module numbers, mass balance, power requirement. The wastewater treatment operation and mass balance calculations are dealt with in chapter 15. Chapter 16 discusses sludge treatment operation and composting. The calculations based on analytical, microbiological and hazardous waste are covered in chapters 17–19 respectively. Chapter 20 deals with the calculation of wastewater generated from various industries and processes, while chapter 21 with pollutant mixing with water and land. The reuse of water and cost reduction benefit are explained in chapter 22, while the domestic waste and radioactivity-related calculations are covered in chapters 23 and 24 respectively.

The book consists of 560 solved problems along with detailed solutions that facilitate easy understanding on quantification of pollution control operations. The quantitative calculations, discussed in each chapter envisage the recent developments in pollution control operations. They may help environmental researchers evaluate the pollution levels instantaneously. This book will definitely serve as a valuable reference material for environmental regulators, environmental engineers and engineering students. Realizing the significance of environmental education, GoI has mandated environmental education. This book could act as a ready reckoner for environmental engineering students. It is only one of its kind as a guide to comprehend the various pollution control calculations in the Indian context, but could be used elsewhere as well. The book is highly recommended for both undergraduate and postgraduate students, research scholars, prospectors and the concerned regulatory authorities in the Government.

RANGHABHASHIYAM SELVASEMBIAN*
BALASUBRAMANIAN PARAMASIVAN**

*Agricultural and Environmental Biotechnology Group,*
*Department of Biotechnology and Medical Engineering,*
*National Institute of Technology,*
*Rourkela 769 008, India*
*e-mail: *rambhashiyam@gmail.com;*
***biobala@nitrkl.ac.in*


**Encyclopedia of the Anthropocene.** Dominic A. DellaSala and Michael I. Goldstein (eds). Elsevier, Waltham MA, Oxford (England), 2018, vols 1–5. 2280 pages. Price: US$ 4200.

During World War II and in the succeeding decades, there has been unprecedented industrial development, rapid rise in population and related land-use changes, intensification of agricultural activity, indiscrimate disposal of industrial and agricultural waste products, etc. All of these have led to a situation where we realize that the natural ecosystems are changing so fast that the world is no more similar to what we had inherited. The five-volume *Encyclopedia of the Anthropocene* presents state-of-the-art knowledge on various facets of this rapid change that has taken place during the past 70–75 years under various themes – geological history and energy, climate change, biodiversity, ethics and contaminants. This series indeed presents encyclopaedic knowledge on these aspects.

In the first volume on geologic history and energy, Anthropocene is accorded the status of a geological epoch that records a major departure from normalcy. The book identifies the early 1950s as the beginning of the Anthropocene, when industrial and technological advancements grew at a pace similar to human population. The book highlights the advancement of tools, Industrial Revolution (1750–1900), introduction of the atom bomb (1945), as well as introduction of plastics and widespread mechanized agriculture in the developing world (1950) as the events building up to the Anthropocene.

The second volume recognizes climate change as a planetary-scale alteration affecting human and ecological systems. During the Anthropocene, the focus is on anthropogenic climate change, the velocity of which was much faster than what many species can adapt to. Land-use changes along with climate change have affected the size and distribution in the populations of various species. With time still available to reverse climate change, the book recommends that mitigation and adaptation efforts should go hand-in-hand for an effective climate change strategy. The mitigating steps should include reducing greenhouse gas emissions by switching to renewable energy and storing the atmospheric carbon in ecosystems. Adaptation planning should include conservation of species and human community.

The third volume on biodiversity considers Anthropocene as the beginning of the sixth mass destruction/extinction, with cascading impacts on the functioning of the entire ecosystem. This volume covers the drivers of biodiversity loss that include change, loss and fragmentation of habitat, human population and conflict, and climate change. Activities like agricultural expansion, further accelerated by increasing human population, have driven the levels of consumption of natural resources. Also, anthropogenic climate change impacts all levels of biodiversity, including organisms, populations, ecological networks, ecosystems and biomes. Throughout this volume, climate change is considered to be the big unknown factor affecting the future of biodiversity as it impacts the timing of reproduction of species, development of novel ecological communities, migration of species and other important aspects of biodiversity.

The fourth volume on ethics recognizes that during the Anthropocene, though the quality of life had improved owing to human intelligence and creativity, these human gains have come at the cost of many destabilizing consequences on other forms of geophysical, geochemical and biological ecosystems. The volume comes up with the ethical challenge of the Anthropocene, which is to discover 'how to use human creativity for betterment in ways that are sustainable, respectful of human dignity and equality and compatible with the value and resilience of all life'. Several articles in this volume analyse the ethical and value dimensions of the relationship between humans and nature on a planetary scale.

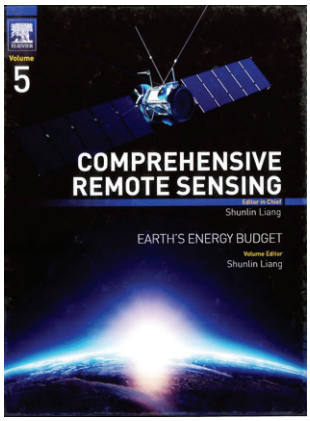
The fifth volume on contaminants calls the Anthropocene as the 'chemical era' that has seen massive industrialization and development of natural chemicals, proliferation of synthetic chemicals and increased dependence on petroleum

hydrocarbons. The debate as to which synthetic contaminant – pest-control chemicals or plastics – best characterizes the anthropogenic era still continues. The volume has rightly stated that while anthropogenic contaminants are increasing at an alarming rate, the old ones are slow to be retired. Also, while long-lived chemicals in the environment are problematic down the road, even short-lived chemicals have harmful effects (e.g. proliferation of pharmaceuticals and personal-care products in waterways). The volume argues that despite successes like the Montreal Protocol, most regulatory systems have been unsuccessful and remain bound to industrial interests.

These volumes succinctly summarize our knowledge on how human intervention with natural systems is affecting the basic framework of our environment and what our responsibilities are to protect the Earth. The volumes must be on the shelves of all libraries.

S. PRIYA

*(S. Ramaseshan Fellow)*
*e-mail: priya@ias.ac.in*




**Comprehensive Remote Sensing: Vol. 5 – Earth's Energy Budget.** Shunlin Liang (ed.), Elsevier, Radarweg 29, PO Box 211, 1000 AE Amsterdam, The Netherlands. 2018. xxii + 331 pages. Price not mentioned.

The regional climate of planet Earth is controlled by the amount of energy received from the Sun and the way it is dispersed or redistributed. The Sun, like other stars, is a variable star emitting varying energy due to sunspot and magnetic activity cycles. The amount of solar energy incident at a location on Earth is constantly modulated on a variety of timescales ranging from millennia to seasons due to periodic changes in the Earth's orbital precession, eccentricity, obliquity, etc., and the changing environmental conditions. The Earth receives maximum heat from the Sun over the tropics and distributes it polewards through atmospheric and oceanic circulations.

This book presents a multi-faceted description of satellite-based techniques on the Earth's energy balance and also provides information on various available satellite-based products and data sources. Further, it emphasizes the challenges in addressing the issue of climate change in terms of continuity of long-term accurate and calibrated records of different components of energy balance. Authors are experts in the field of satellite remote sensing and their views represent state-of-the-art in this field. The articles in the book provide recent estimates and an understanding of the Earth's energy balance of top of atmosphere (TOA), and radiative and energy budget at the surface.

Earth's energy budget refers to the balance of energy incident on the Earth system from the Sun at TOA and the energy lost to space. We require knowledge on what is the incoming shortwave radiative flux from the Sun and how much of it are reflected shortwave and emitted long-wave fluxes from the Earth. The amount of absorbed solar radiation by the Earth system plays an important role in balancing the energy during the process. The amount of solar radiation absorbed by the Earth is a function of total solar irradiance integrated over all wavelengths at the mean Earth–Sun distance and the planetary albedo of the Earth.

With the increase in population and industrialization, concentration of greenhouse gases (GHGs) in the atmosphere is increasing over the decades resulting in significant global warming. Global warming in the lower atmosphere and on the surface is because of the reduced outgoing longwave radiation (OLR) and net positive imbalance of energy due to greenhouse effects. This warming continues until the TOA energy is balanced reaching a new equilibrium state. Further, the internal and external causes are associated with many positive and negative feedbacks. The climate system is, therefore, an extremely complex one with nonlinear interactions between its components.

It is challenging to study the Earth's energy balance through accurate measurements of different radiative fluxes. Satellite observations have helped in quantifying the variations in energy balance over a range of space- and timescales. Major concerns are in the uncertainties of estimated quantities. The book accounts for various methods of estimating the TOA energy balance as well as surface radiation budget. It provides an informative review on how meteorological satellite systems have significantly advanced the understanding of the Earth through global measurements from the Earth Radiation Budget (ERB), Earth Radiation Budget Experiment (ERBE), Clouds and Earth's Radiant Energy System (CERES), etc. This includes Geostationary Earth Radiation Budget (GERB) sensors, Broadband Bolometric Oscillation (BOS) sensor and Scanner for Radiation Budget (ScaRaB) sensor operated from various satellite missions.

Inter-sensor calibration and long-term stability in the data are important for their use as essential climate variables (ECVs). The ECVs refers to a well-characterized, long-term data record, usually involving a series of instruments, with potentially changing measurement approaches, but with overlaps and calibrations sufficient to allow the generation of products that are accurate and stable, in both space and time, to support climate applications.

Implementation plan for the global observing system for climate by the Global Climate Observing System (GCOS) has emphasized the need of continuity, homogeneity and overlap of satellite observations with special emphasis on calibration and instrument characterization, and validation of products. ERB is considered as one of the most important ECVs where satellite observations can make significant contributions. Other ECVs include more than 50 geophysical parameters in the domain of atmosphere, ocean and land.

The ERB which describes the over all balance between incoming energy from the Sun and outgoing thermal (longwave) and reflected (shortwave) energy from the Earth is required to relate to the amount of radiative forcing significant with respect to global GHG forcing.