Aerodynamic Characteristics

Related terms:

Particulate Matter, Evapotranspiration, Contaminant, Aerodynamics, Aerosol, Antibiotic, Respiratory System

View all Topics

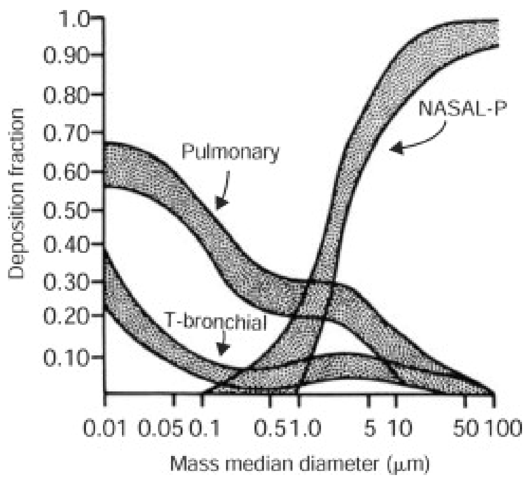
Effects on Health and Human Welfare

DANIEL A. VALLERO, in Fundamentals of Air Pollution (Fourth Edition), 2008

A. Particle and Gas Behavior in the Lung

Particle behavior in the lung is dependent on the aerodynamic characteristics of particles in flow streams. In contrast, the major factor for gases is the solubility of the gaseous molecules in the linings of the different regions of the respiratory system. The aerodynamic properties of particles are related to their size, shape, and density. The behavior of a chain type or fiber may also be dependent on its orientation to the direction of flow. The deposition of particles in different regions of the respiratory system depends on their size. The nasal openings permit very large dust particles to enter the nasal region, along with much finer airborne particulate matter. Particles in the atmosphere can range from less than 0.01μm to more than 50 μm in diameter.

The relationship between the aerodynamic size of particles and the regions where they are deposited is shown in Fig. 11.9 [9]. Larger particles are deposited in the nasal region by impaction on the hairs of the nose or at the bends of the nasal passages. Smaller particles pass through the nasal region and are deposited in the tracheobronchial and pulmonary regions. Particles are removed by impacts with the walls of the bronchi when they are unable to follow the gaseous streamline flow through subsequent bifurcations of the bronchial tree. As the airflow decreases near the terminal bronchi, the smallest particles are removed by Brownian motion, which pushes them to the alveolar membrane.



1.0
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
Deposition fraction
Pulmonary
NASAL-P
T-bronchial
0.01
0.05
0.1
0.5
1.0
5
10
50
100
Mass median diameter (μm)

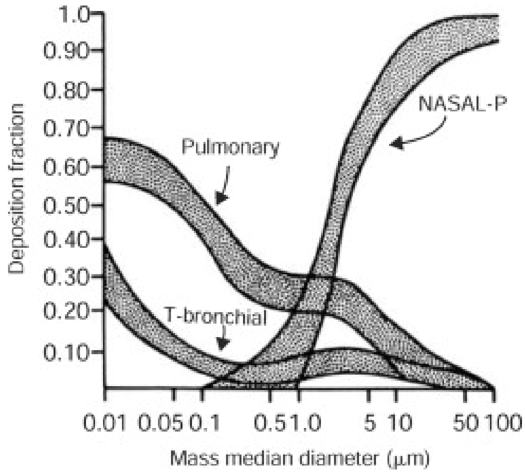


Fig. 11.9. Particle deposition as a function of particle diameter in various regions of the lung. The nasopharyngeal region consists of the nose and throat; the tracheo-bronchial (T-bronchial) region consists of the windpipe and large airways; and the pulmonary region consists of the small bronchi and the alveolar sacs. *Source:* Task Group on Lung Dynamics, *Health Phys.* **12**, 173 (1966). Copyright © 1966

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Water at the Surface of the Earth

In International Geophysics, 1977

Ecosystem Environments of Snow Cover

As we saw in Chapter VI, snow accumulates in different ecosystems differently than in ecosystems of grass or annual species, because aerodynamic deposition processes are affected by the greater roughness. These aerodynamic characteristics, little studied, also affect turbulent energy fluxes that bring about metamorphosis and melting of the snow cover. Characteristics of these ecosystems also affect radiation components; the intermixture of branches, foliage, and snow increases absorptivity and accelerates melting.

Snow cover under forest canopies is an environment that is characterized by dominant diffuse-source radiation and weak turbulent transfer. Deposition is less an aerodynamic and more a gravitational process; organic debris is mixed into the snow cover, and the snow cover is pitted by clumps and drip water falling from the canopy overhead. In a south-slope cedar-hemlock forest in Idaho, Haupt (1972, p. 9), using a special lysimeter in the snow, measured 104 mm of dripwater percolate during winter. Aerodynamic and radiative processes in metamorphosis and ablation are also modified in the forest environment.

Snowfalls in urban ecosystems were discussed in Chapter II; these systems also form a special environment for snow cover. Obvious characteristics are deposition of contaminants, patchiness resulting from snow removal activities, and the effects of urban aerodynamics on accumulation and melting. These effects operate even in small settlements. For example, Barrow Village on the Arctic Coast of Alaska experiences "meltout" 2 weeks earlier than adjacent tundra ecosystems, due to lower albedo of the urban snow cover, its patchiness, and the aerodynamic roughness of the village. These factors increase both the radiative components of the snow energy budget and its turbulent fluxes in warm-air advection. Computer simulation of the energy budget of the urban and tundra ecosystems (Outcalt *et al.*, 1975) indicates that the radiative effects are more important in ablation than the aerodynamic.

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Respiratory Effects of Air Pollutants

Daniel Vallero, in Fundamentals of Air Pollution (Fifth Edition), 2014

9.1 Respiration in Humans

In the previous chapter, the discussion of exposure to air pollutants began with two equations for the inhalation route of exposure, which reflect the two major respiratory phases, particulate and vapor:

(9.1)

(9.2)

The first equation addresses inhalation of particulate matter (PM) and the second equation the inhalation of vapors and gases.[a]

Both equations include an inhalation rate (IR). In addition, Eq. (9.1) includes a respirable fraction, since exposure to particles needs to reflect the amount that actually penetrates into the respiratory system. Equation (9.2) lacks this term. Vapors do not need this fractionation because vapors are assumed to be completely respirable, given the gas laws. Thus, respiration is arguably the most important means by which humans and other breathing animals encounter air pollutants. By extension, respiratory effects are the most direct health outcomes associated with air pollutants.

The human body and other biological systems have a tremendous capacity for the uptake of myriad types of chemicals, thereafter either utilizing them for some bodily function or eliminating them from the body. As analytical capabilities have improved, increasingly lower concentrations of chemicals have been observed in various parts of the body. Some of these chemicals enter the body by inhalation.

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The primary function of the human respiratory system is to deliver O_2 to the bloodstream and to remove CO_2 from the body. These two processes occur concurrently as the breathing cycle is repeated. Air containing O_2 flows into the nose and/or mouth and down through the upper airway to the alveolar region, where O_2 diffuses across the lung wall to the bloodstream. The counterflow involves transfer of CO_2 from the blood to the alveolar region and then up the airways and out the nose and mouth. Because of the extensive interaction of the respiratory system with the surrounding atmosphere, air pollutants or trace gases can be delivered to the respiratory system.

The anatomy of the respiratory system is shown in Figure 9.1. This system may be divided into three regions: the nasal, tracheobronchial, and pulmonary. The nasal region is composed of the nose and mouth cavities and the throat. The tracheobronchial region begins with the trachea and extends through the bronchial tubes to the alveolar sacs. The pulmonary region is composed of the terminal bronchi and alveolar sacs, where gas exchange with the circulatory system occurs. Figure 9.1 illustrates the continued bifurcation of the trachea to form many branching pathways of increasingly smaller diameter through which air moves to the pulmonary region. The trachea branches into the right and left bronchi. Each bronchus divides and subdivides at least 20 times; the smallest units, the bronchioles, are located deep in the lungs. The bronchioles end in about 3 million air sacs, the alveoli.

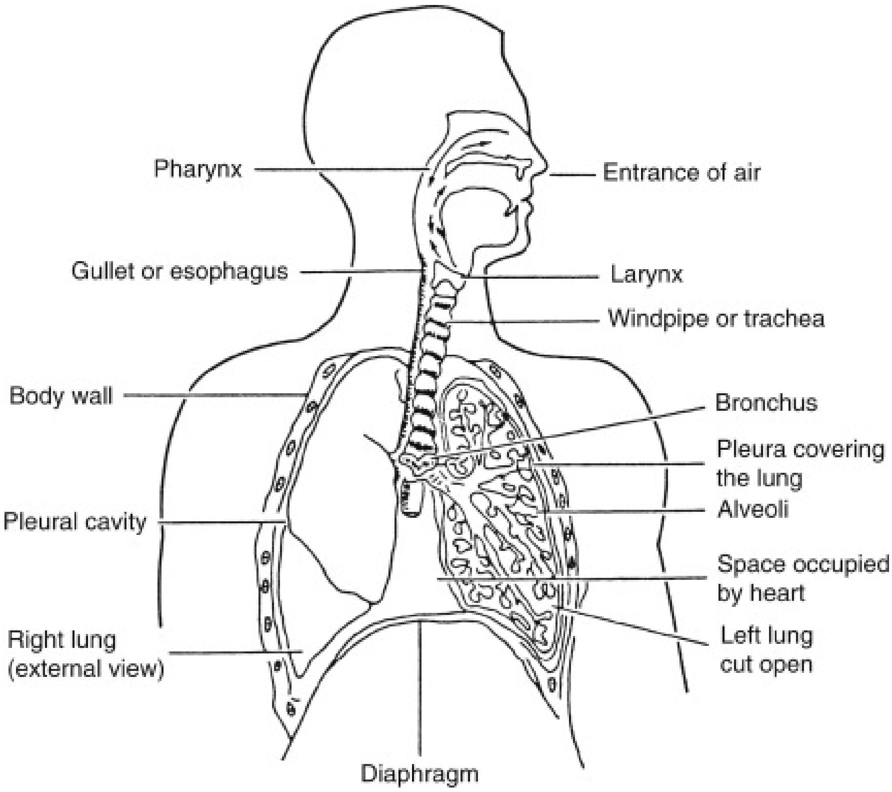

FIGURE 9.1. Anatomy of the human respiratory system. Vallero DA. Fundamentals of air pollution. 4th ed. Burlington (MA): Elsevier Academic Press; 2008.

The behavior of particles and gases in the respiratory system is greatly influenced by the region of the lung in which they are located.[1] Air passes through the upper region and is humidified and brought to body temperature by gaining or losing heat. After the air is channeled through the trachea to the first bronchi, the flow is divided at each subsequent bronchial bifurcation until very little apparent flow is occurring within the alveolar sacs. Mass transfer is controlled by molecular diffusion in this final region. Because of the very different flows in the various sections of the respiratory region, particles suspended in air and gaseous air pollutants are treated differently in the lung.

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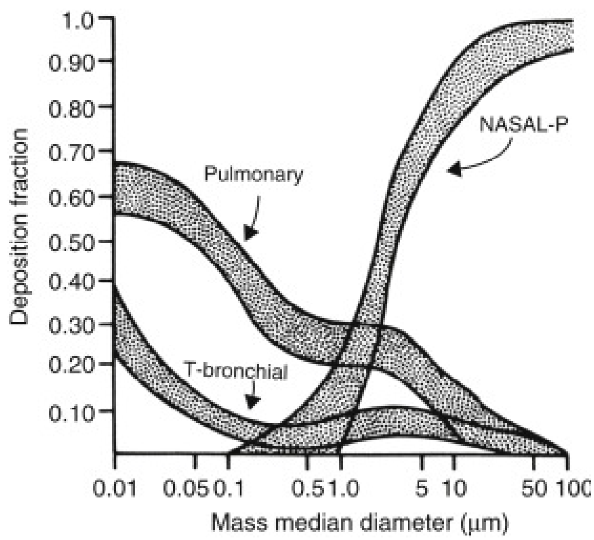

FIGURE 9.2. Particle deposition as a function of particle diameter in various regions of the lung. The nasopharyngeal region consists of the nose and throat; the tracheo-

bronchial (T-bronchial) region consists of the windpipe and large airways; and the pulmonary region consists of the small bronchi and the alveolar sacs.Task group on lung dynamics. Health Phys 1996;**12**:173.

has usually sought a standard size range of 1–5 μm, but a recent study used particles of nonstandardized density and aerodynamic diameter. Specifically, the researchers expect that large porous particles would have the mass and dynamics of smaller particles but since they are bigger they would more effectively evade scavenging macrophages in the alveoli. Thus, doses would be less frequent, since more of the medicine would penetrate to the desired, deeper locations in the lungs.[3] Air pollutant particles with these properties would have to be removed since they are so bioavailable.

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Characterization of Mixed-Phase Clouds: Contributions From the Field Campaigns and Ground Based Networks

Constantin Andronache, in Mixed-Phase Clouds, 2018

1.2 Aircraft Icing

Aircraft icing is the formation of ice that can occur on the aircraft while on the ground or in flight. Since ice nuclei are often present in small concentration in the atmosphere (Phillips et al., 2008), for a large temperature range − 38°C < T < 0°C supercooled liquid water (SLW) can exist for a long time. The surface of an aircraft flying through such clouds or areas of rain acts as an ice nucleus. Ice accretion in flight may affect the aerodynamic characteristics and engine performance. In this context, ice accretion is the process by which a layer of ice forms on objects exposed to freezing precipitation, supercooled cloud droplets, or fog droplets. There are several types of airframe icing related to supercooled MPC conditions. The first has the aspect of a white opaque deposit that forms in clouds of low water content, containing small SLW droplets, at temperatures well below 0°C. The second consists of a coating of clear ice that forms in clouds of high liquid water content consisting of large SLW droplets in the form of drizzle or rainfall on aircraft, with a temperature near or below 0°C. The third is a mixed cloud, an icing that occurs in clouds with a mix of ice crystals, cloud droplets, and snowflakes. These icing scenarios involve the presence of SLW droplets, a characteristic of MPCs, and have been studied extensively (Cober et al., 2001; Cober and Isaac, 2012; Isaac et al., 2005; Köhler and Görsdorf, 2014).

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Environmental Health Issues for Railroads

Environmental Health Issues for Railroads

Y. Kanagawa, in Encyclopedia of Environmental Health, 2011

Efforts to save energy related to vehicles

1. Reduction of the weight of the body: The material used for the body of the vehicle has been changed from steel to aluminum alloy (stainless steel) and the body work has been redesigned to reduce the weight.
2. Reduction of air resistance: To smooth the body surface, the windows of passenger rooms are made flat without unevenness between the outside panel and the window, and surrounding diaphragms have been installed between all cars. The fender skirt has been improved to smooth the body surface and the surface under the floor. The body having low air resistance reduces the energy consumption of the train when it is in motion, which leads to a reduction in CO_2 emission. The N700 Series Shinkansen introduced in July 2007 (Figure 1) has an aero double wing at the top of the body, and is shaped with excellent aerodynamic characteristics.
3. Reduction of energy to operate trains: The power regenerative brake can switch a motor to a generator at the time of braking, and convert the kinetic energy into electric energy while decelerating, then return the generated electricity to the overhead cable for later use. Thus, the brake allows energy recycling and savings. Furthermore, a new generation energy-saving train equipped with variable voltage and variable frequency (VVVF) inverter, which allows effective control of the motor, has been introduced.
4. Development of a hybrid system: A diesel hybrid railcar (Figure 4), which uses both electrical energy generated by a diesel engine and that generated and stored by motor at the time of braking, was developed and has been in commercial operation since July 2007. Figure 4. The world's first diesel hybrid railcar operating on the Koumi Line (excerpts from Aiming for a Sustainable Society. *JR East Group Sustainability Report 2007*). The mileage of the diesel hybrid railcar is better than that of a conventional diesel train by approximately 20%. Additionally, it emits less noise (30 dB) while stopping at stations. Furthermore, the latest exhaust system has reduced toxic substances in the exhaust gas (nitrogen oxide, graphite, etc.) by approximately 60%.
5. Development of the fuel cell train: A fuel cell is characterized by its high power generation efficiency and its emissions are limited to water and unused air; thus, this is a clean power generation technology with low environmental load. A study on the world's first fuel cell hybrid railroad vehicle began in 2006. Te

runs of this vehicle on a commercial railway at speeds up to approximately 100 km h^{-1} began in the spring of 2007.

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Unmanned Aerial Systems

James S. Aber, ... Susan E.W. Aber, in Small-Format Aerial Photography and UAS Imagery (Second Edition), 2019

8-4.1 Fixed-Wing Design and Flying Characteristics

Today's fixed-wing UAVs come in two main variants, like their manned equivalents. Relatively conventional airplane types have a distinct fuselage, large main wings, and a smaller horizontal stabilizer or tailplane (see Fig. 8-1A). So-called flying wings are tailless without a horizontal stabilizer (Fig. 8-6). The wings usually have a more triangular or delta-shaped planform, and the fuselage is merged seamlessly into the wings or lacking altogether. Flying wings differ from conventional airplanes in their aerodynamic characteristics. Their whole-body airfoil generates more lift and has lower aerodynamic drag, but their lack of a tail assembly with stabilizer surfaces makes them less stable in pitch and yaw.

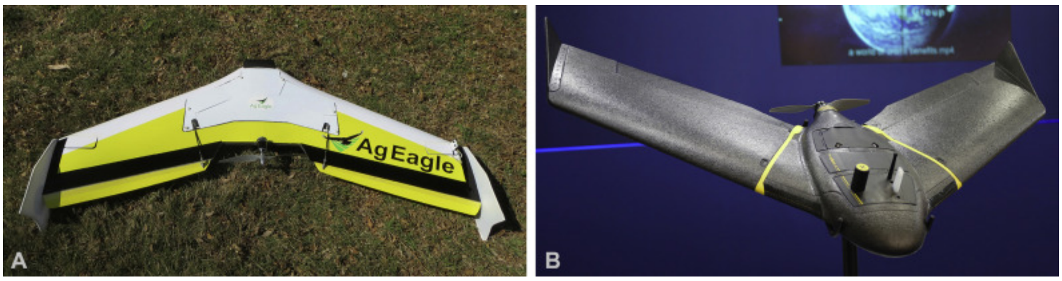

Fig. 8-6. Two flying-wing UAVs. (A) *AgEagle*, designed and marketed mainly for agricultural applications of aerial imagery. It carries a color-infrared digital camera for producing NDVI images. This catapult-launched flying wing is made from carbon-composite material; wingspan is 1.4 m, weight is 3.2 kg (AgEagle 2018). (B) *SenseFly eBee X* is equipped with RTK/PPK GNSS and accepts various sensor modules. Its foam body with a wingspan of 1.2 m weighs 1.4 kg. Not visible here is the *senseFly S.O.D.A. 3D* camera model, which rotates perpendicular to flight direction for taking oblique as well as nadir images for improved 3D capture.

Flying-wing designs are particularly popular in the small UAS class with light sensor payloads for agricultural applications, possibly also due to their sleek body with comparatively few protruding parts that may be damaged when landing on crop-covered or rough fallow fields. Another reason for their popularity in the small UAS category might also be that the flying-wing appearance better conveys the idea of a modern high-tech drone, while the fixed-wing aircraft more resembles a traditional model airplane. For larger payloads, nonetheless, conventional-tailed, fixed-wing UAV are usually required or preferable for better stability.

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In most small fixed-wing UAS, the sensor is completely concealed in the plane fuselage beneath the wings. It is fix-mounted, may be embedded in foam or rubber damping, and is aligned with the principal axes of the aircraft (Fig. 8-3)—hence, any rotation of the UAV is directly transferred to the camera, and free panning and tilting of the sensor is not possible. Larger UAS with more space for a payload bay may employ a so-called flat mapping gimbal, a 2-axis gimbal that keeps the sensor plane parallel to the ground while the airplane is moving. 3-axis gimbals of the pendulum type, as typical for rotorcraft UAS (see next section), are obviously difficult with fixed wings for aerodynamic reasons, and impossible for belly-landing models. Some recent UAVs featuring landing gear do, however, use outside-mounted gimbal units that allow tilting and rotating the camera for oblique views in 360° directions.

Fixed-wing models with landing gear may be launched in the traditional way from a runway, but this requires sufficiently large, even, and hard surfaces which often are not present at geoscientific research sites. Also, the motor needs to be powerful enough to create the acceleration required for take-off. Most micro UAVs of the airplane type are hand-launched (Fig. 8-7). This requires a second person besides the operator with the RC, and a controlled, horizontal pushing of the plane in the air with the propeller running at full throttle, which may be quite dangerous if carelessly done.

Fig. 8-7. Hand-launching of a fixed-wing UAV (*MAVinci Sirius* I).

Fig. 8-7. Hand-launching of a fixed-wing UAV (*MAVinci Sirius* I).

Many flying wings (which have no fuselage to grip) and many larger fixed-wing airplanes are launched by catapult. Various types of catapult systems exist for giving the aircraft the necessary acceleration to take off: pneumatic, hydraulic, or mechanical systems. In the most common variety for micro and mini UAS, the plane is clamped into a cradle tensioned by a bungee or nylon rope which is then released to propel the platform into the air at a suitable angle (Fig. 8-8). This eliminates the need for a runway, avoids possible contact with the airscrews, and saves battery energy in the starting phase.

Fig. 8-8. The *Abris Flirt* fixed-wing UAS is launched with a catapult and landed with a parachute system.

Finally, landing of fixed-wing aircraft may again be done on a runway or otherwise even surface for models with wheels or skids. Some models use parachutes for landing. But most flying wings and airplanes without landing gear are belly-landed, which obviously is rather risky and stressful for both the material and the pilot. It requires not only suitably flat ground surfaces, such as short grass, evenly plowed fields, or smooth tarmac, but also sufficient space for a low-angle approach. Few fixed-wing UAVs have thrust reversal capability, which means that speed needs to be reduced by shutting off the motor as early as possible before gliding in for landing (see also below). Choosing an appropriate site and piloting position for landing before even launching the aircraft is an important task in flight preparation—once the UAV battery is running low at the end of the survey, there may be not much time left to think about where to find a clear area and a good position to control and monitor the touch-down process.

In summary, the main strengths of fixed-wing UAS are their aerodynamic efficiency and stability, the comparatively long endurance (usually 45–60 min), and suitability for large survey areas. The main disadvantages are the need for horizontal landing space and lack of hovering capacity, thus impeding precise image positioning and small-area coverage, as well as restriction to (near-) vertical image orientation.

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Spaceflight Mechanics

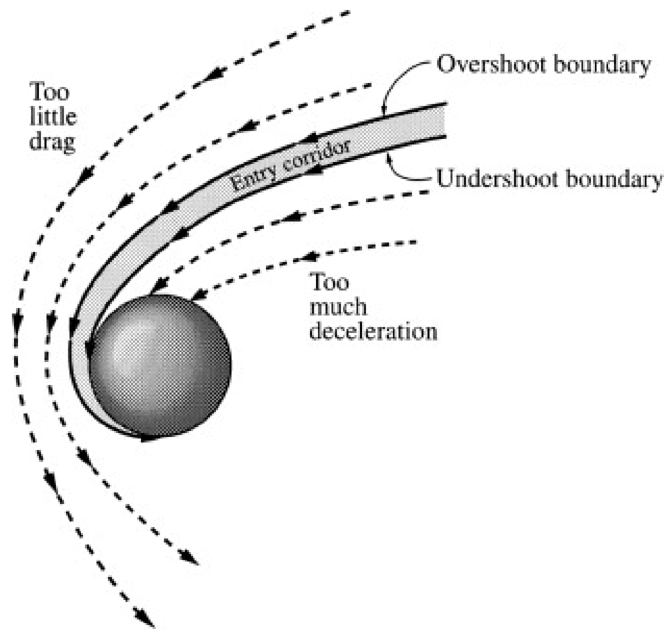
Craig A. Kluever, in Encyclopedia of Physical Science and Technology (Third Edition), 2003

VI Atmospheric Entry Trajectories

VI.A The Entry Problem

Unlike the launch trajectory phase, the problem of atmospheric entry does not occur in every space mission. However, crewed spacecraft or robotic probes destined to land on planets containing atmospheres must eventually encounter atmospheric entry from orbital flight conditions. In either case, a spacecraft entering an atmosphere from orbital conditions must dissipate the large amount of kinetic energy associated with the orbital speed at the entry interface (EI). For the earth, the EI begins at an altitude of 122 km (400,000 ft). Atmospheric drag is used to slow the space vehicle and dissipate the kinetic energy, but this aerodynamic force introduces very large thermal heating loads and deceleration loads.

As the vehicle descends through the atmosphere, the atmospheric layers become denser and the deceleration rate increases as aerodynamic drag increases. If the descent angle is too steep, the deceleration, and possibly thermal heating will become too large and exceed the structural limitations of the spacecraft. If the descent angle is too shallow, then the drag deceleration will not be large enough to slow the vehicle and keep it within the atmosphere. Hence, the spacecraft will “skip” out of the atmosphere and continue on an altered orbital path. Therefore, the spacecraft must remain within an “entry corridor” defined by the undershoot boundary (too much deceleration) and overshoot boundary (too little deceleration) as shown in Fig. 10. The entry corridor depends on the aerodynamic characteristics of the spacecraft and the EI velocity.



Overshoot boundary
Too
little
drag
Entry corridor
Undershoot boundary
Too
much
deceleration

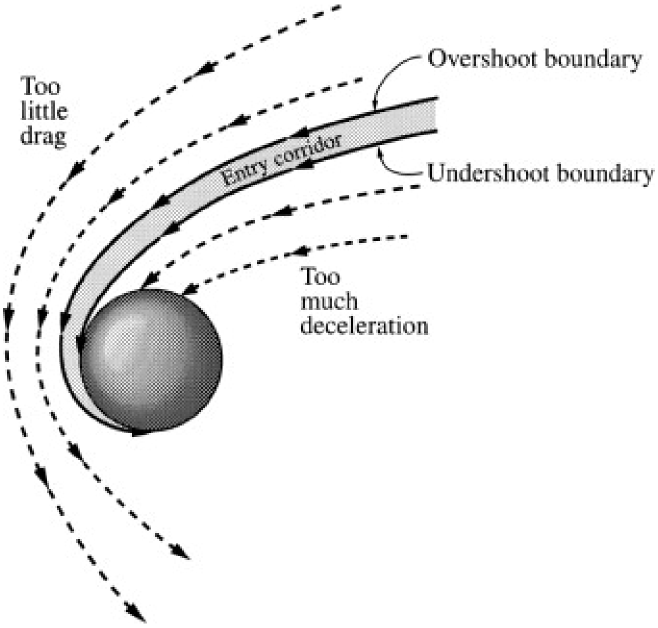


FIGURE 10. Entry corridor.

VI.B Planar Equations of Motion

Figure 11 shows the geometry of atmospheric entry and the forces acting on the spacecraft during entry. The kinematic and dynamic equations of motion for two-dimensional flight over a spherical, nonrotating planet are

FIGURE 11. Geometry of an atmospheric entry trajectory.

(37)

(38)

(39)

increases as entry velocity and entry angle increase. While the first-order analysis is fairly accurate for steep entry angles, it is unreliable for a shallow entry and underestimates the maximum deceleration. A second-order analysis provides an improved estimate of maximum vehicle deceleration and shows that maximum deceleration is constant at about 8 *g* when the entry flight-path angle is between 0 and –1.5°. The first- and second-order methods estimate the maximum deceleration to be 17 and 19 *g*, respectively, for a –6° entry angle.

heat loads are most critical. The flight-path angle remains nearly constant during the equilibrium glide subphase as drag acceleration is steadily increased to about 1 *g*. As the name implies, the drag acceleration is held constant at about 1 *g* during the constant drag subphase, which begins at 4.3 km/s and continues to 3.2 km/s. The transition subphase completes the atmospheric entry by decreasing the drag acceleration and angle of attack to levels comparable to traditional aerodynamic flight.

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Volume 2

Y. Kanagawa, in Encyclopedia of Environmental Health (Second Edition), 2019

Impacts on Global Warming

Efforts to Save Energy in the Operation of Trains

CO_2 emission

In the Law Concerning the Promotion of Measures to Cope with Global Warming established in 1998, six gases including carbon dioxide, methane, dinitrogen monoxide, and alternative freons are defined as greenhouse gases. The greenhouse gas emission in Japan was 5.2% higher in 2005 than in 1990. The emission of CO_2 accounts for more than 90% of all greenhouse gas emission. In 2004, approximately 26,530 million tons of CO_2 was emitted throughout the world, of which Japan accounts for approximately 5%.

Approximately 40% of CO_2 emission in Japan is from the industrial sector, 20% is from the transportation sector (including automobiles, aircrafts, and trains), and 30% is from commercial (e.g., service and offices), residential, and other sectors. Emission from the industrial sector has decreased since the reference year, in 1990, whereas there has been an approximate 20% increase in the emission from the transportation sector and more than a 40% increase in the emission from the commercial and other sectors. This is because automobile passenger transportation accounts for about half of the transportation sector. Approximately 90% of CO_2 emission in the transportation sector is attributable to automobiles. CO_2 emission from automobiles transporting passengers increased by approximately 50% from 1990 to 2005 because of the significant increase in the number of automobiles owned and number of miles driven. The rates of CO_2 emission increase are out-standing for aircrafts and automobiles compared with other passenger transportations (Figs. 2 and 3).

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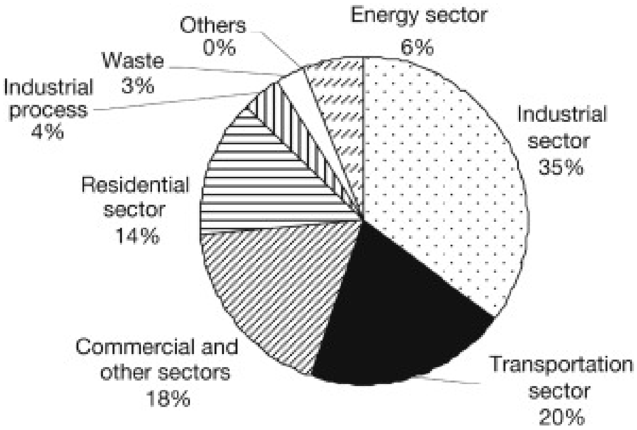

Fig. 2. CO_2 emission levels sector-wise in Japan (2005). *Source*: Annual Report on the Environment and the Sound Material-Cycle Society in Japan (2007).

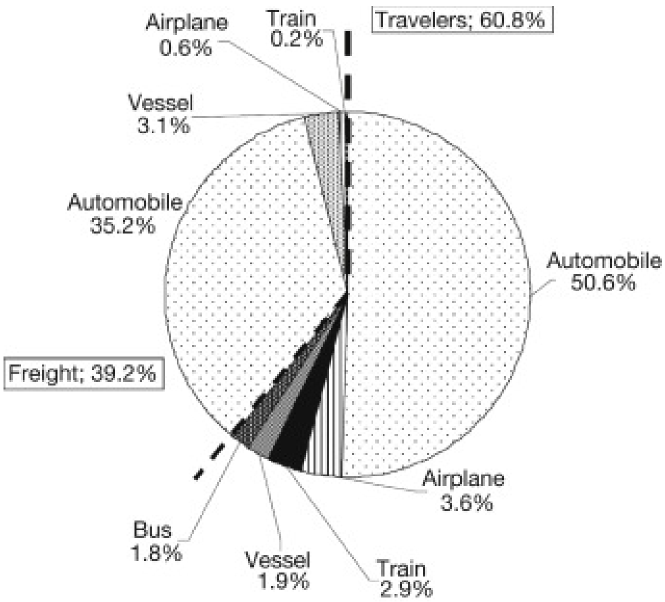

Fig. 3. Structure of CO_2 emissions from the transportation sector (2005). *Data source*: Greenhouse Gas Inventory.

Thus, the transportation sector consumes large amounts of electricity, and reduction of CO_2 emission associated with the use of electricity is considered as an important task. To accomplish this task, the following efforts have been made:

Efforts to save energy related to vehicles

1. Reduction of the weight of the body:

The material used for the body of the vehicle has been changed from steel to aluminum alloy (stainless steel) and the body has been redesigned to reduce the weight.

2. Reduction of air resistance:

To smoothen the body surface, the windows of passenger rooms are made flat without unevenness between the outside panel and the window, and surrounding diaphragms have been installed between all cars. The fender skirt has been improved to smoothen the body surface and the floor. The body having low air resistance reduces the energy consumption of the train when it is in motion, which leads to a reduction in CO_2 emission. The N700 series Shinkansen introduced in July 2007 (Fig. 1) has an aero double wing, and the top of the body is shaped with excellent aerodynamic characteristics.

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Fig. 4. The world's first diesel hybrid railcar operating on the Koumi Line. Excerpts from Aiming for a Sustainable Society, *JR East Group Sustainability Report 2007*.

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5.

5. Development of the fuel cell train:

A fuel cell is characterized by its high power generation efficiency and its emissions are limited to water, and thus is clean; thus, this is a clean power generation technology with low environmental load. A study on the world's first fuel cell hybrid railroad vehicle began in 2006. Test runs of this vehicle on a commercial railway at speeds up to approximately 100 km h-1 began in the spring of 2007.

Effects of efforts to save energy

On the Tokaido Shinkansen line, efforts to reduce the weight of the body of the train resulted in the reduction of 250 tons or more for vehicles of the 300 or later series compared with the first Shinkansen introduced in 1964, the 0 series. Additionally, energy consumption has improved through the development of the simple body structure to reduce air resistance and the adoption of high performance power control systems such as the power regenerative brake and the VVVF inverter. For example, the power required to run from Tokyo to Shin-Osaka compared with that required for the first 0 series to make the same trip, given as a percentage, is 73% for the 300 series (launched in 1992), 66% for the 700 series (1999), and 51% for the N700 series (2007). Even with a 50 km h-1 higher maximum speed, vehicles of the 300 or later series consume less electricity: 91% for the 300 series, 84% for the 700 series, and 68% for the N700 series (Fig. 5).

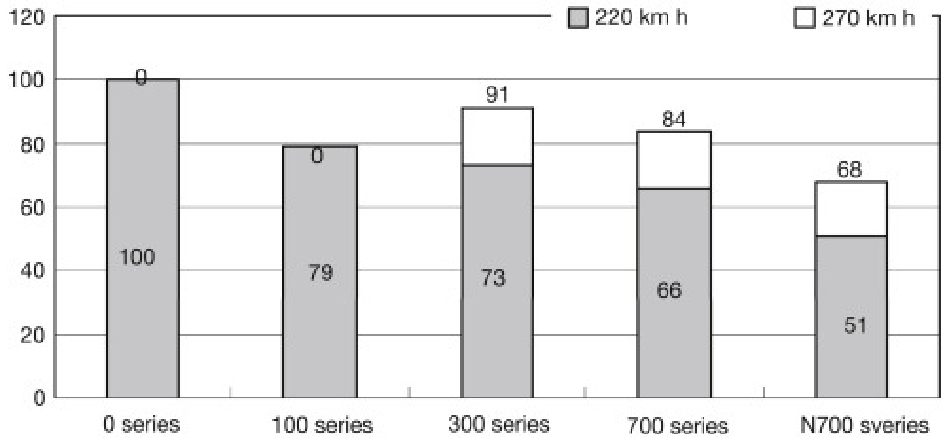

Fig. 5. Power consumption of different types of Tokaido Shinkansen trains. Data source: Central Japan Railway Company Environmental Report 2007.

Railroad companies are also trying to improve the energy efficiency of conventional trains through weight reduction of the vehicles and the introduction of the power regenerative brake and the VVVF inverter. JR East replaced 83% of trains with the energy-saving trains by the end of 2006. As a result, the energy consumed per unit transport volume in 2006 was 13% less than that in 1990. To reduce energy consumption, the railroad companies are also reviewing the management of trains to reduce the number of out-of-service trains and to adjust the number of carriages of a train based on how the train is used by passengers.

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Reduction of Energy Consumption Not Related to Train Operation

Compared with the energy required for the operation of trains, less energy is used for automatic ticket gates, elevators, escalators, and air conditioners in the stations. However, tens of billions of mega Joules of energy is consumed annually for such purposes. Such energy consumption is currently increasing owing to the improvement of facilities for the safe transportation of trains, installation of barrier-free equipment in stations, and the introduction of automatic ticket gates. Therefore, the railroad companies are trying to reduce the energy consumption in the stations by reviewing the performance of equipment and introducing inverter control systems when they replace deteriorated equipment.

Reduction of CO_2 Emission From Power Generation

Railroad companies have improved the efficiency of power generation by replacing facilities in their self-supply power stations and by using natural energies in their efforts to reduce the CO_2 emission from power generation.

The combined cycle generation facility, which is a combination of a gas turbine facility in which a turbine is driven by fired gas, and a steam turbine facility in which a turbine is driven by steam generated with waste heat, is a highly efficient electric power facility. As a result of the replacement of the conventional electric power facilities with the combined cycle generation facilities, and optimized operation of the facilities, the CO_2 emission per unit electric power generation has decreased by 38% compared with the value for 1990. Thermal power stations are also trying to reduce the emission of nitrogen oxide (NO_x) and sulfur oxide (SO_x) included in the waste. For this purpose, fuels such as natural gas, kerosene, and low sulfur fuel oil with relatively low environmental loads are used, and denitrification and dust collecting equipment are being installed.

Natural energies are also used. For example, hydraulic power generation, which does not emit CO_2, is used and photovoltaic (PV) panels are installed on the roofs of stations and other buildings. The PV system with an area of approximately 800 m^2 installed on the roof of the platform of Kyoto Station on the Tokaido Shinkansen line in 1997 generates up to 100 kW of electricity, which is equivalent to the electrical energy used for lighting on the Shinkansen platforms of the station. It reduces annual CO_2 emission by approximately 60 tons. Furthermore, trees are being planted on the roof floors of station buildings or office buildings to reduce the heat island effect, absorb CO_2, and reduce the energy needed for air-conditioning in the buildings (by intercepting the heat from sunlight).

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Efforts to Reduce CO_2 Emission from an Overall Traffic System

Carbon dioxide emission from rail freight transport is approximately 1/45 of that from private trucks and approximately 1/8 of that from business trucks. The energy consumption per unit of rail freight transportation is approximately 1/6 that of business trucks, indicating excellent characteristics with regard to the reduction of the environmental load (Fig. 6).

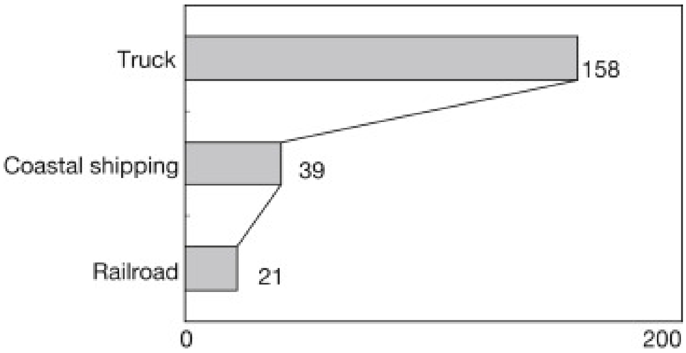

Fig. 6. CO_2 emission factor of different types of transportation (2004). Amount of CO_2 emitted to transport freight of 1 ton for a distance of 1 km (g-CO_2/t-km). *Data source*: Modal Shift Promotion Campaign 2004 (Council for the Promotion of Modal Shift, Ministry of Land, Infrastructure and Transport).

In the transportation sector, the present CO_2 emission considerably exceeds the targeted level specified in the “Outline for Promotion Efforts to Prevent Global Warming.” As measures within each mode of transportation, low-emission cars were developed and popularized and the convenience of railroad and marine transportation was improved. As measures to improve the transportation system, modal shift was promoted and load efficiency was improved through cooperation and upsizing of truck transportation. Shippers, distributors, and consumers should then make further efforts within this framework.

The use of railroad and coastal shipping, which are the two types of mass transit with low environmental load, are recommended (modal shift). A modal shift ratio (share of railroad and coastal shipping in long-distance freight transportation of 500 km or more) of more than 50% has been set as a target to be achieved by 2010. To shorten the lead time of rail freight transportation, the train operation systems have been revised and, for example, the number of trains between main stations has been increased. Maintenance and improvement of facilities has also been done. For example, the container platforms in freight stations have been improved for more efficient cargo handling. Furthermore, exceptional taxation measures are taken for the replacement investment of high-performance locomotives and freight cars, and government subsidy measures are taken for the maintenance of infrastructure.

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To promote the consumers' use of intermodal transport (a transportation system in which various means of transportation are continuously used from a certain point to a destination), the convenience and comfort of the railroad must be improved. For instance, parking lots were constructed in front of stations, and services such as "park and ride" (traveling by car to the nearest station, then on a train) and "rail and rent-a-car" (traveling by rent-a-car from the nearest station to the destination) have been marketed.

Use of the same lines by two or more railway companies, improvement in convenience, expansion of the service area of transit with integrated circuit (IC) cards such as Suica, and barrier-free stations are also being thought of. For various products commonly used by consumers, the Eco Rail Mark certification has been established to indicate environment-friendly products.

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Aerodynamics of railway train/tunnel system: A review of recent research

Jiqiang Niu, ... Yanping Yuan, in Energy and Built Environment, 2020

4.1.2 Reynolds number effect

The Reynolds number effect on the aerodynamic characteristics of a train in the open air has been studied, and the effect was found to be obvious [63,74,75]. According to study in [76], the Reynolds number effect on the pressure wave in tunnels is also significant, and the Reynolds number effect in the case where two trains are passing by each other in a tunnel is greater than that of a single train running through a tunnel. From Fig. 25, the amplitude of the positive pressure caused by a train passing through a tunnel increases with decrease of the Reynolds number, and the Reynolds number effect in the case where two trains are passing by each other in a tunnel is greater than that of a single train running through a tunnel. The reasons for the above phenomena can be found in Figs. 26 and 27. Fig. 26 shows that the thickness of the boundary layer at the same position on the train surface increases with a decrease of Reynolds number. The increase of the boundary layer around the train decreases the effective clearance area of the tunnel, which would also increase pressure changes in the tunnel. This can be observed in Fig. 27. For the situation where two trains pass by each other in a tunnel, the Reynolds effect is more significant.

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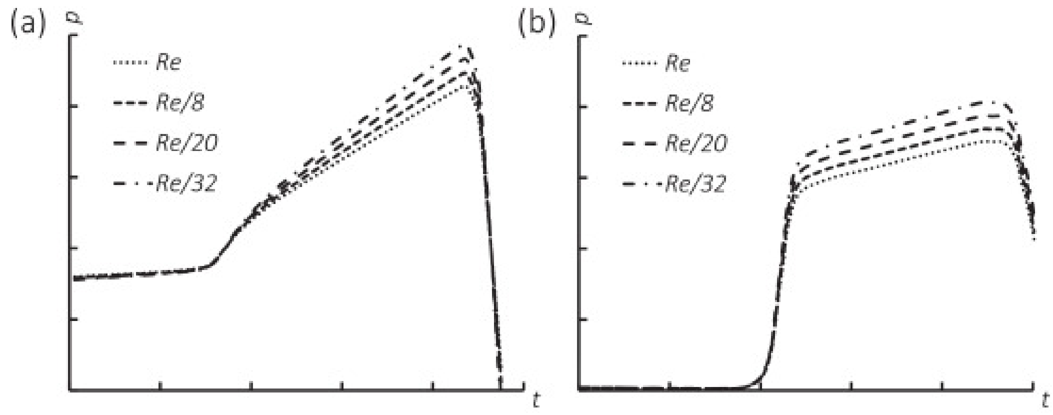

Fig. 25. Initial compression wave comparison: (a) Measurement point on train surface (middle of the first car); (b) Measure point on tunnel surface (250 m distance from the entrance of the tunnel). (*Re*=17.2 × 10^6).

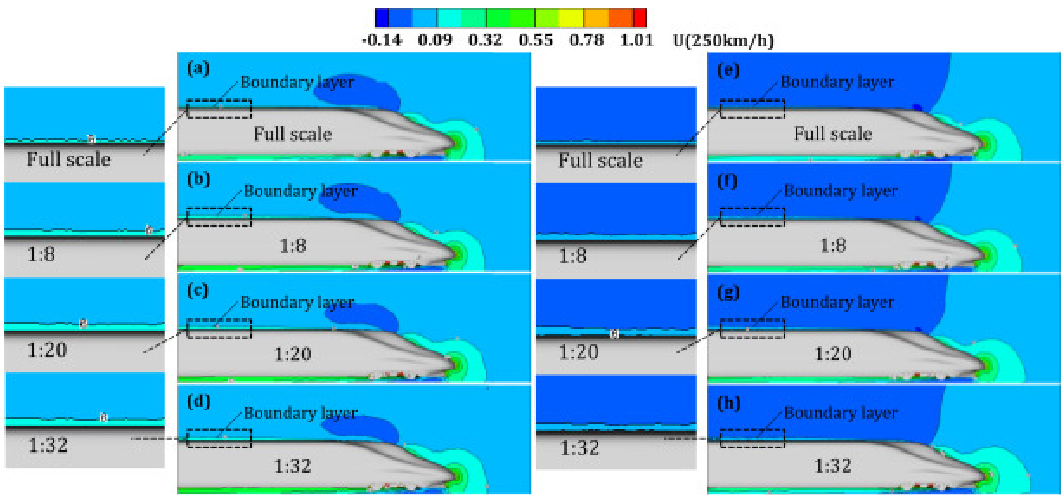

Fig. 26. Velocity distribution around the train nose with different scales. (a)–(d) are the cases of a train running in open air; (e)–(h) are the cases of a train running in a tunnel (inside the tunnel, the train arrives at a distance of 386 m from the entrance of the tunnel). [76] (0.54 × 10^6<*Re*<17.2 × 10^6).

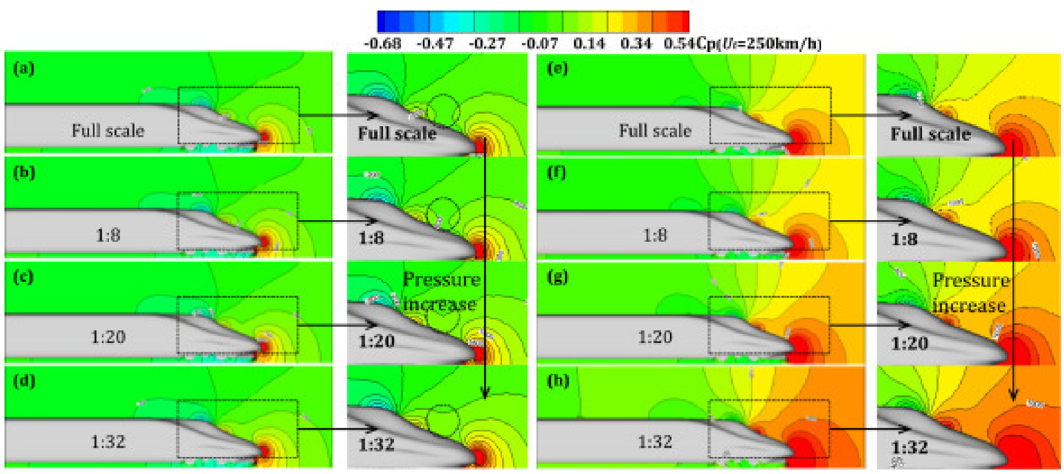

Fig. 27. Pressure distribution around trains with different scales in open air and a tunnel: (a)–(d) are the cases of a train running in open air; (e)–(h) are the cases of a train running in a tunnel (inside the tunnel, the train arrives at a distance of 386 m from the entrance of the tunnel). [76] (0.54 × 10$_6$<*Re*<17.2 × 10$_6$).

Fig. 27. Pressure distribution around trains with different scales in open air and a tunnel: (a)–(d) are the cases of a train running in open air; (e)–(h) are the cases of a train running in a tunnel (inside the tunnel, the train arrives at a distance of 386 m from the entrance of the tunnel). [76] (0.54 × 10_6<*Re*<17.2 × 10_6).

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Evapotranspiration information reporting: I. Factors governing measurement accuracy

Richard G. Allen, ... Marvin E. Jensen, in Agricultural Water Management, 2011

1 Introduction

Evapotranspiration (ET) is typically modeled using weather data and algorithms that describe surface energy and aerodynamic characteristics of the vegetation. ET is typically measured using systems that require the employment of relatively complex physical principles and techniques. In many agricultural systems, plant density, height, vigor and water availability are generally uniform, and the application of estimation algorithms and the measurement of ET can be relatively straightforward, although they are still not without substantial challenge. In the case of non-agricultural systems such as forest, desert and riparian systems, the heterogeneous nature of vegetation, terrain, soils and water availability makes surface energy and aerodynamic processes highly variable and poorly defined. This is especially true, for example, for riparian systems, such as cottonwood, tamarisk and Russian olive in semi-arid regions that can have widely varying vegetation density, tree height, stand extent and availability of water. Most information and estimates of water consumption by forest and riparian systems come from in-place measurements that have a strong empirical and local character. ET data and ET models or model calibrations reported in the literature for even ‘well-behaved’ agricultural systems can contain serious biases caused by flaws in experimental design, measurement equipment, vegetation management, data reduction, model parameterization, and interpretation of results. Therefore, it is essential that reporting of ET measurements and related products such as crop coefficients or parameterized models contain sufficient description of the procedures used to measure and derive ET information so that readers can be aware of potential flaws or shortcomings in data measurement and can be alerted to the need to question representativeness of ET presentations. ET information is more and more frequently used as a foundation for court determinations of injury among water users, for parameterization of important hydrologic and water resources planning and operation models, for operating weather and climate change forecasting models, and for water management and allocation in water-scarce regions, including the partitioning of water resources among states and nations. All too frequently the ET information used in these processes is deficient or uncertain, with too little descriptive information in the reporting to facilitate judgment of its quality.

and water resources planning and operation models, for operating weather and climate change forecasting models, and for water management and allocation in water-scarce regions, including the partitioning of water resources among states and nations. All too frequently the ET information used in these processes is deficient or uncertain, with too little descriptive information in the reporting to facilitate judgment of its quality.

Because of the wide range of complexities in making ET and associated weather measurements and the abundance of opportunities for biases to enter ET and weather data sets, users of ET literature need sufficient information reported in articles on ET to assess the likelihood for opportunities of biases to enter reported data as well as sufficient information to examine or recreate the reported data using some type of ET model. This is currently often not the case, and many journal articles do not contain sufficient information to enable readers to gauge accuracies and representativeness of information. This article is part one of a two-part series on I: ET measurement requirements and accuracies and II: ET reporting recommendations (Allen et al., 2011a). This first article describes common ET measuring systems including water balance, lysimeters, Bowen ratio, eddy covariance, scintillometry, sap flow and remote sensing. The second article lays out recommendations for the type and nature of useful documentation and description of information that should accompany ET findings reported in ET-related articles. In this first article, common errors, biases and shortcomings of common ET measuring systems are discussed to provide support for why the accompanying reporting information is needed.

Measurements of ET include a variety of methods ranging from soil water sampling to lysimeters to eddy covariance to scintillometry. Inherent to all of these methods is the reality that an improperly designed experiment or measurement can lead to highly erroneous water use estimates. Many of the erroneously high ET estimates reported in the literature violate the law of conservation of energy that governs the conversion of liquid water to vapor during the transpiration and evaporation processes. The environmental energy provided by solar radiation plus heat energy advected to the vegetation may be insufficient to explain the measurements. Relatively simple comparisons with reference ET estimates based on available energy are recommended to give cause for review of data and measurement procedures.

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