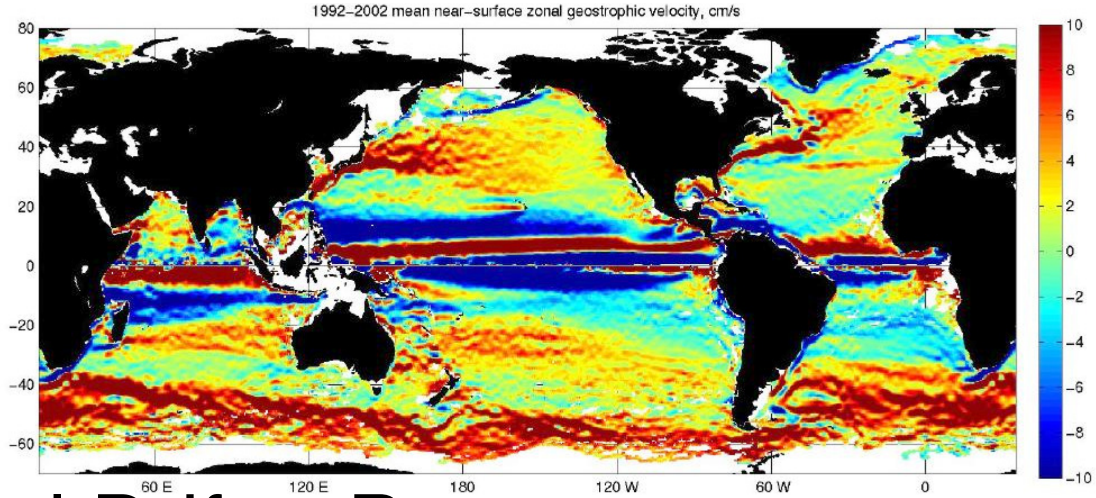

The Global Drifter Program: Operations and Scientific Applications

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LAMMA workshop, 4/18/2012, Livorno Italy

The Global Drifter Program (GDP)

The GDP is a semi-operational oceanographic program:

- The GDP maintains an array of1,250 drifters (nominal);
- The GDP has a meteorological component (Sea Surface Pressure, wind, SST, and a air-deployable hurricane array);
- The GDP reached is full implementation in September 2005.

The GDP benefits from international co-operation

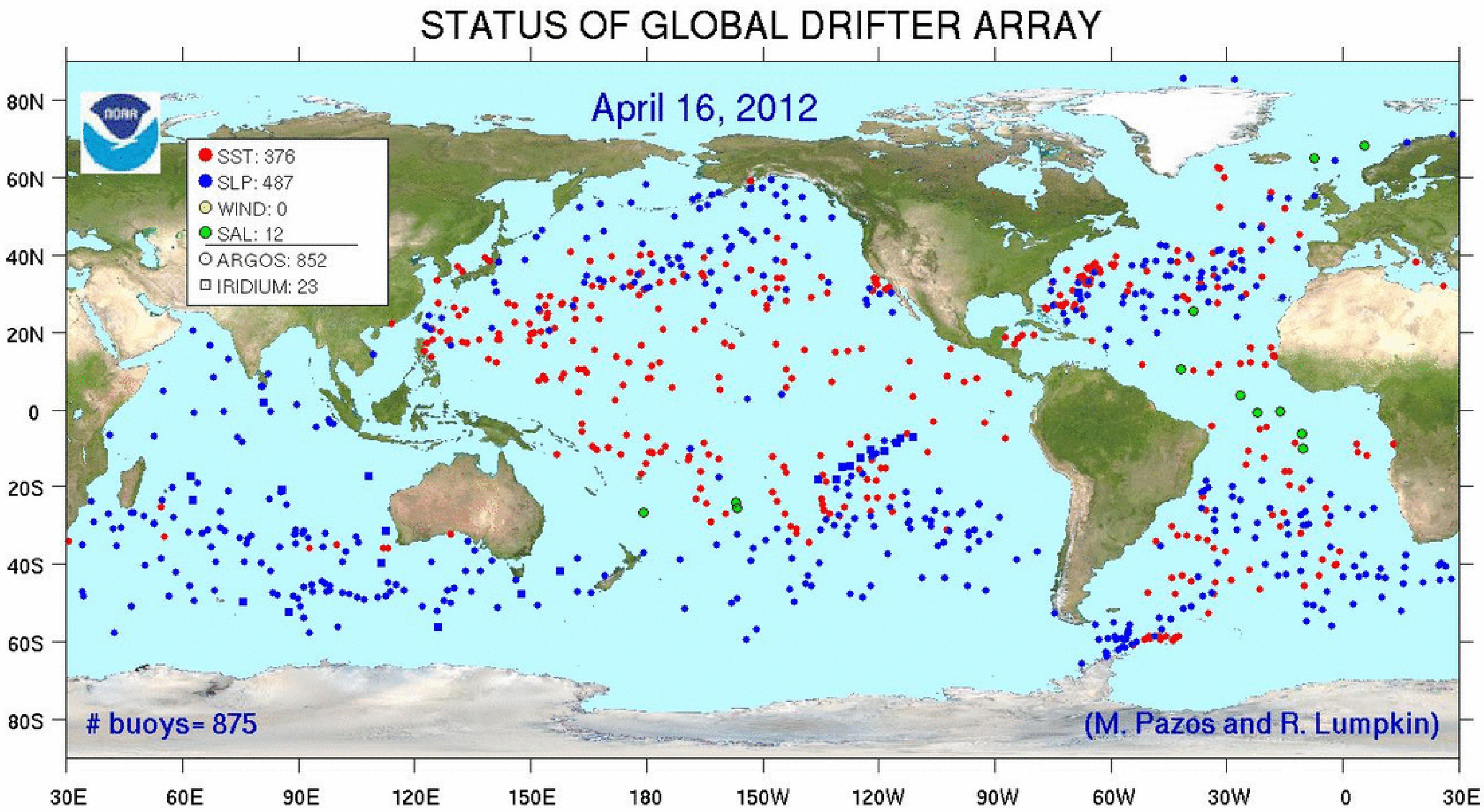
- The GDP is a component of the Global Ocean Observing System of NOAA and a scientific program of the Data Buoy Cooperation Panel (WMO-IOC) ;
- Several countries contribute to the success of the program.

The GDP is a scientific program

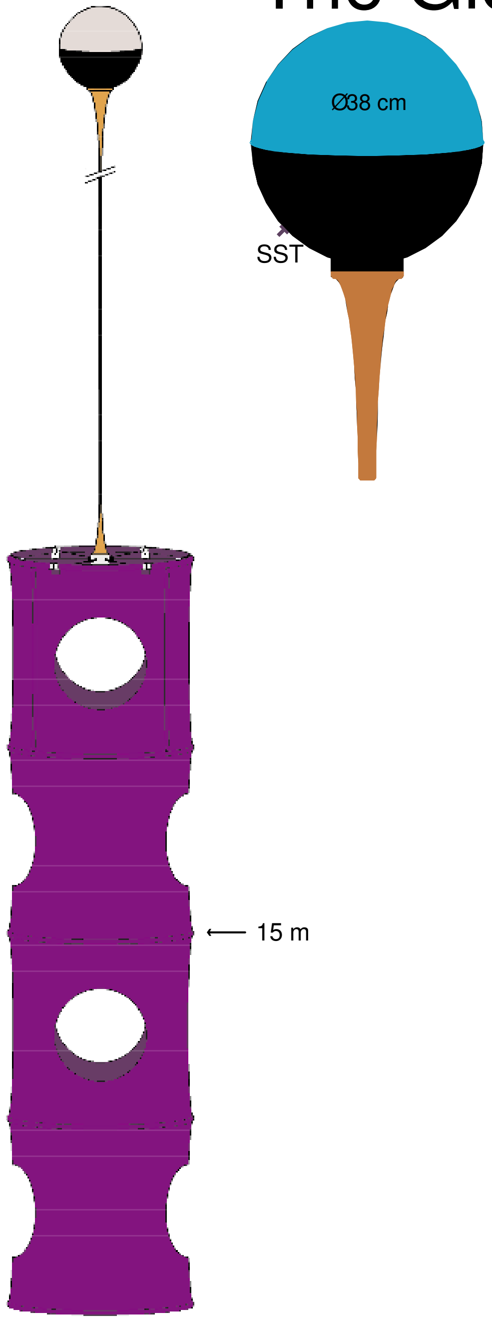
- A very large number of papers based on drifter data have been published;
- The GDP continuously seeks and fosters the development and the implementation of other sensors such as sea surface salinity and wind velocity.

Global Drifter Program Management Structure

1) SIO (Centurioni) procures over 90% of the GDP drifters, oversees the technology, develops new drifters, maintains an enhanced global surface currents dataset and uses drifter data for research.
2) AOML (Lumpkin) organizes the global deployments, manages the real-time data, performs quality control, compiles performance statistics and uses drifter data for research.


STATUS OF GLOBAL DRIFTER ARRAY
April 16, 2012
SST: 376
SLP: 487
WIND: 0
SAL: 12
ARGOS: 852
IRIDIUM: 23
buoys= 875
(M. Pazos and R. Lumpkin)
80N
60N
40N
20N
0
20S
40S
60S
80S
30E
60E
90E
120E
150E
180
150W
120W
90W
60W
30W
0
30E

The Global Drifter Program: the instruments



THE WORKHORSE: THE MINI SVP (VELOCITY AND SST ONLY)

<u>Mini SVP technical specs:</u>

•Spherical ABS float, 38 cm diameter;

•Tether made of polyurethane impregnated wire;

•Holey sock drogue (length ~ 5m);

•Strain relief (carrots of urethane);

•SST (thermistor +- 0.1-0.05 ° C);

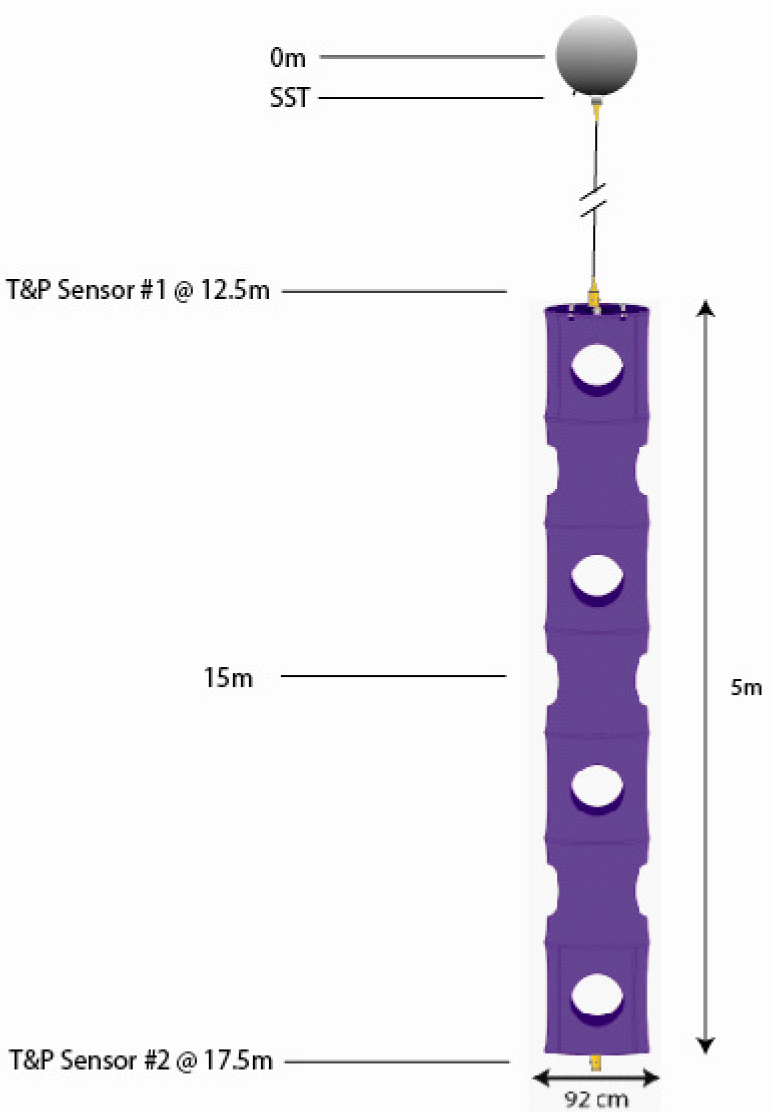
•Drogue on/off sensor (strain gauge,)

•ARGOS telemetry and fixing (acc: 150 – 1000 m)

• Iridium with GPS

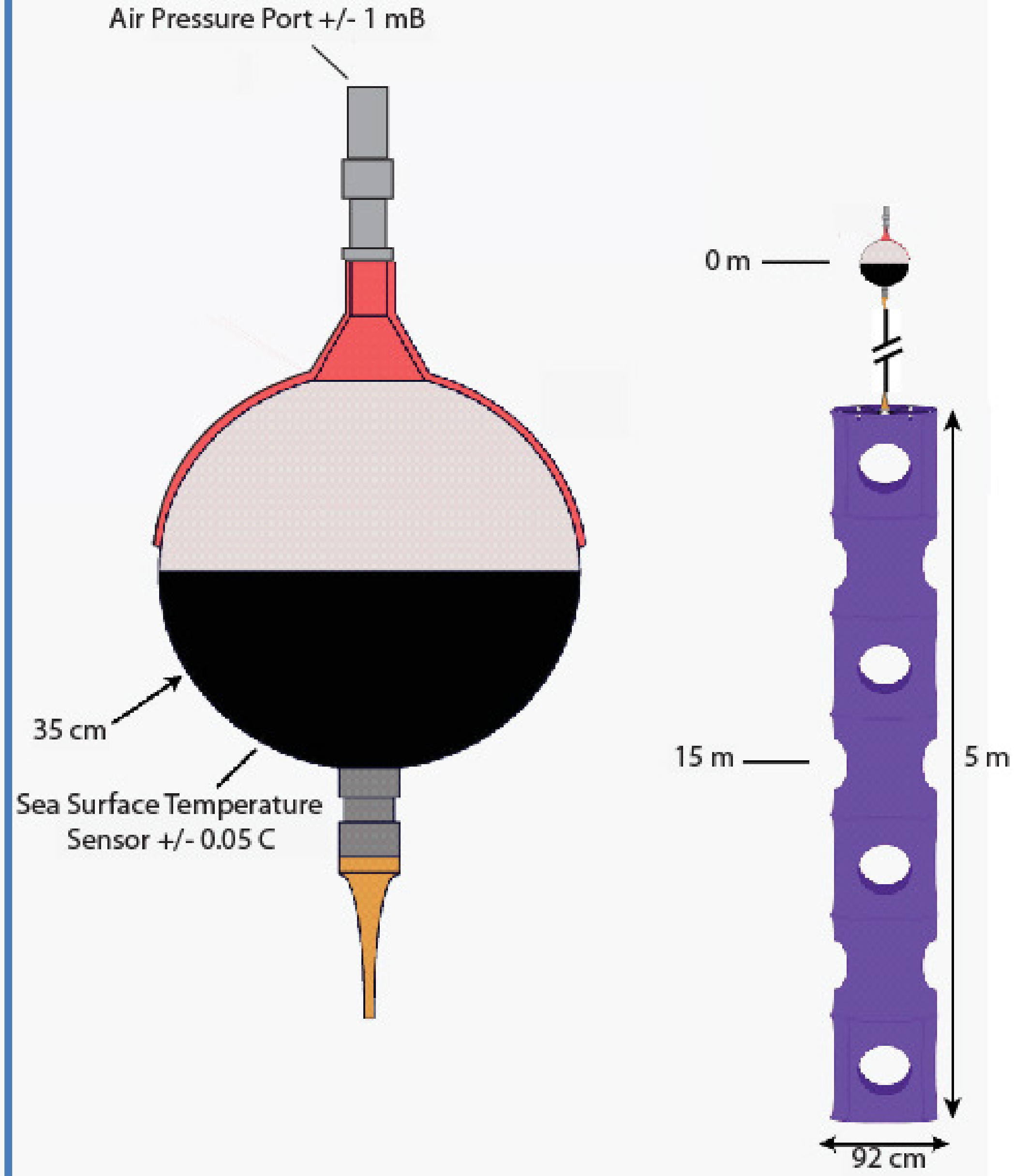
•Drag area ratio (=$C_{Ddr}\ d_{dr}\ h_{dr}/C_{Doth}\ A_{oth}$) ~ 40;

SVP-2T

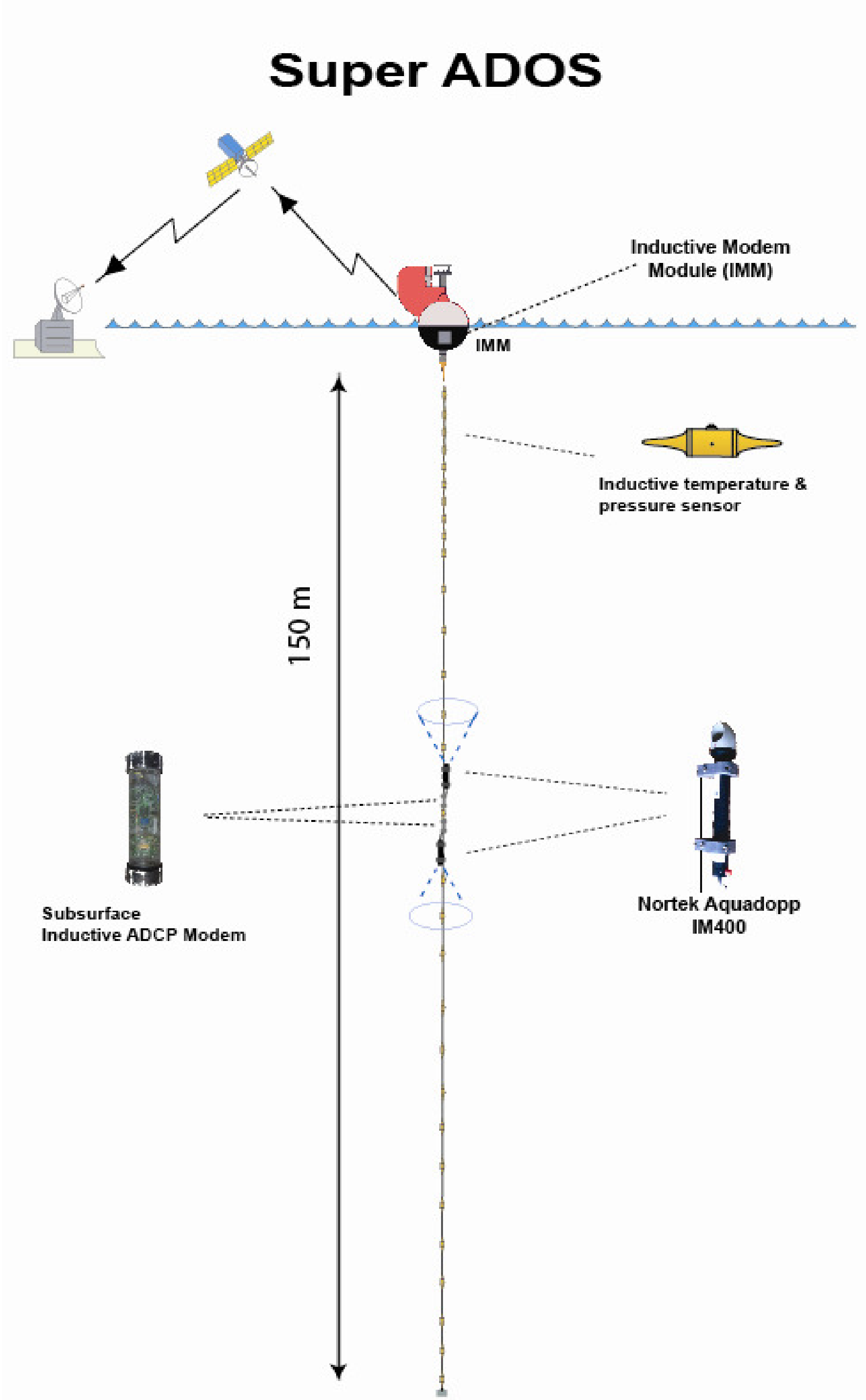


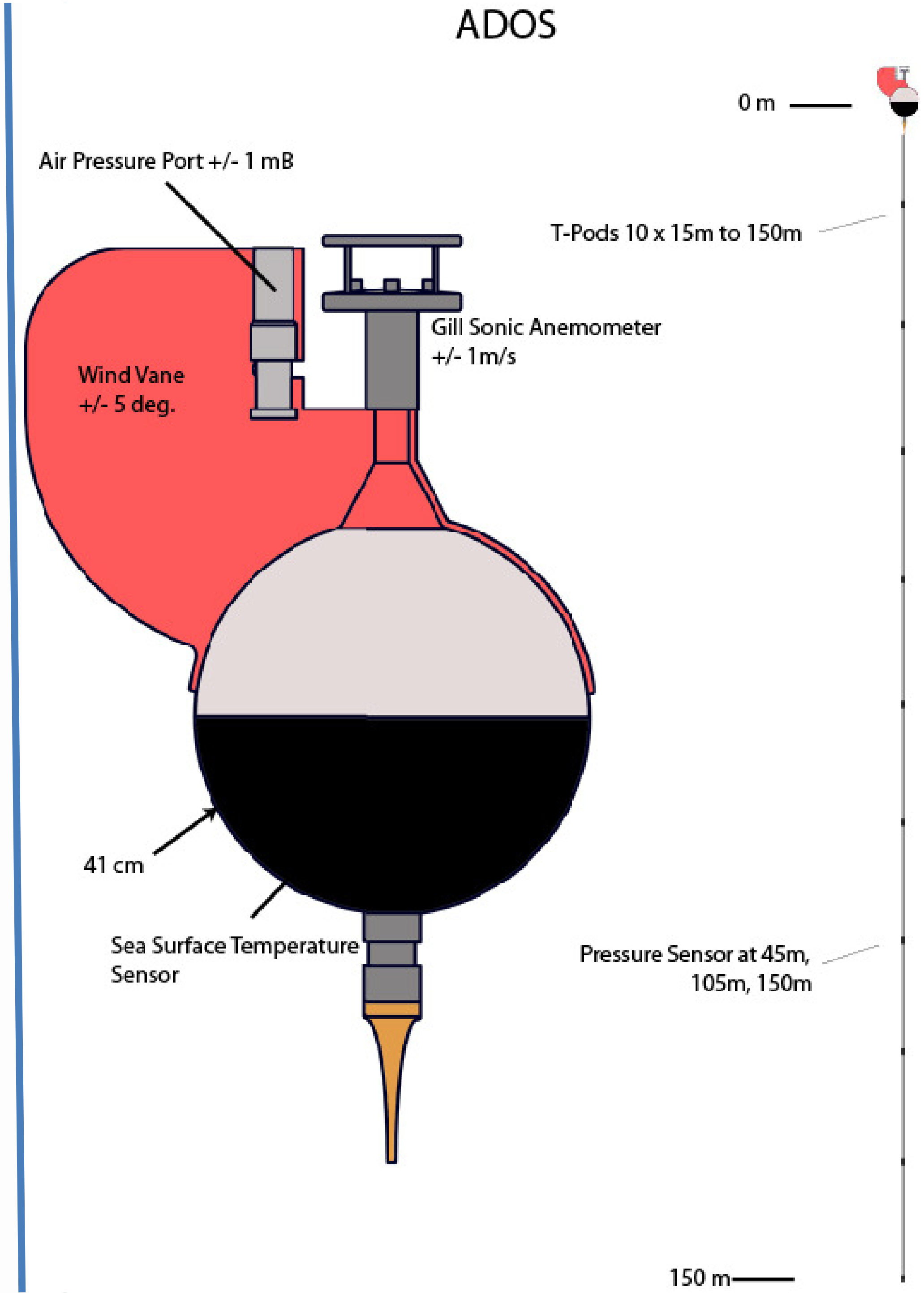
0m
SST
T&P Sensor #1 @ 12.5m
15m
5m
T&P Sensor #2 @ 17.5m
92 cm

SVPB



Air Pressure Port +/- 1 mB
35 cm
Sea Surface Temperature Sensor +/- 0.05 C
0 m
15 m
5 m
92 cm


Super ADOS
Inductive Modem
Module (IMM)
IMM
Inductive temperature &
pressure sensor
150 m
Subsurface
Inductive ADCP Modem
Nortek Aquadopp
IM400


ADOS
0 m
Air Pressure Port +/- 1 mB
T-Pods 10 x 15m to 150m
Gill Sonic Anemometer
+/- 1m/s
Wind Vane
+/- 5 deg.
41 cm
Sea Surface Temperature
Sensor
Pressure Sensor at 45m,
105m, 150m
150 m

The Global Drifter Program: goals

Provide accurate measurements on a global scale of:

- Horizontal velocity at 15 m depth;
- Accurate Sea Surface Temperature;
- Atmospheric Pressure;

Provide real-time data and delayed-mode quality-controlled data for:

- Operational tasks;
- Scientific research;

Key Areas of Operational Applications

Drifter SST is fundamental for satellite SST Cal/Val to keep bias below 0.5°C;

Atmospheric pressure from drifters is assimilated in NWP systems and is shown to be most important in the 12-48h forecast (source ECMWF and MeteoFrance);

Atmospheric pressure from drifters provides inverse barometer corrections for satellite altimetry data.

Example of state-of-art scientific applications 1/4: General Ocean Circulation

Drifter observations are sparse in space and time due to their Lagrangian nature. As a result bin-averaged drifter velocity are a biased estimator of the mean-velocity field.

$$\boldsymbol{V} = \boldsymbol{V}_{gm} + \boldsymbol{A}\boldsymbol{V'}_{g} + \boldsymbol{B}\frac{\boldsymbol{W}}{\sqrt{\boldsymbol{f}}},$$

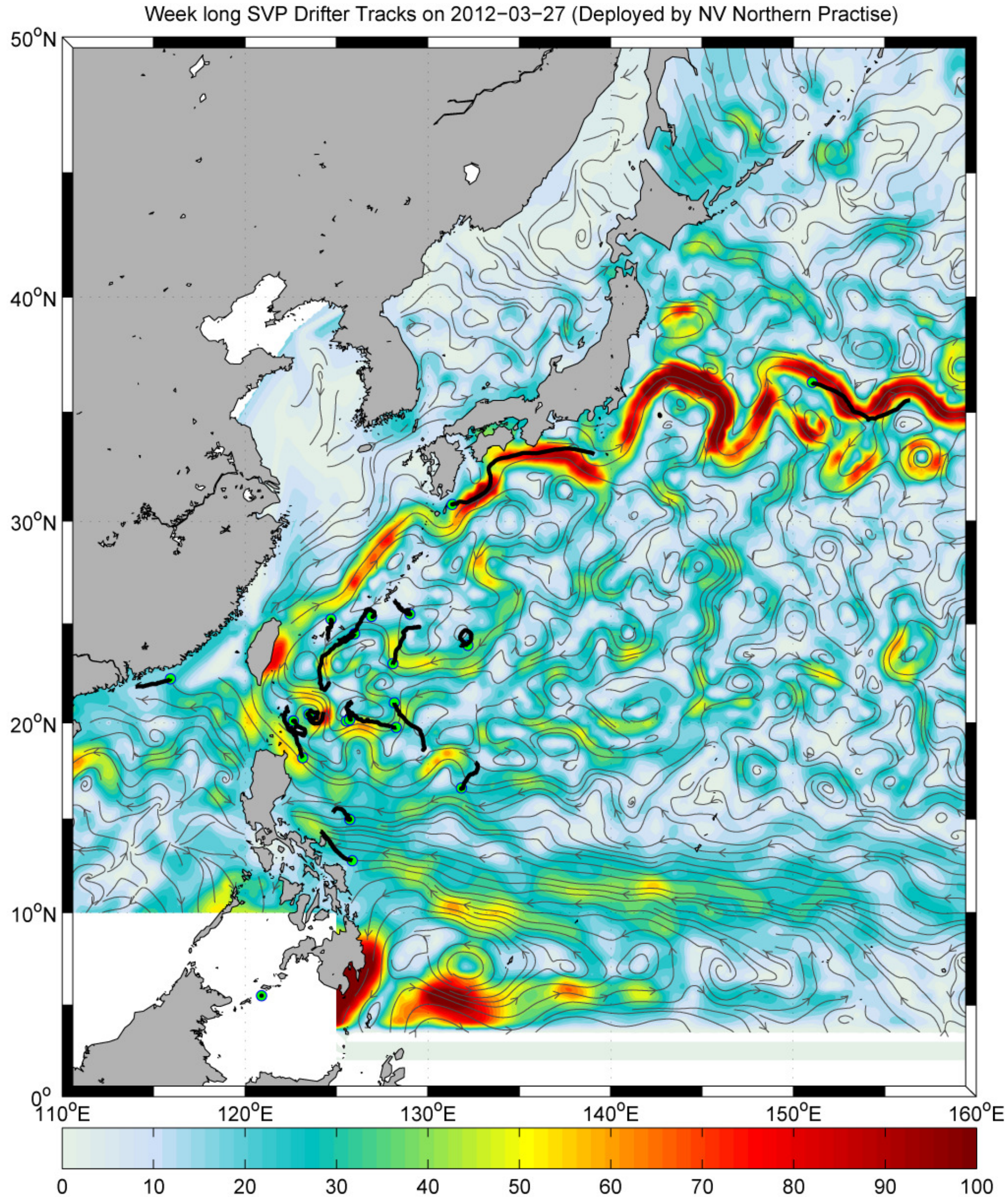
where $\boldsymbol{V}_{gm}$ (unbiased mean geostrophic current)
$\boldsymbol{V'}_{g}$ (geostrophic current from AVISO SLA)
$\boldsymbol{W}$ (wind) and $\boldsymbol{f}$ (Coriolis parameter).

Find $\boldsymbol{V}_{gm}$, $\boldsymbol{A}$ and $\boldsymbol{B}$ by minimizing cost function E for each grid,

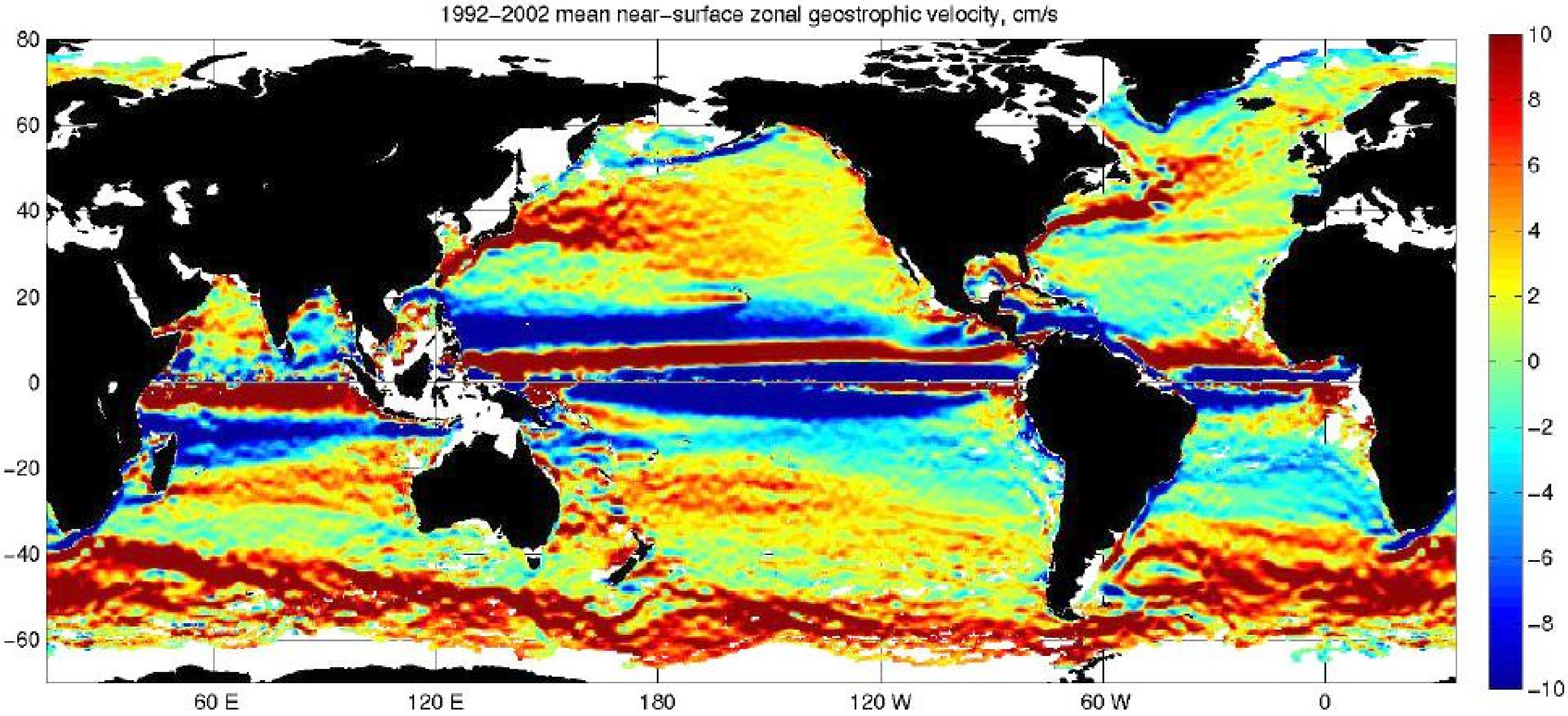
$$\boldsymbol{E = (V - V_D)\ X\ (V - V_D)^*}$$

where $\boldsymbol{V}_D$ is drifter velocity.

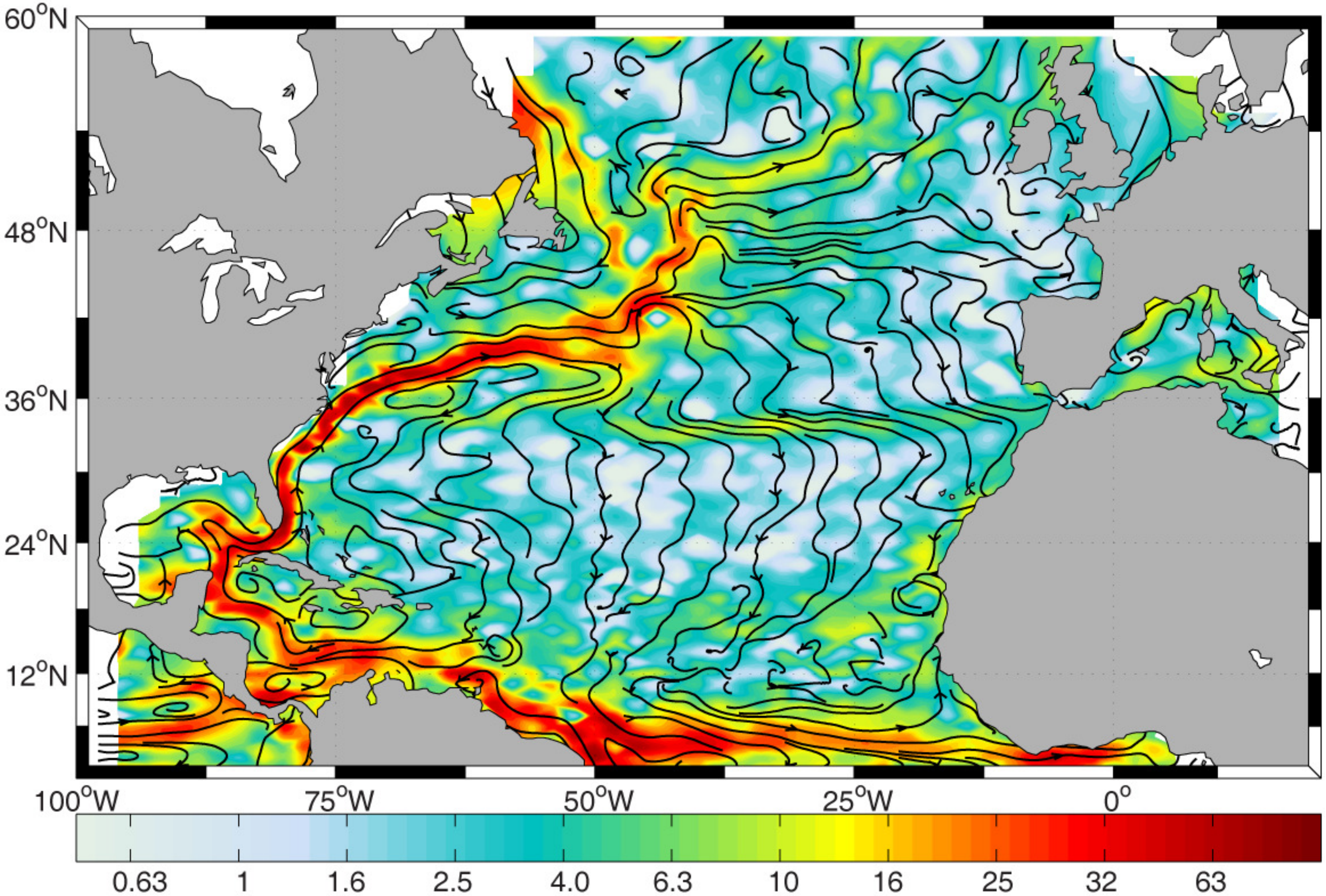
Operational Current Map



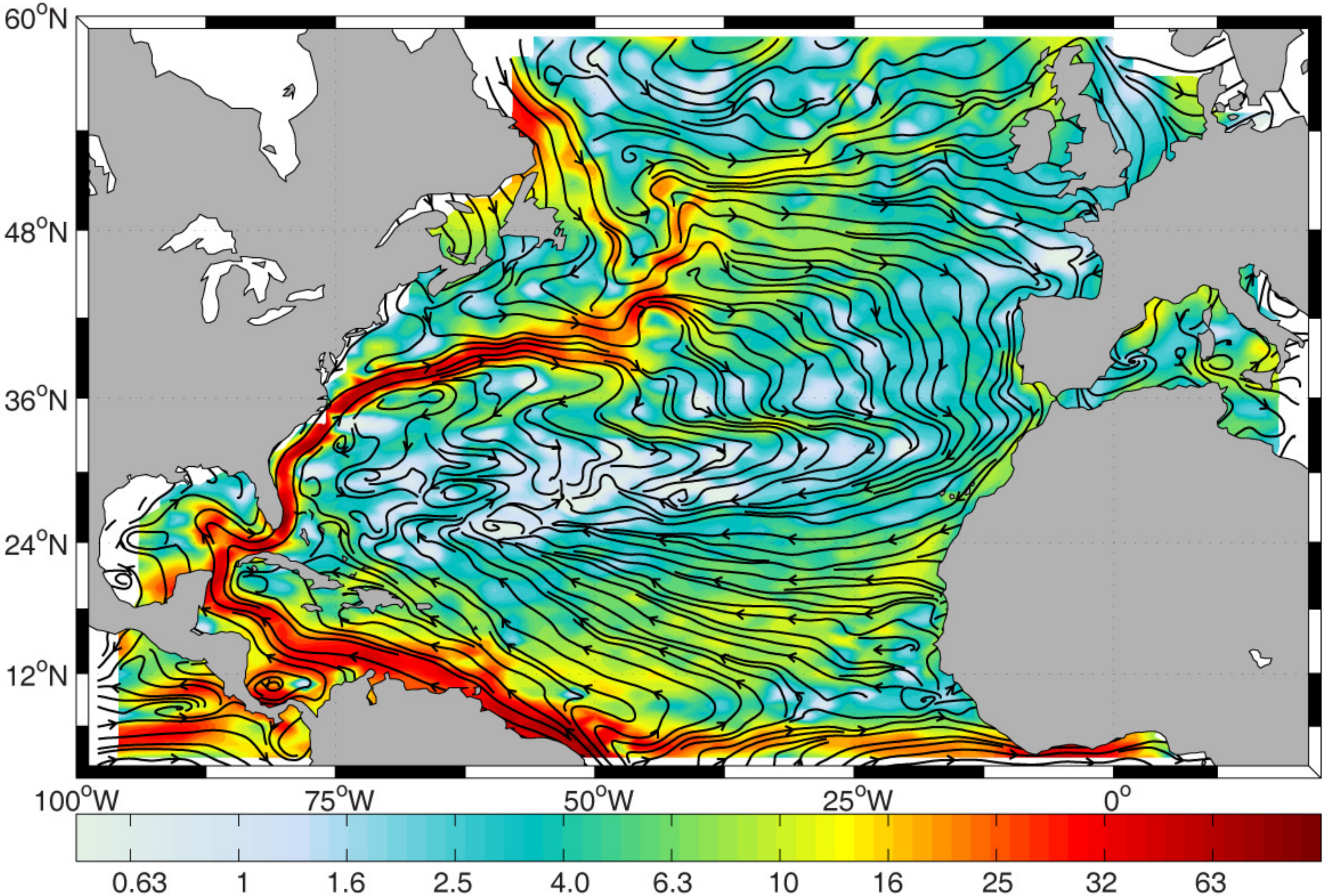
Zonal, unbiased geostrophic velocity (-10,+10 cm/sec)



Unbiased Geostrophic Velocity

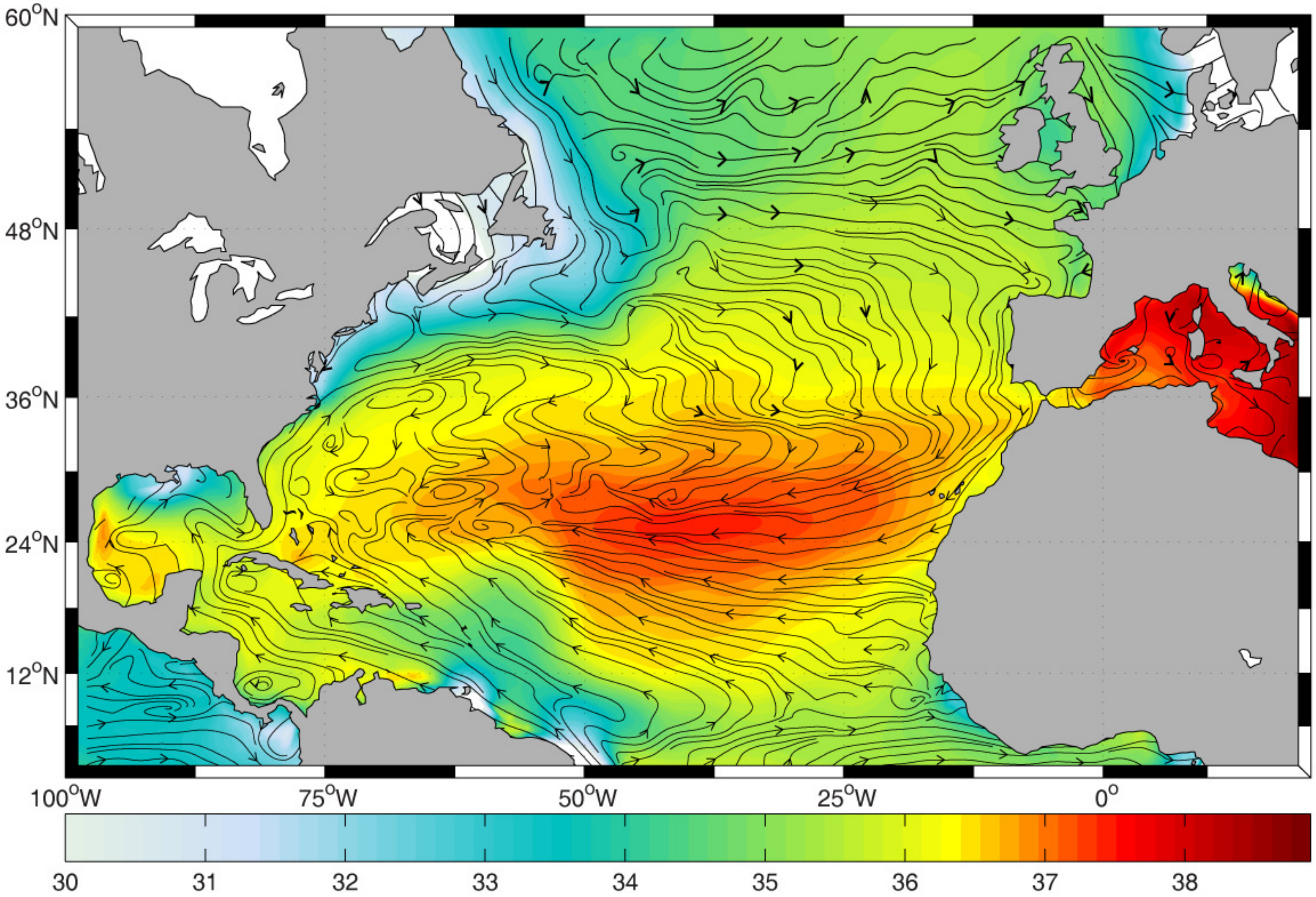


Unbiased Total (geostrophic + Ekman)

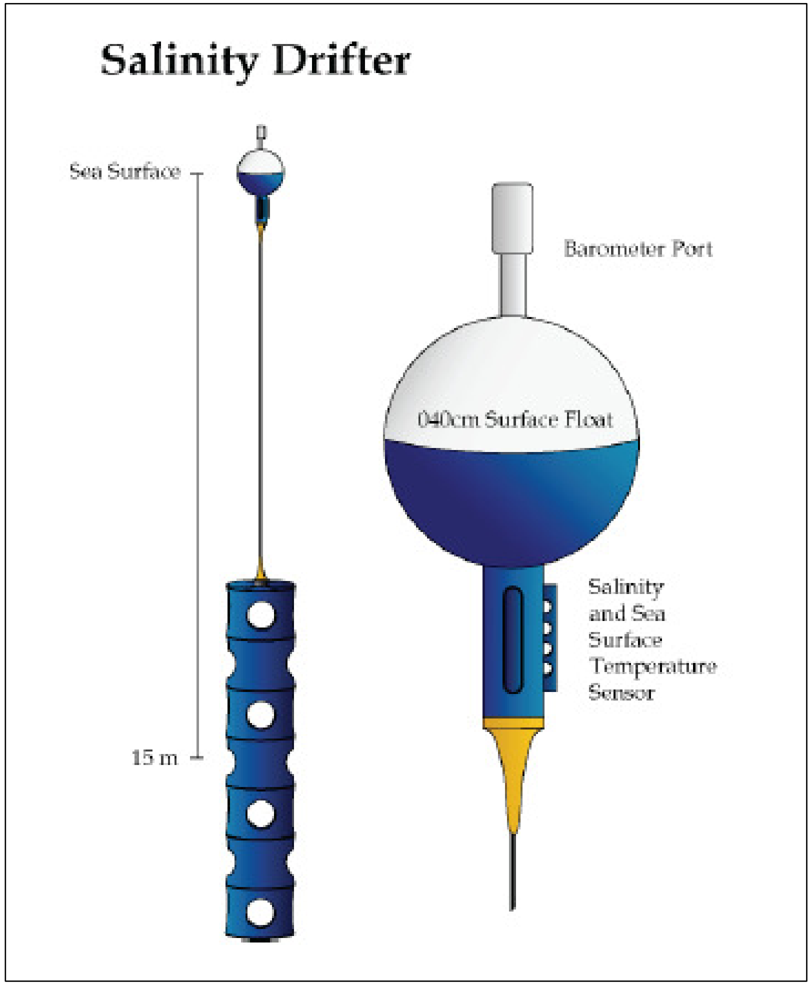


Example of state-of-art scientific applications 2/4: Freshwater cycle

Mean Sea Surface Salinity

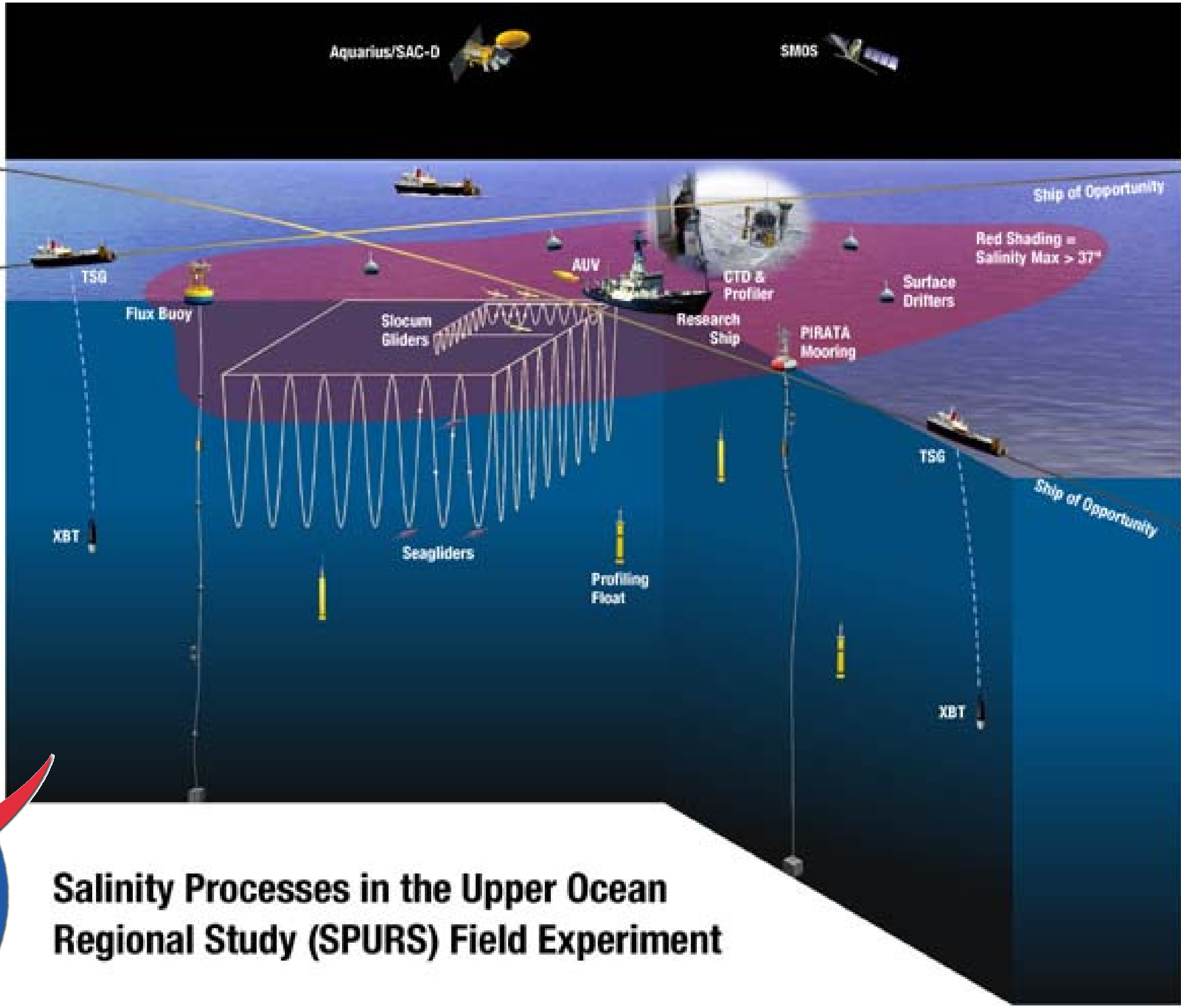


SEACATs on SVP-B drifters

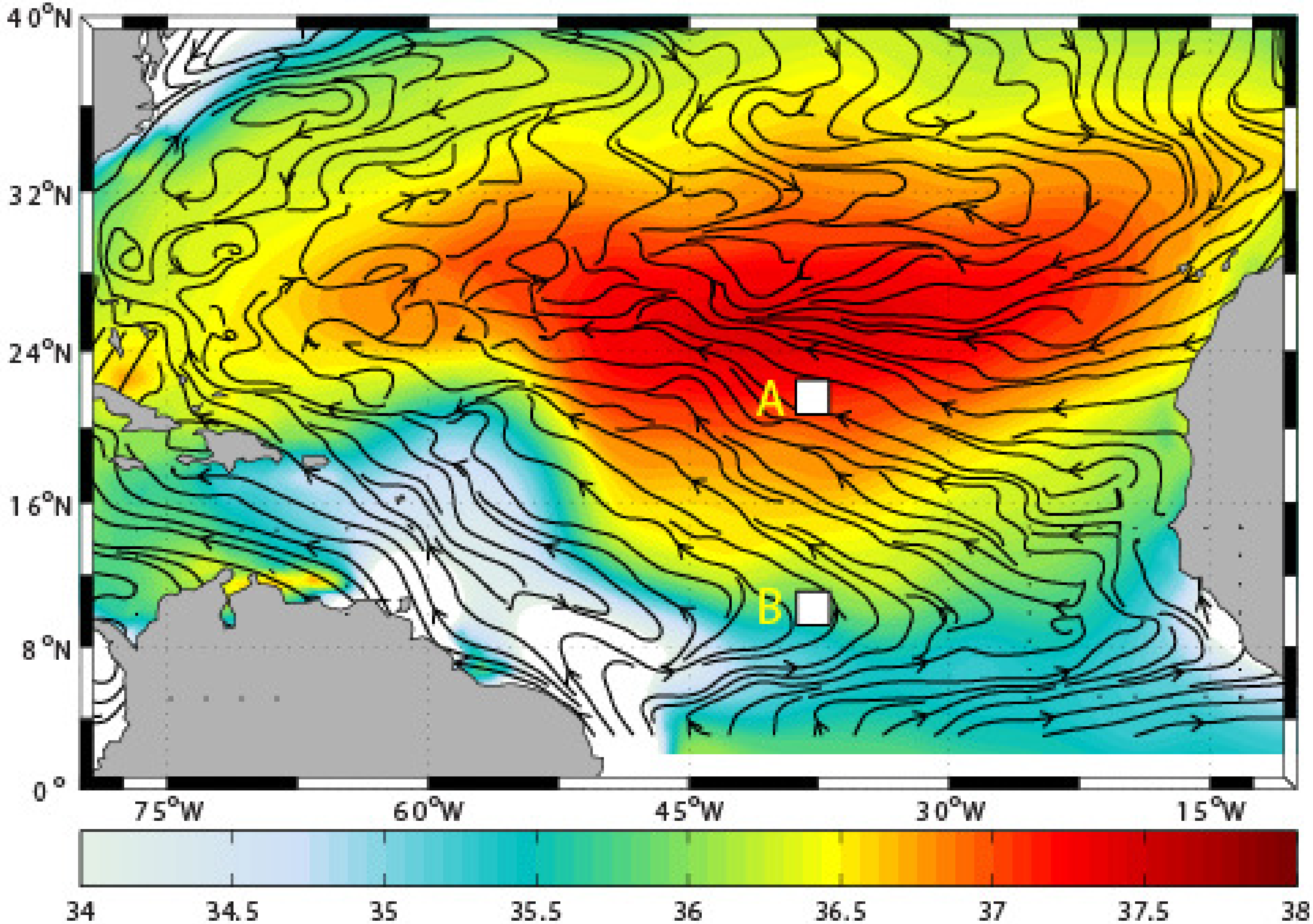


Tracking System	Location accuracy	Overall length	Depth at the drogue center	Life-span	Sea surface conductivity	Sea Surface temperature
Argos III & GPS	300-1000 m (Argos) 5m, 2DRMS (GPS)	~19 m	15.	> 2 years	0.0003 S/m	0.002℃

SPURS experiment on SSS



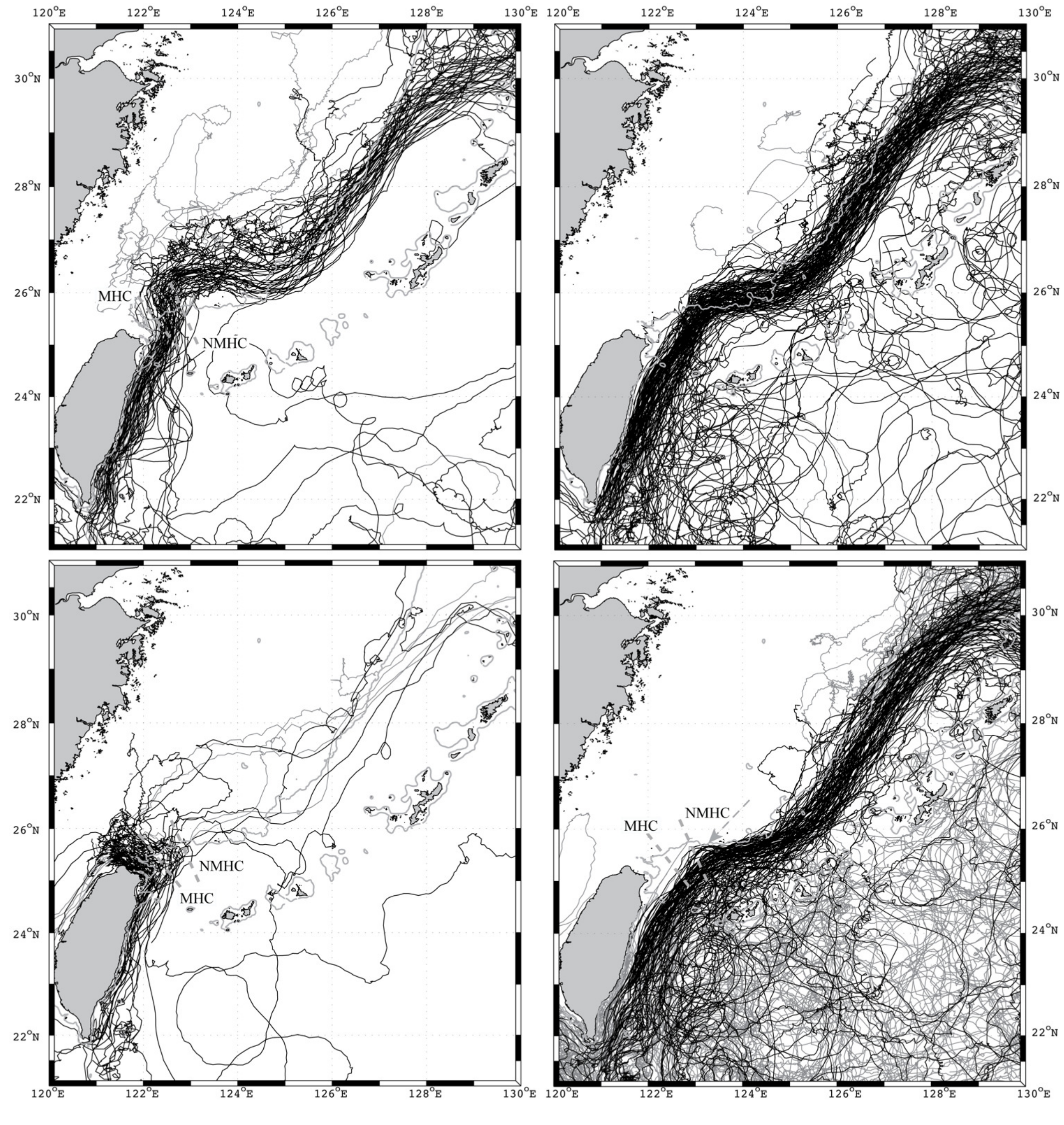
SPURS (2012-2013) – 87 GDP salinity drifters will be deployed around location A



Existing large scale near-surface Salinity data

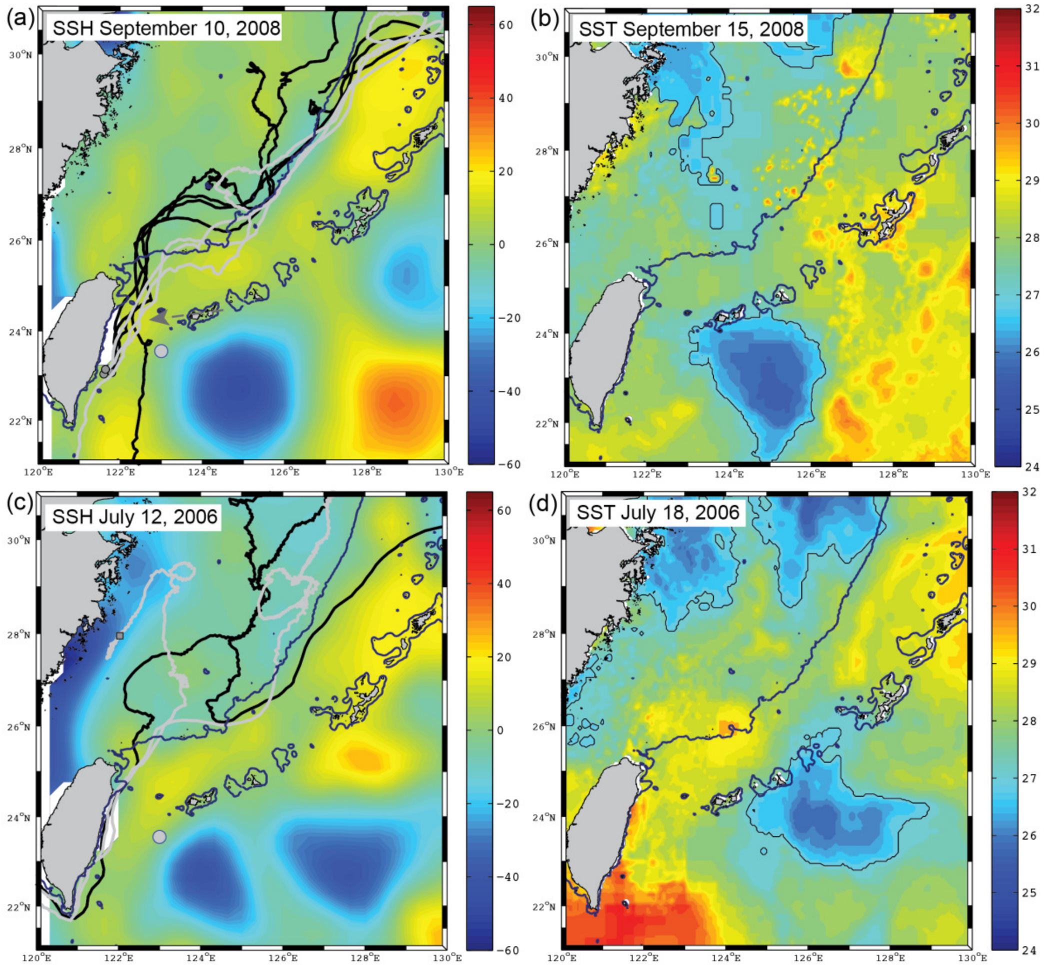
- 3500 Argo floats (floats surface every 10 day and provide one salinity data-point at 5 m depth) provide 350 obs/day globally;
- SPURS drifters (87) will each provide ~12 observations per day (1044 obs/day) in spurs domain (~1000 km X 1000km) and beyond as they disperse in the Atlantic Ocean;

Example of state-of-art scientific applications 3/4: Western Boundary Current Observing System

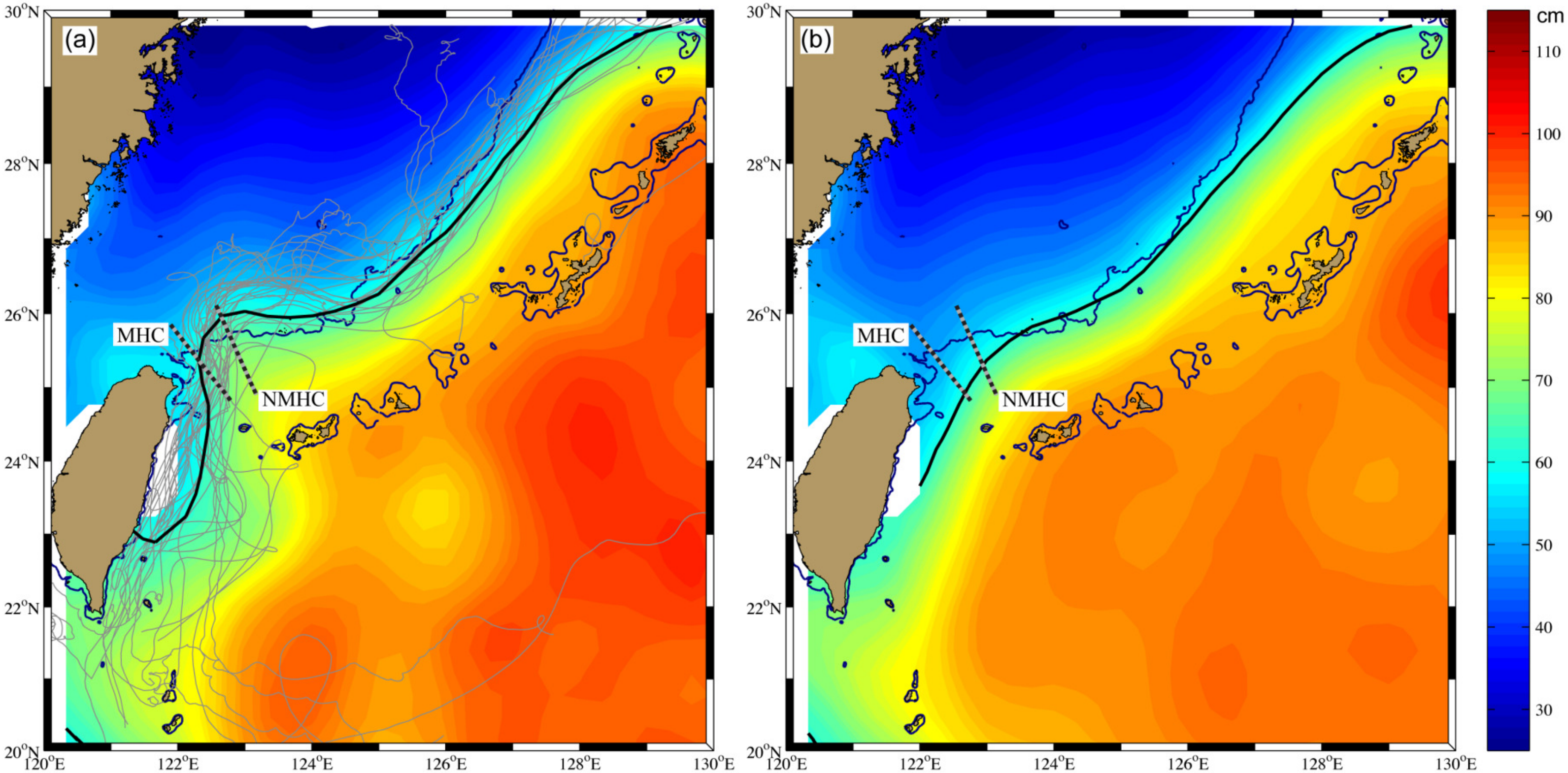


Kuroshio intrusions onto the ECS continental shelf

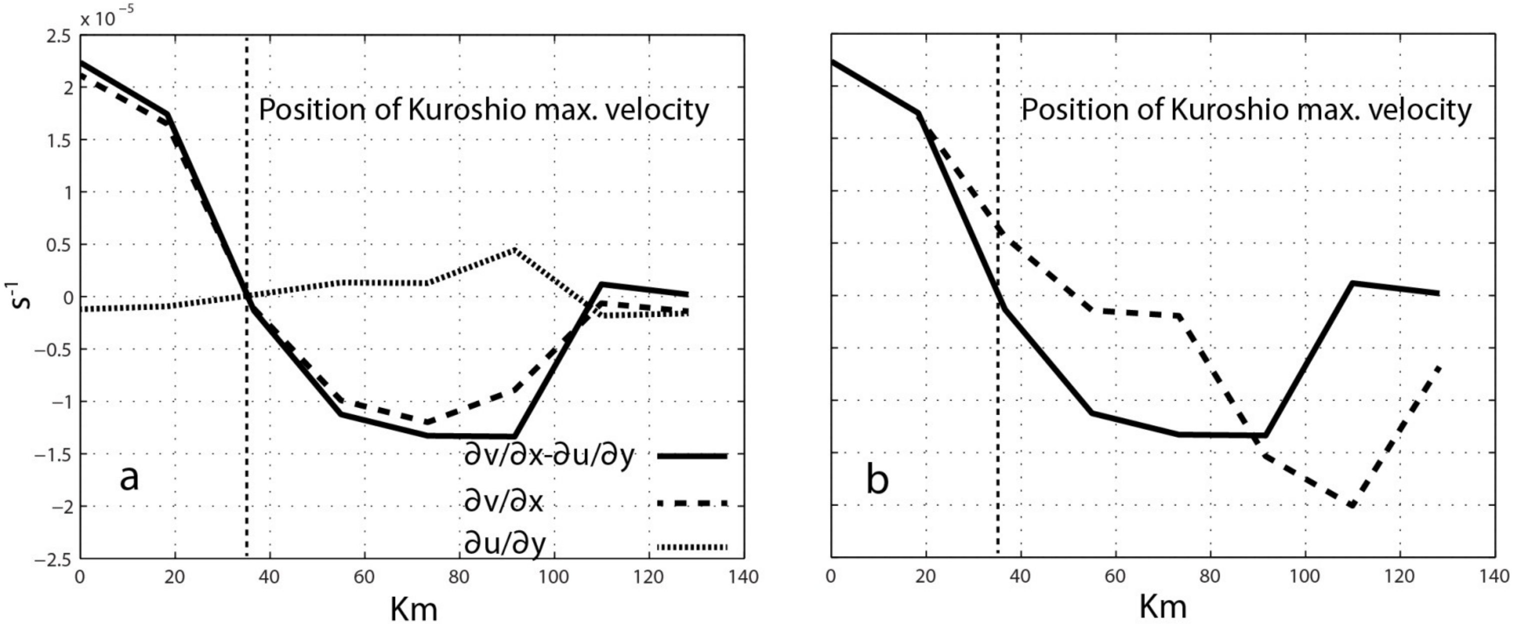
Westward propagating cyclonic eddies are correlated with KC intrusions



Mean state of intruding KC current



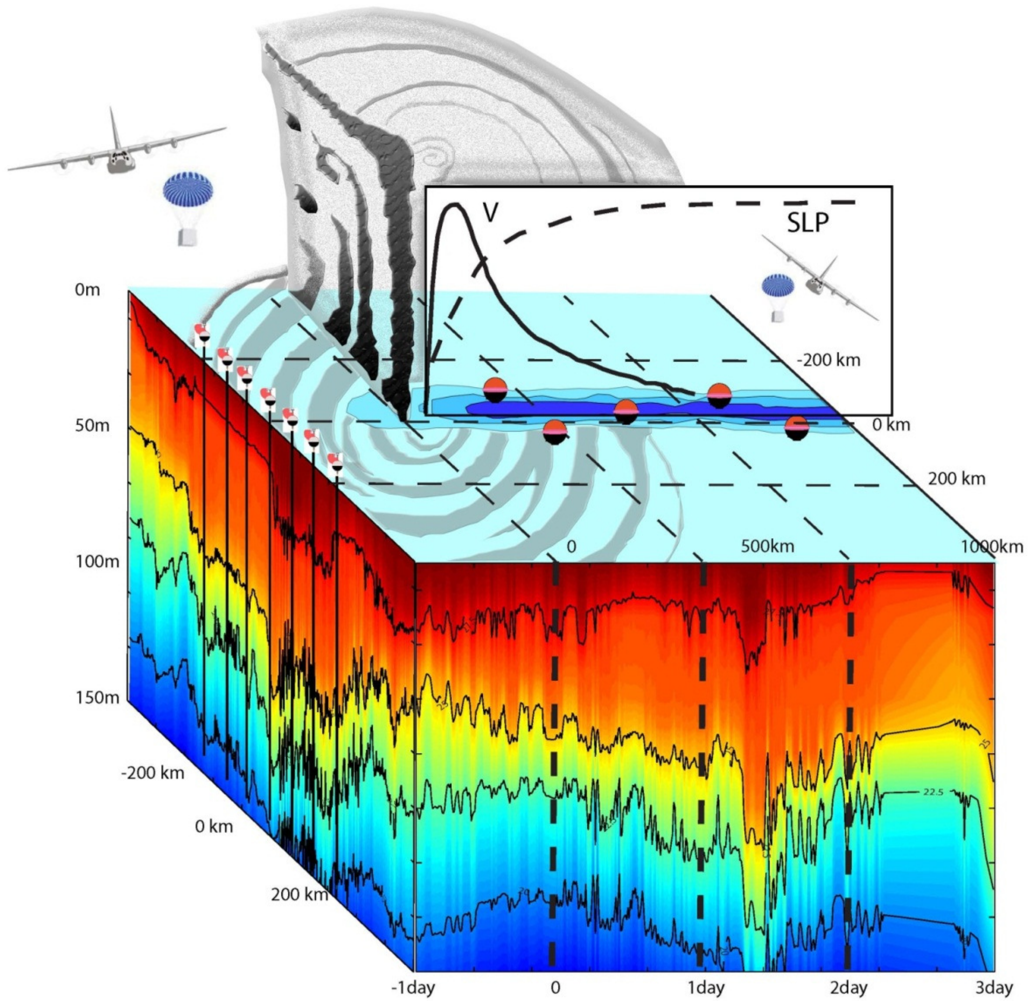
Eddy/jet transfer of cyclonic vorticity?



Example of state-of-art scientific applications 4/4: Drifters for Tropical Cyclones Research

Air-Deployment by 53rd Hurricane Hunter Squadron of Air National Guard

Deployments ahead/in the wake of tropical cyclones

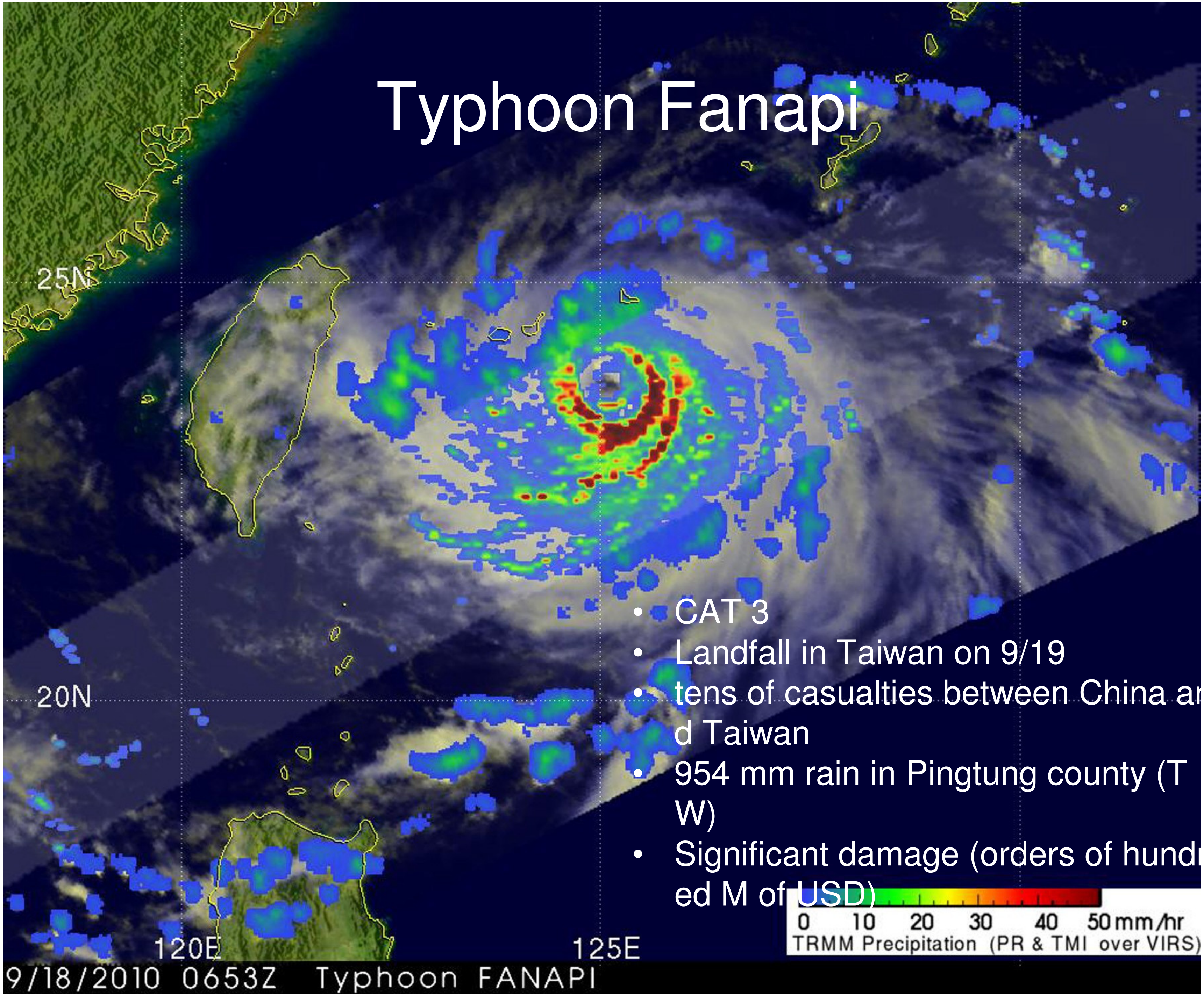


Drifter Deployments in Hurricanes (6) and Typhoons (4), 2003-2010

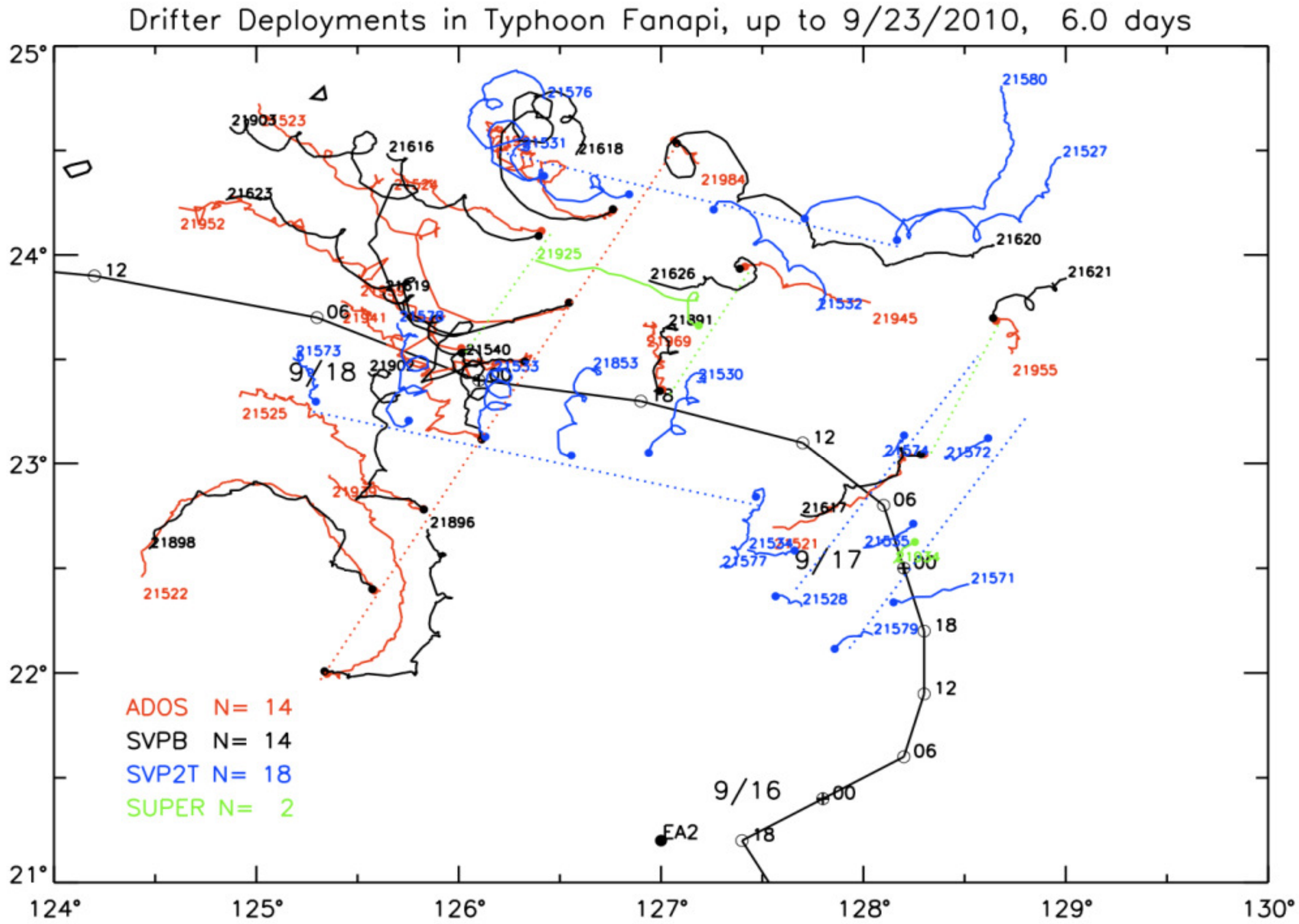
Name	Date	CAT max	CAT drifter	Dist min	N Drifter (deployed)	N Temperature subsurface
Fabian	9/04/2003	4	3	48 km	11 (16)	--
Frances	9/01/2004	4	4	30 km	38 (39) + 29	--
Rita	9/23/2005	5	4	12 km	20 (20)	8
Dean	8/20/2007	5	5	30 km	12 (12)	8
Gustav	9/01/2008	4	2	13 km	12 (12)	6
Ike	9/12/2008	4	2	3 km	8 (9) + 12	5
Hagupit	9/21/2008	4	1	14 km	11 (12)	6
Jangmi	9/27/2008	5	5	18 km	11 (12) + 11	9
Fanapi	9/17/2010	2	1	4 km	48(53)	39
Malakas	9/29/2010	2	-	Wake	12(12)	6

- Wind speed from ambient noise (WOTAN) (2003-2009)
- Wind speed sensor from Gill sonic anemometer (2010-)
- 93% success rate

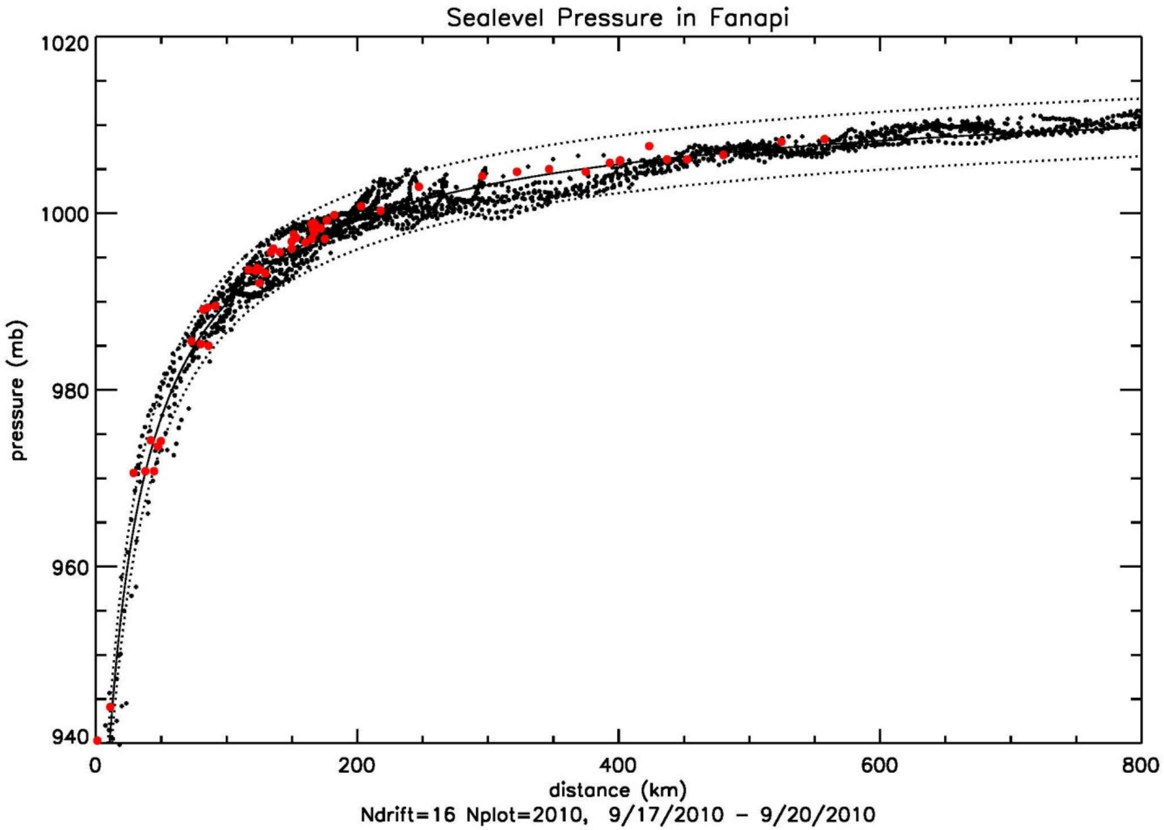
Typhoon Fanapi

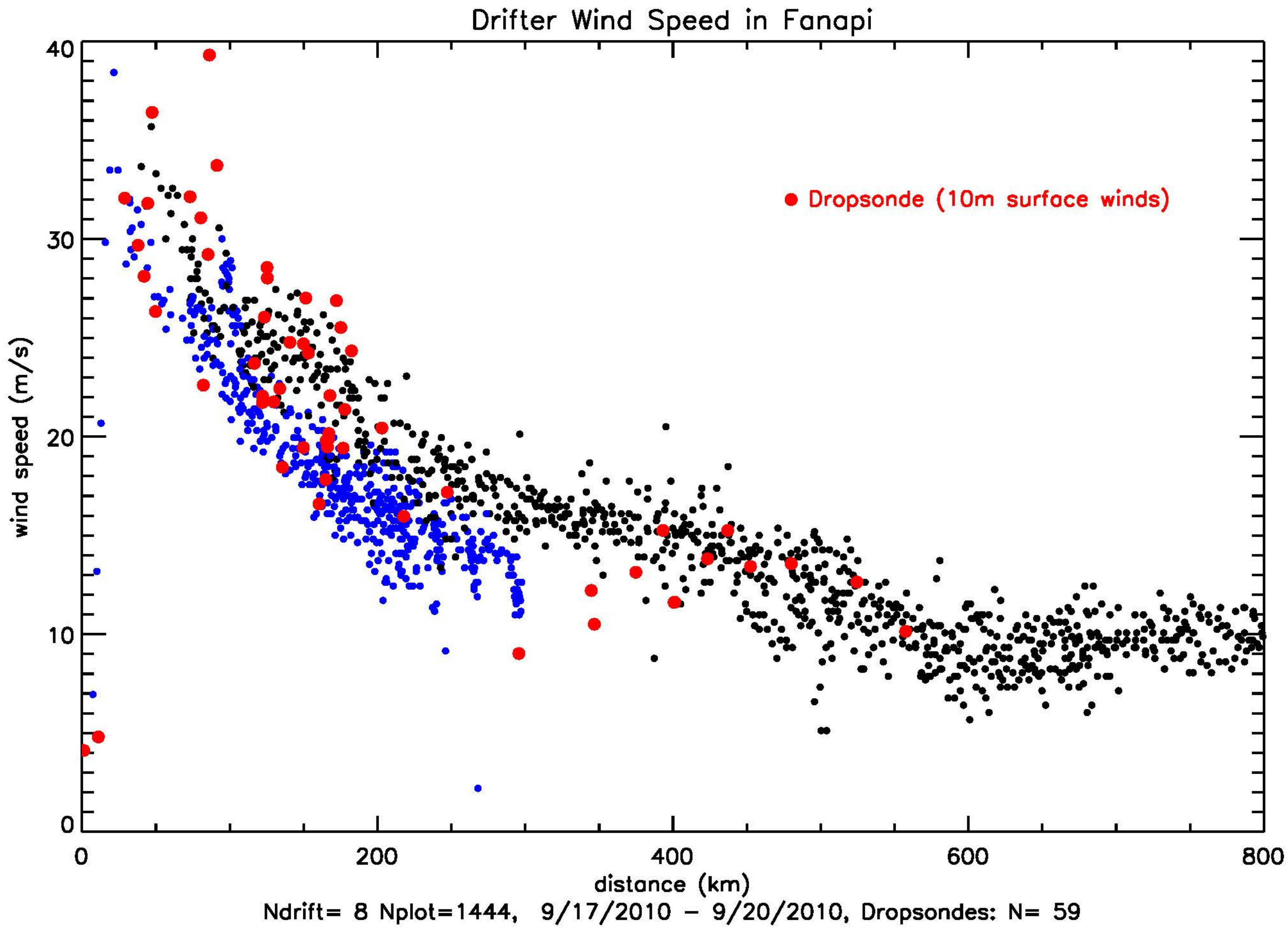


- CAT 3
- Landfall in Taiwan on 9/19
- tens of casualties between China and Taiwan
- 954 mm rain in Pingtung county (TW)
- Significant damage (orders of hundred M of USD)

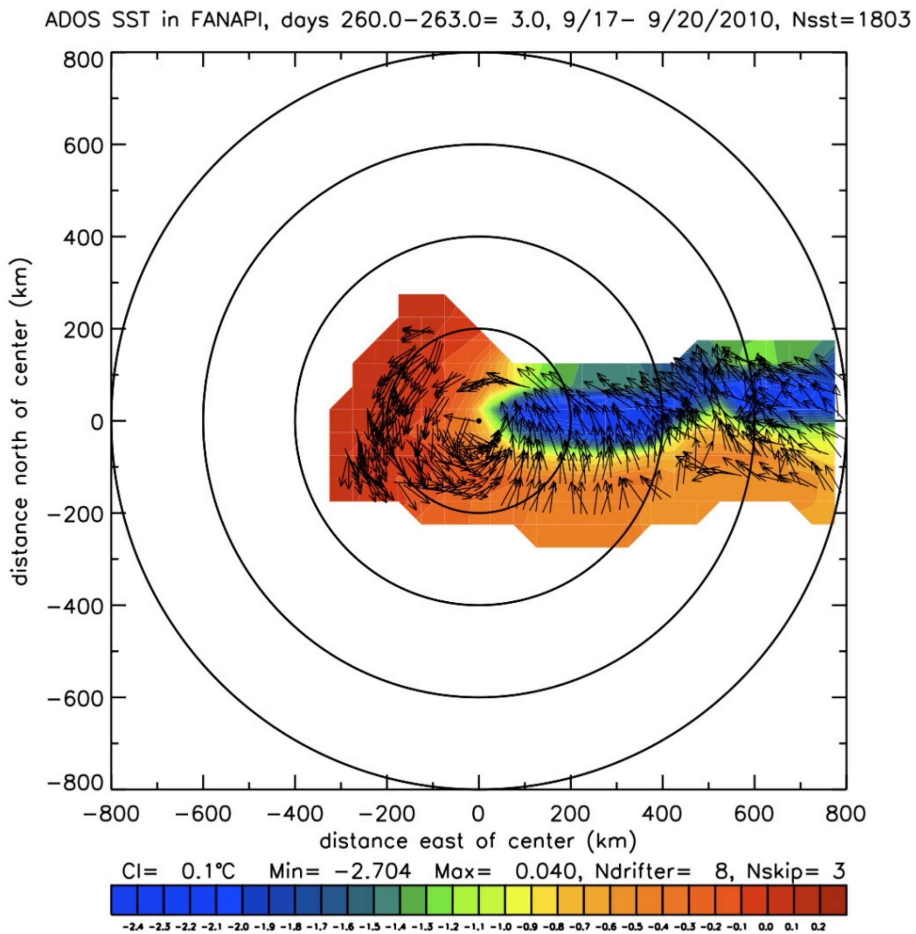


Deployments: Pre-Storm 9/16/2010 23Z(6.0days), Wake 1 9/19/2010 Z(4.0days), Wake 2 9/20/2010 Z(2.8days), Wake 3 9/22/2010 Z(0.8days)


Sealevel Pressure in Fanapi
1020
1000
980
960
940
pressure (mb)
0
200
400
600
800
distance (km)
Ndrift=16 Nplot=2010, 9/17/2010 - 9/20/2010


Drifter Wind Speed in Fanapi
Dropsonde (10m surface winds)
wind speed (m/s)
distance (km)
0
10
20
30
40
0
200
400
600
800
Ndrift= 8 Nplot=1444, 9/17/2010 - 9/20/2010, Dropsondes: N= 59

Cold Wake & Wind Observations from the ADOS Array



SST observations from the eight ADOS drifters deployed ahead of typhoon Fanapi on Septe mber 17, 2010. SST changes during first 3 days after Fanapi passed over the ADOS drifters a re shown. The vectors represent wind directions. For clarity, only every third wind vector is plotted. The data are plotted in storm co-ordinates, i.e. referred to the center of the storm. Th e storm is advancing approximately from east to west.