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ESA CLIMATE CHANGE INITIATIVE – PHASE 2

ECV Sea Level- Technical proposal

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| [Reference] |
| **Technical proposal** |
| 1. 0 |
| 07/06/2013 |

**Executive Summary**

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| **Validation of the proposal.** | | | | |
|  | Written by | Checked by | Approved by | Application authorized by |
| Name | *M. Ablain G. Larnicol* | *G. Larnicol* | *S. Limouzin* | *Christophe Vassal* |
| Photo (option) |  |  |  |  |
| Visa |  | [Checker] | [Approver] |  |

NB : Merci de veiller à l’application de la décision CLS sur la délégation de signature.

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## Task 2000: Thematic investigations (resp CLS)

The thematic investigations task (WP2000) is central to the project. Its main objective is to develop, test and select the necessary corrections to generate SL-CCI ECV products required by the end-users. Sensitivity studies to altimeter standards used in SSH calculation are also performed in order to better characterize the sea-level errors in WP2500. This section justifies and describes in details our technical solution.

*Reading guidelines: each work package is structured as follows:*

1. *short summary of the WP at the beginning of WP 2x00 description contain a diagram of the main sub-tasks,*
2. *description of work of each sub-task,*
3. *table summarizing which algorithm is developed or tested depending of its origin, and to which mission it is applied*
4. *the bibliography is referenced in* ***Erreur ! Source du renvoi introuvable.****.*

*For readers that may have a quick overview of the technical details, it is advised to read the first and third part of the work package (points 1 and 3).*

### Overview of the WP2000 work logic

WP2 is divided into several subtasks defined in the figure below. The development of new algorithms is performed in WP2100 to WP2400. They will be developed in details in next following sections. WP2600 corresponds to the evaluation of these new algorithms in order to select the best ones. WP2500 consists in analysing the loss of ENVISAT mission for sea-level ECV and also to prepare the Sentinel-3 mission.

The planning of this task is the following:

* From January 2014 to June 2015 : development of new altimeter corrections and algorithms
* From January 2015 to November 2015 : validation of new corrections and algorithms
* December 2015 : selection of best corrections and algorithms for Sea-Level ECV

Some tasks relative to sensitive study (as in WP 2500) will be finished after the selection step.

Given the constraints of the planning, new corrections will be available until the end of 2014 for altimetry missions on-going (Jason-2, SARAL/Altika, Cryosat-2). As explained in previous parts, the ECV products in phase 2 of SL-CCI will be reprocessed over the [1993, 2014] period.

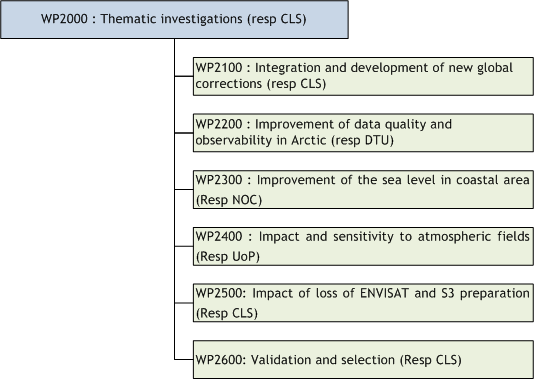


Figure 1: Work breakdown structure of WP2000

### Task 2100 : Integration and development of new global corrections (resp CLS)

#### Overview

TBC by Michaël

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Algorithm** | **Data output** | **Covered period** | **Applicability** | | | | | | | | |
| **E1** | **E2** | **EN** | **TP** | **J1** | **J2** | **G2** | **C2** | **AL** |
| WP2110 | Mutiple data : 1Hz along-track measurements, etc... | [1993-2014] | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| WP2120 | Ephemerid files (sp3) | [1993-2014] |  |  |  | **X** | **X** | **X** |  |  |  |
| WP2130 | To be defined | [2002-2011] |  |  | **X** |  |  |  |  |  |  |
| WP2140 | No data output | [1993-2014] | **Not applicable** | | | | | | | | |

Table .1: Data covered and missions impacted by new altimeter corrections in WP2100

#### WP2110: New external contributions (resp CLS)

TBC by Michaël

#### WP2120: New orbits solutions (resp GFZ)

Description :

New, more precise and additional models became available in the recent years allowing computing satellite orbit with increased accuracy, as before. They include EIGEN-6C (Shako et al., 2013) Earth's combined gravity field model, EIGEN-6S2 time variable Earth's gravity field model (Förste et al., 2012), FES2012 ocean tide model and some other models. Preliminary tests (Rudenko et al., 2013) show, that use of these models reduces root-mean-square (RMS) errors of observation residuals and altimetry single crossover RMS values. So, these or analogous newer models, if available, will be implemented in the EPOS-OC software, tested and used for orbit determination in the Phase 2 of the SLCCI project, if they provide better results.  
ITRF2013 reference frame realization is expected to be available in July-August 2014. Taking into account longer time interval of observations, improved modeling and approach to be used for the ITRF2013 generation (Altamimi, 2013), one can expect that ITRF2013 should be more consistent and stable ITRF realization, than its predecessors, like ITRF2000, ITRF2005 and ITRF2008. It was shown (Morel and Willis, 2005) that imprecision in the terrestrial reference frame can lead to systematic errors in mean sea level. Beckley et al., 2007 confirmed that when reprocessing TOPEX data from ITRF2000 to ITRF2005 (1.8 mm/yr difference in Zrate). This effect is often ignored or under-estimated in the global error budget. That is why the influence of the recent ITRF realizations (ITRF2013 and ITRF2008) and new background models on the precise orbits of altimetry satellites is very important.  
All these activities will allow computing homogeneous orbits of the altimetry reference missions (TOPEX/Poseidon, Jason-1 and Jason-2) with improved accuracy in the same reference frame. This should increase the accuracy and stability of mean sea level determination.

Data output:

* Ephemerid files (SP3 format) for TOPEX (1993-2005), Jason-1 (2002-2013) and Jason-2 (2008-2014)

#### WP2130: Improvement of the Instrumental processing (resp isardSAT)

TBC by Monica : Text + Output data description (see WP2120 for example)

#### WP2140: Improvement of algorithms to merge missions together

TBC by Yannice

This task is not funded by ESA SLCCI project but directly by CNES.

* a mon avis il faut se focaliser ici sur l’intégration de sea-level en Arctique dans un produit global ?

### Task 2200: Improvement of sea-level in the Arctic (resp DTU)

#### Overview

**Sea level estimation at high latitudes can be significantly improved with the use of the ESA altimeter missions (ERS-1&2, ENVISAT) since they cover the oceans up to higher latitudes (82°) than T/P and Jason 1&2 (66°). One of the largest obstacles in Polar Regions is the presence of sea-ice. To date, sea level is only calculated away from sea ice in the open ocean. Editing of spurious SSH measurements close to sea ice also degrades the quality of SSH determination and seasonal coverage of data hampers the use of these for climate studies. Altimetry range and geophysical correction errors impacts sea level estimation as for instance errors in the oceanic tidal correction, drift in pressure models (in high latitudes), spurious measurements of wet troposphere correction (close to sea ice).**

**Improved editing and corrections will be applied to update satellite altimetry derived products at high latitude. Improved pre-editing using an improved MSS covering the entire high latitude region will also be implemented for better editing of data. Methods for integrating information of sea ice thickness through corporation with the Sea Ice ECV will be performed to use the sea ice thickness for sea surface height prediction and interpolation within open leads in the ice. Laser altimetry from ICESat with is much narrower footprint can also be used to constrain radar satellite altimetry close to opean leads (Andersen and Knudsen, 2009)**

TBC by OLE: description of objectives and why this task is important to improve sea-level at climate scales and for climate applications

We have also  defined all the sub-tasks of this WP. You will find in attachment a file listing all this tasks.   
  
You are responsible of **WP2200: Improvement of sea level in Arctic.** In this WP, we have identified

he sub-tasks concerning your work are WP2210 and WP2230. I think the work retive to these both tasks is clear for you. Do you agree ? There is also another contribution from your side :WP2620: Dedicated validation of sea-level in Arctic . The objective of this task is you copare the sea-level estimation between DTU and CLS/PML in Arctic.  
  
1) Please, could you tell me if you agree with these 3 tasks ? Do you  want modify  the name or your sub tasks ? Do you want add other sub-tasks ?   
  
2)  Please, could you check or complement the columns concerning :  
- the data output that you have to provide by the end of June 2015.   
- the altimeter missions impacted by your work   
- the period cover by your new corrections  
=>  it's crucial for the project that you provide the larger improved datasets (all the period, all the coasts) by the end of June 2015  
  
3)  Please, could you provide us your definitive technical contributions **before next Monday (on 22th of July)**. We need a short text (1 page or 2 pages maximum by sub-tasks). Keep in mind, it's important that you explains clearly your expected improvements to improve sea-level at climate scales.   
  
4) As you are responsible of WP2200, please could you also write a short text explaining why WP2200 is of great interest for improving altimetry data at climate scales ?  
  
Thank you very much for your strong implication.

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| **Algorithm** | **Data output** | **Covered period** | **Applicability** | | | | | | | | |
| **E1** | **E2** | **EN** | **TP** | **J1** | **J2** | **G2** | **C2** | **AL** |
| WP2210 |  |  |  |  |  |  |  |  |  |  |  |
| WP2220 |  |  |  |  |  |  |  |  |  |  |  |
| WP2230 |  |  |  |  |  |  |  |  |  |  |  |

Table .1: Data covered and missions impacted by new altimeter corrections in WP2200

#### WP2210: New Sea-level estimations in the Arctic by DTU

TBC by OLE : Text + Output data description (see WP2120 for example)

#### WP2220: New Sea-level estimations in the Arctic by CLS/PML

TBC by Pierre : Text + Output data description (see WP2120 for example)

The basic idea is to produce two independent data sets of altimetry sea-level measurements for the 10 years of ENVISAT measurements (2002-2012) by both groups :  one from DTU, and the other one from CLS/PML. Then,  both groups will perform a validation exercise (round robin) aiming at characterize the improvement of the sea-level in Arctic.  In fine, CLS will integrate the best Arctic sea-level product (DTU or CLS/PML) in SL-CCI products which is the main objective of the project.  Of course, it would be more interesting to cover all the altimetry period (1993-2014). For now, we prefer to focus on the Envisat period in order to move forward step by step. We will see later in the project if it could be possible to extend the period (in the past with ERS-1 and ERS-2 and in the future with Cryosat).

Data output:

* New High resolution MSS improved at high latitude regions using 3 years of reprocessed CryoSat-2 satellite altimetry.

#### WP2230: Improvement of MSS in the Arctic

**An accurate MSS is a prerequisite for accurate data editing and pre-processing of satellite altimetry in Polar Regions. This task will benefit from corporation with the MONARC-A project in the Arctic Ocean and the expertise gained will be used to determine improved MSS and sea level trends in both hemispheres. Algorithms for correction of seasonal sea-ice cover and seasonal sea level signal must be developed and implemented for computing MSS models and sea level trends. Comparisons with existing tide gauges will be performed for the quality control of sea level trend estimates.**

TBC by OLE : Text + Output data description (see WP2120 for example)

### Task 2300: Improvement of the sea level in coastal area ( Resp NOCS)

#### Overview

TBC by Paolo : description of objectives and why this task is important to improve sea-level at climate scales and for climate applications

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Algorithm** | **Data output** | **Covered period** | **Applicability** | | | | | | | | |
| **E1** | **E2** | **EN** | **TP** | **J1** | **J2** | **G2** | **C2** | **AL** |
| WP2310 |  |  |  |  |  |  |  |  |  |  |  |
| WP2320 |  |  |  |  |  |  |  |  |  |  |  |
| WP2330 |  |  |  |  |  |  |  |  |  |  |  |

Table .1: Data covered and missions impacted by new altimeter corrections in WP2300

#### Task 2310: New GPS Wet troposhere corrections (resp Uop)

TBC by Joana : Text + Output data description (see WP2120 for example)

#### Task 2320: Improvement of the altimeter corrections in coastal areas (resp NOCS)

TBC by Paolo : Text + Output data description (see WP2120 for example)

#### Task 2330: How to extract climate signals from the coasts ? (resp NOCS)

TBC by Paolo : Text + Output data description (see WP2120 for example)

### Improvements of atmospheric corrections (Resp Uop)

#### Overview

TBC by Joana : description of objectives and why this task is important to improve sea-level at climate scales and for climate applications

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Algorithm** | **Data output** | **Covered period** | **Applicability** | | | | | | | | |
| **E1** | **E2** | **EN** | **TP** | **J1** | **J2** | **G2** | **C2** | **AL** |
| WP2410 |  |  |  |  |  |  |  |  |  |  |  |
| WP2420 |  |  |  |  |  |  |  |  |  |  |  |
| WP2430 |  |  |  |  |  |  |  |  |  |  |  |

Table .1: Data covered and missions impacted by new altimeter corrections in WP2400

#### WP2410: Improvement of composite wet troposphere corrections (Resp Uop)

TBC by Joana : Text + Output data description (see WP2120 for example)

#### WP2420: Improvement of atmospheric corrections thanks to new atmospheric reanalyses (Resp CLS)

TBC by Loren (et michaël)

#### WP2430: Better characterization of error of atmospherical corrections (Resp CLS)

The wet tropospheric correction is one of the major sources of uncertainty on the altimetry error budget and then has a non negligible role on the mean sea level trend estimation. Ablain et al. (2009) have estimated the wet path delay uncertainty at 0.3 mm/year over 1993-2008 whereas the MSL trend has been estimated as 3.11mm/year on the same period.

Some papers have been published on the climatological trends of water vapour at global scale (Keihm et al. 2009, Trenberth et al. 2005) but the literature is still poor on the specificities of the wet tropospheric correction over ocean.

A paper by S. Thao [submitted] has proposed a systematical approach for the comparison of water vapour in a mean sea level point of view provided by a reference instrument (AMSRE), two radiometers on altimetry missions (JMR on Jason-1 and MWR and Envisat RA2) and a model (ERA-Interim) from 2002 to 2010. An effort has been put on the statistical representativeness of the trends.

The objective of this task will be to extend this work considering the full altimetry era and to provide a synthesis review of the different wet tropospheric correction. This work will be complemented by the analysis of the brightness temperatures stability. Indeed, the required stability of less than one millimeter per year leads to a stability of some tenths of a Kelvin per year on brightness temperatures which represents a real challenge on the instrumental stability. A comparison of radiometers on altimetry missions to a reference instrument will be performed with the same metrics but this time on brightness temperatures in order to highlight eventual instrumental drifts.

#### WP2440: Synergy with atmospheric communities (Resp CLS)

The objective is to gather different communities on the common objective of the estimation of the trends on the wet tropospheric correction during the altimetry area.

Specialists of instrumental aspects, teams working on retrievals, people from weather forecast and from in-situ measurements, all have a pertinent view on critical aspects of this subject:

- is there instrumental drifts, how are they detected and with which accuracy?

- what are the differences on trends between the various sources (satellite and in-situ measurements, modeling) ?

- could the community agrees on a reference and an error on this reference?

Since this the wet tropospheric correction is a pure altimetric correction, the problematic will be extend to the total water vapour content; the relation between them will be one of the objective of the meeting.

TB complement by Bruno

### Task 2500: Impact of loss of ENVISAT and S3 preparation (Resp CLS)

#### Overview

TBC by michaël

#### WP2510: Impact on of loss of Envisat on the MSL evolution

TBC by michaël

#### WP2520: Sensitivity of the MSL calculation changing the orbit of the reference mission: Sentinel-3 instead of Jason-2

TBC by michaël

#### WP2530: How transponder measurements can contribute to the precision of the S3 MSL estimation (range and sigma0) ?

TBC by Monica

### Task 2600: Validation and Selection of best altimeter standards (Resp CLS)

#### Overview

TBC by michaël

#### WP2610: Validation of altimeter corrections and algorithms (Resp CLS)

TBC by michaël

#### WP2620: Dedicated validation of sea-level in Arctic (Resp DTU and CLS)

Data output:

* New High resolution MSS improved at high latitude regions using 3 years of reprocessed CryoSat-2 satellite altimetry.

TBC by Ole and Michaël

#### WP2630: Selection of best altimeter corrections and algorithms (Resp CLS)

TBC by michaël