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Assistant Director, Division of Astrophysical Research
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# SMITHSONIAN PYRHELIOMETRY AND THE ANDEAN VOLCANIC ERUPTIONS OF APRIL 1932

By L. B. ALDRICH
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In early June 1912 the volcano Mount Katmai in Alaska ejected great quantities of fine dust into the atmosphere sufficient to reduce materially the transparency of the atmosphere in the Northern Hemisphere. Two months after the eruption, the total direct radiation from the sun was about 20 percent below normal at the Smithsonian stations at Bassour, Algeria, and at Mount Wilson, California.[1] The effect of this dust persisted in the observations of 1913 and was slightly noticeable in 1914.[2] In 1916 Dr. Abbot pointed out in a paper[3] discussing pyrheliometry observed at Arequipa, Peru, that no effect of the dust from Mount Katmai had ever been disclosed in the Arequipan observations.

A letter to Dr. Abbot received recently from George G. Gallagher of Glendale, California, says:

> Your article "Arequipa Pyrheliometry," on the lack of influence of Katmai dust on Peruvian atmospheric transparency is thought provoking. I had no idea that the air mass circulation of the Northern and Southern Hemispheres was so separate and distinct. And yet, in contrast to Katmai, the dust from Krakatau (August 1883) was apparent on a world-wide scale. However Krakatau lies close to the Equator (lat. 6° S.) and that might explain the difference.
>
> Now, does dust from an eruption in the Southern Hemisphere influence the atmospheric transparency of the Northern Hemisphere? The only large eruption in the south during recent years was the activity of the Chilean Andes in April 1932. There was some smaller activity in the Alaskan Peninsula at this time but it was not of the same order of magnitude and probably would not cause a large error. The Chilean eruptions might cause a 2 to 3 percent variation in atmospheric transparency. Does such a change show in your records?

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[1] Abbot, C. G., and Fowle, F. E., Volcanoes and climate, Smithsonian Misc. Coll., vol. 60, No. 29, 1913.

[2] Annals of the Astrophysical Observatory of the Smithsonian Institution, vol. 4, p. 195, 1922.

[3] Abbot, C. G., Arequipa pyrheliometry, Smithsonian Misc. Coll., vol. 65, No. 9, 1916.

During the period following the April 1932 eruptions mentioned in this letter, the Smithsonian Institution was operating solar-radiation stations at Montezuma in the Southern Hemisphere (lat. 22°40′ S., long. 68°56′ W.) and at Table Mountain, California, in the Northern Hemisphere (lat. 34°22′ N., long. 117°41′ W.). It was not difficult, therefore, to investigate the question Mr. Gallagher raised, and Dr. Abbot asked the writer to do so.

The Andean eruptions of 1932 started on April 10, involving some seven volcanoes extending 200 miles along the Chile-Argentine border from Tupungato (altitude 21,000 feet, lat. 33°.5 S.) southward to Quizapu (altitude about 10,000 feet). Loud explosions were heard 100 miles on either side of the volcanoes. The explosions continued for 3 days. Surrounding towns were in semidarkness owing to the steady fall of dust and ashes. In Montevideo, 850 miles away, the steady fall of dust continued for many hours. Dr. Davison[4] estimated the total fall of dust over the area to be more than 5 cubic miles. Capt. R. Wooten, United States Air Attache at Santiago, who flew across Quizapu at an altitude of 14,000 feet, estimated that at the time of greatest activity the smoke column rose to a height of 30,000 feet. Evidences of unusual dust in the atmosphere were noted at Wellington,[5] New Zealand, on May 7, reaching a maximum about the 26th. Unusual skies were also reported during May from various places in South Africa.[6]

At the Smithsonian solar stations, on all days when the sky around the sun was clear, observations have been made with the silver-disk pyrheliometer, measuring the total solar radiation received upon a surface normal to the radiation. Simultaneously, readings were taken with a pyranometer, measuring the brightness of the sky in a circular zone about 10 degrees wide, concentric with the sun. These pyranometer readings are an index of the quantity of dust in the atmosphere. Values of pyrheliometry and pyranometry at air mass 2.0 (solar altitude 30°) were selected from the observations and used uncorrected to mean solar distance. These were grouped by months and so chosen that the average amount of water vapor in the air above the station was the same in each year for a given month. The amount of water vapor in the air is represented by the spectrobolometrically determined precipitable water value described in the Annals of the Astrophysical Observatory,

[4] Nature, vol. 129, No. 3260, p. 604, 1932.

[5] Quart. Journ. Roy. Meteorol. Soc., vol. 59, No. 250, p. 268, 1933.

[6] Nature, vol. 129, No. 3269, p. 932, 1932, and vol. 130, No. 3273, p. 139, 1932.

TABLE I.—*Summary of monthly means of selected days*

| Month | Montezuma | | | | Table Mountain | | | | Solar constant (imp. preferred mean) (Calories per cm.$^2$ per minute) |
|---|---|---|---|---|---|---|---|---|---|
| | No. of values | Prec. water in .1 mm. | Pyran. in calories per cm.$^2$ per minute | Pyrhel. in calories per cm.$^2$ per minute | No. of values | Prec. water in .1 mm. | Pyran. in calories per cm.$^2$ per minute | Pyrhel. in calories per cm.$^2$ per minute | |
| 1930 | | | | | | | | | |
| May .... | 15 | 42 | .0135 | 1.451 | 7 | 31 | .0325 | 1.366 | 1.948 |
| June .... | 25 | 25 | .0130 | 1.472 | 22 | 39 | .0237 | 1.379 | 1.948 |
| July .... | 15 | 23 | .0125 | 1.478 | 20 | 74 | .0201 | 1.363 | 1.947 |
| Nov. .... | 15 | 44 | .0183 | 1.504 | 15 | 32 | .0179 | 1.492 | 1.947 |
| 1932 | | | | | | | | | |
| May .... | 20 | 42 | .0347 | 1.399 | 6 | 31 | .0251 | 1.377 | 1.941 |
| June .... | 20 | 25 | .0278 | 1.424 | 13 | 39 | .0229 | 1.372 | 1.946 |
| July .... | 11 | 23 | .0234 | 1.441 | 16 | 74 | .0190 | 1.361 | 1.945 |
| Nov. .... | 17 | 44 | .0263 | 1.473 | 12 | 32 | .0181 | 1.492 | 1.944 |
| 1933 | | | | | | | | | |
| May .... | 8 | 42 | .0109 | 1.449 | 7 | 31 | .0355 | 1.361 | 1.940 |

NOTE.—Pyranometer and pyrheliometer values are not reduced to mean solar distance.

Smithsonian Institution, vol. 3, page 171, 1913. Taking the year 1930 as a standard of comparison, monthly means of pyrheliometry, pyranometry, and precipitable water at air mass 2.0 are given in table 1 for May, June, July, and November of the years 1930 and 1932, and for May 1933. For the same months, the improved preferred mean solar constants are also given in table 1, as taken from table 27 of the Annals, vol. 6, 1942. The percentage variations of pyrheliometry, solar constants, and pyranometry are given in tables 2 and 3.

Table 2.—*Percent deviations of pyrheliometry and solar constants from corresponding month of the year 1930*

| Month | Pyrheliometry: Montezuma Percent | Pyrheliometry: Table Mt. Percent | Solar constant Percent |
|---|---|---|---|
| May, 1932 | —3.7 | +0.8 | —0.4 |
| June, " | —3.4 | —0.5 | —0.1 |
| July, " | —2.6 | —0.1 | —0.1 |
| Nov., " | —2.1 | 0.0 | —0.2 |
| May, 1933 | —0.1 | —0.4 | —0.4 |

Table 3.—*Percent change of sky brightness around the sun from corresponding month of the year 1930*

| Month | Montezuma Percent | Table Mt. Percent |
|---|---|---|
| May, 1932 | +157. | —23 |
| June, " | +114. | — 3 |
| July, " | + 87. | — 5 |
| Nov., " | + 44. | + 1 |
| May, 1933 | — 19. | + 8 |

No effect of the Andean eruptions is discovered in the Table Mountain, California, observations. A definite effect occurs in the Montezuma pyrheliometer values, with a maximum of 3.7 percent depletion in May 1932, and an average of 3.0 percent for the months May, June, July, November. This agrees with Mr. Gallagher's estimate.

From the Montezuma records, we find the following unusual sky conditions reported in April 1932 by C. P. Butler, director of the station. Montezuma, it should be noted, is over 800 miles north of the erupting volcanoes.

April 13: Horizon to south very hazy with yellowish-looking dust.

Nothing further is noted until

April 22—Good sky. Very hazy over mountains to east.

April 23—Very heavy layer of yellowish haze over mountains to east, extending up about 10°.

April 24—Very poor sky. Streaks from horizon to zenith, with whitish glare about sun.

April 25 and 26, same notes as April 24.

April 27 through 30—Dust in atmosphere almost totally obscures sun.

On April 30 the pyranometer value at air mass 2.0 was .131 calorie —10 times the normal value.