Eco-emotions: validation of the multi-dimensional inventory of climate emotions in an Australian sample

Kylie Rice[1]*, Kim Usher[2], Nicola S. Schutte[1], Emma Austin[1,2,3,4], Rebecca Patrick[5], Syadani Riyad Fatema[2], Humayun Kabir[2], Adam John Rock[1], Rikki Jones[6] and Ryan L. Davies[1]

[1]School of Psychology, University of New England, Armidale, NSW, Australia, [2]Faculty of Medicine and Health, University of New England, Armidale, NSW, Australia, [3]Centre for Water, Climate and Land, The University of Newcastle, Callaghan, NSW, Australia, [4]College of Engineering, Science and Environment, University of Newcastle, Callaghan, NSW, Australia, [5]Melbourne School of Population and Global Health, Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne, Carlton, VIC, Australia, [6]School of Health, University of New England, Armidale, NSW, Australia

Introduction: Australia's diverse climate and temperatures render it susceptible to adverse and extreme weather events, and the impacts on social, emotional and psychological wellbeing are complex. Recent studies in Poland, Ireland and Norway validated a multi-dimensional and integrative assessment of the eco-emotions tool, the Inventory of Climate Emotions (ICE).

Methods: Given the extreme variations in geographical, climatic, political and cultural factors experienced worldwide, it is necessary to evaluate the ICE across countries. This study is the first validation of the ICE in an Australian sample ($N = 659$), and provides evidence of its structure, reliability and validity.

Results: Confirmatory factor analysis indicated a good fit after the removal of one item from the isolation subscale, with model fit indices of CFI = 0.96, TLI = 0.95, SRMR = 0.045, and RMSEA = 0.049. The ICE demonstrated strong internal consistency, with Cronbach's alphas ranging from 0.79 to 0.94, and moderate test−retest reliability across all subscales except for Powerlessness (ICC = 0.48 to 0.74). Convergent validity was supported by significant positive correlations between ICE subscales and the Hogg Eco-Anxiety Scale, while divergent validity was demonstrated through weak or non-significant correlations with the Riverside Life Satisfaction Scale.

Discussion: As the ICE was not developed in Australia, it may not account for the full range of eco-emotions in the unique ecological and socio-cultural context. However, this study provides important initial support for the use of the ICE in Australia and suggests that some ecological emotions may be common across cultures.

KEYWORDS

climate, emotions, wellbeing, extreme weather, eco-anxiety, eco-emotions

Introduction

One of the current, defining public health issues is climate change (Patrick et al., 2023). The planet is under stress, with more frequent, severe and widespread extreme weather events being experienced, presenting ongoing threats to human health (Longman et al., 2023). Australia is experiencing widespread adverse and extreme weather events at unprecedented rates (Ghosh and Orchiston, 2022), with vulnerable communities and health systems disproportionately impacted (Gergis et al., 2023). Multiple climate-related priorities have been identified for Australia, including

increasing droughts and floods, water supply issues, ecosystem vulnerability, coral reef destruction, diminished snowfall in alpine regions, coastal and tropical vulnerability, and further disadvantages for Indigenous people (IPCC, 2023). These ubiquitous and cascading impacts from climate-related events affect all levels of society, through interconnected systems of health and wellbeing, culture, the economy, ecosystems, agriculture and food security, water, infrastructure, energy, transport and communications (Niggli et al., 2022). These interconnected relationships can be understood within a One Health approach, that recognises the systemic interdependency between people, the environment, plants and animals (WHO, 2024). Climatic changes disrupt the symbiosis between people and their environment (Usher et al., 2024) and have serious and significant consequences for human physical and mental health and wellbeing (Ingle et al., 2020).

Climate emotions have been linked with generalised emotions, emotional regulation, and behavioural action (Orrù and Mannarini, 2024; Orrù et al., 2024). Various new terms have been offered in the literature to describe emotions associated with the environment. In a recent systematic review, Cianconi et al. (2023) identified 21 categories of terms that describe emotions related to the environment and climate change, including variations of environmental stress; climate change distress and worry; a range of eco-emotions such as eco-guilt, shame, fear, anxiety, paralysis, phobia, anger, depression, nostalgia; climate anxiety, burnout, pre- and post-trauma responses, and grief and despair. However, quantitative measures of these new eco-emotion concepts are limited or not rigorously developed and validated (Massazza et al., 2022; Charlson et al., 2022). The measures that do exist are mostly limited to the assessment of one emotion in isolation, such as eco-anxiety (e.g., Clayton and Karazsia, 2020) or climate change worry (Stewart, 2021). Research has suggested that a wide range of emotions toward climate change can be experienced and may relate to behaviour and wellbeing (Marczak et al., 2024); hence a multi-dimensional assessment tool is needed.

In an effort to provide a multi-dimensional and integrative assessment of eco-emotions, the Inventory of Climate Emotions (ICE) was recently developed in Poland (Marczak et al., 2023). The ICE contains 32 items within eight subscales of emotions related to climate change, scored on a 5-point Likert scale. An exploratory factor analysis (EFA) and further validation in an independent sample through confirmatory factor analysis (CFA) identified eight factors of: *anger* (feeling annoyed around the perception that authority has not been doing enough to counteract climate change); *contempt* (disregarding the issue of climate change); *enthusiasm* (believing in the possibility of successful climate change mitigation); *powerlessness* (limited personal ability to combat climate change leaving one helpless); *guilt* (feeling bad due to past actions); *isolation* (others disinterest in the issue of climate change might leave one feeling alone); *anxiety* (feeling anxious believing that climate change is a major threat to human survival); and *sorrow* (feeling sad that climate change is significantly changing the world with great losses of life) (Marczak et al., 2023). Internal consistency reliability was supported, as well as convergent, discriminant and concurrent validity. Subsequently, the inventory has been psychometrically tested for use in the European countries of Norway and Ireland, providing further psychometric validation and supporting possible cross-cultural relevance (Marczak et al., 2024). Marczak et al. (2023, p. 2) defined climate emotions as "affective phenomena that accompany specific climate-change related perceptions." They assessed the meaning of the emotional experiences as understood by the conceptual act theory of emotions (Barrett, 2014), whereby language plays a fundamental part in assessing emotions, therefore using language-based self-report measures

as the optimal method to assess emotions in the ICE. Also influenced by Barrett's (2014) theory is the use of contexts in the ICE to capture specific perspectives, which were narrowly defined to maintain the robustness and internal consistency of the subscales (Furr, 2011).

Given the extreme variations in geographical, climatic, political and cultural factors that are experienced worldwide, and that these are likely to differentially relate to environmental emotions, cross-cultural and global research is needed. Specifically, there are marked differences between Poland, Norway and Ireland, where the ICE was developed and validated, and other countries, for example Australia. Firstly, all four countries have disparate climates, from temperate Poland to arctic Norway, mild, rainy but lush green of Ireland, to Australia with a combination of temperate, arid and tropical climates. Each also experience a different range of natural hazards. Poland and Norway experience flooding and avalanches respectively, while Australia is exposed to a wider range of natural hazards including droughts, floods, cyclones and bushfires. Politically, the four countries differ significantly, as Norway is a global leader in renewable energy and sustainability while Poland, Ireland and Australia are still transitioning from a reliance on fossil fuels. Norway, Ireland and Australia have similar cultural connections to outdoor sports and activities, and many enjoy an outdoor lifestyle. In contrast, Poland has less of an inherent devotion to leisure time in nature. Finally, Australia is one of the most multicultural countries in the world, in comparison to the more homogeneous society of Poland, while Norway and Ireland both have growing immigrant populations.

Thus, it is necessary to evaluate the ICE (Marczak et al., 2023) for use in Australia, with its unique socio-cultural and environmental context. As such, this study aimed to psychometrically evaluate the ICE (Marczak et al., 2023) in an Australian sample and provide further evidence of structure, reliability and validity for the measure.

Method

Participants

Following approval from the University Human Research Ethics Committee, the Online Research Unit (ORU) recruited a sample of 659 Australian adults. Participants were selected using a quota-based stratified sampling method to ensure representativeness of the Australian population based on key demographic characteristics including age, gender, State/Territory, and regional versus urban residency. The stratification was informed by Australian census data to enhance generalisability. Participants were invited to complete the survey a second time approximately 4 months later, to assess the stability of the measure over time. The survey was completed by 201 participants at the second timepoint. Participants were required to be 18 years or older and residing in Australia at the time of the study. There were no exclusion criteria. Additionally, participants were compensated for their time according to ORU's standard, notional incentive structure. Participant demographic characteristics are presented in Table 1.

Analysis plan

The ICE structure has been thematically derived and empirically assessed in other samples. As such, a confirmatory factor analysis was employed to evaluate the fit for the existing structure (Marczak et al., 2023) in the current sample. Pearson's Product–Moment Correlations

TABLE 1 Demographic characteristics of participants at Timepoints 1 and 2.

	Timepoint 1		Timepoint 2	
	M	SD	*M*	SD
Age (years)	46.5	19.9	46.1	16.1
Gender	*n*	%	*n*	%
Female	306	46.7%	87	43.3%
Male	348	53.1%	114	56.7%
Other	1	0.2%	0	0%
State of residency				
ACT	10	1.5%	4	2.0%
NSW	202	30.9%	63	31.8%
NT	1	0.2%	0	0%
VIC	190	29.1%	53	26.8%
SA	53	8.1%	13	6.5%
TAS	11	1.7%	2	1.0%
QLD	134	20.5%	52	26.3%
WA	52	8.0%	11	5.6%
Geographic location				
Regional	177	72.7%	135	68.2%
Metropolitan	471	27.3%	63	31.8%
Cultural background				
Australian	367	57.8%	116	59.8%
Asian	118	18.6%	38	19.6%
European	115	18.1%	32	16.5%
African/Middle Eastern	16	2.5%	0	0%
Pacific/Oceania	14	2.2%	5	2.6%
American	5	0.8%	3	1.5%
Relationship status				
Live with partner	69	10.6%	17	8.5%
Married	343	52.4%	125	62.2%
Separated/Divorced	56	8.5%	11	5.5%
Single	175	26.7%	46	22.8%
Other	12	1.8%	2	1.0%

ACT, Australian Capital Territory; NSW, New South Wales; NT, Northern Territory; VIC, Victoria; SA, South Australia; QLD, Queensland; WA, Western Australia.

were employed to assess validity. Associations between the ICE climate emotion subscales and the Hogg Eco-anxiety (HOGG; Hogg et al., 2021) scale were utilised to assess convergent validity. As the scales assess similar underlying constructs it was expected that significant, positive correlations would be found. While alternative measures of general anxiety, depression, or climate-related worry could have been used, the HOGG was selected as it specifically assesses a range of eco-anxiety symptoms, making it the most conceptually relevant measure for convergent validity. To assess divergent validity, the relationship between the Riverside Life Satisfaction Scale (RLSS; Margolis et al., 2018) and the ICE subscales was calculated. As the scales assess different constructs, a weak or non-significant association is expected, providing evidence of divergent validity. The RLSS was chosen for divergent validity as it assesses a broad well-being construct rather than specific emotional

responses to climate change. These choices align with the primary goal of validating the ICE as a measure of climate-related emotions rather than general mental health conditions.

Measures

Inventory of Climate Emotions (ICE; Marczak et al., 2023). The ICE is a 32 item, eight subscale measure, with the subscales assessing climate related anger, contempt, enthusiasm, powerlessness, guilt, isolation, anxiety, and sorrow. Each subscale consists of four items, for example: "I am outraged that politicians allowed climate change to come this far" (anger); "I am bored of hearing about climate change" (contempt); "The increasing public engagement with climate change gives me hope" (enthusiasm); "I feel confused about what I can do to

reduce climate change" (powerlessness); "I feel guilty that my lifestyle contributes to climate change" (guilt); "I feel alienated because society considers concern for climate change as something strange" (isolation); "Everything seems uncertain because of climate change" (anxiety); and "The thought that the world I know is disappearing forever because of climate change makes me sad" (sorrow). Previous subscale reliabilities have been deemed acceptable for the English version of the scale, ranging from 0.72 to 0.94 in Norway, and 0.65 to 0.94 in Ireland (Marczak et al., 2024). As the focus of this paper is the psychometric properties of this measure, the details for this sample are presented in the results below.

The HOGG (Hogg et al., 2021) was included to evaluate convergent validity. The HOGG is a 13-item measure that assesses four symptom dimensions within the convergent of eco-anxiety; affective, rumination, anxiety and behavioural. The factorial structure of the original English HOGG was validated, and all subscales demonstrated internal consistency (all Cronbach's alphas greater than 0.82). In the present sample Cronbach's alpha was 0.96.

Riverside Life Satisfaction Scale (RLSS; Margolis et al., 2018) was included to assess divergent validity. This scale contains six items that assess contentment with life, desire for change, and the absence or presence of envy, and high internal consistency reliability has been reported in both American ($\alpha = 0.75$; Margolis et al., 2018) and Australian samples ($\alpha = 0.86$; Smith et al., 2024). In the present, sample Cronbach's alpha was 0.85.

Results

Confirmatory factor analysis

The initial confirmatory factor analysis of the ICE scale using all 32 items associated with the respective climate emotion subscales did not show a good fit. Inspection of fit indices suggested that one of the items comprising the isolation emotion subscale was not well aligned with the isolation factor; 'I feel like one of the few people who actually understand what climate change entails'. This item was reviewed and considered to be possibly theoretically distinct from the construct, and removed for an additional analysis. When this item was removed, a satisfactory fit was found, with the following indices: CFI = 0.96, TLI = 0.95, SRMR = 0.045, and RMSEA = 0.049 (95% CI = 0.045, 0.053), χ^2/df = 2.52. These results led to the creation of 4-item subscales for each of the climate emotions, parallel to those created by Marczak et al. (2023) and an exploratory three item subscale for the isolation emotion subscale. Table 2 shows the mean score and standard deviations of each of the factors, Table 3 presents the scaled means, and Table 4 displays the factor loadings of the final model.

Reliability of the ICE

To assess the internal consistency of the ICE, Cronbach's alphas for each subscale were calculated as: anger = 0.94, contempt = 0.86,

TABLE 2 Means and standard deviations of the ICE climate emotions subscales.

	Mean	SD
Anger 4-item	13.54	4.59
Contempt 4-item	11.98	4.14
Enthusiasm 4-item	12.75	3.66
Powerlessness 4-item	11.54	3.45
Isolation 4-item	10.43	3.68
Isolation 3-item	7.52	3.06
Anxiety 4-item	12.20	4.35
Guilt 4-item	10.48	4.14
Sorrow 4-item	13.27	4.62

TABLE 3 Scaled means for the ICE emotions.

	N	Mean	Std. Deviation
Enthusiasm_scaled	617	3.19	0.91
Powerlessness_scaled	617	2.88	0.86
Anxiety_scaled	617	3.05	1.09
Sorrow_scaled	617	3.32	1.15
Guilt_scaled	617	2.62	1.03
Anger_scaled	618	3.38	1.15
Isolation_scaled	617	2.60	0.92
Isolation_scaled_3	617	2.50	1.02
Contempt_scaled	617	2.99	1.03

Scaled means for the ICE emotions were calculated by dividing the factor total score by the number of items (isolation_3 is the 3 item isolation scale with item 21 removed, the other subscales had four items). This allows for a contrasting of means of the Australian sample with other samples.

TABLE 4 Factor loadings for final model.

95% confidence interval								
Factor	Indicator	Estimate	SE	Lower	Upper	Z	p	Stand. Estimate
Anger	ANG_1	1.03	0.04	0.96	1.11	27.2	< 0.001	0.87
	ANG_2	1.13	0.04	1.05	1.21	28.7	< 0.001	0.90
	ANG_3	1.07	0.04	1.00	1.16	27.2	< 0.001	0.87
	ANG_4	1.17	0.03	1.09	1.25	29.4	< 0.001	0.91
Contempt	CONT_5	0.78	0.04	0.69	0.87	18.0	< 0.001	0.67
	CONT_6	1.10	0.04	1.02	1.19	26.6	< 0.001	0.88
	CONT_7	1.10	0.04	1.01	1.19	24.8	< 0.001	0.84
	CONT_8	0.84	0.04	0.75	0.93	19.1	< 0.001	0.70
Enthusiasm	ENTHU_9	0.90	0.03	0.83	0.97	25.3	< 0.001	0.84
	ENTHU_10	0.83	0.03	0.76	0.91	22.4	< 0.001	0.78
	ENTHU_11	0.81	0.03	0.74	0.88	24.2	< 0.001	0.82
	ENTHU_12	0.89	0.03	0.82	0.96	25.0	< 0.001	0.84
Powerless- ness	PWLS_13	0.72	0.04	0.63	0.80	16.8	< 0.001	0.66
	PWLS_14	0.74	0.04	0.66	0.83	17.0	< 0.001	0.66
	PWLS_15	0.74	0.04	0.65	0.83	16.9	< 0.001	0.66
	PWLS_16	0.84	0.04	0.75	0.92	20.4	< 0.001	0.77
Guilt	GLT_17	1.01	0.03	0.94	1.09	26.6	< 0.001	0.86
	GLT_18	1.00	0.03	0.92	1.07	26.9	< 0.001	0.87
	GLT_19	1.03	0.03	0.96	1.10	27.9	< 0.001	0.89
	GLT_20	0.94	0.03	0.87	1.01	25.7	< 0.001	0.84
Isolation	ISOL_22	0.98	0.03	0.91	1.06	26.4	< 0.001	0.86
	ISOL_23	0.99	0.03	0.92	1.06	27.5	< 0.001	0.89
	ISOL_24	0.92	0.03	0.85	0.99	25.0	< 0.001	0.84
Anxiety	ANX_25	1.07	0.04	0.99	1.15	25.5	< 0.001	0.83
	ANX_26	0.97	0.04	0.89	1.05	24.0	< 0.001	0.81
	ANX_27	1.01	0.03	0.93	1.09	25.6	< 0.001	0.84
	ANX_28	1.07	0.03	0.99	1.15	27.1	< 0.001	0.87
Sorrow	SOR_29	1.09	0.04	1.01	1.17	27.4	< 0.001	0.87
	SOR_30	1.15	0.03	1.07	1.22	29.7	< 0.001	0.92
	SOR_31	1.13	0.03	1.05	1.20	28.9	< 0.001	0.90
	SOR_32	1.04	0.04	0.96	1.12	25.8	< 0.001	0.84

enthusiasm = 0.89, powerlessness = 0.79, guilt = 0.92, isolation with 4 items = 0.85, isolation with 3 items (the item 'I feel like one of the few people who actually understand what climate change entails' removed) = 0.90, anxiety = 0.91, and sorrow = 0.94.

Convergent and divergent validity of the ICE

Table 5 displays evidence of the ICE's convergent validity through its varied associations with the HOGG. The HOGG showed significant, positive correlations with all ICE subscales except Contempt. This indicates that higher levels of emotions assessed by the ICE subscales were generally associated with greater climate anxiety. The varying levels of association between the ICE subscales and the HOGG provides support for the ICE subscales as measuring distinct emotions, and differentiating between different ecological emotions.

Additionally, divergent validity was assessed by examining correlations between the ICE and the RLSS. The RLSS showed weak or very weak correlations with all ICE subscales, indicating that the ICE measures a construct distinct from life satisfaction, supporting divergent validity.

The significant correlations of the ICE subscales with anxiety and life satisfaction are in expected directions and provide evidence of convergent and divergent validity. However, even though significant, none of the correlations had shared variance of over 17 percent, indicating that the ICE subscales and the HOGG and RLSS scales

TABLE 5 Correlations between variables.

		Correlations									
		Anger	Contempt	Enthusiasm	Powerlessness	Isolation_4	Isolation_3	Anxiety	Guilt	Sorrow	HOGG	RLSS
Anger												
	Pearson correlation	1	−0.46**	0.66**	0.30**	0.42**	0.42**	0.73**	0.51**	0.79**	0.18**	−0.11**
	Sig. (2-tailed)		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.007
	N	618	617	617	617	617	617	617	617	617	617	617
Contempt												
	Pearson correlation	−0.46**	1	−0.27**	0.10**	−0.09*	−0.14**	−0.40**	−0.21**	−0.47**	−0.01	0.09*
	Sig. (2-tailed)	< 0.001		< 0.001	0.010	0.023	< 0.001	< 0.001	< 0.001	<0.001	0.883	0.026
	N	617	617	617	617	617	617	617	617	617	616	616
Enthusiasm												
	Pearson correlation	0.66**	−0.27*	1	0.27**	0.40**	0.40**	0.61**	0.48**	0.64**	0.18**	−0.01
	Sig. (2-tailed)	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.752
	N	617	617	617	617	617	617	617	617	617	616	616
Powerlessness												
	Pearson correlation	0.30**	0.10**	0.27**	1	0.40**	0.41**	0.41**	0.53**	0.35**	0.26**	−0.25**
	Sig. (2-tailed)	< 0.001	0.01	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	N	617	617	617	617	617	617	617	617	617	616	616
Isolation												
	Pearson correlation	0.42**	−0.09*	0.40**	0.39**	1	0.96**	0.61**	0.60**	0.47**	0.40**	−0.21**
	Sig. (2-tailed)	< 0.001	0.02	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	N	617	617	617	617	617	617	617	617	617	616	616
Isolation_minus21												
	Pearson correlation	0.42**	−0.14**	0.40**	0.41**	0.96**	1	0.62**	0.64**	0.48**	0.41**	−0.23**
	Sig. (2-tailed)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	N	617	617	617	617	617	617	617	617	617	616	616

(Continued)

TABLE 5 (Continued)

	Anger	Contempt	Enthusiasm	Powerlessness	Isolation_4	Isolation_3	Anxiety	Guilt	Sorrow	HOGG	RLSS
Correlations											
Anxiety											
Pearson correlation	0.73**	−0.40**	0.61**	0.41**	0.61**	0.62**	1	0.68**	0.81**	0.33**	−0.19**
Sig. (2-tailed)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001	< 0.001
N	617	617	617	617	617	617	617	617	617	616	616
Guilt											
Pearson correlation	0.51**	−0.21**	0.48**	0.53**	0.60**	0.64**	0.68**	1	0.53**	0.41**	−0.24**
Sig. (2-tailed)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001
N	617	617	617	617	617	617	617	617	617	616	616
Sorrow											
Pearson correlation	0.79**	−0.47**	0.64**	0.35**	0.47**	0.48**	0.81**	0.53**	1	0.18**	−0.17**
Sig. (2-tailed)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001
N	617	617	617	617	617	617	617	617	617	616	616
HOGG											
Pearson correlation	0.18**	−0.01	0.18**	0.26**	0.40**	0.41**	0.33**	0.41**	0.18**	1	−0.26**
Sig. (2-tailed)	< 0.001	0.883	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001
N	617	616	616	616	616	616	616	616	616	617	617
RLSS											
Pearson correlation	−0.11**	0.09*	−0.01	−0.25**	−0.21**	−0.23**	−0.19**	−0.24**	−0.17**	−0.26**	1
Sig. (2-tailed)	0.007	0.026	0.752	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
N	617	616	616	616	616	616	616	616	616	617	617

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

TABLE 6 Test–retest reliability of the ICE.

Factor	ICC	95% CI Lower	95%CI Upper	F	df	p-value
Anger	0.71	0.63	0.77	5.83	190	< 0.001
Contempt	0.74	0.67	0.80	6.62	191	< 0.001
Enthusiasm	0.62	0.52	0.70	4.21	189	< 0.001
Powerlessness	0.48	0.36	0.58	2.85	189	< 0.001
Isolation (4 items)	0.59	0.49	0.68	3.89	191	< 0.001
Isolation (3 items)	0.63	0.54	0.71	4.42	192	< 0.001
Anxiety	0.61	0.51	0.69	4.12	190	< 0.001
Guilt	0.58	0.48	0.67	3.8	187	< 0.001
Sorrow	0.69	0.60	0.76	5.38	187	< 0.001

assess different constructs, providing evidence of divergent validity (Rönkkö and Cho, 2022).

Test–retest reliability

Participants were invited to complete the questionnaire for a second time approximately 4 months after the first administration, to assess test–retest reliability. A sample size calculation was conducted using the PASS software, and a sample size of 22 participants was determined to be the minimum sufficient to detect an intra-class correlation coefficient (ICC) value of 0.50, based on an alpha level of 0.05 and a power of 80%. However, a larger sample ($N = 201$) was recruited in order to sample widely across demographic characteristics and regions. While there were some minor demographic differences across the two timepoints, that may have reduced the relationship between the timepoint 1 and timepoint 2 data, the second sample was deemed a sufficiently large sample of the initial participants for this analysis. According to Koo and Li's (2016) established conventions, an ICC less than 0.50 indicates poor reliability, a value between 0.50 and 0.75 suggests moderate reliability, a range of 0.75 to 0.90 denotes good reliability, and a value greater than 0.90 signifies excellent reliability. The ICCs for each factor are presented in Table 6. All factors demonstrated moderate test–retest reliability, except for Powerlessness, which was approaching moderate reliability.

Discussion

This study sought to psychometrically validate the Inventory of Climate Emotions (ICE; Marczak et al., 2023) with an Australian representative sample. The importance of emotion is highlighted within both environmental and social theories, in understanding the individual and collective response to the climate (Gifford, 2014). Identification of the various emotional responses may assist with understanding associated psychological and behavioural response to the climate, such as attitude, risk assessment and behavioural engagement (Clayton et al., 2015). Climate emotions are relevant to populations worldwide, and to some extent, climate emotions may be similar across various populations, as suggested by the similar structures found in the present study using an Australian population

and the Polish (Marczak et al., 2023), Norwegian, and Irish populations (Marczak et al., 2024). Climate emotions may also differ somewhat depending on socio-environmental conditions, as suggested by the confirmatory factor results of the present study, which indicated a better fit with a slight modification to the factor structure of the climate emotions subscales.

Validation

The results of this study provided preliminary support for the use of the ICE in an Australian sample. Overall, the existing factor structure was supported by CFA, with the exception of one item from the climate isolation factor. The climate isolation factor broadly pertains to feelings of loneliness, alienation, or isolation due to one's beliefs or concerns about climate change, particularly when these views are not shared or understood by others. Item 21 ("I feel like one of the few people who actually understand what climate change entails") deviates from this idea and does not directly express a feeling of loneliness or isolation due to others' attitudes towards climate change. Instead, it focuses on individuals' perception of their own understanding compared to others, without necessarily expressing a feeling of isolation. As such, the removal of item 21 improved the model fit on both conceptual and statistical grounds.

Cronbach's alphas >0.90 may indicate the presence of redundant items (e.g., Pesudovs et al., 2007). Consequently, the results of the present study indicate that the ICE subscales of Anger (0.94), Guilt (0.92), Anxiety (0.91), and Sorrow (0.94) may contain redundancy. The remaining subscales [Powerlessness, Contempt, Enthusiasm, Isolation (with four items), Isolation (with three items)] yielded Cronbach's alphas ranging from 0.79 to 0.90, which can be considered acceptable (e.g., Vaske, 2019).

The ICE demonstrated convergent validity via weak but significant positive associations between the HOGG and all ICE subscales with the exception of Contempt. Given the subscale of Contempt is defined by a disregard for climate change (Marczak et al., 2024), it is incongruent with the notion of anxiety related to climate change, as measured by the HOGG. Thus, the lack of relationship between the Contempt subscale and the HOGG is understandable. Furthermore, the ICE demonstrated convergent validity via significant negative associations between life satisfaction and all ICE subscales with the

exception of Enthusiasm, where no relationship was found. The varying strengths of relationships between the HOGG and the ICE subscales provides evidence of the subscales measuring different underlying constructs, providing evidence of discriminant validity. However, the convergent validity results need to be interpreted cautiously given the measure investigates such a diverse range of ecological emotions, that were not each assessed in the current study. Divergent validity of the ICE was supported through low levels of shared variance with eco-anxiety and life satisfaction. These nuanced results suggest that the ICE subscales discriminate between different emotions. Further, these results are congruent with the underlying constructs being measured, and the limited range of emotions assessed with convergent/divergent measures.

According to Koo and Li's (2016) conventions, in the present study, the Powerlessness factor demonstrated poor test–retest reliability, whereas the remaining factors (Anger, Contempt, Enthusiasm, Isolation [4 items], Isolation [3 items], Anxiety, Guilt, and Sorrow) yielded ICC values ranging from 0.58 to 0.74, thus, demonstrating moderate test–retest reliability. Overall, these results provide initial support for the test–retest reliability of the ICE, with the exception of Powerlessness. This may suggest that Powerlessness has more fluctuation as a construct, compared to other subscales. However, it should be noted that the interval for test–retest reliability was selected to avoid practice effects on the items, and maintain reasonable level of stability on the target condition (Kawakami et al., 2020), eco-emotions. However, this length of time may have resulted in an under-estimate of test–retest reliabilities and the possibility of environmental changes that altered eco-emotions. Thus, while the test–retest reliabilities obtained here should be interpreted with caution due to the length of the interval between the timepoints, the findings are important as they present the first known attempt to assess the stability of the instrument over two timepoints.

Australia's unique socio-cultural and environmental context

Despite the initial psychometric support found for the measure in this Australian sample, it should be noted that this scale was developed in the Polish social, cultural, political and environmental context. This context influenced the range of emotions included, and the item wording. However, it should be noted that while these items (with the exception of item 21), received support in this sample, the items and domains were not created in Australia and potentially do not represent the spectrum of emotions related to the Australian context.

There may be other eco-emotions related to Australia's unique environmental and socio-cultural context that were not captured in this measure as it was developed overseas in Poland. Australia has a unique environmental context, that is characterised by diverse eco-systems and varied agricultural production. A plethora of extreme weather events (e.g., drought, flood, cyclones, and bushfires), making a large proportion of the continent often inhospitable. Furthermore, Australia has a unique socio-cultural context, with Indigenous Australians as Traditional Owners of the land, and the connection to Country that is central to the wellbeing of the Indigenous people of Australia is not represented in this measure. As described by Kingsley

et al. (2013), "Aboriginal communities refer to their traditional lands and territories through more enmeshed language like "Country" or "homelands." Country refers to everything including the land, air, water and stories of "Dreaming," being dynamic and multilayered, forming the rules, norms and beliefs of existence between species and humans through connecting Aboriginal peoples' back to ancestral beings from the time of creation" (p. 682). Connection to Country represents the integral emotional connection between Indigenous people and the land, which is disrupted by extreme weather events (Albrecht, 2012). Thus, specific emotions that are directly related to the Australian context, such as Indigenous Australian's 'connection to Country', were not captured in the measure as it was developed overseas. Similarly, this profound place-based attachment, or 'sense of place', has been found in Australian farmers (Ellis and Albrecht, 2017), who are dependent on the land for livelihood, family, wellbeing, lifestyle and identity (Rice and Usher, 2024). This place-based attachment has been likened to the positive role of nature or the environment that is identified by non-Indigenous Australians in wellbeing (Sangha et al., 2025). Thus, this connection to Country (for Indigenous people) and the environment (for non-Indigenous people) is a crucial component of wellbeing for Australians (Sangha et al., 2025), and is disrupted by extreme weather events and the changing climate (Ellis and Albrecht, 2017). Concepts of connection to Country and sense-of-place are not represented within the ICE measure, as it was developed in the Polish context. In addition, there are potentially other Australian cultural and contextual complexities that are not considered. The ICE developers acknowledge this, stating that the "full phenomenology of the emotional experience of climate change" may not be accounted for, and that the measure "was developed in the cultural context of Poland that has its unique socio-cultural factors and policy landscape that influence people's attitudes, beliefs, and emotional responses regarding climate change" (Marczak et al., 2023, p. 83). Nonetheless, research that was undertaken in Poland (Marczak et al., 2023), Norway and Ireland (Marczak et al., 2024), suggests there may be some climate emotions that are common across cultures and countries.

Limitations and directions for future research

While a strength of this study is the approximation of a representative sample, this sampling method is likely to have resulted in an under-representation of vulnerable groups. Research suggests that vulnerable groups are at a disproportionately greater risk of the impacts of climate change, such as Indigenous people, farmers and those who depend on the land, children, older people, women, those from remote locations, lower socio-economic status and those who are vulnerable to displacement (Usher et al., 2023; Fatema et al., 2021; Fatema et al., 2023). With the broad exception of older adults and women, these vulnerable groups are likely to be under-represented in the current study. While children and young people were not the focus of the current study, further research into the full scope of various climate emotions experienced by Australian youth is needed. In addition, further research on climate emotions specifically experienced by Indigenous Australians and those who depend on the land (e.g.,

farmers) is needed. In addition, future validation studies need to consider including a broader range of validity measures to assess convergent validity across the range of eco-emotions included in the ICE, and consider a shorter interval for test–retest reliability and assessing the stability of the measure over time.

Although the ICE is intended to assess a range of emotional reactions to climate change, it may not adequately capture the range of emotions experienced specifically in response to environmental threats and extreme weather exposure. Thus, further research is needed to understand the nuanced emotional responses related specifically to environmental threats (rather than climate change more broadly). In addition, longitudinal research is needed to assess fluctuations in climate emotions over time, and in response to extreme weather events.

Implications

This validation of the ICE for the Australian context has implications for public health, policy and research. The ICE enables multiple climate emotions to be assessed concurrently, providing a broad assessment of a range of emotions related to the environment. An ability to assess a broad range of climate emotions is useful for policy development, to understand and measure public sentiments over time, and to motivate public engagement and behavioural action (Berry and Owen, 2018). The ICE may be a useful tool to assess the emotional needs of communities in response to the environment, toward enhancing resilience, adaptation, wellbeing, and action (Adger et al., 2013). The ICE may also be useful in public health settings by enabling climate emotions to be identified, monitored and targeted in treatment and prevention programs (Clayton et al., 2017).

Conclusion

This study provides the first validation of the ICE (Marczak et al., 2023), in an Australian sample. By effectively validating this measure, we make a significant contribution to the existing literature and suite of available measures of climate emotions. While the ICE represents a measure of eight specific climate emotions relevant outside Poland, it must be recognised that this measure does not encapsulate all of the relevant climate emotions for the unique Australian socio-cultural and environmental contexts. Nonetheless, the results of the current study suggest that the measure may be a valid tool to assess these eight distinct climate emotions.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request, by email to Kylie.Rice@une.edu.au.

Ethics statement

The studies involving humans were approved by Human Research Ethics Committee, University of New England. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin because Participants provided informed consent online, rather than in writing. All participants provided informed consent to participate.

Author contributions

KR: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing. KU: Conceptualization, Funding acquisition, Investigation, Project administration, Resources, Supervision, Writing – review & editing. NS: Data curation, Formal analysis, Methodology, Writing – review & editing. EA: Writing – original draft, Writing – review & editing. RP: Writing – review & editing. SF: Writing – original draft, Writing – review & editing. HK: Writing – original draft, Writing – review & editing. AR: Conceptualization, Formal analysis, Investigation, Supervision, Writing – review & editing. RJ: Writing – review & editing. RD: Conceptualization, Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing.

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that Gen AI was used in the creation of this manuscript. Gen AI was utilised to identify a list of climatic, political and cultural attributes of the different countries, which informed our written response.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Adger, W. N., Barnett, J., Brown, K., and Marshall, N. (2013). Cultural dimensions of climate change impacts and adaptation. *Nat. Clim. Chang.* 3, 112–117. doi: 10.1038/nclimate1666

Albrecht, G. A. (2012). "Psychoterratic conditions in a scientific and technological world" in *Ecopsychology: Science, Totems, and the Technological Species*. (Eds.) P. H. Kahn and P. H. Hasbach Cambridge: MIT Press.

Barrett, L. F. (2014). The conceptual act theory: a précis. *Emot. Rev.* 6, 292–297. doi: 10.1177/1754073914534479

Berry, H. L., and Owen, J. M. (2018). The psychological impacts of climate change on the health of communities: a systematic review of the literature. *Int. J. Environ. Res. Public Health* 15, 1–15. doi: 10.3390/ijerph15061280

Charlson, F., Ali, S., Augustinavicius, J., Benmarhnia, T., Birch, S., Clayton, S., et al. (2022). Global priorities for climate change and mental health research. *Environ. Int.* 158:106984. doi: 10.1016/j.envint.2021.106984

Cianconi, P., Hanife, B., Grillo, F., Betro', S., Lesmana, C. B. J., and Janiri, L. (2023). Eco-emotions and psychoterratic syndromes: reshaping mental health assessment under climate change. *Yale J. Biol. Med.* 96, 211–226. doi: 10.59249/EARX2427

Clayton, S., Devine-Wright, P., Stern, P. C., Whitmarsh, L., Carrico, A., Steg, L., et al. (2015). Psychological research and global climate change. *Nat. Clim. Chang.* 5, 640–646. doi: 10.1038/nclimate2622

Clayton, S., and Karazsia, B. T. (2020). Development and validation of a measure of climate change anxiety, *Journal of Environmental Psychology* 69:101434. doi: 10.1016/j.jenvp.2020.101434

Clayton, S., Manning, C. M., Krygsman, C. M., and Speiser, M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.: American Psychological Association, and ecoAmerica.

Ellis, N. R., and Albrecht, G. A. (2017). Climate change threats to family farmers' sense of place and mental wellbeing: A case study from the Western Australian Wheatbelt, *Social Science & Medicine* 175, 161–168. doi: 10.1016/j.socscimed.2017.01.009

Fatema, S. R., East, L., Islam, M. S., and Usher, K. (2021). Health impact and risk factors affecting south and southeast Asian women following natural disasters: a systematic review. *Int. J. Environ. Res. Public Health* 18:11068. doi: 10.3390/ijerph182111068

Fatema, S. R., Rice, K., Rock, A., Islam, M. S., East, L., and Usher, K. (2023). Physical and mental health status of women in disaster-affected areas in Bangladesh. *Nat. Hazards* 117, 2715–2733. doi: 10.1007/s11069-023-05964-5

Furr, M. (2011). Scale construction and psychometrics for social and personality psychology. Thousand Oaks, CA: Sage.

Gergis, J., Blashki, G., Gardner, J., and Bradshaw, S. (2023). Climate trauma: the growing toll of climate change on the mental health of Australians. Climate Council of Australia. Available online at: http://nla.gov.au/nla.obj-3199108102 (Accessed October 6, 2023).

Ghosh, R. J., and Orchiston, C. (2022). A systematic review of climate migration research: gaps in existing literature. *SN Social Sciences*, 2:47. doi: 10.1007/s43545-022-00341-8

Gifford, R. (2014). Environmental psychology matters. *Annu. Rev. Psychol.* 65, 541–579. doi: 10.1146/annurev-psych-010213-115048

Hogg, T. L., Stanley, S. K., O'Brien, L. V., Wilson, M. S., and Watsford, C. R. (2021). The Hogg eco-anxiety scale: development and validation of a multidimensional scale. *Glob. Environ. Chang.* 71:102391. doi: 10.1016/j.gloenvcha.2021.102391

Ingle, H. E., and Mikulewicz, M. (2020). Mental health and climate change: tackling invisible injustice. *The Lancet Planetary Health* 4, e128–e130. doi: 10.1016/S2542-5196(20)30081-4

IPCC (2023). Sections. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, 35–115.

Kawakami, N., Inoue, A., Tsuchiya, M., Watanabe, K., Imamura, K., Iida, M., et al. (2020). Construct validity and test-retest reliability of the world mental health Japan version of the World Health Organization health and work performance questionnaire short version: a preliminary study. *Ind. Health* 58, 375–387. doi: 10.2486/indhealth.2019-0090

Kingsley, J., Townsend, M., Henderson-Wilson, C., and Bolam, B. (2013). Developing an exploratory framework linking Australian aboriginal peoples' connection to country and concepts of wellbeing. *Int. J. Environ. Res. Public Health* 10, 678–698. doi: 10.3390/ijerph10020678

Koo, T. K., and Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J. Chiropr. Med.* 15, 155–163. doi: 10.1016/j.jcm.2016.02.012

Longman, J., Patrick, R., Bernays, S., and Charlson, F. (2023). Three reasons why expecting "recovery" in the context of the mental health impacts of climate change is problematic. *Int. J. Environ. Res. Public Health* 20, 5882–5887. doi: 10.3390/ijerph20105882

Marczak, M., Wierzba, M., Kossowski, B., Marchewka, A., Morote, R., and Klöckner, C. A. (2024). Emotional responses to climate change in Norway and Ireland: a validation of the inventory of climate emotions (ICE) in two European countries and an inspection of its nomological span. *Front. Psychol.* 15:1211272. doi: 10.3389/fpsyg.2024.1211272

Marczak, M., Wierzba, M., Zaremba, D., Kulesza, M., Szczypiński, J., Kossowski, B., et al. (2023). Beyond climate anxiety: development and validation of the inventory of climate emotions (ICE): a measure of multiple emotions experienced in relation to climate change. *Glob. Environ. Chang.* 83:102764. doi: 10.1016/j.gloenvcha.2023.102764

Margolis, S., Schwitzgebel, E., Ozer, D. J., and Lyubomirsky, S. (2018). A New Measure of Life Satisfaction: The Riverside Life Satisfaction Scale. *Journal of Personality Assessment* 101, 621–630. doi: 10.1080/00223891.2018.1464457

Massazza, A., Teyton, A., Charlson, F., Benmarhnia, T., and Augustinavicius, J. L. (2022). Quantitative methods for climate change and mental health research: current trends and future directions. *Lancet Planetary Health* 6, e613–e627. doi: 10.1016/S2542-5196(22)00120-6

Niggli, L., Huggel, C., Muccione, V., Neukom, R., and Salzmann, N. (2022). Towards improved understanding of cascading and interconnected risks from concurrent weather extremes: Analysis of historical heat and drought extreme events. *PLOS Climate* 1:e0000057. doi: 10.1371/journal.pclm.0000057

Orrù, L., and Mannarini, S. (2024). Psychological impact of climate change emergency: an attempt to define eco-anxiety. *Front. Psychol.* 15:1375803. doi: 10.3389/fpsyg.2024.1375803

Orrù, L., Taccini, F., and Mannarini, S. (2024). Worry about the future in the climate change emergency: a mediation analysis of the role of eco-anxiety and emotion regulation. *Behav. Sci.* 14:255. doi: 10.3390/bs14030255

Patrick, R., Snell, T., Gunasiri, H., Garad, R., Meadows, G., and Enticott, J. (2023). Prevalence and determinants of mental health related to climate change in Australia. *Austr. N. Z. J. Psychiatry* 57, 710–724. doi: 10.1177/00048674221107872

Pesudovs, K., Burr, J. M., Harley, C., and Elliott, D. B. (2007). The development, assessment, and selection of questionnaires. *Optom. Vis. Sci.* 84, 663–674. doi: 10.1097/OPX.0b013e318141fe75

Rice, K., and Usher, K. J. (2024). The weather as a determinant of farmer's mental health: a dependent, interacting, cumulative and escalating model (DICE) of the effects of extreme weather events. *Int. J. Ment. Health Nurs.* 33, 1602–1606. doi: 10.1111/inm.13328

Rönkkö, M., and Cho, E. (2022). An updated guideline for assessing discriminant validity. *Organ. Res. Methods* 25, 6–14. doi: 10.1177/1094428120968614

Sangha, K. K., Ronju, A., and Jeremy, R-S., and Leigh-Ann, W. (2025). A nature-based solutions assessment framework integrating indigenous biocultural and ecosystem services perspectives: An Australian example, *Ecological Indicators* 172:113230. doi: 10.1016/j.ecolind.2025.113230

Smith, P., Rice, K., Schutte, N., and Usher, K. (2024). Development and validation of the cultural responsiveness assessment measure (CRAM): a self-reflection tool for mental health practitioners when working with first nations people. *Int. J. Soc. Psychiatry* 70, 190–200. doi: 10.1177/00207640231204211

Stewart, A. E. (2021). Psychometric Properties of the Climate Change Worry Scale. *International Journal of Environmental Research and Public Health* 18:494. doi: 10.3390/ijerph18020494

Usher, K. J., Rice, K., Fatema, S. R., Upward, K. L., and Jones, R. (2023). Nurses on the frontline of health care in the escalating context of climate change: climate-related extreme weather events, injustice, mental health and eco-anxiety. *J. Adv. Nurs.*, 1–4. doi: 10.1111/jan.15838

Usher, K., Rice, K., and Williams, J. (2024). An application of the 'one health' approach for extreme weather events and mental health: can the adoption of a 'one health' approach better prepare us for the predicted drought in parts of rural Australia? *Int. J. Ment. Health Nurs.* 33, 220–223. doi: 10.1111/inm.13310

Vaske, J. J. (2019). Survey research and analysis. 1807 North Federal Drive, Urbana, IL 61801: Sagamore-Venture.

WHO, (2024). *"One Health Initiative" World Health Organisation (WHO)*. Available at: https://cdn.who.int/media/docs/default-source/one-health/ohi-one-pager1.pdf?sfvrsn=60d4b1ad_1&download=true (Accessed January 2, 2025).