



**AATSR** *See* ADVANCED ALONG-TRACK SCANNING RADIOMETER.

**ablation** The removal of surface snow or ice by \*sublimation, melting, or \*evaporation. The term is sometimes extended to include snow removed by the wind (\*deflation) and also the calving of \*glaciers.

**ablation zone** The zone of a \*glacier in which losses through various processes, such as calving, \*deflation, melting, etc., exceed any addition through snowfall or accumulation of \*rime ice. *Compare* ACCUMULATION ZONE.

**abroholos (abrolhos)** A violent \*squall, particularly prevalent in summer, that occurs off the south-eastern coast of Brazil.

**absolute humidity** The amount of \*water vapour in air, determined as the mass of vapour per unit mass of air, and normally given in grams per cubic metre. *See also* HUMIDITY; SPECIFIC HUMIDITY.

**absolute instability** The state of a column of air that has a \*lapse rate that everywhere exceeds the \*dry adiabatic lapse rate. The column is therefore unstable throughout its height.

**absolute stability** The state of a column of air that has a \*lapse rate that is always less than the \*saturated adiabatic lapse rate and thus remains stable at all levels. *See* STABILITY.

**absolute zero** The theoretical temperature at which molecules of any substance have the least energy, all molecular motion ceases, and a perfect gas has zero volume. It is the zero point for the \*Kelvin temperature scale, and is equivalent to  $-273.16^{\circ}\text{C}$ .

**absorption** **1.** The process by which a substance, such as a gas or \*water vapour, reacts chemically with another. *Compare* ADSORPTION. **2.** The removal of certain wavelengths from incident radiation by a material such as glass or air by \*scattering or by excitation of an atom or molecule through absorption of an energetic photon. Depending on the substance, the energy thus gained may be either reradiated almost immediately at a different wavelength or converted into thermal motion of the atoms and molecules within the material.

**absorption, atmospheric** The various components of the Earth's atmosphere act to reduce or completely block certain wavelengths of the radiation incident at upper levels. The principal active atoms are \*oxygen and \*nitrogen, and molecules of oxygen, \*ozone (in the ultraviolet), and \*water vapour (in the infrared). The overall spectrum at ground level is complex, but there are major windows where a significant amount of radiation reaches the surface. The most important are in the visible spectrum between about 0.3 and 0.9  $\mu\text{m}$  (300 and 900nm); multiple windows in the infrared between about 1.25 and 30  $\mu\text{m}$ , and also beyond 300  $\mu\text{m}$ ; and at radio wavelengths between about 1 cm and 30 m.

**accessory cloud** A form of cloud that occurs only as an adjunct to certain of the ten principal \*cloud genera (see CLOUD CLASSIFICATION). It is sometimes a distinct cloud mass (as with \*pannus, \*pileus, or \*velum) and sometimes an extension of the main cloud (as with \*arcus, \*incus, \*mamma, \*tuba, or \*virga). All the latter (and \*praecipitatio) are more correctly described as \*supplementary cloud features.

**acclimatization** The process by which animals (including humans) and plants adjust to changes in their environment. Such alterations may be the result of climatic change (see *feature*) or arise from variations in the range of a particular species.

**accretion** **1.** A term used in \*cloud physics for the growth of a frozen \*precipitation particle through the collision of an ice crystal or \*snowflake with \*supercooled water droplets, which freeze instantly on contact. *Compare* COALESCENCE. **2.** In a more general sense, the coalescence or \*agglomeration of either liquid or frozen particles.

**accumulation zone** The zone of a \*glacier in which the amount of snow and ice that is deposited exceeds that lost by \*deflation, \*evaporation, melting, or other means. *Compare* ABLATION ZONE.

**acid rain (acid precipitation)** A popular term for \*precipitation that has a low pH (potential of hydrogen) value as a result of atmospheric (particularly anthropogenic) pollutants, and which causes environmental damage. Although a neutral solution has a pH value of 7, even in pre-industrial times natural rainwater was slightly acid with a pH value of 5.6, most probably because of dissolved \*carbon dioxide, together with \*nitrogen oxides created by \*lightning, and other substances produced by volcanoes and forest fires. At the present day, the principal components responsible for increased acidity are sulphuric acid ( $\text{H}_2\text{SO}_4$ ) and nitric acid ( $\text{HNO}_3$ ). To allow for natural variation, some scientists use a slightly lower limit of 5.0 in defining acid rain.

**acoustic sounding** A method of using high-intensity sound waves to investigate the detailed structure of the \*troposphere. The sound is emitted by one or more loudspeakers and the return signal detected by a suitable receiver.

The technique is capable of mapping \*inversions, determining \*turbulence, and, through the \*Doppler effect, of detecting variations in the wind field.

**Acoustic Thermometry of Ocean Climate (ATOC)** An experiment to measure oceanic temperatures by determining the time for sound to travel from acoustic sources off California and Kauai (in the Hawaiian Islands) to hydrophones at various sites across the Pacific Ocean. The velocity of sound increases with water temperature, which the method should determine to within 0.05–0.1 degC. It is potentially a sensitive method of monitoring global warming (*see feature*).

**ACSYS** *See* ARCTIC CLIMATE SYSTEM STUDY.

**active surface** The surface layer that is in contact with the atmosphere and which undergoes the greatest diurnal temperature changes, absorbing heat by day and radiating it to the atmosphere at night. Examples are: bare soil, the top of a tree canopy, and the uppermost layer of the oceans.

**ACW** *See* ANTARCTIC CIRCUMPOLAR WAVE.

**adiabat (occasionally also known as an adiabatic)** A line on an \*aerological diagram that illustrates the behaviour of dry or saturated air lifted under \*adiabatic conditions. It represents the \*dry, \*pseudo-, or \*saturated adiabatic lapse rate.

**adiabatic** [Greek: 'impassable'] A process in which heat does not enter or leave the system. Under most circumstances, a parcel of air that is not in contact with the surface may be assumed to behave adiabatically, enabling its behaviour to be calculated with a considerable degree of accuracy. A parcel of air that moves upwards is subject to expansion and **adiabatic cooling**, whereas one moving downwards is compressed and undergoes **adiabatic warming**. The rate of change in temperature with altitude is known as the \*lapse rate, and this varies depending on whether the air is unsaturated (the \*dry adiabatic lapse rate) or saturated (the \*saturated adiabatic lapse rate). *See also* PSEUDO-ADIABATIC LAPSE RATE.

**adiabatic atmosphere** An atmosphere that has a \*dry adiabatic lapse rate.

**adiabatic lapse rate** The theoretical \*lapse rate for a parcel of air that moves vertically under \*adiabatic conditions, i.e. that does not gain or lose heat to its surroundings. *See* LAPSE RATE.

**adsorption** The process by which a thin film of gas or liquid forms on a solid surface. The film does not react chemically with the material on which it is deposited. *Compare* ABSORPTION (1).

**Advanced Along-Track Scanning Radiometer (AATSR)** A \*radiometer carried on the European \*Envisat \*polar-orbiting satellite, with

seven channels, four in the visible/near-infrared and three at longer, thermal-infrared wavelengths. Its principal purpose is to obtain highly accurate \*sea-surface temperatures for climate modelling.

**Advanced Microwave Sounding Unit (AMSU)** An improved version of an earlier instrument known as the Microwave Sounding Unit (MSU). A satellite-borne instrument specifically designed to determine the \*humidity at different heights in the atmosphere regardless of cloud cover. The instrument monitors three microwave bands to determine water content and temperature, and hence humidity. It was first flown on the \*NOAA 15 \*polar-orbiting satellite, launched in May 1998. Legacy units are being fitted to \*Eumetsat \*MetOp satellites (*see* INITIAL JOINT POLAR SYSTEM).

**Advanced Scatterometer (ASCAT)** An instrument carried by the \*MetOp satellites, and which is an advanced version of the \*scatterometers employed on the \*European Remote Sensing Satellites. It uses six antennae for simultaneous coverage of two swaths on either side of the ground track. Apart from wave height and wind direction, its observations are used in studies of land and sea ice, snow cover and thawing, snow properties, and soil moisture.

**Advanced Very High Resolution Radiometer (AVHRR)** The \*radiometer carried by the latest \*NOAA \*polar-orbiting satellites. It operates at two wavebands in the visible region, and three in the infrared, with a resolution of 1.1 km. Legacy units are being fitted to \*Eumetsat \*MetOp satellites (*see* INITIAL JOINT POLAR SYSTEM).

**Advanced Weather Interactive Processing System (AWIPS)** A system installed by the \*National Oceanic and Atmospheric Administration which integrates \*Doppler radar (i.e. the \*NEXRAD system), data from automatic surface stations, satellite imagery, and forecast models. The aim is to provide locally specific forecasting, particularly for floods and tornadoes (*see feature*), which has been impractical or difficult with technically distinct systems.

**advection** The transport of a substance (such as air) or of some specific property (such as \*humidity) from one point to another. In meteorology, the term is generally applied to horizontal motion, although vertical advection may be important in certain cases, such as the hydraulic jump (*see* BORE) that accompanies the \*morning glory.

**advection fog** **1.** \*Fog that forms through the \*advection of moist stable air that has been carried over a cold surface, which causes it to cool below its \*dew point. **2.** Pre-existing fog that has been carried over a neighbouring area, e.g. sea fog that has invaded the land.

**aerobiology** The study of airborne organisms, including bacteria, fungal spores, and pollen.

**aerological diagram** A graph of the values of \*pressure, \*temperature, and \*humidity obtained in a vertical sounding of the atmosphere, typically from a \*radiosonde ascent. Reference lines incorporated to assist the plotting and interpretation of the diagram are \*isobars, \*isotherms, and dry and saturated \*adiabats. Three versions are commonly used, each with its own advantages: the \*tephigram, emagram, and Stüve diagram. A specific meteorological form of a **thermodynamic diagram**.

**aerology** A general term for the study of the atmosphere or any of its constituent layers. *Compare* AERONOMY; METEOROLOGY.

**aeronomy** The branch of science that studies the physical and chemical properties of the atmosphere. Although sometimes used for studies of the whole atmosphere (*compare* AEROLOGY), it is generally restricted to describing the investigation of the upper layers (above the lower \*stratosphere), where \*dissociation and \*ionization are dominant processes.

**aerosol** Finely divided liquid droplets or solid particles that are uniformly dispersed and able to remain suspended in the atmosphere rather than settling out. Sizes are typically in the range 0.001–1.0 μm. Although not strictly correct, the term is also frequently applied to larger particles and droplets (<50–100 μm), such as those found in \*fog or \*haze. (Even larger particles may remain in suspension under conditions of extreme \*turbulence, such as those found in vigorous \*cumulonimbus clouds.) Aerosols are important in atmospheric processes, in particular as \*condensation and \*freezing nuclei, and for the part they play in \*atmospheric electricity and various chemical reactions.

**aerosonde** A small robotic aircraft designed to carry out long-duration flights and obtain meteorological data from inaccessible regions, thus complementing data from \*radiosondes, \*ultra-long duration balloons, and \*meteorological satellites. Two types are under development, one for use over oceanic areas, and the second for flights at altitudes over 25 km (and possibly above 35 km). In August 1998, a prototype low-altitude aerosonde crossed the Atlantic Ocean from Newfoundland to Scotland (3200 km) in 26 hours. Proposals exist for solar-powered high-altitude forms that might remain aloft for as long as a year.

**afterglow** *See* ALPINE GLOW; TWILIGHT ARCH.

**Afternoon-Train (Afternoon-Train constellation, A-Train)** A group of \*polar-orbiting satellites flying in formation (known as a **constellation**), and following one another in orbit, thus monitoring a single swathe of the Earth with a sequence of different instruments at essentially the same time. The orbit has a nominal altitude of 705 km, an inclination of 98°, and crosses the Equator at c.13:30 UT (hence 'Afternoon'). The interval between the leading and trailing satellites is maintained to be less than 15 minutes. Currently, the satellites (in order) are: \*Aqua, \*Cloudsat, \*Calipso, \*Parasol, and \*Aura. The \*Orbiting

Carbon Observatory (OCO) will be inserted ahead of Aqua on launch, which is expected to be in 2008.

**ageostrophic wind** An important theoretical wind, representing the vector difference between the \*geostrophic wind and an actual wind. It is related to pressure changes with place and time. There is, for example, an ageostrophic component between the surface wind and the \*gradient wind.

**agglomeration** A term used in \*cloud physics for any of the processes by which \*precipitation grows through the collision and amalgamation of various cloud or precipitation particles. *See also* ACCRETION; AGGREGATION; COALESCENCE.

**aggregation** A term used in \*cloud physics for the process by which ice crystals or \*snowflakes grow by colliding and adhering to one another.

**Agulhas Current (Mozambique–Agulhas Current)** The narrow, warm current, an extension of the Indian Ocean's \*South Equatorial Current, that flows south along the eastern coast of Africa. One of the fastest ocean currents, it may reach as much as 5 \*knots off South Africa. Most of its flow then turns eastward and merges with the \*Antarctic Circumpolar Current, but some may round the Cape of Good Hope into the South Atlantic.

**air 1.** The mixture of gases that forms the Earth's \*atmosphere, i.e. excluding \*aerosols, \*dust particles, \*precipitation (in any form), or \*pollutants. An extremely important variable component is \*water vapour, but if this is excluded, dry air has a relatively constant composition (within the \*homosphere), which is given in the table below. The water-vapour content may vary between zero and about four per cent. Other gases present in variable amounts include \*ammonia, \*carbon monoxide, \*ozone, and \*sulphur dioxide.

| GAS                                | ATMOSPHERIC ABUNDANCE (% BY VOLUME) |
|------------------------------------|-------------------------------------|
| *nitrogen (N <sub>2</sub> )        | 78.09                               |
| *oxygen (O <sub>2</sub> )          | 20.95                               |
| *argon (Ar)                        | 0.94                                |
| *carbon dioxide (CO <sub>2</sub> ) | 0.03                                |
| *neon (Ne)                         | $1.8 \times 10^{-3}$                |
| *helium (He)                       | $5.2 \times 10^{-4}$                |
| *methane (CH <sub>4</sub> )        | $2.0 \times 10^{-4}$                |
| *krypton (K)                       | $1.0 \times 10^{-4}$                |
| *hydrogen (H)                      | $5.0 \times 10^{-5}$                |
| *nitrous oxide (N <sub>2</sub> O)  | $5.0 \times 10^{-5}$                |
| *xenon (Xe)                        | $8.0 \times 10^{-6}$                |

**2.** A gentle breeze; a **light air** being defined as force 1 on the \*Beaufort scale.

**air frost** A temperature below 0 °C, as measured in a standard \*thermometer screen.

**airglow** The weak ultraviolet, visible, or infrared emission produced in the \*ionosphere primarily by the \*recombination of ionized atoms and molecules. These are initially ionized by solar radiation or by collision with energetic particles emitted by the Sun (the \*solar wind). The three forms of airglow (\*dayglow, \*twilight glow, and \*nightglow) have different characteristics.

**air mass** A large body of air, whose properties (\*temperature, \*humidity, and \*lapse rate) are essentially homogeneous over an area several hundred kilometres across. \*Fronts form the boundaries between air masses with differing properties.

The nature of air masses is determined by three factors: the properties of the \*source region; the age of the air mass; and the changes that occur as it moves across the globe. The principal source regions are the semi-permanent high-pressure zones (the \*subtropical and \*polar anticyclones), together with the continental anticyclones that develop in winter. Primary classification is based on temperature, giving \*Arctic (A), \*polar (P), or \*tropical air (T); and on the nature of the surface in the source region: maritime (m), or continental (c), the latter symbols being used as a prefix:

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|    |                           |
|----|---------------------------|
| mA | *maritime Arctic air      |
| cA | *continental Arctic air   |
| mP | *maritime polar air       |
| cP | *continental polar air    |
| mT | *maritime tropical air    |
| cT | *continental tropical air |

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Various additional and secondary types are recognized, in particular \*equatorial air (E), \*Antarctic air (A or occasionally AA), and \*Mediterranean air. Air masses may be modified as they move away from their source regions. If continental Arctic (cA) air crosses the sea, for example, it becomes maritime Arctic (mA) air.

Additional classifications are sometimes used to indicate how in the northern hemisphere (in particular) polar air may move towards the Equator and acquire a particular character and then subsequently be drawn back towards the pole. A suffix indicates whether the air is warmer (w) or colder (k) than the surface. The former becomes more stable, and the latter more unstable. Older works may use the concept of \*returning air (r) and these also often reverse the order of the symbols, with Tc for continental tropical or rPm for returning maritime polar air.

**air-mass analysis** In \*synoptic meteorology, the identification of a specific \*air mass and the location of any \*fronts that form along its boundaries.

**air-mass climatology** A method of describing the \*climate of a particular region in terms of the \*type and frequency of the \*air masses that affect the region during a representative period.

**air-mass thunderstorm** A \*thunderstorm that develops, generally late in the day, within a warm, moist \*air mass through convective heating from the surface. Neither widespread uplift nor vertical motion at a \*front is involved in its formation, and it does not normally become severe or persist for very long.

**air meter** A portable instrument for measuring air flow in buildings, ventilation systems and similar situations. Generally consists of a set of vanes that rotate about a horizontal axis and with some form of mechanical or digital system of recording the air's velocity. *See also* ANEMOMETER.

**Aitken nucleus** *See* NUCLEUS.

**Alaska Current** A relatively warm ocean current that flows anticlockwise around the Bay of Alaska. A branch of the \*Aleutian Current.

**albedo** The ratio (usually expressed as a percentage) between the quantity of radiation falling on to a surface, and the amount that is reflected. For certain surfaces, notably water, the albedo varies greatly depending on the angle of incidence. Some typical values are:

| SURFACE                   | ALBEDO (%) |
|---------------------------|------------|
| water (normal incidence)  | 5          |
| forest                    | 5-10       |
| wet earth                 | 10         |
| rock                      | 10-15      |
| dry earth                 | 10-25      |
| grass                     | 25         |
| sand                      | 20-30      |
| old snow                  | 55         |
| clouds                    | 50-65      |
| water (grazing incidence) | 70         |
| fresh snow                | 80         |

**Aleutian Current** The northern, relatively cold branch of the \*Kuro Shio Extension that flows eastwards across the northern Pacific Ocean. On encountering the western coast of North America, it divides into the \*Alaska Current and the \*California Current.

**Aleutian low** The semi-permanent low-pressure centre located at about 50° N over the Aleutian Islands. It is an important \*centre of action in the northern hemisphere. *See also* PACIFIC DECADAL OSCILLATION.

**Alexander's dark band** *See feature* RAINBOW.

**along-track scanning radiometer (ATSR)** A \*radiometer that scans parallel to the ground track of a \*polar-orbiting satellite, often in a fixed direction, perpendicular to the surface, i.e. looking towards the \*nadir.

**alpine glow** A sequence of colours seen on snow-covered mountain tops at sunset, sometimes called **alpenglow** or (German) *alpenglüh*. The true alpine glow begins when the Sun is still above the horizon. Mountain tops that are illuminated by the Sun become yellow, pink, reddish, and finally purple, before being overtaken by the \*shadow of the Earth. Subsequently, when the Sun is at least 3–4° below the horizon, and if the \*purple light is present, the mountains may be illuminated by a purple glow, known as the **afterglow**. A reversed sequence may be seen at sunrise. *See also* SUNRISE/SUNSET COLOURS.

**altimeter setting** The atmospheric \*pressure reading for a particular airport and time that is to be set on an aircraft altimeter. The latter will then indicate the correct altitude of the airport when the aircraft is on the ground (assuming the appropriate allowance has been made for the instrument's height above ground as installed in the aircraft cockpit).

**altitude 1.** In the horizontal coordinate system, the vertical angle between the horizon and an object, sometimes known as **elevation**. A negative value implies that the object is below the horizon. **2.** The height (in metres or feet) of an aircraft or atmospheric layer above a reference level, usually mean sea level.

**altocumulus (Ac)** One of the main \*cloud genera: a middle-level cloud (*see* ÉTAGE) that occurs as a layer or patch of more or less separate cloudlets in the form of heaps, rolls, or pancakes (Plate 1). The cloud elements have an apparent width of 1–5° (by which they are distinguished from the higher \*cirrocumulus and the lower \*stratocumulus). They are white, or white and grey, normally with darker shading. Altocumulus clouds predominantly consist of water droplets, but ice crystals are often present. They display \*diffraction phenomena such as \*coronae and \*iridescence. Altocumulus clouds are extremely varied, and occur in the \*cloud species \*castellanus, \*floccus, \*lenticularis (Plate 2), and \*stratiformis; and the \*cloud varieties \*duplicatus, \*lacunosus, \*opacus, \*perlucidus, \*radiatus, \*translucidus, and \*undulatus.

**altostratus (As)** One of the main \*cloud genera: a middle-level cloud (*see* ÉTAGE) that occurs as a grey or bluish-grey sheet that may be completely uniform or appear fibrous or striated (Plate 3). It may be thin enough for the disk of the Sun to be visible, but does not exhibit \*halo phenomena. The edges of a layer may sometimes show a \*corona or \*iridescence. Altostratus may be either a water droplet or a \*mixed cloud. It frequently produces \*precipitation, but this may not reach the ground. The main \*cloud varieties are: \*duplicatus, \*opacus, \*radiatus, \*translucidus, and \*undulatus.

**ambient pressure/temperature** The pressure or temperature that applies in the atmosphere immediately surrounding the parcel of air, cloud, or other phenomenon that is being considered.

**ammonia (NH<sub>4</sub>)** An atmospheric pollutant that may react with combustion gases, such as \*nitric oxide, to produce tiny particles of ammonium nitrate, which aggravate respiratory and coronary problems. Often described as arising primarily from livestock wastes, but comparable (or greater) quantities are found in urban areas, produced by certain vehicles, apparently as a result of some action of catalytic converters.

**AMO** *See* ATLANTIC MULTIDECADAL OSCILLATION.

**AMOC** *See* ATLANTIC MERIDIONAL OVERTURNING CIRCULATION.

**amorphous cloud** A term sometimes applied to a low layer of featureless cloud, often \*nimbostratus or \*stratus \*fractus. There are no distinct undulations or breaks, nor even a well-defined \*cloud base.

**amplitude** For a variable quantity that exhibits a sine wave, the greatest divergence from the mean value. With an asymmetrical variation, half the mean difference between the extreme values of the fluctuation. Note that although this is the generally accepted definition in physics, in some fields, notably astronomy, amplitude is taken to mean the overall range of variation.

**AMSU** *See* ADVANCED MICROWAVE SOUNDING UNIT.

**anabatic wind** A localized wind that blows upslope when a mountainside is heated by the Sun, normally in the form of a \*valley wind. Such winds tend to be slightly less common and weaker than the descending counterpart, the \*katabatic wind (\*mountain wind).

**anafront** A warm or cold \*front above which the warm air is ascending relative to the adjacent cold air. Such a front is generally more active and gives greater precipitation than a corresponding \*katafront.

**analogue method** A method of forecasting based on finding past occasions that are analogous to the current \*synoptic situation, and also on the assumption that the weather will subsequently develop in a similar way. For various reasons, including those advanced by \*chaos theory, such forecasting has limited success.

**analysis** Detailed examination of the state of the atmosphere based on \*synoptic observations, in particular for forecasting or research purposes. This usually involves the determination of the values of the individual components, the comparison of observations from adjacent sites, the preparation of the appropriate charts (such as \*isobaric or \*isothermal charts), and their subsequent interpretation.