



# World Ocean Database Development

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# Overview

- The World Ocean Database (WOD) and “data archaeology and rescue” projects have the goal of producing the most comprehensive ocean profile database available internationally without restriction.
- A great deal of national and international cooperation has resulted in a substantial increase in the amount of ocean profile data available to the large WOD user community.
- WOD and associated metadata are available online and via DVD.
- All data are quality-controlled and all data are in one well-documented common format.

# Approach

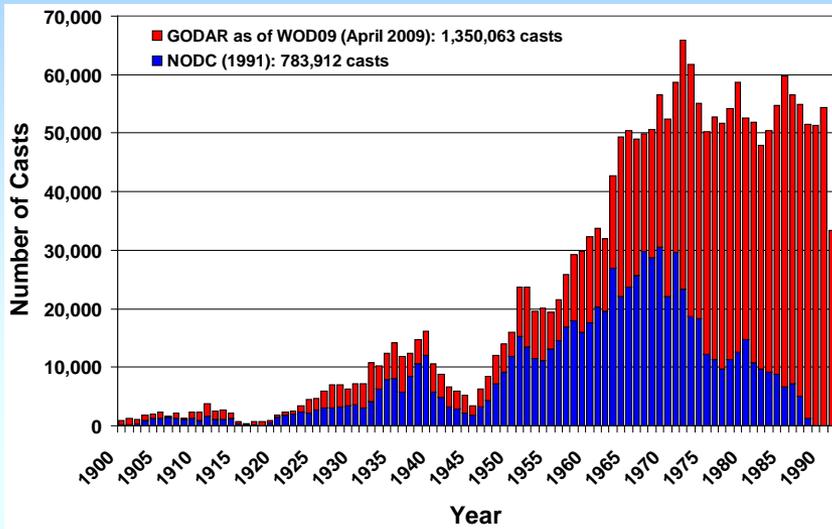
- Normal exchange of ocean data via the Intergovernmental Oceanographic Commission (IOC) (data centers) and the International Council of Science (ICSU).
- NODC Ocean Climate Lab. Director (Levitus) leads two international projects for the IOC that have lead to enhanced ocean data exchange:
  - 1) Global Oceanographic Data Archaeology and Rescue (GODAR) and the
  - 2) World Ocean Database (WOD) project.
- GODAR project focuses on historical data and WOD focuses on modern data.
- Outstanding cooperation from the international data management and scientific communities.

# Results/Accomplishments

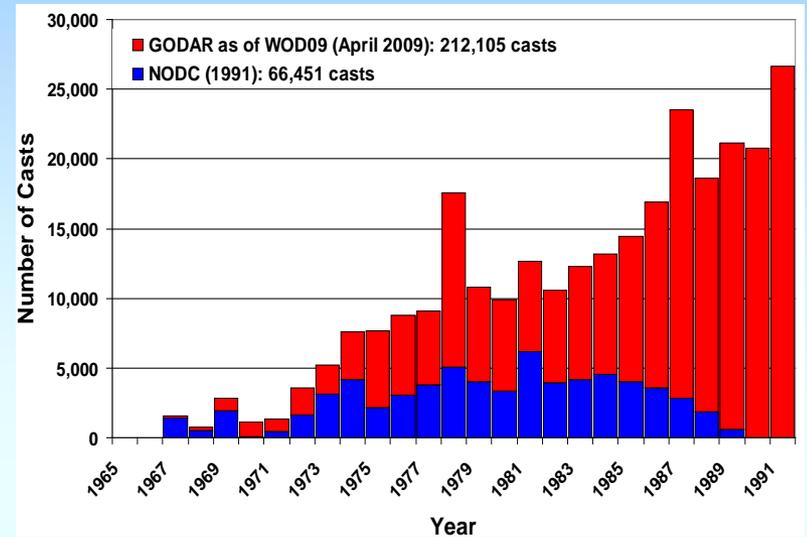


# GODAR results as of April 2009

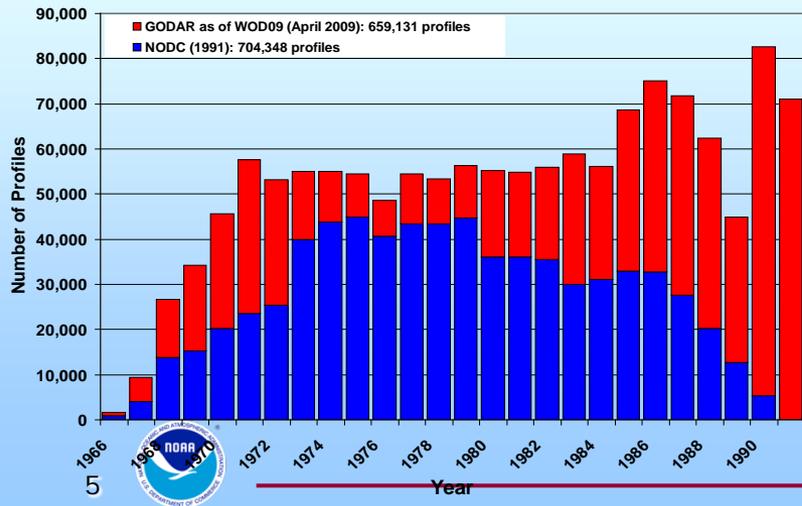
OSD casts data acquired through the GODAR Project for 1900–1991 compared to NODC/WDC archive holding as of 1991



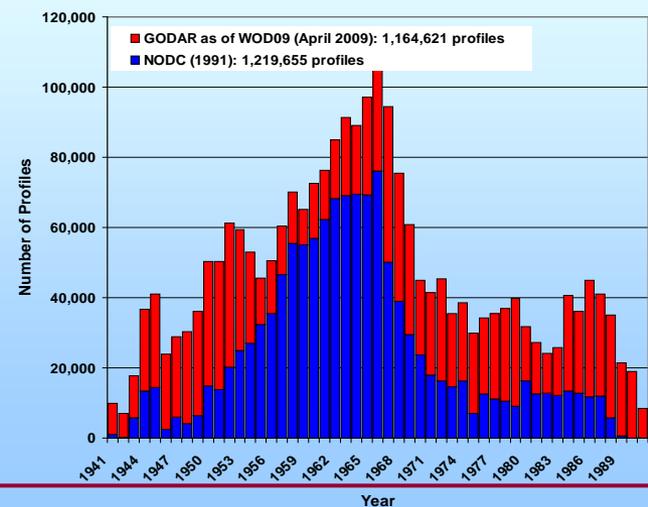
CTD/STD casts data acquired through the GODAR Project for 1965–1991 compared to NODC/WDC archive holding as of 1991



XBT temperature profiles acquired through the GODAR Project for 1966–1991 compared to NODC/WDC archive holding as of 1991

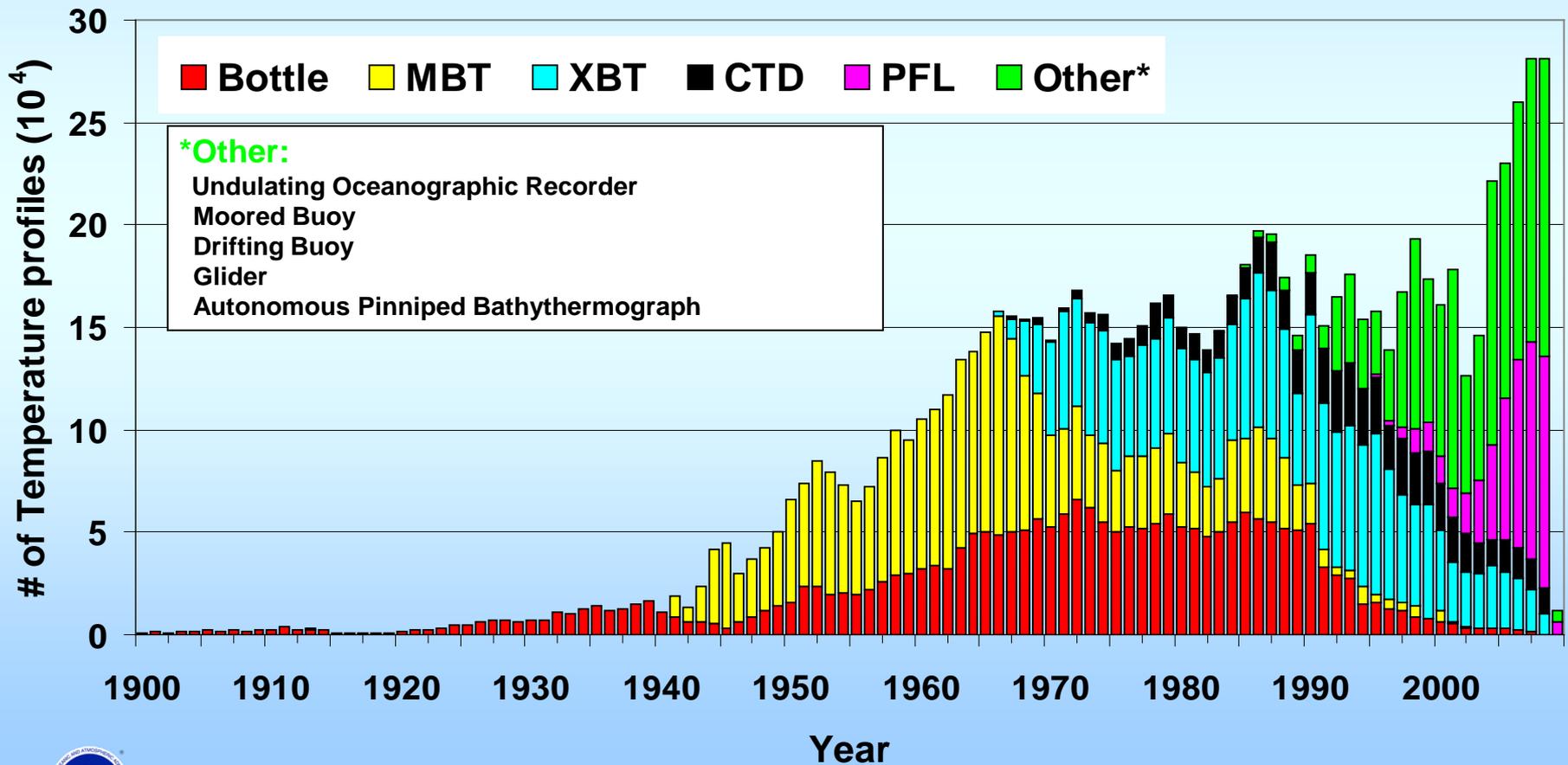


MBT temperature profiles acquired through the GODAR Project for 1941–1991 compared to NODC/WDC archive holding as of 1991



# History of ocean profile data sets available in electronic form from NODC/WDC as contained in WOD09

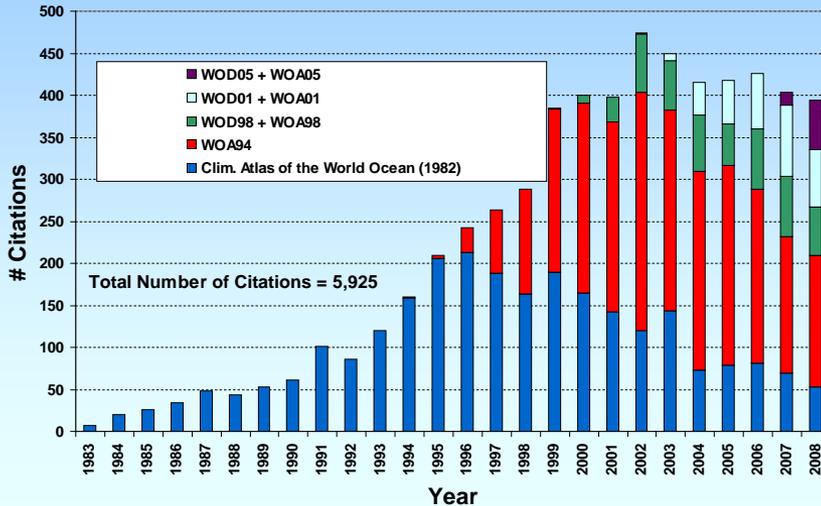
## World Ocean Database



# NODC/OCL is widely recognized for its achievements

## How successful is the OCL based on the metrics of IMPACT and OUTPUT?

### Impact

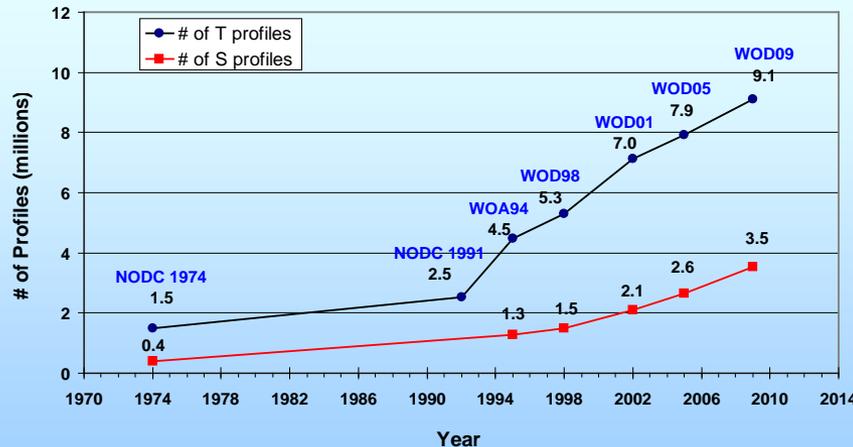


NODC/OCL databases and objective analyses are frequently used by the research and operational communities as evidenced by numerous citations in the scientific literature.

During 1991-2001 NOAA publications were cited 46,058 times. Of this total, 2,653 were citations of databases and atlases based on NODC/OCL profile datasets.

Thus, NODC/OCL works accounted for approximately ~5.8% of all citations of NOAA publications during the 1991-2001 period.

### Output



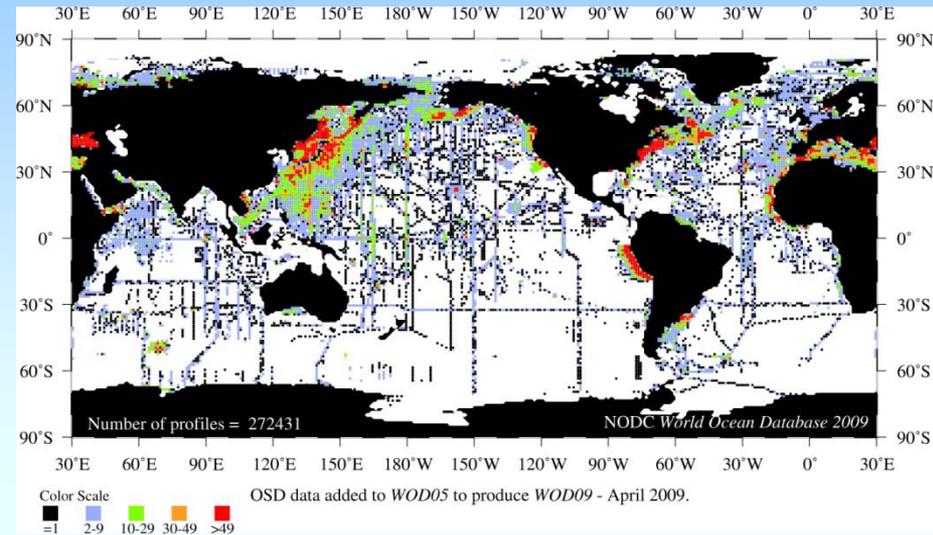
The GODAR project and WOD projects have recovered and made available much historical and modern data.

Another metric:

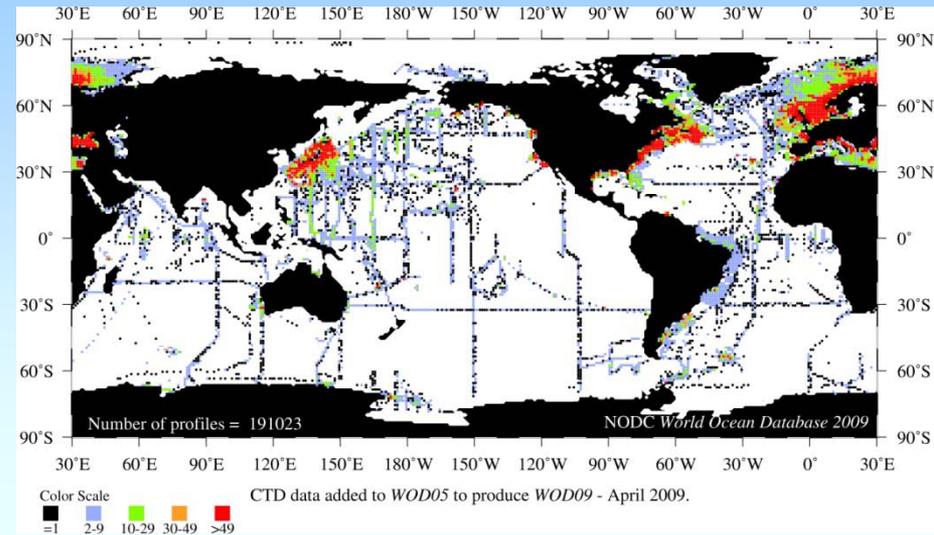
NODC/OCL work figured prominently in the 2007 IPCC Assessment.

# Data added to WOD05 to form WOD09

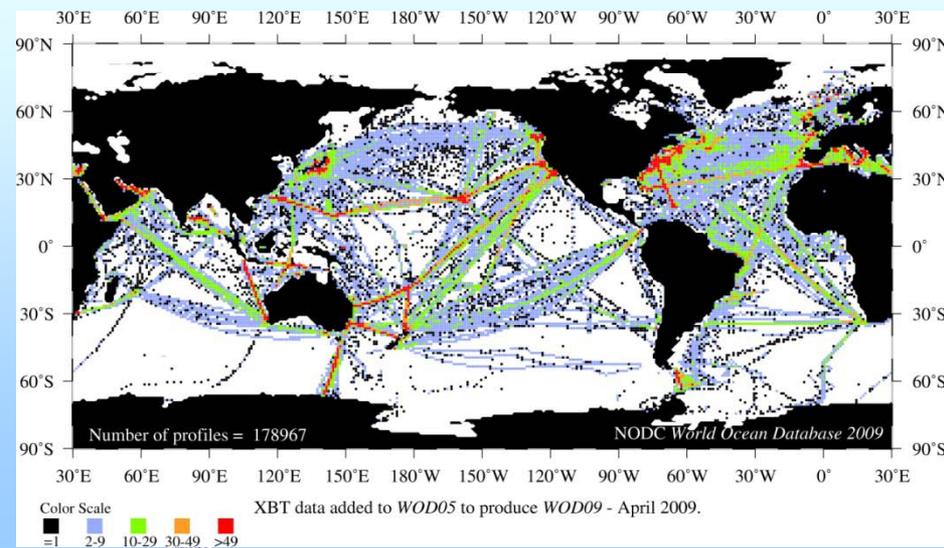
## Ocean Station Data: ~272,000 casts



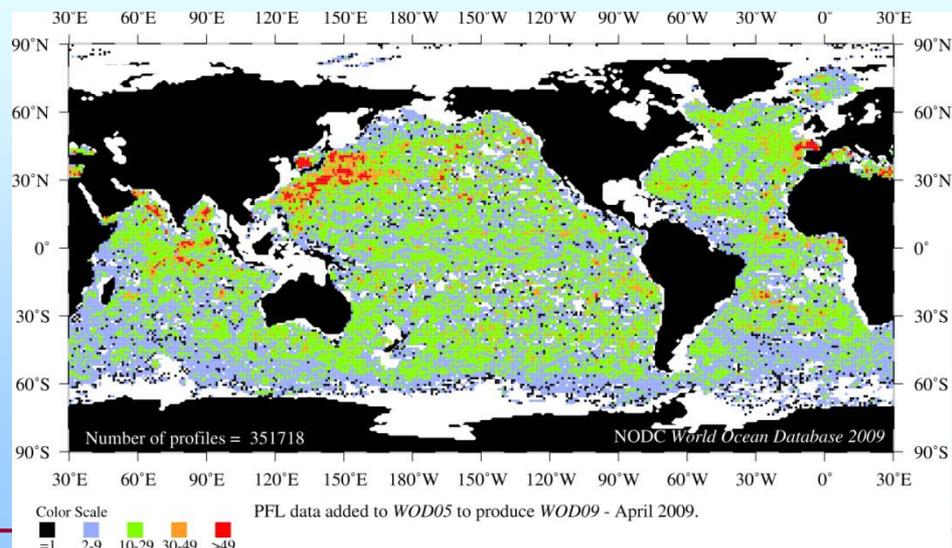
## CTD data: ~191,000 casts



## XBT profiles: ~179,000 casts



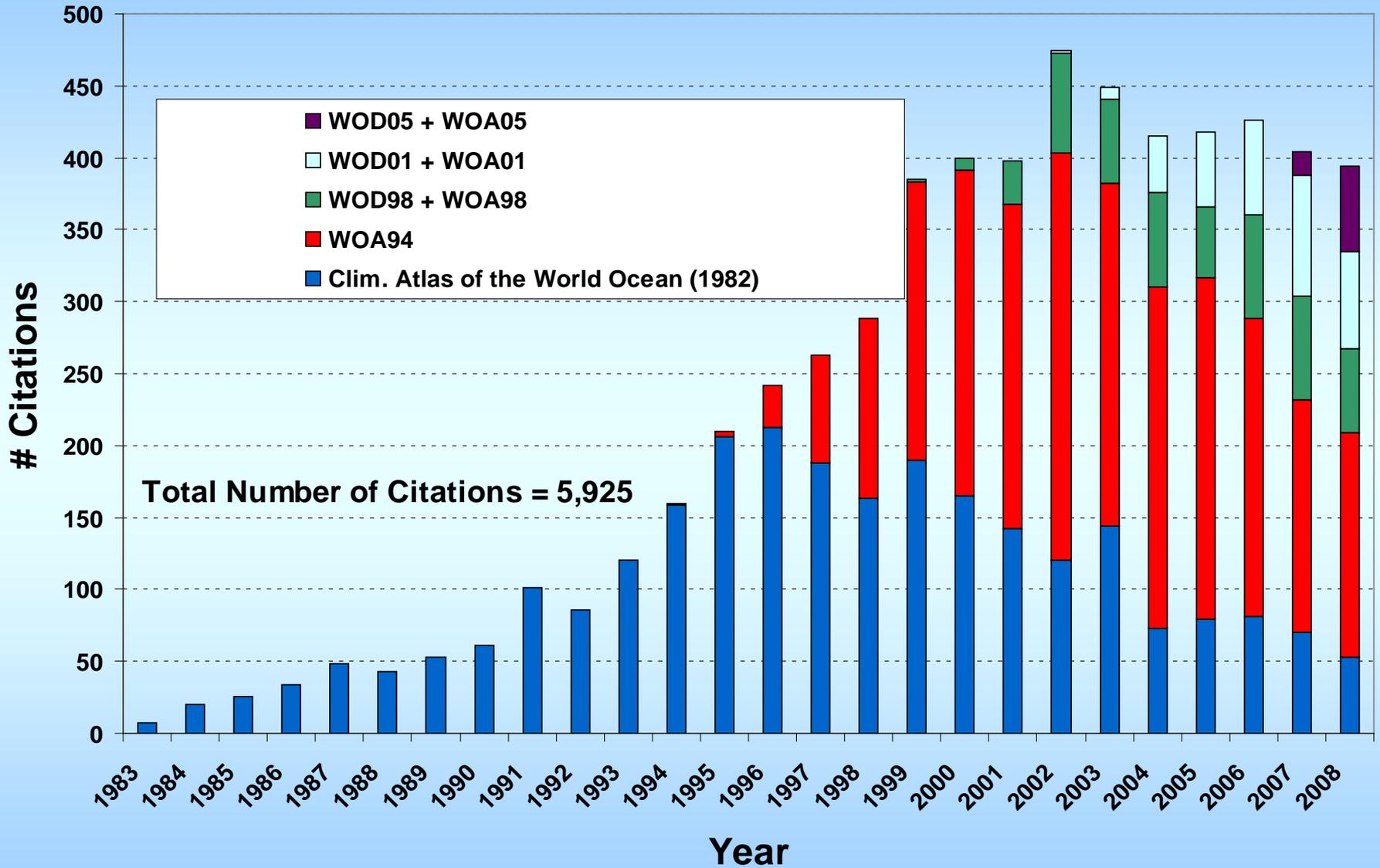
## Profiling Float casts: ~352,000 casts



# Validation Strategy/Results (1- 2 slides)

- <<as appropriate for the type of project >>

# Utility of NODC/WDC profile data as indicated by citations in the scientific literature



\*Based on a search of the ISI *Scientific Citation Index* as of March 2009

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The Greatest Research on Earth http://archive.sciencewatch.com/nov-dec2001/sw\_nov-dec2001\_page2.htm#G


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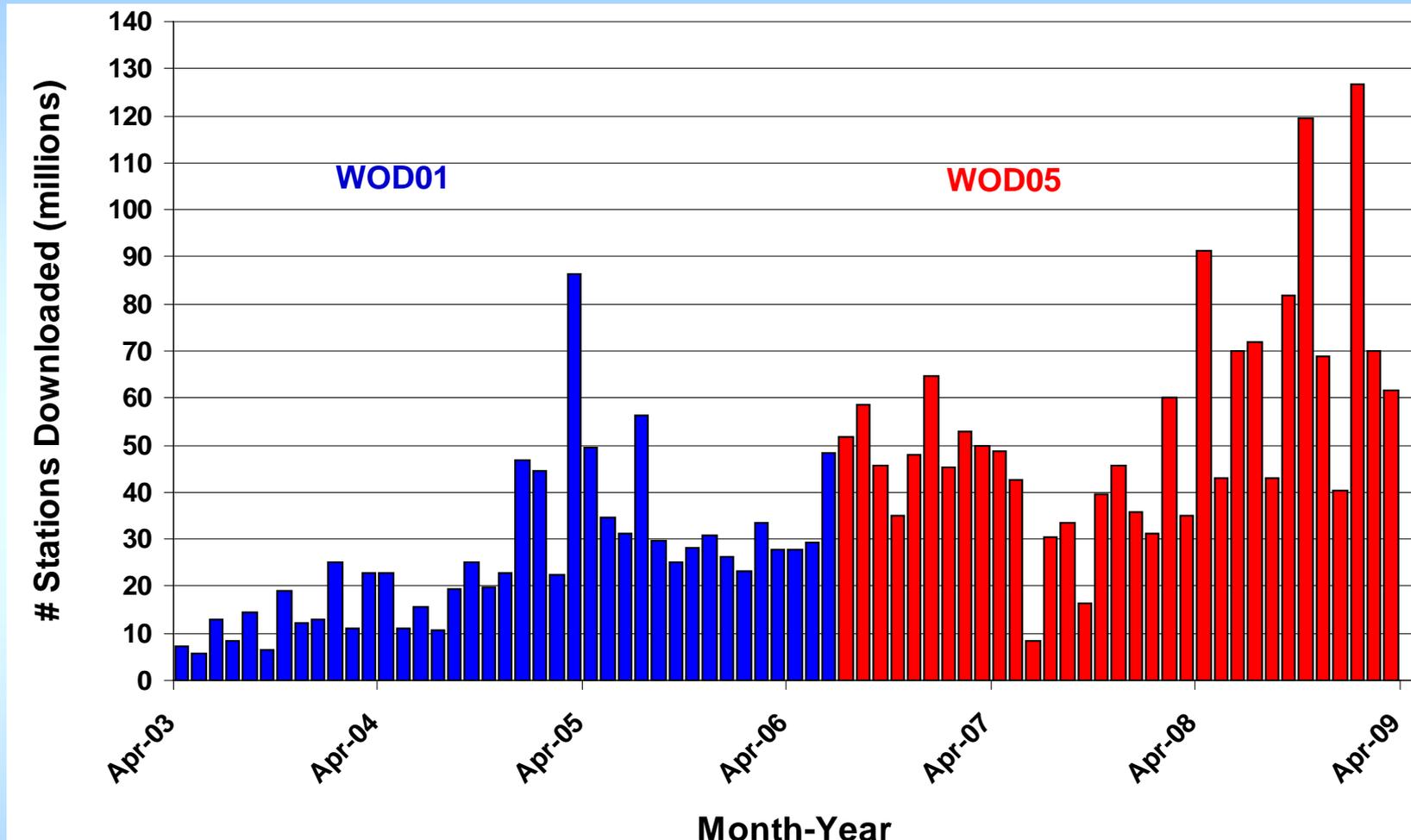
◀ continued from

**Geosciences Research:**  
**Institutions Ranked by Citations and Citation Impact**  
 (among those that published >500 geosciences papers, 1991-2001)

Rank	Institution	Citations 1991-2001	Rank	Institution	Impact 1991-2001
1	NASA	61,984	1	Max Planck Inst. Chemistry	16.33
2	NOAA	46,058	2	Natl. Ctr. Atmosph. Res.	16.15
3	U.S. Geol. Survey	36,241	3	Harvard University	15.24
4	Natl. Ctr. Atmosph. Res.	32,286	4	Columbia University	14.94
5	University of Washington	30,151	5	University of Rhode Island	14.88
6	University of Colorado	28,634	6	Princeton University	14.74
7	Columbia University	24,583	7	University of Washington	14.36
8	Caltech	24,079	8	Carnegie Inst. Washington	13.96
9	Woods Hole Oceanog. Inst.	21,121	9	NASA	13.55
10	MIT	20,588	10	University of Chicago	13.54
11	University of Calif., San Diego	20,320	11	Woods Hole Oceanog. Inst.	13.44
12	Geol. Survey Canada	17,942	12	NOAA	13.44
13	University of Cambridge	15,655	13	MIT	13.41
14	Australian Natl. University	14,627	14	L. Livermore Natl. Lab.	12.44
15	Princeton University	14,341	15	Caltech	12.32
16	University Calif. Los Angeles	14,007	16	University Calif., San Diego	12.17
17	Max Planck Inst. Chemistry	13,243	17	Oregon State University	11.95
18	University of Hawaii	13,226	18	University Calif., Santa Barbara	11.85
19	CSIRO	13,075	19	University of Colorado	11.82
20	Stanford University	12,596	20	SUNY Stony Brook	11.43
21	University of Michigan	12,378	21	Inst. Physique du Globe (France)	11.41
22	Harvard University	12,204	22	University of Maryland	11.36



# World Ocean Database time series of the number of ocean stations downloaded online (ftp) by month



Since the implementation of WODselect in April 2003, WODselect has responded to 63,037 database queries, served over 1.90 billion stations (1007 gigabytes) via the NODC FTP server as of April 2009.

## How Has NOAA C2D2 and SDS Funding Helped Climate System Science ?

Modern data + Data Archaeology & Rescue  $\implies$  Improved data coverage

$\implies$  ability to provide global estimates of heat content, salinity, thermosteric component of sea level change for the past 50 years for the first time!

Paper	# Citations
Levitus, S., J. I. Antonov, T. P. Boyer, C. Stephens, 2000: <b>Warming of the World Ocean</b> . Science, 287, 2225- 2229.	419
Levitus, S., J. Antonov, J. Wang, T. L. Delworth, K. W. Dixon, A. J. Broccoli, 2001: <b>Anthropogenic warming of Earth's climate system</b> . Science, 292, 267- 270.	204
Levitus, S., J. I. Antonov, T. P. Boyer, 2005: <b>Warming of the World Ocean, 1955- 2003</b> . Geophys. Res. Lett., L02604, doi:10.1029/2004GL021592.	230

NOAA/CPO/NODC/OCL is the pioneer and world leader in this research area.

Intense interest by media, Congress, scientific community, IPCC.



## Uses of ocean profile data and products based on such data:

- 1) Diagnostic studies describing role of the ocean as part of earth's climate system;
- 2) Boundary and Initial conditions for numerical models;
- 3) Ocean data assimilation studies;
- 4) Verification for ocean and atmosphere simulations;
- 5) "Sea truth" for satellite ocean altimetry measurements";
- 6) Initial state for acoustic tomography inversions;
- 7) Establishing fields of temperature and salinity for paleoclimatic studies (e.g. CLIMAP);
- 8) Weather forecasting with coupled models.



# Product Maturity

The WOD is always being improved by the addition of data, metadata, and improved quality control.

# Issues/Risks & Work- Off Plans

- Please note
  - current or possible future problems, and
  - approaches to get around or mitigate the problem(s), as appropriate

Lack of funding to perform mission.

“Research-to-Operations” is a myth since our budgets have remained flat and the amount and types of data we receive are increasing.

Funding from C2D2 and SDS are critical to the success of the WOD.



# Schedule

- WOD is updated online every three months with all data we have processed for that quarter.

# Research- to- Operations or Delivery Plan

WOD is updated every three months at NODC and is always available online

# Resources

- Number of personnel employed for project  
C2D2 grant supports 1-2 contractors.

# Supplementary slides



## World Ocean Database 2009 (WOD09)

	INSTRUMENT TYPE	WOD05	ADDED	WOD09	% increase
1	Bottle (OSD)	2,258,437	272,431	2,530,868	12.1
2	High Resolution Conductivity/Temperature/Depth (HCTD)	443,953	191,023	634,976	43.0
3	Mechanical Bathythermograph (MBT)	2,421,940	5,337	2,427,277	0.2
4	Expendable Bathythermograph (XBT)	1,930,413	178,987	2,109,400	9.3
5	Moored Buoys ( <i>e.g.</i> , TAO, TRITON, PIRATA)	445,371	121,169	566,540	27.2
6	Drifting Buoys	108,564	13,662	122,226	12.6
7	Profile Floats (P- ALACE, SOLO, APEX, PROVOR)	168,988	351,818	520,816	208.2
8	Undulating Ocean Recorder ( <i>e.g.</i> , Towed CTD)	46,699	41,485	88,184	88.8
9	Glider	338	5,519	5,857	1632.8
10	Autonomous Pinniped Bathythermograph	75,665	13,933	89,558	18.4



## WODselect, an on- line access tool

**WODselect** allows users to select data on- line from the WOD using the following criteria:

- 1) Geographic area
- 2) Period of observation
- 3) Instrument type
- 4) Measured variables, *e.g.*, temperature, salinity, oxygen, ...
- 5) Deepest measurement in the profile
- 6) Country
- 7) Ship/platform name
- 8) Project name
- 9) Institute name
- 10) Quality control flags
- 11) Biology (plankton)

Data Archaeology & Rescue  $\implies$  Improved data coverage for past years

$\implies$  ability to provide global estimates of heat content, salinity, thermosteric component of sea level change for the past 50 years for the first time!

Paper	# Citations
Antonov, J. I., S. Levitus, T. P. Boyer, 2002: Steric sea level variations during 1957- 1994: Importance of salinity. J. Geophys. Res.- Oceans, 8013, doi:10.1029/2001JC000964.	51
Boyer, T.P., J. I. Antonov, S. Levitus, R. Locarnini, 2005: Linear trends of salinity for the world ocean, 1955- 1998. Geophys. Res. Lett., 32, L01604, doi:1029/2004GL021791.	47
Antonov, J. I., S. Levitus, T. P. Boyer, 2005: Thermosteric sea level rise, 1955- 2003. Geophys. Res. Lett., 32, L12602, doi:10.1029/2005GL023112.	36

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