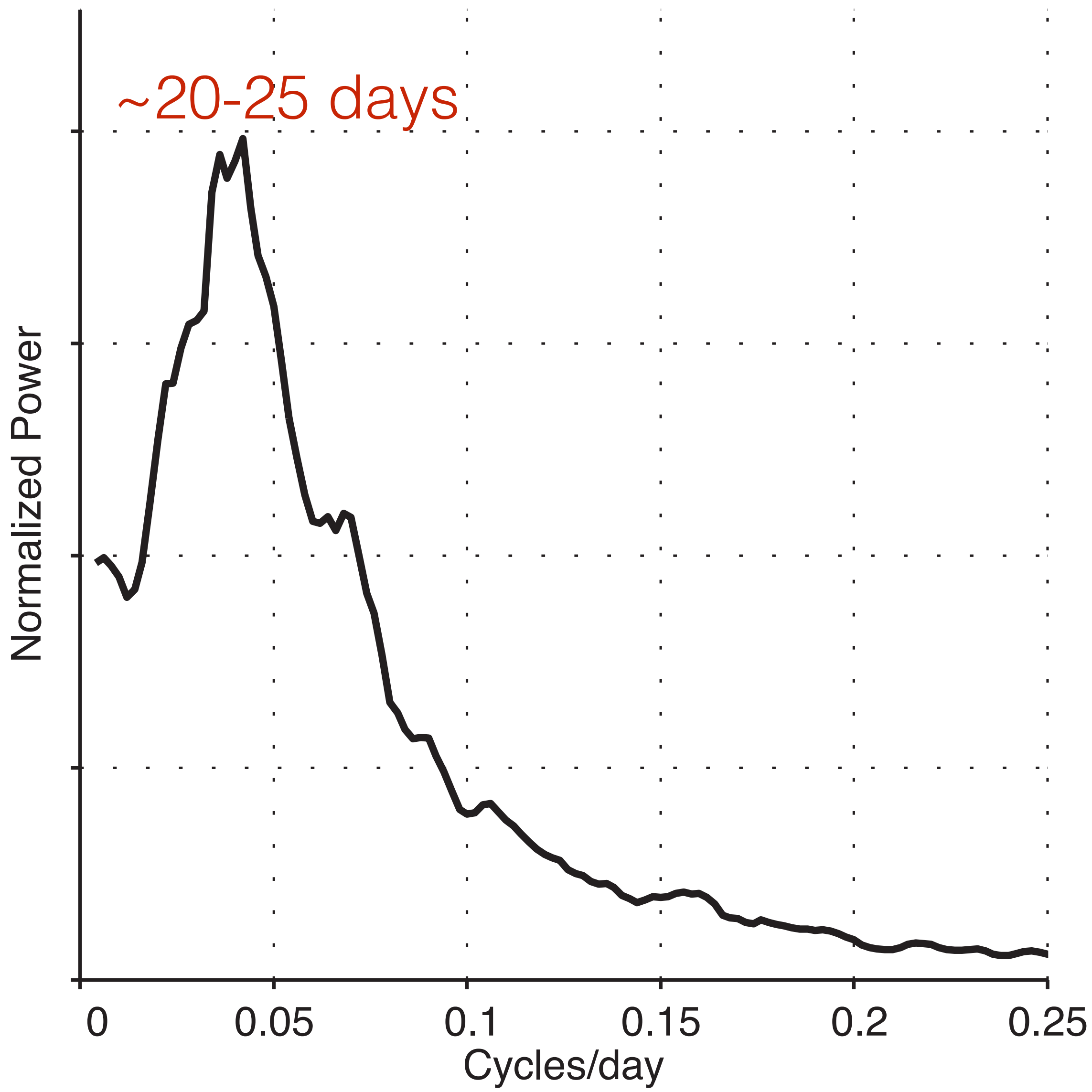
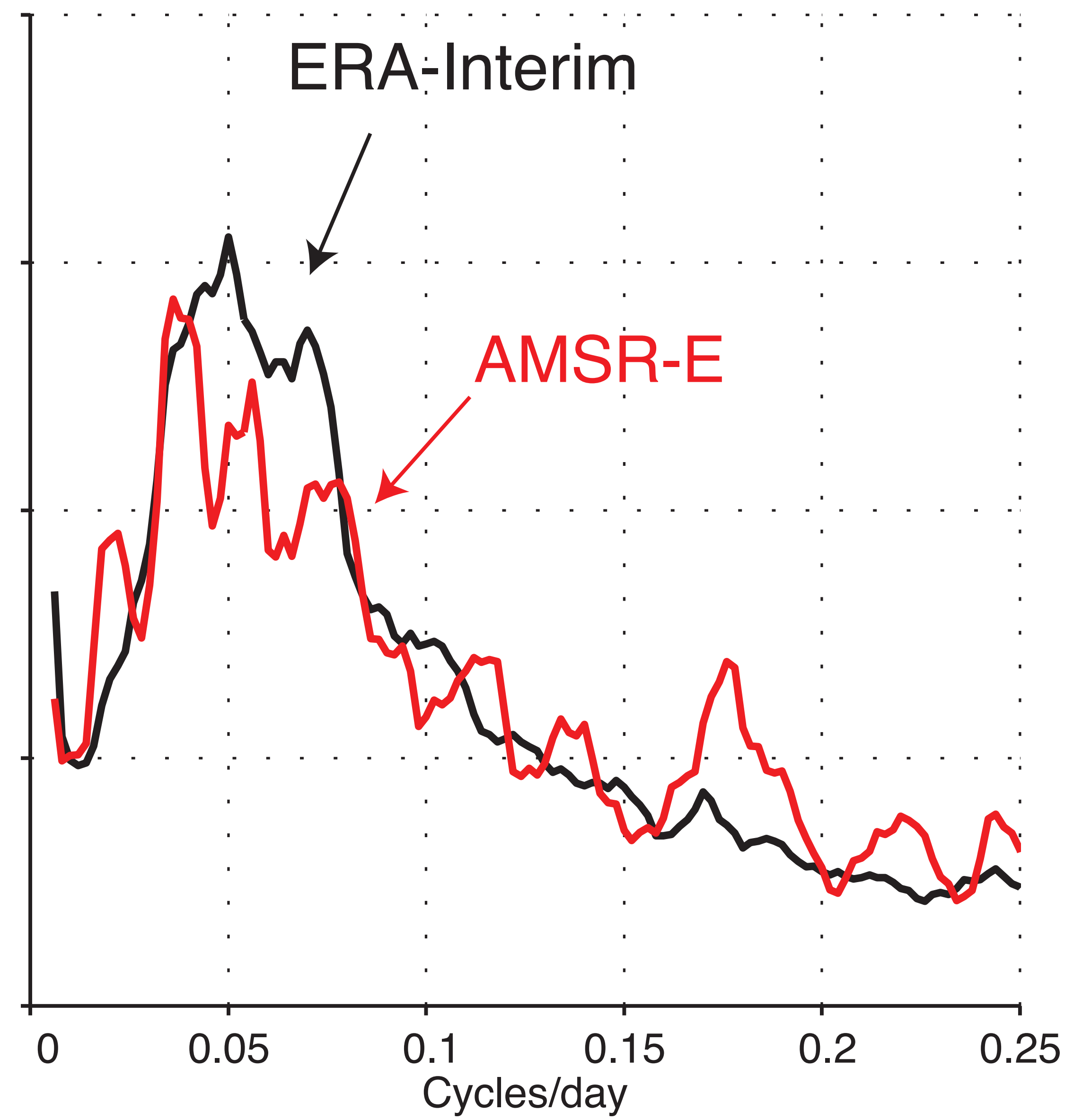
Southern Hemispheric mean spectra

Eddy kinetic energy



Precipitation

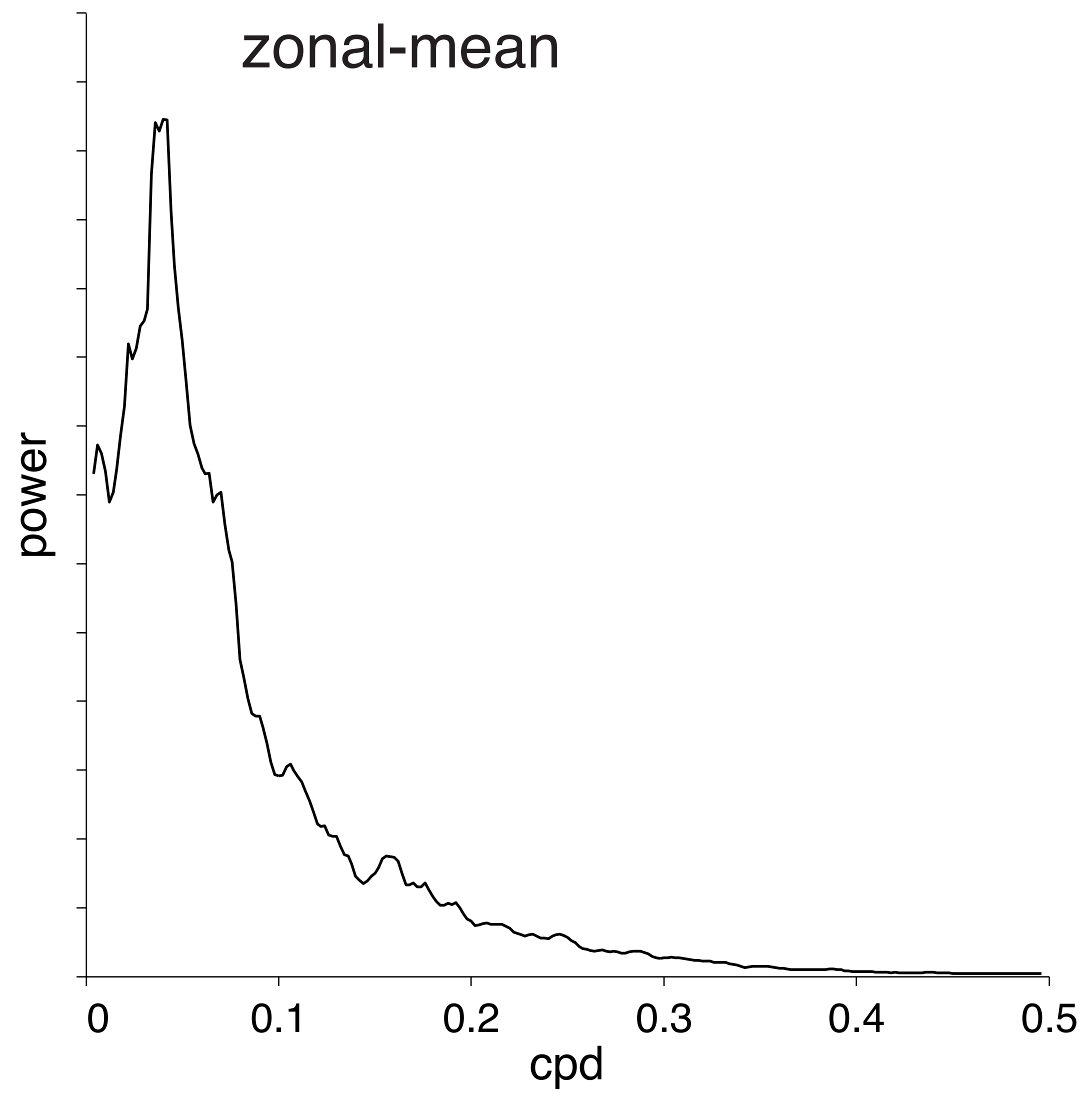


Thompson/Woodworth 2014; Thompson/Barnes 2014

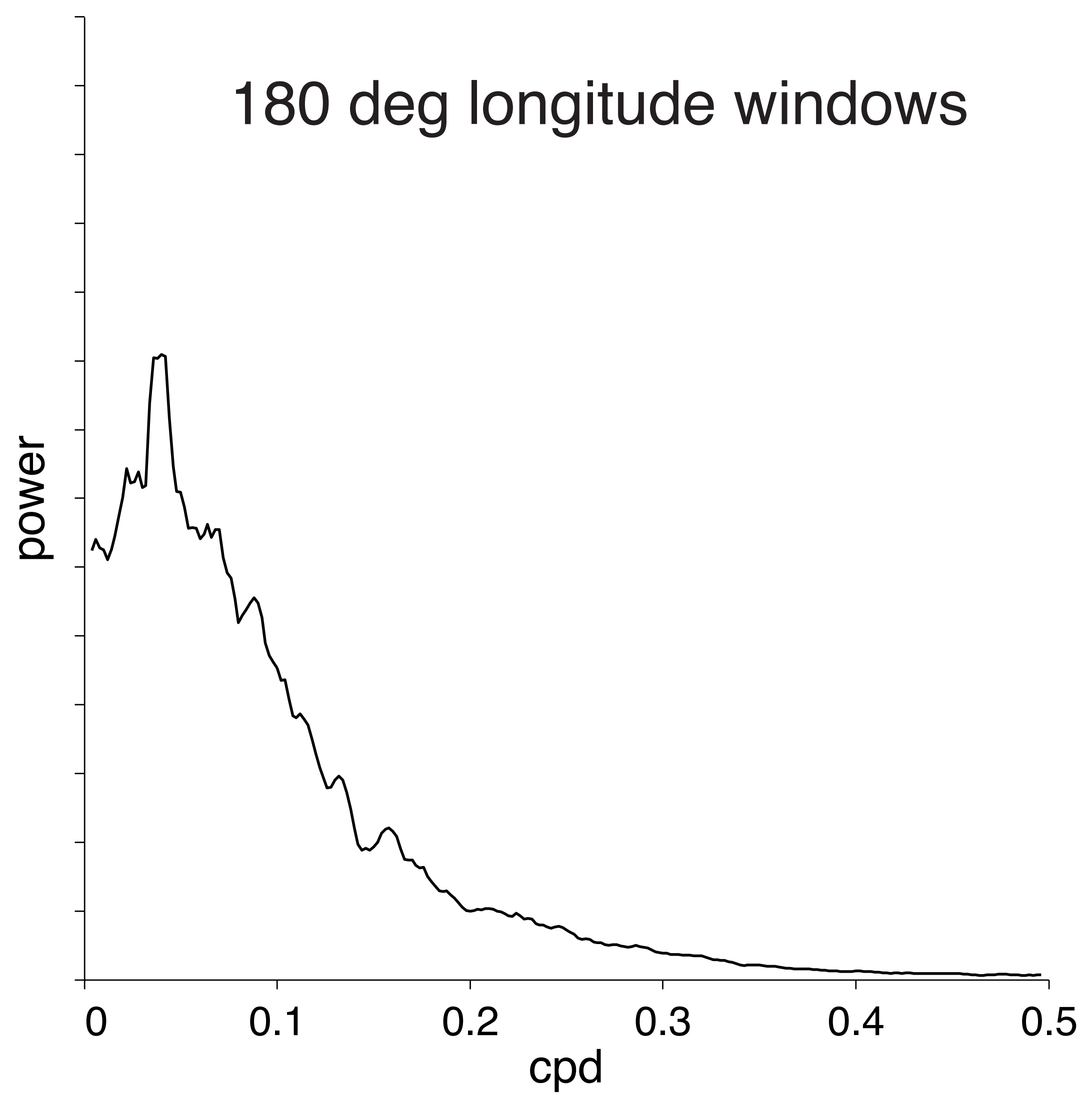
Exploring periodicity in the extratropical circulation on synoptic scales …

David W J Thompson
Dept of Atmospheric Science, CSU

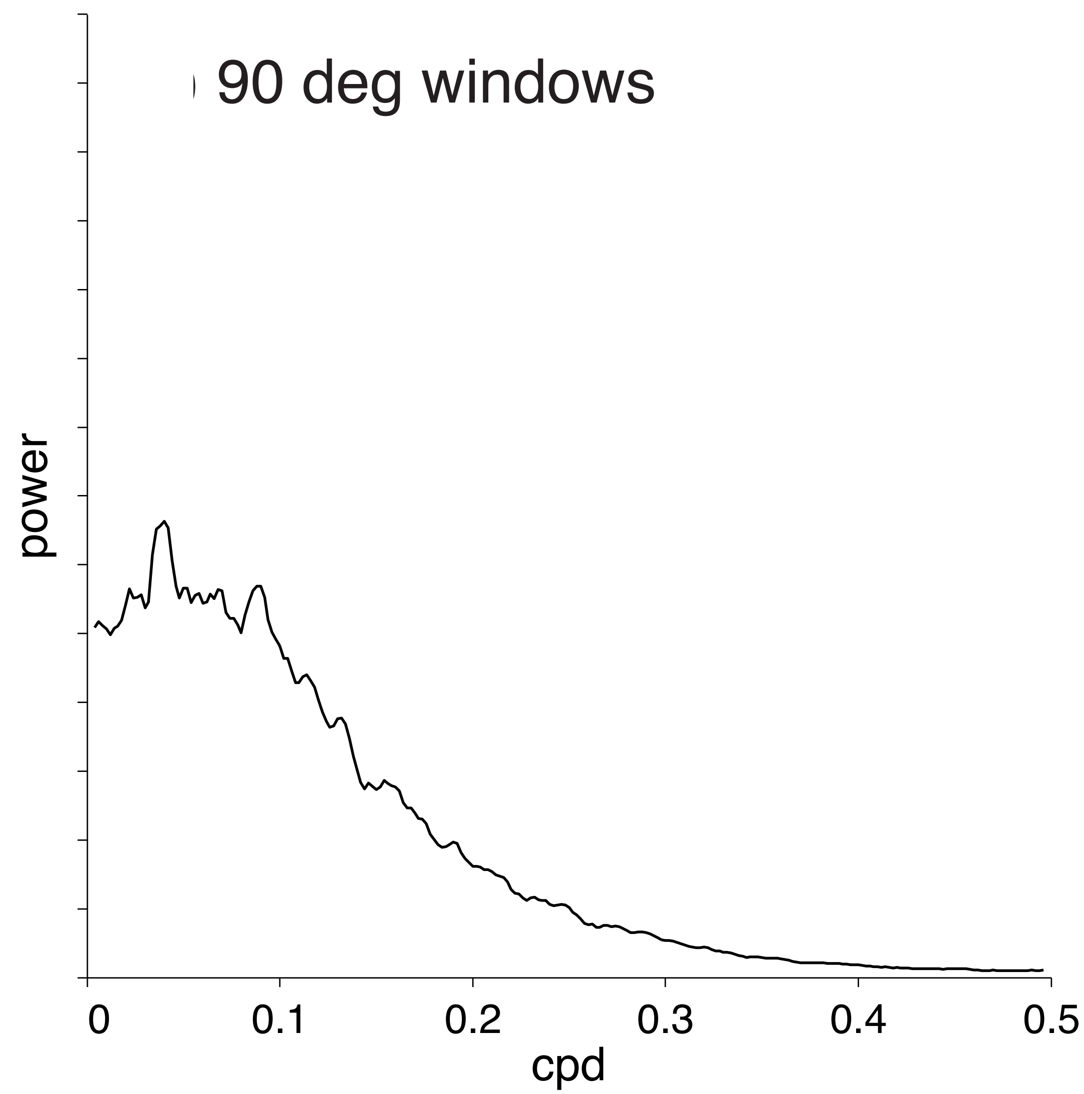
Spectrum of EKE at 300 hPa averaged 40-60S



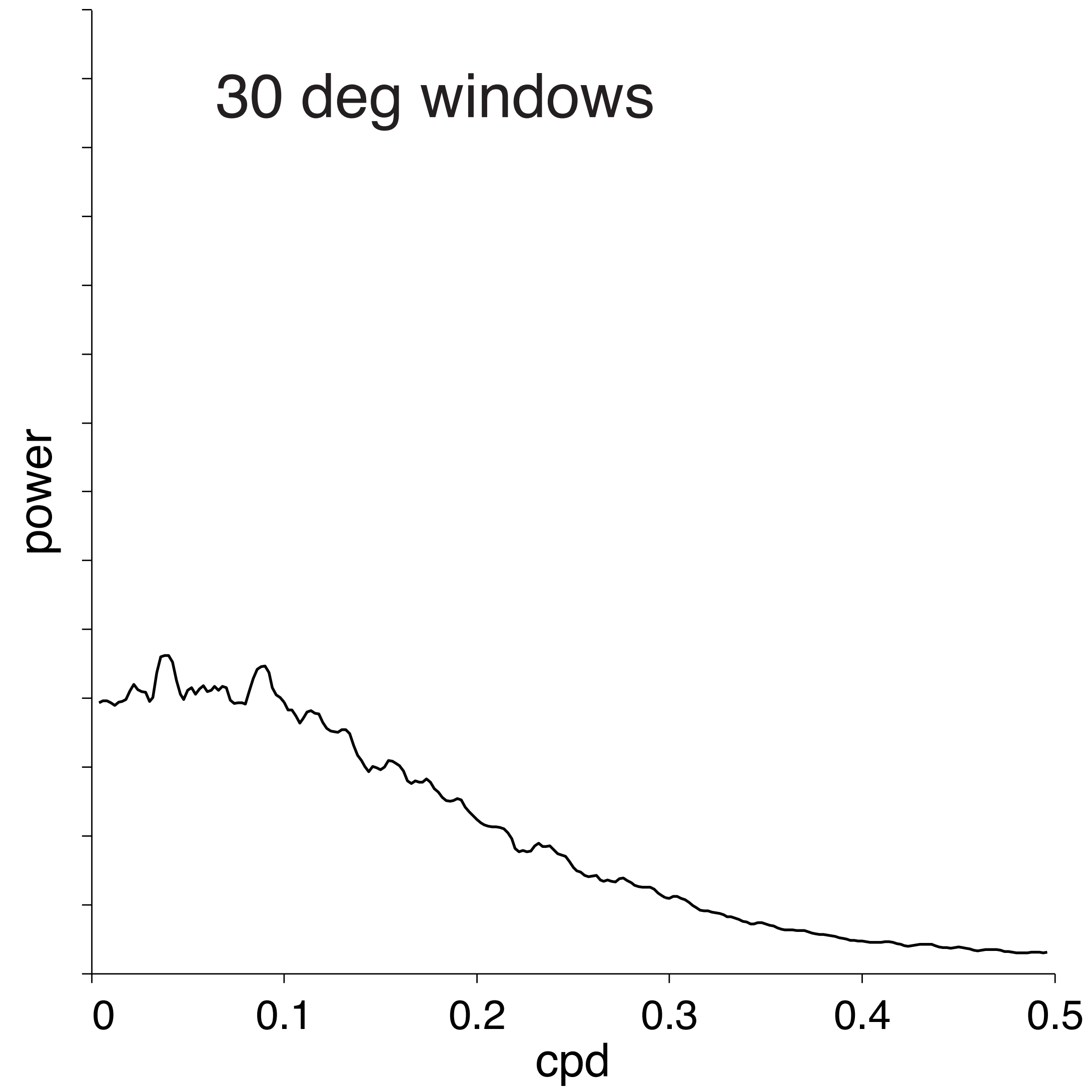
Spectrum of EKE at 300 hPa averaged 40-60S



Spectrum of EKE at 300 hPa averaged 40-60S



Spectrum of EKE at 300 hPa averaged 40-60S



periodicity is largely absent on scales less than <180 degrees

Longitude/time lag regression plots

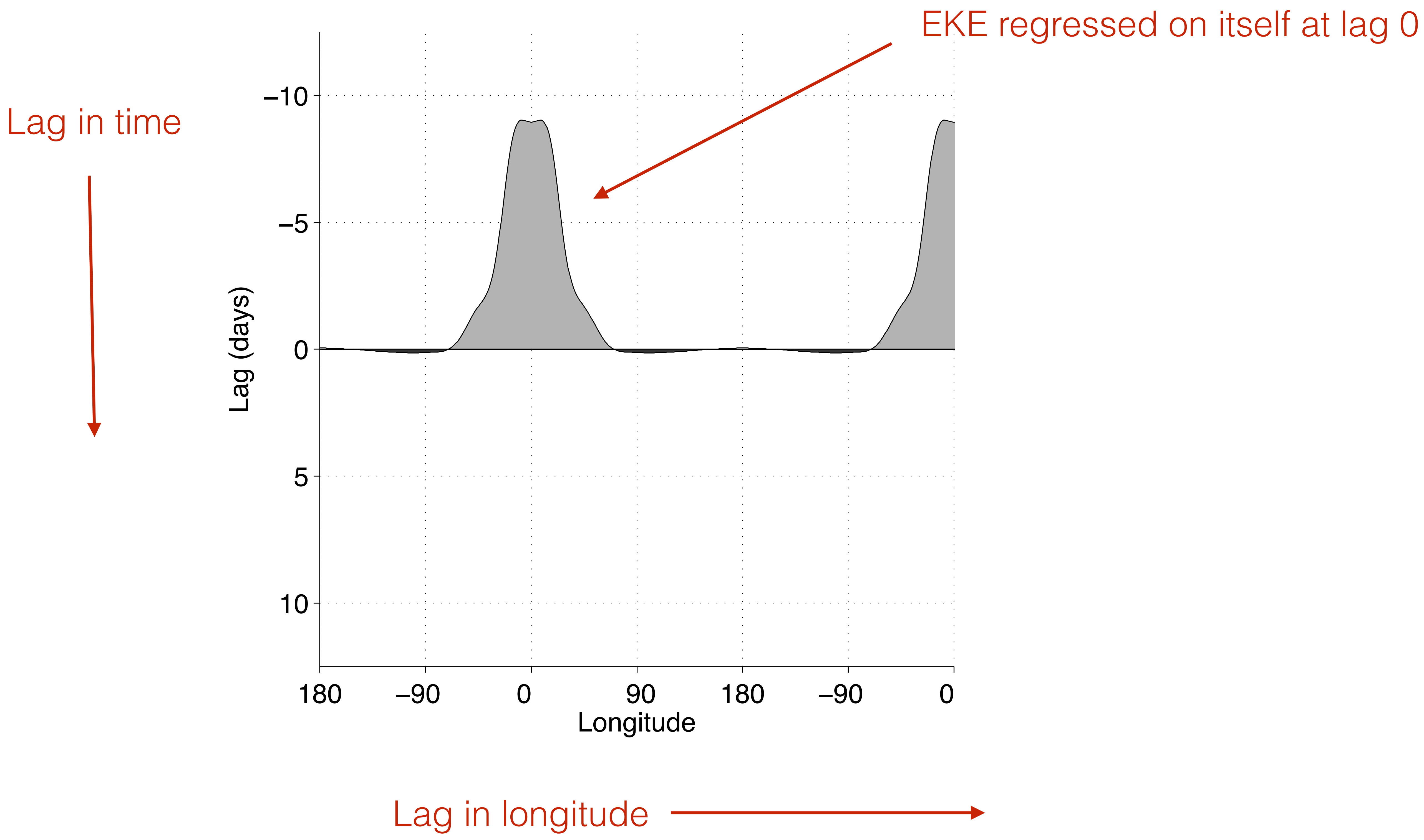
1. Average EKE at 300 hPa over latitudes 40-60S.

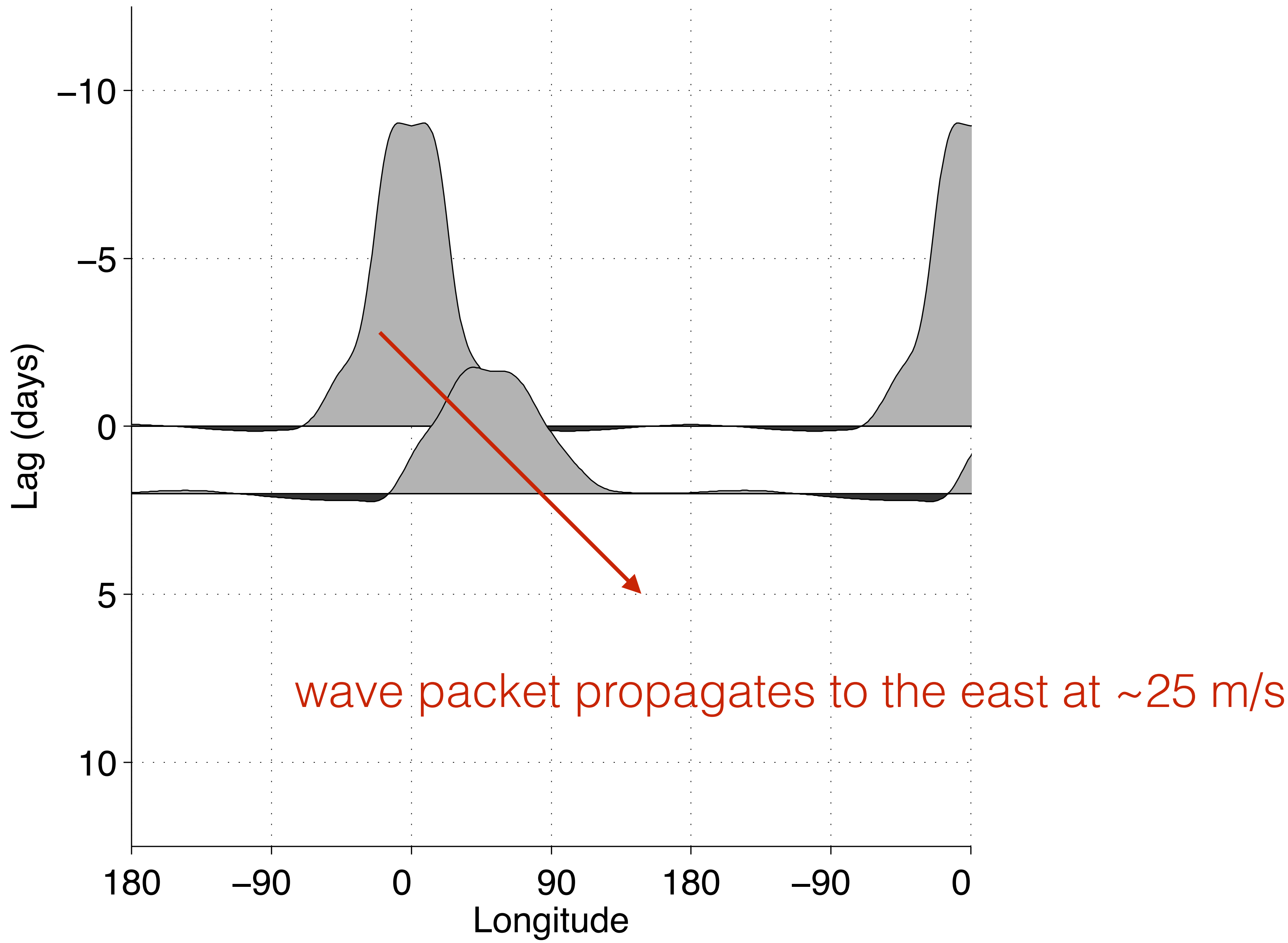
2. Form the longitude/time lag regression map for $EKE_{40\text{-}60}$ at a base longitude of 0E.

3. Repeat 2), but for $EKE_{40\text{-}60}$ at all base longitudes.

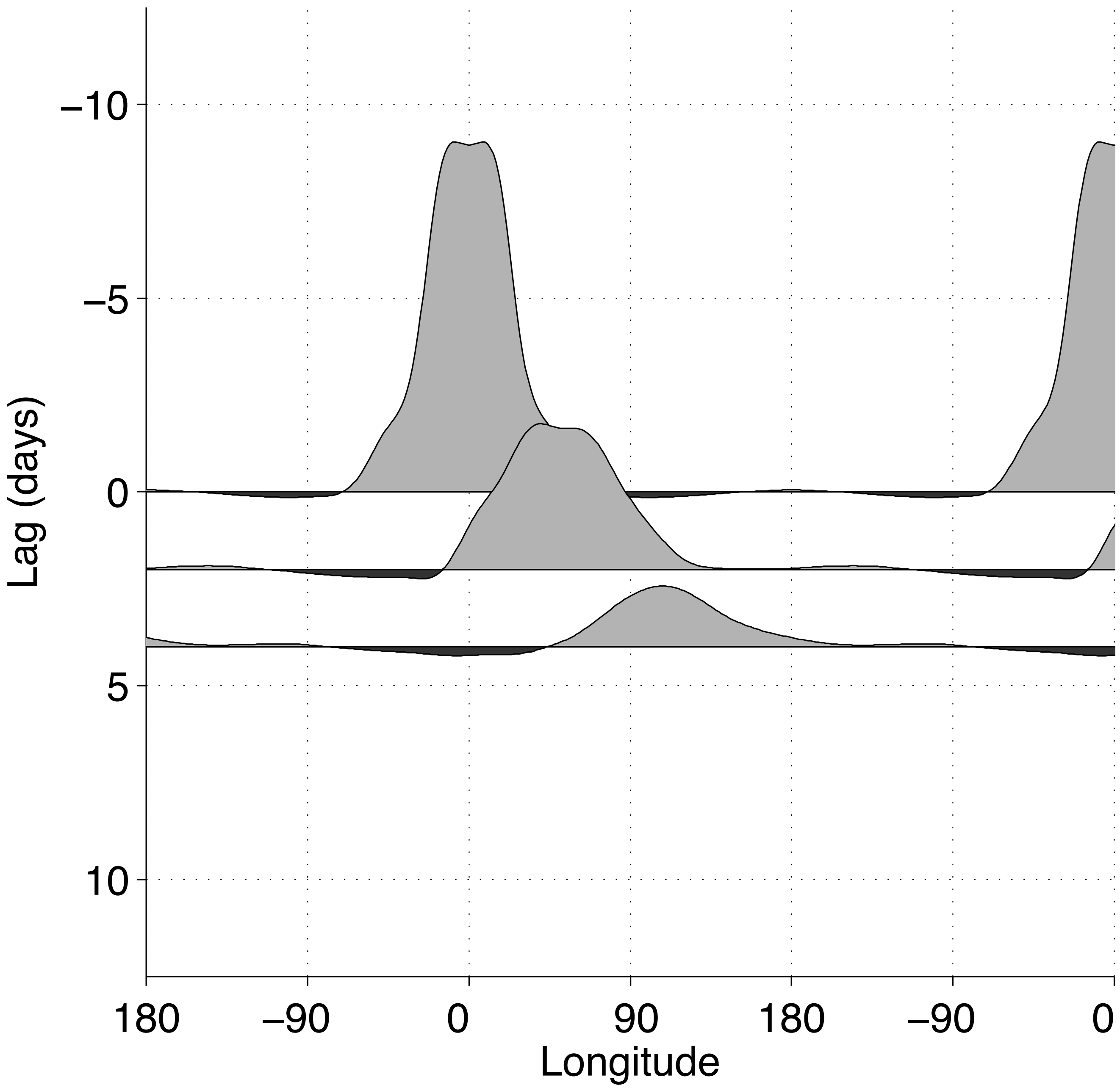
4. Average 3) over all base longitudes to generate a mean lag regression plot.

Lag regression plot of EKE. Starting at lag 0.

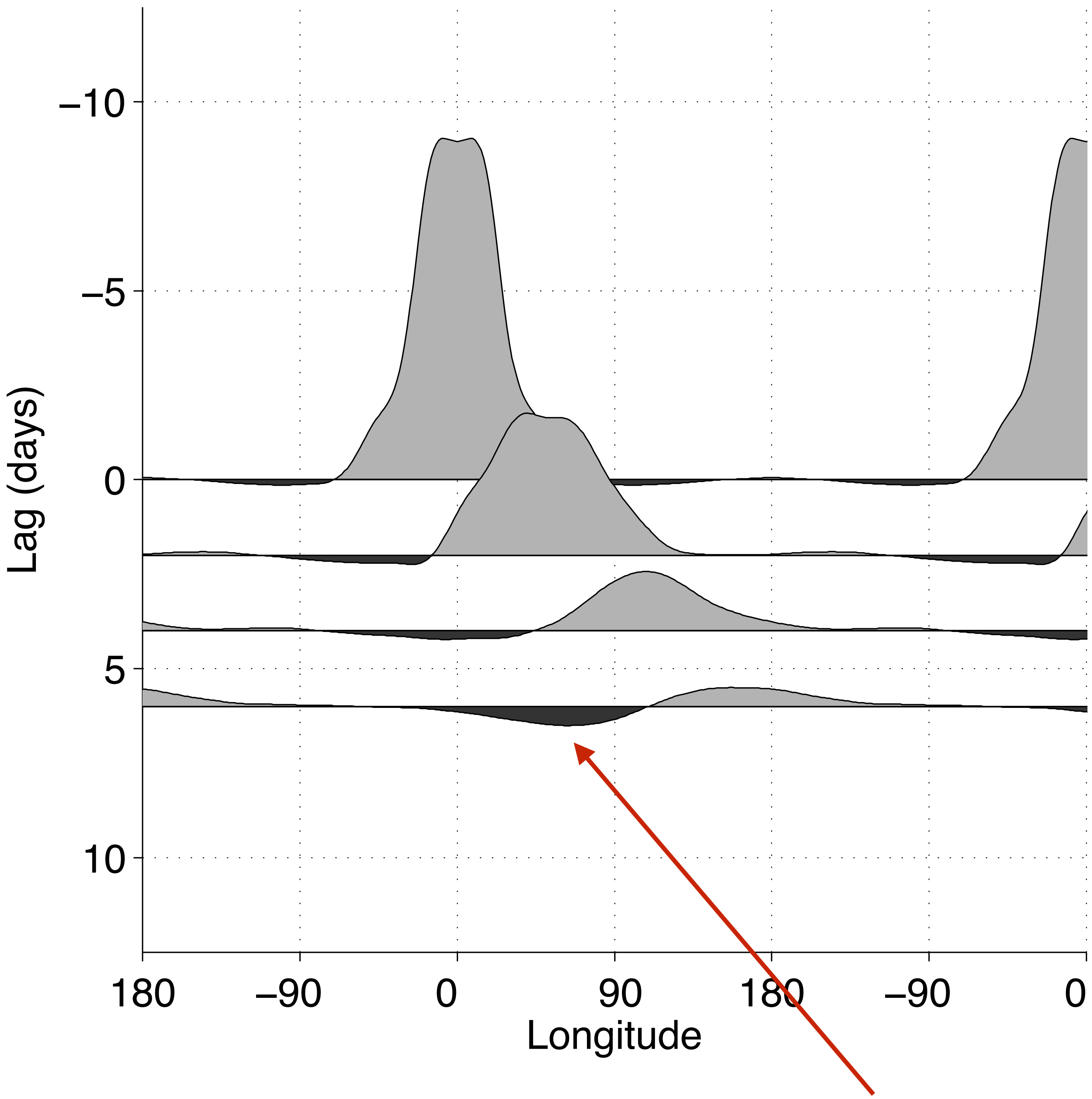




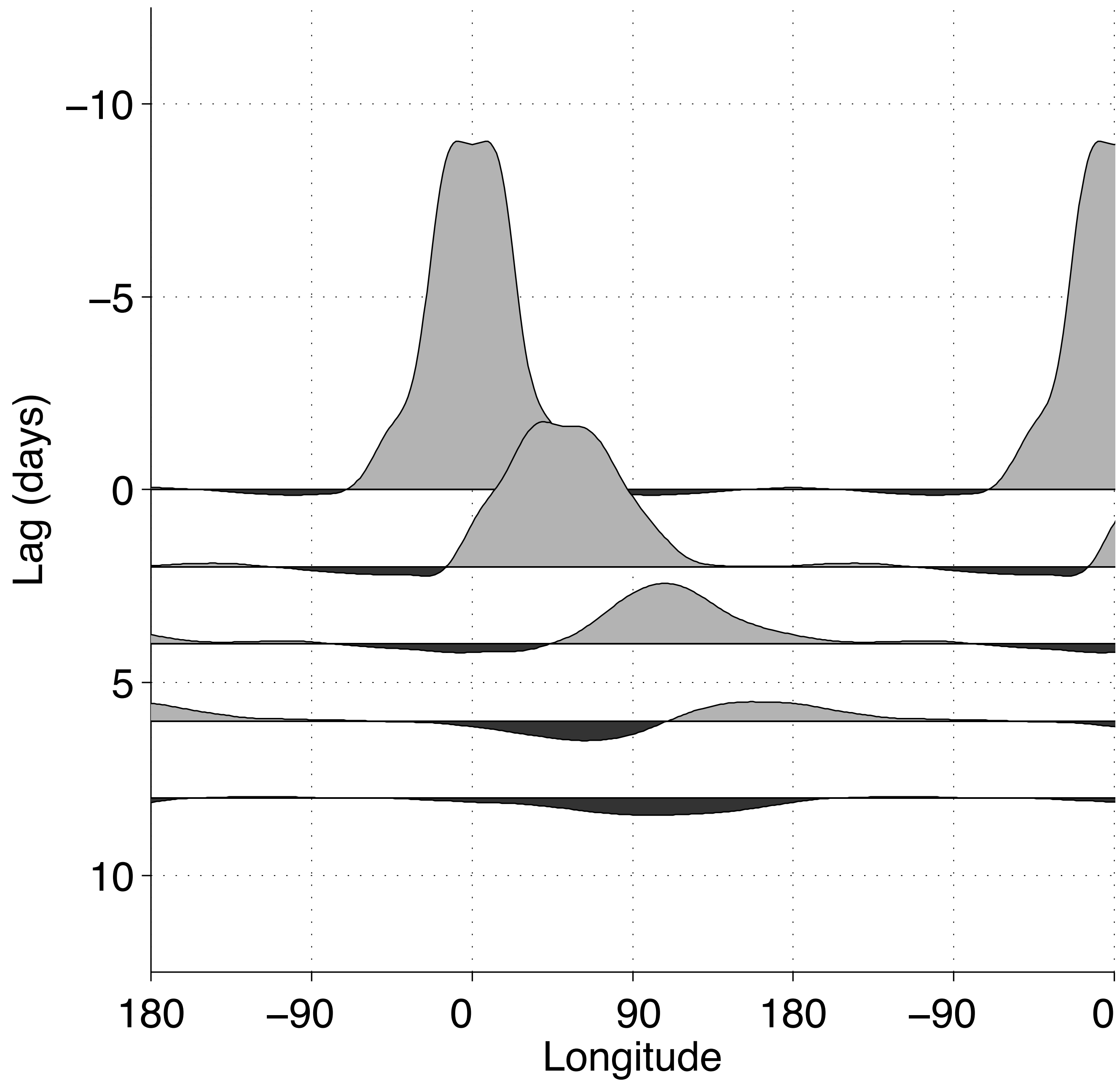
−10
−5
0
5
10
Lag (days)
180
−90
0
90
180
−90
0
Longitude
wave packet propagates to the east at ~25 m/s



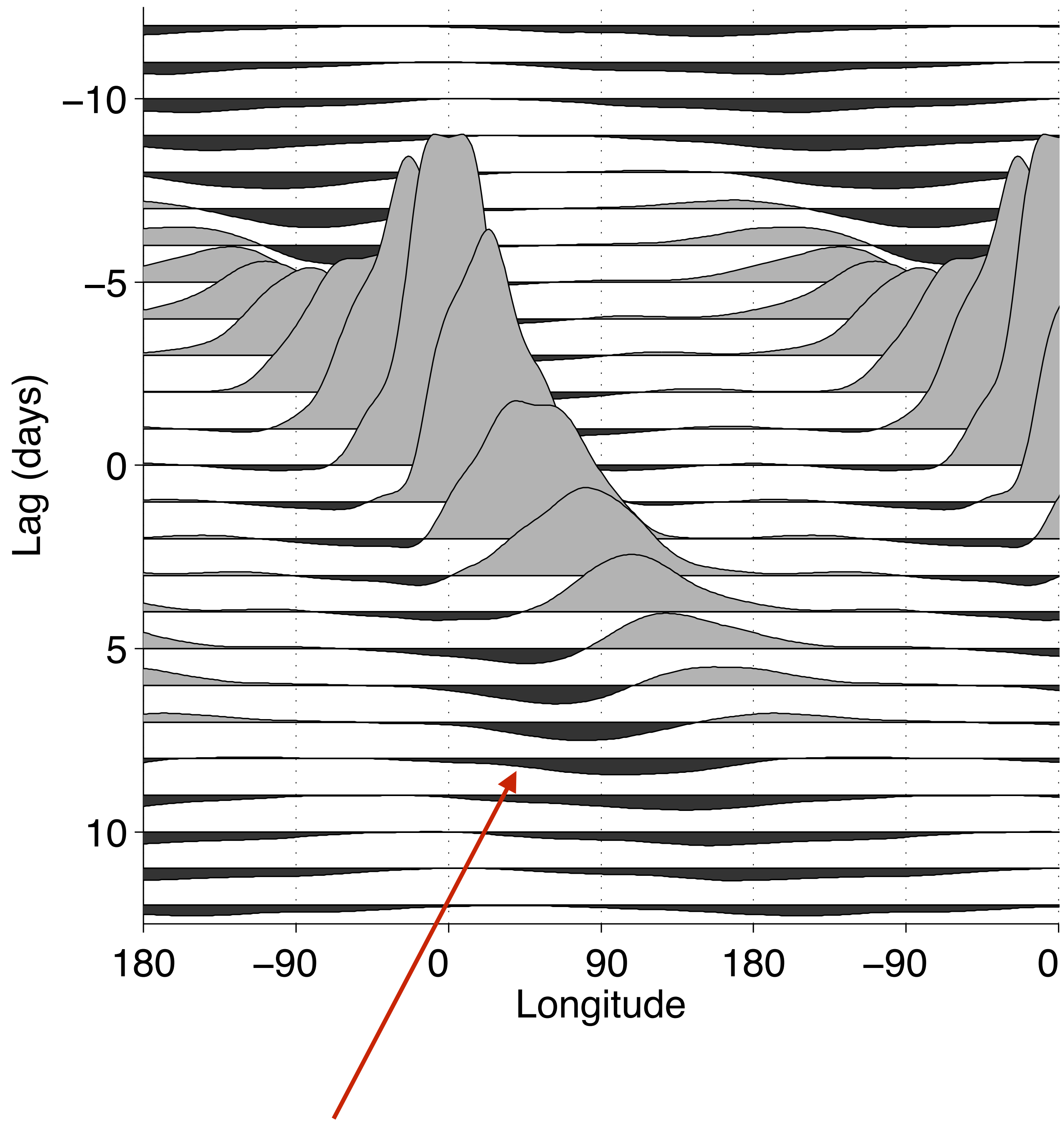
−10
−5
0
5
10
Lag (days)
180
−90
0
90
180
−90
0
Longitude



note the development of EKE anomalies in wake of wave packet

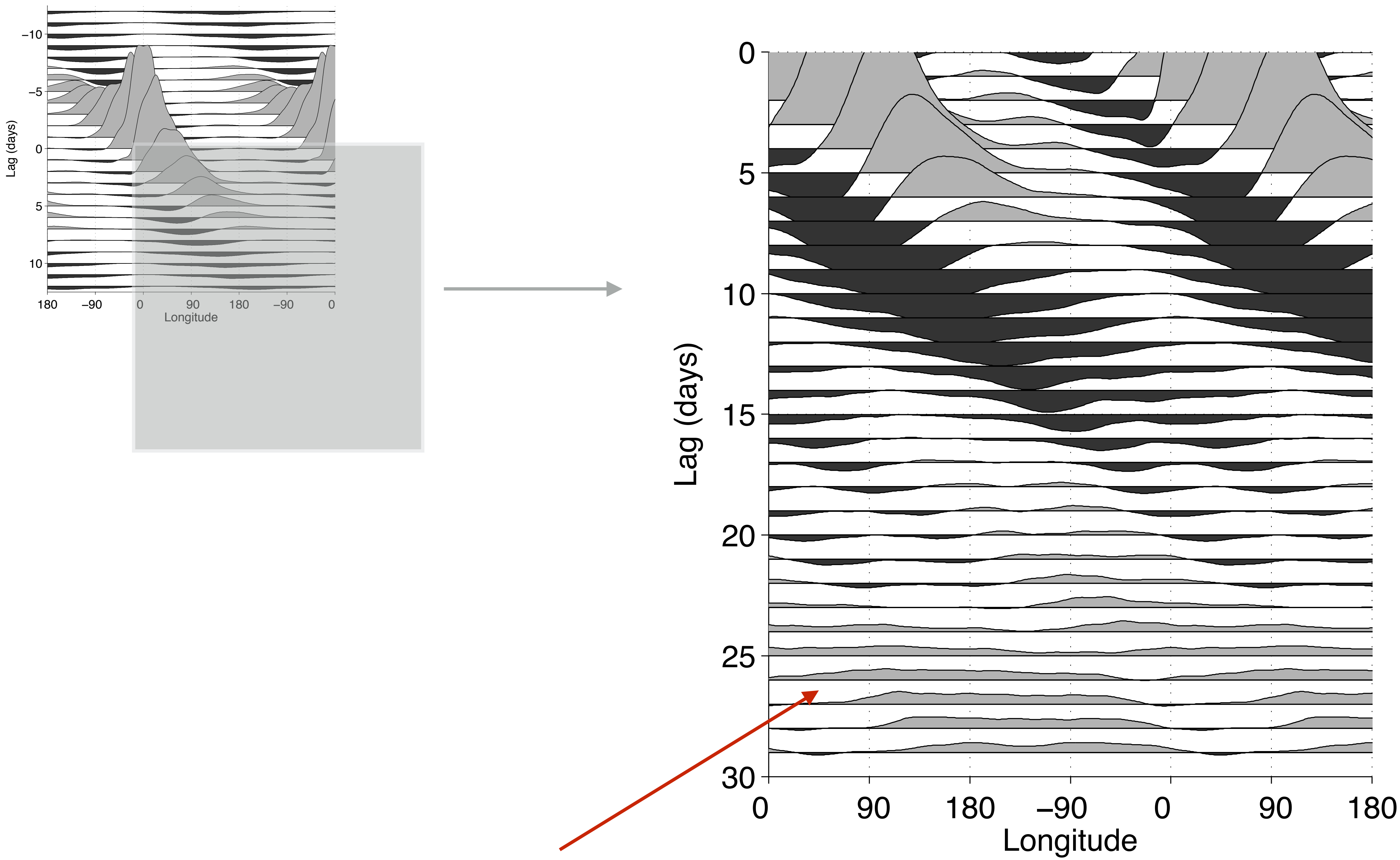


−10
−5
0
5
10
Lag (days)
180
−90
0
90
180
−90
0
Longitude



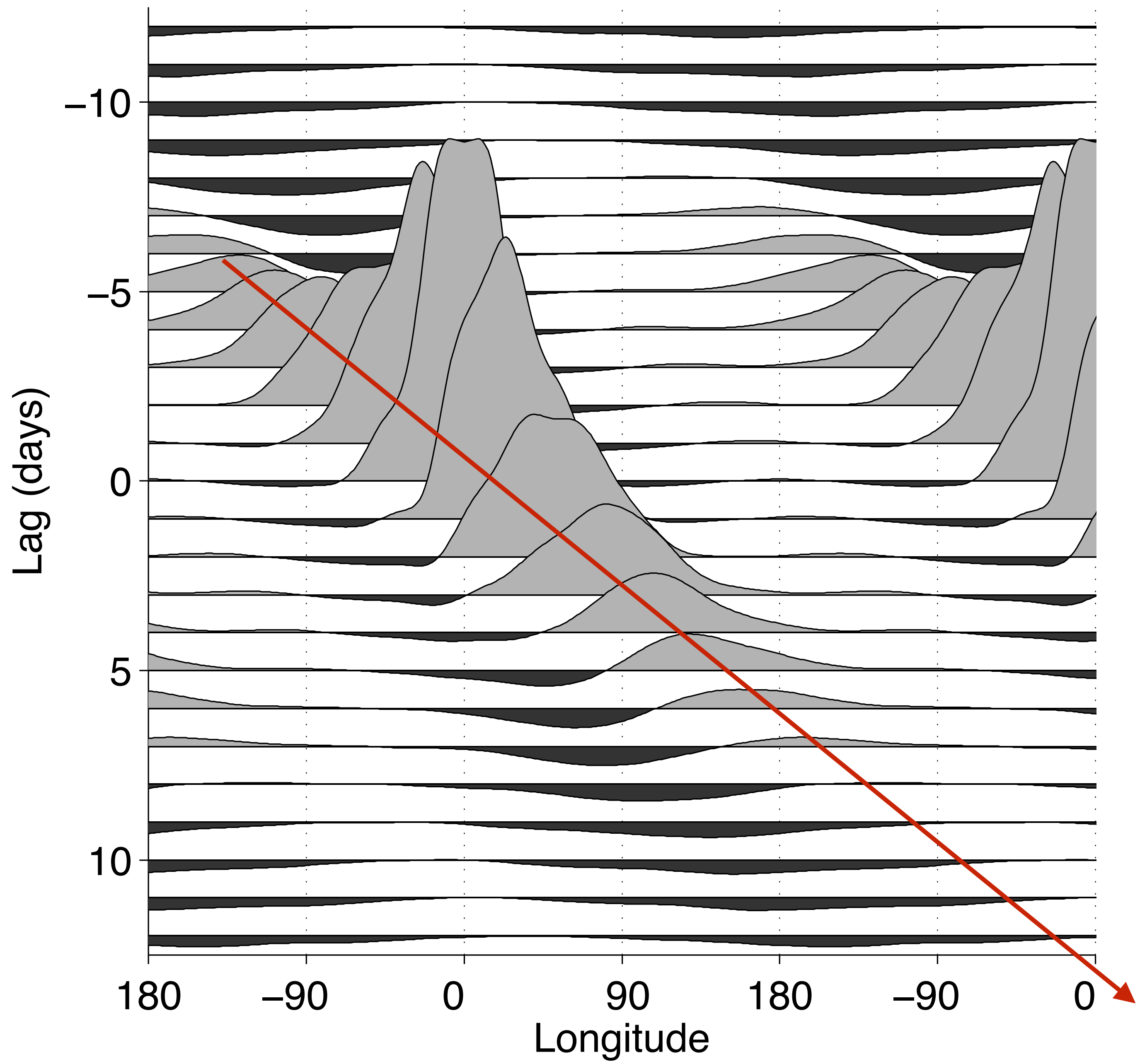
Negative EKE anomalies emerge at lags ~5-10 days.

zooming in on positive lags



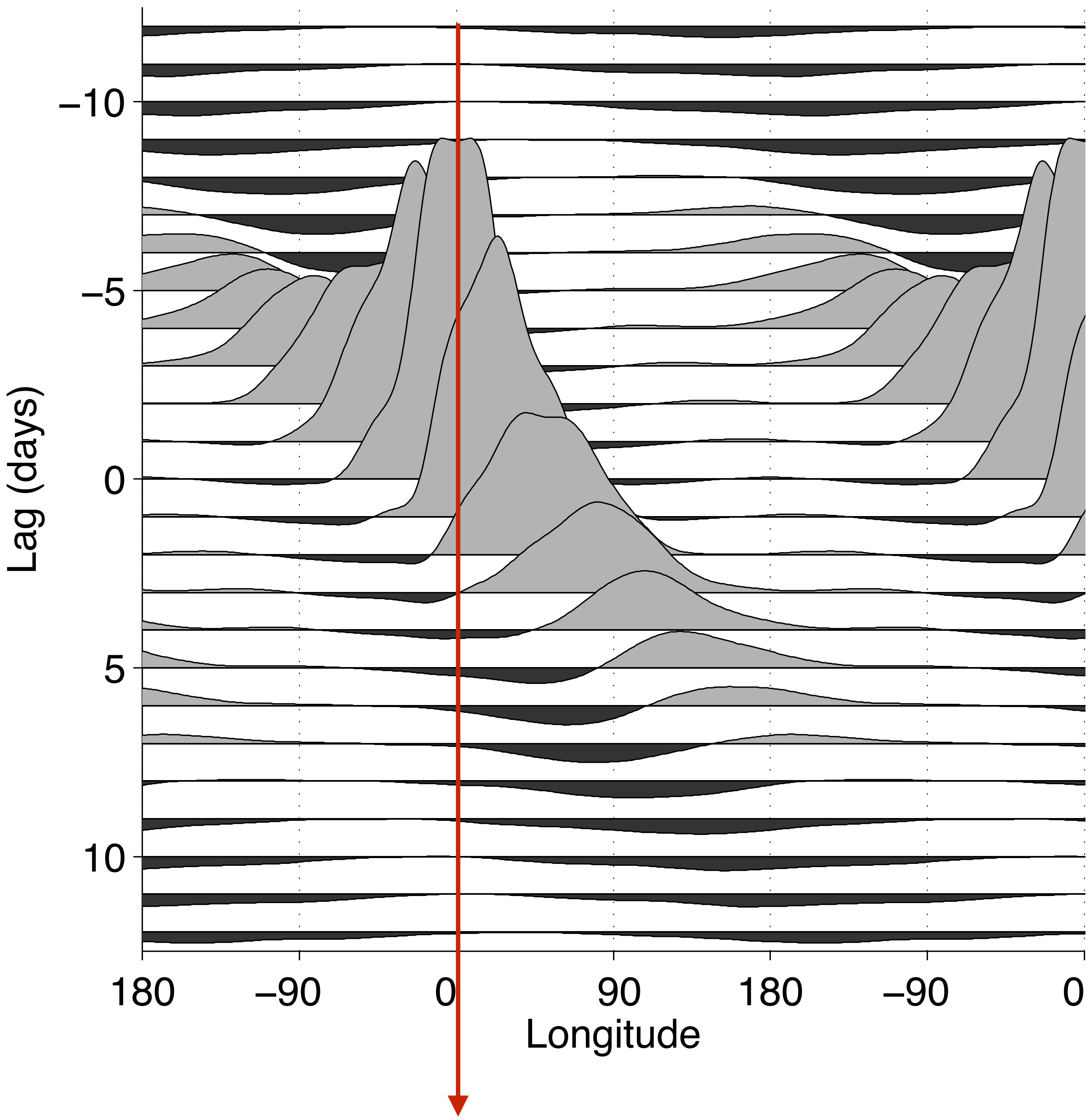
Positive EKE anomalies emerge at lags ~25 days.

How does the periodicity appear along the path of individual wave packets?

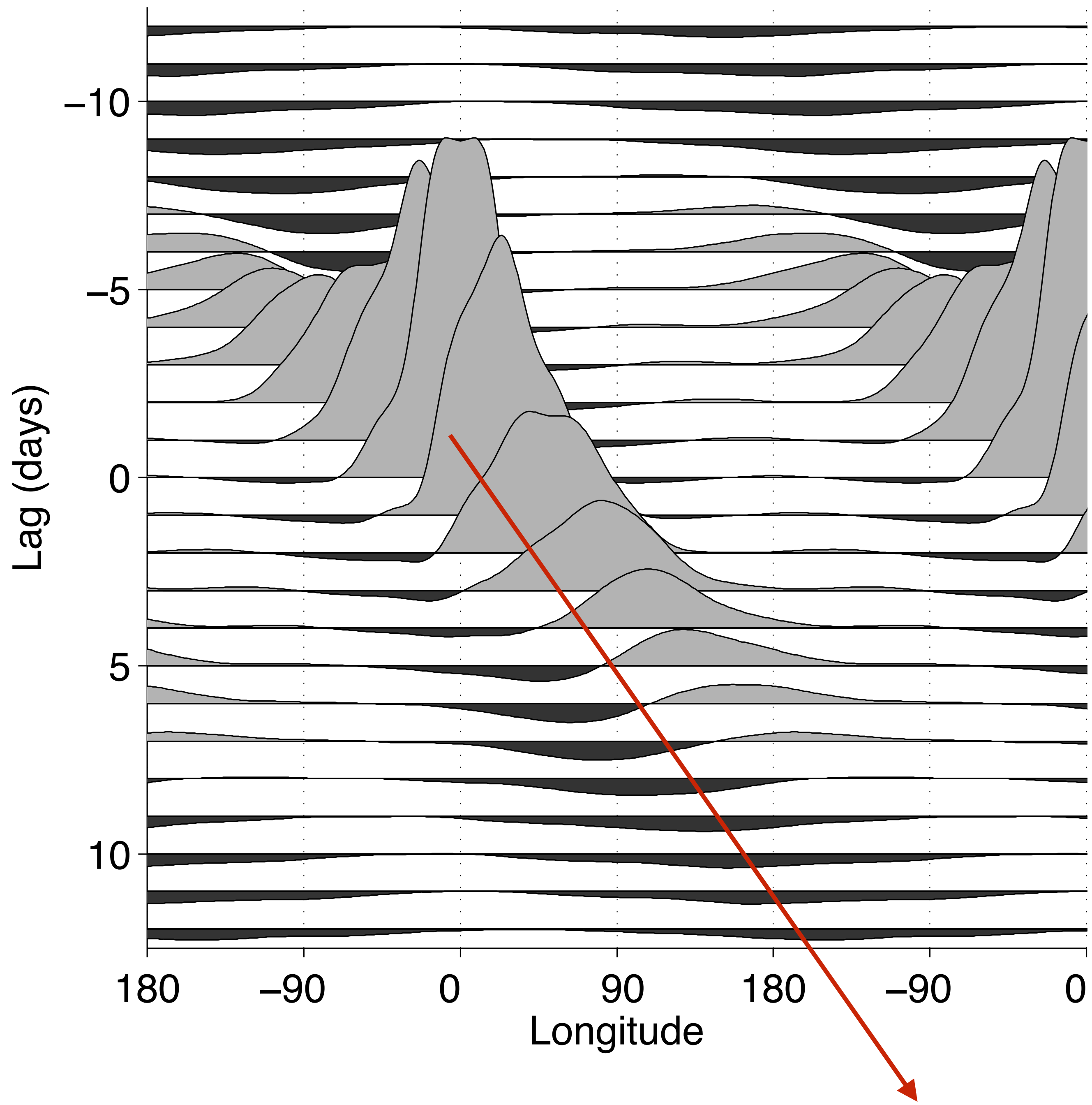


weak periodicity along path of wave packet

Does the periodicity in storm amplitudes project onto regional weather?



weak periodicity at fixed location

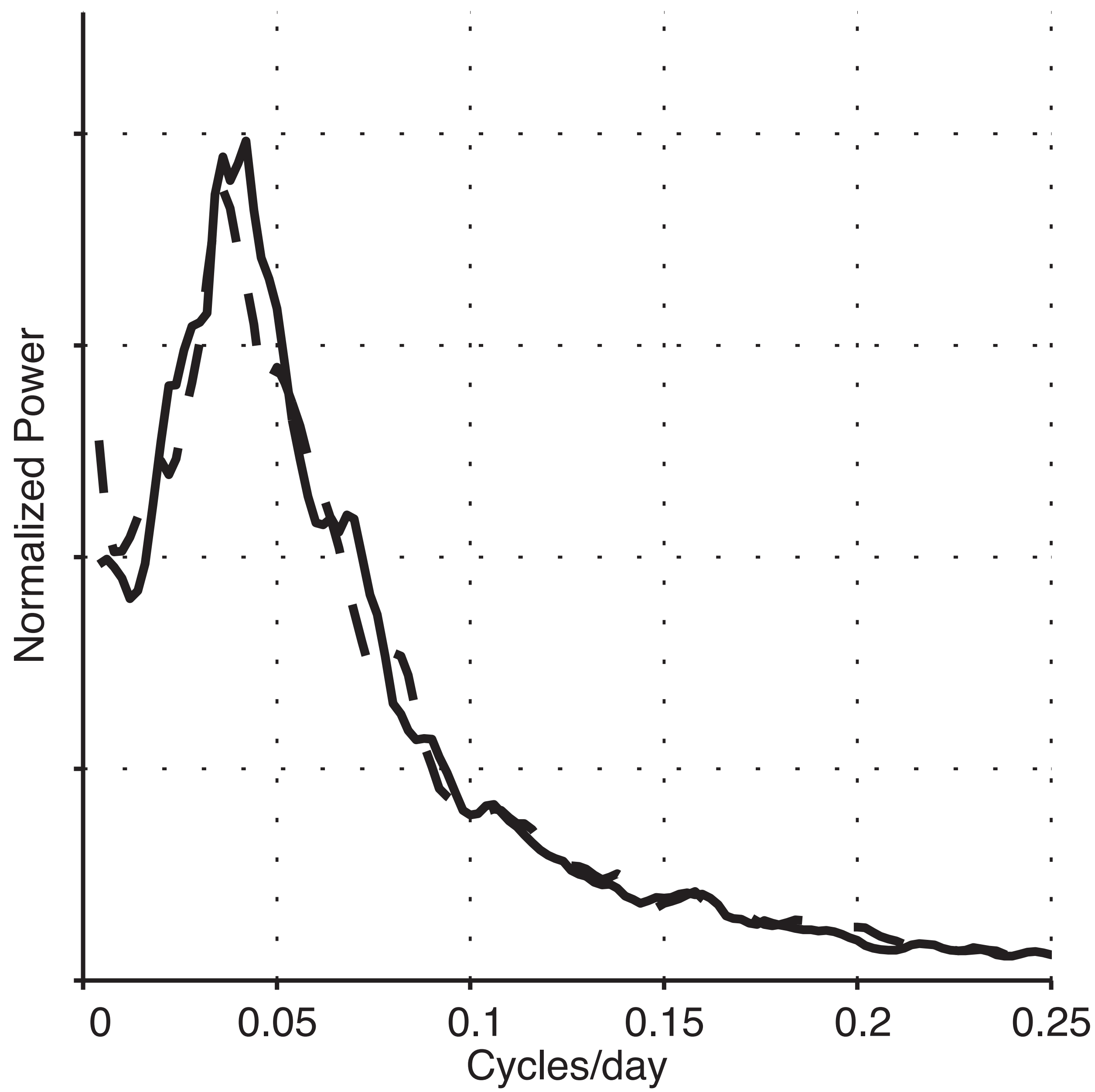


varying periodicity
depending on the flow rate sampled
along the latitude circle

periodicity in a “hierarchy” of models…

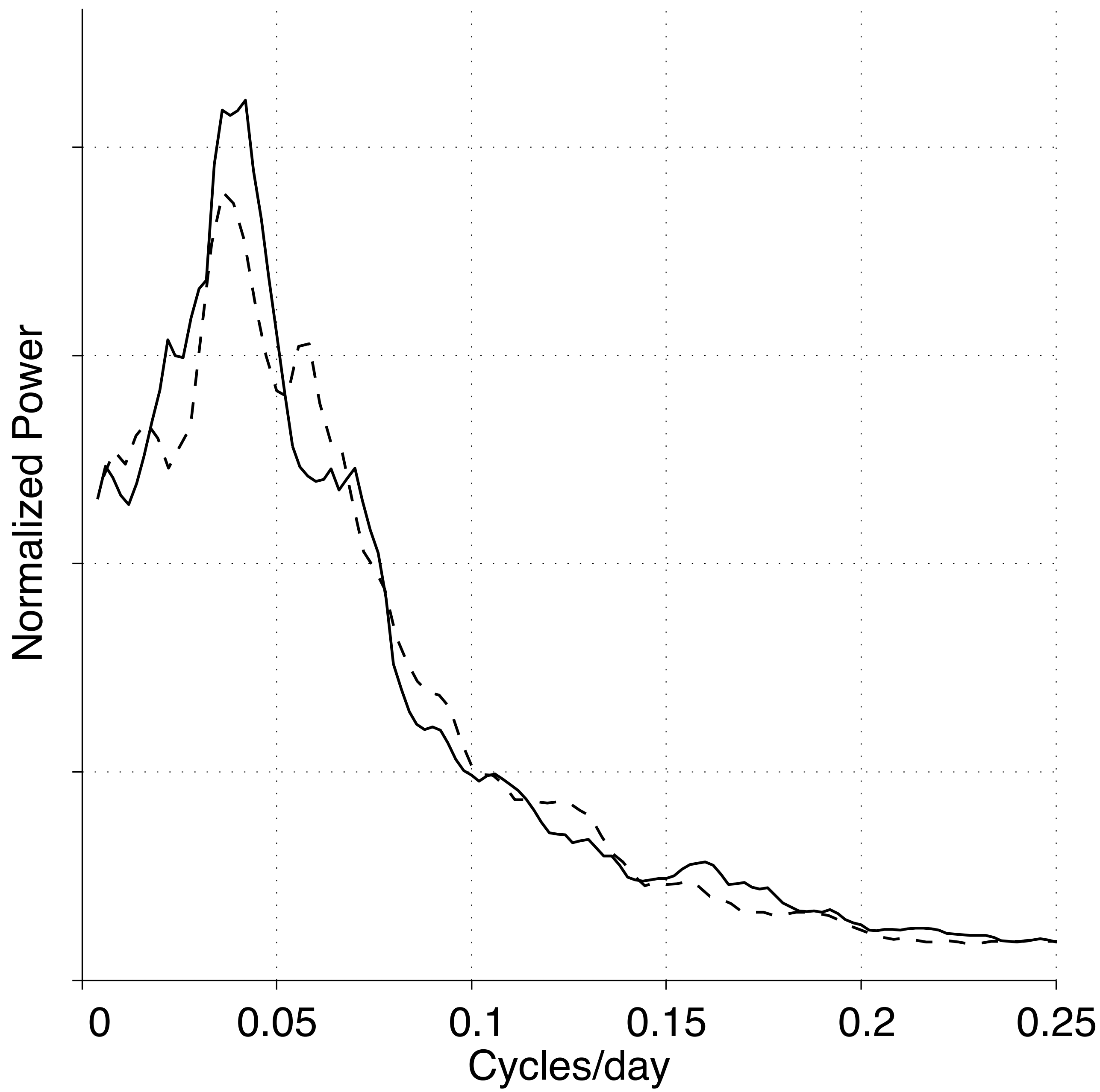
Spectra of SH-mean EKE

observations (solid) and **GFDL CM3** (dashed)



Thompson/Barnes 2014

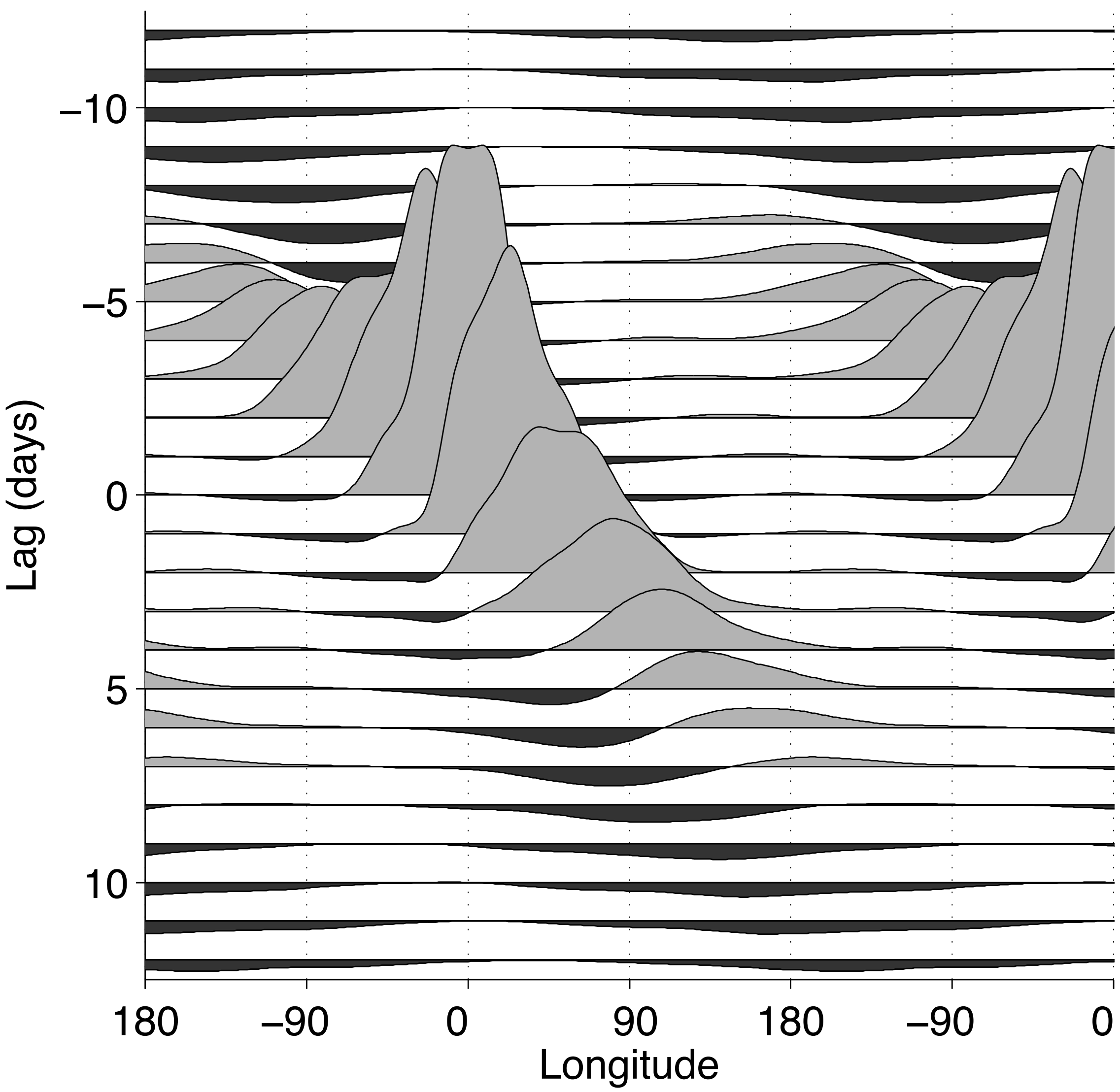
Spectra of SH-mean EKE
observations (solid)
GFDL dry dynamical core in HS framework (dashed)



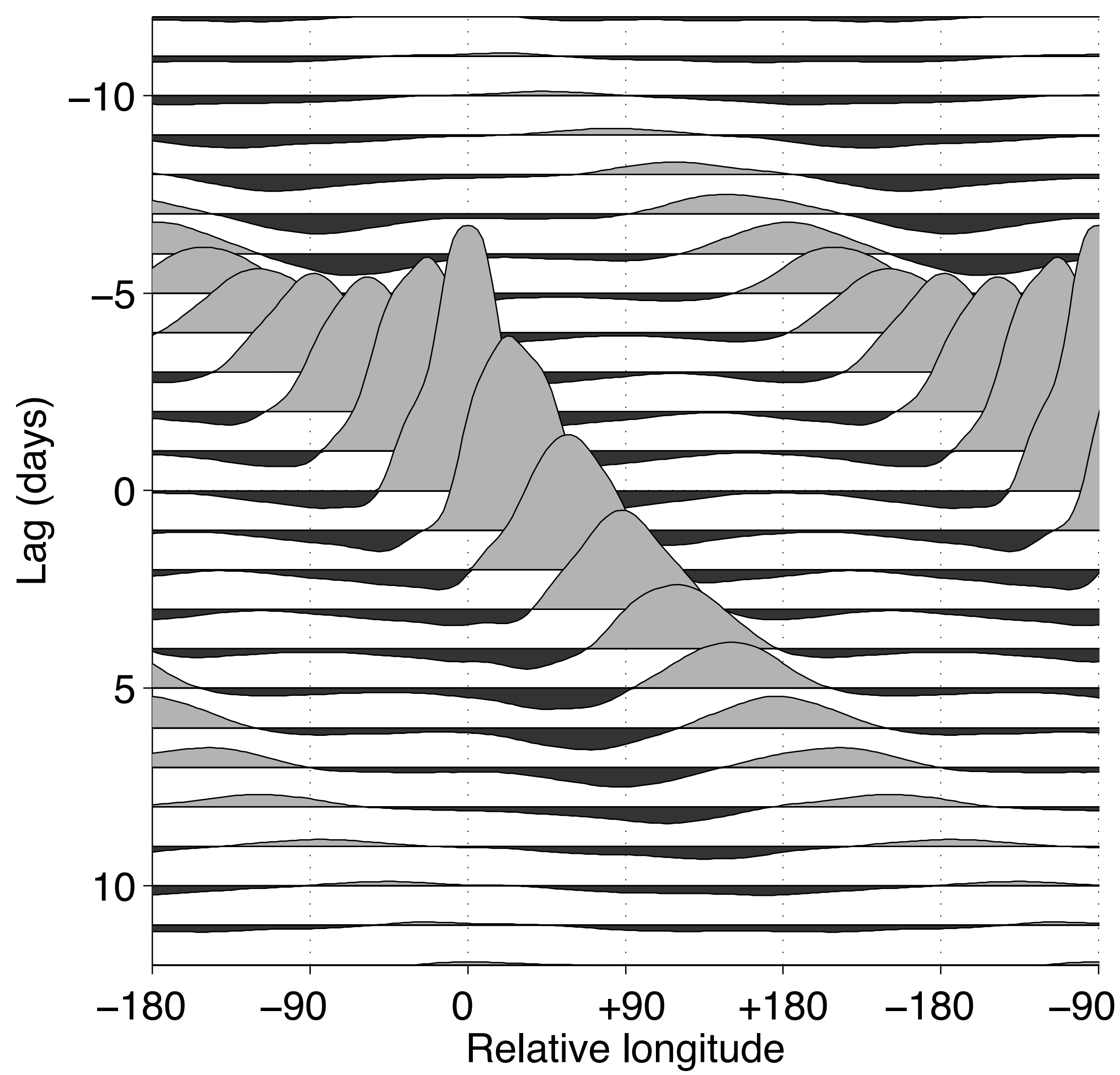
Thompson et al. 2017

Spectra of SH-mean EKE

observations (solid)



Observations



Dry dynamical core

Simple(st?) model of the periodicity

Upper layer

EKE anomalies are driven by heat fluxes in lower layer

Lower layer

Two way interactions between heat fluxes and baroclinicity

Lower layer

H denotes heat fluxes; B denotes baroclinicity.

$$\frac{\partial}{\partial t}B + U_{lower}\frac{\partial}{\partial x}B = \alpha_B H - \frac{B}{\tau_B}$$

Anomalously poleward heat fluxes => decreases in baroclinicity

$$\frac{\partial}{\partial t}H + U_{lower}\frac{\partial}{\partial x}H = \alpha_H B - \frac{H}{\tau_H}$$

Anomalously high baroclinicity => poleward heat fluxes

Upper layer

H denotes heat fluxes; E denotes EKE.

$$\frac{\partial}{\partial t}E + U_{upper}\frac{\partial}{\partial x}E = \alpha_E H - \frac{E}{\tau_E}$$

Anomalously poleward heat fluxes => increases in EKE

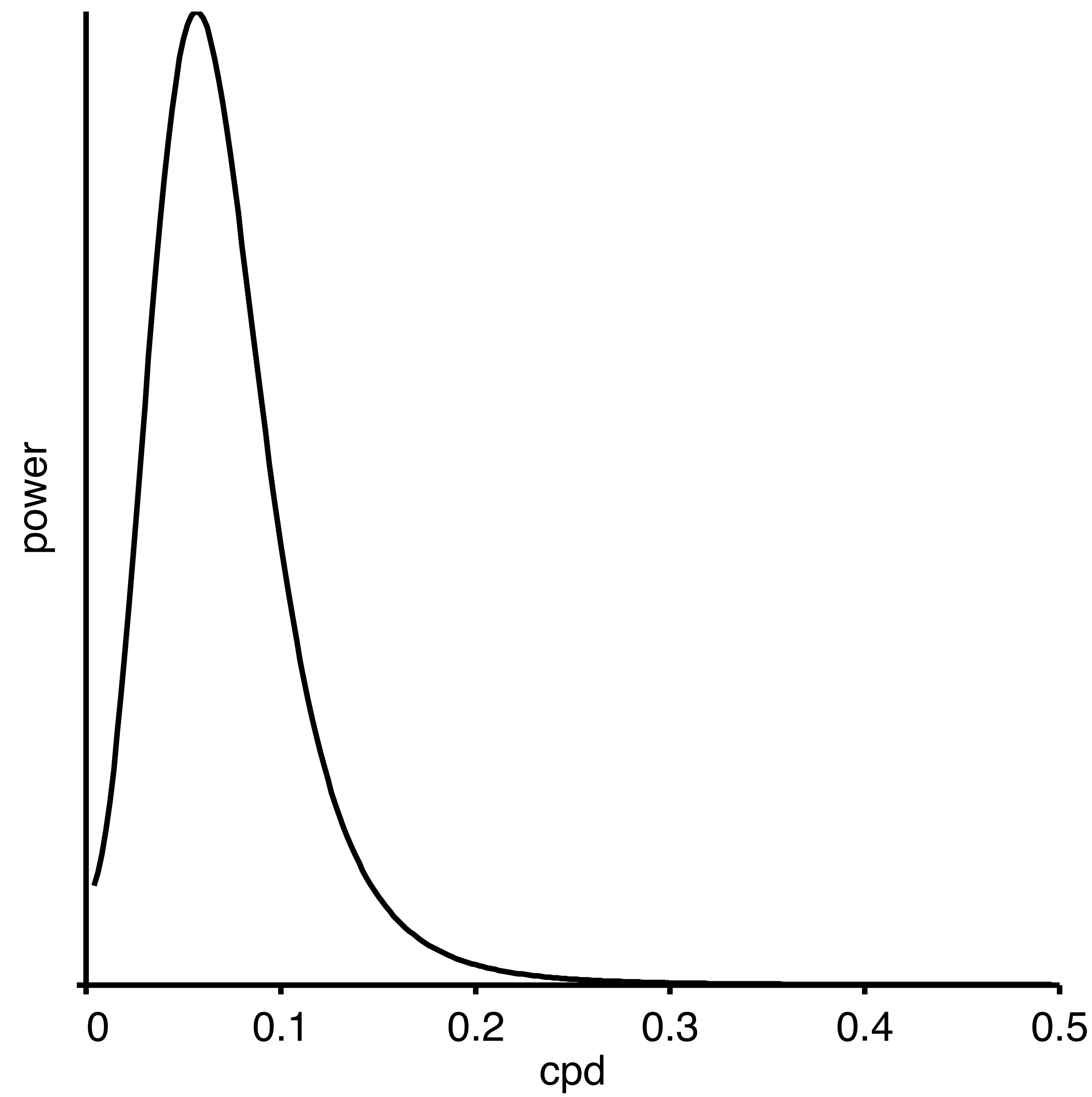
We will consider 3 cases:

$$U_{lower} = U_{upper} = 0$$

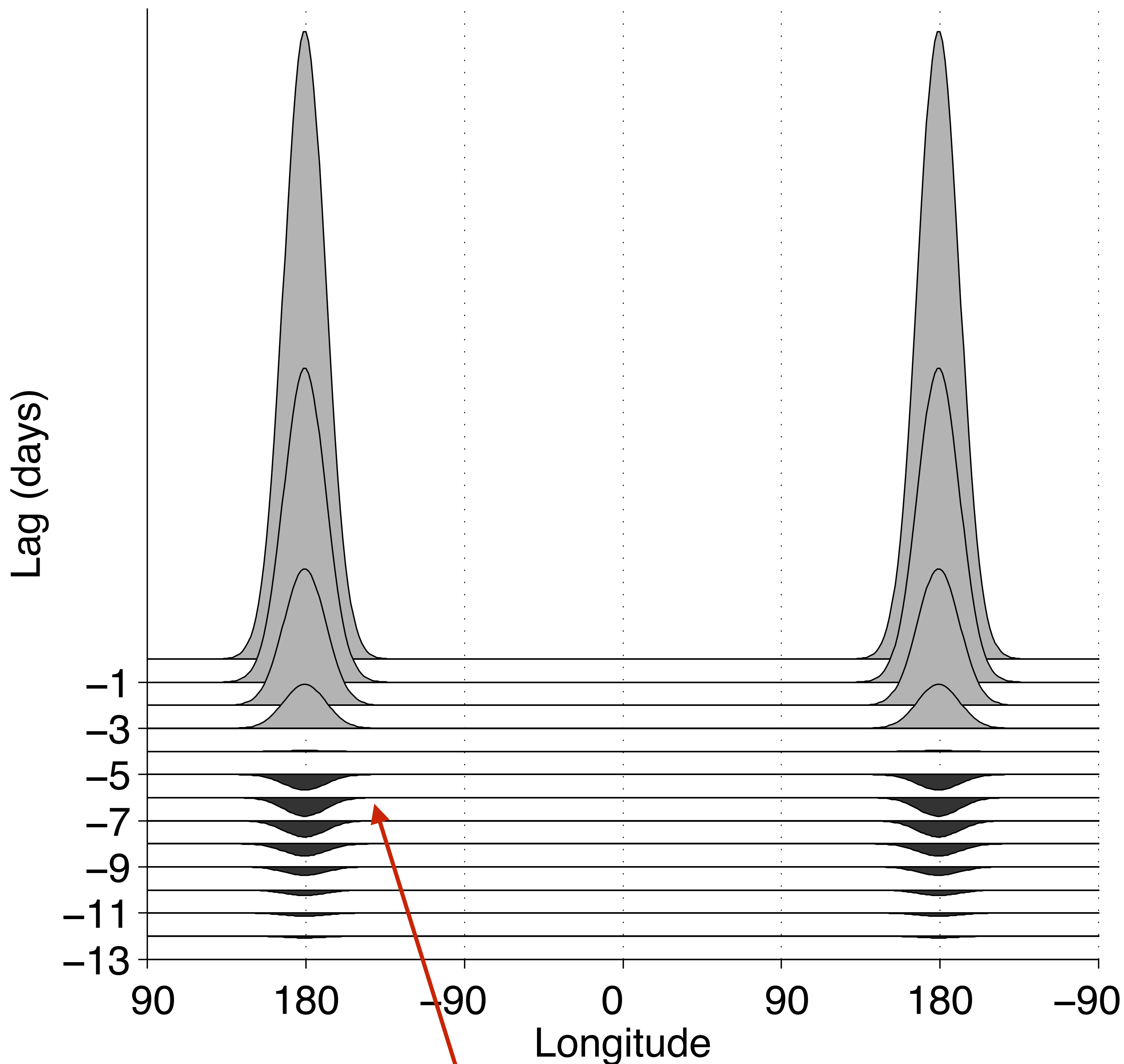
$$U_{lower} = U_{upper} = 25 \text{ m/s}$$

$$U_{lower} = 10 \text{ m/s}; \; U_{upper} = 25 \text{ m/s}$$

Power spectrum of zonal mean EKE

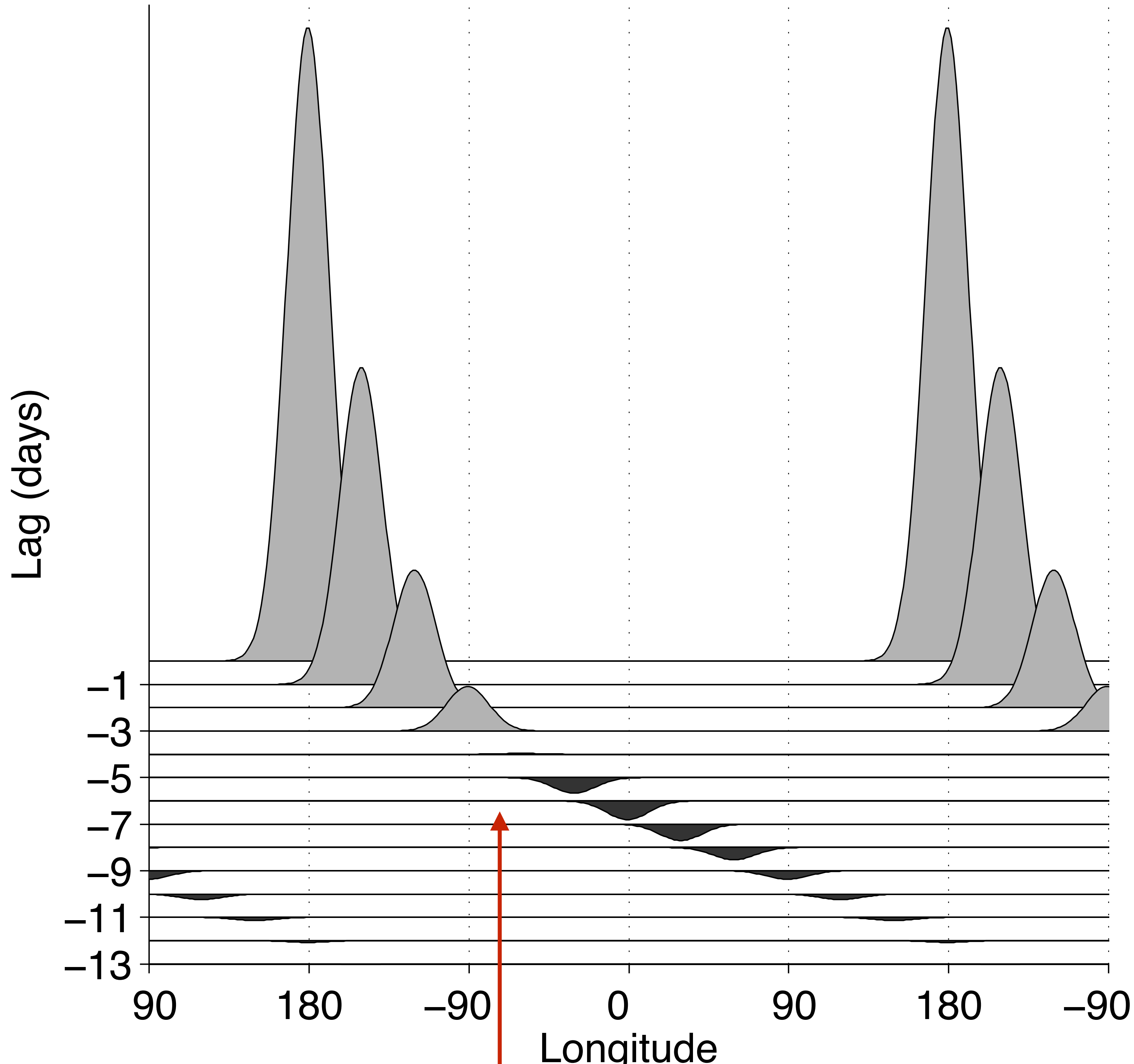


$$U_{lower} = U_{upper} = 0$$



EKE anomalies decay and grow at fixed location.

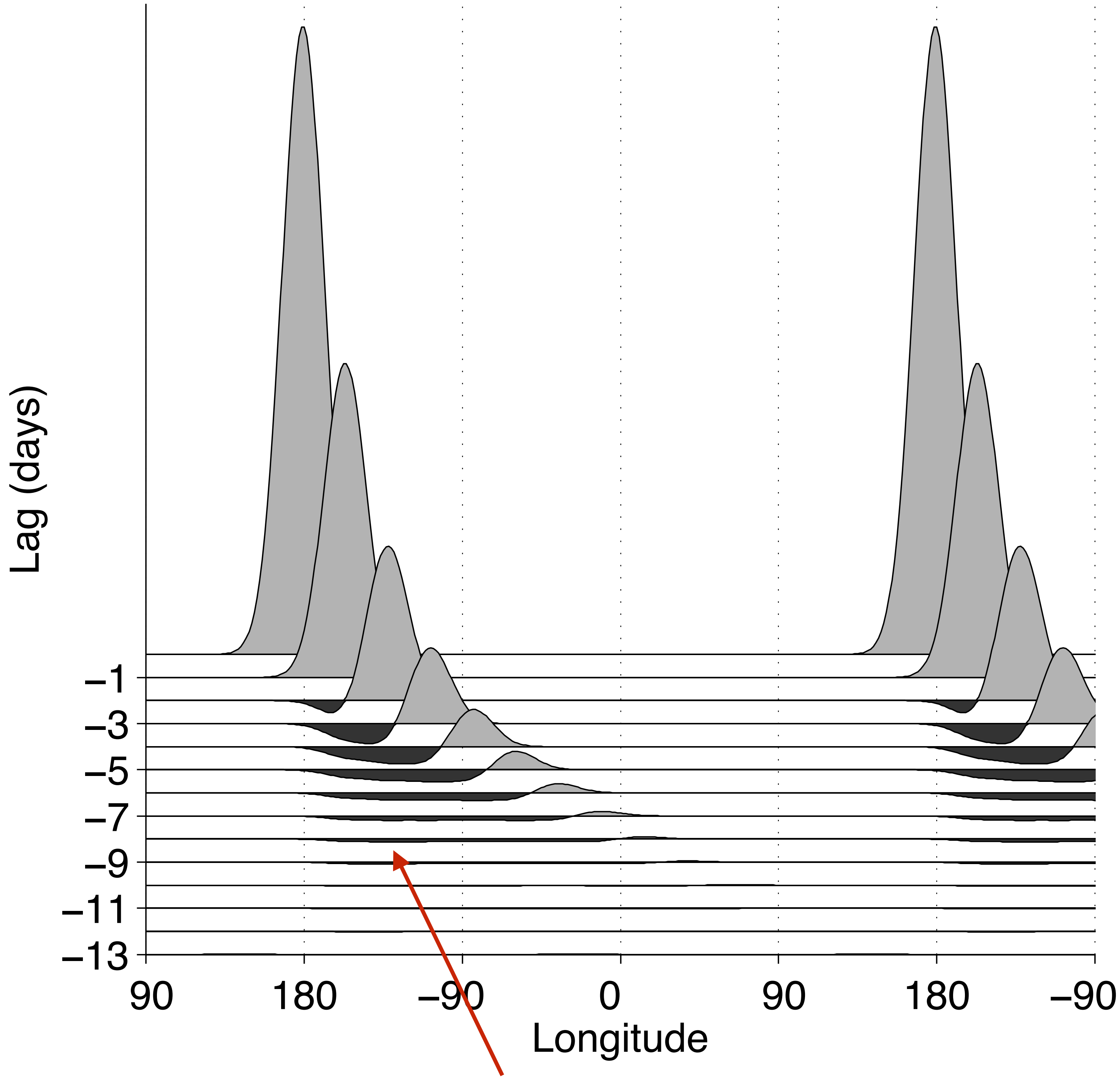
$$U_{lower} = U_{upper} = 25 \text{ m/s}$$



anomalies decay and grow following wave packet

$$U_{lower} = 10 \text{ m/s}$$

$$U_{upper} = 25 \text{ m/s}$$



EKE anomalies develop in wake of existing packets

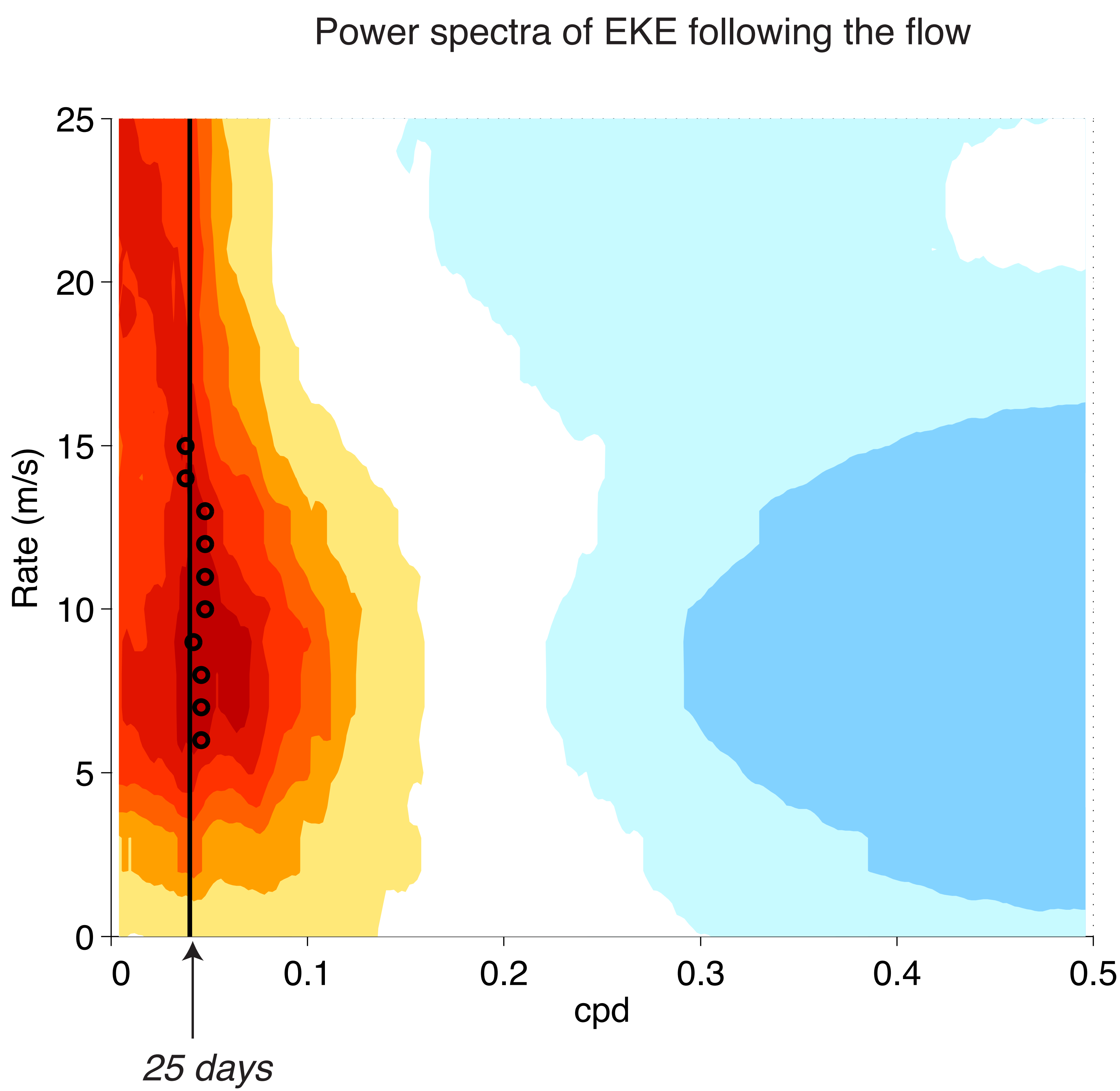
Take home messages

Analyses of increasingly simple models suggest that:

1. The periodicity in SH wave activity derives from (dry) feedbacks between the heat fluxes and baroclinicity in the lower troposphere.

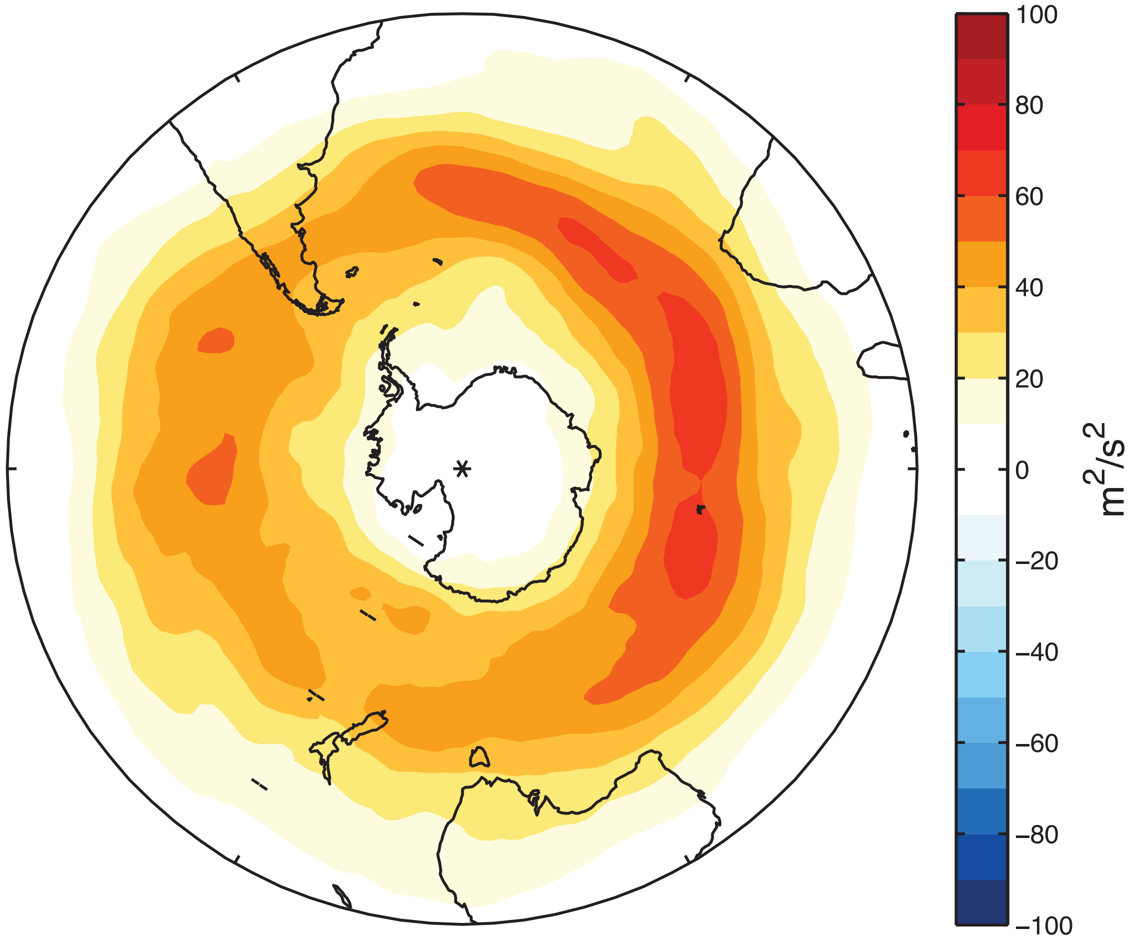
2. The structure of the periodicity on synoptic scales derives from the contrasting eastward speeds of the source of the periodicity in the lower troposphere (~10 m/s) and wave packets in the upper troposphere (~25 m/s).

How does the periodicity appear in the context of individual wave packets?

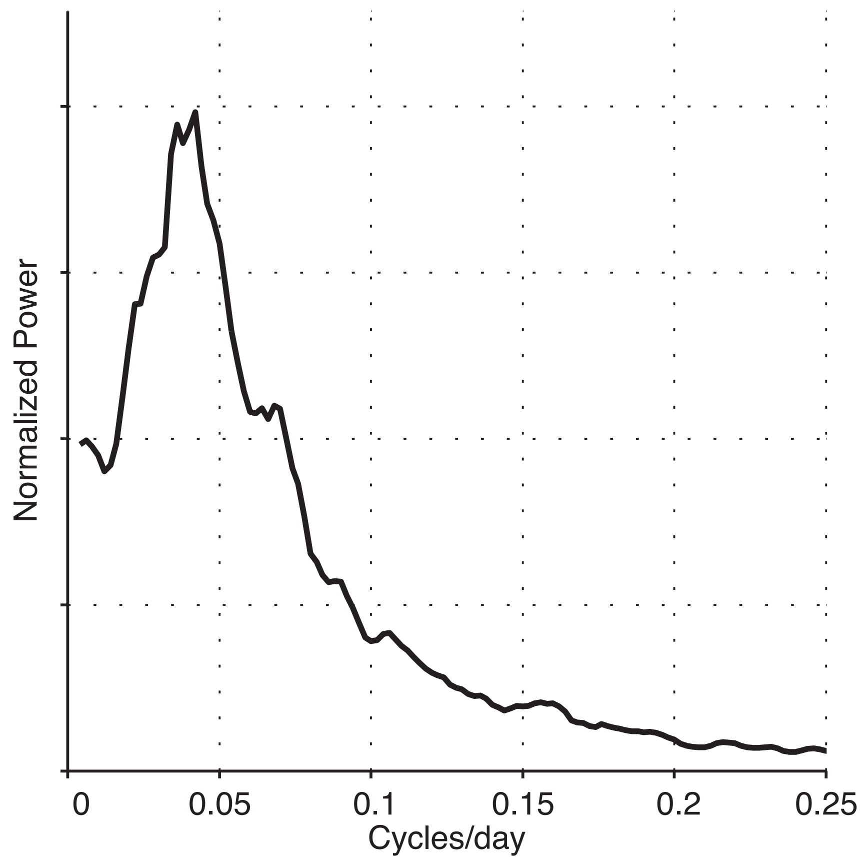


eddy kinetic energy at 300 hPa

spatial signature of BAM



spectrum of field averaged 30-70S



Thompson/Woodworth 2014