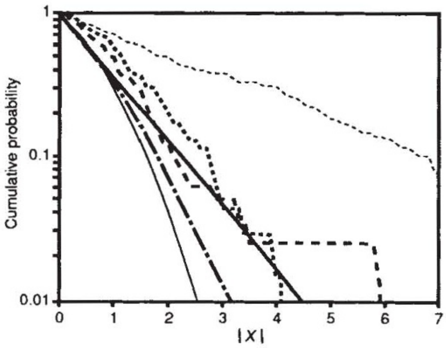
Sea-level rise or fall?

SIR — Schneider[1] provides just one example of how a change in the accepted values of parameters in climate-change models can completely alter the conclusions, turning a predicted sea-level rise into a predicted fall. If a model predicts a sea-level rise of 33 ± 32 cm in the year 2050 (ref. 2), what is the probability of an extreme rise of 150 cm? Or, for example, how should one interpret the 'confidence interval' defined by low- and high-growth schemes for future changes in population and energy production? Such questions can be addressed by comparing the data on the history of previous measurements in other fields and corresponding uncertainty estimates with the 'true' or 'best guess' values obtained later.

A convenient measure of the deviation of 'new' values from the 'old' values is $x = (a - A)/\Delta$, where a is the exact value, A the previously measured value, and Δ the old standard deviation. We analysed 79 elementary particle properties (mainly meson masses and lifetimes; thick dashed line in the figure), 69 forecasts of the primary energy demand for the United States projected for the year 2000 (thick dotted line) and the predictions of population for 133 countries for the year 1985 made in 1973 (thin dotted line, assuming that high and low estimates encompass 50% confidence interval)[3]. The cumulative probability distributions are shown in the figure together with the gaussian curve (thin solid line), which obviously grossly underestimate probability of large deviations. Also plotted is the Student's distribution for 10 degrees of freedom (heavy broken dashed line), illustrating the maximum effect of the finite sample size for energy forecasts (11 points per bin, or 10 degrees of freedom). A better fit to the data is obtained with a simple exponential distribution, $e^{-|x|}$ (heavy solid line).

This asymptotic behaviour appears naturally in a compound distribution where both the mean and standard deviation are independent, normally distributed, random variables. Following ref. 4, we assume that the calculated standard deviation Δ' is distributed around its true value Δ; we denote this distribution by $f(t)$, where $t=\Delta'/\Delta$. If for simplicity, we assume $f(t)$ to be asymptotically gaussian, that is, $f(t) \sim \exp(-t^2/2\delta^2)$ as $t \to \infty$, and consider only the asymptotic behaviour of the probability distribution $P(x)$ when $|x| \gg 1$, it is straightforward to show that for $|x| \gg 1$, the probability distribution is not gaussian but exponential: $P(x) \sim \exp(-|x|/u)$. Here the new parameter u, $u=\delta/\Delta$, measures the unknown systematic component of the total error and quantifies the uncertainty, δ, in the estimation of Δ. Gaussian and exponential distributions can be related by a single-parameter family of curves, so that the parametric uncertainty of current models can be quantified by analysing the record of earlier projections and estimating the value of u (ref. 3). From the figure, it emerges that $u \sim 1$ for physical constants and projections of energy demand, and $u \sim 3$ for models of population growth.

Fundamental physical constants are generally considered to be the most reliably known parameters, yet analysis of the trends in their measured values indicates widespread overconfidence in the completeness of our knowledge[5].



Cumulative probability of finding a deviation greater than $|x|$. The data are drawn from various sources: projections of US energy demand in 2000 AD (heavy dotted line); measured parameters in elementary particle physics (heavy dashed line); projections for population in 2000 AD for 133 countries (thin dotted line). Theoretical curves for a gaussian distribution (thin solid line), Student distribution (heavy broken dash line) corresponding to the sample size per bin for the energy data, and an exponential distribution (heavy solid line) with $u = 1$.

There is every reason to expect similar or greater effects in models of global environmental change. For sea-level rise, there is no long history of projections that we can use to estimate the value of the parameter u. Error estimates in this case are little more than educated guesses; if we conservatively assume $u=1$, in the 'business-as-usual' scheme the normal distribution places the probability in 2050 AD of extreme sea-level rise greater than 1 m at 0.5% (ref. 2) in contrast to the 5% probability based on an exponential distribution[3], a difference of an order of magnitude. We wish to encourage others to quantify the predictive capabilities of their models by using the historical trends in parameter values from previous studies.

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Mirror script

SIR — Smetacek[1] explains the leftward ancient mirror writing of the Semitics and the archaic Romans and Greeks by an ancient use of the left hand. There is another explanation involving leftward eye movements, the left visual field and the right hemisphere.

Eye movements, the covert scanning of letters and mirror-image perception of words, are linked to the two visual fields. Leftward scripts (scanned with leftward eye movements) are read through a visual window extending into the left visual field (rightward ones are read through one extending into the right visual field)[2]. Mirror-reversed words[3] are better identified than their unreversed images in the left visual field, with the opposite being the case in the right field. Visual fields and eye movements are also connected to the two cerebral hemispheres. The left visual field is connected to the right hemisphere and the right with the left hemisphere — in part this explains the connection between mirror perception and visual fields: the two hemispheres in some circumstances represent visual[4] engrams learnt in the other hemisphere in their mirror form. Also, each hemisphere controls eye movements directed in the opposite direction (the right hemisphere controls leftward eye movements and the left hemisphere rightward ones), so images scanned through the left visual field into the right hemisphere are also reciprocally controlled by this hemisphere.

Reading is a demanding ocular-motor activity, particularly for inexperienced (or archaic) readers. Ocular-motor control, at least for tasks that have not been over-learnt, is a right-hemisphere specialization[5]. Thus in the early stages of reading development the ocular-motor requirement to scan writing would have produced a right-hemisphere bias to control reading eye movements with this hemisphere and so favour the rise of the leftward reading (and writing) over the opposite, rightward one. So I suggest that leftward writing originates not in the ancient use of the left hand but in the use of the right hemisphere to control the eye movements of early readers.

Why did writing direction change?