Vertical Geomagnetic Cutoff Rigidities for Epoch 2015

D. F. Smart and M. A. Shea
SSSRC
100 Tennyson Avenue
Nashua, NH 03062, USA

THERE IS A DECREASE IN THE MAIN DIPOLE MAGNETIC FIELD BY ABOUT 5% PER CENTURY

THERE IS A WESTWARD DRIFT OF THE NON-DIPOLE MAGNETIC FIELD.

AS THE REGIONS OF TOTAL MAGNETIC INTENSITY MOVE, CHANGES IN THE GEOMAGNETIC FIELD MODIFY COSMIC RAY ACCESS TO SPECIFIC LOCATIONS ON EARTH.

WE HAVE DERIVED AN UPDATED WORLD GRID OF VERTICAL GEOMAGNETIC COSMIC RAY CUTOFF RIGIDITIES FOR EPOCH 2015.

The equation of charged particle motion in a magnetic field may be written in vector form as

$$\ddot{\mathbf{r}} = (e/mc)\,\dot{\mathbf{r}}\mathbf{B}.$$

In this equation, $\ddot{\mathbf{r}}$ is the particle acceleration, $\dot{\mathbf{r}}$ the particle velocity, and $\mathbf{B}$ the magnetic field vector. The electronic charge is denoted by e, m is the particle's relativistic mass, and c is the speed of light. This equation, when expressed in r, θ, ϕ coordinates, results in three simultaneous differential equations with six unknowns.

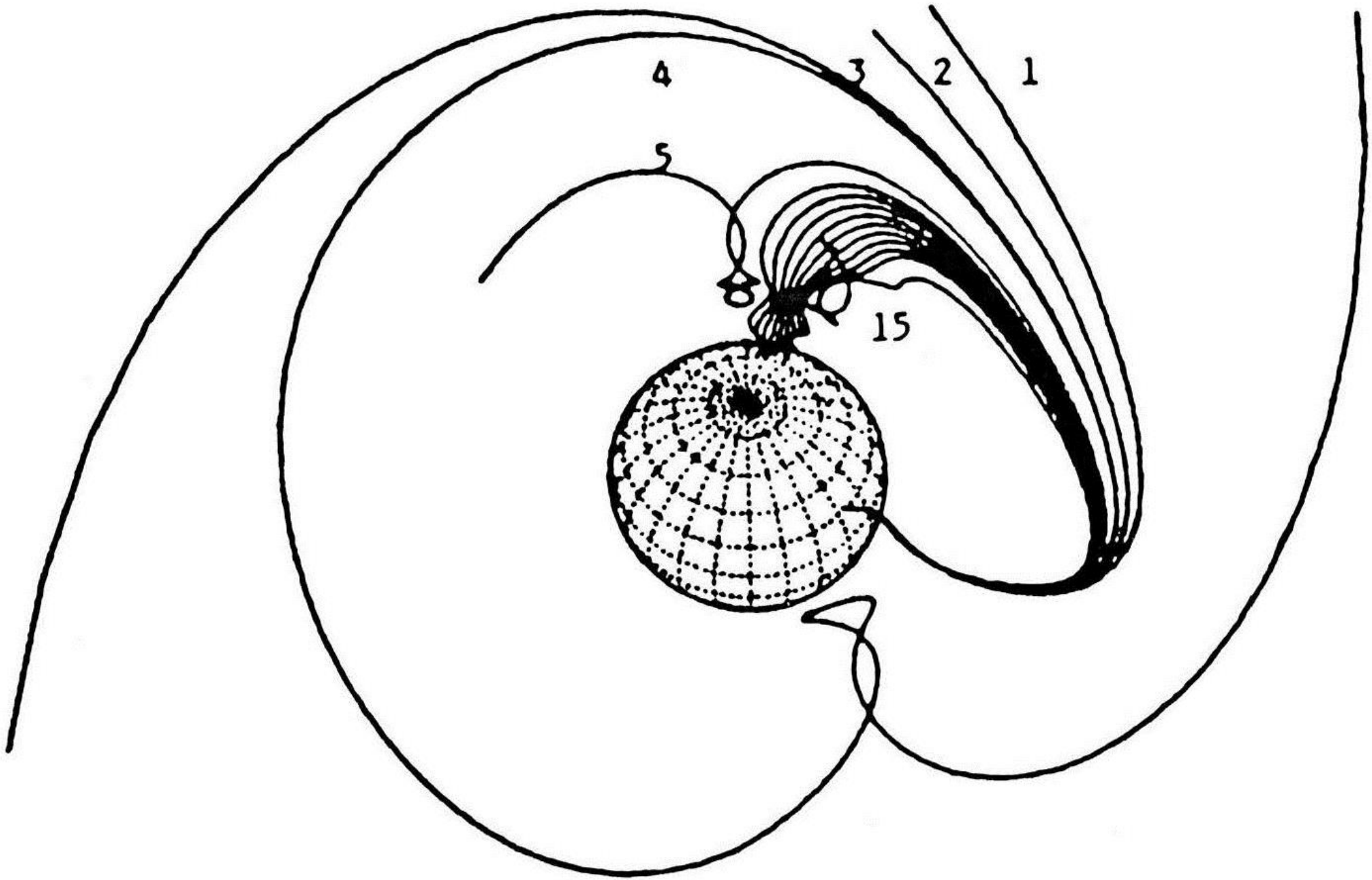
$$\frac{\mathrm{d}v_r}{\mathrm{d}t} = \frac{e}{mc}(v_\theta B_\phi - v_\phi B_\theta) + \frac{v_\theta^2}{r} + \frac{v_\phi^2}{r},$$

$$\frac{\mathrm{d}v_\theta}{\mathrm{d}t} = \frac{e}{mc}(v_\phi B_r - v_r B_\phi) - \frac{v_r v_\theta}{r} + \frac{v_\phi^2}{r\tan\theta},$$

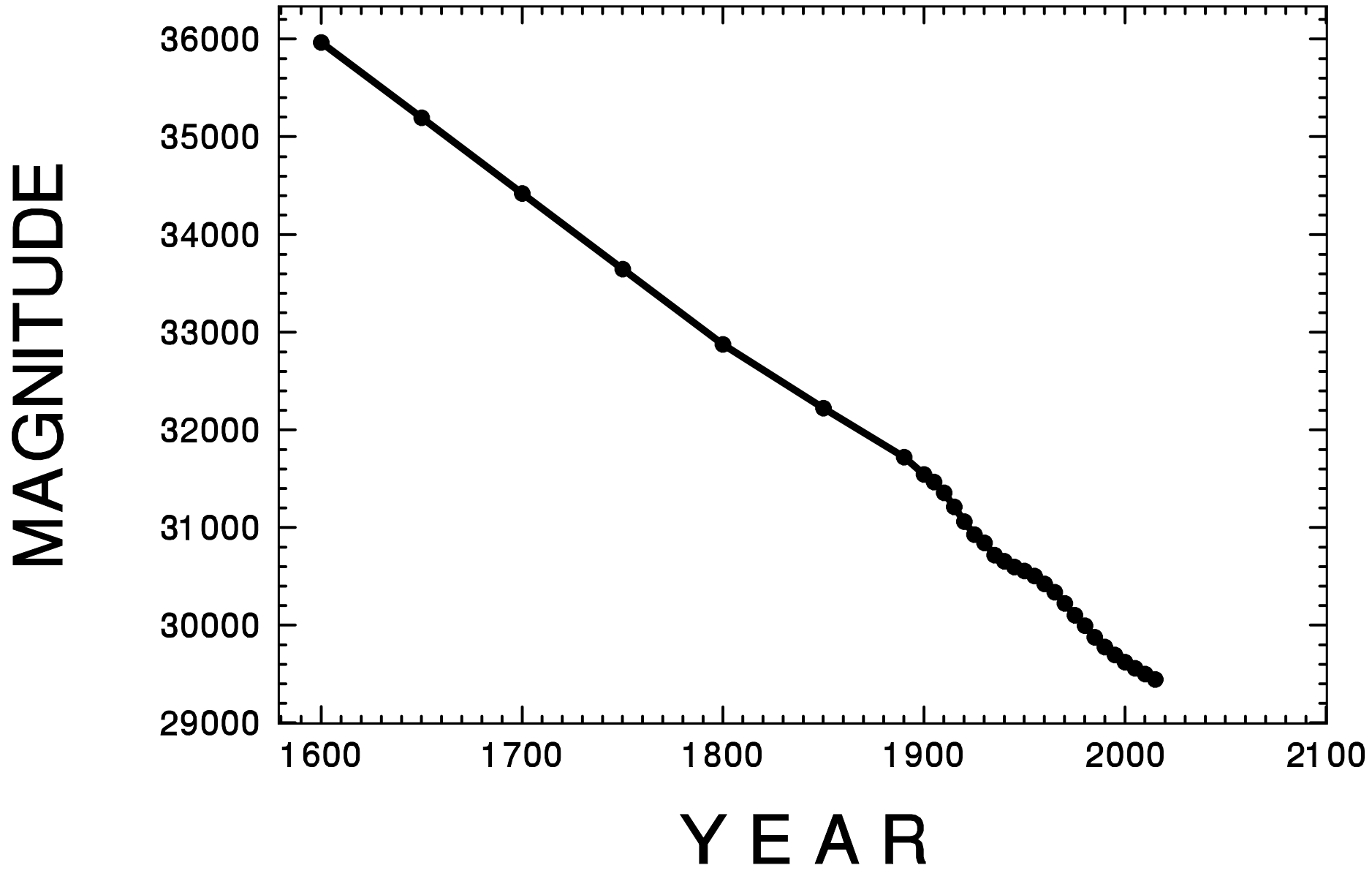
$$\frac{\mathrm{d}v_\phi}{dt} = \frac{e}{mc}(v_r B_\theta - v_\theta B_r) - \frac{v_r v_\phi}{r} - \frac{v_\theta v_\phi}{r\tan\theta}.$$

In these equations the particle velocity terms are

$$\frac{\mathrm{d}r}{\mathrm{d}t} = v_r, \qquad \frac{\mathrm{d}\theta}{\mathrm{d}t} = \frac{v_\theta}{r}, \qquad \frac{\mathrm{d}\phi}{\mathrm{d}t} = \frac{v_\phi}{r\sin\theta}.$$

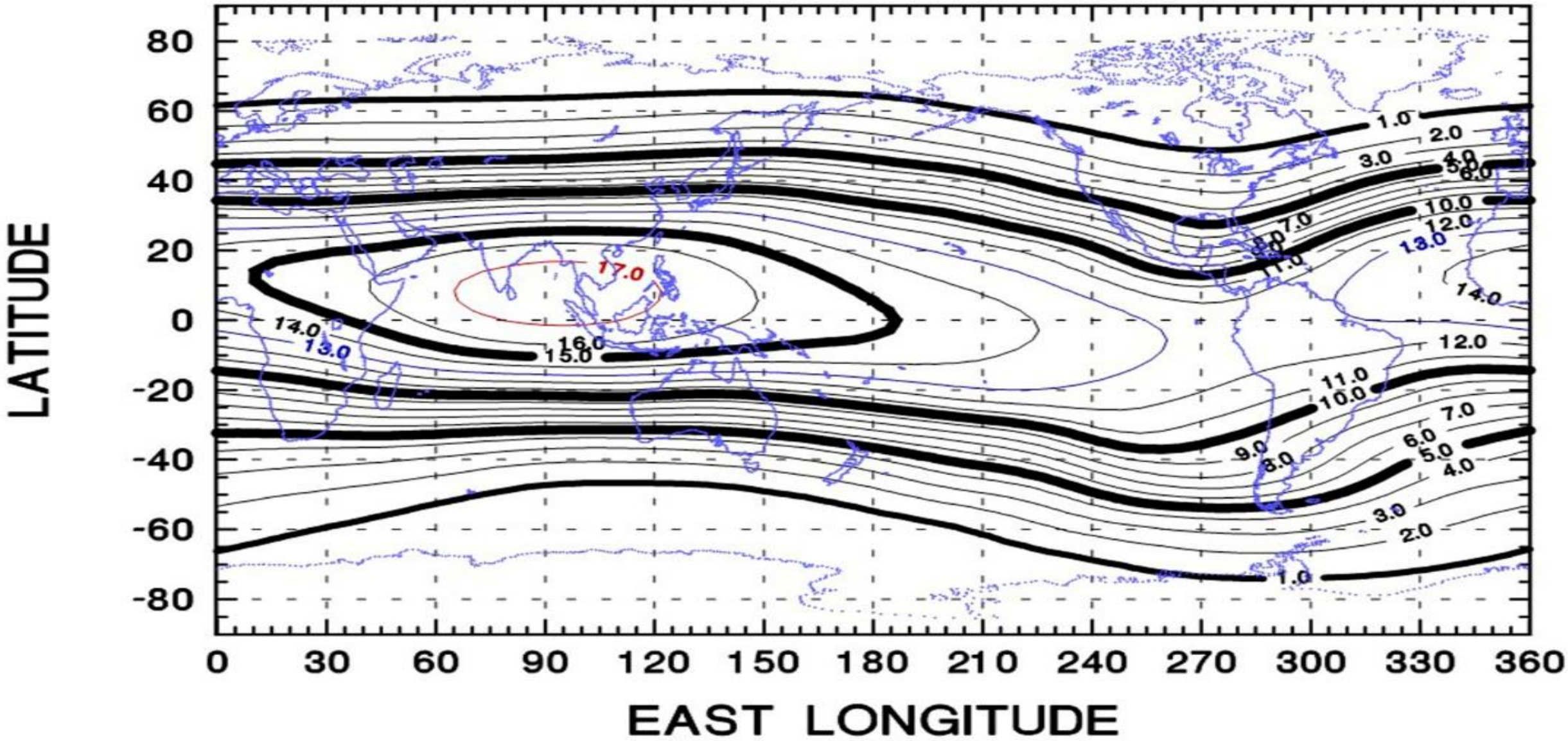

4
3
2
1
5
15

G(1,0) TERM CHANGE

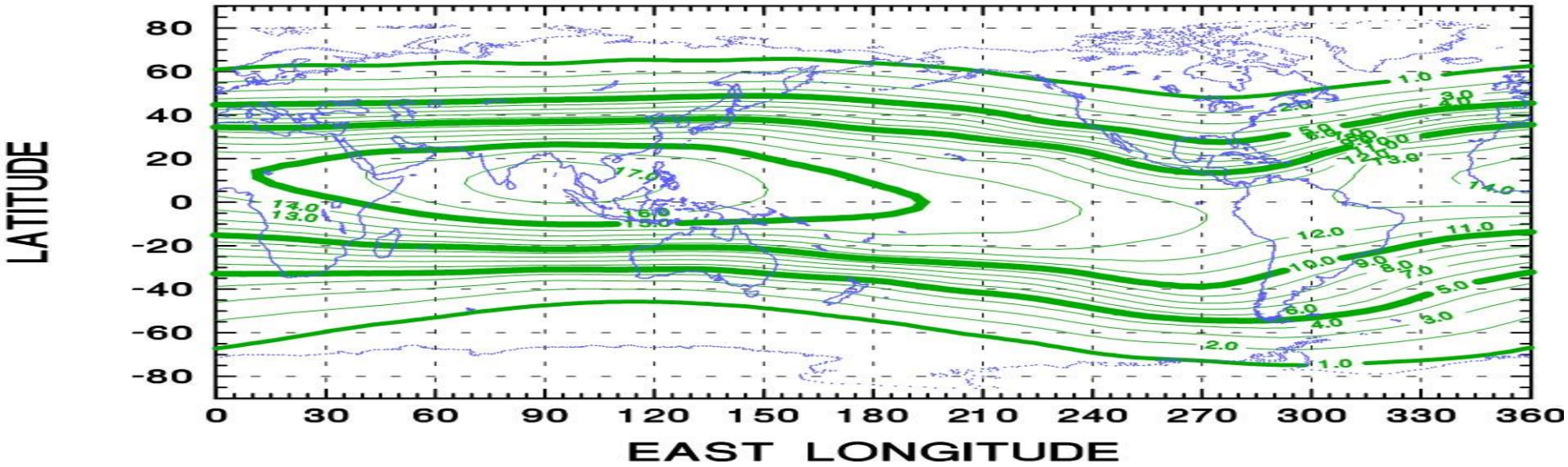


VERTICAL CUTOFF RIGIDITIES (GV)

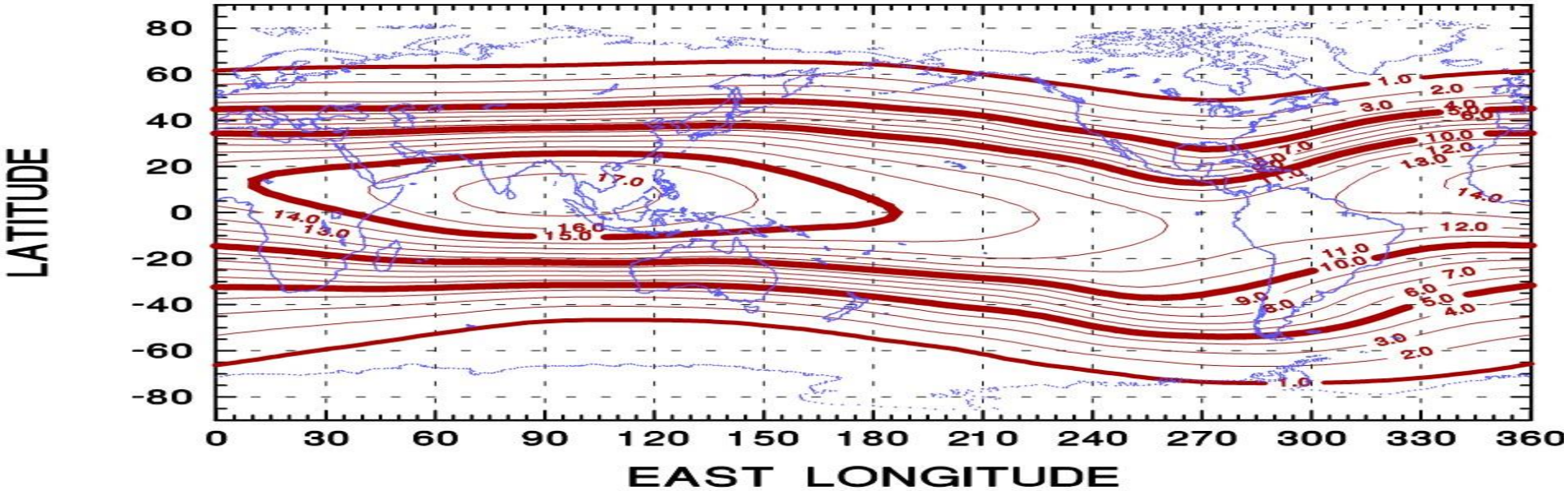
2015 IGRF



VERTICAL CUTOFF RIGIDITIES (GV)
2000 IGRF



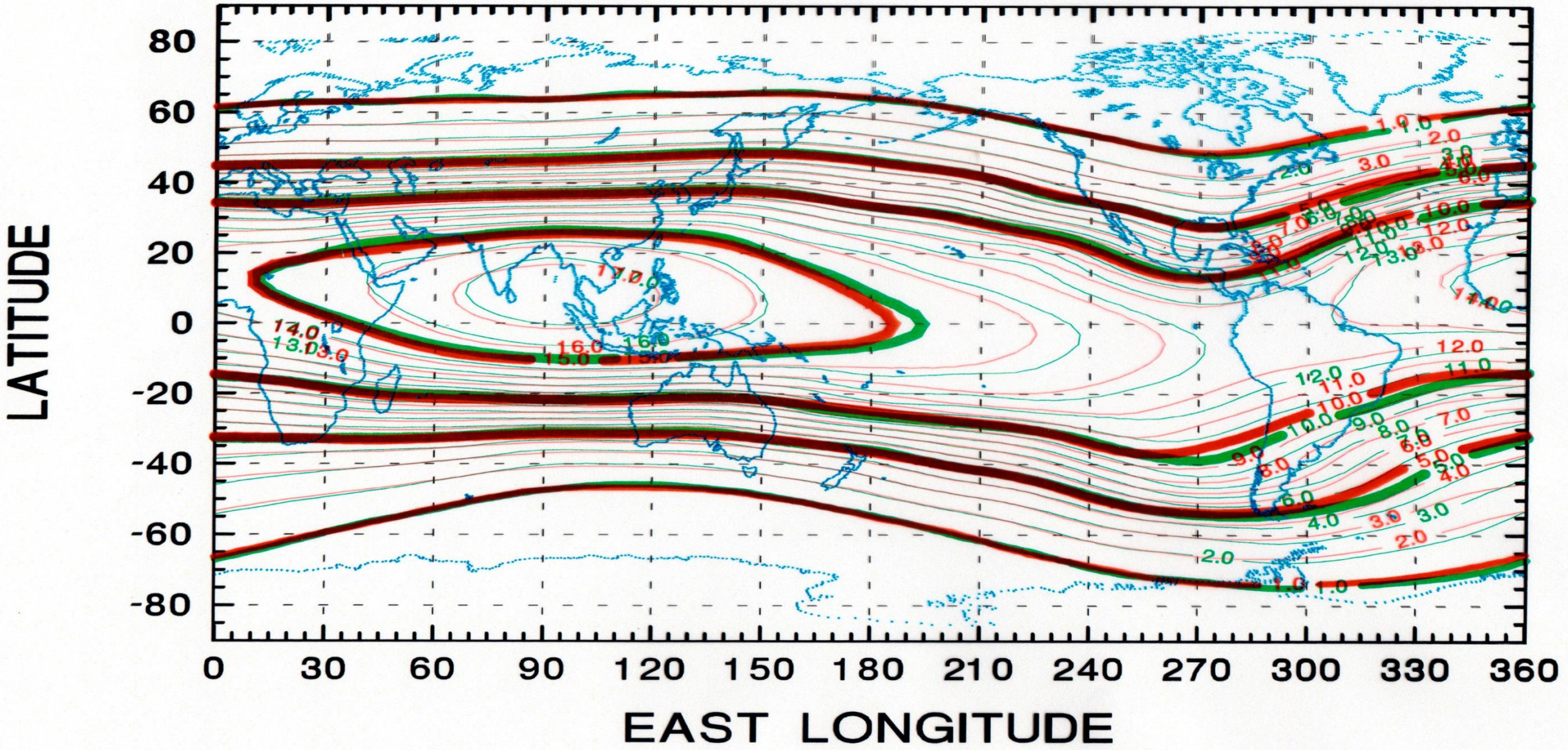
VERTICAL CUTOFF RIGIDITIES (GV)
2015 IGRF



VERTICAL CUTOFF RIGIDITIES (GV)

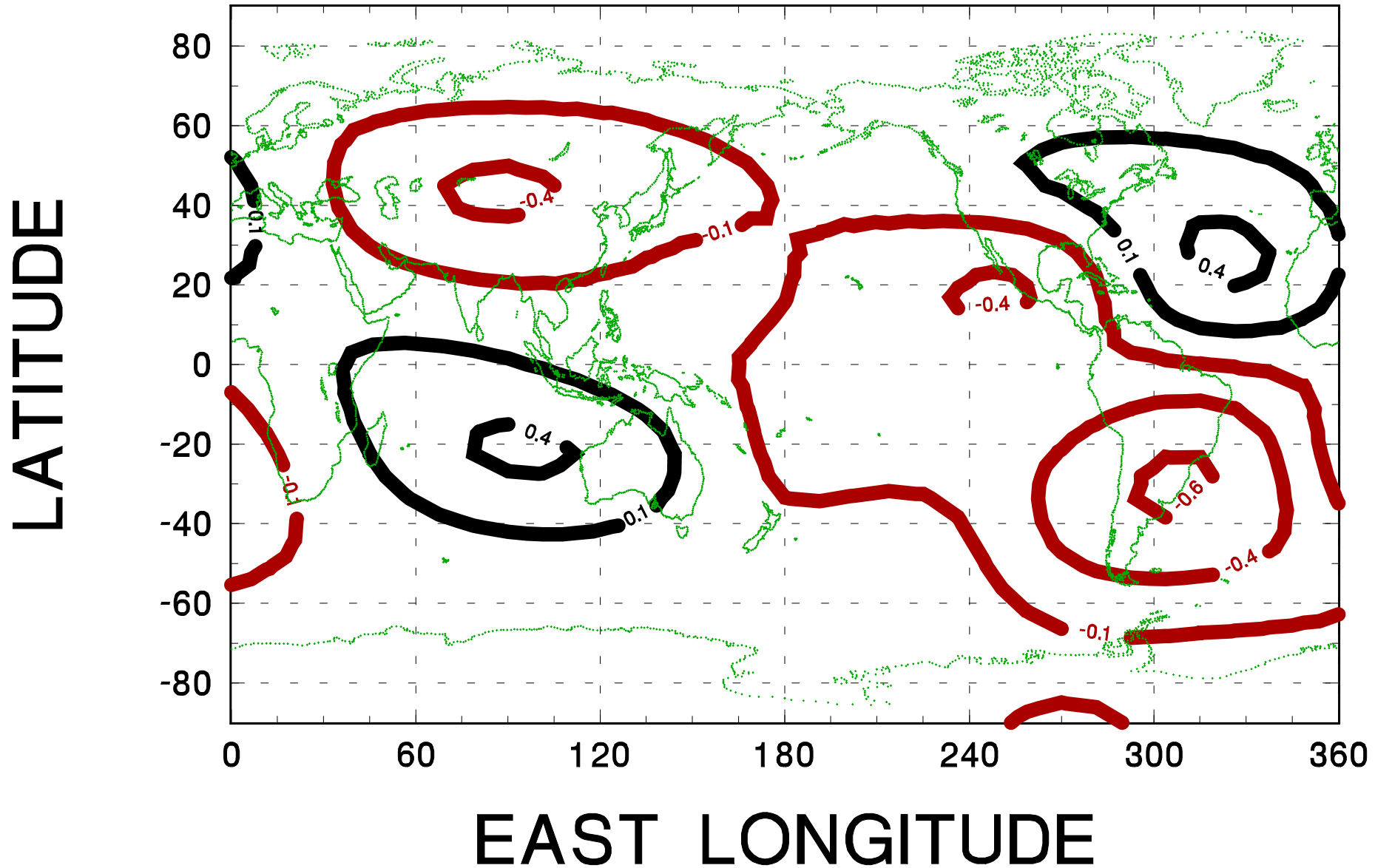
2000 IGRF

2015 IGRF



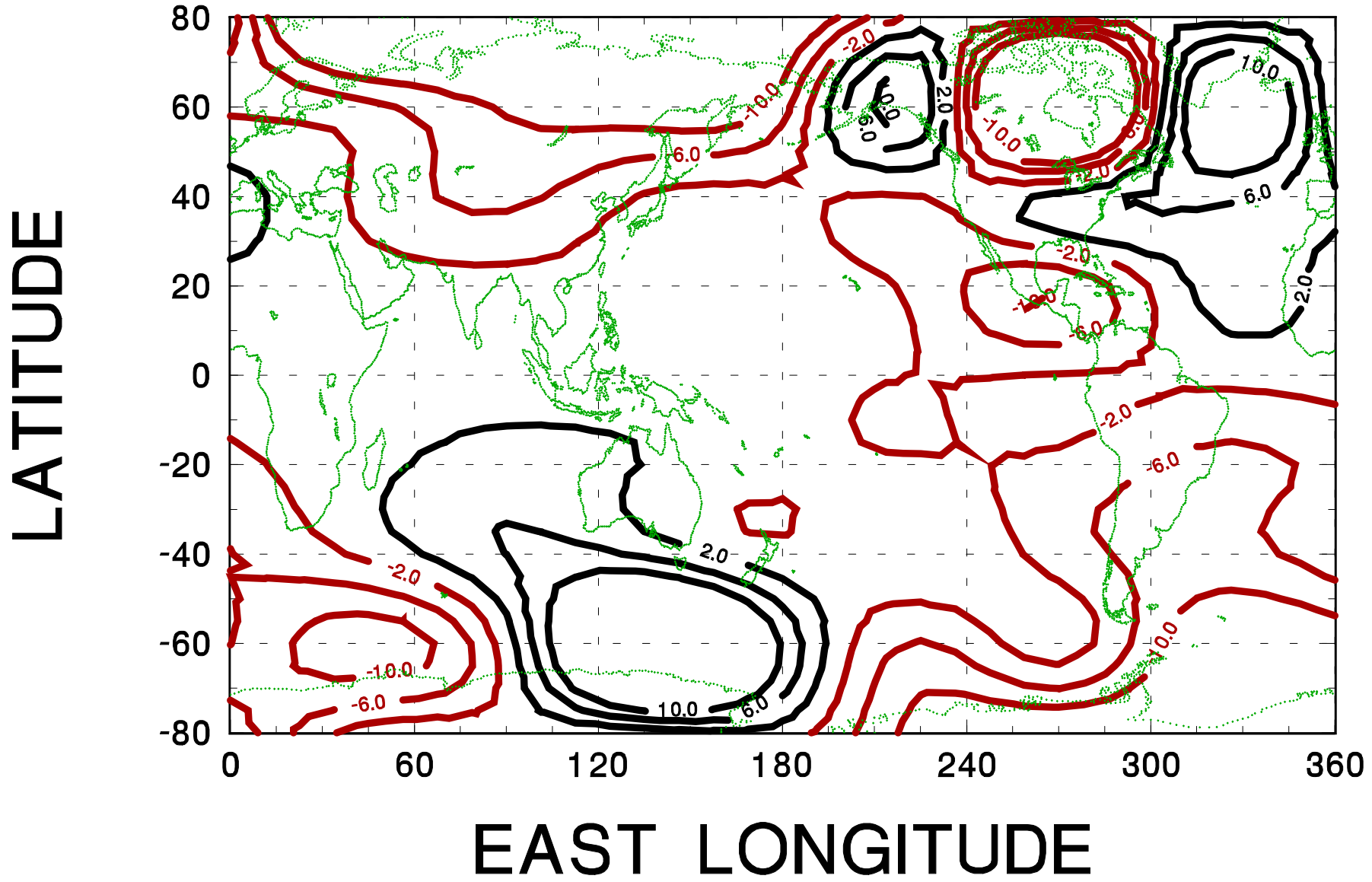
2000-2015

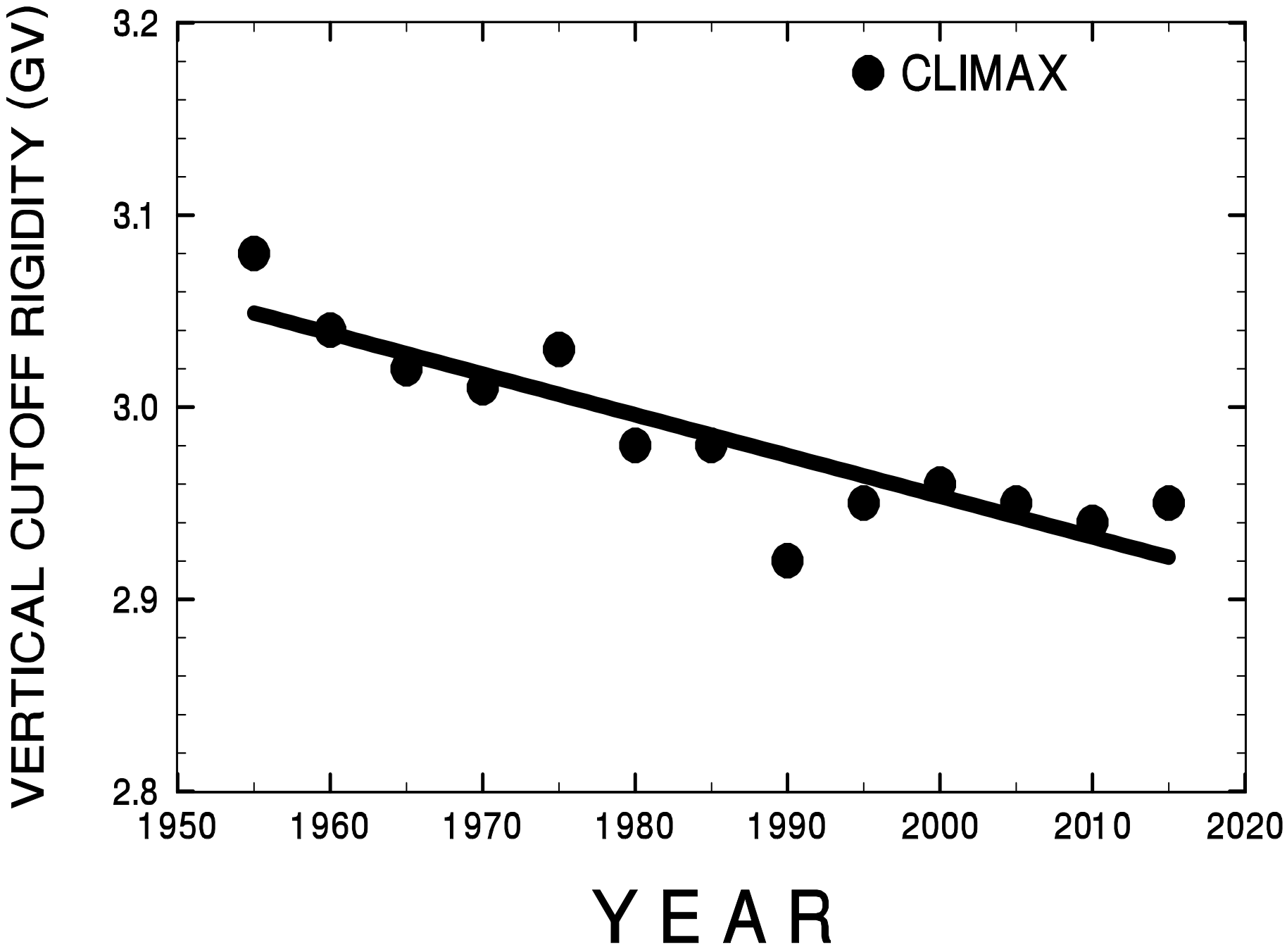
Change in Cutoff Rigidity (GV)

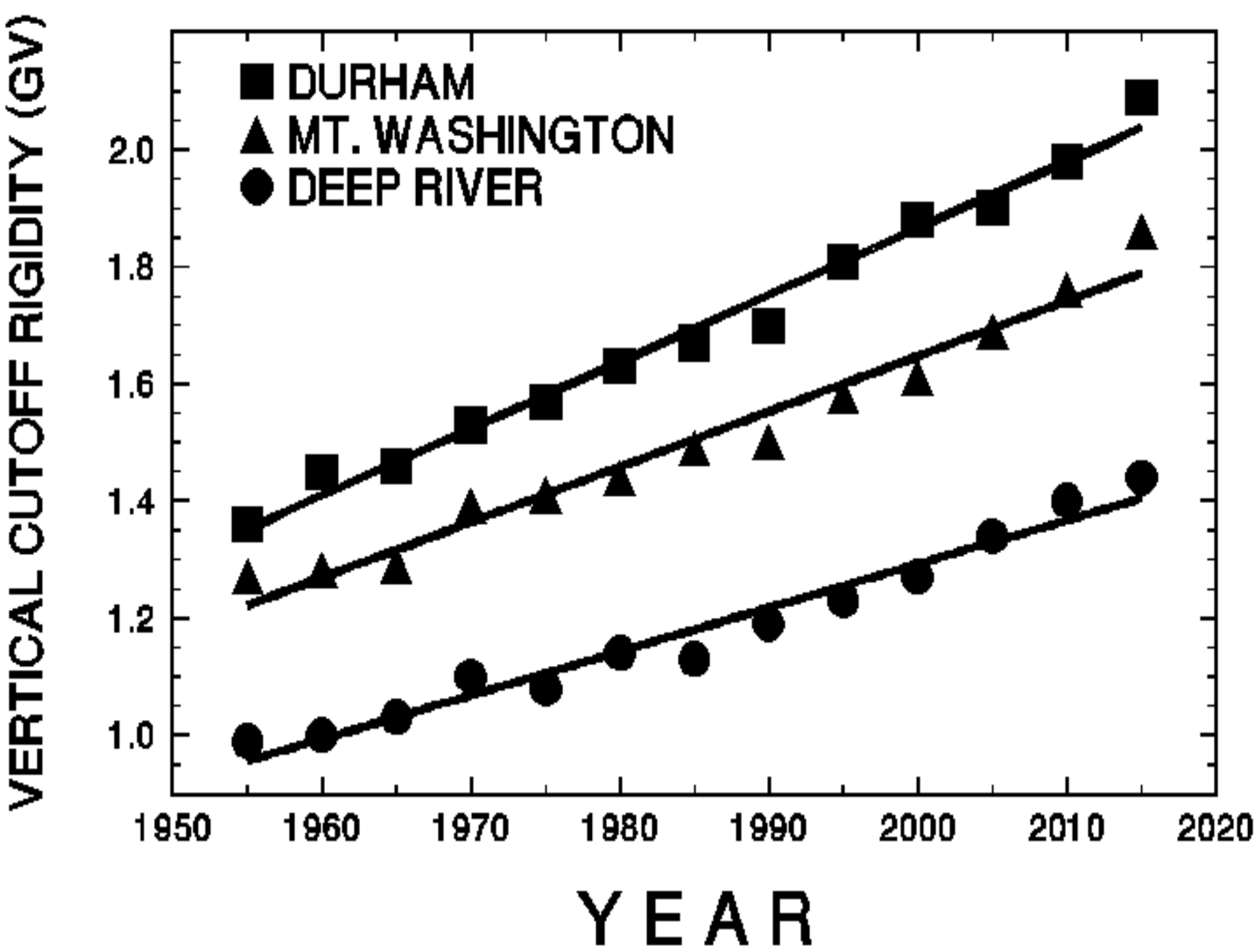


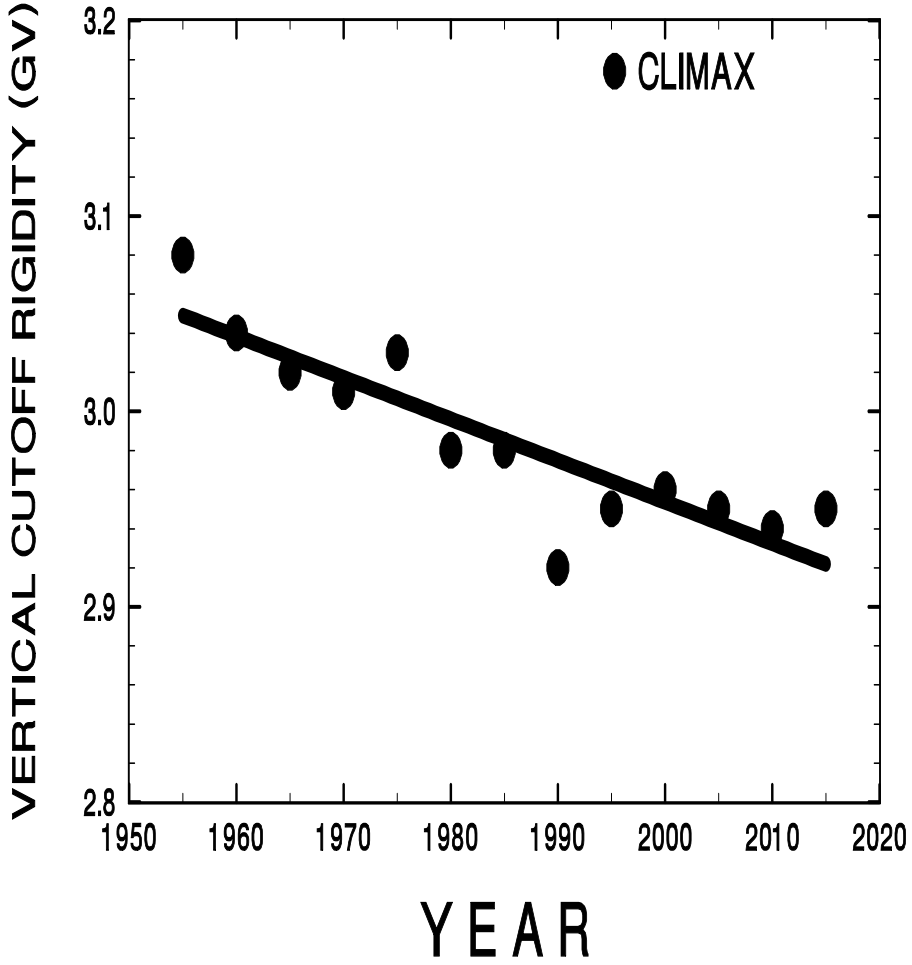
2000-2015

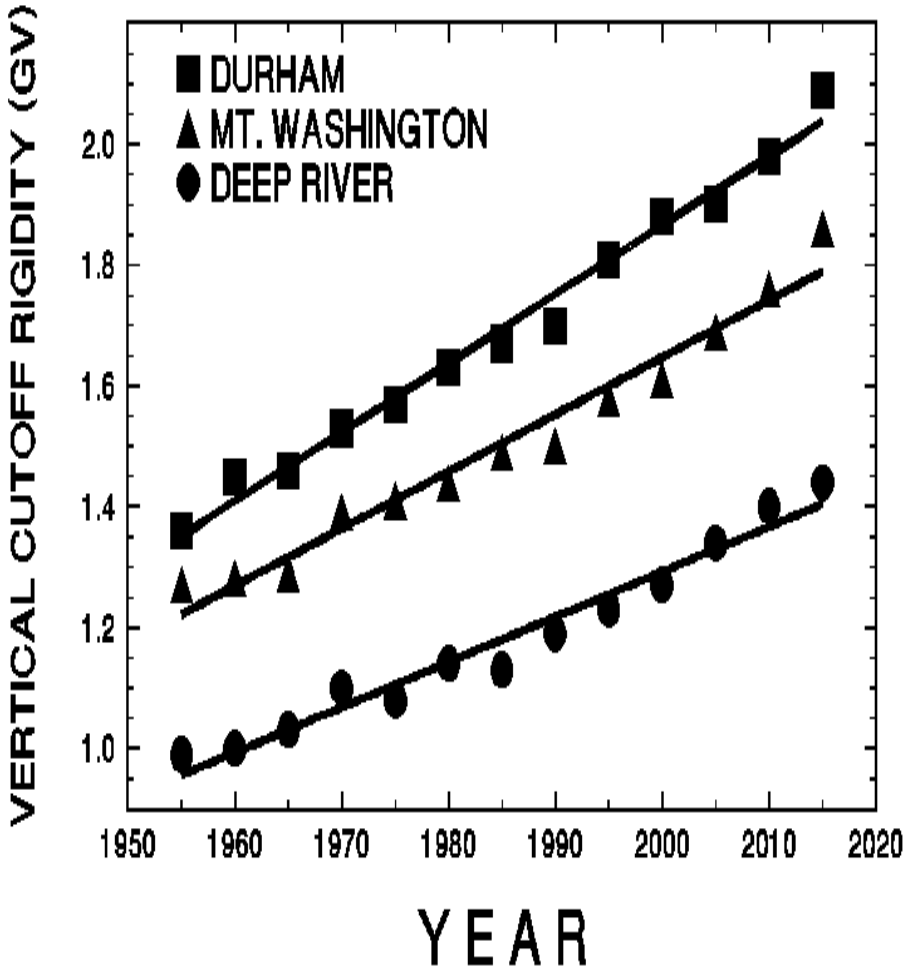
Percent Change in Cutoff Rigidity




VERTICAL CUTOFF RIGIDITY (GV)
3.2
3.1
3.0
2.9
2.8
CLIMAX
1950
1960
1970
1980
1990
2000
2010
2020
YEAR

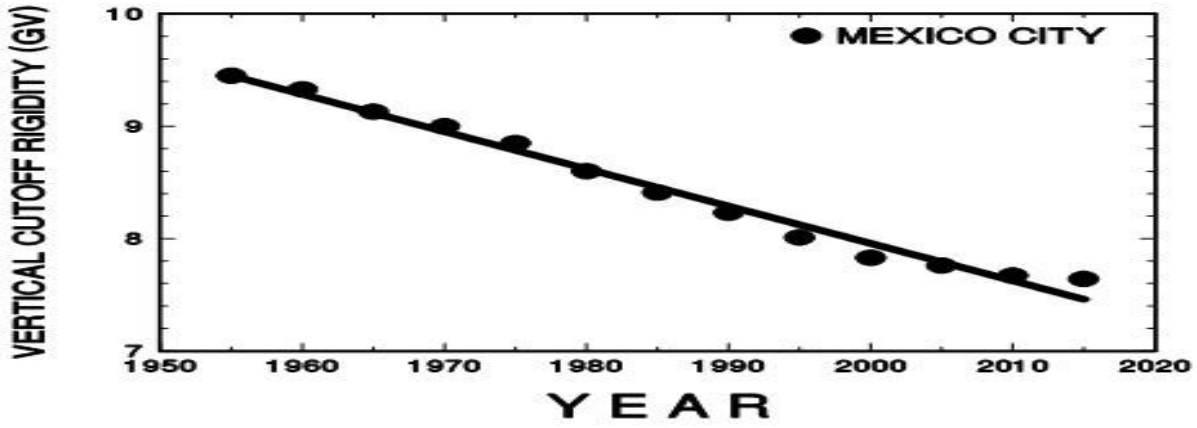

DURHAM
MT. WASHINGTON
DEEP RIVER
VERTICAL CUTOFF RIGIDITY (GV)
2.0
1.8
1.6
1.4
1.2
1.0
1950
1960
1970
1980
1990
2000
2010
2020
YEAR

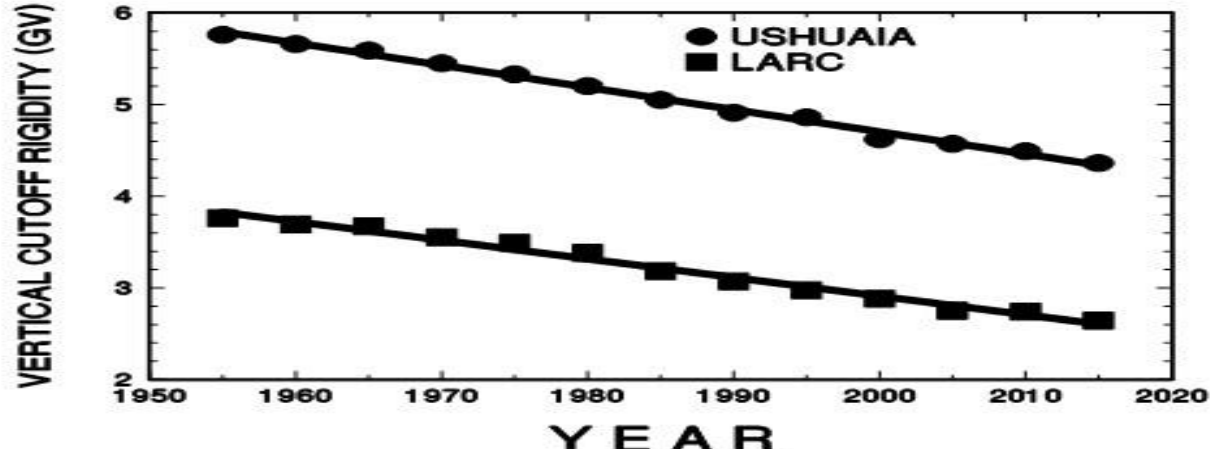


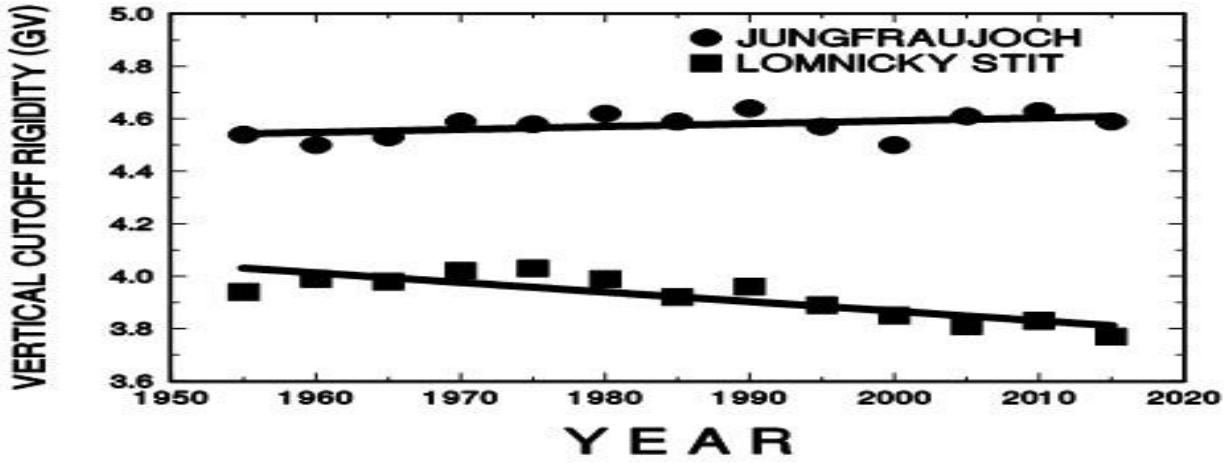


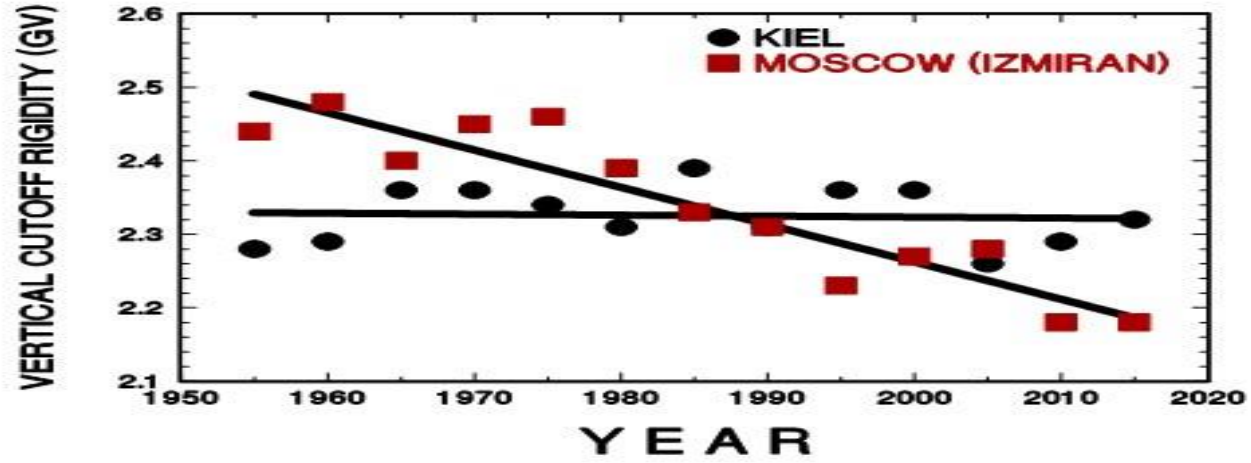
Left: The Climax decrease represents the evolution of the Earth's magnetic field.

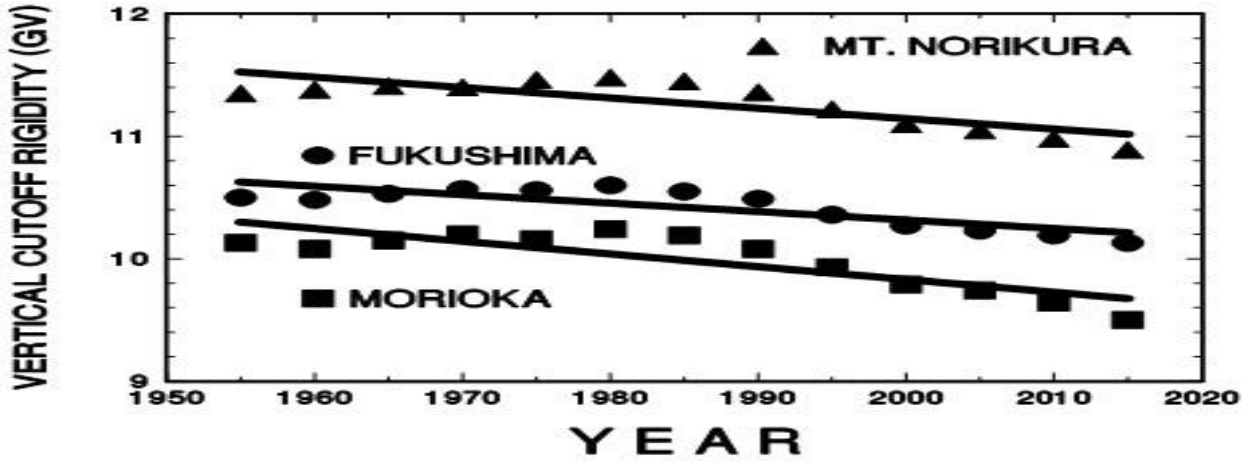
Right: The North-East America increase reflects the **westward drift** of the non-dipole terms of the magnetic field.

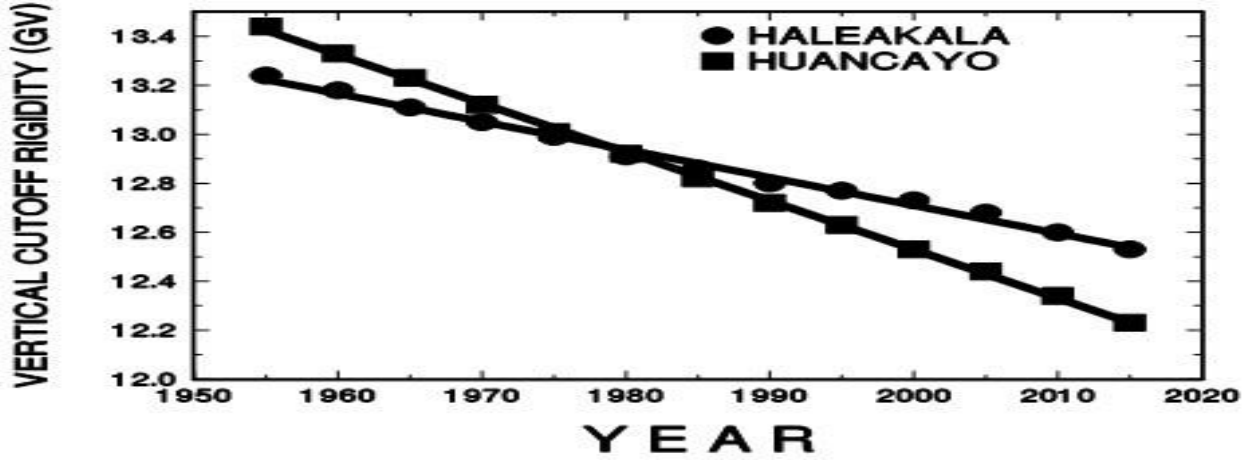

MEXICO CITY
VERTICAL CUTOFF RIGIDITY (GV)
YEAR

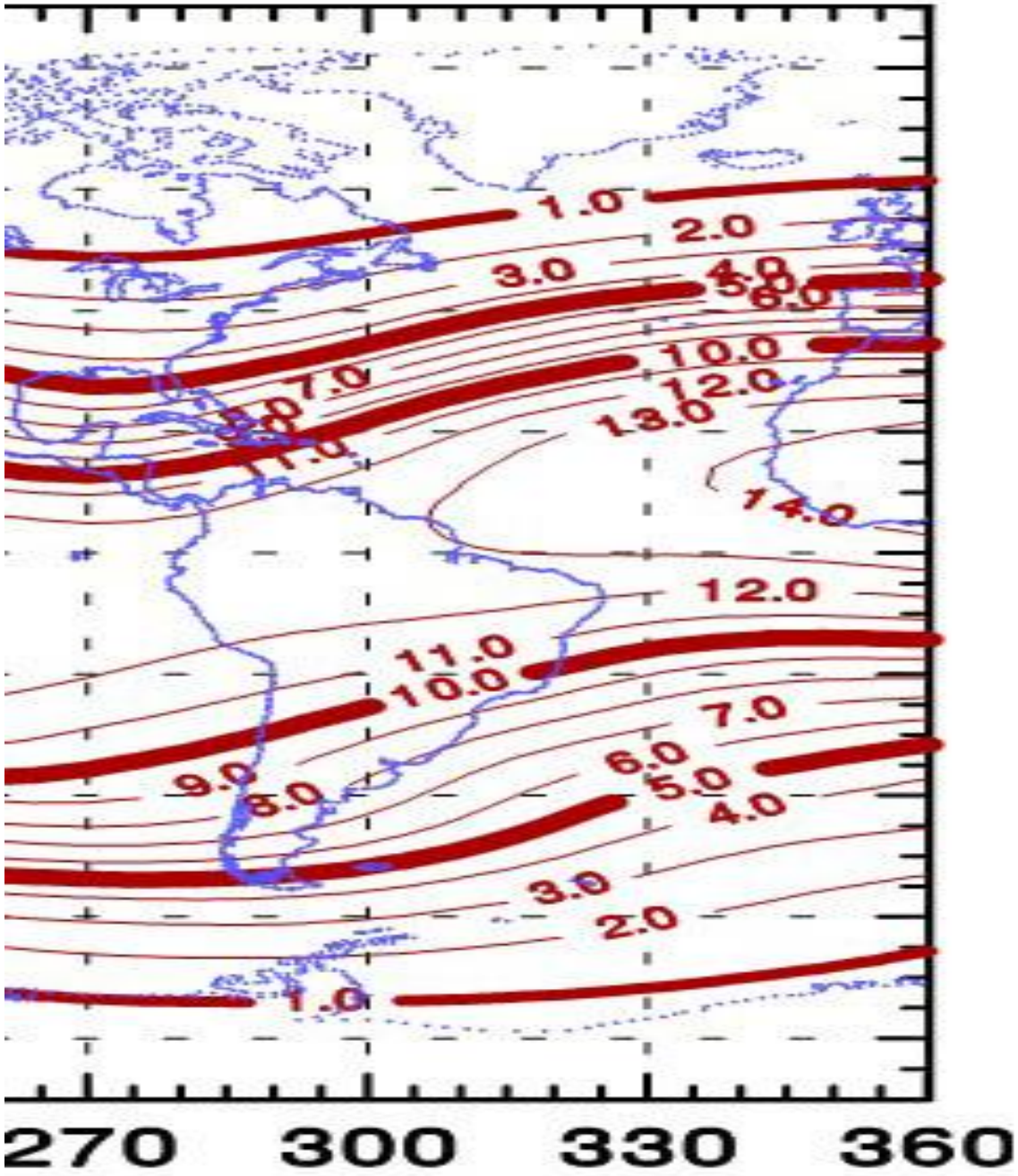

USHUAIA
LARC
VERTICAL CUTOFF RIGIDITY (GV)
YEAR


JUNGFRAUJOCH
LOMNICKY STIT
VERTICAL CUTOFF RIGIDITY (GV)
YEAR


KIEL
MOSCOW (IZMIRAN)
VERTICAL CUTOFF RIGIDITY (GV)
YEAR


MT. NORIKURA
FUKUSHIMA
MORIOKA
VERTICAL CUTOFF RIGIDITY (GV)
YEAR


HALEAKALA
HUANCAYO
VERTICAL CUTOFF RIGIDITY (GV)
YEAR



As a result of the

Westward Drift

of the non-dipole terms,

the cutoff rigidities

in the North Atlantic and

Eastern North America

will continue to increase

In addition the slow general decrease of the main dipole magnetic field, an inspection of a world grid of vertical geomagnetic cutoff rigidities at progressive epochs shows that the westward drift of the non-dipole components of Earth's magnetic field results in an increase in cutoff rigidities along the North American east coast region while there is a continuing decrease in the South American region.

The evolution of these non-dipole components can have a "local effect" on the cutoff rigidity of some cosmic ray stations that must be considered for precision cosmic ray measurements.