Reply

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We appreciate the comments of Juvik and Nullet (1995, hereafter JN) on our proposed standard fog collector (SFC) (Schemenauer and Cereceda 1994a, hereafter SC). The comments serve to emphasize the importance of the fog deposition process in certain upland environments.

Juvik and Nullet indicate they would be less troubled by some of the design features of the SFC if "the authors simply proposed its use for coastal fog deserts such as those of Chile where it was developed." They feel it has limitations for use at high elevations, yet fail to appreciate, first, that the application in Chile was not with "advection fogs off the ocean" but rather with clouds moving over mountainous terrain, and, second, that the application in Chile was at an elevation of 800 m. The application in Canada, described in SC, was at 845 m, and the collectors have been used very successfully in Ecuador at 2800 m. Third, the SFC, like all passive collectors, needs wind in order to collect fog, and that is why we proposed its use in mountainous areas rather than on coastlines where winds are lighter.

1. Fixed orientation

As is rightly stated by JN, and discussed in SC, a cylindrical fog collector has the advantage of a uniform exposure to winds from all directions. However, the flat-panel SFC is simpler and cheaper to construct and can be easily built in workshops in developing countries. The SFC will also collect fog with winds from all directions, though with an acknowledged, diminished efficiency when the wind is parallel to the panel surface. However, even this extreme situation allows for the documentation of the presence of fog by the SFC. In actual field use, this has not been found to be a major problem at mountain sites (100–3000 m) in Chile, Peru, Ecuador, Oman, Canada, Australia, and Namibia where the SFC has been used in projects. This is because it is not the range of wind directions at a site that is important, it is the wind direction during fog events. Most sites have been found to have a restricted range of wind directions during fog events, and thus the SFC panel can be mounted perpendicularly to the prevailing direction from which the fog comes. We have used an omnidirectional (wind-vane driven) SFC to determine the prevailing wind direction during fog events, but do not suggest it be used in large numbers or on a routine basis.

2. Separation of vertical and horizontal precipitation

Juvik and Nullet state that the SFC "provides no mechanism for separating the horizontal and vertical components of precipitation." This is correct. We use the term *fog* instead of "horizontal precipitation" and drizzle, rain, or precipitation, depending on the context, instead of "vertical precipitation," which as most would acknowledge is not often vertical in any case. The subject is discussed in more detail by Schemenauer and Cereceda (1994b). Rain (drop diameters larger than 0.5 mm) can be reasonably excluded from a fog collector by a number of means, either covers or the use of an active (fan driven) collector with a downward-facing aperture and a vane for orientation into the wind. Drizzle is much harder to exclude, especially in high wind conditions. Mechanisms to eliminate drizzle are costly and in the end will often still allow the smaller drizzle drops to be collected. We have used covers as large as 5 m × 5 m in comparison experiments, as well as active collectors. Our conclusion is that the best approach is to make use of the simple, unobstructed, vertical panels and concurrently measure the presence of any precipitation. One then knows if the water collection is due to fog or a mixture of fog and precipitation. The procedure is straightforward and can be carried out by observers with minimal training. It is akin to the approach used in the mountain cloud chemistry work in the United States and Canada, with variations

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of cylindrical Atmospheric Sciences Research Center (ASRC) fog collectors (Falconer and Falconer 1980), where the collection is divided into precipitation, fog, and mixed fog and precipitation categories (Aneja et al. 1992; Schemenauer et al. 1995). The ASRC collector is relatively expensive and challenging to build, but it has the advantage of having been widely studied and used. It could also be considered if a program demands a cylindrical collector for deposition studies.

3. Choice of screen material

We do not feel that a SFC should necessarily be as "efficient as possible" as stated by JN. We believe a SFC should be as efficient as is reasonable to do the job. We have carried out comparisons with other types of flexible and rigid mesh and with aluminum screens. Some materials are more efficient than the Chilean mesh proposed by SC, and others are less efficient. But additional factors are also important, for example, cost, worldwide availability, available sizes of the material, ease of working with it, similarity to mesh used in large operational fog collectors, etc. The degree of tension on the Chilean mesh used in the SFC is simply specified by the number of horizontal lines within the 1-m opening. The polypropylene mesh used in the proposed SFC costs less than $0.25 per square meter and is available in rolls 8 m wide and a hundred or more meters long. Therefore, an international agency could buy perhaps 10 000 m^2 of mesh, for 5000 collectors (double layer), for less than $2500, and have material to meet any conceivable material shortage or change in fabric in the decades to come.

4. Cylindrical collector of Juvik and Nullet

Juvik and Nullet promote the adoption of a "louvered aluminum cylinder," 12.7 cm in diameter and 40.6 cm high as an alternative standard fog collector. They state it has been used in Hawaiian mountain fog work for over four decades; though they do not address the question of why it has not become a standard in other countries during that lengthy period. It is made from a stamped aluminum sheet available from a supplier in Alabama. It appears that JN's criticism of the commercially available Chilean mesh regarding the "possibility of subtle product specification changes" with time might fairly be applied here as well.

Juvik and Nullet state that in their work they have "left the top of the fog gauge open to rainfall and subtracted out the rainfall component from accompanying rain gauge data." It has been known for a very long time (e.g., Fourcade 1942) that this will lead to erroneous data since it does not account for the drizzle and rain that falls at an angle and is collected by the sides of the cylinder. This is discussed by SC and is one of the main criticisms of the Hohenpeissenberg collector, of which the JN collector is a variant. The conical cap proposed by JN will also have no effect on precipitation collected by the sides of their cylindrical collector. However, it will change the wind flow around the collector and thus possibly the fog collection efficiency. Perhaps, in their very low wind speed regimes (only 15% of the time greater than 2 $m\ s^{-1}$), small covers might have some value, but at most mountain sites, with wind speeds of 5 $m\ s^{-1}$ or more, they will not. An additional problem with the JN fog collector is that it has a diameter of 12.7 cm (horizontal cross section of 126.6 cm^2) and sits in a rain gauge with a diameter of 15 cm (horizontal cross section of 176.6 cm^2). Rain can fall directly into all or part of the large annulus (area 50 cm^2) not covered by the fog collector, once again making the interpretation of the results difficult.

Juvik and Nullet do not discuss either manufacturing costs or water collection rates for their collector. The small size of their proposed collector is important. When facing into the wind it presents a vertical cross section of 515.6 cm^2 as opposed to 10 000 cm^2 for the SFC of SC. A large cross section is important in order to generate measurable water flow rates when fog liquid water contents are low or winds are light. In the example shown in Fig. 5 of SC, when only fog was present, collection rates of 0.5–1.5 $L\ h^{-1}$ were common. These rates are easily measurable by a number of simple means.

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