NEWS

Reductions in Arctic Sea Ice Cover No Longer Limited to Summer

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Summer sea ice in the Arctic has shown a significant downward trend of 8% per decade since the late 1970s, leading to a reduction of approximately 20% in sea ice extent in September (when the annual minimum occurs) [*Stroeve et al.*, 2005]. The past three summers (2002–2004) have been among the lowest on record, and 2002 was the extreme minimum. Despite decreasing summer extents, the sea ice extent has typically rebounded to near-normal levels during the winter season, yielding an annual average trend of only -3%. This is not surprising since as temperatures drop below freezing, sea ice quickly forms.

However, this may be changing. All months of the winter and spring of 2004–2005 (December–May) were well below normal, and every month except May 2005 had record low extents (Figure 1). Now the wintertime trend alone is approaching -3% per decade. Also unusual is the fact that the reduction occurred in all regions of the Arctic, on both the Atlantic and Pacific sides (Figure 2). In the past, while one area of the Arctic may be anomalously low, another region will be higher than normal. This may be an indication that the reduced summer sea ice extents are allowing more heat to be absorbed by the ocean and delaying the onset of freeze-up throughout the Arctic.

The very low ice extents have continued into the summer months of June and July, with both months having record low extents. This portends another record low September minimum sea ice extent. From the late 1970s through 2001, extreme minimum years occurred every few years, but they were followed by normal or above normal minimums the following year. However, 2005 will be the fourth consecutive year of record or near-record low September sea ice extent.

There are several possible causes of these record minimums including (1) a lingering effect of change in the mode of the Arctic Oscillation, leading to advection of thicker ice out of the Arctic replaced by thinner ice more prone to melting, (2) increased cyclonic activity advecting warmer air into the Arctic and breaking up the ice earlier, and (3) warming surface air temperatures in the Arctic.

The contributions of these mechanisms are still being investigated. Nonetheless, it appears that significant changes are occurring in the Arctic, and some scientists theorize that the

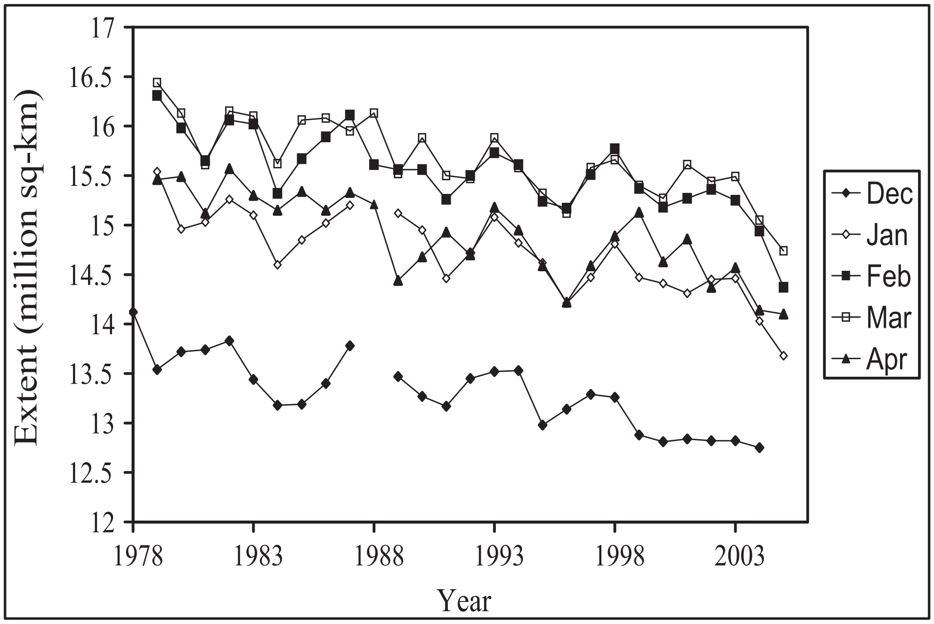

Fig. 1. Monthly mean Arctic sea ice extent for December–April since 1978. All months set record lows in 2004–2005 over the satellite record; there has been a particularly sharp decrease over the past three years in January through March.

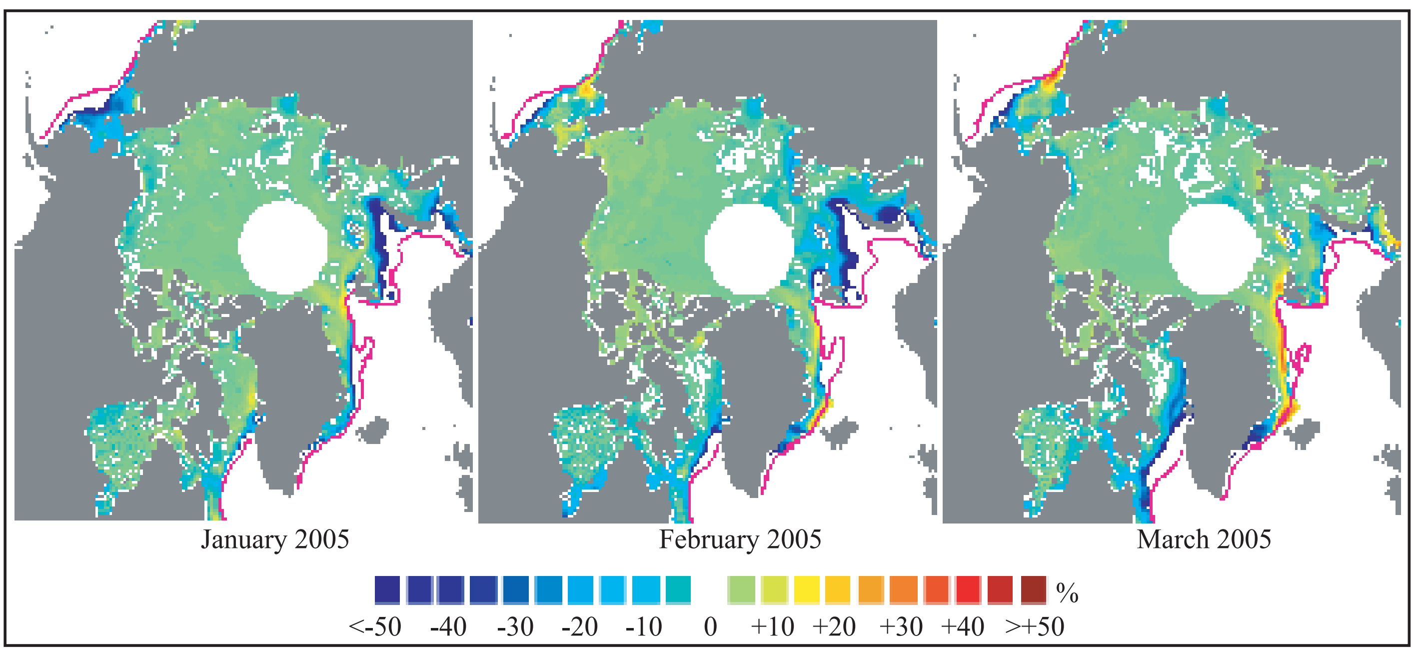

Fig. 2. Monthly mean Arctic sea ice concentration anomaly for January–March 2005. The light purple contour line is the average extent for each month. In all three months, the sea ice receded poleward from the average extent in almost all regions of the Arctic and there are large negative anomalies near the ice edge.

region may have reached a "tipping point" where in the near future (within 50–70 years) the Arctic Ocean will be ice free during at least part of the summer [*Overpeck et al.*, 2005; *Lindsay and Zhang*, 2005]. This would have profound effects on the Arctic ecosystem and on human inhabitants. Monthly sea ice extents, concentrations, anomalies, and trends can be tracked from 1978 to the present at the U.S. National Snow and Ice Data Center's (NSIDC) Sea Ice Index at http://nsidc.org/data/seaice_index/, based on data from NSIDC's NASA Distributed Active Archive Center (DAAC).

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FORUM

What Is a Planet?

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Atmospheric scientists, forensic scientists, life scientists, neuroscientists, ocean scientists, plant scientists, and almost all other scientists know what lies at the heart of their respective fields, but planetary scientists do not.

The last generally accepted definition of a planet, a "wanderer," comes from the ancient Greeks. Although the need for an updated definition has existed since the discovery of the asteroid belt two centuries ago, recent discoveries of objects in the Kuiper belt and in orbit around other stars have reminded planetary scientists of this unsatisfactory situation.

Many undergraduate astronomy textbooks even encourage their readers to define a planet for themselves as an exercise. The general public is also aware of the problem, especially since the discovery by Michael Brown (California Institute of Technology) and colleagues of 2003UB313, a Kuiper belt object that appears to be larger than Pluto. That object was discovered in images taken on 21 October 2003, and the discovery was announced on 29 July 2005.

Two working groups of the International Astronomical Union (IAU), which has a longstanding interest in nomenclature, are wrestling with this problem. The working definition of the IAU Working Group on Extrasolar Planets involves upper and lower size limits, but its lower size limit is merely "the same as that used in our solar system." That refers to the IAU Working Group on the Definition of a Planet, which has not yet issued its report.

The IAU might consider a planet being defined as an object that satisfies the following four criteria:

1. Its mass is small enough that it is not a star, but is large enough that its shape is determined by gravity rather than by strength.
2. It does not have sufficient kinetic energy to escape from orbit around one or more stars.
3. It is not a satellite of a more massive object.
4. It is not part of a belt of objects of similar size.

The first criterion excludes stars and objects smaller than about 500 km across, which ensures that the census of planets in a given stellar system can be completed before every dust grain has been catalogued. The second criterion excludes objects that are not long-term members of a stellar system. The third criterion might be formally expressed in terms of a Hill radius, a length scale often used by planetary dynamicists. All satellites in stable orbits, such as the Moon, are within one Hill radius of their primary object, such as the Earth.

The fourth criterion is challenging since the term "belt" is not clearly defined. A belt, such as the asteroid belt, consists of many objects of similar size in similar orbits. The definition of a belt might include (1) the quantity of objects, (2) the size distribution of these objects, and (3) the distribution of their orbits. Such a definition is likely to be fairly technical in nature, but it should be based on consideration of the properties of the asteroid belt, the Kuiper belt, and numerical simulations of planetary systems.

These four criteria are based on observable physical properties and can be applied to objects in any stellar system. They give reasonable results for challenging cases such as objects orbiting a binary star, planetesimals in the process of forming planets, Trojan objects, which share Jupiter's orbital path, but trail or precede Jupiter by 60° in a delicate gravitational balance between Jupiter and the Sun, and satellites that are almost as large as the planets they orbit around. These criteria may be summarized as, "a planet is neither too large nor too small, orbits a star, is not a moon, and is not part of a belt of similar objects."

Pluto does not satisfy these criteria. I do not believe that any elegant definition of a planet, after being applied to the asteroid and Kuiper belts, can conclude that Pluto, and only Pluto, is a planet.

However, the word "planet" does not belong exclusively to planetary scientists; our definition should not lightly contradict common usage. Accordingly, I add a short caveat to these four criteria: Pluto is a planet. Perhaps future generations of schoolchildren, after learning about the diverse populations of objects in the Kuiper belt and in orbit around other stars, will find it strange that Pluto receives this special treatment. When that time comes, the need for this caveat can be reevaluated.

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