The Earth's energy budget and aerosol radiative forcing

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We examine the Earth's energy balance since 1950 using measurements and radiative transfer calculations, thus identifying results that can be obtained without using global climate models. Important terms that can be constrained in this way are ocean heat content, radiative forcing by long-lived trace gases, radiative forcing from volcanic eruptions, and the increasing emission of heat from a warming Earth. We use correlations between surface temperature and ERBE or CERES data to define the emission of energy by a warming Earth and show that is already quite significant. We find that about 20% of the integrated positive forcing by greenhouse gases and solar radiation since 1950 has been radiated to space. Only about 10% has gone into heating the Earth (atmosphere and oceans). About 20% of the greenhouse gas forcing has been balanced by volcanic aerosols. After accounting for the measured terms, the residual forcing due to direct and indirect forcing by aerosols can be estimated as can be estimated as -1.0±0.4 W m^{-2} (1σ) between 1970 and 2000. This is consistent with the IPCC best estimate for the sum of direct and indirect aerosol but rules out very large negative forcings from aerosol indirect effects. Further, the data are sufficient to constrain decadal changes in aerosol forcings. These are consistent with estimates of trends in global sulfate emissions.

Tritium-helium dating of a TCE-contaminated aquifer for model validation

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Need for Independent Constraints on Model

A deltaic sand aquifer is contaminated with trichloroethylene (TCE), and a numerical groundwater model is being developed to define the transport of dissolved TCE plumes. To further constrain the model, another calibration target is required besides hydraulic heads [1]. ^{3}H-^{3}He ages of groundwater in the plume are measurements that can provide independent estimates of hydrologic parameters to be compared with model simulations [2], and relate parts of the TCE plume to the history of its release [3].

Discussion

^{3}H-^{3}He ages were obtained along flowlines originating from two distinct TCE source zones, which converge to form a single plume. Flowlines were defined by the numerical model. Isotopic ages were compared to simulated ages using a range of values for porosity to determine the best match.

In certain locations, anomalously old ^{3}H-^{3}He ages with high concentrations of terrigenic He indicate areas where groundwater from the underlying proglacial unit flows upward into the deltaic sand aquifer through aquitard windows. The upflow locations correspond with increased TCE concentrations, suggesting significant "late" TCE provenance from the proglacial unit and a possible third source of TCE contributing to the plume.

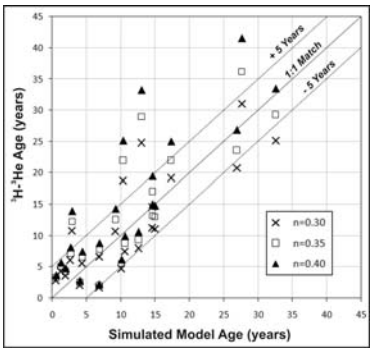

Figure 1: ^{3}H-^{3}He ages compared with model ages at different porosity values

[1] Konikow & Bredhoeft (1992) *Adv. Wat. Res.* **15**, 75-83. [2] Solomon *et al.* (1992) *Wat. Resour. Res* **28**, 741-755. [3] Dunkle-Shaprio *et al.* (1999) *Ground Water* **37**, 861-878.