National Science Challenges

THE DEEP SOUTH | Te Kōmata o Te Tonga

Assessment of Southern Ocean clouds and aerosols in the New Zealand Earth System Model using shipborne and ground-based observations

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Introduction

1 One of the primary objectives of the New Zealand Earth System Model (NZESM) is to reduce shortwave radiation biases over the Southern Ocean, which are related to deficiencies in representation of clouds and aerosols in this region. Comparison with observations is necessary for the identification and correction of the deficiencies. Unfortunately, observations in the Southern Ocean are scarce, with satellites providing the most extensive spatial and temporal coverage. However, these instruments lack the capability to observe low-level cloud when there is a higher-level overlapping cloud. We are creating a multi-year dataset of shipborne and ground-based ceilometer, radar and aerosol observations in the Southern Ocean, especially suited for observation of low-level cloud and aerosols. In general, these observations cannot be compared with the model directly, but require a simulator to be developed which accounts for the limited view of the instrument and its particular wavelength.

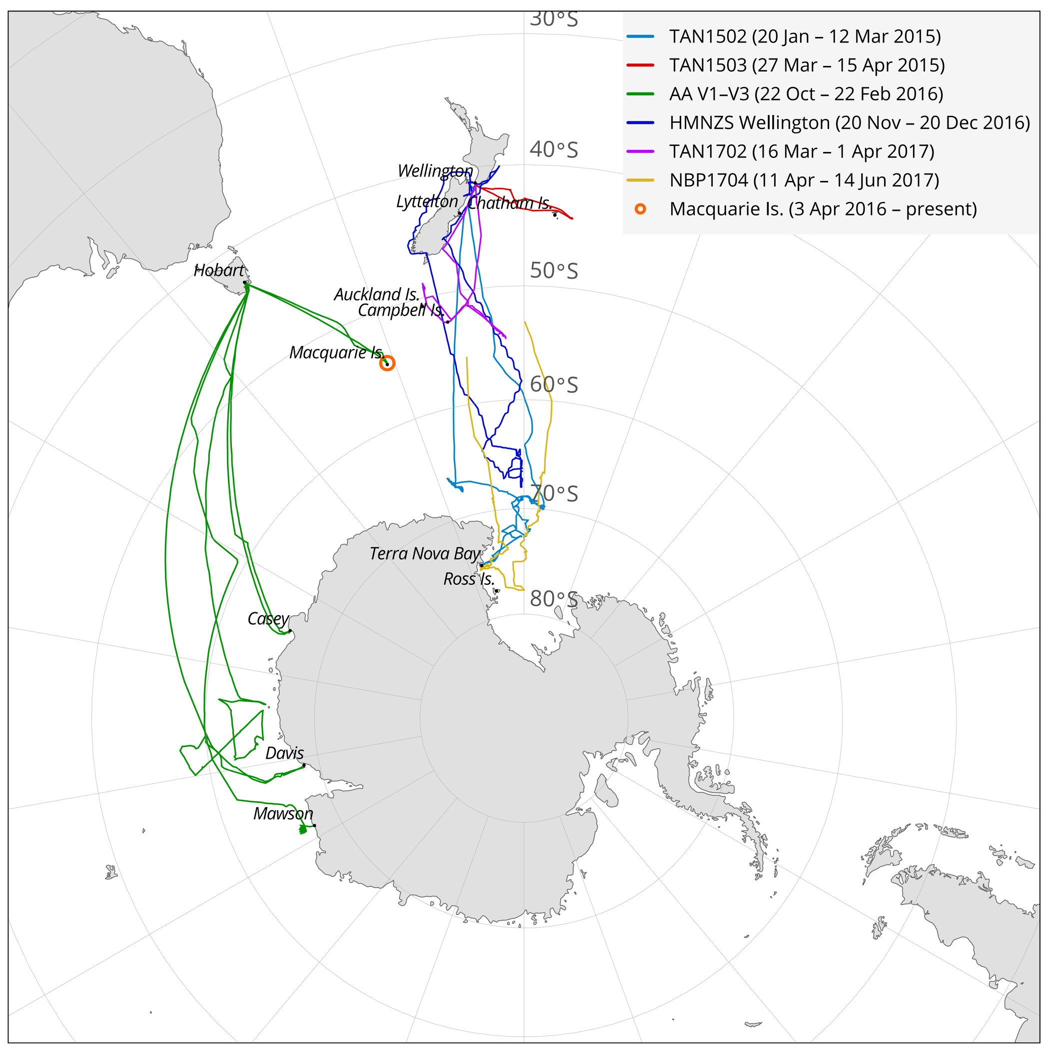


Figure 1 | So far we have collected ceilometer, radar and aerosol measurements on 6 voyages in the Southern Ocean and one ground-based location (Macquarie Island), totalling about 700 days of observations.

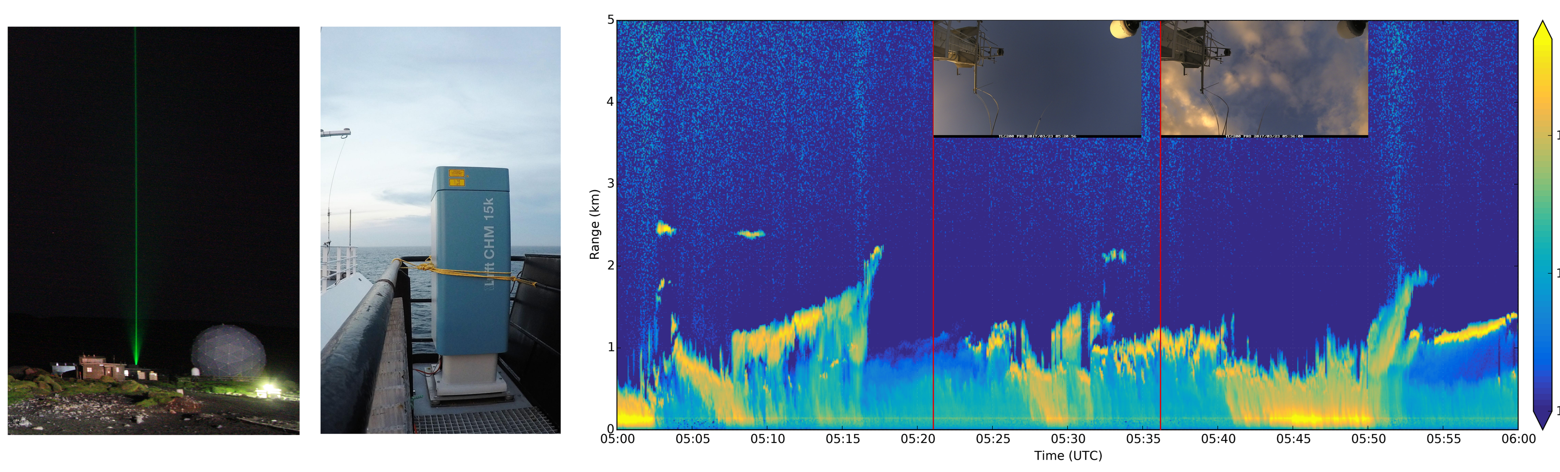


Figure 2 | Ceilometer is an instrument which emits laser impulses, which are subsequently scattered in the atmosphere by cloud droplets and ice crystals. By measuring the backscattered signal a vertical profile of clouds can be reconstructed. **a,** Lidar laser impulse visible during the night at the installation on the Macquarie Island (note that unlike our near infrared ceilometers this particular lidar emits in the visible range of the electromagnetic spectrum as thus can be seen), **b,** Lufft CHM 15k ceilometer deployed on RV Tangaroa voyage to the Campbell Plateau in March 2017. **c,** Vertical atmospheric profile recorded during the same voyage and images captured by a sky camera at two different times.

Ceilometer simulator

2 The CFMIP Observation Simulator Package (COSP) is a software package which can simulate the observations from various satellites, used extensively for climate model validation. It includes the ACTSIM spaceborne lidar simulator, which we use as a basis for development of a ceilometer simulator. When complete, this simulator will allow us to compare NZESM output with our Southern Ocean dataset.

There are several key differences between a spaceborne and a ground-based lidar (ceilometer):

– The viewpoint of a ground-based lidar is from bottom up, which can be accounted for by reversing vertical layers before and after the simulator is run

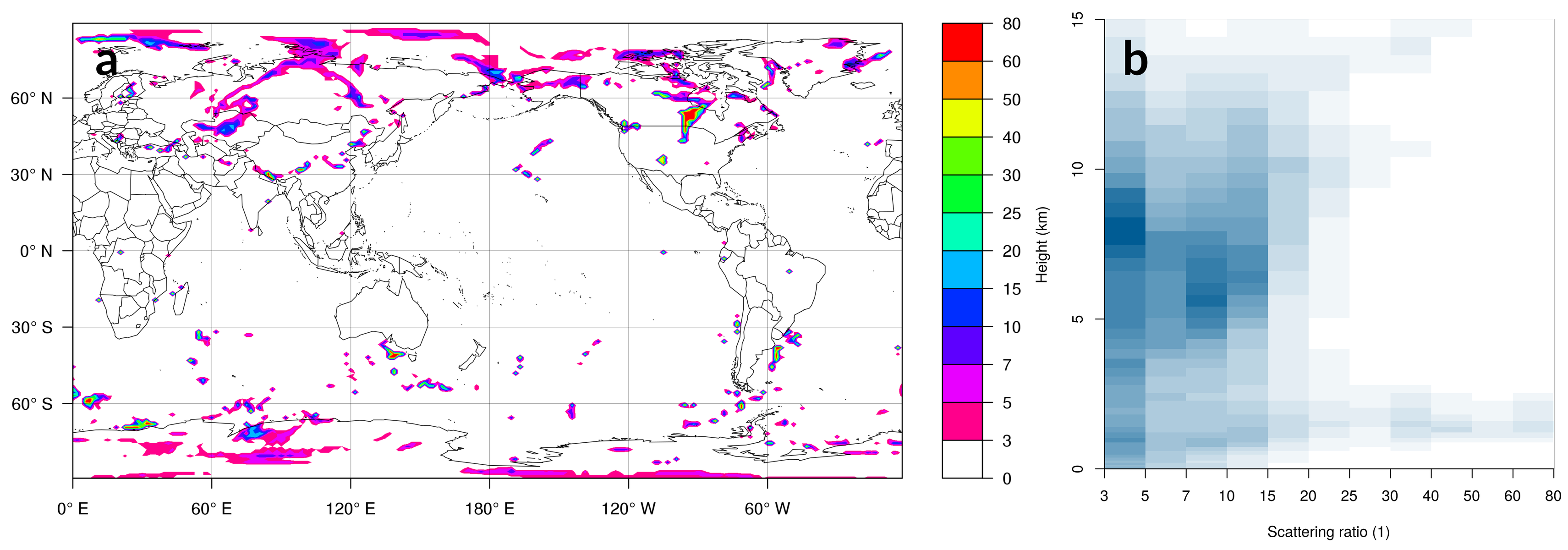
– The wavelength is different, requiring molecular and particle scattering constants to be adjusted and depending on wavelength molecular absorption to be taken into account

Results

3 We present initial results from the new ceilometer simulator in development (Figure 3). The simulator was run on NZESM model output data selected from year 2007. The output of the simulator in the form of histograms and algorithmically derived products such as cloud base height will allow for a direct comparison with the equivalent ceilometer measurements.

Future work will involve validation of the new code with Numerical Weather Prediction (NWP) model output, comparison with observations over longer time periods, and focus on regions in the Southern Ocean where the observations were made. Support for more ceilometer types and contribution of our code to the COSP package is also planned.

Simulated spaceborne lidar, 532 nm wavelength



Simulated ground-based lidar (ceilometer), 532 nm wavelength

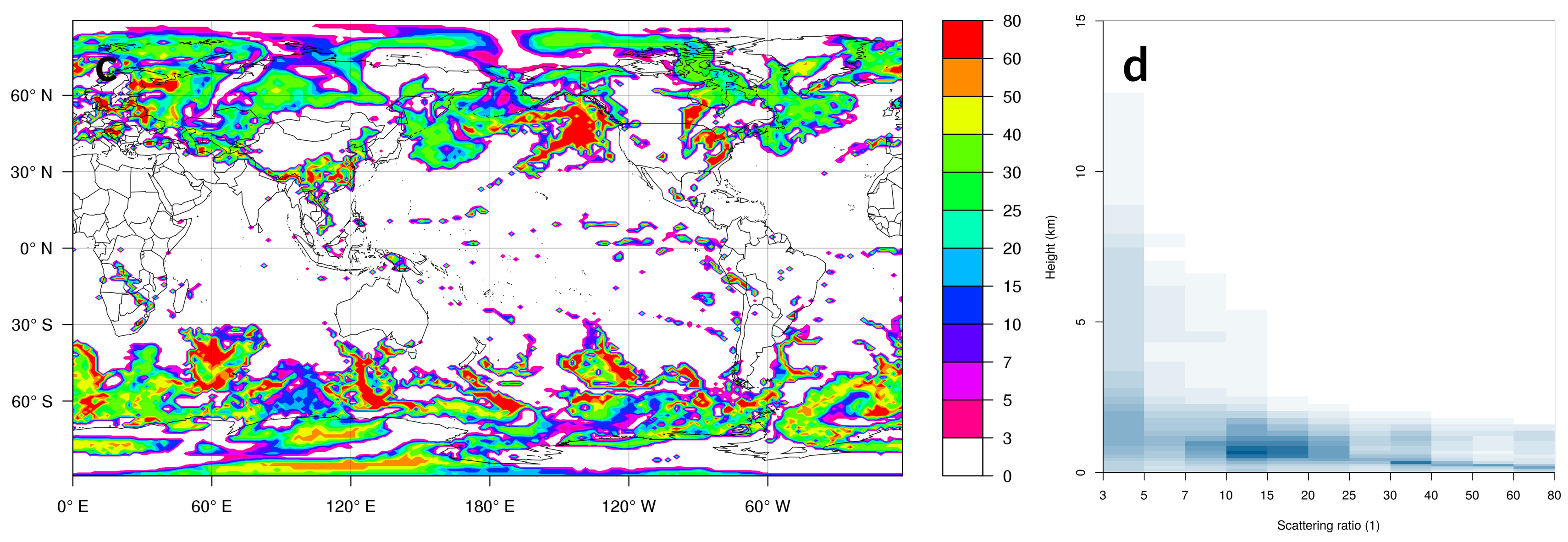


Figure 3 | a, c, Geographical distribution of scattering ratio at 300 m, **b, d,** Histogram of scattering ratio (ratio of total attenuated backscatter coefficient and molecular attenuated backscatter coefficient). The scattering ratio is representative of observed cloud droplets and ice crystals. Attenuation due to overlapping cloud generally causes low cloud not to be observable by the spaceborne lidar, while ground-based lidar can largely observe only the bottom part of clouds.

This poster was presented at the Deep South Challenge Symposium, Wellington, 4–6 September 2017