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47 TW ± 2 TW : A Revised Estimate of Earth's Surface Heat Flow

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Earth's surface heat flux provides a fundamental boundary condition on mantle dynamics. Estimating Earth's total surface heat flow is difficult. The two main issues are the fact that (i) many of the measurements in young oceanic crust are affected by hydrothermal circulation, and (ii) the geographic distribution of heat flow measurements is very uneven.

We used a database of 38347 heat flow measurements (provided by G. Laske and G. Masters) to produce our estimate of the global heat flow. This database represents a 55% increase on the number used previously. We use methods from Geographical Information Science (GIS). This allows accurate registration of geology with heat flow measurements and accurate calculations of areas. We account for the first issue, hydrothermal circulation in young ocean crust, by using a half-space cooling model. Our choice of parameters is guided by the work of Jaupart et al., (2007).

To attempt to overcome the second issue of uneven distribution of data we evaluate an average heat flux for different geological domains. The global surface heat flow is derived by multiplying the average surface heat flux for each geology domain with the total area of that geology domain and summing. The raw data suggests that this method of correlating heat flux with geology has some power. The digital geology data sets used are (i) continental geology - Hearn et al., 2003; and (ii) the global data-set of CCGM – Commission de la Carte Géologique du Monde, 2000. The resulting Earth geology is defined by > 93,000 polygons. To limit the influence of clustering in the original heat flux measurements, we intersect the geology polygons with an equal area grid (1 by 1 degree at the equator). For Antarctica we use an estimate based on depth to Curie temperature and include a 1TW contribution from hot-spots in young ocean age. Geology classes with less than 50 readings are excluded.

Our revised estimate for Earth's global surface heat flux is 47 TW, which is similar but slightly higher than previous estimates (e.g. Pollack et al., 1993 – 45 TW; and Jaupart et al., 2007, - 46 TW). The error estimate, which is also important, is intermediate at 2TW (Pollack et al., 1993 – ± 1 TW; and Jaupart et al., 2007, ± 3 TW). It is challenging to reconcile such a high heat flow with estimates of internal heat sources in a monotonically cooling mantle. Either there is a hidden reservoir with high heat sources, or we do not understand properly the reservoirs currently sampled, or Earth's evolution is not uniform and we are currently in a time of abnormally high heat output. We will discuss some of the dynamic implications of this work.

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