SOLAR PHYSICS

Bold Prediction Downplays The Sun's Next Peak

Every 11 years, a pox of dark spots appears on the face of the sun, and it spits energetic particles and radiation into space. These outbursts, which mark peaks in the sun's magnetic cycle, can destroy space-borne electronics and stir up Earth's upper atmosphere, but researchers are at a loss to predict their intensity. Forecasters are reduced to the equivalent of consulting the *Farmer's Almanac*, says David Hathaway of NASA's Marshall Space Flight Center in Huntsville, Alabama, taking hints from things like the trend of rising solar activity in our century and the unexplained fact that odd-numbered peaks are almost always higher than the preceding even-numbered ones.

Now, researchers may have found a way around the numerology, and they have come up with predictions for the next solar maximum, around 2000, that are sharply at odds with the forecast derived from the *Farmer's Almanac* approach. The "even-odd" numerological methods predict that this one—cycle 23, in the usual numbering scheme—will be the most intense in history. But Sabatino Sofia of Yale University and Kenneth Schatten of Goddard Space Flight Center in Greenbelt, Maryland, say that the sun's current magnetic field, which serves as the "seed" that will grow to the powerful, unstable field of solar maximum, foreshadows only a modest peak, the lowest in decades. Others are not prepared to go quite that far: One rival, for example, predicts a higher but not record-breaking maximum.

Which forecast fares best, say solar physicists, will be a good test of dynamo theory, which describes how the sun generates and transforms its magnetic field. And there's plenty at stake for satellite operators as well. The energetic particles emitted during the solar flares and magnetic storms of a powerful solar maximum can blast the delicate electronics of military, scientific, and commercial satellites. The ultraviolet radiation from an active sun also heats Earth's upper atmosphere, causing it to expand and exert extra drag on satellites, says Bill Wagner, head of solar physics at NASA. "If we get a real barn-burner of a maximum [in 2000], there are maybe even new [shuttle] missions required to bring fuel up" to reboost facilities like the orbiting Hubble Space Telescope and the planned space station, says Wagner. But Schatten and Sofia's prediction suggests that NASA can rest easy.

Presented at an American Astronomical Society Meeting in Toronto last month, it is drawing attention not just for its low-ball numbers. "Their [method] is more grounded in observations and physics than any of the others," says JoAnn Joselyn of the National Oceanic and Atmospheric Administration in Boulder, Colorado. If it falls on its face, adds Spiro Antiochos of the Naval Research Laboratory, "we'd have to really rethink dynamo theory."

During quiet periods, the sun is threaded by a weak polar field—one running mostly parallel to lines of longitude. Because the sun spins faster at the equator than at the poles, those field lines get wound and stretched like colossal rubber bands as they are carried along with the hot gases in the solar interior. This stretching creates powerful fields running mostly parallel to lines of latitude. Bundles of these field lines grow strong enough to push out surrounding gases and become buoyant, bobbing up through the surface of the sun. Dark sunspots appear at the "footpoints" of bundles rearing above the solar surface.

By writhing, reconnecting, and even wrenching free of the sun, these field lines create displays like flares and launch great eruptions of gas called coronal mass ejections. Eventually, says the theory, enough field lines reconnect to restore the smooth polar field of the quiet sun, although it now points in the opposite direction from the original field. But although the events driving every cycle are similar, peak activity varies. "You're talking about a very big range," says Schatten—from almost no sunspots during the last half of the 17th century to an average of 190 per month when cycle 19 maxed out in the late 1950s.

Sofia and Schatten searched for clues to the next peak in the seed field of the quiet sun. They reason that, like an amplifier with a fixed amount of gain, the field strength—and hence the activity—at maximum will depend on the strength of the polar field at minimum. "Those [polar] fields are a telltale sign for the next cycle," says Schatten. They looked at past relations between the polar-field intensity in quiet times and the height of the peaks that followed to calibrate their method, then turned current observations of the field into a prediction for the next peak: an average sunspot number of just 130, with a possible error of 30 in either direction. The even-odd predictions, in contrast, run as high as 200.

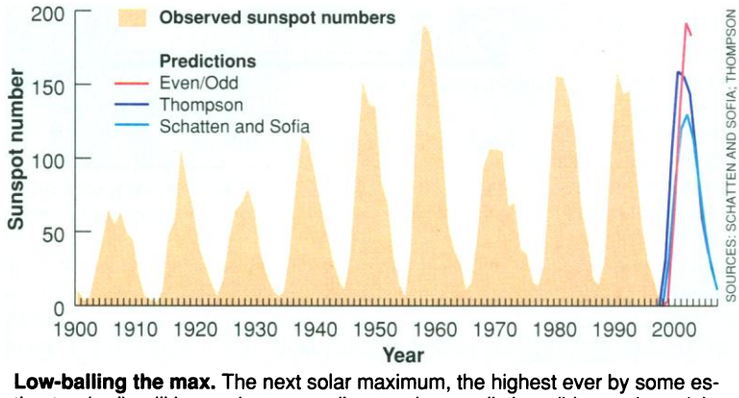
Skeptics point out that measurements of the weak polar field, based on subtle frequency shifts imprinted on sunlight by the magnetic field, cover only a few solar cycles, giving researchers a short track record. And some parts of the dynamo theory itself still need to be firmed up. "To get the best out of the ... technique, we need to have a better understanding of the dynamo model," says Richard Thompson, who heads the Australian Space Forecast Centre and has his own strategy for predicting the solar maximum.

Thompson thinks that, for now, forecasters would do better to rely on a "proxy" for the sun's field that can be measured at Earth's surface. The wind of particles that blows from the sun stretches the polar field far into space, where it disturbs Earth's own field. The surface field fluctuations that result have been monitored continuously since 1868, and their number during each full cycle has shown good correlations with the size of the next cycle's peak, Thompson says. His own work based on this approach yields a prediction of about 164.

That's close to the "consensus value" reached by a NASA-sponsored panel that Joselyn headed last fall. The panel considered 28 prediction methods of all kinds, including high even-odd predictions and these two, says Joselyn. In most cases, "forecasters like to go with persistence," she says, and the panel settled on a maximum of about the same size as the last one.

The next 4 years will tell who is right. "To me, it's a great test of the two models," says Schatten. The outcome could even induce solar prognosticators to put away their almanacs in favor of computers.

–James Glanz



Low-balling the max. The next solar maximum, the highest ever by some estimates (red), will be modest, according to other predictions (blue and purple).