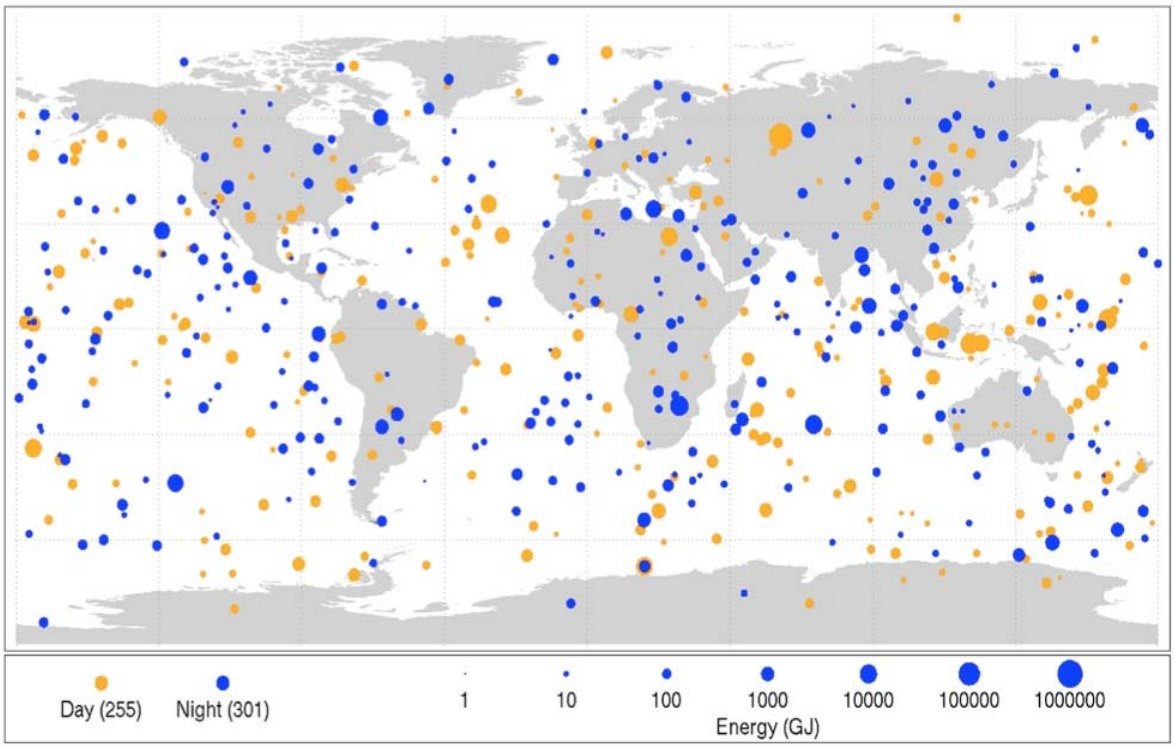

Data gathered by U.S. government sensors between 1994 and 2013 shows that fireballs (called bolides by astronomers) are frequent and random as the map above shows. Over this 20-year interval, 556 bolide events were recorded by satellite sensors in space. On this world map, the size of the orange dots (daytime events) and blue dots (nighttime events) are proportional to the energy of the impact event measured in billions of Joules (GJ) of energy. These bolides were smaller than 20-meters and burned up or exploded in the atmosphere before striking the ground. Every day, Earth is bombarded with more than 100 tons of dust and sand-sized particles from space. About once a year, an automobile-sized asteroid hits Earth's atmosphere. About once every 5,000 years or so on average an object the size of a football field hits Earth and causes significant damage. In the problems below, provide answers to two significant figures.

Problem 1 – What is the average distance between these events, and the average time in weeks between sightings if the surface area of Earth is 5.1×10^{14} meters^2?

Problem 2 – Calculate the average time between bolide events over; a) North America, and B) South America.

Problem 3 – There were 14 events during this time with more energy than 10,000 GJ. If the kinetic energy is given by $E = \frac{1}{2}\ mV^2$, and Mass = Density x Volume, what is the diameter in meters of a bolide with this energy if its speed is 15,000 meters/sec and its density is 2000 kg/meter^3? (Note: E is in Joules, m is in kilograms, and the object is assumed to be a sphere).

For additional information, read the news release at:

http://neo.jpl.nasa.gov/news/news186.html

Problem 1 – What is the average distance between these events, and the average time in weeks between sightings if the surface area of Earth is 5.1×10^{14} meters^2?

Answer: There are 556 bolide events spread across the surface area of Earth. The radius of Earth is 6378 kilometers, and its surface area is $4 \pi (6378000)^2 = 5.1 \times 10^{14}$ meters^2. There are 556 objects spread across this area so the area for one object is 5.1×10^{14} meters^2/556 = 9.2×10^{11} meters^2. A square with this area has a side length of $(9.2 \times 10^{11})^{1/2}$ or 959 kilometers, so the average distance between the bolide sightings is **960 kilometers**. There were 556 events in 2013-1994 = 19 years or 988 weeks, so the average time between sightings is 988/556 = **1.8 weeks**.

Problem 2 – Calculate the average time between bolide events over; a) North America, and B) South America.

Answer: A) Over and in the immediate vicinity of North America, including Canada and Alaska is 35 events, over 19 years or about **1.8 events per year**. B) For South America, there were about 20 events, or **1.1 events per year**.

Problem 3 – There were 14 events during this time with more energy than 10,000 GJ. If the kinetic energy is given by $E = \frac{1}{2} mV^2$, and Mass = Density x Volume, what is the diameter in meters of a bolide with this energy if its speed is 15,000 meters/sec and its density is 2000 kg/meter^3? (Note: E is in Joules, m is in kilograms, and the object is assumed to be a sphere).

Answer: E = 10,000 x 1 billion = 10^{13} Joules. V = 15,000 meters/sec so from $E = \frac{1}{2} mV^2$ we have $10^{13} = 0.5$ M x $(15000)^2$ so M = 89,000 kilograms.

M = 89,000 kg = $4/3 \pi R^3$ x (2000 kg/m^3) so solving for R we have

Volume = 89000/2000 = 44.5 meter^3

$44.5 = 4/3 \pi R^3$

So **R = 2.7 meters**.