# PHD POSITION

Open to domestic (NZ) students who are eligible for a doctoral scholarship at the University of Otago

## Modelling of atmospheric dynamics to understand deposition of re-entering space debris and its effect on ozone chemistry

Please email your expression of interest to:

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**Supervisor:**
**A/Prof Annika Seppälä**
Dept of Physics

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**Co-Supervisor:**
**Dr Priyanka Dhopade**
Dept of Mechanical & Mechatronics Engineering

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## Background

The rapid expansion of the space industry has resulted in an unprecedented pace of rocket launches and satellites to orbit. Over the past 15 years, rocket launches have nearly tripled, and the number of satellites orbiting Earth has surged tenfold. This has raised significant concerns about the environmental impacts of space activities. Current industry practice is to deorbit satellites at the end of their life by re-entering them into Earth's atmosphere. This process is contributing to a growing environmental issue, which highlights a gap in our understanding of the impacts of re-entry on atmospheric chemistry and behaviour.

The re-entry of space debris, which releases hundreds of tons of metallic particles into the atmosphere annually, could have far-reaching consequences, including potential disruptions to the recovery of the ozone hole by introduction of new long-lived ozone depleting substance into the atmosphere. With projections estimating that up to 100,000 satellites could orbit the planet by the end of the decade, the threat of atmospheric contamination is becoming more pressing. High-altitude air pollution from rocket exhaust and satellite re-entries could persist for decades or centuries, with unanticipated consequences for our atmosphere and climate.

This PhD project will provide key insights and recommendations for the management and mitigation of satellite atmospheric re-entry, by building on current understanding of the role of ozone in the atmosphere and climate system, as represented in the Community Earth System Model (CESM2).

### Accounting for atmospheric dynamics

- Analyse atmospheric dynamical patterns at various altitudes to understand how these influence the transport and deposition of satellite debris.
- Investigate the balance between vertical and horizontal atmospheric transport mechanisms that influence where and how satellite materials disperse after re-entry.

### Accounting for deposition of satellite particles

- Identify the typical altitude ranges where satellites and space debris burn up in the atmosphere and release materials.
- Model the transport of satellite materials (e.g., metal oxides) as they re-enter the atmosphere, incorporating data on satellite composition.
- Extend existing investigations that focus on aluminium oxide, a common byproduct of satellite re-entry, to include other advanced materials based on satellite composition.
- Leverage earlier model studies on meteorite impacts on the atmosphere, to analyse satellite re-entry materials.

The research will assess how altitude and atmospheric conditions affect material deposition, with a focus on equatorial versus polar regions, where transport scales and deposition behaviours differ.

### Effect on ozone chemistry

- Explore the effects of satellite debris deposition on ozone chemistry, building on existing research on aluminium oxides as well as meteorite deposition in order to assess interactions with ozone in the middle and upper atmosphere.
- Use models to predict how the introduction of satellite materials, particularly metals, could influence ozone depletion.

The outcomes of the modelling will include determining which atmospheric locations or altitudes are more susceptible to harmful impacts from metal deposition, particularly with respect to ozone chemistry and long-term atmospheric stability.

This project will contribute to a deeper understanding of the environmental effects of satellite re-entries and inform future strategies to mitigate the potential harms associated with the growing space industry.

**Supervision:**

This project will be supervised by Associate Professor Annika Seppälä, Department of Physics, University of Otago, and co-supervised by Dr Priyanka Dhopade, Department of Mechanical & Mechatronics Engineering, University of Auckland.

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**Computational Resources:**

The student will have access to the New Zealand eScience Infrastructure (NeSI) to run complex atmospheric models.

**Skills:**

The student will have some experience of ozone or climate modelling, with a background in physics. Some interest in space and environmental issues is desired but not necessary.

**Contact:**

Please contact A/Prof Seppälä and Dr Dhopade with any questions: annika.seppala@otago.ac.nz

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