Weather and Impact Forecasting

SPC – NIWA Webinar Series
14 September 2021

Stuart Moore, Trevor Carey-Smith, Chris Brandolino, Ben Noll

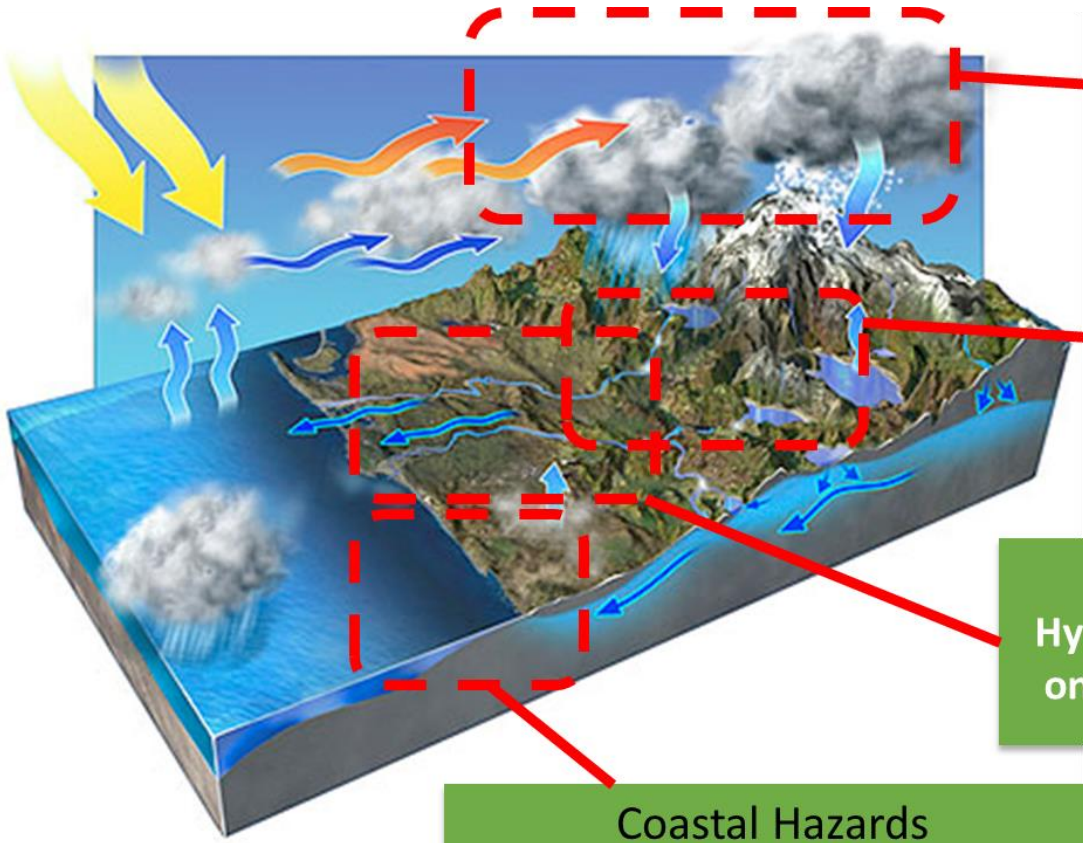
Climate, Freshwater & Ocean Science

NIWA
Taihoro Nukurangi

Weather-Related Hazards Research Programme

- Trends: Increasing
  - Vulnerability of infrastructure at the coast and on flood plains;
  - Risk to human life from weather related hazards
  - Demand for mission-critical, accurate, localised forecasts of high impact weather and hazards information for high-value decision support.
- Drivers:
  - Increasingly capable supercomputers that enable development of the complex and computationally expensive environmental forecasting models required to respond to needs;
  - New satellite observing systems with enhanced capabilities;
  - End-to-end systems approach;
  - Global research collaborations (Grand Challenge problems);
  - Access to ever increasing supercomputing resources.
  - Automation and Deep/Machine Learning

EcoConnect - Multi-Hazards Forecasting System



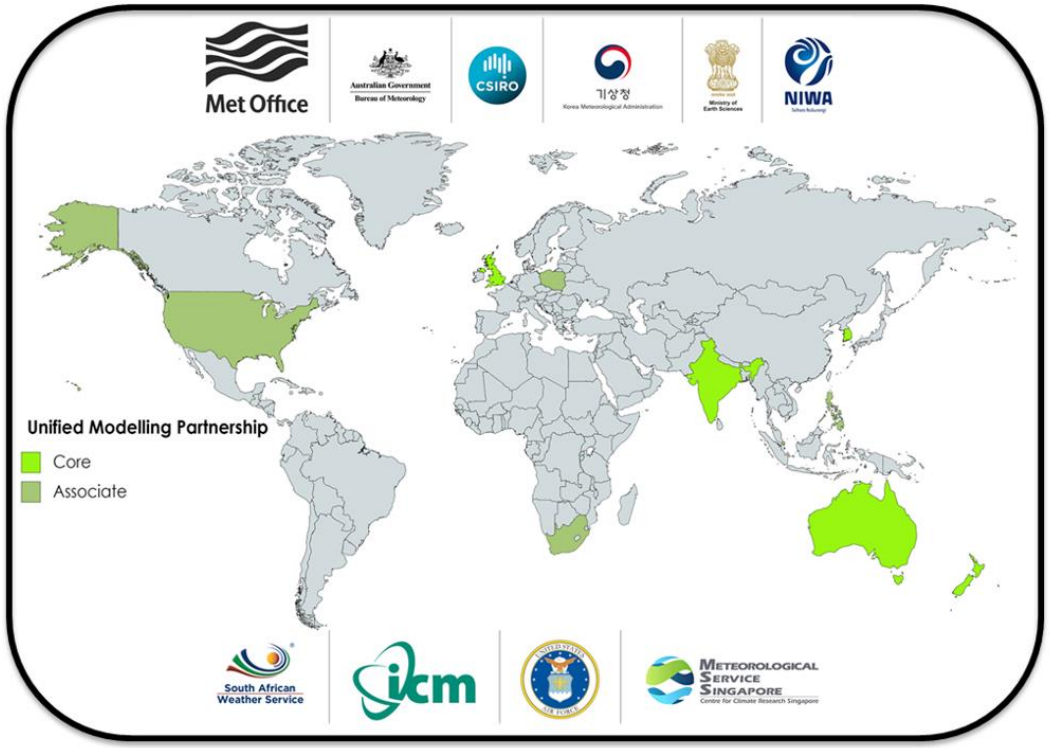
Weather Hazards
Numerical Weather Prediction
Rain, wind, snow, fog

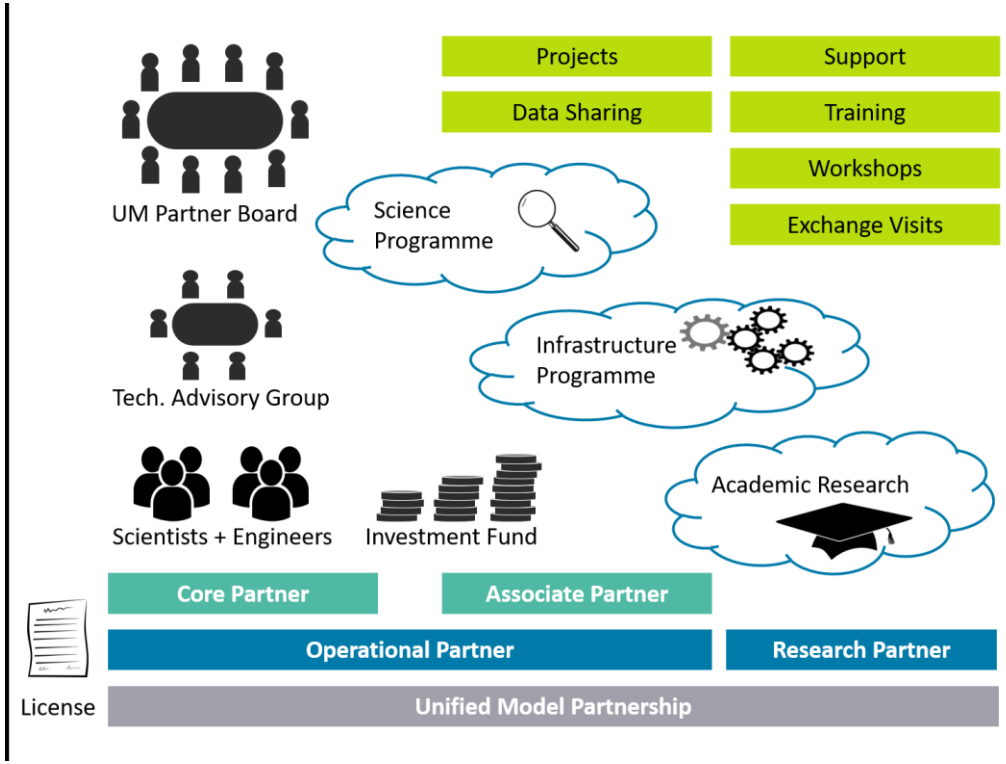
River Hazards
Hydrological Modelling, flow and flood forecasting

Floodplain Hazards
Hydraulic Modelling, inundation on floodplains and urban areas

Coastal Hazards
Sea-state Modelling. Wave, storm surge, tsunami, cyclone hazards

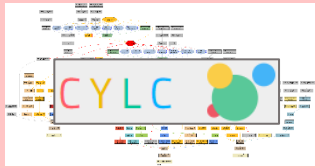
The UM Partnership





https://www.metoffice.gov.uk/research/approach/collaboration/unified-model/partnership

Technical Development



Unified Model

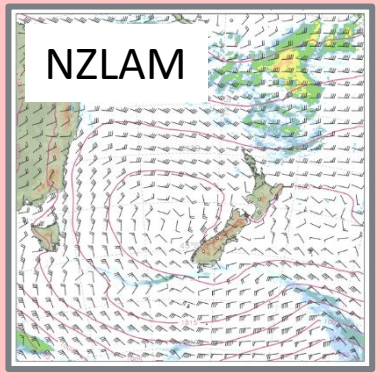
JULES
Joint UK Land Environment Simulator

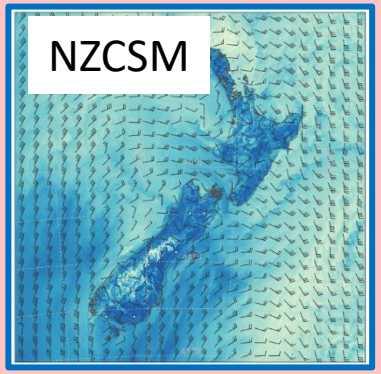
Rose

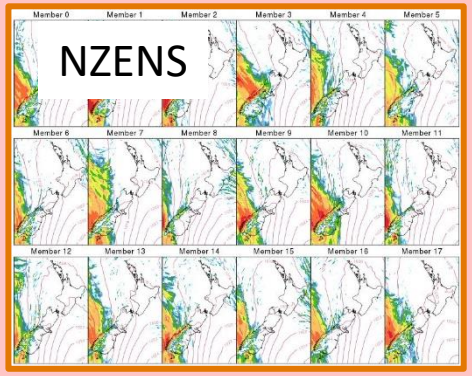
Met Office
NAME
Numerical Atmospheric-Dispersion Modelling Environment

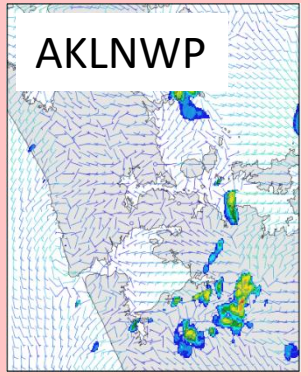
RMED Toolbox

Numerical Weather Prediction

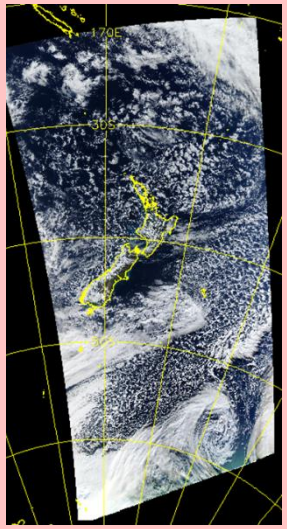


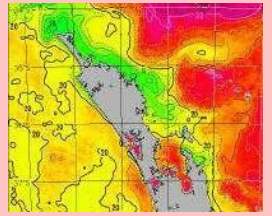






Remote Sensing





Climate, Freshwater & Ocean Science

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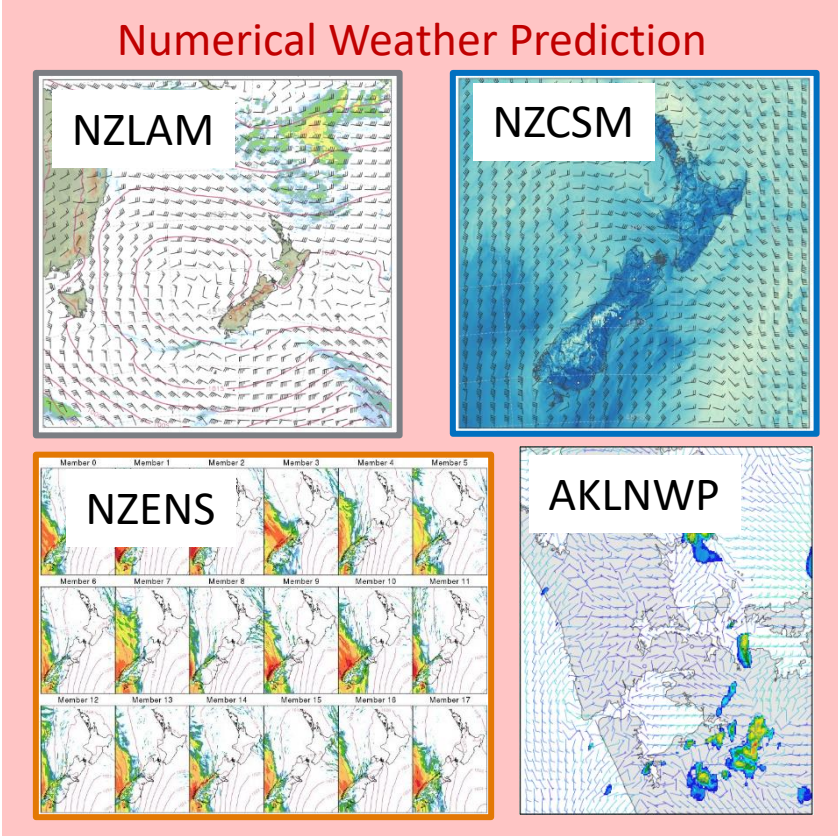
Core NWP model family

NZLAM
- 4.4km resolution
- 3D-VAR data assimilation
- Met Office Global input
- 72 hour forecast 4x daily

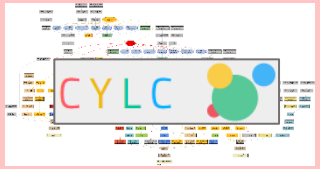
NZENS
- 18 members
- 4.5km resolution
- MOGREPS-G input
- 120 hour forecast 2x daily



NZCSM
- 1.5km resolution
- *3D-VAR data assimilation*
- NZLAM input
- 48 hour forecast 4x daily

AKLNWP
- 1.5km and 0.333km resolution
- NZLAM input
- 36 hour forecast 4x daily

Technical Development



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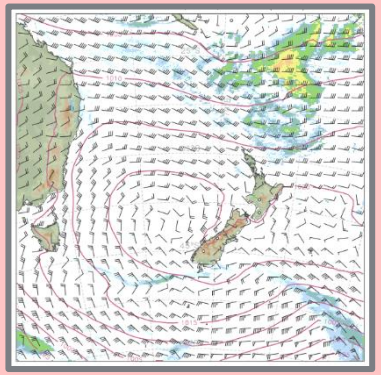

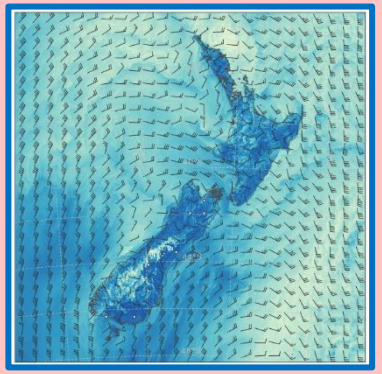

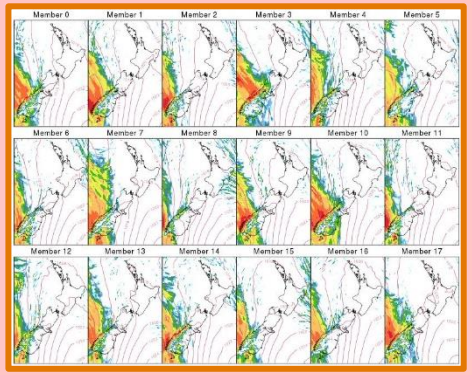

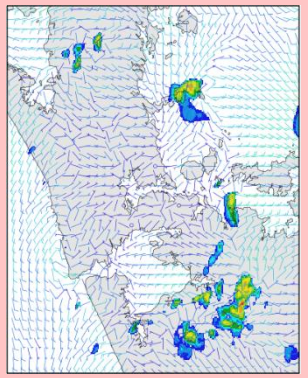

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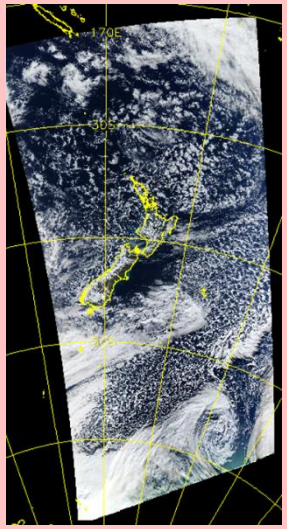
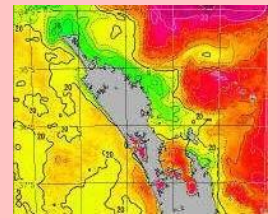
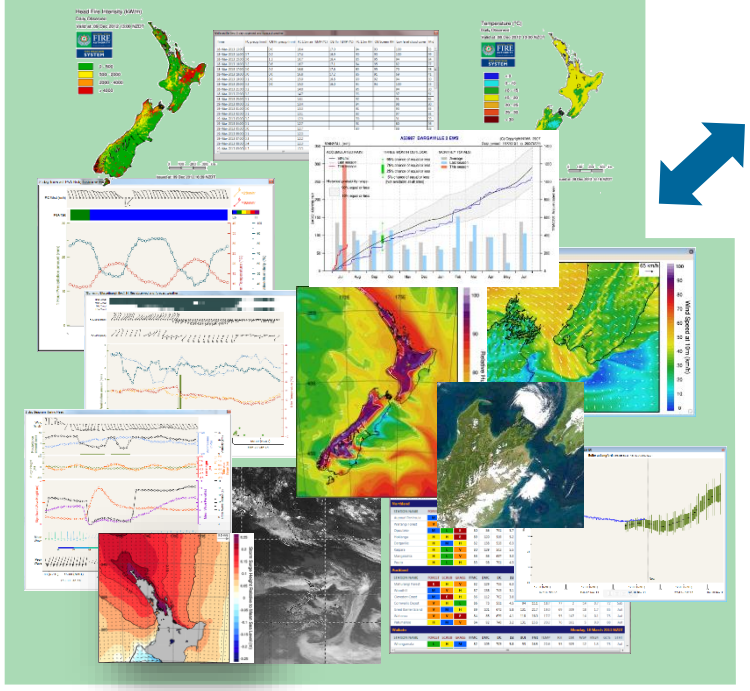




Operational Forecasting



Forecaster Services

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Technical Development

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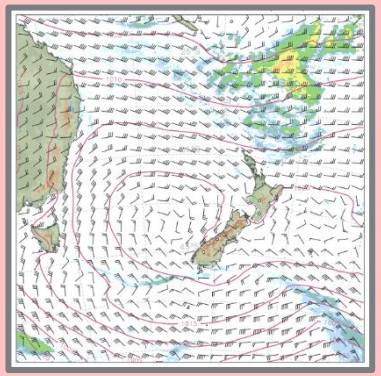

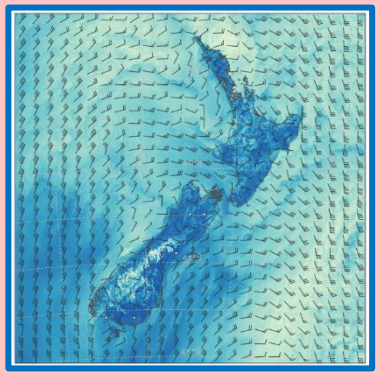

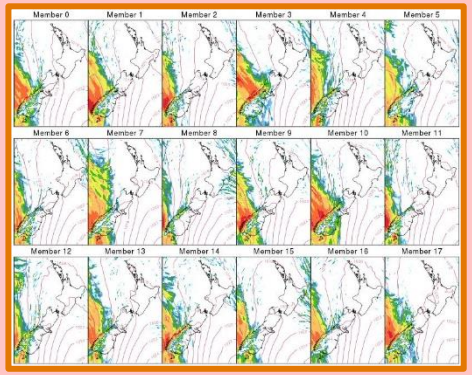

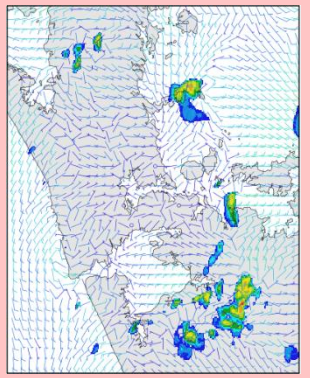

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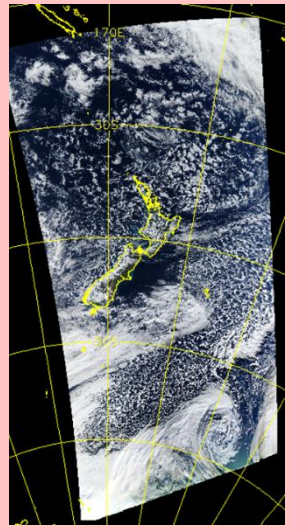

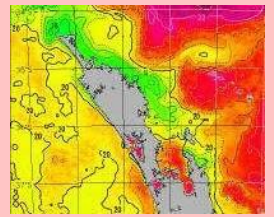

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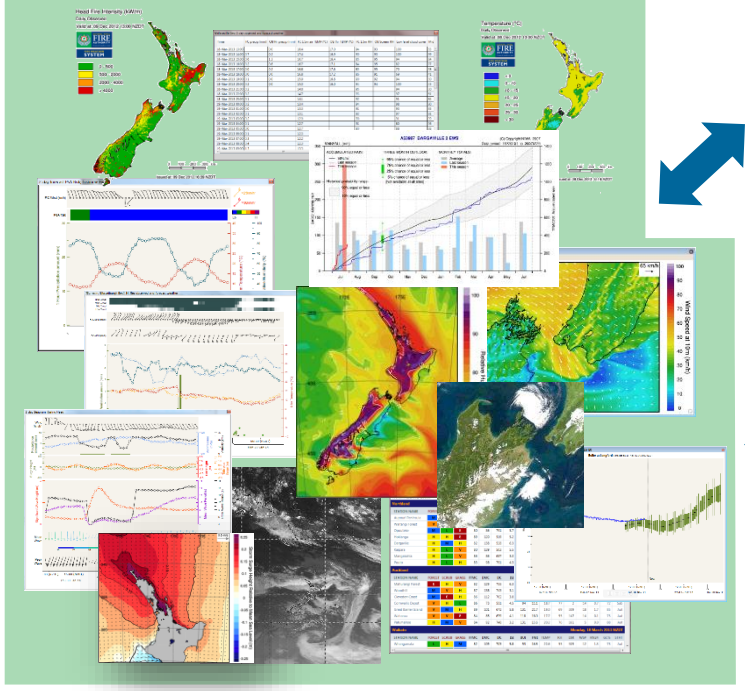

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Other Researchers

RESILIENCE TO NATURE'S CHALLENGES
Kia manawaroa – Ngā Ākina o Te Ao Tūroa
National SCIENCE Challenges

IRRIGATION Insight
ECONOMICALLY SOUND & ENVIRONMENTALLY RESPONSIBLE

CarbonWatch (NZ)
GUIDING CARBON MITIGATION STRATEGIES

Ministry for Primary Industries
Manatū Ahu Matua

Plant & Food RESEARCH
RANGAHAU AHUMĀRA KAI

Evolution of NIWA HPCs

	1999			
Name	Kupe			
System	Cray T3E			
# cores	128 (600Hz)			
Peak performance	153 Gflops			
Memory	19.5 GB			
Storage				

Evolution of NIWA HPCs

	1999	~2010		
Name	Kupe	FitzRoy		
System	Cray T3E	IBM p575 Power P6		
# cores	128 (600Hz)	1,792 (4.7GHz)		
Peak performance	153 Gflops	32,000 Gflops (-> 65,000 Gflops)		
Memory	19.5 GB	5.4 TB		
Storage		500,000 GB (-> 2x10^6 GB) (5 PB tape library)		

Evolution of NIWA HPCs

	1999	~2010	2017/2018 ->	
Name	Kupe	FitzRoy	Maui (NeSI/NIWA)	Maui_ancil
System	Cray T3E	IBM p575 Power P6	Cray XC50	CS500
# cores	128 (600Hz)	1,792 (4.7GHz)	NIWA Operations only gets 200 nodes	1,120 (2.4GHz, 28 nodes)
Peak performance	153 Gflops	32,000 Gflops (-> 65,000 Gflops)	1,425,000 Gflops	
Memory	19.5 GB	5.4 TB	66.8 TB	768 GB (per node)
Storage		500,000 GB (-> 2x10^6 GB) (5 PB tape library)	4,412 TB (scratch) 1,765 TB (persistent) (100 PB offline)	

Model resource comparison

	NZLAM-12 (retired)	NZLAM-4	NZENS (per member)	NZCSM	AKL 1.5km	AKL 333m
Domain Size	*324 x 324 x 70 (L70_80km)*	900 x 900 x 70 (L70_80km)	400 x 450 x 70 (L70_40km)	1200 x 1350 x 70 (L70_40km)	300 x 300 x 140 (L70_40km)	300 x 300 x 140 (L140_40km)
Dynamics timestep (Δt)	*300 s*	120 s	120 s	60 s	60 s	12 s
Forecast period / frequency	*T+75 (4x daily)*	T+75 (4x daily)	T+120 (2x daily)	T+51 (4x daily)	T+36 (4x daily)	T+36 (4x daily)
# HPCF cores	*272 (7 nodes)*	750 (38 nodes)	440 (11 nodes)	1200 (31 nodes)	256 (7 nodes)	256 (7 nodes)
Wallclock time	*~20 mins*	~60 mins	~45 mins	~145 mins	~15 mins	~135 mins
Storage/cycle		822GB	715GB	700GB	20GB	30GB

Forecast model only

NWP Software used and HPC resource

	Software used	Use XC50?	Use CS500?
Prep	Shell scripts		Y
Polling	Cylc task polling, shell scripts		Y
Source	Shell scripts, LFTP, SFTP		Y
Obs processing & DA	UK Met Office OPS and VAR code (Fortran, C, IDL)	Y	
Soil Moisture DA	UK Met Office SURF code (Fortran, C)	Y	
Obs & DA Monitoring	IDL, R		Y
Lateral Boundaries	UK Met Office UM code (Fortran, C)	Y	
UM	UK Met Office UM code (Fortran, C)	Y	
Postprocessing	Shell scripts, R, NCL, C, Python	Y	Y
Ensemble Processing	Shell scripts, R, NCL, C, Python		Y
Verification	R, Python		Y
Housekeeping	Shell scripts		Y

NWP Research

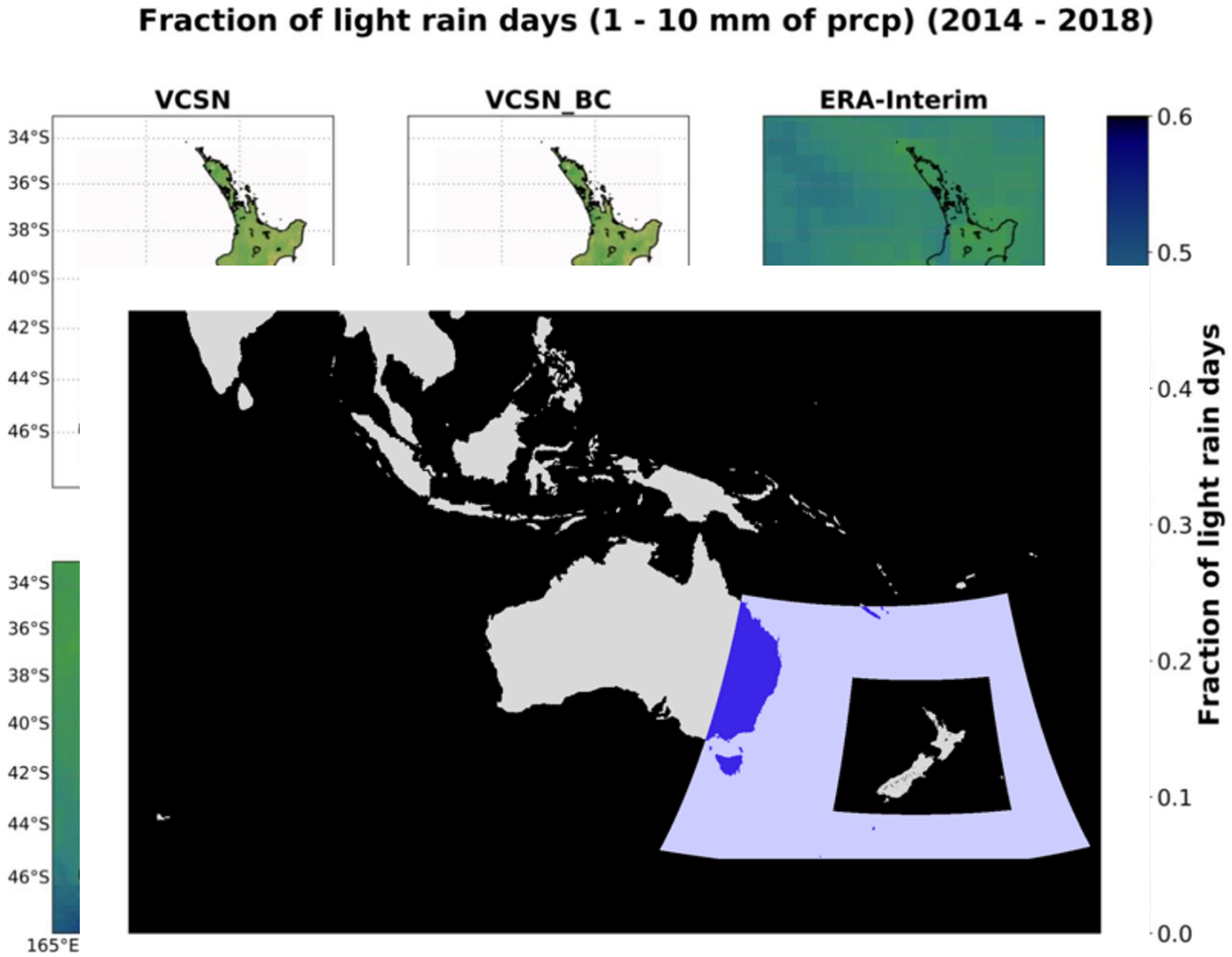
- Model updates, site-specific forecasts and evaluation and R20

NWP Research

- Model updates, site-specific forecasts and evaluation and R20
- Cross-NIWA collaboration with downstream modellers
  - Hydrology (TopNet)
  - Inundation and Coastal (RiCOM, Basilisk & BG-Flood)
  - Wave modelling (Wavewatch III, SWAN) incl. Regional Coupled Modelling (Auckland Model <> Wavewatch III)
  - Hydrodynamics (Delft3D)
  - RiskScape

NWP Research

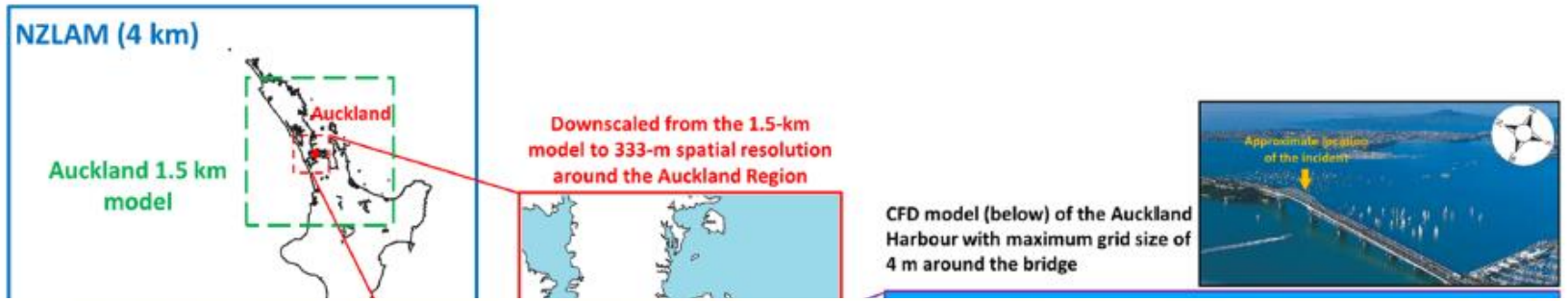
- Model updates
- Cross-NIWA collaboration with d
- NZ Reanalysis

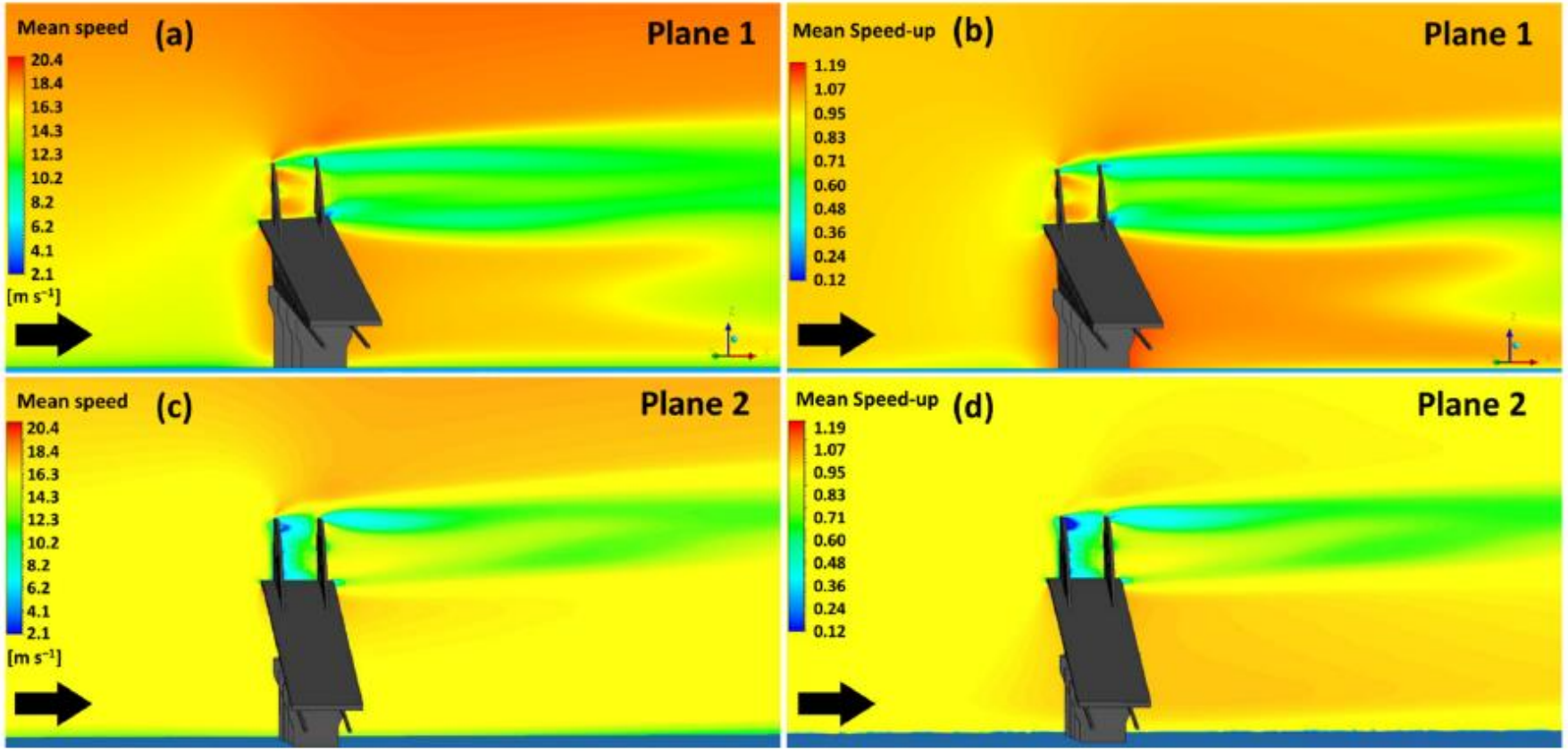


BARRA-R 12km reanalysis domain with NZLAM and NZCSM domains shown.

NWP Research

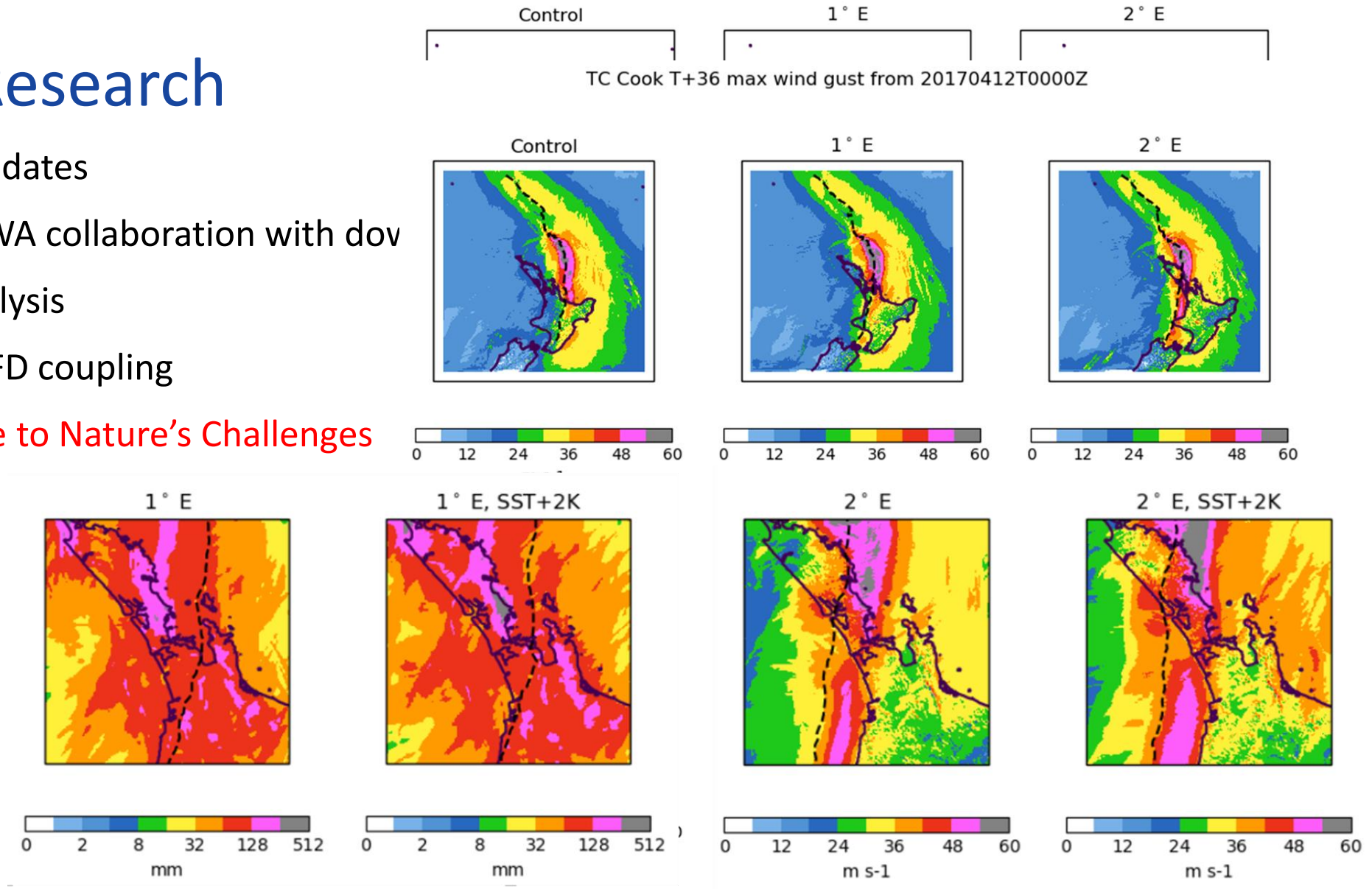
- Model updates
- Cross-NIWA collaboration wi
- NZ Reanalysis
- NWP – CFD coupling





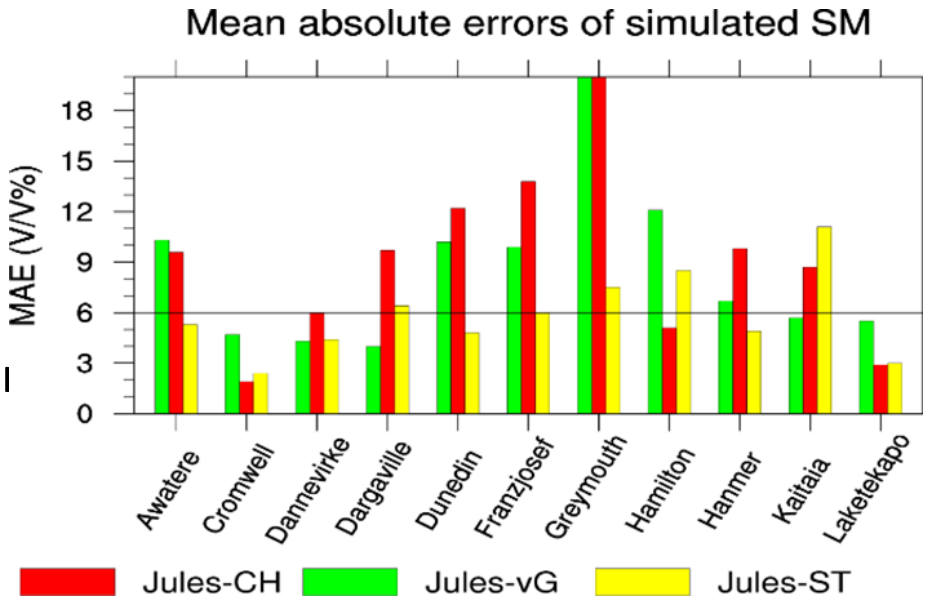
NWP Research

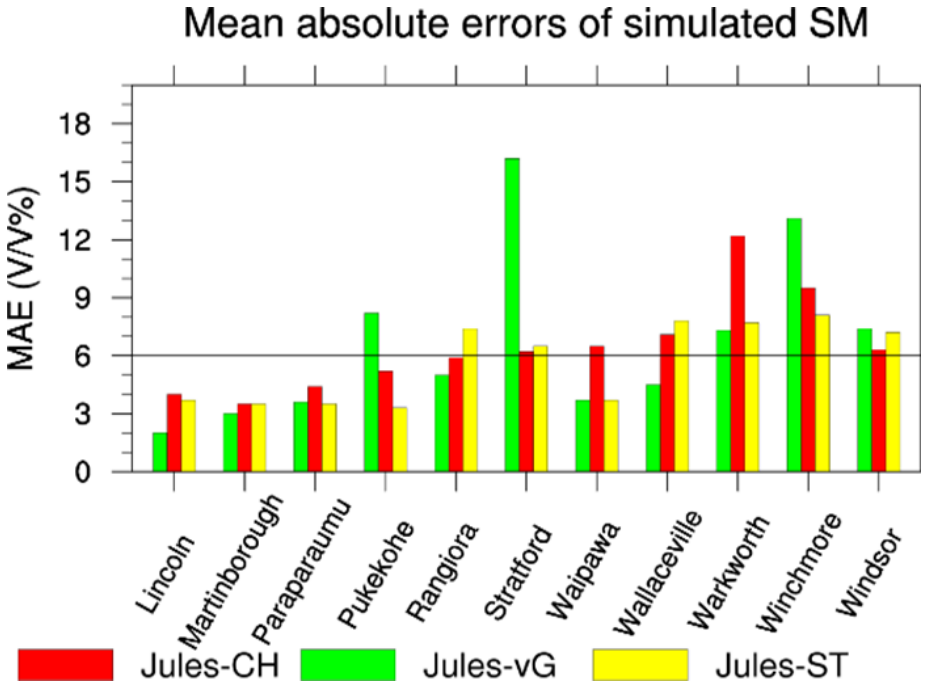
- Model updates
- Cross-NIWA collaboration with dov
- NZ Reanalysis
- NWP – CFD coupling
- Resilience to Nature's Challenges



NWP Research

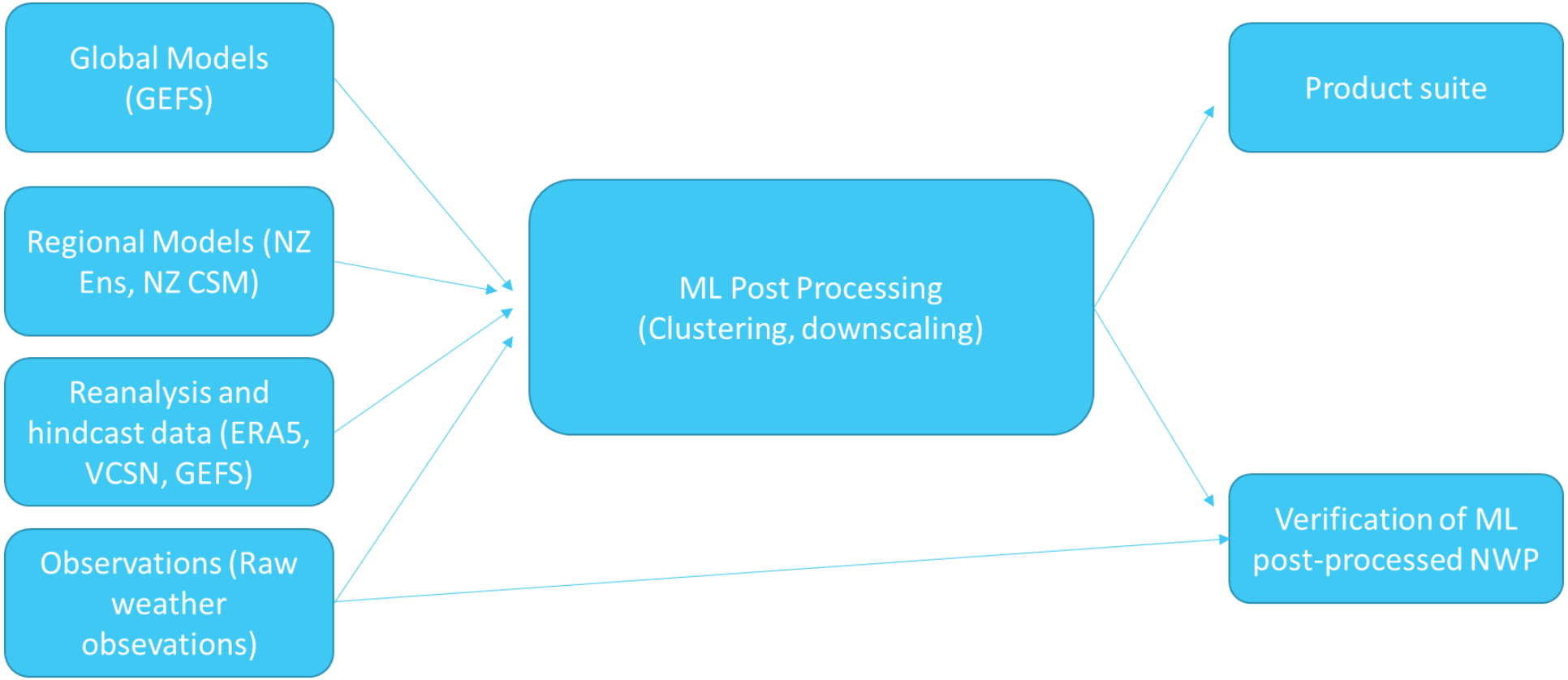
- Model updates
- Cross-NIWA collaboration with downstream
- NZ Reanalysis
- NWP – CFD coupling
- Resilience to Nature's Challenges
- Land Surface





Data Science / ML

- Develop a post-processing ML Ops workflow



Thank You

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