Satellite Water Temperature Indicator for Chesapeake Bay

Indicator Development and Cross-comparison with Chesapeake Bay Program Monitoring Data

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CBP Climate Resiliency Workgroup Meeting

October 16, 2017

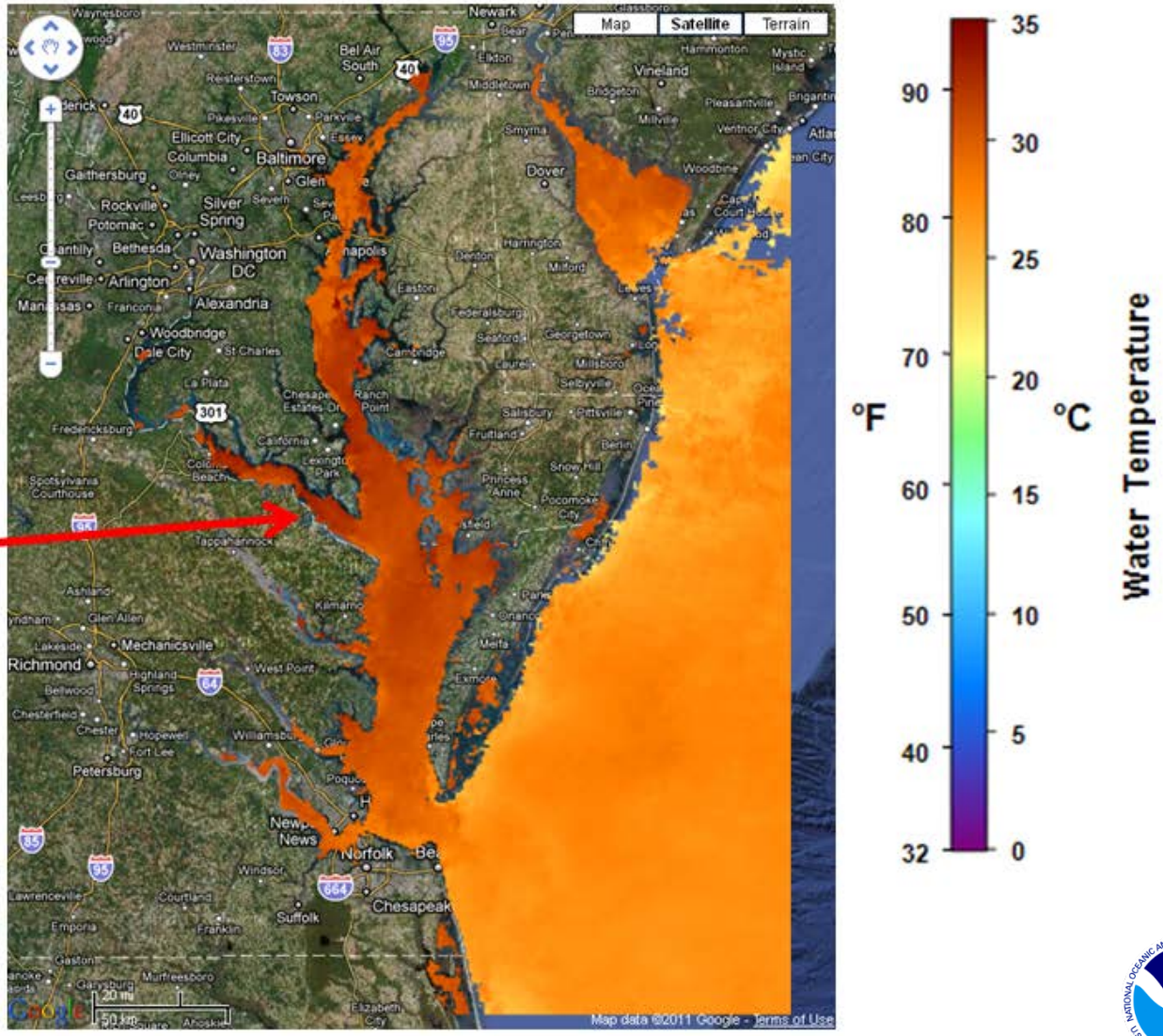
Climate Change and Chesapeake Bay

Are water temperatures rising?

NOAA Satellite
Water Temperature
from AVHRR

July 23, 2011

Mid-Chesapeake Bay and Potomac River at 90+ °F (up to 34 °C)



Outline

- Project Background
- Indicator Data Set Description
- Indicator Methodology
- Data Set Validation for Chesapeake Bay
- Indicator Web Display
- Next Steps

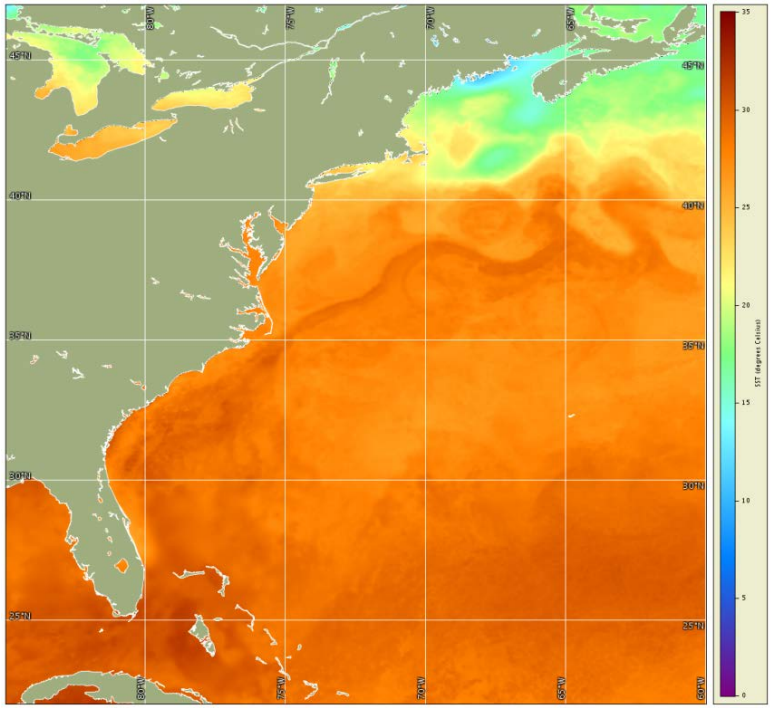
Project Background

- Develop water temperature indicators for U.S. estuaries using satellite data
- Initiated by EPA National Estuary Program
- Discussions between EPA, NASA, NOAA on satellite data sources, selection of data sets, implementation plan
- NOAA CoastWatch is developing the indicator in Pilot Phase
  - Chesapeake Bay added by NOAA to EPA NEP's initial pilot estuaries
- Currently obtaining feedback from NEP estuarine managers of the pilot estuaries
- After pilot phase, expand indicator to 28+ estuaries in EPA NEP and NOAA's National Estuarine Research Reserves. Eventually expand to all U.S. estuaries.

Satellite Sea Surface Temperature (SST)
Long Data Series: Multiscale Ultrahigh Resolution (MUR) SST

- From NASA Jet Propulsion Lab / Physical Oceanography Distributed Active Archive Center
- 2002 – present
- Daily, global, cloud-free
  - Data from all available satellites (infrared, microwave) blended together
  - Data assimilated with global in-situ SST data from NOAA iQuam database to account for differences in the source data sets
  - New data added on a daily basis
- 1 km spatial resolution
- Surface water temperature only

July 30, 2015

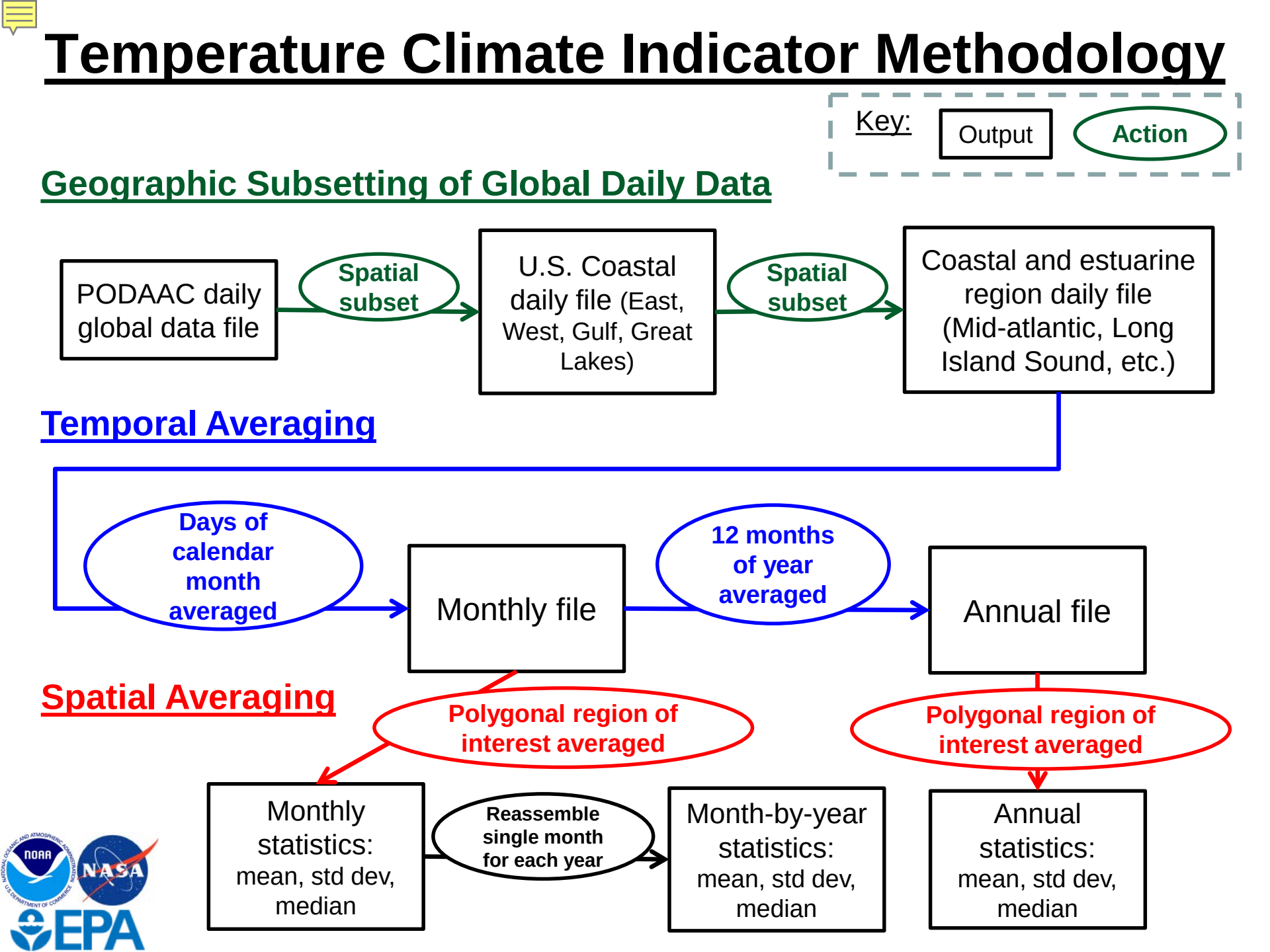


Satellite Sea Surface Temperature (SST)
Long Data Series: Multiscale Ultrahigh Resolution (MUR) SST

- Advantages as an indicator
  - Bay-wide data points at 1km grid spacing
  - Cloud-free
  - On-going, new data available daily
  - Automated processes calculate monthly & annual statistics for web display
- Disadvantages
  - Data only back to 2002
  - Surface water only
  - Nighttime temperature estimation – need to take diurnal bias into account when comparing with other data sets

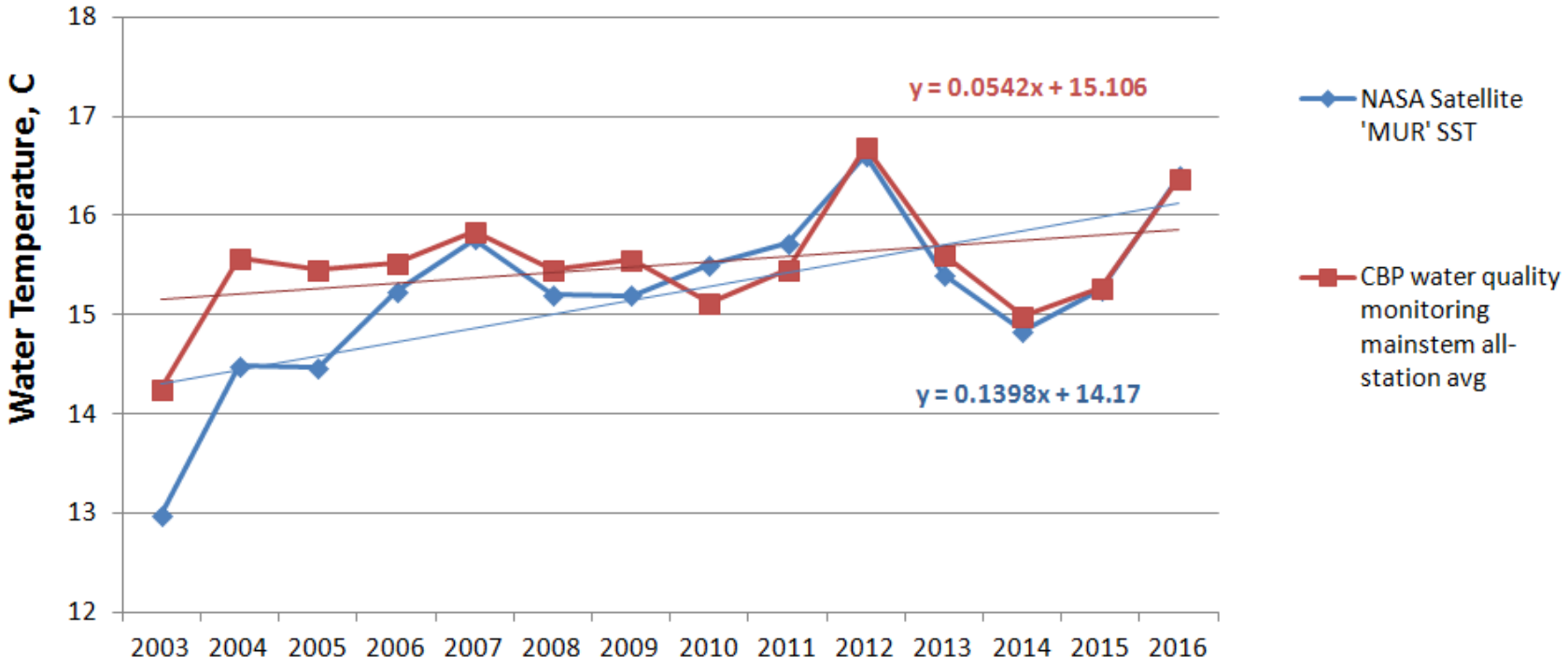
An indicator from this satellite data set capitalizes on spatial coverage, spatial resolution, and temporal resolution (better than ship-based sampling, but not as frequent as buoys), but is weak on temporal coverage (limited years) and vertical coverage in the water column.

Temperature Climate Indicator Methodology



Temperature change from MUR SST Chesapeake Bay

MUR SST vs. Chesapeake Bay Program in-situ water quality monitoring data
Annual average surface temperature comparison



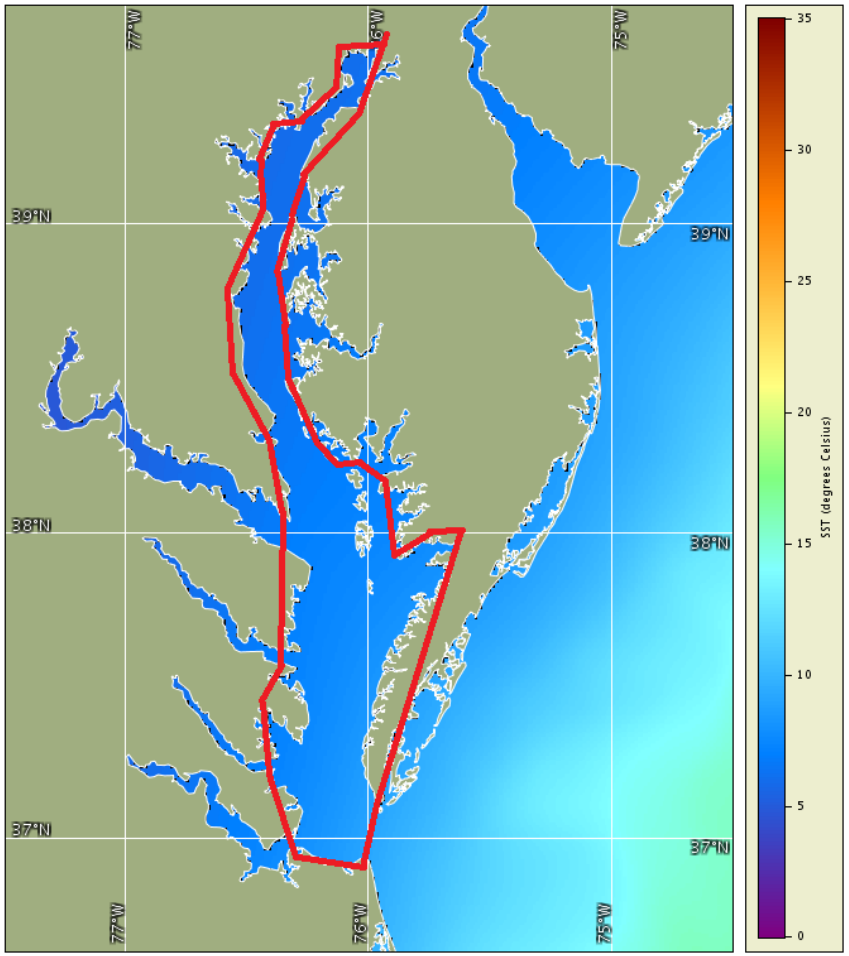
MUR rate of change **2.5x** that of CBP in-situ data

Data Set Validation

NASA MUR SST
vs.
CBP Water-Quality Monitoring Program
temperature

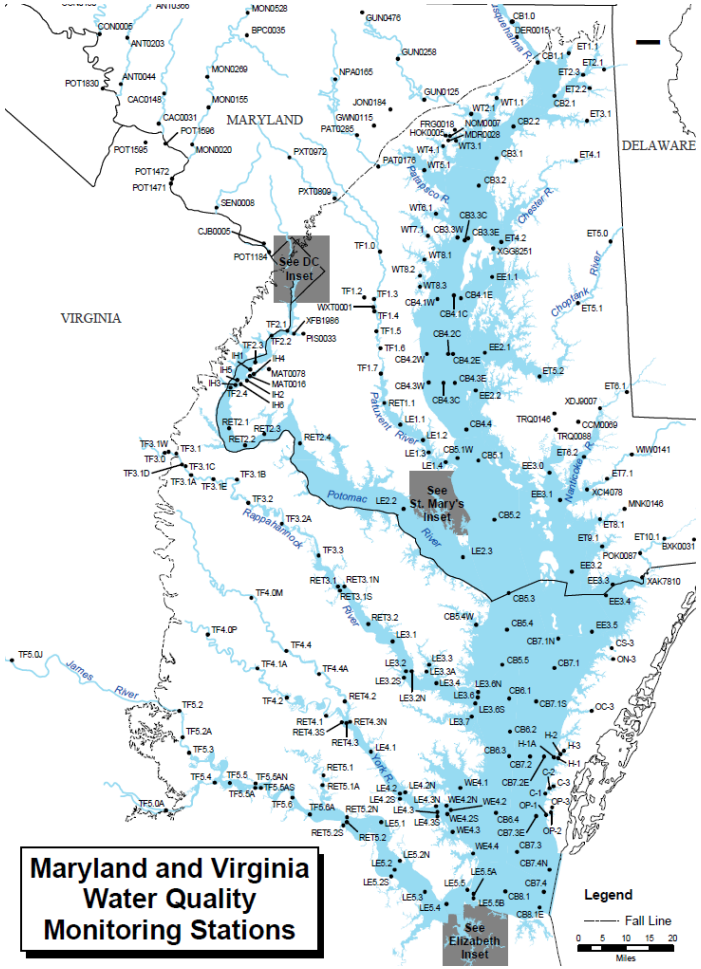
Validation Study Area

MUR region averaged:
Bay mainstem only, no tributaries



Chesapeake Bay Program water quality monitoring stations:

40 Bay mainstem stations

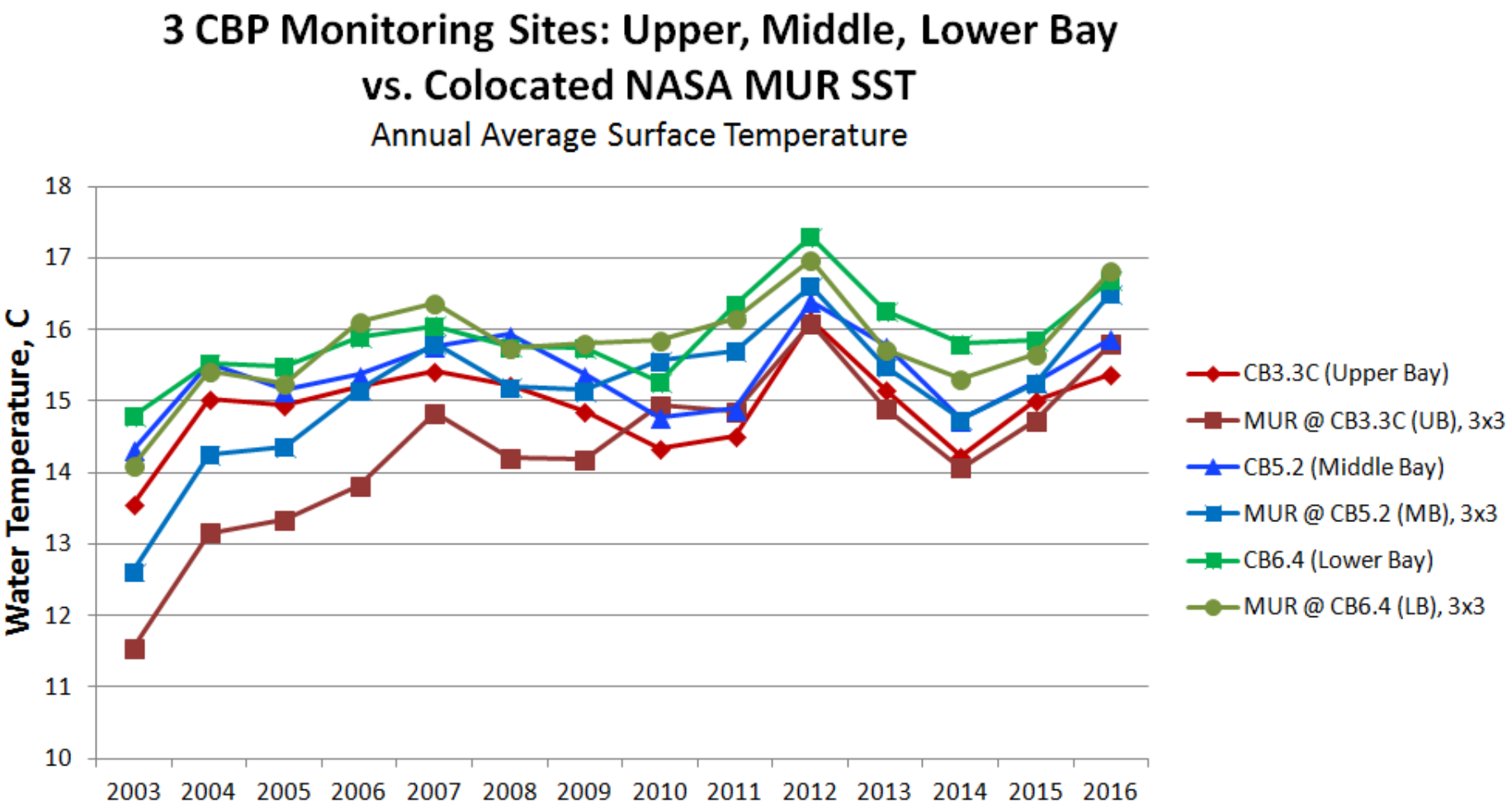


Data Sets

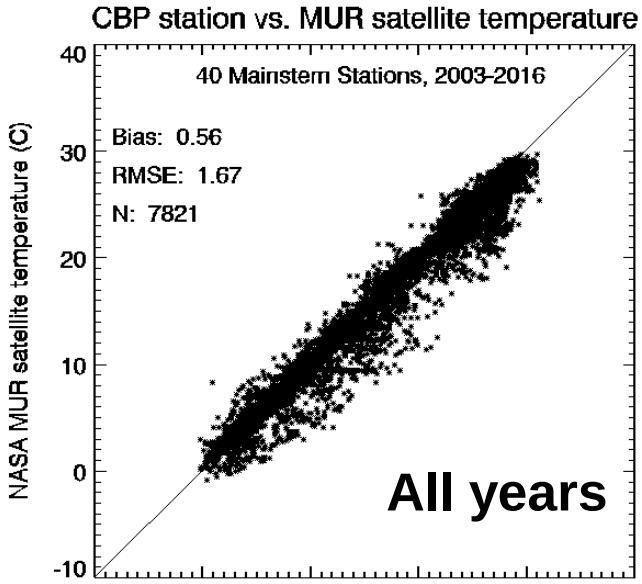
- MUR Satellite Sea Surface Temperature (SST)
  - Daily coverage, multi-satellite blended, cloud-free, 1-km spatial resolution
  - Blending process assimilates in-situ SST measurements to reconcile differences in the satellite inputs
  - Night time SST estimation
  - Surface ‘bulk’ estimation, i.e. ~ top 1 m
- CBP in-situ water quality monitoring program
  - Monthly or bi-monthly water sample collection at multiple depths, including surface (0.5m – 1m). Only surface measurement used in this comparison.
  - 40 of 49 mainstem stations used in this comparison, i.e. all stations except those without data collection Nov-Feb to avoid over-biasing summertime measurements
    - 9 stations not used: CB3.3E,W; CB4.1E,W; CB4.2E,W; CB4.3E,W; 5.4W

Comparison Method

- Study time period: 2003 - 2016
- Match-up: at each CBP station location, MUR 3x3 grid-cell average calculated for day of CBP sample collection
- Scatter plots of daily CBP temperature vs. daily MUR temperature
  - Histograms of daily CBP-MUR temperature difference also available
- Annual average time series: annual avg calculated the same as CBP STAC 2008 report: monthly avg, then yearly avg, then spatial avg of all stations or grid-cells
  - CBP stations missing a month of data collection are gap-filled using average of all existing mainstem station values for that month (i.e. monthly Bay-wide CBP avg is used to fill missing station-months)

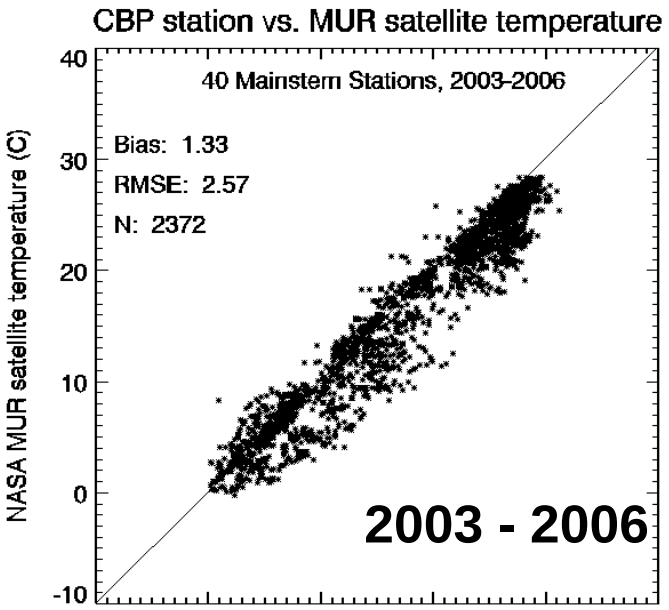


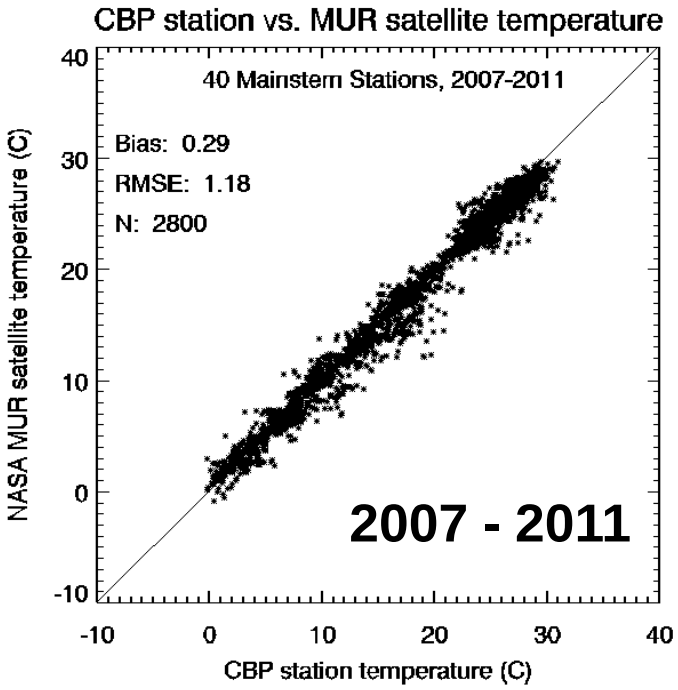
- MUR data at the more northerly station & in earlier years shows distinct low bias



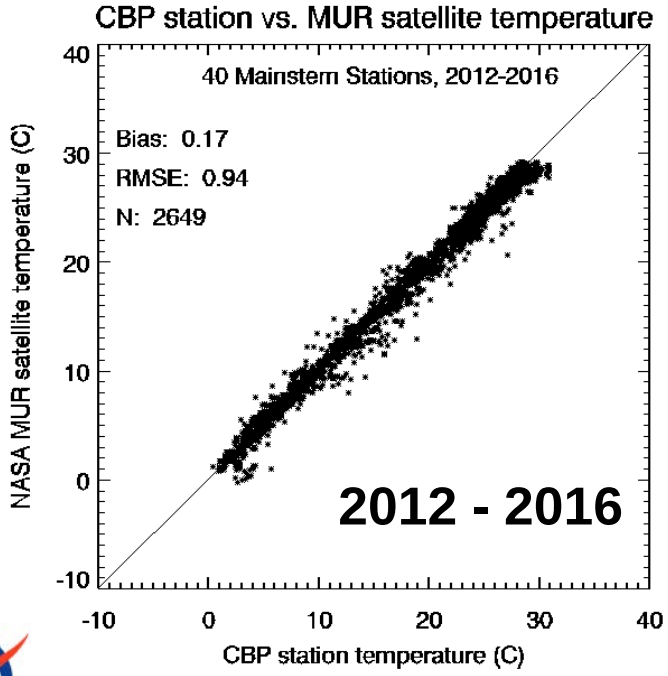
Scatter plots of CBP vs MUR temp

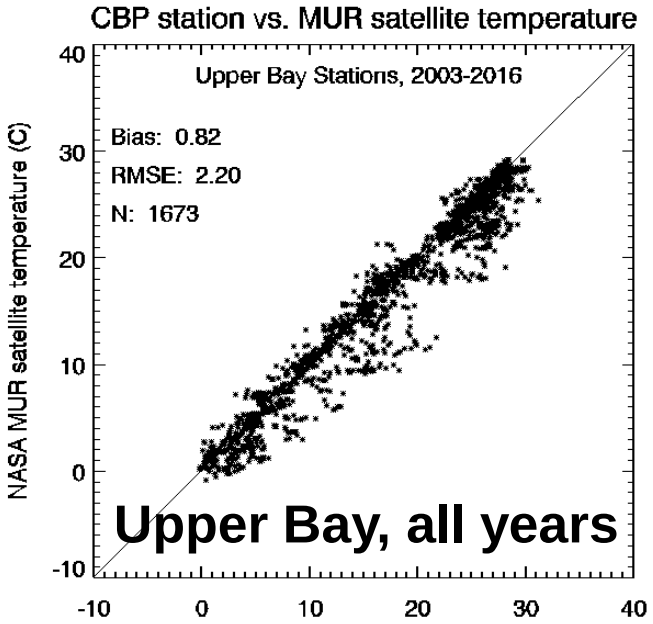
By year

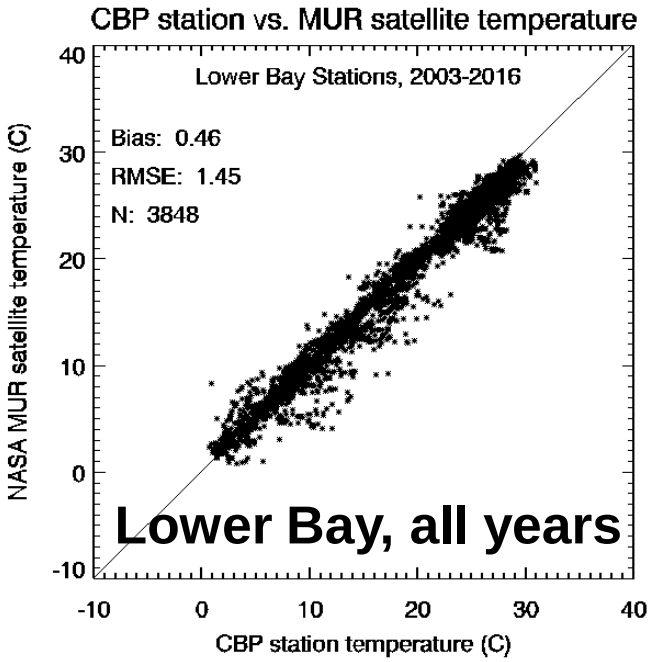




2012-2016:
Lowest bias
Lowest RMSE

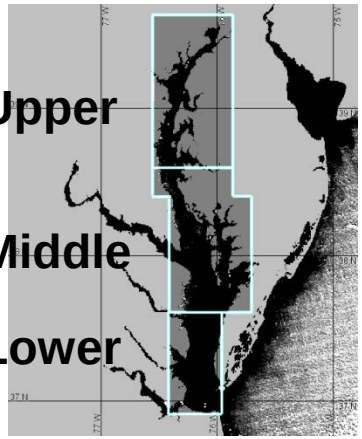




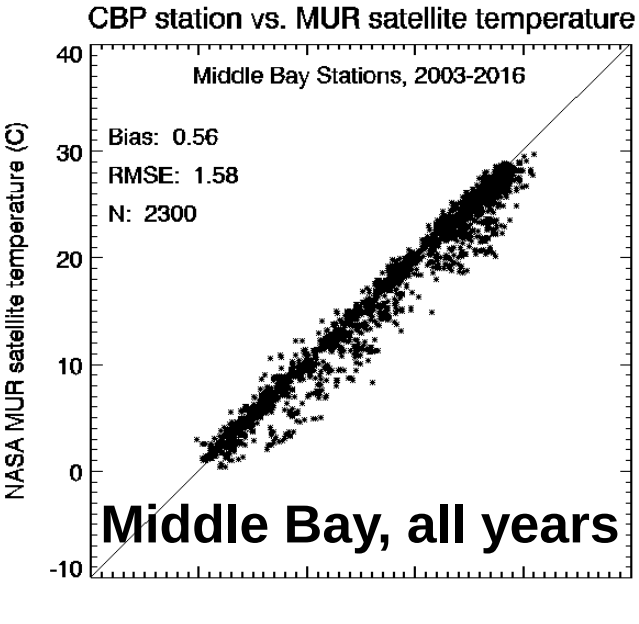


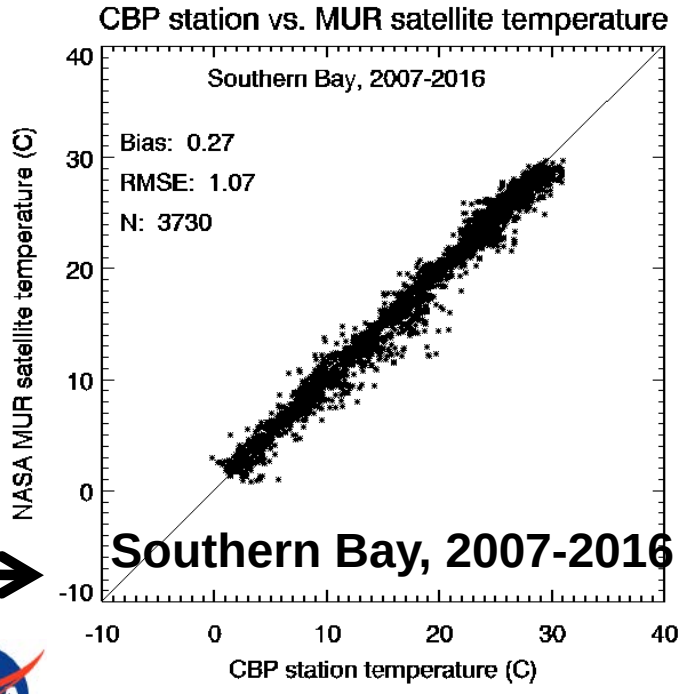
Scatter plots of CBP vs MUR temp

By Region

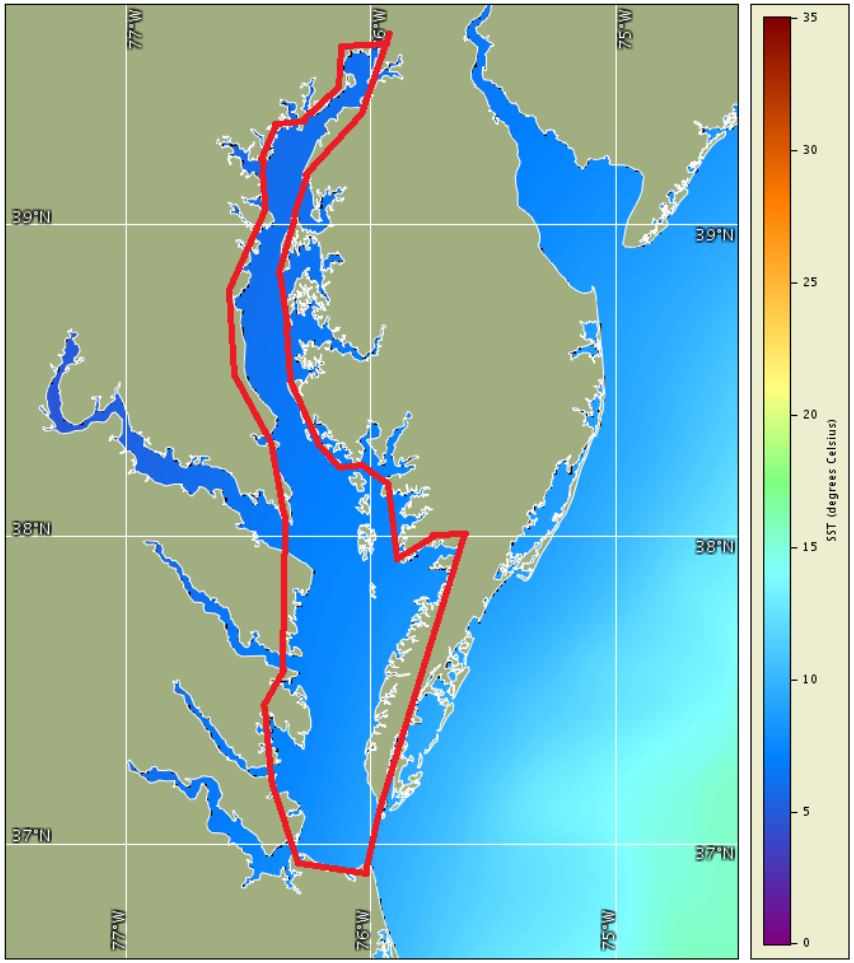


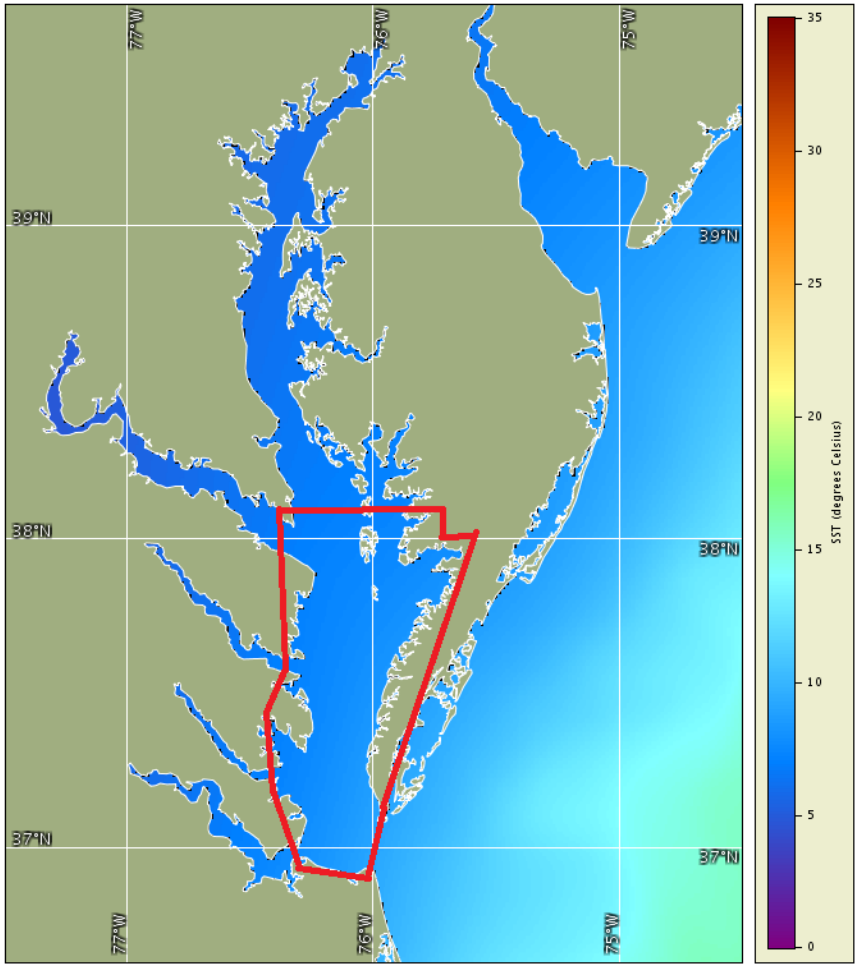
Southern Bay for 2007-2016 shows lowest bias and RMSE



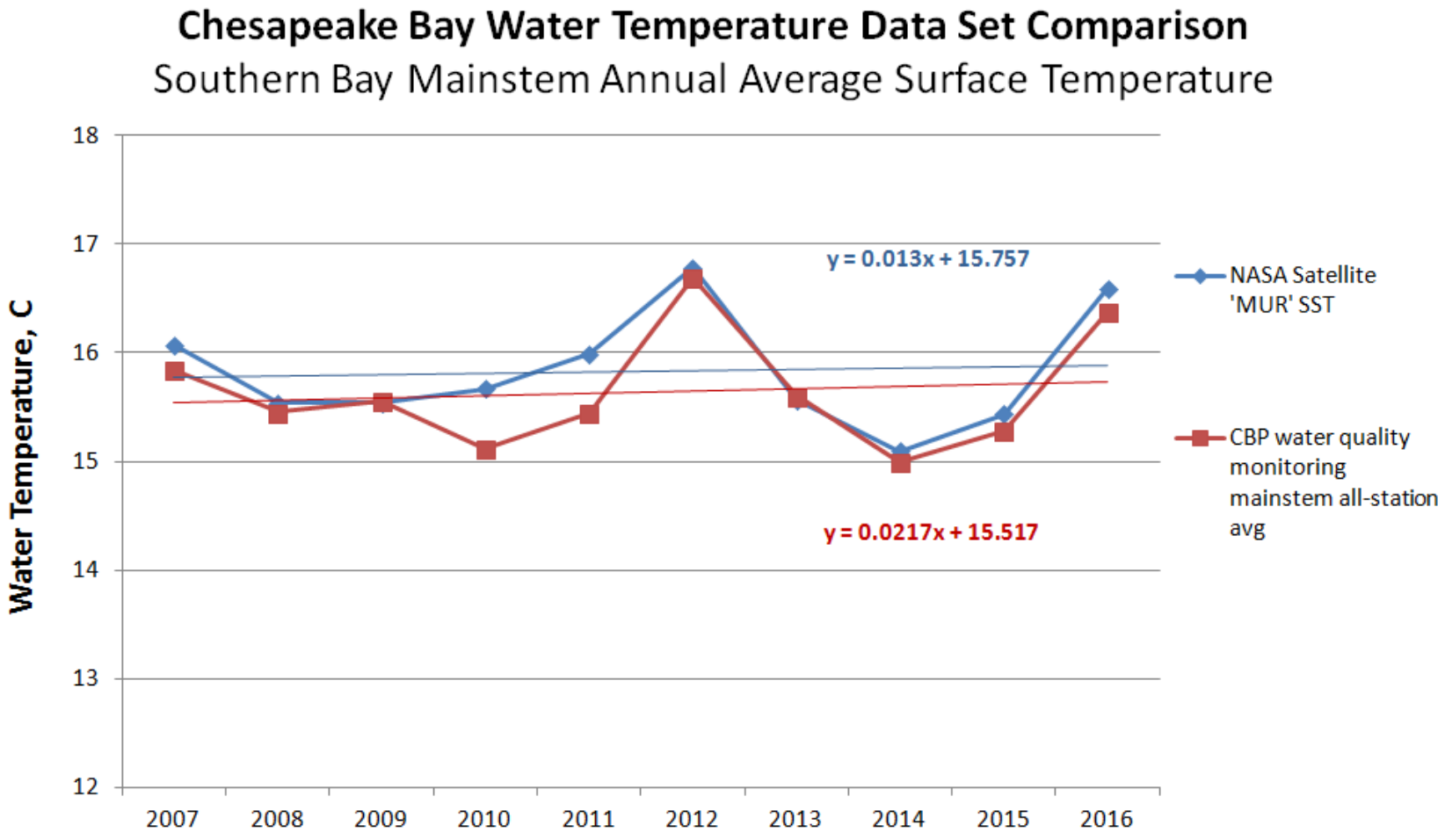


New polygon for Southern Bay to recalculate the rate of change for the less-biased time period





MUR satellite SST comparison with CBP monitoring data recalculated for Southern Bay mainstem & 2007-2016

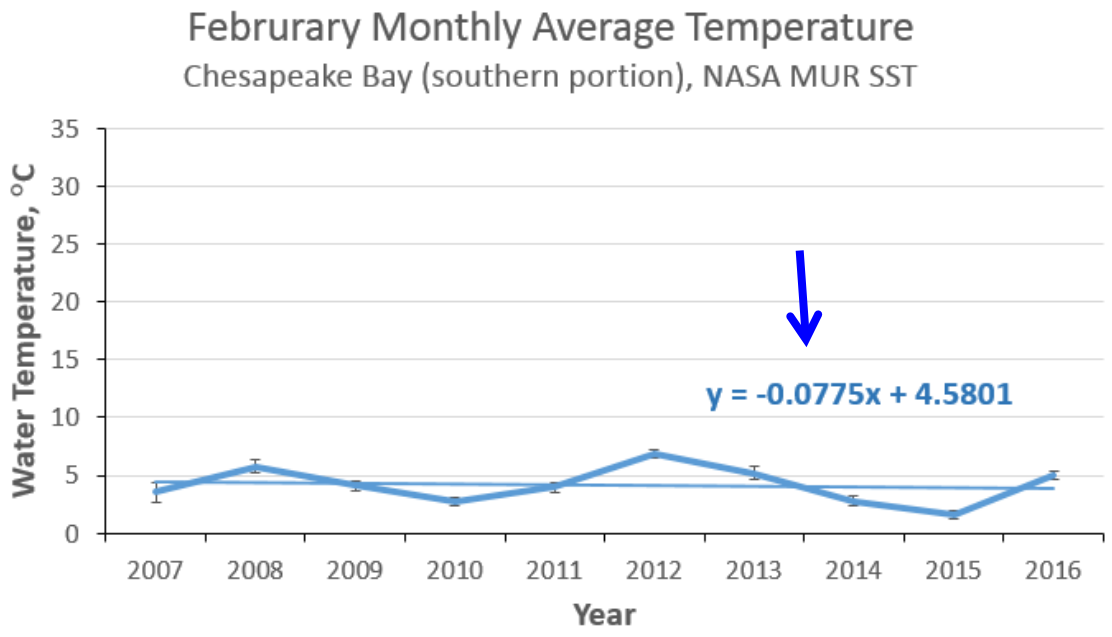


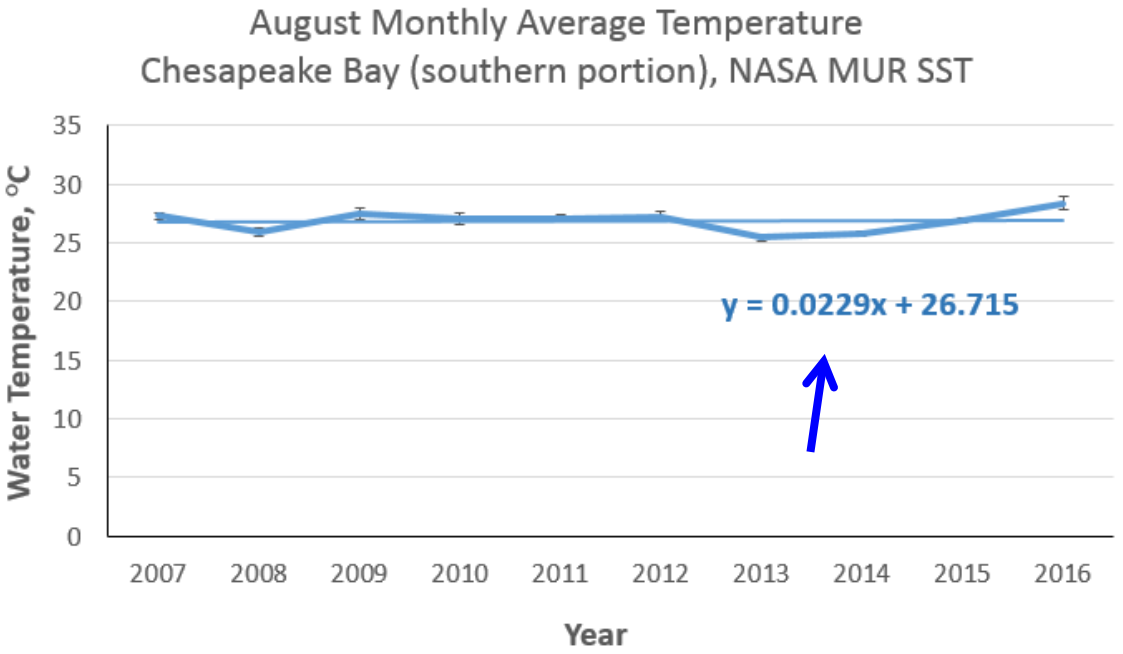
Using only Southern Bay region and time period beginning 2007 gives a rate of change closer to CBP in-situ measurements

Discussion with Mike Chin, NASA PI

- Earlier period (2002-2006) has errors because it uses older versions of two of the input satellite data sets (MODIS, AVHRR).
  - New input versions are now available and MUR SST will be reprocessed for the 2002-2006 time period, maybe by the end of 2017.
  - When the reprocessed MUR SST is available, the climate indicator can be updated to extend back to 2002.
- There is no data earlier than 2002 because several key satellite inputs do not exist (low-res microwave SST measurements and global high-res infrared SST measurements)
- They have not been using coastal in-situ data in the blending/assimilation process and will look into using it. Assimilating with coastal in-situ data may improve the MUR SST accuracy in coastal regions.

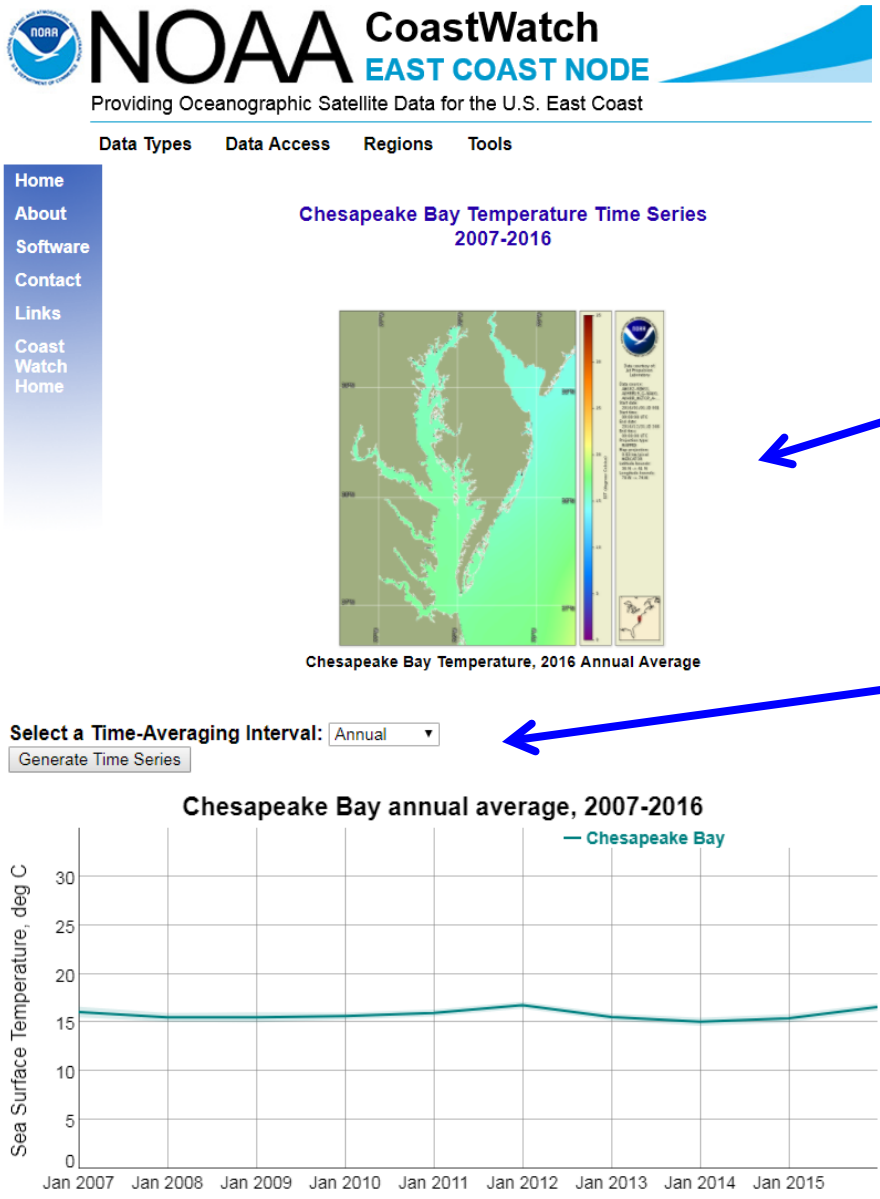
Is there more change in a particular season?





Web Display:

https://eastcoast.coastwatch.noaa.gov/time_series_sst_regions.php



Annual Average map, current year

Drop-down list: select annual or month of interest

Annual Average series, all years

Link to statistics ASCII text files

Web Display:

https://eastcoast.coastwatch.noaa.gov/time_series_sst_regions.php

NOAA CoastWatch
EAST COAST NODE
Providing Oceanographic Satellite Data for the U.S. East Coast

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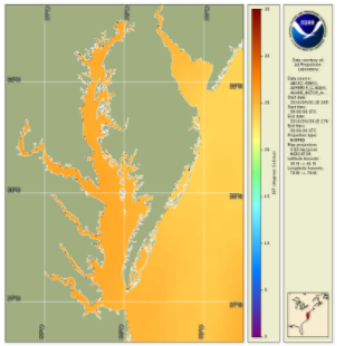
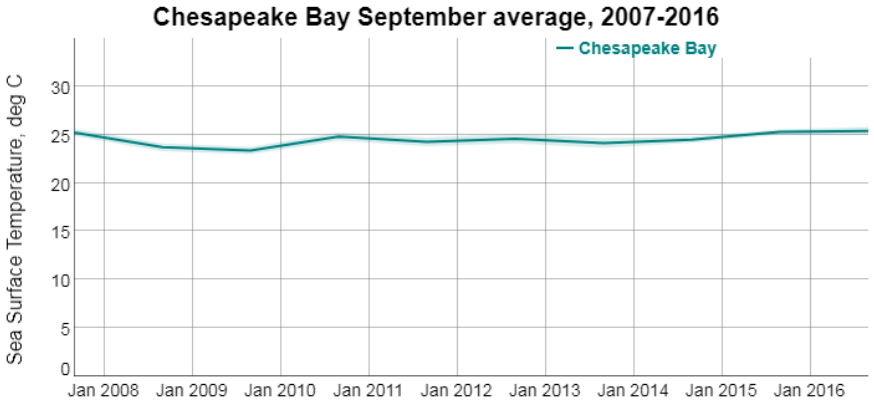
Chesapeake Bay Temperature Time Series
2007-2016



Chesapeake Bay Temperature, September 2016 Monthly Average

September Average map, current year

Select a Time-Averaging Interval: Annual
Generate Time Series



September Average series, all years

Link to statistics ASCII text files

Next Steps for Chesapeake Bay

- Obtain feedback from Chesapeake Bay Program, partners, and general public on indicator needs specific to Chesapeake Bay
  - Add requested statistical averages, improve website
- Add data back to 2002 when quality improved by NASA
- Automate statistics calculation and web display to show new years as they become available
- Work with CBP partners on a multi-dataset water temperature climate indicator if that is chosen by CBP
  - A multi-dataset temperature indicator leverages the advantages of different data sets: temporal coverage, temporal resolution, spatial coverage, spatial resolution
  - Satellite temperature adds excellent temporal & spatial resolution and excellent spatial coverage