

deformation rates from the plate motions and ground movements due to large earthquakes. Beyond these applications, new unexpected uses have also been developed. For example, terrestrial water storages, soil moisture and snow accumulation can be estimated using GPS signals. Now that more of such satellite constellations by Russia, Europe and China are becoming active, Larson who reviews these developments, mentions that contribution from GPS networks will further enhance the warning capabilities for tsunamis, landslides, storms and volcanic eruptions. Uchida and Burgmann summarize the current understanding of repeating earthquakes in various tectonic settings. The recurring earthquakes share some common characteristics. Authors suggest that repeat earthquakes represent recurring seismic energy release from distinct structures such as slip on a fault patch. Repeaters are most commonly found on creeping plate boundary faults, where seismic patches are loaded by the surrounding slow slip.

Several articles in this volume address the themes that have gained importance in the backdrop of spiking greenhouse gases and global warming. In these changing environmental scenarios, the soil resources are under unprecedented threat due to landuse conversion and these changes end up in desertification, decline in organic carbon and physical loss of soil due to erosion. Banwart *et al.* assess soil properties and how they function within the critical zone – the rock and biotic realms. But one salutary take-home message is that the global degradation is reversible, if timely positive steps are taken. Like soil, water resources are also under unprecedented stress. Bowen *et al.* summarize the advances made in isotope data collection the last 20 years in the understanding of the water cycle at spatial scales from cities to the globe. The isotopic composition and its variation can be used to trace the water source and the water cycle process, and isotope hydrology provides investigative tools for many environmental problems. The review evaluates contributions using large-scale isotope data to understand water cycling within the atmosphere, between the land surface and atmosphere, within land-surface hydrological systems, and in human-managed water distribution systems. Systematic isotope sampling is being conducted at regional and city scales. Recent work on water

distributions in Rajasthan and the findings that issued cautionary warnings on high levels of both anthropogenic and natural pollution is an example of such studies that come to our minds. Neuzil addresses the questions regarding how shale, clay and other argillaceous lithologies control fluid flow, mass and heat transfer in the upper crustal parts under various geologic settings. Studies show that petro-physical properties and geological environments provide major controls on the clay and shale permeability.

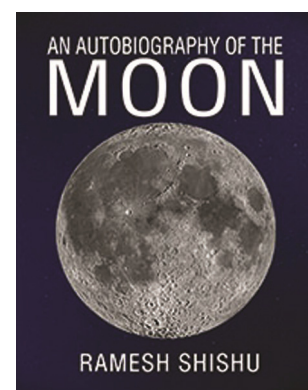
The current satellite technology can provide estimations on global carbon dioxide concentrations. Jiang and Yung explain why both modulations in global circulation patterns and small-scale surface emissions like wild fires, volcanic eruptions and droughts can cause atmospheric CO₂ concentration to increase rapidly. Rapid melting of large sheets of glaciers in high latitudes is now attributed to rising CO₂ levels that cause the Earth to warm. Melting of ice sheets is causing the sea levels to rise globally. Pitcher and Smith synthesize the studies on the growing frequency of supraglacial streams and rivers on glaciers, ice sheets and ice shelves. Supraglacial rivers link surface climatology with ice dynamics and are an important component of how glaciers and ice sheets respond to climate variability. The advances in remote sensing enhance the ability to monitor dynamics and hydrological processes of super-glacial rivers in a much better way. The rising sea level will impact many of the coastal ecosystems like salt marshes. FitzGerald and Hughes assess the vulnerability of coastal salt marshes in the backdrop of accelerated sea level that may outpace their ability to sustain the marsh processes, most importantly, the ecosystem services like sequestration of terrestrial carbon. Future rate of sea-level rise is a major determinant in deciding the fortunes of salt marshes. Brando *et al.* evaluate the toll these stresses emanating global change take on tree mortality and how that will accelerate soil respiration and fire occurrence. Globally forests store 90% of the total carbon in natural terrestrial ecosystems contributing to stabilizing the global climate. Forests are also estimated to remove ~27% of the total anthropogenic carbon emitted into the atmosphere. But the intensity and frequency of droughts and fires are taking a huge toll on forests. The recent massive fire within the Ama-

zon forests is an example. If such challenges continue to increase in their magnitude, the ecosystem properties will respond in such a way that alternative states are more likely, impacting forest carbon stocks in our rapidly warming world.

The latest volume of *Annual Review of Earth and Planetary Sciences* can claim a balanced theme representation of both Earth-based and planetary studies. Most importantly, and justifiably so, some of the articles in this volume offer a fresh perspective on the fraught global ecosystems. The readers will realize that what used to be mere assumptions or projections on climate change some decades ago are now transforming into realistic models driven by actual data and validated by observations. Sceptics and deniers will have a hard time challenging climate warriors like Greta Thunberg who are now armed with such data.

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An Autobiography of the Moon. Ramesh Shishu. Vigyan Prasar, Department of Science and Technology, A-50, Institutional Area, Sector-62, Noida 201 309. 2018. 118 pages. Price: Rs 250.

This book consists of 16 small chapters, each answering one particular aspect of the moon. It is written in the format of an autobiography. It is very readable in view of its language as well as the font

BOOK REVIEWS

size used in printing. Moon, the only satellite of the earth, has been an object of immense interest to astronomers, planetary scientists, the general public, poets, romantics and children. Its changing phases have been a source of curiosity and many folklore stories are abundant in literature. The book starts obviously with the curiosity associated with the birth of the moon, and goes on to state a simple but strange fact that it has not been given any specific name, unlike the satellites of other planets. Many characteristics of the orbit of the moon, its tilt, wobble and rotation about its own axis are described in the next section. Why only one side of the moon is seen from the earth currently, which was not so in the earlier times, is well explained. Its topology, surface composition and interior structure and possible reasons for differences in the composition of the two sides are well

elucidated. In the next section, the author provides a vivid account of the mapping of the moon as early as 450 BC to today's atlases brought out by the moon-orbiting satellites. Why there is no significant atmosphere on the moon and also reasons for its low gravity are the subject of the next sections. Phases of the moon, its eclipses, occultations and how tides on the earth are influenced by the moon are described in a simple manner. The author also dwells on the discovery of hydroxyl molecules and ice in the interiors of craters in the polar regions of the moon using the sensors on-board the Indian mission to the moon, viz. Chandrayaan 1 and other US missions. How existence of helium-3, if exploited, can help in generating vast amounts of fusion energy is another interesting topic. 'What if I was not there' is an interesting topic covered by the author. A list of various missions

to the moon made by different space agencies is also available. The book ends with an invitation to come to the moon to live and also provides a scenario of the end of its existence.

Overall, the book is an excellent read for children, young students, the general public and scientists. The author and the publisher both deserve our appreciation. It is a must in all school libraries and may also be translated into Hindi and other Indian languages.

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