

(Don't) Look up - there are microbes in the sky!



SCELS researchers (L-R: Dr Daniela Moses, Prof Stephan Schuster, Dr Irvan Luhung and Dr Elena Gusareva) have devised a "vertical map" of airborne microorganisms that indicates how global warming will impact global ecosystems.

Scientists around the world have been studying climate change for decades, foretelling dire impacts on our ecosystems. For the first time, SCELS scientists have shown that airborne microorganisms in our atmospheric ecosystem will also be impacted.

The study "[Vertical stratification of the air microbiome in the lower troposphere](#)" was published in the Proceedings of the National Academy of Sciences by a team of interdisciplinary scientists led by SCELS research director (Meta-'omics & Microbiomes) Prof Stephan Schuster. We spoke to him to learn more.

“Microbes in the sky can act as sensors for climate change.”



STEPHAN SCHUSTER
SCELS research director
(Meta-'omics & Microbiomes)

Could you tell us more about this breakthrough?

It became possible for the first time to look at the stratification, or distribution, of microbial organisms in the atmosphere. We investigated from ground level to an altitude of 3,500 metres using a meteorological tower, an airplane fitted with sensors.

We combined this with the latest air sampling technology to collect airborne biomass. Then, using metagenomics sequencing, we determined the composition in terms of the taxonomy and the abundance of the microorganisms in a height dependent manner.



Prof Stephan Schuster with Dr Daniela Moses on the Metrological Tower



Airplane fitted with sensors ready to take flight

Is this the first time this kind of study has been done?

While our finding is novel, we do stand on the shoulders of giants. These being the aeronautic pioneers such as Charles Lindberg who, in 1921 - 23 flew an airplane to the same height as we did (3,500m), and used sticky tape to pin down fungal spores to investigate how they might impact the yield of agricultural crops in the US.

Can you tell us about the vertical map?

This is the first such map produced in a height stratified way - so we can see how the organisms in several thousand metres height differ from those we encounter on the surface of the planet.

By combining the meteorological data with our biological data, we showed that atmospheric turbulence is a temperature-driven mechanism responsible for mixing the air from the ground up, as well as in the atmosphere up to high altitudes.

This mixing results in the microorganisms being globally distributed, some of which will reach the surface and impact terrestrial and aquatic ecosystems. A significant proportion will not come down below the planetary boundary layer. Therefore, the sky becomes the sink.

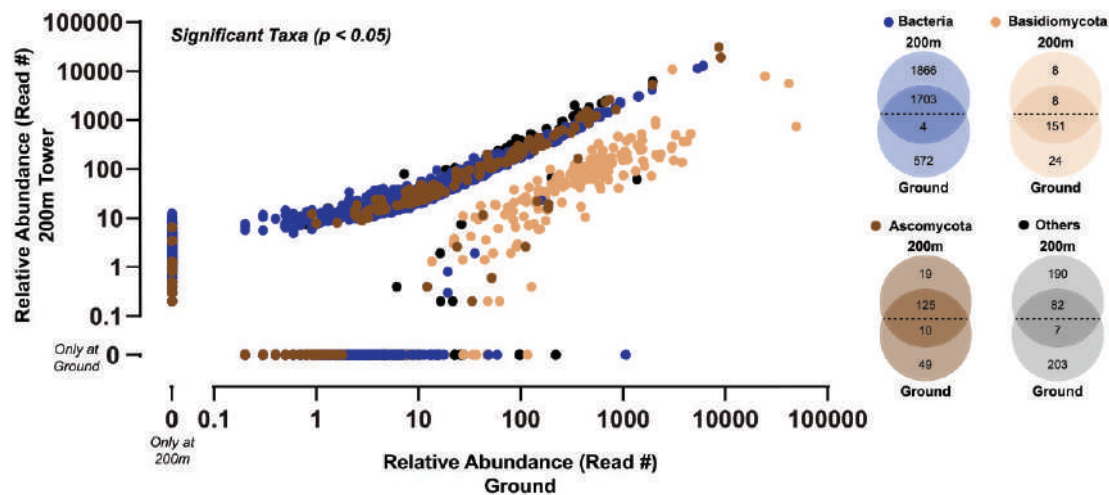


Figure from the Gusareva et al. (2022) showing the relative abundance of microbes in the sky

How would the impact of increased global warming affect the air microbiome?

The key observation from our research is that the cycle we experience (the diel cycle of the air microbiome) is ground based. Once you go to a height of 800-1,000m, microbial community structure does not differ between day and night.

The reason for this difference is that the temperature at these heights remain constant regardless of it being, day and night is the same.

Once we understand that temperature is the only driving physical parameter that plays a role in changes of the air microbiome, it becomes apparent that if the atmosphere warms up, the composition of the air microbiome globally will change.

Singapore is the only country currently that has the experimental capacity to undertake this kind of research at scale. Our team was the first to describe the temporal and taxonomic resolution of airborne microbial communities - describing the dynamics of atmospheric microorganisms at the species level within hours - not days, weeks or months, as was the previous standard.

There are two potential ways this can affect us:

- 1) Susceptible patients with respiratory syndromes may suffer the effects of potentially more pathogens in the air.
- 2) Human society as a whole may be affected - global warming affects the microbial ecosystem in the air, which in turn affects ecosystem function in the terrestrial and aquatic habitats. Changes in the ecosystems can affect the yield of crops, along with changes in planetary carbon cycling and processes that have benefited us over eons. This can then affect our food supply.

Were the findings surprising?

We were surprised to see that the diel cycle that we described in great detail on the ground so rapidly decreased. We were also quite surprised with how stratified microbial communities are.

In a way, you can say there is a cloud of bacteria living up in the sky. The fungal organisms that are so important for our ecosystems are restricted to the lower ground air layers.

The most surprising finding was that there is a high concentration of bacteria that are radio-tolerant, meaning they can tolerate massive amounts of radioactivity. We could show that there is a 20 times higher concentration of this bacteria at several thousand metres height compared to the ground, and that there is no day-night difference for that.

“The most surprising finding was that there is a high concentration of bacteria that are radio-tolerant, meaning they can tolerate massive amounts of radioactivity.”

Collaboration is key and made it possible ...

... to directly pair our meteorological measurements for the first time ever with that of the biological measurements. This was made possible by our international collaborators: Karlsruhe Institute of Technology and the Institute for Flight Guidance from the Technological University in Braunschweig.

By combining the skills of meteorologists, climate researchers, skilled pilots (who could fly as low as 300m during day and night), and scientists that developed sampling systems for the airplane; with that of SCELSE's expertise in air sampling, metagenomics and computational analysis - we were able to produce the microbial map of the skies.

We are also grateful to the institutional funding provided by SCELSE, which enabled such an outrageous, adventurous research setting. Many thanks too to SCELSE's director Staffan Kjelleberg for supporting the project.

What's next?

The next step would be to repeat this sampling in different climatic settings. For instance, in the tropics here in Singapore the scales and boundaries we have described will be different compared to that of a temperate or polar setting. Arctic and desert settings will also be interesting to investigate.



Inspired by the popular Netflix movie 'Don't Look Up', Prof Schuster explains how the research findings have serious implications for human and planetary health in this [2-min video](#).



READ THE PAPER:

Vertical stratification of the air microbiome in the lower troposphere:
<https://doi.org/10.1073/pnas.2117293119>

RESEARCH UPDATES

SCElse earns an “article of significant interest” in Applied & Environmental Microbiology

In their research “[Loss of the acetate switch in *Vibrio vulnificus* enhances predation defense against *Tetrahymena pyriformis*](#)”, SCElse researchers made a significant discovery that underscores the need for continuous environmental monitoring of emerging pathogens.

Bacteria in the environment, including *Vibrio* spp., interact with protozoan predators. To defend against predation, bacteria evolve antipredator mechanisms ranging from changing morphology, biofilm formation, and secretion of toxins or virulence factors. Some of these adaptations can result in strains that are pathogenic to humans. Therefore, it is important to study predator defense strategies of environmental bacteria.

V. vulnificus thrives in coastal waters and infects humans. However, very little is known about the defense mechanisms *V. vulnificus* expresses against predation.

SCElse scientists in collaboration with A/Prof Diane McDougald’s research group in University of Technology Sydney have shown that a *V. vulnificus* strain ENV1 has rewired the central carbon metabolism, enabling the production of excess organic acid that is toxic to the protozoan predator *T. pyriformis*. This is a previously unknown mechanism of predation defense that protects against protozoan predators.

The significance of this discovery is that the same metabolic pathway that we found in *V. vulnificus* strain ENV1 that helps defend predation is also responsible for toxin production in the human pathogen *V. cholerae*. This suggests that such variation in metabolic pathways may improve environmental fitness, e.g, predation defence, as well as increasing virulence in mammalian hosts.



Congrats SCElse team (clockwise from left), Clarence Sim, Dr Viduthalai Rasheedkhan, A/Prof Diane McDougald and A/Prof Scott Rice for this breakthrough discovery!



DR VIDUTHALAI
SCElse senior research fellow

“

This observation presents a compelling case for environmental monitoring of emerging pathogens as sensors for climate change.

”

SCELSE HAPPENINGS

Pushing Boundaries, Creating Legacies - the winning slogan entry for SCELSE's 10-year anniversary slogan contest

Congratulations SCELSE visiting student Muhammad Hasif on clinching the top prize for the SCELSE anniversary slogan contest (\$100 worth of grabfood vouchers!) with his entry "Advancing Discovery, Leaving Legacies".

The slogan was selected and modified by the research directorate to 'Pushing Boundaries, Creating Legacies'. It will feature on the anniversary t-shirts and other materials.

Hasif said: "It was the first thing that came to mind when I thought about what research means to me. It is about continuous progress, creating new knowledge, and

constantly pushing the boundaries of what is known - and that leaves a legacy for others to work on."

Hasif is very excited about his current work with the L'Oréal-SCELSE joint lab, where he is studying how a balanced community of bacteria living on our skin can help keep the skin healthy.

"I believe that no matter how small your project is, it adds value and

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I believe that no matter how small your project is, it adds value and is vital to what science may be in future.

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is vital to what science may be in future. I wish SCELSE a prosperous 10-year anniversary. Here's to pushing boundaries and creating legacies for years to come!"



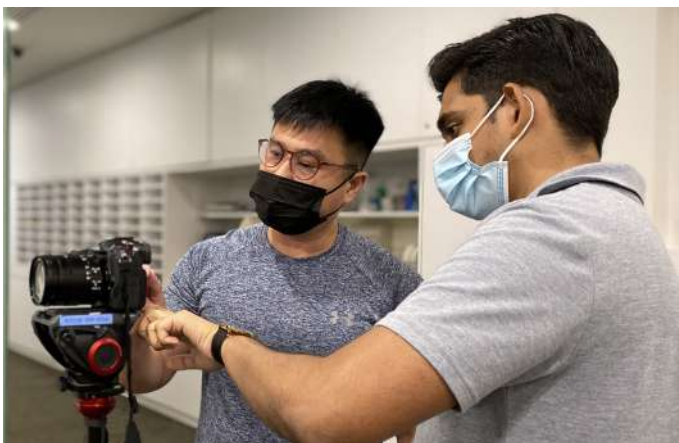
MUHAMMAD HASIF
Visiting UG FYP student (SBS)

Uncovering multiple talents as an SG United Trainee

SCELSE's supportive environment motivates fresh graduate to go above and beyond the job scope.

Mohammed Imran - you may have seen him helping you out with IT issues, but did you know that he has an amazing talent in videography as well?

We get up close with this fresh NTU Mechanical Engineering graduate, who joined SCELSE as an IT operations executive under the SG United Traineeship (UT) programme, and also helped the Science Comms team with various projects, from September 2021 to March 2022.



Imran (right) and Ivan Tan, senior executive, visual communications, working to set up the camera for a shoot



Imran providing IT solutions for SCELSE staff

1) How did you come across this position and what motivated you to apply?

I started searching for jobs online and came across the role of an IT operations executive at NTU, under the SGUT programme. The programme caters for fresh graduates to help them develop industry-relevant skills & experience. I decided it would be interesting to pick up skills in IT, which is an in-demand industry at the moment, so here I am.

2) How has your SGUT experience at SCELSE been? Any surprises?

Working in SCELSE has been a fruitful experience. Everyone is warm and approachable. I feel the enthusiasm and energy every day when I come to the office. Looking at everyone giving their best in the workplace keeps me motivated as well.



IMRAN
SG United Trainee

“ Having the opportunity to learn both IT skills, and interpersonal skills working across various teams will prove very useful to me for my future career path. ”

My IT colleagues Zaweeth and Chee Sern have been amazing. They have been guiding me since the start and have taught me a wide range of skills that I can apply.

I am also grateful to have been able to contribute to the Science Comms team's photo and video shoot activities. I supported the team for projects such as taking head shots for the new website, shooting a 'how to get to SCELSE' video, and setting up the camera for video interviews with professors and researchers.

3) What is the most memorable experience from your traineeship?

One of the most memorable experiences was when I entered SCELSE for the first time. Although I have walked past SCELSE several times during my undergraduate days, I never paid much attention to it. After entering, I was surprised to see how warm and vibrant the office is.

“ One piece of advice for fresh graduates entering the job market? ”

Do not be afraid to explore your interests. Always have an open mind and never stop learning. ”

4) What's next for you?

Looking at the researchers' and engineers' work has sparked my curiosity in the field of science and technology. I will be moving forward by pursuing a career path in the field of engineering, while continuing to work on video projects through my company [Sereno Media](#).



SEND US YOUR PROFILE PHOTOS - LAST CALL

SCELSE's website is getting a makeover and with that, we are updating everyone's profile photos too!

Please email ummi.tasfia@ntu.edu.sg your high-resolution profile photo (min. 1MB file size) with the following specifications if you have not already done so or participated in our photo shoot (**compulsory** for all):

- Half-body shot, tilted to right.
- Hair neat or tied if wearing lab coat.
- Researchers in lab coat.
- Plain background.
- Removed lanyard, flashy jewellery, keys, pens etc from body.

DEADLINE: 10 APR 2022

Sign up to get your head shot taken by Science Comms on 6 or 7 April [here](#).

EVENTS

Catch three SCELSE researchers among many other experts in this year's exciting SIWW lineup!



17 April - 21 April 2022



Dr Mats Leifels
Research Fellow, SCELSE



Dr Anika Cokro
Research Fellow, SCELSE



Ramanujam Srinivasan Vethathirri
PhD Student, SCELSE

Date/Time	Title	SCELSE Presenters
1 18 Apr, 3.45pm	Microbial protein production through mixed-culture anaerobic/aerobic fermentation of soybean processing wastewaters of variable chemical and microbial composition	Ramanujam Srinivasan Vethathirri, PhD Student, SCELSE
2 19 Apr, 9am	Effect of intermittent and continuous flow regimes on the microbial water quality and microbiomes in a pilot-scale drinking water testbed	Dr Mats Leifels, Research Fellow, SCELSE
3 19 Apr, 4pm	Effect of stepwise reduction of solids retention time on the microbial community and functional pathways in mesophilic anaerobic digestion of sludge	Dr Anika Cokro, Research Fellow, SCELSE
4 20 Apr, TBC	Nexus and Circularity	Ramanujam Srinivasan Vethathirri, PhD Student, SCELSE

The Future of Wastewater-Based Epidemiology: Standardization and Expansion Beyond SARS-CoV-2

Monday, March 28, 2022 | 2PM PT



Dr. Mats Leifels
Singapore Centre for Environmental Life Sciences Engineering,
Nanyang Technological University, Singapore



Francisco Bizouarn, M.Sc.
Market Development Manager
Digital Biology Group, Bio-Rad Laboratories, Pleasanton, CA USA

Presented By:

Water Environment Federation
the water quality people

Sponsored By:

BIO-RAD

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