A Climatology of UVI for New Zealand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Auckland	10	8	7	4	2	1	2	2	3	6	8	9
Wellington	9	8	6	3	1	1	1	2	2	5	7	8
Christchurch	8	7	5	2	1	1	1	1	2	4	7	8
Central Otago	8	7	5	2	1	1	1	1	2	4	6	8
Invercargill	7	6	4	2	1	0	0	1	2	3	5	6

Mean UVI (including clouds)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Auckland	13	11	7	4	2	2	3	4	6	8	11	13
Wellington	13	9	6	2	1	1	2	3	4	8	11	12
Christchurch	12	8	5	2	1	1	1	3	4	8	10	11
Central Otago	10	8	5	2	1	1	1	3	4	6	10	11
Invercargill	8	7	4	1	1	1	1	2	2	5	8	10

Peak UVI (cloudless)

NIWA Client Report: LAU2007-02RLM
September 2007

NIWA Project: CAN08601601

NIWA
Taihoro Nukurangi

A Climatology of UVI for New Zealand

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1. Client Agreement

The purpose of this contract was to provide information to the Cancer Society of New Zealand so that they can use it in preparing promotional information to dissemination to the public in a manner that is consistent with the information provided in Australia.

The products to be delivered are:
1. Means of hourly noontime UVI versus month at 5 sites in NZ
2. Maxima of hourly noontime UVI versus month at 5 sites in NZ
3. Diurnal variation in hourly mean UVI versus month at 5 sites in NZ
4. Diurnal variation in hourly maxima UVI versus month at 5 sites in NZ
5. Map of NZ with behavioural messages specified for cities(as in the Australian version). Messages to be jointly developed with clients.
6. Write up into a report

Delivery date for first draft: 12 Oct 2007

2. Introduction and Definitions

The standard classification of skin types, and their sensitivities to sunlight are summarised in table 1.

Skin Type		Burns in the sun	Tans after having been in the sun	* SED/ Erythema
I	melano-compromised	always	seldom	2-3
II		usually	sometimes	2.5-3
III	melano-competent	sometimes	usually	3-5
IV		seldom	always	4.5-6
V	melano-protected	no	naturally brown	6-20
VI		no	naturally black	6-20

Table 1. Skin types and dose for causing erythema.

* It takes 2 to 3 SED (1 SED= 100 Jm-2 of erythemally-weighted UV) to burn skin type I, etc (Fitzpatrick, 1988). It takes up to 20 times that dose (6-20 SED) to burn skin type VI. Therefore, having skin type VI is equivalent to wearing a sunscreen with SPF = 20. But there is a wide range.

If UVI = 12 we can get 2.5 SED in less than 15 minutes (see Box 1)

On a summer's day in NZ there can be more than 70 SED

Box 1.

If UVI = 12, then
UV_{Ery} = 12/40 Wm^{-2}
= 0.3 Wm^{-2}
= 0.3 $Jm^{-2}s^{-1}$

2.5 SED = 250 Jm^{-2}

Time for 2.5 SED @ UVI = 12
= 250/0.3 seconds
= 14 minutes

Note that WHO recommends against "burn time" messages.

The following two tables summarise the WHO definitions of UVI ranges, these range map to the standard colour scale, and the appropriate behavioural messages that should accompany each UVI category for the public of New Zealand.

Descriptor	UVI Range	Colour	rgb	PMS
Low	<2.5	Green	040, 149, 000	375
Moderate	2.5-5.5	Yellow	247, 228, 000	102
High	5.5-7.5	Orange	248, 089, 000	151
Very high	7.5-10.5	Red	216, 000, 029	032
Extreme	>10.5	Purple	107, 073, 200	265

Table 2. Specification of UVI and colour tables

Range	Descriptor	Behavioural Message
UVI < 3	LOW	No protection required.. You can safely stay outside
UVI 3 to 5	MODERATE	Protection required when spending long periods in the sun, especially if you have fair skin.
UVI 6 to 7	HIGH	Protection essential. Slip, slop, slap & wrap.
UVI 8 to 10	VERY HIGH	Seek shade. Slip, slop, slap & wrap.
UVI > 10	EXTREME	Reschedule outdoor activities for early morning and evening. Cover up & reapply sunscreen regularly. Full protection essential.

Table 3. Behavioural messages corresponding to the peak UVI forecast integer values.

Note that in New Zealand the peak UVI usually occurs between 1:30 pm and 1:45 pm.

Data Analysis

Tables of UVI were constructed from at least 5 years of UV measurements taken at Leigh (representing Auckland), Paraparaumu (representing Wellington), Christchurch, Lauder (representing Central Otago), and Invercargill.

The instruments are all Robertson Berger-type meters, which are operated by NIWA at each of these sites. They are calibrated regularly against a spectrometer at Lauder.

The data represent means and peak values of 1-hourly integrations, taken over the period 2002 to mid 2007.

Note that the absolute peak values over intervals shorter than 1 hour can be significantly greater than those reported here.

Data were processed using RBP01.EXE (written in MS Visual Basic). The retrieval algorithm includes the necessary corrections to allow for differences between the instrument response function and the erythemal action spectrum. These corrections depend on the ozone amount and the solar zenith angle for each measurement.

Data were then post-processed using an IDL program to extract the subsets shown in the Tables. The data are colour-coded to match the standard UVI colours recommended by WHO (WHO, 2002).

The following simplifications have been made in the analysis:

- The UVI values given have been rounded to the nearest integer (e.g., 6.8, or 7.2 both become UVI = 7). Data are available to higher precision if required
- Since this product is for the general public, all times are given in local time. The original data are logged in NZST. To convert this to local time we have moved data forward 1 hour for the summer months when daylight savings is operational (i.e., October through March). Data are available in NZST if required.
- For the purposes of splitting data into months, we have assumed that each month is $1/12^{th}$ of the year. The error in any month from this approximation is negligible.

3. Results

Monthly values of the mean (including clouds) and maximum (cloud-free) UVI for the hour centred at solar noon are shown in Table 4 and Table 5 below. The mean values in Table 4 are directly comparable with those given in Australian Position Statement on the Risks and Benefits of Sun Exposure (3 May 2007).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Auckland	10	8	7	4	2	1	2	2	3	6	8	9
Wellington	9	8	6	3	1	1	1	2	2	5	7	8
Christchurch	8	7	5	2	1	1	1	1	2	4	7	8
Central Otago	8	7	5	2	1	1	1	1	2	4	6	8
Invercargill	7	6	4	2	1	0	0	1	2	3	5	6

Table 4. Mean UVI (including clouds)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Auckland	13	11	7	4	2	2	3	4	6	8	11	13
Wellington	13	9	6	2	1	1	2	3	4	8	11	12
Christchurch	12	8	5	2	1	1	1	3	4	8	10	11
Central Otago	10	8	5	2	1	1	1	3	4	6	10	11
Invercargill	8	7	4	1	1	1	1	2	2	5	8	10

Table 5. Peak UVI (cloudless)

Further details of the variation of the mean UVI throughout the day are illustrated for the Auckland site in Table 6. The corresponding details for both the mean UVI and the peak UVI are shown for all 5 sites in Appendix 1.

Auckland - measured at Leigh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	1
8	1	1	0	1	0	0	0	0	1	1	1	1
9	3	2	1	2	1	1	1	1	2	2	3	3
10	5	4	3	3	2	1	1	2	3	3	4	5
11	7	6	5	4	2	1	2	2	4	4	7	7
12	9	8	6	4	2	2	2	3	4	5	8	9
13	10	8	7	4	2	1	2	2	3	6	8	9
14	9	8	6	3	1	1	1	2	3	5	7	8
15	7	6	4	1	1	1	1	1	2	3	5	6
16	5	4	3	1	0	0	0	0	1	2	3	4
17	3	2	1	0	0	0	0	0	0	1	2	2
18	1	1	0	0	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	0	0	0	0	0	0

Table 6. Diurnal and seasonal variation in mean UVI (with clouds) for the Auckland site

4. Discussion

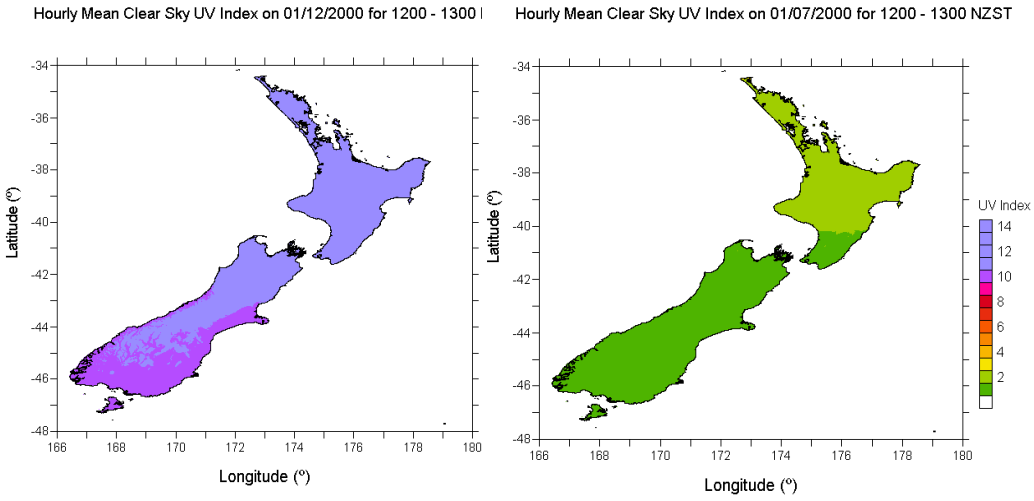
1. The UVI is much less in winter than in summer, particularly in the South where winter values are less than 7% of summer values.
2. The UVI decreases from North to South, especially in winter
3. The mean hourly UVI at noon never exceeds 10 even in the North of New Zealand
4. The peak hourly UVI at noon exceeds 10 for 3 months in the North, and 2 months in the South Island, except for Invercargill where it never exceeded 10 in the these years.
5. In the North, the UVI is less than 2 for 2 months, while in the South it is less than 2 for 5 month.
6. Some UV is necessary to maintain vitamin D in the body. Previous studies have shown that there is insufficient UV to photosynthesise vitamin D at 42N (Boston, USA) in the winter from November through February (Hollis, 2005); and no vitamin D is made at 52N for the months between October and March (Webb, Kline, and Holick, 1988). These periods of insufficiency in UV correspond to times when the UVI is less than 2 (upper limit 1.5). Based on these figure, we can infer that in the winter months in New Zealand, especially in the South, there will be some regions where UVI < 2, so there is insufficient UV for the production of Vitamin D. Further quantification of this threshold is the subject on ongoing research.
7. When the UVI is less than 1, as for some of the winter months in the South Island, it is likely that there will be insufficient UV for synthesis of adequate vitamin D. This threshold is the subject of ongoing research.

5. Interpolation to other sites

The North-South gradient in UVI is clearly apparent in these tables, which implies that to a reasonable accuracy, the corresponding UVI values at locations between the measurement sites may be estimated by interpolation.

An exception to this rule is on ski fields. There, the higher altitudes and reflections from the snow-covered surface lead to UVI values that are approximately 50% more than at nearby populated centres. For example, if UVI = 2 in Christchurch, then UVI =3 at Mt Hutt ski field (Allen and McKenzie, 2005).

If greater detail is required, it would be possible to provide data at other sites using results from NIWA's UV Atlas. This product combines model calculations for clear skies with cloud transmission deduced from measurements of broad band radiation (not UV radiation), as described by Bodeker and McKenzie (1996). Examples of the geographical gradients in UVI at midday on a summer's day and a winter's day are shown in below (from http://www.niwascience.co.nz/services/uvozone/atlas). Note that these maps are for clear skies with no snow cover.



6. How Much Sun is Enough?

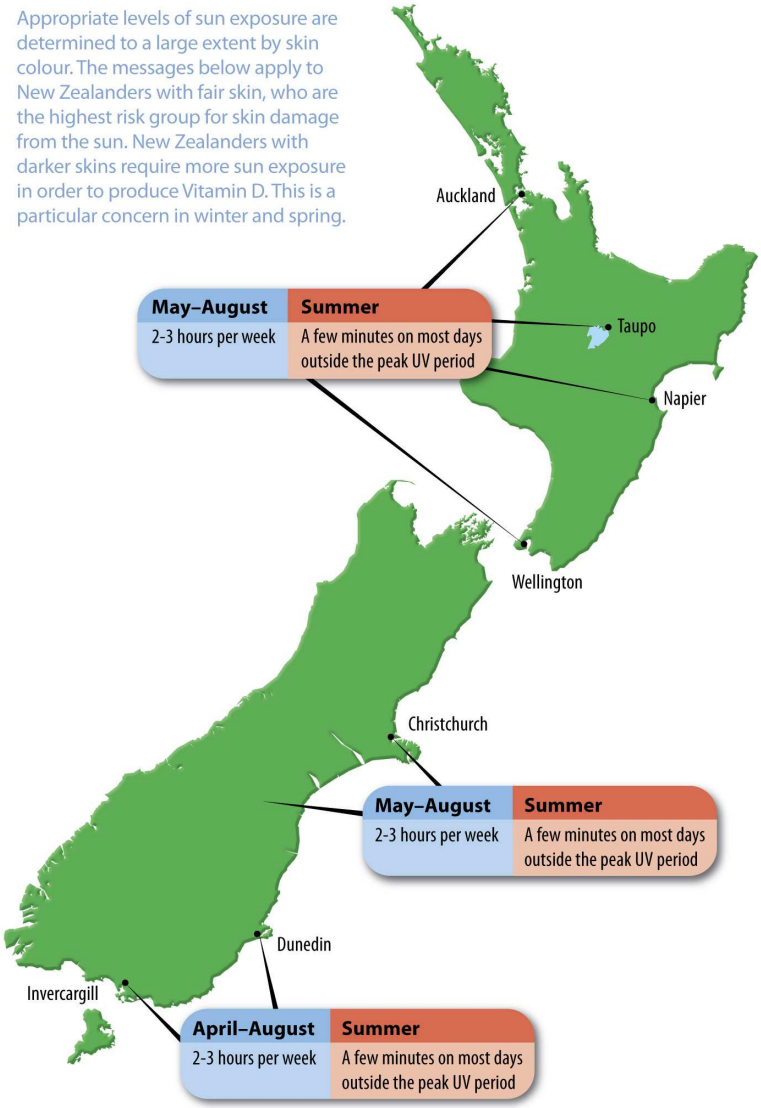
Skin colour and age influence the effects of sun exposure.

New Zealanders with lighter coloured skin, particularly younger people, are more vulnerable, especially during daylight saving months, to the overexposure that is linked with skin cancers. So it is important to limit sun exposure, particularly when the UVI level is higher.

New Zealanders with darker coloured skin, and older people, are more vulnerable, particularly during winter months, to vitamin D insufficiency or deficiency. So it is more important for these people to ensure that they receive adequate sun exposure and, if there is concern about the possibility of vitamin D insufficiency, to seek the advice of their physician.

How much sun is enough?

Appropriate levels of sun exposure are determined to a large extent by skin colour. The messages below apply to New Zealanders with fair skin, who are the highest risk group for skin damage from the sun. New Zealanders with darker skins require more sun exposure in order to produce Vitamin D. This is a particular concern in winter and spring.



To maintain vitamin D levels, get some sun on 15% of the body – for example, face, arms and hands, for the recommended time.

Cancer Society

SUNSMART

NIWA
Taihoro Nukurangi

August 2007

Glossary of terms

UV Ultraviolet radiation

UVB Radiation in the range 280 to 315 nm

UVA Radiation in the range 315 to 400 nm

UV_{Ery} Erythemally Weighted UV. Radiation that causes sunburn. Mainly UVB, but including a small component of UVA radiation (McKinlay and Diffey, 1987).

UVI UV Index, a measure of the intensity of the instantaneous intensity UV radiation (40 x UV_{Ery} in units of Wm-2 (i.e. $Jm^{-2}s^{-1}$)

SED Standard Erythemal Dose is a measure of the accumulated erythemally-weighted UV energy, where 1 SED = 100 Jm^{-2}

MED Minimum Eythemal Dose is a measure of the accumulated erythemally weighted UV energy that would cause the first perceptible sign of reddening (i.e., erythema). The energy-equivalent depends on the skin type. For the most sensitive skin types, 1 MED is approximately 2 SED.

SPF Sun Protection Factor for sunscreens. An SPF of 20 means that it takes 20 times as long to cause the same damage under constant UV radiation. A sunscreen with SPF 20 blocks 95% of the erythemally weighted UV

Acknowledgements

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Reviewed by:	*Approved for release by:*
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Appendix 1

Hourly values of UVI at five sites in New Zealand, based on a 5-year climatology of UV measurements.

Mean UVI Values

Auckland - measured at Leigh

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	1
8	1	1	0	1	0	0	0	0	1	1	1	1
9	3	2	1	2	1	1	1	1	2	2	3	3
10	5	4	3	3	2	1	1	2	3	3	4	5
11	7	6	5	4	2	1	2	2	4	4	7	7
12	9	8	6	4	2	2	2	3	4	5	8	9
13	10	8	7	4	2	1	2	2	3	6	8	9
14	9	8	6	3	1	1	1	2	3	5	7	8
15	7	6	4	1	1	1	1	1	2	3	5	6
16	5	4	3	1	0	0	0	0	1	2	3	4
17	3	2	1	0	0	0	0	0	0	1	2	2
18	1	1	0	0	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	0	0	0	0	0	0

Wellington - measured at Paraparaumu

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	1
8	1	1	0	1	0	0	0	0	1	1	1	2
9	2	2	1	1	1	0	0	1	1	2	2	3
10	4	4	3	2	1	1	1	1	2	3	4	5
11	6	6	4	3	2	1	1	2	3	4	6	7
12	8	7	5	3	2	1	1	2	3	5	7	8
13	9	8	6	3	1	1	1	2	2	5	7	8
14	8	7	5	2	1	1	1	1	2	4	6	7
15	7	6	4	1	0	0	0	1	1	3	4	6
16	5	4	2	0	0	0	0	0	0	2	3	4
17	3	2	1	0	0	0	0	0	0	1	1	2
18	1	1	0	0	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	0	0	0	0	0	0

Maximum UVI Values

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	1	1	1	1
8	1	1	0	1	0	0	0	1	2	2	2	2
9	3	2	1	2	1	1	1	2	4	3	4	5
10	6	4	2	3	1	1	2	3	5	6	6	7
11	9	7	4	4	2	2	2	4	6	8	9	10
12	12	10	6	4	2	2	2	5	7	8	10	12
13	13	11	7	4	2	2	3	4	6	8	11	13
14	13	10	6	3	1	1	2	3	4	7	10	13
15	10	8	5	1	1	1	1	2	3	4	8	11
16	7	5	3	1	0	0	0	1	1	3	5	8
17	4	3	2	0	0	0	0	0	0	1	3	4
18	2	1	1	0	0	0	0	0	0	1	1	2
19	1	0	0	0	0	0	0	0	0	0	0	1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	1	1	1	1
8	1	1	0	1	0	0	0	1	1	2	2	2
9	3	2	1	1	1	1	1	2	3	3	4	4
10	6	4	3	2	1	1	1	2	4	5	7	7
11	9	7	4	3	2	1	2	3	5	7	9	10
12	12	8	5	3	2	1	2	4	5	8	11	11
13	13	9	6	2	1	1	2	3	4	8	11	12
14	12	6	5	1	1	1	1	2	3	7	10	11
15	10	6	3	1	0	0	1	1	2	5	8	9
16	7	4	2	0	0	0	0	1	1	3	5	6
17	4	2	1	0	0	0	0	0	0	2	3	3
18	2	1	0	0	0	0	0	0	0	1	1	1
19	1	0	0	0	0	0	0	0	0	0	0	0

….The table is continued for South Island sites on the next page.

Christchurch

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	1
8	1	1	0	0	0	0	0	0	1	1	1	1
9	2	2	1	1	0	0	0	1	1	1	3	3
10	4	3	2	2	1	1	1	1	2	2	4	4
11	6	5	3	2	1	1	1	1	3	3	6	6
12	8	7	5	3	1	1	1	2	3	4	7	7
13	8	7	5	2	1	1	1	1	2	4	7	8
14	8	7	5	2	1	1	1	1	2	4	6	7
15	6	6	4	1	0	0	0	1	1	3	5	6
16	4	4	2	0	0	0	0	0	0	2	3	4
17	3	2	1	0	0	0	0	0	0	1	1	2
18	1	1	0	0	0	0	0	0	0	0	1	1
19	0	0	0	0	0	0	0	0	0	0	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	1	0	1	1
8	1	1	0	0	0	0	0	1	1	1	2	2
9	3	2	1	1	0	0	1	1	3	2	4	4
10	5	3	2	2	1	1	1	2	4	4	6	7
11	9	5	4	2	1	1	1	3	4	6	8	9
12	11	7	5	3	1	1	2	3	4	7	10	10
13	12	8	5	2	1	1	1	3	4	8	10	11
14	11	8	4	1	1	1	1	2	3	7	9	11
15	9	6	3	1	0	0	0	1	1	4	7	10
16	6	4	2	0	0	0	0	0	1	3	4	7
17	3	2	1	0	0	0	0	0	0	1	2	4
18	2	1	0	0	0	0	0	0	0	1	1	2
19	1	0	0	0	0	0	0	0	0	0	0	1

Central Otago - measured at Lauder

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	0
8	1	1	0	0	0	0	0	0	0	1	1	1
9	2	1	1	1	0	0	0	0	1	1	2	3
10	4	3	2	2	1	0	0	1	2	2	4	4
11	6	5	3	2	1	1	1	1	2	3	5	6
12	7	6	4	3	1	1	1	2	3	4	6	8
13	8	7	5	2	1	1	1	1	2	4	6	8
14	8	7	5	2	1	0	1	1	2	4	6	7
15	6	6	4	1	0	0	0	1	1	3	4	6
16	5	4	2	0	0	0	0	0	1	2	3	4
17	3	2	1	0	0	0	0	0	0	1	2	2
18	1	1	0	0	0	0	0	0	0	0	1	1
19	1	0	0	0	0	0	0	0	0	0	0	0

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	1	1
8	1	1	0	0	0	0	0	0	2	1	2	2
9	2	2	1	1	0	0	0	1	2	2	4	4
10	5	3	2	1	1	1	1	2	3	4	6	6
11	8	5	3	2	1	1	1	2	4	6	8	8
12	10	7	5	2	1	1	1	3	4	7	10	11
13	10	8	5	2	1	1	1	3	4	6	10	11
14	10	8	4	1	1	1	1	2	2	6	9	9
15	9	7	4	1	0	0	1	1	2	5	8	8
16	7	5	2	0	0	0	0	1	1	4	5	6
17	5	3	1	0	0	0	0	0	0	2	3	4
18	2	1	0	0	0	0	0	0	0	1	1	2
19	1	0	0	0	0	0	0	0	0	0	1	1

Invercargill

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	1
9	1	1	0	0	0	0	0	0	0	1	1	1
10	2	1	1	1	0	0	0	0	1	1	2	2
11	4	3	2	1	1	0	0	1	1	2	3	4
12	5	4	3	2	1	0	1	1	2	3	4	5
13	6	5	3	2	1	0	1	1	2	3	5	6
14	7	6	4	2	1	0	0	1	2	3	5	6
15	6	5	3	1	0	0	0	1	1	3	4	6
16	5	4	2	1	0	0	0	0	1	2	3	4
17	3	3	1	0	0	0	0	0	0	1	2	3
18	2	1	1	0	0	0	0	0	0	1	1	1
19	1	1	0	0	0	0	0	0	0	0	0	1

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	0	0	0	0	0	0	0	0	0	0	0	0
8	1	0	0	0	0	0	0	0	0	0	1	1
9	2	0	0	0	0	0	0	1	1	1	2	2
10	4	1	1	1	0	0	0	1	2	3	4	3
11	6	3	1	1	1	0	1	2	3	4	6	6
12	8	5	3	2	1	1	1	2	3	4	8	10
13	8	7	4	2	1	1	1	2	3	5	9	8
14	8	7	4	1	1	1	1	2	2	5	8	9
15	8	7	4	1	0	0	1	1	2	5	7	9
16	8	5	2	0	0	0	0	1	1	3	6	7
17	5	4	1	0	0	0	0	0	0	2	3	4
18	3	2	1	0	0	0	0	0	0	1	1	2
19	1	1	0	0	0	0	0	0	0	0	1	1