NOTES ON THE RIVERS OF THE SACRAMENTO AND LOWER SAN JOAQUIN WATERSHEDS.

By N. R. TAYLOR, Local Forecaster.

Sacramento watershed.—The rainfall throughout this watershed was deficient, especially in the lower reaches of the Sacramento River. As a result of this condition and the small amount of snow in the mountains all streams averaged from 1 foot to over 3 feet below the usual May stages. The little snow that remained in the mountains melted rapidly during the month, causing a slight increase in the run-off of all watercourses. By the close of the month the snow had practically disappeared, except that the higher levels of Mounts Shasta and Lassen were still covered and some isolated drifts remained in the high Sierra.

From all obtainable information the visible water supply on the last day of May was markedly deficient, and the present indications are that all rivers of this watershed will be as low during the coming summer and fall as they were during the low-water season of 1912, when most streams fell to the lowest points ever recorded.

The lower San Joaquin watershed.—All streams in this watershed felt the effects of snow water and averaged from 1.5 to over 5 feet above that of the preceding month. They were, however, below the May normal, especially the lower San Joaquin.

NOTES ON STREAMS OF THE UPPER SAN JOAQUIN WATERSHED.

By W. E. BONNETT, Local Forecaster.

The streams of the upper San Joaquin watershed were much below the average stages in these streams for the month of May, although there was a considerable rise over April stages as the weather became warmer.

The average stage at Merced Falls was 1.5 feet, and it was slightly higher than the 1908 average, which was the lowest of record at that point. At Friant the mean stage was 1.4 feet, as compared with a 7-year average of 3.2 feet and a previous low average of 1.7 feet in 1908. The flow in the Kings River was slightly better than that of 1912 and much better than that of 1908. The average May stage at Piedra this year was 8.9, as compared with 8.1 feet in May, 1912. The lowest stages at all points were recorded during the first few days of the month. The highest stages and the dates on which they occurred are as follows: Merced Falls, 2 feet on the 19th; Friant, 2.2 feet on the 25th; Firebaugh, 5 feet on the 28th; Piedra, 10.5 feet on the 23d and 24th.

THE SUN AS A FOG PRODUCER.

By Prof. A. G. MCADIE.

In the Proceedings of the Royal Society of Edinburgh, volume 32, page 183, Dr. John Aitken discusses at length certain fog formations which may be called in a general way sun fogs. The exact title is "The sun as a fog producer," and Dr. Aitken remarks in the opening paragraph that he fears most people will think the title a printer's or an author's error and that the proper caption ought to have been "The sun as a fog disperser." The point is worth calling attention to, because, without doubt, most of us familiar with the dissipation of fog due to direct insolation have never thought of the possibility of the opposite occurrence, namely, a certain increase of nuclei and consequent condensation under sun action. Some years ago Dr. Aitken noticed at Falkirk, especially during winter months, that on many mornings when the air was clear before sunrise there was a gradual thickening and fogging as the sun rose, while in the pure country air such changes were not detected.

The following distinction by him between haze and fog is worth repeating, as certainly there could be no higher authority. First and foremost—

> there is no hard-and-fast line between what we call haze and fog; we usually call it fog when very thick and damp, but even here the boundary line is unsatisfactory, as we have dry fogs. So, again, there is no hard-and-fast line between fogs and clouds. Fogs are generally composed of a greater number of smaller particles than clouds, but cumulus clouds are very much like fogs in this respect. I have shown that they also are composed of closely packed small particles, and it is only after a time that they become fewer and larger by the evaporation of the smaller particles and the condensation of the vapor on the larger ones. In these phenomena we have a gradual change from haze (the effect of which is mainly due to dust and very little to water) to fog (the effect of which is mostly due to the water condensed on the dust) and to the obscuring effect of cloud (which is almost entirely due to water); but between these three domains there are no hard-and-fast boundaries.

The action of the sun in producing fog as noted by Aitken has been confirmed by the observations of haze at Blue Hill Observatory during a period of 20 years, 1890–1909, inclusive. Palmer, in an article on Atmospheric humidity as related to haze fog and visibility at Blue Hill (Bulletin of the Mount Weather Observatory, vol. 5, pt. 4, Apr. 8, 1913), shows that haze occurs more frequently in the early morning than in the afternoon. As the sun rises the increasing insolation deepens the haze stratum, renewed convection stirs it up, and occasionally a cumulus cloud develops in an especially strong ascending current.

Aitken's observations to determine if the morning fogs were a sun effect necessitated a record of the humidity of the air, the direction and velocity of the wind, the transparency of the air, and the amount of cloud on the eastern horizon, to show the amount of sunshine. Two observations on transparency were made, one before sunrise and the other about 9.30 a. m. The transparency of the air was observed by noting the amount of haze or fog on a hill 400 feet high and 300 feet above the place of observation and three-quarters of a mile south-southwest. Specimen observations taken from his note book give the year, month, day, wind direction and force, night minimum, dry and wet bulb readings, sunshine, and limit of visibility in miles for the two observations.

It is to be regretted that in connection with these observations there were not available continuous records of the vapor content of the air, also records giving the intensity of solar radiation and electric potential.

On many mornings the air did not lose its transparency after sunrise, which was due either to absence of sunshine or excessive wind preventing accumulation of impurities in the air or to dryness of the air or other cause of comparative purity. It was observed that increase in haziness was directly proportional to humidity and sunshine and inversely to air dryness and wind velocity. Clear sun at sunrise gave a maximum effect; but sunlight through clouds was also effective though less marked. The conditions favoring the formation of the sun fog are cloudless sunrise, a wet-bulb depression of 1° or less, and absence of wind after blowing from an impure direction. If the air be nearly saturated "the sun soon gets hazed out and dense fog is formed." The fogging is not due to the air becoming colder, as the temperature was always higher at the time of observation than during the night. Nearly all the formations occurred under anticyclonic conditions, but no special significance need

be attached to this, and fogs formed when the center of the anticyclone was north, southeast, or west. The densest fog occurred when there was no general circulation, a condition favoring the accumulation of impurities in the air. These conclusions are borne out by the Blue Hill Observations (Palmer, in article referred to above), where the conclusion is reached that "haze seems to be associated with a relatively stagnant condition of the atmosphere."

Aitken advances the hypothesis that as these fogs are only formed in air which has come from densely populated parts of the country, they are probably formed by the action of the sunlight upon impurities. There are two kinds of nuclei of cloudy condensation. One has no affinity for water vapor and the other has. The latter condenses water vapor into minute drops even in unsaturated air and so causes dense fog. Aitken makes a distinction between cloud particles where the smaller drops tend to evaporate, and fog particles which hold their own share of water. Evaporation is checked by the concentration of the impurities in the smaller particles and by dilution in the larger. The fog particles, therefore, or nuclei with affinity for water are persistent and retain their numbers and fogging effect. Only those nuclei which have an affinity for water can be called true fog formers in unsaturated air.

Aitken then describes at length his apparatus for testing air and the various experiments made to determine whether the nuclei had any affinity for water vapor. There is one interesting experiment in connection with the use of chloride of sodium dissolved in water. The effect of the presence of salt on ordinary condensation resulted in a discovery that the cloud did not remain so long a time as usual, but vanished rapidly. The affinity of the salt for water was so great that it robbed the nuclei of their water, which evaporated, diffused, and was absorbed by the salt solution. This shows that the rate of diffusion of water vapor in air is very rapid. This is of importance in connection with experiments which have been made on evaporation, for it has been assumed that diffusion under quiet conditions of air motion was an extremely slow process.

Aitken then studies the sulphur oxides which are products of combustion, in their rôle of nuclei producers. SO_2 while kept in pure air shows little tendency to produce nuclei, but combines readily with other products of combustion and then, as Aitken puts it—

> Falls from its high state of a free-moving gaseous molecule to the condition of a solid or liquid particle confined to Brownian movements, and probably ends its independent existence in a fog particle, or possibly in a rain drop.

SO_2 remains free from nuclei if kept in the dark. If exposed to light, especially sunshine, it becomes an active nucleus producer and some of the nuclei thus formed have an affinity for water. More marked effects were obtained when burning sulphur was used in place of a solution. Furthermore, the action of light is a *cumulative* one, the particles growing in size under the continued influence of light.

It was found that when an electric discharge occurs in air containing SO_2 an enormous number of nuclei were produced which gave a very dense fog on expansion; furthermore, many of the nuclei caused condensation in unsaturated air.

After testing various gases and finding that neither oxygen, nitrogen, nor water vapor had any special effect upon SO_2 Aitken proceeded to test other products of combustion, such as ammonia, hydrogen peroxide, and ozone. The former probably plays no part in the formation of the morning fog; but the peroxide causes a dense condensation both with and without expansion, showing that there has been produced an immense number of nuclei with a strong affinity for water. Ozone also reacts powerfully on the SO_2 producing dense condensation upon exposure to the sun.

Aitken is of opinion that peroxide of hydrogen produced by sunshine is active in producing nuclei. This gas is generally admitted to be produced by the ultra violet rays. It is found in dew and in rain; but not in dew formed during the night, only in that condensed after sunrise.