

Linear equatorial wave model

Part I: model introduction

This linear equatorial wave model generally follows Yu and McPhaden (1999, see attached PDF file). It's briefly described in the following:

1. The mean density profile based on the Hawaii-Tahiti shuttle experiment is used to derive the vertical structure functions $\psi_n(z)$, which form an orthogonal and complete set (see Table I and attached dataset).
2. For each baroclinic mode, a “shallow-water” model (zonal and meridional momentum equations plus a continuity equation) can be derived with associated equivalent depth and wave speed.
3. The set of equations for each baroclinic mode admits a whole set of equatorial wave solutions (e.g., Moore and Philander, 1977; Philander 1990). If we make long-wave and low-frequency assumption, only equatorial Kelvin wave and long Rossby waves are kept.
4. For each wave mode, a wave propagation equation can be derived with projected forcing (mainly zonal wind stress) onto this mode. Through solving this wave equation, one can derive the wave coefficient, thus construct the dynamic fields (horizontal velocity and sea level) associated with this wave mode. Sum up all wave modes (Kelvin wave and six gravest Rossby waves in current case), we can derive the total solution for each baroclinic mode.
5. Sum up all baroclinic modes (first 4 gravest modes in current case), we can derive the final solution.

Table I: parameters associated with baroclinic modes

	Mode 1	Mode 2	Mode 3	Mode 4
Equivalent depth H_n (cm)	76.0	30.9	11.5	5.9
Wave Speed (m/s)	2.73	1.74	1.06	0.76
Rossby Radius (Km)	346	276	216	183
Surface amplitude $\psi_n(0)$	4.29	3.90	1.70	1.25

Part II: dataset description

Since all datasets are in netcdf format, which is self-descriptive, so they are briefly introduced here.

1. vert_mode.cdf

This file shows the vertical structure of baroclinic modes. Only parameters of 10 gravest modes are shown.

N2: Buoyancy frequency (m^{-2})

PSI: Vertical structure function (unitless)

Cm: wave speed (cm/s)

Hn: Equivalent depth (cm)

2. wave_model.cdf

This file contains output from the linear equatorial wave model.

usx: surface zonal velocity anomalies (cm/s) from the baroclinic mode x (x=1,2,3,4)

vsx (vsxa): surface meridional velocity anomalies (cm/s) from the baroclinic mode x (x=1,2,3,4)**

**Due to the way Meridional velocity is calculated, please ignore values between 4N and 4S. vs? is same as vs?a except that values between 4N and 4S are masked.

hsx: sea level anomalies (cm) from the baroclinic mode x (x=1,2,3,4)

us, vs, hs are sums of output from each baroclinic modes, i.e.,

us=us1+us2+us3+us4, vs=vs1+vs2+vs3+vs4, hs=hs1+hs2+hs3+hs4

psi1: vertical structure function (same as psi in vert_mode.cdf, but just for the upper 500m)

To derive horizontal velocity or pressure below surface, you may do so by multiplying the surface values of one mode with associated vertical structure function of that mode. For example, to derive zonal velocity of mode 1 below surface, you may do so (In Ferret program):

let u1=us1*psi1[i=1]/psi1[i=1,k=1], similarly zonal velocity of mode 4 is

u4=us4*psi1[i=4]/psi1[i=4,k=1].

3. extra_data.cdf

This file includes some extra data which were either used to force the wave model or to verify model performance.

Taux: zonal wind stress anomalies from ECMWF data set, which is a mixture of ERA-40 reanalysis (before Aug. 2002) and operational data (from Aug.2002 to current)

SL: Sea level anomalies derived from T/P and Jason altimeters

SST: Reynolds SST anomalies

Z20: Z20 anomalies derived from BMRC subsurface temperature dataset.