RESEARCH DEPARTMENT MEMORANDUM

ECMWF

To:	RD, OD, COP	
Copy:	Simon Good, John Siddorn	
From:	Phil Browne, Patricia de Rosnay, Ioannis Mallas, Hao Zuo, Kristian Mogensen, Magdalena Balmaseda	
Date:	November 3, 2017	File: RD17-291
Subject:	**OSTIA product change on 28 November 2017**	

Summary

The OSTIA Sea Surface Temperature (SST) and Sea Ice Concentration (CI) product will change its analysis method from 2D Optimal Interpolation (OI) to using a method based on NEMOVAR. The UK Met Office have provided representative test data which we assess in this memo.

The SST product contains much finer scale structures which increases the variability in our HRES analysis without greatly changing the mean. The CI product gives a consistent improvement in scores when no sea ice model is used, as in 43R3.

We recommend to move to this new product at the same time as implementing 45R1.

1 Background

The OSTIA product is a L4 data set providing Sea Surface Temperature (SST) and Sea Ice Concentration (CI) fields used as the lower boundary conditions for the IFS. Further, OSTIA CI is assimilated in the OCEAN5 analysis system and the OSTIA SST field is the target that the analysis SST field is relaxed towards.

OSTIA is produced by the UK Met Office (UKMO) and has its website here: http://ghrsst-pp.metoffice.com/pages/latest_analysis/ostia.html

For sea ice, the OSTIA product is a regridding and infilling of the OSI SAF L3 product OSI-401-b. The OSTIA SST analysis is created by a 2D Optimal Interpolation (2D-OI) as described in Donlon et al. (2012)[1].

The UKMO propose to change the analysis method that produces OSTIA from their bespoke 2D-OI system to using NEMOVAR. Note that there is still no dynamical model used to produce OSTIA, so it remains solely observation based.

The UKMO have provided test data from 20160801 until 20170331. This is a reprocessed data set and so has potentially seen extra observations than an operational NRT product. Hence we can assume that the dataset is possibly higher quality than we would receive in NRT.

[1] Craig J. Donlon et al. "The Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) system". In: *Remote Sensing of Environment* 116 (2012), pp. 140–158. ISSN: 00344257. DOI: 10.1016/j.rse.2010.10.017. URL: http://linkinghub.elsevier.com/retrieve/pii/S0034425711002197.

In this memo we assess the impact of this new SST and CI product on the IFS.

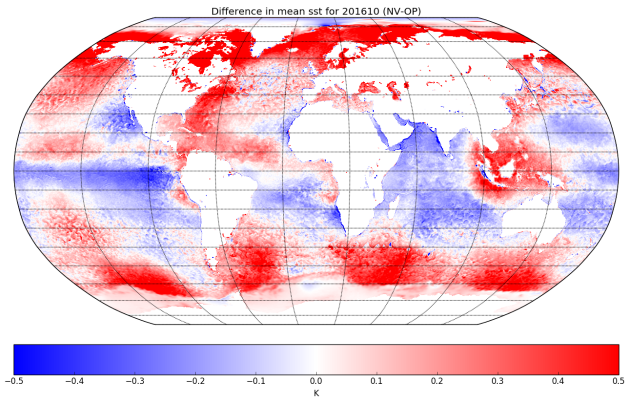
2 Possible impact on OCEAN5

OCEAN5 uses NEMOVAR to assimilate the OSTIA CI product that is a regridded and in-filled version of the OSI SAF OSI-401-b L3 product. The new OSTIA CI product will be an analysis created using NEMOVAR. We do not know how the background error covariances are specified for CI in the new OSTIA system, but it is likely that they are similar to those used in OCEAN5. Care will be required to assess the impact of the new product in OCEAN5, but it not addressed here. Tests in the OCEAN5 system are under way.

3 Test dataset

The UKMO have provided test data from 20160801 until 20170331. In order to assess the impact on the operational system we should compare results against the operational OSTIA stream. However the current operational product was changed during the period of the test data. On 20161108 the OSTIA product we receive operationally changed from using MetOp-A AVHRR for bias correction to ACSPO VIIRS. This changed the statistical properties of the product as can be seen in Figure 1.

(a) Previous bias correction



(b) Current bias correction

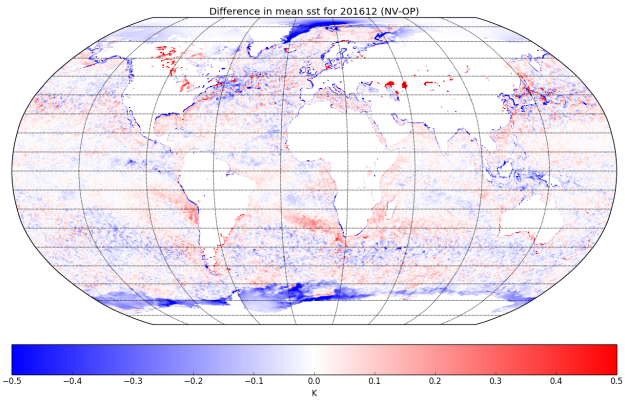


Figure 1: Difference in monthly mean fields between the new and operational OSTIA SST (K) before (1a) and after (1b) the change in bias correction of the operational OSTIA product

The new NEMOVAR OSTIA product is bias corrected against ACSPO VIIRS, so it is in better agreement with the operational product produced after 201160108 (Figure 1b) than before (Figure 1a). Residual differences between the new and operational SST after 201160108 are mostly due to the use of NEMOVAR vs 2D-OI.

Hence the appropriate test period to compare against the current operational product is 20161108 onwards. Monthly averaged differences are shown in the appendix.

3.1 Sea ice concentration changes

We know that over the winter 2016-2017 OSTIA suffered from problems of spurious sea ice that were inherited from the OSI SAF product (see RD17-095[2]). A natural question to ask is whether the spurious sea ice is present in the new OSTIA product generated using NEMOVAR instead of OI.

(a) Operational OSTIA product

(b) New OSTIA product using NEMOVAR

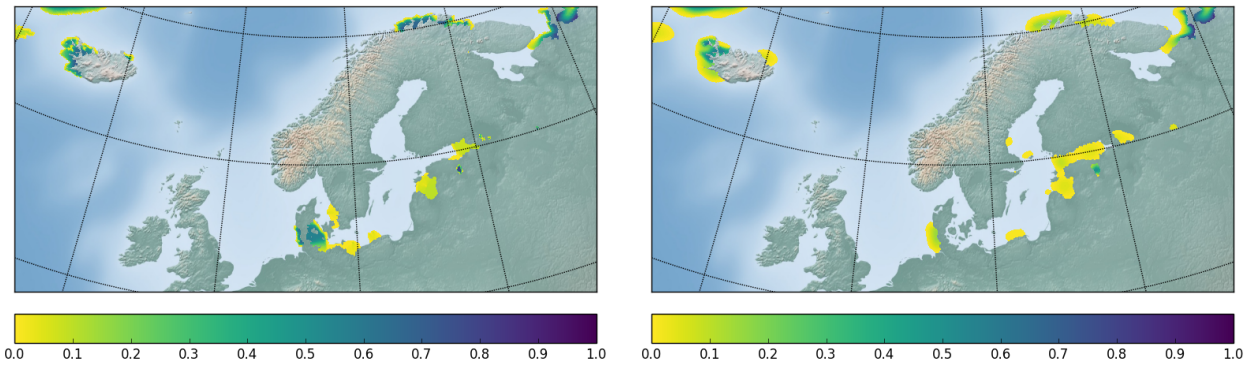


Figure 2: Sea ice concentrations in Northern Europe on 20161201

Figure 2 shows the raw sea ice concentration values in both the existing and proposed new product. Consider Denmark - OSI SAF has a spurious pixel of sea ice to the west of the country. In the current operational product this gets *smeared* out by the OI resulting in an area of spurious sea ice on both the west and east of Denmark. In the new NEMOVAR generated product, the impact of the spurious observation is confined to the western coast of Denmark. It also appears to be spreading the sea ice more thinly than in the operational OI product. This spurious sea ice appears to be below the current 0.2 threshold in our processing of the sea ice concentration. A similar thing can be seen around Iceland and northern Norway - the maximum values are reduced and the extent increased.

Hence this new NEMOVAR OSTIA product does not alleviate the issues related to spurious sea ice observations in the OSI SAF product, but it may mitigate them. N.B. The new product should be using the filtered sea ice concentration product from OSI SAF which became operational on 20170320, hence spurious areas of sea ice should be minimal in both versions of the product from then onwards.

4 Tests conducted

Tests 43R3 experiments were conducted at various resolutions and are summarised in Table 1. For the TCo1279 experiments, the experiment `gsw9` uses the new OSTIA product. `fetchobs` was modified to retrieve the new OSTIA product instead of the current product. A control experiment `gsw8` was run. The date of the first cycle was `2016112800` to coincide with the planned implementation date of 20171128.

Full Iver scores are available at `file:///perm/rd/dipb/iver/plots/gsw9_gsw8/index.html` and correct obstat scores for the satellite products (due to archiving issues early in the experiment) are available here `file:///perm/rd/dipb/iver/plots/gsw9_gsw8sat/index.html`. Ocean only scores are available at `file:///perm/rd/dipb/iver/plots/gsw9_gsw8ocn/index.html`

[2]Phil Browne et al. *OSTIA sea ice product change on 20 March 2017*. Research Department Memo RD17-095. ECMWF, 2017.

Table 1: Experiments conducted

ExpID	Control	Resol	Start Date	End Date
gsw1	gsw0	TL159	20160804	20170314
gsw4	gsw3	TCo399	20160804	20170314
gsw9	gsw8	TCo1279	20161128	20161231

Iver scores for the lower resolutions are here:

TCo399: file:///perm/rd/dipb/iver/plots/gsw4_gsw3/index.html

TL159: file:///perm/rd/dipb/iver/plots/gsw1_gsw0/index.html

5 Iver scores at TCo1279

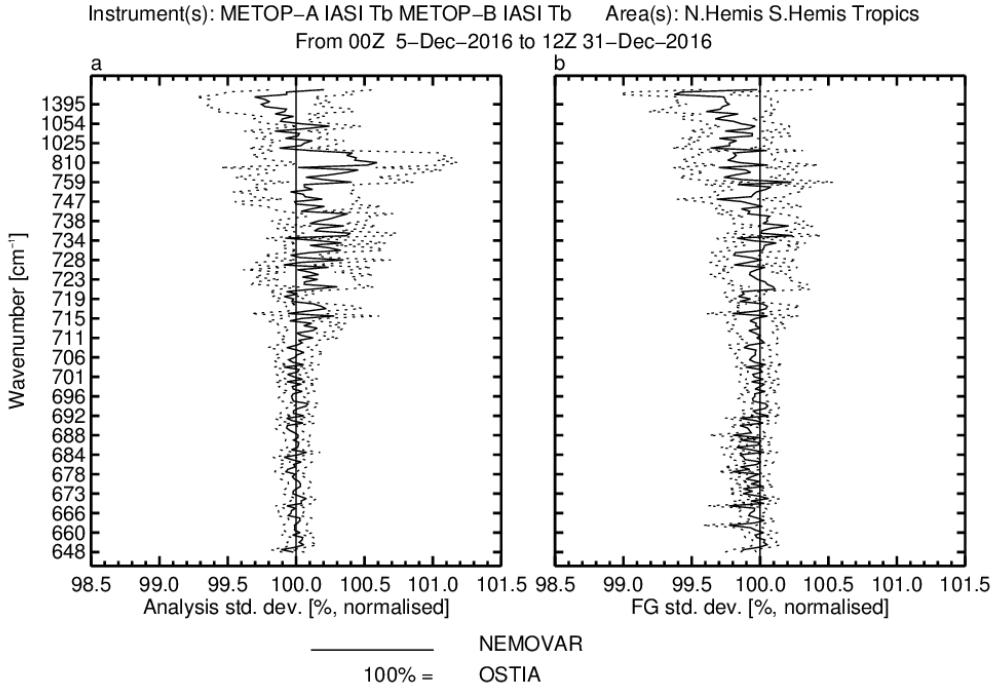


Figure 3: Global obstat scores from IASI. Note that wavenumbers $\approx$ 750–1000 are sensitive to the SST. One can see that the analysis standard deviation increases whilst the first guess standard deviation decreases. Not shown is that the total observation count for IASI increases by $\approx$0.8–1% for these channels.

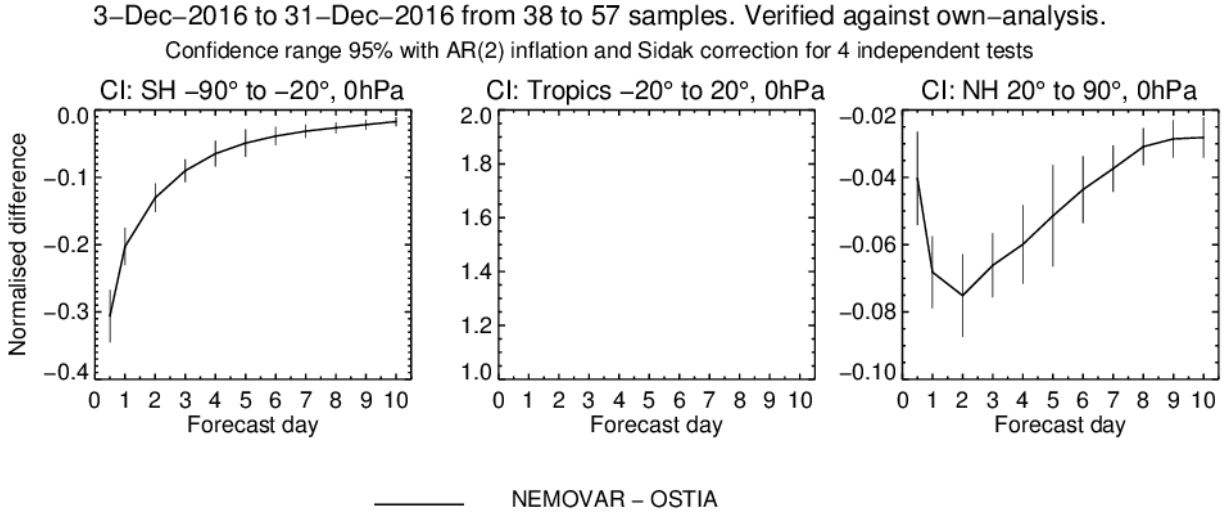


Figure 4: Regional normalised RMSE of sea ice (CI). This is a positive and statistically significant impact in both northern and southern hemispheres. However, note that there is no sea ice model in 43R3 so this improvement indicates that the new product has less temporal variability than the old product. This signal could be different in 45R1 when a dynamical sea ice model is used.

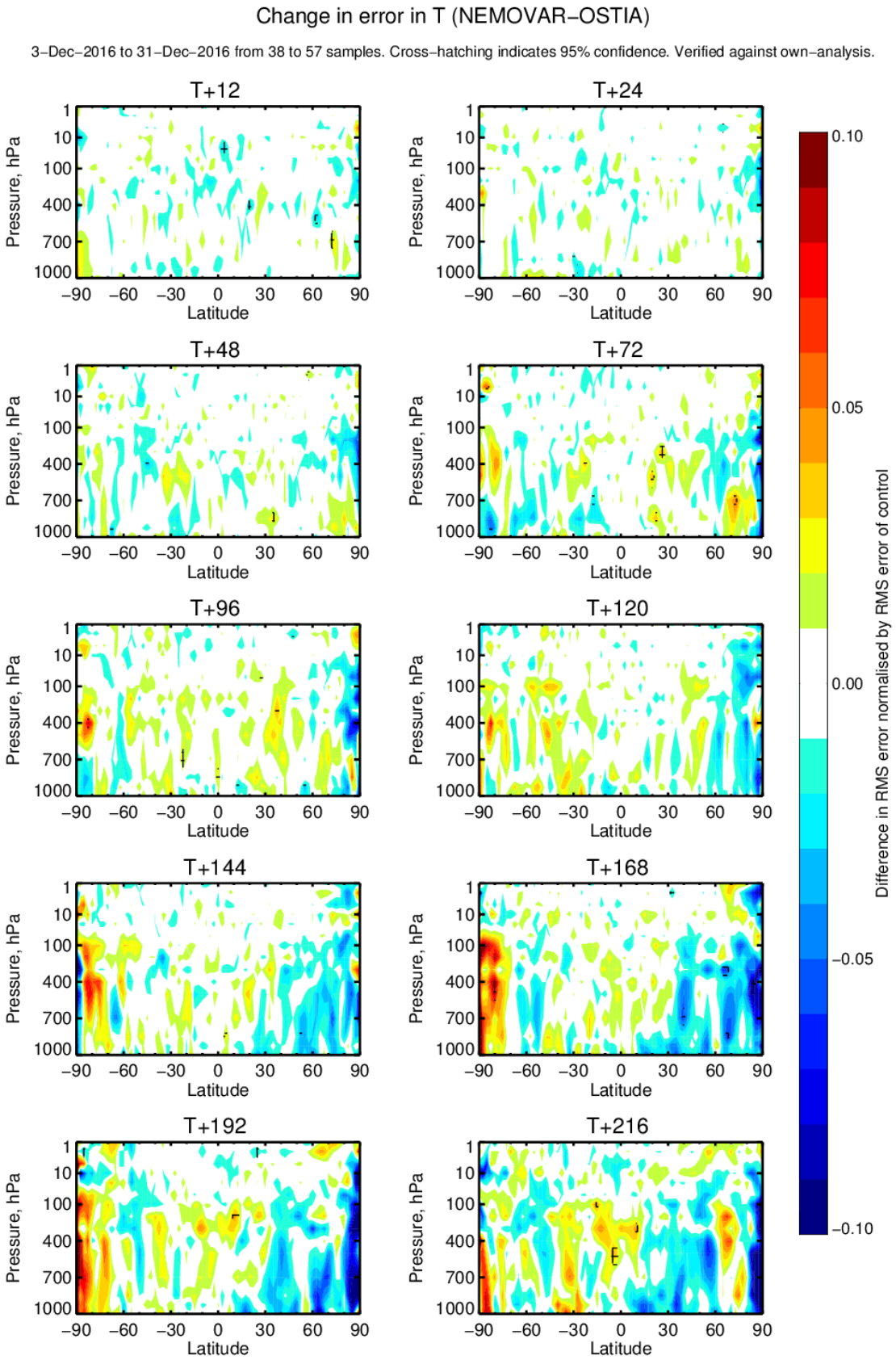


Figure 5: Normalised RMSE error for T

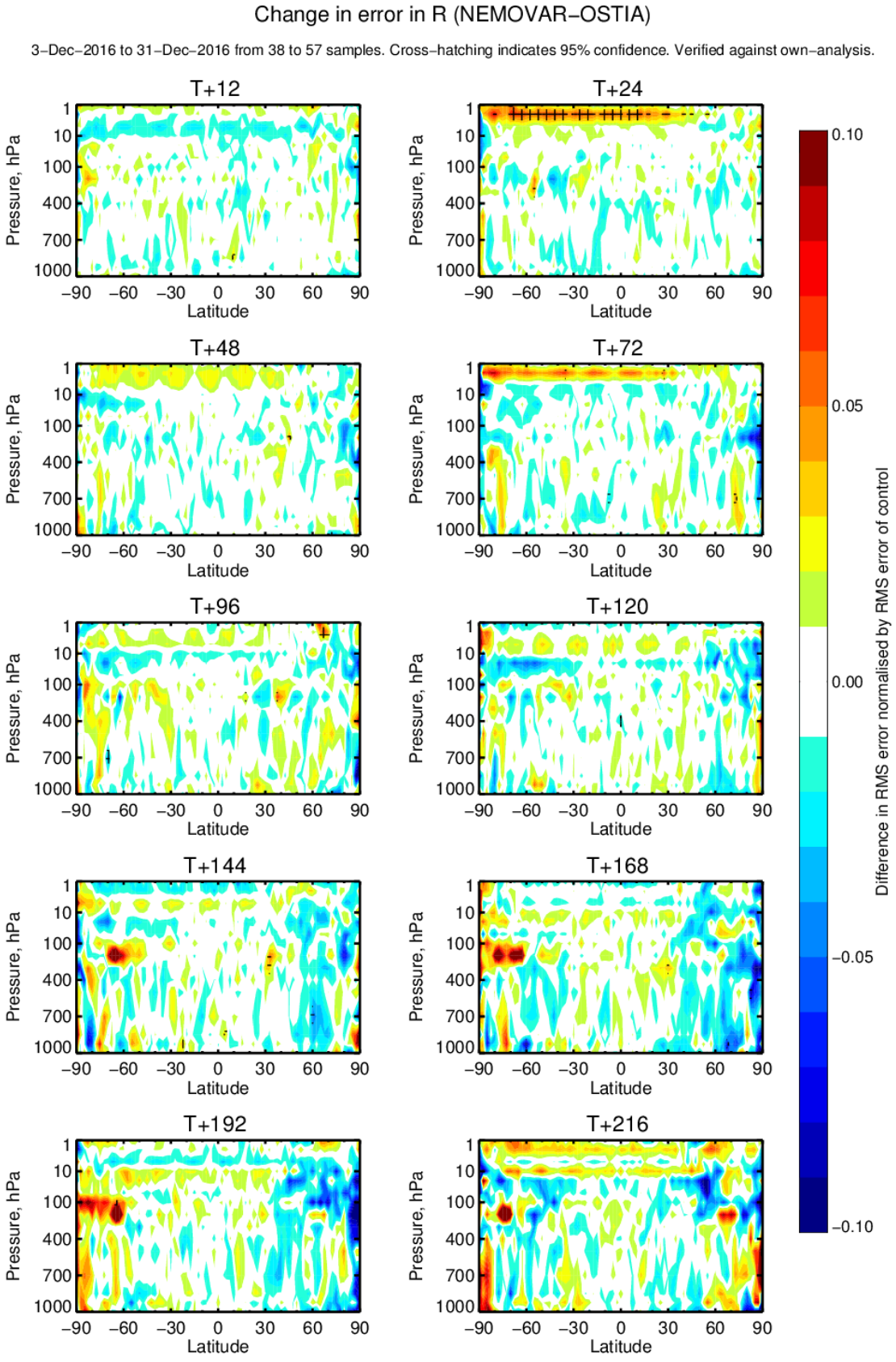


Figure 6: Normalised RMSE error for R

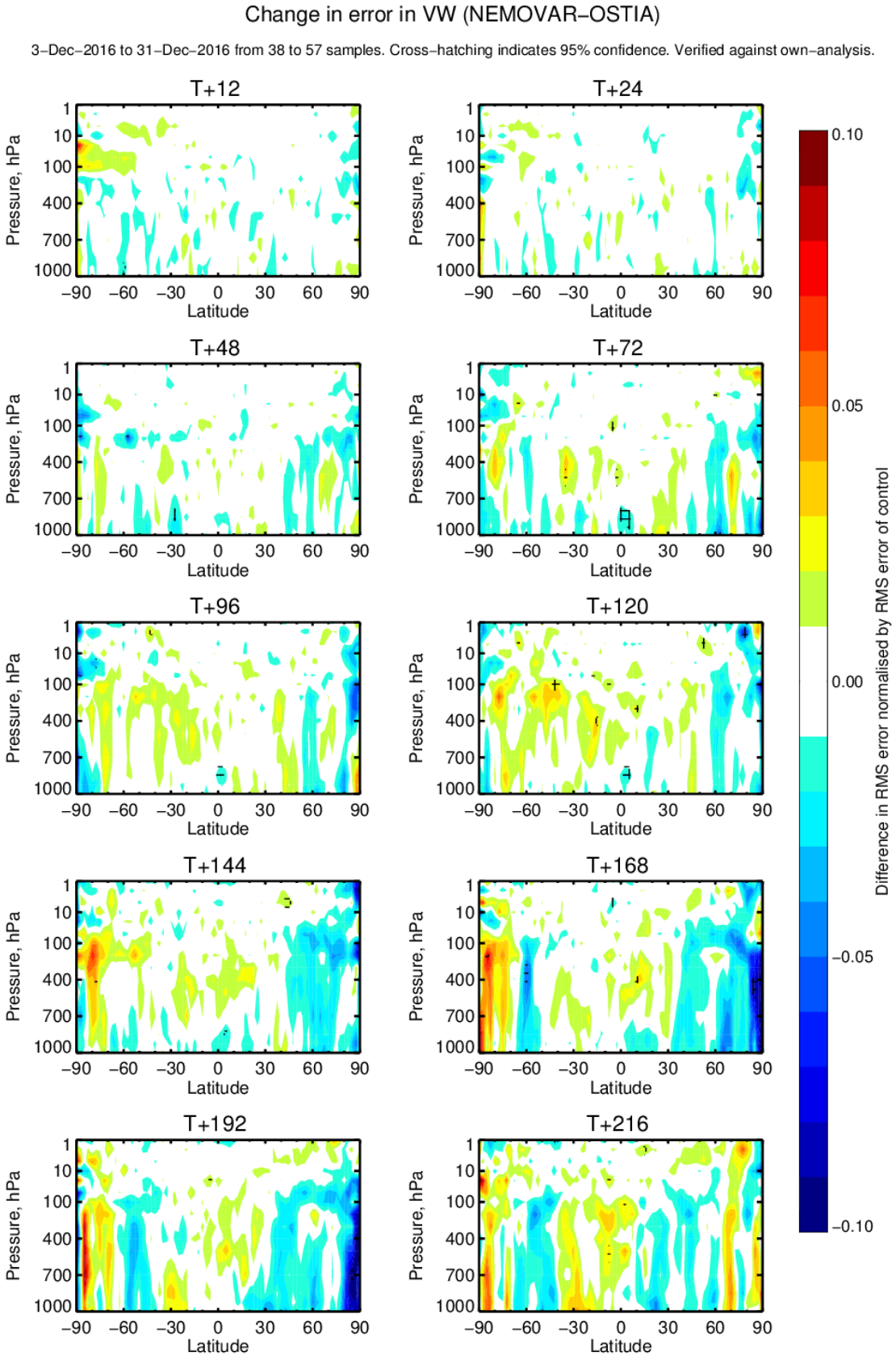


Figure 7: Normalised RMSE error for VW

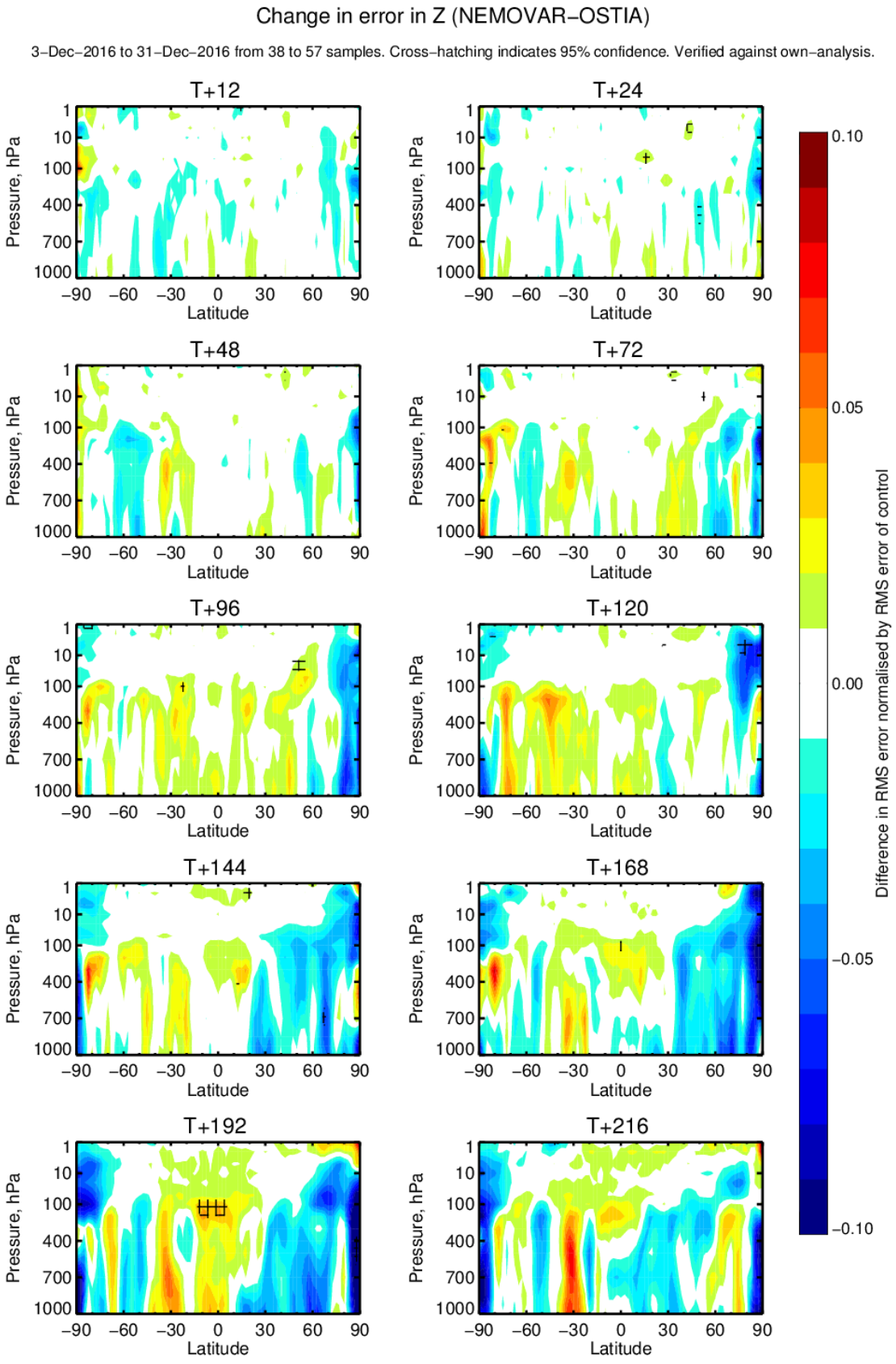


Figure 8: Normalised RMSE error for Z

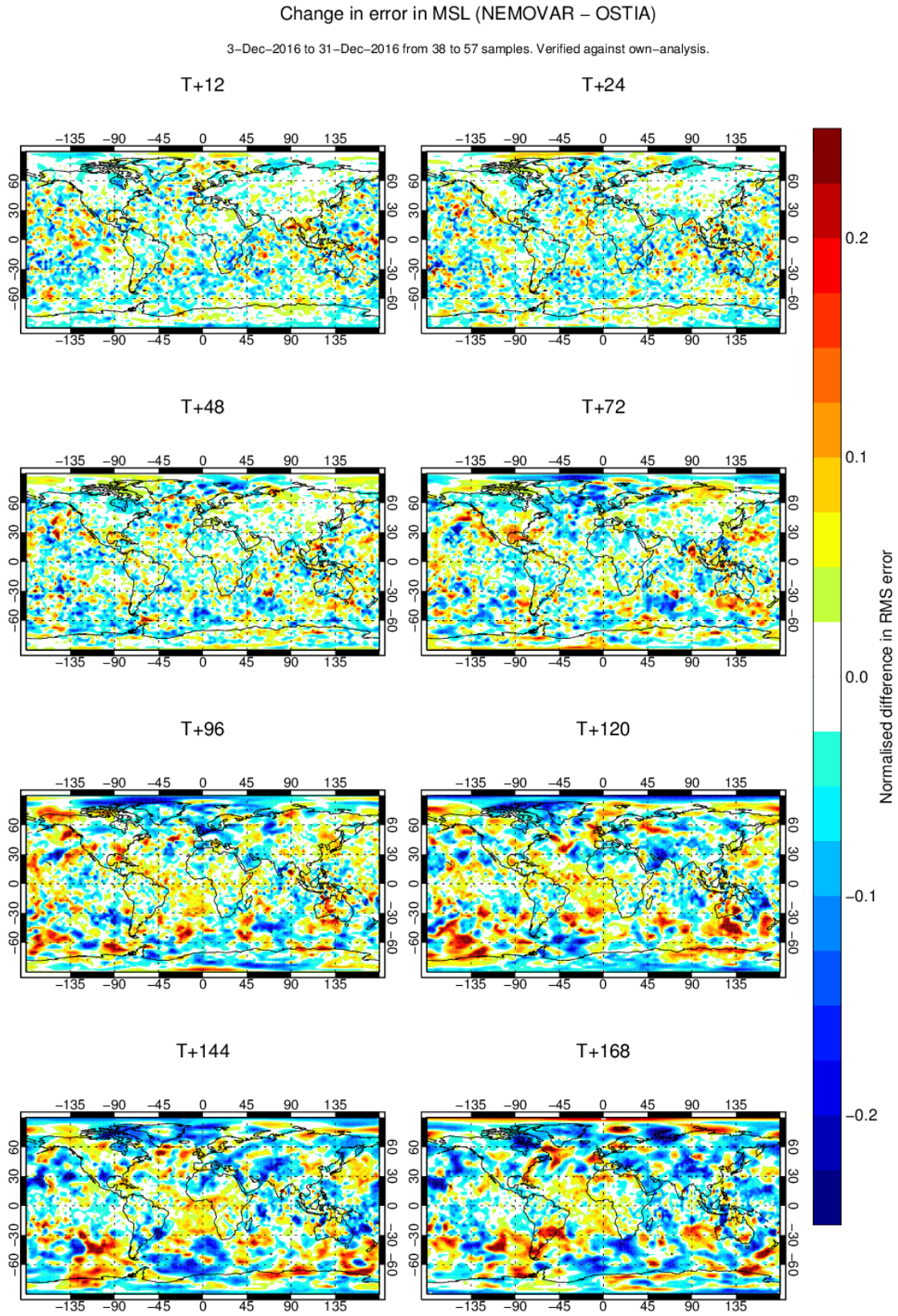


Figure 9: Normalised RMSE error for MSL

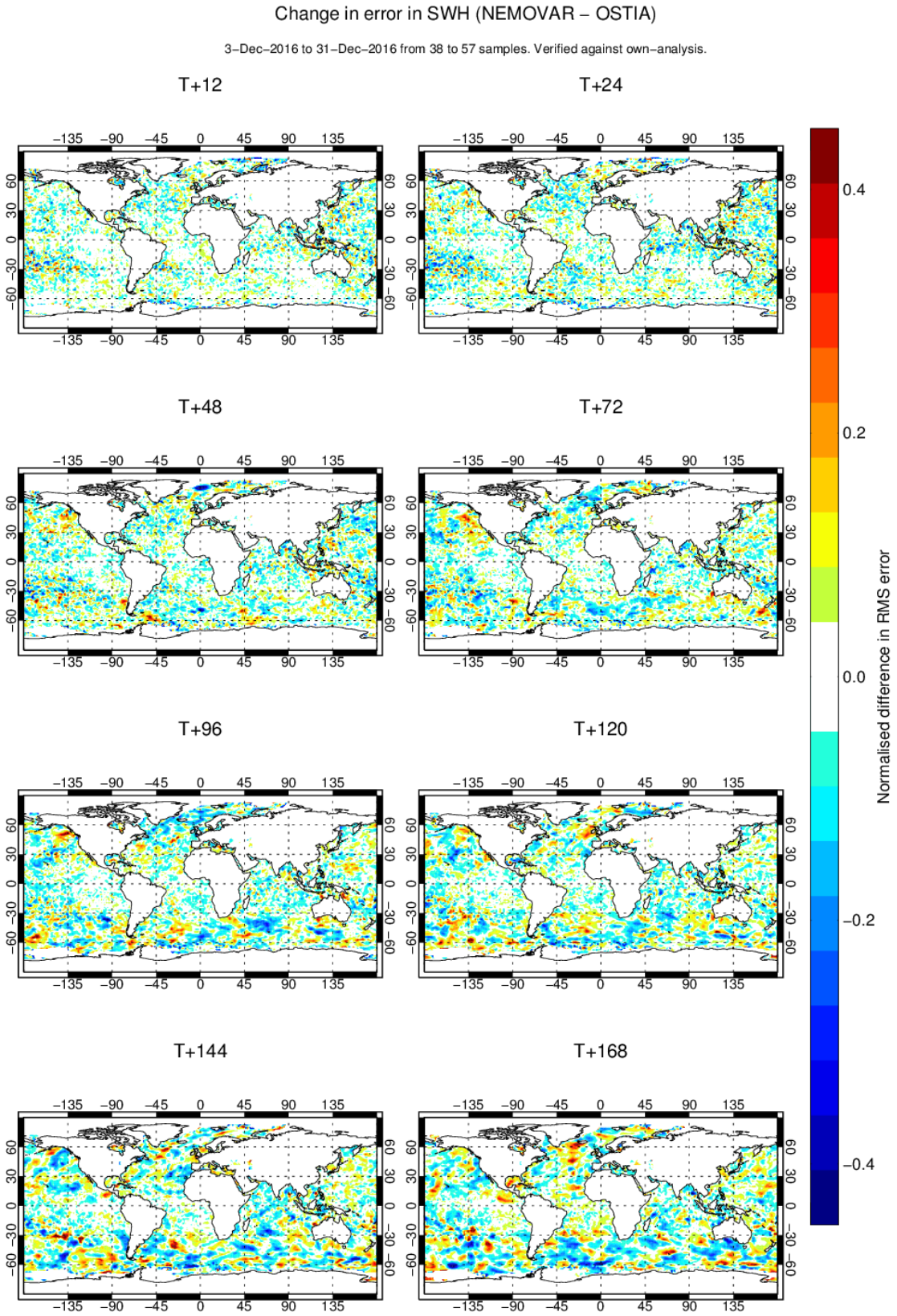


Figure 10: Normalised RMSE error for SWH

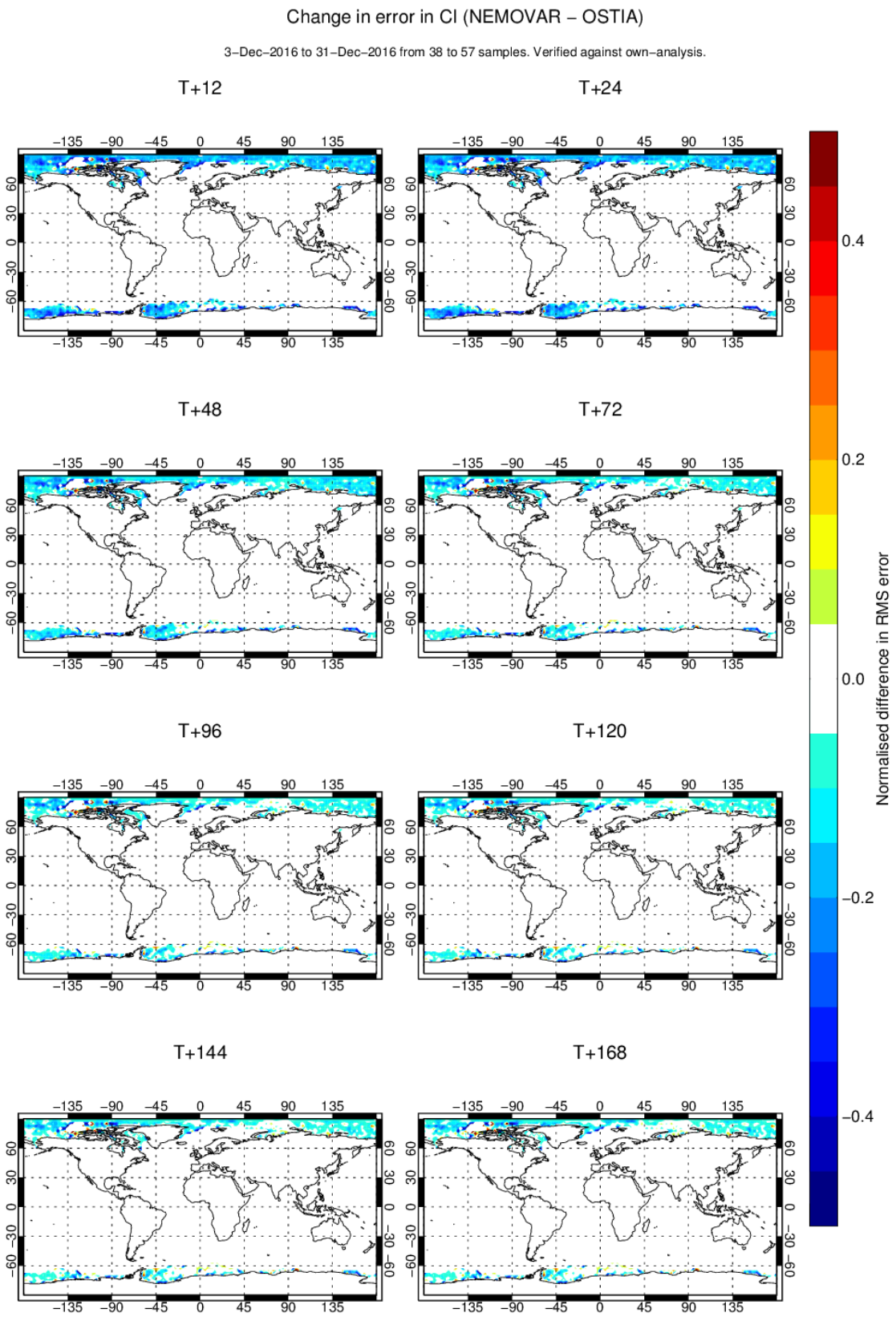


Figure 11: Normalised RMSE error for CI

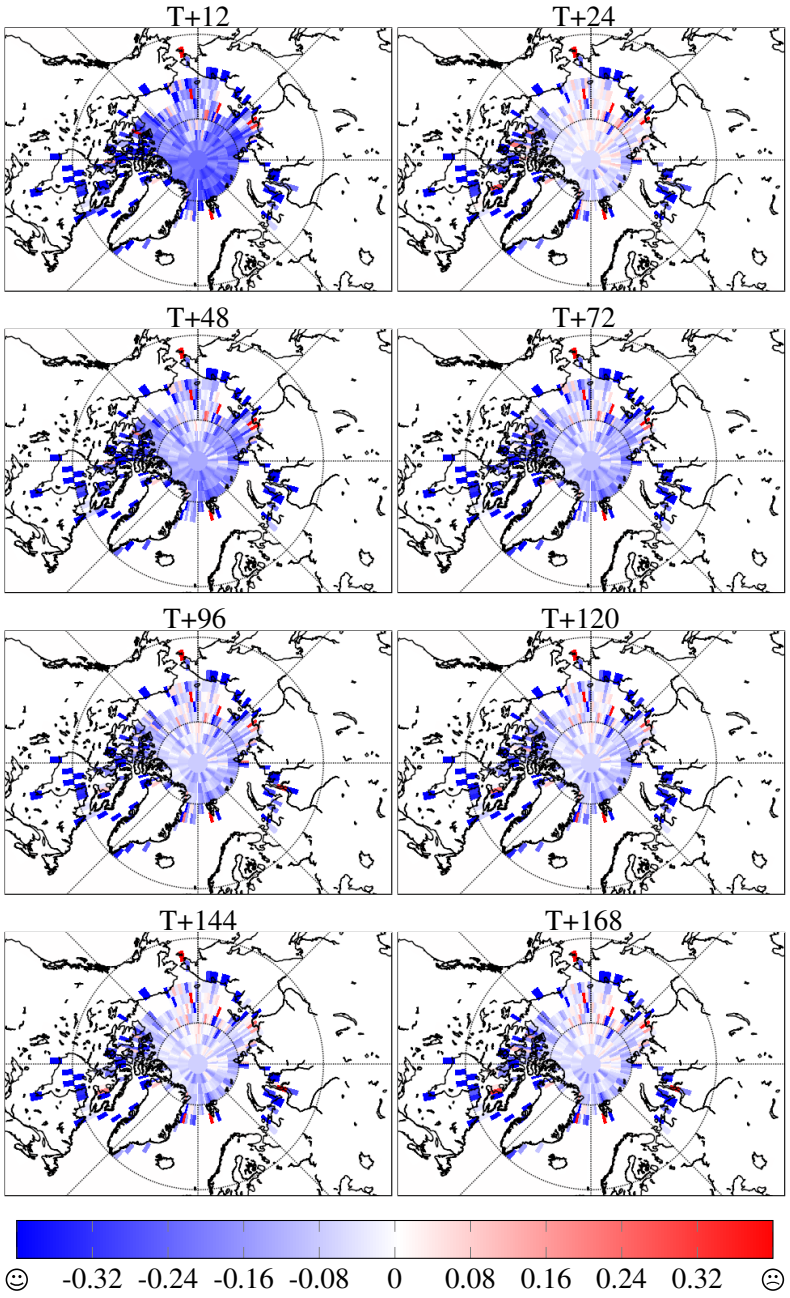
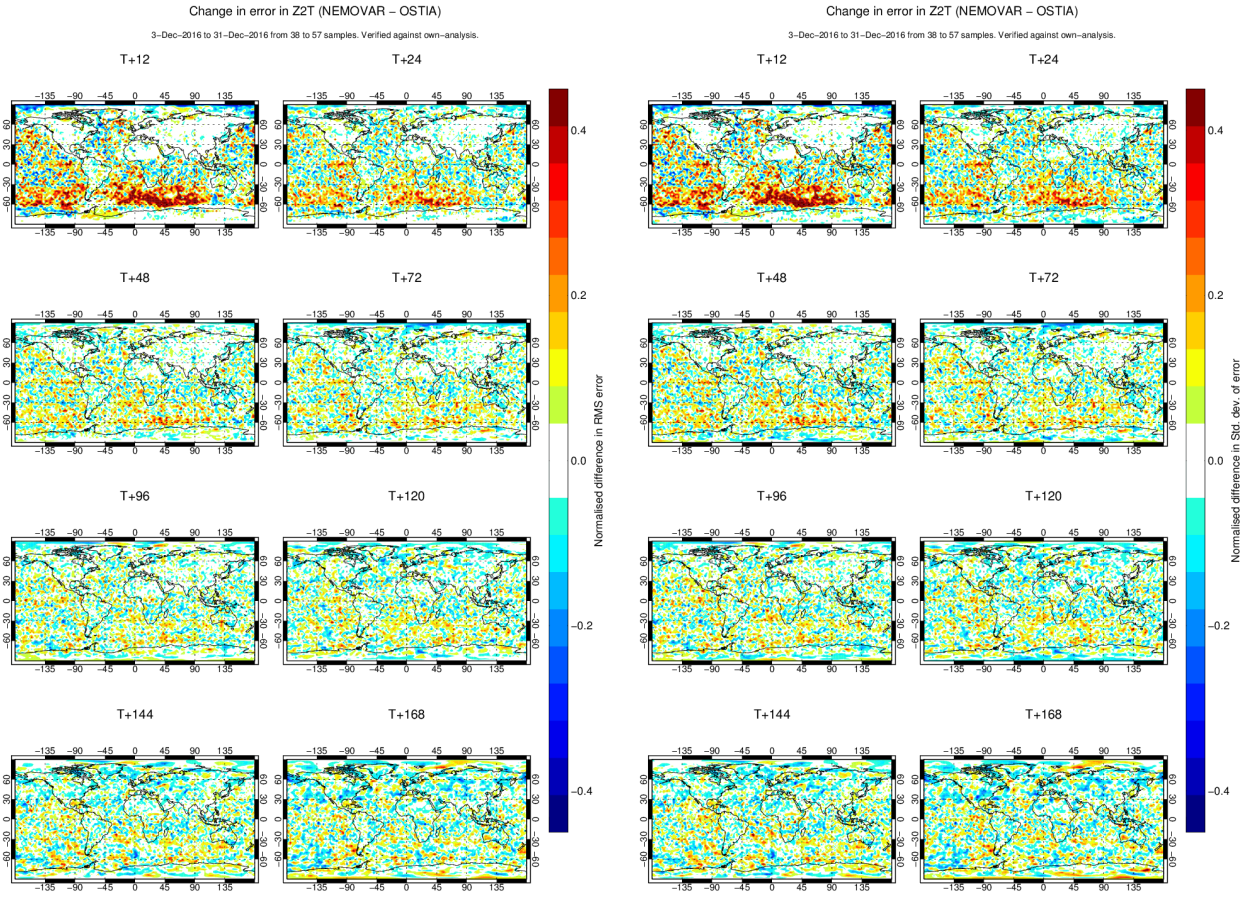


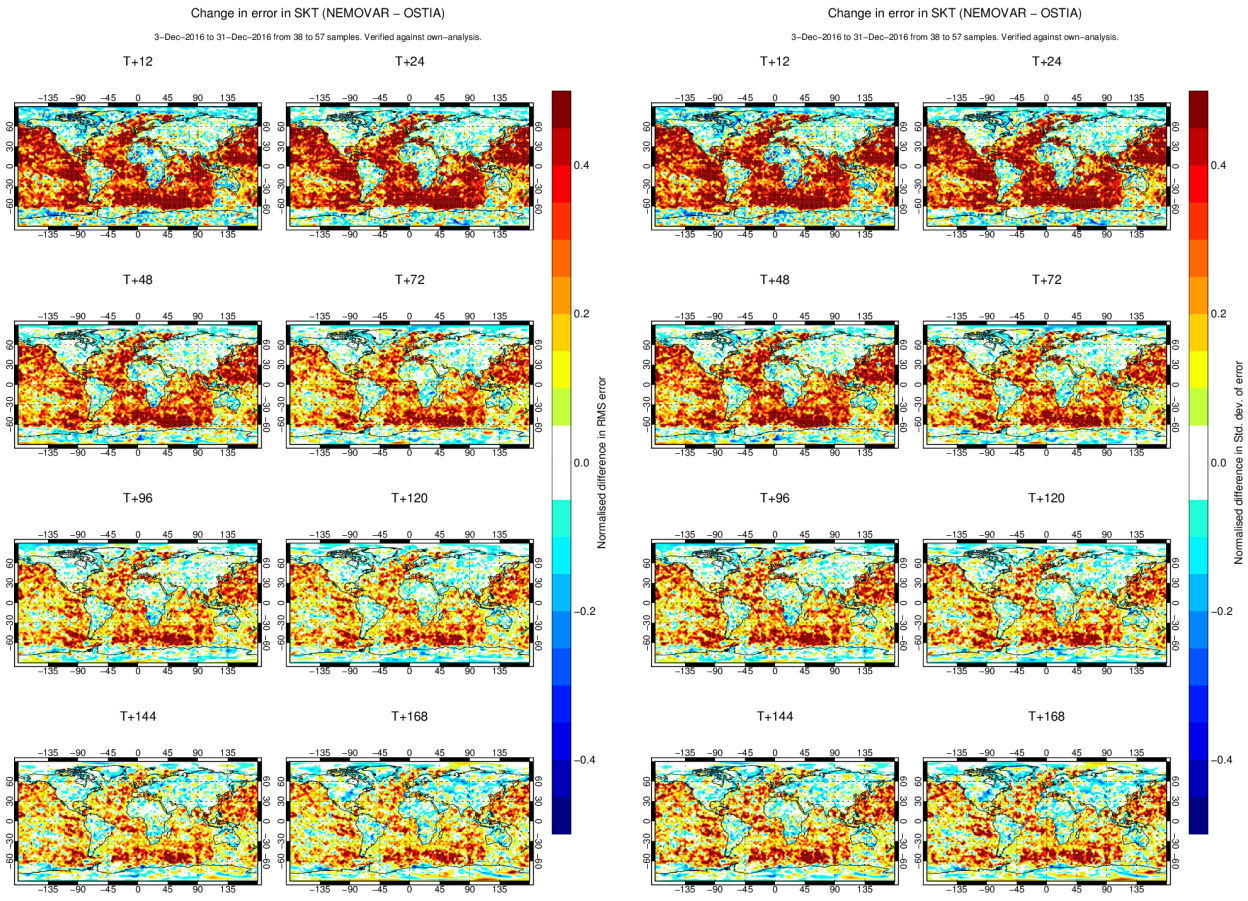
Figure 12: Normalised RMSE error for CI - polar projections



(a) Normalised RMSE

(b) Normalised STD

Figure 13: Errors for Z2T - note that the RMSE error is increasing due to an increase in the STD not the mean error

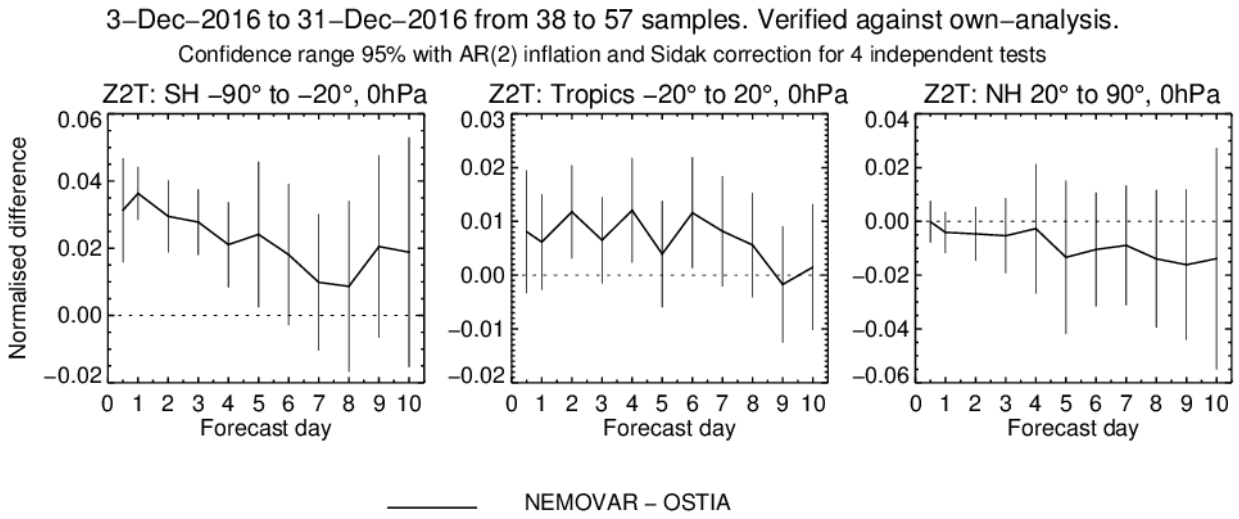


(a) Normalised RMSE

(b) Normalised STD

Figure 14: Errors for SKT - note that the RMSE error is increasing due to an increase in the STD not the mean error

(a) DRMSE against forecast day



(b) DSTD against forecast day

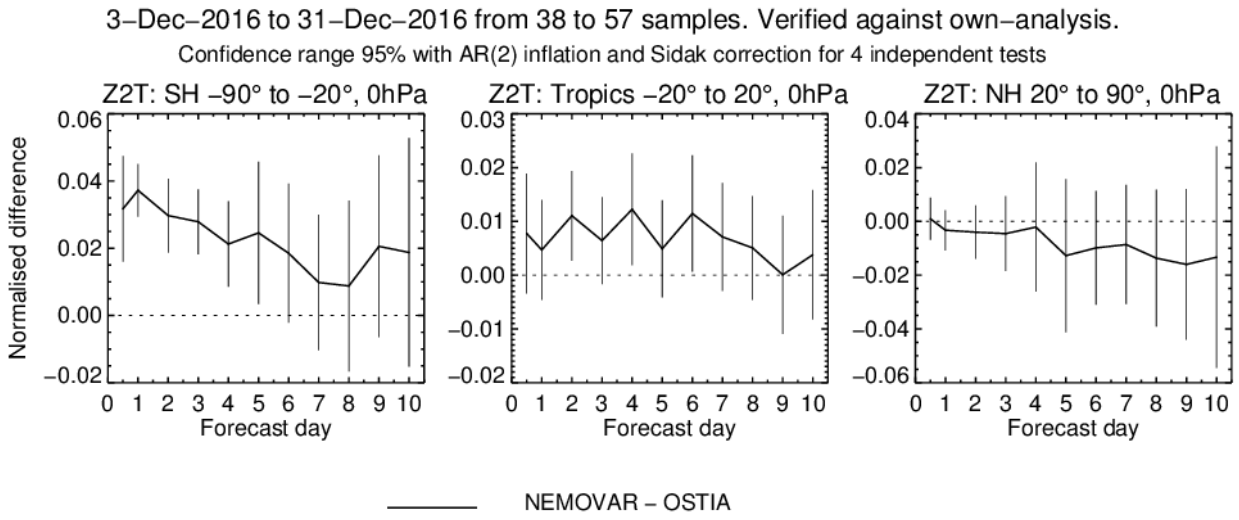
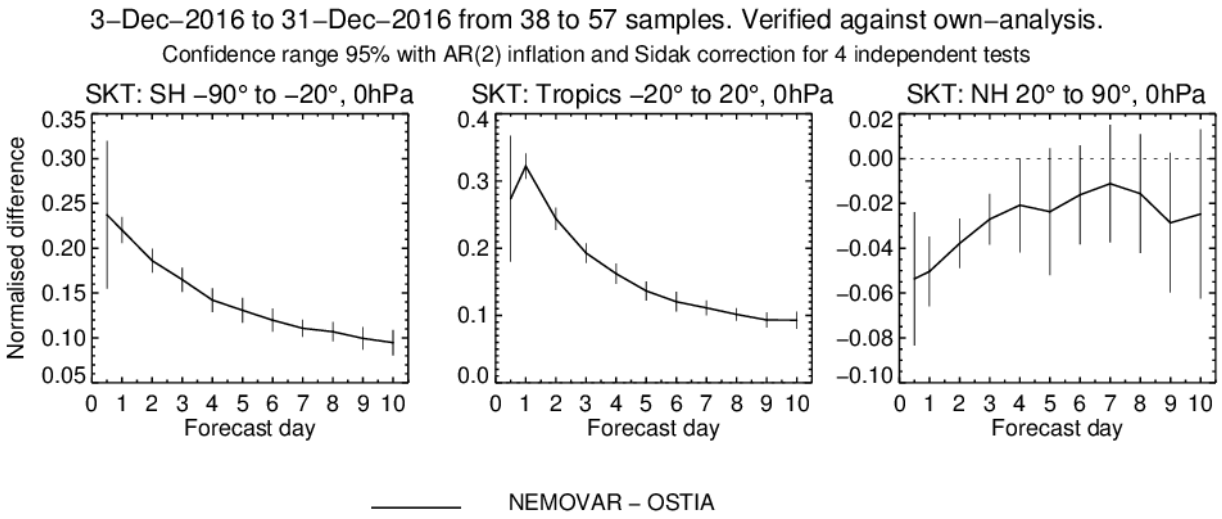


Figure 15: Regional normalised RMSE and STD of Z2T over ocean only. The positive impact in the northern hemisphere may be due to winter sea ice improvements, whereas the degradation over the southern hemisphere could be due to the relatively larger contribution from the ice free regions of the ocean.

(a) DRMSE against forecast day



(b) DSTD against forecast day

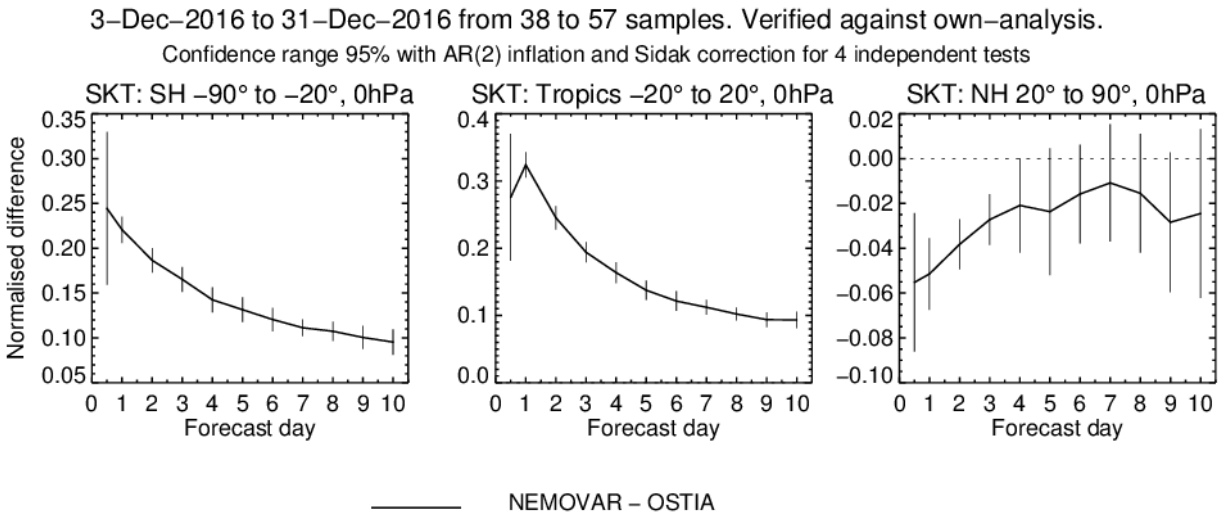


Figure 16: Regional normalised RMSE and STD of SKT over ocean only. The positive impact in the northern hemisphere may be due to winter sea ice improvements, whereas the degradation over the southern hemisphere could be due to the relatively larger contribution from the ice free regions of the ocean.

6 Conclusions and recommendations

The new NEMOVAR product shows an improvement in the sea ice concentration related impacts. Due to the lack of a dynamic sea ice model in 43R3 these impacts can be attributed to a CI field with less variability. Whilst provided on the same grid, the new product has much more resolution (i.e. more spatial variability) in the SST field. This is not unrealistic and leads to an increase in the standard deviation component of variables sensitive to the SST. The mean state is not strongly impacted.

A systematic cooling of the SST around coastlines has been noted. Verification against SYNOP (not shown) indicates a neutral impact over land with non significant rmse reduction of T2m (0.001K).

The new product has only been tested in HRES. Changes to the OCEAN5 analysis both directly from the different SST and CI fields, and indirectly from the resulting changes in the forcing from HRES should be tested.

As the implementation of the new product is scheduled for 28 November 2017, we recommend that the new product should be used for the entirety of the forecast department 45R1 e-suite. As this will have both an atmosphere and an ocean component this will allow the testing of the ocean, as well as giving a consistent SST field for the length of the e-suite.

A Plots of monthly average differences of the OSTIA products

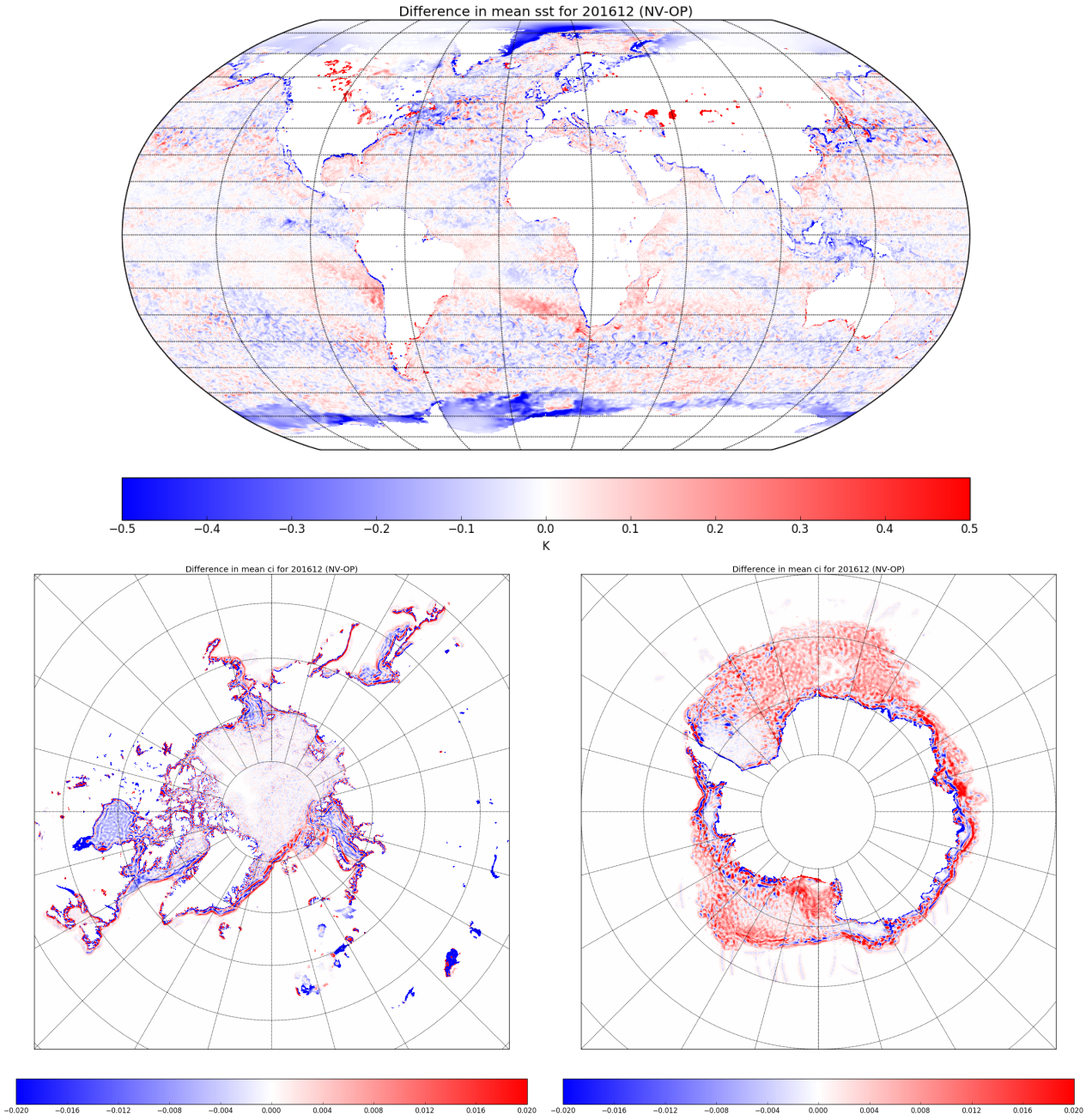


Figure 17: Difference in monthly mean fields for 201612

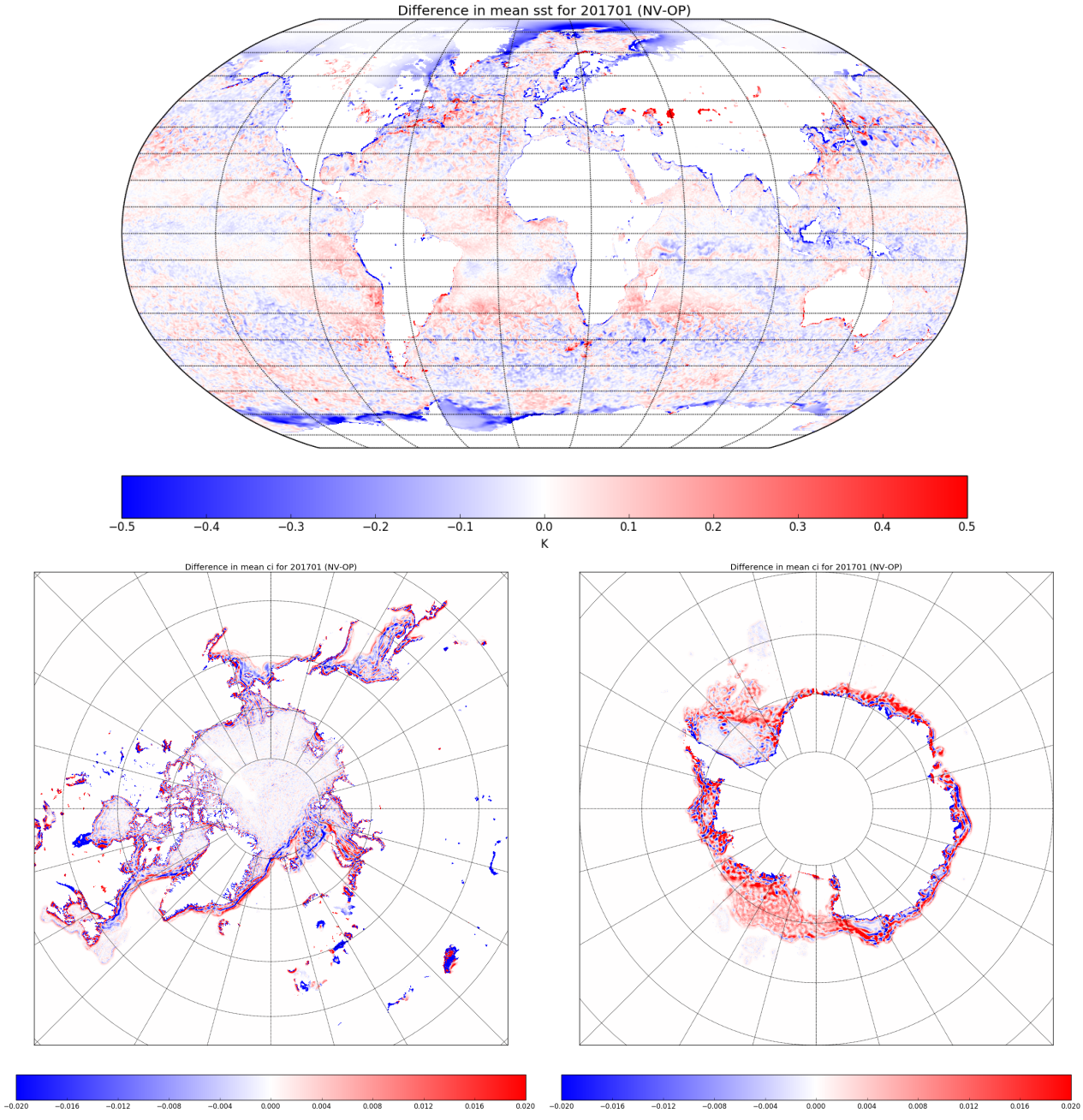


Figure 18: Difference in monthly mean fields for 201701

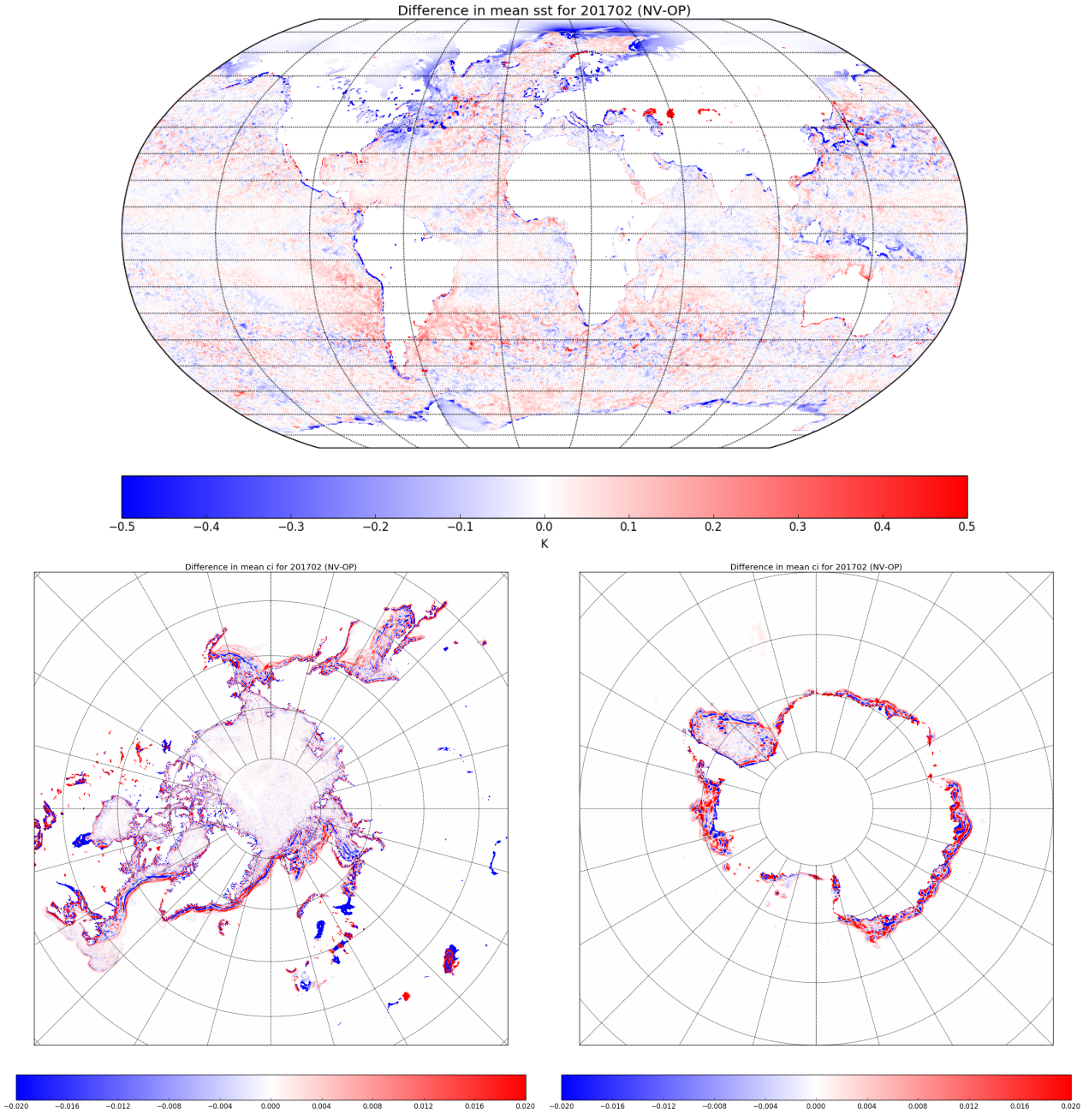


Figure 19: Difference in monthly mean fields for 201702

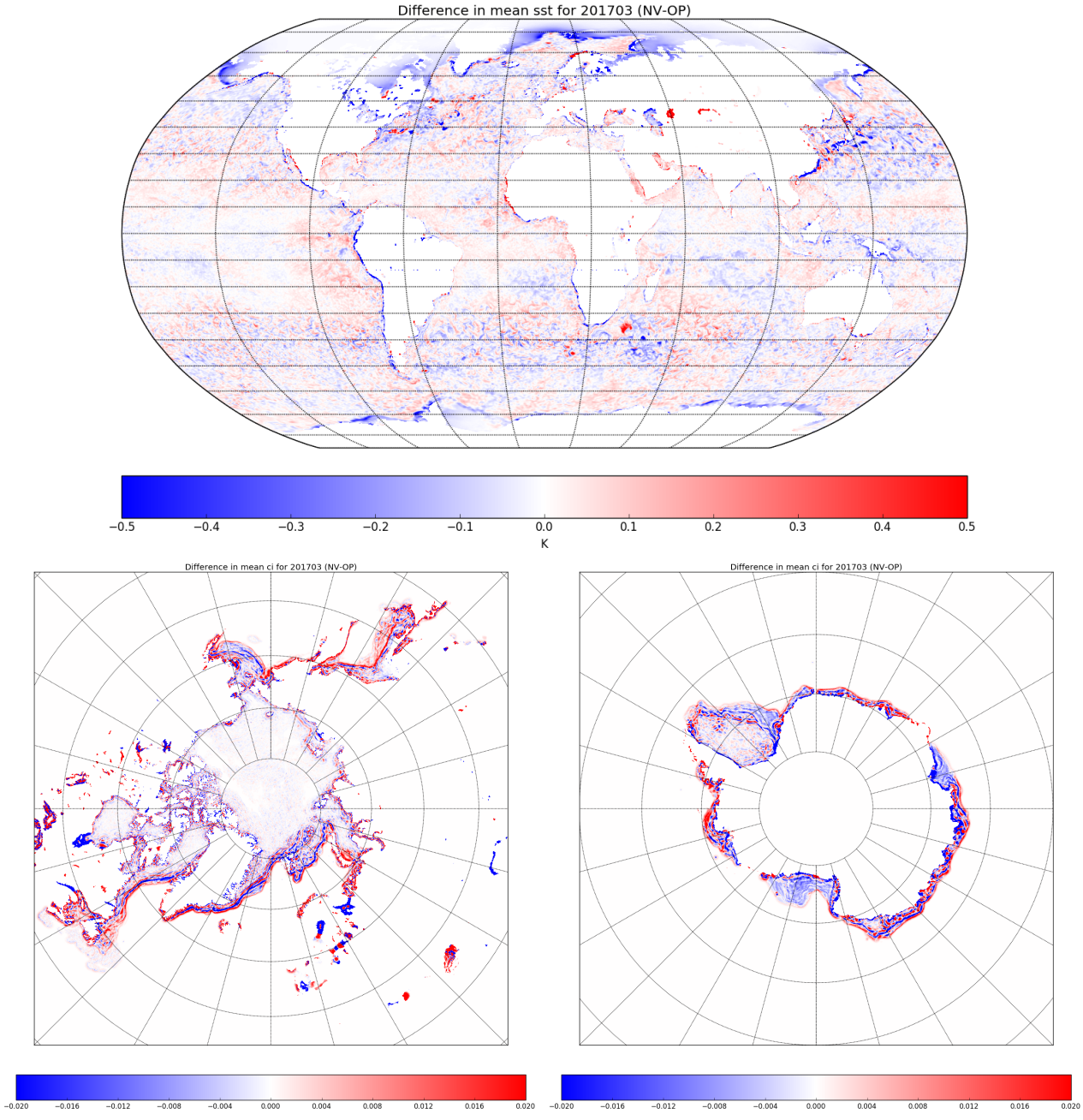


Figure 20: Difference in monthly mean fields for 201703