

## Book Reviews

**POLAR REMOTE SENSING, VOLUME 1: ATMOSPHERES AND OCEANS.** Dan Lubin and Robert Massom. 2006. Berlin, Heidelberg, New York: Springer / Praxis. xlii + 756 p, illustrated, hard cover. ISBN 3-540-43097-0. £138.50; US\$179.00; EUR 179.95. doi:10.1017/S0032247407216341

The climatological significance of the polar regions is well known, as is the value — sometimes necessity — of using airborne and spaceborne remote sensing techniques to study them. Remote sensing, with its historical origins in the airborne photographic reconnaissance of the wars of the last century and its present shaped very much by the national and international space agencies, can collect a wide variety of calibrated, systematic data from huge areas of the Earth's surface, and huge volumes of its atmosphere, in a short period of time. The task of interpreting the data, converting the numbers collected by the airborne or spaceborne sensors into 'geophysical' variables, such as a three-dimensional map of the ozone concentration in the stratosphere or a two-dimensional map of the plankton in the ocean, is the task of the remote sensing specialist. This book is written for polar remote sensing specialists, or those who want to know what we do, or can do, or have discovered.

At 756 pages, it is a big book. Its scope, however, is not quite as wide as suggested by the title. The term 'remote sensing' is very largely interpreted to refer to observations from satellites, with only fleeting mentions of a few airborne systems, and indeed there is a strong bias towards the coarser-resolution satellite systems such as AVHRR, MODIS, and passive microwave instruments, rather than the higher-resolution instruments such as those carried on the Landsat satellites. This gives some indication of the underlying approach of the book, which tends to be towards the synoptic. The scope is also somewhat limited in respect of the aspects of the polar regions that are investigated. This is most noticeable in the treatment of 'oceans,' which is in fact almost entirely devoted to sea ice. The reader who wants to know something about oceanic geoid mapping or wave spectra, for example, will need to look elsewhere. According to the publisher's web site, volume 2 will deal with remote sensing of the polar ice sheets. There is no indication that a third volume is planned, so presumably the other significant parts of the polar regions — including tundra, snow cover, maybe even boreal forest depending on the definition of the Arctic — will not be covered. All of these are, of course, eminently justifiable restrictions on the scope of the

book, but the principles on which the selection of topics and approach have been made could usefully have been discussed.

What of the many things that *are* included? Chapter 1 provides an 'introduction to satellite remote sensing of the polar regions.' This does not really have the space to explain some difficult or confusing concepts, and it is quite odd, for example, to find that the very first table to be presented in the book, which shows the wavelengths of electromagnetic radiation used in satellite remote sensing, excludes the ultraviolet wavelengths that are so critical in chapter 3. The chapter then surveys the current population of satellite instruments and programmes. This is fairly useful, although the attribution of satellites to different space agencies is not always clear: the NASA section includes several non-NASA satellites, and the Canadian Space Agency does not receive an explicit mention, its very successful Radarsat satellite being rather oddly included in a section about the European Space Agency. Something I did miss here was a discussion of the fact that the era of continuous Landsat coverage is coming to an end. This is the source of primary data for many remote sensing specialists within and beyond the polar regions, and we are concerned to know that there will be no data from when the fuel runs out in Landsat 5 and Landsat 7 (in 2010 at the latest) to when Landsat 8 becomes operational (2012 at the earliest). The chapter concludes by recommending two particular commercial software packages for the analysis of satellite imagery, which the authors describe as 'industry standards.' There are other commercial packages, and there is even some free software in the public domain. A review of strengths and weaknesses would have been useful.

Chapter 2, 'Satellite imaging and radiometry,' is also introductory. It is a useful compendium of the nuts and bolts, the principles and technology, of passive (visible, infrared, and microwave) remote sensing. Consideration of active sensors is deferred to chapter 5 for some reason. Most of the chapter has been adapted from other books, as the authors acknowledge. It includes satellite orbital dynamics, 'radiometric quantities' — a term that here embraces scattering and absorption, black-body radiation, and the radiative transfer equation itself, as well as definitions of radiometric quantities like albedo, intensity, and flux (the astrophysicists' terms that the authors use in preference to the more usual remote sensing terminology of radiance and irradiance) — scanning and detector technology, and passive microwave radiometry. The level of technical detail is rather high in places, and the ordering of

the material is not entirely logical but it is easy enough to find. Two typos evaded editorial vigilance in this chapter, to the amusement of this reader: *radiant excitance*, which sounds a lot more fun than *radiant exitance*, and *Bouger's law* (rather than *Bouguer*), which made me think of an informal French version of Newton's laws of motion.

The remainder of the book is devoted to three chapters on the application of satellite remote sensing methods to specific polar phenomena. Chapter 3, the first of two chapters justifying the inclusion of the word 'atmosphere' in the book's title, deals with the polar stratosphere. I confess that I am not a specialist in atmospheric chemistry, but the chapter certainly seems to be a straightforward, largely self-contained contribution. Mostly it deals with the Antarctic 'ozone hole,' and the satellite-based TOMS (Total Ozone Mapping Spectrometer) instrument that provided data from 1978 to 1993. (Follow-on instruments have extended the coverage to the present day.) The material on TOMS is presented in great, and valuable, detail. Later parts of the chapter deal with stratospheric and mesospheric clouds and the Arctic ozone hole, concluded by a short section on remote sensing of some of the ecological effects of Antarctic ozone depletion. Chapter 4, 'Polar climate and meteorology,' begins with a very brief sketch of some issues in polar meteorology and a description of the Antarctic automatic weather station programme, then moves to a short discussion of techniques using visible, near infrared, and thermal infrared imagery to identify polar lows, katabatic winds over ice sheets, and wind vectors by tracking the motion of clouds. This is followed by quite a lot of material on cloud detection and classification, focussed mainly on AVHRR imagery lacking the snow/cloud discrimination band at  $1.6 \mu\text{m}$ , a short section on measurement of sea-ice albedo that ought really to be in chapter 5, and a longer treatment of radiation budget measurements.

This brings us to chapter 5, on sea ice. This huge chapter occupies more than half of the book. It contains a good, non-technical introduction to sea ice formation, processes and significance (with a good joke — 'the life of brine' — in the title!). The discussion of the principles relating to remote sensing of sea ice is less successful, containing rather too many technical errors and confusing statements. For example, the imaginary part of the refractive index is confused with the absorption coefficient; the treatment of the concept of optical depth is hard to follow and is seriously misapplied to snow, where the main mechanism of light attenuation is scattering, and not, as assumed on page 361, absorption; the definitions of complex dielectric constant and complex refractive index are inconsistent; an approximate formula for the absorption length is presented as though it were exact (and attempts to apply it to a lossy material such as wet snow would in fact lead to significant errors); and so on. Some of the formulations — notably of the radiative transfer equation and the Rayleigh-Jeans approximation — are quite different from the way they were presented in chapter 2, with no discussion of the relationship between

the two. (Something similar happens in chapter 3, where, for example, the concept of 'optical path' appears, without being defined anywhere else in the book.) The next major section is a survey of the main types of remote sensing system, and this must surely be misplaced within the book since it is not specific to sea ice and clearly overlaps with material in chapter 1. The subdivision of this section has gone awry too: subsection 5.8.2 is headed 'Active microwave,' but its sub-sub-section 5.8.2.4 is about 'visible to thermal-infrared sensors.' The meat of this chapter is the massive (196 pages) section 5.9, 'Key geophysical parameters from satellite data.' This is a wide-ranging review of the applications of satellite remote sensing to sea ice, including discussion of the results and their significance. The list includes, but is not confined to, ice concentration, ice extent, fast ice, polynyas, ice dynamics and kinematics, ice thickness, classification of ice types, snow cover and its physical properties, surface roughness, floe size distribution, ice and ocean surface temperatures, albedo, melt and refreezing processes, ice-edge processes, and operational ice forecasting. It is very extensively referenced, and it more than makes up for the earlier deficiencies of the chapter.

In summary, then, I think that what this book does really well is to present extensive and up-to-date surveys of applications of satellite remote sensing methods applied to the polar atmosphere and to sea ice. The value of this aspect of the work is enhanced by the copious bibliographies — 138 pages or so, of which more than 100 are in the sea-ice chapter. Other aspects of the book are less successful. There is a lack of consistency to the treatment of underlying principles, which means that it is sometimes quite hard to relate the material from the earlier chapters to the later ones, and the structure of the book as a whole is not entirely logical. Fortunately the index is reasonably comprehensive so that it usually is not too difficult to find the material one needs even if it is spread across several chapters or located in unexpected places (for example, the treatment of ocean colour measurements in the chapter on the polar stratosphere).

There is a curious digression in chapter 1. This is section 1.1, which has the intriguingly paradoxical title 'NASA in the 19th century: the great US exploring expedition discovers Antarctica.' Of course, NASA did not exist in the nineteenth century: it was founded in 1958, while the closest equivalent in the United States of a little over a century earlier, the period with which this section deals, would have been the United States Navy. It is hard to know quite what to make of this section. It is a partial history (where is Bransfield?) of the events leading to the discovery of the Antarctic continent in the years around 1840, by Wilkes and others. Wilkes famously erred in his reckoning of the positions of land, by tens to more than 100 nautical miles. As this section points out, the error was almost certainly due to a mirage phenomenon called 'looming.' But it is probably going too far in Wilkes' defence to imply, as the book does, that he could scarcely be expected to have thought of this potential source

of error. The looming phenomenon was known to the ancients, and had certainly not been forgotten: Jefferson discussed it in his 'Notes on the State of Virginia' (1781–82), Scoresby had carefully documented similar unusual refraction phenomena off Greenland in the 1820s, and theoretical explanations already existed. So what is the purpose of this parable? Is it to remind us that we can all make mistakes? Or that it is difficult to get large projects funded? Or is its purpose to establish the entry of the United States into the field of polar exploration? The story is revisited briefly in chapter 3, where a couple of pages draw parallels between the fact that credit for discovery of the Antarctic ozone hole went to the British Antarctic Survey with their ground-based data rather than to NASA with their TOMS data, and the fact that Captain Wilkes received less credit than he deserved for mid-nineteenth century Antarctic discoveries. I must admit that I could not really see the point that the authors were trying to make here, or why NASA would need to be defended against a charge of sitting on their data rather than publishing it, when the data were derived from a new and only partially validated technique. But setting aside the question of relevance, it is an interesting digression. (W.G. Rees, Scott Polar Research Institute, University of Cambridge, Lensfield Road, Cambridge CB2 1ER.)

**NORTH-EAST PASSAGE TO MUSCOVY: STEPHEN BOROUGH AND THE FIRST TUDOR EXPLORATIONS.** Kit Mayers. 2005. Stroud: Sutton Publishing. xiv + 241 p, illustrated, hard cover. ISBN 0-7509-4069-7. £20.00.  
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A copy of Hakluyt's *Principall navigations voiajes and discoueries of the English nation* is found among the books of a deceased father, and the first accounts to be read by the legal heir are those of Stephen Borough of Devon about his voyages in Russian waters in the mid-sixteenth century. The would-be historian is so captivated by the story that he wants to find out more about the man, his exploits, and their effect on English maritime traditions. Can a good book result from such a beginning? Yes, it can, when the author is Kit Mayers and the pathway to this book has proceeded via the Maritime History Department of the University of Exeter. The present book is an enlarged and rewritten version of a dissertation that Mayers submitted some years ago. I have not read the dissertation, but I surmise that the text of the current book has been adapted so as to make it accessible to the general reader.

Stephen Borough, who is presented as a 'Tudor hero from Devon,' came from a family of sailors; his uncle, brother, and son were all well-known captains and explorers, and these are important facts among the scant biographical data that exist about Borough. His uncle, John Aborough, and his principals in London were probably the factors that pushed Borough into his career. In his footsteps followed his younger brother, William

Borough, who became Comptroller of the Navy, and his son, Christopher Borough, who was later in the service of the Muscovy Company, travelling in that capacity and exploring parts of Asia.

Mayers historicises his hero in a very instructive and educational way. He explains how vessels were built in the period under consideration (the fifteenth and sixteenth centuries), which saw the development from the single-masted to the three-masted rig. True enough, we do not really know what Borough's vessels were like, but Mayers extrapolates from other ships about which we know more, drawing conclusions about what Borough's *Edward Bonaventure* and *Serchethrift* most probably looked like. Since their tonnage is known, it is also possible to reconstruct their size with a high degree of certainty.

Stephen Borough's accounts also substantiate the level of navigational skills at that time. Mayers shares his knowledge of how a shipmaster in the sixteenth century made soundings, how he measured latitude, and to what extent he would have been able to estimate longitude. This is very informative for a reader who is not an expert on the practical side of seamanship. Mayers also demonstrates convincingly that Stephen Borough was one the earliest practitioners of the new scientific methods that had been put to use. This is all very well done.

The author leaves little room for doubt that Stephen Borough was a very competent master, which also explains why he avoided the fate that befell many other sailors in the service of the Muscovy Company, and why he returned safely from all his expeditions. Mayers underlines the uniqueness of Borough's voyages, which is thought-provoking. However, they were hardly, as Mayers will have it, the first of the great Tudor explorations, since there were several earlier ventures, like John Cabot's Northwest Passage expeditions of 1497 and 1498, and Sebastian Cabot's Northwest Passage expedition of 1508–09, all of which were just as 'great' and all of which were commissioned by King Henry VII — the first of the Tudor monarchs. But Borough's expeditions were, indeed, among the first English sea-borne expeditions, and they set off in a previously completely unknown direction. They did not discover what they were supposed to find, namely the Northeast Passage, even though they did venture as far as Novaya Zemlya, which Borough in 1556 may have been the first westerner to catch sight of (or was that Sir Hugh Willoughby and his ill-fated crew in 1553?). Instead they 'discovered' Russia, which nobody had expected to find in this direction. This led to the establishment of the Muscovy Company, which organised the first English trading stations outside Western Europe. This company set the pattern for all other overseas companies, including the East India Company.

One of the criteria for evaluating the scholarly quality of a work like this is whether the author is familiar with all the relevant literature, and whether he clearly positions himself in relation to earlier research. All this is necessary if the reader is to be able to decide whether the author himself has contributed something new, or to what extent