

IX. *Some observations on the formation of Mists in particular situations.* By Sir H. Davy, Bart. F. R. S. V. P. R. I.

Read February 25, 1819.

ALL persons who have been accustomed to the observation of Nature, must have frequently witnessed the formation of mists over the beds of rivers and lakes in calm and clear weather after sun set; and whoever has considered these phenomena in relation to the radiation and communication of heat and nature of vapour, since the publication of the researches of M. M. RUMFORD, LESLIE, DALTON, and WELLS, can hardly have failed to discover the true cause of them. As, however, I am not aware that any work has yet been published in which this cause is fully discussed, and as it involves rather complicated principles, I shall make no apology for offering a few remarks on the subject to the Royal Society.

As soon as the sun has disappeared from any part of the globe, the surface begins to lose heat by radiation, and in greater proportions as the sky is clearer; but the land and water are cooled by this operation in a very different manner: the impression of cooling on the land is limited to the surface, and very slowly transmitted to the interior; whereas in water above 45° FAHRENHEIT, as soon as the upper stratum is cooled, whether by radiation or evaporation, it sinks in the mass of fluid, and its place is supplied by warmer water from below, and till the temperature of the whole mass is reduced

nearly to 40° F. the surface cannot be the coolest part. It follows, therefore, that wherever water exists in considerable masses, and has a temperature nearly equal to that of the land, or only a few degrees below it, and above 45° F. at sunset, its surface during the night, in calm and clear weather, will be warmer than that of the contiguous land; and the air above the land will necessarily be colder than that above the water; and when they both contain their due proportion of aqueous vapour, and the situation of the ground is such as to permit the cold air from the land to mix with the warmer air above the water, mist or fog will be the result; which will be so much the greater in quantity, as the land surrounding or inclosing the water is higher, the water deeper, and the temperature of the water, which will coincide with the quantity or strength of vapour in the air above it, greater.

I shall detail some observations which appear to me to show the correctness of this view. June 9th, 10th, 11th, the temperature of the atmosphere and of the Danube was repeatedly examined during a voyage that I made upon this river from Ratisbonne to Vienna, and on each of these days, the sky being perfectly clear, the appearance of mist above the river in the evening uniformly coincided with the diminution of the temperature of the air from three to six degrees *below* that of the river, and the disappearance of fog in the morning with the elevation of the temperature of the air *above* that of the river. From Ratisbonne to Passau, the temperature of the Danube was pretty uniform throughout the 24 hours, being highest, 62° F. or $62\frac{1}{4}^{\circ}$ F., between 12 and 2 o'clock, and about one degree less before sun-rise, and the temperature of the air from 61° F. to 73° F. during the day,

and from 61° to 54° F. during the night. Below Passau, the Inn and the Ilz flow into the Danube.* On examining the temperature of these rivers at 6 o'clock, A. M. June 11, that of the Danube was found to be 62° F., that of the Inn $56\frac{1}{2}^{\circ}$ F., and that of the Ilz 56° F.: the temperature of the atmosphere on the banks where their streams mixed, was 54° . The whole surface of the Danube was covered with a thick fog; on the Inn there was a slight mist, and on the Ilz barely a haziness, indicating the deposition of a very small quantity of water. About 100 yards below the place where the three rivers joined, the temperature of the central part of the Danube was 59° F., and here the quantity of mist was less than on the bed of the Danube before the junction; but about half a mile below, the warmer water had again found its place at the surface, and the mist was as copious as before the union of the three rivers. June 12th, the evening was cloudy, and the temperature of the atmosphere remained till after dark higher than that of the river, being, when the last observation was made, 63° F. when there was not the slightest appearance of mist. The sky was clearer before sun-rise on the 13th, and the thermometer immediately after sun-rise, in the air above the river, stood at $55\frac{1}{2}^{\circ}$ F. the temperature of the Danube being 61° F.; a thin mist was seen immediately above the river; but there being no mass of vapour to exclude the sun-beams, it rapidly disappeared, and was not visible a few feet from the surface; and in half an hour the whole atmosphere was perfectly transparent.

In passing along the Rhine from Cologne to Coblentz,

* The Danube was greenish, the Inn had a milky blueness, the Ilz was perfectly pellucid; but from the rapidity with which the Inn descended, its waters at this spot give their tint to the whole surface.

May 31st and June 2d and 3d, the nights being very clear, the same phenomenon of the formation of mists was observed, precisely under the same circumstances; but as I could examine the temperature of the air and of the river only close to the banks, and in two or three situations, my observations were less precise and less numerous; the mist formed later in the evening, and disappeared sooner in the morning than on the Danube; which was evidently owing to the circumstances of the atmosphere being warmer and the river colder, the temperature of the one being from 66° F. to 75° F. during the day, and that of the river, where I examined it, from 59° to 60° F.

July 11th. I examined the temperature of the Raab near Kermond in Hungary, at 7 o'clock, P. M. and found it 65° F. that of the atmosphere being 72° F. During the whole evening there were some thin fleecy clouds in the western sky, which being lighted up by the setting sun, greatly interfered with the cooling by radiation from the earth, and at half past nine the thermometer, in the atmosphere, was still 69° F. and at half past ten 67° F., when there was not the slightest appearance of mist. In the morning, before sun-rise, the temperature of the atmosphere on the banks was 61° F., that of the river 64° F., and now the bed of the river was filled with a white thin mist, which entirely disappeared half an hour after sun-rise.

I made similar observations on the Save in Carniola, in the end of August; on the Isonzo in the Friul, in the middle of September; on the Po near Ferrara, in the end of September; and repeatedly on the Tiber and on the small lakes in the Campagna of Rome in the beginning of October; and I have never in any instance observed the formation of mist on a

river or lake, when the temperature of the water has been lower than that of the atmosphere, even when the atmosphere was saturated with vapour.

It might at first view be supposed, that whether the cooling cause existed in the water or the land, the same consequences ought to result ; but the peculiar properties of water, to which I referred in the beginning of the paper, render this impossible. Water in abstracting heat from the atmosphere becomes lighter, and the warmer stratum rests on the surface, and its operation in cooling the atmosphere is extremely slow ; besides, the cooled atmospheric stratum remains in contact with it, and water cannot be deposited from vapour, when that vapour is rising into an atmosphere of a higher temperature than its own ; and the law holds good, however great the difference of temperature. Thus, August 26th, at sun-set, the day after a heavy fall of rain, and when the atmosphere was exceedingly moist, I ascertained the temperature of the Drave near Spital in Carinthia, and though it was 14° F. below that of the air, yet the atmosphere above the river was perfectly transparent.

It may be imagined, that without any reference to the cooling agencies of air from the land, mist may form upon rivers and lakes, merely from the loss of heat by radiation from the air, or the vapour itself immediately above the water ; and that the phenomenon is merely one of the formation of vapour, the source of heat being in the water ; and its deposition, the source of cold, being in the atmosphere ; but it is extremely improbable, that air or invisible vapour, at common temperatures, can lose any considerable quantity of heat by radiation ; and, if mist could be formed from such a

source, it must always be produced to a great extent upon the ocean in calm weather during the night, particularly under the line, and between the tropics, which the journals of voyages sufficiently prove is not the case. I have myself had an opportunity of making some observations which coincide with this view. During a voyage to and from Pola, I passed the nights of September 3, 5, and 6, off the coast of Istria; there was very little wind on either of the nights, and from sun-set till nearly midnight it was perfectly calm in all of them. On the 3d it was cloudy, and the lightning was perceived from a distant thunder storm, and the vessel was never far from the shore: but on the 5th and 6th the sky was perfectly clear, and the zodiacal light, after sun-set, wonderfully distinct and brilliant, particularly on the 5th, and we passed by the help of oars from two to eight miles from the shore. The temperature of the sea at sun-set was 76° F. on the 5th, 77° F. on the 6th, that of the atmosphere immediately above it 78° F. and 79° F. On the 5th, at midnight, about five miles from the shore, the temperature of the sea was 74° F. and that of the atmosphere 75° F., and on the 6th, at the same hour, at about four miles from the shore, the temperature of the sea was 73° F. and that of the atmosphere 75° F. There was not the slightest appearance of mist on either of these nights on the open sea, or at any distance from the land: but close under the hills of Istria there was a slight line of haze visible before sun-rise, which was thickest under the highest land; and as we approached at sun-rise, on the 7th, the mountains of the Friul, the tops of those nearest to Trieste were seen rising out of a thick white mist, which did not reach a quarter of a mile from the shore.

After mists have formed above rivers and lakes, their increase seems not only to depend upon the constant operation of the cause which originally produced them, but likewise upon the radiation of heat from the superficial particles of water composing the mist; which produces a descending current of cold air in the very body of the mist, whilst the warm water continually sends up vapour: it is to these circumstances, that the phenomena must be ascribed of mists from a river or lake, sometimes arising considerably above the surrounding hills. I have often witnessed this appearance during the month of October, after very still and very clear nights, in the Campagna of Rome above the Tiber, and on Monte Albano over the lakes existing in the ancient craters of this extinguished volcano, and, in one instance, on the 17th of October, before sun-rise, there not being a breath of wind, a dense white cloud of a pyramidal form was seen on the site of Alban lake, and rising far above the highest peak of the mountain, its form gradually changed after sun-rise, its apex first disappeared, and its body, as it were, melted away in the sun beams.

Where rivers rise from great sources in the interior of rocks or strata, as they have the mean temperature of the climate, mists can rarely form upon them except in winter, or late in autumn, or early in spring. In passing across the Apennines, October 1st, 2d, and 3d, 1818, there having been much rain for some days preceding, and the nights being very clear, I observed the beds of all the rivers in the valleys filled with mist, morning and evening, except that of the Clitumnus near its source, in which there was no mist, and this river rises at once from a lime-stone bed, and when I examined it,

at half past six o'clock, A. M. October 3, was $7\frac{1}{2}^{\circ}$ lower than the atmosphere.

Great dryness in the air, or a current of dry air passing across a river, will prevent the formation of mist, even when the temperature of the water is much higher than that of the atmosphere: thus on the 14th of June, near Mautern, though the Danube at five in the morning was 61° F. and the air only 54° , yet there was no mist; but a strong easterly wind blew, and from the rapidity with which water evaporated it, it was evident that this wind was in a state of extreme dryness.

The Tiber has furnished me with a number of still more striking examples. October 13th, the night having been very clear, on arriving at the Ponte Molle, at half past six in the morning, I found no mist on the river, yet the temperature of the air immediately above it was 48° F. and that of the river 56° F., a strong north wind blew, which indicated, by the hygrometer, a degree of dryness of 55° , and this part of the river was exposed to it; but the valley above, where the river was sheltered from the wind, was full of mist, and the mist in rising to the exposed level might be seen, as it were, dissolving, presenting thin striæ which never reached above a certain elevation, and many of which disappeared a few seconds after they rose. From the 13th to the 25th of Oct. during which time the tramontane or north wind blew, I witnessed repeatedly the same phenomenon, and in the whole of this time there was only one morning when there was no mist in the sheltered valleys, and the cause was perfectly obvious; the night had been very cloudy, and the thermometer, before sun rise, indicated a difference of only one degree in the atmosphere below that of the river.

It is not my intention to discuss the general subject of the deposition of water from the atmosphere, in this paper ; but merely to describe a local cause of considerable extent and variety in its modifications : and which is not without an effect in the economy of nature, for verdure and fertility, in hot climates, generally follow the courses of rivers, and by the operation of this cause, are extended to the hills, and even to the plains surrounding their banks.

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