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

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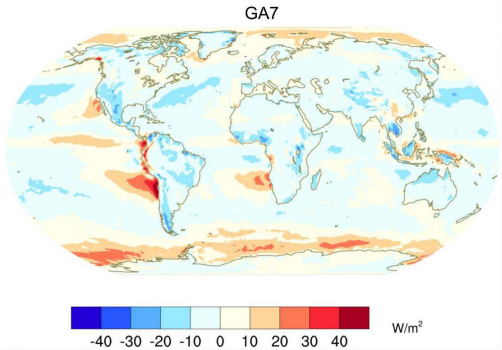
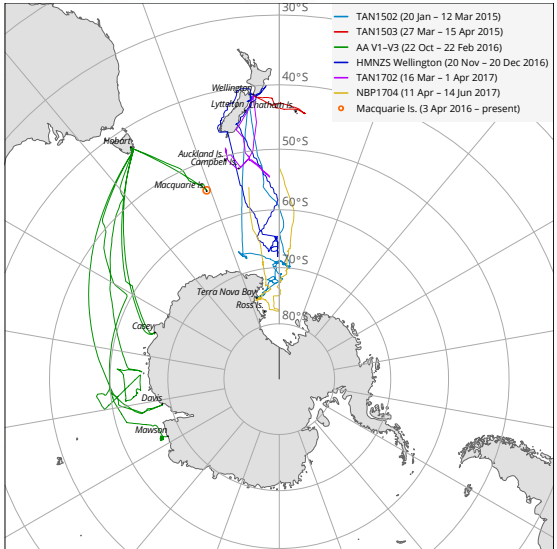
Southern Ocean Radiative Bias

- Shortwave radiative bias in Southern Ocean in CMIP5 models
- Net cloud radiative effect (UM - CERES):



Adapted from presentation by Varma et al. 2017

Southern Ocean Observations (2015-present)



- **6** voyages: RV Tangaroa, Aurora Australis, NB Palmer, HMNZS Wellington
- **1** ground-based station (Macquarie Is.)
- **269** days of shipborne observations
- **580** days of ground-based observations

Instruments


RV Tangaroa (2017)

Metek MRR2
Micro Rain Radar


Macquarie Is. (2016-present)

Vaisala CL51
Ceilometer

Lufft CHM 15k
Ceilometer

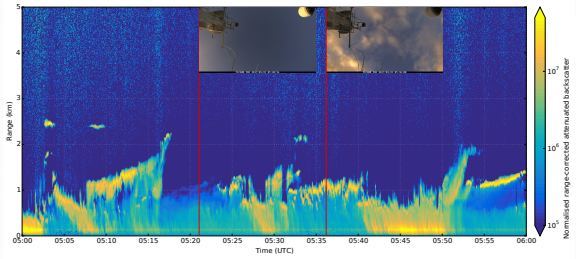

NB Palmer (2017)


RV Tangaroa (2017)

Radiosondes
iMet

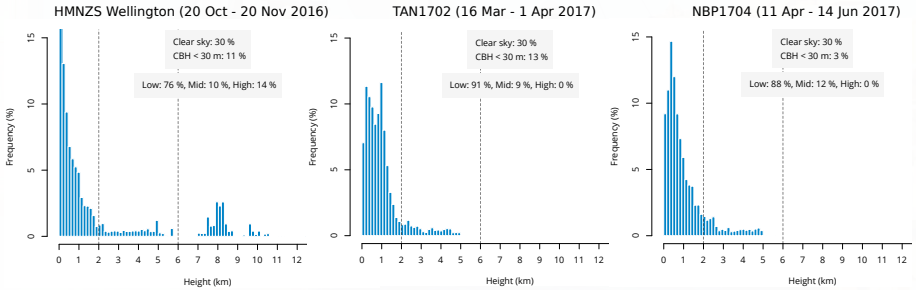
Ceilometer

- Visible or near infrared lidar – 2D profile of atmosphere (time × height)
- Wavelengths:
  - Vaisala CL51 910 nm
  - Lufft CHM 15k 1064 nm
  - (spaceborne lidar CALIPSO 532 nm)



Cloud Base Height

- Lufft CHM 15k – 3 voyages:

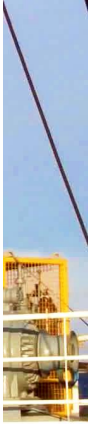


- mostly low level cloud observed from the ground

COSP / ACTSIM

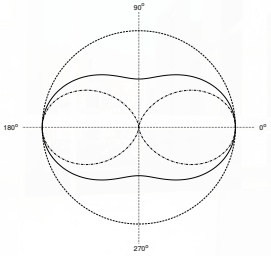
- COSP – “satellite” simulator package (CFMIP)
- ACTSIM – lidar simulator in COSP (Chepfer et al. 2008)
- liquid water/ice content, droplet/ice crystal effective radius → molecular backscatter, total backscatter

```
SUBROUTINE lidar_simulator(npoints,nlev,npart,nrefl &
         , undef &
         , pres, presf, temp &
         , q_lsliq, q_lsice, q_cvliq, q_cvice &
         , ls_radliq, ls_radice, cv_radliq, cv_radice &
         , ice_type, lidar_wavelength, surface_lidar &
         , pmol, pnorm, pnorm_perp_tot, tautot, refl )
```

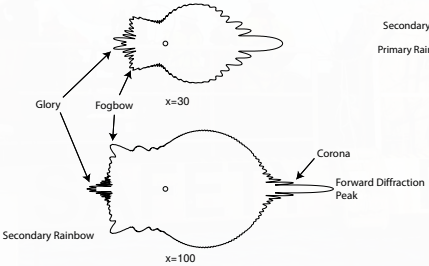


Atmospheric (Back)Scattering

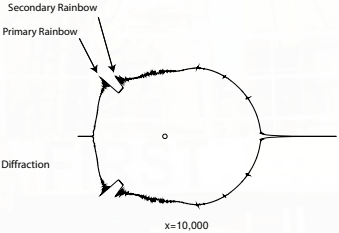
- Mie scattering (molecules)
- Rayleigh scattering (cloud droplets)
- Scattering phase function (size parameter $x = 2\pi r/\lambda$):



Rayleigh scattering



Mie scattering



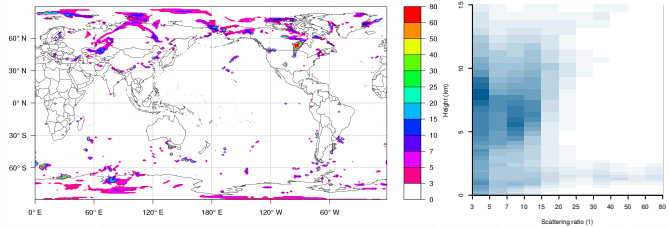
Mie scattering

Adapted from Petty 2004

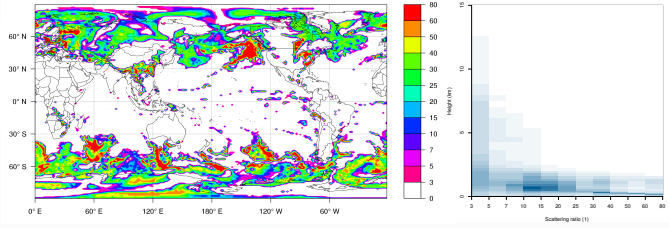
Spaceborne vs. Ground-based Lidar

- Scattering ratio (total/molecular backscatter) at 300 m above sea level

Simulated spaceborne lidar, 532 nm wavelength



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



Auxiliary Software

cl2nc

Vaisala CL31/51 → NetCDF

https://github.com/peterkuma/cl2nc

cl2nc

cl2nc is a command-line Python program for converting Vaisala CL51 and CL31 dat files to NetCDF.

Example

On the command-line:

```
cl2nc input.dat output.nc
```

where `input.dat` is a Vaisala CL51 or CL31 dat file and `output.nc` is the name of a NetCDF output file.

See example.nc.zip for an example output.

mrr2c

Metek MRR2 → HDF

https://github.com/peterkuma/mrr2c

mrr2c

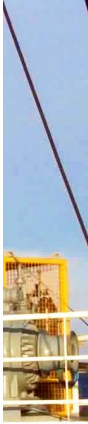
Convert Metek MRR-2 data files to HDF.

Usage

```
mrr2c [--debug] <infile> <outfile>
```

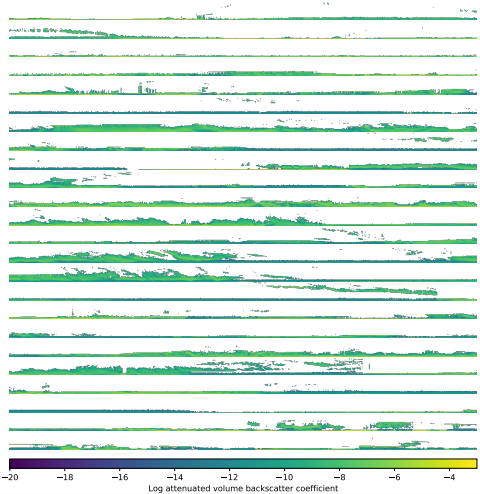
Arguments:

- `infile` - MRR-2 `raw`, `pro` or `ave` file
- `outfile` - output file (HDF5)
- `debug` - enable debugging output

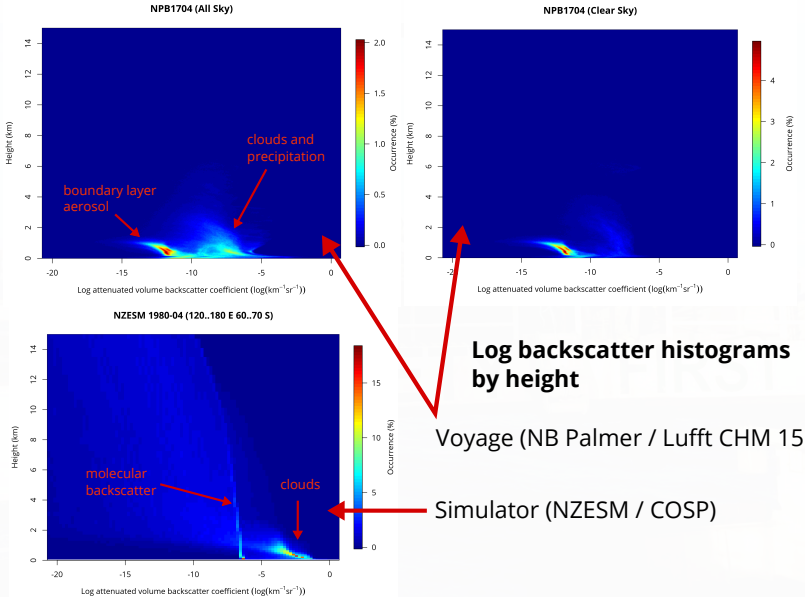


Observations

- 1 month of backscatter profiles from NBP1704:



Results



Log backscatter histograms by height

Voyage (NB Palmer / Lufft CHM 15k)

Simulator (NZESM / COSP)