Advances in the AVHRR Pathfinder Sea Surface Temperature Climate Data Record and its Connections with GHRSST Reanalysis Activities

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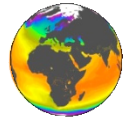
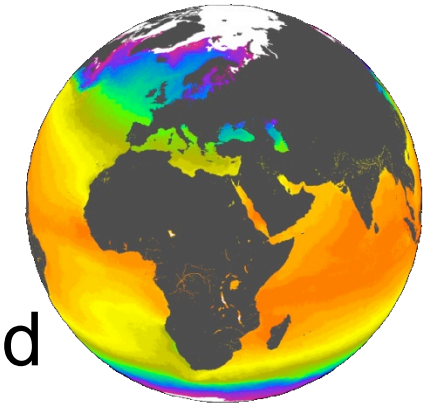
CLIMAR-III, Gdynia, Poland, May 2008

AVHRR Pathfinder

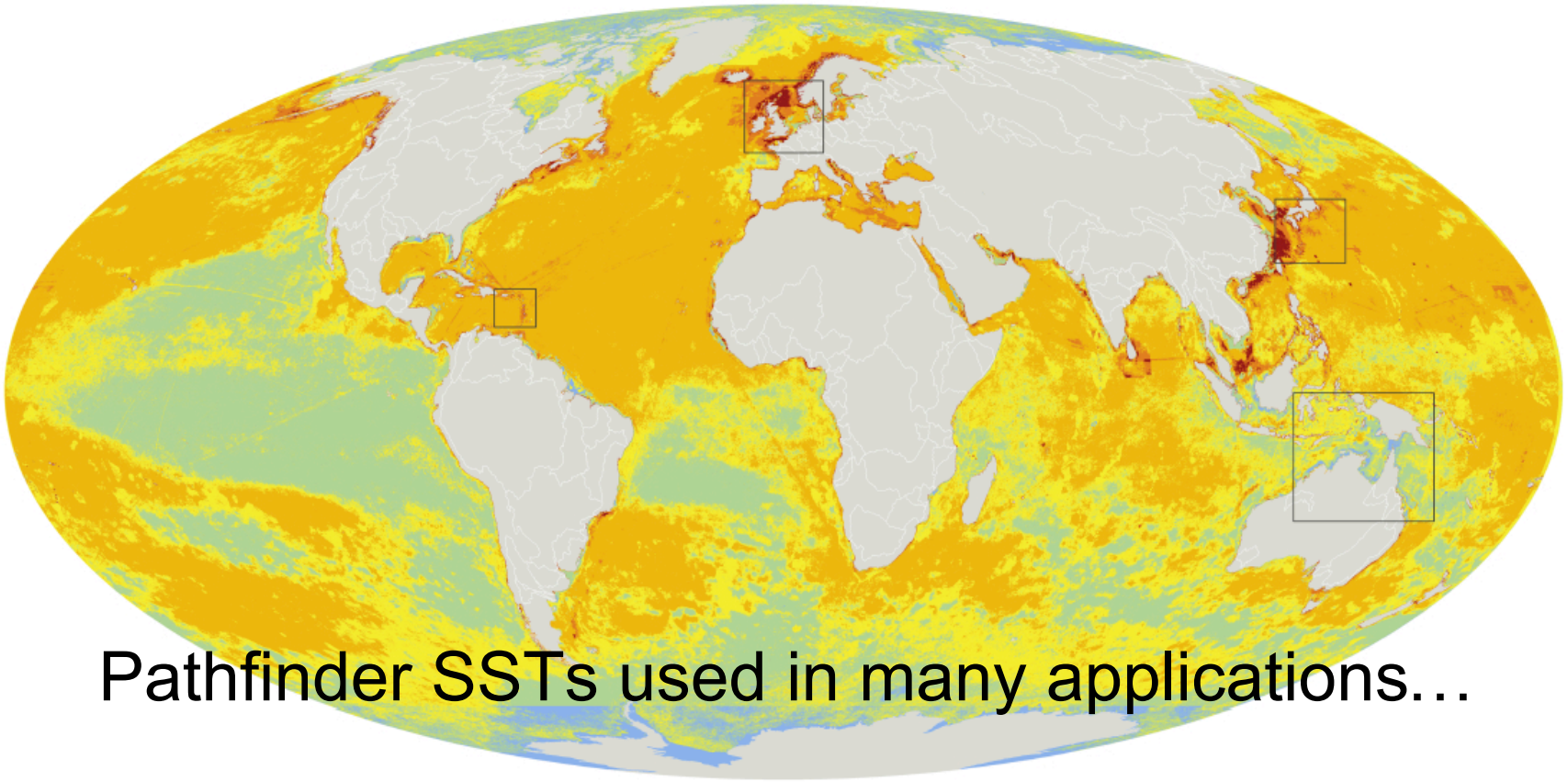


- Working toward the SST Climate Data Record from Space:
  - All AVHRRs 1981-near present
  - Consistent and accurate, with errors
  - Global (GAC) resolution of 4.6 km and some regional 1 km (LAC/HRPT)



- Goals partially met:
  - 1985-near present
  - Afternoon satellites, (NOAA-9,11,14,16,18 and morning NOAA-17)
  - Uncertainties and LAC/HRPT in progress

Global Map of Human Impacts



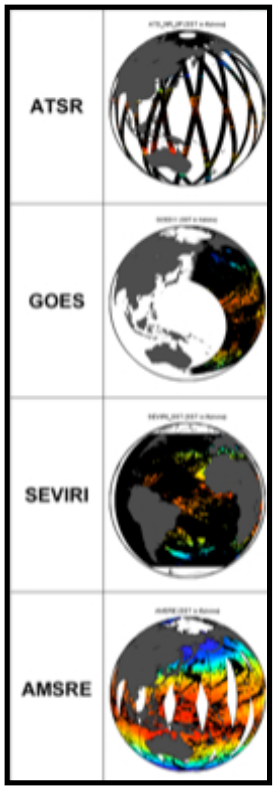
Pathfinder SSTs used in many applications…

Very Low Impact (<1.4)
Low Impact (1.4 - 4.95)
Medium Impact (4.95 - 8.47)
Medium High Impact (8.47 - 12)
High Impact (12 - 15.52)
Very High Impact (>15.52)

Benjamin S. Halpern, S. Walbridge, K. A. Selkoe, C. V. Kappel, F. Micheli, C. D'Agrosa, J. F. Bruno, K. S. Casey, C. Ebert, H. E. Fox, R. Fujita, D. Heinemann, H. S. Lenihan, E. M.P. Madin, M. T. Perry, E. R. Selig, M. Spalding, R. Steneck, R. Watson (2008). A global map of human impact on marine ecosystems. *Science*, vol. 319, no. 5865, pp. 948-952 (DOI: 10.1126/science.1149345).

GHRSST-PP Regional/Global Task Sharing Framework

GODAE High Resolution Sea Surface Temperature Pilot Project



Interoperable User Access via OPeNDAP, TDS, WCS, FTP...

Regional Data Assembly Centers (RDACs)

NCDC | UKMO | REMSS | PODAAC | ABOM | EUR

NAVO | JAXA | OSDPD | GOS | DMI | And More...

Level 2, 3, and 4 GHRSST satellite SST data in COARDS/CF-compliant netCDF-3 with GCMD DIF metadata

Global Data Assembly Center (GDAC)

JPL PO.DAAC GDAC

Rolling Archive | Data Ingest | User Services | MMR System | Data Tools | Data Access

GMES/European GDAC Mirror

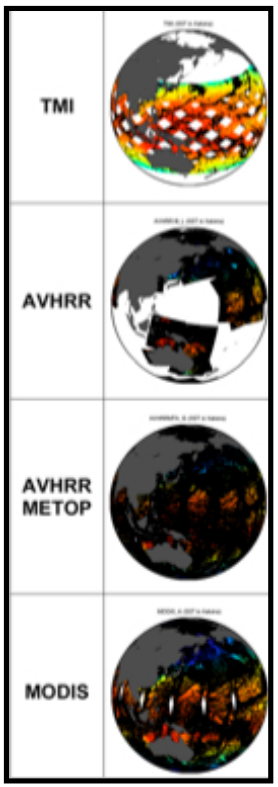
Ancillary fields filled as needed, initial FGDC metadata records appended, data provided in 30-day rolling store

NODC Long Term Stewardship and Reanalysis Facility (LTSRF)

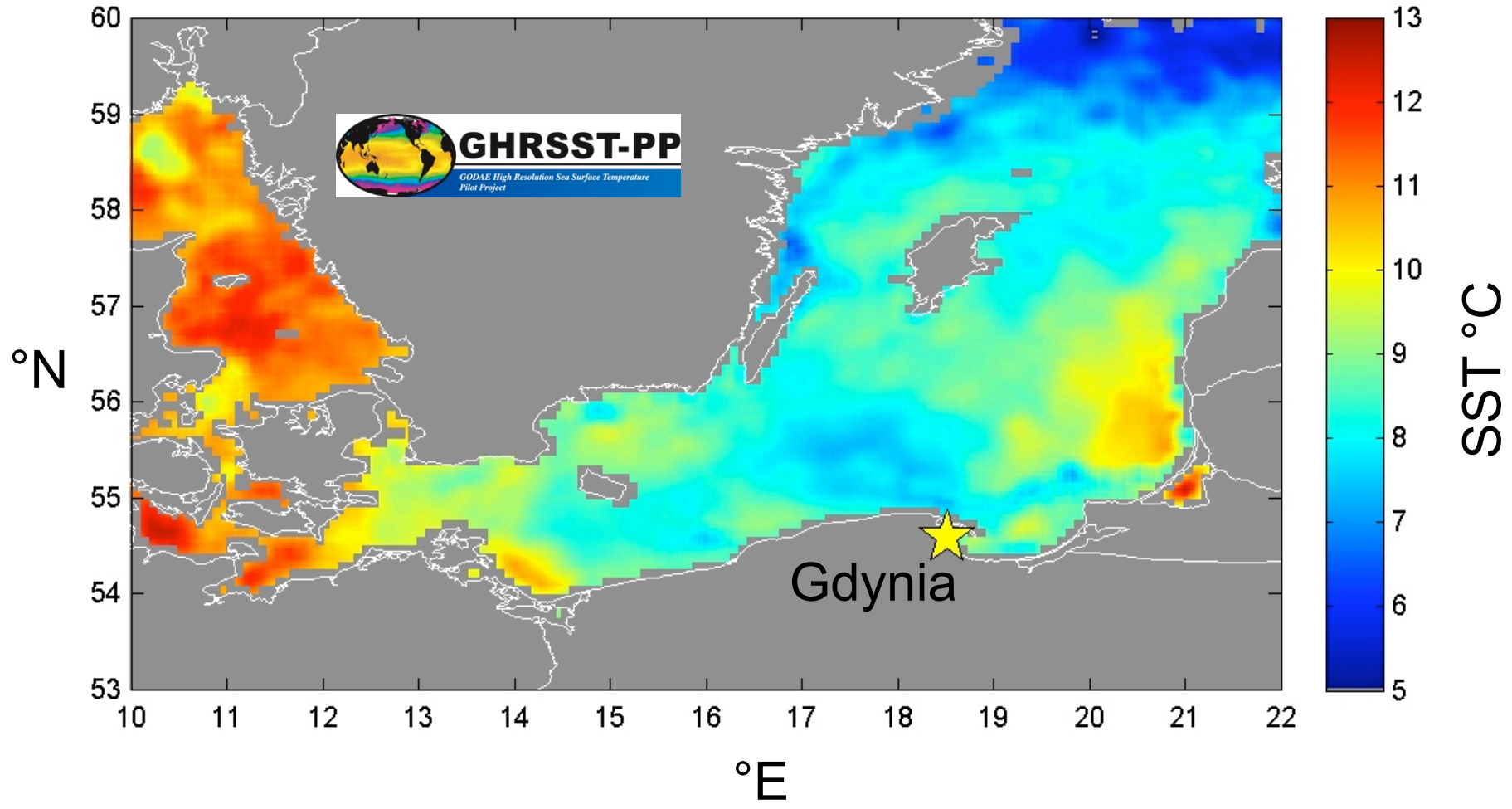
Data Ingest | Aggregation | CDR Production | Data Access | Metadata | Perpetual Archive

Perpetual archive services, data access and aggregation, climate data records, and complete FGDC and DIF metadata

User Requirements, Services, and Feedback at all Levels...

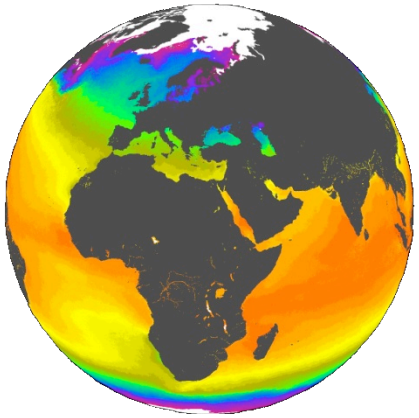


DMI SST for 06 May 2008



Pathfinder and GHRSST

- AVHRR Pathfinder
  - Focused solely on the AVHRR sensor series back to 1981

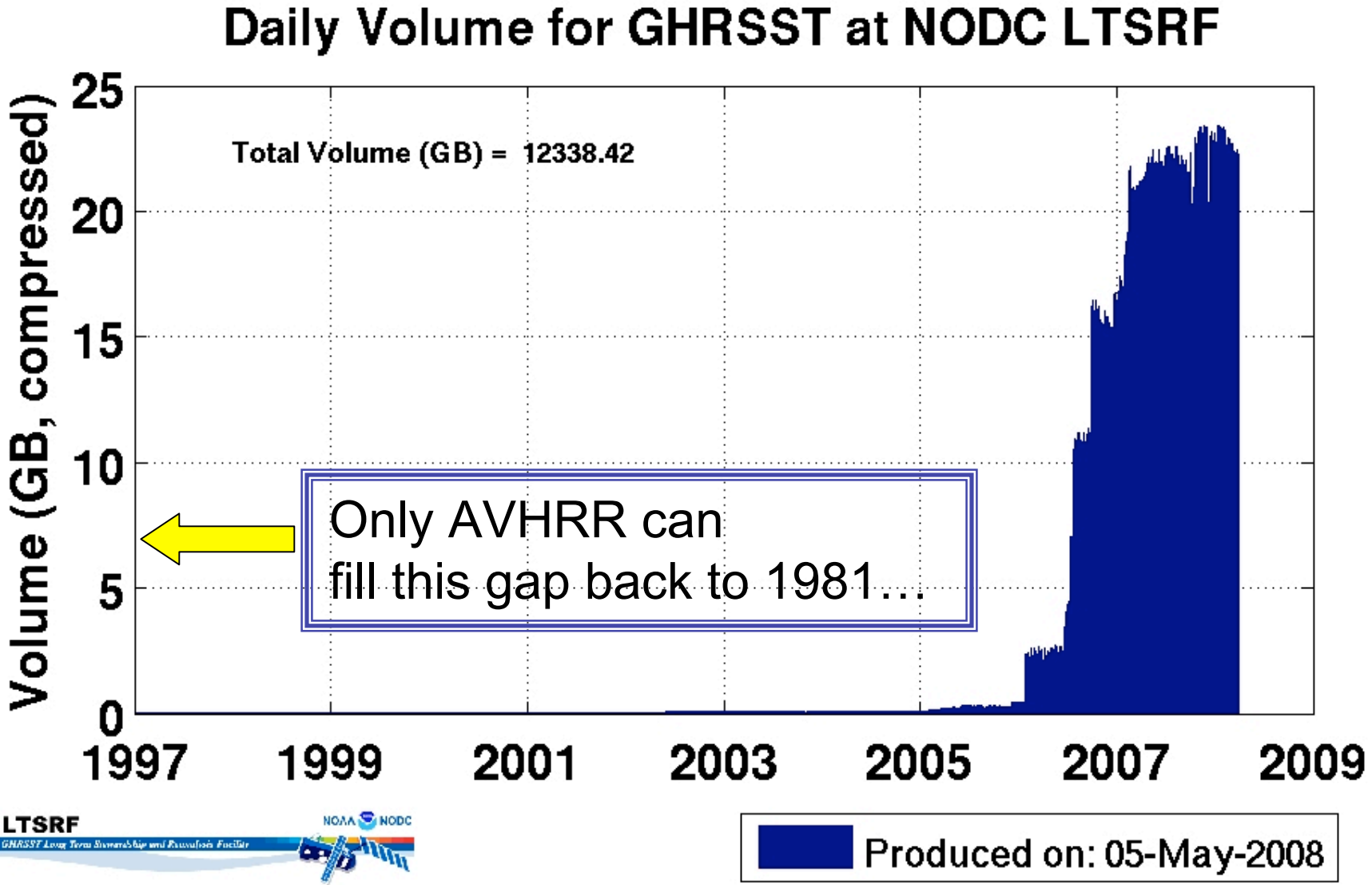


- GODAE High-Resolution SST (GHRSST)
  - Focused on bringing together multiple sensors

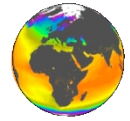
GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

Why Connect the Two?



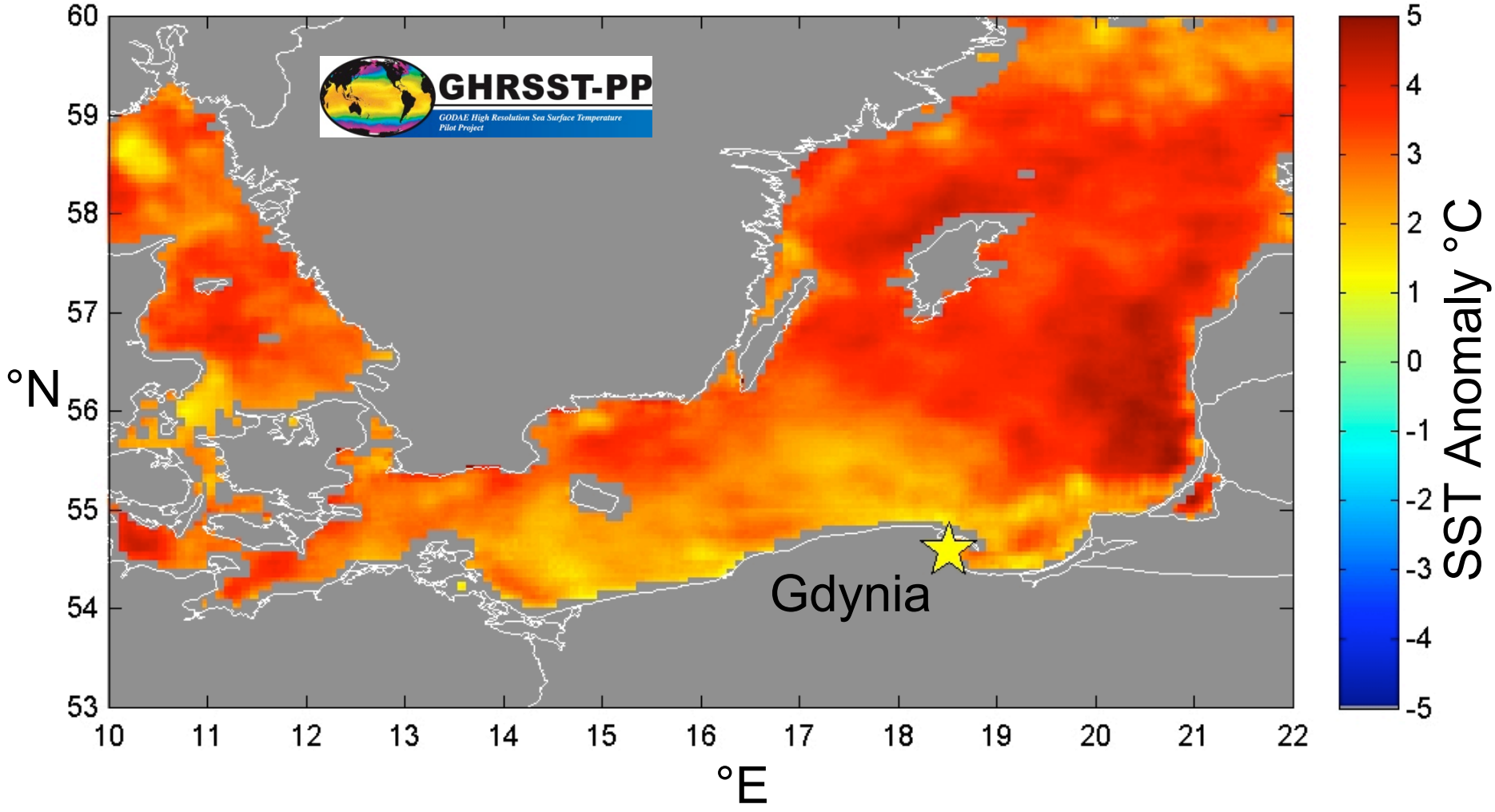
Filling the Gaps



	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
(A)ATSR												(A)ATSR Reanalysis for Climate															
GOES	GOES																										
SEVIRI	SEVIRI																										
AMSRE	AMSRE																										
MODIS	MODIS																										
AVHRR	AVHRR Pathfinder *Version 6*																										
TMI	TMI																										

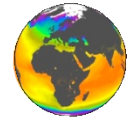
Sensor not in operation or capable of SST observations	
No active effort to create GHRSST L2 P	
Efforts underway to create GHRSST L2P	
Data available in GHRSST L2 P	

SST Anomaly for 06 May 2008



CLIMAR-III, Gdynia, Poland, May 2008

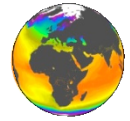
Pathfinder Since CLIMAR-II



- Added final data for 2002-2006 and interim 2007
- Generated pre-cloud screened temporal and spatial averages for 1985-2007
- Established techniques for doing 1981-1984
- Created new harmonic climatologies
- Used in Reynolds Daily 25 km OI
- Provided for OSTIA-based GHRSST Reanalysis
- Processing being transferred to NODC for Version 6: In GHRSST L2 and L3 formats

New! NASA supporting error estimate and LAC/HRPT development!

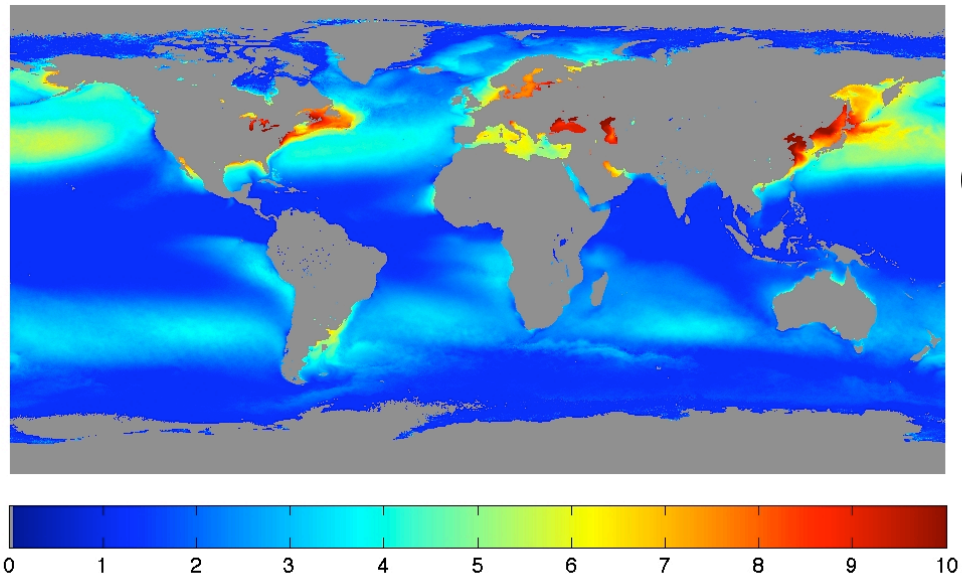
New Pathfinder Climatology



- Based on AVHRR Pathfinder V5
  - Uses highest quality data only (qf=7)
  - 1985-2006
  - 4.6 km resolution
- Developed using Harmonic Analysis
  - Annual and semi-annual components fit to five-day average time series

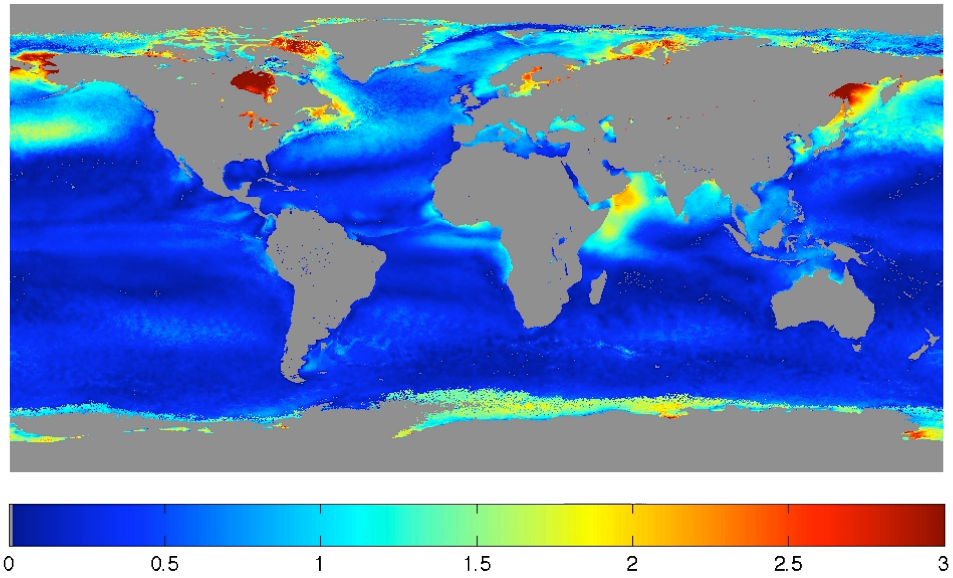
$$SST_{clim} = \mathbf{A}cos(2*pi*t + \mathbf{B}) + \mathbf{C}cos(4*pi*t + \mathbf{D}) + \mathbf{E}$$

PFV5 Harmonics

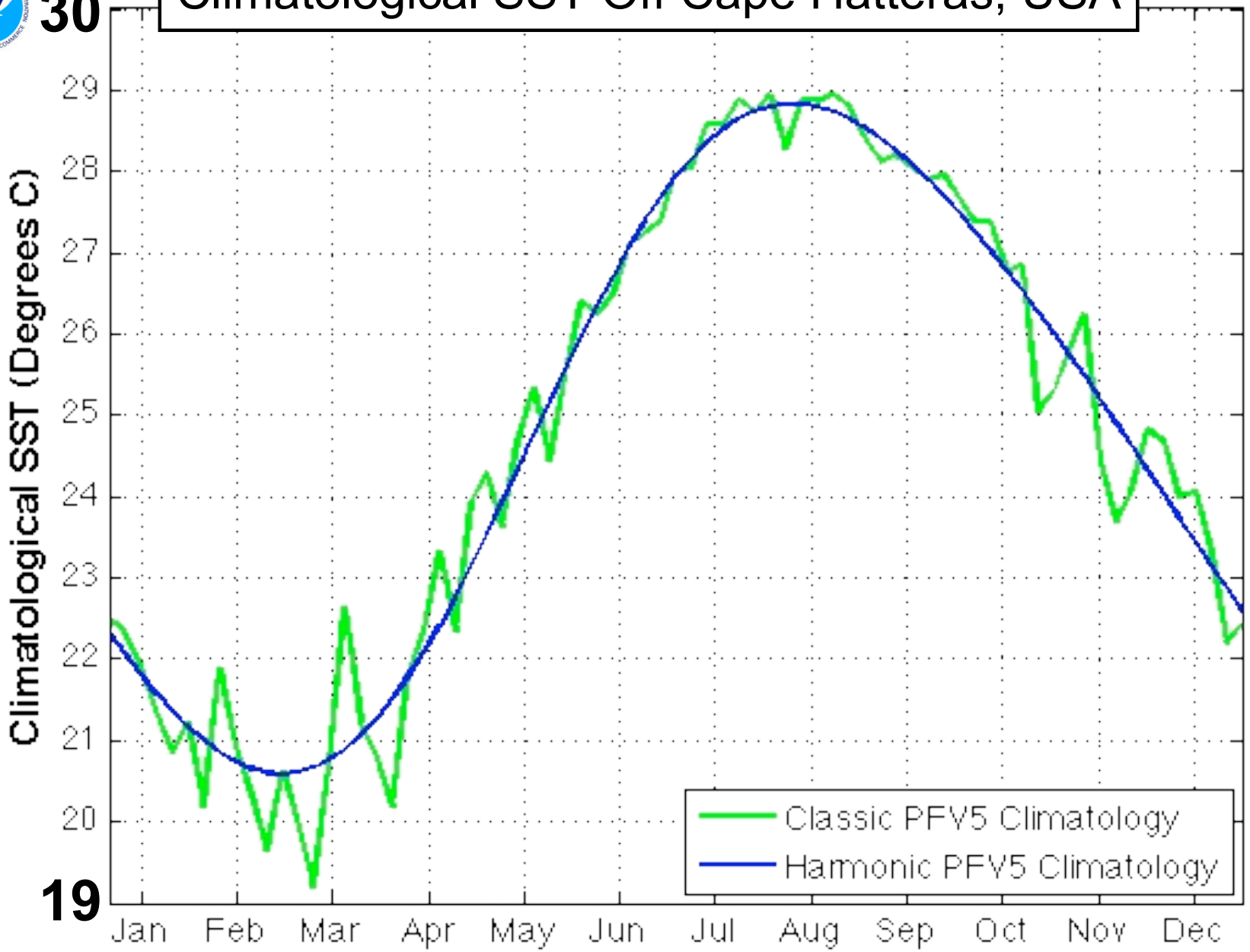


Annual Amplitude
(0 to 10 degrees C)

Semi Annual Amplitude
(0 to 3 degrees C)



Climatological SST Off Cape Hatteras, USA

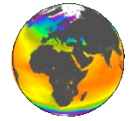


Climatology Evaluation

Climatology	#	Bias (ºC)	Std (ºC)
Harmonic PFV5	151.43 M	-0.04	1.43
ICOADS Clim.	150.23 M	0.13	1.50
NESDIS Clim.	148.11 M	0.05	1.65

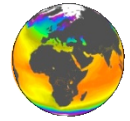
Based on assessment method of Casey and Cornillon (1999), using standard deviation of differences between climatology and individual ICOADS in situ observations

So….



- Numerous advances made in AVHRR Pathfinder and in connecting it with GHRSST, but…
- Recommendation #13 from MARCDAT-1 (Boulder 2002):
  - **Regular comparisons of SST analyses should commence.**
  - Status: Little progress
- Enter, the GCOS SST and SI Working Group…

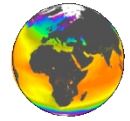
Pathfinder-GHRSST-GCOS



- GHRSST Reanalysis goal: Link historical reconstructions to satellite-era analyses
- MARCDAT (and other recommendations)
- GCOS SST and Sea Ice Working Group Intercomparison site established at GHRSST Long Term Stewardship and Reanalysis Facility:

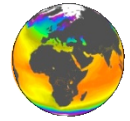
http://ghrsst.nodc.noaa.gov/intercomp.html

Initial Intercomparison Data



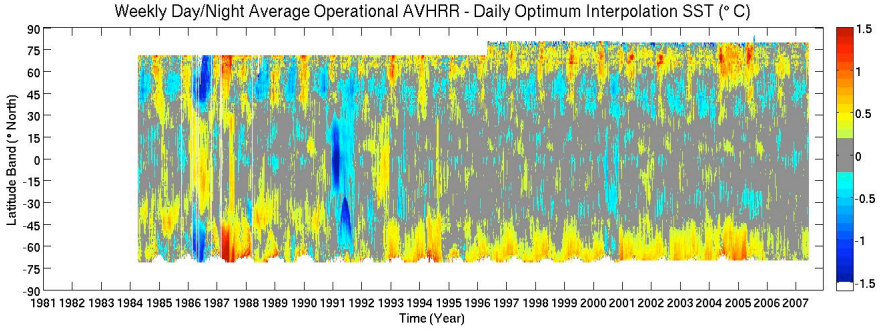
Data Set Name	Resolution	Date Range
AVHRR Pathfinder Version 5	Weekly One Degree, Monthly Five Degree	Jan 1985 – Dec 2007
Operational AVHRR	Weekly One Degree	Dec 1981 – July 2007
Hadley Centre SST	Weekly One Degree, Monthly Five Degree	Dec 1981 – Nov 2005
NOAA Optimum Interpolation Version 2	Weekly One Degree, Monthly Five Degree	Jan 1985 – Dec 2007
NOAA Daily ¼-degree Optimum Interpolation	Weekly One Degree, Monthly Five Degree	Dec 1981 – Oct 2007
Hadley Centre Sea Ice and SST (HadISST)	Monthly Five Degree	Jan 1981 – Nov 2007
NOAA Extended Reconstruction	Monthly Five Degree	Jan 1981 – Oct 2007
Kaplan Reconstructed	Monthly Five Degree	Jan 1981 – Oct 2007

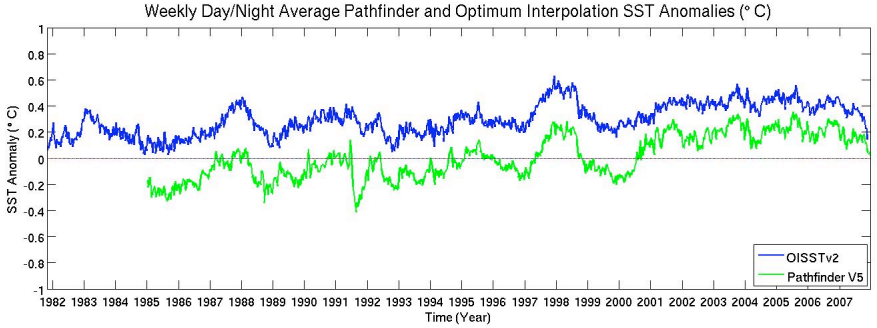
Initial Intercomparison Metrics

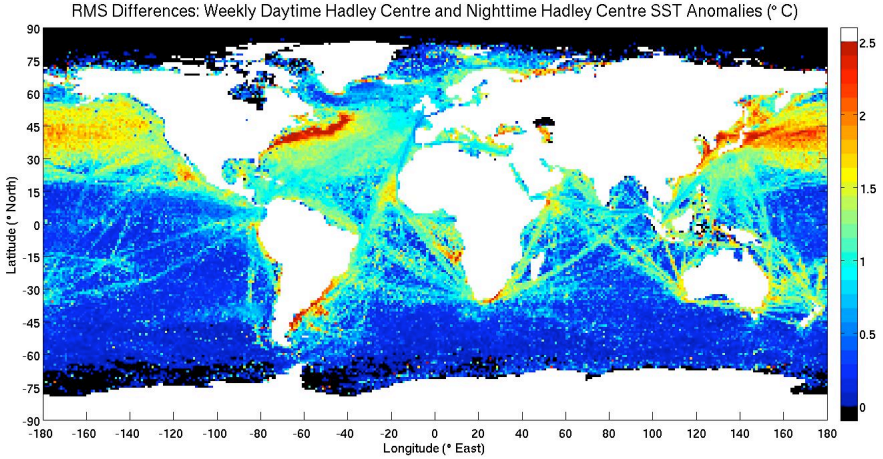


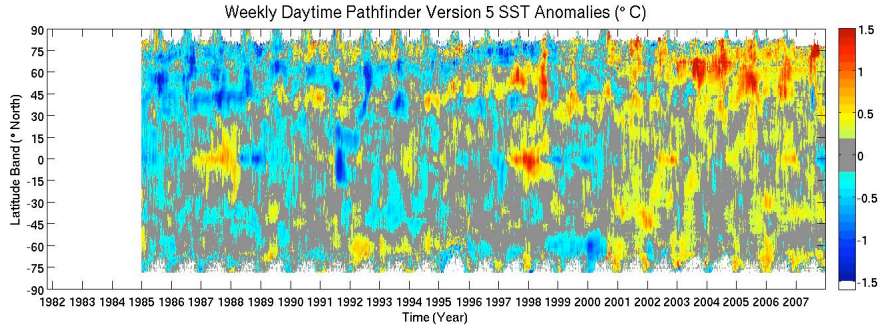
- Phase One
  - Time series of global and hemispheric anomalies
  - Time-latitude sections of anomalies
  - Fields of standard deviation, *linear trend, lag1 autocorrelation*
- Phase Two
  - Maps of RMS differences between fields
  - Maps of time-averaged differences between fields
  - *Time series for selected regions and a small selection of GHRSST diagnostic data set sites*
  - *Spatial autocorrelation*

Example Comparisons

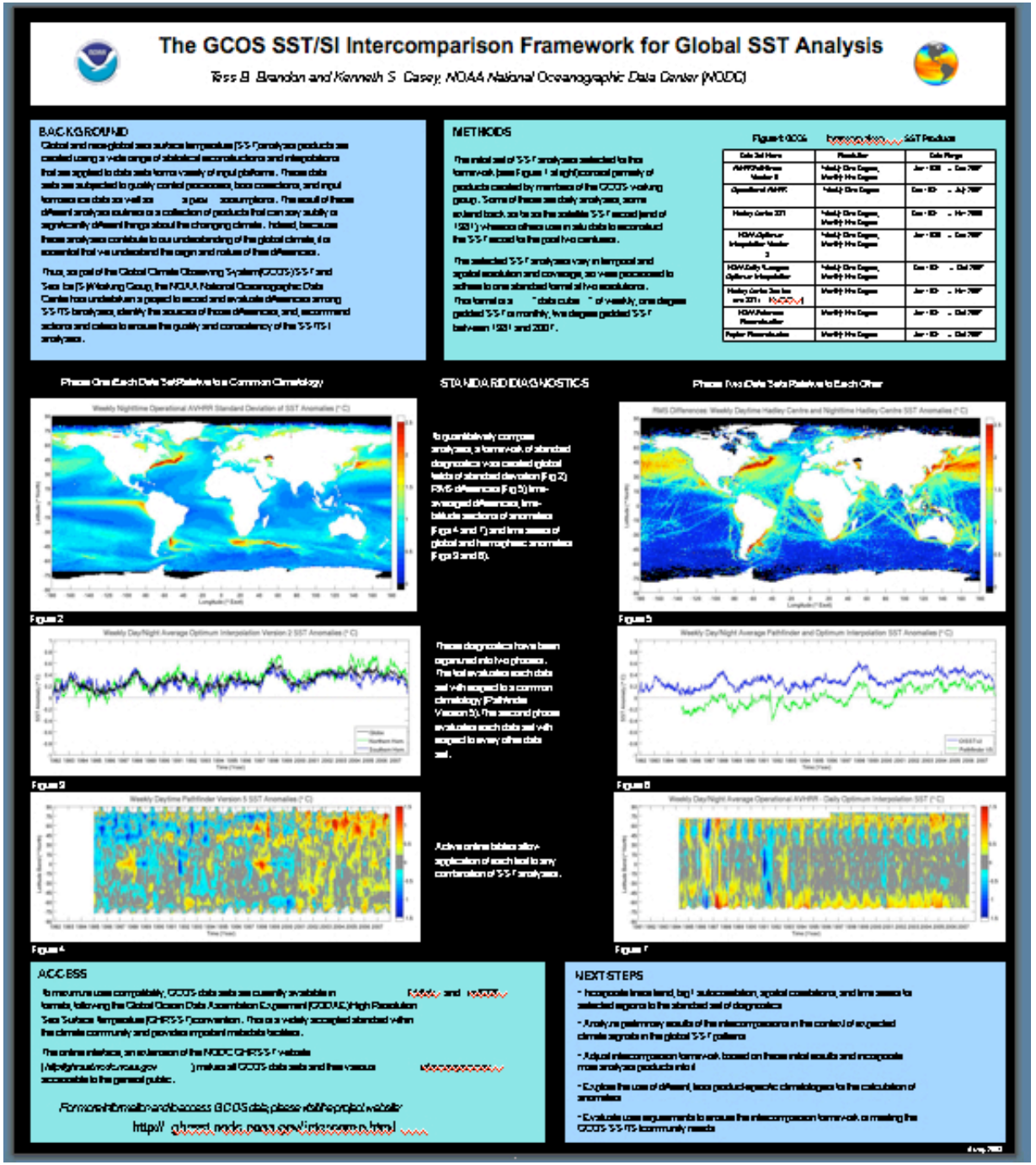








Tess Brandon's Poster



The GCOS SST/SI Intercomparison Framework for Global SST Analysis

Tess B. Brandon and Kenneth S. Casey, NOAA National Oceanographic Data Center (NODC)

BACKGROUND

Global and near-global sea surface temperature (SST) analysis products are created using a wide range of statistical reconstructions and interpolations that are applied to data sets from a variety of input platforms. These data sets are subjected to quality control processes, bias corrections, and input from various ancillary data sets as well as a priori assumptions. The result of these different analysis routines is a collection of products that can vary subtly or significantly different things about the changing climate. Indeed, because these analyses contribute to our understanding of the global climate, it is essential that we understand the origin and nature of these differences.

Thus, as part of the Global Climate Observing System (GCOS) SST and Sea Ice (SI) Working Group, the NOAA National Oceanographic Data Center has undertaken a project to record and evaluate differences among SST/SI analyses, identify the sources of those differences, and recommend actions and criteria to ensure the quality and consistency of the SST/SI analyses.

METHODS

The initial set of SST analyses selected for this framework (see Figure 1 at right) consist primarily of products created by members of the GCOS working group. Some of these are daily analyses, some are land/sea, some are for the satellite SST record (end of 1981), whereas others use in situ data to reconstruct the SST record for the past two centuries.

The selected SST analyses vary in temporal and spatial resolution and coverage, so were processed to adhere to one standard format and resolution. This format is a "data cube" of weekly, one degree gridded SST from monthly, five degree gridded SST between 1981 and 2007.

Figure 1: GCOS [illegible] SST Products

Data Set Name	Resolution	Date Range
AVHRR Pathfinder Version 5	Weekly, One Degree, Monthly, Five Degree	Jan - 1981 - Dec 2007
Operational AVHRR	Weekly, One Degree	Dec - 1981 - July 2007
Hadley Centre SST	Weekly, One Degree, Monthly, Five Degree	Dec - 1981 - Mar 2008
NOAA Optimum Interpolation Version 2	Weekly, One Degree, Monthly, Five Degree	Jan - 1981 - Dec 2007
NOAA Daily Optimum Interpolation	Weekly, One Degree, Monthly, Five Degree	Dec - 1981 - Oct 2007
Hadley Centre Sea Ice and SST	Monthly, Five Degree	Jan - 1981 - Mar 2007
NOAA Reynolds Reconstruction	Monthly, Five Degree	Jan - 1981 - Oct 2007
Pacific Reconstruction	Monthly, Five Degree	Jan - 1981 - Oct 2007

Phase One: Each Data Set Relative to a Common Climatology

STANDARD DIAGNOSTICS

Phase Two: Data Sets Relative to Each Other

Figure 2

To quantitatively compare analyses, a framework of standard diagnostics was created: global fields of standard deviation (Fig 2), RMS differences (Fig 5), time-averaged differences, time-latitude sections of anomalies (Figs 4 and 7), and time series of global and hemispheric anomalies (Figs 3 and 6).

Figure 5

Figure 3

These diagnostics have been organized into two phases. The first evaluates each data set with respect to a common climatology (Pathfinder Version 5). The second phase evaluates each data set with respect to every other data set.

Figure 6

Figure 4

Active online tables allow application of each tool to any combination of SST analyses.

Figure 7

ACCESS

To maximize user compatibility, GCOS data sets are currently available in [illegible] and [illegible] formats, following the Global Ocean Data Assimilation Experiment (GODAE) High Resolution Sea Surface Temperature (GHRSST) convention. This is a widely accepted standard within the climate community and provides important metadata facilities.

The online interface, an extension of the NODC GHRSST website ([illegible]) makes all GCOS data sets and their various [illegible] accessible to the general public.

For more information and to access GCOS data, please visit the project website:

http:// [illegible]

NEXT STEPS

- Incorporate linear trend, lag-1 autocorrelation, spatial correlations, and time series for selected regions to the standard set of diagnostics
- Analyze preliminary results of the intercomparison in the context of expected climate signals in the global SST patterns
- Adjust intercomparison framework based on these initial results and incorporate more analyses products into it
- Explore the use of different, less product-specific climatologies for the calculation of anomalies
- Evaluate user requirements to ensure the intercomparison framework is meeting the GCOS SST/SI community needs

Closing Thoughts

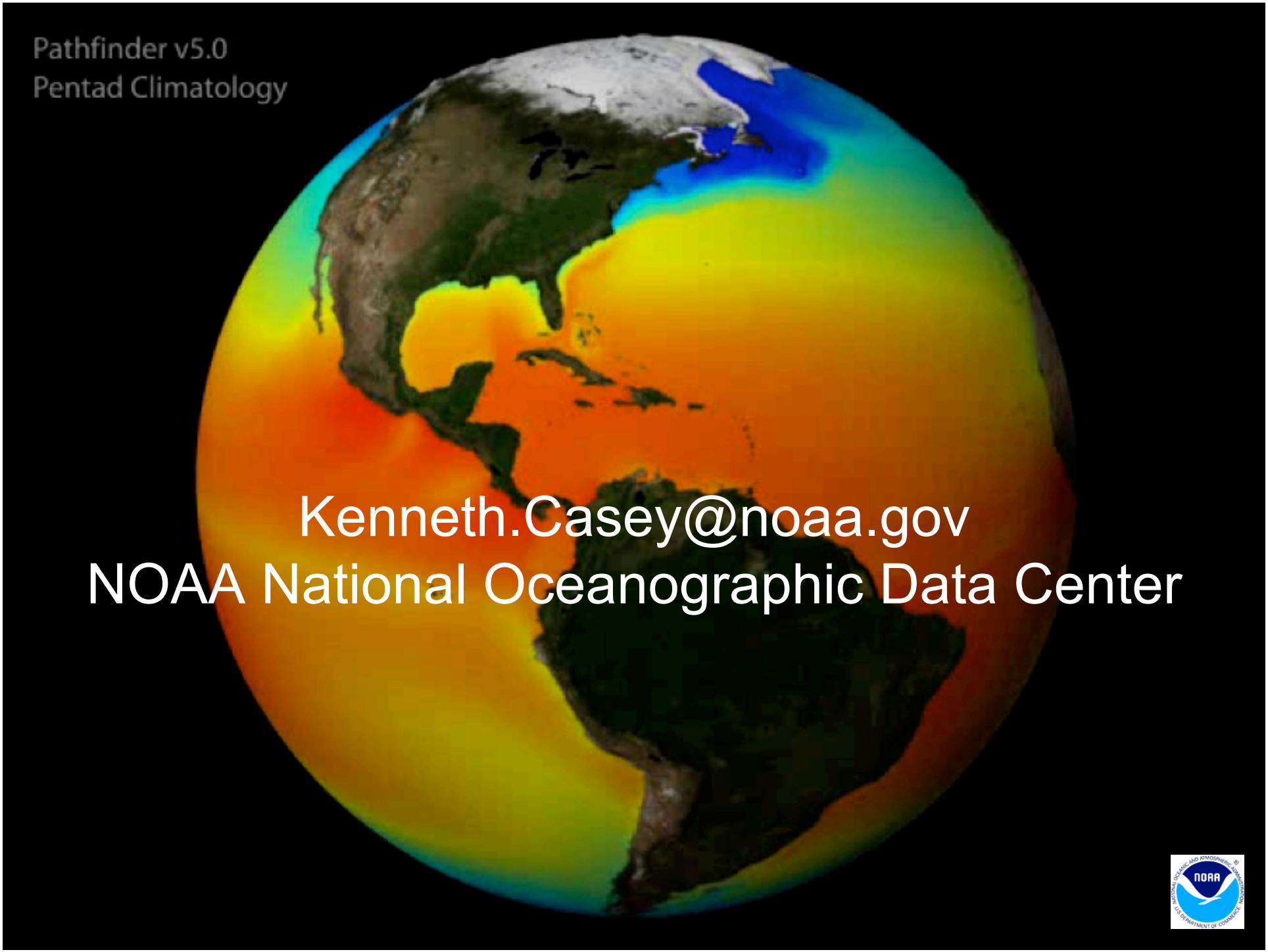
- We've come a long way since Boulder in 2002:
  - GHRSST
  - Pathfinder
  - GCOS SST and SI WG

1000 netCDF/day!

Over 23 years!

Intercomparisons!

- But we have a long way to go…
  - Complete Pathfinder as a sustained system
  - Maturity of the GCOS intercomparisons
  - Producing full-scale GHRSST Reanalysis



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