The Classic Problem of Indian Monsoon-what AMSR-2 can reveal

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GCOM-W in Tokyo 1/15/2015

- EXTEND THE TIME SERIES WE PRODUCED WITH AMS-E DATA
- CONTINUE TO FIND NEW WAYS OF APPLYING AMSR DATA

Ocean's Role in Water/Energy/Carbon Cycles

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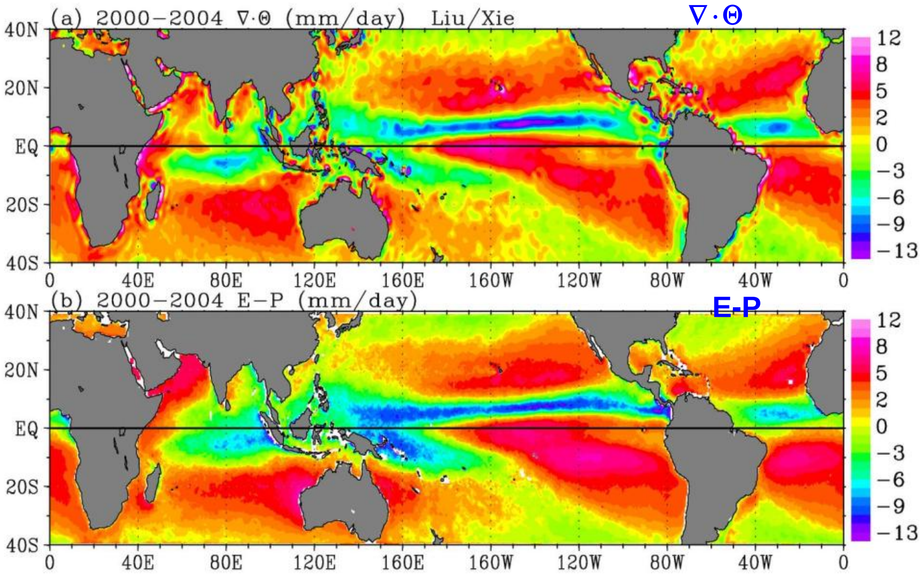
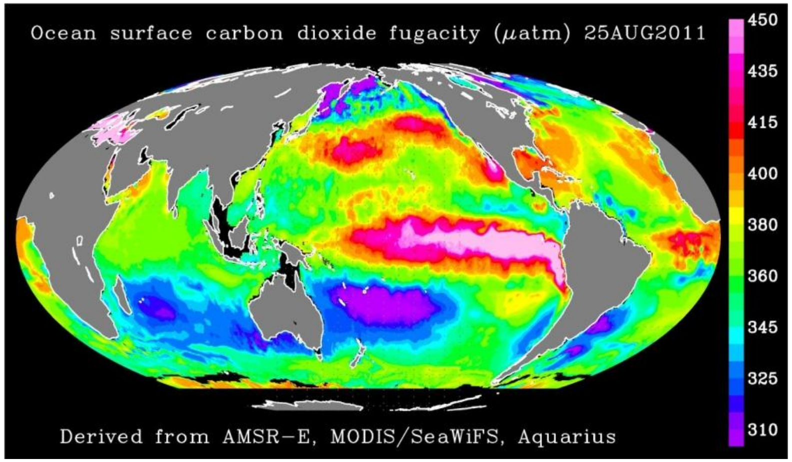
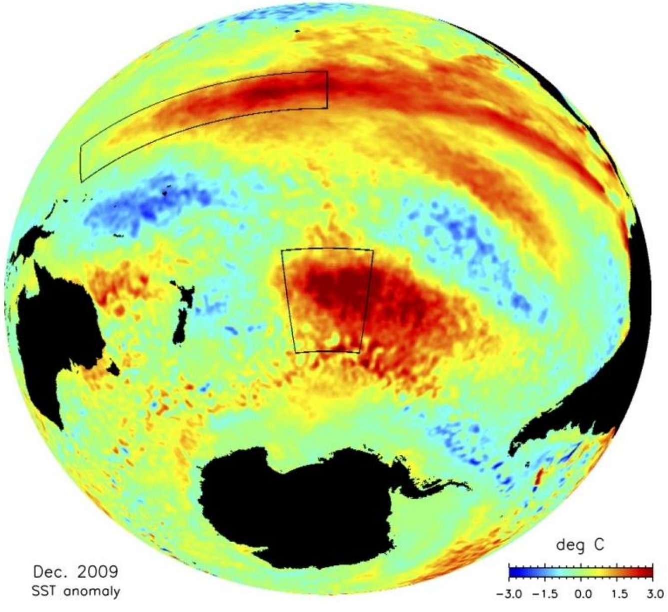
Water Cycle



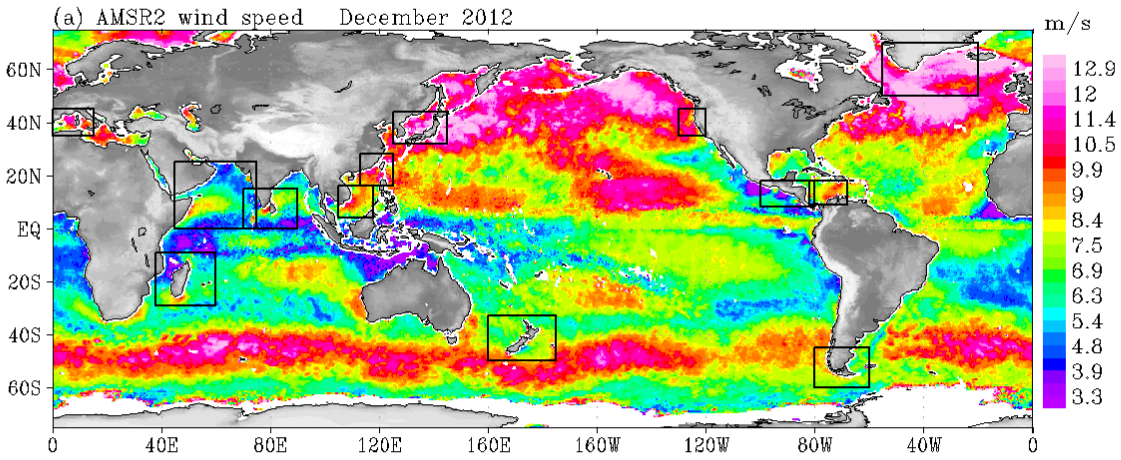
Carbon Cycle



Temperature Anomalies



Wind Farm Deployment



Extending Data Sets Derived from AMSR-E with AMSR-2

Using AMSR data, we developed and validated retrieval methods for

(1) Ocean surface evaporation (E) through bulk parameterization

(2) E directly from brightness temperatures measured by AMSR-E

(3) Integrated water transport. The divergence of the transport is E-P

(4) Wind power distribution for deployment of floating wind farms

(5) Ocean surface carbon dioxide fugacity

Produced and provided accessibility to 9 years (6/2002-9/2011) data of (1)-(5)

http://airsea.jpl.nasa.gov/seaflux/seaflux.html

Monsoon-the basic definition

- Monsoon is the seasonal reversal of transport between land and ocean that has strong rain effect
- Synoptic rain events should be linked to seasonal oceanic moisture supply.
- Interannual and decadal modifications of monsoon in terms of global teleconnection between rain and SST must be interpreted through regional ocean-land exchanges.
- Besides rain, soil moisture has given us an additional spacebased observation on terrestrial response to ocean influcence

HYDROLOGIC BALANCE

$$\frac{\partial W}{\partial t} + \nabla \bullet \Theta = E - P$$

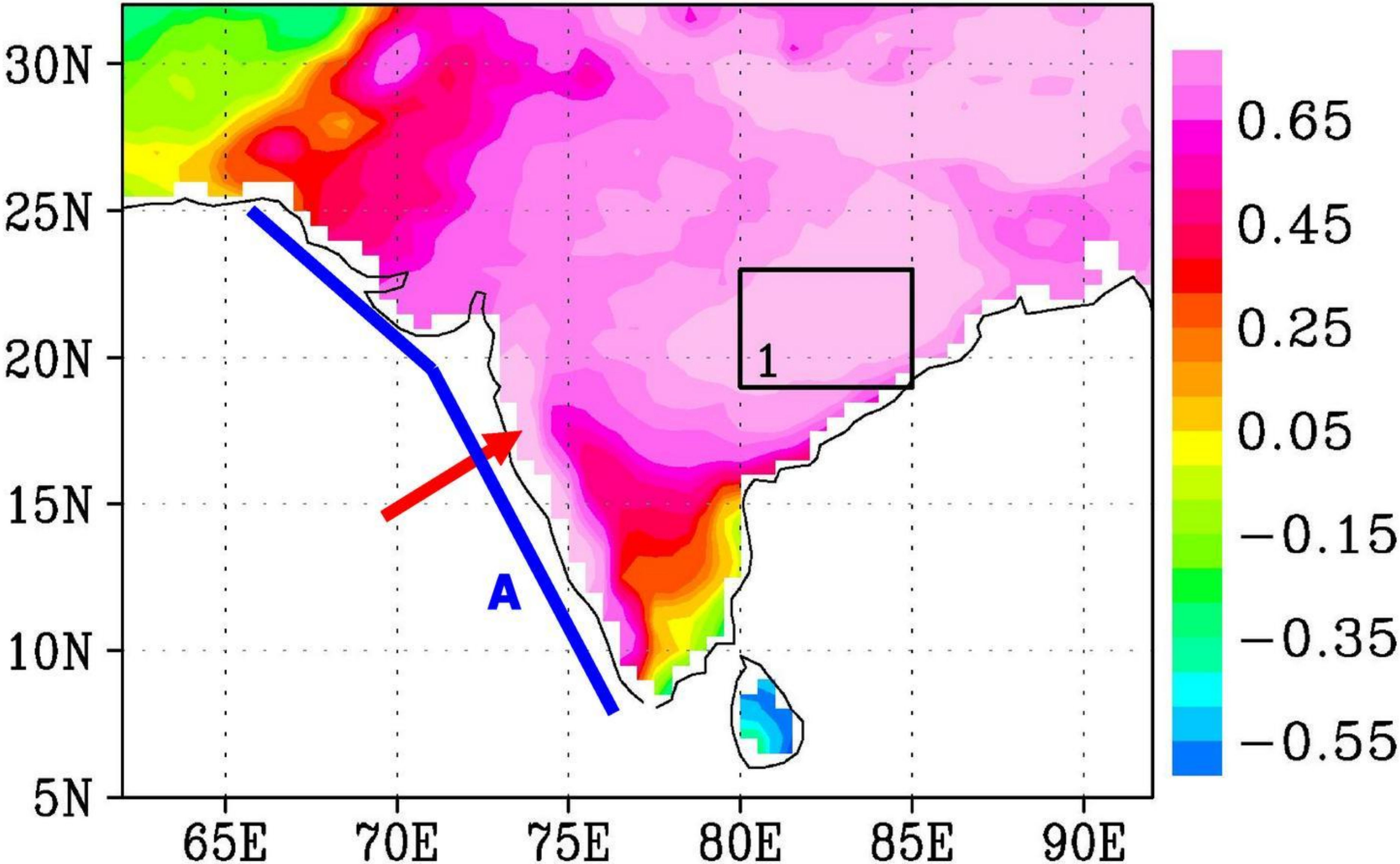
$$\Theta = \frac{1}{g}\int_0^{p0} qU\mathbf{d}p$$

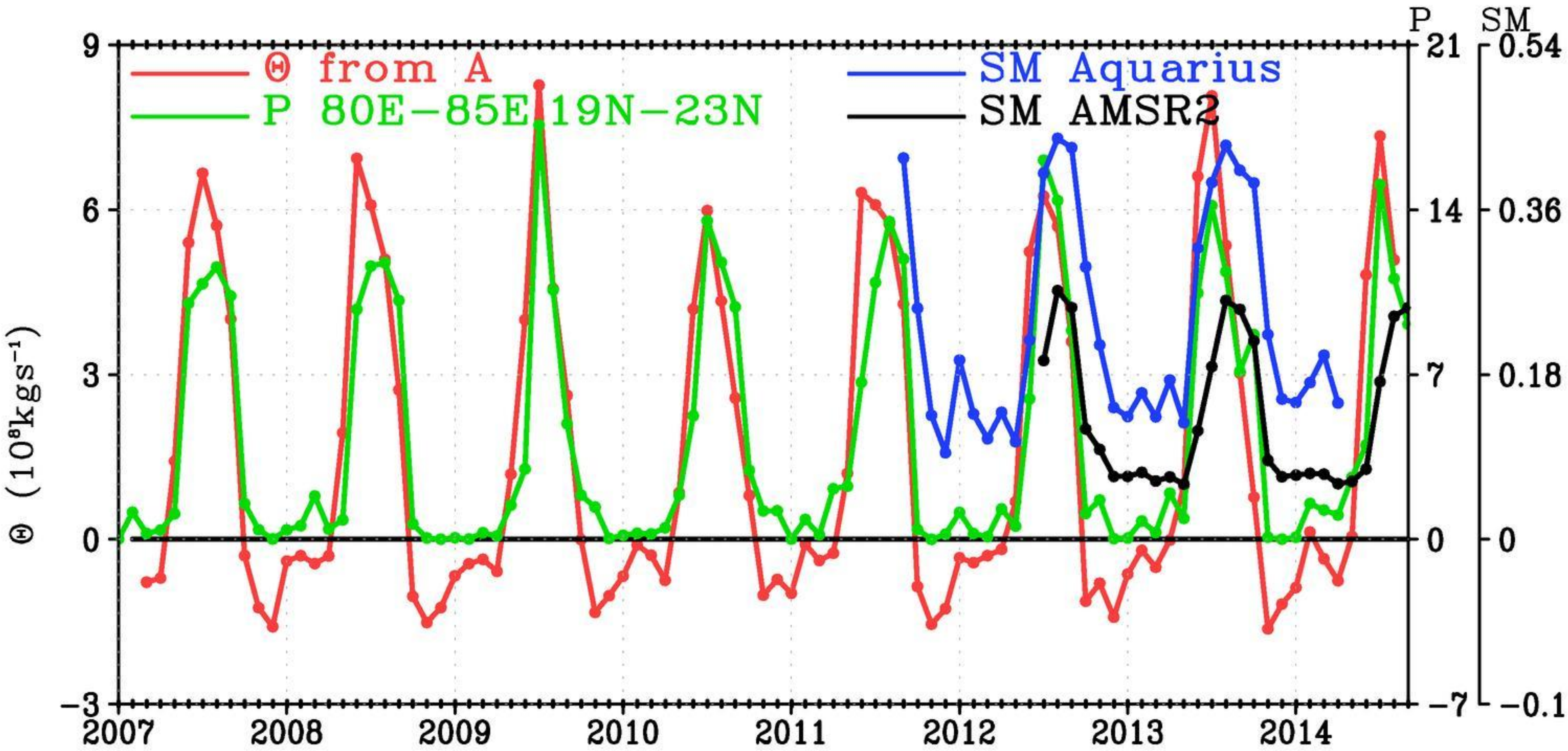
$$\mathbf{W} = \frac{1}{g}\int_0^{p0} q\mathbf{dp}$$

$$\Theta = \mathbf{Ue}\ \mathbf{W}$$

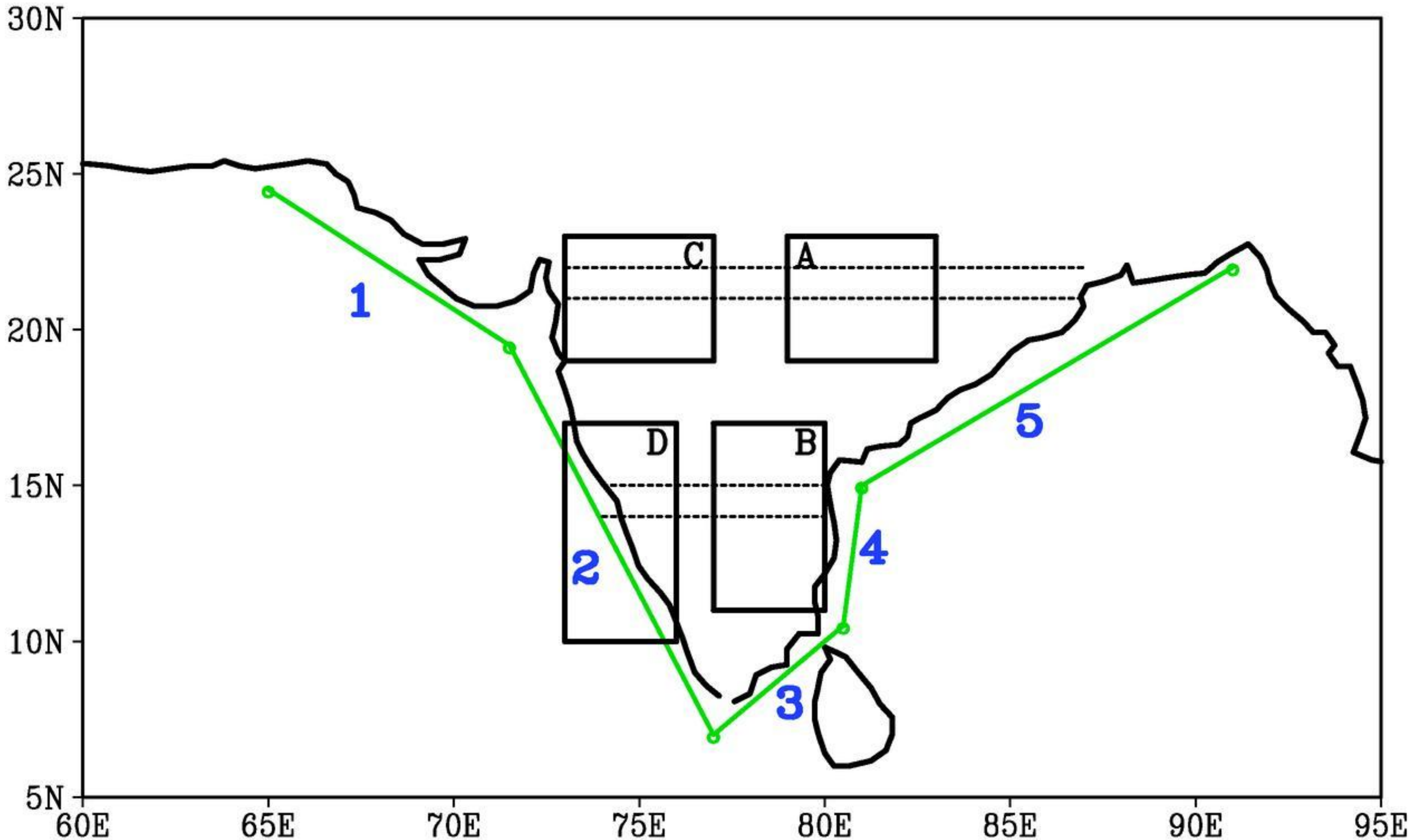
Θ is equivalent to column water vapor W advected by Ue.
Ue is the depth-averaged wind weighted by humidity
We use SVR to relate Ue to wind at two levels:
1. U_N: scatterometer surface wind stress
2. U_{850mb}: cloud drift wind (free-stream wind)

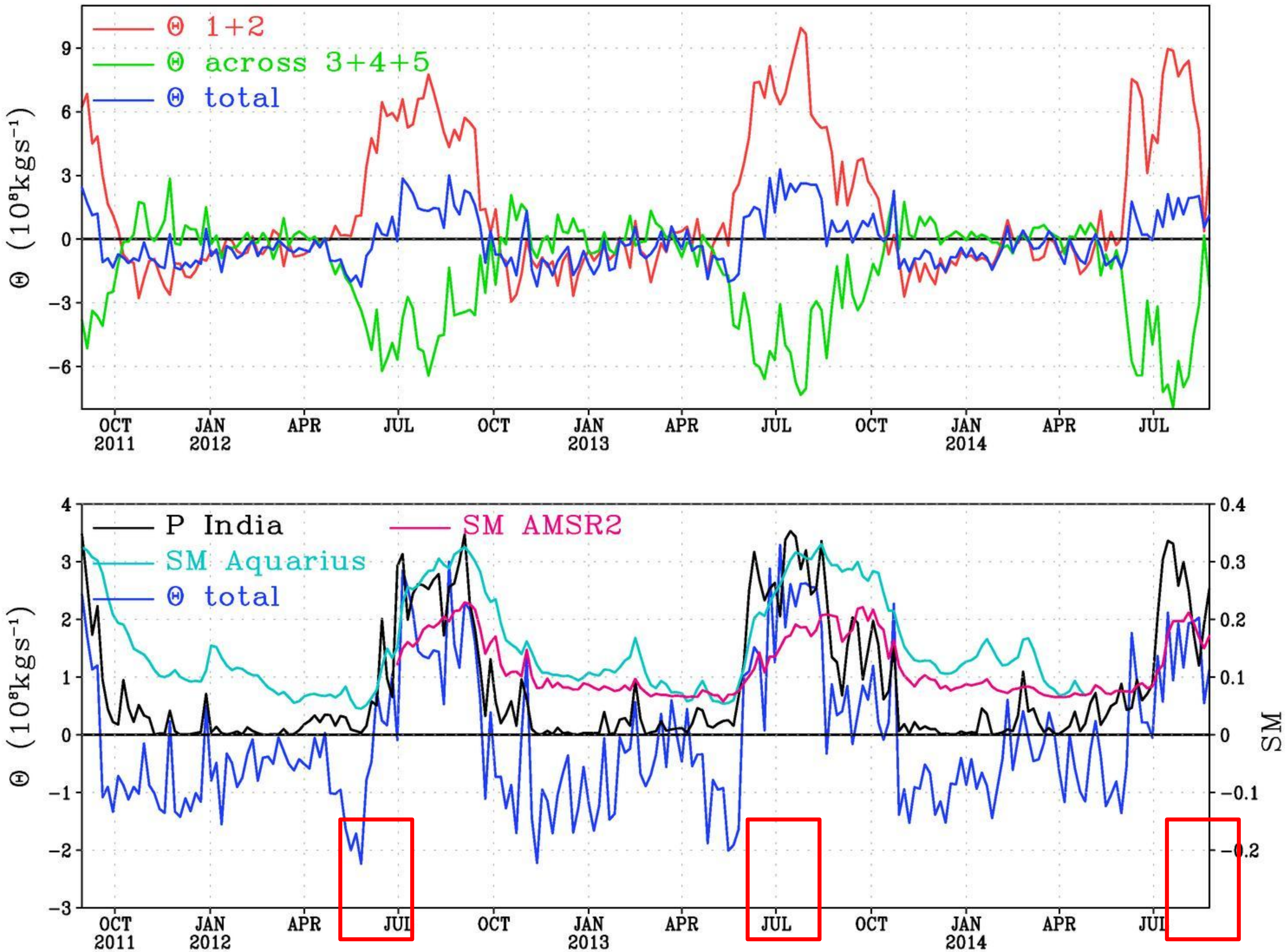
Correlation coefficient between Θ from A and precipitation



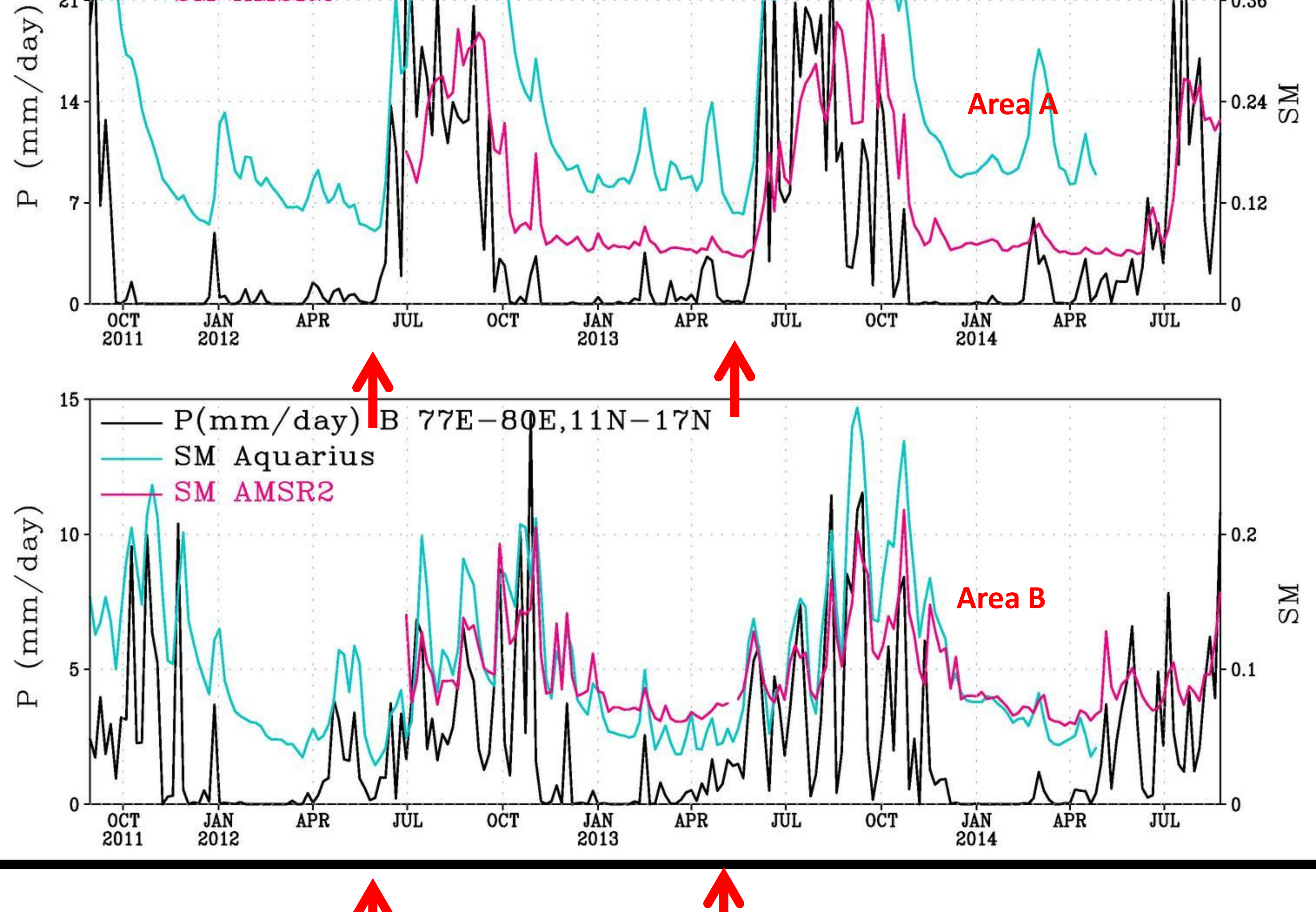


Obvious bias in soil moisture between AMSR-2 and Aquarius

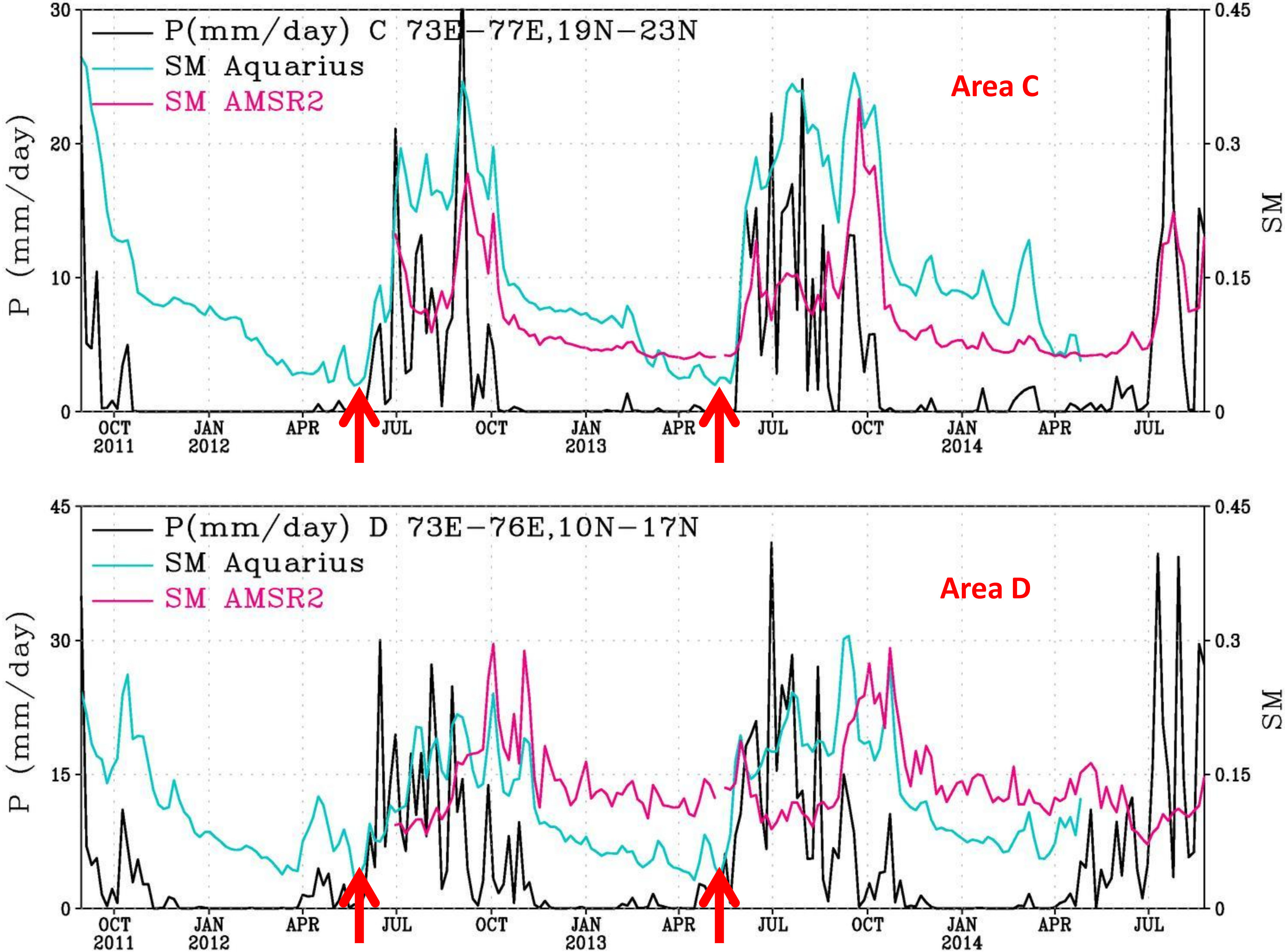

30N
25N
20N
15N
10N
5N
60E
65E
70E
75E
80E
85E
90E
95E
A
B
C
D
1
2
3
4
5

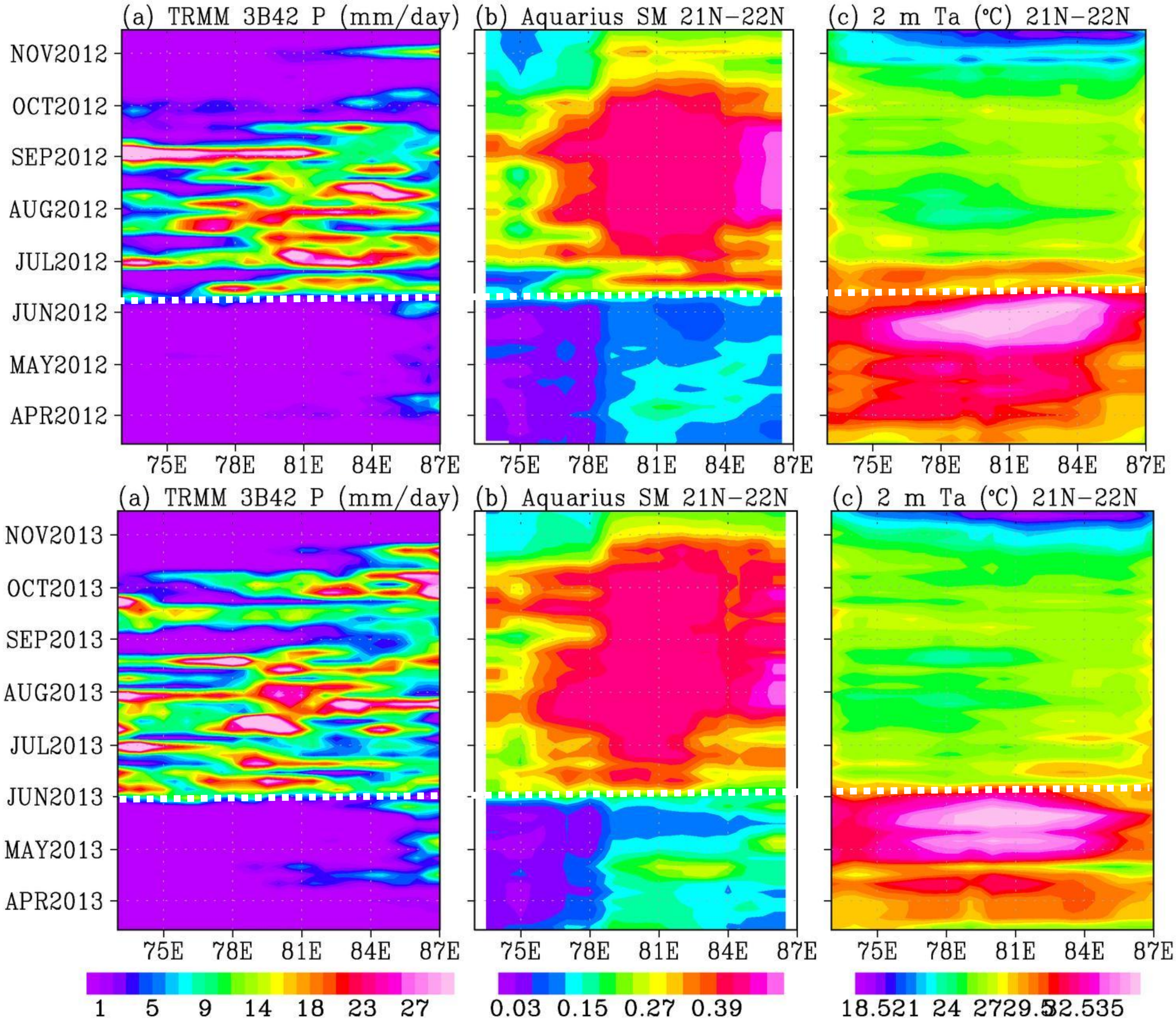


More moisture advected out to BB than coming in from AS before monsoon onsets

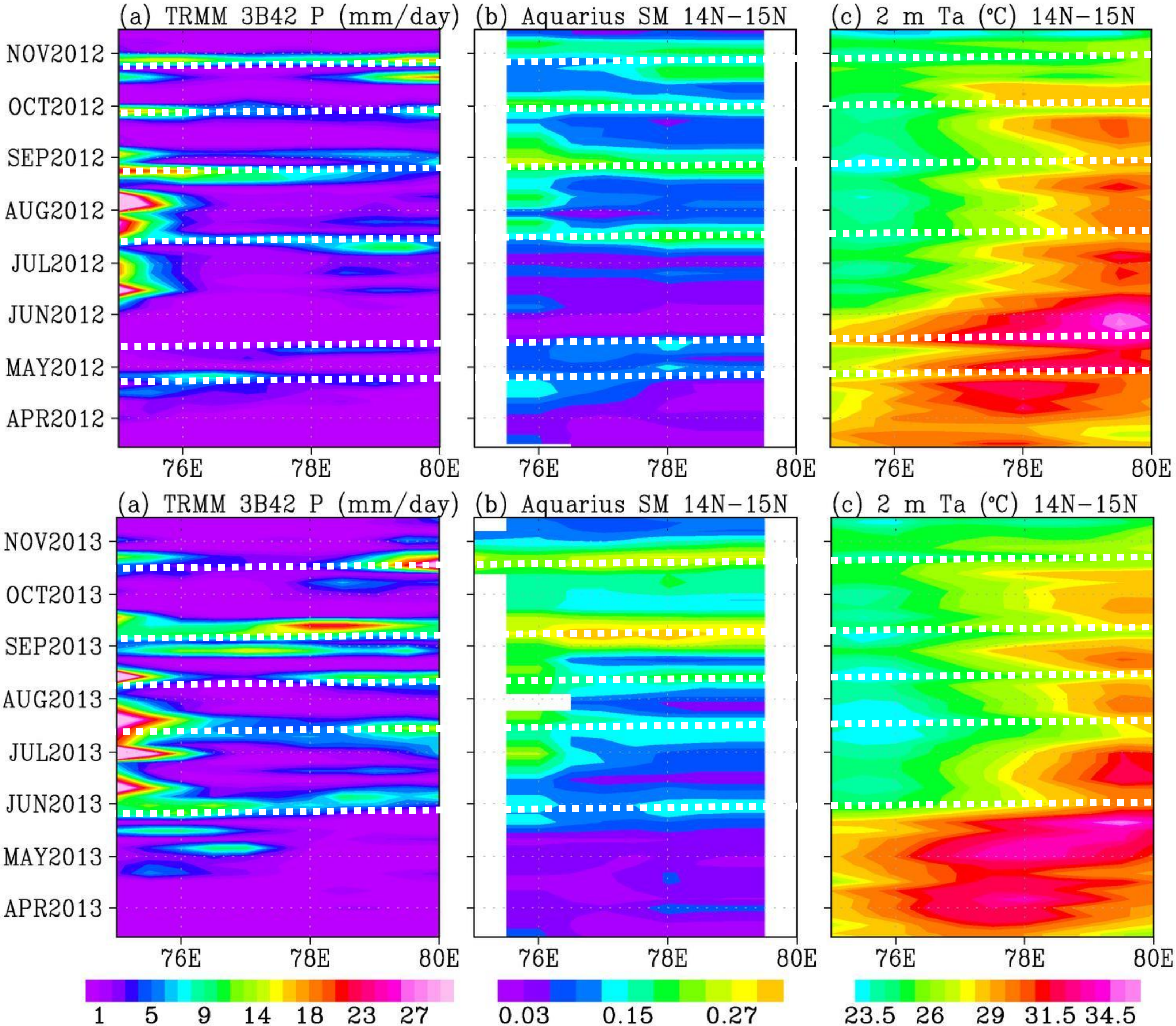


Pre-monsoon drought reflected in soil moisture

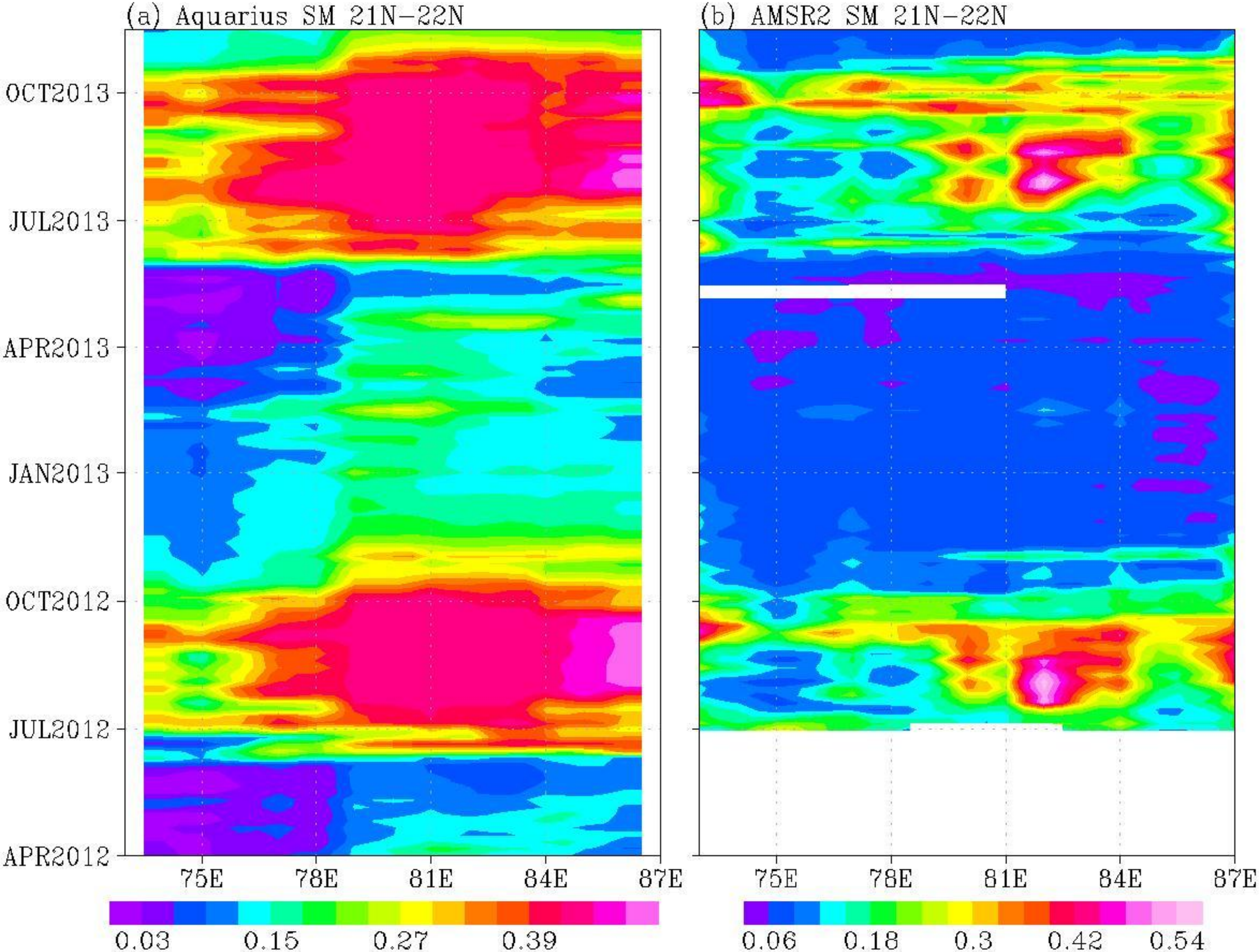

P(mm/day) C 73E–77E,19N–23N
SM Aquarius
SM AMSR2
Area C
P (mm/day)
SM
OCT 2011
JAN 2012
APR
JUL
OCT
JAN 2013
APR
JUL
OCT
JAN 2014
APR
JUL
P(mm/day) D 73E–76E,10N–17N
SM Aquarius
SM AMSR2
Area D
P (mm/day)
SM

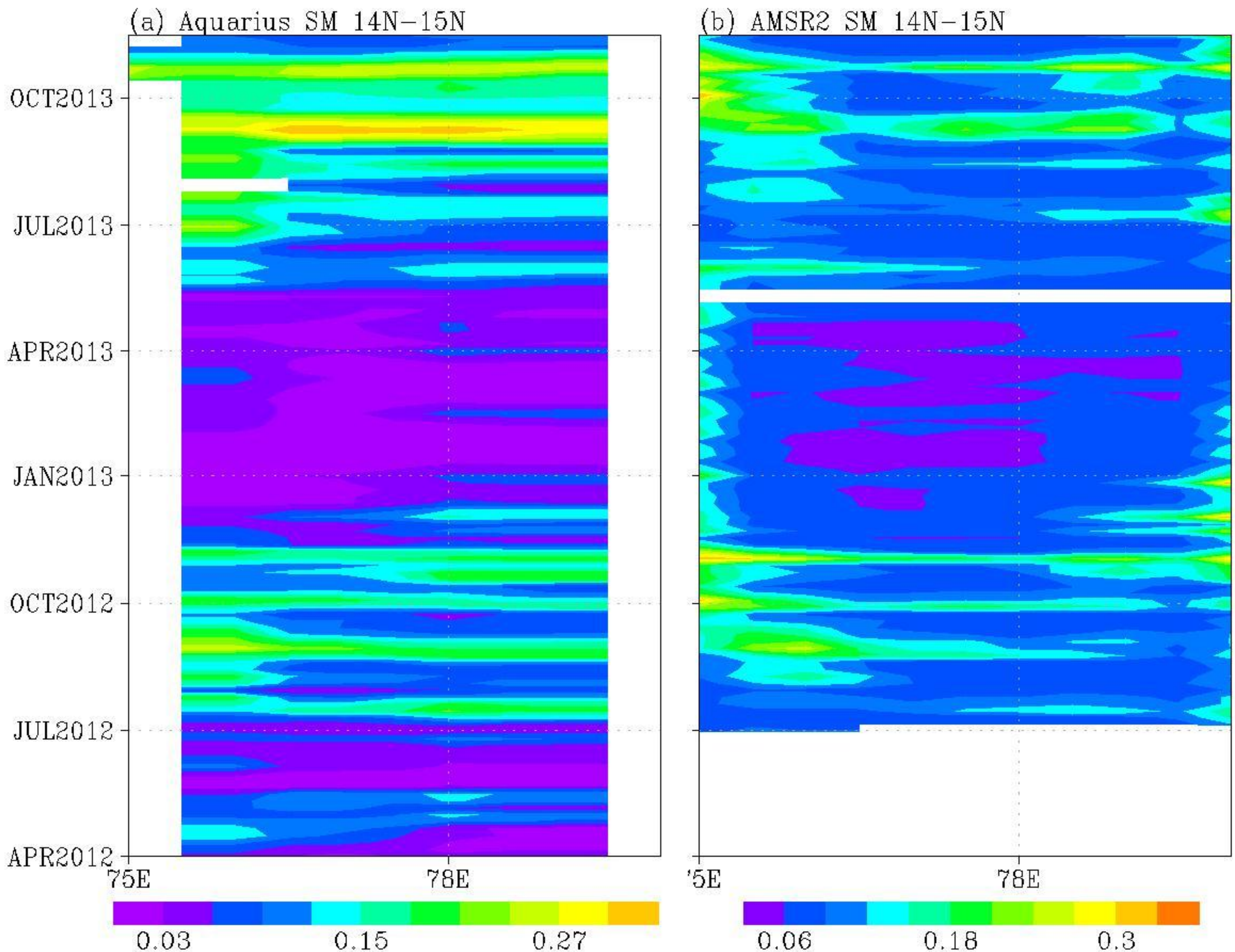


(a) TRMM 3B42 P (mm/day)
(b) Aquarius SM 21N-22N
(c) 2 m Ta (°C) 21N-22N
NOV2012
OCT2012
SEP2012
AUG2012
JUL2012
JUN2012
MAY2012
APR2012
NOV2013
OCT2013
SEP2013
AUG2013
JUL2013
JUN2013
MAY2013
APR2013
75E 78E 81E 84E 87E
1 5 9 14 18 23 27
0.03 0.15 0.27 0.39
18.5 21 24 27 29.5 32.5 35



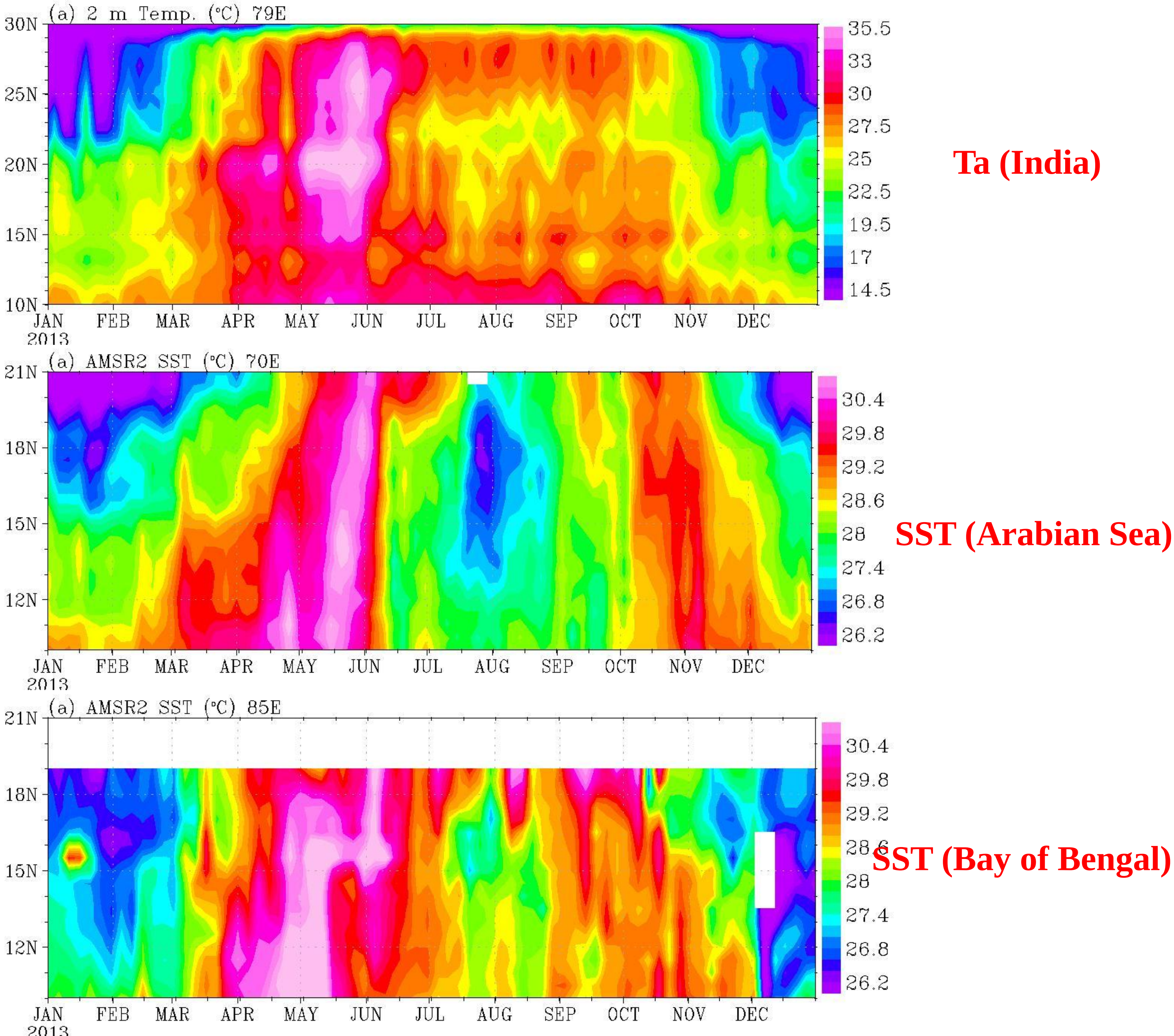
(a) TRMM 3B42 P (mm/day)
(b) Aquarius SM 14N−15N
(c) 2 m Ta (°C) 14N−15N
NOV2012
OCT2012
SEP2012
AUG2012
JUL2012
JUN2012
MAY2012
APR2012
76E
78E
80E
(a) TRMM 3B42 P (mm/day)
(b) Aquarius SM 14N−15N
(c) 2 m Ta (°C) 14N−15N
NOV2013
OCT2013
SEP2013
AUG2013
JUL2013
JUN2013
MAY2013
APR2013
76E
78E
80E
1 5 9 14 18 23 27
0.03 0.15 0.27
23.5 26 29 31.5 34.5

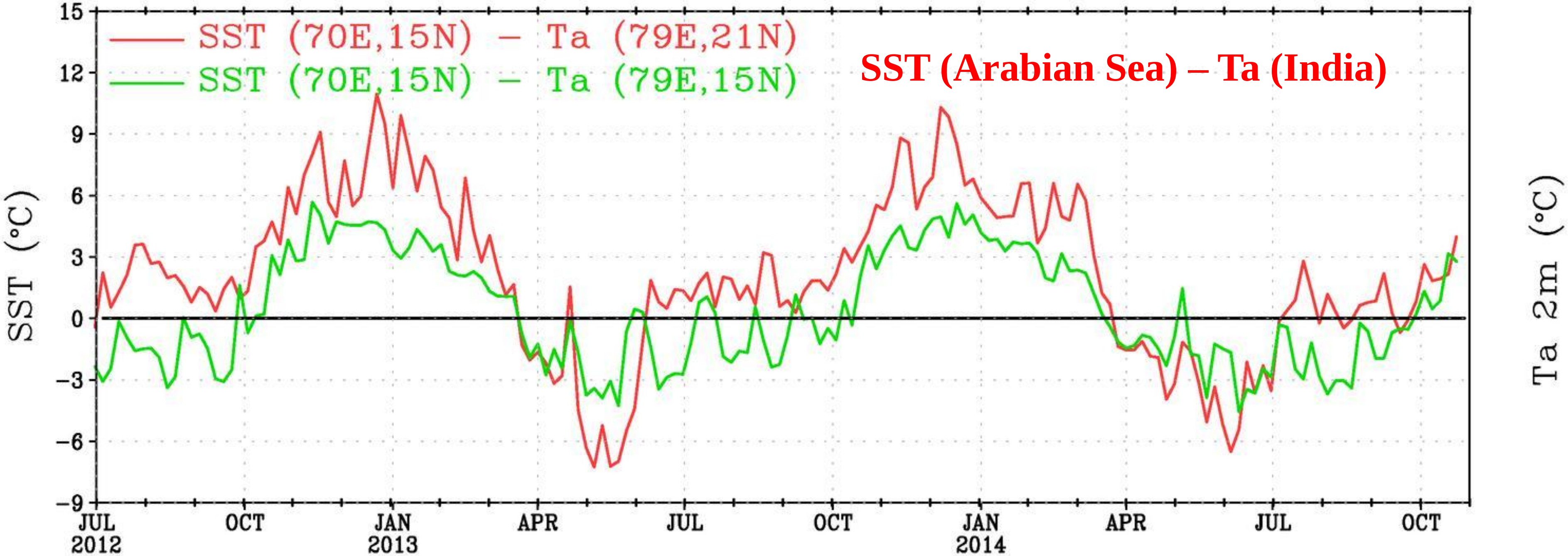

(a) Aquarius SM 21N-22N
(b) AMSR2 SM 21N-22N
OCT2013
JUL2013
APR2013
JAN2013
OCT2012
JUL2012
APR2012
75E
78E
81E
84E
87E
0.03
0.15
0.27
0.39
0.06
0.18
0.3
0.42
0.54

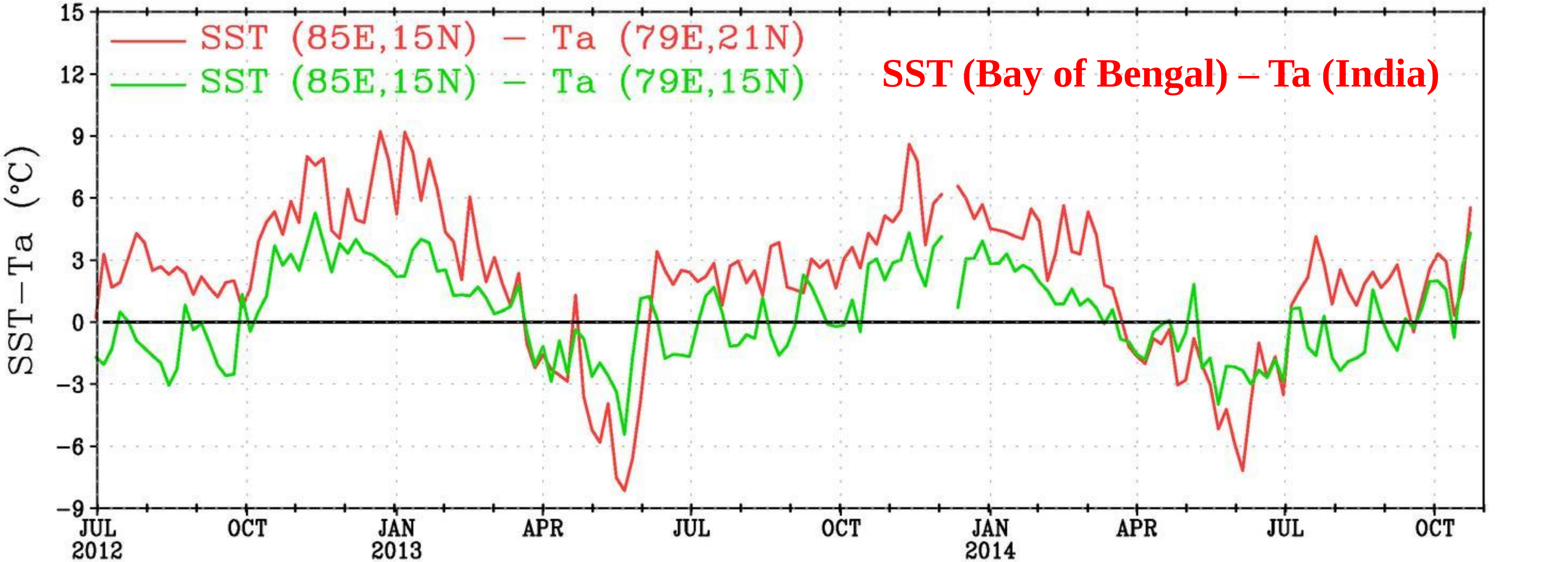


(a) Aquarius SM 14N-15N
(b) AMSR2 SM 14N-15N
OCT2013
JUL2013
APR2013
JAN2013
OCT2012
JUL2012
APR2012
75E
78E
0.03
0.15
0.27
0.06
0.18
0.3

Temperature gradient


(a) 2 m Temp. (°C) 79E
30N
25N
20N
15N
10N
JAN
2013
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
35.5
33
30
27.5
25
22.5
19.5
17
14.5
Ta (India)
(a) AMSR2 SST (°C) 70E
21N
18N
15N
12N
JAN
2013
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
30.4
29.8
29.2
28.6
28
27.4
26.8
26.2
SST (Arabian Sea)
(a) AMSR2 SST (°C) 85E
21N
18N
15N
12N
JAN
2013
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
30.4
29.8
29.2
28.6
28
27.4
26.8
26.2
SST (Bay of Bengal)


SST (70E,15N) – Ta (79E,21N)
SST (70E,15N) – Ta (79E,15N)
SST (Arabian Sea) – Ta (India)
SST (°C)
Ta 2m (°C)
JUL 2012
OCT
JAN 2013
APR
JUL
OCT
JAN 2014
APR
JUL
OCT


SST (85E,15N) – Ta (79E,21N)
SST (85E,15N) – Ta (79E,15N)
SST (Bay of Bengal) – Ta (India)
SST–Ta (°C)
JUL 2012
OCT
JAN 2013
APR
JUL
OCT
JAN 2014
APR
JUL
OCT

Summary

- The monsoon rain in central Indian Subcontinent is closely linked to the moisture flux from the Arabian Sea, with onset in early June and peak in July/August.

- Before the onset of the Indian summer monsoon, the Indian subcontinent is characterized by extremely hot air temperature, with maximum in May. The air temperature immediately cools down with the monsoon onset. There is strong northerly winds at 850 mb in April/May, which coincide with the pre-monsoon drought. Soil moisture shows very dry land before the monsoon onset. The net moisture flux to the Indian subcontinent in May is negative, with weaker flux from the Arabian Sea and stronger out flux into the Bay of Bengal.

- Rain along the west coast starts around mid-May, approximately two weeks before rain in the center part of the subcontinent.

- The soil moisture increases in sync with the monsoon onset and remains high until the end of October, two months after the peak monsoon rainfall.

- Soil moisture measured by AMSR2 is lowerin magnitude and range than that by Aquarius in the central India.

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