How does Antarctica cool itself? Exploring the far-infrared outgoing radiation

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Motivation

- Antarctica's heat budget defines how it will respond to climate change.
- Antarctica's surface cools itself mainly by emitting infrared radiation into space. 50% of the emission happens at wavelengths beyond 15 µm.
- While other areas of the world also emit radiation in the far-infrared, water vapour in the atmosphere prevents the radiation from being emitted out to space.
- Unfortunately, there no spatially resolved measurements of the surface spectral emissivity at these wavelengths, making it difficult to quantify how Antarctica cools itself.

Our current lack ofknowledge

Far-infrared radiation influences the radiation budget where the atmosphere is very dry, i.e. above Antarctica, Greenland and the Himalayas.

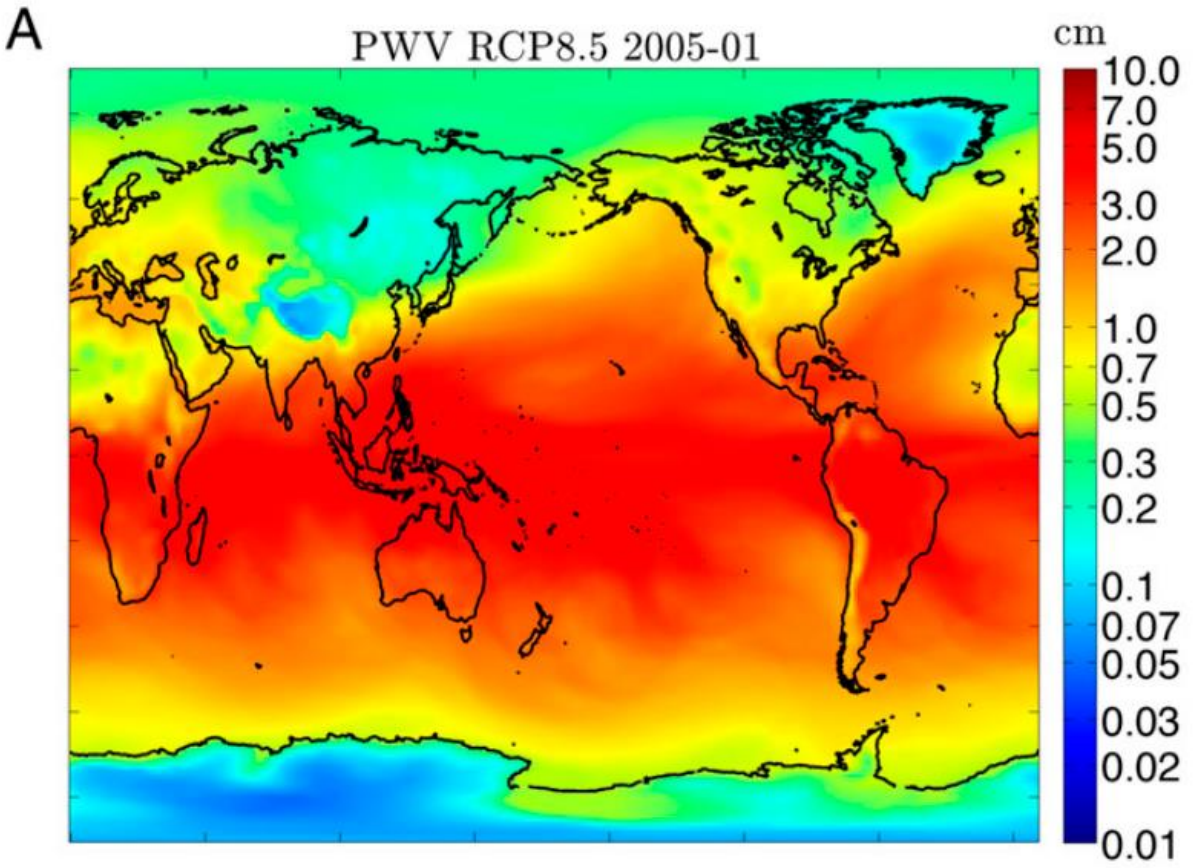

Figure 1: Monthly averaged precipitable water vapour from CESM integration of RCP8.5 for January 2005. From Feldman et al., 2014.

Implications for climate models

- Due to the lack of measurements, far-infrared surface emissivities are usually set to 1.0 in climate models (perfect black body radiator)
- The figure shows the differences in outgoing longwave radiation when slightly perturbing the far-infrared surface emissivity by 0.05.
- This parameter has major impact in climate model results.

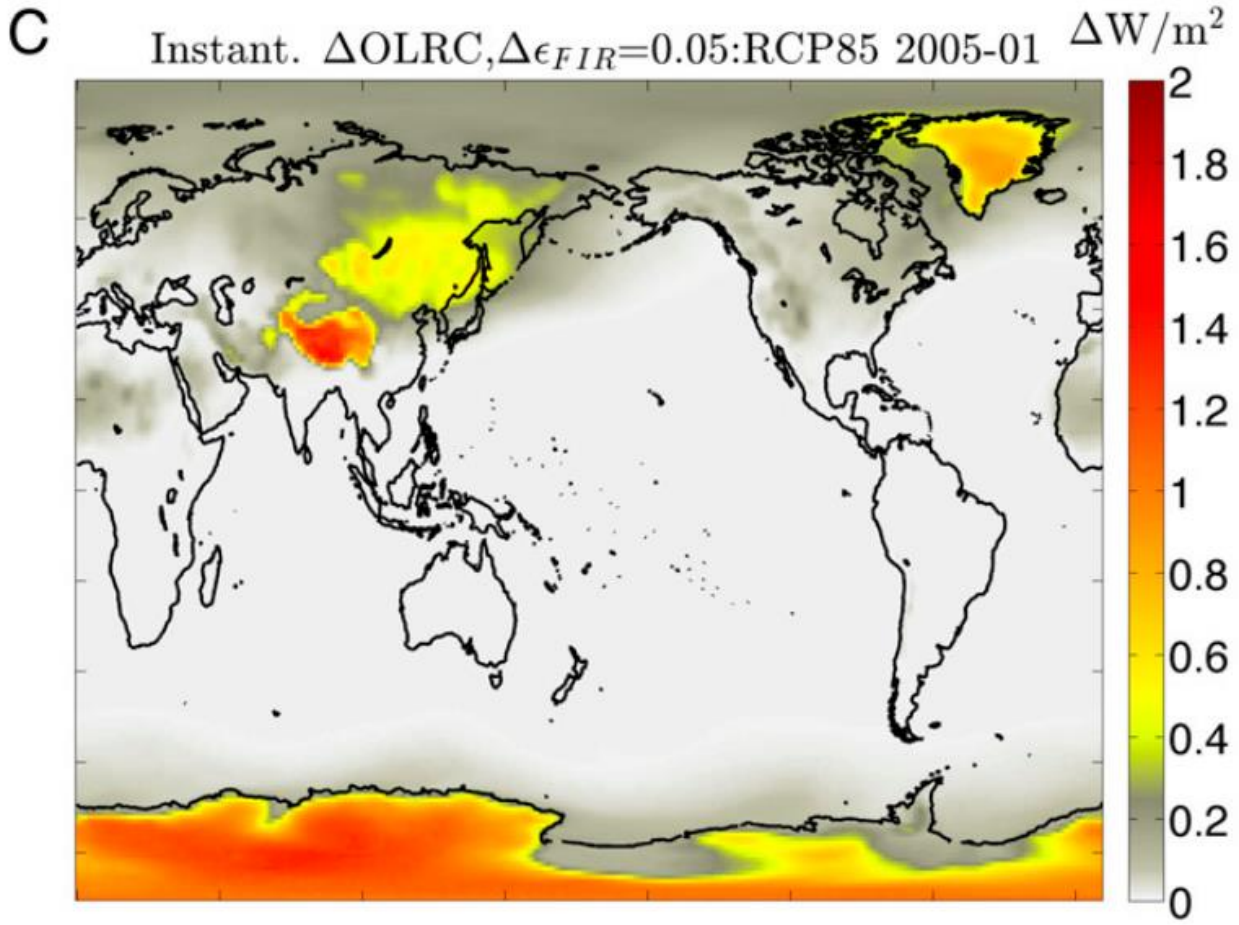

Figure 2: Instantaneous change in clear-sky OLR based on a spectrally uniform perturbation of far-IR surface emissivity of 0.05.
From Feldman et al., 2014.

International efforts and New Zealand contribution

- Better quantification of far-infrared surface emissivities will improve our confidence in climate model simulations of Antarctic climate.

International efforts to make new measurements of the far-infrared part of the spectrum are underway, e.g.:

- NASA: Will provide funding for the *Polar Radiant Energy in the Far Infrared Experiment (PREFIRE)* satellite
- ESA: Concept proposal for the *Far-infrared Outgoing Radiation Understanding and Monitoring (FORUM)* mission. If funded it will be deployed on Earth Explorer 9.
- Jordis has been applying for funding to be involved in these activities and aims to run a validation campaign in Antarctica once the satellites are in space.

New Zealand effort to mitigate the lack of knowledge

We are proposing a two step approach to improve our knowledge of far-infrared surface emissivities and thereby support the international efforts.

Step 1: Robustly estimate the sensitivity of Antarctica's far-infrared radiation budget to changes in the far-infrared surface emissivity.

- We plan to develop a method that could later be used to validate PREFIRE and FORUM against high-quality radiosondes.

Step 2: Perform measurements with an aircraft or balloon-borne far-infrared spectrometer above Antarctica.

- This campaign would support validation of NASA‘s PREFIRE and ESA’s FORUM mission.
- Provide independent measurements of far-infrared radiation above Antarctica.

Step 1: Determining effects of our lack of knowledge (1)

Profile measurements of temperature, water vapour, and ozone together with a state-of-the-art radiative transfer model can be used model one column of the Antarctic atmosphere.

- Changing the surface emissivity in the radiative transfer model allows tests of how the outgoing longwave radiation above Antarctica is affected by changes in this parameter.
- In contrast to a climate model, the proposed method is able to propagate uncertainties through all calculations.
- In this way we can robustly estimate the effects of our current lack of knowledge has on the Antarctic radiation budget.

Step 1: Determining effects of our lack of knowledge (2)

Global climate model results can be downscaled to estimate effects on New Zealand:

- The Imperial College London is currently generating simulations with spectrally-resolved far-infrared surface emissivities, which had prior been set to unity without spectral resolution.
- Comparing this model output to a control run will be used to estimate the effects of an improved surface emissivity scheme on the global climate.
- Downscaling the results for New Zealand will give us a better understanding of what this means for projections of New Zealand's climate.

Step 2: Measure the outgoing longwave radiation above Antarctica

To close the knowledge gap and improve our confidence in the climate model simulations, measurements of far-infrared outgoing radiation are required.

- We are aiming to run an airborne validation campaign in Antarctica once a satellite-based instruments are in space.
- Underflying the satellite with a spectrometer measuring the far-infrared outgoing radiation would provide an extremely valuable data set and support PREFIRE/FORUM.
- The measurements can then be used to retrieve the far-infrared surface emissivity leading to a better representation of this parameter in climate models and, thus, to more confidence in the results of these models.

Summary

- We are currently exploring funding sources for these activities and are working closely with international colleagues which are part of the NASA and ESA team.
- As New Zealand does not currently have much expertise in this field, we are planning to establish a new area of research.

Thank you very much for your attention!