity range between 30 psu and 38 psu. Therefore, ZGW's model seems to be a new good candidate to improve the salinity retrievals. A study in depth on the impact of using M&W, K&S or ZGW model will be assessed.

- **To assess the optimal climatology**: As shown in Figure 4, there are many regions in the Arctic with very few measurements (or none) of SSS and probably any reference may provide wrong SSS values in those regions. For this reason, to evaluate the impact of using different SSS references, we will generate a testing data set using two different annual references: WOA2013 (Zweng, 2013), which is the one currently used; the Polar science center Hydrographic annual Climatology (PHC) (version 3) [Steele et al., 2001] ; and Unified Database for Arctic and Subarctic Hydrography (UDASH) [Behrendt et al, 2017]. Therefore, we will compare in situ TSG data with these two SMOS SSS products. For this assessment we will use TARA expedition in situ which is, from the data we have, the only one that surround all the Arctic Ocean.

- **Study of the optimum correlation radii**: The choice of the correlation radii used in the OA should be analysed. This analysis might give different results than in a global scale since the high latitude SSS product noise is larger than the mid latitude products. This analysis will be done testing different radii and comparing them with ARGO SSS, the cases with lowest differences will be preferred ones. The largest correlation radii, the largest the smoothing effect, and therefore the lower the noise. However, if the radii are too large, we might reduce the capability of SMOS to reproduce the spatial dynamics of the region. So the selection of the radii is a trade-off between noise level and ocean dynamic.

- **Time-dependent bias corrected improvement**: This correction is need to mitigate the seasonal biases which affects the TB. Olmedo et al. 2017 propose subtracting the global mean of the SMOS SSS anomaly for each 9-day map. This assumption is appropriated for global SSS maps, as it implies that the total content of salt remains constant on time. However, this hypothesis applied regionally is not robust, since we cannot assume that the total content of salt is constant regionally. We will explore the possibility to use multivariate analysis to characterize and mitigate the time-dependent bias in the SMOS SSS maps.

- **Sea ice contamination and ice masking**: The ice sea contamination effect will be analysed and new algorithms might be proposed to reduce it. [Garcia-Eidell et al 2017] states that the BEC product has little coverage in the Arctic Basin because of poor sea ice masking. Therefore the ice masking should be revised. The ice mask used currently is the one given in OSTIA but other ice masks should be explored. The proposed candidate is the ESA Sea Ice CCI product (http://esa-cci.nersc.no/)

These improvements are indicated as orange boxes in figure 7.

WP320: Prototype development for merging SMOS and SMAP SSS products

Due to the lack of in situ measurements in the historical record and the foreseeable future, the production of SSS time series at high latitudes relies almost completely on the use of satellite platforms, i.e., SMOS and SMAP.

The debiased non-Bayesian approach (Olmedo et al. 2017) developed by ICM-CSIC retrieves L3 SMOS salinities at high latitudes directly from the SMOS L1b product. The L4 merged SSS product prototype will therefore be based on L3 products. Note though that L3 products from SMAP and SMOS have different temporal coverage, resolution and grid projection. Therefore, the L3 products to be merged will be generated from their corresponding L2 grid. The new prototype routines developed in this WP are indicated by blue boxes in figure 5.

Input Satellite data

In order to generate merged L4 product, the following satellite products will be used:

• SMOS Level-3 high latitude BEC product produced in WP310

• SMAP Level-2 JPL and/or REMSS products

The current dataset releases for SMAP JPL and SMAP REMSS products are v4.0 and v2.0, respectively. Nevertheless, if new versions are released, they will be integrated in the product generation (a new version of REMSS product is expected for summer 2018).

SMAP L2 Filtering

The SMAP Level-2 products contain brightness temperatures, quality flags and ancillary data from auxiliary files that will be used by the filtering algorithm. The exact filtering criteria depends on the sensor and product under consideration but it will be based on the guidelines followed by [García – Eidell et al, 2017] and the descriptions provided by REMSS [Meissner et al, 2016] and JPL [Fore et al, 2017].

L3 generation

Once the L2 SSS filtering is performed it is necessary to generate L3 maps in the same grid resolution and temporal window as the SMOS L3 high latitude BEC product. The Arctic remote sensing data users prefer to use equal kilometer grid instead of the rectangular grid (equal degrees) commonly used in the global products. A survey to assess the most convenient grid will be done. However, we start assuming to use the EASE2 grid, the new version of EASE grid (EASE-Grid 2.0, 25km resolution). This is the current SMAP L2 product grid and should be the grid of the future SMOS high latitude products.

The SMOS L3 product uses a temporal window of 9 days. Therefore, the SMAP L3 maps should be generated for the same time windows. The SMAP instrument provides global coverage every 8 days whereas SMOS every 9 days. Regenerating SMAP L3 products from L2 products avoids the use of temporal interpolation to get a uniform temporal resolution. This products will be generated with the same SMOS arctic products grid.

L4 generation

Merging L3 products from SMOS and SMAP is only possible for common operation periods. Therefore, the L4 generation will cover from April 2015 up to the present time. Temporal systematic errors of the different L3 products are expected to be characterized using intercalibration algorithms (e.g., triple collocation).

Since the L3 products have the same temporal and nominal spatial resolution, the construction of the merged L4 product can be done using a simple averaging of the L3 sources. Nevertheless, a more sophisticated technique is the so-called multifractal fusion [Olmedo et al 2016]. This is a blending algorithm combining two different variables with the only condition that advection is important on them.

In this case the fusion will be performed between SMOS L3 Arctic maps produced in WP310 and the SMAP L3 generated in this WP from REMSS and/or JPL L2.

The assessment of the spatial resolution of the resulting merged or aggregated product can be determined using the so-called singularity power spectra [Hoareau et al., 2018]. This powerful technique assesses the geophysical consistency of the different satellite-derived SSS maps and provides an indication of their resolved scales.

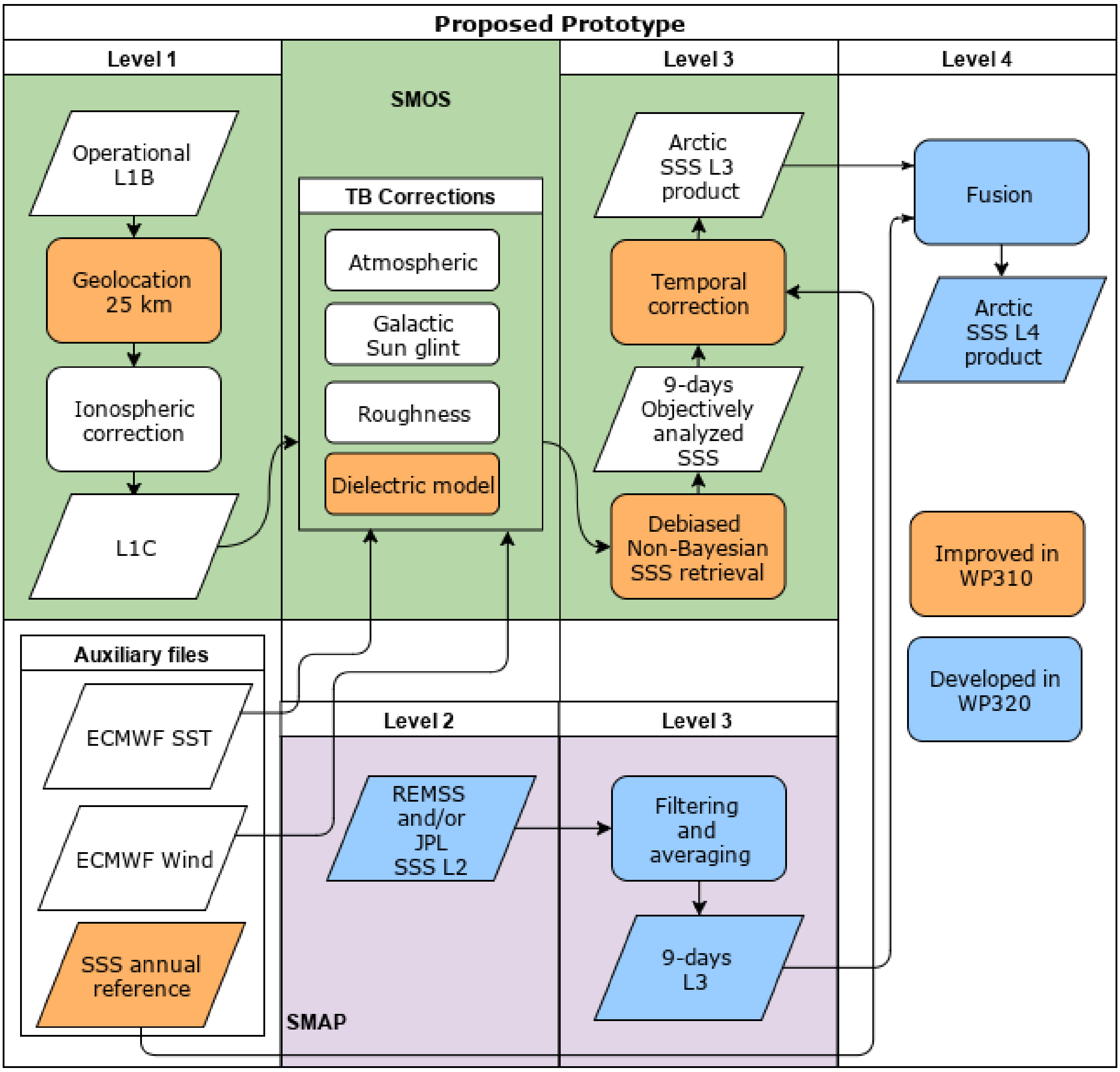

Figure 7: Proposed prototype scheme

Task 3b: Validation (WP400)

Addresses requirements: SOW-3 Task 3

The team decided to split the Task 3 "Development and Validation" for the following reasons:

a. To produce an assessment of the data quality generated at each iteration of the retrieval algorithm development that is performed by an independent team not associated to its production.

b. To allow for parallel execution of both activities and exchange of information that could be relevant for both activities performed by separated teams.

Nevertheless, certain degree of collaboration between the two groups working at each sub-task is important and relevant, as deficiencies/improvements spotted by the validation shall be taken into account into the algorithm development whenever is possible. In the same way, known limitations of the retrieval algorithm shall be communicated to the validation team.

The validation process is connected to the uncertainties estimation process. However, they are different branches of the same exercise (see Figure 8: Schematic overview of the general validation process., below). Technically speaking, validation is intended to ensure that the retrievals meet the product requirements specified in the Scientific Requirements Document (WP100) and will do so by means of datasets coming from additional and independent datasets.

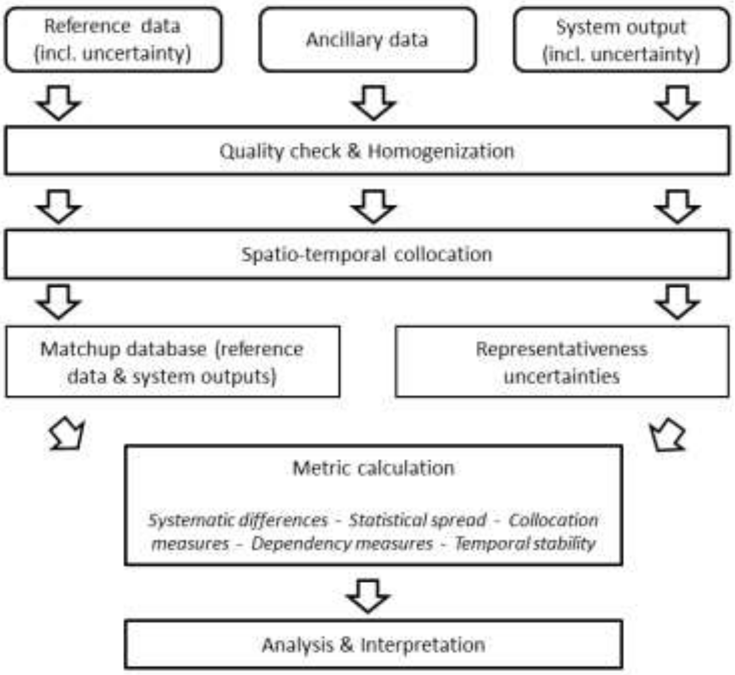

Figure 8: Schematic overview of the general validation process.

The full process requires the definition of a validation plan. Such plan defines the datasets that shall be generated by the development team for their evaluation (test datasets or TDS) plus any ancillary data that could be required for the task; it also establishes the conditions by which independent datasets are matched up with the data generated by the algorithm to perform such comparisons; it determines the scales of representativeness of such comparisons (spatial and temporal scales), taking into account the nature of the data used as reference in comparison with the data used to generate the product plus its specific output scales; and finally, it fixes the set of metrics that shall be used to determine the quality of the data generated and understand the shortcomings that shall be fixed prior final release of the software. When that is not possible, it will provide evidences that shall be taken into account for assimilation exercises and final uncertainties budget computation (Task 4 of the SOW, WP500 of this proposal).

The first step is to propose a list of candidate areas for its consideration in this exercise. The final set of test areas will be part of the Scientific Requirements document (WP100), to be completed during the first 3 months of the project and before the development starts. This means the list will be available before any validation exercise is done. Up to date, the scenarios under consideration are:

1. A river mouth to reflect impact in salinity of continuous freshwater plumes associated to rivers, with a high temporal variability and spatial distribution, (e.g. River Mackenzie outflow over the Canadian Arctic region).
2. Influence of melting continental ice, which is rather occasional but can cover vast areas of the Arctic (e.g. event in Greenland on April 2016) and introduce large changes of salinity that are not easy to predict or model, but in which satellites can contribute.

   Potential effect of ocean currents into the SSS dynamics or vice-versa with relevance for climate studies (e.g. the North Atlantic cold blob and its relationship with AMOC via superficial currents) *(Rothrock et al.*, 1999; *Francis and Vavrus*, 2012; *Josey et al.*, 2018).
3. Seasonal variations associated to the annual cycle of sea ice formation and melting (e.g. area surrounding Svalbard islands).

The development team will produce data over the final set of proposed test areas so they can be used in the validation exercise. These datasets will be contrasted against various sources of in situ data, including:

a. Estimation of fresh water fluxes by means of Oceans Melting Greenland (OMG).
b. Comparison against predicted values generated by HYCOM (commonly used in SMAP data processing).
c. Filtered Argo floats data close to surface (less than 10m depth) following a match-up protocol compatible with spatial and temporal scales.
d. CTD and TSG data from the CMEMS In Situ TAC when available for the test areas.
e. TARA transects when available for the final test areas.
f. Cargo ship data when available for the final test areas.
g. The UDASH data from AWI over the selected test areas, following also a match-up protocol compatible with spatial and temporal scales.
h. Any additional suitable dataset identified during WP100.

To prevent the introduction of a circular development in a scenario where in situ data is limited, these datasets will be used only over the test areas and for limited lengths of time, according to their scarcity and relevance. Performing the validation using the entire dataset of reference would be in conflict with the need to determine the errors, as established in Task 4 (WP500), due to the limited amount of data for validation and error estimation purposes. Hence it is common practice to use a smaller dataset fraction known as “training dataset” (or TDS) and use the total set for final estimation of the performance. The variety of independent sources used for the validation assures the availability of data for the exercise, plus also avoids that any possible “over-training” is introduced towards a specific data source. All datasets will be available as part of the activities of Task 2 (WP200).

To deal with the scale problems, the validation datasets will be matched-up and re-scaled adequately to the scales of the TDS generated by the development team. The match-up will take into account the following information:

a. Determine the integration time used for the TDS, understood as the number of hours, days, weeks or months of satellite data used to generate them.

b. Relate such integration times with the own time scales of the validation datasets. This is particularly relevant for ARGO and TSG data.

c. Re-scale spatially the samples to match the spatial resolution of the TDS, so information is compared at equivalent scales. This will be done having into account distance to the grid point or node and number of measurements falling within the cell to be produced.

d. When not possible, direct comparison of punctual measurements will be produced. This could be necessary when not enough data can be found in a given source to allow for this data pre-processing to match the scales.

e. Different resulting validation sets over a same test area will be also compared between them, particularly to understand their variability and offsets respect to satellite data and to other validation data sources.

The team will explore the possibility of using ESA Pi-MEP platform to support the validation once it is made available. Both ICM-CSIC and ARGANS have key personnel presented in this project as part of the Scientific Advisory Group of Pi-MEP. This role enables them to obtain some tailored services from the platform. As Pi-MEP is expected to be used as a validation platform form SMOS products, it makes sense trying to use it. However, it is necessary to test if the capabilities of Pi-MEP are aligned with the needs of this project and if it is also technically feasible to run the metrics on it. Nonetheless, this will be explored with both ESA and PI representatives of the Pi-MEP project.

The information about scales driving the match-up will come from the Scientific Requirements document and the Algorithm Theoretical Baseline document, in which the specifications of the test products shall appear. The team will define a match-up protocol according to such specifications.

For the validation purposes, a set of basic metrics is presented here, in order to estimate bias and noise of the provided TDS. These metrics will be computed over each test area, separately, and by comparing against each of the data sources taken into consideration. These are:

a. Mean of the differences between TDS and datasets of reference.

b. Standard deviation of the differences as mentioned above.

c. RMSE between TDS and datasets of reference.

d. Correlation coefficient between TDS and datasets of reference.

e. Exploration of the resulting time series and maps of the differences.

This set of parameters will help to the development team to understand the specific limitations of the TDS under the diverse conditions reflected in the test areas. This will help them to devise additional de-biasing techniques and noise reduction approaches to further improve the algorithm and enhance the quality of the final products.

In addition, in close collaboration with the development team, the validation team will propose parameters to be included in the TDS and products specs that can be useful to further the validation and the expected error analysis of Task 4 (WP500) (e.g. provide statistical information about the histograms used in the non-Bayesian retrieval method).

The results of WP400 will be delivered within the Product Validation Report (PVR), which will include a definition of all the test areas finally used in the exercise, a description of the datasets used for the validation and a full description of the proposed validation protocol. It will also show the results of the metrics for each case study and will include recommendations for the final review of the algorithm and to be taken into account during the assimilation exercise. In this sense, as propagation of errors is not expected to be performed as part of the algorithm development, an assessment of the experimental uncertainties will be produced at this stage by means of combining statistical information provided with the products -as agreed between validation and development teams- with the bias and noise estimations obtained with this validation protocol.

Task 4: Scientific Analysis and Impact Assessment (WP500)

Addresses requirements: SOW-3 Task 4

The production of the SSS data is carried out as part of WP300WP3. WP500 concentrates on the exploitation of the resulting data, it is separated in two parallel tasks, WP410 provides an oceanographic interpretation of the new data with respect to freshwater fluxes, E-P and the Arctic circulation and WP420 measures the impact of the new data in a data assimilation system (the TOPAZ4 system used for the Arctic MFC Copernicus Marine Services, both in forecast and reanalysis modes). The assessment will consider the pan-Arctic region (EASE-2 grid, consistent with the Copernicus ARC MFC product domain).

TOPAZ4 is a coupled ice-ocean data assimilative system, using the HYCOM-CICE model at a resolution of 10 km over the whole Arctic and the Ensemble Kalman Filter (EnKF) running 100 dynamical members to assimilate all available ocean and sea ice observations jointly (Xie et al. 2017). The TOPAZ system is presently being upgraded to a horizontal resolution of 6 km. The atmospheric forcing fields are from the ECMWF. The hydrographic properties of TOPAZ4 have been validated in Lien et al. (2016) and Xie et al. (2017).

WP510: Scientific Analysis

The new SSS L3 and L4 products will be assessed in terms of the following quantities

- **Freshwater fluxes** from Arctic rivers and Greenland Ice Sheet: the river freshwater fluxes will be calculated from the A-HYPE database from SMHI (http://hypeweb.smhi.se/arctichype/time-series/), as well as the river climatology used at NERSC, combined from the ERA-Interim runoffs and the Total River Integrating Pathways hydrological model (TRIP, Oki & Sud 1998). The Greenland Ice Sheet mass loss will be estimated from the ESA Ice Sheet CCI project (https://data1.geo.tu-dresden.de/gis_gmb/index.html) and NERSC will distribute freshwater corresponding to the land ice loss from each of the 8 sub-basins down to the 30 largest terminal glaciers around Greenland. The river plumes in the ocean will have a simplified shape increasing as a function of the runoff. See Figure 9 for illustration. The discharges from the 6 largest rivers are available from https://arcticgreatrivers.org/ and will be used for quality checks (not as model input because of interruptions).
- **Evaporation-minus-Precipitation**: the new SSS products will be used to calculate E-P fluxes, according to the CORE2 formulas (Large and Yeager 2008) using as auxiliary data the precipitations, air temperature, wind speeds and humidity from the ERA-Interim database.
- **Freshening of the Arctic:** the new SSS products will be used to investigate the decreasing trend in the SSS of the Arctic reported in recent studies (e.g., von Schuckmann et al., 2018), with specific focus on the anomalous years, its link to the atmospheric variability in the Arctic, and on the associated changes in the Beaufort Gyre dynamics. Further the potential of the SSS product as a proxy for the variability (temporal) in the fresh water content of the Arctic will be investigated.
- **Ocean circulation**: Since it is not easy to calculate freshwater pathways from surface salinity tracer maps (due to vertical mixing, sources and sinks), the TOPAZ4 numerical model will be integrated in order to propagate the above sources of freshwater (plus the freshwater from the Pacific through Bering Strait) both horizontally and vertically (through mixing processes). A new

50-layers version of TOPAZ will be used in order to better represent the surface circulation and mixing., simulated with the advanced KPP mixed layer model [Large et al. 1994]

The comparisons will provide new insights on freshwater sources and pathways in the Arctic.

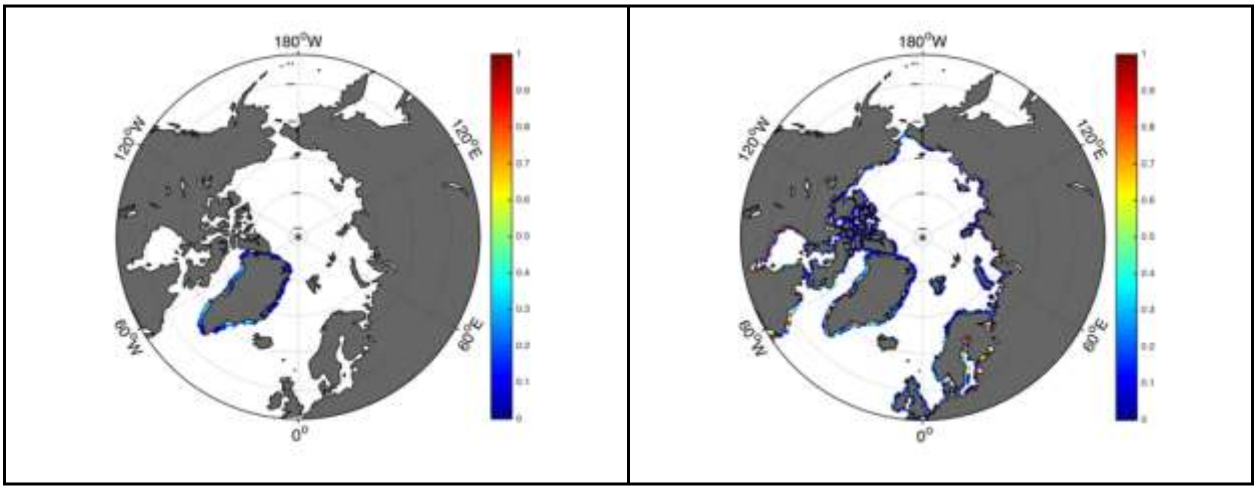

Figure 9: Freshwater flux from the Greenland Ice melt and (b) the total river runoff flux.

WP520 Impact Assessment

Two parallel runs of the TOPAZ4 reanalysis system (Xie et al. 2017) will be integrated for the year 2015 assimilating both the SMAP and SMOS data in addition to all other data sources available in 2015 (altimeter data, SST, sea ice concentration, sea ice drift, T/S profiles, sea ice thickness). The assimilation will be carried out on a weekly basis as is practiced in the TOPAZ reanalysis, the L4 data available on the analysis day will be assimilated. The model error terms are assumed to arise from uncertainties in surface forcing fields and receive random spatially correlated perturbations, in particular:

a) The wind forcing (of amplitude standard deviation about 10 m/s)

b) The air temperature (of standard deviation 3K)

c) The precipitations (of standard deviation 100% using a lognormal probability law).

No uncertainties are assumed in the river inputs (both runs will use the same river inputs), but this will be added to the model error if the ensemble spread turns out insufficient for an effective assimilation.

The EnKF will re-use the L4 SSS uncertainty estimates provided by WP300 and increase them to account for representation error (i.e., the mismatch of the model and observation grids and the time difference between the satellite passage and the EnKF assimilation time). Since the spatial and temporal mismatch is rather small in the case of L4 SSS, this process should result in a relatively minor increase of the errors but a further increase may be necessary for the stability of the assimilation process, depending on how well the model represents the spatial and temporal variability of SSS. We will therefore evaluate the observation errors with respect to the Desroziers et al. (2005) diagnostics which indicate optimal values as a function of the model background error as follows:

$$\tilde{\sigma}^o = \sqrt{\frac{1}{\mathrm{p}}\sum_{j=1}^{\mathrm{p}}(\mathrm{y_j} - \mathrm{H}\bar{\mathrm{x}}^{\mathrm{a}})(\mathrm{y_j} - \mathrm{H}\bar{\mathrm{x}}^{\mathrm{f}})}$$

Where $\mathbf{y}_j$ represent the observation assimilated at the *j*th time, and the terms of $\underline{x}^a$ and $\underline{x}^f$ represent the ensemble mean of analysis and forecast state. Here *p* is the number of data assimilation steps. A two-month test run will be carried out to calibrate the observation errors for best performance and stability.

The data assimilation runs with and without SSS will be fully multivariate, following the EnKF principles, so that the ocean 3D variables and the sea ice variables in the vicinity of SSS observations will be updated as well according to the background covariances from the 100-members ensemble. The comparison of the two runs will therefore be carried out with respect to the following quantities:

a) Freshwater contents (FWC) in the upper ocean.

   The FWC is a vertical integration of salinity anomalies and will be compared to observation estimates from the latest version of the Coriolis Reprocessing Analysis (CORA)

b) Compared to the 2015-2016 mooring data from the Beaufort Gyre Exploration Project (BGEP, http://www.whoi.edu/page.do?pid=148556), the fresh contend and the Cold Halocline Layer depth in the two model runs can be evaluated against independent observations. Changes of the ocean circulation

   a. Since salinity controls water density and geostrophic currents we can expect changes of the horizontal circulation

c) Vertical mixing (convection) will be affected by the assimilation of SSS so that the circulation may change indirectly by this means. Changes of sea ice cover.

   a. since sea ice will melt faster on top of fresher water, changes of the sea ice properties (concentrations and thickness) may be expected at least in the vicinity of the ice edge.

   b. The sea ice concentrations will be compared to the OSI-SAF reprocessing data, which is based on the ESA sea ice CCI algorithm.

d) The thin sea ice thickness will be compared against the latest version of SMOS retrievals from the University of Hamburg (Tian-Kuntze et al. 2014). Ice Mass Balance buoys (http://imb-crrel-dartmouth.org/imb.crrel/buoysum.htm) will also be used in thicker ice. Changes of E-P fluxes. (through the evaporation part)

The relative importance of the new SSS product relatively to all other input data will be quantified by Degrees of Freedom for Signal (DFS) as done previously with the SMOS sea ice thickness product (Xie et al. 2016). . The DFS is commonly used to monitor the relative impact of different observations in a data assimilation system (Rodgers 2000; Cardinali et al, 2004)

$$DFS = tr(\frac{\partial \hat{y}}{\partial y}) = tr\{\frac{\partial [H(\underline{x}^a)]}{\partial y}\} = tr(KH)$$

Where $\hat{y}$ is the analyzed observation vector, **H** is the observation operator to project the model variables into the observation space, and *tr* defines the trace of **KH**. The DFS measures easily the reduction of uncertainty caused by a given observation type expressed as a number of equivalent degrees of freedom. The DFS quantity is linear, and can be split by observation types, and accumulated in time periods. The averaged DFS for the *k*th type of observation can then be used to represent the relative impact of the *k*th type of observations with respect to the whole observation network. We apply this approach to quantitatively evaluate the relative impact of L4 SSS product to indicate how much the L4 SSS data competes with other sources of data within the Arctic observing system. The approach has been used previously in the ESA SMOS+ Ice and GARCA projects for assimilating SMOS ice thickness and synthetic GNSS-R sea level data respectively.

The test reanalysis run will be made publicly available. Should the assimilation of SSS lead to an improvement of the TOPAZ4 reanalysis (at least to a non-regression check) the test run will become the new Arctic reanalysis product on the CMEMS portal and the assimilation of the SSS product will be implemented in operational forecasts by MET Norway, which shares the same source code.

WP530 Error analysis

Errors in satellite data products are known unknowns (Loew et al., 2017). Assessing the inherent uncertainties in satellite data products – and decomposing the inherent uncertainty components for each sub-component – is a challenging task.

To address the validation problem, we propose using well established technical approaches, with focus on those approaches which have been recommended by various EO communities in high-level papers/reports (Loew et al., 2017; Zeng et al., 2015) as well as international programs (e.g. CGOS, CEOS-LPV) and research projects (Copernicus CCS; QA4ECV; OLIVE).

These recommendations aim to standardize and make product validation routines and the corresponding results traceable to the data user community, in line with the ITT mission requirements. We add to this our own experience in this field, as published in various papers (Richter et al., 2012; Meroni et al., 2013; Widlowski et al., 2015).

Key of all activities is to ensure an enhanced traceability of uncertainties and error propagation. Hence, our validation will involve different (parameter-specific) validation data sets, thereby fully recognizing that validation approaches depend on the intermittency and inhomogeneity of the geophysical variables. We also strive to consider potentially diverging priorities of producers, respectively, users. Including these limited datasets and uncertainties into the validation routines should optimize the algorithm. For instance, since uncertainty estimates are retrieved at pixel level, it is possible to identify the best retrieval regions (e.g. SSS retrievals seem to be better in open waters). Therefore the output of this study might be inform whether algorithm development still need further improvements.

Following Otto et al. (2016), validation and uncertainty assessment are crucial requirements for end users of EO products. We define here validation as the process of evaluating the accuracy of satellite-derived products by independent means (Justice et al., 2000), and the quantification of uncertainties by analytical comparison with reference data. A key component of our validation task is therefore the consistency check (comparison) of the EO data with reference measurements, which are assumed to be representative of the truth within their own reported uncertainties. The comparison against reference measurements is a straight forward way to link the EO data back to an agreed standard, because pre-launch calibrations etc., usually cannot be repeated in space. One has to recognize, however, that (in-situ) reference measurements will not be feasible for all components involved in the processing, and hence, there are some imposed limitations that constrains the error propagation.

For consistency, the same team involved in WP400 will perform the error analysis over the final products and the entire time series generated for such purpose. The error analysis will have two elements:

a. The production of the error estimation as by considering the entire area under study (not just the test areas) and all the available datasets that can be matched against these products.

b. The performance of a modified triple-collocation exercise between the final products and the available sources for data comparison. Note that we do not include TOPAZ neither in the validation nor in this error analysis, so to prevent comparing with a model that has assimilated the data. A specific validation over TOPAZ is done in WP520 (see above text for further details).

Nevertheless, triple collocation only allows for Type B random errors estimation, following terminology established by the QA4EO guidelines produced by CEOS/IVOS working groups for Earth Observation data. This is the case because the triple collocation only operates in terms of variability of the sources compared against a common natural variability that is expected to be observed (and shared) by all the independent sources under consideration (*Hoareau et al.*, 2018).

Type B systematic errors are only possible to assess by means of the analysis of the differences between the resulting products and the datasets employed as a reference. This is the case because errors would be relative to a “ground truth” that cannot be easily (or at all) traced back to an absolute standard.

Type B Total uncertainties can be provided by geometric combination of the systematic and random uncertainties.

Because of the nature of the datasets and algorithms to be used, Type A cannot be determined, which is generally the case when there is a lack of absolute references for the validation. Whilst it is true that in situ measurements are a proxy of absolute measurements, in most of the cases the work to be performed to trace them back towards the calibration source is very difficult and unpractical. Type B uncertainties are more pragmatic in scenarios like the ones expected for this project.

Each of the experimental errors will be also modified according to the specific statistical parameters provided by the retrieval algorithm with the products. For instance, the non-Bayesian methodology proposed by ICM-CSIC makes uses of characteristics of the histograms constructed with the individual SSS retrievals associated to SMOS. This information can be used to estimate the expected random uncertainty and determine the dispersion of the mode (resulting in the comparison of different classes), that could be propagated to a L4 product (i.e. SSS product combining data from SMOS and SMAP). Such information will be compared with the Type B uncertainties found in this activity. These results will allow the discrimination of what fraction of the total uncertainties are due to intrinsic limitations of the retrieval methodology of choice, and which ones are a result of the accuracy absence of the data respect to a “ground truth” (i.e. values selected from the TDS during the intercomparison exercise).

The uncertainty analysis will be presented both in form of time series and maps for the entire area. It will also include the test areas as an entire time series, to compare the performance of the algorithm during the training period with the data generated outside such period. This will provide a measurement of the stability of the algorithm and its sensitivity to the initial conditions.

These results will be integrated within the Impact Assessment Report (IAR), to be delivered at the end of Task 4 (WP500).

Task 5: Scientific Roadmap (WP600)

Addresses requirements: SOW-3 Task 5

The main objectives of this package is to elaborate a Scientific Roadmap (SR) and to ensure the systematic production, updating and distribution of the L3 and L4 products resulting of the work performed during the project beyond its ending.

As per the statement of work, only the SR is required in this Work package. However, the visibility and impact of the project, and its capability of influencing future work in the Arctic, will be increased by the presence of an up-to-date web server where Arctic+ Salinity products will be freely accessible. This web server will be hosted at the already existing facilities at ICM-CSIC, and the Arctic+ Salinity products will be integrated in the set of products already been served. As ICM-CSIC will take care of the future distribution of Arctic+ Salinity products, this ensures that any future improvement in the processing chain will be eventually implemented into the production, and that the products will be reprocessed and the production period extended on a regular basis.

ARGANS is the prime contractor of the new Sea Surface Salinity (SSS) Climate Change Initiative (CCI), which is also an ESA funded project (http://cci.esa.int), which aims to obtain the best global measurements of SSS from space from different payload, including SMOS and SMAP. The objective of the Arctic+ Salinity is of an obvious interest for the CCI+SSS community, so there will be a significant collaboration between these two projects. Thus, the development of the new algorithms to retrieve salinity in the Artic will be included in the planned Round Robin exercise (i.e. comparison exercise to obtain the best SSS algorithm retrieval), which is projected to take place within the CCI+SSS project. Finally, this collaboration ensures the continuation of all the activities developed within the Arctic+ Salinity upon the success of retrieving

Sea Surface Salinity at high latitudes. One example of relevant cross-information is that Arctic+ Salinity could benefit of the User Requirement Document (URD) generated in the CCI+ SSS project in some aspects, like, for instance, consider the relevant spatial and temporal scales for the products. This approach could ensure a smooth inclusion of the prototypes into the CCI list of products.

Regarding the SR, it will consist in two parts: technical assessment and strategic planning.

- **Technical assessment:** During the final phase of the project, a critical review of the documents and data will be carried out. This part of the report will be devoted to analyse the characteristics of the resulting products, especially accounting for the limitations and the situations in which the requirements as stated in the Statement of Work would not be accomplished, and in particular in terms of accuracy, precision, spatial coverage and time domain. Special attention will be given to analyse the regional performance, focusing in the more challenging regions and acquisition times. The reasons for the lack of accomplishments, if any, and the possible strategies to overcome them in future developments will be summarized in the technical part of the SR.

The second part of the technical assessment will be to match the capabilities of Arctic+ Salinity products with their scientific exploitation. This will consist on the exploration of new areas of scientific study not previously considered as identification of episodes of sudden continental runoff and the tracking of the propagation of the resulting mass water into the open sea, or the analysis of the effect of long ocean waves on SSS in that region. As stated in the SoW, freshwater fluxes monitoring are of special interest further understand the on-going climate change (see AR6 Special Report on the Ocean and Cryosphere in a Changing Climate). The science outcome expected from this activity is expected to contribute produce publications to be included in the next annual (i.e. AR6) review for the climate change report or IPCC (http://www.ipcc.ch).

The final part of the technical assessment will consist on a review of the existing datasets and foreseen satellite missions and in situ campaigns in order to identify the existing and foreseeable data gaps. This will include the analysis of the hydrography of the region to characterize the sampling by autonomous systems (e.g., Argo floats), the foreseen experiments and campaigns, and the planned experiments and missions in L and P bands. Those gaps will be classified according to their importance for scientific goals, and correction measures for the most critical ones will be proposed.

- **Strategic planning:** As part of WP600 Arctic SSS products will be assimilated into TOPAZ in the test areas. In case this assimilation of SSS lead to an improvement of the TOPAZ4 reanalysis the test run will become the new Arctic reanalysis product on the CMEMS portal and the assimilation of the SSS product will be implemented in operational forecasts by MET Norway. Arctic+ Salinity products can be integrated with other products centered on the diverse components of the hydrological cycle in the Arctic for their use in operational models and to improve the description of physical processes. In particular, ESA-funded Arctic+ Ice and Arctic+ ArcFlux can provide this complementary information, essential for the observation and understanding of key processes such as sea ice melting and formation. We have contacted Dr. Ole Baltazar Andersen from DTU Space and Monica Roca from isardSAT, who, on behalf of Arctic+ ArcFlux and Artic+ Ice respectively, have confirmed their interest in collaborating with us. Annexe 5 of this proposal contains a Letter of Support from the ARCFLUX team indicating their willingness to collaborate with our team in the context of Arctic+ Salinity. Our long-term goal is to integrate our products in the validation and eventually assimilation chain in ECMWF and Copernicus models. Another long-term goal is to integrate our products in Copernicus; as NERSC is already participating in the operational prediction of sea ice and SSS in their area.

Finally, Arctic+ Salinity products will serve as a basis for the development of a dedicated Climate Data Record of SSS on the Arctic region, in cooperation with ESA CCI+ project which is about to start and in which the participation of ICM-CSIC and ARGANS is foreseen.

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1.3.2.2 Work Breakdown Structure (WBS)

The WP activities and responsibilities can be traced on the diagram, below.

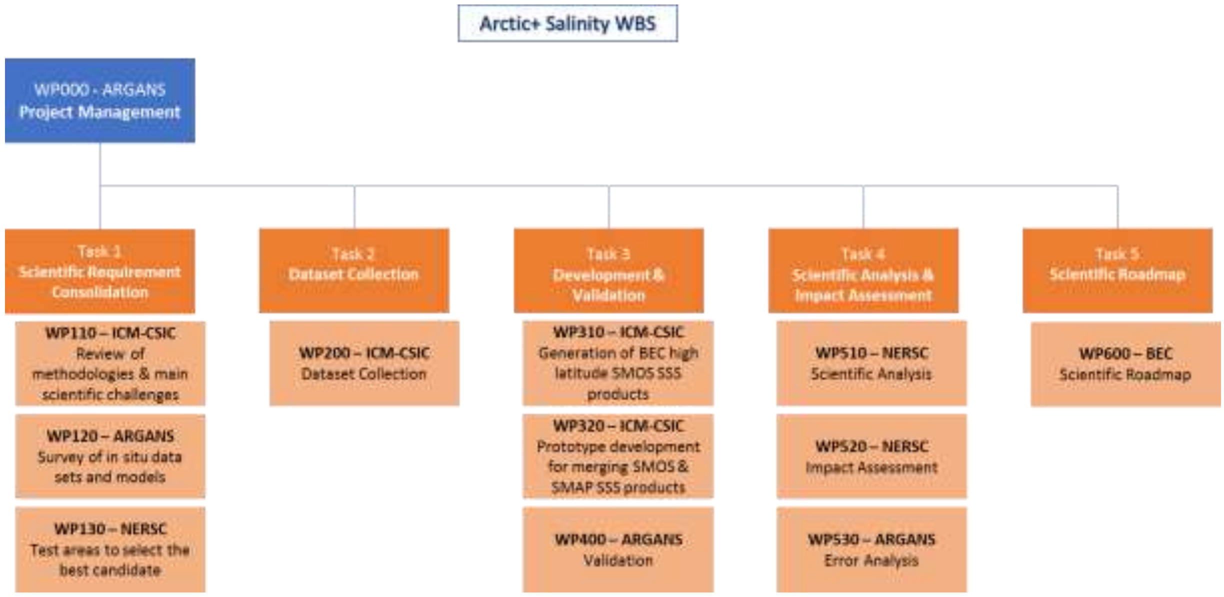

Figure 10: Work Breakdown Structure in relation to requirements of the SOW

The proposed Work Packages have been presented in section 1.3.1 of this document. According to them, the distribution of work agreed by the consortium is as follows:

WP100: Scientific Requirement Consolidation - ICM-CSIC

WP110: Review of methodologies and main scientific challenges (ICM-CSIC)

WP120: Survey of in situ data sets and models for development, validation and comparison (ARGANS)

WP130: Test areas to select the best candidate (NERSC)

WP200: Dataset collection - ICM-CSIC

With contributions from NERSC and ARGANS

WP300: Development - ICM-CSIC

WP310: Generation of improved ICM-CSIC high latitude SMOS SSS products (ICM-CSIC)

WP320: Prototype development for merging SMOS and SMAP SSS products (ICM-CSIC)

WP400: Validation – ARGANS

With contributions from NERSC

WP500: Scientific Analysis and Impact Assessment – NERSC

WP510: Scientific Analysis (NERSC)

WP520 Impact Assessment (NERSC)

WP530 Error analysis (ARGANS)

WP600: Scientific Roadmap - ICM-CSIC

With contributions of NERSC and ARGANS

The diagram shows each of the WPs against SOW requirements, the organization responsible for each activity and the key personnel involved. A more detailed team description is provided in section 2.1.1 of this document, in which specific roles and related expertise are detailed.

The work logic has been defined in section 1.3.1 of this document. ARGANS acts as prime contractor in the consortium and is in charge of WP000 (Project Management, promotion and Coordination) and WP400 (Validation). ICM-CSIC will be responsible of WP100 (Scientific Requirements), WP200 (Dataset Collection), WP300 (Development) and WP600 (Scientific Roadmap), whilst NERSC will be in charge of WP500 (Scientific Analysis and Impact Assessment).

1.3.2.3 Work Package Description (WPD)

The WPs have been fully described, using ESA templates, in Annexe 3 of this proposal.

1.4 Background

1.4.1 Existing own concepts/products relevant to the activity and/or to be used

1.4.1.1 ICM-CSIS

- ICM-CSIC supports and maintains a production and distribution platform of several remote sensing products mainly focused on SMOS, which nowadays receives 2000 visits and 2 Gb of downloaded data per month.
- Inner processing chain, breadboard testing capabilities of new algorithms
- Concepts of Nodal sampling, Debiased non-Bayesian SSS retrieval, fusion, etc.

1.4.2 Third party's concepts/products relevant to the activity and/or to be used

The consortium does not plan to include any third party's concepts and/or products during the performance of this project.

1.4.3 Other achievements (technical or scientific) relevant to the activity and/or to be used

1.4.3.1 ARGANS

- Is the Prime Contractor for the recent awarded (May 2018) contract Climate Change Intiative for Sea Surface Salinity. ARGANS will interface between both Arctic+ Salinity and CCI+ SSS to ensure both projects obtain maximum benefit from each other.
- Has successfully coordinated the ESLs for the evolution and maintenance of SMOS Level 2 Sea Surface Salinity prototype and operational processors for more than 10 years. It is in this context that many of the techniques proposed in this project to generate a high latitude product appeared.
- Successfully managed and executed an R&D project for exploitation of SMOS SSS to obtain information of rainfall over the oceans (STSE SMOS+ Rainfall: Ocean). This project has same basic structure and general goals and run into some similarities. Arctic+ Salinity will profit form the lessons learned during this STSE contract.
- Keeps an on-going science and technical collaborations with the National Oceanography Center in Southampton (UK), one of the potential end-users for the products resulting of this project.

- Includes staff members that are part of the Scientific Advisory Group (SAG) from ESA Pi-MEP project. This opens opportunity to exploit this validation platform within Arctic+ Salinity as soon as is operational.

1.4.4 Background of the companies

1.4.4.1 ARGANS

ARGANS has significant experience demonstrating its full capacity to successfully achieve all the requirements of this project;

- Under ESA contract, since 2008, ARGANS has continuously and successfully coordinated the ESLs for the evolution and maintenance of SMOS Level 2 Sea Surface Salinity prototype and operational processors.
- Under ESA contract, ARGANS has also managed and executed an R&D project for exploitation of SMOS SSS to obtain information of rainfall over the oceans (STSE SMOS+ Rainfall: Ocean);
- Under ESA contracts, ARGANS has developed the Sentinel-3 l2 Optical data processors 2 prototypes and currently is an ESL for OLCI radiometric and spectral verification and validation;

Applications for SSS retrieval from L-band and its exploitation

Current EO technologies for monitoring and measurement of Sea Surface Salinity (SSS) from space rely in the observation of the emissivity of the sea surface at L-band. This is the case for SMOS (ESA), Aquarius (NASA) and SMAP (NASA) missions, with some others at different degree of preparation. Salinity interacts with photons in such band, producing a polarization effect via the dielectric constant of the sea water. By means of the Fresnel equation, which relates the expected emission at each polarization as a function of the incident angle of the observation, it is possible to implement a geophysical forward model to perform the inversion of the observed Tbs and extract the information about salinity they contain. The studies performed in this matter show that space borne instruments are able to “see” the salinity information contained within the first centimetre of the water column of the oceans.

The advantages of EO applied to SSS measurements rely on the synoptic view of SSS fields provided by satellites, impossible to achieve with in situ measurements. Coverage in time and space is substantially increased when putting into practise L-band detectors able to observe the polarization effect inducted by salinity. However, retrieval from Tbs is a challenging task, as the signal of SSS in L-band is small in comparison with external sources of contamination or other natural contributors. Because of that, a significant effort has to be done to define the corresponding forward models and remove with effectiveness such contaminations.

Tackling these problems is the main goal of the SMOS L2 Ocean Salinity Expert Support Laboratory contract, led by ARGANS. In addition to the scientific studies, the contract handles the design, maintenance and constant improvement of the L2 Ocean Salinity operational processor, used by ESA at DPGS for both near-real-time (NRT) and data reprocessing. ARGANS is in charge of the contract and its corresponding continuations uninterruptedly since 2007, therefore being one of the most experienced institutions in the retrieval of SSS from L-band and in the scientific studies associated to it, plus all the corresponding systems engineering required for the operational data processing and distribution.

The experience of ARGANS in the field of SSS is further extended by their leadership in the Support to Science Element (STSE) SMOS+ Rainfall: Ocean contract (2015-2017), by ESA. In such contract, team is involved in the analysis of SSS data to isolate any potential rainfall signature into the SSS fields, aiming to derive rainfall information from SMOS data. This type of studies involved a good understanding of the oceanographic processes impacting SSS, other key factor for the development of the CCI+ Salinity project.

The expertise accumulated by ARGANS in these two projects involves:

- The coordination of a large team of scientist and engineers spread around different countries and various institutions and companies.
- The provision and maintenance of the substantial technical documentation and administrative tasks.
- The performance of quality control of the products generated at each contract and their constant evolution to further improve them.
- Participation in numerous meetings organized by ESA within the contract, and also into international scientific conferences devoted to Ocean Salinity and Water Cycle, often with a focus in SMOS data exploitation and promotion.
- A strong link with world experts in terms of Ocean Salinity, and in particular, in SSS, at scientific level, data exploitation, and also in the technical implementation of the retrieval algorithms.
- Significant IT skills to support the activities of the other Expert Support Laboratories.
- A thorough understanding of the science behind retrieving SSS from L-band.
- An in-depth knowledge about the sources of errors within SSS measurements.
- A good assessment of the current limitations found within SSS products from L-band plus on the datasets used for validation.
- A significant knowledge base in terms of the dynamics of SSS and its link with oceanographic processes.

EO Sensor Calibration and Validation (CalVal)

ARGANS has large expertise in other disciplines including radiometric intercomparison tools, management of in situ data databases, etc., which is allowing ARGANS to be at front most studies for radiance and reflectance models, mapping tools. ARGANS expertise is cross interest between science and business by promoting and enhancing Earth Observation tools.

- On the land side: ARGANS manages DIMITRI (Database for Imaging Multispectral Instruments and Tools for Radiometric Inter-comparison) and leads the software development, defining the key elements to put in place to go towards an operational radiometric calibration of the medium resolution multi-spectral imager component of GEOSS (MEREMSI, ESA/ESTEC 2010 – 2019). These activities are linked to the CEOS Working Group on Calibration and Validation, subgroup on Infrared and Visible Optical Sensors (IVOS).
- On the sea side: design, implementation, management and maintenance of the MERIS matchup In-situ Database (MERMAID), with expert support from the European remote sensing community such as the MERIS Validation Team (MVT)

Feasibility studies and concept design

As part of its activities, ARGANS is currently supporting ESA in the development of mission concepts for the future generations of EO satellites. This is the case in the project “Remote Sensing for Marine Litter (RESMALI)” (2017-2018), funded by ESA/ESTEC, and performed in partnership with AIRBUS. The project requires the gathering of the state-of-the-art knowledge about marine litter, its physical characterisation and patterns, so to identify the requirements, both technological and practical, that shall be tackled for a potential mission devoted to the study and monitoring of its presence at the oceans.

Radiative Transfer modelling, Radiance (albedo) and reflectance:

- ARGANS is an ESA Expert Support Laboratory (ESL) for the ESA EO missions and Third Party Missions, e.g. the coordinator of ESLs for the MERIS 4th reprocessing validation, a member of the

Sentinel 3 Validation Team (S3VT), the ESL for Level 1 radiometry of Sentinel 2/MSI, the ESL for Level 2 radiometry of Sentinel 3/OLCI ocean products.

- The company has successfully led the prototyping of the Sentinel 3 level 2 data processors on behalf of ESA.
- GeoHR: EO geostationary mission, including the development of two radiative transfer codes.

Mapping:

- ARGANS is a pioneer in mapping with Satellite Derived Bathymetry (SDB) and sea-bottoms classifications with EO, because of its expertise in Radiative Transfer Modelling;

  ARGANS is currently engaged in validating new algorithms and software to upgrade a nautical charting production mechanism focused on meeting IHO stringent S-44 standards and S-4 Zone of Confidence requirements. ARGANS has undertaken two ESA projects for the World Bank on Bathymetry and benthic habitat mapping (ECOSERVE and G-ECO-MON - 2013/2014), tests and updating of the Satellite-Derived Bathymetry production chain of the French Hydrographic Agency (SHOM) - 2013/2014 and inter-comparison of coastal mapping schemes with EO data for the US Navy.

  Note: the company's commercial activity in coastal survey and mapping, differentiates from competitors' owing to the tight control of measurement, the assessment of Auxiliary Data errors, of atmospheric correction computations and uncertainties propagation in data processing (QC/Cal/Val as described in the previous paragraphs).

Promotion & outreach:

- Edition of the Sentinel User Handbook and distribution of the data Exploitation Tools which target in the COPERNICUS Sentinel 1, 2 and 3 missions which is published on ESA websites (the SUHET project)
- Edition of SMOS Mission Handbook (Ocean Salinity section) – currently, under review and editorial review.
- Participation in international symposiums related to Earth Observation (e.g. Living Planet 2016) and of meetings of international organisations (e.g. International Hydrography Office – IHO).

Management:

- ISO9001 certified
- Currently:
  - Management of the Sea Surface Salinity (SSS) Climate Change Initiative (CCI) ESA project.
  - Management of SMOS Ocean Salinity L2 Expert Support Laboratory and data processor maintenance teams, under ESA contract.
  - Technical management of the Sentinel-2 MPC, under C-S / ESA contract
  - Management of the MERIS Validation Team (MVT), under ESA contract
  - Management of the SEN2CORAL project (ESA SEOM) , under ESA contract
- In the past:
  - Management of the prototyping of the Sentinel-3 OLCI & SLSTR Level 2 data processors, under ESA contract

1.4.4.2 ICM-CSIC

The Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC) is the largest public multidisciplinary research organisation in Spain with more than 13,000 employees and 132 institutes. CSIC is listed the 6th organisation in Europe in the 7th Framework Programme. In addition, CSIC presents a large participation in other European programmes such as LIFE+, INTERREG, EMRP, RFCS and ERANET.

The Barcelona Expert Center (BEC) is a joint venture among Institute of Marine Sciences, CSIC (ICM), Universitat Politècnica de Catalunya (UPC) and Institute of Space Studies (IEC). BEC was created in 2007 under SMOS Co-Lead Jordi Font's leadership. The initial commitments by BEC were to give support to the calibration and validation activities in SMOS mission, to design the algorithms for the production of high-level SMOS products (both SSS and SM), and to give support to the Spanish production platform for high-level SMOS products. Since 2013 BEC is on charge of the operational production of SMOS products in Spain. BEC gathers together expertises from different areas, mainly remote sensing engineers, mathematicians, physicists and oceanographers. Carolina Gabarro is an Executive director of the BEC.

1.4.4.3 NERSC

The Nansen Environmental and Remote Sensing Center (NERSC, www.nersc.no) is an independent non-profit research foundation affiliated with the University of Bergen, Norway. NERSC has 74 employees from 28 nations and has taken the initiative to start Nansen Centers in 6 countries (Russia, China, India, South Africa and Bangladesh). The vision of the Center is "to pioneer understanding of the Earth system and science-based innovation for society". The Center conducts multidisciplinary sciences with focus on marine, cryosphere and atmospheric research with integration and links to innovation and service development.

The remote sensing of high latitudes and the Arctic have historically been central issues to NERSC, who has participated to the SMOS mission requirements as early as 2002. NERSC has been a leading contributor to data assimilation techniques since the introduction of the Ensemble Kalman Filter. NERSC leads the Arctic Monitoring and Forecasting Center of the Copernicus Marine Environment Monitoring Services (CMEMS) and participates to the Sea Ice Thematic Assembly Center until March 2021. NERSC will strive to provide the best possible forecast and reanalysis of the Arctic and will make optimal use of SMOS salinity data to reach that goal.

1.5 Reservations-Compliance

1.5.1 Reservations

The proposed team does not make any reservation/exclusion from deliveries and/or activities requested in the SOW, the Letter of Invitation to Tender, the Draft Contract, nor in the General Conditions of Tendering or Specific Conditions of Tender. All these documents referred to this ITT and its associated annexes.

1.5.2 Compliance Matrix (Statement of Work / Requirements)

Compliance matrix ID formats:

- SOW-xxx - where xxx is the § number

Table 2: Compliance matrix - Scientific part

Requirement ID	Requirement Text	Compliant (Y/N/P)	Remarks
SOW-2.1.1	In this context, the primary objectives of Arctic+ Salinity are: • Establish a link with the Arctic+ ArcFlux team [http://www.arcflux.eu] to explore potential synergies to be exploited during the project. • Explore, develop and validate novel approaches to generate accurate sea surface salinity measurements on the Arctic from SMOS and SMAP missions;	Y	Section 1.1

Requirement ID	Requirement Text	Compliant (Y/N/P)	Remarks
	• Generate a long-term dataset (SMOS and SMOS/SMAP) covering at least the full SMOS life time; • Perform a thorough scientific analysis of the dataset investigating the observed dynamics and its links with Arctic processes (ocean circulation, land-ocean freshwater flows, E-P); • Explore together with river flow data and other datasets (e.g., E-P, Greenland water flows, glacier flows) and models new approaches (including data assimilation) to connect salinity dynamics to land-ocean fresh water fluxes at regional scale targeting quantification of freshwater fluxes. • Develop a scientific roadmap for future research activities.		
SOW-3	In the following, a generic description for each of the tasks to be carried out in the context of Arctic+ Salinity is provided. Any possible departure from the presented structure shall be properly justified by the Contractor. The project shall be completed within a maximum of 18 months from kick-off. • Task 1: Scientific Requirement Consolidation; • Task 2: Dataset collection; • Task 3: Development and Validation; • Task 4: Scientific Analysis and Impact Assessment; • Task 5: Scientific Roadmap.	Y	Section 1.3.2
SOW-3 Task 1	In this task, the Contractor shall consolidate the preliminary scientific requirements for the project. This shall include: • Establish a link with the ArcFlux team to explore potential synergies to be exploited during the project (Contact person: Louise Sandberg Sørensen, e-mail: slss@space.dtu.dk). • A detailed review, assessment and analysis of the main scientific challenges, knowledge gaps and scientific problems to be addressed in the project. • A survey of all accessible associated datasets (space, airborne and in situ) to be used for development and validation (problems such as the lack of sufficient datasets shall be investigated and practical solutions identified); • A survey of accessible models to be used in the subsequent tasks of the project. • An analysis and identification of the best candidate test areas to be used in successive tasks for development and validation of the prototype products. This shall include a complete analysis and description of the available data over those test areas. This Task shall be complemented by a consolidated risk analysis pointing out which risk areas could affect the final success of the project and the proposed solutions. On the basis of such analysis, the Contractor shall then derive a consolidated, coherent and complete view of the scientific and operational requirements associated with the topic in consideration. Moreover, the Contractor shall describe in detail the technical and scientific constraints for the methods and models to be developed.	Y	Section 1.3.2.1
SOW-3 Task 2	A database of suitable products based on Earth Observation (EO), airborne, in situ data and relevant ancillary information shall be collected over the areas of interest in order to perform the required work. The database shall be made accessible, in the limits of the different data licences, on a project webpage and described in detail in a user manual. Any restrictions in the use of any type of datasets (e.g., proprietary campaign data) shall be communicated to ESA in due time. The datasets shall be used in later tasks for development and validation purposes.	Y	Section 1.3.2.1

Requirement ID	Requirement Text	Compliant (Y/N/P)	Remarks
SOW-3 Task 3	In this task, the Contractor shall explore, analyse, develop, test and select the necessary methods and algorithms to derive the required based products and develop the target test cases relevant to the project. Major scientific efforts shall be devoted to this task to perform a thorough experimental analysis on different test sites in order to develop the suitable algorithms and novel prototype products. The final methods and algorithms shall be selected on the basis of a detailed experimental analysis of the potential alternative methods and approaches supported by a sound inter-comparison and validation. In this context, a detailed experimental error analysis for testing and verifying all the different implementation choices and ultimately evaluate the accuracy and reliability of the developed methods and products shall be carried out under different sites, assumptions or conditions that could affect or influence the performances of the methods and the final accuracy of the products. A detailed description of the final version of the algorithms (including related data sources, processing steps and output data) shall be reported by the Contractor in the form of an ATBD. This shall also include a scientific analysis of the results driving to specific development choices and trade-offs (including technical considerations justifying the selected methodologies). In addition, a detailed cross-comparison of the resulting products/estimates with existing EO-based equivalent/alternative datasets shall be performed in order to gain a thorough understanding of the range of validity, limits and benefits of the different existing products in the relevant thematic area. The Contractor shall also report a detailed description of the error and validation analysis as well as the cross-comparison experiment exercise into the Validation Report (VR).	Y	Section 1.3.2.1
SOW-3 Task 4	On the basis of the developed methodology, the target prototype products shall be generated (hereinafter called experimental dataset) and the proposed application shall be demonstrated over a number of selected areas and suitable time frames including a regional assessment. The geographical areas and the time frames to be covered by the dataset shall be representative of the faced scientific problem and application, allowing a complete demonstration of the feasibility of the proposed methodology and its potential value in terms of scientific and operational potential returns. This should include: • A thorough scientific analysis of the dataset investigating the observed dynamics and its links with Arctic processes (ocean circulation, land-ocean freshwater flows, E-P); • Explore together with river flow data and other datasets (e.g., E-P, Greenland water flows, glacier flows) and models new approaches (including data assimilation) to connect salinity dynamics to land-ocean fresh water fluxes at regional scale targeting quantification of freshwater fluxes. This experimental dataset shall be integrated into the project dataset generated in Task 3 and the user manual shall be updated accordingly. The experimental dataset shall be publicly available via the project website. On the basis of the resulting dataset, the Contractor shall interpret, analyse and quantify the impact and benefits of the results obtained in the context of the Arctic processes quantification and understanding. This shall include: • Comparison of the results with existing and current state of the art results quantifying the improvement of the development methods and models; • Analyse the errors/uncertainties; • Investigate the potential of the derived product to enhance the current knowledge and state-of-the-art in the context of Arctic fresh water fluxes;	Y	Section 1.3.2.1

Requirement ID	Requirement Text	Compliant (Y/N/P)	Remarks
	• Determine the benefit and impact of the obtained results on the specific test areas considered in the project in close collaboration with the relevant scientific and user communities; • Determine the general potential benefit and impact of the results on the scientific and operational areas addressed by the project.		
SOW-3 Task 5	In this task, the Contractor shall define a Scientific Roadmap for fostering future developments aimed at transferring the outcomes of the Arctic+ project into future scientific activities for the time frame 2017-2021 and where applicable, into pre-operational services in the future. In this context, the consultation with scientific and existing operational organisations which operated in the Arctic is considered fundamental. Note that at least the following issues shall be considered: • Providing a critical analysis of the project results obtained vs. the specific scientific objectives of the project and the challenges associated it. • Identifying the required additional scientific work and developments to further advance towards achieving the overarching scientific objectives of the project and the Arctic+ initiative; • Identify potential observational gaps (satellite, in-situ) that may be addressed in the future by novel products, new datasets, in-situ campaigns and or even future missions; • Investigate the potential for integrating the project results into existing or planned large scientific initiatives; • Define a solid scientific agenda and development and evolution plan for the project in the timeframe 2019-2021. • Identify and coordinate with the relevant projects and teams at international, EC and national level that may be relevant for a potential project evolution in the time frame 2019-2021, ensuring that the proposed roadmap fits within planned projects and initiatives in preparing the future; • Defining a potential plan for fostering a transition from research to operational activities, when relevant.	Y	Section 1.3.2.1

2 Implementation Part

2.1 Team Organisation and Personnel

2.1.1 Proposed team

2.1.1.1 Overall team composition, key personnel

Figure 11: Key Personnel.

2.1.1.1.1 Key Personnel Bio's

Rafael Catany is the CCI+SSS Project Manager. He has a long-time experience in environmental studies, in particular processing Level 2 data of sea surface salinity from ESA SMOS mission, and projects' coordination, and has worked on various scientific projects, especially at the National Oceanography Centre, UK. Leveraging his combined background in project management and scientific projects, Rafael will work hand in hand with the science co-leaders to efficiently drive the CCI+SSS project with very strong abilities to both understand scientific and engineering issues and constraints.

Manuel Arias graduated in Marine Sciences with a Bachelors and Master's degree from the University of Cadiz, Spain with several years' post-graduate research experience contributing towards a Doctoral degree. Scientific background in Physical Oceanography and Remote Sensing applications with specific experience in Software Engineering, Quality Control and scientific application development. His activities include the project management and scientific leadership for the ESA-funded project RESMALI, devoted to the definition of mission requirements for a potential EO mission dedicated to marine litter. Additional activities cover project and technical management for SMOS L2 Ocean Salinity Expert Support Laboratory, STSE SMOS+ Rainfall and the various MOSAEC/DIMITRI projects about radiative transfer modelling and vicarious calibration, with responsibilities involving algorithm validation, analysis and assessment including development of applications and tools to assist quality control. He is also appointed member of the Scientific Advisory Group (SAG) for the ESA-funded project Pi-MEP (Pilot Mission Exploitation Platform), and contributes in regular basis into symposiums and conferences related to the topics above mentioned.

Carolina Gabarro is a PhD specialist in remote sensing with large experience on developing algorithms and models to retrieve Sea Surface Salinity from L-band radiometers. Recently she has been working also on Arctic sea ice remote sensing. She is the executive director of BEC and one of the Spanish delegates of IASC.

Justino Martinez is a PhD specialist in remote sensing with experience in microwave radiometers, specialist on developing algorithms to process the SMOS and SMAP data, as well as combine both datasets.

Antonio Turiel is a specialist in signal and image processing, Statistical Physics and oceanic turbulence. He works in the improvement of remote sensing processing algorithms at different levels.

Laurent Bertino has 15 years' experience in coupled ice-ocean data assimilation and operational forecasting in the Arctic. Leader of the Arctic MFC in the Copernicus Marine Environment Monitoring Services. Member of the CLIVAR/CLiC Northern Oceans Region Panel.
He has managed industry-driven modelling studies in the South China Sea, in the Gulf of Mexico and in the Barents and Kara Seas and has participated to the following ESA projects: EMOFOR (2003), Synergy SMOS-Aquarius (2004), OC CCI Phase 1 (2010) SMOS+Ice (2016), GARCA (2016).

2.1.1.1.2 Non-key personnel

Dr Rhiannon Davies completed her PhD titled "Modelling the atmospheric boundary layer of the Arctic marginal ice zone" 18 months ago, working with Professors Ian Renfrew and Roland von Glasow at the University of East Anglia UK, Ian Brooks at the University of Leeds and Dr John King at the British Antarctic Survey, which concluded that our understanding of the marginal ice zone and our ability to represented a major challenge to numerical weather prediction in the Arctic. Since joining ARGANS, Rhiannon has specialised in oceanography, and is the dedicated developer for the SMOS ocean salinity level 2 processor, giving her an in-depth knowledge of SMOS and its data. Rhiannon is proficient with python for data analysis and visualisation, and has experience with PostgreSQL which she is using to create a database for SMOS Level 1 data analysis. Rhiannon is keen to develop her expertise by further exploring the relationships between cryosphere and ocean.

Estrella Olmedo is a PhD specialist in applied mathematics with 6 years' experience in the development of algorithms for processing SMOS brightness temperature and sea surface salinity. She has leaded and leads BEC participation as SMOS Expert Support Laboratory for Level 2 Ocean Salinity, and an ESA Support to Science Element (STSE) project, SMOS+ Med. Estralle will be involved in the activities relating to WP300.

Verónica González is a PhD specialist in remote sensing with experience in microwave radiometry, with special focus in the development of calibration and image reconstruction algorithms for improving the quality of SMOS brightness temperatures. She leads BEC participation as SMOS Expert Support Laboratory Level 1. Verónica will be involved in the activities relating to WP300.

Roshin P. Raj has 10 years' experience working in Arctic Oceanography. Roshin will be in charge of the oceanographic studies associated with this project.

Jiping Xie has 10 years' experience working in Ocean modelling and data assimilation and will be in charge of the OSSEs.

2.1.1.2 Reporting lines within the team

ARGANS has experience in leading large scale, complex projects, which include several companies/institutes. ARGANS is a recognised for its ability to understand and overcome any issue(s) which can happen during the life of a project. We have learnt the importance of:

- ensuring that the technical and managerial schedule are disseminated and understood by all parties involved in the delivery of the project;
- concise and regular communication, including regularly reviewing work progress and quality, evidenced through regular reporting;
- collaboration with the subcontractors, particularly where there are a large number of suppliers.

The contractual link between ARGANS and a subcontractor is formally done with a subcontract including a statement of work defined on the basis of the project Work Breakdown Structure. This contract also includes the budget, schedule, list of deliverables that the subcontractor must respect. This subcontract is a partial flow down of the master contract between the Agency and the Prime Contractor.

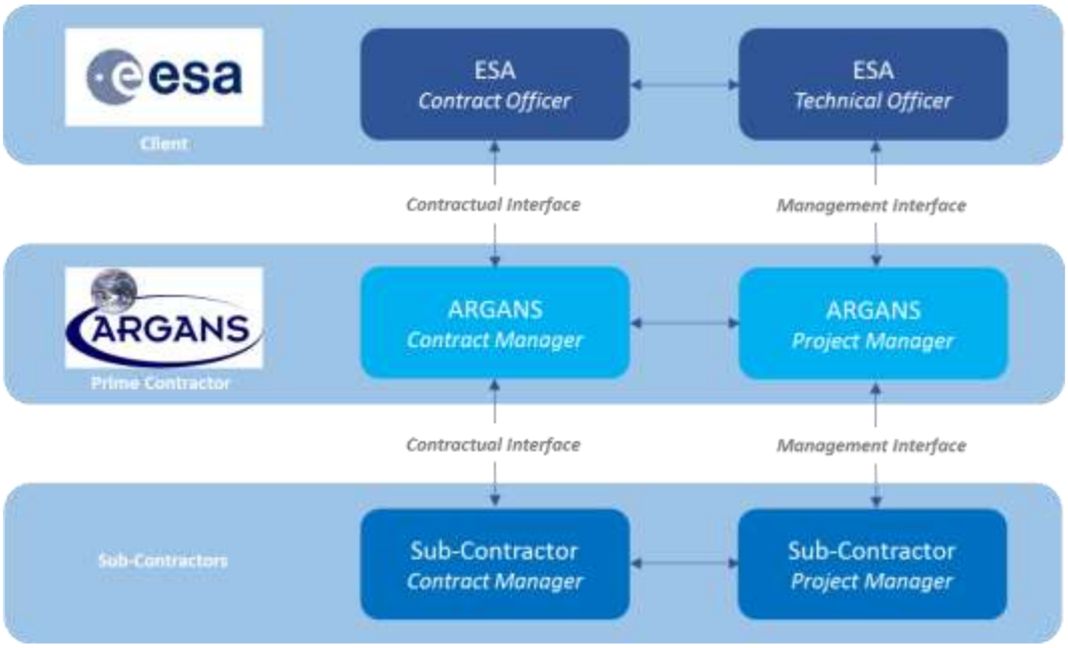

Figure 12: Sub-contractor management - Lines of communication.

The ARGANS Project Manager supported by the Contract Manager for contract and administrative aspects, is fully responsible for coordinating and controlling all sub-contractors' activities. In this respect, they are in charge of:

- Before the beginning of the work:
  - Signature of the contract between ARGANS and the subcontractor before the Kick Off Meeting of the project;
  - Presentation of the management and organisation principles and standards applied in the frame of the project;
  - Presentation of the activities to be performed by the sub-contractor, the deliverables or the contribution to the deliverables to be provided and the associated schedule;
- During the project:

- Maintain a strong focus on communication; frequent interaction with the sub-contractor using regular teleconference, videoconference, electronic exchanges or face-to-face meetings;
- Monitoring and control of all activities performed by the sub-contractor and assessment of the work progress, including formal monthly progress reporting by the sub-contractor as a contribution to the Monthly Progress Report sent by the Project Manager to the Agency;
- Review of the deliverables provided by the sub-contractor for acceptance before final delivery to the Agency and anticipation of possible issues originating from the sub-contractor and proposition of mitigation actions to reduce the associated risk;
- Granting to the Agency free access to all the documentation, specifications, procedure and plans related to the programme of work.

▪ After the end of the contract:

- Proposition of a meeting with the sub-contractors to capture learnt lessons about the project and the partnership.

In case of unsatisfactory performances of a subcontractor, the ARGANS Project Manager is responsible for taking a corrective action or a workaround solution not impacting the final delivery to the client.

2.1.1.3 Position of each of the team members within his/her own company's (or institute's) structure

The position of each team member within their organisation is summarized in Table 3, section 2.1.1.4.

2.1.1.4 Time dedication of key personnel

Table 3 and Table 4 below summarize the Time dedication in % of time per working hours/year and in hours per WP of the key personnel identified in section 2.1.1.1 of this proposal.

Table 3: Key personnel roles and average working time percentage

Key personnel	Company	Position	Project role	%Time
Rafael Catany	ARGANS	▪ Project Manager ▪ EO Scientist	▪ Project Manager	21%
Carolina Gabarro	ICM-CSIC	▪ Scientist ▪ Executive director of BEC	▪ WP 100 & 200 lead	43%
Justino Martinez	ICM-CSIC	▪ Scientist	▪ WP300 lead	43%
Manuel Arias	ARGANS	▪ EO Senior Scientist	▪ WP400 lead	18%
Laurent Bertino	NERSC	▪ Research Director	▪ WP500 lead	17%
Antonio Turiel	ICM-CSIC	▪ Scientist	▪ WP600 lead	14%

Table 4: Key personnel effort breakdown per WP

Key personnel	WP000	WP100	WP200	WP300	WP400	WP500	WP600
Rafael Catany	158 h	12 h	-	-	25 h	20 h	22 h

Manuel Arias	39 h	42 h	-	-	65 h	50 h	6 h
Carolina Gabarro	-	150 h	250 h	400 h	-	70 h	55 h
Justino Martinez	-	50 h	150 h	700 h	-	30 h	-
Antonio Turiel	-	40 h	-	150 h	-	30 h	80 h
Lauren Bertino	-	15 h	15 h	-	25 h	50 h	30 h

2.1.2 Curricula Vitae

The CV's for the key personnel and the expert consultants are included in Annexe 4 of this proposal.

2.1.3 Rationale of the proposed industrial organisation

The consortium is a collaboration between three organisations who each individually have a range of complementary skills and experience. By bringing together this expertise the consortium believes it will significantly increase the impact and results of the project.

ARGANS has a wide experience with remote sensing processing projects (what ensures efficient, good managerial practices) and in particular with SMOS, having been the prime contractor of the SMOS ESL L2OS contract for years, what give them unique expertise in SMOS SSS production. Besides, they have significant IT resources that allow the massive processing and testing required for validation, and a long record of SSS verification and validation.

BEC at ICM-CSIC is a leading research group in SMOS processing from Level 1 to Level 4, has introduced ground-breaking techniques that improve the coverage and accuracy of SMOS products and also in combination with SMAP, and maintains a distribution platform from which the only existing SMOS Arctic SSS product is being served right now and that will serve the products resulting of this project in the long run.

NERSC has a long trajectory of high-impact research for a better understanding of the Arctic, particularly from the oceanographic point of view; and presently leads Copernicus marine activities in the Arctic and through the TOPAZ system they can easily integrate the results of the project in Copernicus.

The combination of the expertise and capabilities of these three organisations ensures that high-quality, well-validated, quality-controlled products will be generated and that those products will be incorporated in Copernicus. The long-term maintenance of the products will help to raise the interest of research groups and of institutions such as ECMWF and IPCC.

2.2 Planning

2.2.1 Proposed schedule and milestones

Table 5: Main events in the project associated to deliveries and technical milestones

Meeting	Purpose	Date	Place	Deliverables	Milestone
Kick-Off (KO)	Start of the work, overview of whole project	T0+00	WEBEX	-	KO
Progress Meeting (PM#1)	Review of WP100 and WP200 outputs	TO+03	WEBEX	[RB] [DUM] [AD]	-
Progress Meeting (PM#2)	Review progress with WP300	TO+06	WEBEX	-	-

Mid Term Review (MTR)	Review of WP300 outputs	TO+09	Barcelona	[ATBD]	MS-1
Progress Meeting (PM#3)	Review of WP400 outputs and progress in WP500	TO+12	WEBEX	[PVR]	-
Progress Meeting (PM#4)	Review of WP500 outputs	T0+15	WEBEX	[IAR] [ED]	MS-2
Final Review	Review of WP600 outputs & review of overall project conclusions	TO+18	ESRIN	[SR]	FR

2.2.2 Bar chart

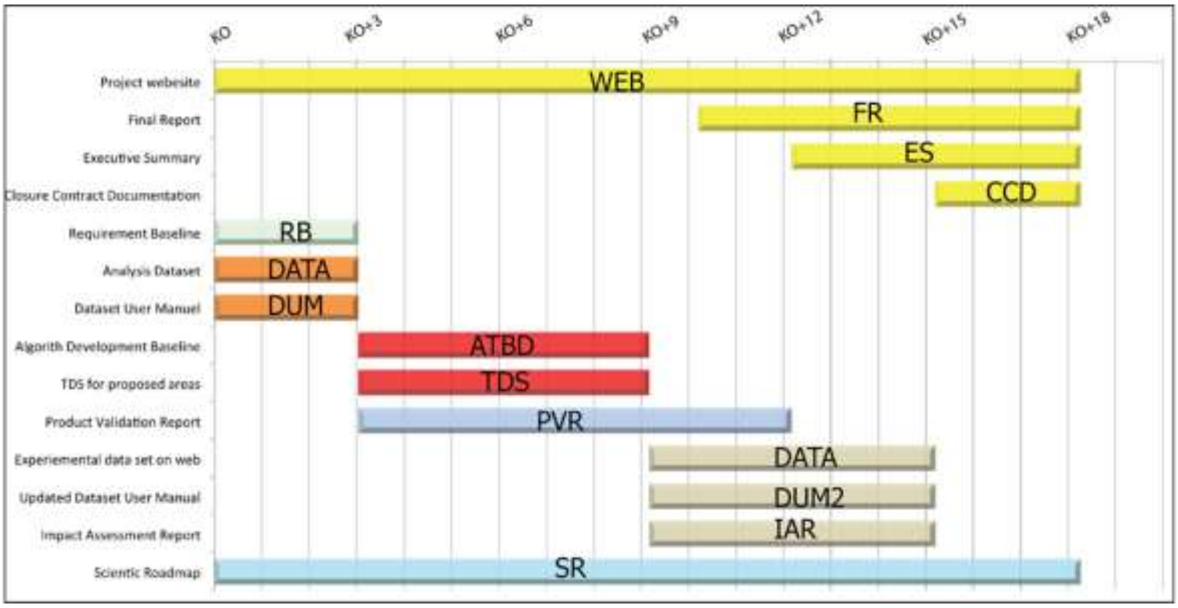

Figure 13: Project overall Gantt chart

2.3 List of deliverable items – Specification of any non-conformance

Addresses requirements: SOW-4.1, SOW-4.2

2.3.1 Deliverable items

The following compounds the list of deliverable items associated to the activities of this project, in accordance with the Draft Contract (Article 2) included in the ITT.

Table 6: List of key documentation deliverable items

ID	Title	WP	Task	Units#	Date/Frequency	Milestone
[RB]	Requirement Baseline	WP100	Task 1	1	PM#01	MS-1
[DUM]	Dataset User Manual	WP200 WP500	Task 2 Task 4	1	PM#01 FR	MS-1 MS-2
[ATBD]	Algorithm Theoretical Basis Documents	WP300	Task 3	1	MTR	MS-1
[PVR]	Product Validation Report	WP400	Task 3	1	PM#03	MS-2

[IAR]	Impact Assessment Report	WP500	Task 4	1	PM#04	MS-2
[SR]	Scientific Roadmap	WP600	Task 5	1	FR	FR
[FR]	Final Report	WP000	Task 1 to 5	1	FR	FR
[ES]	Executive Summary	WP000	Task 1 to 5	1	FR	FR
[CCD]	Closure Contract Documentation	WP000	N/A	1	FR	FR

The team will generate, and the Contractor will deliver the technical documentation requested in the SoW. WP leaders will be in charge of the coordination and completion of the documentation associated to the WPs for what they are responsible. Sub-contractors will deliver these documents to the Contractor for its review and approval before submission to the Agency. In addition to the related documentation, the team will deliver the datasets reflected in Table 7 via website of the project.

Table 7: List of datasets

ID	Title	WP	Task	Units#	Date/Frequency	Milestone
[AD]	Analysis Dataset	WP200	Task 2	1	PM#01	MS-1
[ED]	Experimental Dataset	WP500	Task 4	1	PM#04	MS-2

Finally, the Contractor will produce and deliver the items corresponding to management and promotion shown in Table 8, below.

Table 8: List of management and promotion deliverable items

ID	Title	WP	Task	Units#	Date/Frequency
[WEB]	Project website	WP000	N/A	1	Monthly from KO+03
[PUB]	Publications	WP000	Task 1 to 5	Variable	When pertinent
[PPT]	Presentations	WP000	N/A	Variable	Each meeting
[COM]	Communication material	WP000	N/A	Variable	When pertinent
[MPR]	Monthly Progress Report	WP000	N/A	1	Each month
[MoM]	Minutes of Meeting	WP000	N/A	1	Each meeting
[AGM]	Agenda of the Meeting	WP000	N/A	1	Each meeting
[LIA]	List of Actions	WP000	N/A	1	Each meeting

2.3.2 Non-conformances / limitations / additions regarding deliverable items

The team has not identified non-conformances or limitations to the list of deliverable items.

3 Financial Part

3.1 Price quotation for the contemplated contract

3.1.1 Total Price

The total price of this contract is:

199,958 EURO

(One hundred and ninety nine thousand nine hundred and fifty eight euros)

3.1.2 Price type

The price type of the proposal is "Firm Fixed Price" (FFP) as set out in Article 3 of the Draft Contract.

ARGANS declares that prices are formulated in accordance to requirements of the PSS forms. They include all direct labour and management costs, general expenses, travel and subsistence expenses, and profit.

3.1.3 Currency and conversion rates

All the prices detailed in the PSS forms are in EURO currency for ARGANS and any sub-contractors. However, the Contractor does not form part of the Euro zone and its national currency is the GBP. The following exchange rate applies:

1 EURO = 0.87 GBP

In addition, NERSC is also outside the Euro zone, their national currency is NOK; they have applied the following exchange rate:

1 EURO = 8.50 NOK

3.1.4 Quotations free of taxes and customs duties

All prices quoted within this proposal, and all associated documentation, are free of taxes and customs duties.

The consortium acknowledges that, in case of contract award, if entitled only the Prime Contractor will have the benefit of the VAT exemption.

3.1.5 Royalties and licence fees

The consortium does not plan to include licence fees and/or royalties in the calculation of the financial part of the proposal.

3.2 Sub-contracting plan

Table 9: Price Breakdown per company/Institutions

Company /Institution	ARGANS	ICM-CSIC	NERSC	Total
Country	GB	ES	NO	-
Assigned WP's	000 & 400	100, 200, 300 & 600	500	-
Place of Execution	GB	ES	NO	-
Price (Euros)	50,000	85,000	64,958	199,958
%	25.0%	42.5%	32.5%	100%

3.3 Detailed price breakdown

3.3.1 PSS costing forms

The corresponding forms PSS A1, PSS A2, PSS A2-Exhibit B and PSS A8 are included in Annexe 1 of this proposal.

3.3.2 Milestone payment plan

The consortium accepts the rules governing payments laid down in Article 4 of the Draft Contract. The proposed milestone payment plan has been included in Table 10 below, including the conditions for acceptance.

Table 10: Milestone Payment Plan

Milestone (MS) Description	Schedule Date	Payment in Euro from ESA to Prime Contractor (country)	Country (ISO code)
Progress (MS-1): Upon successful completion of WP 100, 200 and 300, and successful MTR acceptance of all related deliverable items.	T0 + 09 months	69,985 EURO	GB
Progress (MS-2): Upon successful completion of WP 400 and 500, and/or successful [review and] acceptance of all related deliverable items.	T0 + 15 months	89,981 EURO	GB
Final Settlement (MS-3): Upon the Agency's acceptance of all deliverable items due under the Contract and the Contractor's fulfilment of all other contractual obligations including submission of the Contract Closure Documentation.	T0 + 18 months	39,992 EURO	GB
TOTAL		**199,958.00 EURO**	

ARGANS also would like to claim and Advance payment, according to the clause 4.1.1 of the Draft Contract.

Table 11: Advanced Payment

Prime	Company Name	ESA Entity Code	Country (ISO code)	Advance Payment (in Euro)	Offset against	Condition for release of the Advance Payment
P	ARGANS	1000003558	GB	10,000	MS1	Upon signature of the Contract by both Parties

As requested, the Milestone Payment Plan that is envisaged for each partner is shown in Table 12.

Table 12: Milestone payment plan per partner

Milestone	ARGANS (GB)	ICM-CSIC (ES)	NERSC (NO)
MS-1	17,501	29,750	22,734
MS-2	22,500	38,248	29,233
FS	9,999	17,002	12,991
Total	**50,000 EURO**	**85,000 EURO**	**64,958 EURO**

3.3.3 Travel and subsistence plan

Addresses requirements: SOW-4.2

The expected travel plan is presented in Table 13.

Table 13: Travel plan

Meeting	Participants	Date	Place	Duration	Milestone
Mid Term Review (MTR)	ARGANS ICM-CSIC NERSC ESA	TO+09	Barcelona	2 days	MS-1
Final Review (FR)	ARGANS ICM-CSIC NERSC ESA	TO+18	ESRIN	1 day	FR

The travel and subsistence costs for each participating entity are included in the corresponding Exhibit B of PSS-A2 forms provided in the Annexe 1 of this proposal.

4 Contract conditions Part

4.1 Background intellectual properties rights

The consortium shall bring background expertise, gained in the frame of former activities, which will be reflected in the outcomes of the study. This background expertise was gained in the frame of former ESA however, the consortium does not intend to claim existing Background Intellectual Property Rights (BIPR) directly within the deliverables of this project.

On this basis all results of the study shall be deemed and treated as not containing any Background Intellectual Property that would limit their further exploitation by the scientific community.

4.2 Specification of all inputs to enter into the blanks existing in the draft contract

Addresses requirements: STC-0.1

ARGANS confirms that the contract terms and conditions have been read, and are understood and accepted, and that any sales conditions of our own do not apply to the award of this contract.

As requested by the TCs, the Contractor provides the required information to fill the blanks presented in the Draft Contract provided by ESA in this ITT:

- **Page 1**

  ARGANS Limited
  Plymouth Science Park
  1 Davy Road
  Plymouth
  Devon, PL6 8BX
  Jean Laporte, Managing Director
  François-Régis Martin-Lauzer, CEO & Chairman

- **Article 1, 1.2(c)**
  Reference: ARG-003-053
  Date: 4th May 2018

- **Article 1, 1.3.2** United Kingdom

- **Article 1, 1.3.3** Plymouth, United Kingdom

- **Article 3, 3.1**

  The price of this contract amounts to:

  199,958 EURO

  (One hundred and ninety nine thousand nine hundred and fifty eight euros)

  broken down per Contractor and subcontractors as follows:

Company	ESA Entity Code	Type	ISO Code	Total Amount In Euro
ARGANS Ltd	1000003558	P	GB	50,000
CSIC, publish research centre (ICM-CSIC)	1000015129	SI	ES	85,000
Nansen Environmental and Remote Sensing Center (NERSC)	1000005026	SI	NO	64,958

- **Article 4, 4.1.4** Include reference to “sub-contractor(‘s)”
- **Article 4, 4.1.8 (c)** Include option 1; remove option 2.
- **Article 5, 5.1.2**

  ARGANS Ltd
  Plymouth Science Park
  1 Davy Road
  Derriford
  Plymouth
  Devon
  PL6 8BX, UK

- **Article 5, 5.1.2(a)**

  To:

  Name Rafael Catany
  Telephone +44 (0)1752 764298
  Fax +44 (0)1752 772227
  e-mail RCatany@argans.co.uk

  With copy to:

  Name Manuel Arias
  Telephone +44 (0)1752 764289
  Fax +44 (0)1752 772227
  e-mail MArias@argans.co.uk

- **Article 5, 5.1.2(b)**

  To:

  Name Lorraine Sanders
  Telephone +44 (0)1752 764298
  Fax +44 (0)1752 772227
  e-mail LSanders@argans.co.uk

  With copy to:

  Name Jean Laporte
  Telephone +44 (0)1752 764298

Fax +44 (0)1752 772227
e-mail JLaporte@argans.co.uk

Page 16 remove 'option' section – this is not applicable

4.3 Other remarks on the draft contract

There are no additional remarks contemplated for this contract.

4.4 Management and Administrative compliance matrix

The compliance matrix for the Management and Administrative parts of the proposal is found below.

Compliance matrix ID formats:

- SOW-xxx - where xxx is the § number
- STC-xxx - where xxx is the § number

Table 14: Compliance matrix – Management and Administrative parts

Requirement ID	Requirement Text	Compliant (Y/N/P)	Remarks
SOW-4.1	The Contractor shall: • Promote the Project(s) results within the relevant scientific and/or operational communities; • Promote the resulting products, methods and datasets to the user community; • Represent the project at scientific conferences and other international forums through scientific presentations and exhibitions; • Based on the results provide multimedia content to be used for communication, educational and promotional purposes, such as image files, animations, presentation slides, etc.; • Submit at least one paper to an international peer-reviewed journal.	Y	Section 2.3
SOW-4.2	The Contractor shall provide at least the following management deliverables: • Monthly Executive Summary Progress Reports (maximum one page); • Final Report for public access; • Executive summary of the project summarising relevant achievements. The schedule of planned activities shall comply with the milestones reported in the table below.	Y	Section 2.3 & 3.3.3
STC-0.1	For the purposes of "EXPRO" and "EXPRO+" categories of Requests for Proposal (RFP) and Invitations to Tender (ITT) aimed, respectively, at the placing of contracts for low- to medium-value procurements through a simplified tendering procedure, the Agency's ESA Procurement Regulations (ESA/REG/001, rev. 4) shall be the applicable regulatory framework, as specified, amended or supplemented by these EXPRO TENDERING CONDITIONS ("EXPRO/TC").	Y	Section 4.2

Annexe 1 - Signed PSS forms

PDF versions of the PSS forms are included in this Annexe. The excel copies, requested in the ITT, are submitted alongside our proposal in the 'Other' section of the ESA Star tender submission portal.

PSS A2 - Full Consortium

COMPANY PRICE BREAKDOWN FORM			Form No. PSS A2	Page no. 1 of 1	Issue 5
RFQ/ITT No.:	AO/1-9158/18/I-BG			COMPANY	
Proposal/Tender No.:	ARG-003-053			Name:	ARGANS Limited
Type of Price:	FFP	Firm Fixed Price		Country:	UK
Economic Condition:	2018				
National Currency (NC):	GBP			Representative	Francois-Regis Martin-Lauzer, CEO and Chairman
Exchange Rate (X):	1 EURO =	0.87000	GBP	Name and Title:	
Contractual Phase:				Signature:	
Project/Work Package(s):					
Arctic+ Salinity					

							TOTAL (NC) GBP	TOTAL (EURO) NC / X
	LABOUR							
Direct Labour cost centres or categories Code / Description		*No. of FTE (calculated)* ***U = W / V***	*Sold Hours per ManYear* ***V***	*Manpower Effort No. of Hours* ***W***	*Gross Hourly Rate in NC*			
	Project Manager/Advanced Scientist	0.12	1,641	197	77.32		15231	17507
	Thematician Scientist / Developer	0.08	1,641	128	63.09		8075	9282
	Junior Scientist / Operator	0.17	1,641	280	45.17		12646	14536
							0	0
							0	0
							0	0
							0	0
							0	0
							0	0
							0	0
							0	0
1	Total Direct Labour Hours and Cost	*0.4*		*605.0*		A	*35953*	*41325*
	INTERNAL SPECIAL FACILITIES							
Code	*Description*		*Type of unit*	*No. of units*	*Unit rates in NC*			
							0	0
							0	0
							0	0
							0	0
							0	0
2	*Total Internal Special Facilities Cost*					B	*0*	*0*
	OTHER DIRECT COST ELEMENTS	*Base amounts in NC*	*+ OH %*	*OH amounts in NC*				
3.1	Raw materials						0	0
3.2	Mechanical parts						0	0
3.3	Semi-finished products						0	0
3.4	Electrical & electronic components						0	0
3.5	HIREL parts							
	a) procured by company						0	0
	b) procured by third party						0	0
3.6	External Major Products						0	0
3.7	External Services						0	0
3.8	Transport and Insurances						0	0
3.9	Travel and Subsistence	2,217		0			2217	2548
3.10	Miscellaneous						0	0
3	*Total Other Direct Cost*	*2,217.00*		*0.00*		C	*2217*	2548
4	**SUB-TOTAL DIRECT COST**				**(A+B+C)**	**D**	**38170**	**43873**
	GENERAL EXPENSES	*Cost items to which % applies*		*Base Amount in NC*	*OH %*			
5	General & Administration Expenses	A+B+C		38,170	12.5%	E	4771	5484
6	Research & Development Expenses					F	0	0
7	Other					G	0	0
8	**TOTAL COMPANY COST**				**D+(E+F+G)**	**H**	**42941**	**49357**
		Cost items to which % applies		*Base Amount in NC*	*%*			
9	PROFIT			35,952.8	8.0%	**I**	**2876**	**3306**
10	COST WITHOUT ADDITIONAL CHARGE					**J**	0	0
11	FINANCIAL PROVISION FOR ESCALATION					**K**	0	0
12	**TOTAL COMPANY PRICE**				**(H+I+J+K)**	**L**	**45817**	**52663**
13	TOTAL SUB-CONTRACTOR PRICE					**M**	130464	149958
14	REDUCTION for COMPANY CONTRIBUTION					**N**	2317	2663
15	**TOTAL PRICE FOR ESA**				**(L+M-N)**		**173964**	**199958**

PSS A8 – Full Consortium

COMPANY MANPOWER AND PRICE SUMMARY PER WP Form no. **PSS A8** Page 1 of 1 Issue 5

ITT/RFQ:	AO/1-9158/18/I-BG
Proposal/Tender No.:	ARG-003-053
Company Name:	ARGANS Limited
Contractual Phase:	2018-2020
WBS-Level (Number and Title):	
Price Type:	FFP
Economic Conditions:	2018
National Currency (NC):	GBP
Exchange Rate: 1 EUR =	0.87

WP Title		Project Management, Promotion and	Scientific Requirement Consolidation	Dataset Collection	Development	Validation	Scientific Analysis and Impact	Scientific Roadmap	
WP Number		000	100	200	300	400	500	600	Total WBS-Level
Labour Hours per category	Hours								
Project Manager/Advanced Scientist	#	197	0	0	0	0	0	0	197
Thematician Scientist / Developer	#	0	30	0	0	40	30	28	128
Junior Scientist / Operator	#	0	50	40	0	110	80	0	280
...	#								-
...	#								
...	#								
...	#								
...	#								
Total Labour Hours	#	197	80	40	0	150	110	28	605
1. Total Labour Cost	NC	15,232	4,151	1,807	-	7,492	5,506	1,767	35,955
2. Internal Special Facilities Cost	NC								
3.1-3.4 Material Costs	NC								-
3.5 High Rel Parts Costs	NC								-
3.6 External Major Products Cost	NC								-
3.7 External Services Cost	NC								-
3.8 Transport/Insurance Cost	NC								-
3.9 Travel and Subsistence Cost	NC	2,217							2,217
3.10 Miscellaneous Cost	NC								-
3. Total Other Costs (sum of above 3.x)	NC	2,217	-	-	-	-	-	-	2,217
4. Sub-Total Direct Cost	NC	17,449	4,151	1,807	-	7,492	5,506	1,767	38,172
5.- 7. General expenses	NC	2,181	519	226	-	937	688	220	4,771
8. Sub-Total Company Cost	NC	19,630	4,670	2,033	-	8,429	6,195	1,987	42,943
9. Profit Fee	NC	1,219	332	145	-	599	441	141	2,876
10. Cost without additional charge	NC								-
11. Financial Provision for escalation	NC								-
12. Total Company Price	NC	20,849	5,002	2,177	-	9,028	6,635	2,128	45,819
	EURO	23,964	5,750	2,503	-	10,377	7,627	2,446	52,666
13. Total Sub-Contractors Price	NC	3,135	9,970	22,719	41,887	3,137	32,361	17,253	130,464
	EURO	3,604	11,460	26,114	48,146	3,606	37,196	19,831	149,958
14. Reduction for Company contribution	NC	2,317	-	-	-	-	-	-	2,317
15. Total Price for ESA	NC	21,667	14,973	24,896	41,887	12,166	38,996	19,381	173,966
	EURO	24,902	17,210	28,617	48,146	13,984	44,823	22,277	199,958

PSS A1 – ARGANS

COMPANY RATES AND OVERHEADS	FORM No. **PSS A1**		Page no. 1 of 1	Issue 5
			COMPANY NAME:	ARGANS Limited
RFQ/ITT no.:	AO/1-9158/18/I-BG			
PROPOSAL no.:	ARG-003-053		Name and title:	Francois-Regis Martin-Lauzer, CEO and
ECONOMIC CONDITIONS:	2018			
NATIONAL CURRENCY (NC):	GBP		Signature:	
VALIDITY PERIOD :	From. 01-Jan	To. 31-Dec		
ESA Audit agreement reference / date	00/01/1900			

Agreed by: ESA — Status (x when applicable)

1. LABOUR									
Direct labour cost centres or categories Code and Name		*Basic Hourly Rate (NC)*	*Direct Overhead (% or Rate in NC)*	*Gross Hourly Rate (NC)*			ESA		
	Project Manager/Advanced Scientist	77.32		77.32			X		
	Thematician Scientist / Developer	63.09		63.09			X		
	Junior Scientist / Operator	45.17		45.17			X		
		0.00		0.00			X		

2. INTERNAL SPECIAL FACILITIES			
Facility Code and Name		*Type of Unit*	*UNIT RATE (NC)*

3. OTHER COST ELEMENTS			
Standard ESA type		*According to normal company type*	*OVERHEAD %*
3.1	Raw materials		
3.2	Mechanical parts		
3.3	Semi-finished products		
3.4	Electric & electronic components		
3.5	Hirel parts		
	a) procured by company		
	b) procured by 3rd party		
3.6	External major products		
3.7	External services		
3.8	Transport, insurance		
3.9	Travels		
3.10	Miscellaneous		

GENERAL EXPENSES			
According to ESA type	*According to normal company type*	*Applicable on cost element no.*	*OVERHEAD %*
5. General & Administration expenses			
6. Research & Development expenses			
7. Other (specify)			

PSS A2 – ARGANS

COMPANY PRICE BREAKDOWN FORM			Form No. PSS A2	Page no. 1 of 1	Issue 5
RFQ/ITT No.:	AO/1-9158/18/I-BG		COMPANY		
Proposal/Tender No.:	ARG-003-053		Name:	ARGANS Limited	
Type of Price:	FFP	Firm Fixed Price	Country:	UK	
Economic Condition:	2018				
National Currency (NC):	GBP		Representative	Francois-Regis Martin-Lauzer, CEO and Chairman	
Exchange Rate (X):	1 EURO =	0.87000 GBP	Name and Title:		
Contractual Phase:			Signature:		
Project/Work Package(s):					
Arctic+ Salinity					

							TOTAL (NC) GBP	TOTAL (EURO) NC / X
	LABOUR							
Direct Labour cost centres or categories Code / Description		*No. of FTE (calculated) U = W / V*	*Sold Hours per ManYear V*	*Manpower Effort No. of Hours W*	*Gross Hourly Rate in NC*			
	Project Manager/Advanced Scientist	0.12	1,641	197	77.32		15231	17507
	Thematician Scientist / Developer	0.08	1,641	128	63.09		8075	9282
	Junior Scientist / Operator	0.17	1,641	280	45.17		12646	14536
							0	0
							0	0
							0	0
							0	0
							0	0
							0	0
							0	0
							0	0
1	Total Direct Labour Hours and Cost	*0.4*		*605.0*		**A**	*35953*	*41325*
	INTERNAL SPECIAL FACILITIES							
Code	*Description*		*Type of unit*	*No. of units*	*Unit rates in NC*			
							0	0
							0	0
							0	0
							0	0
							0	0
2	*Total Internal Special Facilities Cost*					**B**	*0*	*0*
	OTHER DIRECT COST ELEMENTS	*Base amounts in NC*	*+ OH %*	*OH amounts in NC*				
3.1	Raw materials						0	0
3.2	Mechanical parts						0	0
3.3	Semi-finished products						0	0
3.4	Electrical & electronic components						0	0
3.5	HIREL parts							
	a) procured by company						0	0
	b) procured by third party						0	0
3.6	External Major Products						0	0
3.7	External Services						0	0
3.8	Transport and Insurances						0	0
3.9	Travel and Subsistence	2,217		0			2217	2548
3.10	Miscellaneous						0	0
3	*Total Other Direct Cost*	*2,217.00*		*0.00*		**C**	*2217*	2548
4	**SUB-TOTAL DIRECT COST**				**(A+B+C)**	**D**	**38170**	**43873**
	GENERAL EXPENSES	*Cost items to which % applies*		*Base Amount in NC*	*OH %*			
5	General & Administration Expenses	A+B+C		38,170	12.5%	**E**	4771	5484
6	Research & Development Expenses					**F**	0	0
7	Other					**G**	0	0
8	**TOTAL COMPANY COST**				**D+(E+F+G)**	**H**	**42941**	**49357**
		Cost items to which % applies		*Base Amount in NC*	*%*			
9	PROFIT			35,952.8	8.0%	**I**	**2876**	**3306**
10	COST WITHOUT ADDITIONAL CHARGE					**J**	0	0
11	FINANCIAL PROVISION FOR ESCALATION					**K**	0	0
12	**TOTAL COMPANY PRICE**				**(H+I+J+K)**	**L**	**45817**	**52663**
13	TOTAL SUB-CONTRACTOR PRICE					**M**	0	0
14	REDUCTION for COMPANY CONTRIBUTION					**N**	2317	2663
15	**TOTAL PRICE FOR ESA**				**(L+M-N)**		**43500**	**50000**

PSS A2 Exhibit B – ARGANS

TRAVEL PLAN AND COST DETAIL — **EXHIBIT "B" TO PSS-A2** — Issue 1

RFQ/ITT No.:	AO/1-9158/18/I-BG	Project:	**Arctic+ Salinity**
Proposal/Tender No.:	ARG-003-053	Company:	**ARGANS Limited**
Contractual Phase			
Economic Condition:	2018	Type of Price:	
National Currency (NC)*:	**GBP**	Exchange (**X**): 1 EURO =	0.87 GBP

WP Reference Number	WP Title	Purpose/Event	Departure	Destination	Nr. of Trips	Avg.People per Trip	Travel Cost p.p. (NC)	B / E	Avg.Days per Trip	Subsistence Cost p.d. (NC)	A / R	Total Cost (NC)	Total Cost (EURO)
WP000	Project Management, Promotion and Coordination	MTR	Southampton, UK	Barcelona	1	1	696	E	3	165	A	1,191	1,369
WP000	Project Management, Promotion and Coordination	FR	Southampton, UK	ESRIN	1	1	696	E	2	165	A	1,026	1,179
												0	0
Total Cost, WBS level 1 (equal to the item 3.9 of PSS-A2)												**2,217**	**2,548**

PSS A8 – ARGANS

COMPANY MANPOWER AND PRICE SUMMARY PER WP — Form no. **PSS A8** — Page 1 of 1 — Issue 5

ITT/RFQ:	AO/1-9158/18/I-BG	Price Type:	FFP
Proposal/Tender No.:	ARG-003-053	Economic Conditions:	2018
Company Name:	ARGANS Limited	National Currency (NC):	GBP
Contractual Phase:	2018-2020	Exchange Rate: 1 EUR =	0.87
WBS-Level (Number and Title):			

WP Title		Project Management, Promotion and	Scientific Requirement Consolidation	Dataset Collection	Development	Validation	Scientific Analysis and Impact	Scientific Roadmap	
WP Number		000	100	200	300	400	500	600	Total WBS-Level
Labour Hours per category	Hours								
Project Manager/Advanced Scientist	#	197	0	0	0	0	0	0	197
Thematician Scientist / Developer	#	0	30	0	0	40	30	28	128
Junior Scientist / Operator	#	0	50	40	0	110	80	0	280
...	#								-
...	#								
...	#								
...	#								
...	#								
Total Labour Hours	#	197	80	40	0	150	110	28	605
1. Total Labour Cost	NC	15,232	4,151	1,807	-	7,492	5,506	1,767	35,955
2. Internal Special Facilities Cost	NC								
3.1-3.4 Material Costs	NC								-
3.5 High Rel Parts Costs	NC								-
3.6 External Major Products Cost	NC								-
3.7 External Services Cost	NC								-
3.8 Transport/Insurance Cost	NC								-
3.9 Travel and Subsistence Cost	NC	2,217							2,217
3.10 Miscellaneous Cost	NC								-
3. Total Other Costs (sum of above 3.x)	NC	2,217	-	-	-	-	-	-	2,217
4. Sub-Total Direct Cost	NC	17,449	4,151	1,807	-	7,492	5,506	1,767	38,172
5.- 7. General expenses	NC	2,181	519	226	-	937	688	220	4,771
8. Sub-Total Company Cost	NC	19,630	4,670	2,033	-	8,429	6,195	1,987	42,943
9. Profit Fee	NC	1,219	332	145	-	599	441	141	2,876
10. Cost without additional charge	NC								-
11. Financial Provision for escalation	NC								-
12. Total Company Price	NC	20,849	5,002	2,177	-	9,028	6,635	2,128	45,819
	EURO	23,964	5,750	2,503	-	10,377	7,627	2,446	52,666
13. Total Sub-Contractors Price	NC								-
	EURO								-
14. Reduction for Company contribution	NC	2,317							2,317
15. Total Price for ESA	NC	18,530	5,002	2,177	-	9,028	6,635	2,128	43,500
	EURO	21,298	5,749	2,503	-	10,377	7,627	2,446	50,000

PSS A1 – ICM-CSIC

COMPANY RATES AND OVERHEADS	FORM No. **PSS A1**	Page no. of	Issue 5
		COMPANY NAME:	Institut de Ciencies del Mar -CSIC
RFQ/ITT no.:	AO/1-9158/18/I-BG		
PROPOSAL no.:	ARG-003-053	Name and	Dr. Josep Lluis Pelegri, ICM-CSIC
ECONOMIC CONDITIONS:	2018		
NATIONAL CURRENCY (NC):	EUR	Signature:	
VALIDITY PERIOD :	From. Jan-01 To. Dec-31		
ESA Audit agreement reference / date			

Agreed by ESA — Status (x when applicable)

1. LABOUR

Direct labour cost centres or categories Code and Name		Basic Hourly Rate (NC)	Direct Overhead (% or Rate in NC)	Gross Hourly Rate (NC)	Agreed by ESA
RES	Tenured Scientist	38.15	23,46	47.10	X
TEC	Research Engineer	30.25	23,46	37,35	X

2. INTERNAL SPECIAL FACILITIES

Facility Code and Name	Type of Unit	UNIT RATE (NC)

3. OTHER COST ELEMENTS

Standard ESA type		According to normal company type	OVERHEAD %
3.1	Raw materials		
3.2	Mechanical parts		
3.3	Semi-finished products		
3.4	Electric & electronic components		
3.5	Hirel parts		
	a) procured by company		
	b) procured by 3rd party		
3.6	External major products		
3.7	External services		
3.8	Transport, insurance		
3.9	Travels	Ticket, expenses and subsistence	23,46
3.10	Miscellaneous		

GENERAL EXPENSES

According to ESA type	According to normal company type	Applicable on cost element no.	OVERHEAD %
5. General & Administration expenses			0.0
6. Research & Development expenses			
7. Other (specify)			

PSS A2 – ICM-CSIC

COMPANY PRICE BREAKDOWN FORM			Form No. PSS A2	Page no. 1 of 1	Issue 5
RFQ/ITT No.:	AO/1-9158/18/I-BG		COMPANY		
Proposal/Tender No.:	ARG-003-053		Name:	CSIC	
Type of Price:	FFP	Firm Fixed Price	Country:	Spain	
Economic Condition:	2018				
National Currency (NC):	EUR		Representative		
Exchange Rate (X):	1 EURO =	1.00000 EUR	Name and Title:	Dr. Josep Lluis Pelegrí, ICM-CSIC Director	
Contractual Phase:	Phase I	2018-2020	Signature:		
Project/Work Package(s): Arctic+ Salinity					

							TOTAL (NC) EUR	TOTAL (EURO) NC / X
	LABOUR							
Direct Labour cost centres or categories Code	Description	No. of FTE (calculated) U = W / V	Sold Hours per Man/Year V	Manpower Effort No. of Hours W	Gross Hourly Rate in NC			
RES	Tenured Scientist	0.13	2,200	300	47.10		14,130.00	14,130.00
TEC	Research Engineer	0.82	2,200	1,855	37.35		69,278.04	69,278.04
			Note: per 1.5 years				0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
1	Total Direct Labour Hours and Cost	0.98		2155.0		A	83,408.03	83,408.03
	INTERNAL SPECIAL FACILITIES							
Code	Description		Type of unit	No. of units	Unit rates in NC			
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
2	Total Internal Special Facilities Cost					B	0.00	0.00
	OTHER DIRECT COST ELEMENTS	Base amounts in NC	+ OH %	OH amounts in NC				
3.1	Raw materials						0.00	0.00
3.2	Mechanical parts						0.00	0.00
3.3	Semi-finished products						0.00	0.00
3.4	Electrical & electronic components						0.00	0.00
3.5	HIREL parts							
	a) procured by company						0.00	0.00
	b) procured by third party						0.00	0.00
3.6	External Major Products						0.00	0.00
3.7	External Services						0.00	0.00
3.8	Transport and Insurances						0.00	0.00
3.9	Travel and Subsistence	1,320.00	23.5%	310			1,629.67	1,629.67
3.10	Miscellaneous						0.00	0.00
3	Total Other Direct Cost	1,320.00		309.67		C	1,629.67	1,629.67
4	**SUB-TOTAL DIRECT COST**				(A+B+C)	D	85,037.70	85,037.70
	GENERAL EXPENSES	Cost items to which % applies		Base Amount in NC	OH %			
5	General & Administration Expenses			85,037.70	0.0%	E	0.00	0.00
6	Research & Development Expenses					F	0.00	0.00
7	Other					G	0.00	0.00
8	**TOTAL COMPANY COST**				D+(E+F+G)	H	85,037.70	85,037.70
		Cost items to which % applies		Base Amount in NC	%			
9	PROFIT			83,408.03	0.0%	I	0.00	0.00
10	COST WITHOUT ADDITIONAL CHARGE					J		0.00
11	FINANCIAL PROVISION FOR ESCALATION					K		0.00
12	**TOTAL COMPANY PRICE**				(H+I+J+K)	L	85,037.70	85,037.70
13	TOTAL SUB-CONTRACTOR PRICE					M		0.00
14	REDUCTION for COMPANY CONTRIBUTION					N		37.70
15	**TOTAL PRICE FOR ESA**				(L+M-N)		85,037.70	85,000.00

If insufficient space is available to identify all required information, please use additional sheet or insert lines

PSS A2 Exhibit B – ICM-CSIC

TRAVEL PLAN AND COST DETAIL				EXHIBIT "B" TO PSS-A2									Issue 1
RFQ/ITT No.:	AO/1-9158/18/I-BG									Project:	Arctic+ Salinity		
Proposal/Tender No.:	ARG-003-053									Company:	CSIC		
Contractual Phase	2018-2020												
Economic Condition:	2018									Type of Price:	FFP		
National Currency (NC)*:	EUR									Exchange (X): 1 EURO =	1	EUR	
WP Reference Number	WP Title	Purpose/Event	Departure	Destination	Nr. of Trips	Avg.People per Trip	Travel Cost p.p. (NC)	B / E	Avg.Days per Trip	Subsistence Cost p.d. (NC)	A / R	Total Cost (NC)	Total Cost (EURO)
WP000	Project Management, Promotion and Coordination	MTR		Barcelona		2	0.00	E		0.00	A	0.00	0.00
		FR		ESRIN	1	2	400.00	E	2	130.00	A	1,320.00	1,320.00
Total Cost, WBS level 1 (equal to the item 3.9 of PSS-A2)												**1,320.00**	**1,320.00**

PSS A8 - ICM-CSIC

COMPANY MANPOWER AND PRICE SUMMARY PER WP — Form no. PSS A8 — Page 1 of 1 — Issue 5

ITT/RFQ:	AO/1-9158/18/I-BG	Price Type:	FFP
Proposal/Tender No.:	ARG-003-053	Economic Conditions:	2018
Company Name:		National Currency (NC):	EUR
Contractual Phase:	Phase 1 / 2018-2020	Exchange Rate: 1 EUR	1.0000
WBS-Level (Number and Title):			

WP Title		Project Management, Promotion and Coordination	Scientific Requirement Consolidation	Dataset Collection	Development	Validation	Scientific Analysis and Impact Assessment	Scientific Roadmap	
WP Number		000	100	200	300	400	500	600	Total WBS-Level
Labour Hours per category	Hours								
Advanced Engineer/Project Manager	#	0	40	0	150	0	30	80	300
Junior Engineer/Operator	#	0	200	400	1,100	0	100	55	1,855
Total Labour Hours	#	0	240	400	1,250	0	130	135	2,155
1. Total Labour Cost	NC	0.00	7,576.00	12,100.00	38,997.50	0.00	4,169.50	4,715.75	67,558.75
2. Internal Special Facilities Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1-3.4 Material Costs	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5 High Rel Parts Costs	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6 External Major Products Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7 External Services Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8 Transport/Insurance Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9 Travel and Subsistence Cost	NC	1,320.00	0.00	0.00	0.00	0.00	0.00	0.00	1,320.00
3.10 Miscellaneous Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Total Other Costs (sum of above 3.x)	NC	1,320.00	0.00	0.00	0.00	0.00	0.00	0.00	1,320.00
4. Sub-Total Direct Cost	NC	1,320.00	7,576.00	12,100.00	38,997.50	0.00	4,169.50	4,715.75	68,878.75
5.- 7. General expenses	NC	309.67	1,777.33	2,838.66	9,148.81	0.00	978.16	1,106.31	16,158.95
8. Sub-Total Company Cost	NC	1,629.67	9,353.33	14,938.66	48,146.31	0.00	5,147.66	5,822.06	85,037.70
9. Profit Fee	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10. Cost without additional charge	NC	1,629.67	9,353.33	14,938.66	48,146.31	0.00	5,147.66	5,822.06	85,037.70
11. Financial Provision for escalation	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12. Total Company Price	NC	1,629.67	9,353.33	14,938.66	48,146.31	0.00	5,147.66	5,822.06	85,037.70
	EURO	1,629.67	9,353.33	14,938.66	48,146.31	0.00	5,147.66	5,822.06	85,037.70
13. Total Sub-Contractors Price	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	EURO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
									0.00
14. Reduction for Company contribution	NC	37.70	0.00	0.00	0.00	0.00	0.00	0.00	37.70
15. Total Price for ESA	NC	1,591.97	9,353.33	14,938.66	48,146.31	0.00	5,147.66	5,822.06	85,000.00
	EURO	1,591.97	9,353.33	14,938.66	48,146.31	0.00	5,147.66	5,822.06	85,000.00

If more than 12 WPs are to be reported, then duplicate the form as necessary, do not add columns.
If Labour Categories require more lines, please add as necessary.

PSS A1 – NERSC

COMPANY RATES AND OVERHEADS	FORM No. **PSS A1**	Page no. of	Issue 5
		COMPANY NAME:	
RFQ/ITT no.:	AO/1-9158/18/I-BG	Nansen Environmental and Remote Sensing Center	
PROPOSAL no.:	ARG-003-053	Name and title:	
ECONOMIC CONDITIONS:	2018	Sebastian Mernild Director	
NATIONAL CURRENCY (NC):	NOK	Signature:	
VALIDITY PERIOD :	From. Jan-01 To. Dec-31		
ESA Audit agreement reference / date	12/10/2016		

Agreed by: ESA — Status (x when applicable)

1. LABOUR					
Direct labour cost centres or categories Code and Name		*Basic Hourly Rate (NC)*	*Direct Overhead (% or Rate in NC)*	*Gross Hourly Rate (NC)*	ESA
R1-2018	Researcher 1 - 2018	0.00	0	1,193.91	X
R1-2019	Researcher 1 - 2019	0.00	0	1,226.14	X
R1-2020	Researcher 1 - 2020			1,259.25	X
R2-2018	Researcher 2 - 2018			1,027.77	X
R2-2019	Researcher 2 - 2019			1,055.52	X
R2-2020	Researcher 2 - 2020			1,084.02	X

2. INTERNAL SPECIAL FACILITIES		
Facility Code and Name	*Type of Unit*	*UNIT RATE (NC)*

3. OTHER COST ELEMENTS			
Standard ESA type		*According to normal company type*	*OVERHEAD %*
3.1	Raw materials		
3.2	Mechanical parts		
3.3	Semi-finished products		
3.4	Electric & electronic components		
3.5	Hirel parts		
	a) procured by company		
	b) procured by 3rd party		
3.6	External major products		
3.7	External services		
3.8	Transport, insurance		
3.9	Travels		
3.10	Miscellaneous		

GENERAL EXPENSES			
According to ESA type	*According to normal company type*	*Applicable on cost element no.*	*OVERHEAD %*
5. General & Administration expenses			0.0
6. Research & Development expenses			
7. Other (specify)			

PSS A2 – NERSC

COMPANY PRICE BREAKDOWN FORM				Form No. PSS A2	Page no. 1 of 1	Issue 5
RFQ/ITT No.:	AO/1-9158/18/I-BG			COMPANY	Nansen Environmental and Remote Sensing Center	
Proposal/Tender No.:	ARG-003-053			Name:		
Type of Price:	FFP	Firm Fixed Price		Country:		
Economic Condition:	2018					
National Currency (NC):	NOK			Representative		
Exchange Rate (X):	1 EURO =	8.50000	NOK	Name and Title:	Sebastian H. Mernlid, Director	
Contractual Phase:	Phase I	2018-2020		Signature:		
Project/Work Package(s):						
Arctic+ Salinity	2,WP4, WP5,WP6					

Code	Description						TOTAL (NC) NOK	TOTAL (EURO) NC / X
	LABOUR							
Direct Labour cost centres or categories Code /	*Description*	*No. of FTE (calculated) U = W / V*	*Sold Hours per Man Year V*	*Manpower Effort No. of Hours W*	*Gross Hourly Rate in NC*			
R1-	Researcher 1 - 2018	0.03	1,180	30	1,193.91		35,817.24	4,213.79
R1-	Researcher 1 - 2019	0.06	1,180	75	1,226.14		91,960.77	10,818.91
R1-	Researcher 1 - 2020	0.03	1,180	30	1,259.25		37,777.48	4,444.41
R2-	Researcher 2 - 2018	0.1	1,310	75	1,027.77		77,082.77	9,068.56
R2-	Researcher 2 - 2019	0.2	1,310	200	1,055.52		211,104.01	24,835.77
R2-	Researcher 2 - 2020	0.1	1,310	75	1,084.02		81,301.43	9,564.87
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
1	Total Direct Labour Hours and Cost	*0.38*		*485.0*		A	*535,043.70*	*62,946.32*
	INTERNAL SPECIAL FACILITIES							
Code	*Description*		*Type of unit*	*No. of units*	*Unit rates in NC*			
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
							0.00	0.00
2	*Total Internal Special Facilities Cost*					B	*0.00*	*0.00*
	OTHER DIRECT COST ELEMENTS	*Base amounts in NC*	*+ OH %*	*OH amounts in NC*				
3.1	Raw materials						0.00	0.00
3.2	Mechanical parts						0.00	0.00
3.3	Semi-finished products						0.00	0.00
3.4	Electrical & electronic components						0.00	0.00
3.5	HIREL parts							
	a) procured by company						0.00	0.00
	b) procured by third party						0.00	0.00
3.6	External Major Products						0.00	0.00
3.7	External Services						0.00	0.00
3.8	Transport and Insurances						0.00	0.00
3.9	Travel and Subsistence	**17,100.00**		0			17,100.00	2,011.76
3.10	Miscellaneous						0.00	0.00
3	*Total Other Direct Cost*	*17,100.00*		*0.00*		C	*17,100.00*	*2,011.76*
4	**SUB-TOTAL DIRECT COST**				**(A+B+C)**	**D**	**552,143.70**	**64,958.08**
	GENERAL EXPENSES	*Cost items to which % applies*		*Base Amount in NC*	*OH %*			
5	General & Administration Expenses			552,143.70	0.0%	E	0.00	0.00
6	Research & Development Expenses					F	0.00	0.00
7	Other					G	0.00	0.00
8	**TOTAL COMPANY COST**				**D+(E+F+G)**	**H**	**552,143.70**	**64,958.08**
		Cost items to which % applies		*Base Amount in NC*	*%*			
9	PROFIT			535,043.70	0.0%	I	**0.00**	**0.00**
10	COST WITHOUT ADDITIONAL CHARGE					J		0.00
11	FINANCIAL PROVISION FOR ESCALATION					K		0.00
12	**TOTAL COMPANY PRICE**				**(H+I+J+K)**	**L**	**552,143.70**	**64,958.08**
13	TOTAL SUB-CONTRACTOR PRICE					**M**		0.00
14	REDUCTION for COMPANY CONTRIBUTION					**N**		0.00
15	**TOTAL PRICE FOR ESA**				**(L+M-N)**		**552,143.70**	**64,958.08**

PSS A2 Exhibit B – NERSC

TRAVEL PLAN AND COST DETAIL		EXHIBIT "B" TO PSS-A2		Issue 1
RFQ/ITT No.:	AO/1-9158/18/I-BG	Project:	Arctic+ Salinity	
Proposal/Tender No.:	ARG-003-053	Company:	Nansen Environmental and Remote $	
Contractual Phase	2018-2020			
Economic Condition:	2018	Type of Price:	FFP	
National Currency (NC)*:	**NOK**	Exchange (**X**): 1 EURO =	8.5 NOK	

WP Reference Number	WP Title	Purpose/Event	Departure	Destination	Nr. of Trips	Avg.People per Trip	Travel Cost p.p. (NC)	B / E	Avg.Days per Trip	Subsistence Cost p.d. (NC)	A / R	Total Cost (NC)	Total Cost (EURO)
WP000	Project Management, Promotion and Coordination	MTR	Bergen	Barcelona	1	1	4,500.00	E	3	1,350.00	A	8,550	1,005.88
WP000	Project Management, Promotion and Coordination	FR	Bergen	ESRIN	1	1	4,500.00	E	3	1,350.00	A	8,550	1,005.88
Total Cost, WBS level 1 (equal to the item 3.9 of PSS-A2)												**17,100.00**	**2,011.76**

PSS A8 - NERSC

COMPANY MANPOWER AND PRICE SUMMARY PER WP Form no. **PSS A8** Page 1 of 1 Issue 5

ITT/RFQ:	AO/1-9158/18/I-BG
Proposal/Tender No.:	ARG-003-053
Company Name:	Nansen Environmental and Remote Sensing Center
Contractual Phase:	Phase 1 / 2018-2020
WBS-Level (Number and Title):	

Price Type:	FFP
Economic Conditions:	2018
National Currency (NC):	NOK
Exchange Rate: 1 EUR =	8.5000

WP Title		Project Management, Promotion and Coordination	Scientific Requirement Consolidation	Dataset Collection	Development	Validation	Scientific Analysis and Impact Assessment	Scientific Roadmap	
WP Number		000	100	200	300	400	500	600	Total WBS-Level
Labour Hours per category	Hours								
Advanced Engineer/Project Manager	#	0	15	15	0	25	50	30	135
Junior Engineer/Operator	#	0	0	75	0	0	200	75	350
Total Labour Hours	#	0	15	90	0	25	250	105	485
1. Total Labour Cost	NC	0.00	17,908.62	94,991.39	0.00	30,653.59	272,411.19	119,078.91	535,043.70
2. Internal Special Facilities Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.1-3.4 Material Costs	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5 High Rel Parts Costs	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.6 External Major Products Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.7 External Services Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.8 Transport/Insurance Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.9 Travel and Subsistence Cost	NC	17,100.00	0.00	0.00	0.00	0.00	0.00	0.00	17,100.00
3.10 Miscellaneous Cost	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Total Other Costs (sum of above 3.x)	NC	17,100.00	0.00	0.00	0.00	0.00	0.00	0.00	17,100.00
4. Sub-Total Direct Cost	NC	17,100.00	17,908.62	94,991.39	0.00	30,653.59	272,411.19	119,078.91	552,143.70
5.- 7. General expenses	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8. Sub-Total Company Cost	NC	17,100.00	17,908.62	94,991.39	0.00	30,653.59	272,411.19	119,078.91	552,143.70
9. Profit Fee	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10. Cost without additional charge	NC	17,100.00	17,908.62	94,991.39	0.00	30,653.59	272,411.19	119,078.91	552,143.70
11. Financial Provision for escalation	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12. Total Company Price	NC	17,100.00	17,908.62	94,991.39	0.00	30,653.59	272,411.19	119,078.91	552,143.70
	EURO	2,011.76	2,106.90	11,175.46	0.00	3,606.30	32,048.37	14,009.28	64,958.08
13. Total Sub-Contractors Price	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	EURO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14. Reduction for Company contribution	NC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15. Total Price for ESA	NC	17,100.00	17,908.62	94,991.39	0.00	30,653.59	272,411.19	119,078.91	552,143.70
	EURO	2,011.76	2,106.90	11,175.46	0.00	3,606.30	32,048.37	14,009.28	64,958.08

Annexe 2 - Description of tenderer's facilities for the execution of the work

ARGANS

ARGANS uses its own IT infrastructure, as well as its mother company ACRI-ST infrastructure in a Cloud mode (both are described below).

ARGANS Data Centre is structured around a clustered VMware vSphere virtualised environment. Business services are based on Microsoft SBS2011 (2010 Exchange Server), operating within the virtual environment, complimented by Microsoft Server 2008 R2 on a physical server for Business Continuity. The vSphere environment is configured for High Availability (HA) i.e. single physical node failure results in automatic migration of virtual machines to working nodes. Linux is available both as virtual machines (Centos 6, RHEL 5, Ubuntu 12.04) and on a dedicated 32GB RAM Primergy server running RHEL 5.9.

Storage is provided within a 3-tiered SAN comprising an EMC SAS device, providing Tier 1 block access storage for virtual machines, a Nexsan Tier 2 SATA device providing 42TB RAID 5 storage, and a 42TB RAID 6 NAS providing Tier 3 storage.

Networking within the datacentre is provided by dual, redundant, 4GB optic fibre QLogic switch based fabric. Data Centre and office linked by Cisco switches and optic fibre, providing Gigabit bandwidth to client machines. External access is provided via a dedicated (non-contended) 100Mb/s connection used for bulk transport and a 50Mb/s 1:3 contended WAN for email, remote access etc.

Security is provided by a Fortinet Firewall (intrusion detection, virus/malware detection), which also mediates remote access via SSL-VPN and monitors access to internally hosted FTP/SSH servers (the latter only providing access to authenticated users using public/private key encryption). Email, both incoming and outgoing, passes through a third-party Symantec filtered service that also provides continuity, i.e. caching, in the event of a failure of the Exchange server. Clients and servers are protected using Symantec AV software. All external interfaces are monitored in real time to detect potential exploits.

Business continuity and Disaster Recovery procedures are in place; including external backup of business-critical files and routine backup of file systems, both internal and external (the web server).

ARGANS operates internal web servers for development purposes and a third-party provided dedicated web server, which hosts the company web site, web services for projects such as DIMITRI (www.ARGANS.co.uk/dimitri), an Atlassian Confluence Wiki used for collaboration and as a project management service for projects, IT support via dedicated help desks, and web forum capability.

The data centre is physically secure (swipe card access, CCTV monitoring, 24/7 security guards), provisioned with dual UPS and a diesel generator should a power blackout occur, environmental controlled both by air-conditioning and with a fire-suppression system to minimise the risk of fire damage.

ICM-CSIC

ICM-CSIC is the main contributor and maintainer of Institute of Marine Sciences (ICM) Data Processing Center (CPD), a medium-sized computation cluster composed by 240 cores that hosts ICM-CSIC inner processing chain and operational production and distribution activities at ICM-CSIC, as well as scientific research. The CPD will be used for the development, testing and verification of the processing algorithms, and also for the massive processing of data.

NERSC

NERSC has access to Norwegian supercomputing and data storage infrastructures through the Sigma2 project, and receives a yearly quota of about 5 million CPU hours on the Lenovo HPC Fram in Tromsø (http://www.sigma2.no). The two runs planned for WP400 are anticipated to use about 100.000 CPU hours on Fram. Sigma2 also supports the publication of digital data with a DOI and will be used to make the test run publicly available.

Annexe 3 - Work Package Description

Arctic+ Salinity		WP 000
WP Title: Project Management, Promotion and Coordination		Sheet 1 of 1
WP Lead: ARGANS		Issue Ref: 1.0
Major Constituent: N/A		Issue Date: 04/05/2018
Start Event: KO	**Planned Start Date**: T0	
End Event: FR	**Planned End Date**: T0 + 18	
WP Manager: Rafael Catany		

Objectives:
- Ensure the project, and its tasks, are completed within the agreed timeframe and in line with the SOW.
- Promote the results of the project within the relevant scientific and/or operational communities.

Inputs:
- Statement of Work for Arctic+ Salinity.
- The Proposal.

Activities:
- Organization and record of meeting, record and tracking of actions throughout the project.
- Supervision and provision of deliverable items agreed in the contract.
- Liaising with ESA when pertinent and progress reporting.
- Documentation tracking and version control and its delivery to ESA.
- Maintenance of updated Gantt charts throughout the project.
- Problem detection, tracking and reporting to ESA, including risk assessment and mitigation strategies.
- Provide multimedia content to be used for communication, educational and promotional purposes.
- Submit at least one paper to an international peer-reviewed journal.
- Represent the project at scientific conferences and other international forums through scientific presentations and exhibitions.

Outputs:
- Project Website.
- Monthly Progress Reports and Agendas and Minutes of Meeting (MoMs).
- Final Report (FR), Executive summary (ES) of the project and Contract Closure Documentation (CCD).
- Publications.
- Presentations and Communication material.

Excluded activities:
- None.

Effort in hours

ARGANS	ICM-CSIC	NERSC	Total
197	0	0	197

Arctic+ Salinity			WP 100
WP Title: Scientific Requirement Consolidation			Sheet 1 of 1
WP Lead: ICM-CSIC			Issue Ref: 1.0
Major Constituent: N/A			Issue Date: 04/05/2018
Start Event: KO		**Planned Start Date**: T0	
End Event: PM#1		**Planned End Date**: T0 + 03	
WP Manager: Carolina Gabarro			

Objectives:

- Review of the state of the art, identify dataset, models and test areas to be used for the successive development and validation tasks.
- Produce the associated risk analysis.
- Report the constraints for methods and models to be produced in the activity.

Inputs:

- Statement of Work for Arctic+ Salinity.
- The Proposal.

Activities:

- Contact and create a link with ArcFlux team to explore potential synergies to be exploited during the project.
- Identification of datasets (space, airborne and in situ) to be used for development and validation.
- Investigation of practical solutions for problems related to lack of sufficient data.
- Identification of models to be used for the activities throughout the project.
- Definition of best candidate test areas to be used in successive tasks for development and validation of the prototype products.
- Complete analysis and description of the available data over those test areas.
- Consolidated risk analysis pointing out which risk areas could affect the final success of the project and the proposed solutions.
- Obtain a complete view of the scientific and operational requirements.
- Describe in detail the technical and scientific constraints for the methods and models to be developed.

Outputs:

- Requirement Baseline (RB)

Excluded activities:

- None.

Effort in hours

ARGANS	ICM-CSIC	NERSC	Total
80	240	15	335

Arctic+ Salinity			WP 200
WP Title: Dataset Collection			Sheet 1 of 1
WP Lead: ICM-CSIC			Issue Ref: 1.0
Major Constituent: N/A			Issue Date: 04/05/2018
Start Event: KO	**Planned Start Date**: T0+00		
End Event: PM#1	**Planned End Date**: T0+03		
WP Manager: Carolina Gabarro			

Objectives:

- Collect the necessary and relevant datasets for the development of the activity.
- Provision of access to the collected dataset to the scientific community via web.

Inputs:

- Statement of Work for Arctic+ Salinity.
- The Proposal.
- Requirement Baseline (RB)

Activities:

- Download and catalogue the relevant datasets reported in the Requirement Baseline for the test areas identified by the team.
- Organize the dataset according to the needs of the project.
- Ensure accessibility of the scientific community to the collected datasets.
- Produce a user manual for the dataset describing its contents, possible post-processing, matchups strategies (if any) and usage that is envisaged for each set within the project.

Outputs:

- Analysis Dataset.
- Dataset User Manual (DUM).

Excluded activities:

- None.

Effort in hours

ARGANS	ICM-CSIC	NERSC	Total
40	400	90	530

Arctic+ Salinity			WP 300
WP Title: Development			Sheet 1 of 1
WP Lead: ICM-CSIC			Issue Ref: 1.0
Major Constituent: N/A			Issue Date: 04/05/2018
Start Event: PM#01	**Planned Start Date**: T0+03		
End Event: MTR	**Planned End Date**: T0+09		
WP Manager: Justino Martinez			

Objectives:

- Explore, analyse, develop, and select the methods and algorithms required to produce the targeted products.
- Generate prototypes for the test cases identified in the RB.
- Produce the theoretical baseline for the proposed data processor and products.

Inputs:

- Statement of Work for Arctic+ Salinity.
- The Proposal.
- Requirement Baseline (RB)
- Analysis Dataset.

Activities:

- Perform a thorough experimental analysis on the different test areas to develop the algorithms and products.
- Select final methods and algorithms on the basis of a detailed experimental analysis of the potential alternative methods and approaches supported by a sound inter-comparison and validation.
- Describe the final version of the algorithms.
- Execute a scientific analysis of the results justifying the development choices and the associated trade-offs.
- Generate TDS associated to the test areas for using in the validation.

Outputs:

- The Algorithm Theoretical Baseline Document (ATBD).
- TDS for the proposed test areas.

Excluded activities:

- None.

Effort in hours

ARGANS	ICM-CSIC	NERSC	Total
0	1250	0	1250

Arctic+ Salinity		WP 400
WP Title: Validation		Sheet 1 of 1
WP Lead: ARGANS		Issue Ref: 1.0
Major Constituent: N/A		Issue Date: 04/05/2018
Start Event: PM#01	**Planned Start Date**: T0+03	
End Event: PM#03	**Planned End Date**: T0+12	
WP Manager: Manuel Arias		

Objectives:

- Test and propose the methods and algorithms required to produce the targeted products.
- Develop the test cases identified in the RB.
- Produce the validation for the proposed data processor and products.

Inputs:

- Statement of Work for Arctic+ Salinity.
- The Proposal.
- Requirement Baseline (RB)
- Analysis Dataset.
- The Algorithm Theoretical Baseline Document (ATBD).
- TDS for the test areas.

Activities:

- Provide a sound inter-comparison and validation.
- Carry out a detailed experimental error analysis for testing and verifying all the different implementation choices and ultimately evaluate the accuracy and reliability of the developed methods and products.
- Perform a detailed cross-comparison of the resulting products/estimates with existing EO-based equivalent/alternative datasets.
- Report a detailed description of the error and validation analysis as well as the cross-comparison experiment exercise.

Outputs:

- Product Validation Report (PVR).

Excluded activities:

- None.

Effort in hours

ARGANS	ICM-CSIC	NERSC	Total
150	0	25	175

Arctic+ Salinity		**WP 500**
WP Title: Scientific Analysis and Impact Assessment		Sheet 1 of 1
WP Lead: NERSC		Issue Ref: 1.0
Major Constituent: N/A		Issue Date: 04/05/2018
Start Event: MTR	**Planned Start Date**: T0+09	
End Event: PM#04	**Planned End Date**: T0+15	
WP Manager: Laurent Bertino		

Objectives:

- Generate the experimental dataset.
- Demonstrate the feasibility of the proposed methodology and its potential value for scientific and operational applications over representative geographical areas.
- Establish the impact and benefits of the results for Arctic studies.

Inputs:

- Statement of Work for Arctic+ Salinity.
- The Proposal.
- Requirement Baseline (RB)
- Experimental Dataset.
- The Algorithm Theoretical Baseline Document (ATBD).
- Product Validation Report (PVR).

Activities:

- Analysis of the experimental dataset to investigate its dynamics and its links with Arctic processes.
- Use river flow data and other datasets and models to explore new approaches to connect salinity dynamics to land-ocean fresh water fluxes at regional scale targeting quantification of freshwater fluxes.
- Produce and publish the Experimental dataset and integrate it with the Analysis dataset.
- Compare the results with existing results quantifying the improvements.
- Analyse the errors/uncertainties of the final products.
- Investigate the potential of the products to enhance the current knowledge and state-of-the-art.
- Determine the benefit and impact of the results on the specific test areas considered in RB
- Estimate the benefit and impact of the results on the scientific and operational areas.

Outputs:

- Experimental dataset publication on the web.
- Updated Dataset User Manual (DUM).
- Impact Assessment Report (IAR).

Excluded activities:

- None.

Effort in hours

ARGANS	ICM-CSIC	NERSC	Total
110	130	250	490

<table>
<tr><th colspan="3">Arctic+ Salinity</th><th>WP600</th></tr>
<tr><td colspan="3">WP Title: Scientific Roadmap</td><td>Sheet 1 of 1</td></tr>
<tr><td colspan="3">WP Lead: ICM-CSIC</td><td>Issue Ref: 1.0</td></tr>
<tr><td colspan="3">Major Constituent: N/A</td><td>Issue Date: 04/05/2018</td></tr>
<tr><td>Start Event: KO</td><td colspan="2">Planned Start Date: T0</td><td></td></tr>
<tr><td>End Event: FR</td><td colspan="2">Planned End Date: T0+18</td><td></td></tr>
<tr><td colspan="3">WP Manager: Antonio Turiel</td><td></td></tr>
<tr><td colspan="4">Objectives:
▪ Define a Scientific Roadmap for fostering future developments aimed at transferring the outcomes of the Arctic+ Salinity project into future scientific activities for the time frame 2017-2021 and where applicable, into pre-operational services in the future.</td></tr>
<tr><td colspan="4">Inputs:
▪ Statement of Work for Arctic+ Salinity.
▪ The Proposal.
▪ Requirement Baseline (RB)
▪ Experimental Dataset.
▪ The Algorithm Theoretical Baseline Document (ATBD).
▪ Product Validation Report (PVR).
▪ Impact Assessment Report (IAR).</td></tr>
<tr><td colspan="4">Activities:
▪ Provide a critical analysis of the results of the project in respect to the established scientific objectives.
▪ Identify the required additional scientific work and developments necessary to further advance towards achieving the overarching scientific objectives of the project and the Arctic+ initiative.
▪ Determine potential observational gaps that may be addressed in the future by novel products, new datasets, in-situ campaigns and or even future missions.
▪ Investigate the potential for integrating the project results into existing or planned large scientific initiatives.
▪ Define a scientific agenda and a development and evolution plan for the project in the timeframe 2019-2021.
▪ Identify and coordinate with the relevant projects and teams at international, EC and national level that may be relevant for a potential project evolution in the time frame 2019-2021, ensuring that the proposed roadmap fits within planned projects and initiatives in preparing the future.
▪ Define a potential plan for fostering a transition from research to operational activities, if relevant.</td></tr>
<tr><td colspan="4">Outputs:
▪ Scientific Roadmap (SR).</td></tr>
<tr><td colspan="4">Excluded activities:
▪ None.</td></tr>
<tr><td colspan="4">Effort in hours</td></tr>
<tr><td>ARGANS</td><td>ICM-CSIC</td><td>NERSC</td><td>Total</td></tr>
<tr><td>28</td><td>135</td><td>105</td><td>268</td></tr>
</table>

Annexe 4 - Curricula Vitae

PERSONAL INFORMATION

Rafael Catany

Plymouth Science Park, 1 Davy Road, Derriford, Plymouth, PL6 8BX

(+44) 7873522726

rcatany@argans.co.uk

POSITION

Earth Observation Scientist/Project Manager

WORK EXPERIENCE

19/02/2018–Present

Project Manager

ARGANS Ltd., Southampton (United Kingdom)

Managing the scope and schedule to deliver project meeting datelines
Communicating project plans to stakeholders
Identifying and addressing areas that need improvement
Ensuring that all project documents are complete current and archived properly
Writing routine reports and minute taking during meeting
Efficient communicating job expectation to team members
Liaison and team building within an international consortium by keeping using different cloud collaborative tools
Ability to think and act proactively
Willingness to travel internationally
Assertive in interpersonal relationships

01/10/2013–Present

Research and management on atmosphere to ocean interactions under Tropical Cyclones

University of Southampton, Southampton (United Kingdom)

PhD thesis focusing on atmosphere to ocean interactions under tropical cyclones events. The project aims to understand the negative feedback between the intensity attained by a tropical cyclone and the underlying physical state of the ocean
Developed MATLAB toolboxes for processing and archiving large datasets
Experience with using remote connection techniques for Internet data transferring protocols including fast transfer protocol (FTP) and hyper text transfer protocol secure (HTTPS)
Collaborated with international scientific network to develop a white paper to further research sea surface salinity from space
Managed and routinely prepared meetings with colleagues and supervisors
Gained experience in critical reading and appraisal of peer reviewed work
Presented research results to large and small audiences
Improved project funding proposal writing skills
Gained teaching experience helping to teach Remote Sensing methods and applications for Earth Observations
Thesis writing and submission (December 2017) to earn the PhD degree by the University of Southampton

10/2012–11/2012

Scientist on research Cruice on board of RRS Discovery

National Oceanography Centre, Southampton (United Kingdom)

Managed and organized night work flow for a team of five scientist and two technicians
Prepared and tested oceanographic instrumentation including surface drifters and Argo floats
Processed and calibrated ship instrumentation recording oceanographic and meteorological data
Produced scientific reports to summarise key achievements of the oceanographic campaign (RAPID array monitoring the Meridional Overturning Circulation)

10/2010–04/2011

Scientist in Remote Sensing work placement

National Oceanography Centre, Southampton (United Kingdom)

Processed Level 2 data of sea surface salinity data from ESA SMOS mission
Exploited new oceanographic applications using salinity data from space
Developed tool boxes to improve spatial and temporal combination of satellite data with in situ observation
Participated in international meetings to strengthen collaborations with the international community
Gained skills in edition and graphic customisation using Illustrator and Photoshop

11/2008–04/2009

Scientific Assistant

Instituto de Planeación, Baja California (Mexico)

Organised regular meetings with local authorities to start a project for local sustainable exploitation of the coastal line in Baja California
Minute note taking to include in project report
Design of key performance activity index
Developed area monitoring and created Environmental Studies Impact Assessments
Prepared public meetings to raise the awareness of urbanization of the first coast line to promote a more sustainable use of the coast and green areas
Made and interpreted geographical referenced maps using GIS

EDUCATION AND TRAINING

10/2013–Present

PHD candidate at the National Oceanography Center

University of Southampton, Southampton (United Kingdom)

09/2011–09/2012

Master of Research in Ocean Sciences

University of Southampton, Southampton (United Kingdom)

09/2005–09/2009

Master in Coastal Environmental Sciences

University of Vigo, Vigo (Spain)

09/2001–09/2005

Degree in Marine Sciences

University of Vigo, Vigo (Spain)

PERSONAL SKILLS

Mother tongue(s): Spanish, English, Portuguese, Catalan/Valencian

Communication skills: Experience with advising getting to end different projects whilst working as a teaching assistant in a module of Remote Sensing at the University of Southampton

Good communication skills gained as working as a library assistant in the front desk at the University of Southampton

Organisational / managerial skills

Management skills earned as organising meetings with group of scientist from different organisations between the University of Southampton and the National Oceanography Centre

Team leader skills earned organising 2013-2014 and 2014-2015 NOC triathlon

Job-related skills

Experience establishing international collaborations

Travel to participate in different international workshops of measuring sea surface salinity from SMOS

Collaborate in reviewing the document of measuring salinity from space white paper

Support development of scientific reports not related to my job by giving science insight

Digital skills

SELF-ASSESSMENT				
Information processing	Communication	Content creation	Safety	Problem solving
Proficient user	Proficient user		Proficient user	Independent user

Digital skills - Self-assessment grid

Excellent knowledge of Microsoft Office applications including Excel, Word and PowerPoint

Accomplished user for email and tasks management software Outlook

Fine developing online collaborative work documents using different tools including Dropbox professional and gdrive

PERSONAL INFORMATION

Manuel Arias Ballesteros

ARGANS Limited, 1 Davy Road, Plymouth Science Park, Derriford, PLYMOUTH, PL6 8BX (United Kingdom)

+44 (0)1752 764 295

marias@argans.co.uk

PROJECT POSITION: EO SENIOR SCIENTIST (LEAD FOR WP400)

WORK POSITION: PROJECT MANAGER / SENIOR SCIENTIST

WORK EXPERIENCE

2013–Present

Project Manager / Senior Scientist

ARGANS Limited
1 Davy Road, Plymouth Science Park, Derriford, Plymouth, PL4 8BX (United Kingdom)
http://argans.co.uk

Project Manager and Scientist Support for ESA/ESRIN SMOS L2 OS ESL contract, which involves the coordination of an international team of researchers, devoted to the R&D activities related to the L2 Ocean Salinity processor used by ESA in the SMOS mission. Besides the management, supporting research is also provided to the team, as well as all the interactions with ESA representatives, including meetings, teleconferences, minutes of the meetings, writing of technical notes and review/confirmation of deliverables. Responsibilities also include the actual programming and Factory Assurance Tests required for this contract, plus support ESLs in the data analysis and devising new methodologies/approaches to improve the models and subsequently the L2OS processor.

Project Manager and Scientist Support for ESA/ESRIN STSE SMOS+ Rainfall (Ocean component) contract, which includes R&D activities to derive rainfall estimations from SSS anomalies obtained using SMOS L2OS data, combining with ancillary data from other satellites (SSMIs) and compare with other exiting products (IMERG/GMORPH). The project involves development o retrieval algorithm and validation exercises plus exploitation of in situ data for such purposes.

Project Manager and Scientific Lead for ESA/ESTEC contract RESMALI, a feasibility study to define the mission requirements for a potential instrument devoted to marine litter monitoring from space. The activity includes experimental data acquisition to characterise the optical properties of marine litter and advanced radiative transfer modelling to estimate signature of potential litter scenarios at realistic observational scenarios with their associated uncertainties. The project aims to generate a mission concept to be presented to ESA for further consideration and development.

In the same context of management and technical work, activities related to the ESA/ESTEC software DIMITRI (Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison (DIMITRI) manages L1 data from various medium resolution imagers over terrestrial targets chosen for their radiometric properties and/or the availability of in-situ radiometric measurements. DIMITRI comes with a suite of tools that allow comparison of the L1 data originating from various sensors in the database at Top Of the Atmosphere (TOA) level. The software is currently used in the Copernicus S-2 and S-3 MPCs w.r.t the optical sensors CalVal activities.

Additional activities: Business development, Scientific Research and Engineering (R&D).

2011–2013

Scientific and Professional Programmer

Solaris Consulting y Desarrollo S.L. (Madrid, Spain); L.A.V. (Acoustic Engineering Laboratory, Universidad de Cadiz, Spain) – CASEM, Poligono Rio San Pedro, CP 11510, Puerto Real, Cadiz, Spain.

In Solaris Consulting: Development of web-based tools to manage databases; Building of software to perform automatic analysis and technical reports. In L.A.V.: Management and handling of an advanced traffic simulation model (VISSIM); Optimisation of traffic routines; Derivation of environmental parameters related to the traffic from the model.

Additional information: Consulting and web-based tools. In L.A.V.: Research and Engineering (R&D).

2010 **Project Assistant Researcher**

RNM337 Oceanography and Remote Sensing Research Team. Applied Physics Department, Marine and Environmental Sciences Faculty, Universidad de Cadiz – CASEM, Poligono Rio San Pedro, CP 11510, Puerto Real, Cadiz, Spain.

Analysis of remote sensing databases, focused in altimetry and SST. Study of the tele-connections between climate indices and these databases. Building of analytical and numerical models to study the mesoscale signals derived from remote sensing sources. Development of code to an automatic assimilation of remote sensing data into the models.

Business or sector: Research

2008-2010 **MEC Associated Researcher (FPU Program)**

Spanish Ministry of Education and Research. Applied Physics Department, Marine and Environmental Sciences Faculty, Universidad de Cadiz – CASEM, Poligono Rio San Pedro, CP 11510, Puerto Real, Cadiz, Spain.

Development of a research work with the corresponding quality, in order to achieve a doctoral degree. Participate in the research tasks of the receptor team. Being part of the lectures given by the department, if required. Take part of symposiums or conferences as part of the doctoral training, and supporting the research activities of the team. Learn and put in practice the methodology required in the publishing of peer-reviewed articles.

Business or sector: Research

2006–2008 **FPU Program Fellow**

Spanish Ministry of Education and Research. Applied Physics Department, Marine and Environmental Sciences Faculty, Universidad de Cadiz – CASEM, Poligono Rio San Pedro, CP 11510, Puerto Real, Cadiz, Spain.

Development of a research work with the corresponding quality, in order to achieve a doctoral degree. Participate in the research tasks of the receptor team. Being part of the lectures given by the department, if required. Take part of symposiums or conferences as part of the doctoral training, and supporting the research activities of the team. Learn and put in practice the methodology required in the publishing of peer-reviewed articles.

Business or sector: Research

2004–2005 **Project Assistant Researcher**

RNM337 Oceanography and Remote Sensing Research Team. Applied Physics Department, Marine and Environmental Sciences Faculty, Universidad de Cadiz – CASEM, Poligono Rio San Pedro, CP 11510, Puerto Real, Cadiz, Spain.

Get a comprehensive use of the Princeton Ocean Model, doing special efforts in the assimilation of external altimetry data. Collect and prepare a TOPEX/Poseidon database to be used by the model. Write algorithms to isolate the cross-over points of the T/P database, building the corresponding time series for further analysis about their long-term behaviour.

Business or sector: Research

EDUCATION AND TRAINING

2008-2013 **PhD ‘Influence of climate change on the dynamics of the Mediterranean Sea from altimetry and sea surface temperature data.’**

Universidad de Cadiz, Marine and Environmental Sciences Faculty.

Principal subjects covered: Physical Oceanography and Remote Sensing

2005-2008

PhD Program in Marine Sciences – Research period and Certification

Universidad de Cadiz, Marine and Environmental Sciences Faculty.

Principal subjects covered: Physical Oceanography

2004-2005

PhD Program in Marine Sciences – Educational period

Universidad de Cadiz, Marine and Environmental Sciences Faculty.

Principal subjects covered: Physical Oceanography, Marine Geology, Marine Ecology, Remote Sensing, Radiometric techniques.

1999-2004

MSc and degree in Marine Sciences

Universidad de Cadiz, Marine and Environmental Sciences Faculty.

Principal subjects covered: Physical Oceanography, Chemical Oceanography, Biological Oceanography, Marine Geology, Marine Ecology, Remote Sensing, Coastal Management, Marine Pollution and Contamination.

PERSONAL SKILLS

Mother tongue(s): Spanish

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C2	C1	C1	C1

Levels: A1 and A2: Basic user - B1 and B2: Independent user - C1 and C2: Proficient user

Common European Framework of Reference for Languages

Technical skills and competences

Project Management, Data Analysis and Software Engineering, including scientific modelling and uncertainties budget estimation. Advanced analytical tools including conventional time series and spatial data analysis, but also non-conventional information theory-based tools, including Lyapunov exponents, fractal dimensions, Singular Spectral Analysis, Maximum Entropy Analysis. Skills also in radiative transfer modelling, forward modelling and minimization algorithms, including basics on machine-learning. Fluent also in version control via GitHub and Atlassian tools (both JIRA and Confluence).

Organisational skills and competences

Experience in Project Management for numerous projects (current and past ones), as listed above, including coordination of partners, planning tasks and activities according to agreed scheduling, monitoring of performance and evolution of the project and activities, definition of work packages and estimations of efforts. In addition, currently line manager for 3 people in current organization. Used also to team working in a context of international teams and also within the company. Skills in managing multiple projects and conflicts with deadlines as result of that. Experience in the use of project management tools like Atlassian Confluence and CANBAS model under an AGILE environment.

Computer skills and competences

Programming languages: Python, Ansi-C, C++ Builder, C++, BASIC, FORTRAN, Matlab, VB, HTML, CSS, PHP, ASP, MySQL, Javascript

Software: Matlab 2012, Mathematica 4.0, Surfer 11, Sigmaplot 12, Eviews 6, MS Office 2013, Adobe Dreamweaver CS6, Adobe Photoshop CS6, Adobe Fireworks CS6, Adobe Acrobat XI, Camtasia Studio 6. Windows and Linux environments.

ADDITIONAL INFORMATION

Publications and Participation in

- Arias, M., Cozar, A., Bonnery, G., Lebreton, L., Garaba, S. (2018) - Towards a better understanding

Conferences

of marine litter signature from space – 6th International Conference for Marine Debris, San Diego (USA).

- Arias, M., Spurgeon, P., Olmedo, E., Turiel, A. (2017) - OTT components analysis: Towards a better SMOS SSS retrieval - Global Ocean Salinity and the Water Cycle Workshop, Woods Hole Oceanography Institution.
- Spurgeon, P., Arias, M., Davies, R., Turiel, A., Olmedo, E., Boutin, J., D'Amico, F., Marchand, S., Waldteufel, P., Reul, N., Tenerelli, J., Vergely, J-L, (2017) - Seven years of Ocean Salinity from SMOS - Global Ocean Salinity and the Water Cycle Workshop, Woods Hole Oceanography Institution.
- Davies, R., Arias, M., Spurgeon, P. (2017) - Impact of a New Bias Correction on SMOS Data - Global Ocean Salinity and the Water Cycle Workshop, Woods Hole Oceanography Institution
- Turiel, A., Olmedo, E., Martinez, J., Gonzalez, V., Ballabrera-Poy, J., Gabarro, C., Arias, M. (2017) – Analyzing the Balance Equation of SSS Using SMOS Data - Global Ocean Salinity and the Water Cycle Workshop, Woods Hole Oceanography Institution.
- Alhammoud, B., Bouvet, M., Jackson, J., Arias, M., Thepaut, O., Lafrance, B., Gascon, F., Cadau, E., Berthelot, B., Francesconi, B. (2016) - On the vicarious calibration methodologies in DIMITRI: Applications on Sentinel-2 and Landsat-8 products and comparison with in-situ measurements. ESA Living Planet Symposium - Viena (Austria).
- Spurgeon, P., Arias, M., Font, J., Turiel, A., Olmedo, E., Portabella, M., Vergely, J-L., (2015)- Five years of SMOS ocean salinity: Selecting data -2nd SMOS Science Conference. ESAC, Madrid (Spain).
- Arias, M., Alonso, J.J., Gómez-Enri, J., Villares, P. (2009) - Oceanografía y Satélites –Capítulo: Altímetros: Nivel del Mar, Mareas, y Velocidades Geostróficas. Oceanografía y Teledetección (Oceanography and Remote Sensing-Chapter: Altimeters: Sea Level, Tides, and Geostrophic Velocities). Ed. Tebar. Editor in chief: Instituto Español de Oceanografía (Spanish Oceanography Institute).
- Alonso, J.J, Arias, M., Villares, P. (2007) - On the effect of subinertial phenomena on the internal lee waves generation in the Strait of Gibraltrar. Stochastic Environmental Research and Risk Assessment 21, pgs. 100-110.
- Medina, C., Gómez-Enri, J., Alonso, J.J., Villares, P., Arias, M., Catalán, M., Labrador, I. (2007) - Interannual water level variations in Lake Izabal, Guatemala, using radar altimetry and its relationship with oceanographic features. Proceedings of SPIE (2007).
- Arias, M., Medina, C., Alonso, J.J., Villares, P., Gómez-Enri, J., Catalán, M., Labrador, I. (2007) - Cramer-Rao lower bounds for sinusoidal models from TOPEX/Poseidon data in the Indian Ocean. Proceedings of SPIE (2007).
- Medina, C., Gómez-Enri, J., Alonso, J.J., Villares, P., Arias, M., Catalán, M. (2007) - Water level fluctuations in Lake Izabal, Guatemala from ENVISAT RA-2 and in-situ measurements. Proceedings of the 27th EARSeL Symposium.
- Gómez-Enri, J., Arias, M., Jiménez-Garay, R., Villares, P., Alonso, J.J., Catalán, M. (2006) - Measuring ocean wave skewness in the Austral Ocean from radar altimetry. Proceedings of the 26th EARSeL Symposium.
- Arias, M., Alonso, J.J., Villares, P., Catalán, M., Gómez-Enri (2006) - Mean sea level variations from TOPEX/Poseidon data in the Mediterranean Sea and Iberian Atlantic and its relationship to climate indexes. Proceedings of the 26th EARSeL Symposium.
- Arias, M., Alonso, J.J., Gómez-Enri, J., Villares, P., Catalán, M. (2006) - Variabilidad de la Corriente Circumpolar Antártica a partir de datos de altimetría (Variability of the Antarctic Circumpolar Current from altimetry data). Revista de Teledetección AET-25, pgs 30-34. (AET Remote Sensing Journal).
- Arias, M., Villares, P., Castro, N., Alonso, J.J., Catalán, M. (2006) - Analysis of the mean sea level and its trend in the Iberian Atlantic and Mediterranean Sea from altimeter data and PSMSL data base. Proceedings of the 25th EARSeL Symposium.
- Alonso, J.J., Arias, M., Villares, P., Catalán, M. (2005) – Fractal dimension and altimeter data. Proceedings of SPIE (2005).
- Arias, M., Villares, P., Alonso, J.J., Catalán, M. (2005) – Use of fractal techniques in the study of the MSL evolution from altimeter data in the Mediterranean Sea. Remote Sensing: Advances on the Earth Observation. Ed. AET (Spanish association of Remote Sensing).
- Arias, M., Catalán M., Catalán-Morollón, M., Villares, P. (2005) – Sea water mass fluxes In the Antarctic Circumpolar Current. Proceedings of from III International Symposium in Marine Science & Technology.

- Arias, M., Villares, P., Catalán, M., Alonso, J.J. (2005) – Computation of the MSL trend in the Mediterranean Sea. Proceedings of III International Symposium in Marine Science & Technology.
- Arias, M., Catalán M., Catalán-Morollón, M., Villares, P., Jiménez-Garay, R., Alonso, J.J., Gómez-Enri, J. (2005) – Analysis of altimetry measurements in the Southern Ocean. Proceedings of III International Symposium in Marine Science & Technology.
- Alonso, J.J., Villares, P., González, M.J., Arias, M., Marín, B. (2005) - Ocean tides and fractal geometry: Tidal station stability. Thalassas, Vol. 21, pgs. 9-16.

PERSONAL INFORMATION

Carolina Gabarro

ICM-CSIC

PROJECT POSITION: SCIENTIST

WORK POSITION: SCIENTIST

WORK EXPERIENCE

More than 10 years of post-doctoral experience with of remote sensing processing data, specially working in SMOS mission. She was part of the SMOS ESL of L2. She is the BEC executive director. She is a Spanish delegate of the International Arctic Science Committe (IASC).

2000–Present

Research Engineer

Institut de Ciencies del Mar-CSIC

2005–2007

Lecturer

Universitat Politecnica de Catalunya

1999

System Engineer

ACRI Group, Sophia-Antipolis, France

1998

Graduate trainee System Engineer

ESTEC, ESA

1997

Stagiaire Grant

ESTEC, ESA, Holland

EDUCATION AND TRAINING

2010

Master in High School Teacher

Universidad Pompeu Fabra

2004

PhD in Marine Science

Universitat Politécnica de Catalunya and U. Barcelona

2002

Master of Marine Science

Universitat Politécnica de Catalunya

1998

Telecommunications Engineering

Universitat Politécnica de Catalunya

ADDITIONAL INFORMATION

Selected Publications

Gabarro, C., Turiel, A., Elosegui, P., Pla-Resina, J. A., and Portabella, M.: New methodology to estimate Arctic sea ice concentration from SMOS combining brightness temperature differences in a maximum-likelihood estimator, The Cryosphere, 11:4, 2017, 1987–2002.

E. Cardellach, C. Gabarro, et al... GNSS Transpolar Earth Reflectometry exploriNg system (G-TERN): Mission concept. IEEE Access PP . 2018

Gabarró C., V. González-Gambau, I. Corbella, F. Torres, J. Martínez, M. Portabella, J. Font, 2013: Impact of the Local Oscillator Calibration Rate on the SMOS Measurements and Retrieved Salinities. IEEE Transactions on Geoscience and Remote Sensing. Vol. 51- 9, pp. 4633 - 4642. 2013.

Guimbard S., J. Gourrion, M. Portabella, A. Turiel, C Gabarró, J. Font, 2012: SMOS Semi-empirical Ocean Forward Model Adjustment. IEEE Transactions on Geoscience and Remote Sensing. DOI: 10.1109/TGRS.2012.2188410. 50 – 5, pp. 1676 - 1687. 2012.

M. Talone; A. Camps; B. Mourre; R. Sabia; M. Vall-llossera; J. Gourrion; C. Gabarró; J. Font. Simulated SMOS Level 2 and 3 Products: the Effect of Introducing ARGO Data in the Processing Chain and its Impact on the Error Induced by the Vicinity of the Coast. IEEE Trans. on Geoscience and Remote Sensing. 47 - 9, pp. 3041 - 3050. USA2009.

C. Gabarró; M. Portabella; M. Talone; J. Font. Towards an Optimal SMOS Ocean Salinity Inversion Algorithm. IEEE Geosciences and Remote Sensing Letters. 6 - 3, pp. 509 - 513. 2009.

C. Gabarró; J. Font; A. Camps; M. Vall-llossera; A. Julià. A new empirical model of the sea surface microwave emissivity for the salinity remote sensing.Geophysical Research Letters. Vol. 31, L01309, doi – 2003GL018964, 2004.

PERSONAL INFORMATION

Justino Martinez

ICM-CSIC

PROJECT POSITION: SCIENTIST

WORK POSITION: SCIENTIST

WORK EXPERIENCE

2009–Present

Scientific Programmer

Instituto de Ciencias del Mar (ICM)

Involved in SMOS mission as a part of BEC (Barcelona Expert Centre). Currently centered in the improvement of brightness temperature acquisition and SMOS/SMAP products fusion. Involved in the creation of a processing chain to retrieve ocean salinity departing from brightness temperature. Creation of the necessary tools to perform the validation of SMOS and SMAP ocean salinity products.

1991-1999

Assistant Professor

Universidad Autónoma de Barcelona (UAB) Physics Department, Statistical Physics Group

Research field: Introduction of irreversible thermodynamics in the gravitational collapse of dense stars. Numerical simulation.

EDUCATION AND TRAINING

1995

PhD in Physics

Universitat Autònoma de Barcelona (UAB)

1991

Degree in Physics

Universitat Autònoma de Barcelona (UAB)

PERSONAL SKILLS

Programming languages: C, C ++ , CUDA, fortran, awk, python, bash, perl
System administration: Centos, Fedora, Ubuntu, Rocks Cluster
Data distribution/visualization: ncWMS, THREDDS, GEOSS (user level)
Documentation: L A TEX
Database servers: PostgreSQL, MySQL
Software: Matlab, NCO, IDL knowledge

ADDITIONAL INFORMATION

Selected Publications

Mitigation of RFI Main Lobes in SMOS Snapshots by Bandpass Filtering • J.Martínez, V. González Gambau, A.Turiel•IEEE Geoscience and Remote Sensing Letters • in press•DOI: 10.1109/LGRS.2018.2818285

- Validating SMAP SSS with in situ measurements•W. Tang, A. Fore, S. Yueh, A. Hayashi, A. Sánchez-Franks, J. Martínez, B. Jing, D. Baranowski •Remote Sensing of Environment, (2017), 200, 326-340 •DOI: 10.1016/j.rse.2017.08.021

- Debiased non-Bayesian retrieval: A novel approach to SMOS Sea Surface Salinity•E. Olmedo, J. Martínez, A Turiel, J. Ballabrera-Poy, M. Portabella •Remote Sensing of Environment, (2017), 193, 103-126•DOI: 10.1016/j.rse.2017.02.023

-Improvements on Calibration and Image Reconstruction of SMOS for Salinity Retrievals in Coastal Regions•V. González-Gambau, E. Olmedo, J. Martínez, A. Turiel, I. Durán •IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, (2017), 10(7), 3064-3078 •DOI: 10.1109/JSTARS.2017.2685690

-Spatial Correlations in SMOS Antenna: The Role of Effective Point Spread Functions
J. Martínez, A. Turiel, V. González-Gambau, E. Olmedo •IEEE Transactions on Geoscience and Remote Sensing, (2016), 54(8), 4906-4916 •DOI: 10.1109/TGRS.2016.2552647

-Improving time and space resolution of SMOS salinity maps using multifractal fusion • E. Olmedo, J. Martínez, M. Umbert, N. Hoareau, M. Portabella, J. Ballabrera-Poy, A. Turiel • Remote Sensing of Environment, (2016), 180, 246-263 •DOI: 10.1016/j.rse.2016.02.038

-Enhancing SMOS brightness temperatures over the ocean using the nodal sampling image reconstruction technique • V. González-Gambau, E. Olmedo, A. Turiel, J. Martínez, J. Ballabrera-Poy, M. Portabella, M. Piles •Remote Sensing of Environment, (2016), 180, 205-220 •DOI:10.1016/j.rse.2015.12.032

-About the Optimal Grid for SMOS Level 1C and Level 2 Products•M. Talone, M. Portabella, J. Martínez, V. González-Gambau •IEEE Geoscience and Remote Sensing Letters, (2015), 12(8), 1630 - 1634 •DOI: 10.1109/LGRS.2015.2416920

- On the potential of data assimilation to generate SMOS-Level 4 maps of sea surface salinity• N. Hoareau, M. Umbert, J. Martínez, A. Turiel, J. Ballabrera-Poy • Remote Sensing of Environment, (2014), 146, 188-200•DOI: 10.1016/j.rse.2013.10.005

PERSONAL INFORMATION

Antonio Turiel

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turiel@icm.csic.es

Sex Male | Date of birth 01/05/1970 | Nationality Spanish

WORKING EXPERIENCE

From 2008 to present

Staff Researcher (Científico Titular)

Institute of Marine Sciences, CSIC, Barcelona, Spain

- President of the Executive Committee of Barcelona Expert Center (2016 to present).
- Secretary of the Executive Committee of Barcelona Expert Center (2007 to 2015).
- Head of Physical Oceanography Department (2012-2013)
- Remote sensing of the oceans (mainly microwave passive), physical oceanography, analysis of dynamic process of the ocean by means of Eulerian and Lagrangian techniques, data processing, data distribution.

Business or sector Research

From 2004 to 2008

Post-doctoral fellow Ramón y Cajal

Institute of Marine Sciences, CSIC, Barcelona, Spain

- Operational oceanography, remote sensing of the ocean (mainly infrared and altimetry), physical oceanography, models of horizontal turbulence for the ocean.
- sadas

Business or sector Research

2003

Post-doctoral fellow RED from Generalitat de Catalunya

Universitat de Barcelona, Spain

- Statistical analysis of time series of several types, including stock market series

Business or sector Research & Education

From 2001 to 2002

Post-doctoral contract

Institut National de la Recherche en Informatique et en Automatique (INRIA), site Paris-Rocquencourt, France

- Analysis of remote sensing images, models for turbulence

Business or sector Research & Education

From 1999 to 2001

Post-doctoral contract from Spanish Ministry of Education

Laboratory of Statistical Physics, École Normale Supérieure de Paris, France

- Image processing, analysis of turbulent flows, statistical methods to describe complexity

Business or sector Research & Education

EDUCATION AND TRAINING

From 1994 to 1999

PhD in Theoretical Physics, mention Cum Laude

EQF Level 8

Universidad Autónoma de Madrid

- Replace with a list of principal subjects covered or skills acquired

From 1991 to 1994

B.Sc in Mathematics (Licenciatura)

EQF Level 6-7

Universidad Autónoma de Madrid

- Algebra, calculus, linear algebra, topology, differential geometry, statistics, probability, numerical analysis, measure theory, functional analysis, algebraic topology,

From 1988 to 1993

B.Sc in Physics (Licenciatura)

EQF Level 6-7

Universidad Autónoma de Madrid

- Linear algebra, calculus, general physics, general chemistry, thermodynamics, analytical mechanics, electromagnetism, quantum physics, optics, electrodynamics, statistical mechanics, numerical analysis, statistics and probability, quantum field theory, nuclear physics, cosmology, astrophysics,...

PERSONAL SKILLS

Mother tongue(s) Spanish

Other language(s)	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	C1
	Replace with name of language certificate. Enter level if known.				

Other language(s)	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
French	C2	C2	C1	C2	C1

Levels: A1/A2: Basic user - B1/B2: Independent user - C1/C2 Proficient user

Common European Framework of Reference for Languages

Communication skills

- Good communication skills gained through my experience: more than 100 presentations in scientific congresses, more than 80 presentations in dissemination activities, frequent radio and TV interviews, articles other than my scientific production and a regularly maintained dissemination blog.

Organisational / managerial skills

- Leadership (currently responsible for a team of 6 people, I have managed a team of 15 some years ago)
- Project supervision: Participation in over 20 research projects and contracts with industry, being PI of 5 of them, writing progress reports, attending progress meetings and general assemblies.

Job-related skills

- Experience with the management of databases and data distribution (responsible of Barcelona Expert Centre production centre, CP34).
- Experience with the use and management of massive computing facilities.

ADDITIONAL INFORMATION

Selected Recent Publications

- Isern-Fontanet J., Olmedo E., Turiel A. & Ballabrera-Poy J., 2016. “Observation of Algerian eddies in satellite Sea Surface Salinity retrieved from SMOS measurements”. *Geophysical Research Letters* **43**, 10.1002/2016GL069595.
- Lin W., Portabella M., Turiel A., Stoffelen A. & Verhoef A., 2016. “An improved singularity analysis for ASCAT quality control: Application to low winds”. *IEEE Transactions on Geoscience and Remote Sensing* **54**, 3890-3898
- Martínez J., Turiel A., González-Gambau V. & Olmedo E., 2016. “Spatial Correlations in SMOS Antenna: The Role of Effective Point Spread Functions”. *IEEE Transactions of Geoscience and Remote Sensing* **54**, 4906-4916.
- Olmedo E., Martínez J., Umbert M., Hoareau N., Portabella M.,Ballabrera-Poy J. and Turiel A., 2016. “Improving time and space resolution of SMOS salinity maps using multifractal fusion”. *Remote Sensing of Environment* **180**, 246-263.
- González-Gambau V., Turiel A., Olmedo E., Martínez J., Corbella & Camps A., 2016. “Nodal sampling: a new image reconstruction algorithm for SMOS”, *IEEE Transactions of Geoscience and Remote Sensing* **54**, 2314-2328.
- Umbert M., Guimbard S., Lagerloef G., Thompson L., Portabella M., Ballabrera-Poy J. & Turiel A., 2015. “Detecting the surface salinity signature of Gulf Stream cold-core rings in Aquarius synergistic products”. *Journal of Geophysical Research* **120**, 10.1002/2014JC010466.
- Lin W., Portabella M., Stoffelen A., Verhoef A. & Turiel A., 2015. “ASCAT Wind Quality Control Near Rain”. I*EEE Transactions in Geoscience and Remote Sensing* **53**, 1-13.
- Hoareau N., Umbert M., Martínez J., Turiel A. & Ballabrera J., 2014. “On the potential of data assimilation to generate SMOS-Level 4 maps of sea surface salinity”. *Remote Sensing of Environment* **146**, 188-200
- Umbert M., Hoareau N., Turiel A. & Ballabrera J., 2014. “New blending algorithm to synergize ocean variables: the case of SMOS sea surface salinity maps”. *Remote Sensing of Environment* **146**, 172-187.
- Lin W., Portabella M., Stoffelen A., Turiel A. & Verhoef A., 2014. “Rain Identification in ASCAT Winds Using Singularity Analysis”. *IEEE Geoscience and Remote Sensing Letters* **11**, 1519-1523.

Presentations

168 presentations to national and international scientific congresses.

- PROMISES (ESP2015-67549-C3-2-R), funded by the Spanish Ministry of Economy with 290 K€. Main goal: foster exploitation of SMOS data for geosciences, combining SMOS data with other sources of info to increase added value.
- MIDAS-7 (AYA2012-39356-C05-03), funded by the Spanish Ministry of Economy with 1.388 M€. Main goal: consolidate SMOS processing and exploitation.

PERSONAL INFORMATION

Laurent Bertino

NANSEN ENVIRONMENTAL AND REMOTE SENSING CENTER (NERSC)

PROJECT POSITION: RESEARCHER

WORK POSITION: RESEARCH DIRECTOR

RELEVANT EXPERIENCE

15 years of experience in coupled ice-ocean data assimilation and operational forecasting in the Arctic. Leader of the Arctic MFC in the Copernicus Marine Environment Monitoring Services. Member of the CLIVAR/CLiC Northern Oceans Region Panel.

He has also managed industry-driven modelling studies in the South China Sea, in the Gulf of Mexico and in the Barents and Kara Seas.

He has participated to the following ESA projects: EMOFOR (2003), Synergy SMOS-Aquarius (2004), OC CCI Phase 1 (2010) SMOS+Ice (2016), GARCA (2016).

EDUCATION AND AFFILIATIONS

2001 — **Doctor In Geostatistics**

Ecole des Mines de Paris, France

2003 to date — **Leader of data assimilation group at NERSC**

ADDITIONAL INFORMATION

Selected Publications

- **Bertino L.** and M. M. Holland (2018): Coupled ice-ocean modeling and predictions. *J. Marine Res.* Special Issue "The Sea". in press.
- Rabatel, M., Rampal, P., Carrassi, A., **Bertino, L.**, and Jones, C. K. R. T.: Impact of rheology on probabilistic forecasts of sea ice trajectories: application for search and rescue operations in the Arctic, *The Cryosphere*, 12, 935-953, https://doi.org/10.5194/tc-12-935-2018, 2018.
- Aalstad, K., Westermann, S., Schuler, T. V., Boike, J., and **Bertino, L**. (2018): Ensemble-based assimilation of fractional snow-covered area satellite retrievals to estimate the snow distribution at Arctic sites, *The Cryosphere*, 12, 247-270, https://doi.org/10.5194/tc-12-247-2018
- Xie, J., **L. Bertino**, E. Cardellach, M. Semmling, J. Wickert, An OSSE evaluation of the GNSS-R altimetry data for the GEROS-ISS mission as a complement to the existing observational networks, *Remote Sensing of Environment*, 209, pp. 152-165, https://doi.org/10.1016/j.rse.2018.02.053, May 2018.
- Xie, J., **Bertino, L**., Counillon, F., Lisæter, K. A., & Sakov, P. (2017). Quality assessment of the TOPAZ4 reanalysis in the Arctic over the period 1991–2013. *Ocean Science*, 13(1), 123–144. http://doi.org/10.5194/os-13-123-2017
- Xie, J., Counillon, F., **Bertino, L**., Tian-Kunze, X., & Kaleschke, L. (2016). Benefits of assimilating thin sea-ice thickness from SMOS into the TOPAZ system. *The Cryosphere*, 10(November), 2745–2761. http://doi.org/10.5194/tc-10-2745-2016
- Lien, V. S., Hjøllo, S. S., Skogen, M. D., Svendsen, E., Wehde, H., **Bertino, L**., Counillon, F., Chevallier, M., Garric, G. (2016). An assessment of the added value from data assimilation on modelled Nordic Seas hydrography and ocean transports. *Ocean Modelling*, 99, 43–59. http://doi.org/10.1016/j.ocemod.2015.12.010

Annexe 5 - Letters of Support

ARCFLUX Letter of Support

DTU Space

DTU

Carolina Gabarró Prats
Institut de Ciències del Mar - CSIC
Barcelona Expert Center on Remote Sensing (BEC-RS)

14 April 2018

ARCFLUX SUPPORT LETTER

Dear Carolina

On behalf of the ESA Arcflux project I am happy to support your tentative ESA ITT, called ARCTIC+ SALINITY, EXPRO+ with the primary objectives to explore, develop and validate novel approaches to enhance sea surface salinity measurements on the Arctic from SMOS and SMAP missions.

Arctic Ocean salinity is a limiting factor for freshwater flux determination in and out of the Arctic Ocean as well as its contribution to sea level change in the Arctic Ocean.

The ESA project ArcFlux is formally finishing within the spring of 2018. However the consortium aim to keep the project running (potentially via a CCN) in order to be able to perform updates and use results as an outcome of a project like Arctic+Salinity, EXPRO+.

We are also happy to commit to exchange of results and knowledge amongst the project for the mutual benefit to both projects and if possible host a joint meeting amongst the teams.

Best wishes

Senior Scientist
Dr. Ole Baltazar Andersen,

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isardSAT Letter of Support

isardSAT

Budowlanych 54 A
80-298 Gdańsk
Polska
Tel. +48 509.710.321
www.isardSAT.pl

Gdansk, May 3rd, 2018

Reference: Letter of Support for the ARCTIC + Salinity, EXPRO+ project
Att.: Carolina Gabarró

Dear Carolina,

We understand that your team is applying for the ESA ITT called ARCTIC + Salinity, EXPRO+, with the primary objective of exploring, developing and validating novel applications to enhance sea surface salinity measurements on the Arctic from SMOS and SMAP missions.

With this letter, and as Prime contractor of the STSE Artic + Theme 1(Snow on sea ice) and STSE Theme 2 (Sea ice mass inter-comparison) ESA projects, we want to express the support to your team in this application. Also, we declare the intentions of the above named projects teams to exchange results and knowledge with your tentative ESA ITT proposal on the ARCTIC + Salinity project. At the same time we express our will to study the possibility of hosting a join meeting with this purpose. Should this not be possible, we will use other opportunities, such as workshops or conferences, for this exchange of results and knowledge.

Mònica Roca
-
Prezes Zarządu – isardSAT Director
Monica.Roca@isardSAT.pl

isardSAT Sp. z o.o. KRS No. 0000475245 NIP No. 522-30-08-449 REGON No. 146475581 Registration Date: 30.08.2013