Improvements to an AVHRR satellite derived sea surface temperature climatology

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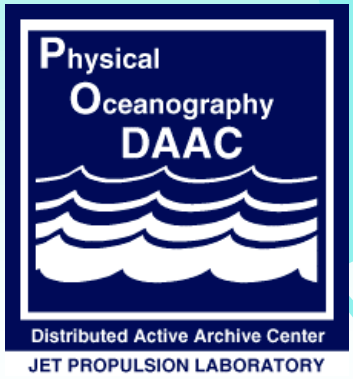
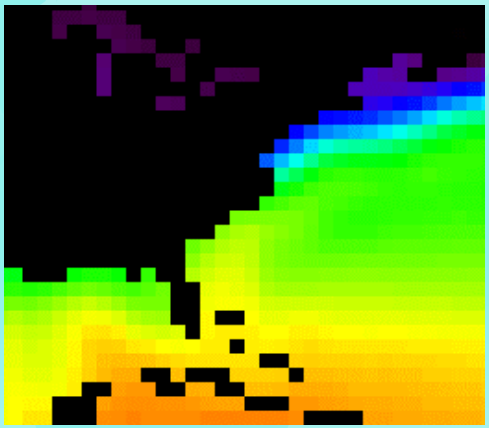


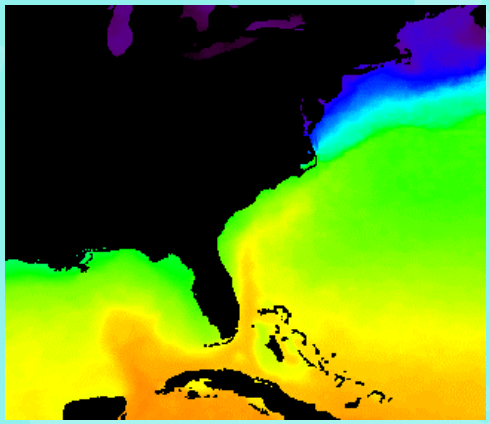
Spatial Characteristics

January



1 degree

1-5 January



Satellite-based 9 km

JPL climatology interpolation approach

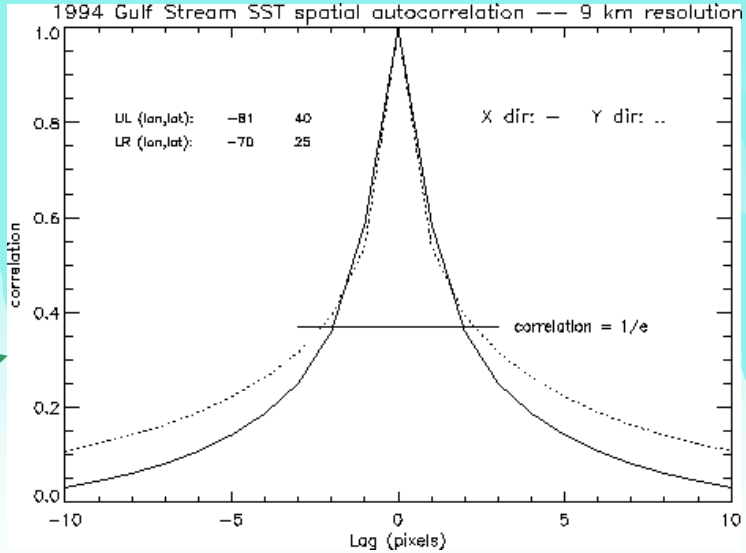
Spatially and temporally interpolate daily data to a 9 km grid/5 day time step using a Gaussian function:

$$e^{(-0.6931*(x-x_o/x_h)^2 + (y-y_o/y_h)^2+ (z-z_o/z_h)^2)}$$

x,y,z = satellite SST locations in space and time

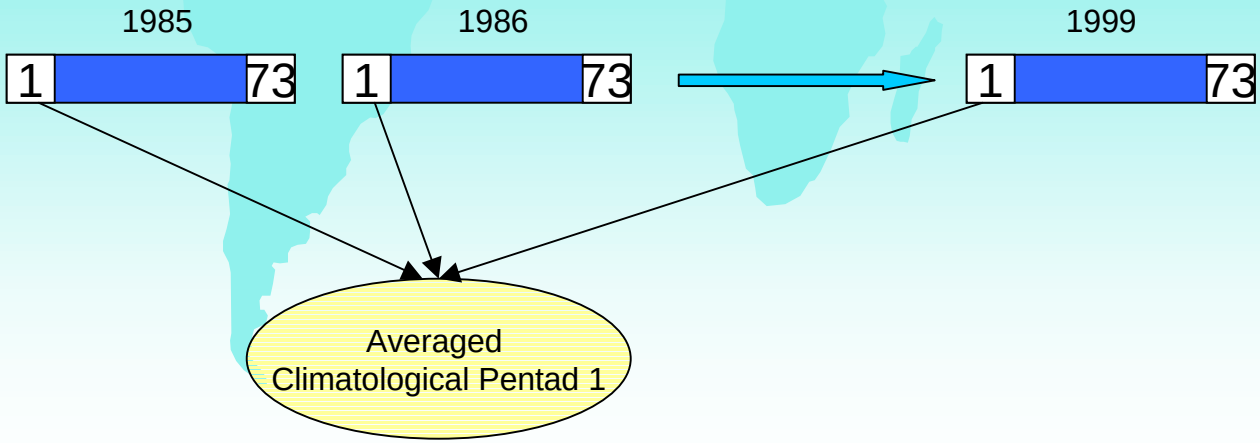
x_o, y_o, z_o = interpolation grid centers (9 km and 5 day)

x_h, y_h, z_h = "e-folding" scales



The JPL Pathfinder pentad (5 day) climatology

- Based on “all pixel” daily 9 km Pathfinder AVHRR SST data (day and night) from 1985-1999 using highest quality flag
- Gaussian interpolated approach
- No cloud erosion filtering as performed by Casey



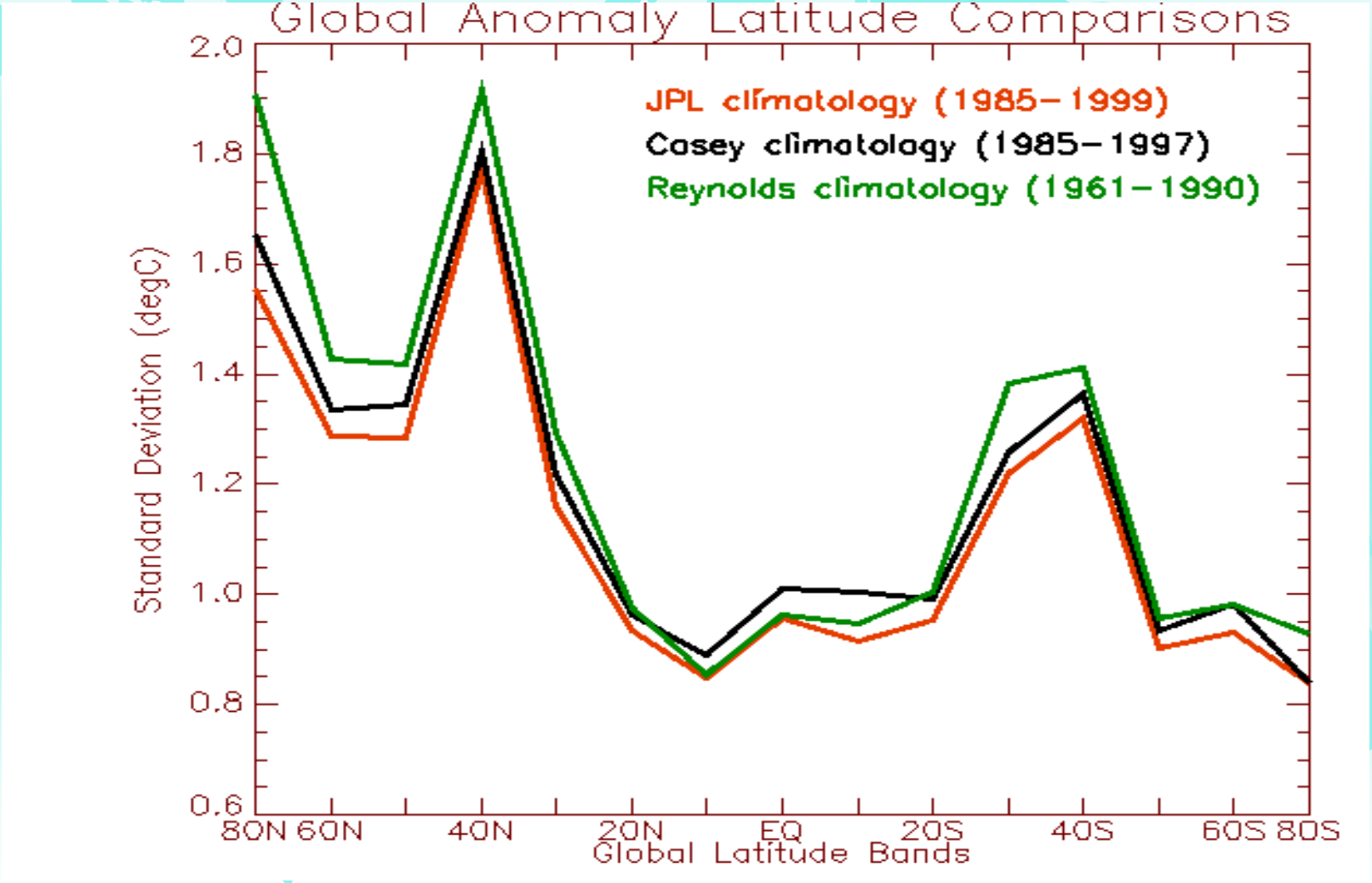
Anomaly performance test

For a global long-term *in situ* SST data set determine the standard deviation (σ) of the anomaly data set formed by subtracting the climatological SSTs from the *in situ* SSTs

i.e., find the σ of the time series of anomaly values ($SST_{anomaly}$) calculated as:

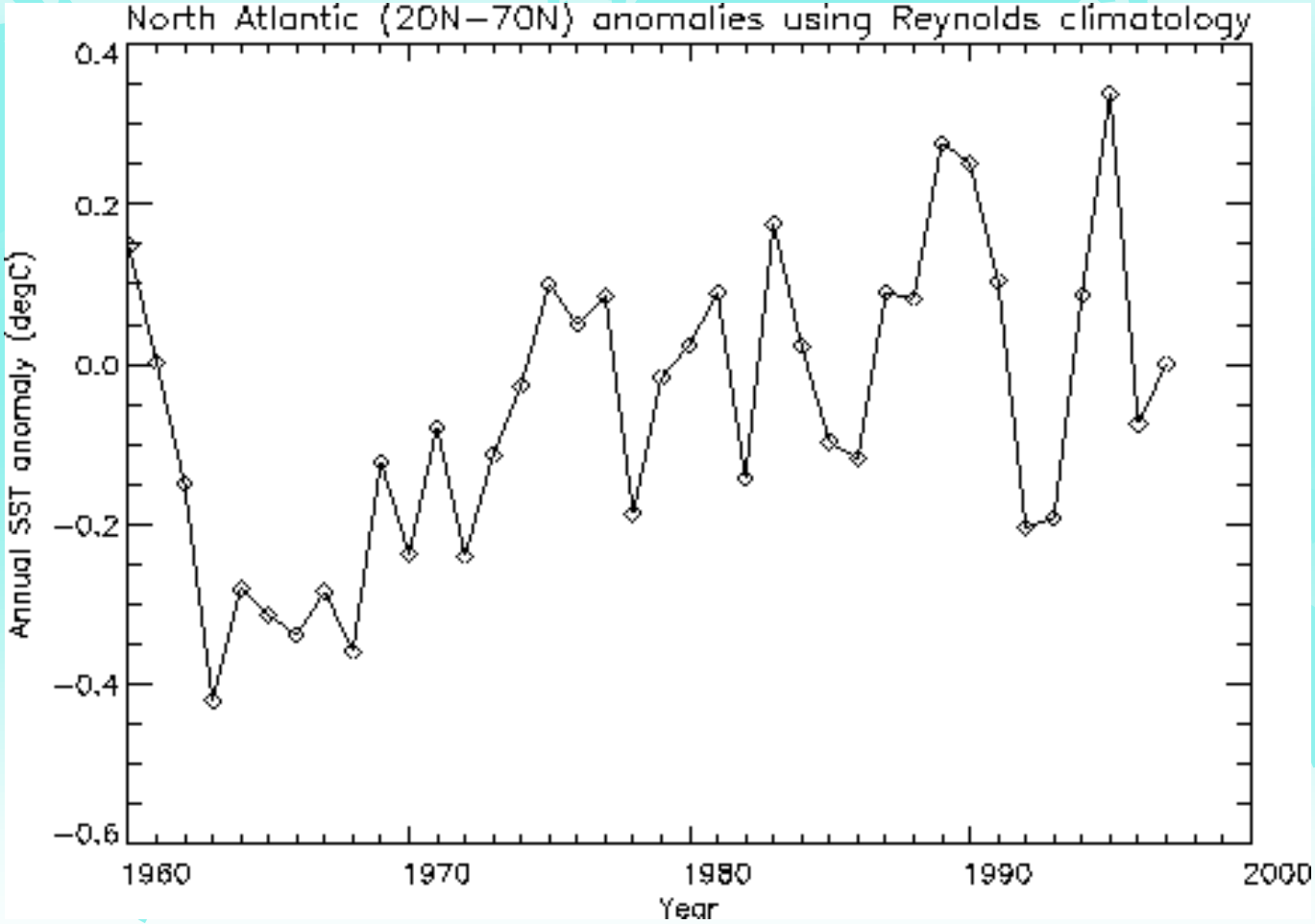
$$SST_{anomaly} = SST_{insitu} - SST_{climate}$$

Anomaly Std Dev by Latitude Band

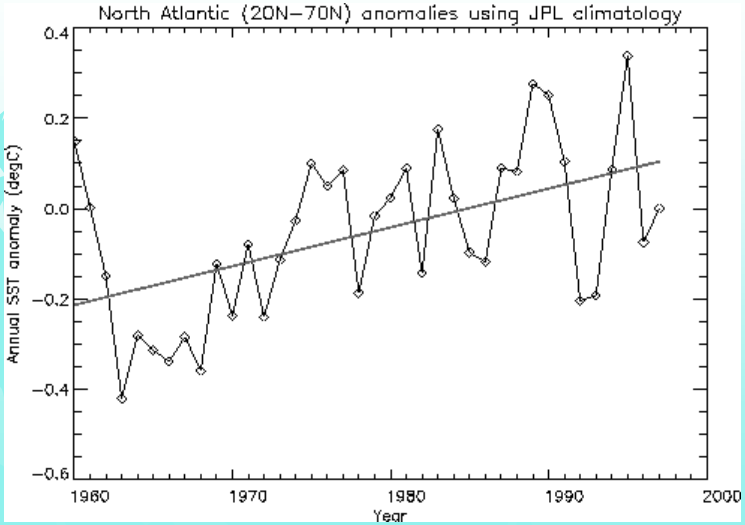


North Atlantic SST anomalies

(1960-1996)



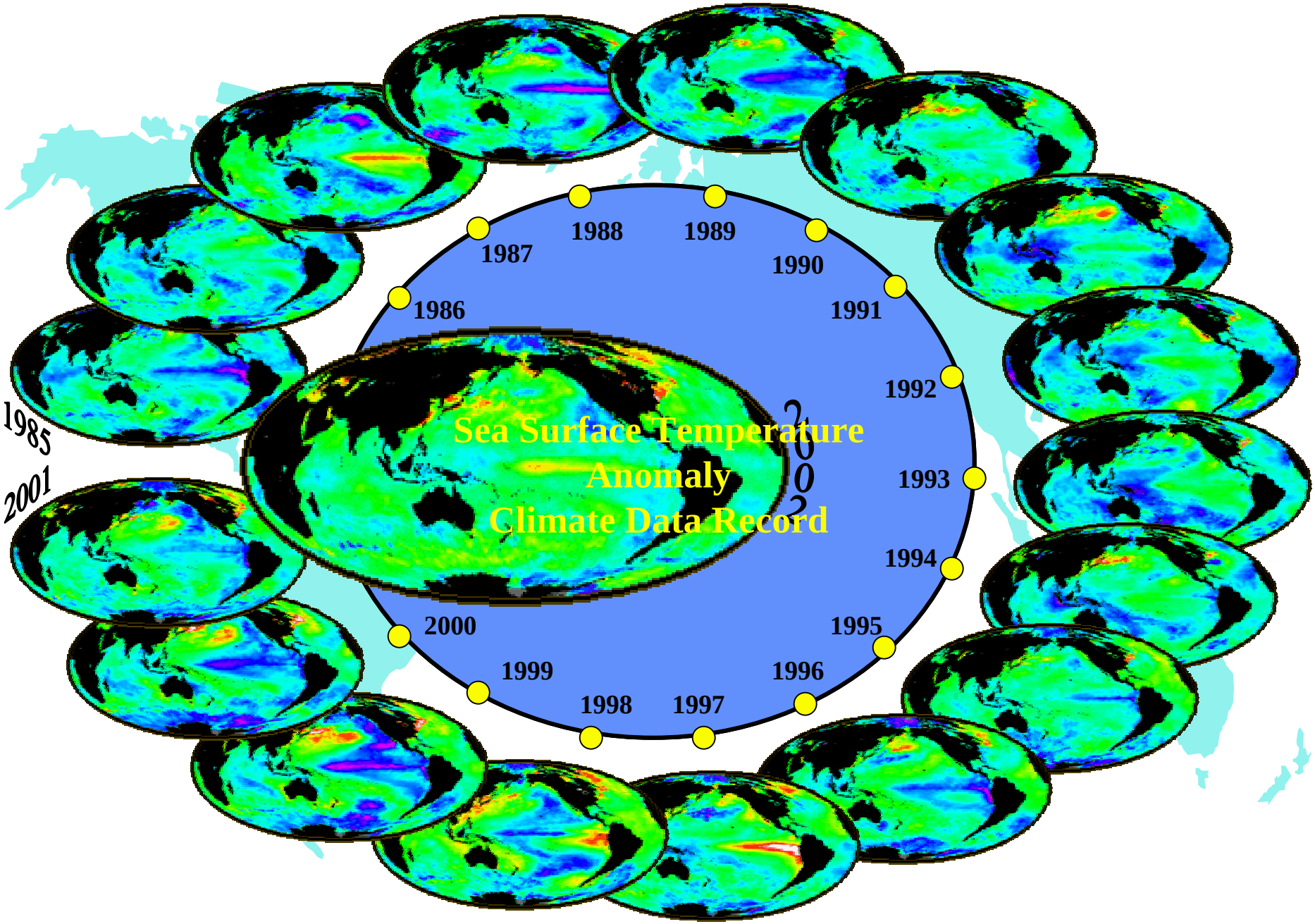
North Atlantic SST anomaly trends



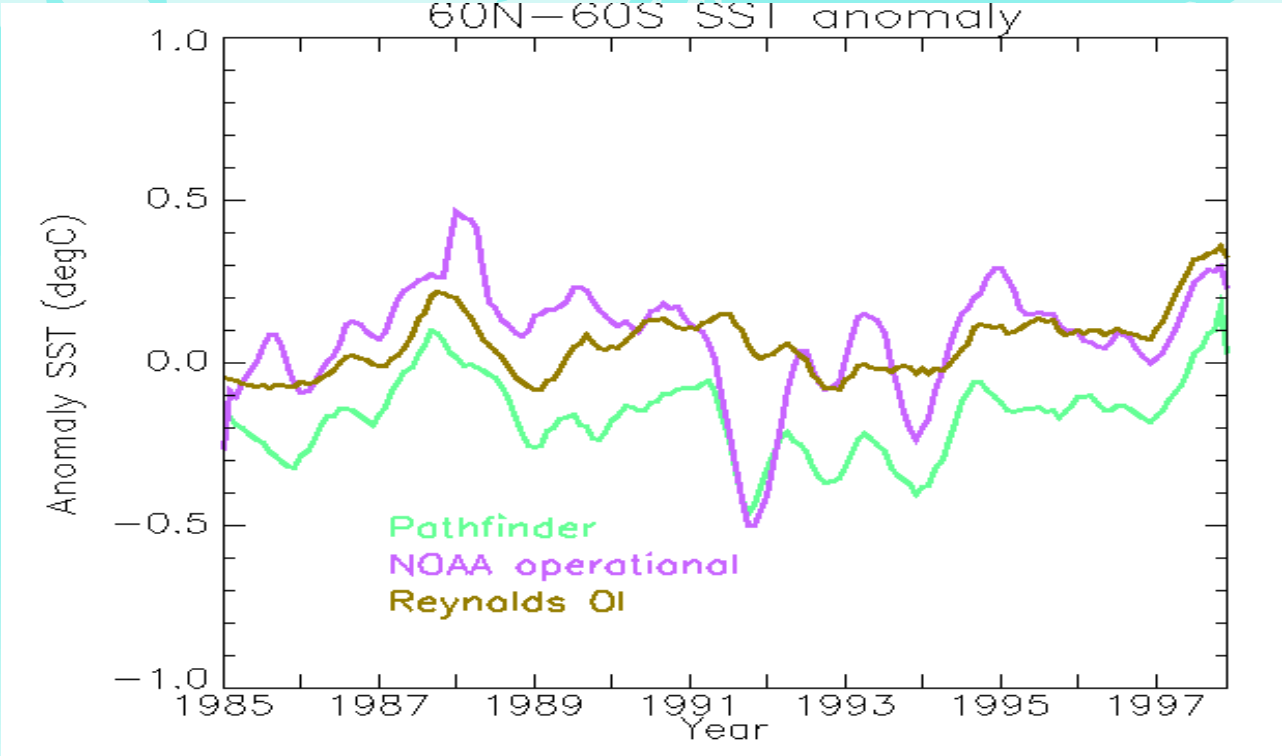
Climatology	*Slope (°C/year)*	*r^2*	*Std error (°C)*
JPL	.009	.265	.159
Reynolds	.007	.191	.166

Limitations of satellite climatologies

- Cloud contamination
- Aerosol contamination
- Ice
- Relatively short time series – regime bias

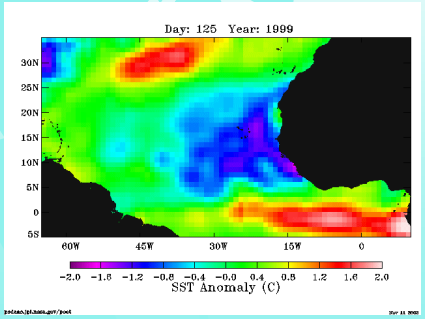

1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
Sea Surface Temperature
Anomaly
Climate Data Record

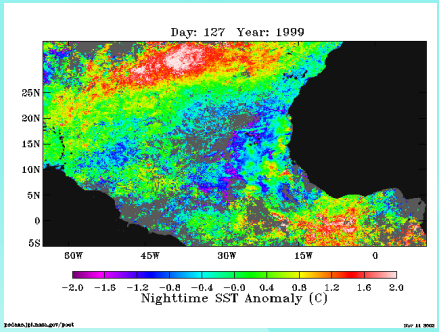
Monthly anomaly time series

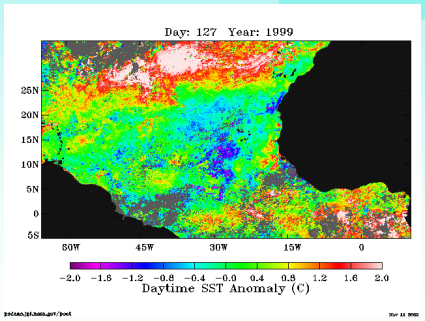


- Time series of monthly MPSST, ONSST, and OISST minus WOA98 climatological SST.
- Satellite data are nighttime values.

Aerosol contamination in SST measurements ?



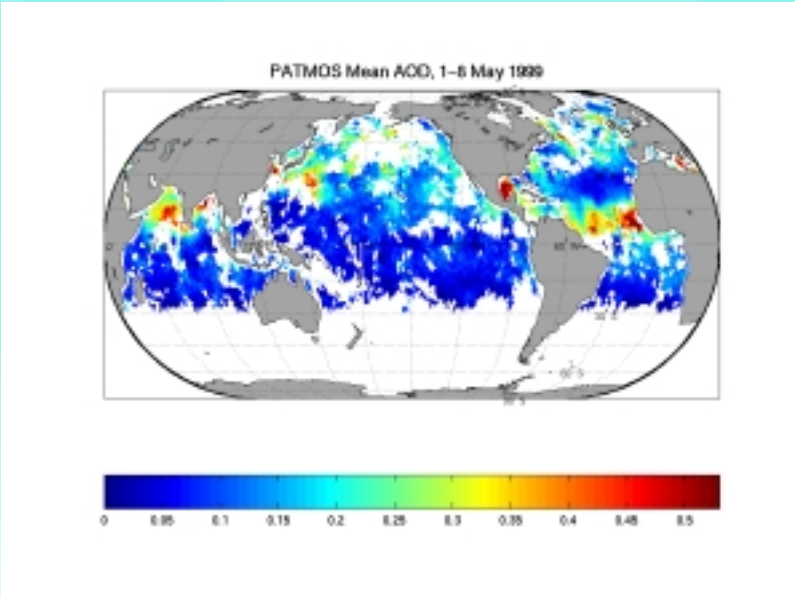




Mean bias (°C)	Std dev (°C)	Number of matchups
-0.27	0.56	90

PATMOS AVHRR dataset

Pathfinder Atmosphere AVHRR data set (1981-2001)



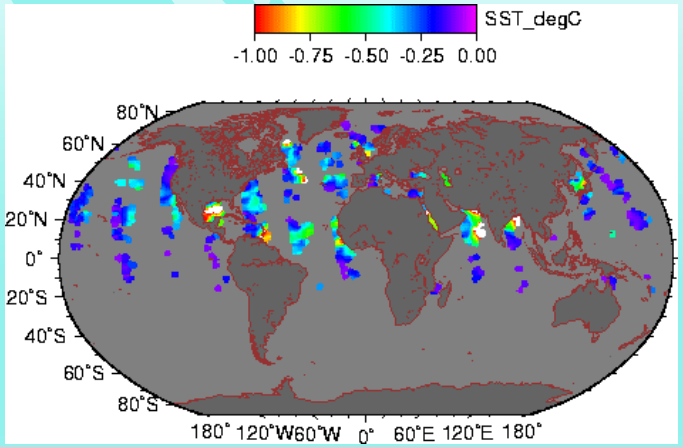
- Global, daily one degree resolution
- Visible and Near IR solar reflectances (ch 1&2)
- IR channel brightness temps (ch 3,4 &5)
- Channel 1 aerosol optical depth (AOD)
- Other parameter: satellite zenith angles, cloud distribution

AVHRR Aerosol correction

- Described in Nalli and Stowe; JGR, 2002
- Uses two predictors of aerosols: AOD (slant path correction) and ch1/ch2 reflectance ratio. Uses Pathfinder Matchup database (in situ SST data).
- Define two aerosol regimes, stratospheric (i.e., volcanic) and tropospheric (i.e., continental dust, smoke, marine aerosols etc.)
- Regressions of SST residuals ($SST_{sat} - SST_{insitu}$) to linear and quadratic combinations of the predictors.
- Choose simple linear correction using the AOD predictor:

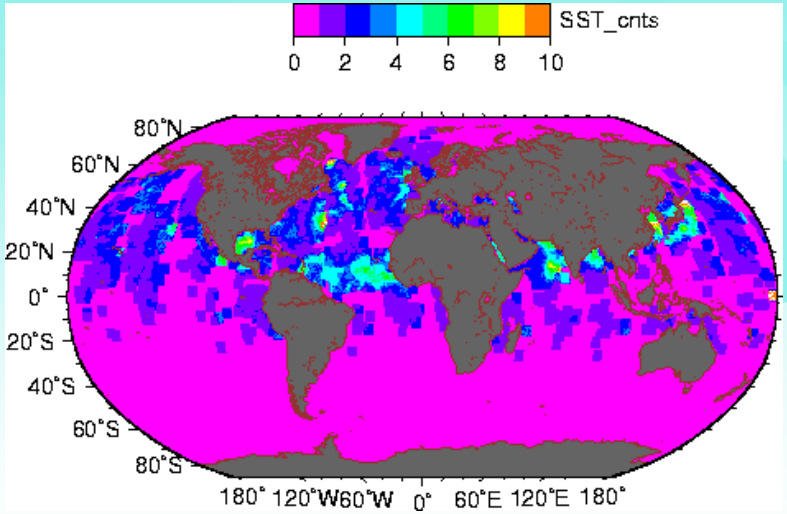
$$SST_{correction} = b_0 + b_1 * AOD$$

Daily aerosol correction files

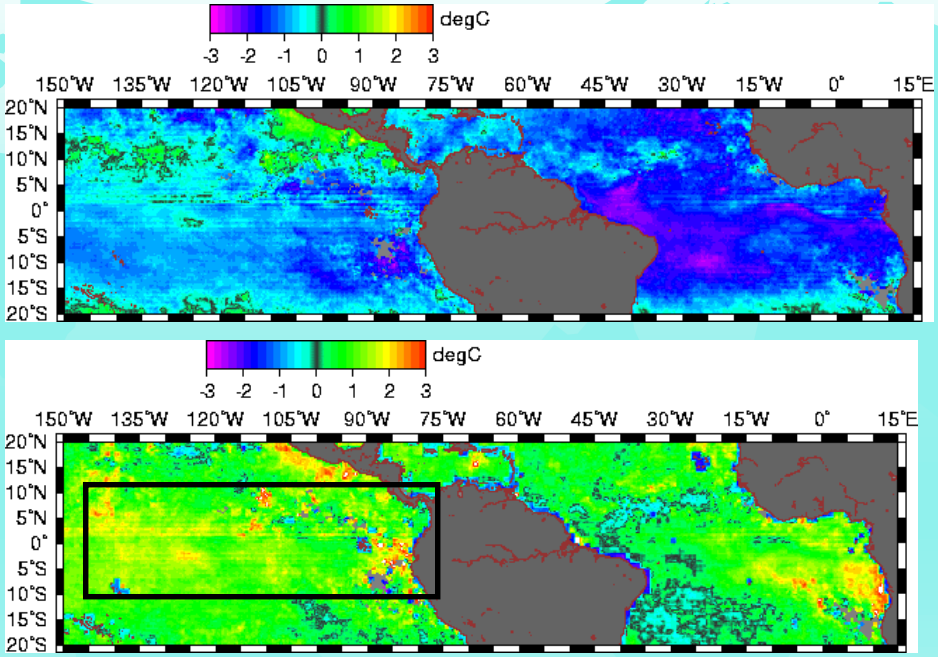


3 May 1999 – all daily data

3 May 1999 – updated with 5 day data (1-5 May)



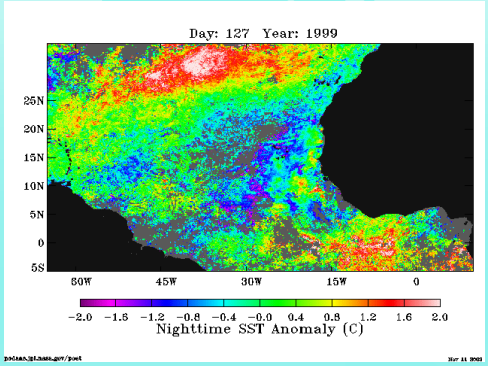
Aug 1991 – Mt Pinatubo



Matchups statistics (satellite SST – insitu SST)

Type	Mean bias (°C)	Std dev (°C)	Number of matchups
No corr.	-1.57	0.78	165
Aer. corrected	0.46	0.75	165

1-8 May 1999 -Atlantic



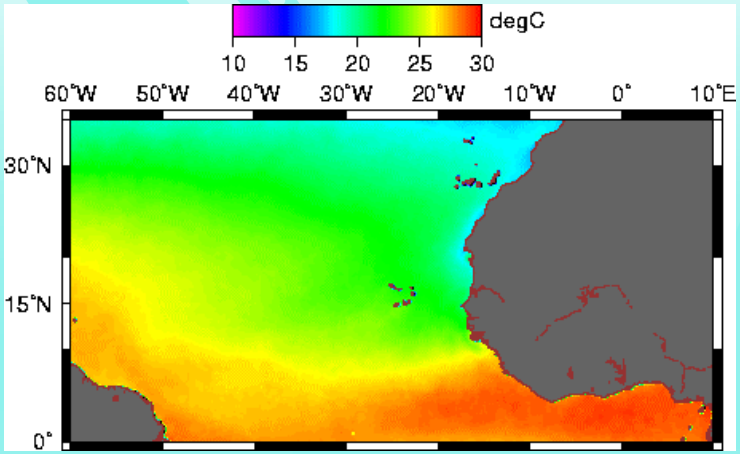
Matchups statistics (satellite SST – insitu SST)

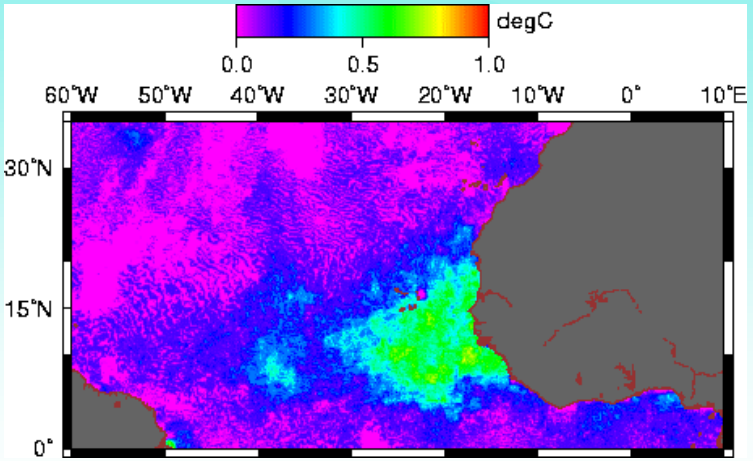
Type	**Mean bias (°C)**	**Std dev (°C)**	**Number of matchups**
No corr.	-0.27	0.56	90
Aer. corrected	-.03	0.48	90

Satellite climatology experiments

- Motivation: determine the effect of aerosol correction approach on Pathfinder satellite climatologies
- Assemble regional interpolated climatologies for 1985-1999
    - Atlantic off northwest Africa
    - Equatorial Pacific (NINO3 region)
- Apply aerosol correction using daily prepared files
- Use Pathfinder SST “all pixel” data with highest quality flag (flag 7)
- Performance test (SD of anomaly time series) with the WOD 2001 surface observations with spatial matchups of +/- one satellite pixel (9km).

mid-Atlantic climatology

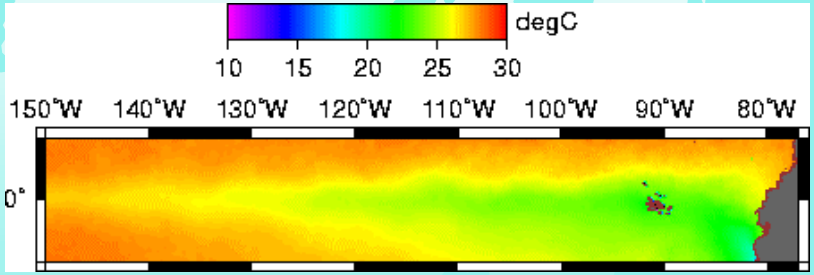




Performance statistics

Type	Mean bias (°C)	Std dev (°C)	Number of matchups
No corr.	0.12	0.98	~240K
correction	-0.08	0.96	~240K

NINO3 region climatology



Type	Mean bias (°C)	Std dev (°C)	Number of matchups
no corr	0.08	1.24	> 70K
corr	-0.02	1.24	> 70K
“best pixel” w/ cloud erosion	0.10	1.29	> 70K
“best pixel”	.152	1.25	> 70K

Pathfinder AVHRR / ATSR-2 matchup comparisons – west coast of Africa (1997-1999)

Satellite SST	Mean bias (°C)	Std dev. (°C)	Matchups
Pathfinder day Flag of 7	-0.28	0.64	373
Pathfinder night Flag of 7	-0.33	0.55	196
ASST2 daytime	-0.20	0.46	234
ASST2 nighttime	-0.03	0.41	128

Summary and Future Work

- Positive results are found using Nalli aerosol corrections approach. Improvements (increased SST warming) found in
  - Mid-Atlantic (correcting for Saharan Dust)
  - Eastern eq. Pacific (primarily mitigating Mt. Pinatubo contamination)
- Possible overcorrection ?? More experiments necessary to separate for the effects of AOD on the SST correction.
- Improvement seen from using highest quality “all pixel” data with flag 7
- Further work:
  - Assign probability based on distance from cloud
  - Merge selected ATSR-2 measurements
  - Add more years of Pathfinder data (data up to 2003)