Antarctic Science 10 (2): 215–219 (1998)

Book Reviews

Physics of the Upper Polar Atmosphere

Asgeir Brekke

Wiley-Praxis Series in Atmospheric Physics, Chichester, UK (1997).

491 pages. £29.95. ISBN 0 471 96018 7.

The polar upper atmosphere of the Earth is a highly complex environment which is influenced by a large number of mutually-interacting factors. In its various regions it is influenced by the topography and geography of the surface layers, by accumulating anthropogenic pollutants, by variable solar heating which generates winds and tides, by the absorption of energetic solar photons which strongly effects its temperature, composition, and electrical properties, and by the coupling via the Earth's magnetic field to the magnetosphere, solar wind, and Sun beyond. An overall appreciation and synthesis of these subjects requires a broad understanding over a range of disciplines, including atomic physics and photochemistry, fluid dynamics in rotating systems, the physics of collisional plasmas and cosmic electrodynamics, and the interplays which may take place between all of these aspects in the real system. Given the degree of individual specialization which this level of complexity typically engenders, ProfessorBrekke's attempt to survey the whole of this area at an up-to-date and advanced level is particularly welcome, and provides an important resource of information and understanding both for professional researchers and for advanced postgraduate students.

As indicated above, the canvas of this book is very broad, extending from the interior of the Sun to the surface of the Earth, via the solar corona, solar wind, magnetosphere, ionosphere, and upper, middle and lower atmosphere. Since its central topics are the ionospheric and atmospheric ones, but whose properties are fundamentally determined by solar and magnetospheric inputs, knowing where to start and where to finish is not wholly obvious, and there are probably no ideal solutions. Professor Brekke chooses to begin in Chapters 1 and 2 with a discussion of the Sun as a solar cycle-dependent source of photons over a broad spectral range, and also as a source of thermal plasma and embedded magnetic field via the corona and solar wind. This last topic already involves the introduction of at least basic concepts of magnetohydrodynamics (MHD) and "frozen-in" flow. Rather than following through into the magnetosphere and thence into the ionosphere and atmosphere, however, the book then moves in Chapter 3 directly to the atmosphere, beginning with a description of its overall structure, followed by a thorough discussion of atmospheric ozone and the effects of natural and man-made pollutants. This is followed by a chapter on the Earth's magnetic field and its secular variations, including a discussion of collision-free adiabatic particle motion in large-scale electromagnetic fields, Størmer's theory for a dipole field, and an application to energetic charged particles in the radiation belts. In Chapter 5 we move back down to the ionosphere, concentrating on its structure and photochemical origins, though we then again move out to larger distances with the origins of the plasmasphere and plasmapause via the interplay between magnetospheric plasma corotation and solar wind-driven convection whose physical origins have yet to be discussed. Chapter 6 returns to the neutral atmosphere with a discussion of fluid dynamics in a rotating system, and atmospheric winds, tides, and waves. The first of these subjects includes a discussion of the effects of ion drag due to magnetospheric electric fields, which still have not been systematically introduced. Chapter 7 goes back to the subject of the ionosphere and its electrical conductivity, and the current systems which result as a consequence of both neutral atmospheric winds and (again!) magnetospheric effects. It is only at the end of the book, in Chapters 8 & 9, that the author attempts a systematic discussion of magnetospheric dynamics and the solar wind interaction, high-latitude convection, and the effects on the atmosphere and ionosphere of magnetospheric particle precipitation, ending with a few pages on substorm phenomenology.

This reviewer apologises for the boring chapter-by-chapter approach taken, but I wanted through this to illustrate directly why, taken at a run over the Christmas "holiday", I found this book to have some problematic elements as an intellectual experience, and hence as a pedagogical tool. Overall, because of its structure, the treatment tends to be episodic, with related aspects of physical theory in separated tranches that will be hard for the beginner to connect together. I feel that it was a particular mistake not to have made an early foray into magnetospheric dynamics in order to inform the sections on high-latitude flow and current systems. I do, however, rather sympathize with the author that whatever presentational order one chooses for this multi-faceted subject some picky reviewer with attitude but no direct experience is likely to take exception to it.

Before entering into the valediction, however, I must comment briefly on another aspect on which I am rather less sympathetic. This is the eventual treatment given in the book to reconnection and open magnetosphere dynamics, which appears to be afflicted by traditional Scandinavian coyness and uncertainty. Dungey's name is nowhere mentioned, and, despite the (rather back-to-front) discussion of flow in an open magnetosphere, the author still finds it impossible to refer to magnetopause coupling via reconnection except as one possibility amongst "several suggestions" (p. 422). Mercifully, however, he does not comment at length on any of the others. Do we still see the effects here of Alfvén's towering shadow, or is it just my acknowledged paranoia in these matters? Would it not be therapeutic for all concerned if we could gather together all Scandinavian solar-terrestrial physicists in one place, and insist that they chant five hundred times in unison "Reconnection and the Dungey flow cycle"? They would find that the words do not kill. Perhaps we could interest Gillian Wearing in the project. I might also comment that I read the author's discussion on MHD and frozen-in flow particularly carefully, since this is another traditional area of Scandinavian angst. Here however, the author acquits himself honourably (*"the concept of the "frozen-in" magnetic field is a very useful one"*, p. 47), though I did notice some fairly awful bloopers in the development of this discussion (on pages 45, 46 & 407), the details of which I leave as an exercise for the author.

Finally, I should end by emphasising that it would be an abuse of my privileges as a reviewer to leave an overly negative impression of this book. Despite the perceived problem areas mentioned above, in the main the book is thorough, scholarly, clearly written, comprehensive, and contains a good mix of phenomenology, basic theory, and modelling results. It does suffer, however, from organizational problems which in my view limit its use as a teaching aid. Nevertheless it represents a welcome addition to my bookshelf, and I think it will be of lasting value to a broad range of professional research workers and advanced graduate students in solar-terrestrial and upper-atmosphere physics.

STANLEY W.H. COWLEY

Geology and Seismic Stratigraphy of the Antarctic Margin, 2

Edited by *Peter F. Barker & Alan K. Cooper*
Antarctic Research Series, Volume 71
American Geophysical Union, Washington, USA (1997).
187 pages. $60 (AGU members $42). ISBN 0 87590 884 5.

This book, published in the Antarctic Research Series, represents the second volume devoted to the efforts of ANTOSTRAT (the Antarctic Offshore Acoustic Stratigraphy Project). This is an international group of researchers dedicated to developing an understanding of the Cenozoic evolution of the Antarctic continental margin, with particular emphasis on its history of glaciation. As the Antarctic has probably experienced extensive glaciation since early Oligocene time (about 35 million years ago), its record of ice-sheet history has major implications for mid- to late Cenozoic, global climate studies. In keeping with the excellent publication record of the ANTOSTRAT group, this book presents a wealth of data on a variety of aspects of Antarctic continental-margin geology, stratigraphy and glaciation. Although it is a relatively slim volume (10 papers, 187 pages), its quality is high and covers a wide geographic range, from the West Antarctic margin and Antarctic Peninsula, to Prydz Bay and the Ross Sea region, with a geomorphic range from onshore to the deep-sea.

As the title of the book implies, most of the papers consider aspects of the development of the Antarctic continental margin. One of the keys to understanding the origin of depositional sequences on continental margins, in general, is the reliable determination of their frequencies in order to establish the major controls influencing sedimentation. Continental-margin sedimentary sections commonly respond to input signals with a broad range of frequencies. Unravelling the Cenozoic development of the Antarctic margin is no exception, and the effects of tectonics, climate, relative changes in sea level and bottom-current activity as controls on sedimentation and sequence resolution are clearly demonstrated in several of the papers.

Larter *et al.* and Rebesco *et al.* present excellent overview summaries of the tectonic, sedimentary and glacial history of, respectively, the continental shelf and the continental rise of the Pacific margin of the Antarctic Peninsula. The tectonic setting of the south-east Pacific Ocean has clearly influenced the Paleocene to middle Miocene record of sedimentation adjacent to the western margin of the Peninsula, the nature of which changed during this interval from an actively-subducting to a largely passive, subsiding margin. However, as both papers demonstrate, the present expression of the continental margin has mainly developed since latest Miocene time when, following a significant phase of uplift, extensive seaward progradation of the outer shelf and slope occurred in response to the onset of extensive shelf-wide glaciation. Such a prograding geometry is characteristic of many late Cenozoic, high-latitude, glaciated margins both in the southern and northern hemispheres, where the high input of sediment to the shelf-margin environment occurred at times of maximum shelf glaciation with grounded ice-sheets located at the shelf break. The effects of increased sedimentation are also preserved in the deep-sea record where deep-water bottom currents have sculpted large sediment drifts (superbly illustrated by Rebesco *et al.*).

Farther to the south-west, Nitsche *et al.* consider the seismic expression of glacially-deposited sequences in the Bellingshausen and Amundsen seas, on the West Antarctic margin. They clearly demonstrate a history of depositional-sequence development similar to the Peninsula region, a comparison which begins to emphasize to the reader the significant, regional control that ice sheets have exerted on the growth of the continental margin. North-east of the Antarctic Peninsula, the small, oceanic Powell Basin represents a more complex tectonic setting where King *et al.* have had to unravel the regional tectonic evolution in order to understand the genesis of the basin infill. They use seismic facies to suggest that a glacial signal may be preserved in the upper part of the sedimentary section. Although reworked by bottom currents, these deposits do not appear to form major positive features and, thus, provide a contrast in geometry with the similarly-reworked deposits west of the Peninsula. Such variability is fast becoming, globally, a characteristic of deep-water, bottom-current-influenced deposits.

The above studies of the long-term record of glaciation are complemented by the following two papers which present a higher-resolution signal of the last deglaciation of the Antarctic ice sheet. These types of studies are crucial if we are to understand natural rates of environmental change, and their implications for future change. O'Brien & Leitchenkov report that the deglaciation of Prydz Bay is relatively recent with grounded ice having existed in the middle of the bay until about 10.6 ka when open marine conditions were established. In contrast, Brambati *et al.* describe the palaeoenvironmental setting of Drygalski Basin, Ross Sea, where the ice was floating by at least 18.1 ka, and a glacimarine environment prevailed until 10.9 ka when the present-day open-marine sedimentary regime was established. This variation emphasizes the diachroneity inherent in the glacial sedimentary record, and highlights the need to understand local variations in glaciological and climatological conditions if one is to build an accurate picture of the regional decay of the Antarctic ice sheet.

Two onshore papers are included which have significant implications for the offshore record. In the Antarctic Peninsula region, the source of most of the Peninsula-margin sequences was the Peninsula itself, and Elliot discusses the possible origin and timing of uplift of Graham Land on the northern part of the peninsula. He suggests that uplift of Graham Land probably occurred in the Neogene, and that its planar crest was at least modified by glaciation. A further implication is that uplift may have had a crucial impact on the regional-scale climate, and thus a significant role in the expansion of ice onto the continental shelves. This is an interesting idea, particularly in the light of recent suggestions linking tectonic uplift of key middle latitude zones with the onset of global, late Cenozoic glaciation. On a different theme, Delisle presents radio echo sounding delineation of subglacial topography in Victoria Land, Ross Sea. He concludes that the valley system is largely of preglacial origin, and little modified by glacial erosion due to cold-based ice-sheet conditions. Consequently, and in contrast to other parts of the Antarctic margin, Delisle suggests that due to the lack of erosion, the sedimentation rate in the adjacent Ross Sea (particularly the Victoria Land Basin) was reduced during extensive glaciation.

The book ends with two, more general papers. Quilty presents a review paper of Antarctic Neogene biostratigraphy and highlights many of the constraints, most of which can be attributed to the physical environment of Antarctica. Despite the problems, this is a timely review for all those concerned with the Neogene evolution of the Antarctic continental margin, and must serve as an indicator of future priorities. Without stratigraphy there is no framework on which to build the glacial history of Antarctica. Finally, the paper of Powell and Alley is also generalized but, as with the previous paper, forms a very useful summary, in this case of grounding-line systems. The value of the paper is that it draws upon examples from both the southern and northern hemispheres, and provides a timely reminder that whilst Antarctica is isolated geographically, with many unique characteristics, it also has many features in common with glaciated margins elsewhere. Understanding glaciated continental margins is a global issue.

In conclusion, the editors should be complimented for putting together an excellent collection of papers which can only improve our understanding of Cenozoic glaciation. The illustrations are excellent, especially some of the seismic profiles. The book should be regarded as of significant interest to all marine geologists, palaeoceanographers, glaciologists and climatologists concerned with interpreting the marine sedimentological and stratigraphical records of high-latitude, glaciated, continental margins.

MARTYN S. STOKER

Antarctic Meteorology and Climatology

J.C. King & J. Turner
Cambridge University Press, Cambridge, UK (1997).
409 pp. £55 ($90). ISBN 0 521 46560 5.

It is 13 years, since the last comprehensive work on Antarctic meteorology and climatology was published by W. Schwerdtfeger. This book is a timely update on our present state of knowledge.

The book is divided into seven chapters, starting out with an Introduction, which is short and precise. The authors limit their review to the troposphere (no discussions on the ozone hole) and recent historic climatological measurements (no ice core analyses). This is a good choice, as the literature on ozone and ice core analysis is extensive. Each of these deserve a volume in their own right.

Some minor criticism: I could not find the names of mountains and places e.g. Mount Kirkpatrick, Vinson Massif (p. 2 & 3) on any map. This would have been helpful for readers who are not familiar with the geography of Antarctica. When discussing maximum ice extent, "late summer" should be "late winter" (p. 4).

Chapter 2 on Observations and Instrumentation is long, and in part too detailed. Substantial progress has been made in Antarctica with the help of remotely sensed data, but such progress is not limited to Antarctica; the large areas of the oceans have been even less well represented with conventional data. I would have liked to see the authors concentrate more on what is unique to Antarctica. Useful tables of stations, observation periods and agencies, from where data can be obtained, are presented. One minor point: In Appendix B the station locations are stated to be found in Fig. 1.1; actually, it is Fig. 2.3.

It is not easy to estimate cloud amount and heights in polar regions during the period of darkness. However, ceilometer data, which do not rely on human observations, for Barrow, Alaska, have shown that measurements are generally acceptable (Kahl 1990, Dissing 1997), in place of human observations. The algorithms, which are used to derive cloud coverage from satellite data, are not well enough advanced over snow surfaces to give useful data; this discredits the surface observations.

Physical Climatology in Chapter 3 is well written. The authors explain it in the context of the radiation balance and surface energy budget. In general, I would have liked to see this chapter expanded. It is great to have a table of all the stations in Antarctica as an appendix, and it would have been very useful to have some extensive table (probably again as an appendix), of the climatological data observed. I find this a shortcoming, as now one has to go through the appropriate figures to find basic climatological values. Some are missing altogether.

In Fig. 3.25 the summer fractional cloud cover is presented for South Pole Station; a value of 51% was observed. Summer values by human observers are relatively good due to continuous daylight. The following figure (Fig. 3.26) shows the values derived from satellite data; a value of less than 5% is found. This shows that satellite derived observation can be **totally incorrect** at a specific place and for specific seasons. For this specific location and season, they do not detect even 10 % of the observed cloud amount. Even though the authors discuss difficulties in automatically obtaining derived cloud amount from satellites due to the high surface albedo and surface temperature inversion (clouds can be brighter or darker than the surface, they can be cooler or warmer than the surface), Fig. 3.26 does not belong in the book; it is a typical example of an algorithm giving totally incorrect and meaningless values at high latitudes. The algorithm was originally developed for water surfaces, where it has given very good results.

Subchapter 3.5.2 (Southern Ocean environment) is, even though well written, too long for a book on Antarctic meteorology. Why do the authors not explain the observed pressure minima around equinoxes over the temperature contrast or extraterrestrial zonal radiative gradient (Schwerdtfeger & Prohaska 1956, van Loon 1966)?

I liked Chapter 4 on The large-scale circulation of the Antarctic atmosphere. It is clearly written and informative. It is good to see that the authors did not follow W. Schwerdtfeger, who distinguished between thermal inversion (interior) and katabatic (coastal areas) winds. There is no specific area in Antarctica in which the wind characteristics change suddenly. Normally the wind increases fairly steadily towards the periphery of Antarctica, and reaches its maximum some distance inland from the coastline. This should however not be taken as a criticism of the otherwise substantial book of the late Prof W. Schwerdtfeger.

One minor point: in Chapter 3 mean radiative measurements are given as monthly sums in Mj m^{-2} (e.g. Fig. 3.1), in Chapter 4, the components of the heat budget are given as flux density W m^{-2} (e.g. Fig. 3.3). Either units would do, but consistency would make it easier for the less experienced reader.

Chapter 5 entitled "Synoptic scale weather systems" is the longest one, probably partly due to the special interest the authors have in this topic. The detailed description of case studies (e.g. p. 203–206, 209–213), though interesting, could have been omitted and the major results summarized in a couple of paragraphs. There are a large number of excellent satellite images presented in this chapter which is commendable. Two minor points. First, at the beginning of the chapter (p. 185), sizes of synoptic systems are discussed. The upper end is given as 6000 km, which is too large in the opinion of this reviewer. Second, in Fig. 5.4b (p. 194) it would have been helpful to define the pressure tendency (hPa day^{-1}) either in the figure, or in the caption.

Chapter 6 on Mesoscale systems and processes is subdivided into five topics: local winds, internal gravity waves, atmospheric boundary layer, blowing snow and mesocyclones. The last subchapter is nearly as long (34 pp) as the other four combined (40 pp). I would have given more emphasis to the four earlier topics, especially the katabatic winds and the boundary layer, as these two phenomena are so unique for Antarctica. However, the coverage in these subchapters is adequate.

I like the definition "katabatic nature" that the authors used for the winds deduced from their warm IR signature and frequently found on the Ross Ice Shelf which indicates their origin. I agree totally with the authors when they state (p. 280): "For the katabatic wind to propagate substantially further than R_i without significant change in direction, some other force must be acting to balance the Coriolis force. It is likely that synoptic or mesoscale pressure gradients provide the required support."

Concerning blowing snow, I would have liked a little more discussion on the methods of measurements, as great progress has been made in the last decade or so, giving hope that a better understanding of this process can be obtained. We are still very uncertain about the decrease of blowing snow with height and the increase towards very high wind speeds. Blowing snow was originally measured with so called "snow traps" in which the air movement is decelerated and the snow crystals are collected. All these devices had, of course, an efficiency coefficient, which was difficult to determine, as it depended also on the wind speed. During the last two decades, two different methods have been developed, making direct measurements possible. One uses photo-sensitive diodes and a light source, giving the number and average diameter of the crystals (e.g. Schmidt 1982), the other one uses an oscillating crystal, and observing frequency changes which are related to the impact of the ice crystals (König 1985). As can be seen in their Fig. 6.20 (p.305), there is a discrepancy in the flux of over 500% at 20 m s^{-1} between different authors, and this discrepancy will increase with increasing wind speed. This is not only of academic interest, as the snow export by wind can be important for the mass balance of Antarctica. As pointed out correctly the drift amount is related to about the 5th power of the wind speed. In Commonwealth Bay, Eastern Antarctica, the mean monthly wind speeds are about 20 m s^{-1}, but one winter storm a month normally reaches 50 m s^{-1}. One such storm, lasting eight hours, transports about as much snow as the rest of the month at 20 m s^{-1}. Hopefully, future measurements with more modern technology will decrease the present uncertainties.

Climate variability and Change is dealt with in Chapter 7. While Fig. 7.1 shows effectively the observed temperature increase for most stations, I was disappointed that the observations were not more up to date. With the exception of the British stations, the last data are for 1990, seven years before the publishing date of this book. For Scott Base observations stopped in 1984. Why were other stations such as Mawson and Dumont d'Urville not included? Papers have been published on their respective climatologies. Also, I would have liked to have seen more discussion on the two inland stations, South Pole and Vostok, one of which shows an increase (Vostok), the other one a decrease (South Pole) in temperature. Are these trends real? What is the estimated accuracy of the annual temperatures? Were there systematic changes in instrumentation or procedures during the time period? If they are real, how can they be explained? How do other shorter term inland stations (e.g. Dome C, Mizuho) fit into the picture? I would expect more from the two authors, who are experts in the field, than the sentence (p. 350):" It thus seems likely that, although much of the East Antarctic plateau may have warmed slightly since 1957, a considerable area has also cooled over this period."

The statement (p. 356):"The hemispheric long waves also play a role in the maintenance of the 'coreless' winter,...." is somewhat misleading. In contrast to mid-latitudes, where there is an annual sinusoidal course of solar radiation, on the Antarctic Plateau the sun is below the horizon during part of the winter, and the net radiation is only determined by the IR fluxes. Hence, a coreless winter is to be expected, albeit that the advection (hemispheric long waves) shows a systematic cycle for these winter months.

Three minor points. On p.353, the increase in accumulation is compared to the increase in saturation water pressure as deduced from the observed temperature increase. The increase in accumulation is described as "significantly greater". This comparison is done for the mean annual temperature. However, as water vapor pressure is not a linear function of temperature (as the authors point out), the difference would be reduced to about half its value if it is done for different temperature classes. If the fact that precipitation is more likely to occur at warm temperatures (summer) than at cold ones (winter) is taken into account, the difference is reduced and probably within the accuracy of such an investigation.

On p. 358 the authors discuss the semi-annual surface pressure oscillation. While this discussion is correct, they do not offer any explanation (see discussion in chapter 3).

Under "future research needs" (p.369) the authors state: "More specifically, the role of the South Pacific Conversion Zone .....needs to be better understood and this can be probably best accomplished through theoretical and numerical modelling studies." While I agree with the importance of modelling and theoretical analyses, it would have been good to include observations, especially as there will be a number of advanced satellite systems in the near future.

In general the authors have done a fine job in presenting an updated version of the meteorology and climatology of Antarctica. The references are good but the most recent ones are from 1995. Some of the material presented in the book is taken from other publications and the authors could have made a better effort to update the material as well as to bring it into conformity with the rest of the book. In my view, too much importance is put on the Peninsula, which is small in terms of the size of the continent; this is probably due to the fact that the highest density of stations occurs there. Considering the length of the book (409 pp), it is, of course, very easy to find a few points of disagreement, and this should not distract from the general good quality.

GERD WENDLER

References

DISSING, D. 1997. Solar Radiation Climatology of Alaska. M.Sc. thesis, University of Alaska. [Unpublished].

KAHL, J.D. 1990. Characteristics of the low-level temperature inversion along the Alaskan arctic coast. *International Journal of Climatology*, **10**, 537-548.

KÖNIG, G. 1985. Roughness length of an Antarctic ice shelf. *Polarforschung*, **55**, 27-32.

SCHMIDT, R.A. 1982. Vertical profiles of wind speed, snow concentration and humidity in blowing snow. *Boundary Layer Meteorology*, **23**, 223-246.

SCHWERDTFEGER, W. & PROHASKA, F. 1956. Der Jahresgang des Luftdrucks auf der Erde und seine halbjährige Komponente. *Meteorologische Rundschau*, **9**, 33-43.

VAN LOON, H. 1966. Summary of a paper on the half-yearly oscillation of sea-level pressure in middle and high southern latitudes. *WMO, Technical Note* No. 87, 419-427.