NIWA and UK Met Office Science Overview

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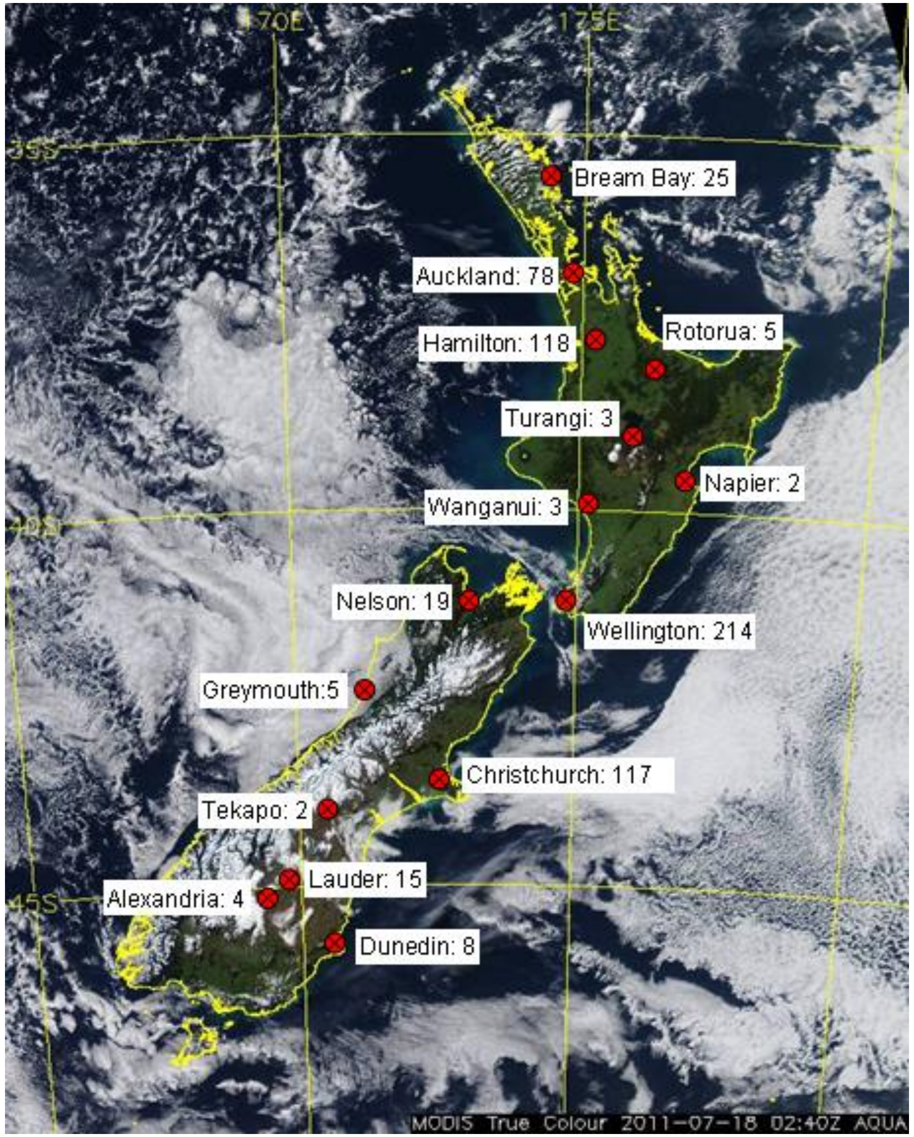
National Institute of Water & Atmospheric Research – A Primer

- Crown Research Institute (NZ Government owned)
  - NIWA's purpose is to enhance the economic value and sustainable management of New Zealand's aquatic resources and environments, to provide understanding of climate and the atmosphere and increase resilience to weather and climate hazards to improve the safety and wellbeing of New Zealanders.
- 618 staff (excl. Vessels)
  - 15 sites (including Lauder)
- Key assets/capabilities:
  - Observing networks & instrumentation;
  - Climate Database
  - Supercomputer;
  - Satellite reception systems;
  - Operational NWP production & delivery systems;
  - Science staff.
- Member of Unified Model Consortium: UK Met Office research collaboration.



NIWA Weather and Climate Research Themes

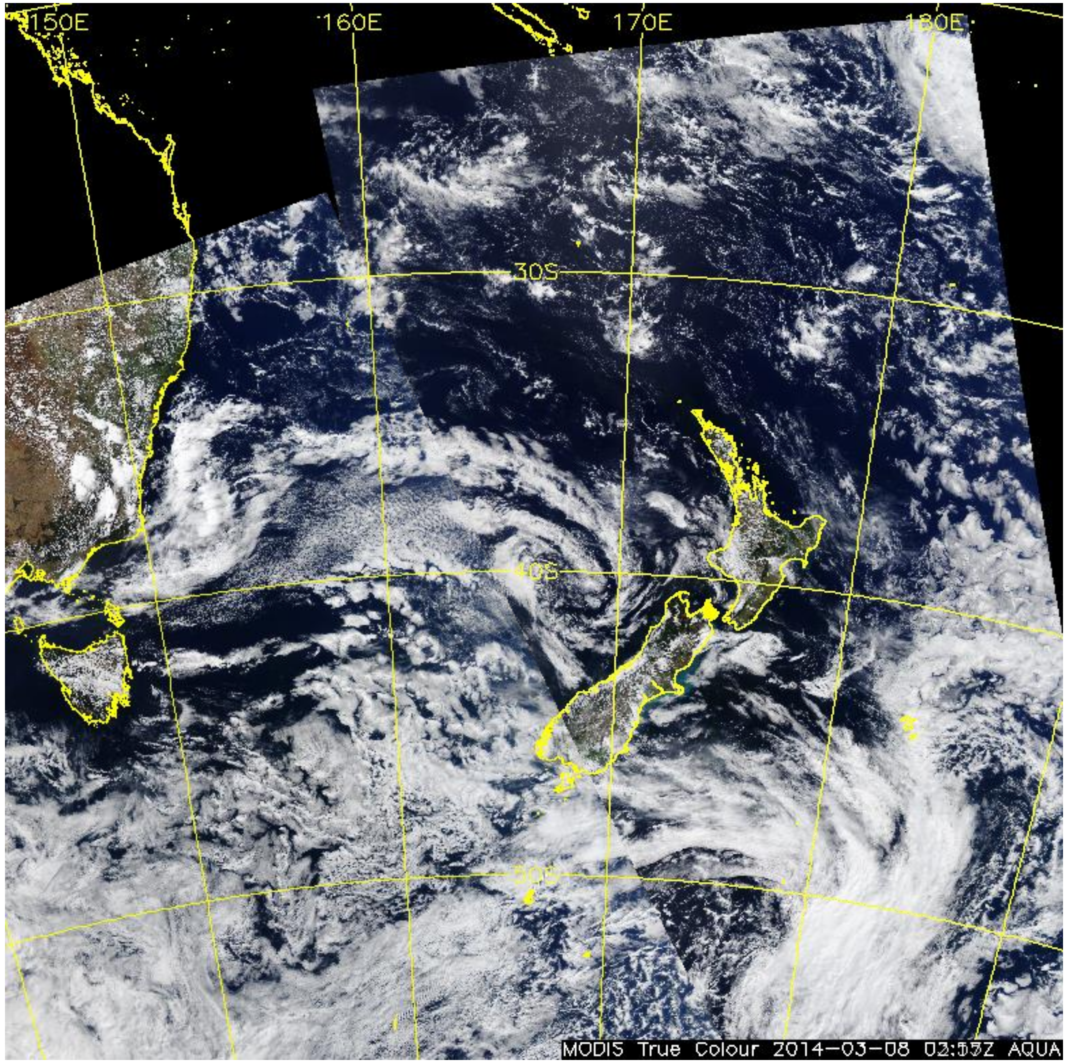
- Numerical Weather Prediction:
  - Data Assimilation (ATOVS, AIRS, IASI, GPS-RO, etc., B Matrix), 3DVAR, FGAT VAR, 4DVAR;
  - Model performance & process evaluation: for parametrized convection (NZLAM) and resolved convection (NZCSM) formulations – verification, and post processing;
  - Very high resolution simulations – down to 100 m resolution over 60 × 60 km domains;
  - Land Surface processes;
  - High resolution ensemble prediction;
  - Primary tool: UK Met Office Unified Model System: UM, OPS, VAR, CVT, Rose, Cylc, etc.
- Regional Climate Simulation:
  - Climate predictions/projections from seasonal to centennial scale;
  - Gravity Wave Drag parametrization;
  - Primary tool: HadGEM3.x RC. (i.e. Unified Model), GA3

Scientific Questions: NIWA NWP Research

- To model / simulate observed gravity wave structure and downslope wind storms:
  - What vertical and horizontal resolution is needed to simulate observed wave activity, and what are the advantages (or not) of the new ‘ENDGame’ dynamical core?
  - What physics settings are needed to best simulate the observations;
  - How sensitive is the simulation to the initial/upstream conditions?
  - Do current operational observing systems (e.g. AMSU, AIRS, IASI, AMDAR, CDW, Scatterometer, GPS-RO, RAOB, SHIP, SYNOP, DRIBU etc.) together with Variational DA systems provide enough information to adequately specify the initial conditions?
  - What additional forecast accuracy can be gained by incorporating Deepwave observation system data (e.g. dropsondes, campaign RAOBs, profiler) in the DA scheme.
- And…
  - How well does output from the operational NZLAM and NZCSM forecast systems verify against Deepwave upper level observations etc.?

New Zealand Limited Area Model (NZLAM)

- Domain: 324 × 324 × 70 (80 km top);
- Computational Grid: Rotated latitude / longitude;
- Resolution: 12 km (parametrized convection)
- Dynamics time step: 300 s;
- Physics time step: 3600 s;
- DA: FGAT VAR (IAU: AT ± 3h), 12 km resolution:
  - Surface, Aircraft, ATOVS, IASI, AIRS, SSMI, GPS-RO, Satwind, Scatwind).
- LBCs: 3 hourly, from UM Global model;
- Forecast period: 48 h (increasing to 72 h);
- Frequency: (4× daily), AT: 00, 06, 12, 18 UTC, available at AT + 4 h 25 min;
- Output frequency: hourly.



New Zealand Convective Scale Model (NZCSM)

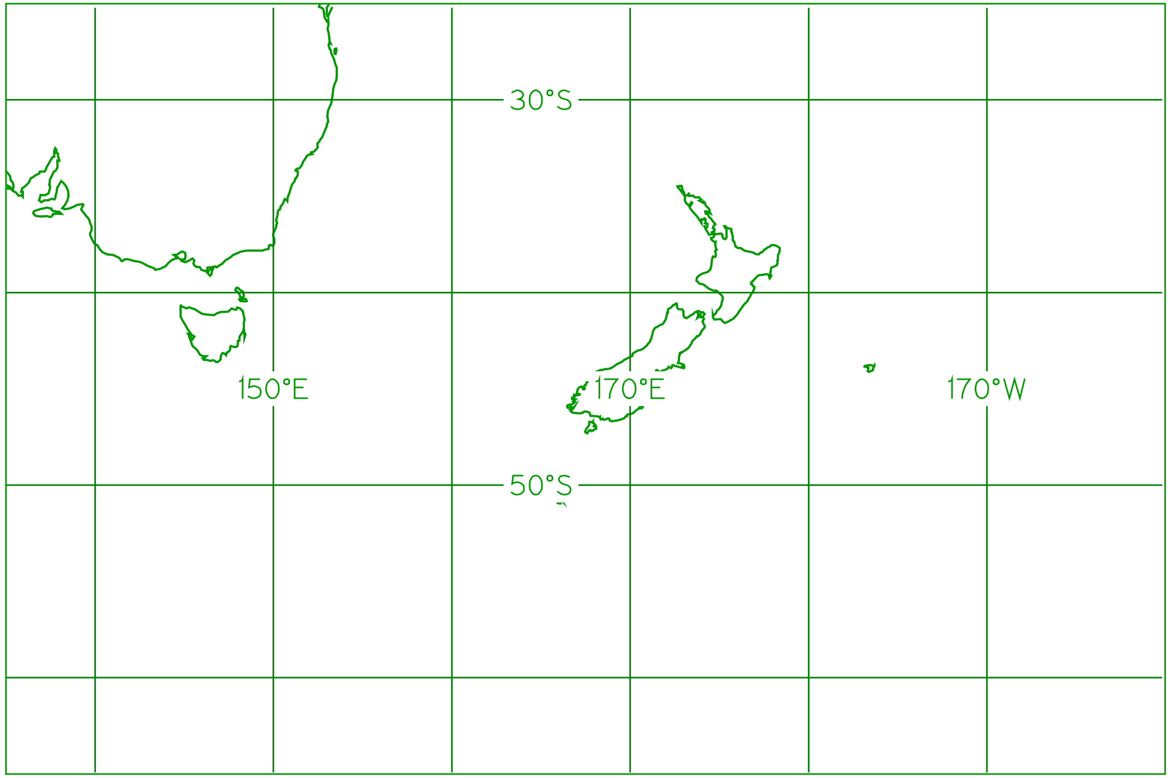
- Domain: 1200 × 1350 × 70 (40 km top);
- Computational Grid: Rotated latitude / longitude;
- Resolution: 1.5 km (explicit convection)
- Dynamics time step: 50 s;
- Physics time step: 600 s;
- DA: Pseudo analysis (FGAT VAR, IAU AT ± 1h research);
  - Surface, Aircraft, ATOVS, IASI, AIRS, SSMI, GPS-RO, Satwind, Scatwind);
- LBCs: 30 minute, from NZLAM;
- Forecast period: 36 h;
- Frequency: (4× daily), AT: 03, 09, 15, 21 UTC, available at AT + 6 h 15 min
- Output frequency: 30 minutes.

Scientific Questions: UK Met Office NWP Research (Vosper)

- Use DEEPWAVE observations to determine the UM's ability to explicitly capture the generation and propagation of gravity waves through the lower and middle atmosphere. Understand how this is affected by resolution (both horizontal and vertical).
- Understand the relative importance of orographic vs non-orographic gravity waves and what part of the spectrum is most important for the wave drag.
- Improve parametrizations of orographic and non-orographic schemes. An important aspect is the handover between resolved and unresolved waves and the gravity wave "greyzone". Do spurious waves exist in the models?
- Use observations and high resolution modelling of the tropospheric orographic processes (flow blocking, wave breaking) to improve the low-level aspects of the drag parametrization schemes.

UM Global: N768L70

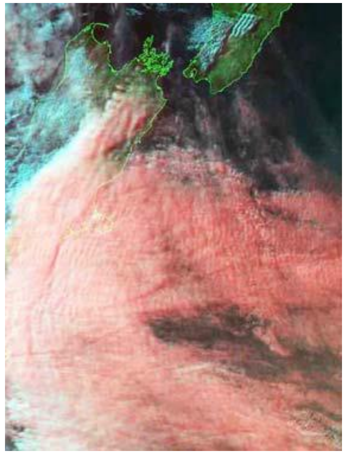
- Domain: 1536 × 1152 × 70 (80 km top);
- Computational Grid: Rotated latitude / longitude;
- Resolution: 17 km (mid-latitudes)
- Dynamics: ENDGame, GA6.1
- Data Assimilation: 4DVAR, inner loop N320 ≈40 km;
- Domain Cutout:
  - BLC: 65°S, 135°E
  - TRC: 25°S, 160°W
- Frequency: (4× daily)
  - 00 and 12 UTC to T+144 h
  - 06 and 18 UTC to T+78 h
- Output Frequency: 3 h (or better)

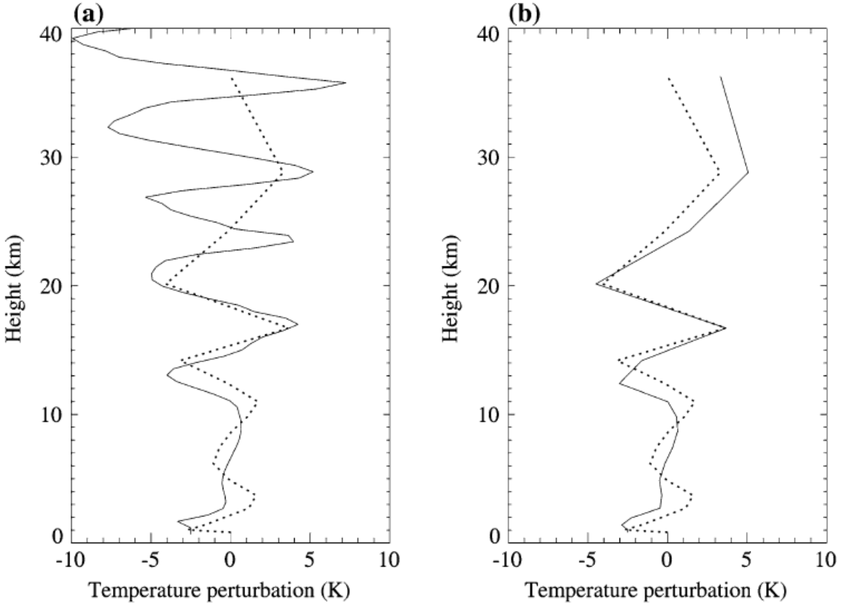


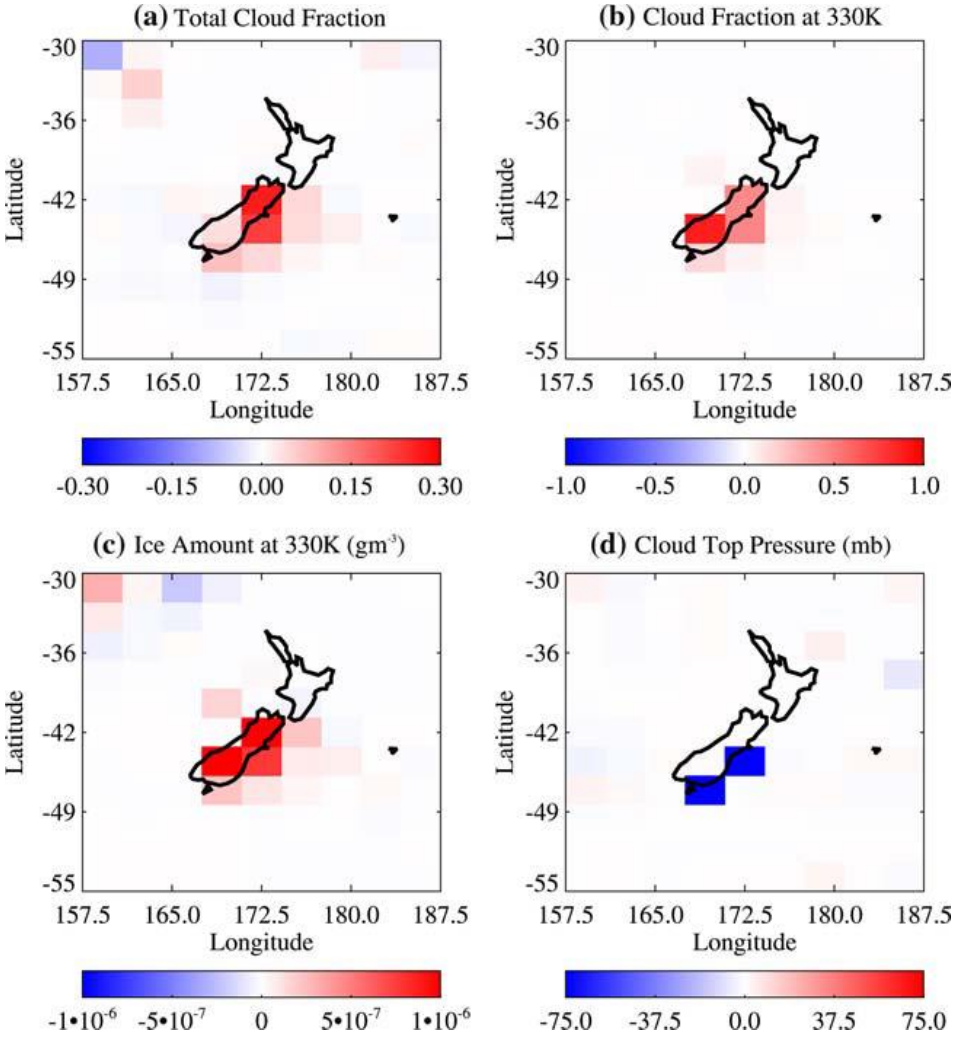
Cutout for UM Global, N768T70 model output

Scientific Questions: Climate Research

- To parametrize gravity wave impacts: parametrization of orographic cirrus, polar stratospheric clouds, and chemistry. e.g. Dean et al. 2007, Orr et al. 2014.

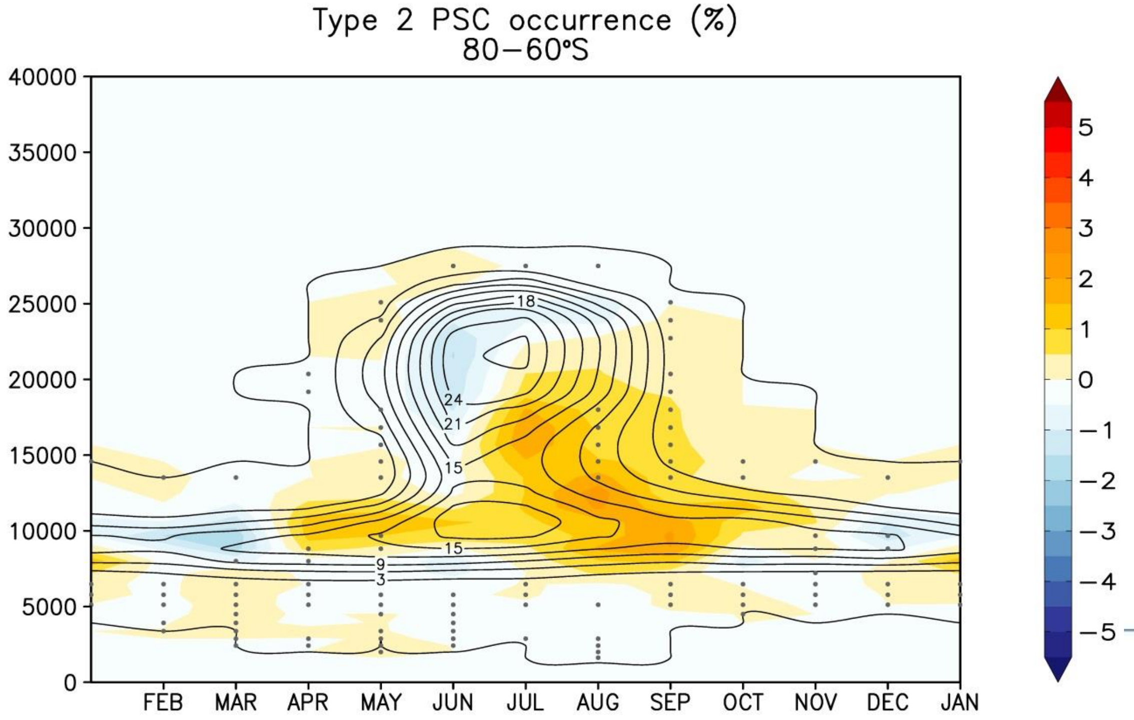


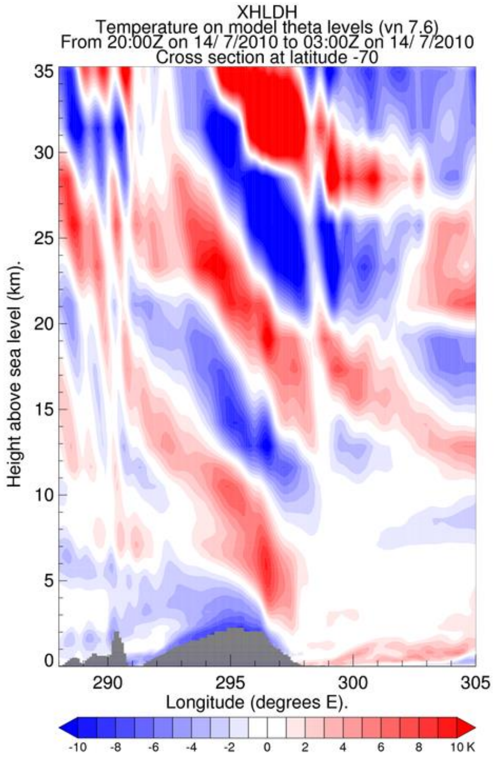


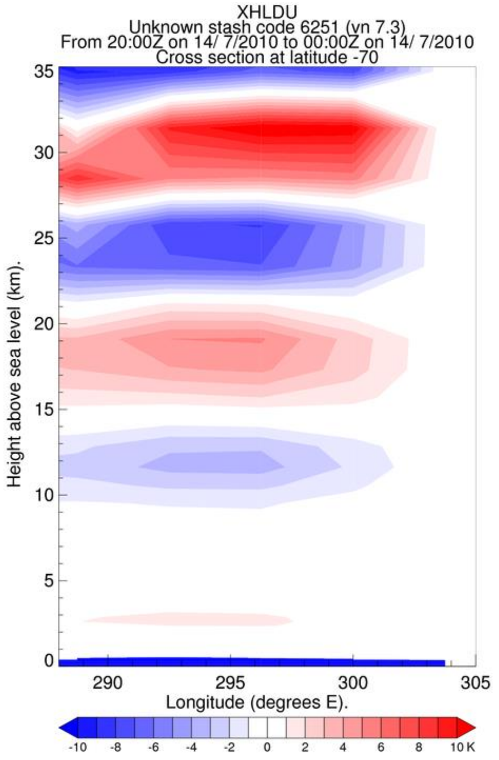


Polar Stratospheric Clouds: Orr et al 2014.

- Gravity wave scheme of Dean et al 2007, implemented in Met Office Hadley centre model HadGEM3-UKCA by Andrew Orr at BAS. Scheme passes temperature perturbation to chemistry scheme to model PSCs over Antarctic Peninsula and other chemical reactions sensitive to temperature.





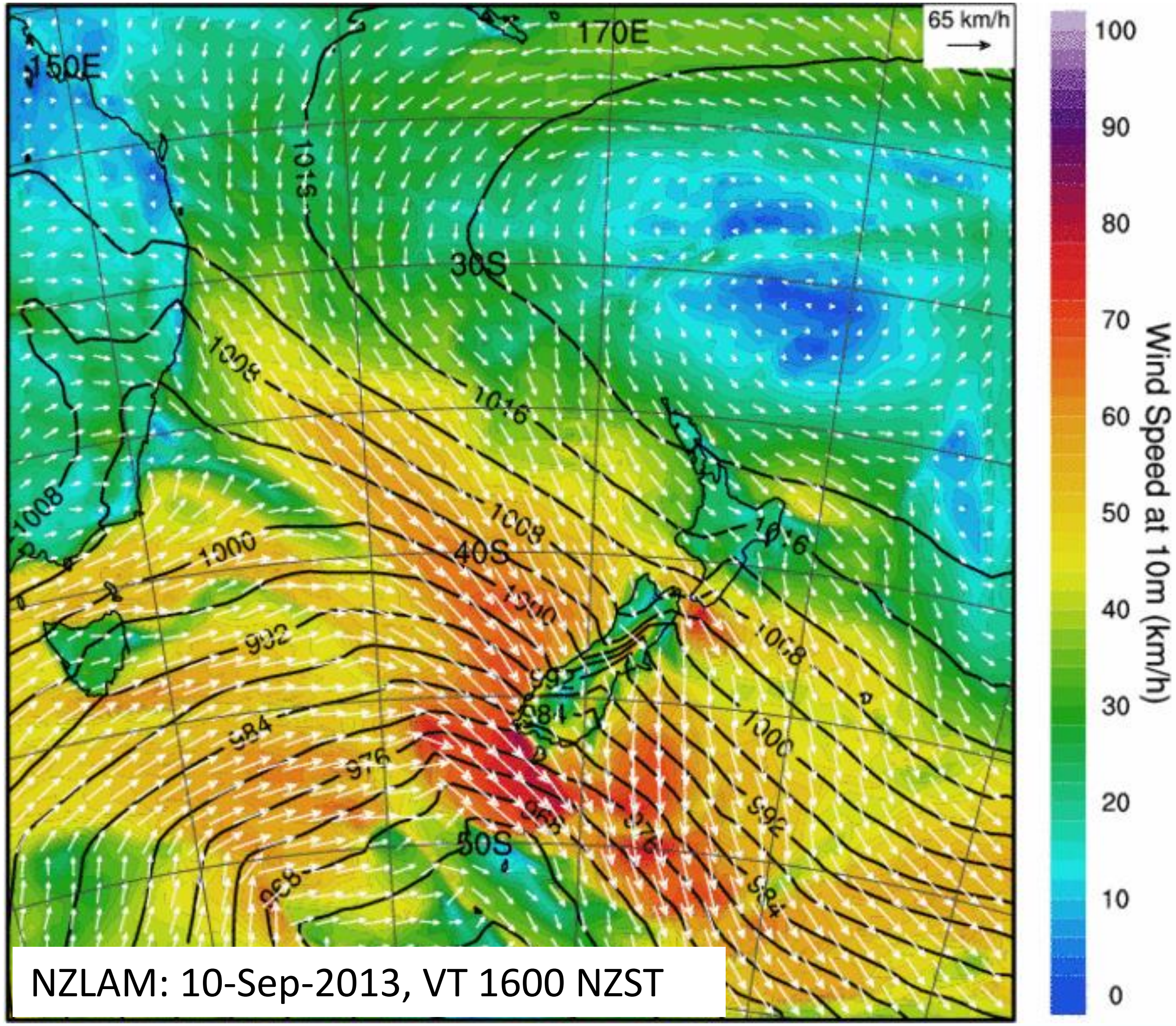


Summary

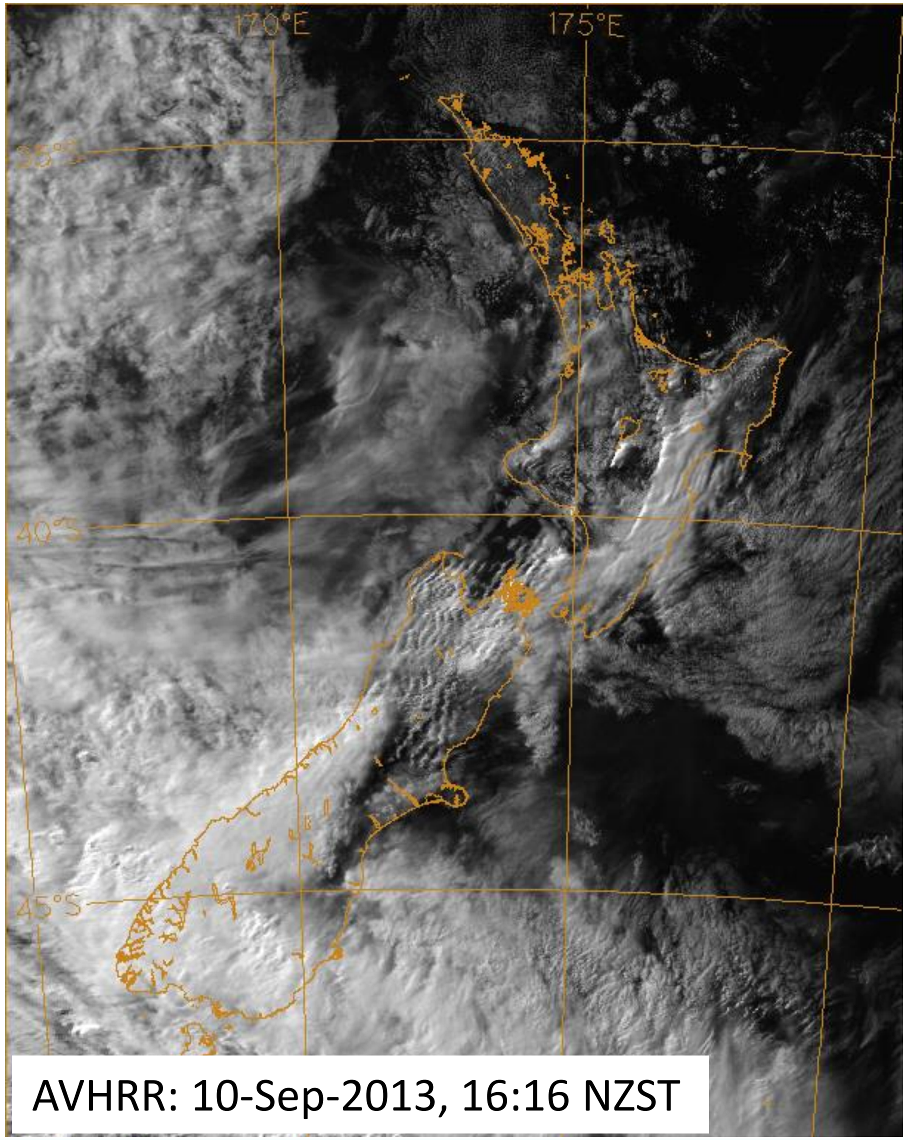
- NIWA and the Met Office see the Deepwave Experiment as an ideal opportunity to gain insight into the performance of the new ENDGame dynamical core within the Unified Model (and to compare with other modelling systems), and to:
  - Investigate and compare the performance of the ENDGame core versus the New Dynamics core (with respect to GWs from all sources);
  - Investigate model physics and observational sensitivities;
  - Examine observation impacts on the data assimilation system;
  - Improve GWD parametrization schemes.
- NIWA science staff (investigators) can provide forecast guidance / interpretation during the field campaign (telephone, VC, and on site).

Additional Plots

Severe Downslope Wind Event: 10-Sep-2013

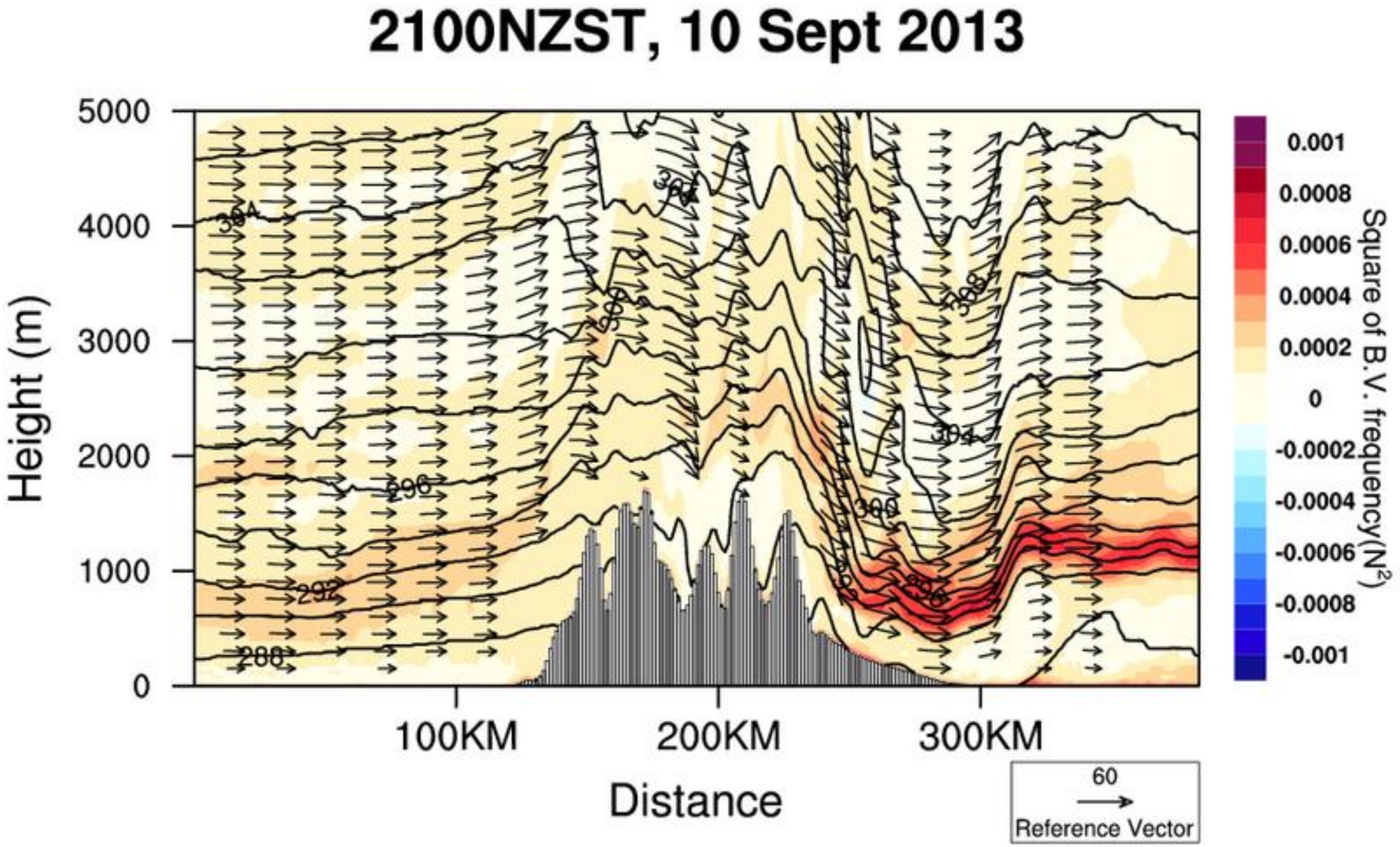


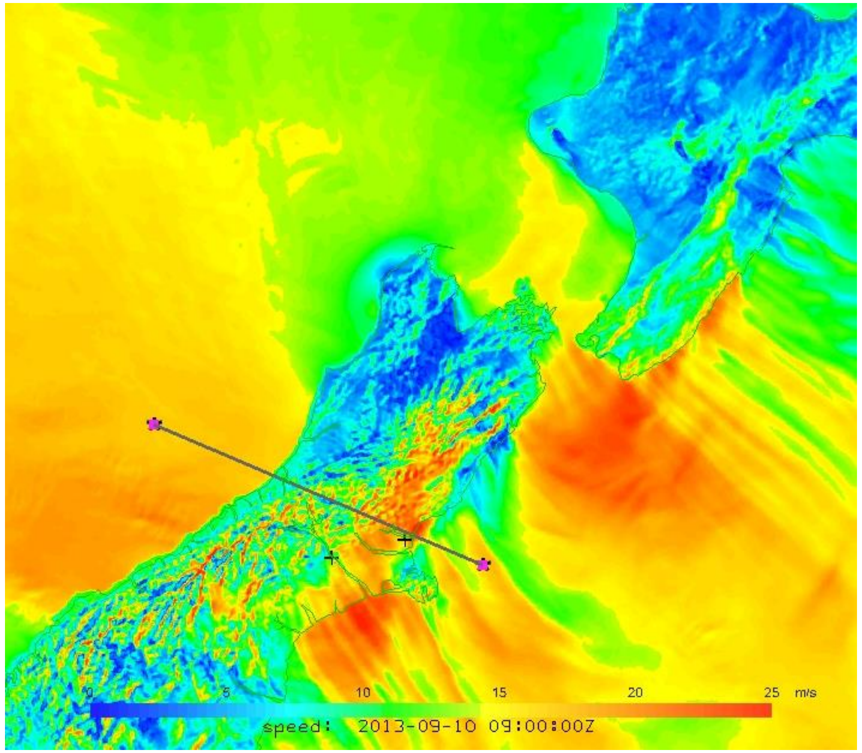
NZLAM: 10-Sep-2013, VT 1600 NZST



AVHRR: 10-Sep-2013, 16:16 NZST

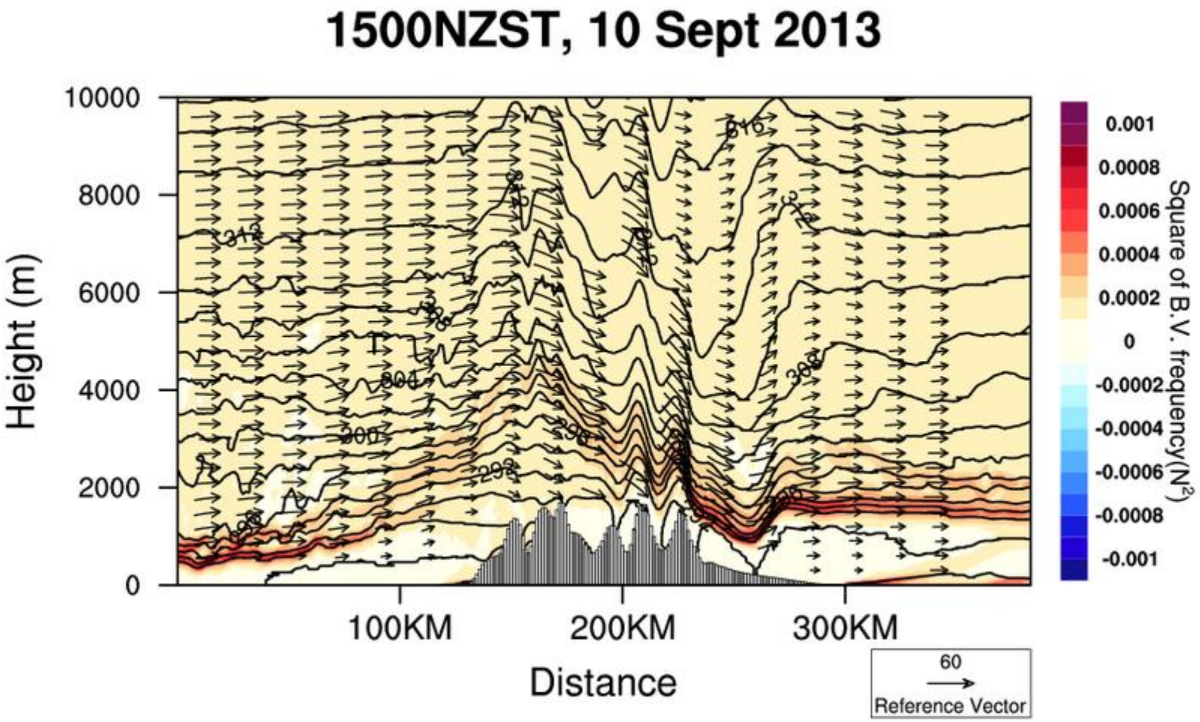
NZCSM Cross Sections: Theta, Wind, (Brunt-Väisälä Frequency)^2

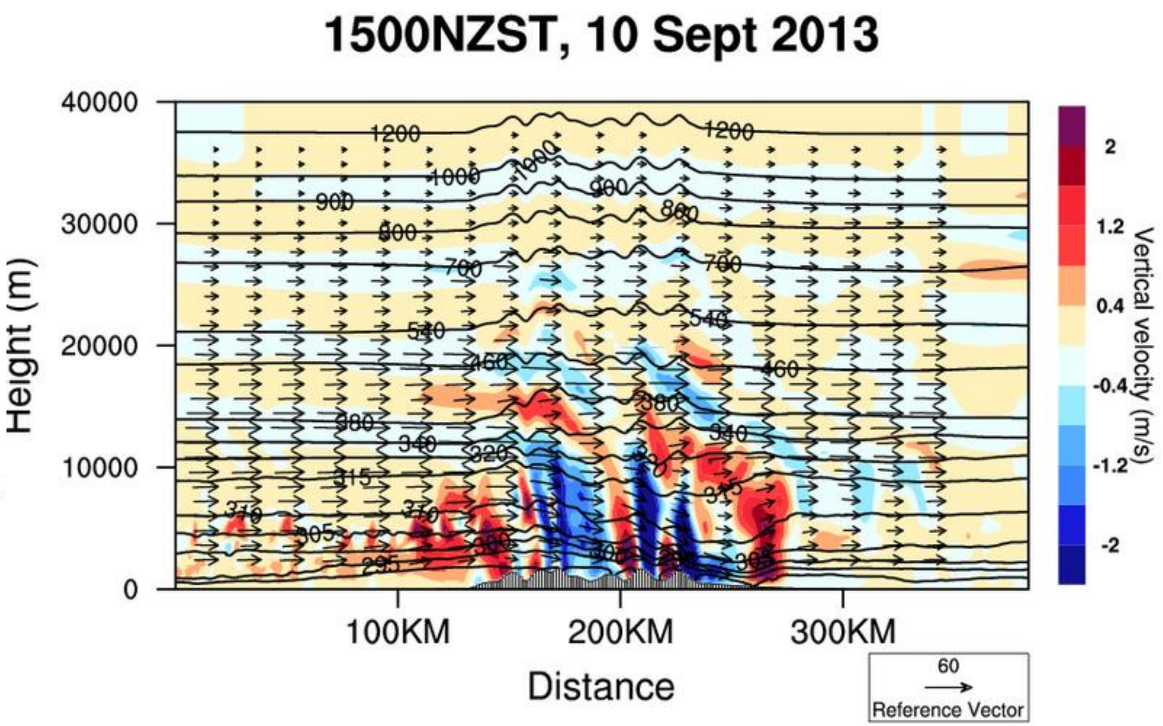




One hour prior to the onset of high winds observed at Rangiora (for 2 hours only).

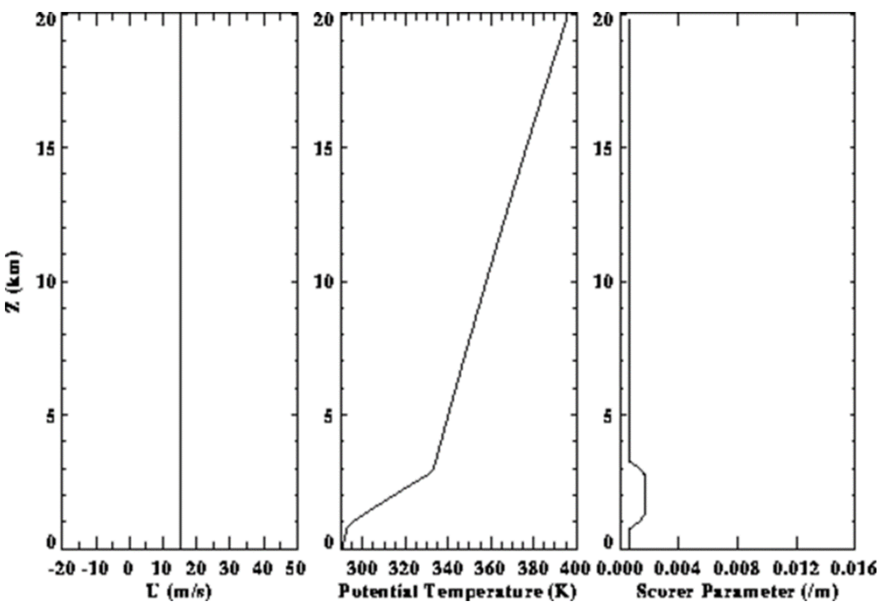
NZCSM Cross Sections: Theta, Wind, (Brunt-Väisälä Frequency)^2, w



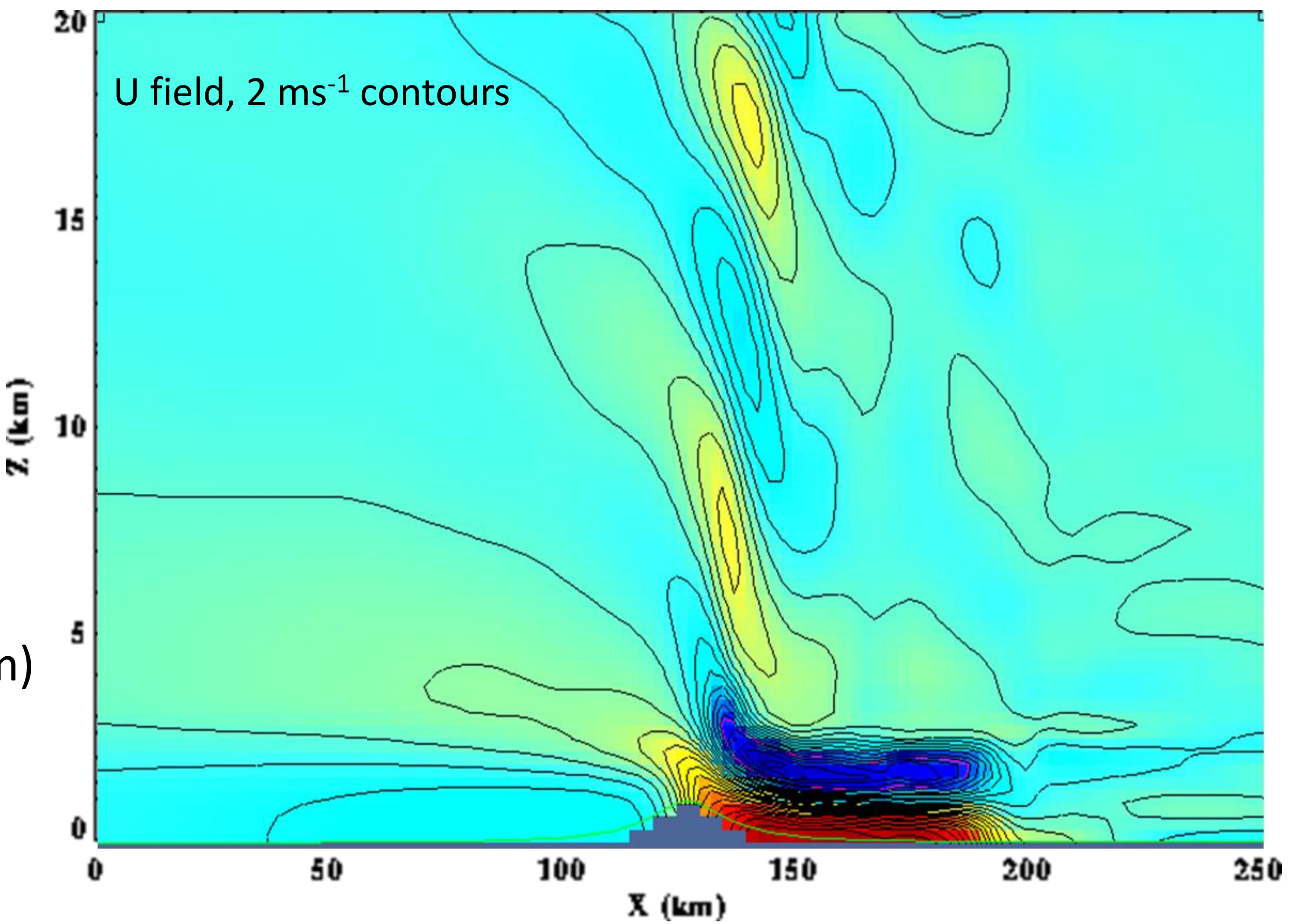


- Time at which high sustained winds were observed at inland Canterbury sites (and 1 h before the NOAA daytime pass);
- Left: 0 – 10,000 m: Theta, u,w (along cross-section), (Brunt-Väisälä Frequency)^2 ;
- Right: 0 – 40,000 m w (vertical velocity).

Idealised Model: Stable Layer at top of Mountain

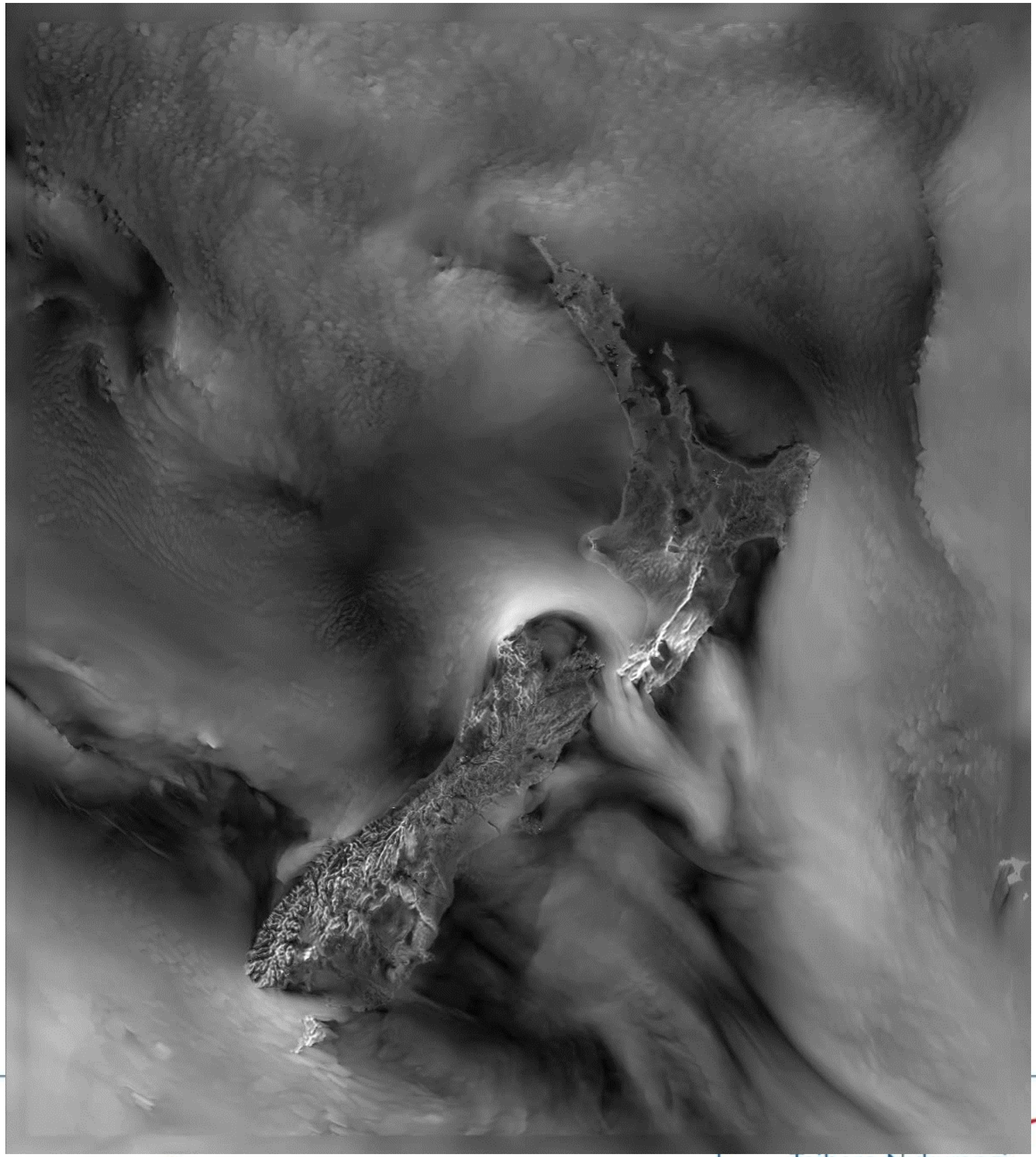


- U = 15 ms^{-1}
- N^2 = 1, 6.52 (1 km), 1 × 10^{-4} s^{-2} (3km)
- H = 1 km, H_w = 10 km
- In this configuration we get a lee slope wind event and upward propagating gravity waves.



Numerical Weather Prediction: NZCSM

- NZ Convective Scale Model;
- Unified Model (UM8.4, PS33 (ND));
- 1200 × 1350 × 70 levels:
  - 38 levels in the Boundary Layer (≈5 km), 40 km top;
  - 1.5 km resolution;
  - “New Dynamics” dynamical core;
  - 50 s (dynamics) time step.
- Explicit convection;
- Explicit gravity waves;
- JULES Land Surface Model;
- LBCs (from NZLAM 12 km model, 30 min – NZLAM includes full Variational DA);
- NZCSM pseudo-analysis (3DVAR planned), cycled 3 hourly, 4x daily to 36 h.



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