Could planting trees in the desert mitigate climate change?

EGU press release on research published in Earth System Dynamics

As the world starts feeling the effects of increasing atmospheric carbon dioxide and consequent global temperature rise, researchers are looking for a Plan B to mitigate climate change. A group of German scientists has now come up with an environmentally friendly method that they say could do just that. The technique, dubbed carbon farming, consists in planting trees in arid regions on a large scale to capture CO_2. They publish their study today in Earth System Dynamics, a journal of the European Geosciences Union (EGU).

"Carbon farming addresses the root source of climate change: the emission of carbon dioxide by human activities," says first-author Klaus Becker of the University of Hohenheim in Stuttgart.

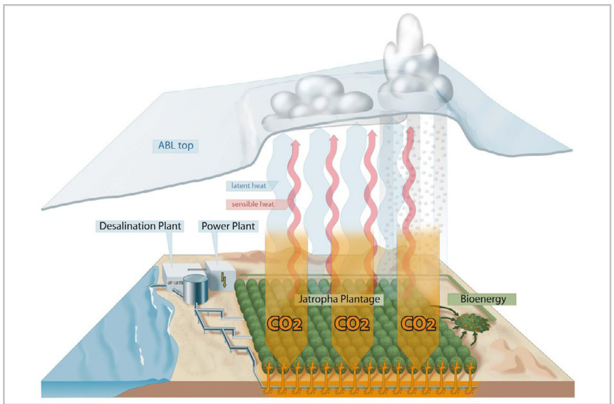
"Nature does it better," adds Becker's colleague Volker Wulfmeyer, "if we understand and can make use of it in a sustainable manner."

When it comes to sequestering carbon from the atmosphere, the team shows that *Jatropha curcas* does it better. This small tree is very resistant to aridity so it can be planted in hot and dry land in soil unsuitable for food production. The plant does need water to grow though, so coastal areas where desalinated seawater can be made available are ideal.

"To our knowledge, this is the first time experts in irrigation, desalination, carbon sequestration, economics and atmospheric sciences have come together to analyse the feasibility of a large-scale plantation to capture carbon dioxide in a comprehensive manner. We did this by applying a series of computer models and using data from *Jatropha curcas* plantations in Egypt, India and Madagascar," says Wulfmeyer.

The new Earth System Dynamics study shows that one hectare of *Jatropha curcas* could capture up to 25 tonnes of atmospheric carbon dioxide per year, over a 20 year period. A plantation taking up only about 3% of the Arabian Desert, for example, could absorb in a couple of decades all the CO_2 produced by motor vehicles in Germany over the same period. With about one billion hectares suitable for carbon farming, the method could sequester a significant portion of the CO_2 added to the atmosphere since the industrial revolution.

But there are more advantages. Carbon farming's price tag ranges from 42 to 63 euros per tonne of CO_2, making it competitive with other CO_2-reduction techniques such as carbon capture and storage. Further, after a few years, the plants would produce bioenergy (in the form of tree trimmings) to support the power production required for the desalination and irrigation systems.



Processes involved in carbon farming. Technological and economic issues include the set up and operation of desalination plants and large-scale irrigation and their power supply, such as the production of bioenergy from the plantation. Land-surface-atmosphere processes, including heat release and CO_2 absorption, also play a role in carbon farming. These modify the atmospheric boundary layer (ABL, the lowest part of the atmosphere) in such a way that may lead to the formation of clouds and precipitation. (Credit: Becker et al. 2013)

"From our point of view, afforestation as a geoengineering option for carbon sequestration is the most efficient and environmentally safe approach for climate change mitigation. Vegetation has played a key role in the global carbon cycle for millions of years, in contrast to many technical and very expensive geoengineering techniques," explains Becker.

The main limitations to implementing this method are lack of funding and little knowledge of the benefits large-scale plantations could have in the regional climate, which can include increase of cloud coverage and rainfall. The new Earth System Dynamics paper presents results of simulations looking into these aspects, but there is still a lack of experimental data on the effects of greening arid regions. Also, potential detrimental effects such as the accumulation of salt in desert soils need to be evaluated carefully.

The team hopes the new research will get enough people informed about carbon farming to establish a pilot project. "We strongly recommend more emphasis is put on this technology – at both small and large scales – and that more research is done to investigate its benefits in comparison to other geoengineering approaches," concludes Wulfmeyer.

This press release was originally published on the EGU website

Reference

Becker, K. et al.: Carbon farming in hot, dry coastal areas: an option for climate change mitigation, Earth Syst. Dynam., 4, 237–251, 2013

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Cluster spacecraft detects elusive space wind

EGU press release on research published in Annales Geophysicae

A new study provides the first conclusive proof of the existence of a space wind first proposed theoretically over 20 years ago. By analysing data from the European Space Agency's Cluster spacecraft, researcher Iannis Dandouras detected this plasmaspheric wind, so-called because it contributes to the loss of material from the plasmasphere, a donut-shaped region extending above the Earth's atmosphere. The results are published today in Annales Geophysicae, a journal of the European Geosciences Union (EGU).

"After long scrutiny of the data, there it was, a slow but steady wind, releasing about 1 kg of plasma every second into the outer magnetosphere: this corresponds to almost 90 tonnes every day. It was definitely one of the nicest surprises I've ever had!" said Dandouras of the Research Institute in Astrophysics and Planetology in Toulouse, France.

The plasmasphere is a region filled with charged particles that takes up the inner part of the Earth's magnetosphere, which is dominated by the planet's magnetic field.

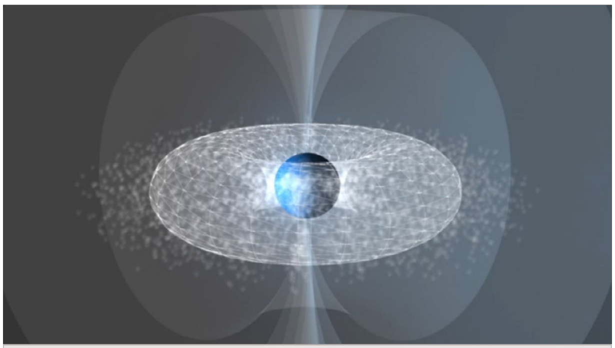
To detect the wind, Dandouras analysed the properties of these charged particles, using information collected in the plasmasphere by ESA's Cluster spacecraft. Further, he developed a filtering technique to eliminate noise sources and to look for plasma motion along the radial direction, either directed at the Earth or outer space.

As detailed in the new Annales Geophysicae study, the data showed a steady and persistent wind carrying about a kilo of the plasmasphere's material outwards each second at a speed of over 5,000 km/h. This plasma motion was present at all times, even when the Earth's magnetic field was not being disturbed by energetic particles coming from the Sun.

Researchers predicted a space wind with these properties over 20 years ago: it is the result of an imbalance between the various forces that govern plasma motion. But direct detection eluded observation until now.

"The plasmaspheric wind is a weak phenomenon, requiring for its detection sensitive instrumentation and detailed measurements of the particles in the plasmasphere and the way they move," explains Dandouras, who is also the vice-president of the EGU Planetary and Solar System Sciences Division.

The wind contributes to the loss of material from the Earth's top atmospheric layer and, at the same time, is a source of plasma for the outer magnetosphere above it. Dandouras explains: "The plasmaspheric wind is an important element in the mass budget of the plasmasphere, and has implications on how long it takes to refill this region after it is eroded following a disturbance of the planet's magnetic field. Due to the plasmaspheric wind, supplying plasma – from the upper atmosphere below it – to refill the plasmasphere is like pouring matter into a leaky container."



This animation (click to play or view online) shows the Earth's plasmasphere – the innermost part of our planet's magnetosphere – and the plasmaspheric wind, an outward flow of charged particles. The doughnut-shaped plasmasphere is centred around the Earth's equator and rotates along with it. The steady plasmaspheric wind continuously transfers material from the plasmasphere into the magnetosphere, releasing about 1 kg of plasma every second – almost 90 tonnes a day – into the outer magnetosphere. (Credit: ESA/ATG medialab)

The plasmasphere, the most important plasma reservoir inside the magnetosphere, plays a crucial role in governing the dynamics of the Earth's radiation belts. These present a radiation hazard to satellites and to astronauts travelling through them. The plasmasphere's material is also responsible for introducing a delay in the propagation of GPS signals passing through it.

"Understanding the various source and loss mechanisms of plasmaspheric material, and their dependence on the geomagnetic activity conditions, is thus essential for understanding the dynamics of the magnetosphere, and also for understanding the underlying physical mechanisms of some space weather phenomena," says Dandouras.

Michael Pinnock, Editor-in-Chief of Annales Geophysicae recognises the importance of the new result. "It is a very nice proof of the existence of the plasmaspheric wind. It's a significant step forward in validating the theory. Models of the plasmasphere, whether for research purposes or space weather applications (e.g. GPS signal propagation) should now take this phenomenon into account," he wrote in an email.

Similar winds could exist around other planets, providing a way for them to lose atmospheric material into space. Atmospheric escape plays a role in shaping a planet's atmosphere and, hence, its habitability.

This press release was originally published on the EGU website

Reference

Dandouras, I.: Detection of a plasmaspheric wind in the Earth's magnetosphere by the Cluster spacecraft, Ann. Geophys., 31, 1143–1153, 2013