Oceanic Variability and Trends - Toward a System to know the World Ocean

D.E. Harrison

Ocean Observations Panel for Climate

(GOOS, GCOS, WCRP)

Gijon, Spain

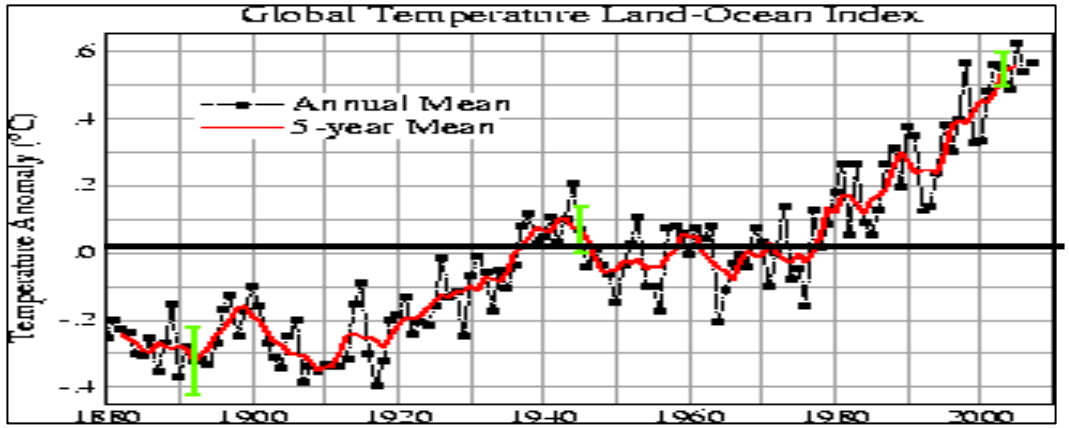
May 2008

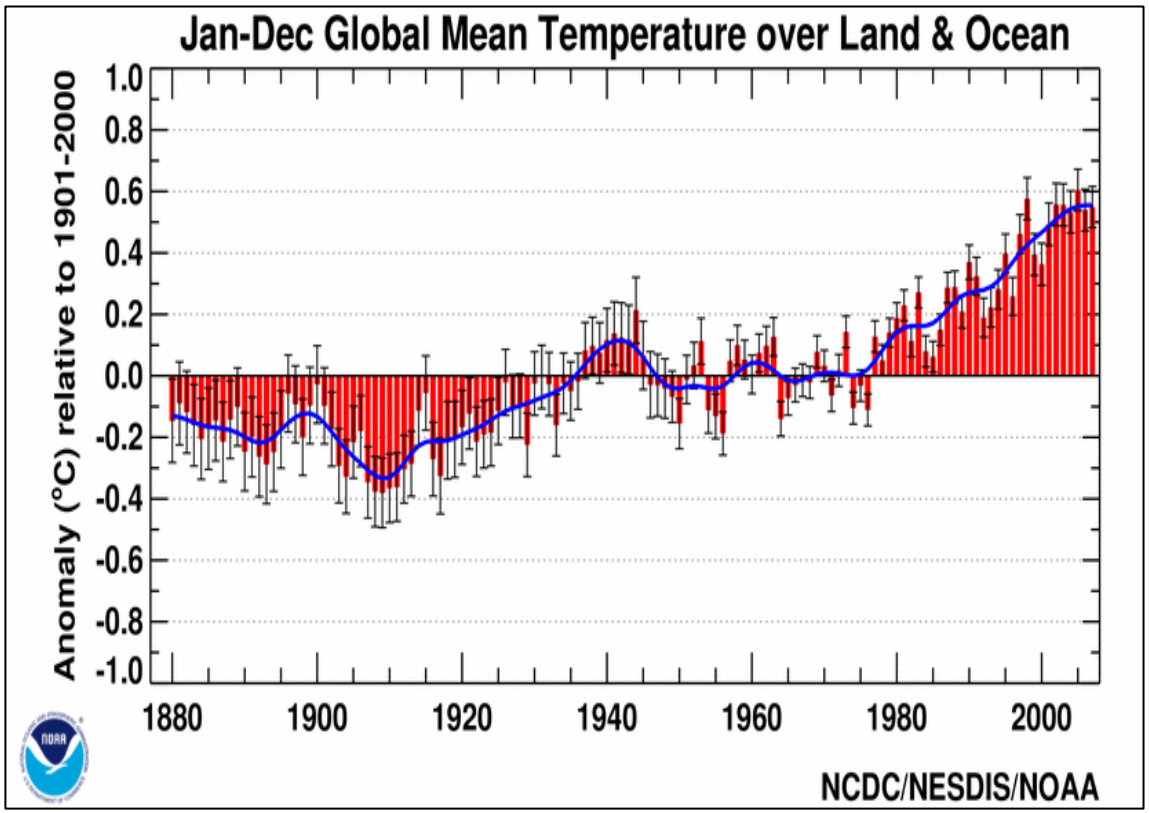
Outline

- Wanting to know the world ocean – past, trends, possible futures
- Toward a sustained oceanic observing system for society
- The present system
- Expanding the system as capabilities and capacity mature
- OceanObs2009 – agreeing a plan for the next decade

Sustained Accurate Observing Is Essential

- Our knowledge of even the planet's recent past is more uncertain than desirable, because have not had a climate observing system.
- We have to adjust/interpolate the historical obs in order to compute the quantities we care about.
- In fact, we still haven't got the system we need, but we are improving. At last we are starting to observe the ocean systematically.





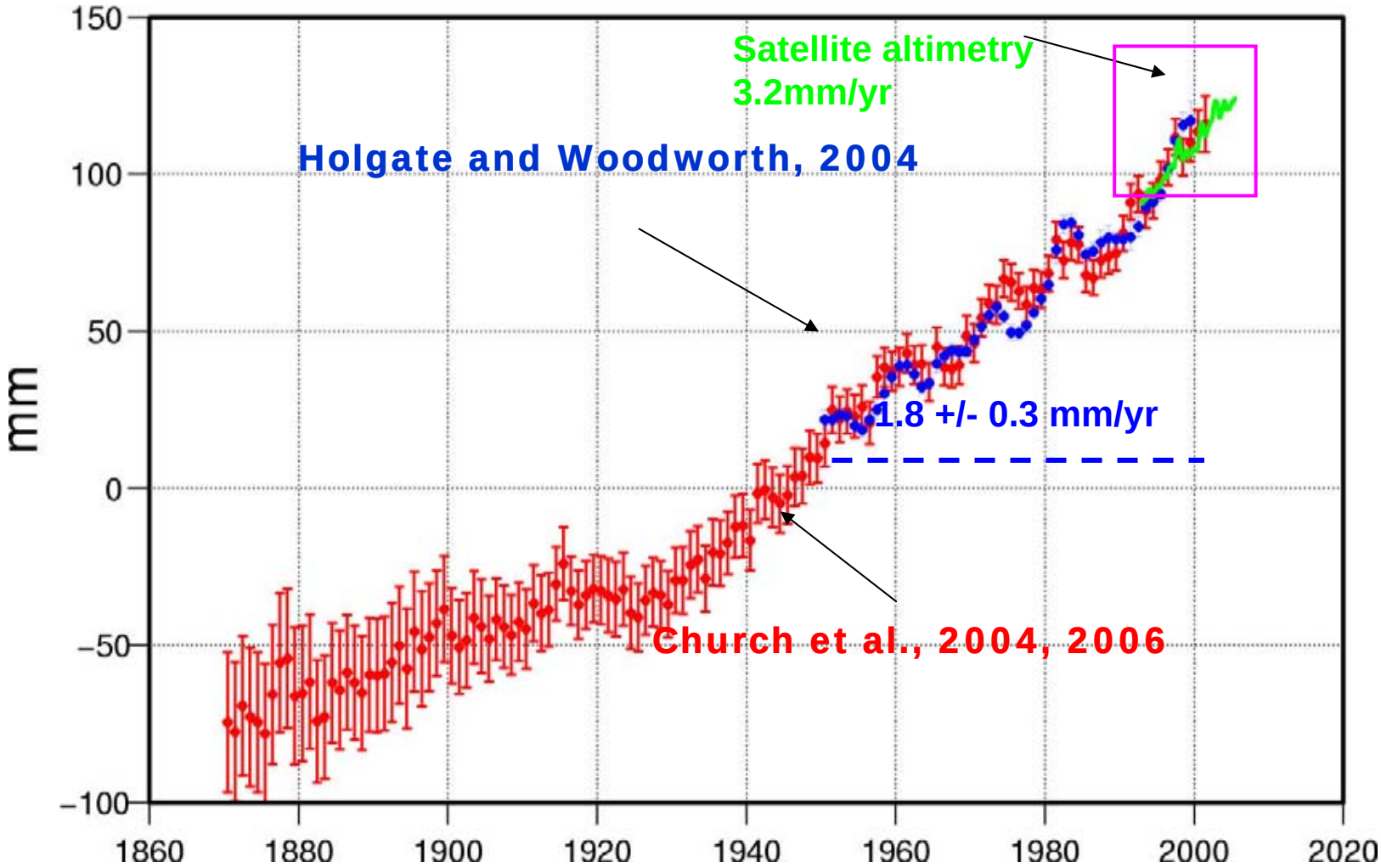
Estimated Global Mean Surface Temperature since 1880

We've had to adjust a lot of numbers, due to shortcomings of the historical obs, to make these plots.

There remain observing system challenges for Ts even now.

20th century sea level rise
Is trend increasing?

Lots of decadal variability. Need to keep precision altimeters flying.

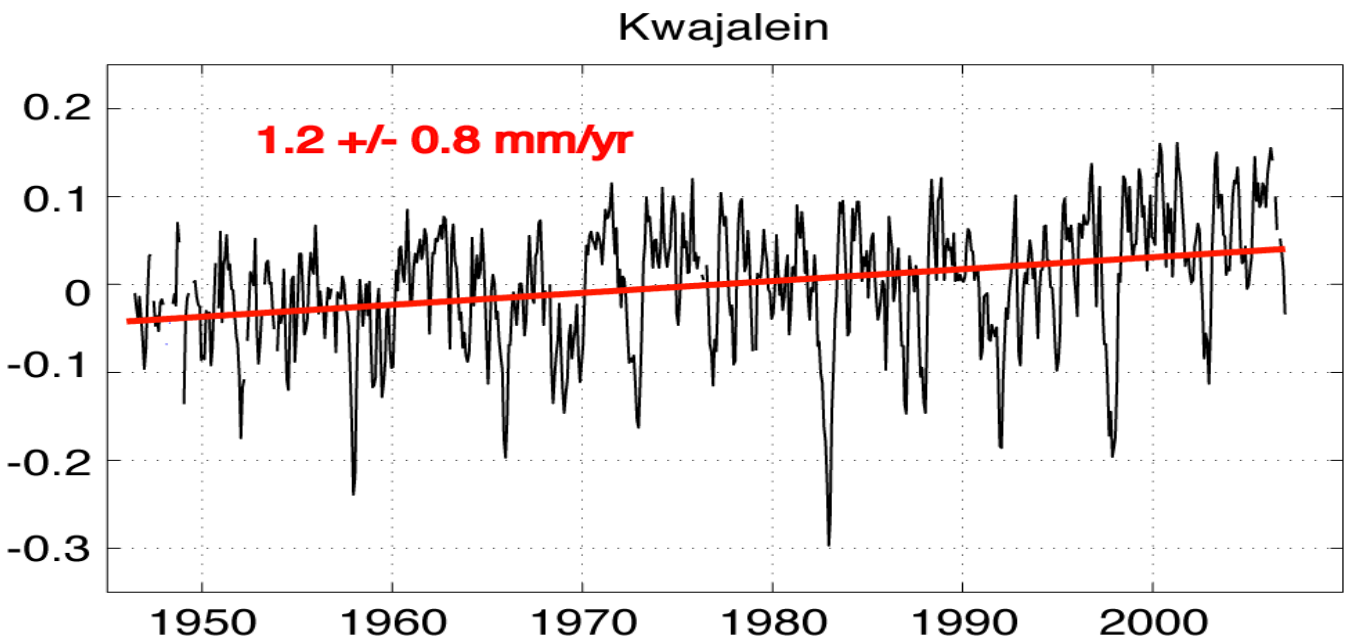


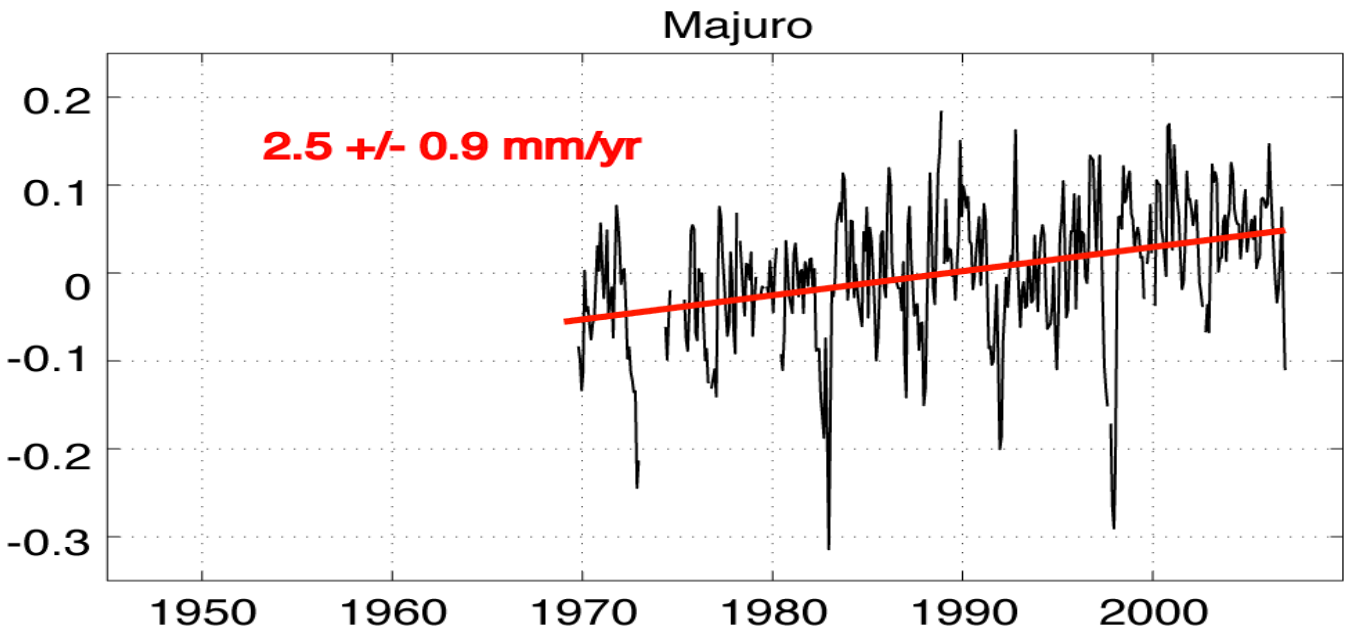
Also need better local info!

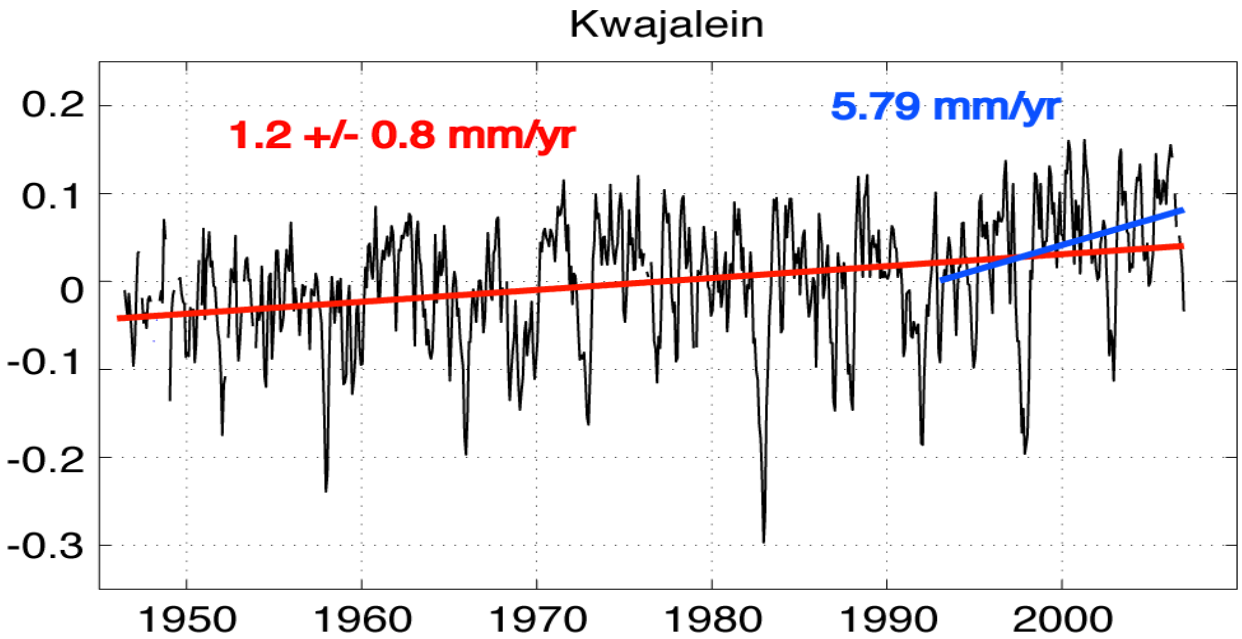
Next Slides on
Marshall Is. Sea Level
are from

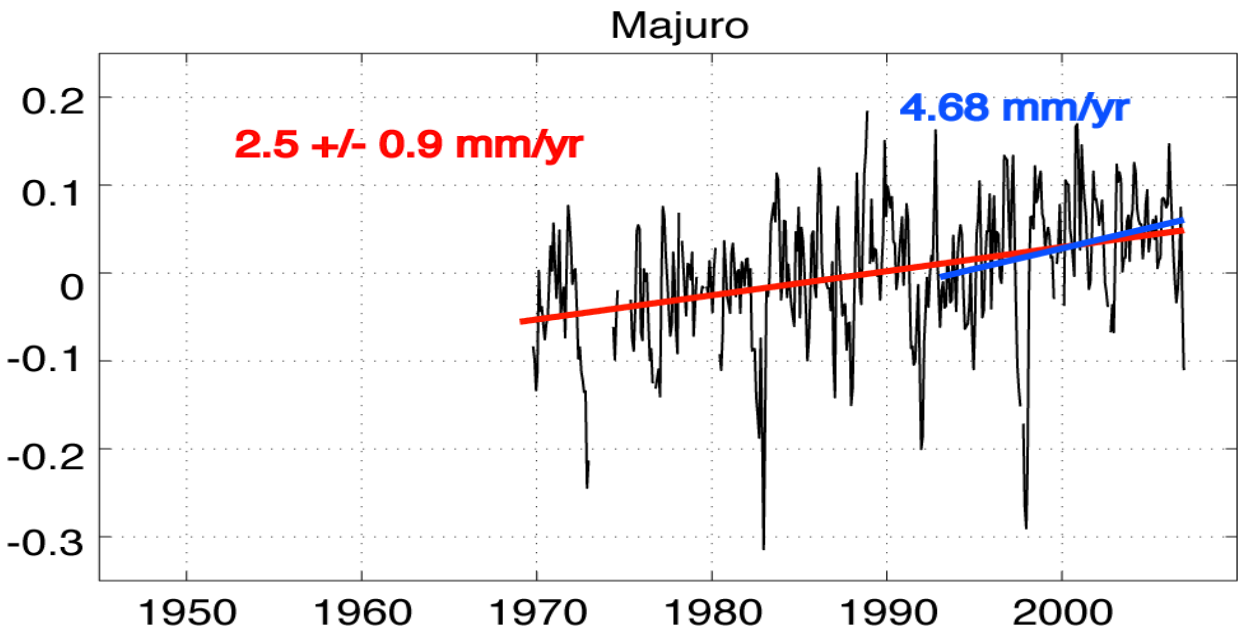
Mark Merrifield

Univ. Hawaii, Manoa


Kwajalein
1.2 +/- 0.8 mm/yr
0.2
0.1
0
-0.1
-0.2
-0.3
1950
1960
1970
1980
1990
2000


Majuro
2.5 +/- 0.9 mm/yr
0.2
0.1
0
-0.1
-0.2
-0.3
1950
1960
1970
1980
1990
2000





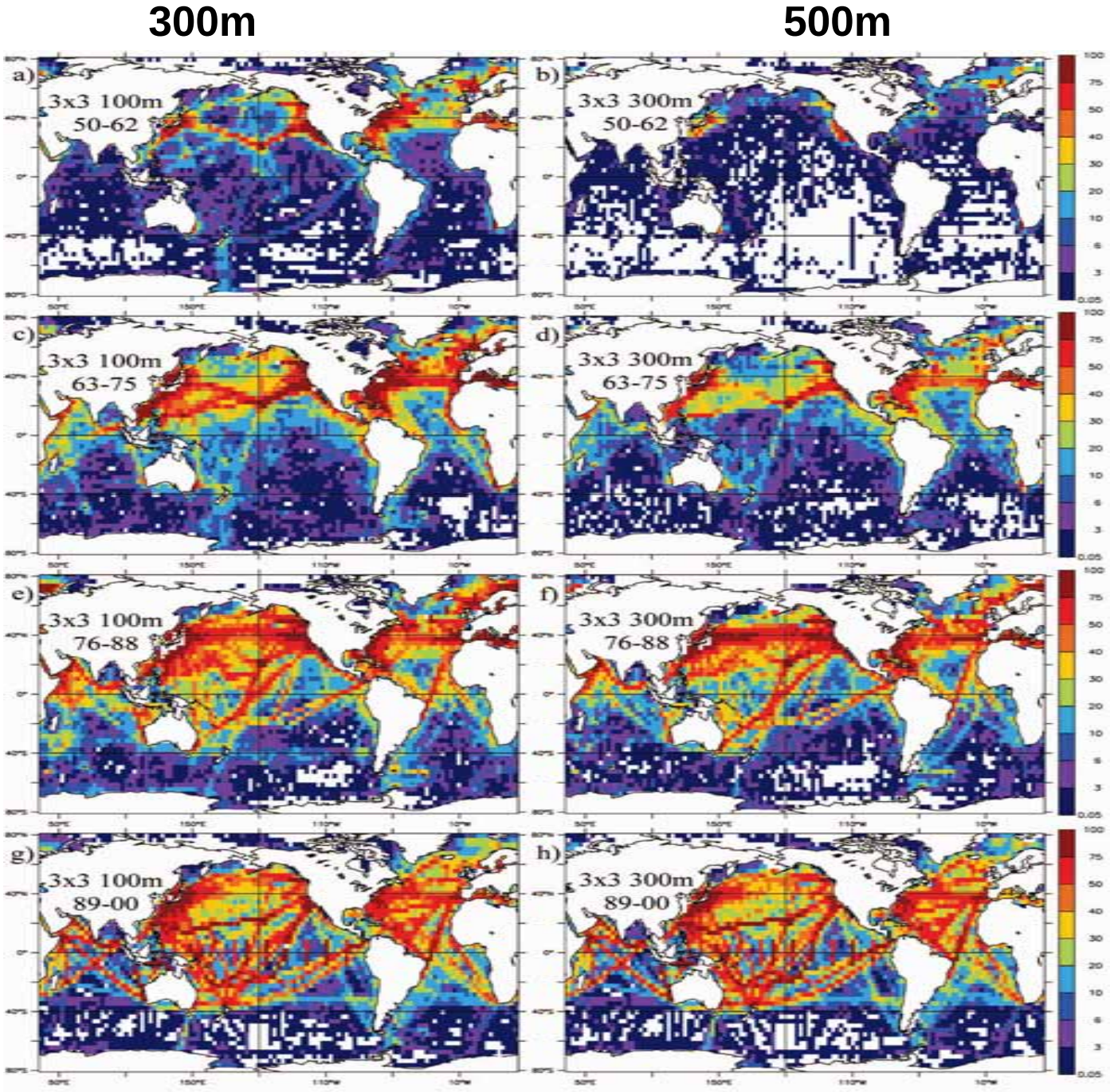
Mark notes:

Altimeter-era larger trends are similar in amplitude to those over some earlier periods

Lots of interannual and decadal variability

Ocean Subsurface poses big challenges

- The historical data record even for upper ocean temperature is very uneven.
- Different sensors used
- Very uneven sampling of World Ocean
- Lots of variability in regional and multi-decadal trends
- Not straightford to make confident uncertainty estimates of world ocean averages.



Temp Data Distributions since 1950.

1950-62

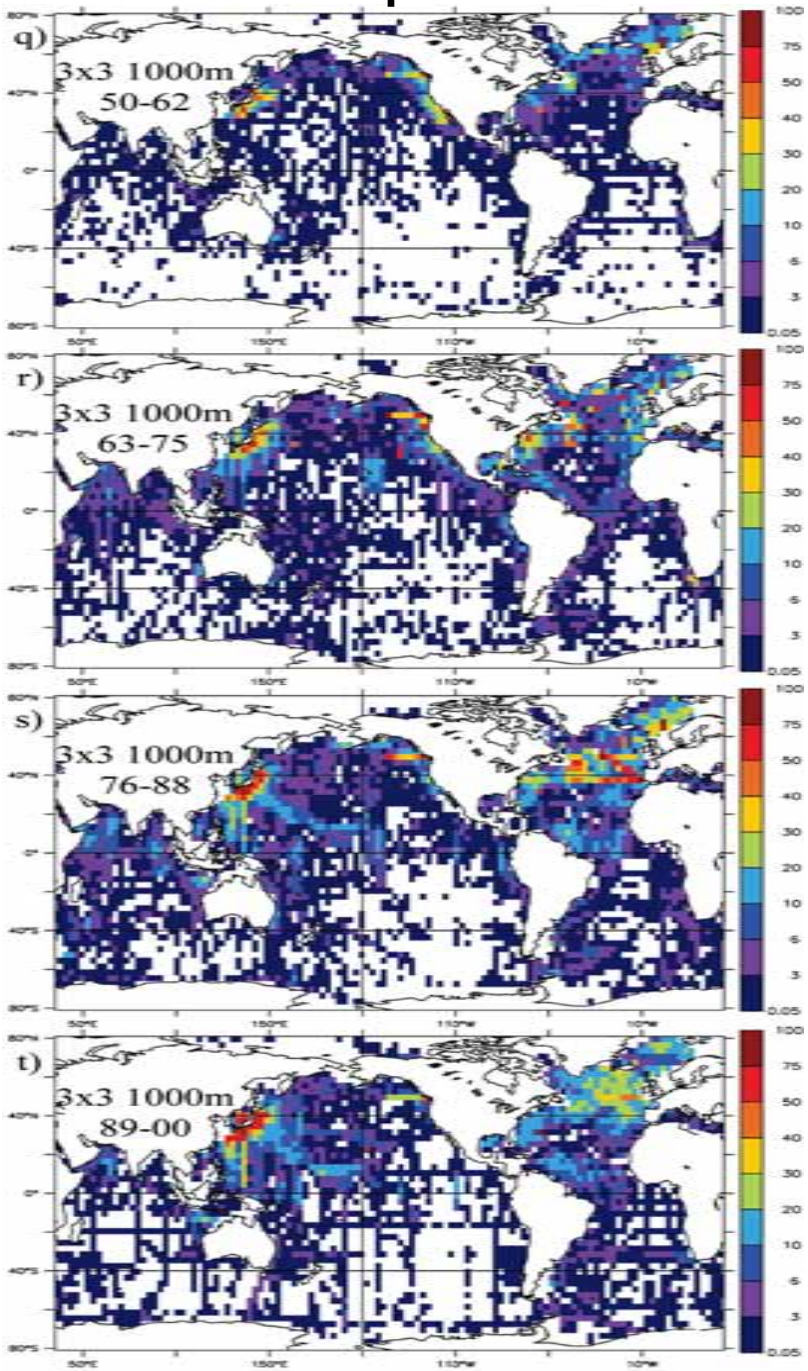
1963-75

1976-88

1989-00

Blue colors mean fewer than 20% of months had any obs.

1000m depth



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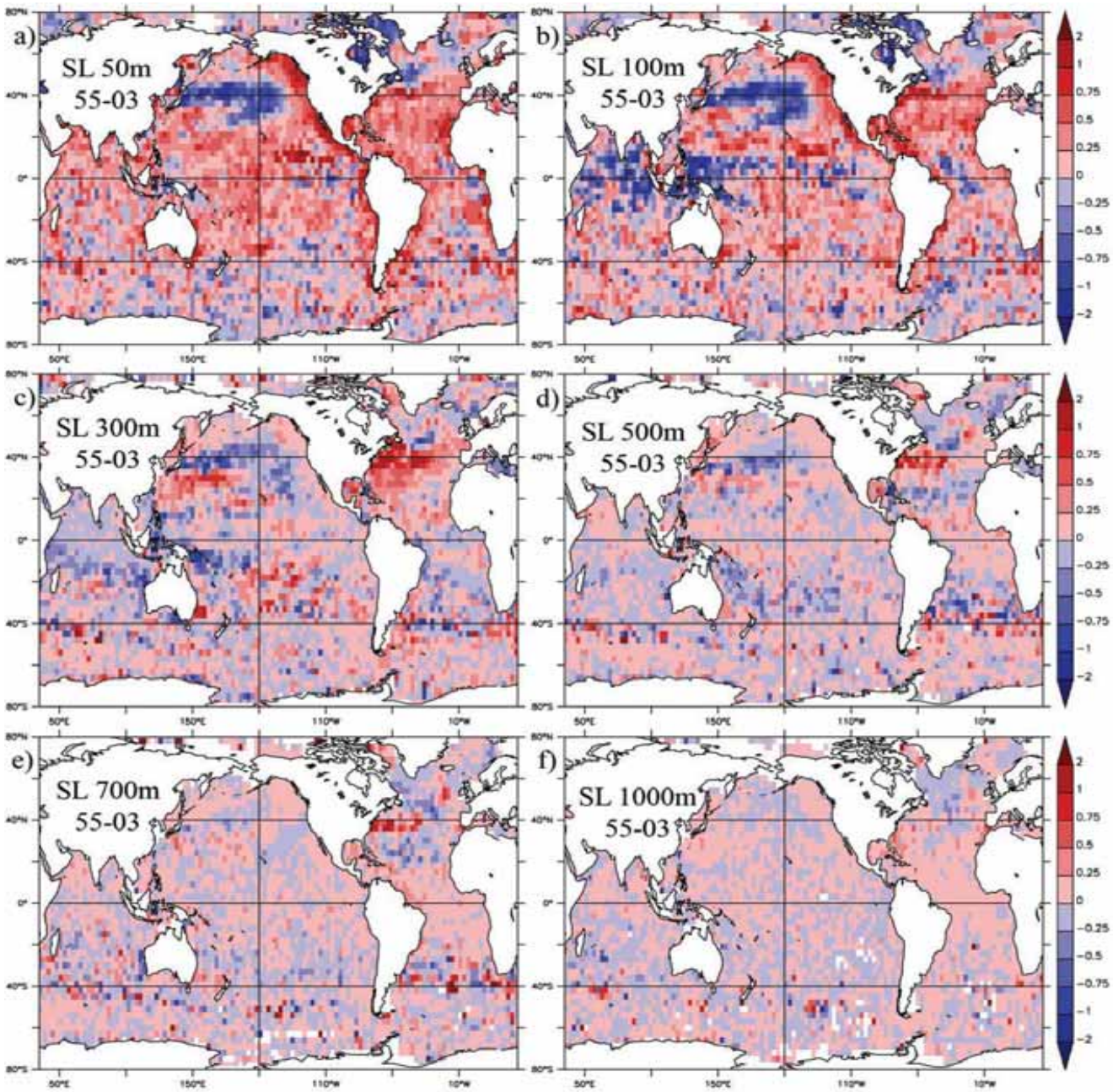
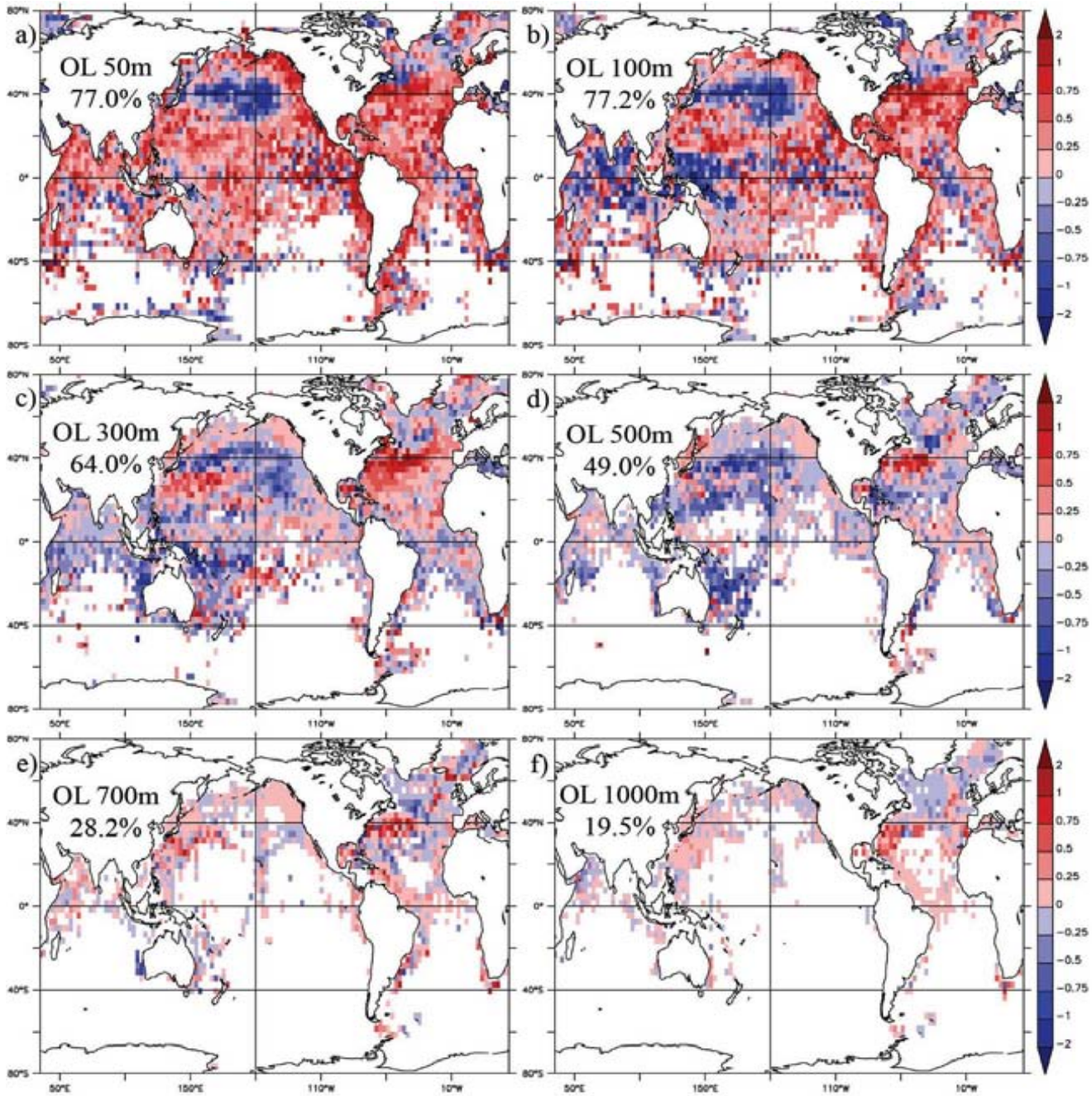


"50Yr" temp trends from WOD05

"Standard Level" Analysis

Much of ocean very poorly sampled

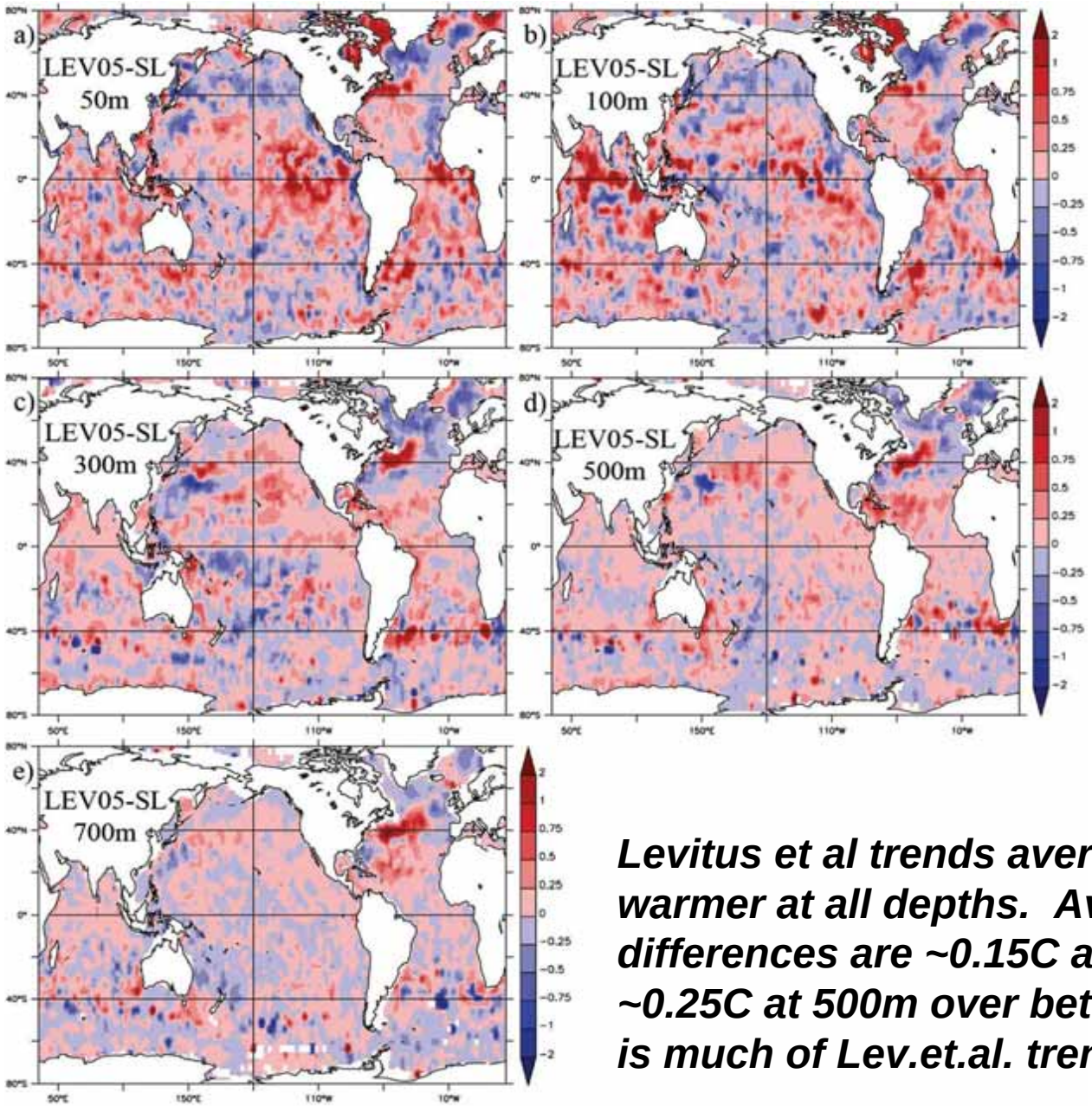
Carson & Harrison 2008



"50Yr" Temp Trends from WOD05

Delta Temp shown for boxes with at least 3obs/decade for 4/5 decades

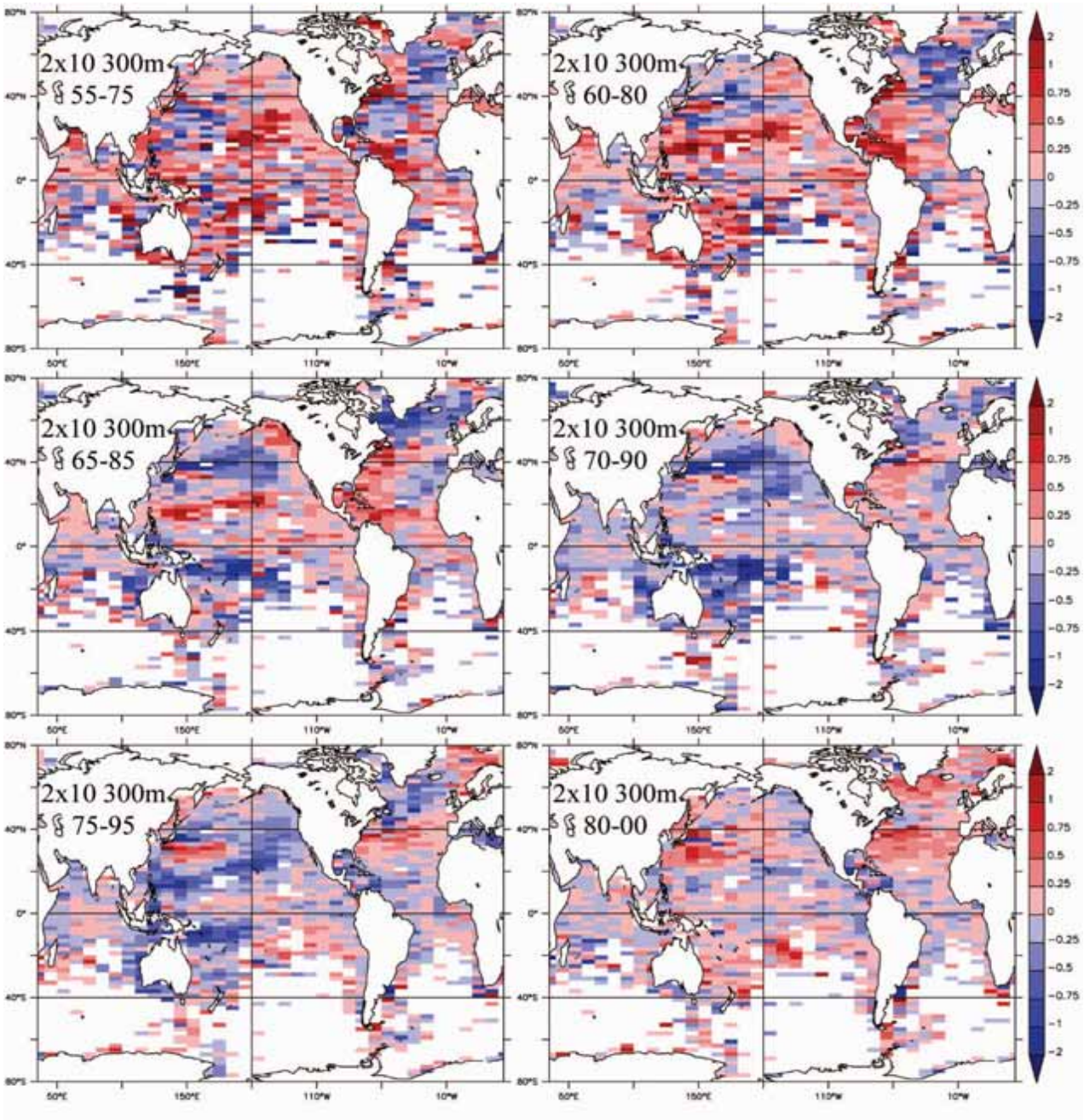
Look how little of the ocean has been observed even to this weak standard!



Difference in "50Yr" Temp Trends

Levitus et al (2005) minus Carson and Harrison (08)

Levitus et al trends averaged over basins are warmer at all depths. Ave. temperature differences are ~0.15C at upper depths and ~0.25C at 500m over better-data regions. This is much of Lev.et.al. trend.



Running 20yr Temp Trends at 300m

55-75, 60-80

65-85, 70-90

75-95, 80-00

Red – warming

Blue – cooling

95% of regions change sign

Harrison & Carson 07 JPO

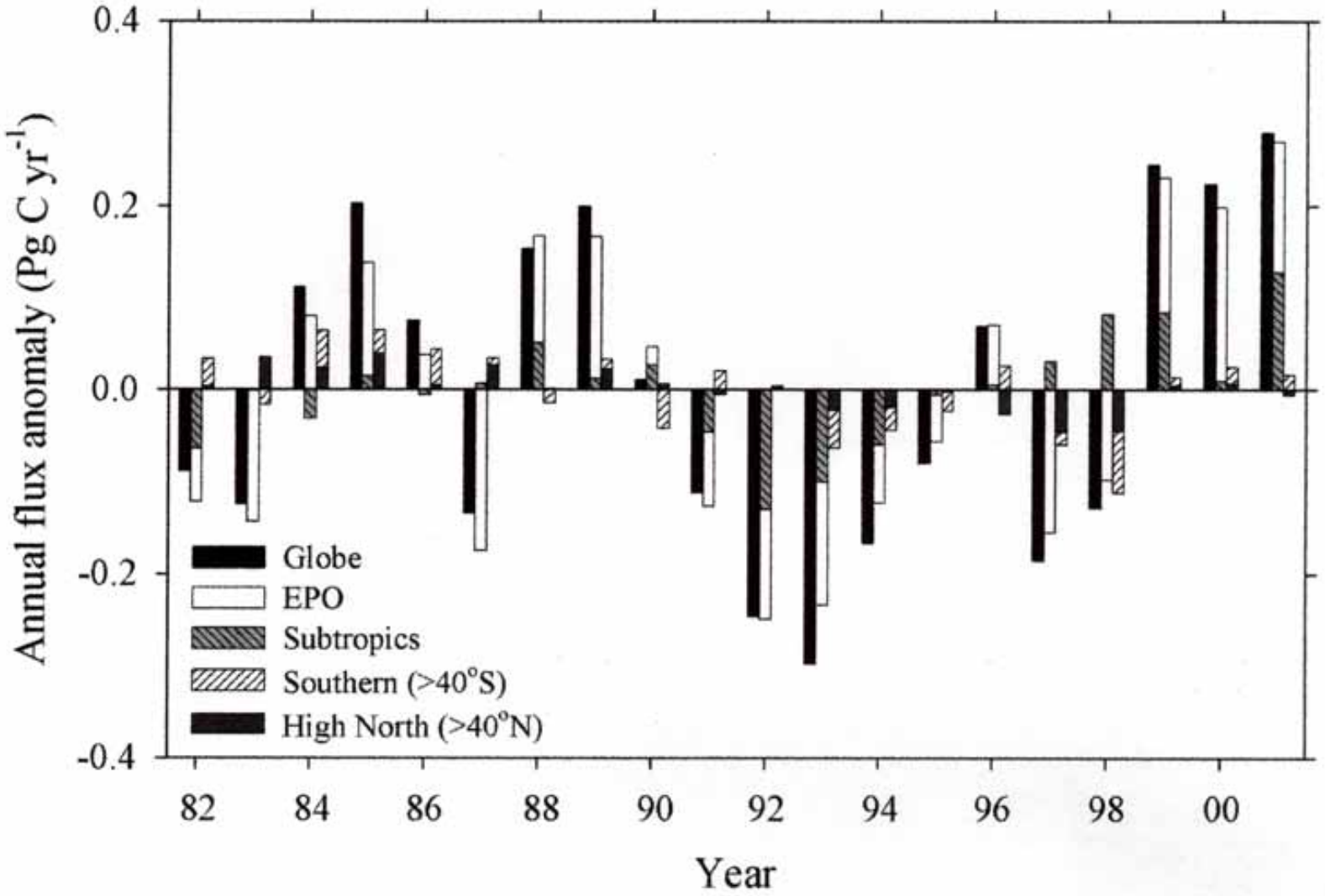
The non-physical marine world varies a lot, too

- One example here from Dick Feely on estimated air-sea carbon flux over 15 years.
- Cannot estimate long term trend even from this long a record.
- We need to build long records!

Air-Sea Carbon Flux variability (est.)

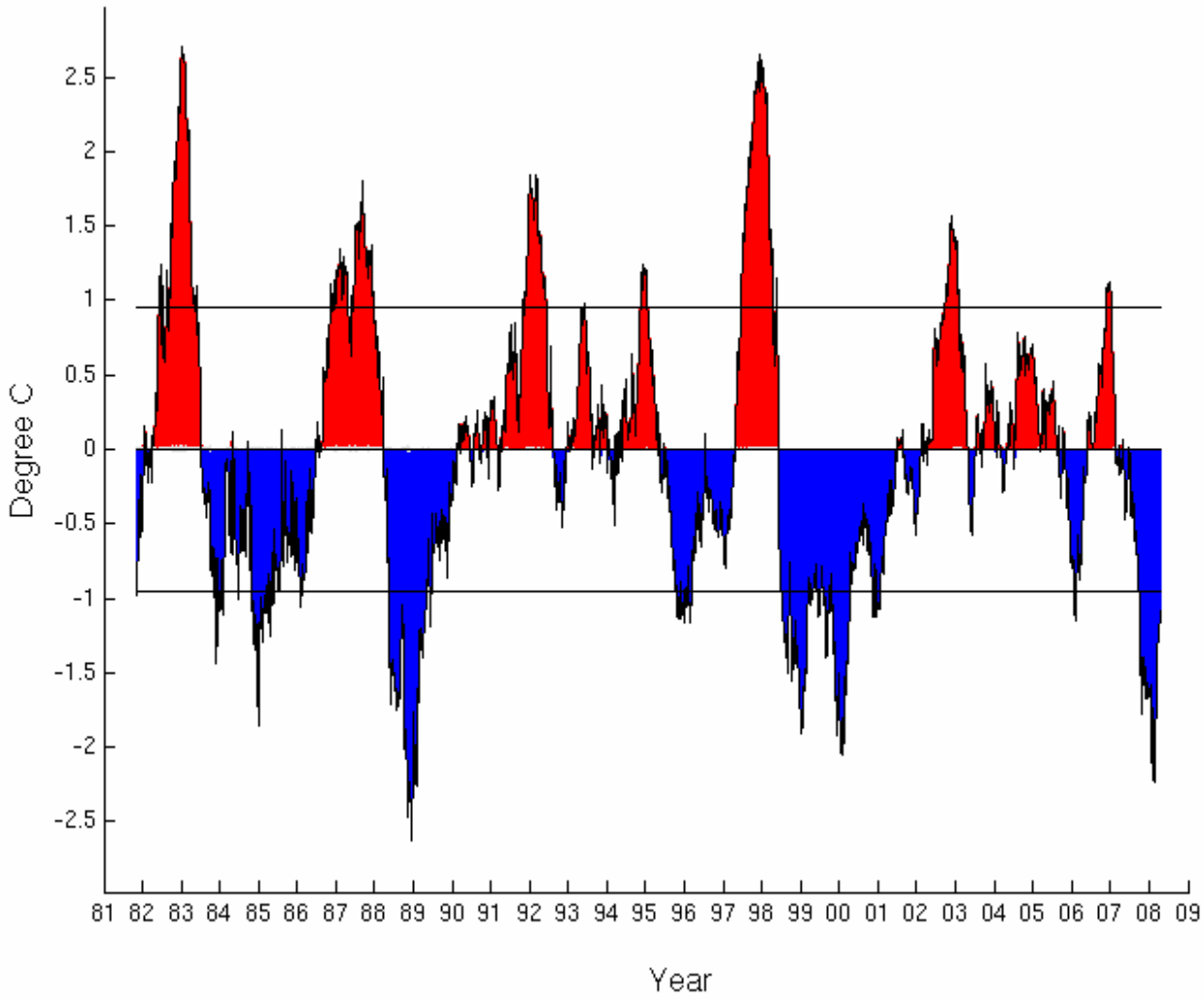
w. time and region of ocean (Feely, pers comm)

Is Ocean Carbon Uptake Changing?



Ocean Information from Observations

- Forecasting the ENSO state of the equatorial Pacific has been a societal priority since the 80s
- ENSO Observing System implemented to support science and forecasting
- We have been learning a lot, but it's still a challenge.
- Are we missing key observations?
- Or is it the models? Or both?



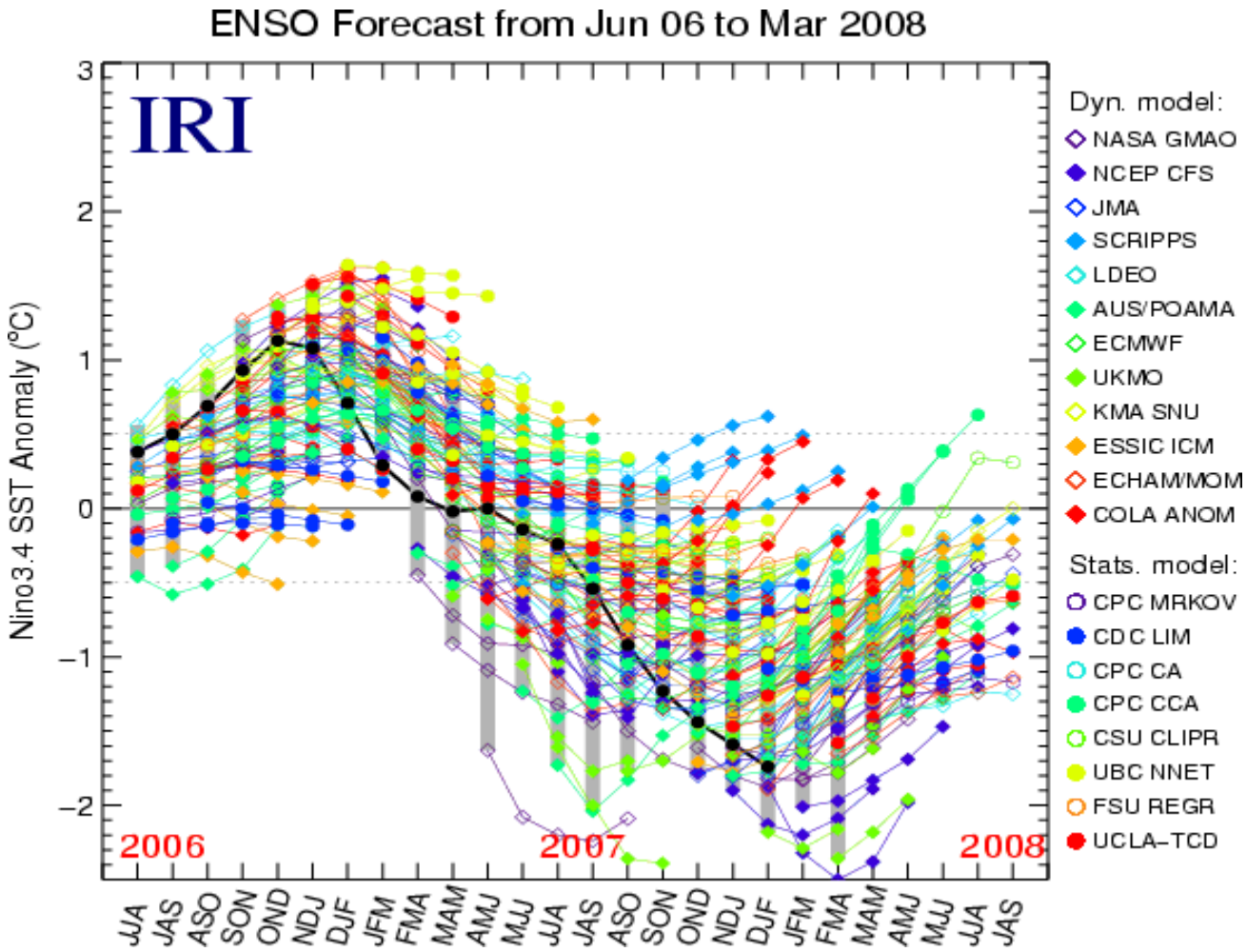
Major La Nina Event in 2007

At least everyone now can know this time series, week by week.

That's progress!

But how well did we forecast it?

This is "NINO3.4" SSTA, from central Equatorial Pacific

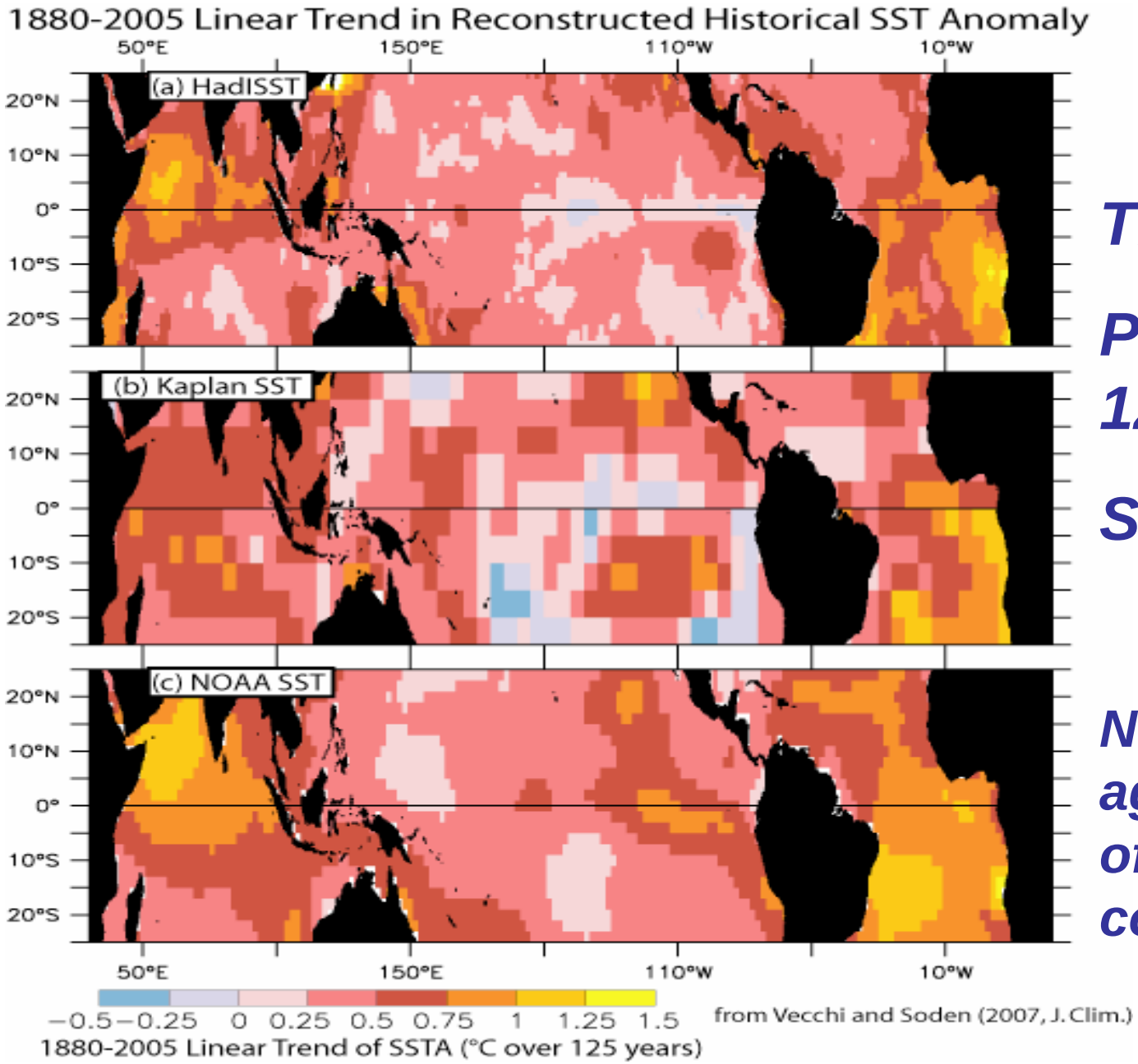


Forecasting is hard…

Major La Nina event in 2007 was not forecast at end of 2006

Now the question is:

Will it continue into 2008?



Tropical Pacific 125yr SST Trends

Note: do not agree on sign of change in cold tongue

A Global Observing System for Climate - 1

- Tropical Ocean-Global Atmosphere (TOGA) program developed ENSO observing system for ENSO science and forecasting
- World Ocean Circulation Experiment carried out a decade-long global hydrographic and carbon survey, building on previous less complete surveys.
- Research process studies and instrument R&D
- Major ocean satellite sensor development
- OceanObs1999 symposium proposed a way forward built on White Papers and community consensus

A Global Observing System for Climate - 2

- The UN Framework Convention on Climate Change asked the GCOS program to assess the Adequacy of present efforts to support needs for climate assessment, research and forecasting.
- Adequacy review was led by scientific community. Many shortcomings were identified; Implementation Plan was requested and written. Approved in 2004 (GCOS-92)
- GCOS-92 also taken up in 10-year Work Plan of the Global for Earth Observations (GEO)
- Ocean Domain implementation ongoing, as national resources permit. Funding mostly from research community. JCOMM was established to support implementation including data mgmt and services.

Initial Sustained Ocean System

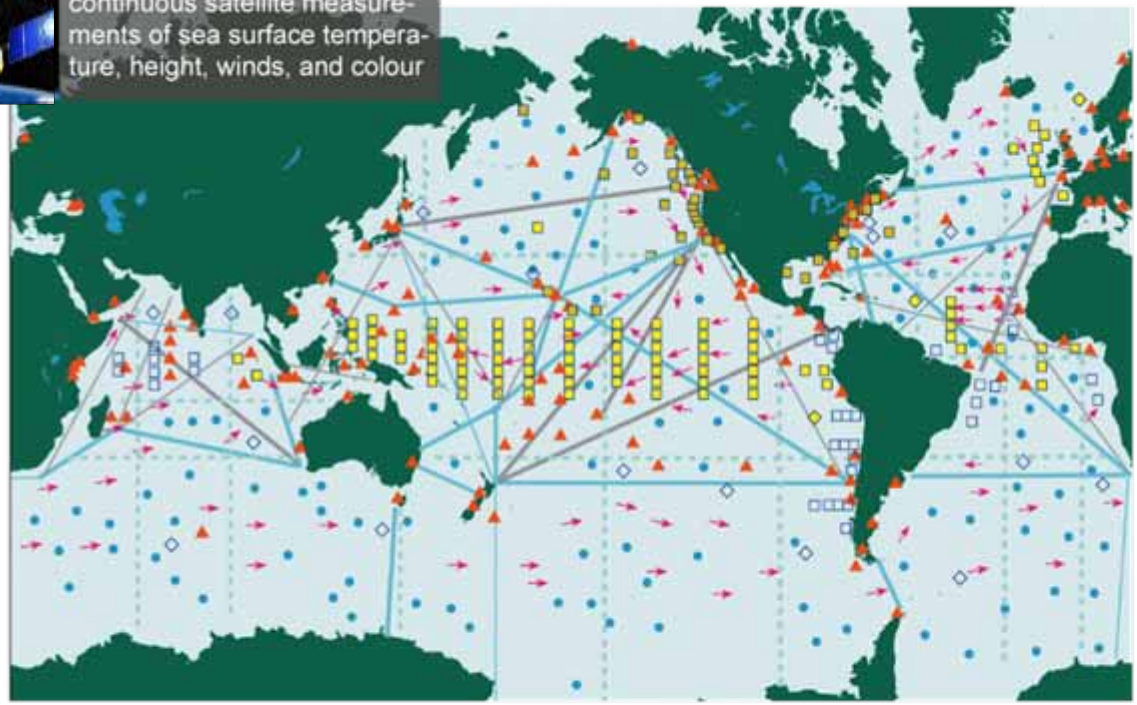
- Depends on (largely) proven technology capable of (largely) autonomous use on basin scales.
- Thus initial system mostly addressed physical climate and ocean carbon variables
- Serves ocean forecasting as well as climate, through near-real time data transmission and GODAE data servers. Real time metadata near implementation for some variables
- Free and open data access (largely).
- GCOS-92 identified the importance of non-physical variables, and of a process to enhance the ocean system as new observing technologies were proven and standards agreed. Time for second stage of system!
- Test-beds called to be available via OceanSites mooring program

Initial Global Ocean Observing System for Climate

Status against the GCOS Implementation Plan and JCOMM targets

Total *in situ* networks **60%** February 2008

continuous satellite measurements of sea surface temperature, height, winds, and colour



87% **Surface measurements** from volunteer ships (VOSclim)

200 ships in pilot project

100% Global **drifting surface buoy** array

5° resolution array: 1250 floats

62% **Tide gauge** network (GCOS subset of GLOSS core network)

170 real-time reporting gauges

81% **XBT** sub-surface temperature section network

51 lines occupied

100% **Profiling float** network (Argo)

3° resolution array: 3000 floats

43% Repeat **hydrography** and **carbon inventory**

Full ocean survey in 10 years

Reference time series 24%

58 sites

48% Global **reference mooring** network

29 moorings planned

79% Global tropical **moored buoy** network

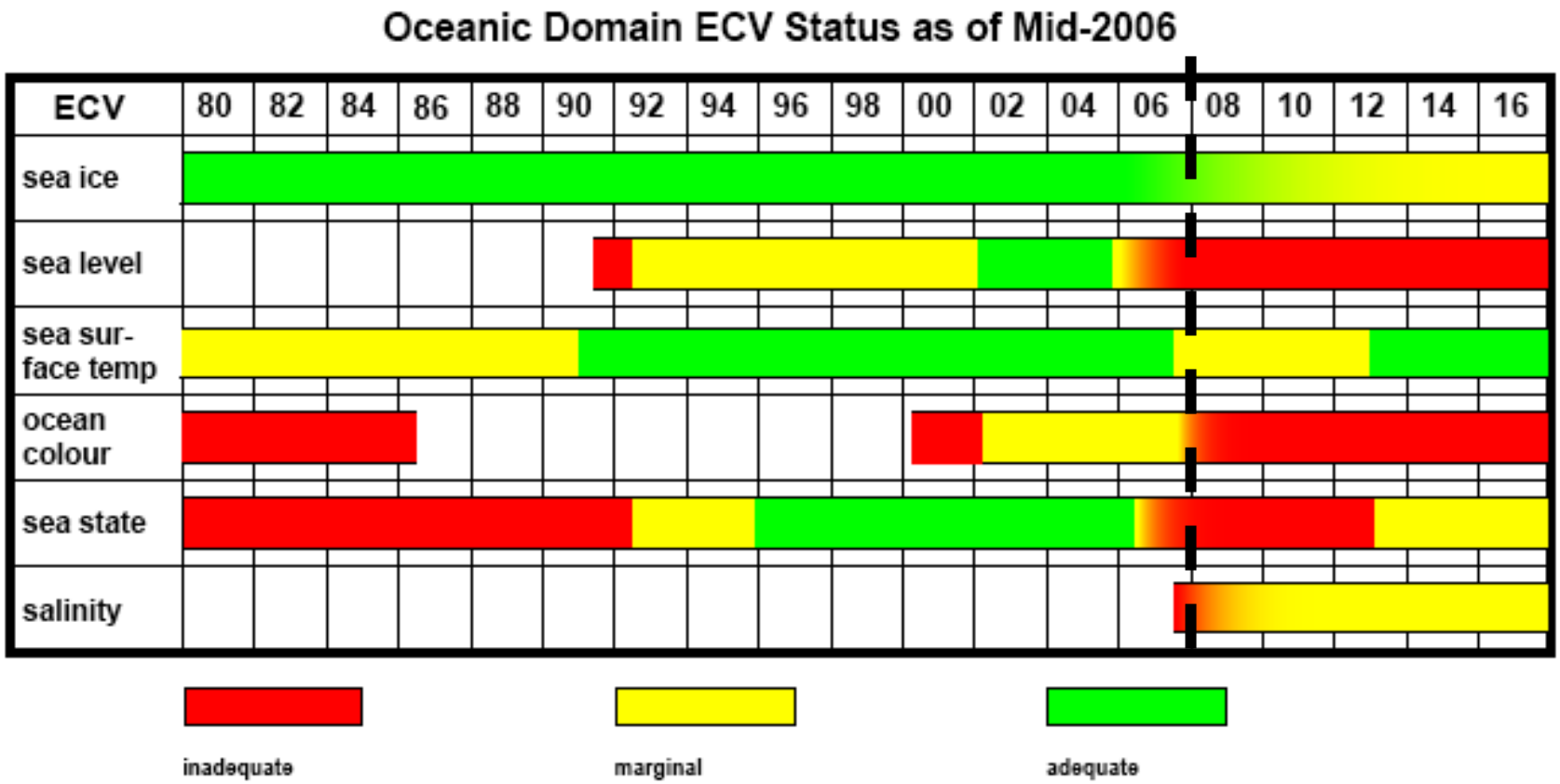
119 moorings planned

GCOS

GOOS

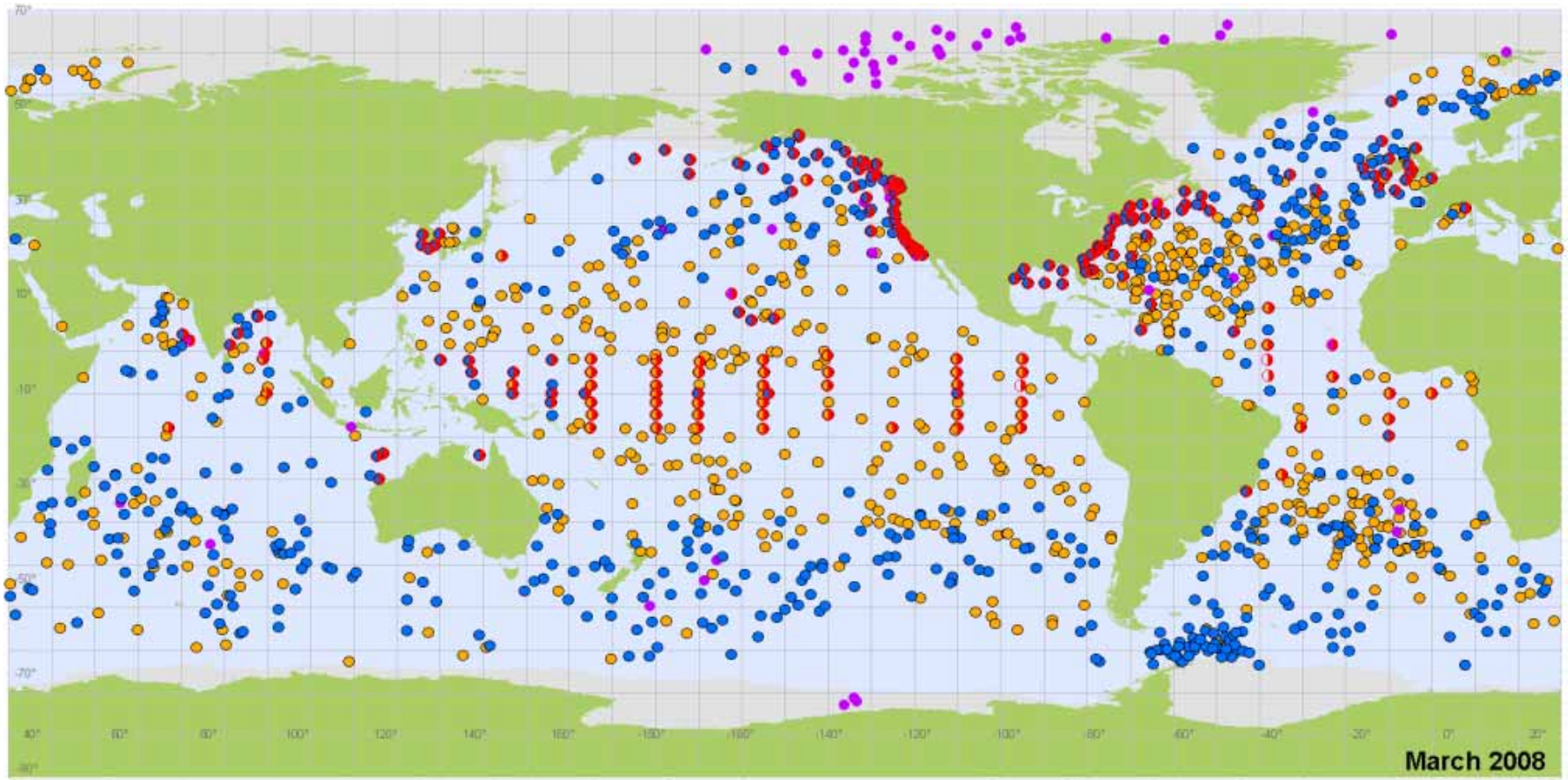
jcomm

Ocean Satellite Status Summary

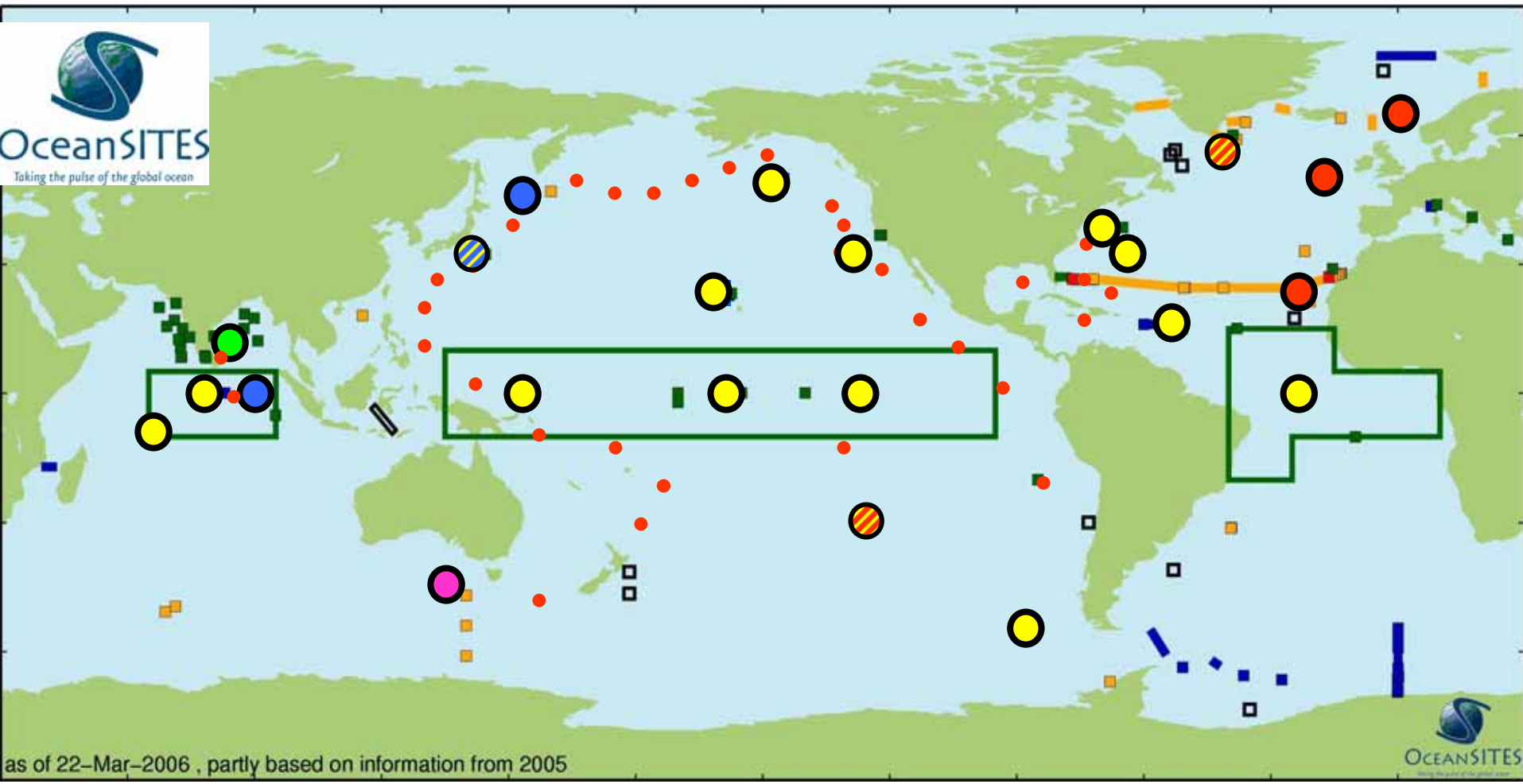


See CEOS Response to GCOS-IP Report to UNFCCC (2006) for more

Surface Obs on GTS March 2008



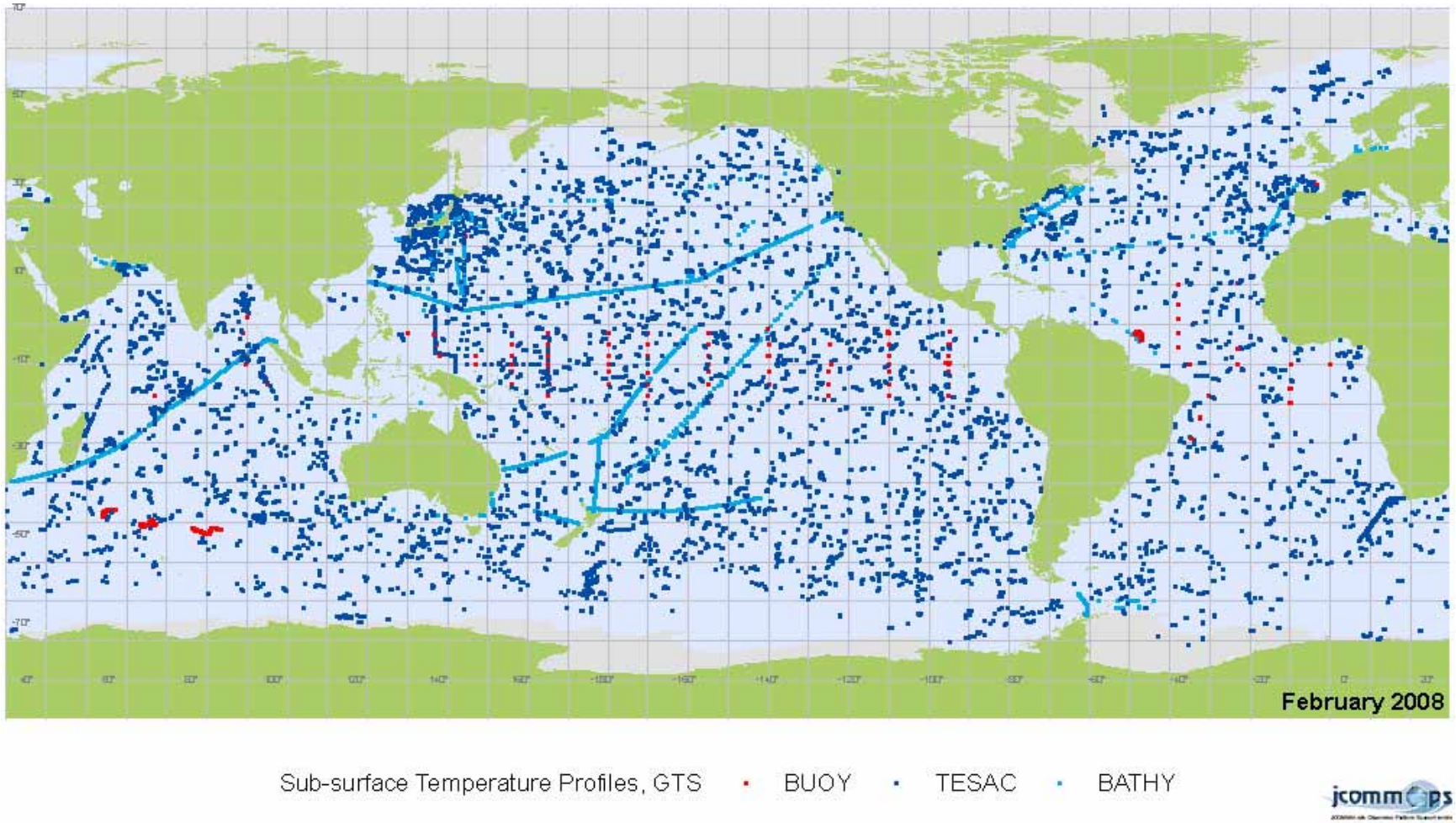
Straw man set of “OCEANsites” moorings that have the potential to become an integrated core time series system



U. Send - OceanSites Workshop @EGU 2008

Ocean Temperature Profile Obs on GTS Feb 2008

From JCOMM OPS web site



Argo floats, moorings, XBT lines, CTD stations reporting in real time

OceanObs2009

- To celebrate a decade of progress together,
- To inform broader community of successes and value of sustaining system
- To identify key issues, opportunities, technologies and products ahead,
- To put forward agreed plans for enhancements for the next decade of the sustained observing system
- To expand system to include ecosystem and biogeochemical variables that are ready

Toward OceanObs09

- See www.oceanobs09.net for present goals and plans.
- Celebrating success; sustaining what is proven; identifying opportunities ahead
- Success depends upon each community developing agreed plan via a White Paper process. OO09 provides a forum, including marine-community-wide acceptance.
- White Paper topics and co-authors being agreed by the Program Committee, with wide consultation.

Exciting Times Ahead

- The coming decade could be the first with world-ocean wide sustained observations of many non-physical ocean variables
- Agreeing standards and best practices
- Collecting and sharing data for the benefit of the world as well as for one's own program and colleagues
- New generation of information products for science and society.