Linking People and Climate

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New Zealand Population Conference

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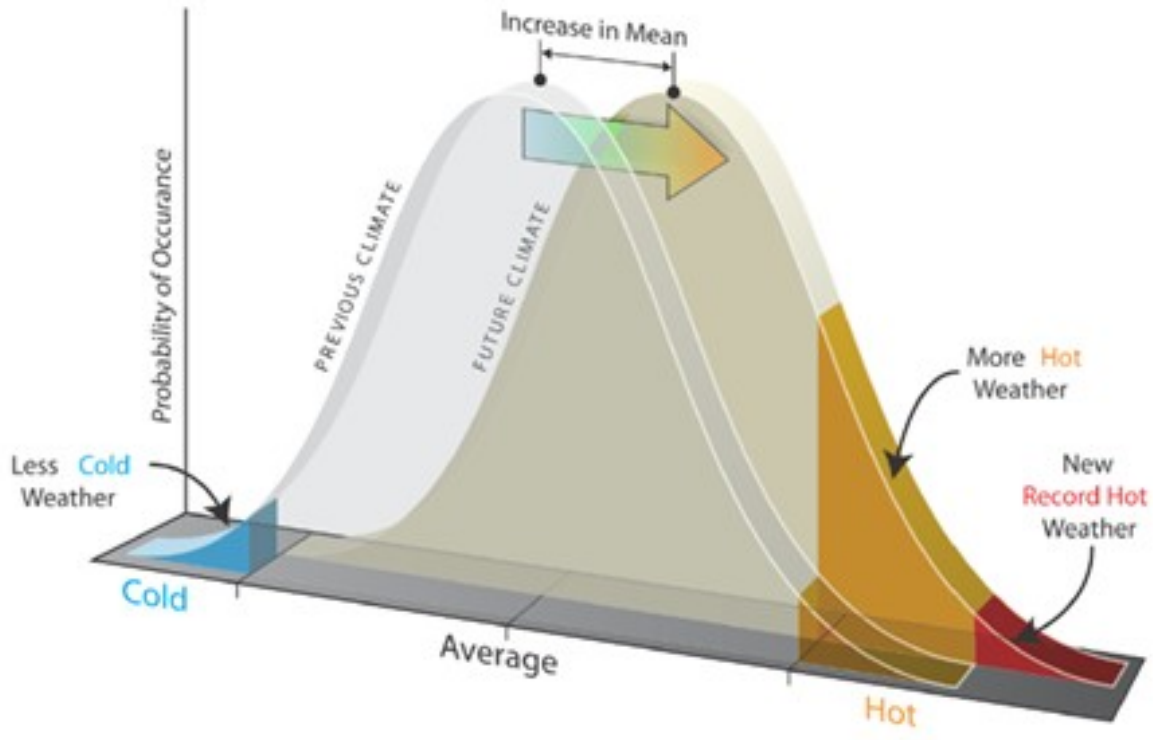
Climate Change

Seemingly simple to ask but complex to answer question:

“Is climate changing noticeably?”

Extreme Events

“It’s the tails that matter.”



Changes in extremes scale with global warming so that at 2°C extremes are projected to double, while at 3°C they quadruple from levels expected with 1.5°C of warming.

(IPCC AR6 WG1)

Sources: Seneviratne, S. I., Zhang, X., Adnan, M., …, & Zhou, B. (2021). Weather and Climate Extreme Events in a Changing Climate. In V. Masson-Delmotte, P. Zhai, A. Pirani, . . . B. Zhou (Eds.), Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press. In Press.
Reisinger, A. (2009). *Climate Change 101 An Educational Resource: Science, Impacts, Adaptation, Mitigation, Decision-making Challenges*.

- Expert Team on Climate Change Detection and Indices (ETCCDI)

Composite Extreme Indices

- **NOAA Climate Extremes Index (CEI)**
- **Actuarial indices**

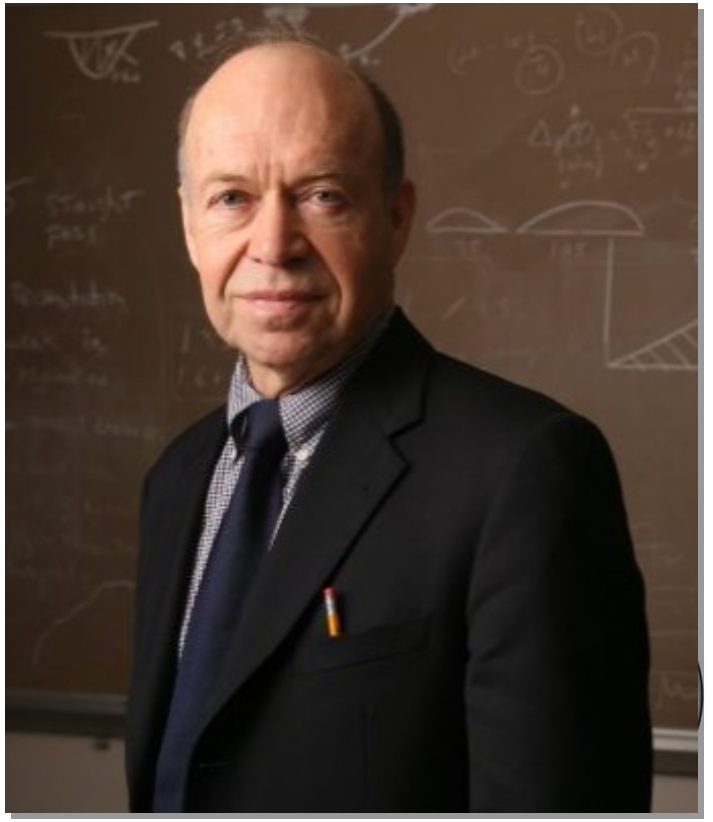
Definitions of Extremes	IPCC Reports	Year	CEI family of Extreme Indices	Actuarial family of Indices
	IPCC FAR	1990		
		1991		
		1992		
		1993		
		1994		
	IPCC SAR	1995		
		1996	NOAA Climate Extremes Index (CEI)	
Expert Team on Climate Change Detection and Indices (ETCCDI)		1997		
		1998		Hansen's Common-Sense Climate Index*
		1999		
		2000		
	IPCC TAR	2001		
		2002		
		2003		
		2004		
		2005		
		2006		
	IPCC AR4	2007		
		2008	Revised CEI by Gleason (Operational CEI)	
		2009		
		2010	Modified CEI (mCEI and dmCEI), Australia	
		2011		
	IPCC SREX	2012		
	IPCC AR5	2013		
		2014	mCEI and dmCEI for US, Europe, Australia	
		2015	ETCCDI-based modified CEI (EmCEI)	
		2016		Actuaries Climate Index (ACI), North America
		2017		
Expert Team on Sector-specific Climate Indices (ET-SCI)	IPCC SR 1.5°C	2018		Australian Actuaries Climate Index (AACI)
		2019		
		2020	CEI for Climate Models and Spatial CEI	
	IPCC AR6	2021	CEI with Z-scores Extremes Vulnerability Index (EVI)	European Extreme Events Climate Index (E^3CI)

* Not an actuarial index, but conceptually closer to this family of indices

Hansen's "Common-Sense" Climate Index

- "… a climate index [that provides] an objective assessment of practical climate change".
- "Our aim is to help people judge whether or not climate fluctuations are a significant indication of change and to provide improved understanding of climate variability."

- Use "climate indicators noticed by people".
  - **Temperature Index** (four components)
  - **Moisture Index** (three components)

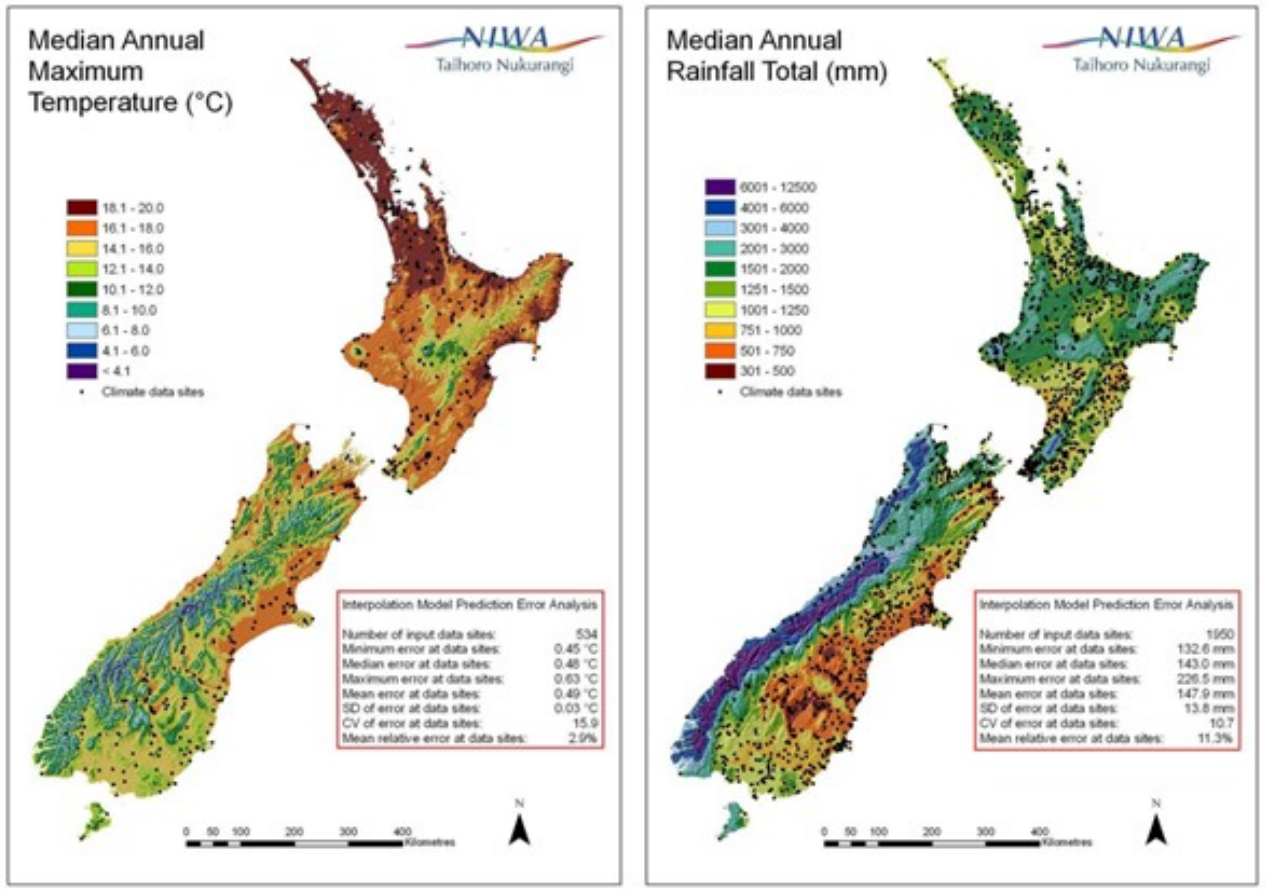


Source: Hansen, J., Sato, M., Glascoe, J., & Ruedy, R. (1998). A common-sense climate index: Is climate changing noticeably? Proceedings of the National Academy of Sciences, 95(8), 4113-4120.

Philosophical Approach

- Followed a path “from first principles” - a return to basics and the underlying data.
- The approach is to “listen to the stories” held in the data to find a simple way to share those stories more widely.

NIWA VCSN: Gridded Daily Data



After interpolation, with location of climate stations used

- Thin plate spline interpolation from daily observational data. Trivariate splines.
- 14 measures
- Results produced for 0.05° latitude/longitude grid across New Zealand at ~5km resolution
- **11,491 virtual stations**

Sources: Tait, A., Henderson, R., Turner, R., & Zheng, X. (2006). Thin plate smoothing spline interpolation of daily rainfall for New Zealand using a climatological rainfall surface. International Journal of Climatology, 26(14), 2097-2115

Tait, A., & Zheng, X. (2007). Analysis of the Spatial Interpolation Error associated with Maps of Median Annual Climate Variables. NIWA.

VCSN Stations and Pilot Areas

- Daily data for 50 years (1972-2022)
- **11,491 virtual stations** (210 million lines)

- **Pilot subsets:**
- ECAN (2,013 stations, 37 million lines)
- Hurunui District (381 stations, 7 million lines)
- Hanmer Springs (one station, 18,250 lines)

- **“Ground-truthing”**

Conceptually simple “Days with …”

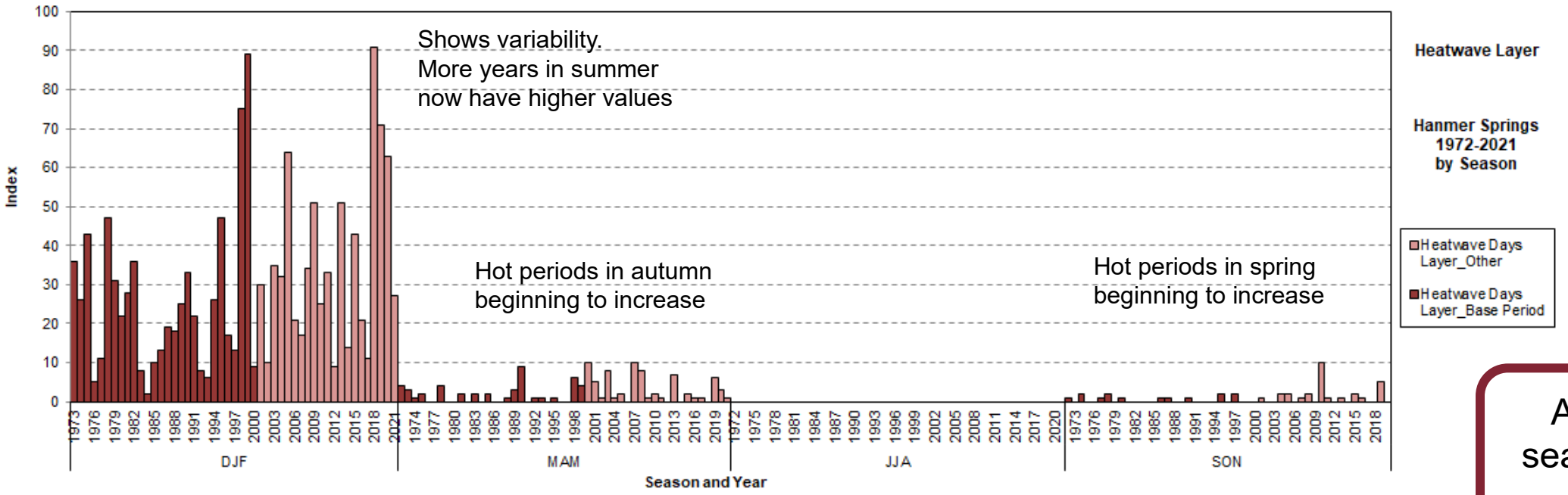
Layered to enhance the signal

Measures by meteorological season

Summer (DJF), Autumn (MAM), Winter (JJA), Spring (SON)

Seasonal change: see Ministry for the Environment (2019) Arotakenga Huringa Āhuarangi: A Framework for the National Climate Change Risk Assessment for Aotearoa New Zealand

Hot days and Heatwaves 25°C



Aggregating by season is the most useful.

Heatwave layer = TXa25 + HWD3 + HWD5 + HWD10

TXa25 = Hot days = count of days where maximum temperature TX > 25°C

HWD3 = Heatwave days 3 or more = count of days where TX > 25°C for 3 or more consecutive days

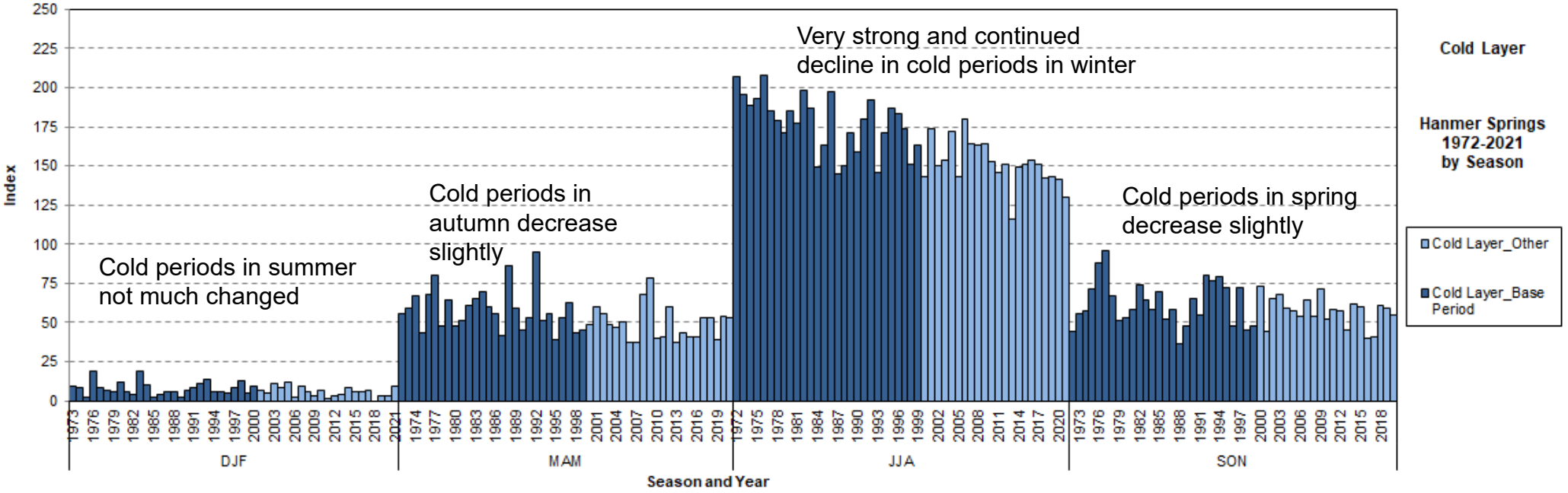
HWD5 = Heatwave days 5 or more

HWD10 = Heatwave days 10 or more

Also, Extreme Heatwave layer using 30°C

Data Source: NIWA VCSN data 1972 to 2021, 11491 virtual stations. Hanmer Springs (Agent 20951).

Cold Layer



Cold layer combines four ETCCDI measures:

Frost mornings (minimum temperature TN < 0 °C) +
Cold nights (TN < 5 °C) +
Ice days (maximum temperature TX < 0 °C) +
Cold days (TX < 10 °C).

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Imagine graph including projections for mid-century and late-century.

Data Source: NIWA VCSN data 1972 to 2021, 11491 virtual stations. Hanmer Springs (Agent 20951).

Extreme Events Climate Index for Aotearoa

- **Heatwave** layer (hot days and continuous heatwave periods, above 25°C)
- **Extreme Heatwaves** layer (extreme hot days and continuous extreme heatwave periods, 30°C)
- **Cold** layer (combination of four cold temperature measures)
- **Heavy Rain Days** layer (intensity of rainfall, from 10mm to 150mm)
- **Wet Days and Spells** layer (rain days and continuous periods of rain)
- **Dry Days and Spells** layer (dry days and continuous periods of drought)
- **Soil Moisture Deficit** layer (three measures of increasingly dry soil)
- **Snow** layer (combination of measures of low temperature and rainfall)
- **Wind** layer (levels of mean wind speed)
- **Fire Weather Seasonal Severity** (effects of high temperature, low humidity, droughts, and strong winds).

Spatial Amalgamations
by Lassoing Grid-Points

VCSN Stations and Lassoing

- Daily data from 1 January 1972
- 11,491 virtual stations (~210 million lines)

- Transformed to seasonal index
- Fifty years from 1972_MAM to 2022_DJF
  (~2.3 million lines in Excel pivot table)

To find climate for lassoed area (region, territorial authority, …), divide by number of VCSN stations in chosen area.

Spatial Boundaries

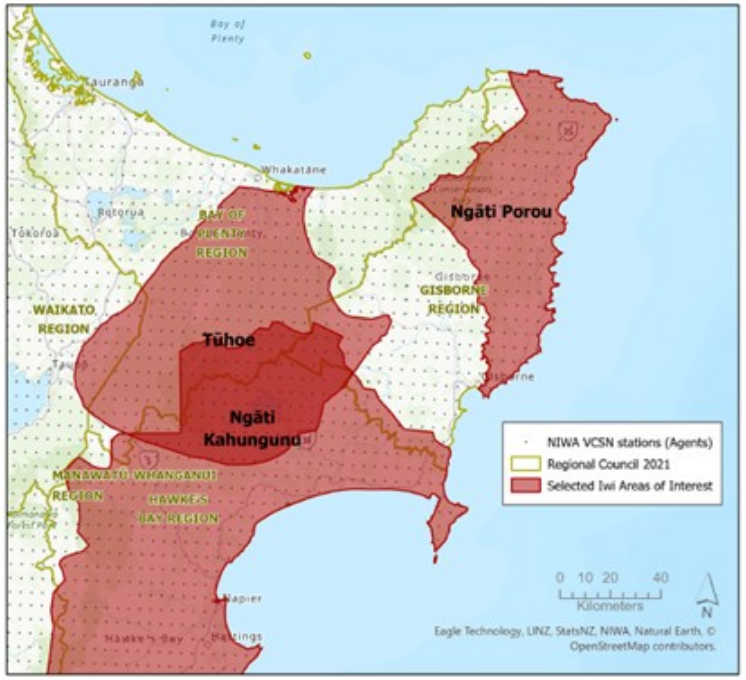
Sub-categories of the index created by “lassoing” virtual stations in ArcGIS.

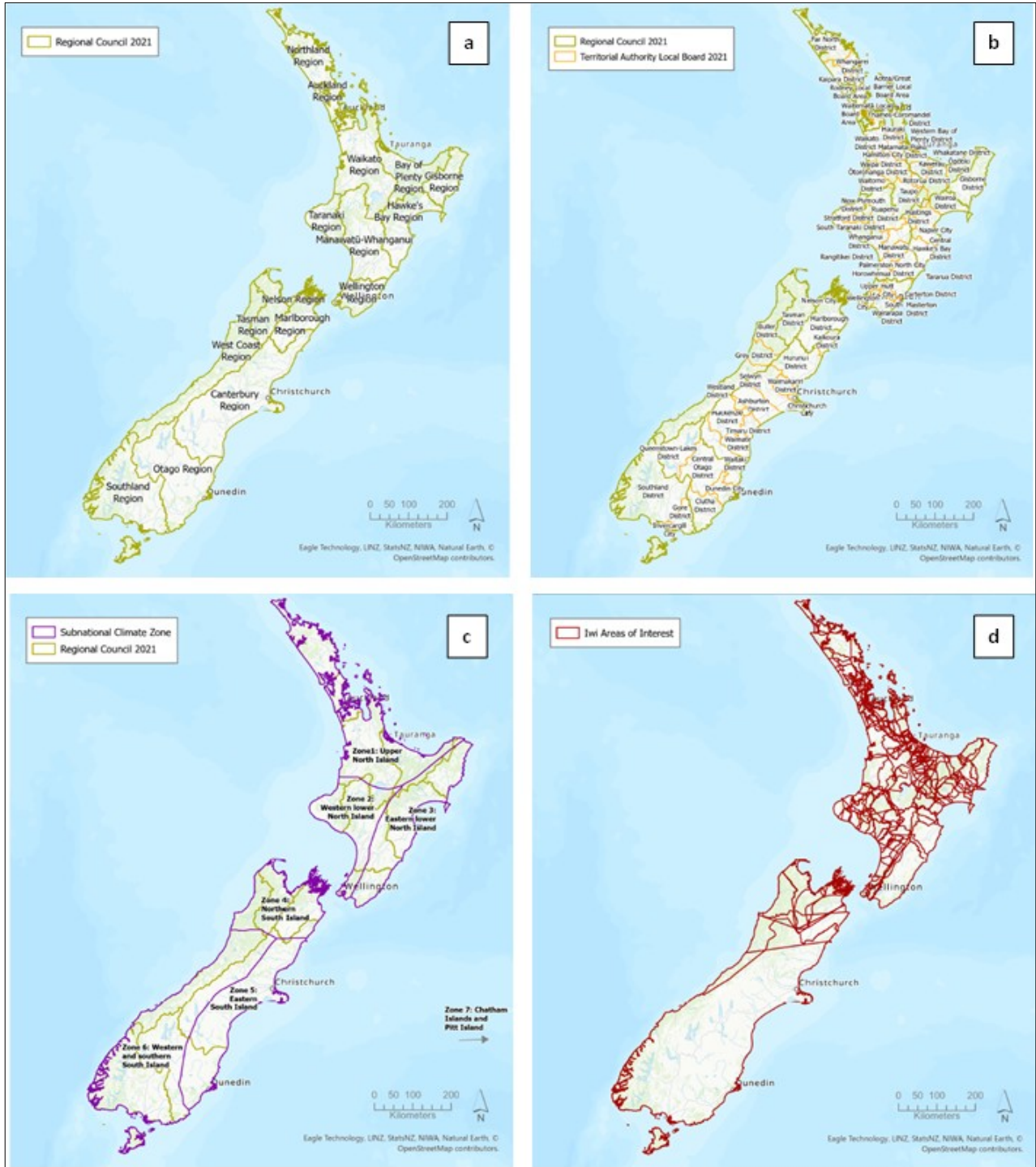
a) 15 **Regional Councils**

b) 67 **Territorial Authorities**

c) Six **Climate Zones**

d) 109 **Iwi rohe** - areas of interest





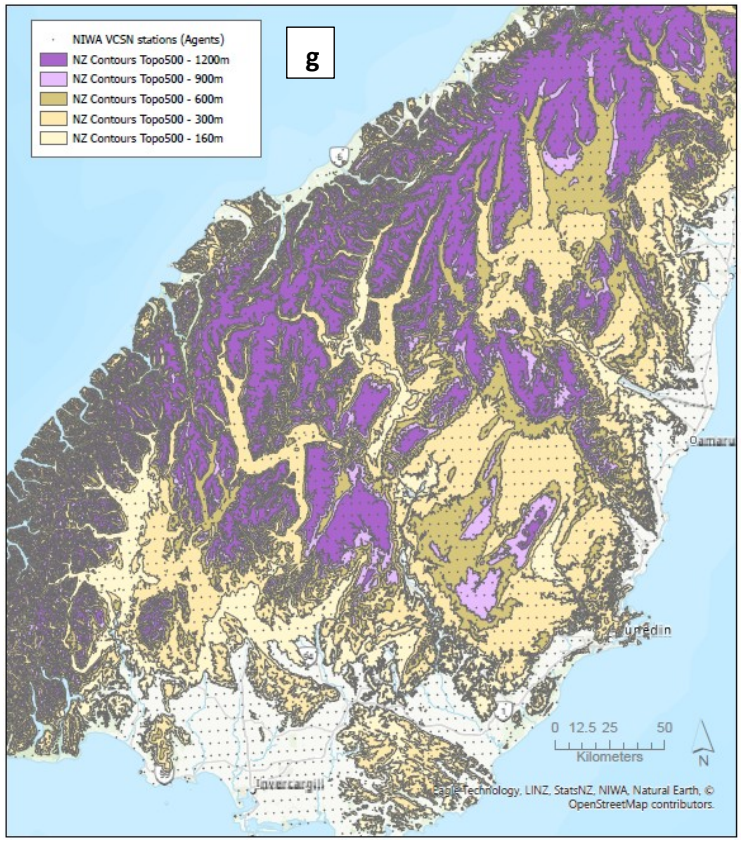
Spatial Boundaries

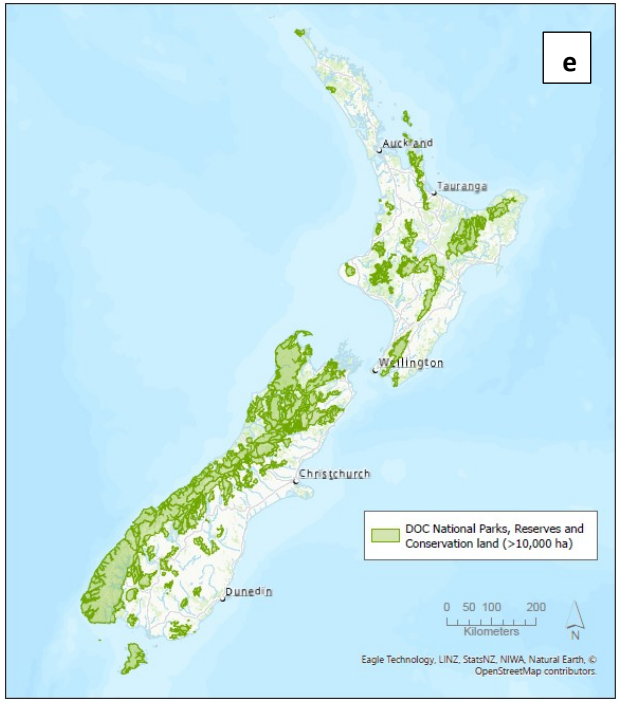
e) **Department of Conservation**: DOC Operations Districts and Regions; DOC National Parks, Reserves and Conservation Lands (>10,000 ha); DOC Ecological Districts; Kea Habitat in 2019.

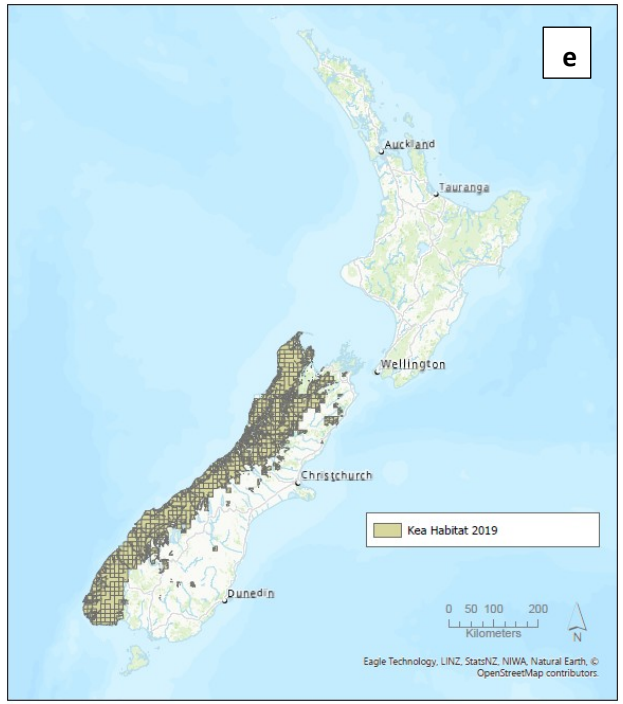
f) **Te Whatu Ora Health New Zealand**: Regions and Districts

g) **Altitude groups**

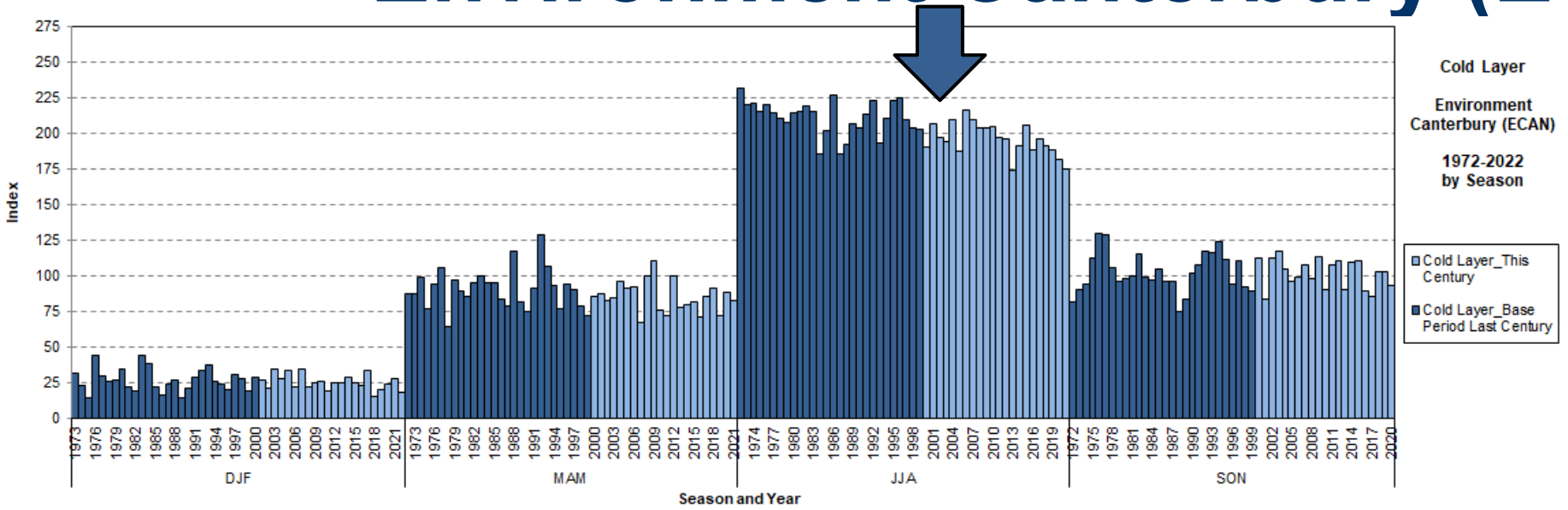
Any GIS polygon



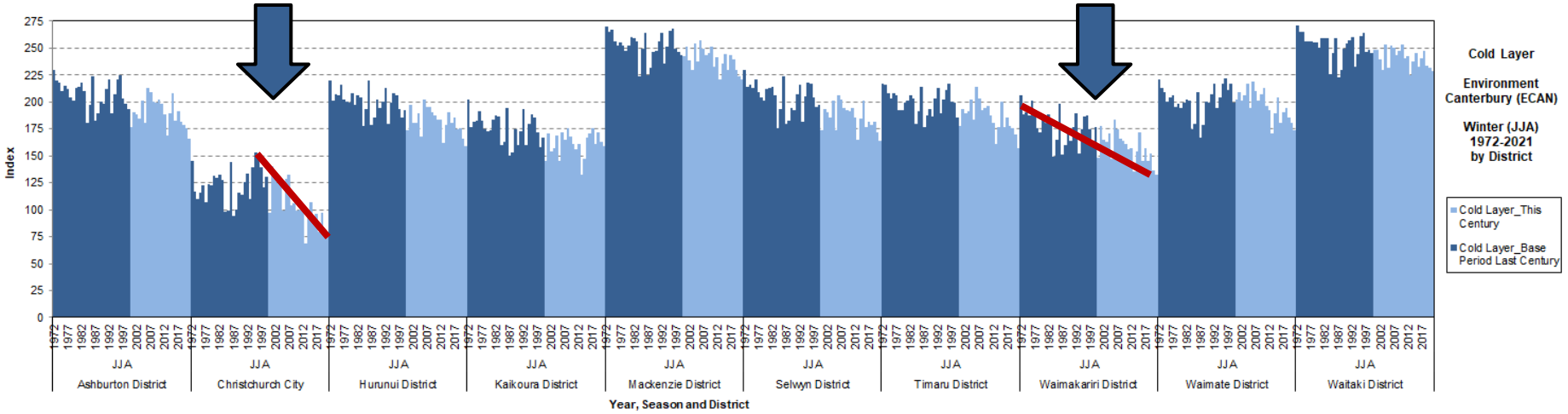




Environment Canterbury (ECAN)



Is cold declining in all seasons?

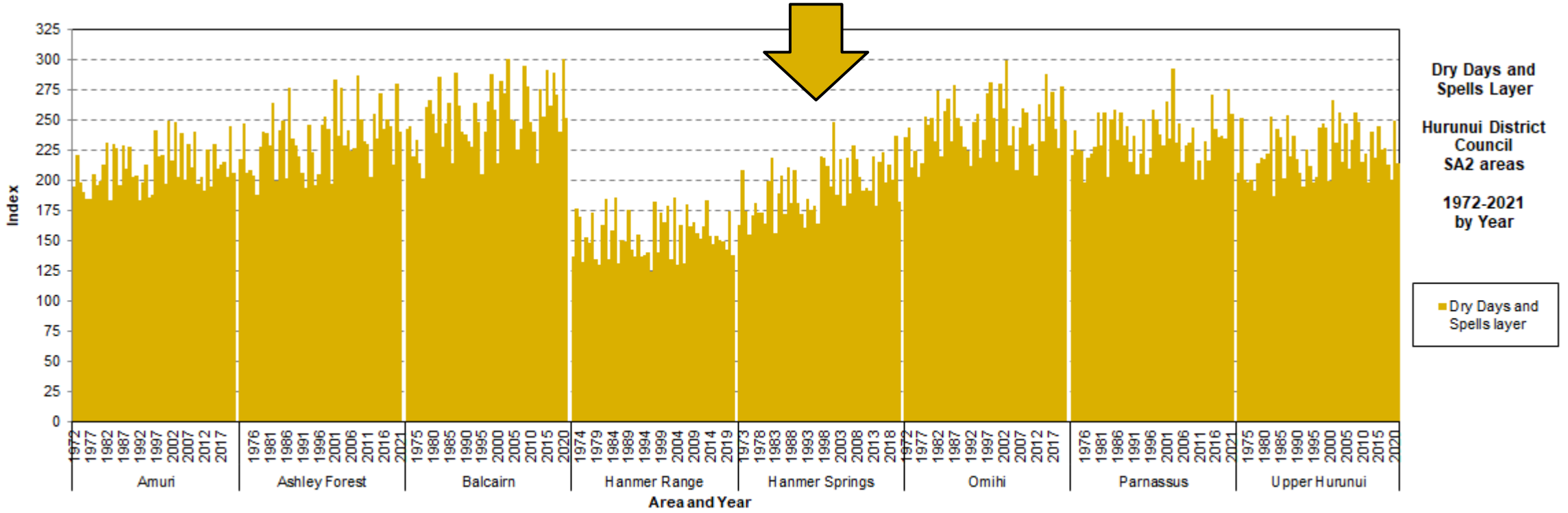


How is winter cold declining by district?

Implications for a reduction in heating needed and reduction in air pollution from log burners in winter.

Data Source: NIWA VCSN data 1972 to 2022, 11491 virtual stations, Extreme Events Climate Index for Aotearoa

Hurunui District Council: Where are dry spells getting worse in the district?



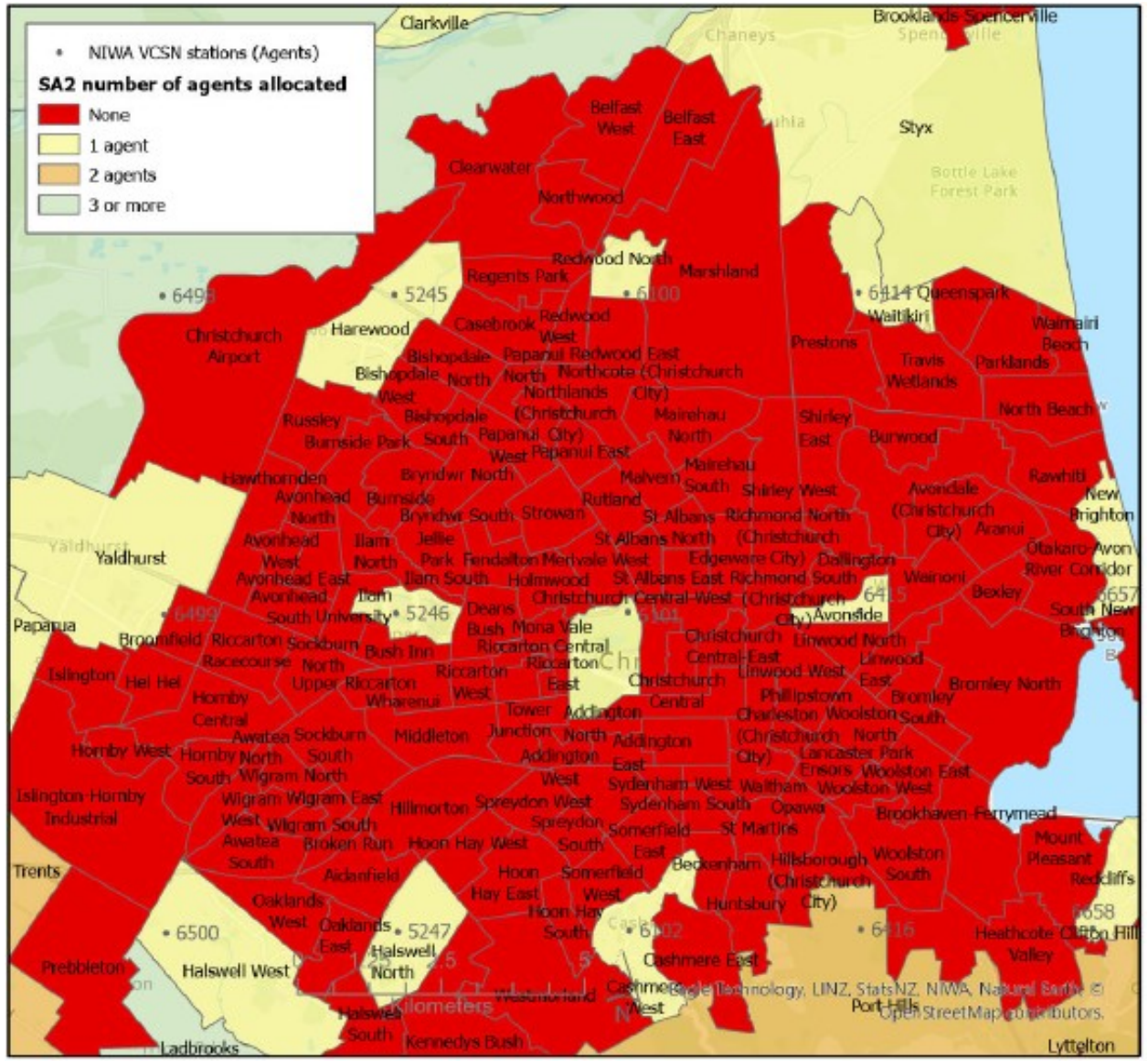
The simple average makes all SA2 areas directly comparable.

No transformations to standardise the values – the magnitude has meaning.

Data Source: NIWA VCSN data 1972 to 2022, 11491 virtual stations, Extreme Events Climate Index for Aotearoa

Spatial Amalgamations
by Thiessen Polygons

Number of Agents allocated to SA2s



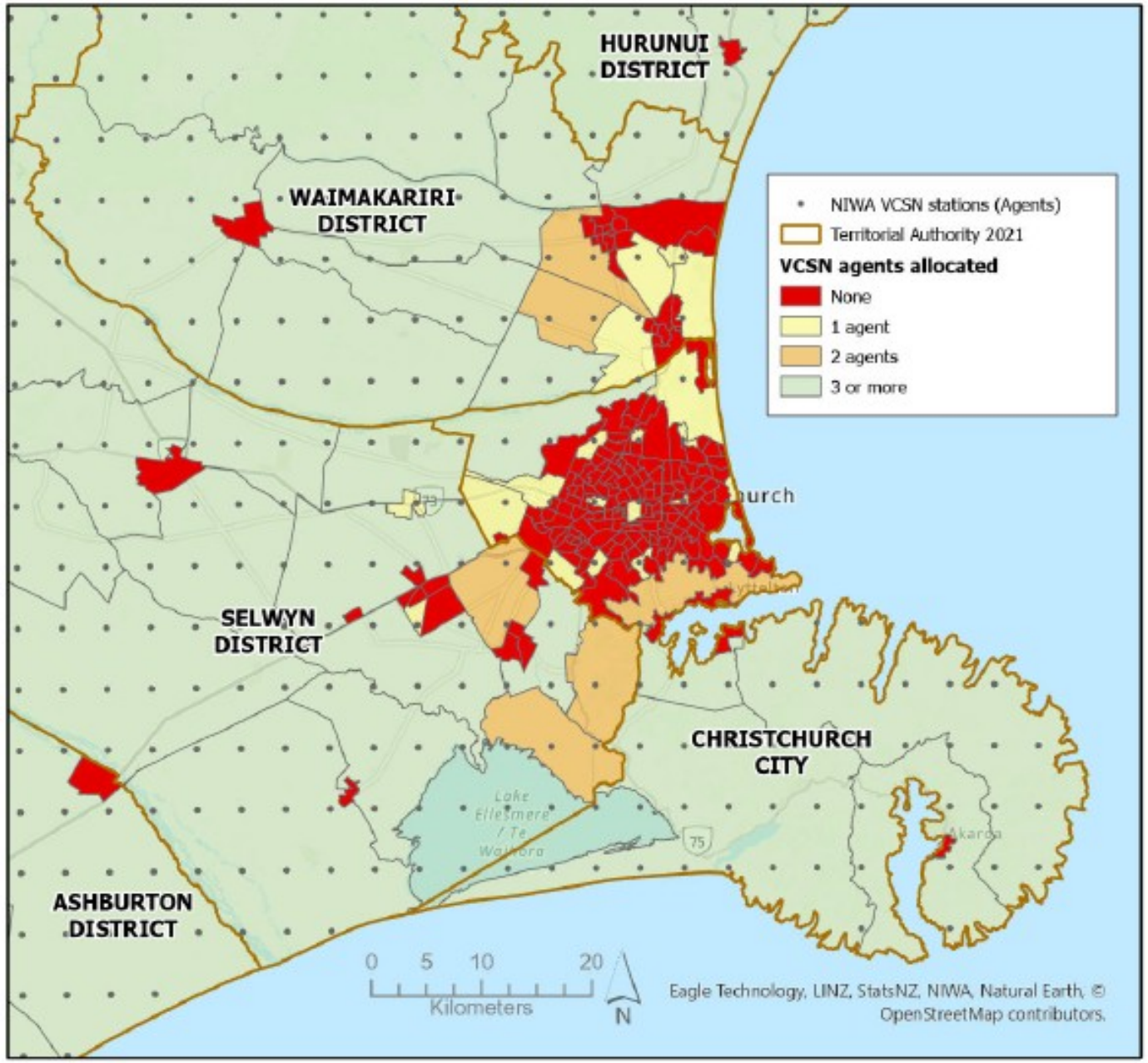
Christchurch

"Swiss cheese" effect in dense city.

At a national level, most of the country allocated.
But people not allocated.

	Allocated	Not
Land Area (sq. kms)	**98.4%**	1.6%
Count SA2s	**30.9%**	69.1%
ERP 30 June 2018	**22.3%**	77.7%

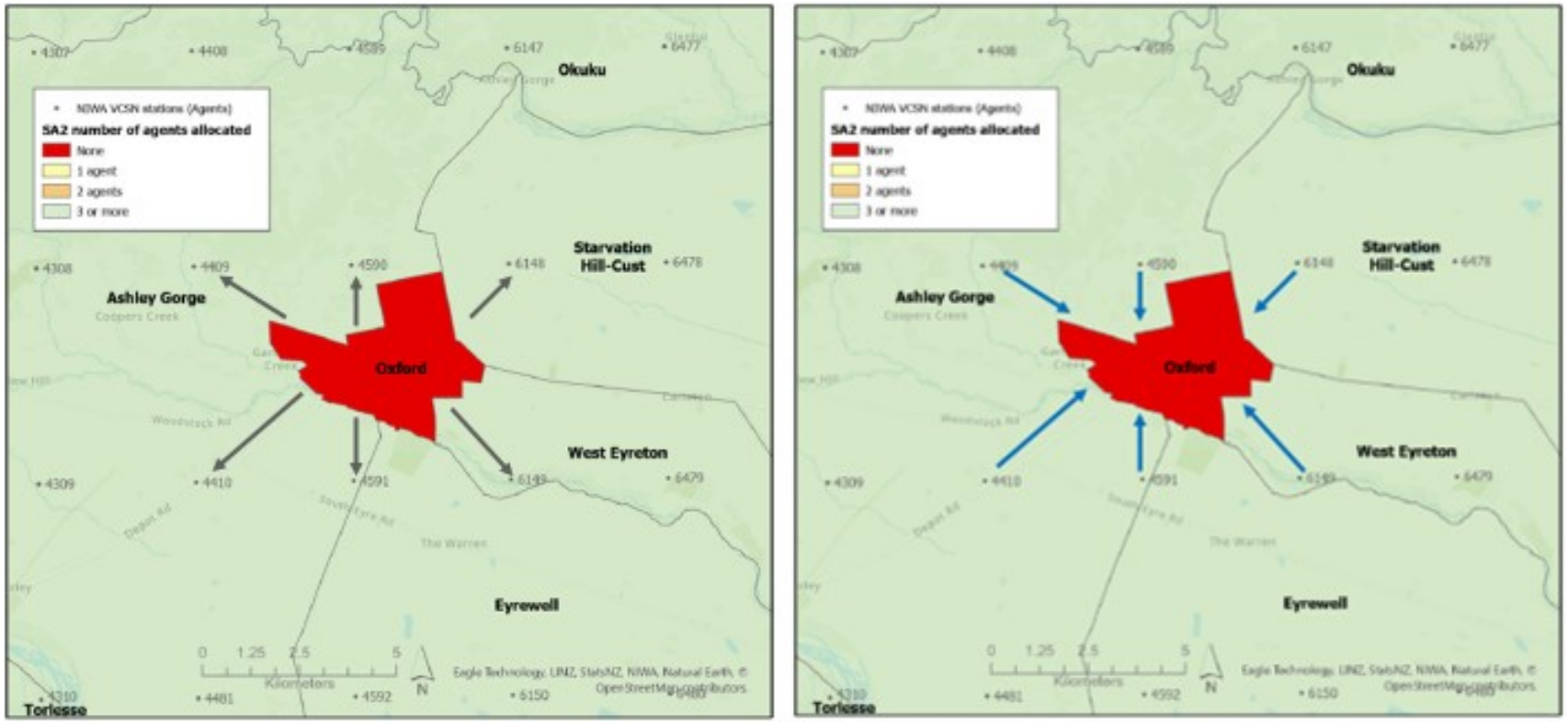
Number of Agents allocated to SA2s



Not just a city issue – affects towns and villages.

See Oxford, Darfield, Rakaia, Amberley, Rolleston, Leeston, Akaroa.

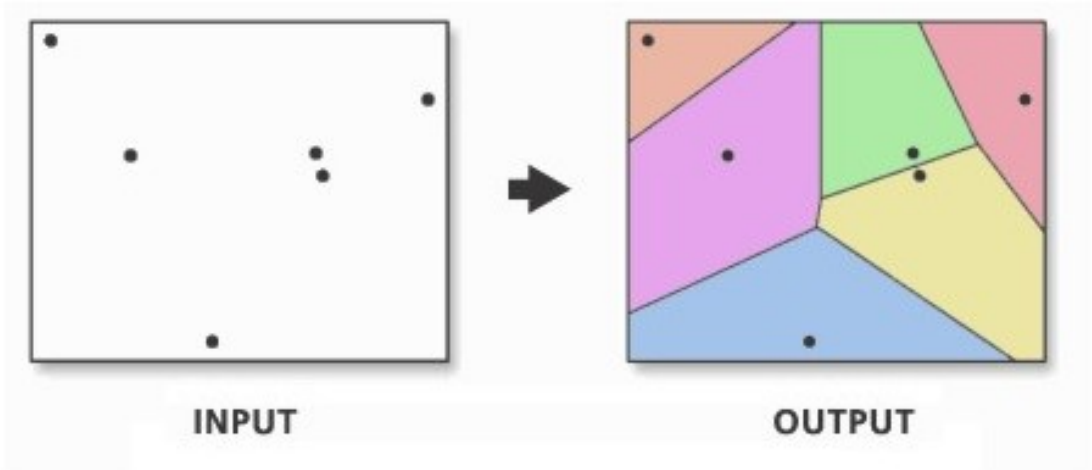
Taking People to Climate or Climate to People?

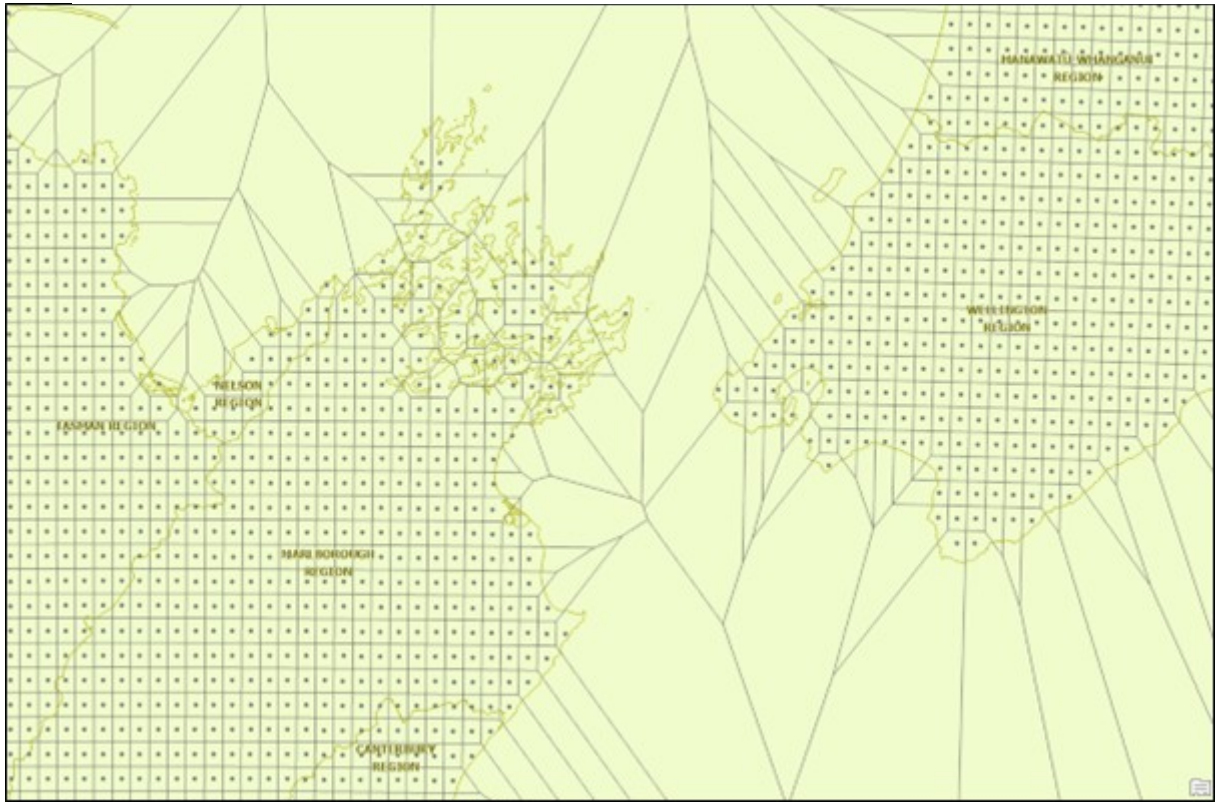


If we take people to climate, Oxford as a name and an urban area would completely disappear. Means loss of around one in five named urban areas. Runs counter to intent of the index, which is to assist communities to understand and act on climate change.

Resolved to take climate to people.

Thiessen Polygons





Each Thiessen polygon contains a single point. Any location within a Thiessen polygon is closer to its associated point than to any other point.

Useful way to generate grid squares around the VCSN grid-points and visualise areas of influence.

Odd shapes of Thiessen polygons at coast, as VCSN grid clipped to the coast.

1,281 of the polygons (11.1%) join the coast and some stretch 100s of kms offshore.

Dendritic effect in Cook Strait.

Source: ArcGIS Pro, Create Thiessen Polygons (Analysis).

Thiessen Polygons for Gisborne

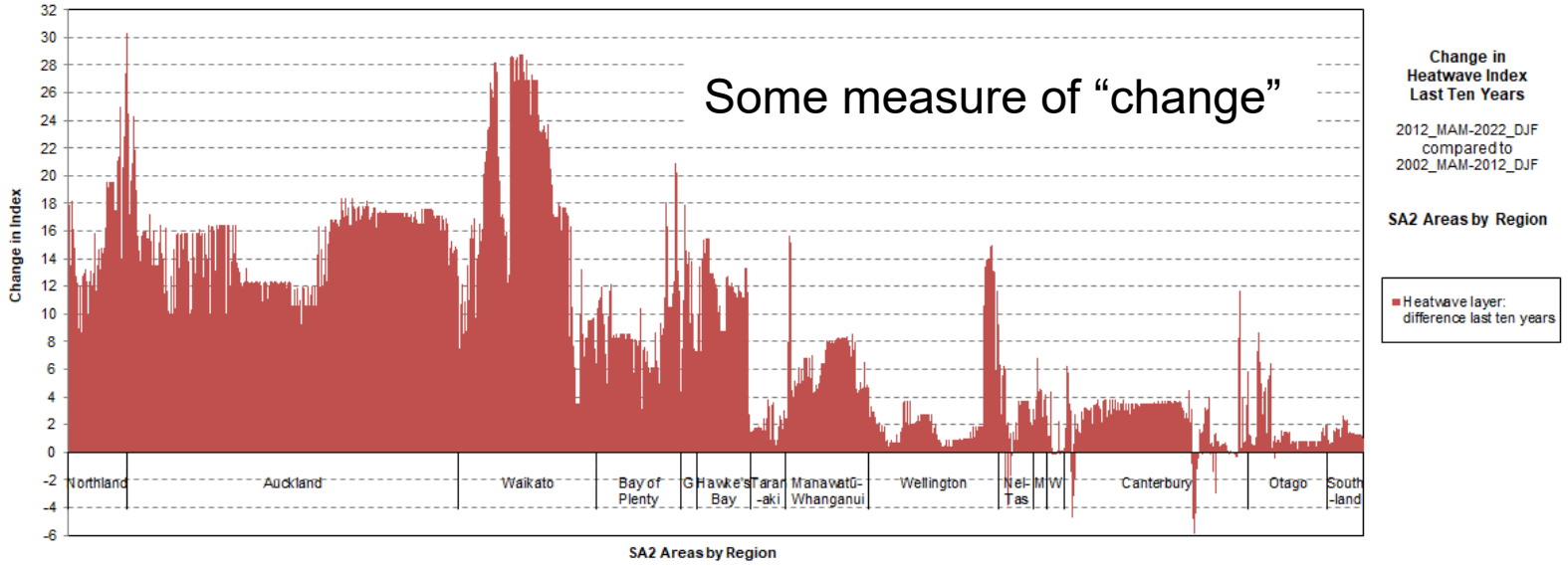
Gisborne urban area has no allocation using the Lasso method.

Determine proportion of urban area that overlaps each Thiessen polygon.

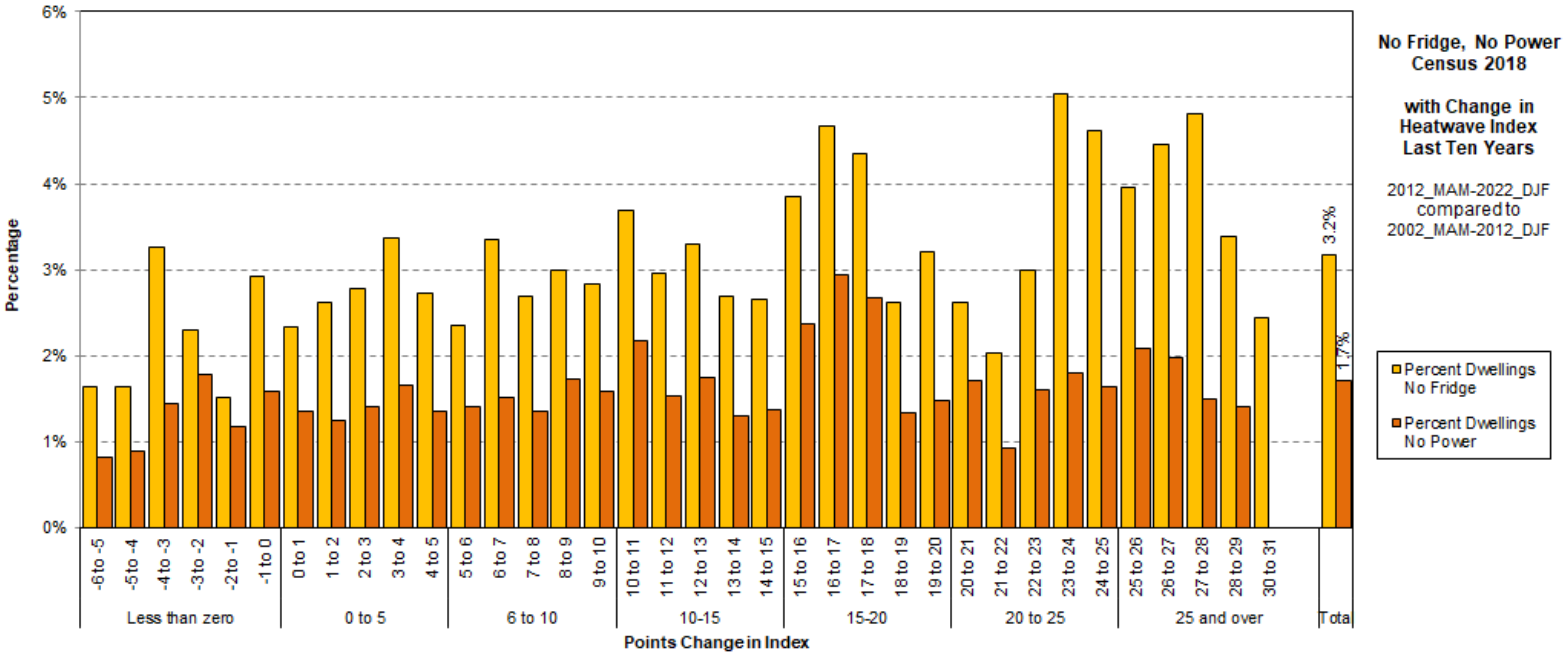
This gives weights in black (clockwise):

26.5%, 37.4%, 30.8%, 5.3%.

These weights are applied to the VCSN index values.



Linkage of People and Climate



Socio-economic data linked at SA2-level:
EHINZ Social Vulnerability Indicators,
NZ Deprivation Index.
Both derived from Census 2018.

Data Source: NIWA VCSN data 1972 to 2022, 11491 virtual stations, Extreme Events Climate Index for Aotearoa

Conclusions

- This work has established the linkage of historical climate data to socio-economic data at the same scale.
- The NIWA VCSN grid is also used for climate model projections and this approach could be combined with population projections by SA2 area.
- The linkage makes possible research on a range of questions on relationships between climate extremes, both historical and projected, the people affected and measures of vulnerability.
- Possible to use this technique on the domicile definition in Te Whatu Ora National Collections, and thereby create linkages between climate, people and health data.

- Partnered with EHINZ to make climate index available: https://www.ehinz.ac.nz/

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Body, Mind, Soul
Earth

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