



NEWS! From the NAVAL OBSERVATORY

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U.S. Naval Observatory Press Release

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FOR IMMEDIATE RELEASE

New Research Explains Moving Meridian Mystery

A paper recently published in the *Journal of Geodesy* has now answered a long-standing question asked by navigators, academics, and London tourists: Why doesn't zero longitude run through the Royal Observatory, Greenwich?

In 1884, the International Meridian Conference recommended that the prime meridian “to be employed as a common zero of longitude and standard of time-reckoning throughout the globe” pass through the “centre of the transit instrument at the Observatory of Greenwich”. This instrument, erected by Astronomer Royal George Biddell Airy in 1835, is now augmented by a brass and steel strip in the pavement marking the meridian line and is one of the most popular tourist attractions in London.

However, a GPS receiver will indicate a longitude of $00^{\circ} 00' 05.3''\text{W}$, when placed over the meridian line so that visitors must walk east approximately 102 meters before their navigation devices indicate zero. Most explanations of this longitude offset at Greenwich — particularly those aimed at the general public — acknowledge it, but do not assign a cause, or offer incorrect explanations.

The scientific reasons for this offset have now been addressed through the collaborative effort of researchers working with government, academic, and commercial organizations: Stephen Malys and Nikolaos K. Pavlis of the National Geospatial-Intelligence Agency (NGA), John H. Seago of Analytical Graphics, Inc. (AGI), P. Kenneth Seidelmann of the Astronomy Department, University of Virginia, and George H. Kaplan, a contractor with the U. S. Naval Observatory in Washington, DC. These authors attribute the difference to a change from astronomical to geodetic coordinates in the Terrestrial Reference System.

Astronomical time (determined by the rotation rate of the Earth) was originally measured by astronomical instruments like the Airy Transit Circle. These optical devices used mercury basins to establish a local vertical plane of reference aligned to local gravity.

By the 1980s, however, space-age techniques like satellite-navigation receivers, satellite and lunar laser-ranging, and Very Long Baseline Interferometry replaced the older technology of transit instruments. These systems were not affected by gravitational anomalies at the surface of the Earth. In 1984, the *Bureau International de l'Heure* (BIH, International Bureau of Time)

fully converted from using “astronomical” station coordinates based on local gravity, to a “geocentric” system of station coordinates, based on verticals going through the rotation axis of the Earth as opposed to locally-measured verticals. There was also the requirement that continuity be maintained in the measurement of astronomical time through that transition. This BIH Terrestrial Reference System provided the basis for orientation of subsequent geocentric reference frames, including the World Geodetic System 1984 (WGS 84) used by GPS.

The 102-meter offset at Greenwich can be attributed to the difference between astronomical and geodetic coordinates, called the deflection of the vertical, in the east-west direction at the Royal Observatory. High-resolution global gravitational models of the Earth confirm that the direction of gravity at Greenwich is of the proper sign and magnitude to support this interpretation, conclusive to ± 10 meters in longitude using the most recent vertical deflection model. Specifically, the gravitationally deflected meridian plane originally observed by Airy’s Transit must be translated about 102 meters to the east if that directional plane is to pass through the axis of the Earth *and* maintain the same astronomical time as would have been observed from the old observatory site.

For supporting evidence, the authors also analyzed the differences between astronomical and geodetic coordinates of many observatories contributing to the global determination of astronomical time during the 20th century. This analysis affirms that no significant global rotation of longitudes occurred between the former astronomical system, based on the Airy Transit Circle, and the current geocentric system, used by GPS. Instead, the differences in the local coordinates of old astronomical stations are simply a localized gravity effect due to the deflection of the vertical.



**The Airy meridian marked as the “Prime Meridian of the World” (dotted line), and the ITRF Reference Meridian indicating zero longitude using GPS (solid line).
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