FOUR LONGITUDES: THE WAVE-4 STRUCTURE OF THE EQUATORIAL IONOSPHERE AND THE LIMITS OF LONGITUDINAL INDIFFERENCE (ON IMMEL ET AL., 2006)

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Four Longitudes: The Wave-4 Structure of the Equatorial Ionosphere and the Limits of Longitudinal Indifference (on Immel et al., 2006)

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Abstract

In August 2006, Immel and colleagues reported in Geophysical Research Letters that the equatorial ionosphere, seen from orbit in the far-ultraviolet airglow, is organised into four bright regions spaced around the globe in longitude. They traced the pattern to atmospheric tides driven by weather in the tropics. It is the clearest evidence yet that the upper atmosphere above the equator is not the same at every longitude.

In 1885 the Sociedad Ecuatorial de Quito held that longitude is acoustically indifferent. We test the limits of that position. We report a year of evening shortwave reception logged at four equatorial sites, and find that reception quality, at matched local time, differed between the sites in a pattern consistent with the four-peaked structure. We conclude that the Society was right about the listening room and wrong about the sky. Longitude does not reach a recording, a cable or a loudspeaker, but it does reach anything that arrives by way of the ionosphere.

1. INTRODUCTION

The equatorial ionosphere has long been known to form two crests of enhanced density on either side of the magnetic equator, strongest in the afternoon and evening: the equatorial ionization anomaly. Ground stations see it at their own longitudes. It took a satellite to map it at every longitude.

Immel et al. (2006) used the far-ultraviolet imager on NASA's IMAGE spacecraft to map the anomaly's airglow around the globe. They found that its brightness is not even in longitude. It forms four peaks, with four troughs between them. They showed that the pattern matches a non-migrating atmospheric tide excited by the release of latent heat in tropical thunderstorms, which is modulated by the distribution of land and sea. Weather near the ground imprints a four-fold pattern on the ionosphere a few hundred kilometres above it.

2. THE SOCIETY'S POSITION

This laboratory holds the bound proceedings of the Sociedad Ecuatorial de Quito. In its memorial of 1885 on the Washington Meridian Conference, the Society held that longitude is acoustically indifferent: that a sound produced on one meridian is the same as a sound produced on any other at the same latitude. Its argument was sound. Every meridian is equal to every other, the Earth favours none, and the Society's tuning forks heard no difference along the equator.

Immel and colleagues have shown that one part of the Earth's environment does favour some longitudes over others. The question is whether anything audible passes through it.

3. WHAT PASSES THROUGH THE IONOSPHERE

A recording, a cable and a loudspeaker do not. Their signals stay within a few metres of the ground.

Radio does. Shortwave broadcasting reaches distant listeners by reflection from the ionosphere, and the quality of reception depends on the density of the layer that reflects it. If the ionosphere above the equator is organised into four bright regions, a listener's reception should depend on the longitude of the path. The Society's indifference would then hold for the listening room and fail for the antenna.

4. METHOD

Identical shortwave receivers, antennas and logging equipment were installed at four sites within one and a half degrees of the geographic equator and widely separated in longitude: Quito, Nairobi, Pontianak and Singapore. From September 2005 to August 2006, each receiver logged the signal-to-noise ratio of the same fixed set of international broadcasts each evening between 20:00 and 22:00 local time.

The survey was begun to study seasonal fading. After Immel et al. was published, the paths to each transmitter were classified by the longitude of the point at which they crossed the equatorial anomaly. To compare sites, the readings were matched by local time and by daily solar radio flux.

CONFIDENTIAL

5. RESULTS

After matching, median evening signal-to-noise differed between sites by as much as 4.1 dB for the same broadcasts. The ordering of the sites changed with the transmitter, as it must when each path crosses the anomaly at a different longitude.

When each path's reception was compared with the longitude at which it crossed the anomaly, paths crossing near the four longitudes of greatest airglow reported by Immel et al. were received differently, as a group, from paths crossing near the four troughs. The difference held in every month of the year, and it was largest at the equinoxes, when the anomaly itself is strongest.

6. CONCLUSIONS

The Society's indifference to longitude holds for the room. Nothing we have measured suggests that a recording, a cable or a loudspeaker on one meridian behaves differently from the same object on another at the same latitude.

It does not hold for the sky. The equatorial ionosphere has four preferred longitudes, and a listener whose programme arrives by shortwave hears them.

We propose a distinction that the Society did not need in 1885: between the listening room, where longitude is indifferent and latitude is not, and the path by which a broadcast reaches it, where both matter. A listener who wishes to be free of the first concern should live on the equator. One who wishes to be free of the second should not rely on the sky.

EDITORIAL NOTE (2026)

This is the last technical note Dr Magnus Ferro published at the Geomagnetic Laboratory of the University of Quito before his attention turned to audio, and it is reproduced from that series. Its distinction between the room and the path still informs Equatorial Audio's position on longitude, in a refined form. Dr Ferro's 2006 view that longitude is simply indifferent to the listening room was later qualified: the local field's declination, inclination and intensity do vary with longitude, and the Society's indifference holds only once present-day installation procedures have compensated all three.

Immel et al. (2006) is real and summarised accurately. The four-peaked longitudinal structure has since been confirmed by other satellites and is now studied as a standard feature of the equatorial ionosphere. Thomas Immel later led NASA's Ionospheric Connection Explorer (ICON), launched in 2019 to study exactly this coupling between weather below and the ionosphere above. The reception survey is reproduced as recorded and has not been repeated.

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