CryOcean-QCV - quality control/validation for CryoSat-2

Monthly Data Quality report for June 2014

Reprocessed Baseline C

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This Version

Version 1.0r1 – issued by National Oceanography Centre on 26/07/19

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Checked by: C. Banks

Approved by: 

Distribution List

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<td>ftp</td>
<td>Jerome Bouffard, EOP-GMQ Pierre Féménias, EOP-GMQ</td>
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<tr>
<td>NOC</td>
<td>ftp</td>
<td>F.M. Calafat H.Snaith</td>
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Date: 26/07/19
MONTHLY QUALITY ASSESSMENT FOR June 2014

Report issued on 26/07/19

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Annex. Geographical distribution of corrections
1 Quality control assessment for GOP

**Note 3.1:** unless otherwise stated, measurements taken over polar polygons have been excluded from the computation of all statistics shown in this section.

**Note 3.2:** most statistics shown in this section have been computed separately for the low resolution mode (LRM) and the pseudo low resolution mode (SAR).

**Note 3.3:** “flag-valid” refers to those records that have not been flagged as bad by either the average status flag or the measurement confidence flag.

**Note 3.4:** “science-valid” refers to flag-valid records (over oceans and lakes and excluding polar regions) that meet the editing criteria described in the Tables 12, 13, 14, 15.

1.1. Data used

Product: GOP
Date and time of the first record: 01 06 2014 00:00:00.737
Date and time of the last record: 03 06 2014 23:59:59.675
Range of complete orbits in present month: 21979 to 22020

1.2. Data flow

**Median latency [min max]:** NaN days [27.4 - 48.5]

![Box-and-whiskers plot for the GOP latency showing for each day in June 2014 the first and third quartiles (bottom and top of the box), the median (thick black), the 5% and 95% percentiles (lower and upper whiskers), the mean (blue) and the mean ±1 standard deviation (blue dashed line). The percentage of records delivered within 3 days is also shown (red, right y-axis). The horizontal black line denotes the 30 days threshold.](image)

**Figure 66.** Box-and-whiskers plot for the GOP latency showing for each day in June 2014 the first and third quartiles (bottom and top of the box), the median (thick black), the 5% and 95% percentiles (lower and upper whiskers), the mean (blue) and the mean ±1 standard deviation (blue dashed line). The percentage of records delivered within 3 days is also shown (red, right y-axis). The horizontal black line denotes the 30 days threshold.
Figure 67. Histogram of the GOP data latency for June 2014. The y-axis denotes the number of files that are made available with a delay of x-hours with respect to the mean time of the records stored in the file.

### 1.3. Data coverage and completeness

<table>
<thead>
<tr>
<th></th>
<th>Present in month</th>
<th>Theoretical max.</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>240586</td>
<td>266710</td>
<td>90.2</td>
</tr>
<tr>
<td><strong>Oceans and lakes</strong></td>
<td>173988</td>
<td>198845</td>
<td>87.5</td>
</tr>
</tbody>
</table>

Table 11. Number of total (land and ocean/lake) and only ocean/lake records (based on the surface_type flag) together with their percentage relative to the theoretically expected number of measurements from the orbits ground tracks for June 2014. Theoretical values are also shown.
**Figure 68.** Percentage of GOP 1-Hz records over land and ocean/lake (red) and only over ocean/lake (blue) relative to the theoretically expected number from the orbits ground tracks for each day in June 2014.

![Figure 68](image)

**Figure 69.** Percentage of GOP 1-Hz records over land and ocean/lake (red) and only over ocean/lake (blue) relative to the theoretically expected number from the orbits ground tracks for each orbit in June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown.

![Figure 69](image)

### 1.4. SSH anomaly coverage and validity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min threshold</th>
<th>Max threshold</th>
<th>Percentage edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flagged as bad</td>
<td>-</td>
<td>-</td>
<td>1.4%</td>
</tr>
<tr>
<td>Biased orbit</td>
<td>-</td>
<td>-</td>
<td>0.0%</td>
</tr>
<tr>
<td>SSH anomaly</td>
<td>-3 m</td>
<td>3 m</td>
<td>0.1%</td>
</tr>
<tr>
<td>Standard deviation of SSH anomaly</td>
<td>0 m</td>
<td>0.20 m</td>
<td>1.4%</td>
</tr>
<tr>
<td>Inverse barometer correction</td>
<td>-2 m</td>
<td>2 m</td>
<td>0.0%</td>
</tr>
<tr>
<td>Wet tropospheric correction</td>
<td>-0.5 m</td>
<td>-0.001 m</td>
<td>0.0%</td>
</tr>
<tr>
<td>Dry tropospheric correction</td>
<td>-2.5 m</td>
<td>-1.9 m</td>
<td>0.0%</td>
</tr>
<tr>
<td>Ionospheric correction</td>
<td>-0.4 m</td>
<td>0.04 m</td>
<td>0.0%</td>
</tr>
<tr>
<td>Sea state bias</td>
<td>-0.5 m</td>
<td>0 m</td>
<td>0.1%</td>
</tr>
<tr>
<td>Sigma0</td>
<td>7 dB</td>
<td>30 dB</td>
<td>0.1%</td>
</tr>
<tr>
<td>Standard deviation of sigma0</td>
<td>0 dB</td>
<td>0.23 dB</td>
<td>5.5%</td>
</tr>
<tr>
<td>All together</td>
<td>-</td>
<td>-</td>
<td>6.1%</td>
</tr>
</tbody>
</table>

**Table 12.** Editing criteria. The percentage of “flagged as bad” refers to records that have been flagged as bad by either the average status flag or the measurement confidence flag. Such percentage is computed only for records over oceans/lakes and outside polar regions. All other percentages refer to the percentage of flag-valid
records that have been rejected by the corresponding criteria or by all criteria ("All together"). The biased orbit criteria in the table refers to the orbits highlighted in the 'Warnings' table at the beginning of this report as being suspicious of suffering from a significant orbit bias. For such orbits, all records are rejected.

Figure 70. Percentage of science-valid GOP 1-Hz SSH records over ocean and lakes relative to theory for each day in June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown.

Figure 71. Geographical distribution of science-valid GOP 1-Hz SSH anomaly data over oceans and lakes for June 2014. The statistical values shown in the table refer to the SSH anomaly in cm and are calculated separately for LRM and SAR regions. Wmean and Wstd denote the spatial area-weighted average and its standard deviation. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure 72. Histogram of science-valid GOP SSH anomaly over oceans and lakes for LRM (blue), SAR (red), and PLRM (black) and for June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown. Note that values outside [-50 50] cm are excluded from the histogram for the sake of readability but not from the computation of $\mu$ and $\sigma$.

Figure 73. Along-track power spectrum density of the science-valid 20 Hz GOP SSH anomaly over oceans and lakes for LRM (red) and SAR (blue) for June 2014.
Figure 74. Geographical distribution of flag-valid 20-Hz SSH anomaly measurement noise over oceans and lakes for LRM/SAR (top) and LRM/PLRM (bottom) and for June 2014. The statistical values shown in the table refer to the SSH anomaly noise and are calculated separately for LRM and SAR/PLRM regions. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
**Figure 75.** Mean science-valid GOP SSH anomaly noise for LRM (blue dot), SAR (red dot), and PLRM (red dot). The corresponding standard deviation (blue error bar and thin red lines, respectively) for each day in June 2014 is also shown.
Figure 76. Science-valid GOP 20-Hz SSH anomaly noise as a function of distance from the coast for SAR (top panel), LRM (middle panel), and PLRM (bottom panel) for June 2014. Noise values have been calculated as the median of the absolute value of the difference between consecutive 20-Hz records.
Figure 77. 2D histogram showing science-valid GOP SSH anomaly noise as a function of SWH for SAR (top), LRM (middle), and PLRM (bottom) for June 2014. The black line denotes the median SSH anomaly noise as a function of SWH.
Figure 78. Scatter plot of the science-valid GOP SSH anomaly at the two nearest points outside (LRM, x-axis) and inside (SAR, y-axis) the Pacific SAR mode box for each pass. The RMS of the differences is 2.1 cm for the pairs shown in the figure as compared to a RMS of 2.9 cm for the differences between such outside points and their respective nearest neighbour also outside the box in the LRM region.

1.5. Crossover analysis
Figure 79. Crossover differences (absolute values) for the science-valid GOP SSH anomaly for June 2014. The difference at each crossover is computed as the difference between median values over 2-second windows centered about the crossover.

Figure 80. Standard deviation of differences at crossovers for GOP SSH anomaly for each day in June 2014. The values shown in this figure have been computed for the science-valid data further edited according to the following two additional criteria: 1) rejecting crossover differences larger than 20 cm; and 2) rejecting shallow waters (1000 m). The mean ($\mu$) and standard deviation ($\sigma$) are also shown.

1.6. SWH coverage and validity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min threshold</th>
<th>Max threshold</th>
<th>Percentage edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flagged as bad</td>
<td>-</td>
<td>-</td>
<td>1.4%</td>
</tr>
<tr>
<td>SWH</td>
<td>0 m</td>
<td>15 m</td>
<td>0.0%</td>
</tr>
<tr>
<td>Standard deviation of SWH (1-Hz block)</td>
<td>0 m</td>
<td>1 m</td>
<td>2.0%</td>
</tr>
</tbody>
</table>
All together  -  -  2.0%

Table 13. Editing criteria. The percentage of “flagged as bad” refers to records that have been flagged as bad by either the average status flag or the measurement confidence flag. Such percentage is computed only for records over oceans/lakes and outside polar regions. All other percentages refer to the percentage of flag-valid records that have been rejected by the corresponding criteria or by all criteria (“All together”).

Figure 81. Percentage of science-valid GOP 1-Hz SWH records over ocean and lakes relative to theory for each day in June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown.

Figure 82. Geographical distribution of science-valid GOP SWH data over oceans and lakes for June 2014. The statistical values shown in the table refer to the SWH in m and are calculated separately for LRM and SAR regions. Wmean and Wstd denote the spatial area-weighted average and its standard deviation. Measurements taken
over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.

**Figure 83.** Histogram of science-valid GOP SWH over oceans and lakes for LRM (blue), SAR (red), and PLRM (black) and for June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown. Note that values larger than 12 m are excluded from the histogram for the sake of readability but not from the computation of $\mu$ and $\sigma$. 

**Table:** Science-valid SWH noise Jun–2014

<table>
<thead>
<tr>
<th>Mode</th>
<th>p5</th>
<th>p25</th>
<th>median</th>
<th>p75</th>
<th>p95</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRM</td>
<td>32.2</td>
<td>40.4</td>
<td>46.9</td>
<td>54.7</td>
<td>70.2</td>
<td>48.4</td>
<td>11.7</td>
</tr>
<tr>
<td>SAR</td>
<td>25.5</td>
<td>32.5</td>
<td>39.4</td>
<td>53.7</td>
<td>62.5</td>
<td>45.1</td>
<td>17.6</td>
</tr>
</tbody>
</table>
Figure 84. Geographical distribution of flag-valid 20-Hz SWH measurement noise over oceans and lakes for LRM/SAR (top) and LRM/PLRM (bottom) and for June 2014. The statistical values shown in the table refer to the SWH noise and are calculated separately for LRM and SAR/PLRM regions. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.

Figure 85. Mean science-valid GOP SWH noise for LRM (blue dot), SAR (red dot), and PLRM (black dot). The corresponding standard deviation (blue error bar and thin red lines, respectively) for each day in June 2014 is also shown.
Figure 86. Science-valid GOP 20-Hz SWH noise as a function of distance from the coast for SAR (top panel), LRM (middle panel), and PLRM (bottom panel) for June 2014. Noise values have been calculated as the median of the absolute value of the difference between consecutive 20-Hz records.
**Figure 87.** Scatter plot of the science-valid GOP SWH at the two nearest points outside (LRM, x-axis) and inside (SAR, y-axis) the Pacific SAR mode box for each pass. The RMS of the differences is 29.2 cm for the pairs shown in the figure as compared to a RMS of 19.8 cm for the differences between such outside points and their respective nearest neighbour also outside the box in the LRM region.

### 1.7. Sigma0 coverage and validity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min threshold</th>
<th>Max threshold</th>
<th>Percentage edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flagged as bad</td>
<td>-</td>
<td>-</td>
<td>0.9%</td>
</tr>
<tr>
<td>Sigma0</td>
<td>7 dB</td>
<td>30 dB</td>
<td>0.1%</td>
</tr>
<tr>
<td>Standard deviation of Sigma0 (1-Hz block)</td>
<td>0 dB</td>
<td>0.23 dB</td>
<td>5.9%</td>
</tr>
<tr>
<td>All together</td>
<td>-</td>
<td>-</td>
<td>5.9%</td>
</tr>
</tbody>
</table>

**Table 14.** Editing criteria. The percentage of “flagged as bad” refers to records that have been flagged as bad by either the average status flag or the measurement confidence flag. Such percentage is computed only for records over oceans/lakes and outside polar regions. All other percentages refer to the percentage of flag-valid records that have been rejected by the corresponding criteria or by all criteria (“All together”).
Figure 88. Percentage of science-valid GOP 1-Hz sigma0 records over ocean and lakes relative to theory for each day in June 2014. The mean (μ) and standard deviation (σ) are also shown.

Figure 89. Geographical distribution of science-valid GOP sigma0 data over oceans and lakes for June 2014. The statistical values shown in the table refer to the sigma0 in m and are calculated separately for LRM and SAR regions. Wmean and Wstd denote the spatial area-weighted average and its standard deviation. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure 90. Histogram of science-valid GOP sigma0 over oceans and lakes for LRM (blue), SAR (red), and PLRM (black) and for June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown. Note that values larger than 12 m are excluded from the histogram for the sake of readability but not from the computation of $\mu$ and $\sigma$. 

<table>
<thead>
<tr>
<th>Mode</th>
<th>$p_5$</th>
<th>$p_{25}$</th>
<th>median</th>
<th>$p_{75}$</th>
<th>$p_{95}$</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRM</td>
<td>7.2</td>
<td>8.9</td>
<td>10.1</td>
<td>11.7</td>
<td>15.8</td>
<td>16.6</td>
<td>2.7</td>
</tr>
<tr>
<td>SAR</td>
<td>7.3</td>
<td>8.1</td>
<td>10.6</td>
<td>13.5</td>
<td>19.3</td>
<td>11.8</td>
<td>3.7</td>
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</tbody>
</table>
Figure 91. Geographical distribution of flag-valid 20-Hz sigma0 measurement noise over oceans and lakes for LRM/SAR (top) and LRM/PLRM (bottom) and for June 2014. The statistical values shown in the table refer to the sigma0 noise and are calculated separately for LRM and SAR/PLRM regions. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.

Figure 92. Mean science-valid GOP sigma0 noise for LRM (blue dot), SAR (red dot), and PLRM (black dot). The corresponding standard deviation (blue error bar and thin red lines, respectively) for each day in June 2014 is also shown.
Figure 93. Science-valid GOP 20-Hz sigma0 noise as a function of distance from the coast for SAR (top panel), LRM (middle panel), and PLRM (bottom panel) for June 2014. Noise values have been calculated as the median of the absolute value of the difference between consecutive 20-Hz records.

1.8. Wind speed coverage and validity

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min threshold</th>
<th>Max threshold</th>
<th>Percentage edited</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flagged as bad</td>
<td>-</td>
<td>-</td>
<td>0.8%</td>
</tr>
<tr>
<td>Altimeter wind speed</td>
<td>0 m/s</td>
<td>30 m/s</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
Table 15. Editing criteria. The percentage of “flagged as bad” refers to records that have been flagged as bad by either the average status flag or the measurement confidence flag. Such percentage is computed only for records over oceans/lakes and outside polar regions. All other percentages refer to the percentage of flag-valid records that have been rejected by the corresponding criteria.

Figure 94. Percentage of science-valid GOP 1-Hz wind records over ocean and lakes relative to theory for each day in June 2014. The mean (\(\mu\)) and standard deviation (\(\sigma\)) are also shown.

Figure 95. Geographical distribution of science-valid GOP wind data over oceans and lakes for June 2014. The statistical values shown in the table refer to the wind in m and are calculated separately for LRM and SAR regions. Wmean and Wstd denote the spatial area-weighted average and its standard deviation. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure 96. Histogram of science-valid GOP wind over oceans and lakes for LRM (blue), SAR (red), and PLRM (black) and for June 2014. The mean (μ) and standard deviation (σ) are also shown. Note that values larger than 12 m are excluded from the histogram for the sake of readability but not from the computation of μ and σ.

Figure 97. Scatter plot of the science-valid GOP wind speed at the two nearest points outside (LRM, x-axis) and inside (SAR, y-axis) the Pacific SAR mode box for each pass. The RMS of the differences is 34.6 cm/s for the pairs shown in the figure as compared to a RMS of 20.4 cm/s for the differences between such outside points and their respective nearest neighbour also outside the box in the LRM region.

1.9. Mispointing coverage and validity
Figure 98. Percentage of science-valid GOP 1-Hz mispointing records over ocean and lakes relative to theory for each day in June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown.
Figure 99. Geographical distribution of science-valid GOP mispointing data over oceans and lakes for ascending (top) and descending (bottom) passes for June 2014. The statistical values shown in the table refer to the wind in m and are calculated separately for LRM and SAR regions. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.

<table>
<thead>
<tr>
<th>Mode</th>
<th>p5</th>
<th>p25</th>
<th>median</th>
<th>p75</th>
<th>p95</th>
<th>mean</th>
<th>std</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRM</td>
<td>1.0</td>
<td>1.6</td>
<td>2.2</td>
<td>3.1</td>
<td>4.5</td>
<td>2.5</td>
<td>1.8</td>
</tr>
<tr>
<td>PLRM</td>
<td>0.4</td>
<td>2.0</td>
<td>2.7</td>
<td>3.2</td>
<td>4.7</td>
<td>2.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Figure 100. Histogram of science-valid GOP mispointing over oceans and lakes for LRM (blue) and SAR (red) for June 2014. The mean ($\mu$) and standard deviation ($\sigma$) are also shown. Note that values larger than 12 m are excluded from the histogram for the sake of readability but not from the computation of $\mu$ and $\sigma$. 
2 GOP validation

2.1. Validation against in situ measurements and models

Figure 101. Location of the tide gauge stations used in the validation of GOP SSH. Red dots denote stations that have good ties with a nearby GPS stations and have been used in the absolute validation (numbers are used as labels to identify such tide gauges).

2.1.1. Absolute validation of GOP SSH against selected tide gauges
2.1.2. Validation of GOP SSH anomaly against tide gauges

**Figure 102.** Mean difference in cm between the GOP SSH from CryoSat-2 and the ellipsoidal heights at 9 tide gauge stations (La Coruña, Spring Bay, Marseille, Ponta Delgada, Chichijima, Virginia Key, and Funafuti) over the period April 2014 to June 2014. The numbers correspond to those used in Figure 100 to identify the tide gauge stations.
Figure 103. Map showing the correlation between the GOP SSH anomaly and the sea level from tide gauge records over the period April 2014 to June 2014 for the cases with (top) and without (bottom) the tidal component. For this comparison the atmospheric component has not been subtracted. Empty dots denote statistically non-significant correlation.
Figure 104. Map showing the RMS difference between the GOP SSH anomaly and the sea level from tide gauge records over the period April 2014 to June 2014 for the cases with (top) and without (bottom) the tidal component. For this comparison the atmospheric component has not been subtracted.
Figure 105. Map showing the normalized RMS difference (i.e., the RMS divided by the standard deviation of the tide gauge record) between the GOP SSH anomaly and the sea level from tide gauge records over the period April 2014 to June 2014 for the cases with (top) and without (bottom) the tidal component. For this comparison the atmospheric component has not been subtracted.
Figure 106. Comparison of the GOP SSH anomaly and the sea level at the Papeete tide gauge for the cases with (top) and without (bottom) the tidal component. For this comparison the atmospheric component has not been subtracted.
Figure 107. Comparison of the GOP SSH anomaly and the sea level at the La Coruña tide gauge for the cases with (top) and without (bottom) the tidal component. For this comparison the atmospheric component has not been subtracted.

2.1.3. Validation of GOP SWH and wind speed against buoy data

[Location of the buoys used in the validation]
Figure 108. Location of the buoys used in the validation of GOP SWH (top) and wind speed (bottom).

Figure 109. Scatter plot showing a comparison of GOP SWH with SWH from NDBC buoy data for June 2014. The inset plot shows a zoomed-in for SWH < 1.5 m.
Figure 110. Regression slope of GOP SWH on SWH from NDBC buoy data over time. The red dot highlights the value for the month analysed in this report.

Figure 111. RMS difference between GOP SWH and SWH from NDBC buoy data over time. The red dot highlights the value for the month analysed in this report.
Figure 112. Scatter plot showing a comparison of GOP wind speed with wind speed from NDBC buoy data for June 2014.

Figure 113. Regression slope of GOP wind speed on wind speed from NDBC buoy data over time. The red dot highlights the value for the month analysed in this report.
Figure 114. RMS difference between GOP wind speed and wind speed from NDBC buoy data over time. The red dot highlights the value for the month analysed in this report.

2.1.4. Validation of GOP SWH against Wavewatch III model data
Figure 115. Histograms (normalized to have a total area of 1) of the GOP SWH (blue bars) and the SWH from the Wavewatch III model (red line) for June 2014.

2.1.5. Validation of GOP derived geostrophic velocities
Figure 116. Map showing the regions where HF radar velocities are available and thus where the validation of GOP geostrophic velocities is performed. Each region is identified by a number.

Figure 117. Comparison of the GOP geostrophic velocity anomalies with HF radar velocity anomalies perpendicular to the altimetry tracks in the regions shown in Figure 111 over the period April 2014 to June 2014. The numbers on the x-axis correspond to those used to identify each region in Figure 111. HF radar velocity anomalies have been obtained by subtracting the mean velocity over the period 2010-2014 from the observed velocities. GOP geostrophic velocities have been computed using the optimal difference operator by Powell and Leben (2004). Each dot represents a comparison at a particular location (hence different dots correspond to different points in space). Dots joined by a continuous line correspond to single altimeter passes.
Figure 118. Comparison of the GOP geostrophic velocity anomalies with geostrophic velocities anomalies from the Ocean Surface Current Analyses – Real time (OSCAR) for June 2014 in the Atlantic (top, 20ºN – 40ºN, 315ºE – 325ºE) and Pacific (bottom, 20ºN – 40ºN, 220ºE – 230ºE) boxes as a function of latitude (i.e., for each latitude the geostrophic velocities have been averaged over the longitudes within the box). GOP geostrophic velocities have been computed using the optimal difference operator by Powell and Leben (2004).

2.1.6. Comparison of GOP SSH anomaly with steric heights derived from temperature and salinity ARGO profiles.
**Note 4.1:** To be consistent with the GOP SSH anomalies, the steric height anomalies at each Argo float were obtained by subtracting a mean steric height computed over the period 1993-2009 (same as the base period for DTU10 MSS) from the absolute (i.e., referred to 1000m) steric height. The steric height is the dynamic height at the surface scaled by gravitational acceleration.

**Figure 119.** Map showing the correlation between the GOP SSH anomaly and the steric height anomaly (referred to 1000 m) derived from the temperature and salinity provided by Argo floats over the period April 2014 to June 2014. Each dot in the map represents the mean position of each Argo float used in the validation.

**Figure 120.** Map showing the normalized RMS difference between the GOP SSH anomaly and the steric height anomaly (referred to 1000 m) derived from the temperature and salinity provided by Argo floats over the period April 2014 to June 2014. Each dot in the map represents the mean position of each Argo float used in the validation.
Figure 121. Map showing the mean difference (bias) between the GOP SSH anomaly and the steric height anomaly (referred to 1000 m) derived from the temperature and salinity provided by Argo floats over the period April 2014 to June 2014. Each dot in the map represents the mean position of each Argo float used in the validation.
Figure 122. Comparison of the GOP SSH anomaly and the steric height anomaly (referred to 1000 m) for one particular Argo float (top). The location of the Argo float over time is also shown (bottom).
2.2. Validation against Jason-2

Figure 124. Histograms (normalized to have a total area of 1) of the SSH anomaly from GOP (blue bars), Jason-2 (red line) and RADS CryoSat-2 (green) for June 2014.
Figure 125. Histograms (normalized to have a total area of 1) of the SWH from GOP (blue bars), Jason-2 (red line) and RADS CryoSat-2 (green) for June 2014.

Figure 126. Histograms (normalized to have a total area of 1) of the wind speed from GOP (blue bars), Jason-2 (red line) and RADS CryoSat-2 (green) for June 2014.
2.3. Global mean sea level time series

![Graph showing global mean sea level time series](image)

**Figure 127.** Global mean sea level (latitude < 65°) from GOP CryoSat-2 (grey) together with that derived from OSTM/Jason-2 at the University of Colorado (red).
Figure A1. Geographical distribution of the wet tropospheric correction over oceans and lakes for ascending (top) and descending (bottom) passes for June 2014. The statistical values shown in the table refer to the wet tropospheric correction in cm. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure A2. Geographical distribution of the dry tropospheric correction over oceans and lakes for ascending (top) and descending (bottom) passes for June 2014. The statistical values shown in the table refer to the dry tropospheric correction in m. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure A3. Geographical distribution of the Ionospheric correction over oceans and lakes for ascending (top) and descending (bottom) passes for June 2014. The statistical values shown in the table refer to the Ionospheric correction in cm. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure A4. Geographical distribution of the sea state bias over oceans and lakes for ascending (top) and descending (bottom) passes for June 2014. The statistical values shown in the table refer to the sea state bias in cm. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.
Figure A5. Geographical distribution of the atmospheric correction over oceans and lakes for ascending (top) and descending (bottom) passes for June 2014. The statistical values shown in the table refer to the atmospheric correction in cm. Measurements taken over polar polygons have been excluded from the computation of the statistical values. The black lines mark the outer limit of the Arctic and Antarctic polar polygons.