



# **Pathfinder, GHRSSST, and the SST Essential Climate Variable Framework**

Kenneth S. Casey and Tess B. Brandon

NOAA National Oceanographic Data Center

Robert H. Evans, UMiami/RSMAS

MARCDAT-III – Frascati – May 2011

**Pathfinder, GHRSSST, and the SST Essential Climate Variable Framework**

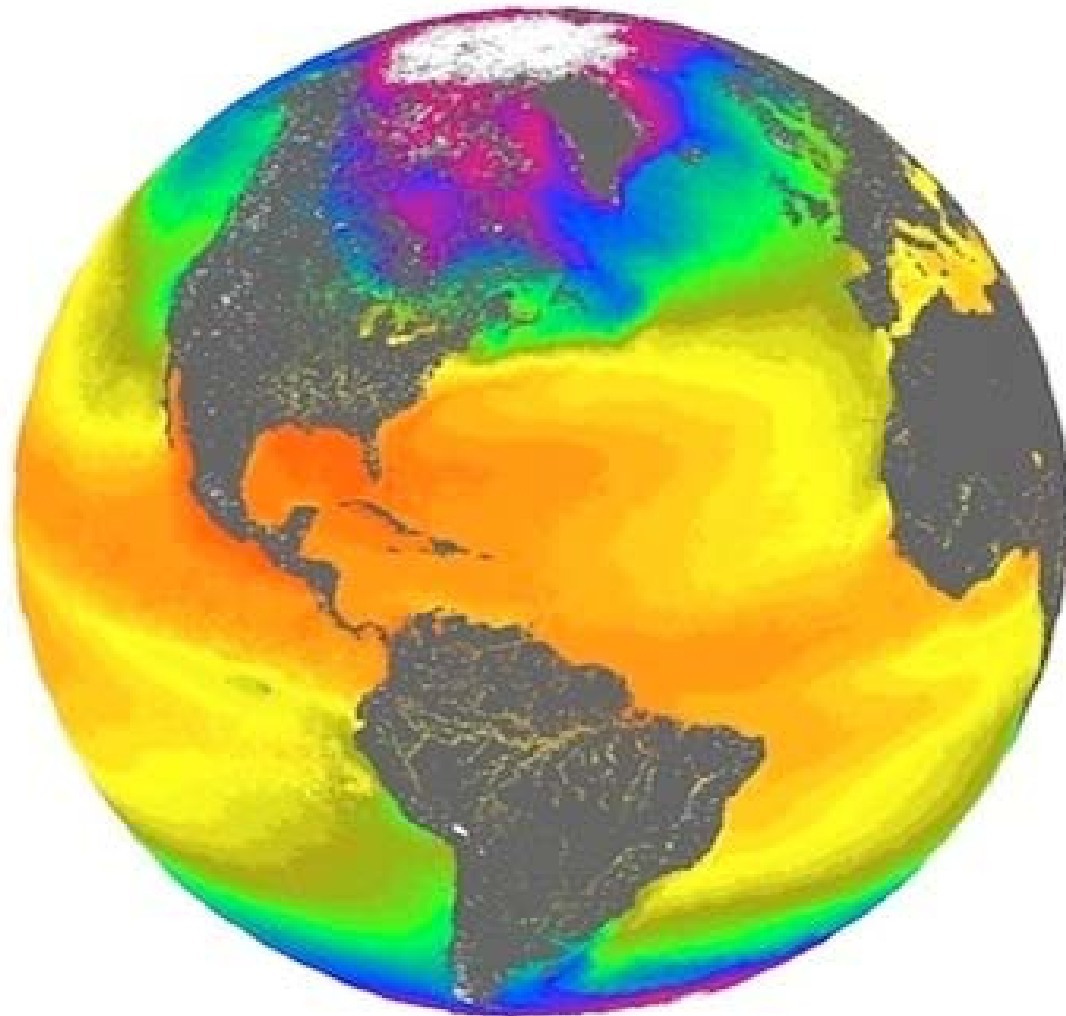
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# Building the SST climate data record...

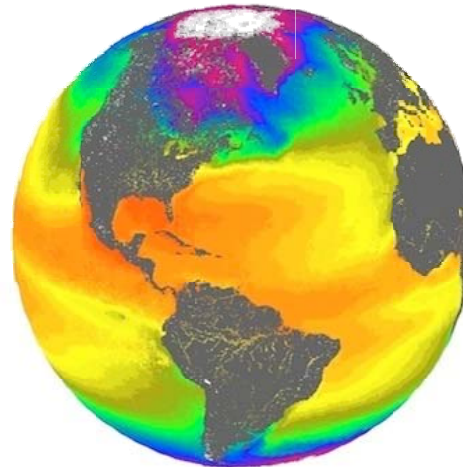


... So many pieces to the puzzle ...

# Rewind Ten Years...

With so many pieces, no one nation or organization could do it all, and efforts were:

- Disorganized
- Uncoordinated
- Ad hoc
- Piecemeal



Yet still productive, and progress on many fronts.

# Early 2000s: Coming into Focus



## **GCOS SST and Sea Ice Working Group**

# GCOS SST Intercomparisons

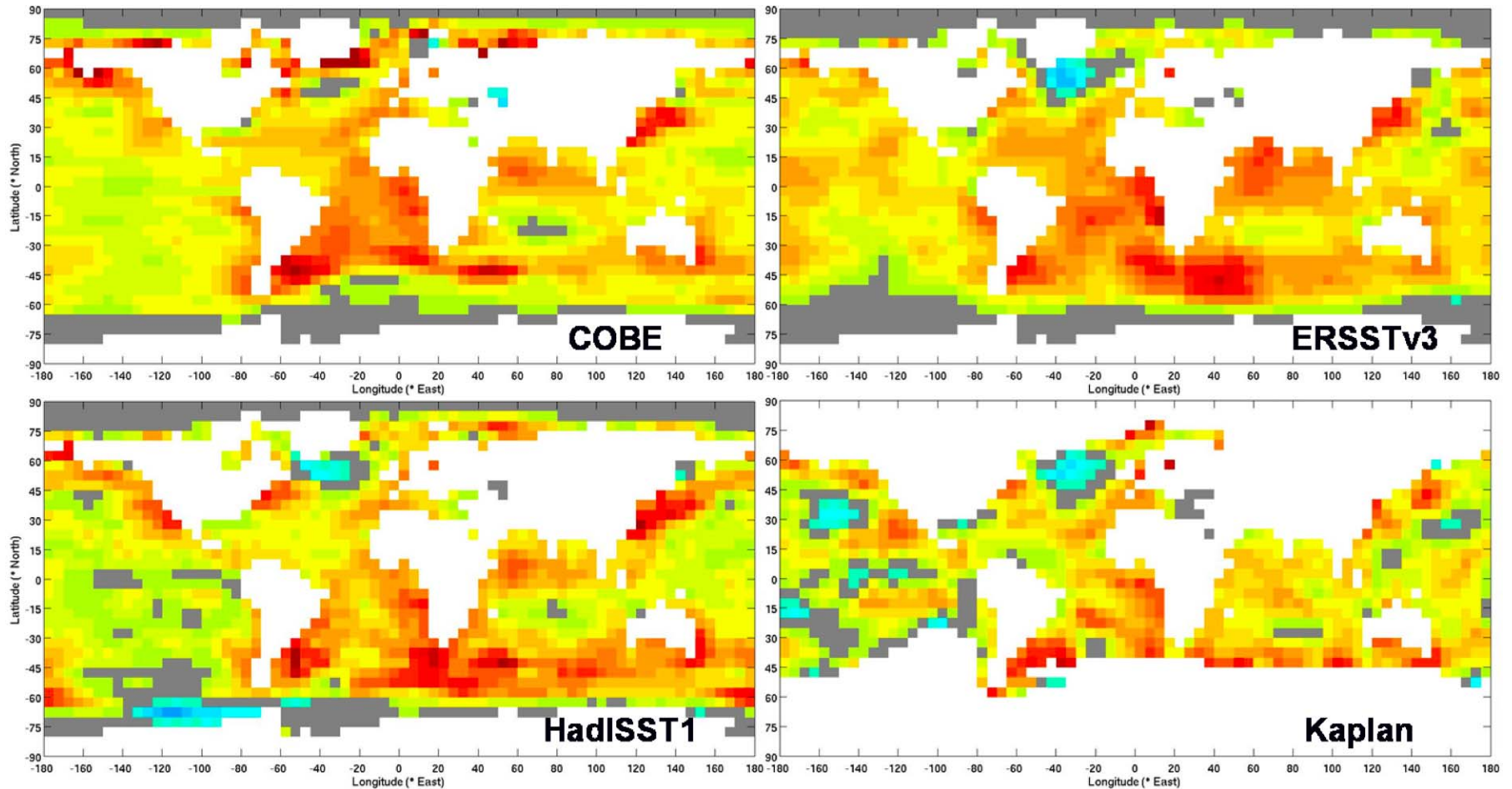
Data Set Name	Satellite Era (1981 – 2007)	Historical Era (1850 – 2008)
AVHRR Pathfinder Version 5	X	
Operational AVHRR	X	
NOAA Optimum Interpolation (OI) Version 2	X	
NOAA Daily ¼-degree OI Version 1	X	
Hadley Centre SST V2	X	X
Hadley Centre Sea Ice and SST (HadISST) V1	X	X
NOAA Extended Reconstruction Version 3	X	X
Kaplan Reconstructed	X	X
International COADS Version 2.4		X
COBE Analysis		X

Connecting historical in situ and satellite records

# GCOS SST Intercomparisons

- GCOS SST WG Experiment
  - Goal: understand the differences arising from the analysis systems themselves
  - Develop a common input data set for all the analysis systems to use
  - Produce the analyses
  - Compare!
- COBE and ERSST provided so far

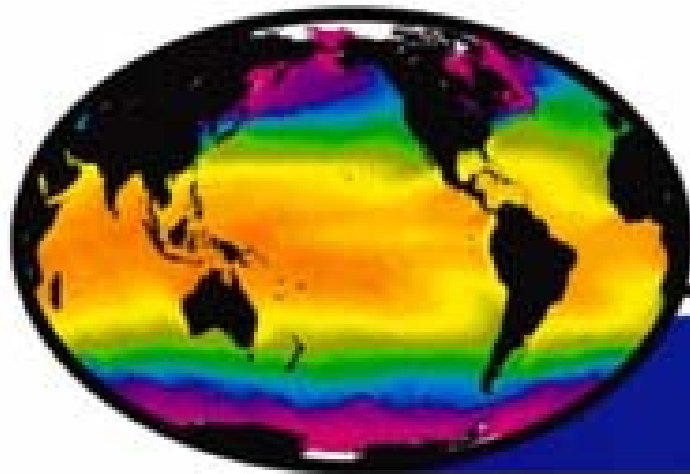
# GCOS SST Intercomparisons



Example: Linear trend comparisons –  
<http://ghrsst.nodc.noaa.gov>



# Early 2000s: Coming into Focus

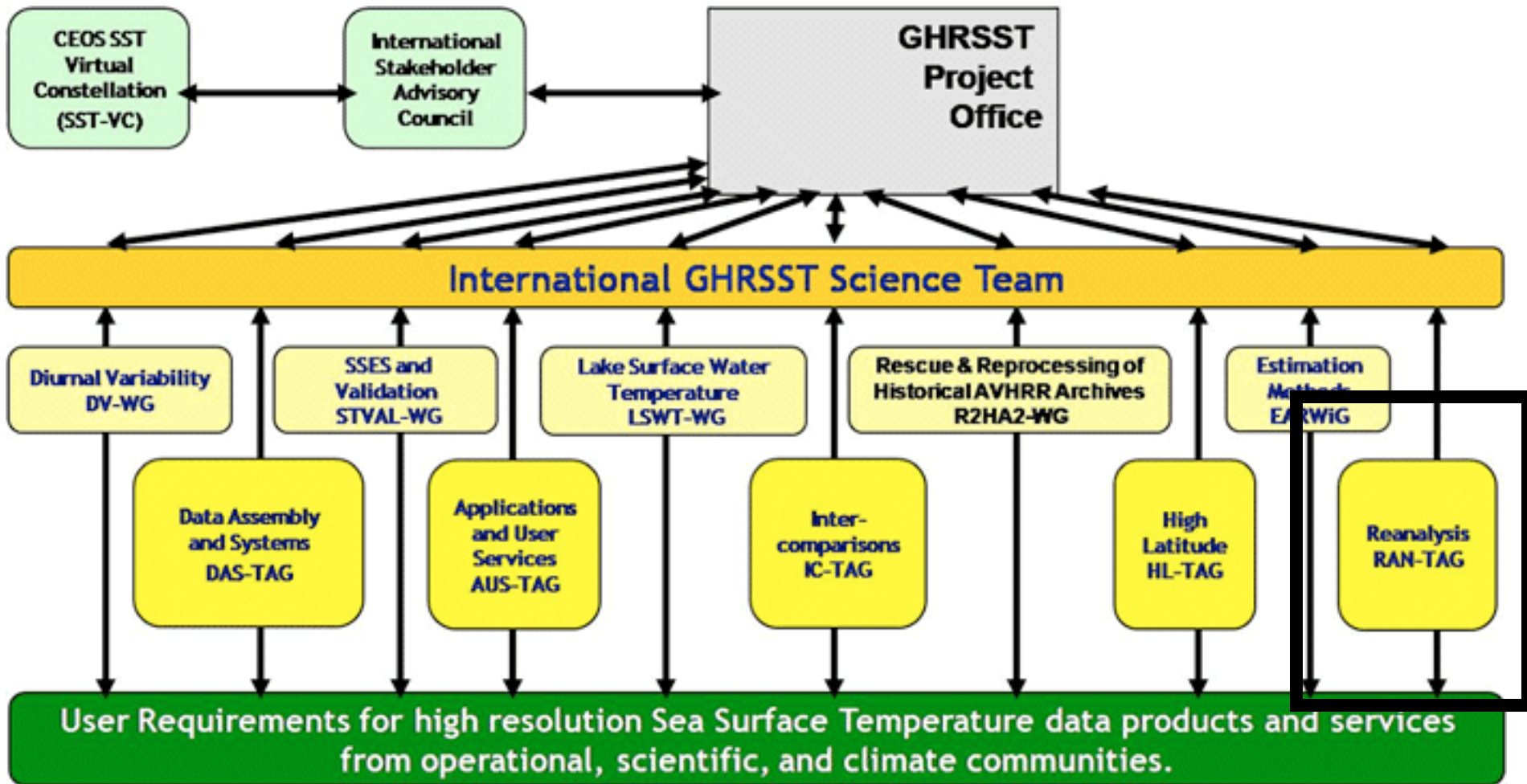


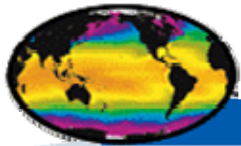
# **GHRSSST**

*Group for High Resolution  
Sea Surface Temperature*

## **GHRSSST and the Reanalysis Technical Advisory Group (RAN-TAG)**

# RAN-TAG





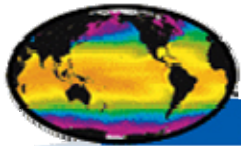
# 2009 GHRSSST Data Availability

GHRSSST Long Term Stewardship and Reanalysis Facility



	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 2008 2009	
(A)ATSR	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	
GOES	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green
SEVIRI	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Red	Red	Red	Green	Green	Green
MSG	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	
MTSAT	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	
AMSRE	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	
MODIS	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Red	Red	Red	Red	Red	Red	Green	Green
AVHRR GAC	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green
AVHRR HRPT	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green
TMI	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
IASI	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Red	Red
Windsat	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Red	Red	Red	Red	Red	

Sensor not in operation or capable of SST observations	Grey
No plans yet for GHRSSST L2P	Red
Efforts underway or proposed for GHRSSST L2P	Yellow
Data available in GHRSSST L2P	Green



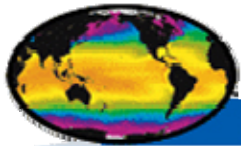
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Windsat	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Red	Red	Red	Red	Red	Red

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# 2011 (?) GHRSSST Data Availability

GHRSSST Long Term Stewardship and Reanalysis Facility



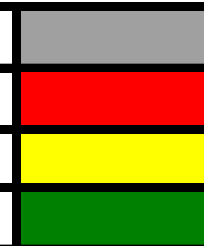
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007 - 2011	
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Windsat																												

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No plans yet for GHRSSST L2P

Efforts underway or proposed for GHRSSST L2P

Data available in GHRSSST L2P



# 2010 International Status Report



Summary of Current and Planned Future Reanalysis Activities from around the world

21 projects summarized and gaps identified, in an easy to understand and consistent format

Available at LTSRF and GHRSSST web sites  
<http://ghrsst.nodc.noaa.gov>  
<http://www.ghrsst.org>

# Now and Into the Future

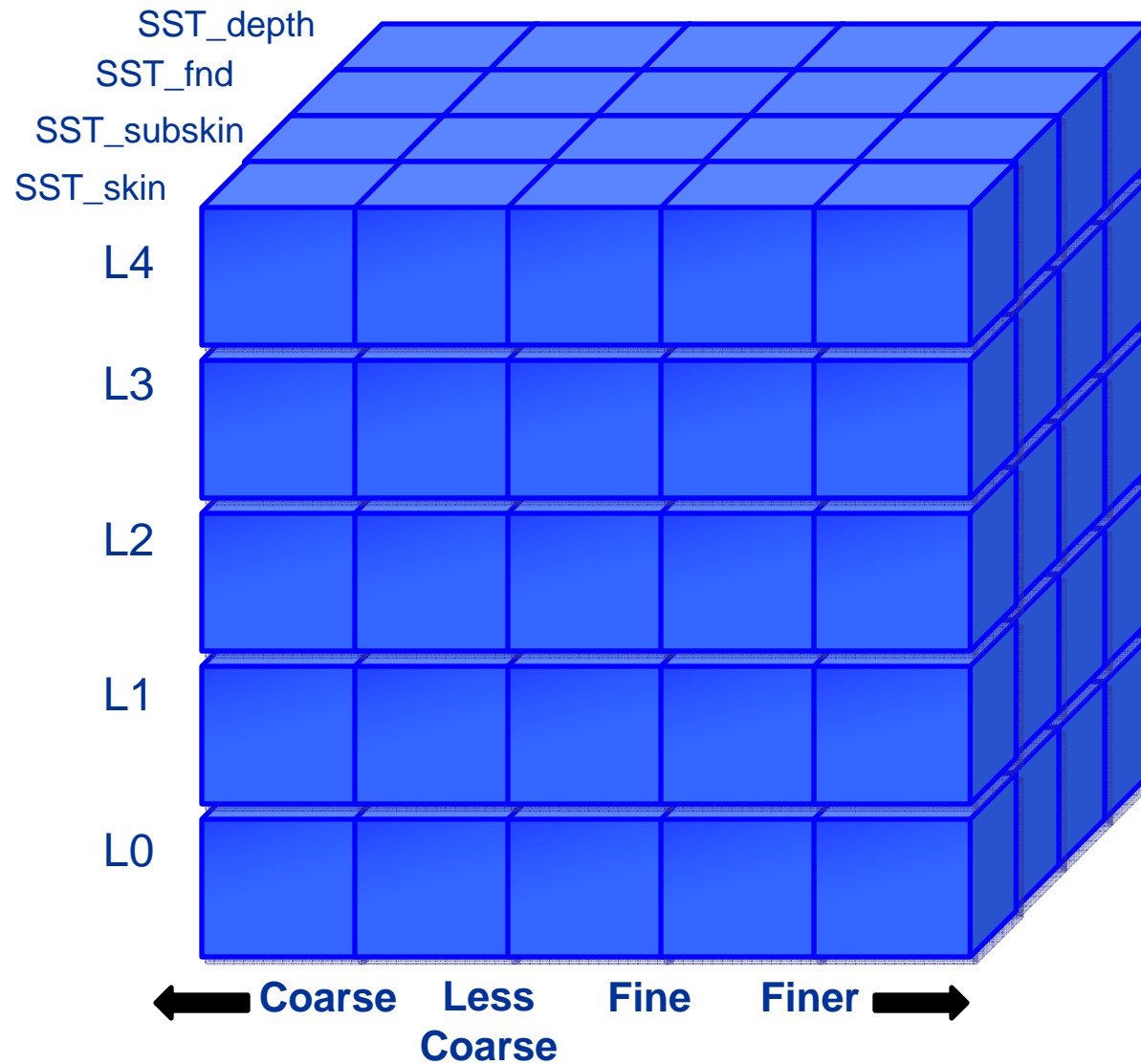
Now...

- More Coordination
- Clearer understanding of the interrelated pieces

National programs: NOAA Climate Data Record Program (CDRP) and the ESA Climate Change Initiative (CCI)

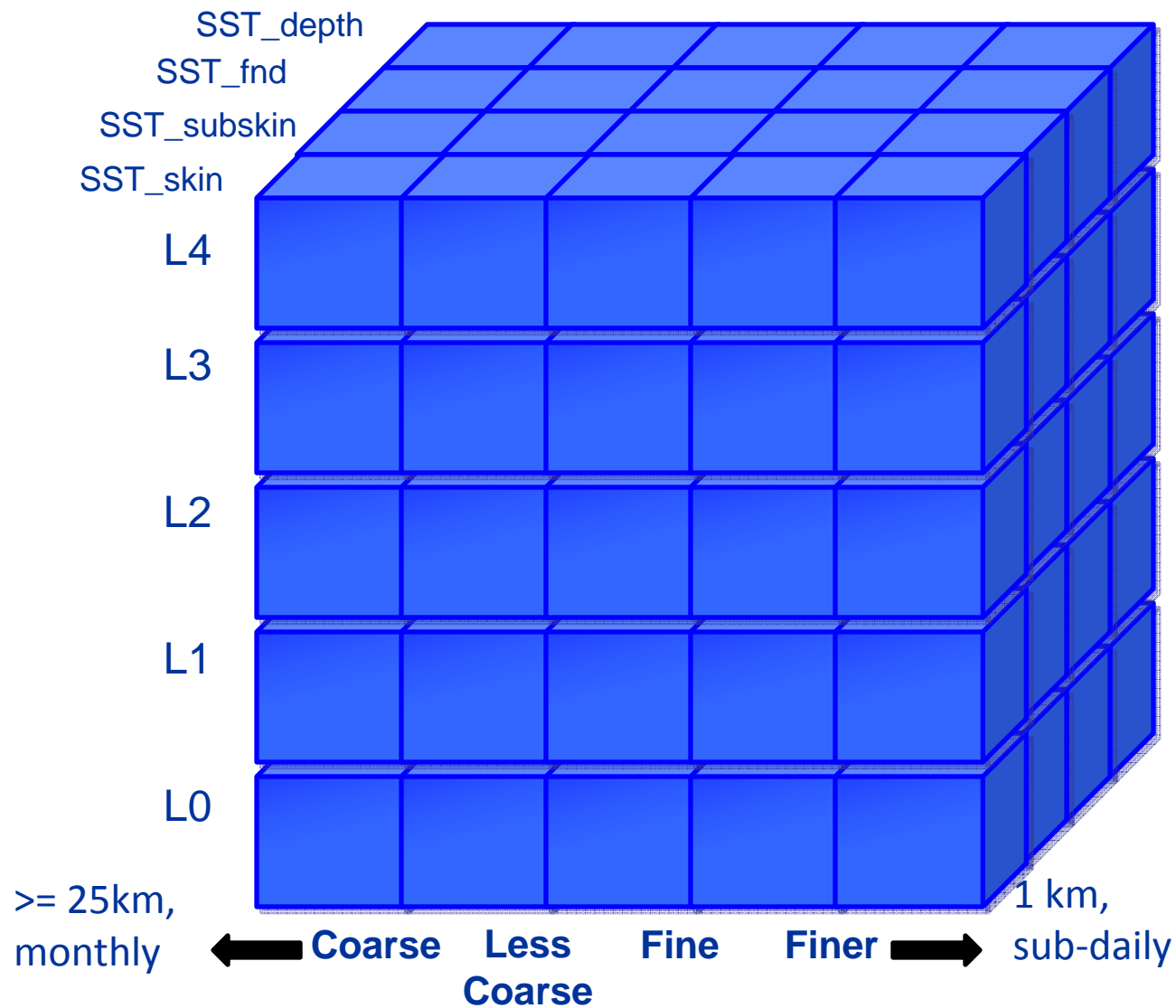
GHRSSST RAN-TAG and GCOS SST and Sea Ice WG  
Coordination leading to...

# The SST ECV Product Framework

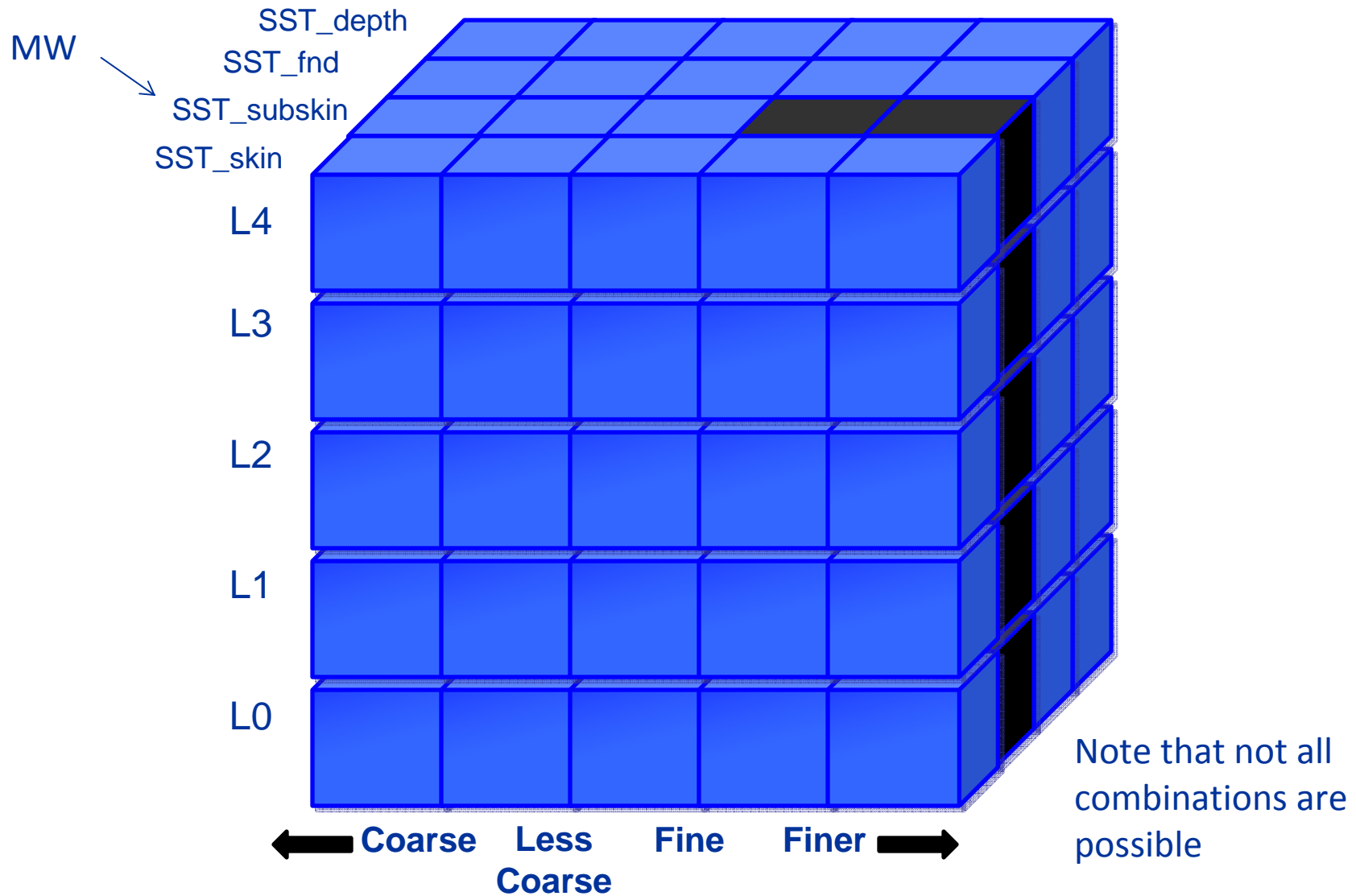




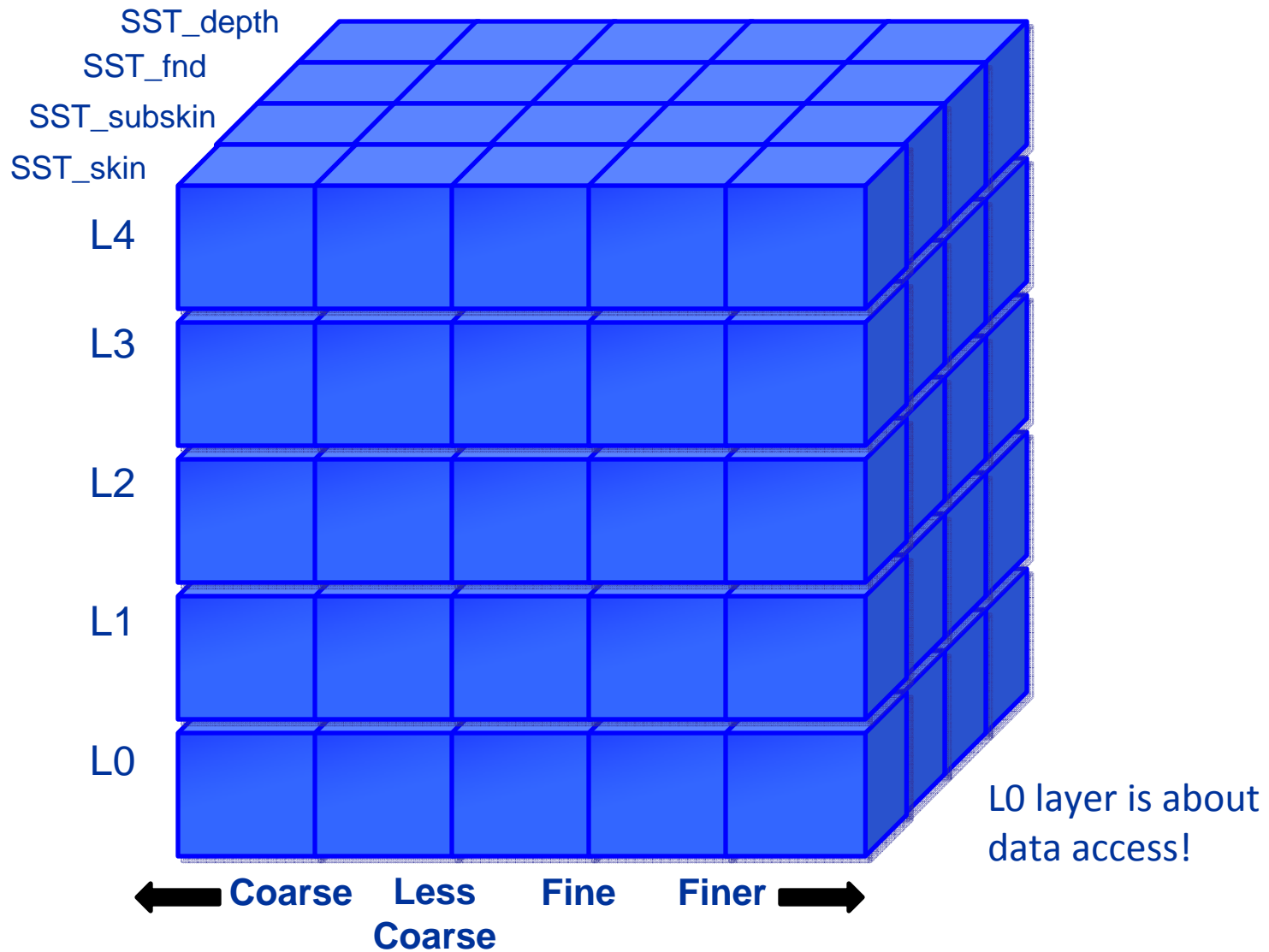
# The SST ECV Product Framework



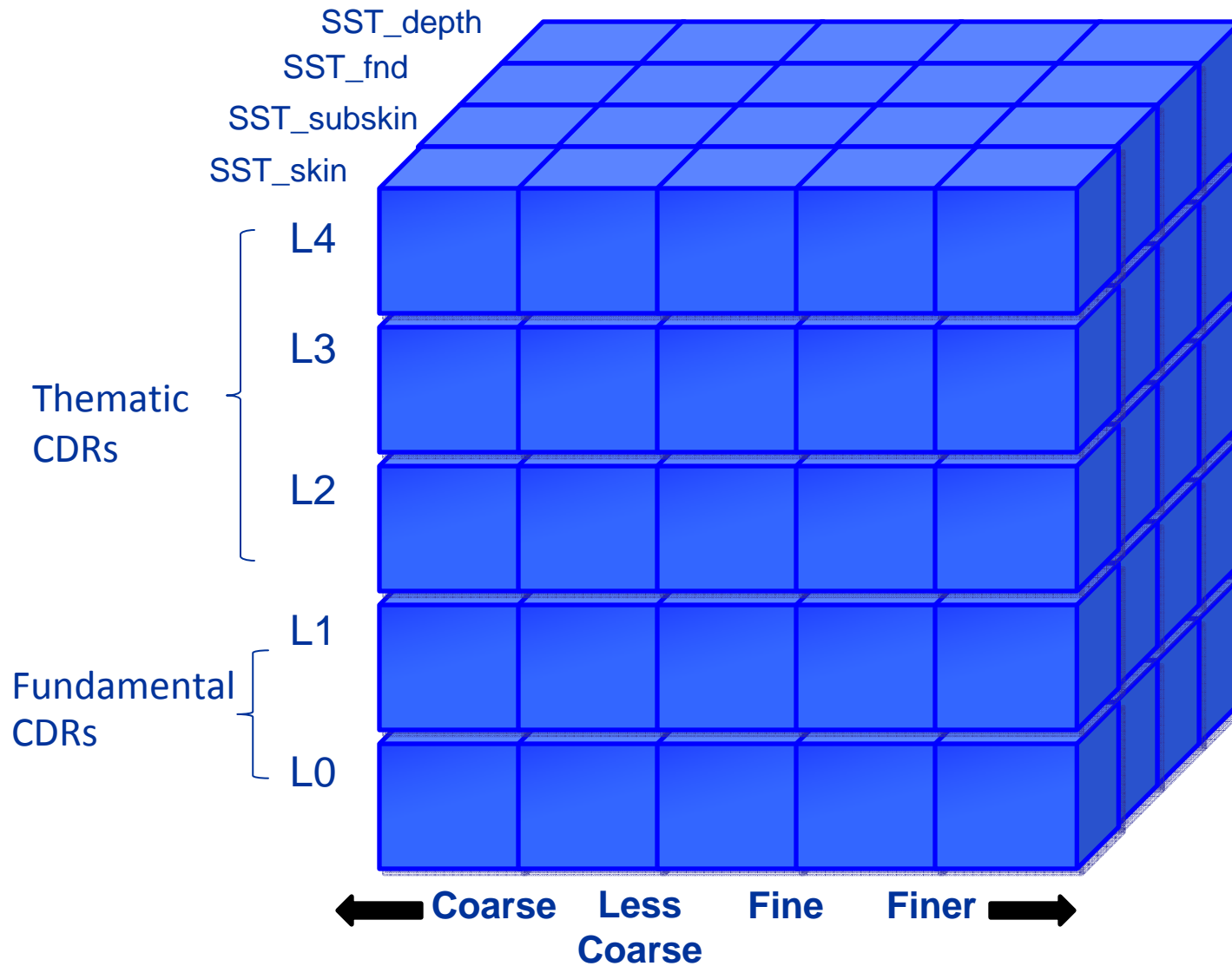
# The SST ECV Product Framework



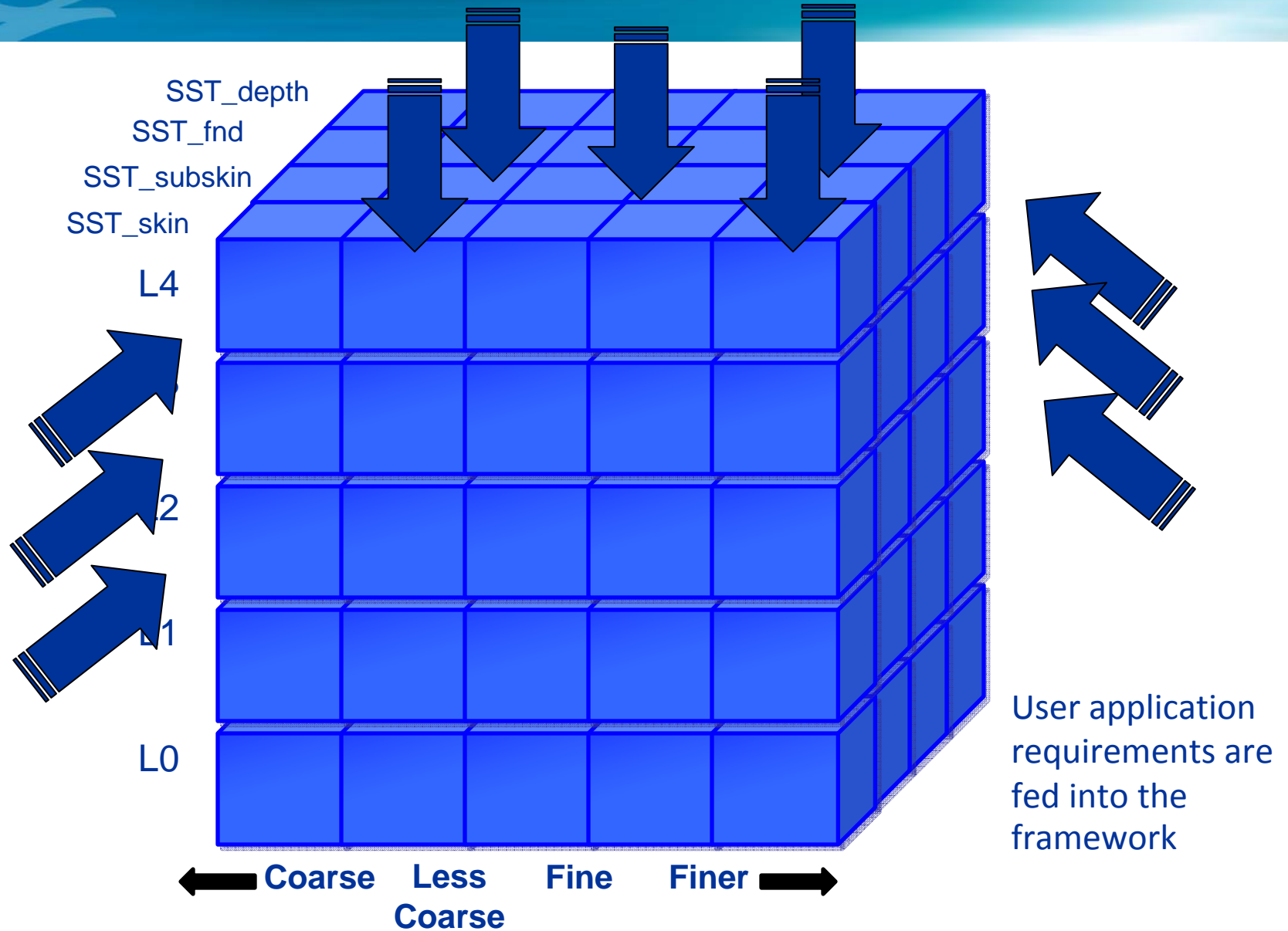
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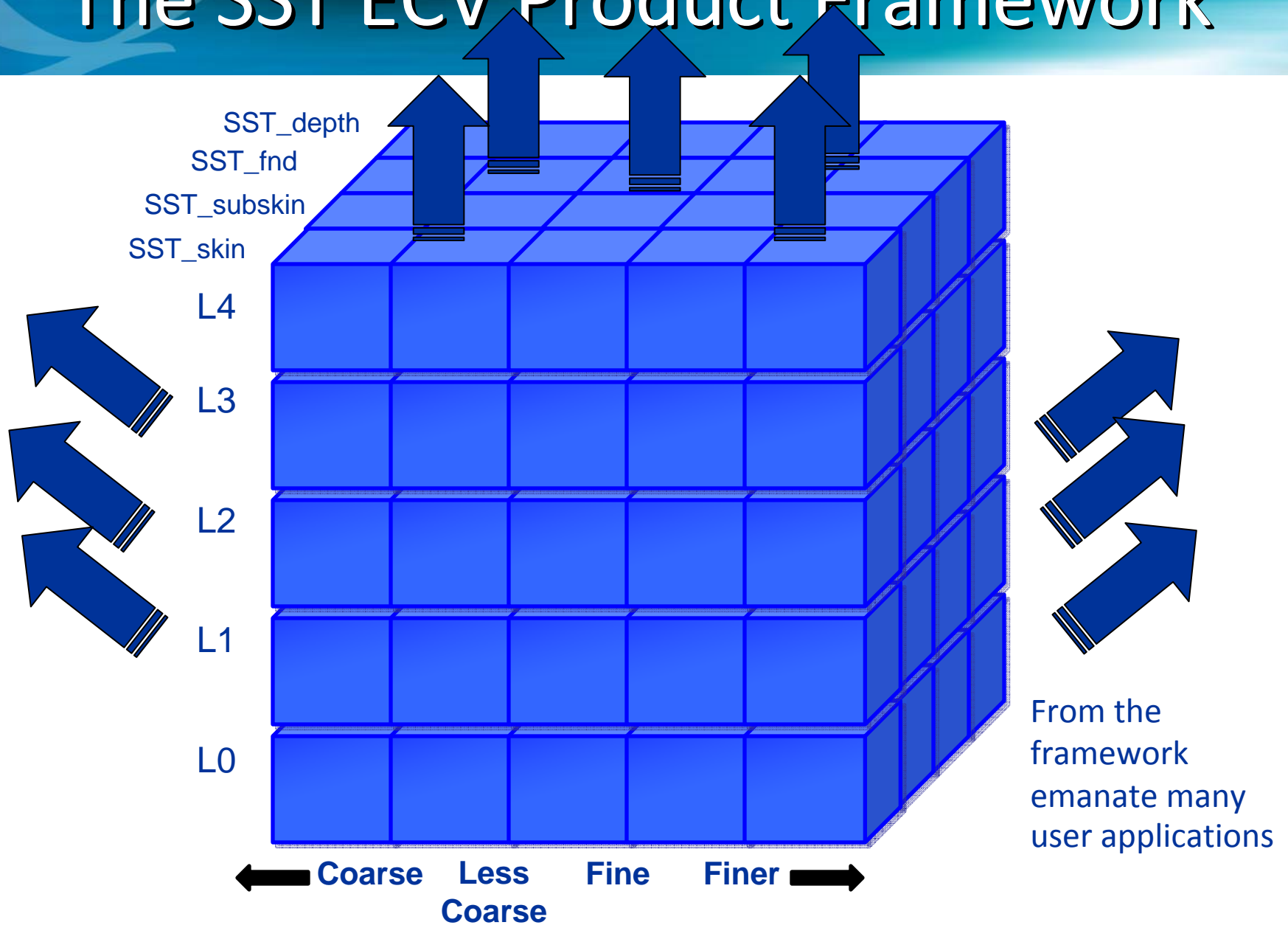
# The SST ECV Product Framework



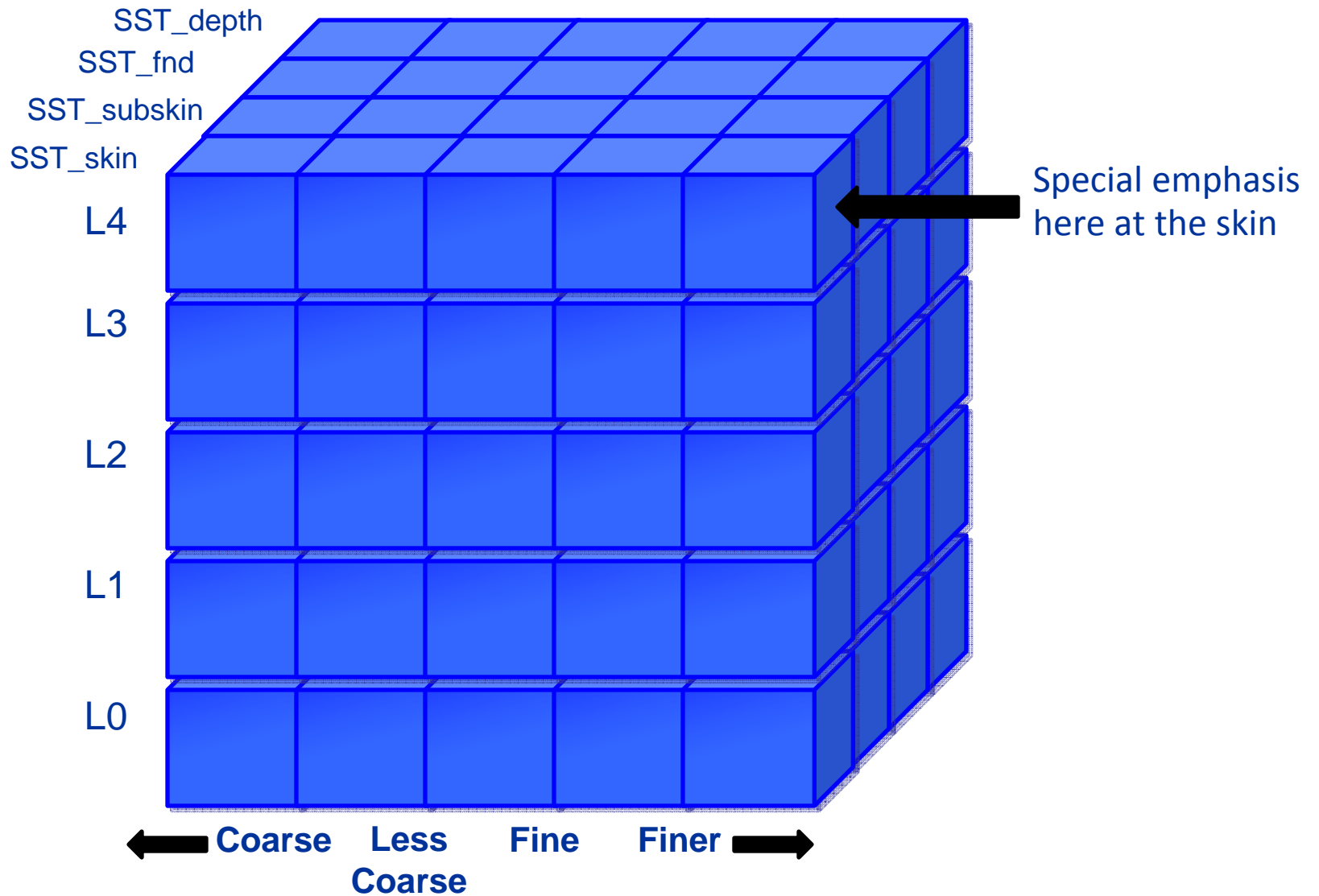
# The SST ECV Product Framework



# The SST ECV Product Framework



# The SST ECV Product Framework



# Clarifying the Connections

This model is clarifying the connections and provides the basis for a systematic, sustained, coordinated global effort.

Using the SST ECV Framework, the GHRSSST RAN-TAG established a list of prioritized actions necessary to begin piecing together the framework.



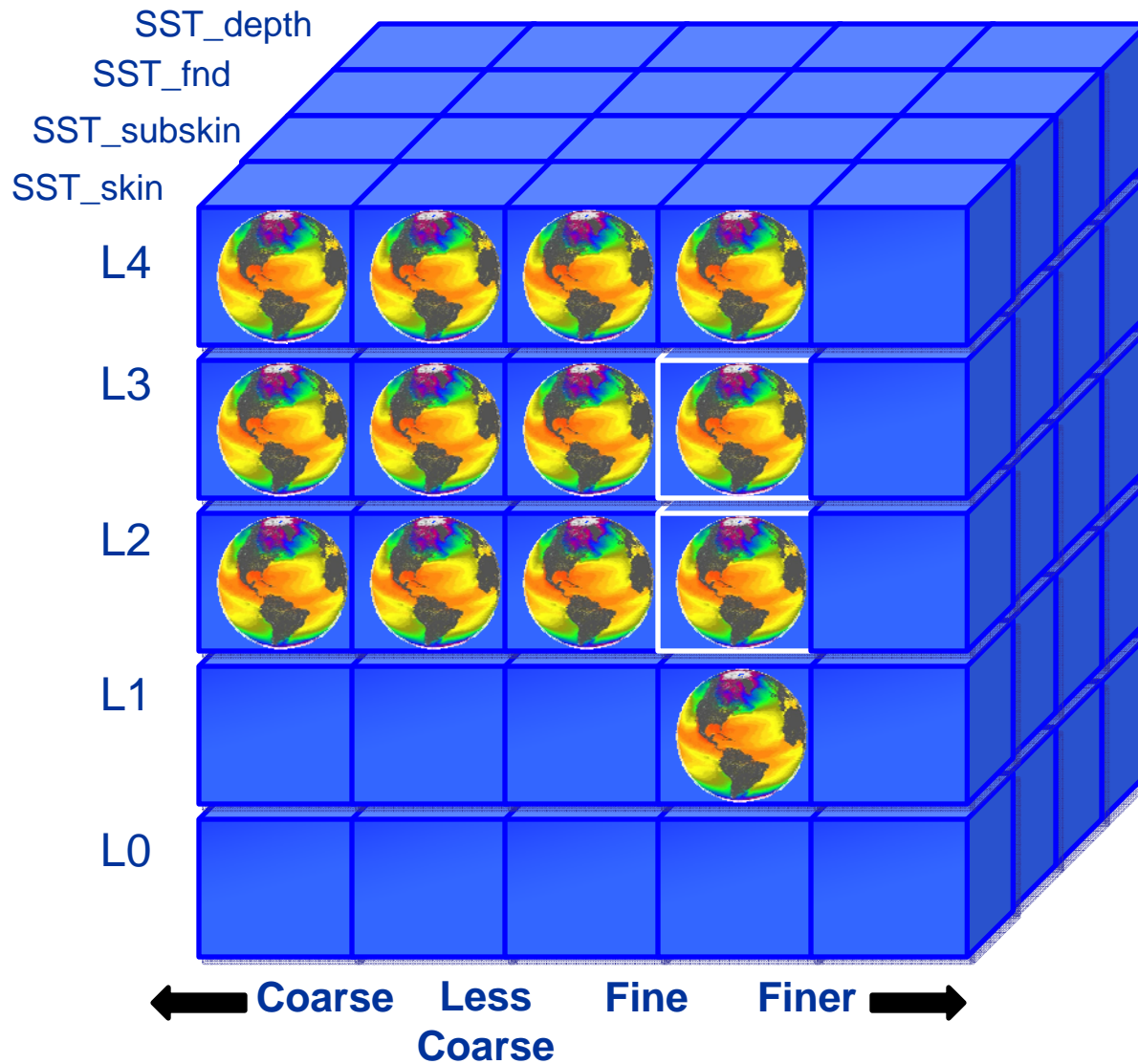
# Piecing it Together

- GHRST Prioritized List:
  1. Begin production of Pathfinder V6, 1981-near present, in GHRSSST L2 and L3 format, for GAC and available LAC/HRPT
  2. Fix the calibration of AVHRR and AMSR-E to remove latitudinal and other biases before reprocessing of data sets
  3. Create MODIS retrospective data in GHRSSST format
  4. Complete ARC science for ATSR-1 to AATSR

# Piecing it Together

- GHRSSST Prioritized List:
  5. Assign proposed HadSST3 in situ bias adjustments on a per-observation basis to allow incorporation into GHRSSST reanalysis products
  6. Test and possibly integrate improved AVHRR BTs and/or physical retrieval methods into Pathfinder
  7. Create GOES retrospective data in GHRSSST format
  8. Improve data discovery and access mechanisms at GDAC and LTSRF – Live Access Server and THREDDS Catalog

# AVHRR Pathfinder

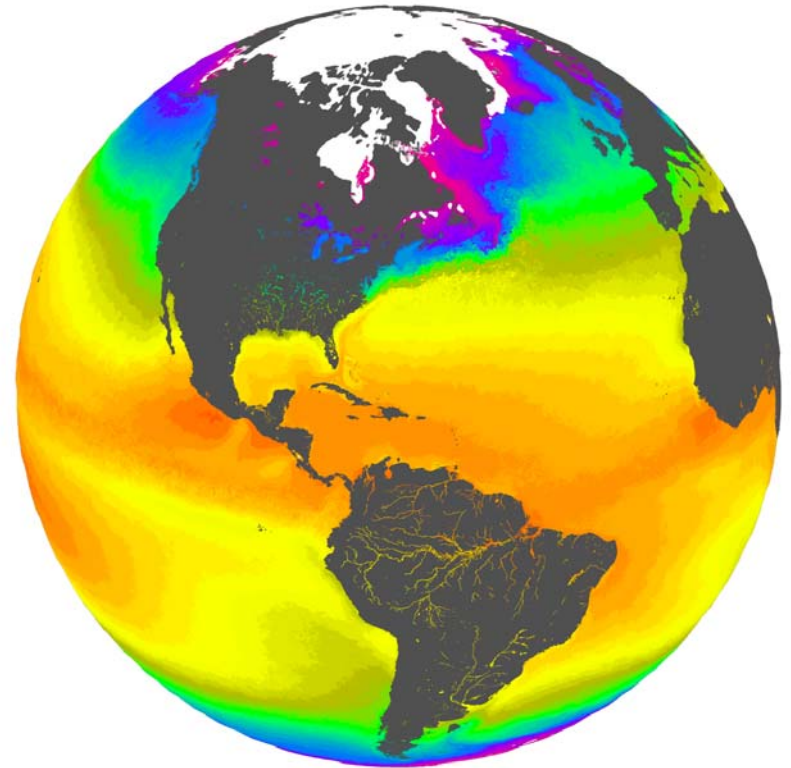


# Pathfinder “Phases”

Phase 1	Phase 2	Phase 3
NOAA/NASA AVHRR Oceans Pathfinder SST Project (Versions 1-4)	NOAA-supported Pathfinder SST Program (Versions 5.0 and 5.1)	NOAA-supported with targeted NASA funding (Versions 5.2 and 6 in preparation)
1990-2001	2002-2008	2009-2011+

# Current Status of PFV5.0/5.1

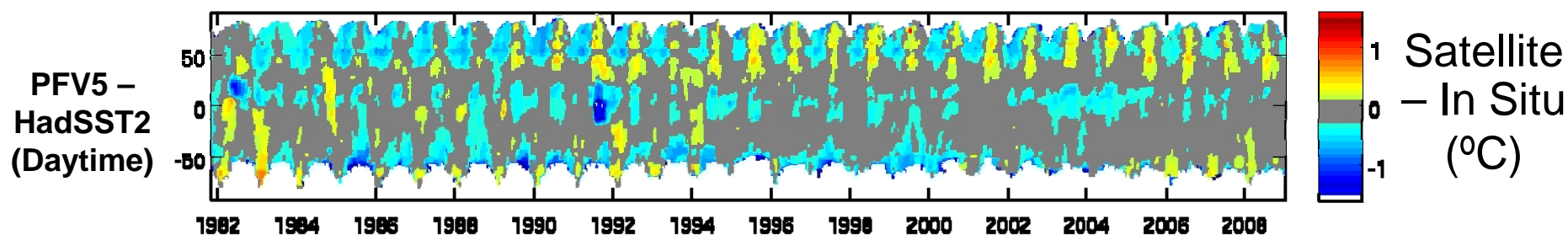
- 1981 through 2009, 4.6 km
- Twice-daily, 5-day, 7-day, 8-day, and monthly
- <http://pathfinder.nodc.noaa.gov>
  - FTP
  - HTTP
  - OPeNDAP
  - WCS and WMS via TDS
  - Live Access Server



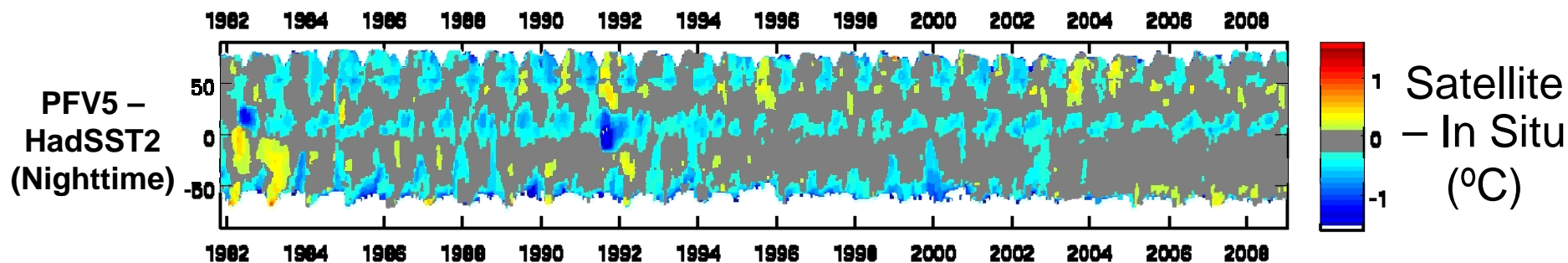
Casey, K.S., T.B. Brandon, P. Cornillon, and R. Evans (2010). “The Past, Present, and Future of the AVHRR Pathfinder SST Program”, in *Oceanography From Space, Revisited*, eds. V. Barale, J.F.R. Gower and L. Alberotanza, Springer.

# Pathfinder Still Being Improved!

Improvements to reference field, land mask, spatial binning, and GHRSSST-compliance



Reducing seasonal and latitudinal patterns with  
“LATBAND” coefficients, and error estimates



# Pathfinder Still Being Improved!

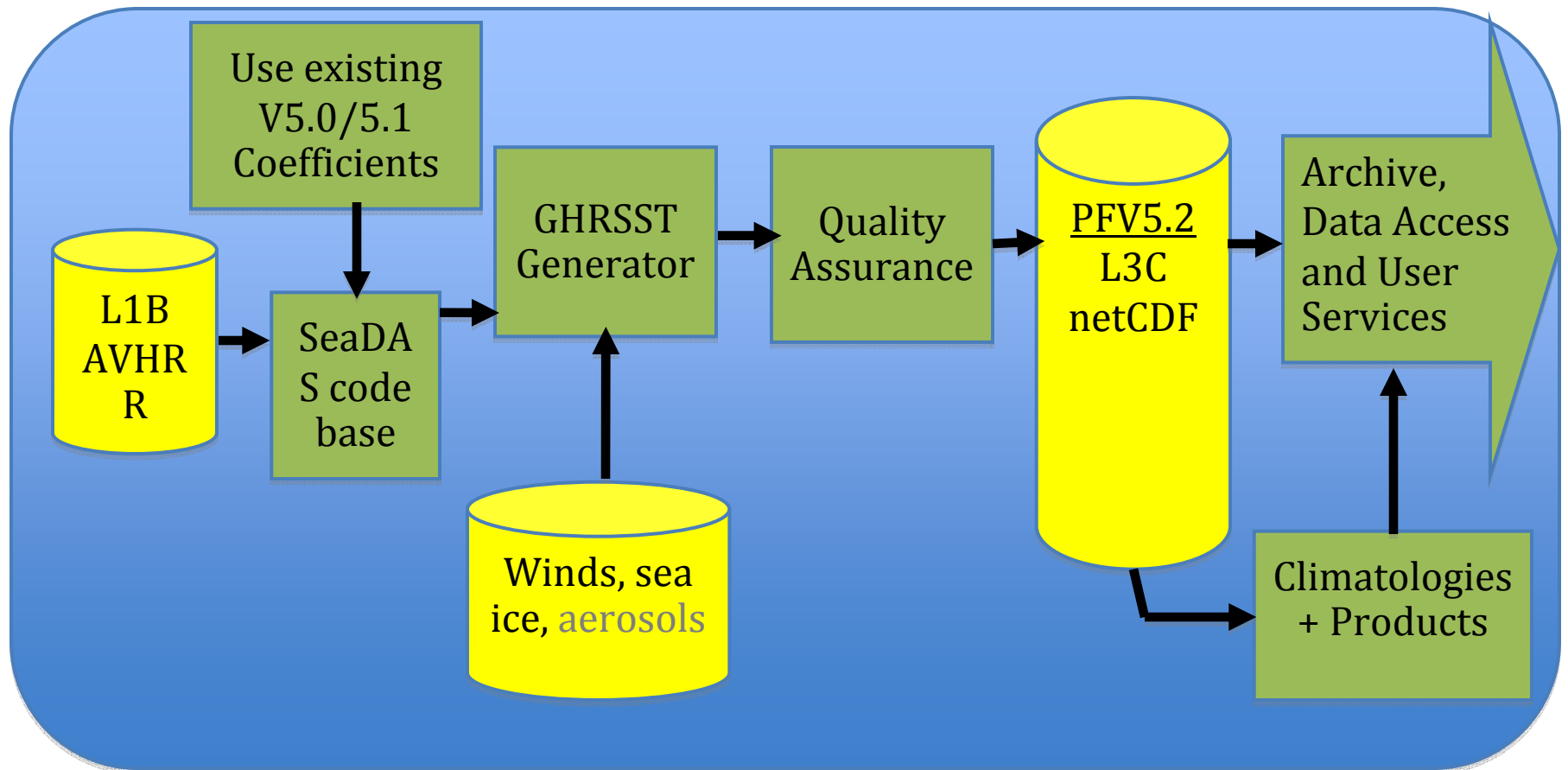
Improvements to reference field, land mask, spatial binning, and GHRSSST-compliance

**- Pathfinder Version 5.2 -**

Reducing seasonal and latitudinal patterns with “LATBAND” coefficients, and error estimates

**- Pathfinder Version 6 -**

# PFV5.2 Workflow Overview





# PFV5.2 – Public Comment Period

- **Announcing today the start of a three-week public review and comment period!!**
- **Please review and examine the data, then send questions, comments, or concerns to [Kenneth.Casey@noaa.gov](mailto:Kenneth.Casey@noaa.gov) by 11:59 PM EST on Monday, 23 May 2011**
- **We'll address as many of the comments as we can, prior to full production of PFV5.2**
- **Intend to complete PFV5.2 production by next GHRSSST Science Team Meeting, 27 June 2011**

# PFV5.2 – Public Comment Period

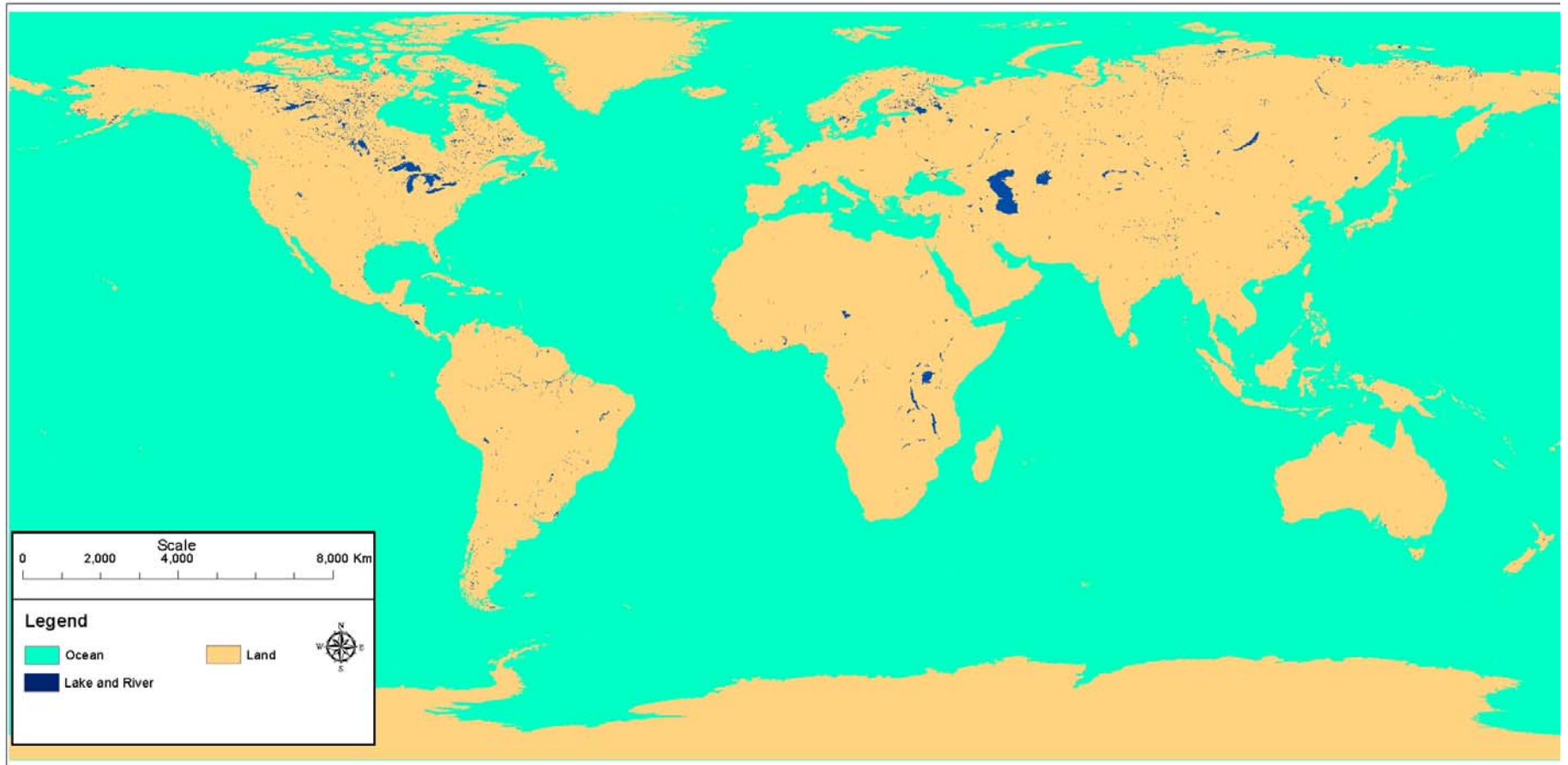
## Several ways to get the data:

- **HTTP:**  
[http://data.nodc.noaa.gov/pathfinder/PFV52\\_PublicReview](http://data.nodc.noaa.gov/pathfinder/PFV52_PublicReview)
- **FTP:**  
[ftp://ftp.nodc.noaa.gov/pub/data.nodc/pathfinder/PFV52\\_PublicReview](ftp://ftp.nodc.noaa.gov/pub/data.nodc/pathfinder/PFV52_PublicReview)
- **THREDDS:**  
[http://data.nodc.noaa.gov/thredds/catalog/pathfinder/PFV52\\_PublicReview](http://data.nodc.noaa.gov/thredds/catalog/pathfinder/PFV52_PublicReview)

# **PFV5.2 Land mask built from ground up!**

- **Rasterize the Global Self-consistent Hierarchical High-resolution Shoreline (GSHHS) Database from the NOAA National Geophysical Data Center**
- **Any 4 km Pathfinder pixel whose area is 50% or more covered by land = LAND**
- **Rasterize the World Wildlife Fund's Global Lakes and Wetlands Database (GLWD)**
- **Any 4 km Pathfinder pixel whose area is 50% or more covered by lake | river = LAKE | RIVER**
- **Consistent set across multiple resolutions**

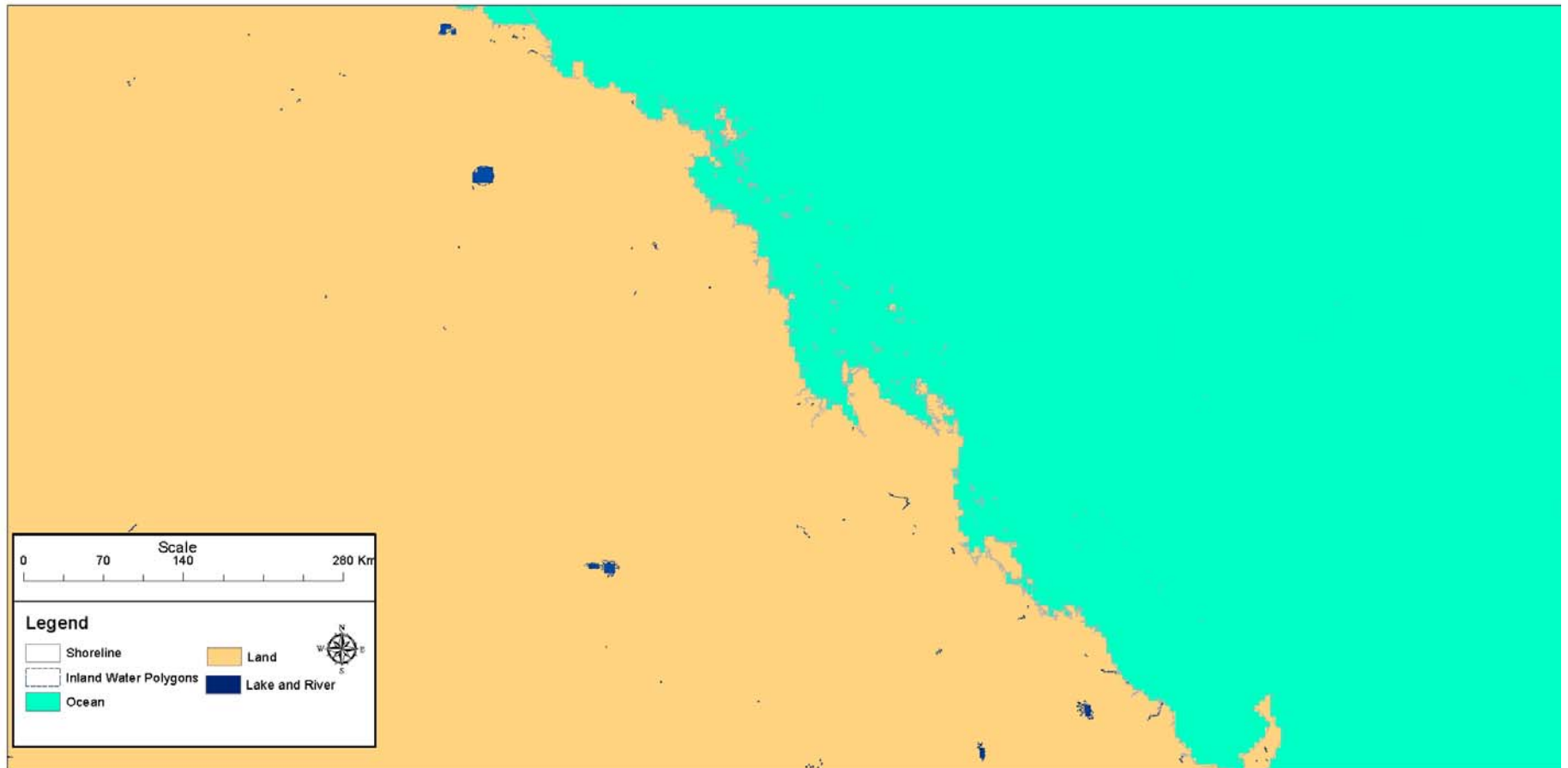
# PFV5.2 Land mask built from ground up!



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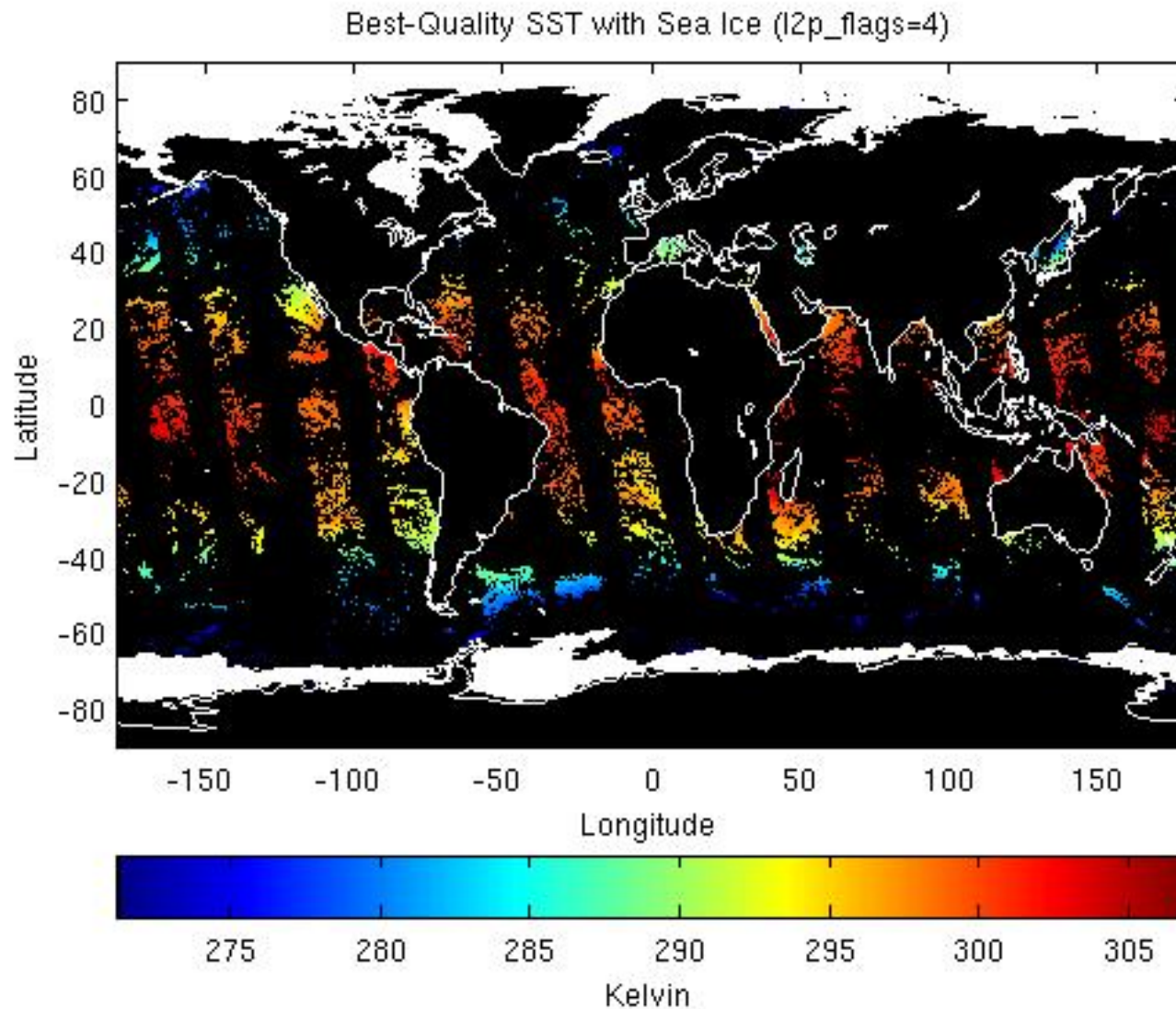


# PFV5.2 corrects “18-line” problem

- **Error was revealed in persistent SST frontal analyses, showing false fronts every 18-lines**
- **New grid eliminates round-off error problem in old Pathfinder grid**
- **8640 x 4320 (was 8192 x 4096)**



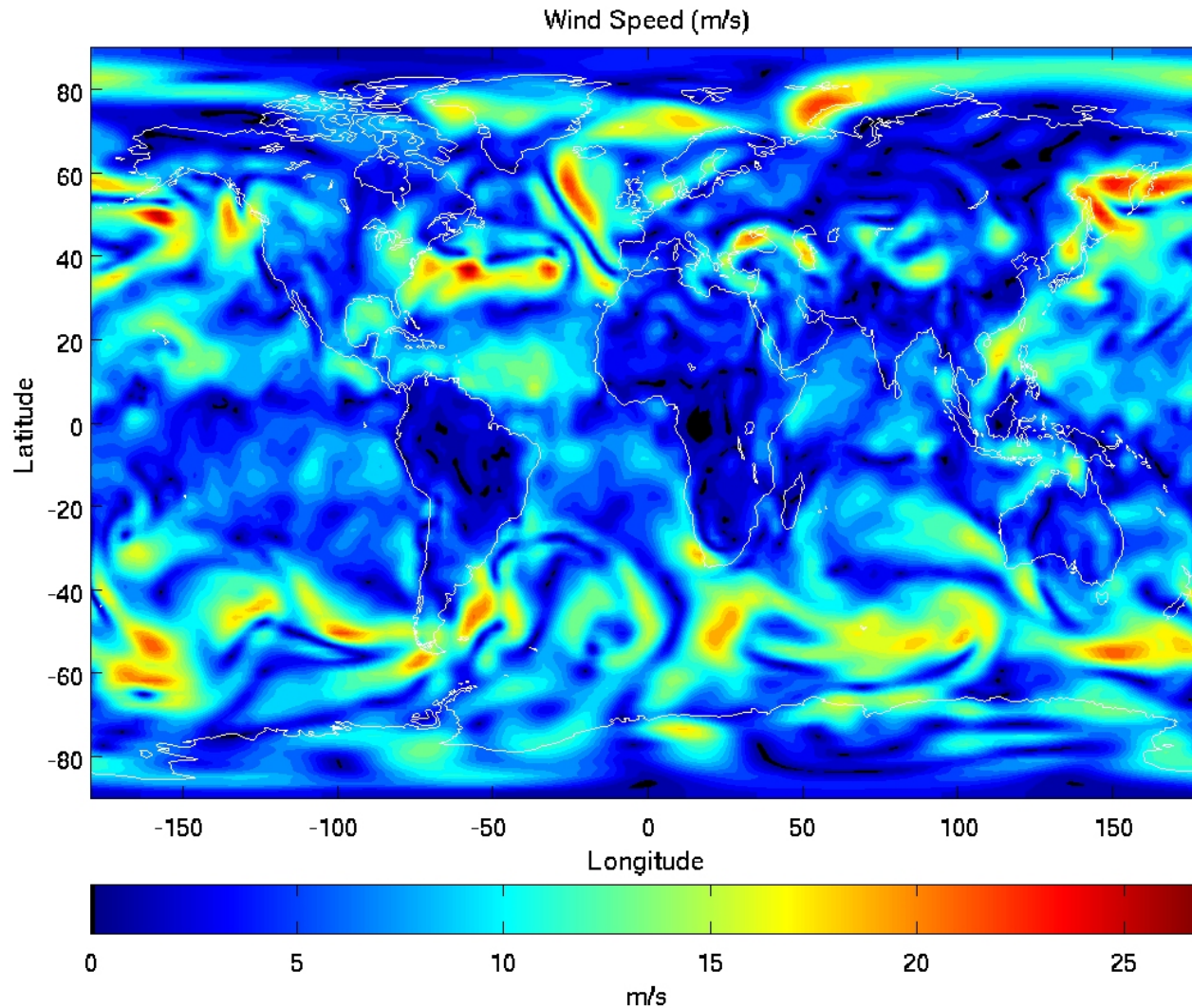
# PFV5.2 in GHRSSST GDS2 \*



netCDF-  
4  
(classic  
data  
model)

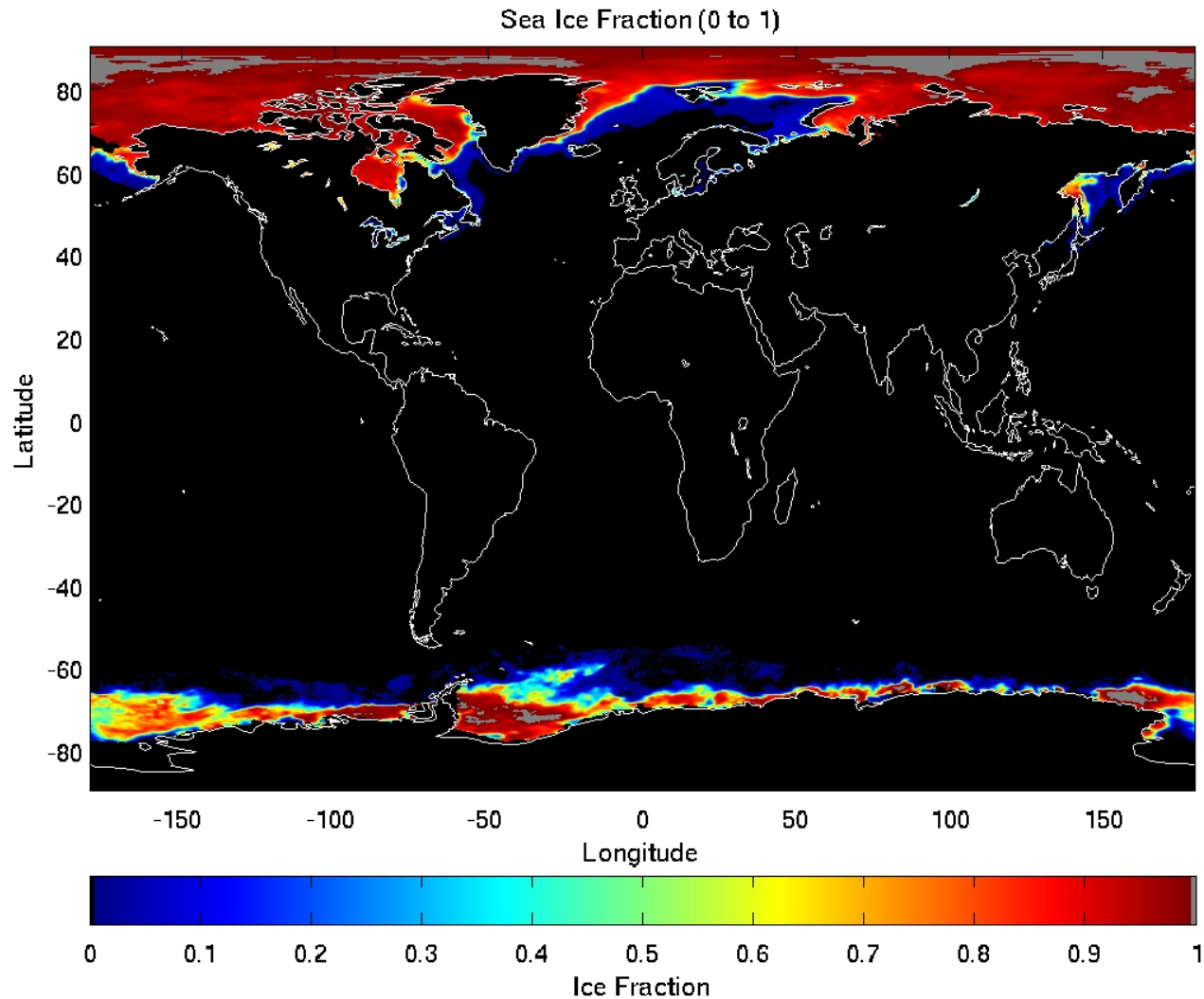
Empty sst\_dtime, sses\_bias, sses\_standard\_deviation; Missing aerosol\_dynamic\_indicato

# PFV5.2 Includes Wind Speed



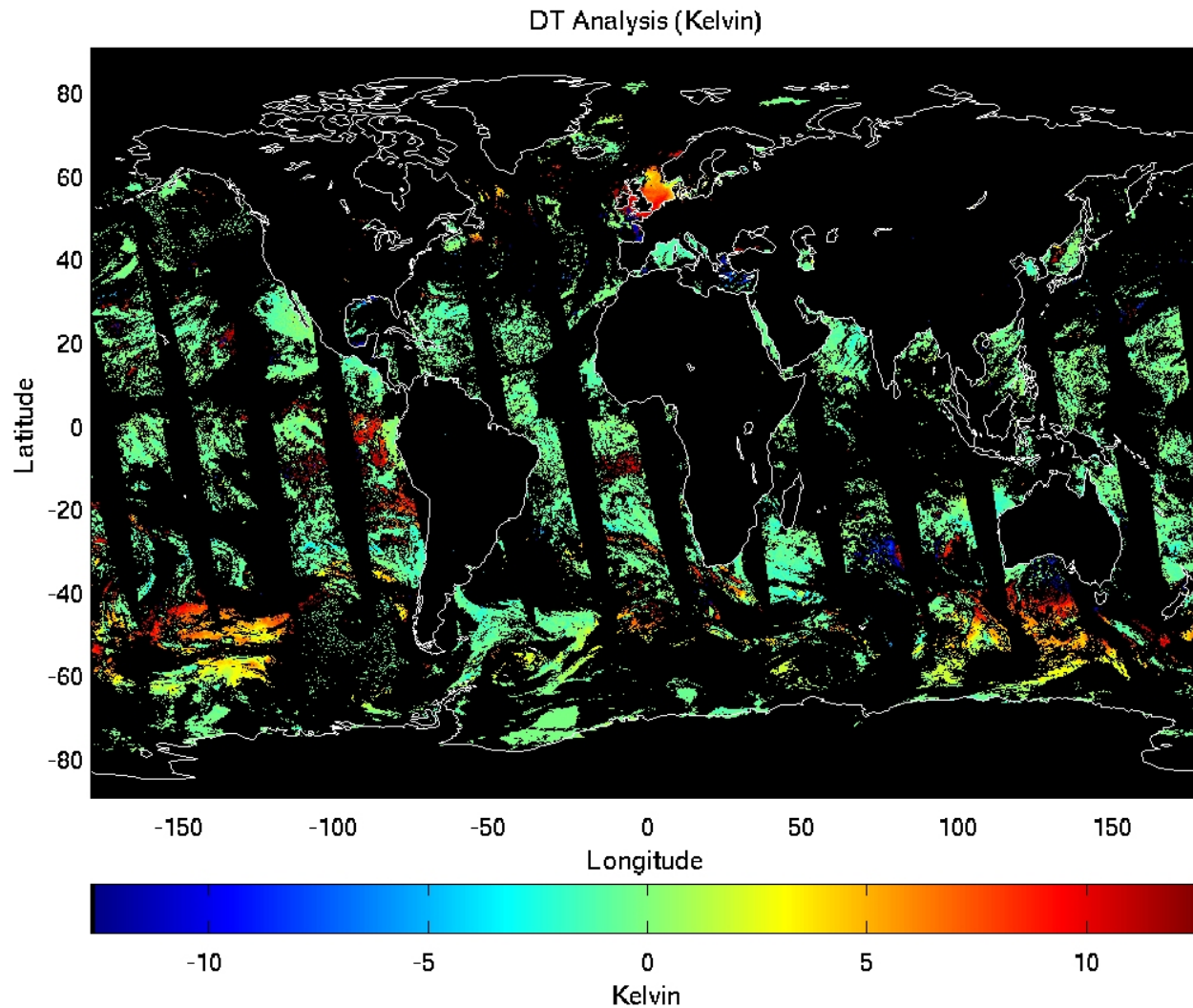
NCEP/DOE AMIP-11 Reanalysis-2 Winds

# PFV5.2 Includes Sea Ice Fraction



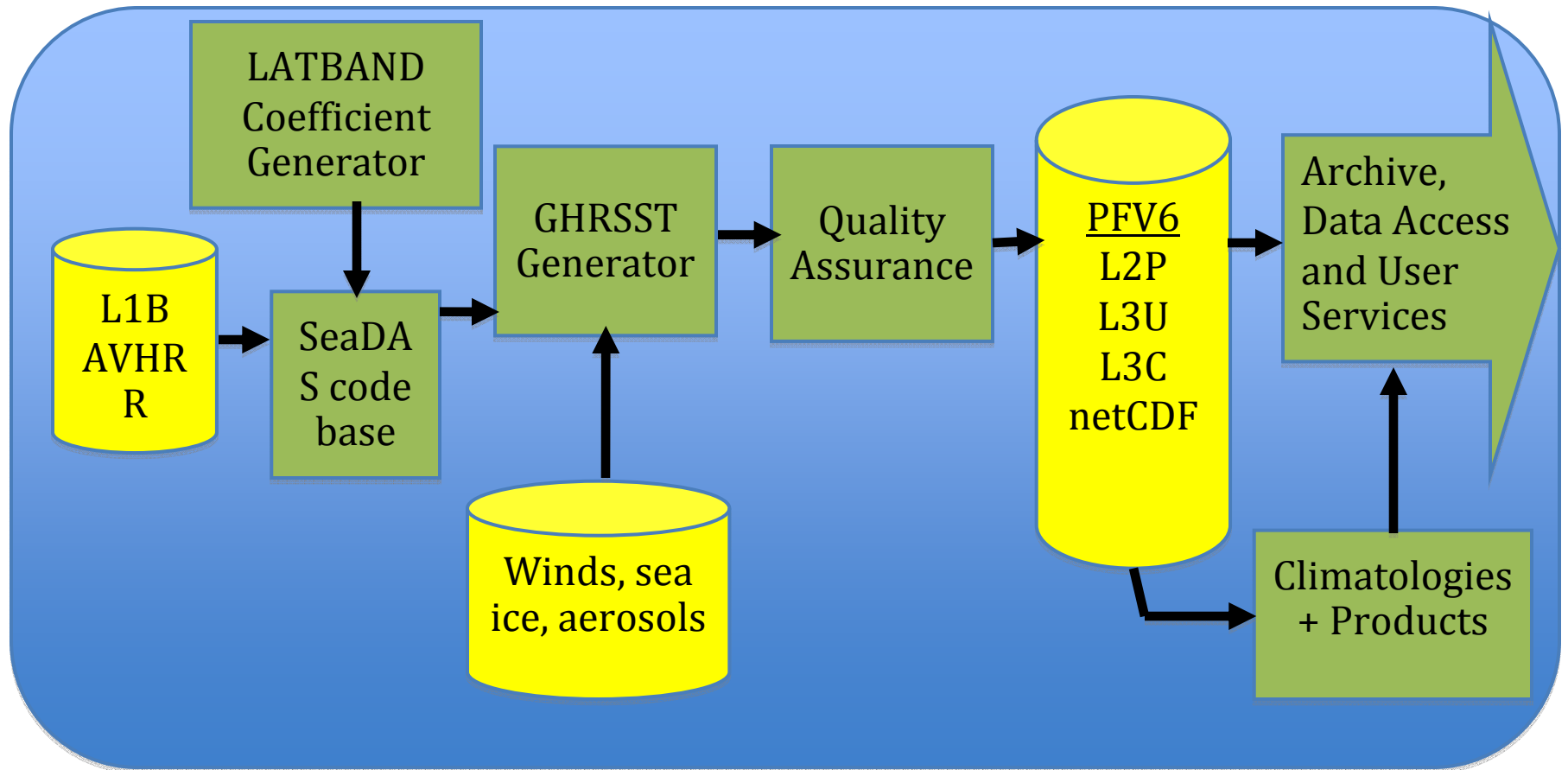
OSISAF Global Daily Sea Ice Concentration

# PFV5.2 Includes *dt\_analysis*



NCDC Daily OISST (AVHRR\_OI)

# PFV6 Workflow Overview



Much progress on PFV6...

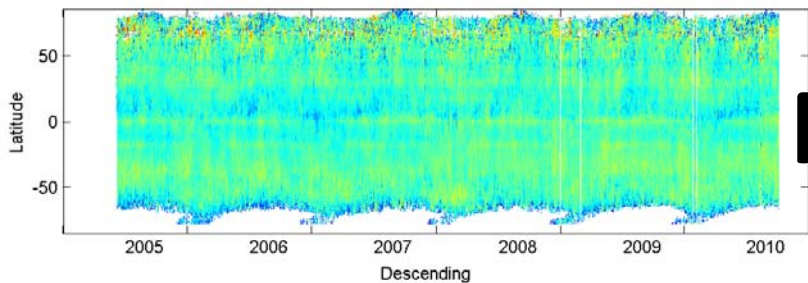
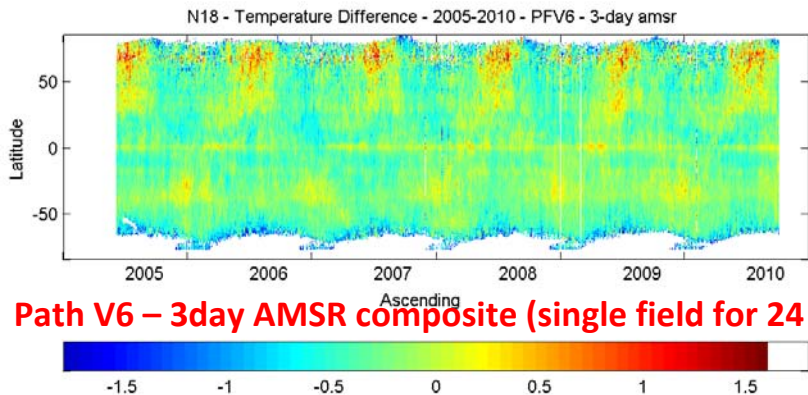
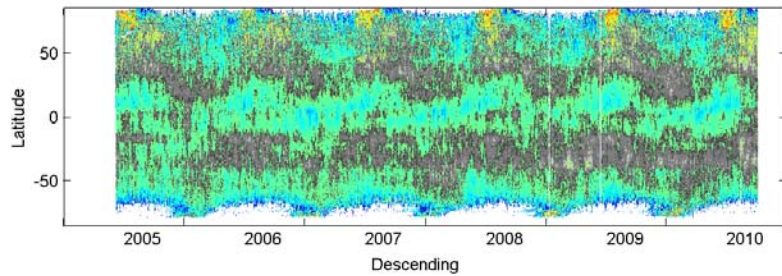
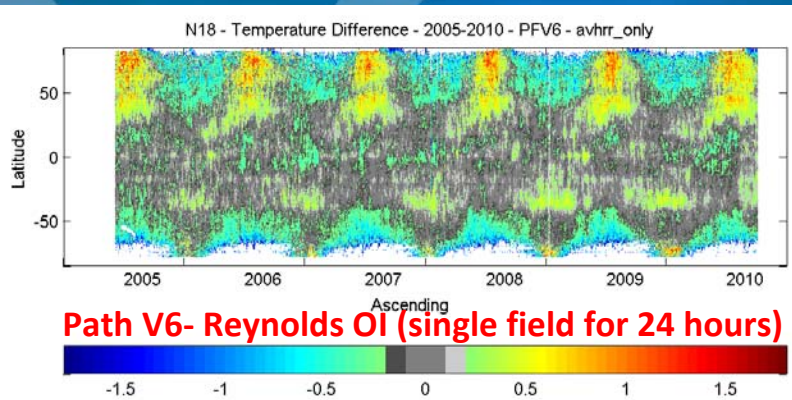
# PFV6: Reference Field Experiments

- Five different reference fields tested
- Richard Reynolds provided 3 versions of the  $\frac{1}{4}$  degree, daily V2 OI
  - OI + AVHRR (from NAVO, day + night satellite data)
  - OI + AVHRR + AMSR (day + night satellite data)
  - OI + AVHRR + AMSR (night only satellite data, minimize possible impact of residual diurnal warming)
- 3 Day AMSR composite (day + night), daily,  $\frac{1}{4}$  degree field (RSS)
- AATSR (night only), based on 0.1 degree night only, 3 channel, dual view product (processing version: May, 2010)
  - R . Reynolds processed AATSR daily fields into monthly,  $\frac{1}{4}$  degree maps to fill gaps due to combination of narrow swath and cloudy observing conditions

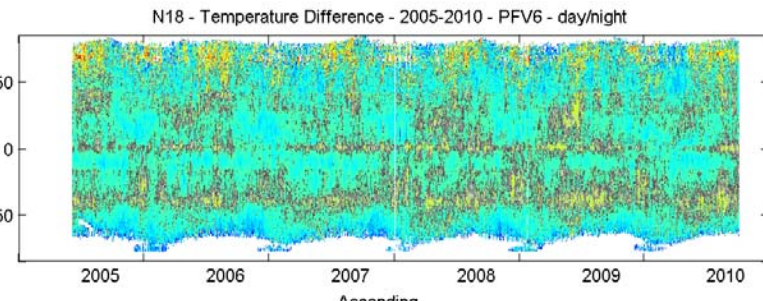
# Impact of diurnal warming on comparison to reference fields

Differences larger when a single reference field is used for both day and night satellite fields

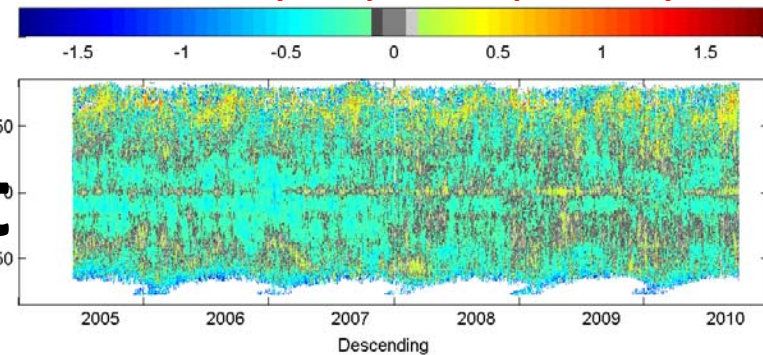
Differences smaller when reference field is temporally matched to satellite observation time



Day



Path V6 - AMSR 3 day composite, separate day and night



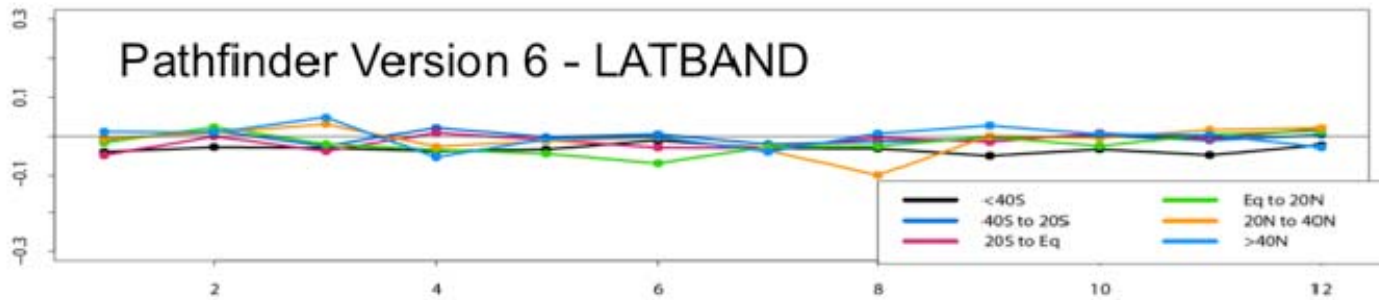
Night

# Buoy Comparison for PFV5.2 and 6

## Application of LATBAND to NOAA-18

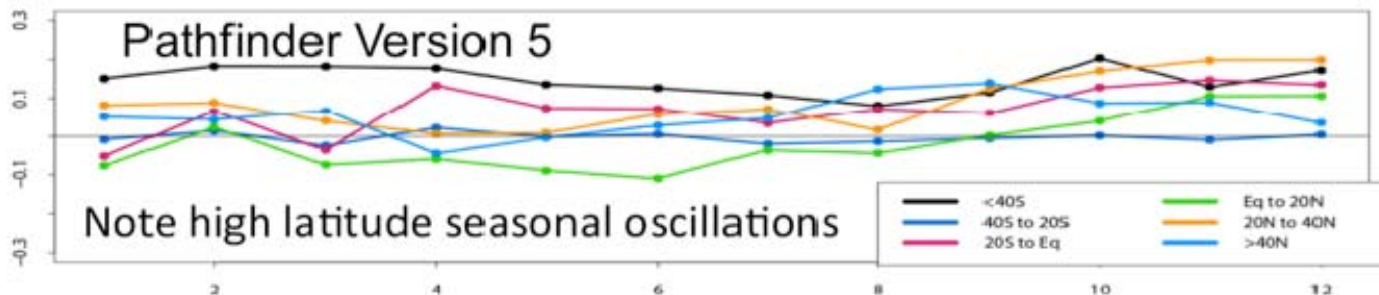
Medium of Residuals  
 +/- 0.3 K

NO18 – Latband1 SST Median of Residuals



Latband implementation removes seasonal residual oscillations

NO18 – Latband1 SST Median of Residuals

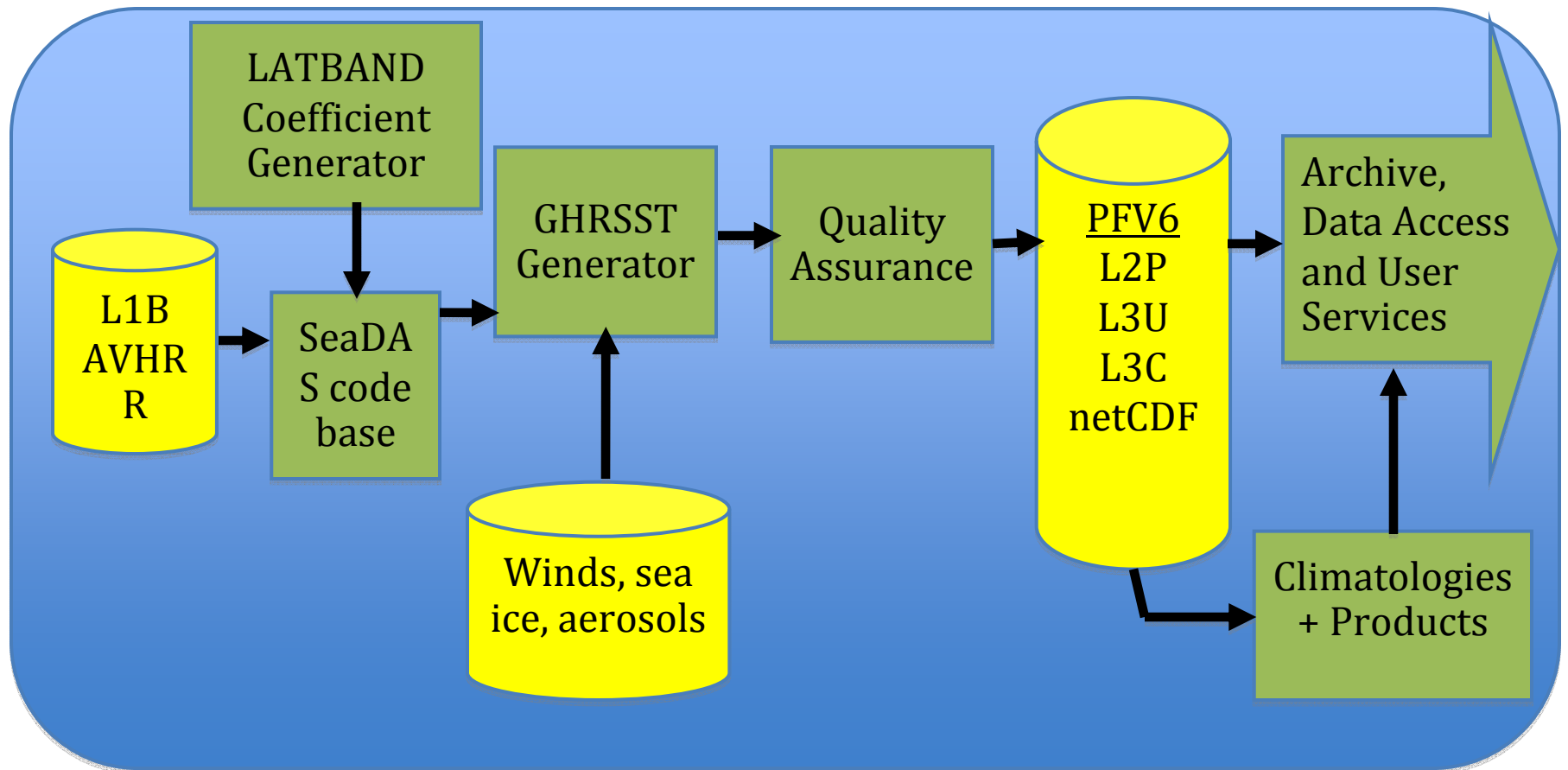


Summary statistics for SST residuals, NOAA-18. (11-12 $\mu$ m bands)

Pathfinder Algorithm	Median	Mean	StdDev
Validation LATBAND (skin)	-0.178	-0.198	0.37
Validation Pathfinder V5	-0.093	-0.115	0.39



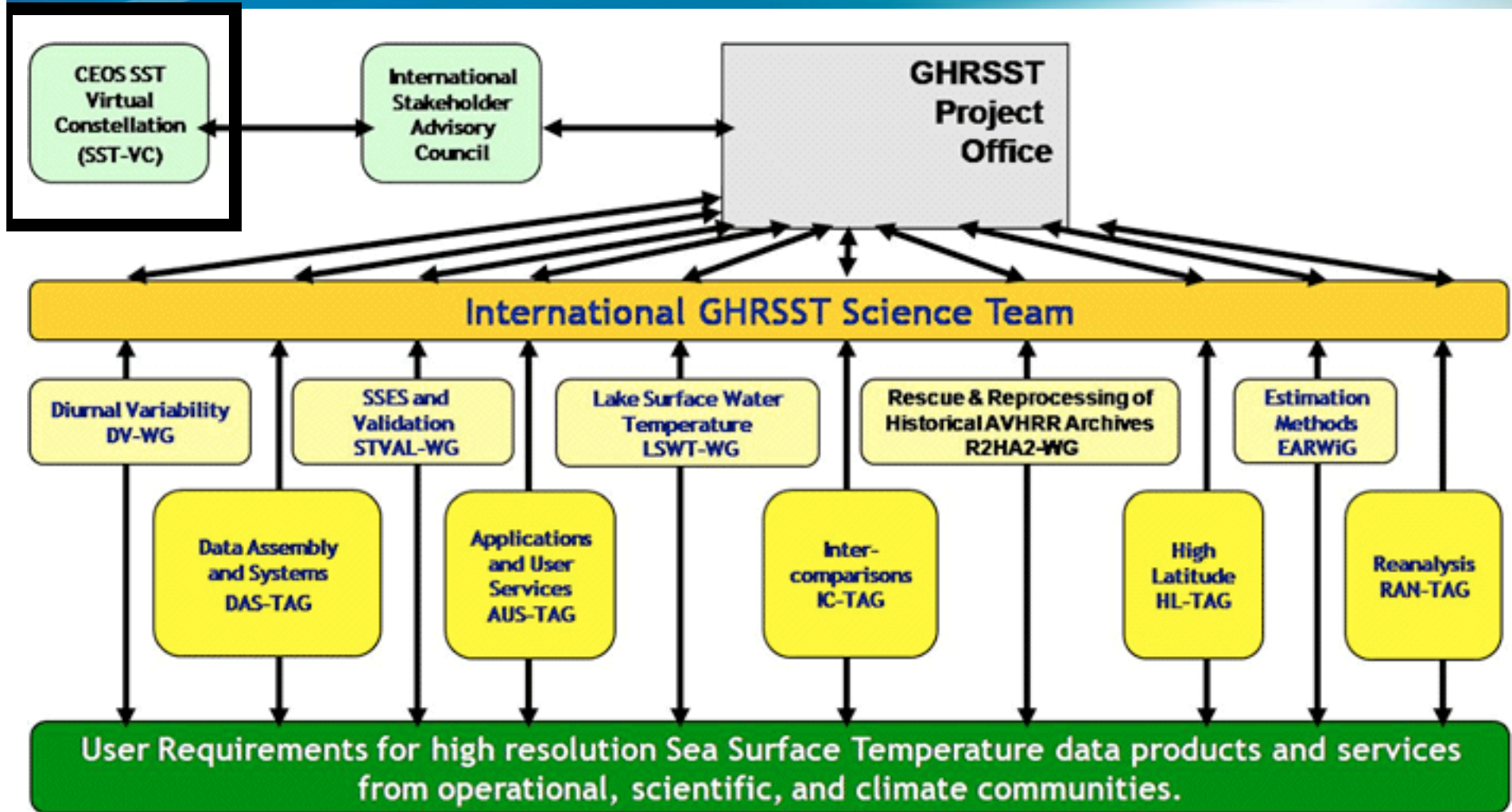
# PFV6 Workflow Overview



...but completion of PFV6 is in jeopardy ☹

Remaining issues include GDS-compliant time stamps and coefficient generation for all satellite

# CEOS Virtual Constellation for SST



Coordination matures... Formal connection with CEOS



**Thank-You!**  
**Questions?**