PERSPECTIVES: PALEOCLIMATE

Ice Sheet Collapse and Sea Level Change

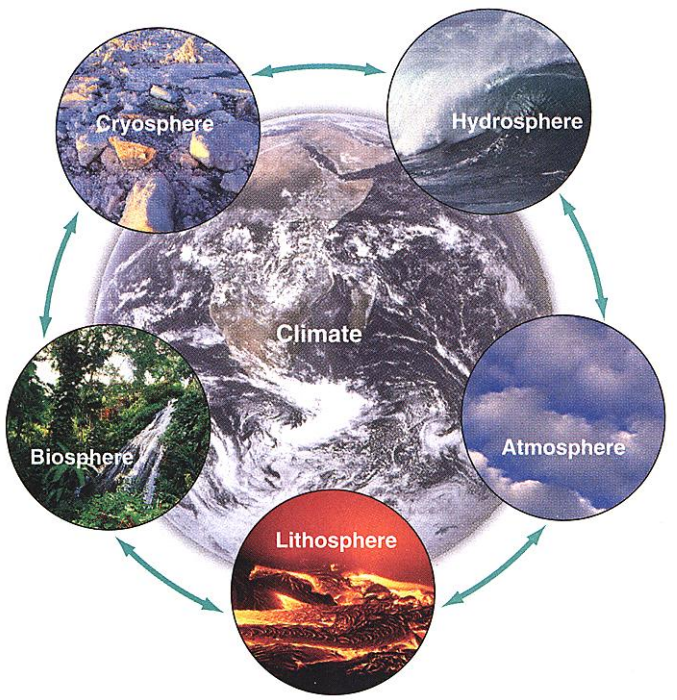
Roberto Sabadini

Sea level records contain fundamental information on Earth's climatic changes and the relative motion between the sea surface and the topography of the sea floor. On a global scale, they provide a measure of how much water was locked up in ice sheets and glaciers at different times in Earth's history. But this is not all. On page 2438 of this issue, Clark *et al.* (*1*) show that geographic patterns of sea level change can provide clues to the origin of meltwater pulses during deglaciation.

Increasingly sophisticated models that simulate the phenomena responsible for past sea level changes enable us to understand the complex interactions among the various parts of the Earth system—hydrosphere, cryosphere, lithosphere, and atmosphere—and their impact on climate and the biosphere (see the figure). They are complemented by existing and planned satellite and space missions that aim to refine our capability to detect present-day sea level changes (*2*–*5*). The report by Clark *et al.* (*1*) opens new perspectives in our ability to make use of such sea level data to understand the interaction among the various parts of the Earth system and their feedback on Earth's climate.

Clark *et al.* make use of a notion they discovered in earlier work on the recent mass balance of polar ice sheets (*6*): a meltwater pulse from ice sheet complexes belonging to the cryosphere induces a distinct geographic sea level signature—a fingerprint—that is not uniform or eustatic over the oceans.

Using a sophisticated sea level model that accounts for the physical properties of Earth's lithosphere and mantle and the latest techniques for analyzing fast, large glacial discharges, Clark *et al.* demonstrate that this fingerprint allows the source-point of a previously enigmatic meltwater pulse from Earth's cryosphere at the end of the last ice age to be identified. The pulse occurred 14,200 years before present and lasted for about 500 years; the associated sea level rise exceeded 40 mm/year at Barbados and the Sunda Shelf, a value that, compared with the modern sea level rise of 1 to 2 mm/year, testifies to the exceptionality of the event.



Feedbacks and connections. The five realms of the Earth system, biosphere, lithosphere, atmosphere, hydrosphere, and cryosphere, interact as shown by green arrows. Processes in each realm have an influence on climate (**center**). [Adapted from (*7*)]

The authors make use of the fingerprint technique to select, among the possible reservoirs from the huge ice-sheet complexes (the Laurentide, Fennoscandia, Antarctic, and Barents Sea ice sheets), the source of the meltwater pulse. The widely held belief that the Laurentide Ice Sheet was the source of this pulse is based on a rather weak clue; on previous evidence, the Barents Sea and the Fennoscandia ice sheets could also have been the ice reservoirs for the pulse. The evidence either for or against Antarctica's ice-sheet complex as the source of the meltwater event are not compelling.

The first two panels of fig. 1 in Clark *et al.* (*1*) help one to understand how it is possible to discern the site of the pulse among these possible scenarios. For two modeled melting events in the southern part of Laurentide and in Western Antarctica, the sea level change is far from eustatic, and sea level changes differ substantially from site to site for each meltwater pulse. Furthermore, the pulses from the two different reservoirs show distinct geographic patterns. The geographic variation, or fingerprint of the meltwater pulses, of widely represented possible scenarios, from Laurentide to Barents Sea and Fennoscandia passing through Antarctic sources, is striking. For example, these sea level changes show that the marked difference in sea level rise predicted by Clark *et al.* (*1*) for Barbados and Tahiti for a Laurentide source would disappear if the source of the meltwater pulse is sited within Antarctica. In this latter case, a small sea level rise on the Argentine Shelf would be diagnostic of an Antarctic source.

Applied to the Barbados and Sunda Shelf sea level records, which show the enigmatic pulse, Clark *et al.*'s sea level fingerprint test makes it possible to rule out that the meltwater pulse originated solely from the southern Laurentide Ice Sheet. The sea level rise at Barbados and the Sunda Shelf produced by such a pulse would have been substantially different from that observed in the data, which suggest a rise of about 25 m at both sites. The authors conclude that a substantial contribution to the meltwater pulse may have originated from Antarctica.

The sea level fingerprint test by Clark *et al.* (*1*) provides a powerful tool for detailing the ice sheet disintegration of the last deglaciation. The methodology is also applicable to present-day ice mass imbalance, allowing us to detect the events that occur in the cryosphere from the sea level patterns that shape the hydrosphere. This tool is particularly appropriate for dealing with fast, large glacial discharges like those considered by Clark *et al.* (*1*). For these cases, no tectonic correction to the observed sea level data is necessary, because active tectonics, over a time span of

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about 1000 years, contributes a rise of a only fraction of a meter, much less than the site-to-site scatter among the various modeled sea level patterns.

The fingerprint technique of Clark *et al.* (*1*) is a major step forward in our understanding of the interactions among the various realms depicted in the figure and their impact on the climate, because the decrease in ice thickness and the large increase in freshwater flux into the oceans in areas of deep water formation may have affected the atmospheric and ocean circulation during the last deglaciation.

References

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PERSPECTIVES: PSYCHOLOGY

The Effects of Media Violence on Society

Craig A. Anderson and Brad J. Bushman

Concerns about the negative effects of prolonged exposure to violent television programming emerged shortly after broadcasting began in 1946. By 1972 sufficient empirical evidence had accumulated for the U.S. Surgeon General to comment that "...televised violence, indeed, does have an adverse effect on certain members of our society" (*1*). Other scientific bodies have come to similar conclusions. Six major professional societies in the United States—the American Psychological Association, the American Academy of Pediatrics, the American Academy of Child and Adolescent Psychiatry, the American Medical Association, the American Academy of Family Physicians, and the American Psychiatric Association—recently concluded that "the data point overwhelmingly to a causal connection between media violence and aggressive behavior in some children" (*2*). In a report on page 2468 of this issue, Johnson and colleagues (*3*) present important evidence showing that extensive TV viewing among adolescents and young adults is associated with subsequent aggressive acts.

Despite the consensus among experts, lay people do not seem to be getting the message from the popular press that media violence contributes to a more violent society. We recently demonstrated that even as the scientific evidence linking media violence to aggression has accumulated, news reports about the effects of media violence have shifted to weaker statements, implying that there is little evidence for such effects (*4*). This inaccurate reporting in the popular press may account for continuing controversy long after the debate should have been over, much as the cigarette smoking/cancer controversy persisted long after the scientific community knew that smoking causes cancer.

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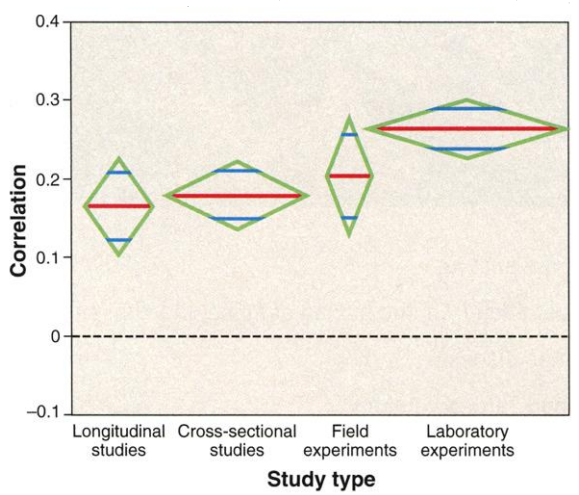
Aggression researchers have adopted a triangulation strategy to examine the effects of violence in the media. Specifically, divergent research methods have been applied in the belief that using several unique methodological approaches yields a clearer picture than would be possible with any single method. Results of a meta-analysis of all available studies investigating the hypothesis that exposure to media violence increases aggression are displayed in the figure (*4*). A positive link between media violence and aggression regardless of research method is clearly shown (see the figure). Experimental studies demonstrate a causal link. Laboratory experiments yield slightly larger effects than other studies, presumably because of greater control over irrelevant factors (see the figure). Field experiments demonstrate causal effects in naturalistic settings. Cross-sectional studies demonstrate a positive association between media violence and types of real-world aggression (for example, assault) that cannot be studied ethically in experimental settings. Longitudinal studies reveal long-term effects of early media violence exposure on later aggressive acts. These effects are not trivial in magnitude. For example, they are larger than the effects of calcium intake on bone mass or of lead exposure on IQ in children (*4*). Interestingly, recent work demonstrates similar-sized effects of violent video games on aggression (*5*).



Media violence and aggression. Effects of media violence on aggression for different types of studies. Diamond widths are proportional to the number of independent samples. There were 46 longitudinal samples involving 4975 participants, 86 cross-sectional samples involving 37,341 participants, 28 field experiment samples involving 1976 participants, and 124 laboratory experiment samples involving 7305 participants. Red lines indicate the mean effect sizes. Blue lines indicate a 95% confidence interval. Note that zero (dashed line, indicating no effect) is excluded from all confidence intervals.

The longitudinal study by Johnson and colleagues (*3*) is important for at least three reasons. It is the first published longitudinal study to link television exposure during adolescence and young adulthood to subsequent aggression, contradicting the common assumption that media violence affects only children. It therefore adds to extant research linking childhood TV habits to adult aggression and violence (*6*, *7*). Second, its relatively large sample size (707 families) and time span (17 years) allowed a meaningful test of television exposure on severe aggressive behaviors (such as assault and robbery). Third, by statistically controlling for key childhood factors known to affect aggression (including childhood neglect, family income, neighborhood violence, parental education, and psychiatric disorders) the investigators were able to rule out numerous alternative explanations.

One potential problem with the Johnson *et al.* study is the use of hours of TV viewing, rather than hours of viewing violent TV. This is somewhat problematic because the primary source of TV viewing effects on aggression is believed to be violent content. However, about