Climate Change & Engineering Lifelines

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Waikato & Bay of Plenty Engineering Lifelines Groups

Rotorua, 13 June 2008

Ministry for the Environment
Manatū Mō Te Taiao

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Climate change is a real and happening thing …

- The evidence for global warming is unequivocal (IPCC)
- It is very likely to be human-induced (IPCC)
- Represents a “real and present danger”
  Sir David King, Chief Advisor to UK Government

The climate is changing and it is our fault … but there are things we can do!




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Engineering Lifelines Context

- "…climate change is not a new hazard, it is an exacerbator…"
- Historic climate conditions no longer accurate indicators
- Design of new structures must account for climate scenarios several decades into the future
- Urban infrastructure needs to adapt to new climate risks to ensure safety & quality of life, as well as reduce long-term costs.

www.mfe.govt.nz/issues/climate/sectors/engineering.html

and

www.mfe.govt.nz/issues/climate/resources/engineering/index.html

and

www.mfe.govt.nz/issues/climate/resources/adaptation/index.html

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Climate change in NZ

- In NZ, changes already observed since 1950 include:
  - Mean temperature increase of 0.4 °C
  - Decrease in cold nights & frosts
  - Sea level rise of 0.07 m
  - Loss of >¼ of alpine ice mass
  - Increased beech seed production
- NZ's climate "virtually certain" to be warmer in 21st century, with noticeable changes in extreme events
- Natural systems, water security and coastal communities most vulnerable



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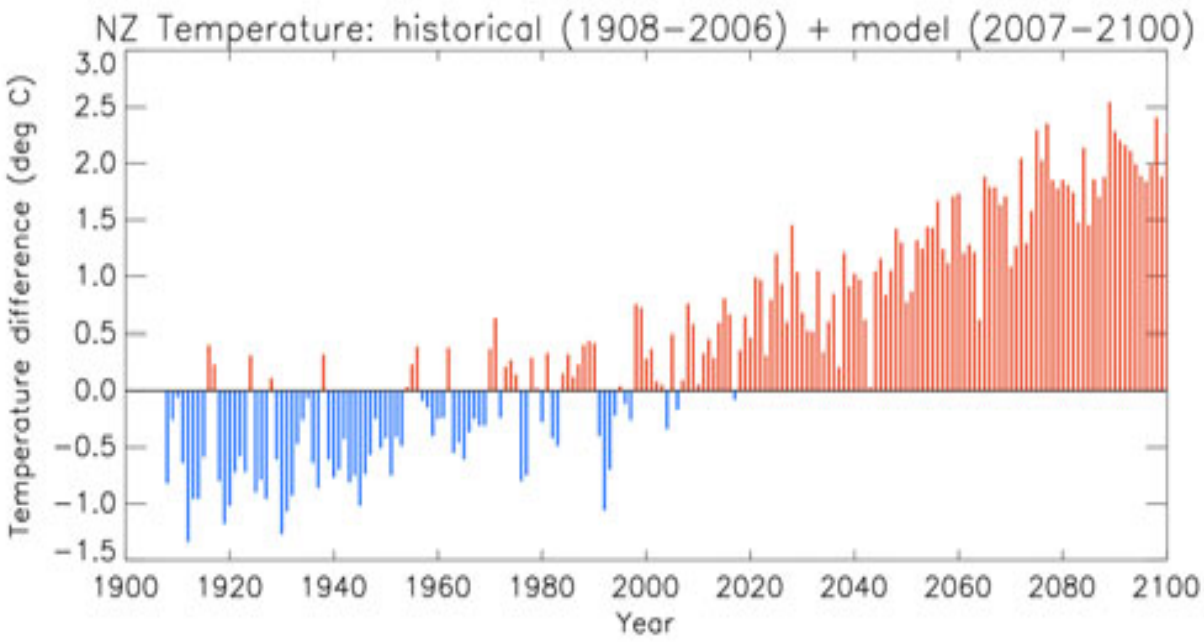
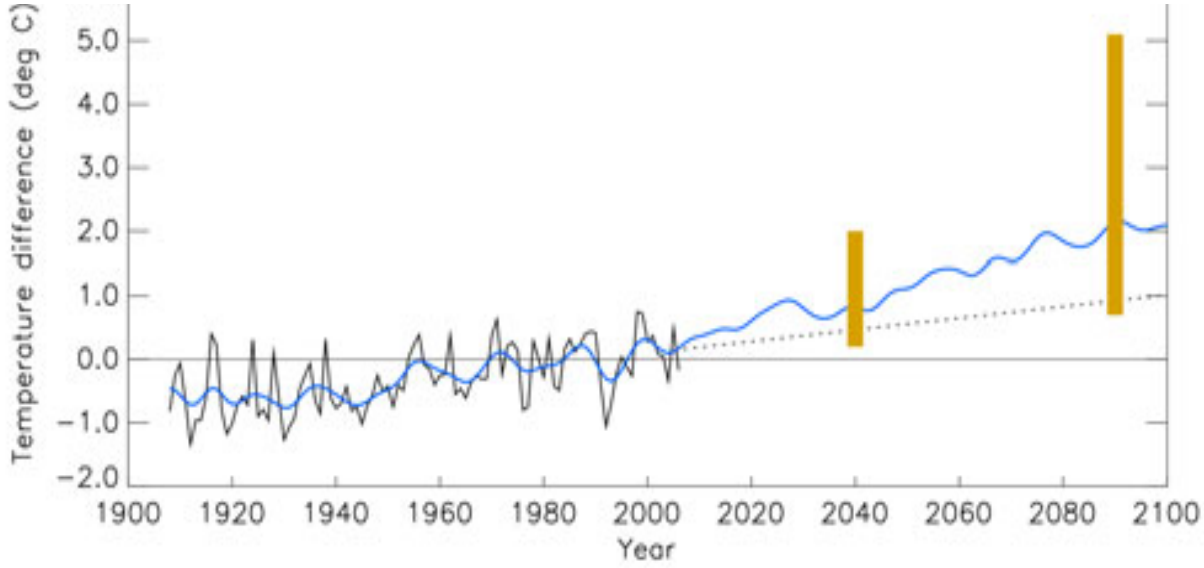
NZ: Past and Projected Temperature





Slightly more warming in the North

+1.9 to 2.1 ºC

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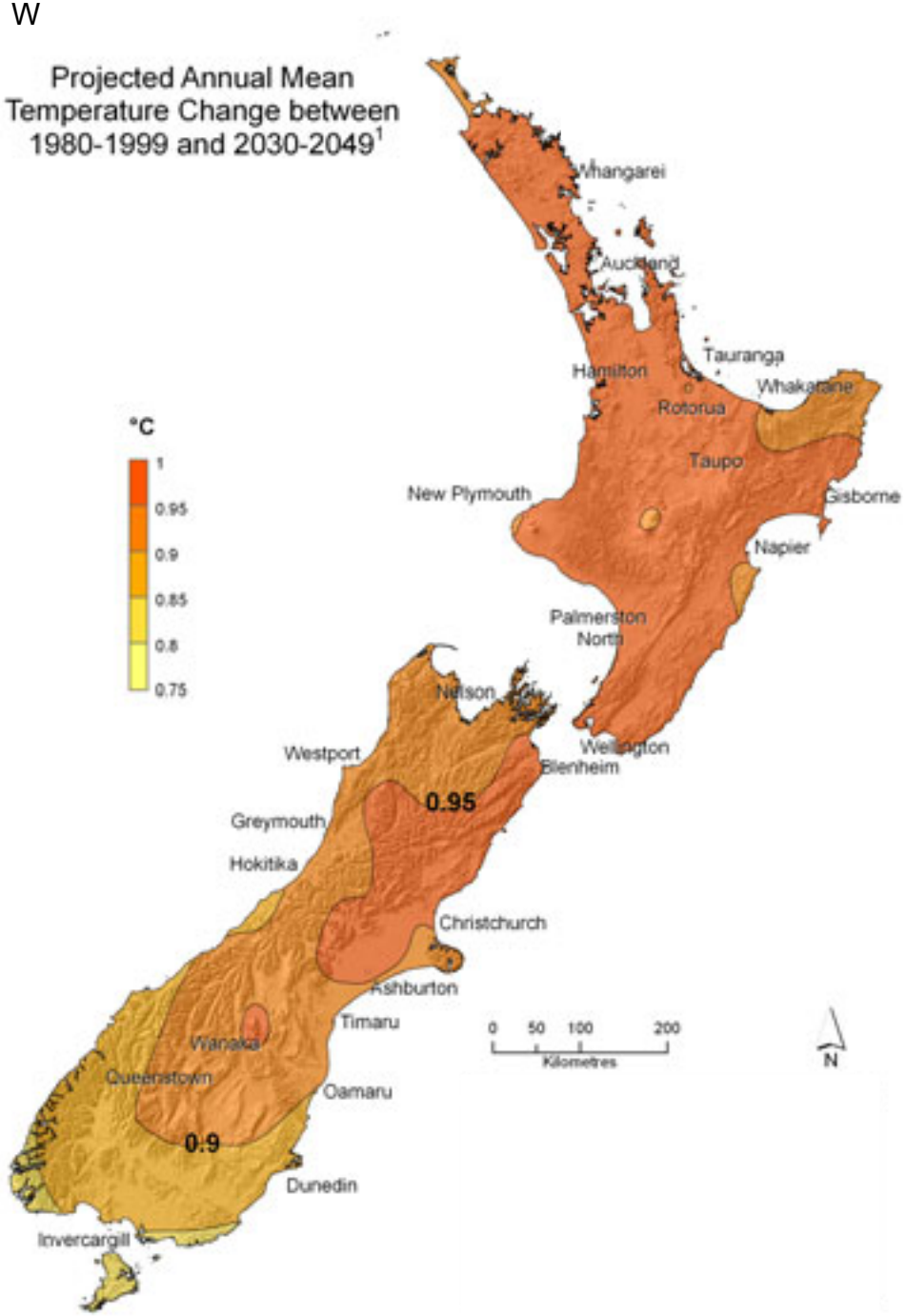
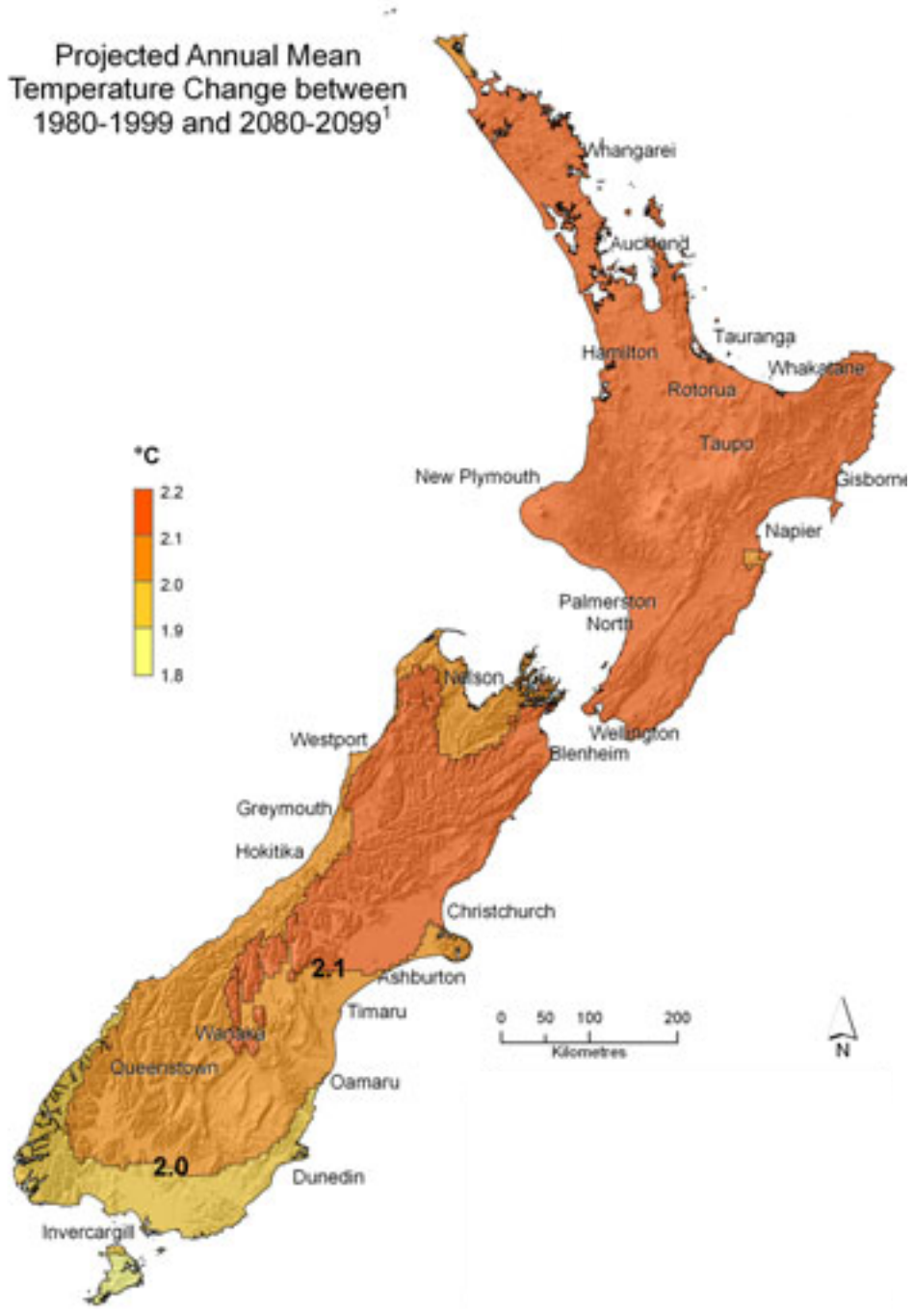

Projected Annual Mean
Temperature Change between
1980-1999 and 2030-2049[1]
°C
1
0.95
0.9
0.85
0.8
0.75
Whangarei
Auckland
Tauranga
Hamilton
Whakatane
Rotorua
Taupo
New Plymouth
Gisborne
Napier
Palmerston
North
Nelson
Wellington
Blenheim
Westport
Greymouth
Hokitika
0.95
Christchurch
Ashburton
Timaru
Wanaka
Queenstown
Oamaru
0.9
Dunedin
Invercargill
0 50 100 200
Kilometres
N


Projected Annual Mean
Temperature Change between
1980-1999 and 2080-2099[1]
°C
2.2
2.1
2.0
1.9
1.8
Whangarei
Auckland
Tauranga
Hamilton
Whakatane
Rotorua
Taupo
New Plymouth
Napier
Palmerston
North
Nelson
Wellington
Blenheim
Westport
Greymouth
Hokitika
Christchurch
2.1
Ashburton
Timaru
Wanaka
Queenstown
Oamaru
2.0
Dunedin
Invercargill
0 50 100 200
Kilometres
N

Current climate/weather impacts

- How does our current weather affect your sector now?
- Note down any climate elements of importance
- “mark” boxes to indicate importance to sector
  - e.g. Is roading affected by intense rainfall? Yes, can lead to slips/washout

Climate Change in the Coastal Environment

Extra high tide floods road, Funafuti, Tuvalu (Pacific Ocean) © 2005 Gary Braas
Rising sea level documented by World View of Global Warming

Sea Level Rise · Wind · Storm Surge · Waves

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Global Sea Level Rise

- Global average sea level rose by approx. 0.17m (±0.05m) over 20thC, faster than sea level rise in 19thC
- Recent sea level rise (1993–2003) has been an average of about 3.1 mm/yr
- 2007 IPCC model projections: globally-averaged sea level rises of 0.18 to 0.59m by 2100
- NB: Estimates could be higher if melting of Greenland & Antarctic ice sheets continue to increase (extra 25%?)

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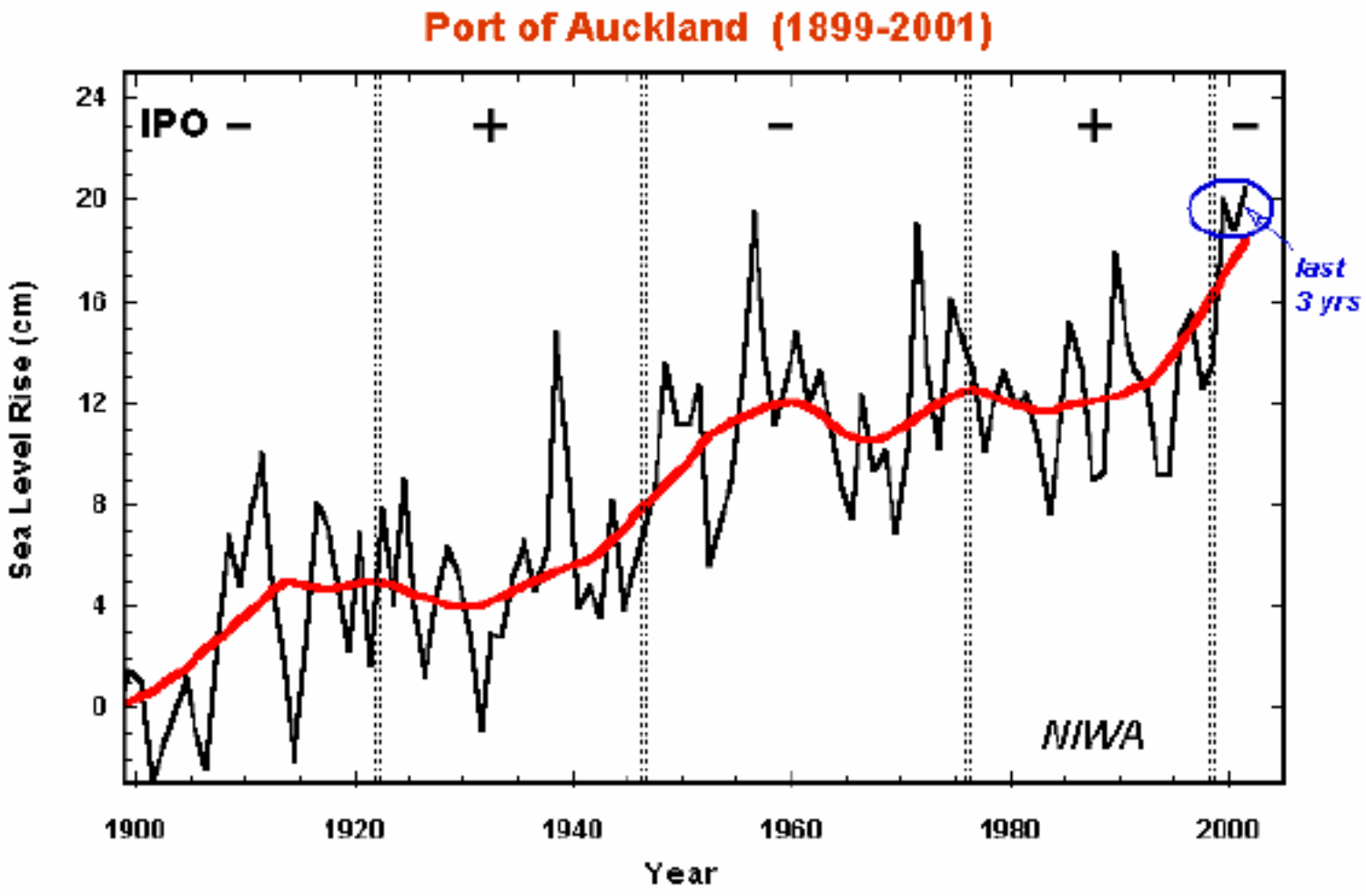
NZ Sea Level Rise



Annual fluctuations and the 20-year moving-average (thick red line) for mean-annual sea level from the Port of Auckland, compared with the positive and negative cycles of the IPO. [Note: the overall linear trend in historic sea-level rise is +0.16 m/century.]

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NZ Sea Level Rise

MfE recommends for planning for 2090s:

- A base sea-level rise of **0.5 m relative to the 1980–1999 average**
- Assess the vulnerability to a sea-level rise of **0.9 m relative to the 1980–1999 average**
- Beyond 2100 plan for **10 mm/year**
- Sea level also influenced by seasonal, El Niño-Southern Oscillation and IPO cycles

- NB: MfE sea level rise guidance is being updated

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Drivers in the Coastal Environment: Storms

- Latent heat effects
  - Warmer air can hold more moisture
  - This moisture releases heat when it forms cloud
  - That heat intensifies the storm
- Baroclinicity
  - Storms form as a result of the Eq-pole temperature difference
  - This temperature difference is greater with CC in our region
  - Storms become more frequent, more intense, or both.
- Storms are very likely to be more intense
  - Higher waves
  - Higher storm surge
- Implications beyond coasts

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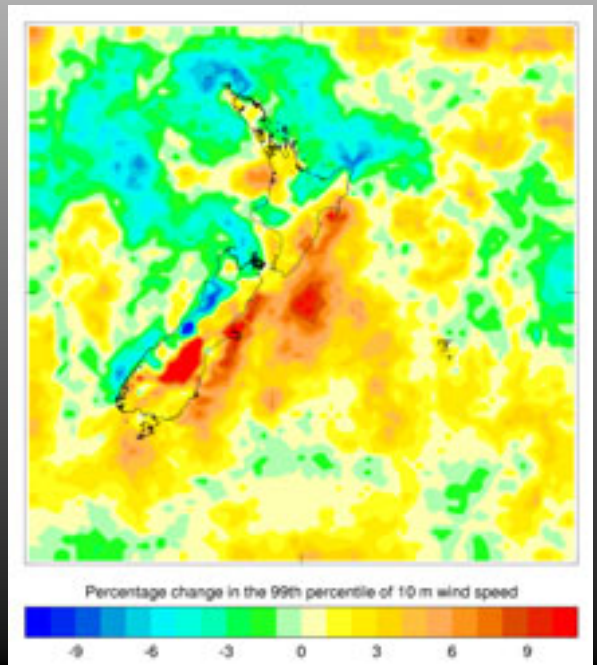
Wind, Storm Surge & Waves

- Wind
  - Increase in westerlies in Winter (+20%)
  - Decrease in westerlies in Summer (-5 to -20%)
  - Wind > 10m/s might increase by 10% by 2090
  - *Annual frequency ≥30 m/s might increase by about 40% by 2030 and 100% by 2080*.
  - Wind important in coastal environment but also in a wider context



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Wind, Storm Surge & Waves

- Storm Surge
  - magnitude may increase
  - both setup and inverse barometer
- Waves
  - increased frequency of heavy seas & swell along western & southern coasts
  - possibly higher extreme waves during more intense ex-tropical cyclones and mid-latitude storms

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Ex-Tropical Cyclones

- Not the same as tropical cyclones
  - Ex-TC broader, less intense
- Likely increase in number of intense XTCs
- CC means increases in wind, waves, storm surge & rain

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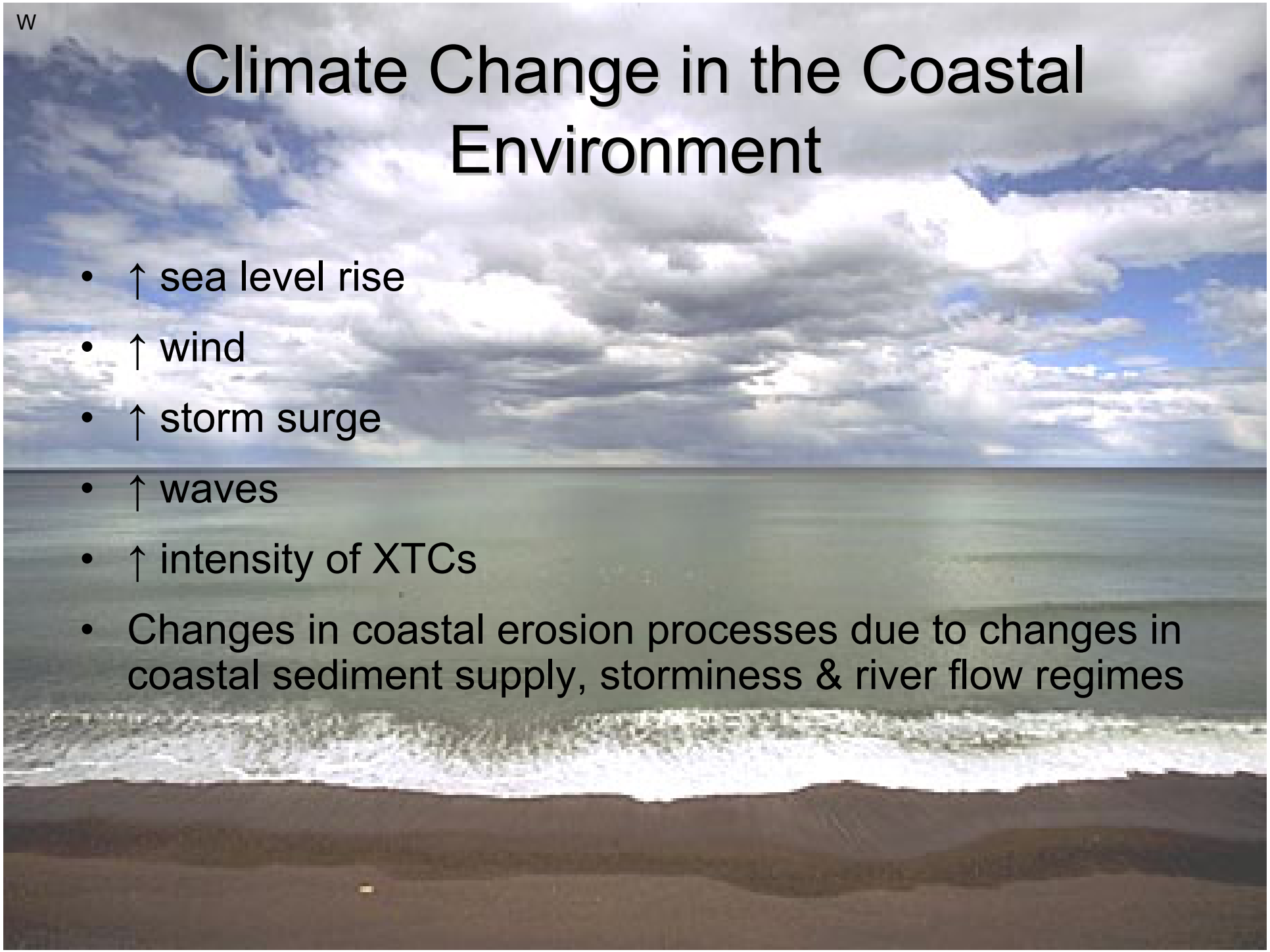
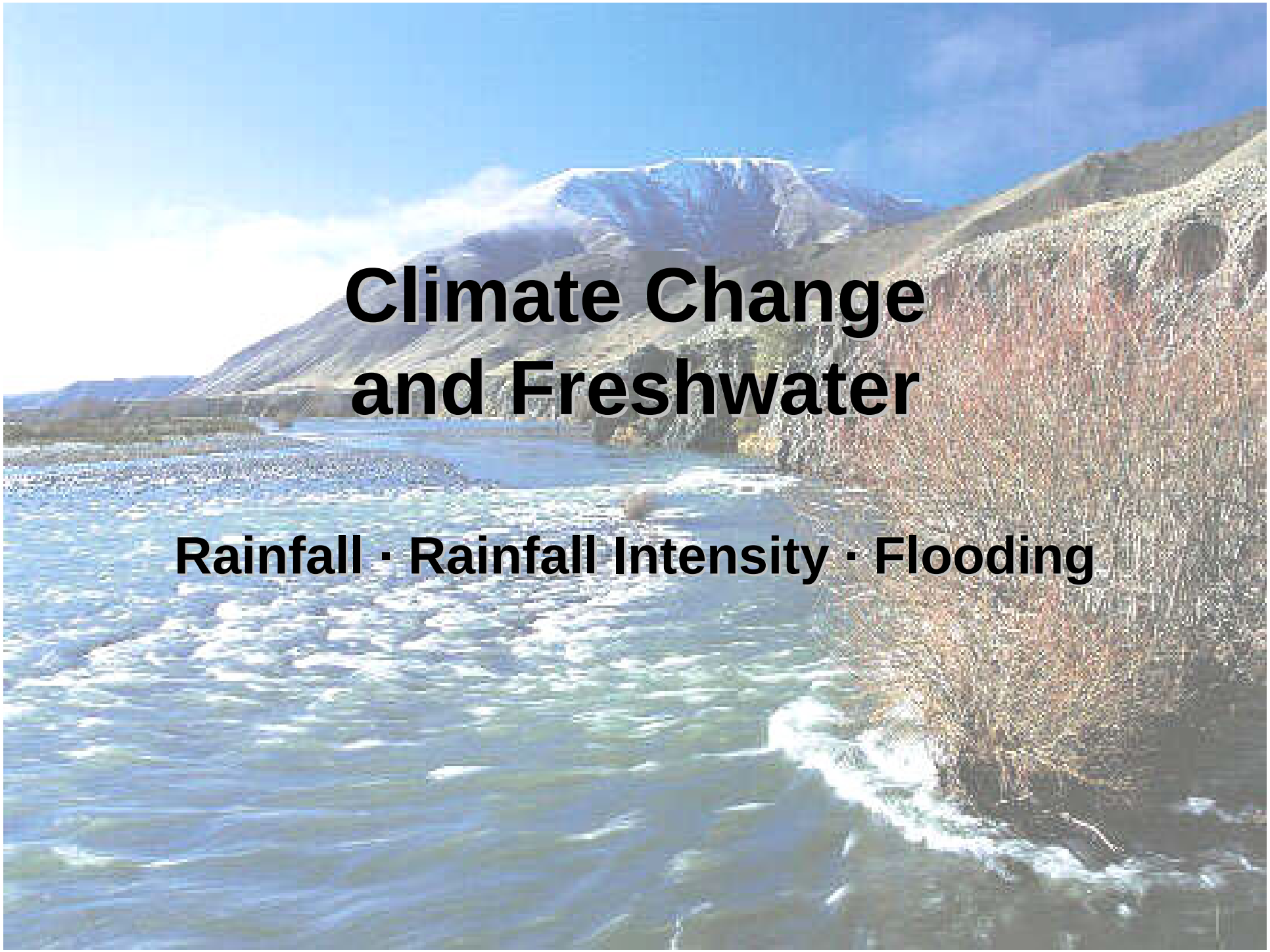
Climate Change in the Coastal Environment



- ↑ sea level rise
- ↑ wind
- ↑ storm surge
- ↑ waves
- ↑ intensity of XTCs
- Changes in coastal erosion processes due to changes in coastal sediment supply, storminess & river flow regimes


Climate Change
and Freshwater
Rainfall · Rainfall Intensity · Flooding

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Changes in Rainfall

- A warmer atmosphere holds more moisture
  - +8% for every 1°C increase in temperature

→ Hence, possible increase in rainfall intensity

- Potential for heavier extreme rainfall
  - Waikato & BOP 7% [2, 19] by 2040s, 17% [5, 45] by 2090s
  - Doesn't include effects of storm changes, latent heat etc
- NIWA unpub. data suggests 40% increase in annual rainfall event by 2080s

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Changes in Rainfall

- Annual rainfall:
  - Substantial variation around country.
  - Increase in south and west, decrease in N and E.
  - Waikato 2090: -1% [-11, 11]
  - BOP 2090: -2% [-12, 5]

- Extreme rainfall:
  - Heavier and/or more frequent extreme rainfalls, especially where mean rainfall increase predicted

- Flow on effects for rainfall-triggered landslides, flooding, snowfall, droughts, water security/supply, CDEM planning

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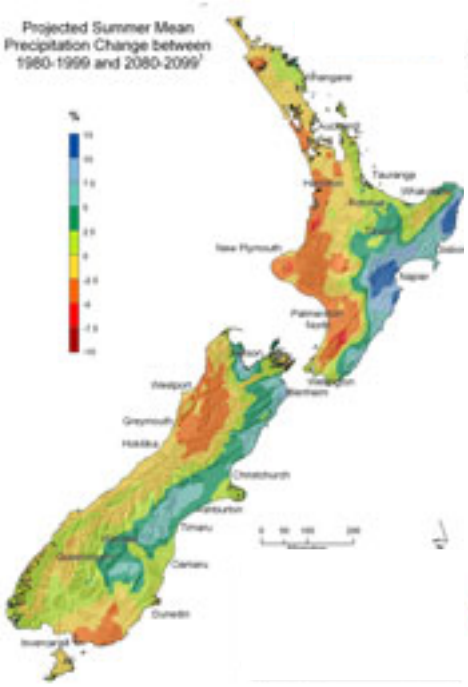
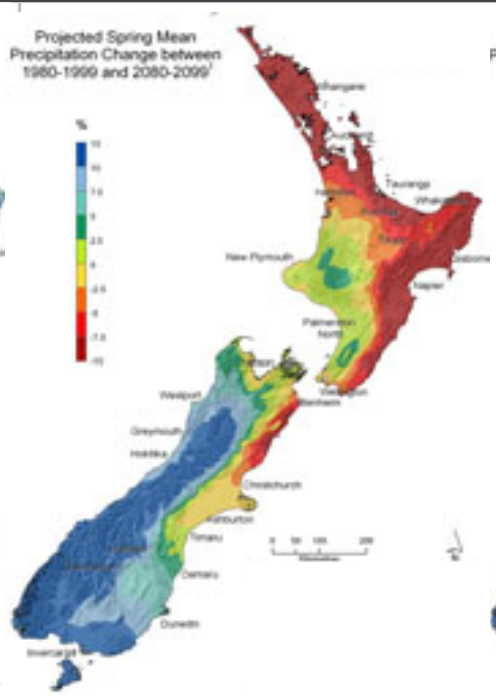
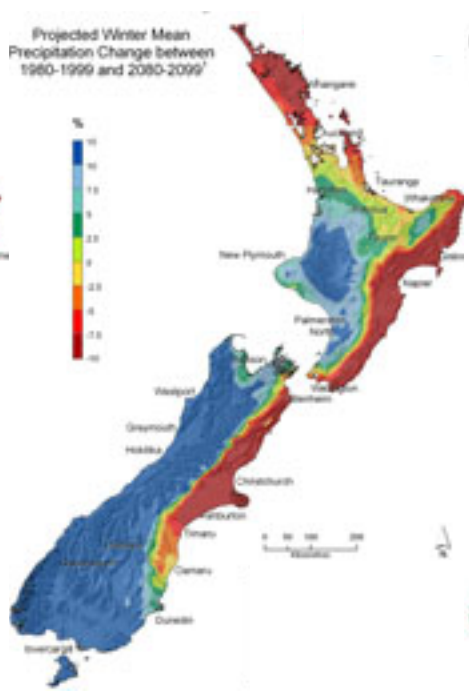
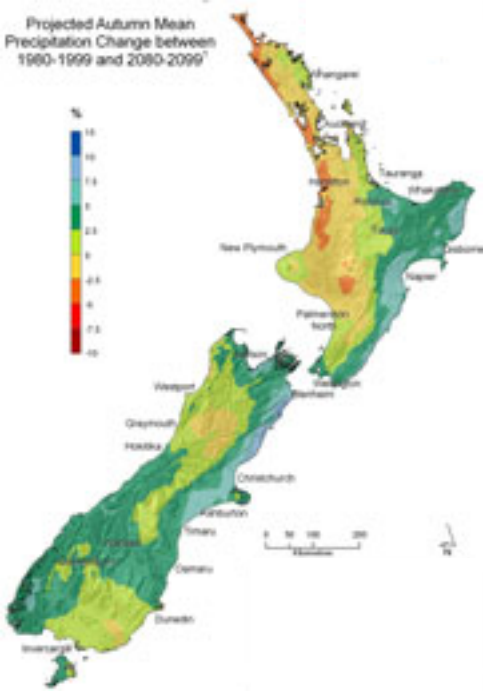
Seasonal Rainfall









Region	Summer	Autumn	Winter	Spring
Waikato	-1 [-34, 18]	-1 [-24, 10]	3 [-7, 15]	-4 [-23, 16]
BOP	2 [-20, 23]	2 [-15, 16]	-3 [-16, 8]	-9 [-32, 12

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Flooding

- Rain events likely to become more intense:
  - → greater storm-runoff
  - → increased flood frequency, flood peak & max. discharge
- But with lower river levels between events
- Heavy rainfall events expected to occur ***up to*** 4x as often
- Drier areas still at risk of flooding, due to:
  - Source area of rainfall e.g. for rivers with catchments in Southern Alps but draining on Canterbury plains
  - Infrequent but intense rainfall events in eastern coastal areas e.g. coastal Otago, Wairarapa

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Climate Change and Freshwater

- ↑ in rainfall intensity

  +8% by 2040, and +16% by 2090

- ↑ in annual rainfall event (+40%)
- ↑ frequency of heavy rainfall events (*up to* 4x)
- ↑ in flood frequency, flood peak & max. discharge


Questions??

Future climate change impacts for Engineering Lifelines

Group Discussion

Discussion

- Aim:
  - To stimulate thinking and action about climate change and lifelines
  - To inform with latest results
- To get some feedback on "The Issues"
  - Areas of concern
  - Gaps
  - Ideas for action

The climate change matrix

Lifelines Sector		Climate Variable and Change Indicators					
		Sea Level Rise	Wind	Storm Surge + Waves	Erosion + Slipping	Rainfall Intensity	Floods
		↑ 0.18 - 0.59m by 2100	60% ↑ westerly component	↑storm surge ↑waves ↑coastal erosion	↑ potential Linked to rainfall intensity	8-24% ↑ intensity 40% ↑ annual event 1-4x ↑ heavy events	↑ frequency ↑ flood peak ↑ max. discharge
Transport	Road						
	Rail						
	Aviation						
	Marine						
Power	Gas						
	Fuel						
	Electricity						
Telecoms	Phone						
	Radio						
Civil	Urban						
	Storm water						
	Sewage						
	Water Supply						

Risk Assessment

- Use the 2nd matrix with future climate change focus
- How will changes to our climate affect your sector in the future?
- Discuss & identify the **top 3** climate change impacts we have discussed that you think will be the most significant, interesting, overlooked or important for your sector and why.
- Prepare to report back to the group

Results

- Rain intensity often top issue
- Rain totals next
- Wind, sea level and storm surge

- Lightning, hail
- Snow

Mind catching!

- Liquefaction
- Fog
- Copper cable underground at coast
- Quote: Possibly the key is to design in flexibility to “allow” for future change rather than make things bigger/stronger.
- “Current capacity inadequate!”

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Thunderstorms

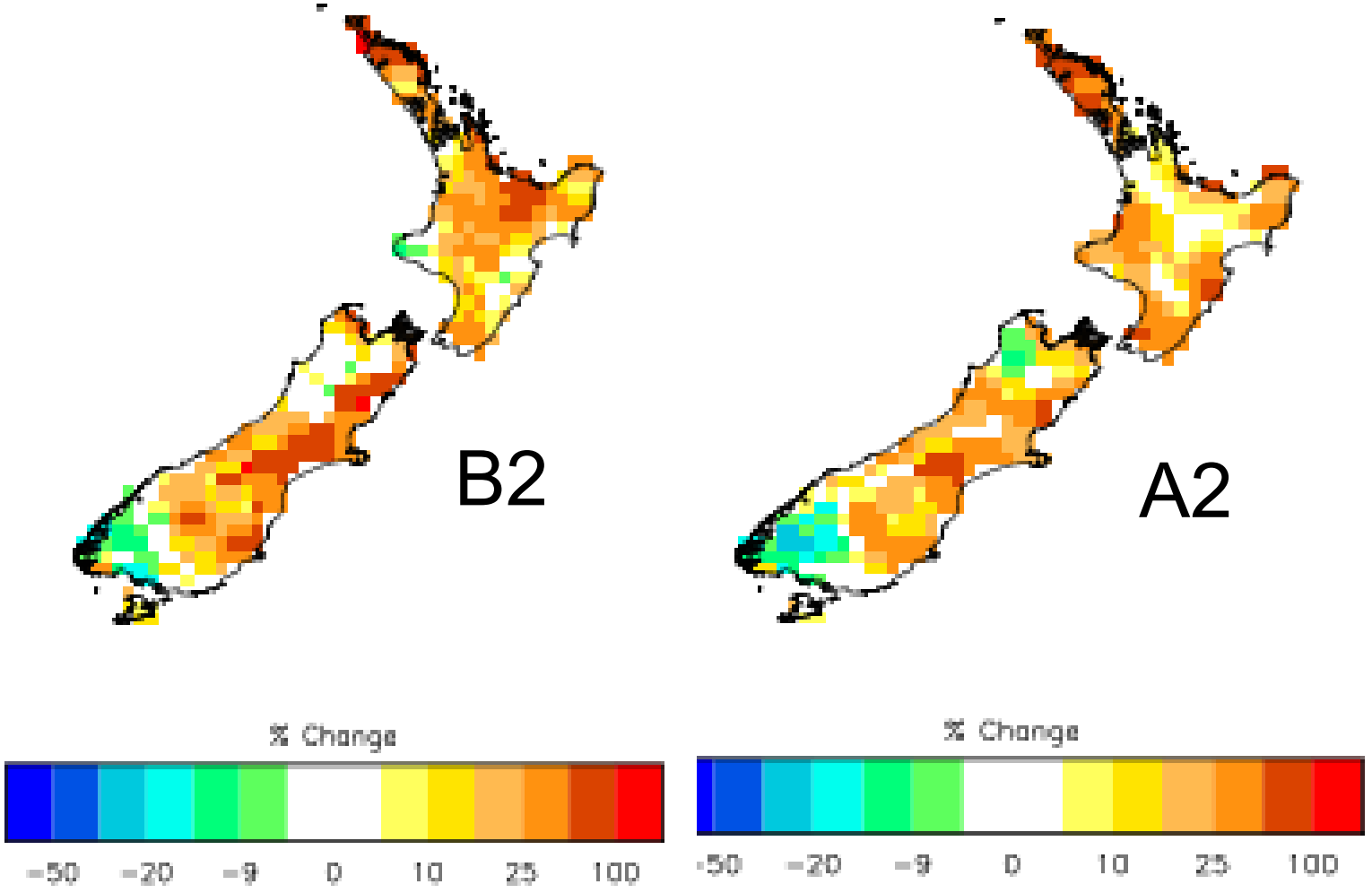
- No definitive answers
- Possible changes:
  - No change in instability = same frequency **
  - Increased moisture
    - More intense rain ****
    - More intense downburst **
    - More intense tornadoes, same number *
  - Higher freezing = Smaller hailstones *
  - Lightning = no change **

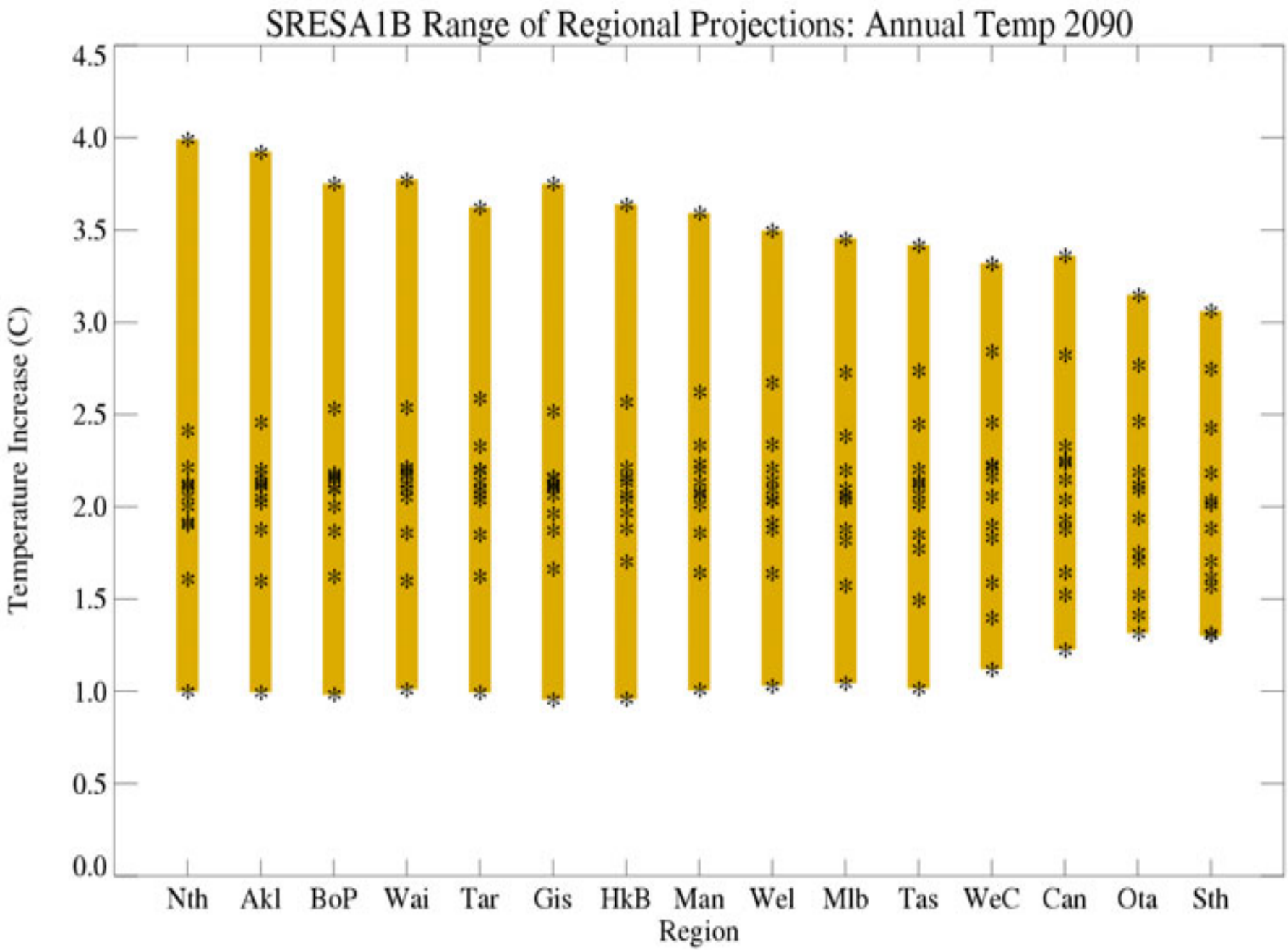
**** likely
** possible
* conceivable

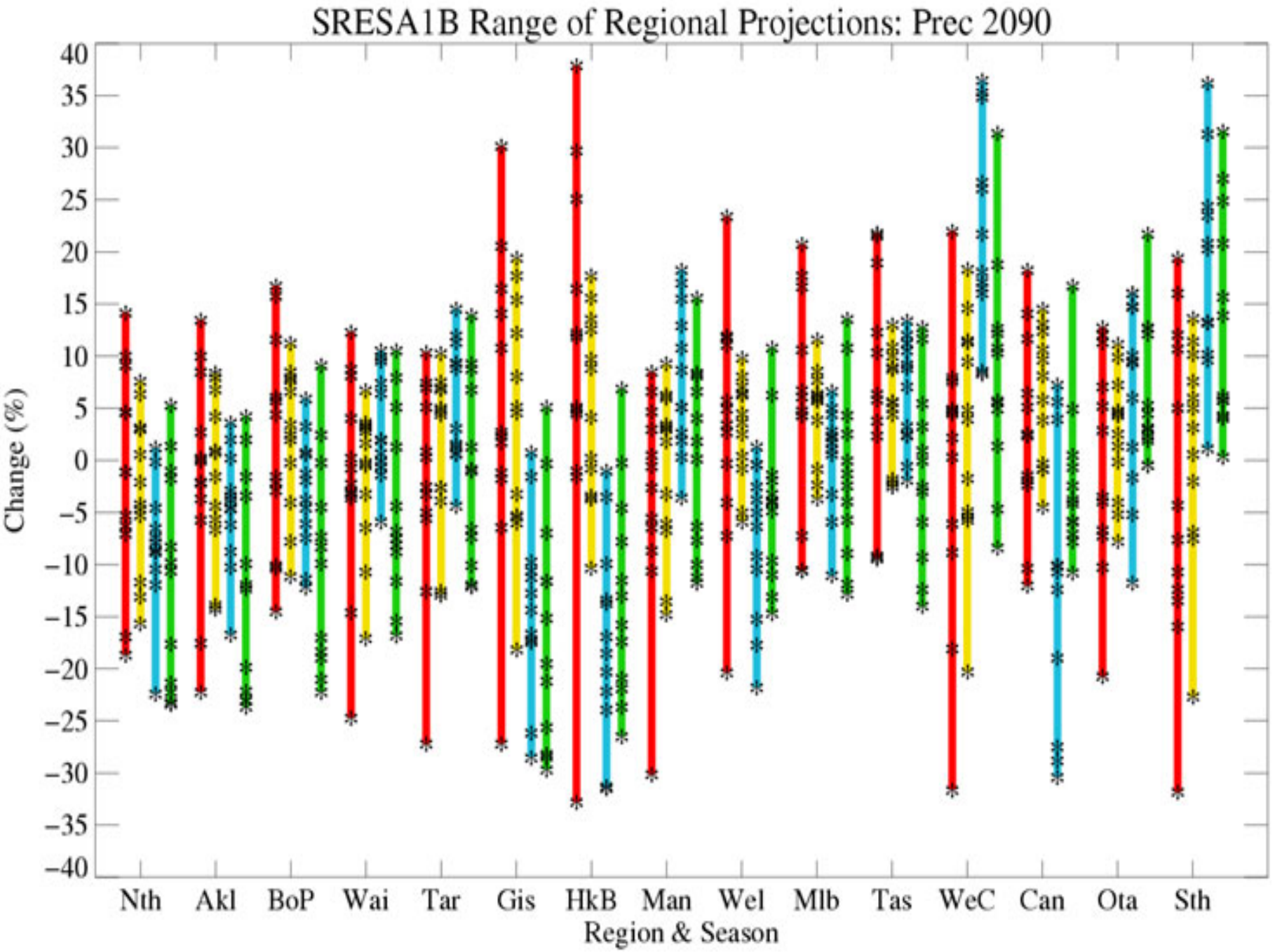
Flooding

- Increased demands for better of flood plain management
- Possible reduction in resilience of communities where flood events are larger but occur further apart
- An example, enhanced rainfall:
  - Case study – from experimental campaign
  - used regional atmospheric model,
  - Modelled +2ºC, kept relative humidity constant
  - Rainfall doubled over the Tararua ranges
- River Flooding & Climate Change Guidance

Extreme Rainfall – Change in 20 year return periods




SRESA1B Range of Regional Projections: Annual Temp 2090
Temperature Increase (C)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Nth
Akl
BoP
Wai
Tar
Gis
HkB
Man
Wel
Mlb
Tas
WeC
Can
Ota
Sth
Region


SRESA1B Range of Regional Projections: Prec 2090
Change (%)
40
35
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
−35
−40
Nth
Akl
BoP
Wai
Tar
Gis
HkB
Man
Wel
Mlb
Tas
WeC
Can
Ota
Sth
Region & Season

Seasonal Rainfall Changes