Submesoscale Spatial Variability of Ocean Turbulence

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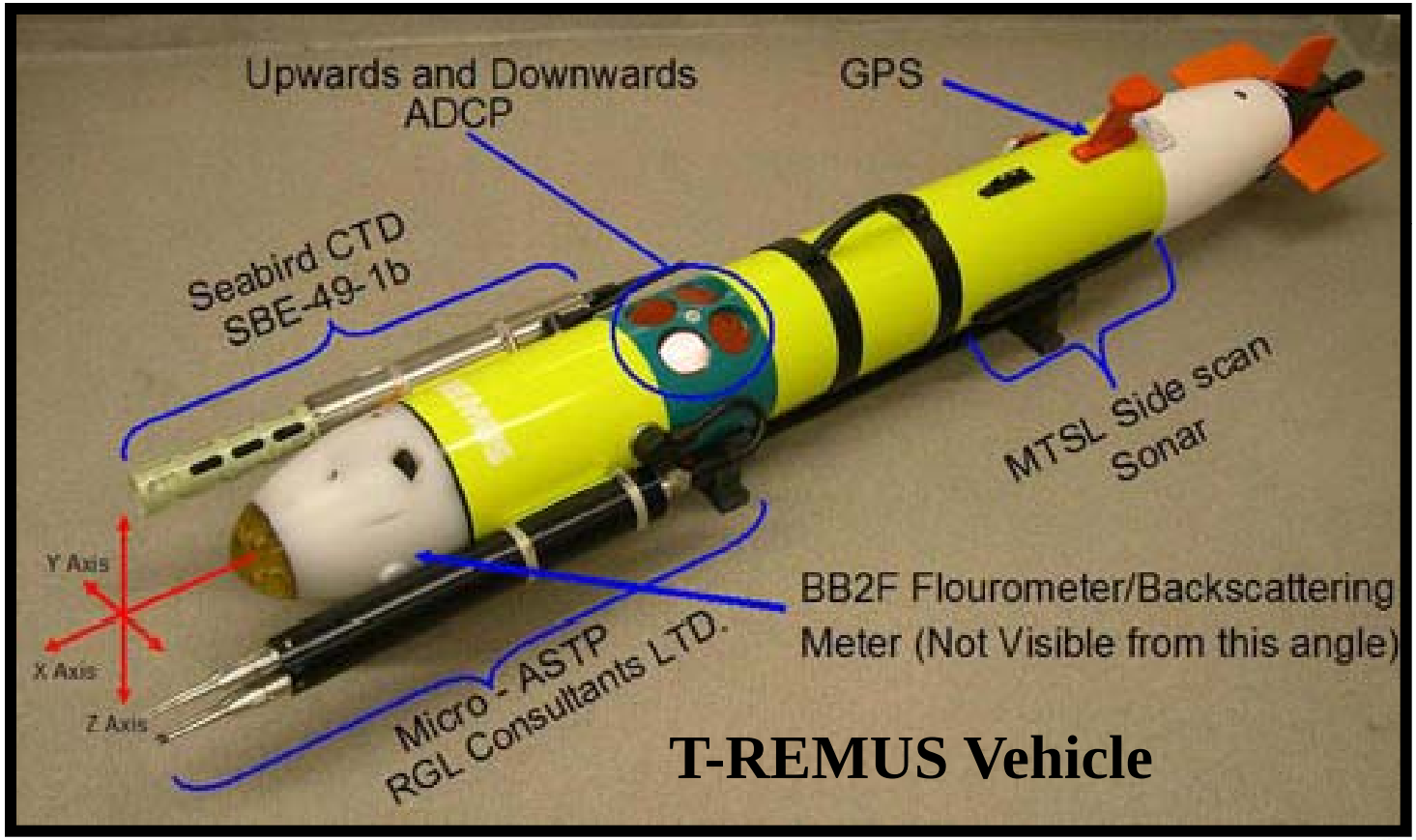
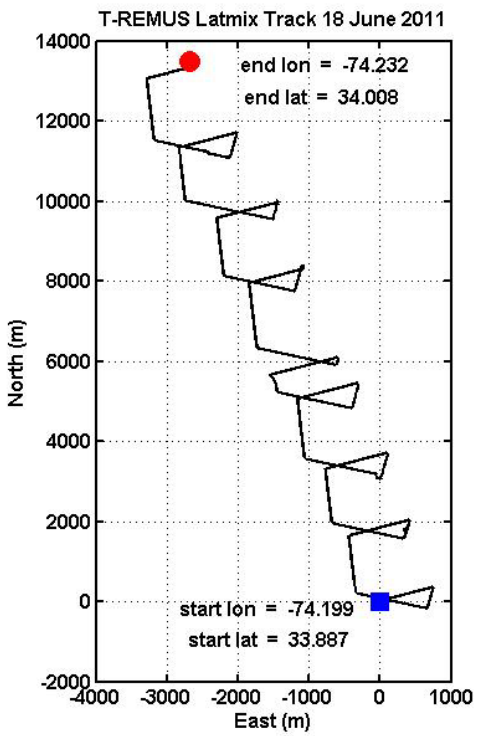


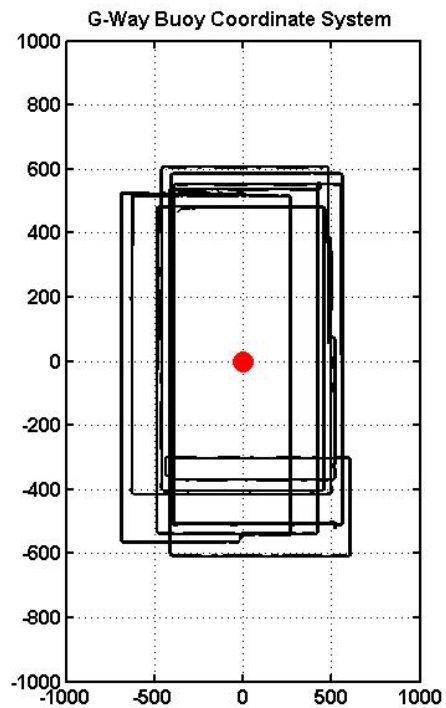
T-REMUS Vehicle

T-REMUS Drogued Gateway 3 Buoy System

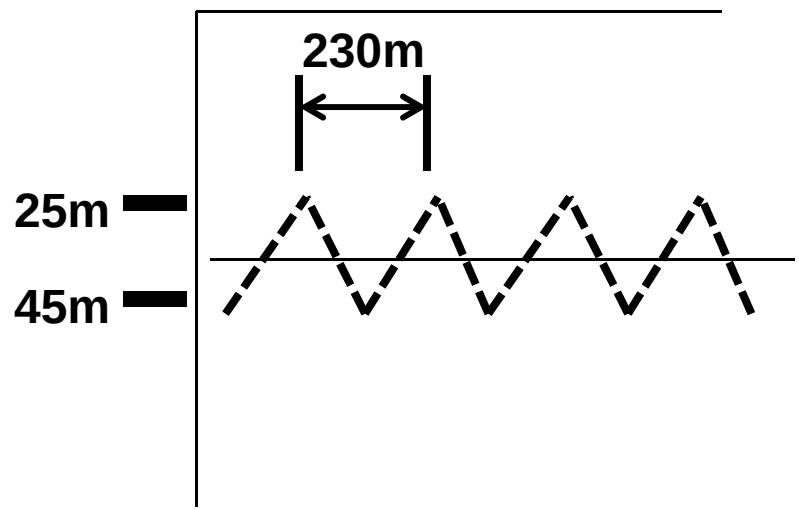
LatMix T-REMUS Deployments

Date in	06/03/11	06/05/11	06/08/11	06/10/11	06/14/11	06/16/11	06/18/11
Time in (UTC)	06:03:14 PM	02:34:42 PM	05:46:34 PM	11:32:09 AM	01:17:11 PM	01:03:08 PM	01:03:24 PM
Time out (UTC)	08:25:23 PM	10:50:43 PM	11:16:32 PM	09:44:37 PM	10:57:00 PM	10:58:05 PM	08:23:43 PM
Starting Longitude	-72.7449	-73.1243	-73.021	-72.9881	-73.0789	-73.5908	-74.1988
Starting Latitude	31.99	32.0734	31.9384	31.7897	32.5184	33.0707	33.887
Ending Longitude	-72.7407	-73.1082	-73.019	-73.0147	-73.1451	-73.7004	-74.2319
Ending Latitude	31.9744	32.0842	31.9196	31.7416	32.6475	33.2104	34.0078

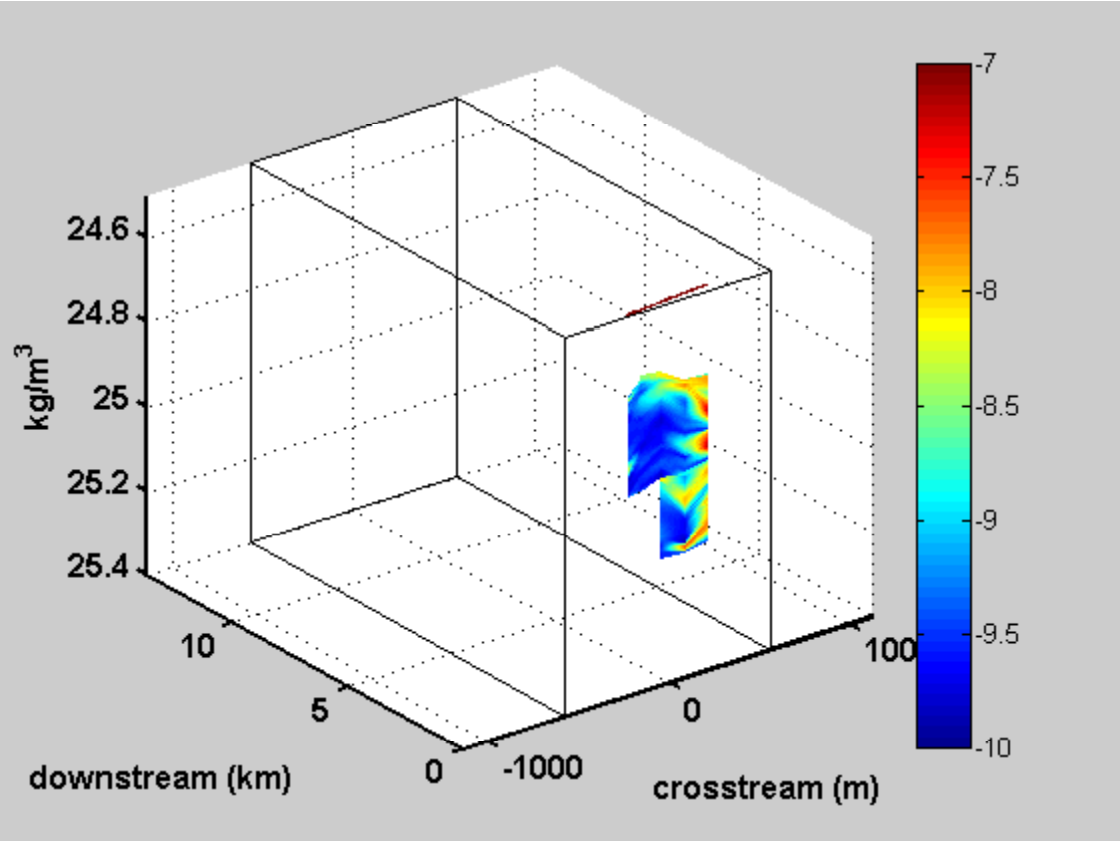




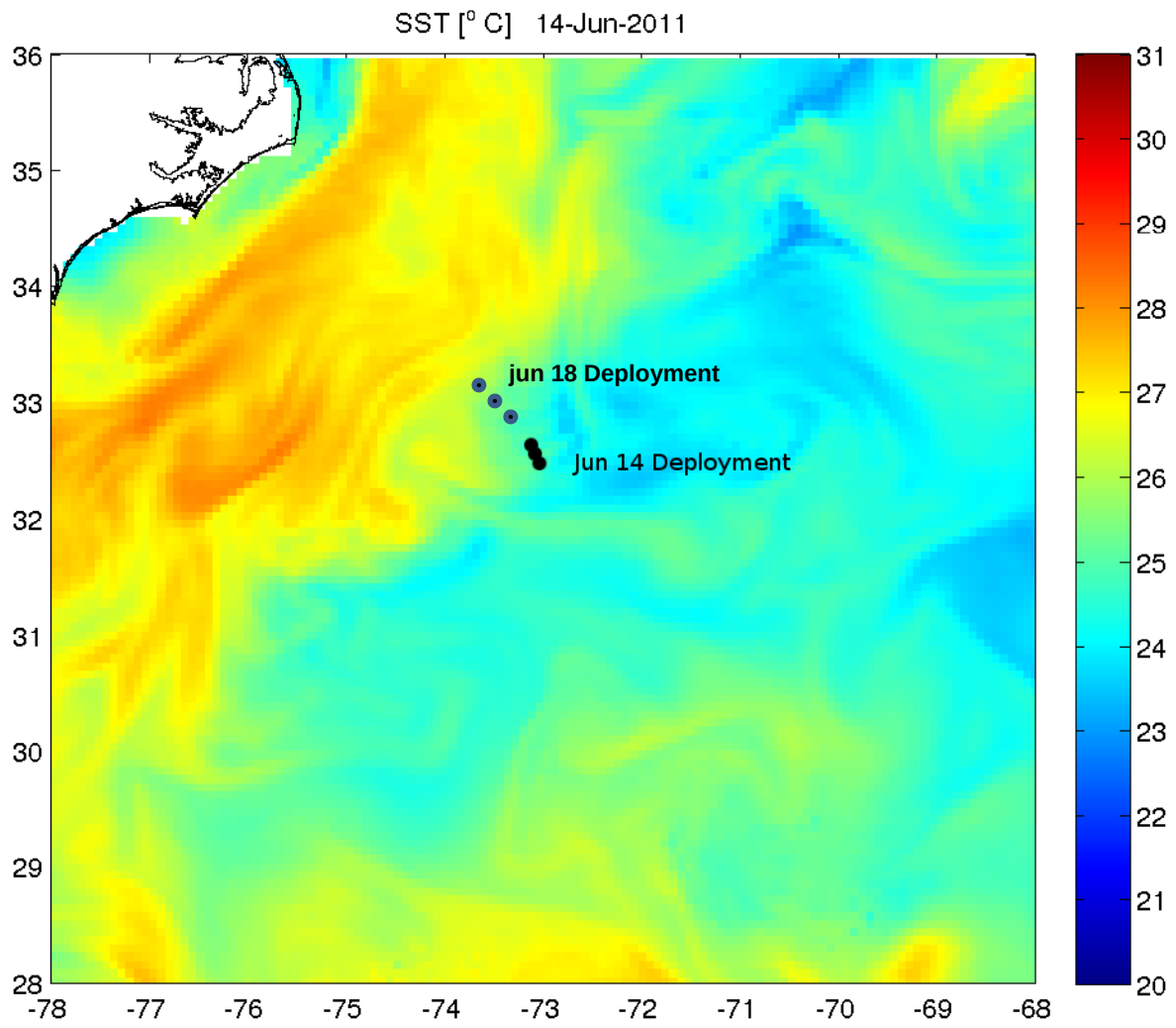
T-REMUS Vertical Track

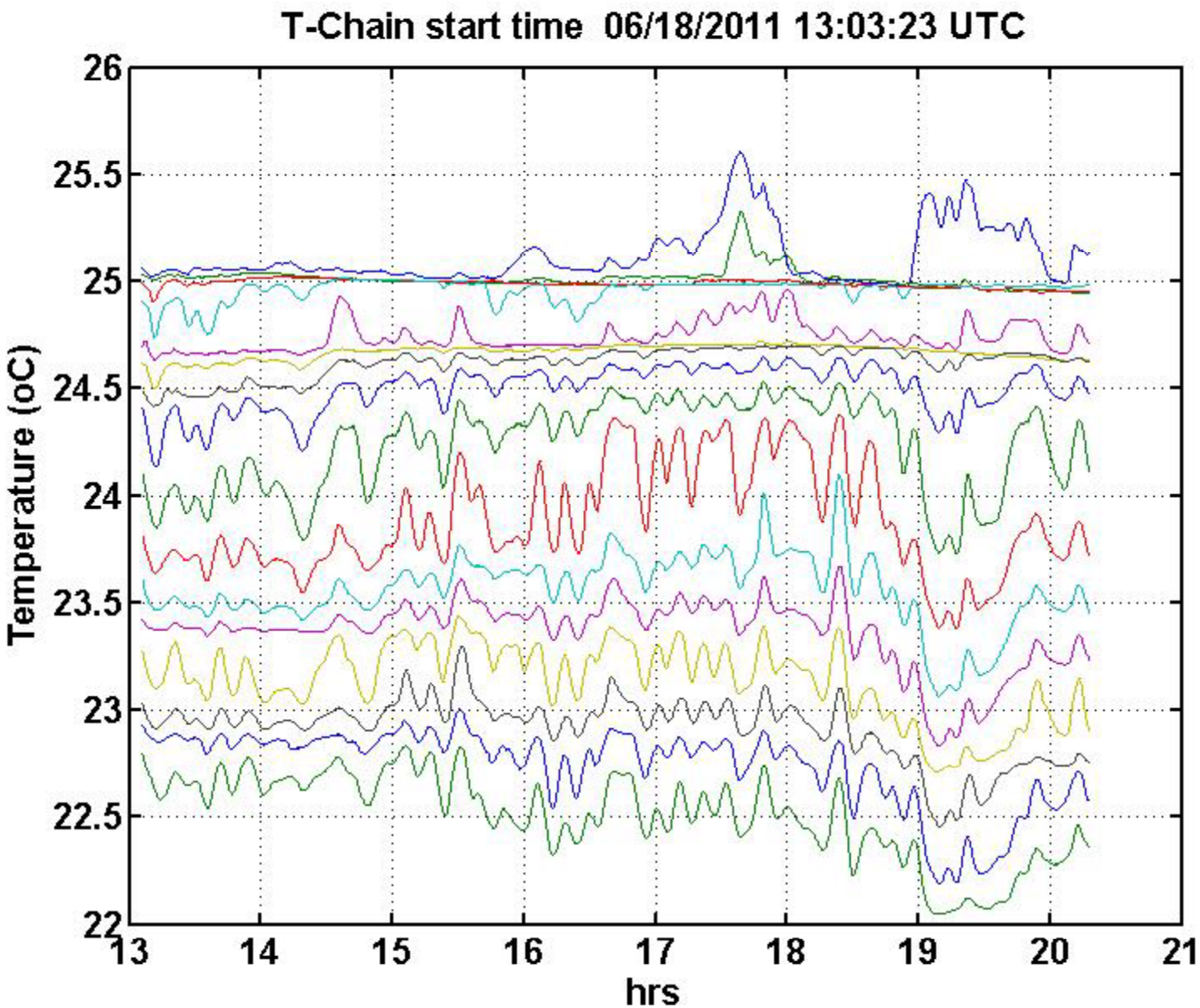


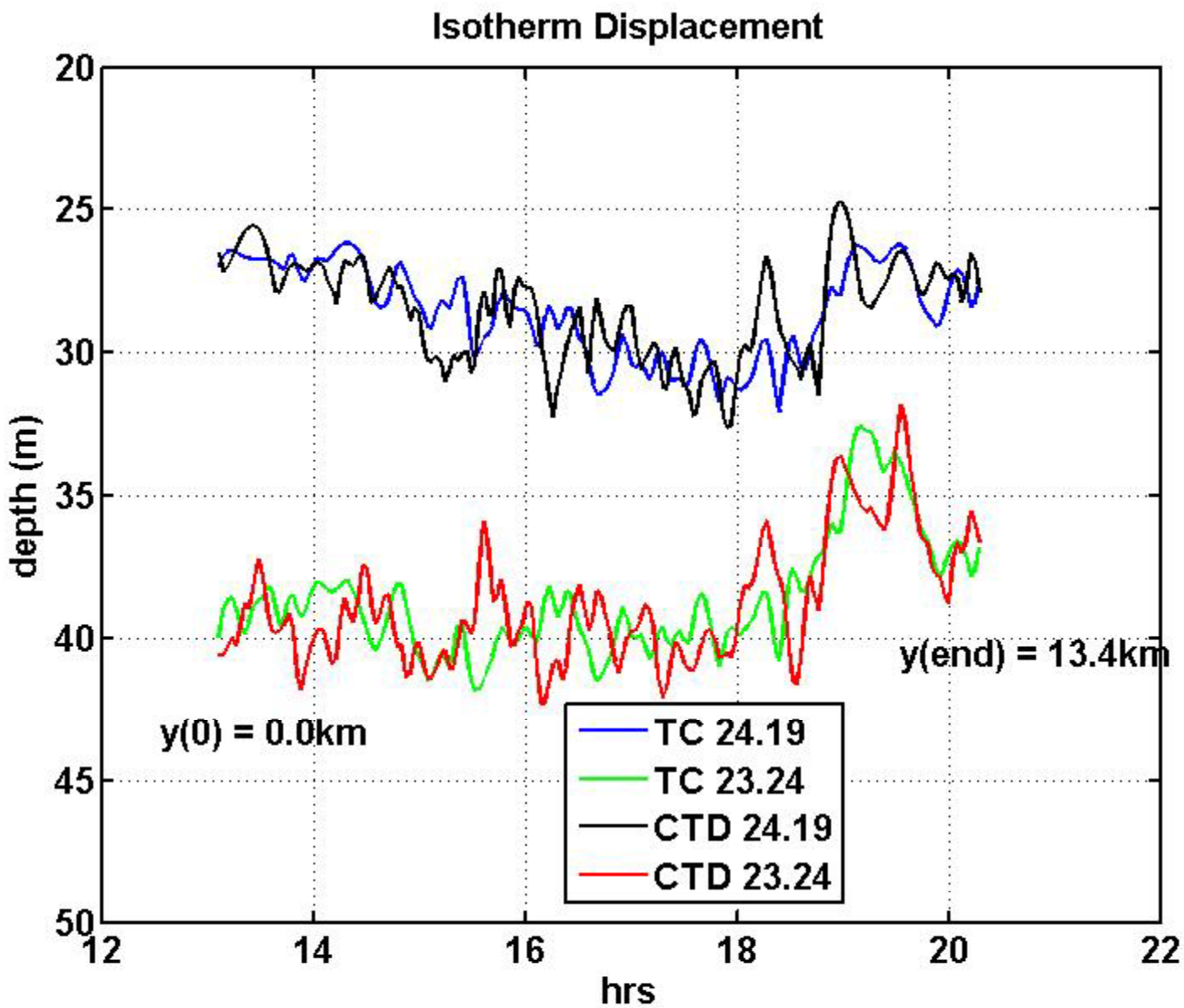
T-REMUS LatMIX Sampling

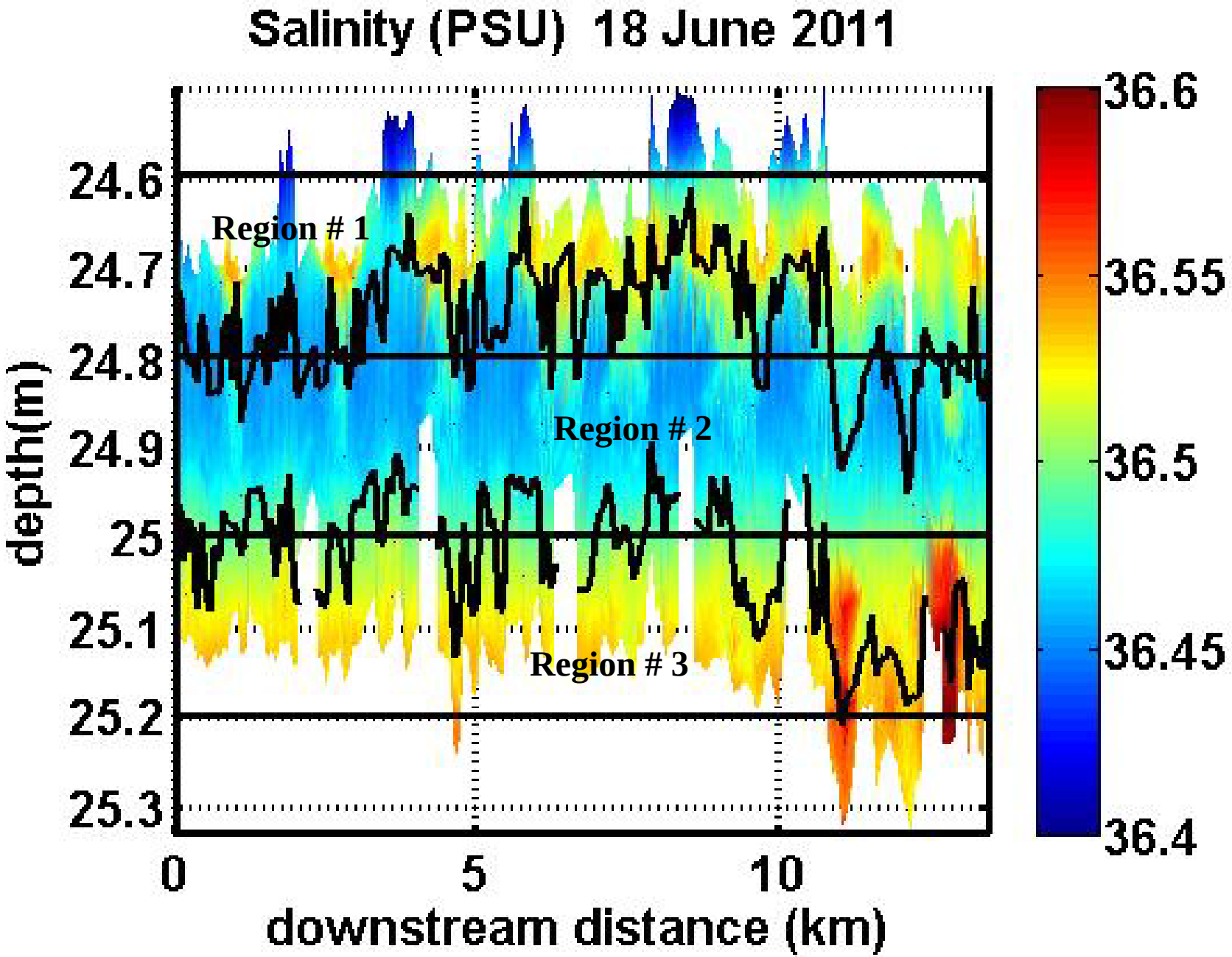


LatMIX 2011

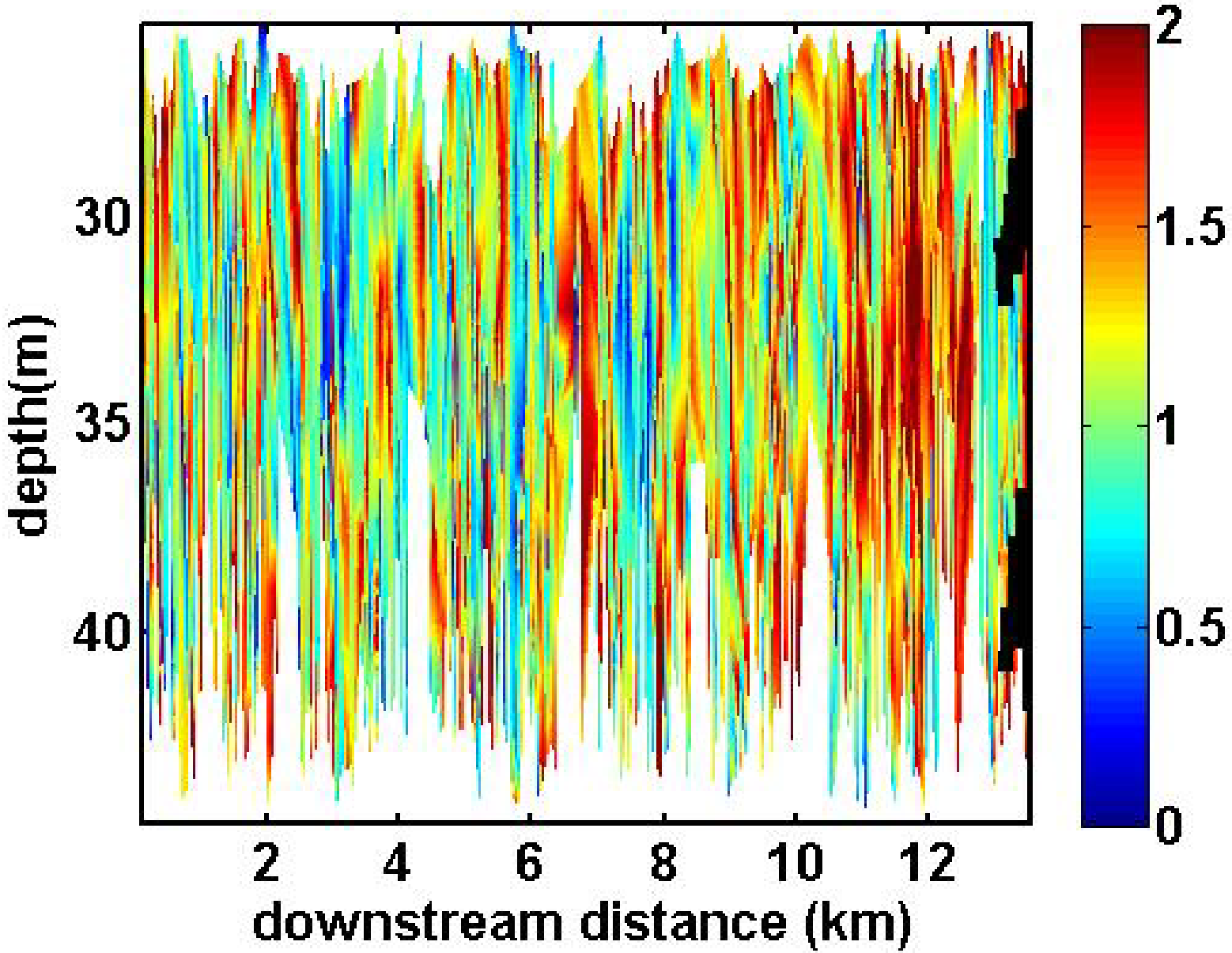

SST [° C] 14-Jun-2011
jun 18 Deployment
Jun 14 Deployment
36
35
34
33
32
31
30
29
28
-78
-77
-76
-75
-74
-73
-72
-71
-70
-69
-68
31
30
29
28
27
26
25
24
23
22
21
20

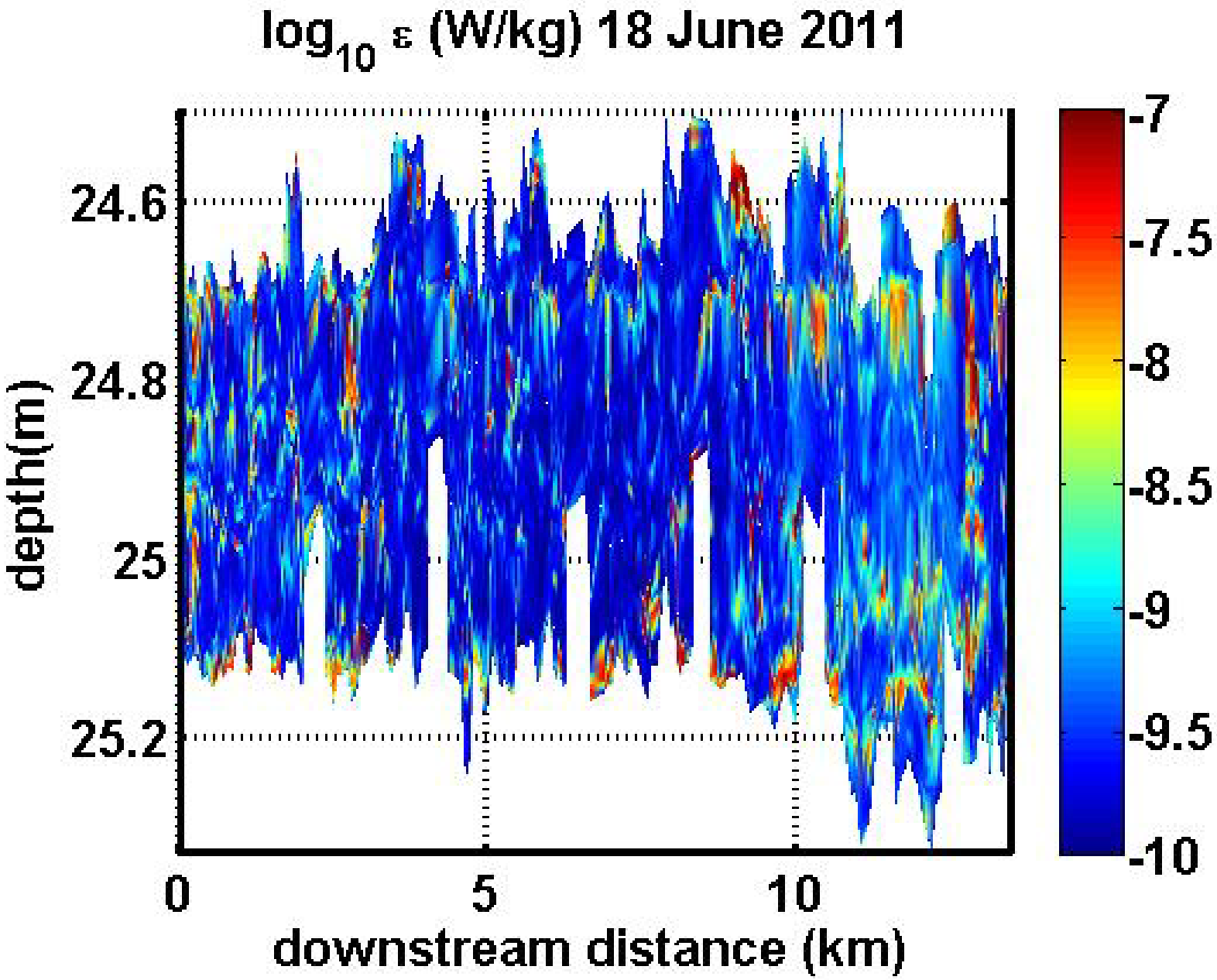

T-Chain start time 06/18/2011 13:03:23 UTC
Temperature (oC)
26
25.5
25
24.5
24
23.5
23
22.5
22
13
14
15
16
17
18
19
20
21
hrs

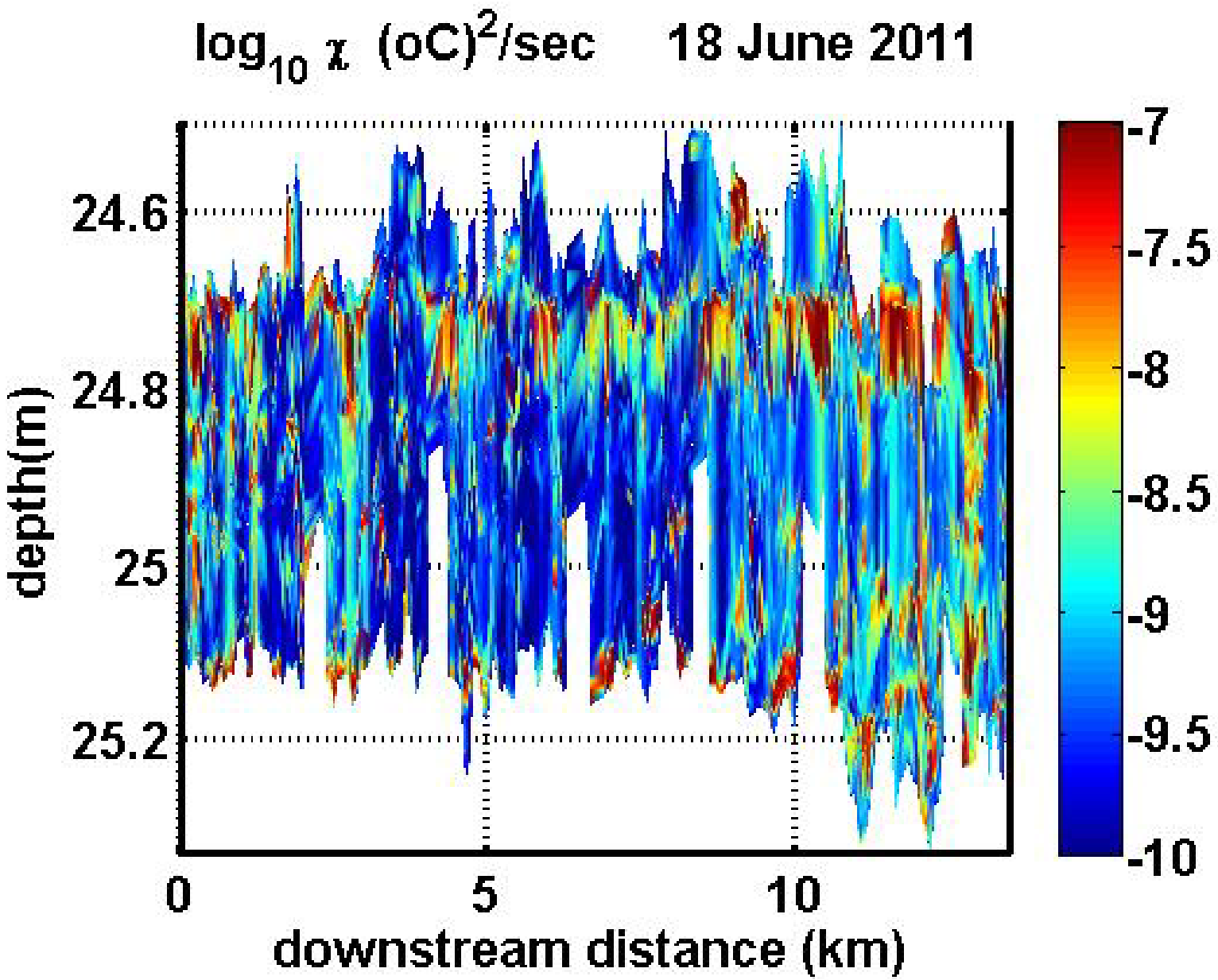

Isotherm Displacement
depth (m)
hrs
20
25
30
35
40
45
50
12
14
16
18
20
22
y(0) = 0.0km
y(end) = 13.4km
TC 24.19
TC 23.24
CTD 24.19
CTD 23.24

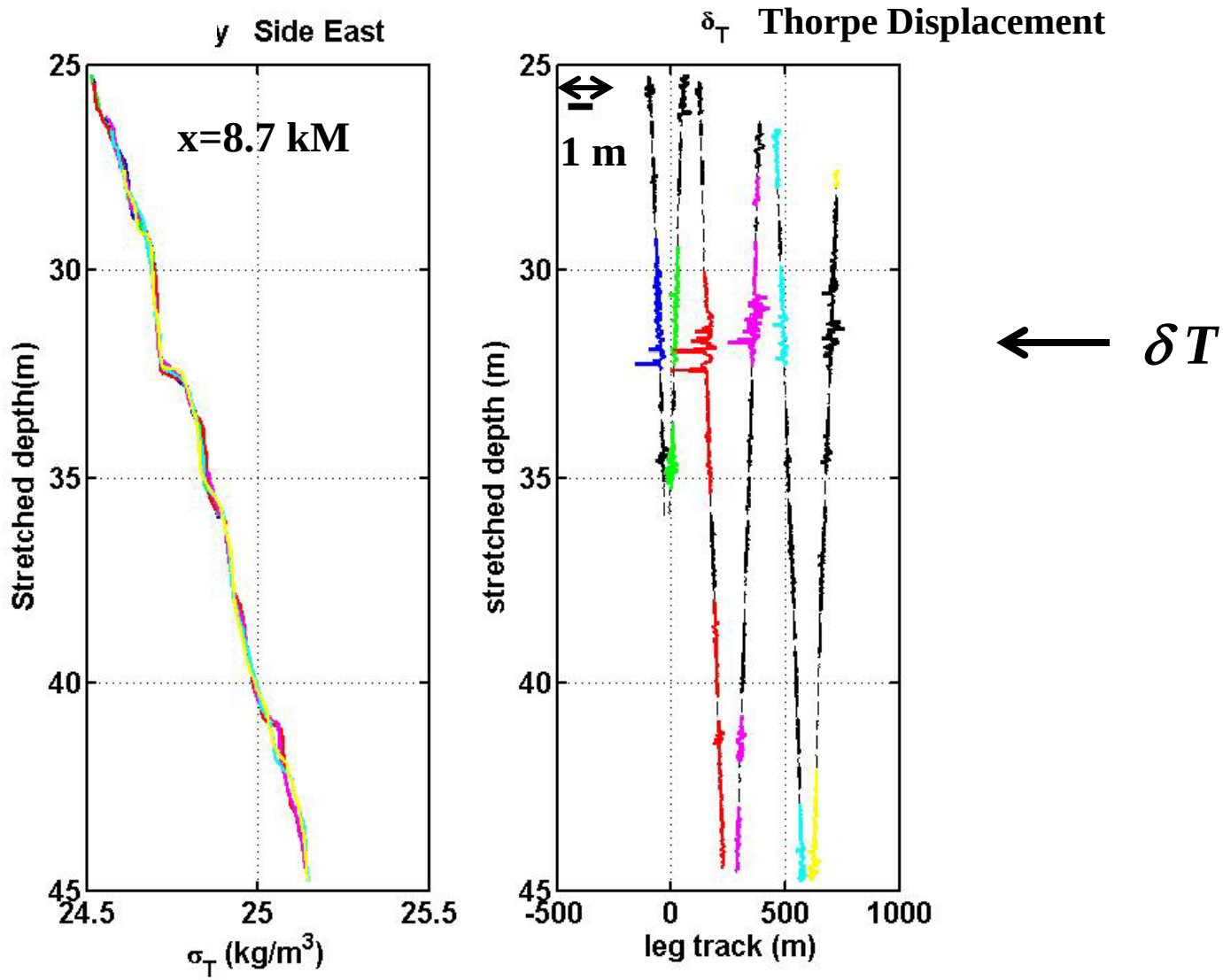

Salinity (PSU) 18 June 2011
depth(m)
24.6
24.7
24.8
24.9
25
25.1
25.2
25.3
Region # 1
Region # 2
Region # 3
0
5
10
downstream distance (km)
36.6
36.55
36.5
36.45
36.4

Froude Number 5 m average



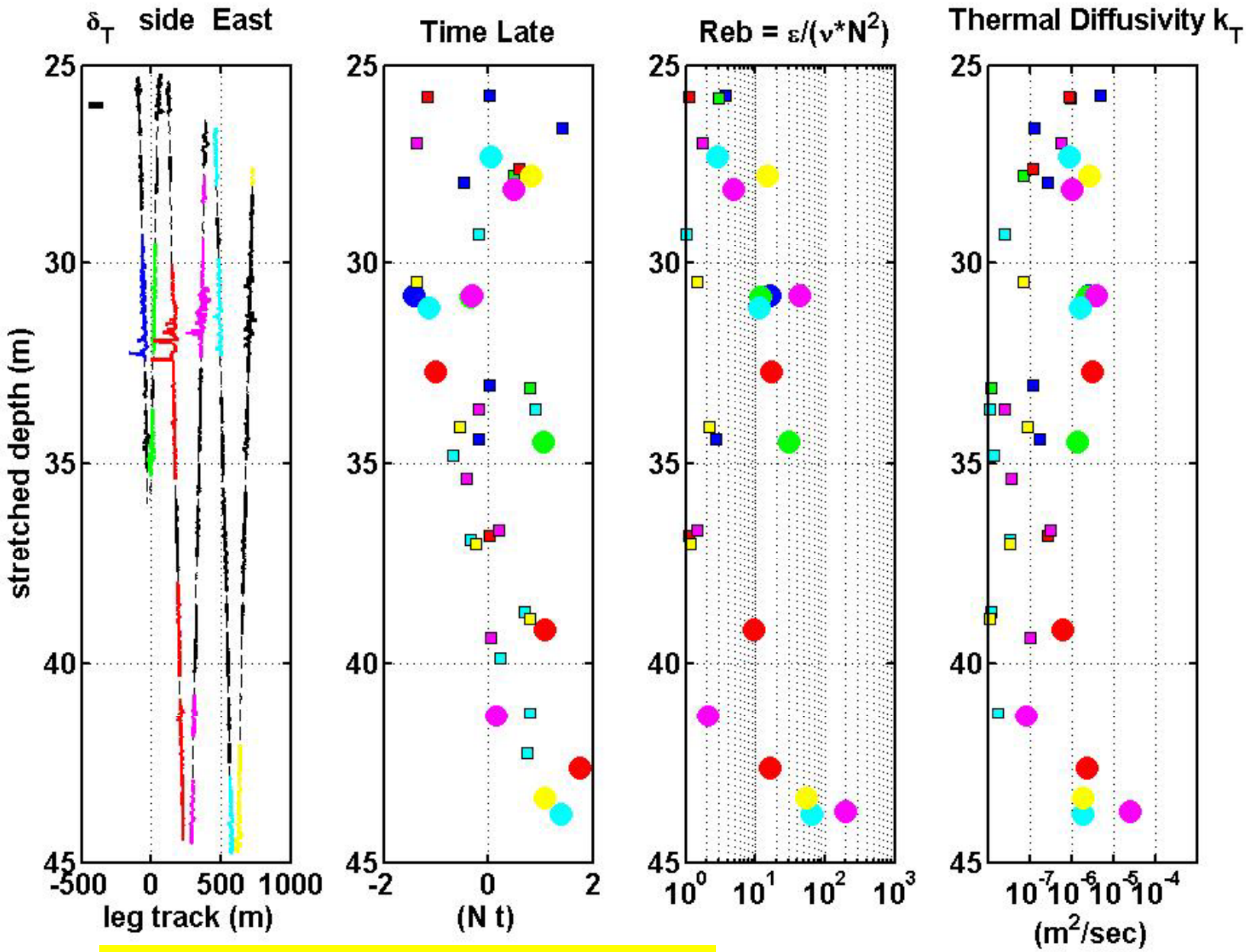

log10 ε (W/kg) 18 June 2011
depth(m)
24.6
24.8
25
25.2
0
5
10
downstream distance (km)
-7
-7.5
-8
-8.5
-9
-9.5
-10


log10 χ (oC)2/sec 18 June 2011
depth(m)
24.6
24.8
25
25.2
0
5
10
downstream distance (km)
-7
-7.5
-8
-8.5
-9
-9.5
-10

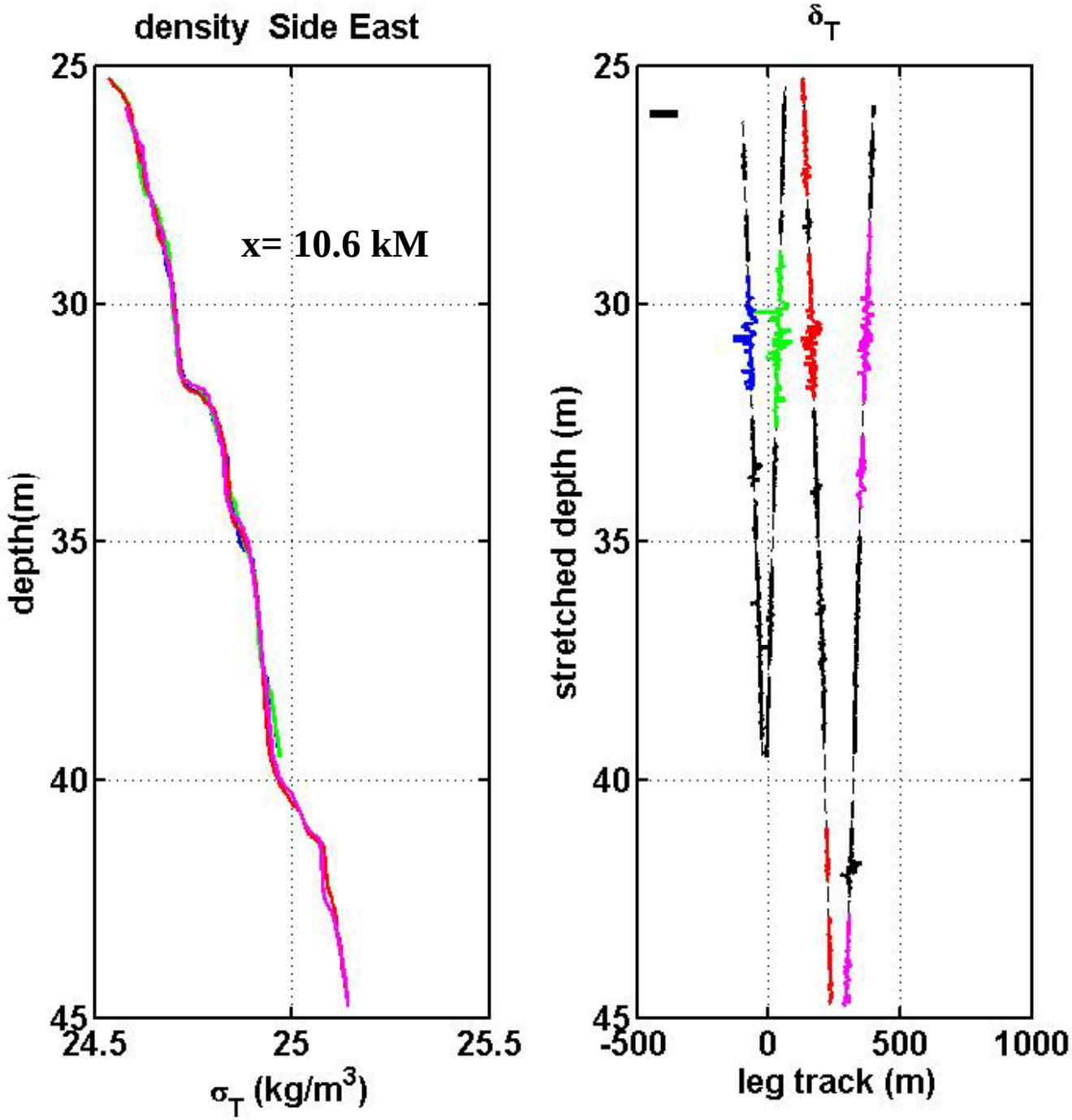


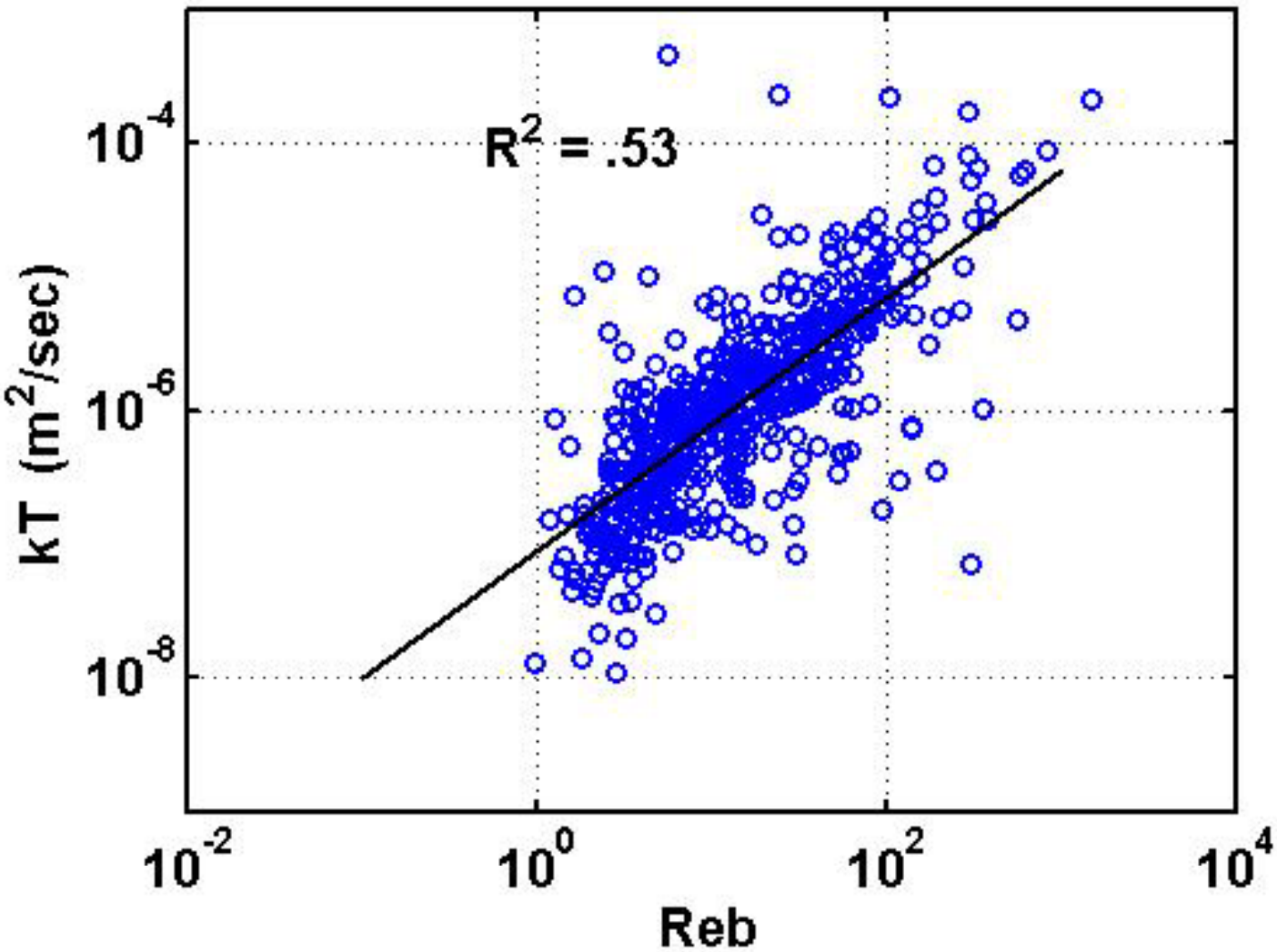
Turbulent Patch Criteria

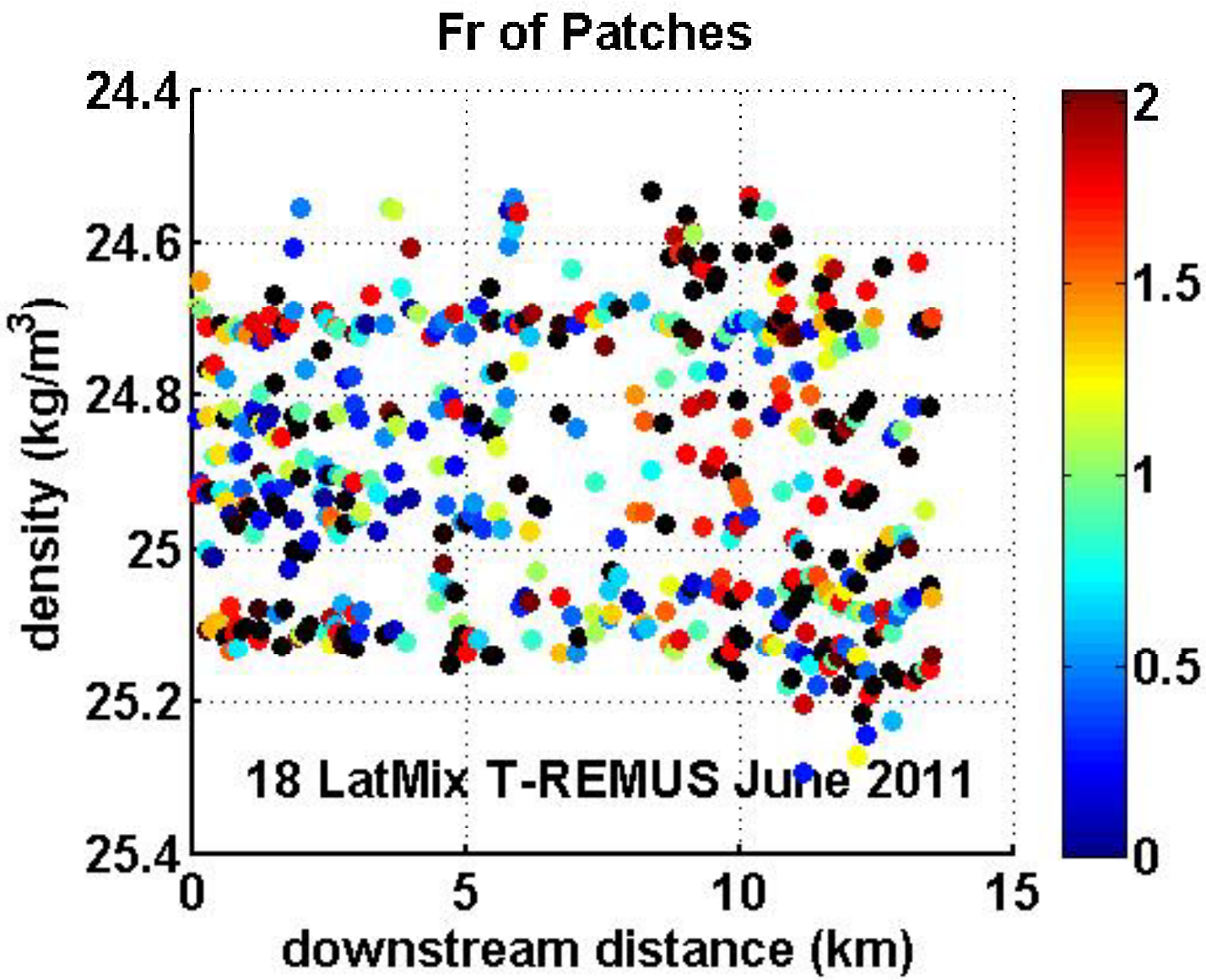
δ_T > 1.5 cm , Patch Extent, Δz > 30 cm, Patch Separation > 30 cm

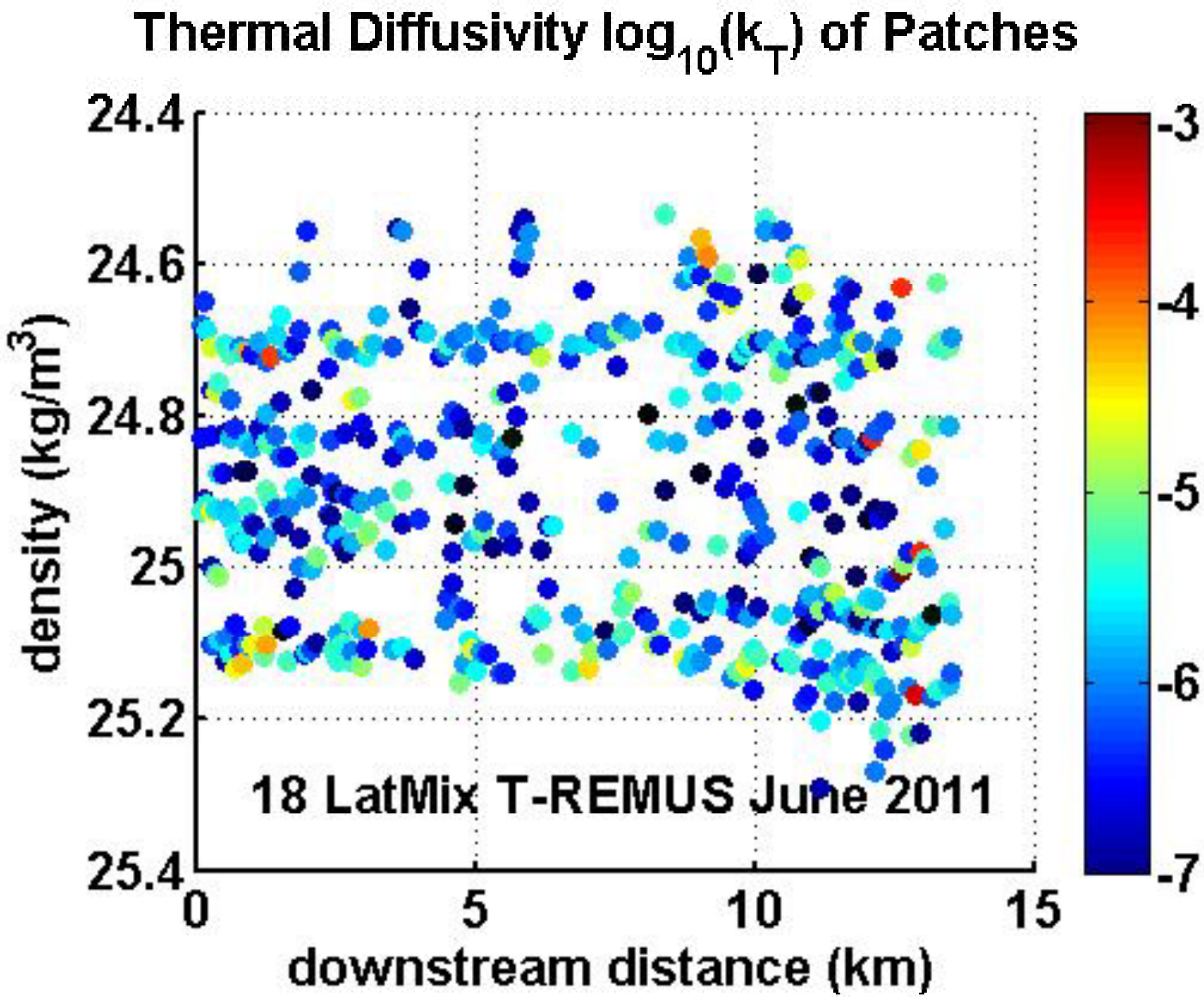


Analysis based on Smyth et al. (2001)

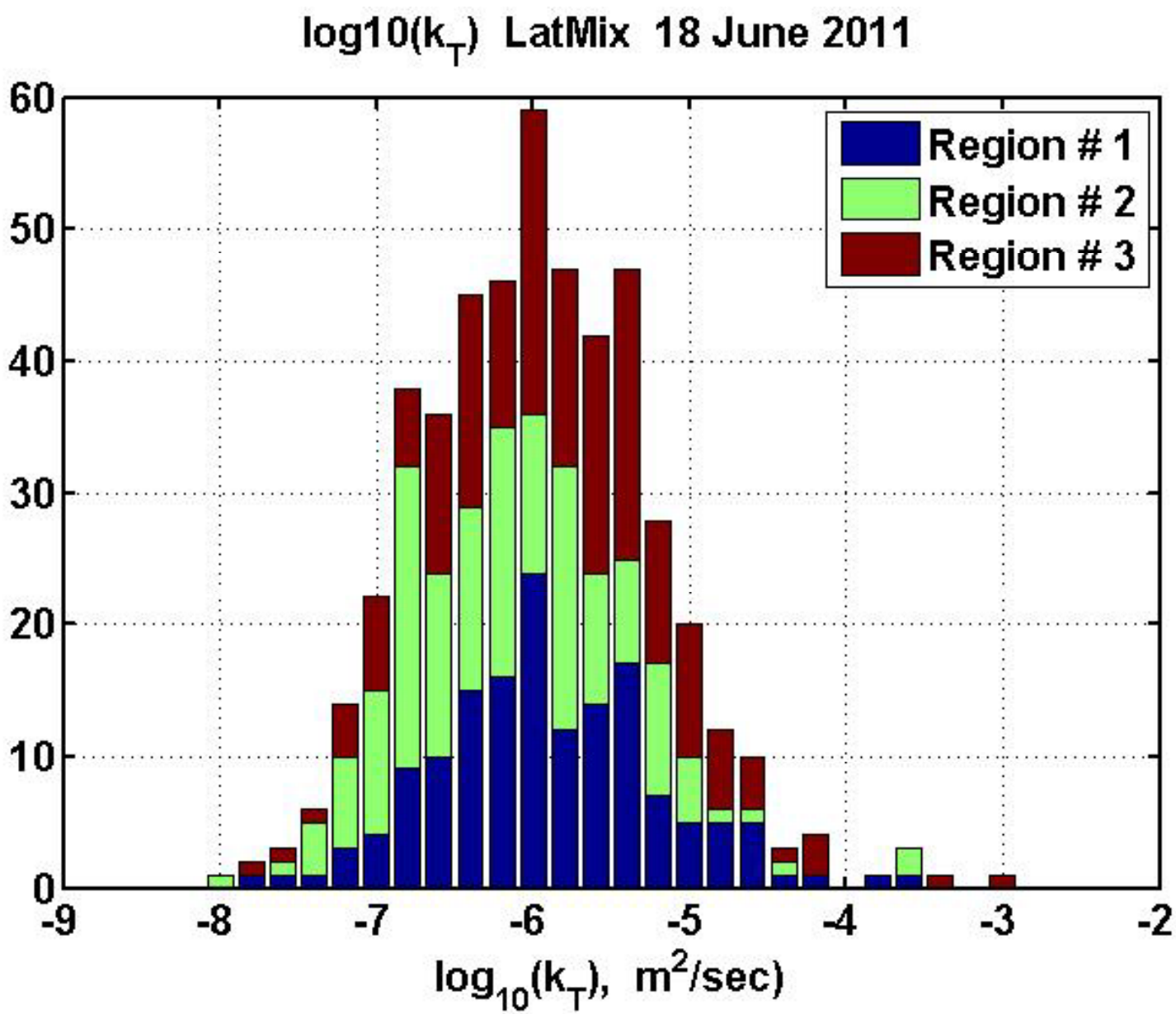

density Side East
x= 10.6 kM
depth(m)
25
30
35
40
45
24.5
25
25.5
σT (kg/m3)
δT
stretched depth (m)
-500
0
500
1000
leg track (m)


R^2 = .53
10^{-4}
10^{-6}
10^{-8}
kT (m^2/sec)
10^{-2}
10^{0}
10^{2}
10^{4}
Reb


Fr of Patches
density (kg/m3)
24.4
24.6
24.8
25
25.2
25.4
0
5
10
15
downstream distance (km)
18 LatMix T-REMUS June 2011
2
1.5
1
0.5
0



$$\langle (k_T) \rangle_{weighted} = 3.7 \times 10^{-6} \frac{m^2}{sec}$$


log10(k_T) LatMix 18 June 2011
Region # 1
Region # 2
Region # 3
60
50
40
30
20
10
0
-9
-8
-7
-6
-5
-4
-3
-2
log_10(k_T), m^2/sec)

Tentative Conclusions

18 June 2011 T-REMUS data (LatMix I, Site 2)

- **A cold fresh intrusion occurred at mid depth of the sampling.**
- **Turbulence was weaker within the intrusion and stronger at its edges.**
- **Patch vertical (cross isopcynal) scales ~1-3 meters.**
  Patch along isopycnal scales , at time, > 500 m.
- **Diathermal diffusivity of order 4.0 e-6 m^2/sec.**
- **A sharp change in density occurred at x =11 km (submesoscale front?) beyond which ε increased.**

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