The dynamics of wind-driven intraseasonal variability in the equatorial Indian Ocean

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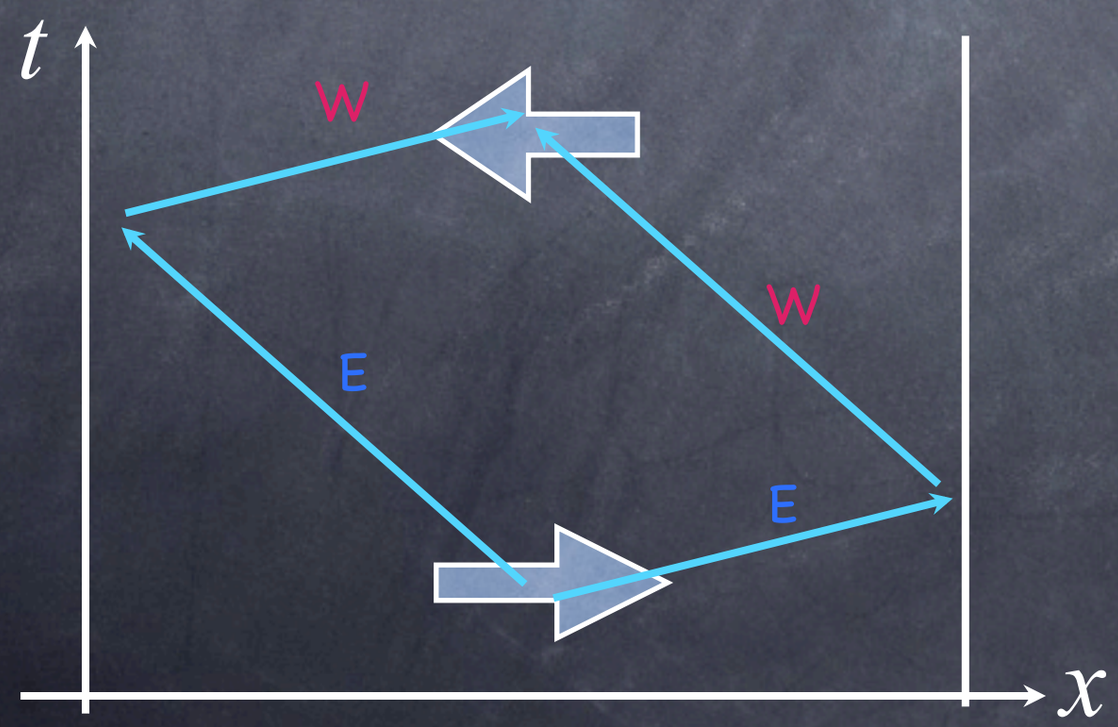
Introduction

- Intraseasonal variability is widely observed in SSH and velocity at periods of 30-110 days.
- Basin mode resonance (Han et al. 2001, 2011; Han 2005; Fu 2007)



Period of 90 days

winds

wave path

E eastward velocity

W westward velocity

Purpose

- Provide detailed description of spatial/ temporal intraseasonal variability using recently available observations.
- Describe dynamics using an analytical wave model and examine the basin mode hypothesis.
- Examine wind forcing using high quality satellite winds. Details of wind forcing (e.g., stationary or propagating) matters (Kessler et al, 1995; Hendon et al. 1998).

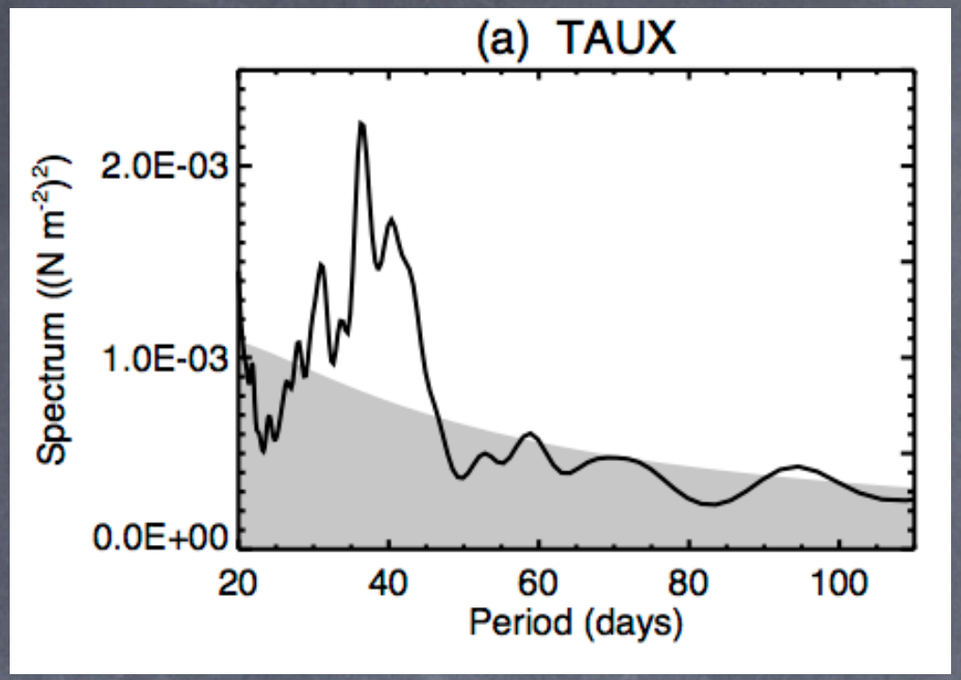
Observations

- 10 year time series of surface wind from QSCAT satellite measurements, with daily averages on a 0.5° x 0.5° grid.
- 4 year record of daily zonal velocity in the upper 100m at 0° 80.5°E observed by acoustic Doppler current profilers.
- 17 year time series of surface zonal velocity from OSCAR analysis, with 5 day averages on a 1° x 1° grid.

Model

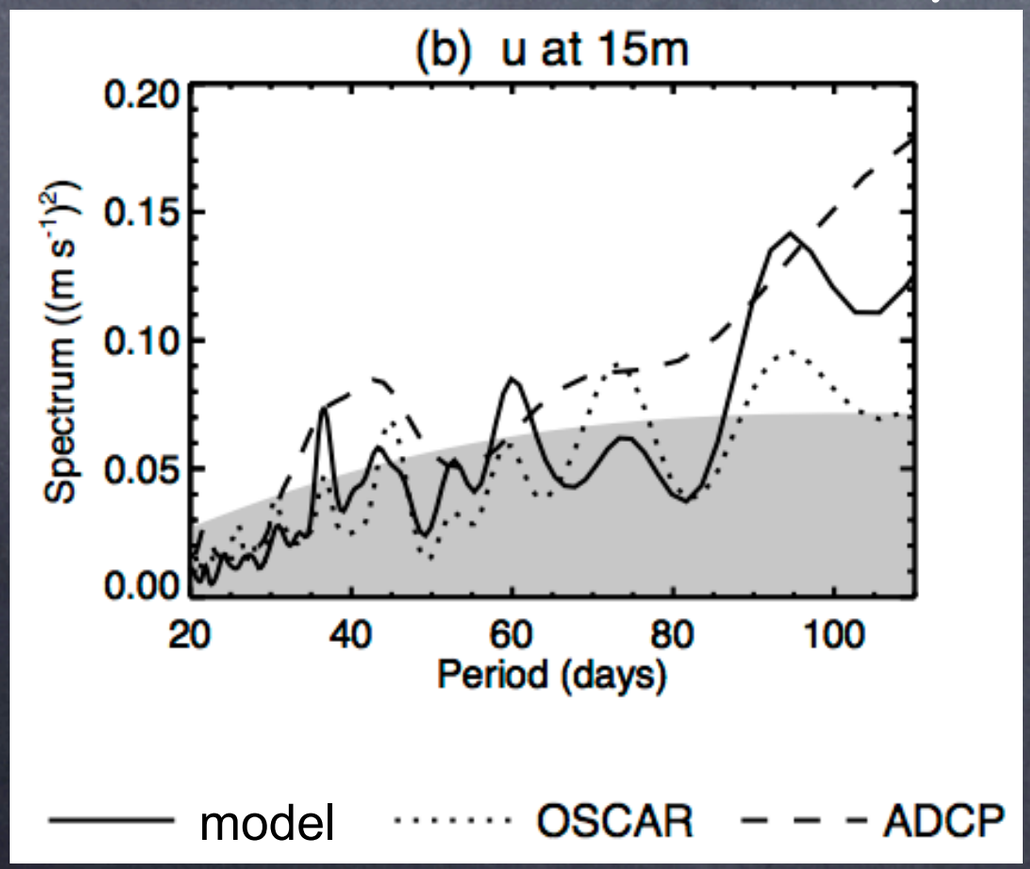
- Linear, continuously stratified longwave model on an equatorial β plane.
- Basic stratification is obtained from Argo float observations.
- The domain is bounded zonally by meridional walls at 40°E and 100°E. The 85% is used for boundary reflectivity. It is unbounded meridionally. Wind forcing is from QSCAT satellite winds.
- The two gravest baroclinic mode Kelvin and first meridional mode Rossby waves are included.

zonal wind stress



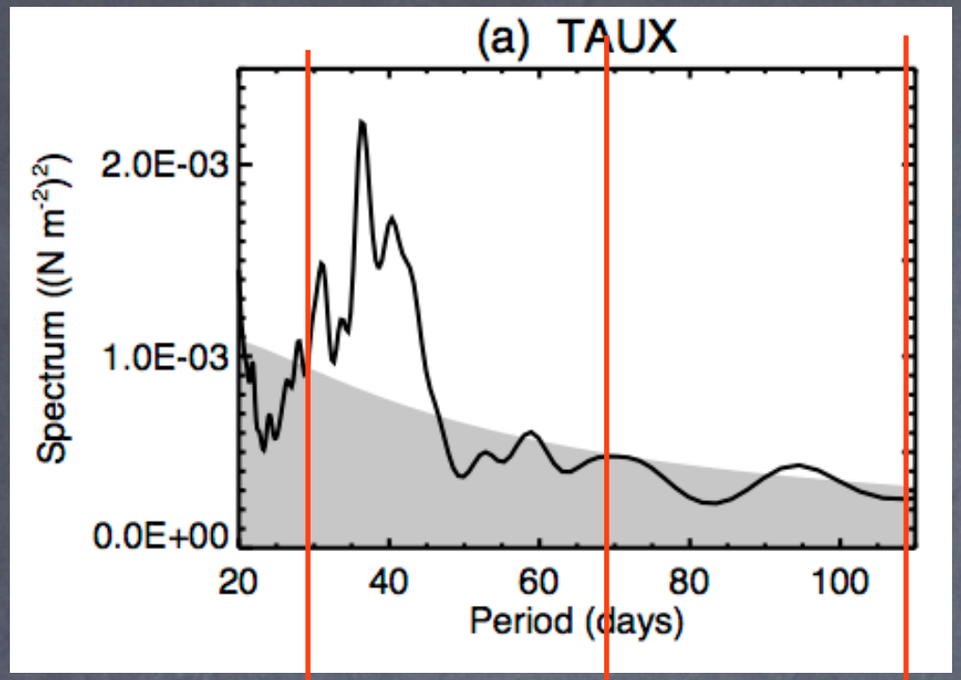
Power spectrum
at 0°, 80°E

surface zonal velocity



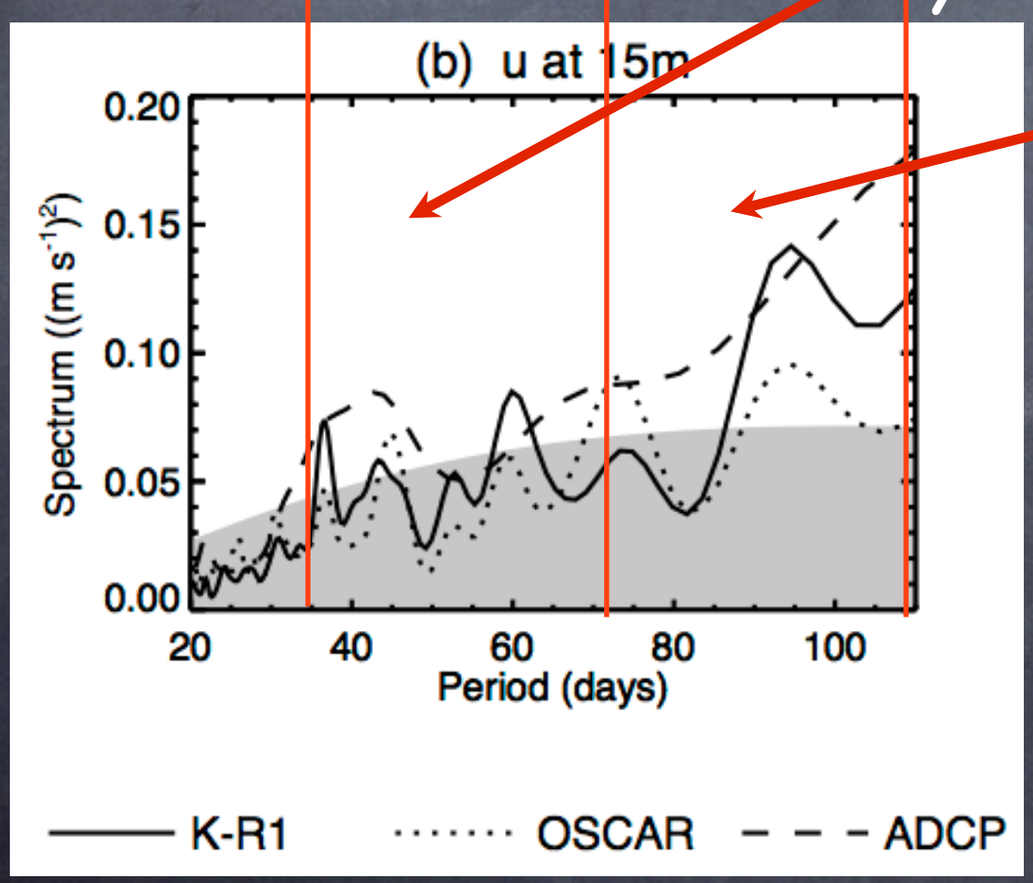
red shift of
velocity spectrum

zonal wind stress



Power spectrum
at 80°E

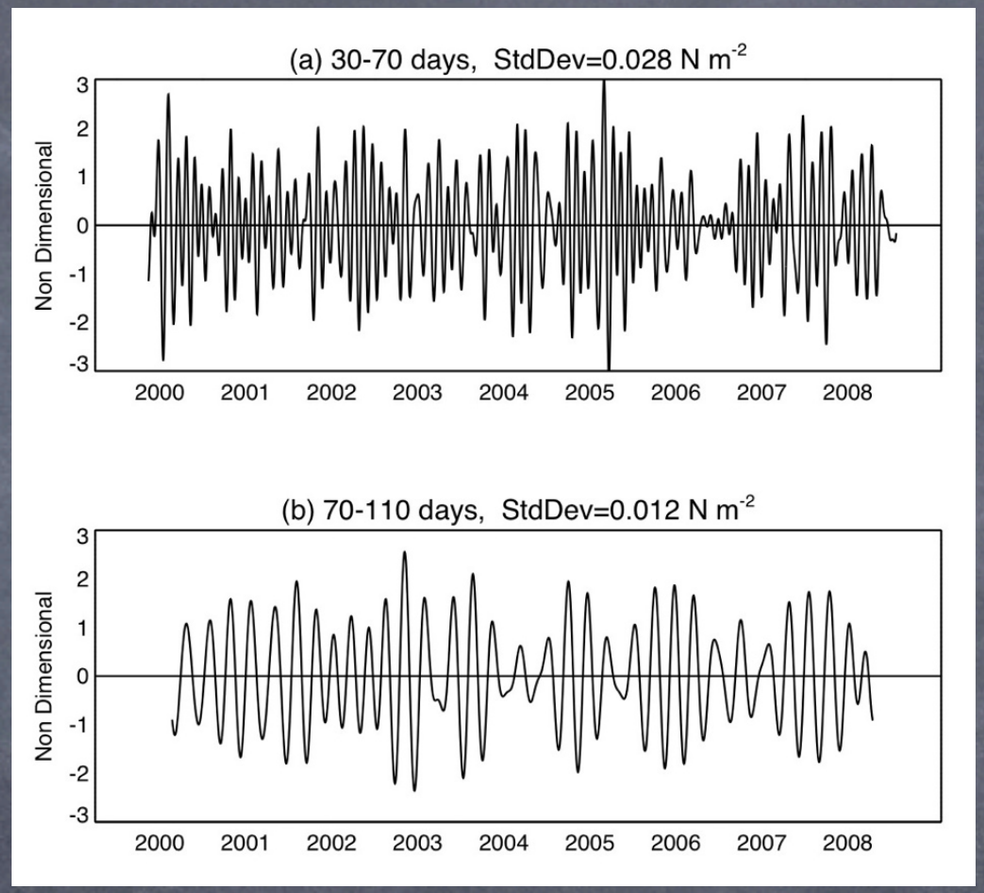
surface zonal velocity



30-70 day variability

70-110 day variability

- Wind stress at 0° 80°E is used as an index for intraseasonal wind forcing.



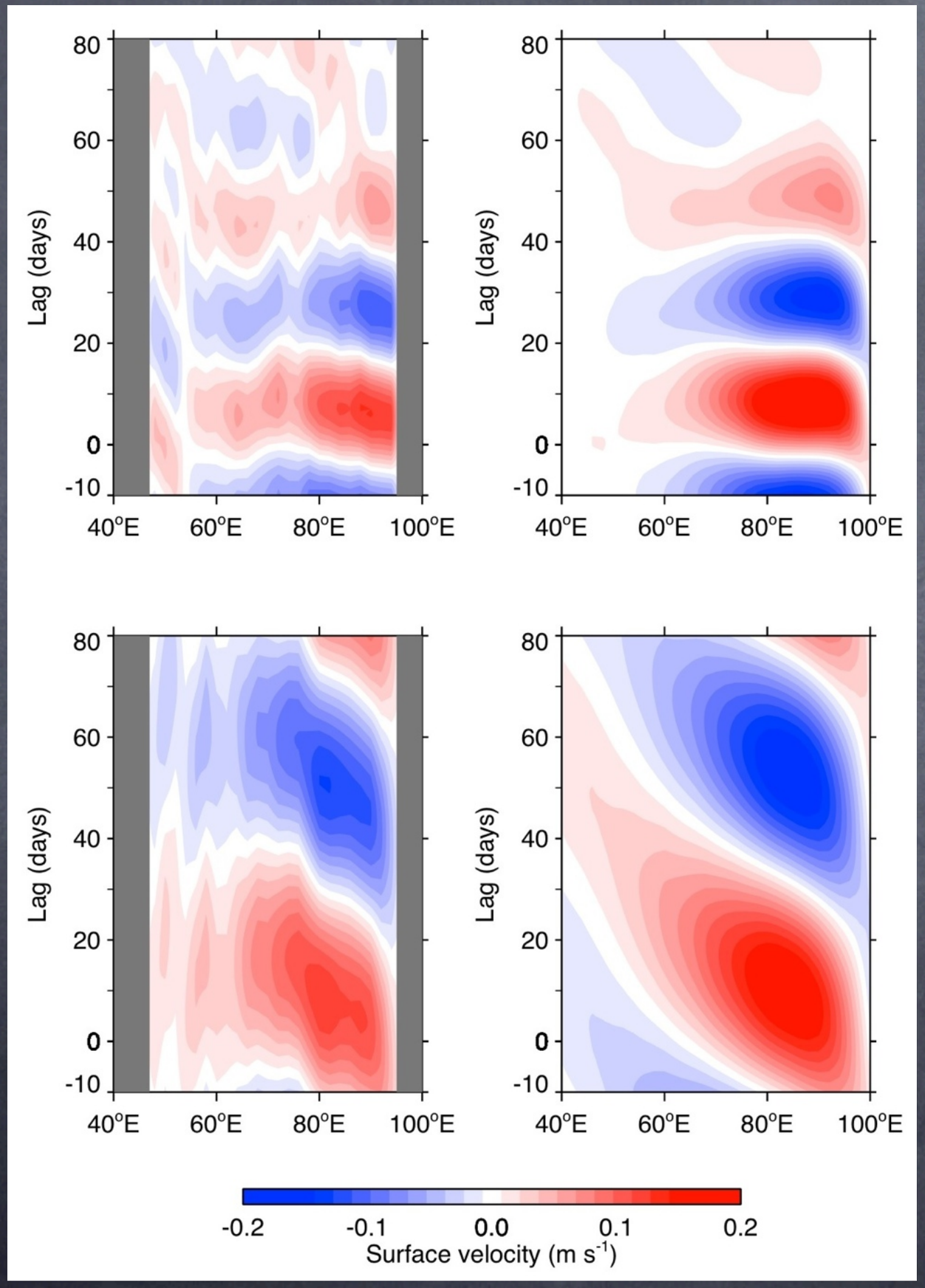
30-70 days

70-110 days

- Model and observed velocities on the equator are regressed onto the normalized wind index at various time lags.

OSCAR

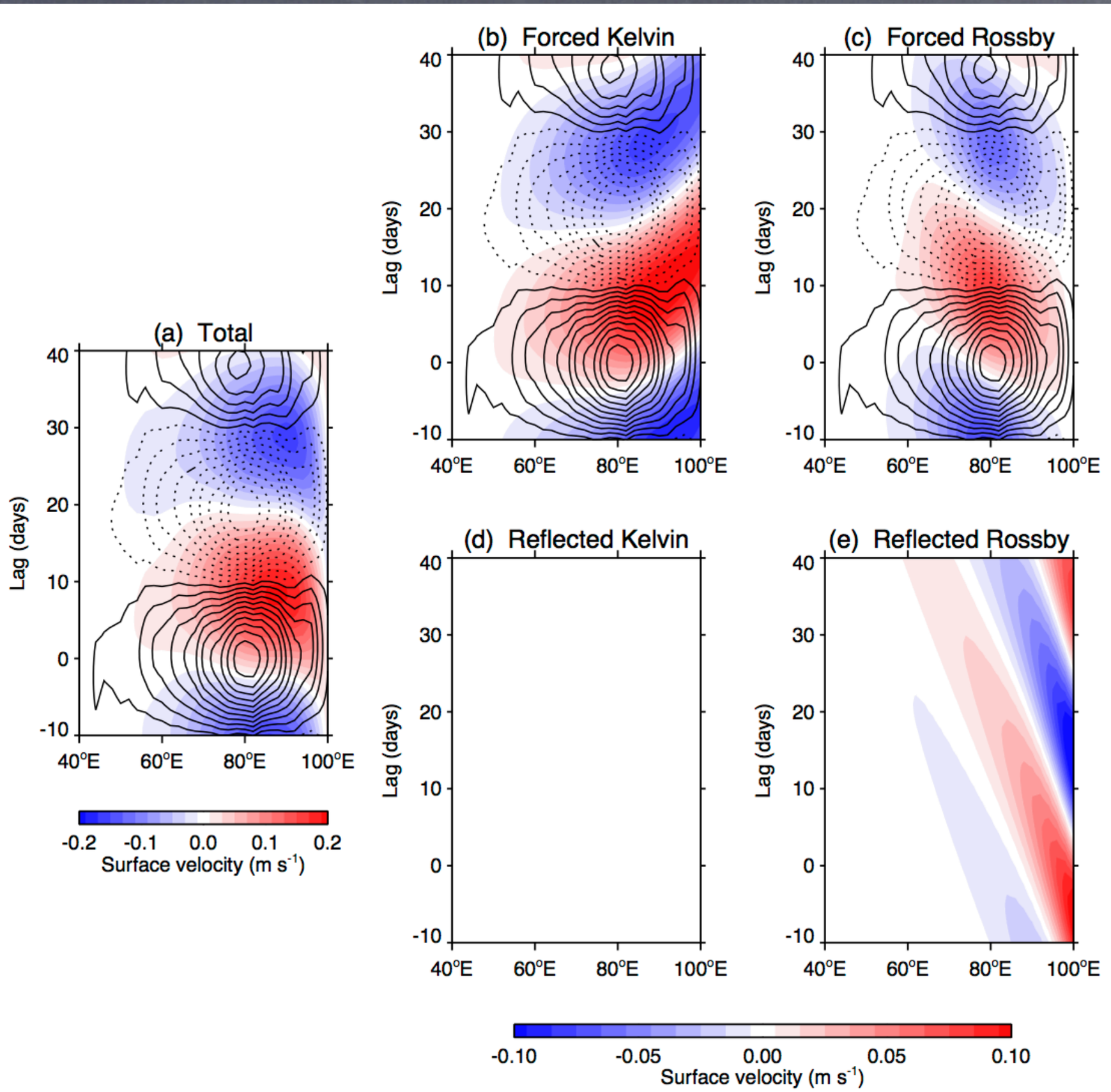
Model



30-70 day

Regressed velocity

70-110 day

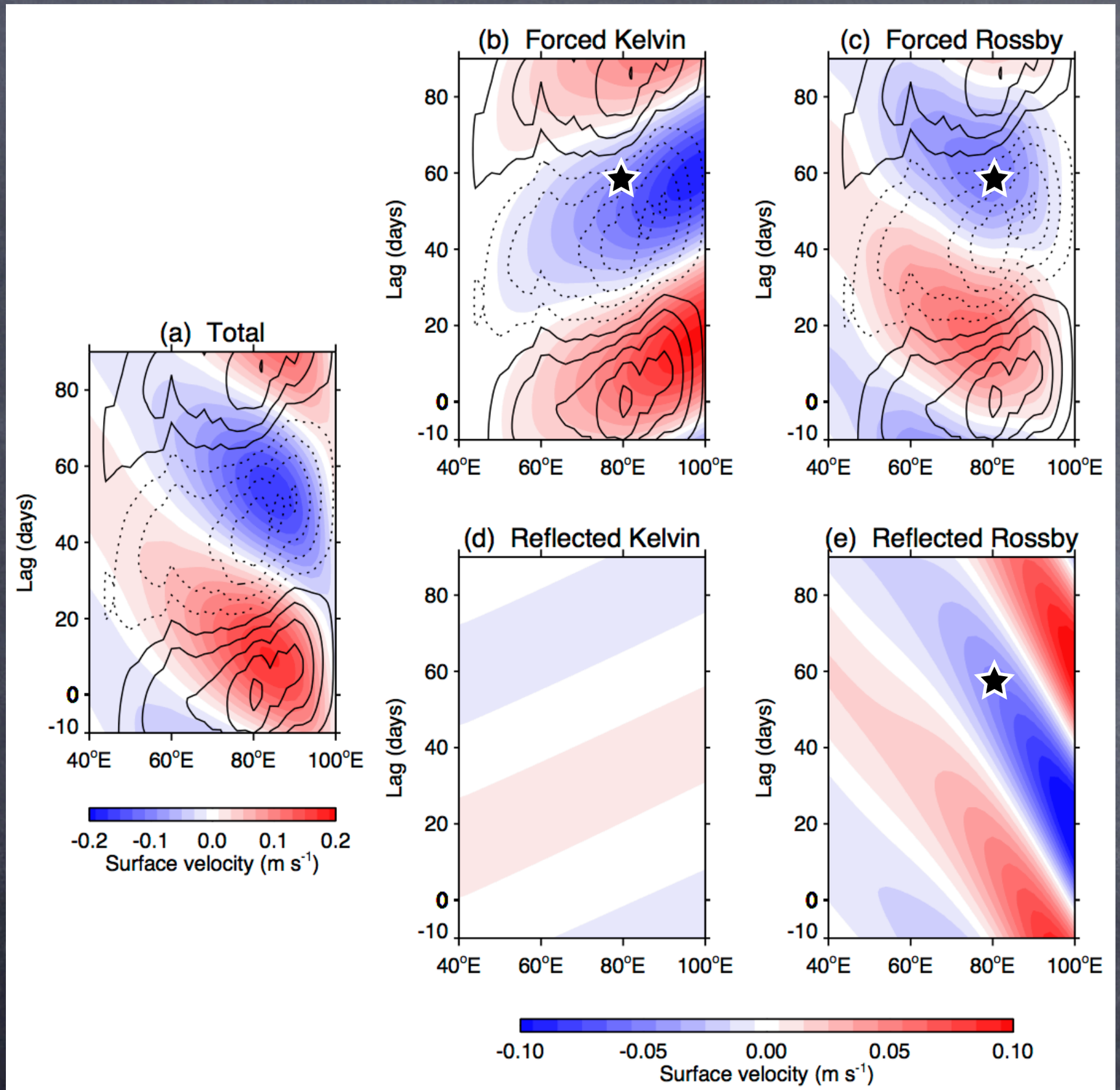


30-70 day periods

color: regressed model velocity

contour: regressed zonal winds

(C.I.=2.5x10^{-3} N m^{-2})



70-110 day periods

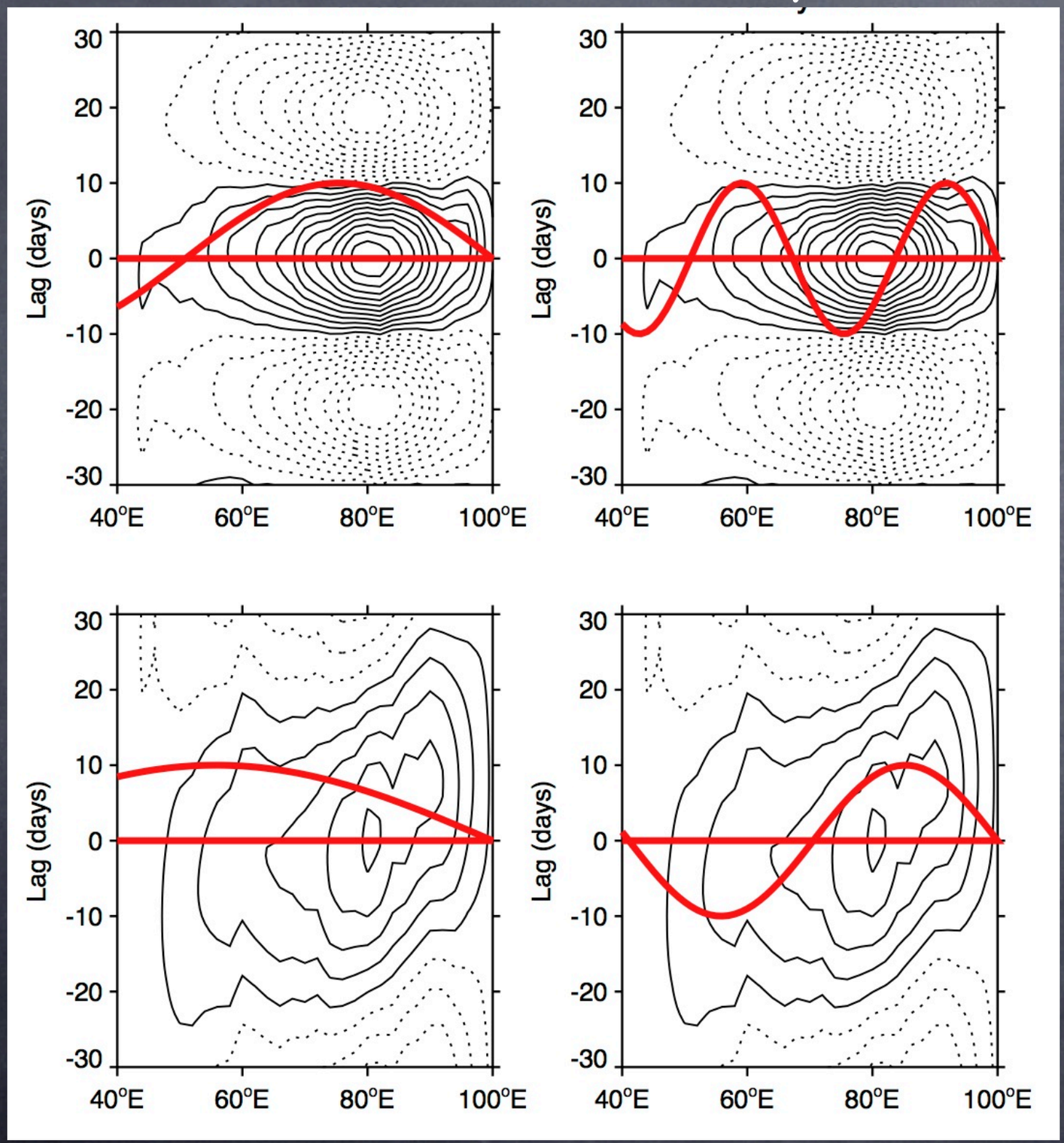
Resonant forcing by eastward propagating winds

Constructive relationship between eastern boundary generated waves and forced waves

Scale selection by the fetch of the wind patch

Kelvin wave

Rossby wave



30-70 days

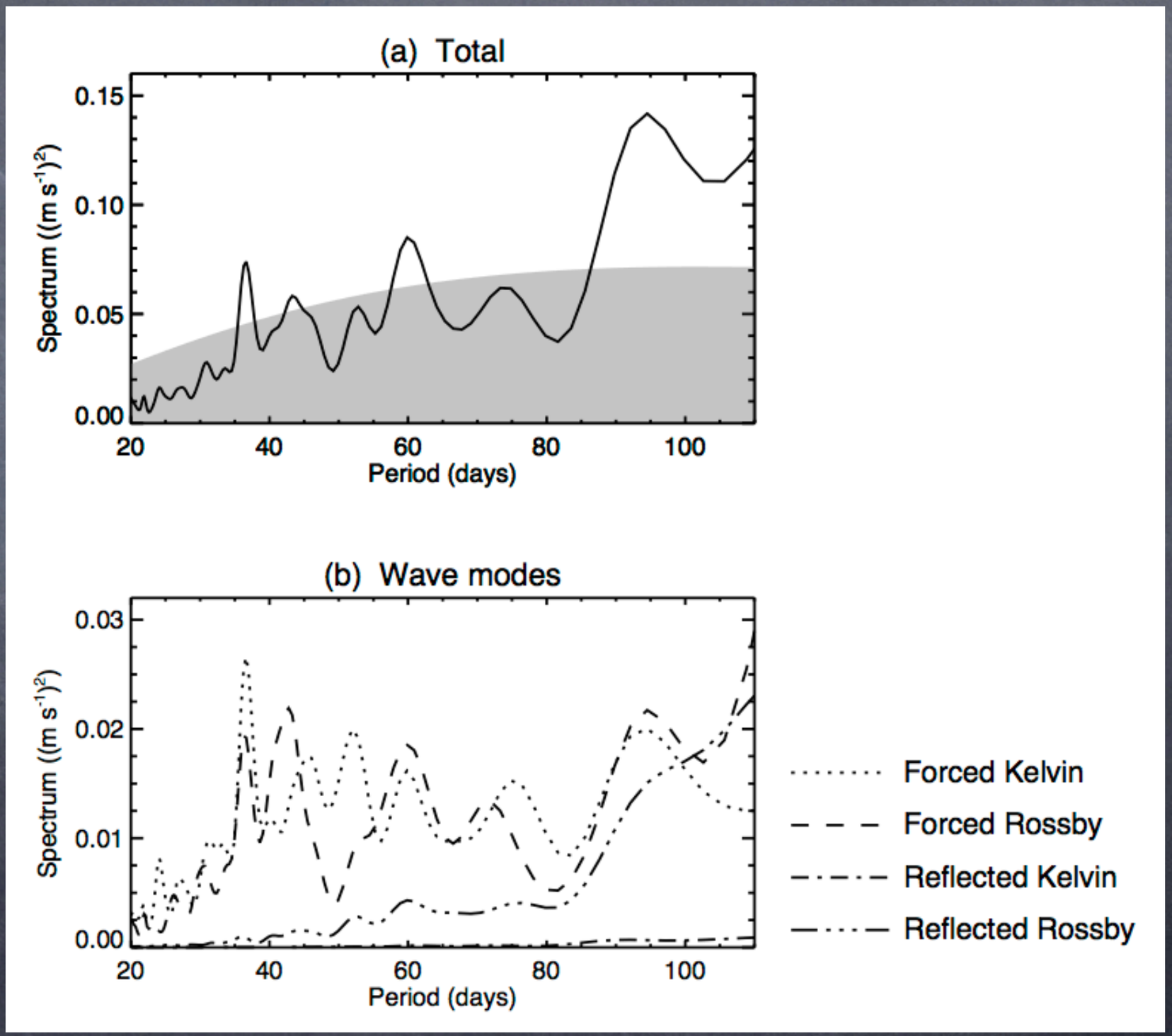
Regressed zonal winds
(C.I.=2.5x10^{-3} N m^{-2})

70-110 days

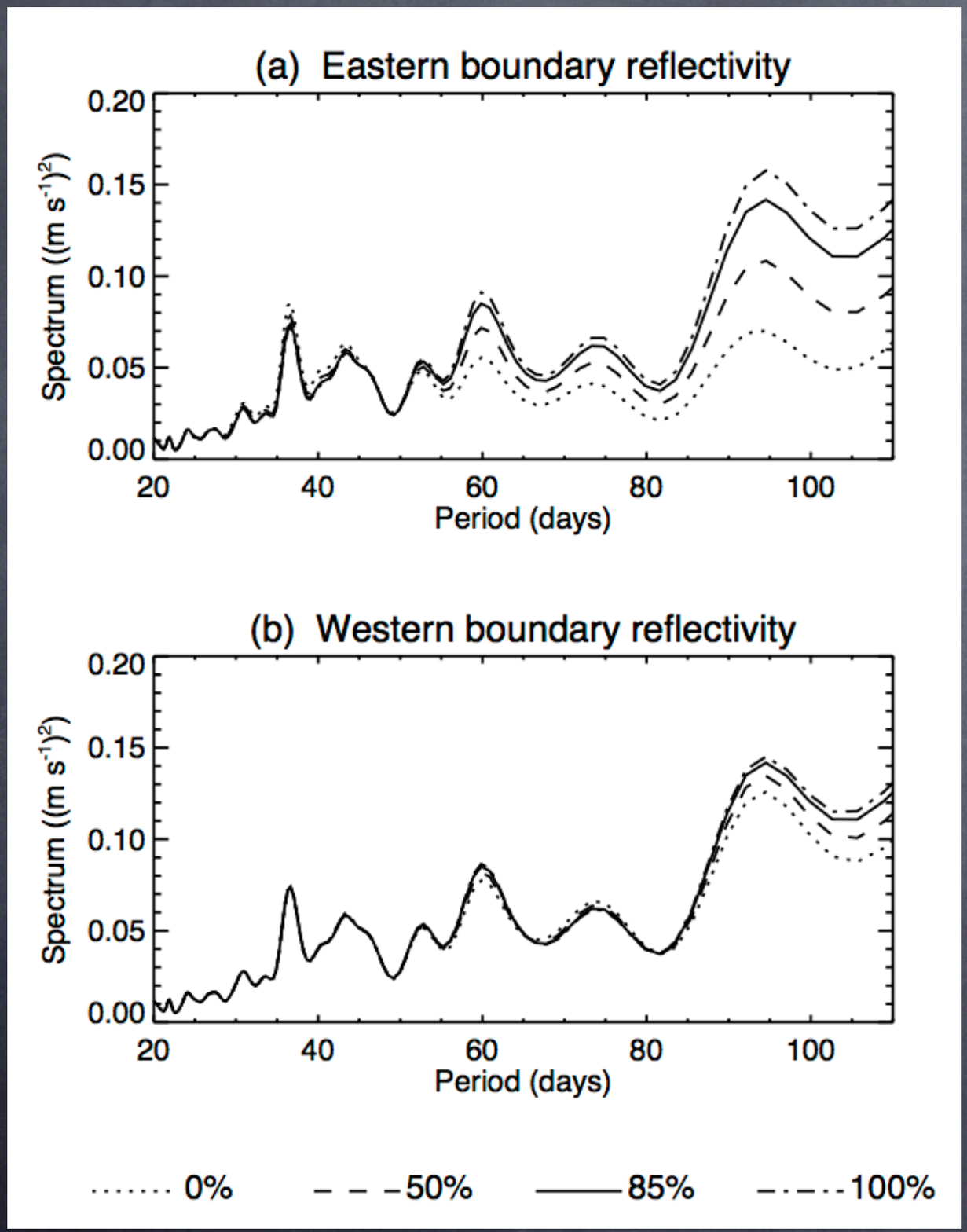
Velocity spectrum at 0° 80°E

Total velocity

Wave mode



Velocity spectrum at 0° 80°E



Eastern boundary generated waves are crucial

Western boundary generated waves do little

Summary

- Intraseasonal variability in the equatorial Indian Ocean is investigated using observations and an analytic linear wave model.
- The model with Kelvin and 1st meridional Rossby mode for two gravest baroclinic modes explains most of observed velocity variability.

Summary

- The red shift in velocity spectrum relative to wind spectrum is attributable to a combination of factors. These include:
  1) Near resonant excitation of Kelvin waves by eastward propagating winds;
  2) Constructive interference between wind-forced waves and eastern boundary generated waves;
  3) Scale selection by the fetch of wind patch.

- The western boundary generated waves are negligible. The basin mode resonance, which includes both reflected Kelvin and Rossby waves, is not found in our model solutions.