ФИЗИЧЕСКИЕ ПАРАМЕТРЫ ОКЕАНА: ИЗМЕРЕНИЕ, ПРОГНОЗЫ, ГЛОБАЛЬНЫЕ ТЕНДЕНЦИИ

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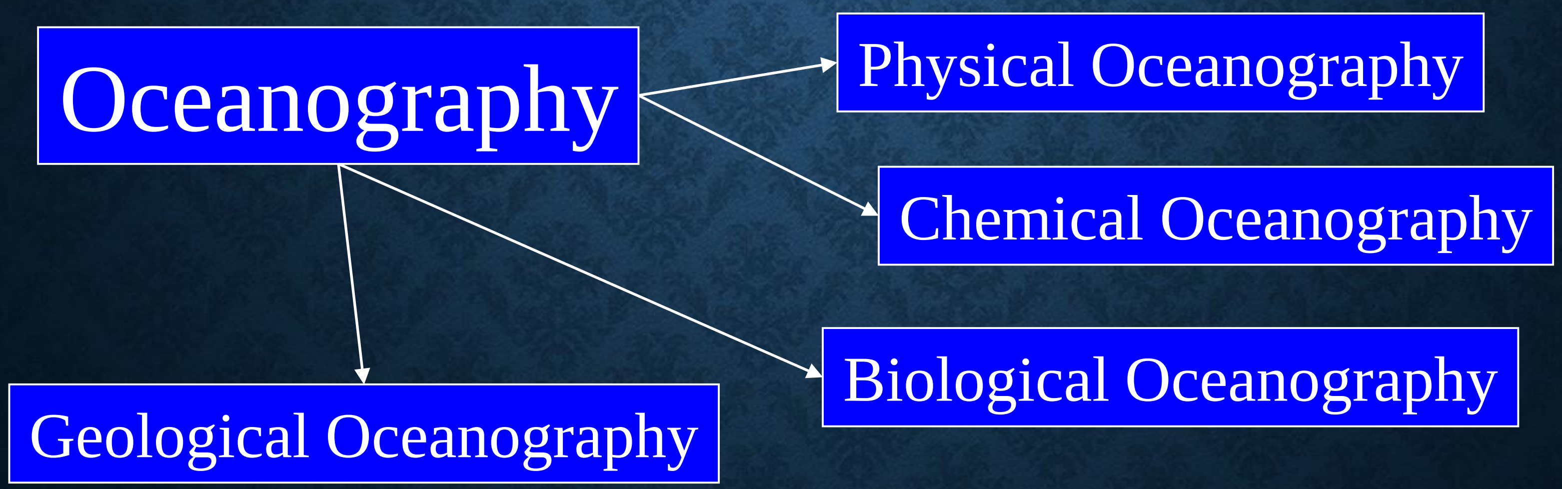
OUTLINE

- Physical Oceanography – what is it?
- Hydrosphere
- In situ Data Acquisition.
- Historical Oceanographic Data Storages.
- Major Findings based on in situ Data
- Operational Forecasting
- Long - Term Changes

- Physical oceanography is the study (לימוד) of physical conditions and physical processes within the ocean, especially the motions and physical properties of ocean waters.

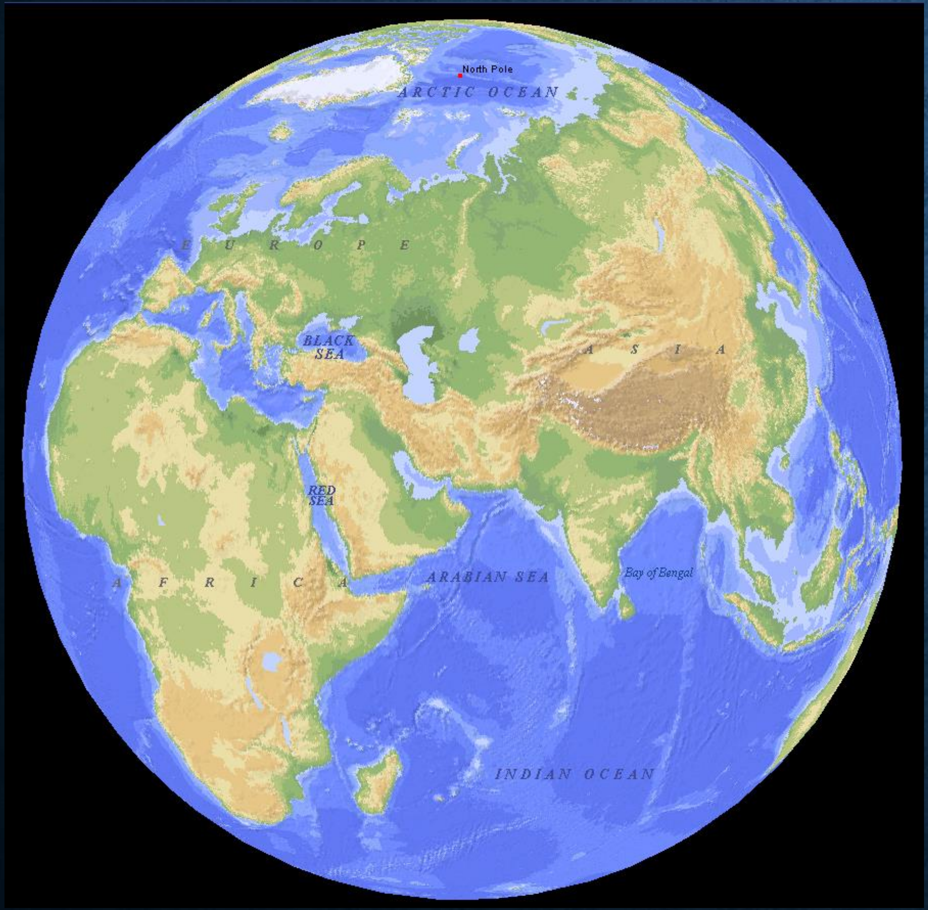
- Physical oceanography is one of several sub-domains (תת-תחומים) into which ***oceanography*** is divided
- Oceanography – scientific study of the oceans.

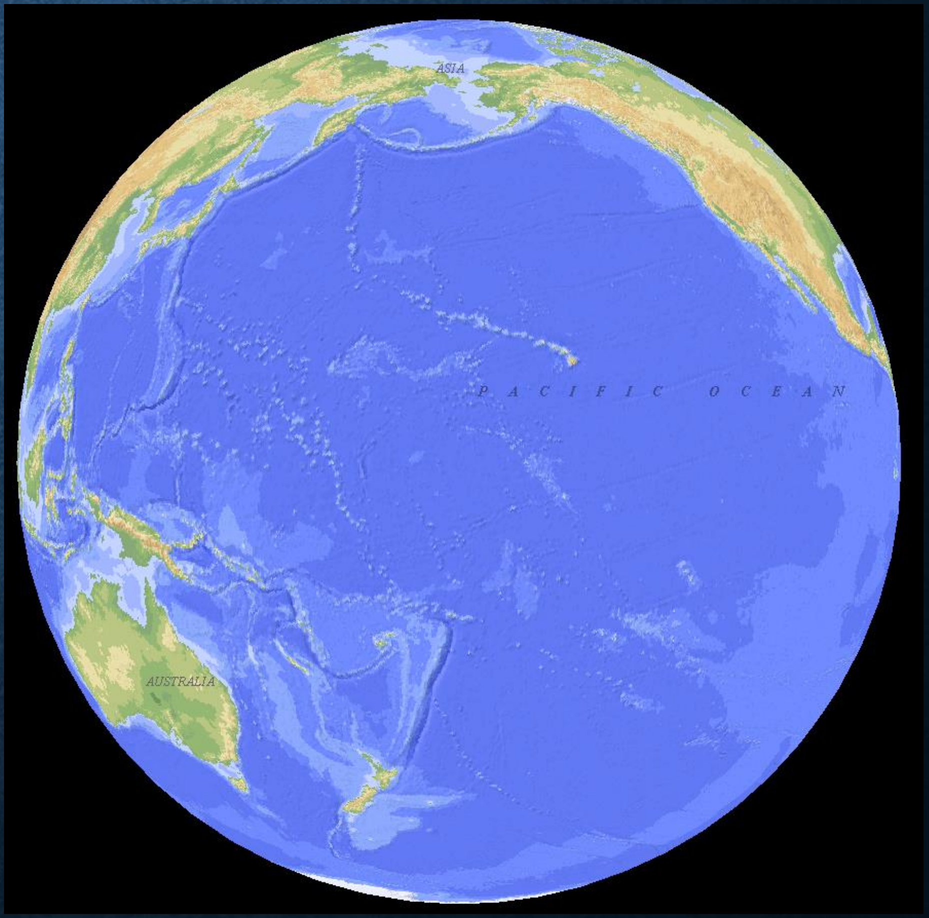


BASIC GOAL OF PHYSICAL OCEANOGRAPHY

- The basic goal of oceanography is to obtain a clear and systematic description of the oceans, sufficiently quantitative (כמותי) to permit us to predict their behavior in the future with some certainty.
- To achieve this goal the study of Physical Oceanography is divided into sub-disciplines (תת-נושאים):
  - Physical properties of sea water
  - Air-Sea Interaction (השפעה הדדית)
  - Ocean motions such as Currents, Water Mixing, Sea Level Changes, and Waves.

VIEW OF THE EARTH





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OCEAN DIMENSIONS AND SHAPES

- Proportion **water:land**

southern hemisphere **4:1**

northern hemisphere **1.5:1**

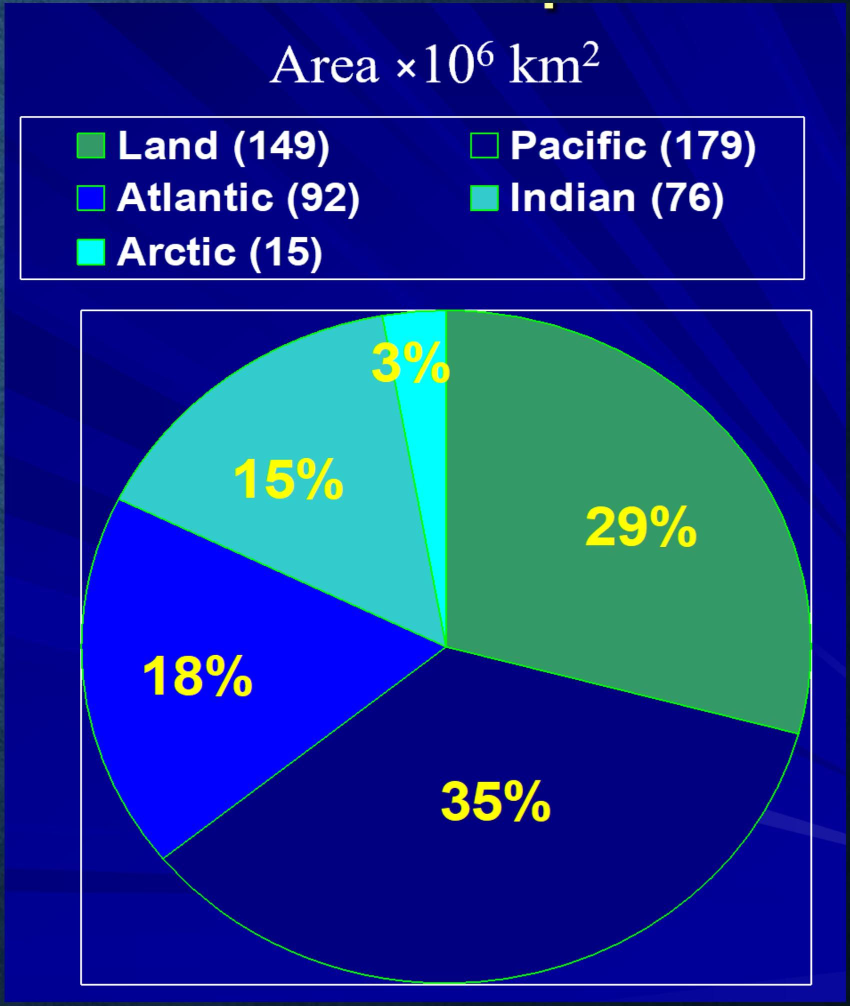
- Pacific ≈ Atlantic + Indian
- Average depth of oceans ≈ **4000 m**, Horizontal dimensions

(מידות אופקיות)

5000-15000 km

- Oceans very thin relative the Earth dimension

אם נקבץ את כדור הארץ לגודל של כדור
רגל עובי של שכבת האוקיאנוסים
תהיה כעובי דף נייר



TWO APPROACHES IN PHYSICAL OCEANOGRAPHY

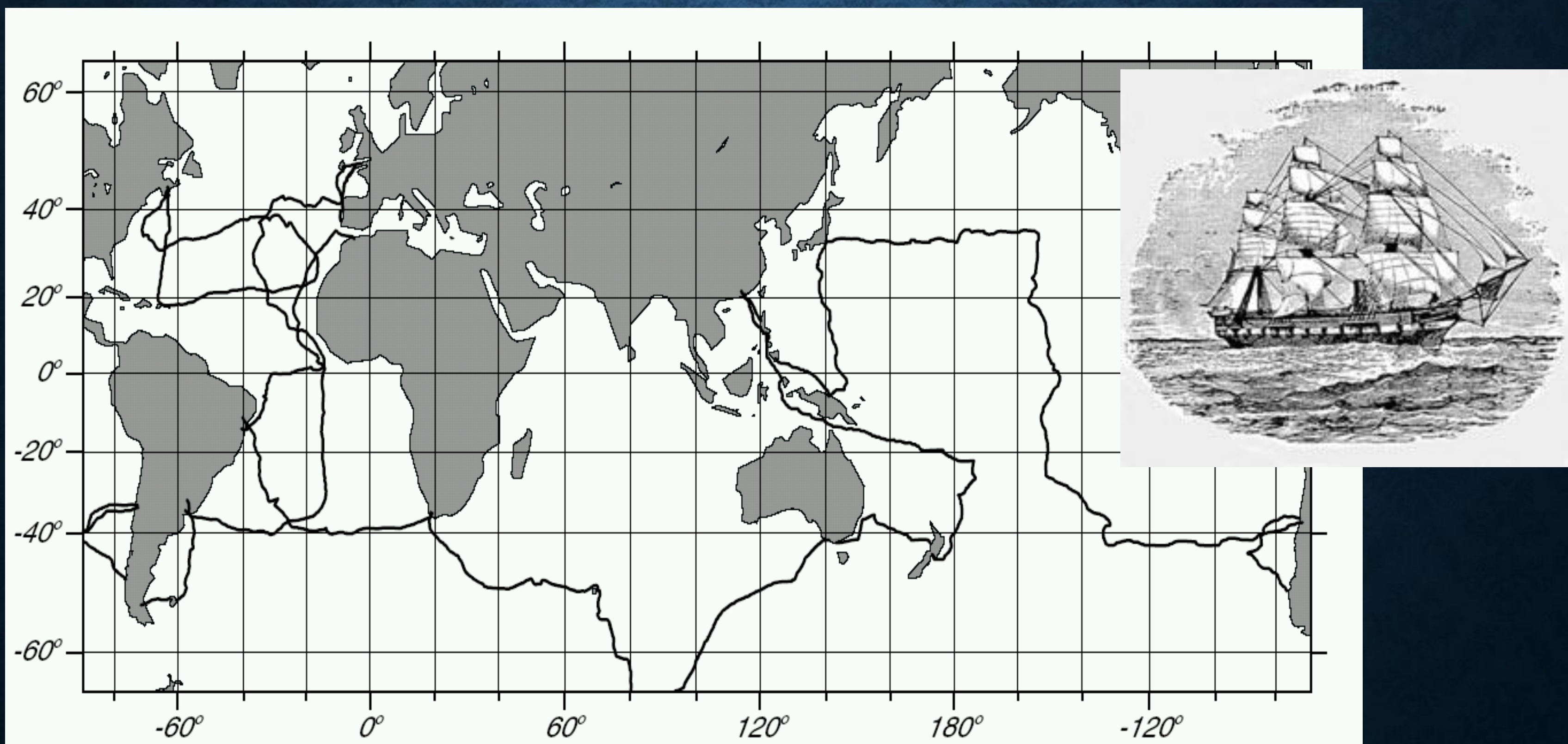
- Descriptive approach: from observation to regularities (סדירות) and parametrization

- Theoretical approach: implementation of physical laws to the ocean environment

(הטמעת חוקים פיזיקאליים לסביבה ימית)

OBSERVATIONS: FROM TRADE AND WAR SHIPS TO OCEANOGRAPHIC SHIPS

Track of H.M.S. Challenger during the British Challenger Expedition 1872–1876. After Wust (1964).

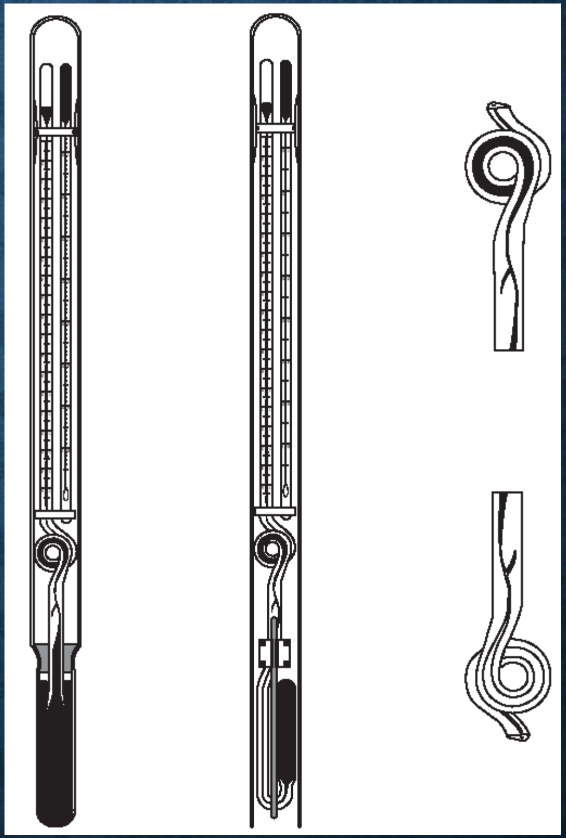


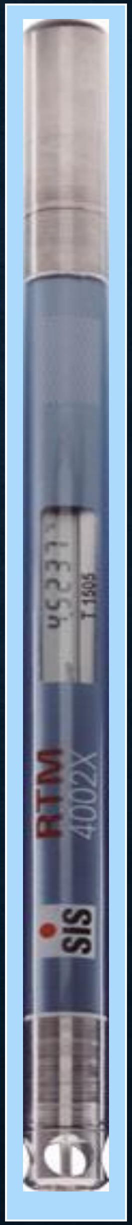
TYPICAL EQUIPMENT FOR MULTI-BOTTLE CAST

- Nansen water bottles before (I), during (II), and after (III) turning
- Niskin bottle, GO bottle

TYPICAL EQUIPMENT OF *T*,S MEASUREMENTS

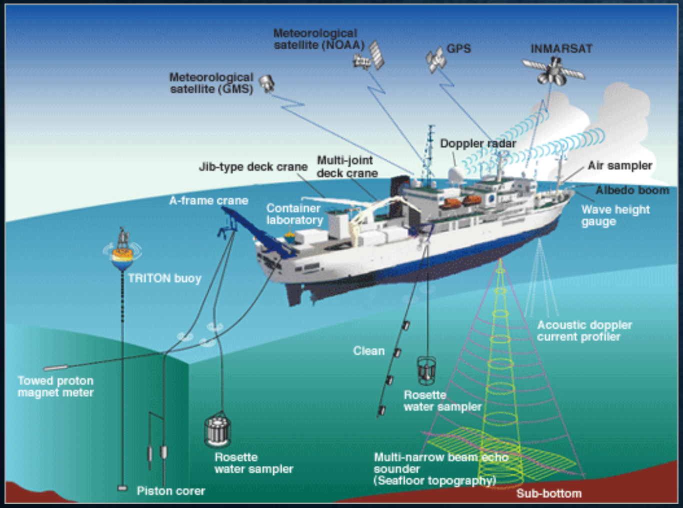
- Reversing thermometers
- Salinometers

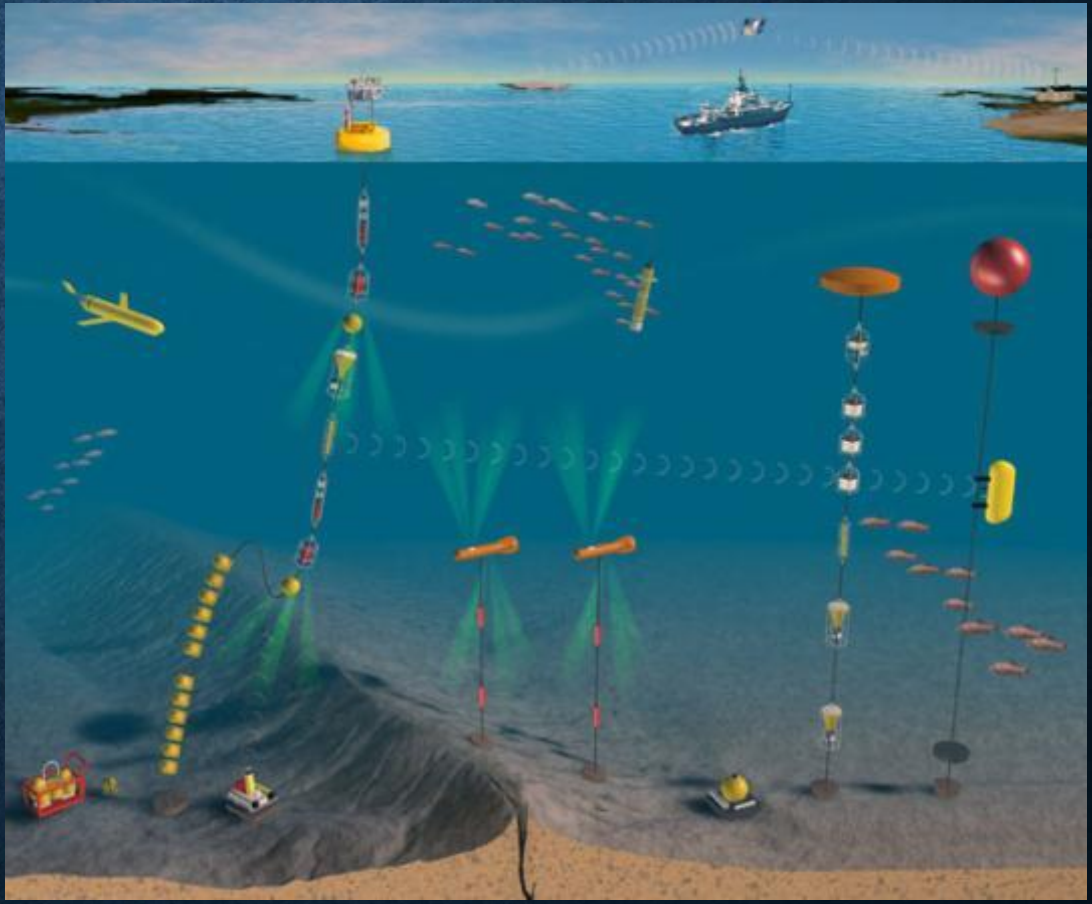




OCEANOGRAPHIC IN SITU DATA ACQUISITION

- Research Vessels
- Coastal Stations
- Moorings
- Autonomous systems





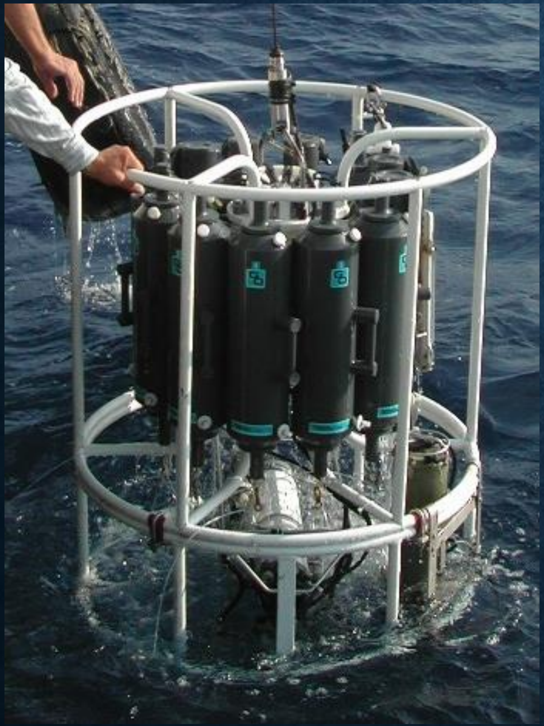
CTD
CONDUCTIVITY-TEMPERATURE-DEPTH PROBES

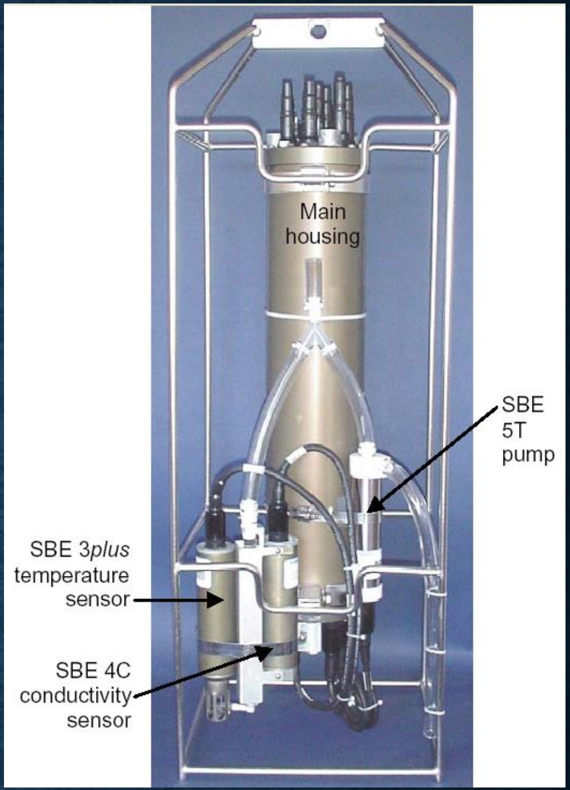
Neil Brown Instrument System
Mark III CTD (1980-1990)

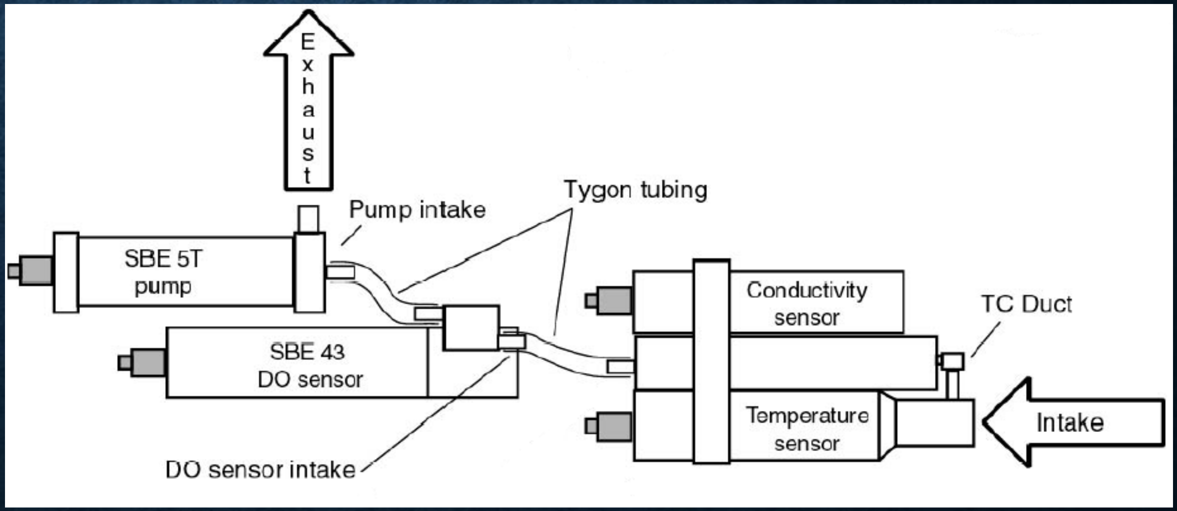
Soviet CTD ZOND-BATHOMETER
(1980-1990)

SEA BIRD CTD + ROSETTA

- CTD Conductivity-Temperature-Depth probes

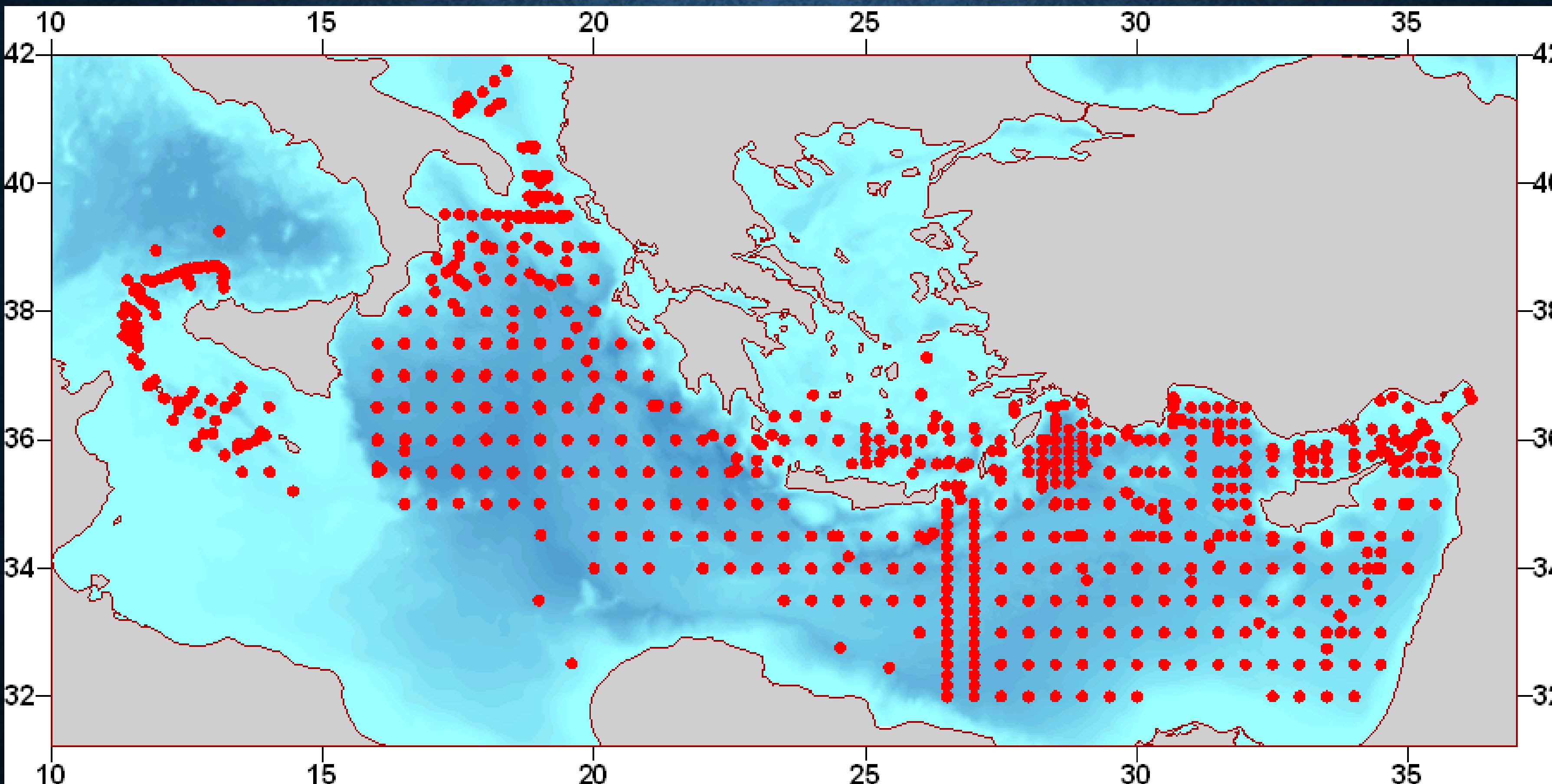




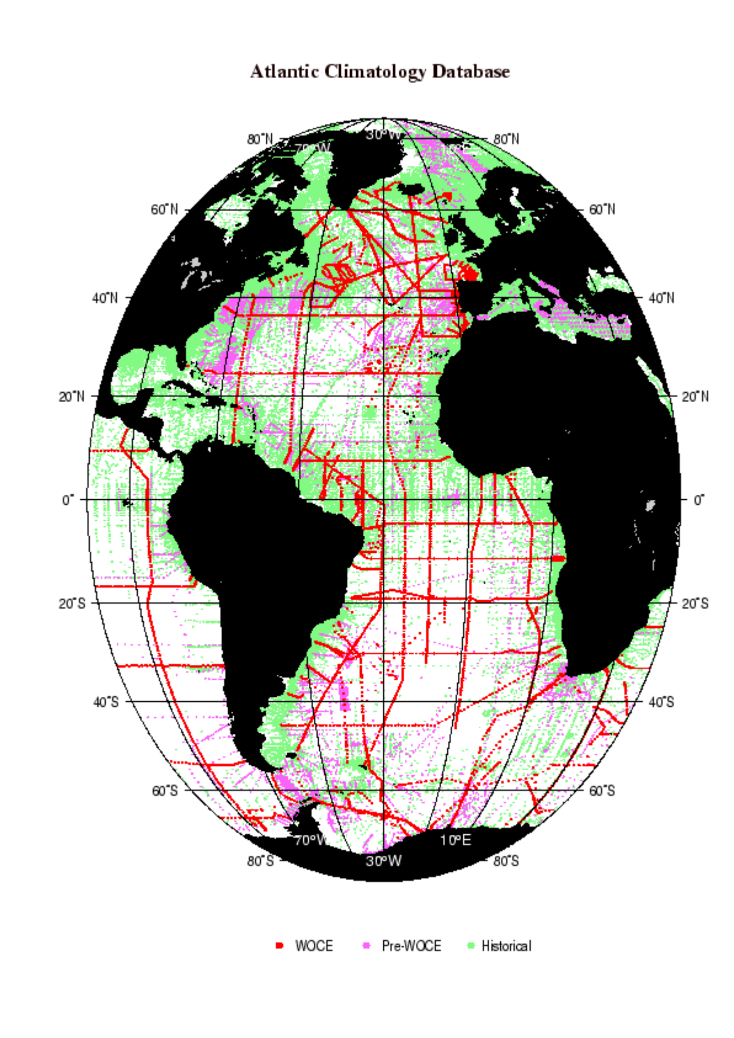


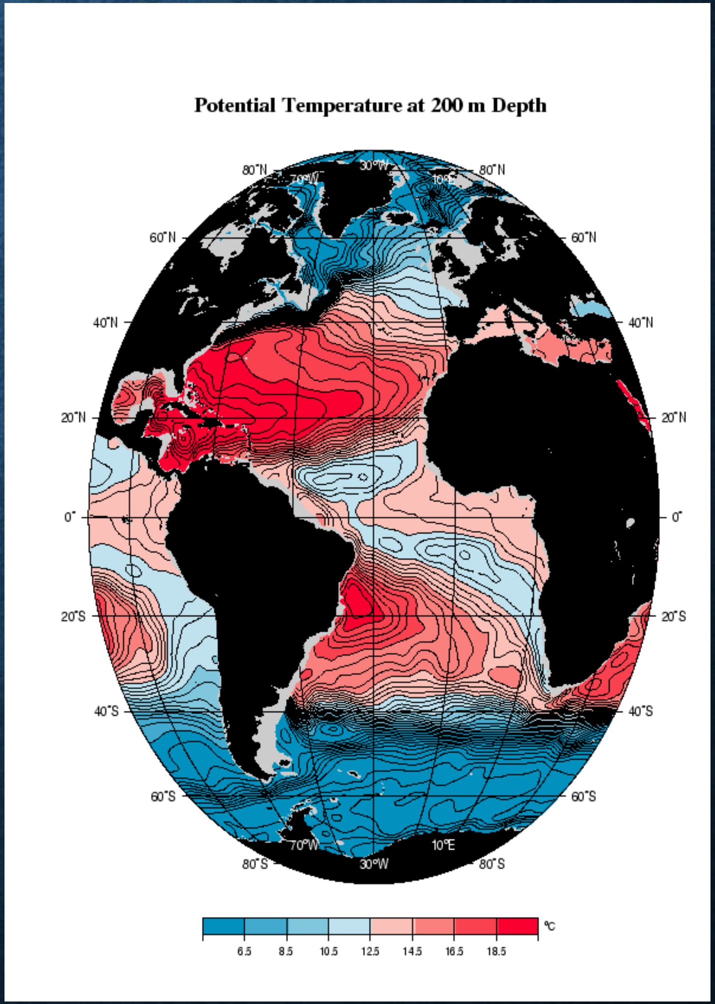
CTD CAST FROM R/V METEOR

Physical Oceanography of the Eastern Mediterranean Experiment (POEM) Casts Location (Germany, Greece, Israel, Italy, Turkey (1986-1990)

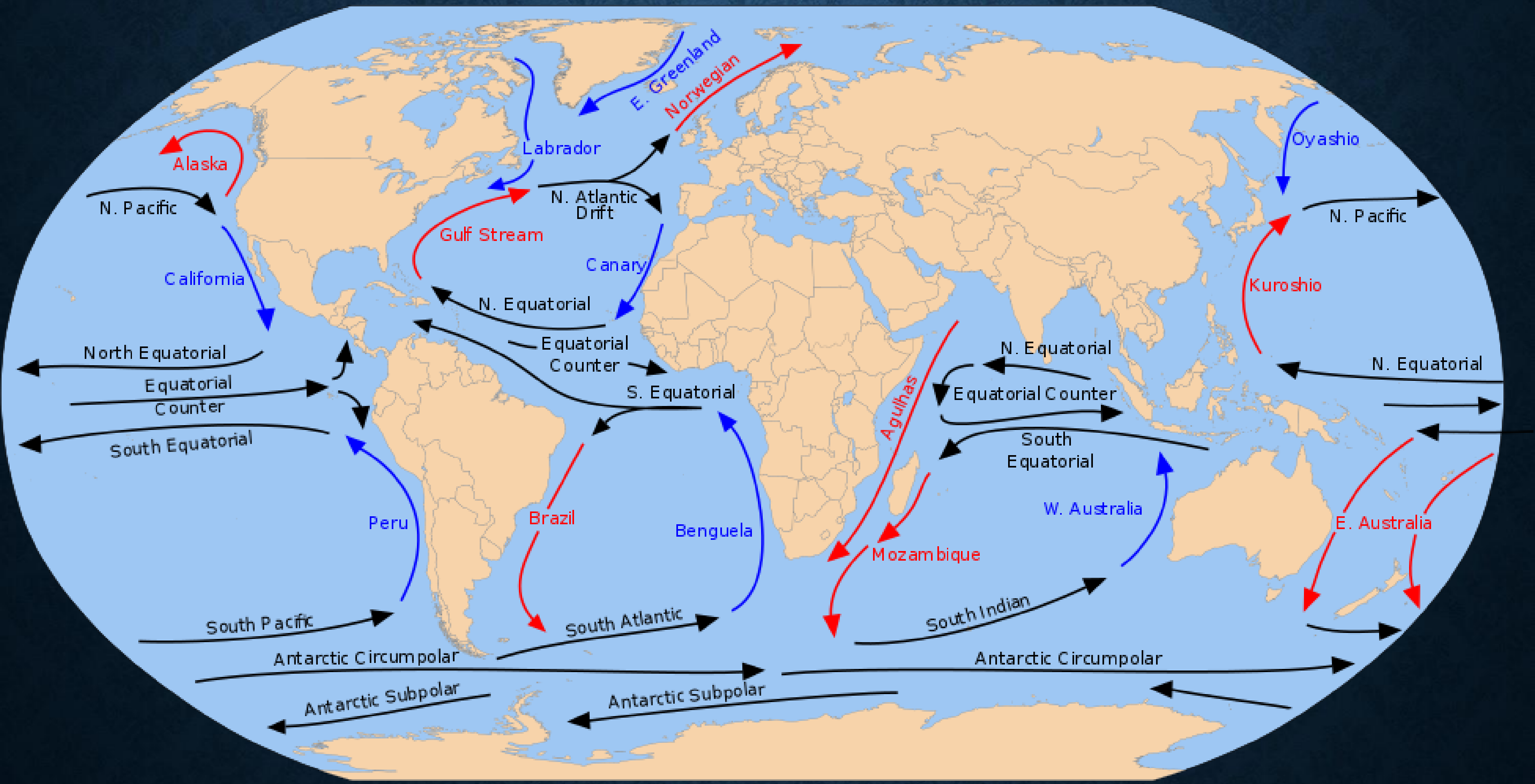


CLIMATOLOGICAL DESCRIPTION DERIVED FROM HISTORICAL COLLECTION OF OCEANOGRAPHIC CASTS IN ATLANTIC (LEVITUS, 1990)

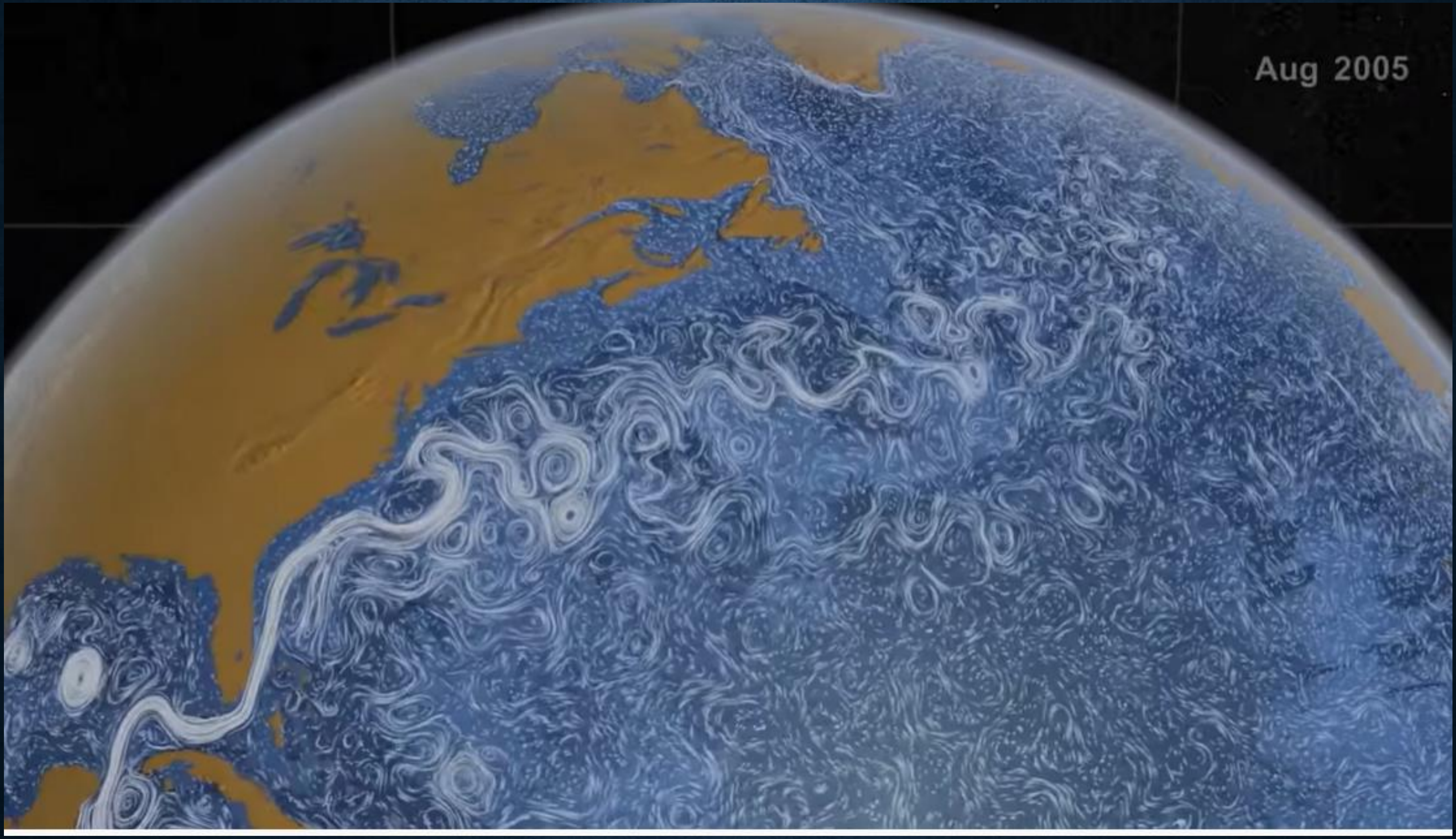




Generalized ocean surface currents



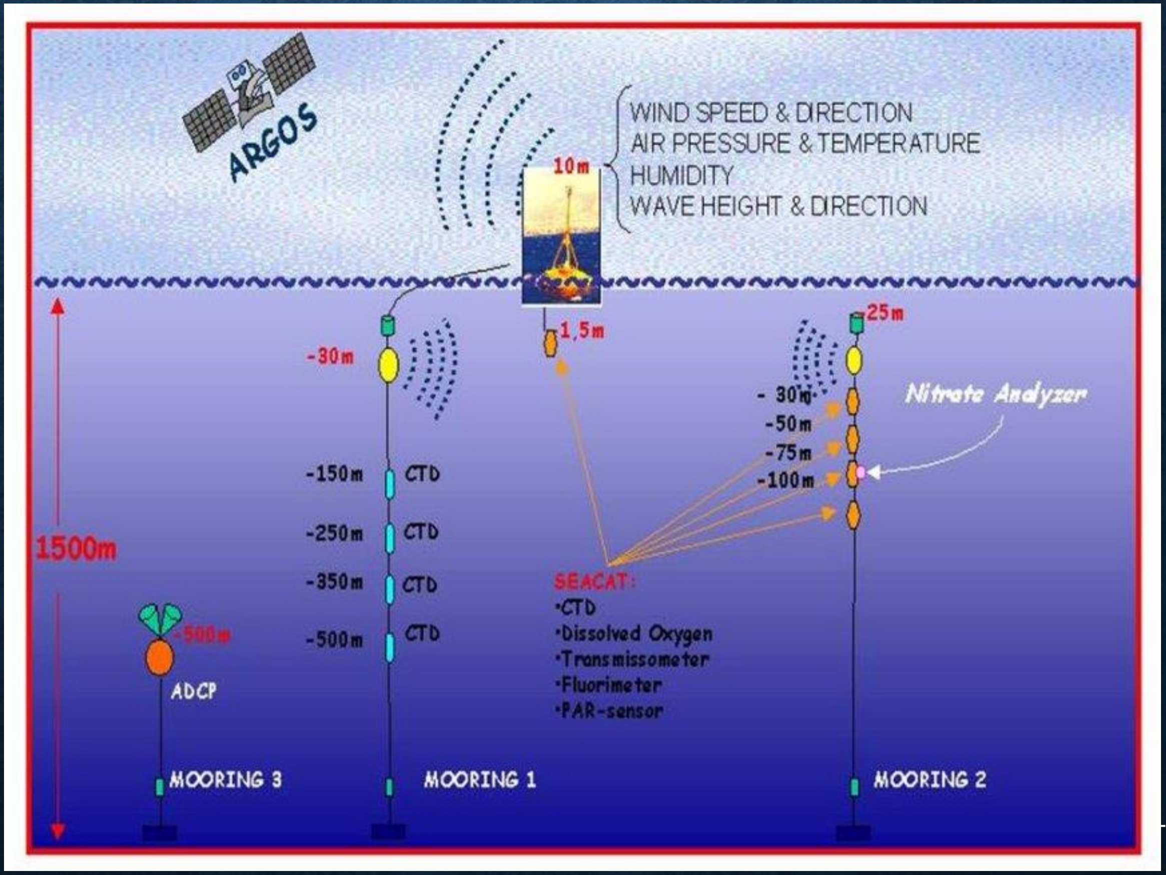
https://www.youtube.com/watch?v=CCmTY0PKGDs



MODERN OCEANOGRAPHIC OBSERVATIONS

(CURRENT STAGE - השלב הנוכחי)

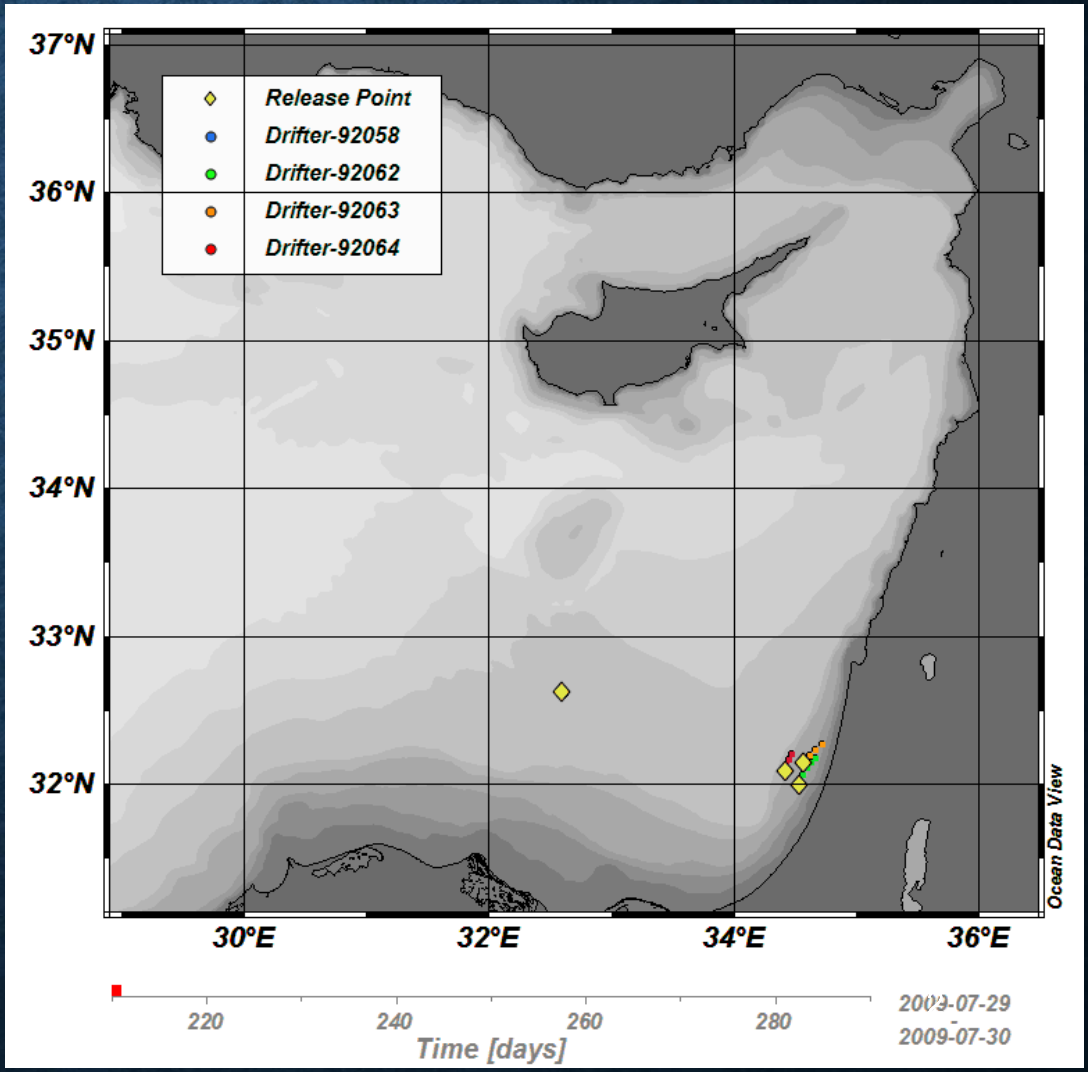
- Observation from autonomous (אוטונומי) sea and space platforms.



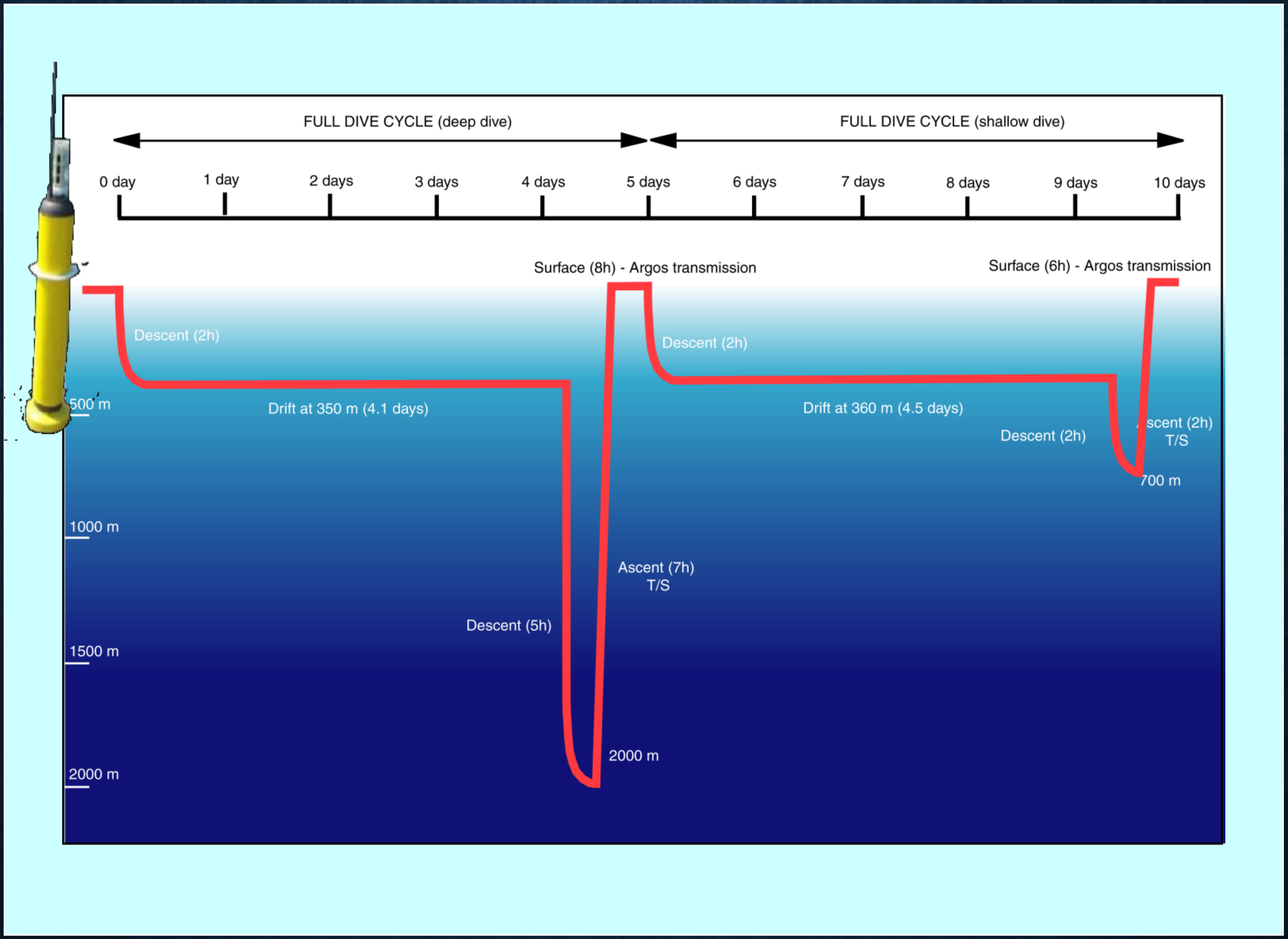
DRIFTERS TRAPPED BY SHIKMONA EDDY SUMMER 2009

Drifters - Lagrangian current meters.

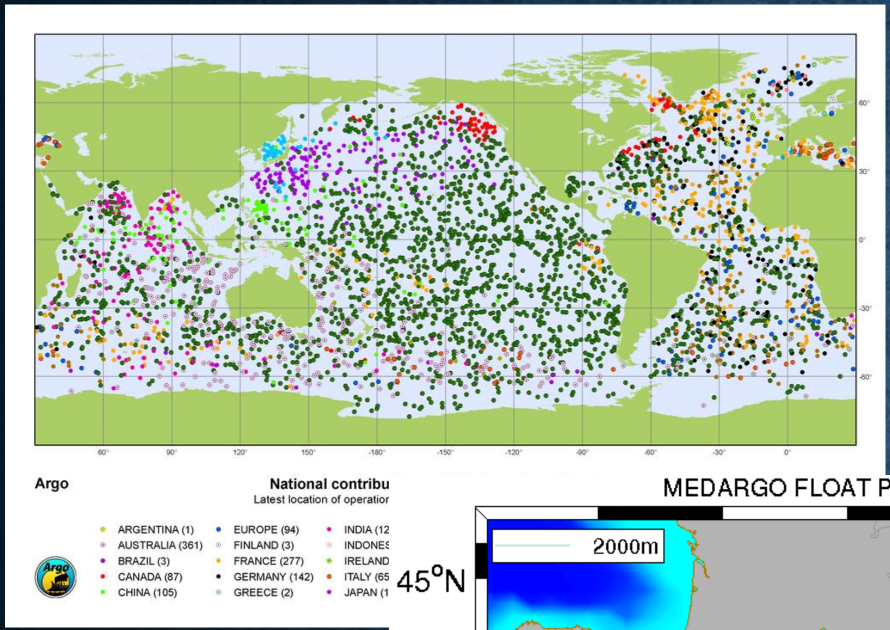
(Anchored Buoy station - Eulerian current meters.)

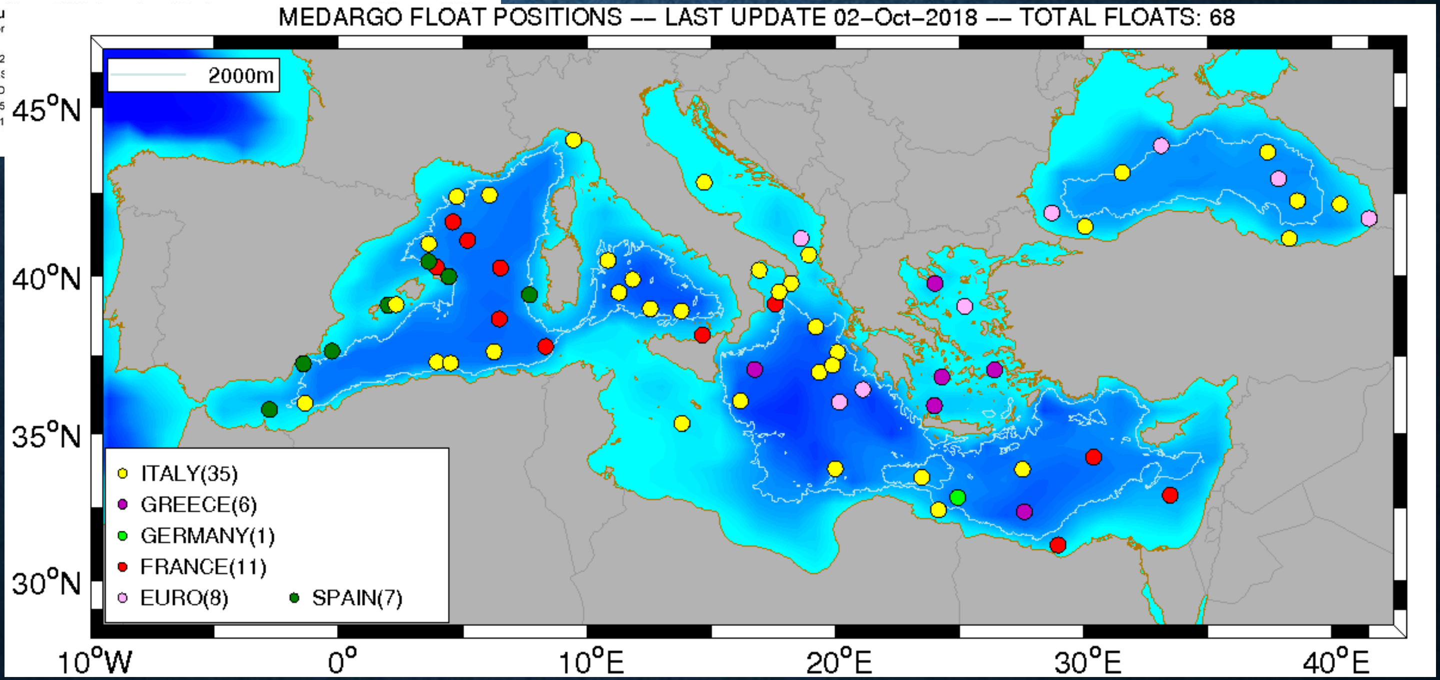


Argo Floats – Regular diving & Sampling Characteristics



The International Argo Programme



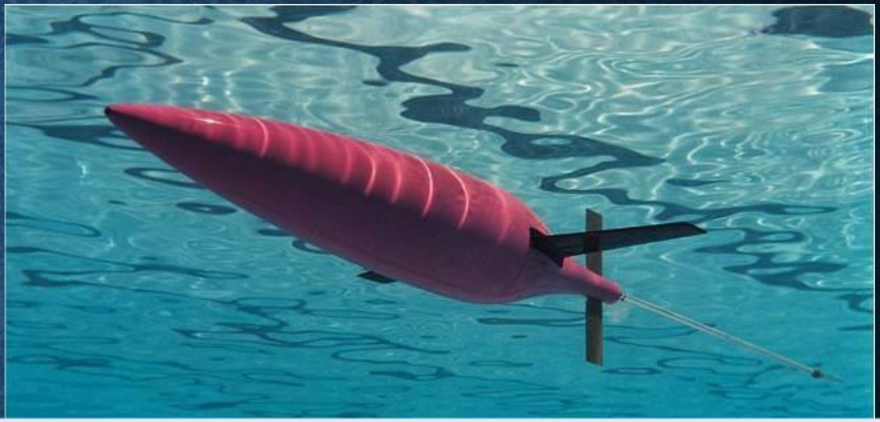


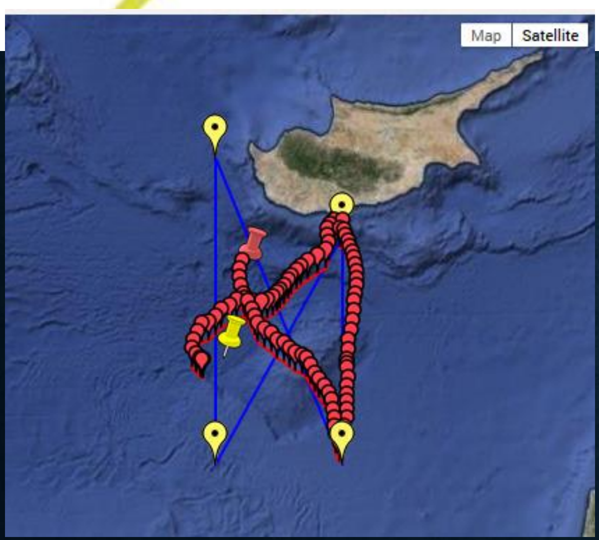
Expected result:

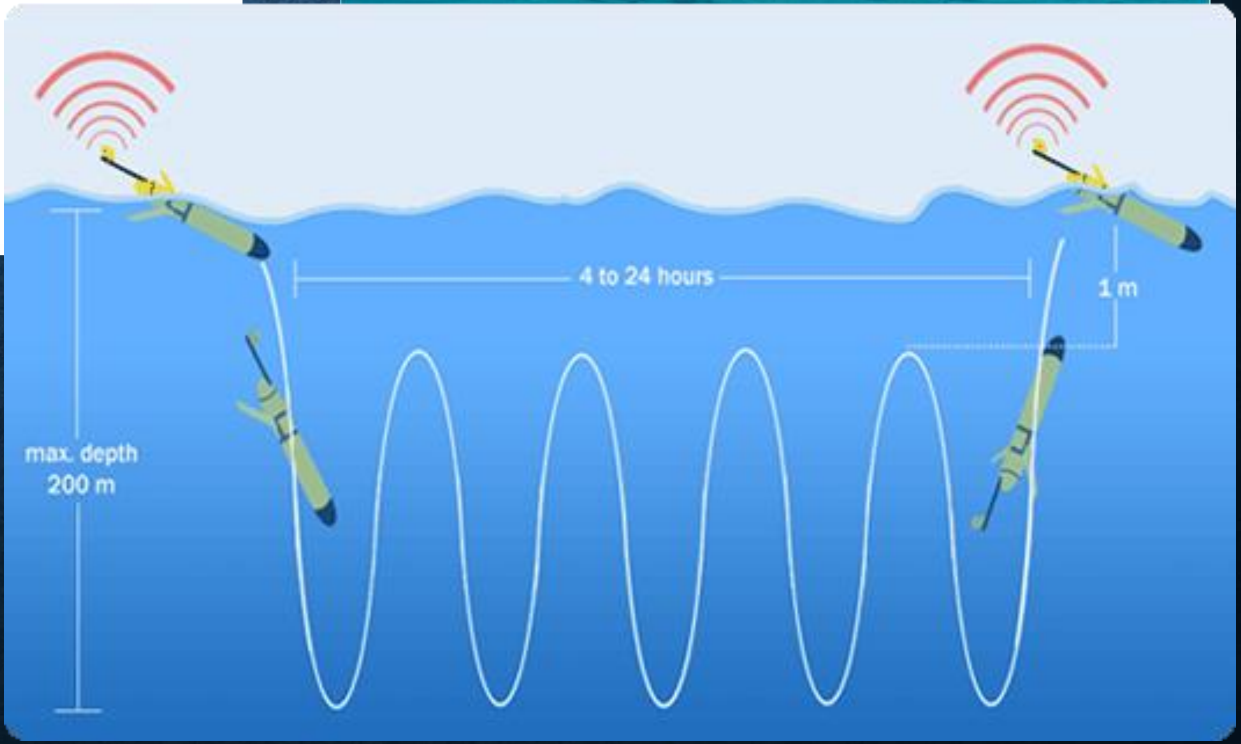
Short term and Long term

Ocean forecasts.

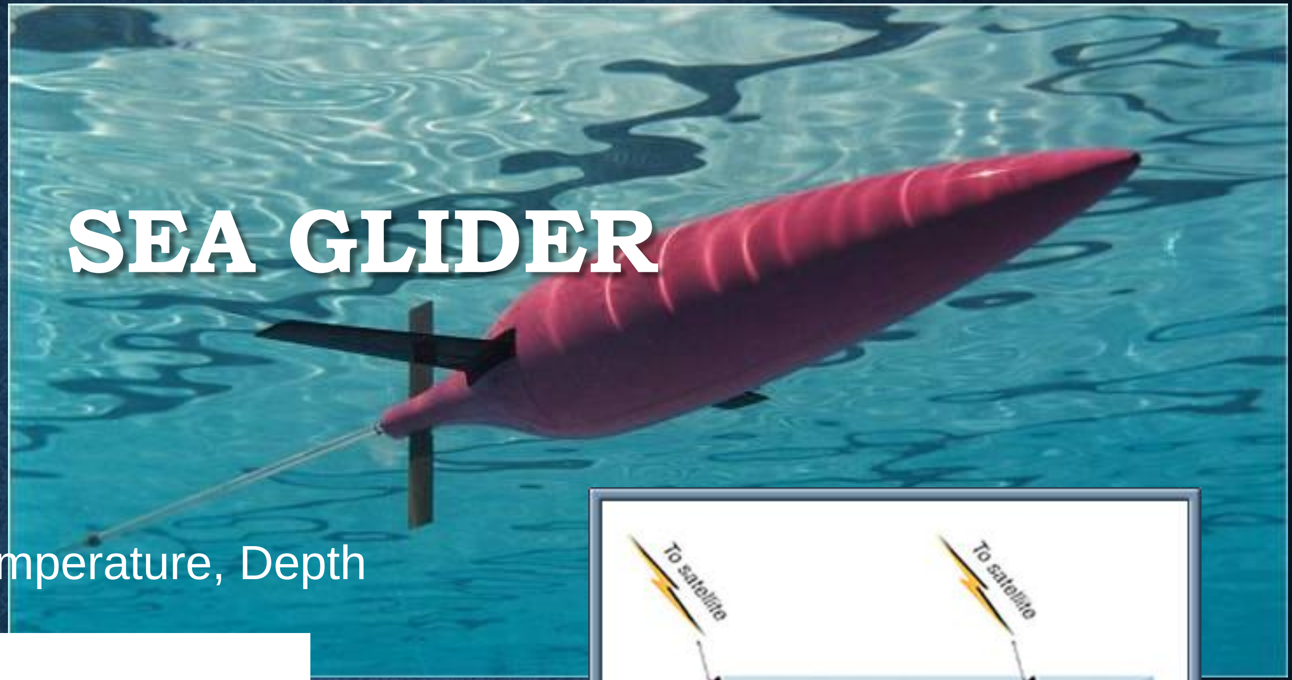
GLIDERS FOR OCEAN OBSERVATORIES



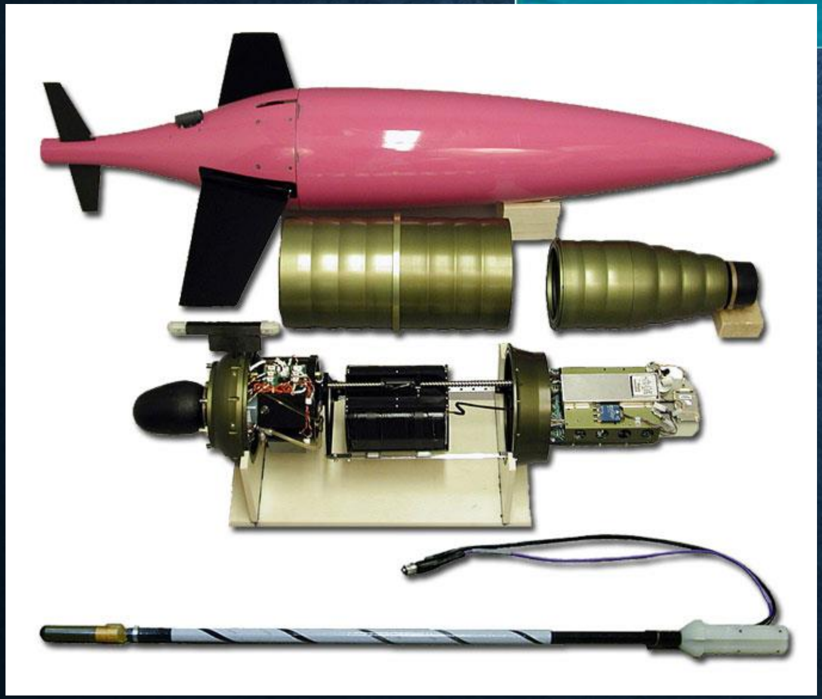


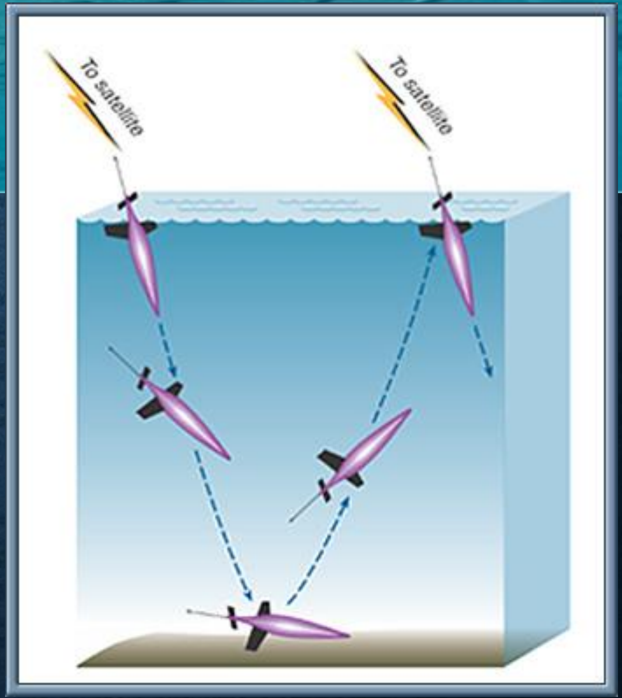


SEA GLIDER



Observations of
CTD – Conductivity, Temperature, Depth





Chemical measurements from a boat are still more accurate

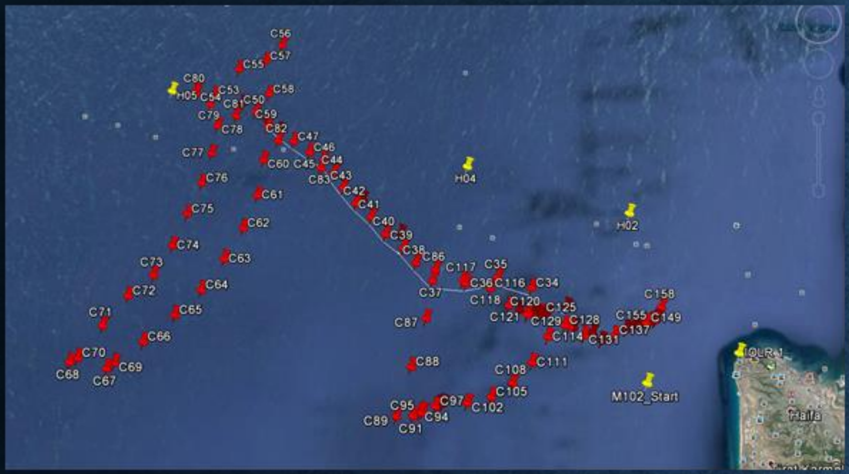
GENERAL FEATURES

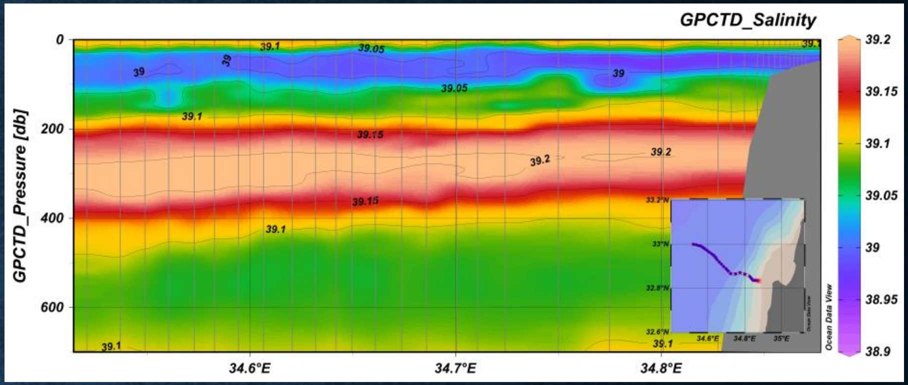
- Depth coverage: 30-700 meters.
- Horizontal coverage: 20-25 Km per day.
- Endurance: up to 2 months.
- Rechargeable Lithium batteries.
- Deployable from small boats (<7 m).
- Interchangeable Science payload.
- Real-time data via iridium satellite Com.

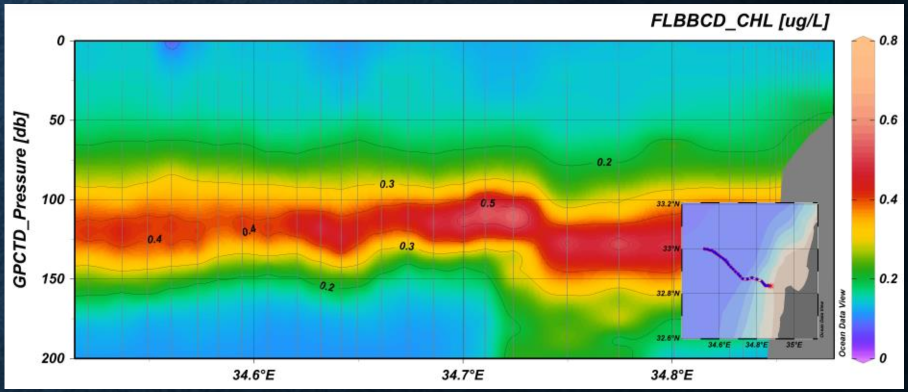
THE ISRAELI SCIENCE PAYLOAD SETUP

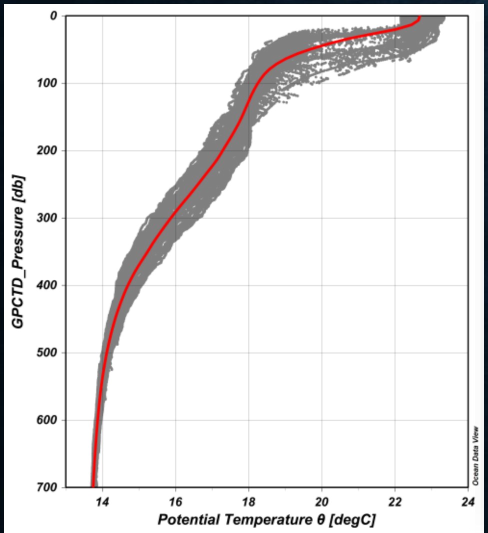
- SeaBird GPCTD – Conductivity (Salinity), Temperature & Depth (pressure)
- SeaBird Dissolved Oxygen.
- Wetlabs Triplet – Chlorophyll, Scattering, CDOM.
- Alseamar MiniFluo UV – Hydrocarbons.

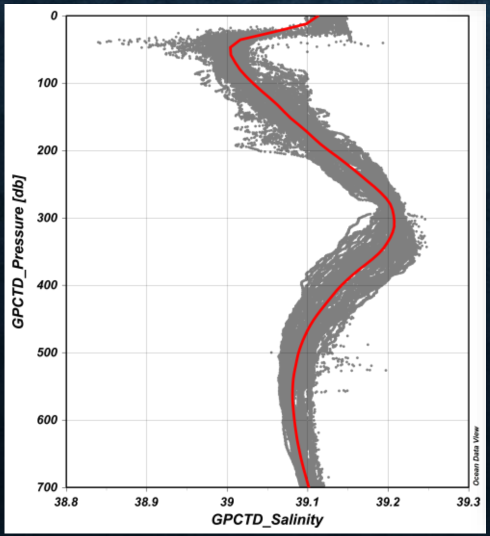
DATA EXAMPLE

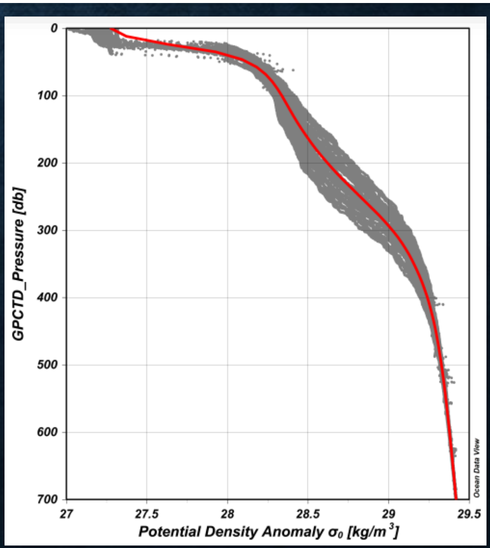








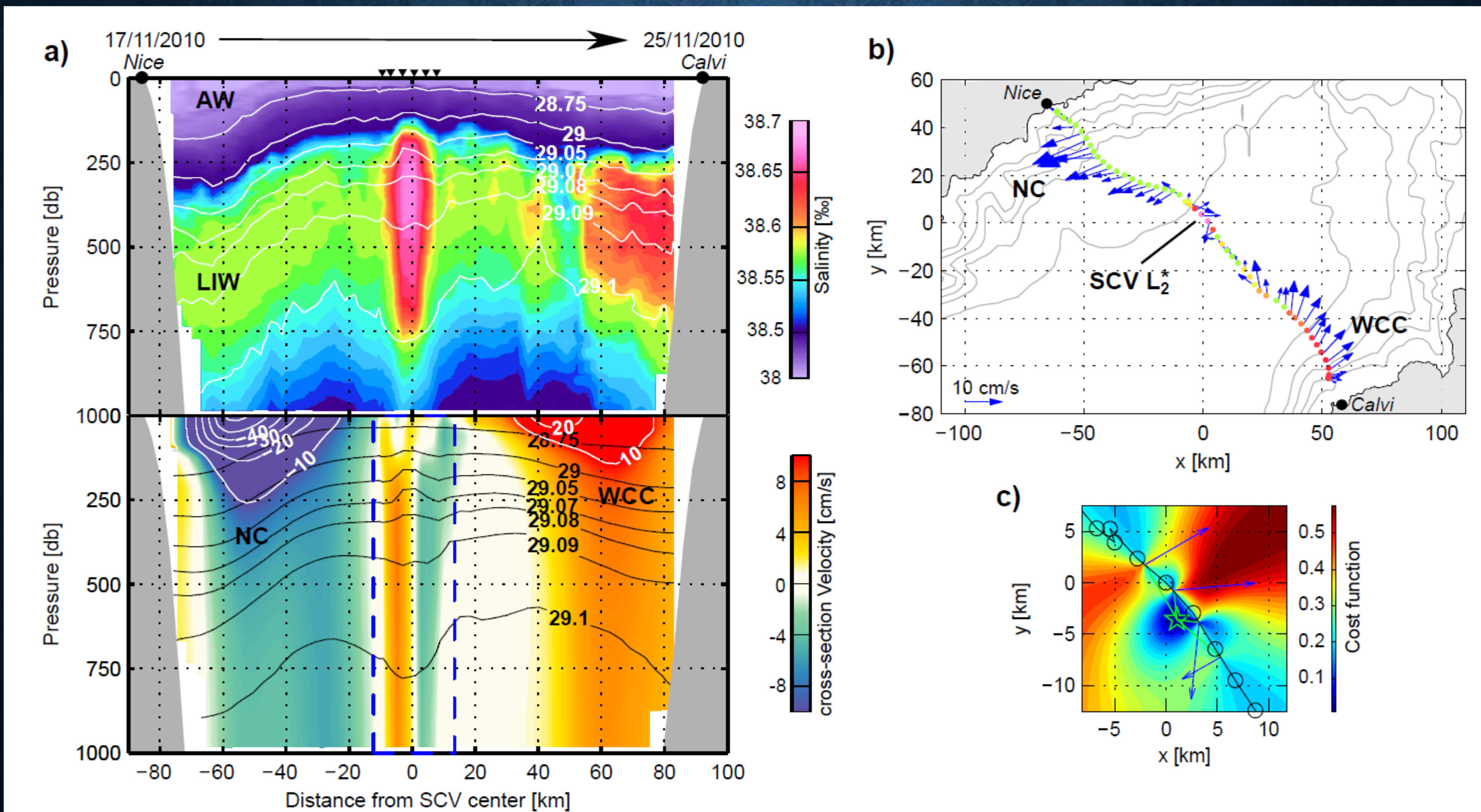




SUBMESOSCALE COHERENT VORTICES (ANTICYCLONES) IN THE NORTHWESTERN MEDITERRANEAN SEA AS OBSERVED WITH GLIDERS

WARM (+0.4°C) AND SALINE (+0.1PSU) AT INTERMEDIATE DEPTH CHARACTERIZED BY A SMALL RADDIUS (~5KM)

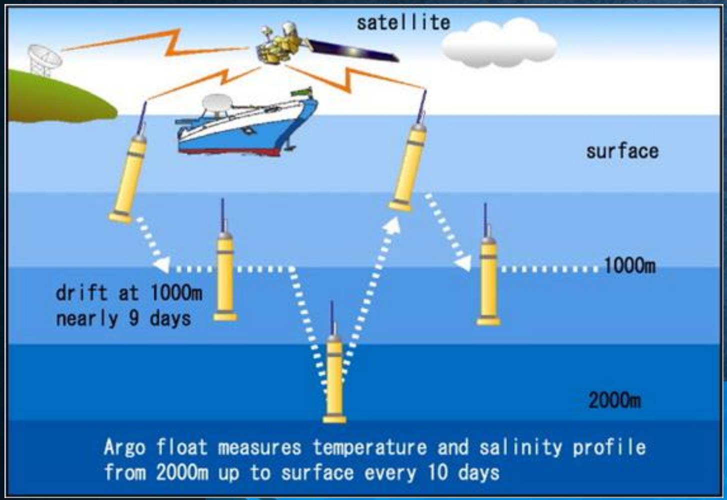
BOSSE ET AL. 2015



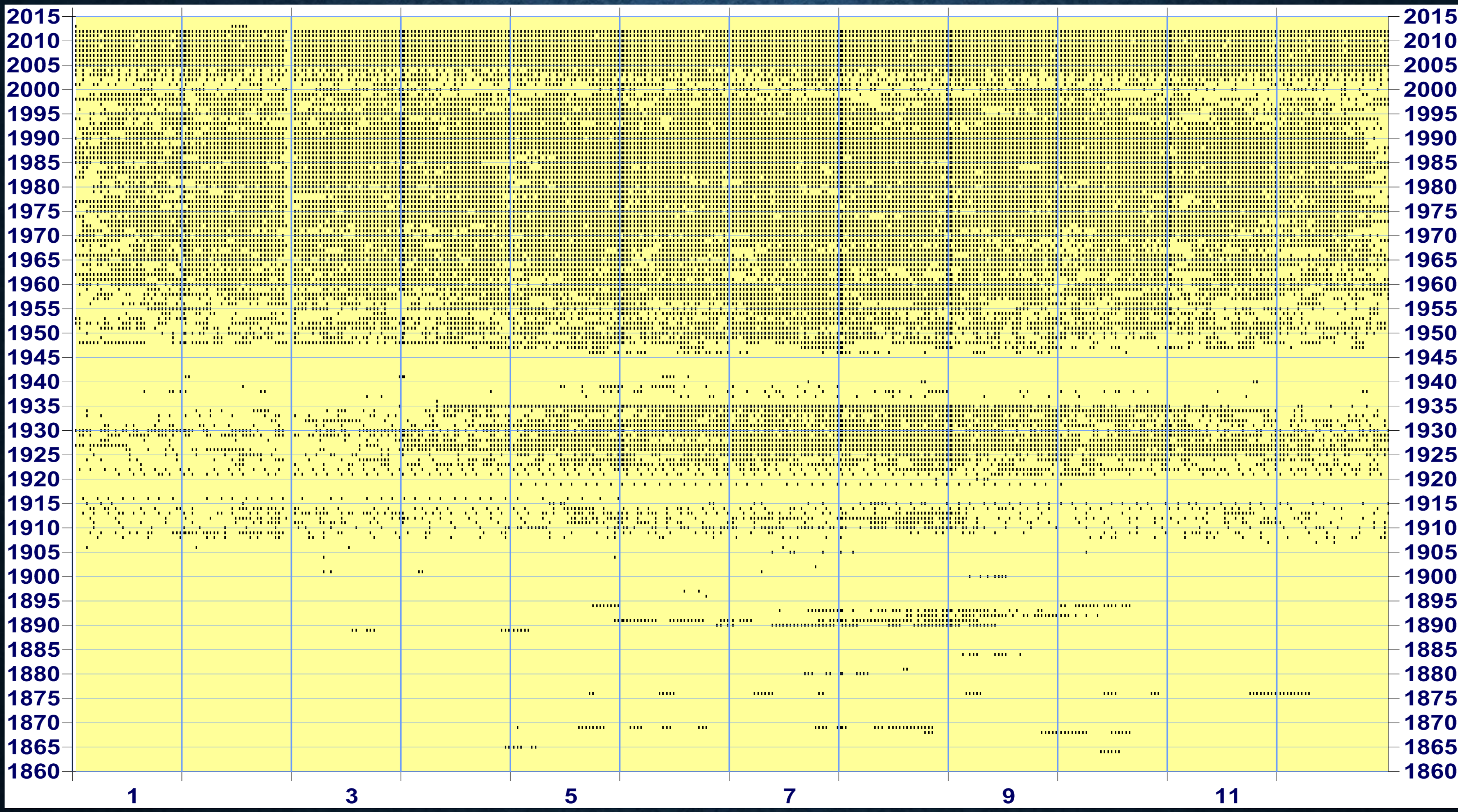
ISRAEL MARINE DATA CENTER (ISRAMAR)

MEDITERRANEAN CAST DATA BASE

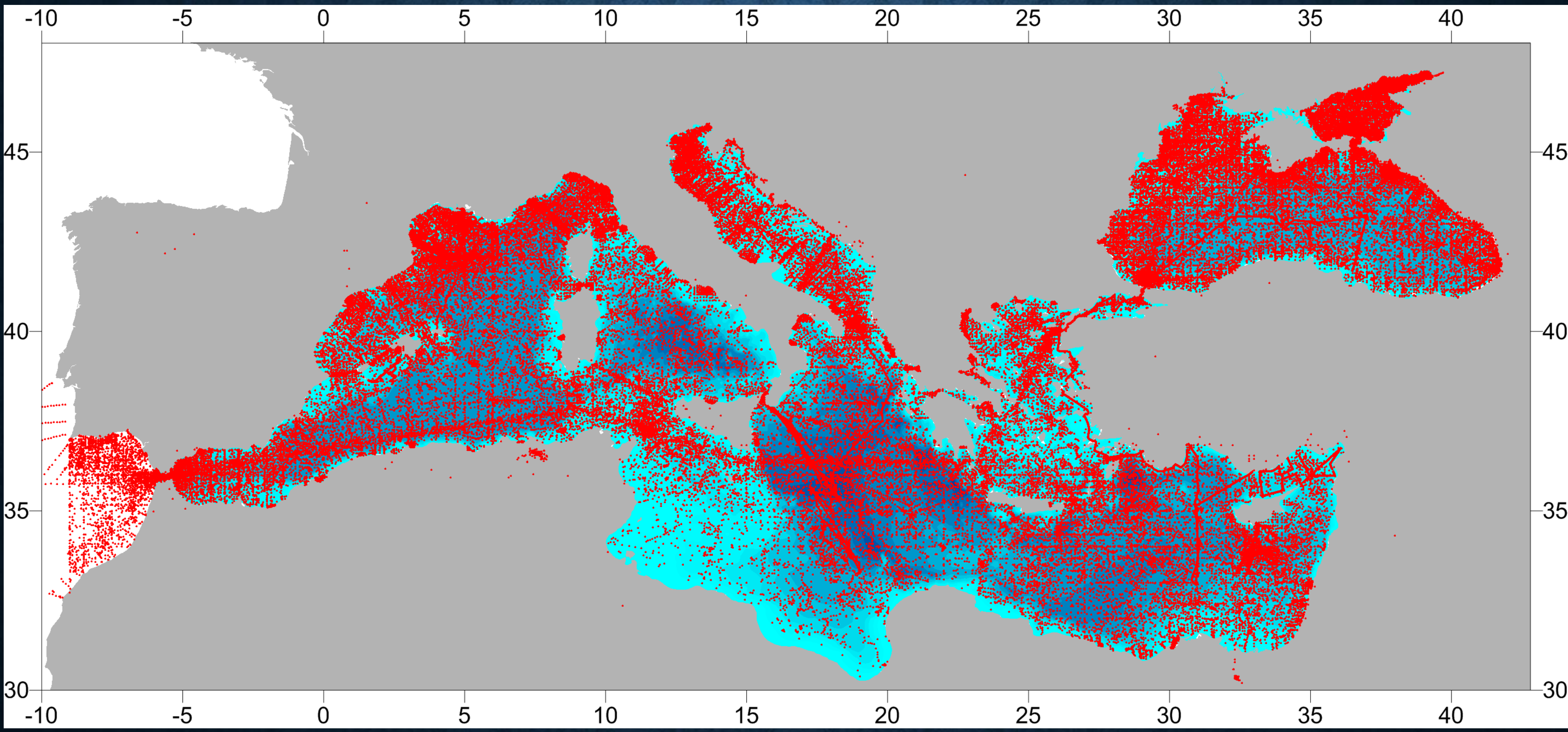
- An oceanographic cast or oceanographic vertical profile is a logical unit of physical and chemical parameters of sea water obtained by different equipment:



TIME DISTRIBUTION OF CASTS



SPACE DISTRIBUTION OF CASTS

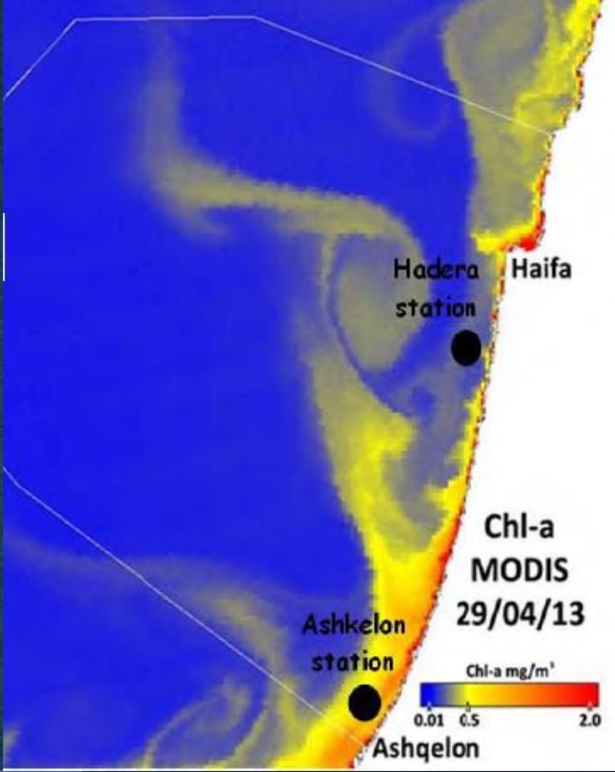


TIME SERIES DB

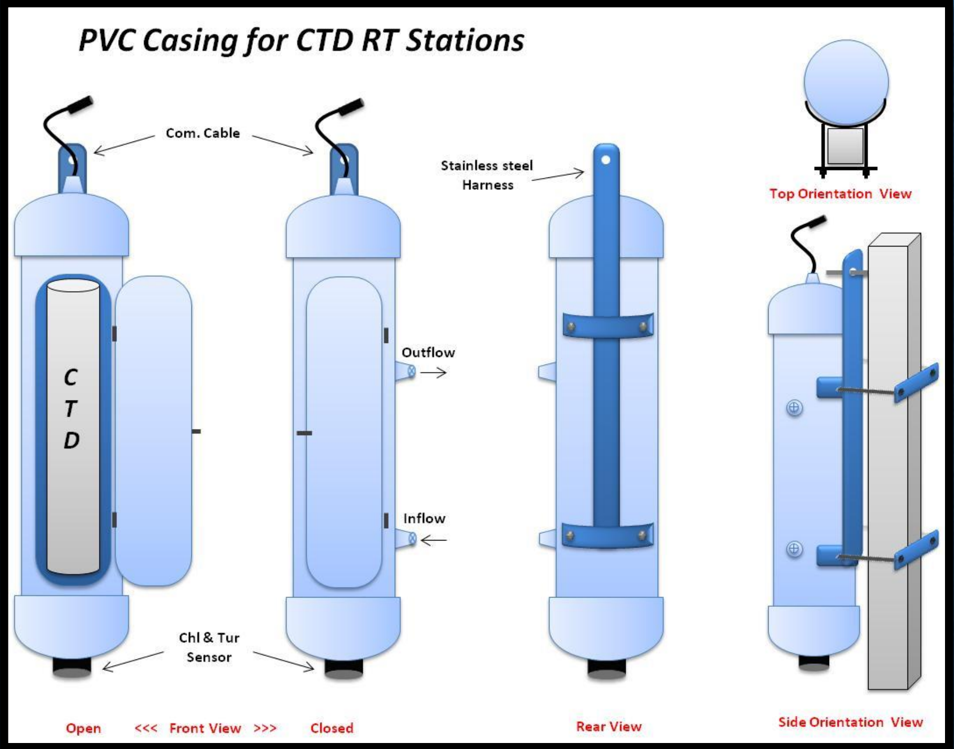
(CONTAINS TIME SERIES OF PHYSICAL, CHEMICAL AND BIOLOGICAL DATA OBSERVED AT FIXED STATIONS)

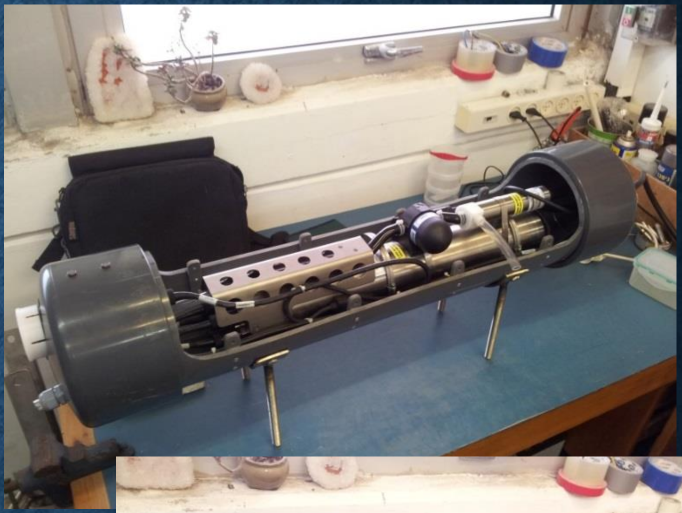
Coastal Stations

- Coastal stations in Hadera and Ashkelon
- Sensors: ADCP+Waves, CTD (T, S, Oxygen, Chlorophyll, Turbidity), Sea-level, Atm. Pressure.

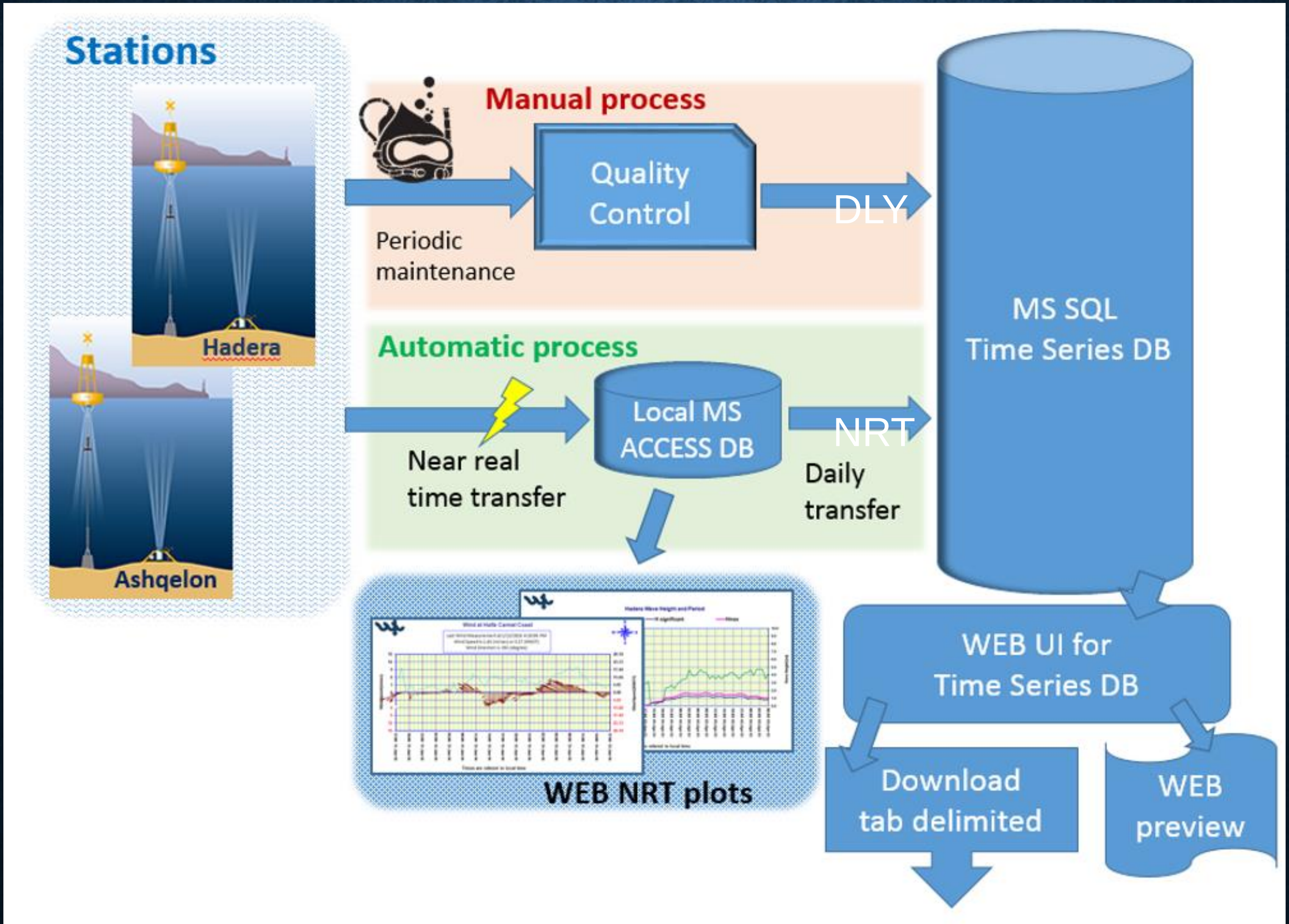


CTD ANTI-FOULING HOUSING





DATA FLOW IN THE IOLR TIME SERIES DB



GLOBAL HISTORICAL COLLECTIONS OF CAST DATA

NOAA NATIONAL OCEANOGRAPHIC DATA CENTER (NODC)
UNITED STATES DEPARTMENT OF COMMERCE

World Ocean Database

The World Ocean Database (WOD) provides access to scientifically quality-controlled global ocean profile and plankton data that includes measured *in situ* variables gathered since 1773.

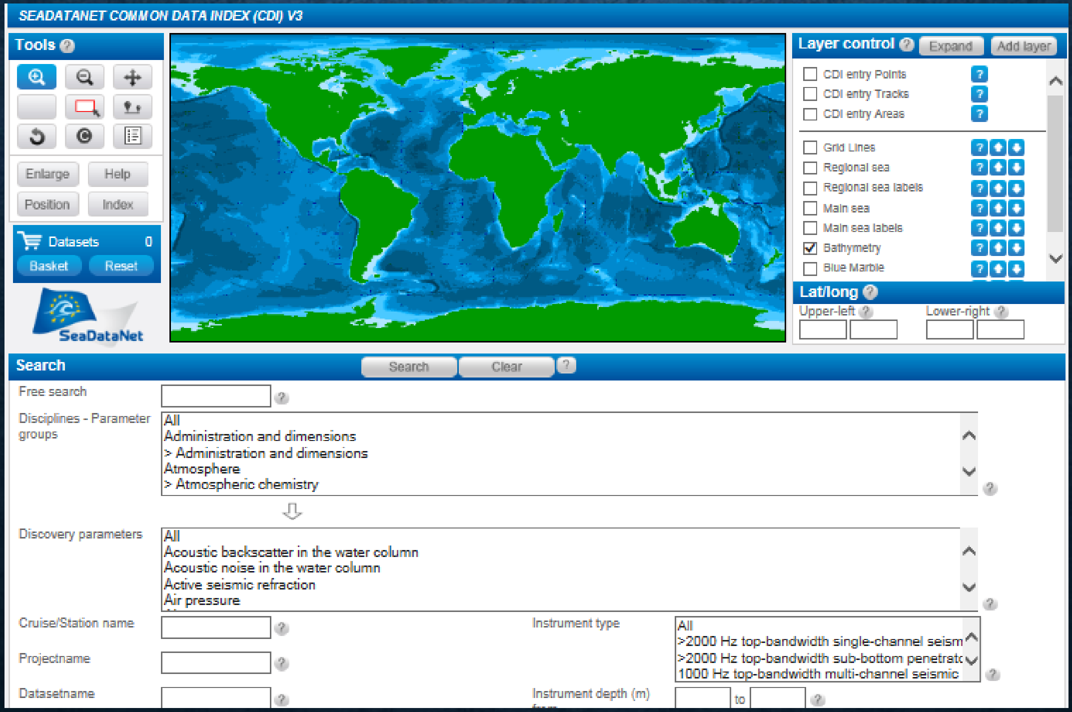
SEARCH CRITERIA: (definitions)	DEFAULT:
☐ GEOGRAPHIC COORDINATES	- whole world
☐ OBSERVATION DATES - *e.g., Year(s), Month(s), Day(s)*	- all years/months/days
☐ DATASET - *e.g., OSD, CTD, XBT*	- all datasets
☐ MEASURED VARIABLES - *e.g., Temperature, Salinity, Nutrients*	- all available variables
☐ BIOLOGY - *e.g., Phytoplankton, Zooplankton*	- all available plankton
☐ DEEPEST MEASUREMENT	- all depths
☐ COUNTRY	- all countries
☐ SHIP/PLATFORM	- all ships/platforms
☐ CRUISE	- all cruises
☐ ACCESSION #	- all accessions
☐ PROJECT	- all projects
☐ INSTITUTE	- all institutes
☐ DATA EXCLUSION USING WOD QUALITY CONTROL FLAGS	- no exclusion
☐ DATA ADDITIONS	- WOD13 released data

Build a query | Reset

EUROPEAN GLOBAL HISTORICAL COLLECTIONS OF CAST DATA

COMMON DATA INDEX (CDI)

The Common Data Index (CDI) service gives users a highly detailed insight in the availability and geographical spreading of marine data sets, that are managed by the SeaDataNet data centres. Moreover it provides a unique interface for requesting access, and if granted, for downloading data sets from the distributed data centres across Europe.



NUMERICAL MODELS

- Numerical models are used to simulate oceanic flows with realistic and useful results.
- Most recent models resolve:
  - **3D time dependent flow**
  - **containing mesoscale eddies**
  - **using realistic coasts and sea-floor features**
  - **and synoptic atmospheric forcing.**
- Resent models are now so good, that they show previously unknown aspects of the ocean circulation.
- Numerical models are not perfect. They solve:

discrete approximated and simplified equations, which are not the same as the exact equations of motion.

GOVERNING EQUATIONS OF OCEAN CIRCULATION MODEL (OCM)

$$\rho\left(\frac{\partial V}{\partial t}+adv(V)\right)=F_{pressure}+F_{coriolis}+turbdiff(V)+F_{gravity}$$ NavSt E

$$div(V)=0$$ Cont E

$$\frac{\partial\theta}{\partial t}+adv(\theta)=turbdiff(\theta)+R_{Sources}$$ Heat B E

$$\frac{\partial S}{\partial t}+adv(S)=turbdiff(S)$$ Salt B E

$$\rho=\rho(\theta,S,p)$$ State E

HOW IT WORKS

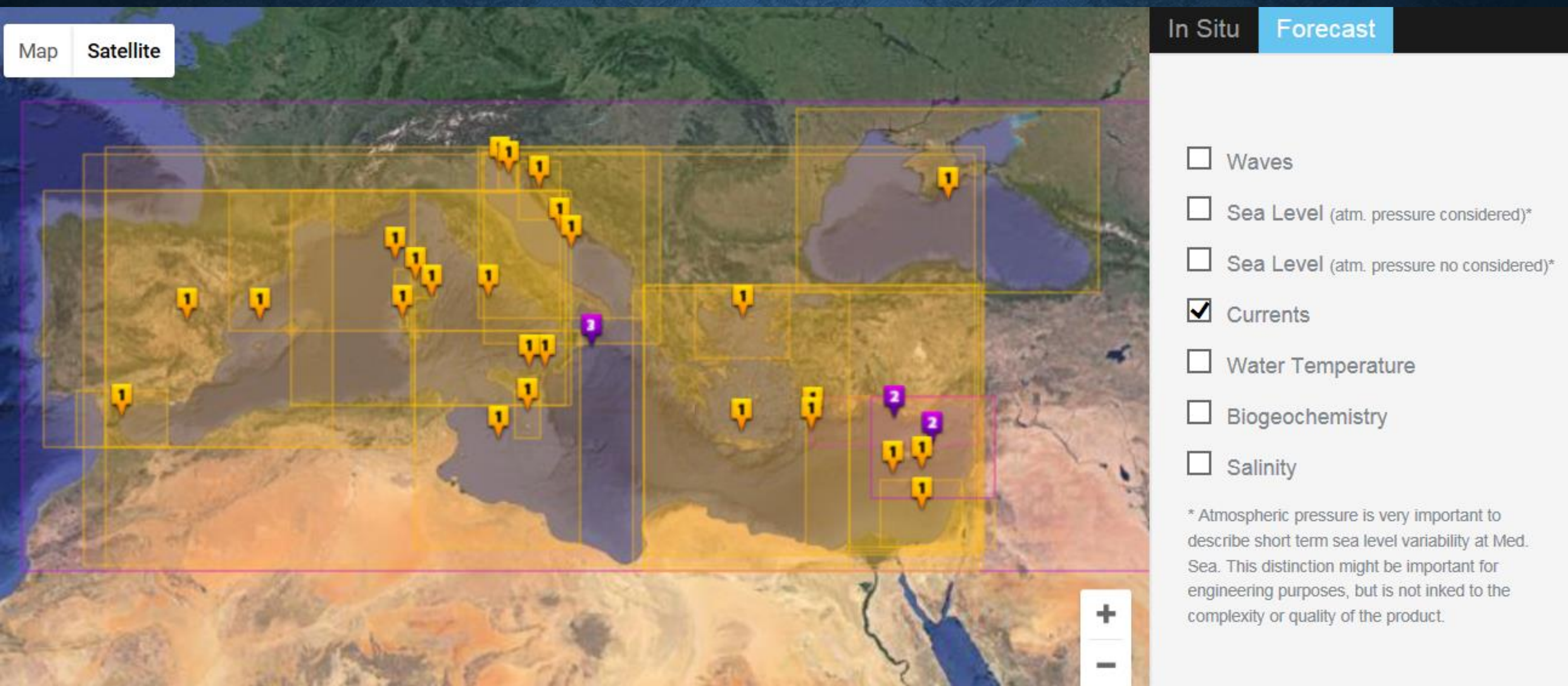
- Creating the model:
  - Simplifying the physical processes (e.g. UML formation, Side Friction)
  - Choosing the numerical schemes (Discretization)
- Model setup:
  - Domain and grid definition
  - Choosing parameters (time step, space steps, …)
- Running the model:
  - Specify initial conditions including data assimilation
  - Specify boundary lateral conditions
  - Specify heat, salinity, momentum, water fluxes through the sea surface.
  - Time integration

$$V(t+\Delta t, x, y, z) \approx V(t, x, y, z) + \Delta t \cdot \frac{\partial V(t, x, y, z)}{\partial t}$$

mongoos
http://mongoos.eu

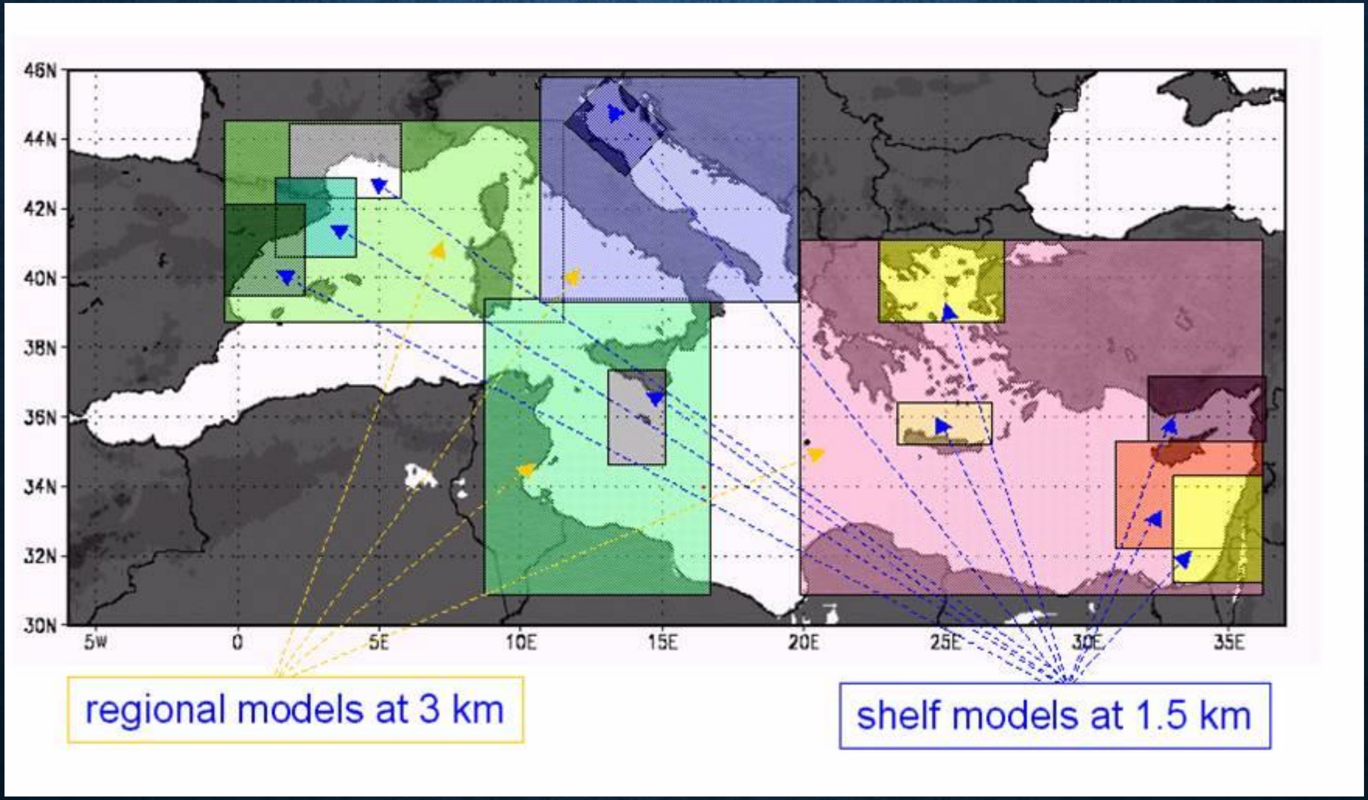
The **Mediterranean Operational Network for the Global Ocean Observing System** (MONGOOS)

Partners



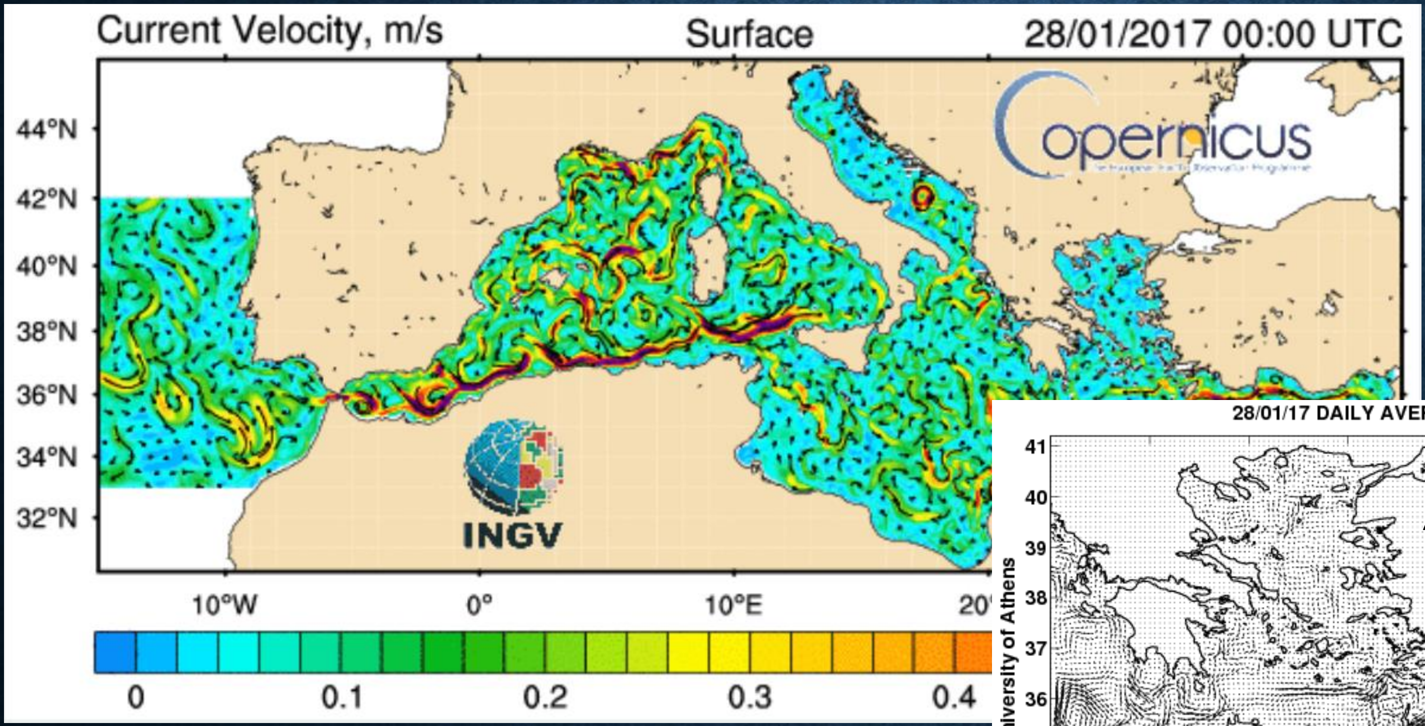
HIERARCHY OF NESTED MODELS FOR DAILY FORECASTS

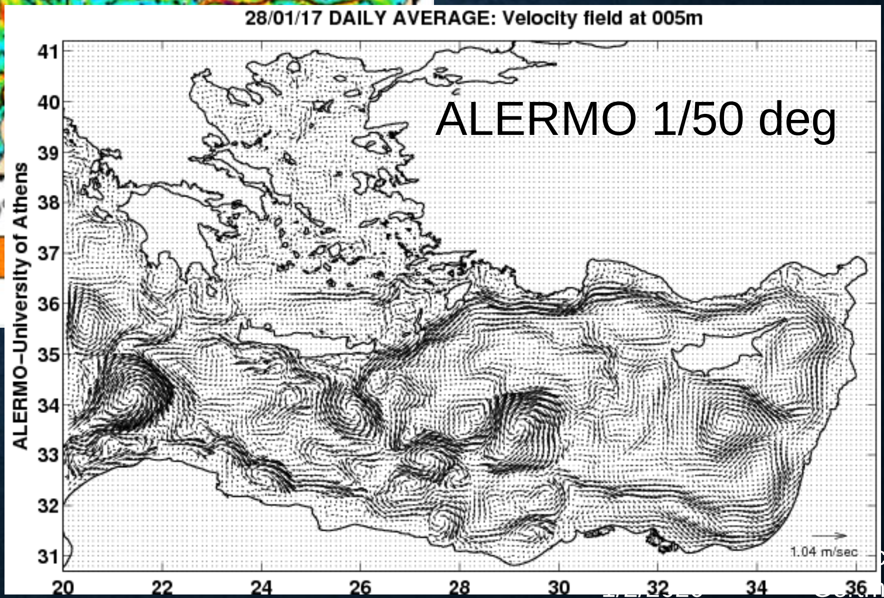
From Global Mediterranean Model (at 7 km resolution) to Regional Models (at 3 km) and to Shelf Models (at ~1 km)



SOUTH EASTERN LEVANTINE ISRAELI PREDICTION SYSTEM (SELIPS)

From Global Mediterranean Model (at 7 km resolution) to Regional Models (at 2 km) and to Shelf Models (at ~1 km)

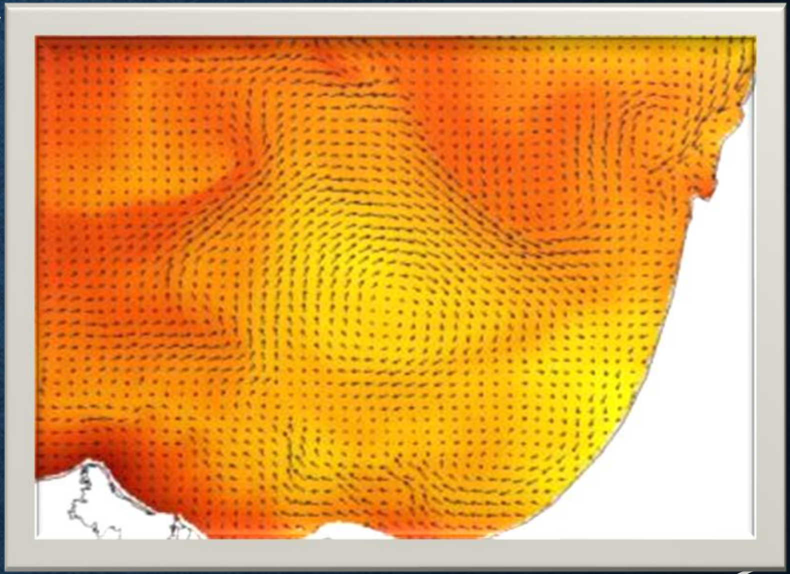




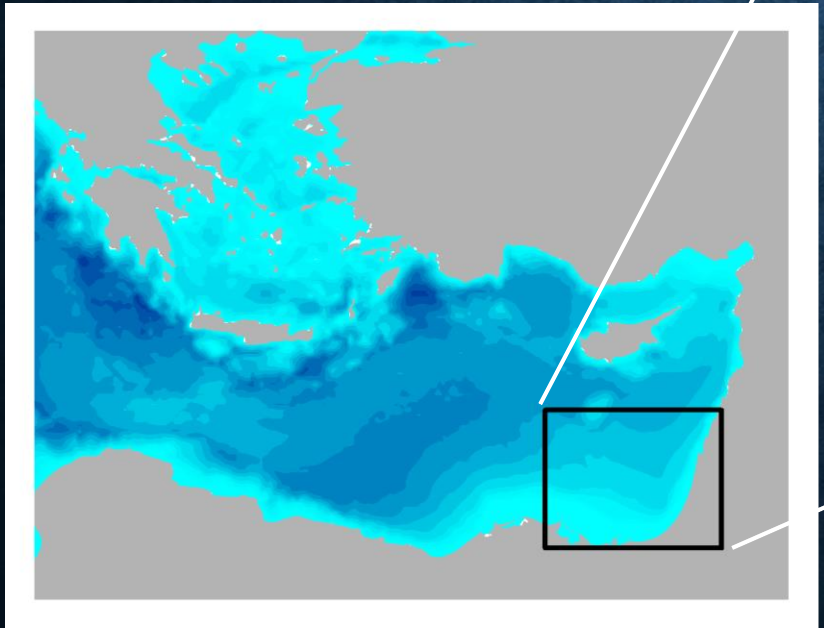
INGV model: now is 1/24 deg instead of 1/16

SOUTH EASTERN LEVANTINE ISRAELI PREDICTION SYSTEM (SELIPS)

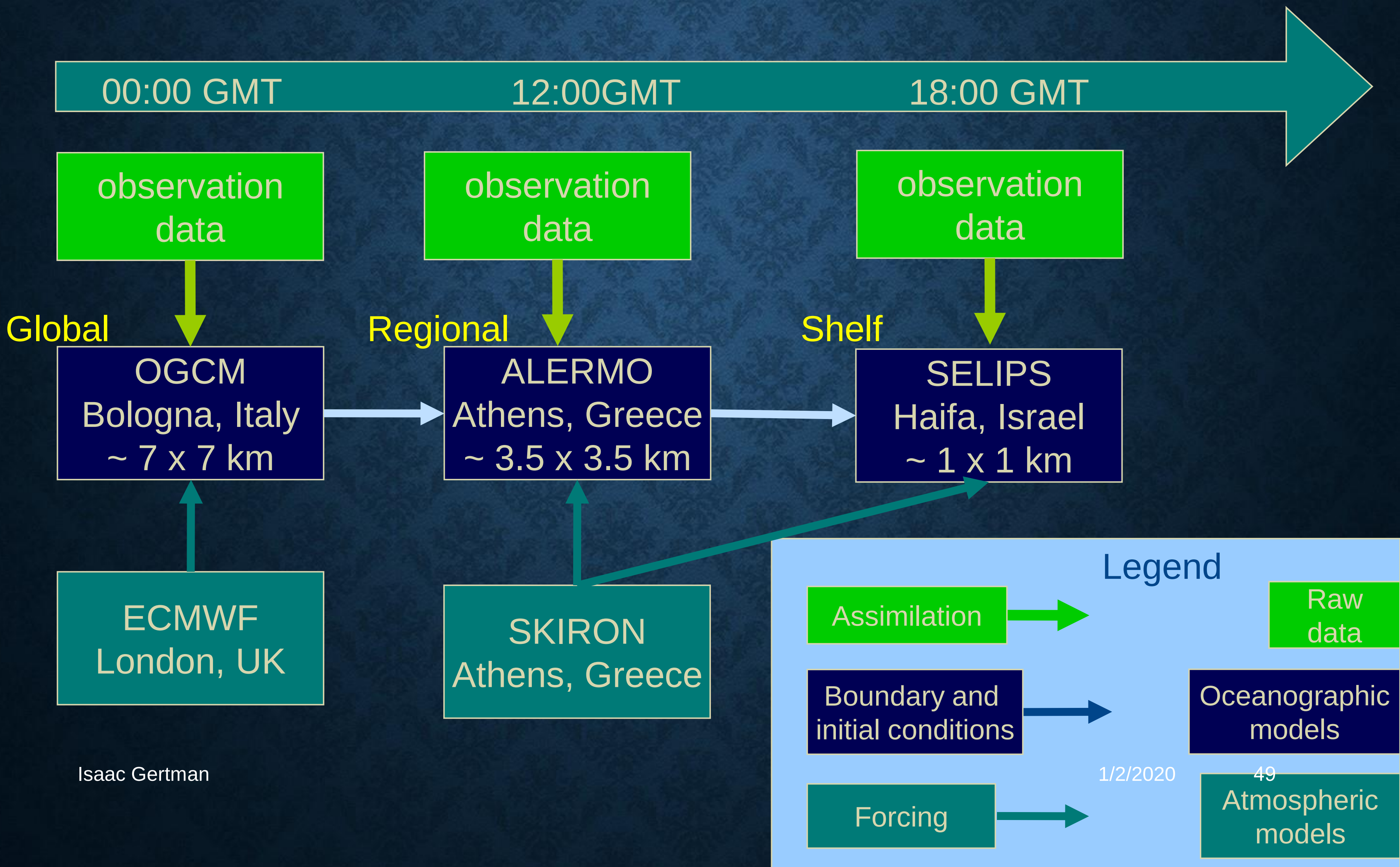
SELIPS is one way nested to ALERMO
(which is nested in turn to MFS)
and forced by the SKIRON atmospheric model.

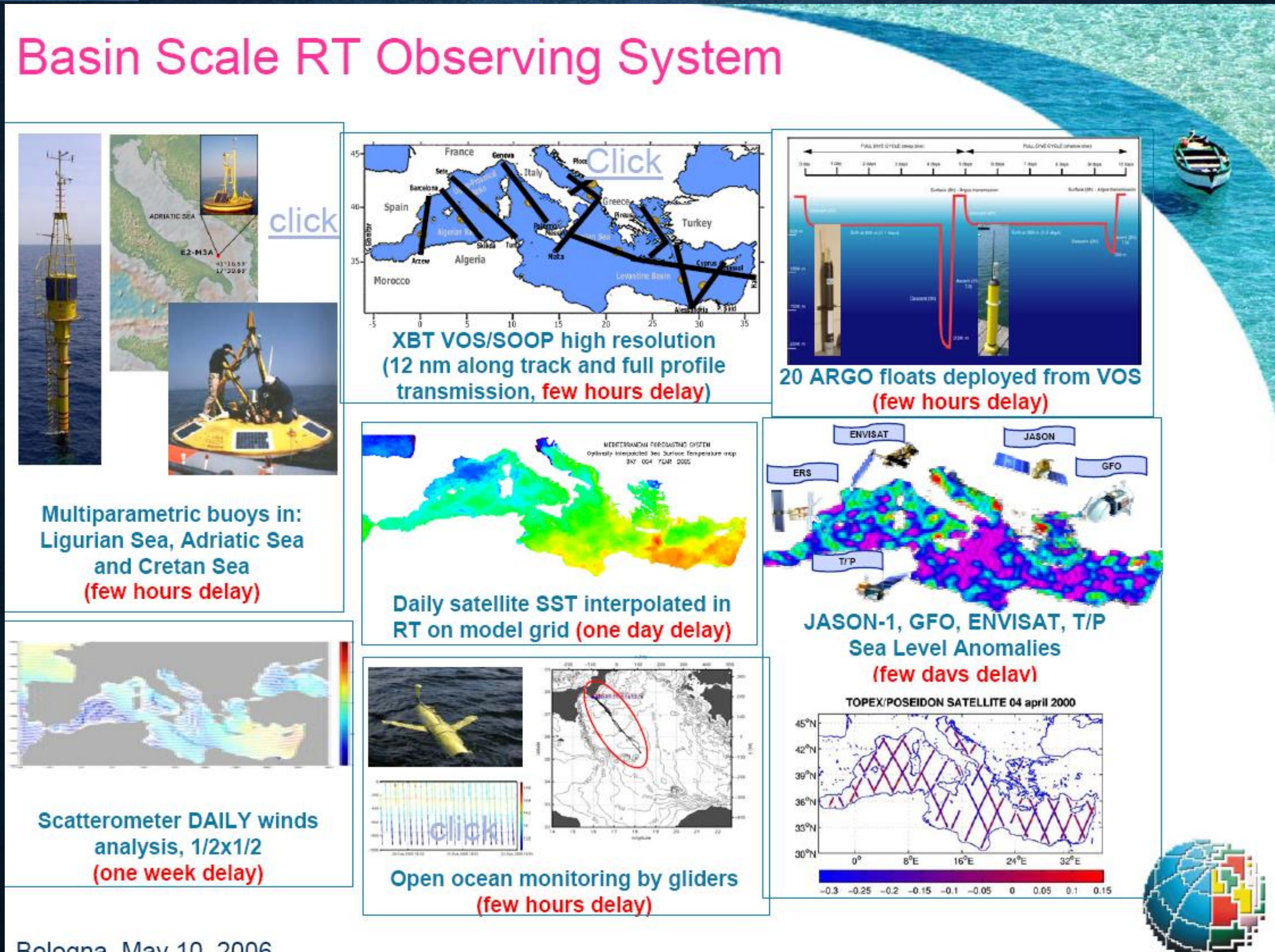


<u>SELIPS provide daily high resolution 4 day forecast of</u>:
Temperature,
Salinity,
Current,
Sea level elevation



SYSTEM OPERATION

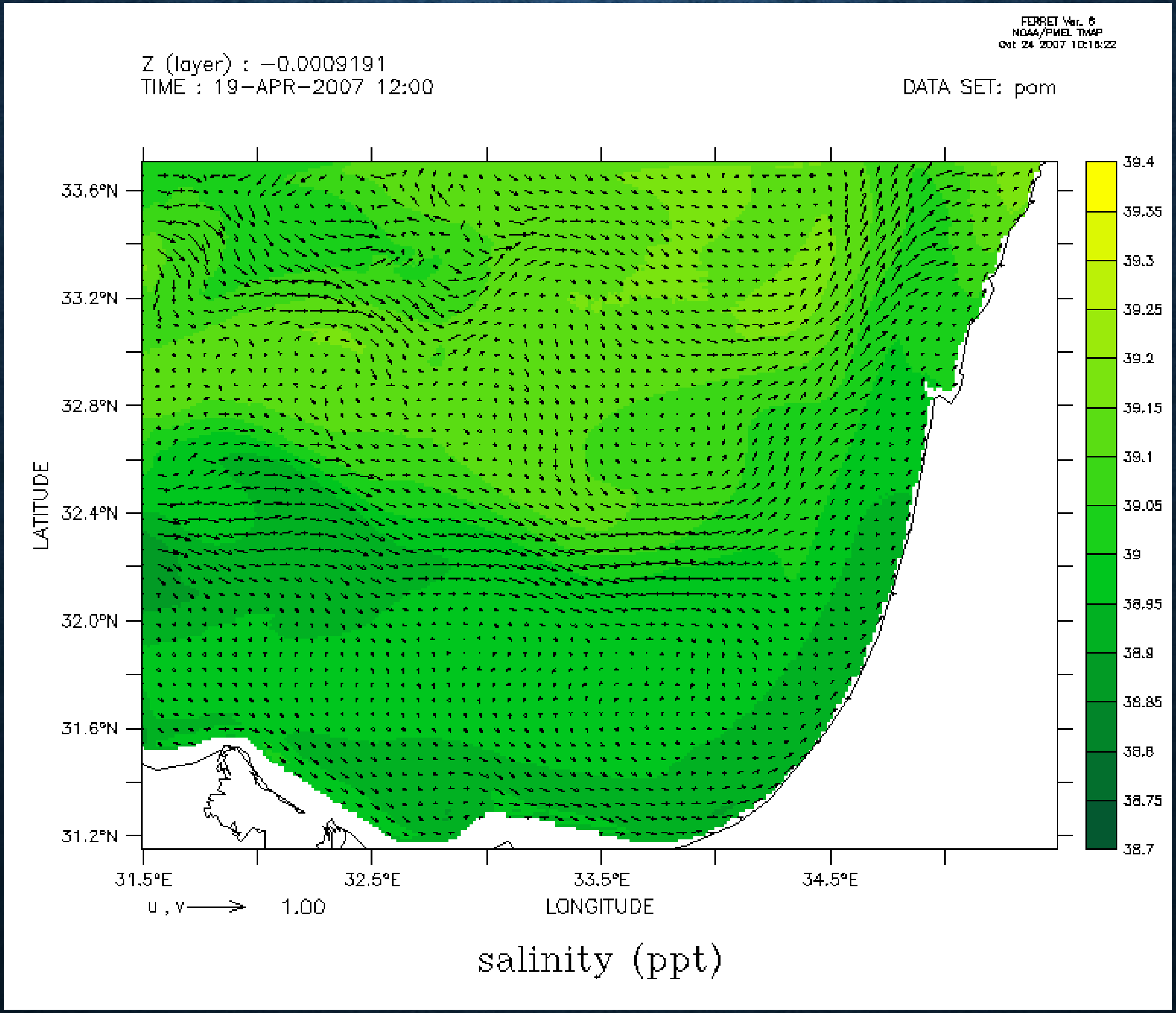




Basin Scale RT Observing System
click
Multiparametric buoys in:
Ligurian Sea, Adriatic Sea
and Cretan Sea
(few hours delay)
Click
XBT VOS/SOOP high resolution
(12 nm along track and full profile
transmission, few hours delay)
20 ARGO floats deployed from VOS
(few hours delay)
Daily satellite SST interpolated in
RT on model grid (one day delay)
ENVISAT
JASON
GFO
ERS
T/P
JASON-1, GFO, ENVISAT, T/P
Sea Level Anomalies
(few days delay)
TOPEX/POSEIDON SATELLITE 04 april 2000
Scatterometer DAILY winds
analysis, 1/2x1/2
(one week delay)
click
Open ocean monitoring by gliders
(few hours delay)
Bologna, May 10, 2006

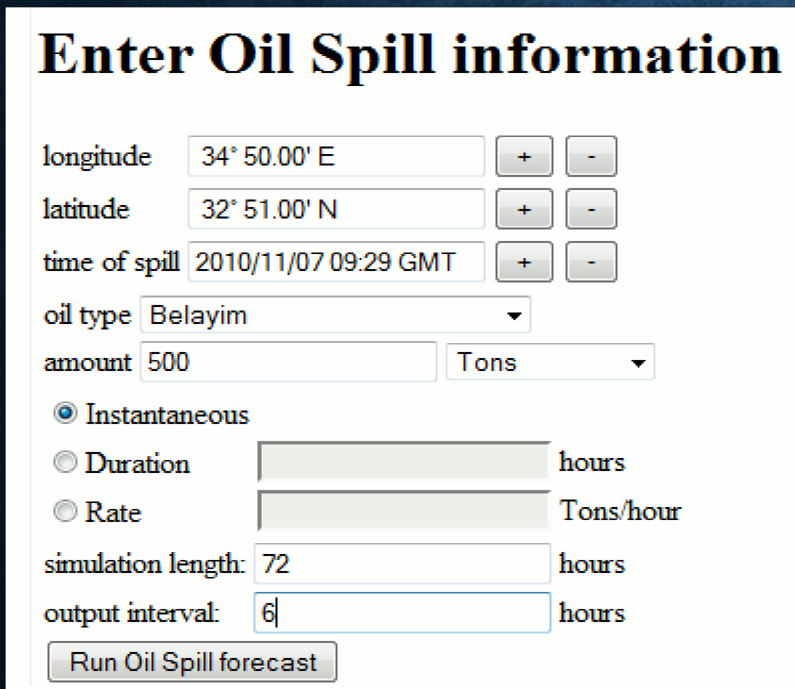
SOUTH EASTERN LEVANTINE ISRAELI PREDICTION SYSTEM (SELIPS)

HTTP://ISRAMAR.OCEAN.ORG.IL/SHELFMODEL/DEFAULT.ASP



OIL SPILL PROPAGATION FORECAST (MEDSLIK) BASING ON SELIPS

HTTP://ISRAMAR.OCEAN.ORG.IL/ISRAMAR2009/MEDSLIK



Enter Oil Spill information

longitude 34° 50.00' E + -

latitude 32° 51.00' N + -

time of spill 2010/11/07 09:29 GMT + -

oil type Belayim

amount 500 Tons

Instantaneous

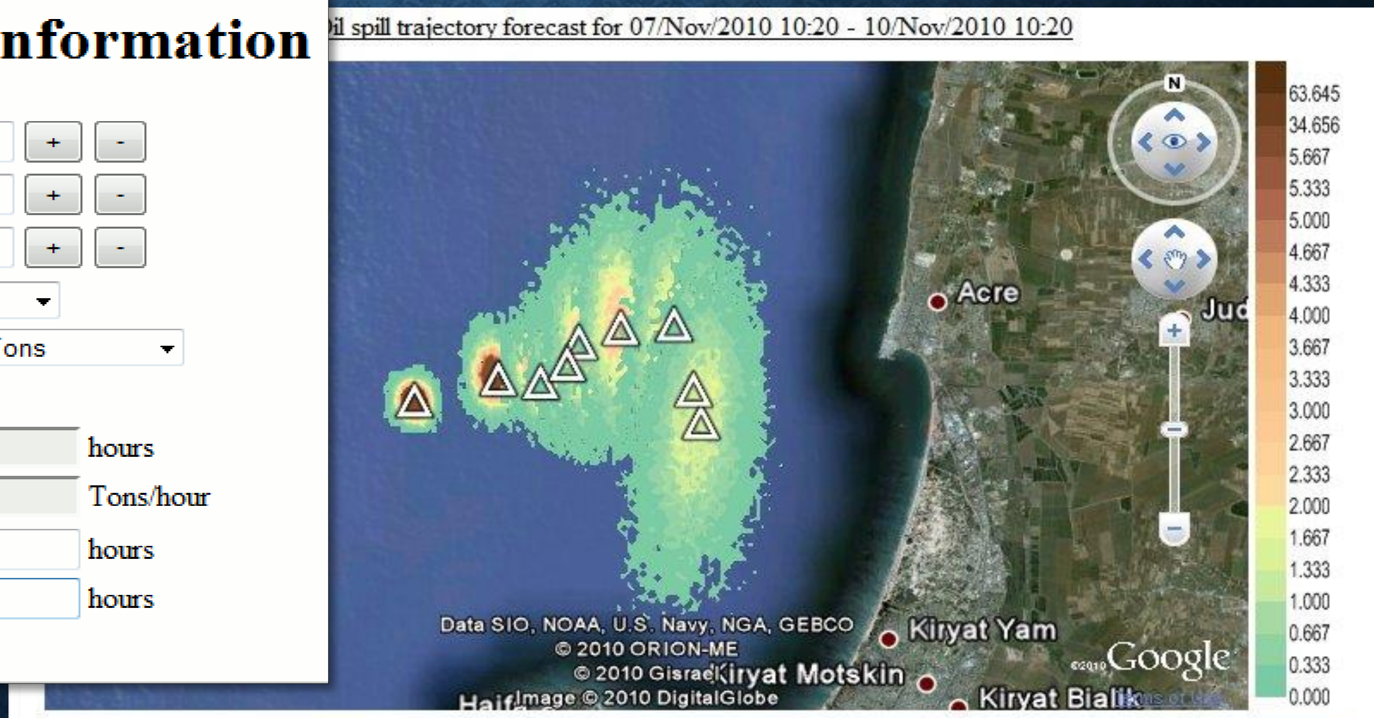
Duration hours

Rate Tons/hour

simulation length: 72 hours

output interval: 6 hours

Run Oil Spill forecast



Show	Date Time	Location of maximal oil spill concentration		Total Tons	Spill area, m^2
		Latitude	Longitude		
☑	07/Nov/2010 10:20	32°53'13"	34°54'17"	511.176	340000
☑	07/Nov/2010 14:20	32°54'31"	34°56'12"	645.708	2150000
☑	07/Nov/2010 18:20	32°54'51"	34°57'36"	775.128	4050000

LONG-TERM CHANGES CONNECTED WITH GLOBAL WARMING

NEAR TO SURFACE TEMPERATURE ANOMALY (RELATIVE MEAN 1961-1990)

- The globally averaged combined land and ocean near to surface temperature data (**2m above the earth**) as calculated by a linear trend, show a

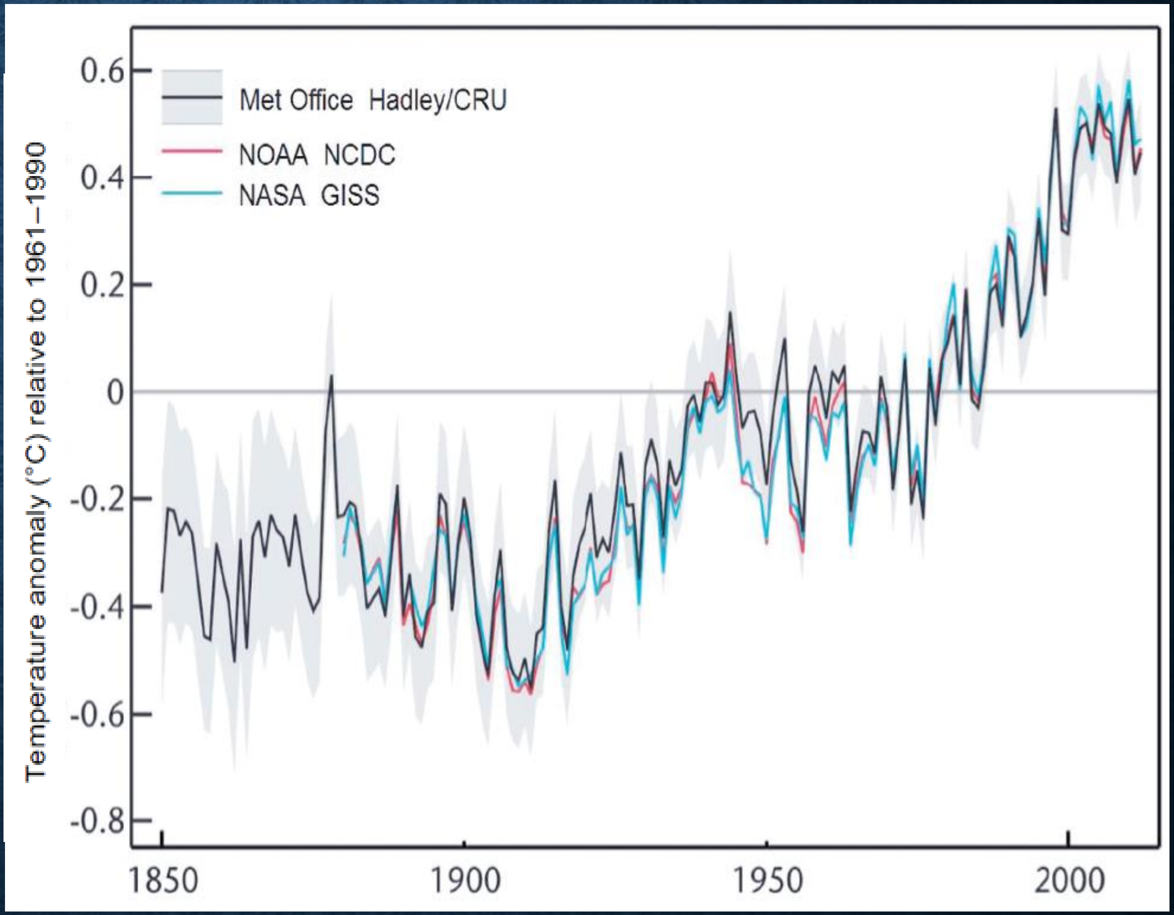
warming of

0.85 [0.65 to 1.06] °C,

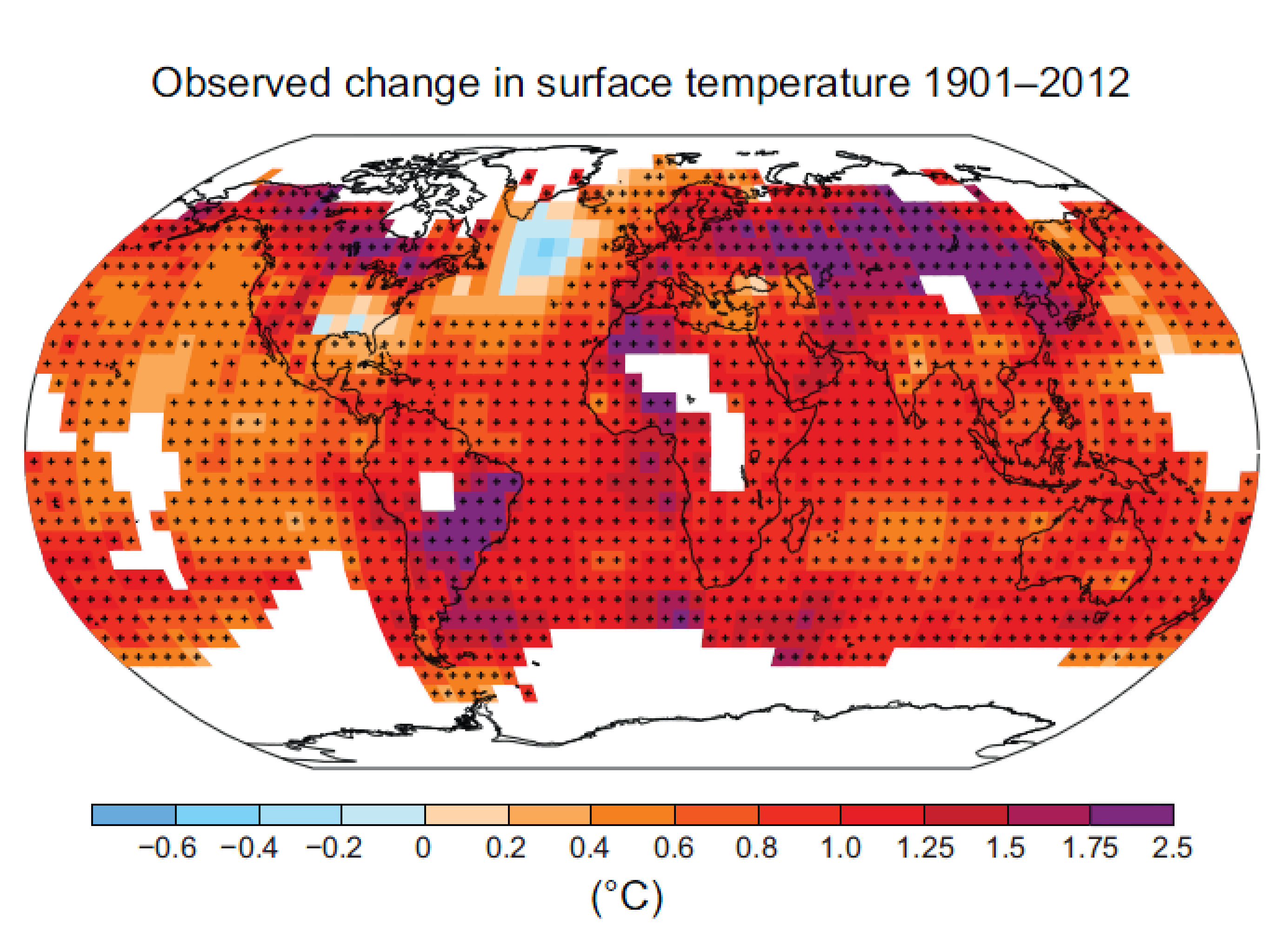
over the period

1880 to 2012

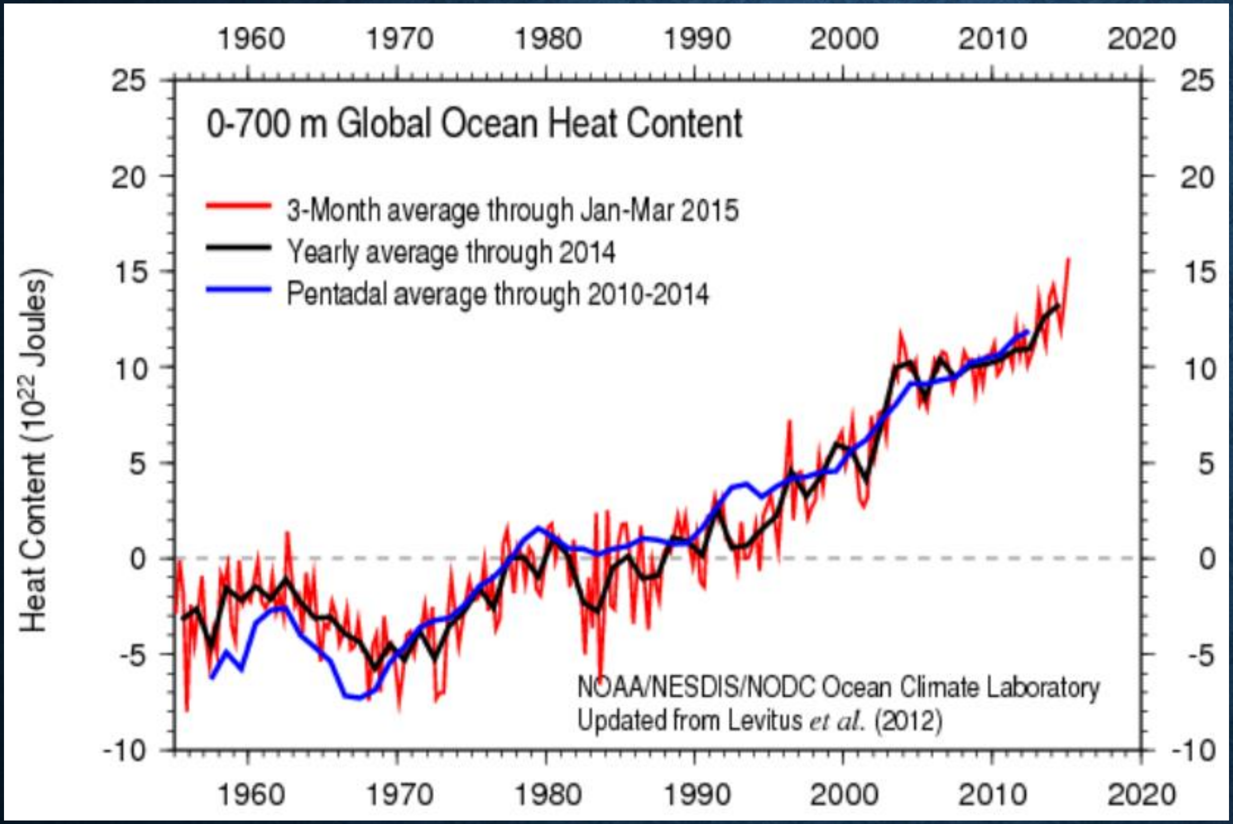
- Derived from 3 independent datasets



OBSERVED SURFACE TEMPERATURE CHANGE FROM 1901 TO 2012 DERIVED FROM TEMPERATURE TRENDS DETERMINED BY LINEAR REGRESSION



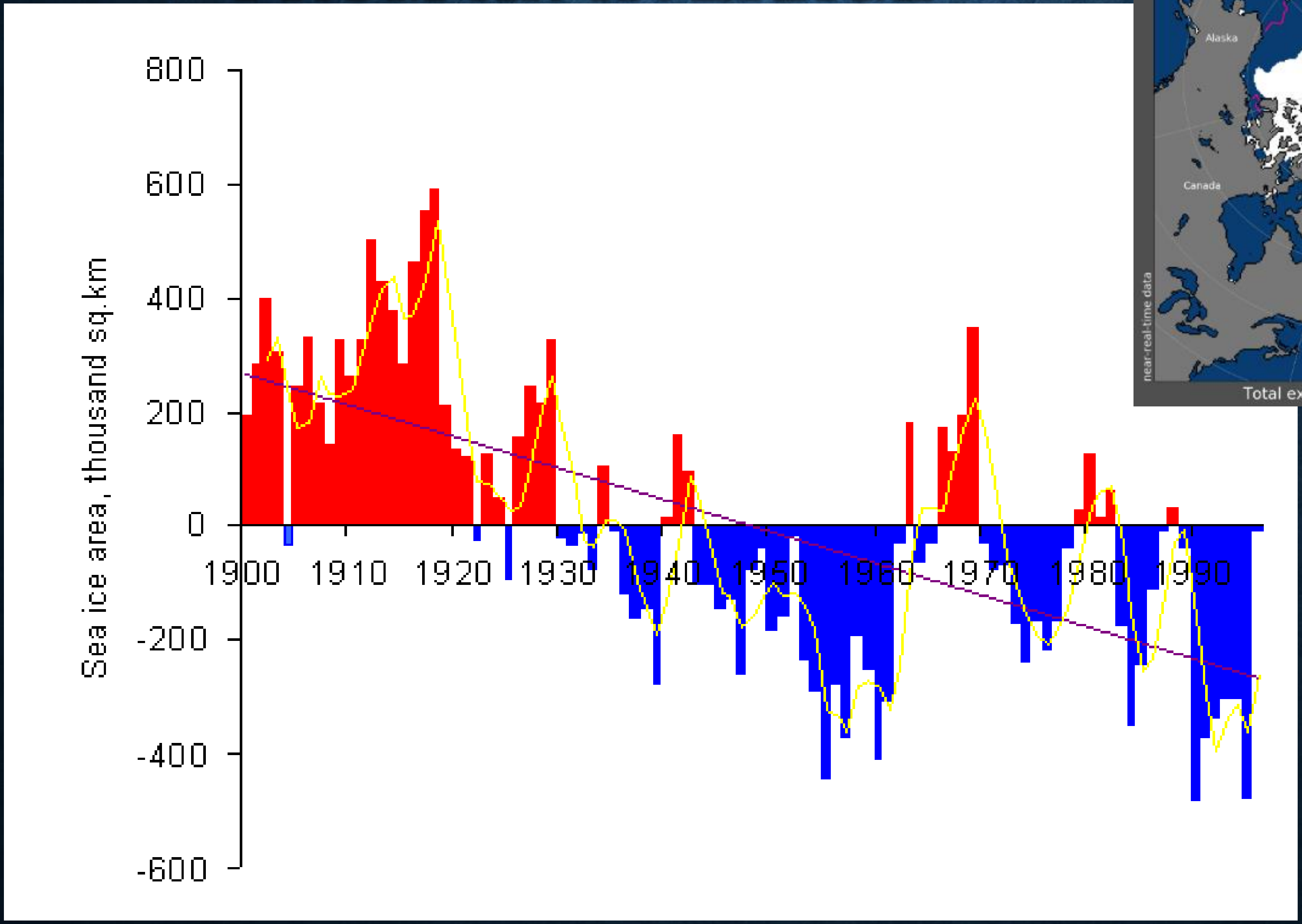
NOAA POSTS REGULARLY UPDATED MEASUREMENTS OF THE AMOUNT OF HEAT HEATING-REVEALS-ABOUT-GLOBAL-WARMING (HTTP://WWW.NODC.NOAA.GOV/OC5/3M_HEAT_CONTENT/)

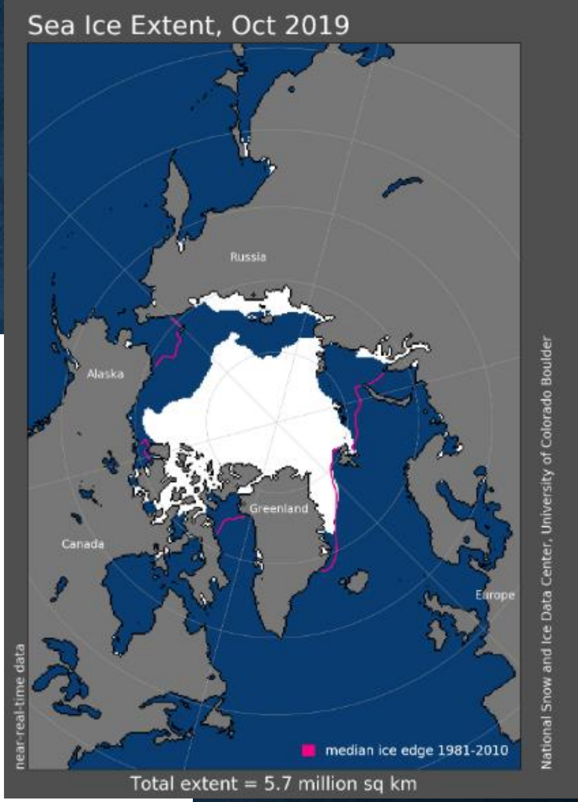


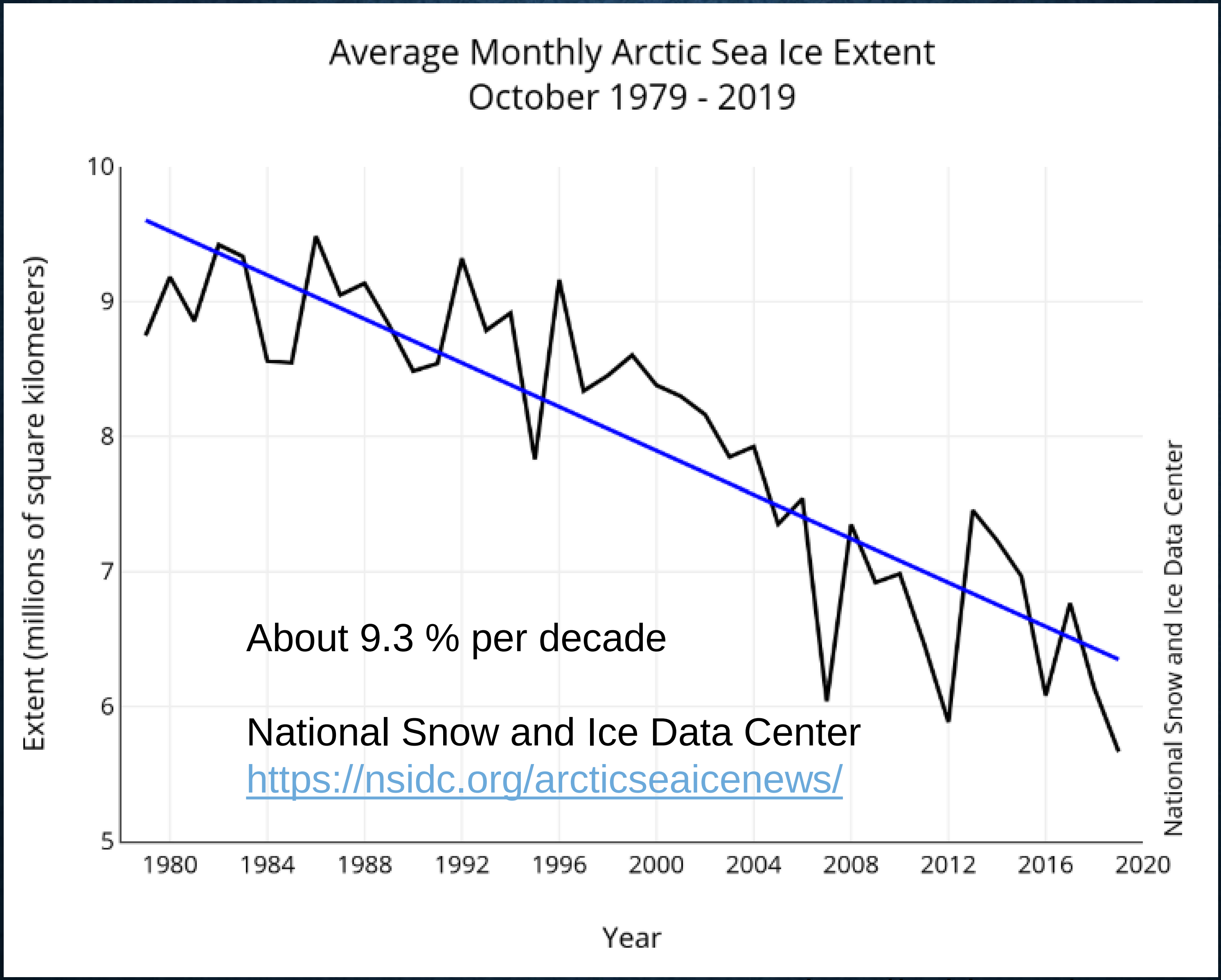
The increase in the amount of heat in the oceans amounts to 17 x 10^{22} Joules over the last 30 years (it is equivalent to exploding a Hiroshima bomb every second in the ocean for thirty years)

- The amount of heat stored in the **oceans** is one of the most important diagnostics for global warming, because **about 93%** of the additional heat is stored there
- The **atmosphere** stores only **about 2%** because of its small heat capacity

MEAN ANNUAL SEA ICE AREA IN THE ARCTIC OCEAN IN DEVIATIONS FROM AN AVERAGE







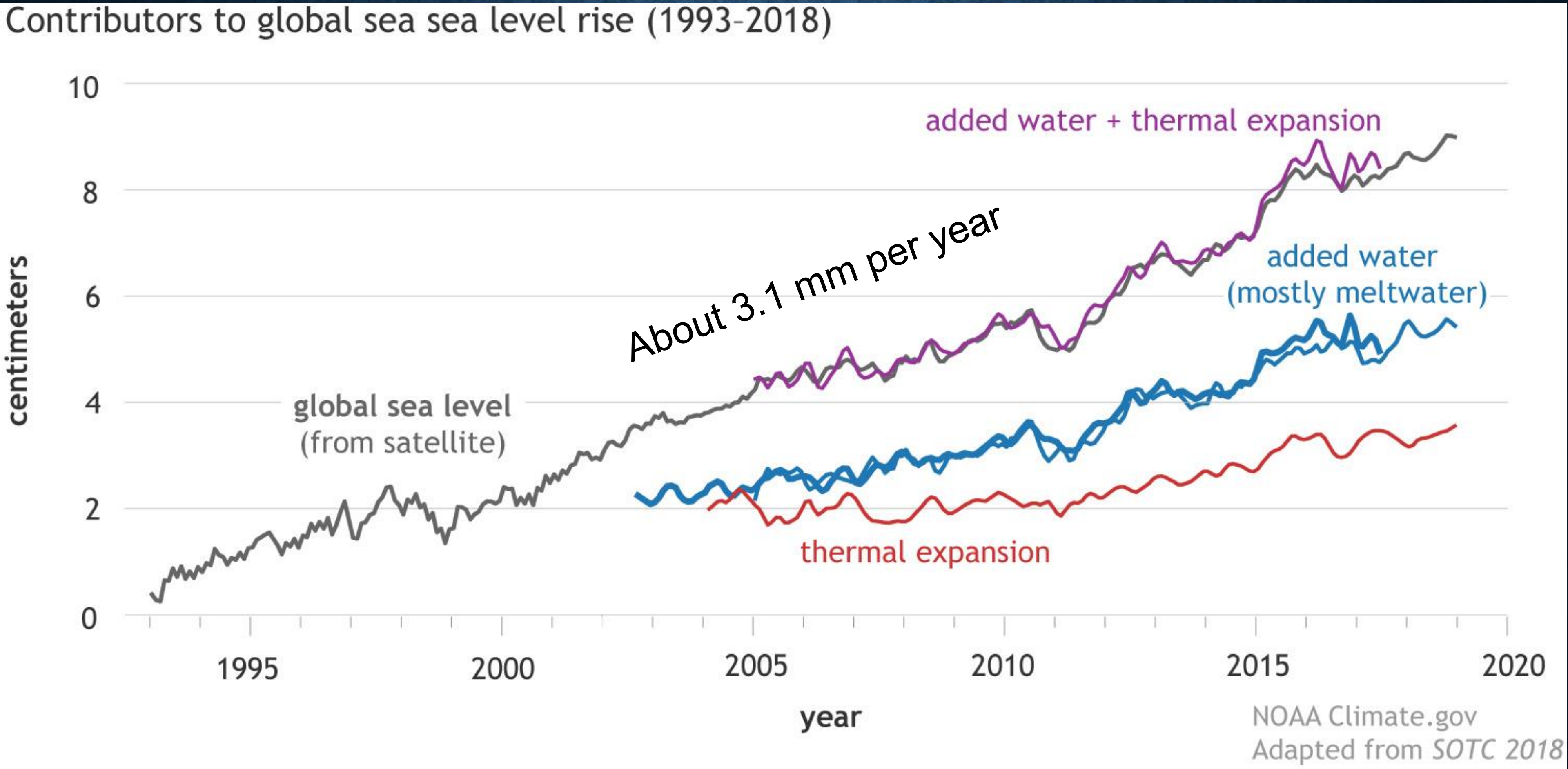
About 9.3 % per decade

National Snow and Ice Data Center
https://nsidc.org/arcticseaicenews/

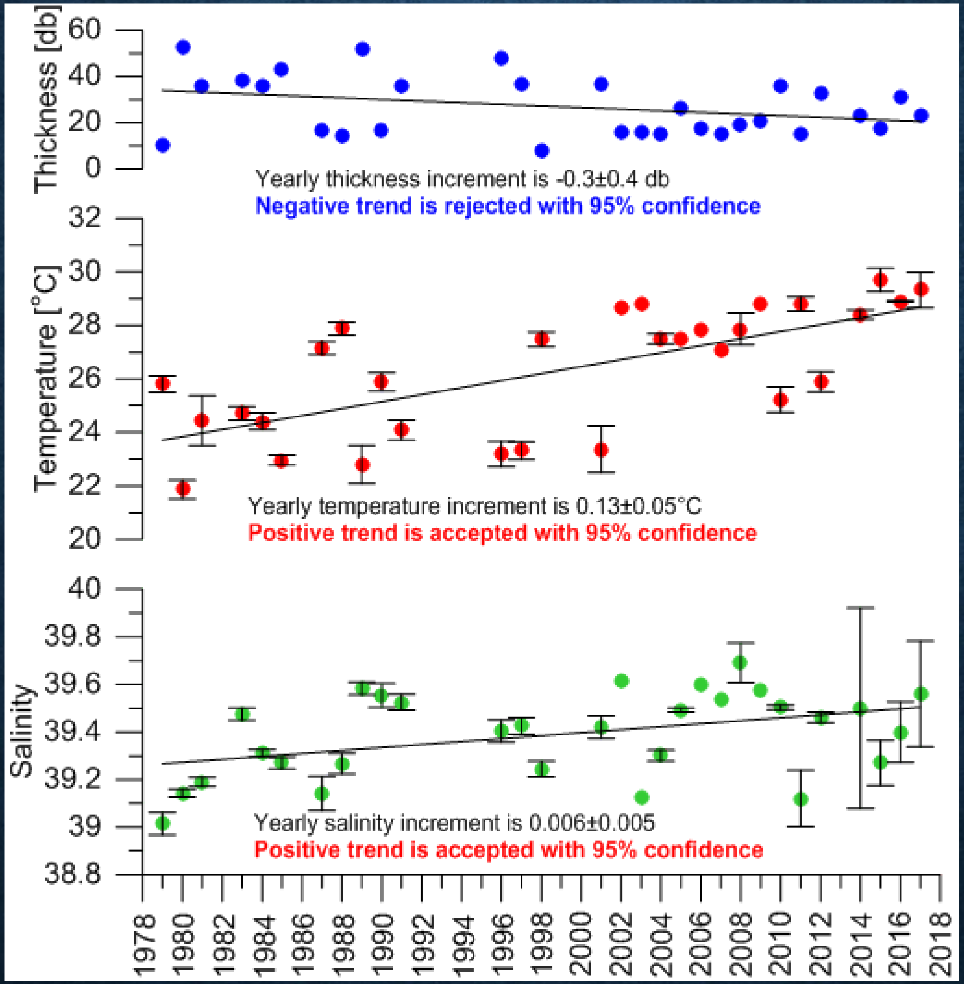
http://nsidc.org/

SEA LEVEL CHANGE 1993-2018

https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

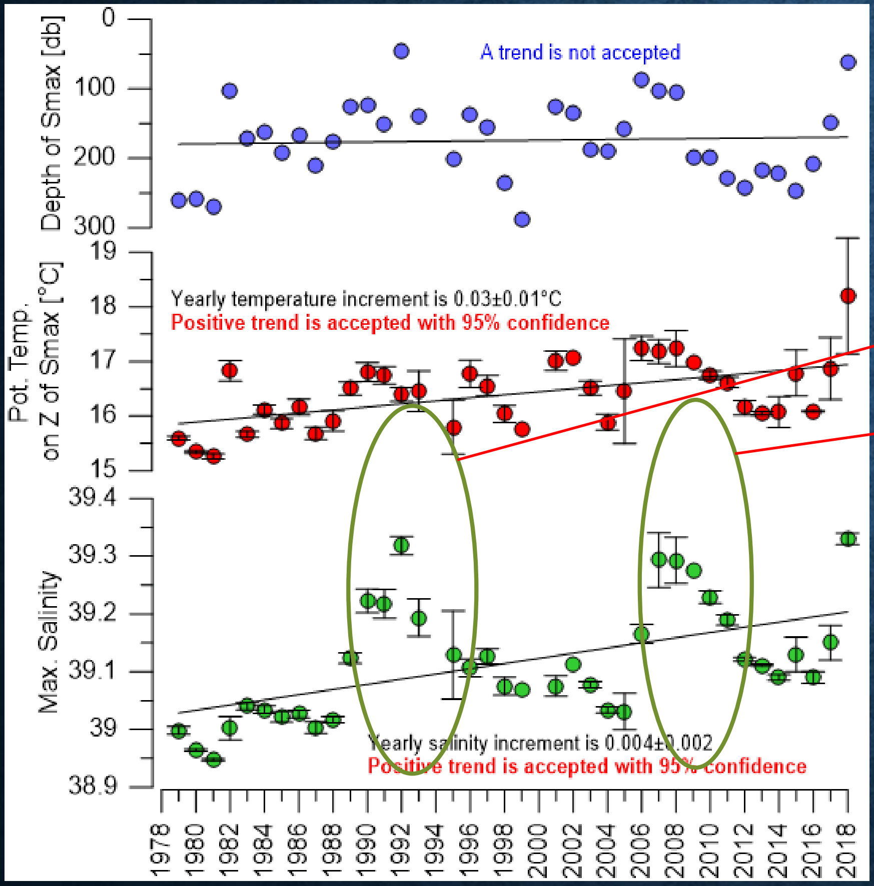


LONG-TERM INCREASE OF TEMPERATURE (ABOUT 0.1°C PER YEAR) AND SALINITY (ABOUT 0.006 PER YEAR) OF LSW

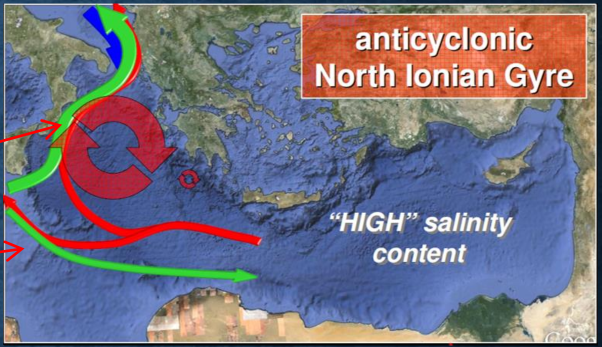


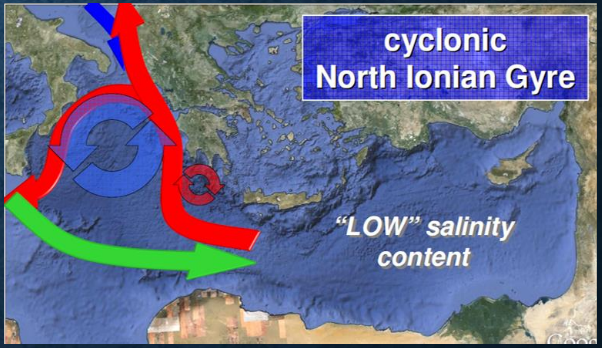
The moderate salinization process in the upper layer of the SEM can be attributed to the damming of the Nile in 1964.

LONG-TERM INCREASE AND INTERANNUAL FLUCTUATIONS OF TEMPERATURE AND SALINITY OF LIW



Bimodal Oscillating System
(BIOS: Gacic et al., 2010)





Two evident maxima of salinity in LIW (1992 and 2008) can be explained in the framework of the Ionian Bimodal Oscillating System (BIOS: Gacic et al., 2010). Both maxima result from periods of anticyclonic circulation in the north Ionian (1988-1997 and 2006-2009) and limited AW advection to the SE Levantine.