

JPL scientist analyzes pros and cons of the science in dystopian drama *IO*

Enlarge / Micah (Anthony Mackie) and Sam (Margaret Qualley) are two of the last people on a toxic Earth in the Netflix original movie *IO*.

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Much of the human race has decamped to a distant colony, leaving behind an uninhabitable Earth, in *IO*, Netflix's modest follow-up to its post-apocalyptic thriller, *Bird Box*. Directed by Jonathan Halpert, it's an ambitious film that doesn't quite work, with glacial pacing, little dramatic tension, and a rather flat tone. But it still has some lovely moments and a thought-provoking premise. It made us wonder how much of the film is based in real science, and we turned to Kevin Hand, an astrobiologist and planetary scientist at the Jet Propulsion Laboratory, for answers.

Hand is an ideal person to comment on the film's science. His research interests include studying the ocean worlds of the outer solar system, most notably Jupiter's moon Europa, considered to be one promising site for extraterrestrial life. He's attempted to recreate the conditions on Europa in the laboratory—what he dubs “Europa in a can”—to see if any telltale forms of life might form. (It hasn't so far, but who knows when a breakthrough might occur?) And Hand is part of

NASA/JPL's Europa Clipper mission to send a robotic spacecraft to perform repeated close flybys of the distant moon. He even consulted on the 2013 sci-fi "found footage" film, *Europa Report*, which dramatized a fictional crewed mission to Jupiter's moon.

(Spoilers below for *IO*.)

The world of *IO* is bleak. A catastrophic event has turned Earth's atmosphere toxic, and most of the surviving humans have decamped to a colony on one of Jupiter's moons, Io. Those who clung to hope and remained were forced to move to high altitudes, although many died before they could do so. Our protagonist, Sam Walden (Margaret Qualley), lives a solitary existence on one such mountaintop, carrying on her late father's scientific research on bees and hoping for a genetic miracle that will one day enable her to breathe freely again.

Sam scavenges whatever she needs from the abandoned ruins of human civilization below, using oxygen tanks to survive those short excursions. Every night she peers through a telescope at Io, where her boyfriend Elon (voiced by Tom Payne) is working on an interstellar mission to find the colonists a new Earth-like planet to call home. Their long-distance messages are her only human contact. Then, one day, a hot-air balloon descends from the sky, carrying Micah (Anthony Mackie), who lost his family in the catastrophe. He urges Sam to come with him for the final shuttle launch, carrying any remaining Earthbound survivors to the colony.

Setting up a human colony on Io is "just not tenable."

Unfortunately, setting up a human colony on Io is "just not tenable," according to Hand. The moon has no atmosphere, and it's the most volcanically-active body in our solar system, far more active than Earth. Any colony would be dealing daily with lava flows and plumes of volcanic material raining down. And since Io is deep within Jupiter's magnetic field, any

colonists would also be exposed constantly to intense radiation. Fun fact: it would take between 35 minutes to an hour, one way, for a message to travel from Earth to Io (or vice versa). No wonder Sam finds communication with her distant beloved difficult.

In short, “There are many, many more places that are much more habitable for a human colony than Io,” said Hand-Mars, for instance. But director Ridley Scott already made a blockbuster film about setting up a colony on Mars. Setting up a series of space stations to house former Earth denizens might make more sense, but if a society is sufficiently advanced to accomplish such a huge project, it should also be able to take care of its home planet.

Still, “I’ll give them a mulligan on [colonizing Io], because it’s not actually central to the film,” Hand said. “That premise is just a mechanism to motivate the plot. But I love that it brought Io to the attention of many Netflix viewers.”

A toxic Earth

- The ruins of civilization on Earth after a catastrophic event rendered the atmosphere toxic.
YouTube/Netflix
- Project Exodus: most of Earth’s inhabitants have relocated to a colony on Jupiter’s moon, Io.
YouTube/Netflix
- Sam Walden (Margaret Qualley) leads an isolated existence after the death of her father.
YouTube/Netflix
- There’s still breathable air in pockets at high altitudes.
YouTube/Netflix
- Sam’s mountaintop encampment.
YouTube/Netflix
- A simple candle flame shows it’s safe to breathe.
YouTube/Netflix

- Sam's trusty little ATV has an internal combustion engine and probably wouldn't work in the toxic atmosphere.
YouTube/Netflix
- The atmosphere is radioactive as well as toxic to breathe.
YouTube/Netflix
- Sam's only means of communication.
YouTube/Netflix
- There's a handy old observatory with a working telescope, at least.
YouTube/Netflix
- Every night, Sam looks for Io, where her boyfriend has decamped.
YouTube/Netflix
- A mysterious stranger arrives by balloon one day.
YouTube/Netflix
- Anthony Mackie plays Micah, whose family perished after choosing not to go to the colony.
YouTube/Netflix
- Checking the wind conditions, old school.
YouTube/Netflix
- Io has no atmosphere and an abundance of volcanic activity. It's lovely, but not really good for a colony.
YouTube/Netflix

Hand did find the notion of a toxic lower Earth's atmosphere fascinating, however—a situation that would force any living thing that needs oxygen to move to higher elevations. “Perhaps the oxygen is thinner, but they can still survive,” he said. The film never really explains how this happened; it merely references a certain catastrophic event that pushed our planet past the tipping point, causing a sudden shift into toxicity.

A massive series of cataclysmic volcanic eruptions might do the trick, according to Hand, like a Yellowstone supervolcano eruption (such events occurred in the region 2.1 million, 1.3

million, and around 630,000 years ago). The other option is the standard “get out of jail free” card for a planetary scientist casting about for a viable explanation: a large asteroid or comet hit the earth, similar to the extinction event that wiped out the dinosaurs.

One small nitpick: in the film, Earth now has a very clearly stratified atmosphere. This is a common feature on several other planets, but in reality, Earth has a very dynamic, constantly circulating atmosphere. “We’ve got all sorts of zonal winds that kick around, both as a function of altitude within the atmosphere, and longitude and latitude,” said Hand. That makes achieving a stable stratified atmosphere much more difficult on Earth.

Another minor nitpick: Sam drives a sporty ATV up and down the mountain when she ventures into the danger zone. And it seems to run on an internal combustion engine, which requires oxygen. “If she can’t breathe, neither can the engine,” said Hand. An electric vehicle with a charging station (maybe even solar powered) would have made more sense and is entirely feasible for this supposedly near-term future.

“There is a lot of this kind of good high-concept, low-budget science fiction that is ripe for the plucking.”

Even more intriguing for Hand is the research Sam is continuing on her father’s behalf, studying bees and other insects to see if they would be able to mutate to survive in the harsher conditions. If bees could do it, couldn’t humans develop a symbiotic relationship with some helpful microbes that would also enable Sam to eventually breathe the toxic air without dying? Exactly how this might work is yet another gap in the film’s plot, but it’s not an entirely baseless scenario, since some form of life has been found to thrive even in the extreme conditions of deep-sea hydrothermal vents.

While still a grad student, Hand joined filmmaker James

Cameron's team to collect marine biology samples from deep-sea hydrothermal vents, and he was featured in the director's 2005 IMAX documentary, *Aliens of the Deep*. So he's studied that ecosystem firsthand. The macrofauna (crabs, mussels, shrimp) manage to subsist just fine in a sulfur-rich environment that should be fatal. But they've developed symbiotic relationships with useful microbes that detoxify the water as the macrofauna cycle through. "Humans have plenty of microbes in our guts, for instance," said Hand. So "you can certainly imagine our microbiome adjusting in some way—not just our digestive system but also our respiratory system—that allows us to survive in more toxic environments."

Like us, Hand found a lot to like in *I0*, in terms of the performances and cinematography. "I think there is a lot of this kind of good high-concept, low-budget science fiction that can be done, and it's ripe for the plucking with a venue like Netflix," he said. "So it's wonderful to see Netflix investing in these kinds of stories."

[embedded content]

Trailer for *I0*.

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