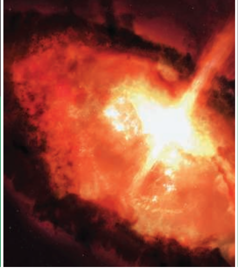
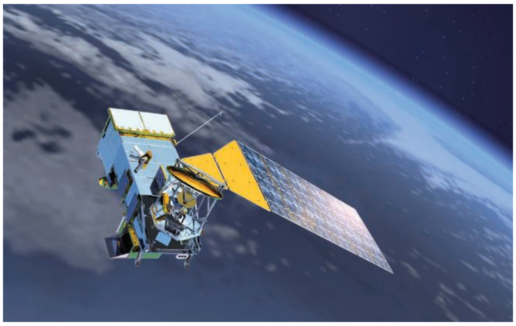


LETTERS

edited by Jennifer Sills

Cloudy Forecast for Weather Satellite Data

IN THE NEWS FOCUS STORY "WEATHER forecasts slowly clearing up" (9 November, p. 734), R. Kerr nicely summarizes how the growing improvement in prediction is coming from a focus on "more computer power, the assimilation of radar observations, and more physically realistic models." He emphasizes that better assimilation of satellite data is a key element of improved forecasting.



NPOESS Preparatory Project satellite (artist's rendition).

Unfortunately, these potential improvements will have little effect on forecasts if the basic data set from the existing polar-orbiting weather satellite system is not available. In a report issued in June 2012 (*1*), the U.S. Government Accountability Office noted that "data from this system is the predominant input to numerical weather prediction models" and warned that "there will likely be a gap in satellite data lasting 17 to 53 months" when the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project satellite ceases operations and NOAA's new satellite system (the Joint Polar Satellite System) launches. The report also notes that there are "potential satellite data gaps in DOD [Department of Defense] and European polar satellite programs which provide supplementary information to NOAA forecasts." These gaps are a grave problem and would seriously degrade weather forecasts. Therefore, the agencies responsible for weather forecasting—NOAA, DOD, and NASA—should make filling the polar satellite data gaps the first priority in order to ensure that future forecasts are as good as possible.

D. JAMES BAKER

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Big Brains, Little Bodies

IN THE NEWS FOCUS STORY "WHY ARE OUR brains so big?" (5 October, p. 33), M. Balter claims that "the size of the *Homo sapiens* brain outstrips that of any other animal" once an adjustment is made for body weight. When expressed as a percentage of body mass, the brain masses of some small mammals considerably exceed the approximate 2% value for humans [e.g., the brains of Eurasian harvest mice (*Micromys minutus*) comprise roughly 10% of their total mass] (*1*, *2*). Many invertebrate animals have brains that are relatively even larger (*3*), including tiny ants with brains that account for nearly 15% of their body mass (*4*). Perhaps this is one reason Darwin noted that "the brain of an ant is one of the most marvelous atoms of matter in the world, perhaps more marvelous than the brain of man" (*5*).

WILLIAM T. WCISLO

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Response

WCISLO IS BASICALLY CORRECT IN REGARDS TO the actual ratios of brain and body weight. What I meant to refer to was the fact that the relationship between brain size and body weight is not a linear one, an idea expressed in the Encephalization Quotient (EQ) referred to in the story. Humans have a much higher EQ than any other animal; the EQ of a mouse is actually very low.

MICHAEL BALTER

Pushing the Planetary Boundaries

IN HIS PERSPECTIVE "A MEASURABLE PLANetary boundary for the biosphere" (21 September, p. 1458), S. W. Running proposes a new "planetary boundary" definition for land use based on net primary (plant) production (NPP). On the face of it, NPP is a much more robust scientific indicator of biospheric constraints to human populations than the arbitrary 15% of global ice-free land converted to crops proposed by Rockström *et al*. (*1*). Earth's NPP is fairly constrained as a global process and is a critical resource for both human and ecological systems. Humans need biomass as food, feed, fiber, and bioenergy. In ecosystems, biomass is the ultimate energy resource sustaining the metabolism of all species on Earth and replenishing the carbon stored in biota and soils (*2*).

However, basing policy-relevant boundaries for land use on NPP is not straightforward. First, NPP is a poor indicator of food and other resources available for consumption by humans. For example, the NPP of a tropical forest is exceedingly high, yet the food resources for humans are far less in a tropical forest than if the land were converted to a field of soybeans with lower NPP. Second, NPP can be both reduced and increased by human activities in agricultural and other land-use systems, and it is more dynamic at regional scales and over longer time spans than indicated by short-term global averages (*3*–*5*). Third, improvements in agricultural and processing technology as well as livestock management allow major increases in the efficiency with which NPP is converted into the raw materials that humans use (*6*).

All of this suggests that NPP—despite being a critical, ultimately limiting resource, as argued by Running—is a moving target rather than a fixed boundary imposed by natural laws. It is the access to technology, land, and capital to increase food production that is determining the amount of NPP usable by humans rather than any absolute biophysical boundary to NPP overall. Thus, sound indicators are required that put these complex links between human activities and NPP into focus.

Furthermore, there is no one-to-one correspondence between human appropriation of NPP and sustainability of land use: Intermediate, perhaps even high, levels of human appropriation might be sustainable, and degradation can occur even at low levels of human appropriation if land management is poor. Using NPP to indicate boundaries might therefore result in silent degradation remaining undetected (*7*) and a disincentive for the development of innovative, sustainable but intensive agricultural systems. By ignoring the well-known potentials for more efficiently using these resources (*8*, *9*), Running all too easily argues that further intensification is not possible due to constraints entailed by boundaries for water, nitrogen, and phosphorous.

Using NPP as an integrating boundary, as proposed by Running, conceals the range of available options for land use. NPP-based metrics are complements, not substitutes for indicators of boundaries such as N pollution, climate change, soil degradation, or biodiversity loss. The trade-offs between them require monitoring all boundaries separately to avoid displacement and leakage effects, and fixing one problem by creating others. Although the prospects of a global and comprehensive measure of human limits based on NPP is appealing, it is not sufficient to grasp the complex, dynamic nature of human interactions with the Earth system and the trade-offs humanity must make on its road to a sustainable future.

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Response

ERB *ET AL.* DO NOT CHALLENGE MY ASSERTION that global NPP may be a constant boundary. Rather, they argue that partitioning the 38% of global NPP appropriated for human use will be complex and that the efficiency of agricultural crop production is variable.

The fraction of agricultural NPP consumable by humans as food varies widely by crop type, as Erb *et al.* have previously reported (*1*, *2*). In addition, more efficient use of current irrigation and fertilizer will allow agricultural food output to be improved in some regions. However, there is much evidence cited in the original Rockström analysis (*3*) that nitrogen and phosphorus cycles may already be saturated, so increasing the use of fertilizer to enhance future NPP to satisfy growing demand may be environmentally counterproductive. Many studies also warn that major new sources of irrigation water are not likely and that dewatered rivers and groundwater depletion suggest that even current levels of global irrigation are not sustainable (*4*–*6*). Thus, whereas the current NPP for human use may be a "moving target" for the reasons Erb *et al*. suggest, the total global NPP does seem like a planetary boundary that, once reached, humans cannot extend.

There appears to be adequate capacity for global food production as human populations and living standards increase over the next century, assuming increasing efficiency and reducing waste, and (if needed) potentially devoting the remaining 10% of available NPP to agriculture (*7*, *8*). However, if this same 10% of available global NPP were all devoted to bioenergy (not considered by Erb *et al.*), it would not even satisfy current global energy consumption, regardless of what type of conversions and final fuels were produced (*9*). A future of food competing against bioenergy for the remainder of available global NPP seems likely.

Planetary boundaries have been criticized as being conceptually attractive but lacking in measurable global metrics. Global terrestrial NPP provides a measurable and policy-relevant boundary, a real "limits to growth," which strategic economic thinking can no longer ignore (*10*).

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CORRECTIONS AND CLARIFICATIONS

Reports: "A large-scale model of the functioning brain" by C. Eliasmith *et al*. (30 November, p. 1202). The name of the sixth author was incorrect. It should be Yichuan Tang. The HTML and PDF versions online have been corrected.

News Focus: "Making sense of a senseless act," by M. Hvistendahl (23 November, p. 1025). Suicide researcher Matthew Miller is quoted as saying that mental illness may be underdiagnosed in Asia for reasons that aren't fully understood. He had said that there may be differences in the recognition, reporting, and incidence of mental illness in Asia, not that mental illness is underdiagnosed. The HTML and PDF versions online have been corrected.

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