Aquarius

Sea Surface Salinity from Space

Teacher's Workshop

Federation of Earth Science Information Partners (ESIP)

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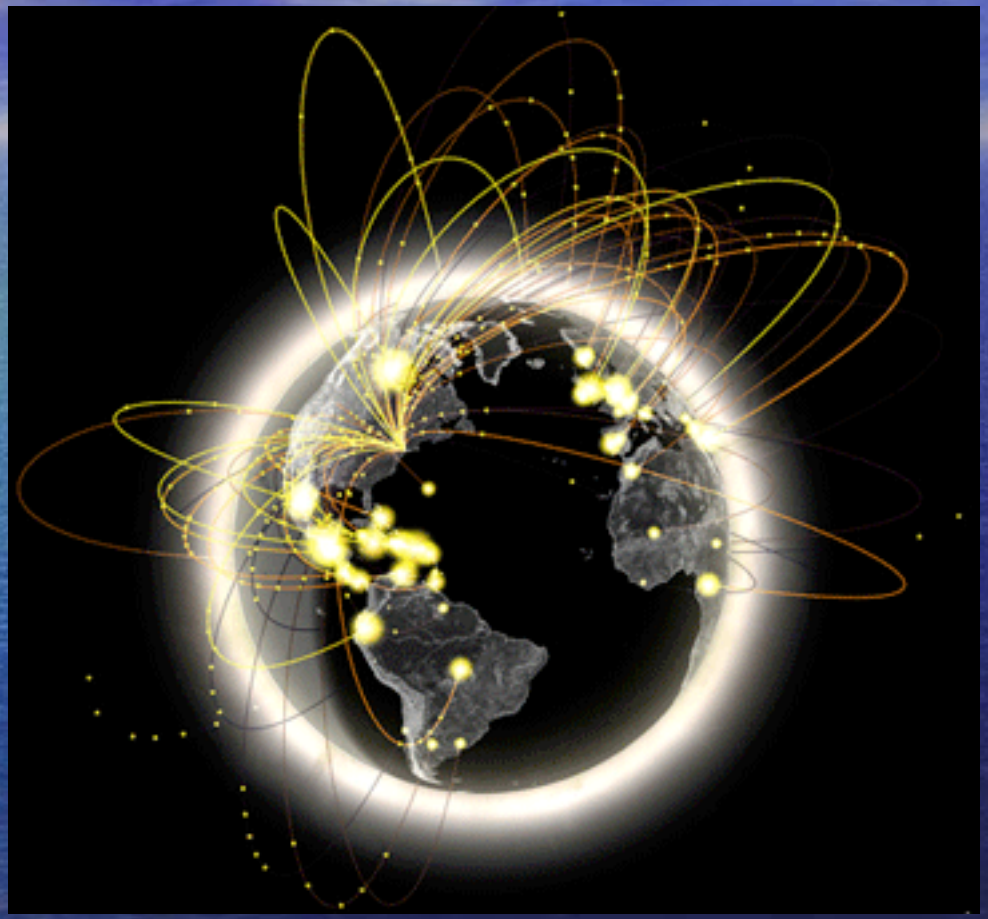
Physical Oceanography, Distributed Active Archive Center
PO.DAAC

July 8th, 2009



Overview

- Why is ocean remote sensing important?
- In Situ (place) measurements
- Satellite Instruments, including Aquarius
- Educational Tools & Activities
- PO.DAAC Products

Water cycle Ocean vs. Land

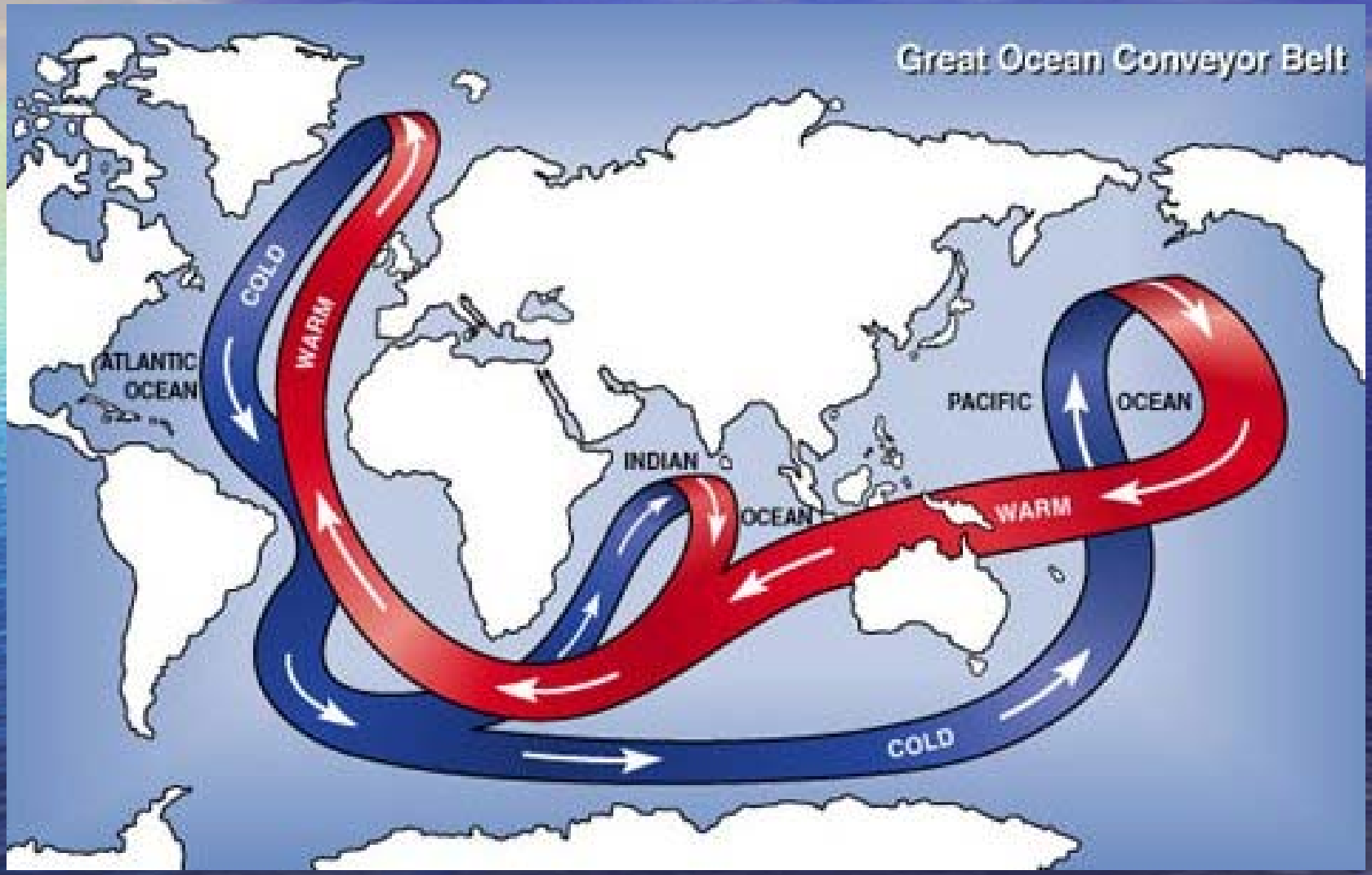
- ~70% of earth is covered by water
- Volume of water in oceans ~ 1.4×10^9 km^3
  - 24 times as much as glaciers and lakes
  - 100,000 times as much as the atmoshpere holds
- Heat capacity is 1100 times higher than atmosphere

Global Water Cycle Fluxes

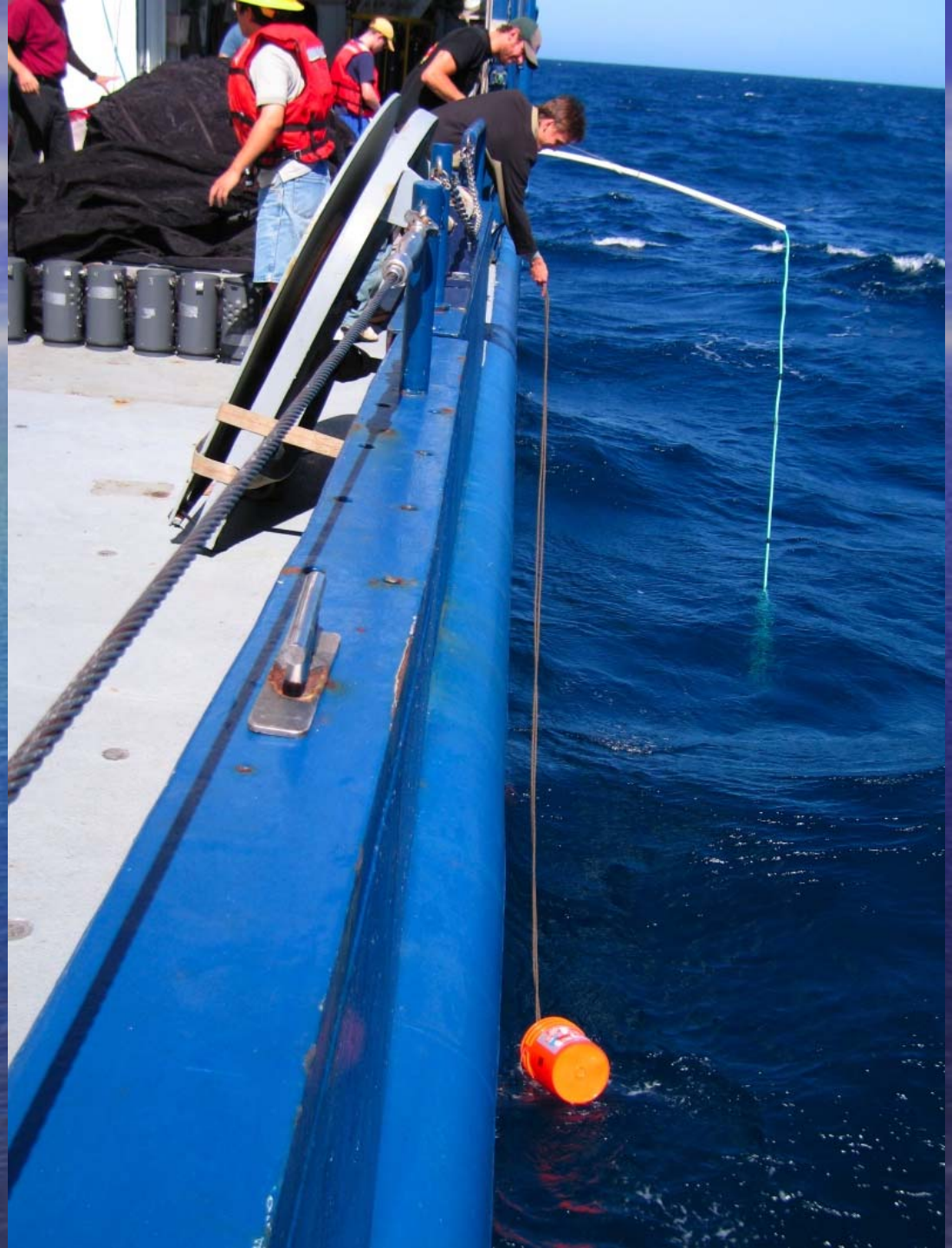
- Rainfall over oceans ~ 12 Sverdrups (Sv, 1 Sv = 1 million m^3/s)
- Rainfall over land ~ 3 Sv
- Evaporation over ocean ~ 13 Sv
- Evaporation over land ~ 2 Sv
- Terrestrial Runoff ~1Sv

- Water Cycle is dominated by ocean - atmosphere fluxes!

Conveyor Belt



In Situ Measurements




R/V
LAKE
GUARDIAN
7
6
5

Salinometer

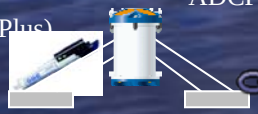
Samantha Miller

Mooring Design

CT Sensor

(SBE 16 Plus)

RDI
ADCP



15m depth – 30 m chain

20m depth – 40 m chain

3/8” chain

1000 lb. for 4 CFR

500 lb. for 5 CFR

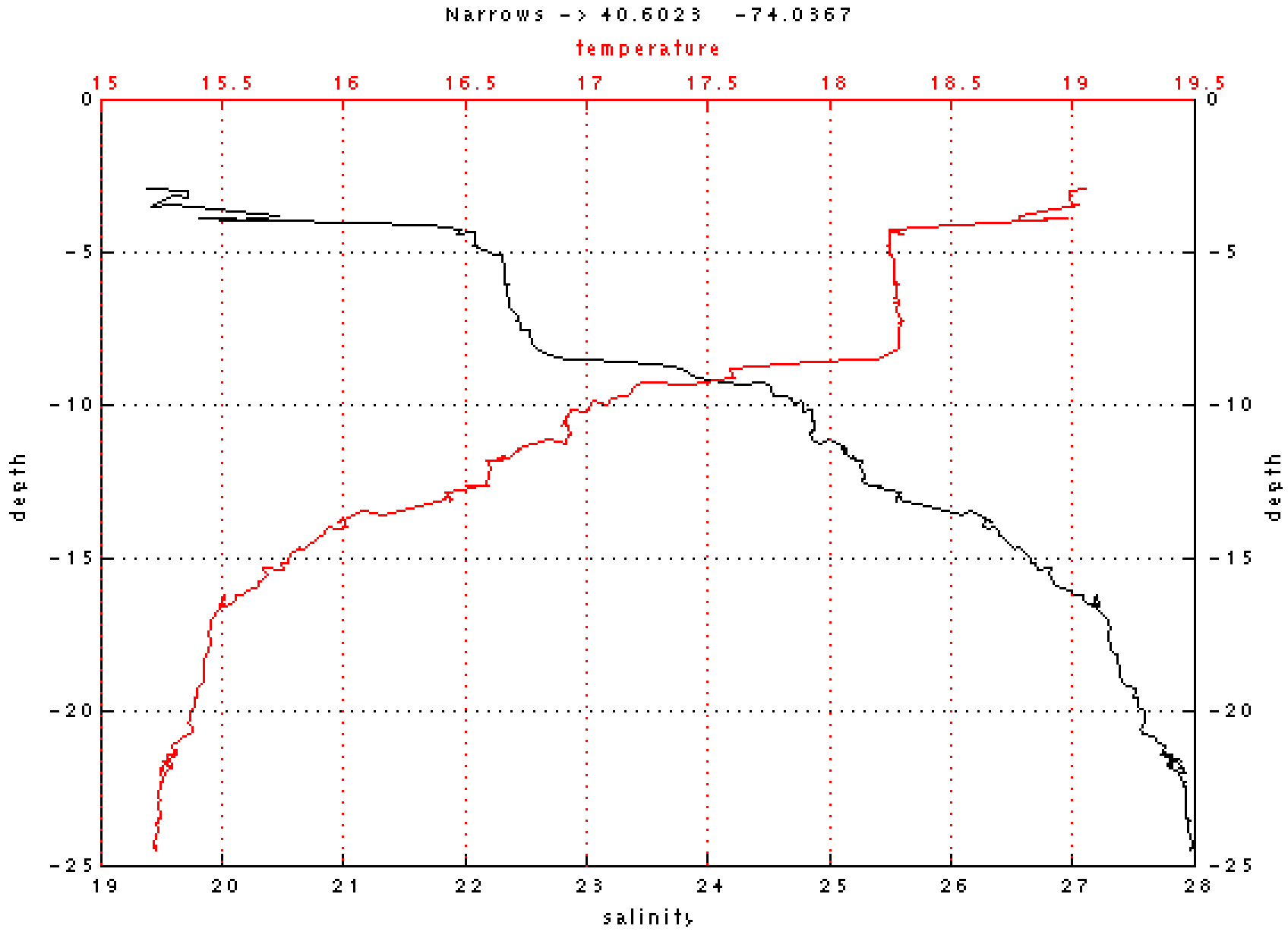
- CTD
- Conductivity
- Temperature
- Depth (pressure)


Tidbit Temp Logger
StowAway


Dr. Robert Chant
732-932-6555

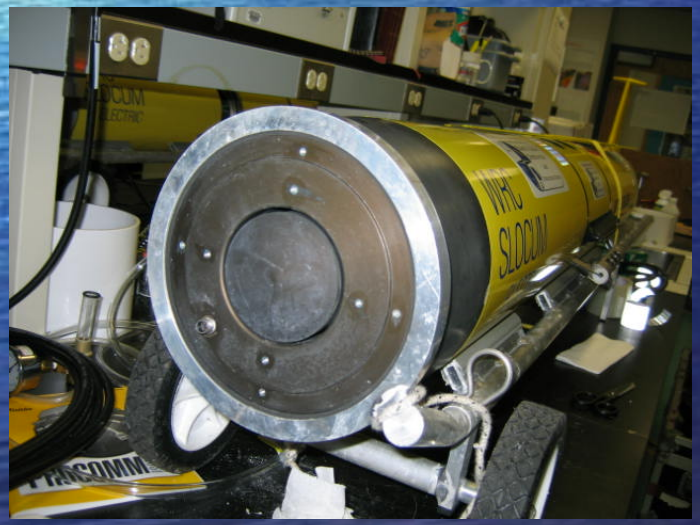

SWL
4 TONS
MILLERS

Official USCG Photo courtesy Jim Flynn


Narrows -> 40.6023 -74.0367
temperature
15
15.5
16
16.5
17
17.5
18
18.5
19
19.5
0
-5
-10
-15
-20
-25
depth
19
20
21
22
23
24
25
26
27
28
salinity

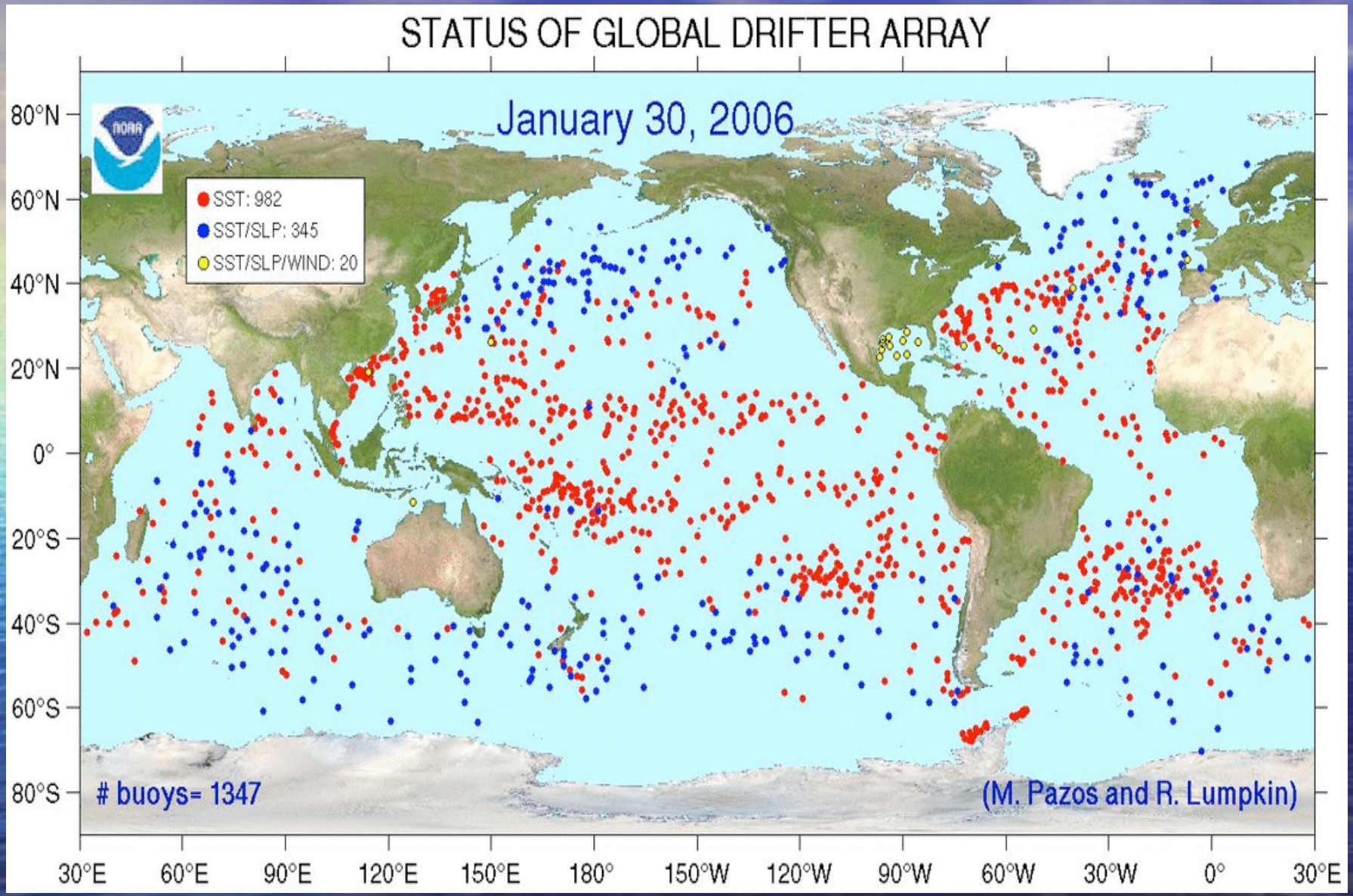
Glider


06


WHOI
SLOCUM

Glider Specs

- ***Glider Specifications***
- **Weight:**52 Kg
- **Diameter:** 21.3 cm
- **Length:**1.5 meters
- **Depth Range:**4 - 200 meters
- **Speed:**0.4 m/sec
- **Energy:** Alkaline Batteries
- **Endurance:** ~30 days
- **Range:**1500 km
- **Navigation:** GPS,internal dead reckoning, altimeter
- **Sensor Package:** Conductivity, Temperature, Depth
- **Communications:** satellite telephone, Freewave Radio ARGOS satellite


STATUS OF GLOBAL DRIFTER ARRAY
January 30, 2006
SST: 982
SST/SLP: 345
SST/SLP/WIND: 20
buoys= 1347
(M. Pazos and R. Lumpkin)
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S
30°E
60°E
90°E
120°E
150°E
180°
150°W
120°W
90°W
60°W
30°W
0°
30°E

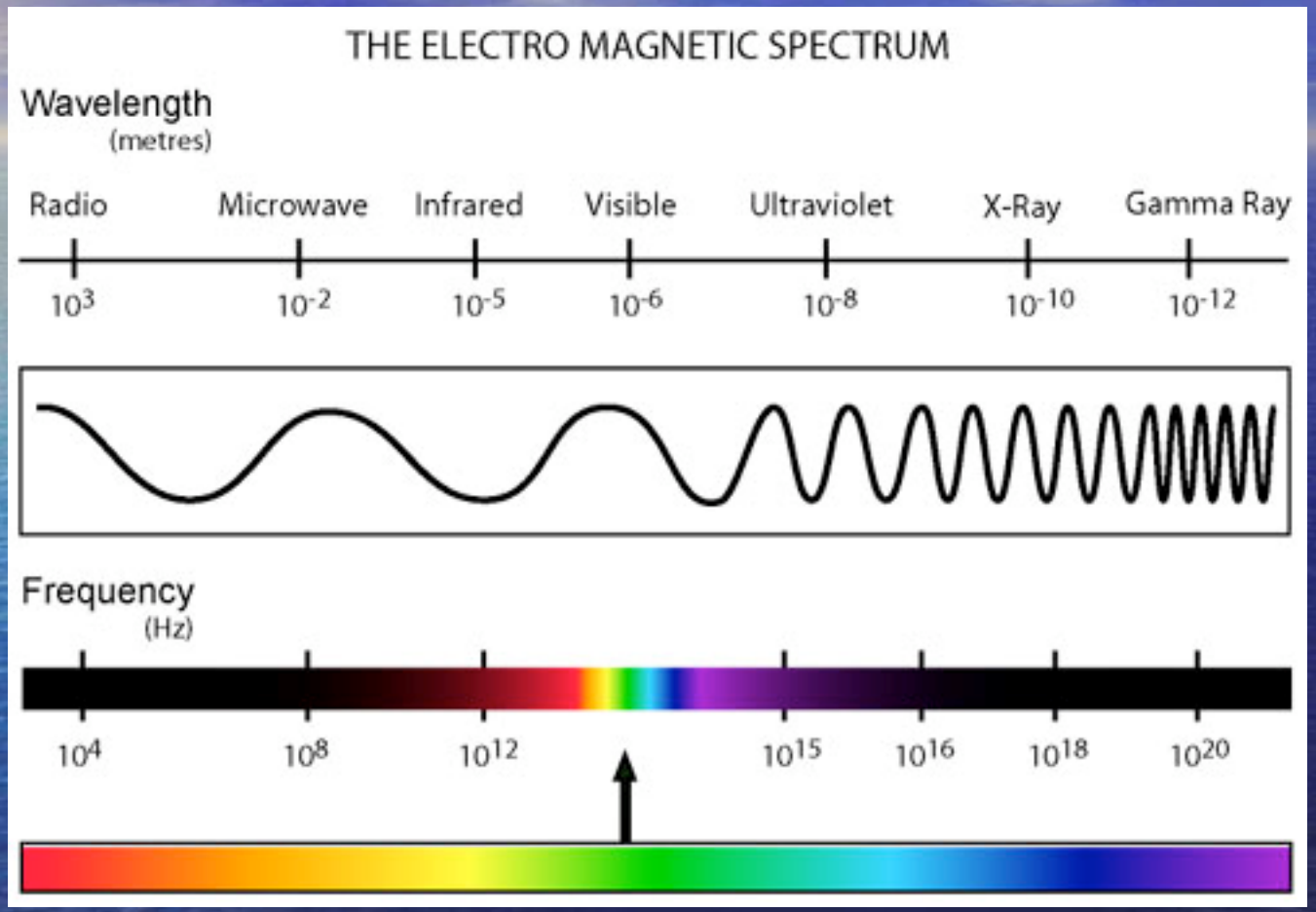

Aquarius

Requirements

- 390 km swath
- 8 samples per month near equator
- 0.2 psu (0.0002) accuracy after temporal averaging over a month
- Temporal Resolution 1 month
- Spatial Resolution 100km

Instrument Specifications

- Radiometer & Scatterometer
  - Footprint size - 76x94, 84x120, 96x156
  - Orbit 657 km Sun Synchronous
- Radiometer
  - Frequency ν = 1.413 GHz +/- 25MHz
  - Wavelength $\lambda = c/\nu \sim 0.212$m
  - L band = 0.39 - 1.55 GHz


THE ELECTRO MAGNETIC SPECTRUM
Wavelength
(metres)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-Ray
Gamma Ray
10^3
10^-2
10^-5
10^-6
10^-8
10^-10
10^-12
Frequency
(Hz)
10^4
10^8
10^12
10^15
10^16
10^18
10^20

Scatterometer

- Frequency ν = 1.26 GHz
- Wavelength $\lambda = c/\nu \sim 0.238$m

Orbit Altitude vs. Orbit Time

$F_{centrifical} = F_{gravity}$

$F_c = ma = m\,\Delta v/\Delta t$

$t = 2\pi r/v$

$r/v = v/a$

$F_c = m\,v^2/r = GMm/r^2$

$v = 2\pi r/t$

$t^2 = 4\pi^2 r^3/(GM)$

$F_g = GMm/r^2$

$d = v\,\Delta t$

$t = 2\pi v/a$

$a = v^2/r$

$v^2 = GM/r$ (no sat. mass)

$4\pi^2 r^2/t^2 = GM/r$

Orbit Altitude vs. Orbit Time

$t^2 = 4\pi^2 r^3/(GM)$

$G = 6.67E\text{-}11\ Nm^2\ kg^{-2}$ $M_e = 6E24\ kg$

$N = kg\ m\ s^{-2}$ $R_e = 6378\ km$

mean altitude of satellite = 657km

r = 6378km + 657km = 7035km

$$t^2 = \frac{4\pi^2 (7035km\ (1000m/km))^3}{6.67E\text{-}11\ kg\ m\ s^{-2}\ m^2\ kg^{-2}\ 6E24\ kg}$$

t ~ 97 2/3 minutes

- Ocean remote sensing from space is the only practical way to obtain global coverage of ocean surface properties
- In Situ (place) measurements important for below surface measurements and for validating satellites

AQUARIUS/SAC-D

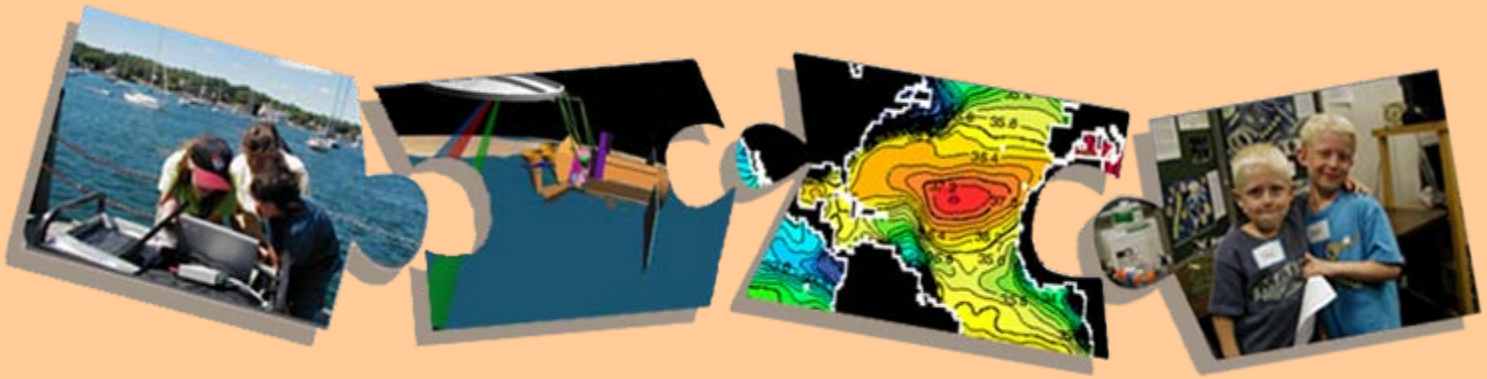
EDUCATION & PUBLIC OUTREACH

Will present two activities:

- Hands-on lab
- Online data tools

Goal is to demonstrate how these complementary activities support this "Big Idea":

Salt causes water to freeze at a lower temperature. The oceans do not freeze -- and are layered -- because of salinity (and this is critically important to the overall earth system).



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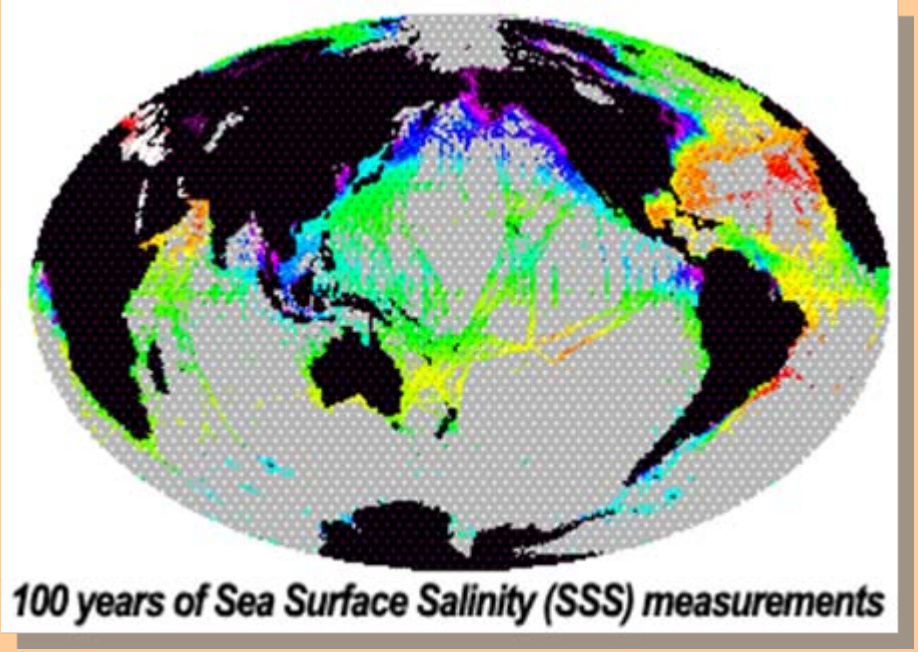

This map shows a seven-day average, based on all known measurement locations sampled over the past 100 years for Sea Surface Salinity (SSS)

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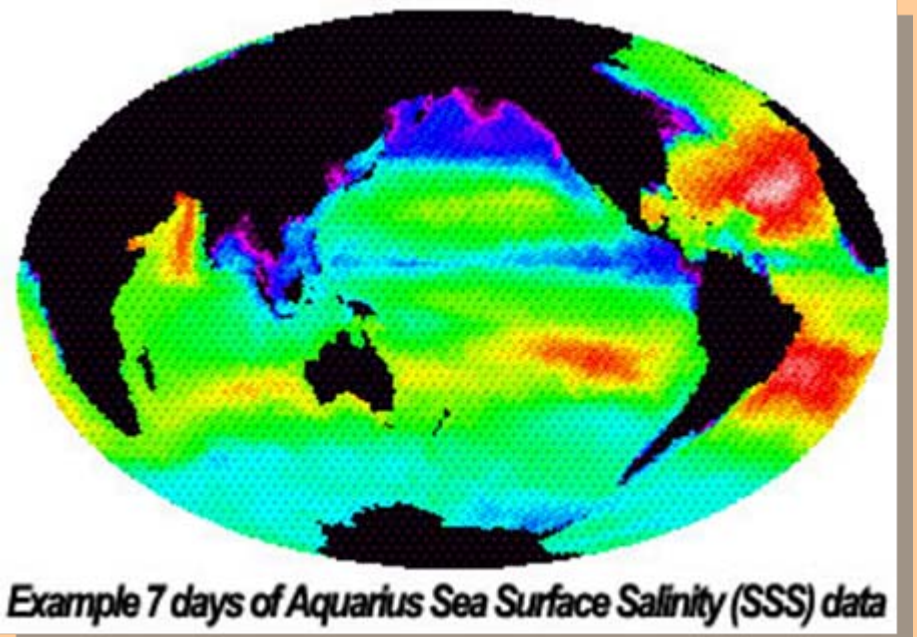


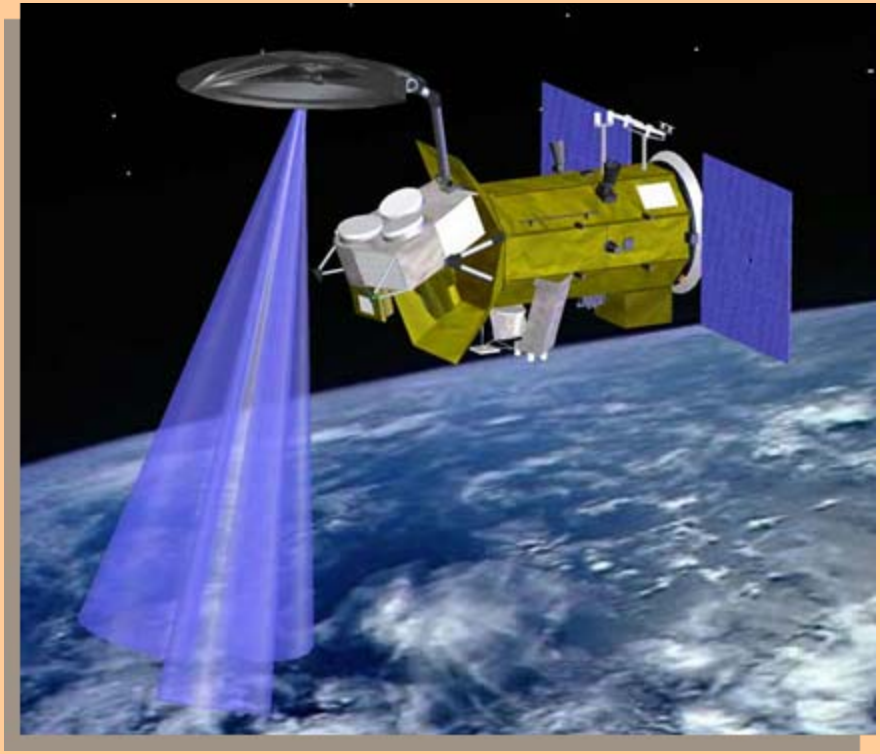
Example 7 days of Aquarius Sea Surface Salinity (SSS) data

Not presently measured by satellite, this map shows the weekly SSS coverage that will be achieved by *Aquarius* after its 2010 launch

Aquarius / SAC-D is a joint U.S. (NASA) - Argentine (CONAE) venture

AQUARIUS/SAC-D

EDUCATION & PUBLIC OUTREACH



Aquarius instrument accuracy will be 0.2 psu*. How much salt should be added to 1 gallon of water to change its salinity by 0.2 psu?

- 1 tablespoon
- 1 teaspoon
- 1/2 teaspoon
- 1/6 teaspoon

•**Used to describe the concentration of dissolved salts in water, the UNESCO Practical Salinity Scale of 1978 defines salinity in terms of a conductivity ratio, so it is dimensionless. Salinity was formerly expressed in terms of parts per thousand or by weight (parts per thousand or 0/00). That is, a salinity of 35 ppt meant 35 pounds of salt per 1,000 pounds of seawater. Open ocean salinities are generally in the range between 32 and 37.*

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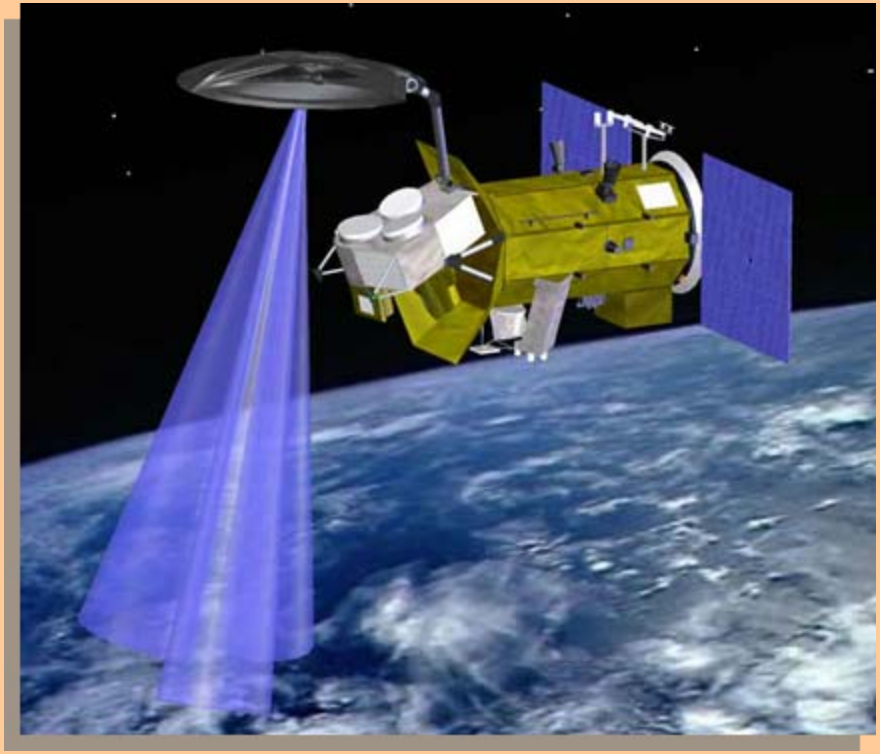

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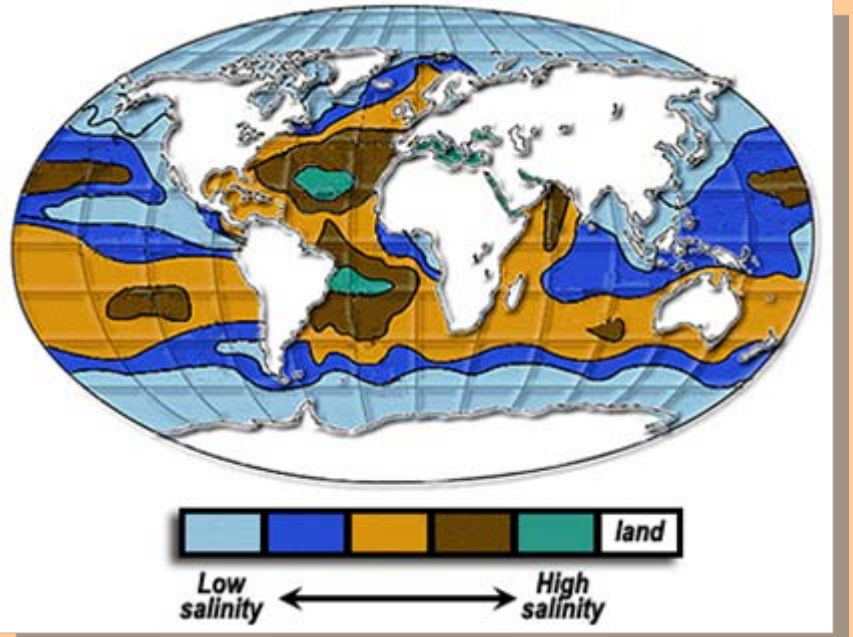

The mission will help answer questions about how our oceans respond to climate change and the water cycle.

Like on land, some areas of the ocean are rainy whereas others are arid. *Aquarius* SSS data will reveal the water cycle's ever-changing "fingerprint."

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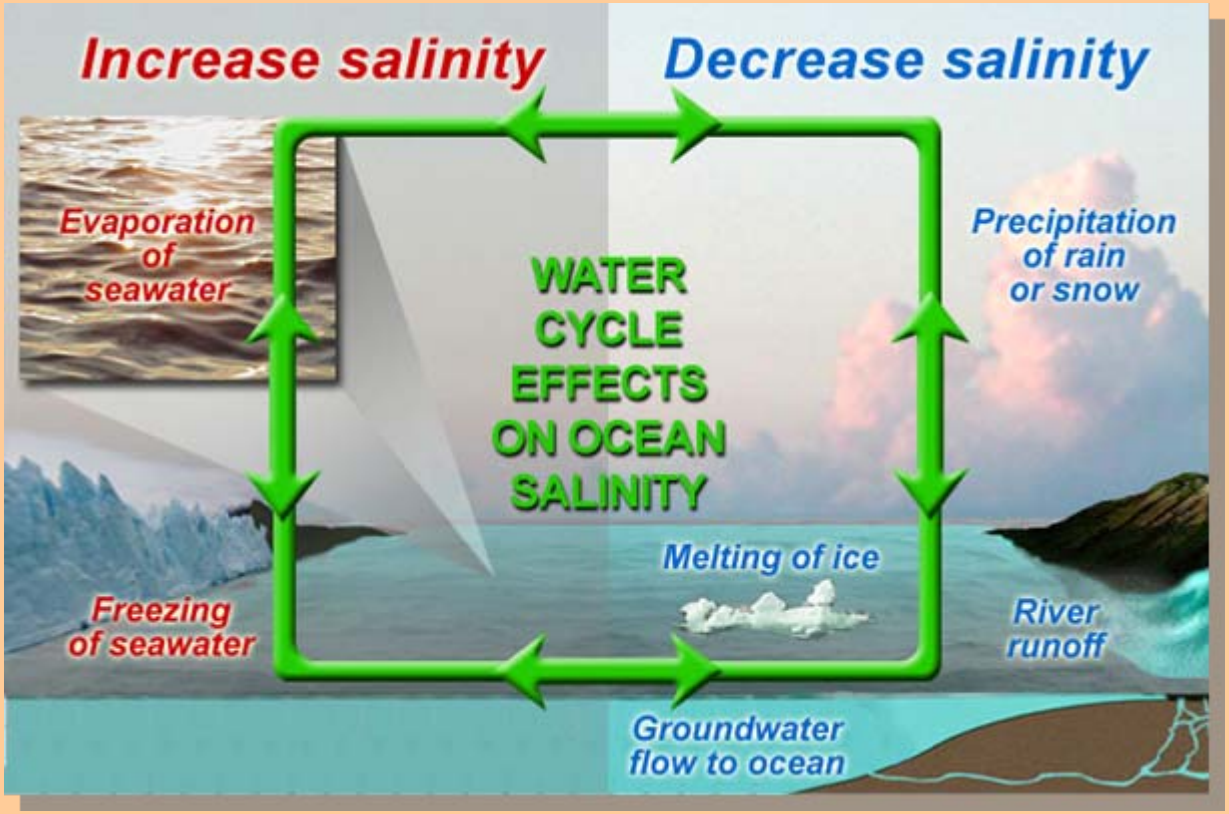
SSS maps can be used to directly track variations in the water cycle such as river runoff, sea ice freezing & melting, ocean evaporation & precipitation:



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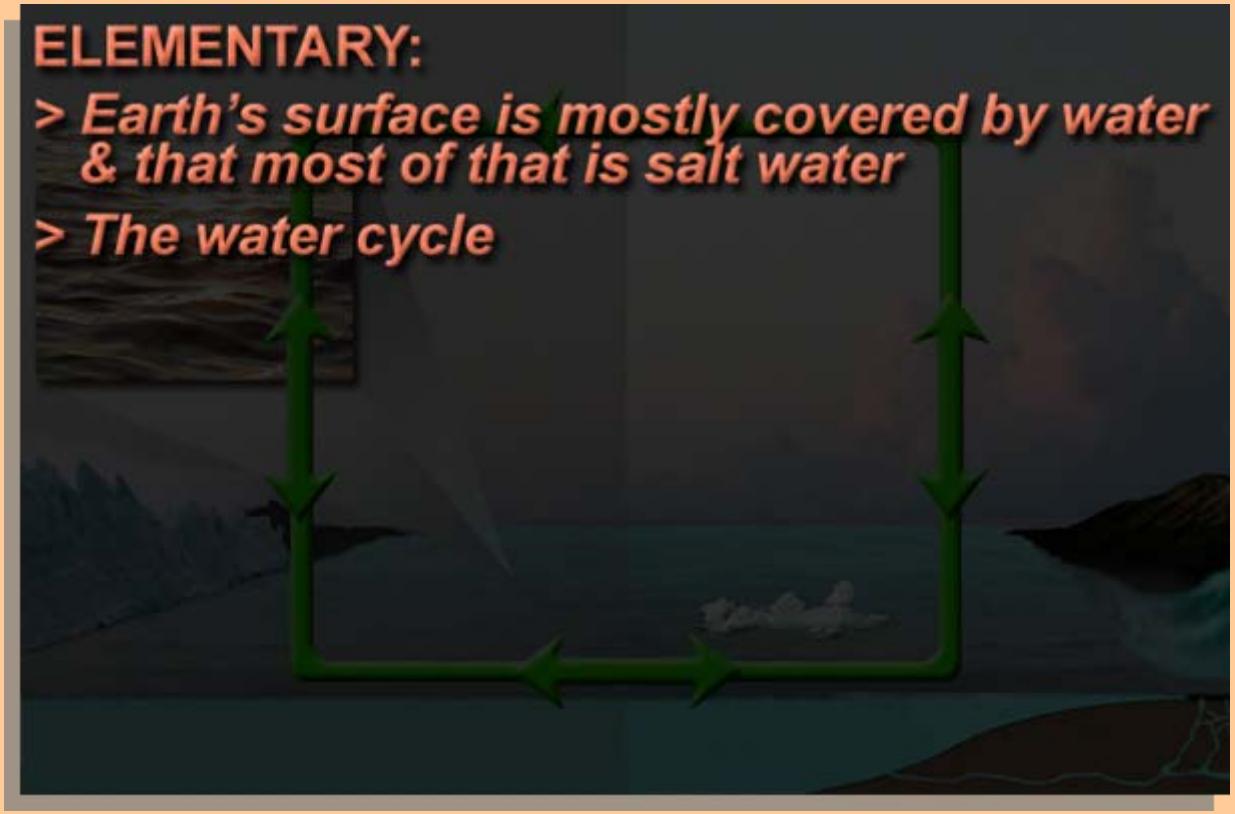
These concepts are directly aligned with content knowledge Standards & Benchmarks:



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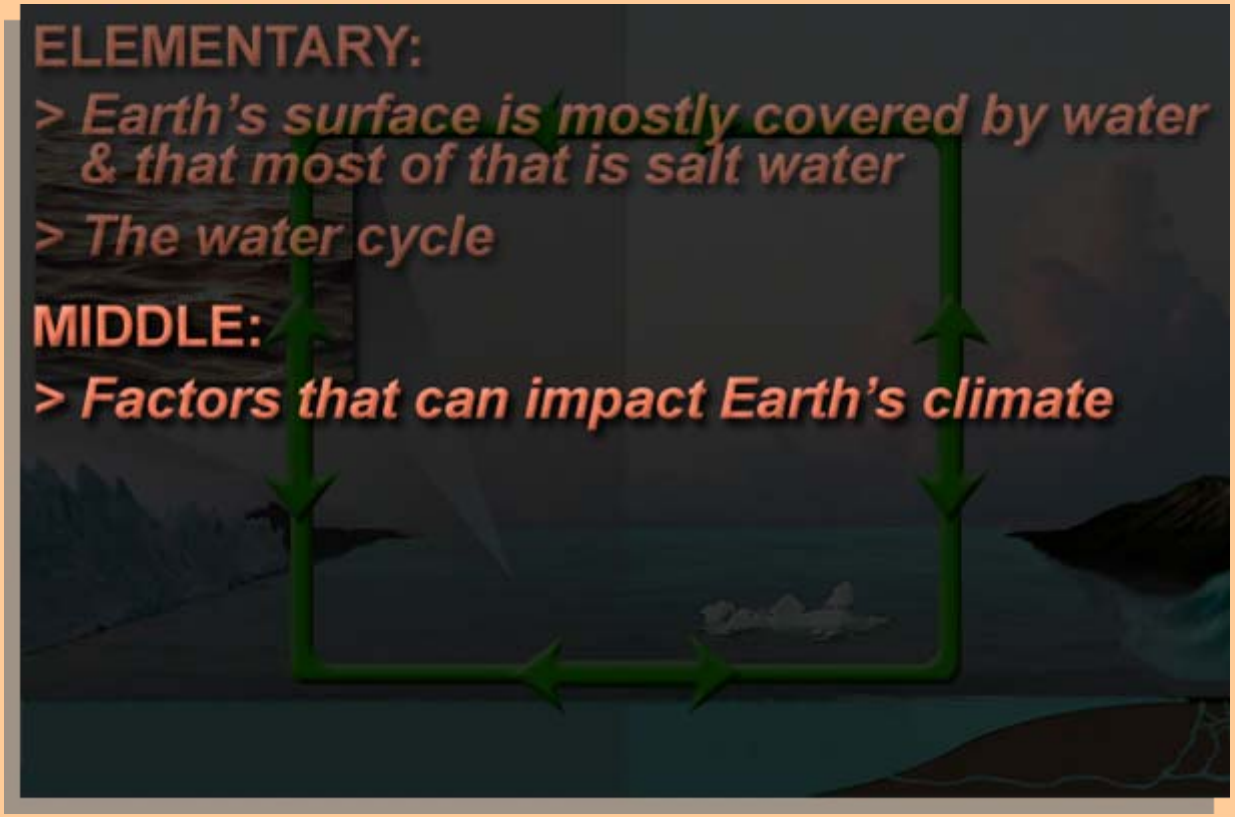

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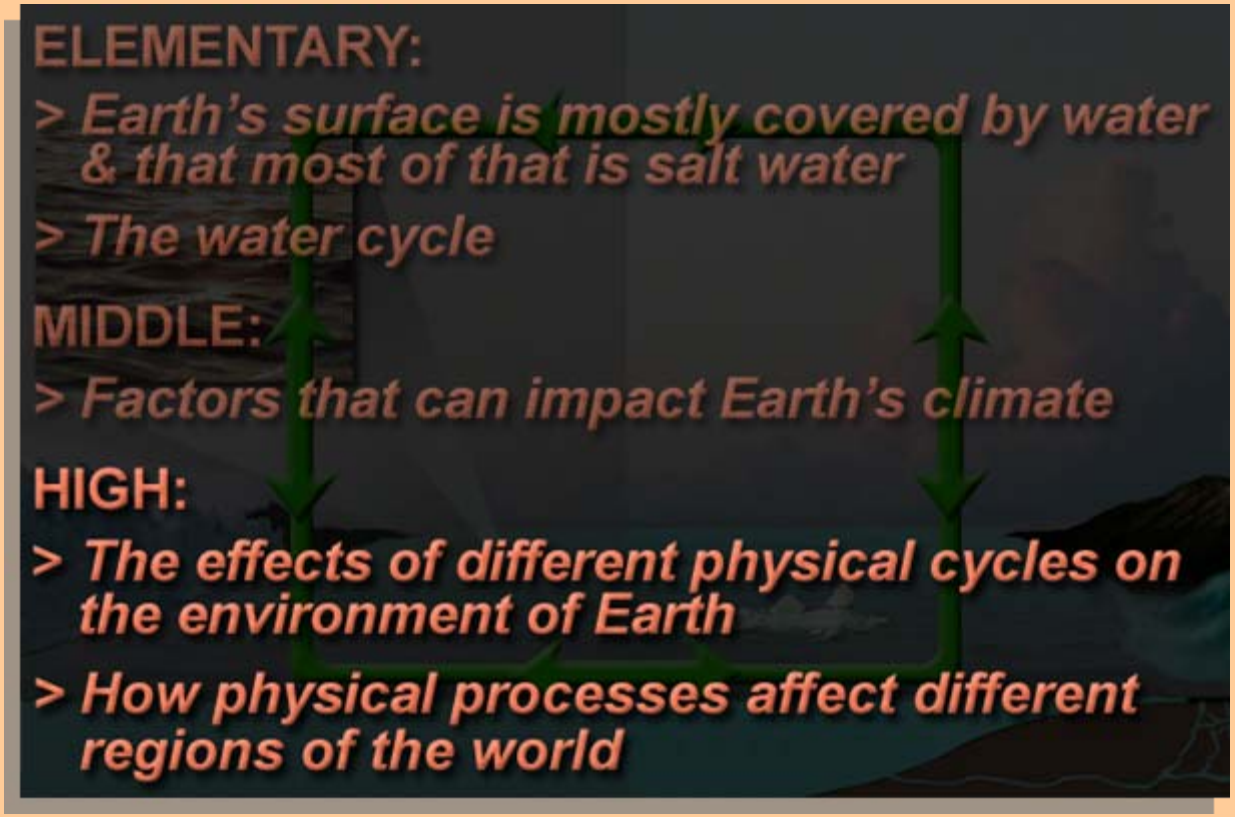

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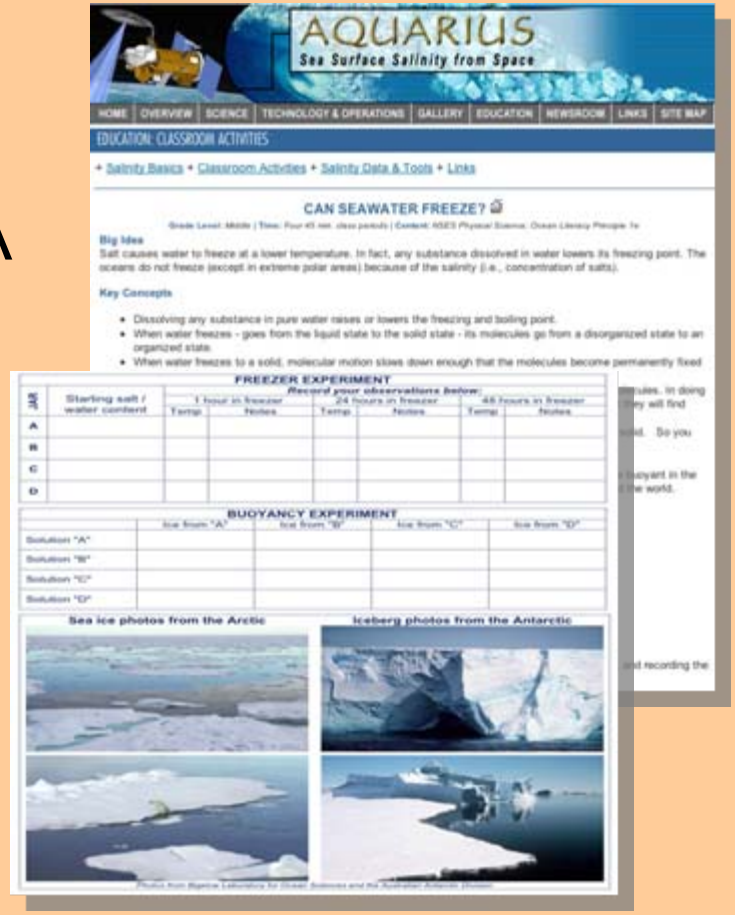
"Salinity Patterns & the Water Cycle" module recently rated "Very Good-Outstanding" by NASA Earth Science Education Products Review panel.



Includes nine activities aligned with physical sciences standards for elementary through high school students.

http://aquarius.nasa.gov/education.html

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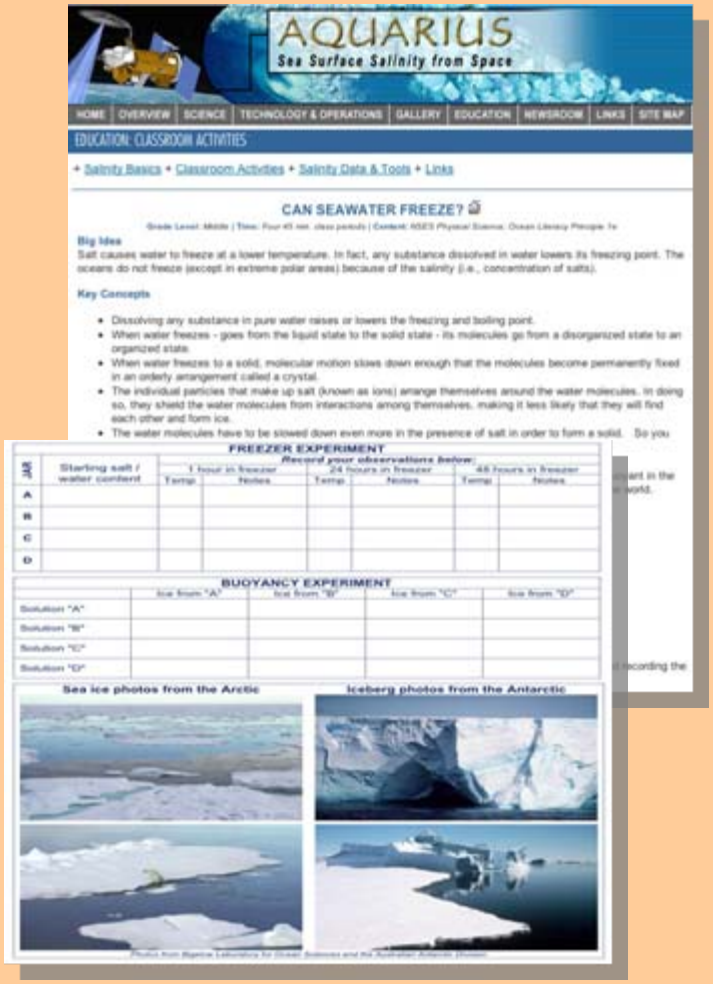
Each activity follows the format:

- Big Idea
- Key Concepts
- Essential Questions
- Knowledge and Skills
- Prior Knowledge
- Common Preconceptions



And is linked to the comprehensive concept map: "Water & its patterns on Earth's surface"

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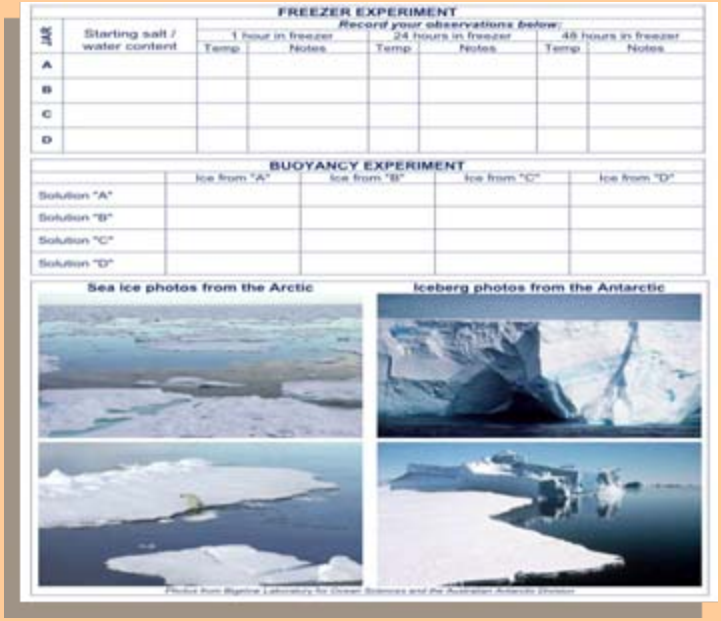
”Can Sea Water Freeze?" is a middle school activity

- *Let's begin the experiment!*



FREEZER EXPERIMENT

Record your observations below:

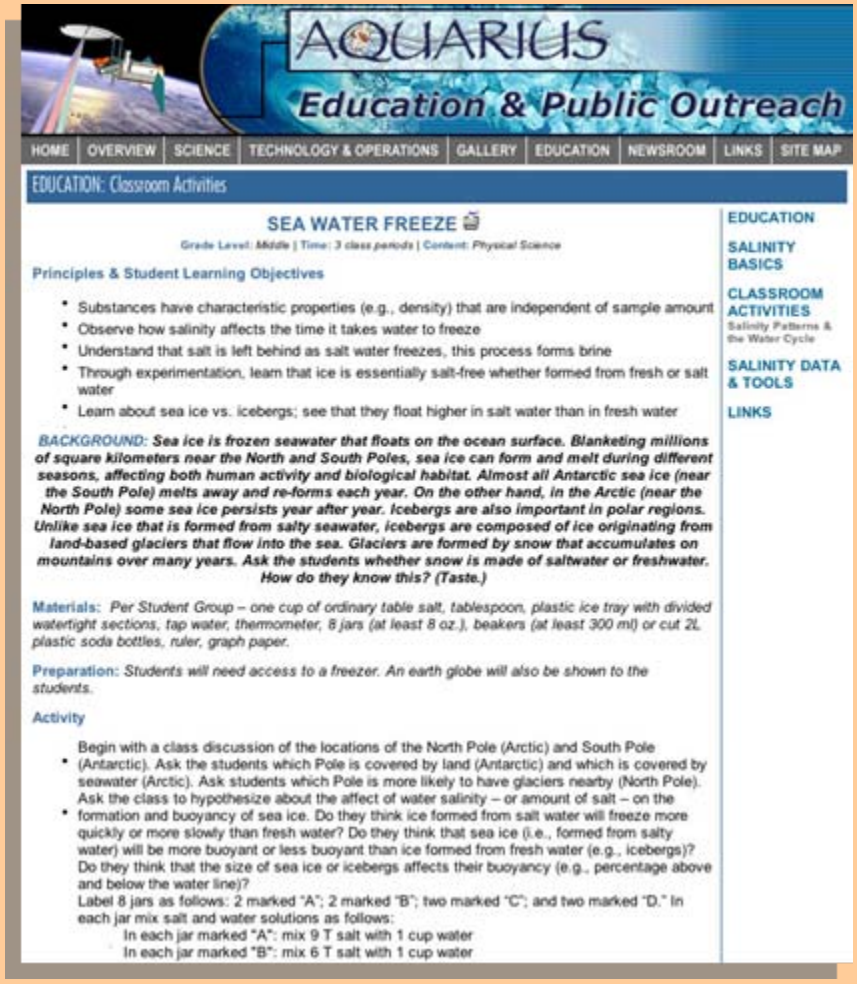
JAR	Starting salt / water content	1 hour in freezer		24 hours in freezer		48 hours in freezer	
		Temp	Notes	Temp	Notes	Temp	Notes
A							
B							
C							
D							

BUOYANCY EXPERIMENT

	Ice from "A"	Ice from "B"	Ice from "C"	Ice from "D"
Solution "A"				
Solution "B"				
Solution "C"				
Solution "D"				

Sea ice photos from the Arctic

Iceberg photos from the Antarctic



AQUARIUS

Education & Public Outreach

HOME | OVERVIEW | SCIENCE | TECHNOLOGY & OPERATIONS | GALLERY | EDUCATION | NEWSROOM | LINKS | SITE MAP

EDUCATION: Classroom Activities

SEA WATER FREEZE

Grade Level: Middle | Time: 3 class periods | Content: Physical Science

Principles & Student Learning Objectives

- Substances have characteristic properties (e.g., density) that are independent of sample amount
- Observe how salinity affects the time it takes water to freeze
- Understand that salt is left behind as salt water freezes, this process forms brine
- Through experimentation, learn that ice is essentially salt-free whether formed from fresh or salt water
- Learn about sea ice vs. icebergs; see that they float higher in salt water than in fresh water

***BACKGROUND:* Sea ice is frozen seawater that floats on the ocean surface. Blanketing millions of square kilometers near the North and South Poles, sea ice can form and melt during different seasons, affecting both human activity and biological habitat. Almost all Antarctic sea ice (near the South Pole) melts away and re-forms each year. On the other hand, in the Arctic (near the North Pole) some sea ice persists year after year. Icebergs are also important in polar regions. Unlike sea ice that is formed from salty seawater, icebergs are composed of ice originating from land-based glaciers that flow into the sea. Glaciers are formed by snow that accumulates on mountains over many years. Ask the students whether snow is made of saltwater or freshwater. How do they know this? (Taste.)**

Materials: *Per Student Group – one cup of ordinary table salt, tablespoon, plastic ice tray with divided watertight sections, tap water, thermometer, 8 jars (at least 8 oz.), beakers (at least 300 ml) or cut 2L plastic soda bottles, ruler, graph paper.*

Preparation: *Students will need access to a freezer. An earth globe will also be shown to the students.*

Activity

- Begin with a class discussion of the locations of the North Pole (Arctic) and South Pole (Antarctic). Ask the students which Pole is covered by land (Antarctic) and which is covered by seawater (Arctic). Ask students which Pole is more likely to have glaciers nearby (North Pole). Ask the class to hypothesize about the affect of water salinity – or amount of salt – on the
- formation and buoyancy of sea ice. Do they think ice formed from salt water will freeze more quickly or more slowly than fresh water? Do they think that sea ice (i.e., formed from salty water) will be more buoyant or less buoyant than ice formed from fresh water (e.g., icebergs)? Do they think that the size of sea ice or icebergs affects their buoyancy (e.g., percentage above and below the water line)?

Label 8 jars as follows: 2 marked "A"; 2 marked "B"; two marked "C"; and two marked "D." In each jar mix salt and water solutions as follows:

In each jar marked "A": mix 9 T salt with 1 cup water

In each jar marked "B": mix 6 T salt with 1 cup water

EDUCATION

SALINITY BASICS

CLASSROOM ACTIVITIES

Salinity Patterns & the Water Cycle

SALINITY DATA & TOOLS

LINKS

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Students in action!

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Students in action!

For complementary online activities,
let's visit the prototype website:

http://aquarius.jpl.nasa.gov/

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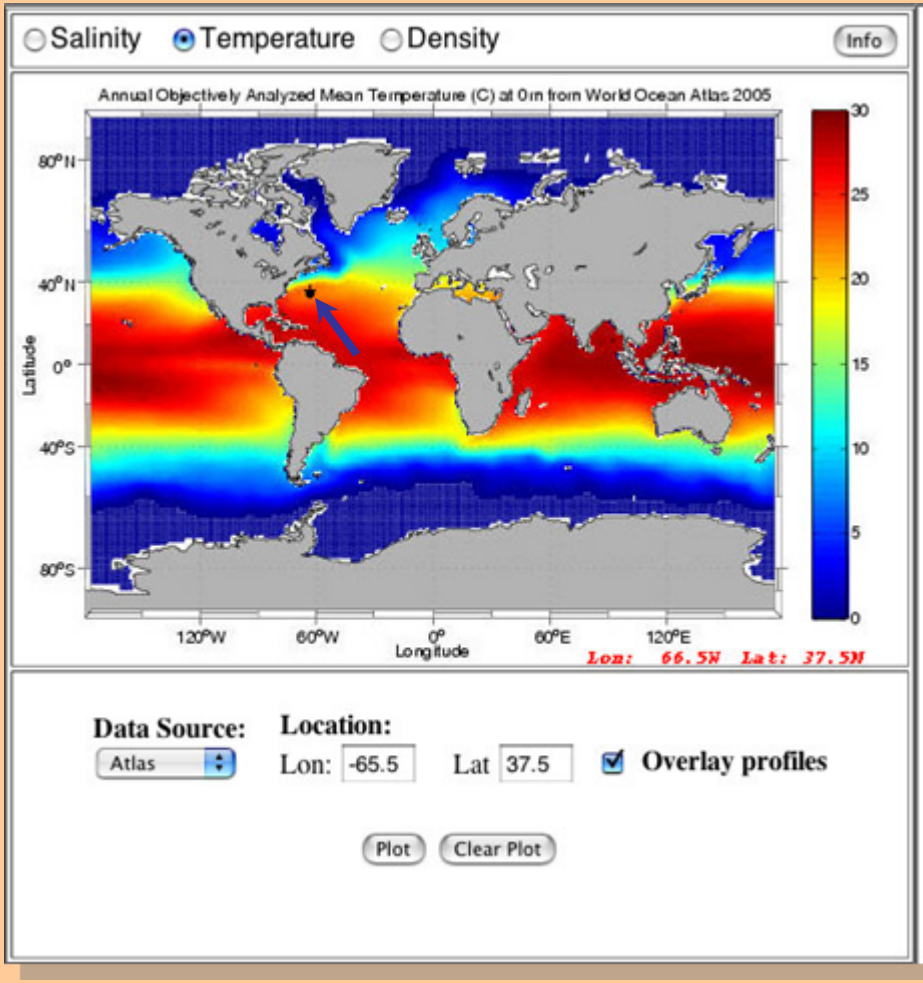
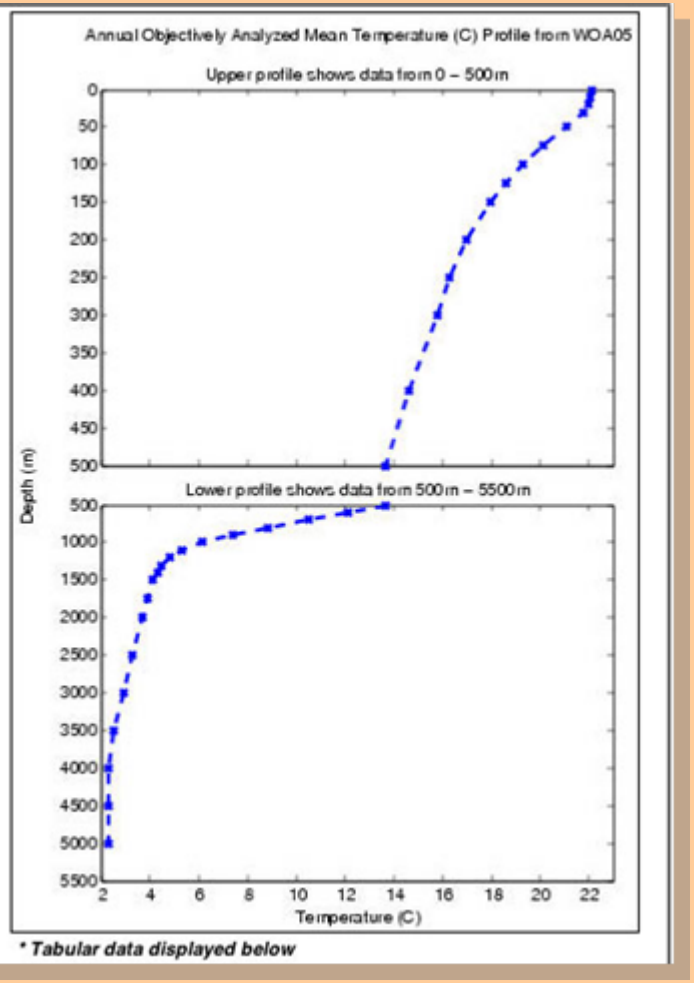
EDUCATION & PUBLIC OUTREACH

Annual mean maps & In-water profiles: Salinity, temperature & density





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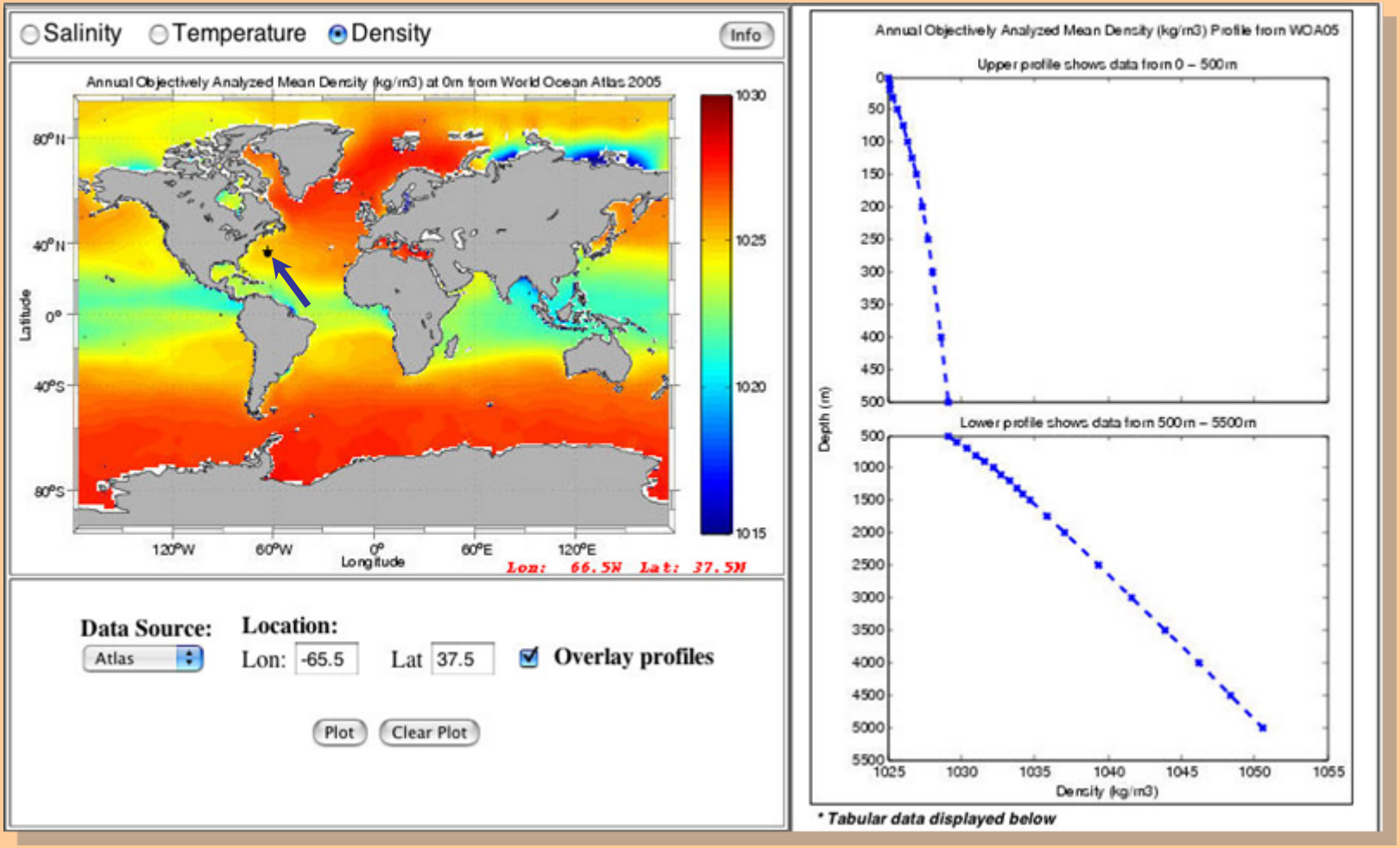

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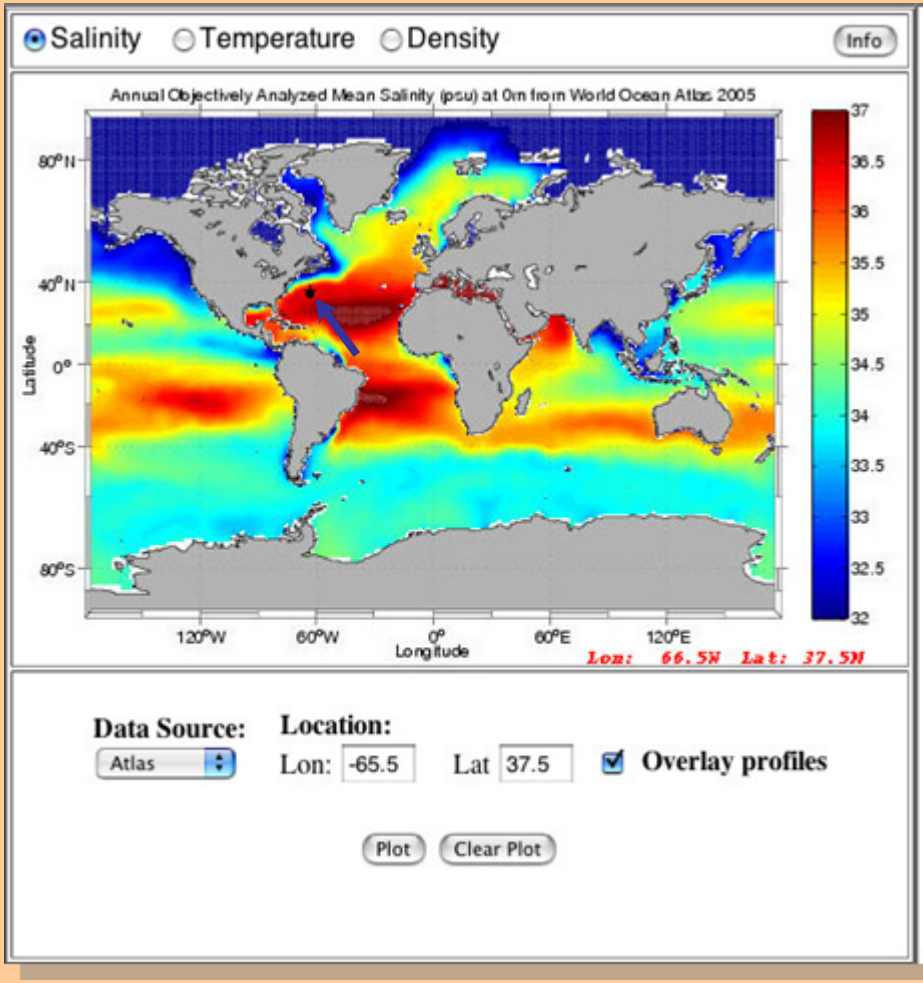

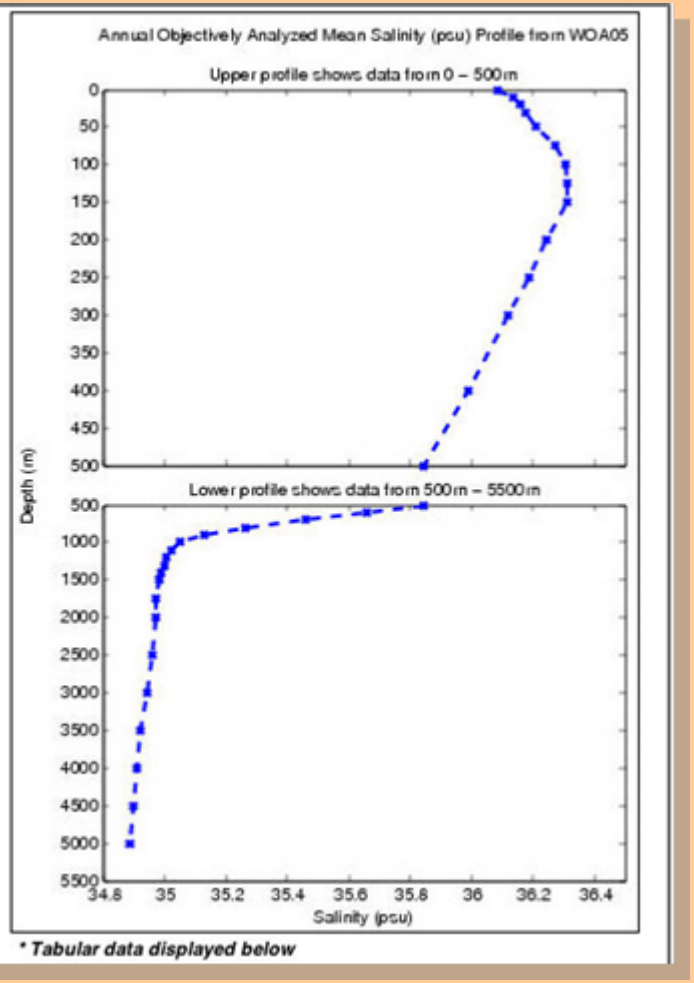

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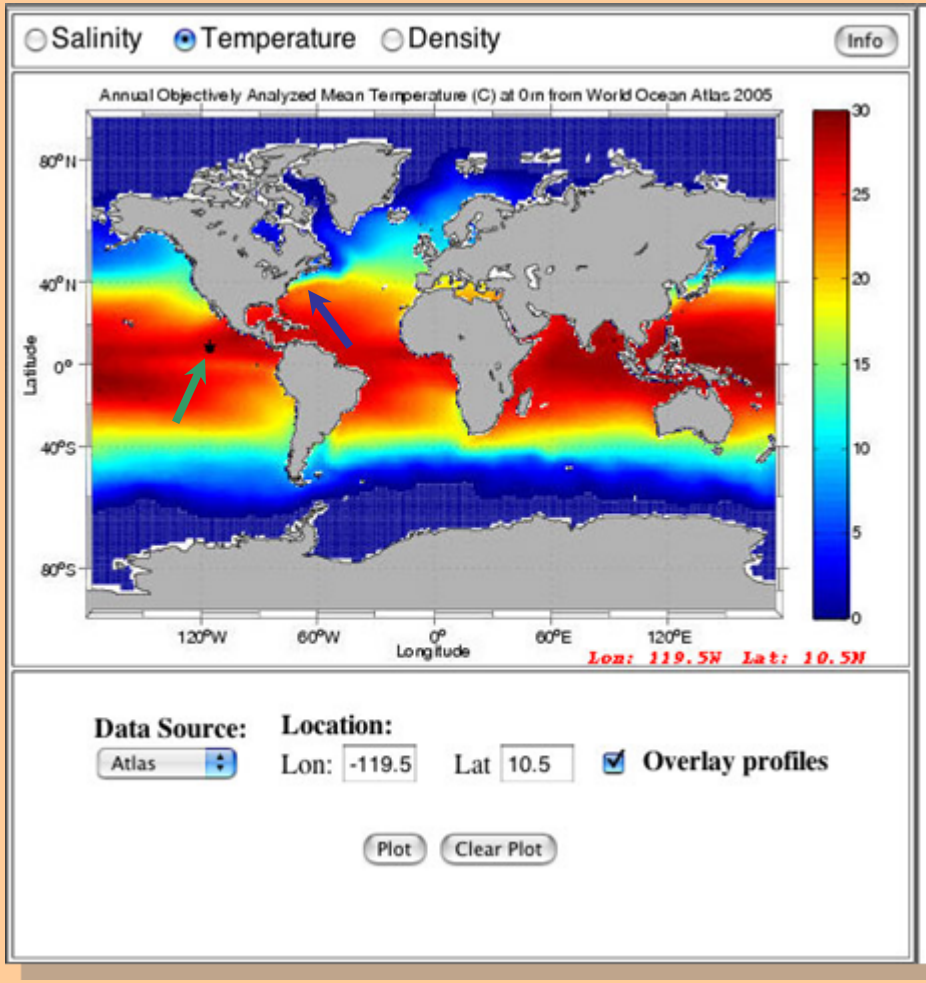

Can choose up to six locations at once

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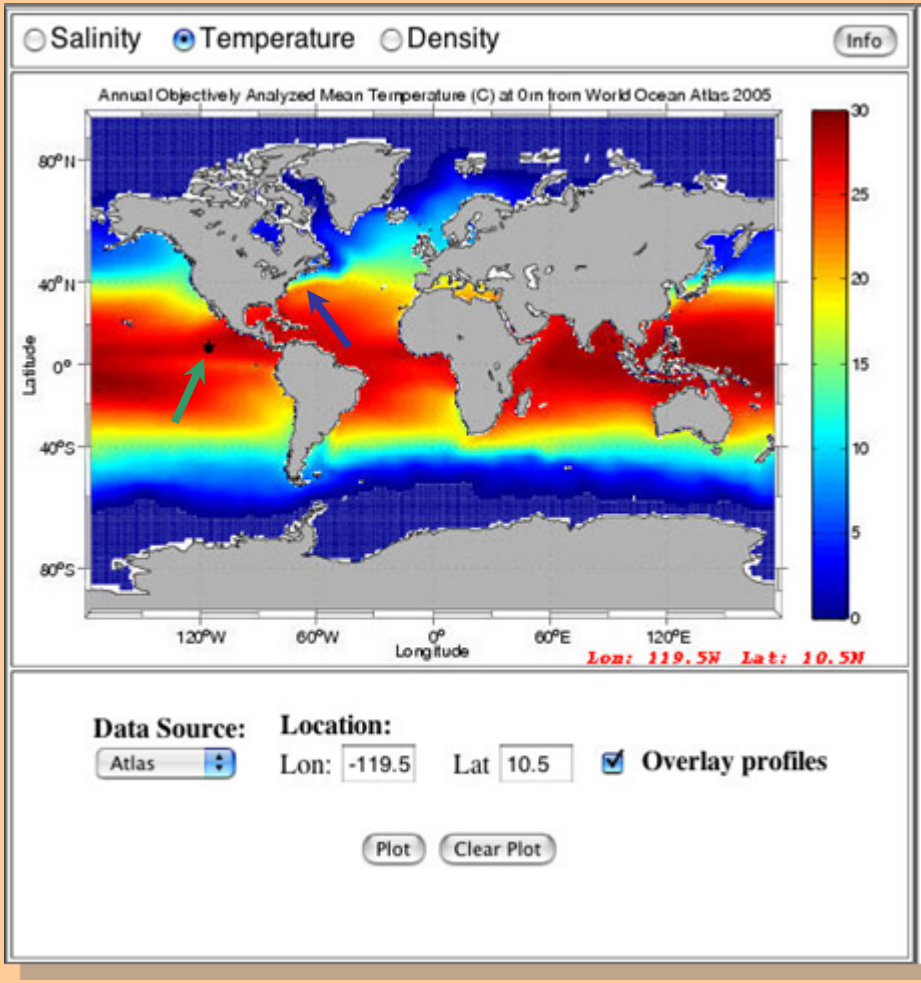
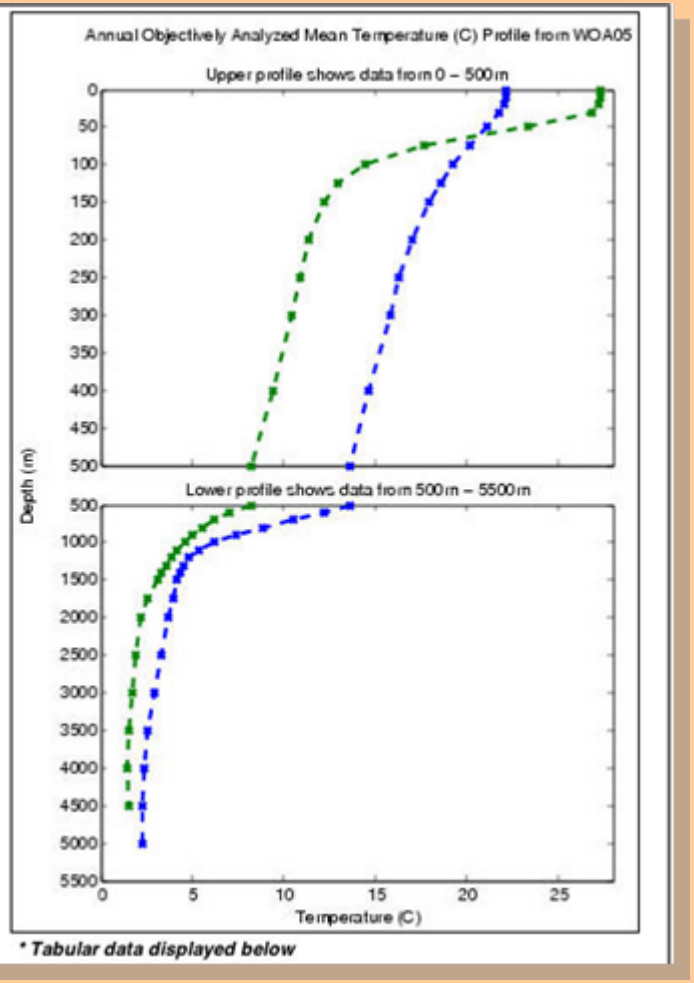
Annual mean maps & In-water profiles: Salinity, temperature & density





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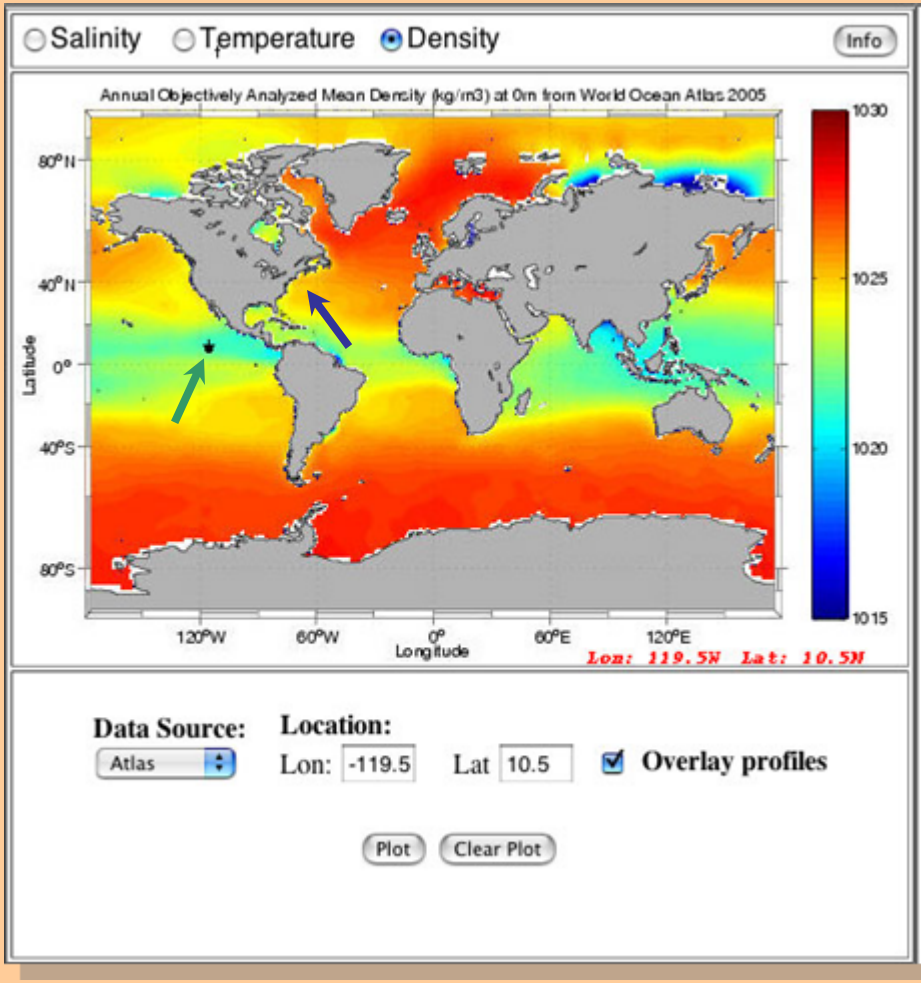

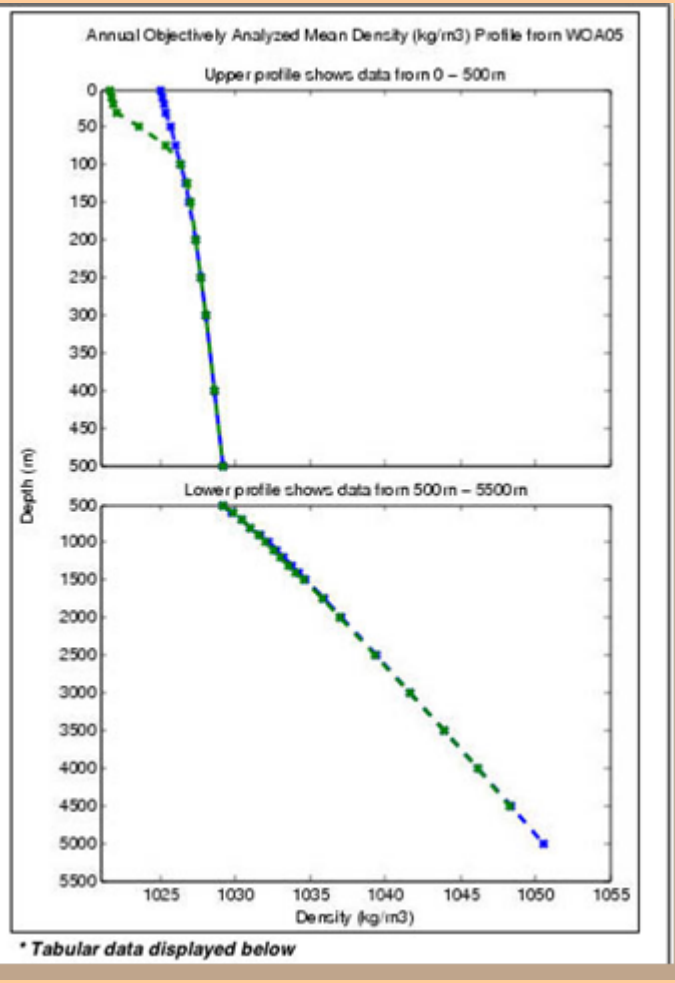

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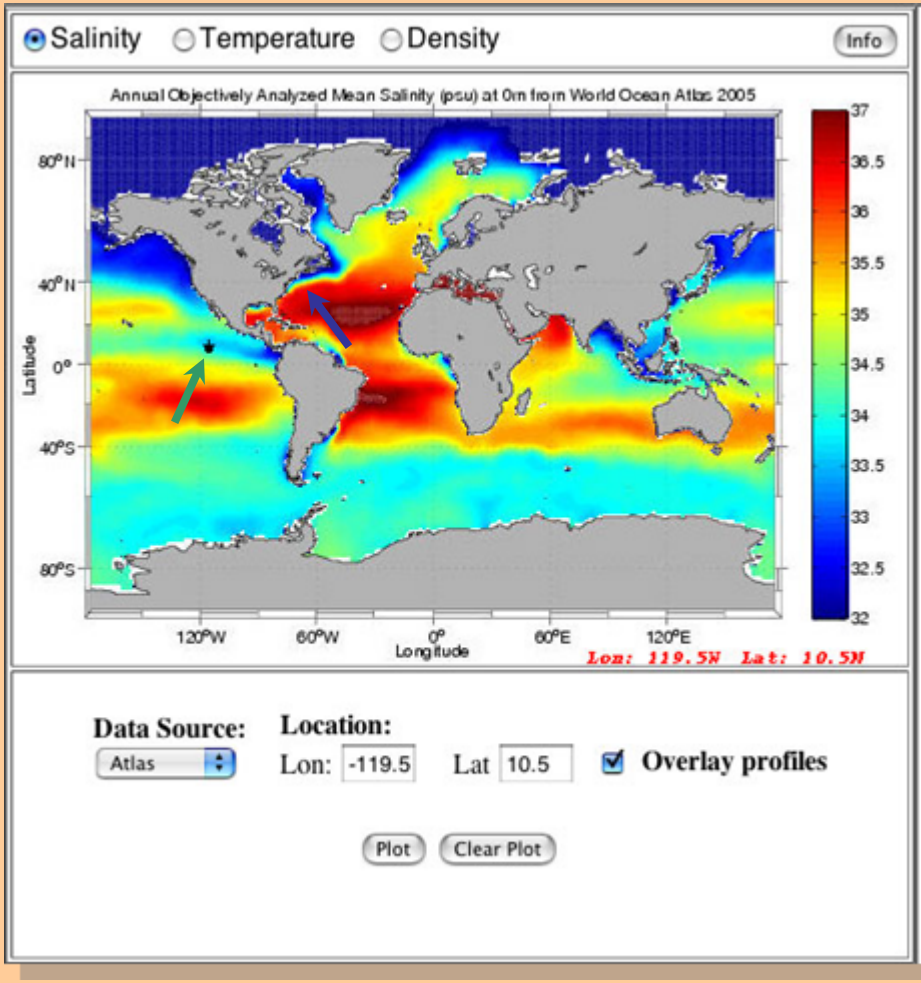
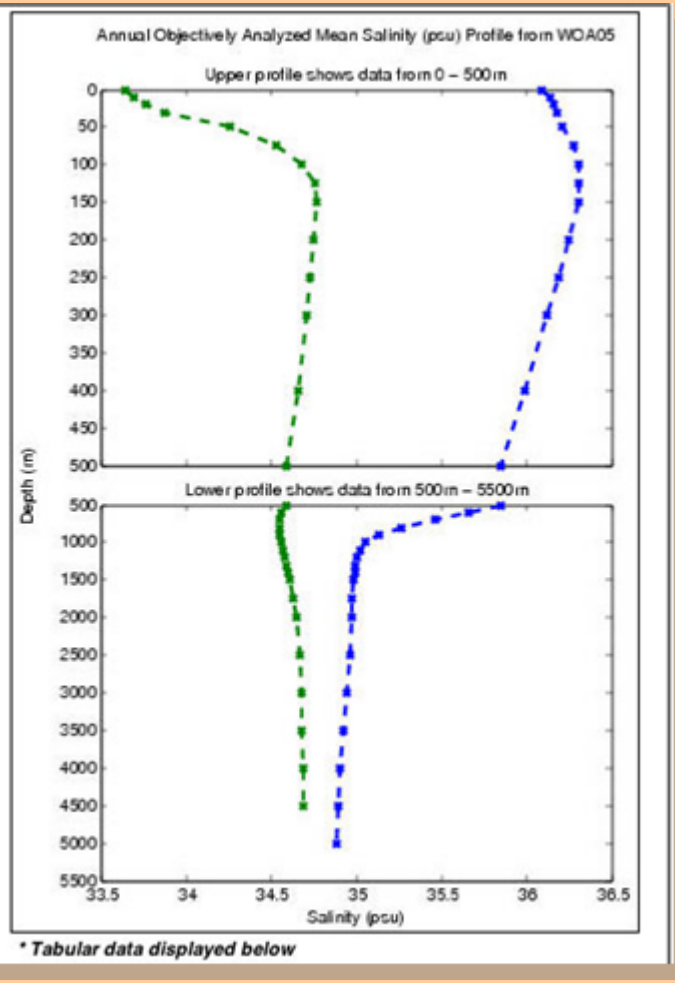
EDUCATION & PUBLIC OUTREACH

Annual mean maps & In-water profiles: Salinity, temperature & density





AQUARIUS/SAC-D

EDUCATION & PUBLIC OUTREACH

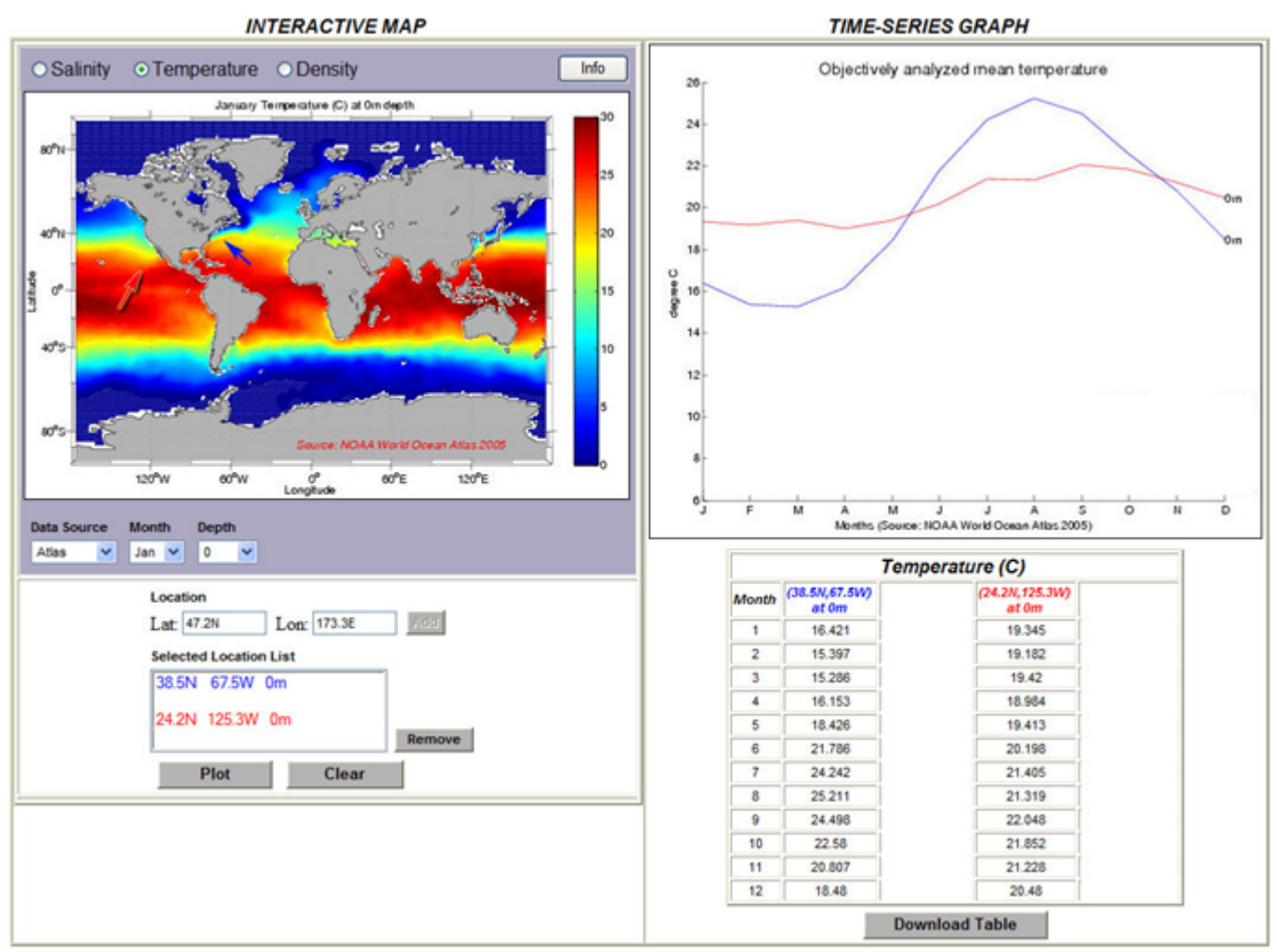
Monthly mean maps

&

Time-series graphs

Salinity, Temperature & Density

from 1 - 6 depths!



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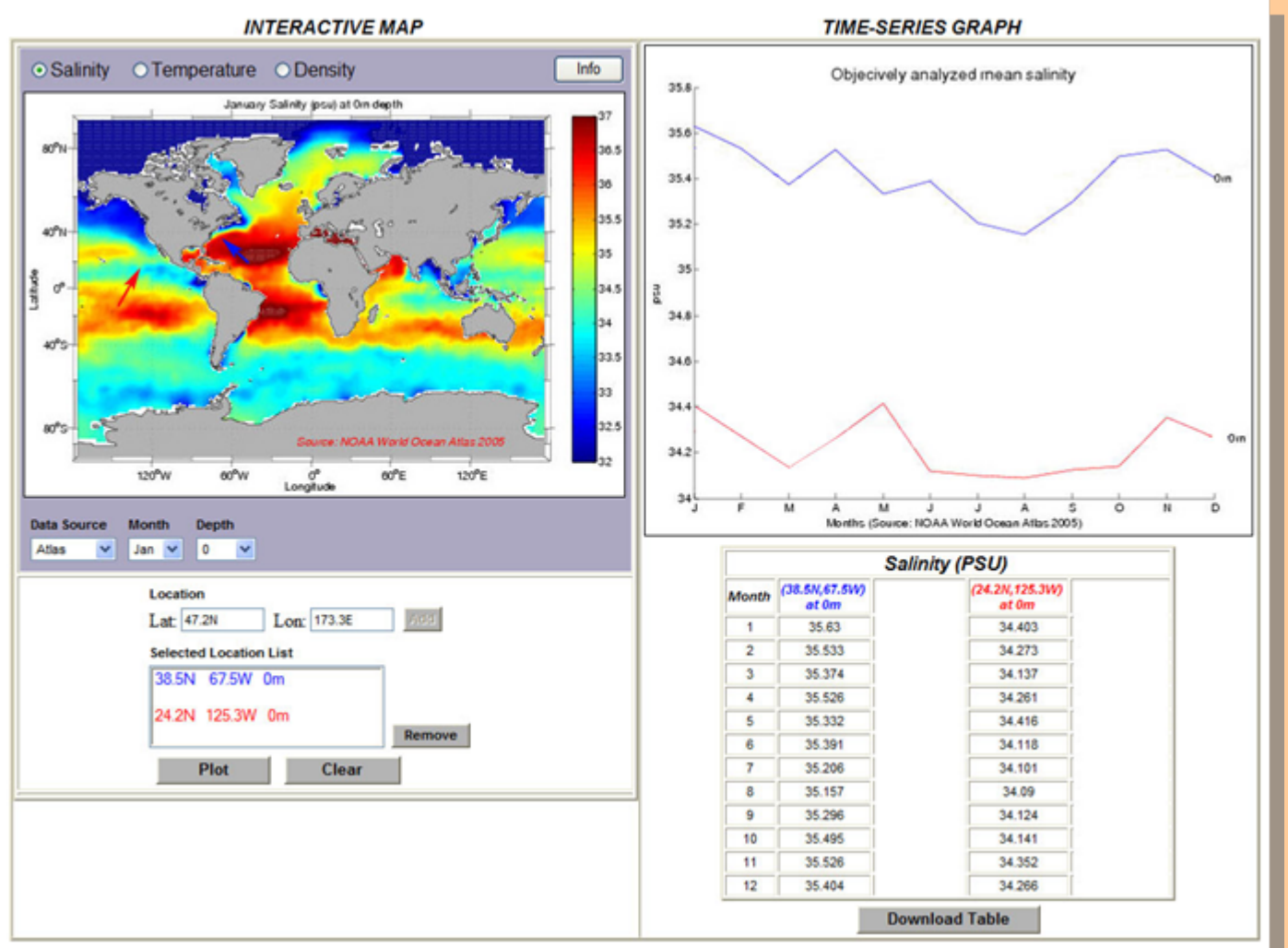

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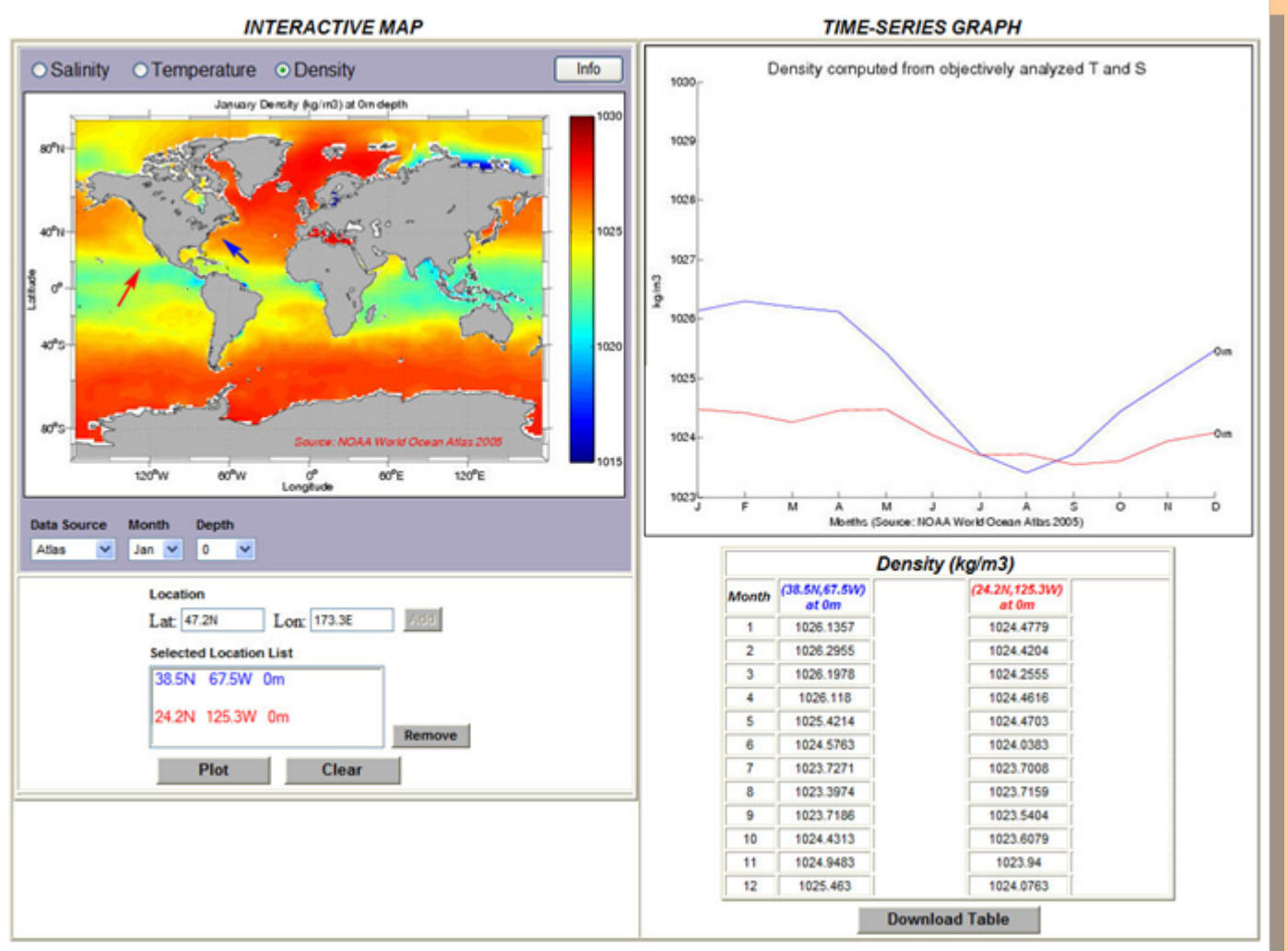

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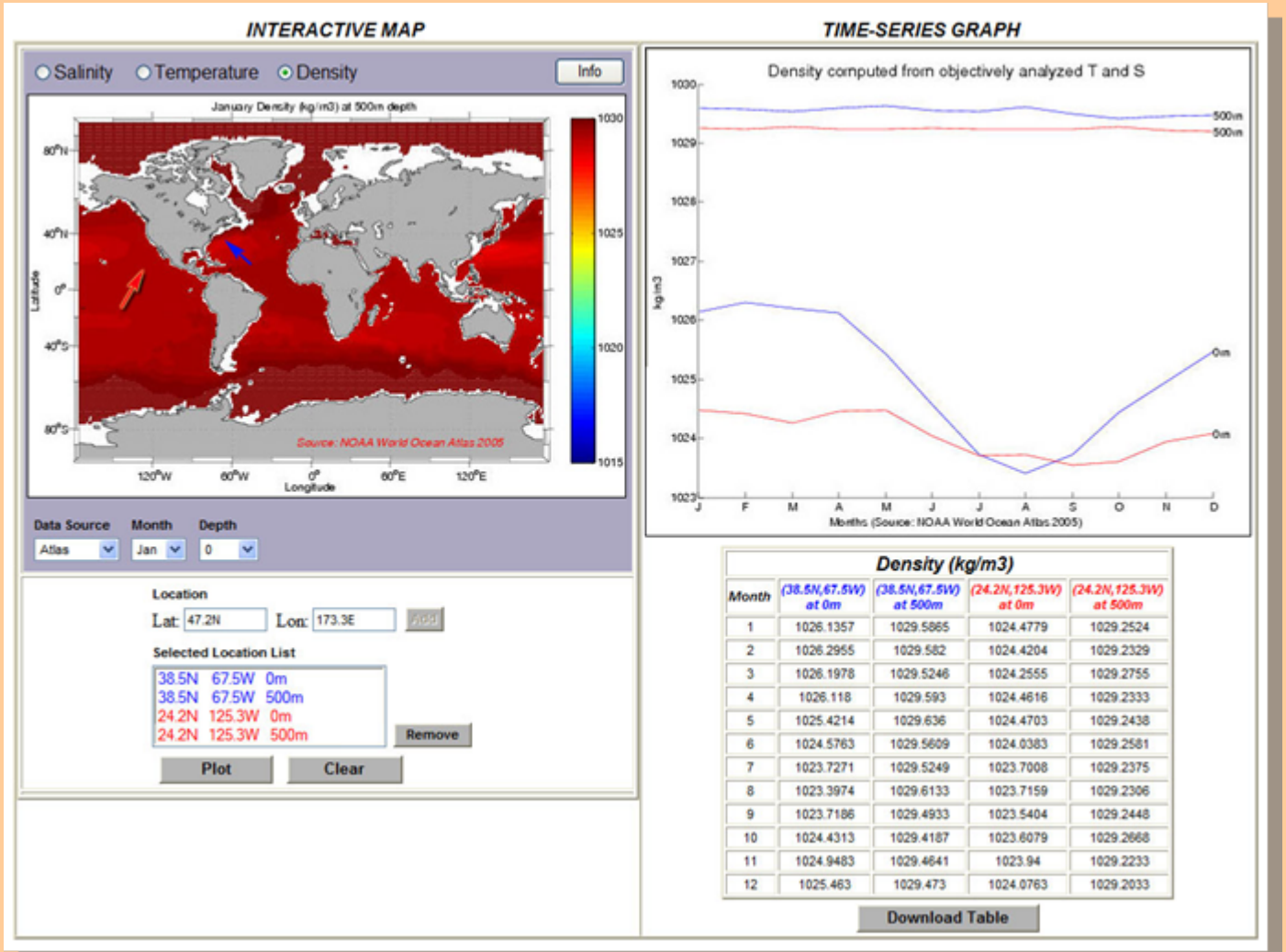

Month	(38.5N,67.5W) at 0m	(38.5N,67.5W) at 500m	(24.2N,125.3W) at 0m	(24.2N,125.3W) at 500m
1	1026.1357	1029.5865	1024.4779	1029.2524
2	1026.2955	1029.582	1024.4204	1029.2329
3	1026.1978	1029.5246	1024.2555	1029.2755
4	1026.118	1029.593	1024.4616	1029.2333
5	1025.4214	1029.636	1024.4703	1029.2438
6	1024.5763	1029.5609	1024.0383	1029.2581
7	1023.7271	1029.5249	1023.7008	1029.2375
8	1023.3974	1029.6133	1023.7159	1029.2306
9	1023.7186	1029.4933	1023.5404	1029.2448
10	1024.4313	1029.4187	1023.6079	1029.2668
11	1024.9483	1029.4641	1023.94	1029.2233
12	1025.463	1029.473	1024.0763	1029.2033

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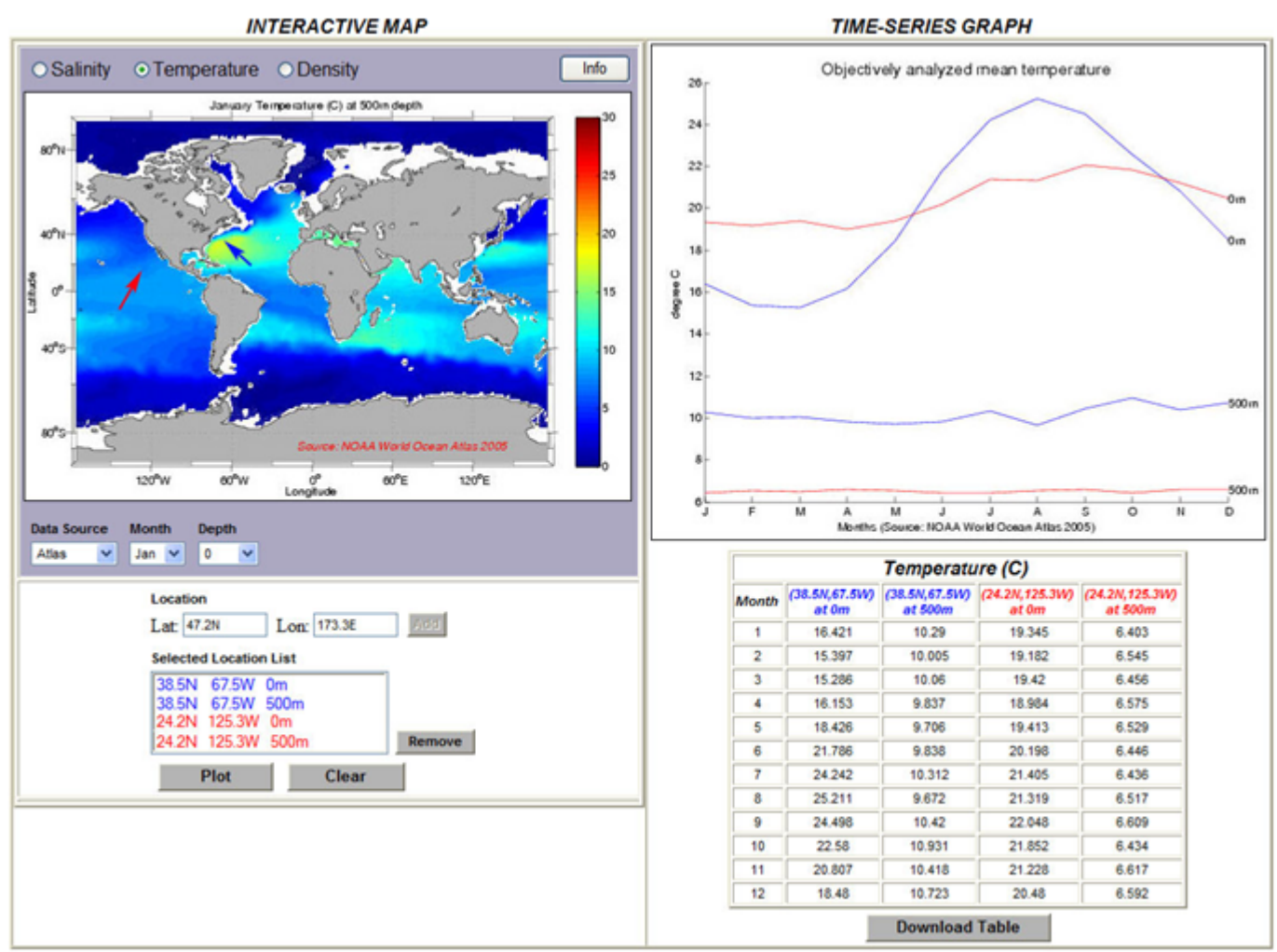

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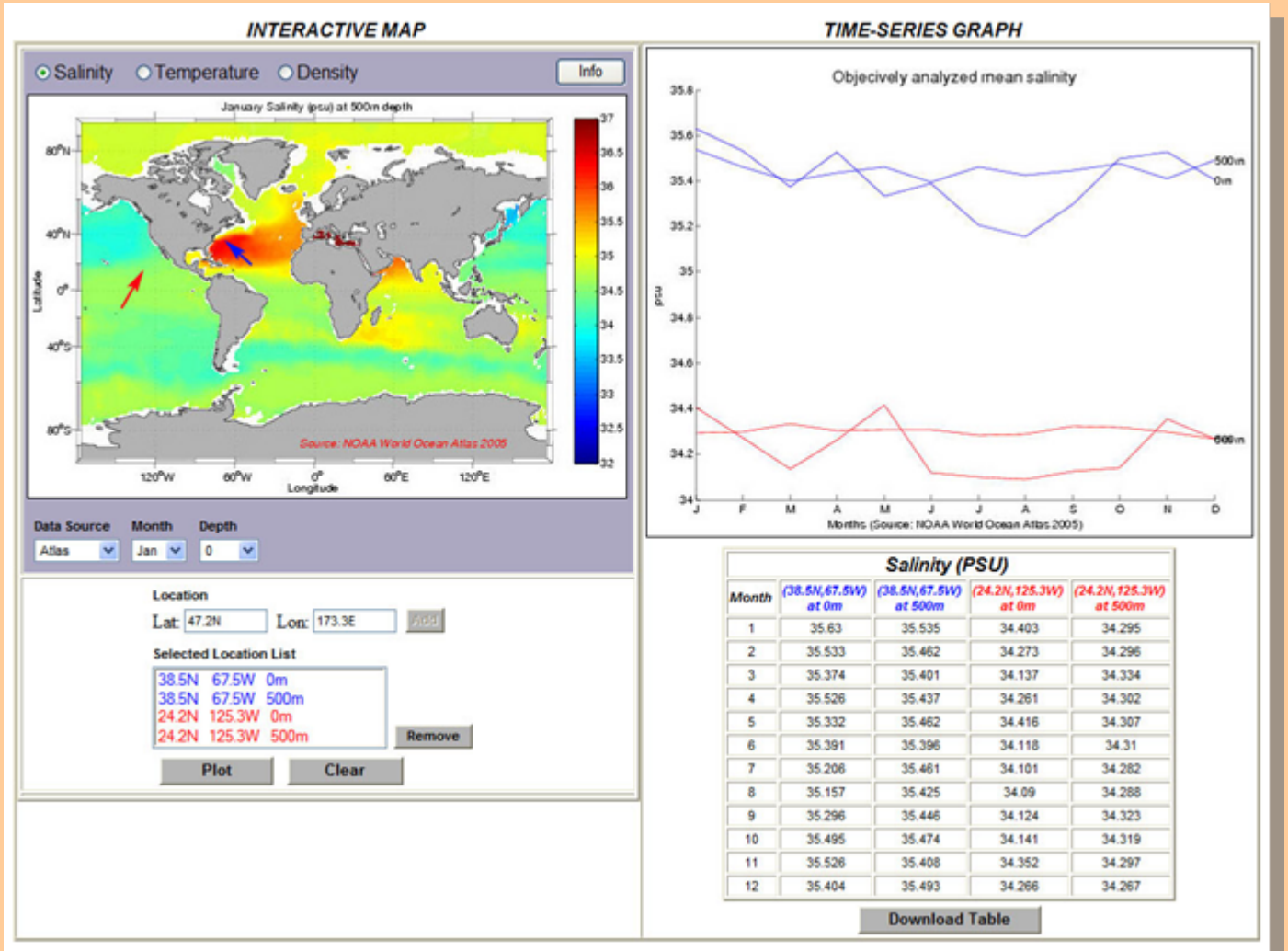

Month	(38.5N,67.5W) at 0m	(38.5N,67.5W) at 500m	(24.2N,125.3W) at 0m	(24.2N,125.3W) at 500m
1	35.63	35.535	34.403	34.295
2	35.533	35.462	34.273	34.296
3	35.374	35.401	34.137	34.334
4	35.526	35.437	34.261	34.302
5	35.332	35.462	34.416	34.307
6	35.391	35.396	34.118	34.31
7	35.206	35.461	34.101	34.282
8	35.157	35.425	34.09	34.288
9	35.296	35.446	34.124	34.323
10	35.495	35.474	34.141	34.319
11	35.526	35.408	34.352	34.297
12	35.404	35.493	34.266	34.267

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