Viewing the Vagaries and Verities of Virga

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Sassen and Krueger (1993) fail to distinguish between a definition and an explanation: they imagine that virga is *defined* as precipitation that evaporates before reaching the ground rather than sometimes being *explained* as such. We chose a definition of virga based upon its observable properties: a sudden change of the brightness of a precipitation shaft. Far from being the "misleading view of virga" [as Sassen and Krueger assert], this is the traditional characteristic used to identify virga apparently from antiquity. Over the centuries, the word "virga," from the Latin *rod* also has been applied to other rodlike, columnar, or streaky structures in the sky, such as segments of the rainbow and sun pillars (Boyer 1959). In recent centuries the word's application has been narrowed to just those sudden brightness changes that accompany precipitation. When Schaefer and Day (1981) published their picture of virga, they were indeed presenting the popular image of the phenomenon as Sassen and Krueger claim, but that image is hardly erroneous, for it defined virga long before the recent revisionist attempts to transform a conjectural explanation (that the brightness change results from evaporation) into a definition.

In the first draft of their criticism of our paper, Sassen and Krueger included no references to glossaries purporting to define virga. After having seen our response to their first draft, in which we quoted the definition from the *International Cloud Atlas* (WMO 1956), they incorporated the definition in their present version as if to imply that it supported their position. However, the World Meteorological Organization definition is strictly descriptive.

"Vertical or inclined trails of precipitation (fallstreaks) attached to the under surface of a cloud, which do not reach the earth's surface."

As the *International Cloud Atlas* is an observer's guidebook, one can but assume that in saying precipitation does "not reach the earth's surface" its authors were asserting that precipitation is not *observed* to reach the surface. There is no presumption as to why it is not seen to reach the surface (for example, because it evaporated). This is in keeping with the way in which we define virtually all natural phenomena: by appearance rather than explanation.

We define everything from a rainbow and a cumulus cloud to a cyclone or a jet stream by their observable features. We (partially) explain them by evoking physical processes such as refraction, convection, Coriolis force, or the thermal wind. We have consistently resisted any temptation to define observable phenomena such as a cumulus cloud, say, on the basis of some modeler's theory of how it works. Yet, that is just what Sassen and Krueger are inviting us to do in the case of virga—not only inviting us but, historical evidence to the contrary, claiming that the explanation of evaporation is the traditional definition.

We acknowledge that there are some books such as the aforementioned Schaefer and Day that sloppily conflate the definition with a conjectural explanation. The first book we are aware to do this is the American Meteorological Society's *Glossary of Meteorology:*

"Wisps or streaks of water or ice particles falling out of a cloud but evaporating before reaching the earth's surface."

In a misguided attempt to be helpful, the authors of this definition offered an untested hypothesis about what caused that which had long been called virga, and in doing so, glibly transformed it into a revealed truth. Other authors, and apparently researchers, believed them.

From the outset of our paper, we tried to make it clear that we were concerned with what people, not instruments, observe—after all, naked-eye observations form the centuries-old criterion for the identification of virga. Thus, we began our paper with a typical textbook assertion about virga as a visual phenomenon. We do not agree with Sassen and Krueger that "[b]rightness is a vague quantity dependent on what part of the electromagnetic spectrum we are probing." Brightness differences are what people see, and people see only a narrow range of wavelengths within the electromagnetic spectrum. Life as we know it is possible only because we see brightness differences.

The first sentence of our abstract contains the theme of our paper: "The visual phenomenon called virga, a

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sudden change in the brightness of a precipitation shaft below a cloud, is commonly attributed to evaporation of raindrops." Everything that follows is a critical examination of the ramifications of this sentence, in which brightness is established as a visual characteristic. If readers are in doubt, they need merely insert "visual" in front of "brightness" wherever it occurs in our paper. It is indeed true that brightness is sometimes used in referring to other parts of the electromagnetic spectrum (rather than the more appropriate "radiance"). And radars observe different brightness variations in a given scene than do humans. Sassen and Krueger's discussion of these other wavelengths is all very interesting but not relevant to a paper devoted in its entirety to explaining observations made by humans making use of visible electromagnetic radiation.

Sassen and Krueger go to great lengths to suggest that somehow their definition by explanation is "demonstrated through remote sensing measurements using radar or lidar." How it is possible to demonstrate a definition by evoking data is beyond us. In the process, they seem to be trying to convince the reader that rain really can evaporate as it descends, while they try simultaneously to convey the impression that we think it cannot. Yet, not only were calculations of evaporation presented in our paper, we used them to show that, within the framework of our conceptual model, rain does not evaporate in such a way as to give abrupt changes in brightness. Thus, to explain such a change—which in our experience is invariably called virga—one must look for other mechanisms. Note the first sentences in our Conclusions: "Evaporating rain shafts do change in optical thickness with distance below a cloud, which can result in observable consequences. But this change is gradual rather than abrupt. Our analysis suggests that evaporation of hydrometeors is not responsible for a sudden change in brightness of a precipitation shaft below a cloud."

We thank Sassen and Krueger for pointing out the short paper by Vonnegut and Moore that we had overlooked, although we do not agree with them that "virga . . . has long been recognized as a visual bright band analogue." Every textbook and monograph we know of, every conversation with colleagues and students, points to the conclusion that the facile explanation of virga (brightness-change definition) as rain that evaporates before reaching the ground is considered to be so self-evident as to require no analysis. What Sassen and Krueger claim to have been "long recognized" is not recognized in any of the works we know, nor, indeed, in any work cited by them [other than the paper by Vonnegut and Moore (1960)].

We note that Vonnegut and Moore ascribe the change in brightness at the melting level to the "larger specific surface area [of snow] than the rain." Although this contributes to the brightness change, it is not the dominant factor. Of greater consequence is the decrease in number density of hydrometeors because of increased fall velocity.

Throughout their note, Sassen and Krueger seem to want to establish two basic points: precipitation can evaporate before reaching the ground; the name for such precipitation is virga. Of the first, we have no quibble. Further, we are at a loss to understand why they think the existence of evaporation (no matter how observed) was ever a source of contention—rather, the contention was whether evaporation could produce the abrupt changes in brightness traditionally known as virga. Of the second, we believe that they have uncritically transformed a dubious explanation of an observable phenomenon into a nouveau definition and in the process tried to appropriate a word with a very different basic meaning.

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