



UC GEOHEALTH LABORATORY

Spatial variations in stress related health compared to earthquake exposure: preliminary results and future directions

Prof Simon Kingham¹, Daniel Hogg¹, Kim Reed¹, Dr Malcolm Campbell¹, Dr Thomas Wilson², and Prof Mike Ardagh³

¹ GeoHealth Laboratory and Dept of Geography, University of Canterbury, Christchurch, NZ

² Dept of Geological Sciences, University of Canterbury, Christchurch, NZ

³ Canterbury District Health Board

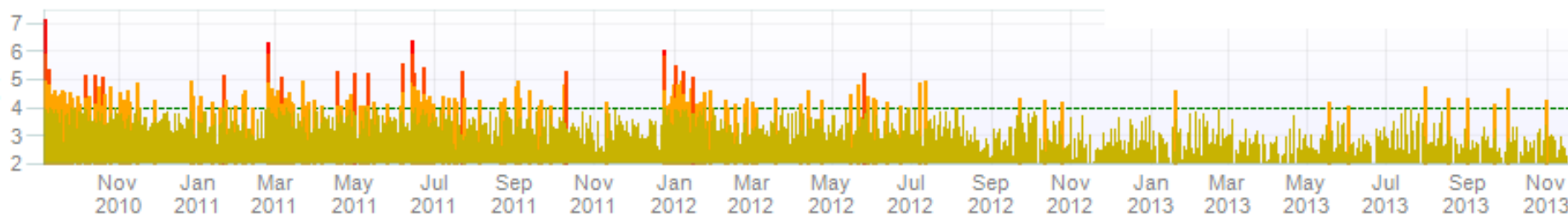
Background

2010/2011 Christchurch earthquakes

- 4th Sept 2010: Darfield earthquake ~40km from Christchurch. Mag 7.1
- 22nd Feb 2011: Port Hills earthquake. Close to Christchurch. Mag 6.3
 - Vertical ground acceleration was highest recorded ever
 - 185 people killed & over 8,000 people injured
 - > 100,000 buildings damaged/destroyed
 - 15,000-20,000 homes to be rebuilt.
 - Estimated NZ\$40 billion rebuild costs (€24bn, US\$32)



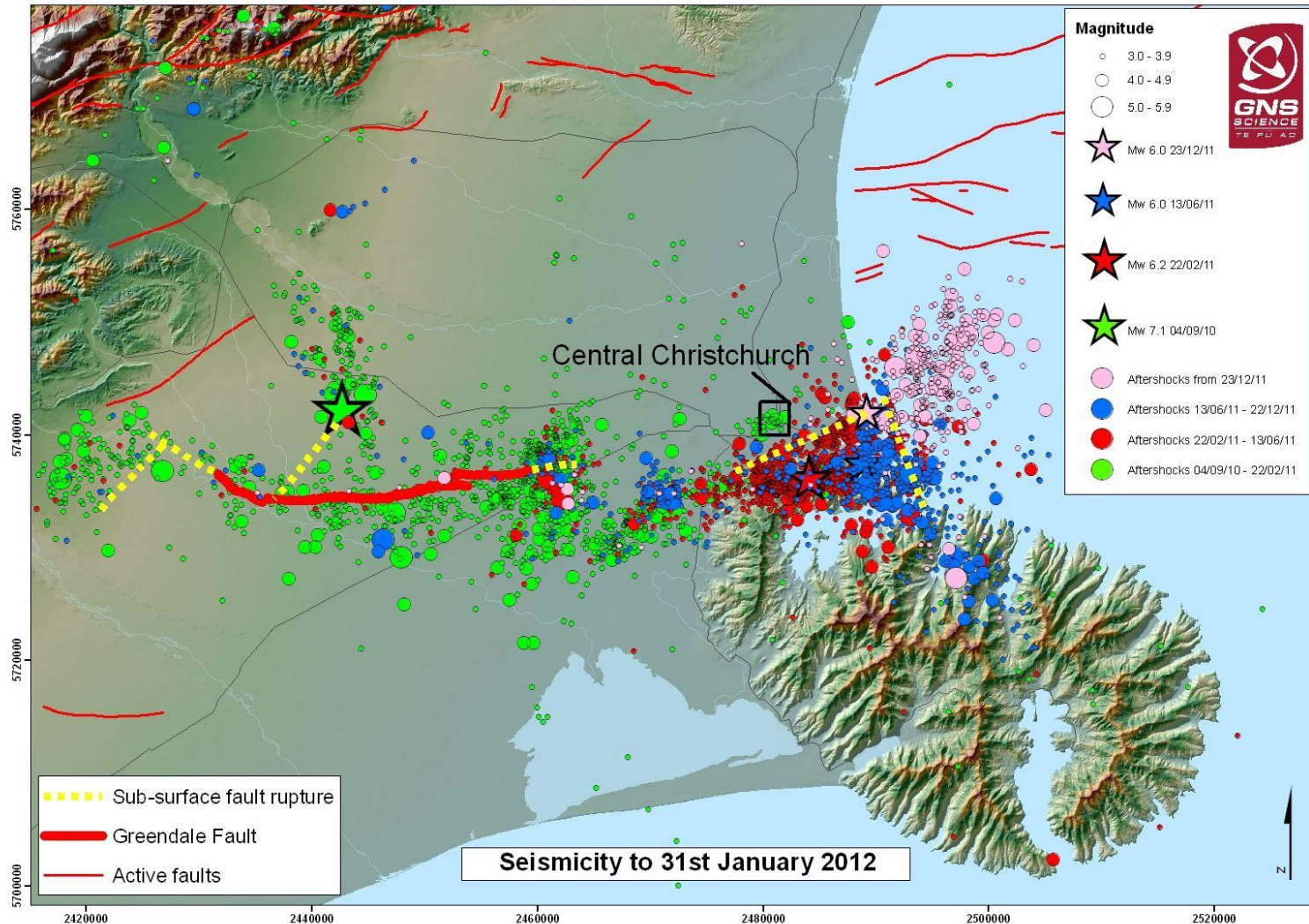
Background



- Over 12,000 aftershocks
- Ongoing

Mag	Last	Shakes
7	04 Sep 2010 4:35am	1
6	23 Dec 2011 3:18pm	3
5	25 May 2012 2:44pm	57
4	18 Nov 2013 11:36pm	476
3	20 Nov 2013 6:45pm	3771
2	21 Nov 2013 2:41pm	9351

Background



Background

Physical Impacts

- Damage/Collapse of Buildings
- Damage to Infrastructure
- Widespread Liquefaction
- Rockfall and Hill Collapse



Background

Ongoing (*years*) community/health impact

- Facilities permanently or temporarily closed e.g schools, shops, GPs
- *Temporary* housing arrangements
 - Smaller housing, garages, even cars + multiple moves
 - Community break up & geographical challenges
- Uncertainty over state of land and rebuild
 - Red, orange, green, white etc.
- Dispersal/Relocation of whole communities
 - *Red zone* area not to be rebuilt
- Ongoing infrastructure repairs

Research questions

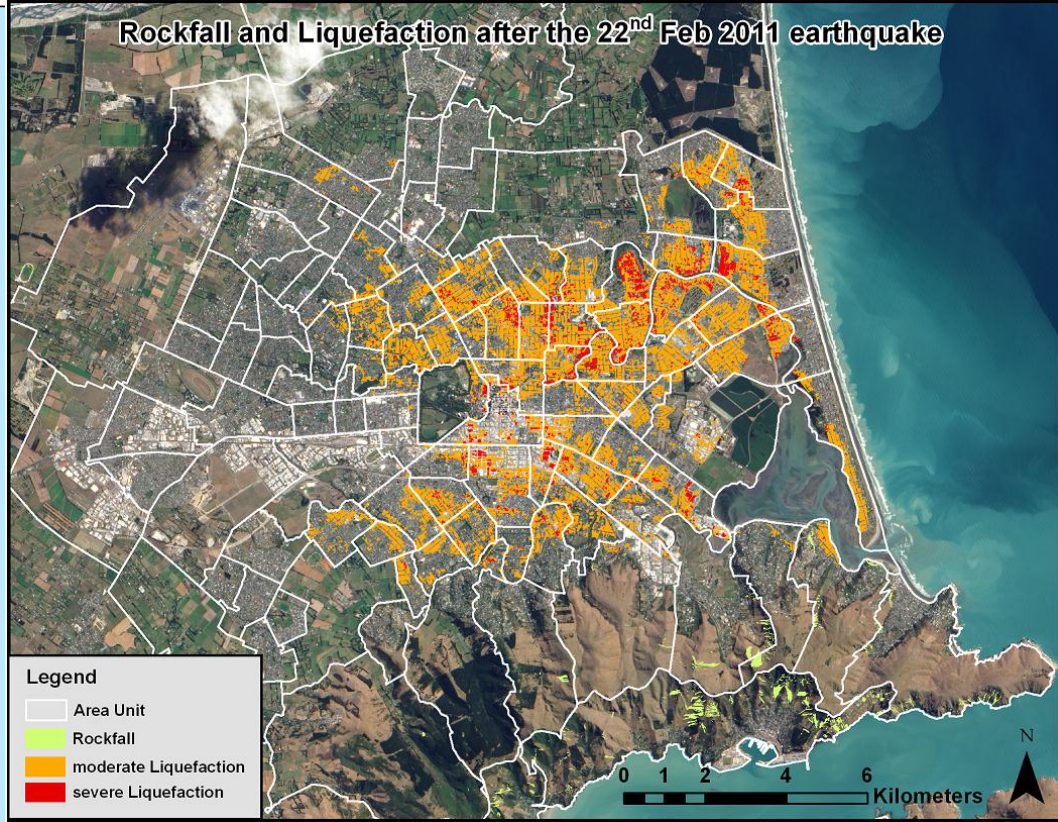
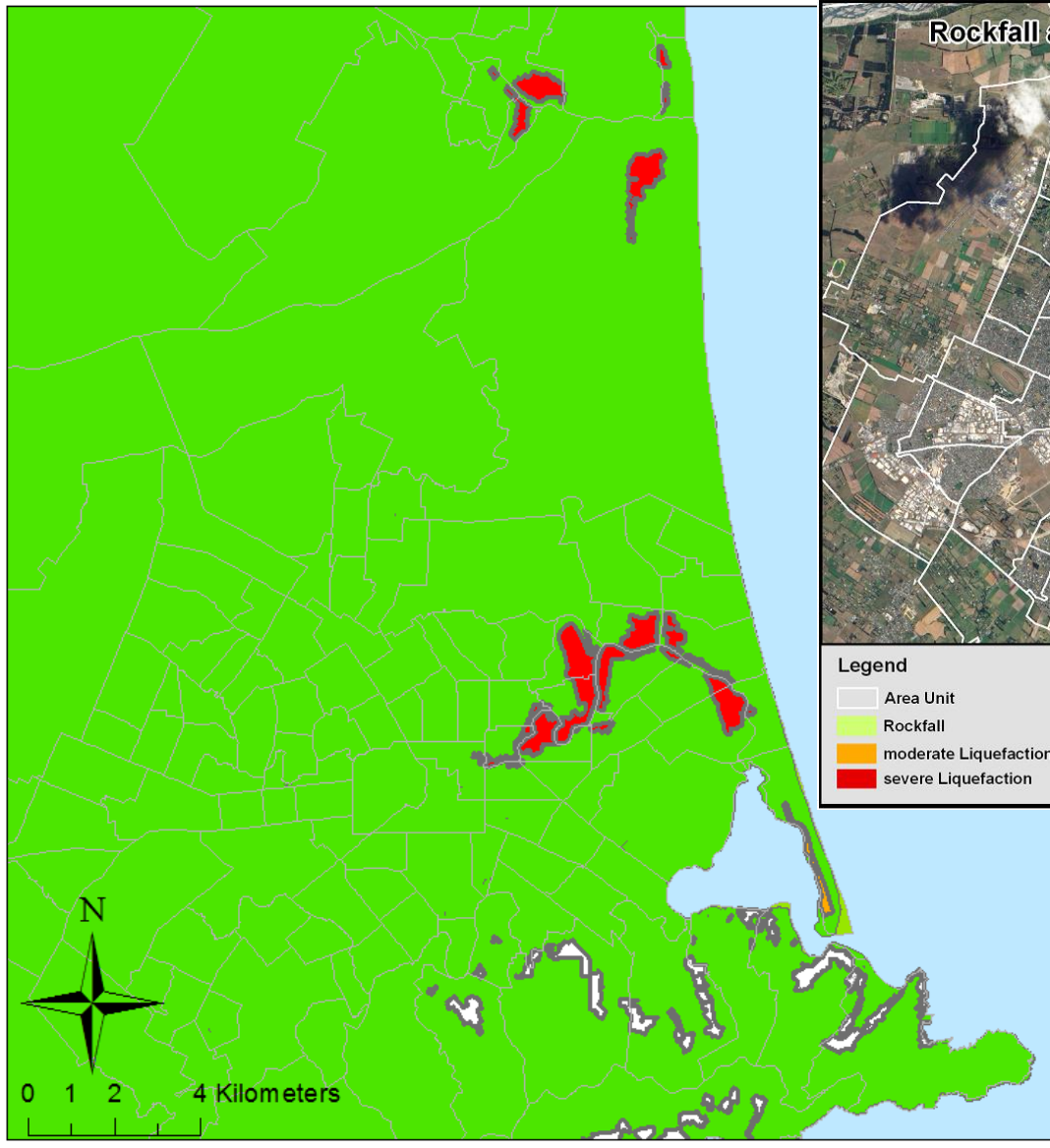
- Is there a spatial relationship between the extent of physical damage from the 2010/2011 Christchurch Earthquakes and stress-related health outcomes?
- Are adverse stress-related health outcomes greater among people who have experienced greater physical damage to their communities and homes than others who have experienced less damage, but who also live in the city?

Challenges

- Estimate exposure to earthquake-related anxiety and stress
- Relate exposure to stress-related health outcomes

Preliminary research

- Hospital admissions for chest pain and anxiety
May 2010-April 2012 aggregated to spatial units
 - Chest pain - mean 408 cases per month (329-545)
 - Anxiety - mean 22 cases per month (9-42)
- Compared to presence of, and proximity to,
 - Liquefaction
 - red zone land areas
- Range of spatio-temporal approaches used
(SatScan, linear and negative binomial regression)



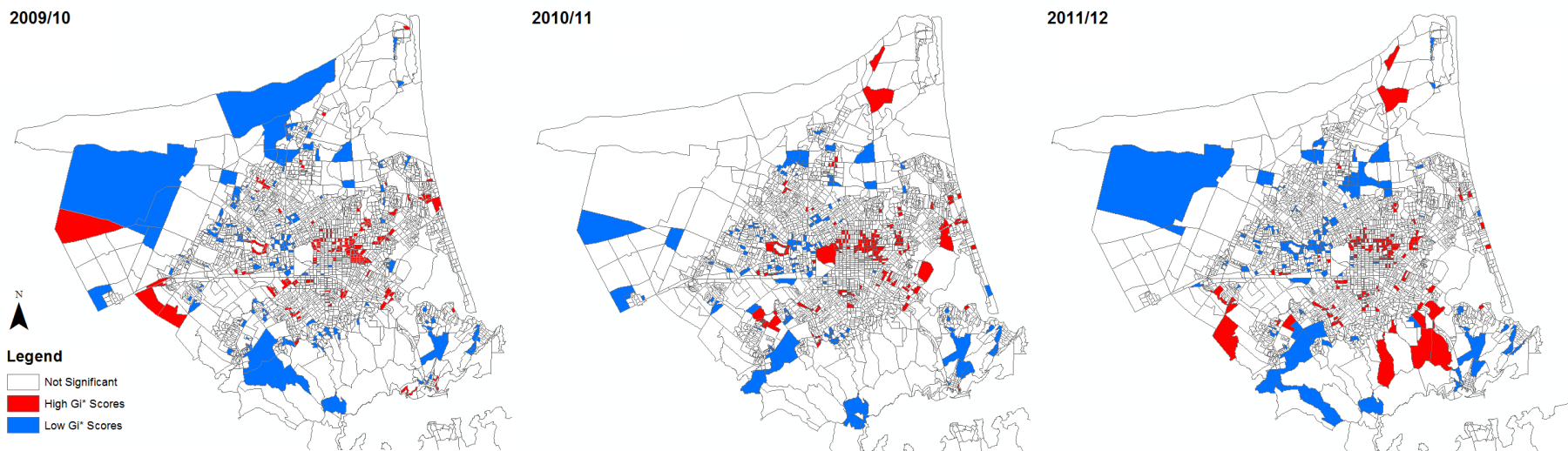
Preliminary findings

- Cluster of both anxiety & chest pain within Christchurch at the same time the earthquakes occurred
- Liquefaction a stronger predictor of anxiety than red zone land
- Chest pain positively associated with all measures of earthquake damage with the exception of being in red-zone
- Significant increase in
 - anxiety cases 1 month after a major earthquake
 - chest pain cases 2 weeks after an earthquake (but then decreased over the following 5 weeks)

Mood/anxiety in Christchurch

- Annual summaries from July 1, 2009 to June 30, 2012
- Data sources from the Ministry of Health:
 - Mental health data (PRIMHD)
 - Pharmaceutical data (PHARMS)
 - Laboratory test information (LABS)
 - Public and private hospital data (NMDS)
 - Intellectual disability data (SOCRATES)
- Diagnoses based on ICD-9 and -10 codes
- Geocoded on a meshblock level based on the Primary Health Organisation (PHO) register

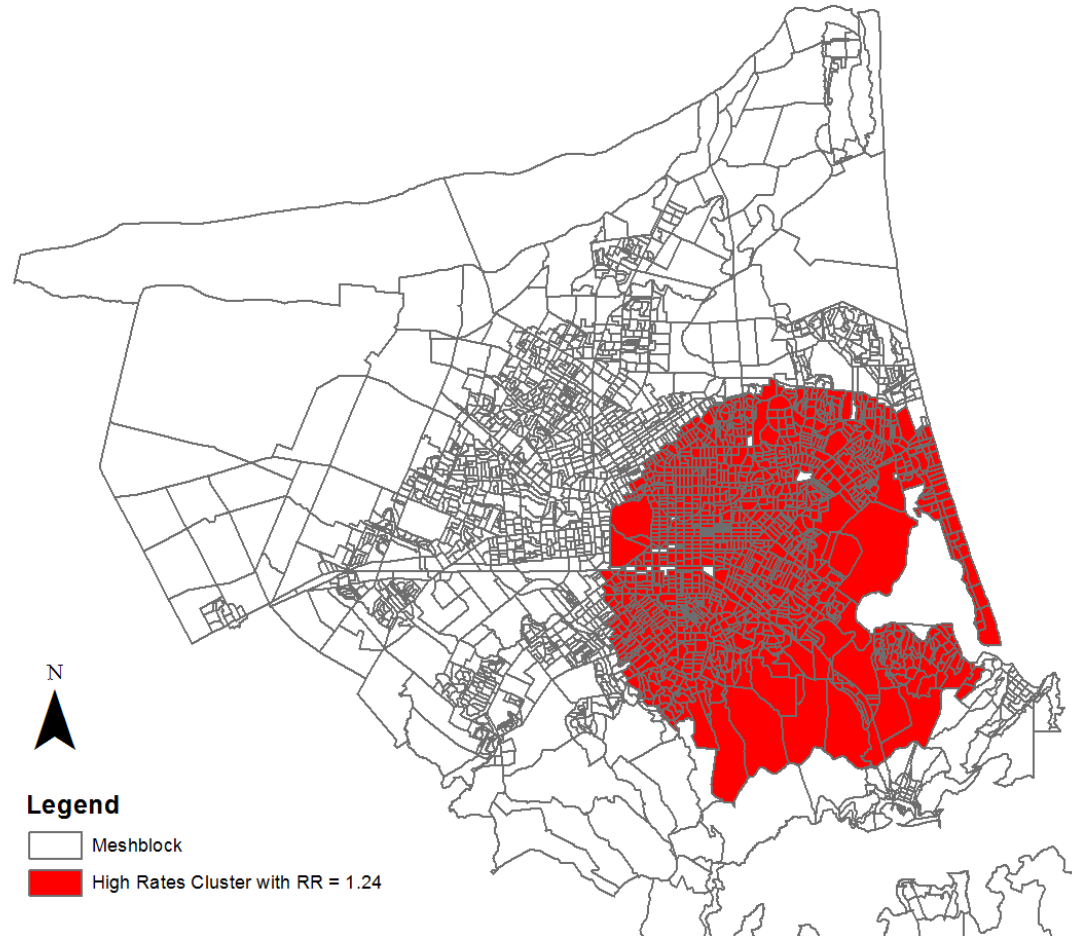
Spatial variation of mood/anxiety



Hot Spot analysis results of mood/anxiety rates per 1,000 people in Christchurch in the years 2009/10, 2010/11 & 2011/12

- Very scattered picture of hot and cold spots, but
 - greater hot spot of mood/anxiety rates northeast of the CBD
 - hot spots mainly found in the east and cold spots in the west of Christchurch
- No big spatial difference before and after the earthquake

Spatio-temporal variation



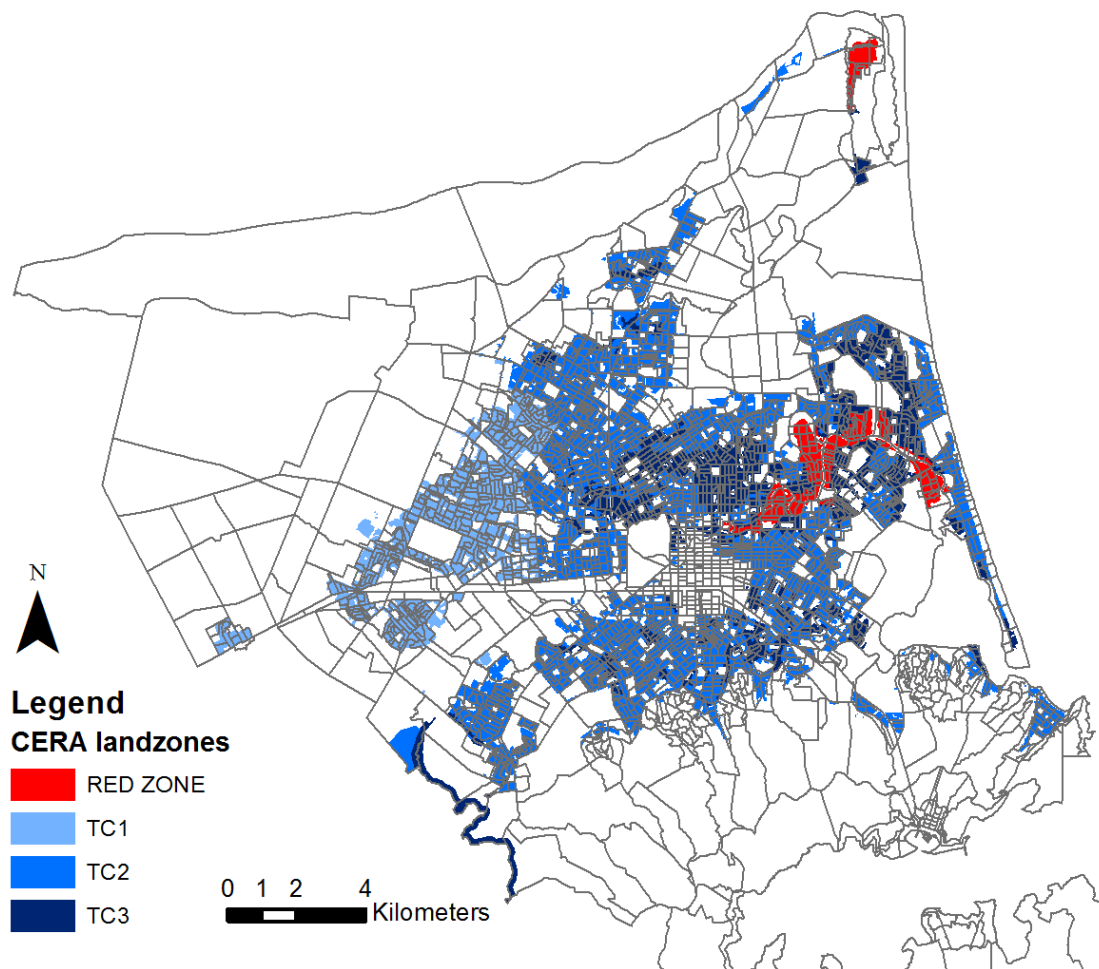
Space-Time cluster analysis results with a high rates cluster of mood/anxiety in 2011/12

Known risk factors

Independent variable	Odds Ratio	p-value	CI (95 %)
Male gender	0.843***	<0.001	0.825 – 0.862
Age 15-39	2.290***	<0.001	2.049 – 2.560
Age 40-64	2.749***	<0.001	2.459 – 3.072
Age 65+	3.118***	<0.001	2.786 – 3.491
Mental health comorbidity	1.954***	<0.001	1.889 – 2.021
Pre-existing mental health disorder	1.085***	<0.001	1.058 – 1.113
Pre-existing mood/anxiety disorder	1297.069***	<0.001	1163.931 – 1445.435
Year 2010/11	1.159***	<0.001	1.129 – 1.190
Year 2011/12	1.301***	<0.001	1.267 – 1.335

Significance level: *** <0.001 ** <0.01 * <0.05

CERA land zones



CERA Red Zone, TC3, TC2 and TC1 land classification published on the 23rd March 2012

Distance to CERA land zones in km

Model	Independent variable	Odds Ratio	p-value	CI (95%)
II ⁱ	Distance to Red Zone areas	1.000	0.948	0.994 – 1.006
III ⁱ	Distance to TC3 areas	0.980*	<0.05	0.965 – 0.996
IV ⁱ	Distance to TC2 areas	0.978*	<0.05	0.958 – 0.997
V ⁱ	Distance to TC1 areas	1.002	0.443	0.997 – 1.007
VI ⁱⁱ	Distance to Red Zone areas	0.859**	<0.01	0.769 – 0.960
VII ⁱⁱ	Distance to TC3 areas	0.791	0.159	0.570 – 1.096
VIII ⁱⁱ	Distance to TC2 areas	0.766	0.234	0.494 – 1.188
IX ⁱⁱ	Distance to TC1 areas	1.020***	<0.001	1.017 – 1.024

Significance level: *** <0.001 ** <0.01 * <0.05

Note:

- i. adjusted for gender, age, comorbidity with other mental health problems, pre-existing other mental health disorders and pre-existing mood/anxiety disorder
- ii. adjusted for gender, age, comorbidity with other mental health problems, pre-existing other mental health disorders excluding people with pre-existing mood/anxiety disorders, so that the risk for new incidences is tested

Peak Ground Acceleration (PGA) & Modified Mercalli Intensity (MMI)

- Intensity of PGA and MMI as risk factors for getting mood/anxiety after the 22nd Feb 11 earthquake
- Increased risk with higher intensity

Independent variable	Odds Ratio	p-value	CI (95%)
PGA	4.210*	<0.05	1.344 – 13.191
MMI	3.170**	<0.01	1.536 – 6.542

Significance level: *** <0.001 ** <0.01 * <0.05

Distance to lateral spreading & liquefaction in km

- Reduced risk as farther away someone lives
- Findings only stat. significant for new incidences

Independent variable	Odds Ratio	p-value	CI (95%)
Distance to severe lateral spreading	0.831**	<0.01	0.734 – 0.940
Distance to moderate to major lateral spreading	0.784*	<0.05	0.649 – 0.946
Distance to severe liquefaction	0.674**	<0.01	0.515 – 0.882
Distance to minor to moderate liquefaction	0.745*	<0.05	0.583 – 0.953

Significance level: *** <0.001 ** <0.01 * <0.05

Results

- Earthquake specific risk factors for getting a mood or anxiety disorder include
 - Distance to TC3 and TC2 areas
 - Distance to Red Zone areas for people*
 - Peak Ground Acceleration (PGA)*
 - Modified Mercalli Intensity (MMI)*
 - Distance to liquefaction and lateral spreading*

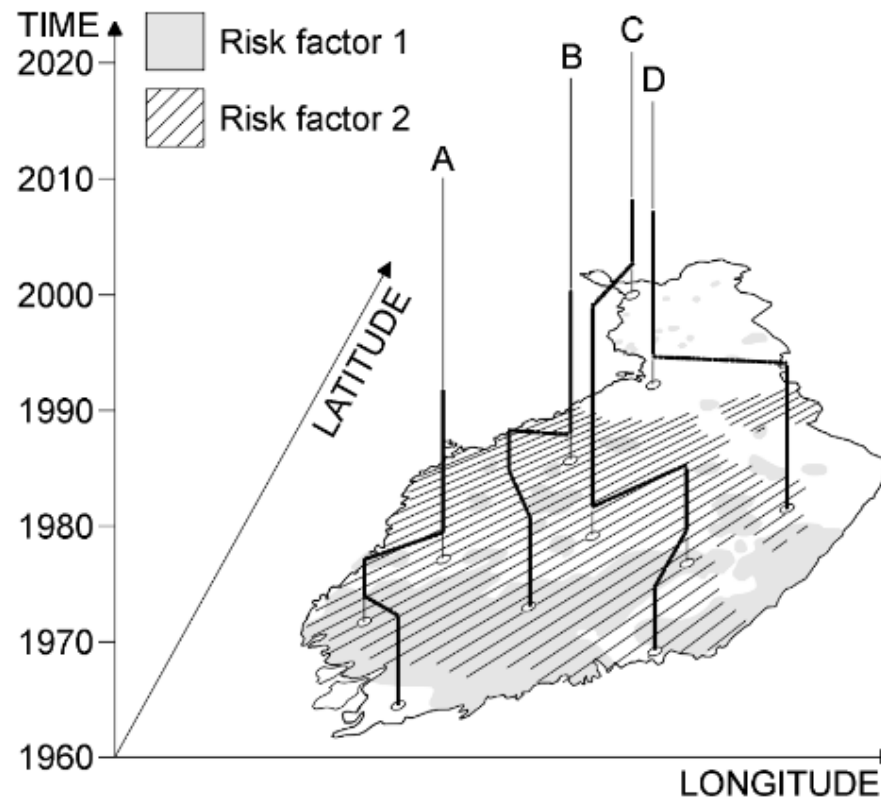
* only statistically significant for new incidences

Limitations

- CERA land zones a crude measure of damage
- Missing confounders, e.g. socio-economic status
- Lot of different diagnoses included in mood and anxiety
- Great number of people with pre-existing mood or anxiety disorder
- Spatial autocorrelation **not** considered within the regression analyses
- Mobility of the people **not** considered

Time as a component

Mobility of the people



Three dimensional space-time prism for four individuals exposed to two risk factors (Source: Sabel et al. 2000)

Future Work

- Compare other stress-related disorders like cardiovascular diseases
- Compare further earthquake impacts like community disruption
- Use spatial regression models to account for spatial autocorrelation
- Use more accurate data to include time as a component

Thanks
Questions?