# The Effects of Orography on African Easterly Waves

Dylan White[1], Anantha Aiyyer[1]
[1]MEAS, North Carolina State University

## Introduction

African easterly waves (AEWs) are synoptic-scale disturbances that impact precipitation in west Africa and are precursors of a majority of Atlantic hurricanes. AEWs can be observed following both a northern and southern track (Figure 1). These tracks coincide geographically with significant orographic features; the northern track with the Ahaggar and Tibetsi (region 1, Figure 2) mountains, and the southern track with the Cameroon mountains (region 2) and Ethiopian Highlands (region 3). Orography is known to affect atmospheric flow and may play a role in AEW development. Lin et al. (2005) concluded that the pre-Hurricane Alberto (2000) AEW originated over the Ethiopian Highlands, and Thorncroft et al. (2008) promotes convective triggering upstream near the Ethiopian Highlands as an AEW genesis mechanism. It seems that orography may indeed impact AEWs. As a first examination of how orography may affect AEWs, we first consider the Ahaggar and Tibetsi mountains and the northern AEW track.

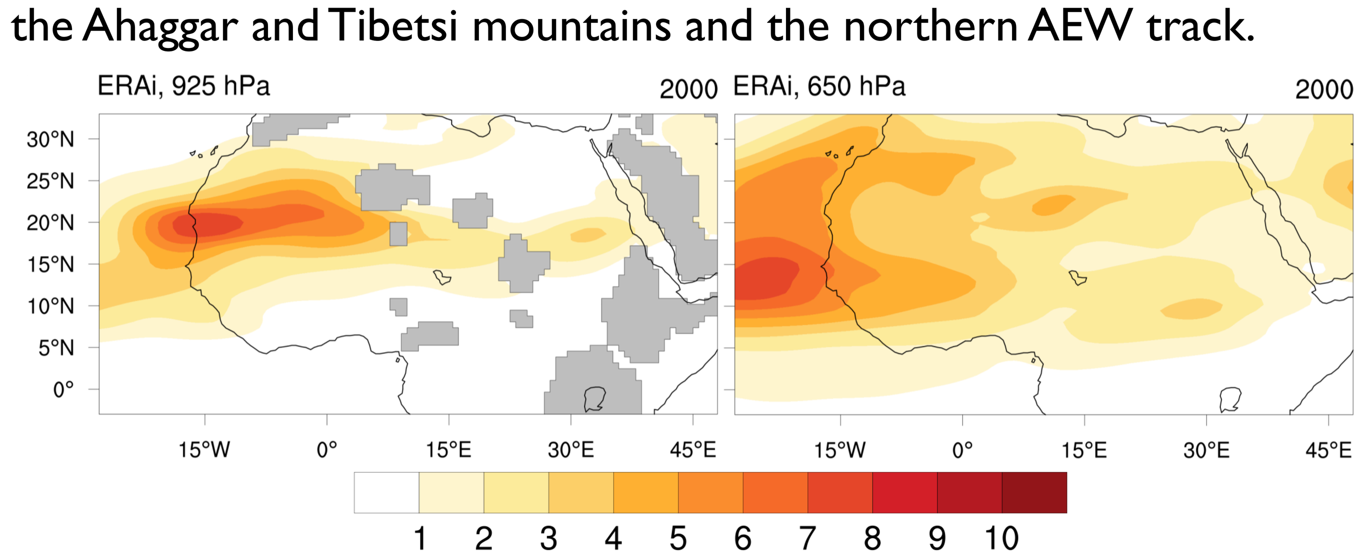



*Figure 1*: From ECMWF Reanalysis Interim, eddy kinetic energy (J/kg) averaged from July-September 2000 at 925 hPa showing the northern track (left) and at 650 hPa showing the southern track (right). Orographic intrusions on the isobaric surface are shaded gray.

## Methods

1. **Use the Weather Research and Forecasting (WRF) model to simulate atmosphere with reduced topography in region 1.**

Control Configuration*:
- 54 km grid spacing
- RRTMG SW & LW radiative schemes
- WDM6 microphysics scheme
- Grell-Freitas cumulus scheme
- Shin-Hong PBL scheme

All simulations are run from June 1 00Z, 2000 until Oct. 31 18Z, 2000 and use the ECMWF Reanalysis Interim data as boundary and initial conditions.

Experiments:
1. Same as control, but with *30%* topography removed in region 1
2. Same as control, but with *50%* topography removed in region 1

*Configuration details not mentioned here are the default WRF settings

2. **Calculate Eddy Kinetic Energy (EKE) and observe AEW tracks**

Filter meridional and zonal winds with 2-6 day band pass filter to get $u'$ and $v'$

Calculate
$$\mathrm{EKE}=\frac{1}{2}(u'^2+v'^2)$$
and take the July-September average

## Reduced Topography in Region 1

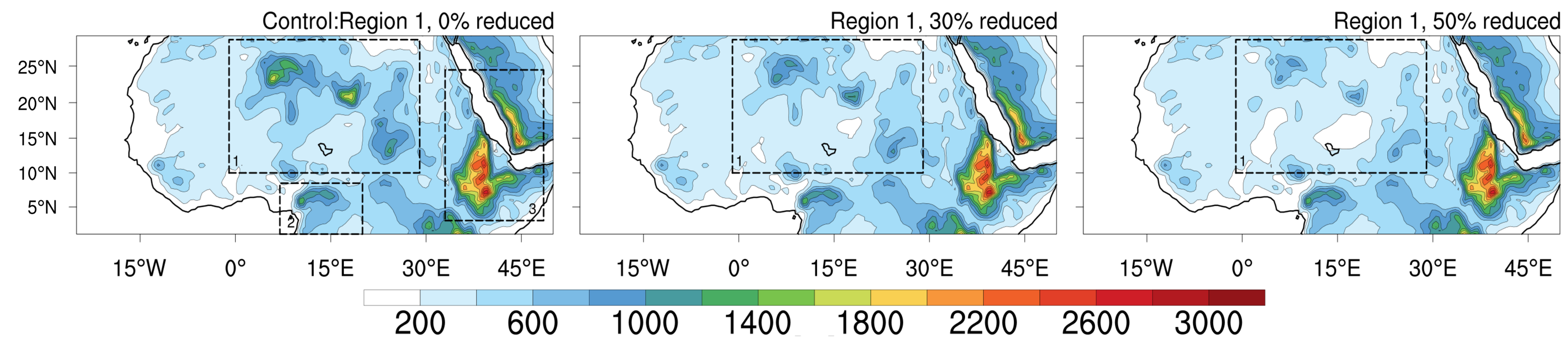



*Figure 2*: North African topography shaded every 200 meters for the control case (right), the 30% reduced topography case (middle), and the 50% reduced topography case.

- Topography is reduced before running the WRF model by editing the *HGT_M* field in the geography domain file
- To avoid large discontinuities in the terrain, the topography in the ten outermost grid cells in region 1 are linearly reduced from 0% on the outermost grid cell to 30% on the tenth innermost grid cell (or 50%)

## Northern and Southern Tracks

**Control**
- Northern and southern tracks reasonably match ECMWF reanalysis data, with some southward shift of the northern track

**30% Topography Removed**
- Slight decreased northern track EKE to the west
- Northern track EKE spreads southward and eastward from the control
- *Increased* southern track EKE, perhaps as a result of the new southern extent of the northern track

**50% Topography Removed**
- Much more notable decrease in northern track *and* southern track EKE

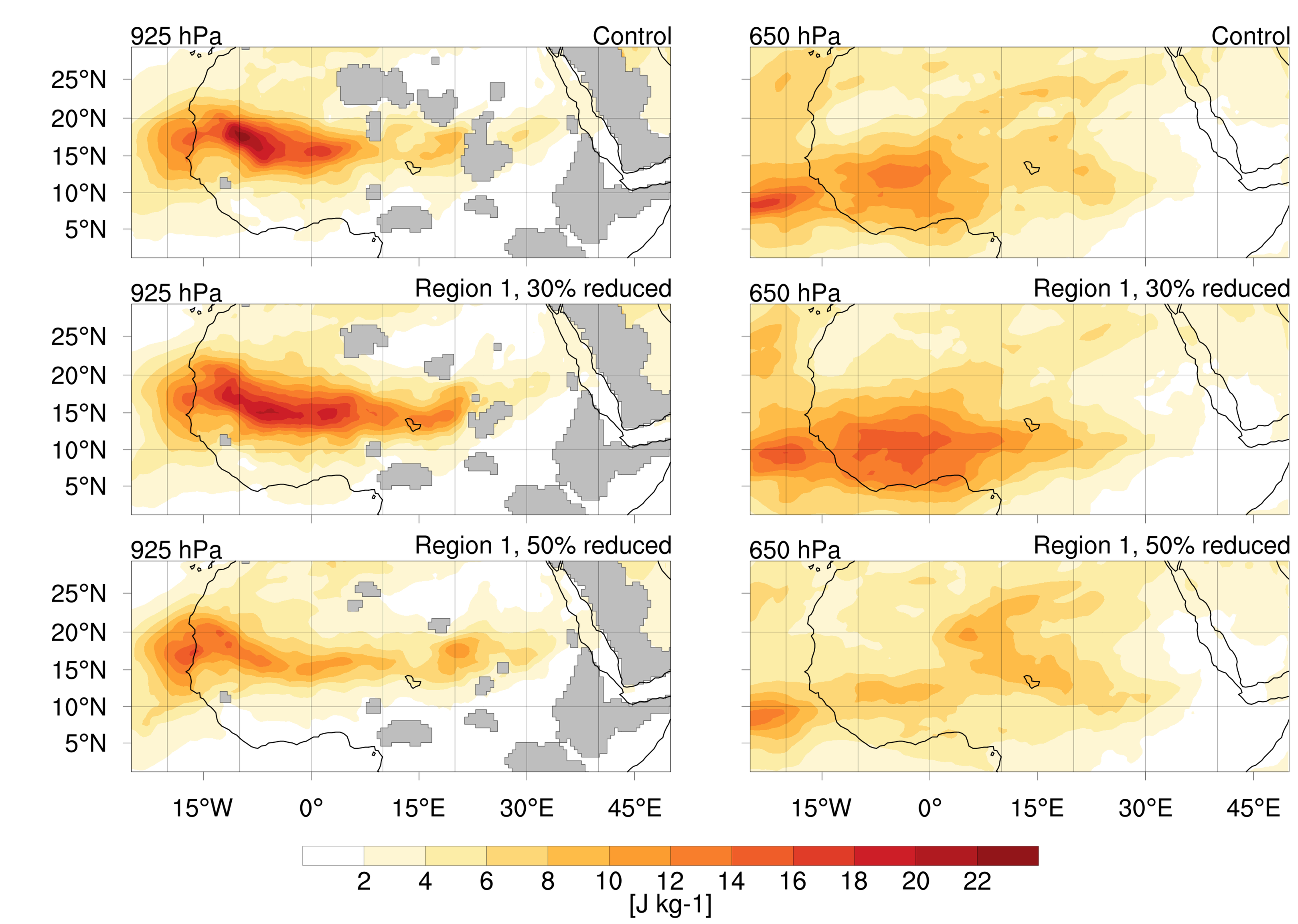
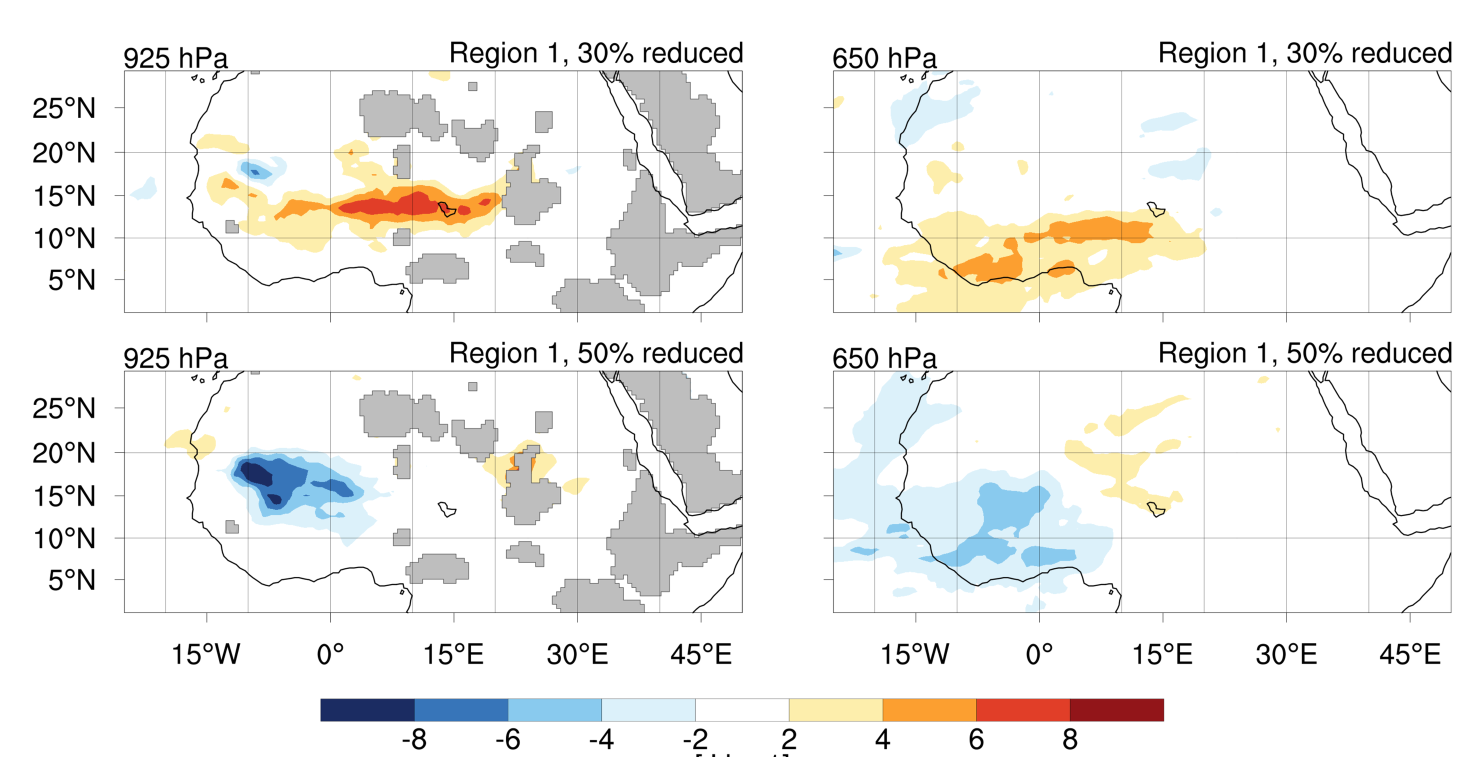



*Figure 3*: As in Figure 1, using WRF output data from the control (top), 30% reduced topography (middle), and 50% reduced topography (bottom).




- 30% topographic removal experiment observed *stronger* tracks
- 50% topographic removal experiment observed *weaker* tracks, especially where the control case tracks were maximized

*Figure 4:* As in Figure 3, but the difference field from the control case. Positive values indicate greater EKE in the experimental output, negative values indicate lower EKE.

## African Easterly Jet

- The African Easterly Jet, extending from 10-15°N, is only *slightly* impacted by reduced orography
- Greatest change is between ±10°E where the southern track is strongest
- Since the instability of the jet contributes to the growth of AEWs, this slight reduction may explain some of the reduction of the AEW track EKE

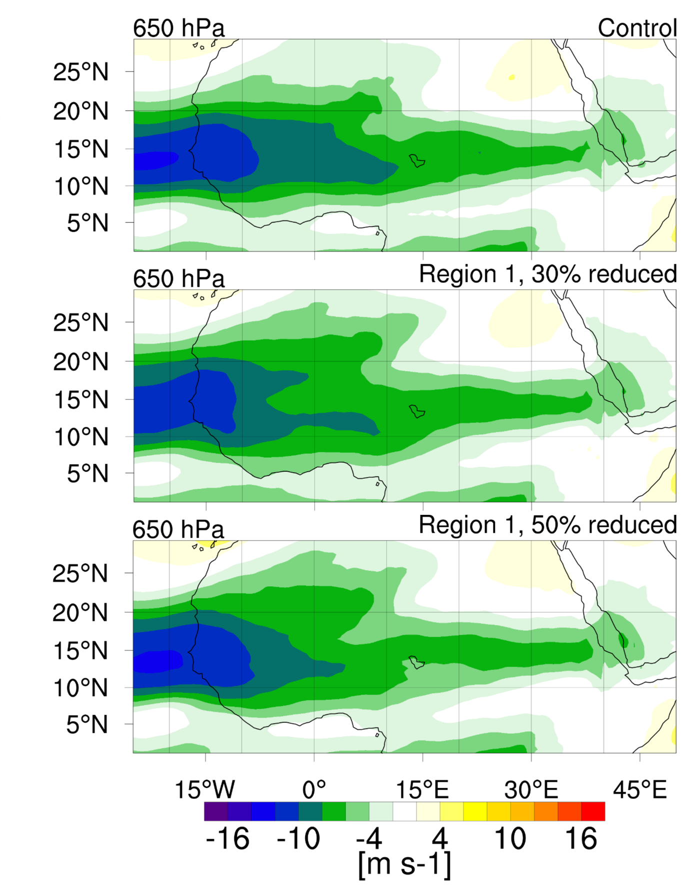



*Figure 5:* July-September averaged zonal wind, shaded every 2 m/s. The strong easterly winds are the African Easterly Jet

## Summary and Conclusions

- Reducing topography in region 1 changes African easterly wave eddy kinetic energy tracks.
- The strongest decrease in eddy kinetic energy was observed in the experiment with 50% reduced topography in both the northern and southern tracks.
- Both EKE tracks in the 30% topography reduction experiment surprisingly *increased.*
- The African Easterly Jet was slightly reduced after altering the orography. This could explain some of the reduction of AEW EKE. It's unclear at this time which particular effect of reducing topography altered the AEW tracks.

**Future Work**
- Repeat experiments for regions 2 and 3 as well as combinations of all three regions.
- Investigate *why* orography has these effects through use of energetics and simplified modelling

## Acknowledgements & References

This research was sponsored by NSF through award #1433763 and through the Science, Mathematics, and Research for Transformation (SMART) scholarship. We are thankful for productive discussions with Mr. James Russell and Dr. Walter Hannah, and especially with Dr. Gary Lackmann.

**References**

1. Lin, Y.-L., K.E. Robertson, and C.M. Hill, 2005: Origin and propagation of a disturbance associated with an African easterly wave as a precursor of Hurricane Alberto (2000), *Mon. Wea. Rev.*, **133**, 3276-3298
2. Thorncroft, C.D., N.M.J. Hall, and G.N. Kiladis, 2008: Three-Dimensional Structure and Dynamics of African Easterly Waves. Part III: Genesis, *J. Atmos. Sci.*, **65**, 3596-3607

Unfortunately, I was unable to personally attend this year's AMS conference, but if you have any comments or questions, please contact Dylan at *jdwhite5@ncsu.edu*.