BACKGROUND STATE OF THE BIOSPHERE

M. M. Adel
University of Arkansas at Pine Bluff, USA

S.A. Hasnath
Department of Geology, Boston University, USA

Keywords: Background, asthenosphere, lithosphere, stellar outbursts, asteroids, meteoroids, meteorite, meteor, radio blackouts, geomagnetic storms, HF radio propagation, volcanoes, earthquakes, landslides, avalanche, tsunamis, wavelength, weather, climate, floods, droughts, El Niño, La Nina, Tornadoes, tropical storms, hurricanes, twister, lightning, blizzard, biomass burning, boreal forests, savannah, NOx, SOx, COx, NMHC, greenhouse gases, incineration, chemical stockpiles, aerosols, dioxins, heavy metals, water diversion, oil exploration, blowout, fires, nuclear detonation, reservoirs, dams, nuclear warheads, wars, indoor pollution

Contents

Summary

The chapter briefly focuses on the extraterrestrial and terrestrial incidences of both natural and artificial origins that take place in the biosphere.

The biosphere outstands the natural and artificial changes occurring in it. The major natural hazards of extraterrestrial origins include stellar outbursts, asteroids, meteoroids, solar radiation storms, radio blackouts, and geomagnetic storms. The ones of terrestrial origins are volcanic eruptions, earthquakes, landslides, avalanches, tsunamis, floods, droughts, El Niños, La Ninas, tornadoes and tropical storms, lightning, blizzards, and epidemics.

The artificial changes are brought about by human activities with feedback effects. The paradigm of land-use and land-cover changes covers this phase. The ones of anthropogenic origins include biomass burning, greenhouse gas production, incineration of chemical stockpiles, constructions of dams and reservoirs and water diversion, oil exploration, mining, fires, nuclear detonation, production of nuclear warheads, and wars. Indoor pollution affects health. Above all, there are always some incidences somewhere on the biosphere where politics is leaving its impact.

1. Introduction

The layered structure of our planet starts from the center and extends all the way up to the atmosphere. The central solid core has a radius of about 1230 km. The outer core, which is believed to be liquid, has a thickness of 2240 km. Above the outer core, there is the mantle which is about 2900 km thick. We live upon the crust, which is thin and rocky. Its depth is about 5 to 8 km underneath the ocean basins. Under the continents, it is about 25 to 40 km deep. The earth's thin and hard outer shell is called lithosphere. Lithosphere is the outer zone of the roughly 2900 km thick mantle that extends from the outer zone to the crust. Lithosphere is divided into large and small fragments called plates. Its thickness is about 70 km. Faults and earthquakes are mostly occurring in this rigid and brittle layer. Underneath lies the semi-molten asthenosphere which churns in slow motion. Aesthenosphere extends to approximately 700 km below the surface of the earth. Lithospheric plates can have three motions – pushing against one another which is convergent, moving away from one another which is divergent, and sliding past each other which is subduction. The lands and oceans form the biosphere.

The floating biosphere in space is open to hazards coming from both terrestrial and extraterrestrial space. There are also natural hazards from within the biosphere itself. Additionally, anthropogenic activities change the background of the biosphere. The virgin state of the biosphere has been undergoing natural and anthropogenic changes. Some regions of the biosphere are more prone to specific natural hazards than the rest. Similarly, some regions have been subjected to artificial hazards to a worse degree than others. Nevertheless, the biosphere still behaves like a sink for all these disturbances.

2. Natural Hazards

Natural hazards have been reigning in the biosphere since the time immemorial. Among these disturbances are stellar outbursts, asteroid and meteoroid hits, solar conditions, geomagnetic storms, volcanic eruptions, earthquakes, landslides, avalanches, tsunamis, floods, droughts, El Niño, La Ninas, tornadoes and tropical storms, lightning, blizzards, and epidemics are worthy of mentioning. These background phenomena have both extraterrestrial and terrestrial origins.

2.1 Extraterrestrial Origin

Biosphere is bombarded by extraterrestrial huge objects, particles, and radiations from prehistoric time until now. Still it carries some probability (however small that be) of getting hit by large objects. Stellar outbursts, asteroids, meteorites, solar radiation, geomagnetic storms - all are counted of extraterrestrial origin.

2.1.1 Stellar Outbursts

Stellar explosions are felt like cosmic ones. Stellar outbursts can send radiations that can reach the biosphere. It can stall momentarily the monitoring instruments placed in space and on the ground. A powerful surge of stellar radiation stripped atoms in the ionosphere (55 to 80 km altitude range) on August 27, 1998. The resulting electric condition of the high night sky severely limited the range of radio transmission. It affected the delicate instruments on seven spacecrafts causing their shutdowns (Wilford, 1999). The wave of gamma ray, x-ray, and high particle radiation burst out from a cataclysmic magnetic flare on a neutron star, called a magnetar, about 20,000 light years away from us. Neutron stars are stellar remnants after supernova explosions. Their mass is like that of the sun but only about 19 km across. The star is located in the constellation Aquilla, designated SGR1900 + 14.

2.1.2 Asteroids

Asteroids are small rocky objects that revolve around the sun. The largest known asteroid, Ceres, is about 1/10,000 times as massive as the planet earth. It measures about 940 km across. In 1968, the asteroid Icarus missed our planet by 6 million km. In cosmic standards, it was a close interaction. In 1989, an unknown asteroid called 1989 FC, came within 800,000 km from the earth. In 1991, asteroid 1991BA missed the earth by only 170,000 km. Dinosaurs lived this planet almost 1000 million years ago.

It is thought that a huge extraterrestrial object hit this planet about 65 million years ago. It could be a 10- to 15-km diameter asteroid or comet that released about as much energy as 10 million or more of the largest hydrogen bomb that human being has ever constructed. It blew a huge amount of dust and debris in the atmosphere. The dust obscured the sun for many years. Plants could not survive. The food chain disrupted. Dinosaurs died out. Whatever was the reason for their death, it is thought that a dramatic environmental change was responsible.

The frequency of impact of extraterrestrial origin ranges from once in a month to once in every 20 million years for objects heavy enough to cause release of 0.01 to $100x10^6$ million megatons TNT equivalent energy. The probability of global catastrophe threshold ranges from about once in every 100 thousand years to once in 2.5 million years that would release an amount of energy of 50,000 to 10,000 megatons of TNT equivalent energy.

2.1.3 Meteoroids

A small body approaching the earth in space is called a meteoroid. It is called a meteor in the phase when it begins to vaporize in the atmosphere. If it survives to reach the earth's surface, it is called a meteorite.

A asteroid of mass of about 900 kg and a meter across can reach the surface of the earth to produce craters. Their kinetic energy will be converted to mechanical energy of damage, thermal energy of heat production, and sound energy of vibration. The dust raised in the atmosphere can obscure the sun. It can affect crop production, plant growth, and climate. Statistical calculations predict that a meteoroid should damage a building on this globe once in every 16 months. Meteoroids of all sizes add about 36,000,000 kg of mass per year. Every day the earth is bombarded by about two meteoroids large enough to make visible impacts. Most meteoroids are small particles in the range of a few centimeters to microscopic dusts.

Meteoroids can explode in space instead of reaching the surface. On June 30, 1908, a meteoroid of about 30 m across exploded several km above the Siberian sky leaving a shallow depression on the ground and no fragments in Tunguska. The explosion had energy equal to that of a 10-megaton nuclear detonation. The explosion was heard hundreds of km away and the dust raised in the atmosphere increased atmospheric aerosol all over the Northern Hemisphere. If the earth had advanced about 71 degrees in rotation, Leningrad which was then called St. Petersburg, would be hit.

The earth is marked by about 100 craters larger than one-tenth of a km across. The Barringer Meteorite Crater near Flagstaff, Arizona is about a km across. It is estimated that the mass of the meteoroid was 45,000,000 kg. It was created about 50,000 years ago by the impact of an iron meteoroid as large as the size of a building (80-100 m).

US Skylab space station discovered the ancient impact basin that forms Quebec's Manicouagan Reservoir. A long time ago, a large meteoroid must have landed there. The oldest meteoroid craters are about 2 billion years old (Seeds, 1997; Chaisson, 1995)

2.1.4 Solar Radiation Storms

The sun undergoes through a maximum condition with a periodicity of 11 years. A violent solar condition is characterized by emission of hazardous radiation. NOAA office calls it solar radiation storms. Solar storms have both biological and telecommunication-disrupting effects. NOAA office classifies the storms according to their scale.

The scaling runs from S 5 to S1. S 5 is an extreme event, S 4 a severe one, S 3 a strong one, S 2 a moderate one, and S 1 is a minor one. A 5-minute average of the emitted particle flux of energy 10 MeV expressed in $s^{-1}.ster^{-1}.m^{-2}$ are. 109, 108, 107, 106, and 104 for extreme, severe, strong, moderate, and minor solar storms, respectively. The average frequency of occurrence of these storms are less than 1, 3, 4 , 10, 25 , and 50 per 11-year solar cycle, respectively.

An S 5 storm is the cause of high radiation hazard to astronauts on extra-vehicular activities. Passengers and crew members in commercial jets at high latitudes encounter a high radiation dose level (about the level of 10 chest x-rays). An S 5 storm hampers satellite operations. Some satellites can be lost. Satellite control is affected by loss of memory. Image data can accompany serious noise. Star-trackers fail to locate sources. Solar panels are permanently damaged. High frequency communication in the polar region is rendered impossible. Navigation becomes extremely difficult due to position errors. An S 4 or severe storm causes the same biological, satellite operational, and telecommunication problems as an S 5 storm.

Astronauts are recommended to avoid radiation hazard on extra-vehicular activities from an S 3 storm. Jet flyers receive about 1 chest x-ray dose level of radiation. In satellite operation, single-event upsets are likely to occur, imaging system picks up noise, exposed components or detectors are permanently damaged, and current in solar panels drop. Further, telecommunication is degraded.

A moderate storm does not cause any biological impact. The only problem in satellite operation is infrequent single-event upsets. In telecommunication, small effects are observed on HF communication in the polar region where navigation is impacted. In case of an S 1 storm, no biological or satellite operational problems are faced. Only HF radio communication in the polar region receives minor impacts (www.sec.noaa.gov).

2.1.5 Radio Blackouts

Radio blackouts are measured by the level of x-radiation received by the GOES satellite. NOAA space weather scale divides the blackout events as R 5 which is extreme, R4 which is severe, R3 which is strong, R2 which is moderate, and R1 which is minor. These scales put GOES X-ray peak brightness by class X20 for the extreme case, X10 for the severe case, X1 for the strong case, M5 for the moderate case, and M1 for the minor case.

These events have X-ray fluxes of $2x10^{-3}$ W. m^{-2}, $1x10^{-3}$ W. m^{-2}, $1x10^{-4}$ W. m^{-2}, $5x10^{-5}$ W. m^{-2}, and $1x10^{-5}$ W. m^{-2}, respectively, in the wavelength range 0.1 to 0.8 nm The extreme class event occur less than 1 per cycle, the severe class 8 per cycle, the strong class 175 per cycle, the moderate class 350 per cycle, and the minor class 2000 per cycle. In terms of the number of storm days, the severe class have 8 days per cycle, the strong class 140 days per cycle, the moderate class 300 days per cycle, and the minor class 950 days per cycle.

In case of the extreme class event, a complete cut-off of HF radio communication prevails for few hours on the sun-ward side of the earth. No contact is possible with mariners or en route navigators. Further, the sun-ward side suffers from hours-long outages of low frequency signals used by maritime and general aviation systems which results in the loss of positioning. Also, hours-long increased satellite positioning errors occur in satellite navigation on the sun-ward side of the planet with the possibility of spreading into the night side.

In the case of the severe class of blackouts, the major sun-ward side of the planet experiences one to two hours-long cut-off of HF radio communication. Mariners and en route aviators experience the same difficulty as in the case of the extreme class. For one or two hours, mariners and general aviators experience outages of low frequency navigation signals. This results in the increase of positioning error. Satellite navigation may experience light disruptions on the sun-ward side of the planet.

An R 3 category of radio blackout is accompanied with a cut-off of HF radio communication signal over a wide area and about an hour-long out-of-radio contact for mariners and en route aviators on the sun-ward side of the planet. Further, it causes errors in maritime and general aviation positioning due to about an hour-long degraded effect in low frequency navigation signals.

An R 2 category of blackout can cause a limited cut-off of HF radio communication signals on the sun-ward side of our planet and a loss of radio contact spanning over tens of minutes for mariners and en route aviators. It further degrades the low frequency navigation signal for tens of minutes introducing errors in maritime and general aviation positioning.

An R 1 category of radio blackout can weaken HF radio communication signals on the sun-ward of the planet, and mariners and en route aviators can lose radio contact occasionally. Further, maritime and general aviation positioning is affected for degraded low-frequency navigation signals spanned over short intervals (www.sec.noaa.gov).

2.1.6 Geomagnetic Storms

The earth behaves like a huge magnet. Fluctuations in its magnetic fields are termed geomagnetic storms.

According to NOAA space weather scale, geomagnetic storms are categorized as G 5 for the extreme case, G 4 for the severe case, G 3 for the strong case, G 2 for the moderate case, and G 1 for the minor case. Kp, an index is used to measure the strength of geomagnetic storms. Every three-hour average values of Kp are 9, 8 (including a 9-), 7, 6, and 5, respectively, for these category of geomagnetic storms. The number of G5, G4, G3, G2, and G1 storms per an 11-year solar cycle are 4, 100, 200, 600, and 1700, respectively, for these categories. The number of storm days are 4 , 60 , 130, 360, and 900 days per cycle, respectively.

Geomagnetic storms affect power lines, spacecraft operations, and telecommunications. An extreme storm can cause collapse of grid systems and damage to transformers. Spacecrafts experience extensive surface charging and orientation problems. Also, uplink/downlink and satellite tracking problems are experienced. Further effects are generation of hundreds of amperes of induced pipeline currents, cut-off of HF radio communication in many areas for a day or two, poor satellite navigation for days, blackout of low-frequency radio navigation for hours, and spreading of aurora up to the equator.

A severe storm can cause voltage instability, collapse of portions of grids, and tripping in protective devices. Also, spacecrafts experience surface charging, tracking difficulty, and orientation problems. Further, it generates induced pipeline currents affecting preventive measures, occasional HF radio propagation, hours-long degradation in satellite navigation, disruption of low-frequency navigation, and spreading of aurora up to the tropics.

A strong geomagnetic storm can cause erroneous voltage reading, triggering of false alarms in protection devices, and likely high readings in Agas-in-oil transformers. In satellite operations, a strong storm can cause surface charging on spacecraft component parts, enhanced drag on spacecrafts, and orientation problems needing corrections. Further, in telecommunication, the storm can cause intermittent satellite navigation and low-frequency radio navigation problems, intermittent HF radio communication problems, and a spread of aurora up to mid-latitudes.

A moderate geomagnetic storms can affect power lines at high latitudes only. In satellite operations, corrective measures are required by ground control, and problems are faced in orbit predictions due to changes in drag. In telecommunication, HF radio propagation does not work at high latitudes. Also, aurora extends up to 50 latitudes.

A minor geomagnetic storm can cause fluctuations in weak power grids, impact lightly on satellite operations. In other effects, aurora is seen up to 60 degrees latitudes and migratory animals' movements are affected (www.sec.noaa.gov).

Canada and New York were affected by the geomagnetic storms of the late eighties.

2.2 Terrestrial Origin

Terrestrial origins can be both natural and artificial. Accordingly, we can divide terrestrial origins into geologic, climatic, and anthropogenic classes.

2.2.1 Geologic Origin

Geologic factors are volcanic eruptions, earthquakes, landslides, and tsunamis. Data on natural hazards of geologic origin can be obtained from these websites – http://www.saa.noaa.gov, http://www.ngdc.noaa.gov/seg/hazard/, and http://www.ngdc.noaa.gov/dmsp/

2.2.1.1 Volcanoes

Active volcanoes have eruptions in historic time, dormant volcanoes do not have eruptions in historic time, and extinct ones do not have eruption record in geologic time scale. Recently active volcanoes group in linear chains the most wonderful one of which is the circum-Pacific zone around most of the pacific coast. A rough estimate shows that the of a volcanic eruption can be 10^{19} J. The May 18, 1980 eruption of the Mount St. Helen, 2900 meter summit above the sea level was lowered by more than 400 meters.

The event devastated timberland on the north side. Trees within a 400 km2 area lay flattened, intertwined, and branchless by the blast. The mud flow carried ash, trees, rock debris 29 km down the Toutle River. Some 59 people were killed from heat suffocation, cloud of ash and gases, blast, and mud flows. About a cubic km of ash and rock debris came out of the eruption.

The blast was strong enough to move some ash by 1.8 km to stratosphere.

Magma compositions are of three types - mafic (basaltic) magma, intermediate (andestic) magma, and felsic (granitic) magma. The first type has at least 50% silica, is the least viscous, contains 1- 2% gas, possesses the least tendency to form pyroclastic materials (rock fragments, lava Abombs fine ash, and dust, and can form shield volcanos, basalt plateaus, and cinder cones landforms. The second type is medium viscous, contains about 60% of silica and 3 - 4% gas, has intermediate tendency to form pyroclastics, and forms composite cones landform.

The third type contains about 70% silica, is the most viscous, contains 4-6% gas, possesses the greatest tendency to form pyroclastics, and produces land forms of the type of volcanic domes and pyroclastic flows. (Turback and Lutgens, 1999). Signs of volcanic eruptions include swarms of earthquakes up to several thousands a week, bulging of land surface as magma rises in a vent underneath a volcano, amount and emission rates of gases like steam, carbon dioxide, and sulfur dioxide, and increase in temperature. The nearer to eruption is a volcano, the better prediction can be made as to the eruption.

The Hawaiian Islands are mostly (99%) of lava. Magma eruption on the earth's surface are responsible for volcanic landforms. Magma introduced below the surface can affect the surface topography. In 1959, eruption at Kilauea Iki had lava fountain rise 575 m. Swanson et al. (1979) reports of 185 million cubic meter of lava during the 1969-71 eruptions along the South Rift zone of Kilauea near Mauna Ulu. Tilling et al. (1987) reported of 162 million cubic meter of during the 1972-74 eruptions. On August 24, 79 AD, the cities of Pompeii in southern Italy lost 15,000 people by the eruption of the Vesuvius.

All but 30 people escaped from the nearby city of Herculaneum. Enough molten rock got out to build 1,100 great pyramids. Pompeii city fell beneath so much ash that heavy rain solidified it to 6-7 m cement-like substance. A northwest wind blew the ash over Pompeii. The ash cloud was so dense that at 100 km away places accumulated 10 cm of ash. They did not know its last eruption time. A new eruption of Vesuvius could kill as many as 500 times more people as the eruption in 79 AD. Stream and friction between the particles of airborne dust charged the air around the eruption with static electricity. Spectacular lighting bolts appeared (Benson, R, and R. Platt, 1997).

Nevada Del Ruiz killed 23,000 lives in Columbia in 1985. In 1991, early evacuation saved 200,000 lives from the eruption of Pinatubo in the Philippines. There are about 434 volcanoes worldwide. Old craters of volcano can form lakes. Vatican City State has one such lake. Mount Jao area in Japan also has one lake. Volcanos spread sea floor, change landforms, and are natural sources of air pollution. Volcanic gases may have 70% water vapor, 15% carbon dioxide, 5% nitrogen, 5% hydrogen sulfide, and some trace amounts of chlorine, hydrogen, and argon, Sulfur dioxide is the cause of acid rain. Scattering of solar radiation by aerosol particles, produces a local unbalance of radiation. Spectacular sunrises and sunsets are observed. Twilight tinge changes. The color of the moon and the sun change. Polarization of skylight happens.

-
-
-

Bibliography

Adel, M. M. (2001). Effects on Water Resources from Upstream Water Diversion in the Ganges Basin, *Journal of Environmental Quality* 30:356-368 [So far, the best-rated article on the effects of upstream water diversion]

Adel, M. M. (2002). Man-Made Climatic Changes in the Ganges Basin, *International Journal of Climatology* , 22:993-1016 [Another reference on the effects of upstream water diversion]

Andreae, M. O. (1993). Global distribution of fires seen from space, *EOS*. Vo. 74, No. 12, March 232, 1993, pp. 129 and 135. [Title refers to the contents]

Andreae, M. O., (1991). Biomass burning: Its history, use and distribution and its impact on environmental quality and global climate, *in Global Biomass Burning: Atmospheric, Climatic and Biospheric Implications*, J. S. Levine (ed.), pp. 3-21, MIT Press, Cambridge MA.[Title expresses the contents]

Bergman, K., C. Ropelewski, and M. Halpert. (1986). The record Southeast drought of 1986, *Weatherwise*, 39, 262. [Title describes the contents]

Borchert, J. The dust bowl in the 1970s. *Ann. Assoc. Am. Geogr.*, 61, 1.[Title expressive of the contents]

Benson, R, and R. Platt, (1997). *DISASTER! CATASTROPHES THAT SHOOK THE WORLD*, DK Publishing, Inc., New York[A book on shocking disasters]

Brown, L. R. (1991). The Aral Sea: Going, Going … *Worldwatch* 4 (Jan/Feb), pp. 24-35 [A fourth reference on the effects of water diversion]

Browning, J. M., (1973), Catastrophic rock slides, Mount Huascaran, north-central Peru, May 31, 1970: *American Association of Petroleum Geologists Bulletin*, v. 57, p. 1335-1341[Title expresses the contents]

Burton, I., and R. W. Kates. (1964). The Perception of Natural Hazards in Resource Management, *Natural Resources Journal*, 3, 412-441. [Imparts knowledge of natural hazards in resource management]

Burton, I., R. W. Kates, and G. F. White, (1978). *The Environment as Hazard.* New York Oxford University Press. [Hazardous aspects of our environment]

Calvert, D. V., (1975). Nitrate, Phosphate, and Potassium movement into drainage lines under three soil systems, *J. Soil Sci*. 34: 733-750.[Title expressive of the contents]

Canty, M. J., and J. Schlittenhardt. (2001). Satellite data used to locate site of 1998 Indian nuclear test. *EOS*, Vol. 82, Number 3, January 16, 2001. pp. 25 & 29 [Title tells of the contents]

Chaisson, (1995), *Astronomy*, Prentice Hall, Inc., Englewood Cliffs, New Jersey, p. 228-238 [Refers to meteorite hits]

Cleverly, D., J. Schaum, G. Schweer, J. Becker, and D. Winters. (1997). The congener profiles of anthropogenic sources of chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans in the United States, *Organohalogen Compounds*, 32:430-435 [Refers to chlorinated organic compounds].

Connel, D. W.,(1997). *Basic Concepts of Environmental Chemistry*, CRC Press LLC, Florida, p. 138. [Refers to biotransformation of PCBs and dioxins]

Cooke, W. F., B. Koffi, and J. –M. Gregoire. (1996). Seasonality of vegetation fires in Africa from Remote Sensing data and application to global chemistry model, *J. Geophys. Res.* 101, 21051-21-065 [Refers to fires in Africa]

Cowen, R. C. (1998). New Lightning Research May Help Illumine Global Warming, http://www.csmonitor.com/durable/1998/03/03/feat/scitech.1.html [Refers to NOx production in lightning]
Crutzen, P. J., and M. O. Andreae. (1990). Biomass burning in the tropics: Impact of atmospheric chemistry and biogeochemical cycles, *Science*, 250, 1968, 1990 [Refers to the impact of biomass burning]

Culver, R. B. (1993). *Facets of Physics: A Conceptual Approach*, p. 290, West Publishing Company, Minneapolis/St. Paul [An Introductory level physics textbook].
D'Almedia, G. A., P. Koepke, and E. P. Shettle. (1991). Atmospheric Aerosols. Global Climatology and Radiative Chasracteristics. A. Deepak Publ., Hampton, VA, pp. 11-50, and 400-420 [A treatise .on aerosols]

Department of the Army, (1997). *Disposal of the Chemical Agents and Munitions Stored at Pine Bluff Arsenal, Arakansas*. [Refers to weapon holdings in Pine Bluff Arsenal]

Department of Education, *1992-93. Annual Statistical Report of the Public Schools of Arkansas, Little Rock, Arkansas* [Provides demographic information of school students]

Douglas, A., and P. D. Marshall. (1996). Seismic source size and yield for nuclear explosions, in Monitoring a Comprehensive Test Ban Treaty, *Proc. NATO ASI*, edited by E. S. Husebye and A. M. Dainty, pp. 309-353, Kluwer Academic Publishers, Dordrecht, The Netherlands [Provides information on nuclear test-generated seismic effects]

Easterbrook, D. J., (1999). *Surface Processes and Landforms*, p. 102-110, Prentice Hall, Upper Saddle River, NJ [A good reference book on earth's background surface processes]

Edwards, R. (2001). The Online Tornado FAQ. http://www/spc.noaa.gov/faq/tornado/ [On tornados]

Ekekwe. (1981). The Funiwa-5 oil blowout. *Proceedings of the International Seminar on the Petroleum Industry and the Nigerian Environment*, 64-68. [Refers to petroleum industry-related environmental impact]

Enfield, D. B. (1989). El Niño, past and present. *Rev. of Geophys*. 27:159-187. [Reviews on El Niño]

Ericksen, G. E., Pflacker, G., and Fernandez, J. V., (1970), Preliminary reports on the geological events associated with the May 31, 1970 earthquake: U. S. Geological Survey Circular 639 [Title tells of the contents]

Evans., D. M. (1966). Man-made earthquake in Denver. *Geotimes*, 10: 11-18 [Refers to anthropogenic activity-related earthquake]

Fishman, J., C. E. Watson, J. C. Larsen, J. A. Logan. (1990). Distribution of troposphere ozone determined from satellite data, *J. Geophys., Res*., 95, 3599 [Refers to satellite observation of ozone]

Friedlander, Jr., B. P. (1996). News from the Northeast Regional Climate Center, http://met-www.cit.cornell.edu/snowmanji.html [Reports weather news]

Fujita, T. T. (1981). Tornadoes and downbursts in the context of generalized planetary scales. *J. Atmos. Sci*., 38, 1511-1534 [On global scale tornados and downbursts]

Fujita, T. T. (1973). Tornadoes around the world, *Weatherwise*, 26, 56-83. [On global occurrences of tornados

Fullekrug, M., and A. C. Fraser-Smith. (1999). Global lightning and climate variability inferred from ELF magnetic field variations, http://www.geophysik.uni-frankfurt.de/~fuellker/PUB/GLA/gla.html [Magnetic field variation signals of climate variability]

Gambolati, D. B. G., and P. Teatini. 2000. Residual Land Subsidence Near Abandoned Gas Fields Raises Concern Over Northern Adsriatic Coastland, EOS, Vol 81, No. 22. pp. 245, 248, & 249 [A article on land subsidence due to oil exploration]

Geerts, B., and E. Linacre, (1998). Tornado frequency worldwide. http://www-das.uwyo.edu/~geerts/cwx/notes/chap07/tornado_clim.html [On tornado occurrences]
Gobron, N. B. Pinty, M. M. Verstraete, and Y. Govaerts. (1997). A semi-discrete model for the scattering of light by vegetation, J. Geophys. Res., 102, 9431-9446 [An article on light scattered by vegetation]

Godish, T. (1997). *Air Quality*, Lewis Publishers, New York, p. 32-43 [A good textbook on air quality]
Goldammer, J. G. (Ed.). (1990). *Fire in the Tropical Biota: Ecosystem Processes and Global Change*, Springer-Verlag, Berlin-Heidelberg [A book on ecosystem processes and global change]

Gupta, V. and F. Pabian, (1996). Investigating allegations of Indian nuclear test preparations in the Rajasthan Desert, http://www.ca.sandia.gov/casite/gupta/index.html [Title speaks of the contents]

Hecht, E. (1998). Physics: Algebra/Trig. 2nd. Ed. Brooks/Cole Publishing Co., Pacific Grove, CA, p. 186. [A textbook on introductory level physics]

Heck, W. W., and C. S. Brandt. (1977). "Effects on Vegetation: Native Crops, Forests". 158-220. In: Stern, A. C., (Ed.) *Air Pollution, Vol. II. The Effects of Air Pollution*, 3rd, ed., Academic Press, New York. [A book on air pollution]

Heim, R. R. (1988). About that drought …, *Weatherwise*, 41, 266. [On droughts]

Henry, J. G. and Heinky, G. W. (1996). *Environmental Science and Engineering*, 2 nd. Prentice Hall, Upper Saddle River, NJ, p. 69-72. [A good textbook on the issue]

Jacobson, J. S. and A. C. Hill (Eds.). (1970). *Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Air Pollution Control Associatio*n, Pittsburgh, PA. [Title speaks of the contents]

Karl, T. R., and R. K. Quayle. (1981). The 1980 summer heat wave and drought in historical perspective, *Mon. Weather. Rev*. 109, 2055. [Reports on the specific incidence]

Karl, T. R., and P. J. Young. (1987). The 1986 Southeast drought in historical perspective. *Bull Am. Meteorol. Soc*., 68, 773 [Reports on the specific incidence

Godish, T. (1997). *Air Quality*, Lewis Publishers, New York, p. 32-43 [A good textbook on air quality]

Karl, T. R., F. Quinlan, and D. S. Ezell. (1987). Drought termination and amelioration: Its climatological probability, *J. Clim. Appl. Meteorol.* 1198 [Referring to droughts]

Keller, E. A. (1984). Environmental Geology, Merrill Publishing Co., Columbus, Ohio, p. 166. [*A textbook on the subject*]

Kent, P. E., (1966), The transport mechanism in catastrophic rockfalls: *Journal of Geology*, v. 74, p. 79-83 [Referring to mechanics of rockfalls]
Kirkpatric, L. D., and G. F. Wheeler. (1992). *Physics, A World View*. Pp. 432-433. Saunders College Publishing, New York [A beginning physics textbook]

Kitamura, S., Sumino, K, Hayakawa, K., and Shibata, T. (1975). Mercury content in normal human tissues. In T. Tsubaki, Ed., *Studies on Health Effects of Alkyl mercury in Japan*. Environmental Agency, Tokyo, Japan. Pp. 20-27. [Reports on mercury contamination]

Levine, J. S. (1990). Global Biomass Burning: Atmospheric, Climate, and Biospheric Implications. *EOS*, Vol. 71, No. 37, pp. 1075-1077, September 11, 1990 [Reports on biomass burning effects upon atmosphere, climate and biosphere]

Lui, B. and E. Xu. (1976). Physical and Economic Damage Functions for Air Pollutants by Receptors, *EPA/600/5-76-011* [Discusses physical and economic damages by air pollutants]

Lucier, A. A., and S. G. Haines (Eds.) (1990). Mechanism of Forest Response to Acidic Deposition, Springer-Verlag, New York [Reports on how forest rersponds to acid deposition]
MacKenzie, J. J., and M. T. El-Ashry. (1988). *Ill Winds: Airborne Pollution's Toll on Forests and Crops.* Yale University Press, New Haven, CT. [Another reference to air pollution effects on forests and crops]

MacKenzie, J. J., and M. T. El-Ashry. (1989). *Ill Winds: Airborne Pollution's Toll on Forests and Crops.* Yale University Press, New Haven, CT. [A later edition of the above reference]

Malachowski, M. J. ((1995). *Health Effects of Toxic Substances*, Government Institute, Inc., Rockville, MD. [Reports on the impact of toxic substances upon human health]

Malins, D. C. (ed). (1977). *Effects of Petroleum on Arctic and Subarctic Marine Environments and Organisms*, Vols. 1 and 2, Academic Press, New York. [Reports on petroleum effects on marine environment]

McDowell B., and Fletcher, J. E., (1962), Avalanche! 3,500 Peruvians perish in seven minutes: *National Geographic*, v. 121, p. 855-880. [Reports on the specific avalanche]

McNab, A. L. (1989). Climate and Drought. *EOS*, Vol. 70, No. 40, October 3, 1989. pp.873, 882-3 [Reports on climate and drought]

Meteoroloy and Atomic Energy (1968), (D. H. Slade Ed.), U. S. Atomic Energy Commission Office of Information Services, Springfield, VA, p. 59

Micklin, M. (1988). Desiccation of the Aral Sea: A Water Management Disaster in the Soviet Union, *Science* 241:1170-1176 [Reports on water diversion effects in the Aral Sea basin]

Namias, J., (1985). Factors responsible for the droughts, in *Hydrologic Aspects of Drought*, M. A. Beran and J. A. Rodier (eds.), pp. 27-64, United Nations Educational, Scientific, and Cultural Organization, Paris, France [Reports on the causes of droughts]
National Research Council, Committee on Biological Effects of Atmospheric Pollutants. 1971. *Fluorides*. National Academy of Sciences, Washington, DC. [Reports on the effects of fluorides]

National Research Council. (1976). *Vapor-phase Organic Pollutants*, National Academy of Sciences, Washington, DC. [Discusses the effects of vapor phase pollutants]

National Research Council, (1977). Subcommittee on Nitrogen Oxides, Committee on Medical Biological Effects of Environmental Pollutants, *Nitrogen Oxides*, National Academy of Sciences, Washington, DC. [Reports the environmental effects of the oxides of nitrogen]

National Research Council, (1977) Subcommittee on Carbon Monoxide, Committee on Medical Biological Effects of Environmental Pollutants, . Carbon Monoxide, National Academy of Sciences, Washington, DC. [Reports on the environmental effects of carbon monoxide]

National Research Council (1994). Recommendations for the Disposal of Chemical Agents and Munitions, Washington, DC, p. 42 [Title expressive of the contents]

Nelson-Smith, A. (1973). *Oil Pollution and Marine Ecology*, Plenum Press, New York [A book on the oil pollution effects upon the marine ecology]

NOAA. URL:www.sec.noaa.gov [Reports on space weather events]

Pakiser, L. C., J. P. Eaton, J. H. Healy, and C. B Raleigh, (1969). Earthquake prediction and control. *Science*, 166: 1467-74. [Contents conforms with the title]

Patton, H. J. (1990). Characterization of spall from observed ground motions on Pahute Mesa, *Bull. Seismol. Soc. Am*. 80, 1326-1345 [Reports on the classification of ground splitting following ground motions]

Peiris, V., 6 September, (2000). Hundreds die in floods in southern India and Bangladesh, WSWS (World Socialist Web Site), http://www.wsws.org/articles/2000/sep2000/ind-s06.shtml [Reports on the flood disaster]

Pinty, B., M. M. Verstraete, and N. Gobron. (2000). Do man-made fires affect Earth's surface reflectance at continental scale? *EOS*, Vol. 81, No. 34, August 22, 2000. pp. 381, 388, & 389.[Focuses on the effects of anthropogenic fires on the earth's reflectance]

Potter, J. G. (1958). An unusually dry spring in central Canada, July 7, 1958 *Weekly Weather Crop Bull*. 45, 8 [Reports on the specific dry season]

Price, C., and D. Rind. (1994). Modeling global lightning distribution in a general circulation model. *Mon. Weather Rev*. 122, 1930-1939. [Incorporates global lightning occurrences in the atmospheric circulation model]

Rasmussen, E. M. (1985). El Niño and variations in climate. *American Scientist* 73:168-177. [Reports on El Nino and climatic variations]

Ruan, H. D., and R.. J. Gilkes, (2000). Phosphorous accumulation in farm ponds and dams in Southwestern Australia, *J. Environ. Qual.* 29:1875-1881 [Reports on the accumulation of phosphorus in Australian pond and dam environments]

Schuster, R. L., and Krizak, R. L., (1978), Landslides: analysis and control: Transportation Research Board, National Academy of Science, *National Research Council Special Report* 176, 234 p. [Reports on landslides]

Science Applications International corporation, (1997). Pine Bluff Chemical Agent Disposal Facility Phase I Quantitative Risk Assessment, prepared by U. S. Army Program Manager for Chemical Demilitarization, Aberdeen Proving Ground, MD 21010 [Focuses on the potential risks associated with the incineration of chemical weapons at the Pine Bluff Arsenal] .

Seeds, M. A., (1997), *Foundations of Astronomy*, Wordsworth Publishing Company, Albany, New York, p. 551-553 [A good textbook on astronomy. Refers to meteorite hits]

Seinfeld, J. H. (1986). *Atmospheric Chemistry and Physics of Air Pollution*, New York, John Wiley, p. 55 [A reference on the chemistry and physics of air pollution]

Setzer, A. W., and M. C. Pereira. (1991). Amazon biomass burnings in 1987 and their tropospheric emissions, *Ambio*, 20, 19 [Effects of biomass burning in the Amazon]

Sharpley, A. N. (1993). Estimating phosphorous in agricultural runoff available to several algae using iron oxide paper strips, *J. Environ. Qual*. 22:678-680. [Prosphorus estimation in agricultural run-offs]

Sharpley, A. N. (1885). Identifying sites vulnerable to phosphorous loss in agricultural runoff, *J. Environ. Qual*. 24:947-951 [Title expressive of the contents]

Sharpley, A. N., and S. J. Smith (1992). Prediction of bioavailable phosphorous loss in agricultural runoff, *J. Environ. Qual*., 21:32-37 [Title tells of the contents]

Sharpley, A. N., T. C. Daniel, and D. R. Edwards. (1993). Phosphorous movement in the landscape. *J. Prod. Agric*. 6:492-500. [Discusses the mobility of phosphorus in the environment]

Sharpley, A. N., T. C. Daniel, J. T. Sims, and D. H. Pote. (1996). Determining environmentally sound phosphorous levels *J. Soil Water Conserv*. 51:160-166 [Reports on the safe level of phosphorus]

Sharpley, A. N., S. J. Smith, and J. W. Nancy. (1987). Environmental impact of agricultural nitrogen and phosphorous use. *J. Agric. Food Chem.* 35:812-817 [Title expresses the contents]

Shipman, J. T., J. D. Wilson, and A. W. Todd. (2000). *An Introduction to Physical Science*, pp. 530-544. 9th ed. Houghton Mifflin Co., Boston [A well-circulated textbook on physical science]

Smithson, A. E., (1994). *The U. S. Chemical Weapons Destruction Program: Views, Analysis, and Recommendations*, pp. 3-8, the Henry L. Smithson Center, Washington, DC. [Title is expressive of the contents]

Sneider, E. (1992). *Christial Science Monityor*. The Christian Science Publishing House. [Reports on the devastating effects of water diversion in the Aral Sea basin]

Strahler, A. N., and A. H. Strahler, (1973). *Environmental Geoscience: Interaction between Natural Systems and Man*, Hamilton Publishing Company, Sanra Barbara, California, p. 279-281 [The best environmental science text in the early years of this science]

Tarbuck, E. J., and Lutgens, F. K., (1999), Earth An Introduction to Physical Geology, Prentice Hall, Upper Saddle River, New Jersey, p. 86-90 [A good physical geology textbook]

Swanso, D. A., W. A. Duffield, D. B. Jackson, and D. W. Peterson. (1979). Chronological narrative of the 1969-71 Mauna Ulu eruption of Kilauea Volcano, Hawaii: *U. S. Geological Survey Professional Paper 1056*, 55p. [Title itself expresses the contents]

Tarbuck, E. J., and F. K. Lutgens. (1999). *Earth, An Introduction to Physical Geology*, 6th ed. Pp. 85-116. Prentice Hall, Upper Saddle River, New Jersey [A good textbook on physical geology]

Terzaghi, K., (1950). Mechanisms of landslides: in Paige, S. ed., Application of geology to engineering practice: Geological Survey of America, Berkely Volume, p. 83-123. [On the mechanics of landslides]
Tilling, R. I. et al., (1987). The 1972-1974 Mauna Ulu eruption, Kilauea Volvano: an example of quasi-steady-state magma transfer in Volcanism in Hawaii, v. 1: *U. S. Geological Survey Professional Paper 1250*, p. 69-92. [Reports of the specific volcanic eruption]

Tollefson, L. (1989). Methylmercury in fish. *In The Risk Assessment of Environmental Hazards*. (Ed. Paustenbach, D. J.), pp. 845-867 [Reports on the risk of mercury contamination in fish]

Tschirley, F. (1986). Dioxin, Scientific America, 254, 29. [Reports on dioxins]

Tzimopoulos, N. D., J. E. Williams, H. C. Metcalfe, and J. F. Castka (1993), Modern Chemistry, [A chemistry textbook]

Turco, R. P. (1997), Earth Under Siege, Oxford University Press, NY, p. 121-138 [A good textbook on environmental science]

U. S. Department of Health, Education, and Welfare (1967). *Air Quality Criteria for Sulfur Oxides*, National Center for Air Pollution Control. [Air quality index for SOx]

U. N. (1973). *The Determinants and Consequences of Population Trends*. New York: United Nations. [Title tells of the contents]

Van Dorn, W. E., (1965), Tsunamis: in *Advances in hydroscience*, v. 2: Academic Press, New York, p. 1-48 [Reports on tsunamis]

Varnes, D. J., (1958), Landslide types and processes: in Eckel, E., ed.., *Landslides and engineering practice*: Washington, DC., Highway Research Board Special Report 29, p. 20-47. [Reports on landslides]

Wallace, T. C., (1998). The May 1998 India and Pakistan nuclear tests, *Seism. Res. Lett*., 69, 386-393, 1998. [Refers to seismic effects of the Indo-Pak nuclear tests]
Wilford, J. N., (1999), Heavens Send the Earth Big Surge of Radiation in Themes of the Time, p. 10, *The New York Times.* [Refers to stellar outbursts]

Wolman, M. G. (1990). The Impact of Man, *EOS*, Vol 71, No. 52, pp. 1884-86. [On anthropogenic activity-related impacts]

Biographical Sketches

Miah M. Adel was born on February 16, 1952, in a village called Bhitorbhag, currently, in the district of Natore, Bangladesh. He received B. Sc. (Hons.) degree in physics from Rajshahi University, Bangladesh, in 1972. He received M. Sc. Degree in physics with specialization in nuclear and particle physics in 1974 from the same university. He earned first classes in both B. Sc. (Hons.) and M. Sc. degrees. In March 1975, he joined the Department of Physics, Rajshahi University as a lecturer. He held this position until he earned the position of assistant professorship in 1978. The same year he left for the American University of Beirut (AUB). Before completion of M. S. degree in physics from AUB, he was offered a teaching assistantship by the Department of Physics and Astronomy, Louisiana State University (LSU), Baton Rouge, Louisiana, USA. He received Ph. D. in space physics in 1988 from LSU. Before his graduation from LSU, he was offered an assistant professorship position in physics by the University of Arkansas at Pine Bluff (UAPB). He received a major grant for space research based on the Japanese EXOS-C satellite observation in 1989. Currently, he is a professor of physics. He takes keen interest in interdisciplinary research projects apart from his specialized field of space physics. He has developed an expertise on the consequences of water diversion. He is married to Mrs. Marufa Adel. They have two sons and one daughter– Mahmood R. Hossain, Muhammad T. Hossain, and Saiyeeda F. Hossain.

Syed A. Hasnath received BA, MA, from Rajshaki University (Bangladesh); MPP, from Bangladesh University of Engineering and Technology, Dhaka; MSC, from the University of Wales (England); and PhD from Boston University. He is now with the Department of Geography, College of Arts and Sciences.