CLIMATE CHANGE PROJECTIONS FOR NZ AND THEIR IMPACTS ON AVIATION

planning for disruption

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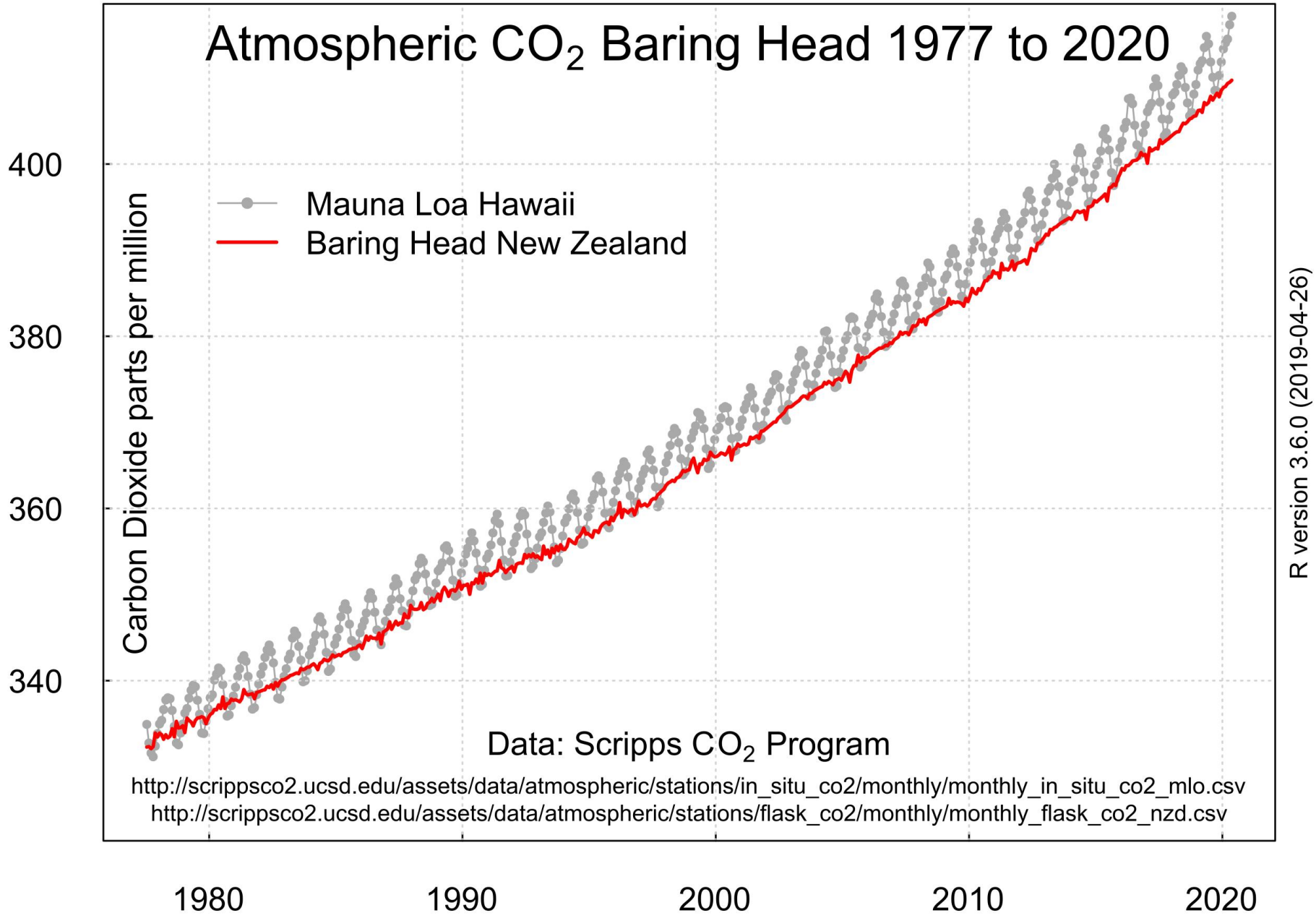
NIWA
Taihoro Nukurangi

MetService
TE RATONGA TIRORANGI


Atmospheric CO_2 Baring Head 1977 to 2020
Mauna Loa Hawaii
Baring Head New Zealand
Carbon Dioxide parts per million
400
380
360
340
1980
1990
2000
2010
2020
Data: Scripps CO_2 Program
http://scrippsco2.ucsd.edu/assets/data/atmospheric/stations/in_situ_co2/monthly/monthly_in_situ_co2_mlo.csv
http://scrippsco2.ucsd.edu/assets/data/atmospheric/stations/flask_co2/monthly/monthly_flask_co2_nzd.csv
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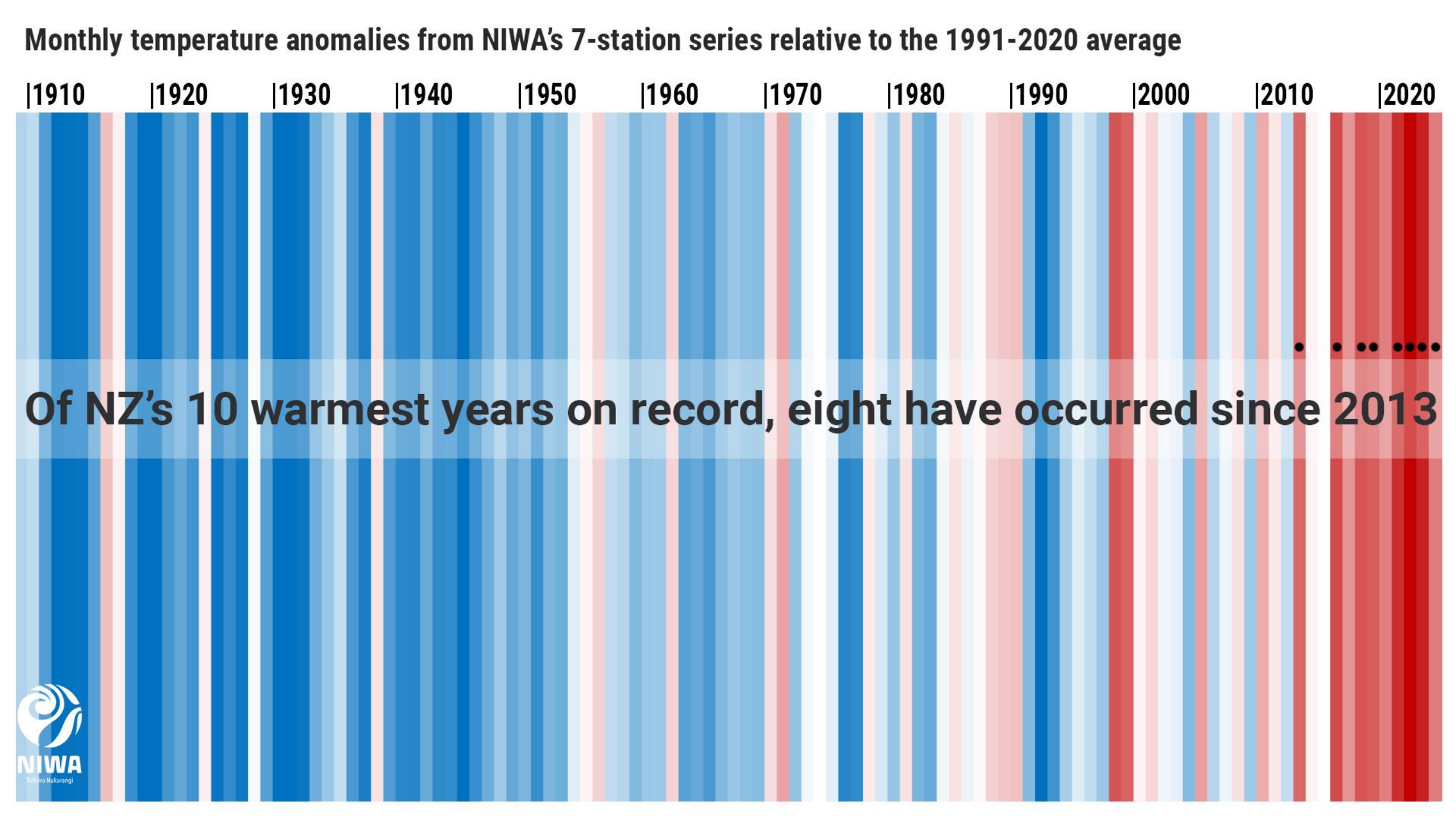
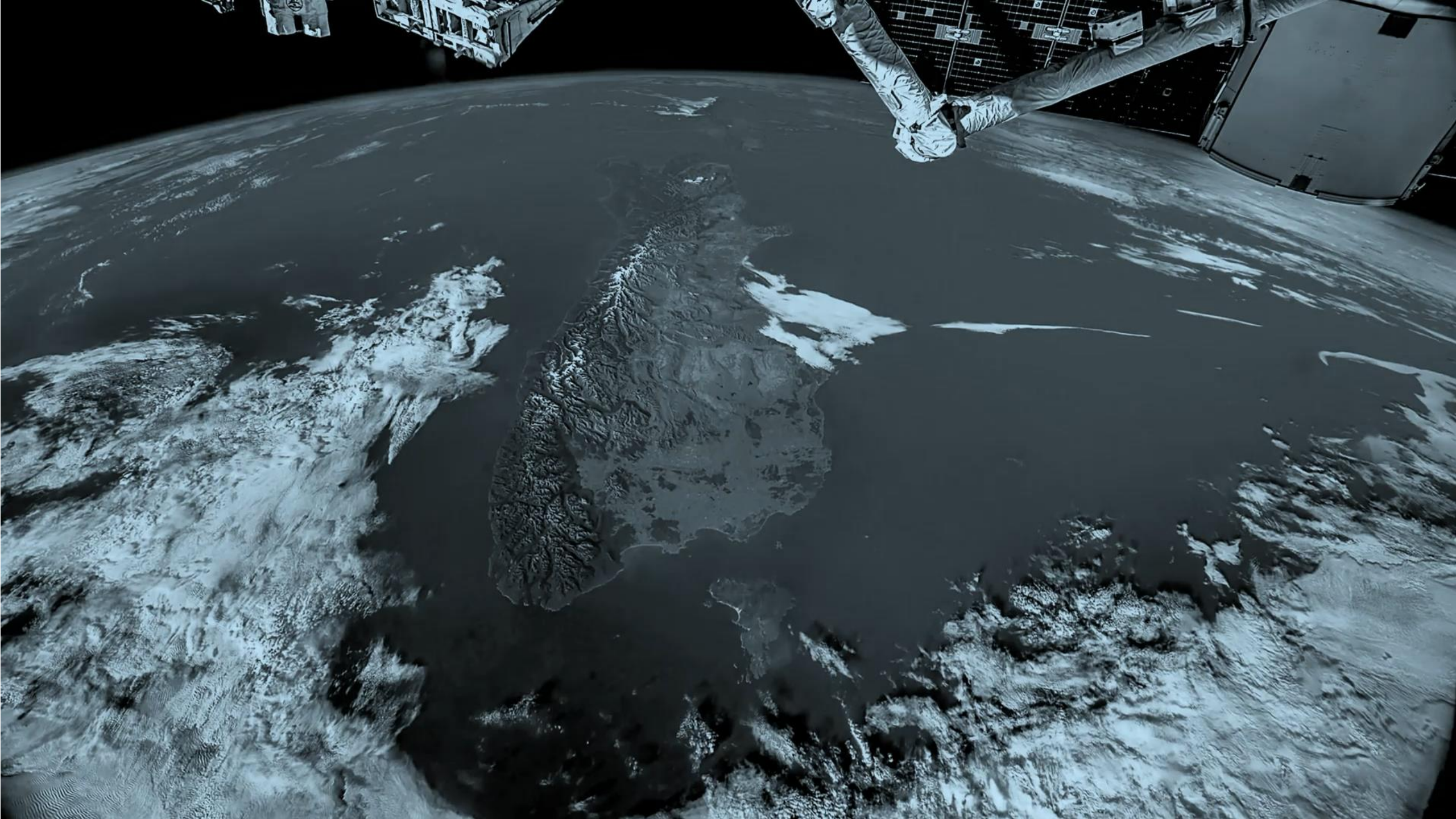
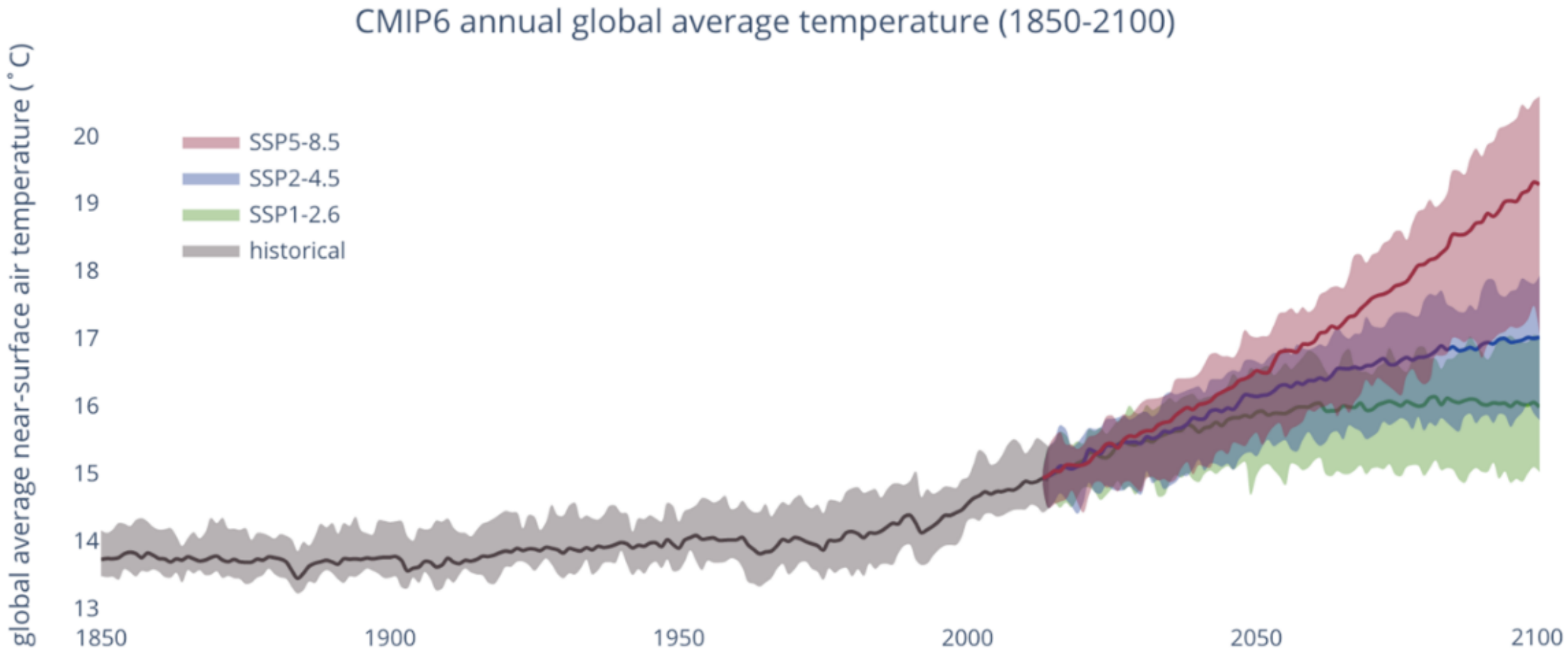

Monthly temperature anomalies from NIWA's 7-station series relative to the 1991-2020 average
|1910
|1920
|1930
|1940
|1950
|1960
|1970
|1980
|1990
|2000
|2010
|2020
Of NZ's 10 warmest years on record, eight have occurred since 2013
NIWA
Taihoro Nukurangi



Future scenarios



Credit: Copernicus Climate Change Service, ECMWF

NIWA
Taihoro Nukurangi

Temperature projections and impacts

NIWA

MEAN TEMPERATURE CHANGE

INCREASE RELATIVE TO 1995-2014 AVERAGE

2025

°C

4.0

3.0

2.0

1.5

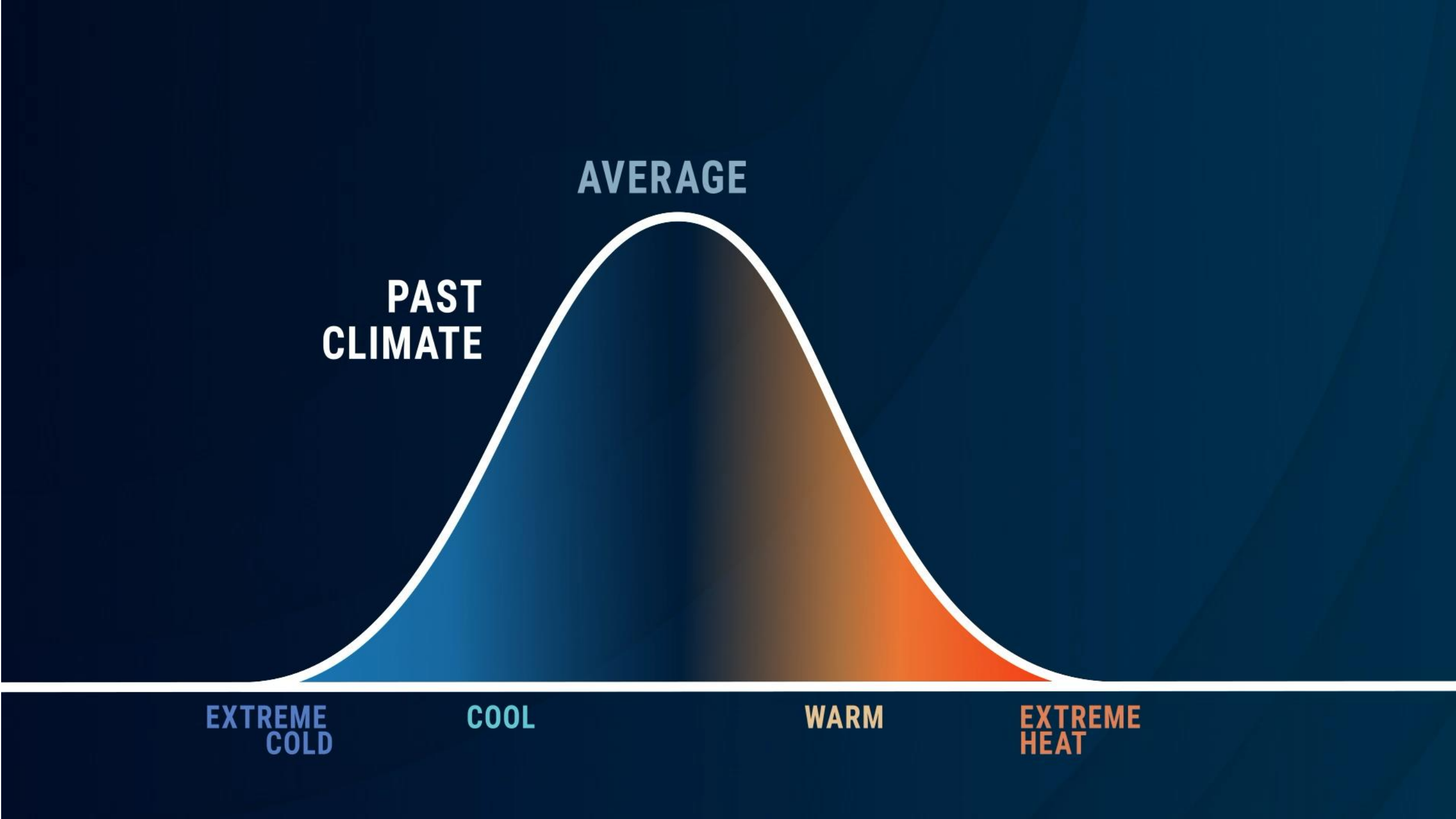
1.0

0.5

REGIONAL RIVALRY

A ROCKY PATH

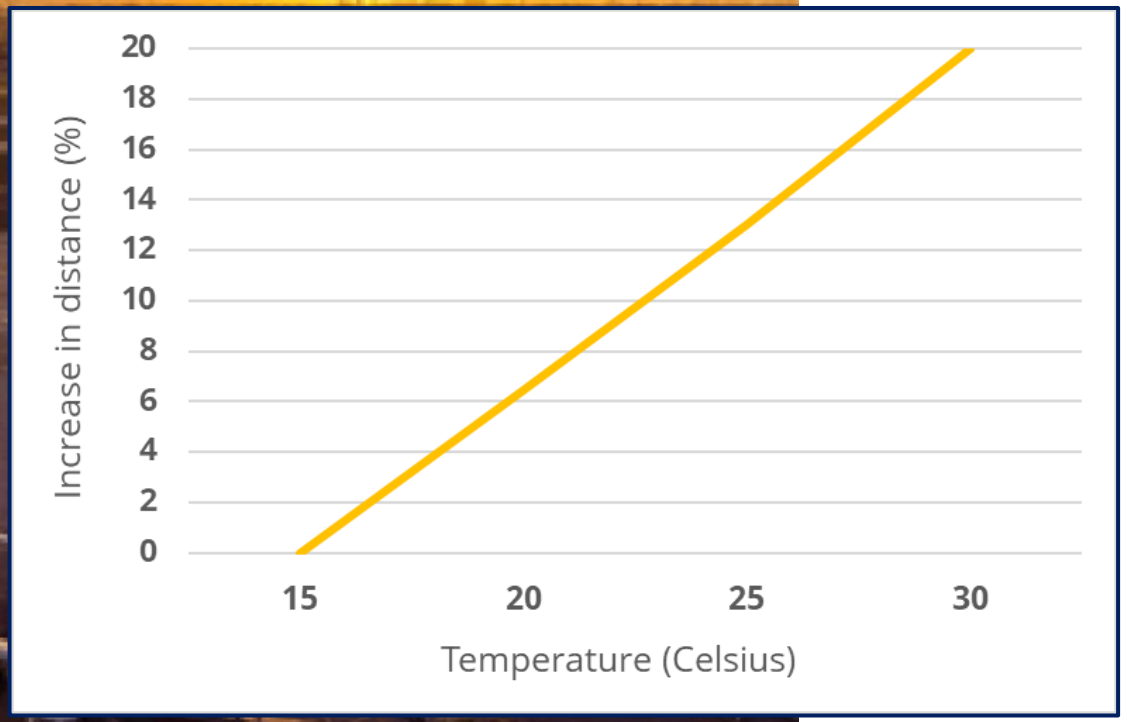
(SSP370)


AVERAGE
PAST CLIMATE
EXTREME COLD
COOL
WARM
EXTREME HEAT


NIWA
INCREASE IN HOT DAYS
HOT DAYS
DAYS ABOVE
25°C

Temperature Projections and Impacts

Change in Take-Off Distance with Temperature



Impacts

- **Take-off limits**:

Passengers, cargo, fuel

- **Human factors**:

Cabin comfort, pilot fatigue,
safety of ground staff

- **Aircraft performance**

Runway capacity/occupancy, Noise management

- **Airport operations**:

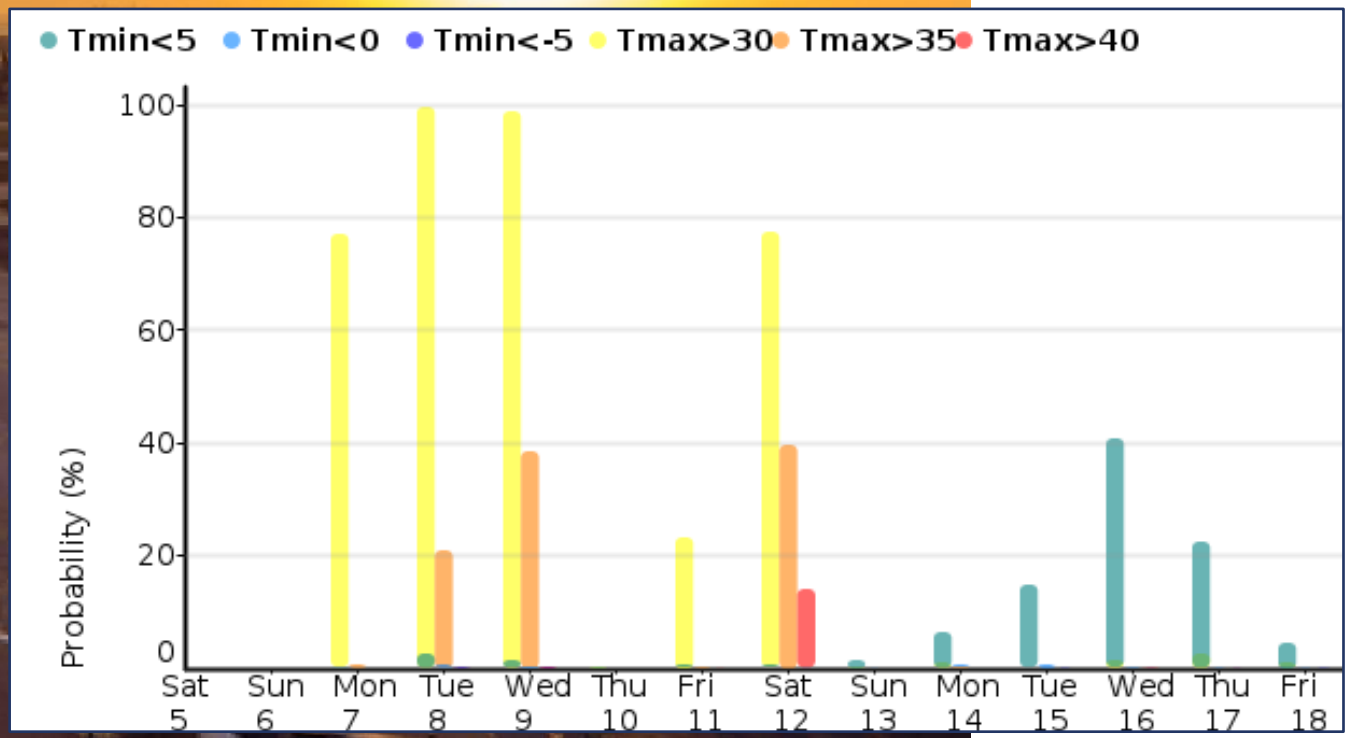
Damage to runways/assets, changes in prevailing wind?

Temperature Projections and Impacts

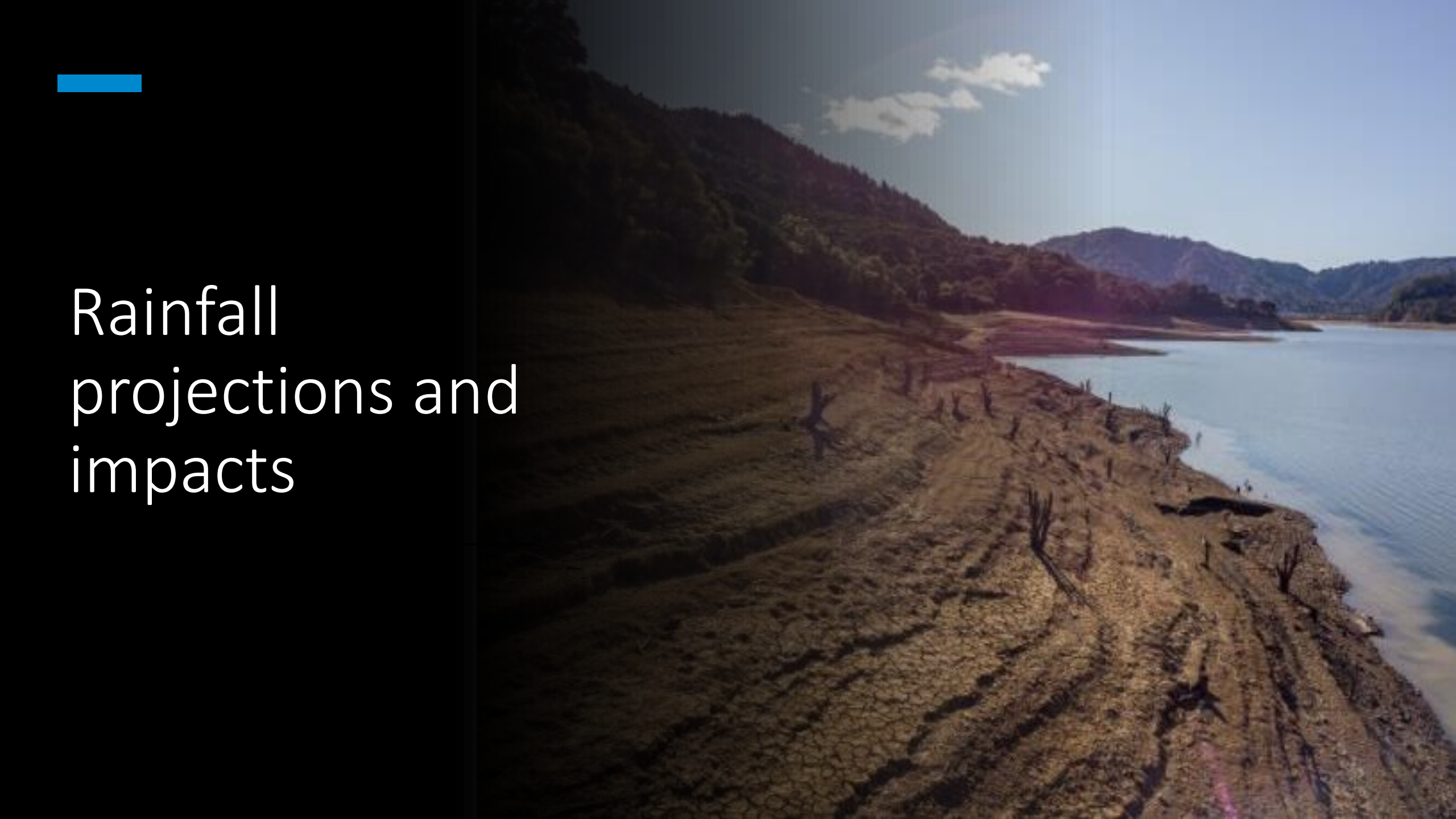
Mitigations

- Smart (accurate, probabilistic) Temperature Forecasts
- Take-Off Mass Forecasts
- More dynamic loading
- Dynamic scheduling
- Impact studies for planning: Aircraft, Runways, Routes, Ops
- Adaptive or preventative crew/ground staff management
- Automation of human-limited systems

E.g. Probabilistic Temperature Forecasts

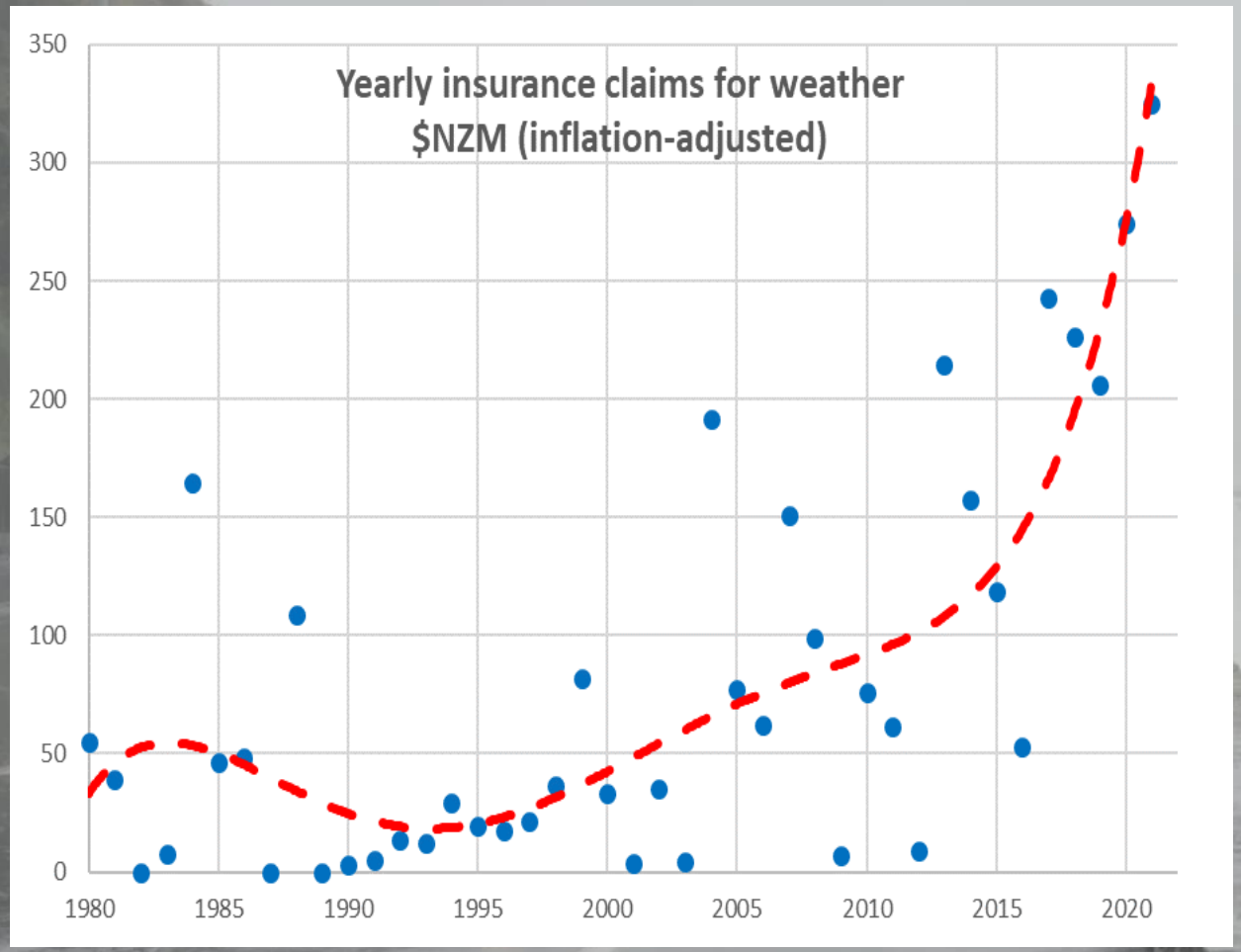


Rainfall projections and impacts



EXTREME WEATHER IS MORE INTENSE & FREQUENT

EXTREME WEATHER IS MORE INTENSE & FREQUENT



"...if we don't make our energy system more resilient to climate change, there will be as big a disruption in the energy system as the war [in Ukraine]"

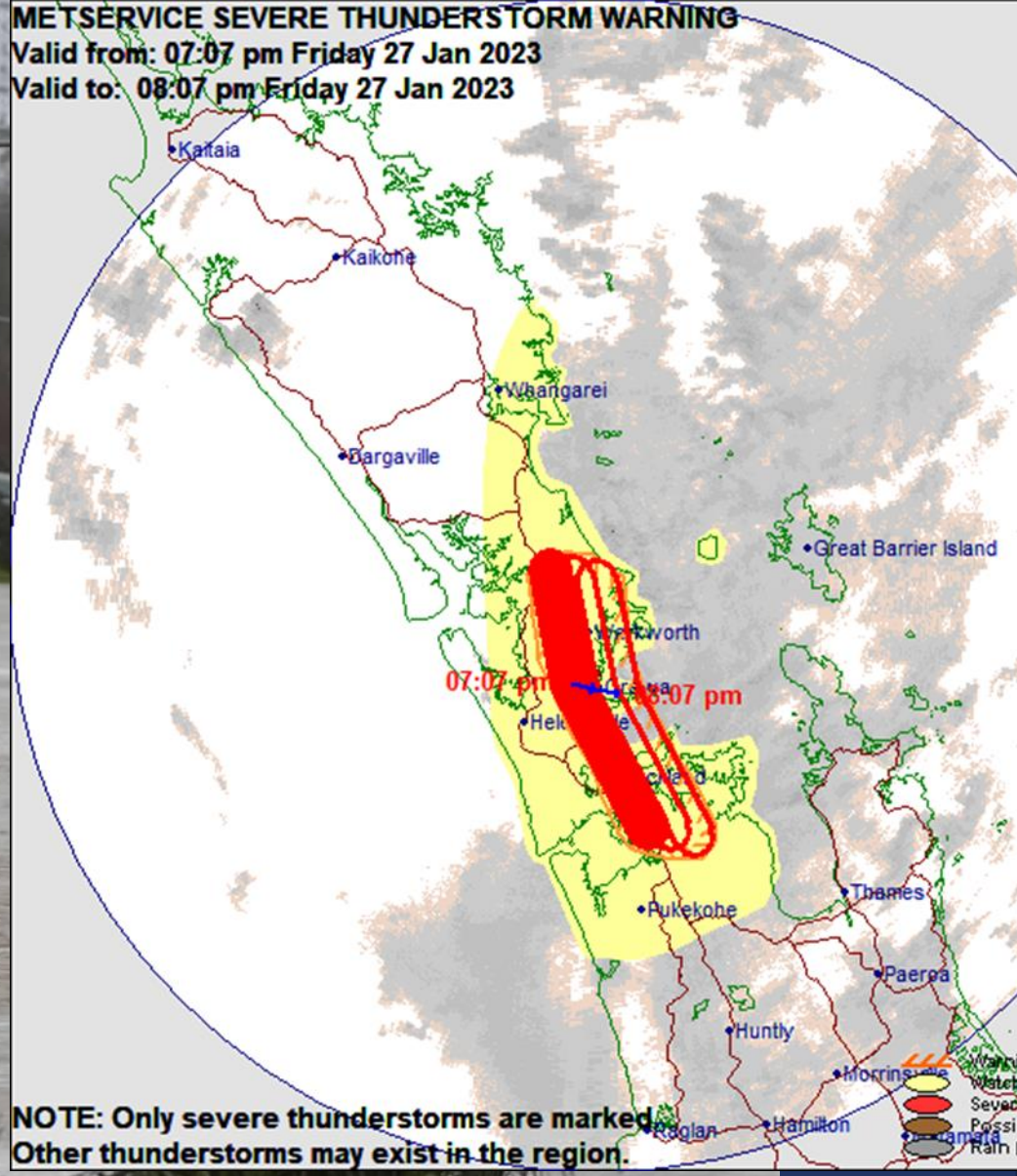
Roberta Boscolo (WMO, 2022)

EXTREME RAIN AND STORM RISKS

Our Changing Risk Profile

- Flash Flooding
- ‘Hybrid’ Rainstorms
- Sub-Tropical Storms
- Ex-Tropical Cyclones

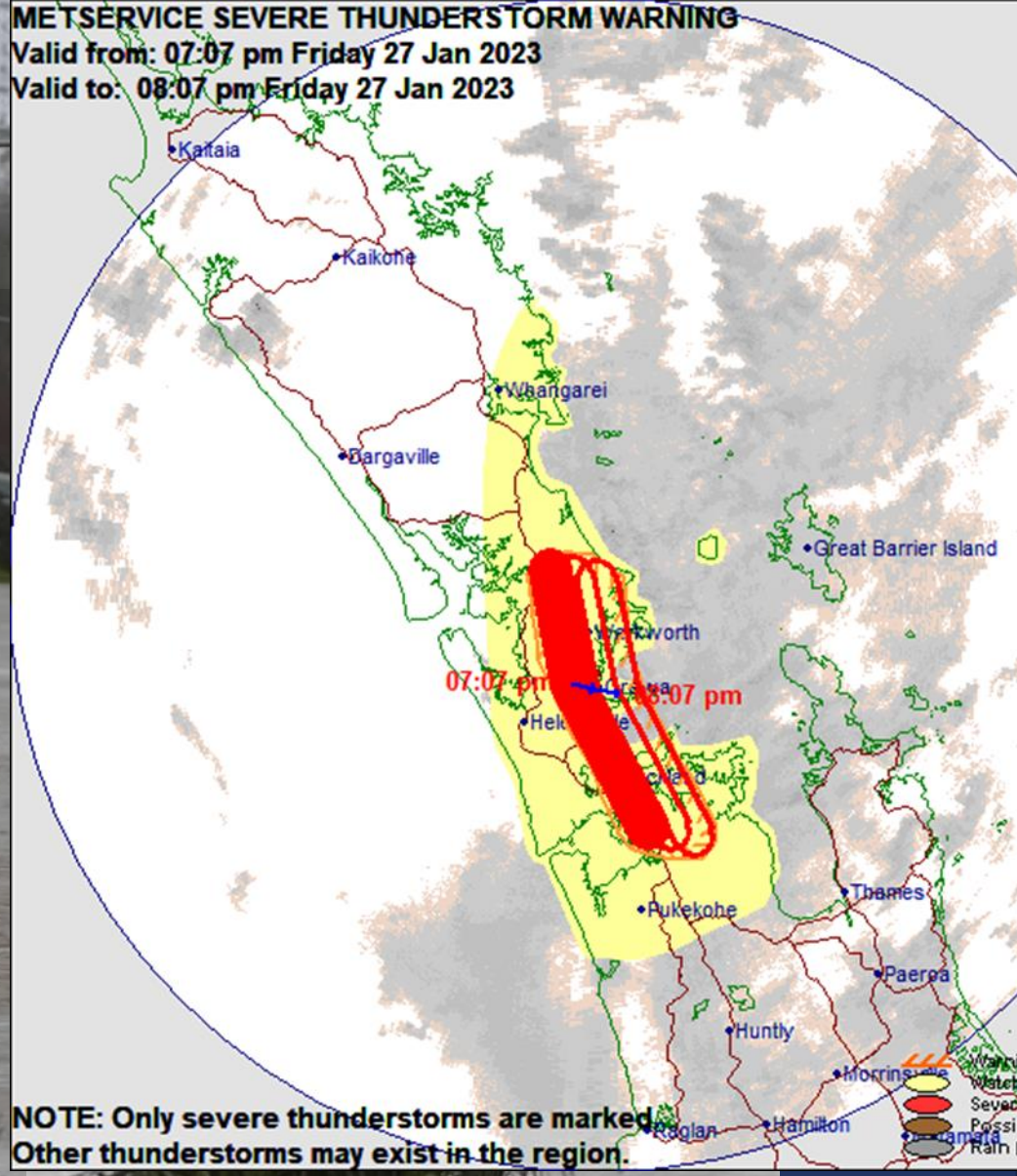
Rainfall Projections and Impacts



Rainfall Projections and Impacts

Impacts

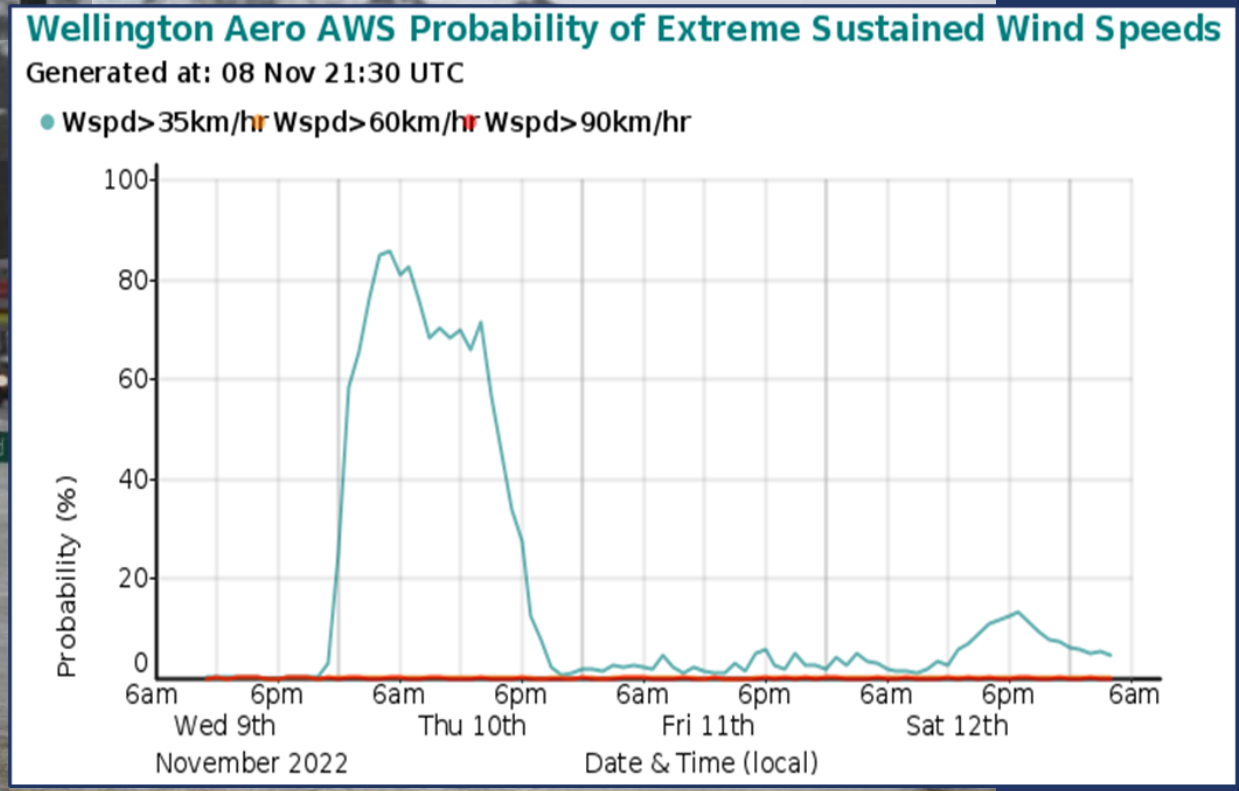
- Both Flash Flood and Prolonged Rain events cause disruption on different time scales, with different predictability
- Damage or disruption to airports, infrastructure, parked aircraft
- Airports may be resilient, but supporting infrastructure may not be
- Hazardous landing conditions due surface water, visibility reduction
- Multiple centres potentially affected



Rainfall Projections and Impacts

Mitigations

- Coordination across agencies and organisations
- Investment in resilience
- Optimisation of weather services into operations
- Development of smart, targeted weather products

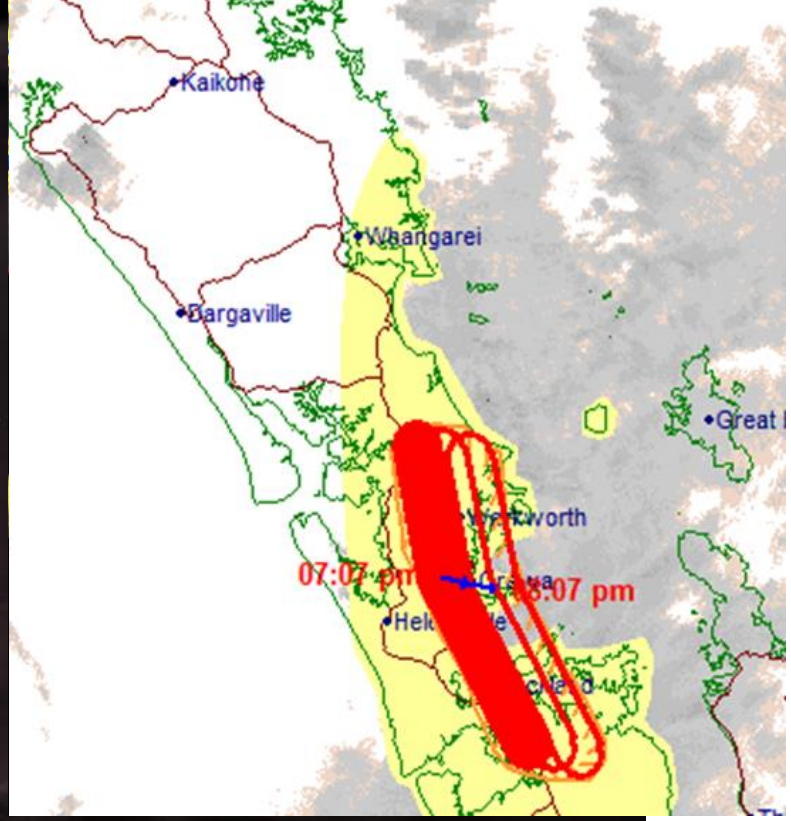


CB and Icing Risks Expected to Increase

Timaru hailstorm 2019 Image: Luke McGoldrick

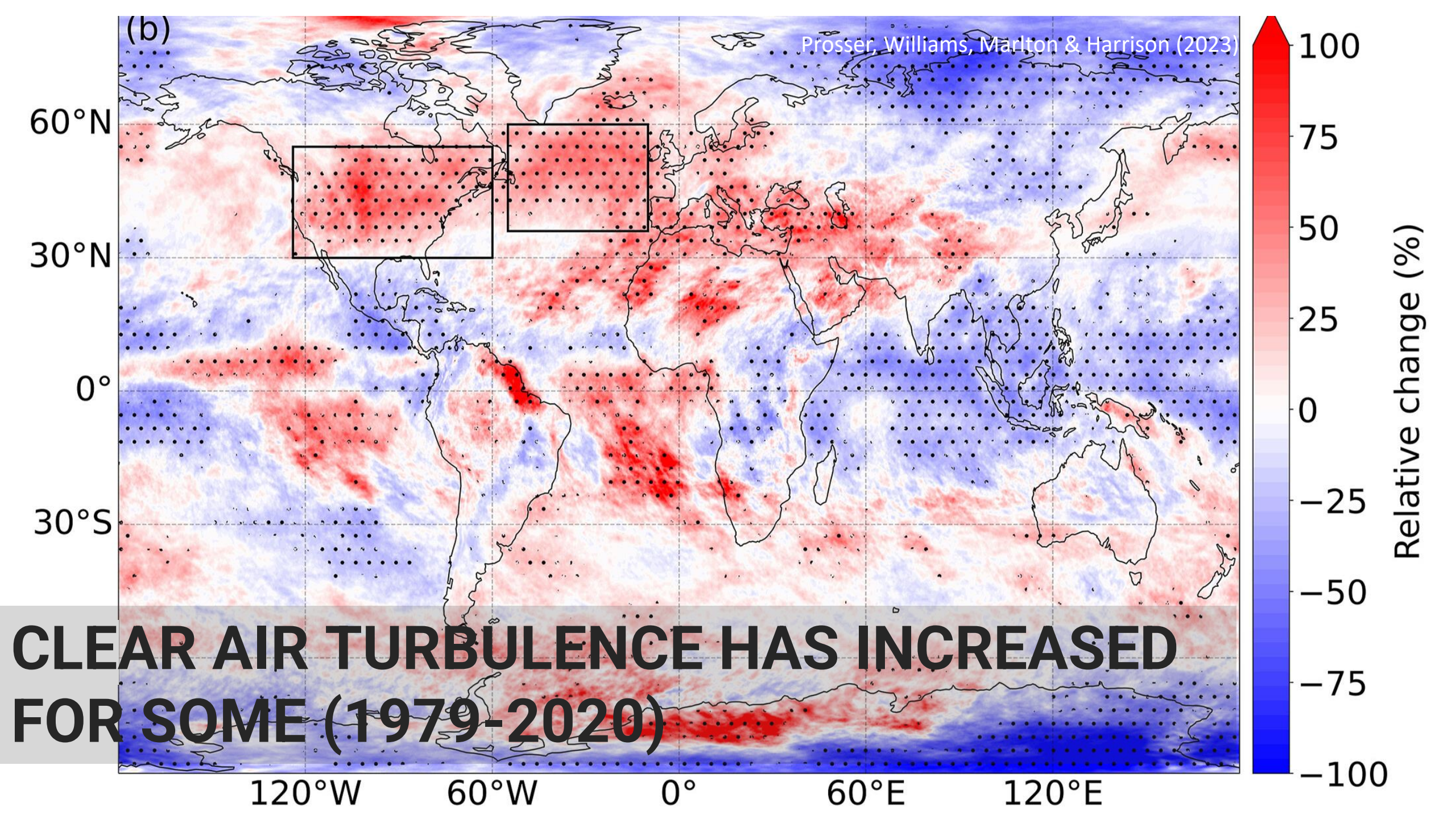
Impacts

- Expect increased convection, thunderstorms
- More severe storms / multicells / supercells?
- Icing, especially at altitude
- Hail? In-flight and for parked aircraft



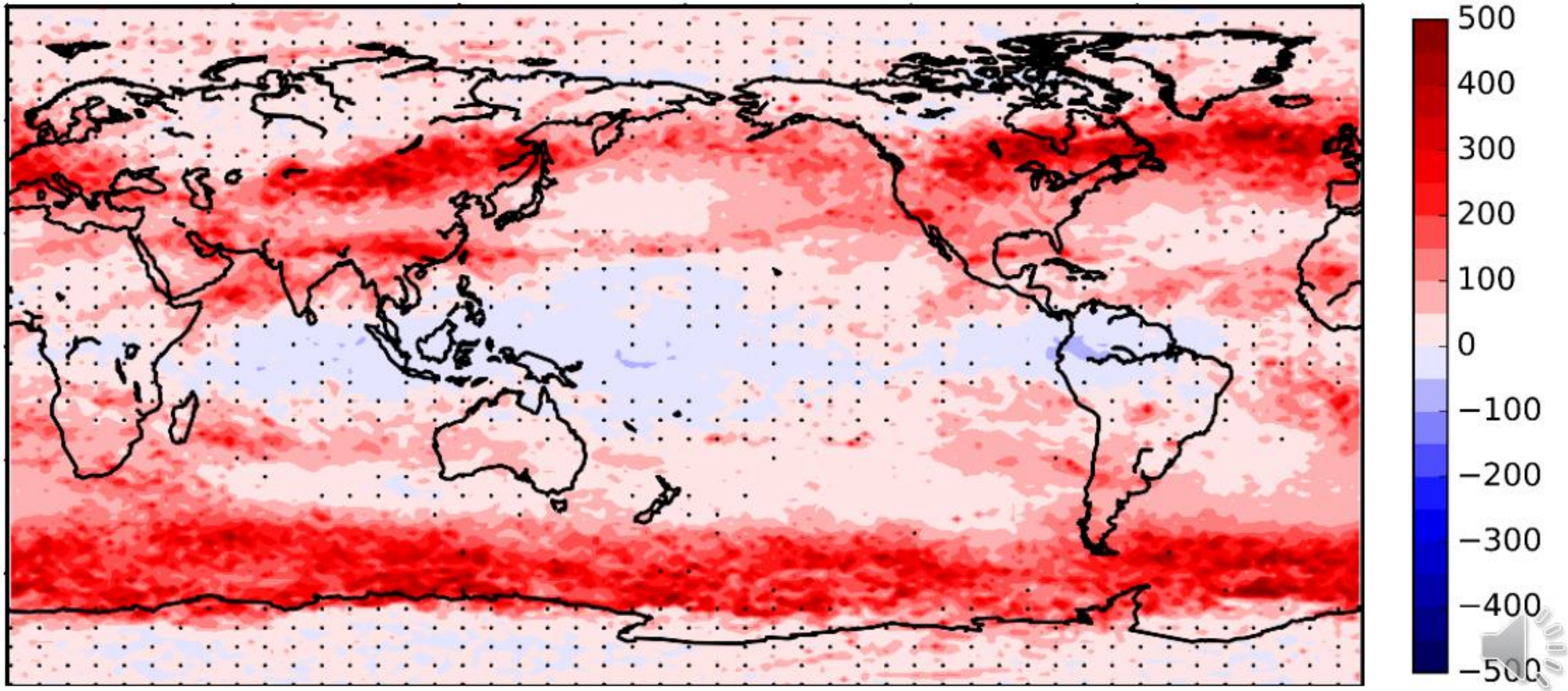
Mitigations

- More integration of smart weather, in flight and for airports
- More flexible airspace
- Agility in operations: airlines and airports



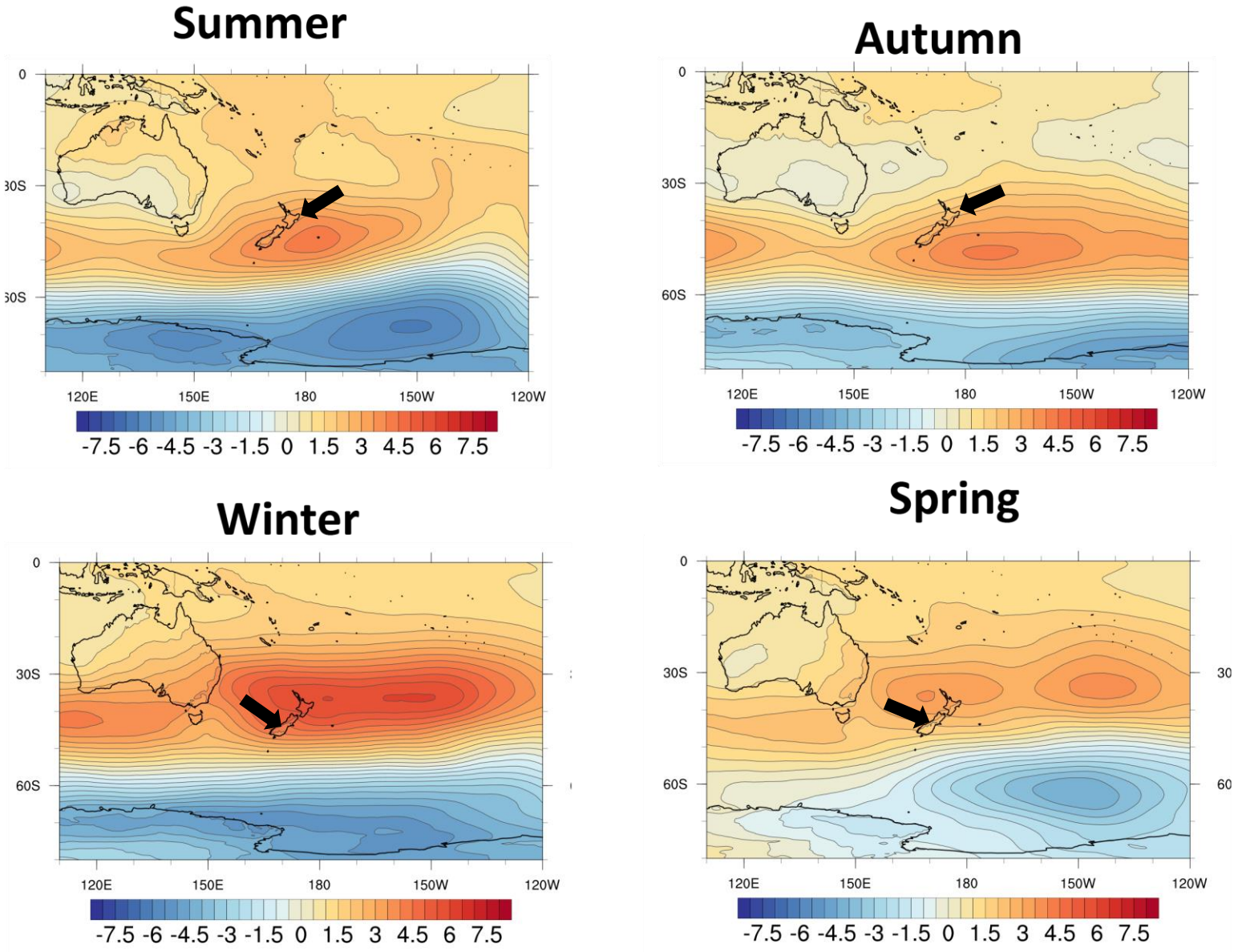
CLEAR AIR TURBULENCE HAS INCREASED FOR SOME (1979-2020)

Clear-air turbulence



Storer, Williams & Joshi (2017)

Changes to air pressure patterns and winds



End of century MSLP projections (SSP370)

- Polar jet stream

Average position expected to move southward

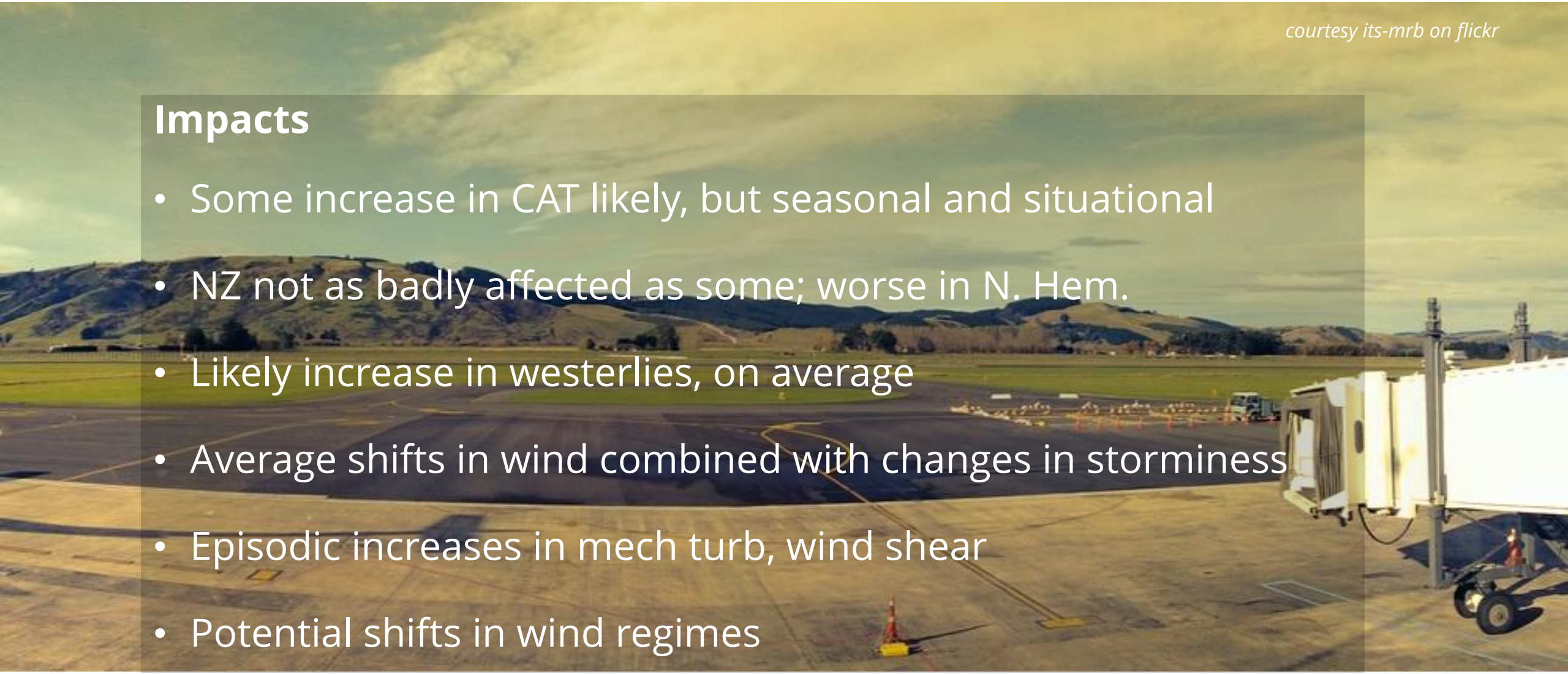
- Summer-Autumn

The shift south is most pronounced, so less activity

- Winter-Spring

Enhanced jet activity and more westerlies overall

courtesy its-mrb on flickr



courtesy its-mrb on flickr

Impacts

- Some increase in CAT likely, but seasonal and situational
- NZ not as badly affected as some; worse in N. Hem.
- Likely increase in westerlies, on average
- Average shifts in wind combined with changes in storminess
- Episodic increases in mech turb, wind shear
- Potential shifts in wind regimes

Mitigations

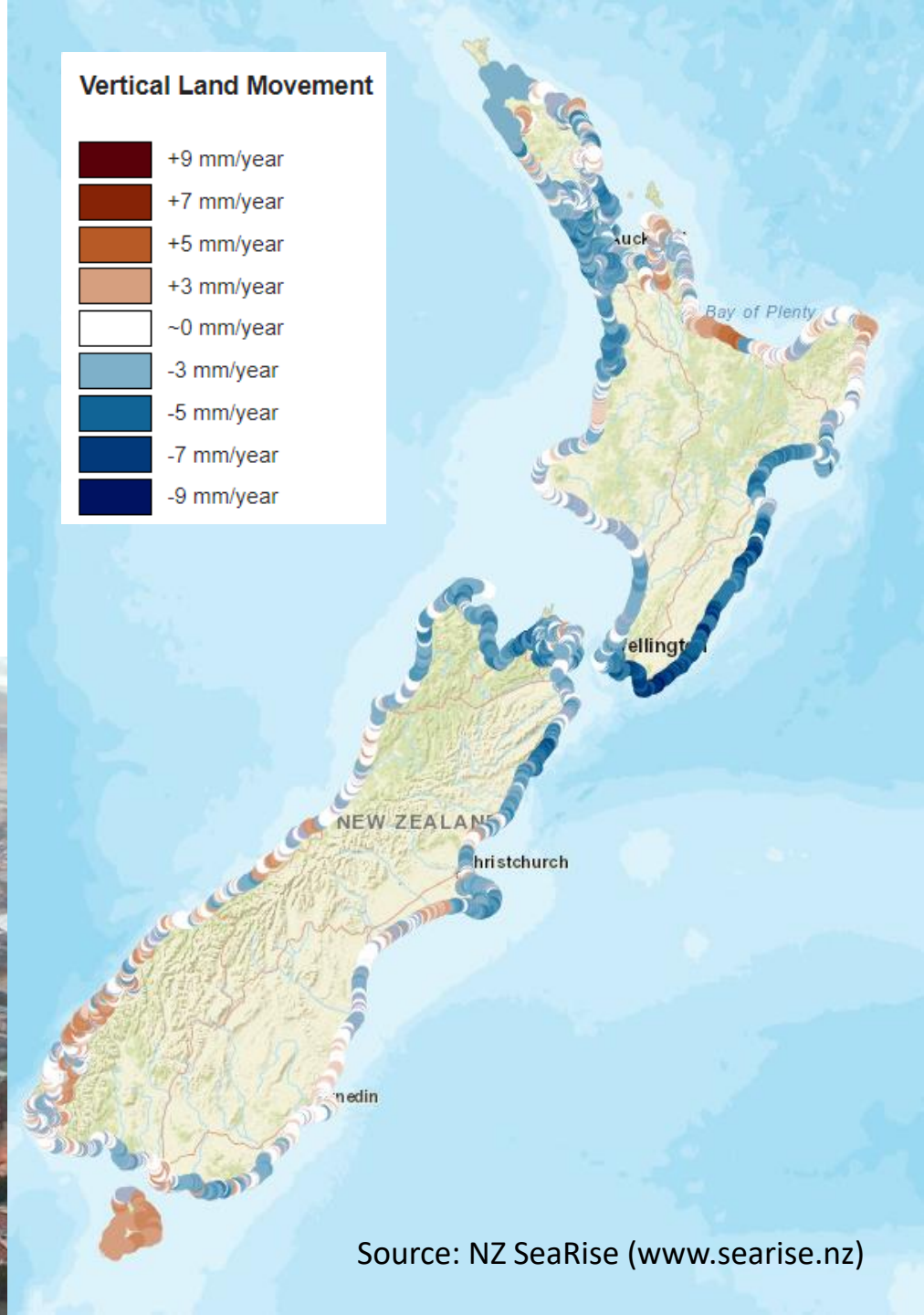
- More dynamic flight planning
- More integration of smart weather
- Resilience planning, anticipation of disruption
- Modifications to aircraft, runways, future design?


Sea level


ON AVERAGE, SEA LEVEL HAS RISEN
20CM NATIONALLY SINCE 1900

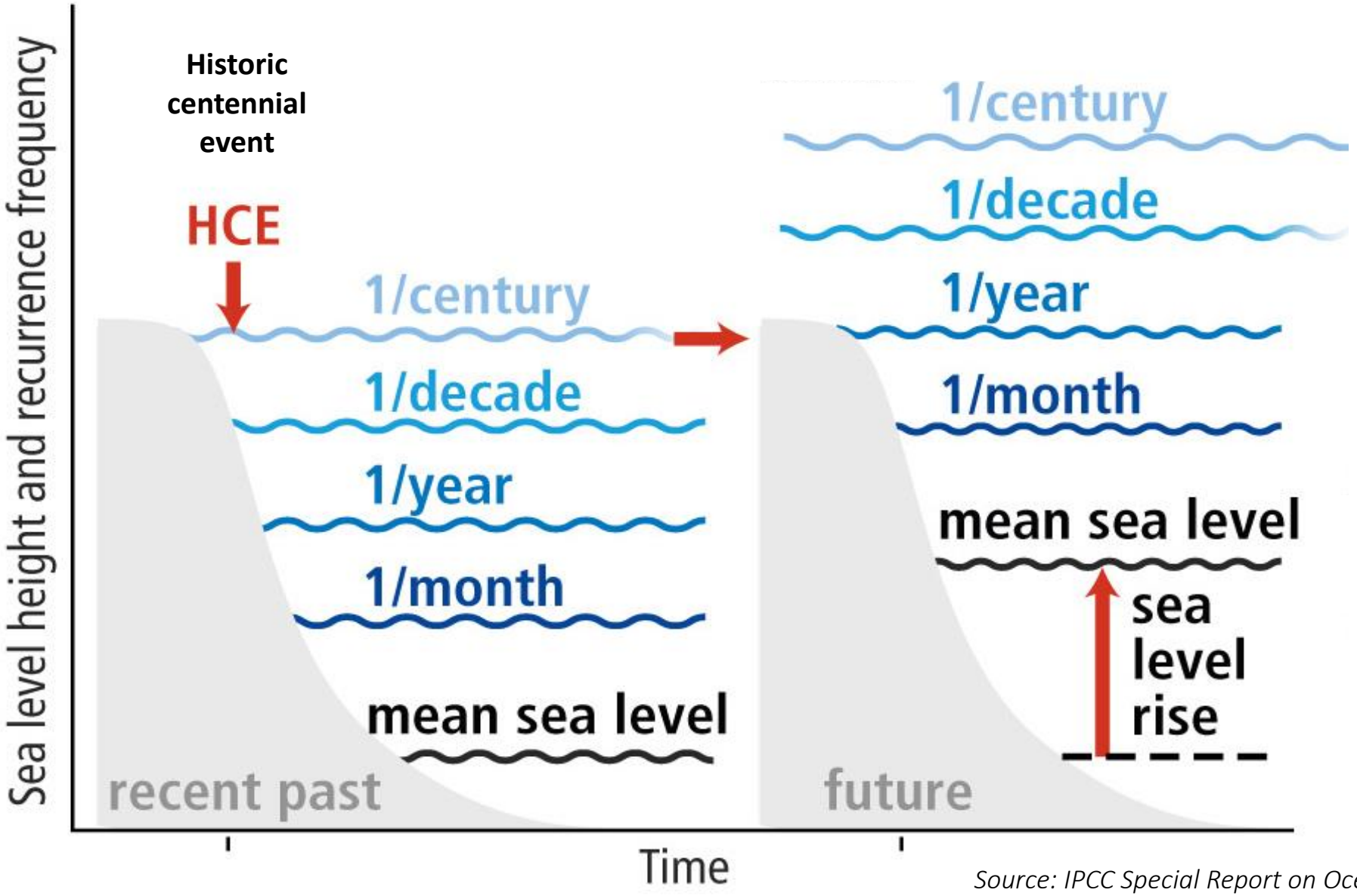
Sea-level rise impacts

- Happening faster than expected (as much of NZ is sinking)
- Lags in the ocean system compared with the atmosphere



Source: NZ SeaRise (www.searise.nz)

Changing frequency of extreme coastal flooding



Source: IPCC Special Report on Oceans & Cryosphere (2019)

Sea Level Rise

Impacts

- Increasing risk from Flooding
- Increasing risk from Inundation
- Increasing risk from Erosion
- Even if Airport not affected, supporting infrastructure may be:

  Ground transport, Drainage/Water/Sewage

Runway elevation AMSL

- NZDN 1m
- NZNV 2m
- NZNR 2m
- NZTG 4m
- NZGS 5m
- NZWK 6m
- NZWU 7m
- NZAA 7m
- NZWN 13m, airport access 2-3m?

- Similar or worse for many overseas links

Sea Level Rise

Mitigations

- Flood and Inundation Warnings
- Planning and Design of Airports
- Planning and Design of supporting Infrastructure

Runway elevation AMSL

- NZDN 1m
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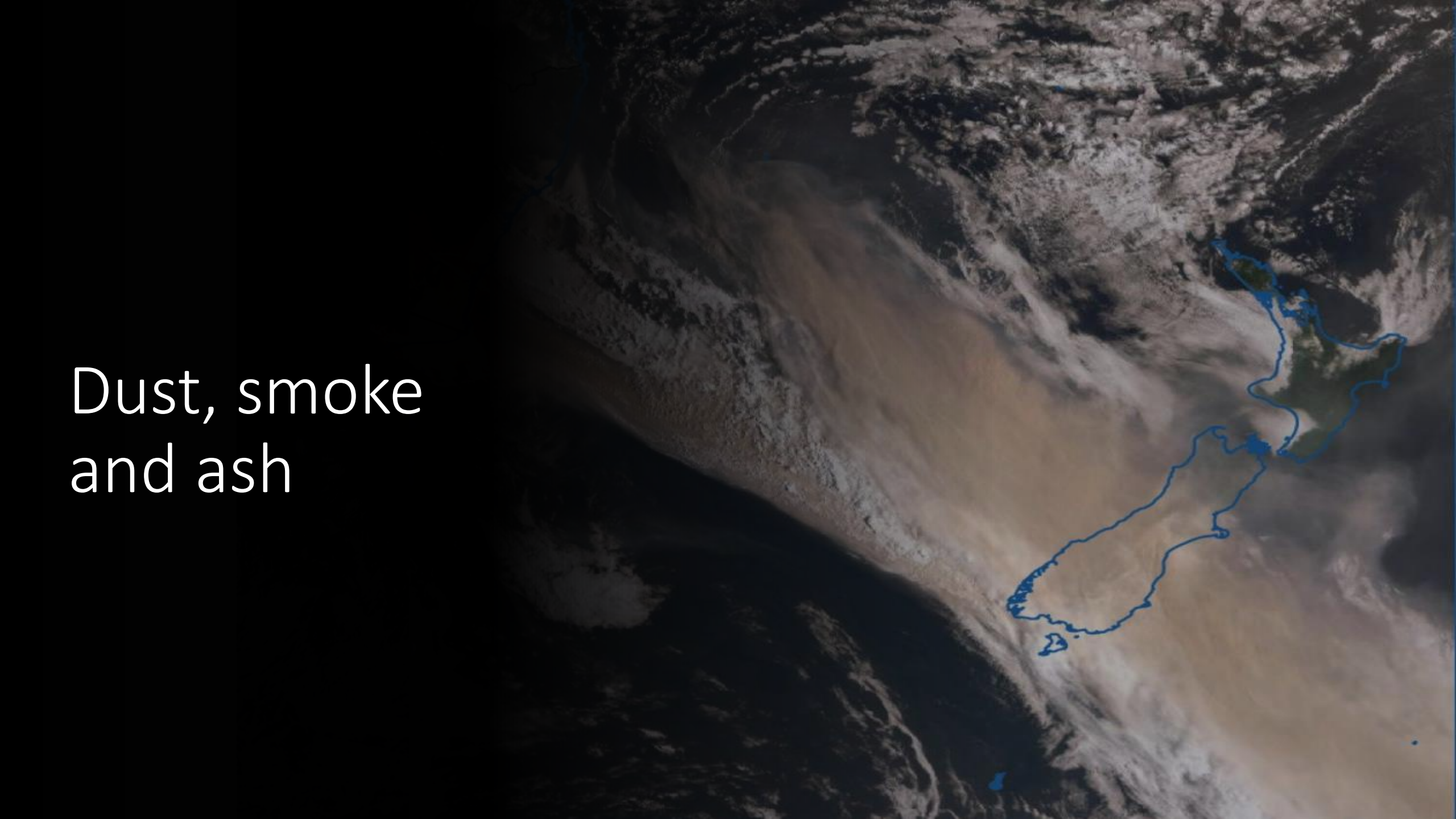
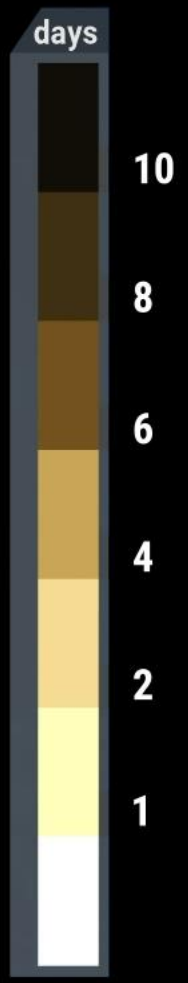
Dust, smoke and ash

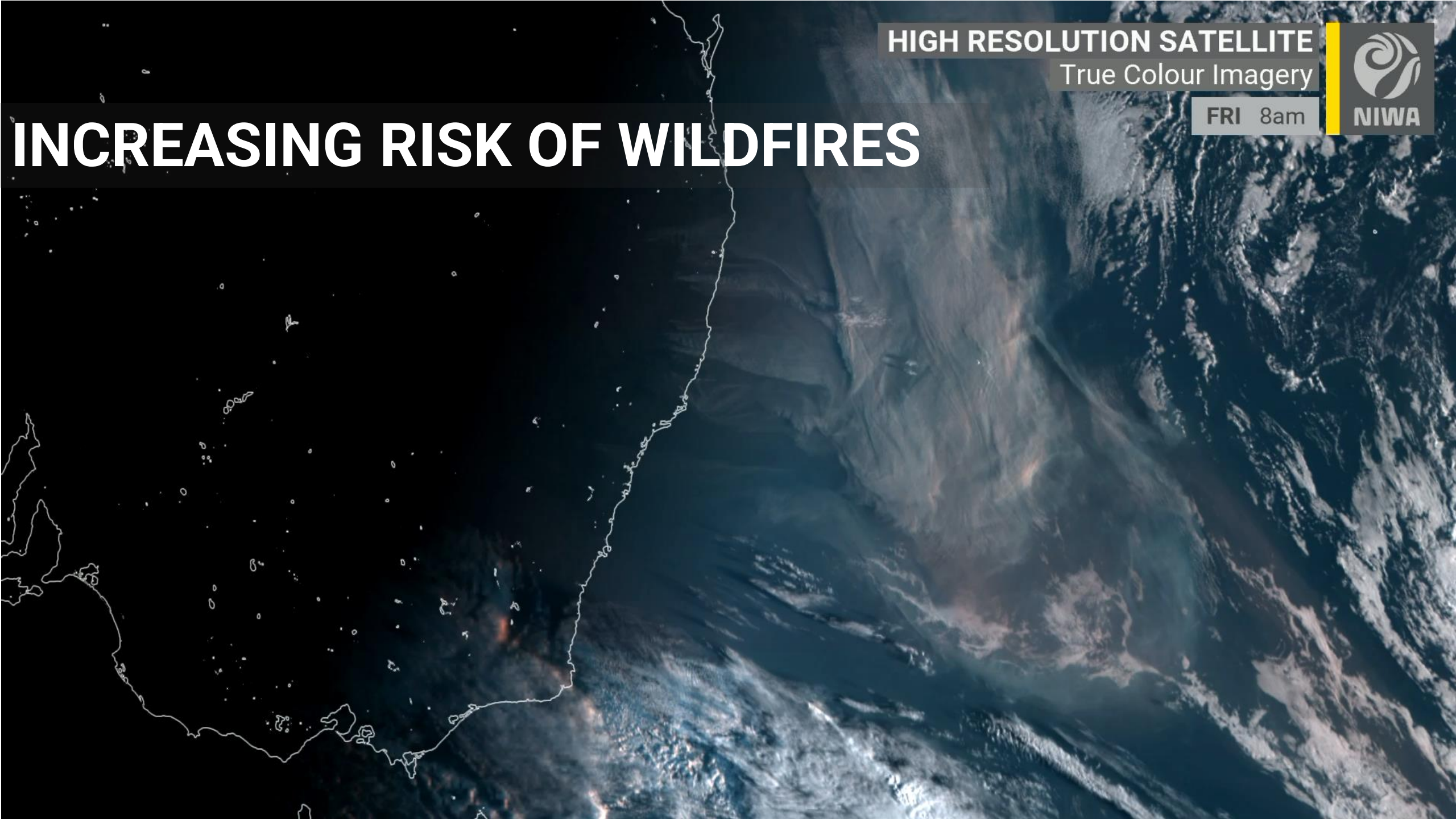


ANNUAL CHANGE IN DRY DAYS

ROCKY PATH



- More frequent & intense droughts
- Soil shrinkage & cracking can damage runways.
- Dry, dusty conditions can reduce vis take off/landing.
- Water restrictions may disrupt operations


HIGH RESOLUTION SATELLITE
True Colour Imagery
FRI 8am
NIWA
INCREASING RISK OF WILDFIRES

Dust, Smoke and Ash

Impacts

- Aerodrome visibility limitation
- Dust and Smoke/Ash as sources of aircraft damage
- Fire as hazard to airport/infrastructure/assets/logistics
- Change in cloud characteristics
- VFR implications

Imagery: JMA

Dust, Smoke and Ash

Mitigations

- Investigate effects on and mitigations for Aircraft
- Investigate effects on cloud properties
- Flexible airspace or agile routing?
- Improved monitoring?
- Incorporate seasonal or forecast risk into planning?

Imagery: JMA

The Future

Expect Change and Disruption

- Increased Heat
- Extreme Rainfall, CB activity
- CAT, mechanical, windshear
- Rising sea levels
- Smoke & Ash, Dust

"Increased weather volatility as a result of climate change can have effects on all aspects of operational performance"
ICAO CAEP AVIATION AND CLIMATE CHANGE FACTSHEET (2020)

"Resilience will likely be a combination of adapting infrastructure and developing processes and plans to respond to impacts quickly and efficiently as they happen"
ICAO CAEP AVIATION AND CLIMATE CHANGE FACTSHEET (2020)

A Response

Invest in Resilience

"…mitigation of extreme weather events and the adaptation to a changing climate demands a multidisciplinary effort from all stakeholders in meteorology and aviation, including through ICAO" *Stéphanie Wigniolle, WMO, via SITA (2022)*

- Smart Weather Services
- Dynamic Operations & Airspace
- Coordination across Logistics, Support, Organisations
- Investment in Resilience, Designing for the Future
- Research: Impacts, Risk Assessments, Aviation Weather