

# NWP gaps and needs

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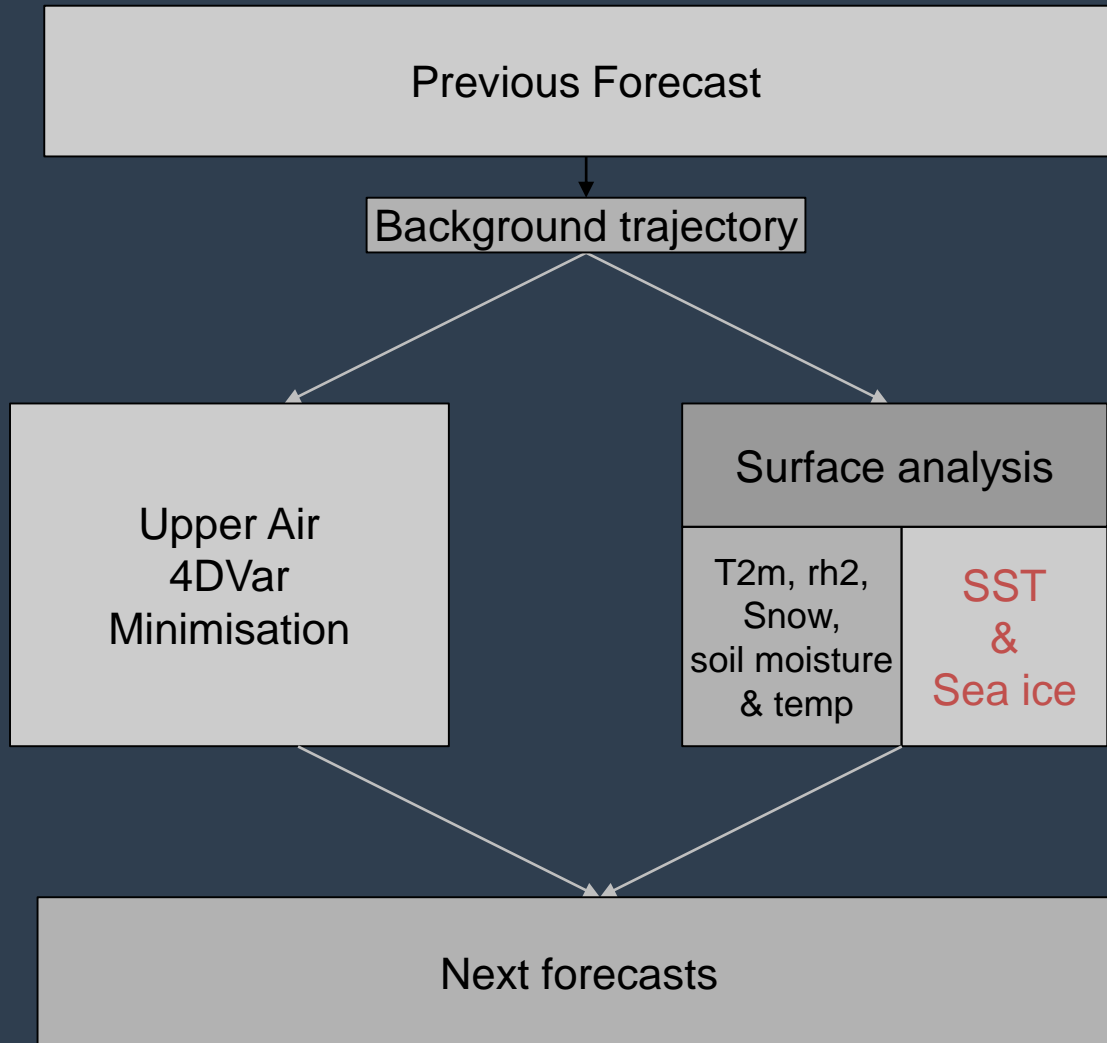
Workshop on observations and analysis of sea-surface temperature and sea ice for  
NWP and Climate Applications

ECMWF 22-25 January 2018

## Outline of presentation:

- Warning: This presentation is going to be very ECMWF centric
- How we deal with SST in the current operational system
  - Uncoupled/coupled systems
- Effect of changes to SST/sea-ice product used
  - Example from today's (23/1 2018) planned upgrade of OSTIA to use "NEMOVAR"
- Effect of SST on uncoupled forecasts.
  - Different SST products:
    - OCEAN5
    - Other products from Copernicus Marine Services CMEMS
  - Effect of timeliness
- Use of SST observations for validation of coupled forecasts
- Conclusions and Recommendations
- Note: In the following **blue** is good, **red** is bad

# SST and Sea Ice in ECMWF Analysis



- The SST and sea ice comes from external sources
- Since 2008 we have been using the OSTIA product
  - SST from the MetOffice
  - Sea ice from EUMETSAT OSI-SAF
    - CI<20% set to 0 (our choice)
- Consistency between sea ice and SST has been challenging. Recent options:
  - Trust sea-ice and adjust SST.
  - Trust SST and adjust sea-ice.
  - Current option: no consistency check.

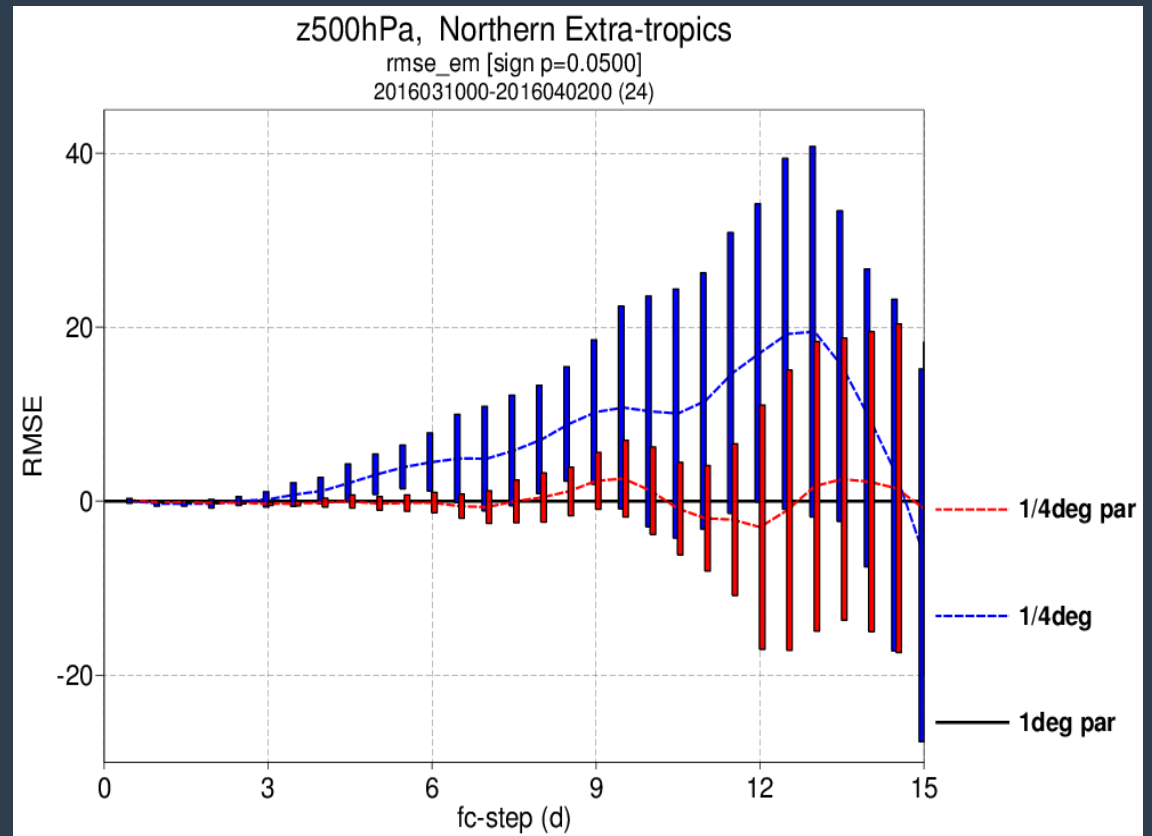


## SST and sea-ice for coupled forecasts

- The ensemble prediction system (ENS) uses the coupled configuration of IFS with the NEMO ocean model
  - 51 forecasts twice a day
- The initial conditions for the NEMO model is from the OCEAN5 data assimilation system described by Hao earlier
- In the first implementation of the coupled model from day 0 was with a very coarse resolution ocean model, so we implemented a “partial coupling” scheme where the atmosphere sees the SST of the atmospheric initial conditions (*e.g* OSTIA) with added SST tendencies from the ocean model rather the full SST from the ocean model
  - Preserves small scales structure of OSTIA in the SST field
  - After 5 day we gradually switched to full coupling where the SST of the atmosphere and the ocean are consistent.
- During the ocean resolution upgrade from 1.0 degree to 0.25 degree we found that it was still beneficial to keep this scheme.

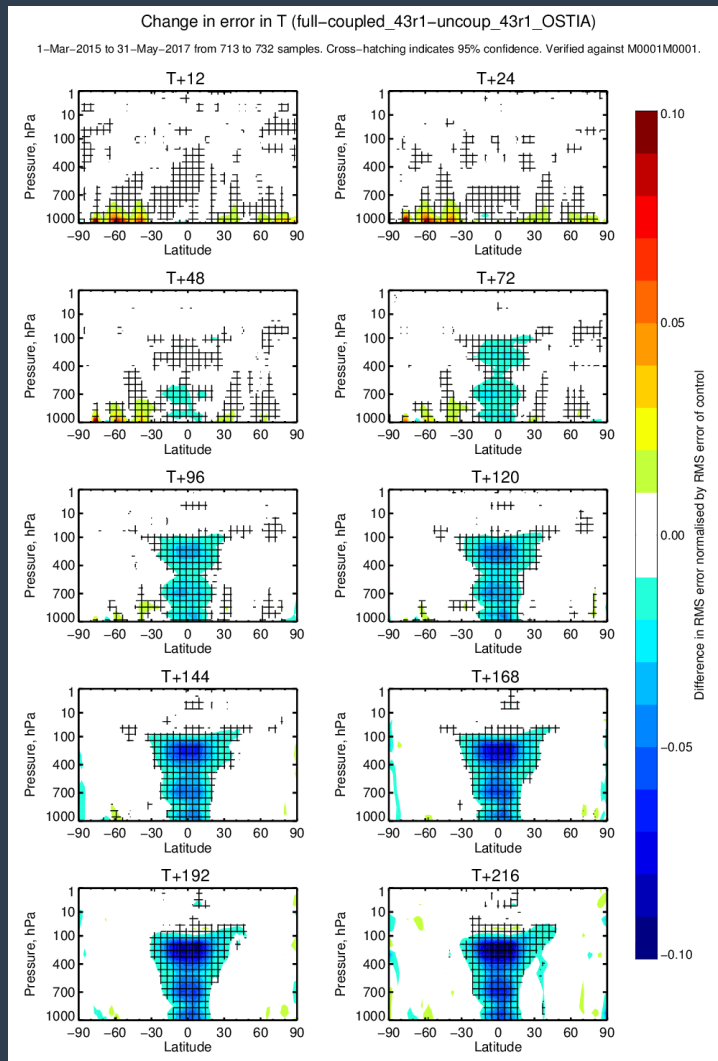
# Partial coupling: What it is and why we do it

- With partial coupling we add the change of SST from the ocean model to the SST of the initial conditions (OSTIA) rather than use the SST of the ocean model
- In practice we only do this for the first 4 days and gradually change to use the ocean SST directly (below figure).
- The ENS scores over Europe improves if we do this (right figure).

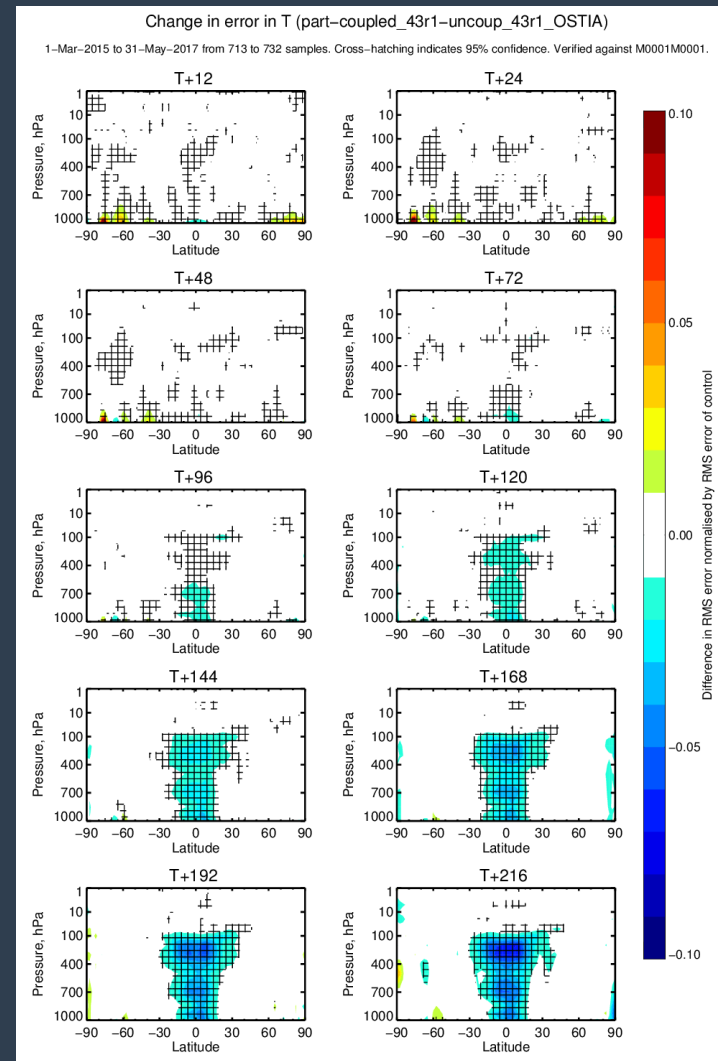


Results from Simon Lang

# Effect of partial coupling as currently implemented



Full coupling

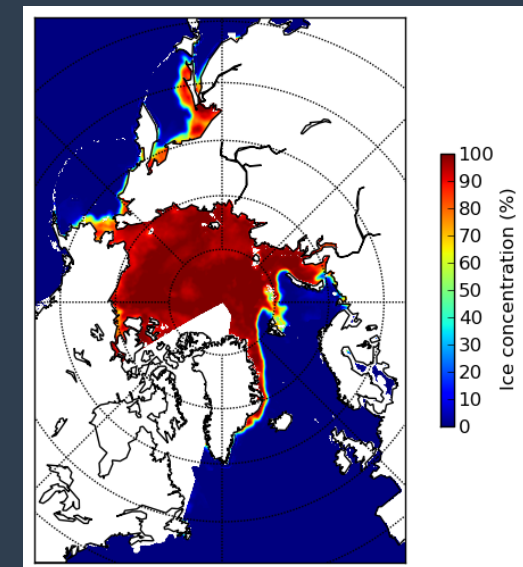
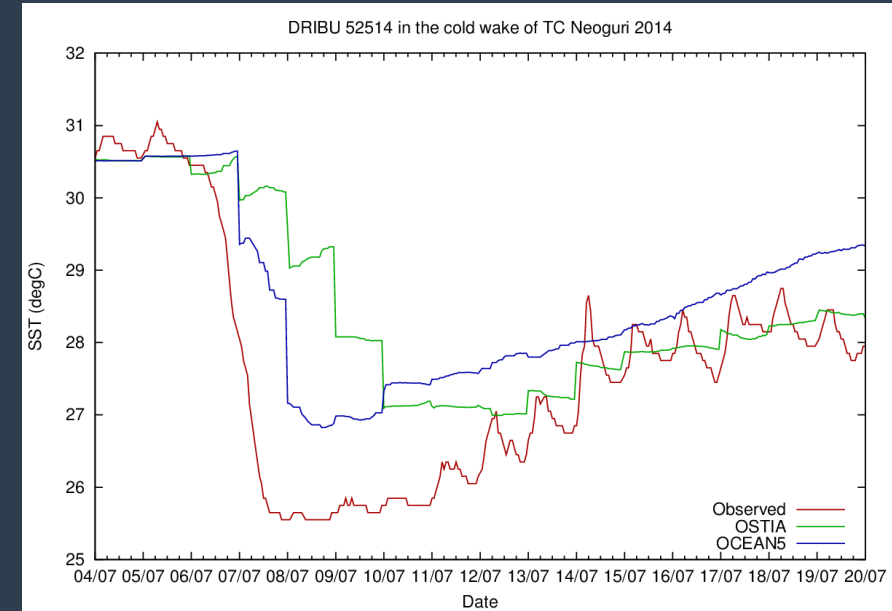


Partial coupling everywhere

- Degradation of temperature at low levels in the extra-tropics with full coupling
  - Seems to effect scores over Europe (previous slide).
- Somewhat mediated with the partial coupling scheme 😊
- However the benefit of coupling in the tropics becomes smaller 😞

# Examples of limitations and recent issues with OSTIA

- Rapid changes in SST (e.g. upwelling) takes a long time absorb in OSTIA
  - For coupled TC predictions this can lead to over prediction of intensity due to unrealistic available heat
  - SST from the OCEAN5 ocean analysis reacts quicker to the change
- Day to day consistency not always good
  - Day -1 solution A, day 0 solution B, day 1 solution A
  - Forecasters don't like that
- Spurious sea ice around Denmark, Iceland, Japan, ...
  - Have been sorted
- Large chunks of sea ice missing in some regions due to problems
- Delivery delays
  - Happens to all of us ☹️

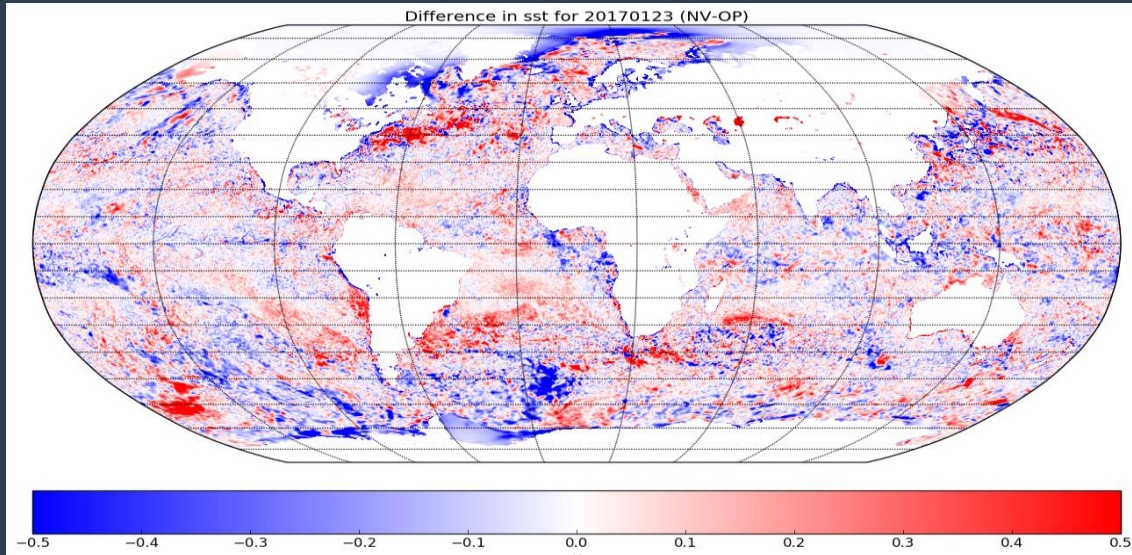




# Effect of change to the SST product in NWP

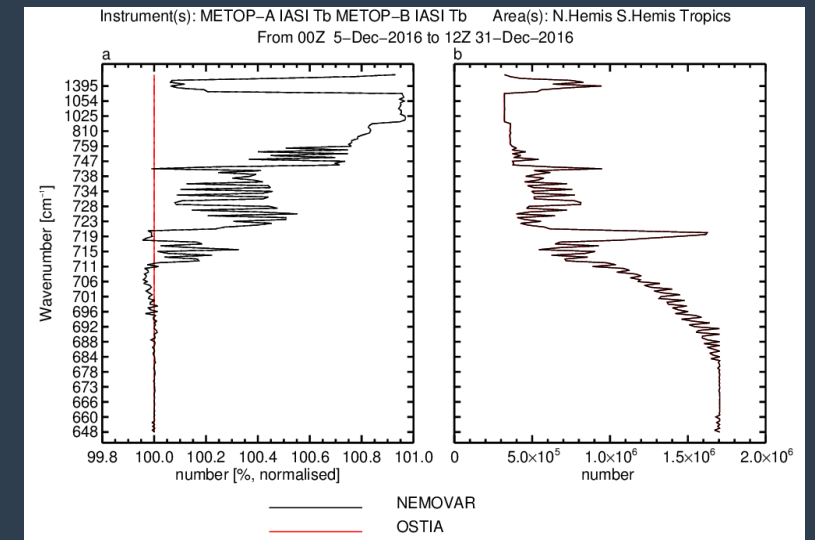
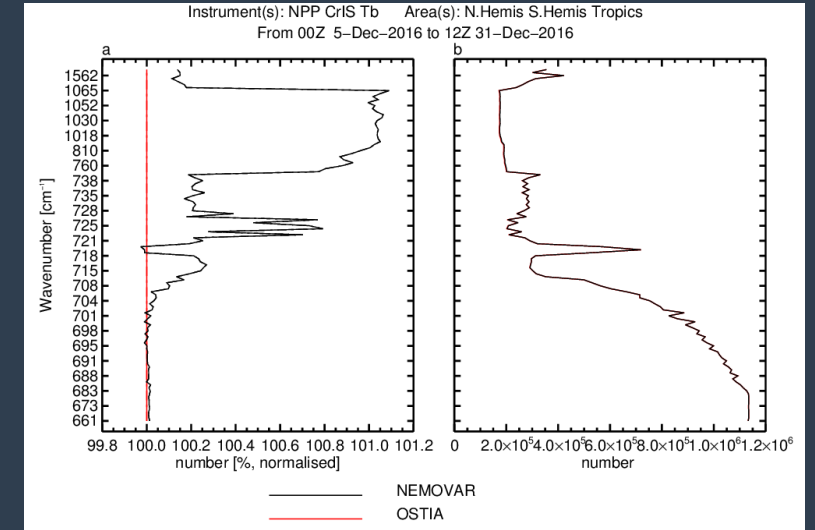
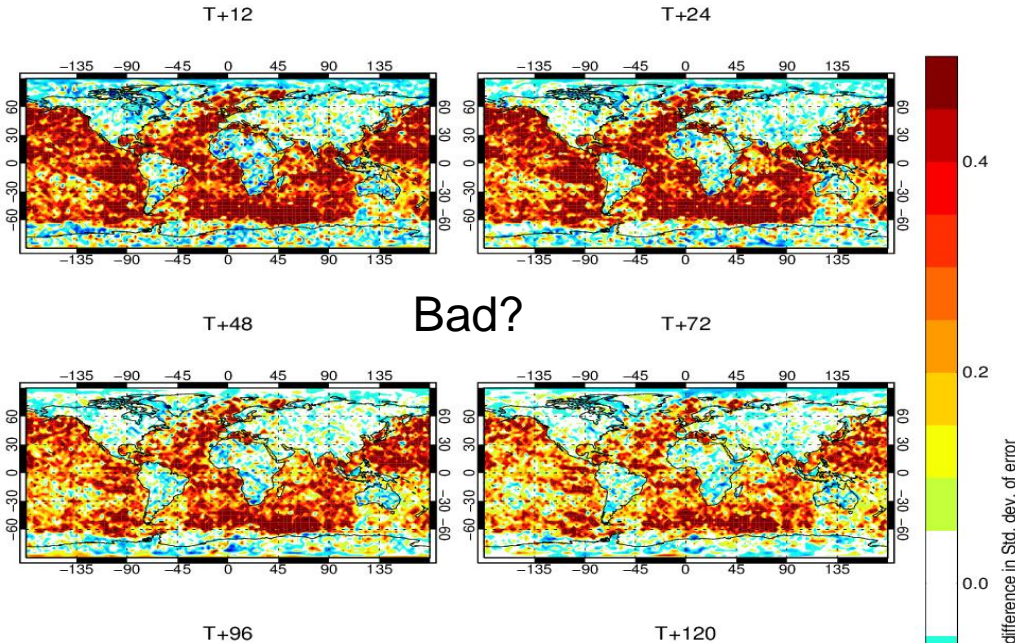
- Today (23/1 2018) OSTIA is supposed to upgrade their system to variational based data assimilation system
  - More small scales in the SST field
  - Assimilation rather than interpolation of the OSI-SAF sea ice
- Increased variability can lead to issues with verification
- SST and sea-ice affects the assimilation of satellite data
  - It is not just the model which are affected!!!
- On the following slide are results from the pre operational test data sets provided by the MetOffice

# SST product with smaller spatial scales



Change in error in SKT (NEMOVAR - OSTIA)

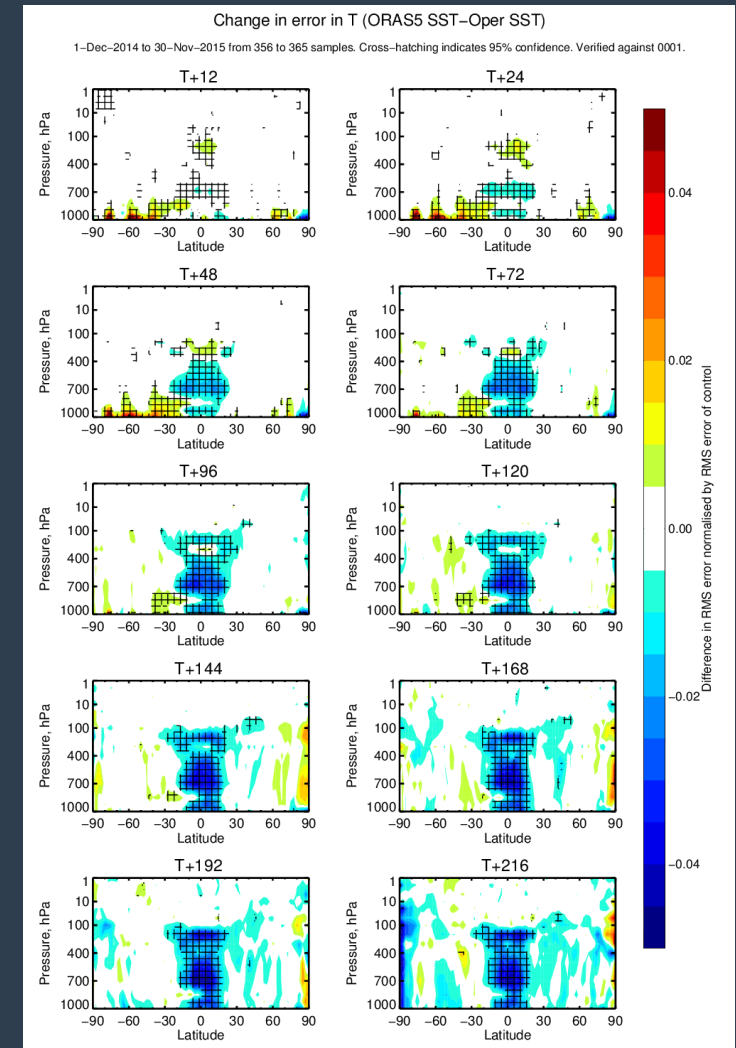
3-Dec-2016 to 31-Dec-2016 from 38 to 57 samples. Verified against own-analysis.



More data accepted: Good. 10

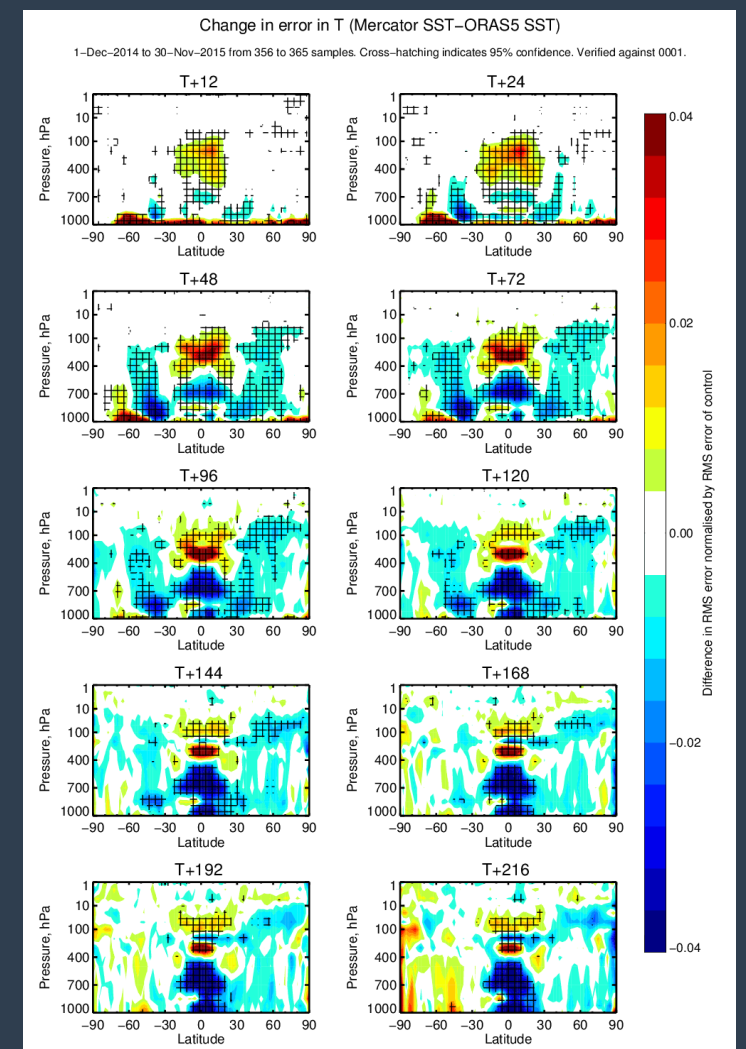
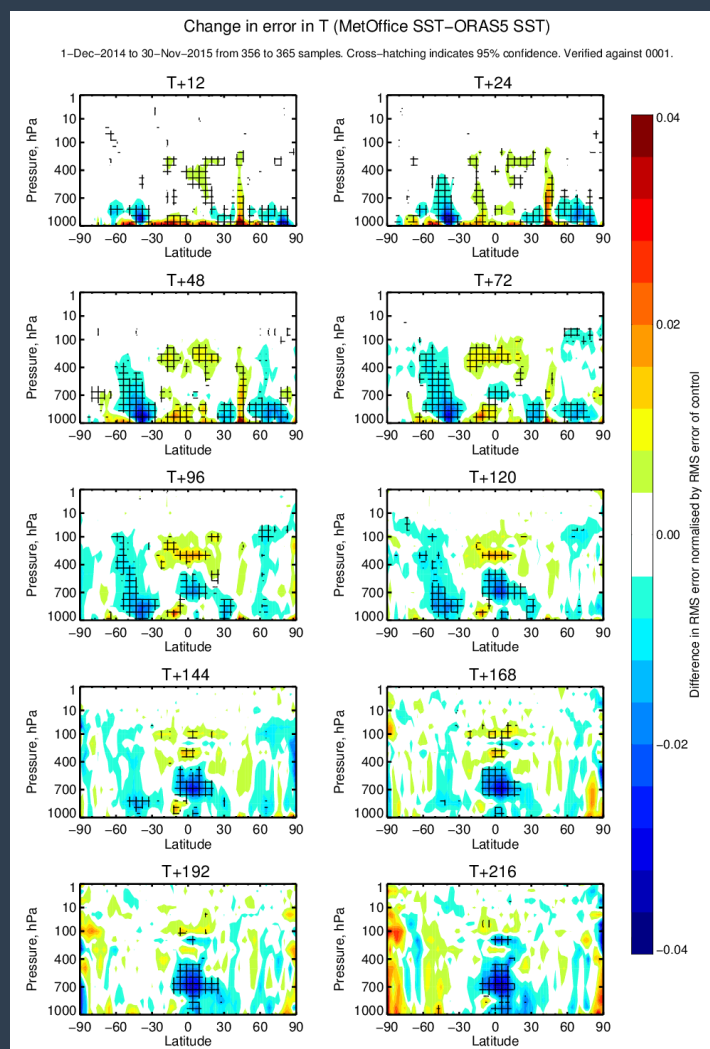
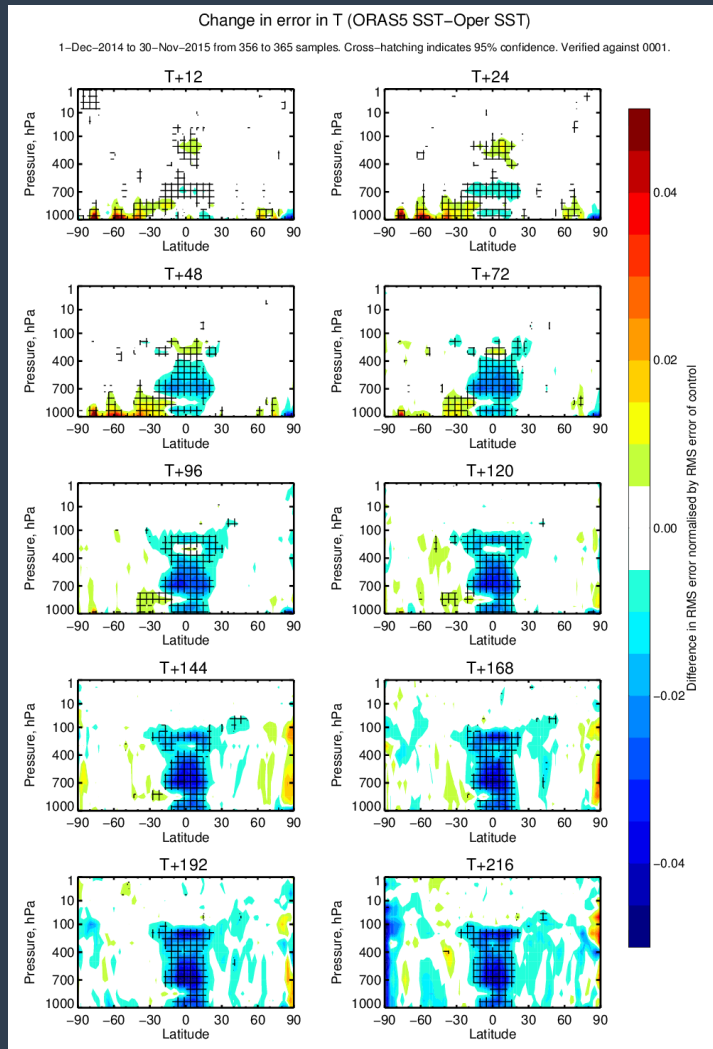
# OCEAN5 SST: temperature RMSE relative to OSTIA SST

- Uncoupled forecasts with SST/sea-ice from either OSTIA or OCEAN5
- Verification against operational analysis which uses OSTIA
- The SST from OCEAN5 seems to do better in the tropics
  - Speculation: Is the dynamically more consistent SST important?
- Similar issue in the short range for the extra-tropics as discussed with partial coupling





# OCEAN5 SST/sea-ice versus other SST/sea-ice products from CMEMS website:



MetOffice 1/4 deg relative to OCEAN5

Mercator 1/12 deg relative to OCEAN5

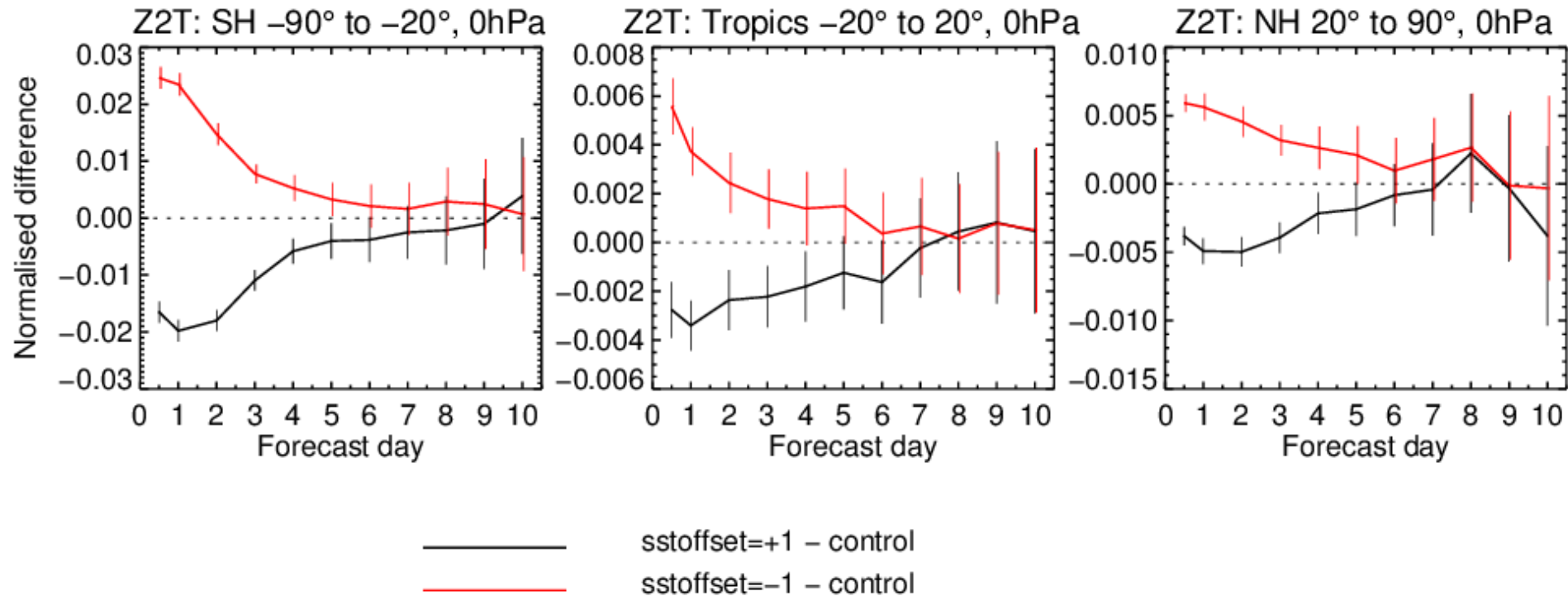
## Timeliness issues of SST with our current setup

- As discussed earlier the SST and sea-ice value can be several days old when we use it
- To investigate the sensitivity to this we designed a set of experiments where we ran a set of forecasts only runs with:
  - Use OSTIA from yesterday as operations (control)
  - Use OSTIA at the right day (SSTDELAY+1)
  - Use OSTIA from the day before yesterday (SSTDELAY-1)
- The experiments were verified against our operational analysis which uses the SST of yesterday
- We can obviously not do this in operations since the data is not available, but positive impact could suggest that we should move the SST/sea-ice analysis closer to the 4D-VAR analysis to get better timeliness of the SST/sea-ice fields

# Effect of timeliness of OSTIA SST products 1

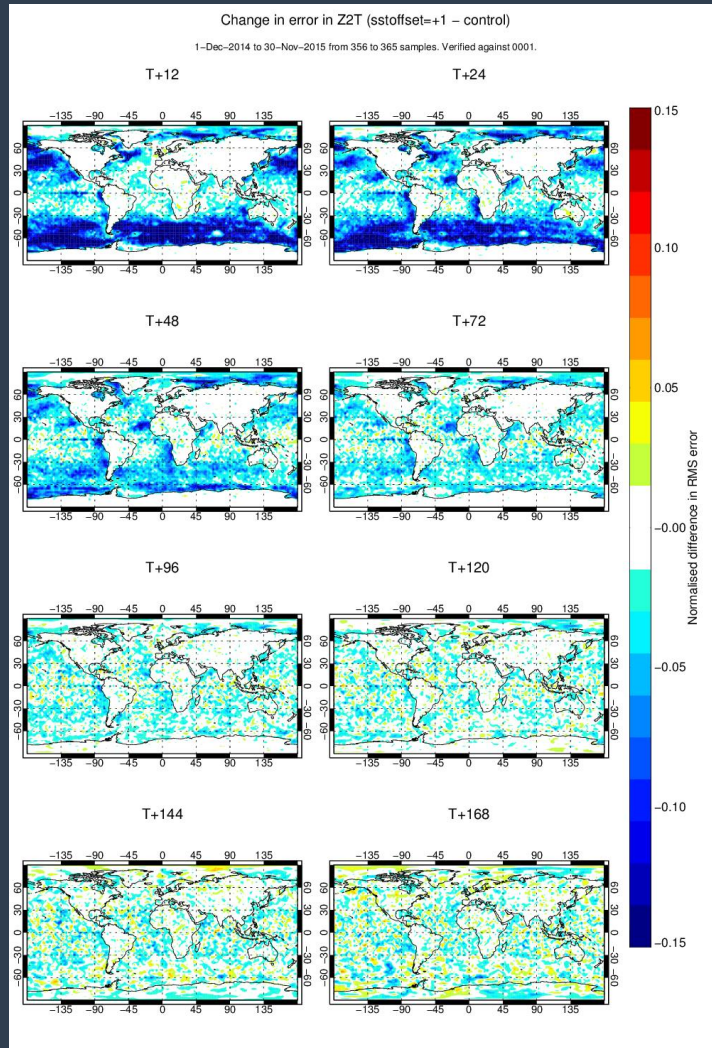
1–Dec–2014 to 30–Nov–2015 from 356 to 365 samples. Verified against 0001.

Confidence range 95% with AR(1) inflation and Sidak correction for 8 independent tests

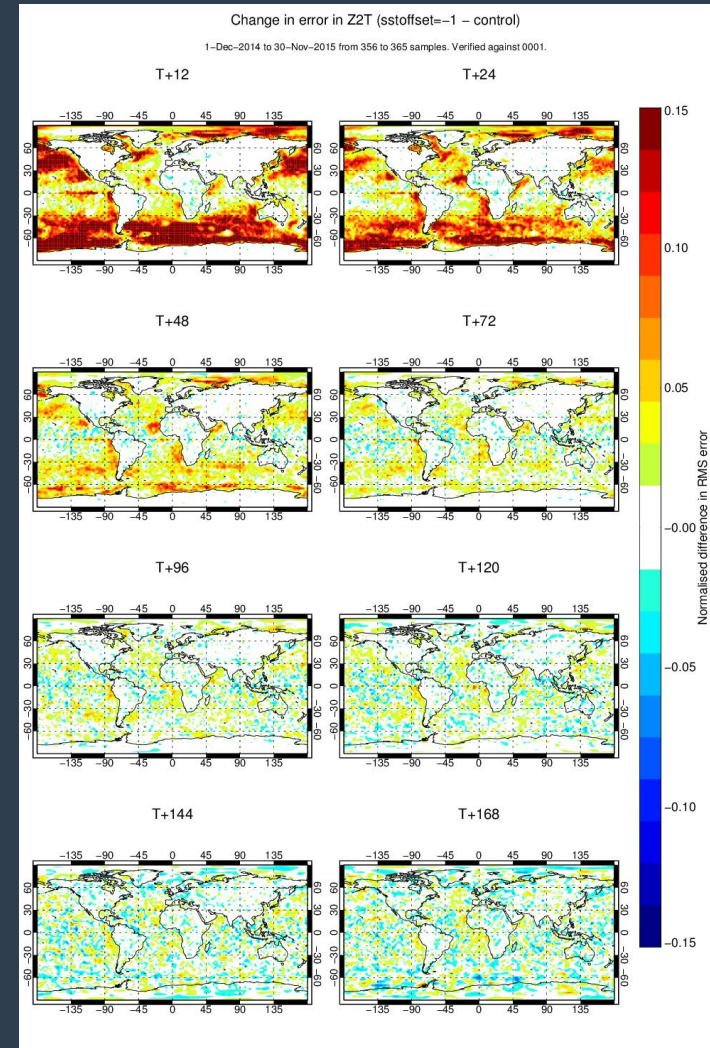


# Effect of timeliness of OSTIA SST products 2

SSTDELAY+1



SSTDELAY-1





# Planned SST/seaice changes the operational NWP system during 2018:

- CY45R1:

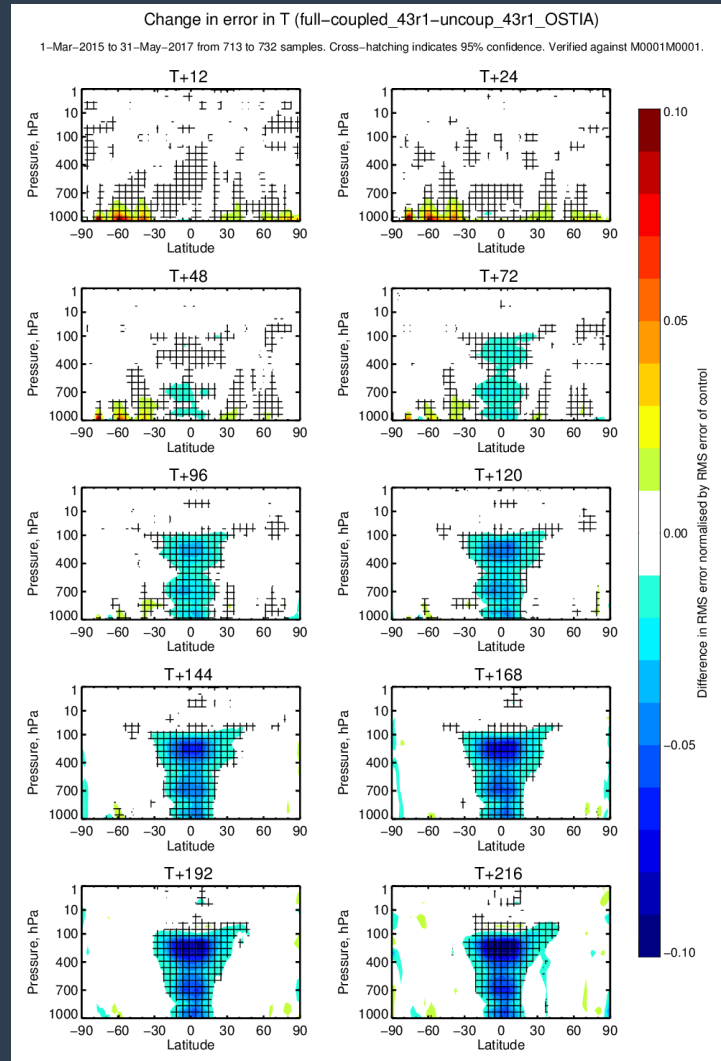
- HRES coupled to NEMO (0.25 degree) for the long forecast
  - This means that all forecasts issued by ECMWF will be using a coupled model
- Introduction of full coupling in the tropics
  - OCEAN5 from day 0 in the tropics
  - This will be done for both HRES and ENS
- Using of OCEAN5 sea-ice in the atmospheric analysis system
  - Increases the coupling between the atmosphere and the ocean in the analysis system

- CY46R1:

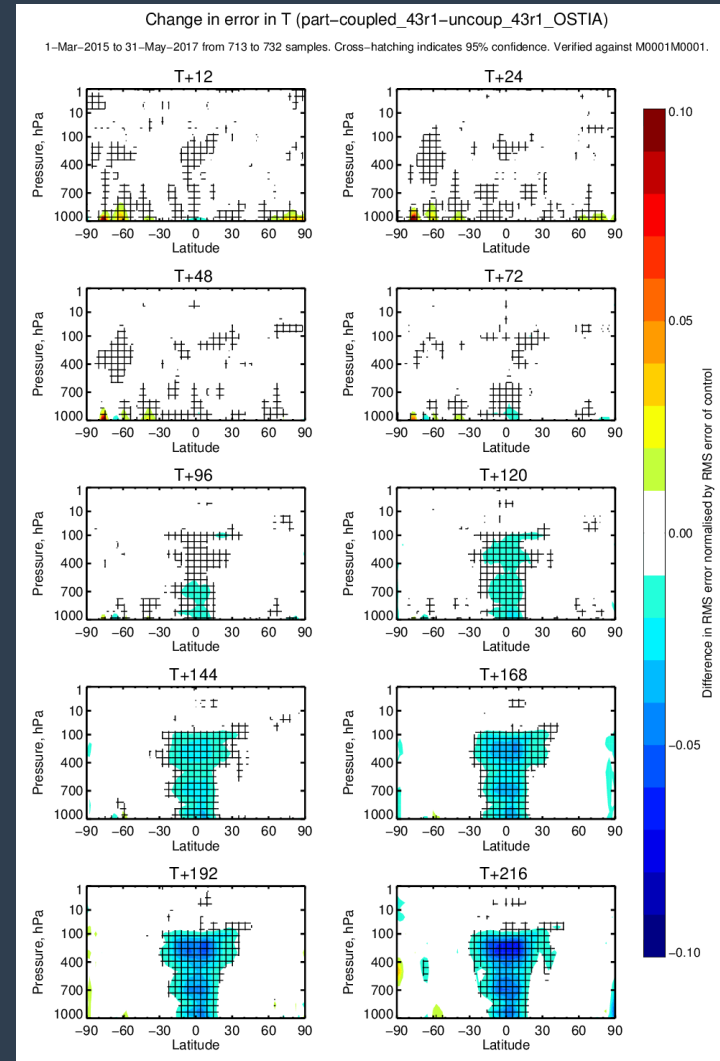
- Use the SST from OCEAN5 in the tropics merged with OSTIA in the extra-tropics in the atmospheric analysis system is been investigated
  - Increases the coupling between the atmosphere and the ocean in the analysis system yet another step
  - Results on next+1 slide comparing this change to a CY45R1 like setup (e.g. with a coupled long forecasts)



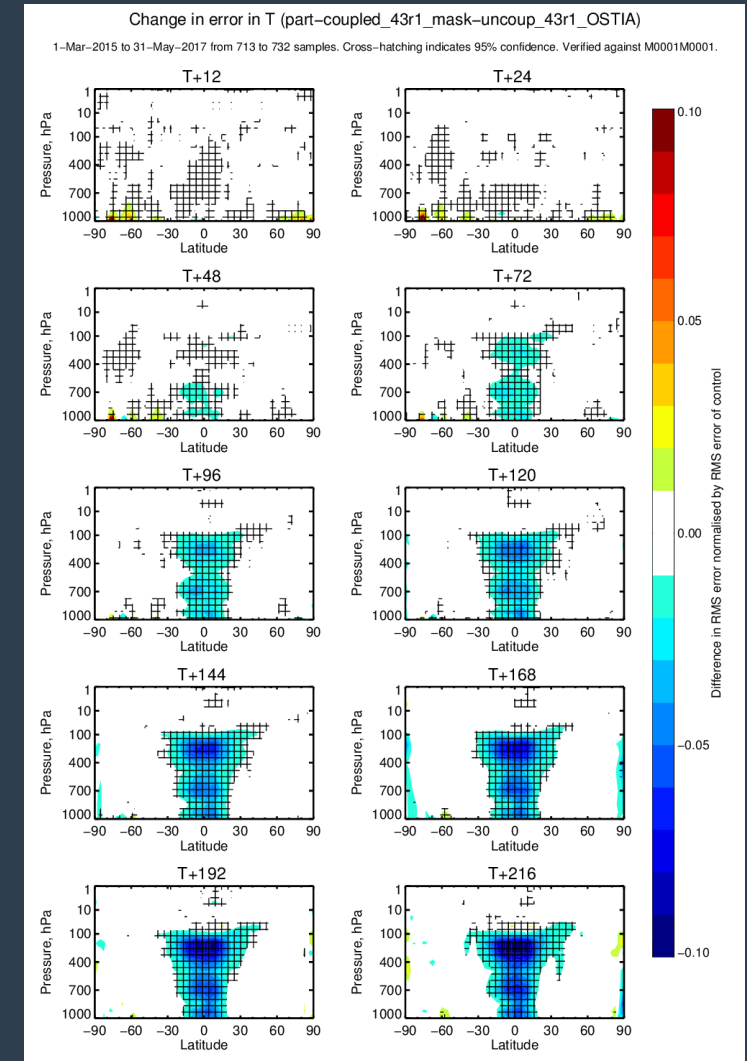
# Effect of partial coupling in the extra-tropics only:



Full coupling

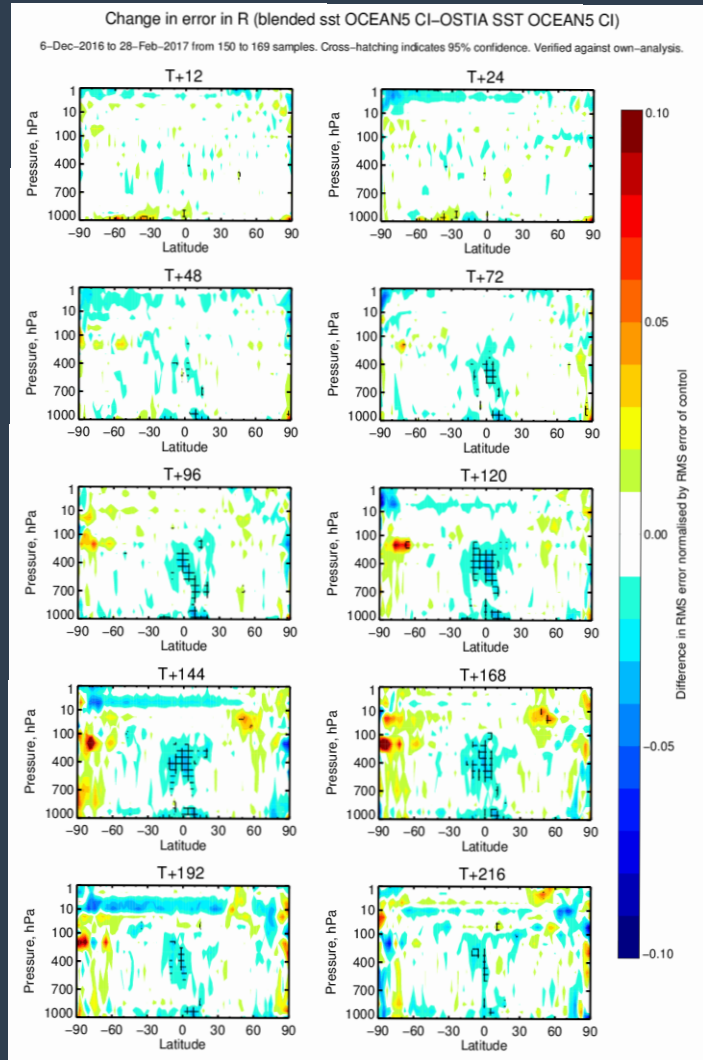


Partial coupling everywhere

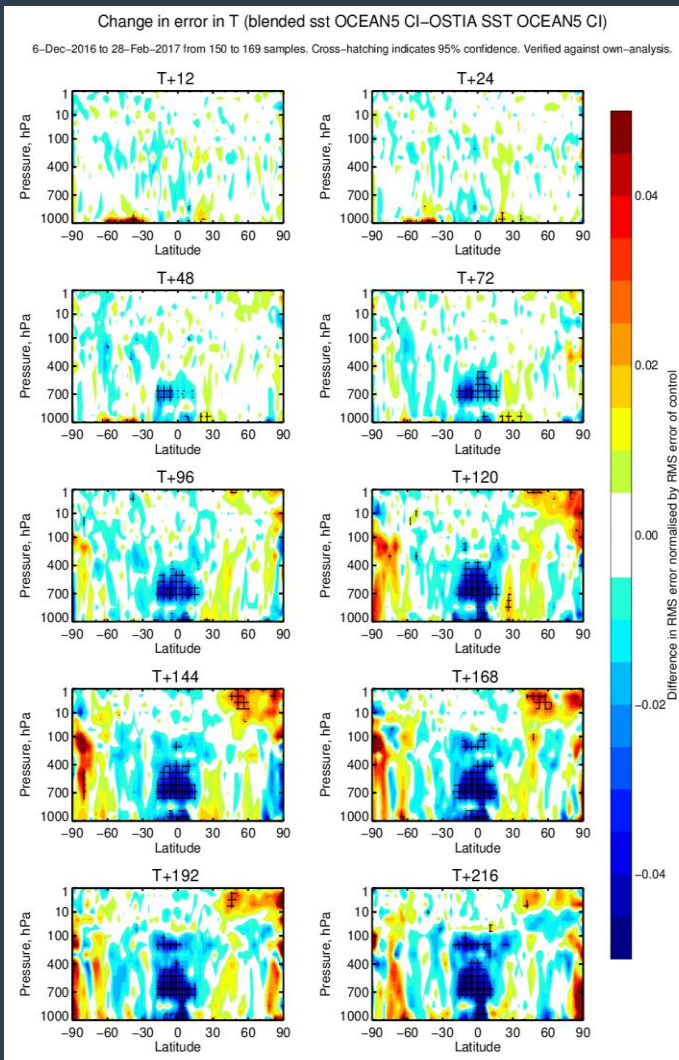


Partial coupling extra-tropics only

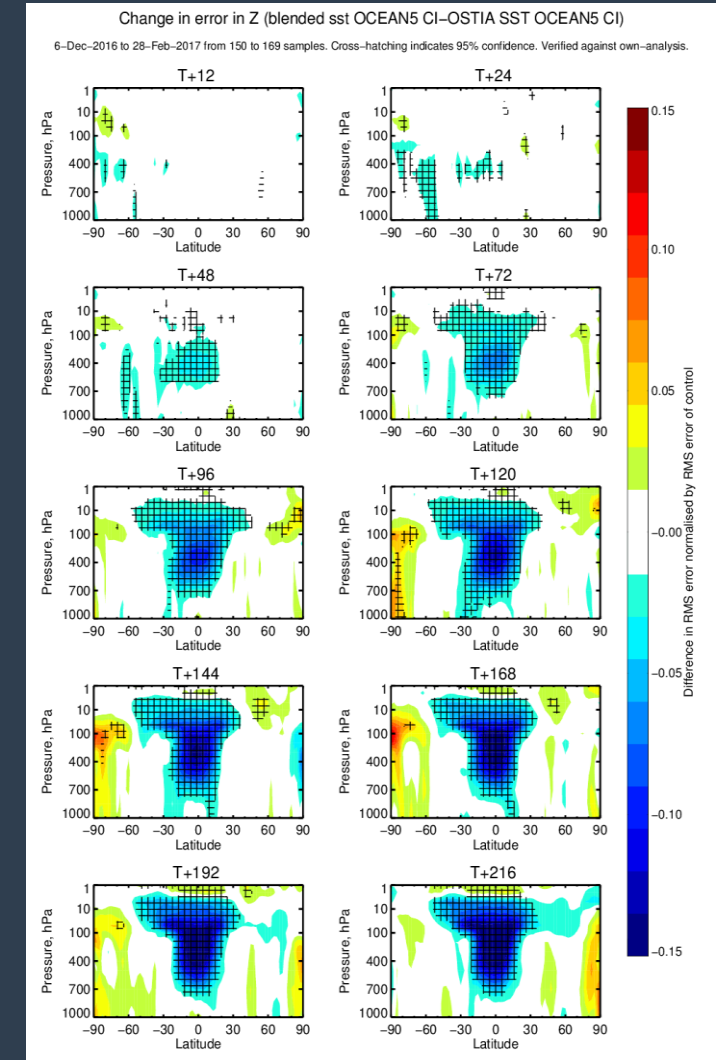
# Impact of using blended SST in the uncoupled analysis



Humidity



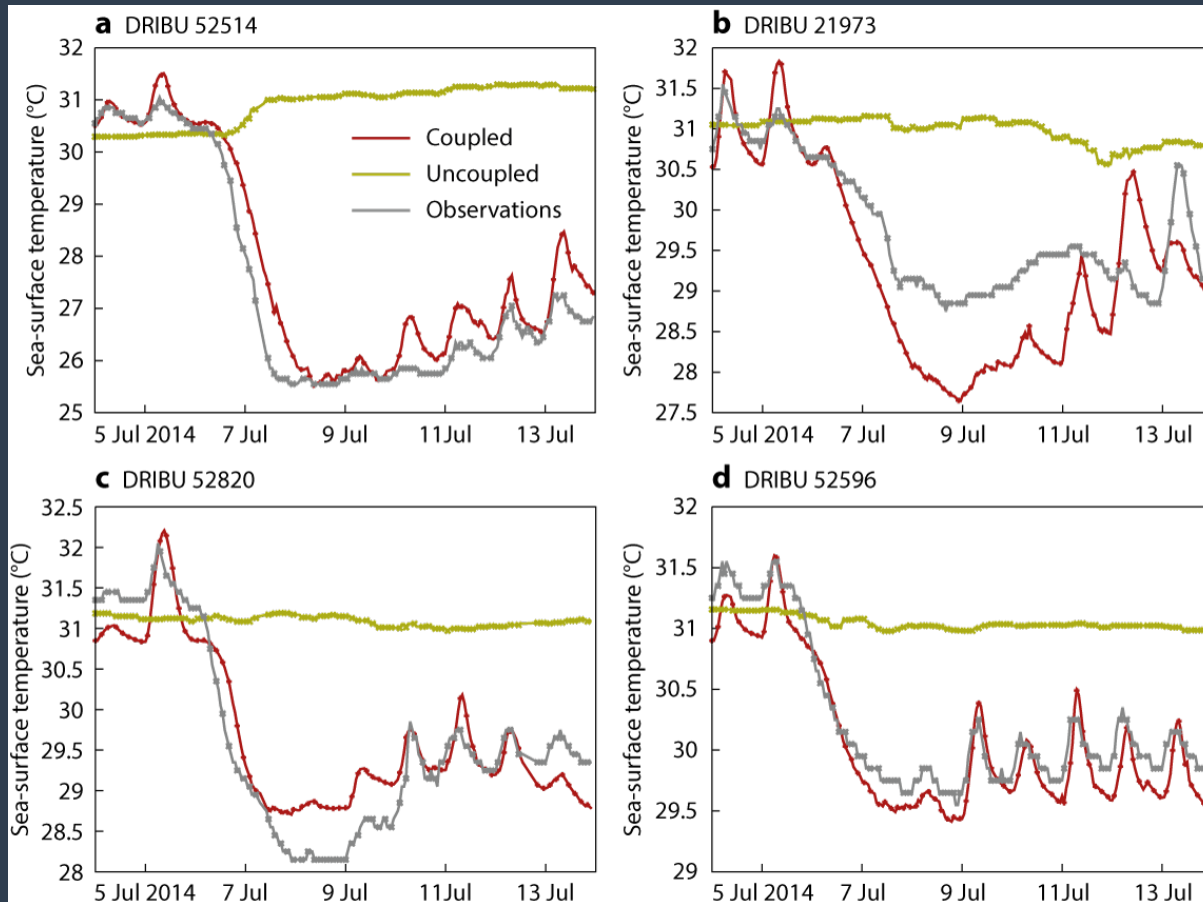
Temperature



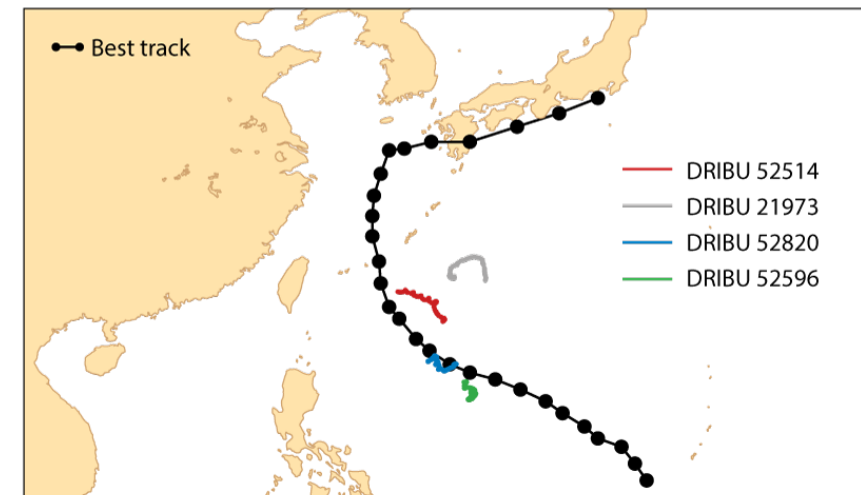
Geopotential

# Example of using SST observations for model evaluation: Coupled model runs of TC Neoguri 2014:

- The coupled model is able to simulate the cool wake after the TC with a realistic response
  - Without observations how do we know this?
- The uncoupled model is obviously not able to simulate this



**e** Buoy tracks



## Conclusions and recommendations

- The quality of SST/sea-ice product used influences the quality of the NWP forecasts in many ways:
  - The assimilation of radiances over the ocean depends on the SST/sea-ice
  - As the lower boundary condition for the model
  - Improved timeliness improves the forecasts
  - SST from dynamic ocean assimilations systems seems to do better than “no-model” assimilation systems in the tropics
- As we move towards more coupling in NWP our requirements for SST/sea-ice might change, but some preliminary wishes/plans are:
  - Faster delivery of data
  - Move from L4 to more low level data
    - Use all the information from the coupled NWP system to fill the gaps
  - More dynamically consistent (atmosphere and ocean) SST/sea-ice fields
- With more and more coupling the validation of predicted SST/sea-ice becomes increasingly important