

## A SPECIAL TRACK ON THE INTERNATIONAL POLAR YEAR

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The International Polar Year (IPY) is a program of coordinated high-latitude observations, research, and analysis whose goals are to better understand the role of the polar regions in global, Earth system processes. The 2007-2008 IPY is particularly notable, and of interest to this magazine's readership, because of the many scientific subdisciplines involved and their use of cutting-edge tools, such as high-performance computing and satellite observations.

To highlight the IPY, the editor in chief of *Computing in Science & Engineering (CISE)* proposed a set of thematic articles focused on current research in the field. However, instead of concentrating this material into a single issue, a series of articles will appear throughout the year in a special horizontal track. This track's goal is to introduce *CISE's* audience to polar research and some of the open questions the IPY will be investigating. We've set this track up horizontally to provide an ongoing connection to IPY and to excite and educate people about the science, which could bring new participants to IPY-related activities. We start this series in the January issue as a lead in to the start of IPY in March 2007. Because polar science is such a broad area, we had to pick and choose from potential topics. Hopefully, we've selected a subset that is both representative of the overall science that researchers have completed and illustrative of the exciting computational problems that remain to be solved. Fortunately, an excellent set of authors is set to participate in this project.

### IPY History

The International Council for Science in conjunction with the World Meteorological Organization formally established the current, fourth IPY, which occurs exactly 125 years after the first one (1882–1883). The dates of the second IPY (1932–1933) and the first International Geophysical Year (IGY; 1957–1958) were picked to mark the 50th and 75th

anniversaries of the first IPY, respectively. These campaigns focused international collaborative efforts on the remote high-latitude regions that cross many international boundaries and are of fundamental importance to the Earth system. International cooperation has increased dramatically over the years, with 12 countries involved in the first IPY, 40 in the second, and 67 in the IGY. The earlier IPY/IGY initiatives introduced major changes in the way high-latitude science is conducted, and there's every reason to expect the same this year.

The current IPY will actually start in March 2007 and end in March 2009; this unusual definition of a year allows for two full observational seasons in both the Arctic and Antarctic regions. Although the main focus will naturally be on observation, the goal is to understand the underlying physics of the Earth system and the need to improve our system models' predictive abilities. Some of the largest uncertainties in both our understanding and our modeling occur in the polar regions—for example, understanding how much of the recent rapid climate change in the polar regions is due to natural variability versus anthropogenic forcing is a high priority. Education and outreach are also essential components of the IPY, to help train a new generation of polar scientists in various subdisciplines. A wide variety of historical and current information is available online, including active research projects and a calendar of events (see the "Online Resources" sidebar).

### Special Track

We start this special track with a review of high-latitude remote sensing. We chose this as the first topic because it motivates polar research and validates the related modeling. Advanced remote sensing is one of the star techniques this IPY will highlight. In addition to informing the big picture, remote sensing also presents huge computational challenges in its own right. Processing the data streams into something useful is an immense computational problem as are storing, manipulating, and visualizing the resulting data sets.

The second article in this series will focus on climate and glaciers, highlighting cross-disciplinary research that uses a hierarchy of models to estimate large-scale climate's influ-

thermal blanket that warms the climate system throughout most of the year.

More recently, new discoveries have shown an equally important meteorological cause of polar climate change, which is ultimately related to climate warming at lower latitudes. *Arctic Oscillation* (AO) is a persistent mode of variability in northern high-latitude atmospheric circulation.<sup>8</sup> Think of it as a "see-saw" in sea level pressure, alternately rising over the central Arctic Ocean and then in a sub-

Arctic belt from southern Alaska to Europe. Today, researchers often consider the AO and the North Atlantic Oscillation (NAO) index to be part of the same dynamical phenomenon, called the Northern Annular Mode (NAM); an analogous mode of variability, called the Southern Annular Mode (SAM), exists in Antarctic circulation.<sup>9</sup> As the global climate warms, the stratosphere cools, and the resulting changes to atmospheric planetary wave propagation increase the polarity of both the NAM

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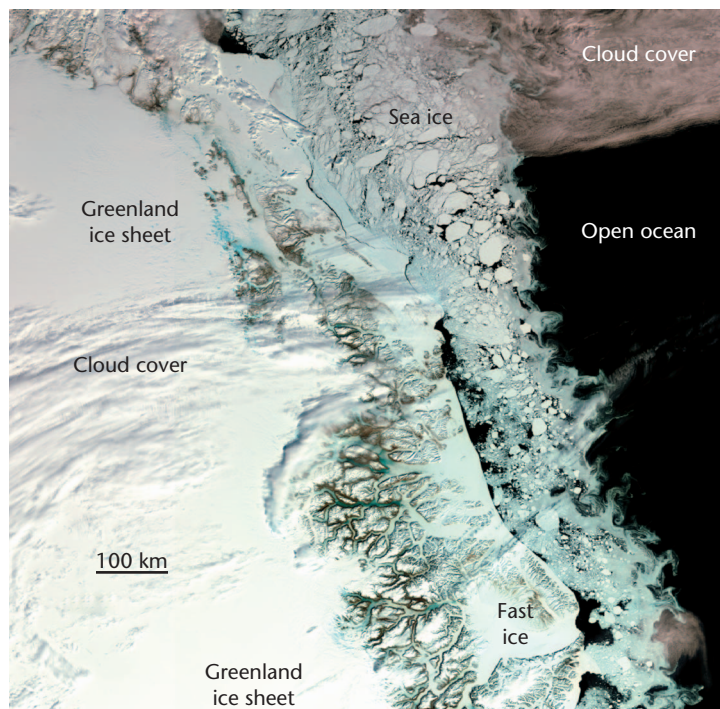
ence on high-latitude local glacier characteristics. In particular, the IPY is stressing this type of interdisciplinary hierarchical approach. Throughout the series, we'll see subsequent articles on other IPY-related topics such as ice-ocean modeling, the coupled biosphere-climate system, and modeling the magnetosphere. The track will end with an article on the interaction between sheared flows and turbulence in the atmosphere and the implications of these interactions for the ozone hole.

Where possible, we've asked the authors to highlight both the computational challenges and the hierarchical nature of the computational approaches they took to the different problems as well as their connections to the IPY. This helps elucidate the physics of the problem at different levels and introduces a wide range of computational and physics techniques and resources. Ideally, this approach should help facilitate active, meaningful participation in the research—

even by undergraduate students—and we hope you find the articles in this track useful in your own work and research.

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**Figure 1. A modern pushbroom imager for polar remote sensing.** This image from the European Envisat Medium Resolution Imaging Spectrometer (MERIS) shows sea ice conditions in East Greenland. The image is a composite of data from the 0.443, 0.560, and 0.865- $\mu\text{m}$  channels. Here, the near-infrared (0.865- $\mu\text{m}$ ) channel enables a clear separation of atmospheric and ice features. Ocean eddies and vortices are visible in the ice edge region. (Figure courtesy of Mark Drinkwater; copyright ESA 2002, used by permission.)

and the SAM.<sup>10</sup> This high-index polarity yields stronger westerly winds shifted to higher latitudes, which isolates colder air toward the poles, allowing much of the Arctic and the Antarctic Peninsula to become warmer, and changes circulation patterns in the Arctic Ocean such that sea ice is more rapidly expelled into the North Atlantic.<sup>11</sup> Global climate model (GCM) simulations are now physically rigorous enough to reproduce these radiative-dynamic interactions,<sup>10</sup> but much observation will be required in the coming decades to document their true impact.

This brings us to the importance of satellite remote sensing. To understand global climate change, we need to observe and monitor the entire geographic extent of both polar regions. However, their extreme remoteness and harsh environments make fieldwork very expensive—indeed, impossible in many cases. Only satellites in low Earth orbit (LEO) can give us the consistent spatial and temporal coverage necessary to document the very real climate and environmental changes throughout the polar regions.<sup>12</sup> Researchers use satellite remote sensors in all the disciplines of polar science, including stratospheric chemistry,<sup>13</sup> meteorology,<sup>14</sup> sea ice mapping,<sup>15</sup> sea ice dynamics,<sup>16</sup> monitoring of the great ice sheets,<sup>17</sup> ocean ecosystem studies,<sup>18</sup> and studies of the terrestrial biosphere.<sup>19</sup> Some of the most advanced Earth remote sensing missions recently deployed are, in fact, dedicated to polar research. Their data analysis involves a high level of