SUPPLEMENTARY MATERIAL

(a) Spatial distribution of Water vapor mixing ratio and OLR

Figure 1s a-b shows the spatial distribution of WVMR at pressure levels 261.0, 215.4, 177.8 and 146.8 hPa over the tropical region for the period of June to September 2007. The low OLR regions in **Figure 1s a-b** are highlighted as black and white contour lines at 220 Wm^{-2} and 200 Wm^{-2} respectively. It is clear from the **Figure 1s a-b** that the region of high WVMR at 261.0 and 215.4 hPa lays directly above the low OLR region and a gradual spatial shift of the WVMR maxima is observed for pressure level < 177.8 hPa. The core region of high WVMR at 146.8 hPa lays somewhat north-westwards of OLR minima region indicating the significance of background winds.

(b) Wind patterns obtained from Era-Interim reanalysis data

Figures 2s a-d show the wind vector plots obtained by using U and V component of wind data obtained from Era-Interim reanalysis over the tropical region at 100 and 125 hPa for the months of June-September, 2007. Average of U and V component of wind is taken at every grid point for the period of June to September 2007 to draw the wind vectors shown in Figure 2s a-d. Presence of anticyclone is observed over Asian and American region at 100 hPa and 125 hPa during the boreal monsoon period. Observed winds are noted to be divergent in nature and connect all three tropical convective regions during the monsoon period. The amalgamation of three convective regions observed in WVMR distribution (Figure 2b) at 100 hPa and 121.2 hPa may be due to the role of horizontal winds in transportation of water vapor at these levels as wind divergence at these pressure levels might have helped in the redistribution of water vapor over tropical region. This is also evident from the fact that water vapor over the three convective regions over tropics tend to intermix or come close as the monsoon progresses from June to September.

(c) *Comparison of MLS water vapor ascent rate with vertical velocity obtained from ERA-Interim*

Vertical ascent rate of water vapor obtained from Aura MLS data is compared with vertical velocity of air obtained from Era-Interim. Monthly mean data of vertical velocity is obtained from ECMWF data portal for the period of 13 Aug 2004 (start of MLS) to 31 Dec 2010. Since the spatial resolution of ERA-Interim data is 1.5x1.5 degrees and doesn’t exactly matches with the 10x20 degree latitude-longitude sector chosen for AURA MLS analysis (Asian: 10-20 °N, 80-100 °E; American: 10-20 °N, 90-110 °W; African: 10-20 °N, 10-30 °E), so the nearest available 12x18 degree latitude-longitude region is chosen (Asian: 9-21 °N, 81-99 °E; American: 9-21 °N, 91-109 °W; African: 9-21 °N, 10.5-28.5 °E). The selected 12x18 degree region was further subdivided into 24 smaller sectors, each with dimensions 3x3 degree latitude-longitude and value of each sector is shown in graphs using a scatter plot.

Figures 3s a-c show the vertical ascent rate of water vapor calculated by using AURA MLS data and vertical velocity of air obtained from ERA-Interim over all three convective regions. These values are also compared with ERA-Interim vertical velocity which has been calculated by using methodology as discussed above. A good agreement between AURA MLS vertical ascent rate and ERA-Interim vertical velocity is observed for pressure levels lower than 82.5 hPa and the deviation between AURA MLS and ERA-Interim data increases for pressure levels higher than 82.5 hPa. This could be due to stronger vertical mixing of air at lower heights. Over Asian region, the downward velocities are not observed inside the selected latitude-longitude region of study, whereas, large downward velocities are observed along with upward velocities over American and African region for lower heights (≥ 100 hPa).

This is to be noted that the water vapor ascent rates computed using Aura MLS data represents the average mesoscale ascent rates over each region. The water vapor ascent rate directly over the convective system (i.e. Microscale velocities) or in-cloud ascent rate may be much different than the mesoscale ascent rate presented here. Era Interim or any other global model cannot depict the vertical velocity of water vapor under sublimation or in-cloud mechanism.

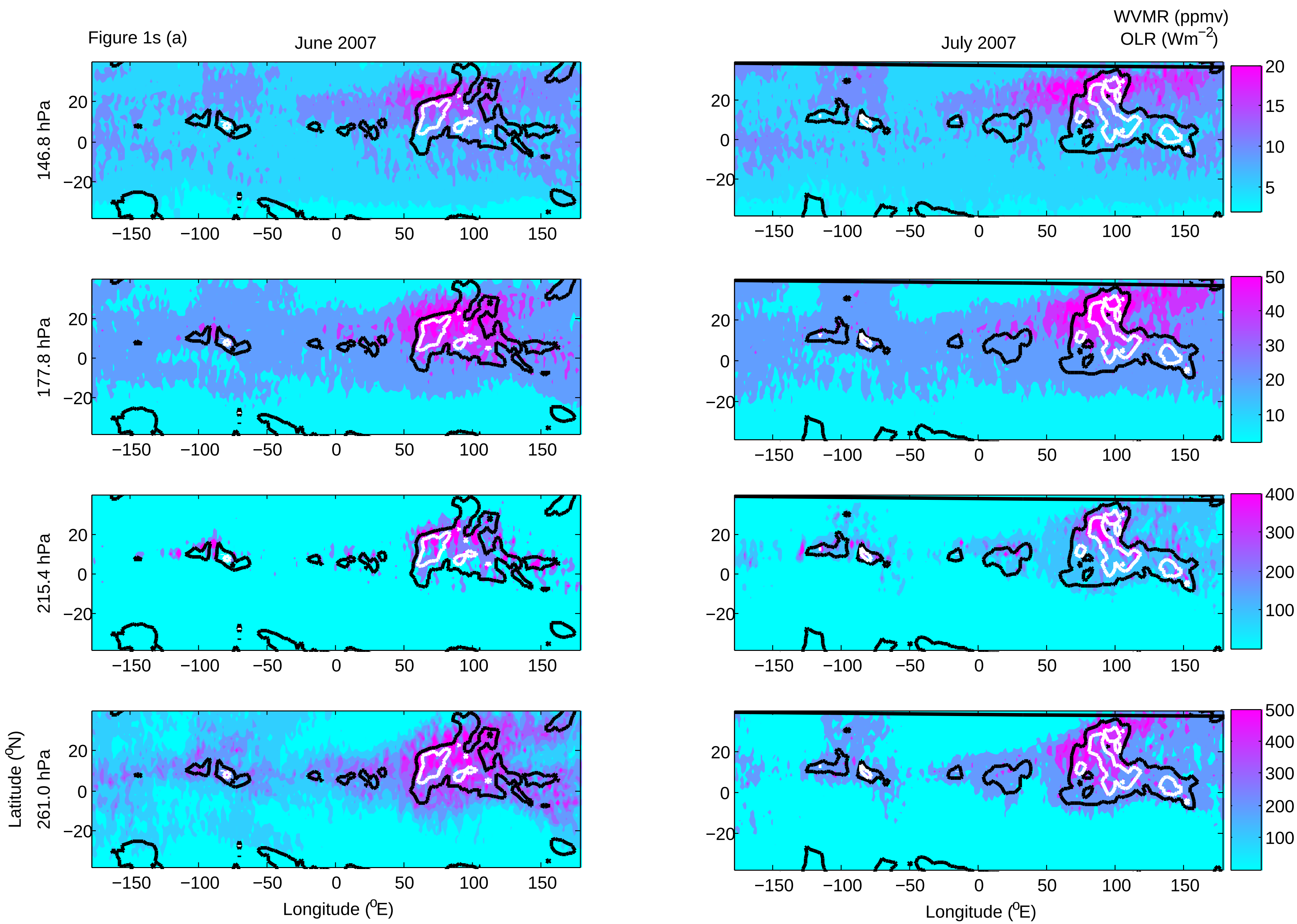
Figure Captions

Figure 1s Composite diagram of monthly mean MLS WVMR (ppmv) distribution at 261.0, 215.4, 177.8, 146.8 hPa and OLR (Wm^{-2}) from NOAA for the time period of (a) June and July 2007 (b) August and September 2007 over the tropical region. Contour lines for OLR value 220 Wm^{-2} and 200 Wm^{-2} are shown by black and white color respectively.

Figure 2s Average wind vector diagrams (June to September 2007) from Era-Interim reanalysis data at 100 hPa for (a) Western Hemisphere (b) Eastern Hemisphere. Similar plots of wind vectors but at 125 hPa for (c) Western Hemisphere (d) Eastern Hemisphere.

Figure 3s Height profiles of water vapor ascent rate obtained from Aura MLS and vertical velocity obtained from ERA-Interim model for (a) Asian region (b) American region (c) African region. The vertical ascent rate of water vapor is defined as —, where Δh signifies the pressure difference between two levels and Δt signifies the time delay in signal propagation between these two pressure level. Vertical ascent rate is shown at the average value of two pressure levels.

Figure 1s (a)



June 2007
July 2007
WVMR (ppmv)
OLR (Wm^{-2})
146.8 hPa
177.8 hPa
215.4 hPa
261.0 hPa
Latitude (^{0}N)
Longitude (^{0}E)

Figure 1s (b)

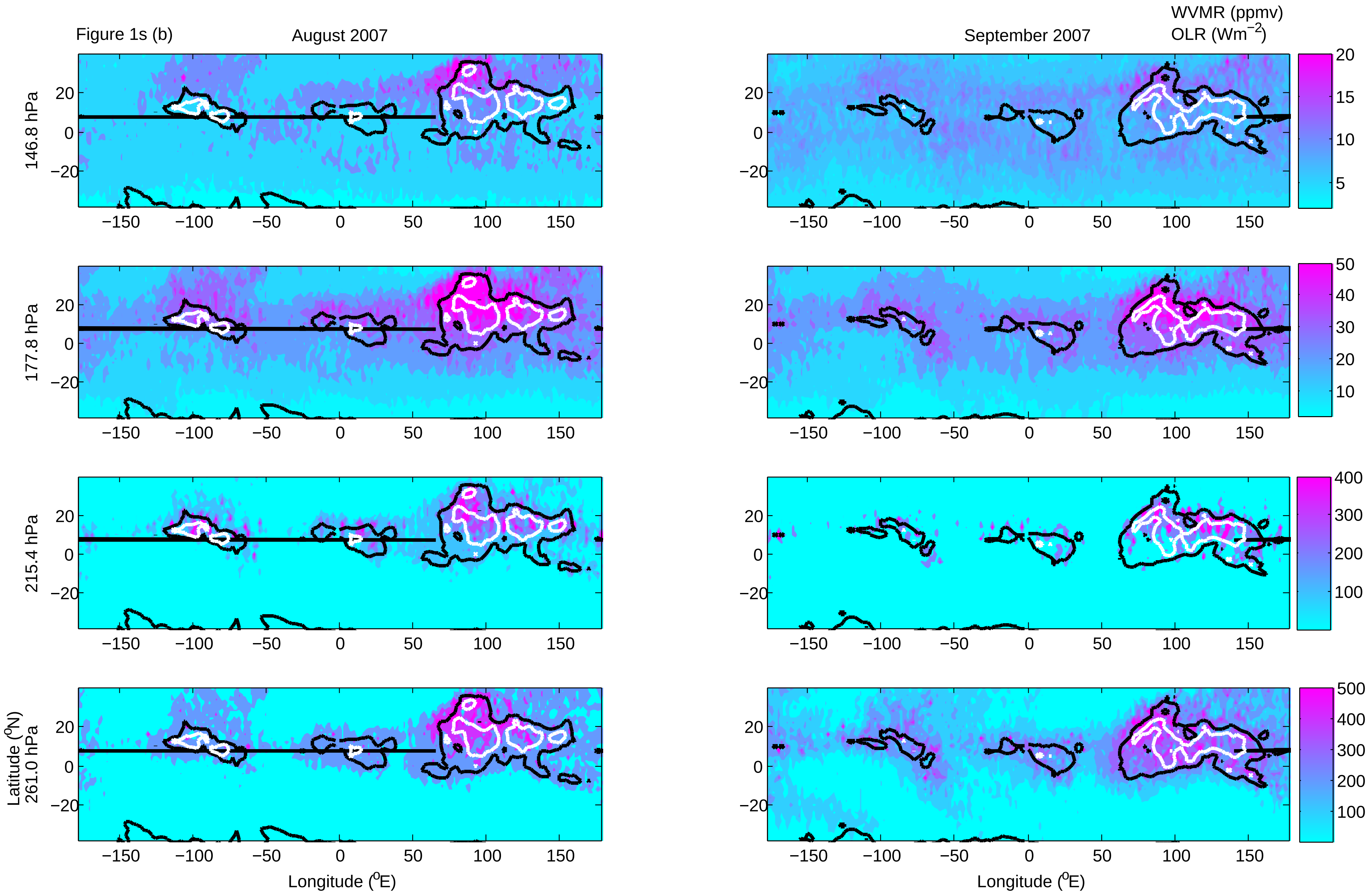
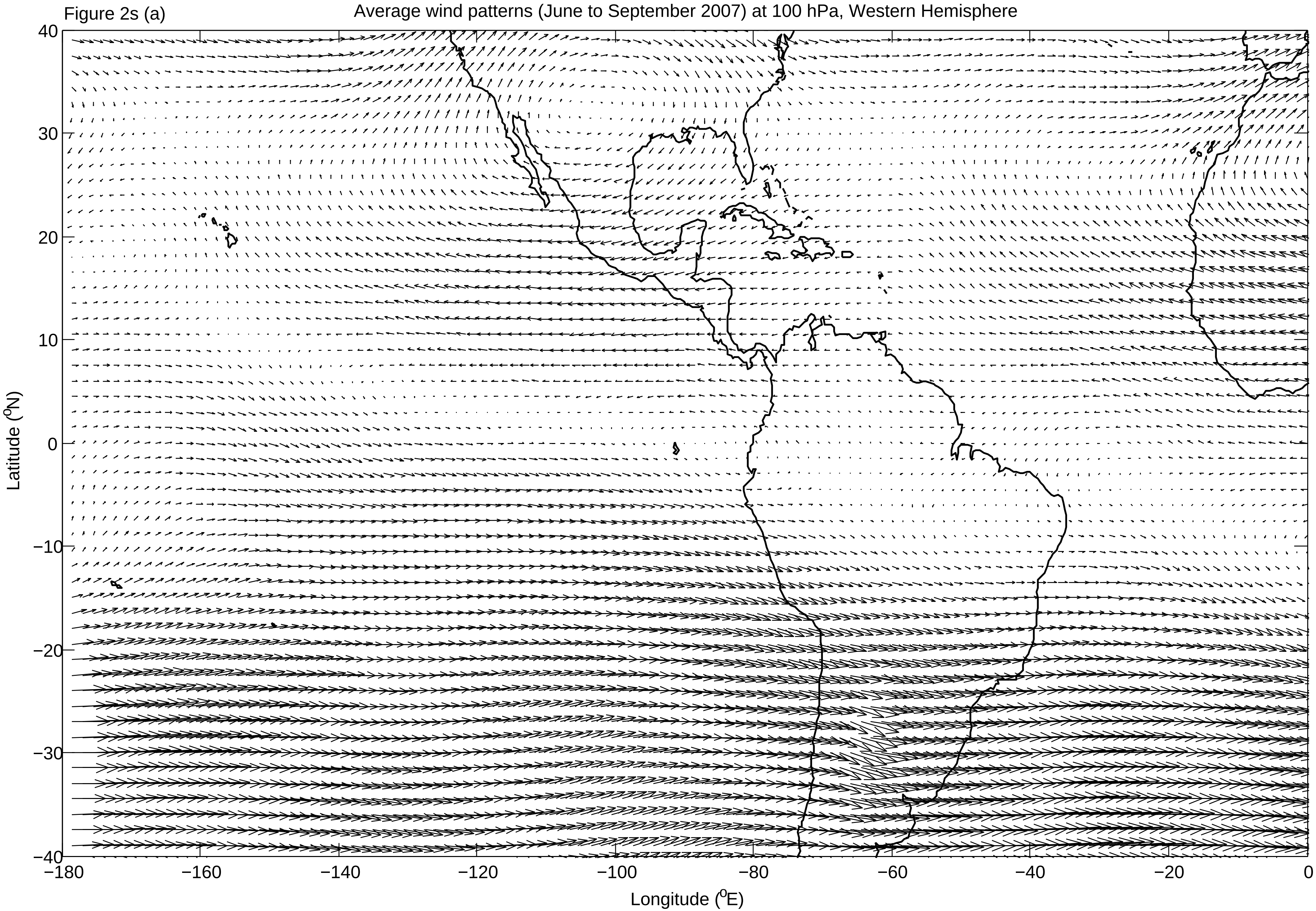
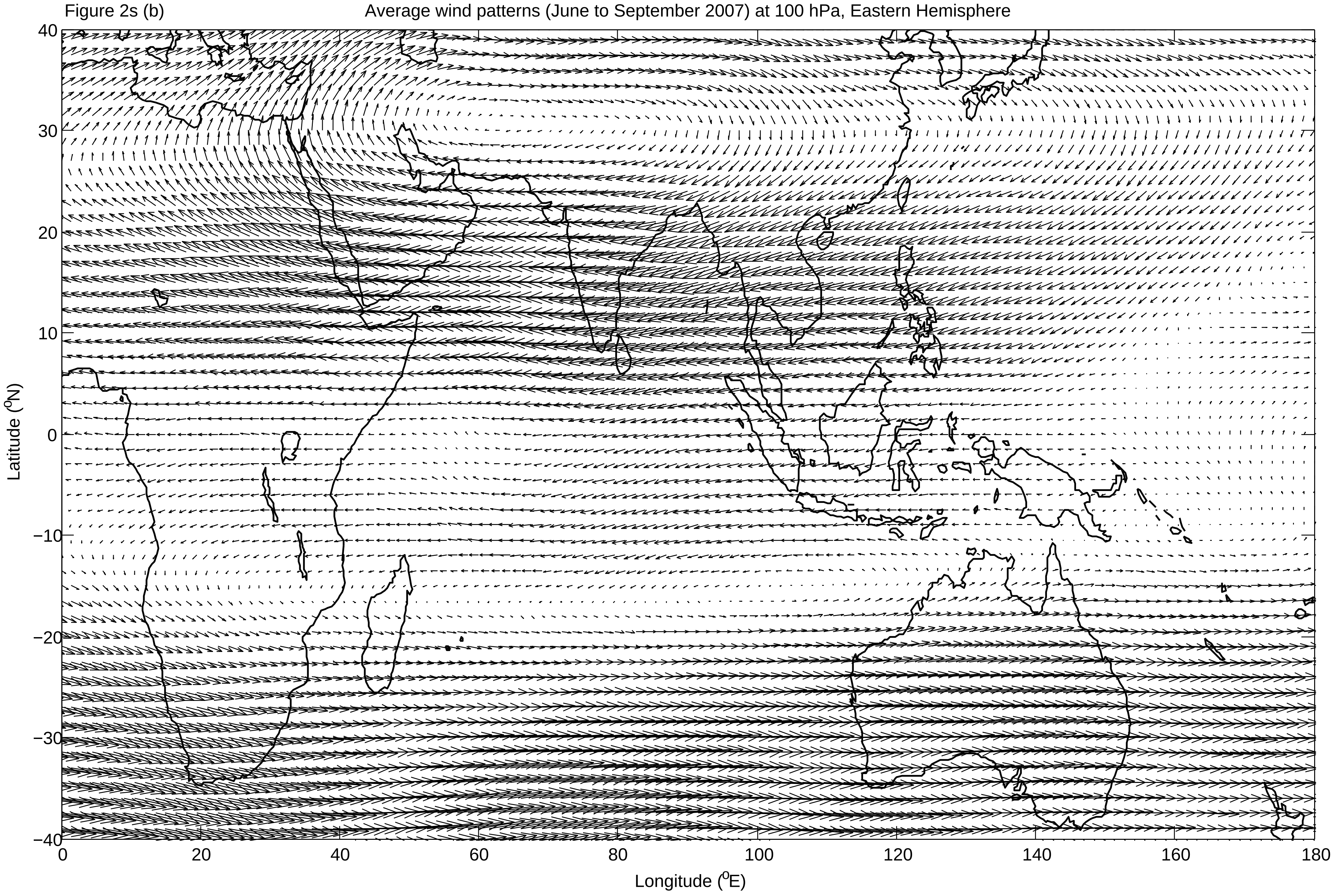

August 2007
September 2007
WVMR (ppmv)
OLR (Wm^{-2})
146.8 hPa
177.8 hPa
215.4 hPa
261.0 hPa
Latitude (^{0}N)
Longitude (^{0}E)
−150 −100 −50 0 50 100 150
20 0 −20
20 15 10 5
50 40 30 20 10
400 300 200 100
500 400 300 200 100

Figure 2s (a)



Average wind patterns (June to September 2007) at 100 hPa, Western Hemisphere
40
30
20
10
0
−10
−20
−30
−40
Latitude (oN)
−180
−160
−140
−120
−100
−80
−60
−40
−20
0
Longitude (oE)

Figure 2s (b)



Average wind patterns (June to September 2007) at 100 hPa, Eastern Hemisphere
40
30
20
10
0
−10
−20
−30
−40
Latitude (^{0}N)
0
20
40
60
80
100
120
140
160
180
Longitude (^{0}E)

Figure 2s (c)

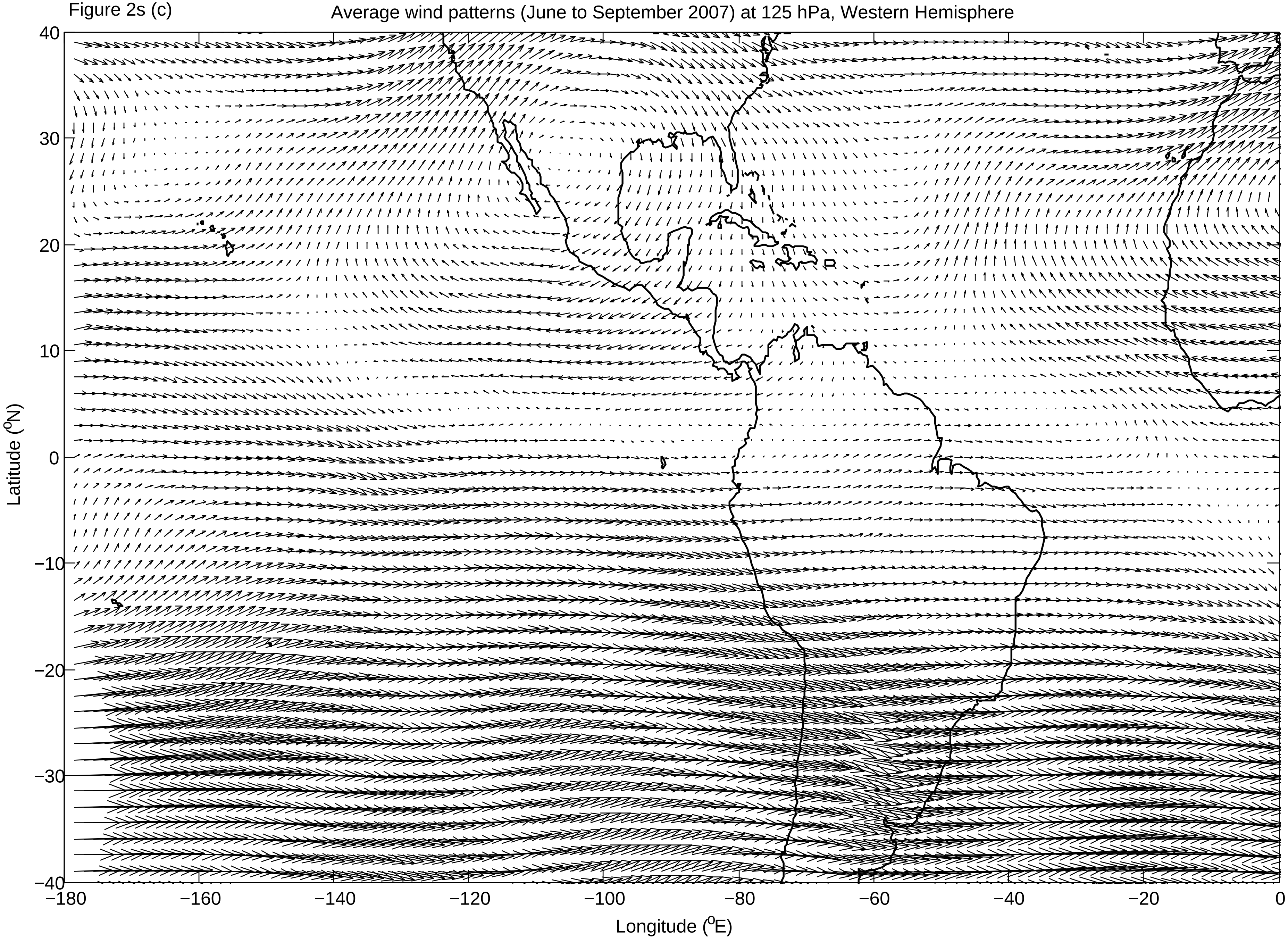
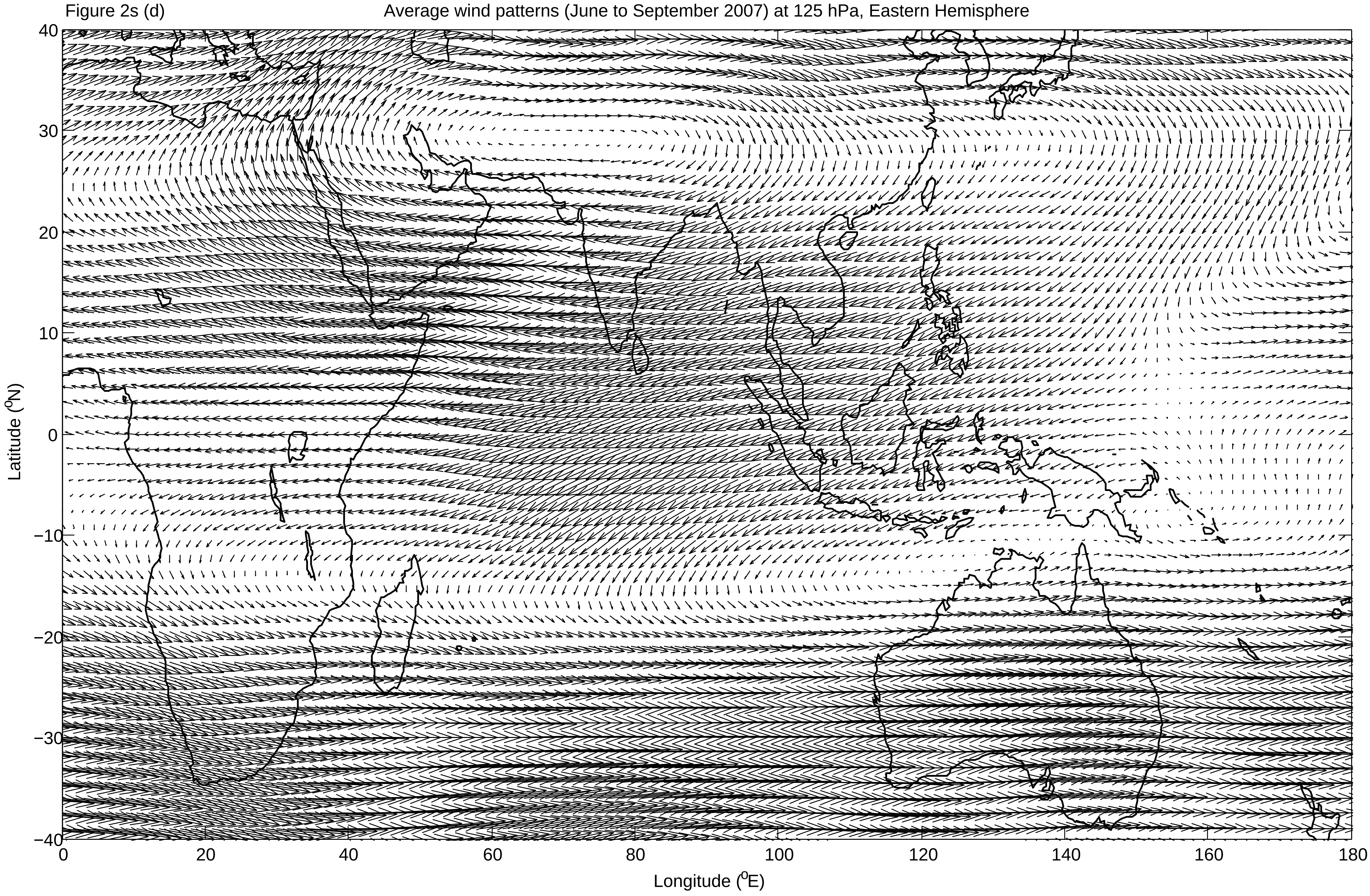

Average wind patterns (June to September 2007) at 125 hPa, Western Hemisphere
40
30
20
10
0
−10
−20
−30
−40
Latitude (°N)
−180
−160
−140
−120
−100
−80
−60
−40
−20
0
Longitude (°E)

Figure 2s (d)


Average wind patterns (June to September 2007) at 125 hPa, Eastern Hemisphere
Latitude (°N)
40
30
20
10
0
−10
−20
−30
−40
0
20
40
60
80
100
120
140
160
180
Longitude (°E)

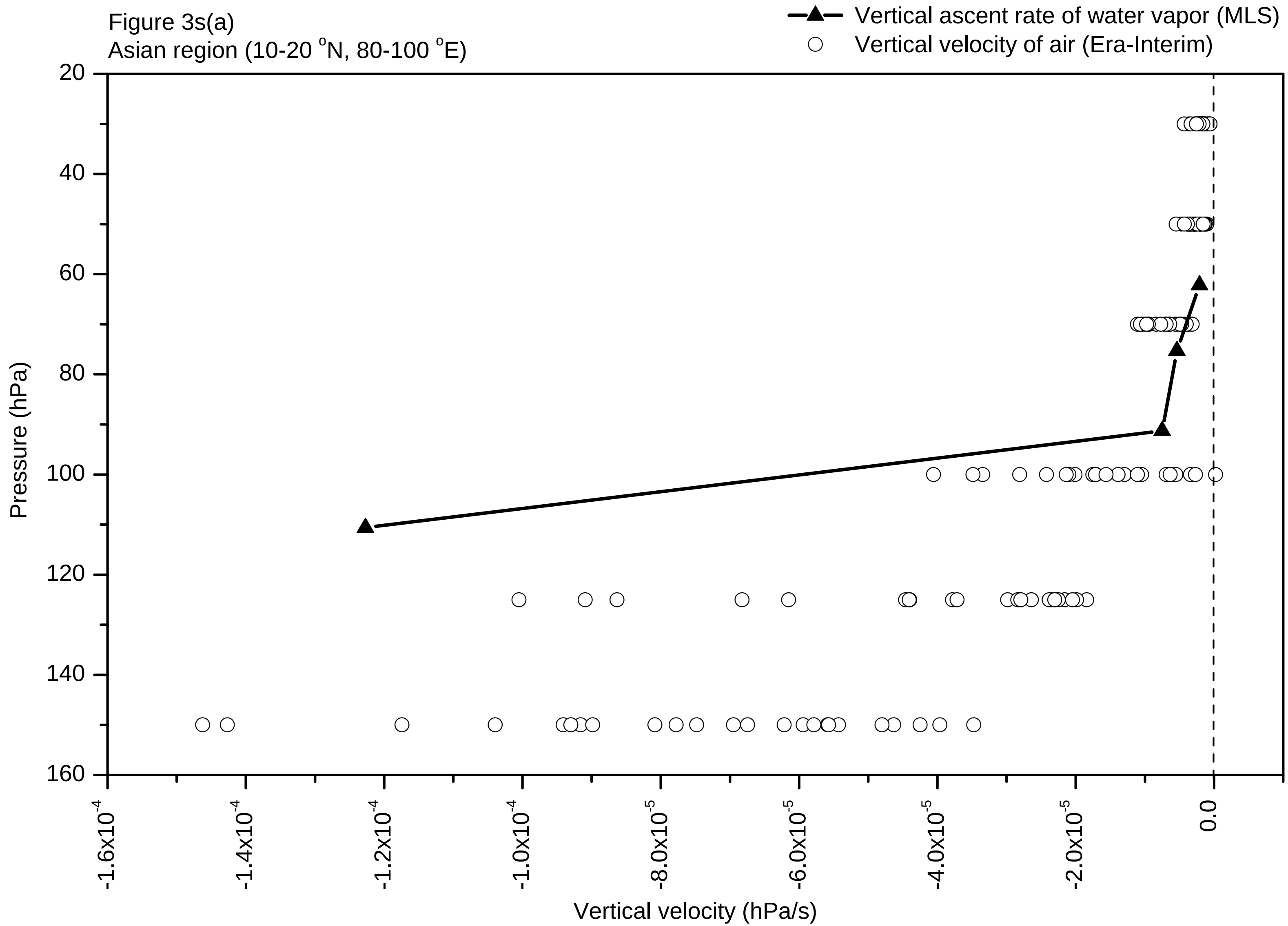


Figure 3s(a)
Asian region (10-20 °N, 80-100 °E)
Vertical ascent rate of water vapor (MLS)
Vertical velocity of air (Era-Interim)
Pressure (hPa)
20
40
60
80
100
120
140
160
-1.6x10^-4
-1.4x10^-4
-1.2x10^-4
-1.0x10^-4
-8.0x10^-5
-6.0x10^-5
-4.0x10^-5
-2.0x10^-5
0.0
Vertical velocity (hPa/s)

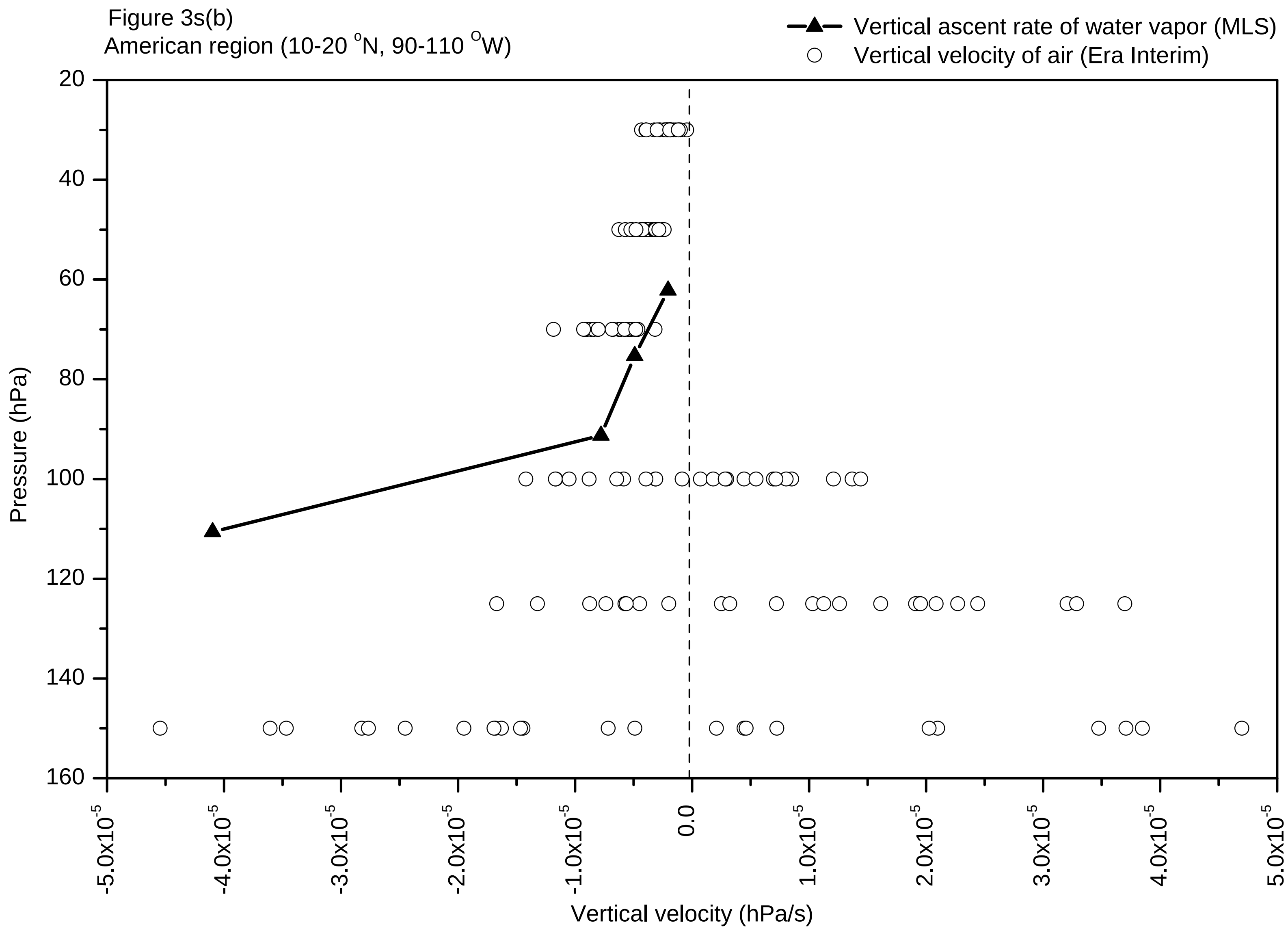


Figure 3s(b)
American region (10-20 °N, 90-110 °W)
Vertical ascent rate of water vapor (MLS)
Vertical velocity of air (Era Interim)
Pressure (hPa)
Vertical velocity (hPa/s)
20
40
60
80
100
120
140
160
-5.0x10^-5
-4.0x10^-5
-3.0x10^-5
-2.0x10^-5
-1.0x10^-5
0.0
1.0x10^-5
2.0x10^-5
3.0x10^-5
4.0x10^-5
5.0x10^-5

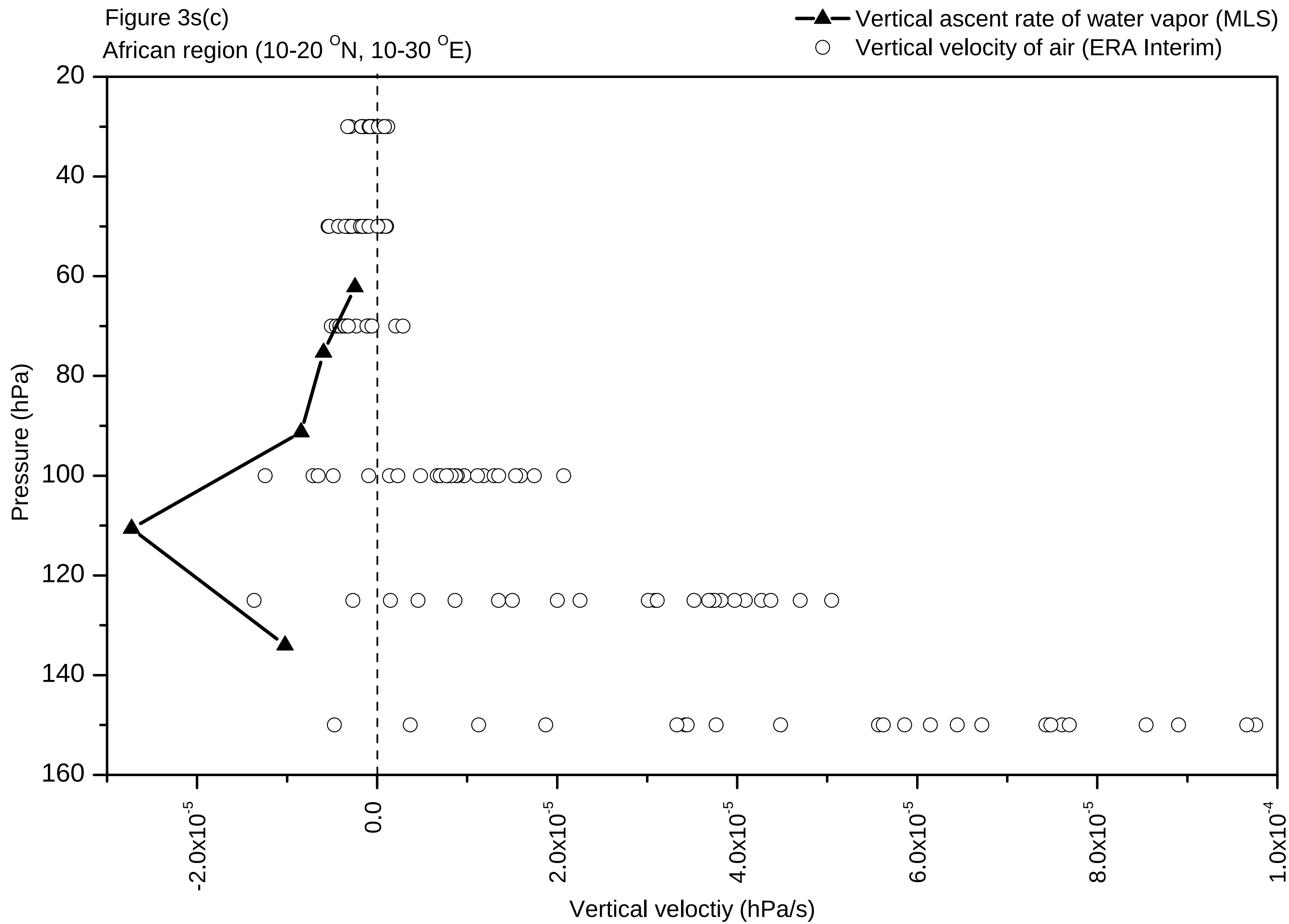


Figure 3s(c)
African region (10-20 ^{O}N, 10-30 ^{O}E)
Vertical ascent rate of water vapor (MLS)
Vertical velocity of air (ERA Interim)
Pressure (hPa)
20
40
60
80
100
120
140
160
-2.0x10^{-5}
0.0
2.0x10^{-5}
4.0x10^{-5}
6.0x10^{-5}
8.0x10^{-5}
1.0x10^{-4}
Vertical veloctiy (hPa/s)