

when I began to feel impatient. But those feelings were significantly tempered when I recognized that Oreskes has performed an enormously important service to the community: Anyone who really wants to understand Cold War-era oceanography now has a definitive text to turn to. Not only does the book provide extensive explanations of the plethora of ideas that have circulated about one of the least understood environments on Earth, but the bibliography alone is a significant contribution that will be useful to scholars in the field.

It would have been helpful for the book to open with a cast of characters as part of its front matter, because there are so many key players that come up repeatedly across its hundreds of pages. Indeed, picking up the book requires a serious commitment: The main text consists of 502 pages spread across nine chapters, to which 145 pages of notes are appended. The font is also on the smaller side, which is to say the text is dense. The endnotes are long but often interesting. To put it bluntly: The book is long, and it took me a while to get through it. At times I got lost reentering the text, and readers who have a hard time tracking complex and large amounts of information would have been better served if Oreskes had broken the content into more, shorter chapters.

Ultimately, the task of *Science on a Mission* is to describe how the military's financial prowess affected what we know about the ocean and how we came to know it. And the text succeeds in that mission. But it is so much more than that. What shines through is Oreskes's utter fascination with the community she decided to study. On some pages it almost felt like I was reading not just history but an actual ethnography.

Science on a Mission makes a strong case for thinking in terms of not just money but power. Oreskes demonstrates that big personalities with sufficient social capital can be incredibly influential—and can even determine how and when military funding produces specific scientific outcomes. Moreover, regardless of whether she intended it, Oreskes makes a strong case for why histories of physics must now encompass oceanography.

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To minimize interference in the radio spectrum, the National Radio Astronomy Observatory employs a fleet of electronics-free vintage cars, such as the Checker Marathon pictured here, for site maintenance.

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The golden age of radio astronomy

Although it originated in the 1930s, radio astronomy reached maturity during the latter half of the 20th century. One of the major sites of radio astronomy during that period was the US National Radio Astronomy Observatory (NRAO). In *Open Skies: The National Radio Astronomy Observatory and Its Impact on US Radio Astronomy*, Kenneth Kellermann, Ellen Bouton, and Sierra Brandt tell the story of that august institution, warts and all: from the NRAO's genesis in the mind of NSF's first director, Alan Waterman; through the growing pains it faced during its early years; to its current status as a world-class radio astronomical facility.

A weighty tome of over 600 pages, the book begins with three chapters describing the early history of radio astronomy before delving into the NRAO's history in chapter 4. In that section, the authors introduce us to the first radio telescope erected at the NRAO's site in Green Bank, West Virginia: a 30 MHz interferometer that saw first light a year before the Green Bank site officially opened in October 1957.

From the start, the plan was to erect 85-foot and 140-foot radio telescopes at Green Bank. But a turf war quickly broke out between two committees involved with the observatory's design. Even after

Open Skies
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and Sierra S. Brandt

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they agreed on the size of the larger telescope—140 feet—there were heated arguments about the type of mounting to be used and the surface accuracy of the parabola. Construction of the 140-foot telescope wasn't finished until 1965, five years later than planned.

While that project was stalled, the NRAO managed to secure about \$1 million in funding from NSF for a simple 300-foot radio telescope with an inexpensive altazimuth mounting. Funding was approved in 1961, and in record time the 300-foot telescope was finished. The NRAO finally was an international-class radio astronomical facility.

Given the focus on instrumentation, people, and politics, *Open Skies* contains little discussion of the major research accomplishments of the NRAO and its

staff. Nevertheless, the authors highlight a few examples of scientific discoveries made at Green Bank, including supernova remnants, planetary nebulae, radio galaxies, and quasars. They also discuss the discovery of radio recombination lines and interstellar molecules.

Perhaps the most famous NRAO instrument is the Very Large Array (VLA), discussed in chapter 7. It comprises 27 mobile parabolas, each 25 meters in diameter, which are arranged in a Y-shape at a radio-quiet site outside Socorro, New Mexico. Construction of the VLA began in late 1972, and in July 1980—18 years after it was first proposed—the VLA was fully operational. It was not only the most powerful radio telescope in the world but also the most complex one ever built.

Another area of radio astronomy for which the NRAO is justly famous is very long baseline interferometry (discussed in chapter 8), which involves electronically linking separate radio telescopes located across Earth, and even in space, to achieve resolutions that greatly exceed those possible using optical telescopes. Canadian and US radio astronomers (including Kellermann) were the early pioneers in that exciting new field.

Although the NRAO had from its founding intended to acquire a very large antenna, after the 140-foot debacle they couldn't find support for such a program. But on 15 November 1988, the 300-foot telescope at Green Bank suddenly collapsed—fortunately with no loss of life. Senator Robert Byrd of West Virginia used the collapse, which the media described as a disaster, to lobby successfully for a replacement antenna. The result was a new 100-meter radio telescope, called the Green Bank Telescope, whose story is related in chapter 9.

Chapter 10 describes the NRAO's first telescope dedicated to millimeter-wave radio astronomy, a 36-foot parabola sited in a dome at Kitt Peak National Observatory near Tucson, Arizona. It practically single-handedly gave rise to the field of astrochemistry. That chapter also discusses the NRAO's role in the planning of the internationally run Atacama Large Millimeter/Submillimeter Array in Chile.

The final chapter in the book covers the NRAO's contributions to 21st-century radio astronomy. It offers reflections on the love-hate relationship between the

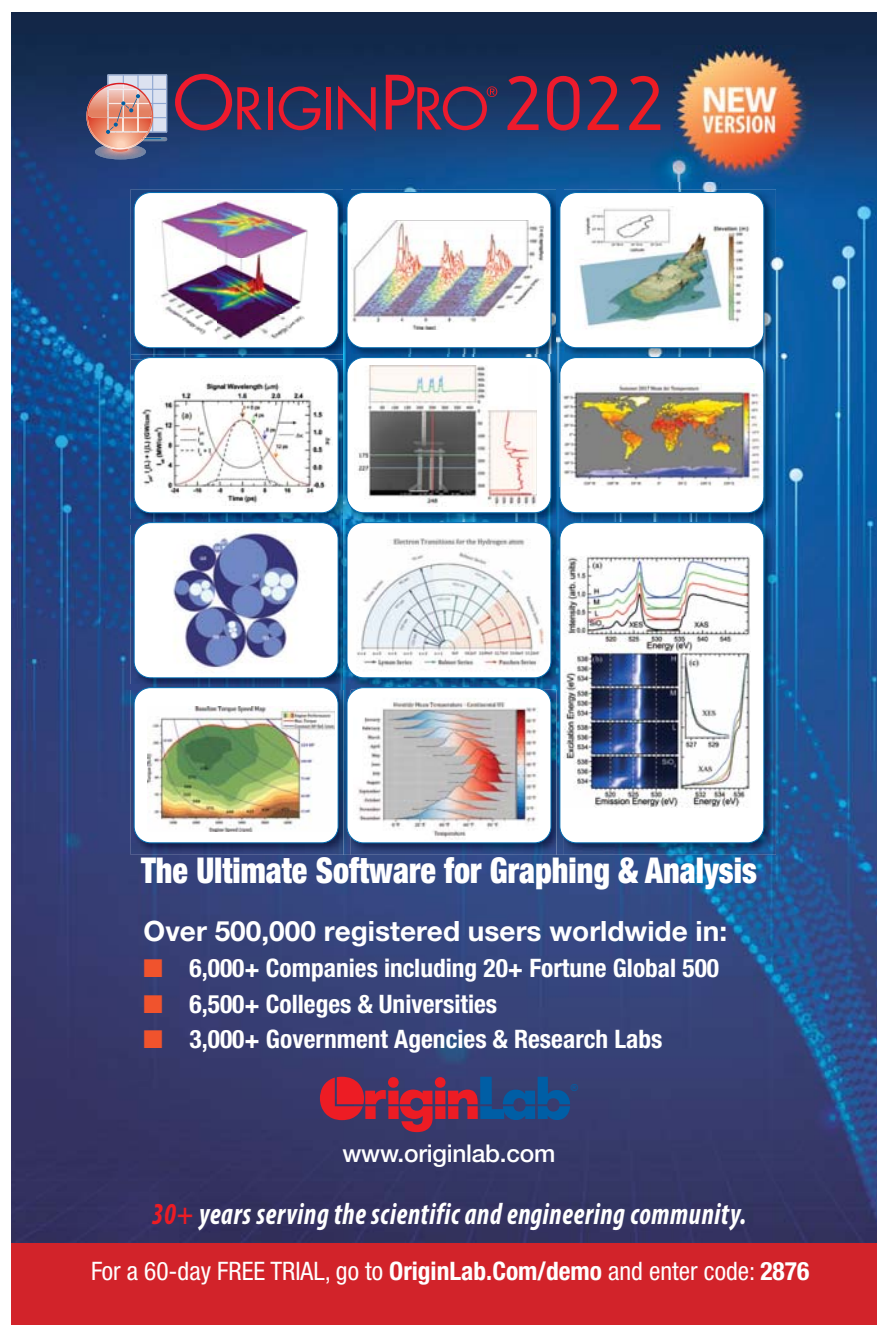
NRAO and university-based radio astronomy programs, the philosophical differences between the NRAO and optical astronomers at the Kitt Peak National Observatory, patterns of conflict and collaboration in US radio astronomy, and the management of frequency spectra. The authors round out the book by discussing the most ambitious international radio astronomy project ever devised: the Square Kilometre Array, currently under construction in Africa and Australia.

Well researched and well illustrated, *Open Skies* contains copious references at

the end of each chapter for those wanting to learn more. It is also an open-access book, which means that the digital edition is freely available for anyone to download and read. Although it focuses on the US, *Open Skies* places the NRAO's achievements in both a domestic and an international context. For those wanting to know about the development of post-World War II radio astronomy—and not just about the NRAO—*Open Skies* is essential reading.

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