EVOLUTION AND COLLAPSE OF ARABIAN SEA WARM POOL AND ITS SENSITIVITY TO INTERANNUALLY VARYING SURFACE FORCING

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Objective

Introduction

Model

Results

Conclusion

Objectives

- **To understand the processes associated With the evolution and collapse of warm pool.**
- **To understand the interannual variability in the warm pool.**
- **To compare the warm pool structure during contrasting monsoons 2002 and 2003.**
- To study the inversions form in the SEAS.

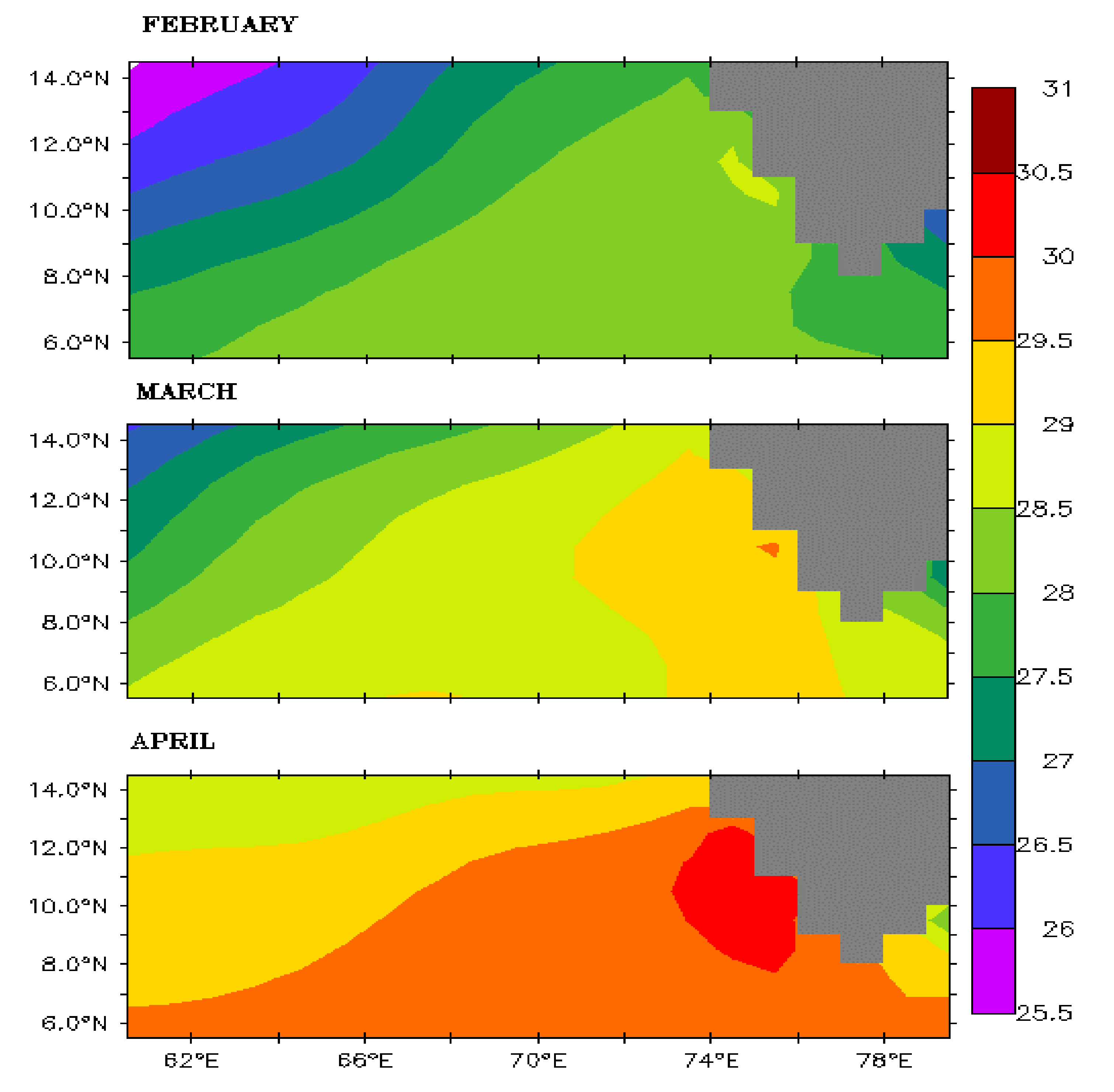
Introduction

- SEAS warm pool forms in early March and peaks in May and collapses with the onset of SW monsoon.
- ARMEX observations show 20m thick barrier layer (BL)
- BL inhibits entrainment cooling of the mixed layer and traps momentum flux (Vialard & Delecluse, 1998).
- BL annihilates in May by upwelling and inflow of high salinity water from north.
- Lakshadweep High (LH), a high in sea level occur in the SEAS during Nov to Jan.
- Downwelling associated with LH and the low salinity surface water provide a stable breeding ground for warm pool formation (Shenoi et al. 1999).

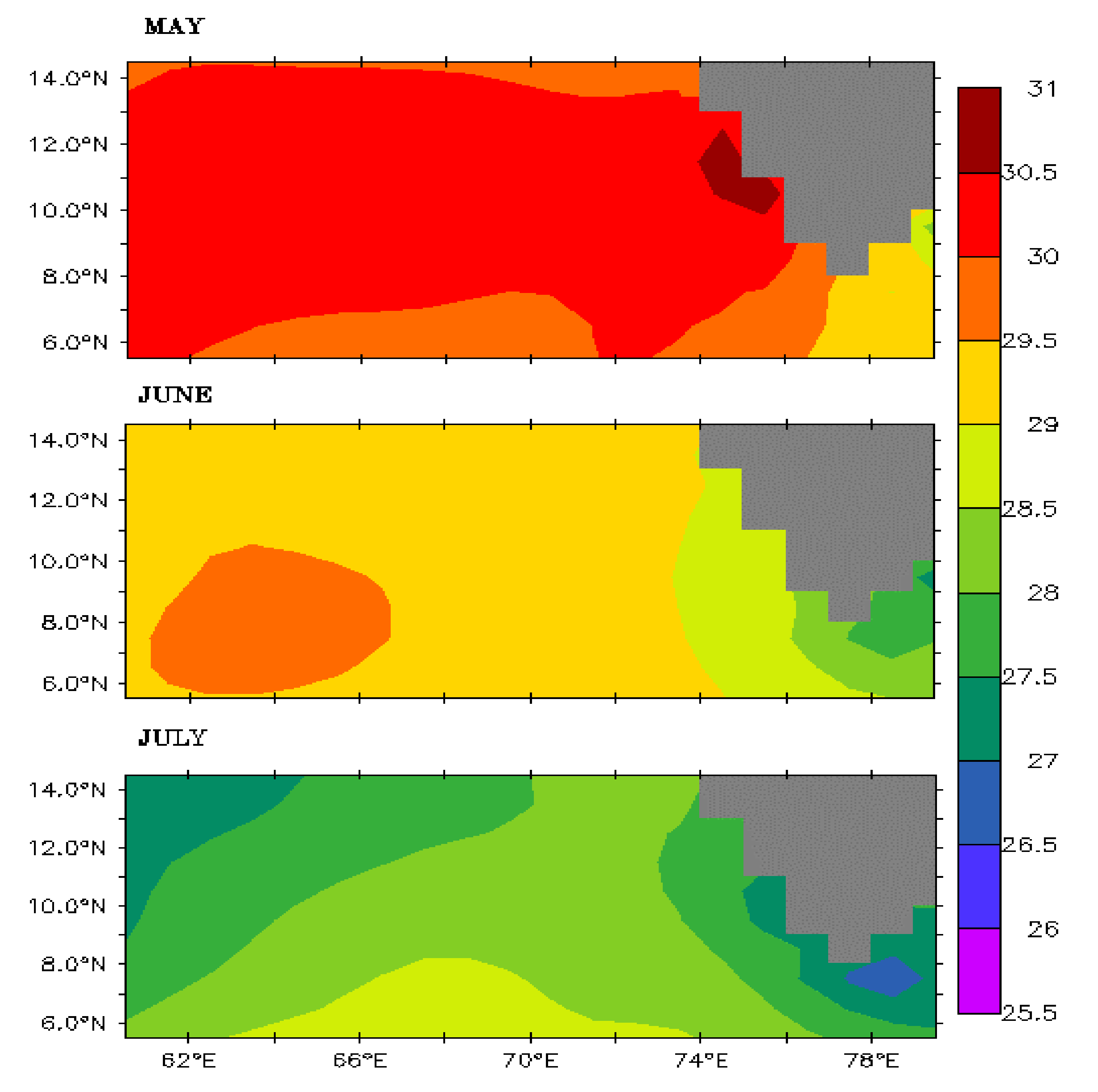
Model

- The model used is Princeton Ocean Model (POM)
- Three dimensional sigma co-ordinate, free surface Primitive equation model.
- Domain 35^{o} E to 115^{o} E and 20^{o} S to 25^{o} N
  Horizontal resolution of 1^{o} x 1^{o}
- Vertical 21 sigma levels

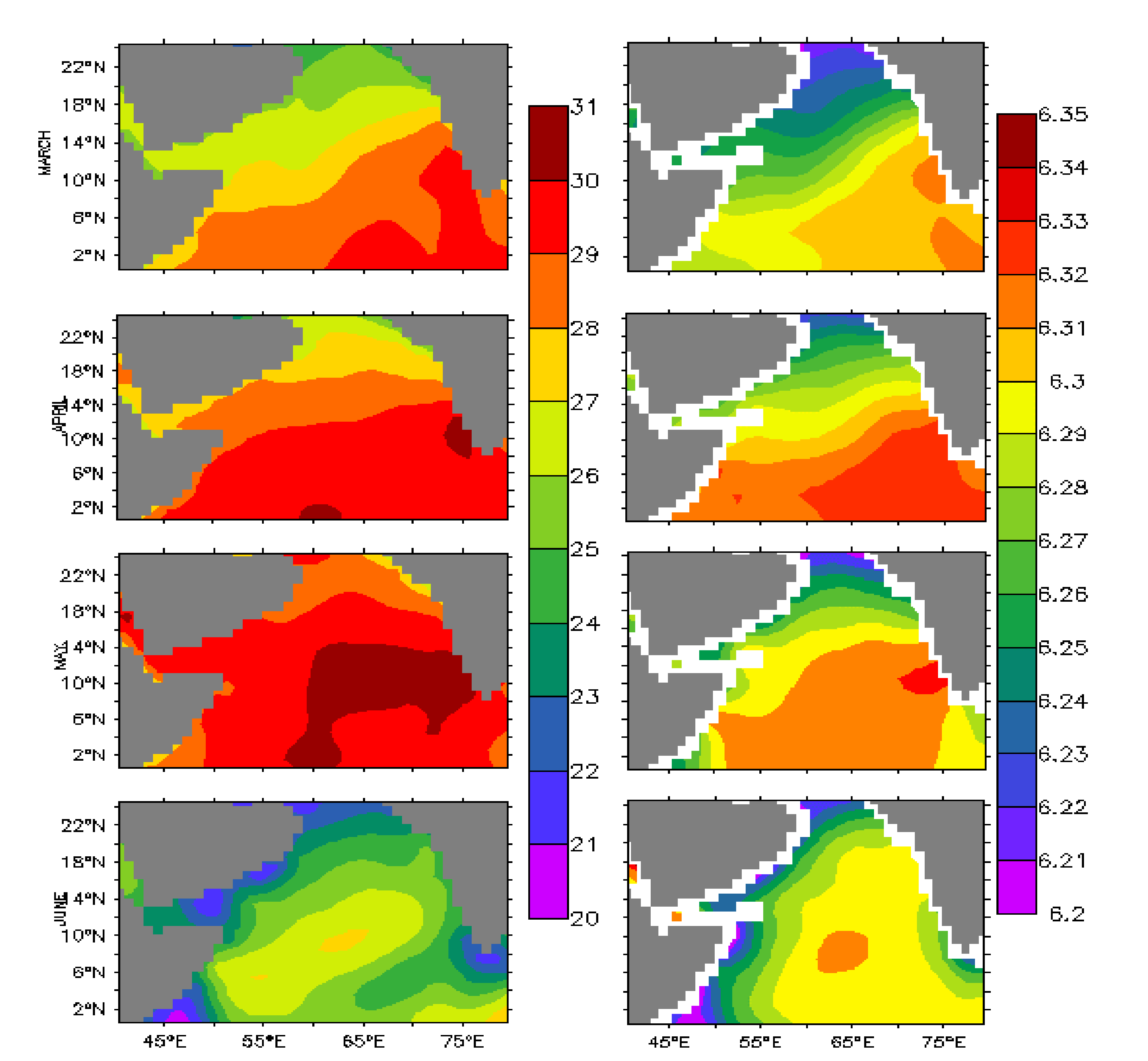
MONTHLY TEMPERATURE CLIMATOLOGY (LEVITUS 98)



MONTHLY TEMPERATURE CLIMATOLOGY (LEVITUS 98)



CLIMATOLOGICAL SST (LEFT) & 50 m HEAT CONTENT (RIGHT) 10^{10}

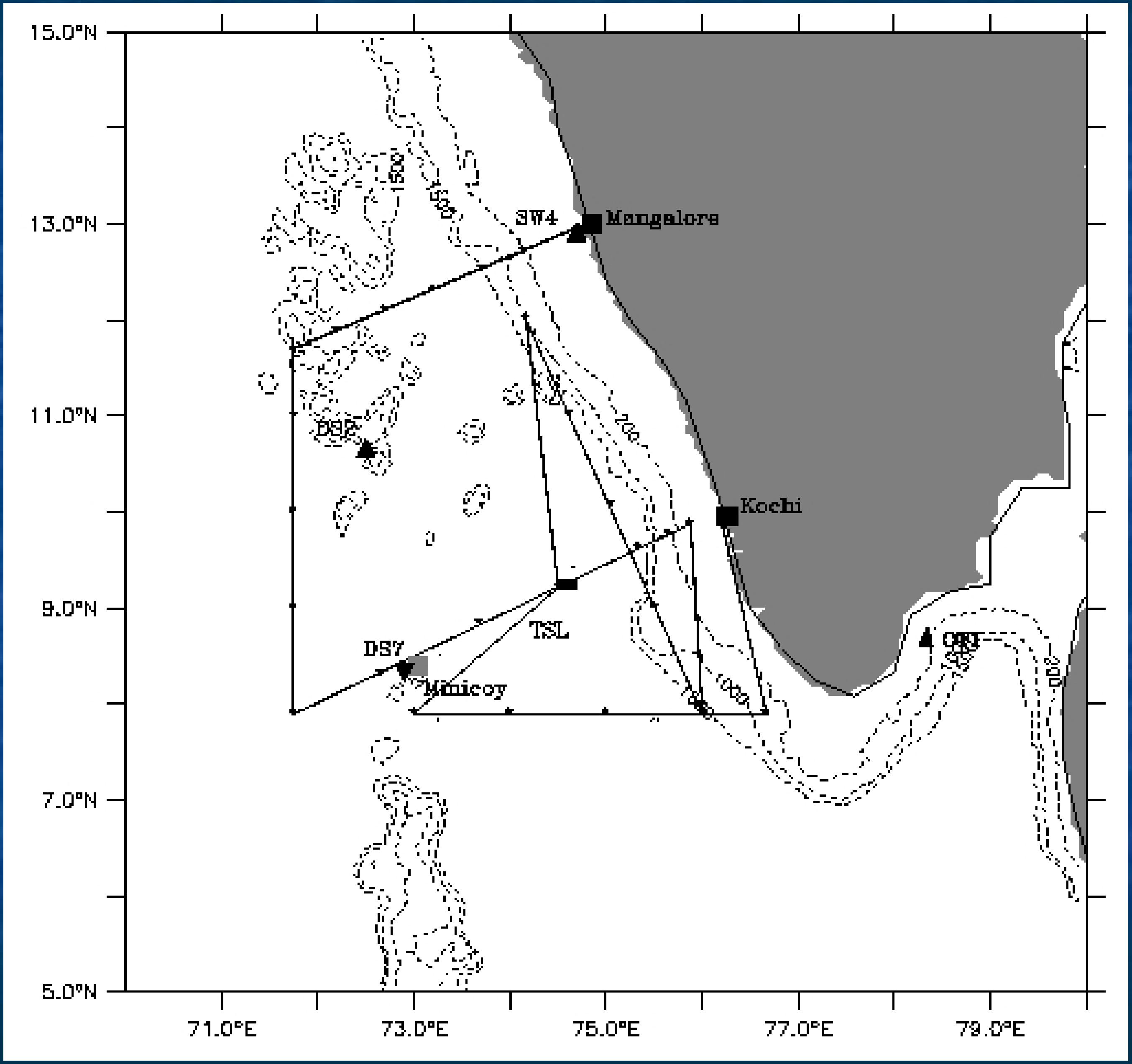


ARMEX 2003 (March –April)

Cross sections

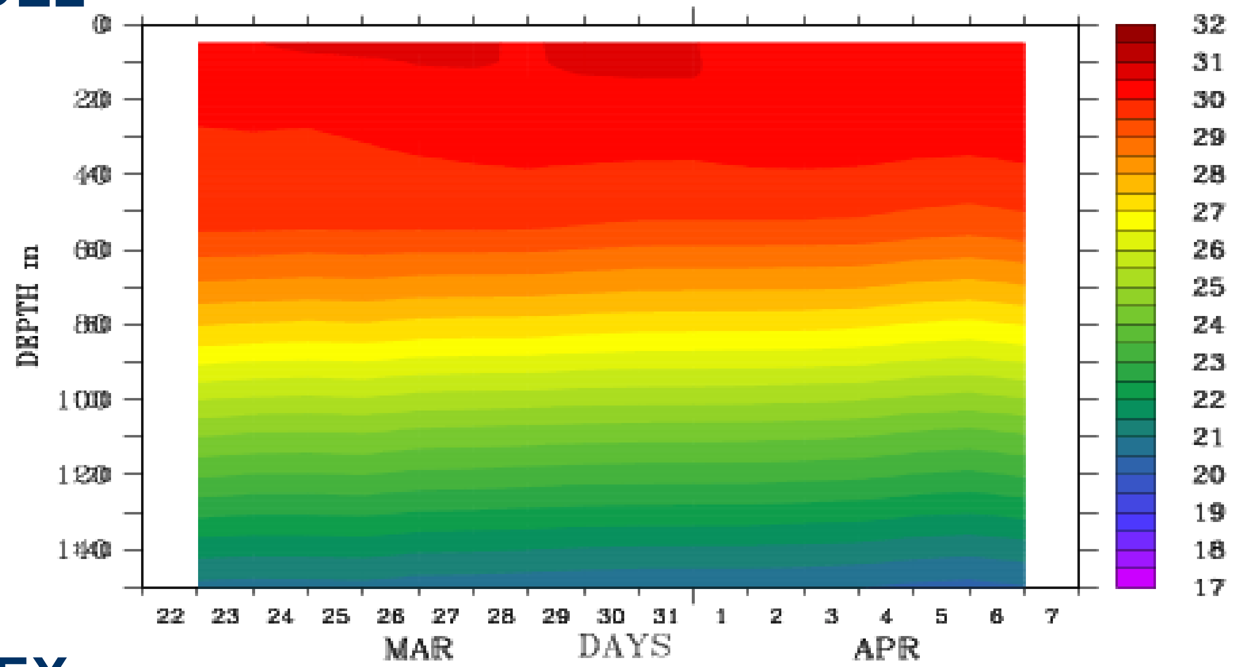
&

Time series

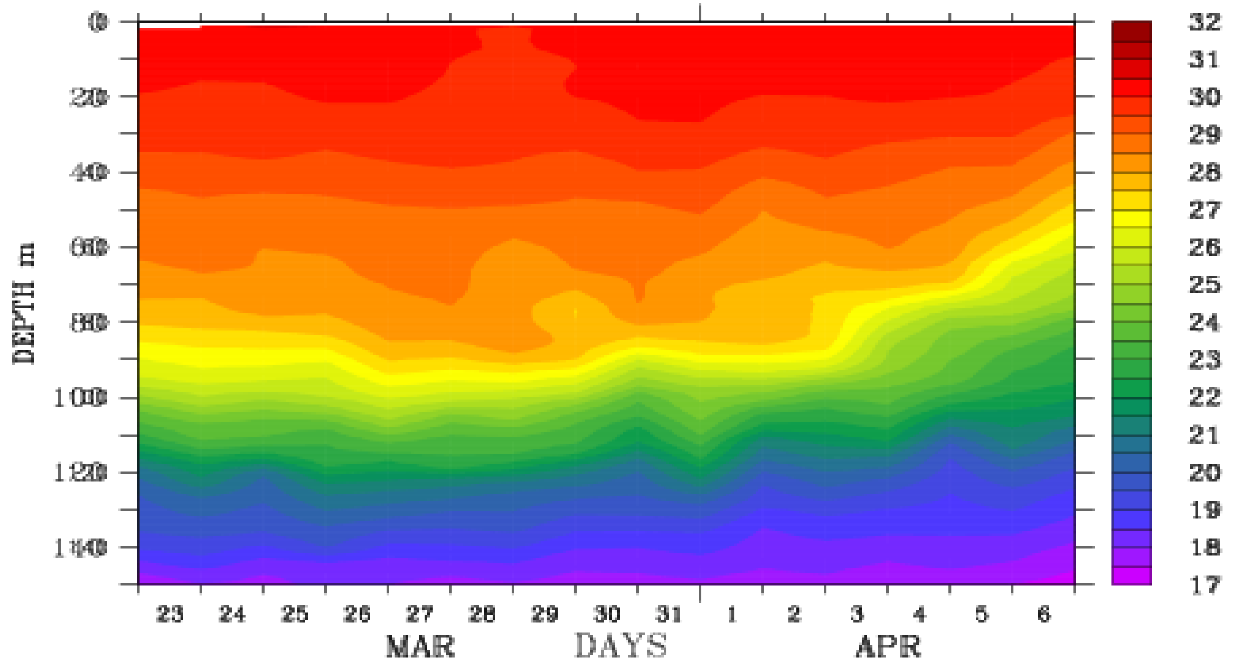


TIME – DEPTH SECTION OF TEMPERATURE AT TSL

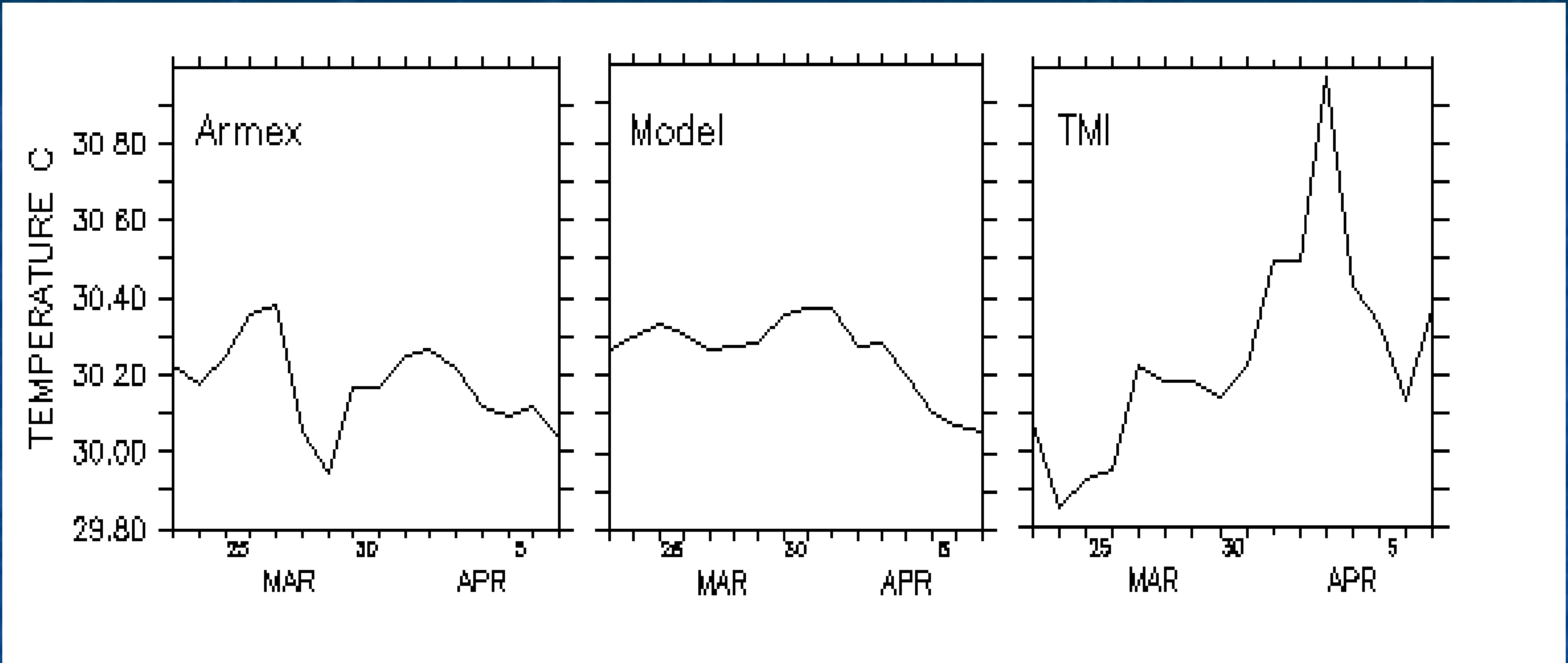
MODEL



ARMEX

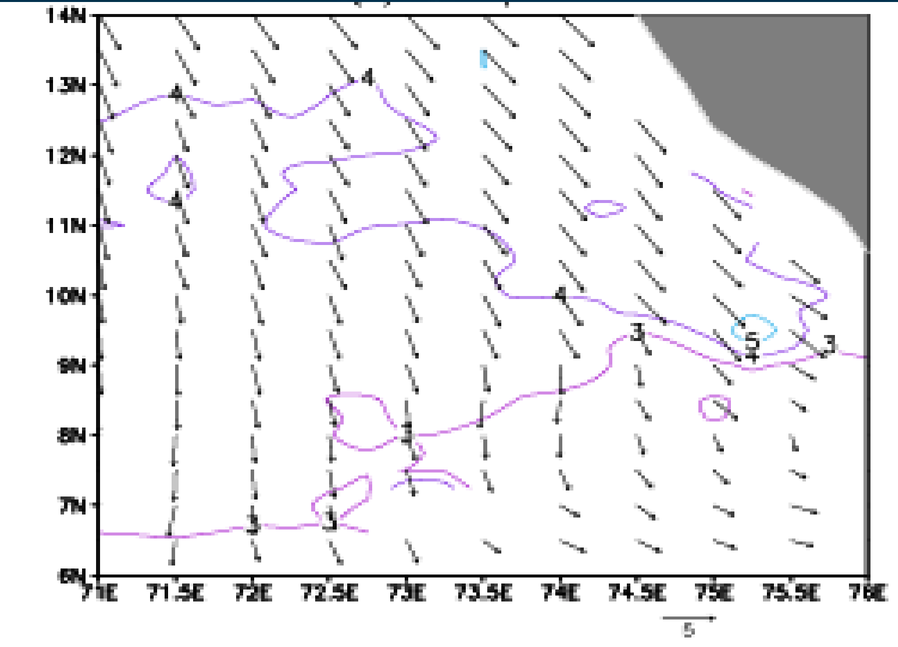


SST Comparison at TSL (9.21ºN, 74.5ºE)

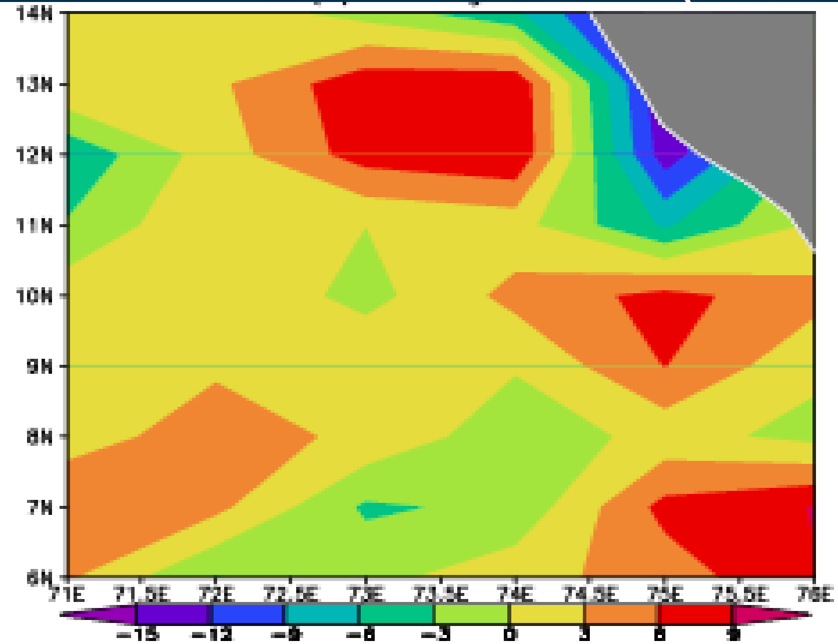


MARCH 25 – 31, 2003

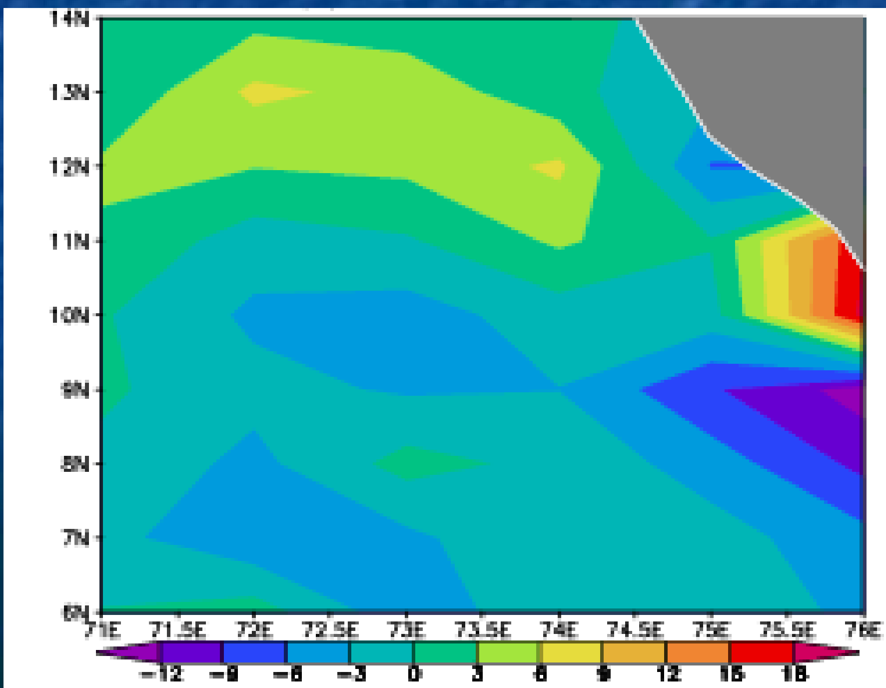
WIND PATTERN



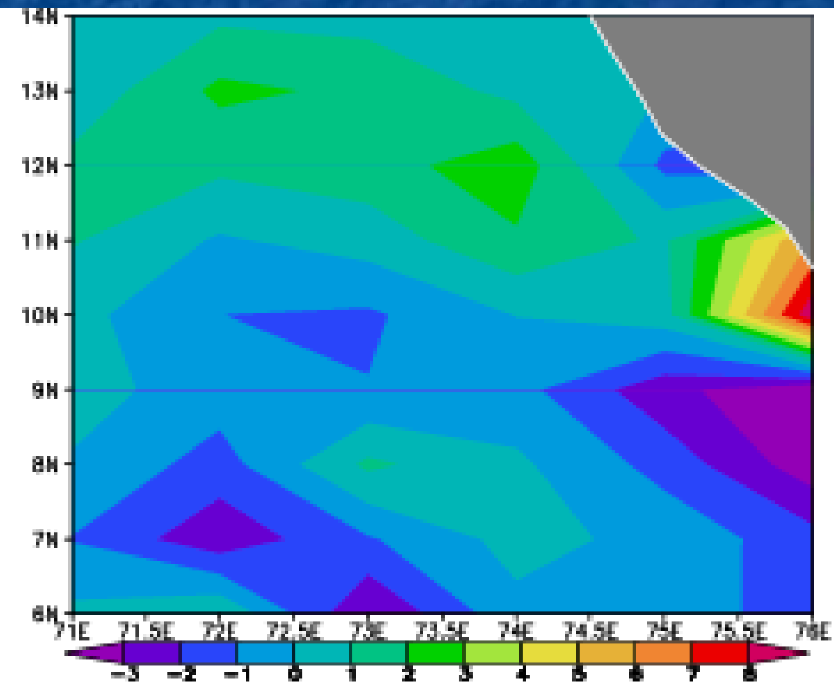
DIVERGENCE (10^{-6} /S



CURL OF WIND STRESS (10^{-8} Nm^3)

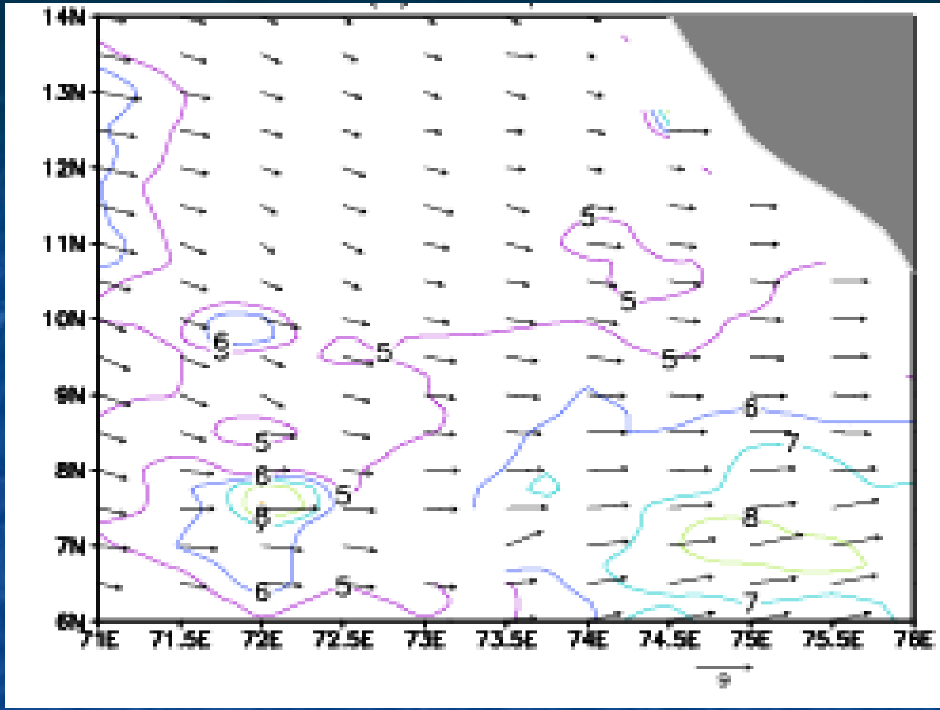


VERTICAL VELOCITY (10^{-6} m/s)

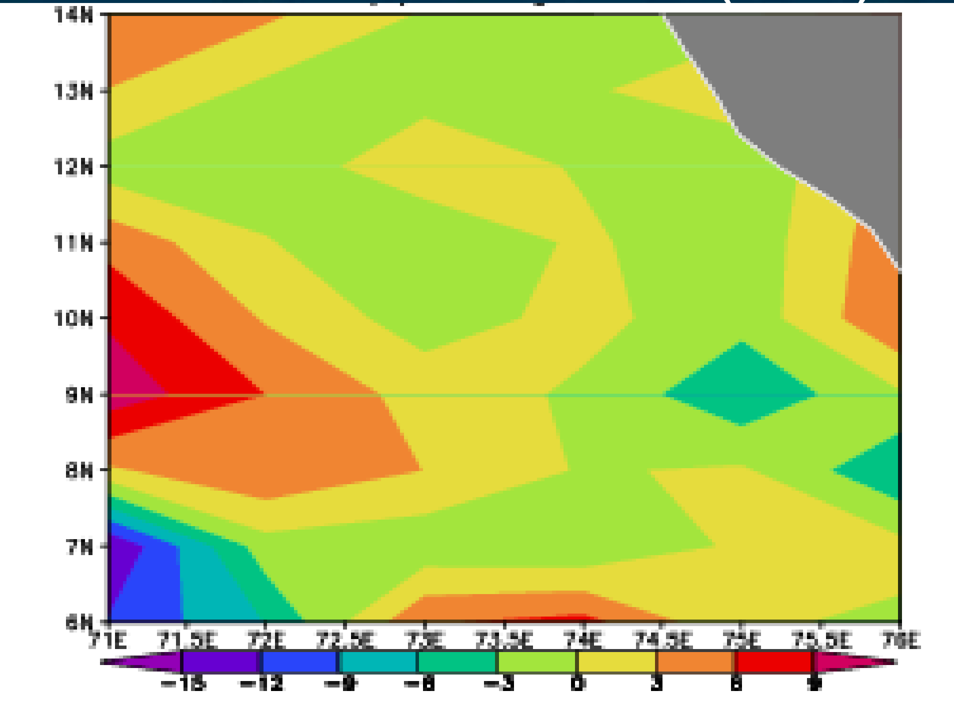


MAY 25 – 31, 2003

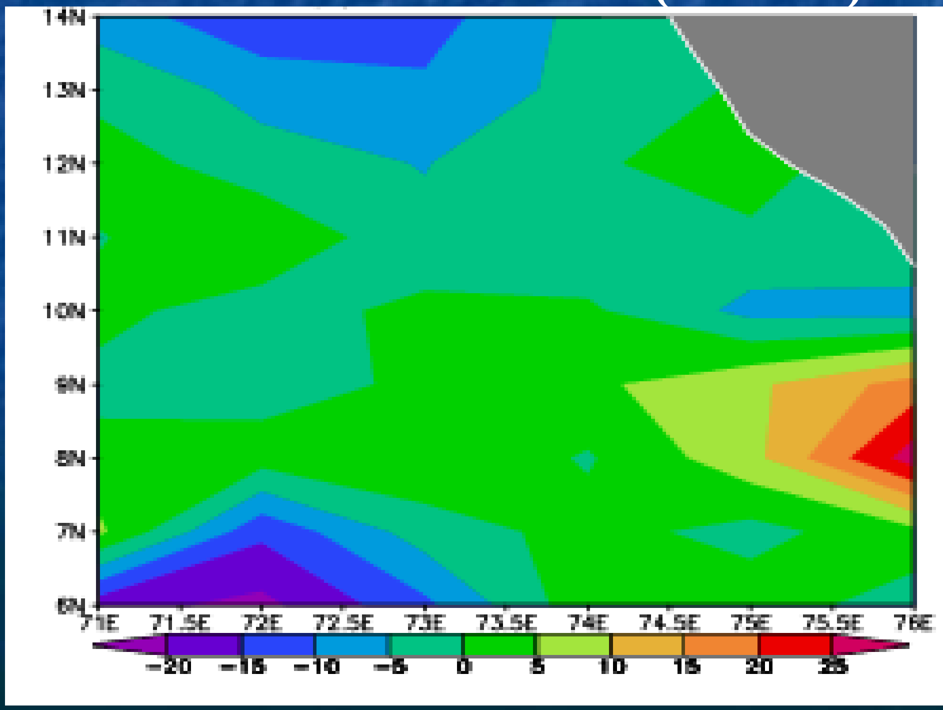
WIND PATTERN



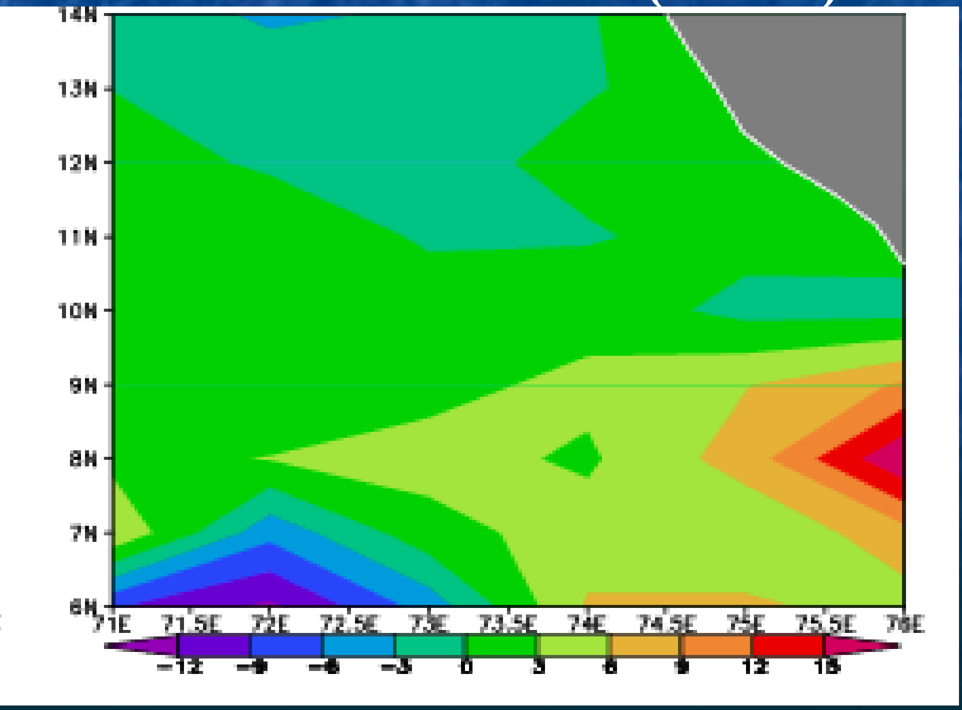
DIVERGENCE (10^{-6} /s)



CURL OF WIND STRESS (10^{-8} Nm^3)

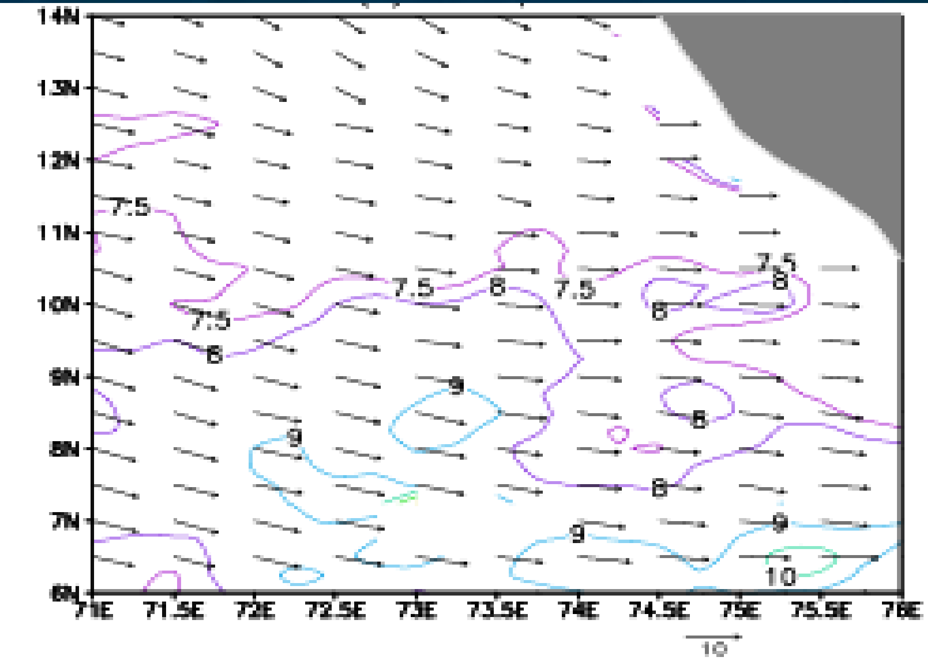


VERTICAL VELOCITY (10^{-6} m/s)

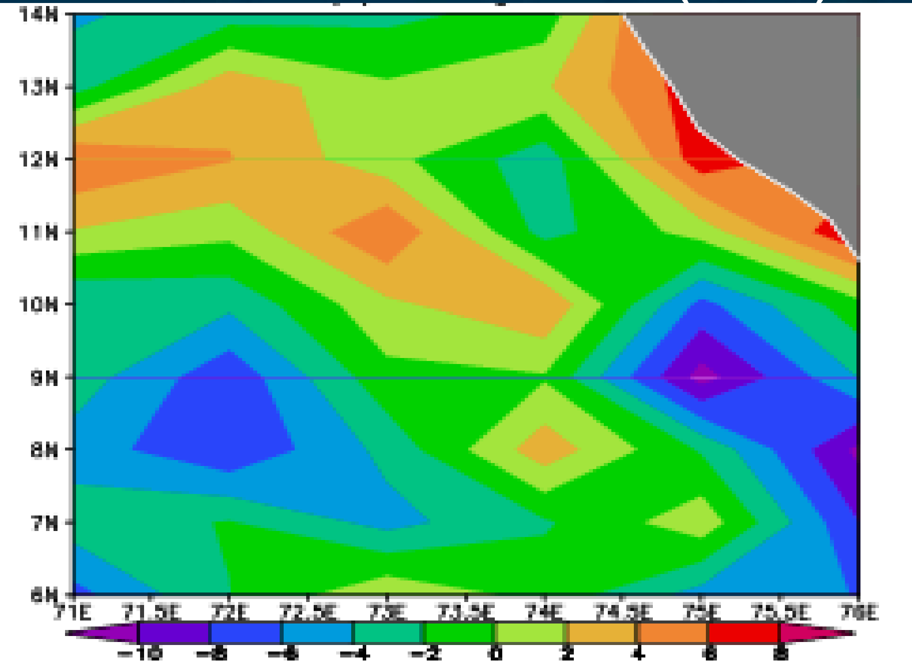


JUNE 1 - 7, 2003

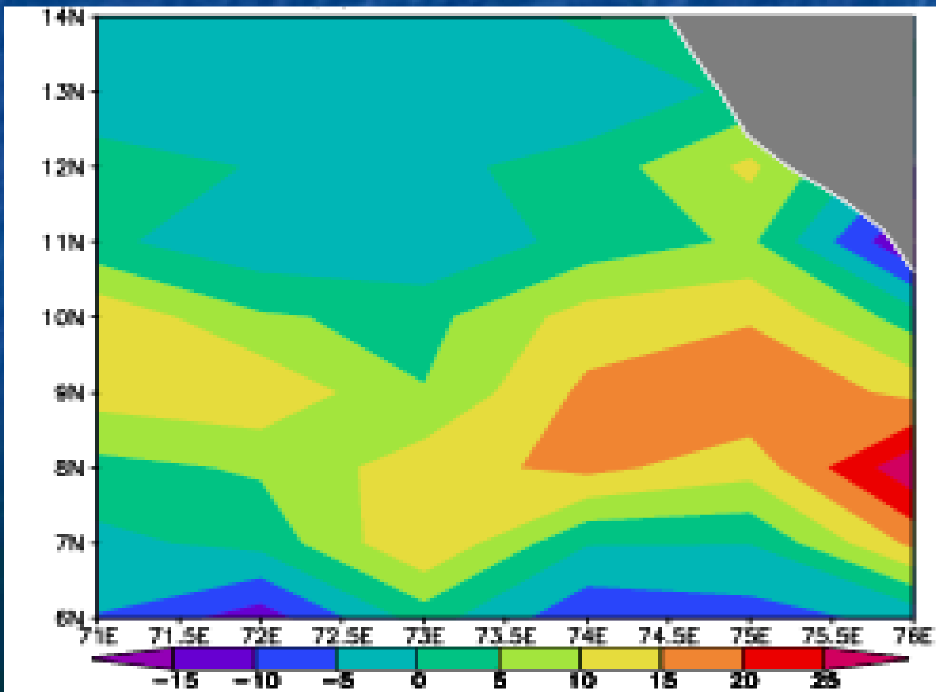
WIND PATTERN



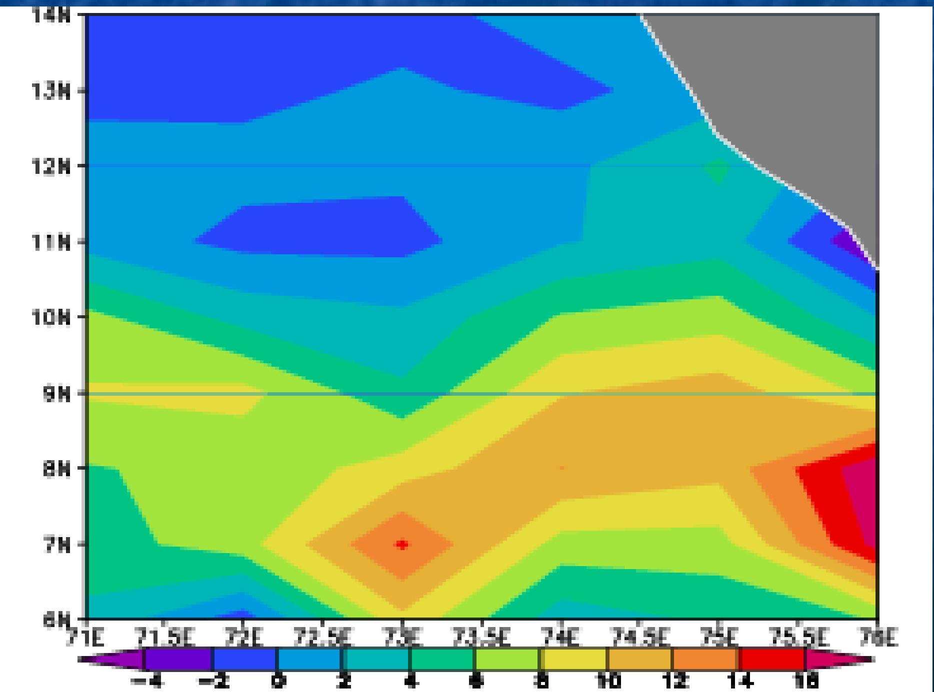
DIVERGENCE (10^{-6} /s)



CURL OF WIND STRESS (10^{-8} Nm^3)

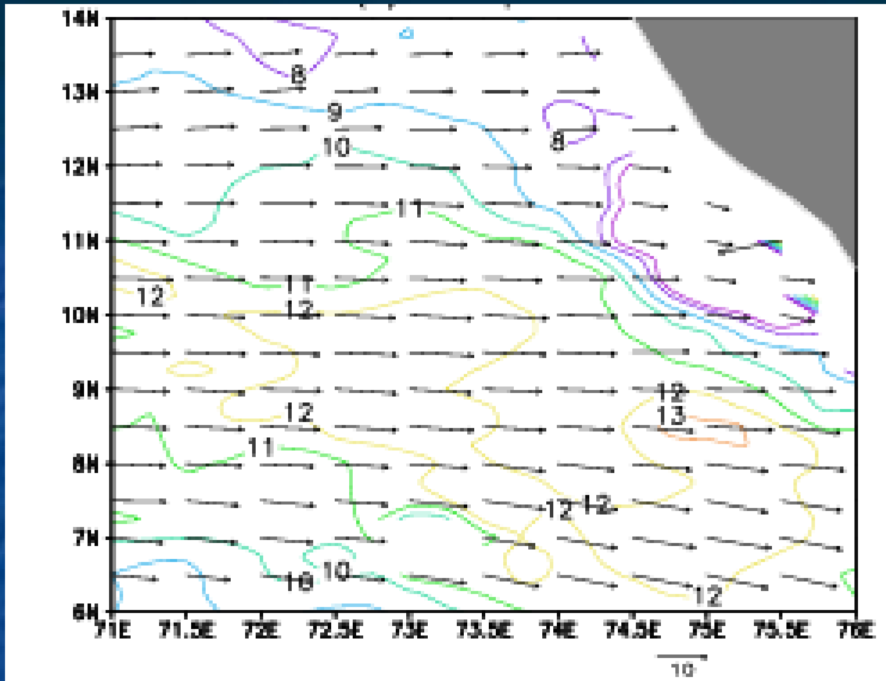


VERTICAL VELOCITY (10^{-6} m/s)

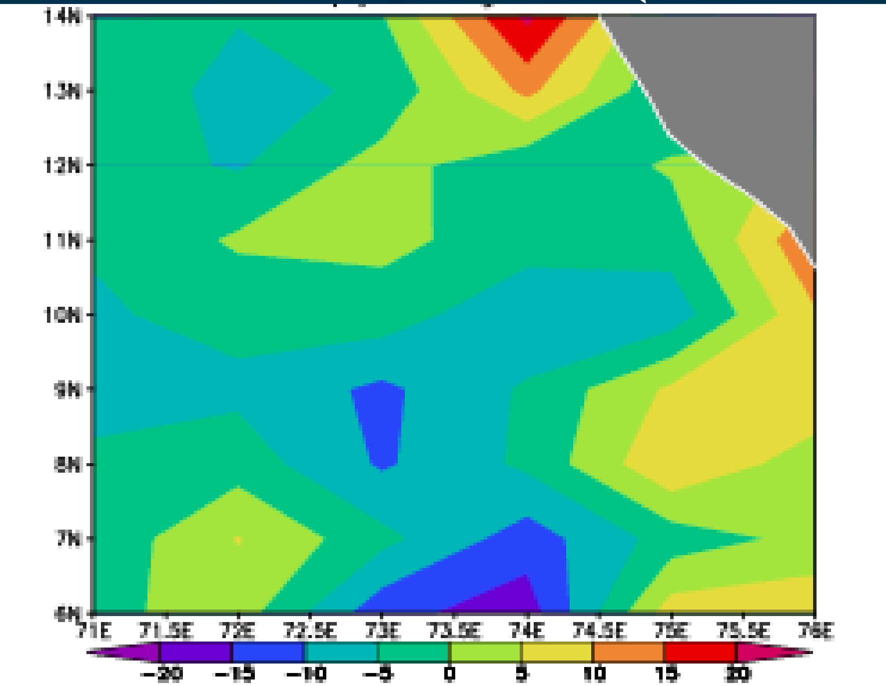


JUNE 8 - 14, 2003

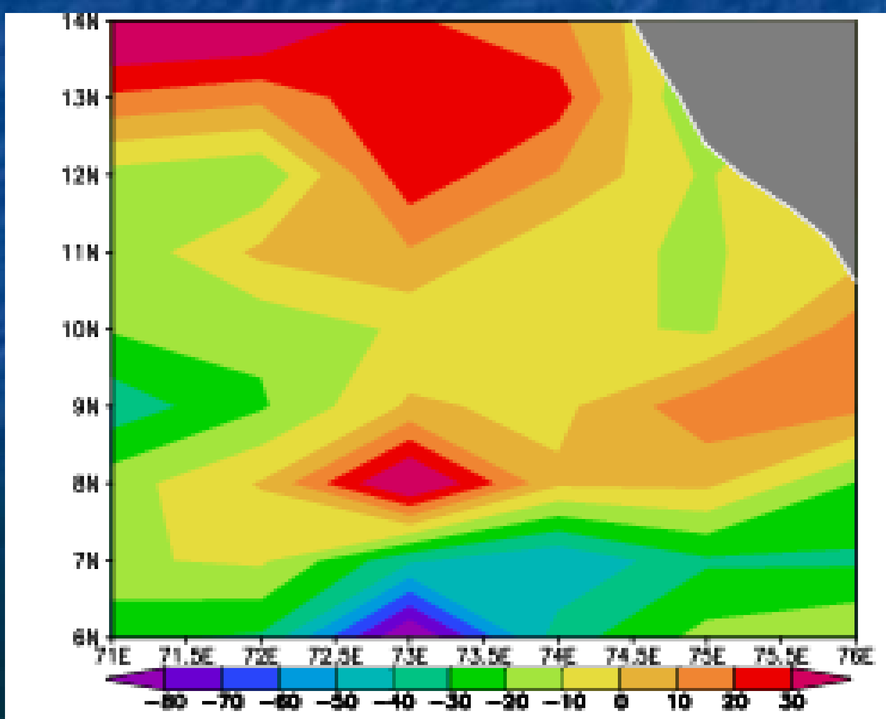
WIND PATTERN



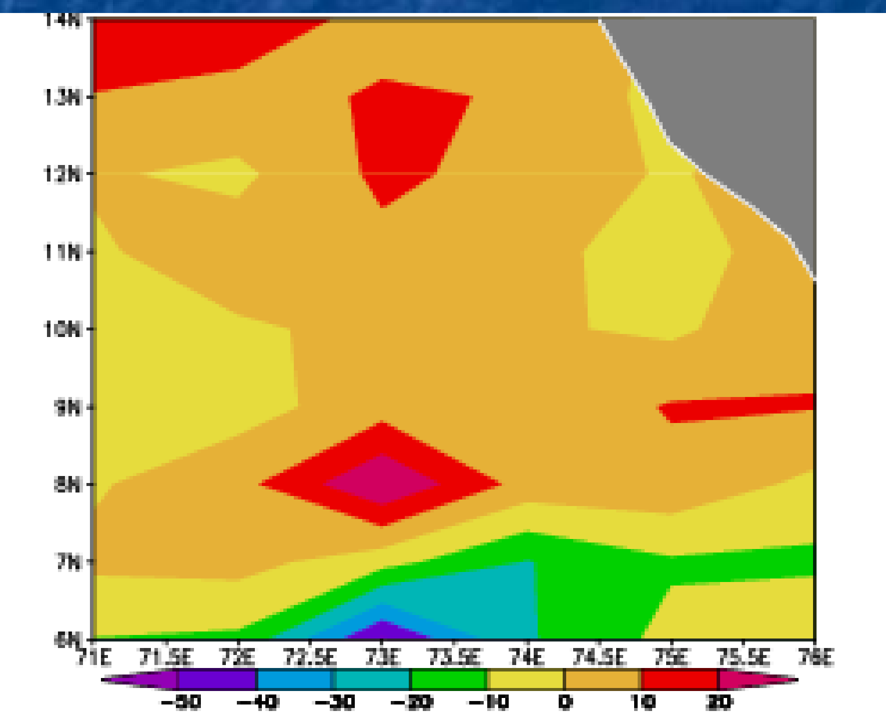
DIVERGENCE (10^{-6} /S



CURL OF WIND STRESS (10^{-8} Nm^3)

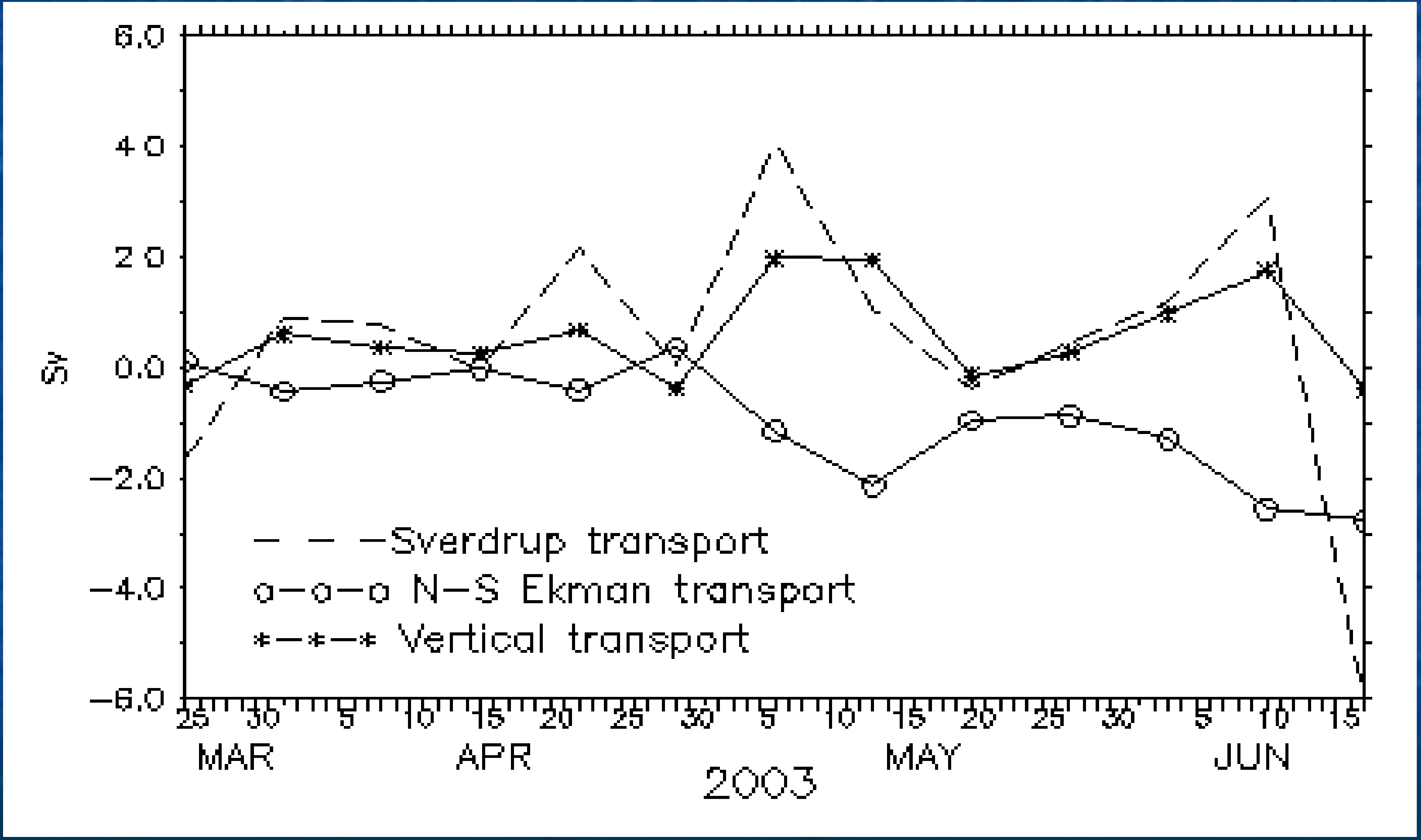


VERTICAL VELOCITY (10^{-6} m/s)

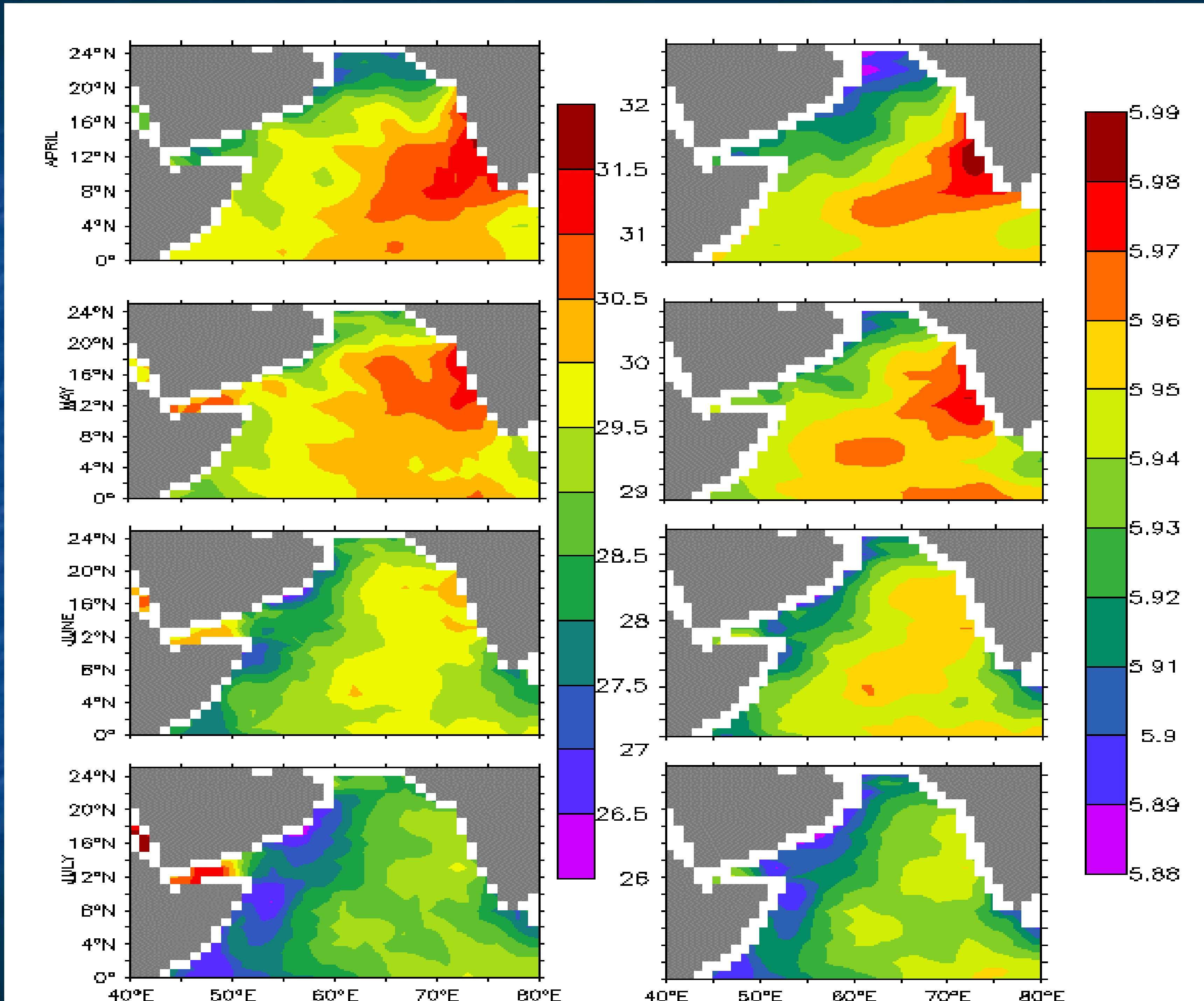


Wind driven Transport along 8.5º N (integrated between 65º E to 75º E)

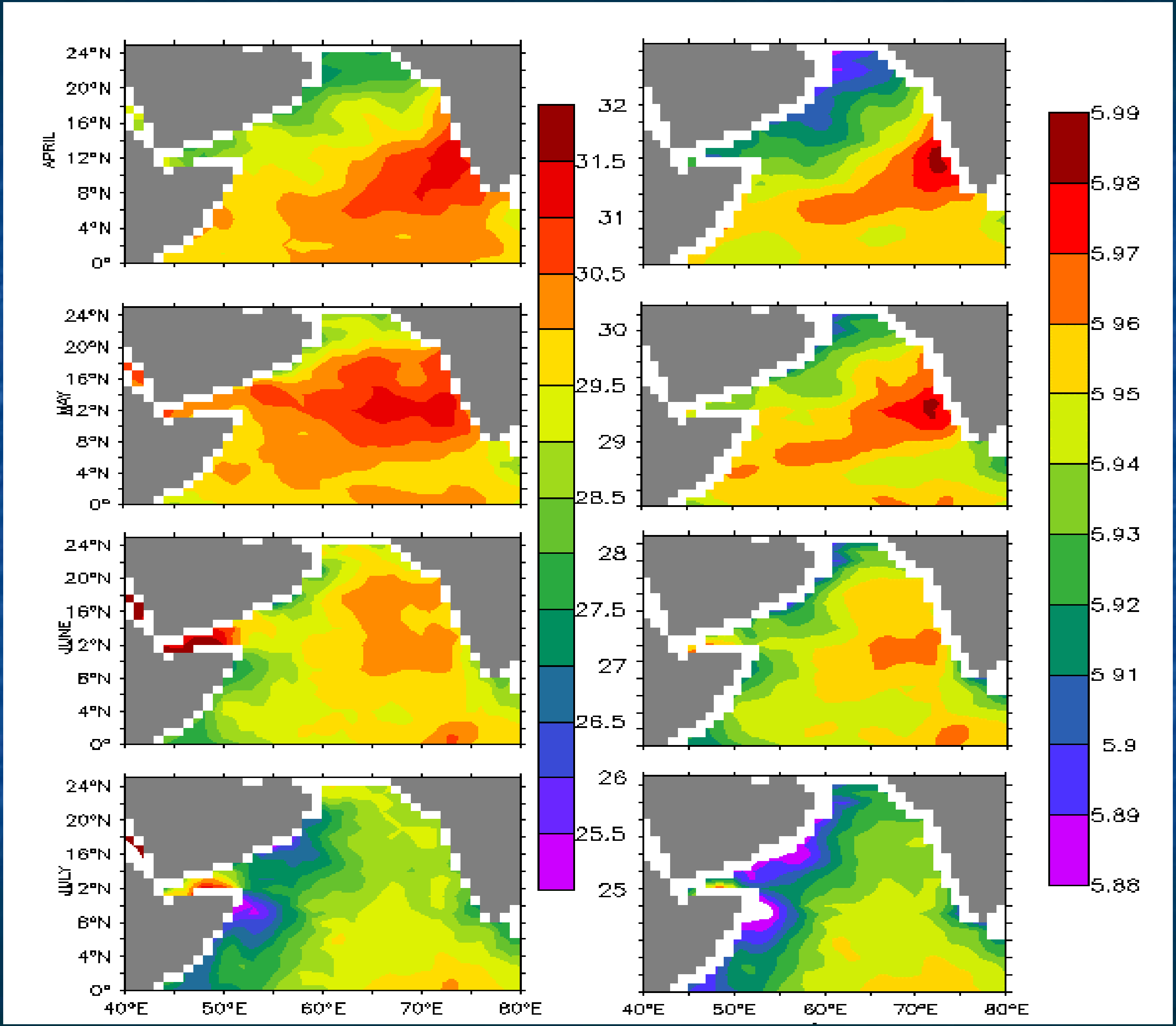
Vertical transport (8º N to 14º N 65º E to 75º E)



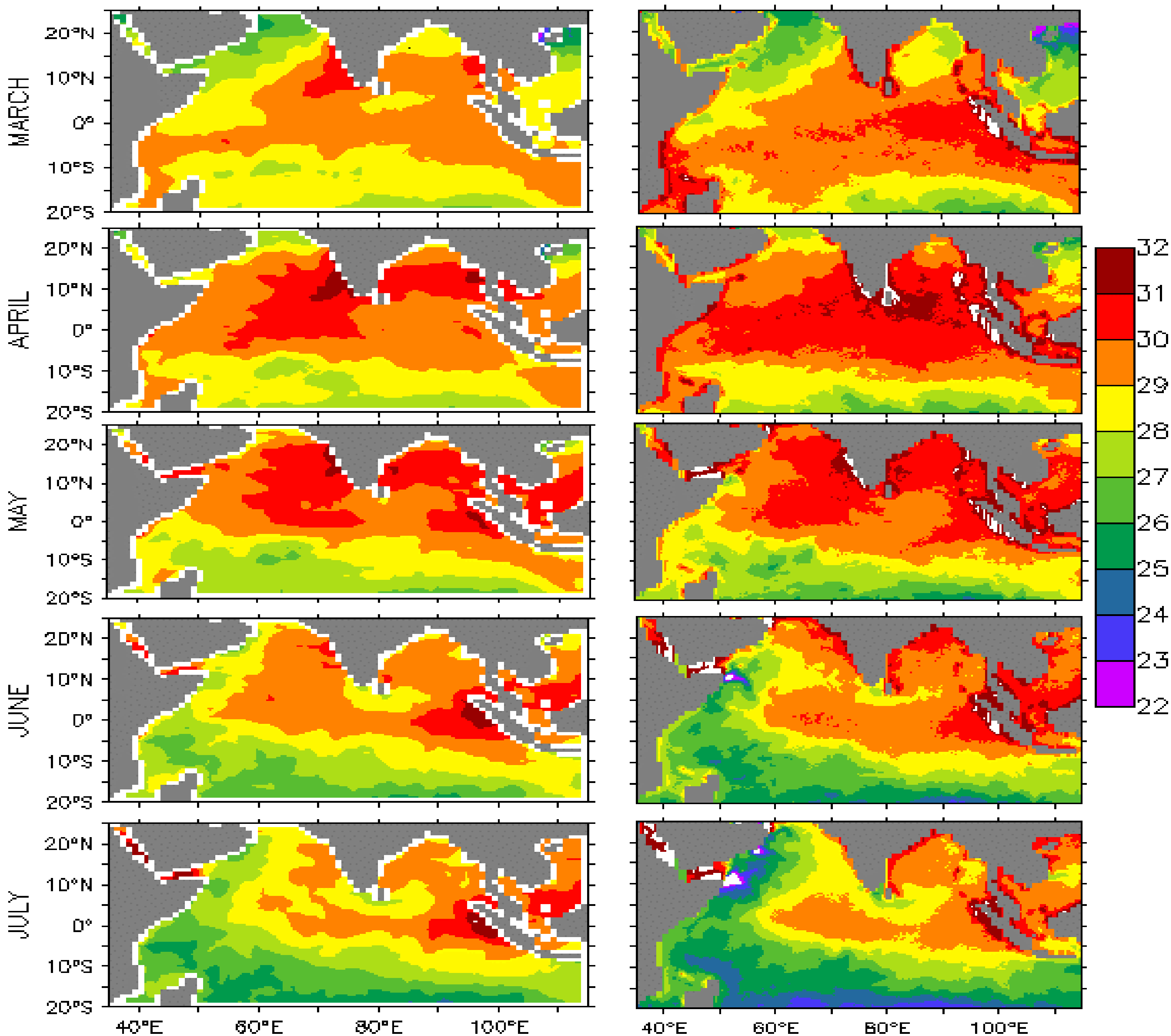
MODEL 2002 SST (LEFT) & 50 m HEAT CONTENT (10^{10} J/m^2) (RIGHT)



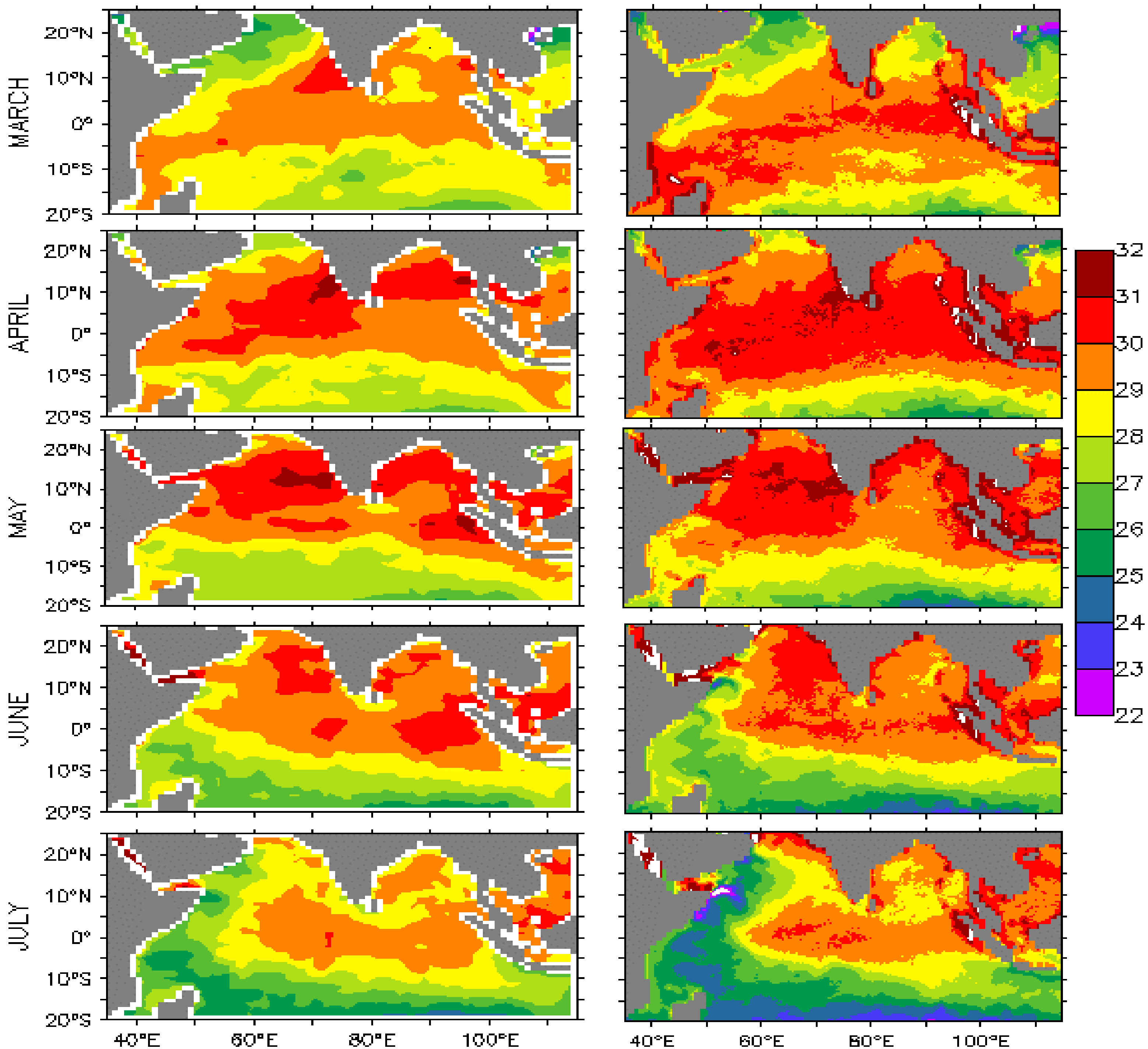
MODEL 2003 SST (LEFT) & 50 m HEAT CONTENT 10^{10} J/m^2 (RIGHT)



2002 SST MODEL (LEFT) & TMI (RIGHT)

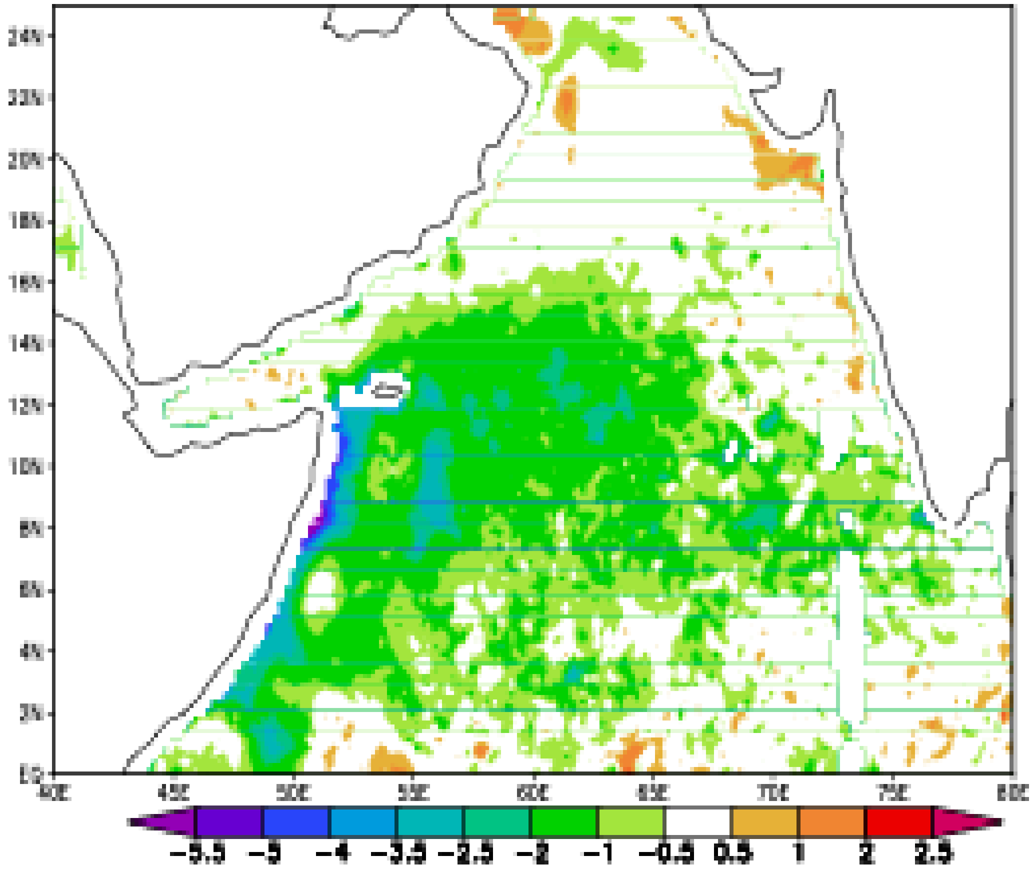


2003 SST MODEL (LEFT) & TMI (RIGHT)

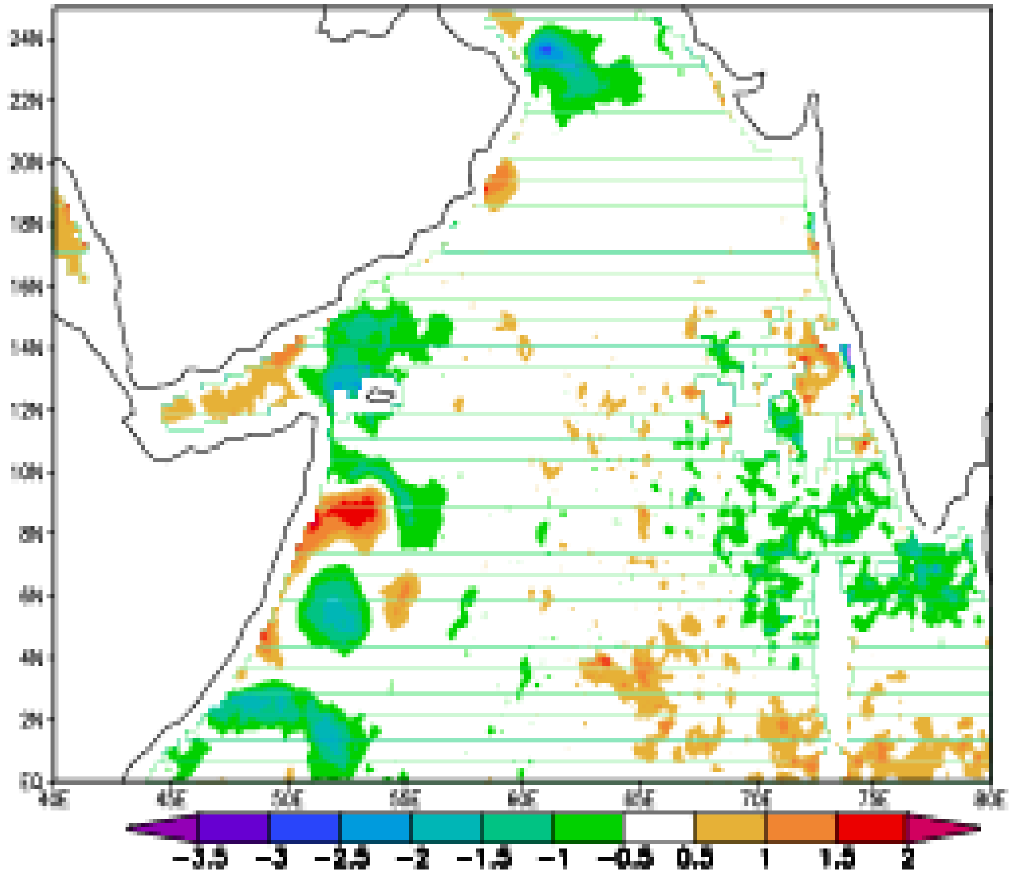


DIFFERENCE OF TMI SST BEFORE AND AFTER ONE WEEK OF ONSET OF SW MONSOON DATE

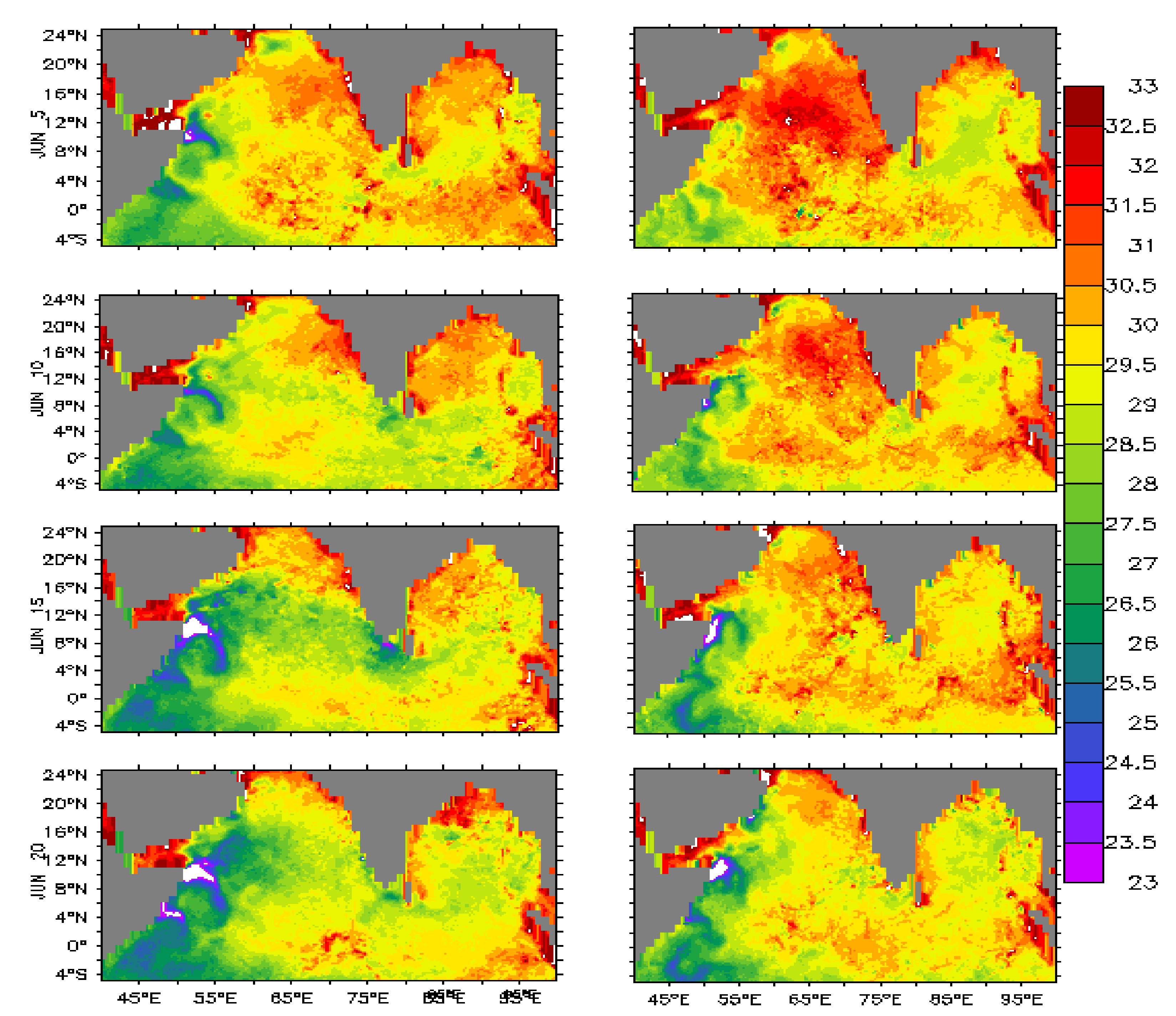
2003 June avg. (9 – 15) - (1 – 7)



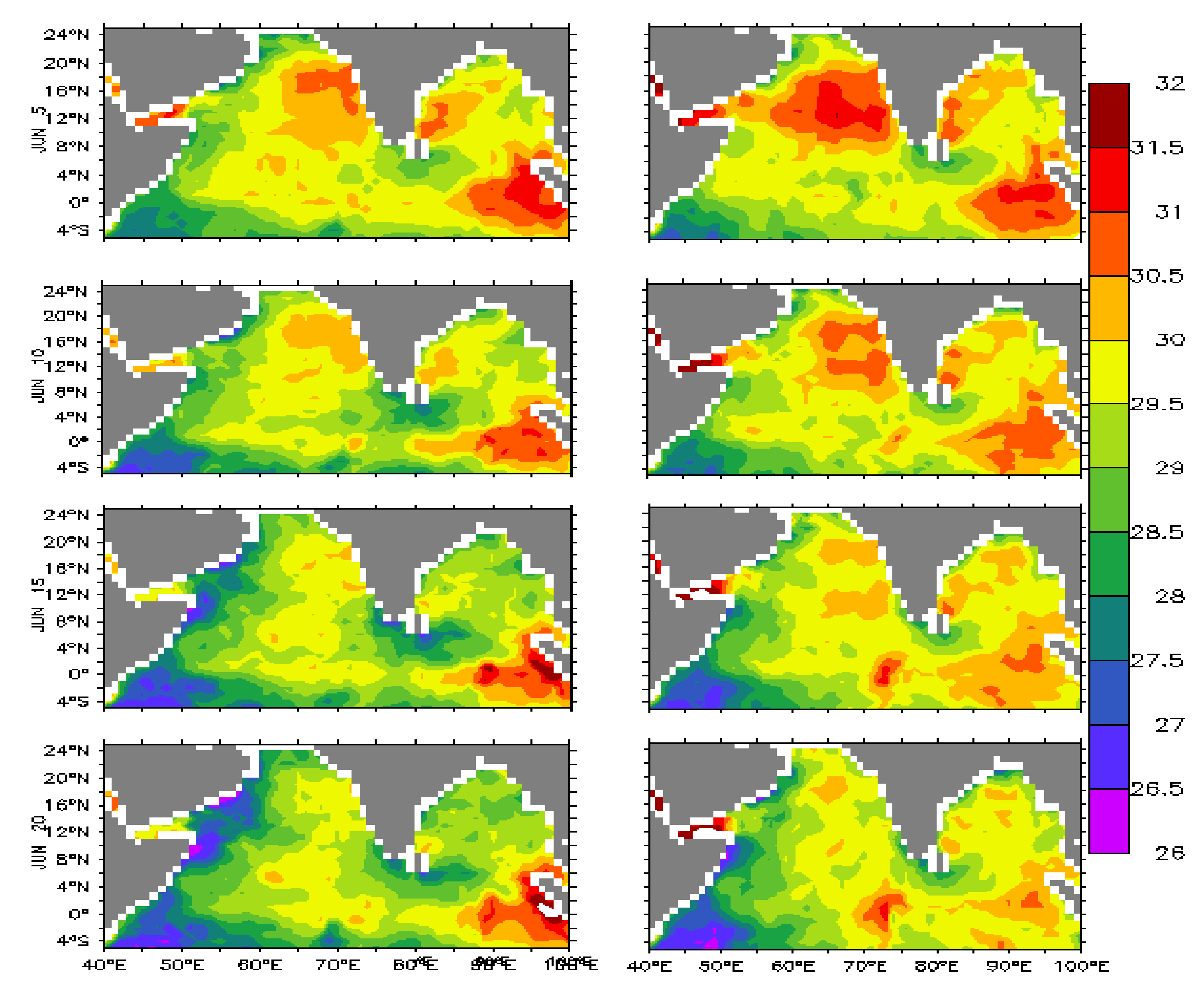
2002 avg. (May 30 – Jun 5) - May (22 – 28)



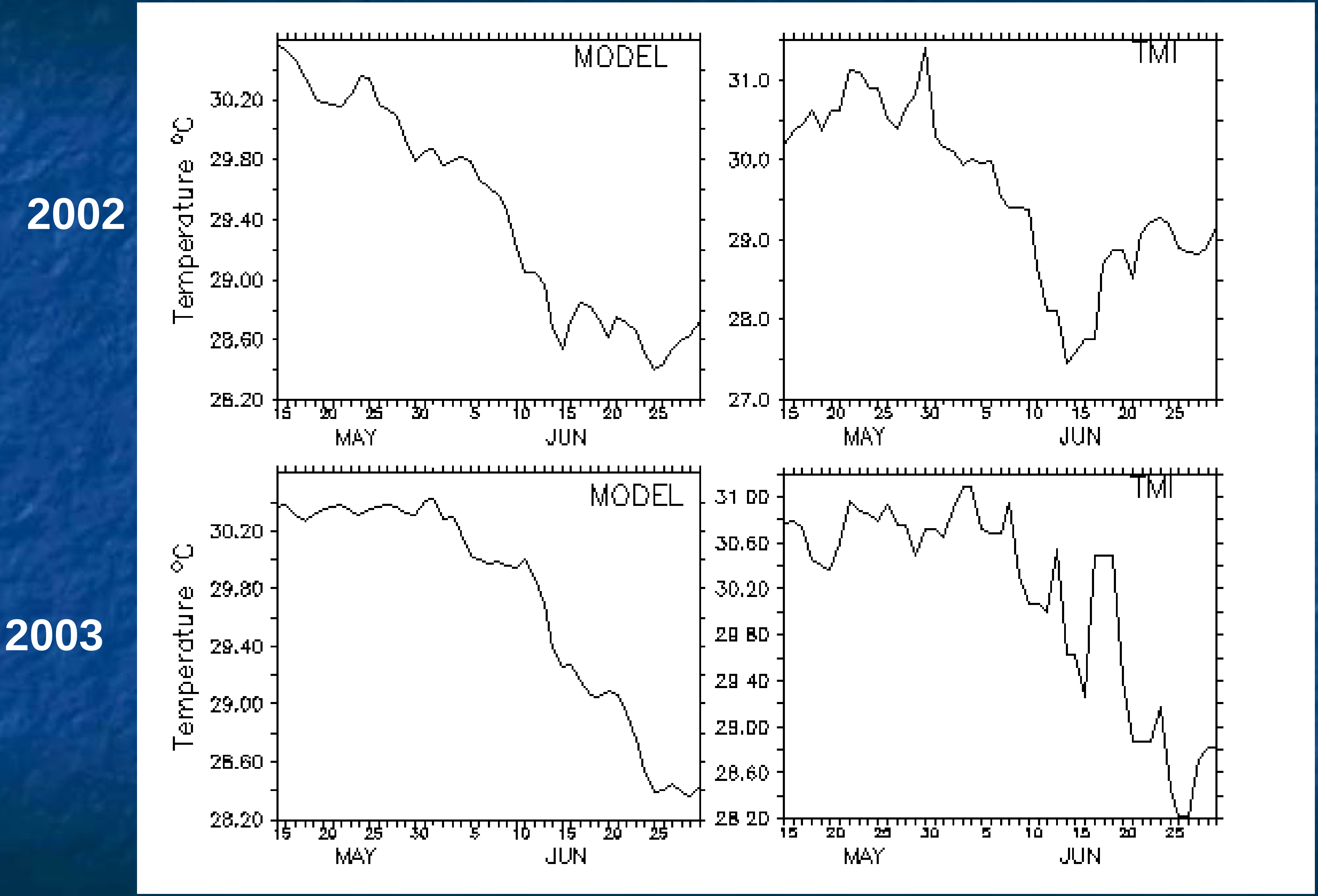
SST (TMI) COMPARISON JUN 2002 (LEFT) & 2003 (RIGHT)



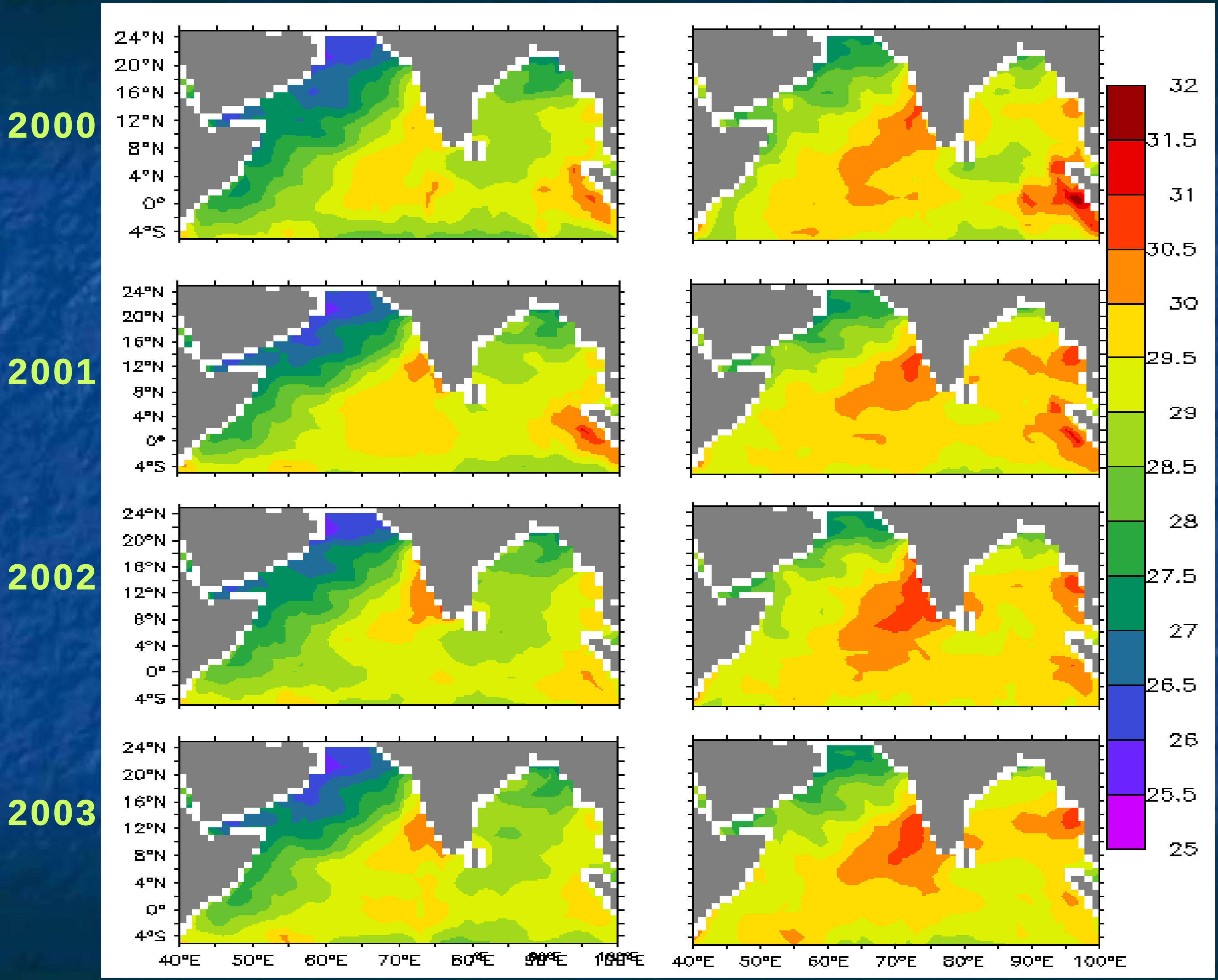
SST (MODEL) COMPARISON JUN 2002 (LEFT) & 2003 (RIGHT)



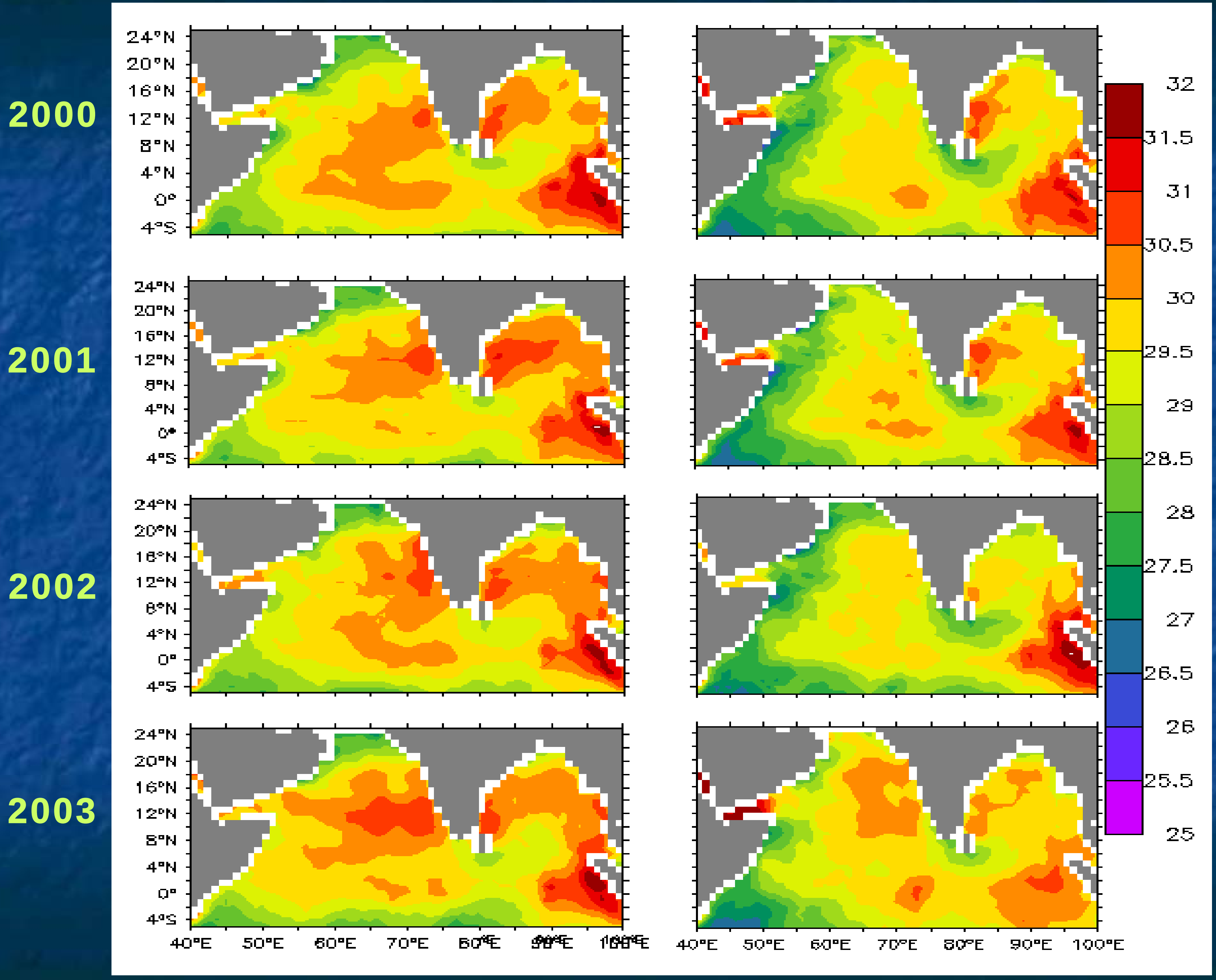
Collapse of Mini Warm Pool

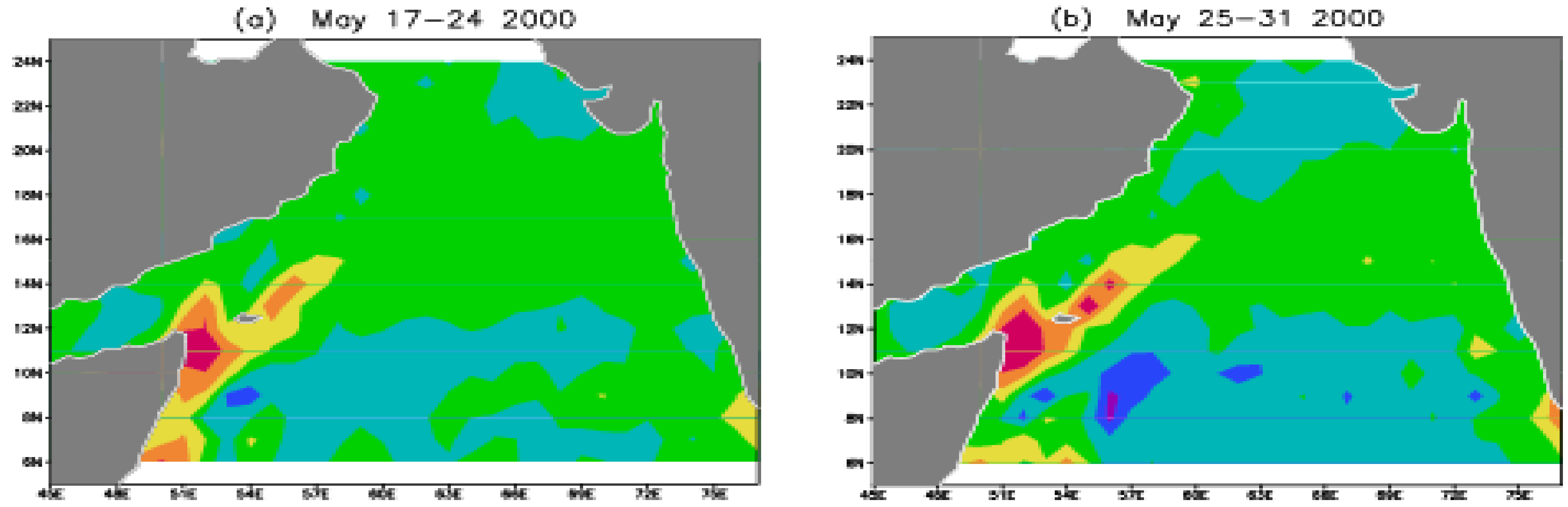


SST (MODEL) COMPARISON MARCH (LEFT) APRIL (RIGHT)

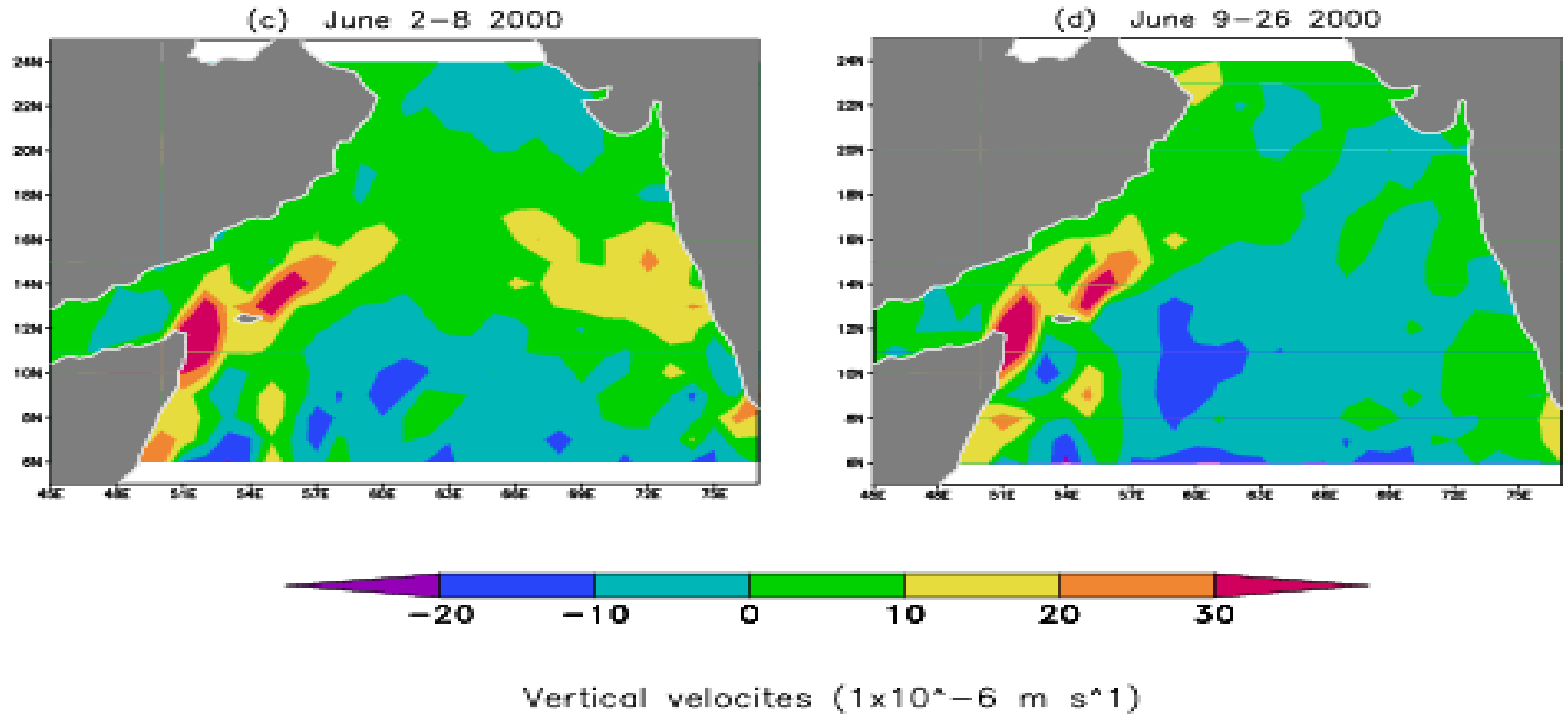


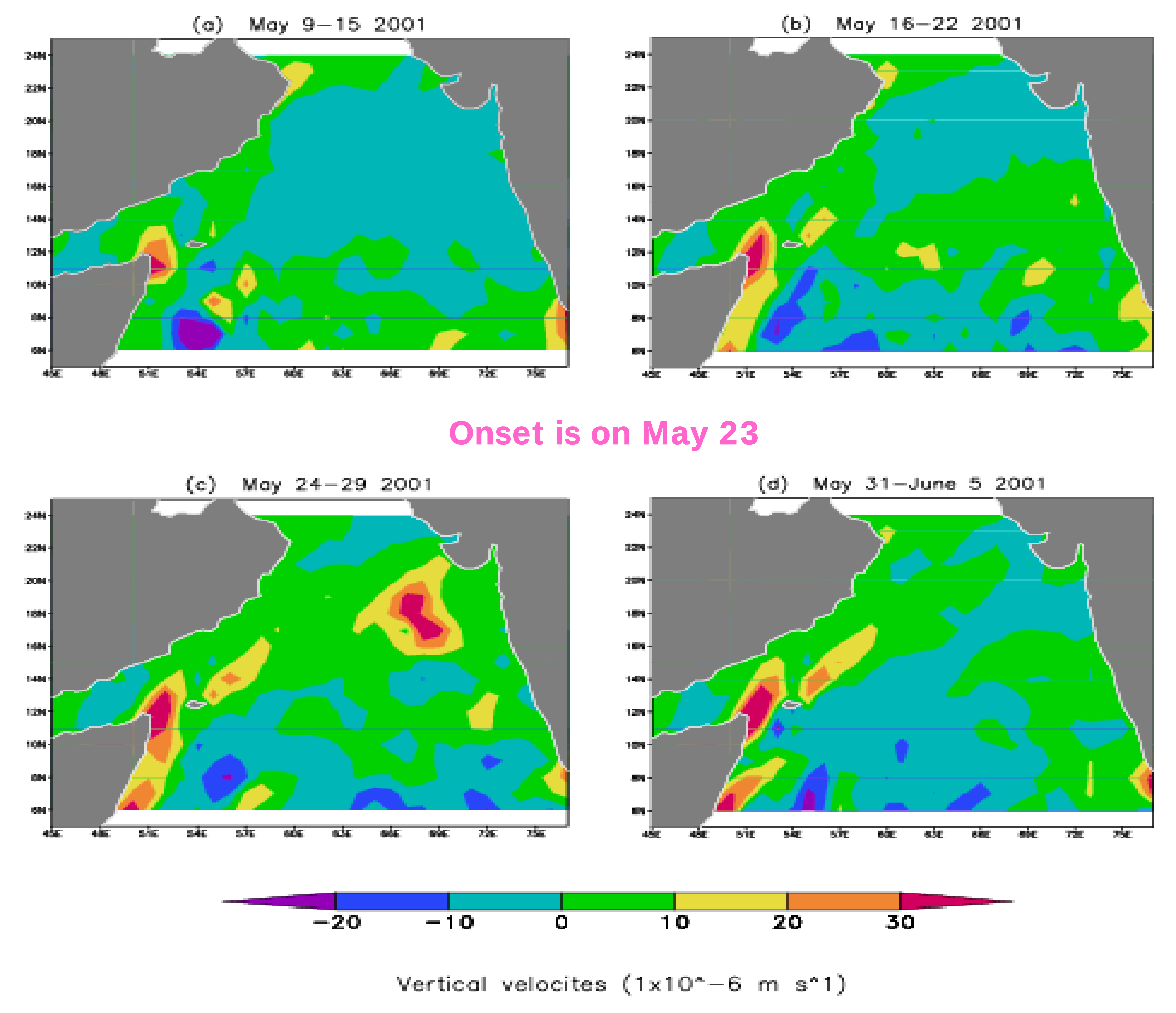
SST (MODEL) COMPARISON MAY (LEFT) JUNE (RIGHT)



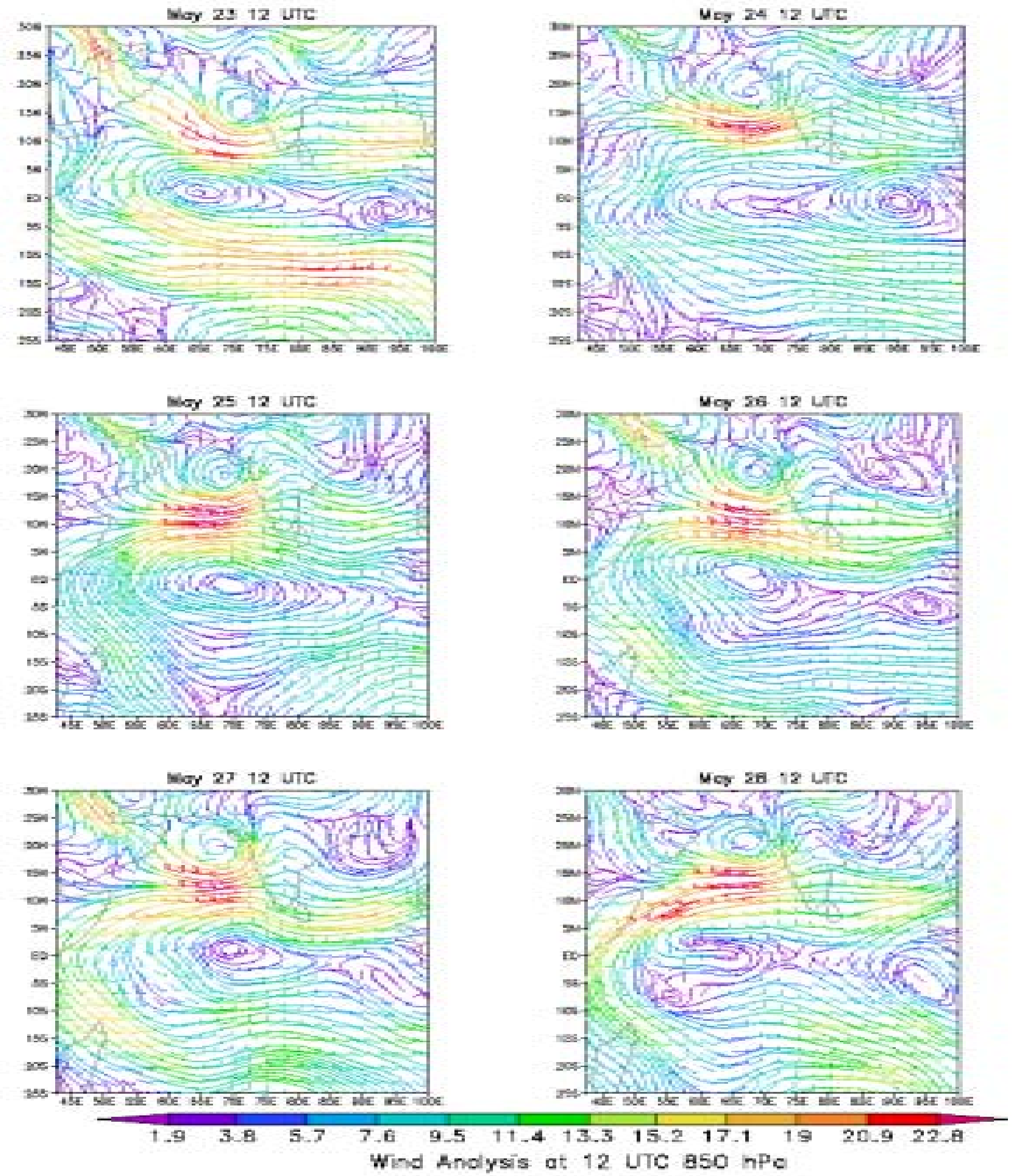


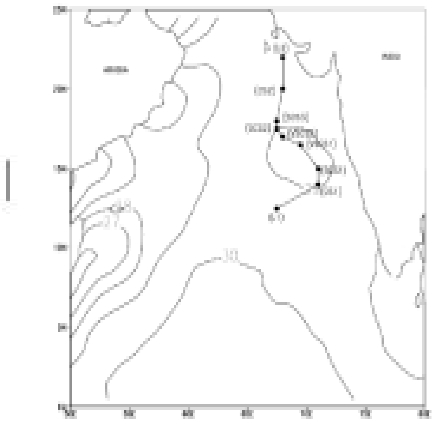
Onset is on June 1



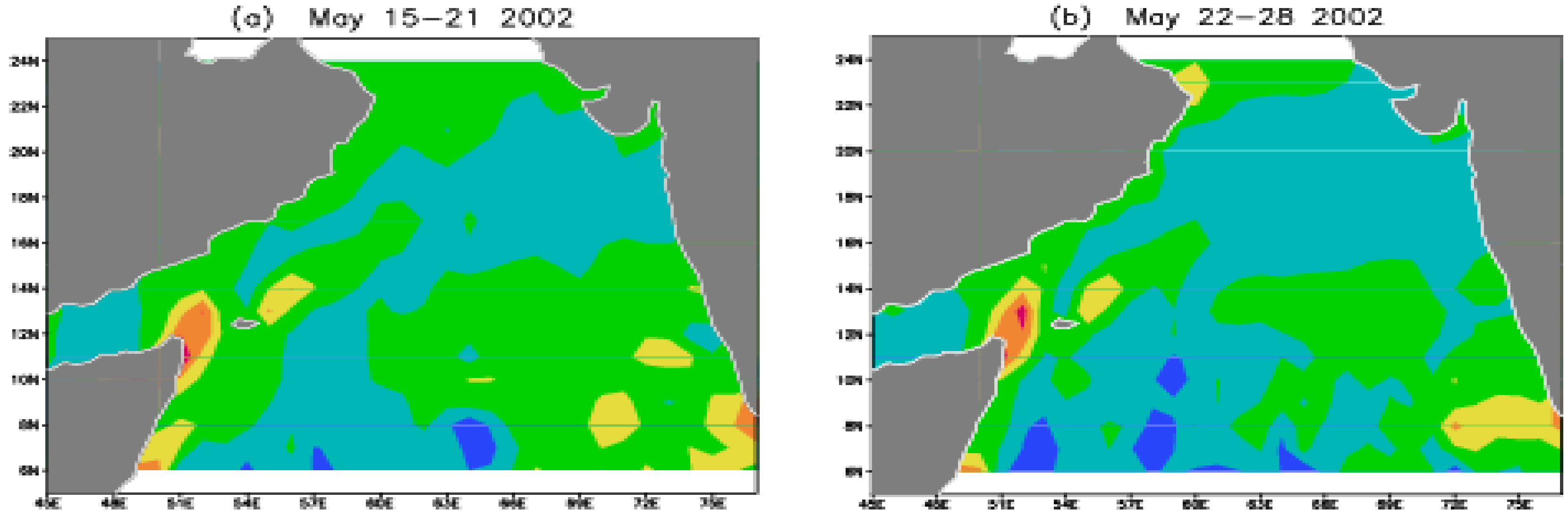

(a) May 9–15 2001
(b) May 16–22 2001
Onset is on May 23
(c) May 24–29 2001
(d) May 31–June 5 2001
−20
−10
0
10
20
30
Vertical velocites (1x10^−6 m s^1)

ONSET VORTEX 2001

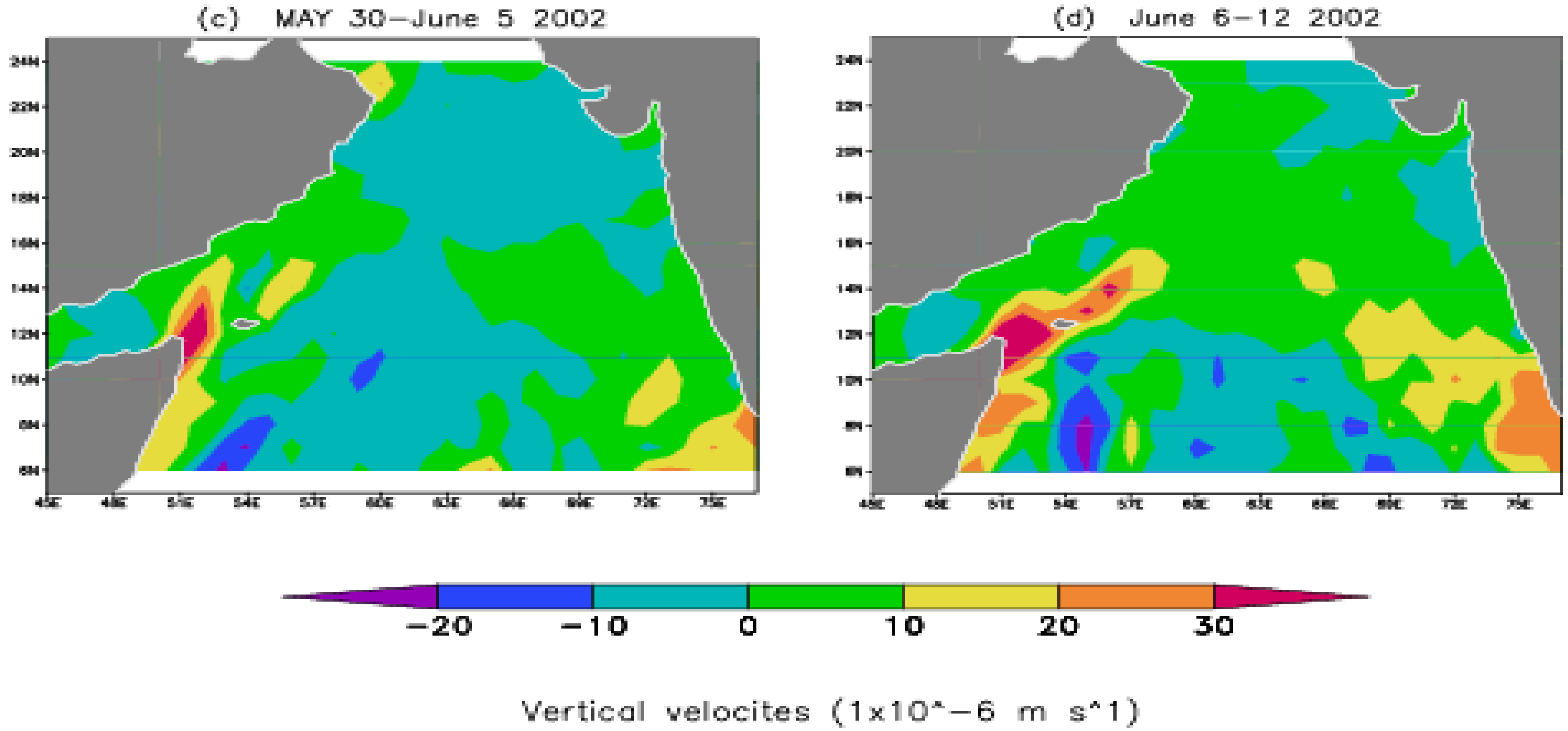


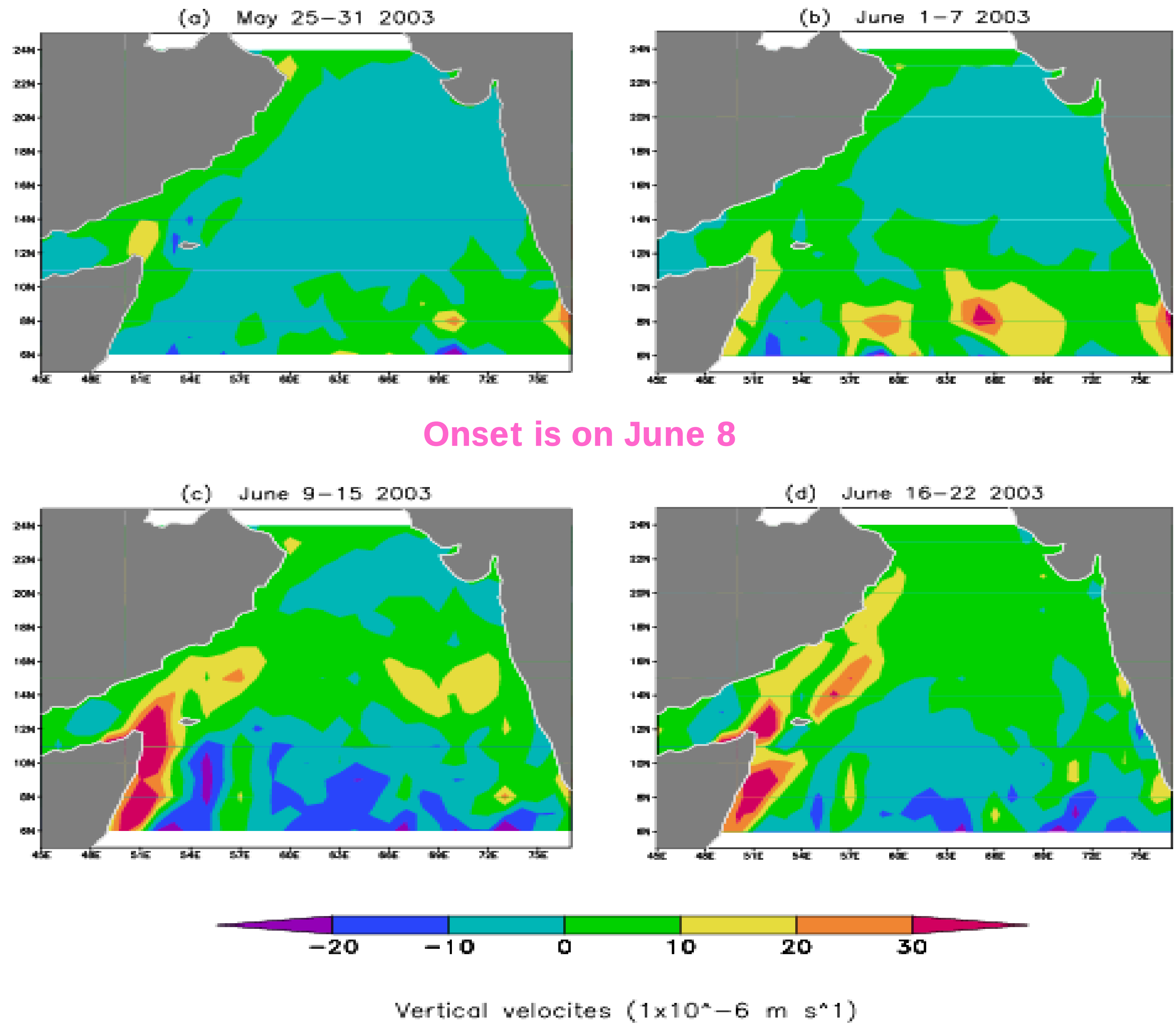


systems L1 on 21/5, CS1 on 22/5, SCS1 on 23/5, VSC1 on 24/5, VSC2 on 25/5, SCS2 on 26/5, SCS3 on 27/5, CS2 on 28/5, L2 on 29/5

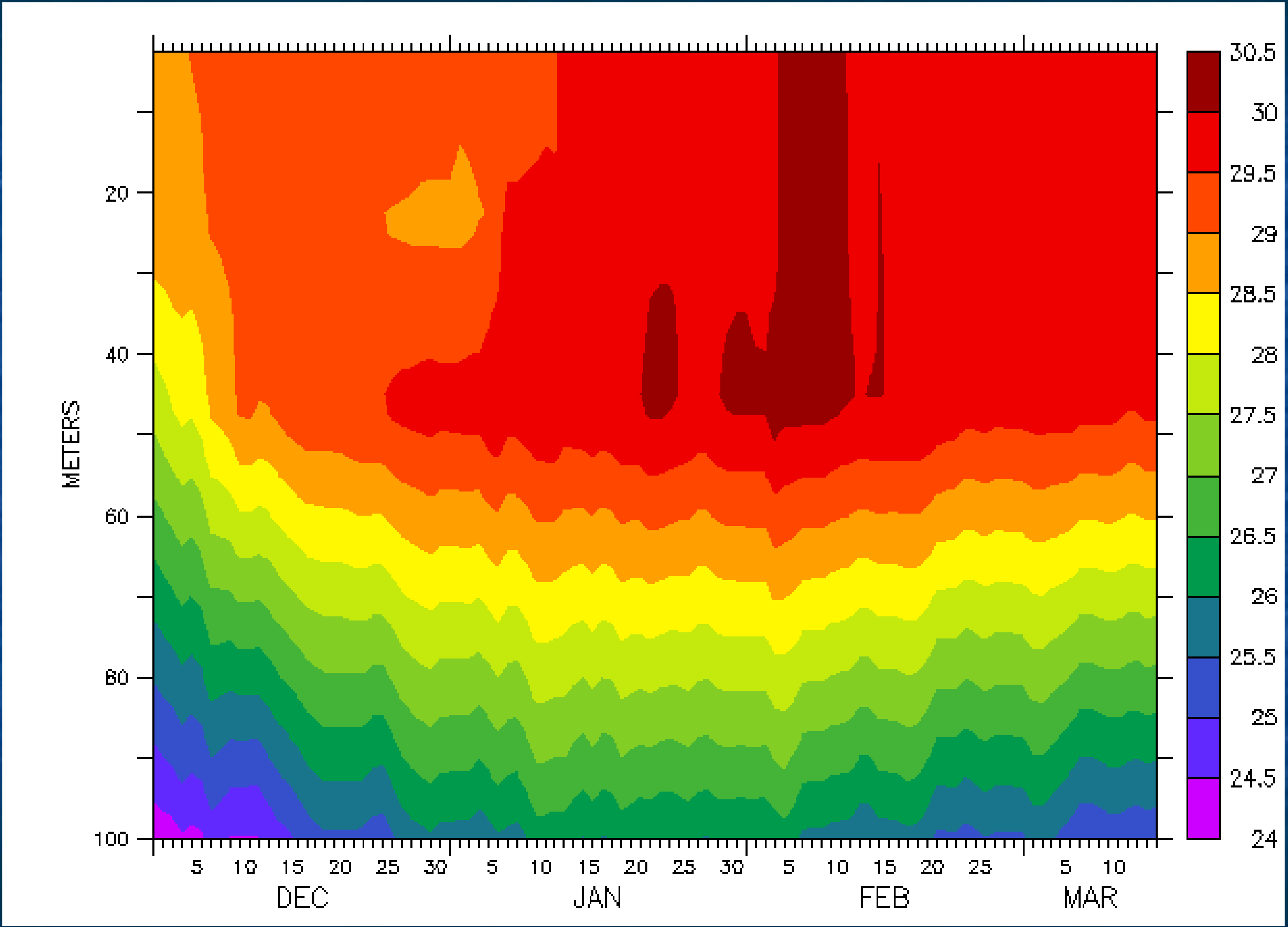


Onset is on May 29

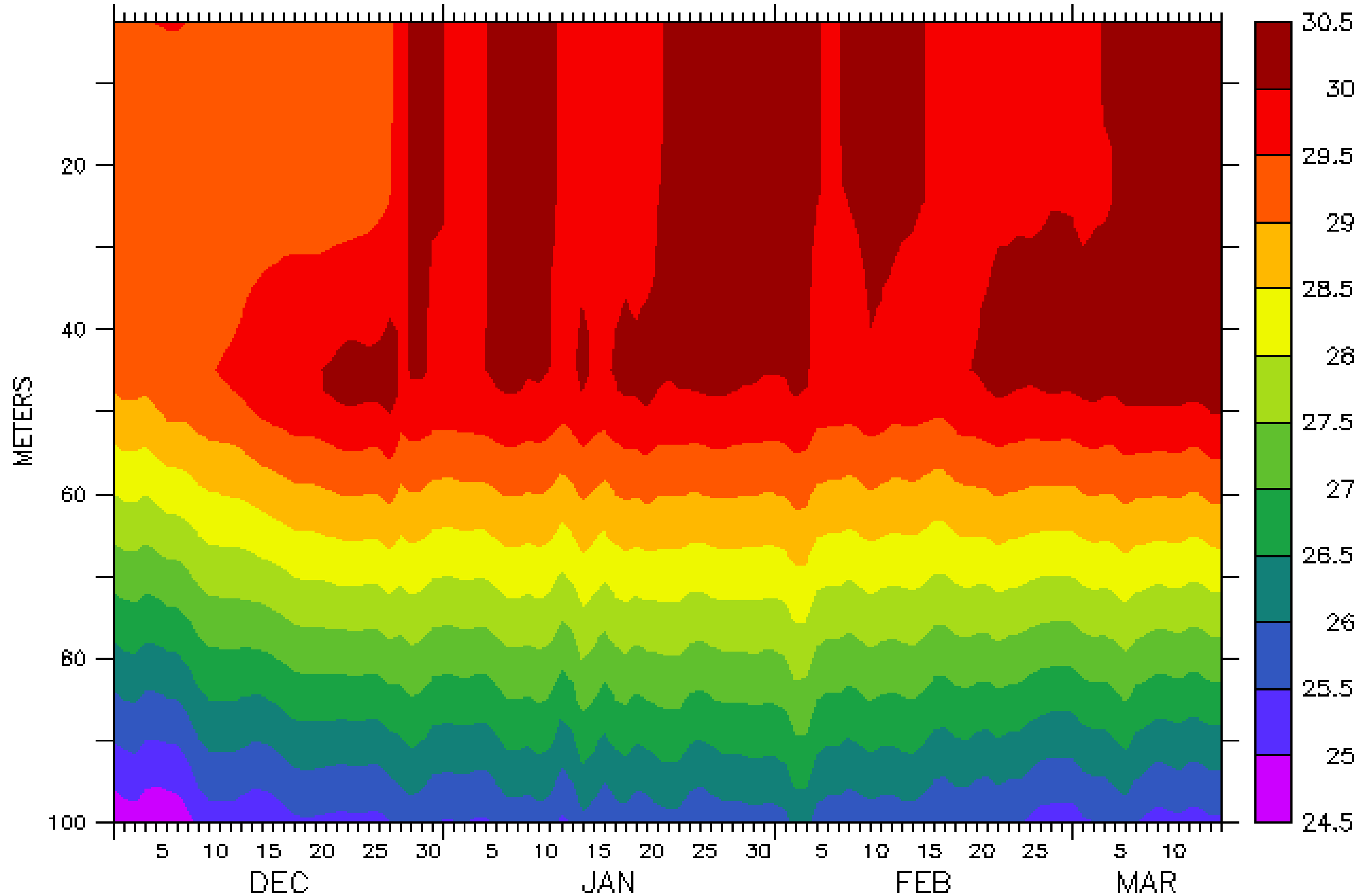



(a) May 25−31 2003
(b) June 1−7 2003
Onset is on June 8
(c) June 9−15 2003
(d) June 16−22 2003
−20
−10
0
10
20
30
Vertical velocites (1x10^−6 m s^1)

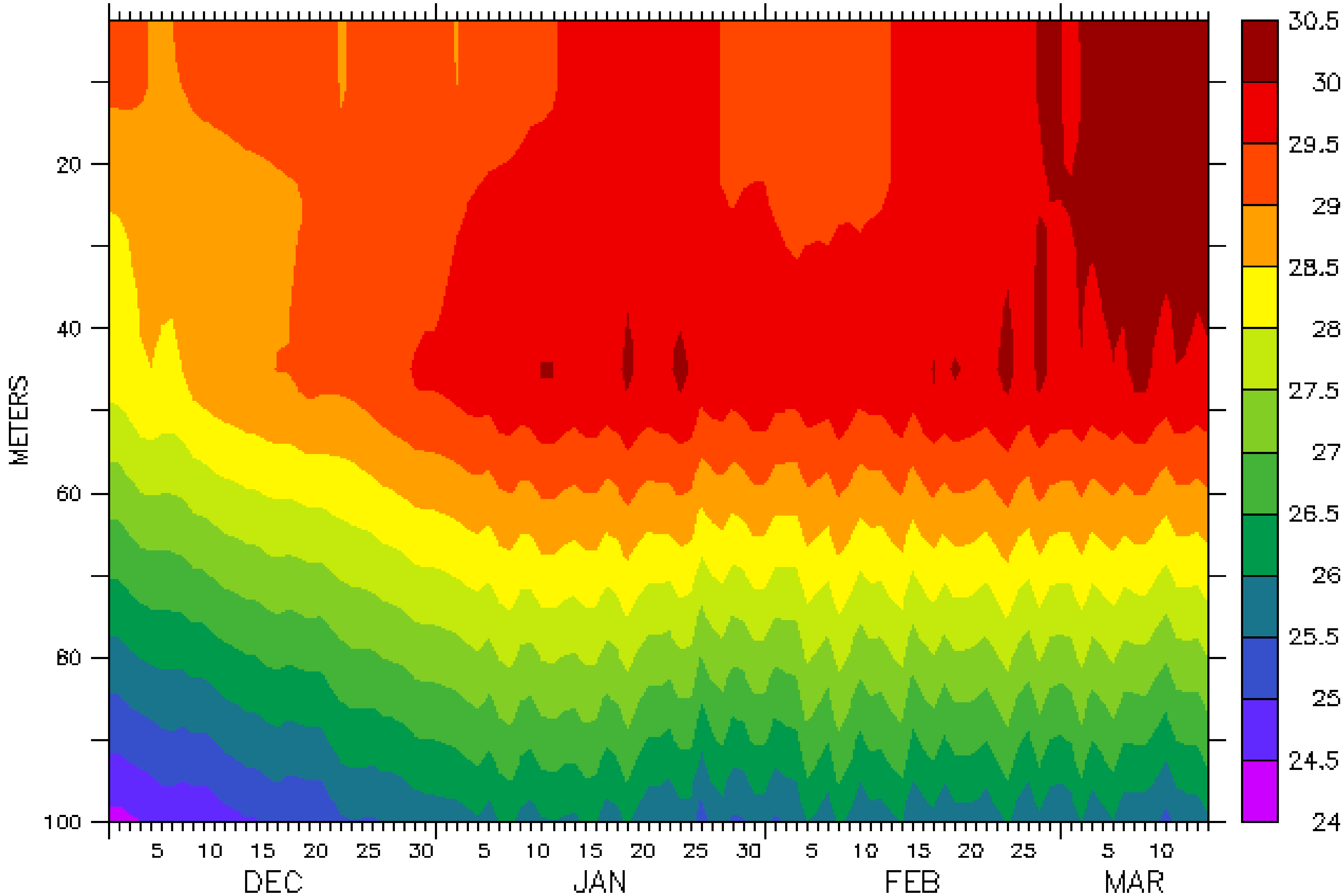
TIME – DEPTH SECTION OF TEMPERATURE (1999 – 2000) AT 10ºN, 75ºE



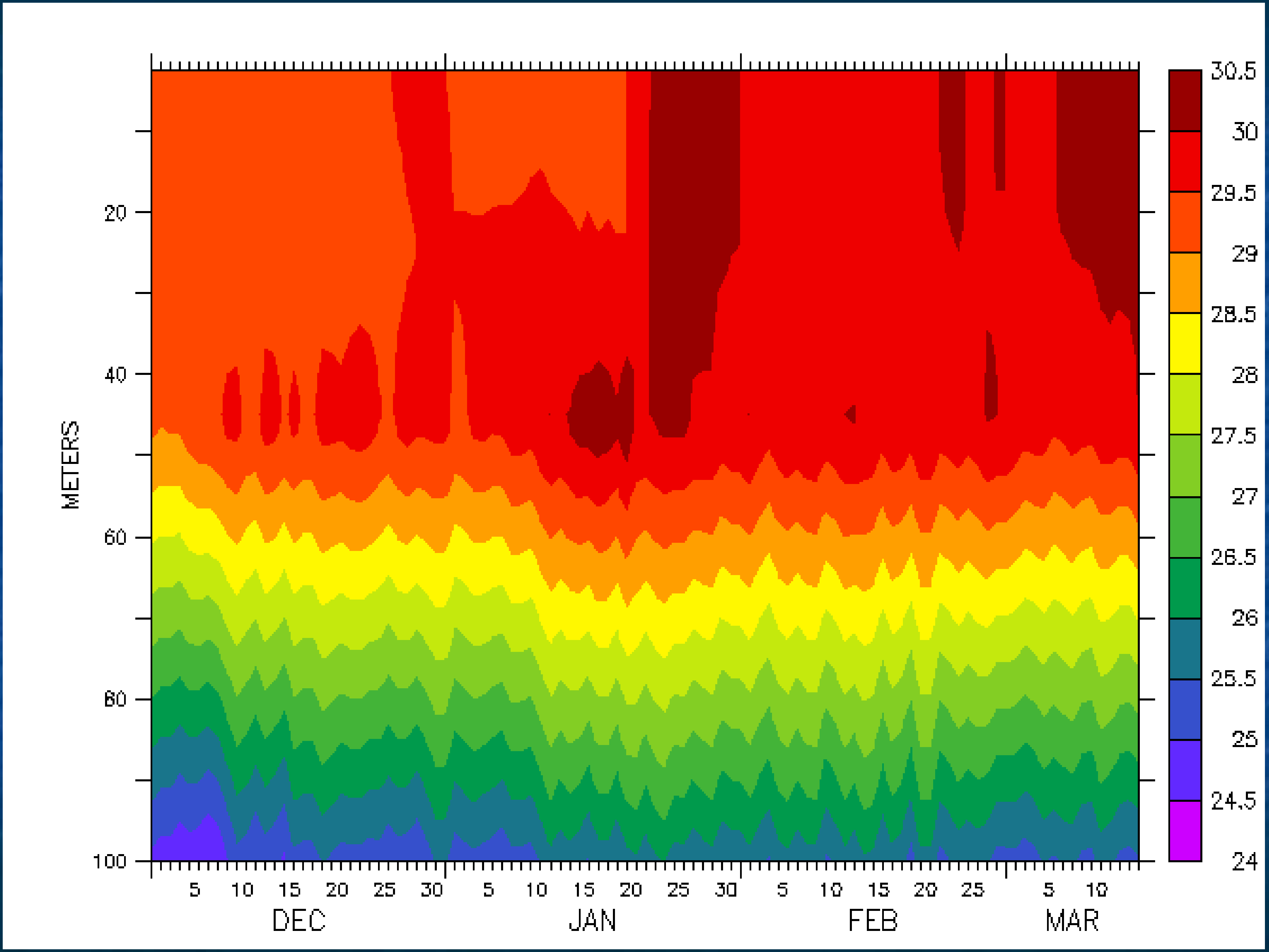
TIME – DEPTH SECTION OF TEMPERATURE (2000 – 2001) AT 10ºN, 75ºE



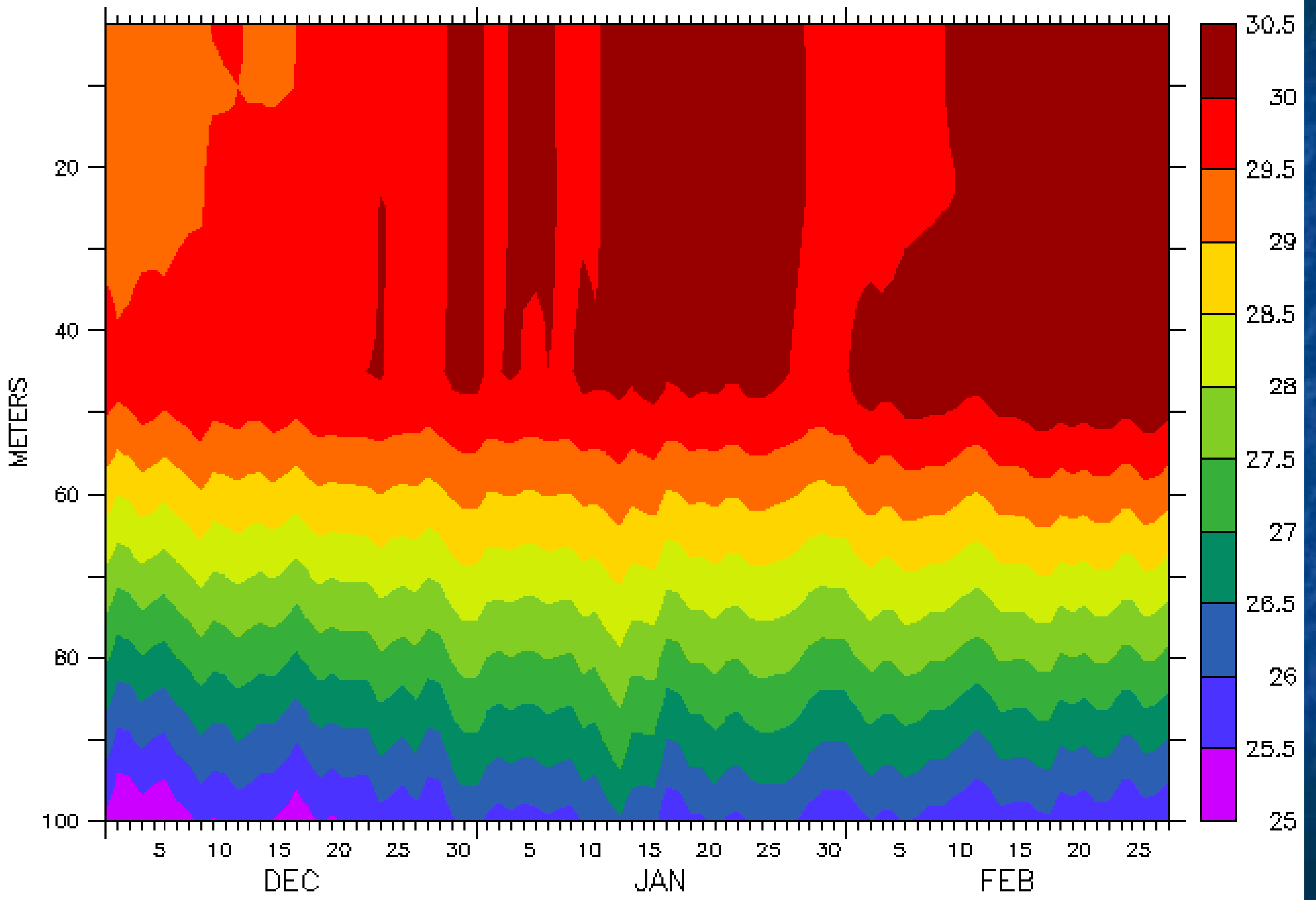
TIME – DEPTH SECTION OF TEMPERATURE (2001 – 2002) AT 10ºN, 75ºE



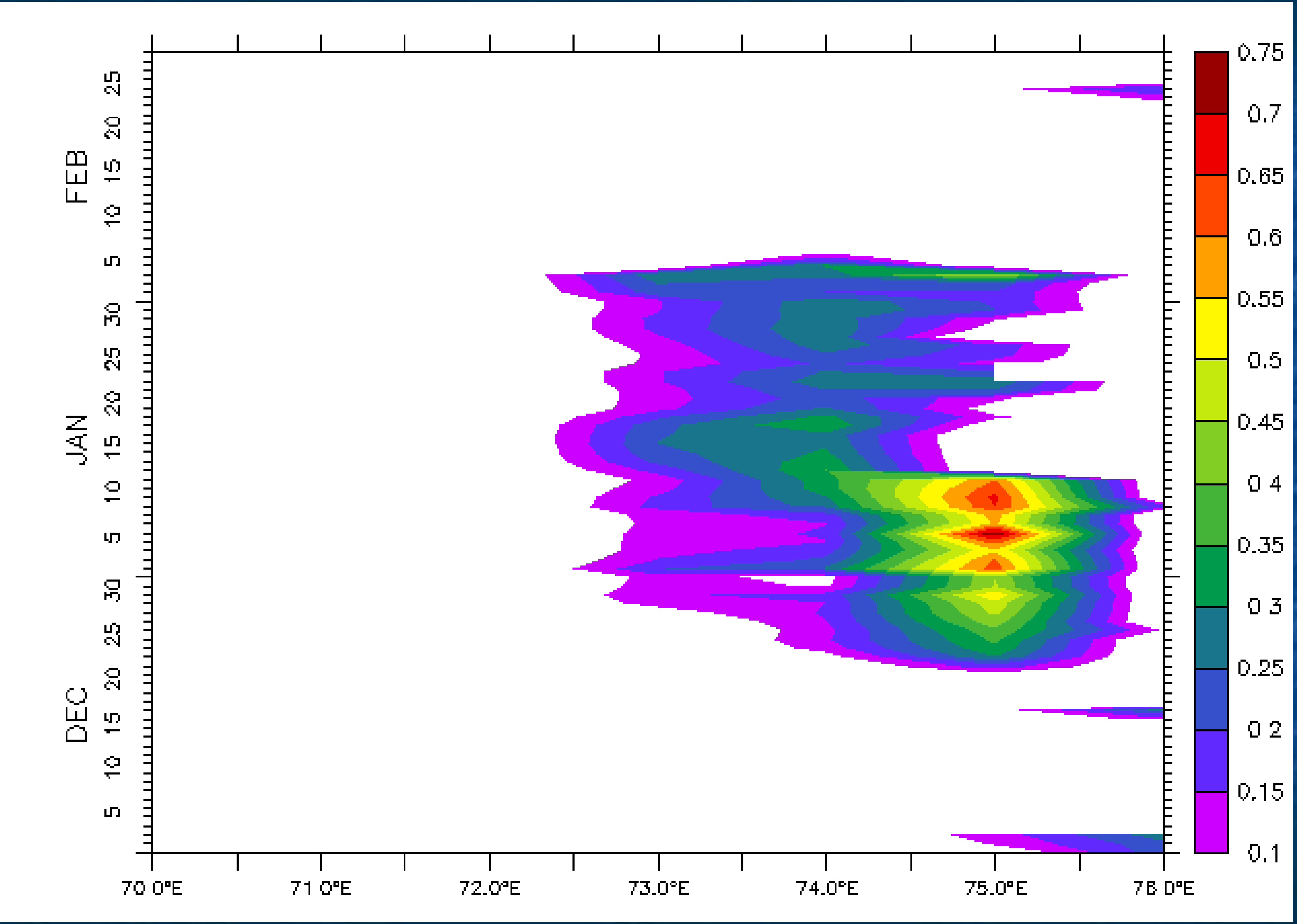
TIME – DEPTH SECTION OF TEMPERATURE (2002 – 2003) AT 10ºN, 75ºE



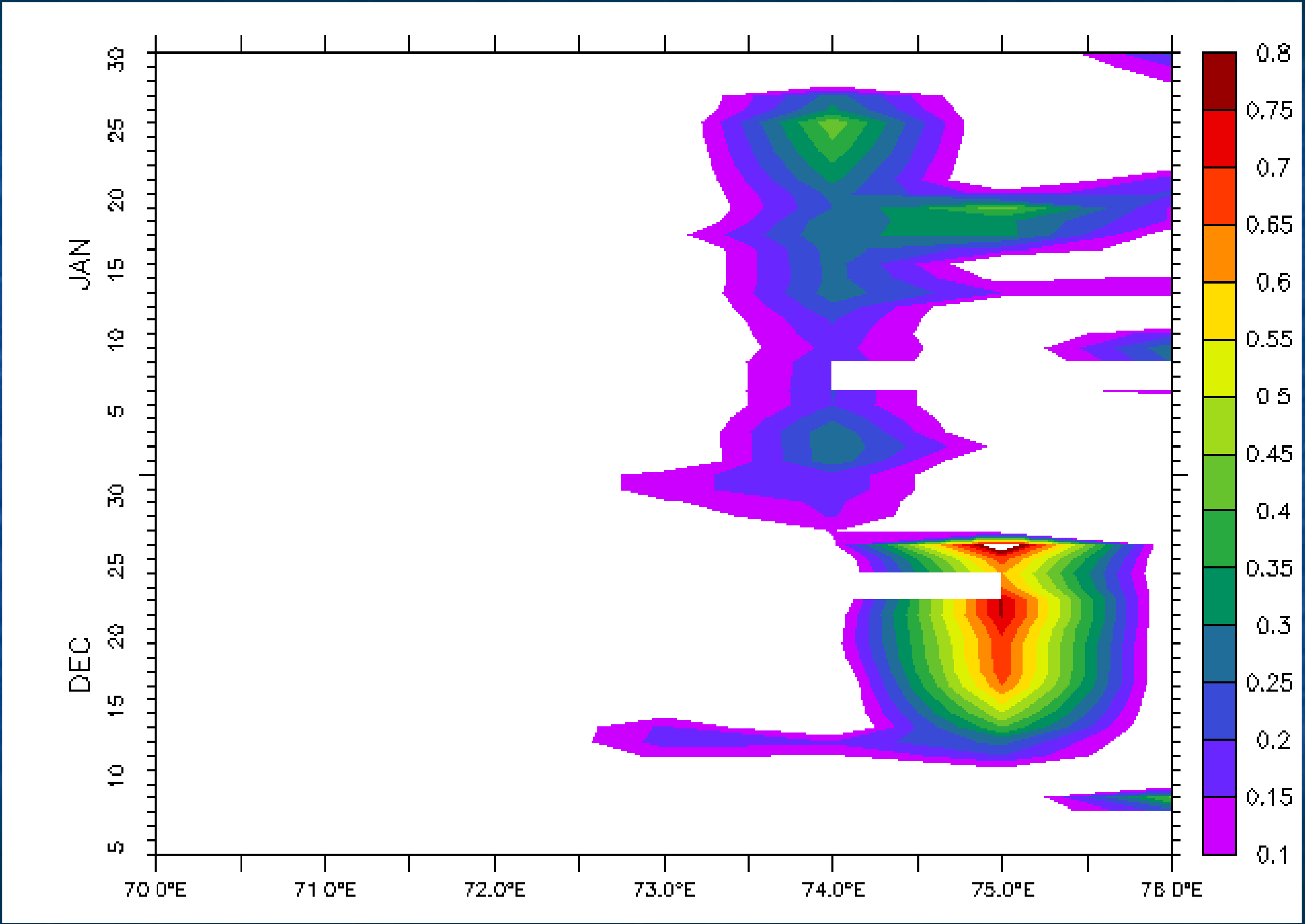
TIME – DEPTH SECTION OF TEMPERATURE (2003 – 2004) AT 10ºN, 75ºE



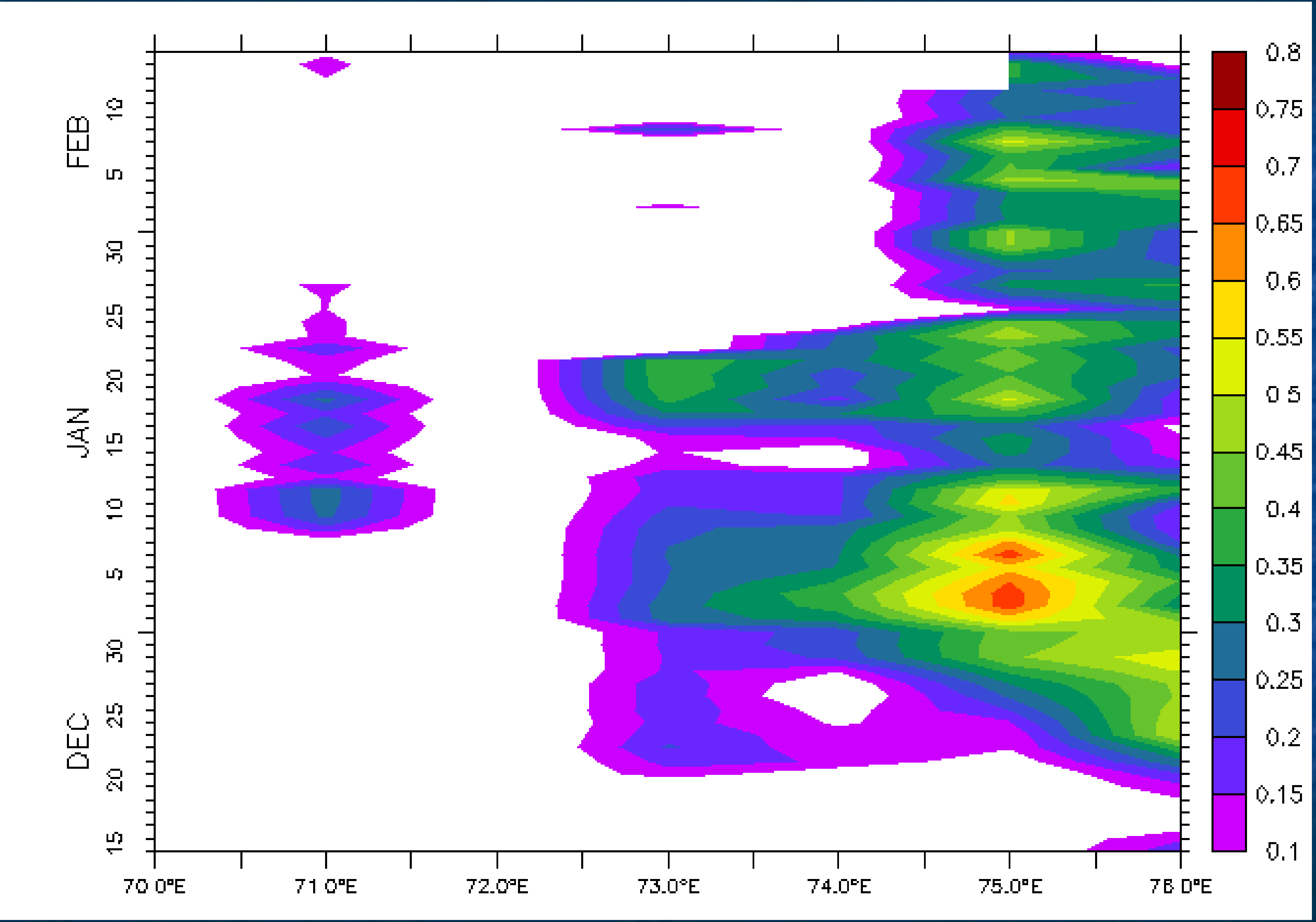
LONGITUDE – TIME SECTION OF INVERSIONS (1999-2000) AT 10ºN



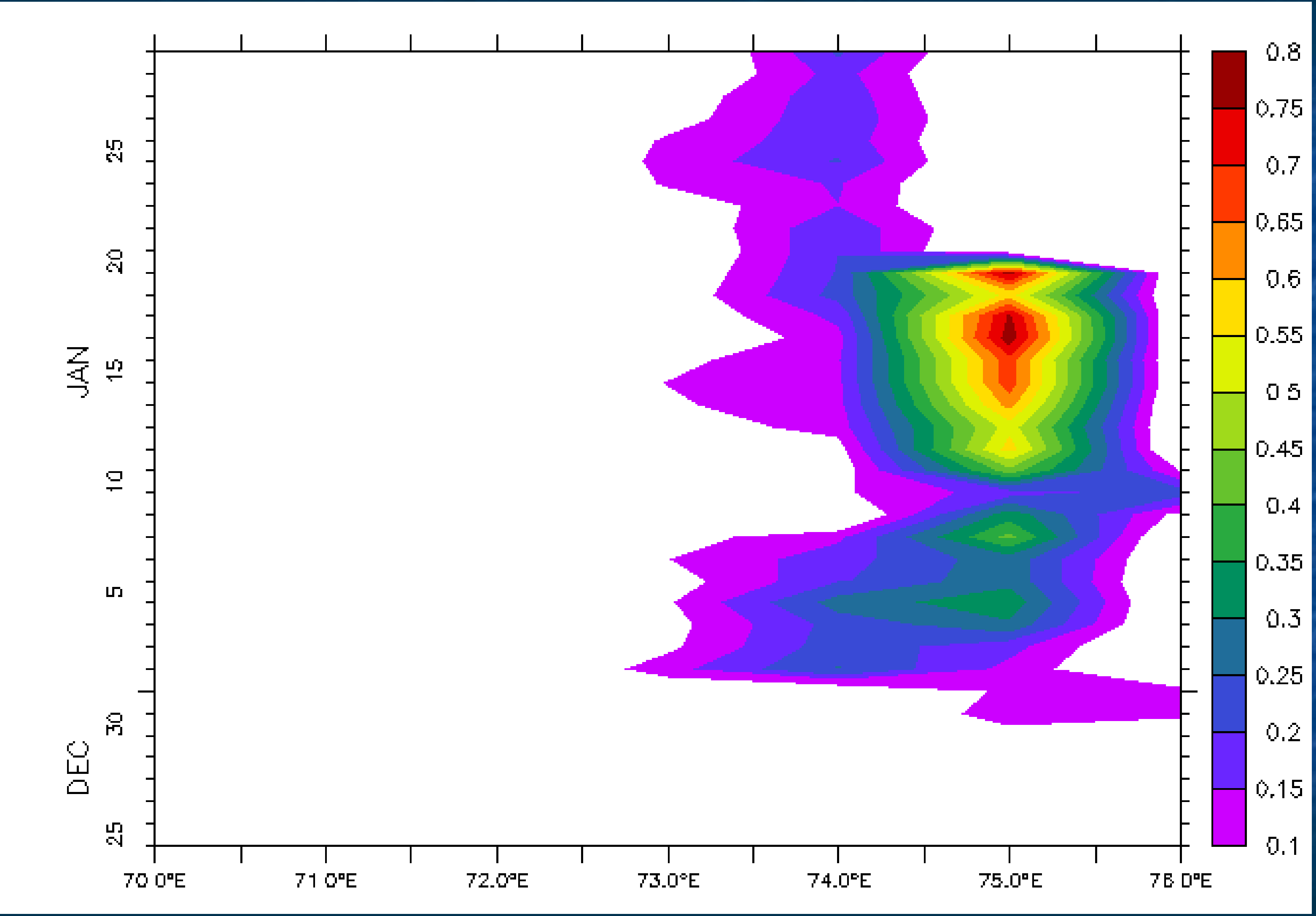
LONGITUDE – TIME SECTION OF INVERSIONS (2000-2001) AT 10ºN



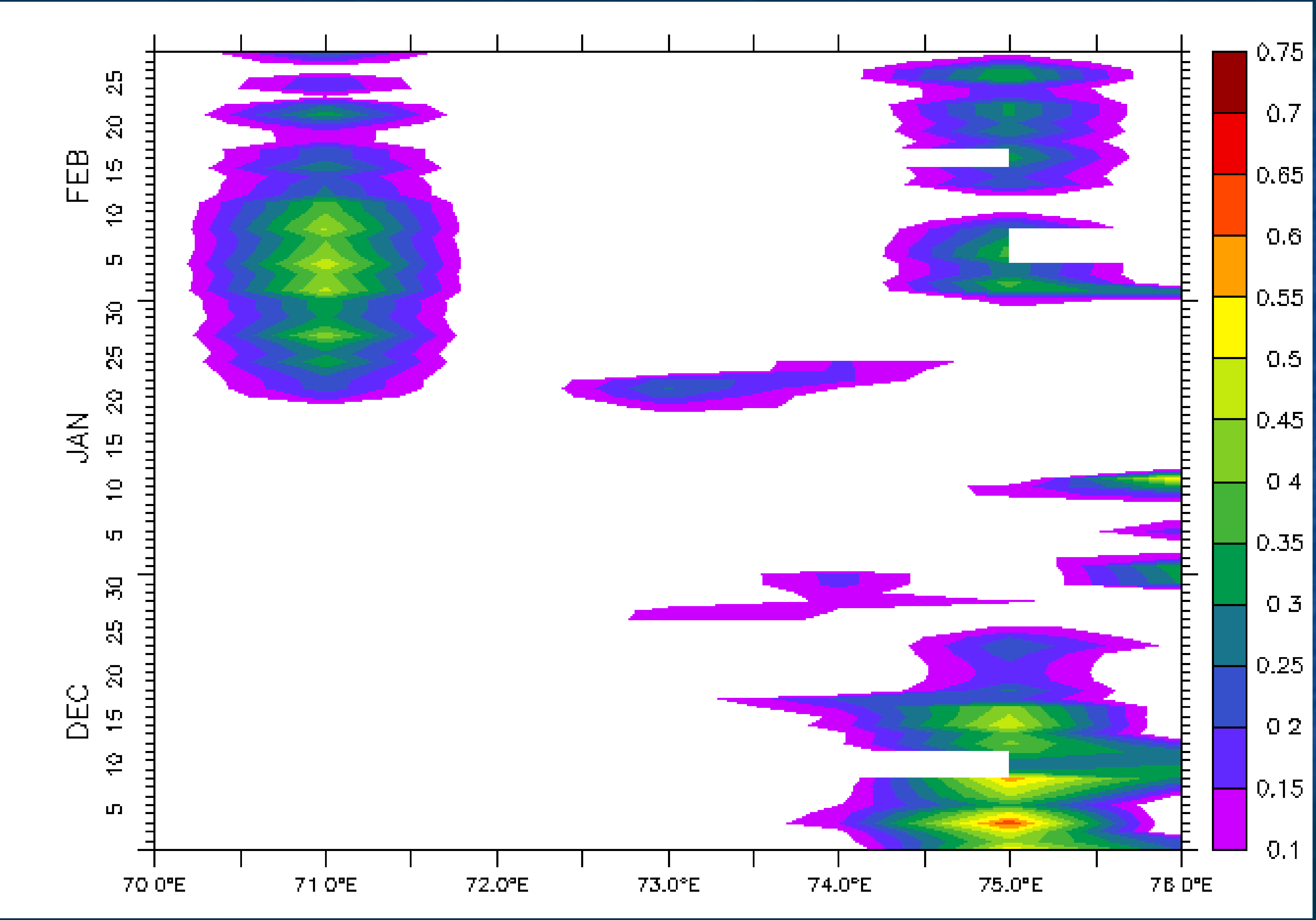
LONGITUDE – TIME SECTION OF INVERSIONS (2001-2002) AT 10ºN



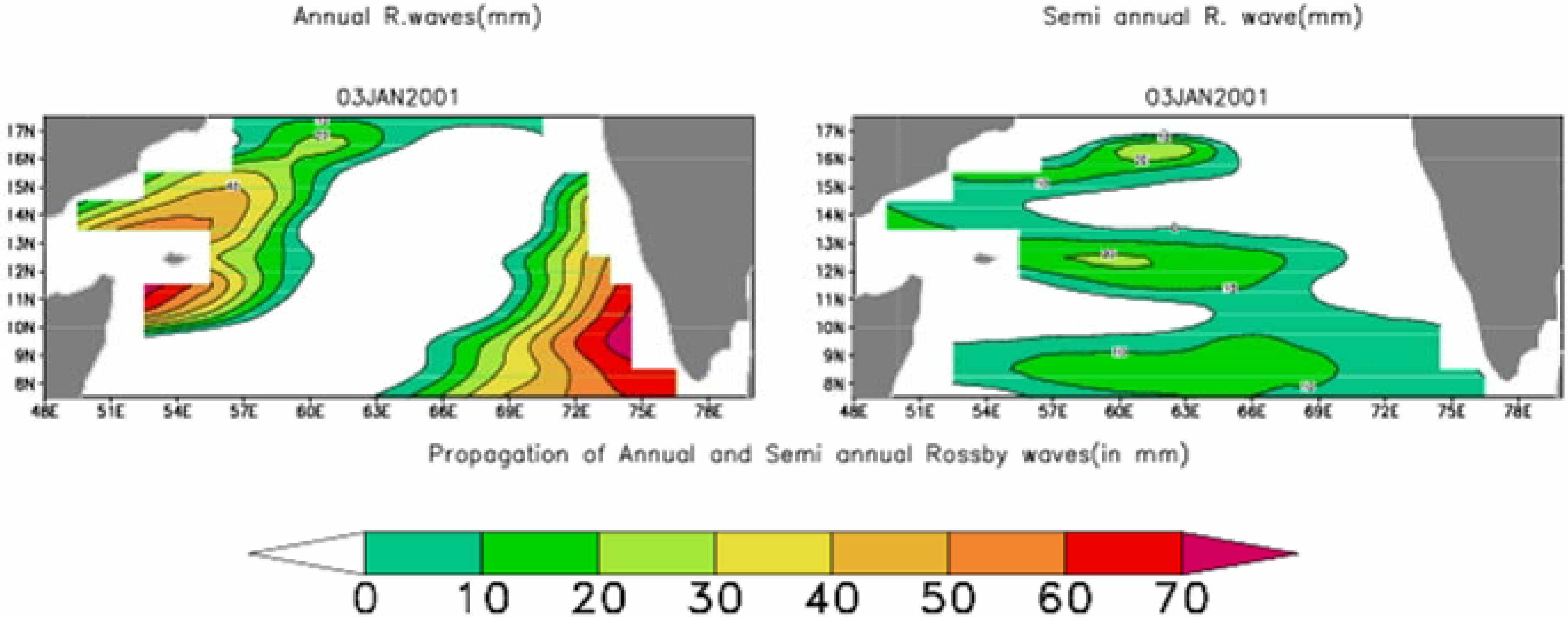
LONGITUDE – TIME SECTION OF INVERSIONS (2002 - 2003) AT 10ºN



LONGITUDE – TIME SECTION OF INVERSIONS (2003 - 2004) AT 10ºN

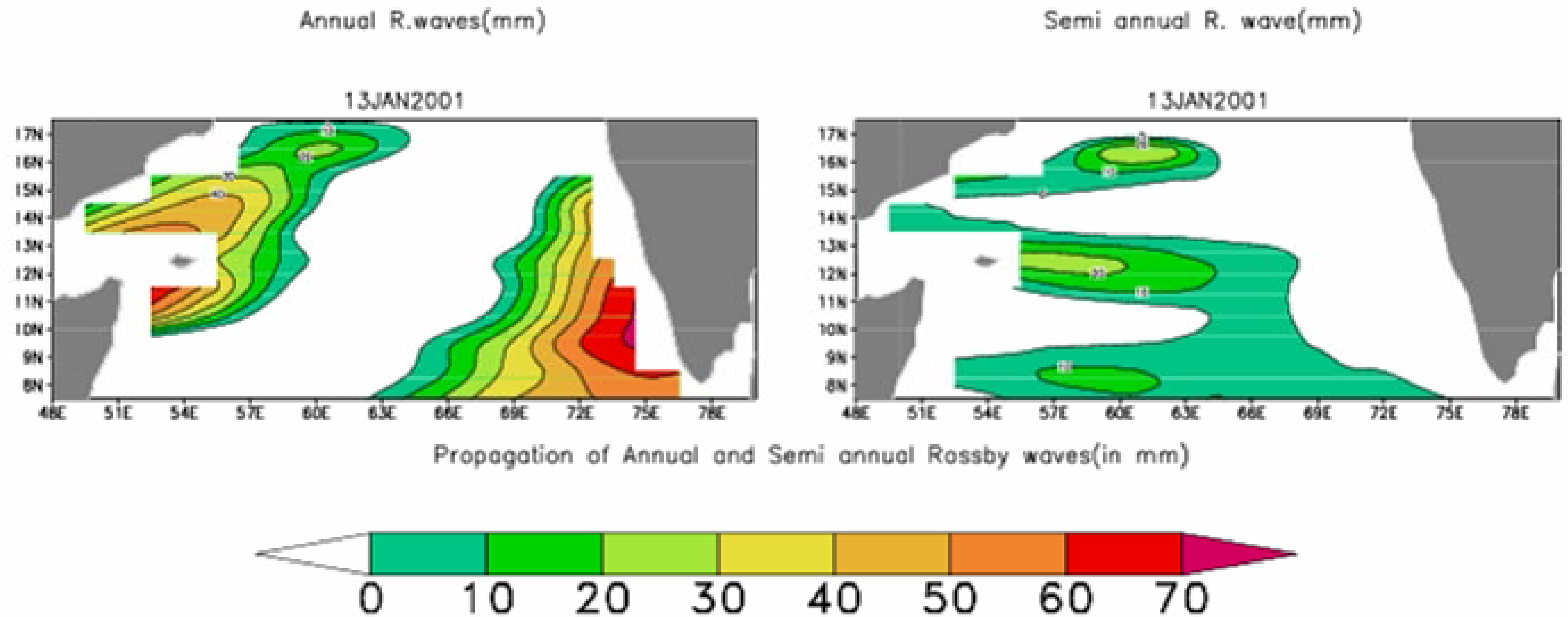


03 Jan. 2001



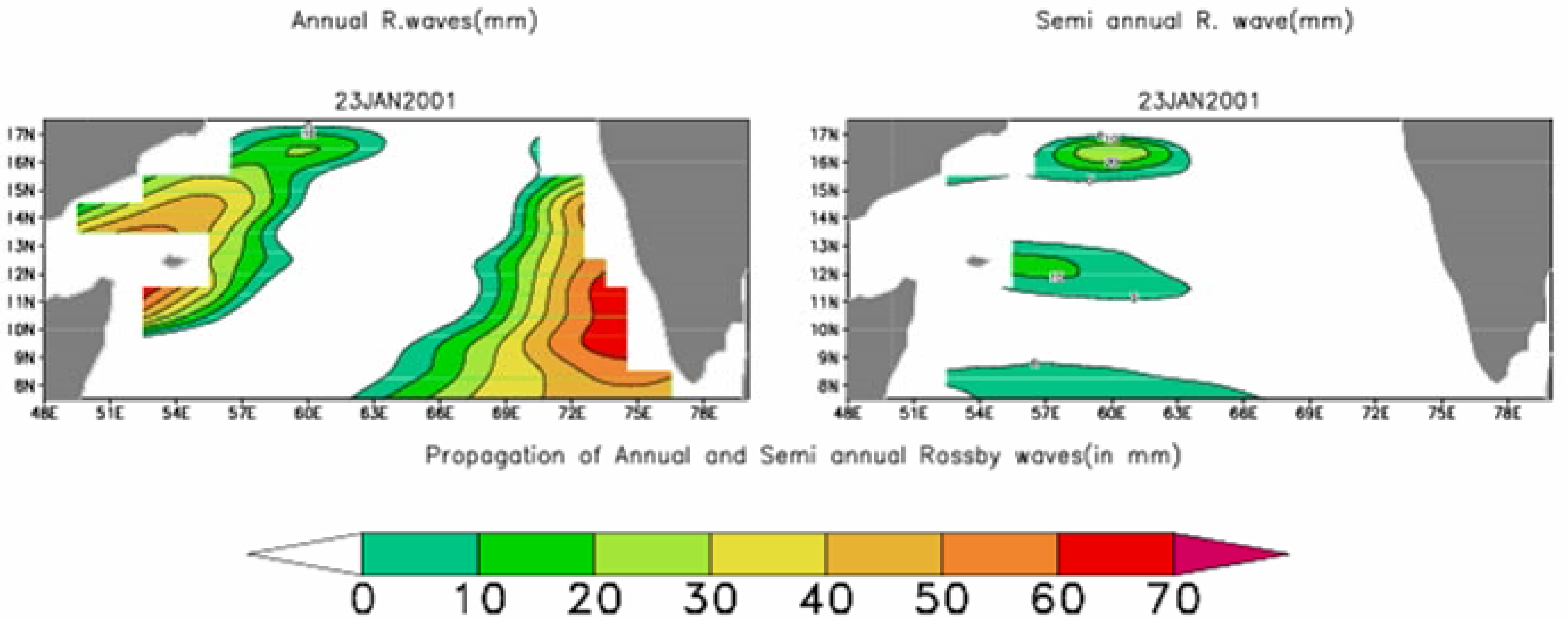
Propagation of Annual and Semi annual Rossby waves(in mm)

13 Jan. 2001



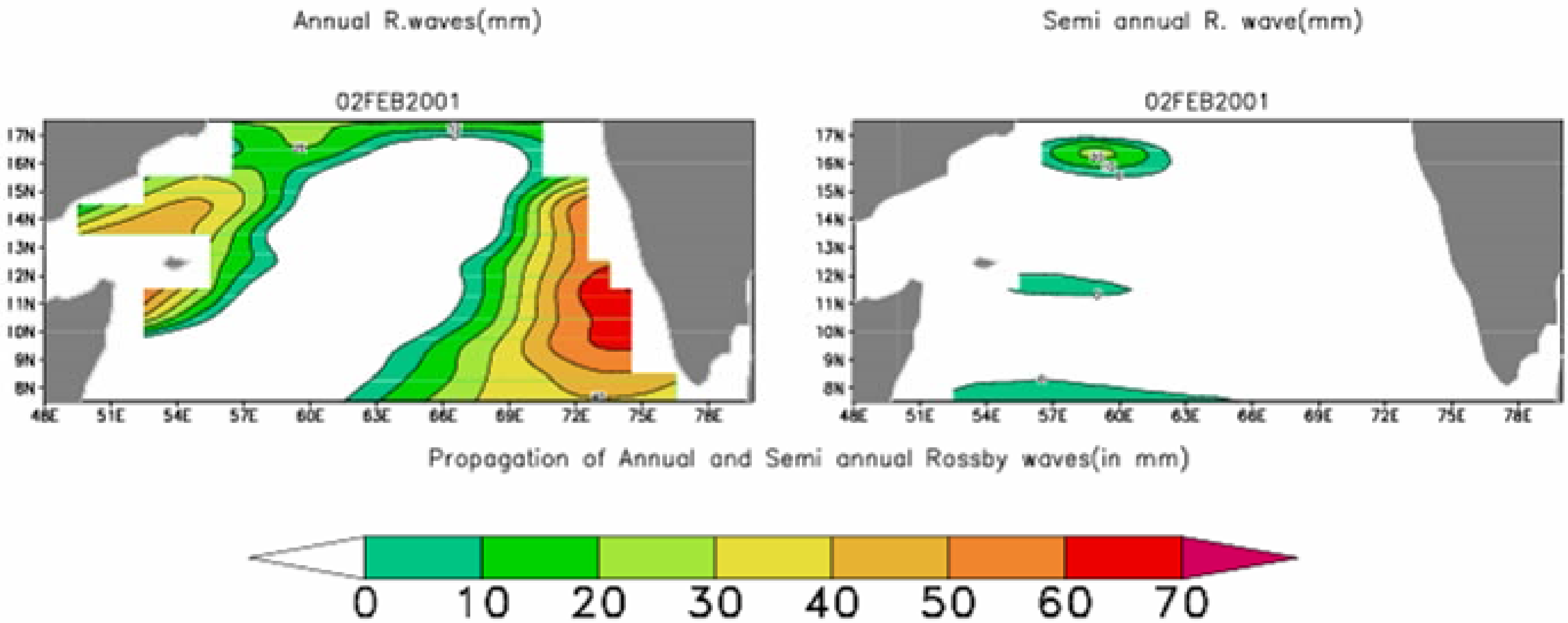
Propagation of Annual and Semi annual Rossby waves(in mm)

23 Jan. 2001



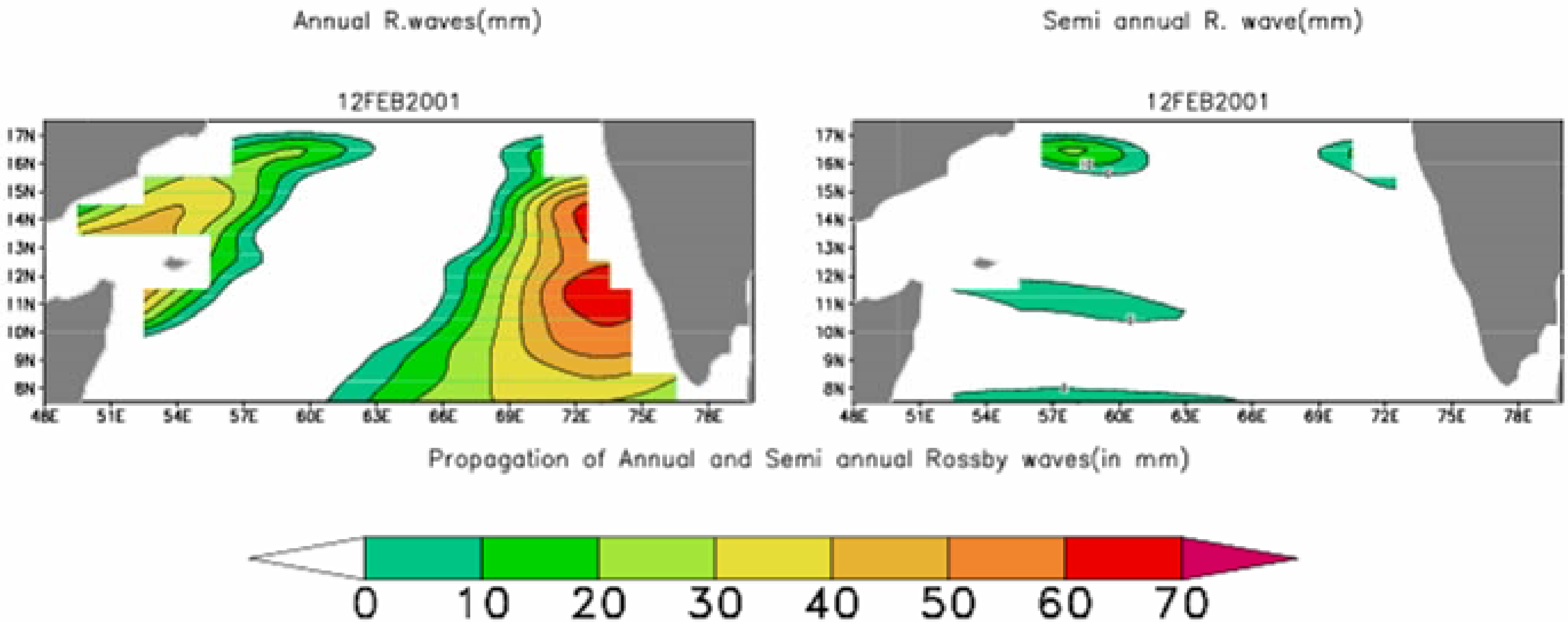
Annual R.waves(mm)
Semi annual R. wave(mm)
23JAN2001
23JAN2001
17N
16N
15N
14N
13N
12N
11N
10N
9N
8N
48E
51E
54E
57E
60E
63E
66E
69E
72E
75E
78E
Propagation of Annual and Semi annual Rossby waves(in mm)
0
10
20
30
40
50
60
70

02 Feb. 2001

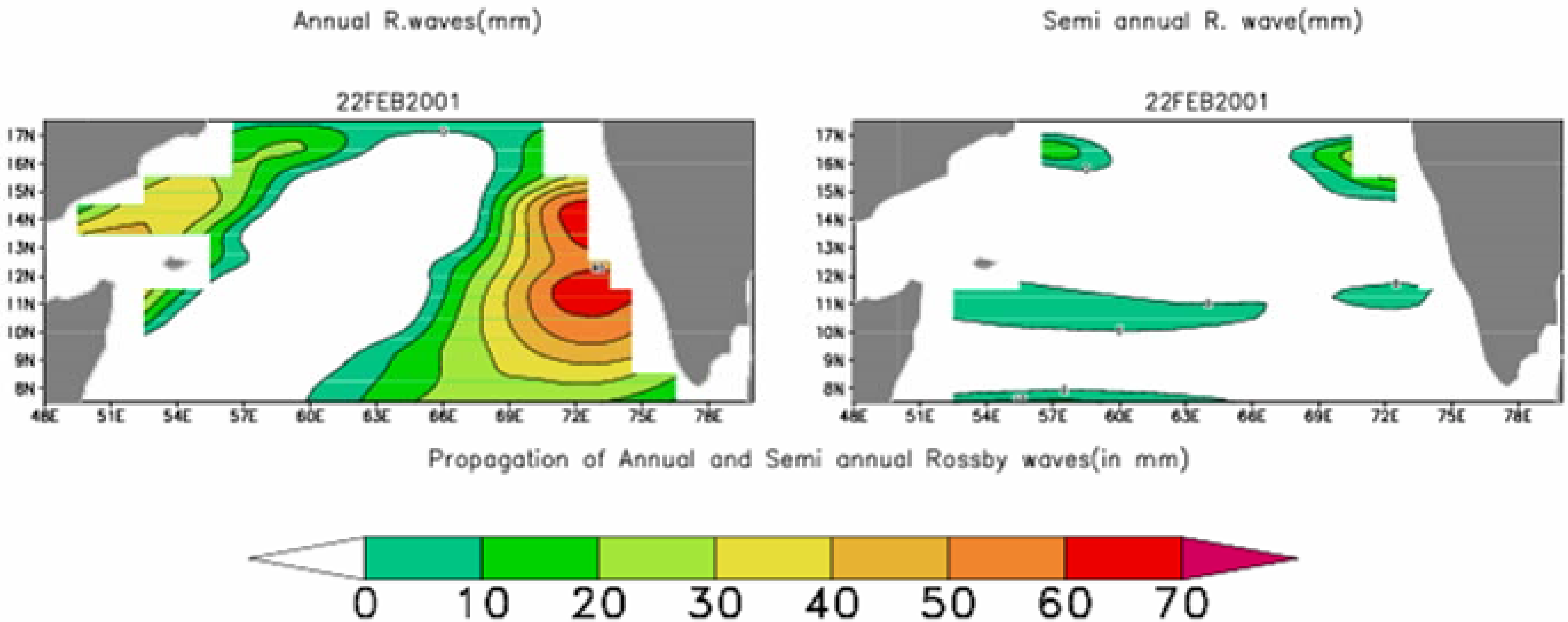


Propagation of Annual and Semi annual Rossby waves(in mm)

12 Feb. 2001

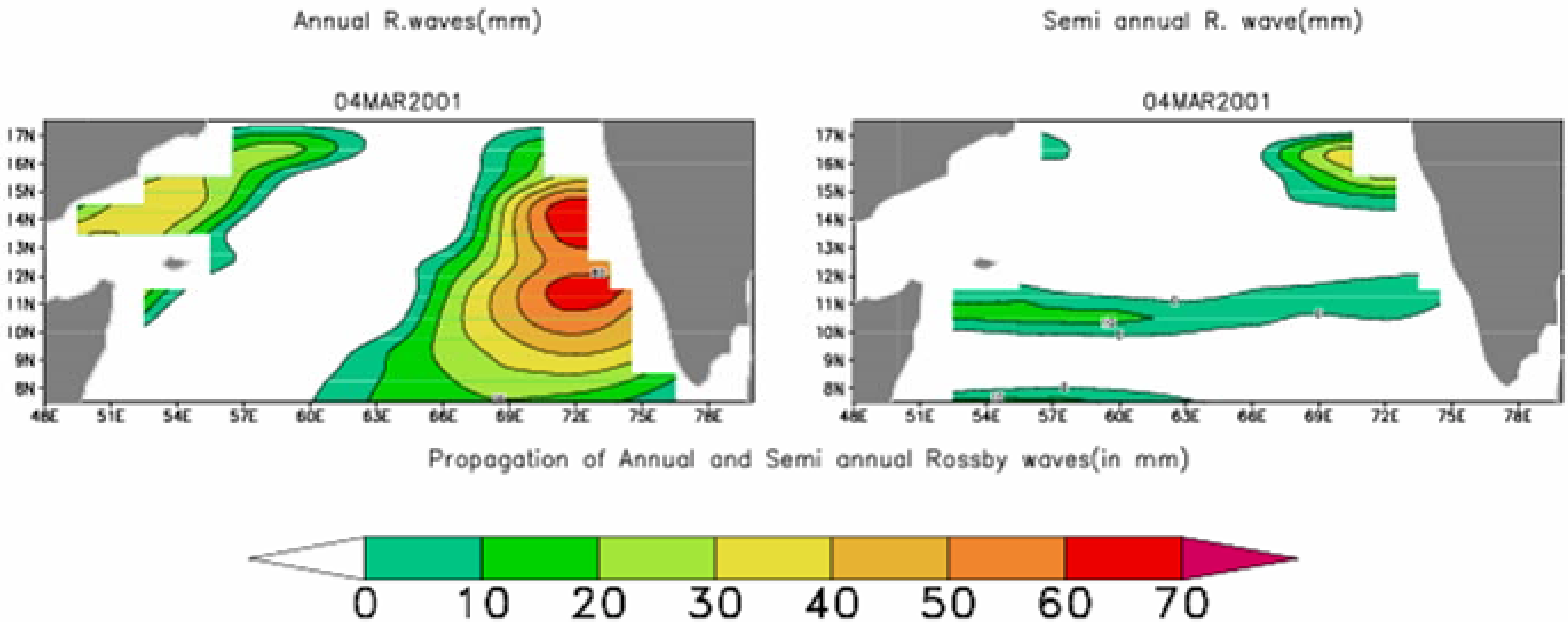

Annual R.waves(mm)
12FEB2001
Semi annual R. wave(mm)
12FEB2001
17N
16N
15N
14N
13N
12N
11N
10N
9N
8N
48E
51E
54E
57E
60E
63E
66E
69E
72E
75E
78E
Propagation of Annual and Semi annual Rossby waves(in mm)
0
10
20
30
40
50
60
70

22 Feb. 2001

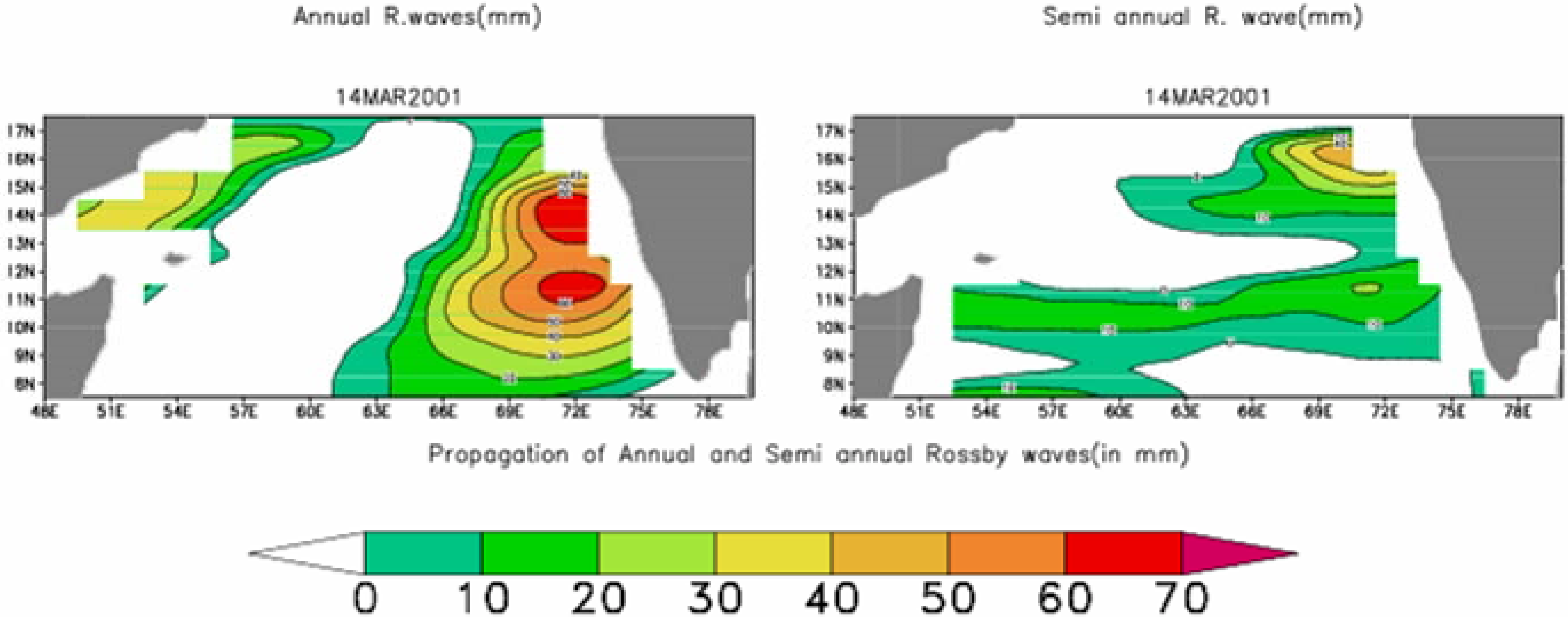


Propagation of Annual and Semi annual Rossby waves(in mm)

04 Mar. 2001

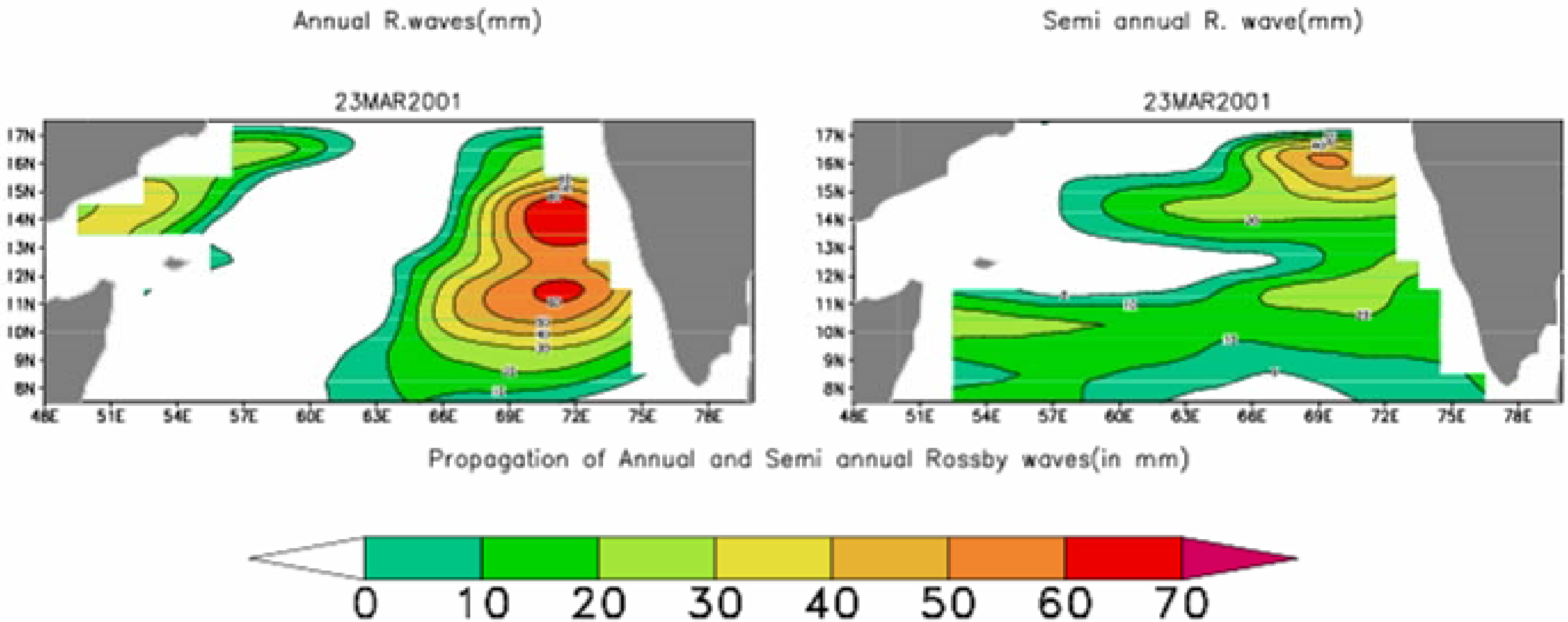

Annual R.waves(mm)
Semi annual R. wave(mm)
04MAR2001
04MAR2001
17N 16N 15N 14N 13N 12N 11N 10N 9N 8N
48E 51E 54E 57E 60E 63E 66E 69E 72E 75E 78E
Propagation of Annual and Semi annual Rossby waves(in mm)
0 10 20 30 40 50 60 70

14 Mar. 2001



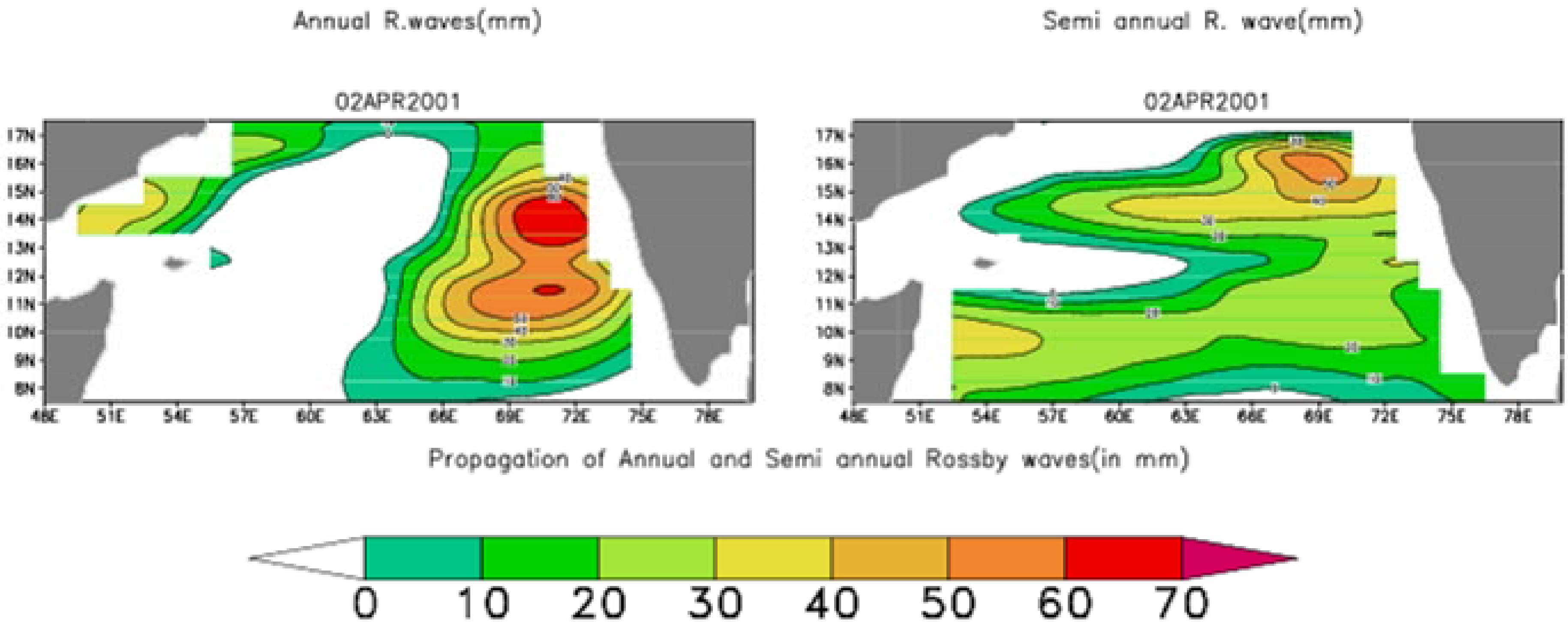
Propagation of Annual and Semi annual Rossby waves(in mm)

23 Mar. 2001



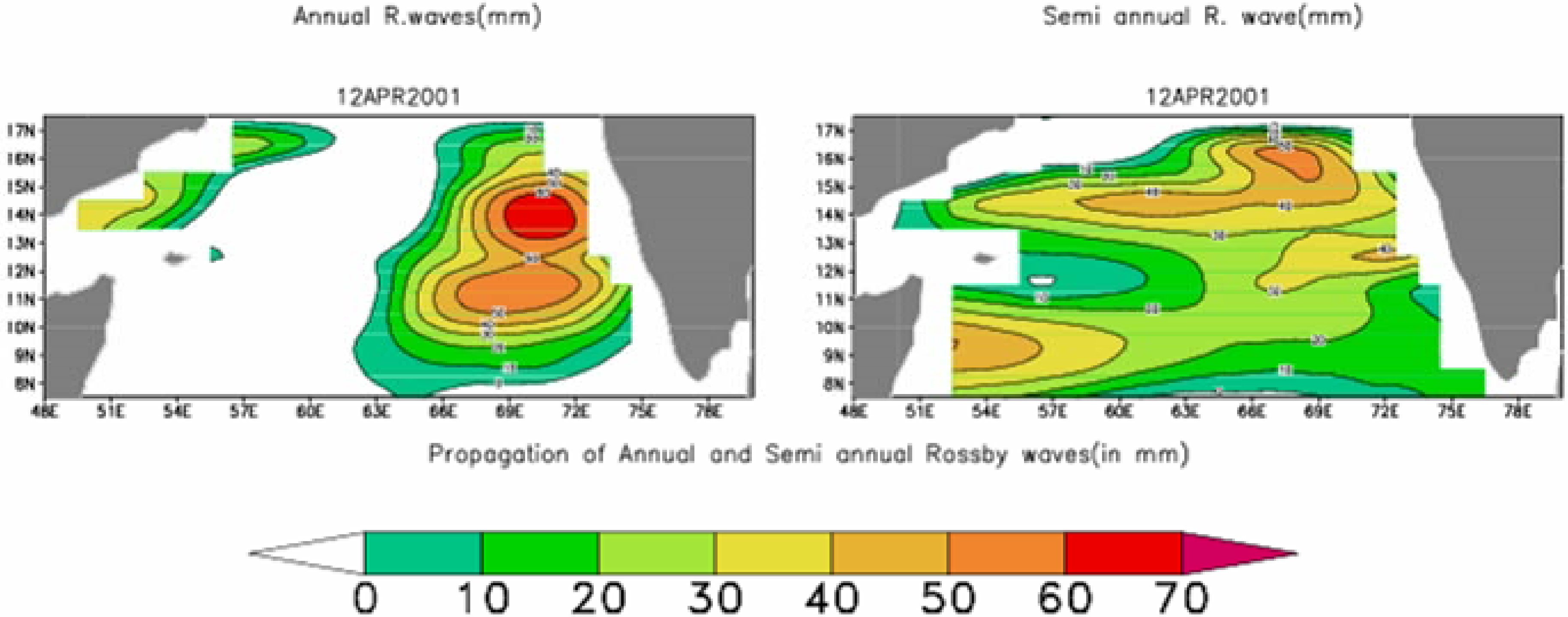
Propagation of Annual and Semi annual Rossby waves(in mm)

02 Apr. 2001



Annual R.waves(mm)
02APR2001
Semi annual R. wave(mm)
02APR2001
17N
16N
15N
14N
13N
12N
11N
10N
9N
8N
48E
51E
54E
57E
60E
63E
66E
69E
72E
75E
78E
Propagation of Annual and Semi annual Rossby waves(in mm)
0
10
20
30
40
50
60
70

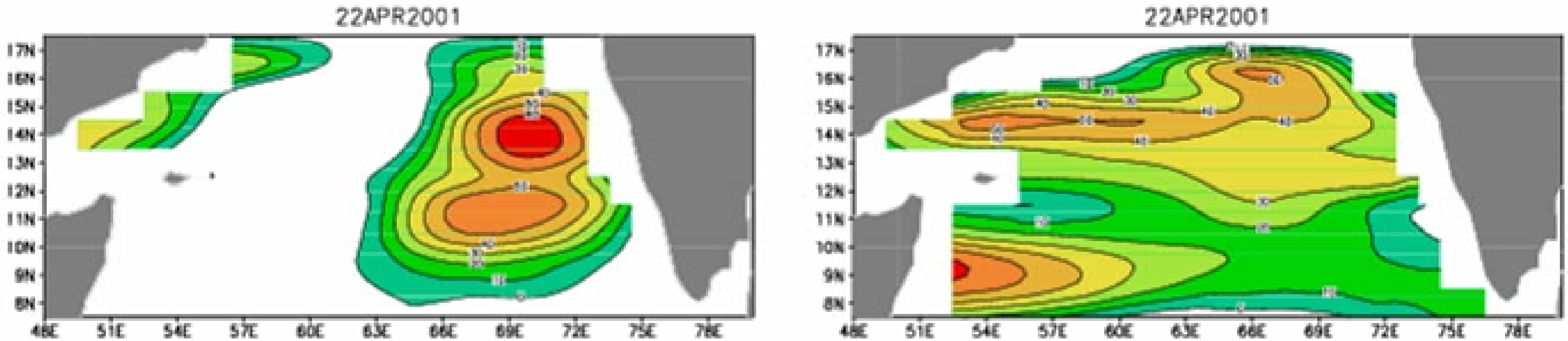
12 Apr. 2001



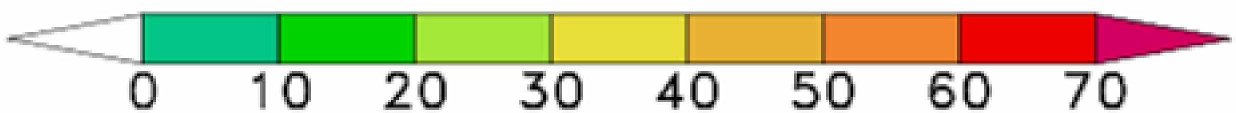
Propagation of Annual and Semi annual Rossby waves(in mm)

22 Apr. 2001

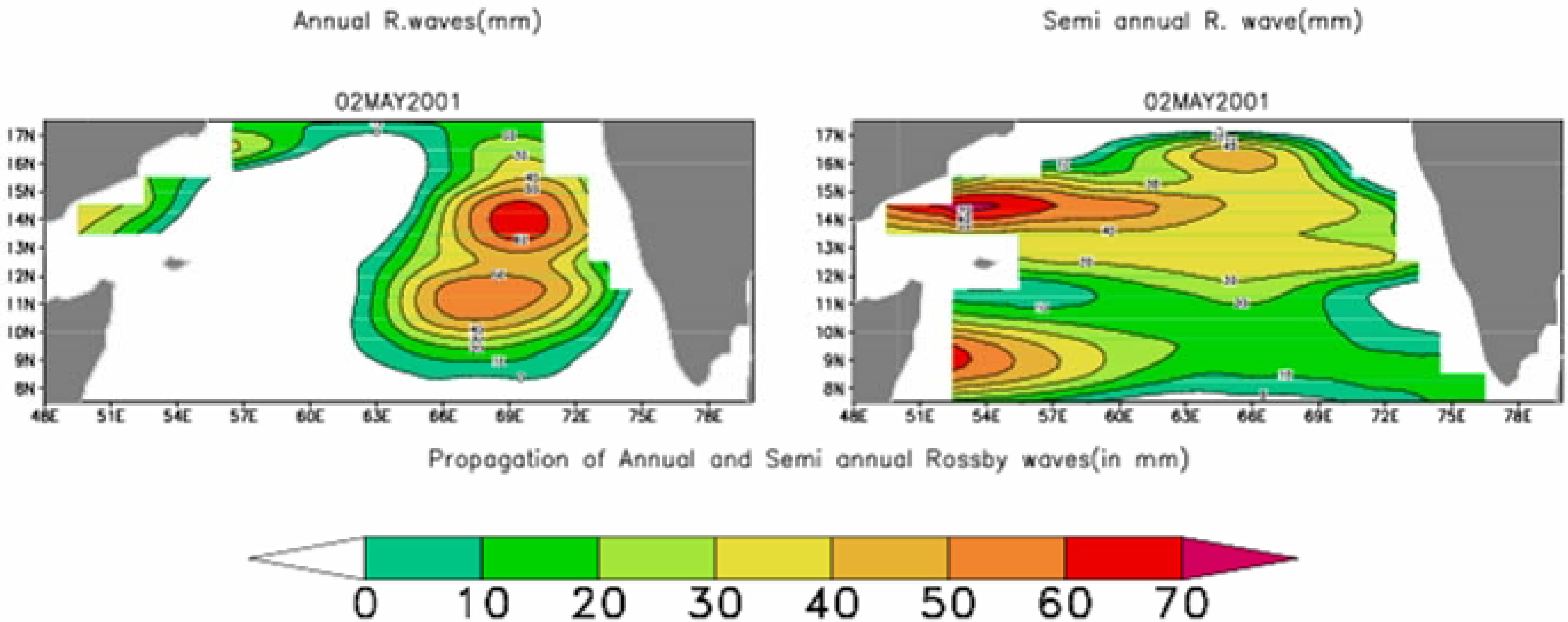
Annual R.waves(mm) | Semi annual R. wave(mm)



Propagation of Annual and Semi annual Rossby waves(in mm)

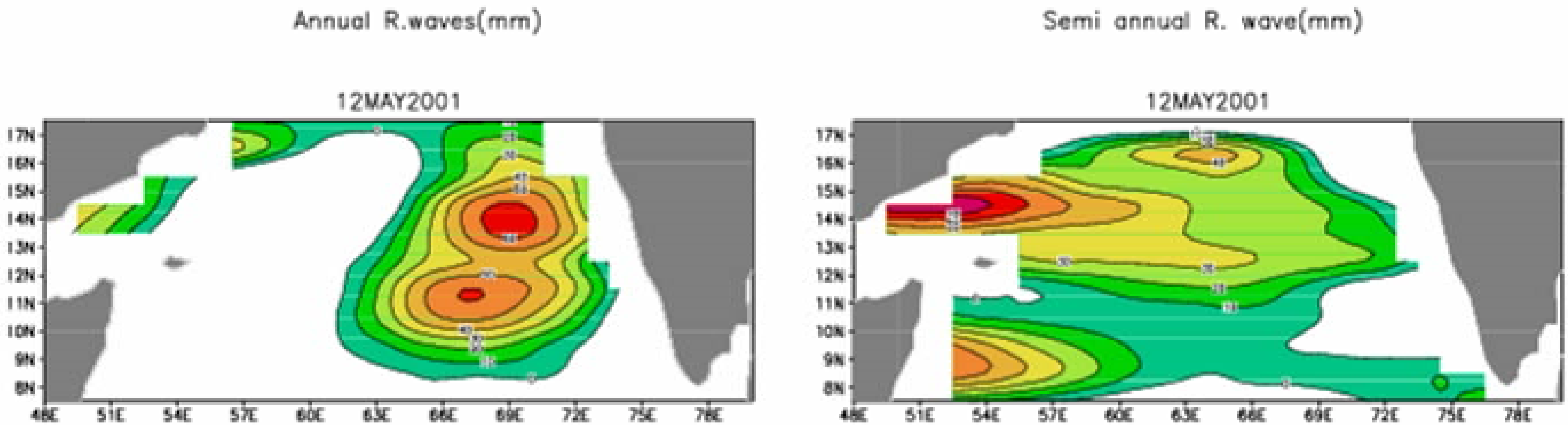


02 May. 2001

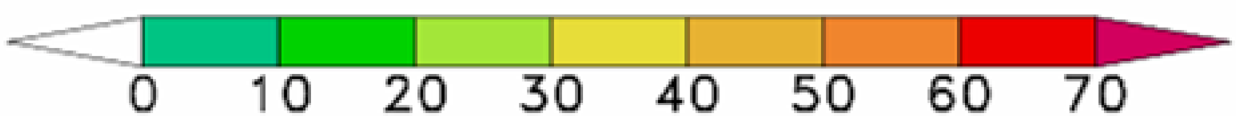


Propagation of Annual and Semi annual Rossby waves(in mm)

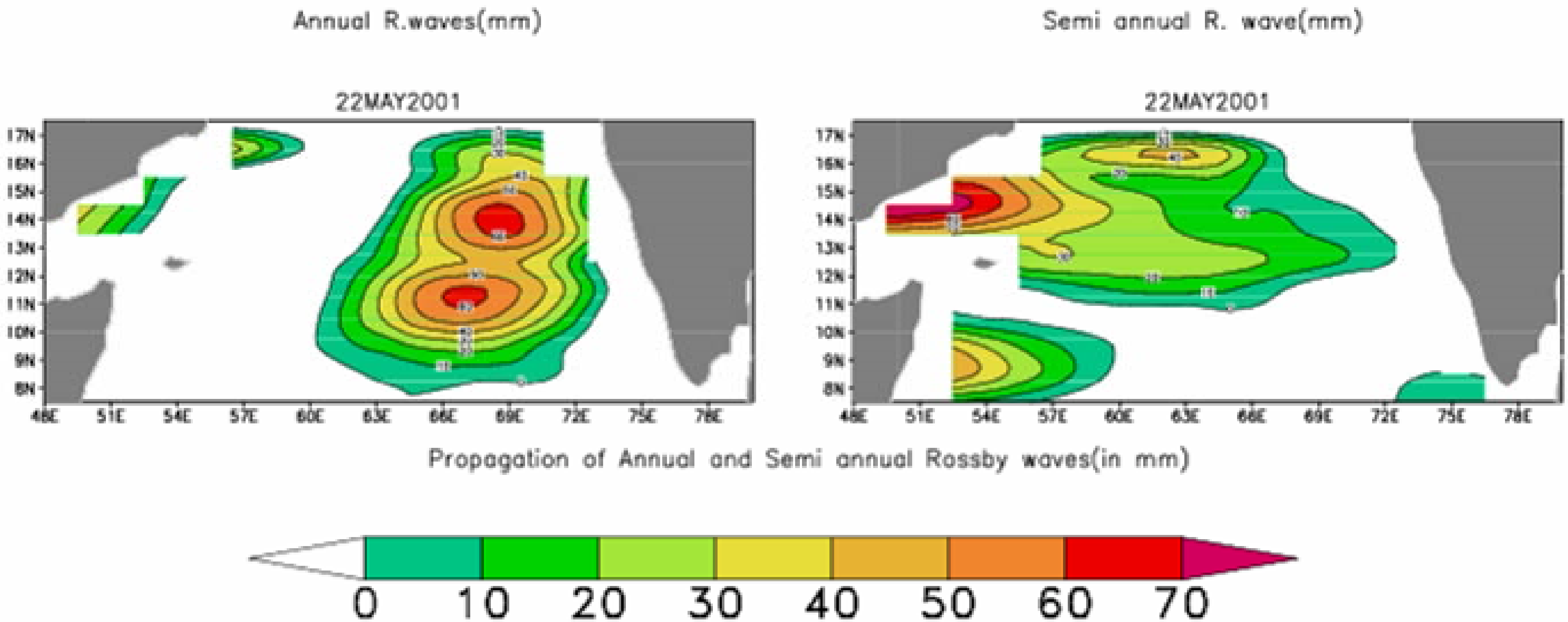
12 May. 2001



Propagation of Annual and Semi annual Rossby waves(in mm)



22 May. 2001


Annual R.waves(mm)
Semi annual R. wave(mm)
22MAY2001
22MAY2001
17N
16N
15N
14N
13N
12N
11N
10N
9N
8N
48E
51E
54E
57E
60E
63E
66E
69E
72E
75E
78E
Propagation of Annual and Semi annual Rossby waves(in mm)
0
10
20
30
40
50
60
70

Conclusions

- Strong temperature inversions in the SEAS were seen both in the observations and in the models.
- Remote forcing plays an important role in the formation of Barrier Layer in the SEAS and the Arabian Sea warm pool.
- Temperature inversions occuring in the SEAS during Nov to Feb propagate westward across the Lakshadweep with the annual Rossby waves.

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THANK YOU