EMINENT PEAKS - found by a new and objective criterion

Joseph Weinstein

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1 Introduction

Atlases and almanacs often include lists of the world's 'highest' or anyhow most eminent peaks. The typical list priority is by height, i.e. summit elevation above sea level. That is, the higher a listed peak, the earlier it is listed, with Everest always the first peak listed.

Two types of list are now common, each with its uses, merits and intuitive appeal. In both types, however, the listed peaks are selected using inherently subjective criteria. After discussing these lists and their criteria, we describe and illustrate a new and fully objective criterion, termed dominance, for selection and prioritized listing of the world's most eminent peaks.

2 Existing lists

The older-style type-1 lists pay heed to geographic diversity as well as to absolute height, so that the lists include locally high peaks of various regions. See, e.g., reference NYT94, The New York Times Atlas of the World, 3rd revised concise edition, 1994. (Note its table, p. 33, of about 50 'Mountain heights'.) The newer-style type-2 lists go more strictly by absolute height: they list mainly Himalayan and a few Andean summits, most of them relatively unknown. See, e.g., reference IP98, Information Please Almanac for 1998. (Note its table, pp. 474-476, of about 120 'Highest mountain peaks of the world'.)

To illustrate the difference between the types, consider a case of three summits - A, B and C - with A very high, B close to A and nearly as high, and C far away and much lower but dominating a large region. For example: A=Everest, B= Lhotse, C=Kilimanjaro. A type-1 list will tend to include A and C but not B. A type-2 list will tend to include A and B but not C.

3 Subjective criteria

Both existing types of list seem to rely on one basic and quite objective criterion - height - for inclusion of summits. However, the lists also tacitly mix in the following three other key criteria which are seriously subjective, being imprecise or arbitrary or both.

Naming. Typical lists include only summits which have been specially 'named', in languages and ways agreeable to the lists compiler. This subjective restriction is silly: after all, every point on earth's surface is uniquely 'named' by its latitude-longitude coordinates.

Geographic diversity. In type-1 lists, the geographic-diversity criterion lacks an objective definition, and moreover is subjectively combined (i.e. traded off) with the height criterion.

Definition of 'summit' For both list types, the most serious subjectivity problem arises from lack of - or arbitrariness in - definition of 'peak' or 'summit'. After all, just which summits are highest depends on just how 'summit' is defined.

4 Details and inherent subjectivity of 'summit' definitions

In essential concept, 'summit' may be defined precisely as follows. Consider any point P on earth's surface. (For the term 'point one may fix either a geometric sense or a more physical sense - e.g., 'molecule'.) For brevity and later convenience we shall say that P dominates another point Q if P is higher than Q. The dominance radius RD of P is the largest distance up to which (in any direction from P) P dominates every point. The circle-bordered zone which surrounds P out to a distance RD we term the dominance zone of P. (For the world's highest point, RD is the distance to the antipodes, i.e. halfway around the earth, and the dominance zone is the entire surface of the earth. For any other surface point P, RD equals the distance to the nearest other surface point Q which is at least as high as P.) P is defined to be a summit (i.e., a summit point) provided its dominance radius RD is sufficiently large, i.e. is at least a minimum required value RDMIN.

Because RDMIN is the minimum allowed distance between distinct summits, different RDMIN values will yield quite different numbers of defined 'summits' (high or other): the smaller the value, the more summits. The basic and inherent subjectivity problem is that there is no agreed-on - or objectively preferable - value for RDMIN.

Taking RDMIN=zero would make absurdly futile any attempt to create a workable list of the world's 'highest summits. Indeed, the worlds first zillion highest summits would all be molecules (or geometric points) within a few me-

ters of the tiptop of Everest.

On the other hand, taking any particular positive value for RDMIN would be arbitrary - and a very small positive value would yield much the same silly situation as for RDMIN=0. As it happens, the most popular tacitly chosen values seem to be decreasing with time. Fifty years ago, few lists deemed Lhotse as a 'summit' in its own right, distinct from Everest; but nowadays various lists not only include Lhotse but indeed attribute two distinct 'summits' to Lhotse.

[Digression: As noted, ever-smaller RDMIN values will yield ever larger numbers of 'summits' and different lists of the highest summits. Likewise, ever-smaller values for another distance criterion, namely pace-length, will yield ever-larger values for another intuitive geographic concept, namely 'length' of a given coastline. Should one pace a coastline mile by mile, yard by yard, or molecule by molecule? Subjectivity of 'coastline length' was allegedly noted decades ago by John von Neumann - the famed genius mathematician, physicist, game theorist and computer scientist - and nowadays is generally recognized. For instance, IP98 - whose supporting text reveals no awareness of the subjectivity of the 'highest peaks' concept - presents also a table of coastline lengths: that table's supporting text gives details of the required arbitrary choices made concerning pace-length and length calculations. As an alternative, to avoid some of the subjectivity in coastline length, one may follow Benoit Mandelbrot and model a coastline as a fractal object, of non-integer dimension (between one and two). However, actual coastlines plausibly admit diverse fractal models of diverse dimensions; anyhow, a fractal-dimensional coastline size no longer responds to intuitive quest for a one-dimensional length.]

5 Dominance: a workable objective criterion of eminence

As noted above, existing lists of prominent peaks are based tacitly on a concept, namely 'summit point', whose precise definition requires comparison of each surface point's dominance radius RD with an arbitrarily fixed value RDMIN. We now propose instead to use RD values directly, without any need to specify RDMIN or to precisely define 'summit point'.

Namely, we may simply and objectively measure the eminence of any surface point P (or of any peak or other feature for which P is the highest point) by its dominance, i.e. the value of its dominance radius (alternatively but equivalently, by the area of its dominance zone).

Use of dominance not only avoids the subjectivity inherent in the definition of 'summit', but also achieves objectively what type-1 lists try to do subjectively. Namely, dominance incorporates both height and geographic diversity, and objectively trades off these elements. The dominance of a point P reflects its height in comparison with the heights of surrounding points: the greater the height of P, or the further away P is from other high points, the greater

the dominance. Like the table in NYT94, or other type-1 lists, the objectively determined '50 most dominant' peaks include not only Everest but also locally high peaks of every continent and region.

6 List orderings

The initially natural priority for listing the world's 50 or 100 or other given number of 'most dominant' points (or peaks) is by dominance (i.e., by size of dominance radius, starting with the largest, i.e. Everest's). Given any two dominance-priority lists of the world's 'most dominant, the shorter list must match the first part of the longer list, entry for entry. For instance, entry number 2 on the length-5 list (namely Aconcagua) will also be entry number 2 on the length-500 list.

Of course, the lists may be rearranged so that priority is by some criterion other than dominance. Then all entries on the shorter list remain on the longer list, but no longer need the lists match entry for entry. For example, if both lists be rearranged to priority by height, the length-5 list keeps Aconcagua as entry 2 but the length-500 list has K2 as entry 2.

7 The world's seven most dominant peaks

Here, in priority of dominance, are the world's seven most dominant points (i.e., the peaks which they cap). Note that this brief list already manifests the geographic diversity which, subjectively, is designed into type-1 lists.

Along with each peak's name is given its general locality, its height in meters, and its approximate dominance radius RD. For the RD values, the unit used is one-eighth ($= 45^o$ of arc) of the earth's equatorial circumference - approximately 5,000 km or 3,100 miles. The RD values were estimated by analog modeling - namely using fingers and string on a small globe.

No.	Peak name	Continent and region/range	Height (m.)	Approx. RD
1.	Everest	Eurasia - Himalaya	8848	4.0
2.	Aconcagua	S. America - Andes	6960	3.2
3.	Denali (McKinley)	N. America - Alaska	6194	1.3
4.	Kilimanjaro	Africa - Tanzania	5895	1.0
5.	Jaya (Carstensz)	Australasia - W. NewGuinea	5030	1.0
6.	Aoraki (Cook)	Australasia - N.Z. /S. Alps	3754	1.0
7.	Vinson	Antarctica - W.	4897	1.0

Table 1: Table for the seven most dominant peaks

The seven listed points are the only ones for which RD is anywhere as large as 1.0 (or more). Among the last four listed points - which have the common

approximate RD value of 1.0 - the listed dominance order is a current best guess, subject to later revision.

8 Regional eminence

The above version of dominance radius of a point P is global: in height, P is compared with all other surface points. However, for any region containing P, there is also a regional version: the regional dominance radius of P is the greatest distance within which P dominates each point Q which lies in the region. Note that the regional dominance radius must be at least the global dominance radius, and may exceed it.

For defining a given region's 'most eminent' points, one may use either version of dominance, global or regional. Just which version is used must be explicitly noted, because the versions may give quite different results.

For one example, the state of Nevada contains two notable peaks, Boundary and Wheeler, both very nearly 4000 meters high. Boundary (4005 m), near the western border with California, is slightly higher than Wheeler (3982 m), near the eastern border with Utah. Boundary is Nevada's highest point, hence is the state's most dominant point, regionally. However, as Boundary is near California's White Mountain (4342 m), Wheeler is by far the more dominant, globally.

On the other hand, for California the three points which are most dominant globally are also the most dominant regionally. Namely, they are (in priority either by dominance or height - both criteria agree here): Whitney (4418 m), Shasta (4317 m), San Gorgonio (3505 m).

9 Conclusion and caution

Dominance is an more feasible objective criterion than absolute height for selecting a finite set of 'most eminent' points on the surface of the earth or of a like planetary body. Dominance incorporates and trades off both height and geographic diversity. Of course, any long prioritized list based on comparison of measured values - be they of dominance radius or of absolute height - is prone to some errors and thus future revisions. Use of dominance will require careful calculation of many hitherto unheeded inter-peak distances.