Chimborazo’s Summit, 2585.39 m Lower Than Everest’s, Is 2079.524 m Farther From Earth’s Centre

— The difference between the equatorial and polar radii of the Earth ellipsoid is **21384.686** m, **2.416660** times the height of Everest — the separator is whether height is measured from sea level or from Earth’s centre (whether the equatorial bulge enters) — [Paper 787]

Yuuki YAMAGISHI (山岸 勇輝)
Yamagishi Complexity Torus Lab, Japan
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— From thinking to syncing. —

Abstract

The highest mountain is Everest. That, however, is the answer when height is measured from sea level.Taking into account that Earth is an ellipsoid bulging at the equator, the same mountains are re-ranked by height above sea level and by distance from Earth’s centre, and how the order swaps is counted.No new theorem or law is claimed. First, the equatorial bulge is larger than Everest——the difference between equatorial and polar radii, 21384.686 m, is 2.416660 times Everest’s height (Section 2). **Second, and this is the core. The summit farthest from Earth’s centre is Chimborazo——2585.39 m lower than Everest, yet 2079.524 m farther from the centre** (Section 2). **Third, this swap is well above the neglected offset——the difference of 2079.524 m is 20.795240 times the scale of the sea-level-to-ellipsoid offset (a hundred metres)** (Section 3). **Fourth, the order among near-equatorial mountains cannot be decided——the 14.601 m difference between Chimborazo and Huascarán is 0.146007 of that scale** (Section 3). **Fifth, nor can the mountain where one weighs least——by the normal gravity formula Huascarán is lightest at 9.760737 m/s^2, but its difference from Chimborazo equals 95.001 m of height** (Section 3). **Sixth, the separator is whether height is measured from sea level or from Earth’s centre (whether the equatorial bulge enters)——“the highest mountain is Everest” has no truth value until one says what it is measured from** (Section 4). **Keywords**: Earth ellipsoid, equatorial bulge, geocentric distance, geoid, normal gravity, mountain height.

Scope of this paper (scope note): **No new theorem or law is claimed——Earth being approximated by an ellipsoid of revolution, the formula for distance from Earth's centre from geodetic latitude and height, the normal gravity formula, and the summit farthest from Earth's centre not being Everest are all known (Hofmann-Wellenhof and Moritz 2006, Torge and Müller 2012).Sea level is taken as the ellipsoid——the offset between sea level (the geoid) and the ellipsoid is neglected. That offset is known to be of the order of a hundred metres over the Earth, and it is used here only as a yardstick for whether a difference is large enough to rank.Gravity is a formula value——changes in gravity from the mass of the mountains themselves or from subsurface density are not included.Mountain values are inputs——the heights and latitudes of nine mountains are representative survey values, and their correctness is not treated.Which is truly highest is not decided——only the order under each yardstick is tabulated.Relation to earlier papers**: **Paper 404 showed that the horizon is not the limit of what can be seen——its scope note stated that Earth was taken as a sphere and that flattening, sea swell and tide were not its subject. There the distance visible on a sphere was counted. Here the sphere gives way to an ellipsoid, and the equatorial bulge is counted as swapping "the highest".**What is added is **tabulating height above sea level, distance from Earth's centre and normal gravity for nine mountains, with distance matched by two formulas, deriving the $\mathbf{2079.524}$ m difference between Chimborazo and Everest, comparing with the scale of the neglected offset to separate orders that may be stated from those that may not**, and **placing the separator on what height is measured from**.

1. Notation and the Question

Setting: **let a be the equatorial radius of the Earth ellipsoid, e its first eccentricity, φ a mountain's geodetic latitude and h its height. The distance r from Earth's centre and the gravity γ, normal gravity with a height correction, are as follows (γ_e and k are GRS80 constants).**

$$N(\varphi) = \frac{a}{\sqrt{1 - e^2 \sin^2 \varphi}}, \qquad r = \sqrt{\left((N + h)\cos\varphi\right)^2 + \left((N(1 - e^2) + h)\sin\varphi\right)^2}$$

$$\gamma(\varphi, h) = \gamma_e \frac{1 + k \sin^2 \varphi}{\sqrt{1 - e^2 \sin^2 \varphi}} - 3.086 \times 10^{-6}\, h$$

Question: **is the highest mountain the same however it is measured?**

2. Three Yardsticks

Computation 2.1: **for nine mountains, height above sea level, distance from Earth's centre and gravity were derived. Distance was derived two ways, by the Cartesian formula and by adding height along the normal to the parametric point of the ellipse, with a largest difference of 1.863×10^{-9} m. Gravity by the normal gravity formula and the 1980 series formula differed by at most 2.063×10^{-6} m/s^2.**

mountain	latitude	height above sea level	distance from Earth's centre	gravity
Everest	+27.9881°	8848.86 m	6382307.005 m	9.764400 m/s^2
K2	+35.8825°	8611.00 m	6379441.846 m	9.771516 m/s^2
Aconcagua	−32.6532°	6961.00 m	6378909.503 m	9.773894 m/s^2
Huascarán	−9.1217°	6768.00 m	6384371.929 m	9.760737 m/s^2
Chimborazo	−1.4692°	6263.47 m	6384386.529 m	9.761030 m/s^2
Denali	+63.0692°	6190.00 m	6367358.307 m	9.802407 m/s^2
Cotopaxi	−0.6838°	5897.00 m	6384030.980 m	9.762135 m/s^2
Kilimanjaro	−3.0674°	5895.00 m	6383971.277 m	9.762281 m/s^2
Mauna Kea	+19.8207°	4207.30 m	6379903.821 m	9.773281 m/s^2

Observation 2.2

the equatorial bulge is larger than Everest.The difference between equatorial and polar radii is 21384.686 m, 2.416660 times Everest's height——which latitude one stands at can matter more than differences in height above sea level.

Observation 2.3

this is the core: the summit farthest from Earth's centre is Chimborazo.By height above sea level the order is Everest, K2, Aconcagua, Huascarán, but by distance from the centre it is Chimborazo, Huascarán, Cotopaxi, Kilimanjaro, and Chimborazo, 2585.39 m lower than Everest, is 2079.524 m farther——mountains standing near the equator are lifted by the bulge.

Observation 2.4

high mountains at high latitude are close to the centre.Denali at 63.0692° N stands 6190.00 m above sea level, higher than Mauna Kea, but its distance from the centre, 6367358.307 m, is less than Mauna Kea's 6379903.821 m.

3. Orders That May and May Not Be Stated

Computation 3.1: **taking the neglected offset between sea level and ellipsoid (the geoid undulation) as of the order of a hundred metres, the differences that decide the order were compared with it.**

pair compared	difference	ratio to the offset scale
Chimborazo – Everest (from centre)	**2079.524** m	**20.795240**
Huascarán – Chimborazo (from centre)	**−14.601** m	**0.146007**
Huascarán – Chimborazo (gravity)	**−0.000293** m/s² (**95.001** m of height)	—

Observation 3.2

the swap between Chimborazo and Everest is well above the neglected offset.The difference of 2079.524 m is 20.795240 times the offset scale——including the sea-level-to-ellipsoid offset would not move this order.

Observation 3.3

the order among near-equatorial mountains cannot be decided.The difference in distance from the centre between Chimborazo and Huascarán is 14.601 m, only 0.146007 of the offset scale. By the normal gravity formula Huascarán is lightest at 9.760737 m/s², but its difference of 0.000293 m/s² from Chimborazo equals 95.001 m of height, so that order is not decided either——even when numbers line up in a table, an order must not be stated on a difference smaller than what was neglected.

4. The Separator

Observation 4.1

the separator is whether height is measured from sea level or from Earth's centre (whether the equatorial bulge enters).Measured from sea level, Everest is first; measured from the centre, Chimborazo, 2585.39 m lower than Everest, is 2079.524 m farther——"the highest mountain is Everest" has no truth value until one says what it is measured from.

Observation 4.2

beside Paper 404.Paper 404 took Earth as a sphere and showed that the horizon is not the limit of what can be seen——here the sphere gives way to an ellipsoid, and the equatorial bulge is counted as swapping "the highest".

Observation 4.3

what is not said.Neither the sea-level-to-ellipsoid offset itself, nor gravity changes from mountain mass, nor the correctness of survey values is treated——what is shown is that changing the yardstick swaps the order, and among such swaps some may be stated and some may not.

5. Roll Call and Closing

1. **equatorial bulge 21384.686 m** (Observation 2.2): **2.416660 times Everest.**
2. **Everest's distance from centre 6382307.005 m** (Computation 2.1): **first from sea level.**
3. **Chimborazo 6384386.529 m** (Computation 2.1): **first from the centre.**
4. **2585.39 m lower, 2079.524 m farther** (Observation 2.3): **the core.**
5. **Denali 6367358.307 m** (Observation 2.4): **high latitude is close.**
6. **20.795240 times the offset scale** (Observation 3.2): **an order that may be stated.**
7. **difference from Huascarán 14.601 m** (Observation 3.3): **an order that may not.**
8. **gravity 9.760737 m/s^2** (Observation 3.3): **lightest by formula.**
9. **95.001 m of height** (Observation 3.3): **also not decided.**
10. **what it is measured from** (Observation 4.1): **the separator; Paper 404.**

Closing: **Chimborazo's summit, 2585.39 m lower than Everest's, is 2079.524 m farther from Earth's centre.The difference between equatorial and polar radii of the Earth ellipsoid is 21384.686 m, 2.416660 times Everest's height, and the order by height above sea level, Everest, K2, Aconcagua, Huascarán, swaps by distance from the centre to Chimborazo, Huascarán, Cotopaxi, Kilimanjaro——the difference of 2079.524 m is 20.795240 times the scale of the neglected sea-level-to-ellipsoid offset, so this swap does not move.By contrast, the 14.601 m difference between Chimborazo and Huascarán is only 0.146007 of that scale, and Huascarán's gravity difference from Chimborazo, lightest by the normal gravity formula, equals only 95.001 m of height, so neither order is decided——changing the yardstick swaps the order, but nothing can be said on differences smaller than what was neglected.The separator is**

whether height is measured from sea level or from Earth's centre (whether the equatorial bulge enters).Placed among the earlier papers——Paper 404 counted visible distance on a spherical Earth; this makes it an ellipsoid and counts "the highest" swapping.To be honest——neither the sea-level-to-ellipsoid offset itself nor gravity changes from mountain mass are treated.

References

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Yuuki YAMAGISHI (山岸 勇輝)

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