Sea Level CCI project

Phase II

2nd annual review

Sea Level CCI – Phase II 2nd annual review – Feb. 18th – 19th 2016
Option Regional and In-situ Validation

Luciana Fenoglio-Marc, TU Darmstadt
Objectives

- To assess regionally the quality of the CCI product with a Water Mass Budget estimation

- To assess regionally the quality of SLCCCI data in an in-situ validation against geodetic data
WP 1100 : Water Mass Budget

WP 1200 In-situ validation against geodetic data
WP1100

Water Mass Budget (D1-D2-D3)
ESA Sea Level Climate Change Initiative
Regional and in-situ Validation

Sea Level CCI – Phase II 2nd annual review – Feb. 18th – 19th 2016
<table>
<thead>
<tr>
<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
<th>Corr</th>
<th>Std (mm)</th>
<th>Trend CCI (mm/yr)</th>
<th>Trend 2 mm/yr</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCI</td>
<td>AVISO</td>
<td>0.954</td>
<td>3.9</td>
<td>3.1</td>
<td>4.9</td>
<td>mov</td>
</tr>
<tr>
<td>CCI</td>
<td>Masc+EN4</td>
<td>0.425</td>
<td>16.4</td>
<td>3.1</td>
<td>2.5</td>
<td>mov</td>
</tr>
<tr>
<td>CCI</td>
<td>INV+INV</td>
<td>0.934</td>
<td>10.92</td>
<td>3.1</td>
<td>3.9</td>
<td>mov</td>
</tr>
<tr>
<td>CCI</td>
<td>GFZ+EN4</td>
<td>0.705</td>
<td>12.3</td>
<td>3.1</td>
<td>4.5</td>
<td>mov</td>
</tr>
</tbody>
</table>

Table 1: Mediterranean Sea: Trend and correlation of direct and indirect interannual sea level and standard deviation of their differences. Interval from January 2004 to December 2013.
ESA Sea Level Climate Change Initiative
Regional and in-situ Validation

Sea Level CCI – Phase II 2\textsuperscript{nd} annual review – Feb. 18\textsuperscript{th} – 19\textsuperscript{th} 2016
ESA Sea Level Climate Change Initiative
Regional and in-situ Validation

Sea Level CCI – Phase II 2nd annual review – Feb. 18th – 19th 2016
<table>
<thead>
<tr>
<th>1st</th>
<th>2nd</th>
<th>Corr</th>
<th>Std (mm)</th>
<th>Trend CCI (mm/yr)</th>
<th>Trend 2 mm/yr</th>
<th>type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCI</td>
<td>AVISO</td>
<td>0.980</td>
<td>5.81</td>
<td>5.26</td>
<td>6.38</td>
<td>ia</td>
</tr>
<tr>
<td>CCI</td>
<td>Masc+inco</td>
<td>0.445</td>
<td>25.3</td>
<td>5.26</td>
<td>5.45</td>
<td>ia</td>
</tr>
<tr>
<td>CCI</td>
<td>INV + INV</td>
<td>0.856</td>
<td>12.09</td>
<td>5.26</td>
<td>4.65</td>
<td>ia</td>
</tr>
<tr>
<td>CCI</td>
<td>INV+INV</td>
<td>0.898</td>
<td>10.92</td>
<td>5.26</td>
<td>6.18</td>
<td>ia</td>
</tr>
<tr>
<td>CCI</td>
<td>Aviso</td>
<td>0.991</td>
<td>3.8</td>
<td>5.48</td>
<td>6.79</td>
<td>mov</td>
</tr>
<tr>
<td>CCI</td>
<td>Masc+inc</td>
<td>0.406</td>
<td>15.8</td>
<td>5.48</td>
<td>5.21</td>
<td>mov</td>
</tr>
<tr>
<td>CCI</td>
<td>INV + INV</td>
<td>0.963</td>
<td>3.9</td>
<td>5.48</td>
<td>4.74</td>
<td>mov</td>
</tr>
<tr>
<td>CCI</td>
<td>INVTOT</td>
<td>0.986</td>
<td>2.45</td>
<td>5.48</td>
<td>6.64</td>
<td>mov</td>
</tr>
</tbody>
</table>

Table 2: Golf of Bengala: Trend and correlation of direct (trend 1) and undirect (trend 2) interannual sea level and standard deviation of their differences. For indirect sea level (sl) the trends of its steric (s) and mass components (m) are given. Interval from Januar 2004 to December 2013.
Conclusions WP1100

• Closure of sea level budget is more difficult at regional that at global scales (drivers different from region & change and trends are larger than the global mean)

• **RMS departure** of 2 two altimetric solutions < departure of two indirect estimations. This is not valid for the trends (1 mm/yr difference found)

• Large error in the budget closure caused by the steric component (e.g. difference in trends of datasets). Contribution of steric form deep water is not accounted for

• **Inverse method** (partitioning the total sea level in its components) allows evaluation of each component of sea level.

• Effects remaining: land contamination, data treatment (e.g. pre-processing atmospheric contribution in GRACE)
WP1200

In-situ validation against geodetic data
WP1200
In-situ validation against geodetic data

WP1210 Computation of coordinates & velocities of GPS stations

WP1220 In-situ Validation of FCDR Products

WP1230 In-situ Validation of ECV Products
WP1200

In-situ validation against geodetic data

WP1210 Computation of coordinates & velocities of GPS stations
## GPS Data Analysis 2015

### GNSS Network Tabelle

<table>
<thead>
<tr>
<th>SLA at TG</th>
<th>GPS at TG</th>
<th>SWH in-situ</th>
<th>U10 in situ</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>19</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

---

**Introduction**

**Method I**

**Results I**

**Conclusions**
GNSS Data Analysis 2008-2015

39 Sites raw Data

PPP daily analysis

Weekly Solution

Daily Tropo based on weekly Coordinates

ftp repository for UoP

Accumulation of 2920 daily solutions

1st Set of Coordinates Velocities => Time Series

Analysis of Disturbances in Time Series

Site Logs and ITRF/EPN Discontinuities

Updated Station Problem File

Final Coordinates, Velocities and Time Series

Trend and Realistic Error Estimation with CATS

2. to n-th Accumulation Coordinates Velocities => Time Series

SLCCI-D5-2015-1
GNSS Data Analysis 2008-2015

HELG coordinates time series

- **East (relative to 427747.870 m)**
  - [cm]
  - Time [year]: 2008 to 2016

- **North (relative to 6003500.760 m)**
  - [cm]
  - Time [year]: 2008 to 2016

- **Up (relative to 48.360 m)**
  - [cm]
  - Time [year]: 2008 to 2016
Solution **SLCCI-D5-2015-1 Velocities and Flicker Noise Sigmas**

![Graph showing velocities and flicker noise sigmas](image)

- **V up mm/yr**

**Introduction**

**Method I**

**Results I**

**Conclusions**
Solution SLCCI-D5-2015-1 Velocities and Flicker Noise Sigmas
Solution SLCCI-D5-2015-1 Velocities and Flicker Noise Sigmas
Vertical Rates
(mm/yr) in
ITRF2008
Error of Vertical Rates (mm/yr) in ITRF2008

stochastic model: white noise + flicker noise (CATS)

Mean values of errors 38 stations:
North (mm/yr): mean = 0.34
East (mm/yr): mean = 0.49
Up (mm/yr): mean = 0.83
Difference (CATS_Velocity wh_pl_m1 - EPN) Statistics (17 stations)

<table>
<thead>
<tr>
<th>Vel. (mm/yr)</th>
<th>Mean (mm)</th>
<th>Std (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>-0.41</td>
<td>0.14</td>
</tr>
<tr>
<td>E</td>
<td>0.13</td>
<td>0.38</td>
</tr>
<tr>
<td>U</td>
<td>-0.02</td>
<td>0.80</td>
</tr>
</tbody>
</table>
Example: Tropospheric delay at TG

Accumulated Tropospheric Total Delay for 2008 to 2015 from the daily solutions
WP1200
In-situ validation against geodetic data

WP1220 In-situ Validation of FCDR Products

D8: Validation metrics for along-track CCI FCDR
D7: “ of Improved SSH 1Hz with local GPD

WP1230 In-situ Validation of ECV Products
WP1200

In-situ validation against geodetic data

WP1220 In-situ Validation of FCDR Products

D8: Validation metrics for along-track CCI FCDR

D7: “ of Improved SSH 1Hz with local GPD
SSH In-situ validation 1 Hz for CryoSat-2

Tide gauge minute data in 2010.5-2015.5 (10-20 Km, 30 min)

Effect of tide correction in reduction of std: 50% reduction
Effect of GPD small changes for C-2 (provided by Uporto, OST2015)
SSH In-situ validation 1 Hz for C2 and Jason-2

Tide gauge minute data in 2010.5-2015.5 (10-20 Km, 30 min)

Effect of GPD+ still to be investigated
SSH In-situ validation 1 Hz for Envisat and Jason-2

Tide gauge minute data in 2010.5-2015.5 (10-20 Km, 30 min)

Absolute Bias not applied in CCI?

N1: 2010.4-2011.09
WP1200

*In-situ validation against geodetic data*

WP1220 In-situ Validation of FCDR Products

WP1230 In-situ Validation of ECV Products
Difference of regional sea level trends between altimeter Products

Data used:

CCI v1.1 ECV
ESACCI-SEALEVEL-IND-MSLTR-MERGED-20141014000000-fv01

AVISO
interval: monthly grids January 1993 – December 2013
regional-mediterranean/delayed-time/grids/climatology/
monthly_mean
downloaded from AVISO

AVISO
interval: 1993-2014
daily products downloaded from AVISO
Trend: CCIv1.1 (left) and recomputed from ECV CCI monthly (right)
Trend : CCIv1.1 (left) and recomputed from ECV CCI monthly (right)

Difference of trends: AVISO minus CCIv1.1 in 1993-2013
Trend of differences AVISO minus CCI 1993-2013
Table 1. Difference of trends between CCI and AVISO in Mediterranean Sea

<table>
<thead>
<tr>
<th></th>
<th>Mean (mm/yr)</th>
<th>Std (mm/yr)</th>
<th>Rms (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVISO - CCIori</td>
<td>0.079</td>
<td>0.558</td>
<td>0.563</td>
</tr>
<tr>
<td>CCIori-CCIcomp</td>
<td>-0.024</td>
<td>0.014</td>
<td>0.028</td>
</tr>
</tbody>
</table>
Altimetry minus TG = VLM

<table>
<thead>
<tr>
<th>station</th>
<th>al-tg (mm/yr)</th>
<th>GPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cuxhaven</td>
<td>0.02 +/- 0.5</td>
<td>-0.6 ± 0.2</td>
</tr>
<tr>
<td>Helgoland</td>
<td>1.5 +/- 0.5</td>
<td>0.2 +/- 0.2</td>
</tr>
</tbody>
</table>
Before a direct validation at tide gauge we have analysed the altimeter database and the Tide gauge with GPS@TG separately.

Differences in trends between AVISO and CCI in 1993-2013 are within 0.56 mm/yr in mean, reach 1.0 mm/yr at few locations (Northern part of the Adriatic Sea).

Difference in trends are due to different processing (orbit, gridding) and to different corrections (DAC) applied.

Validation of trends at stations with GPS@TG. Error in vertical rate is 1 mm/yr. Limitation to select best altimeter dataset based on in-situ data.