

### Modern Doomsday Scenarios: Global catastrophe at the movies

#### Disaster Movies

The genre of science fiction has greatly increased public awareness of global catastrophe.

While disaster movies are designed first, and foremost, to entertain (and therefore take many liberties in stretching the truth for dramatic purposes), most are based on a grain of scientific "truth".

Today, we will look at the "grains of truth" in some recent natural disaster movies with which you should be at least mildly familiar.

#### Two Recent Films: Deep Impact and Armageddon



Deep Impact  
(released May 8, 1998)



Armageddon  
(released July 1, 1998)

#### Deep Impact vs. Armageddon

Both movies have the same premise: big object hurtling through space threatens to hit Earth and it must be stopped!

Differences:

In Deep Impact, the object is a comet.  
In Armageddon, the object is an asteroid

But the message was the same: the threat of impact is real.

#### How real is the threat of bolide impact ?

Based on what we know about geological events, there is always a threat of impact.

Examples already discussed are the Sudbury Basin and the Chicxulub Crater (Mexico).

But these happened a long time ago – are there any relatively recent examples?

#### Tunguska Event: What is Known

Seismic vibrations were recorded by sensitive instruments as much as 1000 km away from ground zero.

At 400-500 km, observers reported "deafening bangs" and a fiery cloud on the horizon.

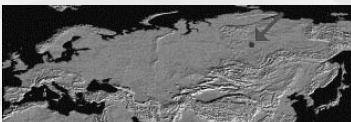


400 km southeast of explosion

#### Tunguska Event (1908)

Although the Tunguska event was not large enough to affect the global population, it emphasizes the possibility of impact by large objects.

At 7:17 AM on the morning of June 30, 1908, a mysterious explosion occurred in the skies over Siberia.



About 170 km from the explosion, the object was seen in the cloudless, daytime sky as a brilliant, sunlike fireball; thunderous noises were heard.



At distances around 60 km, people were thrown to the ground or even knocked unconscious; windows were broken and crockery was knocked off shelves.



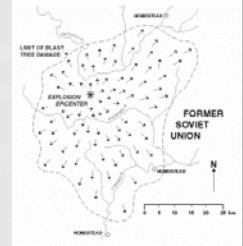
The closest observers were some reindeer herders asleep in their tents in several camps about 30 km from the site. They were blown into the air and knocked unconscious; one man was blown into a tree and later died.



### Felled Trees

An expedition led by Professor Leonid Kulik of the Soviet Academy of Science travelled to the impact site in 1930. Even 22 years after the event the devastation was immense.

Within 30-40 kilometres of ground zero almost all of the trees had been uprooted, burnt, blown flat, forming a radial pattern away from the blast site.



### Felled and Charred Trees



From observations on the pattern of devastation and from eyewitness accounts, it was later determined to have been caused by the breakup of a large meteorite (about 50 metres in diameter) at an altitude of roughly six kilometres in the atmosphere (an air burst).

The energy released was equivalent to 1,000 Hiroshima bombs.

Particles analyzed from tree resin are consistent with the composition of a stony meteorite (rich in iridium).

No crater was produced by this event as the object entirely disintegrated in the atmosphere (i.e. there was no direct impact on the ground).



### Impact

The pieces of comet were like flies on a planetary windshield.

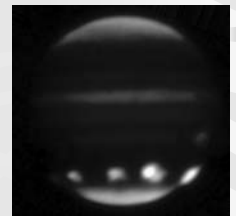


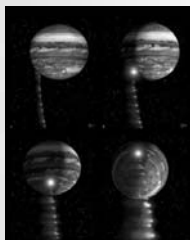
Image of Jupiter was taken by the NASA Infrared Telescope Facility infrared camera at Mauna Kea, Hawaii.

### Comet Impact

So why is a comet the bad guy in Deep Impact ?

The first real-time observations of a significant bolide colliding with a planet in recorded history was Comet Shoemaker Levy 9.

Torn apart by tidal stresses on a close pass to Jupiter in 1992, the comet fragments were discovered in 1993 before meeting a spectacular demise in July 1994 when over 20, kilometre-scale fragments crashed into the planet at 60 km/s.



### Impact Scars

But in the aftermath, mighty Jupiter bore huge, Earth-sized scars which took months to dissipate in its upper atmosphere.

Could an event of this scale affect Earth ?



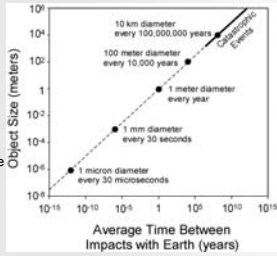
### What Are The Risks ?

As seen in this graph, frequency and size of impacts are inversely proportional.

In other words, the frequency of a very large impact is less than that of a small impact (thank goodness).

However, stations worldwide are currently recording the positions of near-Earth objects (just in case).

Chances of catastrophic impacts are low, but real !

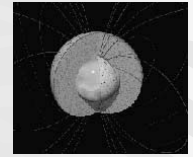


### The Basic Idea

For quite some time, it has been generally thought that Earth's magnetic field is generated within Earth's iron-nickel, outer core.

In essence, convective flow of material in the outer core creates an electric current that, in turn, creates a magnetic field (similar to an electromagnet).

So the main idea of the movie is on par with current knowledge (although it is the flow of convection currents in the liquid outer core, not the core's spin that drives the magnetic field).



### The Core (released March 28th, 2003)



Basic premise: A diabolical military experiment has caused the Earth's core to stop spinning, causing the loss of Earth's magnetic field. Electromagnetic disturbances are everywhere and microwaves threaten to fry the planet.

A crew of terranauts travel to Earth's core in a ship made of "unobtainium" to set off nuclear explosions and get the core spinning again.

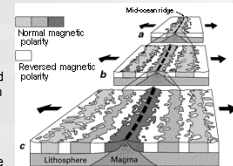
As with many recent movies of this ilk, the conclusion of the movie can be accurately predicted within the first 10 minutes of viewing.

### The Basic Idea

It is also true that the Earth's magnetic field fluctuates in intensity and polarity.

According to Earth's geological record, our planet's magnetic field weakens and flips (in polarity), on average, about once every 200,000 years.

However, the time between reversals does vary. The last time Earth's magnetic field flipped was about 780,000 years ago.



Remember, for example, evidence of polarity reversals at divergent boundaries

### A Few Flaws in The Core

The Core has an unusually large number of erroneous ideas for a "serious" science fiction effort—enough to overshadow obvious problems such as:

A vessel capable of withstanding the intense pressures and temperatures of Earth's interior or (space) suits that do the same thing!

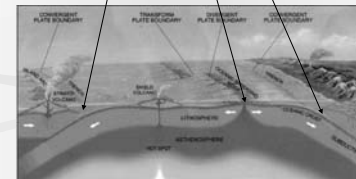
Giant, amethyst-lined cavities in the mantle (under pressures 50,000 times the atmospheric pressure at sea level)

If you watch the movie now, you will probably be able to come up with some of your own criticisms.

Following are a couple of the less obvious ones.



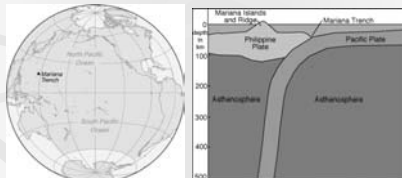
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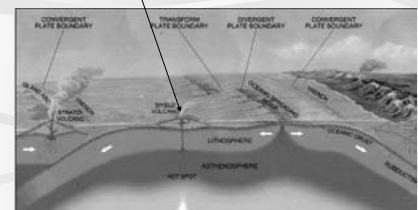
An easier route would be down a mid-ocean ridge (at a divergent boundary) where the lithosphere is thinnest and in a state of tension.

### A Few Flaws in The Core

Even if you could travel to the Earth's interior, why start your descent at the Marianas Trench (at a subduction zone), where the lithosphere is thick and rocks are in a state of compression?



Hotspot volcano (within a plate)



The terranauts decide to return to the surface at Hawaii (which is claimed to lie between two tectonic plates). Hawaii is actually situated within a plate (volcanism here is due to Hawaii's position over a stationary mantle hotspot).

### And a Real Biggie...

If Earth's magnetic field did shut off, we would not be fried by microwaves!

Solar microwaves are too diffuse in space to do any damage (note also the large number of microwave transmission systems around us used for communication).

Also, Earth's magnetic field doesn't block microwaves (it is the atmosphere that does this).

A greater number of charged particles from the sun would reach Earth's surface if our magnetic field was removed, but the atmosphere would provide greater protection than the magnetic field ever could!



### So What About Those Microwaves ?

Again, if the magnetic field was shut down, increased microwave exposure would be of little concern.

Communication systems could be affected, but that's about it.

Cell phones would be disabled. GOD FORBID!

Migratory animals might also be affected by a magnetic reversal, but to what degree—who knows. But as far as we know, no significant biological catastrophes have ever accompanied magnetic reversals.

### The Day After Tomorrow (Release Date: May 28th, 2004)



Basic Premise: The local forecast calls for a monster tidal wave to crash into Manhattan; this is followed by plummeting temperatures (globally?), and by late afternoon, the entire Northeast U.S. is frozen beneath a freshly spawned glacier.

Cause of disaster: Melting of glaciers at poles (due to global warming) has shut off the oceanic circulation system that moderates Earth's climate.

### Thermohaline circulation

Atmospheric circulation is influenced to some degree by ocean currents that flow due to contrasts in temperature ("thermo") and salinity ("haline").

For example, warm seawater in the equatorial Atlantic flows northward along North America (as the Gulf Stream), cools in the North Atlantic (becoming more dense) and flows southward.

Note that the climate of western Europe and Scandinavia is warmed by the northward-flowing Atlantic current. The climates of these regions would be like those of Arctic Canada (at similar latitudes) otherwise.



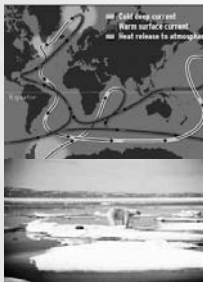
### Could Thermohaline Circulation be Shut Off ?

Possibly, though maybe not entirely.

Global warming would serve to decrease temperature differences between the poles and the tropics, making thermohaline circulation much weaker.

Also, fresh water from melting ice caps is less dense than regular seawater.

Pooling of cold, fresh water in the vicinity of former icecaps (e.g. Greenland, Antarctica) might prevent the descent of thermally dense polar seawater, effectively short-circuiting the thermohaline conveyor system, though the potential extent of such an effect is unclear.



### Effect of Shutting Off Thermohaline Circulation

The result: areas that would normally be warmed by the warm surface current (e.g. NW Europe and Scandinavia) would become colder, while the tropics would become hotter.

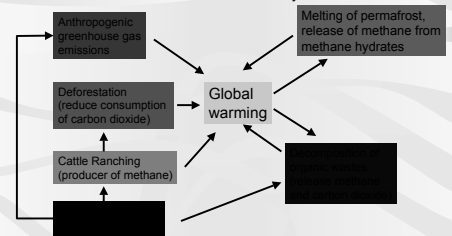
The climates of areas not strongly affected by currents would remain largely the same.

Contrary to the "The Day After Tomorrow" scenario, these changes would take at least several decades to occur (ice sheets of this nature usually take hundreds of years to form through accumulated snowfall), not a few days as suggested, and would have less than a global effect (at least initially). The whole world (or even portions) would not be plunged immediately into an ice age.

Nevertheless, the movie underscores the significance and potential (non-intuitive) effects of global warming.



### Perhaps Doomsday is Staring Us in the Face: Interactions in the Earth System ?



Positive feedback makes slight changes BIG CHANGES!

END OF LECTURE