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# On the origin and meaning of the German word *Luft* and some meteorological terms concerning atmospheric water, especially fog

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## Abstract

The English and French word “air” is derived from the Latin *aer*, which comes from the Greek *ἀήρ*. In contrast, the German word “Luft” is a common Proto-Germanic word; in Old English “*lift*” and “*lyft*”. The word *Luft* (also Danish, Swedish and Norwegian) is associated with brightness; the German *Licht* (light), an air (in an atmospheric sense) without fog or clouds. Air and water were originally “elements” in ancient Greek and were transmutable; they represented two kinds of the “layer of mist” (atmosphere). Dark or thick air was mist or cloud, hiding the gods (who lived in the upper air or sky; the aether). Different terms are presented that describe fog and clouds in connection with the history of the process of understanding. Finally, the word *Luft* (air) as a term for gaseous chemical compounds (“kinds of gases”) is discussed. In addition to the German, all terms are given in Greek, Latin, English and French.

## Zusammenfassung

Das Englische und Französische *air* ist aus dem Lateinischen *aer* und dieses wiederum aus dem Griechischen *ἀήρ* abgeleitet, wohingegen *Luft* ein gemeingermanisches Wort ist; in Altenglisch „*lift*“ and „*lyft*“. Das Wort *Luft* (auch in Dänisch, Schwedisch und Norwegisch) wird mit *Licht* in Zusammenhang gebracht, also eine „*Luft*“ (Himmelsgewölbe) ohne Nebel und Wolken. Luft und Wasser waren als ursprüngliche „Elemente“ der griechischen Antike ineinander umwandelbar und stellten zwei Formen der Dunstschicht („Atmosphäre“) dar. Dunkle oder dicke Luft war Nebel oder Wolke, die Götter verbergend (welche in der oberen Luftschicht, dem Äther, lebten). Die verschiedenen alten Begriffe zur Beschreibung von Nebel und Wolken werden erläutert und in den historischen Zusammenhang der Prozesserkennntnis gestellt. Schließlich wird das Wort „*Luft*“ auch als Bezeichnung für gasförmige chemische Verbindungen (Luftarten) erläutert. Die Begriffe werden neben Deutsch auch in Griechisch, Lateinisch, Englisch und Französisch benannt.

**Keywords** History of meteorology, history of terminology, etymology, air, atmospheric water

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1. Introduction

Alexander von Humboldt, the founder of modern Geography and, in particular, Physical Geography, writes: “The two envelopes of the solid surface of our planet – the liquid and the aëriform – exhibit, owing to the mobility of their particles, their currents, and their atmospheric relations, many analogies combined with the contrasts which arise from the great difference in the condition of their aggregation and elasticity” (Humboldt 1850: 302). He further notes: “The aërial ocean rests partly on the solid earth ..., we find that the strata of air and water are subject to determinate laws of decrease of temperature”. Air, water and soil<sup>1</sup> (or in modern terms: the atmosphere, hydrosphere and pedosphere) were not only the ancient “elements”

forming the earth with all its forms and phenomena but also characterise the states of matter (gas, liquid and solid). “The relative quantities of the substances composing the strata of air accessible to us have, since the beginning of the nineteenth century, become the object of investigations, in which Gay-Lussac and myself have taken an active part ...” (Humboldt 1850: 311). Humboldt cites accurately the concentration of oxygen (20.8 %) and nitrogen (79.2 %)² and named as minor species “carbonic acid gas”³, “carbureted hydrogen gas”, “sulphureted hydrogen gas” and “traces of ammoniacal vapours”. Humboldt also clearly states that “Besides these substances, which we have considered as appertaining to the atmosphere ... there are others accidentally mixed with them ... Fogs, which have a peculiar smell at some seasons of the year ... dust which

Table 1 Historic terms for fog, vapour, drop, fume and exhalation in German, English, French and Latin (empty boxes: no exact translation known)

German	English	French	Latin
Nebel (Wolke)	mist, myst (cloud)	brouillard (nues)	nebula (nubes)
	fog	bruillas, brume	
Dunst	haze		
Dampf	damp	vapeur	
sichtbarer Dampf	visible vapour		
	brume		
Schwaden		nuée	
Brodem		buée	
Feuchtigkeit	moisture	humidité	humidus
Dampf	steam	vapeur	vapor
	vapoury air	vapeur d'eau invisible	
	invisible vapour		
Atmosphärenwasser			
tropfbares Wasser	drop-able water		
Dunstkörperchen		petits corps opaques	
Wassertröpfchen		spères (d'eau)	
Bläschen, Bläsgen	vesicles	Vésicles	vesicula
	spherules	Spérules	bullulae
Tropfen	globules, drops	gouttes (d'eau)	guttae
Tröpfchen	droplet	gouttelettes	guttula
Rauch	smoke, smoak	fumeé	fumus
Ausdünstung	exhalation	exhalaison	exhalatio
	effluvia	Effluence	effluvium
		émanation	
Verdampfen	evaporation	evaporation	
		vaporization	
		volatilization	

darkens the air for an extended area ..." (*Humboldt* 1850: 312f.). Within these few phrases, *Humboldt* used six different terms (aëriform, aërial, atmosphere, air, vapours and gas) for a phenomenon that today we describe simply by air. Old literature (before the middle of the nineteenth century) used terms which today are accurately defined in atmospheric sciences, both synonymously and also with a different sense. Moreover, it is difficult when reading old literature because the same phenomenon might be described by many different terms. Before the middle of the seventeenth century, almost all scientific books were written in Latin but Latin terms for phenomena mostly originate from Old Greek. Only since the seventeenth century, with an increasing number of scientific books in modern languages (German, French and English), were Latin terms rendered differently, through existing words from the colloquial language, by different authors explaining the variety of terms (*Table 1*). However, the decrease in the number of terms (i.e., exactly one term for one phenomenon) together with its accurate scientific definition did not begin stepwise before the middle of the nineteenth century.

### 2. Air (*Luft*) and light (*Licht*)

The word *Luft* (also Old Saxon, Middle High German, Danish, Swedish and Norwegian)<sup>4</sup> finds its primordial roots from medieval texts as the "sphere between earth and heaven" (*Grimm*). Relations of this Proto-Germanic word (*Luft*) with cognate languages have not been found because the most frequent meaning of *Luft* in the old language is a draught of air; Old High German: *luft*, *aër*, *lufft*, *luht*; Gothic: *luftus*; Old North German: *lopt*<sup>5</sup>; Old English or Anglo-Saxon: *lyft*; Middle English (now antiquated): *lift*<sup>6</sup>, Dutch: *lucht*. It is likely that the stem of *Luft* derives from *Licht* (light, German stem: *luk*)<sup>7</sup>, which has been recognised from celestial bodies and its radiation as an atmospheric phenomenon (Latin: *lucis*, *luminis*, *lumen*; Greek: *λυχνος*). The Proto-Germanic word *Luft* shows many variations which even include a similarly sounding Old-English or Anglo-Saxon word *lyft* (after *Kluge* 1999, *Duden* 1963, *Pokorny* 1953). The linguistic affiliation between *Luft* and *Licht* is expressed in old phrases, particularly in relation to the transparency and clearness of air (or atmosphere); cited from *Grimm*, Vol. 12, 1889:

"der claar und heiter luft, *aether apertus* (*Megenberg*); feiner heiterer luft, *liquidæ aureæ*; der schön luft oder heiter himmel, *liber nubibus*

*aether* (*Maaler*)" [clean and bright air; fine bright air; fine air or bright sky].

The relation between light (and sun) and air also follows from the association with growth and life:

"... sie hindern licht und luft, und stehn dem wachsthum vor (*Günther*); noch beraubt dich gott nit der sunnen noch des mons, des lufts und der brunnen (*Kaysersberg*)" [... they hinder light and air and prevent growth; still God robs you not of sun and moon, not of air and wells].

### 3. Air (*Luft*) and wind (*Wind*)

The earliest use of the word *Luft* for wind<sup>8</sup> can be found in the poem "Crist" (991) attributed to the Anglo-Saxon author *Kynewulf* who lived in the eighth century in Southern England (King of Wessex 757-786):

"hû þæt gestûn and se storm and seó stronge lyft brecað bræde gesceaft" [hurricane and storm and tempest break up the wide world]; *Bosworth and Toller* (1898).

*Mohr* (1854) drew attention to the fact that the German language contains words whose pronunciation gives an intrinsic sense (he mentioned "*Atmen*" – breathing); he writes: "Ein anderes höchst malerisches Wort ist "Hauch". Es fängt mit h an und endigt damit. Man muss die Bewegung des Hauchens nachahmen, wenn man es ausspricht" (*Mohr* 1854: 627) [another deeply picturesque word is "Hauch" (breeze breath). It starts with "h" and ends with "ch". One must imitate the movement of a breeze when pronouncing it]. Pronouncing "*Luft*" produces a sibilation like a wind and a blow. The poet *Georg Rudolf Weckherlin* (1584-1653) underlines the "meteorological" elements:

"der luft schiesz dunder, strahl und plitz" [the air shoots thunder, beam and lightning].

*Konrad von Megenberg*, principal of the Vienna Cathedral School and canon in Regensburg, created the first German encyclopaedia of nature, called "Buch der Natur" (originally "Buch über die natürlichen Dinge"). It was primarily a translation from a Latin source, a shortened and changed version of the "*Liber de natura rerum*" by *Thomas of Cantimpré* (about 1200-1270), known as "*Thomas-IIIa*". Therein, we find the ancient description of air as an element (after *Grimm*):

“der luft ist daz nächst element näch dem feur, wann dâ des feurs huot ain end hât, dâ hebt sich des luftes huot an und gêt umb und umb daz mer und umb die erden, ...” [air is the next element to fire and when keeping of fire ends then the air rises and goes around the sea and the earth, ...].

Note the masculine gender of “*der Luft*” (in the course of time all three genders were used).

#### 4. Air (*Luft*) and atmosphere (*Atmosphäre*): air as a body

In Vol. 12 (1889) of *Grimm’s Deutsches Wörterbuch*, the citation of *Megenberg* is given as an indication of the identical use of terms for air, Aerial Ocean and atmosphere:

“luft, der luftkreis selbst, ohne daß mehr die bewegung betont wird, die atmosphäre, nach der alten lehre von den elementen die erde umgebend” [air, aerial ocean itself, without pronouncing the motion, the atmosphere, according to the old doctrine of elements surrounding the earth].

In *Gehler* (1787), one can find the synonymous terms:

*Luftkreis, Dunstkreis, Dunstkugel, Atmosphäre der Erde, Atmosphaera terrestris, Atmosphère de la terre*

The term “atmosphere”, derived from Greek (*ἀτμός* = vapour, *ἄτμις* = vapour, damp, mist, *σφαίρα* = sphere, ball)<sup>9</sup>, is unlikely to have been used before the middle of the eighteenth century. The Dutch astronomer and mathematician *Willebrord van Roijen Snell* (1580-1626) translated the Old Dutch word *damphooghde* (in Latin *altitudine vaporum*, in German *Dunsthöhe*)<sup>10</sup> into a new Latin term “*atmosphæra*” in 1608 (*Snell*), which at first merely described the altitude between the surface of the earth and the bottom of the clouds. The term “*atmosphæra*” was first named in England by astronomers in the context of moon observations (*Weekley* 1967, *Boskovic* 1753). *Gottfried Wilhelm Leibniz* (1646-1716) used the term “*atmosphæra*” manifold in his letters (*Leibniz*). *Robert Boyle* (1627-1691) often used the term “atmosphere” (*Boyle* 1662: 18), partly synonymously with “air” (... the air or atmosphere ...; *Boyle* 1662: 64)<sup>11</sup>. In most cases, *Boyle* used the word air in terms of a substance:

“Since in that part of the Atmosphere we live in, that which we call the free Air (and presume to be

so uncompressed) is crowded into so very small a part of that space, which if it were not hindred it would possess” (*Boyle* 1662: 33f.).

“... the Air may consist of any terrene or aqueous Corpuscle, provided they be kept swimming in the interfluent Celestial Matter; it is obvious that Air may be as often generated, as Terrestrial Particles; minute enough to be carried up and down, by the Celestial Matter, ascend into the Atmosphere” (*Boyle* 1662: 91f.).

*Boyle* also used the terms Corpuscles of Air (*Boyle* 1662: 19), Ambient Air (*Boyle* 1662: 24), Aërial Particles (*Boyle* 1662: 28) and Aërial Corpuscles (*Boyle* 1662: 70), the last one provided with the characteristics of “... gravitating themselves ...”, apparently aerosol particles in today’s understanding as hydrometeors and dust particles. In German (until the middle of the nineteenth century), instead of “*Atmosphäre*” the words *Luftkreis* (“aërial sphere” – air surrounding the earth or a part of it) and *Luftmeer* (aërial ocean) were used, right up until the twentieth century<sup>12</sup>.

#### 5. Air (*Luft*) and water (*Wasser*): air as an element

Until the discovery of the chemical composition of air in the eighteenth century, air was regarded as a body, based on *Aristotle’s* definition of an “element” (together with water, soil and fire). The idea of transmutation (air ↔ water) survived until the end of the eighteenth century, when it was finally rejected by *Lavoisier*; however, *Boyle* (1662) already doubted it from his experiences of “New Experiments Physico-Mechanical Touching the Air” (*Boyle* 1662: 91): “... thought not that Air may be generated out of the water, yet that in general Air may be generated anew”. For the first time, *Boyle* used the term *Æoliphile* (*Boyle* 1662: 85) as an “air-loving” substance<sup>13</sup>, in particular for water; “... that water may be rarefied into true Air”. The close connection between air and water is founded on the ancient Greek. *Aristotle* recognised that water evaporates from waters and the earth soil (*ἀτμός*) and condenses in air (“solidifies” *πύκνωσις* but also named “dense” *δασύς* by the ancients, from which the Latin *dēnsio* and *dēnsus* are derived); in Modern Greek “to condense” means *συμπύκνωσιν* (verbatim “contraction”). The Greek prefix *συν* corresponds to the Latin *con*; hence, we see the origin of the modern *condensare*.

In his book *μετεωρολογικά*, *Aristotle* placed the transformation of four elements (soil, water, air and fire) in

focus. Each of these elements occupies its own region but with the understanding that the matter of *ἀήρ* (air – *aēr*) and *ὑδωρ* (water – *idor*) cannot be treated separately. The changing states of elements are produced, according to the ancient philosophy, by two forces: heat and cold. Whereas older Greek philosophers treated water (*Thales*) or air (*Anaximenes*, *Heraclites*) as elementary bodies, *Aristotle* (and his scholar *Platon*) did not consider the four elements as different basic materials but as carriers of different properties, belonging to a single primary matter (*Meyer* 1914). *Aristotle* attributed to each element paired properties (warm, cold, dry and wet): water is wet and cold and air wet and warm. However, he deemed the four elements insufficient to explain nature and, therefore, introduced *οὐδία* or *αἰθήρ* (aether) as a fifth element, having an ethereal and more spiritual (the quinta essentia in the Middle Ages) property.

While the lower layer of the atmosphere (the celestial hemisphere from the ancient view) was characterised as *ἀήρ*, the upper layer was named *αἰθήρ*; both were regarded not only as different areas but also as different matters (since *Homer*). However, only air (*ἀήρ*) was seen as transmutable. Hence, *ἀήρ* exists as *βαθύς* (thick air) and appears to the eye as fog or cloud (*Gilbert* 1907: 18). Whereas *αἰθήρ* denotes the clean upper air or sky (the igneous sphere) and *ἀήρ* constitutes the lower layer of air, the “atmosphere” (in the German sense *Dunstkreis*, i.e., the misty sphere) is filled with fog and clouds and being in darkness (...to mask the gods).

Initially, water (as precipitation) is celestial and feeds the terrestrial waters. Conversely, terrestrial water rising to heaven and transforming there into fog and clouds stands as a continuous process of becoming and metamorphosis of *ἀήρ* (*Gilbert* 1907: 25). The ancient element “fire” was regarded in the sense of heat until the end of the eighteenth century (*de Luc* 1787). However, in 1806, *Wilhelm August Lampadius* (1772-1842, professor of Chemistry in Freiberg/Saxony) writes: “Das atmosphärische freye Feuer verbindet sich mit dem Wasser zu einem eigenen elastischen Fluidum, dem Wasserdampf; das Feuer ist fortleitendes Fluidum; das Wasser wägbare Substanz” [atmospheric free fire combines with water into its own elastic fluid, the water vapour; fire is the conducting fluid; water is the ponderable matter].

While *Homer* understood air as a gloomy substance (atmosphere), characterised by fog and clouds, *Anaximenes* recognised air as being invisible, only

recognisable through heat and cold, wetness and motion (*Gilbert* 1907: 474). Insofar as the primordial term *ἀήρ* must be understood as fog (dimming), *Anaximenes* already understood *πνεῦμα* as compression of *ἀήρ*, whereas *Anaximander* identified *πνεῦμα* with the thinly dispersed substances of *ἀήρ* (what these might be remains beyond our imagination).

*Aristotle* further subdivided the lower layer of the air. For an understanding of fog (and clouds), the area that immediately adjoins the earth (nowadays called the boundary layer) is of great importance, through “reflected radiance of solar heat” and is characterised through “rising water vapour” (*ἀτμίς*). *Aristotle* denotes a cloud as *πύχνωσις ἀέρος* (thick air). *Aristotle’s* meteorology was regarded as so absolute that it found general acceptance and distribution. *Hellmann* (1908) writes: “The system established by *Aristotle* remained for nearly 2000 years the standard textbook of our science” (i.e. Meteorology), see *Table 2*.

### 6. Air (*Luft*) and fog (*Nebel*): vapour condensation

At this point, *Albertus Magnus* (about 1200-1280) should be mentioned with his work “*De Meteoris Libri*”, which completely corresponds to the work of *Aristotle* but with his own supplements. In his work “*De Passionibus Aëris*” Meteorology is briefly presented. *Magnus* had greatness and two scholars: *Thomas von Aquin* or *Thomas Aquinas* (1224-1275) and *Thomas de Cantimpré*. From the latter, we cite two “typical” phrases on clouds and fog from his work “*De Naturis rerum*” (after *Hellmann* 1904: 123f.):

“Nubes quasi nimborum naves dicuntur; ferunt enim pluvias de terra per vapores ad aera sublimate ... Nebula fit dum humidæ exhalationes vaporaliter trahuntur in aera vel radiis solis repelluntur ad terram” [clouds are quasi called ships of rain-clouds; it is said in particular that rain comes from earth through vapours in rising air ... Fog exists as long as humidity evaporates in air where sunbeams are banished from the earth].

In the above-mentioned book, “*Buch der Natur*” (from about 1350), *Konrad von Megenberg* completely adopted the chapter “*Von dem nebel*” (*De nebula*) from *Cantimpré* (*Hellmann* 1904). In the following, the opening sentences of chapters 10 “*von dem luft*”, 16 “*von dem regen*”, 17 “*von dem tau*” and 26 “*von dem nebel*” are presented in (still understandable today) Middle High German (*Pfeiffer* 1861):

Table 2 Milestones in the exploration of the air

Person / Period	View / Discovery
Homer (ca. 850 B.C.)	Air = fog and clouds
Before sixth century B.C.	Air = emptiness
Anaximenes ( ca. 550 B.C.)	Air as primary element (primordial matter) = invisible, only recognisable through heat and cold, wetness and motion
Empedocles (ca. 450 B.C.)	Introduces the four elements: air, water, soil, and fire
Aristotle (ca. 350 B.C.)	Added a fourth element, the 'aether' and defines air as the lower layer above the earth; his view remains widely spread until the 18 <sup>th</sup> century
Kynewulf (991)	Air = wind
Albertus Magnus, Aquinas (ca. 1250), Meigenburg (ca. 1359)	Continuation of Aristotle's view
Snell (1608)	Introduction of the term 'atmosphera'
Descartes (1637)	Water (vapour) is not (atmospheric) air
Helmont (1653)	Introduction of the term "gas" to distinguish common (atmospheric) air from "alchemistic airs"
Leibniz (ca. 1660)	Uses 'atmosphera'
Boyle (1662)	Uses 'atmosphera' and 'ambient air'
Guericke (1672)	Uses 'aerea atmosphera'
Hales <sup>a</sup> (1727)	Studied elasticity of air and states "the air is full of acid and sulphurous particles"; he called gases, obtained in alchemistic experiment, "airs".
Mayow <sup>b</sup> , Priestley <sup>c</sup> , Scheele <sup>d</sup> , Rutherford <sup>e</sup> (18 <sup>th</sup> century)	Discovery of main air composition (CO <sub>2</sub> , O <sub>2</sub> , N <sub>2</sub> )

<sup>a</sup> Stephen Hales (1677-1761)

<sup>b</sup> John Mayow (1649-1679) English chemist and physiologist

<sup>c</sup> Joseph Priestley (1733-1804) English theologian, philosopher and chemist

<sup>d</sup> Carl Wilhelm Scheele (1742-1786) Swedish Pomeranian pharmaceutical chemist

<sup>e</sup> Daniel Rutherford (1749-1819) Scottish physician, chemist and botanist

“Der luft ist von nâtûr warm und fâuht, aber diu wirm [Wärme] ist gaistlicher [geistig, spiritualis] an dem luft denne an dem feur ...; Der regen kûmpt von wässrigem dunst, dem der sunnen hitz auf hât gezogen in daz mitel reich des luftes ...; Taw wirt auz gar behendem zartem wäsrigem luft, der sô lind und sô zart ist, daz er die kelten der miteln reichs des luftes niht rleiden mag; Der nebel kûmt von grobem wässrigem dunst, dâ vil swærs erdisches rauchs zuo gemischt ist, alsô daz in diu sunne niht aufheben mag hôch von den erden in die lûfte” [the nature of air is warm and wet but the heat in air is spiritual unless in fire ...; rain results from aqueous vapour, which rises aloft into the middle realm of air through solar heat ...; dew consists of slight aqueous air, so balmy and gently that it cannot go to the cold middle realm of air; fog comes from coarse aqueous vapour, add much heavy telluric smoke so that it cannot rise from earth into airs when the sun rises].

In “*Heiligenleben*” (“Fragment of Popular Science from the early English metrical Lives of Saints”) the cli-

matic situation of England is wonderfully expressed, declaring “fog as plague” (Wright 1861: 137):

“Of hawel, of deu, of reyn-forst, and of hor-forst that freoseth so lowe,  
Of clouden and of myst, for a lothing hit is,  
For alle hi cometh of water breth that the sonne draweth up i-wis.”

In the “Anglo-Saxon Manual of Astronomy” (written in the 10th or 11th century) one finds the definition of air (Wright 1861: 17)<sup>14</sup>:

“Aer is Lyft; ignis, fyr; terra, eorðe; aqua, wæter. Lyft is lichamlic ge-sceaft swyde þynne; seo-pfer-gæð ealne middan-eard, ...” [air is atmosphere; ignis fire; terra earth, aqua water. Air is a very thin corporal element; it goes over the whole world, ...].

While fog is always equated with “thick air” and darkness, the terms *μίχλη* (mist), *ἀχλυσ*<sup>15</sup> (gloom), *αὔρα* (breeze of air – *aura*), *νεφέλη* or *νέφος* (Nephele –

cloud Nymph in Greek mythology) were in use. From *nephos*, the Latin terms: *nūbēs*, *nūbilus* and *nebula* are derived (expressing its gloom and darkness); Old High German: *nebul*, Old Slavic: *nebo* (in modern Russian: sky), Sanskrit: *nabhas* (fog, vapour, clouds, air, heaven). *Grimm's Wörterbuch* defines „*Dunst*“<sup>16</sup>: “Im eigentlichen Sinne: eine Menge von Wasserdämpfen, die in tropfbar-flüssigem Zustande unmittelbar an oder über der Erdoberfläche schweben und die Luft mehr oder weniger undurchsichtig machen” [in a proper sense: A lot of water vapours that float in droplet liquid state near to or at the earth's surface and making the air more or less non-transparent]. The English “fog” is defined as (OED) “thick, obscuring mist”. The origin of this term is dated to around 1540 and it is linguistically similar to Old Norwegian *fok*, Dutch *vocht* and German *feucht* (moist). The Old English terms *nebule* and *nifol* (dark, gloomy) were taken from Latin. The differences between “haze”, “mist” and “fog” are not reflected in German<sup>17</sup> where one term (*Nebel*) characterises these words, which is likely to be an effect of the moist “English climate” on language (OED). Nevertheless, in Japanese, there exist more than a hundred terms for different types of atmospheric moisture, and also in French (after *Sachs* 1911) there are several totally different terms in use: *embrun* (mist and overcast sky), *bruine* (sprinkling of rain and fine cold dust rain), *crachin* (drizzle). The closeness of the first two terms to *brume* is remarkable. However, in German, there are descriptive combinations with the word *Regen*: *feiner Regen* (fine rain), *Starkregen* (heavy rain), *Nieselregen* (drizzle), *Sprühregen* (mist, spit, sprinkling of rain), *Eisregen* (freezing rain) etc.

Obviously, the English term “mist” derives from *μίχλη*<sup>18</sup>; as does the Swedish and Norwegian *mist*. In German, *mistig* means (in colloquial language) dirty<sup>19</sup>. Today, “mist” is separated from “fog” mostly by droplet size: Mist consists of larger drops that have a larger tendency to precipitate (more exactly: to sediment)<sup>20</sup>. In Old English, instead of “mist”, the term “brume”, derived from the Latin *bruma* (winter) was used. In French, *brume* is the meteorological term for fog with a visibility of more than 1 km (which in German is called *Dunst*)<sup>21</sup> and *brouillard* for fog with a visibility of less than 1 km (in German *Nebel*). From that stem *brumaille* and *brouillasse* (fine thin fog and fog shower). *Seerauch* (*Meerrauch*, *Flussrauch*) is evaporating fog above water (sea smoke, sea mist, water smoke, steam mist), which in French is *fumée de mer*.

The Proto-German word *Rauch* (smoke, fume; Latin: *fumus*), which was always linked with house, fire and some burning material – in a chemical sense, a mixture from soot, gaseous (including water vapour) and other solid combustion products –, has been and still is in synonymous use with *Dampf* (vapour). *Grimm* defines (Deutsches Wörterbuch, Vol. 2, Col. 714, shortened): *Dampf* as “ein dichter, sichtbarer, feuchter Rauch oder Dunst, schwerer als Duft, leichter als Qualm und Schwaden, Fumus, Vapor, Exhalatio” [... dense, visible, moist smoke or haze, heavier than flavour, lighter than fume and billow]. Interestingly, the adjectives *feucht* [moist] (or *wässrig*, *nass* – aqueous, wet) and *trocken* [dry] were used for the same term in the past to differentiate the state of matter of a general atmospheric phenomenon<sup>22</sup>, i.e., the “visible air” [*sichtbare Luft*], the non-gaseous components for which all terms such as *Nebel*, *Dunst*, *Dampf* and *Rauch* were used. However, it should be noted that *Nebel* [*brouillard*], *Dunst* [*brume*], *Schwaden* [*nuée*] and *Brodem* [*buée*] were used exclusively for water. In English, “steam” is used only for water vapour, whereas *damp*<sup>23</sup>, vapour(s), smoke, *vapeur(s)*, *fumée(s)* are also used for other (evaporating, escaping) substances. Incidentally, *Luft/Lüfte* (air/airs) was used for all gases, in addition to atmospheric air<sup>24</sup>, for a long time after *van Helmont* introduced the term *Gas* (*gas*, *gaz*). In the nineteenth century “*Gas*” became the synonym for town gas, see *Section 7*. The German term “*Ausdünstung*” (in modern usage, evaporation of water, exhalation and more generally, emission for all other substances) denotes the process (evaporation) as well as the product (vapour, gas); French: *émanation*, *exhalation*, *effluence*, *evaporation*, *vaporisation*, *volatilisation*; English: evaporation, effluvium. The German word “*Dunst*” is defined by *Johann Georg Krünitz* (1728-1796) in the “*Oeconomische Encyclopädie*” (Vol. 9, 1785) in the sense of fog, fume and vapours (in modern terms, “trace gases”). Similarly in *Grimm*<sup>25</sup>: “*Luther* gebraucht in der Bibel das Wort nicht, nur Dampf” [*Luther* did not use this word in the Bible, only vapour]. *Goethe* (*Faust I*, *Walpurgisnacht*) writes: “Da steigt ein Dampf, dort ziehen Schwaden, hier leuchtet Gluth aus Dunst und Flor” [there rises a vapour, there flow billows and here lights glow from haze and bloom].

In ancient times, no further ideas on the form and constitution of vapours, fog and clouds originated. The question of what fog and clouds consist of was first asked by the great French philosopher and scientist *René Descartes* (1596-1650) in his work “*Les MÉTÉORES. Discours Premier*” (1637). He describes atmos-

pheric phenomena empirically but based on careful observations (of course, at that time without measurements). *Descartes* distinguishes *exhalaisons* (in terms of vapours) and *vapeurs* (in terms of haze and steam and the German *Dunst*), whereas solely *vapeurs* represent water particles. *Vapeurs* (he did use it only in the plural; the best German equivalent is *Dunst*) he considers as being transparent. Only after *condensant & reserrant* (condensation and compression) are clouds (*nuës*) and fog (*brouillas*) formed. He writes (p. 122): "... si elles s'estendent iusques a la superficie de la terre, on les nomme des brouillas; mais si elles demeurent suspenduës plus haut, on les nomme des nuës" [... one named the vapours, dispersing at the earth surface, fog; when vapours, however, hang on high, they are called clouds]. Although the term *vapeurs* [*Dünste*] is used for water vapour as well as for water droplets, *Descartes* writes (p. 122): "Et il est à remarquer que ce qui les fait ainsi deuenir moins transparentes, que l'air pur, c'est que lorsque leur mouuement's alentist, & que leurs parties sont assés proches pour s'entretoucher, elles se loignent & s'assemblent en diuers petits tas, qui sont autant de gouttes d'eau, ou bien de parcelles de glace" [it is taken into account that what vapours make more non-transparent than clean air is only based on the fact that its motion slows and its particles come so close to each other that they contact each other and combine into small heaps, being either water drops or ice particles]. This corresponds to our present molecular-mechanistic view of condensation. His "*petit parties des vapeurs*" are nothing more than water molecules in air. *Descartes* describes the water particles as "... longues, vnies, & glissantes, ainsi que de petites anguilles" [long, interlinked and slippery as small eels]. *Descartes* also writes only on drops (*gouttes*, from Latin *guttae* = *Tropfen*, *guttula* = droplets, *Tröpfchen*) but never from bulles [vesica, *Blase*] or vésicules [small vesica, *Bläschen*]; the water drops (in contrast to water particles, i.e., molecules) are "*exactement rondes*" [perfectly circular].

Only 20 years later (around 1660), *Otto von Guericke* carried out experiments linking air-filled and air-less flasks. Due to the expansion (without recognising that the saturation arises due to cooling) he observed the formation of fog (*nebula*) or a cloud (*nubes*). In *Chapter 11*, "Versuch, mittels dessen Wolken, Wind und Regenbogenfarben in Glasgefäßen erzeugt werden können" [experiment to produce clouds, wind and rainbow-colours in glass vessels] he writes: "Quod tantò magis apparet, quantò magis vitrum interne humiditatibus refertum est; tunc enim plures ac co-

pioiores exurgunt bullulæ, ita ut (...) nebulam constituant; quæ per intromissionem aliquid aëris ... tunc nebula illa in nubes dispergitur [this phenomenon becomes clearer the larger the humidity in the flask is; after that, more numerous and larger vesicles evolve so that a proper fog forms; but if there is free access to air, the clouds or fogs disappear ...]. Shortly before that phrase, *Guericke* writes on *guttulis minimis* (small droplets) but later he uses the term *bullæ* (in German *Blase*) definitely for a bubble in water. It is unclear whether later scientists stem the term "*Bläschen*" (vesicle, in Latin *vesicula*) from *bullulæ* (*bullæ* = water blister). Generalised, a "vesicular" is a more or less globular envelope filled with water. However, the fog vesicle is a "reverse" *bullæ*, an aqueous envelope filled with air. Although the Latinised term "*atmosphæra*" had already been introduced in 1608, *Guericke* uses the term "*aerea sphaera*" (*aerial sphere*, *Luftkugel* in German). *Guericke* concludes from his experiments on cloud formation in the atmosphere, where his explanation of "compression" is nothing else than the "thick air" in antiquity. It seems that he adopted the knowledge of *Descartes* without changes.

*Christian Gottlieb Kratzenstein* (1723-1795) writes in his "Abhandlung von dem Aufsteigen der Dünste und Dämpfe" [treatise on ascending vapours; it is impossible to find a translation for "*Dünste und Dämpfe*" – both are "vapours" in English]; *Kratzenstein* (1744): "Dünste sind die kleinsten in der Luft schwimmenden Theilchen (wässerichten Materien) unterschieden den Dämpfen ... Die Dünste bestehen aus kleinen Bläßgens ... Die Dunstbläßgens, welche in der Luft schweben, sind inwendig mit Luft gefüllt ..." [*Dünste* are the smallest particles floating in air (aqueous matter), which differ from vapours ... *Dünste* consist of small vesicles ... The vesicles, floating in air, are internally filled with air ...].

*Charles Le Roy* (1726-1779) uses the term "*suspension de l'eau dans l'air*" to describe fog and clouds. The paraphrase "suspension of water in air" for fog (and thus, *Le Roy's* understanding of naturally "drop-able water") is already a modern scientific description of an aerosol<sup>26</sup>; *suspendō* (Latin) = making or keeping floating.

*Horace Bénédict de Saussure* (1740-1799) separates four types of "vapours": *vapeur élastique pure*, *vapeur élastique dissoute*, both in the modern sense water vapour and then two "condensed types": *vapeur vésiculaire*, *vapeur concrète*. He published his findings in

“Essais sur l’hygrométrie” (1783). The Encyclopædia Britannica (1771) defines fog as follows: “FOG, or Mist, a meteor, consisting of gross vapours, floating near the surface or any part thereof”. *Gehler* (1833) notes that fog comprises “... aus wässerigen Dunstbläschen, oder aus Wasserdunste, ...” [... from aqueous vapour vesicles or water vapour, ...]. *Dunst* is already defined, writes *Gehler* (1826), under the keyword *Dampf* [vapour]. Diffusely, he tried to distinguish between gas and vapour, as well as to construct identities (by noncompliance of *Mariotte’s* law through vapours). However, today in Physics, vapour is identical to gas but shows the feature that it is in contact with the liquid or solid phase (e.g., water); in colloquial language, water vapour is still equated with fog (correctly: steam). Hence, *Gehler* equates the terms *Dampf* and *Dunst* but notes that in English one differentiates between vapour and steam. As discussed above, today we no longer define *Dunst* as *Dampf* (in the sense of a gas) but as small dry, as well as wet, particles but also as very small aqueous particles suspended in the air (haze).

### 7. Air/airs and gas/gases: air as a chemical substance

Whereas the (qualitative) description of air quality using terms such as: clean [*reine*], foul [*unreine*], good [*gute*], bad [*böse*], stuffy [*stickige*], corrupted [*verderbte*], cold [*kalte*], cool [*kühle*] and warm [*warme*] had been used verbally since biblical times, different kinds of air [*Luftarten* or *Luftgattungen*] were first discovered by alchemists. This was not yet a complete analysis of atmospheric air but the identification of the formation of different gases (called “airs” at that time) as a result of alchemistic experiments. The term “gas” was still unknown. In his book “*Ortus medicinae* i.e. *initia physicae inaudita*”, published posthumously in Amsterdam in 1653, the alchemist and physicist *Johann Baptist (Jan) van Helmont* (1577-1644) wrote (he believed that all matter could be reduced to air and water):

“ideo paradoxo licentia, in nominis egestate, halitum illum gas vocavi, non longe a chao veterum secretum” [I call this breeze gas, because it is not far from the chaos of the old].

He explains why a new term (*hunc spiritum, incognitum hactenus, novo nomine Gas voco*) is necessary (*Adelung* 1796: 425):

“... dass unsere Naturkundige ein schicklicheres Wort, welches nicht so sehr das Gepräge der Alchymie an sich hätte, ausfündig machten” [... that our natural scientists might find a seemlier word, not so much having the imprint of alchemy].

Obviously there was a requirement to distinguish the vapours<sup>27</sup> and airs found in chemical experiments from (atmospheric or common) air through a new term. It is notable that at that time, atmospheric air was still regarded as a consistent chemical body. The medieval physician and alchemist *Theophrast von Hohenheim*<sup>28</sup>, who was known under the name of *Paracelsus*, in that sense, called the “airspace” chaos. Air and chaos were synonyms to him (*Loewe* 1936). The primordial Greek term *χάος* denotes<sup>29</sup> an empty space and the beginning. However, emptiness cannot be identified with nothing. According to ancient cosmogony, after which the word was born from the chaos and hence, chaos was creativity; having all opportunities (*Genz* 1994). From the primordial chaos (or *mysterium magnum*) arose through “*separatio*” the four elements: water, fire, soil and air. These elements caused further emergence and subsequent decomposition<sup>30</sup>:

“dis mysterium magnum ist ein muter gewesen aller elementen und gleich in solchen auch ein grossmutter aller stern, beumen und der creaturen des fleischs ... und ein element ist ein muter, deren seind vier, luft, feur, wasser, erden; aus den vier mutern werden alle ding geboren der ganzen welt ...” [this mystery magnum was a mother of all elements and contemporary a grant mother of all stars, trees and creatures of bodies ... and an element is a mother, of that are four, air, fire, water, soil; from these four mothers all things of the whole world were born ...].

The great achievement of *Paracelsus* was to use alchemy to search for medical substances. Perhaps he was the first who considered substance-forming properties to be more chemical than philosophical, creating a preconception of chemical elements (however, only introduced scientifically by *Boyle*). Vital processes, telluric and cosmic physics (for *Paracelsus*, the atmosphere acts as the special matter “chaos”) had already been connected through substantial relationships<sup>31</sup> (*Bugge* 1929: 96). Today, there is also the belief that *Helmont* introduced the term “gas” from the term “chaos” (the essays by *Paracelsus* were well known to

Table 3 Historic terms of gases (airs, kinds of airs, vapours) in German and (in footnotes) in English, French and Latin; instead of air [*Luft*] in early alchemistic times spirit [*Geist*] was also used as a general term.

Term	Formula	Notes
dephlogistisirte Luft, Dephlogiston, Lebensluft, gute Luft, reine Luft, einathembare Luft, Feuerluft, künstliche Luft, Empyrealluft, säurezeugendes Gas, Sauerluft, Sauerstoffgas	O <sub>2</sub>	a, c
hepatische Luft, Leberluft, stinkende Schwefelluft, Schwefelleberluft, geschwefeltes Wasserstoffgas, gasförmiger sulphurisirter Wasserstoff	H <sub>2</sub> S	d
flüchtige alkalische Luft, laugenartige Luft, alkalische Luft, urinöse Luft, laugensalzige Luft, flüchtig-alkalische Luft	NH <sub>3</sub>	e
Phosphorluft, phosphorische Luft, geposphortetes Wasserstoffgas, phosphorisirtes Wasserstoffgas, gasförmiges phosphorisirter Wasserstoff, entzündliches Phosphorgas	PH <sub>3</sub>	f
spathsäure Luft, spathsäures Gas, spathgesäuertes Gas, flußspathsäure Luft, Flußspathgas, luftige Flußspathsäure	HF	g
inflammable Luft, brennbare Luft, entzündbare Luft, entzündliche Luft, brennende Luft, Brennluft, Wasserstoffgas	H <sub>2</sub>	h, x
Sumpfluft, schlechte Luft	CH <sub>4</sub>	i
fixe Luft, Luftsäure, luftsäures Gas, Sauerluft, Kalkgas, Kreidensäure, wildes Gas, künstliche Luft, wildes oder weinigt Gas, Kalksäure, Kalkspathsäure, Kalkgas, kohlenesäuertes Gas, mephitische Säure, mephitisches Gas, Kohlensäure	CO <sub>2</sub>	j
reduzierte fixe Luft	CO	k
salzsaure Luft, seesaure Luft, kochsalzsaure(s) Luft (Gas)	HCl	l
dephlogistisirte Salzsäure	Cl <sub>2</sub>	a, m
vitriolische Luft, vitriolsäures Gas, Schwefelluft, schwefelsäures Gas, luftförmige phlogistisirte Vitriolsäure, unvollkommene Schwefelsäure in Dampfgestalt	SO <sub>2</sub>	n
vitriolsäure Luft, vitriolsäures Gas, flüchtiges schwefelsäures Gas, luftförmige Schwefelsäure, luftförmige phlogistisirte Vitriolsäure, Schwefelluft	SO <sub>3</sub>	o
Salpetergeist, Salpeterluft, Salpetersäure, Luftsäure, gemeine Salpeterluft,	HNO <sub>3</sub>	p, x
salpetersäures Gas, unvollkommene Salpetersäure in Dampfgestalt, dephlogistisirte Salpeterluft, dephlogistisirte Salpetersäure	HNO <sub>2</sub>	a, q, x
essigsäure Luft, Essiglufte, vegetabilisch-säure Luft	CH <sub>3</sub> COOH	r
phlogistirte salpetrige Luft	N <sub>2</sub> O	a, s
salpeterartige Luft, salpeterhalbsäures Gas, Salpetergas, Salpeterluft, nitröse Luft, oxydirter Salpeterstoff, salpetrige Luft	NO	b, t, x
salpetersäure Luft, phlogistisirte Salpetersäure, Salpeterdämpfe	NO <sub>2</sub>	a, u, x
phlogistisirte (oder phlogistische) Luft, verdorbene Luft, unreine Luft, Stickluft, Stickgas, Salpeterstoff, Salpeterstoffgas, azotisches Gas, Stickstoff	N <sub>2</sub>	a, v

- a Both spellings were used: *phlogistirt* and *phlogistisirt*; the differentiation between *dephlogistirt* (*Dephlogiston*) and *phlogistiert* is not clear until nowadays. *Phlogiston* denotes a hypothetic gas that evolves when matter burns.
- b Differentiation is not always clear.
- c good, pure, vital, fire air; dephlogisticated air, empyreal air; air dephlogistiqué, gaz oxygène; aër verus factitius, aër vitalis, aër purissimus, aër dephlogisticatus, gas dephlogisticatum, gas oxygenium
- d hepatic air, heptic air, fetid or sulphur air, sulphuretted hydrogen gas; air hépatique, gaz hépatique, gaz hydrogène sulfuré; aër hepaticus, mephitis hepatica, gas hepaticum, gas hydrogenium sulphuratum
- e alkaline air, volatile air, spirit of hatshorn; gaz alcali-volatil, gaz ammoniacal; gas alcalinum volatile, aër alcalinus, mephitis urinosa
- f air (gaz) phosphorique, gaz hydrogène phosphorisé; gas phosphoricum, mephitis phosphorica, gas hydrogenium phosphorisatum
- g acid of spar, acid of sparry; air (gaz) acide spathique, gaz acide fluorique; gas acidum fluoricum, gas fluoris mineralis, gas acidum spathosum, aer acidus spathosus, mephitis fluoris mineralis
- h air inflammable, inflammable air; air inflammable, also (*Ingenhouss*) gaz inflammabile, aer inflammabilis, mephitis inflammabilis, gas carbonum, gas pingue (*Helmont*), gas inflammable, aer inflammabilis
- i marsh gas, swamp gas; carburetted hydrogen; gaz palustre, gaz inflammable des marais
- j air of Hales, fixed air, (mephetic) acid air, acid of aerial, acid of calcareous, acid of chalk, acid of charcoal; air fixe, acide méphitique, gaz méphitique, acide crayeux, gaz acide carbonique; aer fixus, aer factitius, gas aëreum, gas mephiticum, calcareum, gas silvestre, gas vinosum, mephitis vinosa, acidula, acidum mephiticum, acidum aëreum s. atmosphaericum, acidum cretae, gas acidum carbonicum

- k reduced fixed air
- l marine acid (air), muriatic air (acid), acid of salpêtre, spirit of salt, sea-salt (but also = NaCl); mephitic muriatica, gas muriaticum, aër muriaticus, aër acidus saline
- m dephlogisticated marine acid (air), oxymuriatic air
- n vitriolic (acid) air, phlogisticated acid of vitriol, sulphurous acid (gas); gaz acide sulfureux, gaz ou air acide vitriolique, acide de soufre aëriforme; gas acidum sulfureum, gas acidum vitriolicum, gas acidum sulphureum volatile, aer acidus vitriolicus, acidum vitrioli phlogisticatum aëriforme, mephitic acida sulphuris (*vitriol* = sulfate)
- o vitriolic acid air, acid of vitriol (SO<sub>2</sub> and SO<sub>3</sub> were not separated before 1800); see also footnote n.
- p spirit of nitre, acid of nitre, dephlogisticated nitrous air, nitric acid air; acide nitrique, gaz acide-nitreux; spiritus nitri, gas acidum nitrosum, acidum nitri (*nitre* = KNO<sub>3</sub>, and *nitres* = nitrates)
- q acid of nitre, phlogisticated nitrous air; gaz nitreux oxygéné, gaz nitrique, oxide gazeux d'azote
- r gaz acide acetoux; gas acidum, acetosum, aër acidus vegetabilis, mephitic acetosa
- s phlogisticated nitrous air
- t nitrous air; gaz nitreux oxygéné, gaz nitrique, oxide gazeux d'azote; gas acidum nitrosum, mephitic acida nitri, acidum nitrosum, nitri phlogisticatum
- u nitric air; gaz nitreux, air acide-nitreux; gas acidum nitrosum, acidum nitri phlogisticum, mephitic acida nitri
- v mephitic air, impure air, vitiated air, phlogisticated air, inflammable air; gaz ou air phlogistiqué, gaz azotique, azote; aër phlogislicatus, aër vitiatum, mephitic aëris phlogistica, gas phlogislicatum, gas azoticum, azoticum
- w often confused with CH<sub>4</sub> as inflammable air
- x HNO<sub>3</sub>, NO and NO<sub>2</sub> often confused (the constitution of NO<sub>2</sub> was known already around 1790)

him), according to Dutch pronunciation; omitting the “o” and pronouncing “ch” like “g” (*Egli* 1947). However, it is also possible that the term is derived from *Geist*<sup>32</sup> (ghost or spirit, Latin *spiritus*), which at that time was common for gases and airs in alchemy. *Kopp* (1847: 178) writes:

“Woher das Wort zunächst gekommen ist, weisz man nicht; nach *Juncker*, dem bekannten Schüler *Stahl's*, soll es aus Gäscht, dem bei der Gährung entstehenden Schaume, abgeleitet sein” [where the word originally comes from, we do not know; according to *Juncker*, the well-known scholar of *Stahl*, it should stem from Gäscht, the foam forming during fermentation].

*Lavoisier* writes in his work “Opuscules physiques et chimiques” (2e éd., Paris 1802: 5):

“Gas vient du mot hollandais Ghoast, qui signifie Esprit. Les Anglais expriment la même idée par le mot Ghost, et les Allemands par le mot Geist qui se prononce Gaistre. Ces mots ont trop de rapport avec celui de Gas, pour qu'on puisse douter qu'il ne leur doive son origine.”

In *Deutsches Wörterbuch*, Vol. 4 (1897), the term *Gas* is defined as follows: “Gattungsname für Luftarten, oder luftförmige Flüssigkeiten wie die Wissenschaft den Begriff bestimmt, die sich von den Dämpfen unterscheiden durch die Unmöglichkeit oder Schwierigkeit sie in tropfbare Gestalt zu bringen; auch von der gewöhnlichen Luft sind sie ver-

schieden und wurden im Gegensatz zu ihr zuerst erkannt, während dieselbe jetzt selber von der Wissenschaft als gasförmig, als ein Gasgemenge bezeichnet wird” [common noun for kinds of air or aerial liquids as science defines that term, distinguished from vapours through the impossibility or difficulty to bring them into a drop-able form; but also that they differ from common air and in contrast to it they have been at first perceived, while the same now is described by science gaseous, as gaseous mixture].

*Helmont* is said to have called (after *Adelung* 1796) common air [*gemeine Luft*] a gas, or more specifically, *gas ventosum*. After *Gehler*, the terms *gas atmosphericum* and *Dunstkreisluft* [aerial spherical air] were used synonymously<sup>33</sup>. In *Krönitz* (1779: 404) it is written: “Das Gas nennen *Helmont* und andere Chemiker die unsichtbaren flüchtigen Theile, welche von selbst aus gewissen Körpern ausdampfen ... z. e. die Dämpfe der in eine spirituöse oder in eine faulige Gährung gerathenen Materien, tödtliche Dämpfe aus brennenden Kohlen, die Schwaden in Bergwerken, u.s.w., und selbst den spiritus rector gewisser Substanzen, z. e. des Bisams, denn es wurde zuerst unter die spiritus oder Geister der Dinge gezählt” [as gas, *Helmont* and other chemists call the invisible volatile parts that escape spontaneously from certain bodies ... e.g., vapours of a spirituous or in fermentation processing matter, deadly vapours from burning coals, damp in mining etc., and even spiritus rector of certain substances, e.g., that of musk because it was called first among the spirits and ghosts of things].

Robert Boyle proposed in his book “Memoirs for a General History of the Air” (1692) the formation and study of different kinds of air but he writes nothing on its realisation. Ramsay (1907) believed that having carried out such experiments, the composition of the air had been discovered hundreds of years before. As already mentioned, the terms *Luft* [air] and *Gas* [gas] were used in parallel later on, but they were spoken of also in the form of *Luftarten*, *Luftgattungen* [kinds of air] and *luftförmigen Stoffen* [aerial substances]. Until the end of the nineteenth century, the known types of airs (gases) were subdivided into two main classes, those which support combustion and breathing (*einatembare Luftarten* – inhalable airs), and those which fade light and kill animals (*mephistische Luftarten* – mephistic airs). Among the former common air and dephlogisticated air (oxygen) are included which do not allow further subdivision. The second class (mephistic) is subdivided into inflammable and non-inflammable categories and then subdivided again into those mixable with water (in other terms, water-soluble) and those that cannot be mixed with water (Table 3).

## 8. Conclusions

The primordial term *ἀήρ* must be understood as fog (*Homer*). *Aristotle* attributed to the element “air” paired properties (wet and warm). However, he deemed the four elements (air, water, soil and fire) insufficient to explain nature and, therefore, introduced *οὐδία* or *αἰθήρ* (aether) as a fifth element. *Aristotle* denotes a cloud as *πύχνωσις ἀέρος* (thick air). While the lower layer of the atmosphere (the celestial hemisphere from the ancient view) was characterised as *ἀήρ*, the upper layer was named *αἰθήρ*; both were regarded not only as different areas but also as different matters (since *Homer*). The lower layer (*ἀήρ*) *Aristotle* characterised through “rising water vapour” (*ἀτμίς*) and a cloud he denotes as *πύχνωσις ἀέρος* (thick air). However, only air (*ἀήρ*) was seen as transmutable. The idea of transmutation (air ↔ water) survived until the end of the eighteenth century, when it was finally rejected by *Lavoisier*. The German word *Luft* (also Old Saxon, Middle High German, Danish, Swedish and Norwegian with many variations: *luft*, *luftus*, *loft*, *lyft*, *left*, *lift*, *lopt*, *lucht*, *luht*, *locht*) finds its primordial roots from medieval texts as the “sphere between earth and heaven” (Old-English or Anglo-Saxon word “*lyft*” and Middle English “*lift*”; Dutch “*lucht*”). The linguistic affiliation between *Luft* (air) and *Licht* (light – in older German also *Liecht*, *Lioht*,

*Liehte*, *lecht*) is expressed in old phrases, particularly in relation to the transparency and clearness of air (or atmosphere). The term “atmosphere” (vapour layer) is best reflected by the German word *Dunstschicht*, long time in use instead of “atmosphere”. *Willebrord van Roijen Snell* translated the Old Dutch word *damphooghde* (in Latin *altitudine vaporum*, in German *Dunsthöhe*) into a new Latin term “*atmosphæra*” in 1608, which at first merely described the altitude between the surface of the earth and the bottom of the clouds, shortly afterwards used by *Gottfried Wilhelm Leibniz* as “*atmosphæra*” and *Robert Boyle* as “atmosphere”. In German (until the middle of the nineteenth century), instead of *Atmosphäre* the words *Luftkreis* (“aërial sphere” – air surrounding the earth or a part of it) and *Luftmeer* (aërial ocean) were used, right up until the twentieth century. Now “atmosphere” is the term for the “aerial sphere” and “air” is the (chemical) matter filling the atmosphere; however, both terms are still used synonymously (for example: “air chemistry” or “atmospheric chemistry” as the discipline to study the chemical composition of air and chemical reactions therein). A (qualitative) description of air quality using terms such as clean, foul, good, bad, stuffy, corrupted, cold, cool and warm was used verbally since biblical times, different kinds of air (airs, vapours) were first discovered by alchemists. Obviously there was a requirement to distinguish the vapours and airs found in chemical experiments from (atmospheric or common) air through a new term “gas”, introduced by *Jan van Helmont*. The word “gas”, however, became common only in the last decades of the 19th century by use of “town gas” for illuminating, heating and cooking. Before establishing modern Meteorology in the middle of the 19th century, air(s), vapour(s), gas(es), fog and cloud(s) were not well defined scientifically. Whereas the terms “gas”, vapour”, “fog” and “cloud” are now well defined, it seems that the term “air” has never lost its multiple meanings. We should therefore use “atmospheric air” (“common air” in the past) and define it as the multi-substance and multiphase (gas, aqueous, solid) mixture in the atmosphere.

## Notes

<sup>1</sup> Today, soil means the upper part (pedosphere) of the solid earth whereas the rocky part (lithosphere) is situated below. In ancient times, soil was the synonym for the solid earth.

<sup>2</sup> Only at the end of the 19th century was it known that about 1 % of this figure is due to novel gases.

<sup>3</sup> Citing *Boussingault* and *Lewy, Humboldt* (footnote on p.311) mentioned that “the proportion of carbonic acid in the atmosphere ... varied only between 0.00028 and 0.00031 in volume” – a very modern view (*Möller* 2014).

<sup>4</sup> Old Greek *ἀήρ*, also gr. *ἀέριος* = up in air, misty; in Modern Greek: *αέρας*, Engl. air, Lat. *aer*, Ital. *aria*, Portu. *ar*, Roman. *aer*, Span. *aise*

<sup>5</sup> The Old North German *lopt* also means the upper floor and the loft in a house (Low German: *lucht*), a meaning that is continuous in Swedish and Danish *loft*.

<sup>6</sup> The modern English term “lift” (elevator) continues the Old Greek sense of “to raise or rise” (of air).

<sup>7</sup> Old terms: *liecht*, *liocht* (Old High German), *liehte* (Middle High German), *lecht* (Middle Dutch and Middle Low German); the similarity with English light is evident (means also “easy”, in German “*leicht*”; see the difference to “thick air” below). Similar to Norwegian and Danish *lys*, Swedish *ljus* and like French *lumière*, Romanian *lumina*, Italian *lume* (and *luce*), Spanish and Portuguese *luz*, all derive from Latin *lumen* and *lux*.

<sup>8</sup> We also might assume that the word *Luft* comes from the imagination of tangibleness and vehemence; affiliation to Sanskrit *rabh-as* = stormy, force, and Greek *λαβρος* = severe, wild. In Carinthian *lüftig* = rapid, fast.

<sup>9</sup> In old German books, instead of atmosphere (“*Atmosphäre*”), the term “*Dunstkreis*” and the words *Luftmeer* und *Luftozean* (ocean of air) are often used (*Reimann* 1857; *Umlauf* 1891); *atmosphäera*, *atmosphère*.

<sup>10</sup> Dutch: “*Dunstglocke*” *mistigheid* (see the discussion with the term mist below).

<sup>11</sup> In contrast to the terrestrial globe (p. 19 in *Boyle*) as the total solid earth

<sup>12</sup> *Möller* (2002) defined air as the chemical mixture (consisting of gases, hydrometeors and dust particles) that fills the atmosphere.

<sup>13</sup> *Lampadius* (1806) used the term *Atmospärilien* for the first time in German in the sense of all constituents of the air with the exception of gases.

<sup>14</sup> The meanings for cloud, rain and hail are similar between Anglo-Saxon and German: *wolcnu* [*Wolke*], *renas* [*Regen*], *hagol* [*Hagel*].

<sup>15</sup> *Acherōn* is a mythological river in the underworld, identified by poets with the underworld (= darkness).

<sup>16</sup> In English, there exist many terms for *Dunst*: mist, haze, damp, vapour, brume, fume, aura. According to *Deutsches Wörterbuch* (Vol. 2, Col. 1559, shortened) also: “für dünne, nasse oder trockene Flüssigkeit, die in die Luft steigt, meist sichtbar ist, doch auch nur durch den Geruch empfunden wird; vergl. dampf, duft, brodem, qualm, schwadem” [for thin, wet or dry liquid, rising into air, usually visible but also only conceived by smell; compare vapour (dampf, brodem – last term not more in use in German ),

flavour (duft), plume (qualm), billow (schwaden)]. Old High German *tunst*; Middle High German, Swedish and Danish *dunst*. In Gothic, Old-Saxon, Old Friesian, Low German and Dutch *dunst* does not exist; it is related to the Gothic *þinsan* and the lost *þinan* (stretch); Old North German, Anglo-Saxon and English “dust” (Staub). Nowadays, we translate atmospheric *Dunst* with haze.

<sup>17</sup> The chapter “Of Mists and Fogs” in *Prout* (1834: 312) is reduced in the German edition (*Prout* 1836: 214) to “Vom Nebel” [of fog]. The opening sentence of this chapter in *Prout* (1834) “When mists, from other causes, are general and extend to considerable heights above the earth’s surface, they acquire the name of fogs” was deleted completely in the German edition, because mist = fog = Nebel. “Scotch mist” means very thin rain (*Lloyd* and *Noehden* 1836). In many British publications of the nineteenth century the term “mist” was used instead of “fog”. *Giberne* (1890) wrote: “A mist is commonly distinguished from a fog as being made of rather larger drops, therefore feeling more wet”.

<sup>18</sup> In Latin *mingō* and *mejo* (from that also derived the English “mist”, see also notes 17, 20 and 21); in its primordial meaning also: urinate; but in Sanskrit *mih*, *megha* (cloud, mist). The English “misty” (foggy) was in Old English “mistig” (see note 28).

<sup>19</sup> On the other hand, the German word “*Mist*” means dung, but in a colloquial sense also “brass farthing” – again, evidence of “gloom” and “evil” in mist (fog) ...

<sup>20</sup> Such weather in colloquial German is called “*Mistwetter*”: dark, cold and wet. *Ehrenberg* (1849: 122) cites the weather record of the British vessel *Roxburgh* on 4.2.1839 at Cape Verdean: “Der Himmel war überzogen, das Wetter mistig [obviously the English misty was used in the record] ...” [sky was overcast, weather misty]. The term “mistig” (neblig – foggy) is unusual in German; the adjective means: full of “mist”, dirty.

<sup>21</sup> After *Sachs* (1911) *brume* means “thick fog”, i.e., fog with visibility less than 1 km – also exactly reverse in modern meaning. *Bruine* is translated after *Sachs* (1911) as “*Staubregen*” [dust rain], an unknown word in modern German. Nowadays, *bruine* = *Sprühregen* = drizzle (identical with *crachin*); *brume sèche* = haze = *Dunst* after METAR (meteorological aerodrome report)

<sup>22</sup> Today the adjectives “*trocken*” (dry, sec) and “*nass*” (wet, humide) are used in atmospheric science only for the process of deposition to distinguish between dry and wet deposition. In German, there is still a distinguished between “*feuchter Dunst*” (moist haze, i.e., fog with visibility between 1 and 5 km) and “*trockener Dunst*” (dry haze, greater visibilities but still with a discernible opacity of the atmosphere). The latter represents cloud condensation nuclei in larger numbers, activated and exceeding the deliquescence point (almost 60-70 r. H.).

<sup>23</sup> The similarity with German *Dampf* is significant (Old High German: *dampf*).

<sup>24</sup> Atmospheric air (as gas mixture) has also been characterised with the following terms (*Krünitz* 1779): *atmosphärisches Gas*, *gemeine Luft*; Latin *gas atmosphaericum*, *aër atmosphaericus vulgaris, communis, Gas ventosum*; *gas atmosphérique*, *air commun*, *air de l'atmosphère*.

<sup>25</sup> *Grimm* sets a linguistic relation between “*Dunst*” and the English (Old North German and Anglo-Saxon) “dust” = Staub.

<sup>26</sup> The term aerosol was first introduced by *Schmauß* (1920). The terms sol, colloid and colloidal state were introduced by *Thomas Graham* (1861). *Wolfgang Ostwald* (1909) – son of *Wilhelm Ostwald* – clearly saw that the system, which he characterised as heterogeneous or multiphase, must be studied and not only the colloid, i.e., the dispersed phase. *Ostwald* (1909) states fog as an example for the combination of gas-liquid and atmospheric dust for the combination of gas-solid.

<sup>27</sup> *Dämpfe*, *Dünste* and *Lüfte*, also *fumus*, *vapor*, *exhalatio*; Old High German: *dampf*; Middle High German: *tampf*; Danish, English, Dutch and Low German: *damp*; Old North German: *dampi*; Polish: *dim*. It belongs to the strong verb *dimpfen* (reek, smoke). It is related with Old High German *daum*, Middle High German *toum* and Austrian *Dam* (*Ausdünstung*) and Swedish *dam* (flushy cloudy dust).

<sup>28</sup> *Paracelsus*, practically *Philippus Aureolus Theophrastus Bombastus von Hohenheim* (1493-1541); the 16th and 17th centuries are therefore considered as the iatrochemical era. *Paracelsus* became famous for the phrase “Alle Ding’ sind Gift und nichts ohn’ Gift; allein die Dosis macht, das ein Ding’ kein Gift ist” [all things are poison and nothing is without poison; only the dose permits something not to be poisonous], but mostly in a shortened version “sola dosis facit venenum”.

<sup>29</sup> In ancient poetry also used for “airspace”.

<sup>30</sup> In the lifetime of *Paracelsus* only very few books of his were published. It was only after 1560 that (partly in alchemistic compilations) *Paracelsus’s* essays (several hundreds) were published as “Liber Natura, sive Chaos veterum; generalem metallorum generationem, etc. demonstrans”. In: *Liber vexacionen, John Stacy* (1656): 83-89 (Glasgow University, Bibliography MS Ferguson 237).

<sup>31</sup> However, he also retains the three basic substances in alchemy: sulfur, mercurius and sal, which correspond to the physical phenomena of combustibility (oiliness), liquefaction (evaporation) and solidification (solidity).

<sup>32</sup> Dutch and Low North German: *geest*; Anglo-Saxon: *gâst* (also Old Friesian) and *gæst*. The origin is seen in whiff [Hauch] and breath [Atem]. *Luther* writes (*Hiob* 4, 9): Der himel ist durchs wort des herrn gemacht und all sein heer durch den geist seines munds [by the word of the LORD were the heavens made; and all the host of them by the breath of

his mouth]. Insofar the synonymy between breath, spirit, vapour, wind and kinds of air is given.

<sup>33</sup> *Humboldt* writes on kinds of air [Gasarten] in “Versuche über die chemische Zerlegung des Luftkreises” (*Braunschweig* 1799): “Doch ist im Buche selber noch immer mehr von Luft als Gas die Rede” (*Deutsches Wörterbuch*) [experiments on the chemical decomposition of the air: “... however, in this very book, the term ‘air’ is used more often than the word ‘gas’].

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