Updated datasets for atmosphere and climate domain report

Prepared for Ministry for the Environment
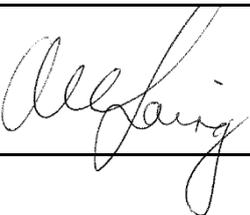
March 2017

Prepared by:
Gregor Macara

For any information regarding this report please contact:

Gregor Macara
Climate Scientist, Climate Data and Applications
NIWA
+64-4-386 0509
gregor.macara@niwa.co.nz

National Institute of Water & Atmospheric Research Ltd
Private Bag 14901
Kilbirnie
Wellington 6241

Phone +64 4 386 0300

Quality Assurance Statement		
SB Tait	Reviewed by:	Dr Andrew Tait
[signature]	Formatting checked by:	P Allen
[signature]	Approved for release by:	Dr Andrew Laing

Contents

Executive summary

The Ministry for the Environment (the Ministry) acquired a variety of climate and atmospheric datasets from NIWA for the 2015 Environmental Reporting Synthesis Report (Environment Aotearoa 2015). The Ministry requested NIWA to update these datasets to the end of 2016, which will contribute to the 2017 Atmosphere and Climate environmental report.

This report describes the datasets that were requested by the Ministry, and outlines the methodologies used to generate the datasets. In most cases a client report detailing the methodologies used has already been written, so references to those reports are provided.

Data were successfully delivered to the Ministry along with this report. Datasets were typically provided as .csv or Microsoft Excel (.xlsx) files, and maps were provided as .png files.

1   Project scope

The Ministry previously acquired datasets from NIWA which contributed to the 2015 Environmental Reporting Synthesis Report (Environment Aotearoa 2015). These datasets typically ended in December 2014. The Ministry requested updated versions of these datasets, so that data to the end of 2016 were provided. The following updated datasets were requested by the Ministry:

- Greenhouse gas concentrations measured at Baring Head (monthly).

- Ozone concentrations measured at Lauder (daily).

- National temperature time-series data (annual seven-station series, plus monthly data for multiple stations that have been infilled).

- Rainfall data (infilled) and associated maps (monthly).

- Wind speed data (infilled, monthly).

- Sunshine hours (annual) and associated percent of normal maps.

- UV intensity (daily).

- Ocean sea-surface temperature (annual).

- Ocean pH (two-monthly).

- Sea level (annual).

- Soil moisture maps (annual standardised PED).

- Growing degree days (annual, based on infilled temperature data).

- Warm days (annual, based on infilled temperature data).

- Frost days (annual, based on infilled temperature data).

Section 2 outlines the methodologies used to generate the datasets. In most cases, these methodologies have been described in previous reports provided to the Ministry, therefore references to those reports have been provided.

2 Data sources and methodologies

2.1 Greenhouse gas concentrations

Greenhouse gas concentrations are measured at NIWA's field site at Baring Head, near Wellington. The methodologies associated with the measurement of these data are described in Mikaloff Fletcher and Nichol (2014).

2.2 Ozone concentrations and UV intensity

Ozone and UV intensity data are measured at NIWA's research facility at Lauder, Central Otago (45.04°S, 169.68°E, altitude 370 m asl). UV intensity data measured is also measured at an additional four NIWA sites: Leigh (36.27°S, 174.80°E, 27 m asl), Paraparaumu (40.90°S, 174.98°E, 5 m asl), Christchurch (43.53°S, 172.61°E, 6 m asl) and Invercargill (46.42°S, 168.33°E, 1 m asl). The methodologies associated with the measurement of these data are described in Liley *et al.* (2014).

2.3 Temperature, rainfall and wind data

The methodologies used to generate the temperature (including warm days, frost days and growing degree days), rainfall and wind datasets are described in Macara and Tait (2015). The recent closure of the primary stations originally used for temperature and rainfall data in Dannevirke and Napier required the selection of a new primary station at each location. The updated descriptive information and regression analyses associated with the generation of the datasets at these sites are provided in Appendix A.

A full peer-reviewed report on the temperature data homogenisation methodology and adjustments for each of the seven climate stations and the combined 7SS has been produced and is available from https://www.niwa.co.nz/climate/information-and-resources/nz-temperature-record.

2.4 Sunshine and soil moisture (PED) maps

The generation of sunshine and soil moisture (PED) maps are described in Tait *et al.* (2014).

2.5 Ocean sea-surface temperature

The methodology used to generate the ocean sea-surface temperature data is described in Uddstrom (2015).

2.6 Ocean pH

Ocean pH data has been provided to the Ministry in the past, however a formal report pertaining to these data wasn't written at the time: rather, the methodology was explained to the Ministry informally (Currie, *pers. comm.*, 21 March 2017). The following description outlines the methodology associated with generating the ocean pH data.

The Munida Time Series Transect extends 65 km from Taiaroa Head at the entrance to Otago Harbour (45.77°S, 170.72°E) to 45.82°S, 171.53°E. Carbonate Chemistry parameters and associated measurements are measured approximately every two months, subject to suitable weather and sea conditions.

pCO2 is measured continuously along the transect using a custom-built instrument. Data are logged every 30 seconds, then averaged into 0.5km bins. Temperature and salinity are measured

continuously using a Seabird thermosalinograph (SBE45/SBE38). Data is logged every 10 seconds, then averaged into 0.5km bins. Alkalinity samples are taken at 9 stations along the voyage transect, and analysed using a custom-built closed cell potentiometric titration instrument.

Data from ≥50 km offshore are averaged to obtain Subantarctic water values.

DIC and *pH* are calculated from the averaged *pCO2* and alkalinity, using refitted Mehrbach equilibrium constants.

2.6.1   Units used

- *Tsw* = mean_surface_temperature_degree_celsius.

- *S* = mean_salinity_unitless (parts_per_1000, ‰).

- *pCO2* = mean_pCO2_microatmospheres.

- *At_mmol_kg-1* = micromoles per kilogram of seawater.

- *DIC* = dissolved_inorganic_carbon_mmol_kg-1 (micromoles per kilogram of seawater).

- pH = the alkalinity or acidity of a solution, with 7 being neutral. Total scale, at in situ temperature.

2.6.2   Treatment of missing values

- Missing salinity: The alkalinity analyses use salinity in the calculation but is not sensitive to it, resulting in a small error. Calculation of *DIC* and *pH* from alkalinity and *pCO2* uses salinity, but is not sensitive to it. Therefore, a "typical" value for salinity is used if that data was not available (shown in red in the associated Excel spreadsheet, but calculated value not highlighted).

- Missing *pCO2*: calculated *DIC* and *pH* are very dependent on *pCO2*. Therefore if *pCO2* is missing, *DIC* and *pH* were not calculated.

- Missing alkalinity: calculated *DIC* and *pH* is slightly dependent on alkalinity. Therefore if alkalinity is missing, a value was estimated for use in the *DIC* and *pH* calculations, with estimated values indicated with a red highlight in the associated Excel spreadsheet.

2.7   Sea level

The methodologies used to generate the sea level datasets are described in Hannah (1990, 2004) and Hannah & Bell (2012).

3   Data delivery

The following table describes the file formats of the updated datasets that were delivered to the Ministry.

Table 1: Datasets delivered to the Ministry and associated file formats.

Dataset	Date range of available data	File format
Greenhouse gas concentrations (monthly)	1972 - 2016	.csv
Ozone concentrations (daily)	1978 - 2016	.csv
National temperature time series (annual), plus monthly temperature data at 30 NZ locations	1909 – 2016 (annual) 1972 – 2016 (monthly)	.xlsx
Rainfall data and associated maps (monthly)	1960 - 2016	.xlsx, .png, .gdb
Wind speed data (monthly)	1972 - 2016	.csv
Sunshine hours and associated percent of normal maps (annual)	1972 - 2016	.png, .gdb
UV intensity (daily)	1993 - 2016	.csv
Ocean sea-surface temperature (annual)	1993 - 2016	.dat, .gif
Ocean pH (two-monthly)	1998 - 2016	.xlsx
Seal level (annual)	1899 - 2016	.csv
Soil moisture maps (standardised PED, annual)	1972 - 2016	.png, .gdb
Growing degree days (annual)	1972 - 2016	.xlsx
Warm days (annual)	1972 - 2016	.xlsx
Frost days (annual)	1972 - 2016	.xlsx

4   Acknowledgements

The following NIWA staff are acknowledged for their contribution to this project:

Greenhouse datasets were provided courtesy of Sylvia Nichol.

Ozone and UV datasets were provided courtesy of Ben Liley.

Sunshine and soil moisture (PED) maps were produced by Vijay Paul, utilising datasets generated by Abha Sood, Andrew Tait and Brett Mullan.

Ocean sea surface temperature data were provided courtesy of Michael Uddstrom.

Ocean pH data and associated information pertaining to its measurement were provided by Kim Currie (NIWA/University of Otago Research Centre for Oceanography).

Sea level data were provided courtesy of Rob Bell.

5   References

Hannah, J. (1990) Analysis of Mean Sea Level Data from New Zealand for the Period 1899-1988. Journal of Geophysical Research, 95, 12399-12405.

Hannah, J. (2004) An updated analysis of long-term sea level change in New Zealand. Geophysical Research Letters, 31, L03307, 4p.

Hannah, J. and R. G. Bell (2012) Regional sea level trends in New Zealand. Journal of Geophysical Research, 117, C01004, 7p.

Liley, B., R. Querel and R. McKenzie (2014) Measurements of Ozone and UV for New Zealand. Client Report no. WLG2014-94. Prepared for the Ministry for the Environment, 13p.

Macara, G. and A. Tait (2015) Infilling of missing climate data for the 2015 Environmental Synthesis Report: Temperature, Rainfall and Wind. Client report no. WLG2015-33. Prepared for the Ministry for the Environment, 37p.

Mikaloff Fletcher, S. E. and S. Nichol (2014) Measurement of Trace Gases in Well-mixed Air at Baring Head: Trends in carbon dioxide, methane, nitrous oxide and carbon monoxide. Client report no. WLG2014-87. Prepared for the Ministry for the Environment, 51p.

Tait, A., G. Macara and V. Paul (2014) Preparation of climate datasets for the 2015 Environmental Synthesis Report: Temperature, Rainfall, Wind, Sunshine and Soil Moisture. Client Report no. WLG2014-91. Prepared for the Ministry for the Environment, 27p.

Uddstrom, M. (2015) Sea surface temperature data and analysis for the 2015 synthesis report. Client report no. WLG2015-7. Prepared for the Ministry for the Environment, 28p.

Appendix A   Temperature and rainfall data series

The recent closure of the primary stations originally used for temperature and rainfall data in Dannevirke and Napier required the selection of a new primary station at these locations. The following three tables indicate the stations used to obtain temperature and rainfall data at each location, and the regression analyses associated with the generation of the daily temperature and rainfall datasets.

Stations selected:

Location	Station (agent #)	VCSN agent #
Dannevirke	Dannevirke Ews (26958) Dannevirke (2534)	27324
Napier	Napier Ews (41330) Napier Nelson Pk (2997)	30044

Regression analyses - temperature:

Original	Comparison	Variable	Regression	R^2
Dannevirke Ews	Dannevirke	Tmax	$0.9999x - 0.6163$	0.9353
		Tmin	$0.9581x + 0.0477$	0.8715
Dannevirke merged	VCSN	Tmax	$1.0114x - 0.6818$	0.9821
		Tmin	$1.0015x - 0.1693$	0.9714
Napier Ews	VCSN	Tmax	$1.0220x - 0.0379$	0.9853
		Tmin	$1.0841x - 0.0850$	0.9668
Napier VCSN adjusted	Napier Nelson Pk	Tmax	$1.0094x - 0.2107$	0.9764
		Tmin	$1.0154x - 0.1590$	0.9657

Regression analyses – rainfall:

Original	Comparison	Regression	R^2
Dannevirke Ews	Dannevirke	$0.9900x - 0.0552$	0.9752
Dannevirke merged	VCSN	$0.9307x + 0.1914$	0.8929
Napier Ews	VCSN	$0.9574x + 0.1013$	0.9747
Napier VCSN adjusted	Napier Nelson Pk	$0.9245x + 0.0505$	0.9345