A validation of error estimates in SST analyses

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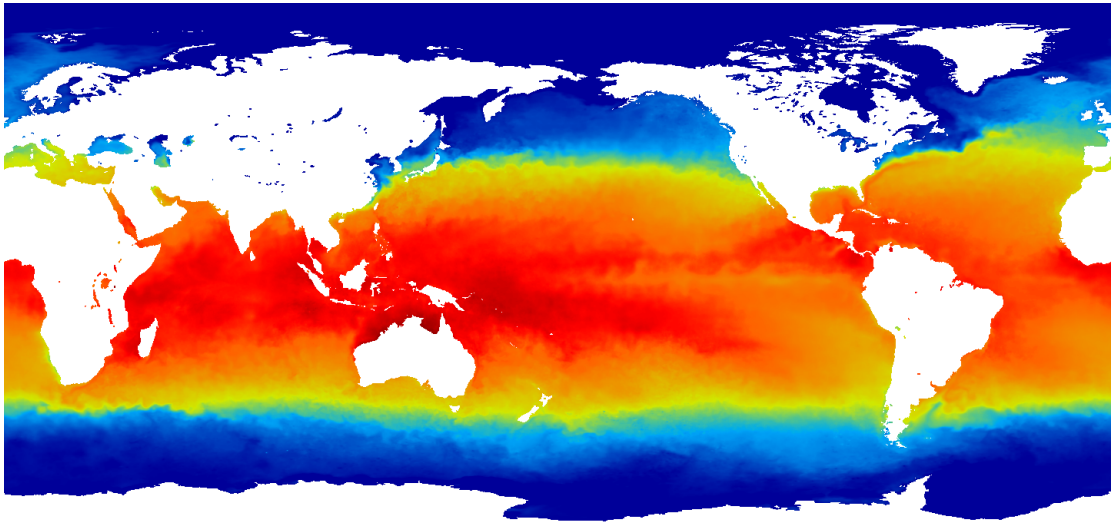
Overview

- Introduction
- Uncertainty estimation in OSTIA
- Validation of OSTIA estimates
- Comparison of uncertainties in L4 analyses using GMPE members
- Summary

Introduction

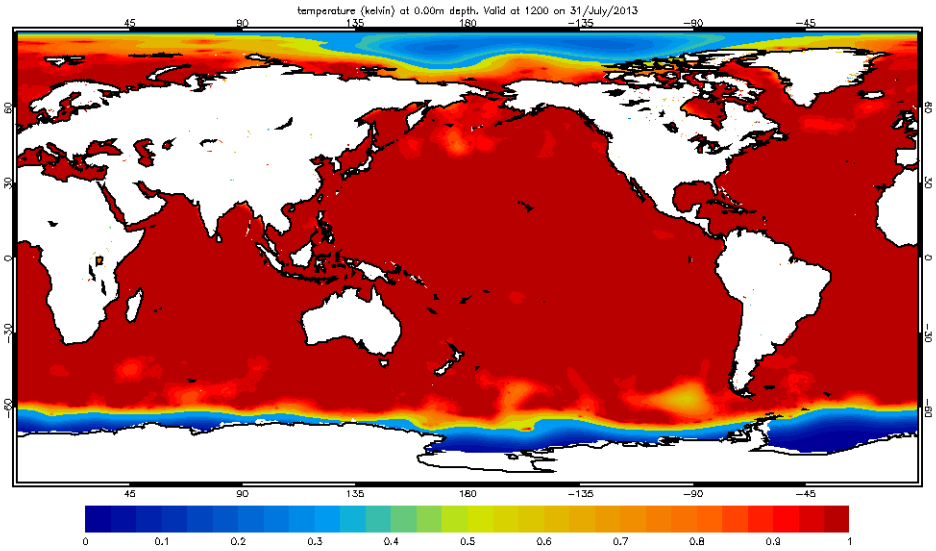
- Gap-free SST analyses (termed L4 products) are produced by a variety of agencies within GHRSST. Both in NRT and reanalysis modes.
- SST analysis assimilate both in-situ and satellite observations onto a background based on persistence. **Generally have no underlying physical model.**
- Developed and used for a variety of applications, e.g. used as a lower boundary condition in NWP models, seasonal forecasting, in SST retrieval radiative transfer modelling.
- Within GHRSST each analysed SST is accompanied by an uncertainty estimate, the “analysis error” in the GDS.
- These estimates are vital to users who require info on the confidence to place in the SST value or may require error estimates to use the SST analysis for assimilation or validation.



Uncertainty estimates in OSTIA

- Operational Sea surface Temperature (SST) and sea Ice Analysis (OSTIA) is run daily in near-real time (NRT) and reanalysis modes at the UK Met Office.
- To estimate the analysis error first the observational weight (ε^0) for each analysis grid point is calculated.
- This is estimated by carrying out another OI analysis where all observations are given a value of 1, background is set to 0.
- The background and observation error covariances used in the SST analysis are used in this analysis.

Observation weight for representative day.



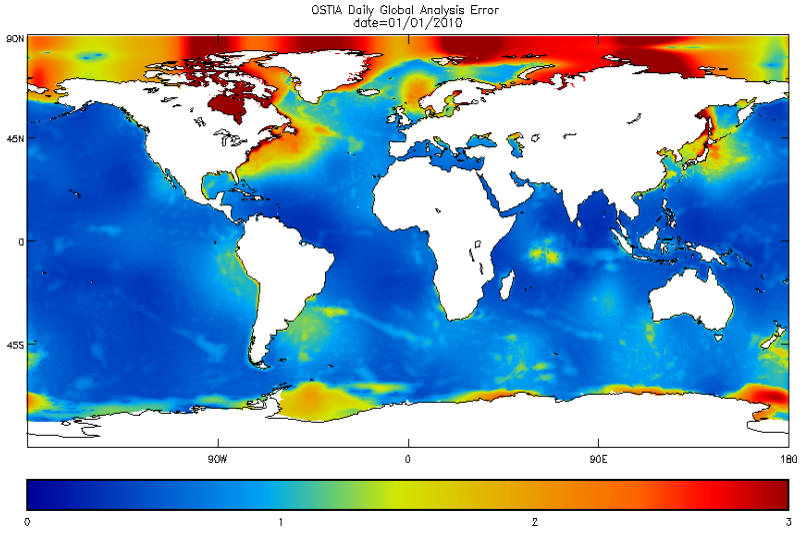
Uncertainty estimates in OSTIA

- The observational weight (ε^0) is combined with the background error variances (B) to estimate the uncertainty in the SST analysis (ε^a)

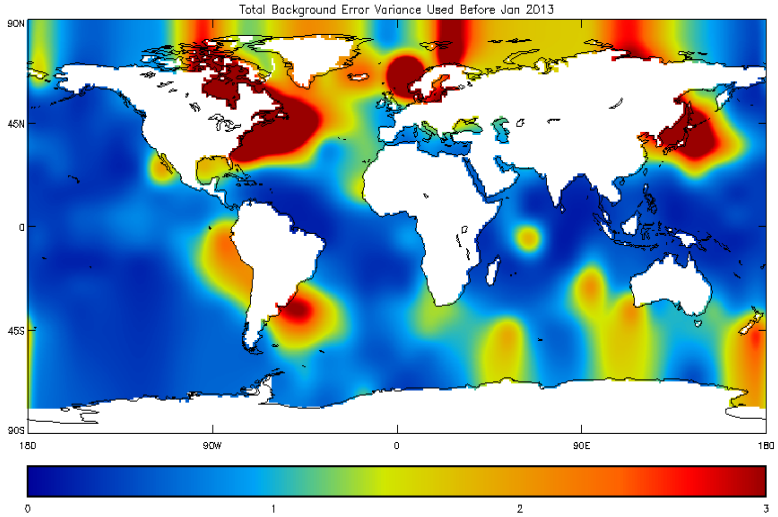
$$\varepsilon_i^a = \sqrt{B_i[\alpha + \beta(1 - \varepsilon_i^0)]}$$

- There are two tuneable parameters α and β.
- In this estimation the majority of the flow dependence of the analysis error is determined by the daily observational network but the uncertainties are heavily constrained by the background error variances (specified a priori).

Daily analysis errors for Jan 2010



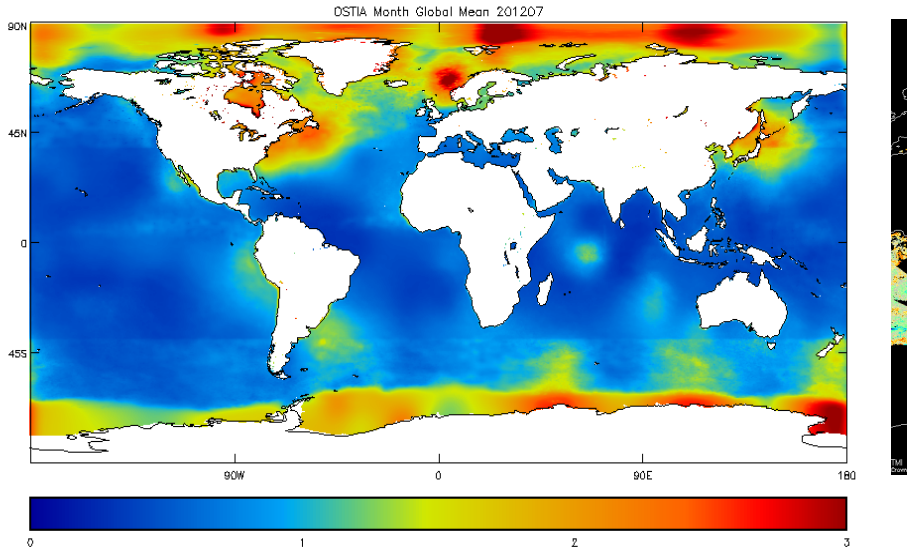
Background error variances used

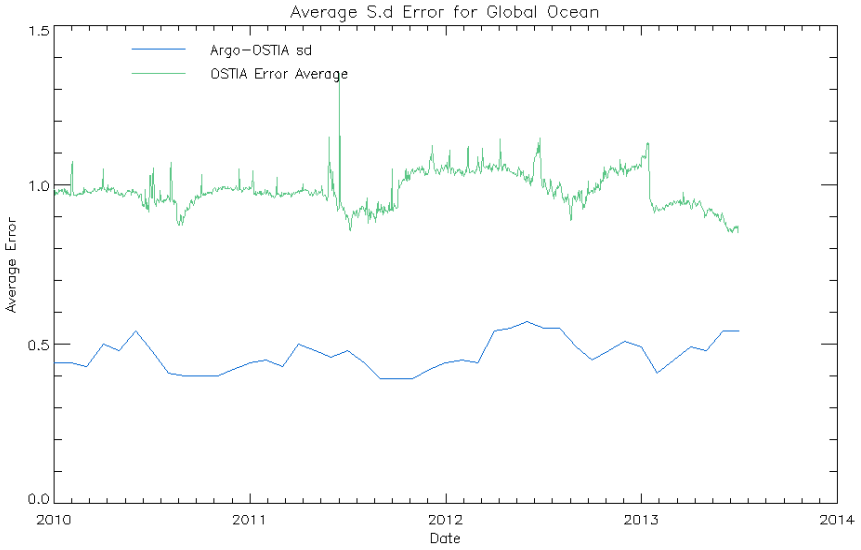


Effect of satellite outages on the uncertainty estimates

- Loss of AMSR-E (Oct 2011) had a large impact on the OSTIA error estimates.
- Due to reduced observational coverage outside of the TMI region the analysis error is enhanced.
- The loss of AATSR which had a major impact on the analysis accuracy had little impact on the analysis uncertainty estimates.

Monthly average error estimates for July 2012

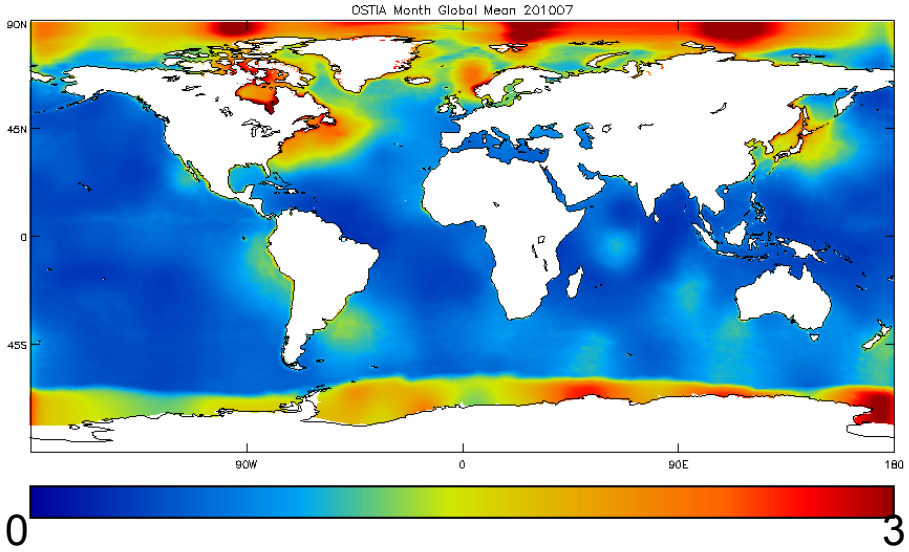




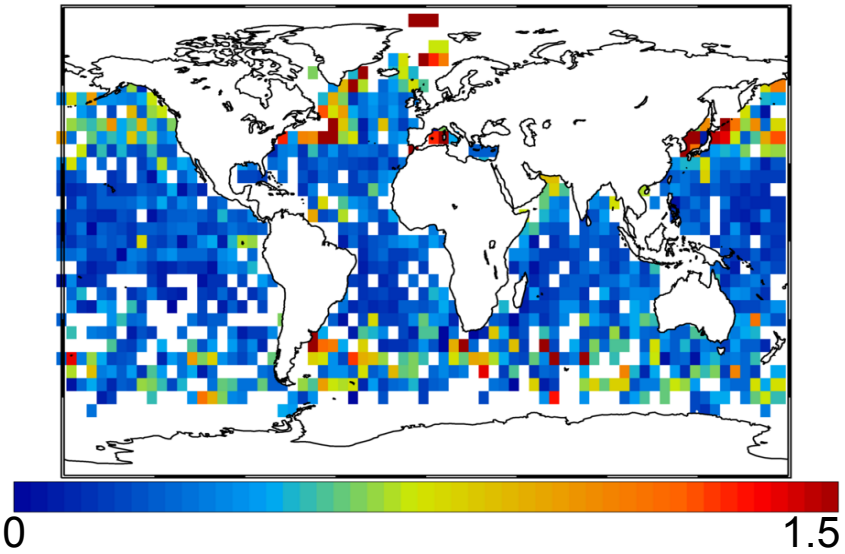
Using Argo observation-analysis differences to validate uncertainty estimates.

- Top-level Argo observations provide an independent estimate of foundation SST, Argo-analysis differences can use to represent the “True” analysis error.
- Spatial pattern of the errors match but analysis error estimates are overestimates (different scales).

Monthly average error estimates for July 2007



Argo-OSTIA rmsdiff 201007

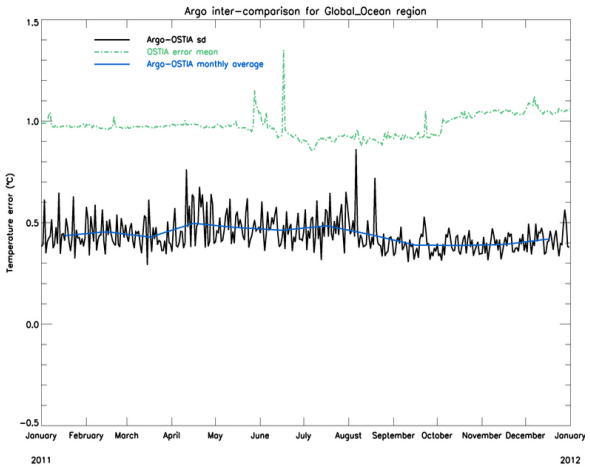


Using Argo observation-analysis differences to validate uncertainty estimates.

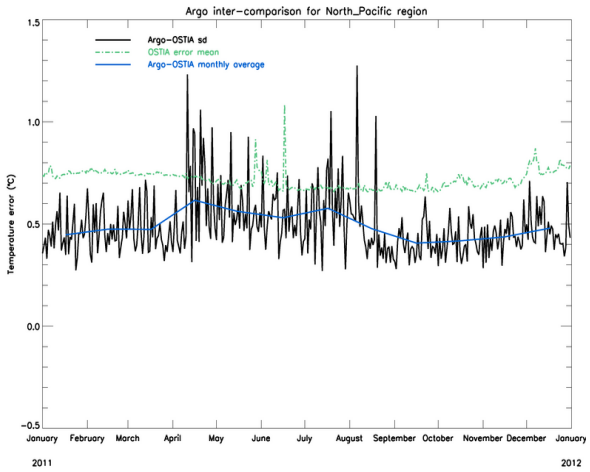
- Top-level Argo observations provide an independent estimate of foundation SST, Argo-analysis differences can use to represent the “True” analysis error.
- OSTIA analysis errors over-estimate those form Argo-OSTIA differences globally and in all regions.
- Seasonal cycles in the two errors don’t match, as they are due to different processes.

Regional validation of analysis errors using Argo-Analysis differences

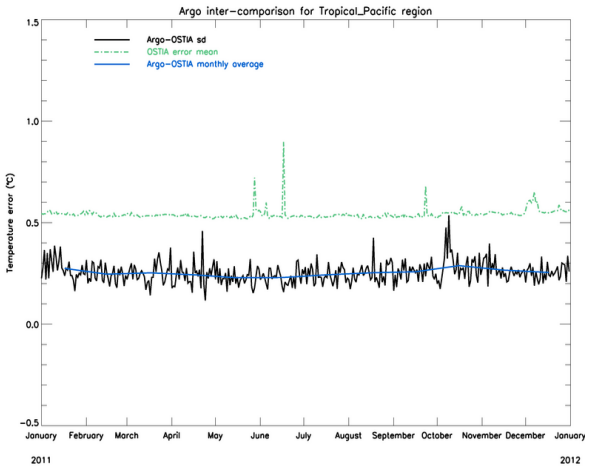
Global



North Pacific

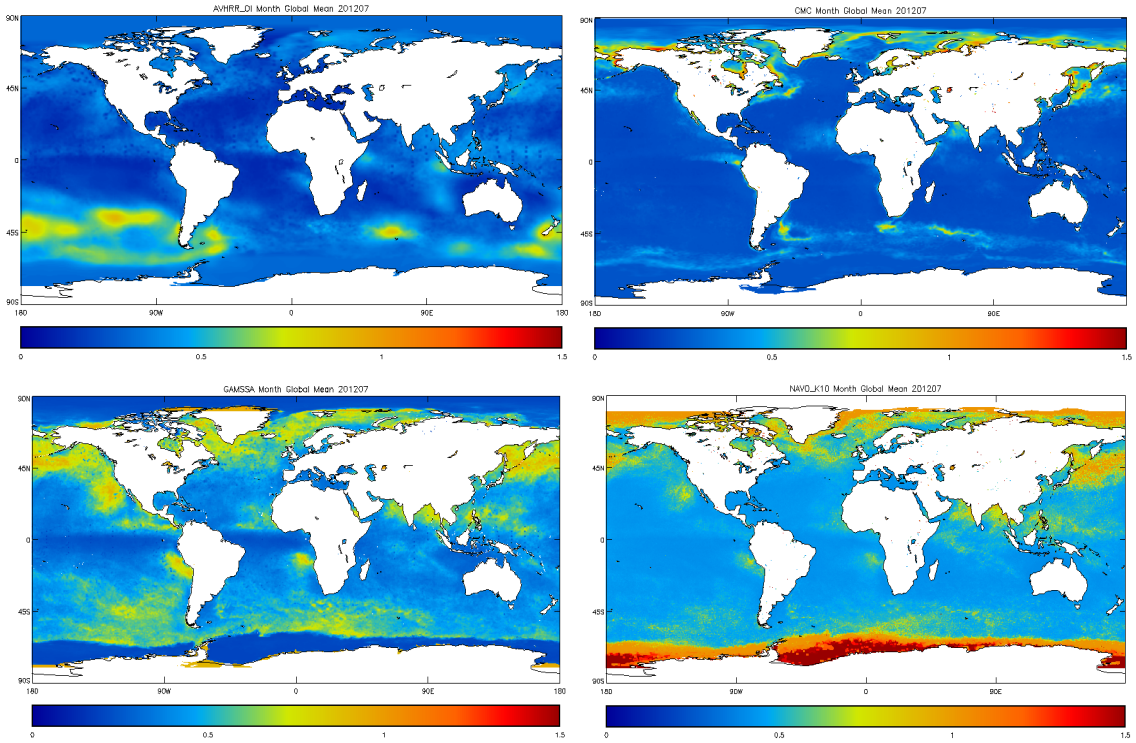


Tropical Pacific



Inter-comparison of uncertainty estimates using GMPE system.

- Different SST analyses uncertainties can be compared using the analyses used in the GMPE system.
- Here error estimates from OSTIA (Met Office, UK), AVHRR-OI (NCDC/NOAA, USA), CMC (Canadian Met Center, Canada), GAMSSA (BOM, Australia) and NAVO K10 (Naval Oceanographic Office, USA) have been compared.
- Analysis producers estimate the analysis errors using different methods.



Monthly average error estimates for July 2012

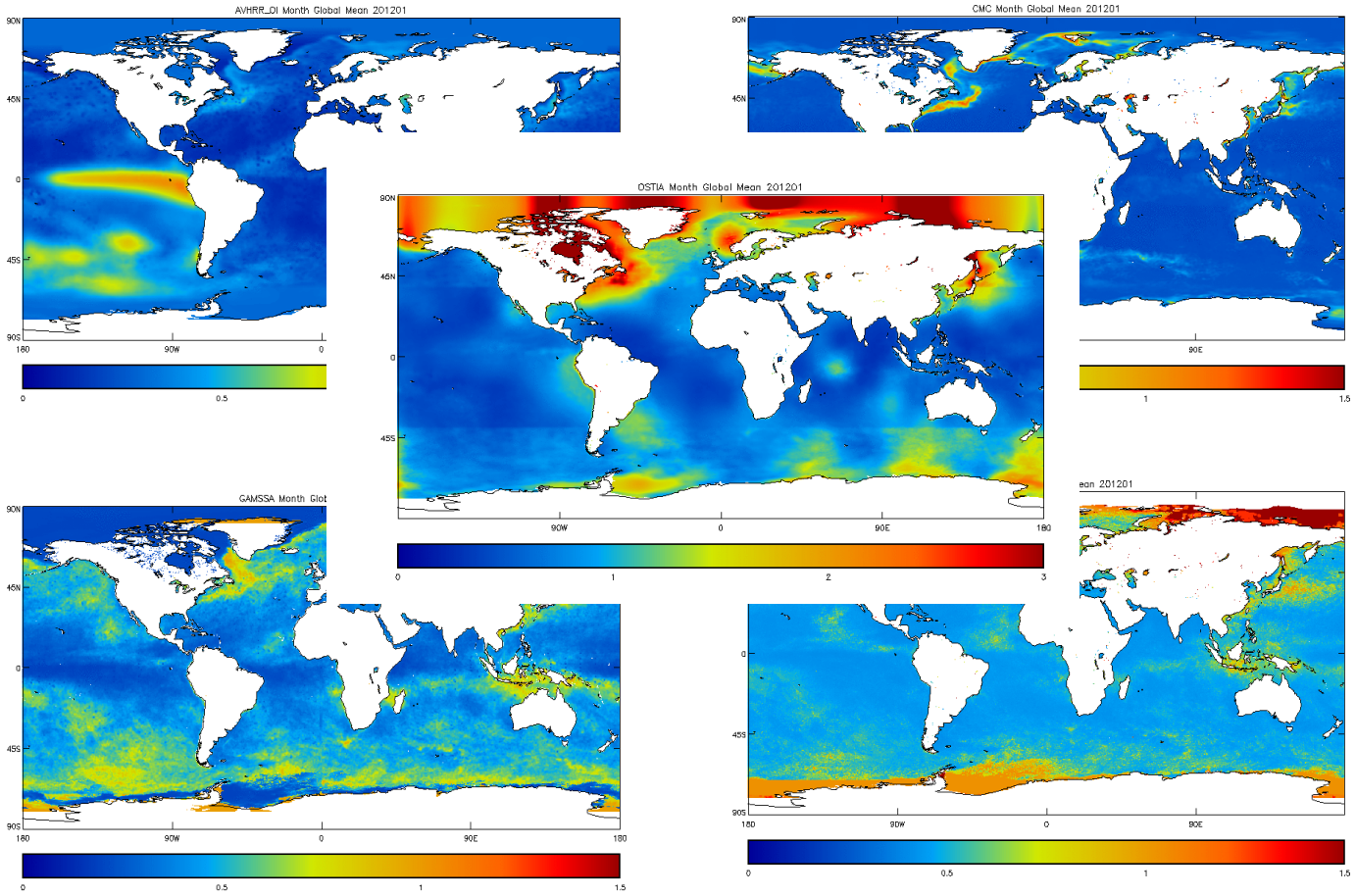
AVHRR-OI, CMC

GAMSSA, NAVO K10

GMPE Members Monthly Error Analysis for 2012

AVHRR OI

CMC



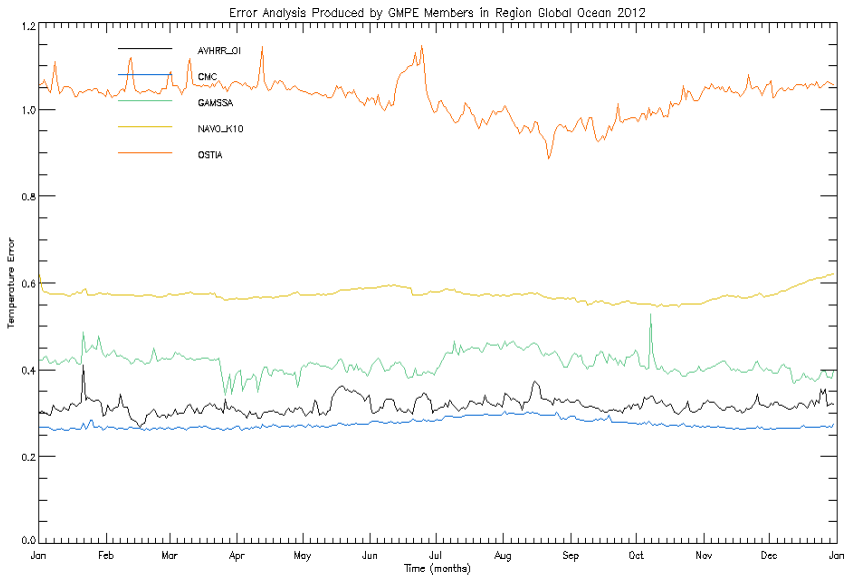
GAMSSA

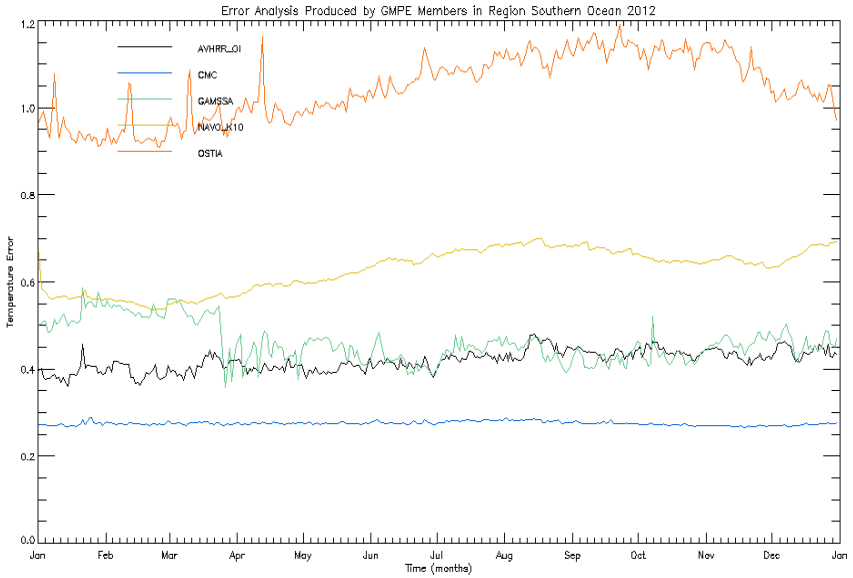
NAVO K10

Global and regional inter-comparison of uncertainty estimates

- Uncertainty estimates produced by OSTIA are considerably higher than other GMPE members in all regions.
- Seasonality can be observed in OSTIA and NAVO K10 error estimates caused by seasonally expanding seaice fields.
- CMC analysis errors are consistently lowest (~0.26K) and robust across different regions.
- Step change in GAMSSA analysis errors in Southern Ocean in March 2012.

Analysis error estimates averaged globally and in Southern Ocean.

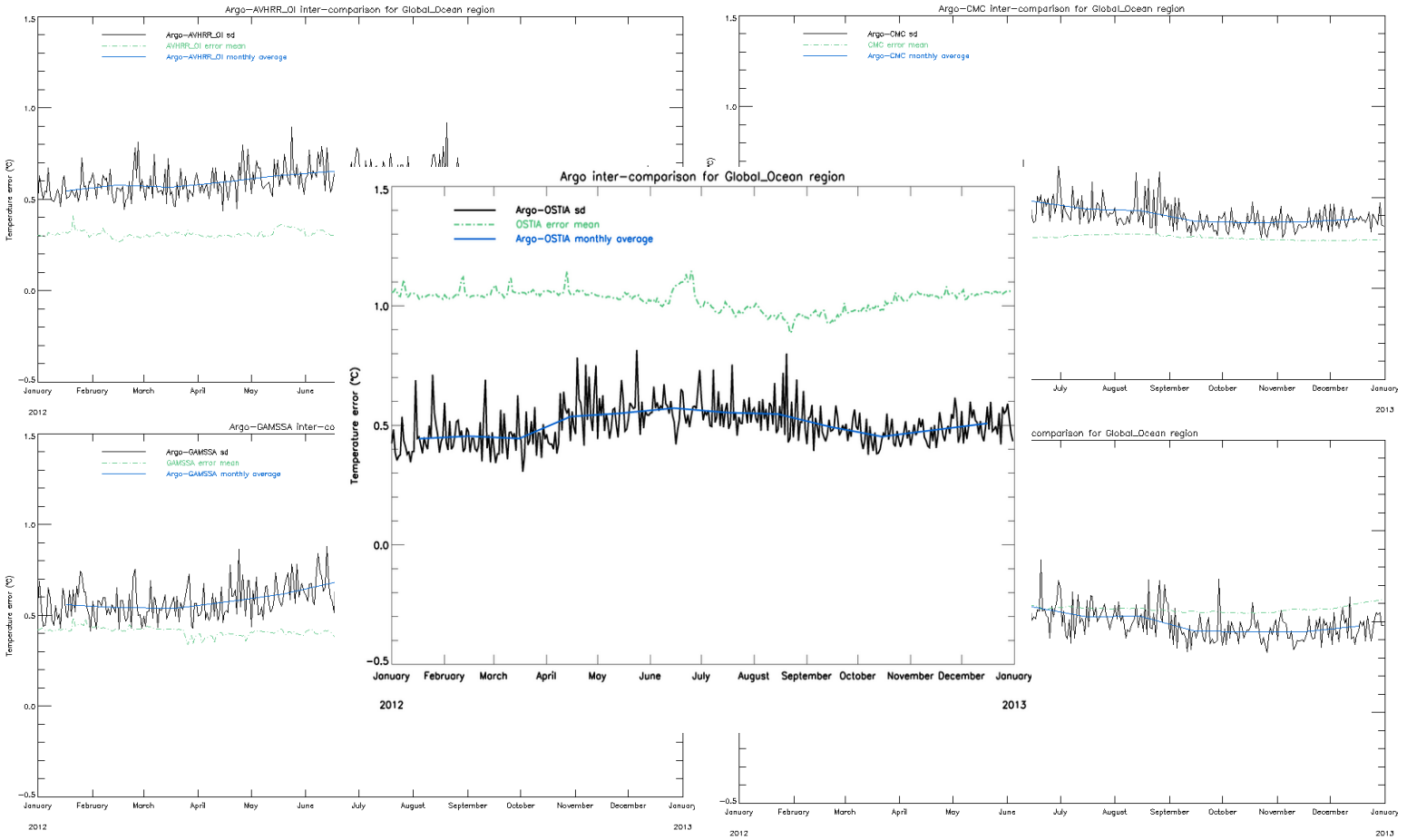




GMPE members analysis errors validated using Argo observations

AVHRR OI

CMC

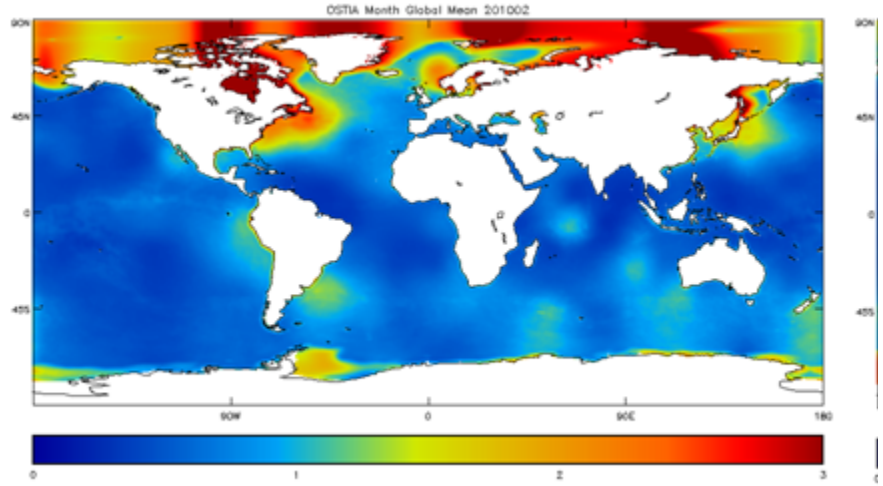


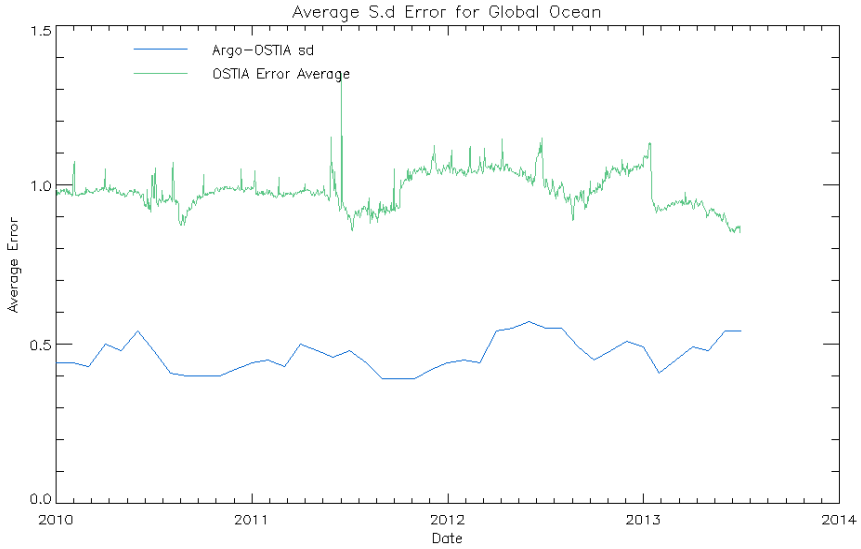
GAMSSA

NAVO K10

Effect of updating background error variances on OSTIA uncertainty estimates

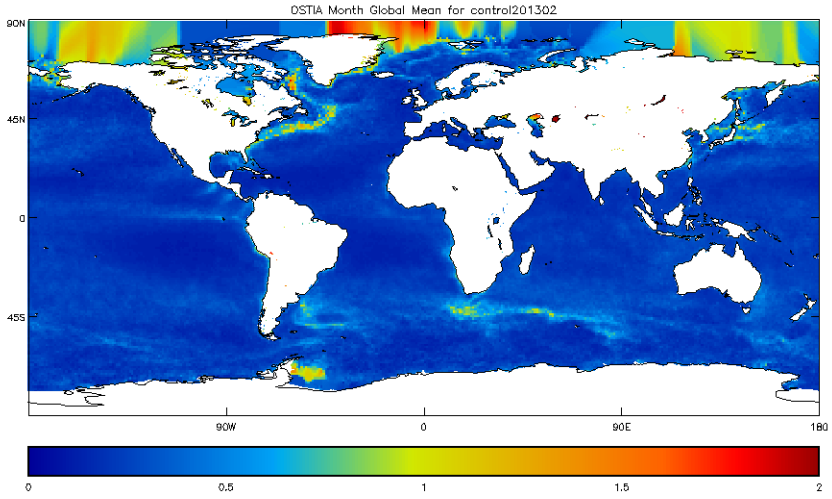
- The increase in analysis iterations (to ensure convergence) resulted in increased observational weight going into the uncertainty estimates, this in turn reduced the analysis errors.
- Bug meant that between Jan 2013 and Jan 2014 new background error variances were used in the OI analyses but old estimates where used in the analysis error equation.
- Prior to the bug fix error estimates showed little seasonality.

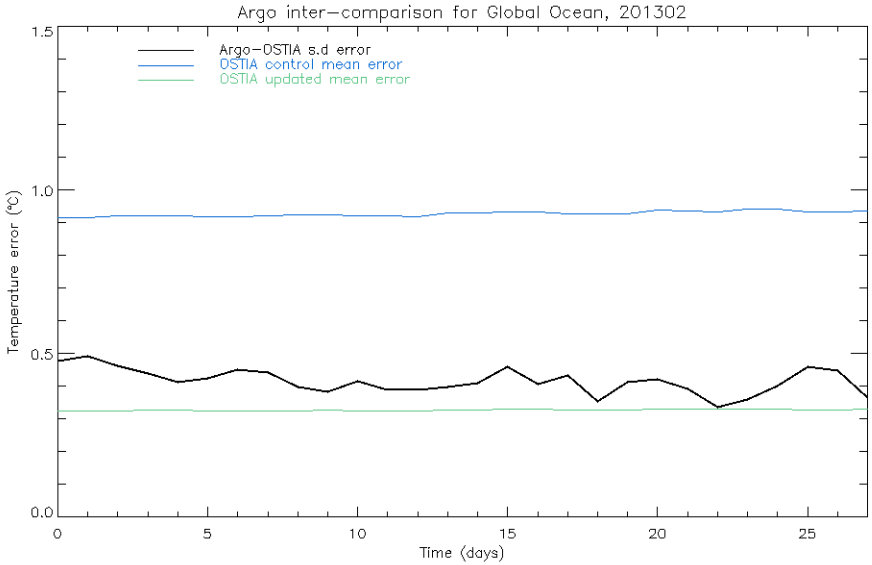




Impact of bug fix on OSTIA error estimates.

- Bug meant that between Jan and ? 2013 new background error variances were used in the OI analyses but old estimates where used in the analysis error equation.
- Using correct background error variances in error estimation equation leads to significant change in both magnitude of analysis errors and in the spatial structure.
- Magnitude of the errors is at least halved in all regions and brings estimates much closer to Argo-OSTIA differences.
- As background error variances are now seasonally varying this follows through into the error estimates.

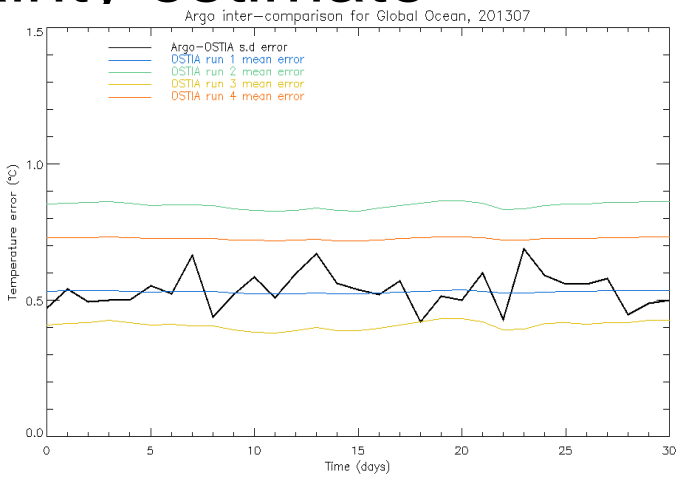




Summary

- Methodology for estimating analysis errors in OSTIA has been presented.
- Validation using Argo data showed that the analysis errors in OSTIA were over-estimates and showed little seasonal variability.
- Bug when new background error variances were implemented that although new variances were used in observational weight analysis they were not used in the error calculation itself.
- Analysis errors from a subset GMPE members were inter-compared and validated using Argo data.
- Large OSTIA errors are an outlier, other GMPE members tend to under-estimate the Argo-analysis errors. CMC analysis errors are closest to Argo estimates.
- Bug fix to OSTIA system changes magnitude and spatial structure of the analysis errors considerably and brings them closer to the Argo estimates.

Future analysis uncertainty estimate developments.



In OSTIA,

- Improve estimates under seaice.
- Tune parameters in the analysis error estimation equation, work done prior to bug fix shows this can achieve good fit to Argo-OSTIA differences.
- Use estimates of the observation error in the error calculation.

Wider SST analysis community,

- Should we try and standardise how the analysis error estimates are calculated within GHRSST?
- Is it wise to strive to match the errors estimated from Argo-OSTIA differences?
- Should we be worried that most analyses underestimate errors regionally and don't capture seasonality observed in the Argo-analysis differences?
- Can we provide correlation information with the analysis error standard deviations?

Questions?

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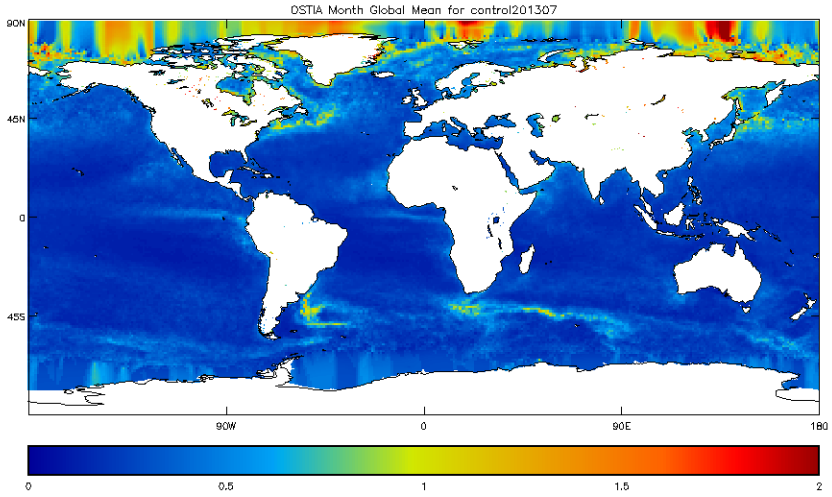
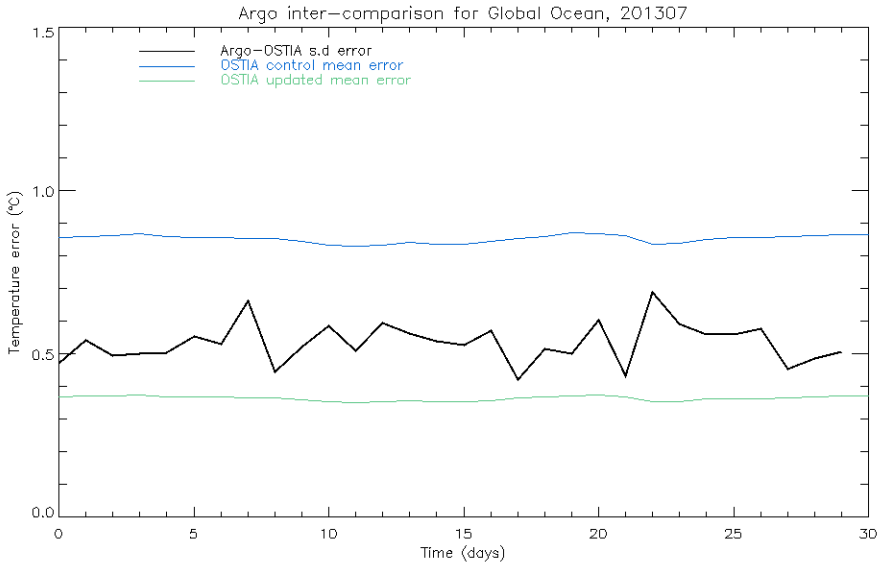
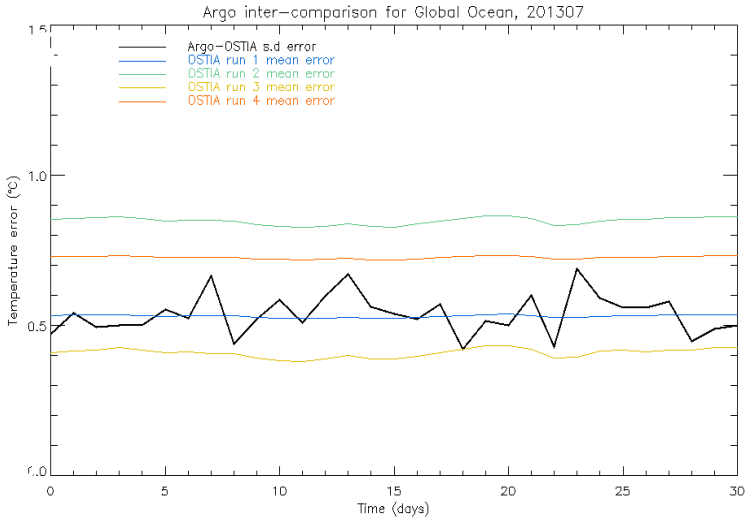
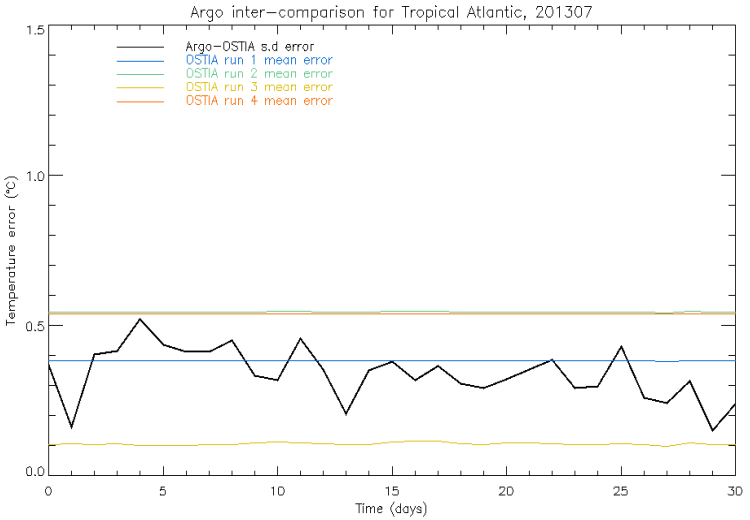


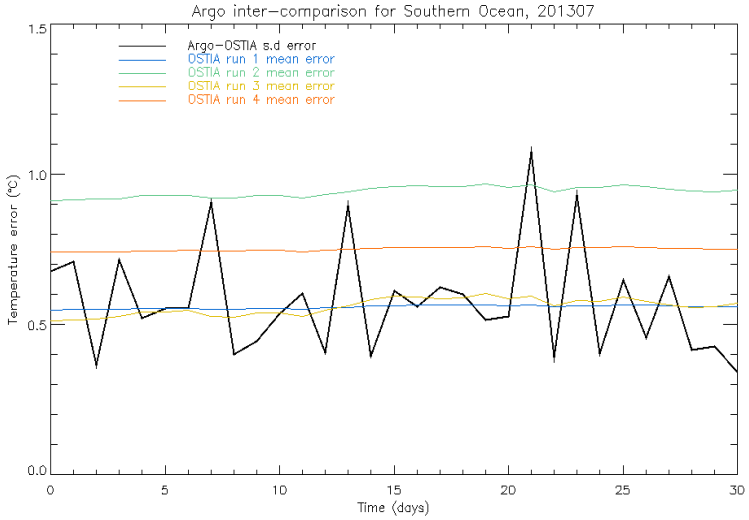


Argo-OSTIA Inter-comparison

July 2013

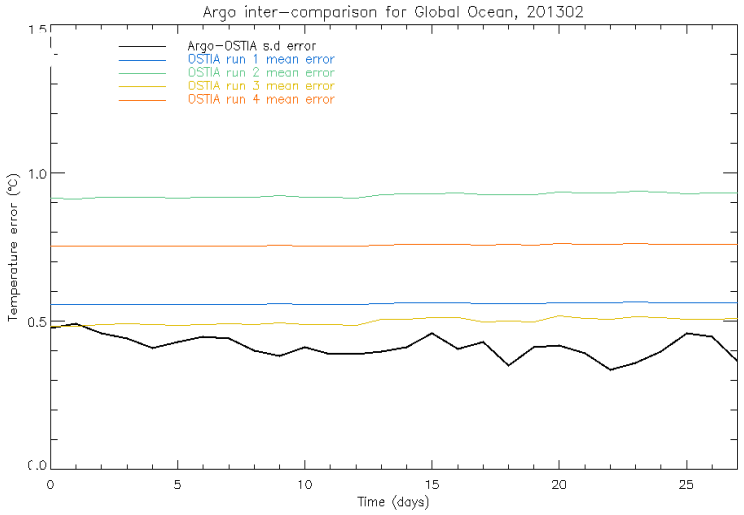


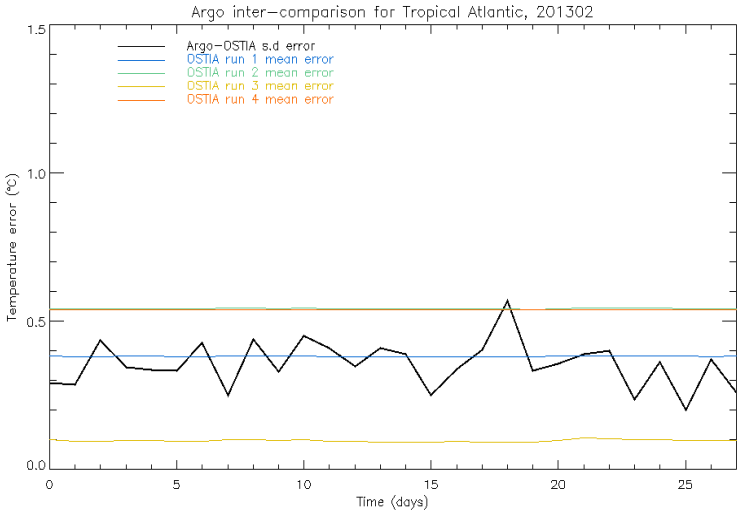


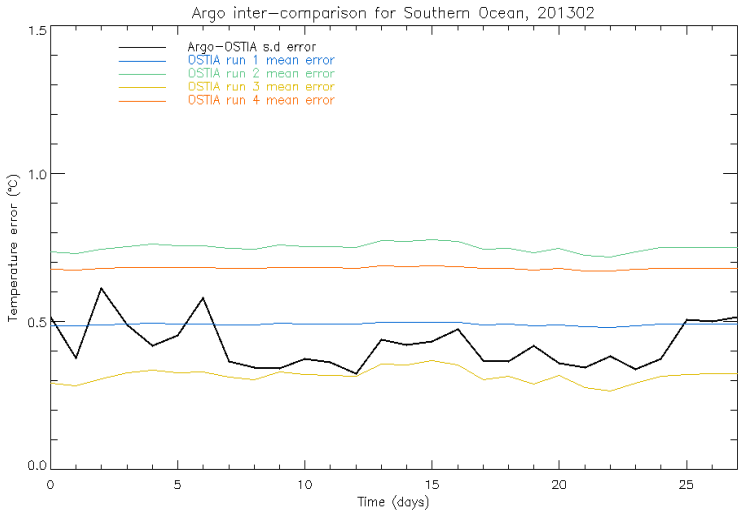


Argo-OSTIA Inter-comparison

February 2013



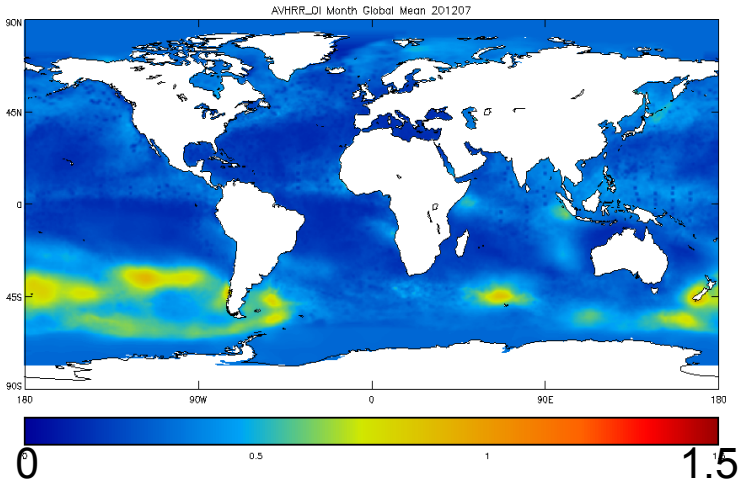




- All OSTIA runs larger this month and Argo-OSTIA smaller when compared to Jul 2013.
- Run 1 and 4 less affected by seasonal trend due to smaller weight on observations.

GMPE Members Error Analysis in July 2012

AVHRR OI



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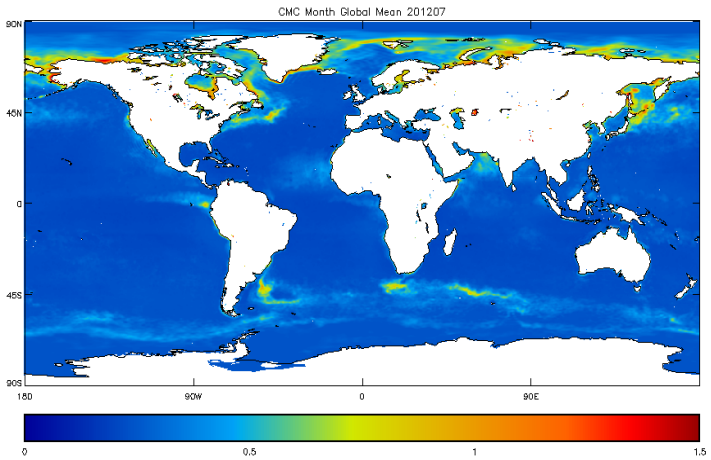

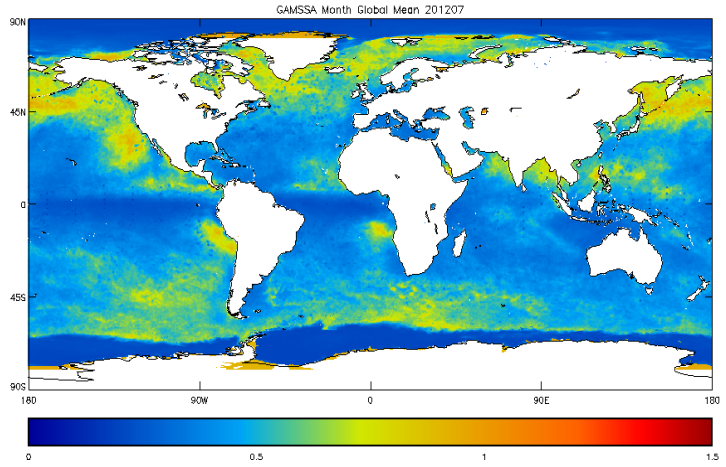

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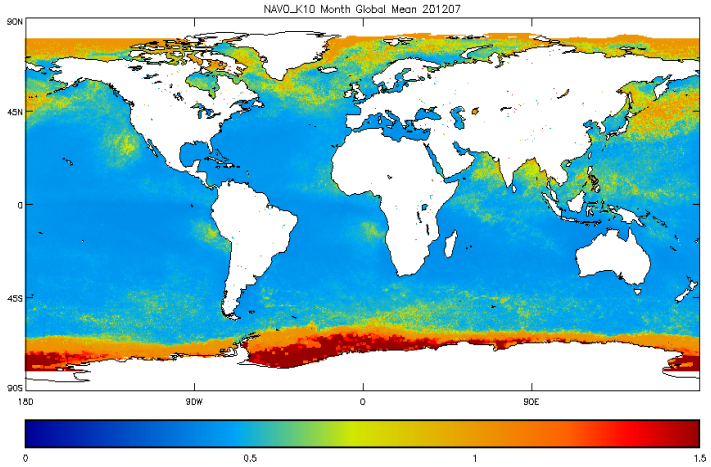

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