Sea Level ECV quality assessment via global ocean model assimilation

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GECCO2 assimilation approach

(Köhl and Stammer, 2008a, b)

Is targeted to quantifying changes in SL-data through the cci effort. Investigate its consistency with a coupled ocean-sea ice model, to test the consistency of the new SL cci Essential Climate Variable (ECV) with other ECVs through the assimilation process and investigate where remaining inconsistencies exist and why.

- This involves the assimilation of the SL cci ECVs as constrains jointly with other available ECVs over the ocean and in situ data.

- The dynamically consistent ocean state estimation adjusts only uncertain model parameters to bring the model into consistency with ocean observations.

- Testing the consistency of observations with ocean dynamics and with prior information about uncertainties relies very much on mathematically consistent data assimilation approaches.

- We use the existing dynamically self-consistent assimilation approach of GECCO2 to test the improvement of the new SL_ECV_V1.1 compared to the SL_ECV_V0 (AVISO) in terms of regional dynamics, trends, consistency with heat and freshwater content etc.
GECCO2 assimilation approach – Phase 2

We perform new assimilation runs with GECCO2
1) using SL_ECV_V0 (AVISO)
2) using SL_ECV_V1.1 and
3) using SL_ECV_V1.1 jointly with other new ESA ECVs

- The model adapts to the assimilated variables V0 or V1.1 respectively, in the best possible way
- Smaller residuals are interpreted as improvement of the data set
- Residuals are investigated in this respect globally and regionally, as
  1) RMS differences
  2) seasonal cycle
  3) SSH trends
  4) among other dynamical parameters
  5) Consistency and all possible crosschecking
GECCO2 assimilation approach – Phase 2

1) GECCO2 assimilates along-track ssh of V0. \textbf{(completed)} Iteration: 23-28
2) GECCO2 assimilates along-track ssh of V1.1 \textbf{(completed)} Iteration: 23-28
3) GECCO2 assimilates along-track ssh of V1.1 + other ECVs Iteration: 23-28 \textbf{(completed)}

- The daily GECCO2 synthesis results at model resolution are taken as „truth“.
- An RMS reduction thus means an improvement of the data set (relative to other dataset).
- Each of the three synthesis results are compared to
  V0 (AVISO) and to
  V1.1 (SL CCI)
- Comparisons are performed for
  ERS series and
  TP series
- Evaluations are performed at
  model resolution and
  along track
GECCO2 assimilation approach – Phase 2

<table>
<thead>
<tr>
<th>RUN -- GECCO2 + V0</th>
<th>RUN – GECCO2 + V1.1</th>
<th>RUN – GECCO2 + V1.1 + other ECV</th>
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</thead>
<tbody>
<tr>
<td>V0</td>
<td>V1.1</td>
<td>V0</td>
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<td>V1.1</td>
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<td>V1.1</td>
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<tr>
<td>ERS series</td>
<td>TP series</td>
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<td>MR AT</td>
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Results shown are for:
- V0
- V1.1
- ERS series
- TP series

at model resolution -> difference to along-track resolution
Normalized RMS are calculated using the GECCO2 model solutions G0 and G1.1, and the SL data sets SL0, SL1 and SL1.1.

The results are named with the model solution and the compared data set. All used combinations are shown. The square root of both variances is the most useful normalization for this analysis.
RMS differences exemplarily for G0_SL0. GECCCO2 solution (G0) that assimilated the original AVISO data (SL0), as it is compared to the AVISO along-track data itself (SL0).

**BLUE**: very good adjustment of GECCCO2 to the assimilated data SL0.

**RED**: poor adjustment of GECCCO2 to the assimilated data SL0.

G0 adapts very well in the tropics whereas it neglects the assimilated data in the more red regions to satisfy the model physics.
The RMS ratios are designed in a way that smaller residuals indicate a better agreement of the upper RMS difference of model (G) and data (SL), compared to the lower.

A consistency cross checking of different model-data combinations has been performed. The numbers demonstrate the closer agreement of the upper model-data combinations as compared to the lower.

<table>
<thead>
<tr>
<th>TP series</th>
<th>ERS series</th>
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<tbody>
<tr>
<td>0.970 ( \frac{G1.1_{-}SL1.1}{G0_{-}SL0} )</td>
<td>0.966</td>
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<tr>
<td>0.990 ( \frac{G1.1_{-}SL1.1}{G0_{-}SL1.1} )</td>
<td>0.990</td>
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<tr>
<td>0.980 ( \frac{G0_{-}SL1.1}{G0_{-}SL0} )</td>
<td>0.970</td>
</tr>
<tr>
<td>0.997 ( \frac{G1.1_{-}SL0}{G0_{-}SL0} )</td>
<td>0.997</td>
</tr>
</tbody>
</table>
For the maps, the RMS ratios are transformed into percent improvement.

**RED**: indicates a closer agreement of the upper model-data comparison (G0_SL1) as compared to the lower (G0_SL0). SL1 has been improved compared to SL0.

**BLUE**: indicates a less good agreement of the upper model-data comparison. In those regions G0 adaptet better to the assimilated data SL0.
**RED**: indicates a closer agreement of G1.1 to SL1.1 than to SL0. SL1.1 has been improved.

**BLUE**: indicates a less good agreement of G1.1 and SL1.1. The reason needs to be model physics that overruled the assimilated SL1.1.

Further, when comparing these RMS ratio comparisons and the one from the previous slide, the combination of:  
1) the improved data set SL1.1 above SL0 and SL1 as well as
2) the improved GECCO2 synthesis G1.1 get evident.
The two different GECCO2 synthesis results (G0 and G1.1) showed, that the SL1.1 product has been improved as compared to versions SL1 and SL0 by up to 30%.

The assimilation of the SL1.1 product into the GECCO2 synthesis demonstrates the changes in the model truth, which bring the GECCO2 model even closer to the assimilated SL data, giving rise that the model physics better accepts and adapts to the assimilated SL1.1.
Where do the differences originate between the comparison at:

- **Model resolution (SL_cci at the GECCO2 grid) shown here**
- **Along-track resolution (GECCO2 interpolated onto the SL_cci along-track points)**
Solved question

TOPEX/POSEIDON

ERS

Along-Track resolution

Model resolution

19th February, 2016, SL cci AR2, Toulouse
TOPEX/POSEIDON

ERS

Model resolution

Along-Track resolution

Filter length

Step width

- 250 km  43.6 km
- 200 km  37.4 km
- 150 km  31.2 km
- 100 km  24.8 km
- 65 km  18.6 km
Along-Track resolution

Model resolution

Averaged over

436 km

374 km

312 km

248 km

186 km

19th February, 2016, SL cci AR2, Toulouse