ESA Climate Change Initiative Phase 1

Sea Surface Temperature (SST)

SST CCI results
The Climate Research Perspective

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ESA CCI Colocation, 4-6th February 2014

www.esa-sst-cci.org

SST CCI products

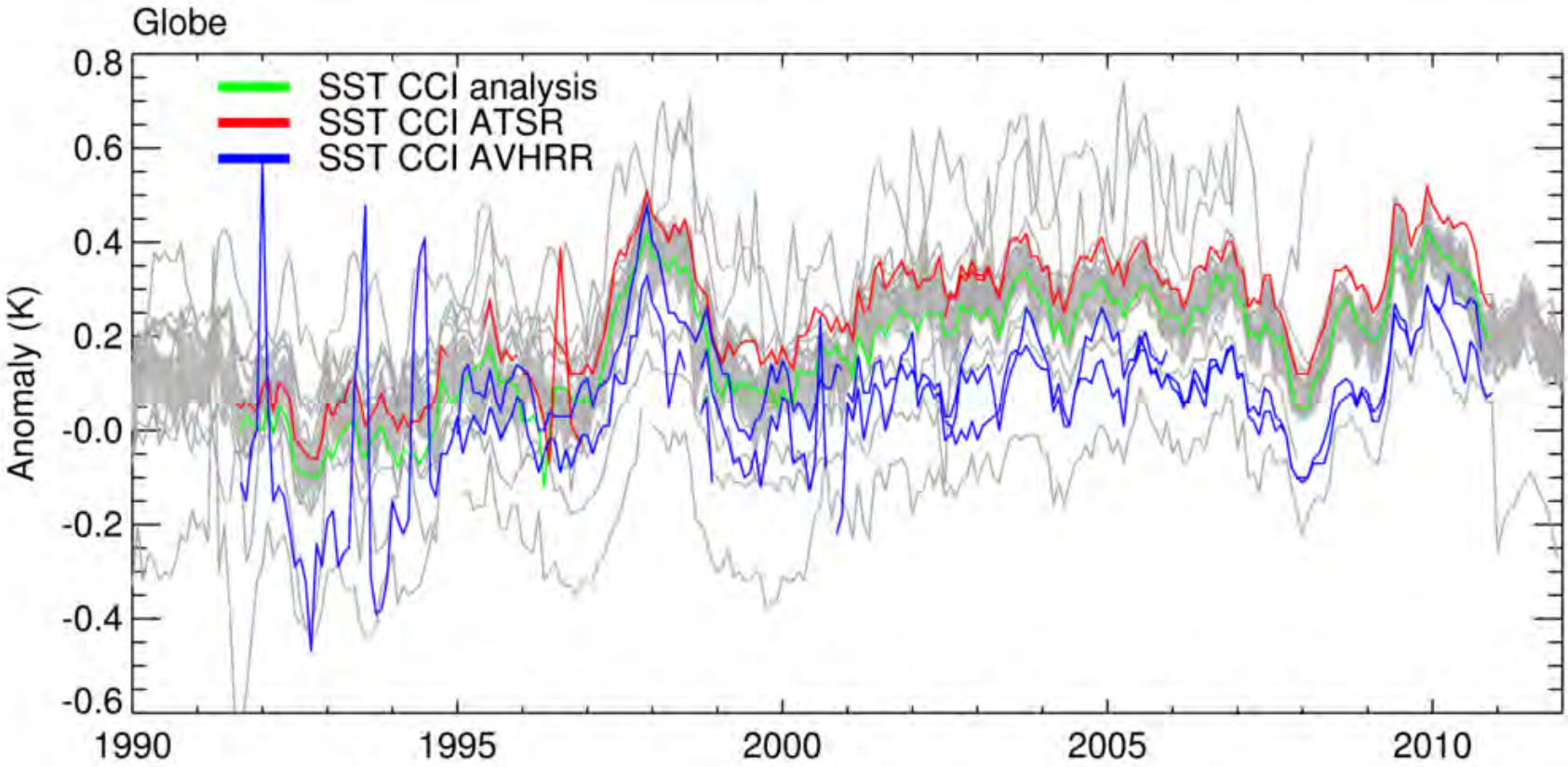
- The three ESA SST CCI LT version 1.0 products assessed are:
  - **ATSR**. SSTs from ATSR instruments in L3U format at 0.05° latitude by 0.05° longitude resolution covering 1991 – 2010. (Hereafter, SST CCI ATSR.)
  - **AVHRR**. SSTs from AVHRR instruments in L2P format at Global Area Coverage (GAC) resolution covering 1991 – 2010. (Hereafter, SST CCI AVHRR.)
  - **Analysis**. Satellite-only SST-depth L4 daily analysis created by OSTIA system from SST CCI ATSR and SST CCI AVHRR products at 0.05° latitude by 0.05° longitude resolution covering 1991 – 2010. (Hereafter, SST CCI analysis.)

- These are utilised over the period 1991-2010.

Climate Assessment approach

- Three main components to the Climate Assessment:
  - Assessment of trends and variability and comparison to other SST products
    - analysis of linear trends both globally and regionally;
    - the exploration of known inter- or multi-annual modes of variability, through calculation of standard indices ;
    - comparison of multi-annual or decadal averages; and
    - the calculation of autocorrelations in time
    - analysis of stability and GMPE from validation WPs
  - Use in climate modelling and other applications
    - Use in model assessment framework at MOHC
    - *Use in other contributed applications*
  - Comparison to other ECVs
    - Analysis of the representation of fronts in SST CCI and OC SST products cf precursors
- Trail blazer users were invited to download the SST CCI products prior to general release and provide feedback on their use.
  - Voluntary user reports included in the Climate Assessment Report alongside funded work

Global, monthly average SST anomaly
(relative to average for 1985-2007)



Overall variability is similar except for erroneous variability in the 1990s in the SST CCI AVHRR and ATSR products.

The SST CCI products are more consistent after 1996.

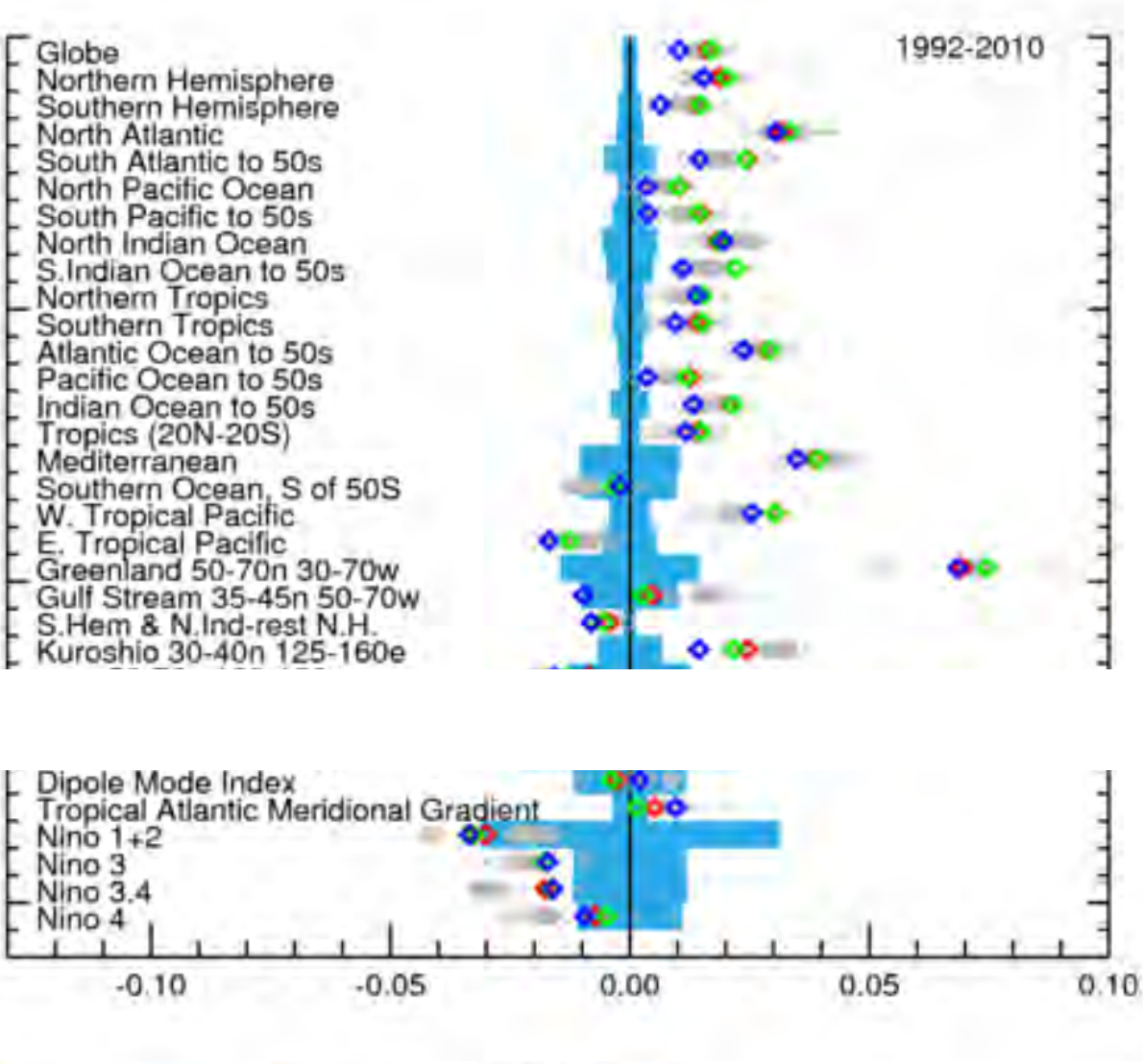
Trend of SST CCI products is at upper end of comparison range

Linear trends (K/yr), 1992-2010
not co-located

Grey: comparison data sets

Red: SST CCI analysis
Green: SST CCI ATSR
Blue: SST CCI AVHRR

Pale blue area: estimate of the uncertainty in the trend arising from measurement and sampling errors in the HadSST3 data



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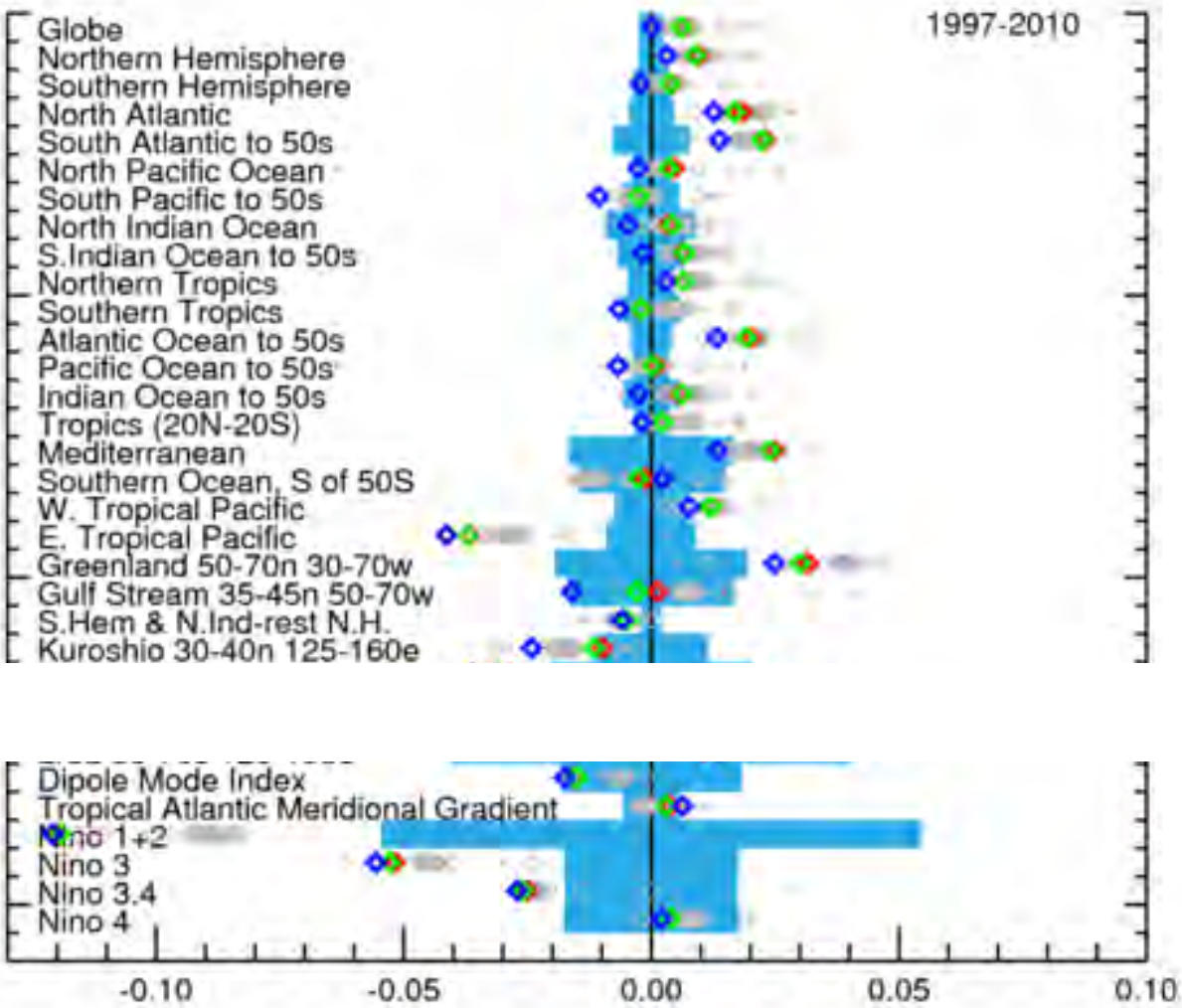
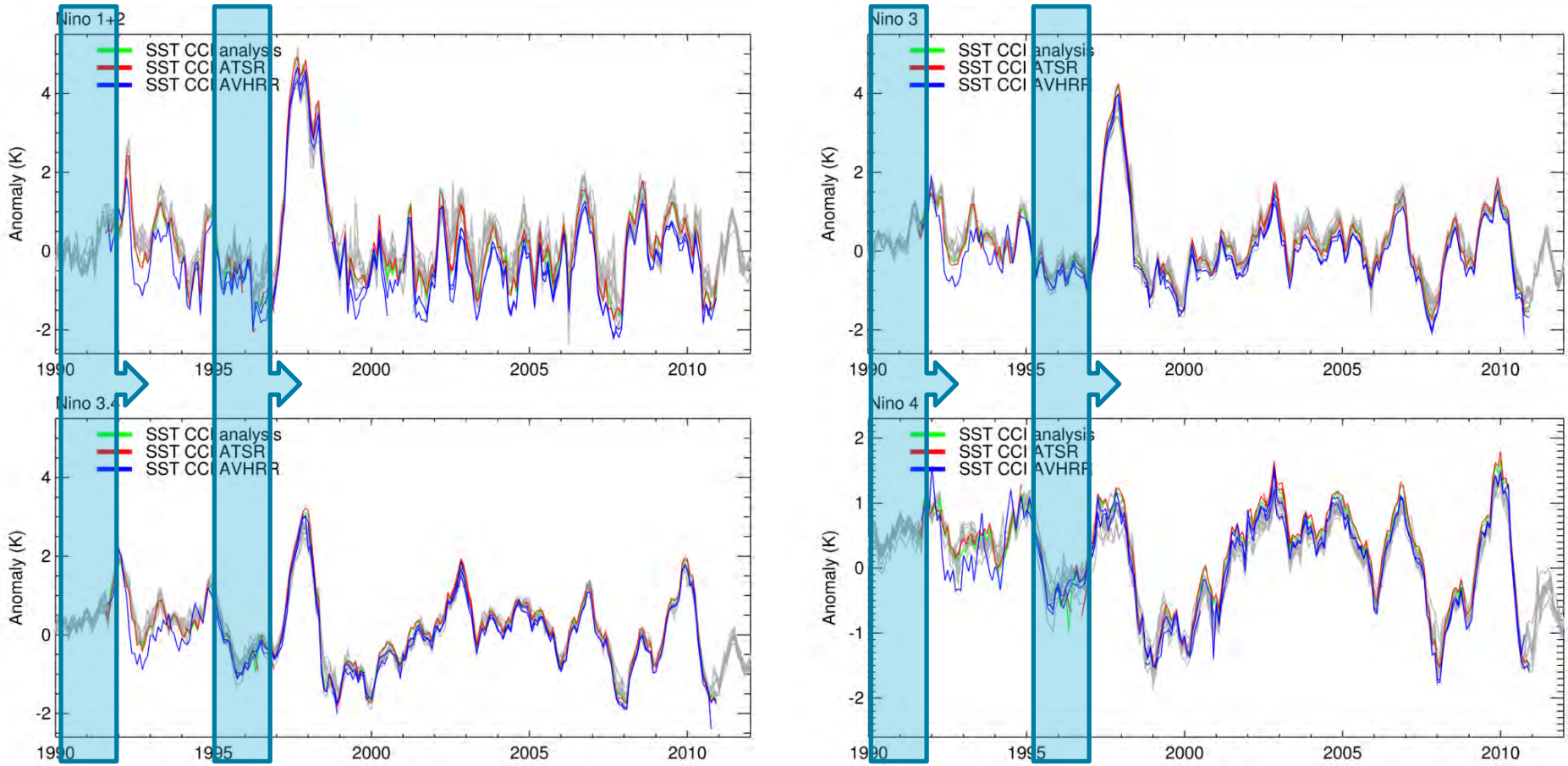
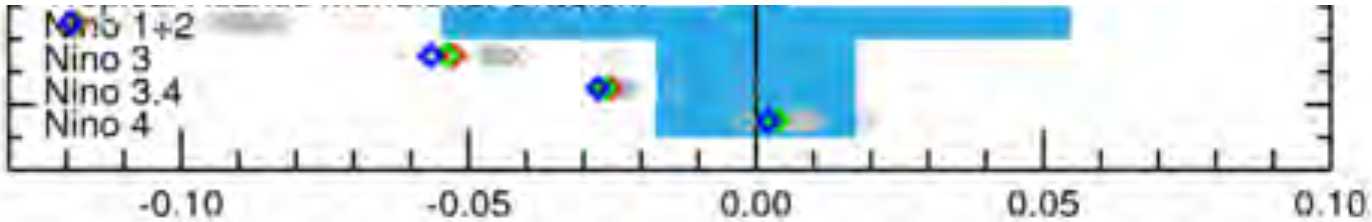
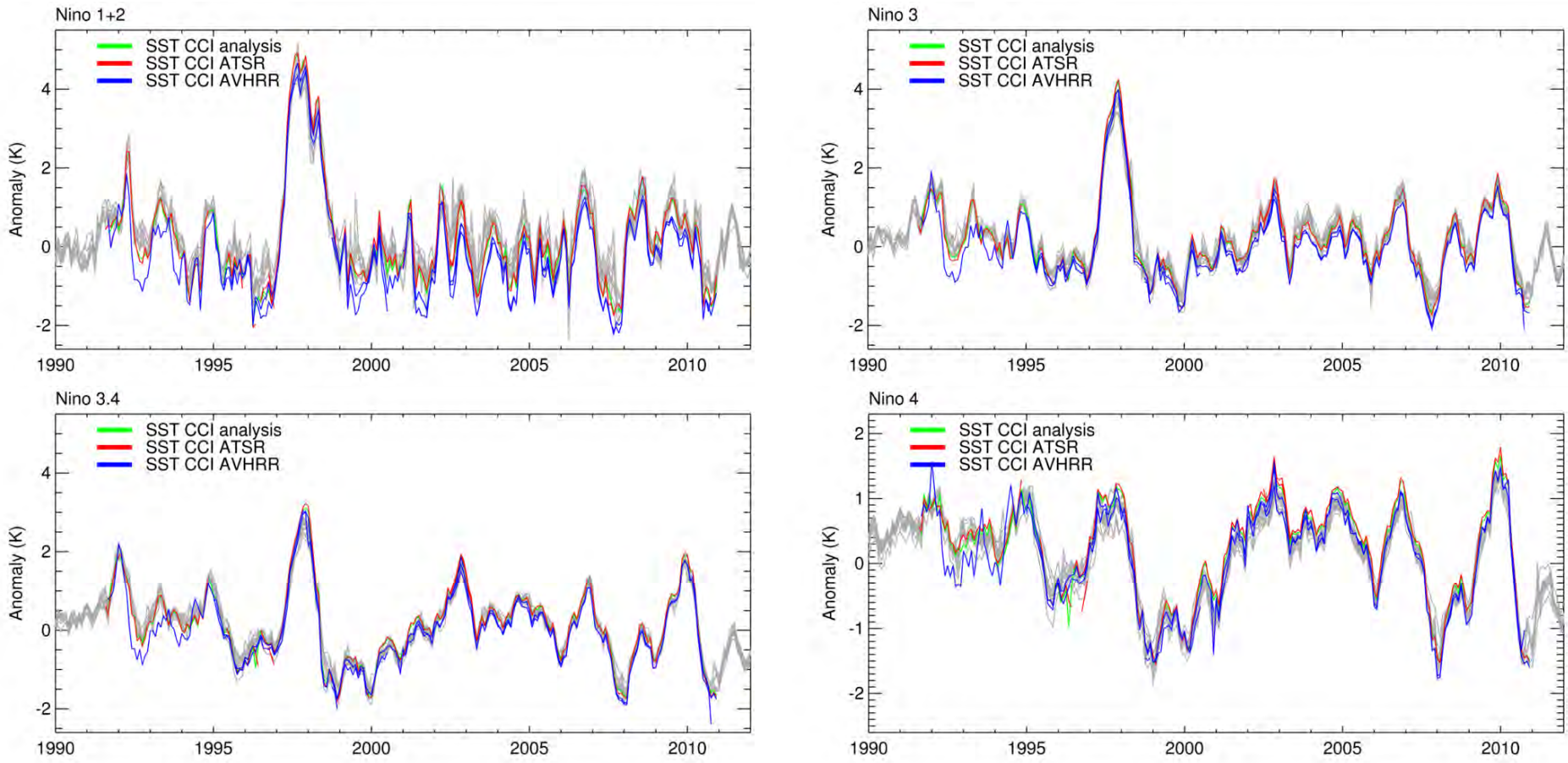


Regional phenomena – Nino indices

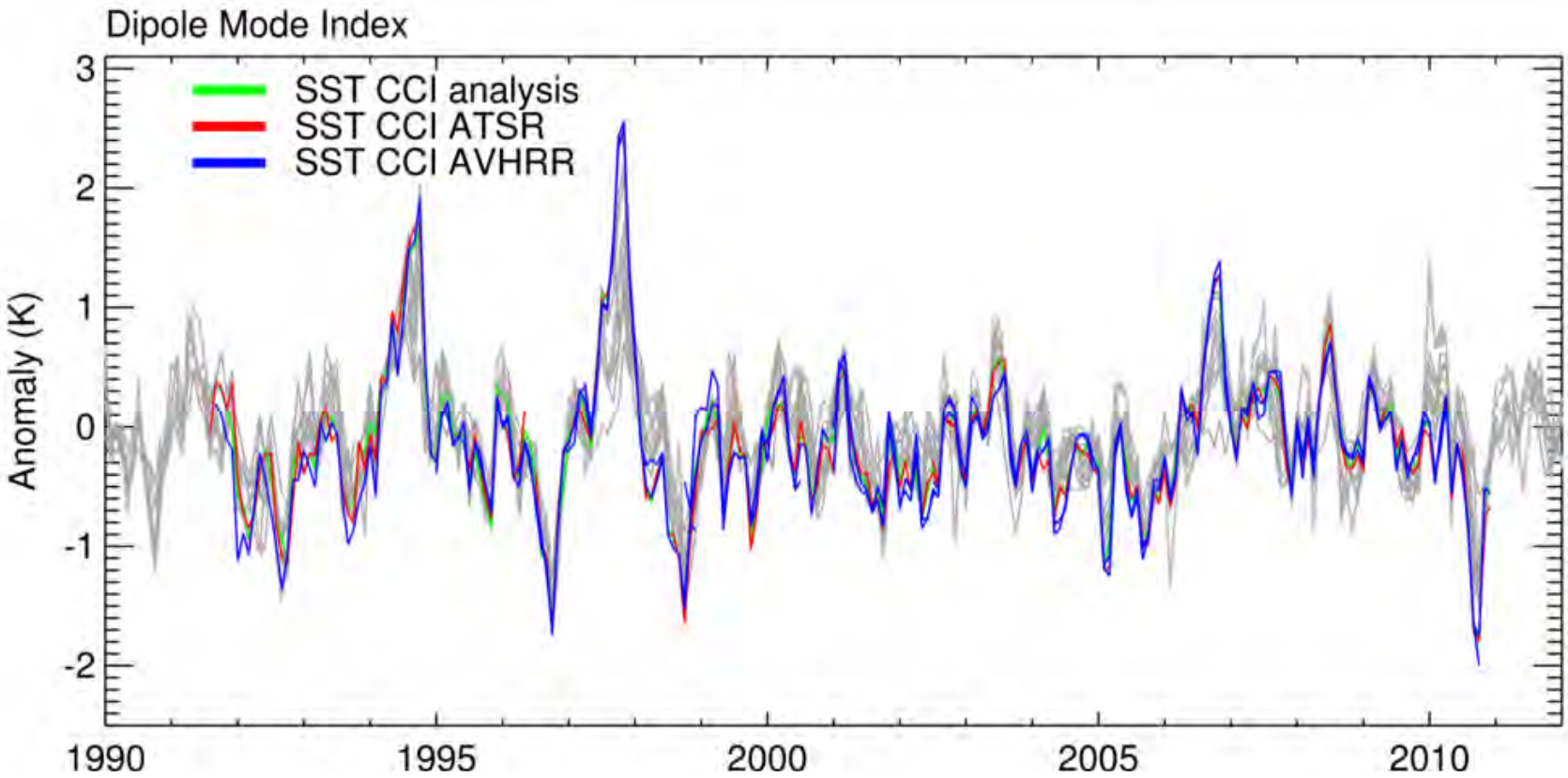




Regional phenomena – Nino indices



Regional phenomena – Dipole Mode Index



Overall variability is similar in the SST CCI and comparison with some differences.

Peak seen in comparison data sets in 2009/10 missing in SST CCI products

Some peaks to trough variability higher in SST CCI products

Results – improved feature resolution

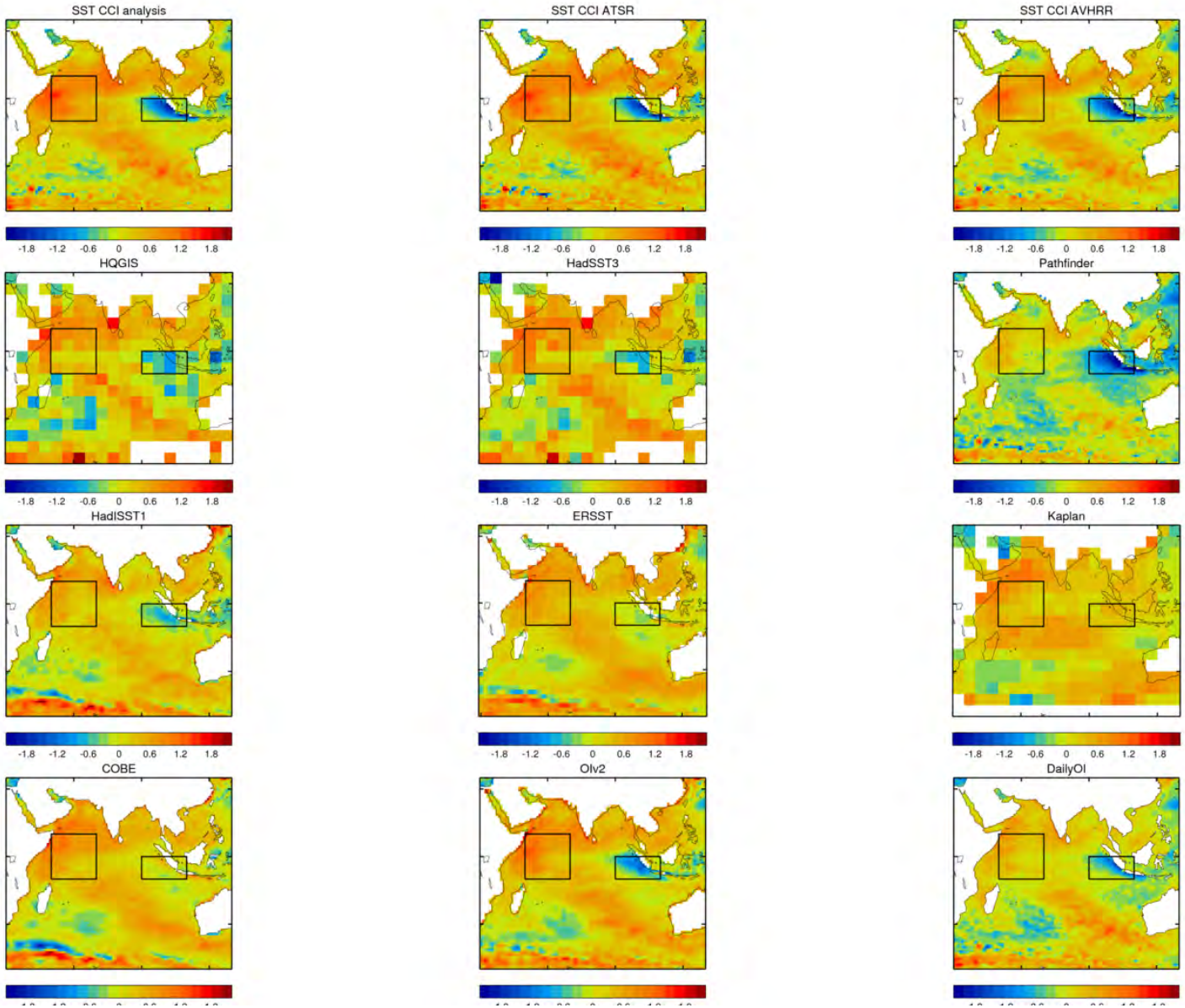
Jun–Dec 1997

Cold area off Indonesia is much colder in SST CCI products

In situ only data sets have much weaker cold anomaly:

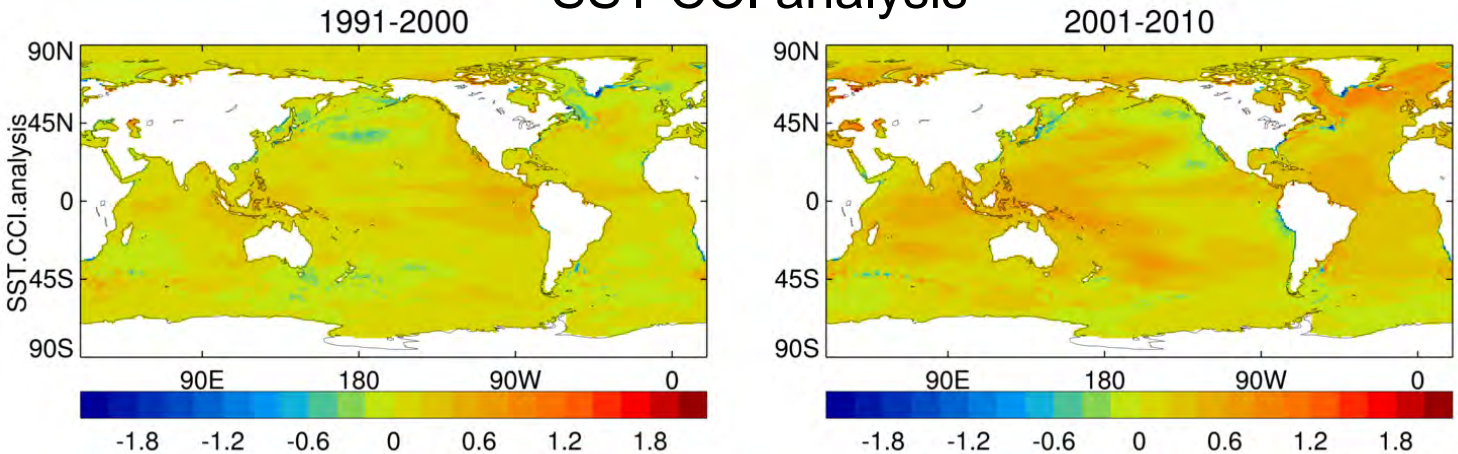
e.g. HadSST3, ERSST, Kaplan, COBE

Similar improvements are seen in the Tropical Atlantic

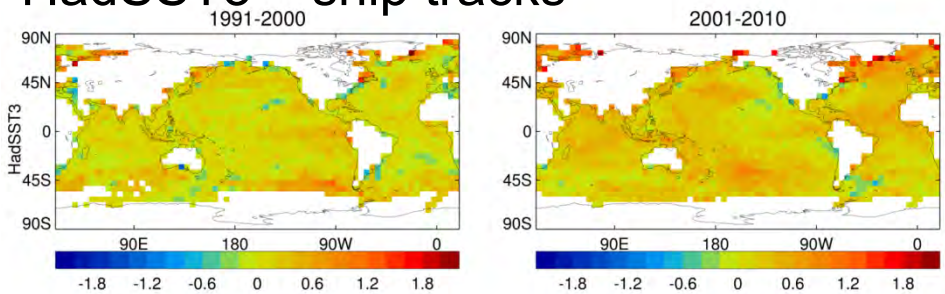


Results – multiyear averages

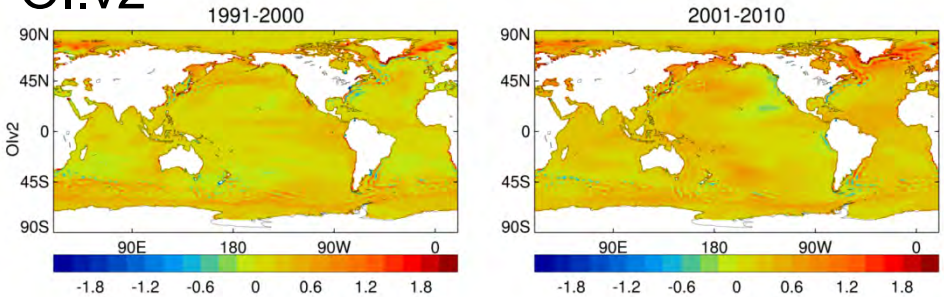
SST CCI analysis



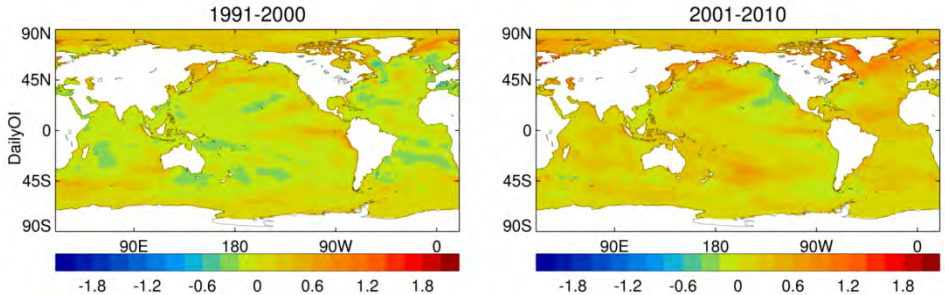
HadSST3 – ship tracks



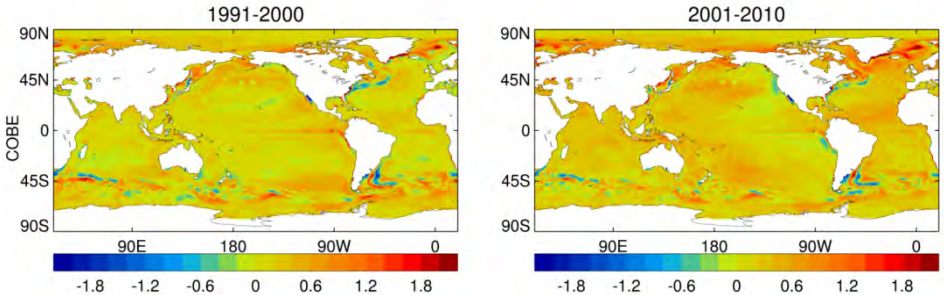
OI.v2



Daily OI – ship tracks, cold bias

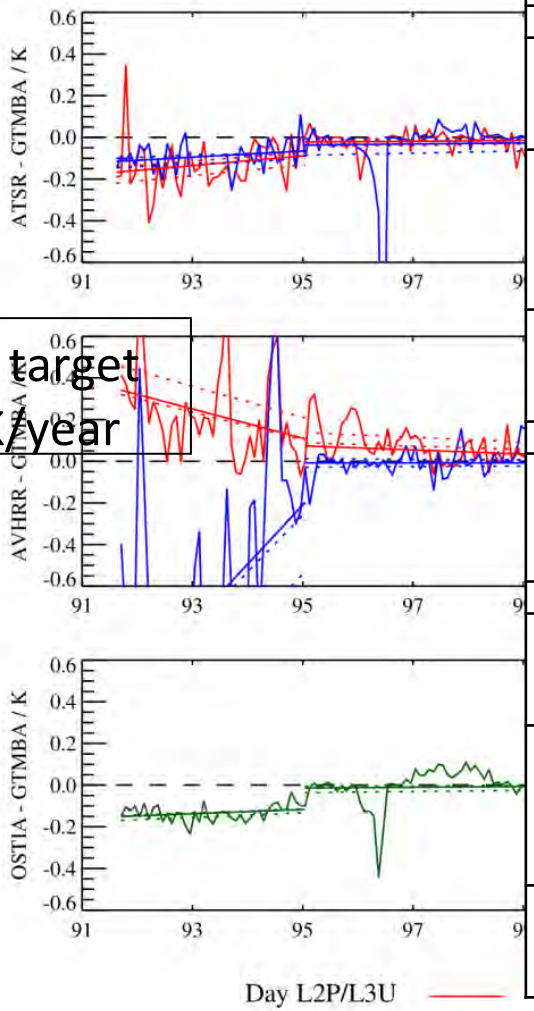


COBE – ship tracks, QC, S.Ocean noise



Stability

SST difference between SST CCI products and the GTMBA



GCOS target is 3mK/year

SST CCI 95% confidence interval (mK year^{-1}) for 1991 – 1995

	Day	Night	Both
SST CCI AVHRR	-137.9<trend<-2.4	105.9<trend<462.3	
SST CCI ATSR	-13.6<trend<60.1	-7.4<trend<36.8	
SST CCI analysis			-1.8<trend<22.1

SST CCI ATSR

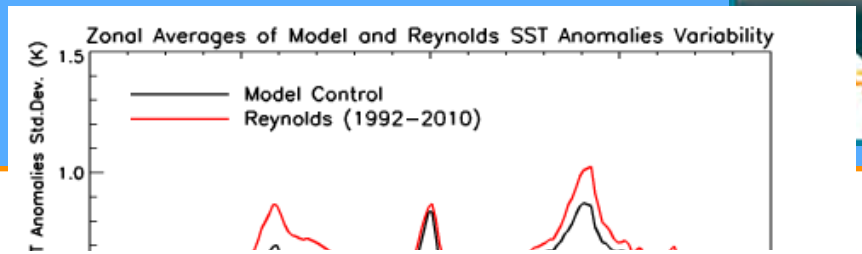
SST CCI AVHRR

SST CCI 95% confidence interval (mK year^{-1}) for 1995 – 2010

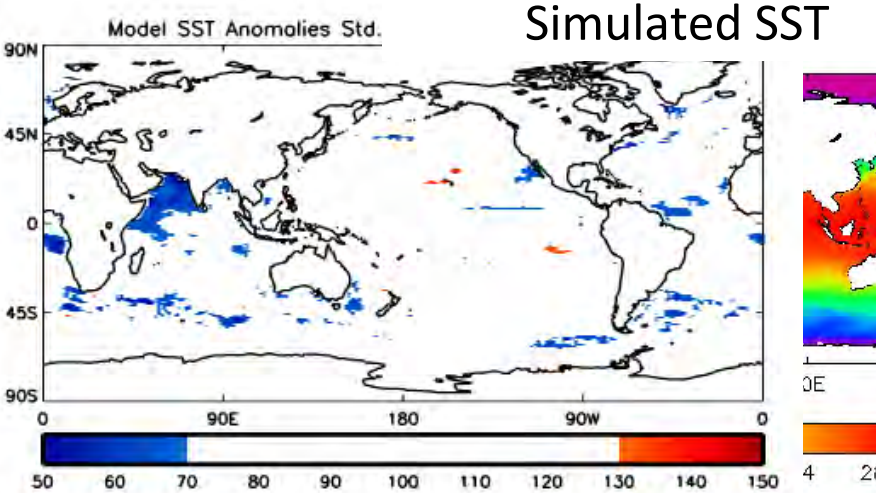
	Day	Night	Both
SST CCI AVHRR	-12.3 < trend < -7.4	-2.0 < trend < 2.0	
SST CCI ATSR	0.7 < trend < 3.2	-1.4 < trend < 6.4	
SST CCI analysis			0.1 < trend < 3.2

SST CCI analysis

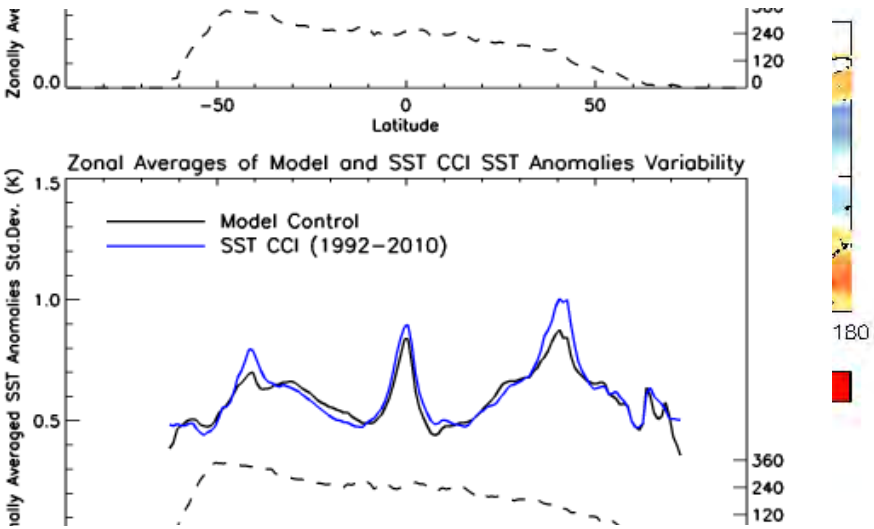
Coupled model evaluation



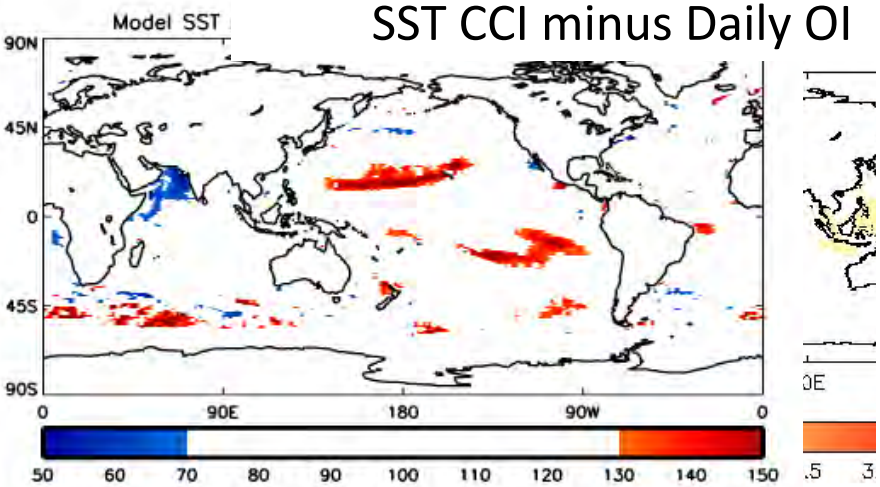
Simulated SST



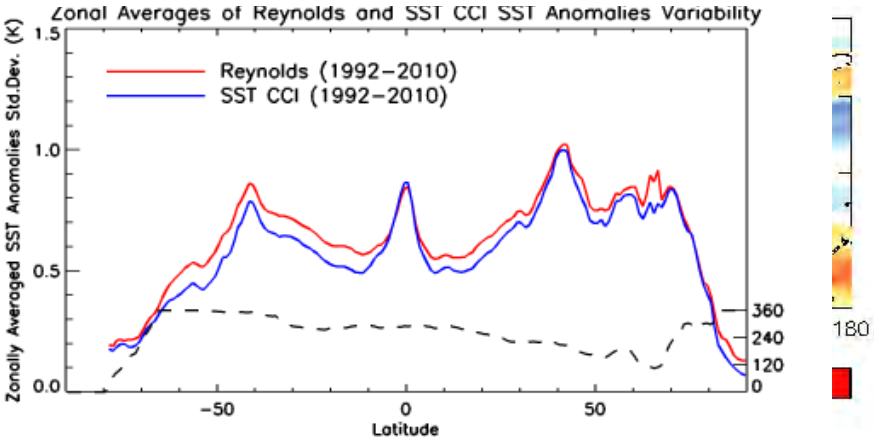
Simulated minus SST CCI



SST CCI minus Daily OI



Simulated minus Daily OI



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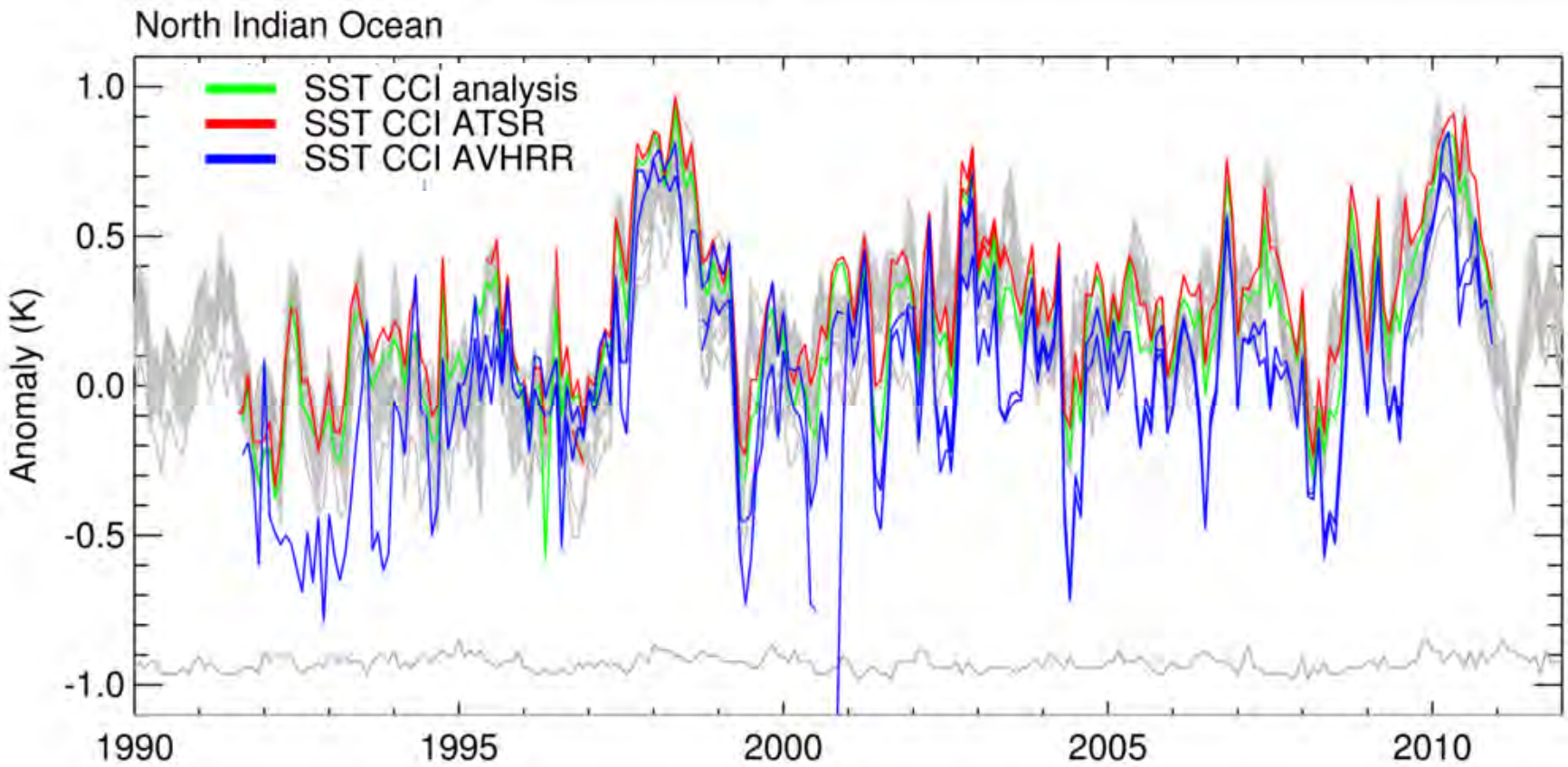
North Indian Ocean



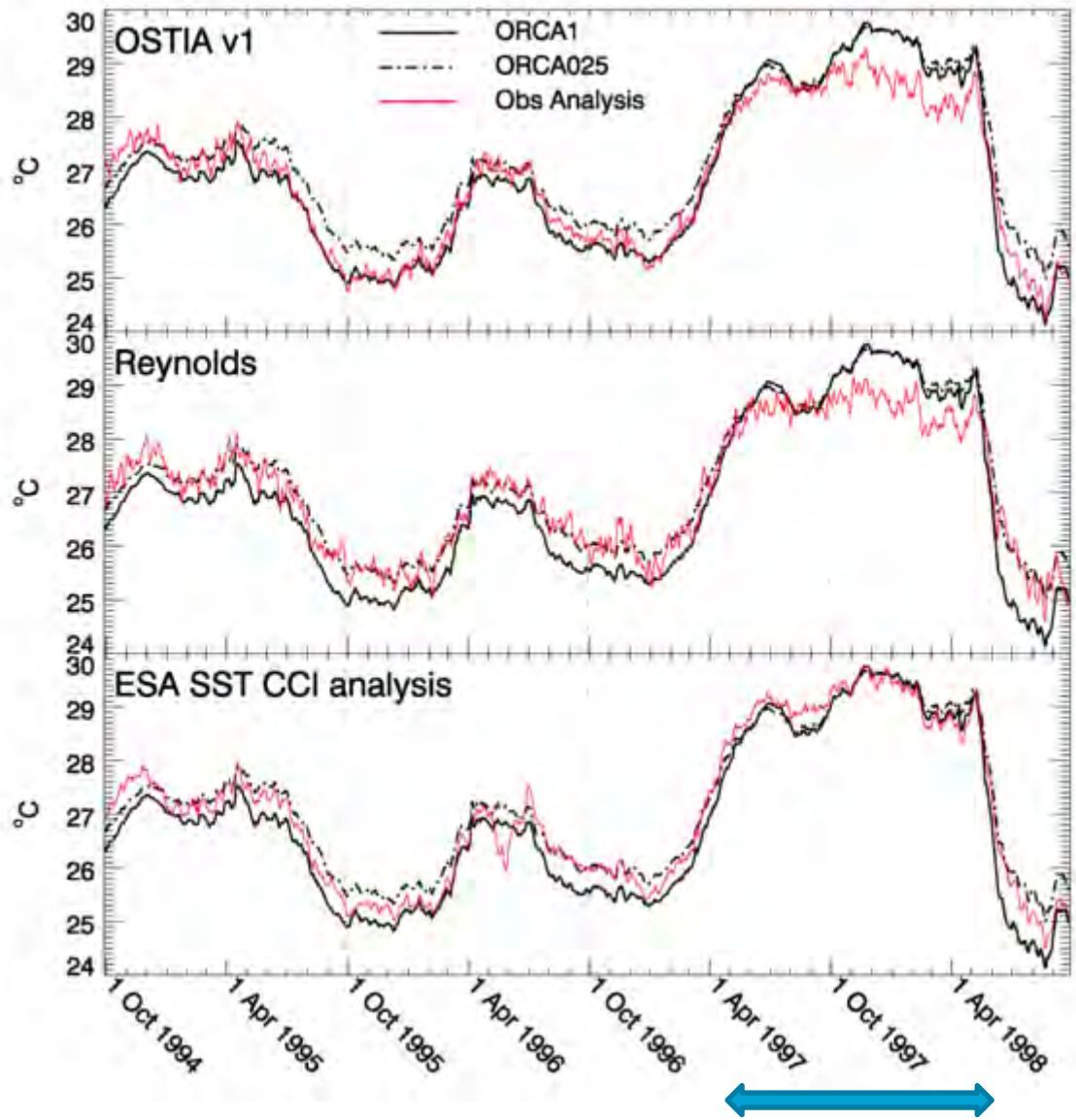
Spurious variability in North Indian Ocean in SST CCI AVHRR product

Thought to be due to CLAVR-X cloud detection passing desert dust

Exploration of heat transport in ocean models via Tropical instability Waves

Provision of daily mean information in SST CCI analysis is a better natural comparator to the simulated daily data than SST_{fnd} or the daily "means" provided in the Daily OI.

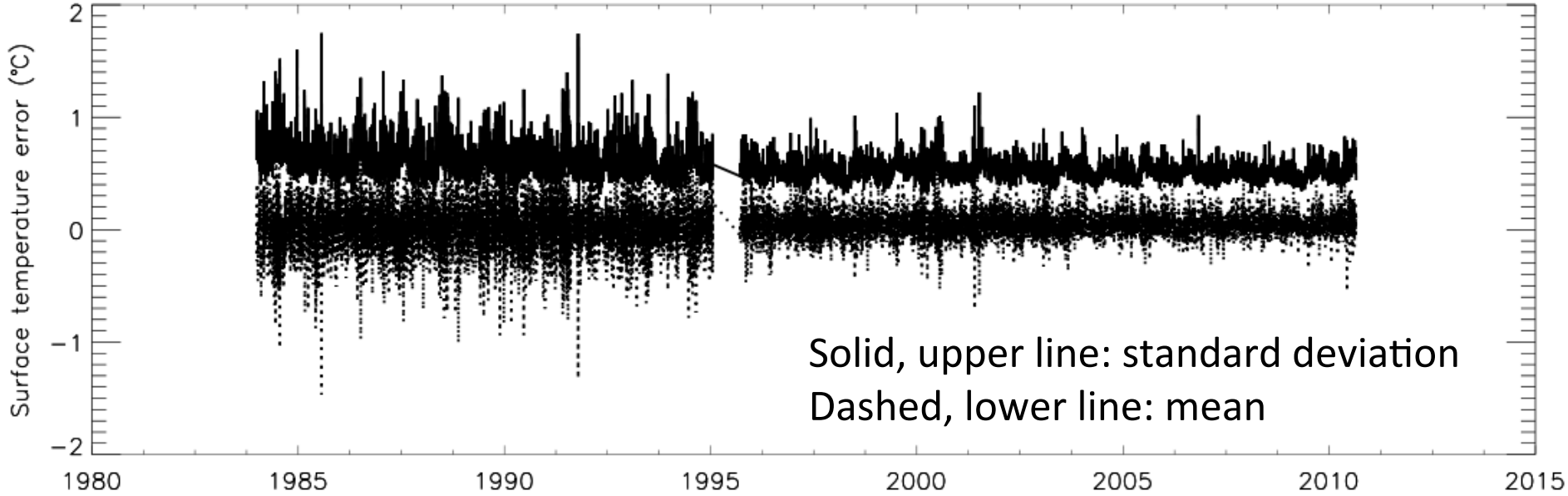
Courtesy Tim Graham (submitted to Ocean Modelling)



Improved agreement during the El Nino period

Assimilation of SST CCI AVHRR product into North-west Shelf Seas reanalysis (courtesy Robert King)

Observation (AVHRR) minus model differences



Assimilating Pathfinder AVHRR using generic Single Sensor Error Statistics

Assimilating SST CCI AVHRR using pixel-specific uncertainty estimates

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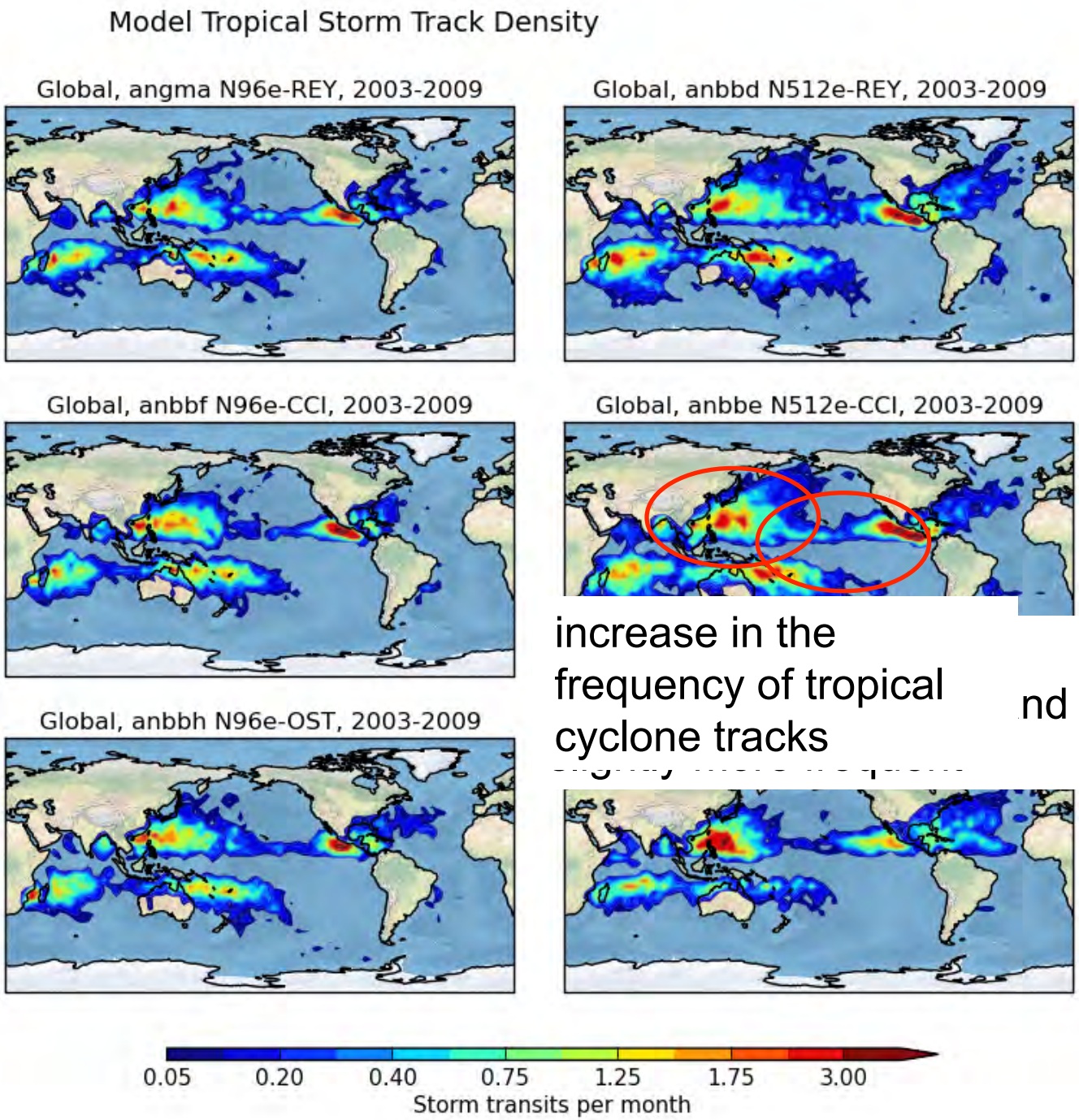
Simulation of tropical storm track density

The tropical cyclone tracks may be influenced by the higher SSTs in the SST CCI analysis compared to those in the Reynolds et al Daily OI.

Courtesy Malcolm Roberts (submitted to CLIVAR Exchanges)



increase in the frequency of tropical cyclone tracks

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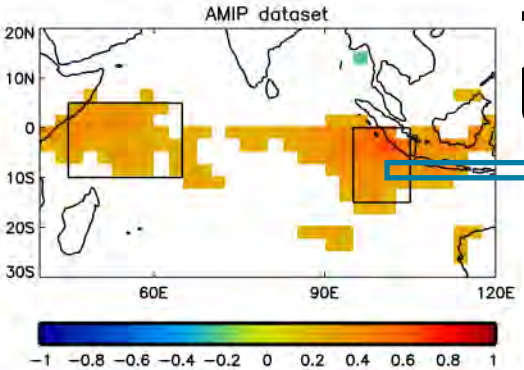
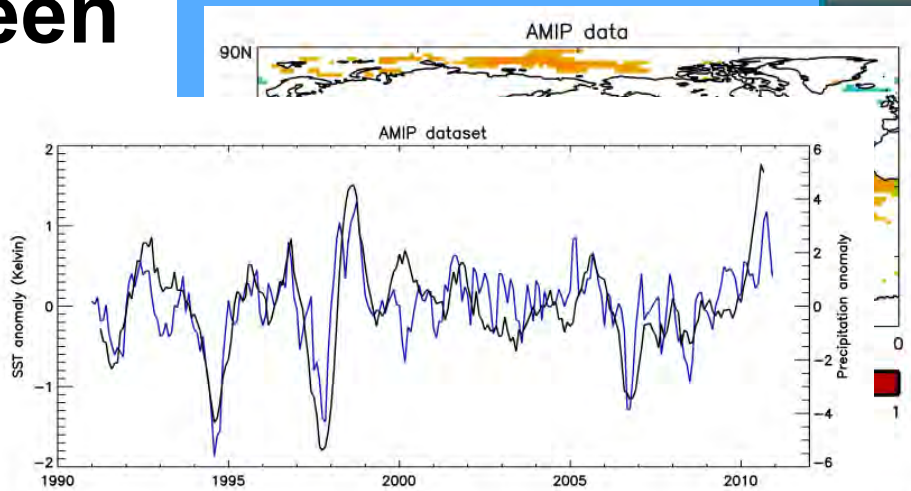
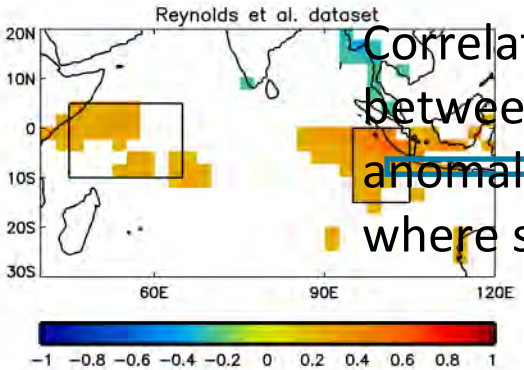
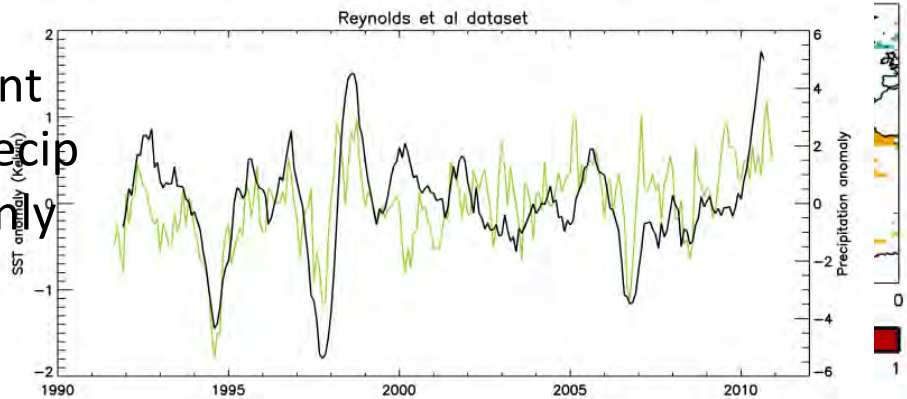
Relationships between cipitati tie Bro

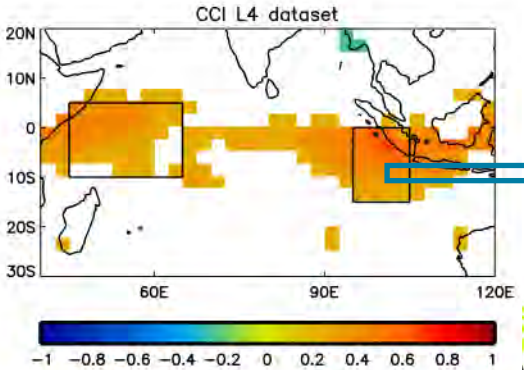


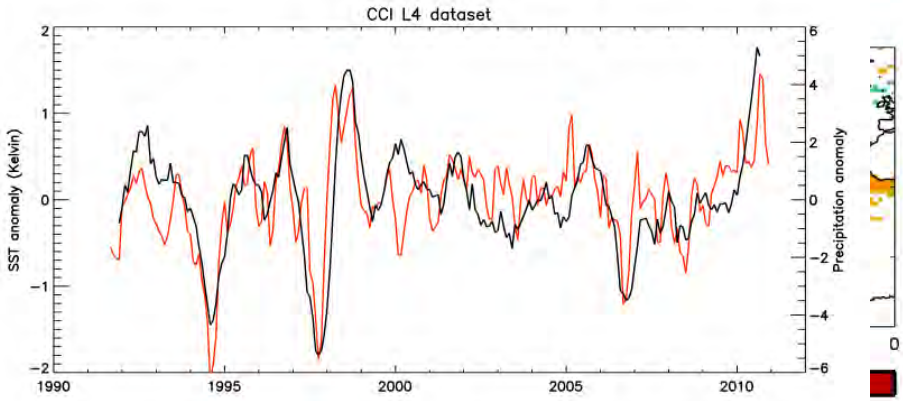




Correlation coefficient between SST and precip anomalies (shown only where significant)







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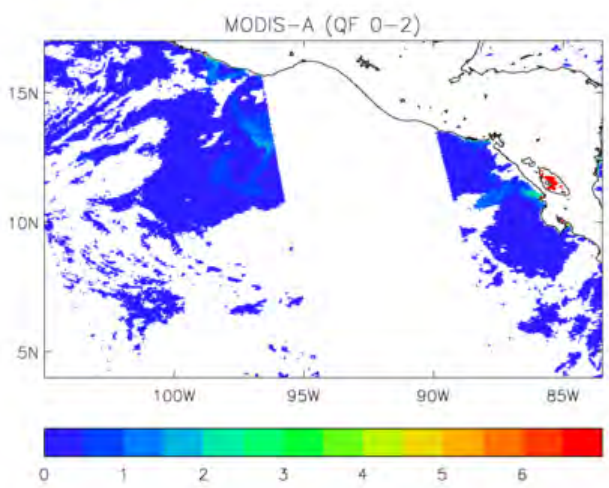
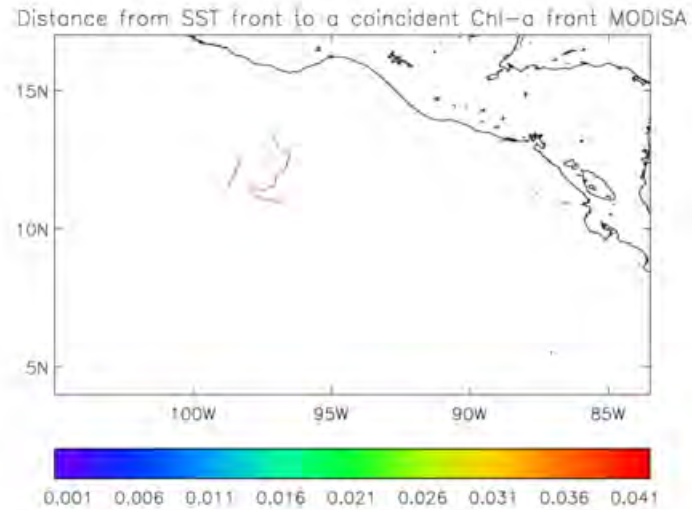
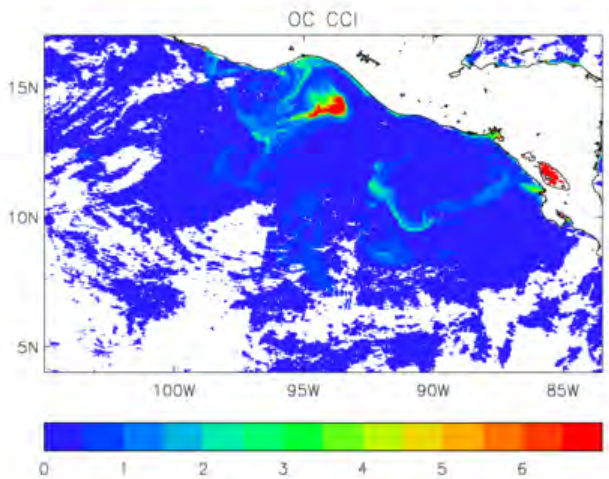
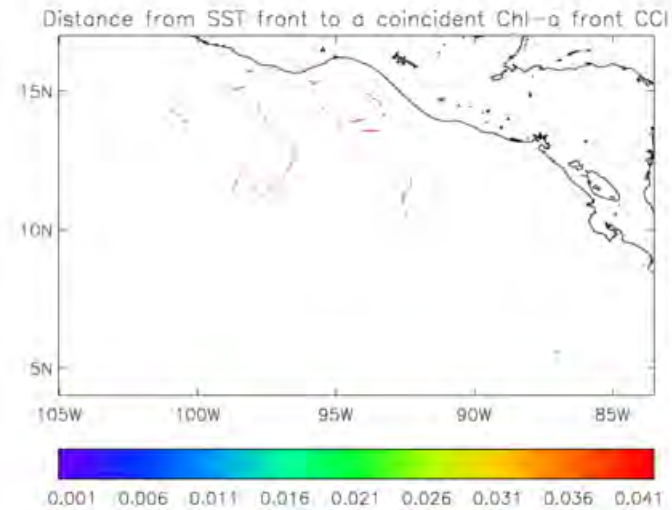
Comparison of SST and chl-a fronts









Key messages #1

- SST CCI LT products comparable to the main population of comparison data sets (general evolution of SST and variability).
  - show smaller differences from HadSST3 on the global average than some comparison datasets (e.g., SST CCI AVHRR [0 K to -0.2 K, with some larger excursions] compared to AVHRR Pathfinder v5.2 [~ -0.4 K]; and SST CCI analysis [~ 0 K] compared to Daily OI [~ -0.1 K]).
- The AVHRR Pathfinder data set is an outlier amongst the data sets compared, with generally relatively cool-biased SSTs.
- There are some anomalous periods of larger bias
  - SST CCI AVHRR (four individual months between 1991 and 1994)
  - SST CCI ATSR (one month in 1996)
- SST CCI AVHRR products are inconsistent in their overall trends relative to SST CCI ATSR (and hence the SST CCI analysis).
  - SST CCI ATSR and SST CCI analysis products warm more rapidly than the majority of the comparison data sets
  - SST CCI AVHRR products tend to warm less rapidly over the period 1992-2010.

Key messages #2

- For some climate indices, peak-to-trough variability of SST CCI LT products is higher than in the comparison data.
  - appears to be due to better feature resolution in the SST CCI LT products, arising from better sampling.
- The period prior to 1995 is characterised by larger cool biases in the SST CCI LT products relative to in situ based data sets, especially in the mid latitudes.
  - seen in comparisons both to the GTMBA and to the wider in situ network, so conclude that these differences arise from the SST CCI products.
- The SST CCI AVHRR product in the northern Indian Ocean exhibits spurious variation on annual timescales.
- Multi-year variability in the SST CCI LT products is generally consistent with that seen in the comparison data.
- Month-to-month correlation is higher in the SST CCI LT products and indicates they are less noisy than in situ only products

Key messages #3

- GCOS stability requirement (of better than 3 mK/year, assessed from trend in difference from GTMBA) is
  - Met in the tropical Pacific over the period 1995-2010 by the SST CCI AVHRR night-time product (-2.0 < trend < 2.0 mK/year).
  - Marginally missed by the SST CCI ATSR daytime (0.7 < trend < 3.2 mK/year) and SST CCI analysis (0.1 < trend < 3.2 mK/year) products 1995-2010.
  - Missed by other products, 1995-2010. [SST CCI AVHRR day time: -12.3 < trend < -7.4 mK/year; SST CCI ATSR night-time: -1.4 < trend < 6.4 mK/year]
- Stability outside tropical Pacific cannot be evaluated using known techniques because insufficient stable reference data elsewhere.
- The SST CCI analysis is apparently less stable in the tropics with respect to GTMBA measurements than other high resolution analyses.
  - non-SST CCI analyses ingest GTMBA data, and this lack of independence means the results obtained are likely to exaggerate their true stability in non-GTMBA locations.

Key messages #4

- The SST CCI analysis product is a suitable tool for the evaluation of coupled model mean state.
  - Differences between observational estimates are smaller than differences between simulated and observed SST.
- Comparing daily SST variability in a HadGEM3 model control run with two SST analyses (SST CCI analysis and Reynolds et al [2007] Daily OI), shows:
  - model and observed variability broadly compares well in terms of both magnitudes and spatial patterns.
  - better general agreement with the SST CCI analysis product than with the Daily OI.
  - more work is needed to understand the correlation structure of SST CCI analysis errors.

Key messages #5

- Variability in AVHRR SSTs may be exaggerated in the Gulf of Arabia/ Arabian Sea due to biases from intermittent desert dust.
  - Here the SST CCI analysis is up to 0.6 K cooler than some other datasets in JJA. Causes a significant reduction in the simulated Indian monsoon rainfall when used to drive a 25 km model, magnifying an existing model bias.
  - Evidence that there may be a positive impact of the use of passive microwave data in this region
- Daily mean SST data provided by the SST CCI analysis is more useful than foundation SST data for the purpose of evaluating model simulations of heat transport by tropical instability waves.
  - daily mean SST CCI analysis is more comparable to simulated daily mean SSTs.
- Surface temperature error in a reanalysis of shelf seas (assimilating only SST) markedly lower when SST CCI products were used, relative to the earlier period when Pathfinder data were assimilated.
  - use of the newly developed SST CCI uncertainties gave a significant reduction in the RMS errors of the shelf seas reanalysis when compared to in situ observations.

Key messages #6

- Different SST datasets were used to force the same global atmosphere-land general circulation model at low (~130 km) and high (~25 km) resolutions. Several differences in the simulated mean state seem to be influenced by differences between the SST datasets, including the Indian monsoon rainfall and surface temperature differences over North America.
  - Not clear whether due to the superior resolution of the SST CCI analysis, or due to other differences between data sets (e,g, in their relative biases)
  - Tropical cyclone climatologies are also affected, particularly in the Eastern and Western Pacific regions.
  - It is important to have a range of forcing datasets, e.g. through provision of an ensemble, so that model biases can be put into context compared to the model response to different forcing datasets.

Key messages #8

- SST and OC CCI products contain information on SST and chl-a concentration off the south coast of Mexico that appears to be largely consistent on daily and 4km scales.
  - SST and OC CCI products, when analysed together, provide a credible source of information for the analysis of coincident SST and chl-a fronts.
- Combining sensors in the OC and SST CCI products provides sufficient coverage of the area south of Mexico to perform daily analyses of frontal positions and to produce summary statistics over a year (2003).
- There may be merit in providing lower quality data alongside best quality data, as it appears to contain useful information for the analysis of ocean fronts.
- Coordinated analysis of strongly connected variables can highlight potential deficiencies in aspects of the processing of either variable.