Environment Canada Environnement Canada

Canada

Assimilating retrievals of sea surface temperature from VIIRS and AMSR2 in the experimental high resolution CMC SST analysis

Bruce Brasnett, Dorina Surcel Colan and Wei Yu

National Prediction Development Division, Meteorological Service of Canada, Environment Canada, Canada

16th International Science Team Meeting (GHRSST XVI)

20-24 July 2015, European Space Agency ESTEC, The Netherlands

Contents

- Introduction
- AMSR2 SST Product
- VIIRS SST Product
- Assimilation Methodology
- Evaluation of Contributions from AMSR2 and VIIRS
- Conclusions

Introduction

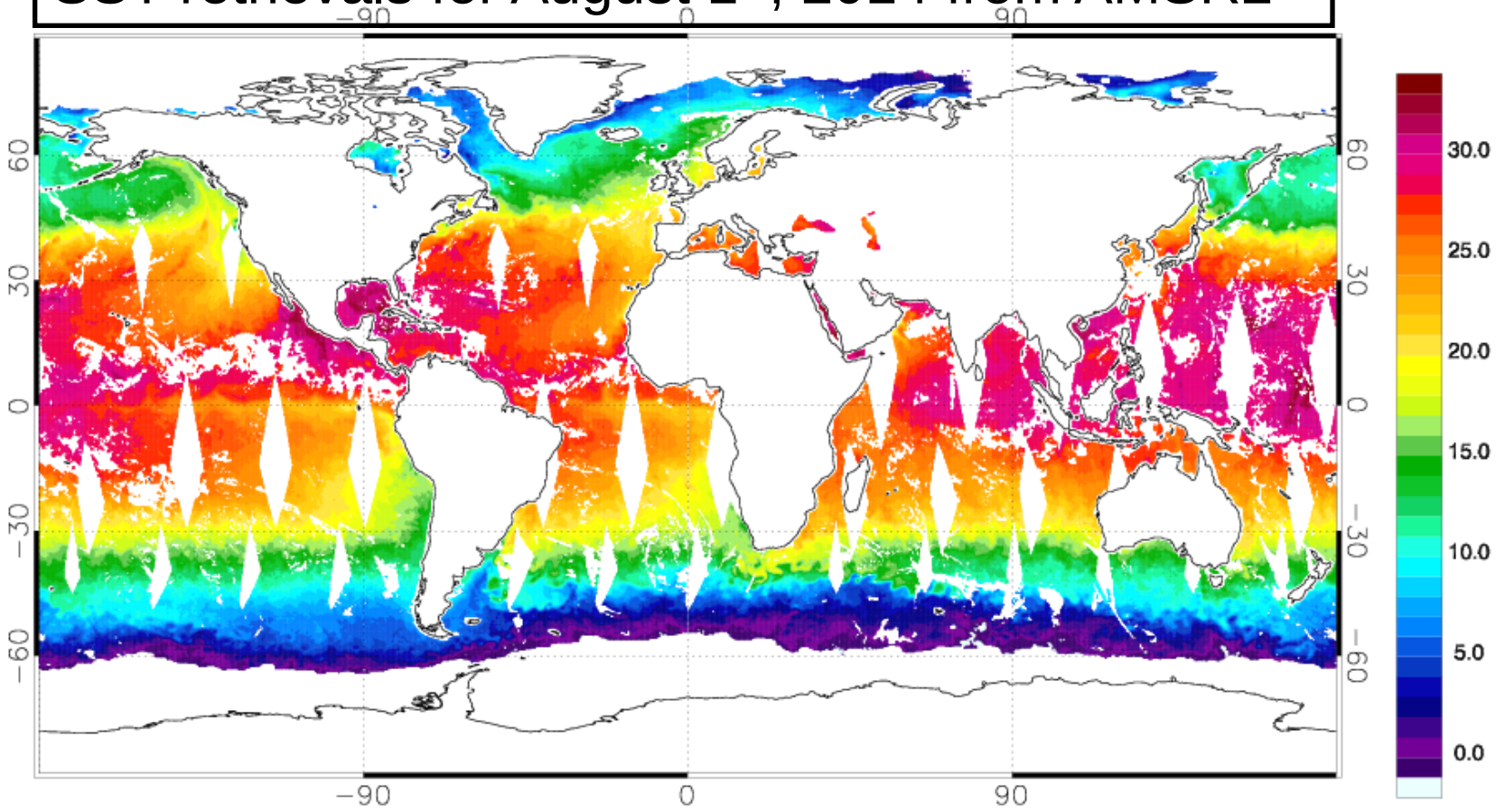
- SST analysis is used daily by many analysis and forecast systems, such as GDPS, RDPS and GIOPS
- CMC operational program produces a daily global 0.2˚ analysis using in situ and satellite data, an updated version of the 1/3 ˚ analysis described by Brasnett (2008)
- The operational SST analysis assimilates retrievals from four AVHRR instruments, in situ observations, and ice data
- SST analysis refers to a depth temperature (foundation SST) without diurnal variability

AMSR2 SST Product

- AMSR2 – Advanced Microwave Scanning Radiometer 2
- Launched on May 18, 2012 aboard the Global Change Observing Mission – Water (GCOM-W1) satellite (Japan Aerospace Exploration Agency)
- The AMSR2 retrievals used by this new analysis are produced by Remote Sensing System (RSS)
- Retrievals are gridded by RSS onto 0.25˚ x 0.25˚ grid, separately for northbound and southbound orbits
- Retrievals are generated in both clear and cloudy conditions
- Limitations: retrievals are not possible through precipitating clouds or within ~75 km of land

AMSR2 SST Product

SST retrievals for August 1st, 2014 from AMSR2



AMSR2 SST Product

To eliminate the observations affected by diurnal variability:

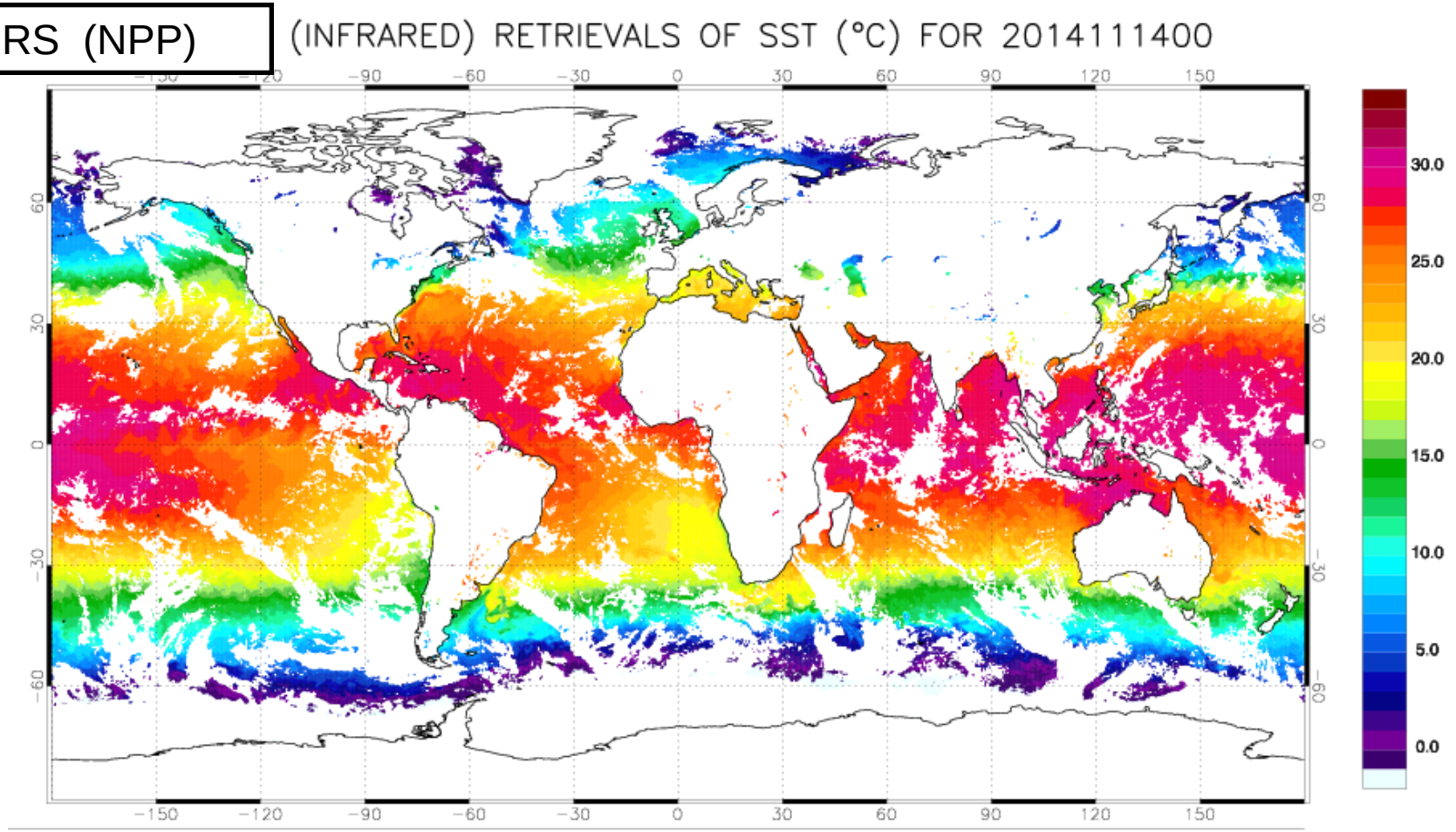
- RSS includes retrievals of surface wind speed
- Daytime retrievals of SST are not used if the wind speed is less than 6 m/s between 25S and 25N
- Elsewhere, daytime retrievals of SST are not used if the wind speed is less than 6 m/s within 45 days of the summer solstice

VIIRS SST Product

- VIIRS – Visible Infrared Imaging Radiometer Suite
- Launched on October 28, 2011 aboard Suomi National Polar-Orbiting Partnership (S-NPP) satellite
- VIIRS instrument – significant advancement from AVHRR and MODIS (Miller et al. 2013)
- Resolution: 740 m at nadir and 1.6 km at the edge of the scan
- Swath width 3000km (as AVHRR)
- Retrievals are not possible through cloud

VIIRS SST Product

VIIRS (NPP)

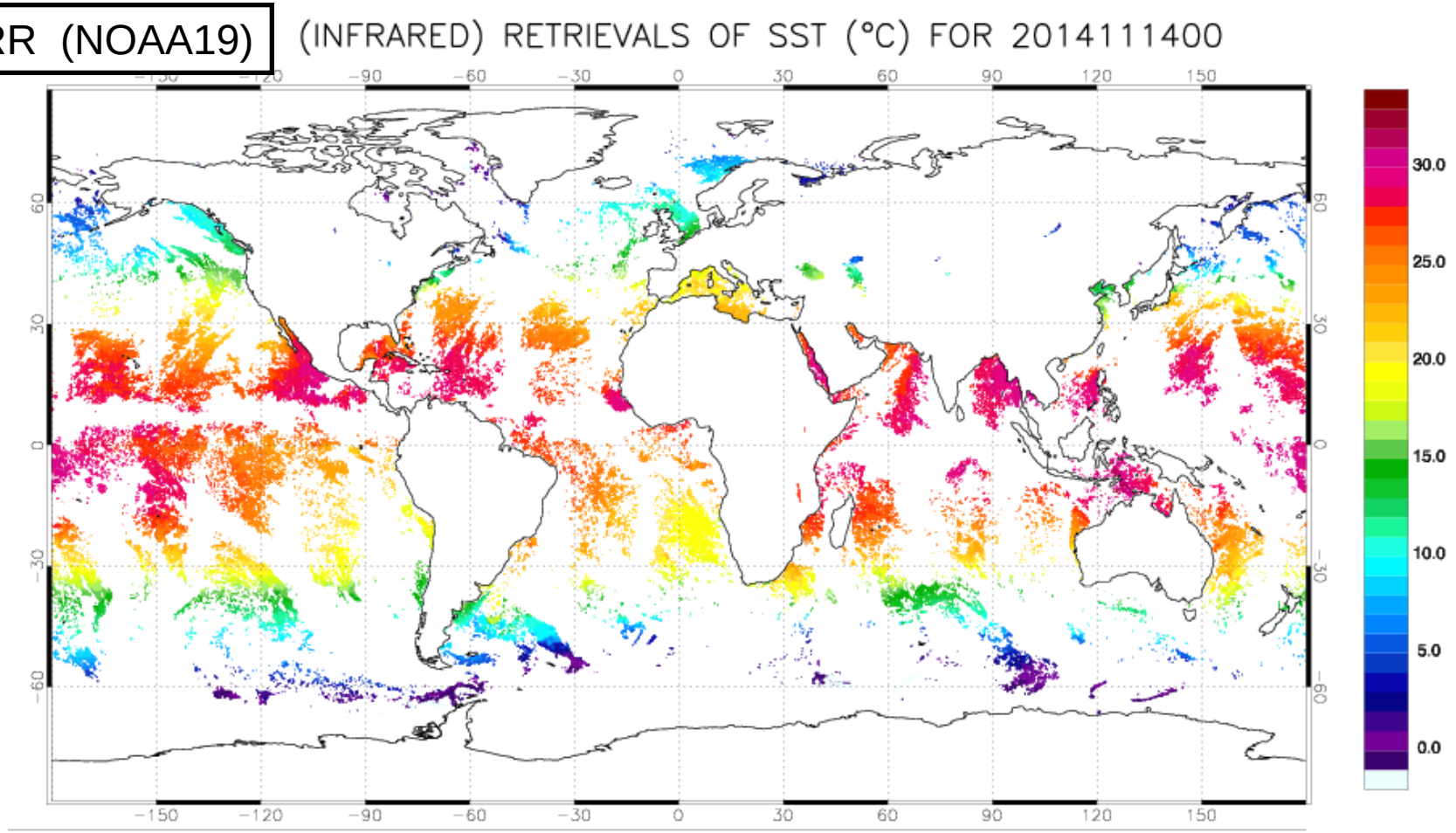


Environment Canada Environnement Canada

Canada

VIIRS SST Product

AVHRR (NOAA19)



NAVO AVHRR retrievals, GAC data, resolution ~ 9km

VIIRS SST Product

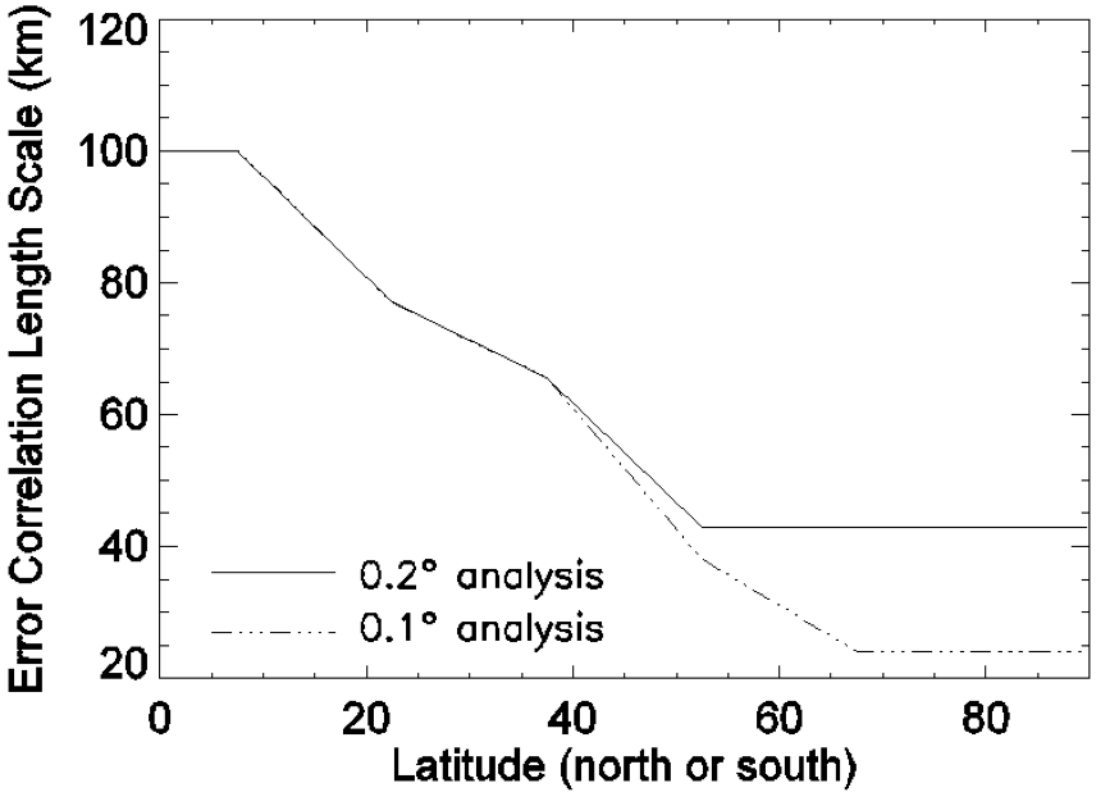
- VIIRS dataset produced by NOAA/NESDIS using Advanced Clear-Sky Processor for Oceans - ACSPO (Petrenko et al. 2014)
- Better coverage than NAVO AVHRR GAC data : 3.2 times more cells with VIIRS data
- Better coverage in high latitudes : 5.6 times more cells with data for VIIRS
- Data publicly available since May 2014, include quality flags and surface wind speeds
- As for AMSR2, daytime retrievals are eliminated when the wind speed is less than 6 m/s between 25S and 25N and elsewhere within 45 days of the summer solstice

Assimilation Methodology

- The statistical interpolation method described in Brasnett (2008) is applied to the analysis problem, the observation quality control, and to the satellite bias correction problem
- Increased resolution to 0.1˚
- Background error correlations length scale reduced for high latitudes

Assimilation Methodology

- Length scales of the background error correlations - isotropic and symmetric about the equator
- No difference between the low resolution and high-resolution analyses from the equator to ± 37.5˚

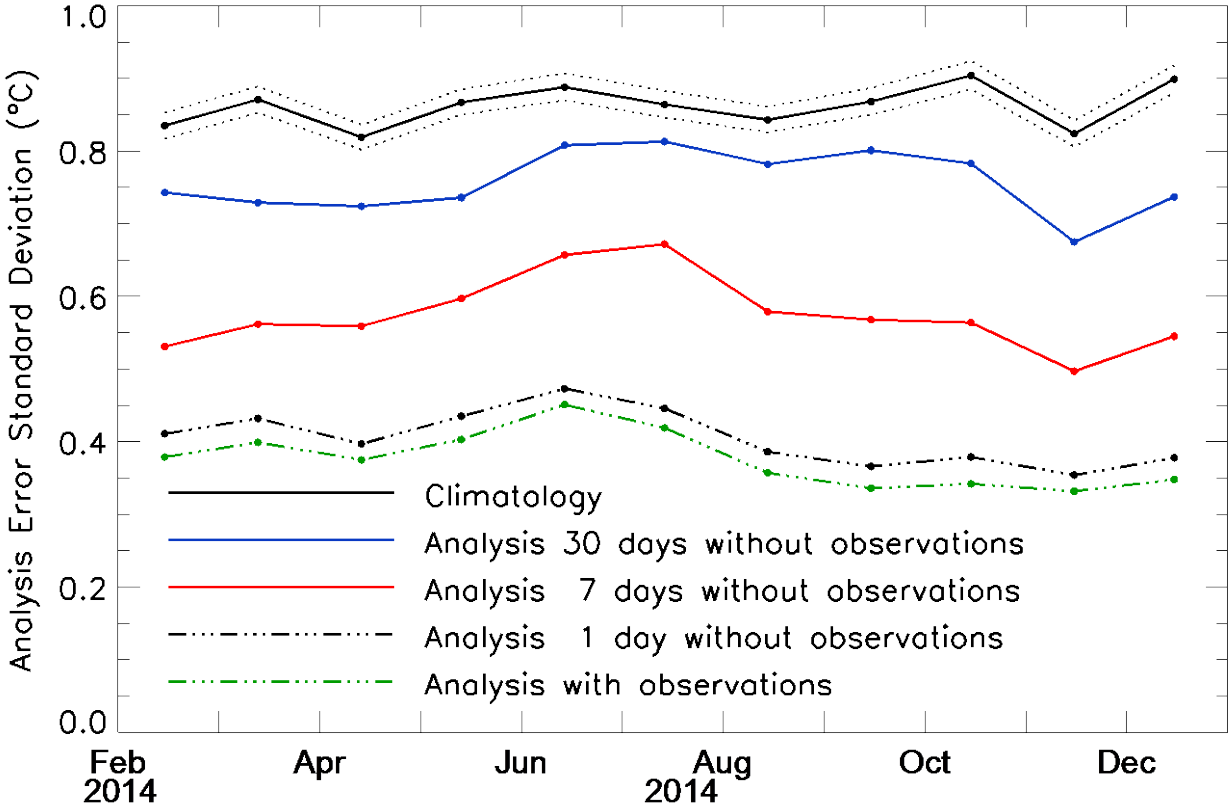


Assimilation Methodology

- The statistical interpolation method described in Brasnett (2008) is applied to the analysis problem, the observation quality control, and to the satellite bias correction problem
- Increased resolution to 0.1˚
- Background error correlations length scale reduced for high latitudes
- Statistical interpolation method used does not take account of correlated observations errors so satellite data are thinned
- Observations spacing reduced compared to the operational SST analysis 0.2˚ (33 km compared to 44 km for infrared data at high latitudes)

Assimilation Methodology

- The analysis variable - SST anomaly from climatology
- Data denial experiments show that prior observations contribute substantial information to each analysis

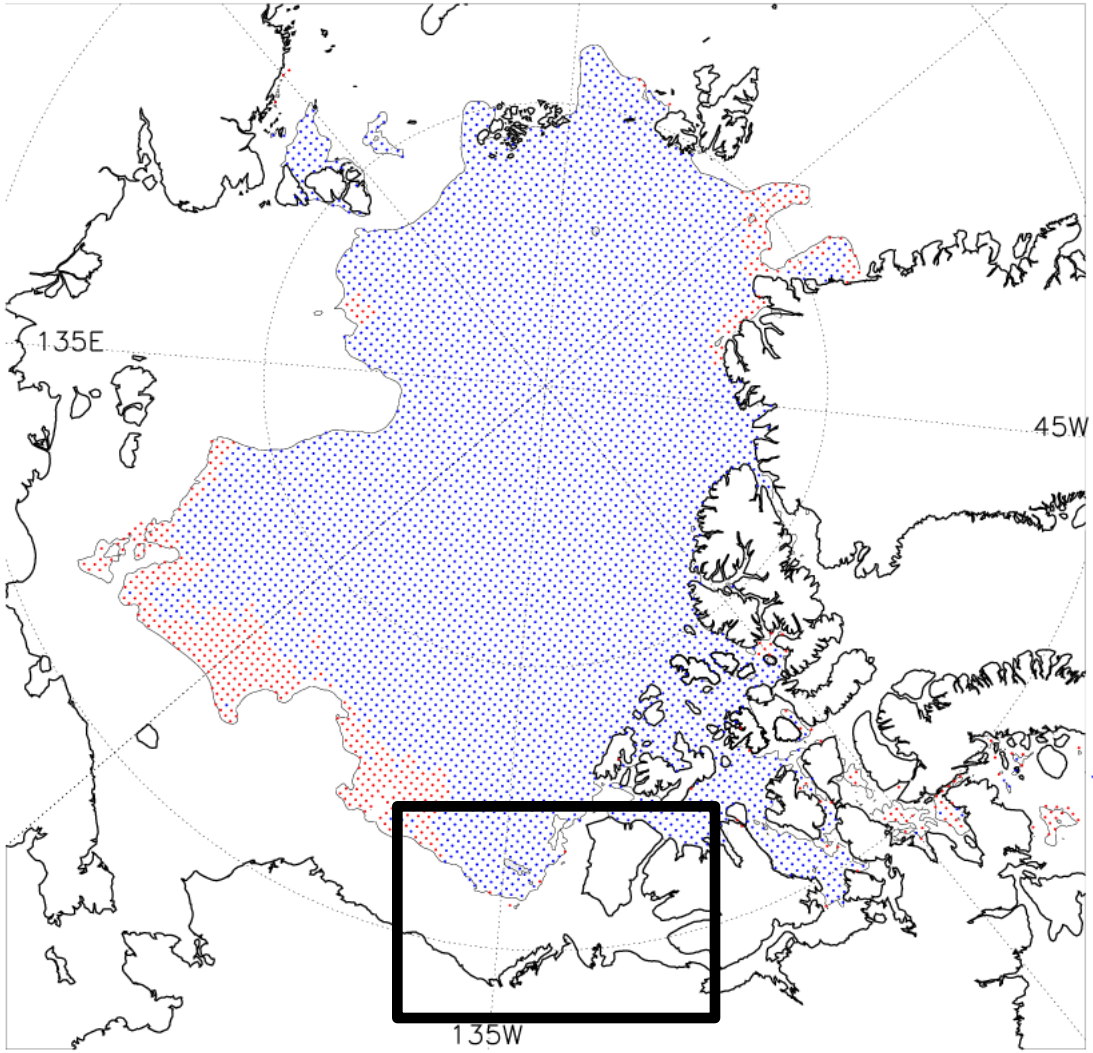


Insertion of Ice Information

- Proxy SST data are inserted at locations where ice is present - ice concentration 0.6 or larger
- Ice concentration from 3DVar CMC ice analysis (Buehner et al. 2014) - 10 km global ice analysis valid at 1800 UTC is sampled
- If the ice concentration is between 0.6 and 0.9 and the time average of surface air temperature is above 0° C, then SST= 0° C
- If the ice concentration exceeds 0.9 then SST=-1.8° C (freezing point of sea water with a salinity of 33 psu)
- The proxy SSTs are assimilated with an ascribed observation error of 1° C

Insertion of Ice Information

Locations of ice proxy data on August 19th 2014



0° C

-1.8° C

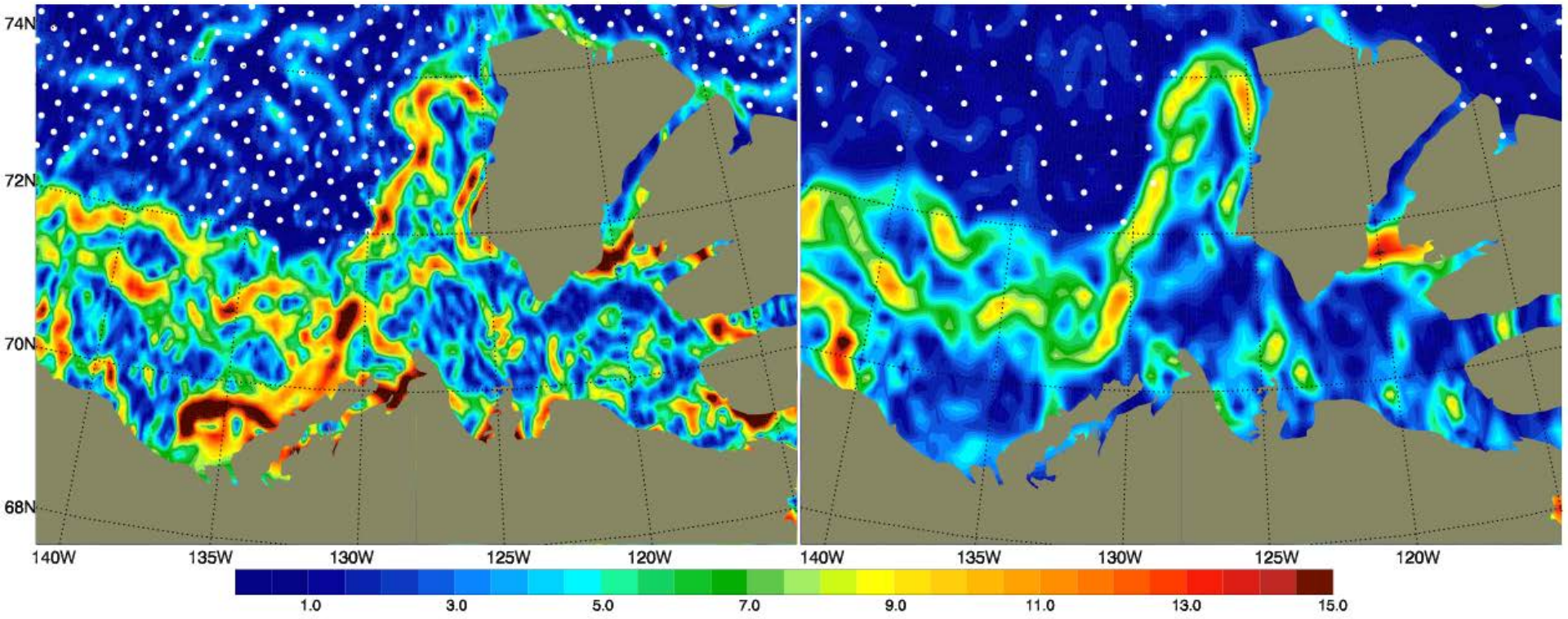
Canada

Insertion of Ice Information

- Better definition of the SST gradient near the ice edge

SST gradient (K/100km) for August 1st 2014

0.1° 0.2°

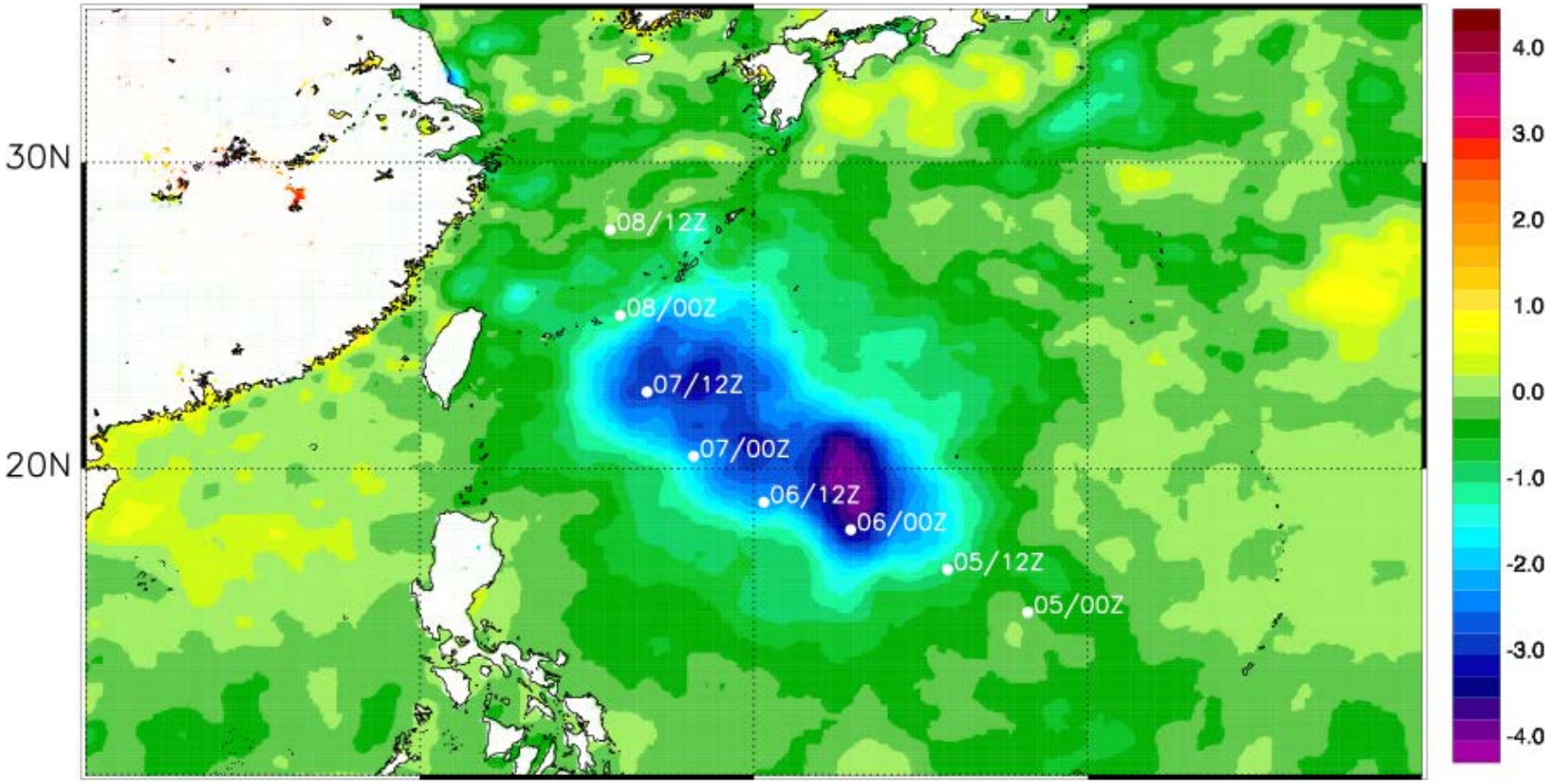


Capturing Sudden SST Changes

- SST changes of 3 K or more in one day occurs during the passage of intense tropical storms
- The analysis quality control rejects good quality observations
- During the quality control, the background error is amplified where the wind speed (from GDPS) is 21m/s or more
- The unaltered background error is used to compute the analysis

Capturing Sudden SST Changes

SST difference between the new analysis and the operational analysis for 9 July 2014, typhoon Neoguri

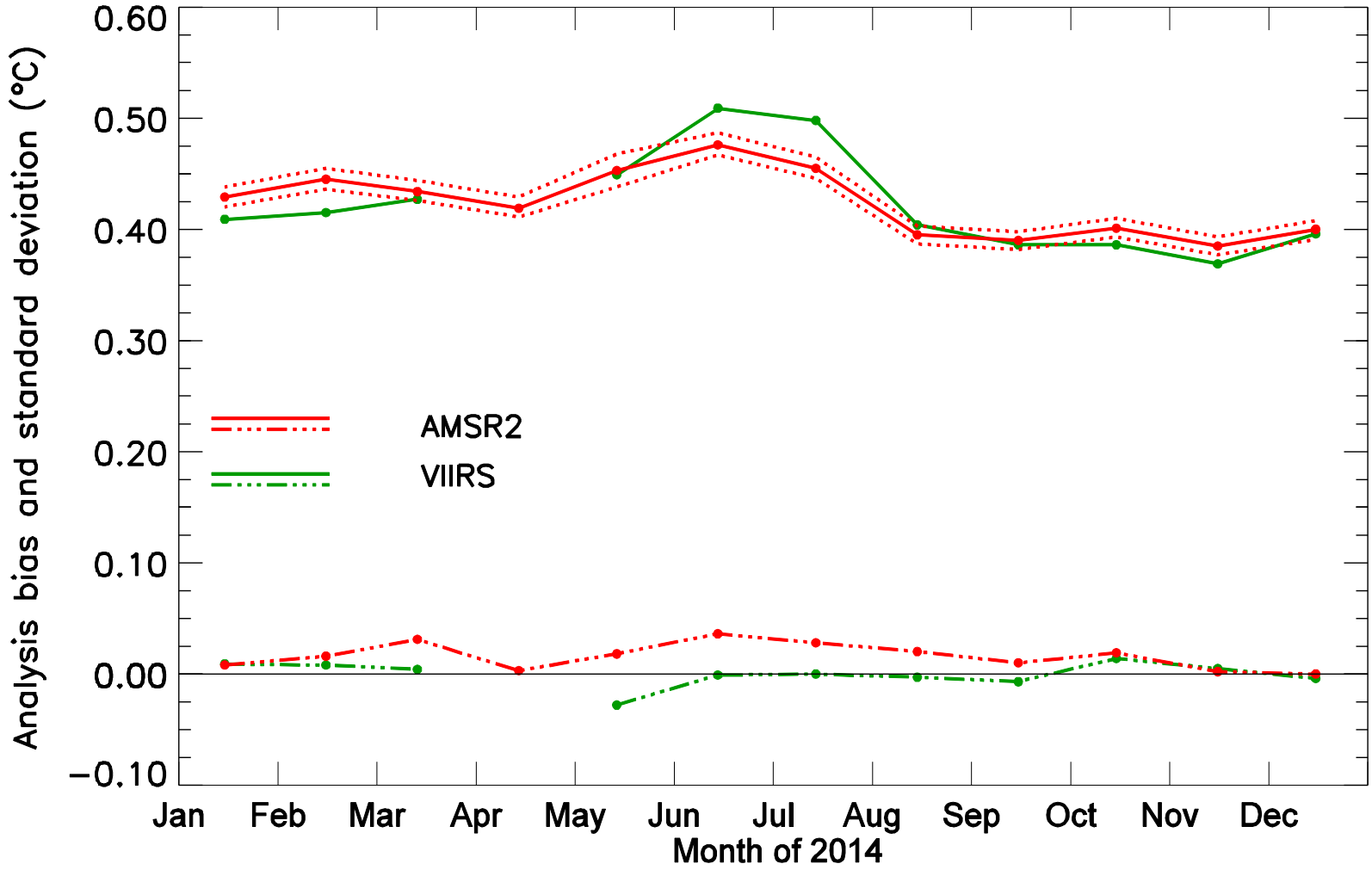


Evaluation

1) Two analysis produced with the same methodology on a 0.2˚ assimilating: a) AMSR2 retrievals and b) VIIRS retrievals

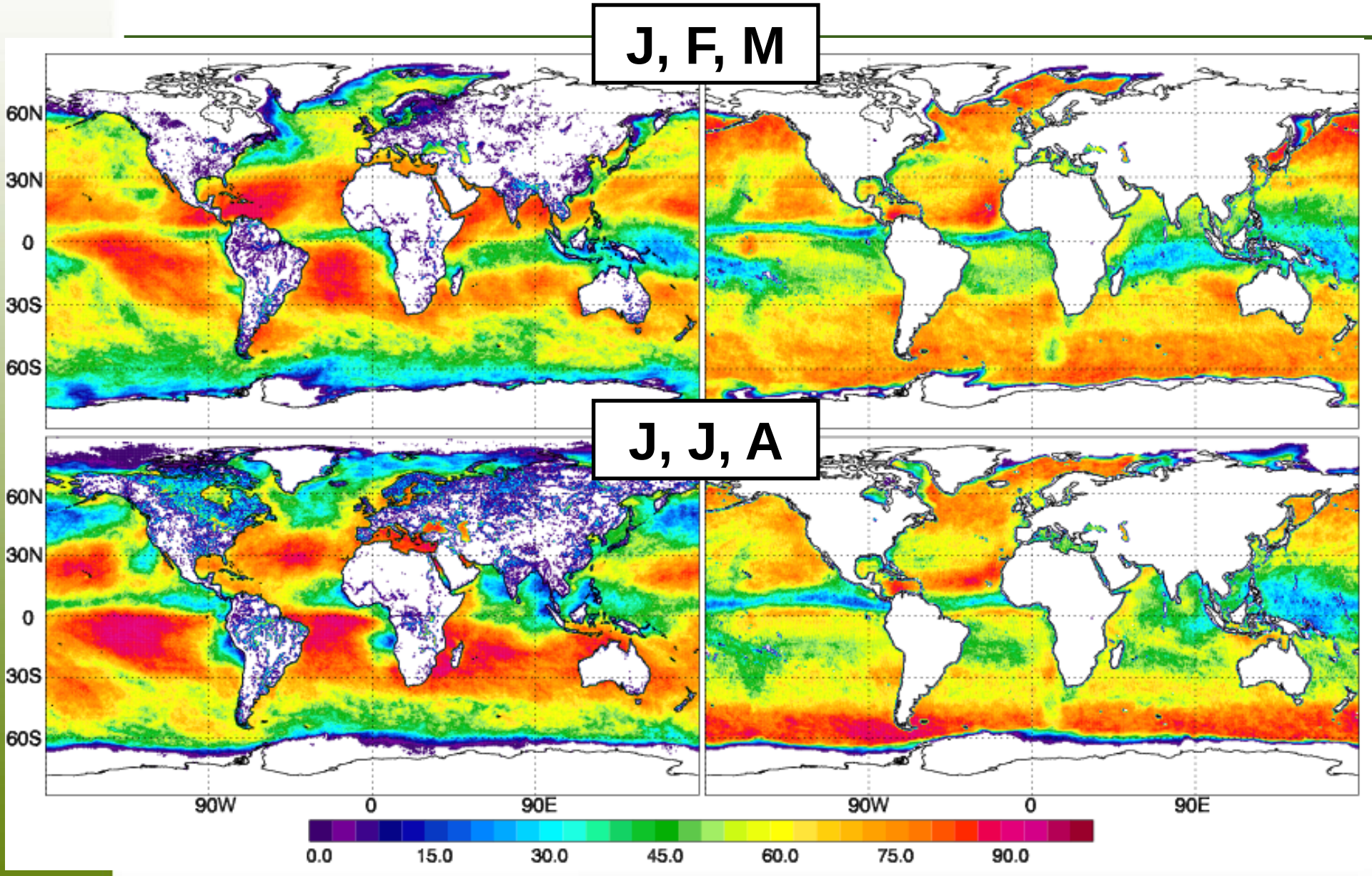
- Verifications against independent measures – Argo floats
- Observations used only if they are between 3 m and 5 m and within four standard deviations of the climatology
- An average 144 observations per day were available for evaluation

Evaluation



Evaluation

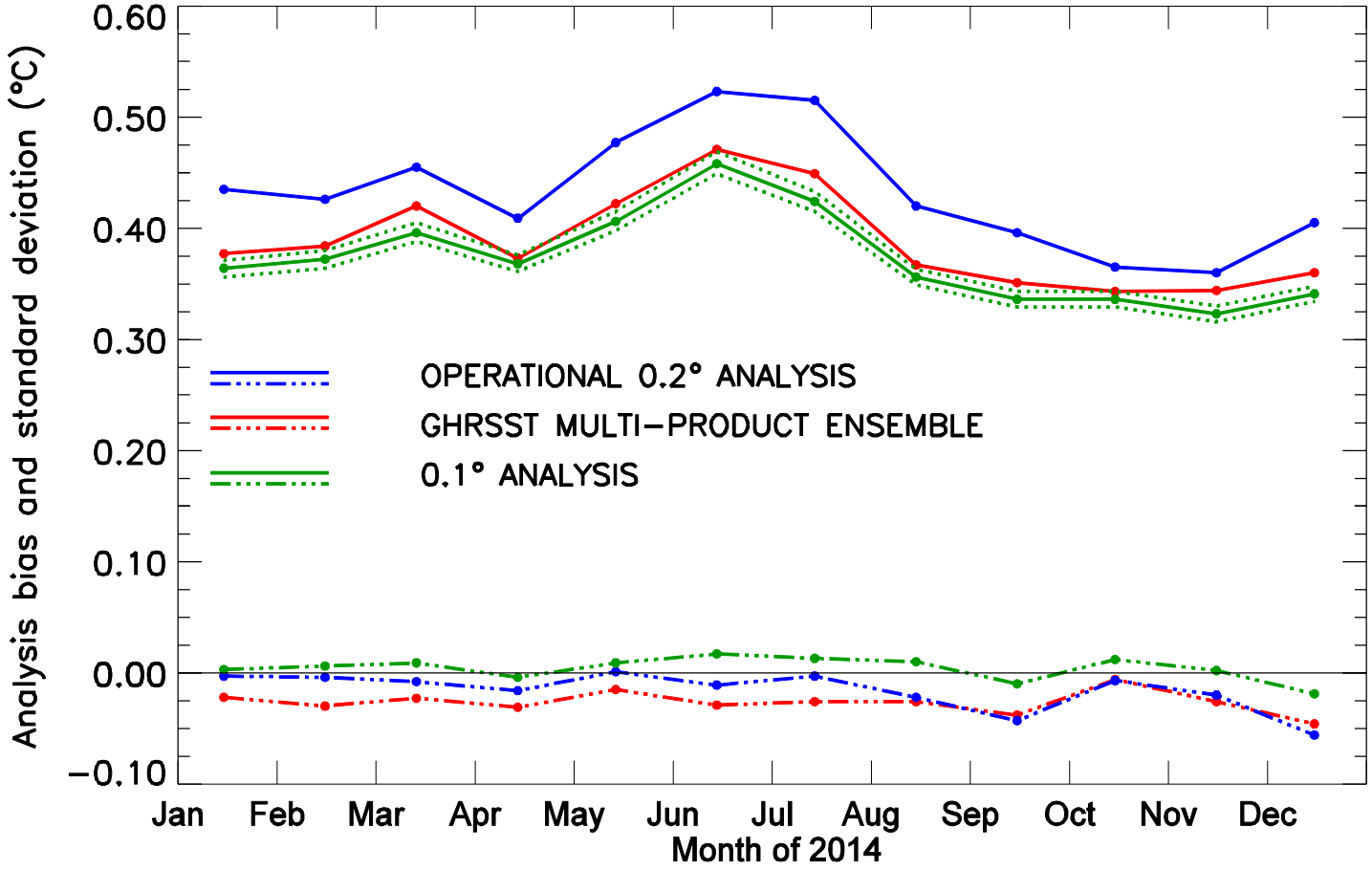
- VIIRS experiment significantly better than the AMSR2 experiment during January, February, October and November
- AMSR2 experiment significantly better than VIIRS during June, July and August
- During the months when AMSR2 experiment was better, AMSR2 data was available 60% of the time compared to 30% of the time for VIIRS over some regions of the globe


VIIRS
AMSR2
J, F, M
J, J, A
60N
30N
0
30S
60S
90W
0
90E
0.0
15.0
30.0
45.0
60.0
75.0
90.0

Evaluation

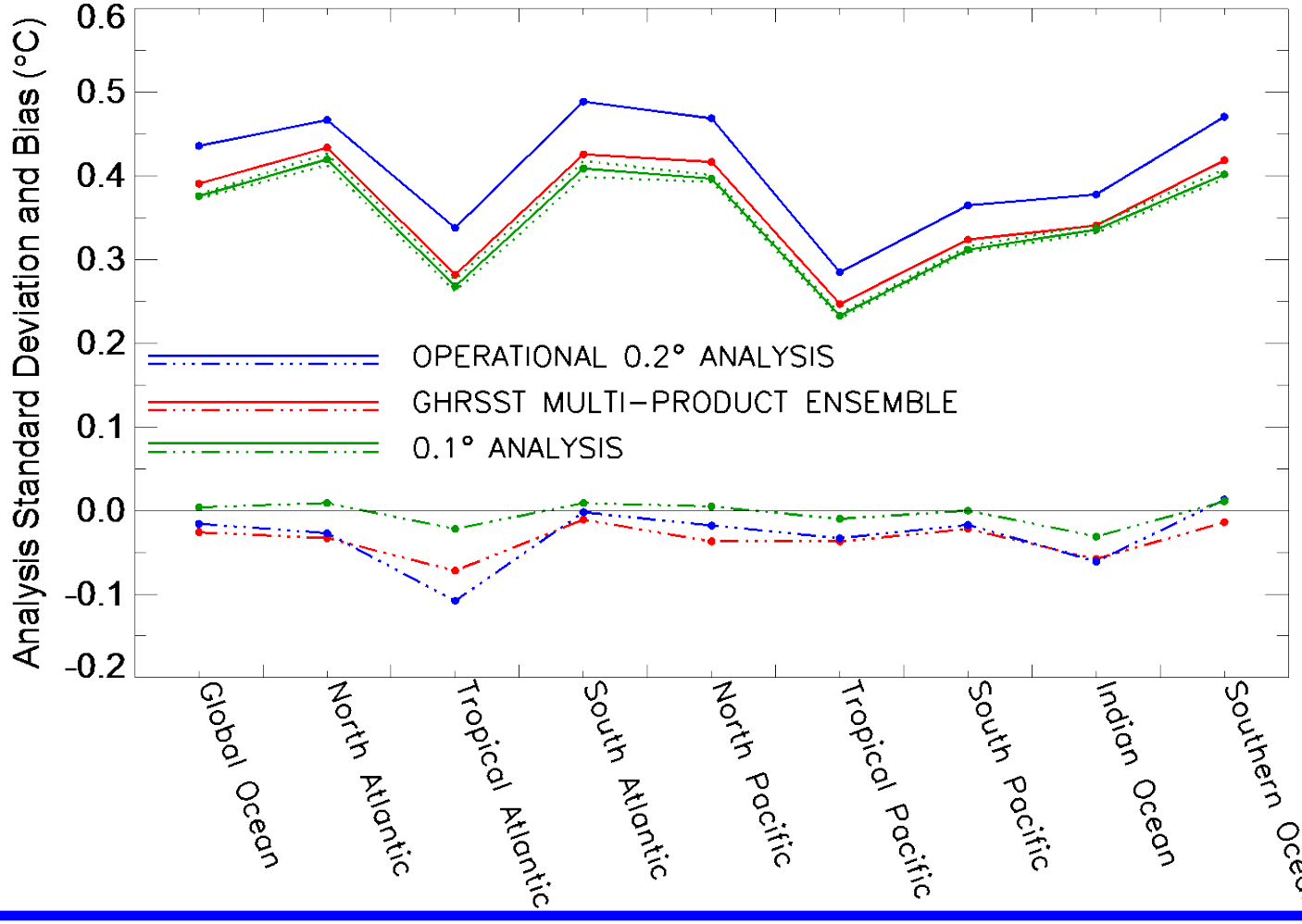
2) Comparison between the operational 0.2° analysis, the new 0.1° analysis, and the GMPE (GHRSST Multi-Product Ensemble) product (Martin at al. 2012)

Evaluation



The 0.1˚ analysis performs better than the operational analysis and than GMPE product even in April when no VIIRS data were available

Evaluation

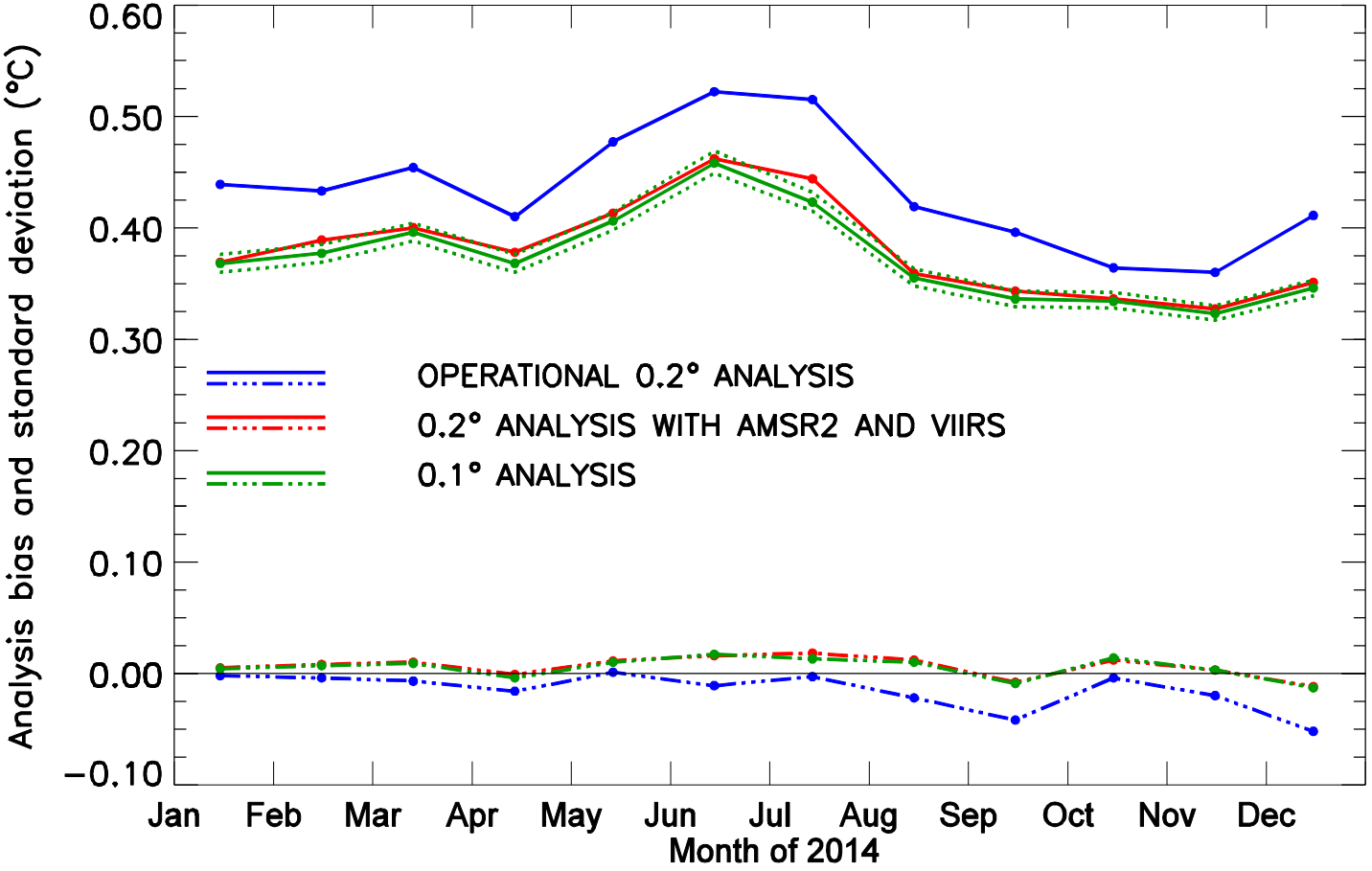


Are the improvements due to changes in the analysis methodology or to the addition of AMSR2 and VIIRS datasets?

Evaluation

3) Comparison between the operational 0.2° analysis, the operational analysis assimilating VIIRS and AMSR2 datasets and the new 0.1° analysis

Evaluation



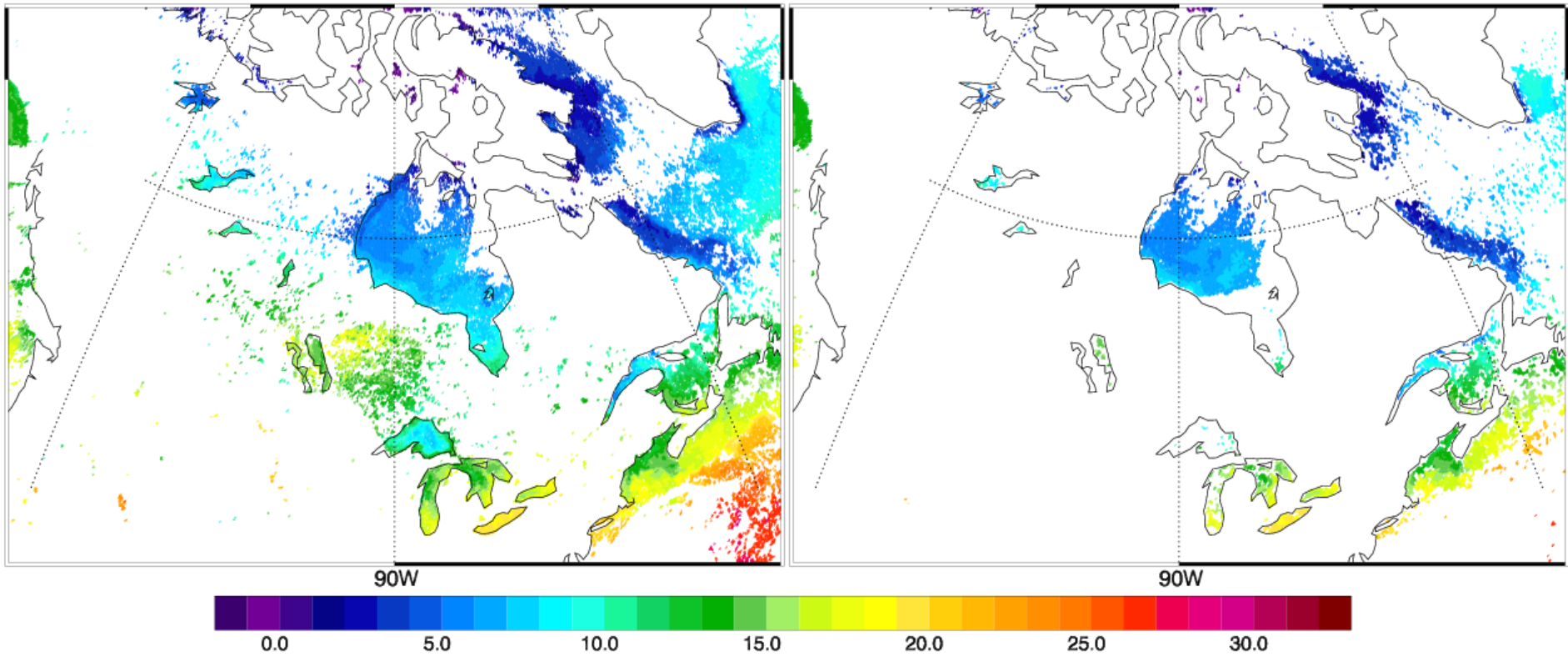
Most of the reduction in analysis standard deviation results from the addition of AMSR2 and VIIRS data

Conclusions

- The new 0.1° analysis shows more skill than the operational analysis and compares well with GMPE product for the period studied
- The most of the improvement is due to the addition of the AMSR2 and VIIRS datasets
- Persistent cloudiness affects VIIRS analysis during the summer, but in clear sky the higher resolution VIIRS retrievals are more valuable than AMSR2
- Improved analysis of SST can have a positive influence on the global and regional atmospheric and oceanic systems, providing better fluxes at the ocean and lake surfaces

Brasnett, B. and D. Surcel Colan, 2015: Assimilating Retrievals of Sea Surface Temperature from VIIRS and AMSR2, *J. Atmos. Oceanic Technol. (in revision)*

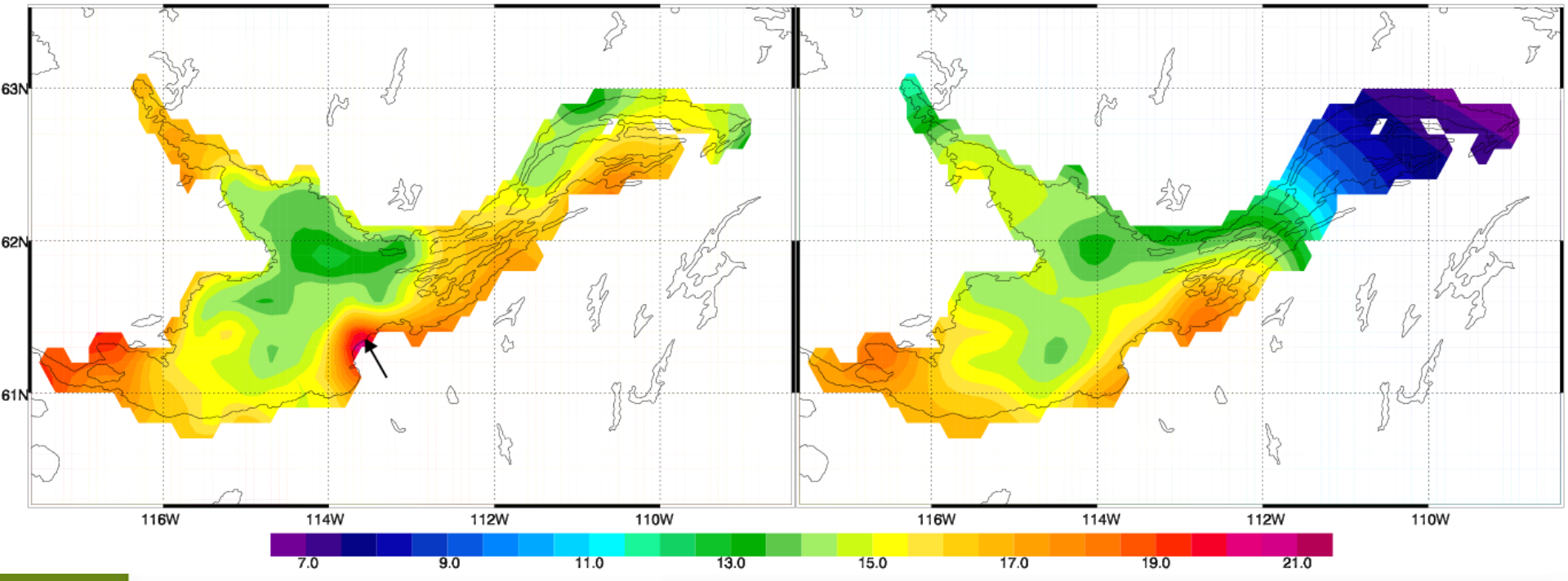
SST retrievals (˚ C) from the NOAA/NESDIS VIIRS dataset (left) and from the combination of three NAVO AVHRR datasets (right) for 24 Sept. 2014



Evaluation

- The new 0.1˚ analysis (left) assimilates many VIIRS retrievals but no satellite data (AVHRR) are available for the the operational analysis (right)

Great Slave Lake, August 15, 2014



- Typhoon Neoguri: 7 Argo observations for 4 days (July 5th - July 8th) for the region (16N- 26N et 124E - 136E).

- The bias for the operational analysis is +2.1 K compared to +1.1 K for the new analysis (0.1 deg).
- The RMS error for the operational analysis is 2.4 K compared to 1.3 K for the new analysis.