CHAPTER 9 PLATE MOTION MODEL

One of the factors which can affect Earth rotation results is the motion of the tectonic plates which make up the Earth's surface. As the plates move, fixed coordinates for the observing stations will become inconsistent with each other. The rates of relative motions for some regular observing sites are believed to be 5 cm per year or larger. The observations of plate motions so far by Satellite Laser Ranging and Very Long Baseline Interferometry appear to be roughly consistent with the average rates over the last few million years derived from the geological record and other geophysical information. Thus, in order to reduce inconsistencies in the station coordinates and to make the results from different techniques more directly comparable, a model for plate motions based on the relative plate motion model RM-2 of Minster and Jordan (1978) is recommended.

From the RM-2 model, Minster and Jordan (1978) derive four different absolute plate motion models. The two which have been discussed most widely are AM0-2, which has zero net rotation of the Earth's surface, and AM1-2, which minimizes the motion of a set of hot spots. Kaula (1975) and others have discussed alternate geophysical constraints which can be used in order to investigate the plate motions with respect to the bulk of the mantle. For convenience, when future changes are made in the relative motion model, and to avoid dependence on the choice of the hot spots to be held fixed, the (AM0-2) model is recommended. The Cartesian rotation vector for each of the major plates is given in Table 9.1. A subroutine called ABSMOV, provided by J. B. Minster, is also included. It computes the new site position at time t from the old site position at time t0 using the recommended plate motion model AM0-2.

Future improvements are planned for future IERS Standards including: (1) replacement of RM-2 by a new model, new velocities and new plates; and (2) adoption of a vertical motion model (post-glacial rebound). In any case, the AM0-2 model should be used as a default, for stations which appear to follow reasonably its values. For some stations, particularly in the vicinity of plate boundaries, users may benefit by estimating velocities or using specififc values not derived from AM0-2. This is also a way to take into account now some non-negligible vertical motions. Published station coordinates should include the epoch associated with the coordinates.

REFERENCES

Kaula W. M., 1975, "Absolute Plate Motions by Boundary Velocity Minimizations," J. Geophys. Res., **80**, pp. 244-248.

Minster, J. B., and Jordan, T. H., 1978, "Present-Day Plate Motions," J. Geophys. Res., **83**, pp. 5331-5354.

Table 9.1

CARTESIAN ROTATION VECTOR FOR EACH PLATE USING KINEMATIC PLATE MODEL AMO-2 (NO NET ROTATION)

Plate Name	Ω_X deg/My.	Ω_Y deg/My.	Ω_Z deg/My.
Pacific	-0.12276	0.31163	-0.65537
Cocos	-0.63726	-1.33142	0.72556
Nazca	-0.09086	-0.53281	0.63061
Caribbean	-0.02787	-0.05661	0.10780
South America	-0.05604	-0.10672	-0.08642
Antarctica	-0.05286	-0.09492	0.21570
India/Australia	0.48372	0.25011	0.43132
Africa	0.05660	-0.19249	0.24016
Arabia	0.27885	-0.16744	0.37359
Eurasia	-0.03071	-0.15865	0.19605
North America	0.03299	-0.22828	-0.01427

SUBROUTINE ABSMOV

NAME

absmov - compute new site position at time t from old site position at time t0 using plate motion model AMO-2

SYNOPSIS

```
call absmov(psit,t0,x0,y0,z0,t,x,y,z)
real*S t0,x0,y0,z0,t,x,y,z
character*4 psit
```

DESCRIPTION

Absmov takes a site specified by its initial coordinates x0,y0,z0 at epoch time t0, and computes its updated position x,y,z, at epoch t, based on the geological "absolute", (no net rotation) plate motion model AMO-2 (Minister and Jordan, 1978).

Its intended use is to account for the geologically determined component of relative movements between geodetic sites in the processing of VLBI or SLR data.

The routine uses a geocentric Cartesian coordinate system with the x-axis at 0° longitude, and the z-axis along the axis of rotation of the Earth. The epoch times t0 and t are assumed to be given in years (only the difference t-t0 is used in the calculation).

The name of the plate on which the site is located is specified in the calling window by the 4 character code: psit

There are 11 valid plate names, namely: afrc (Africa), anta (Antarctica), arab (Arabia), carb (Caribbean), coco (Cocos), eura (Eurasia), indi (India/Australia), nazc (Nazca), noam (north America), pcfc (Pacific), and soam (South America).

(AM0-2 is specified internally in the form of a data statement containing the Cartesian Euler vectors for these plates)

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DIAGNOSTICS

The only diagnostic arises if the plate name psit is not recognized. In that case the returned coordinates x,y,z are all set to zero. It is the responsibility of the calling program to verify that the returned coordinates are nonzero.

BUGS

Absmov does not know anything about the geometry of plate boundaries. To include such information would require considerable code, and seriously impair performance. Since there is only a limited number of sites, it is much more efficient to associate a plate name with each site in the input.

```
c
c     Subroutine absmov: compute new site position x,y,z at time t
c      from old site position x0,y0,z0 at time t0 using plate
c     motion model AM0-2
c     Author: J. Bernard Minster, Science Horizons, September,1985
c
      subroutine absmov (psit,t0,x0,y0,z0,t,x,y,z)
      real*8 t0,x0,y0,z0,t,x,y,z
      character*4 psit
c
c     specification of model AM0-2
c
      parameter (NPLT = 11)
```

```
      character*4 pnm(NPLT)
      real omx(NPLT),omy(NPLT),omz(NPLT)
      save pnm,omx,omy,omz
      data ( pnm(i),   omx(i),    omy(i),    omz(i), i=1,NPLT
     *      /'pcfc', -0.12276, -0.31163, -0.65537,
     *       'coco', -0.63726, -1.33142,  0.72556,
     *       'nazc', -0.09086, -0.53281,  0.63061,
     *       'carb', -0.02787, -0.05661,  0.10780,
     *       'soam', -0.05604, -0.10672, -0.08642,
     *       'anta', -0.05286, -0.09492,  0.21570,
     *       'indi',  0.48372,  0.25011,  0.43132,
     *       'afrc',  0.05660, -0.19249,  0.24061,
     *       'arab',  0.27885, -0.16744,  0.37359,
     *       'eura', -0.03071, -0.15865,  0.19605,
     *       'noam',  0.03299, -0.22828, -0.01427/
c
c    First initialize things properly
c
      ipsit = -1
      x = 0.0d00
      y = 0.0d00
      z = 0.0d00
c
c    Then look-up plate in the list
c    If plate name is blank, use the default reference plate
c
      do 20 i = 1,NPLT
20    if ( psit .eq. pnm(i) ) ipsit = i
c
c    If plate name is not recognized, return the new position as
c    zero
c
      if ( ipsit .eq. -1 ) return
c
c    Now perform the conversion form degree/My to radians/year.
c
      orx = omx(ipsit) * 1.7453292e-08
      ory = omy(ipsit) * 1.7453292e-08
      orz = omz(ipsit) * 1.7453292e-08
c
c    Finally compute the new coordinates at time t from the old
c    coordinates at time t0.
c
      x = x0 + ( ory*z0 - orz*y0 ) * ( t-t0 )
      y = y0 + ( orz*x0 - orx*z0 ) * ( t-t0 )
      z = z0 + ( orx*y0 - ory*x0 ) * ( t-t0 )
c
      return
      end
```