Arctic+
Theme 3: Freshwater fluxes

ArcFlux

EOP/-SA/0332/DFP-dfp

-Proposal-

DOCUMENT STATUS SHEET

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OA	1.0	12 November 2015	Version submitted to ESA
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ACCEPTED BY	O. ANDERSEN	DTU	19/4-2016	

1 Cover Letter

1.1 Theme

The scope of this document is to provide a technical, management, administrative, implementation and financial proposal to the ESA STSE ITT Arctic+, Theme 3: Freshwater fluxes (EOP/-SA/0332/DFP-dfp)

1.2 Summary

The main objective of this proposal is to determine the freshwater budget of the Arctic Ocean. To solve this task we propose to focus on the freshwater fluxes where Earth observation data together with in-situ data is expected to improve the final estimation of the Arctic Ocean freshwater budget. These are;

- Inflow of freshwater related to discharge from rivers
- Inflow of ice and melt run off
- Outflow of sea ice.

Furthermore, we anticipate that a main advance will be the improved capability to monitor and quantify the seasonal variability in these FWFs.

The table below shows how the WP structure of the ArcFlux project proposat relates to the tasks defined in AD-1.

Task [AD-1]	WP ArcFlux
1	WP1000
2	WP2 000
3	WP3000
4	WP4000
5	WP5000

The layout of the proposal

Section 2 contains the Technical Proposal, which in detail explains the objectives of the proposal and proposed approaches to reach these. The section also contains a thorough review of the different work packages. Section 3 is the Management Proposal, which contains information regarding the institutions of the consortium and the CVs of the personnel. Section 4 is the Implementation Proposal, which gives an overview of the work packages and deliverables. Section 5 describes the Financial Proposal and Section contains the PSS forms.

1.3 Tables i, ii and iii

Table i)

	Prime Contractor	Subcontrator 1	Subcontractor 2
Complete Name	DTU	ENVEO	LEGOS/CNRS
SME	NO	Yes	NO
Large Space Integrator	No	No	NO
EMITS Bidder Code	3193	33187	8354
ESA-p Bidder Code	6000006554	6000006864	
ESA-p Vendor Code	1000000428	1000000448	
Country	Denmark	Austria	France
Price Type	Firm Fixed	Firm Fixed	Firm Fixed
Currency	Euro	Euro	Euro
Total Price	95 000,27	53 000.00	51 980.98
Price for any Options	N/A	N/A	N/A
Total	199 981.25		

Table ii)

Country	Percentage of total Amount
DK	48%
FR	26%
AU	26%

Table iii)

Contact Person	Name Telephone Fax Email Postal Adress	Ole Baltazar Andersen + 45 4525 9754 + 45 4525 9775 oa@space.dtu.dk DTU Space, Elektrovej 328, DK-2800 Lyngby Denmark
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	Title	Senior Research Scientist
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Person for Contractual Management	Name Telephone Fax Email Postal Adress	Ole Baltazar Andersen + 45 4525 9754 + 45 4525 9775 oa@space.dtu.dk DTU Space, Elektrovej 328, DK-2800 Lyngby Denmark
Person to Sign the Contract	Name Telephone Fax Email Postal Adress	Kristian Pedersen + 45 4525 9750 + 45 4525 9775 kp@space.dtu.dk DTU Space, Elektrovej 328, DK-2800 Lyngby Denmark

Subcontractor: ENVEO

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Subcontractor: LEGOS / CNRS

Subcontractor	Name Adress	LEGOS OMP-LEGOS, avenue Edouard Belin, 18, 31401 Toulouse cedex 9, FRANCE
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1.4 Key Personnel

This list include the key personnel of ArcFlux; the persons that are (sub)WP leaders

NAMES	INSTITUTION
O. ANDERSEN (OA)	DTU
L. S. SØRENSEN (LS)	DTU
K. NIELSEN (KN)	DTU
H. SKOURUP (HS)	DTU
T. NAGLER (TN)	ENVEO
H. ROTT (HR)	ENVEO
J. WUITE (JW)	ENVEO
M. HETZENECKER (MH)	ENVEO
P. MALCHER (PM)	ENVEO
A. KOURAEV (AK)	LEGOS
E. ZAKHAROVA (EZ)	LEGOS
F. RÉMY (FR)	LEGOS
J-F CRETAUX (JC)	LEGOS

1.5 Full consortium

This list include the full consortium of ArcFlux.

NAMES	INSTITUTION
O. ANDERSEN	DTU
L. S. SØRENSEN	DTU
K. NIELSEN	DTU
H. SKOURUP	DTU
R. MEISTER	DTU
R. FORSBERG	DTU

T. NAGLER	ENVEO
H. ROTT	ENVEO
J. WUITE	ENVEO
M. HETZENECKER	ENVEO
P. MALCHER	ENVEO
A. KOURAEV	LEGOS
E. ZAKHAROVA	LEGOS
F. RÉMY	LEGOS
J-F CRETAUX	LEGOS

1.6 Signed Declaration

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Appendix 3 to ESA/AO/1-8377/15/I-NB
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ANNEX 2: Tender cover letter - Forms to be provided as part of its Annex 2

Form A: Declarations on Key Acceptance Factors

ITT Reference: DTU -2015 - 1 - 8377

Subject: ARC FLUX - THEME 3

By submitting this Form A as Annex to the cover letter of the Tender reference [*insert reference of your tender......*], I/we the undersigned herewith officially declare that the Tender fulfils the Key Acceptance Factors as listed hereunder and accepts that the Tender will be excluded from further evaluation if it turns out that the offer is not in line with any of the declarations given in this form:

		Please tick all the boxes to confirm that you meet the requirements
1	The Tenderer and any subcontractor(s) satisfy/ies the qualification requirements established under Part 1 A " Eligibility requirements" paragraph s b) to i) of the Agency's General Conditions of Tender (see Part 2B-1 of the GCT).	✓
2	The Tenderer confirms, on his behalf and on behalf of its subcontractors, to be compliant with the requirements listed in the "Certification of Free Competition" (see Part 2B-3 of the GCT).	✓
3	The Tenderer confirms, on his behalf and on behalf of its subcontractors, to be compliant with the requirements listed in the "Certification of non-benefit" (see Part 2H of the GCT).	✓
4	The Tenderer confirms, on his behalf and on behalf of its subcontractors, the acceptance of the conditions listed in the "Non commitment of the Agency" (see Part 2B-11 of the GCT).	✓
5	The Tender cover letter and the tender contain a binding price.	✓
6	The Tender cover letter and the tender contain price type compliant with the one requested in the ITT	✓
7	The Tender is compliant with the budgetary limit applicable to the tender as specified in the cover letter and STC	✓
8	The Tender cover letter contains a confirmation that the validity period is 4 months from the date of tender submission with implicit extensions as per Article 37 points 3 &4 of the Procurement Regulations ESA/REG/001 rev.3.	✓
9	The Tender contains a detailed technical description	✓
10	The Tender cover letter and its Annex 2 (Forms A and B) are signed by authorised representative(s) of the Tenderer.	✓

Name: OLE B. ANDERSEN

Current position in the Tenderer's organisation: SENIOR RESEARCH SCIENTIST

Signature: [signature]

Date: 11/11 - 2015

European Space Agency
Agence spatiale européenne

Form B: Declarations on Compliances

ITT Reference: DTU-2015-1-8377

Subject: ArcFlux - Theme 3

By submitting the present Form B as Annex to the cover letter of the Tender reference [insert reference of your Tender ....]

I/we the undersigned herewith officially declare that the Tender is compliant with the following requirements as listed hereunder:

	*Indicate : "**Compliant**" or "**Partially Compliant**" or "**Non-Compliant**"* *(in the last 2 cases give reference of the cover letter specific section containing detailed information on the matter and relevant cross references to the applicable parts of the offer)*
The information provided to ESA for registration as potential supplier (individually for all entities involved in the tender) has been updated in the last 12 months.	COMPLIANT
With regard to the technical requirements of the ITT/RFQ, the Tender is:	COMPLIANT
With regard to the managerial requirements of the ITT/RFQ, the Tender is:	COMPLIANT
With regard to the financial requirements of the ITT/RFQ, the Tender is:	COMPLIANT
With regard to the contract conditions of the ITT/RFQ (please refer to the draft contract and to the present Special Conditions of Tender - Part 3 - section 6.1) the Tender is	COMPLIANT
With regard to the IPR requirements of the ITT/RFQ (please refer to the present Special Conditions of Tender - Part 3 - section 6.3) the Tender is::	COMPLIANT
With regard to the Export/Import requirements of the ITT/RFQ (please refer to the present Special Conditions of Tender - Part 3 - section 6.4) the Tender is:	COMPLIANT
With regard to the Agency's Right of Audit (GCT Part 2 B7), the Tender is:	COMPLIANT

Name: OLE B. ANDERSEN

Current position in the Tenderer's organisation : SENIOR RESEARCH SCIENTIST

Signature: [signature]

Date: 11/11-2015

1.7 Signature

Done and signed for, and on behalf of

Danmarks Tekniske Universitet – Technical University of Denmark.
National Space Institute
Elektrovej, Byg. 327
2800 Kgs. Lyngby, Denmark

Signature:

Ole B. Andersen

Ole B. Andersen

1.8 References

Applicable Documents

AD-1	Statement of work. STSE Arctic+. EOP-SA/0332/DFP-dfp. Issue 1, Revision 0
AD-2	ESA Contract No. xxxxxxxxxx/xx/I-NB. Appendix 2 to ESA/AO/1-8377/15/I-NB
AD-3	SPECIAL CONDITIONS OF TENDER. Appendix 3 to ESA/AO/1-8377/15/I-NB
AD-4	Item no. 15.155.13 in the list of ESA intended Invitations to Tender. ESA-IPL-POE-NB-sp-ITT-2015-815

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RD-38	Papa, F., F. Durand, W. B. Rossow, A. Rahman, and S. K. Bala (2010), Satellite altimeter-derived monthly discharge of the Ganga-Brahmaputra river and its seasonal to interannual variations from 1993 to 2008, J. Geophys. Res., 115, C12013, doi:10.1029/2009JC006075.
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RD-42	Mauritzen, C.: Arctic Freshwater. Nature Geoscience, vol. 5, pp. 162-164. March 2012
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1.9 Acronyms

ATBD	Algorithm Technical Baseline Document
DTU	Danish Technical University
ESA	European Space Agency
CAA	Canadian Arctic Archipelago
FS	Fram Strait
BS	Bering Strait
CS2	CryoSat-2
ITT	Invitation To Tender
FWF	Freshwater flux
FWB	Freshwater budget
GrIS	Greenland Ice Sheet
P	Precipitation
SMB	Surface mass balance
E	evapotranspiration

2 Technical Proposal

The study will be carried out by a consortium led by DTU. The consortium is composed of a core team involved in the day-to-day work. The consortium consists of scientists from three institutes from three European countries:

- DTU, Denmark
- LEGOS, France
- ENVEO, Austria

The consortium holds all the required expertise and experience to successfully carry out the proposed work in ArcFlux, including the management of it.

2.1 Introductionary state of the Art

As pointed out by RD-1, evidence exists for rapid changes occurring in the Earth's climate system. Through both atmospheric and oceanic circulation, heat is transferred from the equator to the poles. The effects of climate change are most pronounced in the Arctic and Antarctic. Possible ways in which Arctic (eco) systems can be affected by warmer temperatures include: changes in amount and duration of snow and ice cover; frequency and extent of spring floods; changes in the ratio of P-E (precipitation minus evapotranspiration); amounts of water transport to lakes and rivers from snow and permafrost melting; and a decrease in frozen precipitation.

The Arctic Ocean is sensitive to freshwater fluxes (FWF) in terms of ocean stratification, circulations and the nutrient balance. The main input to the freshwater budget is river discharge, ice and snow discharge, net precipitation, and inflow of low-salinity water through Bering Strait (see Figure 1). The transport of freshwater out of the Arctic Ocean is dominated by outflow of liquid water through the Canadian Arctic Archipelago (CAA) and outflow of liquid water and sea ice through Fram Strait (see Figure 1).

A change in the freshwater budget (FWB) of the Arctic Ocean has a number of consequences. The most important one is that an addition of freshwater will affect, and possibly slow down, the thermohaline circulation transporting warmer waters northwards. This would result in a cooling of northern Europe and warmer temperatures elsewhere. In addition, a decreased sea ice cover may result in higher humidity and hence increased snowfall. Furthermore, melting of permafrost and draining of wetlands result in an increased amounts of river flow and lake area. With an expected rise in freshwater discharge to the Arctic Ocean of 28%, of which 15%

are attributable to ice melt (RD-11), it is therefore of utmost importance to constrain the FWB, and the individual FWFs.

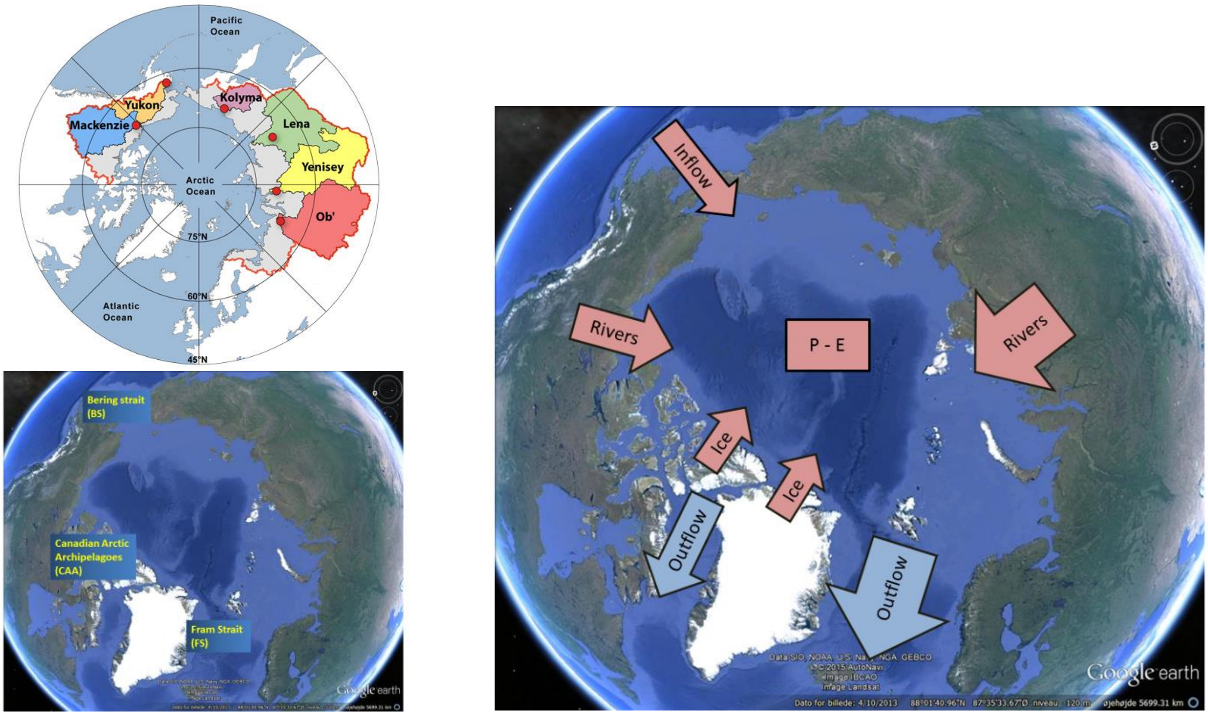

Figure 1 (left) Main inflow and outflow channels on the Actic Ocean FWB. Also Arctic river basins map from the Arctic Great Rivers Observatory, http://arcticgreatrivers.org/
(Right) Freshwater fluxes that mainly defining the Arctic freshwater budget. Red shows inflow while blue outflow of the Arctic Ocean.

The Arctic freshwater flux system is considerably more complicated than visualized in Figure 1 as also notices by RD-11 in 2006, and many of the individual fluxes are associated with huge errors due to lack of data. The Annual mean freshwater budget outlined in RD-11 encompasses the following components as shown in Figure 2.

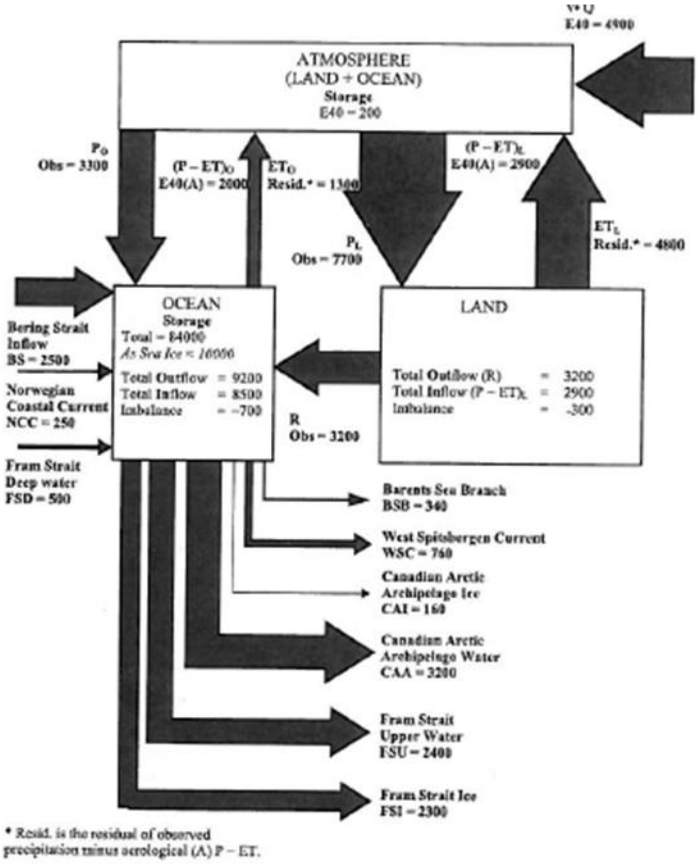

Figure 2: The numbers show in greater detail the contributors and the magnitude of these to the Arctic Freshwater Budget. All values are in km3/y and the figure is adapted from RD-11.

The FWFs in Figure 2 was updated by RD-18 (to the period 2000-2010) due to the rapid changes seen in the Arctic during the last decade, and the increased availability of EO data and independent models. Besides in and outflow via the atmosphere, the outflow of freshwater from the Arctic is mainly as solid water (sea ice) which dominates transport through the Fram Strait and through freshwater diluting the upper layer of the Arctic Ocean and creating the ubiquitous halocline in the upper 50 meters which is seen to dominate the transport in the CAA via the ocean circulation. However all the transports are associated with large uncertainties and RD-18 mentioned that the transports are furthermore currently experiencing large changes.

Some fluxes are also becoming increasingly important in the Arctic FWB. Thawing permafrost is one of the components which are expected to increase the inflow of freshwater into the Arctic as also demonstrated by RD-22. Thawing permafrost generally leads to increased freshwater inflow into the Arctic, but exceptions are seen RD-25. This is somewhat counteracted by the increase in groundwater depletion and abstractions with new abilities to farm at higher latitudes as also mentioned by RD-22.

It is not possible to close the Arctic Freshwater budget without the inter-annual changes in the Arctic Oscillation that drives large variations in freshwater storage inside the Arctic Ocean into account. RD-18 notices the imbalance in FWB to freshen the Arctic Ocean, increasing from 100 km^3/y in the 1980's to around 1200 km^3/y 2000-2010 (with uncertainty of 700 km^3/y). The Arctic Ocean Freshening is particularly seen as an increase in sea level associated with the Beaufort Gyre over the altimetry era where a recent publication RD-23 indicates that the Beaufort Gyre has risen by as much as 40 cm over the last 25 years.

Below is a short description highlighting more state of the art of our knowledge of the main in- and outflow of the FWB of the Arctic Ocean.

Inflows

The main river systems that drain into the Arctic Ocean are the Ob, Yenisey, and Lena in Eurasia and the Mackenzie in Canada (see figure 1) providing around 3200 km^3/y in freshwater (RD-11). The FWF from rivers is estimated from river discharge near the mouth of the draining rivers. Discharge can be obtained directly from gauge measurement or indirectly from the water levels obtained from gauges or satellite altimetry. In the last decade the number of gauge stations has been declining (RD-4), hence satellite altimetry has become a valuable supplement to derive water levels and hence also the discharge as in-situ observations are frequently sensitive to local water-storage and use of the river water for irrigation.

Satellite altimetry has been used extensively to obtain water level of inland river and lake systems, using data from radar altimetry satellite missions such as ERS, Envisat TOPEX/Poseidon, and Jason-2 [RD-39 and RD-36]. Satellite altimetry has also been used to estimate river discharge. The use of rating curves between altimetric height and in situ discharge data provides a good accuracy for estimation of daily discharges as well as annual river input to the ocean. The early studies based on high-frequency TOPEX/Poseidon measurements showed the mean errors of 1,5 - 6% for daily discharge estimation for the Amazon river [RD-37] and 8% for the Ob' river in Siberia [RD-5]. Additional errors are introduced during interpolation of altimetry-derived (10 days repeat period) daily discharges for calculation of annual river outflow. The final errors of estimations of altimetric annual river outflow increase up to 6 and 17% for Amazon and Ob' rivers correspondingly. Recently RD-38 used Jason-2 altimetry data to estimate water outflow from the Ganga and Brahmaptura rivers, based on in situ rating curves. He obtained errors of 13 and 6.5 %, respectively. The polar orbit altimetric missions with quasi-monthly repeat cycle could also be used for river discharge estimations. RD-36 obtained discharge for the Mekong and Ob' rivers using ENVISAT altimetry data over 50 km river reaches with acceptable accuracy, basing on the Manning's resistance formulation. RD-35 demonstrated the original approach to derive the river discharge from ENVISAT altimetric heights using quantile function instead of rating curves. This method can be applied in the cases of absence of overlap between altimetric height and in situ discharge time series.

The performance of CryoSat-2/SIRAL altimetry for river monitoring was investigated by using river levels retrieved from Ganges and Brahmaputra [RD-21]. Although the CryoSat-2/SIRAL has long repeat period orbit of 369 days, which is not well adapted for river and lake monitoring, the results from the method of spatio-temporal interpolation developed in this study show a high potential for river hydrology. The application of this method allows the time series construction with the sub-cycle period of 30 days.

Thawing permafrost with possible release of carbon dioxide and methane will likely add to the inflow in a complex matter which is currently an area of intense investigation but quantification of this is still hard.

Ice and snow discharge from Greenland and ice caps in the arctic region is another positive FWF in the Arctic Ocean FWB but considerably smaller than the input from rivers (300-500 km^3/y, RD-11). This FWF can be estimated by combining information from surface mass balance (SMB) models, satellite altimetry and ice velocities from SAR images.

RD-2 found through a combination of models and GRACE measurements that glaciers in the CAA are losing mass, caused by the fact that meltwater runoff is not sufficiently compensated for by accumulation. This mass loss means that an increasing FWF is added to the Arctic Ocean. Since their study in 2012 [RD-2], Cryosat-2 and Sentinel-1/3 measurements have become available which makes it possible to continuously measure, and hence constrain, the changes of Arctic and Greenlandic glaciers, and hence changes in the FWF.

As mentioned in RD-3, Greenland Ice Sheet (GrIS) mass loss rates have accelerated since the turn of the century. The GrIS mass balance can be measured using a variety of tools; satellite altimetry measurements to detect of changes in the surface height, SAR measurements of changes in ice velocity and gravimetric measurements of mass changes. It is important to note that the ice sheet or glacier mass loss does not define the FWF but a change in it.

In-situ measurements of precipitation (P) and evapotranspiration (E) are sparse in the Arctic region and are affected with large uncertainties. The net P-E is of the order of 2000 km^3/y (RD-11) and is therefore often estimated from climate models with an uncertainty of 10 % (RD-18).

The freshwater flux from inflow of low-salinity water through the Bering Strait and to a lesser degree though deep water outflow of saline water in the Fram Strait are of the order of 3000 km^3/y (RD-11) and can be estimated from mooring data of salinity and velocity (RD-8).

Outflow

A large amount of Arctic freshwater is contained in the sea ice, part of which is transported out of the Arctic Ocean mainly through the Fram Strait (2300 km3/y), and a minor component through the Nares Strait and the straits between the Queen Elizabeth Islands in the northeastern part of Canada (CAA) and with some smaller transport through the Fury and Hecla straits (Bering Strait). To estimate the freshwater outflow of the Arctic contained in the sea ice, a time-series of sea ice thickness through a defined fluxgate combined with sea ice velocities is needed. This has already been demonstrated to work in RD-9.

Oceanic freshwater fluxes of liquid water through mainly the CAA (2300 km3/y) and the Fram Strait (2400 km3/y) can be determined from mooring data of salinity and velocity with an uncertainty of some 10% [RD-18]. Recent availability of high quality SAR altimetry from the Cryosat-2 and Sentinel-3 missions opens up the possibility to use these for studying the liquid transport in the upper 50 meters of the ocean through a geostrophic assumption as demonstrated for the North Atlantic in RD-26.

Current knowledge gap

According to RD-22 one of the major knowledge gaps in relation to estimating the FWB based on models is the lack of in situ observations for validation of the models. RD-11 also pointed out that the uncertainty is very large on the various components in the FWB. RD-18 notices the imbalance in FWB which is the source to freshen the Arctic Ocean has been increasing from 100 km^3/y in the 1980th to around 1200 km^3/y in the 2000-2010 period but with uncertainty of 700 km^3/y. It is also noticed that based on such numbers coupled climate models project continued freshening of the Arctic Ocean during the 21st century with a total gain of about 50.000 km3 which is an increase of about 50%. On top of this our knowledge into the effect of thawing permafrost and irrigation at higher latitudes adds further uncertainty.

Both for present day estimates of the Fresh water balance, but also to serve for improved modelling of FWF and improved model-predictions of FWF and FWB it is fundamental to include EO data. The outcome of ArcFlux will produce independent estimates of several components of the FWF based on EO data which can also serve both model validation and model data.

In the ArcFlux approach the idea is to focus on improving the FWF of the four major FW components using EO data. These four major FW fluxes adds up to more than 90% of the total FW budget of the horizontal water and ice fluxes in and out of the Arctic Ocean according to RD-18.

2.2 Project Objectives

The main objectives of this proposed study are:

1. Identify, and document the major challenges associated with estimation of the Arctic Freshwater budget. This includes identifying gaps in our current knowledge and capabilities.
2. Explore, develop and validate different approaches to address the identified challenges and enhance current approaches to compute the freshwater budget in the Arctic. This should be done maximizing the use of ESA data.
3. Compute a multi-year assessment of the Arctic freshwater budget based on the developed methodology.
4. Validate the obtained results and compute uncertainties. Compare the derived estimates with existing alternative estimates
5. Develop a scientific roadmap for future research activities in this domain of estimating the FWB of the Arctic Ocean.

2.2.1 Proposed approach to reach the primary objectives of the proposal

Within ArcFlux we will focus on contributions (FWFs), where satellite data in combination with available in-situ data is expected to improve the FWF estimates. These are river discharge, ice discharge and melt, sea ice fluxes and ocean fluxes through Bering Strait, Fram Strait and CAA/ Davis Strait. We propose the following approach to derive these FWFs which are listed below. Another major objective in this proposal is to estimate the FWB of the Arctic Ocean in relation to the potential storage of freshwater inside the Arctic Ocean. The freshwater budget of the Arctic Ocean consists of several contributions as described above.

Within ArcFlux, the strategy for determining the FWFs is described in the following sections.

2.2.1.1 Discharge from arctic rivers

Discharge from arctic rivers is one of the major freshwater sources in the Arctic Ocean, but with a declining number of gauge data (RD-4), satellite altimetry is a valuable supplement. Water levels obtained from satellite altimetry has already been applied for arctic rivers to derive discharge (RD-5). Here we intend to use missions such as Envisat, SARAL, T/P, Jason-1, -2, CryoSat-2, and potentially Sentinel-3 data, to estimate water level variations, which can be converted into discharge through a rating curve. The tracks related to the altimetry data in the vicinity of the Ob River are shown on Figure 3. The data coverage is similar for the other large rivers. The altimeter onboard CryoSat-2 is partly operating in SAR/SARIn mode in the arctic region, and these modes have proven to provide more precise water level estimates over smaller water bodies than from conventional radar altimetry (RD-7), due the higher along-track resolution. A first preliminary attempt to estimate a water level time series for the Ob River (virtual station 20 km upstream from Aksarka) is demonstrated in Figure 4. The time series is only based on CryoSat-2 data and it is expected that the result will improve when data from other missions is included.

Our approach enables us to look at the river level variations at various locations which can be a possible key to understand the various contributors. Contribution from thawing permafrost might add water to the rivers, but in principle the altimeter does not distinguish between the sources (i.e., melt water, damn building, seasonal freezing of the ground and permafrost) and only measures the total water level variations, but provide the observations at multiple locations along the river.

To achieve accurate water levels from altimetry it is essential to have an accurate mask of the river outline. We therefore propose to use satellite imagery from Sentinel-1 and Sentinel-2 to derive seasonal masks of the various river systems. These images will further provide information regarding periods of freezing (RD-6), which will help to identify periods where the altimetry derived water levels are uncertain, due to ice cover. Data from Sentinel-1and 2 is available for the areas that cover the mouth of the large Arctic Rivers and can be downloaded from the "Sentinels Scientific Data Hub" (https://scihub.copernicus.eu/)

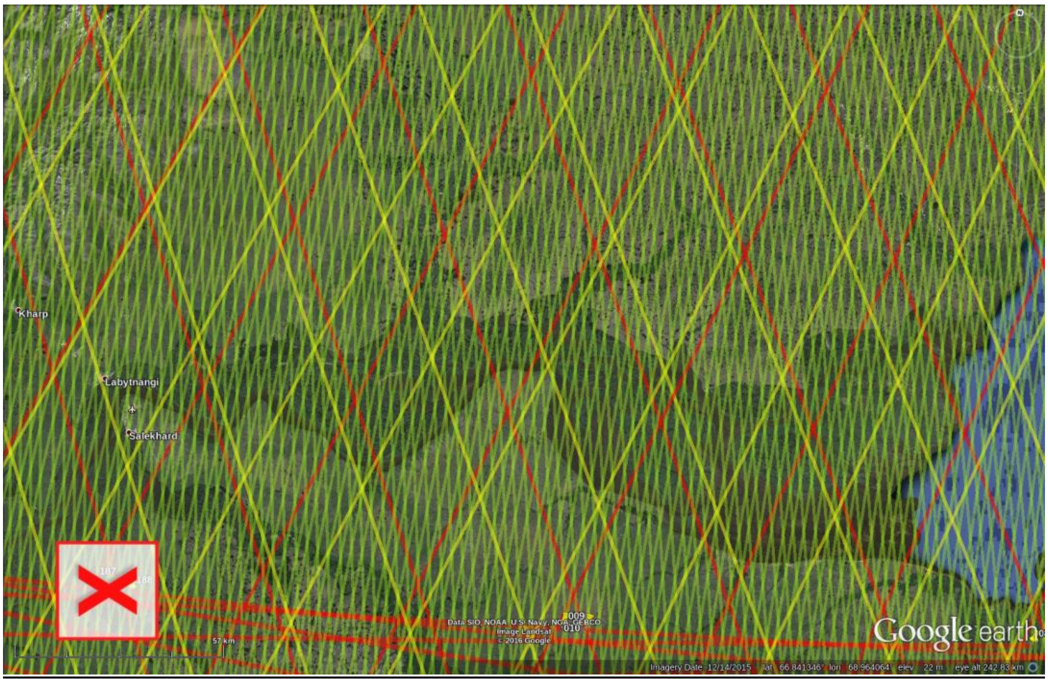

Figure 3: Availeble altimetry data in the vicinity of the Ob Rver. Yellow indicates Envisat and SARAL/Altika orbits, green CryoSat-2 and red Sentinel-3. The almost horizontal tracks are the Jason/Topex orbits.

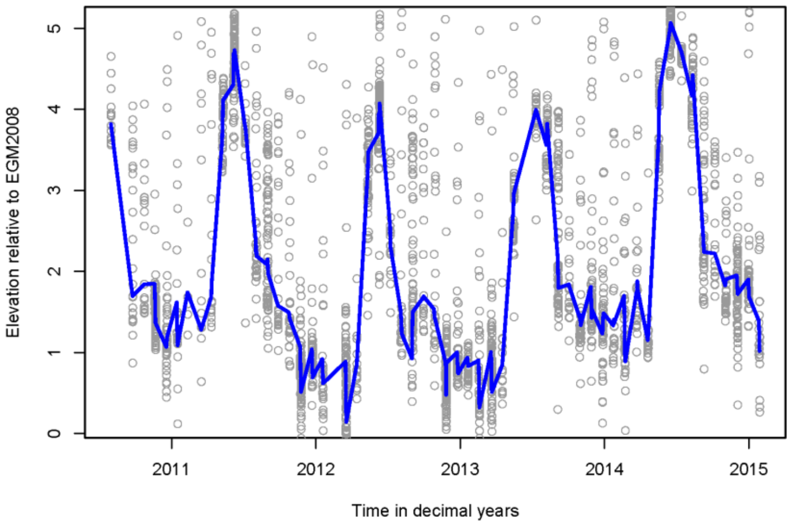

Figure 4: Water level time series for the Ob river based on CryoSat-2 in SARIn mode (credits: Karina Nielsen, 2016)

To convert water levels to discharge we will implement the classical rating curve approach for estimation of river input into the ocean from the four largest Arctic rivers: Ob', Yenisey, Lena and Mackenzie. We will furthermore conduct a feasibility study of the altimetric water height retrieval for medium-size rivers of Eurasia (Pechora, Nadym, Pur, Taz, Khatanga, Yana, Indigirka, Kolyma). The consortium will benefit from the combination of LEGOS experience in conventional altimetry and analysis of height-discharge relations for arctic rivers [RD-5] and DTU's experience in water height processing from CryoSat-2 SAR and SARIn modes [RD-21]. The lower reaches of the Ob' river are covered by CryoSat2 observations in SARIn mode (A preliminary plot based on CryoSat-2 data is shown in Figure 4). So, this basin will be used as a test site for demonstration of the performance of new SAR technology, as compared to conventional altimetry. For other basins we will retrieve the water height using all available missions (T/P, Jason 2, ENVISAT, SARAL/Altika and Cryosat2 LRM) and will evaluate the goodness of combined measurements for discharge estimations. The rating curves will be constructed using in situ discharge data collected by LEGOS during FP-7 MONARCH-A project (historical data until 2006-2009) as well as recent 2008-2012 period data available due to French-Russian collaboration in the frame of GDRI CAR-WET-SIB (http://www.eu-russia-yearofscience.eu/en/1519.php) for about 20 Eurasian rivers draining into the Arctic Ocean (with restricted use).

The presence of ice on boreal and arctic rivers can significantly deteriorate the accuracy of the water height retrievals during winter. But as it was shown in [RD-5], the resulting winter errors of river discharge estimates by rating curves are relatively low because of low values and low variability of the flow under the ice. Since 2004 progress has been achieved in water height retrievals over river ice and the modern algorithm developed at LEGOS uses the parameters of the waveform to select the signals non contaminated by land and retrackers adapted to ice conditions.

The initial GDR altimetry data are archived in the Centre for Topographic studies of the Oceans and Hydrosphere (CTOH) at the LEGOS laboratory (http://www.legos.obs-mip.fr/en/observations/ctoh/). They are accompanied by relevant updated geophysical corrections.

The pan-arctic drainage covers $22.4*10^6$ km^2 [RD-33]. The four largest rivers drain about 42% of this area, but their contribution is about 60% of total water input. A regionalization approach will also be considered in order to obtain lateral water input from small and medium-size rivers. It is based on first establishing relationship between rivers with missing runoff data and neighboring rivers using historical datasets prior to 1998. These relations could be used as proxies to reconstruct poorly gauged continental lateral FWF for recent periods. The accuracy of this approach will be evaluated using the short record period of in situ data (2008-2012) available for Eurasian continent and HYDAT database (Environment Canada) available for Canadian rivers.

For comparison other source of water input from medium and small river watersheds are model simulations. For the Eurasian rivers Pur, Nadym, Taz and Northern Dvina the water flow will be simulated by two regional hydrological distributed models: WATFLOOD and ECOMAG run by LEGOS team. The simulations from the global models (for example GLDAS) will be used for evaluation of river freshwater input from other watersheds.

2.2.1.2 Freshwater flux from Greenland and Artic ice caps

The fresh water flux from the ice sheet and ice caps includes two major processes, (i) the calving flux from marine terminating glaciers and (ii) melt water flux (run-off).

(i) The calving flux is the ice discharge through a defined gate which is defined in general near the grounding line of the outlet glaciers. To calculate the calving flux ice velocity data and the ice thickness at the gate is needed. Ice velocity data can be derived from repeat pass SAR data (i.e. Sentinel-1), while the ice thickness is derived from the difference between ice surface and bedrock elevations. Ice surface DEM will come (and be continuously updated) from satellite/airborne altimetry while the bedrock topography will have to come from models (e.g.

http://sites.uci.edu/morlighem/dataproducts/mass-conservation-dataset/ or

http://www.the-cryosphere.net/7/499/2013/tc-7-499-2013.pdf). The bedrock DEMs may be constrained by airborne measurements carried out by DTU in 2007 and 2011 using ice penetrating radar.

We plan to derive the calving fluxed of the main glaciers of Greenland and ice caps, where suitable data are available.

(ii) The other component to the FWF from the land based ice is run off (melt that did not re-freeze).

The surface mass balance (including run-off) of the ice sheet and ice caps cannot be estimated from remote sensing. Therefore, this component will be quantified through the use of Regional Climate Models (RCMs) within ArcFlux.

There are uncertainties associated with all RCMs, and therefore our strategy is to use several models, and to use their variability as a measure of the error on the run-off term. We will use run off estimates from an ensemble of models, and as a start we plan to use HIRHAM, MAR, and RACMO but if more models become available throughout the duration of the project, these may be included during the progress of the WPs.

Regional Climate Models that can provide surface mass balance (and run off) are:

HIRHAM. The HIRHAM RCM is run at the Danish Meteorological Institute (RD-30). HIRHAM products over Greenland have been validated with ice core and automatic weather station data. The model takes melt and meltwater retention processes in snow into account. HIRHAM5 was run at a horizontal resolution of 0.25◦, but later versions might have higher resolution (RD-29).

RACMO. The Regional Atmospheric Climate Model version 2.3 is run at the University of Utrecht. For Greenland, RACMO is coupled to a multi -layer snow model which calculates melt, percolation, refreezing and runoff of meltwater. RACMO2 was run with a horizontal resolution of 0.1◦. **MAR.** The MAR (Modèle Atmosphérique Régional) RCM is run at the

University of Liège (RD-31). The snow–ice component includes snow thermodynamics, meltwater refreezing, snow metamorphism, snow/ice discretisation, and an integrated surface albedo (RD-32). MAR is run with a horizontal resolution of 25 km. Model output is freely avainable for download here: ftp://ftp.climato.be/fettweis/MARv3.5/Greenland

The test areas for determining the FWF from ice sheets/ice caps can not be finally decided, until at the end of WP1400 in which two or three test areas are defined for determination of the FWF from land ice into the Arctic Ocean. These test areas (glaciers) will be chosen based on an evaluation of available EO data as well as validation data.

Candidates for these two-three areas could be Petermann Glacier (Greenland Ice Sheet), Ryder Glacier (Greenland Ice Sheet) and Flade Isblink (local ice cap). These are shown in Fig. A. These are good candidate test areas because they cover both the ice sheet and a local ice cap, and the two ice sheet glaciers are quite different in size and nature so the method /techniques can be tested in different settings.

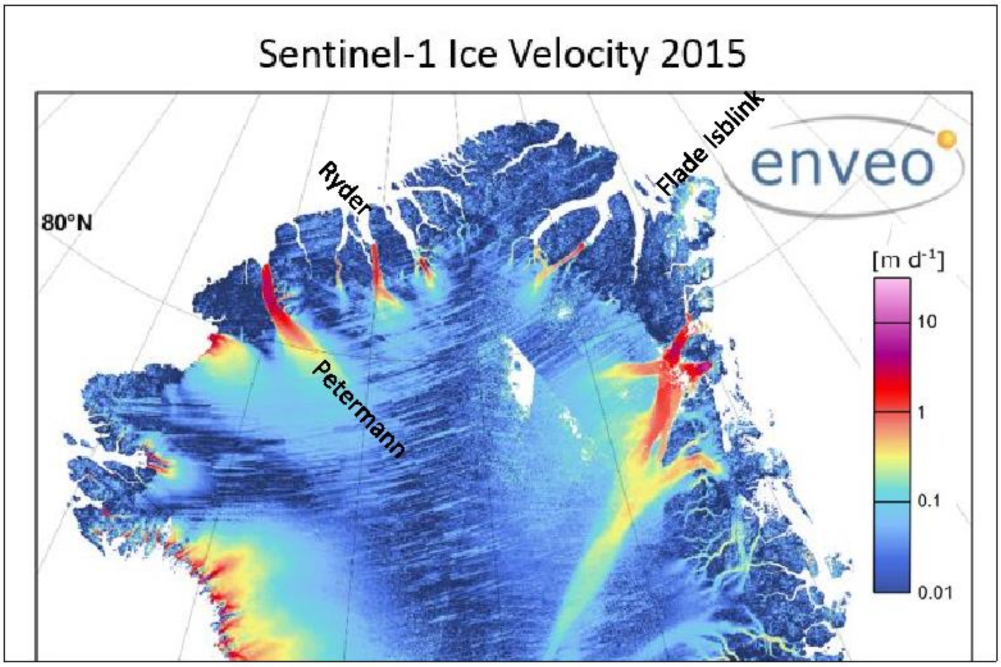

Figure 5: Location of candidate test sites shown on ice velocity map (credit: http://www.enveo.at/)

2.2.1.3 Sea ice Freshwater flux

The content of freshwater transported out of the Arctic via the sea ice, is previous estimated using a combination of ice concentration and ice drift (RD-12). More recent estimate of sea ice transport through Fram Strait to the total FWB (RD-18 and RD-11) uses modelled sea ice thicknesses from models pre-2000 and observed sea ice thicknesses from ICESat data 2003-2008 (RD-9), together with drift and area based on radiometer data.

However, due to the recent availability of sea ice thickness estimates from satellite radar altimeters (RD-13, RD-14, RD-15), and drift from repeated SAR imagery, this study will use a combination of these satellite based observations to estimate the present FWF across the largest outflow fluxgate crossing the Fram Strait.

We will use a combination of CryoSat-2 and ENVISAT monthly sea ice thickness profiles from existing products, see Table 1. Observations of sea ice thicknesses of thickness less than 0.5 m from SMOS mission will primarily be used to estimate the overall storage of freshwater contained in Arctic Ocean, as the sea ice in Fram Strait are primarily older thicker ice types. As the sea ice thicknesses measured by radar altimetry do not include the snow layer on top of the sea ice (RD-17), this is accounted for using snow depths obtained by modified climatology as suggested by (RD-16). A study of an optimal snow depth product for the Arctic is part of Arctic+ Theme 1, and will not be addressed here. In addition, sea ice thickness derived satellite altimetry, are not available in Arctic summer months June-September, due to contaminated signals from meltwater ponds (RD-13-15, RD-17). To fill in these gaps summer month sea ice thickness profiles will be based on model input, e.g. My Ocean or Polar Portalen.

We intend to demonstrate the capability of using sea ice drift based on repeated SAR images, from Sentinel-1 and ENVISAT. The ice drift is already produced in house (DTU Space, Roberto Saldo) and available at the online service www.seaice.dk, see Figure below. Between the end of the ENVISAT era April 2012 and the beginning of Sentinel-1A launched April 2014, the drift data is produced using only RadarSat images, which is sparse for the Fram Strait region. During this period we intend to use existing drift products based on scatterometer and radiometer data, such as OSI-SAF, Polar Pathfinder and CERSAT sea ice motion maps.

Table 1: Sea ice products.

Parameter	Satellite mission	Instrument	Product
Sea ice thickness	CryoSat-2	Altimetry	CPOM, UCL AWI ESA CCI
	ENVISAT	Altimetry	ESA CCI
	SMOS	Radiometry	University of Bremen University of Hamburg
Snow depth	Modified Warren	Climatology	
Drift	Sentinel-1	SAR images	Seaice.dk
	ENVISAT	SAR images	Seaice.dk

The various sea ice thickness and drift products will be validated using information of the sea ice draft and velocities from moored Upward Looking Sonars and drifting buoys (CRREL ice mass balance buoys and AWI snow depth buoys), located in the Fram Strait, see map below.

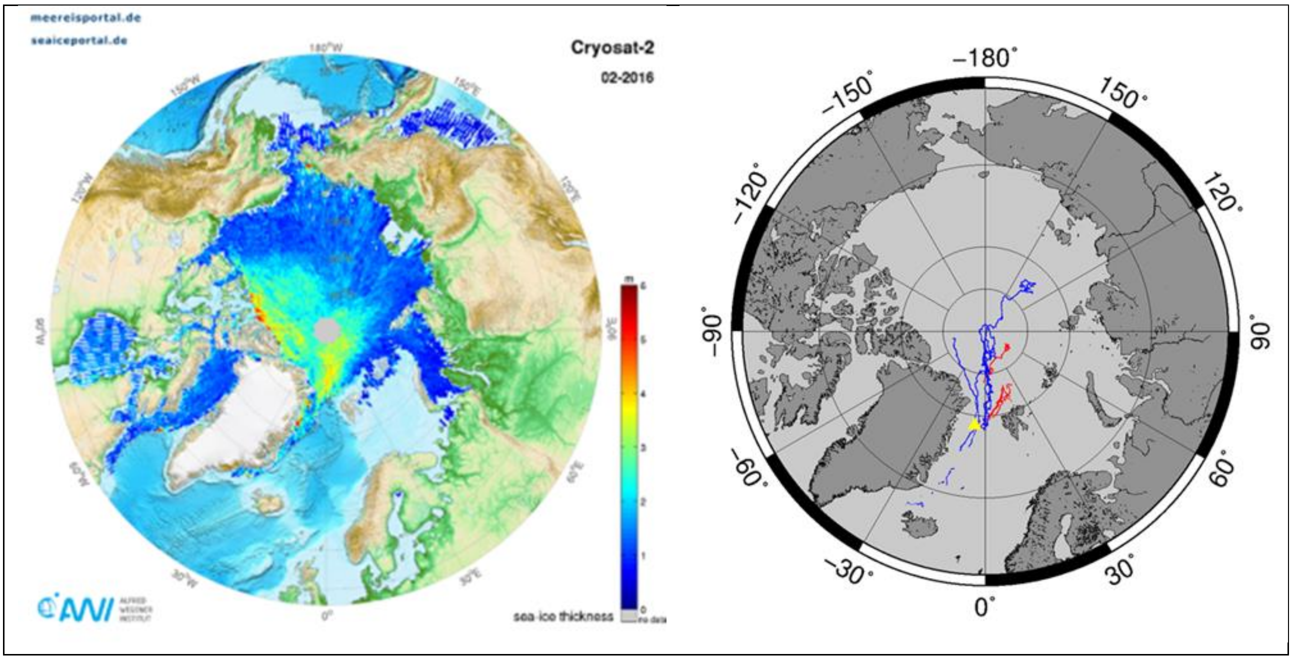

Figure 6: , Left: Most recent sea ice thickness map of the Arctic Ocean, February 2016, from Alfred Wegener Institute, http://www.meereisportal.de. Right: Sea ice thickness and drift validation data in Fram Strait region 2012-present from drifting buoys (blue: CRREL ice mass balance buoys, red: AWI snow depth buoys) and moored upward looking sonar (yellow).

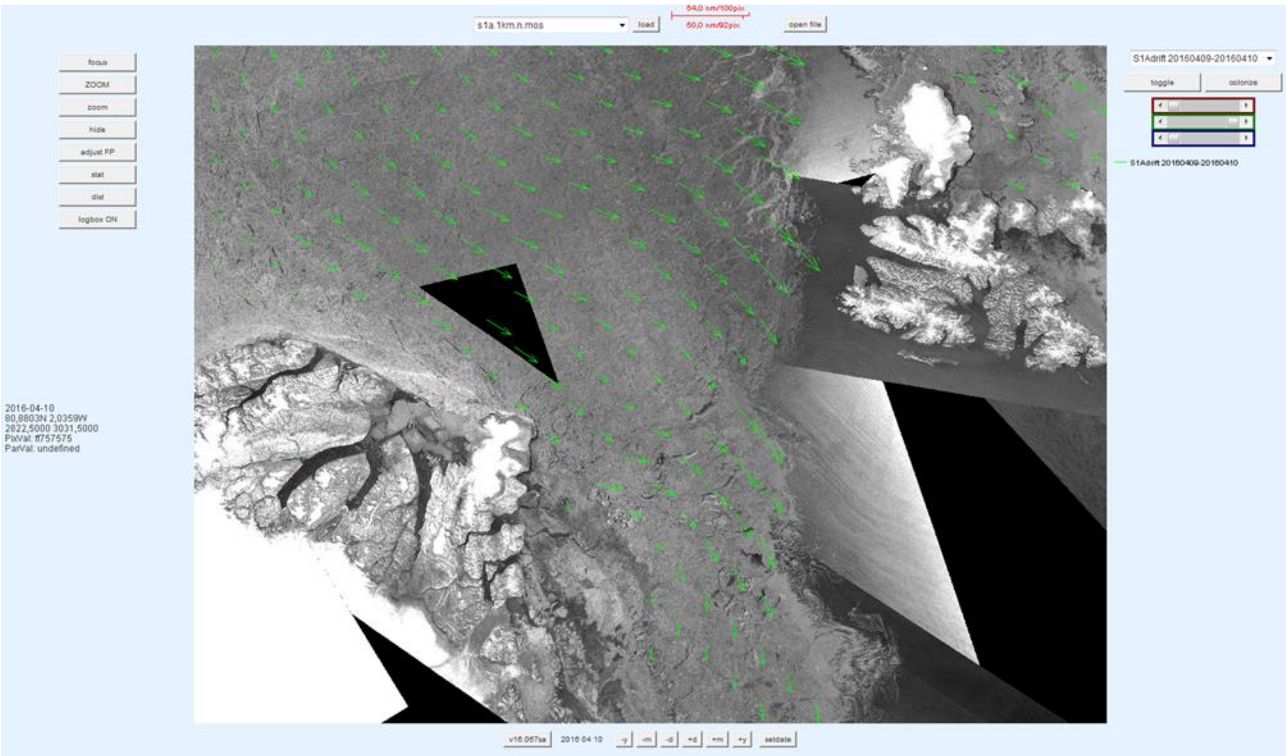

Figure 7: Sea ice drift vectors based on repeated Sentinel-1A SAR images April 9-10, 2016, super imposed on April 10, 2016, mosaic of Sentinel-1A images, www.seaice.dk.

2.2.1.4 Ocean circulation

The primary contributions of liquid freshwater from ocean circulation to the freshwater budget come from inflow of low saline water from the Bering Strait and outflow of saline water from Fram Strait and CAA/ Davis Strait (totally 4600 km3/y per RD-11). These contributions are currently estimated from velocity data and salinity profiles from moorings and ship surveys (RD-11). Ocean models are another way to predict the liquid oceanic contribution to the freshwater budget. An example is the North Atlantic/Arctic Ocean Sea Ice Model (NOASIM) (Karcher et al., 2005).

In this project we attempt to apply a new approach to estimate some of these contributions. Satellite altimetry has for many years been applied to derive ocean currents under the geostrophic assumption through deriving an accurate mean dynamic topography (se Figure 8). However until the launch of CryoSat-2, this has been an impossible task in the Arctic Ocean since it is partly ice covered. The great advantage of the SAR altimeter on-board CryoSat-2 and Sentinel 3 is the fact that the footprint is orders of magnitude smaller than conventional altimeters (100 Km2 for Envisat 4 km2 for Cryosat-2 and Sentinel-3). Hence the new satellites are far less prone to be corrupted by sea ice and far better to capture sea level in leads of the sea ice. Hence we expect that we are able to capture sea level and sea level variations across the major straits in and out of the Arctic (Se Figure 1) using altimetry from these satellites.

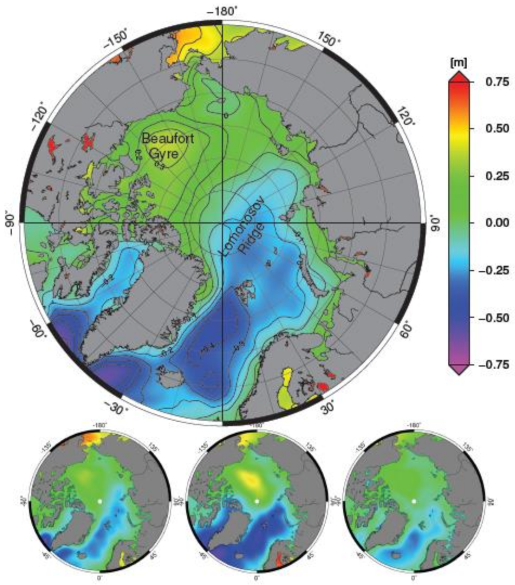

Figure 8: The DTU13MDT (height in meters) for the Arctic Ocean (upper figure). The lower figure shows the MDT computed from 3 years average of the GECCO, the MICOM, and University of Washington PIO (bottom left to right) hydrodynamic MDT (Andersen et al., 2015).

The combined use of the GOCE satellite along with Cryosat-2 and ERS1/ERS2 and ENVISAT in the Arctic Ocean have resulted in the development of the DTU13 Mean Dynamic Topography,which is shown in the Figure for the Arctic Ocean. The novel satellite derived MDT is the first ever satellite only MDT for the use of determining geostrophic ocean currents which governs the the influx and outflux of freshwater in the Arctic Ocean pending on the ice-cover. Together with ice-cover information from seaice.dk we will perform estimation of in and outflux into the Arctic Ocean based on an improved DTU15 version of the MDT along with an improved GOCE geoid model as also demonstrated by RD-27.

2.2.1.5 Continental runoff

The total continental runoff is a combination of river discharge, glacier and ice sheet discharge, subsurface flow and groundwater flow (RD-20). The first to contributions are described in the text above. The subsurface flow is primarily related to the freeze-thaw cycle in the active layer in permafrost soils (RD-20). The subsurface and groundwater flows are considered to be orders of magnitudes lover than the river discharge (RD-19). In this study these contributions are neglected. Contribution from thawing permafrost and its effect through release of carbon dioxide and methane as well and the use of water for irrigation and use for energy production in Arctic is expected to impact the continental runoff in the future but due to the complexity of this we will use available models and GRACE data for the determination of these effects.

2.2.1.6 P-E

Precipitation minus Evapotranspiration/evaporation represents the net precipitation. This contribution can be divided into a land and an ocean part. Over land P-E represent the amount of water that is available for runoff. The major part will flow into rivers and a smaller part, depending on the soil condition and permafrost, is absorbed by the surface. Over the ocean P-E represents the net precipitation that goes directly into the Arctic Ocean. The term P-E can be calculated from reanalysis (RD-11 and RD-18) data such as the ECMWF ERA Interim and NCEP/NCAR. Hence, the P-E contribution over land can be used as a validation check for the estimated river discharge based on altimetry and discharge in-situ data if the subsurface flow/absorption is neglected. Here we will adapt estimates of P-E from the literature e.g. from RD-18. RD-18 provides estimates of P-E based on the period 2000-2010. However, since we also plan to consider the most recent period, adapting these estimates might introduce some errors.

2.2.1.7 Arctic Ocean Freshwater storage

The Arctic Freshwater fluxes are in general not in equilibrium, as large inter-annual changes in the Arctic Oscillation drives large variations in freshwater storage inside the Arctic Ocean. RD23, which is a result of the ESA sea level CCI, demonstrated the use of satellite altimetry for studies of sea level variations which can be used as a proxy to study Arctic Ocean Freshwater storage on inter-annual scales. The spatial distribution of sea level trend for the period 1993-2015 from a combination of ERS-1/ERS-2, ENVISAT and Cryosat-2 is presented in RD23 with a total increase on the order of 2.2 mm/year. If we focus on the Beaufort Gyre, the sea level increase exceeds 1.5 cm/year over the altimetry era, indicating an increase in the freshwater storage in the Beaufort Gyre. This result compliments results for the same period as reported by RD-41 and RD-42.

In addition, freshwater is stored in the sea ice coverage, but the variations are much less than for the ocean freshwater storage (RD-11 and RD-18).

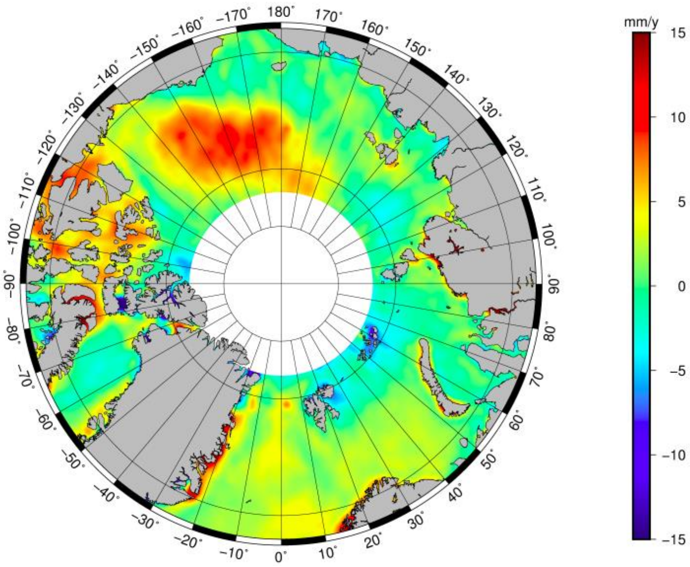

Figure 9: Spatial distribution of linear sea level trend for the period 1993-2015 from a combination of ERS-1 / ERS-2, ENVISAT and Cryosat-2. An increase of 15mm/y is observed in the Beaufort Sea. In the North Atlantic values corresponding to global sea level rise is seen (Andersen and Piccioni, 2016).

Through liaison with the ESA CCI on sea level we will be able to upgrade and reprocess the sea level time series and in this part of the project try to use the sea level increase in the Arctic for certain time-period subsets to use this to address the storage contribution to the Freshwater budget. To quantify the changes in freshwater storage contained in the sea ice cover, a simple approach is proposed by estimating volume changes of based on existing sea ice thickness products from CryoSat-2/SMOS and ENVISAT, see Section 2.2.1.3. A more detailed study of sea ice volume/mass changes losses is addressed in Arctic+ Theme 2 and will not be addressed further in this study.

2.2.2 Computing the budget

The approach taken to compute the final freshwater budget is described below.

To estimate the total FWB we propose to use a similar approach as RD-11. We will use a mean salinity of 34.8 pss as a reference value, thus salinities above this threshold are added as sources and salinities below this threshold is as sinks. By using a similar approach as RD-11, the values updated throughout this project are valid in comparison to changes between the RD-11 reference periods 1979-2000 and the values estimated within this project approx. 2002-present. We will focus primarily on the Arctic Ocean FWB and exclude related areas such as Baffin Bay.

We aim to produce a present state FWB covering the past 10-15 years based on primarily satellite observations. This is huge a step, as previous estimates of total FWB (RD-11, RD-18, and references here in), is primarily based on models.

In the total budget we will include freshwater storage, as well as transport.

The storage is calculated from changes in the Arctic sea level based on altimetry data, and the changes in sea ice volume from existing sea ice products, see Section 2.2.1.7.

Present fluxes updated and estimated from Earth Observation data within this project are:

- River discharge
- Glacier contribution
- Sea ice export through Fram Strait
- Oceanic inflow/outflow (Bering/Fram Strait/CAA)

The P-E fluxes will be based on literature reviews.

To support the FWB, yearly and seasonal variations will be estimated and discussed.

2.2.3 Summary

we will develop a novel approach to estimate four FWFs in the Arctic Ocean by maximizing the use of EO data: river discharge, FWF from the GrIS and Canadian Arctic ice caps, the sea ice freshwater flux and ocean fluxes. Figure 10 shows an overview of which satellite data sets and products we anticipate to use in ArcFlux.

We anticipate that a main advance will be the improved capability to monitor and quantify the seasonal variability in these FWFs. The seasonal signal of the FWFs, which has previously been identified as uncertain (RD-11).

Due to the warming temperatures the Arctic region is subjected to extreme events such as the melt event of the GrIS in 2012. In this project we will study how these extreme event effects the different component of FWFs and how well our proposed methodology for FWF products are able to capture these extreme events.

To quantify the total FWF of the Arctic Ocean, we will use estimates from the existing literature based on model results and in-situ data to quantify the remaining FWFs; P-E over land and ocean and freshwater outflow through CAA and FS, inflow through BS (in the period prior to CryoSat-2).

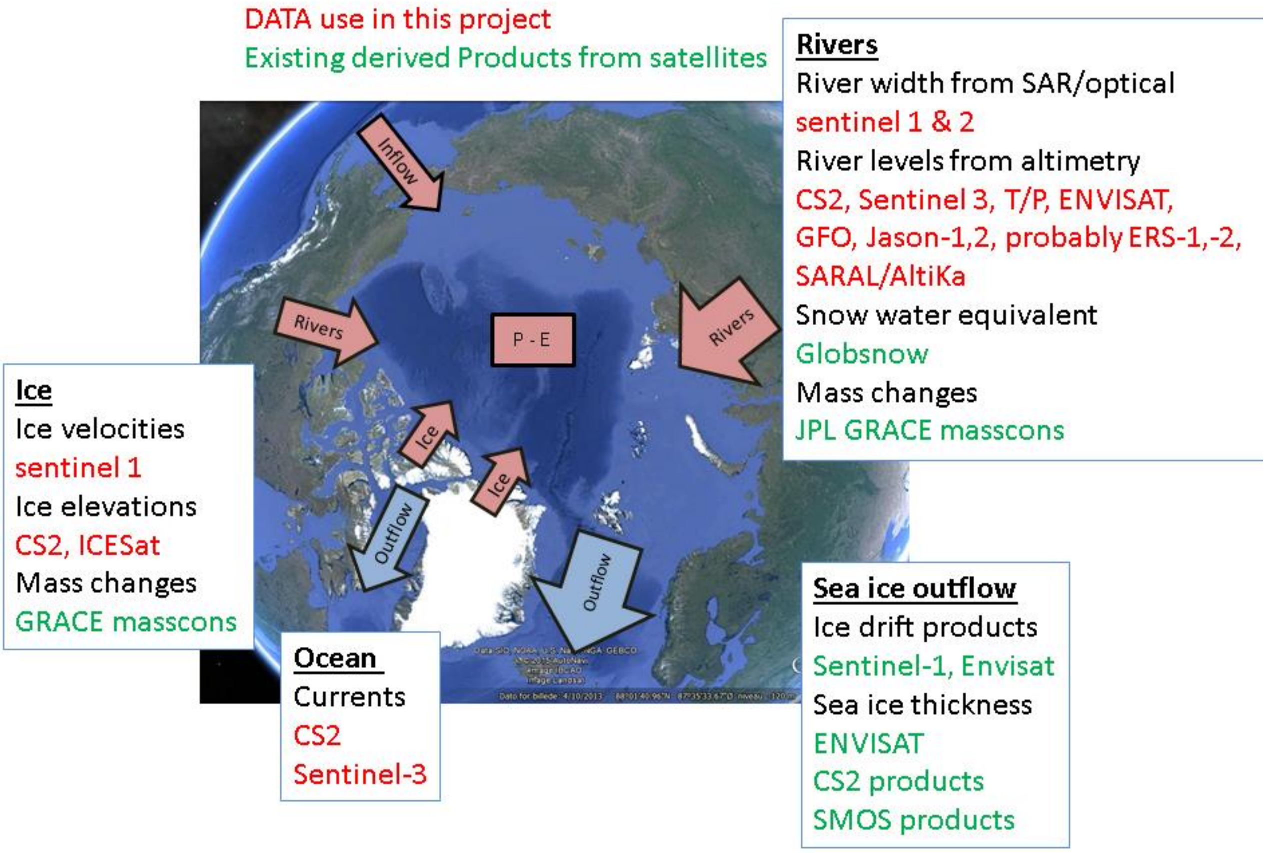

Figure 10: An overview of the satellite data (red) and existing satellite based products (green) that will be used in the project.

2.2.4 Potential problem areas and possible solutions

- The ice cover, which is present on Arctic rivers for more than half of the year influences significantly the radar waveform and backscatter values not only in periods of stable ice cover, but also during ice formation and break-up. A choice of an appropriate retracker and data correction and filtering is thus necessary.

- Is the temporal resolution of the altimetry high enough to observe the spring flood of the Arctic rivers?

Use of altimetric data from several radar altimetry missions and from several tracks covering specific a region will make it possible to increase temporal resolution and improve estimates in the period of rapid changes of river water level and discharge, such as during the spring flood.

- A FWB calculation will rely heavily on model output and results from the literature for e.g. runoff of the GrIS, glaciers and ice caps as well as the P-E component over the Arctic Ocean. Such models are associated with uncertainties that can be difficult to assess.

  To address this issue we propose to evaluate output from different models in order to estimate the variability within the range of model results and to assess the uncertainty.

- We propose to estimate the FWF out of the Arctic Ocean caused by sea ice drift from derived satellite products, and not directly from the satellite data. These derived products are sea ice thickness and drift. To account for snow depth we use a modified version (RD-16) of existing snow depth measurements (RD-44). This together with the potential overestimation of sea ice thicknesses, as the radar most likely does not penetrate all the way to the snow/ice surface, but somewhere in the snow layer (RD-17 and RD-43) will probably lead to an overestimation of the actual FWF.

  Since two entire Themes (1 and 2) within the Arctic+ ITT are dedicated specifically to sea ice mass and snow on sea ice we will not focus on these issues within this project, but the outcomes of Themes 1 and 2 will definitely be useful for a more precise FWF determination in the future.

  In the FWB determination strategy laid out in this project (Sect. 2.2.1) we assume that the freshwater input from the changes in hydrology, permafrost snow melt etc are all captured in the river discharge. This might not be the case as some of the melt water might find its way to the ocean independently from the rivers.
  In order to assess this issue if the determined FWF via the rivers are adequate we propose to compare the estimated river FWF to alternative satellite-derived products such as the snow water equivalent estimated from Globsnow (http://www.globsnow.info/index.php?page=Snow_Water_Equivalent) and model estimates of P-E over the drainage areas in question. Also, water mass redistributions can be compared to masscon solutions from GRACE data (e.g. http://grace.jpl.nasa.gov/data/get-data/jpl_global_mascons/).

- No satellites covers the entire Arctic Ocean and will leave a polar Gap. This is smallest for Cryosat-2 (88N). However the Cryosat-2 satellite is in a drifting orbit; hence the satellite tracks are crossing the rivers at different locations.

  In order to get time series at virtual stations from CryoSat-2 it is necessary to correct the obtained surface elevations for the terrain, since the tracks will cross a given river at different locations. Over relative short distances along the river center line a linear correction can be applied to account for the topography.

2.3 Advancement in science and impact of proposed work with respect to the state-of-the-art

Estimations of the FWB has until now primarily been relying on climate models and in-situ observations of different kinds such as river discharge data. Incorporating EO data such as satellite altimetry and satellite imagery together with advanced data analysis algorithms as it is proposed in ArcFlux is expected to have a large impact, especially on the accuracy of the relevant FWFs, since the volume of in-situ data is declining. FWFs that rely on EO data will provide independent results, which will help to obtain a more qualitative estimate of the FWB and be an important step towards monitoring services for the Arctic Ocean.

EO satellite data provide continuous measurements, which will help to improve the temporal resolution of the FWFs. With satellite altimetry, we anticipate to provide monthly estimates of river discharge for those months when the rivers are not frozen and thus this will add to our understanding of these processes and timescales involved

The outcome of ArcFlux will produce independent estimates of several components of the FWF which is based on EO data and help to close of the major knowledge gaps in relation to estimating the FWB based on models and somewhat compensating for the lack of in situ observations for validation.

Hence, these estimates can be used to validate the models based equivalents. For e.g. the river discharge a large network of discharge estimates and river level time series based on altimetry will be available for the Arctic region. Such estimates are valuable input to hydrological models.

The high temporal resolution of sentinel-1 (12-day repeat) for the Greenland margins will make it possible to estimate sub-monthly FWF estimates.

We will develop novel approaches to estimate four FWFs in the Arctic Ocean by maximizing the use of EO data: river discharge, freshwater flux from the GrIS and Canadian Arctic ice caps,the sea ice freshwater flux and ocean fluxes. We anticipate that a main advance will be the improved capability to monitor and quantify the seasonal variability and possible extreme events in these FWFs. The seasonal signal of the FWFs has previously been identified as uncertain (RD-11).

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2.4 Initial scientific roadmap

An entire workpackage within this project is dedicated to generating a scientific roadmap, which will describe ideas for future developments which will be beneficial for determining the FWFs in the Arctic Ocean from EO data. The details of such a roadmap will depend entirely on the work plans of all the Themes in Arctic+. Therefore only an initial high-level scientific roadmap is presented here.

Since the here-proposed Theme 3 project will contribute to advances in mainly four FWFs; river discharge, land ice contribution, sea ice transport and ocean fluxes, obvious follow-on projects would be focused on all of the FWFs in order to close the FWB. This would be a close collaboration between the climate modeling and remote sensing communities. In such a project the products of this project should be derived for all regions and not just selected test areas.

A schematic of the roadmap is seen in Table 2. Each element in Table 2 is described in the following.

Table 2: Schematic of the Arctic+ scientific roadmap for future developments

		2016	2017	2018	2019	2020	2021
1	Arctic +						
2	River outflow from Sentinel						
3	Freshwater pulses from glaciers						
4	Impact on sea ice growth						

1) Arctic+ [2016-2018]

The different Themes of the Arctic+ all will advance in fields that will contribute to a better FWF determination by e.g. a better sea ice mass determination. During the duration of the Arctic+ projects, the members of each Theme should collaborate on defining both individual and joint element for their respective scientific roadmaps.

Milestone [end of Arctic+ projects]: detailed scientific roadmap laid out in collaboration with the other Themes.

2) River outflow from Sentinel [2017-2018]

Quantify river outflow (Russian and Siberian rivers) using Sentinel data and available in-situ data, by use of the methodology developed in ArcFlux. This will be linked this to changes in Arctic Sea Level with a focus on the Beaufort Gyre. The results obtained in this project could be applied and further developed in the framework of Year of Polar Prediction (YOPP), which aims at improving the environmental prediction capabilities in the Polar region.

Milestone [Early 2017]: Apply for this to be carried out as a CCI+ activity or an STSE study.

Milestone [End of 2018]: Observation and modelling examples as contribution to YOOP.

3) Freshwater pulses from glaciers [2018-2020]

Freshwater pulses from glaciers, ice caps and the Greenland ice sheet will be quantified. Develop a downstream service from ESA CCI products, and model intra-ocean freshwater pulse flow with existing ocean model.

NASA OMG and EU Arctic Integrated Observing System project could provide key process understanding.

Milestone [Start 2019]: Application for this project submitted (could be for H-2020 project, or CCI+)

4) Impact on sea ice growth [2019-2021]

Pilot Service will be developed for integrated freshwater flow to the Arctic, and impact on sea ice growth and decay, assimilating EO data (altimetry, gravimetry/Grace-FO/NGGM).

This could be ESA project with associated P-TEP for user applications (e.g. ice conditions), with goal to be integrated into expanded EU Copernicus marine service.

Milestone [End of 2021]: Freshwater service developed

Besides these specific actions it would be obvious that the combined consortium of the different themes should collaborate on a large project (e.g. in the frame of H2020) on a state-of-the-art determination the individual FWFs and the total FWB of the Arctic Ocean and its temporal evolution. The various observations in the current project will support future calls on the Artic under the Horizon 2020, especially with focus on an integrated Arctic Observing System.

A future development could also be that some/all of the products developed in this project such as e.g. the river discharge can be made operational and be made available under e.g. Polar Thematic Exploitation Platform (P-TEP) http://p-tep.polarview.org/

2.5 Statement of Compliance matrix

Requirement Description	State of Compliance
Perform all works described in AD-1 regarding theme 3: Freshwater fluxes, section 2.5 and 3	Yes
Secure the access to relevant data described in AD-1 section 5	Yes
Deliver all technical documentation described in section 4.2 in the delivery time proposed	Yes
Provide progress Report every month	Yes
Provide minutes and presentations from all project meetings	Yes

2.6 Proposed work logic of ArcFlux

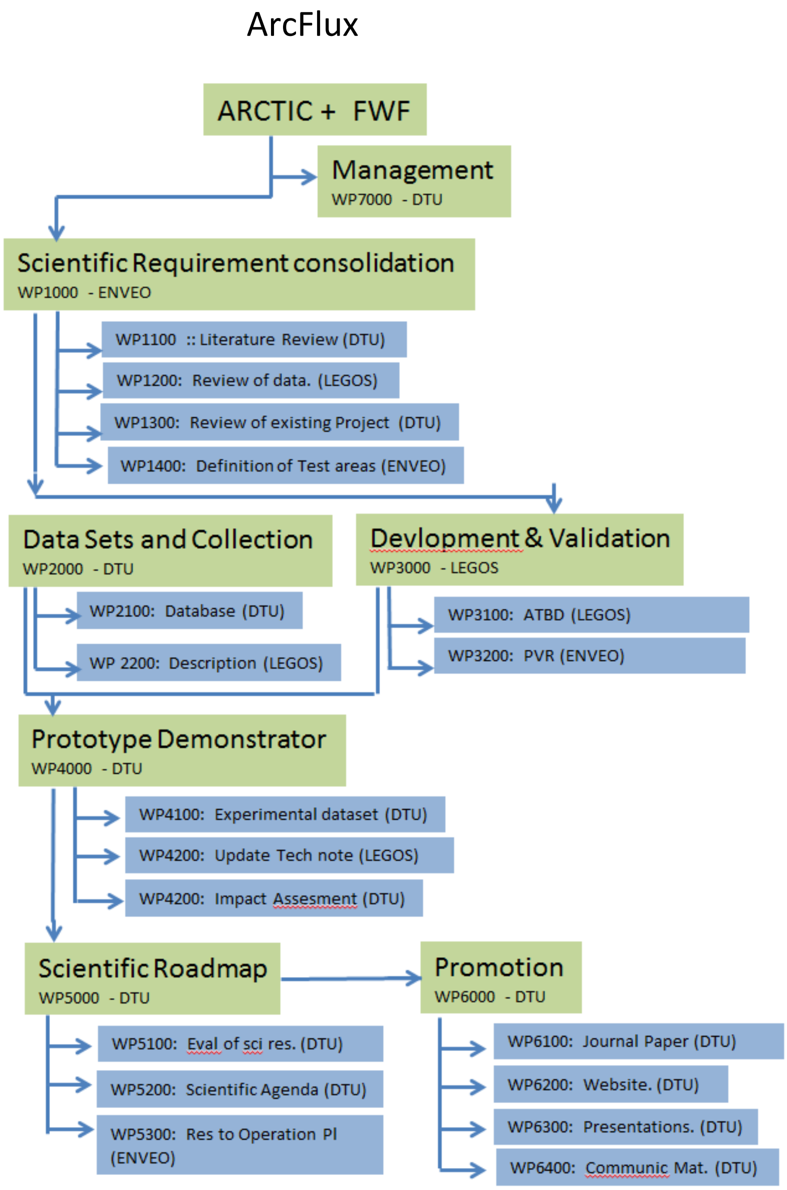


Figure 11: Flow chart that describs the proposed work logic

Figure 11 shows the flow chart of the proposed work logic. For the individual WPs and sub WPs the responsible institutions are listed.

2.7 Proposed Activities Description

The proposed work follows closely the objectives set out in Section 2.2 through seven defined work packages which are described in detail in section 2.7.1 - 2.7.7 .

In Work Package 1000 (WP1000), the required baseline will be established and documented through reviews of existing literature, projects and data. In Work Package 2000 (WP2000) a database containing the data to be used within this project, will be created and described.

Work Package 3000 (WP3000) contains the algorithm and approach development and validation, while Work Package 4000 (WP4000) contains a prototype demonstration using the approach selected in WP3000 applied on an experimental data set.

In Work Package 5000 (WP5000) a scientific roadmap is described, which builds on e.g. an evaluation of the obtained results, and a research-to-operational plan.

Work Package 6000 (WP6000) contains the promotion activities such as presentations, website and journal paper(s), while Work Package 7000 (WP7000) contains all management activities such as delivery of progress reports etc.

2.7.1 WP1000 : Scientific requirement consolidation

The purpose of this WP is to consolidate the scientific requirements for estimating the Arctic freshwater fluxes, maximizing the use of ESA data. The required baseline for doing so will be established and documented through detailed reviews of existing literature, initiatives, projects and data (both satellite, airborne and in-situ). The data sets shall include both development data sets that will be used to estimate the freshwater fluxes , but also validation data. In case that there is a lack of useful and critical datasets this will be described and a practical solution to overcome this will be proposed. This could e.g. be that model output will be included instead of observation-based estimates.

Therefore, this work will include a review of existing models that could possible produce output that can be used to close the Arctic freshwater budget. Examples of such models are regional climate models for GrIS run off (e.g. MAR, HIRHAM or RACMO) and global climate models for providing P-E over land and ocean (e.g. HadCM3, EC-Earth) or re-analysis datasets such as ERA-INTERIM.

A thorough assessment and analysis of the main challenges associated with determining the Arctic FWFs using satellite observations will be carried out and any knowledge gaps and scientific problems will be documented. This work will define and guide the scientific focus of the project to address these issues. Some of these possible gaps and problems are already listed in Sect. 2.2.4

Due to the limited time (and financial) frame of this project, the development and validation of a prototype freshwater flux determination will be restricted to suitable test areas. In this WP, these test areas will be chosen based on the availability of satellite data as well as validation data.

2.7.2 WP2000 : Data set collection

The objective of WP2000 is to build and describe a reference database of carefully selected satellite EO data and airborne and in-situ validation data which covers the test areas defined in WP1000.
The main output of the WP2000, the database, will act as a direct input to the other WPs butwill also be a stand-alone product: a published, well-organized, easily accessible reference database for the use of other scientists. This will make it possible for other scientist to test alternate approaches for determining the FWFs and directly compare with the products derived in this project, and to perform the same validation on their results. The database will be made available to the public at the end of the project via the project website.

The data required to build the database include;

- In situ data on river water level and discharge:
  - The modern international datasets provide discharge data for limited areas and limited periods. For discharge we will make a compilation from the following sources:
    Arctic-RIMS (A Regional, Integrated Hydrological Monitoring Systemfor the Pan-Arctic Land Mass) [http://rims.unh.edu/index.shtml] The data on this portal are currently limited to the period prior to 1999
    Historical data from the Russian Hydrometeorological Service, Environment Canada, USGS and other institutions

- Global Runoff data center http://www.bafg.de/GRDC/EN/Home/homepage_node.html
- Databases with time series over water levels of large rivers, lakes and wetlands around the world.
  - Hydroweb http://www.legos.obs-mip.fr/en/soa/hydrologie/hydroweb/ .This altimetric water level data base at LEGOS contains time series over water levels of large rivers, lakes and wetlands around the world. However spatial coverage of Arctic rivers is still limited. Existing data cover only the Ob' and Lena river watersheds). In order to overcome this limitation, we plan to significantly enhance and update this dataset and construct water level time series for the virtual stations (intersections of altimetric tracks with the river channels) at the

outlets of the main Arctic rivers using combination of multi-mission radar altimetry data (depending on actual coverage of each satellite mission and fluvial geomorphology).

- Satellite data sets
  GDRI for T/P, Jason-1, -2, ENVISAT, SARAL/AltiKa and CryoSat-2 are available at CTOH (center for topography of oceans and hydrosphere) at LEGOS.
- Optical data from Landsat, potentially S2 and other comparable sensors will be used for the geographical selection.

The database will not include those satellite data which is freely available to the public *in the format used in this project*. The database it will include satellite data if it turns out that the available data needs to be processed before being useful in the FWF determination.

The database content and structure will be described in detail, and this documentation will also include instruction to how to get access to the satellite data that is not part of the database but is used in the project.

In case of any restriction in the use of any type of datasets, this will be communicated to ESA. The consortium has the ambition of using none or little restricted data.

2.7.3 WP3000 : Development and validation

In this WP different methods, products and algorithms that can be used to estimate the different Arctic FWFs, shall be explored, analyzed, developed, and tested. The different approaches will be tested against selected test area data, chosen in WP1000 and collected in WP2000.

As described in section 2.2.1 the freshwater fluxes that will be addressed in this project are:

- River discharge
  - The discharge is functionally related to water level, which makes it possible to use EO data. In order to estimate river water level and runoff, it is necessary to test the applicability of satellite altimetry data for arctic rivers, where the presence of ice and snow perturbs the altimetric signal during a large portion of the year. In order to minimise potential contamination of the altimetric signal by land reflections, and at the same time to retain a sufficiently large number of altimeter measurements on water, a geographical selection of the data will be performed

using optical and potentially SAR satellite imagery. Then a dedicated methodology to select and retrieve the altimeter water levels during the various phases of the hydrological regime will be used. If in situ discharge data are available, we will test the possibility to establish relationships between satellite-derived water level and river discharge measurements and assess the accuracy of the annual and monthly altimeter discharge estimates. with account of various parameters (altimetric height errors, spatial and temporal sampling interval, rating curve simplification).

  - River outlines/river width can be determined from SAR/optical imagery.
- Inflow from land ice
  - The FWF from the GrIS and other glaciers and ice caps will be determined by flux gate estimates derived from ice velocities and flux gate sizes (glacier thickness and width).

    Ice velocity data can be derived from repeat pass SAR data (i.e. Sentinel-1), while the ice thickness will be derived from the altimetry and bedrock DEMs. To get the full FWF, it is proposed to use an ensemble of models predicting run-off to quantify the uncertainty related to this component .

- Outflow of sea ice
  - Sea ice drift products based on repeated SAR imagery, ENVISAT and Sentinel-1 is used when available, e.g. from www.seaice.dk. To fill in gaps existing drift maps based on scatterometer and radiometer data will be used, such as OSI-SAF, Polar Pathfinder and CERSAT sea ice motion maps to be downloaded from nsidc.org.
  - The sea ice thickness will come from already existing since several of these are available. Examples are: http://www.cpom.ucl.ac.uk/csopr/seaice.html (CS2), Alfred Wegener Insitute (CS-2), ESA CCI Sea ice project ERS-2, ENVISAT and CryoSat-2.
- In/outflow of liquid water
  - The velocity of the ocean currents are derived from the arctic sea level

The remaining components of the Arctic freshwater budget will come from models, in-situ observations and relevant literature.

Dedicated scientific efforts are devoted to testing the different approaches and the final (chosen) approach – including the preferred solution for each freshwater flux – will be selected from a thorough experimental analysis in the test areas. This analysis will include an error analysis of the different FWFs, including those that comes from already existing products (e.g. sea ice thickness). Here the uncertainty can be assessed through a product intercomparison.

For the products that shall be developed in this project (being River inflow, sea ice drift, inflow from land ice, and ocean fluxes), all implementation choices and trade-offs (such as e.g. retracking algorithm chosen for altimetry) shall be verified in order to evaluate the reliability of the final product (river heights and potentially discharge). In addition, the FWF products will be compared with existing EO-based equivalent/alternative datasets.

2.7.4 WP4000 : Prototype demonstration and impact

In WP4000, the developed and tested methodology selected in WP3000 will be used on a number of test areas over suitable time frames to produce FWF prototype products of River inflow, Inflow from land ice and sea ice outflow. The prototype products will form what is called the 'experimental dataset' within this project.

The test areas and time frames used for generating the experimental dataset will be chosen so that the full potential of the developed methodology can be investigated. For instance, areas and timeframes that represent high temporal variability in the FWFs will be chosen to test the capability of the methodology to capture this.

The experimental dataset will be compared to existing state-of-the-art results in order to quantify the improvements that the prototype products offer. For instance, we anticipate that the methodologies developed within this project will make it possible to estimate FWF at a higher temporal resolution than what has previously been possible. The conclusions will build on an error/uncertainty analysis based on the validation available through the WP2000 database, and the comparison to other products.

The experimental dataset will be included in the database that was built in WP2000, and the documentation describing the database will be updated accordingly.

2.7.5 WP5000 : Scientific roadmap

WP5000 is dedicated to the definition of a so-called scientific roadmap. Based on the successes and challenges learned through the previous WPs, the scientific roadmap will summarize suggestions and ideas for future developments beneficial for determining the FWFs in the Arctic from EO data. It will be aimed at transferring the outcome of this project into scientific activities to be conducted in the time frame 2017-2021. To ensure that the scientific roadmap is relevant to both scientific and operational organizations, such will be consulted in the process of making the scientific roadmap. Examples of organizations to consult could be met offices such as the Danish Met Office, DMI.

The scientific roadmap will include a critical analysis of how the outcome of this project outcome satisfies the specific scientific objectives of Arctic+, Theme 3, namely that:

- The major challenges and knowledge gaps in the estimation of the Arctic freshwater budget are identified
- Different approaches to address those challenges and enhance current approaches to compute the freshwater budget of the Arctic Ocean maximizing the use of ESA data are explored, developed and validated
- A multi-year assessment of the Arctic freshwater budget based on the developed methodology is computed and the results are validated, and the uncertainty of the estimates are computed and compared the obtained results with existing alternative estimates

[from AD-1]

From this analysis it will be made clear what additional scientific work is required in order to advance forward in achieving even more accurate estimates of the Arctic FWF from EO-data, including what new datasets and in-situ validation campaigns might be critical for a further advance in current knowledge and capabilities within this subject.

Finally, the scientific roadmap will include a plan outlines a possible strategy for the transition from research to operational activities related to the FWF product generation in the Arctic.

2.7.6 WP6000 : Promotion

Within WP6000, activities are carried out that ensure that the results obtained within the project are promoted within the scientific and operational communities. This includes to create awareness of the project from its very beginning by presentations at conferences, scientific fora and meetings, and through the setup of a project website which will be continuously updated throughout the project lifetime. The website content shall be submitted to ESA for approval prior to publishing, and it shall provide direct access to the project database once this is created and updated. The website will include also an internal webpage for consortium members only.

One important deliverable of this project will be the database containing all relevant data including the experimental dataset, and an activity in WP6000 the database will be promoted e.g. via announcement on CRYOLIST and other scientific for a including conferences.

Multimedia content useful for communication of the projects objectives and especially results will be created and made available through the project website. This will include e.g. animations, presentations and images.

Another important activity within this WP is to ensure that at least one journal paper is submitted to an international peer-reviewed journal.

Arctic freshwater fluxes

One of the main objectives stated in AD-1, theme 3 is to compute a multi-year assessment of the Arctic freshwater budget. Therefore WP6000 is dedicated to this .

An assessment of the total freshwater budget in the Arctic Ocean requires a compilation of the results obtained within this project estimating the river outflow, with freshwater fluxes from other sources.

The budget is composed of the fluxes outlined in the table below. This table also contains explanation on which components will be estimated within this project and which EO data will be used, together with information on which external data sets / models / products will be used to compile the total budget.

FWF	Source	EO data	Existing data products
River inflow	Project product	CS2, Sentinel-3, T/P, ENVISAT, GFO, Jason-1,2, probably ERS-1,2, SARAL/AltiKA. Sentinel-1,2	Globsnow. GRACE masscons
Land ice inflow	Project product	Sentinel-1, CS2, IceSat	GRACE masscons
Sea ice outflow	Project product + Existing product	CS2, SMOS, Envisat, Sentinel-1	seaice.dk, CS2 and SMOS products, Envisat
Inflow Bering strait	Project product + Existing product	CS2	State-of-the-art literature Mooring data
Outflow Can. Arch.	Project product + Existing product	CS2	State-of-the-art literature

			Mooring data
Outflow Fram Srait	Project product + Existing product	CS2	State-of-the-art literature Mooring data
P-E	Existing product		Climate models/ state-of-the-art literature

The above table will likely be updated through the investigations carried out in WP1000.

2.7.7 WP7000 : Management

This WP7000 contains all the activities associated with management. This includes the monthly production of monthly executive summary progress reports for approval by ESA, and the collection of a final project report to be made publicly available. Furthermore, an executive summary of the projects which summarizes its main achievements will be compiled.

Another management activity is to ensure that regular progress meeting are held via e.g. skype and that satisfactorily progress is made.

Part of the management activities is also to ensure that minutes are recorded from every meeting and that material is provided in due time prior to meetings.

This WP describes the day to day management support to the overall project management described in Section 3.1.

2.8 IPR impact

All background data corresponding to existing intellectual property rights owned by the contractor or sub-contractor will be specified during the Contract negotiation. This data is needed only for the development and it is not necessary subsequent to the delivery.
ESA can use all deliverables of this project with no IPR limitation and restriction but within the intended use/objective of the ITT detailed in AD-1 to AD-4.

Background IPR, ENVEO

All software, relevant or not relevant to this project, developed in other projects by ENVEO is declared as Background Intellectual Property Rights. This includes the in-house developed

SAR analysis software package, software for analysing optical satellite images, and GIS tools related to ice sheet parameter retrieval.

We can confirm that the IPR will not impact the deliverables.

Exact name of BIPR item	Owner	Description	Patent # of Ref. / Issue/ Revision /Version	Contract / Funding Details under IPR was created	Date of the creation of the version of the BIPR listed here	Affected deliverables with description of impacts ESA rights of use and / or distribute
ENVEO Software Package	ENVEO	ENVEO Software for SAR and Optical satellite data analysis (incl.pre-processing of SAR data, coregistration, calibration, geocoding, ice velocity retrieval using offset tracking and InSAR, mass flux calculation),	Ver 2.1 02/2016	-	02/2016	None
ENVEO Cryoportal Software	ENVEO	enveo-cryoportal database and modules for handling and accessing time series of ice velocity maps and mass fluxes for outlet glaciers.	Ver. 0.9 04/2016	-	04/2016	None

2.9 Import / eksport

No restrictions

3 Management Proposal

3.1 Organisation

Acronym used	Institution/Company
DTU	Danmarks Tekniske Universitet
ENVEO	ENVEO IT Gmbh
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales

3.1.1 Roles and Responsibilities

WP	Description	Company	WP leader
WP1000	**Scientific Requirement consolidation**	DTU	OA
WP1000	Required baseline document.	DTU	LS
WP1100	Litterature review. Technical note.	DTU	LS
WP1200	Review of existing and available data.	LEGOS	AK
WP1300	Review of existing projects and models.	DTU	HS
WP1400	Definition test areas used in the project.	ENVEO	TN
WP2000	**Data set collection**	DTU	KN
WP2100	Database containing EO and in-situ data and model output	DTU	KN
WP2200	Description of datasets in database	LEGOS	AK
WP3000	**Development and validation**	LEGOS	EZ
WP3100	ATBD describing the algorithms and methods selected	DTU	KN
WP3200	Product Validation Report	LEGOS	EZ
WP4000	**Prototype demonstration and impact**	DTU	KN
WP4100	Publish experimental data set : target prototype products	DTU	KN
WP4200	Update technical note D3	ENVEO	TN
WP4300	Impact assessment report	DTU	KN
WP5000	**Scientific Roadmap Report**	DTU	LS
WP5100	Evaluation of obtained scientific results. Tech. note	DTU	LS
WP5200	Scientific agenda 2017-2021. Tech. note	DTU	LS
WP5300	Research to operational plan	ENVEO	TN
WP6000	**Promotion**	DTU	OA
WP6100	Journal paper submitted on FWF time series	DTU	KN
WP6200	Website	DTU	LS
WP6300	Presentations	DTU	OA
WP6400	Communication material	DTU	OA
WP7000	**Management**	DTU	OA

WP7100	Monthly reports on progress	DTU	OA
WP7200	Final report	DTU	OA
WP7300	Executive Summary	DTU	OA

3.1.2 Background and Relevant Experience of the Institutions/Companies

3.1.2.1 DTU

DTU Space is part of The Technical University of Denmark (DTU) which is the largest technical university in Denmark with a scientific staff of about 1000, 6000 students preparing for Bachelor or Masters degrees, and 700 Ph.D. students. The research done at DTU forms the basis for a variety of services and products which are offered to Danish industry, authorities and educational institutions - e.g. technology transfer, advice on space-related matters and supervision of PhD students.

DTU Space, the National Space Institute at DTU is the national institute for space-related activities in Denmark. The DTU conducts research in astrophysics, solar system physics, geodesy, remote sensing, space instrumentation and space technology. DTU Space has significant activities within the areas of Earth Observation and Arctic Studies.

DTU-Space specializes in polar remote sensing of ice_sheets and sea_ice (e.g. with ICESat and CryoSat), airborne lidar and geophysics, and general research in physical geodesy. The Geodynamics department is responsible for the national gravity networks of Greenland and Denmark.

DTU Space has many years experience in working with the Arctic using remote sensing data, including derivation of the first ice-sheet wide DEMs, work with early satellite altimetry over the ice sheet, and general monitoring of ice sheet changes from ICESat, GRACE and EnviSat. The department has been deeply involved in the CryoSat mission, and carried out CryoSat calibration and validation campaigns in Greenland, Canada (Devon Ice Cap) and Svalbard (Austfonna) in cooperation with the CryoSat Calibration, Validation and Retrieval Team (CVRT). The Department has recently initiated major science projects also in Antarctica, especially major airborne geophysical campaigns over the Antarctic Peninsula and East Antarctica, including gravity, magnetic, ice-penetrating radar and laser measurements.

Relevant projects:

- Aircraft and coordination of CryoSat cal/val campaigns (2003,2006,2008,2011-12)

- ArcGICE: Combination of Spaceborne, Airborne and In-situ Gravity Measurements in Support of Arctic Sea Ice Thickness Mapping. Study on the synergy of GOCE and CryoSat (2005-7)
- SAMOSA, studies of radar waveforms for CryoSat-like radars for ocean applications (2008-9)
- ESAG, first European GOCE airborne campaign in the Arctic, 2002.
- POLARIS, first deployment of P-band radar in Antarctica, 2010-11
- Ice_Sheets_CCI, ESA climate change initiative (coordinator, 2012-14)
- CryoVAl-LI, Cryosat validation over land ice 2014-2016
- CryoVAl-SI, Cryosat validation over sea ice 2014-2016
- LOTUS, EU, Exploration of SAR altimetry from level 0 data to end user products, 2013-2015
- GOCE++, ESA, Estimation of the mean dynamic topography in coastal regions 2015-2017

3.1.2.2 LEGOS

The Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (LEGOS) is a joint research laboratory of the National Center of Scientific Research (CNRS), of Toulouse University Paul Sabatier III (UPS), of CNES (Centre National d'Etudes Spatiales) and IRD (Institut de Recherche pour le Développement). Overall personal comprises 125 persons with 74 persons of permanent staff, 24 PhD students and 25 PostDocs.

The laboratory is organized through the 5 research groups with support of 4 observational services :

Overall personal comprises 125 persons with 74 persons of permanent staff, 24 PhD students and 25 PostDocs. The laboratory publishes about 100 papers/year in scientific reviews.

Main domain of the research comprises geodesy, geophysics, cryosphere, continental hydrology using satellite remote sensing and in situ data. Continental hydrology using space observation consists of measuring water level fluctuations of continental lakes, major rivers and flood plains by satellite altimetry, estimating snowpack parameters from passive microwave, measuring fluctuations in water storage in soils, underground reservoirs and snow pack by space gravimetry and link with climatic variability and anthropic effects.

The members of LEGOS have been involved in the development and design of space altimetry applications for around 20 years, as PI of the Topex/Poseidon, ERS-1/2, Jason-1/2, Envisat, Cryosat-2 and AltiKa missions. Since 10 years the team members have been involved in studying Lakes, Rivers and floodplains from altimetry, imagery and gravimetry measurements. Analysis of quality of the obtained results to regional hydrology has been undertaken over several hydrological basins.

Application of satellite altimetry for studies of large river systems became a developing field the last 10 years. We have developed methodology for the processing and validation of altimetry data over big rivers and flood plains. We have analysed the altimetry data over big rivers in order to model and determine river discharges based on altimetry-derived time series and volume variations over river flood plain from combination of radar altimetry and satellite imagery. Besides, we also showed that altimetry data can be used for calculating discharge and applied the method to large rivers in very different climatic zones, such as the Ob' river in the Arctic, the Ganga-Bramapoutra and more than a hundred of Amazon Rivers in the tropics and to determine hydrological parameters such as the depth of the river bed, the river slope and the Manning coefficient.

The Legos is also strongly involved in the preparation of the new altimetry missions in Ka Band interferometry (SWOT) for which we are scientific PIs of the mission.

Relevant International projects:

FP7 MONARH-A (Monitoring and Assessing Regional Climate Change in High Latitudes and the Arctic)

ESA Climate Change Initiative: Sea Level CCI,

MyOcean and MyOcean2 Prototype Operational Continuity for the GMES Ocean Monitoring and Forecasting Service.

3.1.2.3 ENVEO

ENVEO was founded in 2001, with main business activities in the field of research and development for remote sensing applications in hydrology, cryosphere and meteorology, including developments of methods and of transfer from research to applications and services in hydrology, water management and climate monitoring. The ENVEO partners have many years of experience on use of satellite-borne remote sensing for environmental monitoring in national and international projects. They served as consultants and evaluators for activities in Earth observation from space for ESA, NASA and the European Commission, and for national programs of several countries. The organisational structure of ENVEO is shown in Figure 3.1.

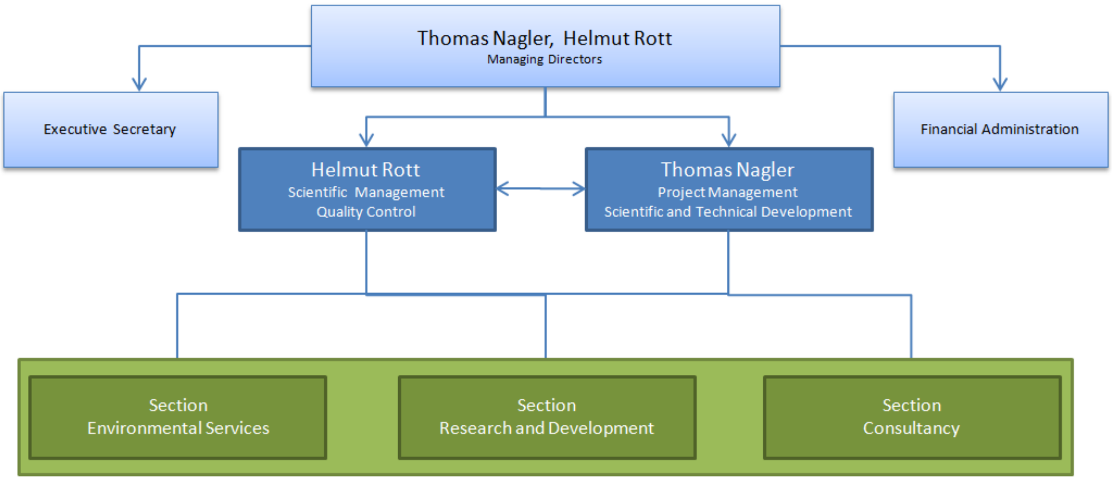


Figure 3.1: The organisational structure of ENVEO

Relevant Experience

ENVEO's experience and research activities include development of methods for monitoring polar regions and retrieval of icesheet/shelf parameters from satellite data; planning of Earth observation systems and sensors for hydrology, water management and glaciology; hydrological monitoring and forecasting in mountain basins; methods and applications of remote sensing of snow, glaciers and polar ice with microwave and optical sensors; methods and applications of image cross correlation and radar interferometry for ice motion of glaciers and ice caps, and ice sheets; methods and applications radar interferometry for motion of unstable mountain slopes and for mapping subsidence in mining districts; principles of microwave radiometry and radar for snow and ice applications ; atmospheric radiative transfer in the optical and microwave region; land use mapping with very high resolution optical sensors; field campaigns for EO validation. ENVEO personnel lead the science team of the EE7 candidate mission CoReH2O (selected for Phase-2). Coordinator of FP7 project CryoLand – GMES Snow and Land Ice Service, and the GLACAPI "Multi-sensor analysis of glacier response to climate change on the Antarctic. Peninsula". ENVEO is WP leader in the ESA CCI projects GLACIER_CCI (Phase-1 and Phase-2; responsible for glacier ice velocity from SAR), the GREENLAND ICE SHEET_CCI (Wp lead for calving front and grounding line, contributing to ice velocity from SAR), ANTARTIC-ICESHEET CCI (WP lead for ice velocity), STSE Massbalance (responsible for I/O Method). ESA ALSPTOMOSAR (Airborne SAR tomography for Alpine glacier). ENVEO is PI of the ESA project "SnowPEx -Satellite Snow Product Intercomparison and Evaluation Experiment". ENVEO was part of the expert user group for Sentinel-1 and Sentinel-2, contributes to the preparation for new satellite systems including HRWS, SAOCOM-CS (science team member, responsible for land cryosphere). ENVEO personal contributes to the WMO Polar Satellite Task Group (PSTG) and SAR

Coordination Working Group. ENVEO produced the first Greenland Ice sheet wide Ice velocity map from Sentinel-1 data (published in 2015).

Relevant Reference Projects (selected):

- GLACAPI - Multi-sensor analysis of glacier response to climate change on the Antarctic. Peninsula" (ESA Contract No. 4000105776; ENVEO; started June 2012; ongoing).
- STSE Antarctic Peninsula Massbalance (ENVEO subcontr. Ongoing; responsible for IOM)
- STSE Cryosat+ GLITter - grounding line location and ice thickness (ENVEO WP Lead; ongoing)
- Glaciers_CCI I+II (ESA Contr. 2010-2013; ENVEO Subcontr. Ongoing);
- Greenland-Ice-Sheet_CCI (ESA Contr. 2011-2014; ENVEO Subcontr. Ongoing);
- Antarctic- Ice Sheet CCI (ENVEO Subcontr.; completed)
- Greenland Ice velocity Map from Sentinel-1 (CCN to Greenland-Ice-Sheet_CCI; ENVEO Lead)
- FP7 CryoLand – GMES Service Snow and Land Ice (FP7; 262926; coord. ENVEO).
- FP7 SEN3APP - Processing Lines And Operational Services Combining Sentinel And In-Situ Data For Terrestrial Cryosphere And Boreal Forest Zone (FP 7 project; ENVEO WP Lead on ice velocity)
- DUE-GlobGlacier; ESA Contr. 21088/07/I-EC; (ENVEO Subcontr.; completed).
- FFG ASAP-10 Sentinel-1 InSAR – Development of Tools for Interferometric Processing of Sentinel-1 TOPS Mode data for Ground Motion Monitoring. (FFG/ BMVIT, ASAP-10 Contract 844386
- STSE - North Hydrology (ESA contract Contract 4000101296/10/I-LG; completed)

Facilities

ENVEO is located in the ICT Technologiepark, Innsbruck, at the Campus of the Technical University of Innsbruck, which offers excellent infrastructure for IT activities (e.g. high speed Internet access, etc). The office's equipment comprises all regular office tools, like printers, scanner, fax, Italian coffee machine, etc. Facilities at ENVEO of relevance for the project include

- LINUX servers with hard-disk arrays (> 100 TB), WWW server, workstations, and notebooks with high speed internet connection
- Colour printing devices
- Instruments and recorders for automatic recording of measurements of snow, soil and atmospheric parameters
- Devices for in-situ measurements of snow parameters incl. hand-held GPS.
- SAR software system for geocoding, interferometry, offset tracking, ice velocity retrieval from SAR and optical satellite data supporting ERS, ENVISAT, PALSAR, TERRASAR-X TANDEM-X RADARSAT-1/2, SENTINEL-1 (TOPS)
- Tools for calving flux calculation using velocity fields and other input data
- Software, tools and service system for snow cover mapping from optical and SAR data
- Software for analysing and processing optical satellite data from various sensors
- Hydrological modelling and software and hydrological and meteorological data management software (in-house development)
- Relational data base system for managing time series of meteorological data and numerical forecasts, satellite based information
- Software for graphics and image processing
- Source code managing software (CVS / SVN) and issue tracking system (REDMINE)
- Archive of spaceborne and airborne SAR data (ERS-1, ERS-2, ENVISAT, SIR-C / XSAR, AIRSAR, E-SAR, ALOS PALSAR, E-SAR, Sentinel-1,), and various optical satellite data.

3.1.3 Key Personnel Curriculum Vitae

3.1.3.1 DTU

Name:	Ole Andersen
Position:	Senior scientist
Qualifications and experience of interest for this proposal	
Senior research scientist Ole Baltazar Andersen has contributed within the use of satellite altimetry for geodetic and oceanographic purposes. Ole has a master in geophysics and a Ph. D. within ocean tide modelling (1996), and is the author of the suite of geophysical fields like DTU13GRA and DTU13MSS high resolution global fields. He is a member of Sentinel-3 SLSTR Quality Working Group and science working teams associated with the NASA-CNES TOPEX/POSEIDON and Jason 1 and GRACE. Ole is also on the science advisory board for GEROS. Ole Andersen has been assistant secretary general within the International Association of Geodesy and member of several international study groups within the field of satellite altimetry. He has participated in numerous national and international projects and headed the national research project HYDROGRAV in 1007-2010 in Denmark and is currently heading the ESA project GOCE++. **A few selected references:** Andersen, O. B (2012). Satellite altimetry for geoid determination. in eds (Sanso and Sideris) The Geoid, Springer Verlag, Heidelberg, Germany 2012 Andersen, O. B., and R. Scharroo (2010), Range and geophysical corrections in coastal regions, book chapter in eds. (Vignudelli i et al), Coastal altimetry, ISBN: 978-3-642-12795-3 Andersen,O. B. Cheng, Y. (2013) Long term changes of altimeter range and geophysical corrections at altimetry calibration sites Advances in Space Research (ISSN: 0273-1177) (DOI: http://dx.doi.org/10.1016/j.asr.2012.11.027), vol: 51, issue: 8, pages: 1468-1477 A,ndersen, O.B. P. Knudsen and P. Berry (2010) Recent Development in High Resolution Global Altimetric Gravity Field Modeling, The Leading Edge, ISSN: 1070-485X, vol: 29, issue: 5, pages: 540-545. Andersen O. B, Knudsen P (2009) The DNSC08 mean sea surface and mean dynamic topography. J. Geophys. Res., 114, C11, doi:10.1029/2008JC005179 Andersen, O. B., Olesen, A.V. Forsberg, R. Strykowski, G. Cordua, K. S. Zhang, X. (2010) Ocean Dynamic Topography from GPS - Galathea-3 First results , Gravity, Geoid and Earth Observation (ISBN: 978-3-642-10633-0), pages: 239-346, Springer Verlag, Heidelberg, Germany Andersen, O. B., Krogh, P. E. Bauer-Gottwein, P. Leiriao, S. Smith, R. Berry, P. (2010) Terrestrial Water Storage from GRACE and Satellite Altimetry in the Okavango Delta (Botswana) Gravity, Geoid and Earth Observation (ISBN: 978-3-642-10633-0), pages: 521-	

526, 2011, Springer Verlag, Heidelberg, Germany

Andersen, O. B., P. Knudsen and P. Berry (2010) The DNSC08GRA global marine gravity field from double retracked satellite altimetry, Journal of Geodesy, Volume 84, Number 3, DOI: 10.1007/s00190-009-0355-9

Andersen, O. B., Egbert, G. D, Erofeeva, L., and Ray R. (2006) Mapping nonlinear shallow water tides: a look at the past and future, Ocean Dynamics 56, 5-6

Name:	Rene Forsberg
Position:	Professor
Qualifications and experience of interest for this proposal	

Educational and Professional:
M.Sc. from University of Copenhagen 1980, Geodesy and Geophysics (double degree).
Visiting scientist, Ohio State University 1983-83.
Visiting scientist, University of Calgary 1984-85.
Visiting professor, University of New South Wales, Australien 1988-89.
External lecturer, Niels Bohr Institute, University of Copenhagen, 1991-2012.

Career Summary:
1980-1997: Research Geodesist, Geodetic Institute and National Survey and Cadastre
1997-2005: State Geodesist and Dept Head, Geodynamics Dept., National Survey and Cadastre
2005-2013: Same position, Danish National SpaceCenter / DTU-Space
2013-: Professor, DTU-Space

International posts and major committees

2010-:	Chairman of Danish National SCAR (Antarctic Research) committee
2010-:	Member of Cryosphere WG, International Arctic Science Committee
2005-9	Member of Danish national IPY committees
2005-2011:	Member of the National Steering Committee for the Continental Shelf Project
2004-2011:	Chairman, International Gravity Field Service (International Association of Geodesy)
2004-2010:	Steering Board Member, Global Geodetic Observing System (GGOS)
2002-2012:	Member of ESA CryoSat cal/val team, coordinator of field activities
1999-2009:	Member of Scientific Advisory Group, ESA CryoSat mission.
1999-2007:	Vicepresident, International Gravity and Geoid Commission. Chairman of ”Arctic Gravity Project”, coordinating arctic gravity data survey coordination.
1995-99:	Section President (Gravity Field), International Association of Geodesy

Miscellanous
Recipient of the Ole Rømer award for astronomers and geodesists (1980).
Fellow of the International Association of Geodesy (1991)
Friendship Medal, presented by President of Mongolia during first Denmark state visit (2010)

Research and projects

Research scientist and Department Head, Department of Geodynamics (current staff of 12). Have worked extensively with geodetic, satellite and airborne research for cryosphere monitoring, general geodesy and mapping, and earth observation. Research focus has been on gravity field modeling, including geoid determination, and the use of gravity field data for environmental applications, as well as developing airborne methods for geophysics and cryosphere mapping (lidar). Numerous consultancy tasks for international and national survey projects (e.g., major bridges), sea-level issues and satellite-related tasks. Managed the Greenland Gravity Mapping program since 1991, and has taken initiative to, planned and carried out countless field expeditions in Greenland, Svalbard, Canada, the Arctic Ocean, and lately also in Antarctica and many regions of Asia of Africa.

Major funded research and government projects:

2015-16: Airborne mapping of the GOCE polar gap, Antarctica (with BAS, LDEO and NPI)
2015-18: SPICES – H2020 project on mapping extreme sea ice events from space
2013-15: ESA Cryosat validation projects (land ice and sea ice)
2012-15: Tanzania and Mozambique airborne geoid and gravity (World Bank and NGA)
2012-17: ESA Climate Change Initiative, Greenland-CCI project (coordinator)
2011-12: IMBIE, NASA/ESA International Mass Balance Intercomparison Experiment.
2010-13: EU-FP7 project Monarch-A, Monitoring Arctic for Climate Change.
2010-14: Nordic Center of Excellence - Stability and Variations of Arctic Land Ice.
2010-13: EU InterReg project BLAST (Bringing Land and Sea Together)
2009-13: ICEGRAV, DTU-Space Antarctic Airborne Geophysics Program (in cooperation with Argentina, Chile, BAS, NGA, U of Texas, Norway, ESA).
2009-13: EU project "Ice2Sea". Satellite measurements of the ice sheets.
2009-12: Indonesian airborne gravity project. NGA and Bakosurtanal.
2007-10: GNET – Support for Greenland GPS and absolute gravity networks for climate related GPS uplift studies (NSF cooperation). KVUG/IPY funding.
2007-15: PROMICE – National monitoring program for the Greenland Ice Sheet (GEUS)
2006-12: UNCLOS program, gravity, magnetic and sea ice measurements from icebreakers, ice camps and aircraft, in support of Danish Law of the Seas program
2006-08: Sea ice monitoring off NW and NE Greenland. BMP, Greenland Government
2005-07: ESA project "ArcGICE": Combination of Spaceborne, Airborne and in-situ Gravity in support of Arctic Sea-ice Mapping
2005-09: EU project DAMOCLES (Developing Arctic Modelling and Observing Capabilities

for long-term environmental studies) 2008-09: Korean airborne geoid survey (Sungyunkwon University) 2004-12: Airborne gravity surveys of Mongolia, Ethiopia, Nepal and Philippines 2003-15: ESA Cryovex, coordinating pre-launch Arctic field campaigns for Cryosat in Cooperation with UCL, NPI, Canada, AWI/DLR (Germany) and NASA. 2003-05: EU project SITHOS (Sea-ice Thickness Observing System) 2003-05: EU project GREENICE (sea-ice and research in the Polar Sea N of Greenland) 2002-03: ESAG-2002, ESA-GOCE Survey of Airborne Gravity and Laser in the Arctic. 2003-04: Malaysia airborne gravity and geoid project (Govt. of Malaysia) 2002-05: EU project GAVDOS – calibration site for satellite altimetry : 1998-03: Greenland gravity project, field surveys and training (NIMA-USA) at 1999-00: Great Barrier Reef project (ARC/Australia and Australian Navy) : 1996-99: Elevation Changes of the Greenland Ice Sheet (FNU/Tupolar programme) 1996-99: EU project AGMASCO, Airborne Geoid Mapping System for Coastal Oceanography
Teaching experience
Supervisor of ph.d. projects (8 completed, 1 ongoing). Supervisor of numerous M. Sc. Thesis projects, and numerous visiting ph.d. students and scientists. Coordinator the DTU-Space ph.d. program 2009-2014. External lecturer at Niels Bohr Institute, 1991-2009. Teacher at the yearly "IAG International Geoid Schools" since 1995. Teacher at numerous international workshops and ad-hoc courses around the world (US, Canada, Russia, Malaysia, Indonesia, Ethiopia, Brasil, Argentina, Saudi Arabia).
Publications
Total number of publications: ca. 270 since 1978, of which 115 in reviewed journals, proceedings or books. Numerous invited lectures and presentations at IAG, IUGG, AGU and EGU meetings. 5 cryosphere-relevant publications: Rene Forsberg, Louise Sørensen, Joanna Levinsen, Johan Nilsson: Mass Loss of Greenland from GRACE, ICESAT and CRYOSAT. Cryosat symposium, Dresden. ESA special publication 717, 2013. Shepherd A, E Ivins, G A, V Barletta, M Bentley, S Bettadpur, K Briggs, D Bromwich, R Forsberg, N Galin, M Horwath, S Jacobs, I Joughin, M King, J Lenaerts, J Li, S Ligtenberg, A Luckman, S B Luthcke, M McMillan, R Meister, G Milne, J Mouginot, A Muir, J Nicolas, J Paden, A Payne, H Pritchard, E Rignot, H Rott, L Sørensen, T Scambos, B Scheuchl, E Schrama, B Smith, A Sundal, J van Angelen, W van de Berg, M van den Broeke, D G Vaughan, I Velicogna, J Wahr, P Whitehouse, D Wingham, D Yi, D Young, H J Zwally: A Reconciled Estimate of Ice Sheet Mass Balance. Science, 338, pp. 2012. Barletta V R, L Sandberg Sørensen and R Forsberg (2012): Variability of mass changes at basin scale for Greenland and Antarctica, The Cryosphere, 6, 3397-3446, doi:10.5194/tcd-6-3397-2012. Forsberg, R., H. Skourup: Arctic Ocean Gravity, Geoid and Sea-ice Freeboard Heights from ICESat and GRACE. Geophyscial Research Letters, vol. 32, L21502, doi:10.1029/2005GL023711, 2005. Mohr, J. and R. Forsberg: Searching for new islands in sea-ice. Nature, vol. 416, p. 35, March 7, 2002

Name:	Louise Sandberg Sørensen
Position:	Senior Scientist

Qualifications and experience of interest for this proposal

Dr. Louise Sørensen is a senior scientist at DTU-Space. Louise is working with present-day changes of the cryosphere, using remote sensing techniques to determine mass changes and surface elevation changes of ice covered areas. She is an expert in EO of ice sheets, especially working on GRACE, IceSat, Envisat and CryoSat. Louise Sørensen acted as "early career" member of the steering committee of the EU FP7 projects Ice2Sea, and is involved in e.g. the ESA project CryoVal-LI.

Education:

2006 : M.Sc. in geophysics, Univ. of Copenhagen
Thesis was awarded a gold medal from the University of Copenhagen
2011 : Ph.D., Univ. of Copenhagen
2014 : Education in University Teaching at DTU.

Career Summary:

2006 : Research assistant at Univ. of Copenhagen
2006-2007 : Research assistant, Danish spacecenter
2007-2011 : PhD student at Univ. of Copenhagen
2011 - 2015 : Scientist at DTU Space
2013 : Visiting scientist at institute of Earth sciences, Univ. of Iceland (2 months). Funded by the Postdoc elite research grant from the Knud Højgaards foundation.
2015 - : Senior scientist at DTU Space

Projects experience:

SVALI : Nordic Centre of Excellence SVALI
Ice2sea : EU FP7 project ice2sea (2009-2013)
ESA CCI-ice sheets : ESA project (2012-2015)
IMBIE : ESA/NASA project Ice Mass Balance Inter-comparison Exercise (2012)
CryoVEx : ESA funded CryoSat validation (2011, 2014)
Cryoval-LI : ESA funded research project (2014-2015)
Polarportal.dk : funded by the Danish Energy Agency (2012-)

Other professional experiences:

- Course responsible for master course at DTU : Cryosphere physics and observations (2014 -)
- Scientific editor for Annals of Glaciology vol. 70 (2014-15)
- Has co-supervised two PhD students
- In review panel for Netherlands Org. for Scientific Research (2012)

- Course participation: Project management for scientists, DTU (2014)
- Course Participation : The PhD supervision Process: Methods and tools (2013)
- Early career member of the steering committee in EU FP7 project ice2sea (2009-13)
- Member of PhD committee, Australian National University (2015)

Publications

Summary:
Peer-reviewed publications: 16, Other scientific publications: ~6
Web of science statistics: Peer-reviewed publications with citation data: 15, H-index: 8. Average citation number 30

Selected publications:

Johan Nilsson, Paul Vallelonga, Sebastian B. Simonsen, **Louise Sandberg Sørensen**, Rene Forsberg, Dorthe Dahl-Jensen, Motohiro Hirabayashi, Kumiko Goto-Azuma, Christine S. Hvidberg, Helle A. Kjær, and
Kazuhide Satow (2015). Greenland 2012 melt event effects on CryoSat-2 radar altimetry, Geophysical Research Letters, 42, doi: 10.1002/2015GL063296.

Sørensen, L. S., Simonsen, S. B., Meister, R., Forsberg, R., Levinsen, J. F., & Flament, T. (2015). Envisat-derived elevation changes of the Greenland ice sheet, and a comparison with ICESat results in the accumulation area. Remote Sensing of Environment, 160, 56-62, doi: 10.1016/j.rse.2014.12.022.

A. Shepherd,E. R. Ivins, A. Geruo, V. R. Barletta, M. J. Bentley, S. Bettadpur, K. H. Briggs, D. H. Bromwich, R. Forsberg, N. Galin, M. Horwath, S. Jacobs, I. Joughin, M. A. King, J. T. M. Lenaerts, Jan, J. Li, S. R. M. Ligtenberg, A. Luckman, S. B. Luthcke, M. McMillan, R. Meister, G. Milne, J. Mouginot, A. Muir, J. P. Nicolas, J. Paden, A. J. Payne, H. Pritchard, E. Rignot, H. Rott, **L. Sandberg Sørensen**, T. A. Scambos, B. Scheuchl, E. J. O. Schrama, B. Smith, A. V. Sundal, J. H. van Angelen, J. van de Berg, J. Willem, M. R. van den Broeke, D. Vaughan, I. Velicogna, J. Wahr, P. L. Whitehouse, D. J. Wingham, D. Yi, D. Young, H. J. Zwally (2012) : A reconciled estimate of ice-sheet mass balance., Science, vol: 338, issue: 6111, pages: 1183-1189, 2012, DOI: 10.1126/science.1228102

L. S. Sørensen, S. B. Simonsen, K. Nielsen, P. Lucas-Picher, G. Spada, G. Adalgeirsdottir, R. Forsberg, C. S. Hvidberg (2011): Mass balance of the Greenland ice sheet (2003–2008) from ICESat data – the impact of interpolation, sampling and firn density, The Cryosphere, 5, 173-186, 2011, doi:10.5194/tc-5-173-2011, www.the-cryosphere.net/5/173/2011

Sørensen, L. S. and Forsberg, R. (2010). Greenland Ice Sheet Mass Loss from GRACE Monthly Models. In Gravity, Geoid and Earth Observation, pages 527-532. Proceedings of International Association of Geodesy Symposia Vol. 135. part 7, doi: 10.1007/978-3-642-10634-7_70

Name:	Karina Nielsen
Position:	Scientist
Qualifications and experience of interest for this proposal	
Karina Nielsen has a PhD degree (November 2012) within the fields of geodesy and climate from the Technical University of Denmark. Since her PhD she had been working at DTU Space as a researcher. During this period she has been Working on the FP7 LOTUS (Land and Ocean Take Up from Sentinel-3) project, where she has gained a large experience within SAR radar altimetry over inland water including development retrackers and water level time series retrieval. Nielsen, K., Stenseng, L., Andersen, O.B., Villadsen, H. and Knudsen, P. (2015), Validation of CryoSat-2 SAR mode based lak elevels. Remote Sensing of Environment, Volume 171, 15 December 2015, Pages 162-170. Villadsen, H., Andersen, O. B., Stenseng, L., Nielsen, K., & Knudsen, P. (2015). CryoSat-2 altimetry for river level monitoring—Evaluation in the Ganges–Brahmaputra River basin. Remote Sensing of Environment, 168, 80-89.	

Name:	Rakia Meister
Position:	Postdoctoral researcher
Qualifications and experience of interest for this proposal	
Rakia Meister analysed both Envisat altimetry and GRACE gravimetry data over the Antarctic Ice Sheet for her PhD research, combining the two to derive postglacial rebound rates. In her postdoctoral research, she has been part of generating surface height change rates from Envisat repeat track altimetry, thus increasing the spatial coverage of surface height changes. She is currently working on establishing a 20-year repeat and non-repeat track time series of ERS-1, ERS-2 and Envisat surface elevation changes for Greenland. This product will include monthly fields of surface heights for Greenland **Educational and Professional:**	

2007 – 2012 PhD thesis at University College London entitled "Estimating Antarctic Ice Sheet Mass Balance from Gravimetry and Altimetry"
2005 – 2006 MSc in Climate Change at the University of East Anglia, UK. Completed with Disctinction
2002 – 2005 Upper Second Class BSc in Combined Honours (main subject Geology) at Durham,University, UK

Publications

- Shepherd, A., E. R. Ivins, A Geruo and others: A Reconciled Estimate of Ice-Sheet Mass Balance, Science, vol 338 no 6111, pp. 1183- 89, doi: 10.1126/science.12281022012, 2012
- Sørensen, L. S., Simonsen, S. B., Meister, R., Forsberg, R., Levinsen, J. F., & Flament, T. (2015). Envisat-derived elevation changes of the Greenland ice sheet, and a comparison with ICESat results in the accumulation area. Remote Sensing of Environment, 160, 56-62, doi: 10.1016/j.rse.2014.12.022
- Meister, R., B. C. Gunter, A. Muir and A. Shepherd: A comparison of Envisat radar and ICESat laser measurements of Antarctic surface elevation changes, in preparation

Name:	Henriette Skourup
Position:	Research scientist
Qualifications and experience of interest for this proposal	

Henriette Skourup is a scientist at DTU Space. Over the years Henriette has worked extensively with developing satellite methods, especially from NASA's laser altimetry mission ICESat, to estimate sea ice thickness and ocean topography in the Arctic Ocean. She participated in related EU project Monarch-A, and is currently involved in ESA Climate Change Initiative (CCI) to estimate and validate long term satellite series of important sea ice parameters, ESA CryoVal project to validate CryoSat data, and EU project ICE-ARC looking into current and future changes in the Arctic sea ice cover.

As an important part of her work is to validate satellite data and monitor cryosphere changes, she has been involved in numerous airborne lidar and radar campaigns in Greenland and the Arctic Ocean, especially related to ESA CryoVEx (CryoSat validation) campaigns, national funded project PROMICE, and EU projects such as DAMOCLES and GreenICE.

S. Kern, K. Khvorostovsky, **H. Skourup**, E. Rinne, Z. S. Parsakhoo, V. Djepa, P. Wadhams, and S. Sandven: The impact of snow depth, snow density and ice density on sea ice thickness retrieval from satellite radar altimetry: Results from the ESA-CCI Sea Ice ECV Project Round Robin Exercise. The Cryosphere, doi:10.5194/tc-9-37-2015, 9, 37-52, 2015

R. Ricker, S. Hendricks, V. Helm, **H. Skourup**, and M. Davidson: Sensitivity of CryoSat-2 Arctic sea-ice freeboard and thickness on radar-waveform interpretation, The Cryosphere, 8, 1607-1622, doi:10.5194/tc-8-1607-2014, 2014

R. Forsberg and **H. Skourup**: Arctic Ocean Gravity, Geoid and Sea-ice Freeboard Heights from ICESat and GRACE. Geophyscial Research Letters, vol. 32, L21502, doi:10.1029/2005GL023711, 2005

3.1.3.2 LEGOS

Name:	Alexei V. Kouraev
Position:	Assistant Professor

Qualifications and experience of interest for this proposal

Alexei Kouraev has a Ph.D. degree (1998) in oceanography from Moscow State Lomonosov Univerity (Russia) and HDR (Habilitation Qualification (2014) from University of Toulouse, France. He has been working at LEGOS/University of Toulouse as a researcher (2001-2006), and since 2006 as an assistant professor. He has published over 50 articles in peer-reviewed journals, books, and monographs. He has supervised 3 PhD and 16 Master students. His main research interest is the synergy of satellite and in situ data for studies of continental hydrology (river, flooding zones, bogs, ice and snow cover). He is piloting several projects dedicated to studies of lake ice cover using satellite radar altimetry: ERA-Net RUS.Plus "ERALECC" (2016-2017), CNES TOSCA "Lakes" (2012-2016), CNRS-Russia Project "BaLaLaICA " (2013-2015).

Zakharova E.A., Kouraev A.V., Remy F., Zemtsov V.A., Kirpotin S.N. Seasonal variability of the Western Siberia wetlands from satellite radar altimetry. Journal of Hydrology, 512 (2014), p. 366-378, http://dx.doi.org/10.1016/j.jhydrol.2014.03.002

Zakharova E.A., A.V. Kouraev, S. Biancamaria, M.V. Kolmakova, N.M. Mognard, V.A. Zemtsov, S.N. Kirpotin, B. Decharme. Snow cover and spring flood flow in the northern part of Western Siberia (the Poluy, Nadym, Pur and Taz rivers). Journal of Hydrometeorology, 2011, Volume 2, p. 1498-1511, DOI: 10.1175/JHM-D-11-017.1

Cretaux J-F, V. Jelinski, S. Calmant, A. Kouraev, V. Vuglinski, M. Bergé-Nguyen, M-C Gennero, F. Nino, R. Abarco Del Rio, A. Cazenave, P. Maisongrande, SOLS, a lake database to monitor in Near real time water level storage variations from remote sensing data, Advances in Space research, 47 (2011), p. 1497-1507, doi:10:1016/j.asr.2011.01.004

Kouraev A.V., M.N. Shimaraev, P.I. Buharizin, M.A.Naumenko, J-F Crétaux, N.M. Mognard, B. Legrésy, F. Rémy. Ice and snow cover of continental water bodies from simultaneous radar altimetry and radiometry observations. Survey in Geophysics - Thematic issue "Hydrology from space" 2008 DOI 10.1007/s10712-008-9042-2

Zakharova E.A., Kouraev A.V., Cazenave A, Seyler F. "Amazon river discharge estimated from Topex/Poseidon satellite water level measurements", Comptes Rendus - Geoscience, 2006, Vol 338, No 3, 188-196, DOI: 10.1016/j.crte.205.10.003

Kouraev A.V., Zakharova E.A., Samain O., Mognard-Campbell N., Cazenave A. "Ob' river discharge from TOPEX/Poseidon satellite altimetry data", Remote Sensing of Environment, 93, 2004, pp. 238-245, DOI: 10.1016/j.rse.2004.07.007

Name:	Frédérique Rémy
Position:	Senior Scientist

Qualifications and experience of interest for this proposal

Dr. Frédérique Remy is Senior Scientist at LEGOS/CNRS. She studies the cryosphere from space, especially the Antarctica ice sheet. She mostly works on radar physics, ice sheet mass balance and ice dynamics with altimetry, radiometry and gravimetry. She belongs to several Scientific Advisory Groups of ESA and CNES and is responsible for the data processing (retracking ice2) of the Envisat radar altimeter. She is now member of the SARAL/AltiKa Science Team and responsible for the Kassis project (KA band for Snow Surface and Ice Survey). She writes about 90 papers in peer reviews, three books and is co-authors of several others.

Employment: Senior Scientist at LEGOS/CNRS.
Experience and Responsibility: Studies the cryosphere from space, especially the Antarctica ice sheet. Main interests are radar physics, ice sheet mass balance and ice dynamics with altimetry, radiometry and gravimetry. Member of several Scientifc Advisory Groups of ESA and CNES and the Leader for the data processing (retracking ice2) of the Envisat radar altimeter. The member of the SARAL/AltiKa Science Team and responsible for the Kassis project (KA band for Snow Surface and Ice Survey).
Education
PhDs in astronomy (1984) and glaciology (1989)
Habilitation qualification (1994)
Supervision:
15 PhD students and 18 Masters
Selected Publications:

- Remy, F., Flament T., Michel, A. and J. Verron, 2014, Ice sheet survey over Antarctica with satellite altimetry: ERS-2, EnviSat, SARAL/AltiKa, the key importance of continuous observations along the same repeat orbit, International Journal of Remote Sensing, 35 (14), 5497-5512, doi:10.1080/01431161.2014?926419, 2014.

- Flament, T., E. Berthier, and Remy, F., 2014, Cascading water underneath the Antarctic ice sheet (Wilkes Land) observed using altimetry and digital elevation models, The Cryosphere, 8, 1-15.
- Zakharova, E.A, A.V.Kouraev, F. Rémy, V.A. Zemtsov, S.N.Kirpotin,,2014, Seasonal variability of the Western Siberia wetlands from satellite radar altimetry, Journal of Hydrology, 512, 366-378.
- Mémin, A, T. Flament, F. Remy, & M. Llubes, 2014, Snow and height changes in Antarctica from satellite gravimetry and altimetry data, Earth and Planetray Science Letters, 404, 344-353..
- A. Michel, T. Flament, F. Remy, 2014, Study of the penetration bias of Envisat Altimeter observations over Antarctica in comparison to ICESat Observations, Remote Sensing, 6, 9412-9434.

Name:	Jean-François Cretaux
Position:	Scientist, Dr of Science, engineer at CNES: Centre National d'Etudes Spatiales

Qualifications and experience of interest for this proposal

Expert in space hydrology since 15 years. Has contribute within the use of remote sensing data to the development of application of satellite altimetry and imagery to hydrology. Has a long experience in Cal/Val activities using GNSS and other tools for satellite altimetry over inland waters. Has developped and is in charge of a global database for dissemination of satellite altimetry products for lakes and rivers. Has coordinated few international projects (INTAS, ECOSUD, CEFIPRA, NATO) on applications of satellite techniques for hydrology. Presently PI of the SWOT (Surface Water and Ocean Topography) NASA/CNES mission. Has supervised 4 phd and several master degree students. Is authors and co-authors of 48 articles in per review journal and has participated to almost 10 chapter books in space hydrology.

Cretaux J-F., Biancamaria S., Arsen A., Bergé-Nguyen M., and Becker M., Global surveys of reservoirs and lakes from satellites and regional application to the Syrdarya river basin, Environmental Research Letter, 10,1, AN: 015002, 2015, **DOI:** 10.1088/1748-9326/10/1/015002

Bergé-Nguyen M., and Cretaux J-F., Inundations in the Inner Niger Delta: Monitoring and Analysis Using MODIS and Global Precipitation Datasets, Remote Sens., 7, 2, 2127-2151, 2015

Crétaux J-F, W. Jelinski , S. Calmant , A. Kouraev , V. Vuglinski , M. Bergé Nguyen , M-C. Gennero , F. Nino, R. Abarca Del Rio , A. Cazenave , P. Maisongrande, SOLS: A Lake database to monitor in Near Real Time water level and storage variations from remote sensing data, J. Adv. Space Res. (2011), doi:10.1016/j.asr.2011.01.004

Crétaux J-F and C. Birkett, lake studies from satellite altimetry, C R Geoscience, doi: 10.1016/J.cre.2006.08.002, 2006

Crétaux J-F, Kouraev A.V., Papa F., Bergé Nguyen M., Cazenave A., Aladin N.V., and Plotnikov I.S., water balance of the Big Aral sea from satellite remote sensing and in situ observations, Journal of Great Lakes Research, 31 (4), 2005.

Longuevergne L., C.R. Wilson, B.R., Scanlon, and J-F Cretaux, GRACE water storage estimates for the middle east and other regions with significant reservoir and lake storage, Hydrol. Earth. Syst. Sci., 17, 12, 4817-4830,2013

Ričko M., C.M. Birkett, J.A. Carton, and J-F. Cretaux, Intercomparison and validation of continental water level products derived from satellite radar altimetry, J. of Applied Rem. Sensing, Volume 6, Art N°: 061710, DOI: 10.1117/1.JRS.6.061710, 2012

Name:	Elena Zakharova
Position:	Scientist
Qualifications and experience of interest for this proposal	

Research scientist, Ph.D, Habilitation qualification

LEGOS, OMP, 14, ave.Edouard Belin, 31400, Toulouse, France

phone +33 561 33 2915, email: elena.zakharova@legos.obs-mip.fr

Born 1969,

Address: 14, Ave. Ed.Belin,31400,Toulouse, France

Education

Habilitation qualification, University of Toulouse, France (2015)

Ph. D. in Hydrology and Water Resources, University of Moscow (1995)

Masters in Hydrology, University of Moscow (1991)

Supplementary

1993 Guest scientist, Plymouth Marine Laboratory, UK

2004 Guest Scientist, Institute Physique du Globe de Paris-IPGP, France

2005 Guest scientist, LMTG, OMP, Toulouse France

1990-present, Field campaigns in Russian Arctic and Siberia (hydrological, oceanographical and glaciological survey)

1995- present, Lectures in Moscow State University, Toulouse-III University Ecole Normale Supérieure (Paris)

Employment

Research scientist, Moscow State University (Russia) 1995-2002

Research scientist, Météo-France ,Toulouse (France) 2010-2011

Research scientist, LEGOS, OMP, Toulouse (France) 2004-2005, 2008-2009, 2012-2014

Recently /currently participating in TOSCA CNES SWOT Sea Ice project, French-Russian project CAR-WET-SIB, Franco-Siberian Centre for Education and Research.

Key Research Topics

Remote sensing, altimetry, radiometry (SMOS), sea ice, land water cycle

Supervision

Ph.D. Students: 2

Master Students: 8

Awards/Grants TOSCA SWOT (CNES Grant) "SWOT application for the arctic and boreal wetlands" 2013-present
Publications 18 publications in Peer Reviewed International (11) and Russian (6) journals
Books Contribution to 4 book chapters
Selected internationally reviewed articles Zakharova EA, Fleury S., Guerreiro K., Willmes S., Rémy R., Kouraev A., Heinemann G., Sea ice leads detection using SARAL/AltiKa altimeter. Marine Geodesy, Special issue on SARAL/AltiKa Volume 38, Issue sup1, 2015, 522-533. Zakharova E., Kouraev A., Remy F., Zemtzov V., Seasonal variability of the Western Siberia wetlands from satellite radar altimetry. Journal of Hydrology, 2014. Zakharova E.A., A.V. Kouraev, S. Biancamaria, M.V. Kolmakova, N.M.Mognard, V.A. Zemtsov, S.N. Kirpotin, B.Decharme. "Snow cover and spring flood flow in the northern part of the Western Siberia (the Poluy, Nadym, Pur and Taz rivers)". Journal of Hydrometeorology. 2011, vol.12, No 6.

3.1.3.3 ENVEO

Name:	Thomas Nagler
Position:	Managing Director
Qualifications and experience of interest for this proposal	

CURRICULUM VITAE	
Name	**Thomas NAGLER**
Qualification	*Doctor rerum naturarum* (Dr.rer.nat) in Natural Sciences, University of Innsbruck (1996) *Magister rerum naturarum* (Mag.rer.nat) in Meteorology and Geophysics, Univ. Innsbruck (1991)
Present Position	ENVEO IT GmbH, Managing Director
Project Role	WP Leader

Relevant Experience	
Activity	**Topic, Role**
Employment	• 2001– present: Managing Director of ENVEO IT GmbH • 2001 – Founding the company ENVEO Environmental Earth Observation IT GmbH • 1991–2004: Research Scientist, Inst. Meteorology / Geophysics, Univ- Innsbruck • 1988: Alpine Weather Service, Innsbruck
Relevant Experience (Selected Projects)	• WP Leader, Project: GlobSnow– ESA DUE, ESRIN Contract (ongoing) • WP-Leader: CoReH2O End-to-End Mission Performance Simulator. ESA Study, Contract 4000101698/10/NL/JC. CoReH2O End • WP-Leader, Project: Definition Study of Concepts for Demonstration of Advanced Techniques and Technologies on an EO Small Mission. (ESA; Lead Astrium Ltd) • Deputy of PI, WP Lead “Ku-band SAR modelling for snow applications”, ESA *18668* • WP leader in ESA Project ALGOSNOW – Algorithms for Snow and Land Ice Retrieval using SAR data. (2011-2013) • WP Leader in ESA CCI Project “GLACIER CCI” (2010-2013) • Coordinator of FP7 Project 262925, “CRYOLAND – GMES SNOW AND ICE SERVICE” (2011-2015) • PI of ESA project GLACAPI - Multi-sensor analysis of glacier response to climate change on the Antarctic. Peninsula” (ESA Contract No. 4000105776; started 6/2012; ongoing)
Research Stays and Scientific Expeditions	• 1992 - Research stays at the CIRES, Boulder, CO, USA. • 1993 Univ. Sheffield, Dep. of Applied and Computational Mathematics • 1992-1999, 2007 Several field campaigns in various alpine test areas in the eastern ALPs (ERS SAR, Radarsat, SIR-C/X-SAR), SARALPS-2007 • 1994-1995: Glaciological expeditions to the Southern Patagonian Icefield and Larsen Iceshelf, Antarctic Peninsula. • 2007: Participation at CLPX-2 experiment, CO, USA. • 2007/2008;Lead of SARALPS 2007 and HeliSnow 2008 Campaign,Alps, NOSREX 2010 • 2012/2013: Lead of ALPSAR Field Campaign, Austria (ESA Contract 4000107780). • 2013/2014: Lead of ALPTOMOEXP Field Campaign, Austria

International Working Groups	• since 1999: Co-Chairman of LISSIG EARSel • DLR: Tandem-L: Speaker for Land Cryosphere • Member of SAOCOM / TANGISAT Science Team
Principal Investigator/ Co-PI of Earth Observation AO experiments	• ESA: ERS, Envisat, JAXA: PALSAR, RADARSAT • DLR: TerrasSAR-X, TanDEM-X; CosmoSkyMed

Name:	Helmut Rott
Position:	Managing Director

Qualifications and experience of interest for this proposal

CURRICULUM VITAE	
Name	**Helmut ROTT**
Qualification	Ph.D. in Meteorology and Physics (1974)
Present Position	ENVEO IT GmbH, Managing director Univ. Innsbruck, Professor for Remote Sensing
Project Role	Project Leader and WP Leader

Relevant Experience

Activity	**Topic, Role**
Employment	• 2001– present: Co-director of ENVEO IT GmbH • 1986– present: Professor at University of Innsbruck • 1988/89: Guest Professor University of Munich • 1974–85: Research Associate, Univ. Innsbruck & Austrian Academy of Sciences • 1969–74: Research Assistant, Univ. Innsbruck
Research projects and >200 publications	• Microwave signatures and inversion methods • Spaceborne microwave radiometry • Atmospheric radiative transfer • Imaging spectrometry for water quality and atmosphere • Synergy SAR/optical for land surface monitoring • Satellite applications for snow & ice research and for hydrology • Antarctic glaciology • Runoff modelling & forecasting using satellite data • Differential SAR interferometry for natural hazards and glaciology
Manager of ESA Studies (Prime Contractor)	• "Tech. Support for the Deployment of Sensors during HeliSnow-2008" ESTEC Cont. 21146 • "Retrieval of Physical Snow Properties from SAR Observations at Ku- and X-Band Frequencies ". 20756/07/NL/CB • "SAR-Alps2007", 20380/06/NL/GS • "Ku-band SAR modelling for snow applications", *18668/05/NL/GLC* • "The Use of SAR Interferometry to Retrieve Bio- and Geo-Physical Variables" /02/NL/MM • "SAR land applications for snow and glacier monitoring",.6618/85/F/FL(SC). • "River runoff prediction based on satellite data. 5376/83/D/(JS(SC). • "Study on use and characteristics of SAR for land snow and ice applications". 5441/83/D/IM(SC). Sub-project manager of 9 other ESA contracts

Offices in Scientific Advisory Groups of ESA	• Earth Science Advisory Committee (2007-2011) • Chair, CoReH2O Mission Advisory Group (2006-) • The SAR Advisory Group (2002-2010) • ASAR Science Advisory Group (1993-2002) • Earth Science Advisory Committee (1996-1999) • Earth Observation Advisory Committee (1994-1995) • SAR Expert Team (1998-1992).
Principal Investigator of Earth Observation AO experiments	• ESA: ERS-1, ERS-2, Envisat, CryoSat • NASA & DLR: SIR-C/X-SAR; SRTM • DLR: Terra-SAR-X, TanDEM-X • CSA: Radarsat • JAXA: PALSAR
Present Positions in Intern. Scientific Organisations	• Fellow of the IEEE • Member, International Academy of Astronautics • Member of the Scientific Steering Group of the Climate and Cryosphere Program (CliC) of WCRP

Name:	Markus Hetzenecker
Position:	Senior Research Scientist

Qualifications and experience of interest for this proposal

CURRICULUM VITAE	
Name	**Markus HETZENECKER**
Qualification	*Magister rerum naturarum* (Mag.rer.nat) in Theoretical Physics, University of Innsbruck (2004)
Present Positions	Senior Research Scientist
Project Role	Senior Research Scientist; design of software; software implementation and tests;

Relevant Experience

Activity	**Topic, Role**
Employment	• 2011–present: ENVEO IT GmbH • 2006–2011: Senior system administrator for Linux/Unix systems at Information Technology Services • of University of Innsbruck • 1999-2006: System administrator for Linux/Unix systems at Information Technology Services of University of Innsbruck

Relevant Experience (Selected Projects)	• Development and implementation of Server/Client Infrastructure in a Linux/Unix environment for Institutes and Departments at University of Innsbruck • Methods and software development for simulation of acoustic waves in inhomogeneous media (Diploma Thesis) • Methodological and software development and implementation for processing and analysing time series of data of spaceborne Synthetic Aperture radar (SAR) and for interferometric SAR processing • SAR software development for Sentinel-1 data analysis related to ice parameters Related Projects at ENVEO • WP Leader in ESA CCI Project "ICESHEET CCI" (2011-2014) • Software Design and Development contributing to ESA CCI Project "GLACIER CCI" (2011-2014) and Icesheets CCI, • WP Leader, "AIM4X - Advanced Interferometric Methods for TanDEM-X" (ASAP, FFG,)) • Contributing to GlacAPI, Antartic-CCI Scoping Study, STSE APMB,
Publications (selected)	Nagler, T., Rott, H., Hetzenecker, M., Wuite, J., Potin, P. (2015): The Sentinel-1 Mission: New Opportunities for Ice Sheet Observations. Remote Sensing, 2015, 7, 9371-9389, doi:10.3390/rs70709371. Nagler, T., Hetzenecker, M., Rott, H., Wuite, J. (2015): Application of Sentinel-1 SAR for monitoring surface velocity of Greenland outlet glaciers. *FRINGE 2015 Workshop*, 23-27 March 2015, ESA-ESRIN, Frascati, Italy. Nagler T., H. Rott, M. Hetzenecker, K. Scharrer, E. Magnússon, D. Floricioiu, C. Notarnicola, 2012. Retrieval of 3D-glacier movement by high resolution X-Band SAR data. Proc. IGARSS 2012. Nagler T., M. Heidinger, H. Rott, G. Bippus, M. Hetzenecker, K. Scharrer. 2012. Snow and glacier monitoring service using Earth Observation data. EGU 2012, Poster Presentation.

Name:	Petra Malcher
Position:	Senior Research Scientist
Qualifications and experience of interest for this proposal	

CURRICULUM VITAE		
Name	**Petra MALCHER**	
Qualification	Graduation to Magistra rerum naturarum (Mag. rer. nat.) in Meteorology and Geophysics, University of Innsbruck, Austria. (2001, with maximum cum laude).	
Present Position	Senior Research Scientist, ENVEO IT GmbH	
Project Role	Senior research	
Relevant Experience		
Activity	**Topic, Role**	

Employment	• Since June 2005 - Research scientist at ENVEO IT GmbH, responsible for development of hydrological models, the use of remote sensing products in hydrology, and hydromet data management, analysis of optical and SAR satellite data for snow and land ice poroducts, contributing to software developemnt at ENVEO. • 2001-2005 Research scientist, Inst. of Meteorology & Geophysics, Univ. Innsbruck, in the EU funded project EnviSnow for the development of generic earth observation based snow retrieval algorithms (optical, SAR) and development of hydrological models and hydromet pre-processing for runoff simulations and real time forecasts • 1995 -2001 - Short term contractional work in various fields of meteorology at the Institute of Meteorology and Geophysics, Innsbruck, Austria; TÜV Bayern Landesgesellschaft Österreich, Jenbach, Austria; Deutscher Wetter Dienst (DWD), Munich, Germany; Zentralanstalt für Meteorologie und Geophysik (ZAMG), Salzburg, Austria; Abfallwirtschaft Tirol Mitte GmbH, Hall i. Tirol, Austria; Mesoscale Alpine Programme (MAP), Innsbruck, Austria; Austro Constrol GmbH, Innsbruck, AT; Innsbrucker Kommunalbetriebe AG, Innsbruck, AT
Experience	Selected Projects: • "ASaG - Preparation for a GMES Downstream Service". FFG ASAP (Austrian National Programme) (FFG ASAP 6 GMES project) • ATX Advanced Tools for TerraSAR-X Applications in GMES (FFG ASAP5 Project) • ASAP-2 – Autrian Settlement and Alpine Environment Cluster for GMES FFG ASAP-2 Project) • INTEGRAL – Interferometric Evaluation of Glacier Rheology and Alterations (EC FP6 Project) • GALAHAD - Advanced Remote Monitoring Techniques for Glaciers, Avalanches, and Landslides Hazard Mitigation • Cryoland – GMES Service Snow and Land Ice (FP7 Project) • Technical Support for the Deployment of Sensors during HeliSnow 2008. (ESA ESTEC Contract) • WP Lead ESA GEOACCA - Feasibility Study for Geolocation Assessment of Optical Sensors (2013-2015)
Publications	• P. Malcher, T. Nagler, and H. Rott, "Synergy of SAR and optical sensors for snow hydrology applications," Proceedings of the 4th International Symposium on Retrieval of Bio- and Geophysical Parameters from SAR Data for Land Applications (Innsbruck, Austria), November 16-19, pp. 433-440 • P. Malcher, D. Floricioiu, and H. Rott, "Snow mapping in alpine areas using medium resolution spectrometric sensors," Proceedings of the IGARSS'03 Symposium (Toulouse, France), July 21-25, CD-ROM, ISBN: 0-7803-7930-6, paper no. I_A32_10, 3 pp. • H. Rott, T. Nagler, P. Malcher, and F. Müller. 2006. A satellite-based information system for glacier monitoring and modelling. Proc. EARSEL GA, 2007. • T. Nagler, H. Rott, P. Malcher, and Florian Müller. 2007. Assimilation of Meteorological and Remote Sensing Data for Snowmelt Runoff Forecasting. Accepted for publication in RSE.

3.1.4 Key personnel dedication

WP	Description	WP leader
WP1000	**Scientific Requirement consolidation**	OA
WP1000	Required baseline document.	LS
WP1100	Litterature review. Technical note.	LS
WP1200	Review of existing and available data. Technical note	AK
WP1300	Review of existing projects and models. Technical note	HS
WP1400	Definition test areas used in the project. Technical note.	TN

WP2000	**Data set collection**	KN
WP2100	Database containing EO and in-situ data and model output	KN
WP2200	Description of datasets in database	AK
WP3000	**Development and validation**	EZ
WP3100	ATBD describing the algorithms and methods selected	KN
WP3200	Product Validation Report	EZ
WP4000	**Prototype demonstration and impact**	KN
WP4100	Publish experimental data set : target prototype products	KN
WP4200	Update technical note D3	TN
WP4300	Impact assessment report	KN
WP5000	**Scientific Roadmap Report**	LS
WP5100	Evaluation of obtained scientific results. Tech. note	LS
WP5200	Scientific agenda 2017-2021. Tech. note	LS
WP5300	Research to operational plan	TN
WP6000	**Promotion**	OA
WP6100	Journal paper submitted on FWF time series	KN
WP6200	Website	LS
WP6300	Presentations	OA
WP6400	Communication material	OA
WP7000	**Management**	OA
WP7100	Monthly reports on progress	OA
WP7200	Final report	OA
WP7300	Executive Summary	OA

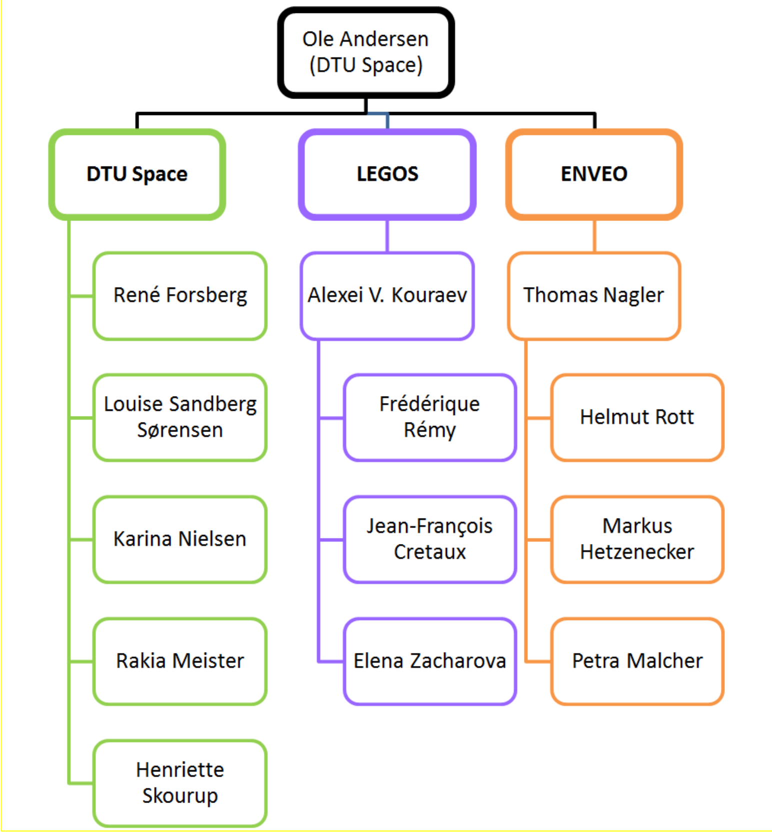
3.2 Management structure.

The following key persons participate in the ArcFlux consortium. DTU space (O. Andersen) will head the proporal supported by Scientis L. S. Sørensen and K. Nielsen in the day to day work.

The management structure of the Project consists of a steering committee, headed by the Project manager (O. Andersen) One Project officer from each Party will be elected.

The Steering Committee shall form a quorum if a minimum of 2/3 of all Steering Committee Members are present or represented by another person by written power of attorney. The Parties shall strive to reach unanimous decisions. If unanimity cannot be achieved, decisions shall be made with 2/3 majority by the Steering Committee Members present or represented, each having 1 vote. The Steering Committee controls the corporation in the consortium and over the subcontractors for handling of disagreement. A The Steering Committee shall meet at least twice a year and as requested by a Party.

The following persons and representatives from the various parties is shown below.

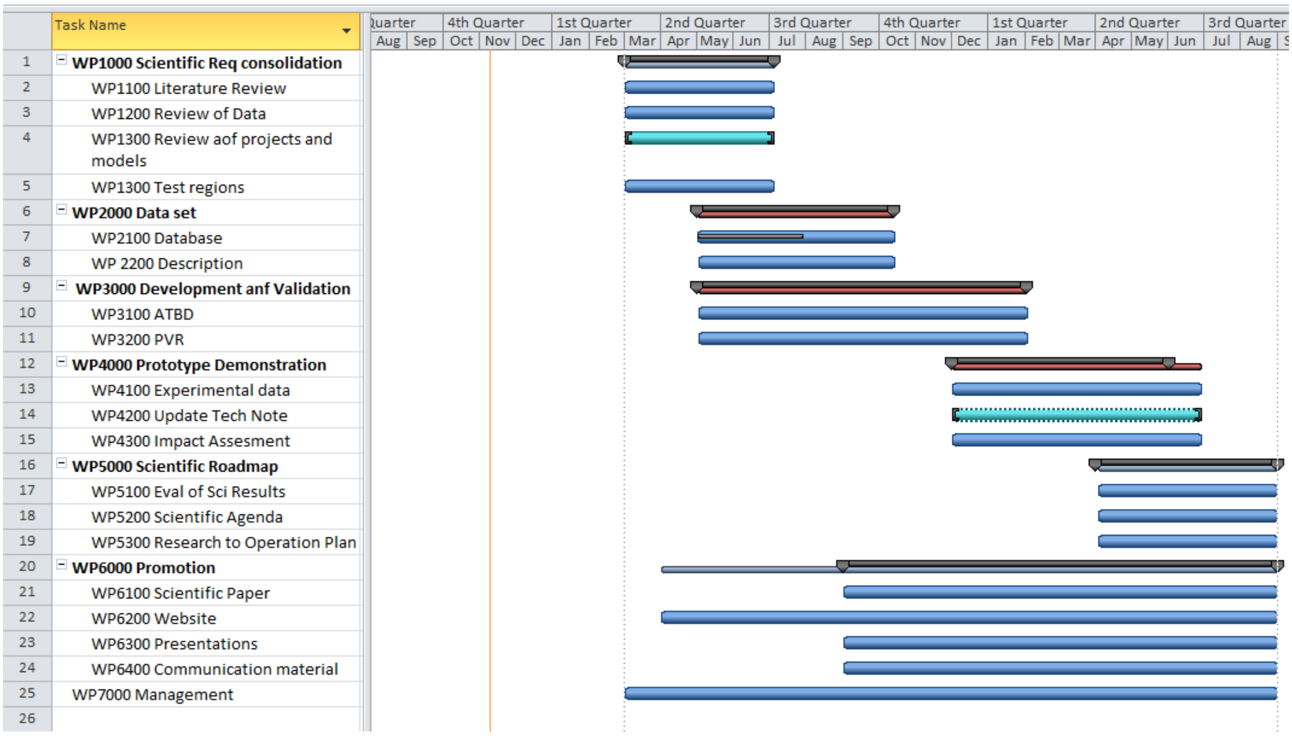


4 Implementation Proposal

4.1 Planning

WP	WP Description	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18
1000	Scientific requirement consolidation	■	■	■	■														
2000	Data set collection			■	■	■	■	■	■										
3000	Development and validation			■	■	■	■	■	■	■	■	■							
4000	Prototype demonstration										■	■	■	■	■	■			
5000	Scientific roadmap														■	■	■	■	■
6000	Promotion							■	■	■	■	■	■	■	■	■	■	■	■
7000	Management	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Gantt diagram



4.1.1 Deliverables

Internal deliverables

ESA deliverables

ID	WP	Description	Date
	WP1000	**Scientific Requirement consolidation**	
D1	WP1000	D5 Required baseline document. This report is a consolidation of the technical notes D1a, D1b, D1c, and D1d.	KO+ 4
D1a	**WP1100**	**Litterature review. Technical note.**	**KO+ 4**
D1b	**WP1200**	**Review of existing and available data. Technical note**	**KO+ 4**
D1c	**WP1300**	**Review of existing projects and models. Technical note**	**KO+ 4**
D1d	**WP1400**	**Definition test areas used in the project. Technical note.**	**KO+ 4**
	WP2000	**Data set collection**	
D2	WP2100	Database containing EO and in-situ data and model output	KO+ 8
D3	WP2200	Description of datasets in database	KO+ 8

	WP3000	**Development and validation**	
D4	WP3100	ATBD describing the algorithms and methods selected	KO+ 11
D5	WP3200	Product Validation Report	KO+ 11
	WP4000	**Prototype demonstration and impact**	
D6	WP4100	Publish experimental data set : target prototype products	KO+ 15
D7	WP4200	Update technical note D3	KO+ 15
D8	WP4300	Impact assessment report	KO+ 15
D9	**WP5000**	**Scientific Roadmap (**This report is a consolidation of the technical notes D9a, D9b, D9c**)**	
D9a	**WP5100**	**Evaluation of obtained scientific results. Tech. note**	**KO+ 18**
D9b	**WP5200**	**Scientific agenda 2017-2021. Tech. note**	**KO+ 17**
D9c	**WP5300**	**Research to operational plan**	**KO+ 18**
	WP6000	**Promotion**	
D10	WP6100	Journal paper submitted on FWF time series	KO+18
D11	WP6200	Website	KO+ 2 (ong. maintanence)
D12	WP6300	Presentations	KO+18
D13	WP6400	Communication material	KO+18
	WP7000	**Management**	
D14x:	WP7100	Monthly reports on progress	Every month
D15:	WP7200	Final report	KO+ 18
D16	WP7300	Executive Summary	KO+ 18

4.1.2 Meetings

Meeting	Place	Date	Deliverables
Kick Off Meeting	DTU	KO	
Progress Meeting 1	telecon	KO+4	D1
Midterm Review Mtg	ESRIN	KO+8	D2 D3
Progress Meeting 2	telecon	KO+11	D4 D5
Progress Meeting 3	telecon	KO+15	D6-D9
Final Meeting	ESRIN	KO+18	D10-D16

4.2 Work Breakdown Structure

List of Work Packages and sub-work packages

WP	Title	Sub-WPs	Title	Responsible

WP1000	Scientific Requirement consolidation	WP1100 WP1200 WP1300 WP1400	Litterature review Data review Review of existing projects and models Definition test areas	DTU LEGOS DTU ENVEO
WP2000	Data set collection	WP2100 WP2200	Create database Dataset description	DTU LEGOS
WP3000	Development and validation	WP3100 WP3200	Algorithm / method selection Validation of various products	ENVEO LEGOS
WP4000	Prototype demonstration and impact	WP4100 WP4200 WP4300	Experimental data set for prototype production Update tech note D3 Impact assessment	DTU LEGOS DTU
WP5000	Scientific Roadmap	WP5100 WP5200 WP5300	Evaluation of obtained scientific results Scientific agenda 2017-2021 Research to operational plan	DTU DTU ENVEO
WP6000	Promotion	WP6100 WP6200 WP6300 WP6400	Journal paper submitted on FWF time series Website Presentations Communication material	DTU DTU DTU DTU
WP7000	Management	WP7100 WP7200 WP7300	Monthly Progress reports Final report Executive summary	DTU DTU DTU

4.2.1 Work Package Description

WP1000

4.2.1.1

The purpose of this WP is to consolidate the scientific requirements for estimating the Arctic freshwater fluxes, maximizing the use of ESA data. The required baseline for doing so will be established and documented through detailed reviews of existing literature, initiatives, projects and data

In WP1000, a thorough assessment and analysis of the main challenges associated with determining the Arctic freshwater fluxes using satellite observations will be carried out and any knowledge gaps and scientific problems will be documented. This work will define and guide the scientific focus of the project to address these issues.

WP1000 consists of four sub-WPs which all contribute to the D1; the Scientific Requirement consolidation report. D1 is the external deliverable of this WP, while the deliverables of the sub-WPs are internal deliverables.

WP	Title	Sub-WPs	Title
WP1000	Scientific Requirement consolidation	WP1100	Litterature review
		WP1200	Data review
		WP1300	Review of existing projects and models
		WP1400	Definition test areas

WP ID:	1100	Start:	KO	End:	KO+4
Title	Literature review			WP Leader	DTU, LS
Contributing Partners:	DTU				
Objective To perform a thorough literature review of the state-of-the-art for determining the freshwater budget in the Arctic Ocean. In this review the main sources of uncertainty will be identified. Special attention will be given to how fluxes have been previously quantified by using satellite EO data.					
Tasks				Responsible	
Perform a dedicated and thorough review of the state-of-the-art for determining the freshwater budget in the Arctic Ocean.				DTU	
Inputs	Planned Effort (man-hours)		End Criteria		
Published journal papers, reports, and presentations.	70		Accepted by ESA		
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D1a	Literature review, technical note which contributes to the scientific requirement consolidation report (D1)			KO+4	

WP ID:	1200	Start:	KO	End:	KO+4
Title	Data review			WP Leader	LEGOS, AK
Contributing Partners:	All				
Objective : To perform a detailed review of data (both satellite, satellite-derived, airborne and in-situ) that can / will be used in the quantification of the Arctic Ocean FWFs. The data sets shall include both development data sets that will be used to estimate the freshwater fluxes , but also validation data. In case that there is a lack of useful and critical datasets this will be described and a practical solution to overcome this will be proposed.					
Tasks				Responsible	
Provide an overview of available satellite EO data for determining FWF from rivers. Both the temporal and spatial coverage will be given.				LEGOS	
Provide an overview of available airborne and in-situ data that can potentially be used for validating the estimated river levels, FWF or river outline.				LEGOS	
Provide an overview of available satellite EO data for determining FWF from land ice. Both the temporal and spatial coverage will be given.				ENVEO	
Provide an overview of available airborne and in-situ data that can potentially be used for validating the estimated ice velocities and ice thickness.				ENVEO	
Provide an overview of available satellite-derived EO products of sea ice thickness and drift for determining FWF from sea ice transport. Both the temporal and spatial coverage shall be given.				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
Data acquisition reports, EO archives, data center archives		70		Accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D1b	Data review, technical note which contributes to the scientific requirement consolidation report (D1)			KO+4	

WP ID:	1300	Start:	KO	End:	KO+4
Title	Review of existing projects and models			WP Leader	DTU, HS
Contributing Partners:	All				
Objective : To perform a detailed review past and on-going projects that have aimed at determining the Arctic ocean FWB or single FWFs. Furthermore, since this project is focused on products that can be quantified from ESA satellite EO data, the FWB will have to be closed by including model output. Therefore another objective it to make a review of which models are available for this.					
Tasks				Responsible	
Make a review of past and on-going projects that have aimed at determining the Arctic ocean FWB or single FWFs.				DTU	
Give an overview of available model output for quantifying the P-E component of the FWB in the Arctic Ocean				LEGOS	
Give an overview of available model output for quantifying the freshwater component that comes from melt water run-off from the GrIS, glaciers and ice caps. This could e.g. be MAR, RACMO or HIRHAM				DTU	

Inputs	Planned Effort (man-hours)	End Criteria
Project and model websites, reports, presentations	70	Accepted by ESA

Deliverables		
Del. ID	Deliverable title	Delivery Date
D1c	Review of models and projects, technical note which contributes to the scientific requirement consolidation report (D1)	KO+4

WP ID:	1400	Start:	KO+2	End:	KO+4
Title	Definition test areas			WP Leader	ENVEO, TN
Contributing Partners:	All				

Objective : Due to the limited time (and financial) frame of this project, the development and validation of a prototype freshwater flux determination will be restricted to suitable test areas. In this WP, these test areas will be chosen.	
Tasks	Responsible
Two-three test areas are defined for determination of the FWF from rivers into the Arctic Ocean. These areas (rivers) are chosen based on an evaluation of available EO data as well as validation data.	LEGOS
Two-three test areas are defined for determination of the FWF from land ice into the Arctic Ocean. These areas (glaciers) are chosen based on an evaluation of available EO data as well as validation data.	ENVEO
One test area is defined for determination of the FWF from sea ice transport out of the Arctic Ocean. This area will (a geographical box) will be chosen based on available EO derived sea ice products; sea ice thickness and drift	DTU

Inputs	Planned Effort (man-hours)	End Criteria
D1b, D1c	70	Accepted by ESA

Deliverables		
Del. ID	Deliverable title	Delivery Date
D1d	Definition test areas used in the project. Technical note which contributes to the scientific requirement consolidation report (D1)	KO+4

4.2.1.2 WP2000

		WP2100	Create database

WP2000	Data set collection	WP2200	Dataset description

WP ID:	2100	Start:	KO+2	End:	KO+8
Title	Create database			WP Leader	DTU, KN
Contributing Partners:	DTU, LEGOS, ENVIO				
Objective					
The objective is to build a reference database of carefully selected satellite Earth Observation (EO) data and airborne and in-situ validation data					
Tasks				Responsible	
Collect relevant data for glacier FWF				ENVEO	
Collect relevant data for sea ice FWF				DTU	
Collect relevant data for river discharge				LEGOS	
Create database				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
Various data sets		100		Deliverable accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D2	Database containing EO, in-situ, and model output			KO+8	

WP ID:	2200	Start:	KO+2	End:	KO+8
Title	Description of data sets in database			WP Leader	LEGOS, AK
Contributing Partners:	All				
Objective					
The objective is to describe the data sets in the database					
Tasks				Responsible	
Describe data sets in database				LEGOS	
Inputs		Planned Effort (man-hours)		End Criteria	
Various data sets		100		Deliverable accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D3	Description of data sets in database			KO+8	

4.2.1.3 WP3000

		WP3100	Algorithm / method selection

WP3000	Development and validation	WP3200	Validation of various products

WP ID:	3100	Start:	KO+2	End:	KO+11
Title	Algorithm / method selection			WP Leader	ENVEO, TN
Contributing Partners:	ENVEO, [illegible]				
Objective:	...package is to find the best algorithms / methods for analysing the individual				
Tasks				Responsible	
River FWF					
Review existing algorithms for data analysis and find most suitable algorithm for Glacier FWF				ENVEO	
Review existing data products and find most suitable ones for sea ice FWF				DTU	
Consolidate results in ATBD				ENVEO	
Inputs		Planned Effort (man-hours)		End Criteria	
Various data sets, PVASR, D1, D2, D3		310		Deliverable accepted by ESA	
D3, D4	ATBD			KO+8	

WP ID:	3200	Start:	KO+2	End:	KO+11
Title	Validation of various products			WP Leader	LEGOS, EZ
Contributing Partners:	All				
Objective : Validate the products derived in the project					
Tasks				Responsible	
Select suitable validation data sets for river FWF				LEGOS	
Describe chosen algorithm for river FWF				LEGOS	
Select suitable validation data sets for glacier FWF				ENVEO	
Describe chosen algorithm for glacier FWF				ENVEO	
Select suitable validation data sets for sea ice FWF				DTU	
Describe chosen algorithm for sea ice FWF				DTU	
Discuss validation and inter-comparison results				LEGOS	
Consolidate PVASR document				LEGOS	
Inputs Various data sets		Planned Effort (man-hours)		End Criteria Deliverable accepted by ESA	
D4		360		Deliverable accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D5	Product Validation and Algorithm Selection Report (PVASR)			KO+11	

4.2.1.4 WP4000

WP4000	Prototype demonstration and impact	WP4100 WP4200 WP4300	Experimental data set for prototype production Update tech note D3 Impact assessment

WP ID:	4100	Start:	K0+9	End:	K0+15
Title	Experimental data sets for prototype production			WP Leader	DTU, KN
Contributing Partners:	DTU, LEGOS, ENVIO				
Objective					
To create experimental data sets of FWF based on the methodology defined in WP3000 for the test areas defined in WP1400.					
Tasks				Responsible	
Create exp. Data set of FWF from river discharge for the selected test areas				LEGOS	
Create exp. Data set of FWF from land ice discharge for the selected test areas				ENVEO	
Create exp. Data set of FWF from sea ice for the selected test areas				DTU	
Collect model data set needed to close FWB.				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
D3		100		Deliverable accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D6	Publish experimental data sets: target prototype products			KO+15	

WP ID:	4200	Start:	KO+9	End:	KO+15
Title	Update technical note D3			WP Leader	LEGOS, EZ
Contributing Partners:	All				
Objective					
To include the experimental data in the database and describe these in the data user manual (D3)					
Tasks				Responsible	
Include the experimental data in the database				LEGOS	
Describe the experimental in the technical note D3				LEGOS	
Inputs		Planned Effort (man-hours)		End Criteria	
D3 Experimental data		96		Deliverable accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D7	Update technical note D3			KO+15	

WP ID:	4300	Start:	KO+9	End:	KO+15
Title	Impact assessment			WP Leader	DTU, KN
Contributing Partners:	DTU, LEGOS, ENVEO				
Objective					
To interpret, analyze, and quantify the impact of the obtained results					
Tasks				Responsible	

Compare experimental data sets to existing state-of-the-art results				DTU	
Perform an error analyses of the obtained results				DTU	
Evaluate the potential to enhance the current state-of-the-art knowledge of FWFs				LEGOS	
Determine the benefit and impact of the FWFs at the specific test areas in collaboration with the scientific and user communities				ENVEO	
Determine the general impact and benefits of the results				DTU	
Inputs		Planned Effort (man-hours)	End Criteria		
Experimental data sets		100	Deliverable accepted by ESA		
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D8	Impact assessment report			KO+15	

4.2.1.5 WP5000

WP5 is dedicated to the definition of a so-called scientific roadmap. Based on the successes and challenges learned through the previous WPs, the scientific roadmap will summarize suggestions and ideas for future developments beneficial for determining the FWFs in the Arctic from EO data.

The output of this workpackage is a scientific roadmap report (D9) which contains a contributions from the sub-WPs 5100, 5200 and 5300.

WP5000	Scientific Roadmap	WP5100	Evaluation of obtained scientific results
		WP5200	Scientific agenda 2017-2021
		WP5300	Research to operational plan

WP ID:	5100	Start:	KO+14	End:	KO+18
Title	Evaluation of obtained scientific results			WP Leader	DTU, LS
Contributing Partners:	All				
Objective : to perform a critical and thorough analysis of the scientific results obtained in ArcFlux, related to the scientific objectives defined for Arctic+, theme 3.					
Tasks				Responsible	

Perform a critical analysis of how the outcome of ArcFlux satisfies the specific scientific objectives of Arctic+ Theme 3, to identify the major challenges and knowledge gaps in the estimation of the Arctic FWB			DTU
Perform a critical analysis of how the outcome of ArcFlux satisfies the specific scientific objectives of Arctic+ Theme 3, to find approaches to address those challenges			LEGOS
Perform a critical analysis of how the outcome of ArcFlux satisfies the specific scientific objectives of Arctic+ Theme 3, to make a multi-year assessment of the Arctic freshwater budget			ENVEO
Inputs	Planned Effort (man-hours)	End Criteria	
D1, D4, D5, D8	70	Accepted by ESA	
Deliverables			
Del. ID	Deliverable title		Delivery Date
D9a	Evaluation of obtained scientific results. Input to the scientific roadmap report (D9)		KO+17

WP ID:	5200	Start:	KO+14	End:	KO+18
Title	Scientific agenda 2017-2021			WP Leader	DTU, LS
Contributing Partners:	All				
Objective					
Tasks				Responsible	
Transfer the outcome of ArcFlux into scientific activities to be conducted in the time frame 2017-2021				DTU	
Ensure that the scientific roadmap is relevant to both scientific and operational organizations, such will be consulted in the process of making the scientific roadmap.				DTU	
Determine what additional scientific work is required in order to advance forward in achieving even more accurate estimates of the Arctic FWF from EO-data, including what new datasets and in-situ validation campaigns might be critical for a further advance in current knowledge and capabilities within ArcFlux.				LEGOS	
Inputs		Planned Effort (man-hours)		End Criteria	
All previous deliverables		70		Accepted by ESA	

Deliverables		
Del. ID	Deliverable title	Delivery Date
D9b	Scientific agenda 2017-2021. Input to the scientific roadmap report (D9)	KO+17

WP ID:	5300	Start:	KO+14	End:	KO+18
Title	Research to operational plan			WP Leader	ENVEO, TN
Contributing Partners:	All				
Objective : To develop a research to operational plan					
Tasks				Responsible	
Describe a plan that outlines a possible strategy for the transition from research to operational activities related to the FWF product for river discharge in the Arctic.				DTU	
Describe a plan that outlines a possible strategy for the transition from research to operational activities related to the FWF product for land ice FW contribution to the Arctic Ocean.				ENVEO	
Describe a plan that outlines a possible strategy for the transition from research to operational activities related to the FWF product for the sea ice transport out of the Arctic Ocean				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
D2, D3, D4		100		Accepted by ESA	

Deliverables		
Del. ID	Deliverable title	Delivery Date
D9c	Research to operational plan. Input to the scientific roadmap report (D9)	KO+17

The result of the activities will be contained in a scientific paper that will be submitted to an international journal. It is also foreseen that the outcome of the proposed work will be published in terms of oral or poster presentations at international conferences like EGU AGU Ocean Sciences and AGU Fall Meeting and

ESA living Planet symposias and special sessions. Also the development and maintaining of the project website and preparation of communication material is foresen in this WP:

WP6000	Promotion	WP6100 WP6200 WP6300 WP6400	Journal paper submitted on FWF time series Website Presentations Communication material

WP ID:	6100	Start:	KO+6	End:	KO + 18
Title	Journal paper submitted on FWF time series			WP Leader	DTU, KN
Contributing Partners:	DTU, LEGOS, ENVEO				
Objective: Condensing the summary report into a scientific paper which will be submitted to an international journal and also be the base of presentations at international conferences.					
Tasks				Responsible	
Journal paper on Arctic FWF				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
Outcome of Scientific Recommendations		50		Journal paper submitted	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D10	Journal paper submitted on FWF time series			KO + 18	

WP ID:	6200	Start:	KO+1	End:	KO+18
Title	Website			WP Leader	DTU, LS
Contributing Partners:	DTU				
Objective: Develop and maintain the project webpages					
Tasks				Responsible	
Create the project Webpages				DTU	
Maintain the project Webpages.				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
None		40		Accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D11	Project Webpage published			KO + 2	

WP ID:	6300	Start:	KO + 6	End:	KO + 18
Title	Presentations			WP Leader	DTU, OA
Contributing Partners:	DTU, ENVEO, LEGOS				
Objective: To present the project at various international conferences (EGU; Living Planet, AGU and other conferences)					
Tasks				Responsible	
Develop a number of oral presentations for presentation at international conf				DTU	
Develop a number of poster presentations for presentation at international conf				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
		20		Presentations given	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D12	Presentations (oral + Poster			KO+18	

WP ID:	6400	Start:	KO + 6	End:	KO + 18
Title	Communication material			WP Leader	DTU, OA
Contributing Partners:	DTU, ENVEO, LEGOS				
Objective To make some Communication material (i.,e. brochure/handouts that can be used for various purposes and i.e. handed out at international meetings.					
Tasks				Responsible	
Develop communication material (brochure) for handout				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
		40		Accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D13	Communication material			KO+18	

4.2.1.6 WP7000

This work package concerns project management an all the necessary tasks to conduct proper project management on all levels in the ARCFLUX project and well as preparing the final report and condensing it to the Executive summary.

The prime will issue reports and send them to ESA with the updated progress report and completion schedule of the different work packages in the last month, the list of the issues encountered and proposed corrective solutions,

WP7000	Management	WP7100 WP7200 WP7300	Monthly Progress reports Final report Executive summary

WP ID:	7100	Start:	KO+0	End:	KO+18
Title	Monthly Progress reports			WP Leader	DTU, OA
Contributing Partners:	DTU, ENVEO, LEGOS				
Objective: To prepare the Monthly Progress reports					
Tasks				Responsible	
Monthly Progress report				DTU	
Inputs		Planned Effort (man-hours)		End Criteria	
		54		Accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D14	Monthly Progress Report			Every Month	

WP ID:	7200	Start:	KO+15	End:	KO+18
Title	Final report			WP Leader	DTU, OA
Contributing Partners:	DTU, ENVEO, LEGOS				
Objective: To prepare the Final report					
Tasks				Responsible	
Prepare the final report					
Inputs		Planned Effort (man-hours)		End Criteria	
All previous deliverables		100		Accepted by ESA	
Deliverables					
Del. ID	Deliverable title			Delivery Date	
D15	Final Report			KO+18	

WP ID:	7300	Start:	KO+15	End:	KO+18
Title	Executive summary			WP Leader	DTU, OA

Contributing Partners:	DTU			
Objective Condensing the final report into a executive summary				
Tasks				Responsible
Condensing the final report into a executive summary				DTU
Inputs		Planned Effort (man-hours)	End Criteria	
All previous deliverables		50	Accepted by ESA	
Deliverables				
Del. ID	Deliverable title			Delivery Date
D16	Executive summary			KO+18

4.3 Estimated Effort Summary

WP	Sub-total [%]
WP1000	15
WP2000	10
WP3000	25
WP4000	15
WP5000	10
WP6000	5
WP7000	10
Travel	10

The table below gives the estimated hours per subworkpackage and workpackage for ArcFlux as well as distribution per Key-Person (please reference acronyms to key persons in section 1.4)

ID	WP							
	WP1000	280	DTU	LEGOS	ENVEO	DTU	LEGOS	ENVEO
D1	WP1000	0				(OA/LS/KN/HS)	(AK/EZ/FR/JC)	(TN/HR/JW/MH/PM)
D1a	WP1100	70	30	20	20	(5/5/10/10)	(5/5/5/5)	(5/5/5/5/0)
D1b	WP1200	70	20	30	20	(5/5/5/5)	(10/10/5/5)	(5/5/5/5/0)
D1c	WP1300	70	30	20	20	(5/10/5/10)	(5/5/5/5)	(5/5/5/5/0)
D1d	WP1400	70	20	30	20	(5/5/5/5)	(10/10/5/5)	(5/5/5/5/0)
	WP2000	200						
D2	WP2100	100	80	10	10	(10/10/30/30)	(5/5/0/0)	(5/5/0/0/0)
D3	WP2200	100	14	76	10	(0/4/0/10)	(30/20/10/16)	(5/5/0/0/0)
	WP3000	670						
D4	WP3100	310	55	55	200	(5/20/20/10)	(20/20/5/10)	(10/50/40/40/60)
D5	WP3200	360	98	190	72	(10/30/30/28)	(50/50/40/50)	(10/20/10/30/10/2)
	WP4000	296						
D6	WP4100	100	60	20	20	(10/20/20/0)	(5/5/5/5)	(5/5/5/5/0)
D7	WP4200	96	16	60	20	(0/8/8/0)	(5/5/5/5)	(5/5/5/5/0)
D8	WP4300	100	60	20	20	(10/10/20/20)	(5/5/5/5)	(5/5/5/5/0)
D9	**WP5000**	257						
D9a	WP5100	70	30	20	20	(0/10/10/10)	(5/5/5/5)	(5/5/5/5/0)
D9b	WP5200	70	30	20	20	(0/10/10/10)	(5/5/5/5)	(5/5/5/5/0)
D9c	WP5300	117	37	20	60	(0/10/17/10)	(5/5/5/5)	(20/10/20/10/0)
	WP6000	150						
D10	WP6100	50	30	10	10	(0/10/10/10)	(5/5/0/0)	(5/5/0/0/0)
D11	WP6200	40	40	0	0	(10/10/10/10)	(5/5/0/0)	
D12	WP6300	20	20	0	0	(5/5/5/5)		
D13	WP6400	40	40	0	0	(10/10/10/10)		
	WP7000	205	0					
D14:	WP7100	54	54	0	0	(10/20/10/14)		
D15:	WP7200	100	80	10	10	(10/30/30/10)	(5/5/0/0)	(5/5/0/0/0)
D16	WP7300	50	50	0	0	(20/10/10/10)		
TOTAL Hours		2057	894	611	552			

5 Financial Proposal

5.1 Total contract cost

The type of price is fixed and this offer is valid for 120 days from the closing date of 13 November 2015. It is expected that most partners will contribute to the proposed investigations through added institutional funds.

Total Cost of Proposal: .... 199981 EUROS

5.2 Price Breakdown

WP		Budget per WP [€]
WP1000		27446
WP2000		19604
WP3000		65676
WP4000		29015
WP5000		23534
WP6000		14704
WP7000		19998
TOTAL price (€)		199981

The following subcontractor will be supplementing the main contractor with high class international knowledge and expertise in various aspects of Arctic Ocean and determination of the horizontal Fresh water fluxes on both land, on the ice cap and within the Arctic Ocean

Name of Organization	Country of origin	Costs (euros)	Effort (hours)	% of costs	% of effort
DTU (prime)	Denmark	95000	877	48	43
LEGOS	France	51981	611	26	30
ENVEO	Austria	53000	552	26	27
Total		199969	2040	100	100

5.3 Travel and Subsidence Plan

Travel cost price is calculated using a rough rate of about 1000 euros. We foresee three face to face meeting within the project

We are very well aware of the fact that the meeting plan is not in-line with the ITT. Kick-off meeting is foreseen as a teleconference, but we are kindly asking ESA to consider this as a face to face meeting at the contractor's facilities. In the past we have very good experience with this particularly as the group has not worked together before and hence its important to meet, to consolidate the project plan and to transfer knowledge.

The Midterm Review and final meeting will be held at ESRIN.

In between these Face to face meeting regular meeting at a 4 month interval will be hosted by Teleconferencing.

Meeting	Place	Date
Kick Off Meeting	DTU	KO
Progress Meeting 1	Telecom	KO+4
Midterm Review Mtg	ESRIN	KO+8
Progress Meeting 2	Telecom	KO+11
Progress Meeting 3	Telecom	KO+15
Final Meeting	ESRIN	KO+18

Summary of travel costs specified in Exhibit B of the PSS forms for each institution.

Institute	Travel rate	Number of meetings	Number of persons	Total budget
DTU	1000	2	2+1	3000
LEGOS	1000	2	1+2	3000
ENVEO	1000	3	1	3000

5.4 Payment Plan

The project plan as shown in the Gant Diagram as well as the list of Deliverables and their dates indicate the major milestones associated with the ArcFLux project

First Progress Meeting (K0+4)

Midterm Review key point (K0+8m)

Final Meeting (K0+18m)

The project is scheduled such that WP1000 is scheduled to be completed at month 4, WP2000 is scheduled to be completed at month 8 for the Midterm Review key point in the Gant Diagram.

For each company/institute the following milestone payment plan (in %) is proposed:

6 Annex: PSS forms

6.1 DTU

COMPANY RATES AND OVERHEADS	FORM No. PSS A1	Page no. of	Issue 5
		COMPANY NAME: DTU	
RFQ/ITT no.:	EOP-SA/0332/DFP-		
PROPOSAL no.:	DTU-2015-1- 8377	Name and title: Kristian Pedersen, Director DTU Space	
ECONOMIC CONDITIONS:	July 2015		
NATIONAL CURRENCY (NC):	DKK	Signature:	
VALIDITY PERIOD :	From. 01/2015 To.12/2017		
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)	Status
Senior Researcher 2016	881,00	0%	881,00	x
Researcher 2016	676,00	0%	676,00	x
Senior Researcher 2017	894,00	0%	894,00	x
Researcher 2017	686,00	0%	686,00	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)			

COMPANY PRICE BREAKDOWN FORM		Form No PSS A2	Page no. 1 of 1	Issue 5
RFQ/ITT No.:	ECP-SA/0332/DFP-		COMPANY	
Proposal/Tender No.:	DTU-2015-1- 8377		Name:	DTU
Type of Price:	FFP	Firm Fixed Price	Country:	Denmark
Economic Condition:	July 2015			
National Currency (NC):	Euros		Representative	
Exchange Rate (X):	1 DKK =	7,45000 Euros	Name and Title:	Kristian Pedersen, Director DTU Space
Contractual Phase:			Signature:	
Project/Work Package(s):	All WPs			

							TOTAL (NC) Euros	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*			
	Senior Researcher 2016	0,1	1.526	114	881,00		100 434,00	13.481,07
	Researcher 2016	0,1	1.526	213	676,00		143 988,00	19.327,25
	Senior Researcher 2017	0,2	1.526	246	894,00		219 924,00	29.520,00
	Researcher 2017	0,2	1.526	321	686,00		220 206,00	29.557,85
							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	*0,6*		*894,0*		A	*684 552,00*	*91.886,17*
	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	23 200		0			23.200,00	3.114,09
3,10	Miscellaneous						0,00	0,00
3	*Total Other Direct Cost*	*23 200,00*		*0,00*		C	*23 200,00*	*3 114,09*
4	**SUB-TOTAL DIRECT COST**				(A+B+C)	D	**707.752,00**	**95.000,27**
	GENERAL EXPENSES	*Cost items to which % applies*		*Base Amount in NC*	*OH %*			
5	General & Administration Expenses					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	**707.752,00**	**95.000,27**
		Cost items to which % applies		*Base Amount in NC*	*%*			
9	PROFIT			91 886,2	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	**707.752,00**	**95.000,27**
13	TOTAL SUB-CONTRACTOR PRICE					M		0,00
14	REDUCTION for COMPANY CONTRIBUTION					N		0,00
15	**TOTAL PRICE FOR ESA**				(L+M-N)		**707.752,00**	**95.000,27**

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

TRAVEL PLAN AND COST DETAIL				EXHIBIT "B" TO PSS-A2									Issue 1
RFQ/ITT No	P-SA/0332/DFP-dfp/8377/ARCTIC+FWF								Project	GOCE++ Height Systems			
Proposal/Tender No	DTU-2015-1- 8377								Company	DTU			
Contractual Phase													
Economic Condition	July 2015								Type of Price	FFP			
National Currency (NC)*	DKK								Exchange (X): 1 EURO =	7,45		DKK	
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)
												0	0
1000		Kick-off meeting	Copenhagen	Copenhagen	1	2	0	E	2	0	A	0	0
2000		PM1	Copenhagen	FRANCE	1	2	3.000	E	2	1.400	A	11.600	1.557
5000		Final meeting	Copenhagen	ESRIN	1	2	3.000	E	2	1.400	A	11.600	1.557
												0	0
												0	0
												0	0
												0	0
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												0	0
												0	0
Total Cost, WBS level 1 (equal to the item 3.9 of PSS-A2)												23.200	3.114

6.2 ENVEO

COMPANY PRICE BREAKDOWN FORM		*Form No.* ***PSS A2***			Page no. of	**Issue 5**
RFQ/ITT No.:	**ESA/AO/1-8377/15/I-NB**			**COMPANY**		
Proposal/Tender No.:	**STSE ARCTIC+**			Name:	**ENVEO IT GmbH**	
Type of Price:	**FFP**	Firm Fixed Price		Country:	AUSTRIA	
Economic Condition:		10.2015				
National Currency (NC):	**EURO**			Representative		
Exchange Rate (X):	1 EURO =	**1.00000**	EURO	Name and Title:	Thomas Nagler / Managing Director	
Contractual Phase:				Signature:		
Project/Work Package(s):						

Code							TOTAL (NC) EURO	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*			
A1	Scientific Manager			115	105.11		12 087.65	12 087.65
A2	Senior Scientist			121	99.63		12 055.23	12 055.23
A3	Scientist			316	71.48		22 587.68	22 587.68
							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	*0.0*		*552.0*		**A**	*46 730.56*	*46 730.56*
	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	3 050	0.0%	0			3 050.00	3 050.00
3.10	Miscellaneous						0.00	0.00
3	*Total Other Direct Cost*	*3 050.00*		*0.00*		**C**	*3 050.00*	*3 050.00*
4	**SUB-TOTAL DIRECT COST**				**(A+B+C)**	**D**	**49 780.56**	**49 780.56**
	GENERAL EXPENSES	*Cost items to which % applies*		*Base Amount in NC*	*OH %*			
5	General & Administration Expenses					**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**	**49 780.56**	**49 780.56**
		Cost items to which % applies		*Base Amount in NC*	*%*			
9	PROFIT	46 731		46 730.6	7.0%	**I**	**3 271.14**	**3 271.14**
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**	**53 051.70**	**53 051.70**
13	TOTAL SUB-CONTRACTOR PRICE					**M**		0.00
14	REDUCTION for COMPANY CONTRIBUTION					**N**	51.70	51.70
15	**TOTAL PRICE FOR ESA**				**(L+M-N)**		**53 000.00**	**53 000.00**

COMPANY RATES AND OVERHEADS	FORM No. **PSS A1**	Page no. of	Issue 5
		COMPANY NAME:	ENVEO IT GmbH
RFQ/ITT no.:	ESA/AO/1-8377/15/I-NB		
PROPOSAL no.:	STSE ARCTIC+	Name and title:	Thomas Nagler / Managing Director
ECONOMIC CONDITIONS:	10.2015		
NATIONAL CURRENCY (NC):	EURO	Signature:	Thomas Nagler
VALIDITY PERIOD :	From. 10/2015 To.06/2017		
ESA Audit agreement reference / date			

Agreed by

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)*
	Scientific Manager	72.49	32.62	105.11
	Senior Scientist	68.71	30.92	99.63
	Scientist	49.30	22.18	71.48

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)			

COMPANY PRICE BREAKDOWN FORM		EXHIBIT "A" TO PSS A2				Issue 5
			Page No.		No. of Pages	
RFQ/ITT No.: ESA/AO/1-8377/15/I-NB			COMPANY NAME: **ENVEO IT GmbH**			
Proposal/Tender No.: STSE ARCTIC+			Name and Title: **Thomas Nagler / Managing Director**			
National Currency: EURO						
Contractual Phase 0			Signature			
Applicable to PSS-A2 elements: 3.1-3.4 - 3.6 - 3.7 - 3.10 - 10						
Project / Work Packages						
Cost El. No.	ITEM DESCRIPTION	Type of Price	Purchase Currency	Purchase Amount	Exchange rate 1 NC =	Amount in NC
3.9	Travel and Subsistence		EURO			3 050.00

TRAVEL PLAN AND COST DETAIL						EXHIBIT "B" TO PSS-A2							Issue 1
RFQ/ITT No.:	ESA/AO/1-8377/15/I-NB								Project:				
Proposal/Tender No.:	STSE ARCTIC+								Company:	ENVEO IT GmbH			
Contractual Phase	0												
Economic Condition:	01.10.2015								Type of Price:	FFP			
National Currency (NC)*:	EURO								Exchange (X): 1 EURO =	1		EURO	
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)
WP1000	Scientific Requirement Consol.	KO Meeting	Innsbruck, AT	Copenhagen	1	1	700	E	1.5	150		925	925
WP3000	Scientific Roadmap	PM2	Innsbruck, AT	Toulouse	1	1	900	E	2.0	150		1 200	1 200
WP6000	Final Presentation	Final Meeting	Innsbruck, AT	ESRIN	1	1	700	E	1.5	150		925	925
												0	0
												0	0
												0	0
												0	0
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												0	0
												0	0
Total Cost, WBS level 1 (equal to the item 3.9 of PSS-A2)												3 050	3 050

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

ITT/RFQ: ESA/AO/1-8377/15/I-NB
Proposal/Tender No.: STSE ARCTIC+
Company Name: ENVEO IT GmbH
Contractual Phase: 0
WBS-Level (Number and Title):

Price Type: Firm Fixed Price
Economic Conditions: 10.2015
National Currency (NC): EURO
Exchange Rate: 1 EUR = 1

WP Title															
WP Number		WP1000	WP2000	WP3000	WP4000	WP5000	WP6000	WP7000							Total WBS-Level
Labour Hours per category															
Scientific Manager	#	20	10	20	14	35	16								115
Senior Scientist	#	25	10	20	15	35	16								121
Scientist	#	30	40	130	100	0	16								316
...															
Total Labour Hours	#	75	60	170	129	70	48	0							552
1. Total Labour Cost	NC	6 737.35	4 906.60	13 387.20	10 113.99	7 165.90	4 419.52	0.00							46 730.56
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	925.00		1 200.00			925.00								3 050.00
3.10 Miscellaneous Cost	NC														
3. Total Other Costs (sum of above 3.x)	NC	925.00	0.00	1 200.00	0.00	0.00	925.00	0.00							3 050.00
4. Sub-Total Direct Cost	NC	7 662.35	4 906.60	14 587.20	10 113.99	7 165.90	5 344.52	0.00							49 780.56
5.- 7. General expenses	NC														
8. Sub-Total Company Cost	NC	7 662.35	4 906.60	14 587.20	10 113.99	7 165.90	5 344.52	0.00							49 780.56
9. Profit Fee	NC	471.61	343.46	937.10	707.98	501.61	309.37	0.00							3 271.14
10. Cost without additional charge	NC														
11. Financial Provision for escalation	NC														
12. Total Company Price	NC	8 133.96	5 250.06	15 524.30	10 821.97	7 667.51	5 653.89	0.00							53 051.70
	EURO														
13. Total Sub-Contractors Price	NC	8 133.96	5 250.06	15 524.30	10 821.97	7 667.51	5 653.89	0.00							53 051.70
	EURO														
14. Reduction for Company contribution	NC	51.70													51.70
15. Total Price for ESA	NC	8 082.26	5 250.06	15 524.30	10 821.97	7 667.51	5 653.89	0.00							53 000.00
	EURO	8 082.26	5 250.06	15 524.30	10 821.97	7 667.51	5 653.89	0.00							53 000.00

LEGOS

COMPANY RATES AND OVERHEADS	FORM No. **PSS A1**	Page no. of	Issue 5
		COMPANY NAME: CNRS - DELEGATION REGIONALE MIDI-PYRENEES on behalf of	
RFQ/ITT no.:	EOP-SA/0332/DFP-	Name and title: Christophe GIRAUD, CNRS regional	
PROPOSAL no.:	DTU-2015-1- 8377		
ECONOMIC CONDITIONS:	oct-15		
NATIONAL CURRENCY (NC):	EUR	Signature:	
VALIDITY PERIOD :	From. 01/2015 To 12/2016	Pour le Délégué Régional Empêché	
ESA Audit agreement reference / date			
		Jean-Paul SWERTS	ESA Agreed by / Status (x when applicable)

CENTRE NATIONAL de la RECHERCHE SCIENTIFIQUE

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				
	Assistant Professor	38,48	80	69,27	x				
	Senior Scientist	54,06	80	97,31	x				
	Scientist	40,21	80	72,38	x				
	Scientist	38,35	80	69,02	x				

2. INTERNAL SPECIAL FACILITIES

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

3. OTHER COST ELEMENTS

Standard ESA type		According to normal company type	OVERHEAD %	ESA
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	3620 euros		
3,10	Miscellaneous			

GENERAL EXPENSES

According to ESA type	According to normal company type	Applicable on cost element no.	OVERHEAD %	ESA
5. General & Administration expenses			11,0	
6. Research & Development expenses				
7. Other (specify)				

COMPANY PRICE BREAKDOWN FORM			Form No. PSS A2		Page no. of			Issue 5
RFQ/ITT No.:	EOP-SA/0332/DFP-dfp/8377/ARCTIC+FWF			COMPANY				
Proposal/Tender No.:	DTU-2015-1- 8377			Name:	CNRS - DELEGATION REGIONALE MIDI-PYRENEES on behalf of LEGOS			
Type of Price:	FFP	Firm Fixed Price		Country:	France			
Economic Condition:	Oct 2015							
National Currency (NC):	EUR			Representative				
Exchange Rate (X):	1 EURO =	1,00000	EUR	Name and Title:	Christophe GIRAUD, CNRS regional représentative			
Contractual Phase:				Signature:				
Project/Work Package(s):								

Pour le Délégué Régional Empêché

Jean-Paul SWERTS

CENTRE NATIONAL de la RECHERCHE SCIENTIFIQUE

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		TOTAL (NC) EUR	TOTAL (EURO) NC / X
	LABOUR							
	Assistant Professor	0,1	1 607	100	69,27		6 926,56	6 926,56
	Senior Scientist	0,0	1 607	32	97,31		3 113,86	3 113,86
	Scientist	0,0	1 607	32	72,38		2 316,10	2 316,10
	Scientist	0,3	1 607	447	69,02		30 853,19	30 853,19
							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	0,4		611,0		A	43 209,71	43 209,71
	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	3 620		0			3 620,00	3 620,00
3,10	Miscellaneous						0,00	0,00
3	Total Other Direct Cost	3 620,00		0,00		C	3 620,00	3 620,00
4	**SUB-TOTAL DIRECT COST**				(A+B+C)	D	**46 829,71**	**46 829,71**
	GENERAL EXPENSES	Cost items to which % applies		Base Amount in NC	OH %			
5	General & Administration Expenses			46 830	11,0%	E	5 151,27	5 151,27
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	**51 980,98**	**51 980,98**
		Cost items to which % applies		Base Amount in NC	%			
9	PROFIT			0,0	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	**51 980,98**	**51 980,98**
13	TOTAL SUB-CONTRACTOR PRICE					M		0,00
14	REDUCTION for COMPANY CONTRIBUTION					N		0,00
15	**TOTAL PRICE FOR ESA**				(L+M-N)		**51 980,98**	**51 980,98**

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

Pour le Délégué Régional Empêché

Jean-Paul SWERTS

CENTRE NATIONAL de la RECHERCHE SCIENTIFIQUE

COMPANY PRICE BREAKDOWN FORM — EXHIBIT "A" TO PSS A2 — Page No. — No. of Pages — Issue 5

RFQ/ITT No.:	COMPANY NAME:
Proposal/Tender No.:	Name and Title:
National Currency:	
Contractual Phase	Signature
Applicable to PSS-A2 elements: 3.1-3.4 - 3.6 - 3.7 - 3.10 - 10 **Project / Work Packages**	

Cost El. No.	ITEM DESCRIPTION	Type of Price	Purchase Currency	Purchase Amount	Exchange rate 1 NC =	Amount in NC

Pour le Délégué Régional Empêché

Jean-Paul SWERTS

CENTRE NATIONAL de la RECHERCHE SCIENTIFIQUE

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

RFQ/ITT No.:	EOP-SA/0332/DFP-dfp/8377/ARCTIC+FWF	Project:	EOP-SA/0332/DFP-dfp/8377/ARCTIC+FWF
Proposal/Tender No.:	DTU-2015-1- 8377	Company:	CNRS
Contractual Phase			
Economic Condition:	Oct 2015	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)
1000		Kick-off meeting	Toulouse	Copenhagen	1	1	500	E	2	225	A	950	950
2000		PM1	Toulouse	FRANCE	1	2	0	E	2	0	A	0	0
3000		MTR	Toulouse	ESRIN	1	1	450	E	2	220	A	890	890
5000		Final meeting	Toulouse	ESRIN	1	2	450	E	2	220	A	1 780	1 780
												0	0
												0	0
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Total Cost, WBS level 1 (equal to the item 3.9 of PSS-A2)												3 620	3 620

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

ITT/RFQ:	EOP-SA/0332/DFP-	Price Type:	FFP
Proposal/Tender No.:	DTU-2015-1-8377	Economic Conditions:	**July 2015**
Company Name:	CNRS	National Currency (NC):	**Euros**
Contractual Phase:		Exchange Rate: 1 EUR =	
WBS-Level (Number and Title):	**All WPs**		

WP Title													
WP Number		1000	2000	3000	4000	5000	6000	7000					Total WBS-Level
Labour Hours per category	Hours	100	86	245	100	60	10	10					611
Assistant Professor	#												100
Senior Scientist	#												32
Scientist	#												32
Scientist	#												447
...	#												
...	#												
Total Labour Hours	#												611
1. Total Labour Cost	NC												
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												
3.10 Miscellaneous Cost	NC												
3. Total Other Costs (sum of above 3.x)	NC												
4. Sub-Total Direct Cost	NC												
5.- 7. General expenses	NC												
8. Sub-Total Company Cost	NC												
9. Profit Fee	NC												
10. Cost without additional charge	NC												
11. Financial Provision for escalation	NC												
12. Total Company Price	NC												
	EURO												
13. Total Sub-Contractors Price	NC												
	EURO												
14. Reduction for Company contribution	NC												
15. Total Price for ESA	NC												
	EURO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	51.980,98

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.