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International Conference on Marine Data and Information Systems

World Ocean Database in 3D:

Development, Dissemination, Deliverables

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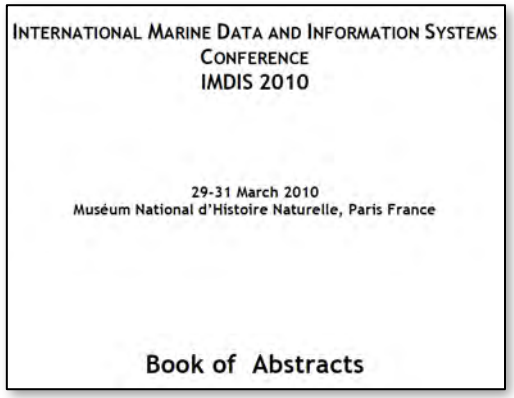
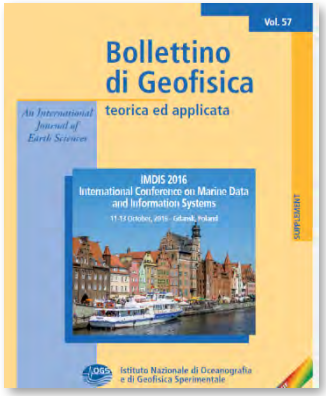
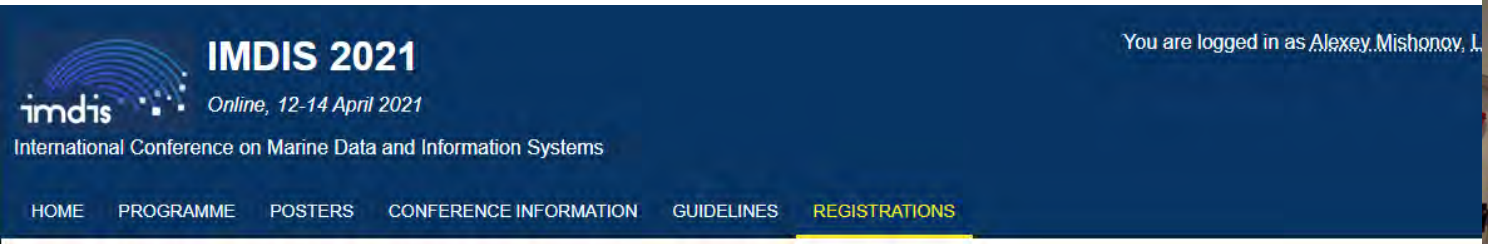
WOD @ IMDIS presentations:

- IMDIS 2005: Brest – ? (WOD01)
- **IMDIS 2008: Athens – yes (WOD05)**
- **IMDIS 2010: Paris – yes (WOD09)**
- IMDIS 2013: Lucca – no
- IMDIS 2016: Gdansk – no (WOD13)
- IMDIS 2018: Barcelona – no
- **IMDIS 2021: Cyberspace – yes (WOD18)**







WOD: Introduction

The World Ocean Database (WOD) is a collection of scientifically quality-controlled ocean profile and plankton data that includes measurements of:

- Temperature
- Salinity
- Oxygen
- Phosphate
- Nitrate
- Silicate
- Chlorophyll
- Alkalinity
- pH
- pCO_2
- tCO_2
- Tritium
- δ^{13}Carbon
- δ^{14}Carbon
- δ^{18}Oxygen
- Freon
- Helium
- δ^{3}Helium
- Neon
- Plankton

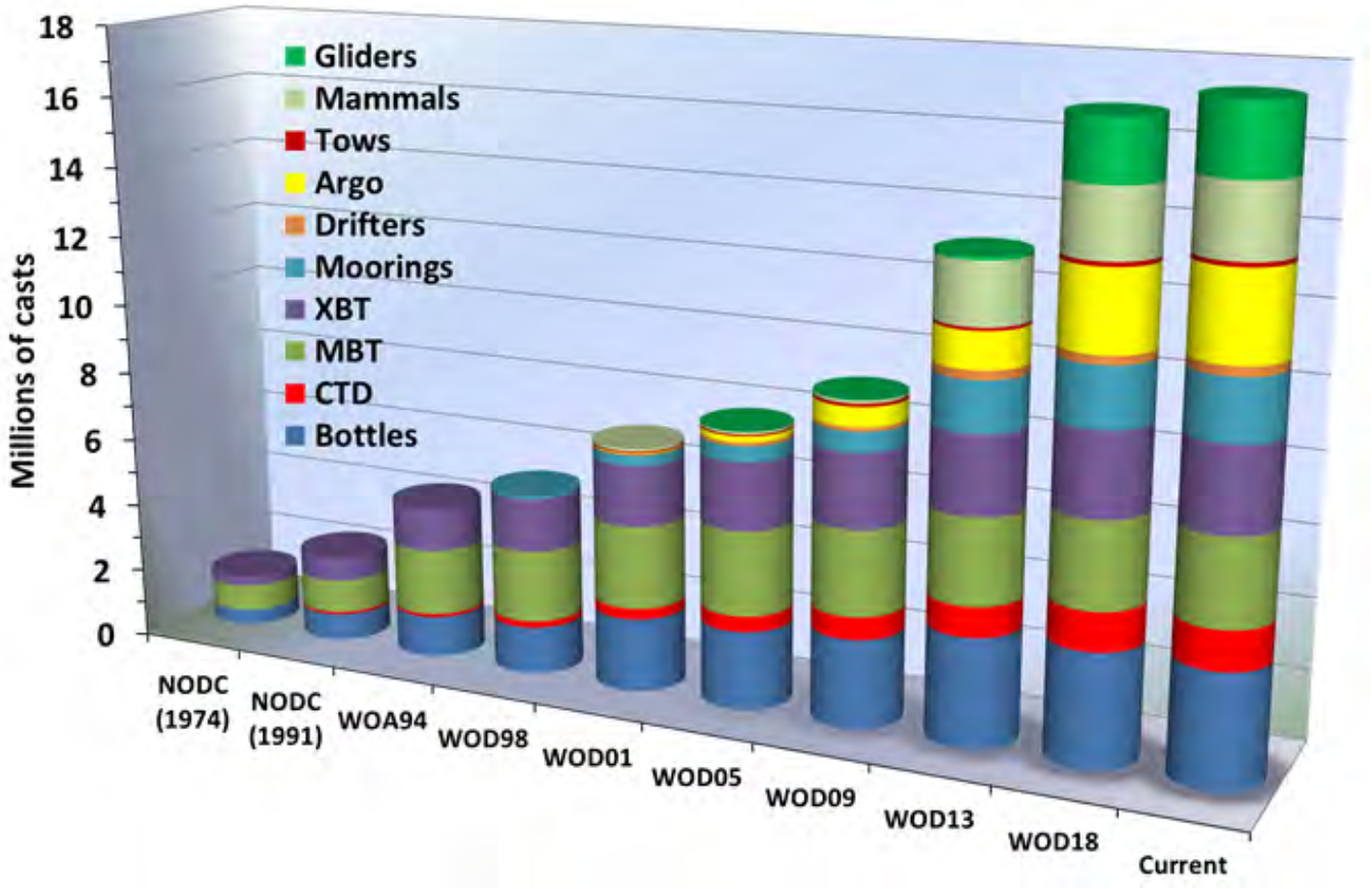
WOD aggregates worldwide ocean profile data: **17.5** million casts (1772-2021). This is the world's most extensive collection of ocean profile data, which is **updated four times per year** and **available without restriction**.

https://www.ncei.noaa.gov/products/world-ocean-database

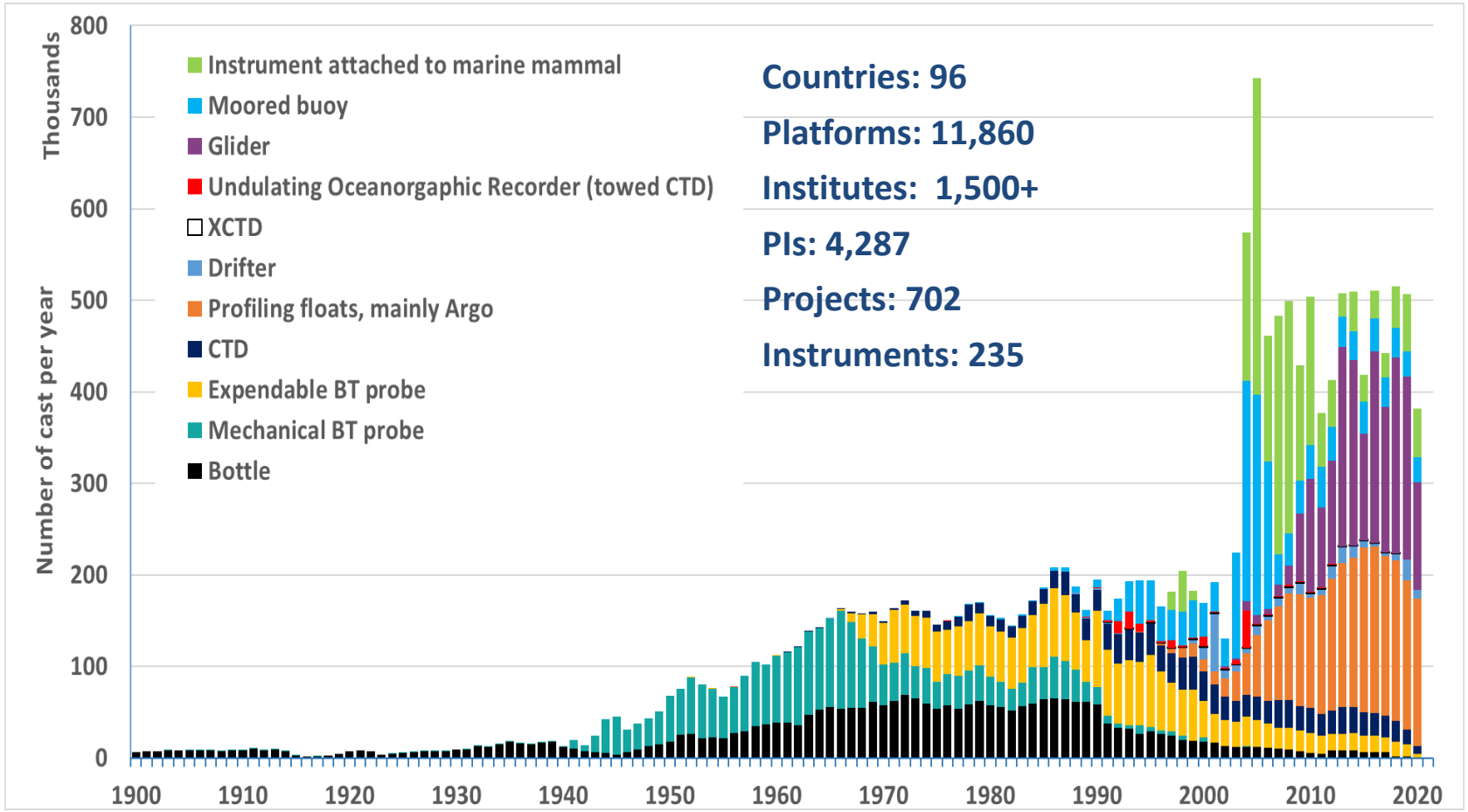
WOD: Development

The work on the WOD began in 1992 by **Syd Levitus**

Six major versions of WOD has been released in 1998, 2001, 2005, 2009, 2013, and 2018



WOD: data sources

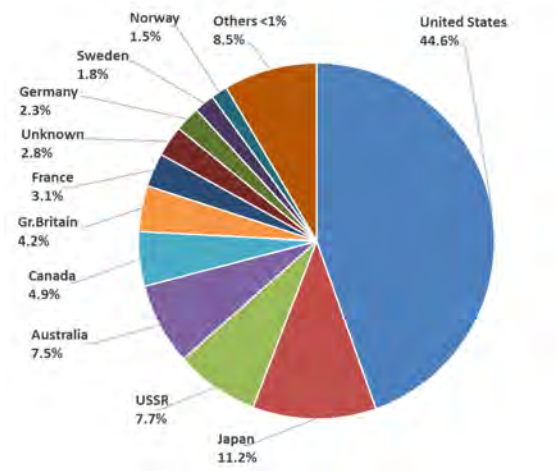


Instrument types: Station data; CTD; XBT; MBT; Towed CTD; Profiling Floats; Drifting buoy (mostly ice drifters); Moored buoy (PIRATA, TAO, etc.); Autonomous Pinniped (instrumented pinnipeds); Gliders

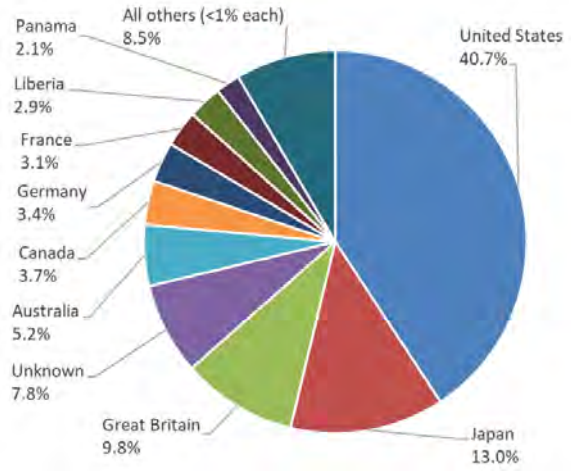
WOD: data submitters

The **WOD** team at NOAA has been ingesting data from multiple countries, many institution, and various platforms and instruments

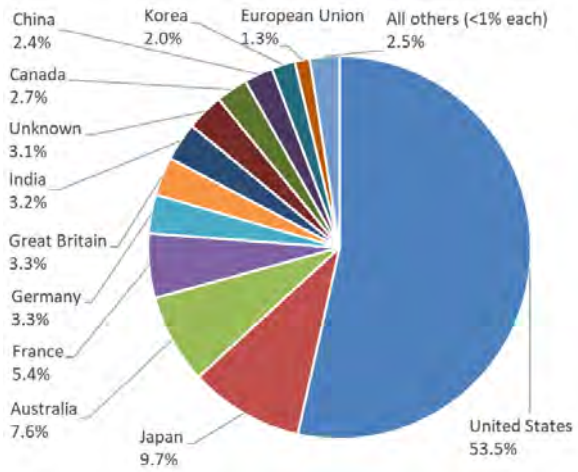
Bottle

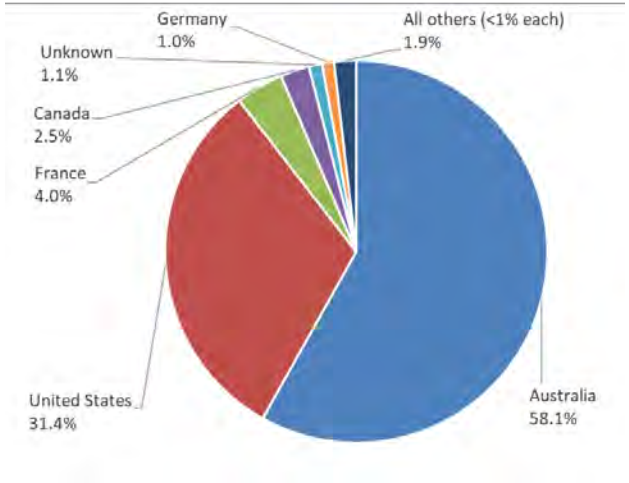


XBT



Floats

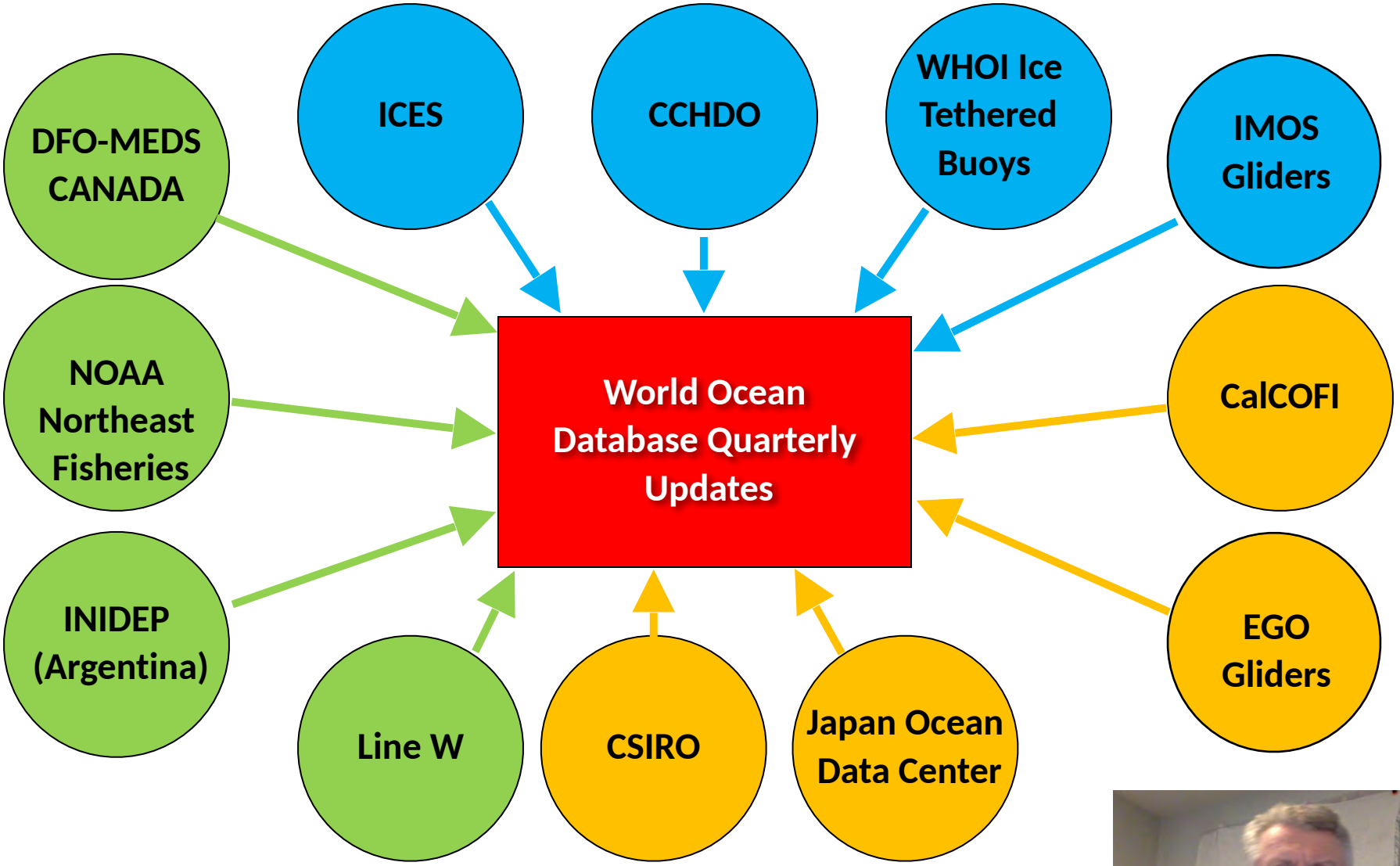




Gliders

The **WOD** can be considered as the final step in gathering oceanographic profile data and preparing them for public dissemination

WOD: updates



Examples of Delayed-mode data Updates: Quarterly Yearly Irregular

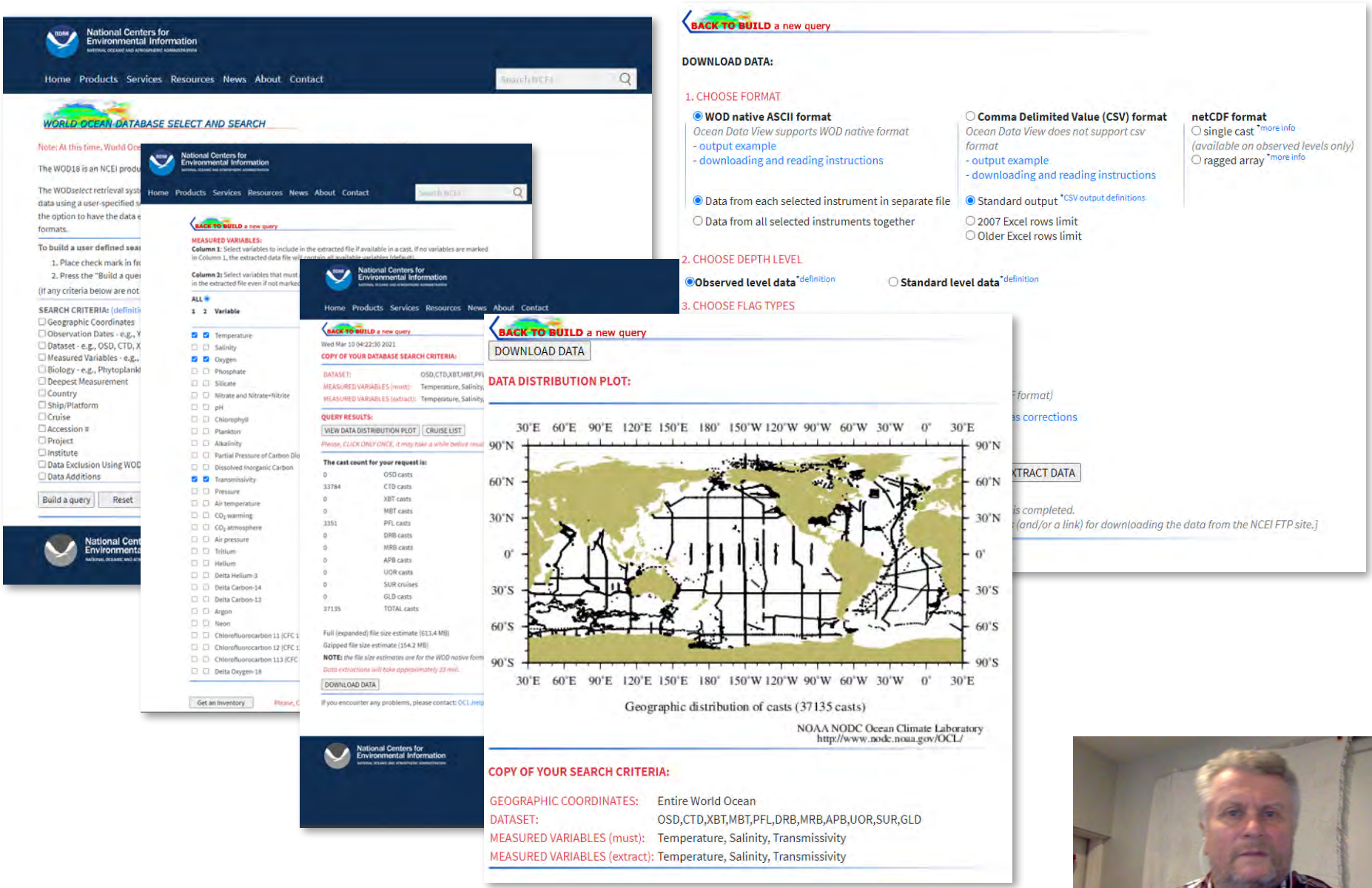
WOD: Dissemination

- The **WOD** and the products based on it go through different stages of preparation and dissemination techniques, which reflects the technological evolution in oceanographic observations and processing.
- It started from 8-tracks mainframe tapes to HD-floppy disks to CDs, to DVDs, and, now completely moved to the web and preparing to be finally transferred to the cloud for being accessible in real time.
- Currently, the entire collection of data in the **WOD** is accessible via ***WODSelect*** web-portal

  https://www.ncei.noaa.gov/access/world-ocean-database-select/dbsearch.html

  where data selection can be made based in different user-defined criteria.
- The data selected by a user request are prepared automatically and can be downloaded from a NOAA server

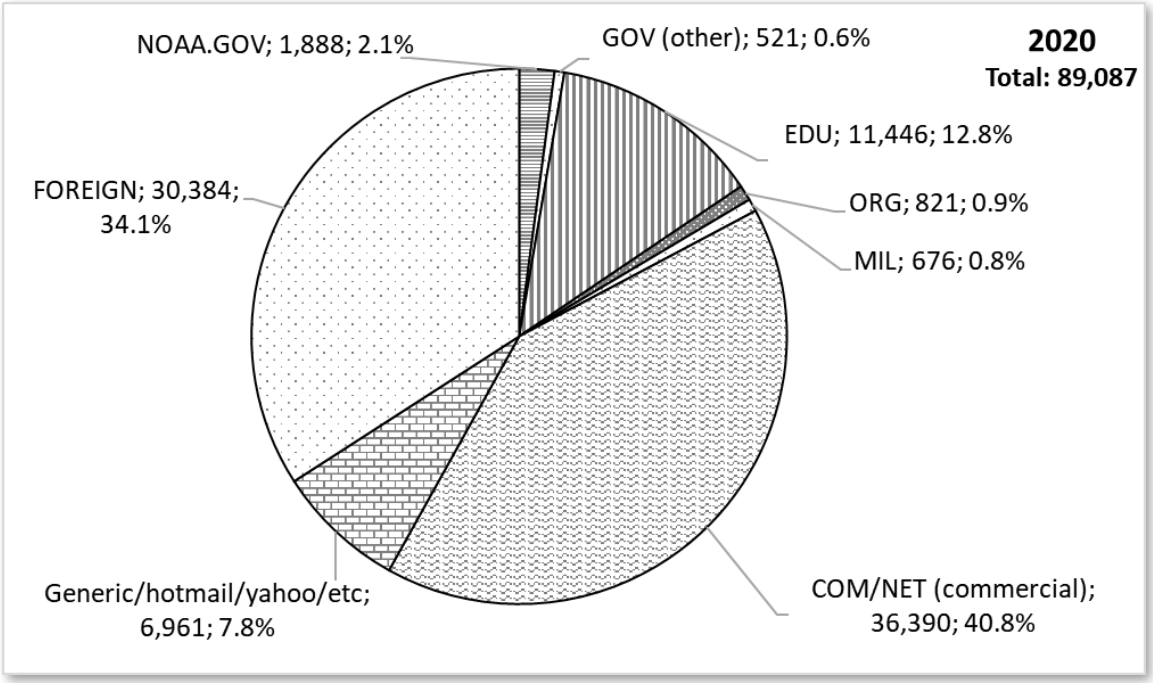
WOD dissemination tool: ***WODselect***



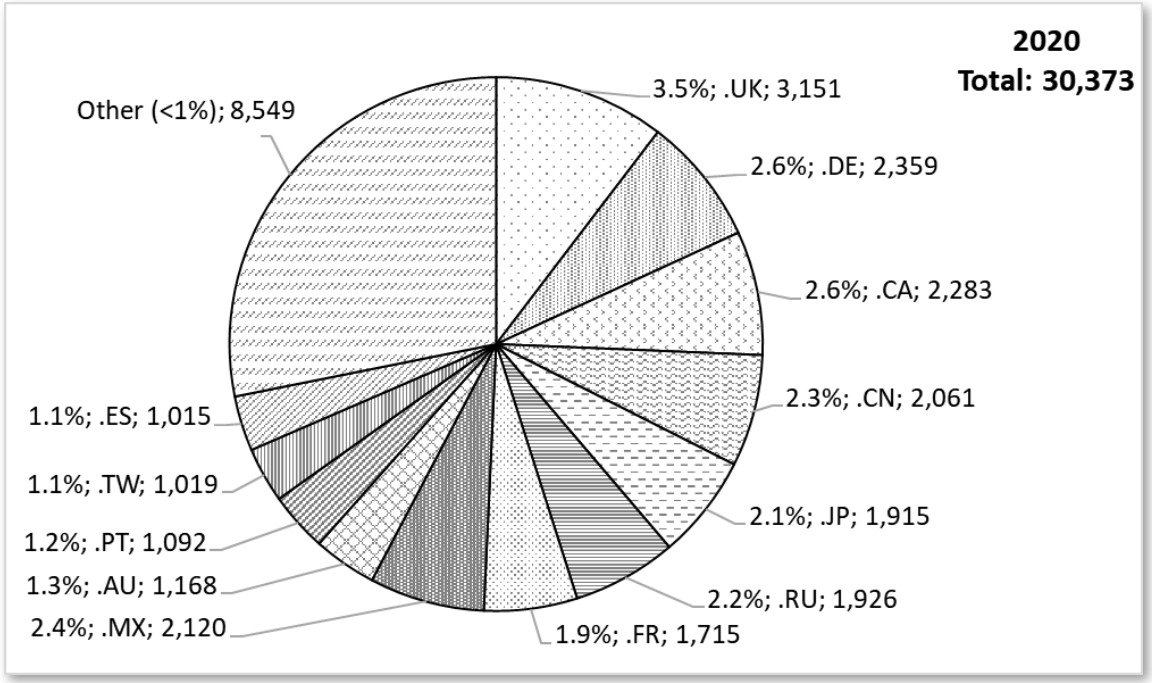
https://www.ncei.noaa.gov/access/world-ocean-database-select/dbsearch.html

WOD: Dissemination

Affiliation download statistics for *WODselect*



Countries download statistics for *WODselect*

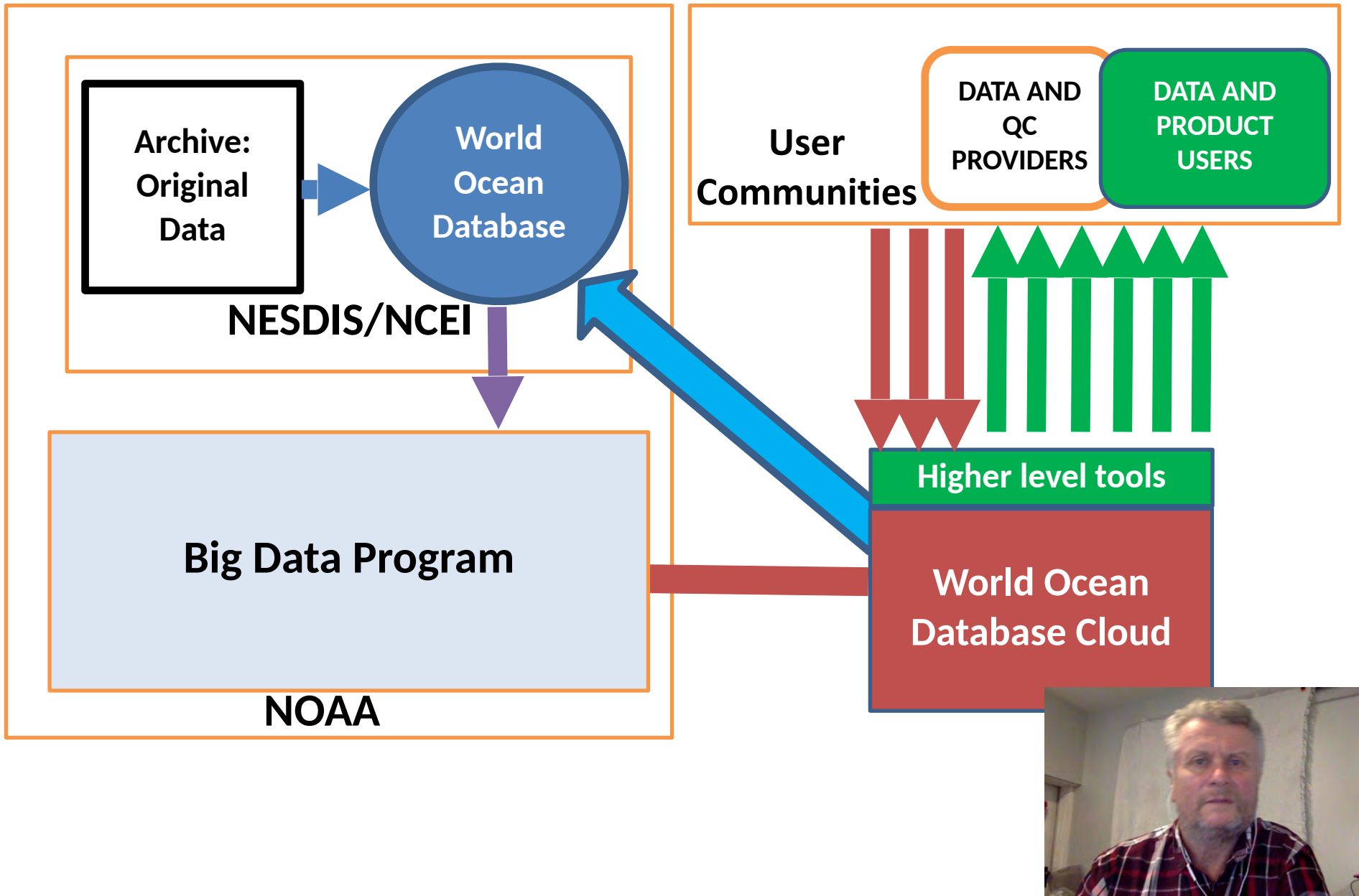


Dissemination –> moving to cloud

World Ocean Database Cloud (**WODc**) : optimized access to and utilization of the world largest oceanographic profile data in the cloud

- ➢ Make WOD freely available through NOAAs Big Data Program (BDP) cloud providers to increase open access data and utility
- ➢ Increase global participation and contribution to the WOD both in data aggregation and quality assurance of the data (e.g., UN Decade of ocean science for sustainable development 2021-2030).
- ➢ Creation and availability of higher level tools for optimized utilization of data by researchers, decision/policy makers, managers, the general public.
- ➢ Control of core WOD to assure highest level of scientific quality of data.

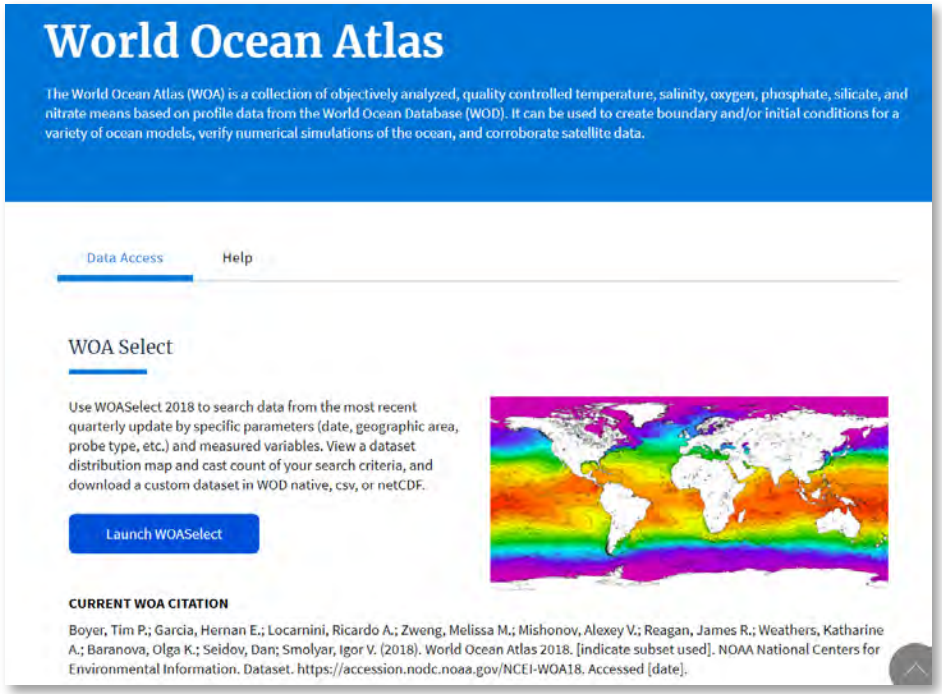
WOD: Dissemination –> moving toward cloud

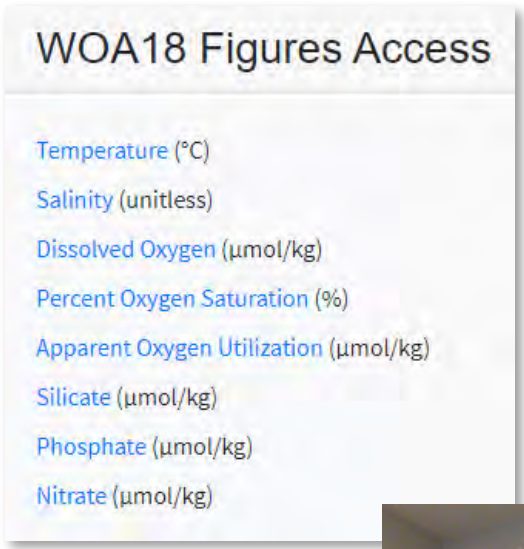


WOD: Deliverables -> WOA

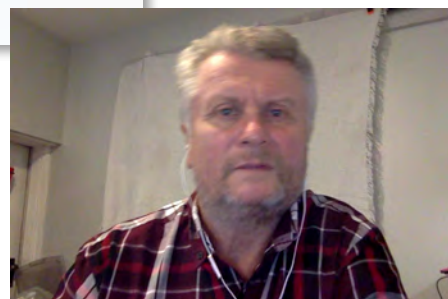
Aside from quality controlled and uniformly formatted oceanographic data, WOD is the foundation for several stand-alone products.

The major product is the **World Ocean Atlas** – a set of global climatological fields of major oceanographic variables – temperature, salinity, etc., calculated at the 102 standard depth levels with one- and quarter-degree spatial resolution grids. These climatologies calculated based on entire data collection as well as on decadal sub-sets.

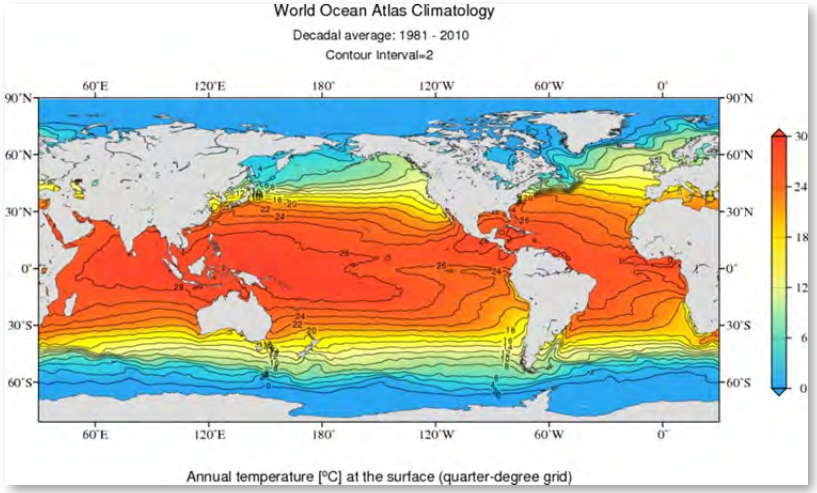


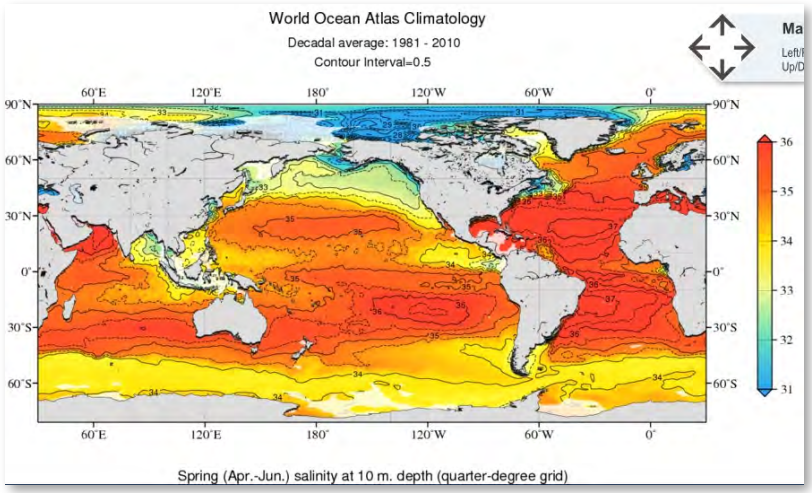


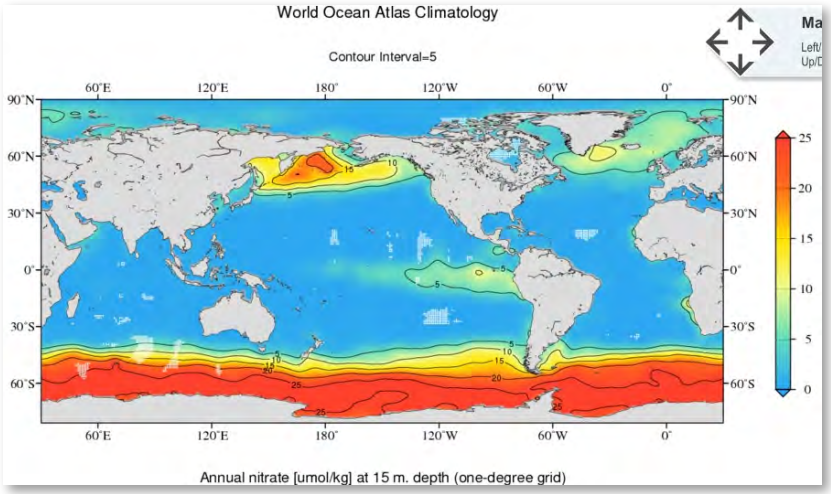
https://www.ncei.noaa.gov/products/world-ocean-atlas

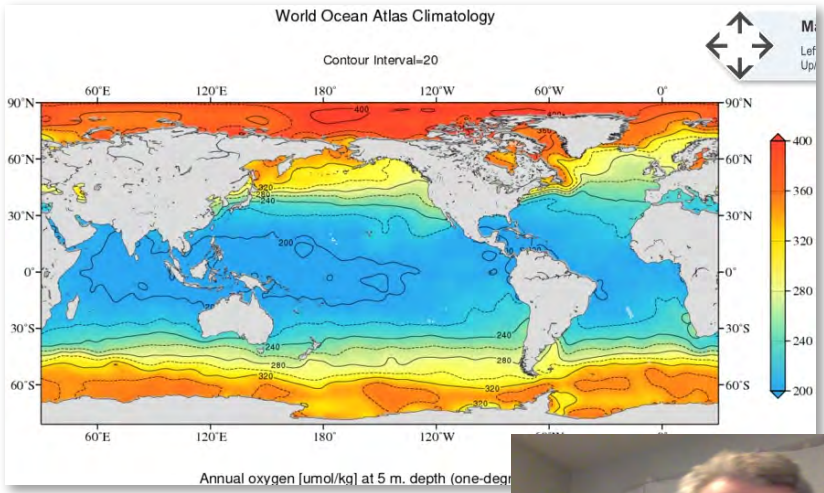


WOD: Deliverables-> WOA figures

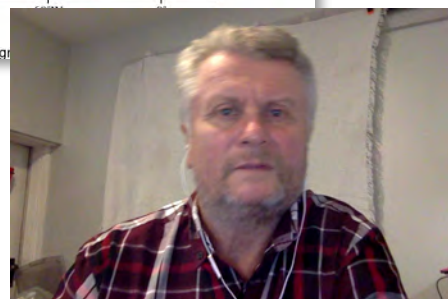








https://www.ncei.noaa.gov/access/world-ocean-atlas-2018f/



WOD: Deliverables -> WOA data access

World Ocean Atlas / WOA 2018 Figures / WOA 2018 Data

WOA 2018 - Data Access: statistical mean of temperature on 1° grid for all decades

The Temperature climatological fields can be downloaded as an individual file or a compressed file of all climatological fields and related statistics.
The WOA documentation includes information on downloading and reading the data.

Available formats:
○ ASCII ◉ CSV ○ ArcGIS ○ NetCDF

Available grids:
○ 5° ◉ 1° ○ 1/4°

Available fields:

- Objectively analyzed mean
- Statistical mean
- Number of observations
- Standard deviations
- Standard error of the mean
- Statistical mean minus analyzed
- Season/month minus annual mean
- Grid points

Available decadal periods:

- Averaged decades years
- 1955-64 years
- 1965-74 years
- 1975-84 years
- 1985-94 years
- 1995-2004 years
- 2005-2017 years

Update data links

Statistical mean data links (1° grid)
All fields woa18_t_decav_1.00_csv.tar.gz (0.4 GB)

Annual	Seasonal	Monthly
t00mn01.csv.gz	t13mn01.csv.gz - Winter	t01mn01.csv.gz - January
	t14mn01.csv.gz - Spring	t02mn01.csv.gz - February
	t15mn01.csv.gz - Summer	t03mn01.csv.gz - March
	t16mn01.csv.gz - Autumn	t04mn01.csv.gz - April
		t05mn01.csv.gz - May
		t06mn01.csv.gz - June
		t07mn01.csv.gz - July
		t08mn01.csv.gz - August
		t09mn01.csv.gz - September
		t10mn01.csv.gz - October
		t11mn01.csv.gz - November
		t12mn01.csv.gz - December

File naming conventions: [V][TT][FF][GG].[EXT]
where:
[V] - variable
[TT] - time period
[FF] - field type
[GG] - grid (01- 1°, 04 - 1/4° 10 - 1/10°)
[EXT] - file extention
Note: '.dat' - ASCII; '.csv' - comma separated value; '.dbf', '.shp', '.shx' - ArcGIS shap

https://www.ncei.noaa.gov/access/world-ocean-atlas-2018/

WOD: Deliverables -> OHC

The top product based on WOD and WOA is **Global Ocean Heat and Salt Content** anomalies accompanied by **Seal level changes** data. These assessments are updated quarterly.

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Global Ocean Heat and Salt Content

Data distribution figures for temperature and salinity observations, temperature and salinity anomaly fields for depths 0-2000m, heat content and steric sea level (thermosteric, halosteric, total) are updated quarterly. Temperature anomalies and heat content fields are detailed in *World Ocean Heat Content and Thermosteric Sea Level change (0-2000 m), 1955-2010*, publication (pdf, 8.1 MB). The same calculations have been extended to keep the fields current and include fields of salinity anomalies, and steric sea level components. Explanation of differences in heat content between published work and online values is outlined in the comments (pdf, 4.2 MB). Information regarding erroneus values is outlined in the notes.

Temperature

- Data distribution figures (0-2000 m)
- Anomaly figures
- Climatological fields ASCII files
- Anomaly fields ASCII and netCDF files

Vertically Averaged Temperature Anomaly

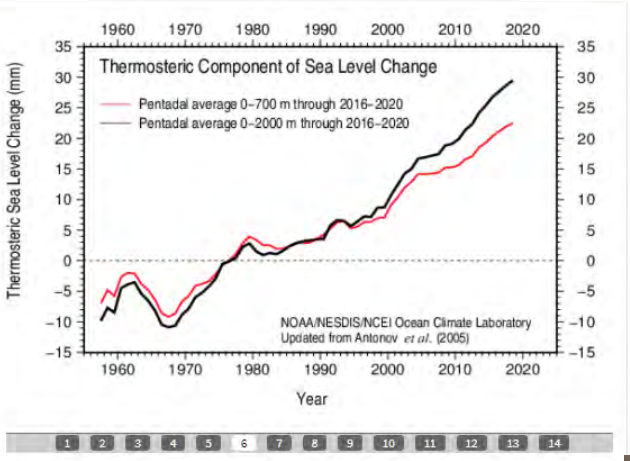
- Figures (0-100 meters)
- Figures (0-700 meters)
- Figures (0-2000 meters)
- Global analyzed fields ASCII and netCDF files
- Basin time series fields ASCII files

Heat Content

- Figures (0-700 meters)
- Figures (0-2000 meters)
- Global analyzed fields ASCII and netCDF files
- Basin time series fields ASCII files

Thermosteric Sea Level

- Figures (0-700 meters)
- Figures (0-2000 meters)
- Global analyzed fields ASCII and netCDF files



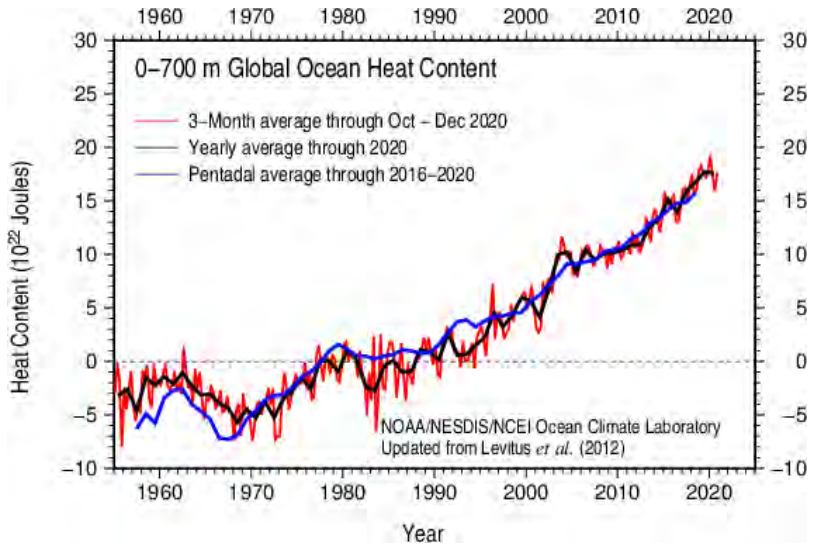
1 2 3 4 5 6 7 8 9 10 11 12 13 14

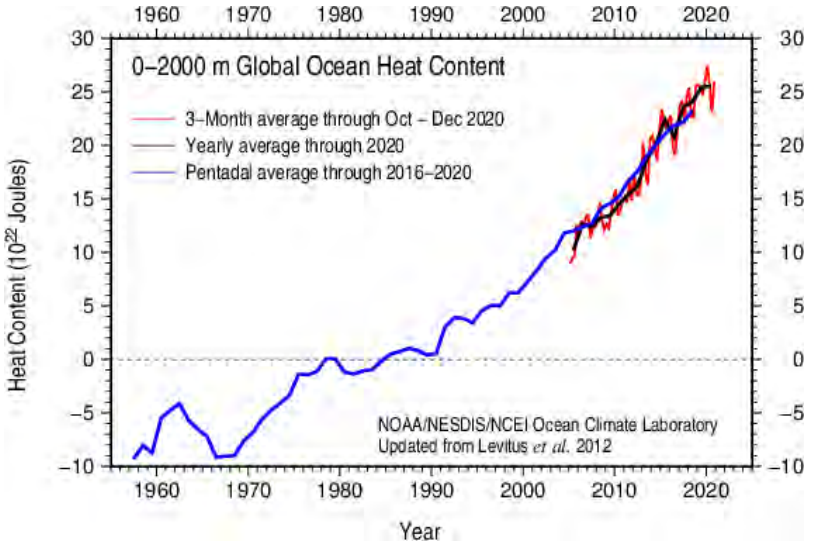
*Notes: Switch to mean anomaly figures / figures with error bars

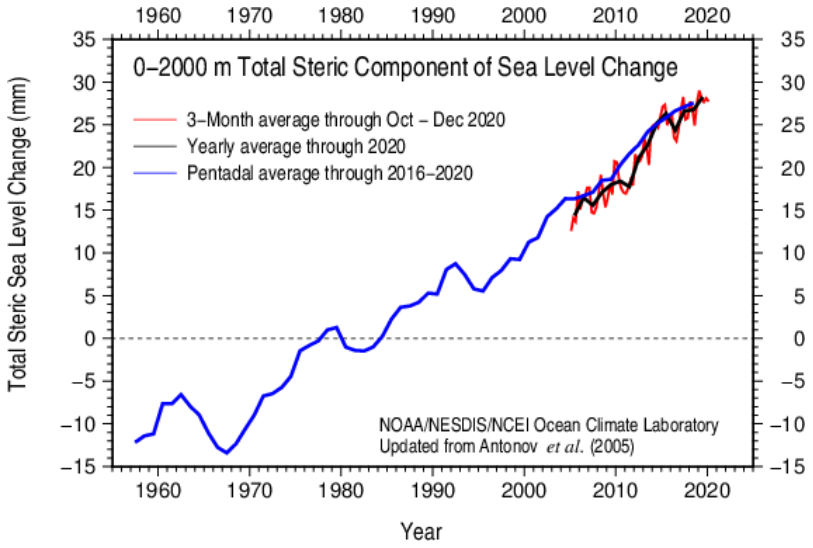
1. Global Heat Content (0-700 meters) layer
2. Global Heat Content (0-2000 meters) layer
3. Comparison of Global Heat Content 0-700 meters layer *vs.* 0-2000 meters layer

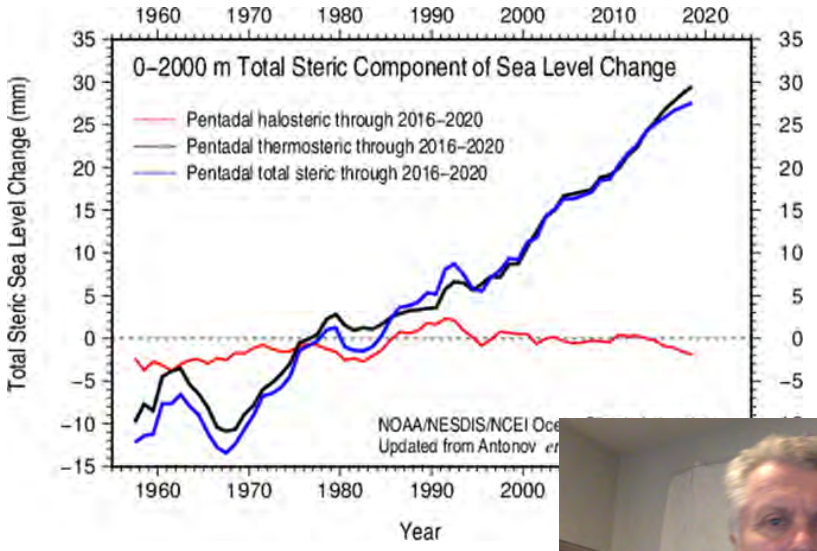
https://www.ncei.noaa.gov/access/global-ocean-heat-content/

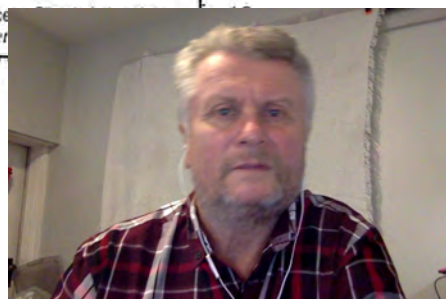
WOD: Deliverables -> OHC and Sea level





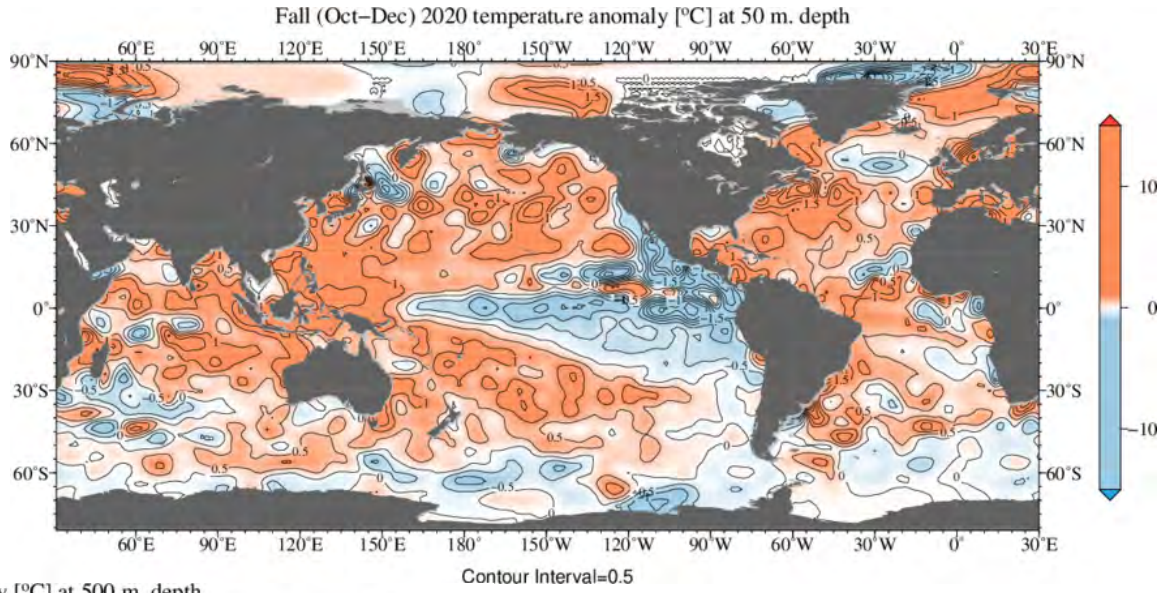


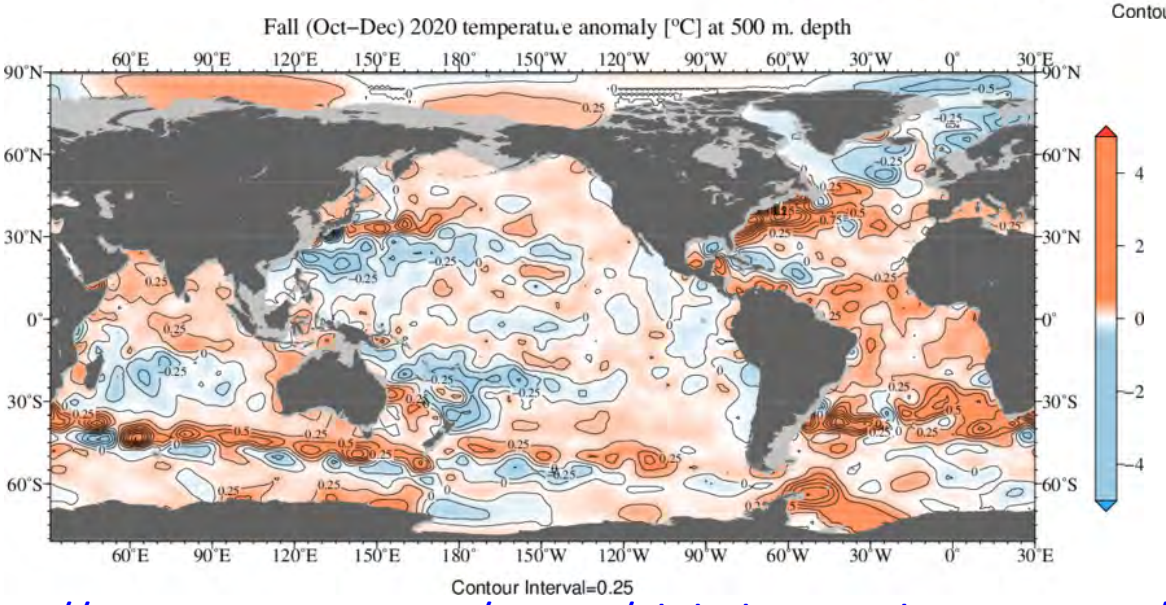




https://www.ncei.noaa.gov/access/global-ocean-heat-content/

WOD: Deliverables -> T anomalies

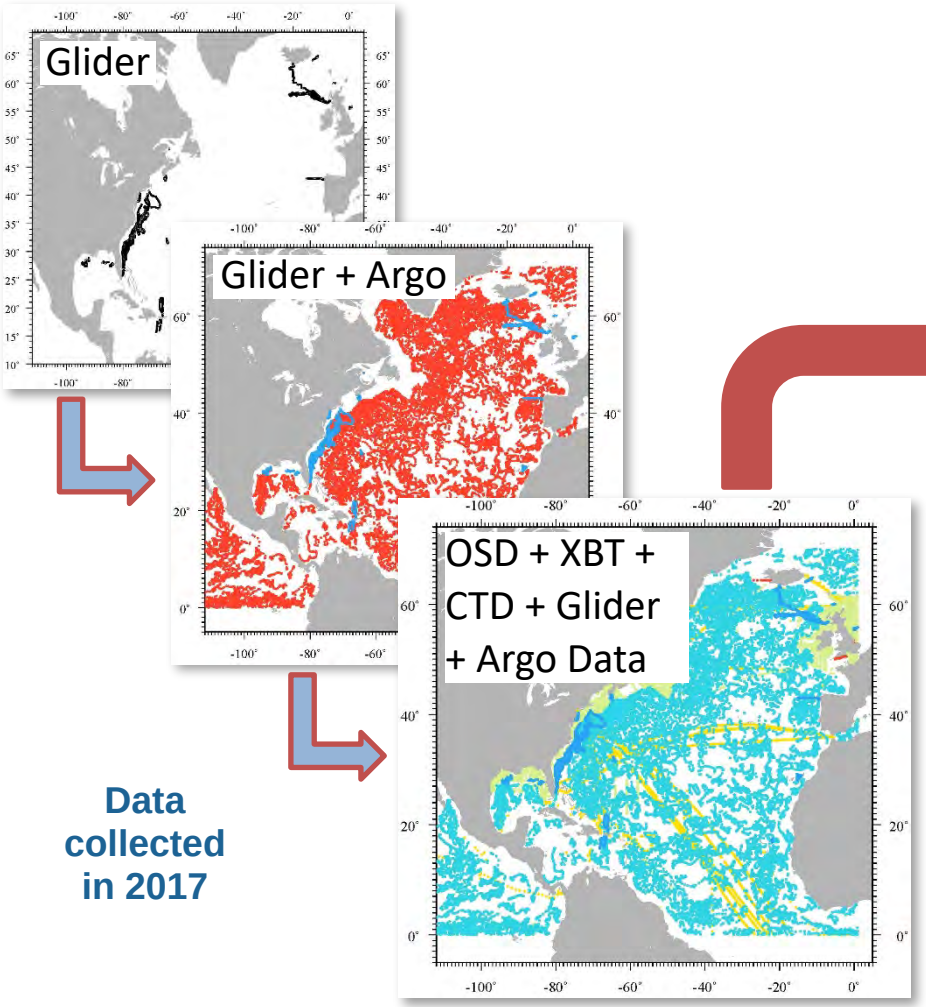




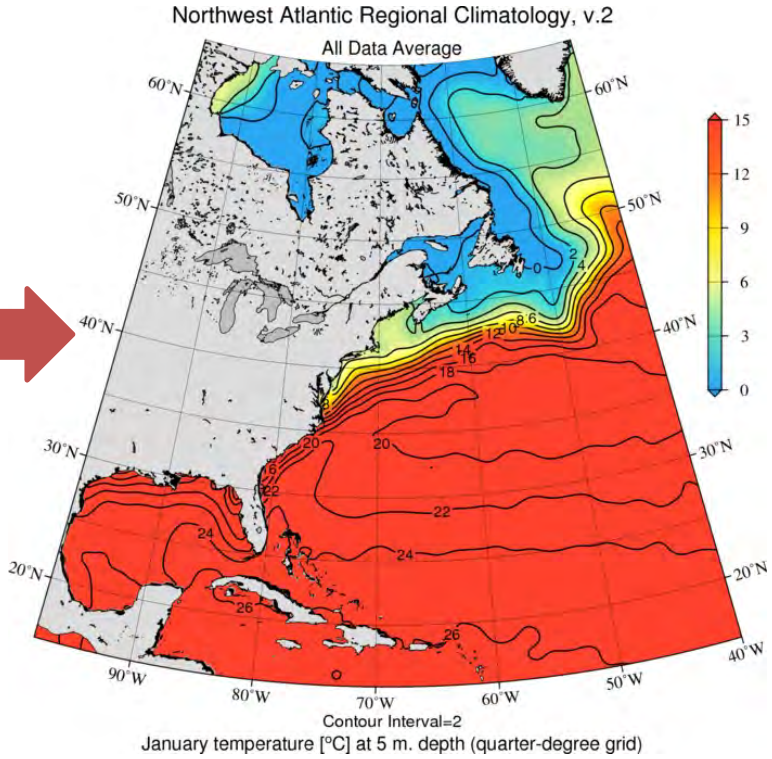
https://www.ncei.noaa.gov/access/global-ocean-heat-content/

WOD: data synergy

Combining data from different sources and platforms into the single entity (WOD) allows comprehensive data analyses and new products development and publication (High-Resolution Regional Climatologies)



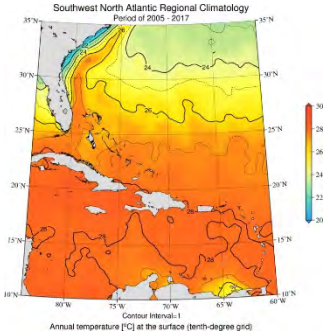
Data collected in 2017

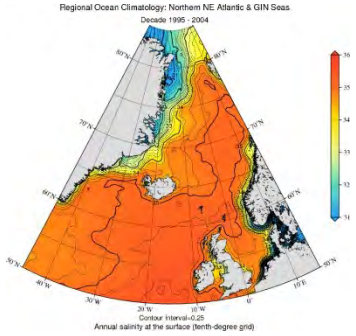


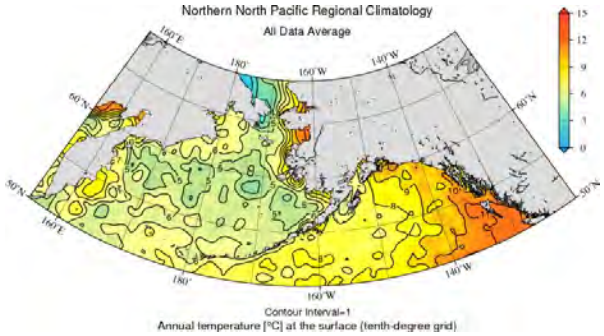
WOD: Deliverables -> RC

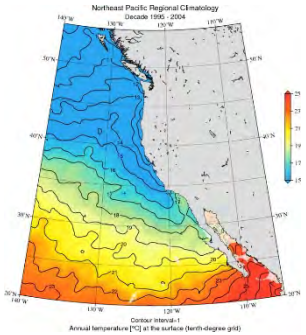
For several regions of the world ocean where data density is sufficient for data analyses on one-tenth-degree grid, the high-resolution **regional climatologies** created.

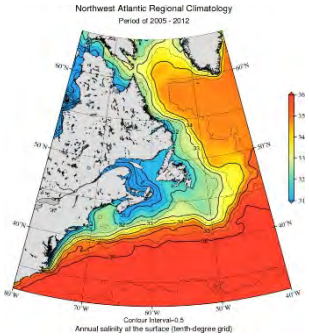
As for now, there are **eight** regional climatologies has been prepared for: Southwest North Atlantic, Greenland-Iceland-Norwegian Seas, Northeast Pacific, Northern North Pacific, Northwest Atlantic, Arctic, East Asian Seas, and Gulf of Mexico.

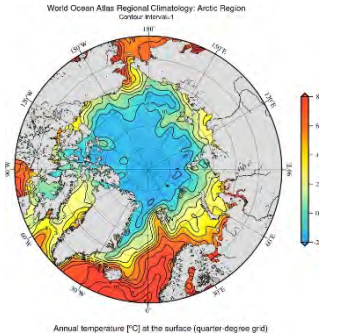


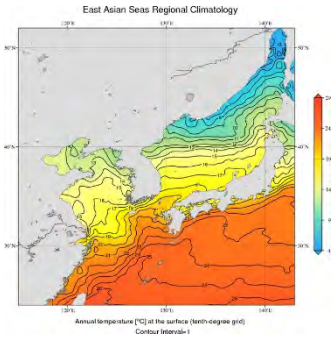


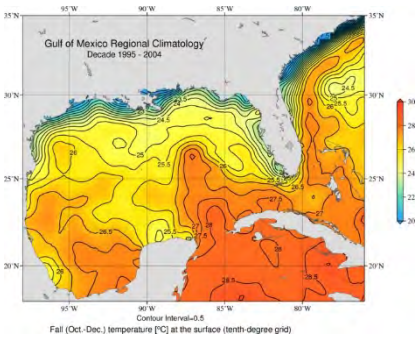






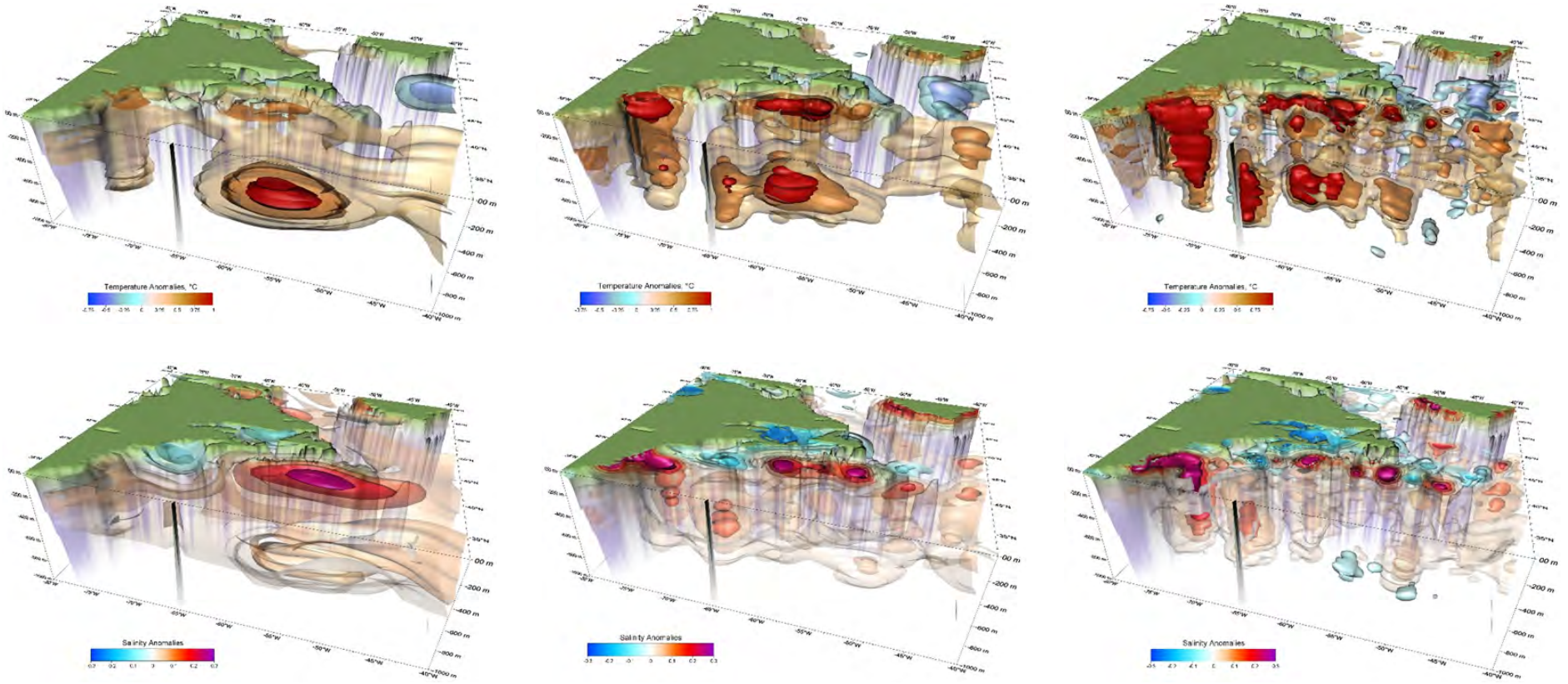






https://www.ncei.noaa.gov/regional-ocean-climatologies

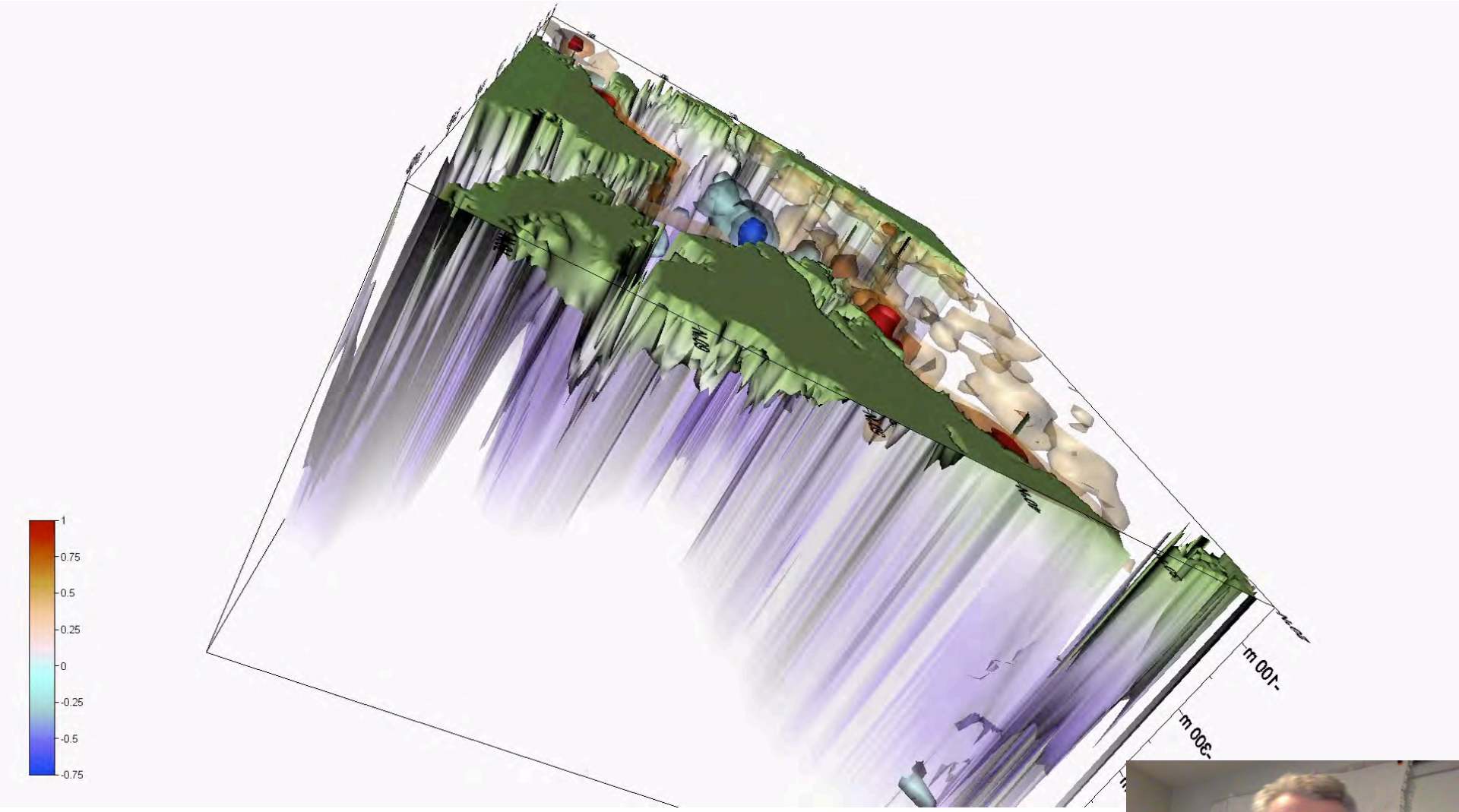
WOD: Deliverables -> 3D analyses

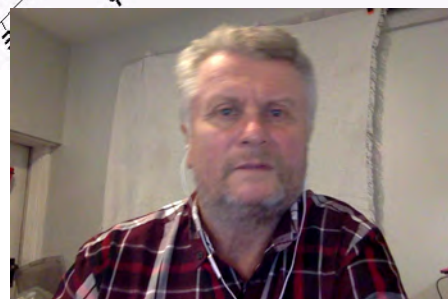


Seawater temperature (top) and salinity (bottom) anomalies between two 30-year ocean climates (1985-2012 minus 1955-1984) within the NWA domain (80°W-40°W, 32°N-65°N) over the 0-1000m depth layer on the 1°, 1/4°, and 1/10° grids. The isothermal surfaces of ΔT = -0.5, -0.25, 0.5, 0.75, and 1°C and isohalines surfaces of ΔS = -0.5, -0.25, 0.5, 0.75, and 1 are shown by different colors.

Seidov et al.(2017), GRL44; doi:10.1002/2017GL073644

WOD: Deliverables, 3D analyses





WOD: Credits

- The **inventors, oceanographers, and engineers** who conceived, designed, and tested the oceanographic instrumentation and measurement techniques are responsible for the plethora and variety of oceanographic data.
- The **primary investigators, marine technicians, ship's crew, and volunteers** who made and continue to make many of the oceanographic measurements, often under harsh conditions, are responsible for the quality and quantity of the oceanographic data.
- The **institutions**, which maintain the platforms and the projects, which plan, fund, and execute the field campaigns and operational ocean monitoring are responsible for the spatial and temporal coverage of the oceanographic profile data.
- The **data managers** are responsible for the preservation and reusability of the data.

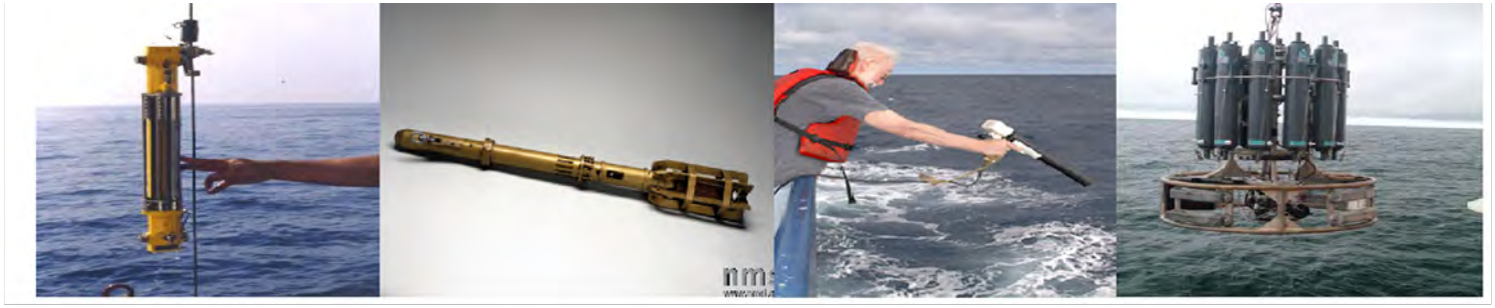
This is a vast network, maintained and updated over time, which should receive the credit for the aggregated WOD. Every cast, which in essence is a central granule of WOD, contains (when supplied) information on the instrumentation, platform, project, institution, and data management entity.

- The archive at NCEI and those who populate and maintain it also deserve credit for the continual availability of historical oceanographic data.
- The **international organizations** such as the Intergovernmental Oceanographic Commission's (**IOC**) International Oceanographic Data and Information Exchange (**IODE**) and the World Data System (**WDS**) for Oceanography should be credited for creating and facilitating a global culture of data exchange and preservation.

Over 40+ years of development more than 17 million casts of oceanographic parameters has been collected, quality controlled and uniformly formatted.

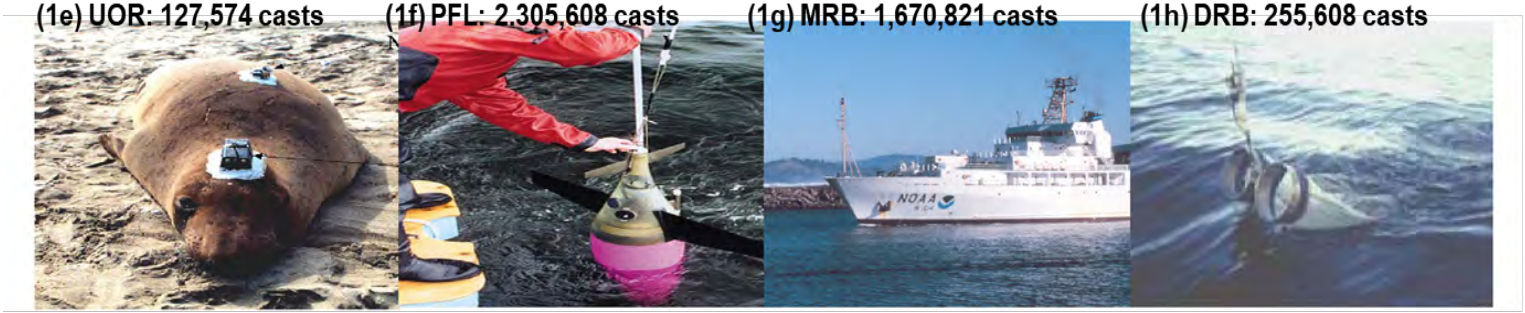
The WOD makes these data available for all to work with confidence and convenience

WOD: Thank You!



(1a) OSD: 3,233,756 casts (1b) MBT: 2,426,301 casts (1c) XBT: 2,337,800 casts (1d) CTD: 1,095,334 casts

(1e) UOR: 127,574 casts (1f) PFL: 2,305,608 casts (1g) MRB: 1,670,821 casts (1h) DRB: 255,608 casts



(1i) APB: 1,940,844 casts (1j) GLD: 1,733,012 casts (1k) SUR: 9,284 cruises (1l) Plankton: 243,374 casts

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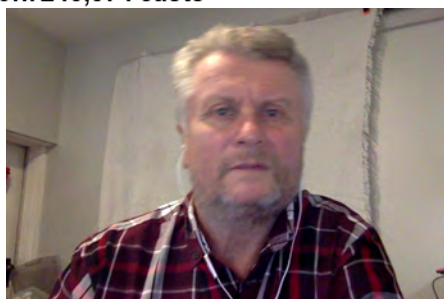

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