

A Discourse concerning Weather, &c. By the learned Dr Garden of Aberdene. Written by way of Letter, to Mr. Henry Scougall, Professor of Theology in that Univerfity; and communicated to the Phil. Soc. of Oxford, by the reverend Dr Middleton, Provost of the Kings College in Aberdeen.

Sir.

I Am forrie, I can give you no better fatisfaction in this account you demand of the Conjecture we had lately occasion to talk about, my other necessarie diversions and the few observations I have made, render it the more imperfect. However since 'tis your pleasure, you shall have it as it is; and if it come afterwards to be cleared & confirmed by the joynt observations and sentiments of others, it may pass for an Aero-Statistical Hypothesis of the various changes of the Weather.

We have been hitherto to seek for an intelligible account of the ascent of Vapours, the ballancing of the Clouds and their dropping down again into rain; and the wind bloweth where it listeth, and we know not whence it cometh, nor whither it goeth; and 'tis like our conjectures about the more immediate causes of all these may be still uncertain Guesfes, yet the works of God are sought out of all those that take pleasure in them: and the late known properties of the Air, viz. its weight and Spring have made men more inquisitive in this matter then formerly: and you know how by the observations of the Baroscope they perceive that the Atmospheres Gravity is not always the same, and are surpriz'd to see the Mercury subside for the most part in Foggy, rainy, windy, or cloudy, weather; and on the contrary to ascend and be highest in calm and clear seasons. I shall not stay here to tell you the Conjectures of others about this, but shall only take occasion to consider how this may

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serve to put us in the right rode in our enquiries about the Variations of the weather.

And first the Air being a fluid, we are to take notice of those properties which it has in common with other fluids, and those wherein it differs from them, in so far as they concern this matter. It agrees with all other fluids in this that it Gravitates; and again it has this peculiar property (which is not so much observ'd of other fluids,) that its *specific Gravity* is not always the same. Now you know according to the certain rules of the ballancing of fluids amongst themselves, every fluid specifically lighter than another will ascend and emerge above it, and every fluid specifically heavier will descend and subside below. Thus if a Glasse in whose bottom there is oyl be fill'd with water, the oyl will emerge above, but if the water be drawn out with a Siphon, and the Air (a specifically lighter fluid,) succeed, the oyl will subside again. Now there is some certain proportion between the specific Gravities of the fluid of Air, and of that which ascends in Vapours and falls down again into rain; and if this proportion were still the same, 'tis like we would have no commixture of those fluids, but the Vapours would either always float above or always stay below. But this proportion of their specific gravity is frequently changed; for it is known that water when warm and tepid is lighter then when it is cold (and yet perhaps too the small particles of it (if figured according to *des Cartes* his conjecture,) are more capable of ascending in Vapours in frost then at another season, as being more extended, and so having a larger portion of the fluid of Air to bear them up;) and the daily observations of the different heights of the Mercury in the Baroscope do make appear that the Atmospheres gravity is not always the same. And now from these known properties may be easily deduced a statical account of the rising of Vapours, their being carried in the Air in Clouds and their falling down again into rain. For

For if we may be allowed to suppose that when the Atmosphere is heaviest, there is some such proportion between its specific gravity, and that of the fluid of Vapours, as there is between water and oyl; the Vapours according to the known laws of fluids must needs ascend, and so long as this proportion continues they must needs float above in the Air: but when the Atmospheres gravity is chang'd, the Vapours must fall down again. Thus you see how easily this may be accounted for, and how reasonable this supposition is from the known properties of these fluids.

Now let us see whether this accords with observation and experience. And first as to the ascent of Vapours, I do not know any determinate Instrument that will Indicate their ascent as certainly as the Baroscope does the change of the Air's weight (for our common Hygroscopes are not very exact, and besides I suppose their change by moisture shews rather the falling then the rising of Vapours) yet there are two or three observations which seem certain Indications of their ascent: as first, if the Horizon and the remote Hills seem Smoakie and inconspicuous, so that nothing can be seen at any distance, and that tho' the Heavens be not cloudy, but clear, and tho' there be no Fog nor yet any Cap of Clouds upon the Hills (which do rather indicate the falling of Vapours,) again if when you look to any distant part of the Country round about you, it appear all in an undulating motion (and this you know our Countrie People call by the name of Summer Colts in the Air,) this seems to be a sign of the plentiful rising of Vapours, for this is only occasioned by looking through an unequall waving Medium, which makes frequent inflections of the beams of light, as you see any object seems to have a tremulating motion in all its parts when you look upon it through Smoak. Another Indication of the ascent of Vapours seems to be the copious rising of Steams above waters, marish grounds and fens,

which is frequently seen in frosts and in cool nights in Summer. To these I may add the redness of the Sun (so as to be easily look'd upon, and moon, a considerable time before their setting or after their rising. Now since I have had occasion to make observations of the Baroscope, I have always taken notice of all these, when the Mercury was rising and consequently in the increase of the Atmosphere's gravity; I have then frequently observed how inconspicuous and as it were Smokie the Horizon & remote Hills would appear tho' there were no Clouds in the Air, and in what a tremulous motion remote objects seem'd to be, and how copiously the Steams did arise from waters and marshes, and how red and easie to be looked on the Sun was for a considerable time before setting. But on the contrary when the Mercury has been low in the Baroscope and so the Atmosphere's gravity less, I have observed none of these effects, but the remote Hills were clear and distinct (unless some times a Cloud had falln down upon them,) and no waving to be observed in the Air nor Steams from the waters. I know not whether I may add here a conjecture about the great light & the *Capræ saltantes* which are some nights to be seen in the North. I have taken notice of them usually when the Mercury has been high in the Baroscope; and then they appearing in that quarter of the Heavens where the Sun is at that time below the Horizon, this has given me occasion to think that perhaps the Steams of Vapours may have ascended so far in the Atmosphere as to be beyond the Earth's shadow in that part of the Horizon, and so by refracting the beams of light towards us to occasion that light and those *Capræ saltantes*. It may be considered also whether the red skies in the Evening which betoken fair weather, do not proceed from the height of the Clouds occasioned at that time by the increase of the specifical gravity of the Atmosphere.

Now as to the falling down of the Vapours again, it is visible

visible by their gathering into thick and dark Clouds, by the falling down of Clouds and Mists on the tops of Hills, and thick fogs in the Air, and by their dropping down into rain, snow, &c. and that these do usually fall out only when the Mercury subsides a little, and consequently when the Atmosphere's gravity is less, is the constant observation of those who have had occasion to take notice of the changes of the Baroscope. And thus you see how this Hypothesis for the ascent of Vapours and falling down of rain, grounded on the changes of the Atmosphere's gravity answers daily observation & experience.

Against this it may be objected, that it is observable many times that even when the Mercury in the Baroscope is rising there will be rain, and particularly sometimes in North East Winds. To this I answer that the Vapours will fall down into rain not only when the specific gravity of the atmosphere is lessened, but also if the Clouds have been carried for some while towards one quarter of the Heavens by the Winds, & then if the Winds do suddenly change into another quarter these Vapours, which were formerly scattered into small particles and so did easily float, are suddenly driven together into little drops and so must needs fall down into rain, and therefore the falling of rain while the Mercury is rising is observable only upon the sudden change of contrary Winds.

But let us consider in the next place whether those frequent commotions in the Air which we call Winds, may not be accounted for upon the same Principles, and this we shall do as formerly by looking into the nature of a fluid in the general and of the Air in particular, as to fluids in general, that known definition of Archimedes is universally acknowledged, *Quod earum partium minus pressæ expellantur a magis pressis*, so that if there be any portion of a fluid of a far less pressure and resistance than the rest, the whole fluid runs in a current thither, till all be reduc'd to an *Æquilibrium*. This principle is so uni-

versally received and known that we need not stay to make it good. Now as to the fluid of Air in particular, it is evident, as has been already made appear that its pressure is not always the same. And 'tis very probable (which Experience will determine by making joynt observations of the Baroscope in severall places of the Earth at the same time,) that the Air's gravity is not alike chang'd throughout the whole Atmosphere in an Instant; but that the Mercury may have subsided in the Baroscope, and consequently the Air become lighter, at *London*, for example, when there is no such change observ'd at *Paris* or *Edinburg*. Now this supposition doth give us an intelligible account of Winds from the known nature of fluids. For when the Air becomes specifically lighter in one place, or its pressure lessened, the Neighbouring parts of the Atmosphere whose weight is not thus lessened, run thither in a Current till the Atmosphere thereabouts be reduc'd to an Æquilibrium again; and according to the portion of Air thus chang'd and the lessened or acquired degrees of the weight and spring, the currents and Winds are strong or weak, of a long or short continuance.

Now Observation and Experience do agree with this, the Mercury being found to subside for the most part in the Baroscope at the rising of Winds; at least it is observ'd to be in motion, and either rising or falling, or consequently there is a change in the Atmospher's pressure at that time. And thus we have an Intelligible and Aero-Statistical account, of the ascent of Vapours, of their falling down again into rain, and of the currents and Impetuosity of Winds, from this known property, the Variation of the Atmosphere's gravity.

But I acknowledg the great difficulty remains still how to account for the different changes of the specifical gravity of the Atmosphere; and to this I shall at present only say these two things, 1. That it is very ordinary and allowable

lowable to endeavour a rational account of the several Phenomena of a portion of matter from some known property of that body which it makes up or which acts upon it, tho' there cannot presently be given a Mechanical account of that property its selfe. Thus all the appearances, which were formerly resolv'd into a *Metus Vacui*, are now accounted for by the weight and spring of the Air, tho' the Air's weight and spring be not resolv'd into their true Mechanism. And in this all I aim at is to offer the most natural and rational method for resolving the ordinary changes of the weather, and to make appear that 'tis more easie and intelligible to account for the falling of rain and the impetuosity of Winds by the change of the Atmosphere's gravity, then to explicate the change of the Air's weight from the rain and Winds.

But now as to the thing its self, there can hardly be expected a satisfactory account till we come to know the cause of gravity in general, and of the Air's weight in particular; and therefore I shall only here offer 2 or 3 hints which perhaps may incite others to consider it more narrowly and 1. it is now almost generally acknowledg'd that there must needs be a fluid much more subtil then common Air and of a far greater pressure then Air which is the cause of the continuity and cohesion of all terrestrial bodys, and in which the Air seems as it were to float and to have the same relation to it, as the Vapours do in and have to the Air, and therefore if we could reach its nature and properties it might be considered what influence this may have upon the change of the Air's gravity. Or 2. Seeing the Infusion of one Liquor into another in Chymical preparations will alter its specific gravity so that the bodys which were formerly born up in it, will fall down and be precipitated (as the particles of Gold floating through *Aqua Regis* will be precipitated by the infusion of another Chymical Liquor,) it may be considered whether plenty of Nitrous Steams or some such
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mixture may not alter the Air's specific gravity. Or 3. We may possibly come to a nearer resolution of this by considering the influence which the Heat and Cold have upon the Air's spring. The Air you know has this peculiar property which is not so much observ'd of other fluids, that it is indu'd with Elasticity as well as gravity, and therefore we are to consider what influence the change of its spring may have upon the change of its weight, and it seems evident that the encrease of its spring doth diminish its weight, and the lessening of its spring will encrease it: for upon the encrease of the Air's spring, the Air is rarified, and so a lesser portion of it presses upon the subjacent fluid, but when it is lessen'd the Air is condensed, and so a greater portion of it presses upon the subjacent body. For example let us suppose the springy particles of Air, to be like to the springy hairs of Wooll, or the spring of a Watch; and that many Millions of rows of them go to make up the Cylinder of Air which from the top of the Atmosphere presses upon the Mercury in the Baroscope and keeps it suspended to the height of 30 Inches; let us suppose this Air rarified, so that all its springy particles expand themselves, and therefore shut off of this Cylinder some Thousands of those rows; this Cylinder being now made up of a far lesser number of those rows of particles, must needs have a lesser pressure upon the Mercury, so that it will subside perhaps to 29. And thus it continues till the Air's spring be weakned, and so the particles crowd'd again into narrower room. Now if this be found to hold in the Theory, Experience seems very well to answer it; for I have hitherto observ'd that in Cold weather and sharp Frosts the Mercury rises highest in the Baroscope, and if the foreign measures agree with ours it is usually higher here than in *France* or *Italy*.

I shall here after all subjoyn two or three observations which may serve to confirm what has been said. The first

first is of the course of the weather under or near the Line. I have read in the 2d, and 4th, parts of *Purchas* his *Pilgrims*, (and I doubt not but later Travellers attest the same truth,) that in *Brasil* and *Guiana* in *America*; in *Guinea*, *Congo* and *Æthiopia* in *Africa*; in the *East-Indies* and the *Maldivè Islands*, they have almost continual floods of rain from about the beginning of *May* to the end of *August*, which they call their Winter, and the rest of the Months of the year fair and clear weather, which they call their Summer; so that when the Sun is nearest to them they have constant rains, and when remotest, fair weather. And this I impute amongst other causes to the extraordinary rarefaction of the Air and lessening of its specific gravity there at that time, so that the Vapours in the Neighbouring parts of the Air do all flow thither, and descend as it were in floods of rain. And as this is reckon'd to be the cause of the Inundation of the Nile and some other Rivers, so perhaps this may be the reason also why those *Countries* which are Neighbouring to them, and somewhat remoter from the Line, such as *Ægypt* and the like, have seldom or never any rain.

My 2d, Observation is of the Baroscope *viz.* that when the Wind is North, North-East, or North-West, the Mercury ever rises, and so the Air is heavier, but when the Wind comes from the South, South-East, or South-West, it falls and so the Air's gravity is less; by which we may see what Influence the Cold and Heat have upon the Air's weight; and you know a Cold Wind is said to drive the Sails of a Ship much more forcibly than a Warm.

My 3d, Observation is of an Experiment of the Honourable Mr. *Boyle* as I find it set down in the Philosophical Transactions *Numb.* 63. *Pag.* 2048, 2049. I made, *saieth he*, by Distillation a blood red Liquor, which chiefly consisted of such saline Spirituous particles as

may be obtain'd from the masse of blood in human bodys; this Liquor is of such a Nature that if a Glafs Viol about half filled with it be kept well stoppt, the red Liquor will rest as quietly as any ordinary one, without sending up any Smoak. But if the Viol be unstoppt so that the external Air be permitted to come in, within a quarter of a Minute or less there will be elevated a copious white Smoak, which will not only fill the upper part of the Glafs, but plentifully pass out into the open Air, till the Viol be again stopped. And a little after he adds ----- If the unstoppt Viol were plac'd in our Vacuum, it would not emit any visible Steams at all, nor so much as appear in the upper part of the Glafs its self that held the Liquor; whereas when the Air was by degrees restor'd at the stop-cock, the returning Air would presently raise the Fumes first into the vacant part of the Viol, whence they would ascend into the Capacity of the Receiver; and likewise when the Air that was requisite to support them was Pumped out, they also accompanied it as their unpleasant smell evinced, and the red Spirit, tho' it remain'd unstopped, emitted no more fumes, till the new Air was let in again; so far He. Such you see was the proportion between the gravity of the Vapours of this red Liquor and the Air, that the Air being in its ordinary degree of gravity these Vapours did ascend; but the Air's gravity being much lessened in the Receiver by the Pumping out a great deal of it, and so expanding the springs of the rest, it was not able to elevate those Vapours.

Thus, *Sir*, in obedience to your Commands, I have scribled over my thoughts about this matter, and you see how necessarie it is for establishing a Theory of the weather, to have a more Universal correspondence in observing joyntly the Various changes of the weather in distant places; the several quarters of the Wind, their strength, the time of their rise and continuance; the va-
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rious changes of the Baroscope observed by an Universal measure agreed upon ; the changes of seal'd and open Thermometers, of Hygroscopes, &c. And the Latitudes and Longitudes of the places. I doubt not but there may be several Inquisitive Persons engag'd in making such remarks ; and if it were thought fit to employ the excellent Correspondence which has been established throughout the Learned World in publishing such joynt observations, as they do many usefull things in other parts of the History of Nature, we might possibly arrive at a more determinate and usefull knowledge of the nature and causes of Vapours, Wind, Rain, &c. and the various alterations of the weather, and find out this *Proteus* in all its changes.
