Glossary of Atmospheric Chemistry Terms

Absorber A device used for the collection or removal of material by absorption, which transfers gases or liquids contained in another gas or liquid into a different phase. The device may be a packed column, scrubber, impinger, or a spray chamber.

Absorption (material) The process by which one material (the absorbent) is retained by another (absorbate); the transfer of a component from one phase to another; in atmospheric chemistry usually the transfer of gas or vapor molecules to the liquid phase.

Absorption (optical) The loss of light intensity at characteristic wavelengths caused by the interaction of light with, and the transfer of radiative energy to, an absorbing substance. In contrast to scattering, absorption results in a real loss of light intensity, whereas scattering causes merely a redirection of light in its path.

Absorption coefficient Wavelength-dependent coefficient, $\varepsilon(\lambda)$, quantifying the extent of absorption of light by a pure compound determined by the Beer-Lambert law: $\log_{10}(I_0(\lambda)/I_t(\lambda)) = \varepsilon(\lambda)\, l\, [A]$, where I_0 and I_t are the incident and the transmitted radiances (intensities), respectively, for an optical path length l and uniform concentration of absorbing compound $[A]$. If the units for concentration are mol per volume, $\varepsilon(\lambda)$ is called the decadic molar absorption coefficient. This form of the Beer-Lambert law is commonly used in reporting absorption coefficients for liquids and aqueous solutions. When Naperian (natural) logarithms are employed, a symbol different from ε should be used to avoid ambiguity. In any case it is necessary to state the base of the logarithm, units of concentration and path length when reporting absorption coefficient data.

Absorption cross section A wavelength-dependent coefficient, $\sigma(\lambda)$, specifying the extent of absorption of light by the Beer-Lambert law in the form $I_t(\lambda)/I_0(\lambda) = \exp(\sigma(\lambda)\, l\, n)$. Here, I_0 and I_t are the incident and the transmitted radiances (intensities), respectively, l is the optical path length (unit: cm), and n is the number concentration (units: molecule cm^{-3}) of the absorbing molecules. The absorption cross section $\sigma(\lambda)$ (unit: cm^2 $molecule^{-1}$) is commonly used in reporting optical absorption data for gases. It is related to the corresponding molar cross section κ by $\sigma = \kappa/N_A$ where $N_A = 6.02214 \times 10^{23}$ is the Avogadro constant.

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Absorption spectrum A plot of the absorption coefficient or absorption cross section versus wavelength (usual) or reciprocal wavelength. A spectrum may consist of a series of discrete narrow lines (line spectrum), a group of bands that with increasing spectral resolution may be shown to consist of a series of lines (band spectrum), or a true continuous spectrum that cannot be further resolved.

Accommodation coefficient (Also called sticking coefficient) A measure of the efficiency by which molecules (atoms, particles, etc.) impinging on aerosol particles, cloud drops, etc. are captured from the gas phase. The accommodation coefficient is the fraction of the total number of collisions that result in the capture of molecules (atoms, particles, etc.) by the particle, cloud drop, etc. The others are returned to the gas phase.

Accretion The external addition of new matter to particles leading to their growth in size. In the early development of the solar system, proto-planets are said to have grown by accretion, that is by the addition of material due to collisions with other small bodies being present.

Accumulation mode A maximum in the size distribution of atmospheric aerosol particles formed by coagulation of smaller particles and deposition of condensable material from the gas phase.

Achondrite Stony meteorite without chondrules, mainly igneous in origin.

Actinic flux The total spectral flux of photons per unit area and wavelength interval available to molecules at a particular point in the atmosphere where the term *actinic* refers to radiation capable of causing photochemical reactions. The actinic flux (actually a flux density) consists of three components: direct solar radiation, diffuse radiation originating from scattering in the atmosphere, and diffuse radiation originating from reflection at the earth's ground surface. Accordingly, the actinic flux at a particular point in the atmosphere is calculated by integrating the spectral radiance over all directions of space. The actinic flux must be distinguished from spectral irradiance, which is the hemispherically integrated radiance weighted by the cosine of the angle of incidence and represents the photon flux per unit area through a plane surface. Both quantities have the same units (m^{-2}, s^{-1} nm^{-1}).

Activated particle Said of an aerosol particle that with rising relative humidity grows by the attachment of water and, when r.h. >100%, overcomes the peak in the Köhler growth curve to grow further and form cloud drops.

Activation energy An energy barrier preventing a chemical reaction (even an exothermic one) unless the reaction partners are endowed with sufficient energy to overcome the energy barrier.

Activity (chemical) In thermodynamics, the activity a_B of a substance B in a mixture of substances is related to the chemical potential $\mu_B = R_g T \log(a_B)$, where R_g is the gas constant and T the absolute temperature. In dilute solutions the activity is a relative concentration defined by $a_B = \gamma m_B / m^{\ominus}$, where m_B is the concentration in mol kg^{-1} (molality), $m^{\ominus}$ is a standard value of molality, often chosen to be 1 mol kg^{-1}, and γ is the activity coefficient of B.

Activity (optical) The phenomenon displayed by many substances whereby plane-polarized light, when passing through the substance, suffers a rotation of the

plane of polarization. In the case of molten or dissolved substances, the effect is due to the asymmetric molecular structure of the substance.

Activity (radioactive) The amount of radioactive material in a unit of air, or the associated number of disintegrations per second in the same unit.

Activity coefficient A factor with which to multiply the concentration of a component in solution; it is used to correct for the departure from ideal behavior. Thus, the true activity of a component A with concentration $[A]$ is $a = \gamma [A]$. The activity coefficient γ is usually determined empirically. It depends not only on the concentration of A but also on its properties and on the concentration and kind of other substances present.

Adsorption The process by which gas molecules, dissolved substances or liquids (adsorbate) adhere to the surface of solids (adsorbent) through either physical forces (physical adsorption) or stronger chemical forces (chemical adsorption).

Adsorption isotherm A function relating the volume of vapor adsorbed on a surface to the pressure of the vapor in the gas phase at fixed temperature.

Advection The transport of air, its properties and trace materials solely by mass motion of the atmosphere, usually in horizontal direction.

Aerodynamic diameter See *equivalent diameter*.

Aerosol Suspension of an assembly of small particles (liquid, solid or a mixed variety) in a carrier gas, usually air. In the atmosphere, the size of the particles ranges from less than 10 nm to more than 100 μm, although the largest particles occur in concentrations so small that they are difficult to detect. Atmospheric aerosol particles are an integral part of and undergo transport with the air, only particles larger than about 25 μm are subject to gravitational settling. The atmospheric aerosol may be characterized by size distribution, optical properties, electric charge, radioactivity or chemical composition.

Aethalometer An instrument used to measure the optical absorption of collected aerosol samples.

Agglomerate (a) Aerosol: a cluster of particles resulting from the adherence of individual particles following successive collisions. (b) Geology: a mass of volcanic rock fragments compacted by heat, typically occurring in volcanic vents.

Aggregate A heterogeneous particle in which the individual components are not easily separated.

Air mass A qualitative term used in meteorology (mainly) to describe a body of air in the atmosphere with essentially uniform physical (not necessarily chemical) characteristics that are maintained for a limited period of time. An air mass residing over a region for a longer time undergoes chemical changes due to the addition of substances by emissions at the earth surface or the removal of substances by wet and dry deposition, etc. Frontal systems separate different air masses. A cold front, for example, separates a warm air mass in its front from cold air occurring in the rear.

Air pollutant A substance, harmful to humans, animals, or materials, which has been brought into the air, usually by human activity, at concentrations high enough to cause harmful effects. Examples for *primary* pollutants, which are emitted directly into the atmosphere, are sulfur dioxide, nitrogen oxides, and

carbon monoxide. Pollutants that derive from primary pollutants by reactions in the atmosphere are called *secondary* pollutants. Ozone is a secondary air pollutant. High concentrations of ozone occur with photochemical smog, which develops when automobile exhaust gases accumulate in the air under adverse meteorological conditions (presence of an inversion layer and intensive sunshine).

Air pollution Atmospheric conditions resulting from excessively high concentrations of substances in the air that impair comfort, health or welfare of people, animals or biota.

Air pollution control Measures taken to reduce the degree and effects of air pollution.

Air pollution control district A geographical region designated by law where emissions of individual specified air pollutants are controlled to a degree specified by law.

Aitken nuclei Atmospheric particles in the approximate size range 0.01–0.1 μm.

Albedo The fraction of energy of electromagnetic radiation reflected from the surface of the earth relative to the incident energy. Whereas the terms reflectivity and spectral albedo are used to describe the reflection of monochromatic radiation, the term albedo refers to a broad wavelength band of radiation in the visible, ultraviolet or infrared wavelength range.

Aliquot A representative portion of the whole.

Alkadiene A hydrocarbon containing two >C═C< double bonds**.**

Alkali Any chemical substance, which when dissolved in water, forms an alkaline solution, especially the hydroxides of sodium and potassium.

Alkali metals The (monovalent) elements of the first group in the periodic table, Li, Na, K, Rb, Cs, Fr, except hydrogen. Francium (Fr) is a radioactive element not occurring naturally.

Alkaline earth metals The (divalent) elements of the second group in the periodic table, Be, Mg, Ca, Sr, Ba, Ra.

Alkalinity The extent to which a solution is alkaline. The alkalinity of seawater is defined as the sum $[Alk] = [HCO_3^-] + 2[CO_3^{2-}] + [B(OH)_4^-] + [OH^-] - [H^+]$, where the square brackets are concentrations in mmol kg^{-1}.

Alkane A fully saturated hydrocarbon. Alkanes exist as straight chains and in branched form.

Alkene A hydrocarbon containing one >C═C< double bond**.**

Alkoxy(l) A radical of the type RO·, where R represents an alkyl radical, produced in the oxidation sequence of an alkane by the removal of an oxygen atom from an alkyl peroxyl radical, *Alkoxy* is common usage, although the correct form would be *alkoxyl*.

Alkyl A radical arising from an alkane when a hydrogen atom is removed.

Alkyl peroxy(l) A radical formed by the addition of an alkyl radical to molecular oxygen, *Alkyl peroxy* is common usage, although the correct form would be *alkyl peroxyl*, similar to hydrogen peroxyl (HOO·).

Ambient air The outdoor air in the particular location.

Ångstrom Unit of length equal to 0.1 nm $= 1 \times 10^{-10}$ m. Although still in use, especially in vacuum ultraviolet spectroscopy, it is not formally defined within the International System of Units (SI).

Anomalistic year The time between two successive perhelion passages of the earth in its orbit. The time (365.25964 days) is longer than the sidereal and tropical years owing to the advance of Earth's perhelion as a result of planetary perturbations. Perhelion is the closest orbital point of Earth from the sun. It occurs around January 3rd each year.

Anthropogenic Produced by human activities.

Apogee The point in the orbit of the moon or an artificial earth satellite that is farthest from Earth.

Appearance potential (energy) In mass spectrometry with electron impact ionization, the minimum accelerating voltage required to produce observable ions. For atomic ions and molecular ions not undergoing fragmentation the appearance potential corresponds closely to the ionization energy (in electron volt). In the case of fragmentation the energy corresponds to the ionization energy augmented by the dissociation energy required to produce the fragment ions. In the case of photo-ionization it is the minimum energy of the quantum of light required to produce ionization of the absorbing molecule.

Arctic Haze The phenomenon of a visible brown haze in the Arctic atmosphere caused by the advection of polluted air.

Aromatic compound An organic compound derived from benzene.

Arrhenius equation The equation $k = A\exp(-E_a/R_g T)$, which describes the temperature dependence of the rate coefficient k for a bimolecular reaction in terms of a pre-exponential factor A and an activation energy E_a, where R_g is the gas constant and T is the temperature.

Ash The solid residue remaining after the combustion of a fuel such as coal. It consists largely of heat-treated mineral matter, but may also contain products of incomplete combustion of the fuel.

a.s.l. Abbreviation for *above sea level*, used to indicate the elevation in mountainous terrain.

Aspirator An apparatus which leads to the movement of a fluid by suction, such as a squeeze bulb, a pump, or a Venturi.

Atmosphere (a) The entire mass of air surrounding the earth, which is largely composed of nitrogen oxygen and argon. (b) A pressure unit roughly equivalent to the pressure of air at sea level: 1 atm = 101,325 Pa (exactly) ≡ 1013.25 mbar ≡ 760 Torr ≡ 760 mmHg. Although the use of atmosphere as pressure unit is no longer recommended by IUPAC (it should be replaced by the corresponding value in Pascal), it is for convenience still used in atmospheric chemistry.

Atomic absorption spectroscopy A technique to determine the abundance of elements by vaporization in a furnace and measuring the optical absorption at the wavelengths characteristic of each element.

Atomic mass The atomic mass refers to the mass of an isotope of an element; the atomic weight is the abundance-weighted average of all isotopes of the same element in the same units relative to ^{12}C. Thus, in the case of ^{12}C the atomic mass is 12.000 g, whereas the atomic weight of carbon, 12.0107 g, takes into account the contribution of about 1.1% of ^{13}C (13.00335 g). See also under standard atomic weight.

Atomizer A device used to produce droplets by mechanical disruption of a bulk liquid.

Auger Process See predissociation.

Aurora The colored light resulting from the precipitation of electrons and protons from the magnetosphere into the Earth's atmosphere, frequently occurring as a cusp or oval surrounding the magnetic poles at altitudes above 100 km.

Auto-ionization The process by which an atom or molecule excited to an electronic state at an energy level higher than the ionization threshold undergoes ionization rather than emission of radiation.

Background concentration (Background level) The concentration of a given species in pristine air as opposed to the higher concentration in polluted air. The background concentration is presumed to be nearly constant at a low level. This applies only to short-lived anthropogenic impurities, however. The global background concentration of many longer lived atmospheric trace gases such as methane, carbon dioxide, the halocarbons, etc. are variable with time due to anthropogenic sources. The true background level would be of purely natural origin if anthropogenic sources were entirely absent.

Barometric law The barometric law states that the pressure $p(z)$ at any altitude z in the atmosphere equals the pressure exerted by the total column of air overhead. The pressure decreases with increasing altitude because of the decrease in air column density. For an atmosphere in hydrostatic equilibrium, the differential decrease of pressure is given by $\mathrm{d}p(z) = -(gM/R_g T)p(z)\mathrm{d}z$, where g is the gravitational acceleration, M is the molar mass of air, R_g is the gas constant and T is the temperature.

Basalt Dark, fine-grained, mafic igneous rock consisting mainly of plagioclase feldspar and pyroxene.

Beer-Lambert law (also Beer's law) Relates the absorption of light to the properties of the material through which the light is traveling; for details see absorption coefficient and absorption cross section.

Benthic A term applied to the sedentary animal and plant life occurring on the sea bottom.

Bergeron-Findeisen process The initiation of precipitation in mixed-phase clouds when the ice particles grow at the expense of liquid water drops.

Bimodal distribution The occurrence of two maxima in a frequency distribution.

Biomass The mass of parts of or the total biosphere existing on earth. On a global scale, the biomass is dominated by the terrestrial biomass occurring in plants, primarily forests, amounting to approximately 650 Pg of carbon.

Biomass burning The (usually incomplete) combustion of living and dead plant organic matter in the open air, such as occurring naturally by forest fires, by the burning of agricultural wastes, or in the clearing of forest and brush land by fire for agricultural purposes. Biomass burning leads to the emission of air pollutants that make a large impact on the global budgets of many trace gases in the troposphere.

Biosphere The portion of the globe that encompasses all forms of life on the earth. It includes life forms on the continents as well as in the oceans.

Boundary layer Tropospheric region closest to the earth surface where air motions are subject to friction forces. The boundary layer is characterized by strong diurnal variations in the degree of turbulence, resulting from convective buoyancy induced by solar heating of the ground surface during the day, and by temperature inversion layers arising from radiative cooling of the surface at night.

Brownian motion The random motion of particles resulting from collisions with molecules of the environment.

Bunsen coefficient A parameter used to describe the absorption of a gas in a liquid. The Bunsen coefficient α is defined as the volume of gas reduced to 273.15 K and 1 atm (101,325 Pa) pressure that is absorbed by a unit volume of solvent under a partial pressure of 1 atm. If ideal gas behavior and Henry's law is obeyed $\alpha = (273.15/T)(V_{gas}/V_{liquid})$.

Carbonaceous chondrites Primitive stony meteorites containing up to 4% carbonaceous material by mass. Most of the carbonaceous chondrites are highly oxidized and have a chemical composition similar to that of the solar photosphere, except for very volatile elements.

Carbonyl compounds Organic compounds featuring a C=O group (carbonyl group) as part of the carbon skeleton; *aldehydes* contain the carbonyl group at a terminal position, in *ketones* the carbonyl group is positioned between two carbon atoms.

Carbonyls Compounds arising from the association of carbon monoxide with a metal, such as nickel tetracarbonyl, $Ni(CO)_4$, a colorless liquid (melting point −25°C, boiling point 43°C). In the laboratory jargon of atmospheric chemists, organic carbonyl compounds (aldehydes and ketones) are sometimes called carbonyls, but this practice is discouraged to avoid possible misunderstandings.

Cascade Impactor A device used for the classification of aerosol particles according to size. It consists of a series of impaction stages with decreasing particle cut-off size so that particles are separated stepwise by momentum differences into a number of relatively narrow intervals of aerodynamic diameter and are simultaneously collected for subsequent chemical analysis.

Catalysis The increase of the rate of a chemical reaction by the addition of a substance (the catalyst), which itself does not generally undergo a net chemical change. In most applications, the use of a suitable catalyst is essential to make exploitation of a reaction for practical purposes possible. If the substance reduces the reaction rate, it is called an inhibitor. The term "negative catalysis" for this type of process has been abandoned.

Catalyst Generally, a substance whose presence accelerates the rate of a chemical reaction. In automobile technology a device used to convert harmful exhaust gases such as nitric oxide or carbon monoxide to less harmful gases (nitrogen and carbon dioxide, respectively); short for catalytic converter.

CCN Abbreviation for cloud condensation nuclei.

Chain reaction A chemical reaction mechanism involving a series of steps that are called initiation, propagation and termination. If the propagation steps recur a number of times for each initiation and termination step, the reaction is called a chain reaction. This requires that a chemical intermediate consumed in the first

step of propagation is regenerated in a second or subsequent step of the propagation mechanism. A pertinent example is the chlorine-hydrogen system, which when irradiated within the Cl_2 absorption band produces two chlorine atoms that react with hydrogen, thus $Cl + H_2 \rightarrow HCl + H$ followed by $H + Cl_2 \rightarrow HCl + Cl$, whereupon the reaction continues. Termination occurs by association of chlorine or hydrogen atoms assisted by a third body. Under suitable conditions (low light intensity) the system leads to chain lengths of up to a million, that is 10^6 HCl molecules are formed for each Cl_2 molecule being photo-dissociated. The oxidation of hydrocarbons in the atmosphere occurs by complex chain reactions involving OH, HO_2 and RO_2 radicals, the oxidation of NO to NO_2 and the photodissociation of the latter.

Chemiluminescence The emission of light from an electronically excited product resulting from a chemical reaction.

Chemiluminescence analyzer An instrument utilizing a chemiluminescent reaction for the detection and analysis of a species. The instrument consists of a reaction chamber with separate inlets for the sample and the reactant gas, an optical filter, a photo-multiplier and signal processing electronics. The reactive gas usually is introduced in excess. The quantity of light produced is proportional to the sample flow rate and the concentration of the measured substance in the sample under specified conditions of temperature and pressure. The filter limits the wavelength to the spectral region of interest and helps to eliminate interferences. The most widely used chemiluminescence analyzer makes use of the reaction between O_3 and NO and is used for the determination of NO_x in air.

Chondrites The most abundant class of stony meteorites, so-called because they contain chondrules. The term is also applied to all meteorites with bulk composition close to that of the solar photosphere, even if they do not contain chondrules (e.g. CI chondrites).

Chondrules Millimeter-sized, nearly spherical grains consisting mainly of olivine and/or low calcium pyroxene, found in chondritic meteorites.

Chromosphere (of the Sun) Transparent, intermediate region between photosphere and corona. Temperatures in the solar chromosphere range from ~4,000 K to 50,000 K at its top.

Cirrus Fibrous ice clouds.

Clastic rocks A term used in geology to describe rocks that consist of fragments of previous rocks. The term is broadly synonymous with sedimentary rocks.

Cloud Generally, an atmospheric aerosol which is dense enough to be perceptible to the eye. The term usually is applied to water clouds, that is, an assembly of small water drops or ice particles suspended in the atmosphere. However, dust clouds also may occur. In this case, a cloud consists of an assembly of particles that has a density about 1% higher than the density of air alone.

Cloud condensation nuclei The fraction of atmospheric aerosol particles that can be activated to form cloud drops at low supersaturation of water vapor, that is, at relative humidities less than about 102%. See also under Köhler diagram.

Cloud element A water drop or ice crystal in a cloud below the size characterizing a rain drop (usually <100 μm).

Coagulation A process by which collisions of aerosol particles with each other and their agglomeration shift the size distribution of an aerosol toward larger values.

Coarse particle mode In the size distribution of the atmospheric aerosol: the largest particles (ca. 2–20 μm) consisting primarily of particles generated by mechanical disintegration processes.

Column density Number of atoms or molecules per unit area. Often obtained from optical absorption measurements with the sun as background source and used to express the total abundance of a constituent in the atmosphere integrated with regard to altitude.

Concentration The chemical amount, number of molecules, or mass of a substance of concern in a given volume divided by that volume. Concentration is the basic quantity required to describe the rate of a chemical reaction. The preferred concentration unit used in gas phase kinetics in atmospheric chemistry is molecule cm^{-3} or molecule m^{-3}; the SI units are mol m^{-3}. Mass concentration is appropriate when the chemical composition of a sample is ill-defined or unknown. Number concentration and mass concentration are used to characterize the atmospheric aerosol (particle m^{-3}, mg m^{-3}).

Condensation The physical process of converting a material from the gas or vapor phase to a liquid or solid phase. Condensation occurs when the partial pressure of the substance exceeds the saturation vapor pressure at a given temperature. This is achieved either by raising the partial pressure or by lowering the temperature.

Condensation nuclei counter (Also known as Aitken nuclei counter) A device in which sub-micrometer-sized particles are grown by vapor supersaturation to a larger size so that they can be detected by light scattering.

Coordinated Universal Time (abbreviated UTC) is the time standard based on International Atomic Time (TAI) with leap seconds added at irregular intervals to compensate for the Earth's slowing rotation. Leap seconds are used to allow UTC to closely track the mean solar time at the Royal Observatory, Greenwich (UT1). Since the difference between UTC and UT1 is not allowed to exceed 0.9 s, the general term Universal Time (UT) may be used if high precision is not required. In casual use, when fractions of a second are not important, Greenwich Mean Time (GMT) can be considered equivalent to UTC or UT1.

Corona (a) Outermost extended region of the Sun, where temperatures reach up to 2×10^6 K. (b) An abbreviation for a corona discharge.

Corona discharge A (sometimes visible) electric discharge resulting from the ionization of a gas, such as air, surrounding a wire or other electric conductor maintained at high electric potential.

Correlation cell radiometer See under gas correlation radiometer.

Cosmic rays Highly energetic particles continuously bombarding the earth from all directions. The particles are composed of all atomic nuclei. Cosmic rays are produced by supernova explosions, pulsars, and perhaps other cosmic events. Cosmic rays interact with nitrogen, oxygen and argon in the atmosphere to produce radioactive nuclei, primarily via spallation reactions.

Coulomb force The magnitude of the electrostatics force of interaction between two point charges is directly proportional to the scalar multiplication of the magnitudes of charges and inversely proportional to the square of the distances between them.

Coulter counter An instrument that measures the volume of individual particles in a liquid by means of the change in resistance as the liquid passes through an orifice.

Critical orifice An orifice through which a constant airflow is maintained when the pressure drop across the orifice is sufficient to cause sonic flow.

Cumulus Clouds with significant vertical extent.

Cut-off particle diameter The diameter of a particle, which has 50% probability of being removed by a device or stage and 50% probability of passing through; a design characteristic especially of an inertial impactor.

Deactivation Loss of energy (total or partial) from an excited (energy-rich) atom or a molecule due to energy transfer by collisions with other atoms or molecules in the surroundings; also called quenching.

Deliquescence The process of dissolution of a salt particle by the absorption of moisture from the surrounding air. The process occurs when the vapor pressure of the saturated aqueous solution of a substance is less than the vapor pressure of water in the air. A crystalline salt aerosol particle will deliquesce in the atmosphere when the relative humidity surpasses a characteristic value, the so-called *deliquescence point*.

Denitrification The process by which bacteria reduce oxides of nitrogen (nitrate, nitrite) to molecular nitrogen (and nitrous oxide, a minor fraction). All denitrifying bacteria are aerobic species that turn to oxides of nitrogen as a source of oxygen when the level of oxygen becomes too low.

Deposition velocity A measure of the efficiency of dry deposition. The deposition velocity is defined by the ratio of flux density of a substance being deposited at the ground surface to the concentration of the substance at a reference height above ground, usually 1 m. The deposition velocity also represents the inverse of the sum of resistances exerted on the transfer of material by the gas phase and the uptake of material at the ground.

Diagenesis In geology, the process by which ocean sediments are modified to form sedimentary rocks. Diagenetic processes include cementation, compaction, diffusion, redox reactions, transformation of organic and inorganic material, and ion exchange phenomena.

Diffraction Change in direction and amplitude of radiation as it passes near an object or through an orifice.

Diffusion Net movement of particles or molecules from a region of higher to one of lower concentration.

Diffusion battery An aerosol spectrometer for sub-micrometer-sized aerosol particles, in which the size is measured by diffusive loss of particles in ducts of various lengths.

Diffusion denuder An apparatus for the separation of particles and gases based on the difference in diffusion velocity, often used for the purpose of separate

chemical analysis. Usually a narrow flow tube is used, which removes gases by reaction with a wall coating, whereas particles pass through the tube and are collected on a filter.

Dispersion (In the atmosphere) The dilution of a pollutant or tracer substance by spreading due to diffusion or turbulent mixing (eddy diffusion); (In chemistry) A system consisting of particles suspended in a fluid; a colloid; (In spectroscopy) The spectral resolving power of a device producing a spectrum from white light; Specifically, the variation of the refractive index of material used in a prism to produce a spectrum.

DOAS (Differential optical absorption spectrometry) A technique for the detection and measurement of certain trace gases in the atmosphere that show a discrete absorption spectrum in an optically accessible spectral region. A long path length (km) is required and the spectrum must be differentiated against the background absorption.

Dobson unit Unit used to describe the total amount of ozone in a vertical column of air overhead (DU). It is given as the thickness (in units of 10^{-3} cm or 10^{-5} m) of the layer that would form if the total ozone in the column were reduced to 1 atm pressure (1 atm = 1013.25 hPa) and 0°C temperature. One DU is approximately equivalent to an ozone column density of 446.2 μmol m^{-2}. A typical column abundance of ozone of 300 DU corresponds to approximately 134 mmol m^{-2}.

Drag coefficient A parameter that relates the drag force experienced by an object to its velocity.

Drag force The resistance experienced by an object when moving in a fluid.

Dry deposition Removal of a trace substance from the troposphere by downward transport and absorption by, and/or chemical reaction with, materials at the earth surface.

Dust Air-borne solid, dry, small particles formed by wind erosion, volcanic eruption or other mechanical disintegration of parent material. Dust particles generally are of irregular shape and occur in the size range 1–100 μm in diameter. They settle slowly under the influence of gravity.

Dust collector A device for monitoring dust emissions. Also, the equipment used to remove and collect dust from exhaust gases. This may employ simple sedimentation (dustfall jars) inertial separation (cyclones), precipitation (electrostatic), or filtration.

Eddy In turbulent fluid motion a small vortex that maintains its character for some time before it blends with the rest of the fluid.

Eddy diffusion A synonym for the process by which individual air parcels are formed and mixed into the surroundings due to atmospheric turbulence, equivalent to the dispersal of an atmospheric tracer due to turbulent mixing. This process can be treated mathematically by a (three-dimensional) diffusion equation, in which the flux of the tracer is proportional to the gradient of the mixing ratio of the tracer. The coefficient involved is treated as an empirical parameter called the *eddy diffusion coefficient*.

Eddy diffusion coefficient A parameter used in the eddy diffusion equation to quantify the rate of turbulent mixing or eddy diffusion. Its magnitude increases

with the degree of turbulence in the air, which, in turn, increases with wind force. The eddy diffusion coefficient can be determined empirically by measuring the rate of dispersion of a tracer in the atmosphere.

Efflorescence The reverse of deliquescence, that is, the drying of a salt solution when the vapor pressure of water in the saturated solution of a substance is greater than the partial pressure of water in the ambient air. The term is also used to describe the loss of crystal water from solid salts such as $Na_2CO_3.10H_2O$.

Electrical aerosol analyzer (also electrical aerosol classifier) An aerosol size spectrometer in which the particles are separated by their different mobilities in an electric field. Those particles occurring within a certain size range can be selected for analysis.

Electrochemical methods (of analysis) Methods in which the change of either current or potential resulting from an electrochemical reaction is measured. The gas or liquid containing the species to be analyzed is sent through an electrochemical cell, where the reaction with the species takes place.

Electrostatic precipitator A device in which airborne particles are charged in a unipolar field and precipitated in a high-voltage electric field.

Elemental carbon (EC) Carbon remaining after a filter sample is oxidized at high temperatures (340°C) in oxygen to convert organic carbon (OC) to carbon dioxide.

Emission General term to describe the discharge of material into the atmosphere. Frequently it is used more specifically for the rate at which a solid, liquid or gaseous pollutant is emitted from a given source. The rate is usually expressed as mass per unit time.

Emission flux The emission per unit area of an appropriate surface of an emitting source.

Emission inventory A systematic survey of air pollution emissions in a given area. The information usually includes the types of sources, such as electric power plants, refineries, traffic routes, etc., as well as regional source distributions, that is, composition and rate of discharge per area. The inventory may focus on a specific pollutant. The variation with time of day, month or year also is desirable information in inventories.

Enrichment factor This factor quantifies the enrichment often observed with elements of the tropospheric aerosol compared to their abundances in Earth's crust. The enrichment factor is defined by $EF = ([X]/[Ref])_{aerosol}/([X]/[Ref])_{crust}$; [X] is the concentration of the element in either the aerosol sample or the average crust, and [Ref] is a suitably chosen reference element (usually aluminum), again in either the aerosol sample or the Earth's crust.

Entrainment The mixing of surrounding air into a cloud, frequently from the top.

Epiphanometer An instrument which measures the surface area of aerosol particles.

Equation of state A thermodynamic equation describing the state of matter under a given set of physical conditions. It is a constitutive equation which provides a mathematical relationship between two or more state functions associated with

the matter, such as its temperature, pressure, volume, or internal energy. Equations of state are useful in describing the properties of fluids, mixtures of fluids, solids, and even the interior of stars.

Equinox The dates around March 21st and September 21st, when the sun crosses from south to north of the earth's equator in the first case (vernal equinox), and from north to south in the second case (autumnal equinox). Equinoxes are not fixed in position but are moving retrograde (westward) at 50.28 arc seconds per year (precession of equinoxes). See also Tropical year.

Equivalent A valence concentration of a solute in aqueous solution to express concentration of a multiply charged ion for the purpose of demonstrating charge balance. For example, the neutralization of NaOH by H_2SO_4 requires one half the amount of acid compared to that of alkali, because two protons are liberated from the acid, whereas one hydroxyl ion is liberated from NaOH. The customary procedure has been to multiply the concentration of each ionic species *i* by its valence z_i and to compare the totals. Nowadays, the use of terms such as equivalent, gram equivalent, equivalent concentration, etc. is considered obsolete. It has been replaced by the equivalent entity defined as the fraction $(1/z_i)$ of the molecular entity. Thus, the equivalent entity of the sulfate ion is $½SO_4^{2-}$. For a one molar solution of sulfuric acid ($[SO_4^{2-}] = 1\,M$) the corresponding equivalent entity is $[½SO_4^{2-}] = 2\,M$.

Equivalent diameter The (theoretical) diameter of an aerosol particle that corresponds to the diameter of a particle with known properties, which produces the same effect. For example, the *aerodynamic equivalent* diameter is that of a unit density sphere having the same gravitational settling velocity as the particle in question; an *optical equivalent* diameter is that of a calibration particle, which scatters as much light in a specific instrument as the particle being measured.

External mixture A term used to describe an aerosol composed of at least two groups of particles with distinctly different chemical composition.

Extinction coefficient A parameter used to specify the loss of intensity along the path of a light beam caused by the combined action of optical absorption and scattering by atmospheric molecules and particles. While absorption causes a real loss of light, scattering results only in a redirection of light out of the beam.

Feldspar Solid solution of calcium-, sodium-, and potassium-aluminosilicate minerals (anorthite, albite, orthoclase).

Ferrel cell In atmospheric meridional circulation the Ferrel cell is a weak secondary feature, which is induced by and occurs poleward of the main Hadley cell but rotates in opposite direction.

Filter A porous material on which particles present in the air (or in another fluid) are caught and retained.

Filter, ceramic A filter made of porous ceramic material.

Filter, fibrous A filter consisting of a mat of fibers, such as fabric or glass.

Filter, membrane A filter prepared with well-defined pore size in a sheet of suitable material (polyfluoroethene, polycarbonate, cellulose esters). The pores consist of 80–85% of filter volume; several pore sizes are available for air sampling (0.45 and 0.8 μm are commonly employed).

Filtration A process of separating different phases in a mixture of substances, such as the separation of suspended solids from a liquid or gas, by forcing the liquid or gas through a porous medium.

Fixed nitrogen This term is used to describe nitrogen contained in chemical compounds that all plants and microorganisms can use. Bacterial nitrogen fixation (see there) is an energetically costly process; the biosphere as a whole tends to preserve fixed nitrogen by extensively circulating it within an ecosystem.

Flash point The lowest temperature at which a substance such as fuel oil will give off a vapor that will flash or burn momentarily when ignited.

Flocculation The process of contact and adhesion of particles, whereby larger clusters are formed. The term is synonymous with *agglomeration* and *coagulation*.

Floccule A small loosely aggregated mass of material suspended in or precipitated from a liquid; a cluster of particles.

Fluid flow The movement of air or other fluid in the open or in a duct, pipe, or passage. Several types of flow are distinguished: *Uniform flow* is steady in time, or the same at all points of space; *steady flow* is one for which the velocity at a point in a fixed system of coordinates is independent of time; *viscous flow* (also called laminar flow or streamline flow), occurring at low Reynolds numbers, features a transverse velocity gradient due to viscous shear and zero velocity at the stationary boundary or boundaries, but the fluid velocity at a fixed point remains constant; *turbulent flow*, occurring at high Reynolds numbers, is characterized by a fluid velocity at a fixed point that fluctuates randomly in time.

Fluorescence The spontaneous re-emission of radiation from an excited state of a molecule or atom, following the absorption of light. If the re-emission connects the initially excited energy level and the ground state, the fluorescence light has the same frequency as the excitation radiation. In this case, the process is called *resonance fluorescence*. It is the only process available to atoms. In molecules the energy may be degraded by collisional quenching to a vibrational level lower than the excitation level. This, and transitions to higher vibrational levels of the ground state, result in a shift of fluorescence light to longer wavelengths. Fluorescence occurs essentially only during irradiation with light of specific wavelengths.

Fly ash Particles of ash entrained in the flue gas resulting from the combustion of fossil fuels.

Fog A general term applied to a suspension of droplets in a gas. In meteorology, it refers to a suspension of water drops resulting in a visibility of less than 1 km.

Fourier-transform-spectrometry A technique for the collection of infrared spectra using a Michelson interferometer. Incoming radiation is split into two beams by means of a half-transparent mirror. One of the two beams is reflected from a fixed mirror, the other beam is reflected from a moving mirror introducing an optical path difference. Both beams are brought to interference and the intensity variations are recorded as a function of the position of the moving mirror. To obtain the source spectrum, the interferogram is subjected to a mathematical procedure known as inverse Fourier transformation.

Fraunhofer lines Absorption lines in the spectrum emitted by the photosphere of the Sun. At visible wavelengths, the most prominent lines are due to singly ionized calcium, neutral (atomic) hydrogen, sodium and magnesium. Many weaker lines derive from iron.

Free troposphere The region of the troposphere outside the boundary layer, located between the top of the boundary layer and the tropopause.

Front The concept of a front refers to the phenomenon of a sharp boundary between geophysical fluids of different density, or temperature or salinity. In the atmosphere, fronts commonly are associated with low pressure systems (cyclones), but may occur also on a lager scale such as the polar front in the 30–40° latitude belt. A typical front in the ocean is the gulf stream front.

Fumarole(s) Small vent(s) on the flanks of a volcanic cone, or in the crater itself, from which gaseous products emanate.

Fume Fine solid particles, predominantly less than 1 μm, that are the result of condensation of a vapor produced in a chemical reaction (often from combustion). In popular usage, the term *fumes* is often used to describe unpleasant and malodorous airborne effluents that may arise from chemical processes.

Gas correlation radiometer An instrument used to measure the concentration of a trace gas in the air by means of infrared absorption spectrometry combined with a modulation technique. The radiation of a suitable light source (or solar radiation) is passed through a cell containing the same gas as that to be monitored. Within an absorption band, the response is greatest at the wavelengths of the absorption lines and smallest at wavelengths in between. Thereby, the instrument offers good selectivity and signal to noise ratio.

Gaussian distribution A distribution function describing the normal curve of error: $f(x) = [\sigma(2\pi)^{1/2}]^{-1}\exp[-(x - \bar{x})^2/2\sigma^2]$, where $\bar{x}$ is the arithmetic mean of x and σ is the standard deviation.

Geostrophic Implies balance between the Coriolis force and the horizontal pressure gradient force in the atmosphere.

Global circulation (atmosphere) The large-scale, global circulation of the atmosphere is characterized by circulation cells (Hadley cell and Ferrel cell), the inter-tropical convergence zone, the tropical easterly wind regime, the extra-tropical westerly wind regime, and meandering jet streams. (ocean) The circulation of the global ocean describes the transport of water masses through the large ocean basins. It includes wind-driven circulation, thermo-haline circulation controlled by surface sources of heat and salt inflow, which generates convective sinking of water masses at high latitudes and gradual up-welling at low latitudes, connected by the conveyor belt mechanism of heat and salt transport.

Global warming potential A factor, which compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide over a specific time interval.

GMT (Greenwich Mean Time) See Coordinated Universal Time (UTC).

Granite Igneous rock consisting mainly of alkali feldspar and quartz.

Graupel A larger ice particle formed by the attachment and freezing of water drops onto an ice crystal.

Gregorian calendar The calendar, now in use throughout most of the world, was instituted by Pope Gregory XIII in 1582, when it became necessary to correct the Julian calendar, used previously, for an accumulated error of 10.4 days. The correction involved removing 10 days from the running year, so that October 15th followed immediately October 4th. A year has 365 days, leap years with 366 days are inserted every year divisible by 4 (as in the Julian Calendar), but centesimal years are leap years only if divisible by 400 (unlike the Julian calendar). Thus, the year 2000 was a leap year, but not the year 1900.

Gross Primary Production *gross primary production* (GPP) is the rate at which primary producers within an ecosystem, that is, plants, algae, etc. capture and store a given amount of chemical energy as biomass in a given length of time. Some fraction of this fixed energy is used by primary producers for cellular respiration and maintenance of existing tissues (i.e., "growth respiration" and "maintenance respiration"). The remaining fixed energy (equivalent to the mass of photosynthate) is referred to as *net primary production* (NPP).

GWP Abbreviation for Global Warming Potential.

Hadley cell The zonal mean mass circulation of the atmosphere in the vertical-meridional plane exhibits an upward transport in equatorial latitudes and a downward transport in the sub-tropics. The pattern exists in both hemispheres but is most pronounced in the winter hemisphere.

Half-life time Time period in which a given species decays to one half of its initial concentration. Usually used for radio-active elements, rarely for chemical reactions. If the decay constant is λ [s^{-1}], the half-life time is $t_{½} = (\ln 2)/\lambda$.

Haze The condition of reduced visibility resulting from increased light scatter in the presence of aerosol particles. The effect may be produced both by an increased concentration of the particles or by the swelling of aerosol particles with the uptake of water with increased relative humidity.

Henry's law Originally the statement that in a closed system containing a gas phase and an aqueous phase at equilibrium the partial pressure p of a substance in the gas phase is proportional to its concentration c in the aqueous phase under ideal conditions: $p = k \times c$. The coefficient k depends on temperature. The condition of ideality requires that the substance does not interact with water, e.g. to form dissociated or ionized species, and it requires in addition that the solution is sufficiently dilute so that the interaction of solute molecules with each other becomes negligible. Henry's law partitioning of gases and vapors is important in clouds and other systems of aqueous particles. In atmospheric chemistry there is an increasing tendency to apply Henry's law in the form $c_a = K_H \times p$ with units mol dm^{-3} for aqueous concentration and atm (1 atm = 1.01325 Pa) for pressure.

Heterosphere The upper portion of the atmosphere where individual atmospheric constituents undergo diffusive separation so that the molar mass of air changes as a function of altitude.

Homopause (also termed turbopause) A border region occurring at ~100 km altitude, where the physical conditions of the atmosphere change from that of a mixed state characterized by an essentially constant molar mass to a state characterized by diffusive separation of individual constituents, causing each constituent to follow its own individual scale height.

Homosphere The bulk of the atmosphere below about 100 km altitude where transport and mixing of air parcels is dominated by turbulent motions. In the homosphere the relative proportions of the main constituents of air, nitrogen, oxygen and argon, remain constant.

Hydrometeor Any atmospheric particle with water as the dominant constituent.

Hydrosol A suspension of particles in water, an aqueous colloid.

Hydrostatic equilibrium This condition applies to fluids at rest. Hydrostatic equilibrium is said to exist when there is no net force in vertical direction. In this case, the vertical pressure gradient force balances the force of gravity: $\mathrm{d}p/\mathrm{d}z = \rho\ g$, where ρ is the density of the fluid and g is the acceleration due to gravity. For liquids ρ is constant and the pressure is $p = \rho\ g\ h$, where h is the column height of the liquid above the point of measurement. In the atmosphere, $\rho(z) = (M/R_g T(z))p(z)$ is a function of altitude, which depends on pressure as well as on temperature; M is the molar mass of air and R_g is the gas constant. The simple equation for liquids remains nevertheless valid, provided the column height h is replaced by the scale height $H_z = R_g T_z/Mg$ at the altitude considered. The column density of air above the selected altitude is $\rho_z H_z$ so that $p_z = \rho_z\ g\ H_z$.

Hydroxyl The radical derived from water (H_2O) by the removal of a hydrogen atom. In the atmosphere, the OH radical is responsible for initiating most oxidation processes. In the gas phase it arises mainly from the reaction of water vapor with excited oxygen atoms $O(^1D)$, produced in the ultraviolet photolysis of ozone, and also by photolysis of nitrous acid, HONO.

Hygroscopicity The property of a substance such as salt indicating its tendency to absorb water from the surrounding air.

Hysteresis Generally, a memory effect of a material after the removal of a force or strain, best known in magnetism. Specifically for a salt particle in the air, the observation that when the relative humidity is increased marginally beyond the deliquescence point the salt crystal suddenly acquires sufficient water to form a solution, whereas upon reducing the relative humidity below the deliquescent point, the salt solution remains liquid until much lower values of relative humidity are attained.

Ideal gas law The equation of state of an ideal gas, which is based on the assumption that intermolecular attractive forces can be neglected. It may be expressed by $p = N\ k_B T$, where p denotes the pressure, N is the number concentration of atoms or molecules, k_B is Boltzmann's constant, and T is the absolute temperature; an alternative expression is $p = (n/V)R_g T$, where n [mol] is the chemical amount present in the volume V, and R_g is the universal gas constant, equal to the product of Boltzmann's constant and Avogadro's number. The ideal gas law is a good approximation for air at pressures encountered in the atmosphere and many trace gases.

Igneous Descriptive of the rock produced when hot molten material from the earth' interior cools either at depth or at the land surface.

Igneous rock Rock formed by melting and subsequent solidification.

Impaction A forcible contact of (aerosol) particles with a surface.

Impactor See inertial impactor.

Impingement Equivalent to impaction; usually refers to a liquid surface.

Impinger A sampling device for the collection of particulate matter in water or an aqueous solution contained in a bottle, with a concentric inlet tube ending in a nozzle of millimeter size immersed in the liquid. Common volumes are the (a) midget impinger, 1–10 cm^3 water, (b) the standard impinger, 75 cm^3 water. Impingers have also been used for the collection of trace gases and vapors in the air.

Inert gas A non-reactive gas under particular conditions, usually a carrier gas; examples are the noble gases, and nitrogen at ordinary temperatures.

Inertial impactor A device for the collection of aerosol particles by impaction on a surface. Ambient air is drawn through a nozzle and directed at normal incidence onto the collecting surface, where the larger particles are deposited due to inertial forces. Smaller particles are carried along with the air flow around the collector. Size and shape of the nozzle determines the cut-off size of the particles that are collected (See also Cascade Impactor).

Insolation Exposure to solar radiation.

Intensity (radiation) In a strict sense, the radiant power per unit solid angle (W sr^{-1}); the term spectral intensity implies differentiation with regard to wavelength (W sr^{-1} nm^{-1}). On the other hand, *intensity* is also used rather loosely to signify the *amount of light*; there is no objection to this usage if the appropriate units are provided.

Interception The process by which particles are caught and retained by an object when the particle carried along with the air flow meets the object's boundary within one particle radius.

Internal mixture A term used to describe an aerosol in which the chemical constituents present in the mixture occur in all the particles of the aerosol. A uniform chemical composition is not necessary. The tropospheric aerosol is – to a large extent – internally mixed because coagulation of particles and deposition of condensable vapors tend to favor mixing processes. Compare this with the term *external mixture*, which indicates the presence of groups of particles that are chemically different.

Intertropical Convergence Zone (ITCZ) is the region encircling the earth near the equator where winds originating in the northern and southern hemispheres come together.

Inversion (temperature) A departure from the normal decrease of temperature with increasing altitude in the troposphere. A temperature inversion may be produced, for example, by the advection of a warmer air mass over a cool one. The inversion layer impedes convection and hampers the vertical exchange of air, so that ground level emissions become trapped in the region below the inversion.

Ionic strength A measure of the total number of ions present per unit volume of an ionic solution. It is defined by $I = \frac{1}{2}\Sigma\, z_i^2 C_i$, where z_i is the charge of the ion of type i, C_i is its concentration, and the sum includes all types of positive and negative ions.

Ionization potential In mass spectrometry, the minimum electron energy necessary for the production of an atomic or molecular ion, given in units of electron volt (eV). The quantity corresponds to the voltage required for acceleration of the electron to reach the required energy for ionization.

Isoaxial sampling Sampling condition in which the air flowing into a sampling inlet has the same direction as the ambient air flow.

Isokinetic sampling Sampling condition in which the air flowing into a sampling inlet has the same velocity and direction as the ambient air flow.

Isotope(s) Atoms that contain the same number of protons but a different number of neutrons are called isotopes. The number of protons determines the atomic number, whereas the total number of nucleons (sum of protons and neutrons) in the nucleus, determines the mass number, as well as the atomic mass.

Jet stream (subtropical jet) A region of westerly maximum wind speed concentrated in mid-latitudes of both hemispheres at a pressure of about 200 hPa. It originates from the differential heating of the rotating planet and is a consequence of the Hadley circulation.

***j*-Value** See photodissociation coefficient.

Kelvin effect The increase in partial vapor pressure over a curved surface such as that of a small water drop or a deliquesced aerosol particle compared to the vapor pressure in equilibrium with a flat surface of the same liquid.

Knudsen number Ratio of gas molecular mean free path to the physical dimension of a particle; indicator of free molecular flow versus continuum gas flow.

Köhler diagram A semi-logarithmic plot of the radius of an aerosol particle as function of relative humidity, usually for particles composed of a pure salt. The Köhler curve combines two effects: Raoult's law, which relates the vapor pressure of water above a salt solution with the concentration of dissolved salt, and Kelvin's law describing the influence of surface curvature upon the vapor pressure of water. The Köhler diagram shows a moderate increase of particle size with rising relative humidity at r.h. <100%. In the region of supersaturation (r.h. >100%) a critical size exists, which depends on the size of the dry particle and the degree of supersaturation. Particles that reach and overcome the critical size are able to grow further and form cloud drops.

Lapse rate The rate of change of temperature with altitude, dT/dz. In the troposphere the gradient is negative, that is, the temperature decreases with altitude due to adiabatic expansion. In dry air the gradient is (minus) 9.8 $K\,km^{-1}$ (Dry adiabatic lapse rate). The presence of moisture lowers the lapse rate to a tropospheric average of about 6.5 $K\,km^{-1}$.

Lee wave A wave-like cloud pattern in the rear of a mountain induced by adiabatic air flow over the mountain top.

Lidar (Light detection and ranging) A technique for the measurement of aerosol particles and trace gases in the atmosphere based on the emission of light pulses from a laser and the detection of the backscattered signal following the emission.

Life time Period of time (τ) during which a substance decays to 1/e of its initial concentration (e = 2.718…, base of the natural logarithm). For substances that decay by first order processes $\tau = 1/k$, where k is the rate coefficient for the reaction A → products. In atmospheric chemistry, second order reactions are often treated as pseudo-first order processes by assuming constant average concentrations of the second reactant(s). Thus, for a substance undergoing simultaneous reactions

with other species and photolysis, the life time is $\tau = 1/(\Sigma k_i[X_i] + j)$, where $[X_i]$ designates the reactant concentration of the ith reactant, the k_i are the corresponding bimolecular (second order) rate coefficients and j is the photolysis rate coefficient (j-value) of the substance under consideration.

Life time (global average) The life time of a given species averaged over latitude, season, year, etc.

Limestone Limestone is a sedimentary rock composed largely of the minerals calcite and/or aragonite, which are different crystal forms of calcium carbonate ($CaCO_3$).

Liquid water content (LWC) the mass of liquid water in a volume of moist air.

Loess An aeolian sediment formed by the accumulation of wind-blown silt, typically in the 20–50 μm size range, and lesser and variable amounts of sand and clay that are loosely cemented by calcium carbonate.

Lognormal distribution A distribution function in which the logarithm of a quantity is normally distributed, i.e. $F(y) = F_{Gauss}(\ln y)$ where $F_{Gauss}(x)$ is a Gaussian distribution. The size distribution of aerosols is often described by a combination of lognormal distribution functions.

Luminescence A general term used for the emission of light by a molecule at temperatures below those required for incandescence. Luminescence generally originates from electronically excited states of molecules (or atoms captured in a solid matrix). If the state is short-lived as for an allowed electronic transition, the emission follows optical excitation almost immediately. In this case the emission is called *fluorescence.* If the emission of radiation occurs from a long-lived energy level by a spin-forbidden transition to the ground state, the emission is significantly delayed and the process is called *phosphorescence*. Optical absorption usually involves allowed transitions to an excited singlet state, from which long-lived lower-lying triplet states are populated by internal energy transfer or intersystem crossing.

Luminol (5-amino-2,3-dihydro-1,4-phthalazinedione, $C_8H_7N_3O_2$) is a versatile chemical that exhibits chemiluminescence, with a striking blue glow, when mixed to react with an appropriate oxidizing agent. It is a white to slightly yellow crystalline solid that is soluble in most polar organic solvents, but insoluble in water. It has been used for measurements of nitrogen dioxide.

Mafic A term used to describe one of the two classes of primary silicate minerals in igneous rocks, namely the ferromagnesian or mafic series, composed of iron and magnesium minerals (olivine, pyroxene). The other type is the felsic series, composed of aluminum silicates (feldspars).

Meridional Along a meridian, that is, in the north–south direction.

Metamorphic Refers to an earth material altered by intense heat or pressure.

Meteor The visible path of a meteoroid that enters Earth's atmosphere, colloquially called a shooting star. The incandescence generally ceases to be visible before the body falls to the earth. If it reaches the ground and survives impact, then it is called a meteorite.

Meteoroid An up to boulder-sized body of debris in the interplanetary space (smaller than an asteroid).

Mie Scattering In the theory of light scattering by dielectric spheres of radius r, Rayleigh scattering refers to the case $r << \lambda$ whereas Mie scattering refers to the case $r \geq \lambda$. In the atmosphere, the latter conditions are met for aerosol particles with radii greater than about 0.25 μm. Mie scattering is nearly independent of wavelength in the near ultraviolet and visible spectrum of light, in contrast to Rayleigh scattering.

Milankowitch Cycles Climatic patterns on Earth caused by orbital variations in eccentricity and oscillations of tilt and precession of the Earth's axis.

Mixing ratio This is a dimensionless fraction specifying the ratio of the amount, mass or volume of a substance in a homogeneous chemical system to the amount, mass or volume of all substances present in the system. In atmospheric chemistry the molar mixing ratio (amount of substance fraction) is often used to describe the abundance of a trace gas in an air parcel because it is independent of pressure and temperature changes associated with altitude or meteorological variability. Since in this case the mixing ratio refers to the total gas mixture, the presence of water vapor causes the mixing ratio to vary with humidity. For water vapor the mass mixing ratio is often used with reference to the mass of dry air. For solid materials, such as soils, minerals, or aerosol particles the mass mixing ratio is used to quantify the abundance of trace elements. The type of mixing ratio used must be specified by the appropriate SI unit, for example pmol mol^{-1}, or μg g^{-1}.

Mole fraction The fraction that an amount of substance contributes to the total amount of the sample (chemical amount fraction); the molar mixing ratio.

Net Primary Productivity The amount of organic matter that is produced by photosynthesis in plants (the difference between autotrophic photosynthesis and respiration).

Nimbus A raining cloud.

Nitrification The oxidation of ammonia to nitrous acid and nitrate by specialized bacteria in well-aerated soils (see also nitrogen fixation and denitrification).

Nitrogen fixation The process by which a small group of bacteria fitted with the necessary enzyme system reduce molecular nitrogen and incorporate it in their cells. The decay liberates fixed nitrogen in the form of ammonium and makes it available to plants and other bacteria.

NMHC Non-methane hydrocarbon.

Noble gases The inert gases He, Ne, Ar, Kr, Xe, and Rn. Radon is a radioactive element produced by the decay of radium.

Normal distribution A bell-shaped or Gaussian distribution (see there).

Non refractory (Aerosol) A particle not having the ability to retain its physical shape and chemical identity when subjected to high temperatures.

Nucleation The process by which particles are initially formed from a (supersaturated) vapor.

Nucleation, heterogeneous The formation of droplets by condensation onto preexisting nuclei, so-called condensation nuclei. In the atmosphere, condensation nuclei are provided by aerosol particles that can grow to form cloud drops at a low degree of supersaturation (<102% relative humidity).

Nucleation, homogeneous The formation of droplets in the absence of condensation nuclei; also called self-nucleation. This process can be observed only in the laboratory. In the atmosphere the ubiquitous presence of aerosol particles favors heterogeneous nucleation.

ODP Abbreviation for Ozone Depletion Potential.

Ostwald coefficient A parameter used to describe the absorption of a gas in a liquid. The Ostwald coefficient is defined as the ratio of the volume of gas absorbed to the volume of the absorbing liquid, all measured at the same temperature.

Oxidant A qualitative term used for atmospheric species with an oxidative power stronger than that of oxygen. Examples include ozone, hydrogen peroxide, the hydroxyl radical, and the nitrate radical.

Ozone depletion potential A factor, which determines the effect of a trace gas on the density of the ozone layer. The ozone depletion potential (ODP) is the relative amount of degradation of the ozone layer, which a compound can cause relative to trichlorofluoro-methane (CFC-11), fixed at an ODP of 1.0.

Partial pressure The pressure exerted by a specific gaseous component occurring in a mixture of gases (and vapors).

Passive sampler A device for the collection of gaseous trace substances from the air by molecular diffusion without controlled conveyance of the gas to be investigated.

Pelagic A term applied to organisms living in the middle depth and surface waters of the ocean. Also applied to sediments formed in deep waters along the slopes of the continents.

Perigee The point in the orbit of the moon or an artificial earth satellite that is closest to Earth. At perigee, the orbital velocity reaches a minimum.

Photochemical reaction Strictly speaking, a reaction involving an electronically excited state of a molecule or atom, which has undergone excitation by the absorption of light. This requires sufficient energy per quantum (usually ultraviolet or visible radiation).

Photochemical smog The mixture of high concentrations of ozone and other oxidants as well as nitrogen oxides, hydrocarbon oxidation products such as aldehydes, and aerosols that forms in urban atmospheres exposed to pollution by automobile exhaust and high sun intensities under stagnant meteorological conditions. Photochemical smog leads to pulmonary and other health-related problems, eye irritation, plant damage, and reduction of visibility.

Photochemistry Chemistry induced by reactions of electronically excited atoms and molecules formed by the absorption of light providing sufficient energy for the excitation. Primary photochemical processes are the various reaction channels open to the excited atoms or molecules. These include molecular decomposition into stable atoms, molecules, or radicals, molecular isomerization, fluorescence, phosphorescence, electronic quenching by collisions, etc. The subsequent reactions of molecular fragments thus formed are correctly referred to as thermal reactions, in that they are analogous to reactions induced by thermal decomposition at high temperatures. Atmospheric scientists sometimes use the term photochemistry (incorrectly) more widely to describe the chemical system as a whole, so that it includes primary processes and thermal (dark) reactions as well.

Photodissociation The process in which a molecule absorbs light endowed with sufficient energy to cause the molecule to split into fragments.

Photodissociation coefficient (j-value) An effective first order rate coefficient for a primary photochemical reaction in the atmosphere. Consider a photochemical process allowing two channels leading to different products, $X + h\nu \rightarrow A + B$ (1), $X + h\nu \rightarrow C + D$ (2); the corresponding two photodissociation coefficients are given by the integrals $j_1 = \int \sigma(\lambda)\phi_1(\lambda)F(\lambda)\mathrm{d}\lambda$ and $j_2 = \int \sigma(\lambda)\phi_2(\lambda)F(\lambda)\mathrm{d}\lambda$, where $\sigma(\lambda)$ is the absorption cross section of the species X being photo-decomposed, $\phi_1(\lambda)$ and $\phi_2(\lambda)$ are the quantum yields for processes (1) and (2), respectively, $F(\lambda)$ is the actinic flux occurring at the location being considered (all quantities depend on the wavelength λ), and the integral is to be taken over the photochemically active relevant wavelength region $\Delta\lambda$.

Photolysis The term means literally the cleavage of a molecular bond by light. It has also been used (incorrectly, however) to indicate the act of irradiating a substance with light. Specific terms such as photodecomposition, photo-isomerization, photodissociation that describe the physical consequences of the irradiation are more precise and are recommended.

Photosphere The visible region of the Sun at temperatures ranging from 4,000 to 6,000 K.

Photosynthesis A metabolic process occurring in plants and some types of bacteria, whence the absorption of visible light by chlorophyll and other photosynthetic pigments results in the reduction of carbon dioxide followed by the production of organic compounds. In plants the overall process leads to the conversion of CO_2 and H_2O to carbohydrates (and other plant material) and the release of oxygen.

Plagioclase feldspar A solid solution of calcium- and sodium-aluminosilicates (anorthite, albite).

Potential temperature The temperature which a dry air parcel would assume if it were lowered or raised adiabatically to a standard pressure (usually 1,000 hPa).

Precipitation (In chemistry) The formation and sedimentation of solid material in a liquid solution. For a precipitate to form, the solid must be present in amounts exceeding its solubility. (In meteorology) The occurrence of rain, snow, hail, etc. (In power plant technology) The separation of particles from the flue gases by application of a high potential difference (12–30 kV) in an electrostatic precipitator. Charged particles are attracted to an electrode of opposite charge and collected.

Precipitation element A condensed water particle of sufficient size to reach the ground before evaporating completely (usually >100 μm)

Predissociation (Spectroscopy, Auger process) The process by which a molecule excited to an electronic state at an energy level higher than the dissociation threshold undergoes decomposition rather than emission of radiation. The phenomenon is due to the overlap of vibrational and/or rotational levels of one electronic state of a molecule by the dissociation continuum belonging to another electronic state of the same molecule. The probability of the process depends on the strength of the mutual interaction of the involved states in competition with the probability of radiation to a lower energy level. In the region of predissociation the spectrum becomes diffuse.

Quantum yield Broadly speaking, the efficiency of a physical or chemical conversion process induced by the absorption of light. Specifically, (a) for a primary process it is the fraction of electronically excited molecules that decompose, isomerise, fluoresce or react by some other specific pathway. The quantum yield for each individual process is less than unity, but the sum of quantum yields for all primary processes following the excitation of a molecule is unity. (b) For secondary products generated by thermal reactions that follow the primary step the quantum yield of any stable product C is defined as the number of molecules of C formed in the system during a given short period of time divided by the number of light quanta absorbed by the photochemically active molecules in the system during the same time period. This type of quantum yield may be greater than unity and can reach large values when chain reactions are involved.

Quenching (Usually collisional quenching, also called deactivation) Removal of energy by collisions with other gaseous molecules or atoms from a molecule excited to a higher energy level, which leads to fluorescence or photodissociation, so that the intensity of fluorescence or the extent of photodissociation is markedly lowered.

Radical (also free radical) A fragment of a stable molecule, generally containing an odd number of bonding electrons. Atoms are radicals by definition, but are not usually called radicals. Radicals occur as intermediates in many complex chemical processes, such as in hydrocarbon oxidation and photochemical reactions. They are very reactive species determining the rate of the reaction in many cases. Important radicals in the atmosphere, responsible for much of the chemical transformation there, are OH, HO_2, Cl, ClO, NO_3, CH_3O_2. The widespread practice of designating a radical by the chemical formula with a dot placed next to the atom carrying the odd electron (example: $CH_3CH_2O\cdot$) is usually not followed in atmospheric chemistry.

Rain-out The mechanism by which small particles occurring in cloud drops are removed by the formation of raindrops followed by precipitation. This process is to be distinguished from *wash-out*, which occurs below cloud level. Both terms are not always used in accordance with these definitions. For clarity, the terms in-cloud scavenging and below-cloud scavenging are recommended.

Raoult's law For dilute solutions, the relative lowering of the vapor pressure of a liquid by dissolved substances. For a binary solution, Raoult's law can be expressed by the ratio of the actual vapor pressure p to the saturation vapor pressure p_s in the absence of a solute $p/p_s = n_{\text{solvent}}/(n_{\text{solvent}} + n_{\text{solute}})$, where n_{solvent} and n_{solute} are the chemical amounts of the two substances present in the solution.

Rayleigh A measure of airglow brightness; one Rayleigh is the brightness of a source emitting 10^6 photon cm^{-2} s^{-1} in all directions (this corresponds to a surface brightness of $10^6/4\pi$ photon cm^{-2} sr^{-1} s^{-1}).

Rayleigh scattering The scattering of light by particles much smaller than the wavelength λ, specifically by atmospheric molecules. The scattering coefficient depends on the square of isotropic polarizability and rises with the fourth power of the reciprocal of the wavelength. The blue appearance of the sky is due to the consequence that blue rays of light are scattered more strongly than red rays of light.

Refraction (Optics) Change in speed and direction of radiation when passing from one medium into another.

Refractive index Ratio of the speed of light in vacuum to that in a material considered.

Refractory elements Elements that condense or vaporize at high temperatures, such as Al, Ca, Os, Re, Ti, W.

Relative humidity A measure of the amount of water vapor in a mixture of air and water vapor. It is commonly defined by the ratio of the partial pressure of water vapor to the saturation vapor pressure at the prevailing temperature, expressed in percent.

Residence time (referring to a geochemical reservoir) The ratio G_s/Q_s, averaged over a suitably long time period, where G_s is the mass content of a substance in the geochemical reservoir and Q_s is the sum of all sources, internal as well as external. For a balanced budget the sum of sources equals the sum of all sinks S_s, internal as well as external. If S_s is proportional to G_s, so that $S_s = (\Sigma k_i)G_s$, where the k_i are coefficients determining the rates of individual loss processes contributing to the total sink strength, the residence time is $\tau = 1/(\Sigma k_i)$.

Residence time (atmospheric) In this case, residence time refers to the whole atmosphere or a part thereof, such as the troposphere, which is treated as a geochemical reservoir exchanging material with adjacent geochemical reservoirs. Adjacent reservoirs of the troposphere are the stratosphere, the oceans and the biosphere. Anthropogenic emissions and production in the troposphere add to the content of materials in the troposphere. The residence time of a substance in the troposphere is determined by the mass content divided by the sum of rates of all emissions, transfer from adjacent reservoirs and internal production processes in the troposphere.

Residence time (instrumentation) Time required for air or any other reagent to pass from the entrance of a duct to the detection unit. This may be approximated by the ratio of interior volume of the duct to the flow rate.

Resonance Fluorescence See under fluorescence.

Respirable fraction Fraction of aerosol that can reach the pulmonary region of the human respiratory system.

Resuspension The process by which dust particles deposited on the ground surface are reactivated by wind force to become airborne again.

Reticle A transparent disk with lines or marks place in the focal plane of optical systems for calibration or alignment.

Reynolds number A non-dimensional ratio used for assessing the similarity of motion in viscous flows: $R = \rho \upsilon L/\eta$, where ρ is the density, υ is the velocity, η the viscosity of the fluid, and L is a characteristic length of the system considered.

Riming The growth of ice crystals in a mixed cloud due to the collection and freezing of liquid water drops. The process leads to the formation of graupel, and eventually to hail stones.

Rotameter A device used to measure the flow rate as indicated by the height of a float centered in a vertical tapered tube.

Salinity The salinity of the oceans is defined as grams dissolved salt per kilogram seawater in parts per thousand, ‰. The average salinity of seawater is $S = 34.7‰$. Salinity is related to chlorinity by $S(‰) = 1.80655\ Cl(‰)$.

Saturation vapor pressure The (partial) pressure exerted by a pure substance at a given temperature when vapor and condensed phase of the substance are at equilibrium.

Scale height A parameter H indicating the rate at which pressure and density decrease with altitude z in an isothermal atmosphere; for example $p = p_0 \exp(-z/H)$. The local scale height in Earth's atmosphere is given by $H = R_g T/Mg = 29.2\,T$ [m]. Here R_g is the gas constant, T is the absolute temperature, M is the molar mass of air, and g is the acceleration due to gravity. The scale height has also been used to indicate the total height of the atmosphere when compressed to a constant density under standard conditions of temperature and pressure.

Scrubber A device for the removal of material by transfer from a gas to a liquid medium. The gas is passed through a space containing the liquid in bulk, as a spray, or as a wetted surface. In the sampling of trace constituents from ambient air, the term *scrubber* is used synonymously with *absorber* (see there).

Sea breeze A local circulation occurring at the shore-lines throughout the world. During the day the sea breeze consists of a shoreward air flow at the surface, rising currents inland, seaward return flow near 900 hPa and sinking currents several kilometers out to sea. At night the air flow may be reversed.

Secondary aerosol Atmospheric particulate matter that is formed within the atmosphere by the chemical conversion of gaseous precursors to less volatile species, which condense to generate either new particles or attach to already existing particles. The most prominent example is ammonium sulfate resulting from the association of ammonia with sulfuric acid produced by the oxidation of sulfur dioxide.

Sedimentary rocks In geology, rocks that are formed from the sediments formed by particles carried to the ocean (and continental basins) with the rivers and by winds. These rocks experience tectonic uplift, become part of the continental crust, and are partly exposed at the earth's surface.

Sidereal year The time for earth to complete one revolution around the sun with respect to fixed stars: 365.25636 days. The sidereal year is 20 min longer than the tropical year.

Sinclair-LaMer Generator A device that produces monodisperse aerosols by the condensation of a vapor onto nuclei

Slip correction factor A factor applied to correct for slip flow using continuum gas flow equations.

Slip flow regime Transition between free molecular flow and continuum gas flow.

Small ion In aerosol physics, a cluster of molecules (mostly water) usually carrying one charge; as opposed to large ions, which represent aerosol particles having acquired charges by the attachment of ions from the surrounding air.

Smog Originally the combination of smoke and fog, a term used in Great Britain to describe the heavy pollution, rich in sulfur dioxide, resulting from coal burning in winter in large cities such as London. More common today in cities is

photochemical smog characterized by high concentrations of ozone and other oxidants.

Smog chamber A large reaction chamber in which sunlight or simulated sunlight is used to irradiate a mixture of selected hydrocarbons and nitrogen oxides in air for the purpose of studying the complex reactions occurring during irradiation. While the results of such studies have led to valuable knowledge regarding the nature of photochemical smog in the atmosphere, unwanted wall reactions and ill-defined spectral intensities inside the chamber require precautions to be exercised when extrapolating the results to atmospheric systems.

Smoke A visible aerosol made up of particles formed by the incomplete combustion of organic matter. Smoke consists largely of carbon and carbon-rich products but does not include steam (condensed water vapor).

Solstice The dates, around June 22nd and December 22nd each year, when the sun's declination is +23.45° and −23.45°, respectively. The sun passes directly overhead at noon at 23.45° latitude north (Tropic of Cancer) in the first case, and at 23.45° south (Tropic of Capricorn) in the second case.

Solubility (General) Maximum amount of material (pure solid, liquid, or gaseous) that will dissolve at equilibrium temperature in a given amount of solvent. The system is in equilibrium when, at a fixed temperature, the solution phase as well as the solid, liquid or gaseous phase remain in contact indefinitely without further net change in amount of either phase. (Specific) The mass of a dissolved substance that will saturate 100 g of a (liquid) solvent. The solubility of gases in water is often considered in terms of Henry's law.

Solute (General) A substance which is dissolved in another. (Specific) A solid, liquid or gaseous substance dissolved in a liquid, the solvent.

Solution A homogeneous mixture of two or more elements or compounds. The term may be applied to solids as well as liquids, but unless so stated, solution normally refers to a liquid medium.

Solvation The association of ions or molecules of a solute with those of a solvent. The interaction is due to electrostatic or van der Waals forces, as well as chemically more specific effects such as hydrogen bonding. The term is also applied to the attachment of water molecules to ions in the gas phase.

Solvent The component of a solution which is present in excess, or whose physical state is the same as that of the solution.

Spallation A nuclear reaction in which the collision of a high energy particle with an atom or a molecule generates a larger number of disintegration products.

Specific Humidity The ratio of water vapor to air (including water vapor and dry air) in a particular air mass expressed in kg of water vapor per kg of total moist air.

Spectrum In the field of optics, a display of the intensity of electromagnetic radiation versus the wavelength; more generally, the frequency distribution of a physical quantity, such as the mass, the velocity or the size of a particle.

Spores Dormant cells of microorganisms.

Spray sampler A device for the efficient collection of water-soluble gases and vapors from ambient air. The air is pumped through a small chamber, where

intimate contact with a fine mist of water drops is established, which are generated by a nebulizer from a fixed volume of liquid water. The loss of water at the exit of the chamber is prevented by a hydrophobic filter.

Standard atomic weight The abundance-weighted sum of the atomic masses of the isotopes of an element in the environment of the Earth's crust and atmosphere as determined by the IUPAC Commission on Atomic Weights and Isotopic Abundances. These values are included in a standard periodic table and are used in most bulk calculations. For synthetic elements the isotope formed depends on the means of synthesis, so the concept of natural isotope abundance has no meaning. Therefore, for synthetic elements the total nucleon count of the most stable isotope (i.e., the isotope with the longest half-life) is listed in brackets in place of the standard atomic weight. Recently, the Commission has proposed a new notation for ten elements, for which published distributions of isotopic composition span a larger range due to variations caused by sampling location rather than the precision of measurement. The ten elements are H, Li, B, C, N, O, Si, S, Cl, Tl. The preference now is to list the range rather than the average. Thus, for hydrogen as example the atomic weight is listed as [1.00784; 1.00811], for carbon the corresponding values are [12.0096; 12.0116] (M.E. Wieser, T.B. Coplen, Pure Appl. Chem. **83**, 359–396 (2011)).

Stern-Volmer Equation An expression for the pressure dependence of the fluorescence yield resulting from an excited atom or molecule, or the product quantum yield associated with the photodecomposition of a molecule. The relation takes into account that an excited atom or molecule may undergo collisions with other atoms or molecules present in the surroundings, whereby excitation energy is transferred and lost (deactivation or quenching). If Φ is the quantum yield of fluorescence or photodecomposition, the Stern-Volmer relation is written $(1/\Phi) = (1/\Phi_0)\,(1 + \alpha p)$ where p is the pressure and α an appropriate constant; Φ_0 is the quantum yield approached at zero pressure for the process under consideration. If only one process occurs, e.g. fluorescence, $\Phi_0 = 1.0$, otherwise Φ_0 is smaller than unity and represents the maximum yield that the process can attain.

Stratosphere The atmospheric region above the troposphere, which is characterized by temperatures increasing with altitude. The stratosphere extends from the tropopause at 10–15 km altitude toward the stratopause at 50 km, where temperatures reach a relative maximum, signaling the beginning of the mesosphere.

Stratus A layer cloud.

Subduction In geology, the tectonic processes by which rocks are moved downward to lower strata of the earth's crust or mantle.

Subsidence In meteorology, the sinking of an air mass, usually caused by the horizontal outflow of air at lower altitudes such as in the center of a high pressure region.

Tectonic Refers to earth movements that typically lead to the faulting, folding, and/or vertical movement of rock.

Terminal settling velocity The downward constant velocity of raindrops reached when falling under the opposing influence of gravity and fluid drag.

Texture The relationship of mineral grains in a rock; the physical graininess of soil.

Thermophoresis Motion of particles in a temperature gradient, i.e. from a hotter to a cooler region.

Thermosphere The outer region of the atmosphere; here the temperature rises with increasing altitude, reaching 700–2,000 K depending on solar activity. This phenomenon is caused by the absence of infrared-active molecules capable of radiating the energy deposited by the absorption of solar ultraviolet radiation back toward space. Heat conduction serves to transport the excess energy to lower atmospheric regions, where infrared radiative emissions become possible.

Total carbon (TC) Sum of elemental carbon and organic carbon (see elemental carbon).

Tropical year The time between two successive passages of the sun through the vernal equinox (around March 21st): 365.24219 days. The tropical year is about 20 min shorter than the sidereal year because precession produces an annual net retrograde motion of 50.28 arc sec of the equinoxes relative to fixed stars.

Tropopause A narrow region in the atmosphere between the troposphere and the stratosphere. It is characterized as a change in the temperature gradient (lapse rate) from negative to positive. The WMO (World Meteorological Organization) definition is: the lowest level at which the lapse rate decreases to 2 K/km or less, and the average lapse rate from this level to any level within the next 2 km does not exceed 2 K/km.

Troposphere The lowest region of the atmosphere ranging from the earth surface to the tropopause, which locates the base of the stratosphere, at 10–15 km altitude depending on latitude and meteorological conditions. The troposphere harbors about 70% of the total mass of the atmosphere.

Turbulent flow See fluid flow.

Vapor pressure For a vapor derived from a liquid or solid, the partial pressure of the vapor in equilibrium with the condensed liquid or solid at the given temperature.

Venturi A convergent-divergent duct in which the pressure energy of the air stream is converted into kinetic energy by acceleration through the narrow part of the wasp-waist passage. It is a common method of accelerating the air flow in a wind tunnel. Small venturis are used in an aircraft to provide a suction source for vacuum operated instruments, which are connected to the low-pressure neck of the duct.

Visibility Defined as the greatest distance at which a black object of suitable dimension can be seen and recognized against the horizon sky. The criterion of recognizing the object, not just seeing the object without recognition, is applied.

VOC (Volatile organic compound) It is defined by the World Health Organization (WHO) as any organic compound having a saturation vapor pressure at 25°C greater than 102 kPa.

Volatile substances Elements or compounds that condense or vaporize at relatively low temperatures.

Wash-out The removal of small particles and gases from the atmosphere by the attachment to, or dissolution in, raindrops on their way from a raining cloud to the earth surface. Unfortunately, the term has also been used for the absorption of material by cloud drops followed by rain formation and precipitation. For clarity, the expression wash-out should be replaced by the term below-cloud scavenging.

Wet deposition The removal of a trace substance from the troposphere by incorporation into cloud, fog or rain drops, followed by their precipitation to the earth surface.

White cell A multi-path optical cell based on the design of White (J. Opt. Soc. Am. **32**, 285–288 (1942)). It consists of three spherical mirrors of identical radii of curvature. The larger front mirror is placed opposite two identical D-shaped rear mirrors, suitably adjusted so that the input beam is directed back and forth between the front mirror and the rear mirrors alternating between both. The re-imaged beam forms two rows of spots on the front mirror whereby interferences are avoided.

Zonal The term zonal means along a latitude circle, that is, in the west–east direction

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