Geostrophic Transport in the Southern Ocean by Combining Satellite Altimetry and Temperature/Salinity Profile Data

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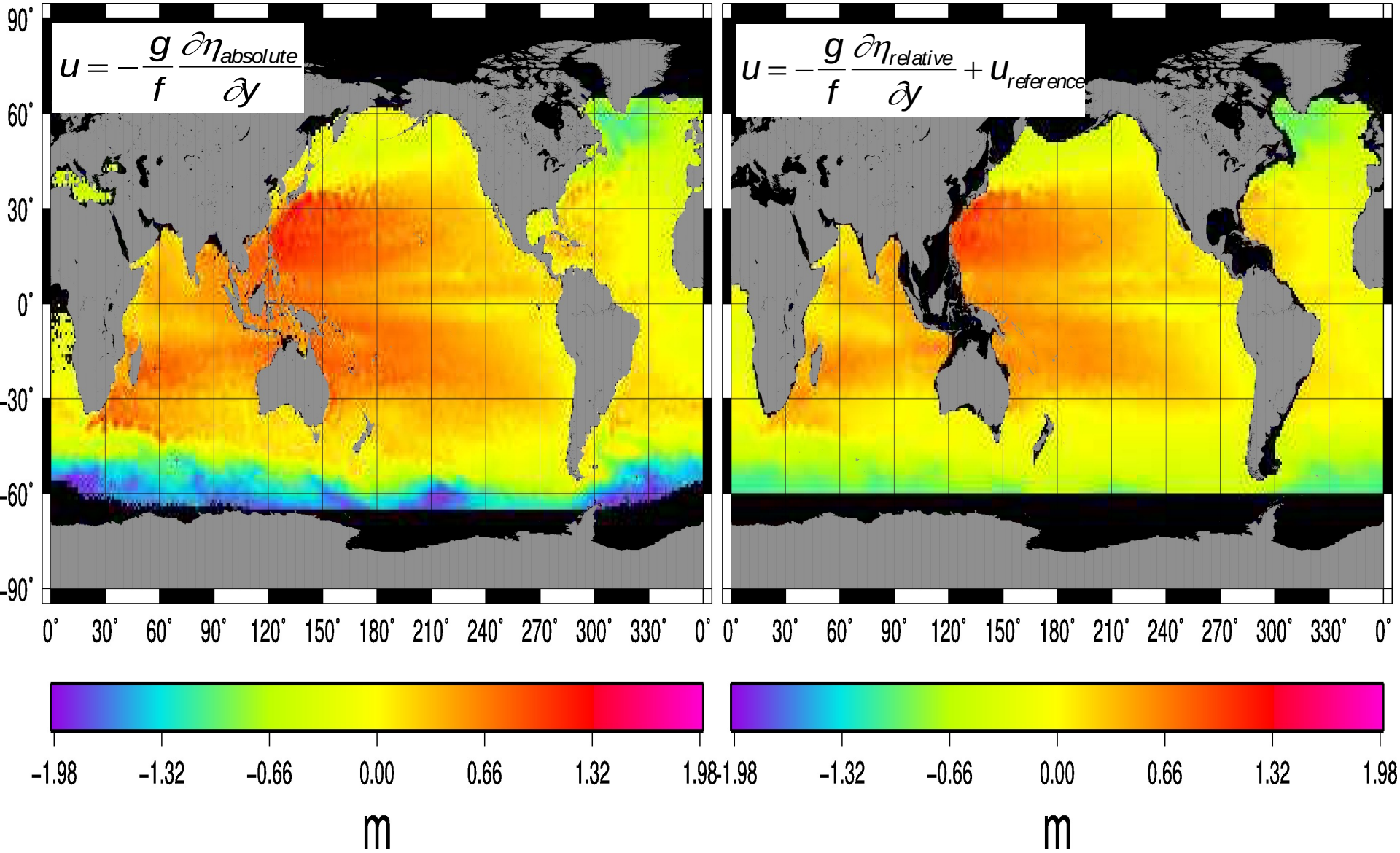
Dynamic Ocean Topography July 2010

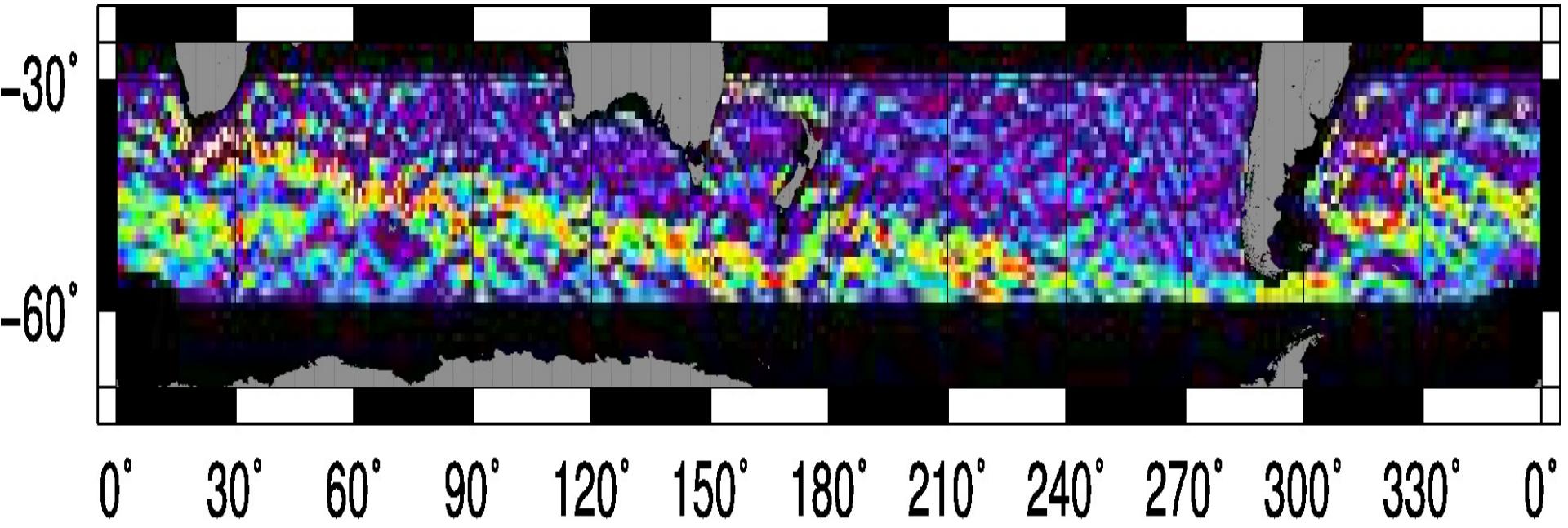
$$u_{reference} = -\frac{g}{f}\left(\frac{\partial \eta_{absolute}}{\partial y} - \frac{\partial \eta_{relative}}{\partial y}\right)$$

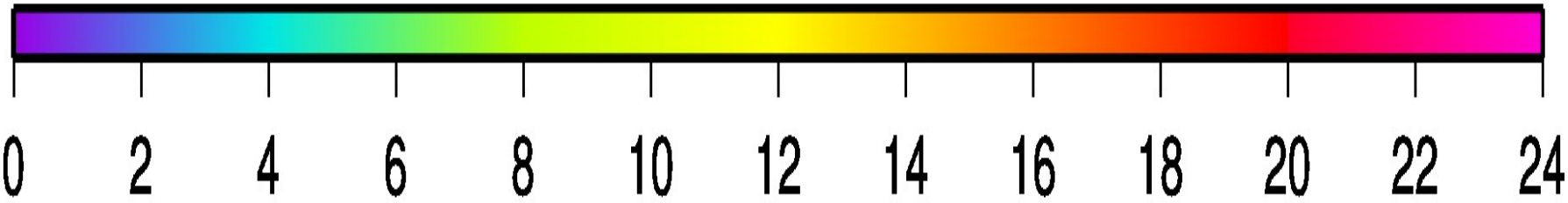
Jason – EGM08 geoid

Argo T/S relative to 1000 dbar



Zonal velocity at 1000 dbar





cm/s

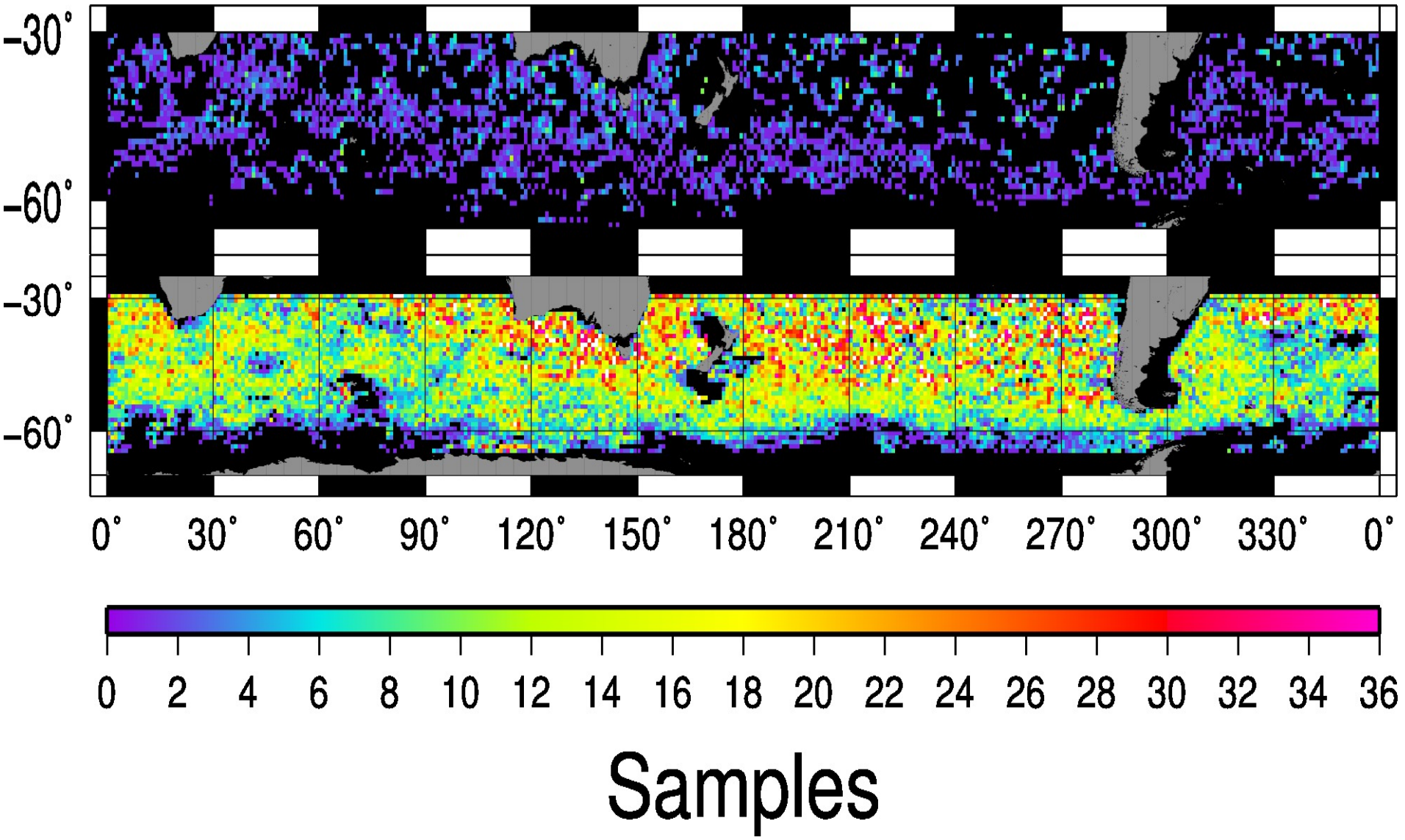
$$u_{reference} = -\frac{g}{f}\left(\frac{\partial \eta_{absolute}}{\partial y} - \frac{\partial \eta_{relative}}{\partial y}\right)$$

July 2010

Validation against Float Trajectories

- Asia Pacific Data Research Center (APDRC) uses Argo Float trajectories to determine absolute current
- Products available at seasonal bin averages
- Validation over 5-year span (2006-2011)

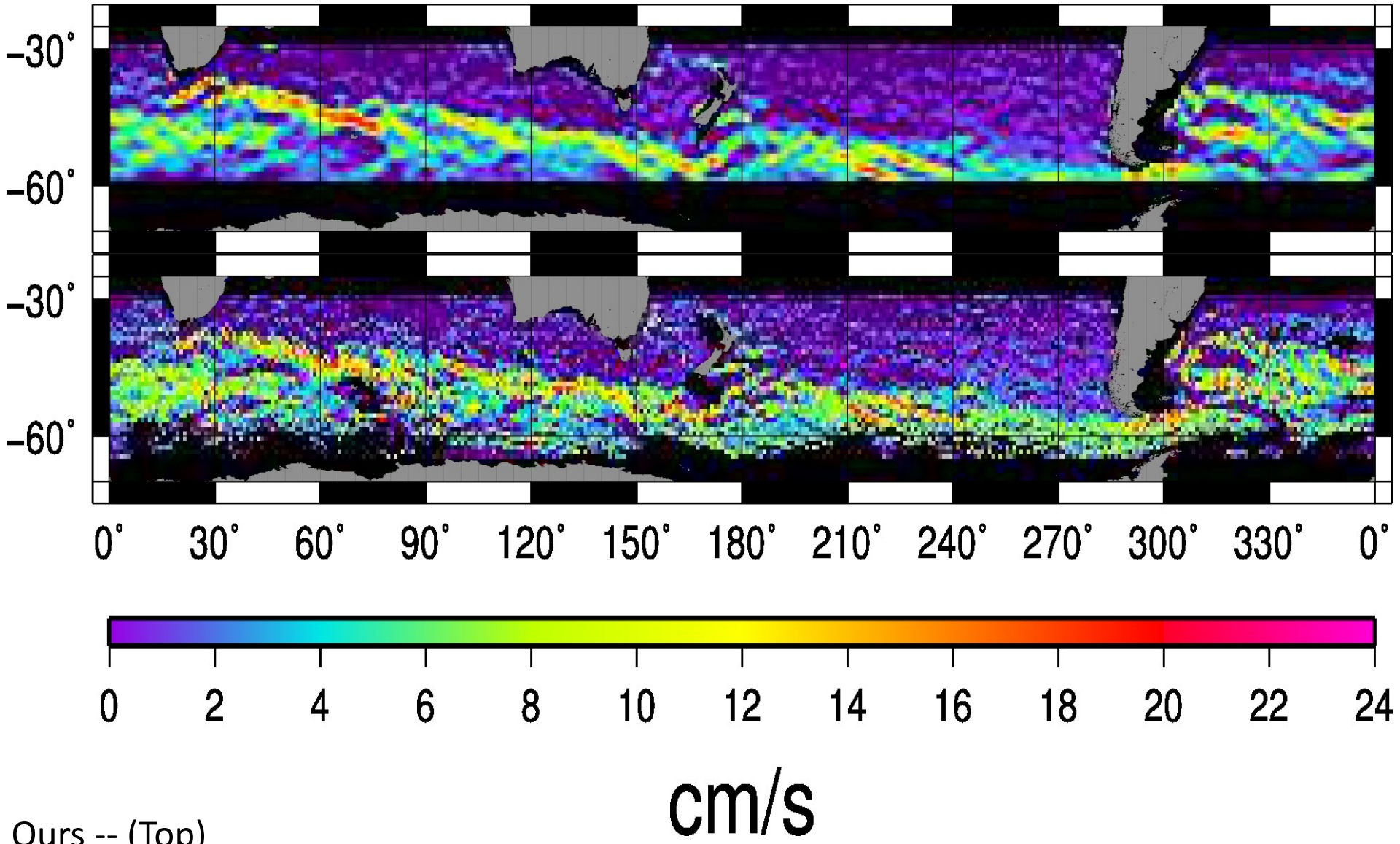
Number of Argo drift observations



July through September, 2010 (top)

2006 through 2010 (bottom)

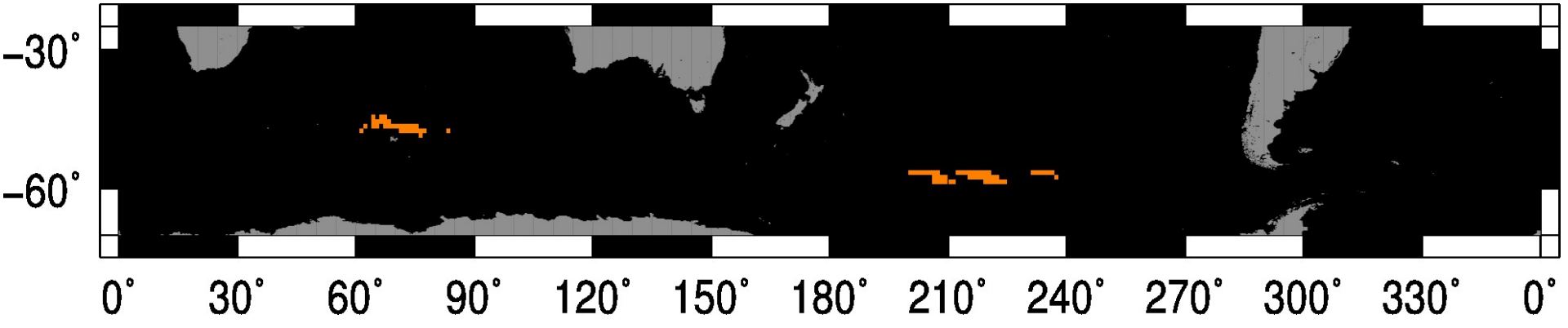
Velocity of 5-year mean zonal velocity at 1000 dbar

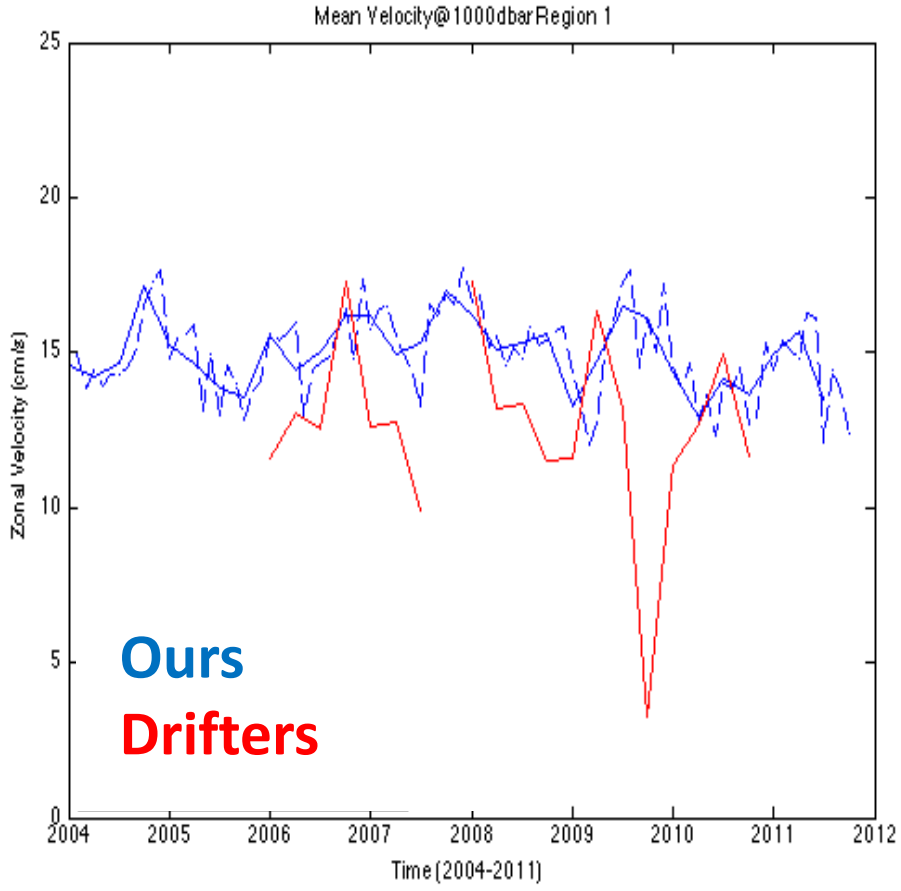


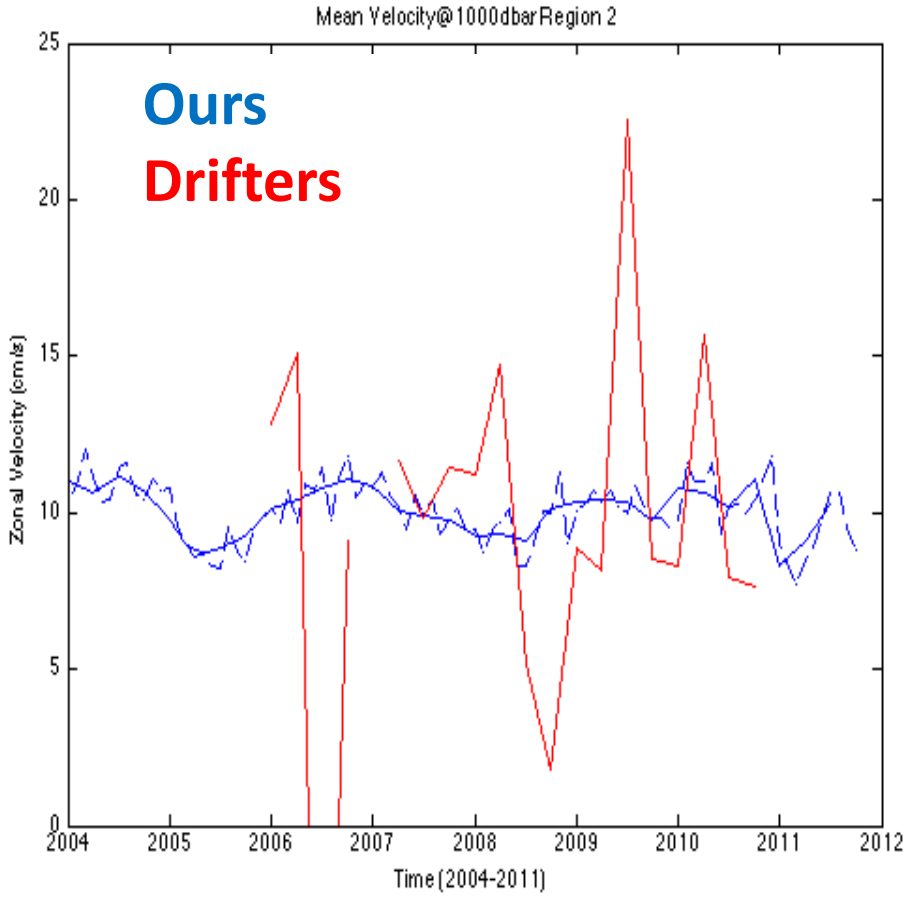
Ours -- (Top)

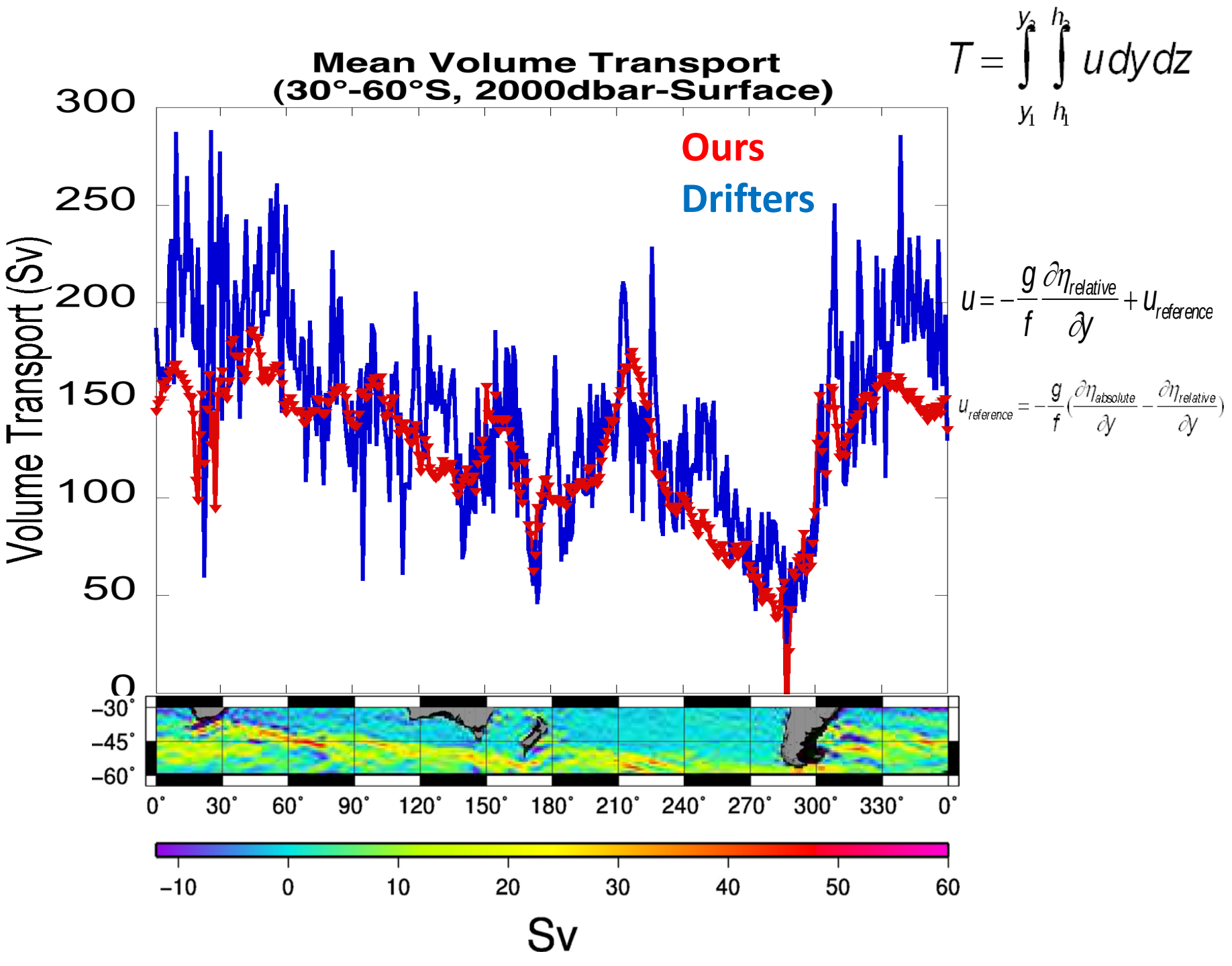
APDRC-- Argo float drift (Bottom)

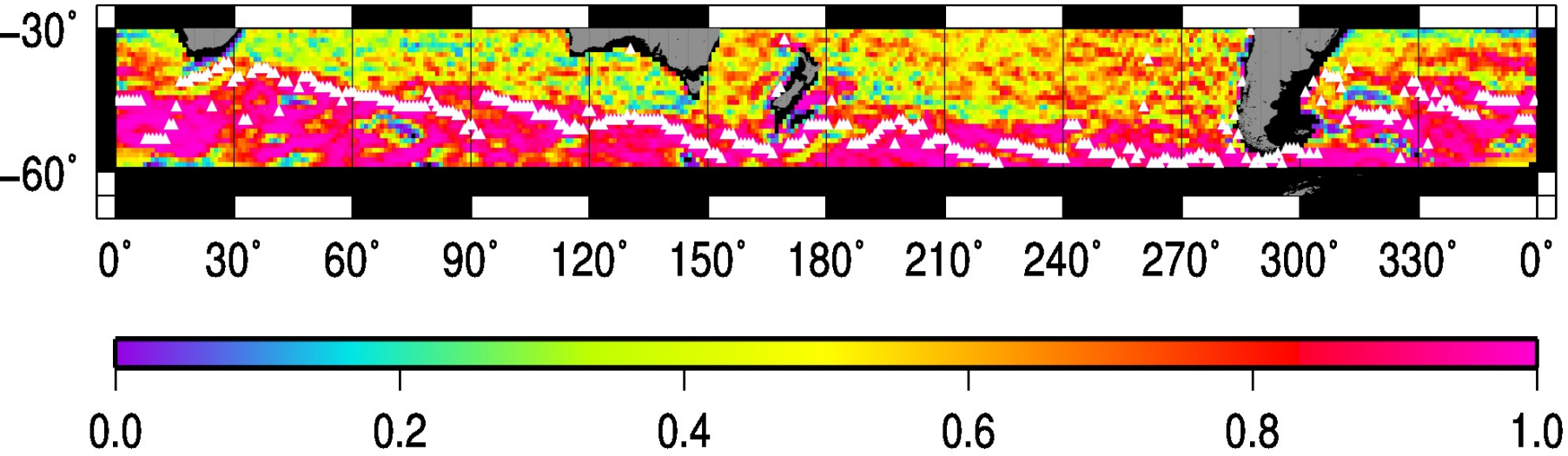
Regional Time Series



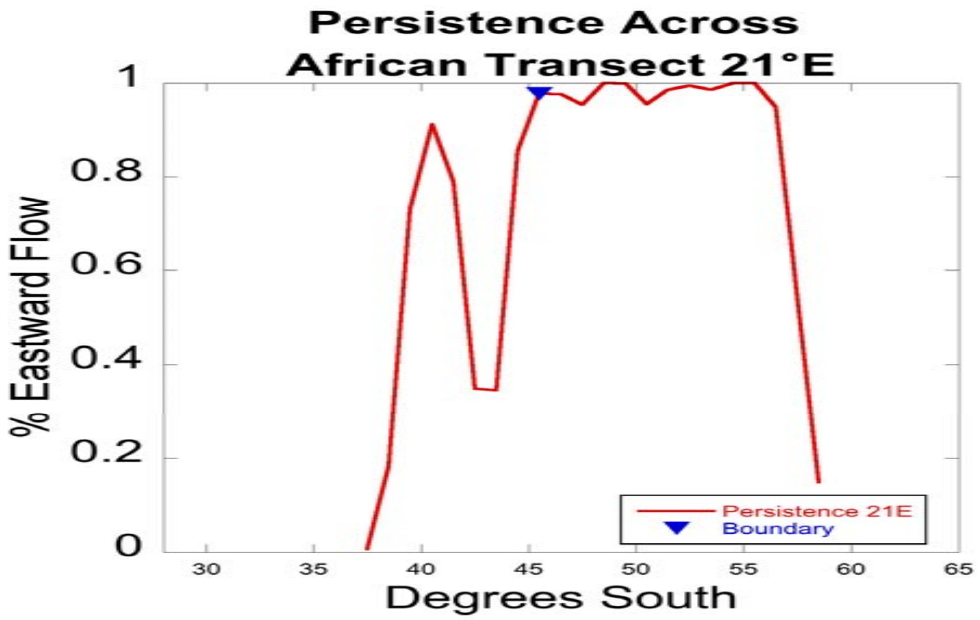


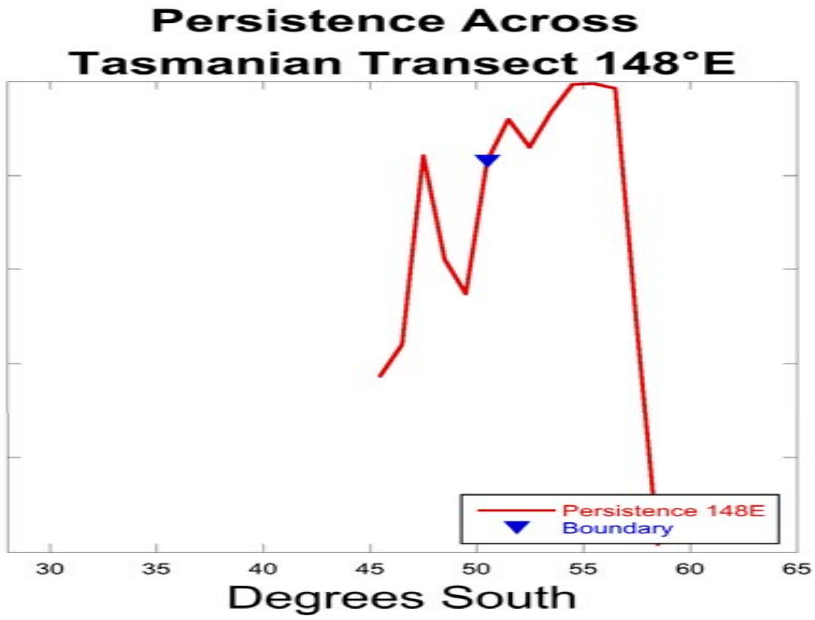


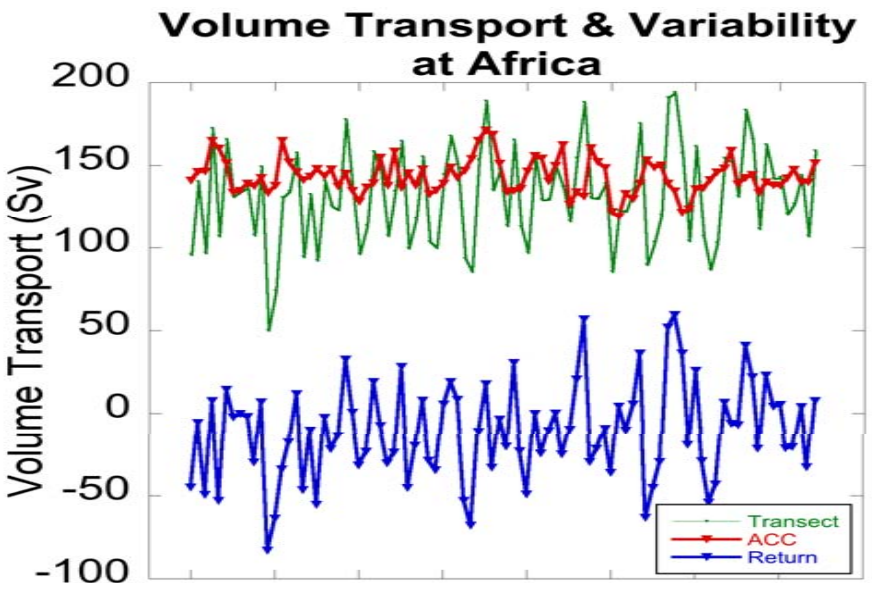

Mean Volume Transport
(30°-60°S, 2000dbar-Surface)
Ours
Drifters
Volume Transport (Sv)
300
250
200
150
100
50
0
−30°
−45°
−60°
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0°
−10
0
10
20
30
40
50
60
Sv
$T = \int_{y_1}^{y_2} \int_{h_1}^{h_2} u\,dy\,dz$
$u = -\frac{g}{f}\frac{\partial \eta_{relative}}{\partial y} + u_{reference}$
$u_{reference} = -\frac{g}{f}\left(\frac{\partial \eta_{absolute}}{\partial y} - \frac{\partial \eta_{relative}}{\partial y}\right)$

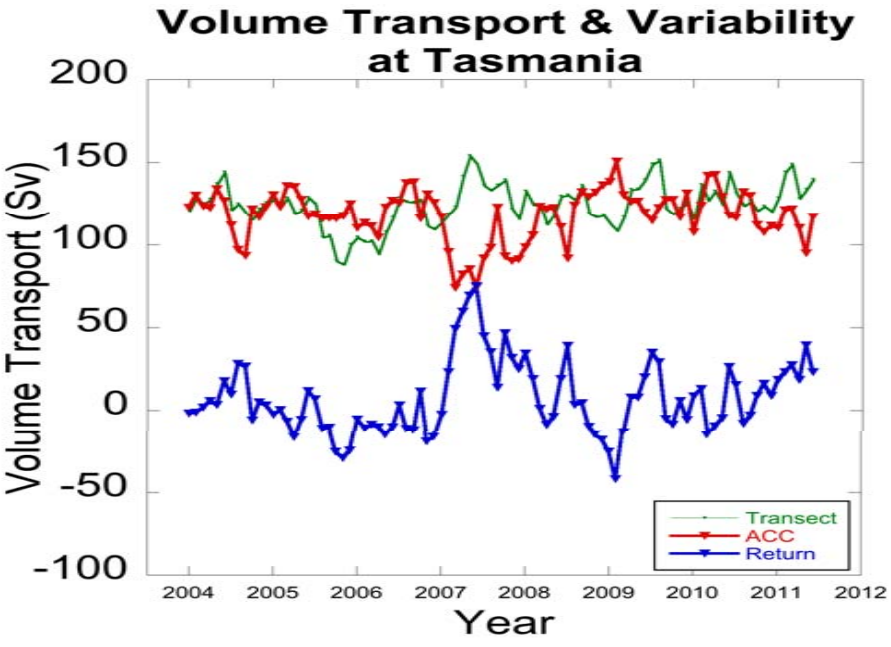


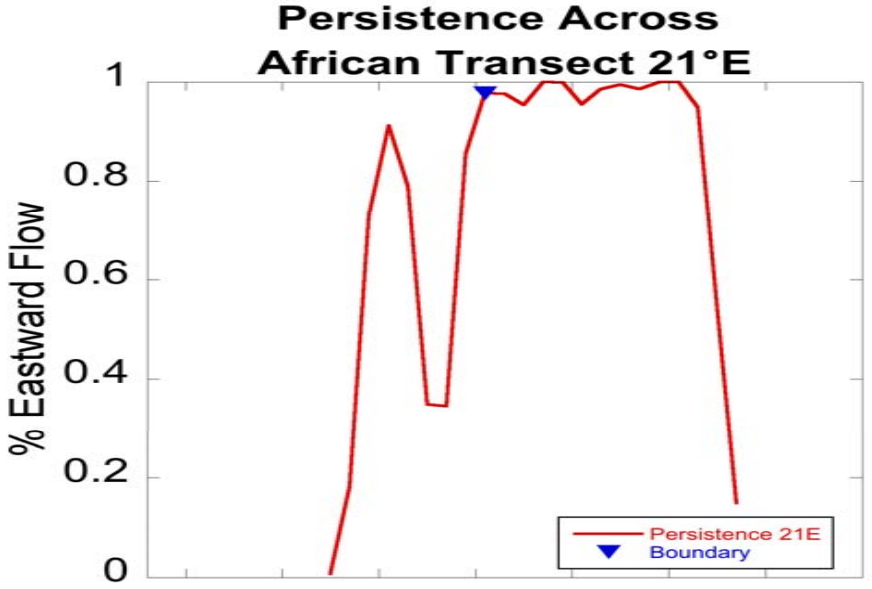
Relative East Persistence

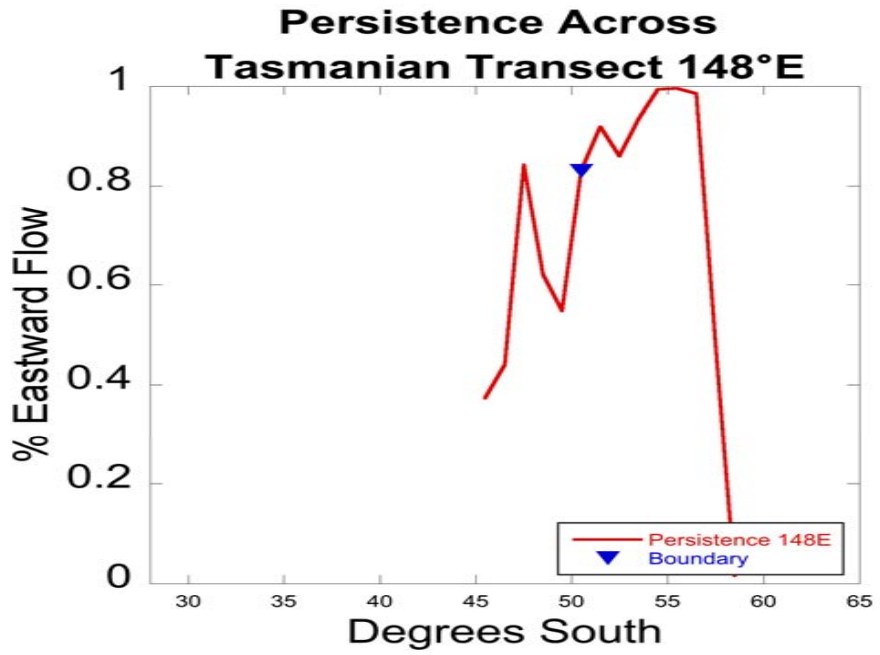





Volume Transport & Variability at Africa
Volume Transport (Sv)
200
150
100
50
0
-50
-100
Transect
ACC
Return


Volume Transport & Variability at Tasmania
Volume Transport (Sv)
200
150
100
50
0
-50
-100
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year
Transect
ACC
Return

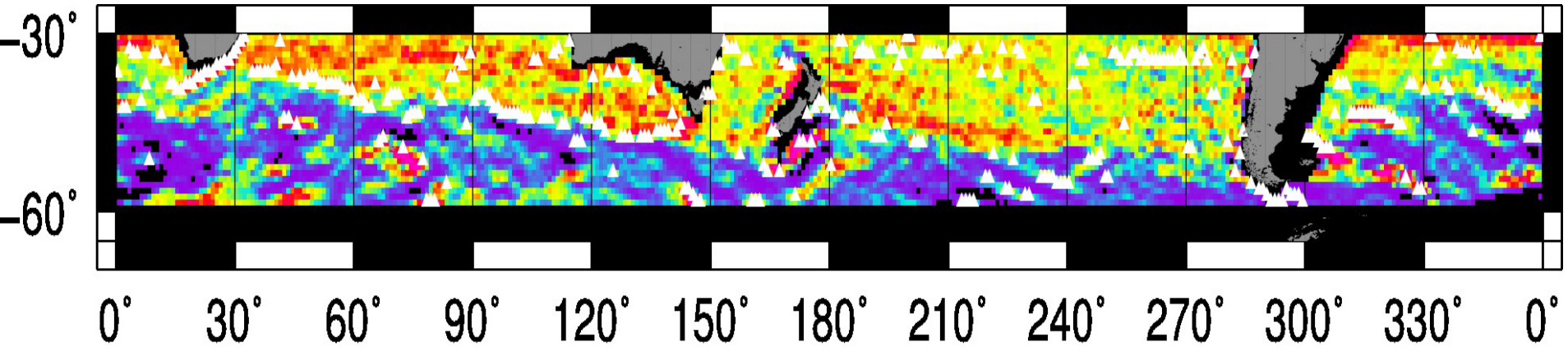

Persistence Across African Transect 21°E
% Eastward Flow
1
0.8
0.6
0.4
0.2
0
Persistence 21E
Boundary


Persistence Across Tasmanian Transect 148°E
% Eastward Flow
1
0.8
0.6
0.4
0.2
0
30
35
40
45
50
55
60
65
Degrees South
Persistence 148E
Boundary

Next Step

- Quantify mesoscale variability on mapping errors using high-resolution model
- Expand time series
- Use hydrographic sections previous to Argo (1993-present)

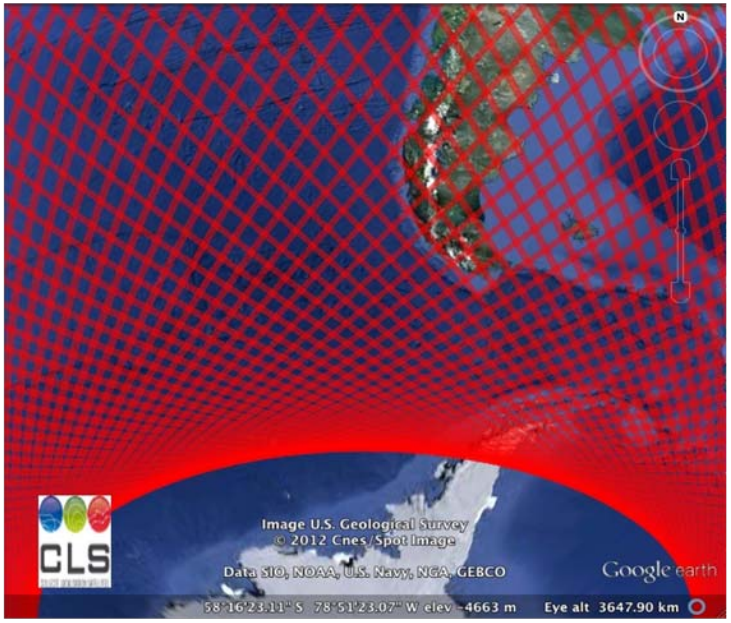
END

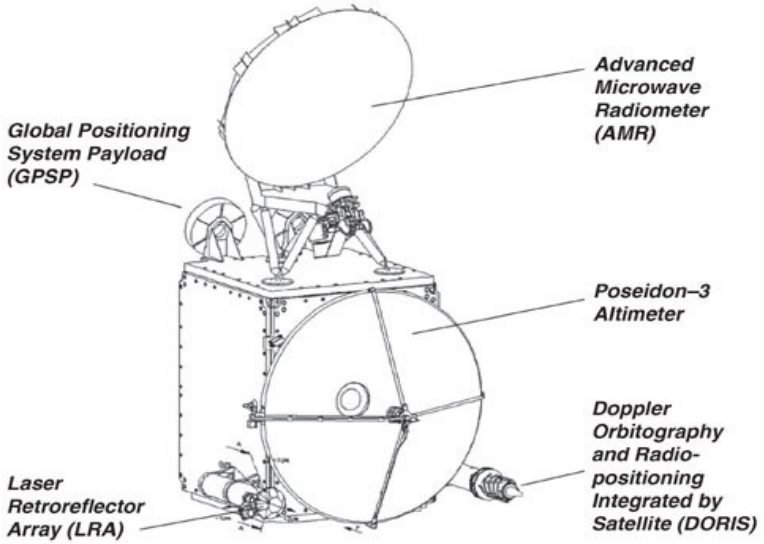


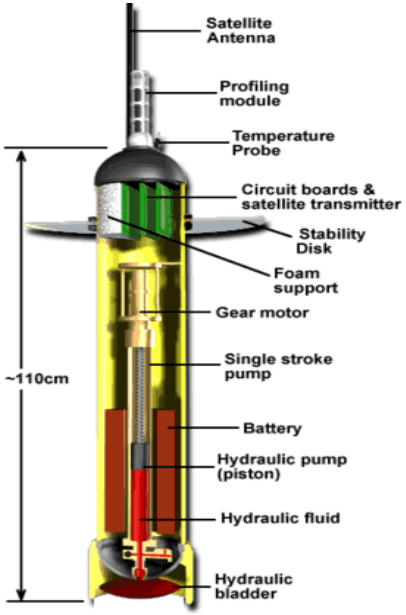
```
                    trend only
                    ax =

transect              123.2645
                        0.1955

                    >> ax2

                    ax2 =

acc                   145.7892
                       -0.0602

                    >> tx

                    tx =

transect              117.381
                        0.1565

                    >> tx2

                    tx2 =

acc                   116.6453
                        0.0189
```

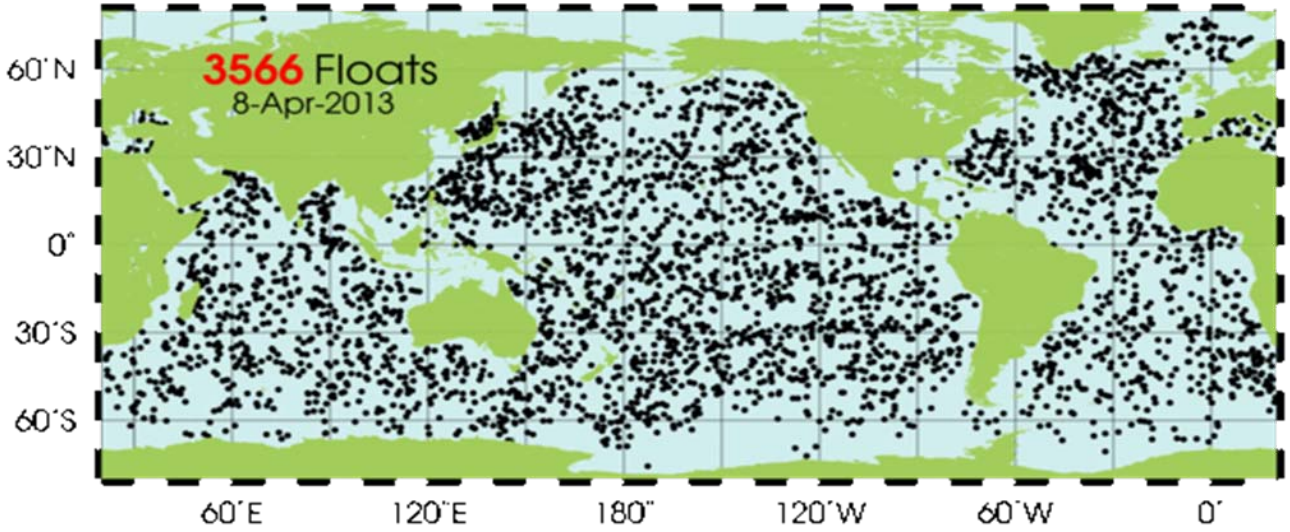
Measurements

$$\eta_{absolute} = SSH - geoid$$



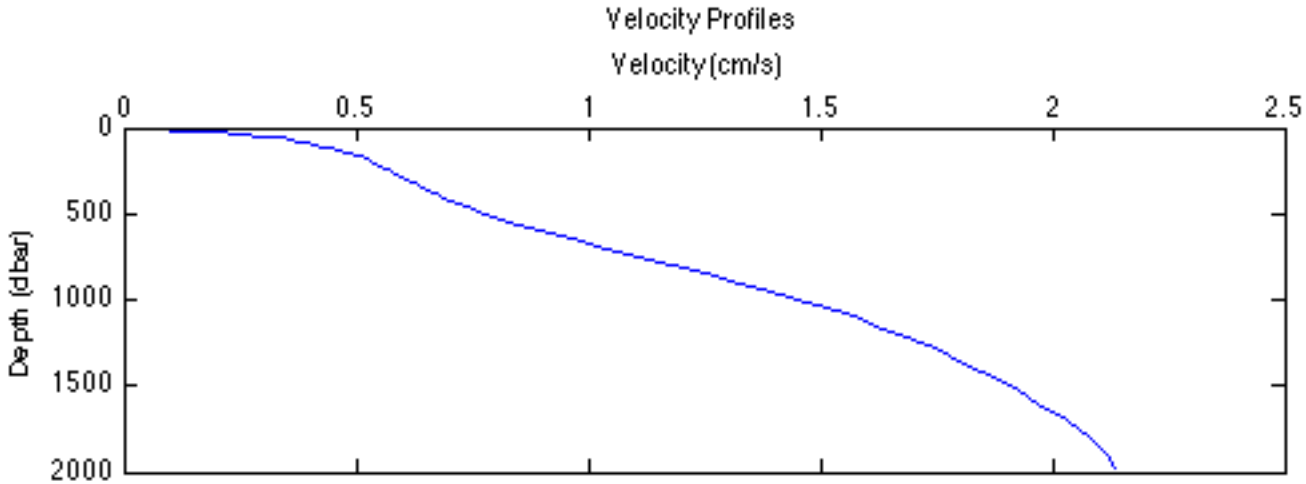






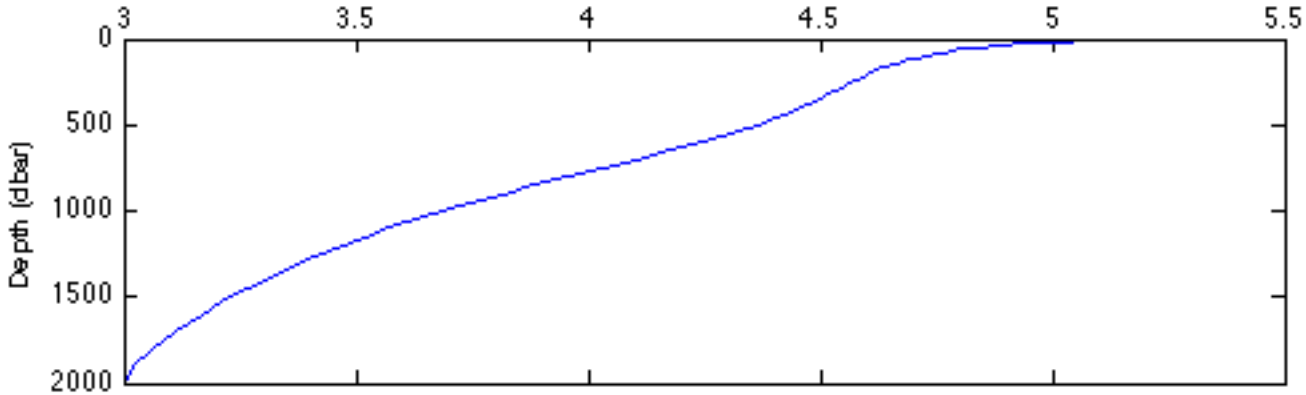
$$\eta_{relative} = \frac{1}{g}\int_{P_r}^{P_{surface}=0} \frac{dP}{\rho(T,S,P)}$$

Velocity Profiles



Argo

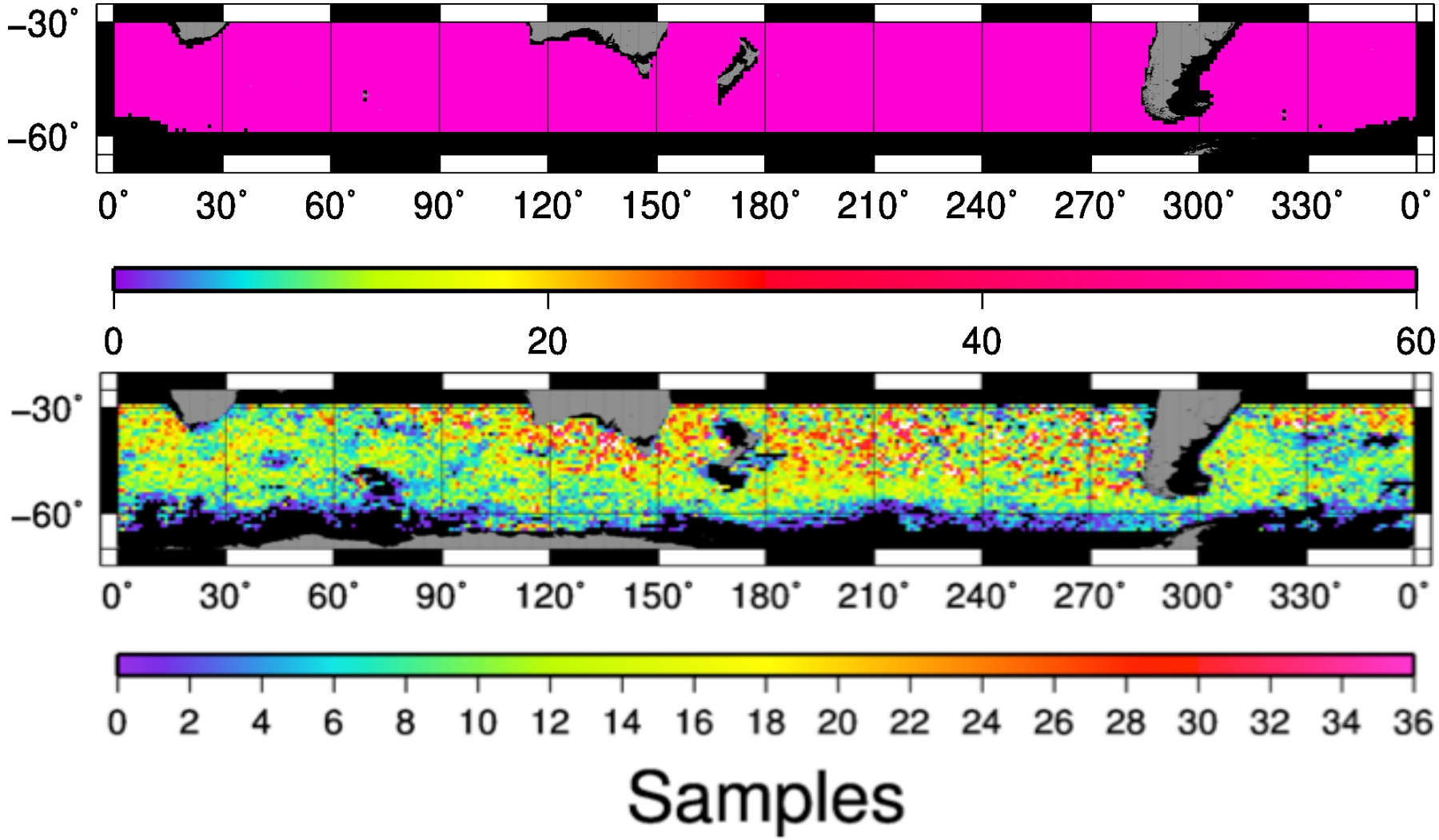
$$\eta_{relative} = \frac{1}{g} \int_{P_r}^{P_{surface}=0} \frac{dP}{\rho(T,S,P)}$$



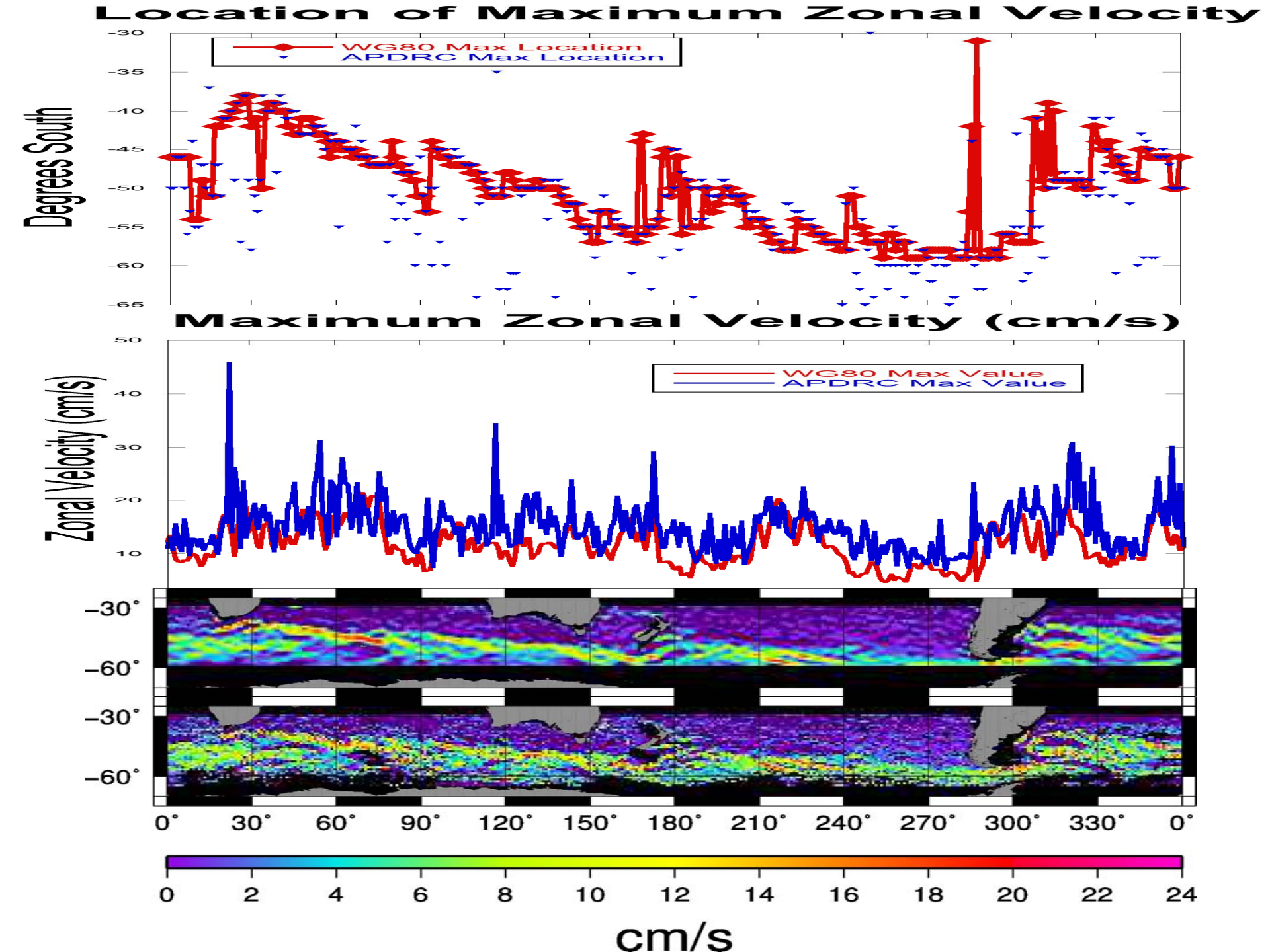
Jason-Argo

$$u_{reference} = -\frac{g}{f}\left(\frac{\partial \eta_{absolute}}{\partial y} - \frac{\partial \eta_{relative}}{\partial y}\right)$$

Velocity observations @ 1000 dbar



Jason+geoid+Argo combination (Top)
Argo drift Velocity (Bottom)
1000 dbar 2006-2011

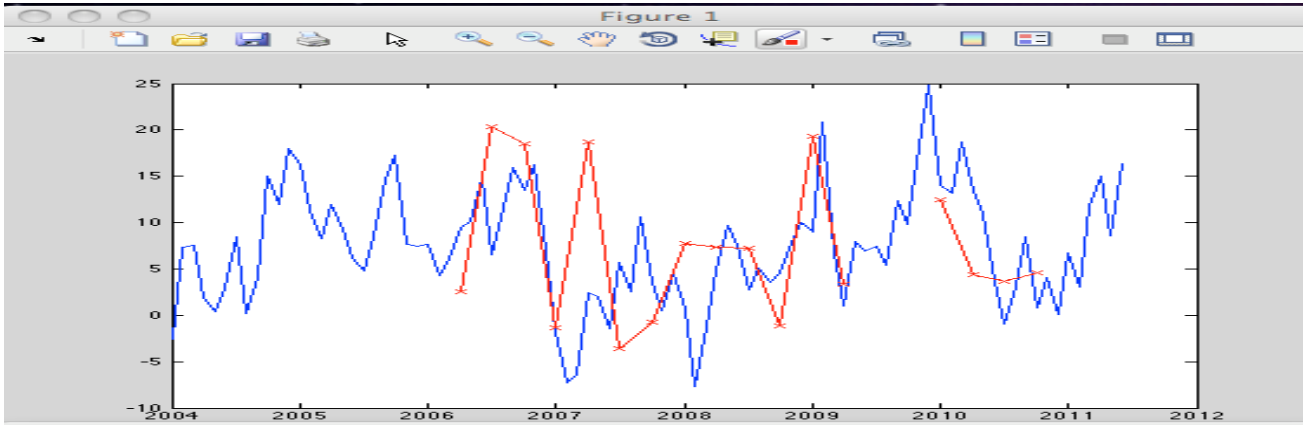

Location of Maximum Zonal Velocity
WG80 Max Location
APDRC Max Location
Degrees South
-30
-35
-40
-45
-50
-55
-60
-65
Maximum Zonal Velocity (cm/s)
WG80 Max Value
APDRC Max Value
Zonal Velocity (cm/s)
50
40
30
20
10
-30°
-60°
-30°
-60°
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0°
0
2
4
6
8
10
12
14
16
18
20
22
24
cm/s

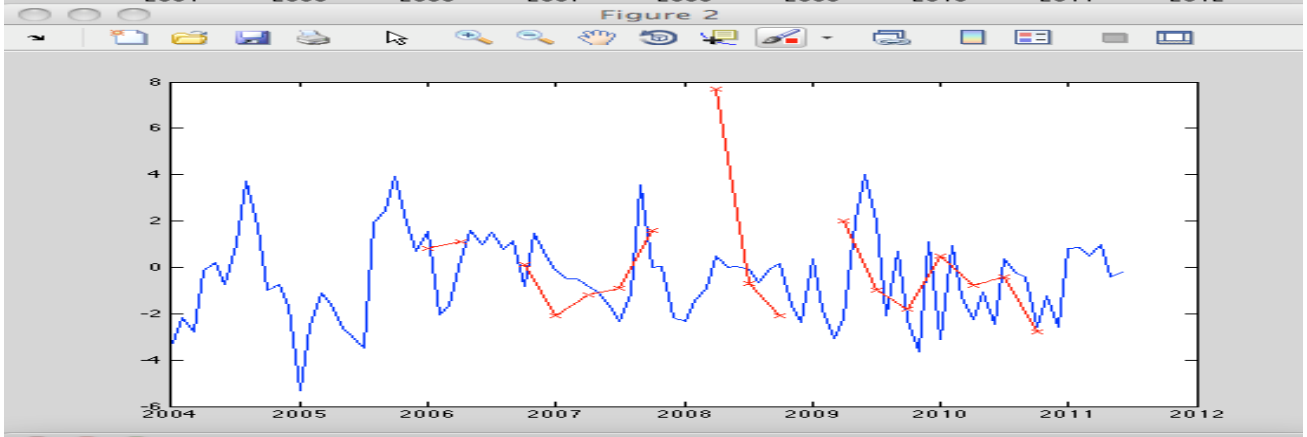
Regional Time Series Table

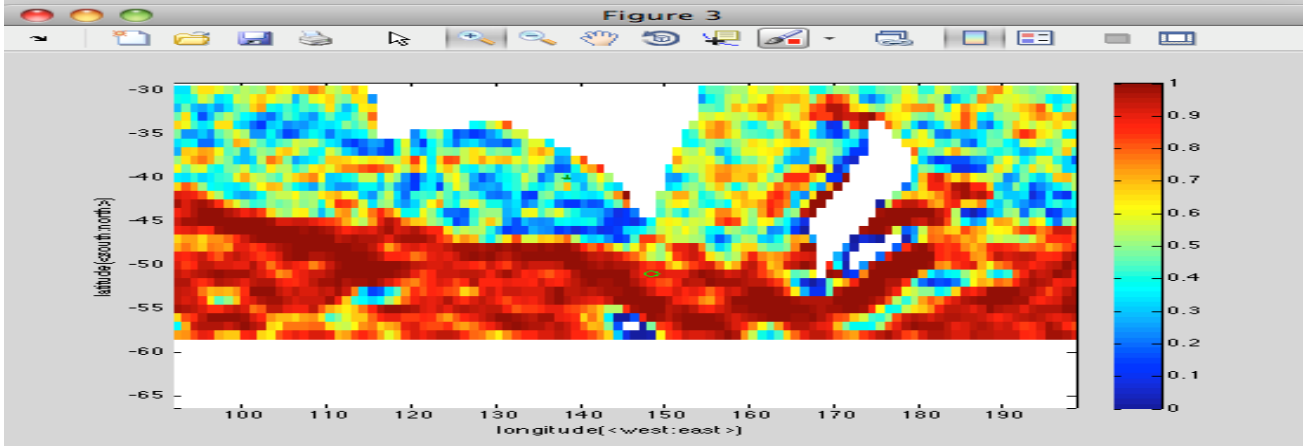
Table 2. Mean and standard deviation of velocity (cm/s) time series from Regions 1 and 2 (see Figure 4) based on the WG80 and APDRC.

	WG80 Monthly Region 1	APDRC Seasonal Region 1	WG80 Monthly Region 2	APDRC Seasonal Region 2
Mean Velocity	15.04	12.63	10.06	9.19
Standard Deviation	1.31	3.03	0.95	7.75
Standard Error of Mean	0.13	0.69	0.1	1.73

Single Degree validation





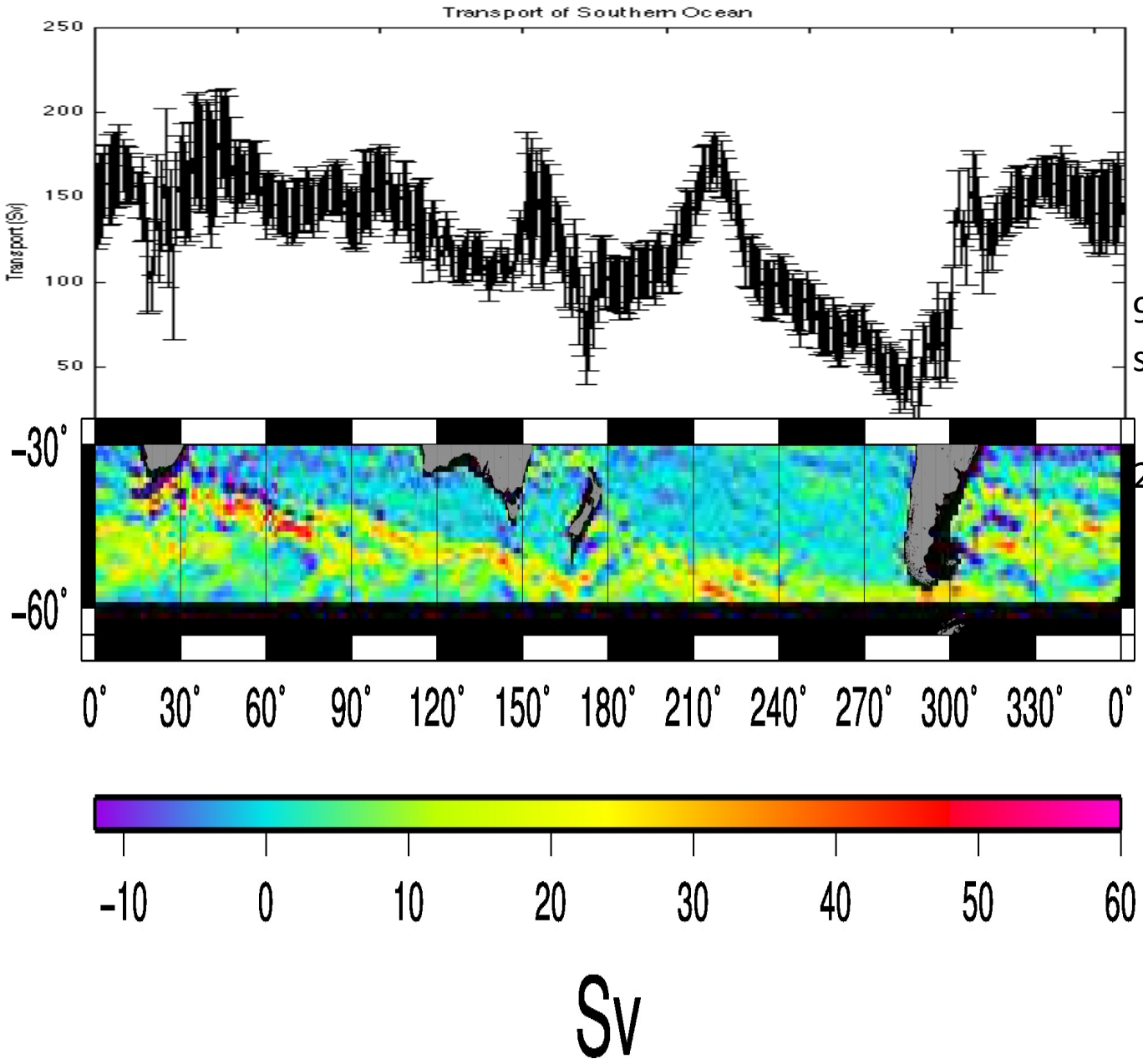


locations with only 3 missing values in 20 seasons. Cell {128,14} and {118,25} have 17 values in the time series.

Cell {128,14} happens to be on the Tasmanian transect and shows agreement in the time series. That cell is shown as figure 2, and located schematically, below.

(line plots shown in cm/s)

South Basin Transport



$$T = \int_{y_1}^{y_2} \int_{h_1}^{h_2} u\,dy\,dz$$

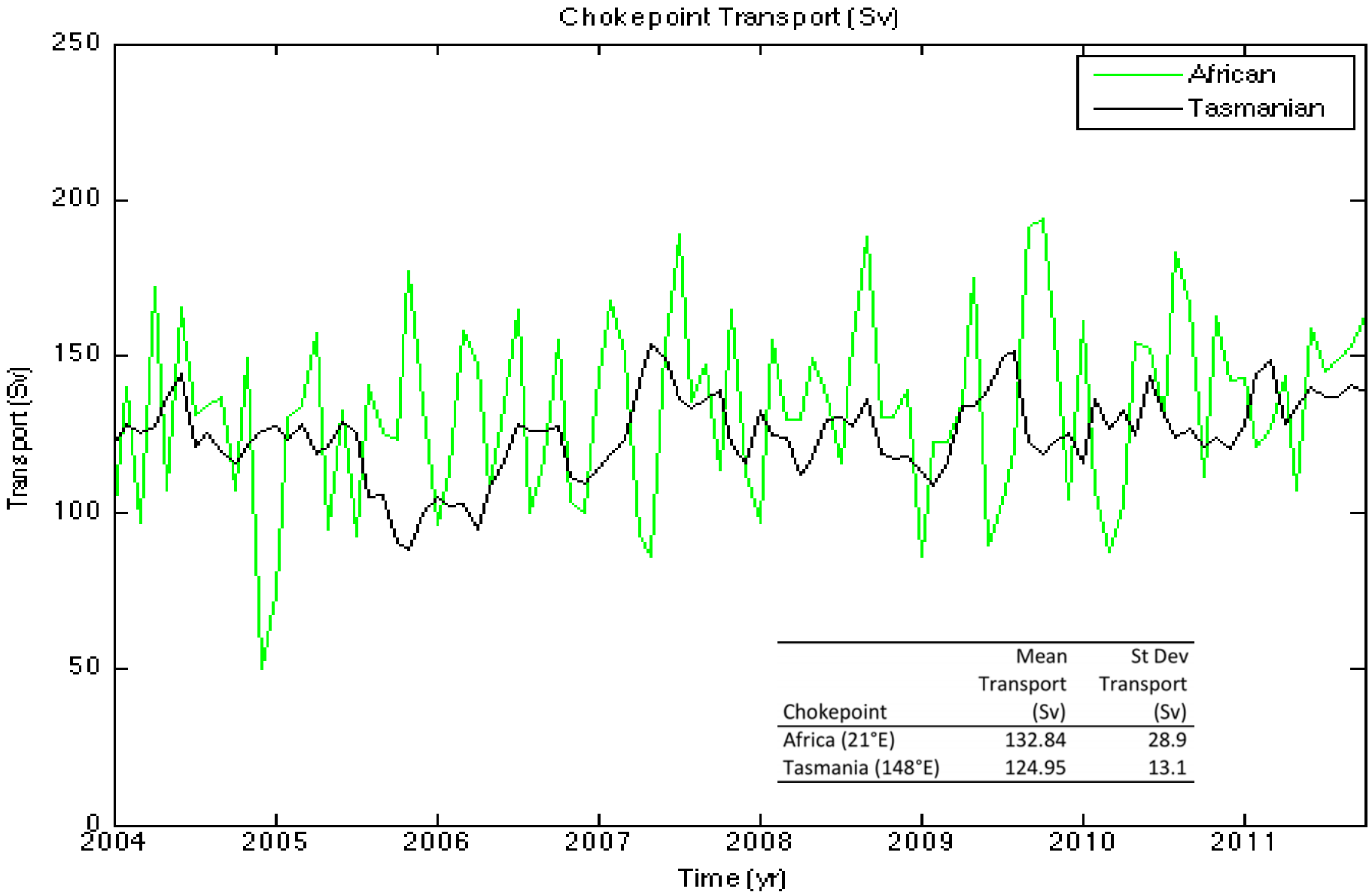
94-month mean with one st dev error bars

2006 mean

30°-60°S & 0-1975dbar

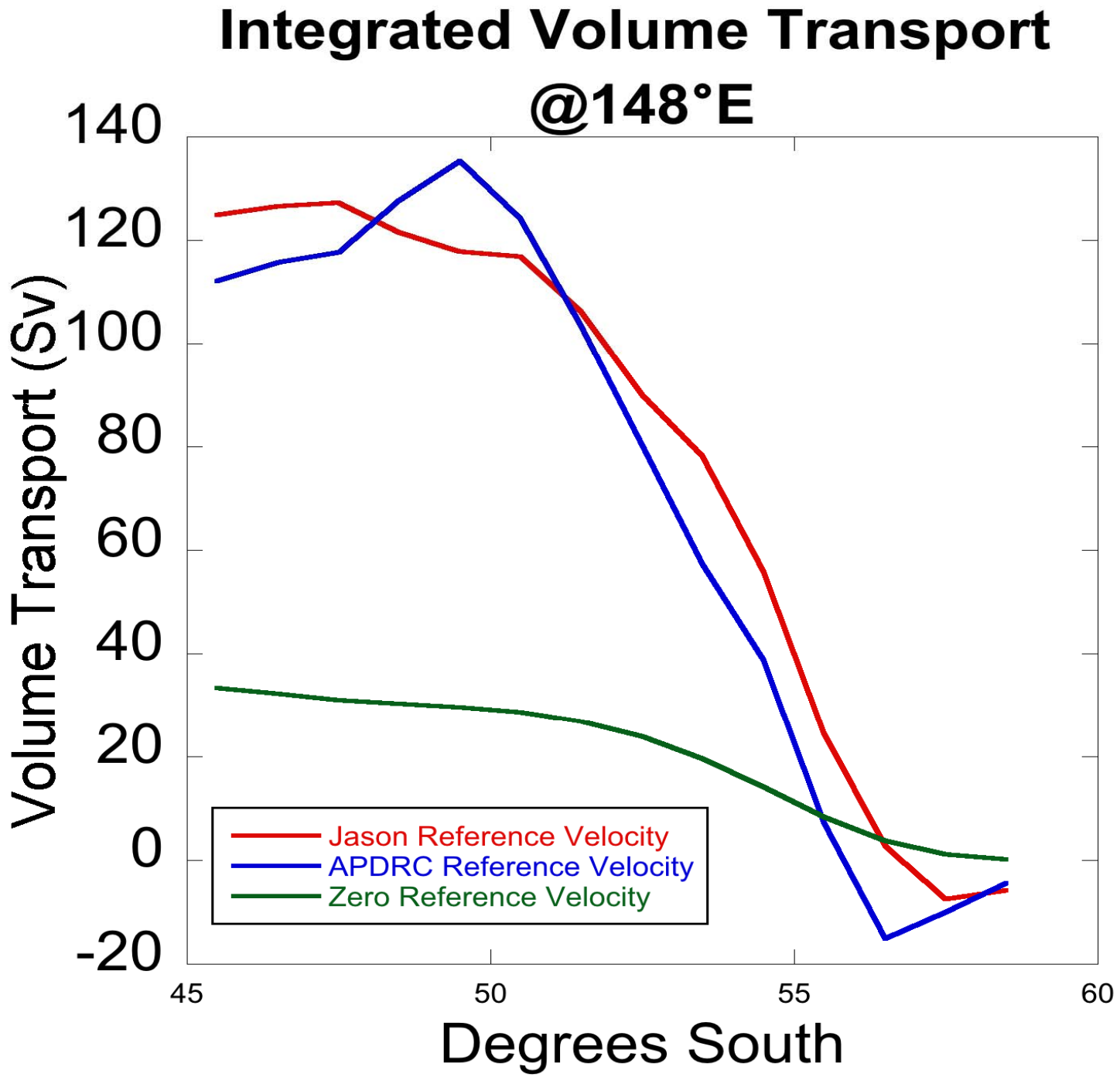
1 Sv = 10^6 m^3/sec

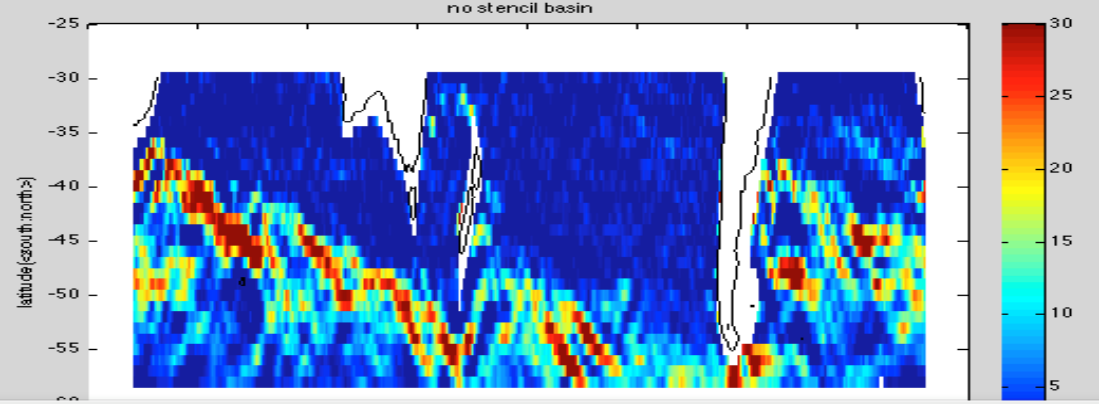
Chokepoint Transport

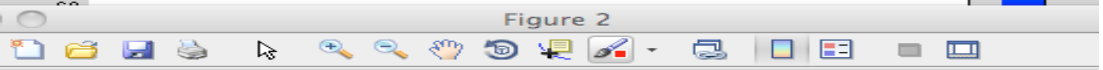


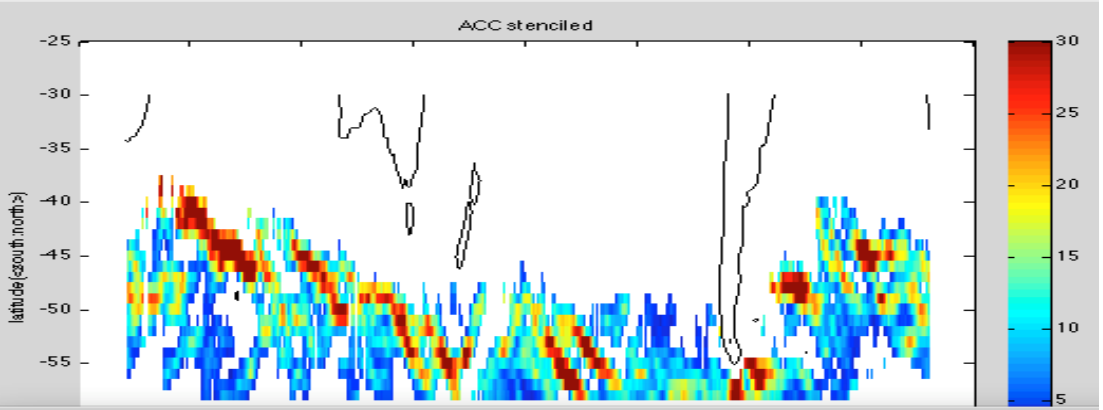
Chokepoint	Mean Transport (Sv)	St Dev Transport (Sv)
Africa (21°E)	132.84	28.9
Tasmania (148°E)	124.95	13.1

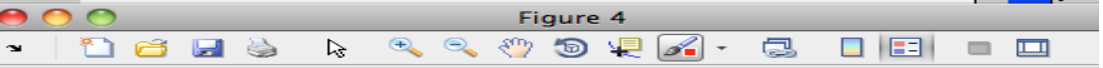
30°-60°S & 0-1975dbar

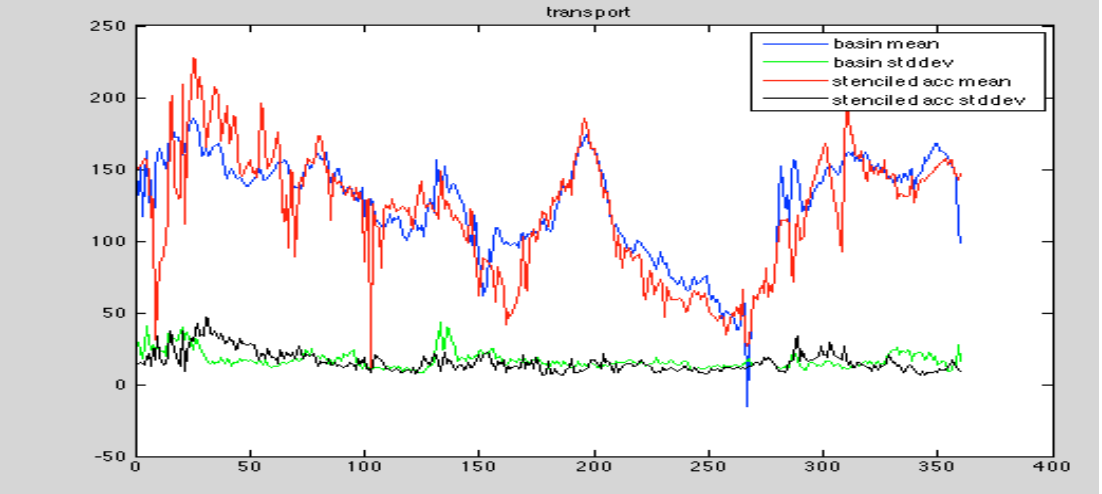

Integrated Volume Transport
@148°E
140
120
100
80
60
40
20
0
-20
Volume Transport (Sv)
45
50
55
60
Degrees South
Jason Reference Velocity
APDRC Reference Velocity
Zero Reference Velocity





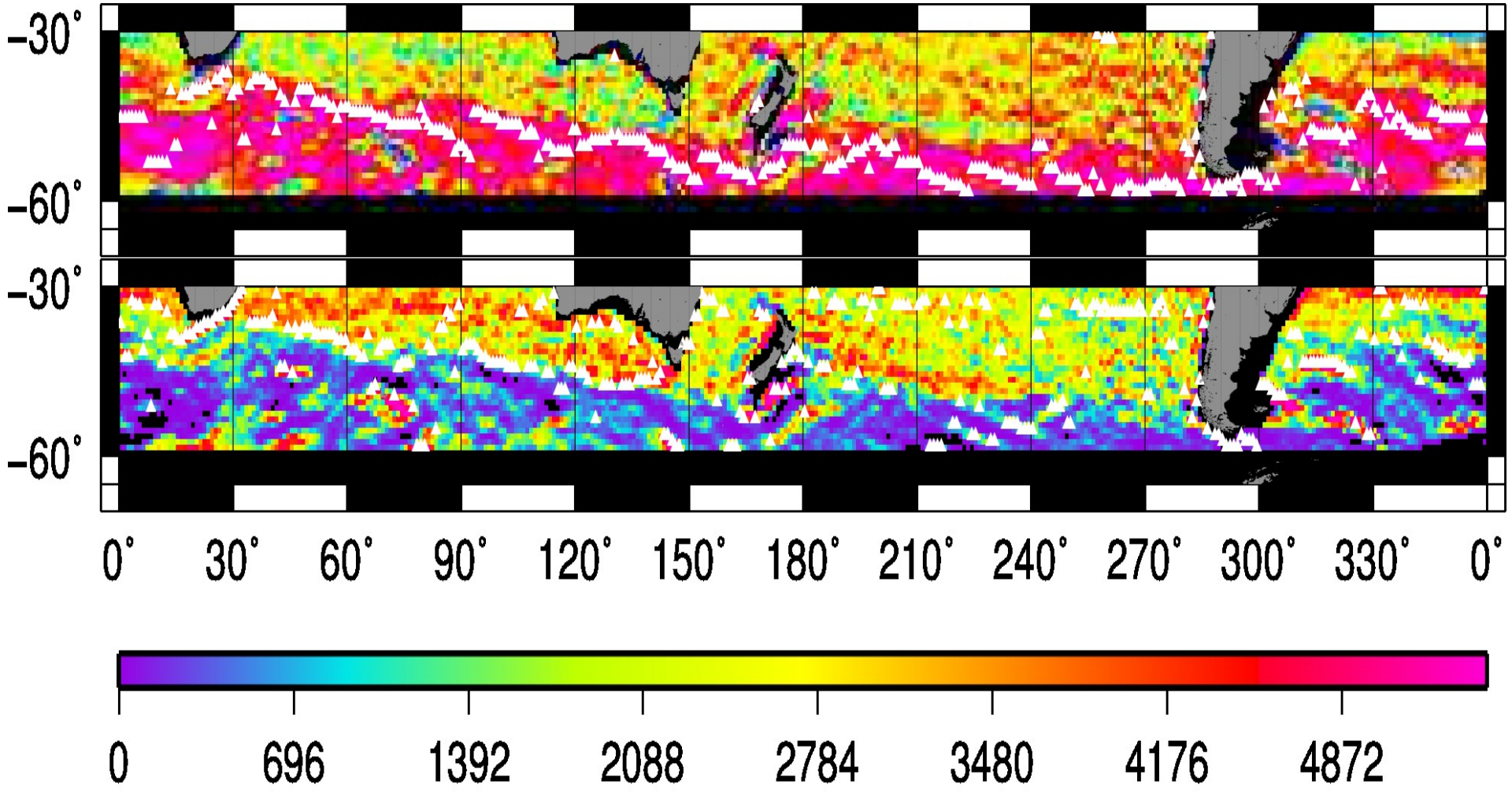






ACC spatial identification algorithm based on eastward persistence. Minimum of 94% to include all meridians with adjacent cells >80%

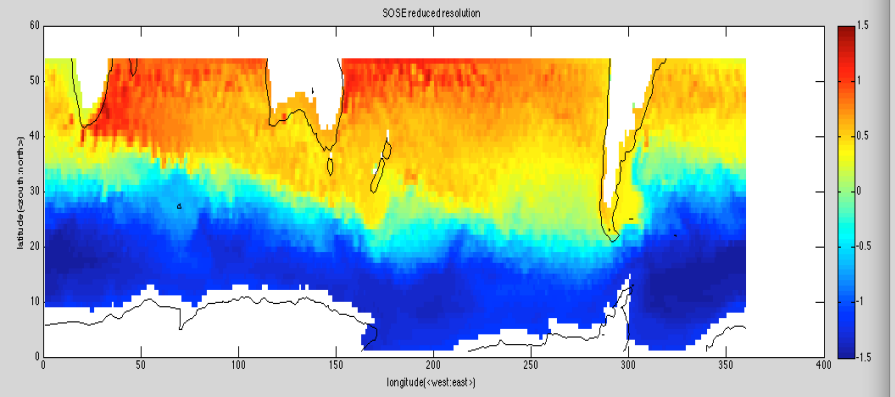
Histograms

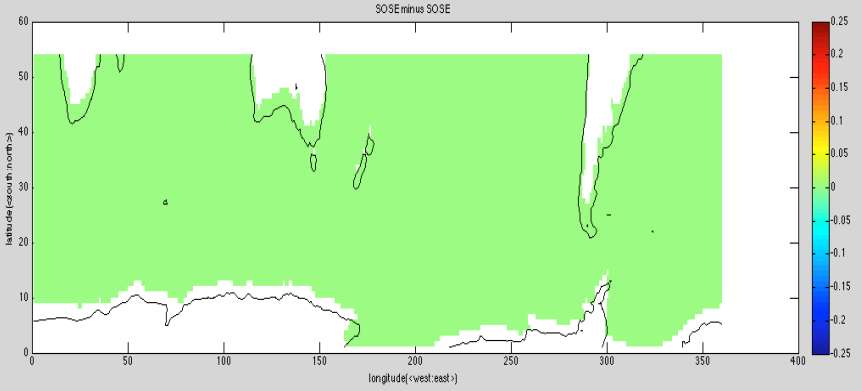


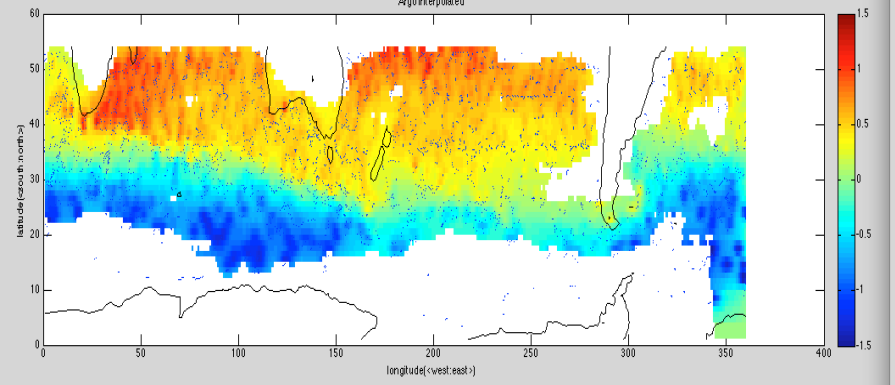
Measurements

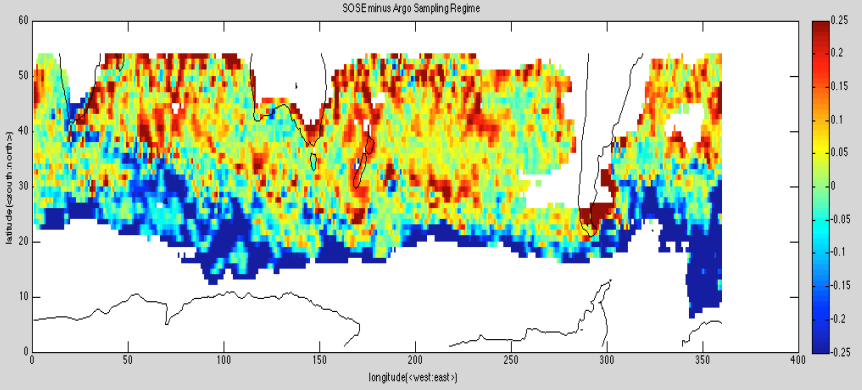
Eastern (Top)
Western (Bottom)
Maximum velocity at 1975 dbar shown as white triangles
58*94=5452

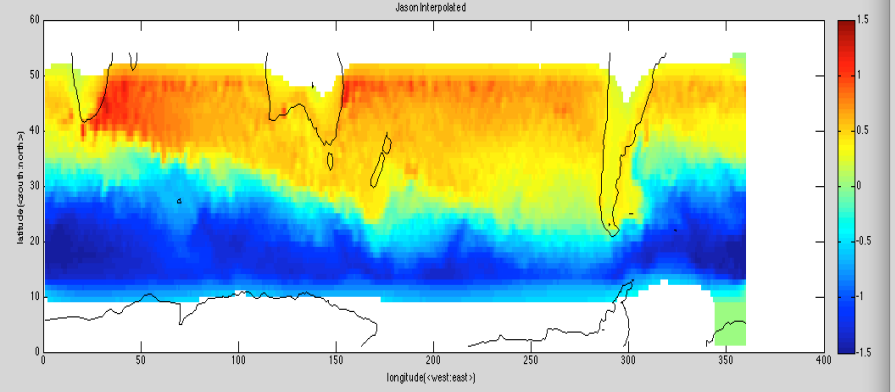
Sampling Regime Mapping Discrepancies

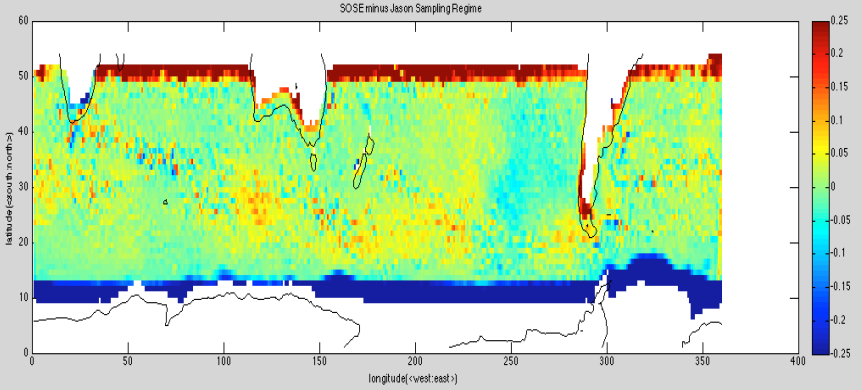




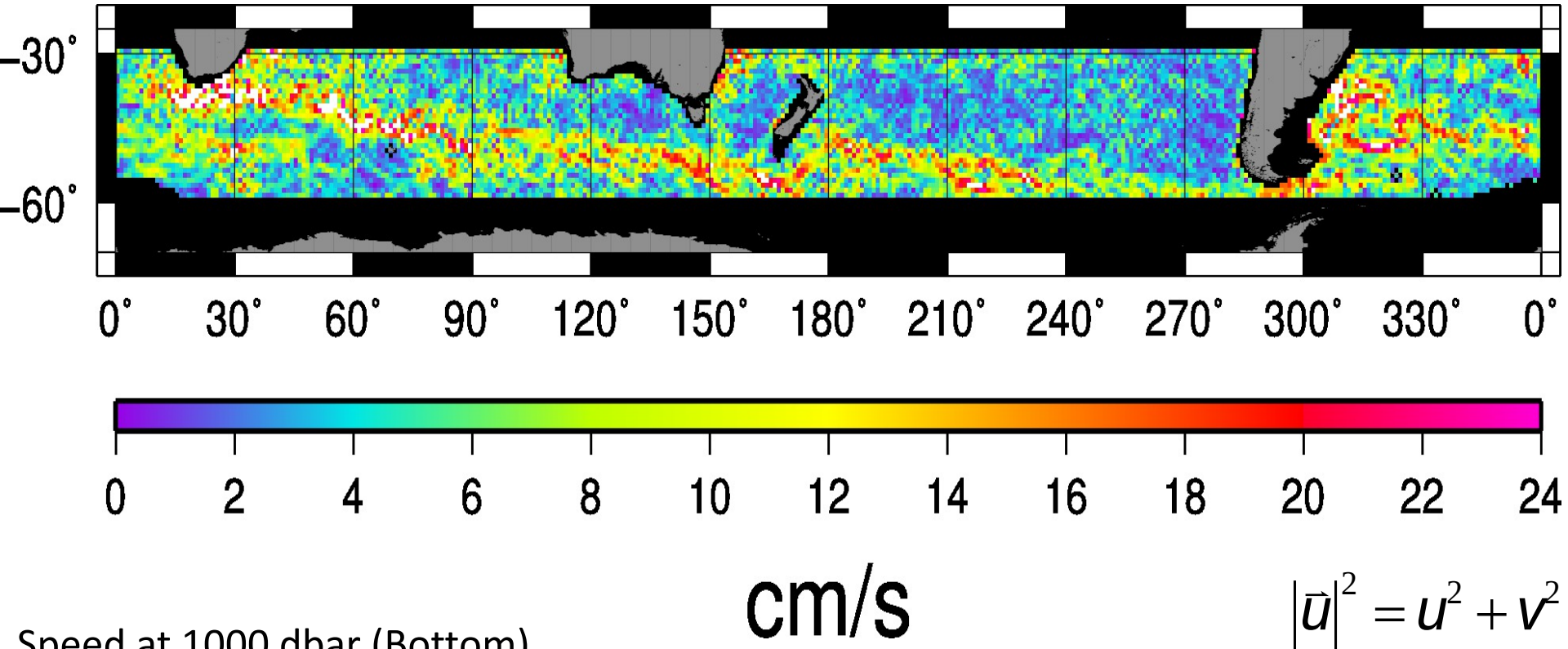








Speed Grid



$$|\vec{u}|^2 = u^2 + v^2$$

Speed at 1000 dbar (Bottom)
July 2010