Movie review on the scientific merit of the day after tomorrow

Environment, Climate

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Introduction

Science fiction and disaster films often must take dramatic liberties with science and truth in order to serve a greater narrative purpose; events are compressed, effects are exaggerated, and realism and physics are thrown out the window in order to provide greater drama and spectacle (Revkin, 2004). In the movie The Day After Tomorrow, directed by Roland Emmerich in 2004, the world is subjected to global disasters brought about by climate change. The effects are myriad; global cooling sets New York in a coating of ice and freezing temperatures, glaciers crack and separate, and a “ superstorm” is said to cause rapid climate change within a matter of days. Despite the admirable efforts of the filmmakers to show the effects of climate change in an immediate and pressing way, the quality of the

scientific accuracy in the film is incredibly lax, leading to a film that does not represent geology and ecological science in a valid way. The scientific validity of the film will be examined through its representation of global warming/cooling, climate change, weather phenomena and geological factors.

Global Cooling

The first and arguably most important, scientific premise of the movie is that the world is rapidly experiencing what paleoclimatologist Jack Hall (Dennis Quaid) refers to as “ global cooling,” in which the Earth would enter a new ice age. Hall notes that “ We know that North America and Eurasia are only habitable because of the thermohaline circulation" (Emmerich, 2004). Thermohaline circulation, it must be noted, is the large-scale circulation of the ocean that occurs due to the changes in surface heat and the density of sea water (Rahmstorf, 2003). This global circulation of ocean currents brings warm water in from the tropics, thus allowing it to become habitable (Monbiot, 2004). It is theorized that this is what caused the last ice age more than 8, 000 years ago. In this period, an ice-dam in northeast Canada burst, leading to a large amount of meltwater that flushed through the Atlantic and over most of North America, leading to the 200-year-long ice age we know to exist (Monbiot, 2004).

In the film, Jack Hall explains the ancient climate shift that occurred during the end of the glacial period that signaled the previous ice age. Sheets of melting ice shut down ocean circulation because of the addition of the large amount of freshwater to the sea. This was known as the Younger Dryas, and

took place approximately 12, 000 ago (Muscheler et al., 2008). In the Younger Dryas, which lasted approximately 1300 years, intense global cooling led to colder climates and drought, making conditions harsh for life in the Northern Hemisphere (Muscheler et al., 2008). In the film, the characters experience a reoccurrence of the same conditions, but at a dramatically accelerated rate.

Figure 1. The nature of thermohaline circulation. (Source: NASA Earth Observatory)

In the film, however, the threat of a new ice age is threatened to happen once more; the thermohaline circulation is rapidly shutting down, which will quickly bring about these rapid decreases in temperature that led to the new ice age. However, there is not enough fresh water to shut this circulation system down, and the speed of the ice age's destruction is rapidly sped up for dramatic effect (Monbiot, 2004). Instead of the years or decades it would take realistically to effect the kind of widespread global cooling that occurs in the film, The Day After Tomorrow has these events occur in a matter of weeks. Research indicates that subtle changes have occurred throughout the waters of the North Atlantic through the next half century, and this kind of change will continue to occur slowly (Duke University, 2004).

Super Storms and Adverse Weather Events

The cruxes of the huge climactic weather event that brings about the disasters the characters must outrun and survive are a series of 3 superstorms that move south from the Polar Regions. However, the superstorms themselves are presented in an extremely inaccurate and

inconsistent fashion; the movie's characters mention that the storms act like hurricanes, but never touch the mainland. However, the only feature of the hurricane which resemble the hurricanes depicted in the movie is the eye of the hurricane; the rest of the storm suggests a combination of cyclone, typhoon and thunderstorm that suggests a muddled presentation (Climatesight, 2012). Therefore, the identifying of it as a hurricane is suspicious. Furthermore, shots of the storms from space show them rotating clockwise; cyclones rotate counterclockwise in the Northern Hemisphere, making the direction of their spin inaccurate (NOAA, 2014). This is due to the Coriolis Effect, in which moving objects are reflected by a rotating reference frame in which clockwise rotation deflects to the left and counter-clockwise rotation to the right (Graney, 2011).

Sea Level Increases

One of the ways in which the climate change is conveyed is through a rise in sea level. Extremely rapid sea level rising is not something indicated by the facts surrounding global warming – the effects will be extremely gradual, with estimates stating that the sea levels will instead rise merely 1 to 2 meters within the next century (Climatesight, 2012). However, The Day After Tomorrow shows the ocean having a 25 feet rise in mere seconds along the North American Atlantic coast. Nothing causes this but the melting of the Greenland ice sheets. In reality, ice ages should cause a lowering in sea level, due to several factors. First, global temperatures would drop, causing a contraction in ocean water. Then, the Northern Hemisphere's growth would lock up much of the ice that would usually be liquid water within the ocean.

The shots of Earth from space show the continents being the same general shape as they are now, having no geological alteration like they realistically would in a 25 foot rise in sea water levels. This is a physical impossibility within the world of the film (Climatesight, 2012).

Throughout the film, this kind of climate change is presented through rapid weather shifts, mostly for dramatic or ironic effect. The Larsen B ice shelf is shown to break up – something that has occurred in the real world, roughly contemporaneous to the time of the film's release (Rahmstorf, 2004). However, because of the aforementioned shutdown of the Gulfstream, an inflow of meltwater stops the North Atlantic Current, leading to global cooling that the film's protagonist warns political officials about in the beginning of the film. Because of the oceanic shutdown, a " superstorm" occurs in which severe winds, rain and cyclones envelop the vast majority of the northern hemisphere. Emmerich uses this as a dramatic catch-all to present many different disaster scenes, including the destruction of LA (and the Hollywood sign) by a large tornado, and a giant hailstorm in Tokyo. On the East Coast, the eye of one of these superstorms sucks down cold air from the troposphere, which shock-freezes the tall buildings and skyscrapers of Manhattan, where several other characters are trapped. In the aftermath of the cyclone, the northern hemisphere is effectively trapped in snow, and is thought to remain that way for a very long time. This is due to the concept of snow-albedo feedback, in which snow reflects the sunlight to the extent that the cold climate will remain (Rahmstorf, 2004).

In order to create an effective story that would simulate the effects of rapid climate change, the filmmakers were forced to create major climactic

disasters one after the other within short periods of time, amplifying the effects of storm surges and hailstorms, as well as blizzards and tornadoes in order to make them seem more immense and terrifying for the audience (Ramhstorf, 2004). While increases in extreme weather will occur in cases of abrupt climate change, they will not happen with the rapidity and immensity of the cyclones tearing apart the LA skyline in this film.

Tidal Waves

In the film, a giant tidal wave, also known as a storm surge, rolls into the ocean and completely decimates the streets of Manhattan; it looks to be over 100 feet in size. However, from a physics standpoint, this tidal wave would be impossible – the storm in the film is traveling south, while winds would need to come in from the northwest. With the New York City geography, northwest wings would not be possible, and would not bring about cataclysmic storm surge. Instead of hitting Manhattan, it would also need to have hit Long Island, which would have taken the brunt of the force of the tidal wave – by the time it hit the mainland, it would not have the severity that it does here. If the power of the wave is to be believed, it would have destroyed the Statue of Liberty instead of merely splashing around her, and would have taken down at least some of the skyscrapers instead of running around them as if it were objects in a rising pool of water. In terms of the tsunami, the waters would have receded approximately an hour after hitting the movie, instead of rising like they do in the film. This would have also prevented the cargo tanker from floating into the streets of Manhattan.

Visualization of Extreme Cold

One particularly egregious instance of dramatic license is a scene where several characters run out to a nearby cargo ship (which had washed in due to flooding and large tidal waves) to get medicine for their sick friend. However, at a certain point in the narrative, they must outrun the rapid freezing of air due to wind currents, leading to a harrowing sequence where the characters slowly drag their friend along the ground, attempting to outpace a rapidly approaching wall of frost. This is inaccurate for several reasons: one, humans cannot outrun the wind, which is in effect what they would have to do to survive this sequence. Secondly, the representation of the cold through frostbite creeping up the walls at them is incredibly unrealistic, as it would not accurately pinpoint where exactly the freezing air would be at that given time.

Scientific Modeling Technology

One of the most interesting scientific failures is in the inaccurate representation of scientific modeling technology that characters like Quaid and Ian Holm's characters use to predict the direction and intensity of these storms. Jack Hall attempts to predict how the storm will develop in the course of several months – this is currently not available with today's technology, as weather models are only reliable for the course of several weeks. Because weather is so chaotic, small rounding errors can completely alter the results of a prediction, making them unreliable (Allen, 2004). The characters also seem to not tell the difference between " forecast," " paleoclimate" and " grid" models of computer simulation – complexity is

usually the barometer that distinguishes climate models, not what they are used for. Hall converts paleoclimate and forecast models in order to predict storm paths; this requires him to write several hundreds of lines of code within 24 hours, a feat that is nearly impossible even within the realms of geological computer science (Allen, 2004).

Conclusion

In conclusion, The Day After Tomorrow represents a fairly inaccurate representation of climate change and global weather phenomena. While the central concept of global cooling is still relatively sound, and the basic ideas behind its implementation are grounded in climatology, the timeline is far too compressed and dramatized to be accurate (Branston, 2007). The cyclones, hurricanes and ice storms presented in the film are exaggerated and intensified to a degree where it could not be reasonably used as a tool to educate audiences on geology and geographical science. While global warming and climate change are very real phenomena that the filmmakers likely sought to highlight through the efforts of this film, the results are mixed, as the dramatization of events can run counter to a complex understanding of the concepts behind it (Reusswig & Leiserowitz, 2005). Computer physics are also exaggerated and compressed for the timeline of the film, leading to the potential geology and the capabilities of paleoclimatology to be overestimated. In short, The Day After Tomorrow can be potentially dangerous to watch for a gullible audience, because its over-dramatic representation of weather phenomena and global cooling can leave a doomsday impression on the audience.

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