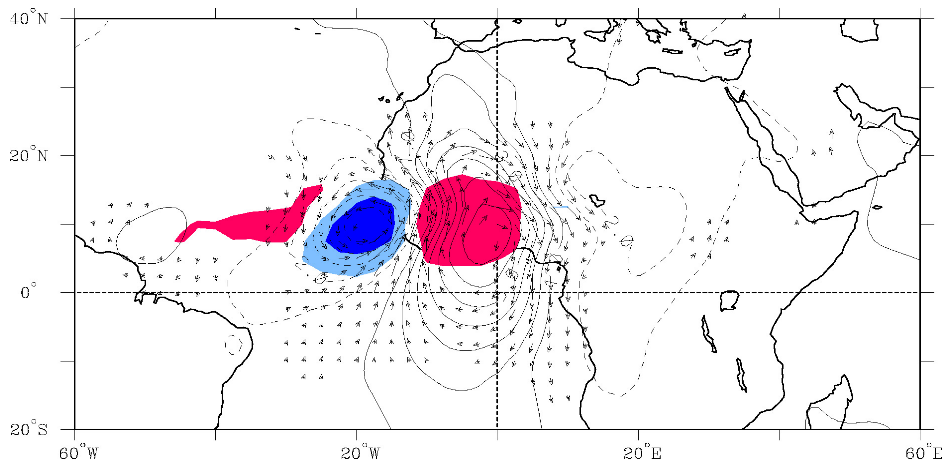
Intraseasonal Variability of African Easterly Waves

Yuan-Ming Cheng, Chris Thorncroft and Alan Brammer

Introduction

- African easterly waves (AEWs) are the dominant weather maker in West Africa
  - critical rainfall producers in the region
  - linked to the hurricane activity over the Atlantic basin

Regression against TD-filtered OLR at 10°N, 10°W



Shadings: OLR (shadings)

Contours: 850 hPa flow

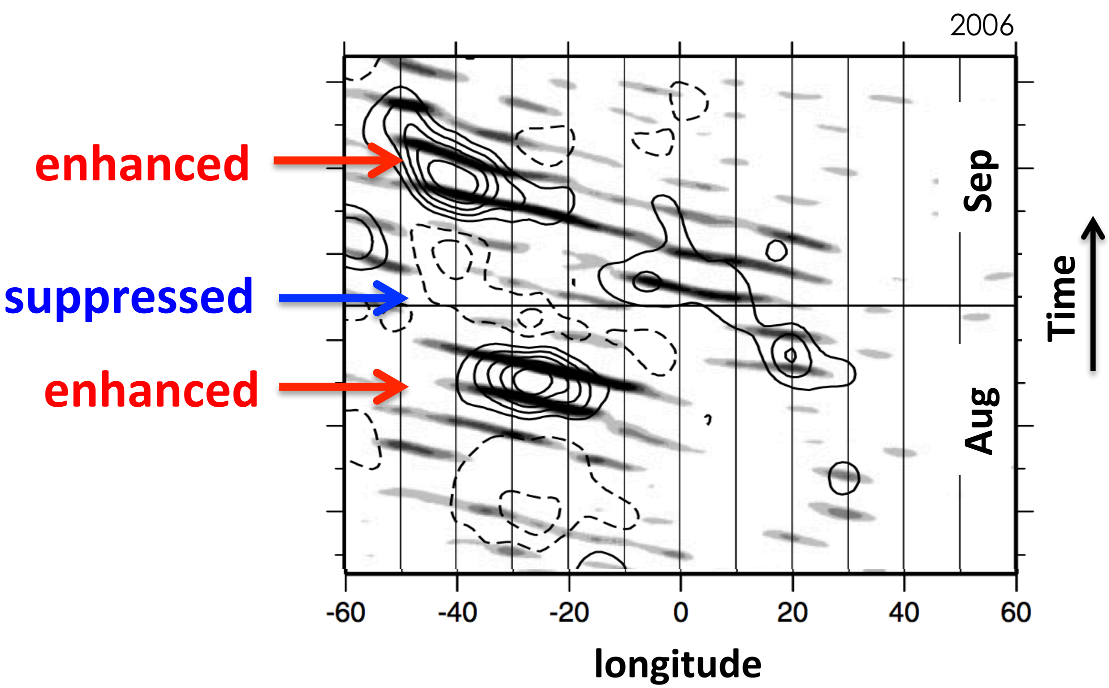
Vectors: 850-hPa wind

+/- 6 W s^{-2}; 10^5 m^2 s^{-1}; m s^{-1}

Kiladis et al. (2006)

Introduction

- There is marked variability in intraseasonal AEW activity
  - e.g., Leroux et al. (2010), Leroux et al. (2011), Ventrice et al. (2011)



Contour: **10-120 day filtered EKE**
Shading**: < 6 day filtered v wind**

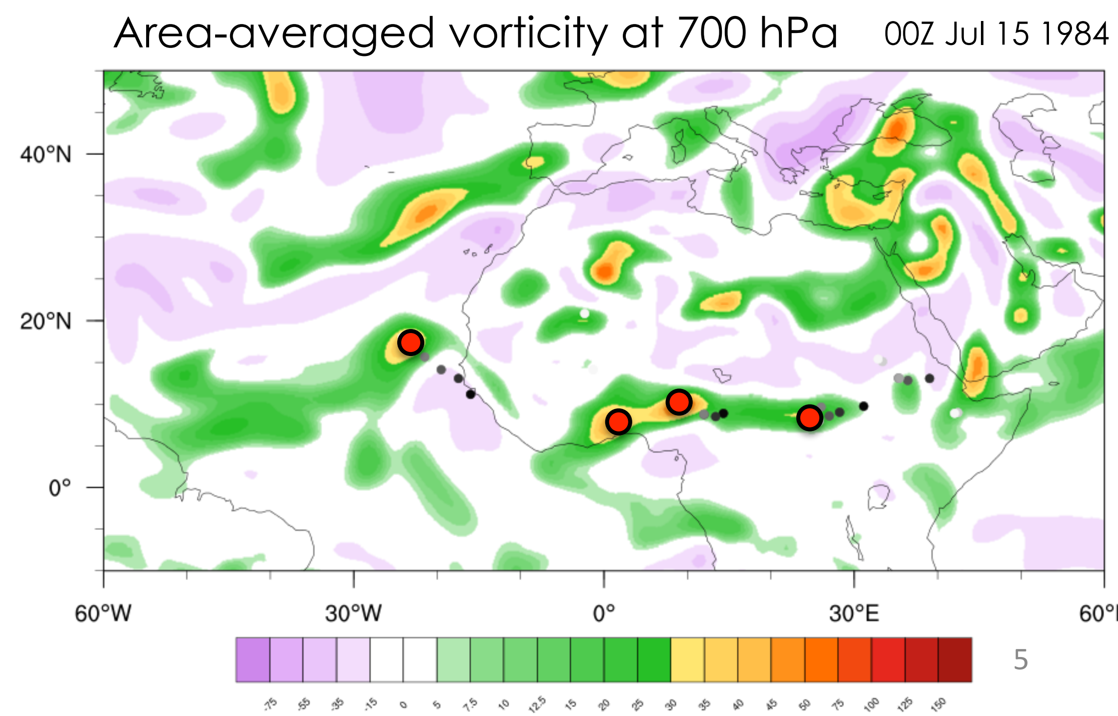
Leroux et al. (2010)

Motivation

- We know little about how intraseasonal variability of AEW activity is manifested in terms of the individual waves, e.g., intensity, structure and tracks
- Eddy kinetic energy (EKE) is commonly used as an AEW activity index
  - EKE can include other wave types, .e.g., Kevin waves and mixed Rossby gravity waves

Method

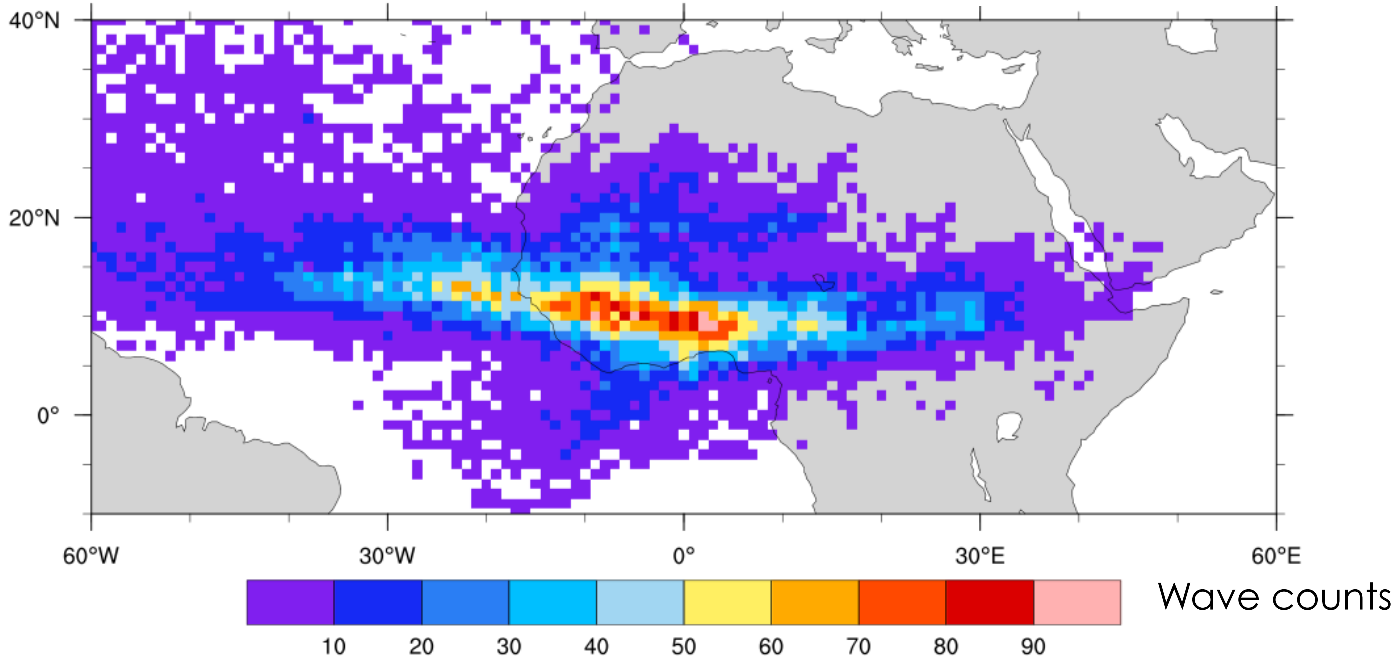
- Tracking of vorticity maxima (Brammer et al. 2018)
  - Using curvature vorticity and vorticity at multiple levels (700, 850, 600 and 500 hPa)
  - “Best Tracks” of AEWs
  - Focusing on individual waves



Data

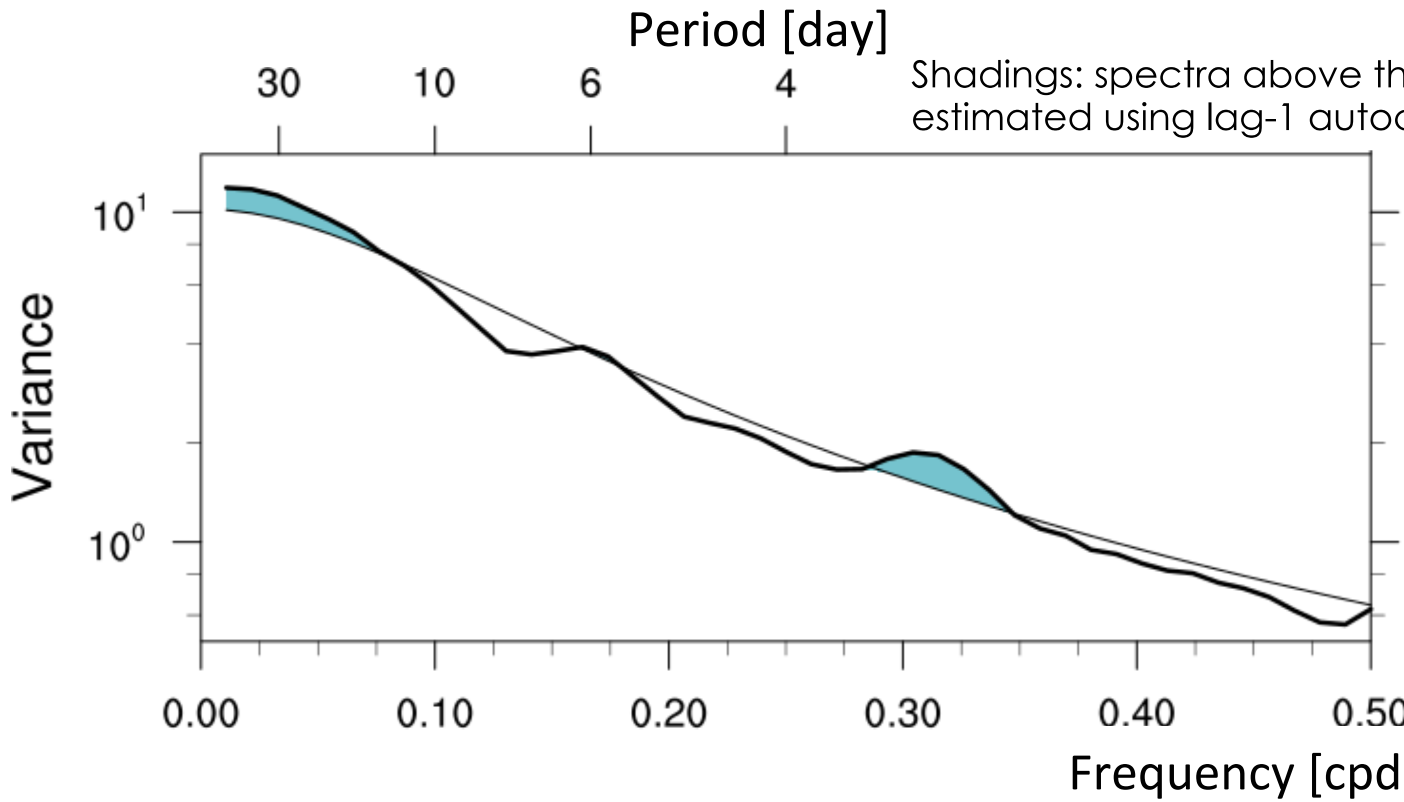
- ERA-Interim reanalysis (Dee et al. 2011)
  - 6 hourly
  - Horizontal resolution of ~0.7°
- Claus IR brightness temperature (Hodges et al. 2000)
  - 6 hourly
  - Horizontal resolution of 2.5° resolution

Track Counts



- AEW storm track along tropical Africa
- AEW genesis region in East Africa (triggering hypothesis)

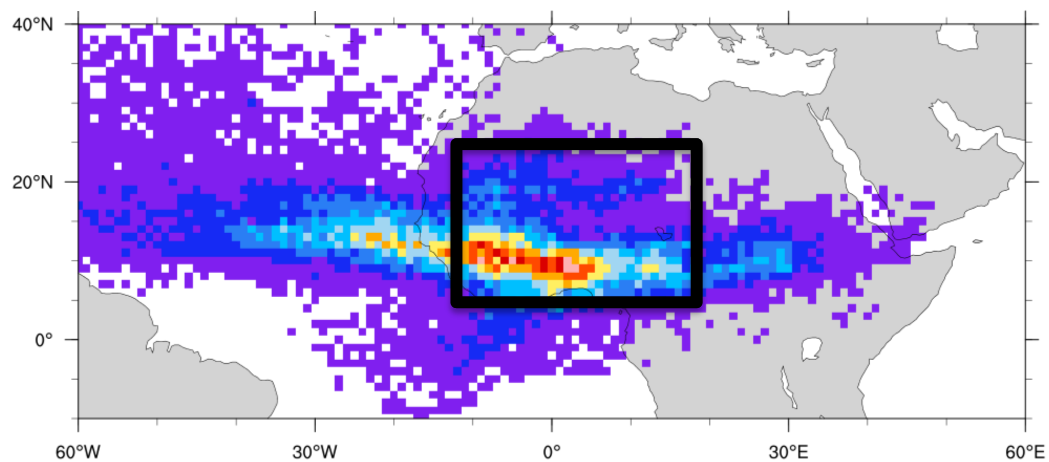
Power spectrum of wave counts



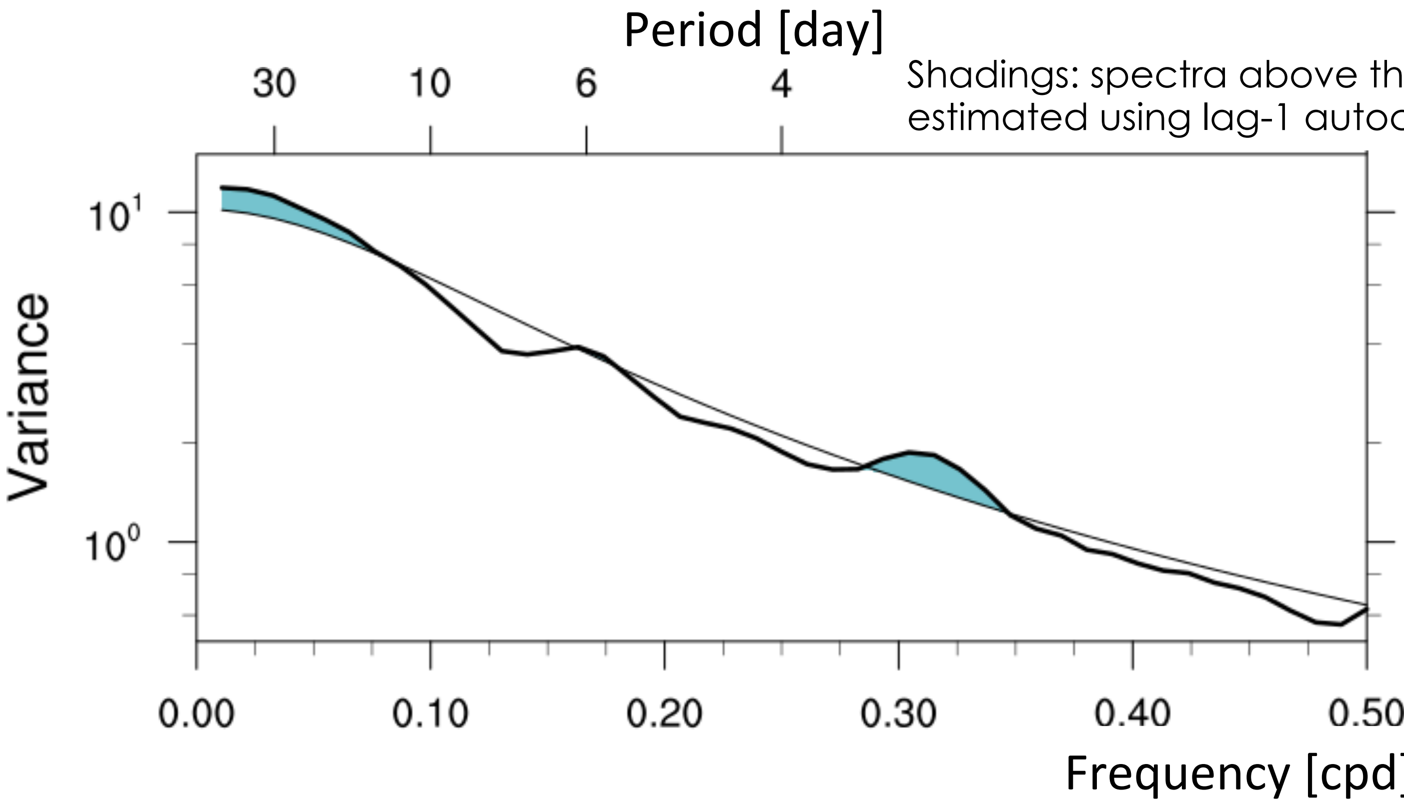
Shadings: spectra above the red noise estimated using lag-1 autocorrelation

Spectral power peaks centered around periods of

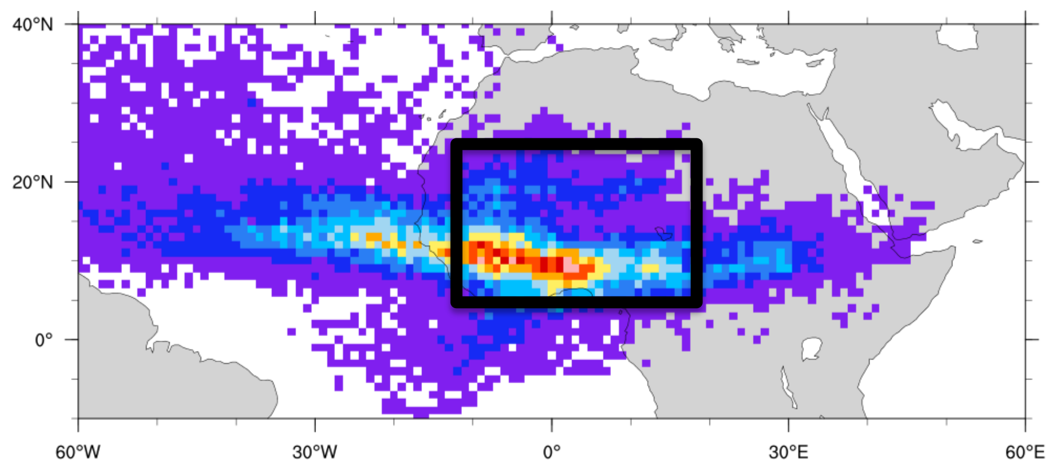
- 3 days
- 30 days



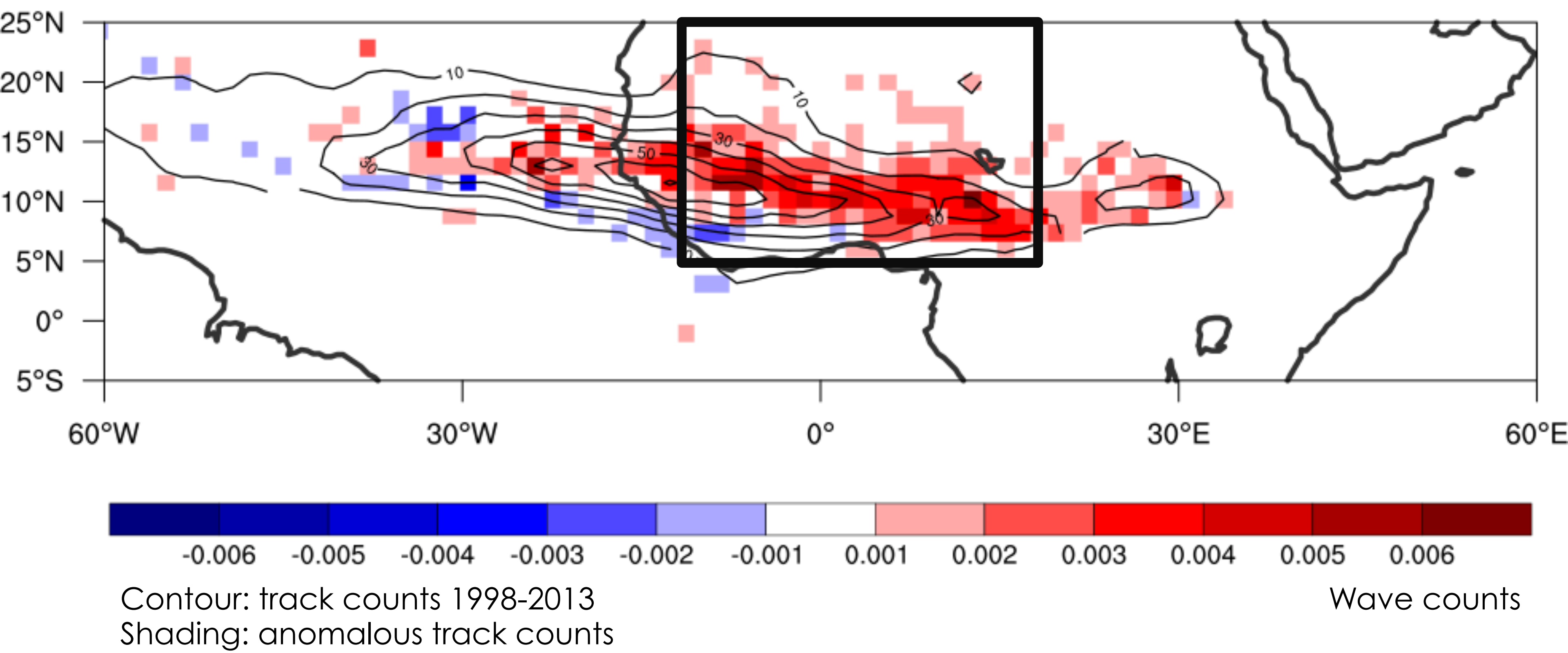
Power spectrum of wave counts



- 20-day-low-pass filter wave counts
- Regress the filtered time series against the map of wave counts

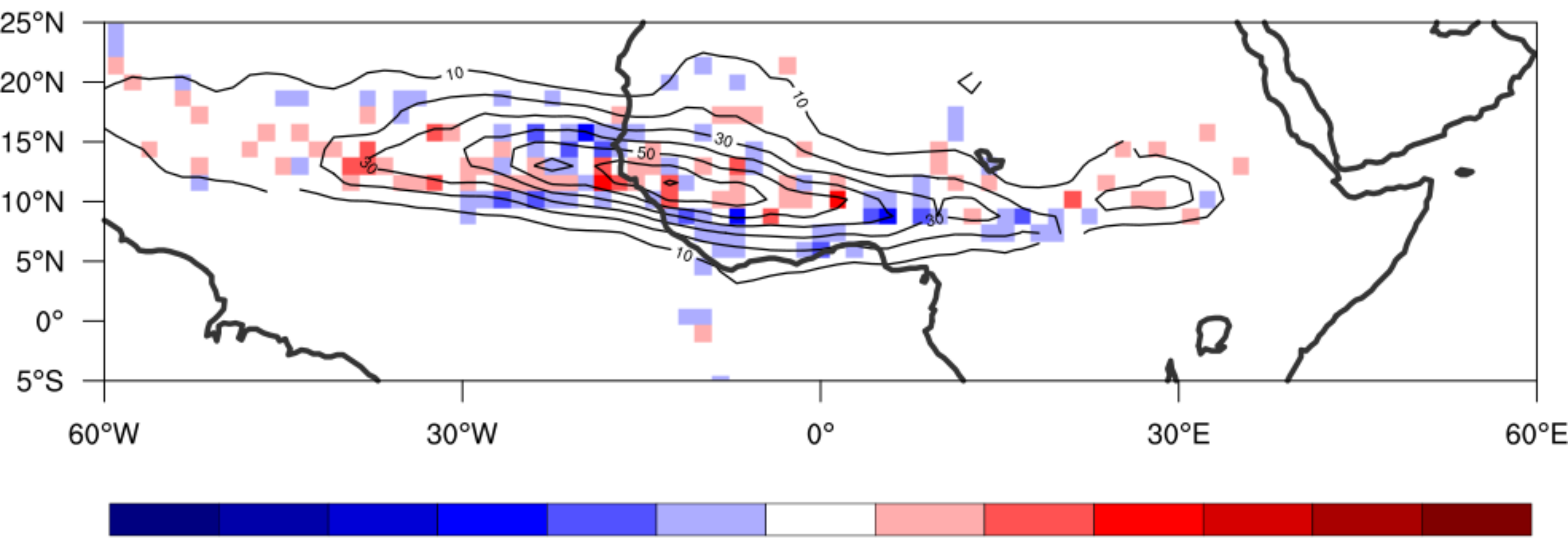


Regression map of wave counts
Day 0



- Enhanced storm counts across tropical Africa
- More AEW genesis over East Africa
- Shifting the mean storm track northward over West Africa

Regression map of wave counts
Day -10

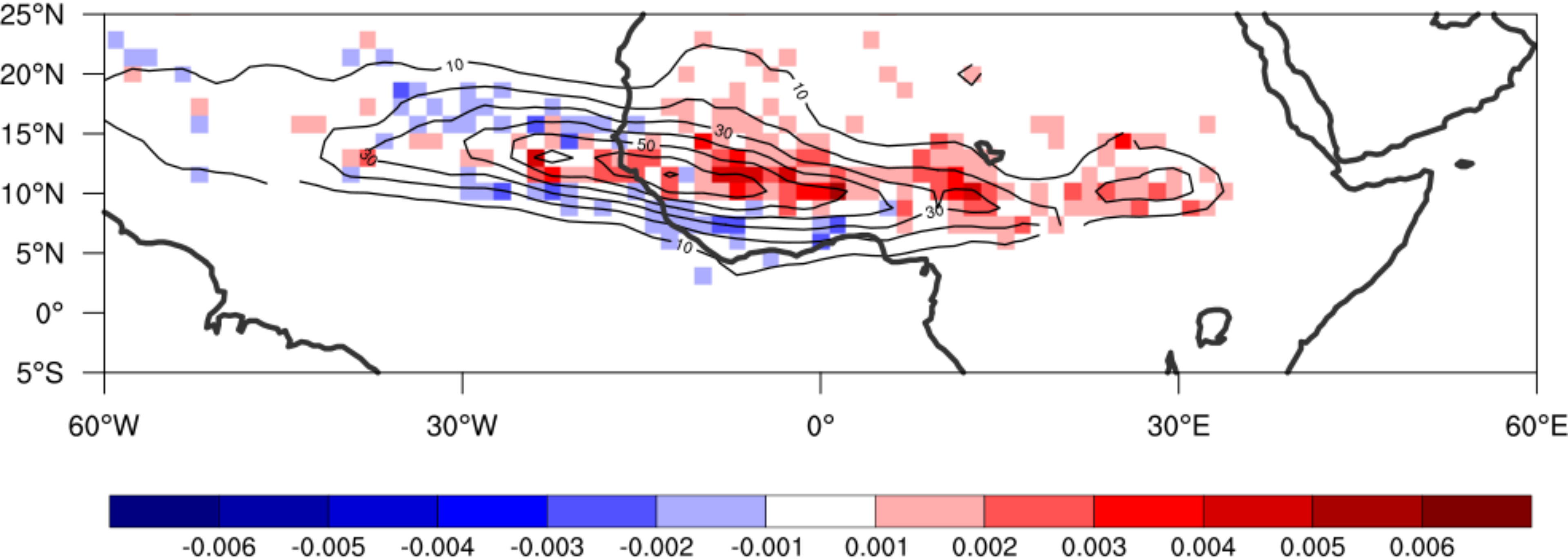


Contour: track counts 1998-2013
Shading: anomalous track counts

Wave counts

- Mostly suppressed wave counts over West Africa/East Atlantic
- Slightly enhanced wave counts over East Africa

Regression map of wave counts
Day -5

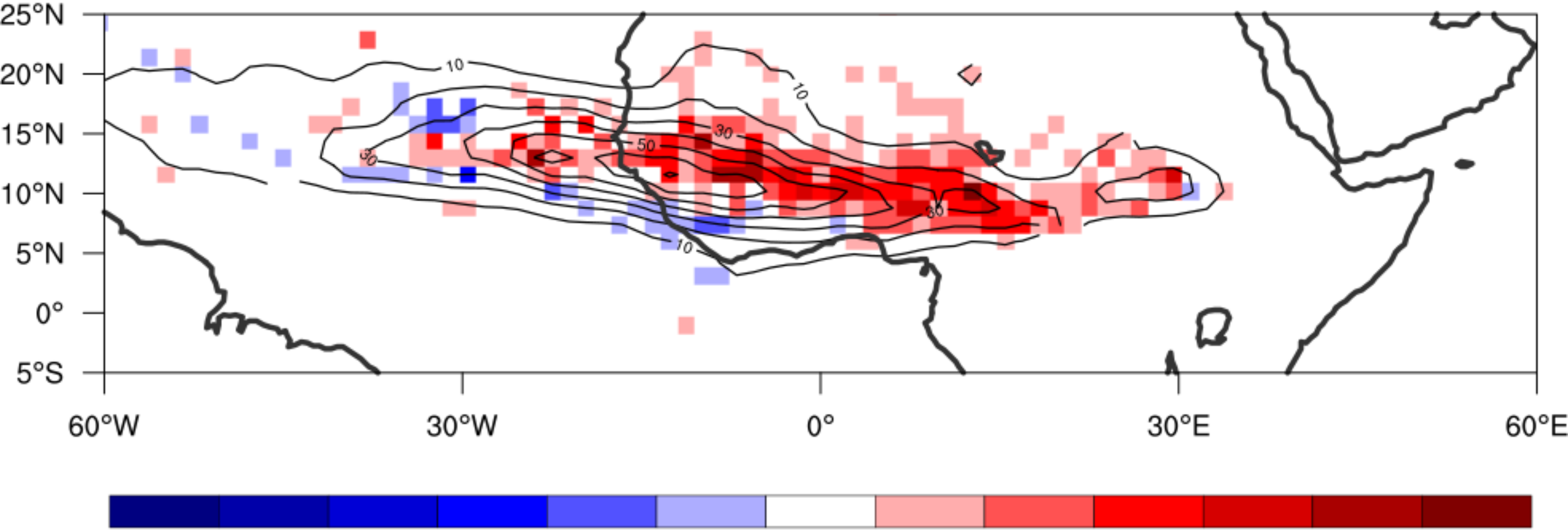


Contour: track counts 1998-2013
Shading: anomalous track counts

Wave counts

- Enhanced wave counts across the continent.
- Northward shift of storm tracks

Regression map of wave counts
Day 0

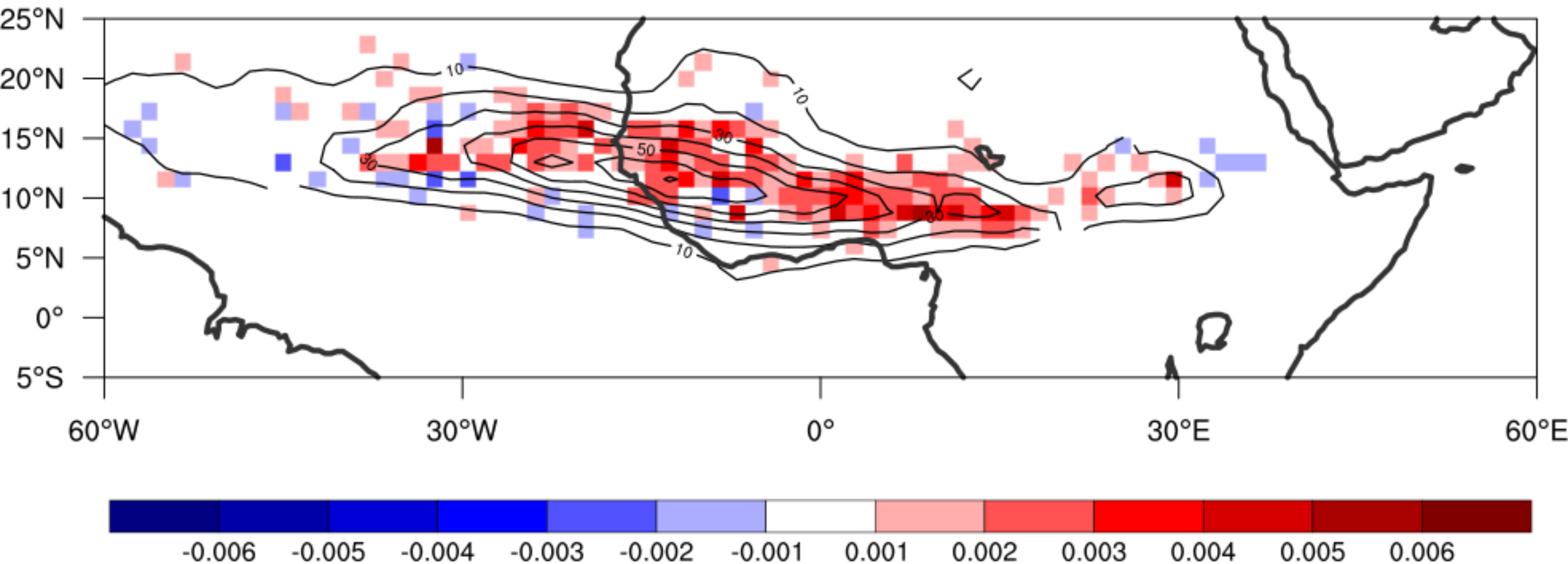


Contour: track counts 1998-2013
Shading: anomalous track counts

Wave counts

- Enhanced wave counts across the continent.
- Northward shift of storm tracks

Regression map of wave counts
Day 5

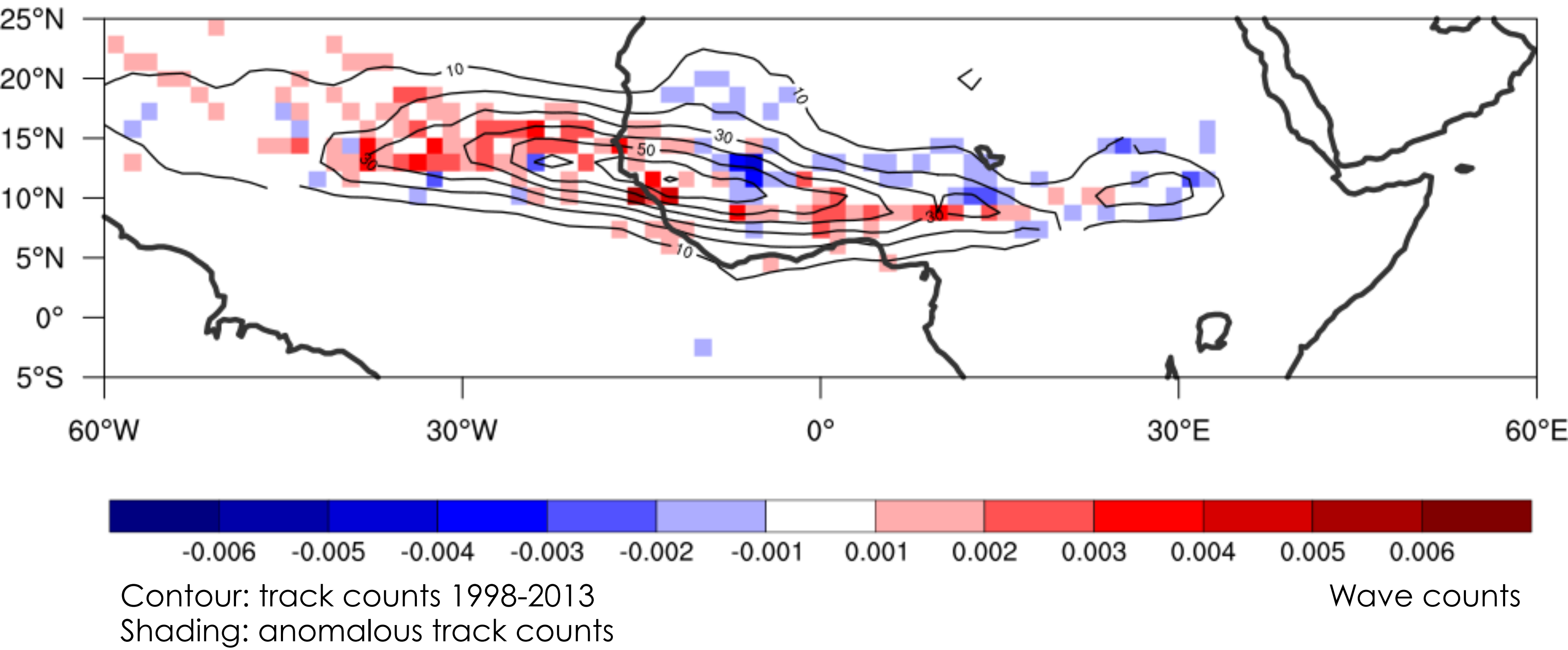


Contour: track counts 1998-2013
Shading: anomalous track counts

Wave counts

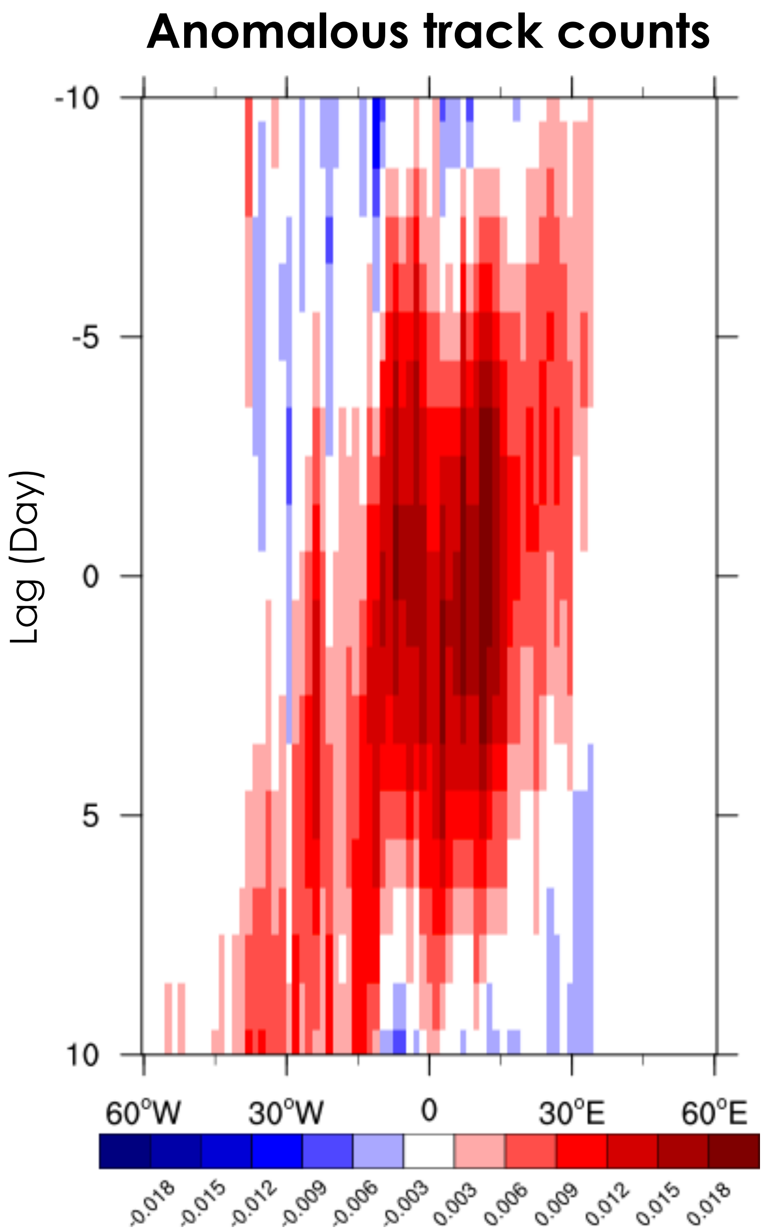
- Enhanced wave counts over the Eastern Atlantic
- Suppressed counts over East Africa

Regression map of wave counts
Day 10



- Enhanced wave counts over the Atlantic
- Suppressed wave counts north of the mean storm track in West Africa

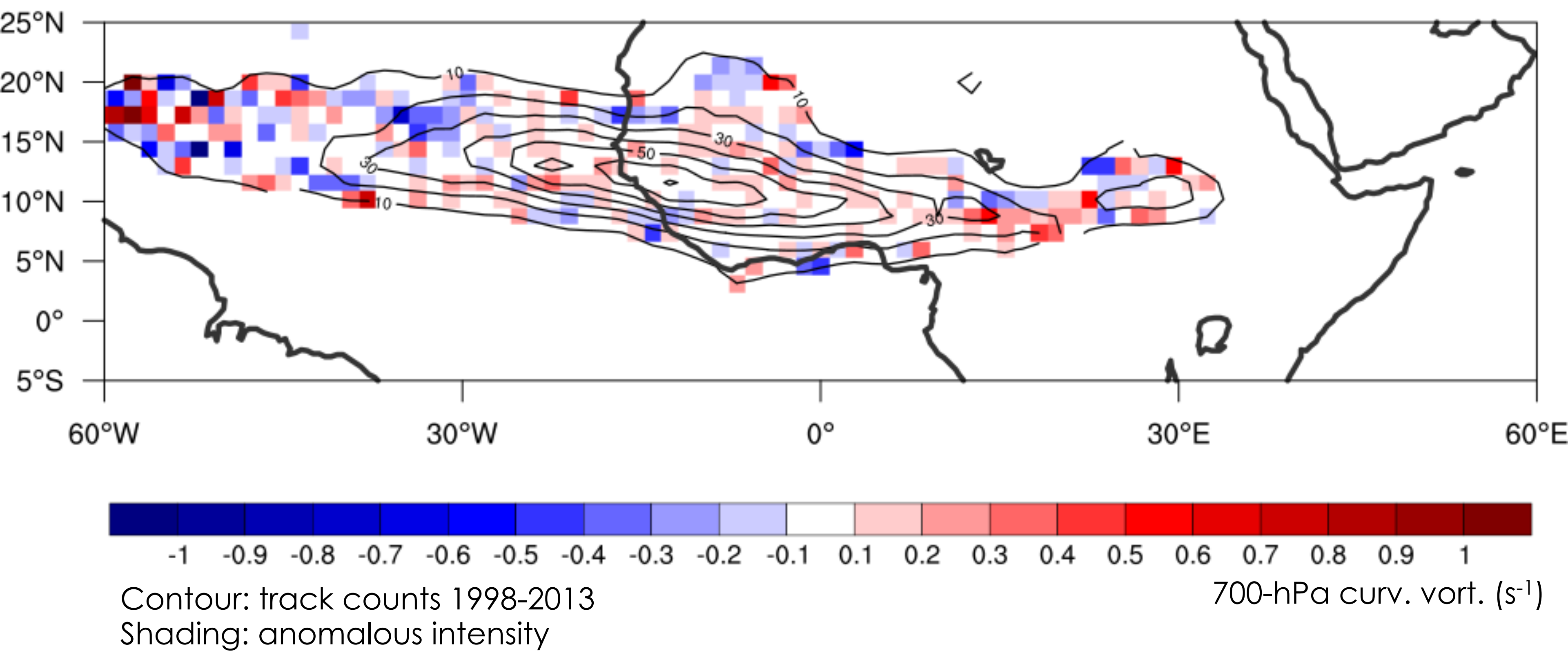
Regression of wave counts (Hovmoller)



Wave counts (5°N-25°N)

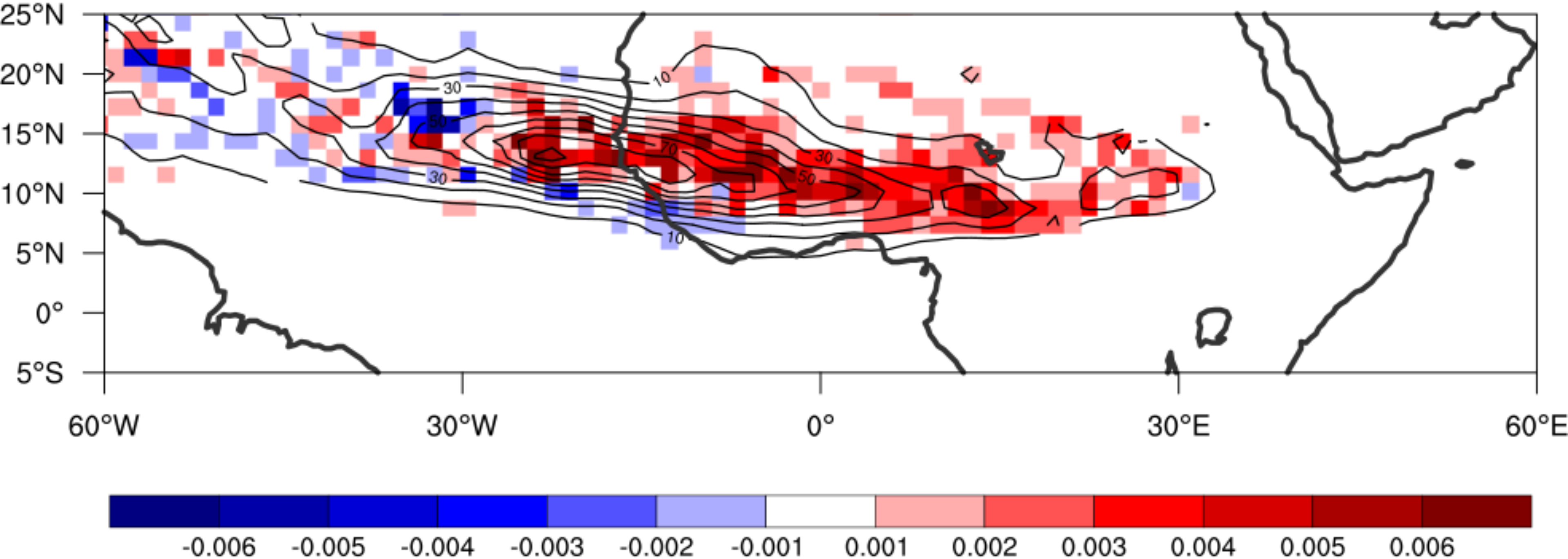
- A clear westward propagating of enhanced wave counts from East Africa across the continent into the Atlantic
- What about the intensity?

Regression map of intensity
Day 0



- Enhanced wave intensity over the Atlantic (due to tropical cyclones)
- Slightly enhanced wave intensity north of the mean storm track

Regression map of wave activity
Day 0



Contour: wave activity1998-2013

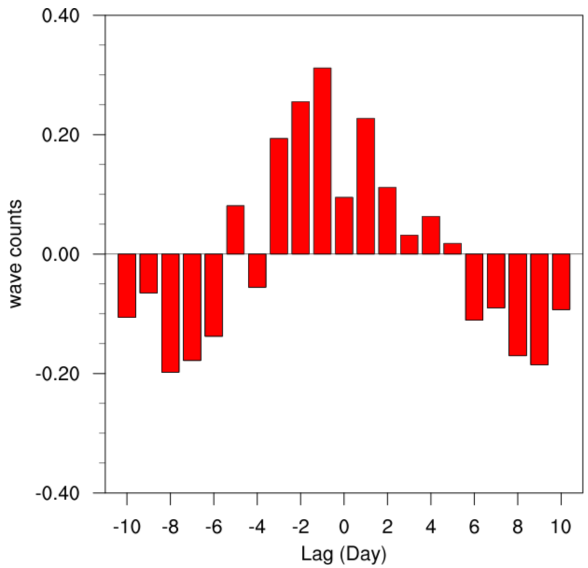
Shading: anomalous wave activity

700-hPa curv. vort. (s^{-1})

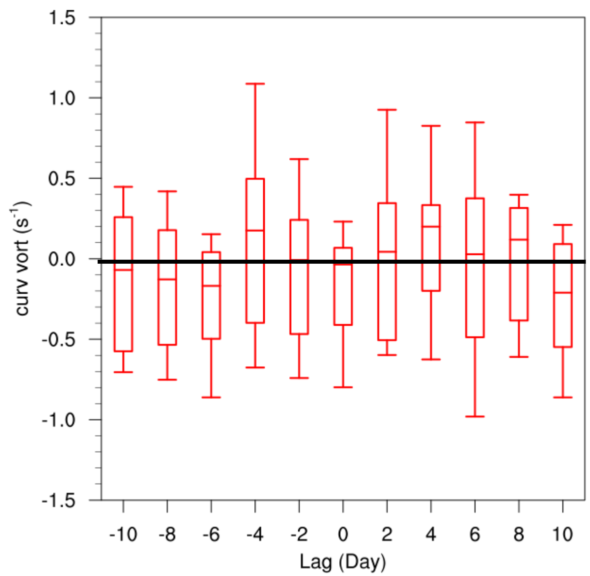
- **Wave activity = number × intensity** (such as hurricane activity)
- West Africa: enhanced wave activity north of the mean storm track
- East Africa and East Atlantic: enhanced activity collocated with the mean storm track

Distribution of wave counts, intensity and wave activity

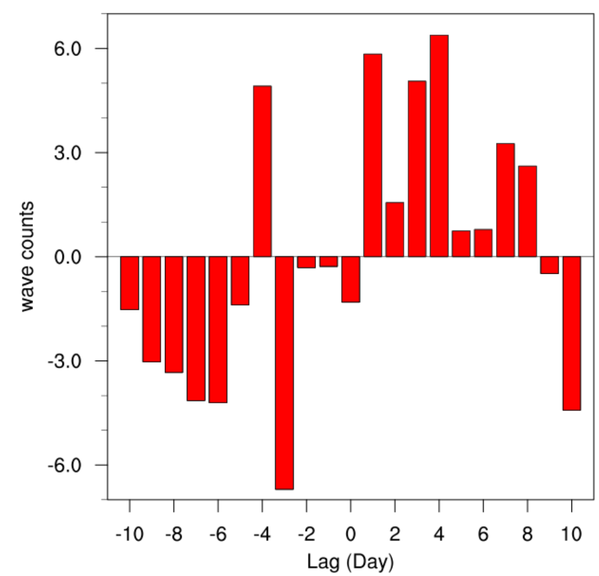
Wave counts anomaly



Intensity anomaly



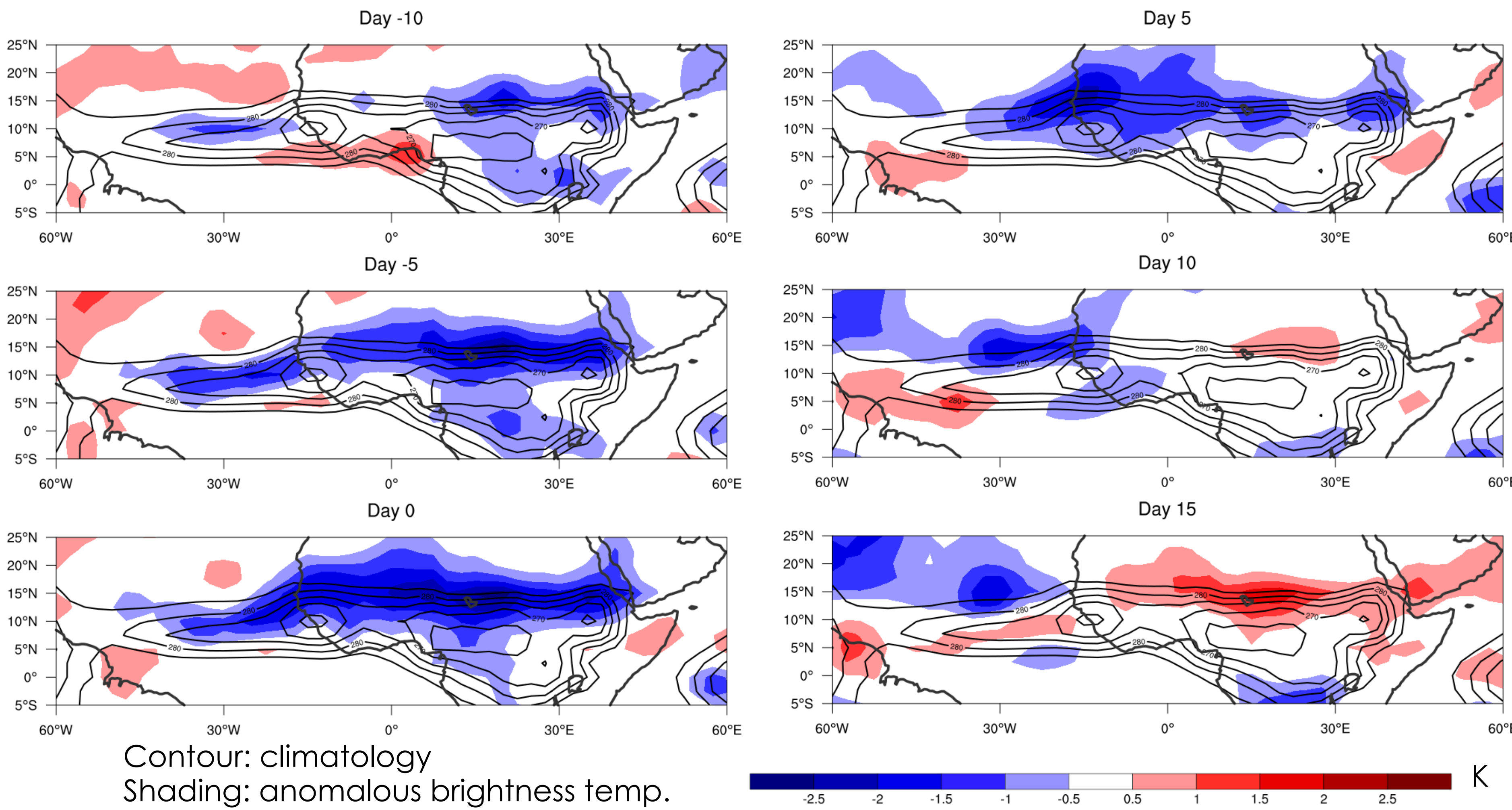
wave activity anomaly



calculation based on intraseasonal track count index ≥ 1 standard deviation

- An increase in intraseasonal wave counts proceed
  - Slightly stronger averaged intensity
  - Enhanced wave activity

Evolution of brightness temperature



Contour: climatology
Shading: anomalous brightness temp.

- Enhanced convection over triggering regions appears to proceed the active AEW period
- Enhanced convection during active AEW activity (Day-5 ~ Day 5)

Summary

- Tracking of vorticity maxima is an effective tool to analyze the variability of AEWs
- A clear intraseasonal peak centered at 30 days stands out in the power spectrum of wave counts
- An increase in wave counts at the intraseasonal time scale
  - westward propagating from East Africa across the continent into the Atlantic
  - accompanied by a northward shift of the storm tracks
- An increase in AEW activity is clear while the increase in the average intensity appears less prominent
- Enhanced convection upstream in the triggering region appears to proceed the increased AEW activity

Ongoing work

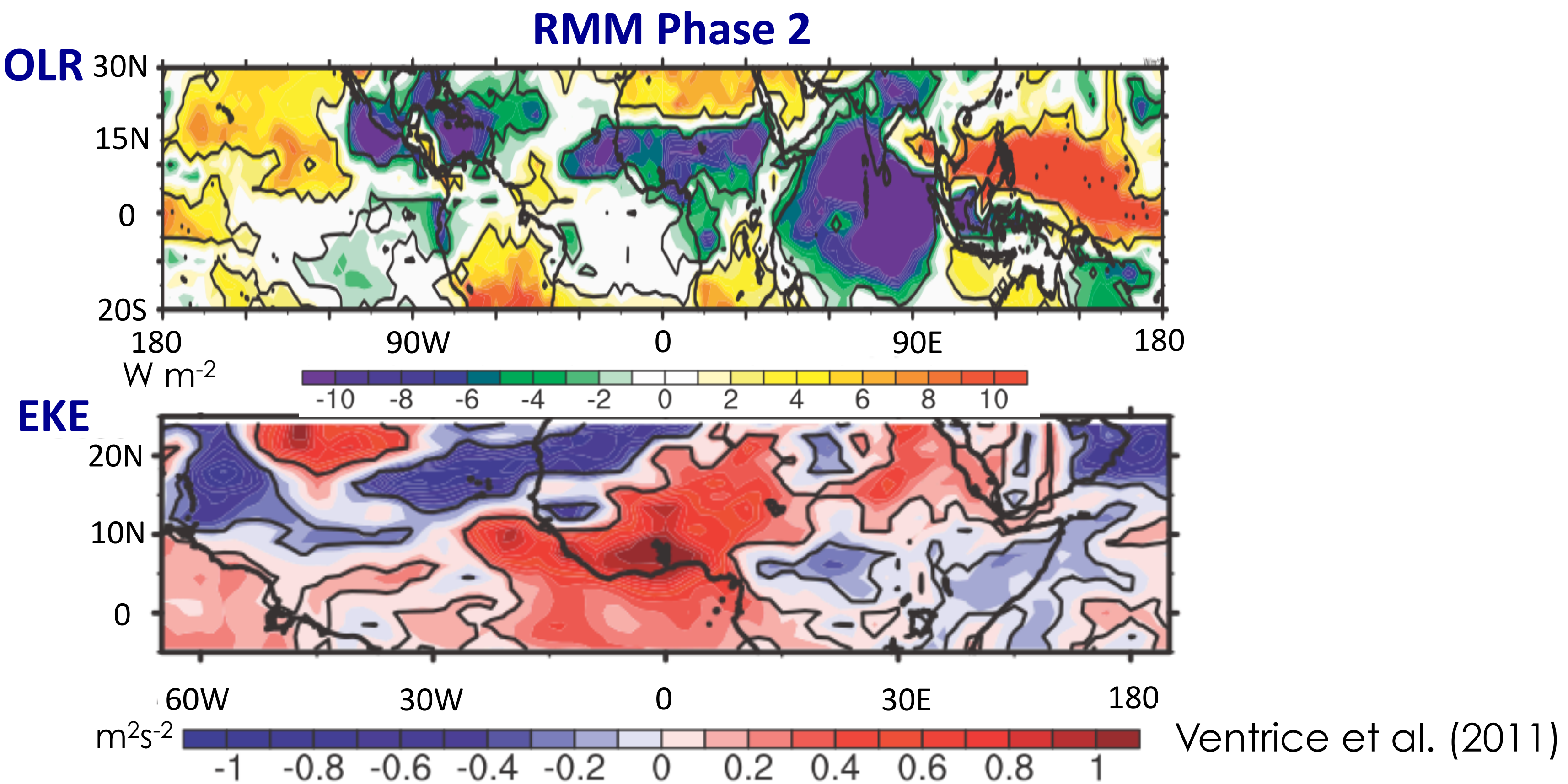
- Is there any structural variability associated with the wave activity variation?
- What is the cause of the intraseasonal variation?
- What is the relative importance of this intraseasonal variability identified by the track counts compared to the known modes, .e.g., the MJO and Kelvin waves?

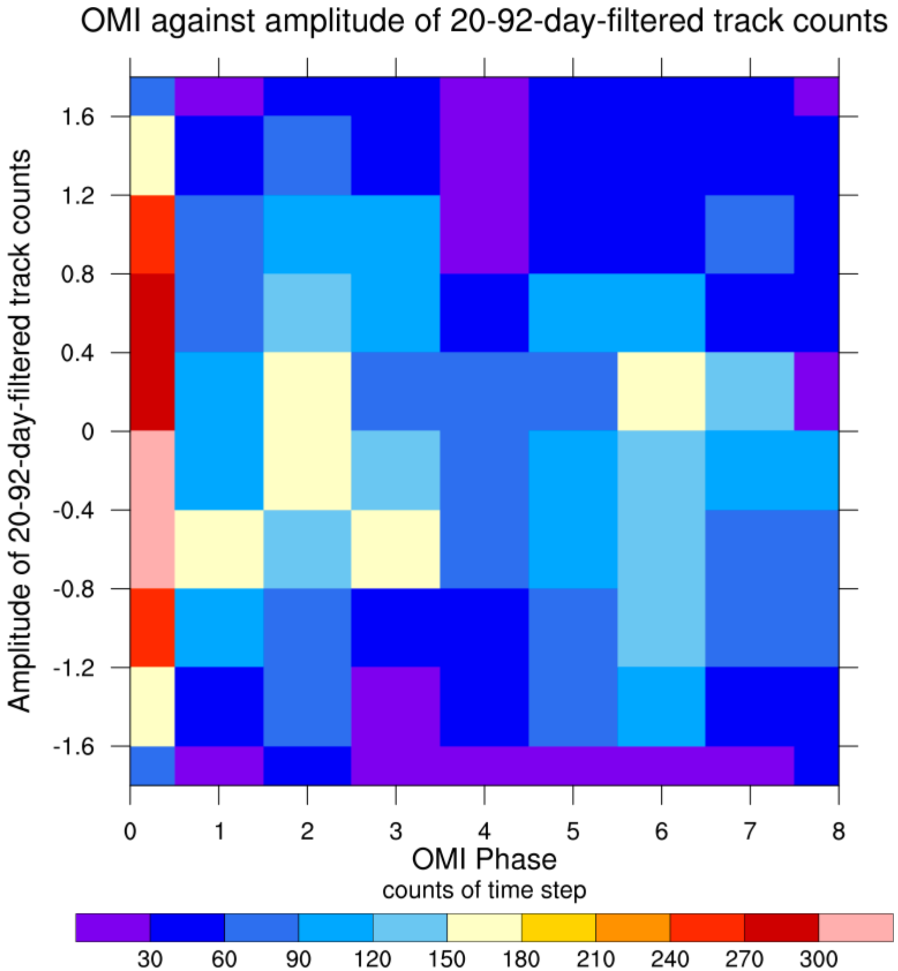
Thank you.

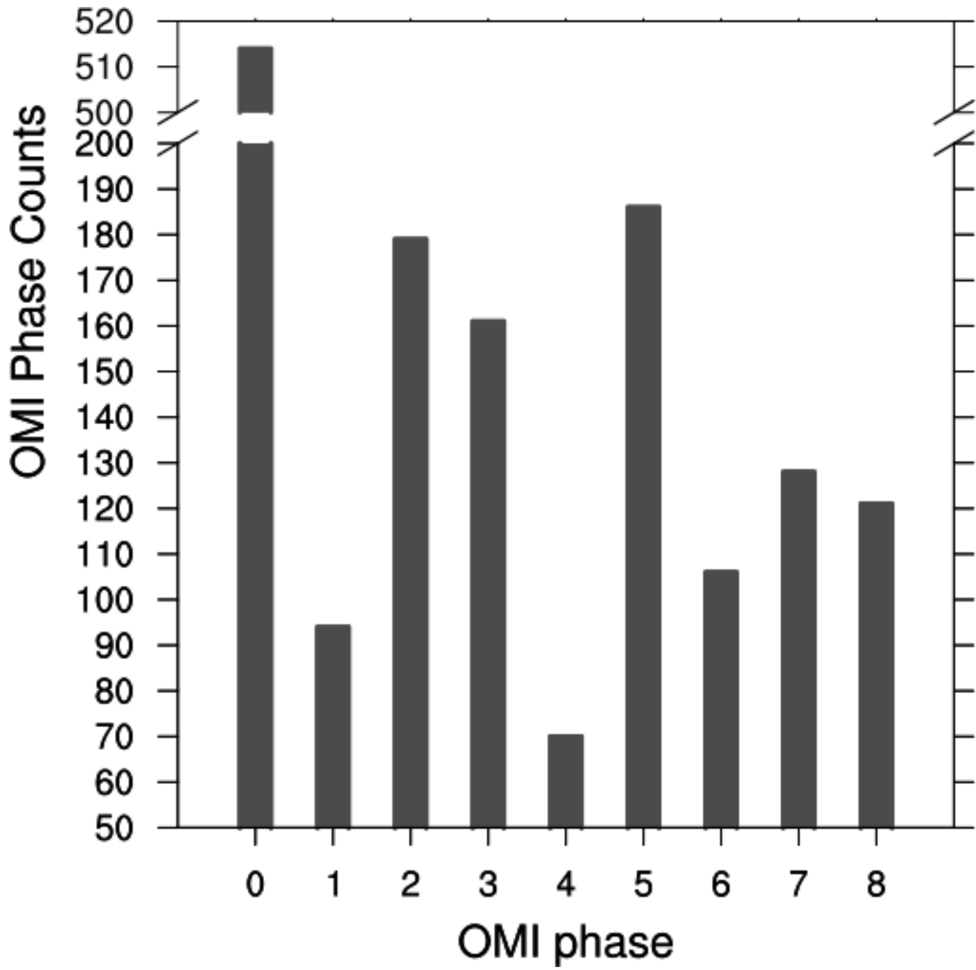
BACKUP SLIDES

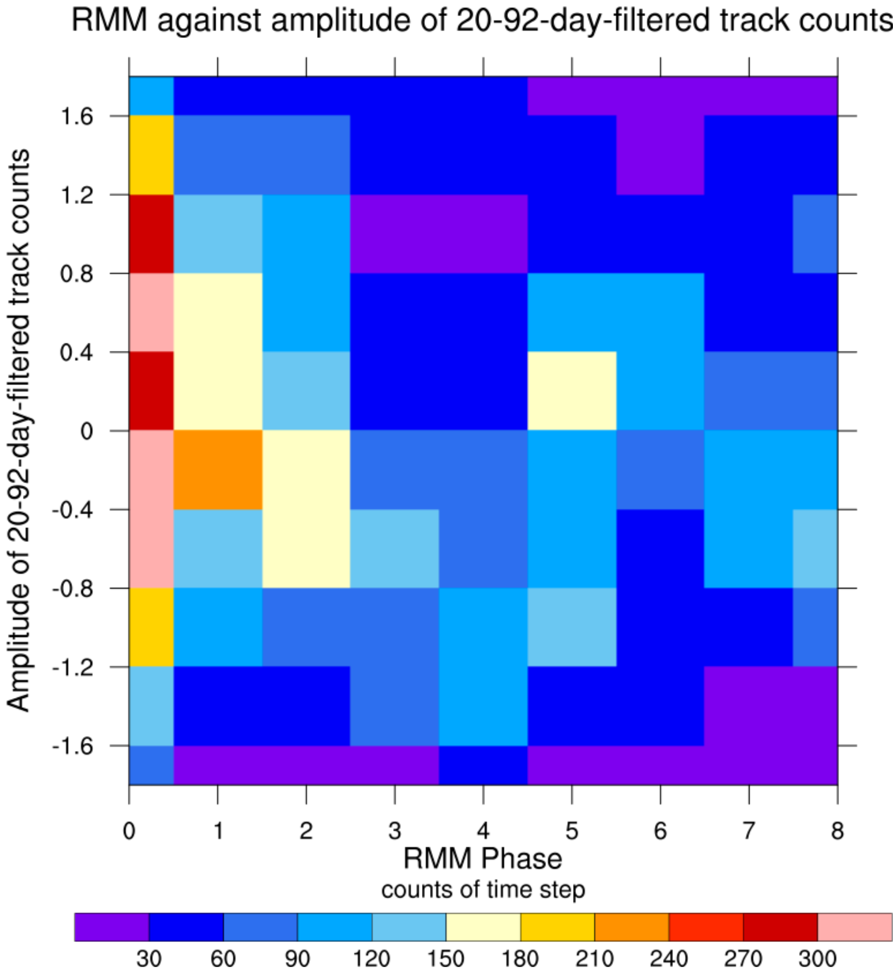
Introduction

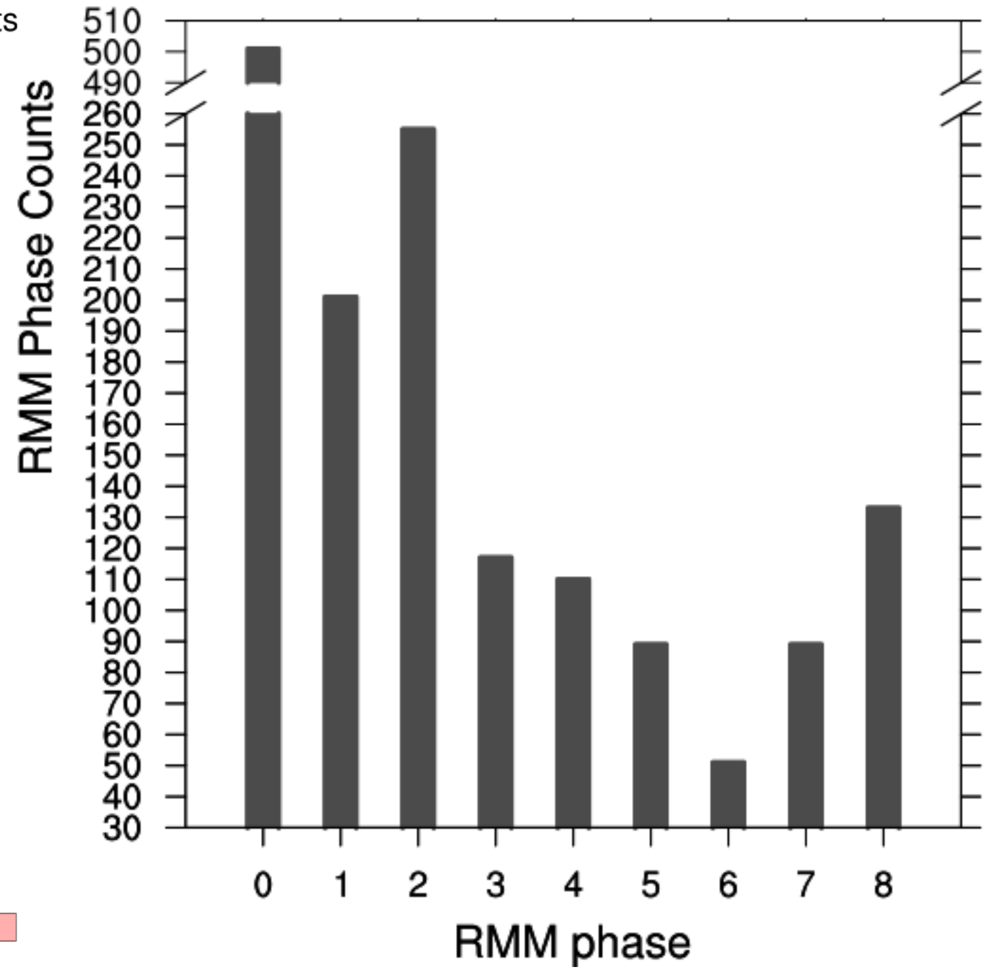
- There is marked variability in intraseasonal and interannual AEW activity
  - e.g., Thorncroft and Hodges (2001), Leroux et al. (2010), Leroux et al. (2011), Ventrice et al. (2011)



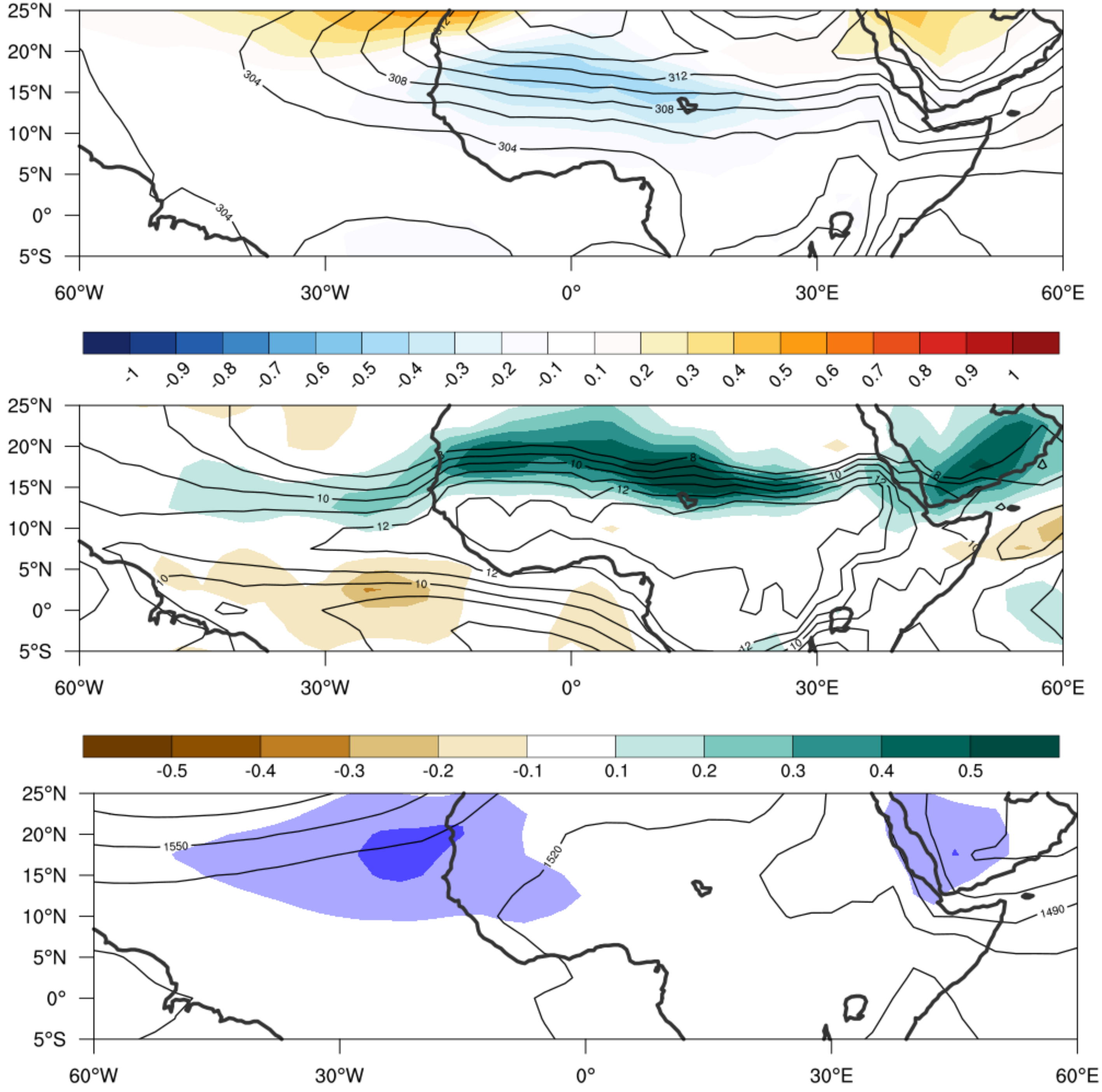

OMI against amplitude of 20-92-day-filtered track counts
Amplitude of 20-92-day-filtered track counts
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
0
1
2
3
4
5
6
7
8
OMI Phase
counts of time step
30
60
90
120
150
180
210
240
270
300


OMI Phase Counts
520
510
500
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
0
1
2
3
4
5
6
7
8
OMI phase


RMM against amplitude of 20-92-day-filtered track counts
Amplitude of 20-92-day-filtered track counts
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
-1.6
0 1 2 3 4 5 6 7 8
RMM Phase
counts of time step
30 60 90 120 150 180 210 240 270 300


RMM Phase Counts
510 500 490 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30
0 1 2 3 4 5 6 7 8
RMM phase

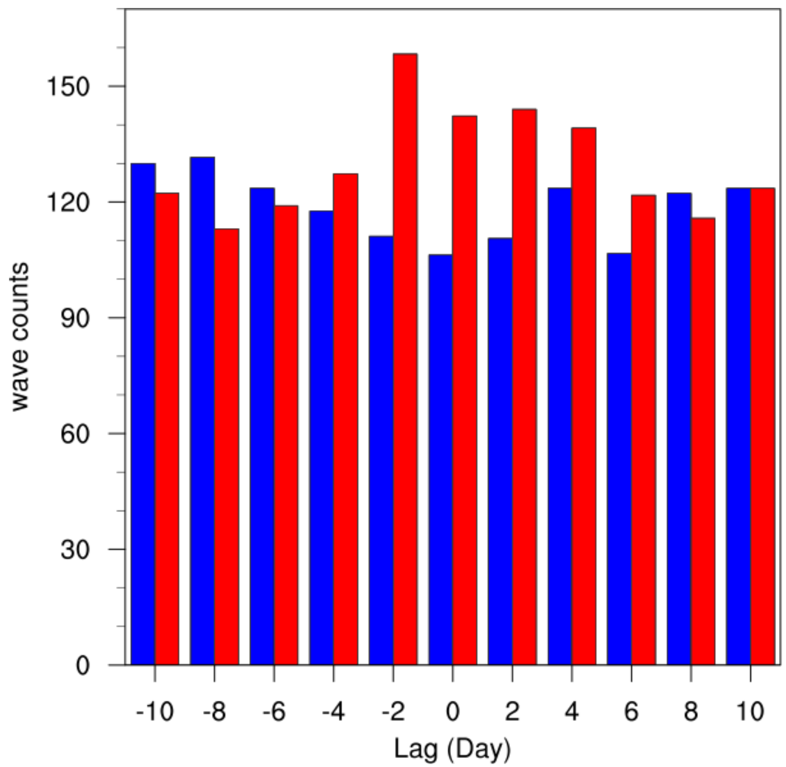
Day 0



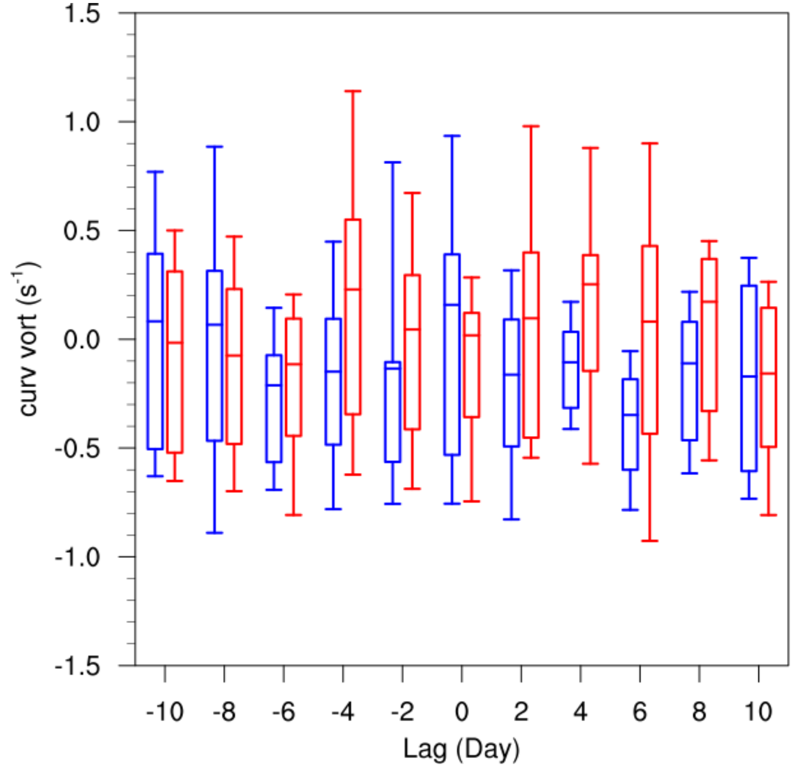
25°N
20°N
15°N
10°N
5°N
0°
5°S
60°W
30°W
0°
30°E
60°E
304
308
312
-1
-0.9
-0.8
-0.7
-0.6
-0.5
-0.4
-0.3
-0.2
-0.1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
8
10
12
-0.5
-0.4
-0.3
-0.2
-0.1
0.1
0.2
0.3
0.4
0.5
1550
1520
1490

Distribution of wave counts and intensity

Wave counts



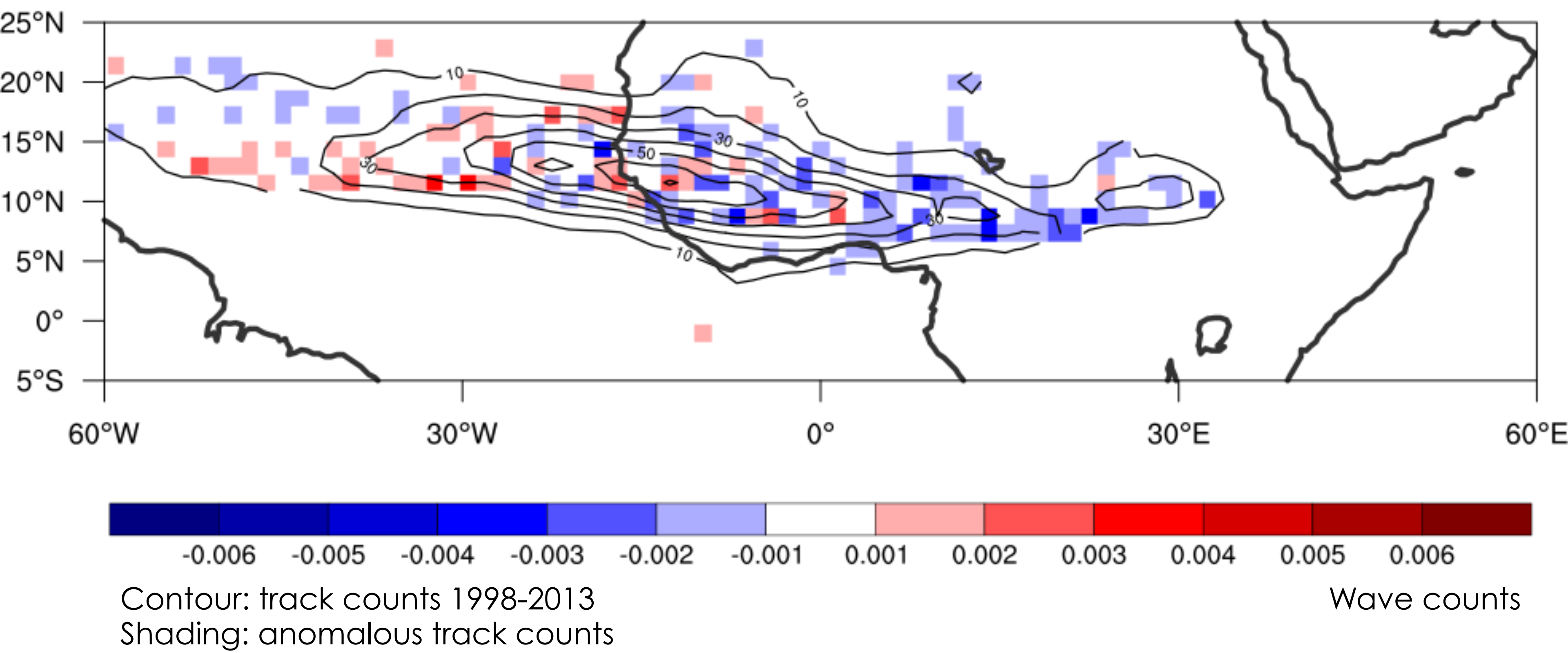
Intensity



Red : intraseasonal track count index > 1 standard deviation
Blue: intraseasonal track count index < 1 standard deviation

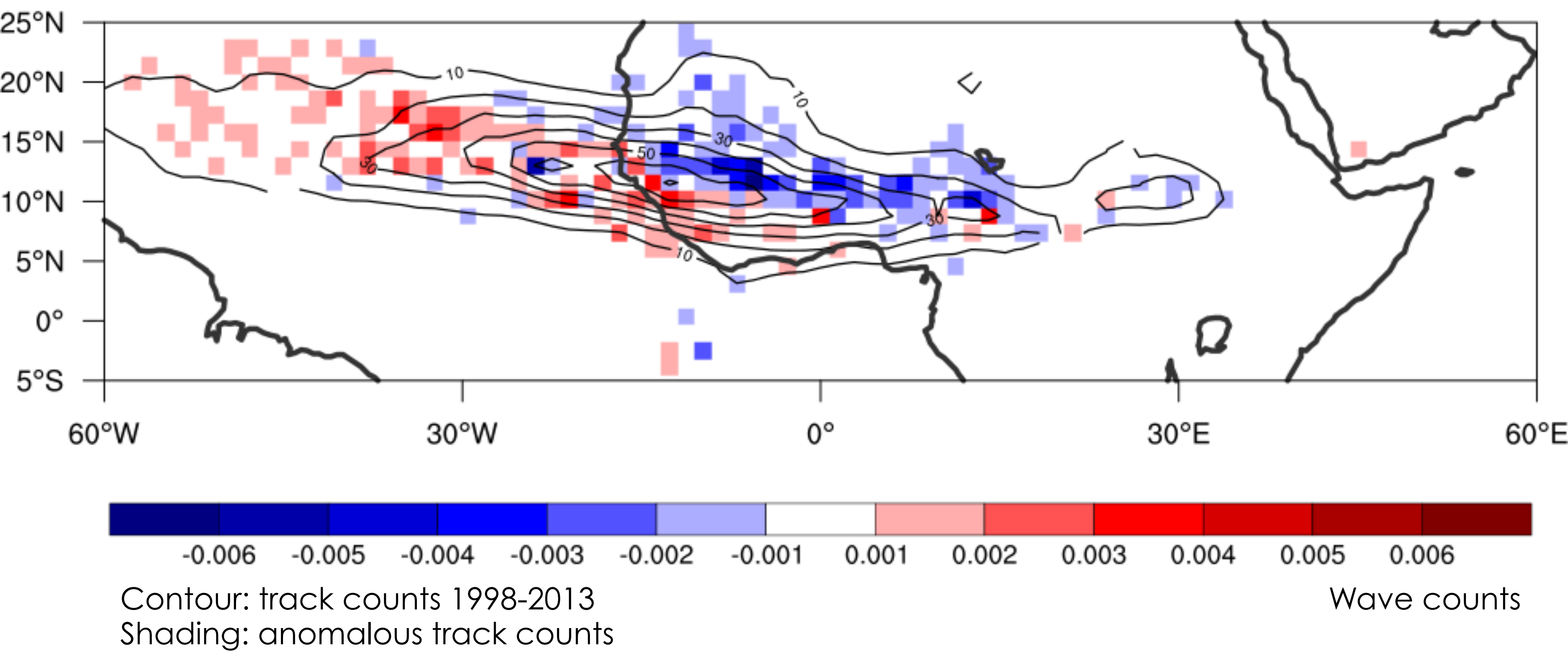
- A clear increase in wave counts

Regression map of wave counts
Day -15



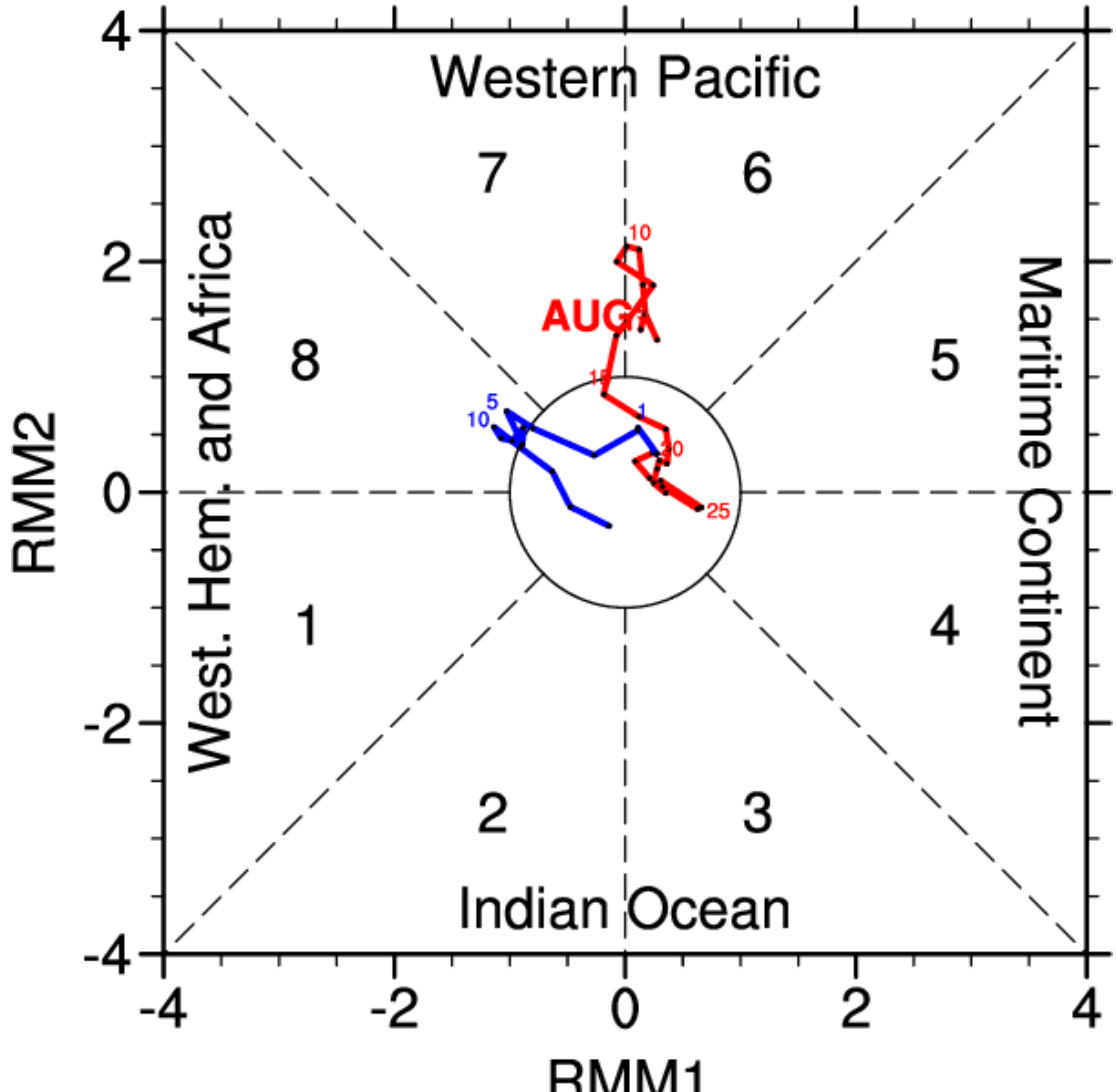
- Suppressed storm activity across the continent
- More AEW genesis over East Africa
- Shifting the mean storm track northward over West Africa

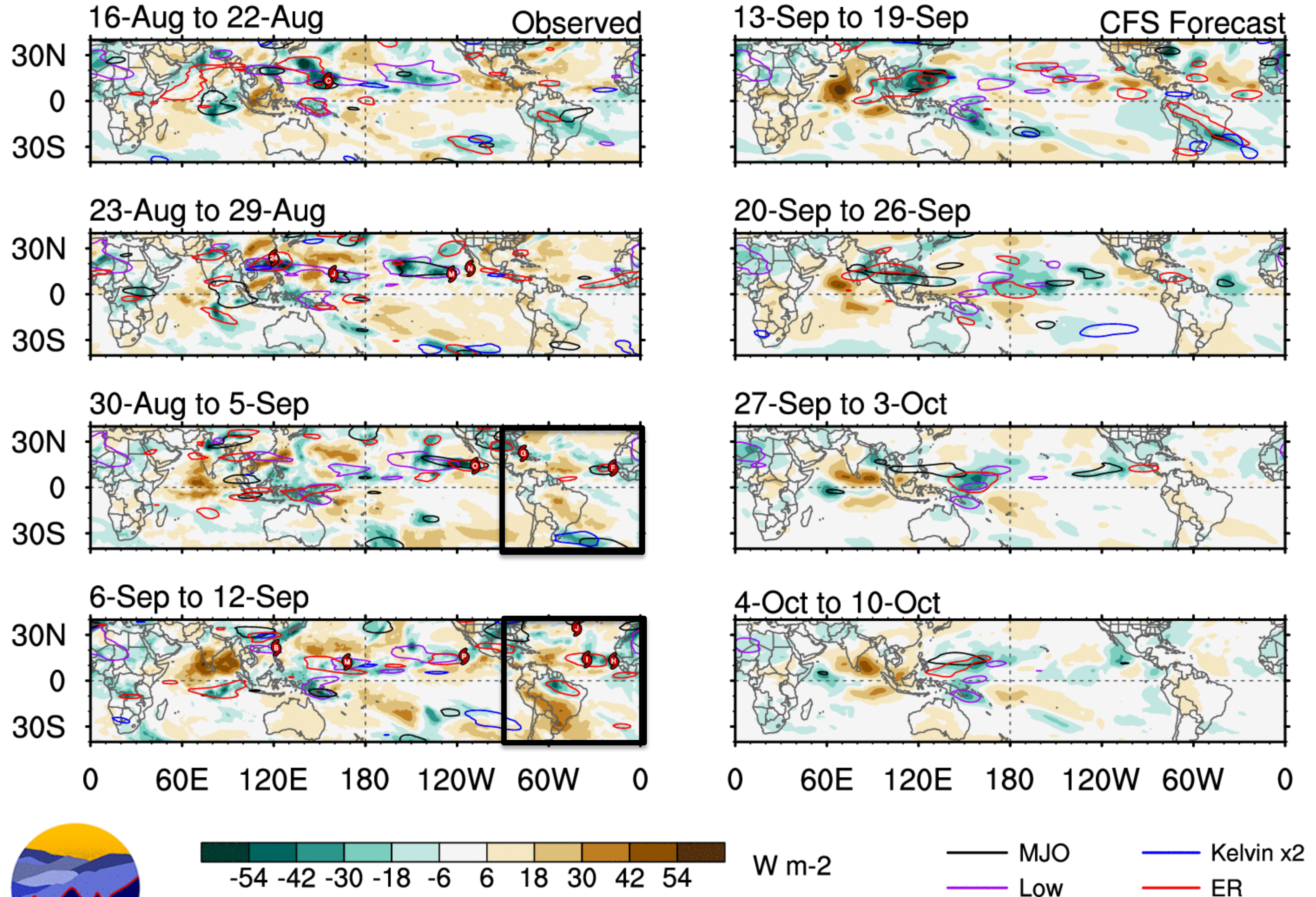
Regression map of wave counts (Day 15)



- Suppressed (enhanced) wave counts north (south) of the mean storm track
- Enhanced wave counts over the Atlantic

5-Aug-2018 to 14-Sep-2018





NCICS

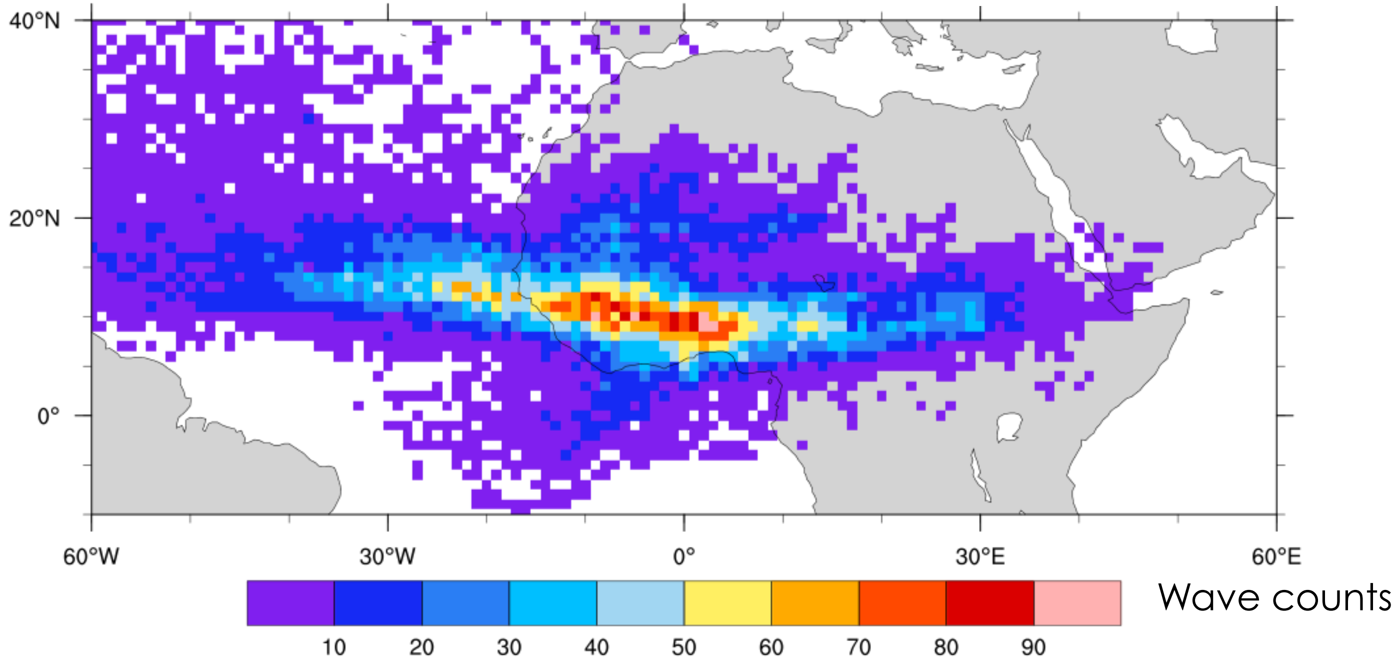
7-day OLR with CFS forecasts

ncics.org/mjo

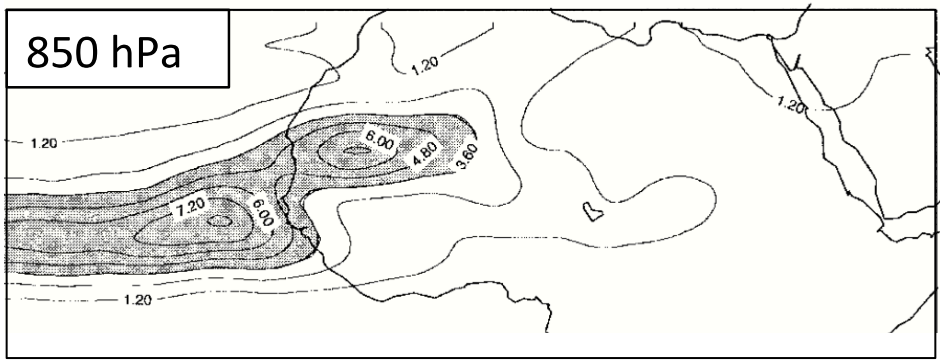
Thu 2018-09-13 1735 UTC

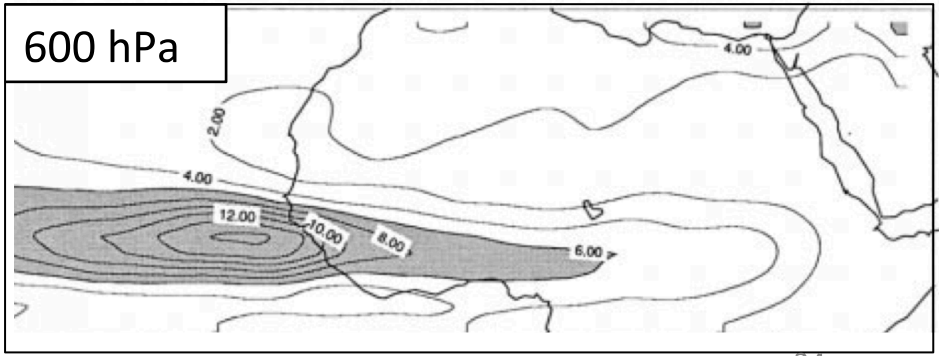
Carl Schreck (cjschrec@ncsu.edu)

Track Counts



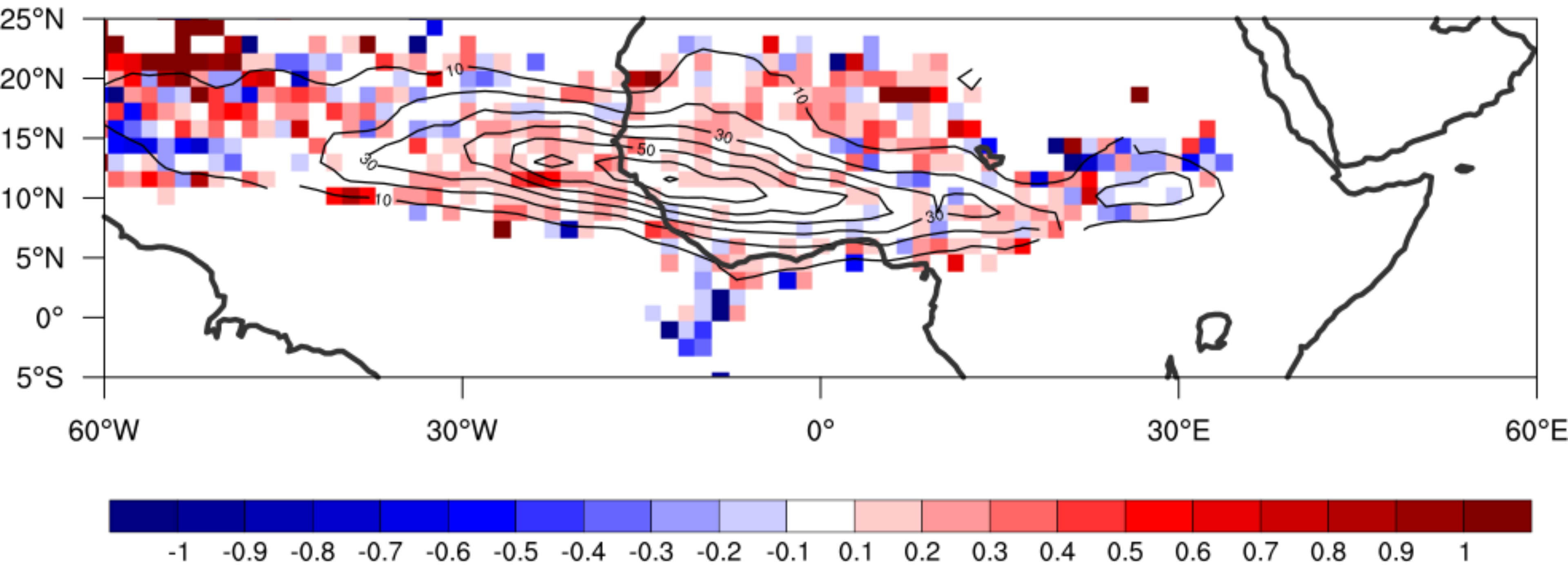
Track counts scaled to number per unit area (10^6 km^2) in MJJASO





Thorncroft and Hodges (2001)

Regression map of intensity Day 5

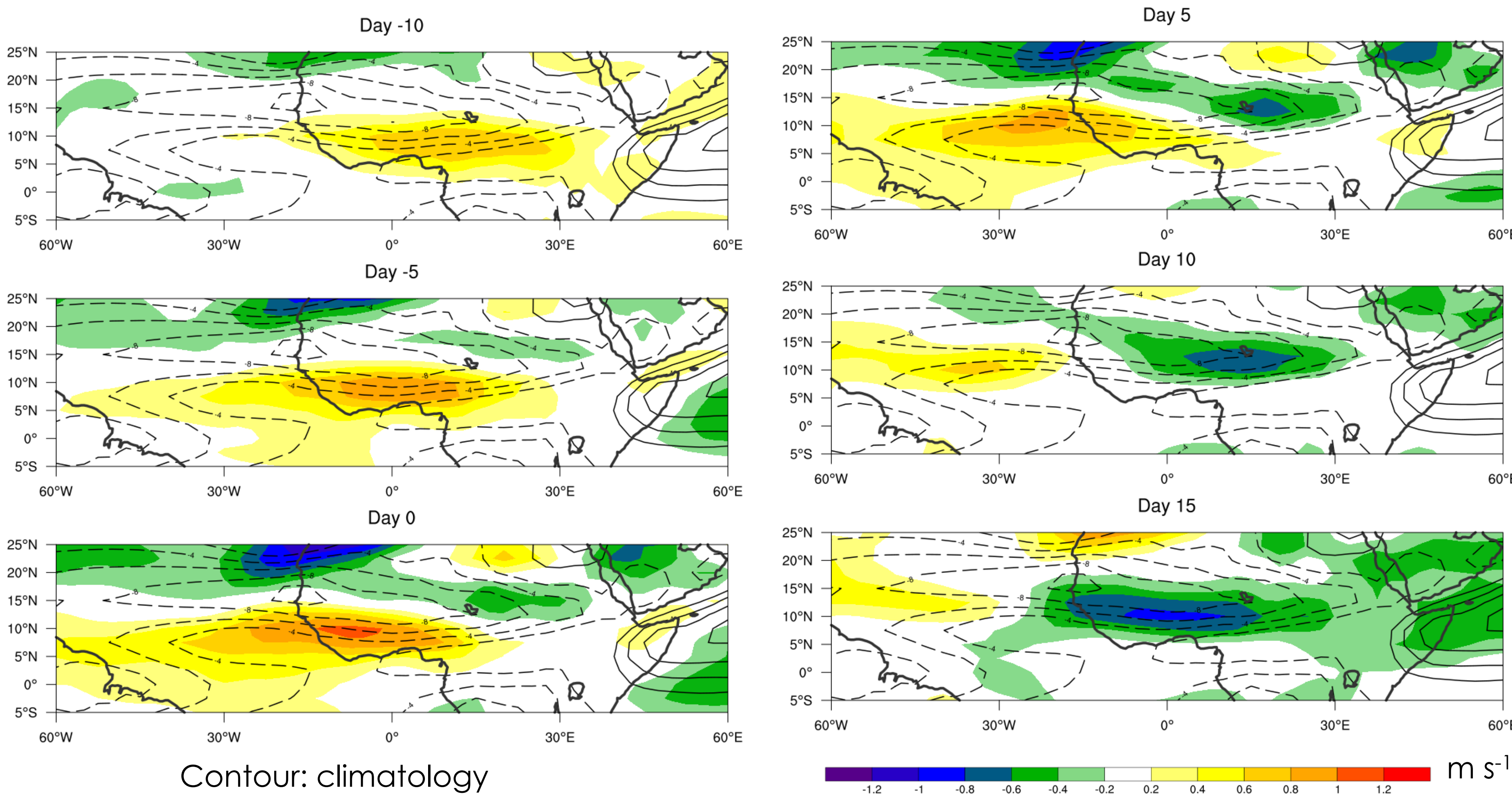


Contour: track counts 1998-2013
Shading: anomalous intensity

700-hPa curv. vort. (s^{-1})

- Slightly enhanced wave intensity north of the mean storm track over the continent
- Enhanced wave intensity in the East Atlantic collocating with the mean storm track

Evolution of the African easterly jet



Contour: climatology
Shading: anomalous zonal wind

Before and during the enhanced wave counts (Day-5 ~ Day 5)

- Eastward extension of the jet
- Northward shift of the jet axis