The human factor in gathering meteorite falls

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The annual meteorite fall rate (AMFR), literally the number of meteorites seen to fall and be collected in a given year, is a complex term to qualify. At the very least it must depend upon the actual distribution of meteorite producing bodies at one astronomical unit from the Sun, as well as the number and distribution of human beings on the Earth (Hughes, 1981; Rasmussen, 1990). It has often suggested that the AMFR should vary in accordance with the world human population. In this manner we should expect to see a gradual increase in the AMFR with time. This result builds upon the simple premise that the more human beings there are in the world, the more observers there must be to spot the in-coming fireballs and their associated meteorites. Does, however, this idea of continually increasing returns actually hold true?

The recent publication of the *Catalogue of Meteorites, 5th Edition* (Grady, 2000) affords us a chance to see how well the AMFR has kept pace with changes in the world human population. The AMFR over the time interval from 1 January, 1800 to December, 1999 has been determined from the *Catalogue*, and the results are shown graphically in figure 1. As one would expect there is some considerable variation in the AMFR from one year to the next. Clearly, the AMFR can be as low as zero but it has ranged as high as 17 (as witnessed in the record breaking year of 1933). Interestingly, however, there appears to be a reasonably clear background trend in the observed AMFR data. This trend is illustrated by the smooth line drawn in figure 1, which is a least square fourth-order polynomial fit to the AMFR data. From 1800 to circa 1940 the average AMFR shows a steady increase, while after circa 1940 it begins to show a decline. Rather than increasing in step with world population since circa 1940 the meteorite fall rate (MFR) has, in fact, been steadily falling. This trend is more clearly seen in figure 2 where we plot averaged values of the MFR since 1800 against world population. From 1800 to 1940 the average MFR increased linearly with world population growth, and every extra 500 million people apparently resulted in an increase of 2.8 in the average MFR. The transitional years, where the increasing trend of the MFR with world population breaks down, appears to have been between circa 1940 to 1960. Since circa 1960 the average MFR has shown a steady decline of about 0.7 for every additional 500 million people.

Only a very small fraction of the actual meteorite producing events become observed falls in any given year. Halliday *et. al.*, (1985), for example, predict that 5,800 meteorite producing events (with ground masses greater than 0.1 kg) should occur per year on the total land mass of the Earth. The problem is, of course, that many meteorites fall unobserved during the day, with their associated 'attention grabbing' fireball going unnoticed due to sunlight conditions, and typically people only spend a very small fraction of any day outside at nighttime. None-the-less this does not explain the steady fall in the average MFR since circa 1960. A number of potential reasons for the downturn can, however, be readily found. Firstly, human beings are not distributed at random around the globe, in the sense that most people live in a relatively few major centers. So, while the population increases with time it need not mean that the sky coverage increases, and it makes no real difference whether a meteorite fall is seen by one person or by one hundred. Second the continuing trend towards greater urbanization mitigates against fireball sightings; light pollution and a 'cocooned' modern life-style will tend to reduce the likelihood of fireball detection.

Hughes (1981) drew attention to the downturn in the meteorite fall rate beginning circa 1940 but argued that it was due to a time lag between a fall occurring and it being reported in the literature. Dodd (1986) likewise reflected that it would be of interest to see if our collective "outreach toward the planets, which began about 1960, [is] reflected in a higher than normal recovery rate for meteorite falls". We find that the average meteorite fall rate has shown a steady decline over the past forty years and we would argue that communication of events is

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now no longer a major issue. In spite of an apparently greater awareness and appreciation of meteorites, the human race is, also apparently, collectively less efficient at gathering-in meteorite falls. It might be tentatively suggested that what we are actual seeing is a sociologically based decline; people are simply becoming less aware of the skies. This, however, seems too simple an answer and one might further suggest that we are also seeing the effect of a continued under funding of meteorite recovery programs (I am talking specifically about fall events here, not the dedicated meteorite 'find' programs). One might also speculate that the actual flux of meteorite producing bodies varies with time (e.g., see Rasmussen, 1990), but there are no obvious mechanisms for producing such short time-scale effects. The other possibility, of course, is that we have just been unlucky over the past several decades in gathering-in actual falls.

In conclusion, however, if we dare believe the essential implications of the data, the average MFR has been on the decline since circa 1960, and it is no longer showing any apparent increase with world population growth. And indeed, Dodd (1986) is, unfortunately, to be disappointed in that our 'outreach' to the planets has not resulted in an increase in the recovery rate of meteorite falls. We note in particular that the decadal average MFR at the end of the 20th Century is, in fact, just one meteorite higher than that at the beginning of the 19th Century! In spite of the apparent trend seen in figure 2, we do not anticipate that the average MFR will drop-off indefinitely, but we would hope that it will begin to stabilize, if not increase, soon.

References

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Figure 1: The annual meteorite fall rate from January 1800 to December 1999. We have not distinguished between the meteorite types in our counts and in total 961 meteorite falls were considered. The smooth curve, which is a 'best fit' fourth order polynomial to the data, illustrates the background trend in the time variation of the AMFR.

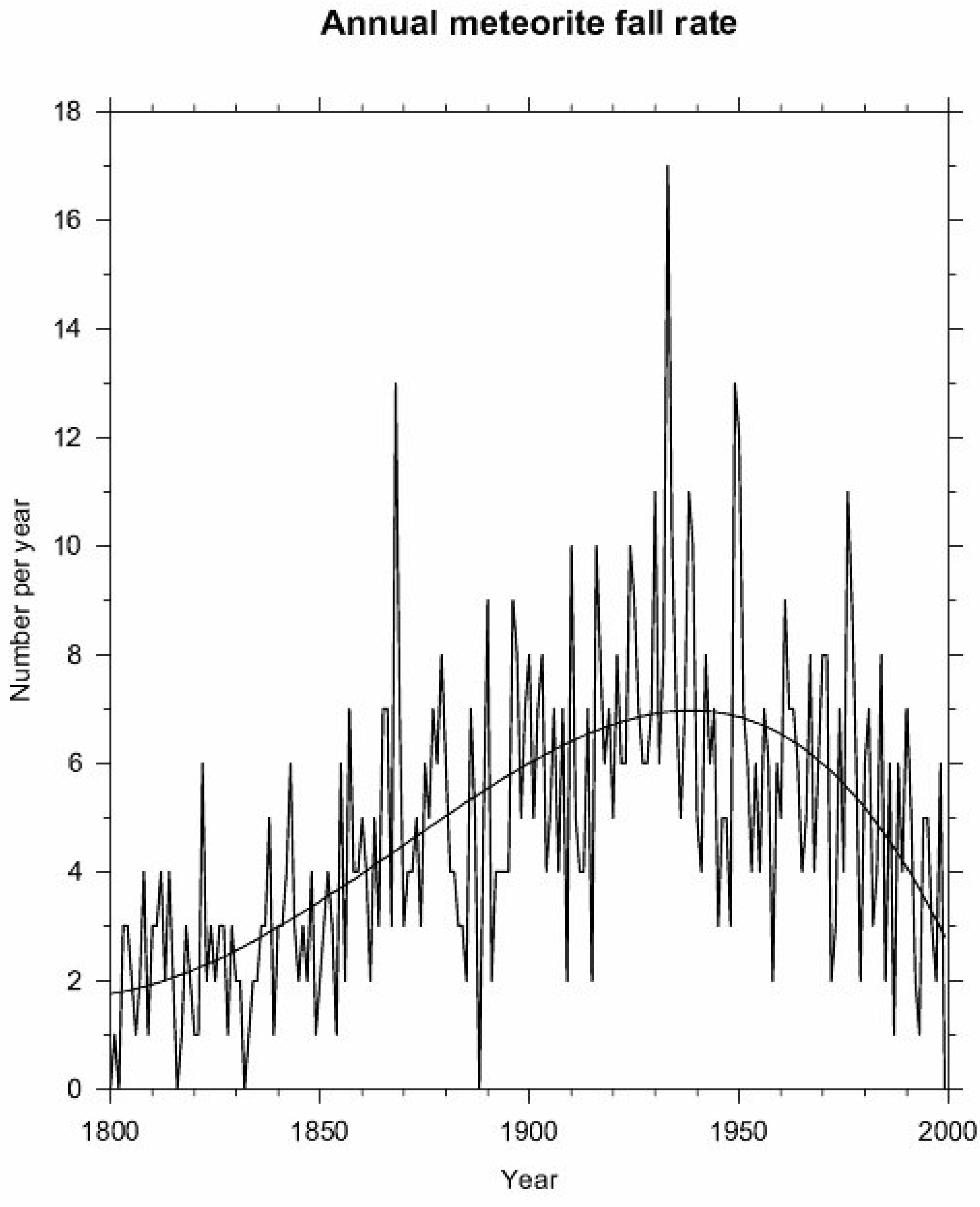

Figure 2: Average meteorite fall rate versus world population in billions of people. The averages are decadal after 1900 and per half-century from 1800 to 1900. The data points are labeled according to the average year of the time interval covered. The world population data has been taken from www.census.gov/ipc/www/worldhis.html.