Developing observational data sets for assessing and validating climate models

Stefanie Kremser, Greg Bodeker, Jared Lewis, Birgit Hassler and Jono Conway

Daily global total column ozone

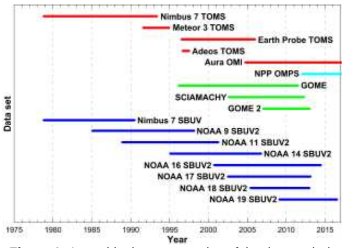


Figure 1: A graphical representation of the time periods of coverage of the different satellite-based data sets used to create the combined TCO database. Highest priority data sets are shown at the top.

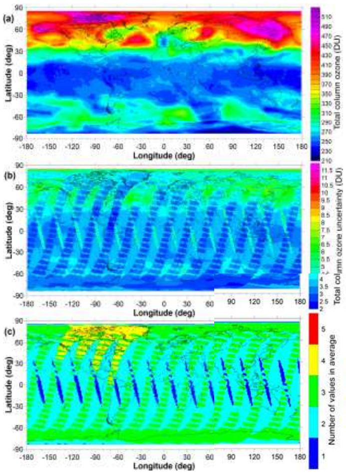


Figure 2: An example of three data fields i.e. (a) the TCO field, (b) the uncertainties on the TCO values and (c) the number of satellites used in each cell. These are for 21 March 2005.

Total column ozone (TCO) measurements from multiple satellites (Figure 1) were combined to create near-global daily time series of TCO fields at 1.25° longitude by 1° latitude resolution spanning 31 October 1978 to 31 December 2016. Comparisons against TCO measurements from ground-based Dobson and Brewer spectrophotometers are used to remove offsets and drifts between satellite data sets.

The newest version of the database includes a wider range of satellite-based instruments, uses updated versions of the current satellite data, extends the period covered, uses improved statistical methods to model the difference fields when homogenizing the data sets, and, robustly tracks uncertainties to create TCO uncertainty fields (Figure 2).

An algorithm has been developed to fill data gaps to better meet the needs of climate model validation (Figure 3). This data set can be used by many international research groups to e.g. derive Antarctic ozone hole metrics, calculate ozone trends, validate other satellite measurements and assess the performance of climate models.

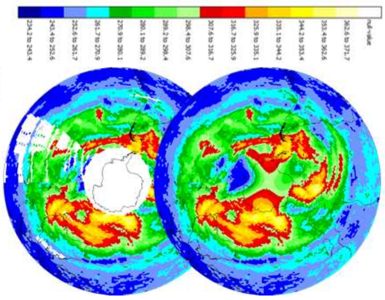
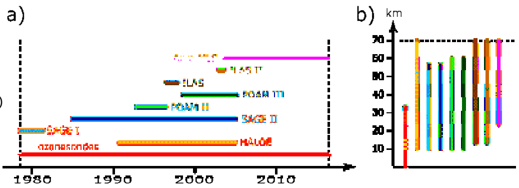


Figure 3: An example of the application of the data filling algorithm. Original field on the left and filled field on the right.

Monthly mean vertically resolved ozone

Changes in the vertical distribution of ozone have important impacts on climate and so it is essential that climate models simulate these changes with high fidelity. Similar to the construction of the total column ozone database, we have also constructed a long-term (1979-2016) vertically resolved, zonal mean (5° latitude zones), global ozone database by combining measurements form multiple satellites and from balloon-borne ozonesondes (Figure 4). Ozone concentrations are provided both in number density and in mixing ratio and on 70 altitude levels (1-70 km) and on 70 pressure levels. Offsets and drifts between different source data sets are removed through inter-satellite comparisons (Figure 5). Regression-model based methods are used to gap-fill the data set to create a filled, global, zonal mean monthly mean database better suited for model validation.

Figure 4: (a) Temporal and (b) vertical coverage of the different data sources used to create the latest version of the vertically resolved ozone database. Dashed lines in both panels denote the temporal (1979-2016) and vertical coverage (1-70km) of the ozone database. Note that ozonesondes are the only data source for the troposphere.



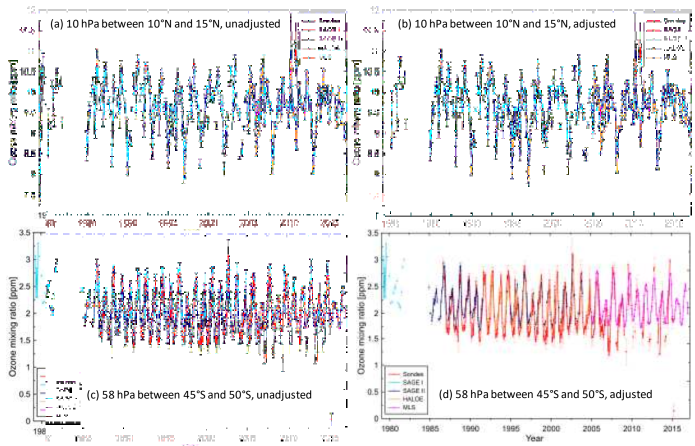


Figure 5: Monthly mean zonal mean ozone mixing ratio from different data sources, including their uncertainties, at 10 hPa (upper row) and 58 hPa (lower row). Panels a) and c) show the unadjusted time series while panels b) and d) show the adjusted time series. Adjustments are small but necessary for robust ozone trend detection.

Cloud field climatologies

Climatologies of various cloud properties have been calculated from data sourced from the International Satellite Cloud Climatology Project (ISCCP). ISCCP provides a variety of data products combining radiance measurements from multiple weather satellites spanning July 1983 to December 2009. For this application, and to simplify comparisons with climate model output, the 3 hourly D1 ISCCP data were re-gridded from a 280 km equal area grid onto the same grid as the New Zealand Earth System Model (NZESM).

To provide a cloud product which can be used to benchmark the cloud fields from NZESM, annual means, as well as daily and monthly climatologies, were calculated. Variables include cloud top pressure, optical thickness, and radiances for 7 different cloud types. These data will later be compared to climatologies calculated from COSP (CFMIP Observation Simulator Package), which emulates the ISCCP cloud fields by producing pseudo-satellite observations from the NZESM fields.

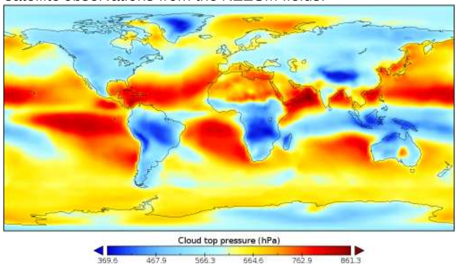


Figure 6: January monthly mean climatology of cloud top pressure over the period 1984-2009.

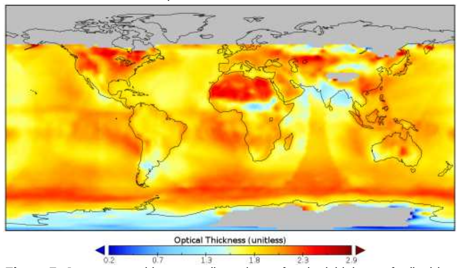


Figure 7: January monthly mean climatology of optical thickness for liquid cumulus clouds over the period 1984-2009.

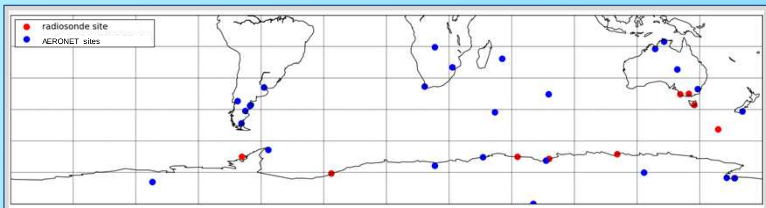


Figure 8: Measurements sites from which high resolution temperature data (red) and aerosol data (blue) were sourced.

High vertical resolution temperature profiles

Daily high vertical resolution temperature profiles obtained from radiosonde measurements have been collected and prepared in a common, easily accessible NetCDF file format for 10 Southern Hemisphere sites (Figure 8), providing information on:

- Pressure and temperature
- Wind speed and wind direction
- Relative humidity

The data are provided at high vertical resolution (about 1 measurement every 10 seconds) for at least 10 years of measurements from the surface to about 2 km altitude. As such, these measurements are suitable for estimating boundary layer (BL) heights and for comparison with the satellite derived BL climatologies.

Because data of sufficiently high vertical resolution and temporal coverage are seldom available from online radiosonde data archives, where traditionally only data on significant levels are stored, these data were obtained directly from the Australian Bureau of Meteorology to be used to calculate the BL heights for model validation (Figure 9).

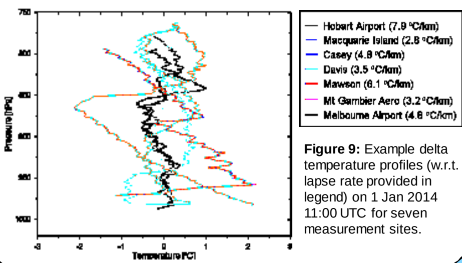


Figure 9: Example delta temperature profiles (w.r.t. lapse rate provided in legend) on 1 Jan 2014 11:00 UTC for seven measurement sites.

Aerosol measurements

Daily aerosol measurements from 26 Southern Hemisphere sites (Figure 10) have been collected and prepared in a common, easily accessible NetCDF file format that contain information on:

- Aerosol optical depth (AOD) at 1020, 870, 675, 500, 440, and 380 nm
- Ångstrom exponent
- Fine and coarse mode of AOD at 500 nm obtained by applying the SDA (Spectral Deconvolution Algorithm) retrieval approach

The measurements were obtained from AERONET (AErosol RObotic NETwork) and cover mostly 10 year periods. While version 3 implements an improved screening algorithm, version 2 is available with final quality assurance applied. Both versions have been made available to support different uses.

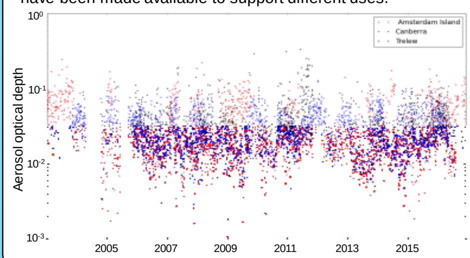


Figure 10: AOD at 1020 nm from three selected Southern Hemisphere measurements sites.

Acknowledgements: We would like to thank Matt Tully from the Bureau of Meteorology, Melbourne, for providing the high resolution temperature data.

We would like to thank the PIs of AERONET, and their staff, for establishing and maintaining the 26 sites from which the aerosol data were obtained.

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