Assisting Adaptation to Climate Change

Preparing Regional Scenario Data and Using it to Model Impacts in New Zealand

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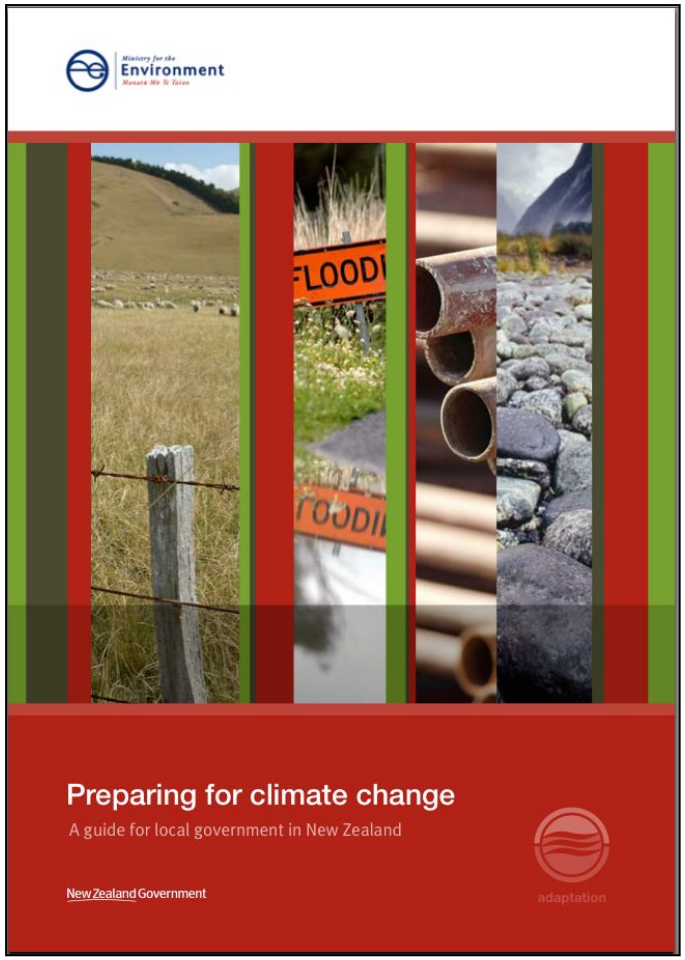
Southeast Asia Regional Climate Downscaling (SEACLID)/CORDEX Southeast Asia Project.
Second Workshop, Ramkhamhaeng University, Bangkok, 9-10 June 2014

Talk Outline



- How climate modellers view adaptation
- How practitioners view adaptation
- Some New Zealand guidance material which uses regional scenarios
- Impacts models and their requirements
- Example: The NZ Land-Based Sector Study
  - Dairy, sheep & beef, crops, horticulture, trees
- Coastal, Water resource impacts
- Is anthropogenic climate change contributing to extreme events?
- Ongoing & Future New Zealand work

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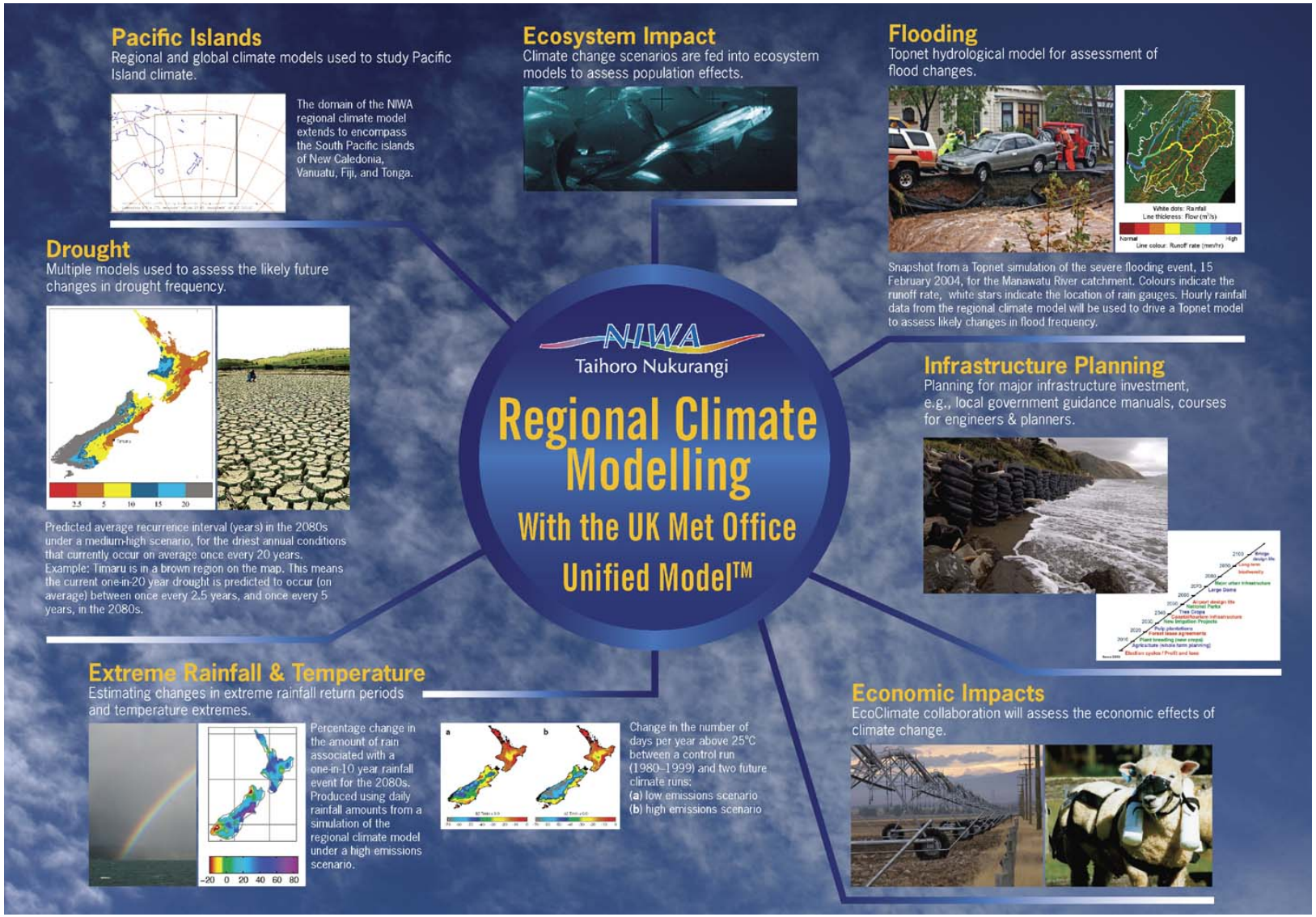
How we (modellers) see adaptation?



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How do Practitioners see Adaptation?

GNS Photo: GH2667 (Hancox & Wright 2005)

Often we need to work with others, e.g. biological scientists, engineers, planners, lawyers, social scientists, economists, educators, communicators

Many factors, including

- How the climate will change
- Vulnerability
- Certainty / uncertainty of projections (real, perceived)
- Risk
- Future changes in population, settlement patterns, infrastructure, …
- Legal responsibilities, legislative requirements
- Robustness of decisions against challenges in court
- Costs and benefits; other demands for resources
- Public attitudes, willingness
- The council election in 3 years' time

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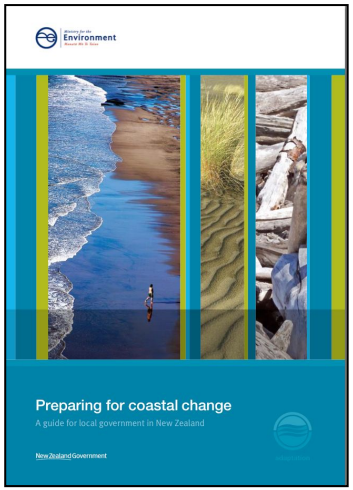
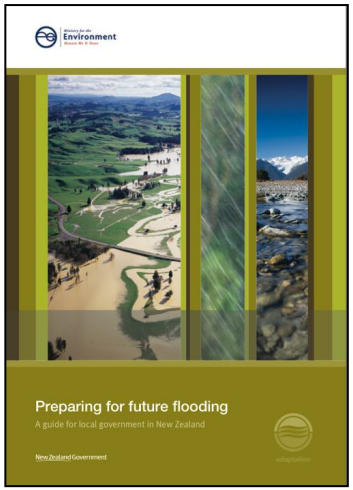
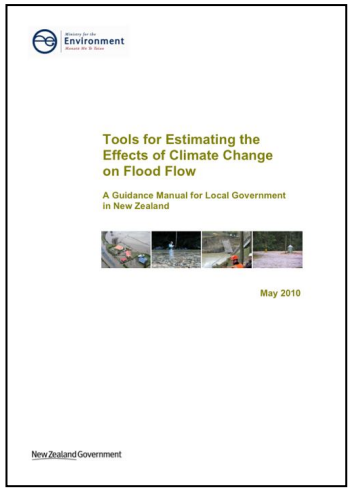
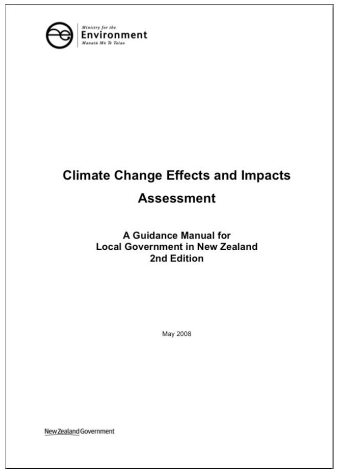
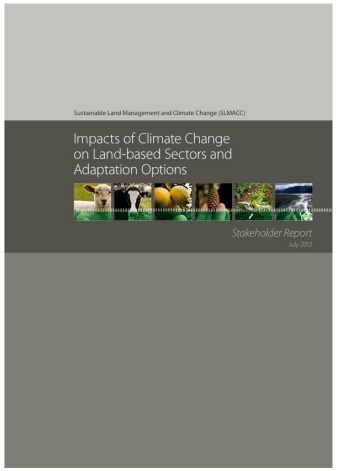
Some New Zealand Guidance Material which draws on Regional Scenarios

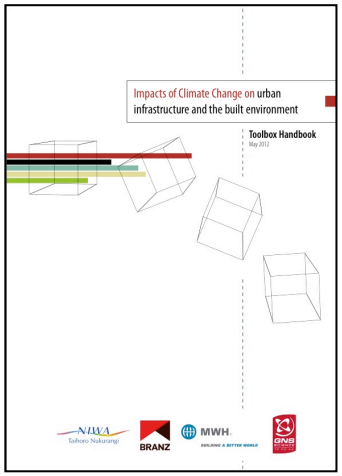


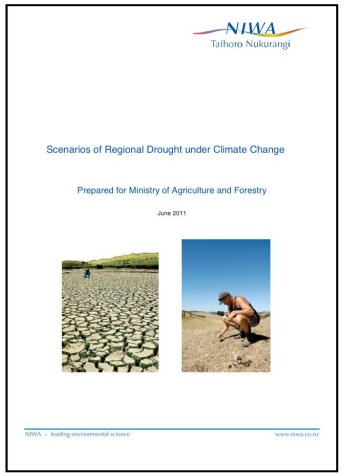












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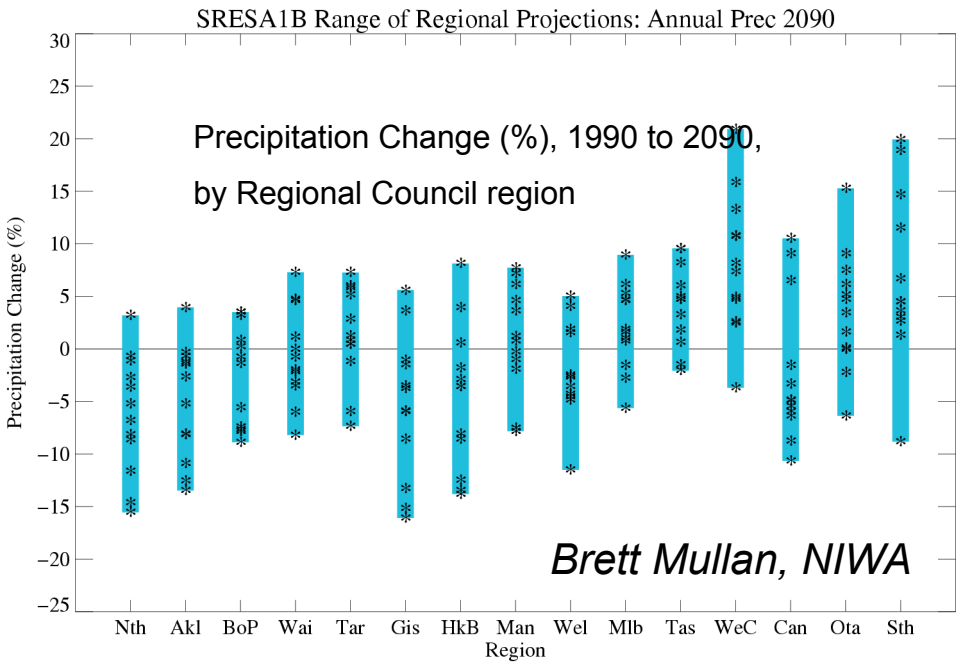
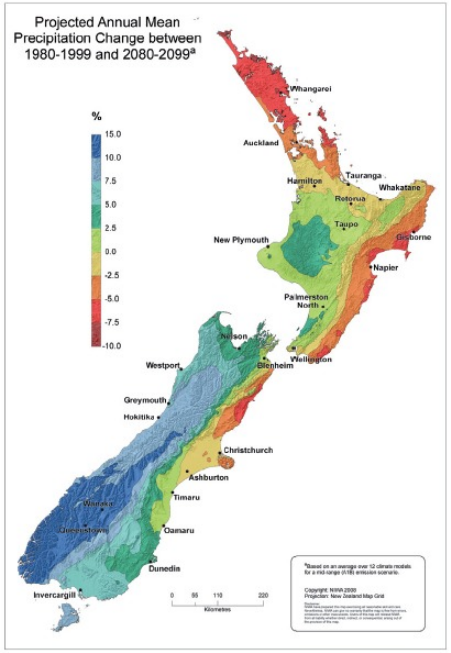
Requirements of Climate Change Impacts Models





High-resolution projections are needed, even when regional uncertainties are large:

- Impacts models need realistic spatial and temporal variability
- Particular global models generally produce particular spatial patterns over NZ, e.g. W-E gradient in change; coherent seasonal behaviour
- Consistent with a “what if ?” scenario-based approach to identifying risk

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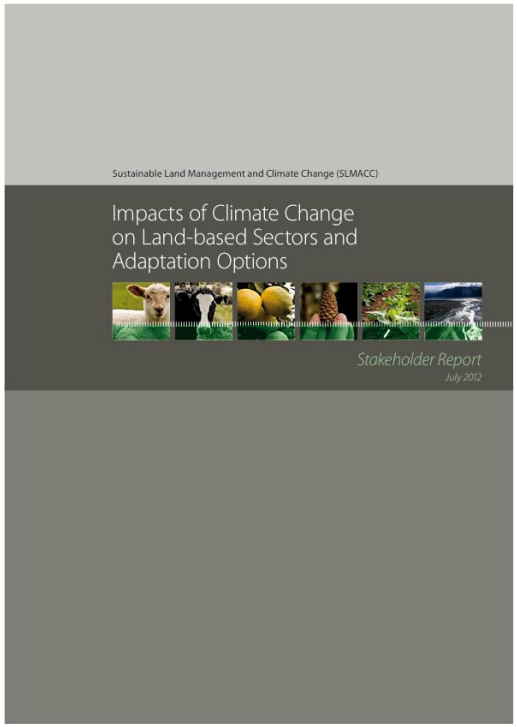
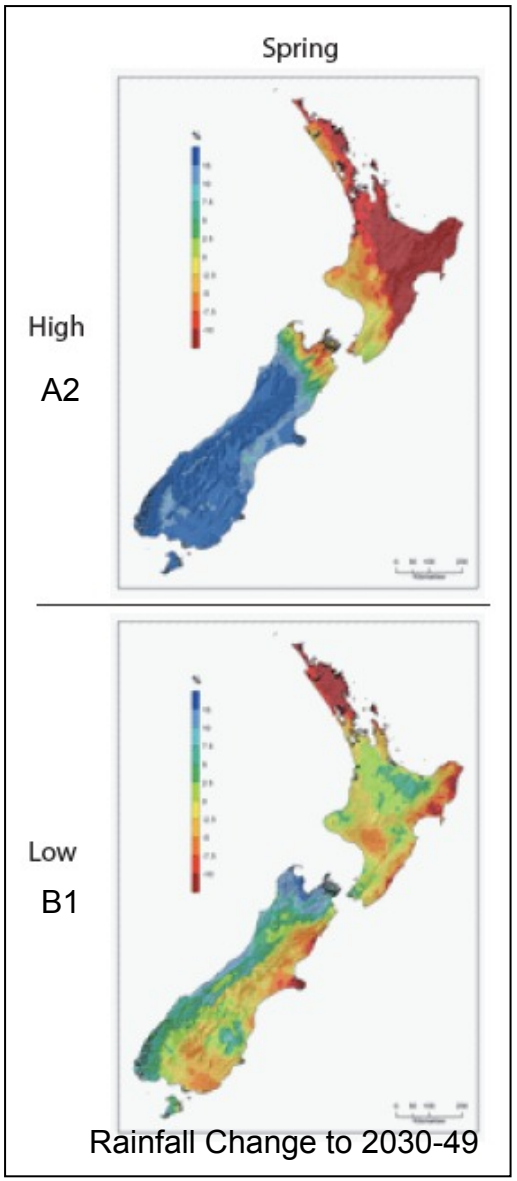
Impacts of Climate Change on Land-Based Sectors and Adaptation Options (ICCLSAO)



- Project completed in 2012 - collaboration between NIWA climate modellers and “production system” modellers from other organizations.
- Included production system modelling for dairy, sheep & beef, crop, horticulture, forestry.
- Stakeholder report, plus detailed report chapters on each “sector” downloadable at http://www.mpi.govt.nz/news-resources/publications
  (Enter the title of this slide in the publications search facility on that page)

Acknowledgements: MPI for Funding; Anthony Clark, Richard Nottage, & 32 co-authors

Regional Scenarios for the New Zealand Land-based Sectors Report



Rainfall Change to 2030-49

- Production system modellers could manage only a limited number of scenarios and sites
- NIWA modellers produced “Primary Sector Adaptation Scenarios” (PSASs).
- High Scenario (SRES A2):
  +1.2°C ΔT (2030-49 cf 1980-99)
- Low Scenario (SRES B1):
  +0.89°C ΔT (2030-49 cf 1980-99)
- HadAM3P global model, PRECIS Regional Climate Model, bias corrected
- Produced daily weather data files, 1970-2100, horizontal grid spacing ~ 30km.

Climate Change Impacts and Implications Project (CCII) presently underway is developing broader range of scenarios (RCP-based) linked to several GCMs

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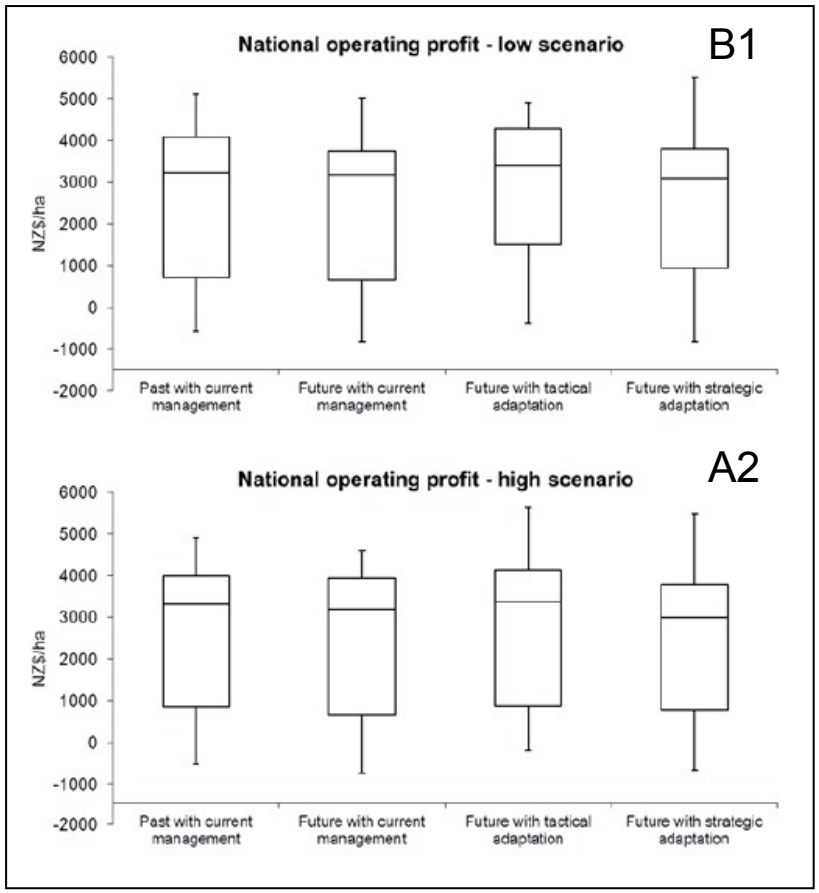
Impacts Modelling - Dairy Production

National operating profit, NZ$/hectare

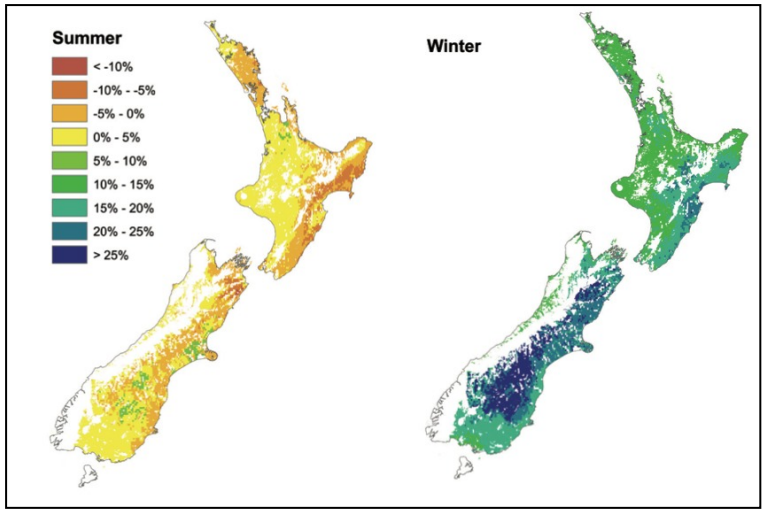


From Lee et al, Chapter 3, ICCLSAO

- DairyNZ Whole Farm Model
- Pasture Module: Driven by daily weather: rainfall, temperature, solar radiation, soil moisture balance
- "Cow" module: Molly - predicts enteric methane, milk, milk solids, animal weight changes
- Management/economic model: Grass-based farm system plus purchased feed
- Projections: Run for 5 sites across NZ. Past (1980-99) and future (2030-49) milk solids production, operating profit

Impacts Modelling - Dairy Production (continued)

Summer Winter



Baisden & Keller, 2012

Percentage change in pasture production, 2050 cf 1980-99, mid-range scenario

- A simpler approach used earlier to develop a national picture
- Monthly empirical downscaling to give monthly soil moisture, temperature
- Estimates of pasture dry-matter production based on empirical relationships between these and dry-matter production, plus estimate of effect of CO_2 change

Impacts Modelling - Sheep & Beef

Parameter	Time period	
	1990	2040
Mean pasture production[1]	8549	9879
Stocking (SU ha^{-1})	12.5	14.7
Sheep, opening numbers (head)	0.1	0.4
Ewes	4061	4236
Ewe hoggets	1181	1233
Rams	48	50
Total sheep	*5290*	*5519*
Performance indicators, ewes		
Lamb/wean date	05 Sep, 28 Nov	15 Sep, 08 Dec
Preg/lamb/wean (%)	167/134/130	202/186/182
Ewe efficiency[3] (%)	62.5	83.2

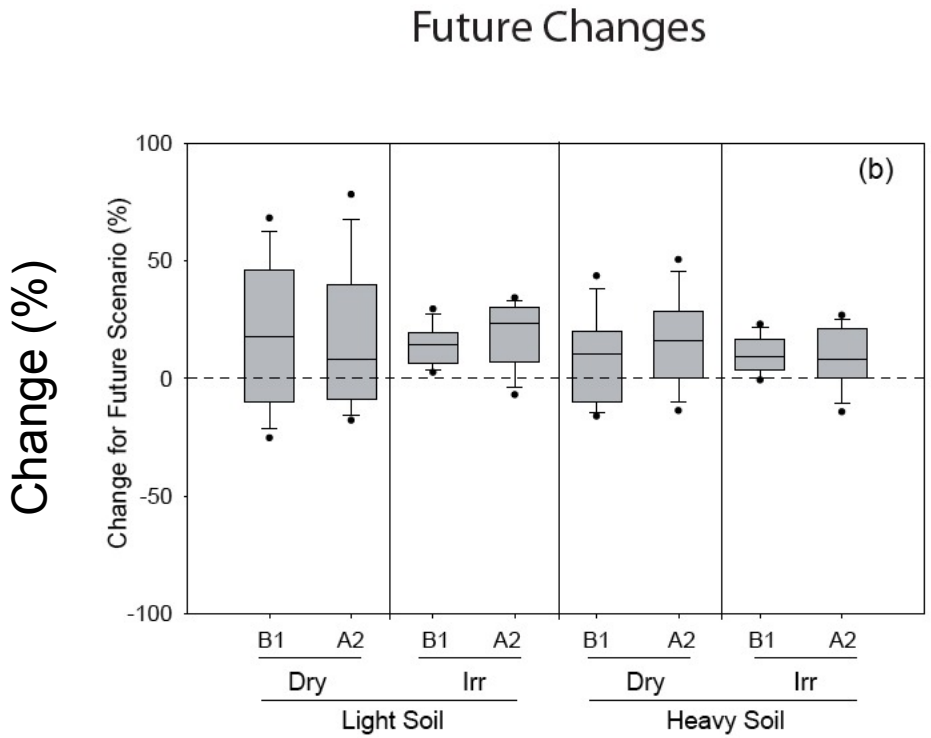
[1]Annual, kg dry matter/hectare

Southland farm, High scenario. Extracted from Table 4.5 which also contains beef cattle, deer

(From Leffering et al, Chapter 4, ICCLSAO).

- Fairmax Pro whole farm system model
- Pasture module: APSIM (driven by daily weather data, also CO_2)
- Run for hill-country farms in three regions: Southland, Hawke's Bay, Waikato

Impacts Modelling - Broad Acre Cropping



- APSIM Plant Module
- Daily time steps. Driven by weather, soil properties, crop management

Maize in Canterbury, 2030-49.

From Teixeira et al, Chapter 5, ICCLSAO

Impacts Modelling - Horticulture

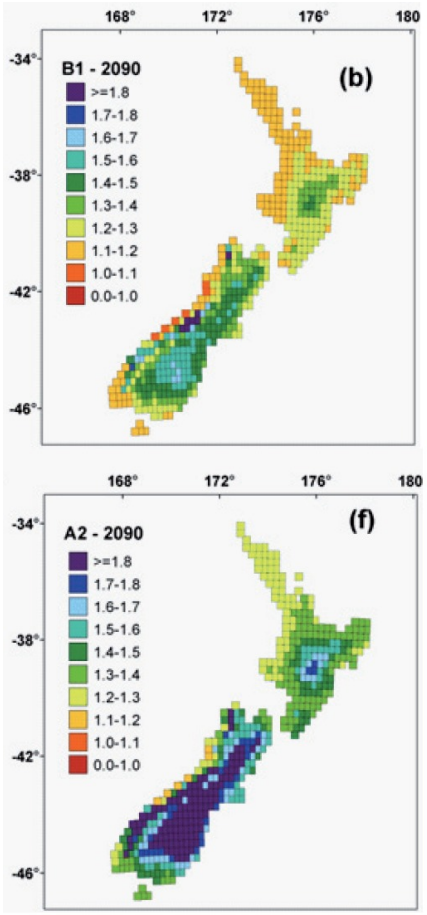
- Models include weather, CO_2
- Work on grapes, apples, kiwifuit - for particular locations
- Predicted changes in dry matter harvested (next slide), also in irrigation water requirements, water requirements for frost protection
- Clothier, Hall & Green, Chapter 6 ICCLSAO

Impacts Modelling - Horticulture

Crop	Variable	Current Conditions	B1 Scenario	A2 Scenario
Royal Gala Apples, Hawke's Bay	Dry matter apple at harvest (kg/ ha)	12807 ± 1191	13437 ± 3314	14493 ± 1281
Kiwi Fruit B.O.P with dormancy breakers	Dry matter, harvest (kg/ha)	5681 ± 453	5656 ± 405	5455 ± 466
Kiwifruit B.O.P without d.b.	Dry matter, harvest (kg/ha)	4916 ± 453	4655 ± 498	4367 ± 529
Sauvignon blanc grapes, Marlborough	Dry matter, berries at harvest (kg/ha)	1009 ± 78	980 ± 169	944 ± 165

Numbers from Clothier et al, Chapter 6, ICCLSAO

Impacts Modelling - Forestry

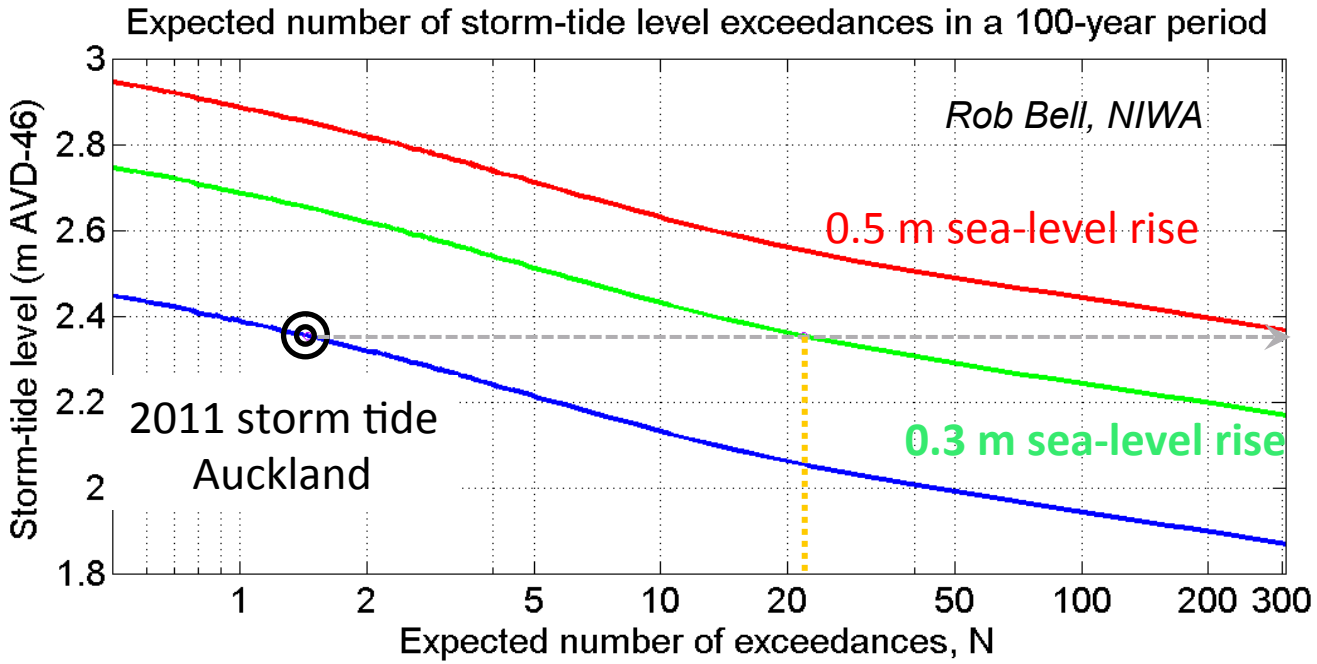


- CenW model, driven by climate, CO_2
- These projections do not include risk from fire, insects, disease and weeds - all of which increase under climate change
- These other factors also discussed in report.

Climate change impacts on future wood productivity to 2040, expressed as ratio of future wood volume productivity over current-day productivity.

From Dunningham et al, Chapter 7, ICCLSAO

Impacts Modelling - Coastal



- Sea level rise perhaps issue creating most questions in NZ
- Most effort so far looking at effect of mean sea-level rise projections on frequency of high-water levels, taking account of tides etc
- Also Ackerly et al 2013 on regional departures from Global average SLR, from AOGCMs

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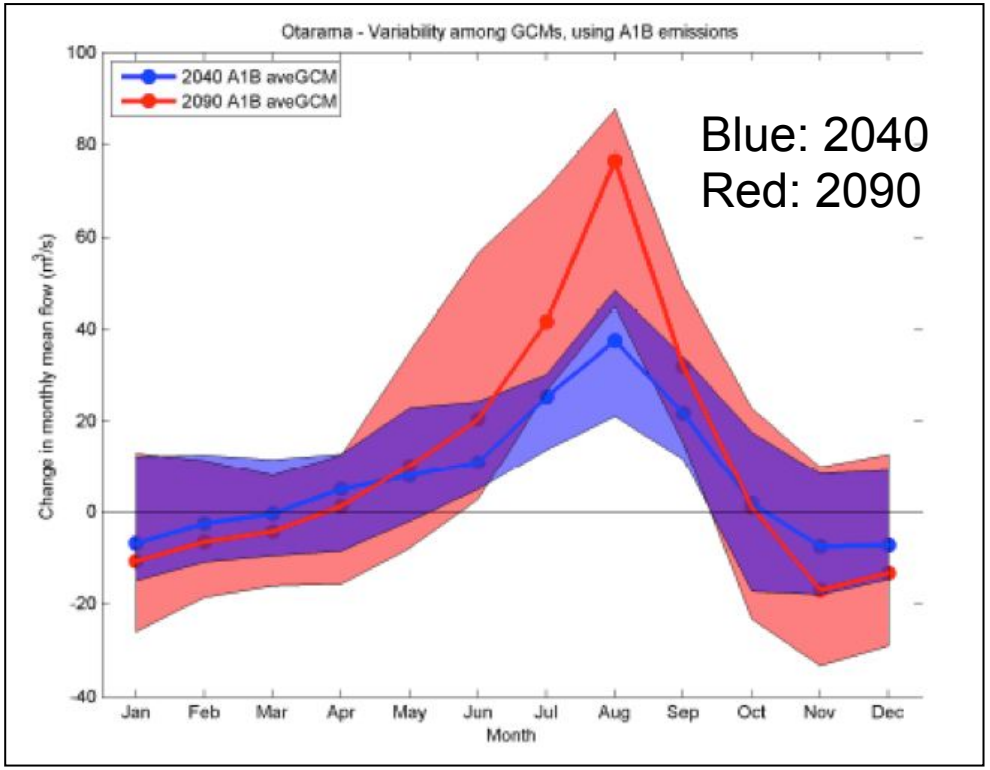
Impacts Modelling - Rivers

Change in monthly mean flow, m^3/s



- Downscaled data (RCM & statistical) fed into:
  - river models (TopNet)
  - snow models
  - glacier models
- Scenario / impacts analyses for NZ catchments

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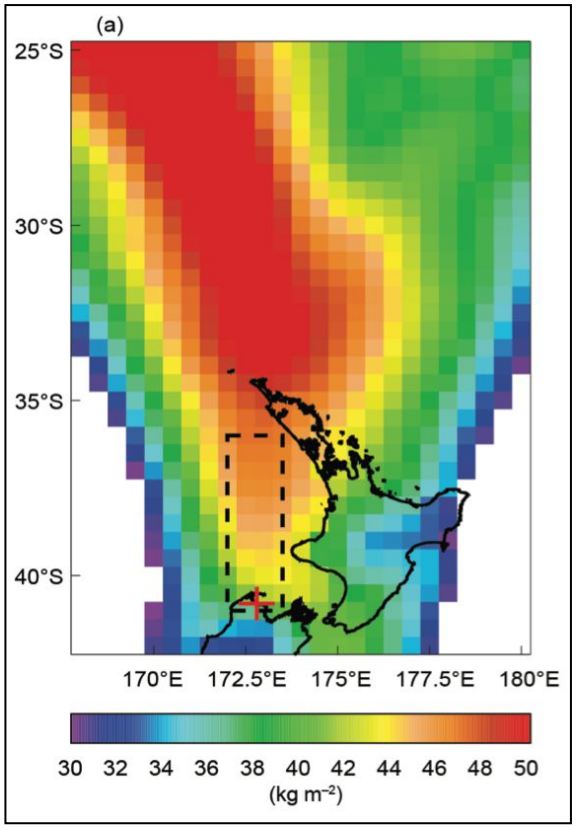
Is anthropogenic climate change contributing to extreme events?

Gerry Draper



Dean et al, BAMS, Sept 2013

- Initial work on extreme events
  - Golden Bay Floods
  - 2012/13 summer drought
- Australia-NZ Weather@home

Acknowledgements: Sam Dean, NIWA

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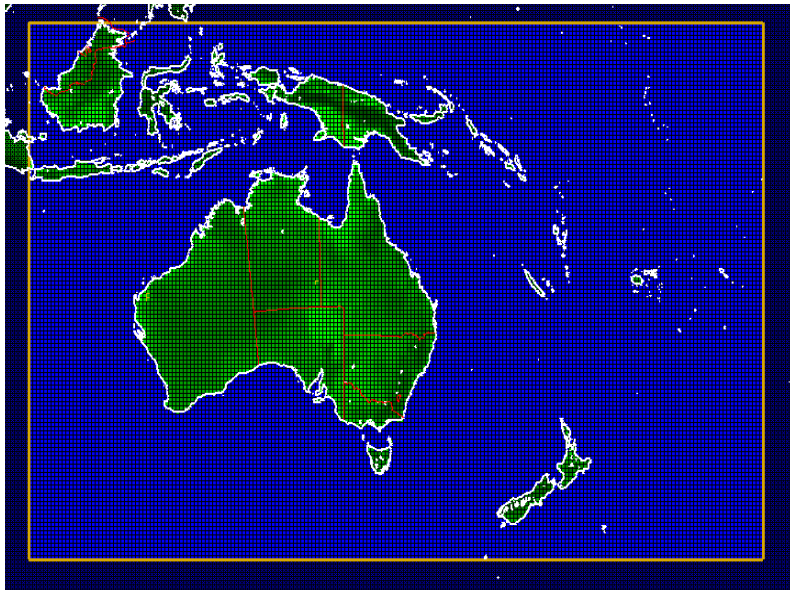
Attribution - ANZ Weather@Home



Extremes being explored:

- Temperature
- Heavy rainfall
- Drought

- Citizen Science
- U.K. Met Office Hadley Centre HadRM3 regional model nested inside HadAM3P global model.
- Uses CORDEX Australasia domain 0.44deg (~35x49 km for NZ), 216x145)
- Produce ensembles for 1960-2010 with and without anthropogenic forcing
- Look for changes in frequency of extremes

Acknowledgements: Sue Rosier, NIWA

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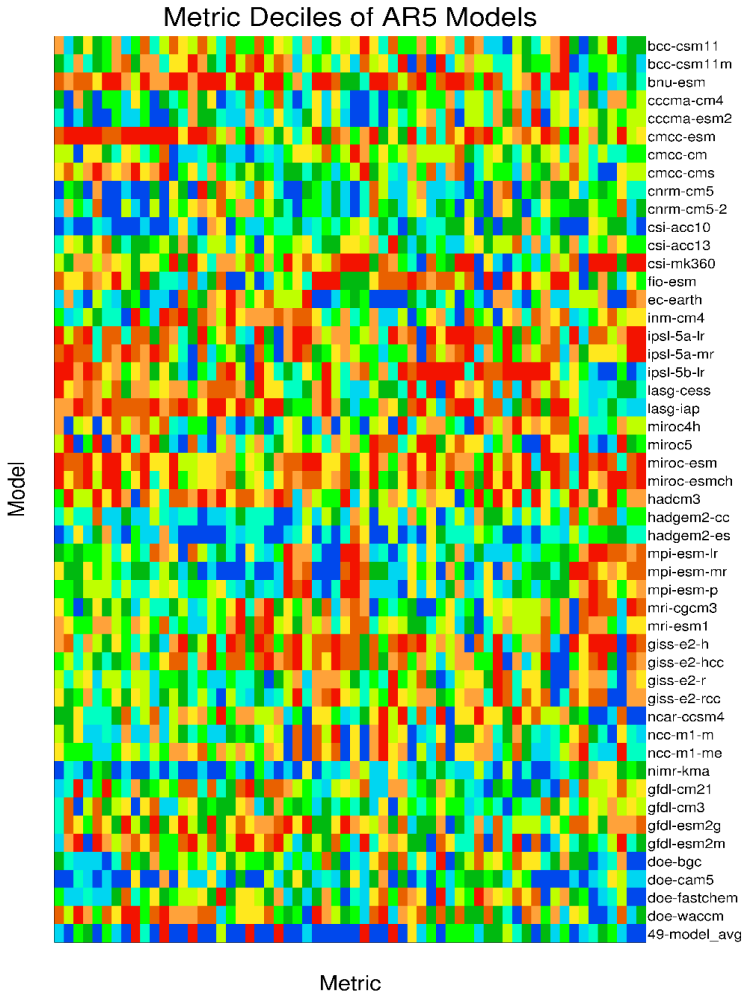
Ongoing & Future NZ Regional Scenario & Impacts Research



Climate Modelling

- Complete matrix of CMIP5-driven RCM projections (“IPCC AR5”) → data sets
- Assess biases in HadGEM3-RA over NZ
- Determine RCM bias corrections & update data set
- Explore new statistical downscaling approach
- Further analysis of reasons for uncertainty in NZ climate projections
- Attribution studies, using the ANZ Weather@home ensembles

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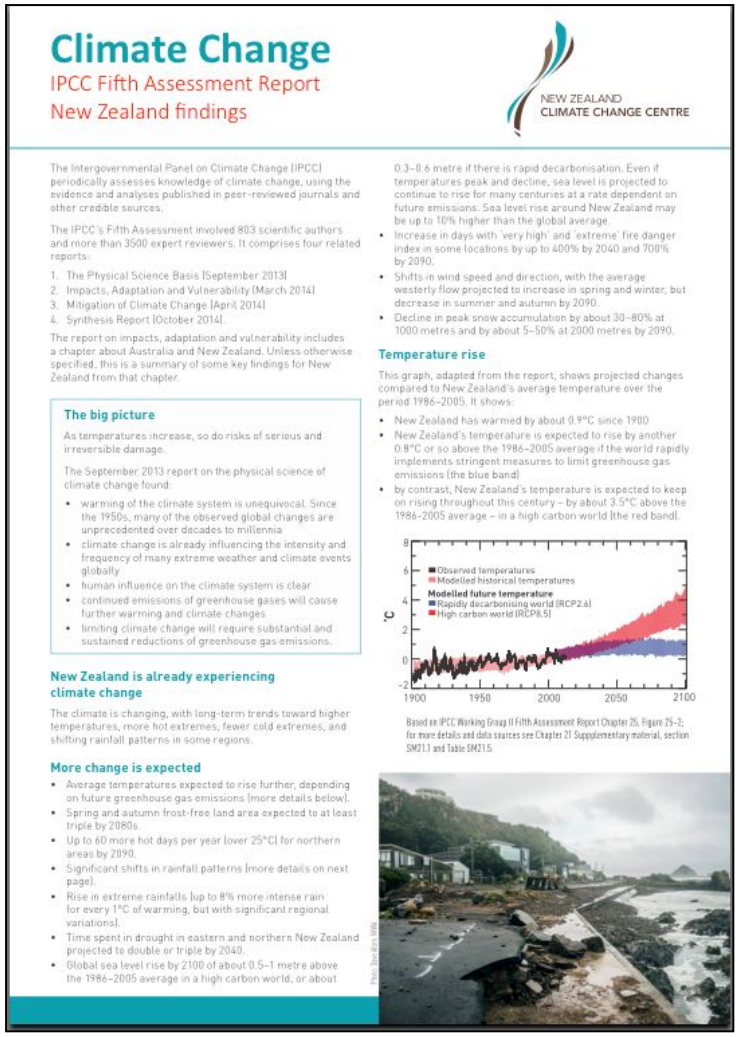
Ongoing & Future NZ Regional Scenario & Impacts Research



Climate Change

IPCC Fifth Assessment Report
New Zealand findings

NEW ZEALAND CLIMATE CHANGE CENTRE

The Intergovernmental Panel on Climate Change (IPCC) periodically assesses knowledge of climate change, using the evidence and analyses published in peer-reviewed journals and other credible sources.

The IPCC's Fifth Assessment involved 803 scientific authors and more than 3500 expert reviewers. It comprises four related reports:

1. The Physical Science Basis (September 2013)
2. Impacts, Adaptation and Vulnerability (March 2014)
3. Mitigation of Climate Change (April 2014)
4. Synthesis Report (October 2014).

The report on impacts, adaptation and vulnerability includes a chapter about Australia and New Zealand. Unless otherwise specified, this is a summary of some key findings for New Zealand from that chapter.

The big picture

As temperatures increase, so do risks of serious and irreversible damage.

The September 2013 report on the physical science of climate change found:

- warming of the climate system is unequivocal. Since the 1950s, many of the observed global changes are unprecedented over decades to millennia
- climate change is already influencing the intensity and frequency of many extreme weather and climate events globally
- human influence on the climate system is clear
- continued emissions of greenhouse gases will cause further warming and climate changes
- limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

New Zealand is already experiencing climate change

The climate is changing, with long-term trends toward higher temperatures, more hot extremes, fewer cold extremes, and shifting rainfall patterns in some regions.

More change is expected

- Average temperatures expected to rise further, depending on future greenhouse gas emissions (more details below).
- Spring and autumn frost-free land area expected to at least triple by 2080s.
- Up to 60 more hot days per year (over 25°C) for northern areas by 2090.
- Significant shifts in rainfall patterns (more details on next page).
- Rise in extreme rainfalls (up to 8% more intense rain for every 1°C of warming, but with significant regional variations).
- Time spent in drought in eastern and northern New Zealand projected to double or triple by 2040.
- Global sea level rise by 2100 of about 0.5–1 metre above the 1986–2005 average in a high carbon world, or about 0.3–0.6 metre if there is rapid decarbonisation. Even if temperatures peak and decline, sea level is projected to continue to rise for many centuries at a rate dependent on future emissions. Sea level rise around New Zealand may be up to 10% higher than the global average.
- Increase in days with 'very high' and 'extreme' fire danger index in some locations by up to 400% by 2040 and 700% by 2090.
- Shifts in wind speed and direction, with the average westerly flow projected to increase in spring and winter, but decrease in summer and autumn by 2090.
- Decline in peak snow accumulation by about 30–80% at 1000 metres and by about 5–50% at 2000 metres by 2090.

Temperature rise

This graph, adapted from the report, shows projected changes compared to New Zealand's average temperature over the period 1986–2005. It shows:

- New Zealand has warmed by about 0.9°C since 1900
- New Zealand's temperature is expected to rise by another 0.8°C or so above the 1986–2005 average if the world rapidly implements stringent measures to limit greenhouse gas emissions (the blue band)
- by contrast, New Zealand's temperature is expected to keep on rising throughout this century – by about 3.5°C above the 1986–2005 average – in a high carbon world (the red band).

Based on IPCC Working Group II Fifth Assessment Report Chapter 25, Figure 25-2; for more details and data sources see Chapter 21 Supplementary material, section SM21.1 and Table SM21.5.

Impacts / Adaptation

- Update (IPCC AR5 - based) adaptation guidance for New Zealand
- Climate Change Impacts & Implications Programme (CCII): Projections, impacts (including cross-sector & cumulative), options, engagement
- Deep South National Science Challenge:
- Modelling / process knowledge;
- Impacts -economic sectors, infrastructure, natural resources; societal needs / community engagement.
- Will incorporate CCII

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NIWA resources & capabilities

- NIWA Computing resource: IBM Power 575, 108 POWER6, 32 way 4.7 GHz nodes for a total of 3456 processors and 9.0 terabytes of memory. Can perform at 65 TeraFLOPS
- Modelling capabilities:
  - Unified Model v 4.5: HadRM3P, ~ 30km resolution, forced by UM-GCM at lateral boundaries
  - Moving to HadGEM3-RA GA3.0: based on v7.8 of the UKMO Unified Model (~12km resolution)
  - NIWA-UKCA CCM (chemistry, photolysis, coupling to ocean + sea ice)
  - WRF v 3.5: multiple two way nested RCM (including chemistry), forced by any GCM/Data
  - CCAM: RCM two way nested in GCM with ocean, sea ice

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