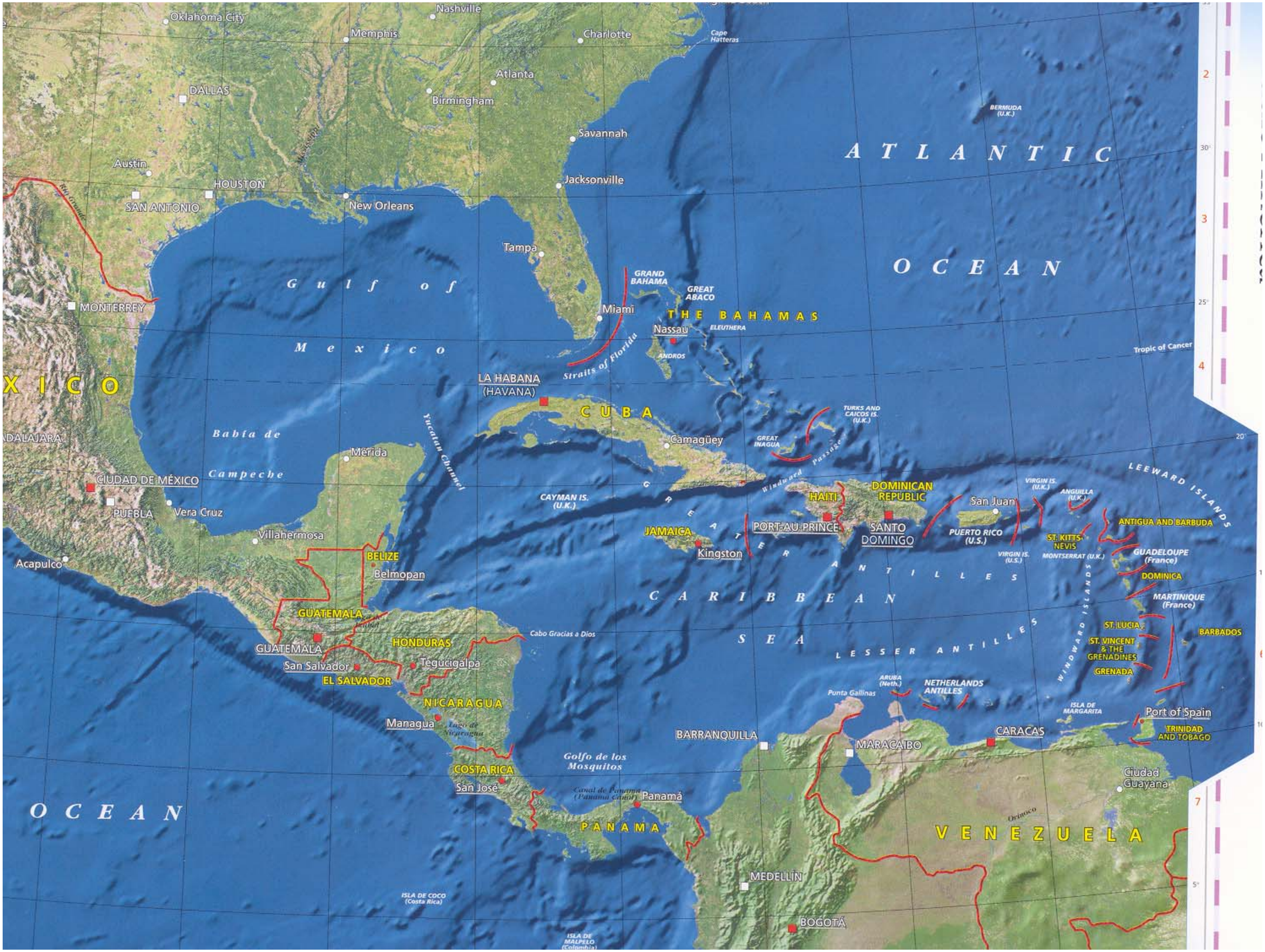
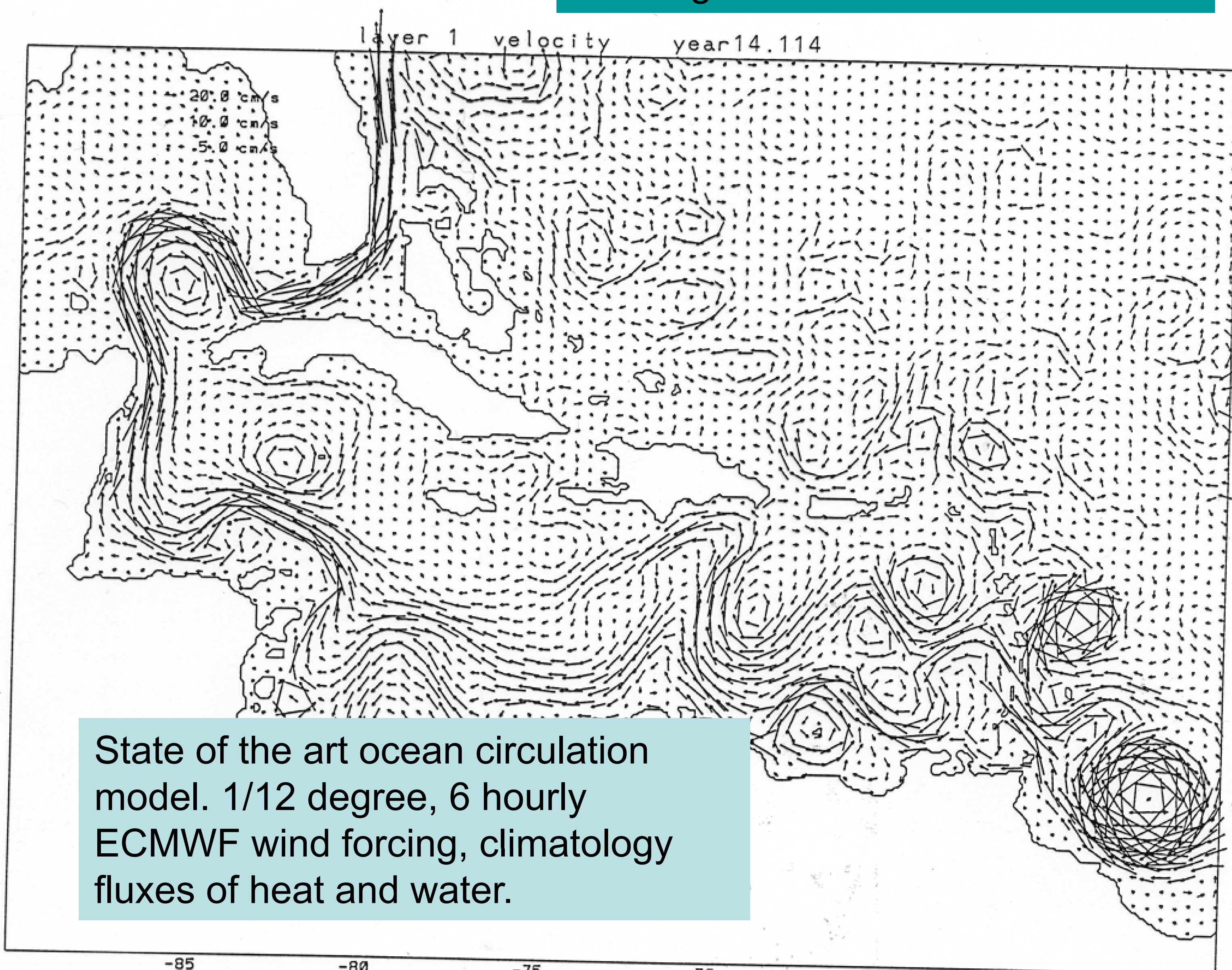
Connectivity of the Bahamas to the Greater Caribbean

Donald B. Olson

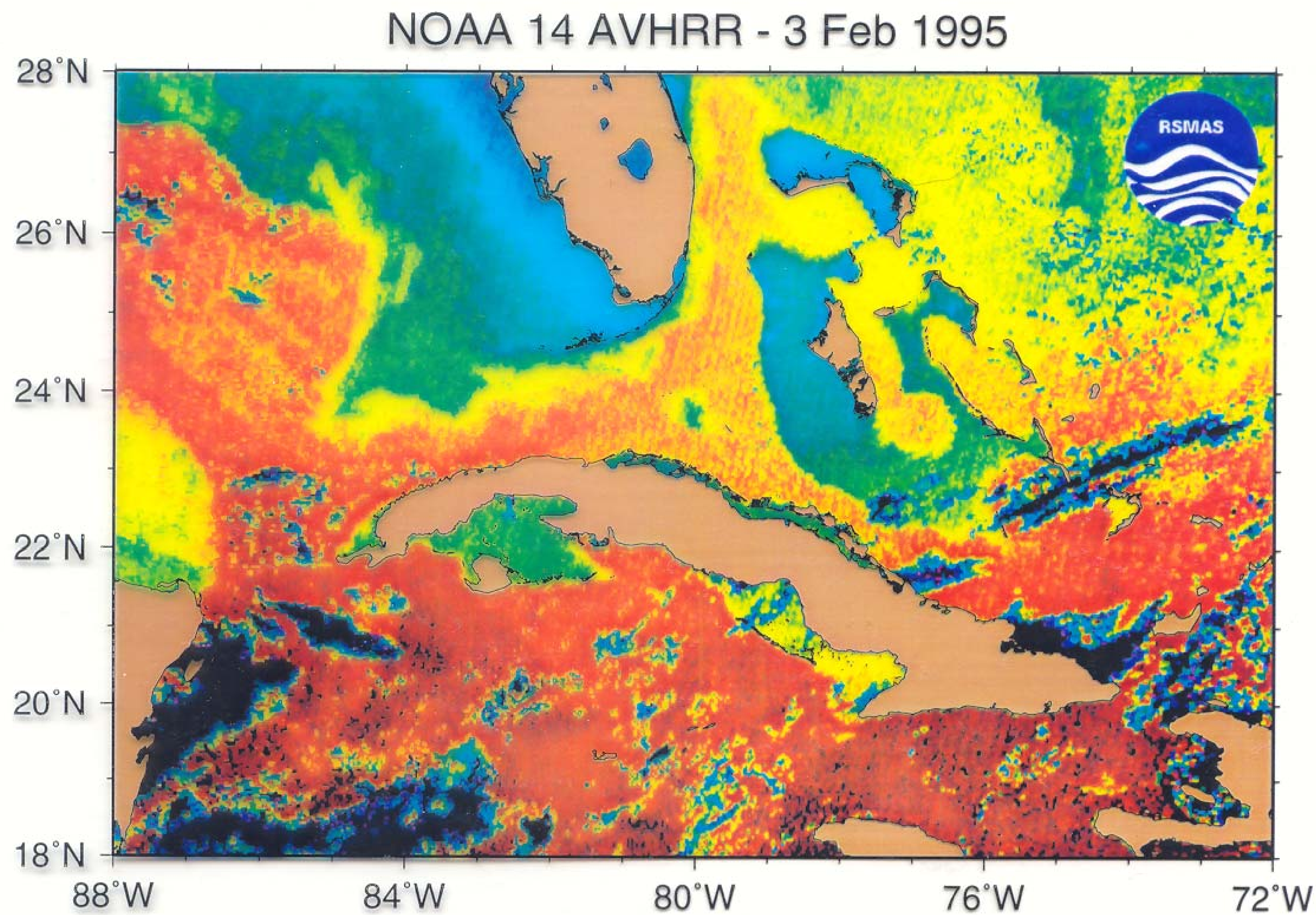
September 2004


Oklahoma City
Nashville
Memphis
Charlotte
Cape Hatteras
Atlanta
DALLAS
Birmingham
Savannah
Austin
HOUSTON
SAN ANTONIO
New Orleans
Jacksonville
Tampa
Mississippi
Rio Grande
BERMUDA (U.K.)
ATLANTIC
OCEAN
Gulf of Mexico
GRAND BAHAMA
GREAT ABACO
THE BAHAMAS
Miami
Nassau
ELEUTHERA
ANDROS
Straits of Florida
MONTERREY
Tropic of Cancer
MEXICO
LA HABANA (HAVANA)
CUBA
TURKS AND CAICOS IS. (U.K.)
Yucatan Channel
GUADALAJARA
Bahía de Campeche
Mérida
Camagüey
GREAT INAGUA
Windward Passage
CIUDAD DE MÉXICO
CAYMAN IS. (U.K.)
DOMINICAN REPUBLIC
HAITI
PUEBLA
Vera Cruz
VIRGIN IS. (U.K.)
ANGUILLA (U.K.)
LEEWARD ISLANDS
San Juan
Villahermosa
JAMAICA
PORT-AU-PRINCE
SANTO DOMINGO
PUERTO RICO (U.S.)
ANTIGUA AND BARBUDA
ST. KITTS-NEVIS
Kingston
GREATER ANTILLES
VIRGIN IS. (U.S.)
MONTSERRAT (U.K.)
GUADELOUPE (France)
Acapulco
BELIZE
Belmopan
DOMINICA
CARIBBEAN SEA
MARTINIQUE (France)
GUATEMALA
Cabo Gracias a Dios
ST. LUCIA
BARBADOS
HONDURAS
ST. VINCENT & THE GRENADINES
GUATEMALA
San Salvador
Tegucigalpa
LESSER ANTILLES
WINDWARD ISLANDS
GRENADA
EL SALVADOR
ARUBA (Neth.)
NETHERLANDS ANTILLES
NICARAGUA
Punta Gallinas
Managua
Lago de Nicaragua
ISLA DE MARGARITA
Port of Spain
CARACAS
TRINIDAD AND TOBAGO
BARRANQUILLA
MARACAIBO
Golfo de los Mosquitos
COSTA RICA
Ciudad Guayana
San José
Canal de Panamá (Panama Canal)
Panamá
OCEAN
Orinoco
PANAMA
VENEZUELA
MEDELLÍN
ISLA DE COCO (Costa Rica)
BOGOTÁ
ISLA DE MALPELO (Colombia)
2
3
4
7
30°
25°
20°
5°

Miami Community Ocean Model.
Chassignet and Garraffo



State of the art ocean circulation model. 1/12 degree, 6 hourly ECMWF wind forcing, climatology fluxes of heat and water.


NOAA 14 AVHRR - 3 Feb 1995
28°N
26°N
24°N
22°N
20°N
18°N
88°W
84°W
80°W
76°W
72°W
RSMAS

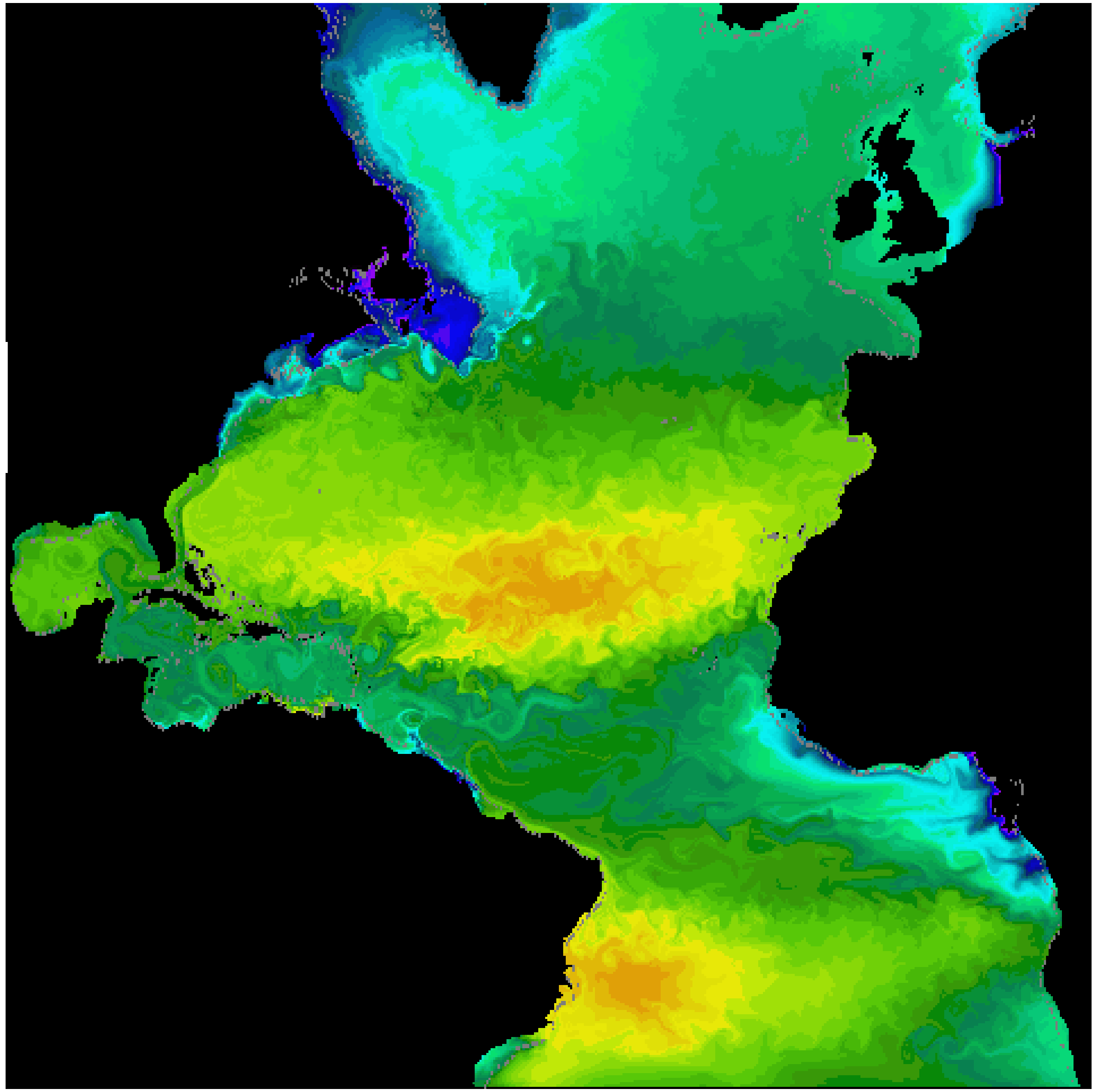
Pathways Based on Water Masses

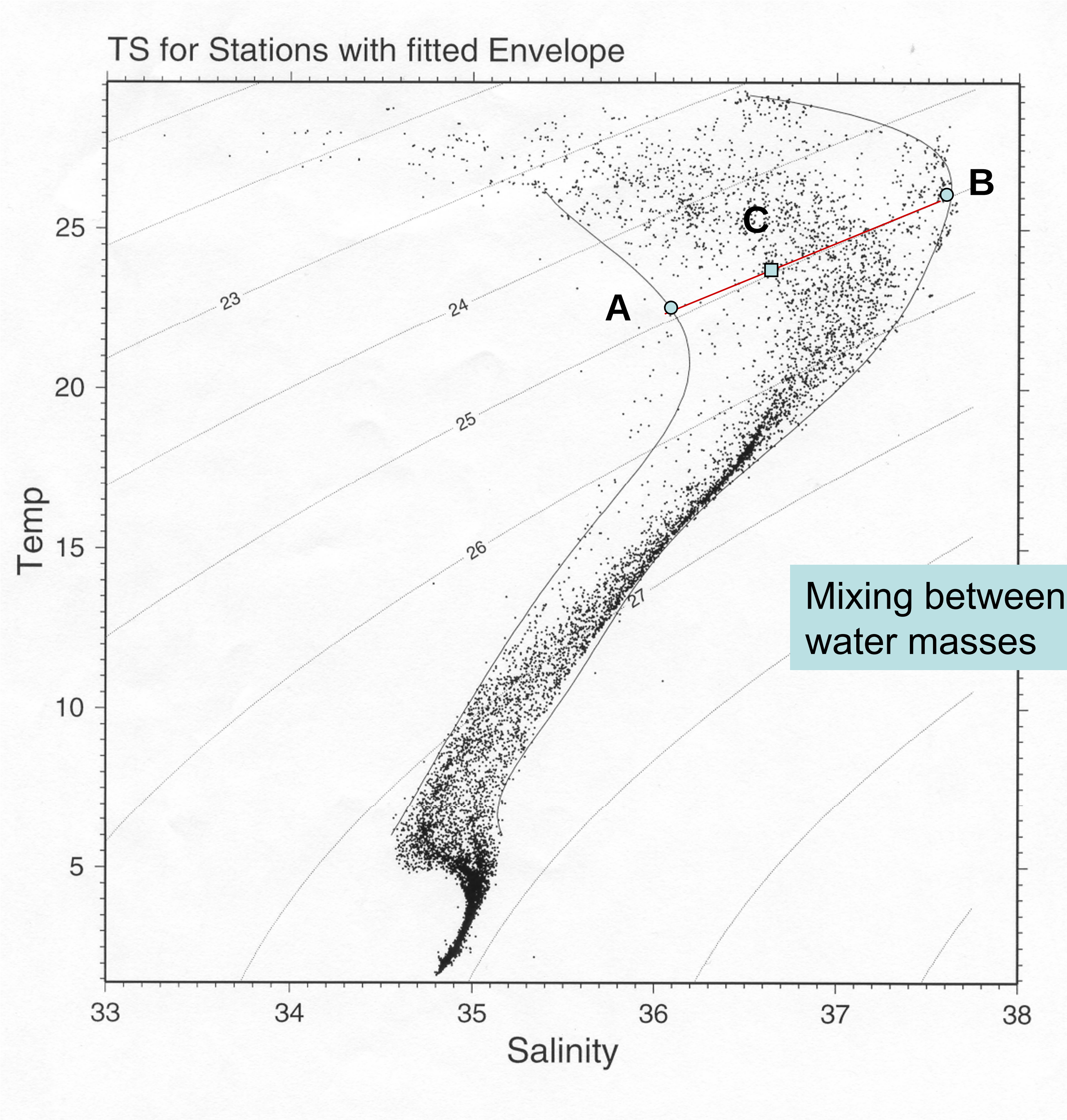
- T/S analysis of water mass origins and mixing percentages.

- Subtropical Underwater and the North Atlantic Subtropical gyre.

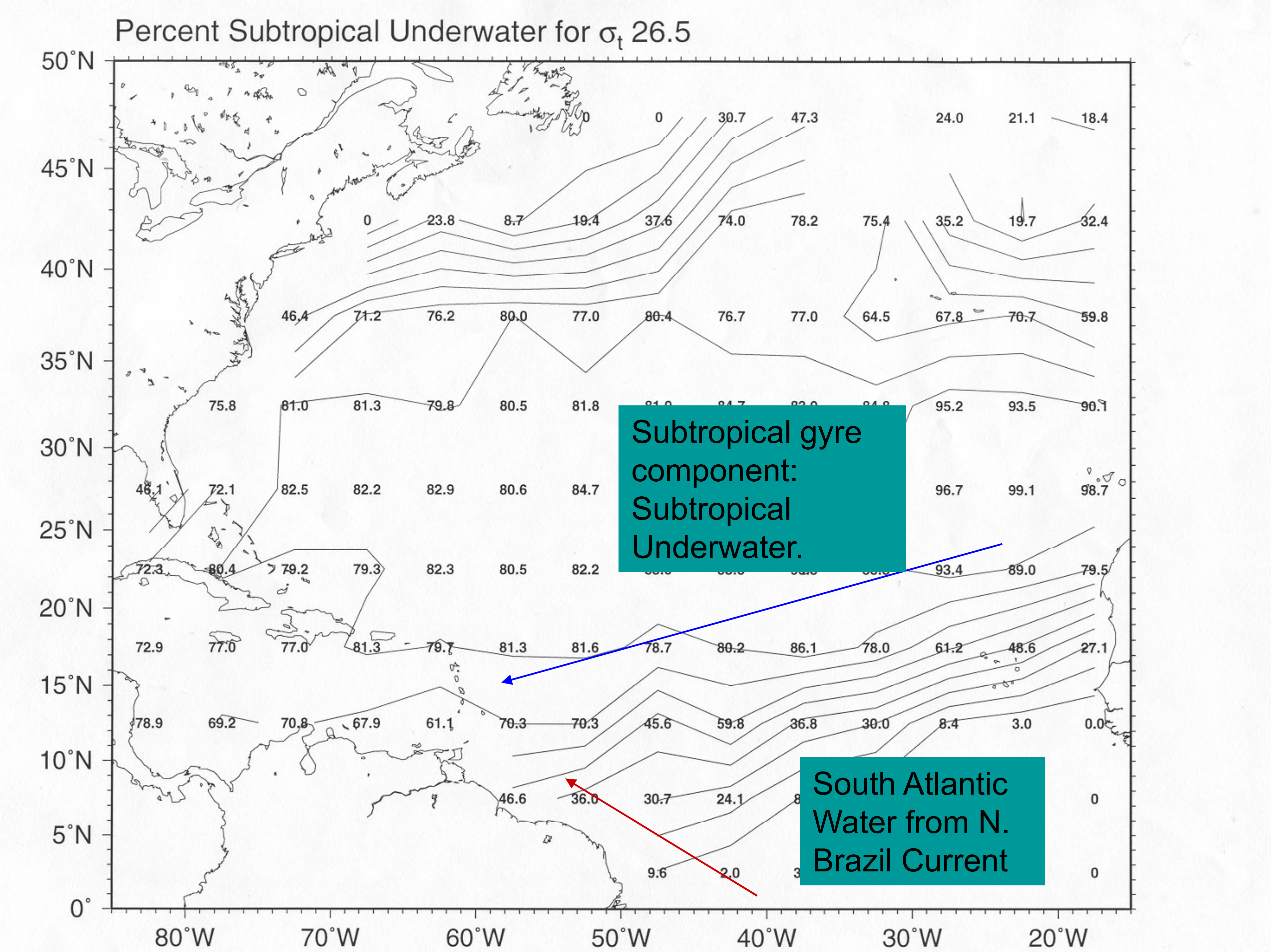
MICOM 1/12 degree Surface salinity

Numerical model of flows



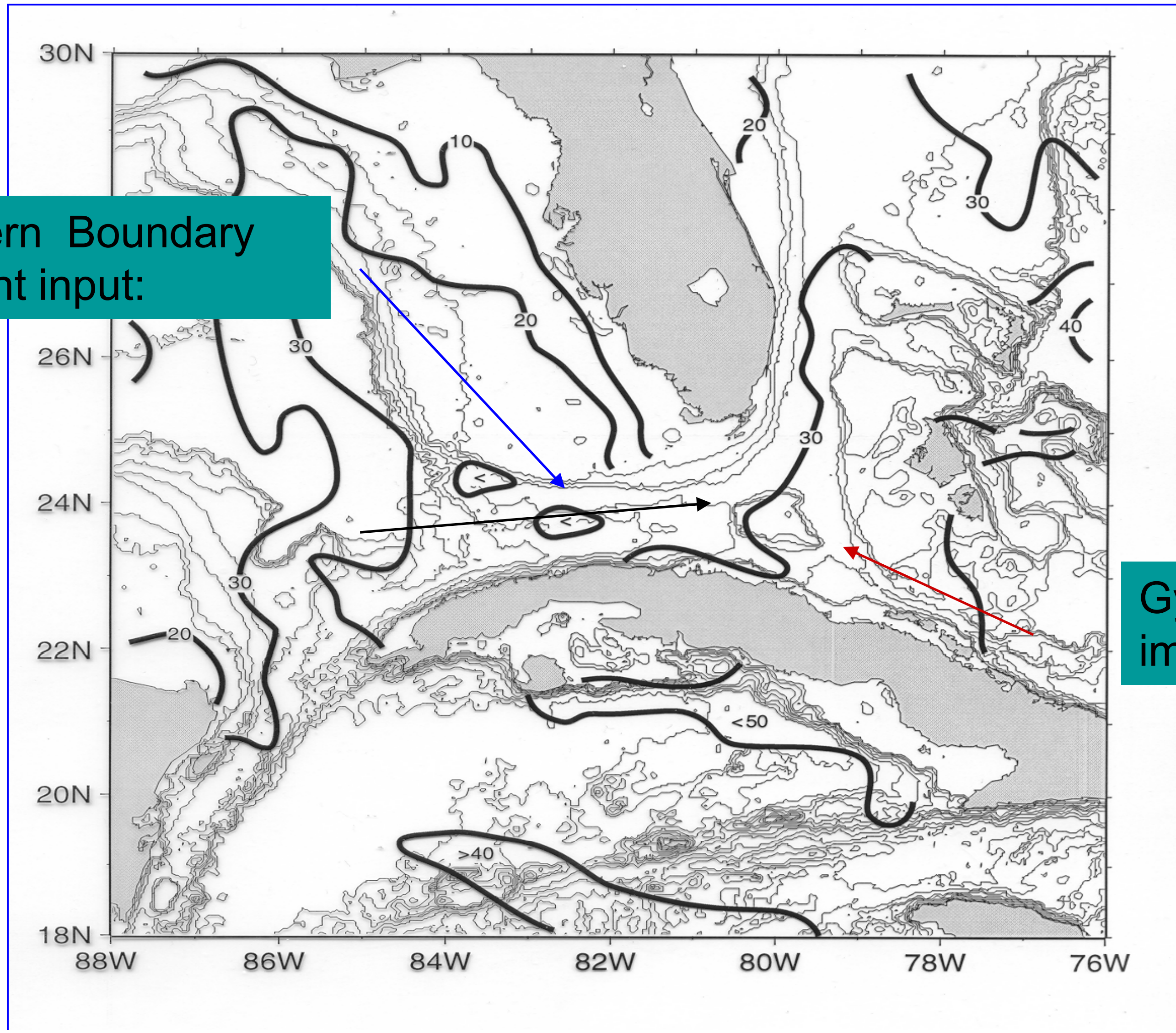


Mixing between water masses


Percent Subtropical Underwater for σ_t 26.5
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
0°
80°W
70°W
60°W
50°W
40°W
30°W
20°W
Subtropical gyre component: Subtropical Underwater.
South Atlantic Water from N. Brazil Current

Percentage of STUW

Western Boundary Current input:



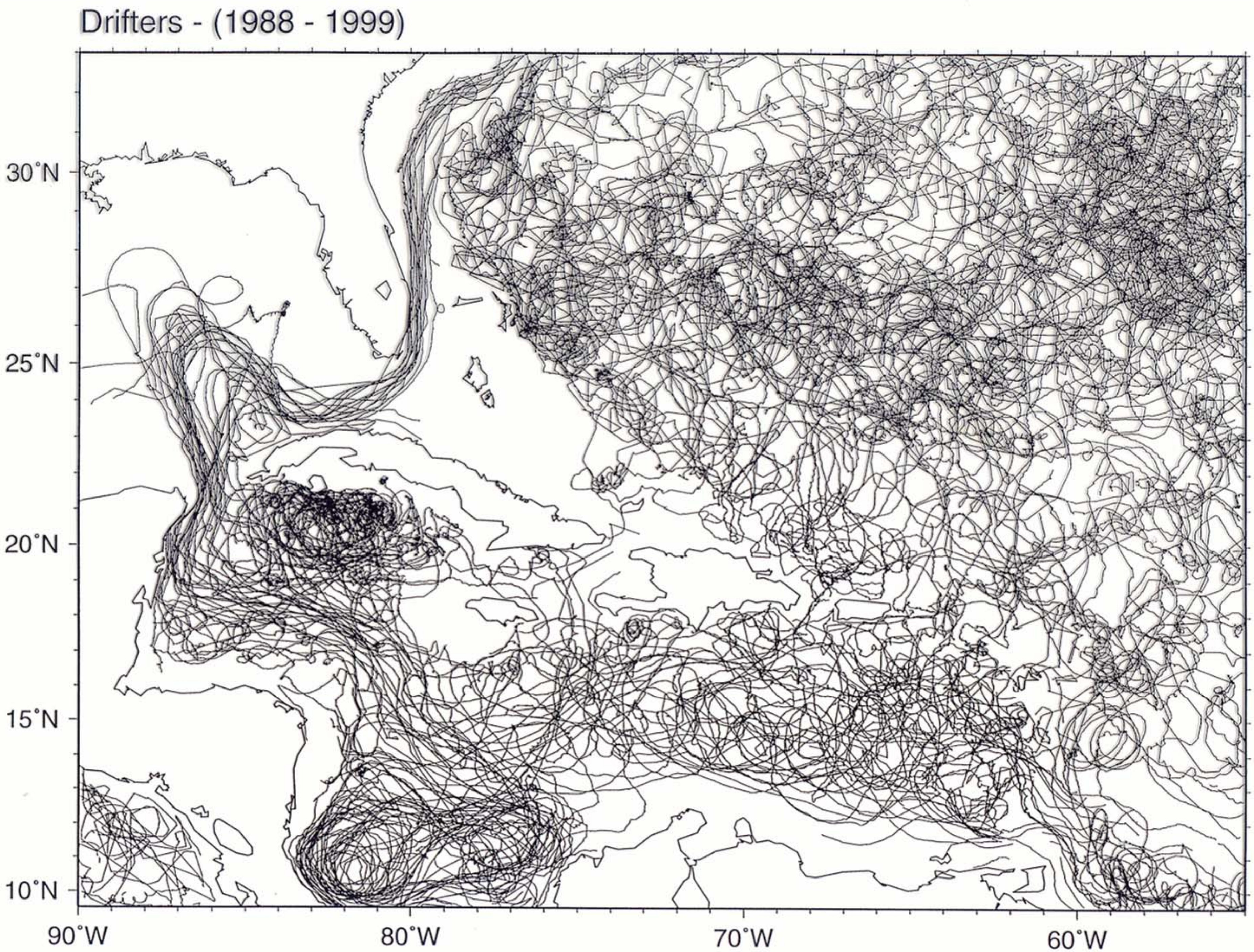
Gyre import

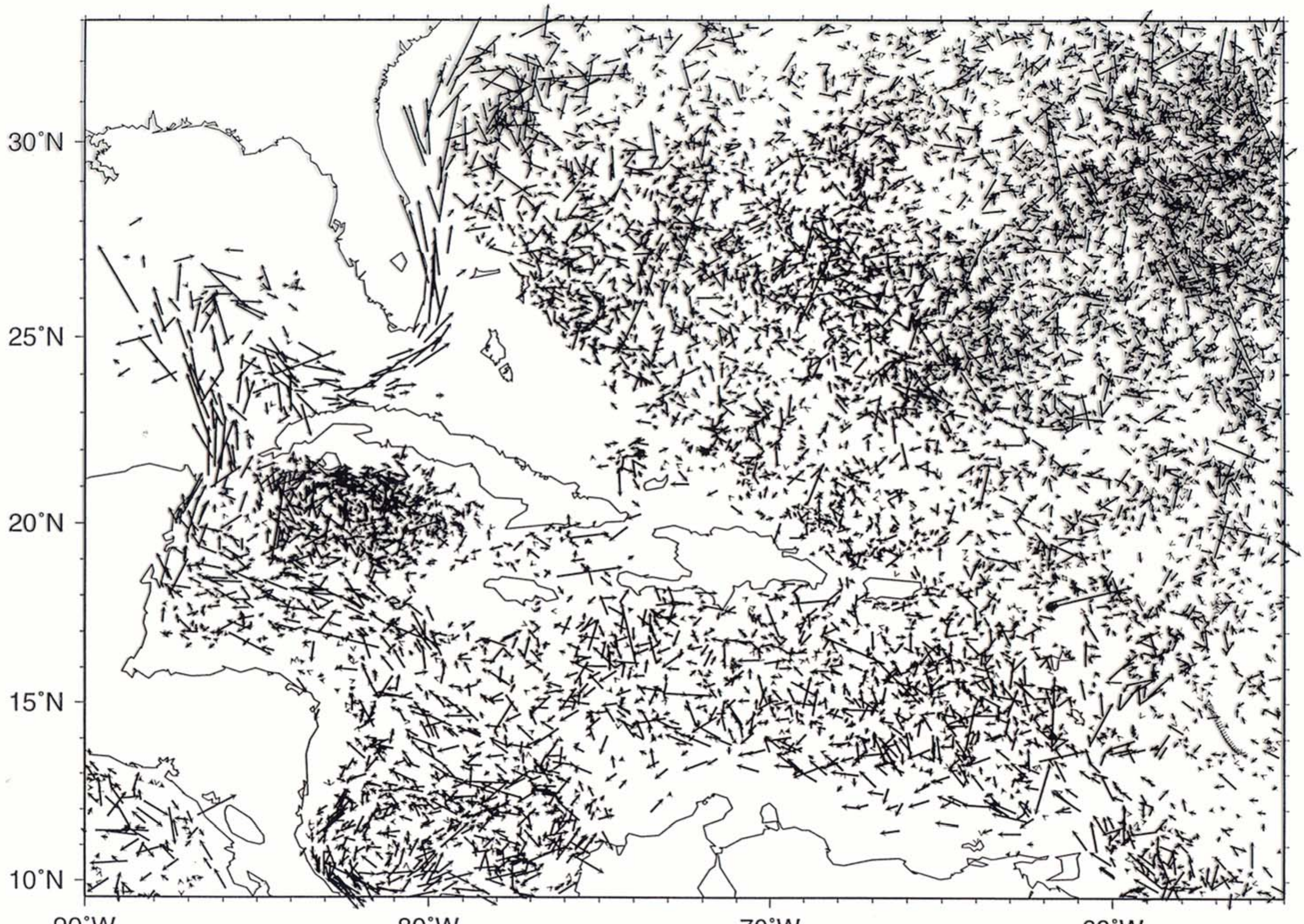
Direct Measurement of Currents with Drifters

- World Ocean Circulation Experiment (WOCE) standard surface drifter
- North Atlantic deployments
- Trajectories and velocity fields.
- Statistical comparison with drift simulations and model outputs.

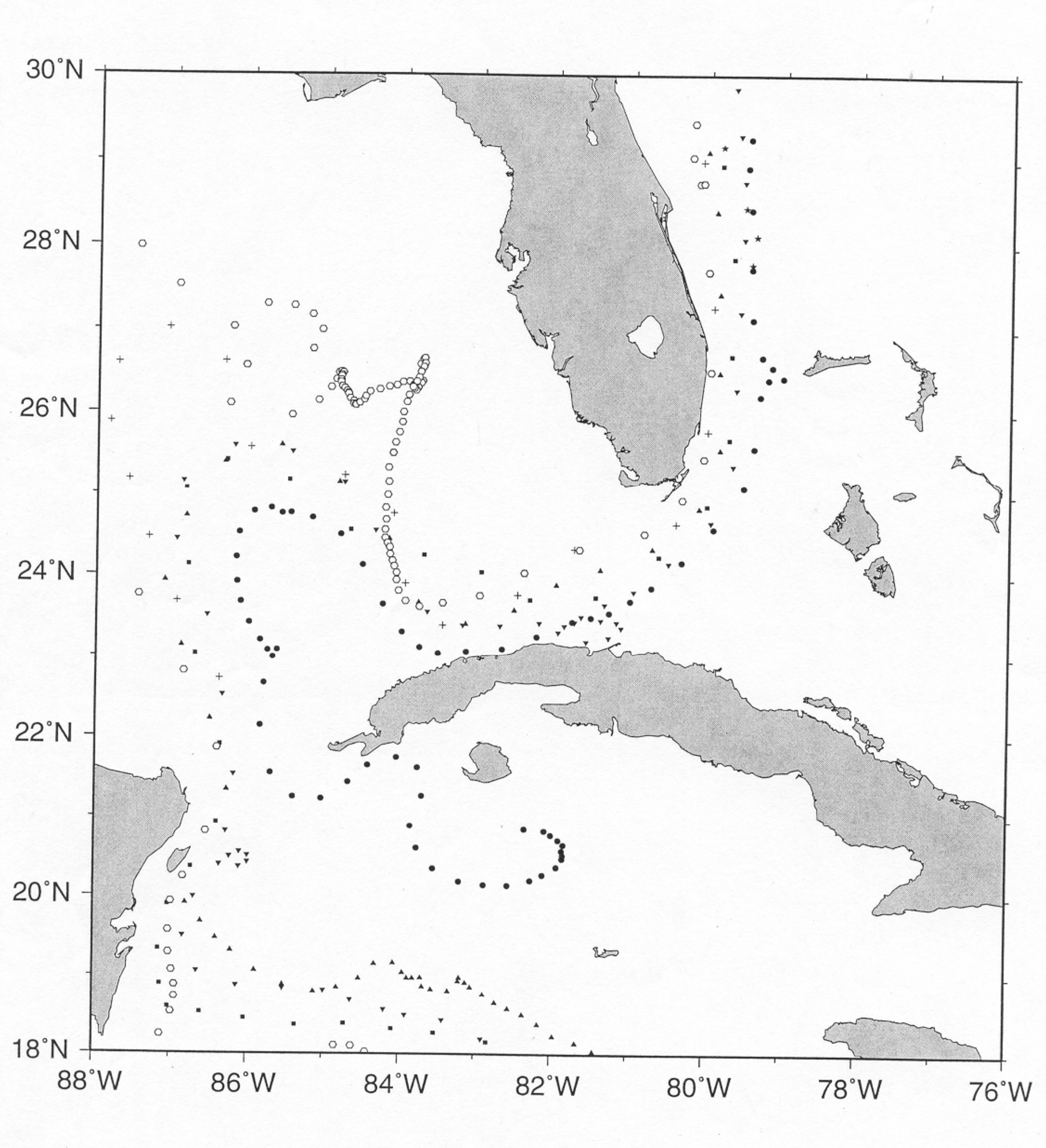
Direct measurements of currents

WOCE standard surface drifter: 10 m drogue at 15 m.


Drifters - (1988 - 1999)
30°N
25°N
20°N
15°N
10°N
90°W
80°W
70°W
60°W

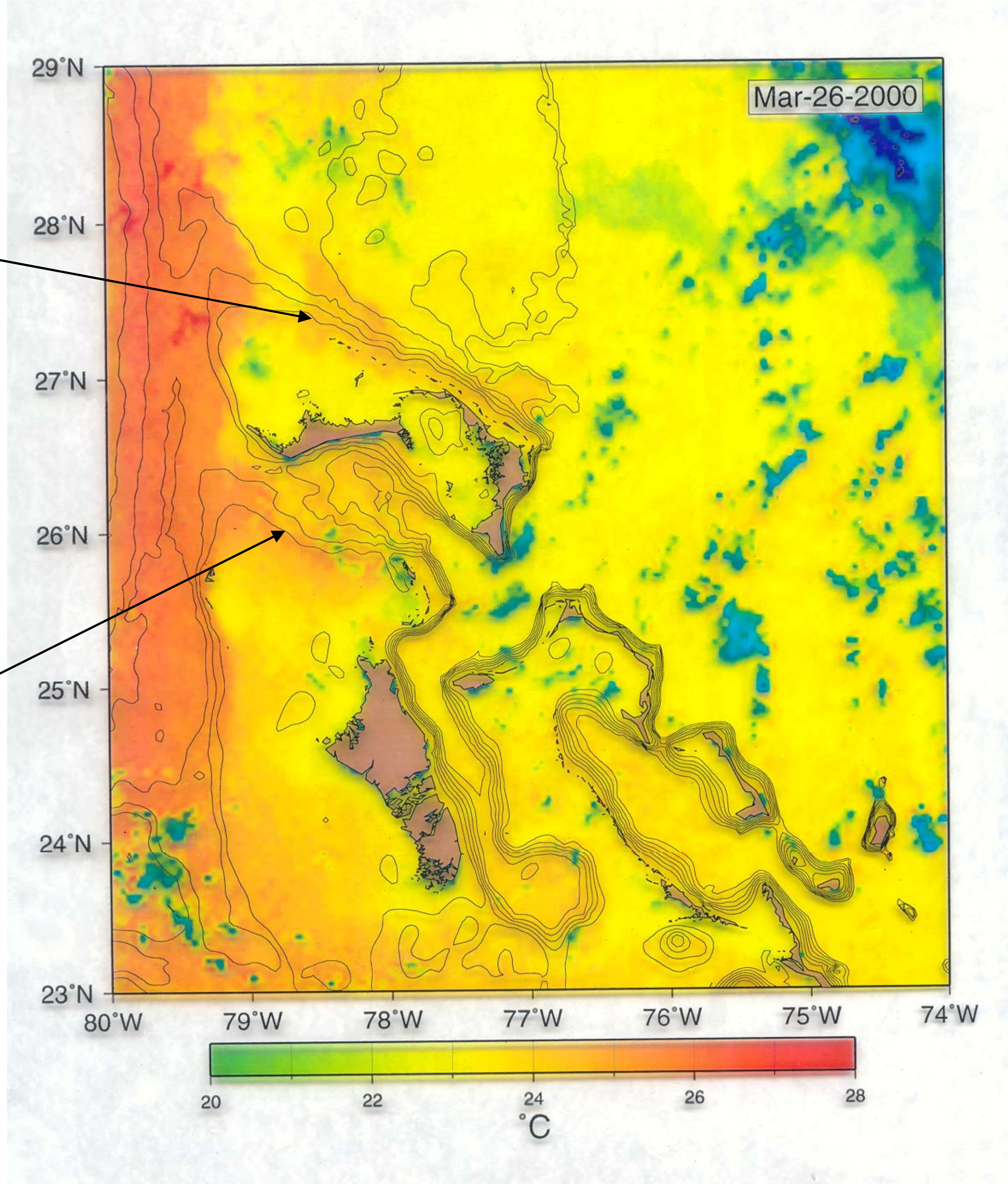

30°N
25°N
20°N
15°N
10°N
90°W
80°W
70°W
60°W

Daily positions



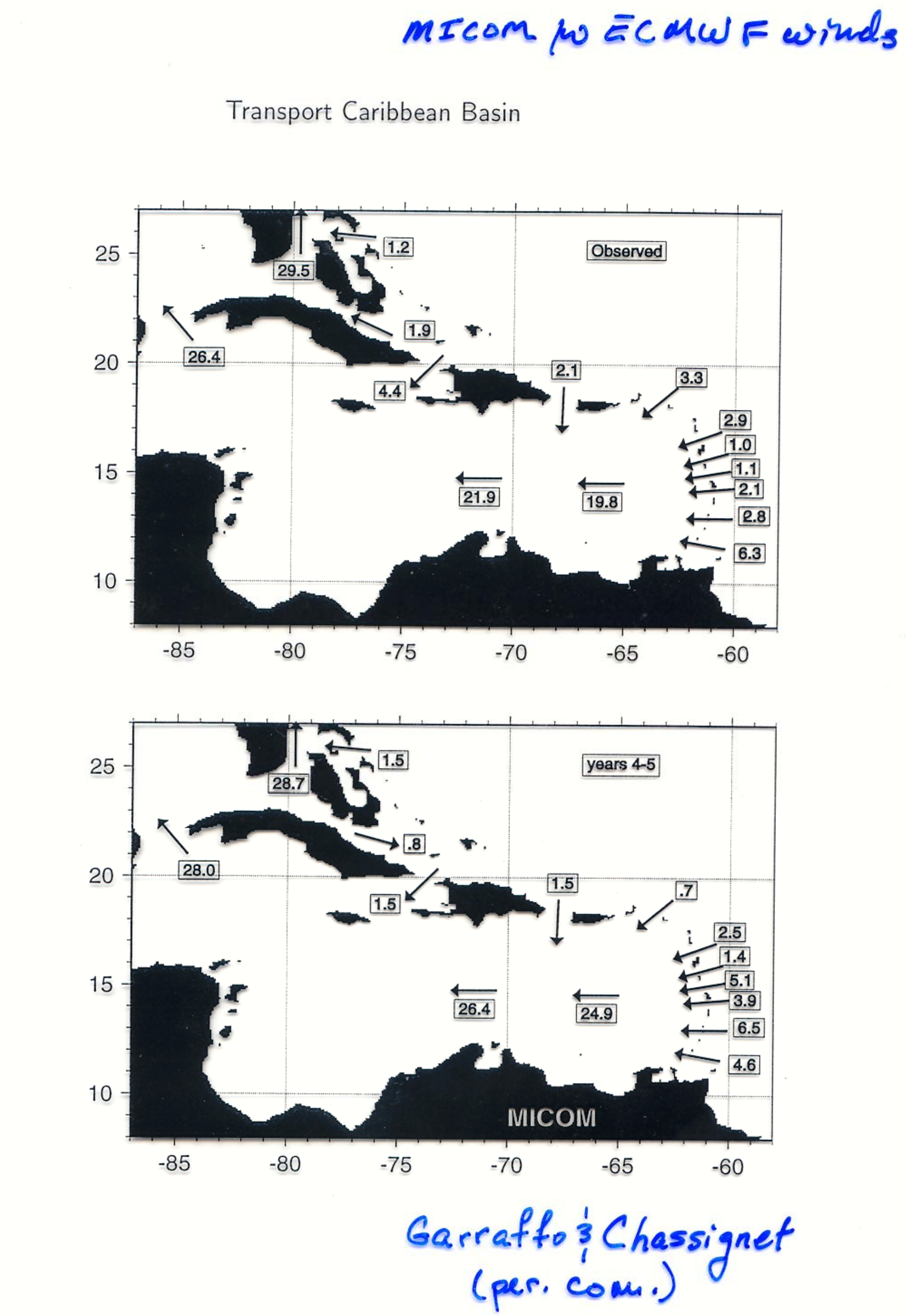
Eastward flow along the Little Bahama Bank

Eastward flow through south side of Providence Channel



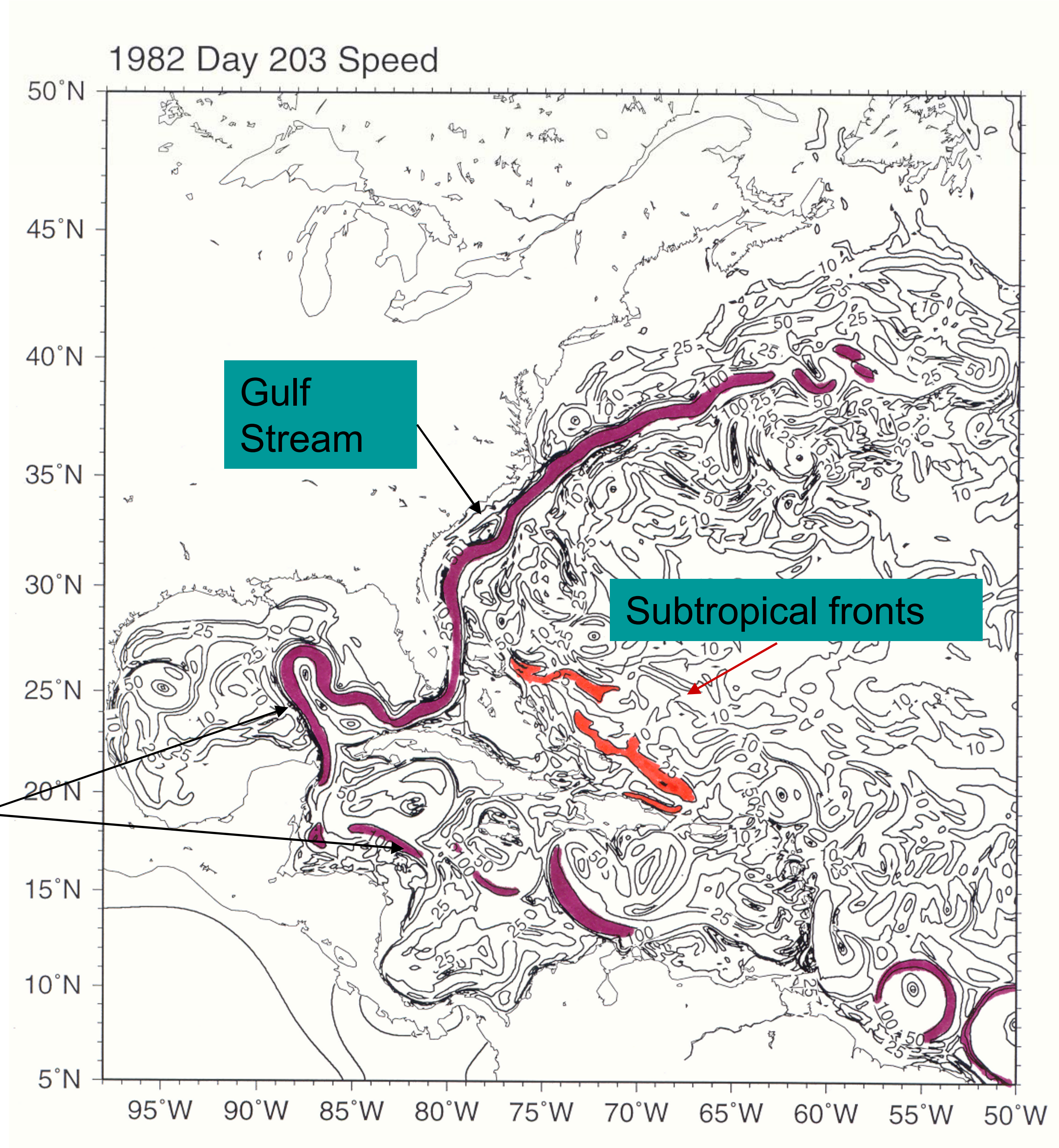
Miami Community Ocean Model (MICOM) 1/12 degree North Atlantic Model.

European Center for Medium Range Forecasting Wind forcing.



MICOM simulations:

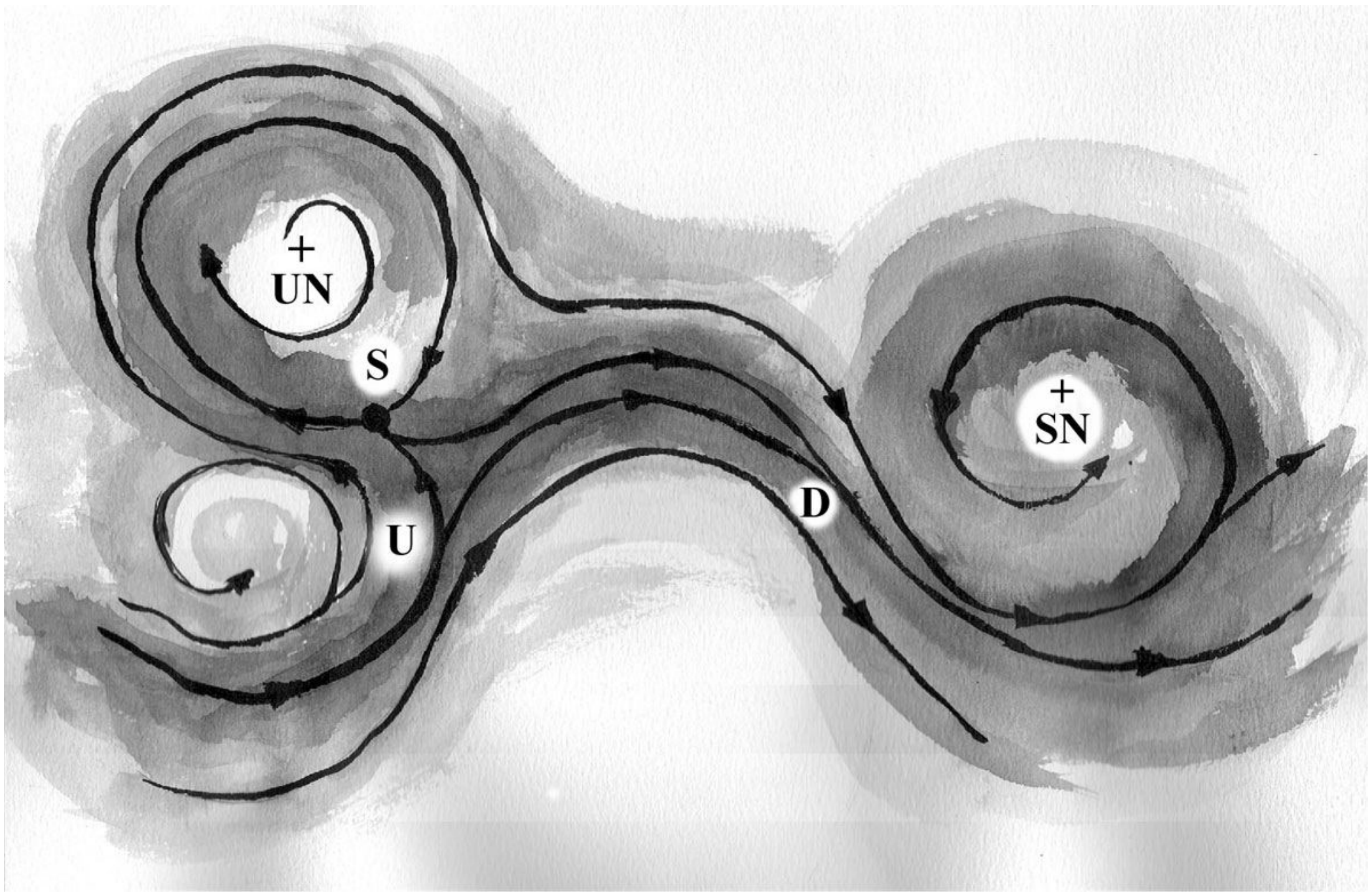
High resolution ocean model of Atlantic.



S. Levin:

a) Hops

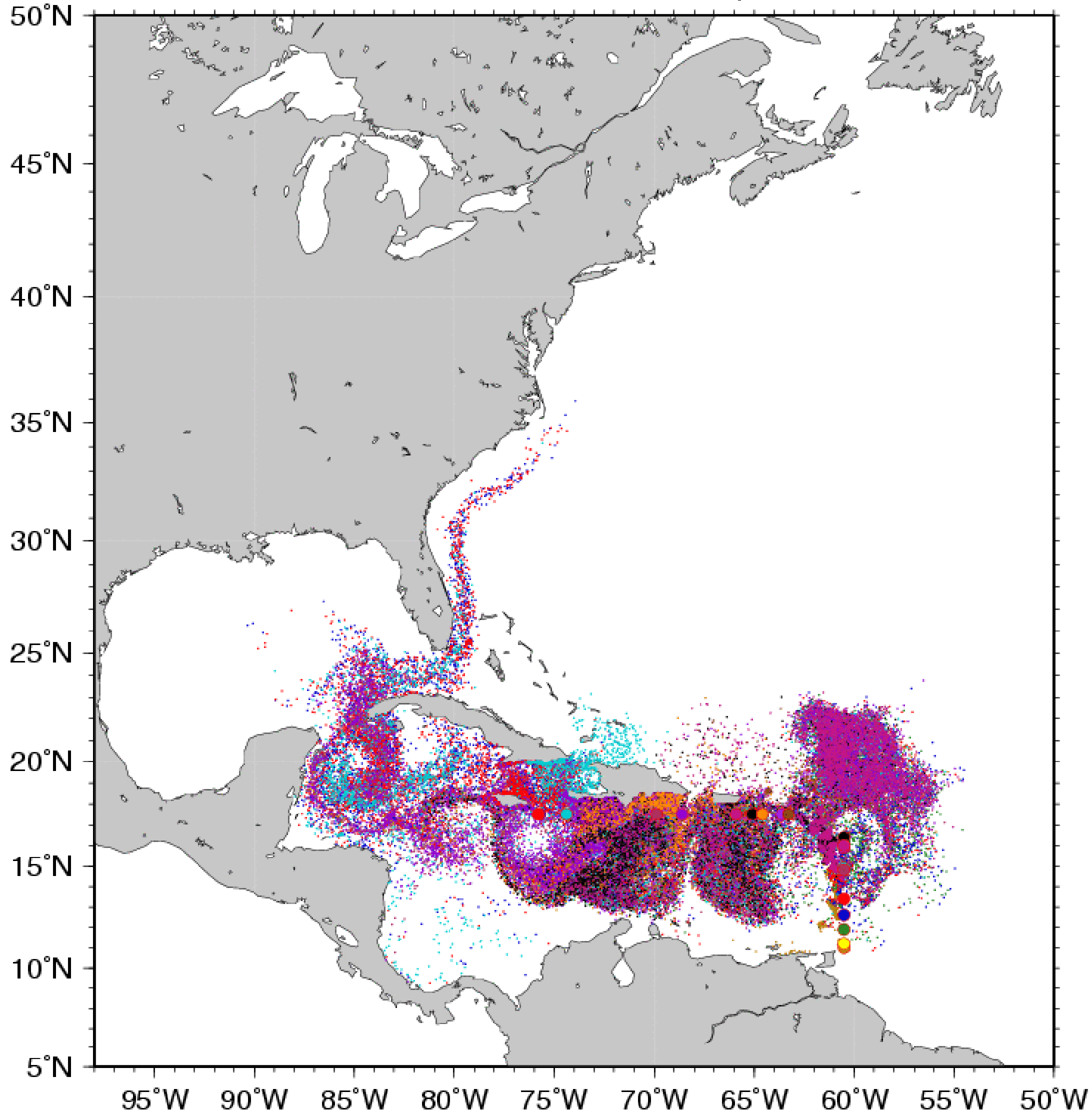
b) Jumps


+
UN
S
U
D
+
SN

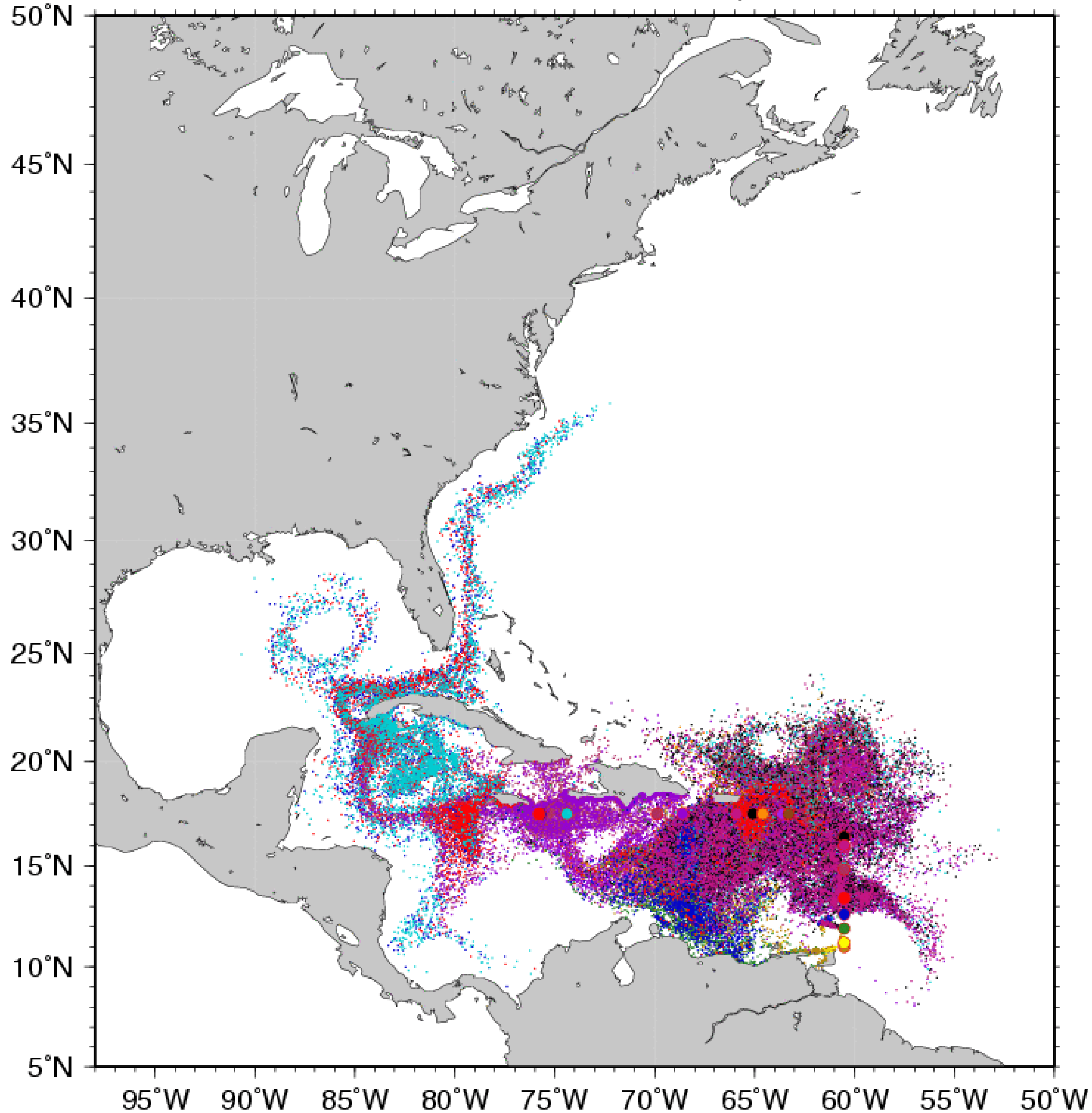
Drift Simulations

- Miami Community Ocean Model surface velocity fields on daily basis for five different years (1982-1986)
- Lagrangian subgrid model (Dutkiewicz et al., 1993; Olson, 2004): Autocorrelated random walk with diffusivity (κ) and time scale (τ) determined by drifter and dye cloud data.

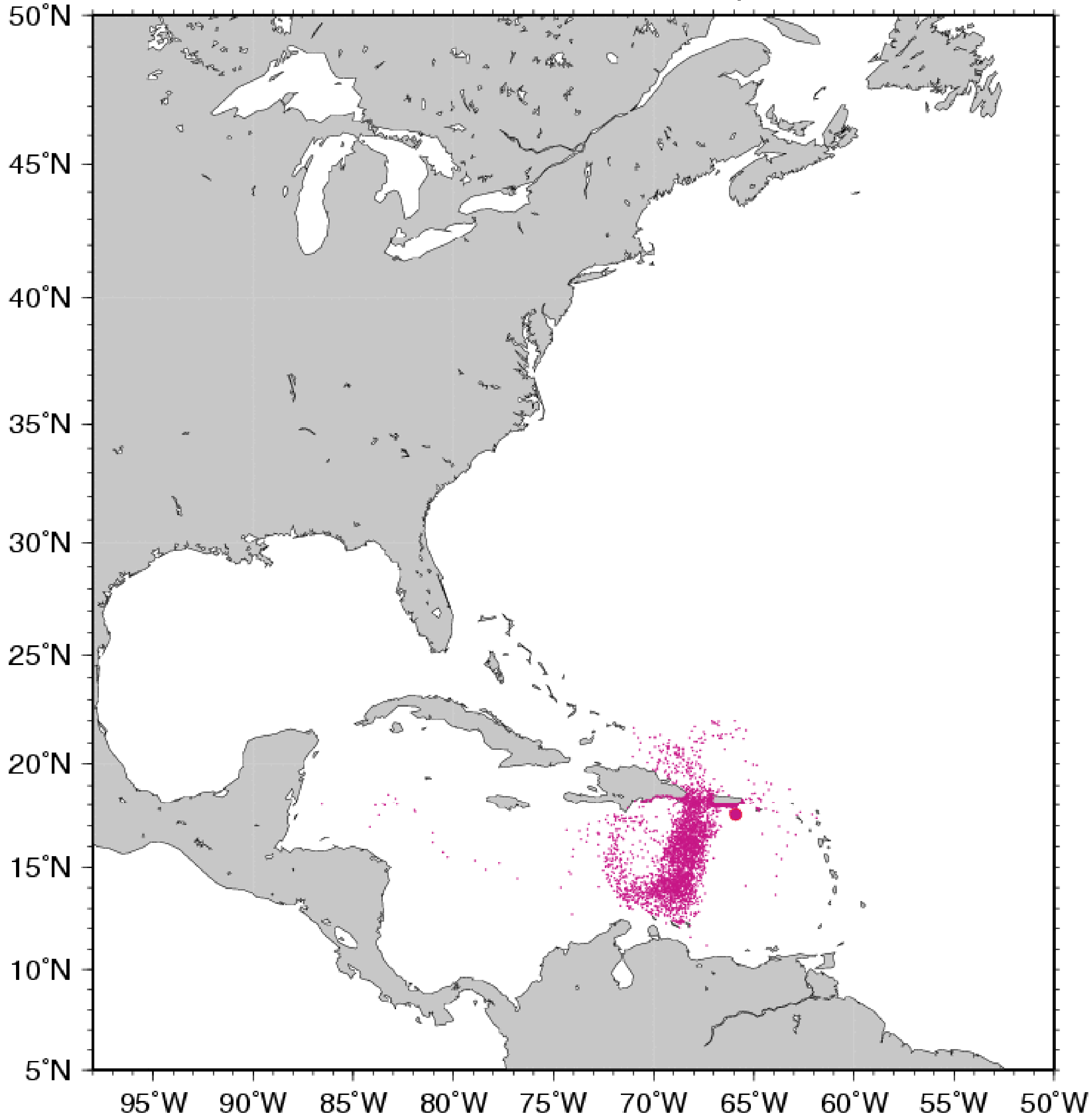
Start and End Points - 1982 Jul 22 - Sep 2



Start and End Points - 1984 Jul 22 - Sep 2



Release Point: 17° 30.0′N 65° 54.0′W
Start and End Points - 1983 Jul 22 - Sep 2



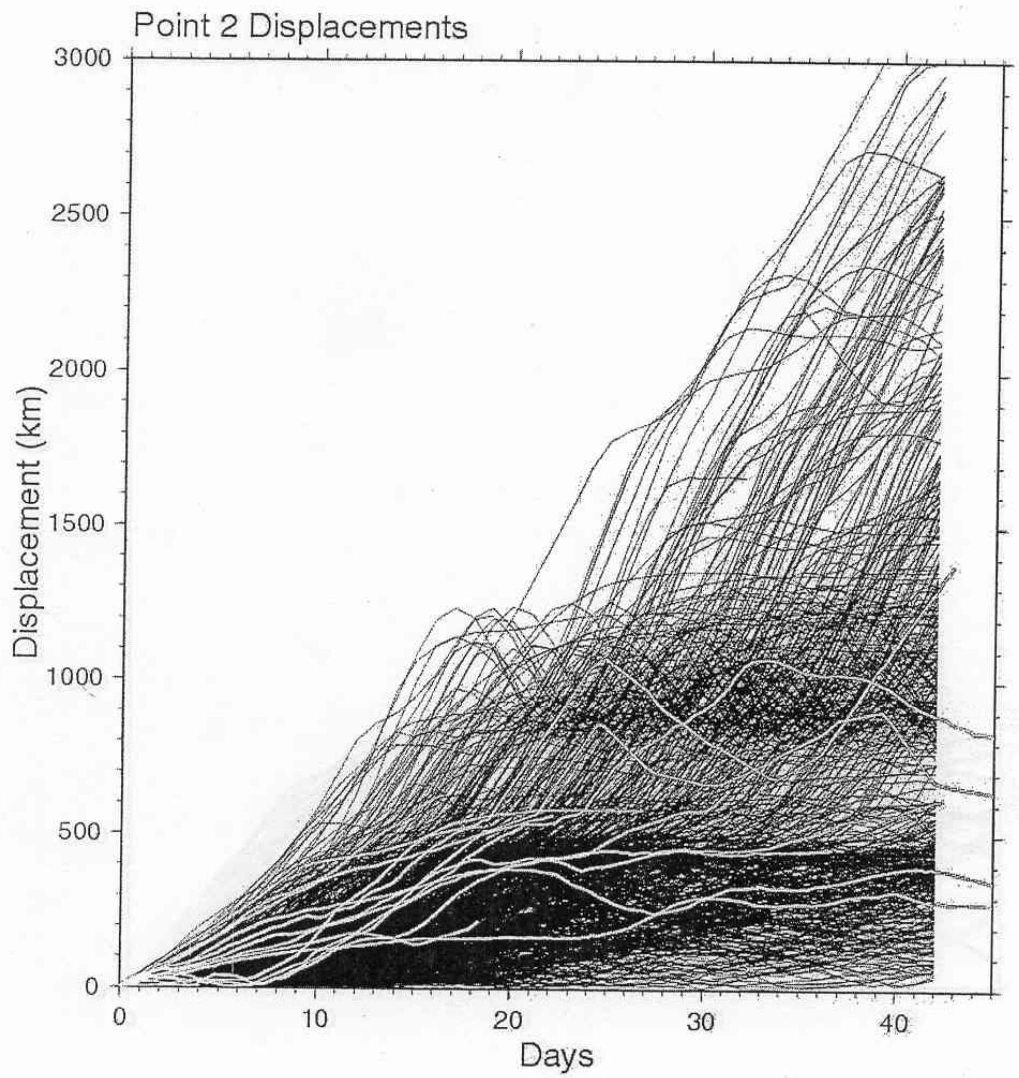
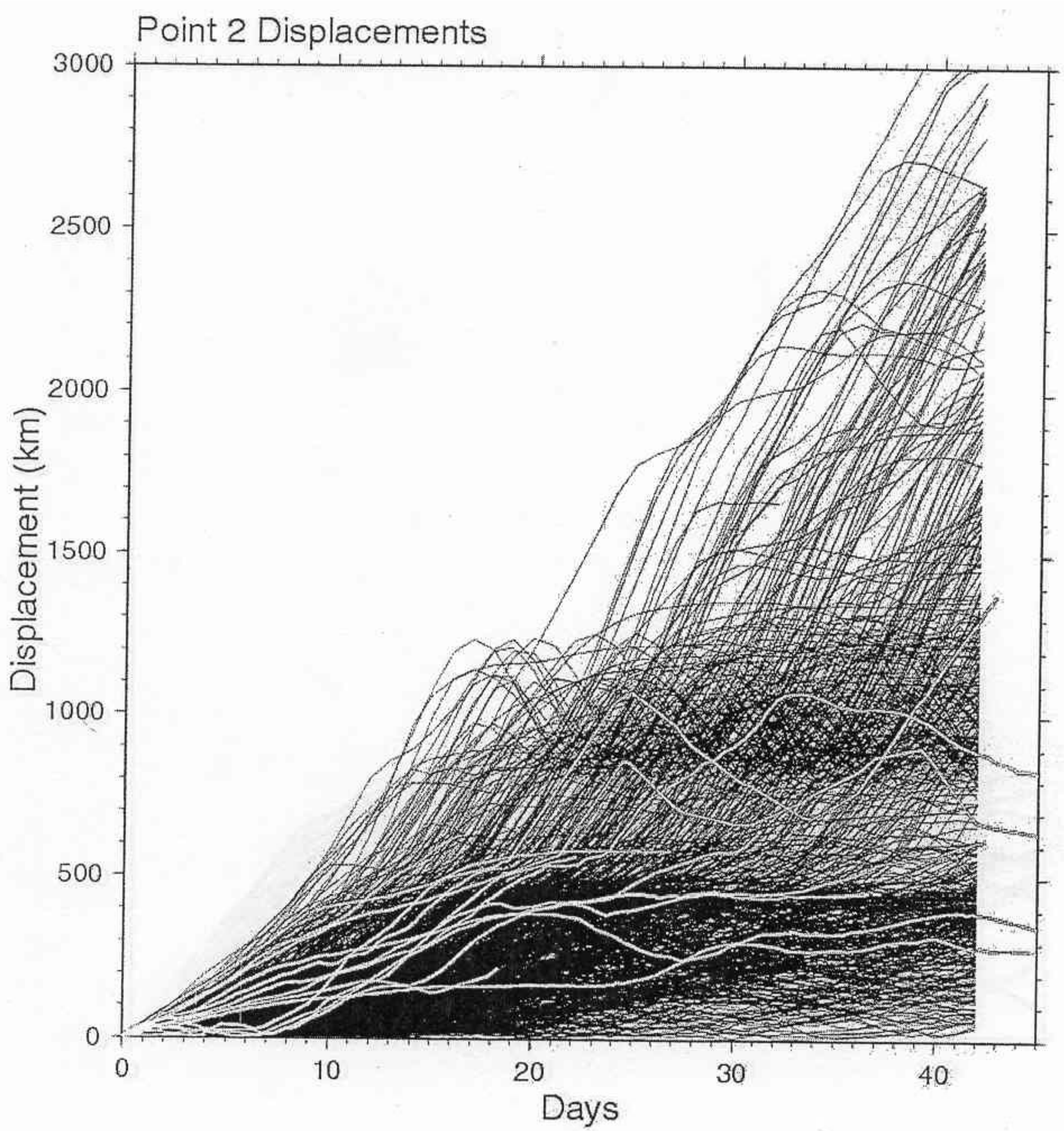

Point 2 Displacements
3000
2500
2000
1500
1000
500
0
Displacement (km)
0
10
20
30
40
Days

Figure 20 a



Point 2 Displacements
3000
2500
2000
1500
1000
500
0
Displacement (km)
0
10
20
30
40
Days

Figure 20 a

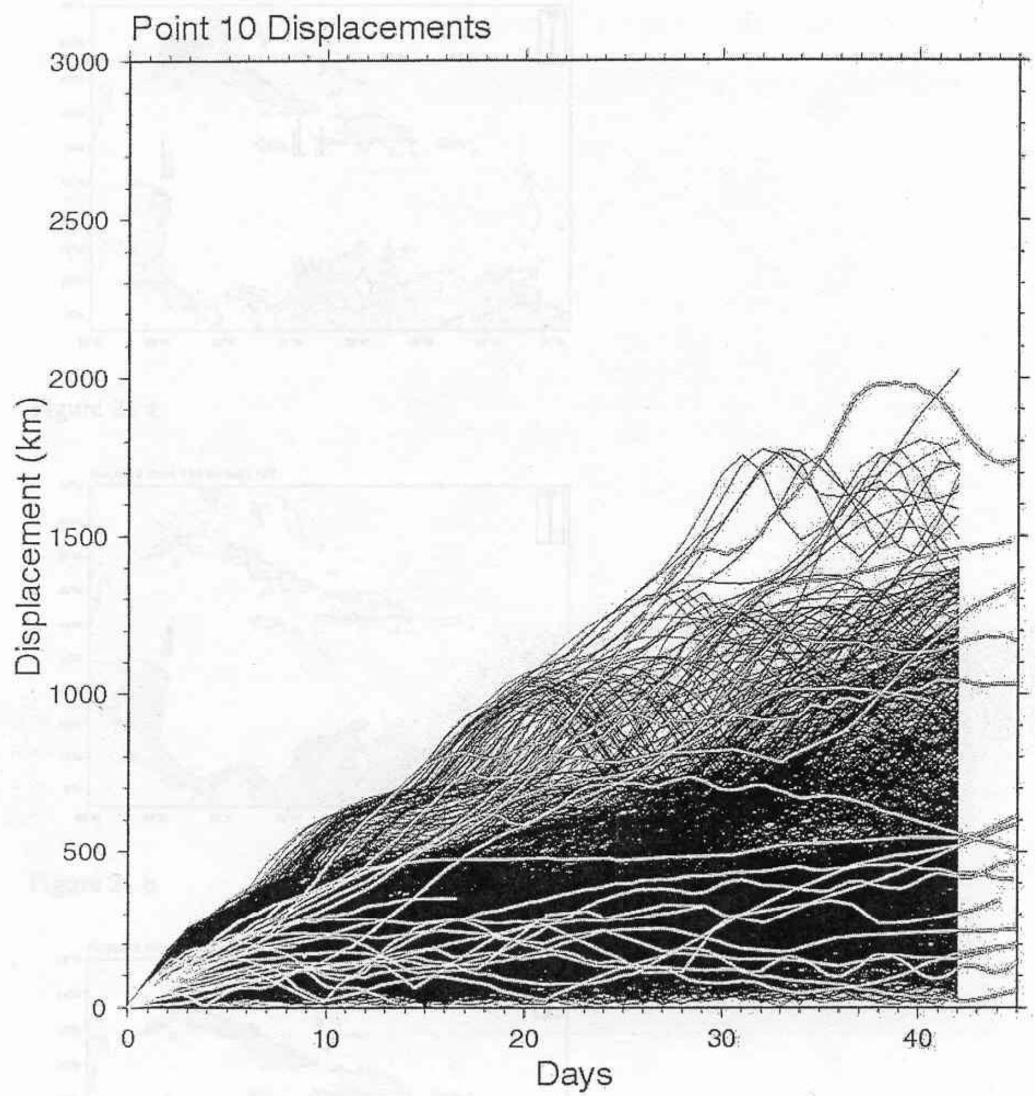
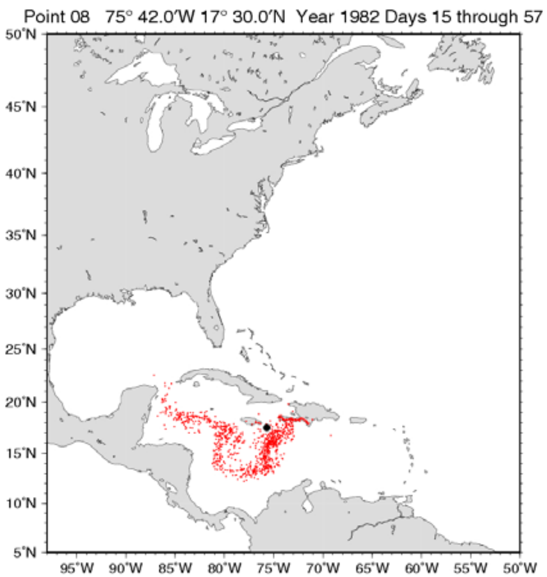
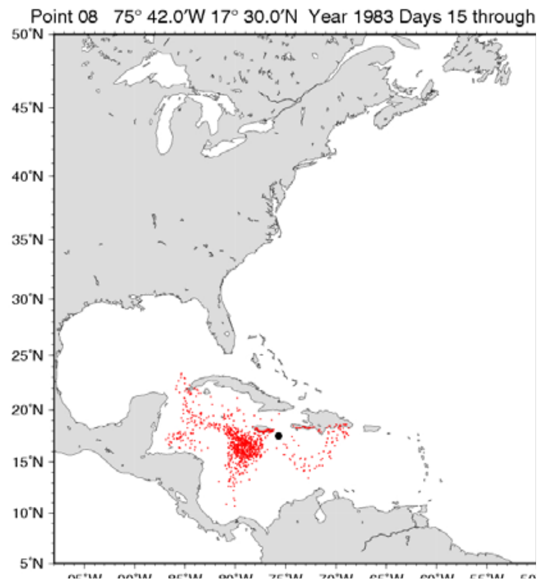
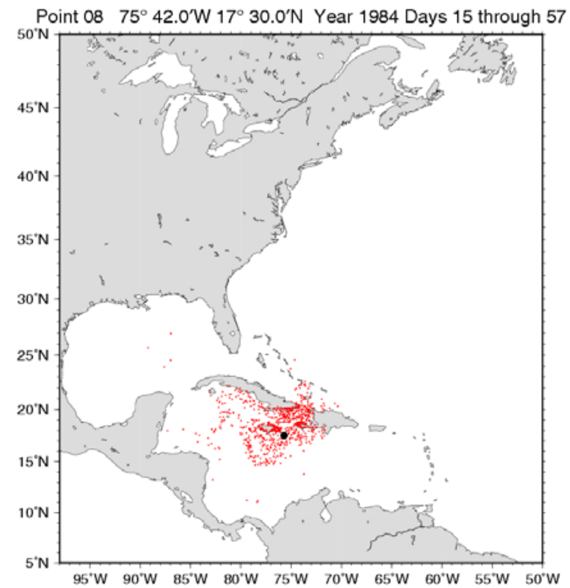
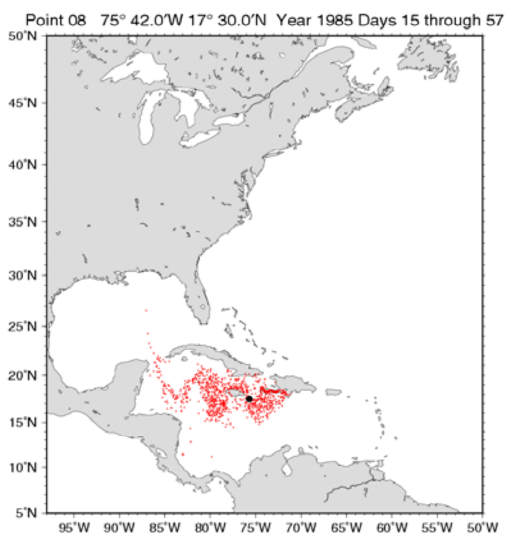

Point 10 Displacements
3000
2500
2000
1500
1000
500
0
Displacement (km)
0
10
20
30
40
Days

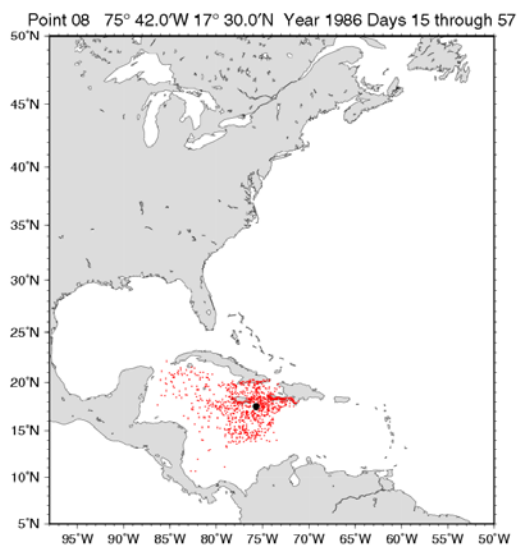
Figure 20 c


Point 08 75° 42.0′W 17° 30.0′N Year 1982 Days 15 through 57
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W 90°W 85°W 80°W 75°W 70°W 65°W 60°W 55°W 50°W

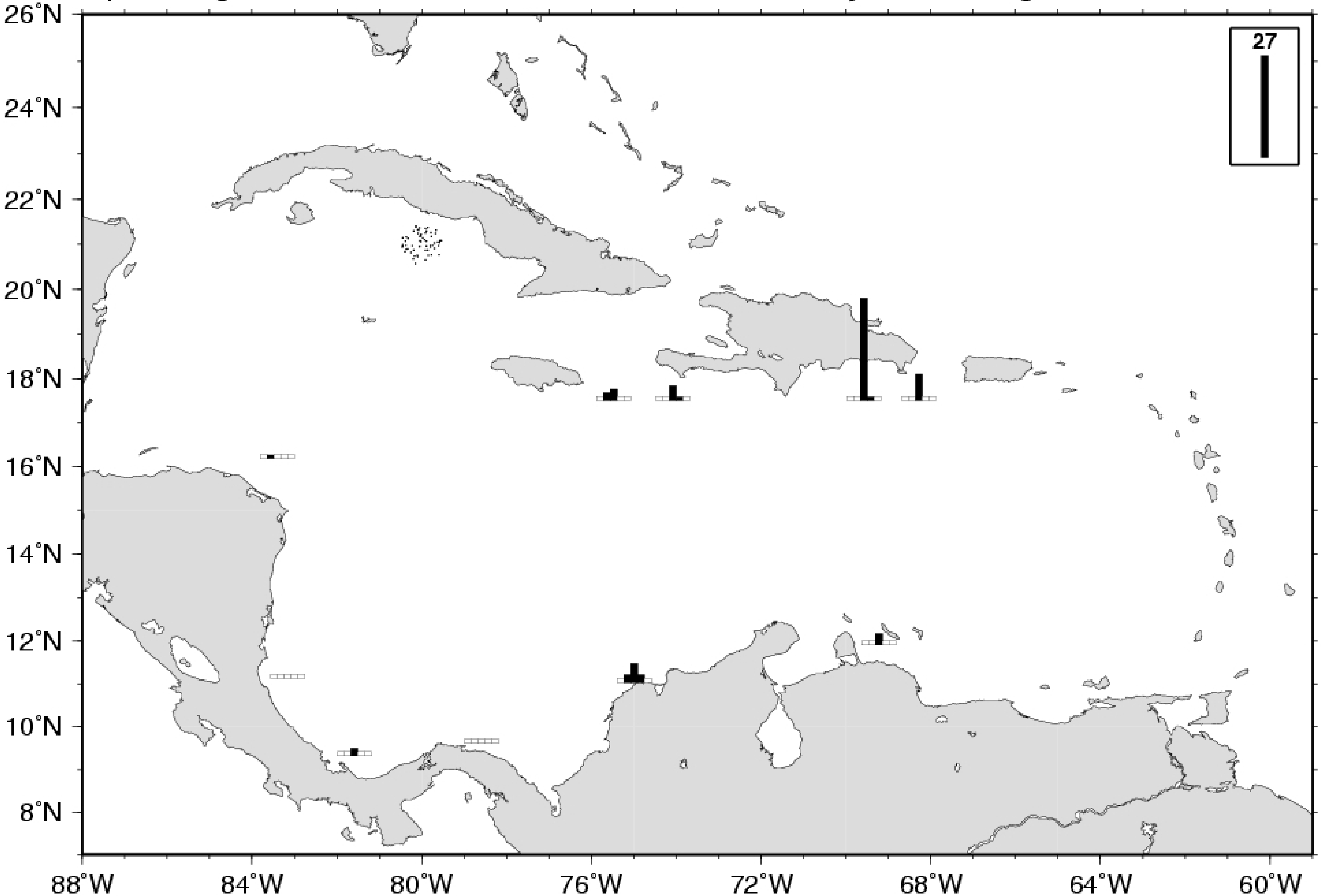

Point 08 75° 42.0′W 17° 30.0′N Year 1983 Days 15 through
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N


Point 08 75° 42.0′W 17° 30.0′N Year 1984 Days 15 through 57
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W 90°W 85°W 80°W 75°W 70°W 65°W 60°W 55°W 50°W


Point 08 75° 42.0′W 17° 30.0′N Year 1985 Days 15 through 57
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W 90°W 85°W 80°W 75°W 70°W 65°W 60°W 55°W 50°W


Point 08 75° 42.0′W 17° 30.0′N Year 1986 Days 15 through 57
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W 90°W 85°W 80°W 75°W 70°W 65°W 60°W 55°W 50°W

Spawning Location: Cuba 21° 0.0′N 80° 0.0′W days 15 through 57



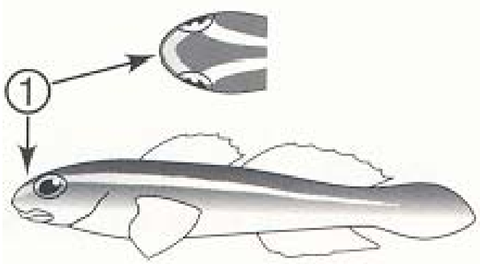
CAYMAN

SHARKNOSE GOBY

Gobiosoma evelynae

Brilliant blue-stripe phase.

FAMILY:
Goby – Gobiidae

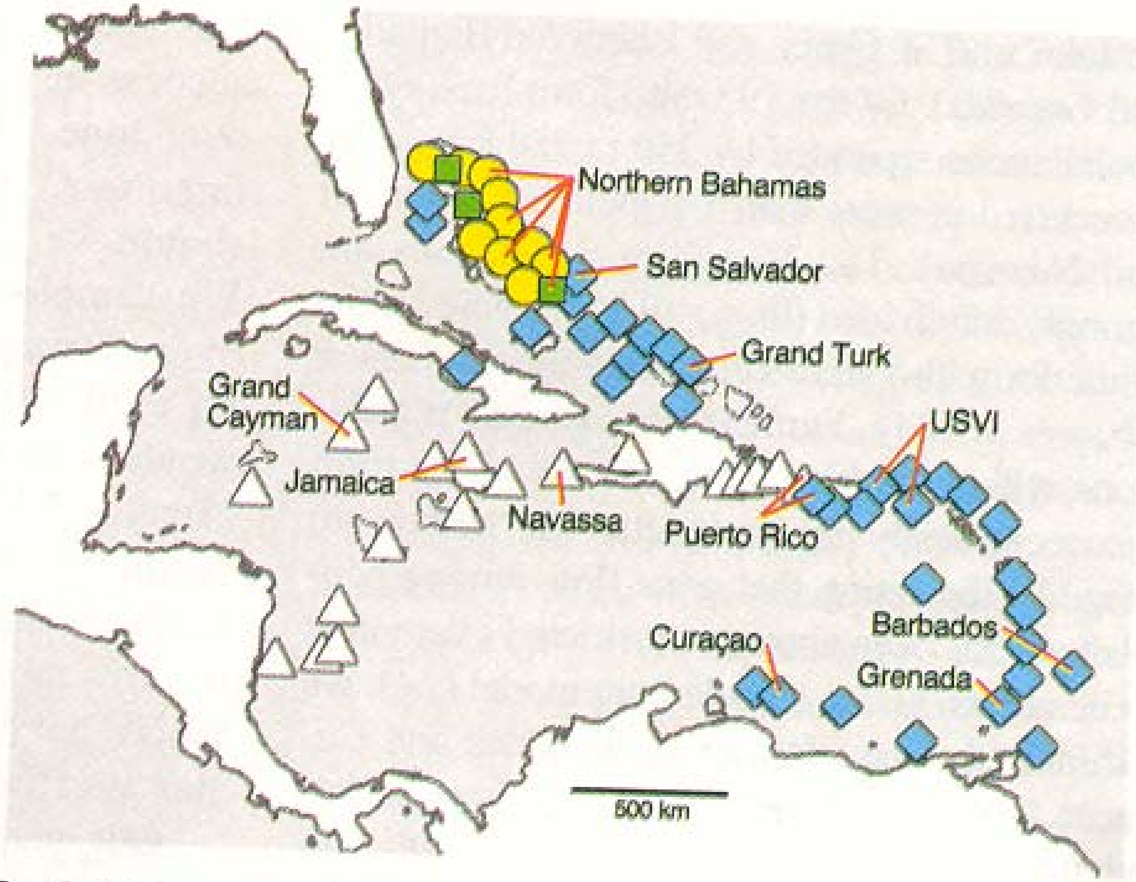


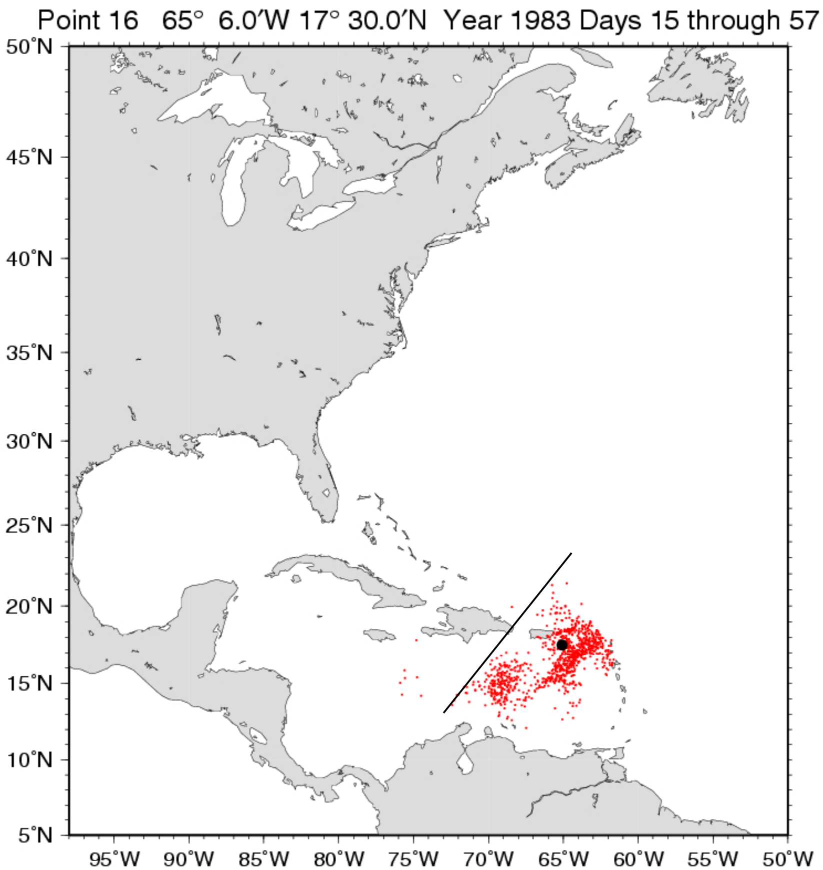
SIZE: 1 - 1¼ in., max. 1½ in.
DEPTH: 30 - 100 ft.

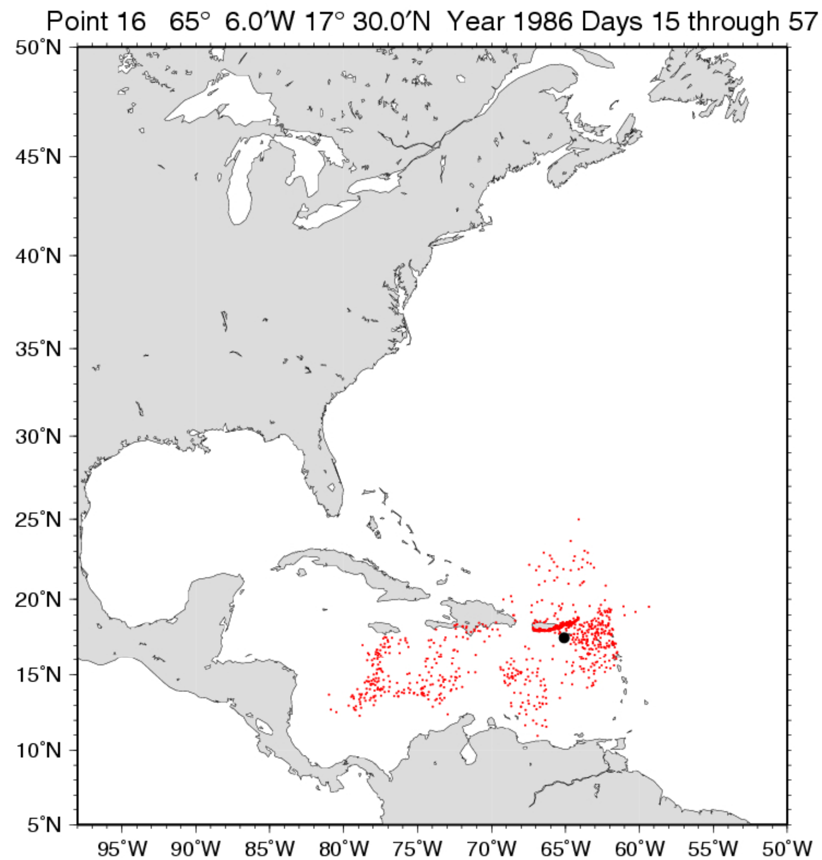
ANGUILLA

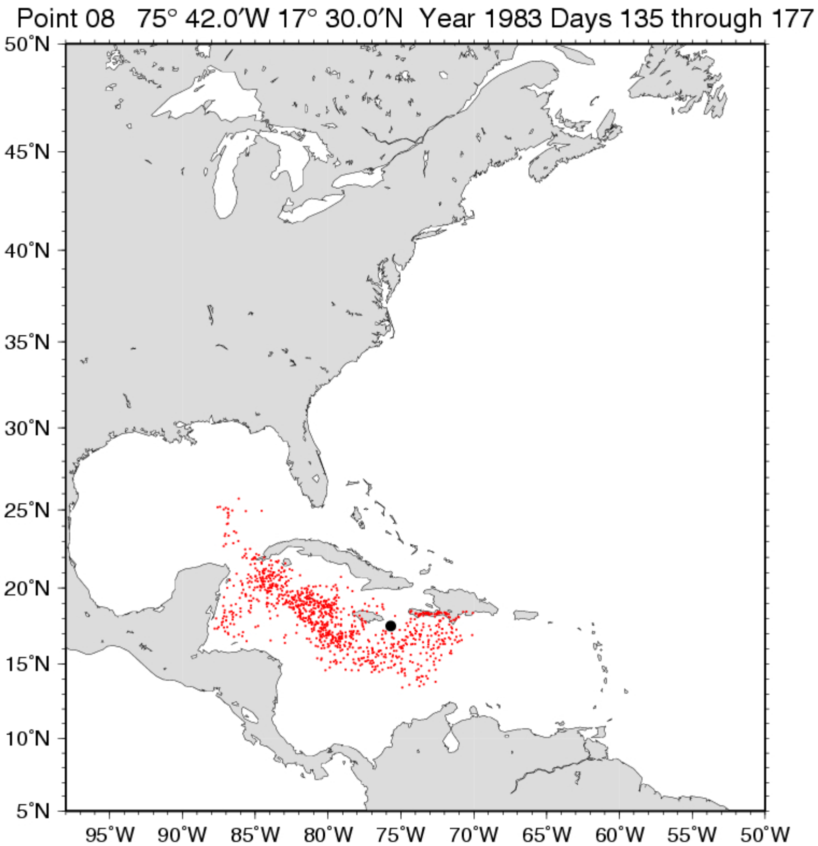
Taylor and Hellberg (2003)

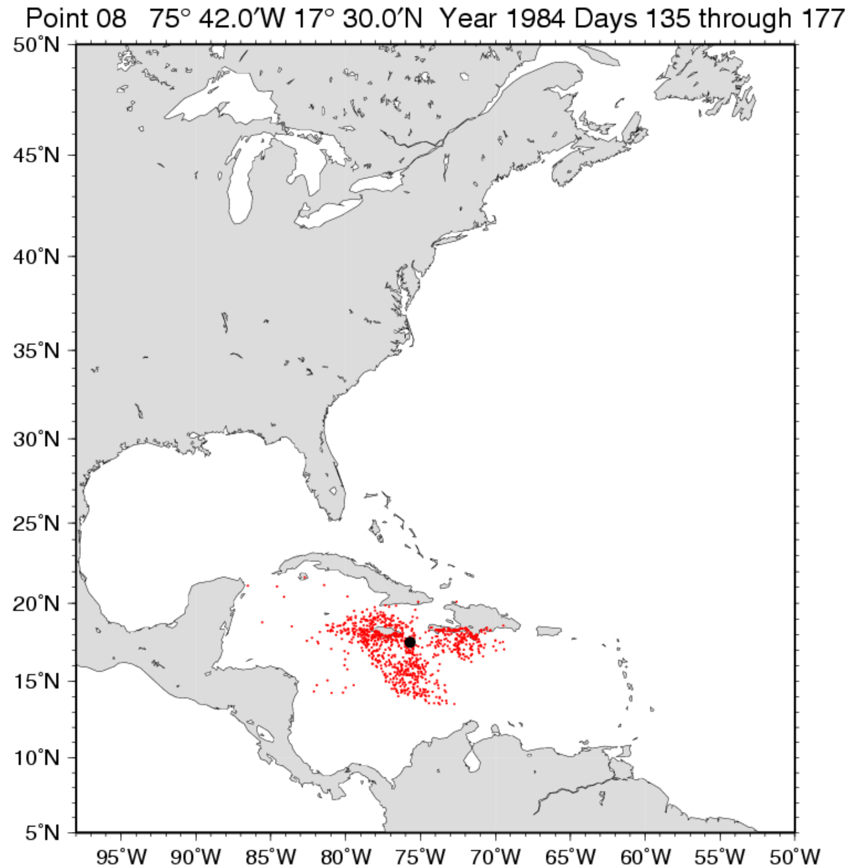
Fig. 1. Distribution of the yellow (circles), blue (diamonds), and white (triangles) color forms of *E. evelynae* across the Bahamas and Caribbean Sea. Green squares indicate localities where both blue and yellow forms have been reported. The 17 sampled populations are indicated with red lines. Northern Bahamas represents five sampled populations (north to south): Sweetings Cay, Eleuthera Island, Lee Stocking Island, Cat Island, and Long Island. Puerto Rico represents two sampled populations, Isla Desecheo (white form) and the main island (blue form). The U.S. Virgin Islands (USVI) represents two sampled populations: St. John and St. Croix.




Point 16 65° 6.0′W 17° 30.0′N Year 1983 Days 15 through 57
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W 90°W 85°W 80°W 75°W 70°W 65°W 60°W 55°W 50°W


Point 16 65° 6.0′W 17° 30.0′N Year 1986 Days 15 through 57
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W 90°W 85°W 80°W 75°W 70°W 65°W 60°W 55°W 50°W

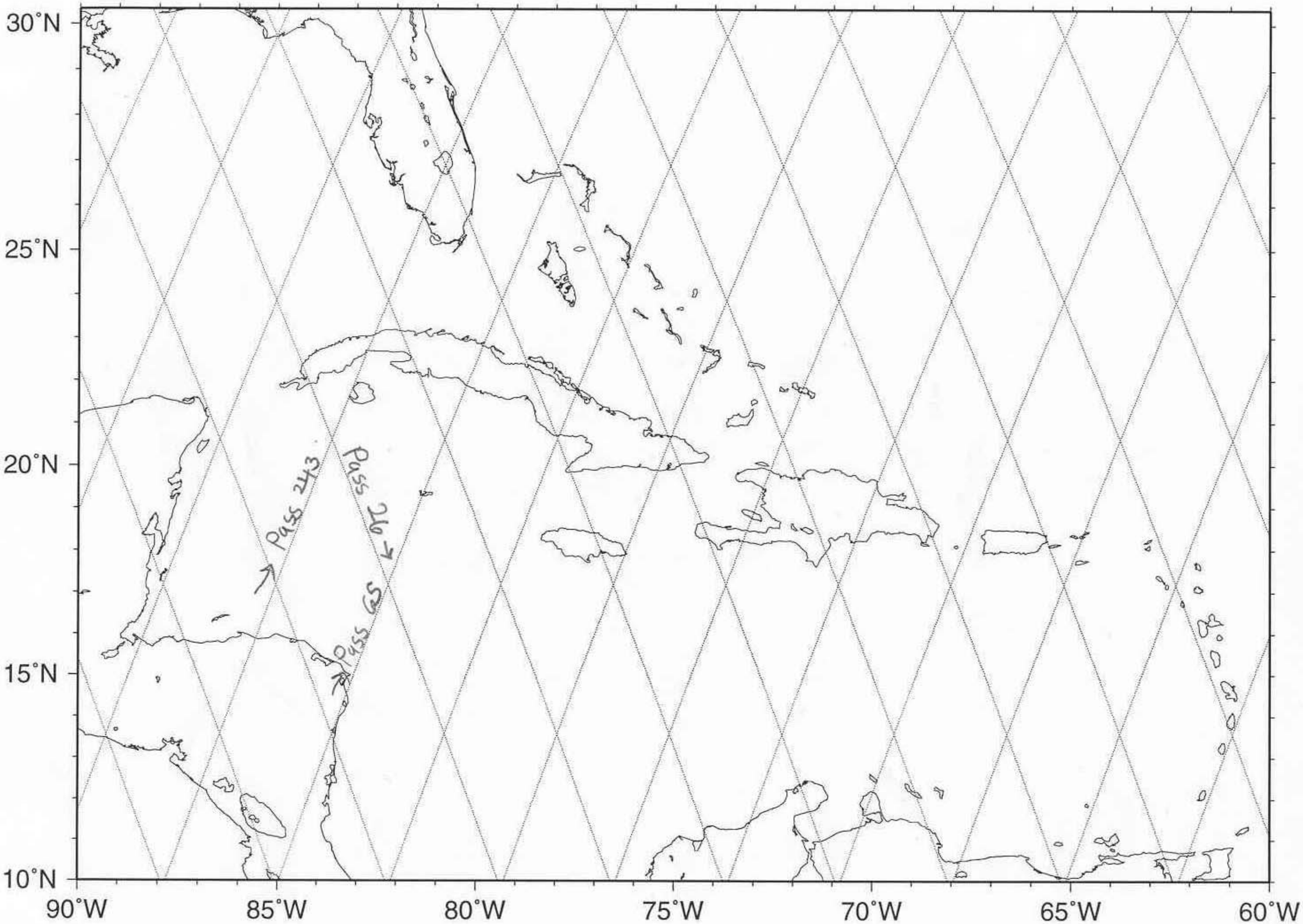

Point 08 75° 42.0′W 17° 30.0′N Year 1983 Days 135 through 177
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W
90°W
85°W
80°W
75°W
70°W
65°W
60°W
55°W
50°W

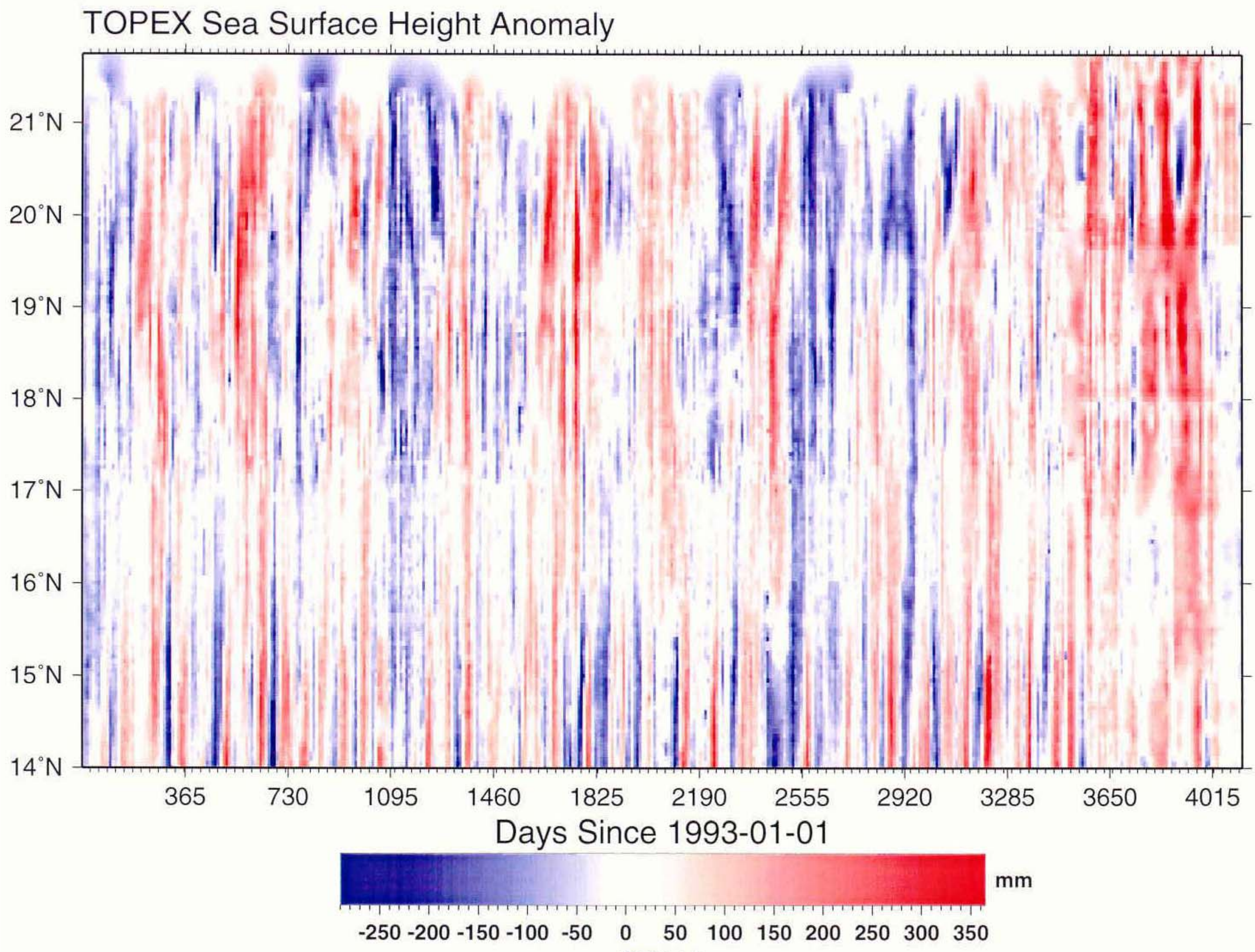

Point 08 75° 42.0′W 17° 30.0′N Year 1984 Days 135 through 177
50°N
45°N
40°N
35°N
30°N
25°N
20°N
15°N
10°N
5°N
95°W
90°W
85°W
80°W
75°W
70°W
65°W
60°W
55°W
50°W

Mechanisms of Interannual Connectivity Change

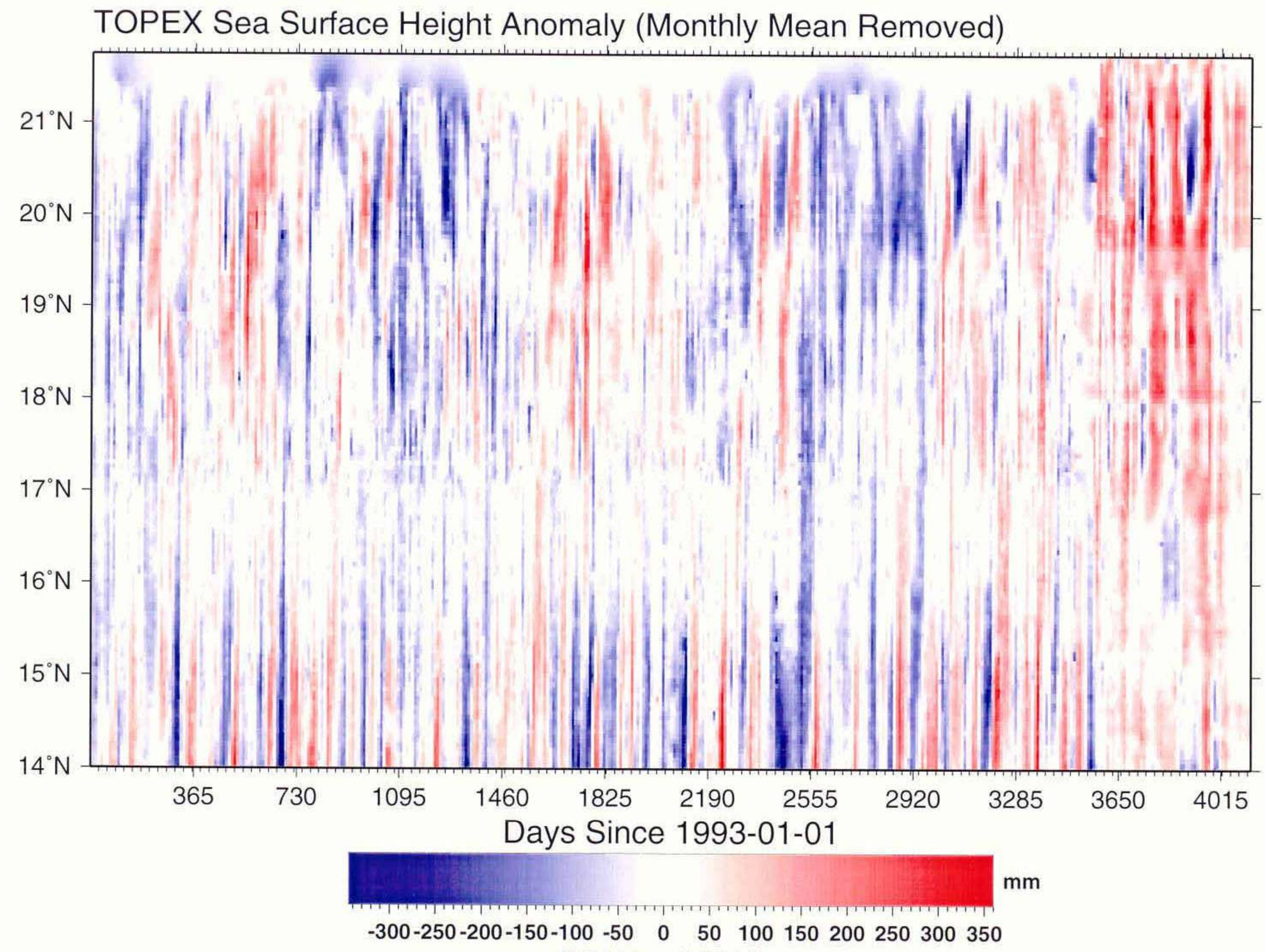
- What mechanisms define connectivity changes in the Caribbean?
- SST anomalies in the Cayman Sea and correlations to ENSO
- Modulation of the circulation and the circulation in the Cayman Sea influences both the temperature field by trapping heat there and reducing connections to the west.

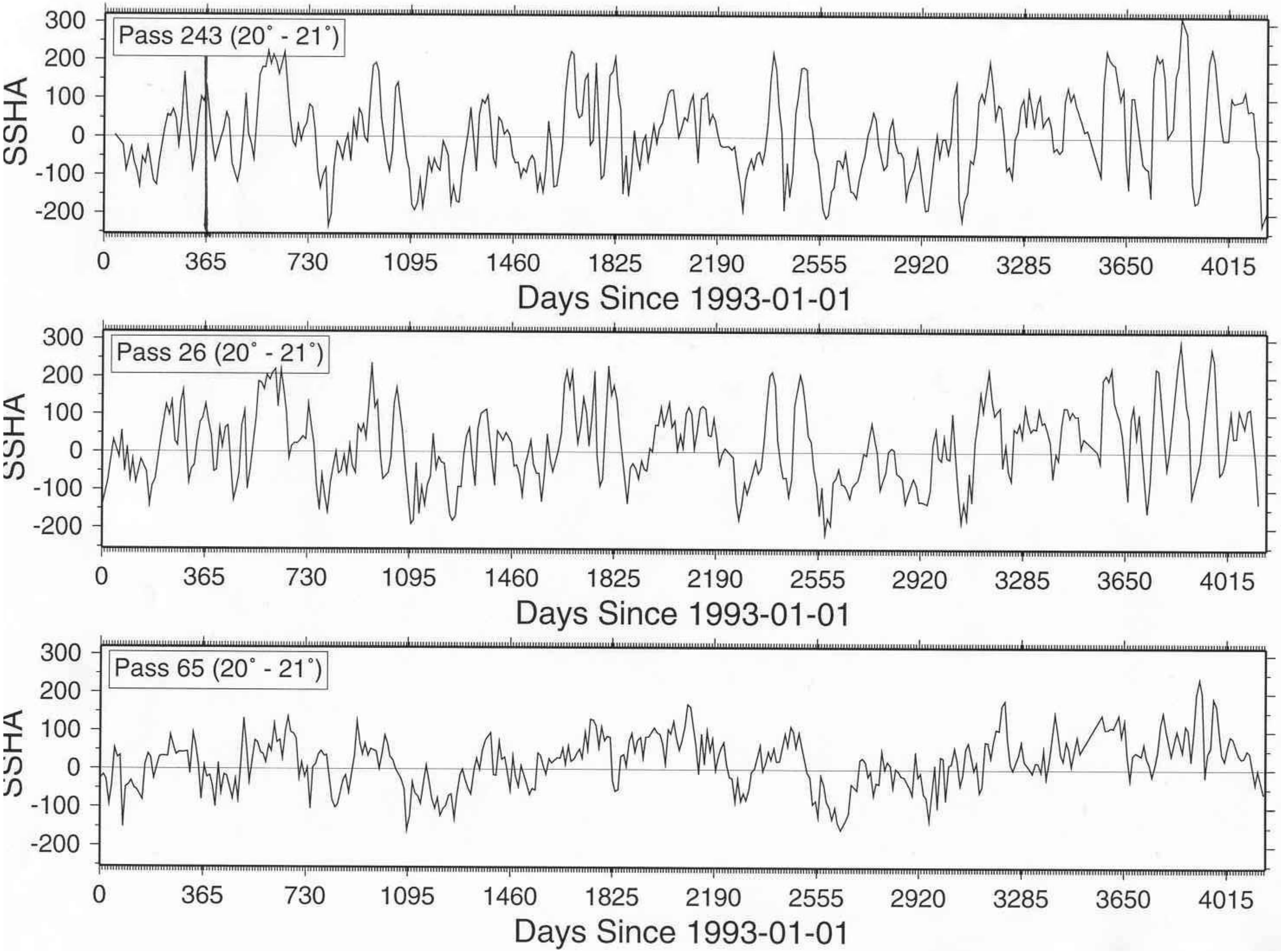
TOPEX Reference Points



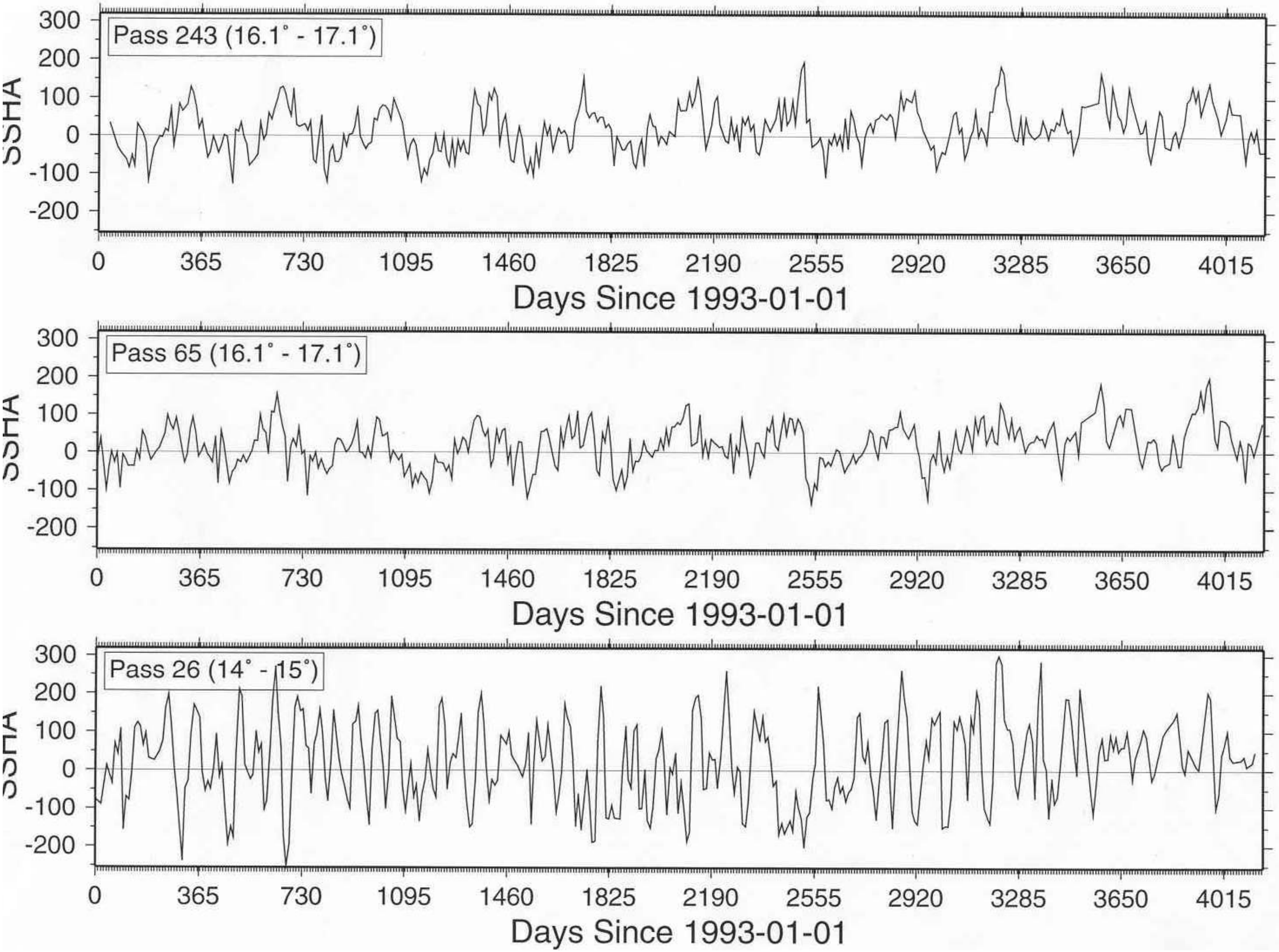


TOPEX Sea Surface Height Anomaly
21°N
20°N
19°N
18°N
17°N
16°N
15°N
14°N
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
Days Since 1993-01-01
mm
-250 -200 -150 -100 -50 0 50 100 150 200 250 300 350


TOPEX Sea Surface Height Anomaly (Monthly Mean Removed)
21°N
20°N
19°N
18°N
17°N
16°N
15°N
14°N
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
Days Since 1993-01-01
mm
-300 -250 -200 -150 -100 -50 0 50 100 150 200 250 300 350



Pass 243 (20° - 21°)
SSHA
300
200
100
0
-100
-200
0
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
Days Since 1993-01-01
Pass 26 (20° - 21°)
SSHA
Days Since 1993-01-01
Pass 65 (20° - 21°)
SSHA
Days Since 1993-01-01


Pass 243 (16.1° - 17.1°)
300
200
100
0
-100
-200
0
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
Days Since 1993-01-01
Pass 65 (16.1° - 17.1°)
300
200
100
0
-100
-200
0
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
Days Since 1993-01-01
Pass 26 (14° - 15°)
300
200
100
0
-100
-200
0
365
730
1095
1460
1825
2190
2555
2920
3285
3650
4015
Days Since 1993-01-01

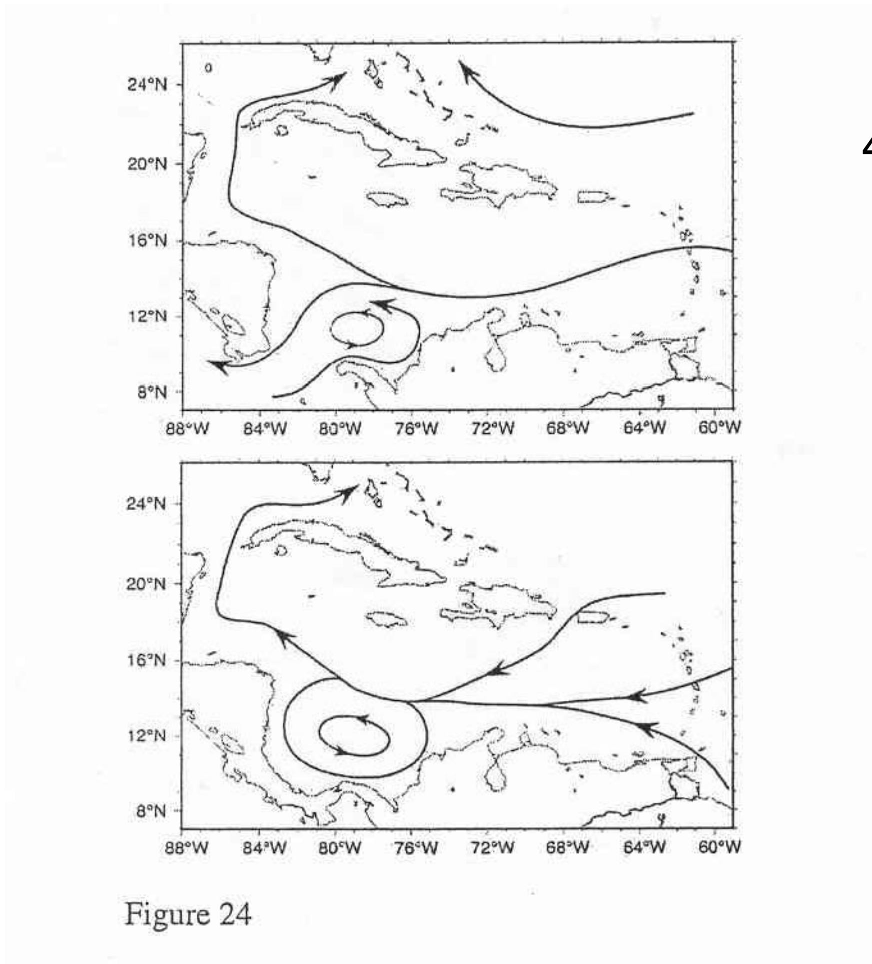


Figure 24

4.0 Myr BP

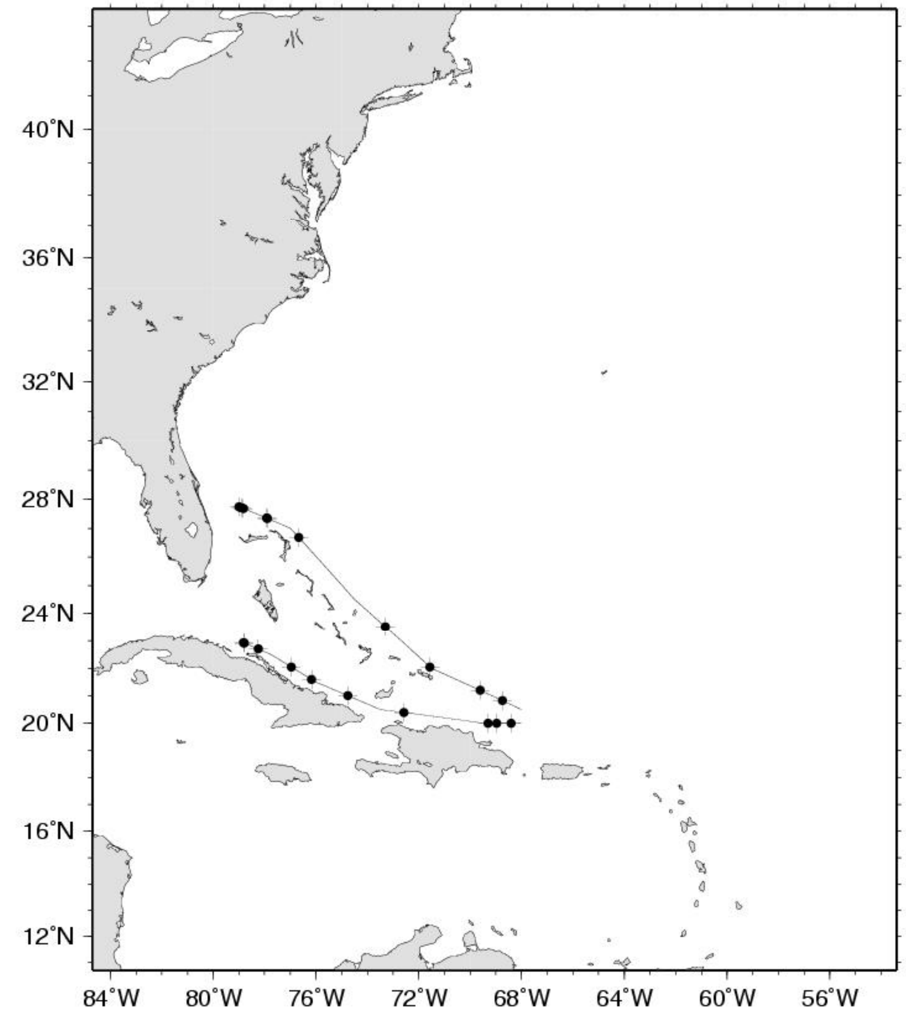
Present

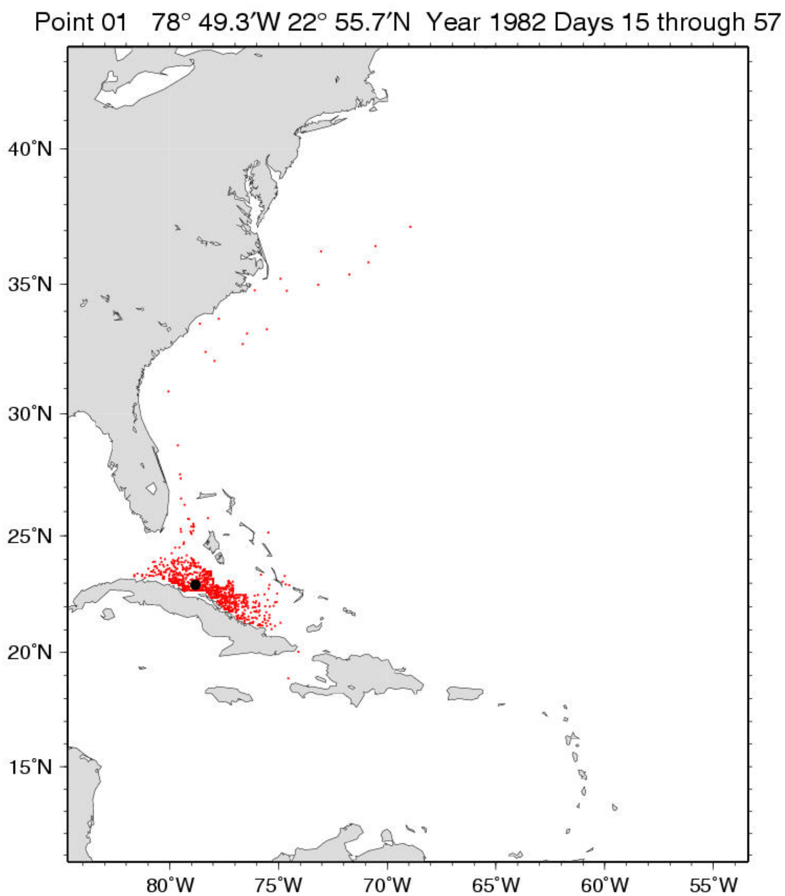
Olson (2005)

Circulation within the Bahamas

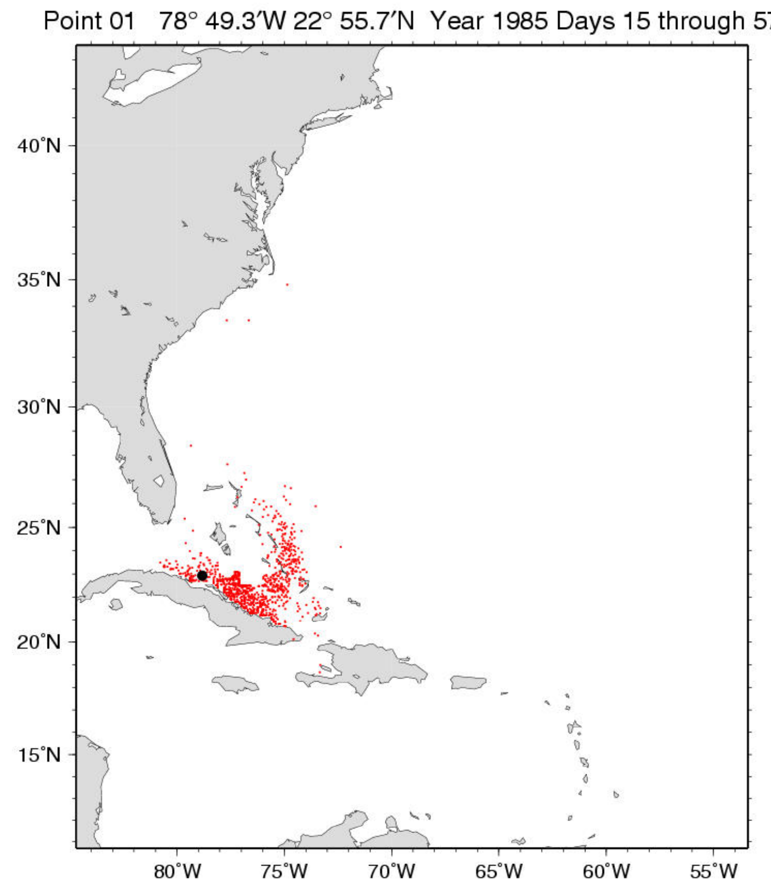
- Simulations within the Bahamas is more problematic: Does the model actually perform in these restricted areas?
- Transports in passages as a check.
- Problem areas: Old Bahama Channel, Tongue of the Ocean

Bahamas Release Points

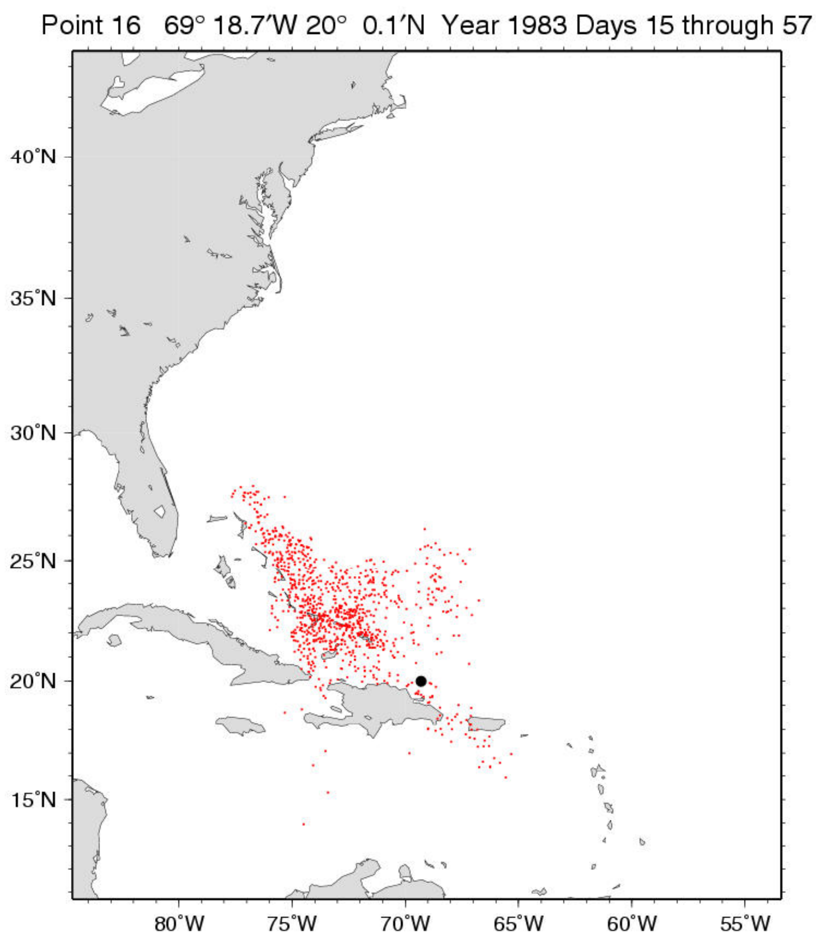


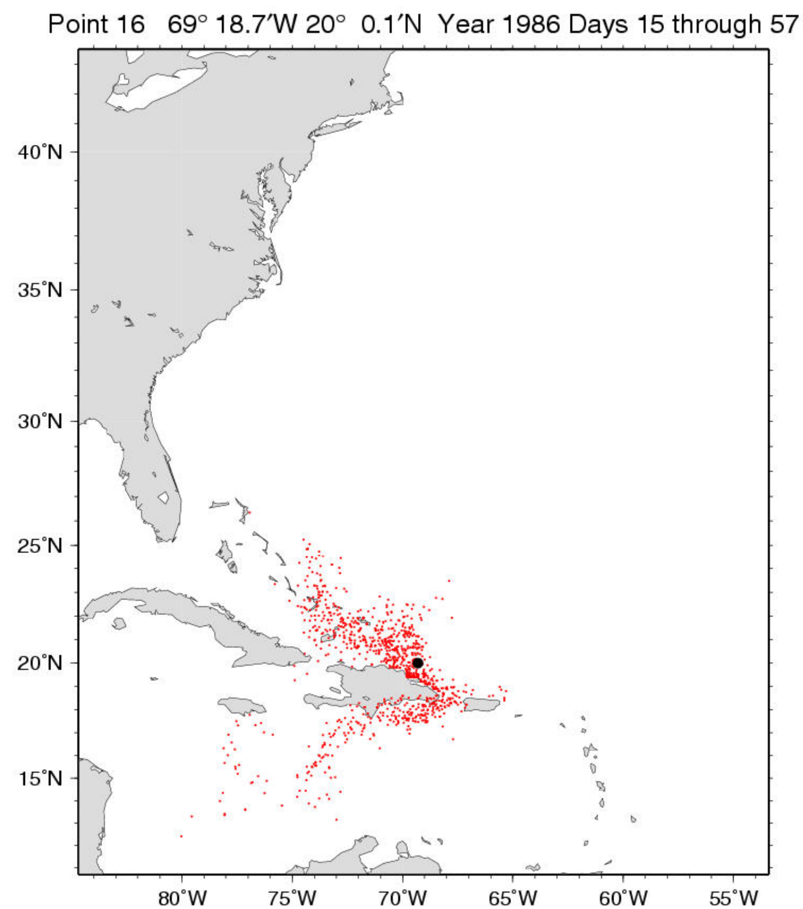


Point 01 78° 49.3′W 22° 55.7′N Year 1982 Days 15 through 57
40°N
35°N
30°N
25°N
20°N
15°N
80°W
75°W
70°W
65°W
60°W
55°W

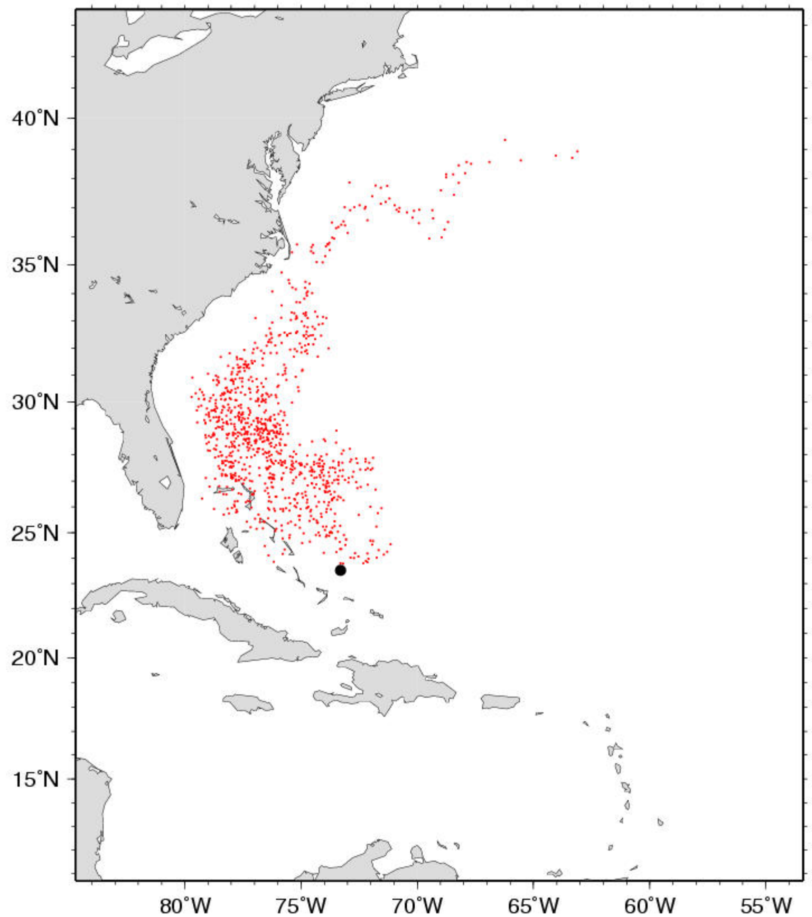


Point 01 78° 49.3′W 22° 55.7′N Year 1985 Days 15 through 57
40°N
35°N
30°N
25°N
20°N
15°N
80°W
75°W
70°W
65°W
60°W
55°W

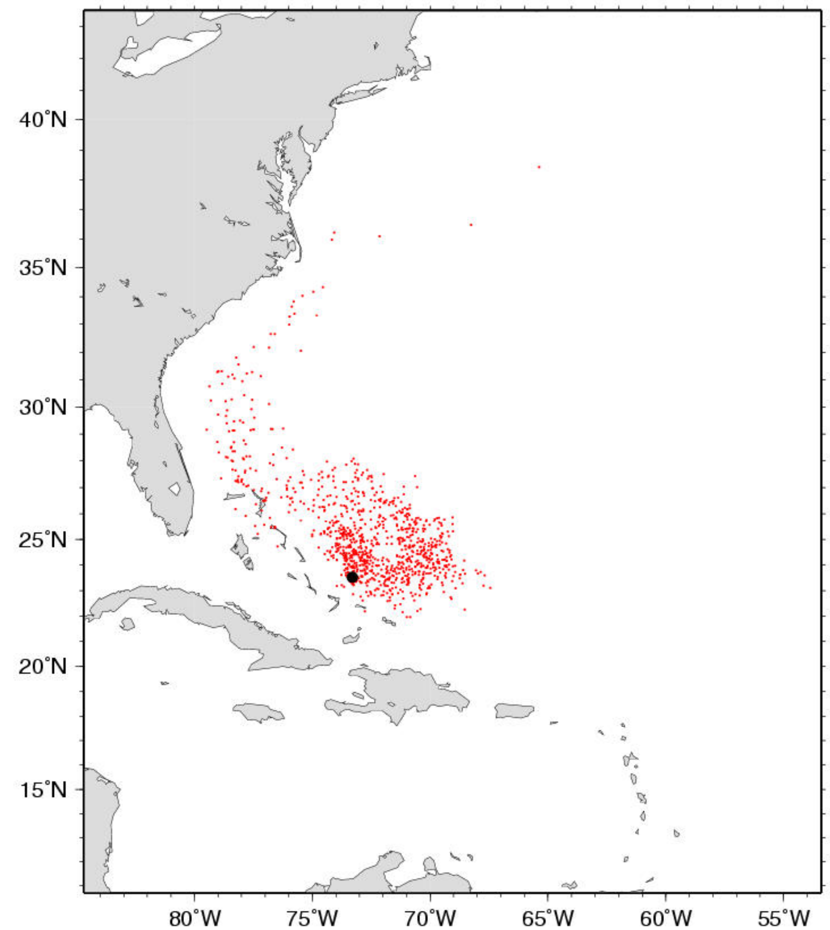

Point 16 69° 18.7′W 20° 0.1′N Year 1983 Days 15 through 57
40°N
35°N
30°N
25°N
20°N
15°N
80°W
75°W
70°W
65°W
60°W
55°W


Point 16 69° 18.7′W 20° 0.1′N Year 1986 Days 15 through 57
40°N
35°N
30°N
25°N
20°N
15°N
80°W
75°W
70°W
65°W
60°W
55°W

Point 13   73° 18.0′W 23° 31.1′N Year 1984 Days 15 through 57



Point 13   73° 18.0′W 23° 31.1′N Year 1985 Days 15 through 57



Conclusions

- Drift simulations seem to be reproducing reasonable pathways in most areas.
- Arrival matrices can easily be provided for all of the runs, but there must be a decision on areas and scales.
- Prototype models for carrying out genetic simulations are underway and can be run on the MICOM or simpler simulations.