

***TIME CONSTANT, HEAT CAPACITY AND SENSITIVITY OF  
EARTH'S CLIMATE SYSTEM***

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**ABSTRACT**

Knowledge of Earth's climate sensitivity, the amount by which global mean surface temperature (GMST) would change in response to an imposed radiative forcing (global average change in a radiative flux component) is important to developing confident ability to project future climate change in response to prospective changes in atmospheric composition resulting from alternative energy use strategies. This climate sensitivity is not well established; recent estimates from international reviews place this sensitivity as about  $3 \text{ K}/(\text{W m}^{-2})$ , with an uncertainty of a factor of 3, unchanged for some 30 years. Here a new approach to determine Earth's climate sensitivity is introduced that is based on an energy balance approach. The climate sensitivity is evaluated as the quotient of the effective climate system time constant divided by the effective planetary heat capacity. The effective heat capacity of the world ocean is inferred from tabulated measurements of ocean heat content as determined by soundings of ocean temperature over the past 50 years to be  $14 \pm 3 \text{ W yr m}^{-2} \text{ K}^{-1}$ ; other contributions to heat uptake raise the global heat capacity to  $17 \pm 3.5 \text{ W yr m}^{-2} \text{ K}^{-1}$ . The effective time constant is inferred from analysis of the autocorrelation of time series of GMST as  $5 \pm 1 \text{ yr}$ ; an alternative approach that uses non-detrended time series data yields 16 years. The resulting estimates of climate sensitivity are  $0.30$  and  $0.96 \text{ K}/(\text{W m}^{-2})$ , respectively; the corresponding sensitivities to doubled atmospheric  $\text{CO}_2$  (forcing  $3.7 \text{ W m}^{-2}$ ) are  $1.1$  and  $3.6 \text{ K}$ , respectively. The issue of which value is appropriate is unresolved. Because of the short time constant of climate system response to perturbations, the climate system response to greenhouse forcing is in near steady state, with little expected further warming due to present greenhouse gases.

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