Question 1:

Dear Cheap Astronomy – What's with Mars dust storms?

Every Martian year there are continent-sized dust storms – not that Mars has continents, but you know what we mean – they're really big dust storms. But some years, those dust storms meld together to produce a PEDE, a Planet-Encircling Dust Event. There was one this year, in 2018, and there was one back in 2012, and in 2007 and in 2001, which suggests PEDEs happen every three Martian years, remembering that one Martian year is 687 days, which almost 2 Earth years, ish. There was even a PEDE way back in 1971 when the Mariner 9 probe arrived, becoming the first spacecraft ever to orbit another planet – although, because of the PEDE, it had to wait in orbit for several months to get a clear view of the surface.

But anyway, whether they are PEDEs or just really big dust storms, these events happen once a Martian year around perihelion, when Mars' elliptical orbit brings it 19% closer to the Sun than when it's at aphelion. The additional solar flux at perihelion heats the surface, which heats the thin carbon dioxide atmosphere nearby and that heated gas rises. Also, Mars spins nearly as fast as Earth does, so its atmosphere is spun too and it also undergoes day to night heating and cooling – all of which creates winds, just like it does on Earth. And, just like it does on Earth, those winds move laterally as well as upwards, generating vortices and whirlwinds all of which work to lift a substantial amount of dust into the sky. Furthermore, Mars' axial tilt of 25 degrees means the poles get sunlit for long periods during its orbit – so at perihelion, a lot of the frozen polar carbon dioxide sublimates, adding a bit more gas to the atmosphere and hence a bit more oomph to the whole dust storm process.

Why you get big dust storms every Martian year, but you only get a PEDE every three years, is not fully understood, but might be about the way the dust settles back on the surface after a storm. So maybe the two successive years in which there just local storms, concentrates the dust in a way that feeds a PEDE in the third year which then disperses all the dust over a much wider area – which resets everything so for the next two years there's only enough concentrated dust for local storms.

And it's also worth considering what we think of as normal. So, while we might ask why does Mars have all these crazy huge dust storms, we might equally ask why Earth doesn't have them. After all, it's always hotter here and we've also got way more atmosphere than Mars does – meaning Earth has all the factors needed to produce vastly denser winds which are capable of lofting vastly more dust off the surface – and that much is actually true. But what we also have in abundance on Earth, is water. Any appreciable amount of moisture in the air means that small particles lofted upwards will quickly clump together to create larger particles that even our denser atmosphere can't keep aloft – and of course one solid downpour of rain will strip all dust from the sky in matter of moments.

On the very dry Mars there is always dust in the air – most of the dust put up there by the perihelion dust storms does fall back out of the sky, but never all of it – which is why all the probes we've ever landed on the surface look up to see a red sky.

Anyhow, if you really needed another reason why it's such a terrible idea to send people on a one way trip to Mars any time soon – well, here is another reason. Unless, we're going to fly nuclear reactors along with the colonists, the only current solution we have to powering a Martian base is solar power. But, we know that every two Earth years there's a real risk of a

dust storm that might decimate that electrical power production and every six Earth years there be a planetary-wide event that will definitely decimate that electrical power production.

So look, we will get to Mars, really – just not today. There's a whole bunch of stuff we still need to think through. So, pay your taxes, fund your space programs and inspire your children – that's how we'll get to Mars.

Question 2:

Dear Cheap Astronomy – How many microphones have we landed on Mars?

Well technically none, at least none that have landed in working order. You may have recently heard sounds from Mars as picked up by the NASA's insight lander in December 2018. However, these sounds don't quite fit the definition of what we normally consider sounds. One was the output of the Insight seismometer detecting the movement of Insight's solar panels in the Martian wind and the other was an air pressure sensor responding to faint fluctuations in pressure resulting from that same Martian wind. In both cases, the frequency of the signal had to be raised to be made audible. For the movement of the solar panels in the wind, it wasn't much - essentially just adjusting a very low bass tone up to a treble, but the frequency of the air pressure signal had to be raised a thousand times.

So, while it's true that sound is just mechanical energy propagated by pressure waves through the atmosphere – there is a point where you have to start asking whether a sound that you can't hear is actually a sound at all. It's reasonable to accept that there are some sounds that we can't hear, like those sounds that dogs and even bats can hear – not to mention sounds that younger people can hear. But once you have to raise the frequency of a signal by a thousand times to make it audible, it becomes a bit of stretch to keep calling that a sound.

In any case, if you landed a bog-standard audio microphone on Mars you really would hear something – at least now and again. In a laboratory on Earth, we can simulate the cold, 0.01% atmospheric pressure of Mars' carbon dioxide atmosphere – and when you do that, what we consider to be sounds on Earth are still audible. Those sounds will have a lower frequency, that is a lower pitch – mainly because it's a carbon dioxide atmosphere and it's cold. Here's an example the Planetary Society developed – Ray Bradbury on Earth and Ray Bradbury on Mars.

The very low atmospheric pressure on Mars mainly affects sound attenuation, which means that sounds on Mars will fade more quickly over distance than they would on Earth. This means that Mars will be a much quieter place than Earth is, notwithstanding there's not that much going on on Mars to make sounds in the first place. But we are confident we will hear wind and perhaps some electrical disturbances in the atmosphere that produce thunder, although it will be very quiet thunder. The loudest things of all will be sound of our own robots going about their business. Mars is after all a robot planet.

The reluctance to send microphones to Mars, is mostly because anything you send to Mars will cost you. There's a certain financial cost, but more importantly there are opportunity costs, because there's always a huge long list of stuff that people want to send Mars, so if a

microphone goes, then something else doesn't go. And while there's a certain scientific value in getting audio data, no-one's expecting that you'll get a lot of different data, since the only things moving around are either the atmosphere or your robot. The sound of the wind might change a bit when you get different wind speeds, but if wind speed data is what you want you'd be much better off sending an anemometer, which measures wind speed directly and can send back more high-precision data than what you would estimate from a microphone. And the data you get from an anemometer is just numerical data, which will take up far less of the limited bandwidth available to send data back to Earth than audio would.

Carl Sagan suggested sending a microphone to Mars – and it does seem a bit like turning Voyager 1 around to photograph the distant pale blue dot of Earth – that is, it's more about captivating public interest than it is about science. The Planetary Society, founded by Sagan and colleagues, has since led the way and they did actually manage to get one on board the Mars Polar Lander, but sadly it crashed rather than landed and that was that. The next attempt will be the Mars 2020 rover, which is not all that far off really. So, while Mars Insight only gave us pseudo sounds, the real thing may only be a couple of years away. Onwards and upwards – and let's turn it up to 11.