National Institute of Water and Atmospheric Research (NIWA)

NIWA
Taihoro Nukurangi

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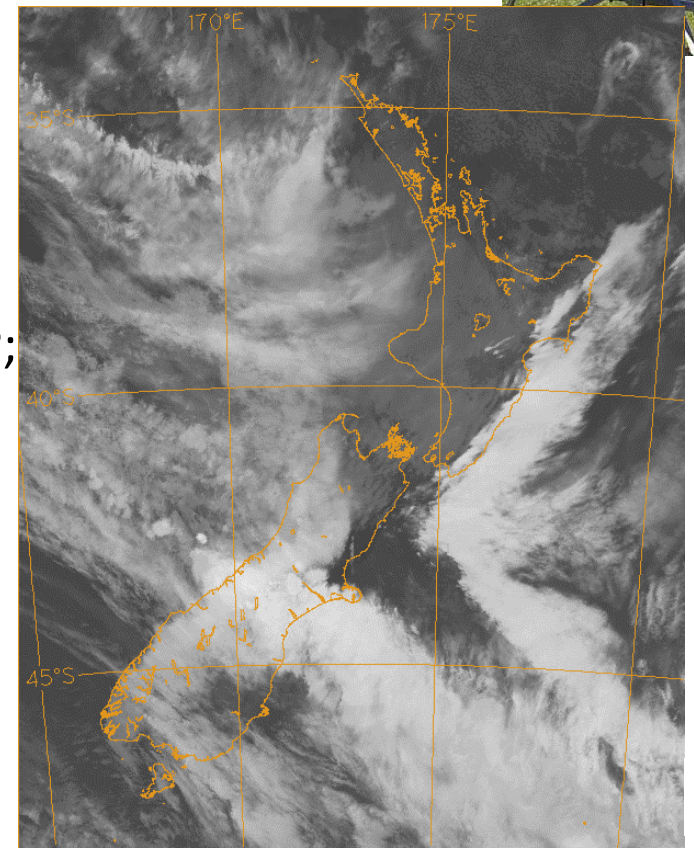
Outline

- Overview of NIWA scientific focus (wrt Deepwave)
- Science Questions / Objectives:
  - NWP;
  - Climate;
  - UK Met Office.
- Facilities:
  - Observing network;
  - Mobile UT/UW, Lidars, High elevation P;
  - Satellite receivers;
  - Operational NWP models;
  - Research NWP models.
- Potential areas of collaboration;
- Data
- Summary

More than 800 like this…



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10-Sep-2013, 2223 NZST

Overview of NIWA Weather and Climate Modelling Research

- Research (outcome) focus: Natural Hazards Mitigation (Weather, Flood, Inundation, Sea State, Sea Level, Landslide, …):
  - 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;
    - 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
  - Making climate predictions/projections from seasonal to centennial scale
  - Understanding climate variability and change
  - Improving global and regional climate models
  - Primary tool: HadGEM3.x RC.

Scientific Questions: NIWA NWP Research

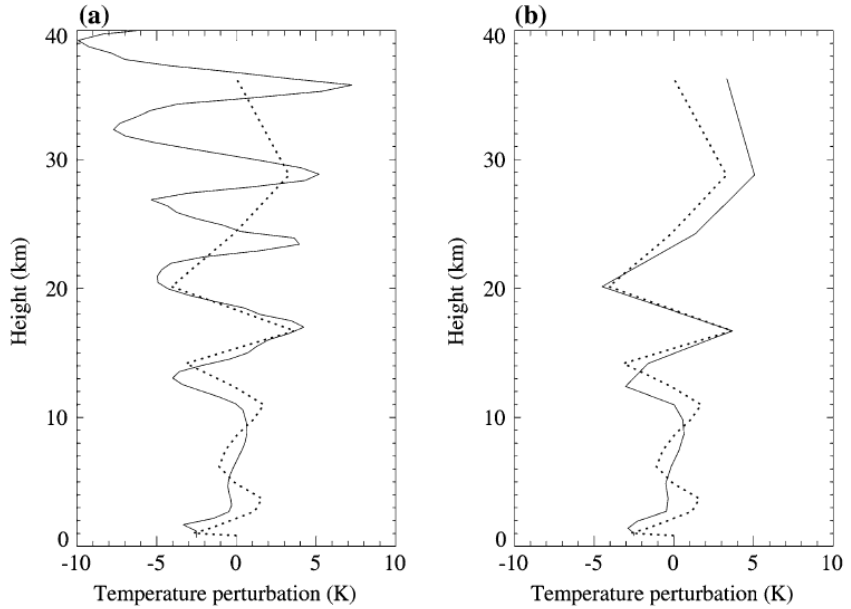
- In order to model / simulate observed gravity wave structure and downslope wind storms:
  - What vertical and horizontal resolution is needed to simulate observed wave activity, and what are the advantages of the 'ENDGame' dynamical core over the 'New Dynamics' core.
  - What physics settings are needed to best simulate the observations;
  - How sensitive is the simulation to the 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.?

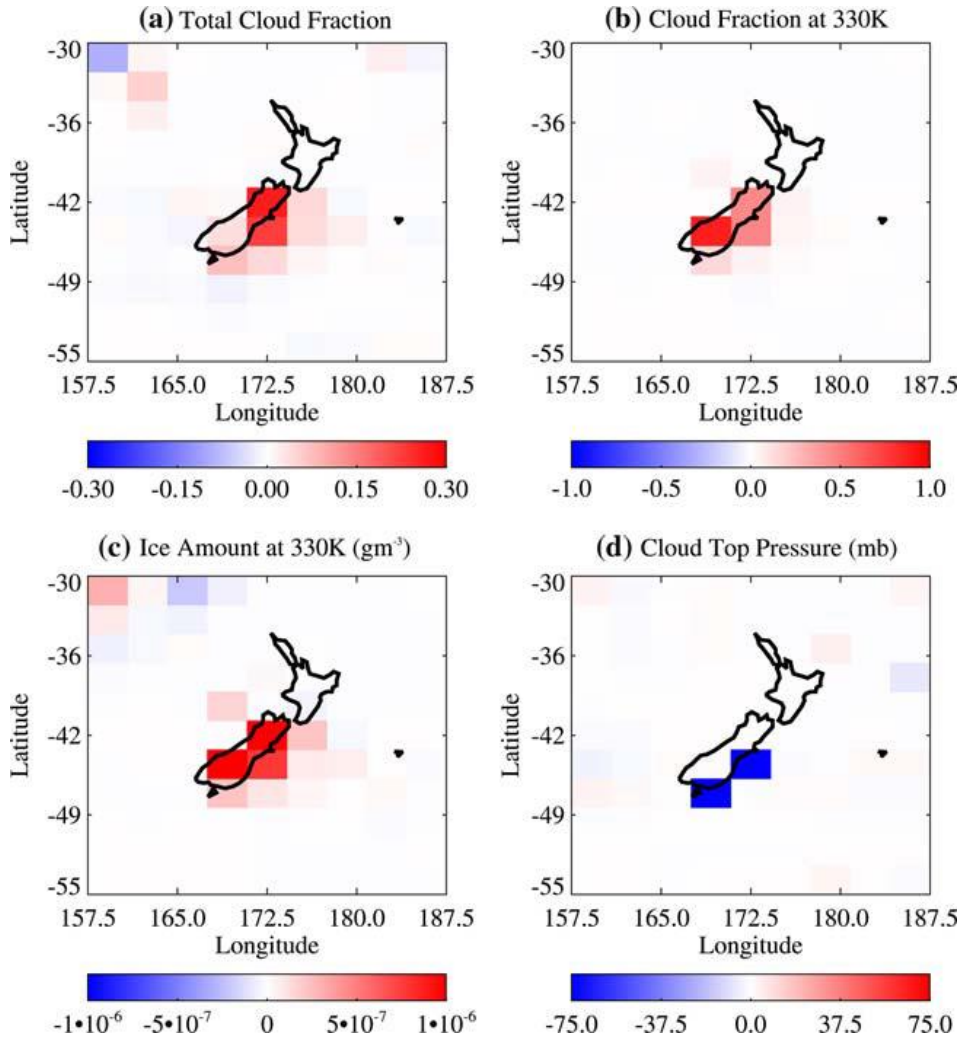
Scientific Questions: UK Met Office NWP Research (Vosper)

- 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.

Scientific Questions: Climate Research

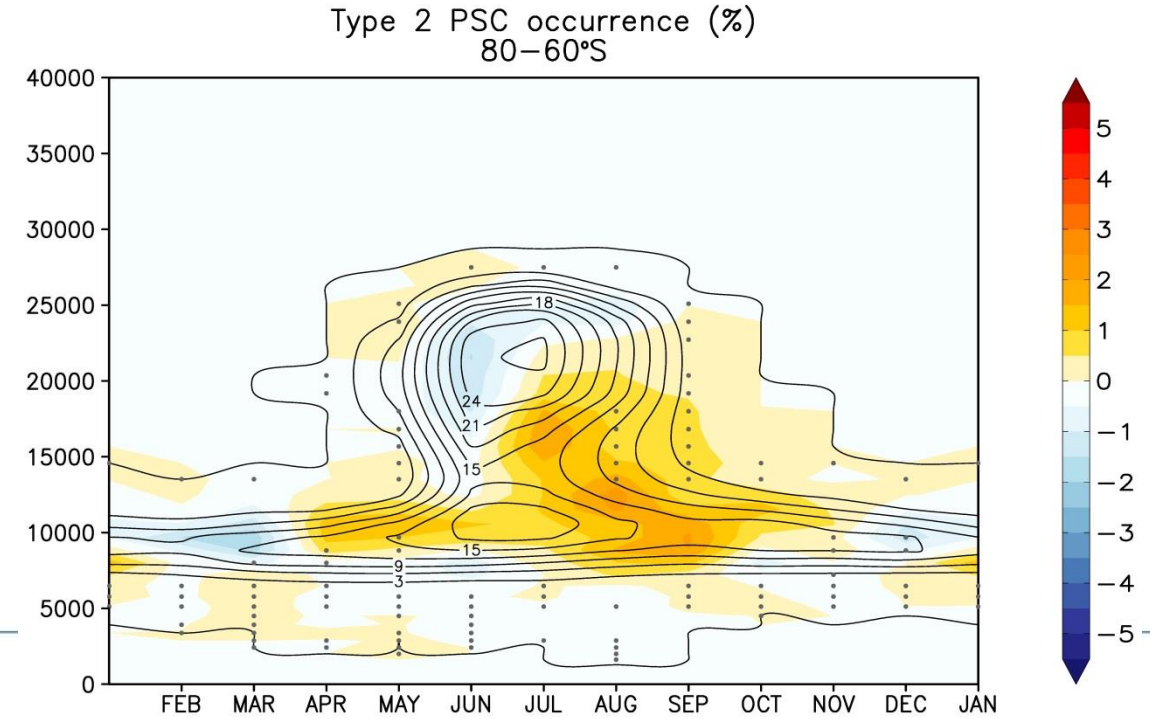
- To parametrize gravity wave impacts: parametrization of orographic cirrus, polar stratospheric clouds, and chemistry. e.g. Dean et al. 2007, Orr et al. 2014.

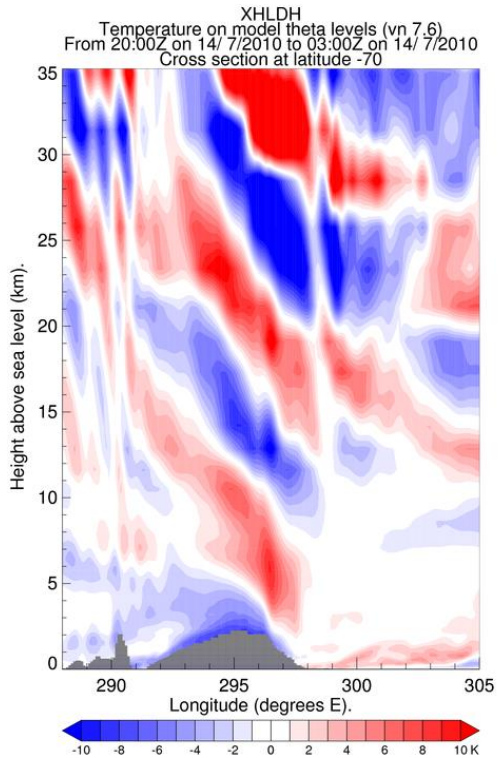


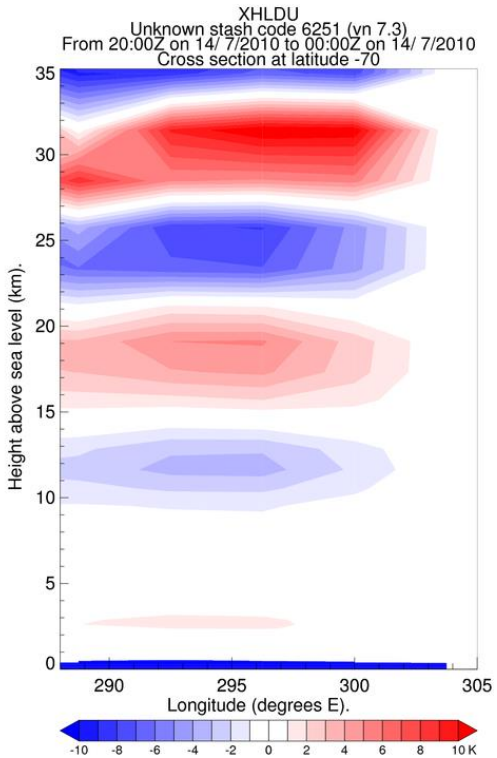


Polar Stratospheric Clouds: Orr et al 2014.

- 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.

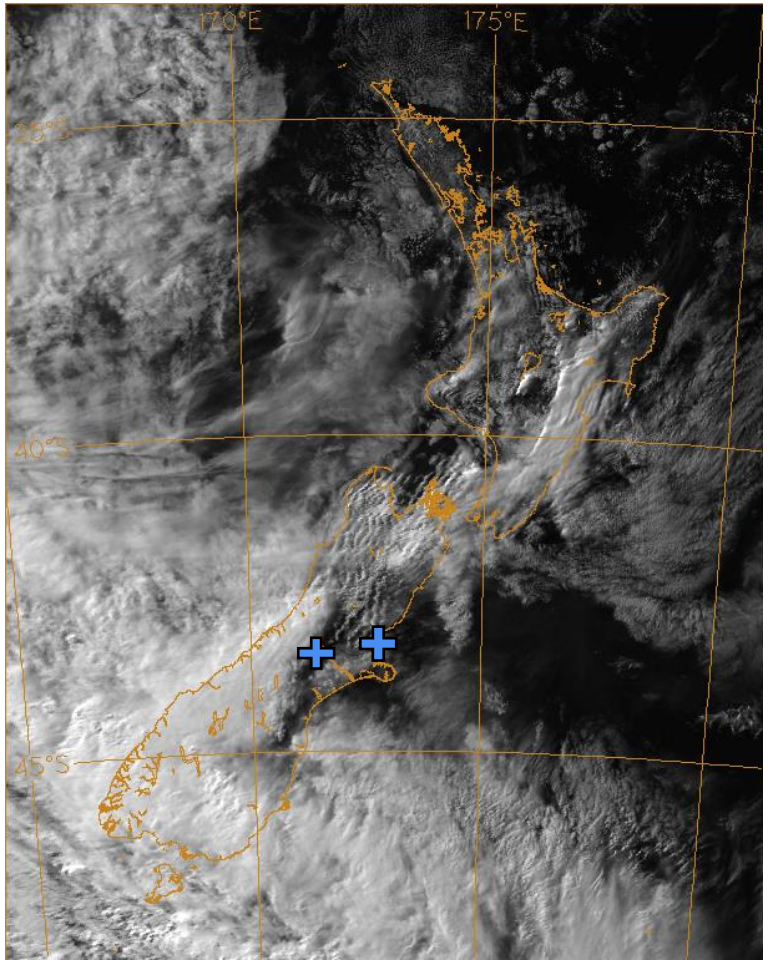






Downslope Windstorm: 10-September-2013

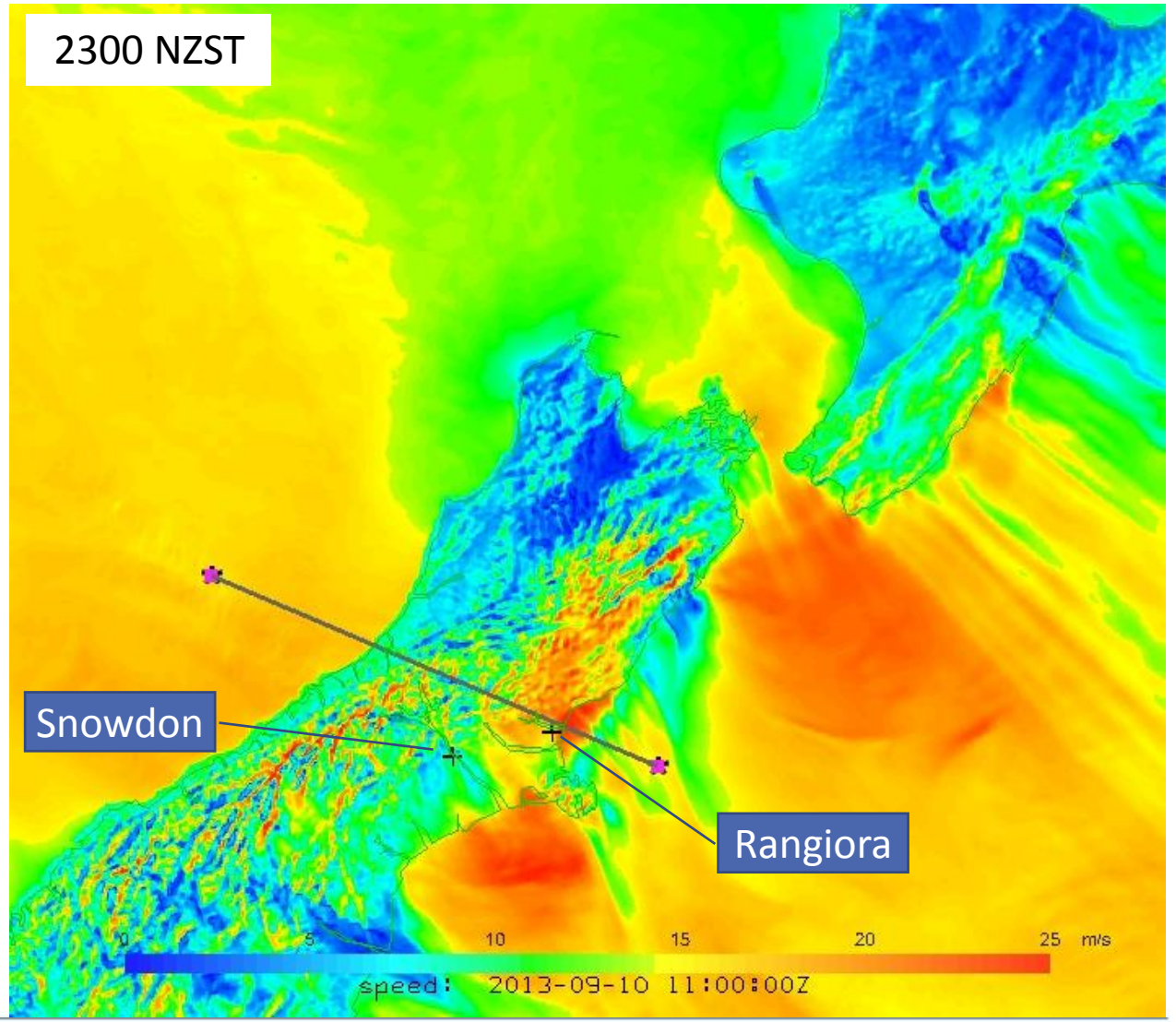
- Impacts:
  - NZ$80M in insurance claims;
  - 28,000 customers lost power in Canterbury;
  - Significant damage to Forests;
  - More than 800 irrigators destroyed ($NZ38M);
  - Significant flooding (West Coast);
  - Forest fires on the East Coast;
  - Significant rural economic, animal welfare and environmental impacts (e.g. Dairy herds could not be milked, effluent disposal etc.)
- Other points:
  - Observed gusts of 140 km/h;
  - Sustained winds of >70 km/h for 10 hours at Snowdon (lee of the Southern Alps);
  - Sustained winds of ~60 km/h reached the east cost for a period (e.g. Rangiora).
- Question: Can NZCSM simulate this event?



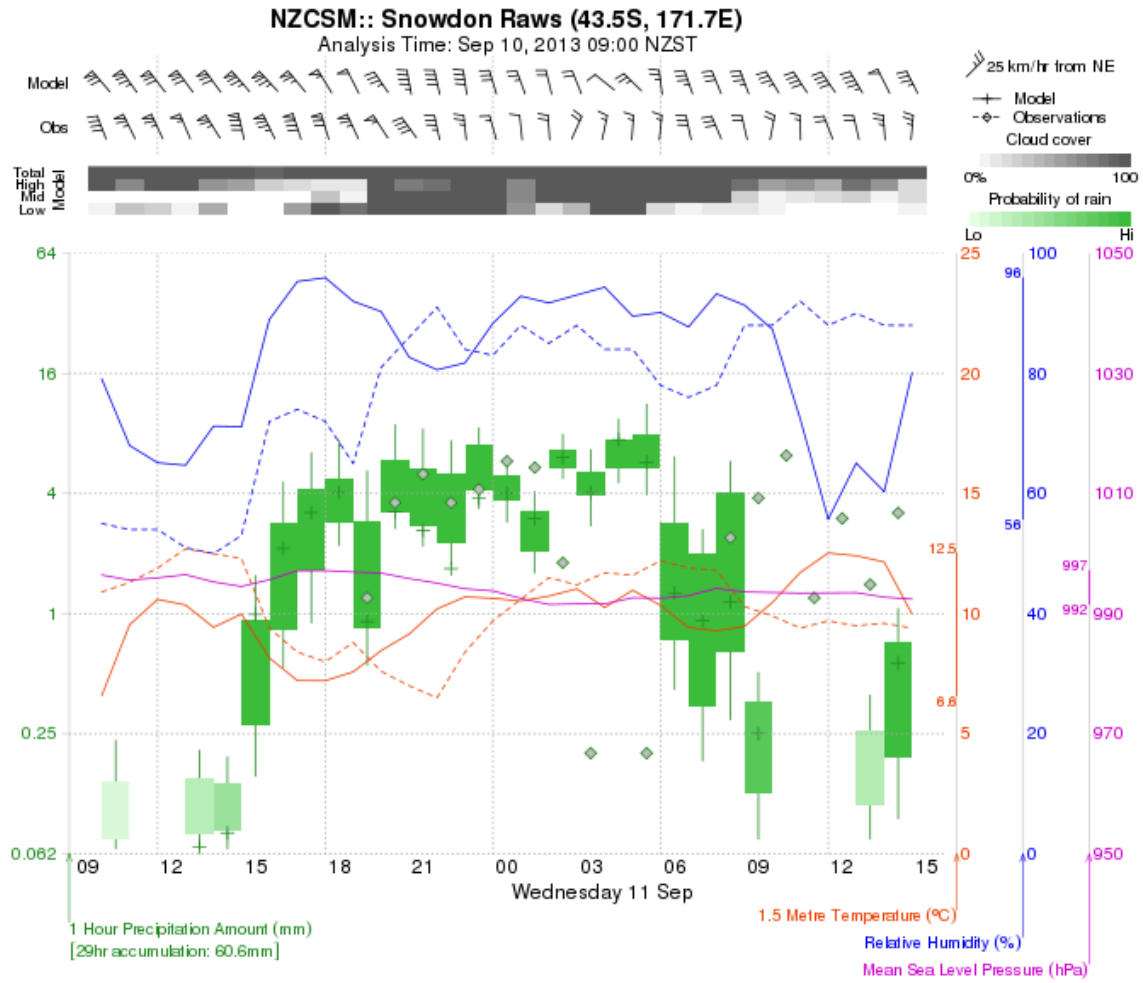
AVHRR Vis: 10-Sep-2013, 1606 NZST

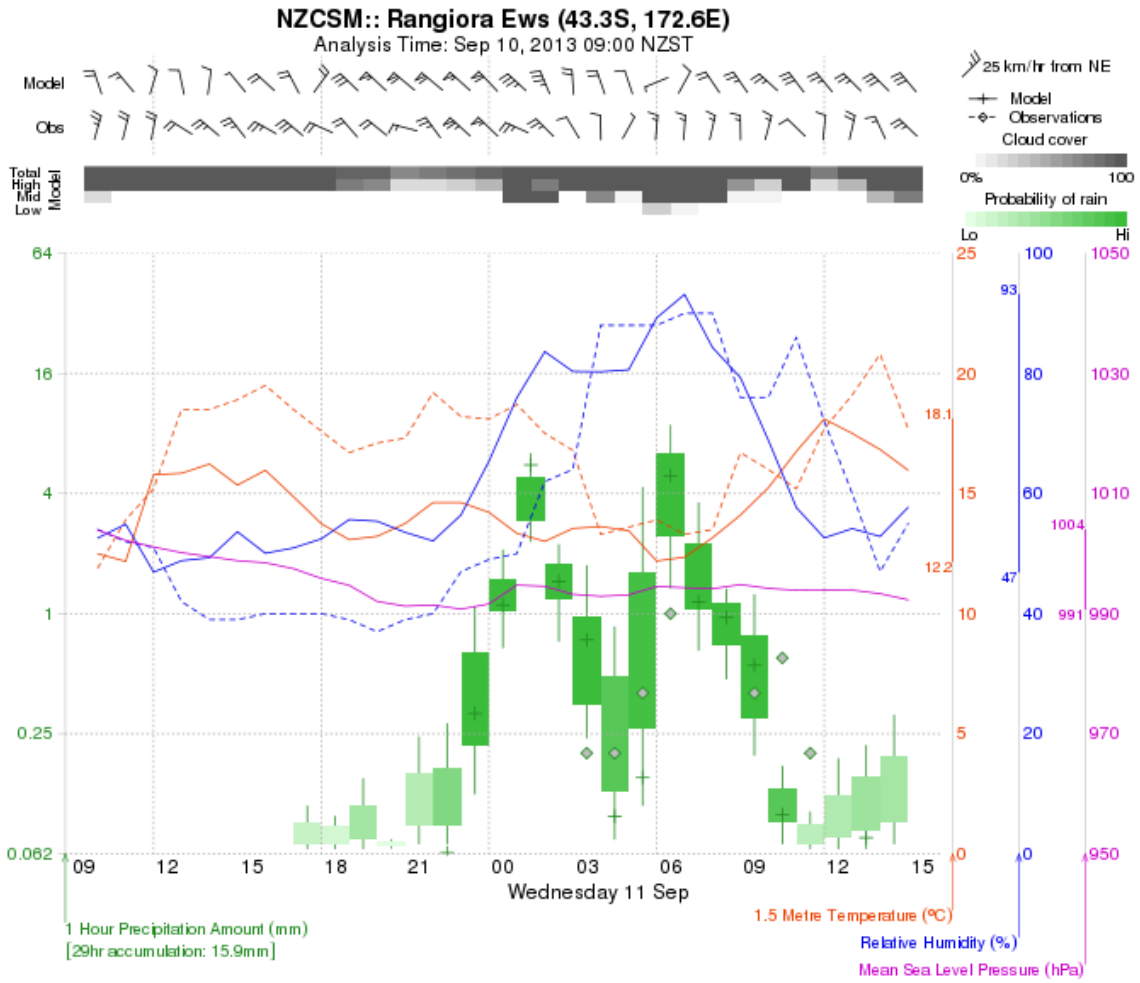
NZCSM Forecasts of the 10-Sep-2013 Event: 10 m Wind Speed

- 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;
- No GWD paramatrization;
- JULES Land Surface Model;
- LBCs (from NZLAM 12 km model, 30 min – NZLAM includes full Variational DA);
- NZCSM cold started (in the case shown here) from 09/09/13:2100 UTC (10/09, 0900 NZST).



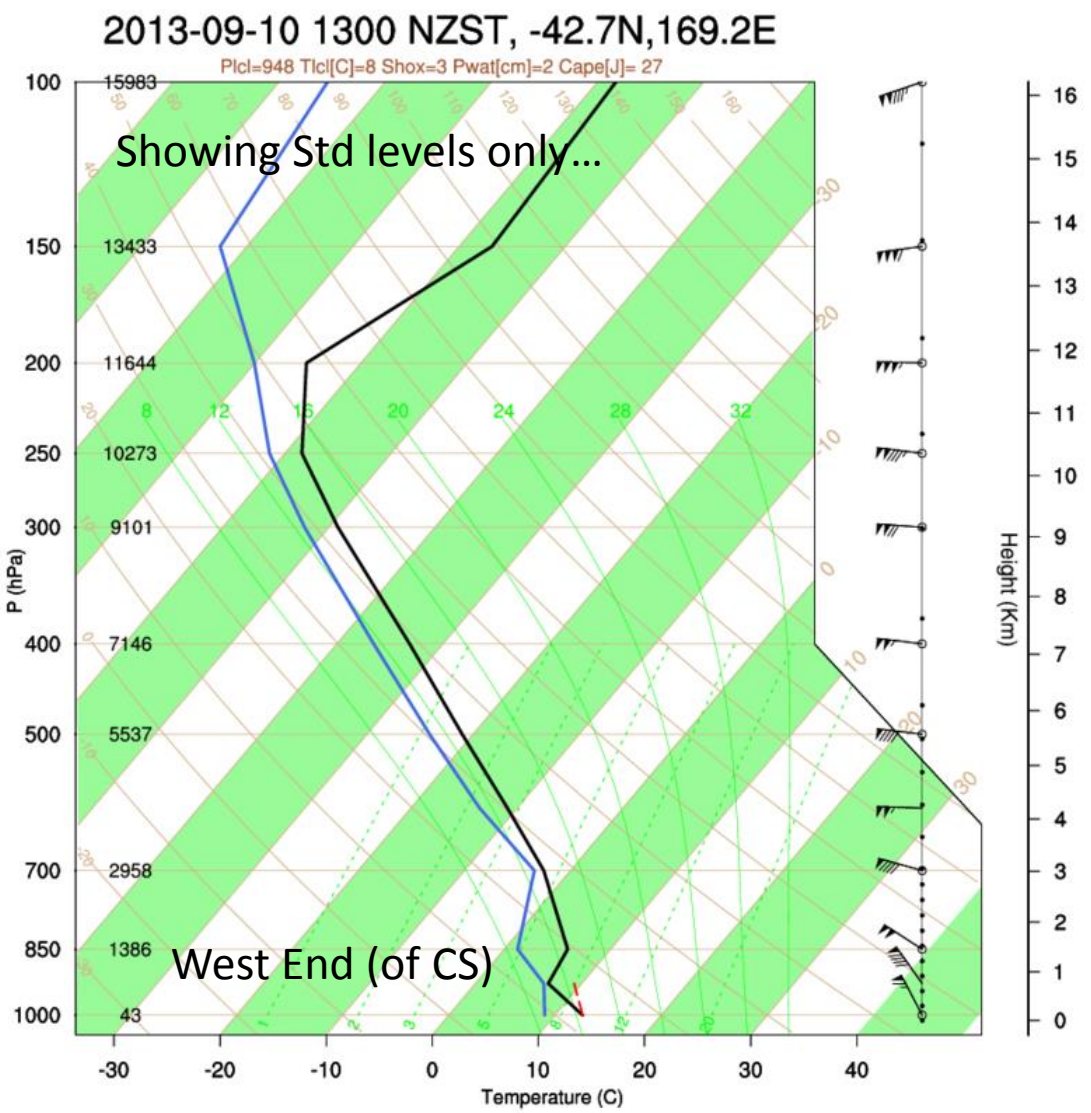
NZCSM Meteograms: Snowdon, Rangiora

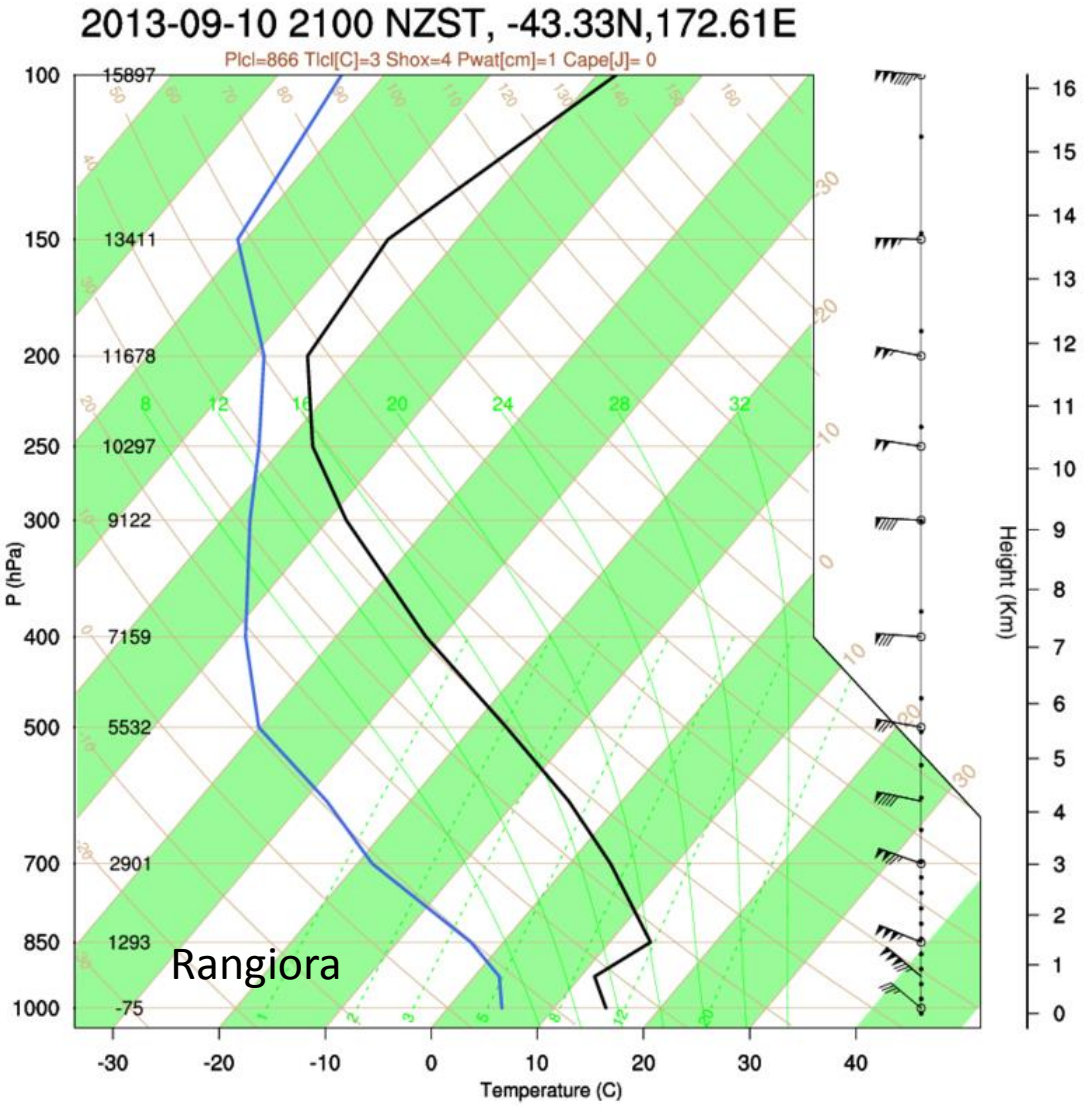




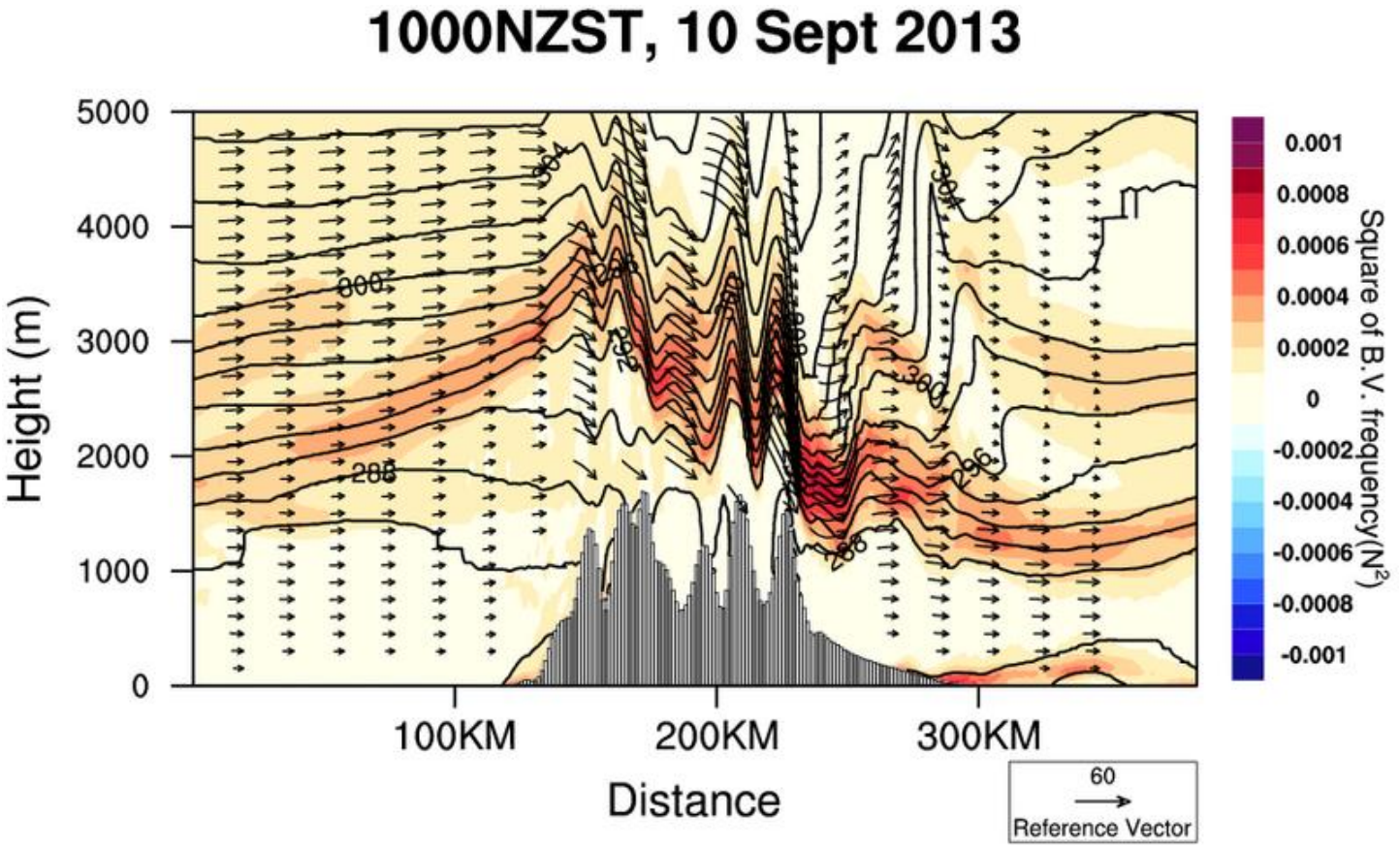
Model Output (no post processing): Wind (10m), Cloud, $T_{1.5m}$, $RH_{1.5m}$, MSLP, Precip Accumulation (h)

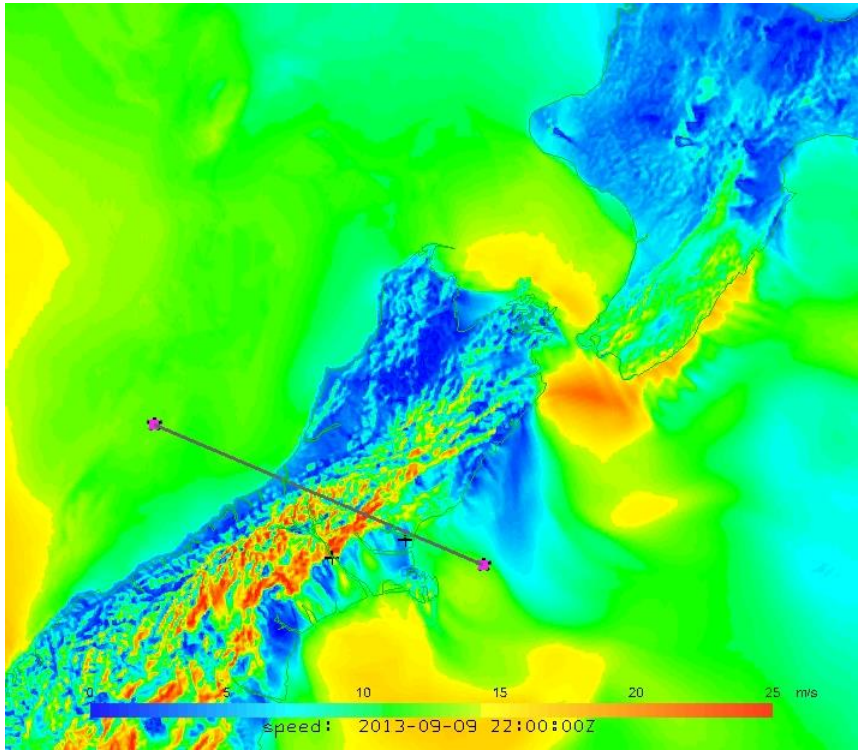
NZCSM SkewT LogP: 10-Sep-2013 Upstream & Rangiora (1300, 2100)





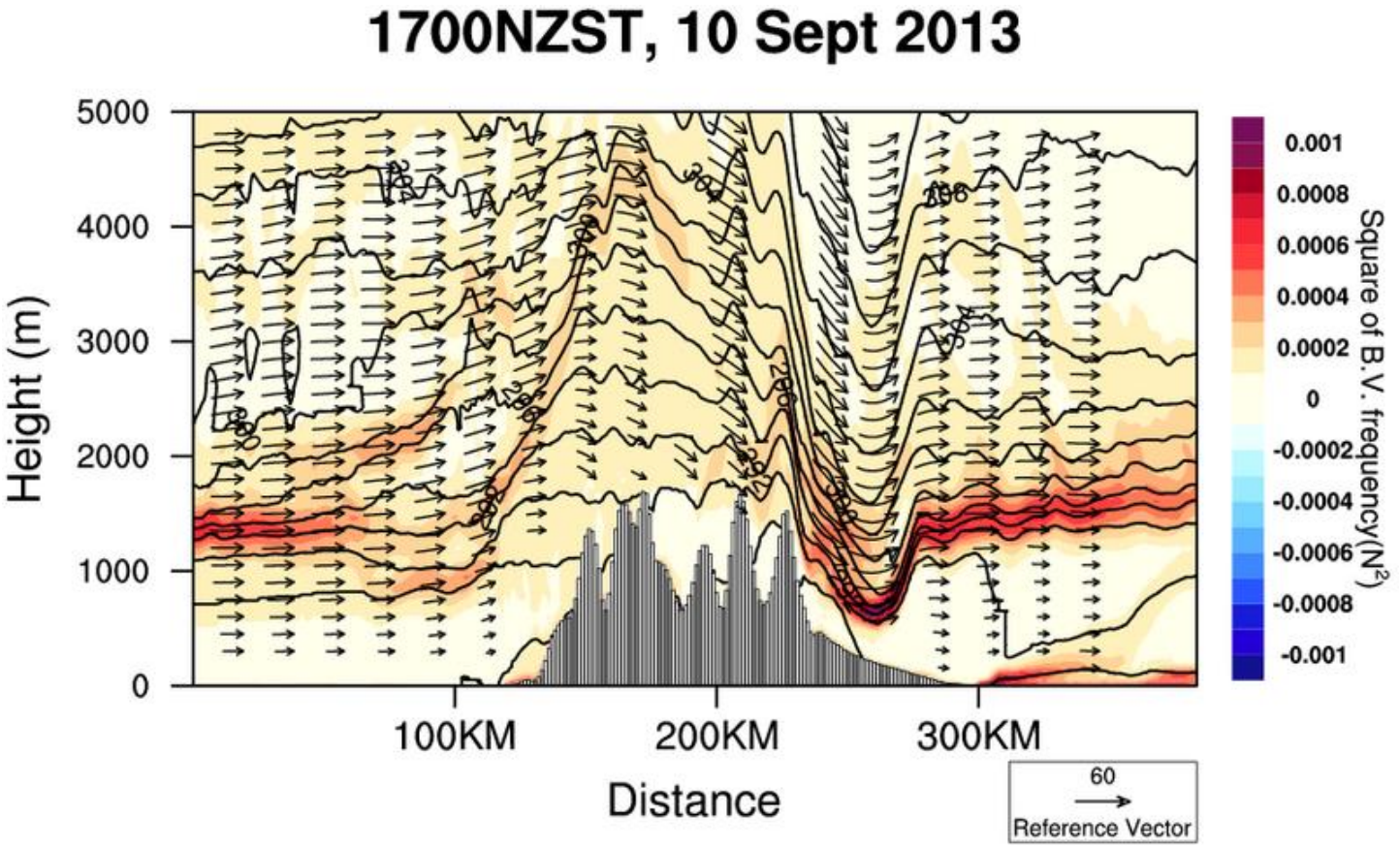
NZCSM Cross Sections: Theta, Wind, (Brunt-Väisälä Frequency)^2

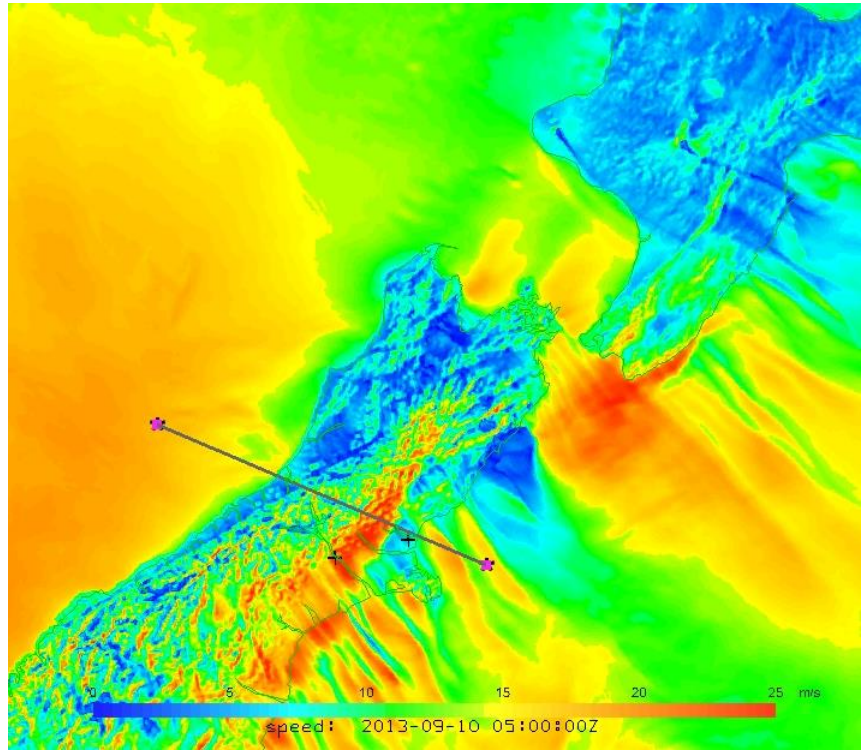




T+1: Stable layer established near level of mountain tops.

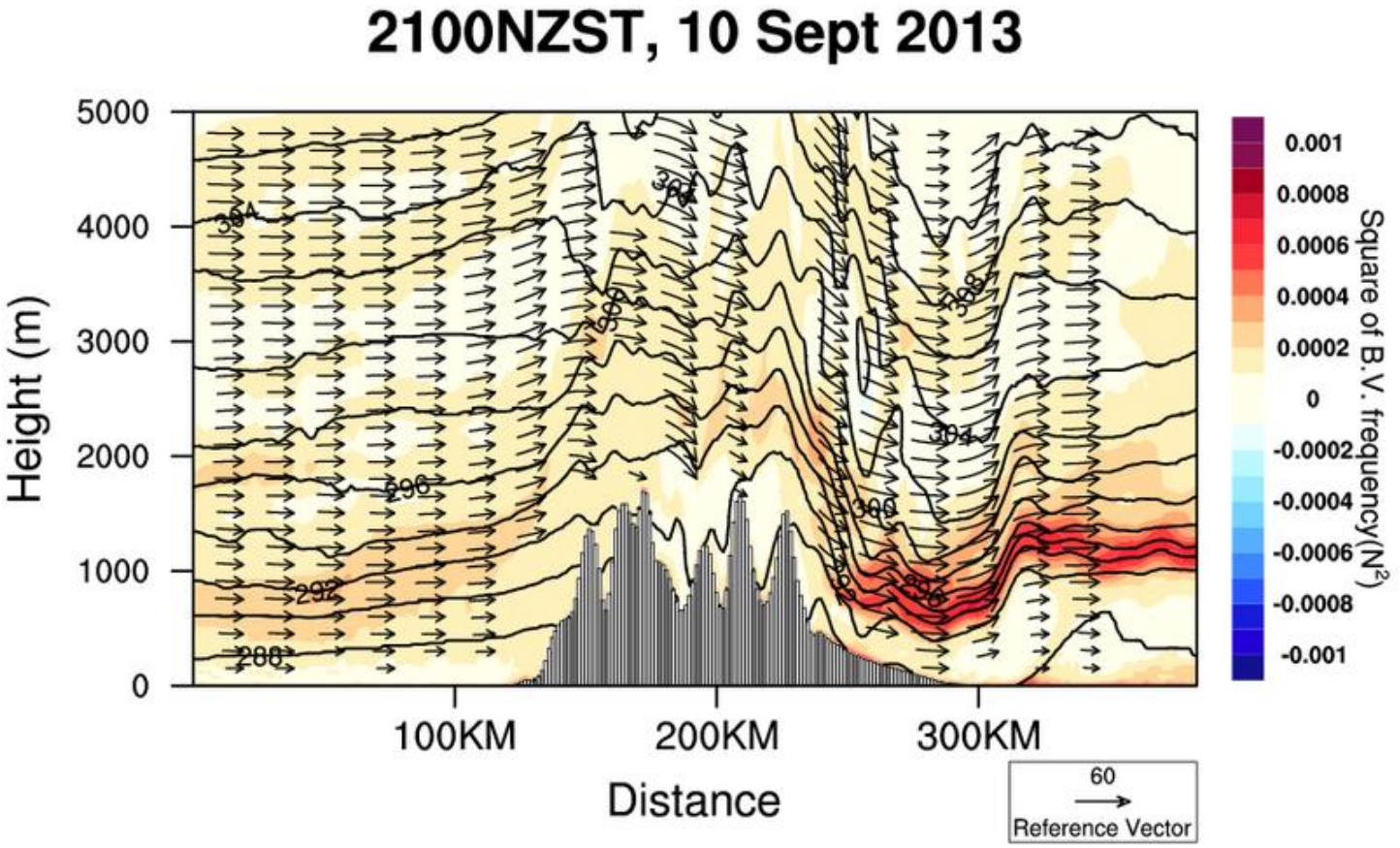
NZCSM Cross Sections: Theta, Wind, (Brunt-Väisälä Frequency)^2

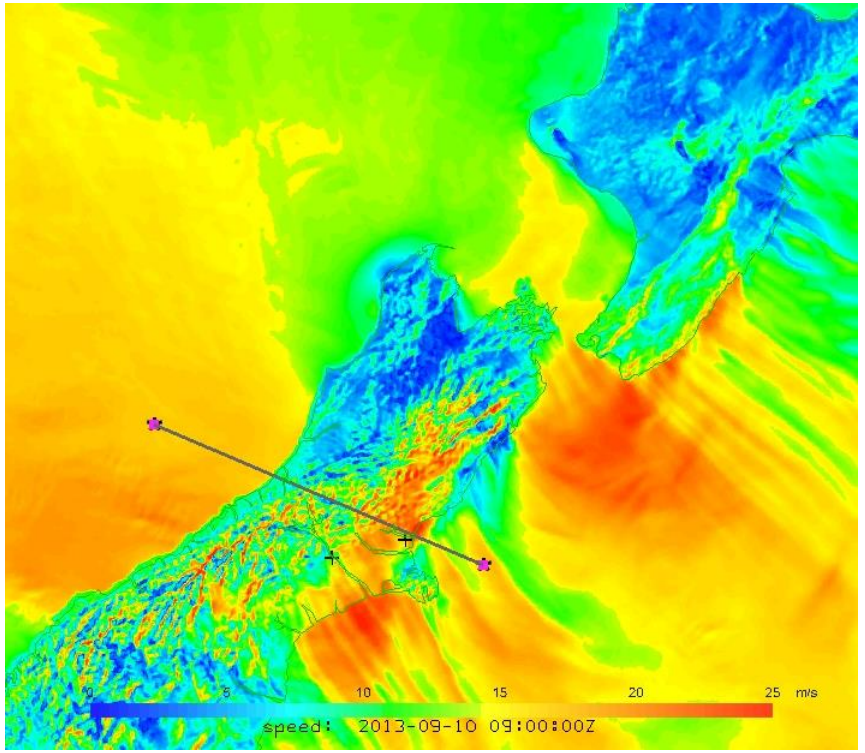




Time at which high sustained high winds (~70 km/h) were observed at Snowdon (and other inland sites)

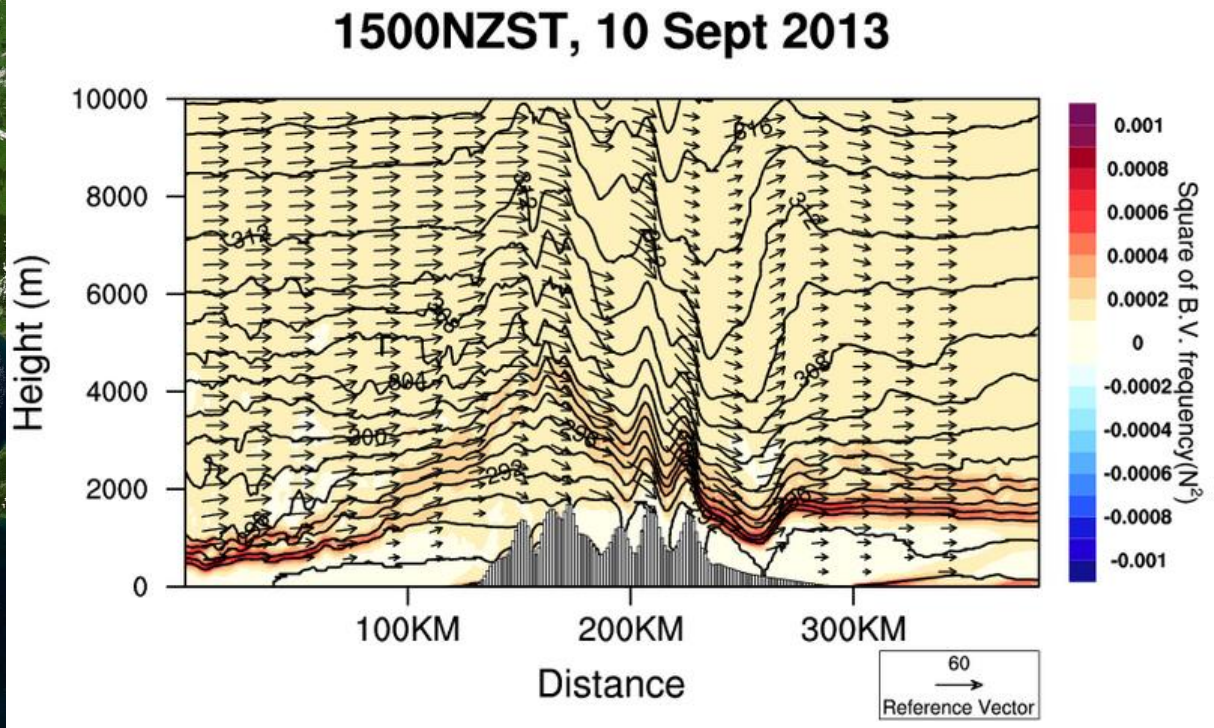
NZCSM Cross Sections: Theta, Wind, (Brunt-Väisälä Frequency)^2

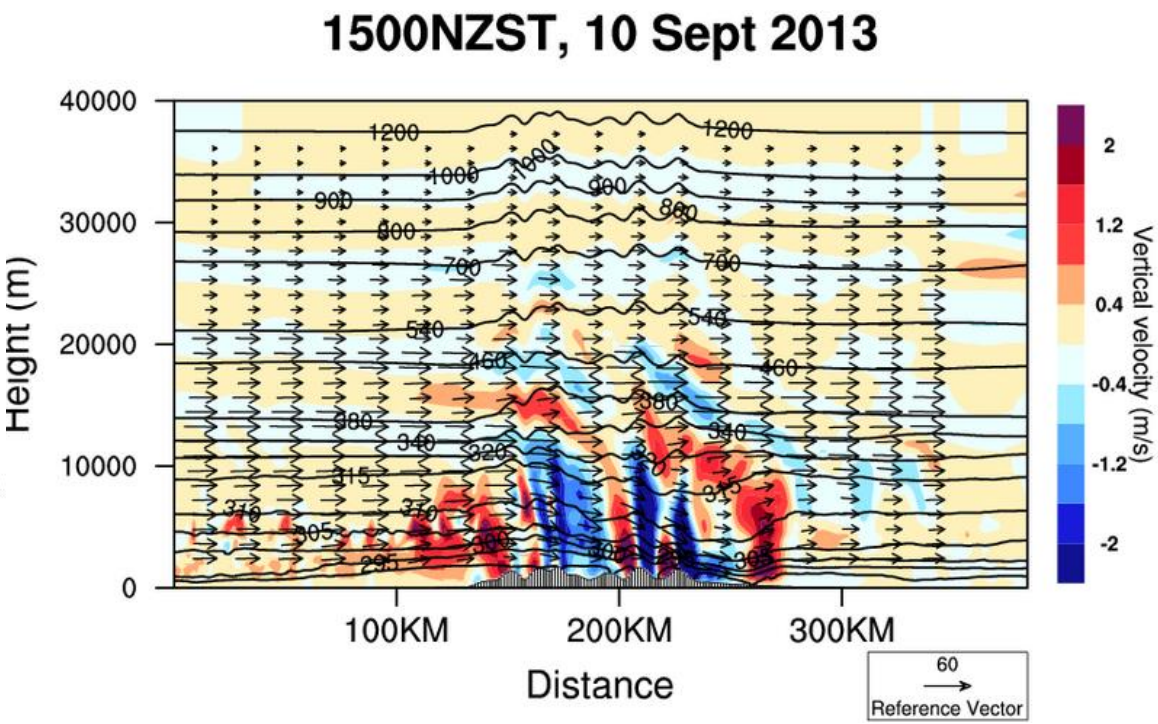




One hour prior to the onset of high winds observed at Rangiora (for 2 hours only).

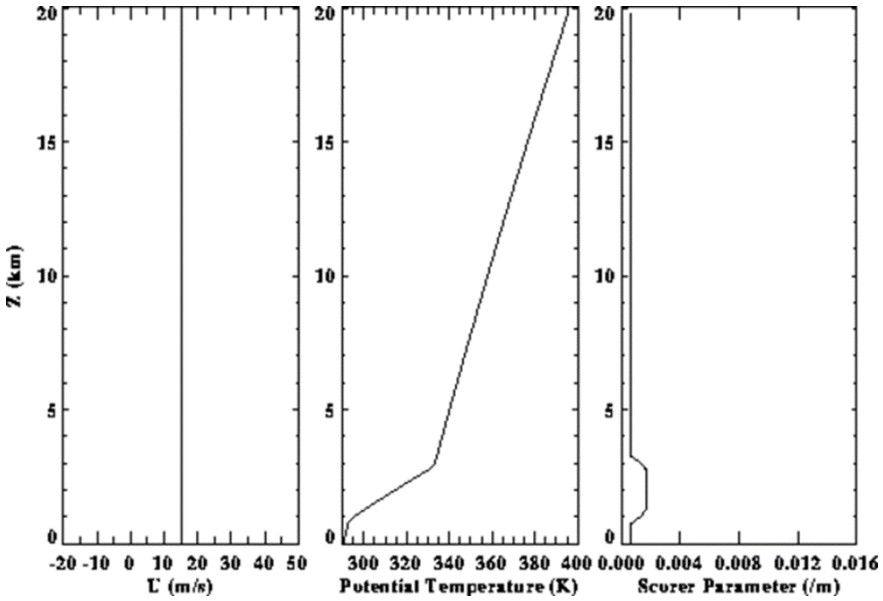
NZCSM Cross Sections: Theta, Wind, (Brunt-Väisälä Frequency)^2, w



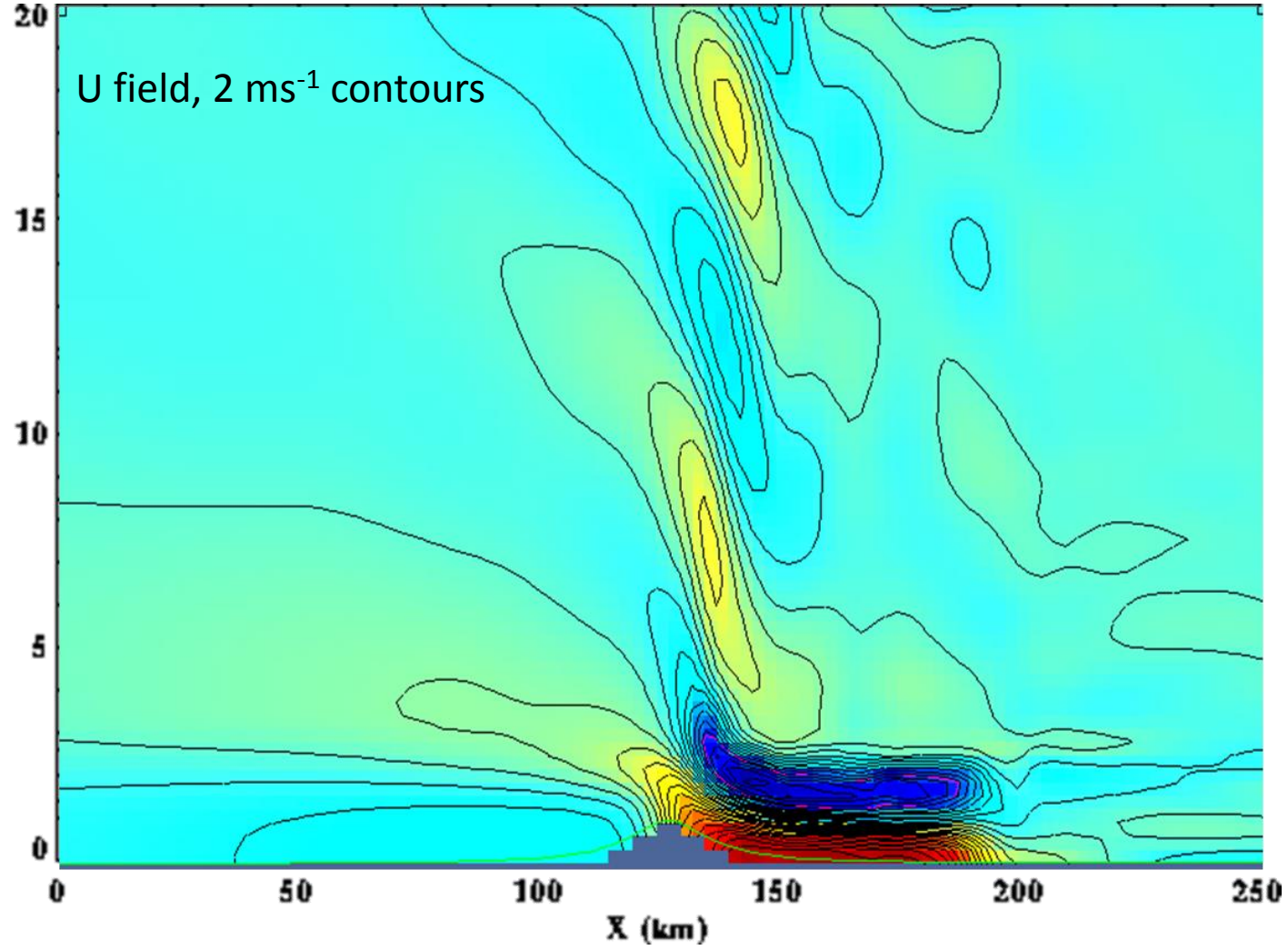


- Time at which high sustained winds were observed at inland Canterbury sites (and 1 h before the NOAA daytime pass);
- Left: 0 – 10,000 m: Theta, u,w (along cross-section), (Brunt-Väisälä Frequency)^2 ;
- Right: 0 – 40,000 m w (vertical velocity).

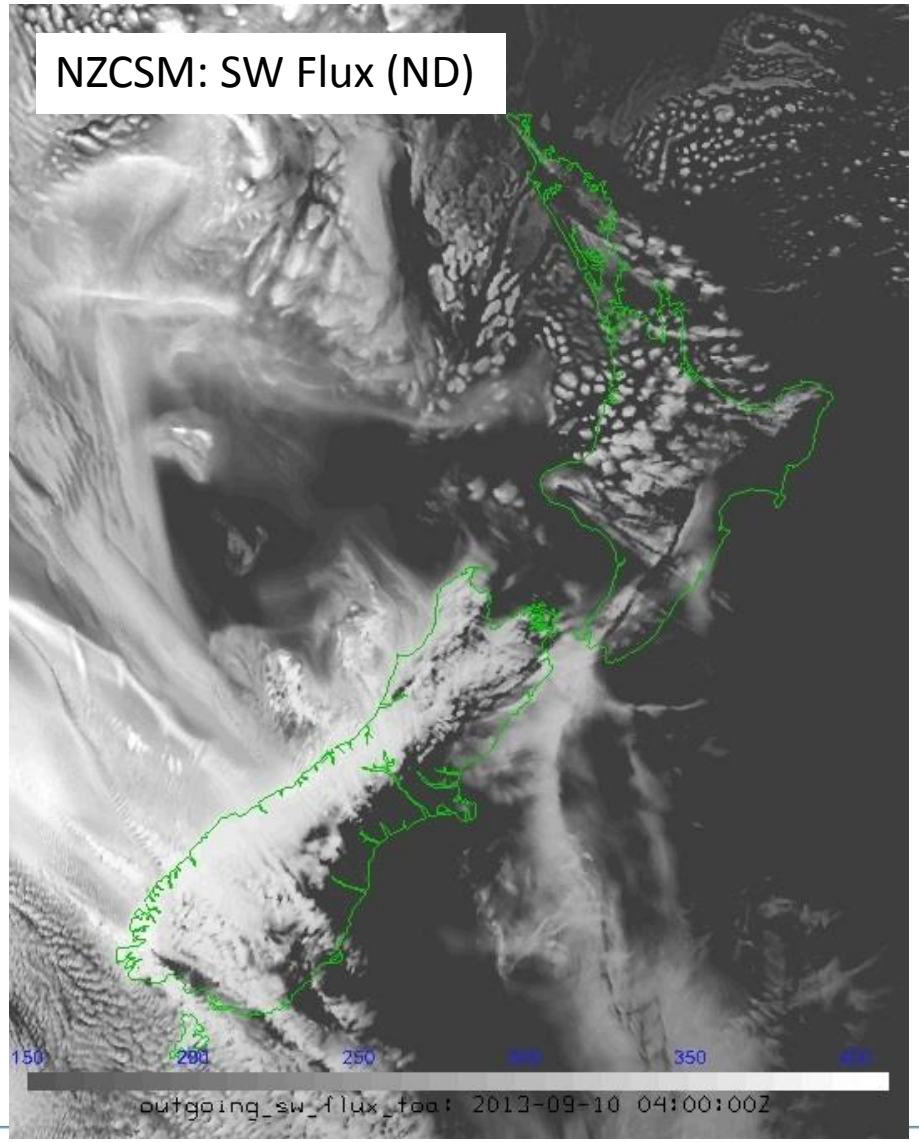
Idealised Model: Stable Layer at top of Mountain

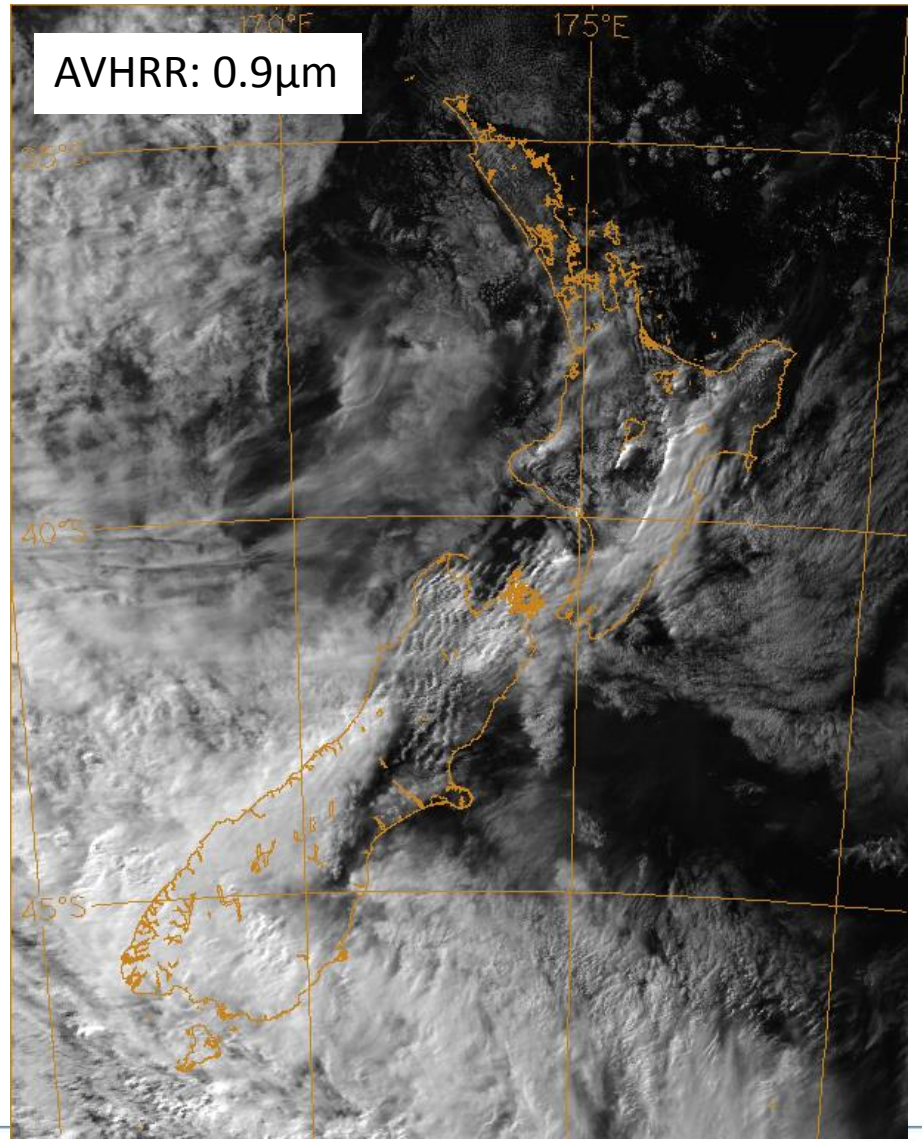


- U = 15 ms^{-1}
- N^2 = 1, 6.52 (1 km), 1 × 10^{-4} s^{-2} (3km)
- H = 1 km, H_w = 10 km
- In this configuration we get a lee slope wind event and upward propagating gravity waves.



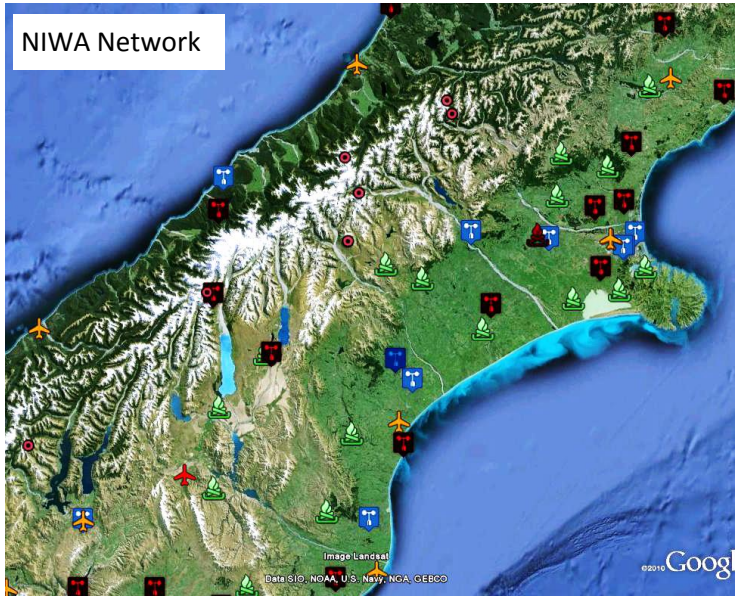
NZCSM: Short Wave TOA Flux, 10-Sep-2013 1600 NZST

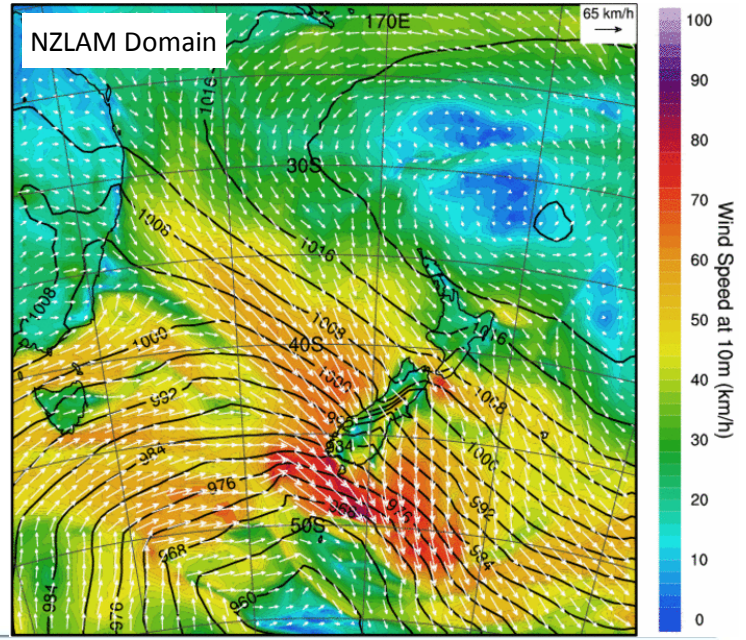




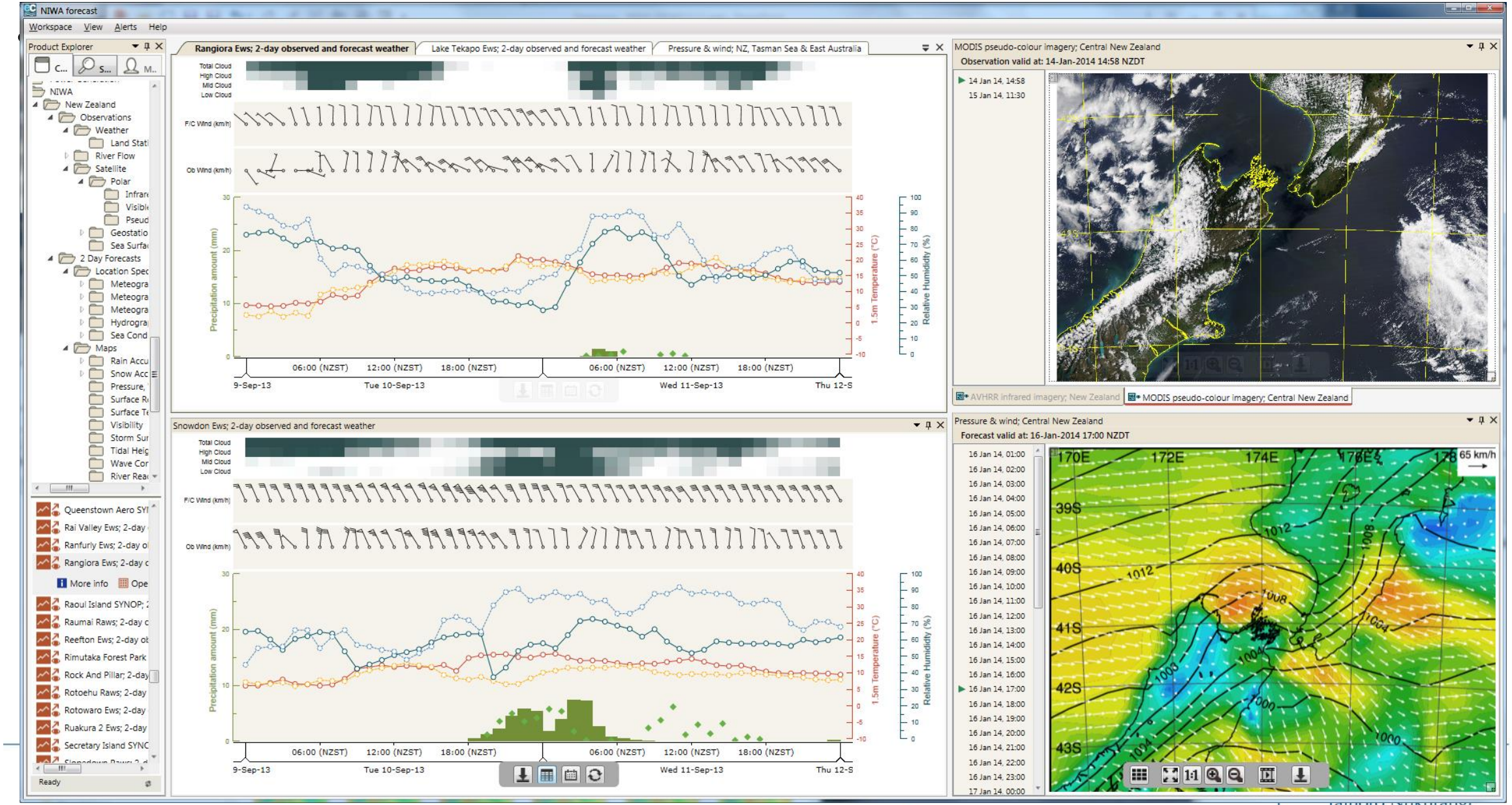
NIWA Facilities

- Observing Network
  - Access to (hourly) observations from ~200 AWS stations
  - Lauder Lidars (Aerosol & Ozone)
  - Satellite data (Lauder X and L band, Wellington L Band)
- Further Opportunities
  - Vaisala DigiCORA Sounding System;
  - Radiosondes from Lauder;
  - Add pressure sensors to Snow & Ice data network (orange circles)
- NWP Models
  - NZLAM: UM, FGAT VAR, Warm cycled, 4× daily (00, 06, 12, 18) to 48 h, 12 km resolution, 70 levels (80 km top), LBCs from UM Global (N512 now, N768 by June);
  - NZCSM: UM, FGAT VAR, Warm cycled, 4x daily (03, 09, 15, 21) to 36 h, 1.5 km resolution, 70 levels (40 km top), LBCs from NZLAM
  - NZCSM-R: UM simulation at ultra high resolution (100 m, on domains of the order of 60 × 60 km).





EcoConnect (GUI & SOAP Webservices) – Data Access

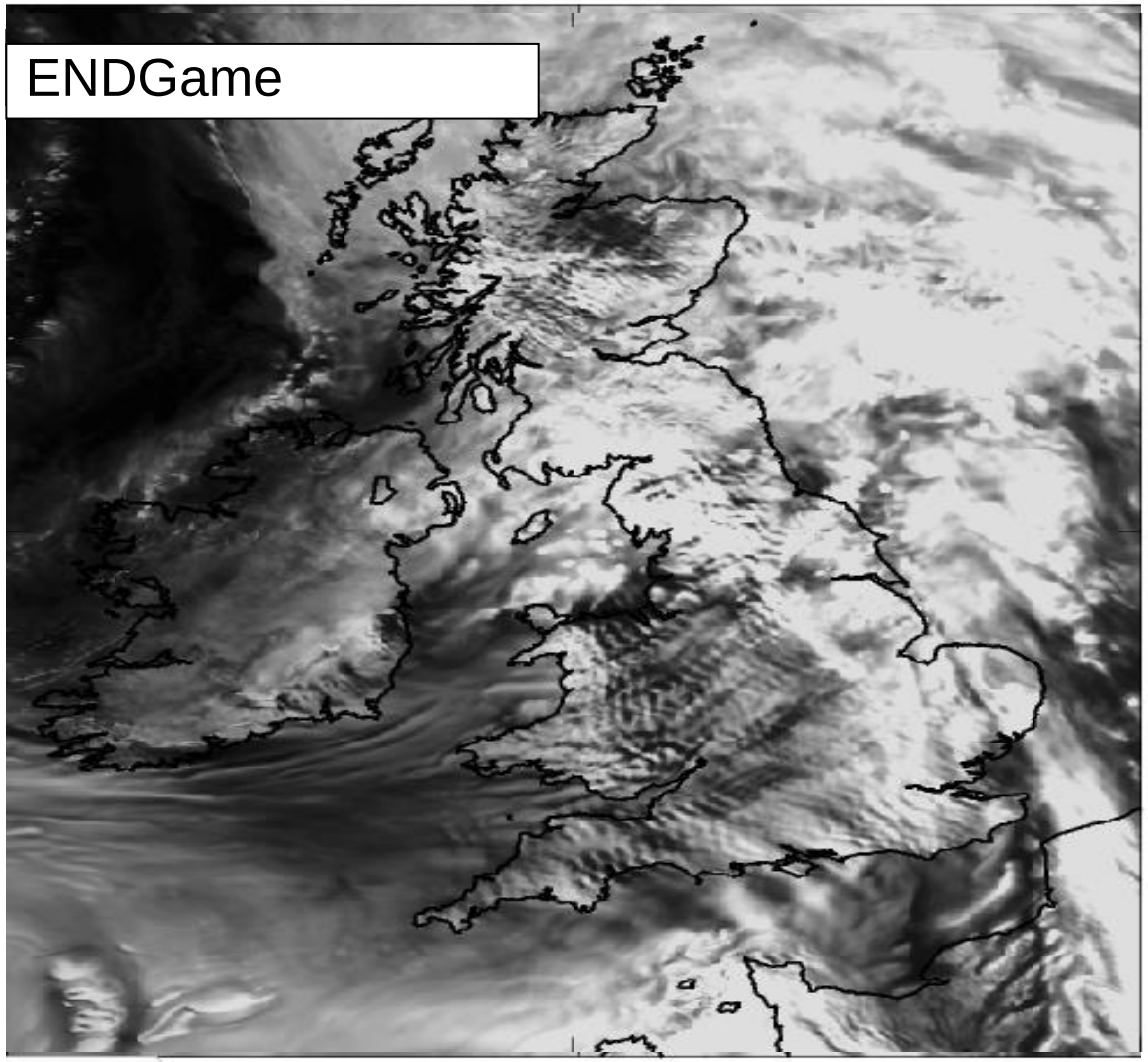


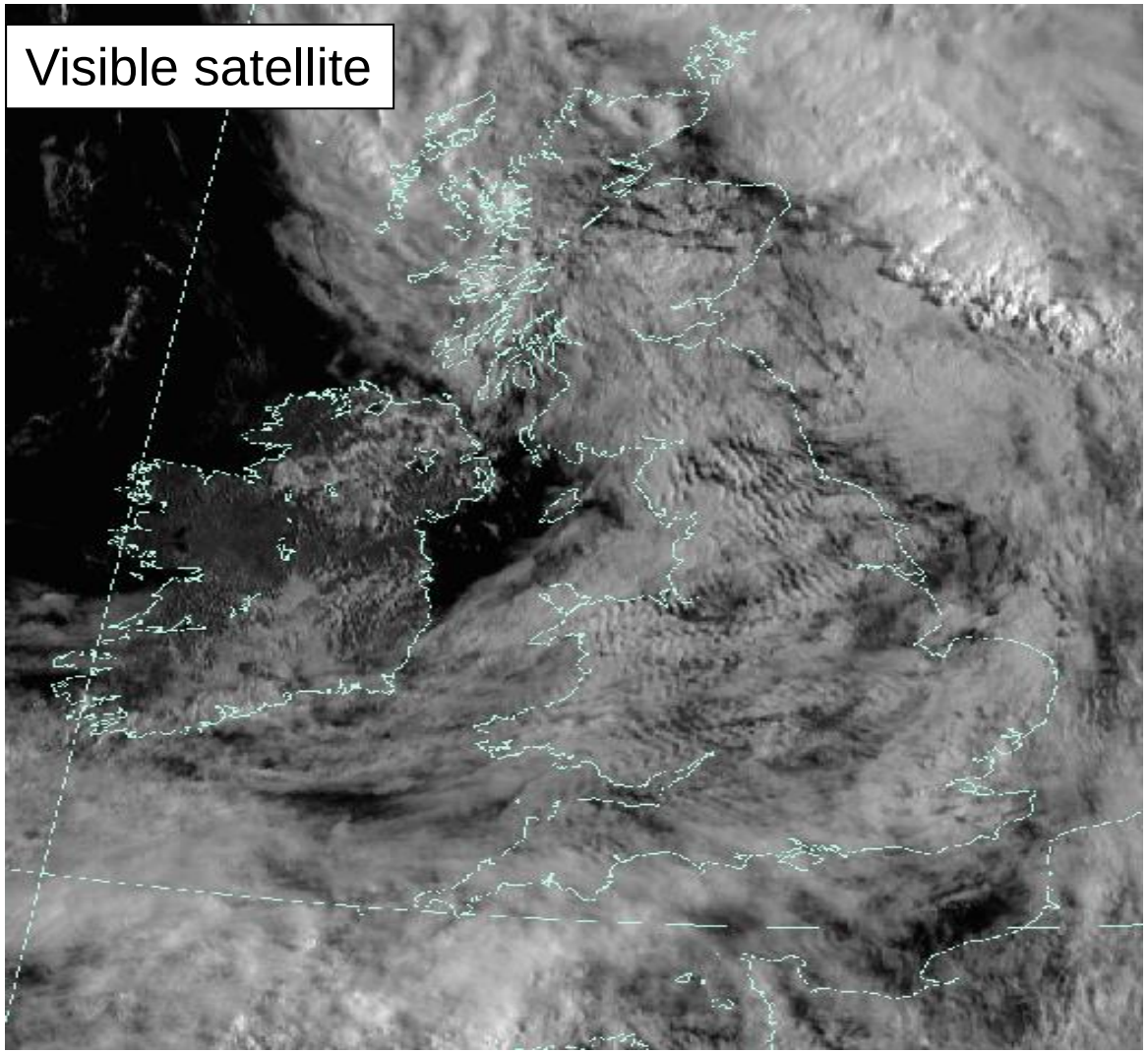
Collaboration

- NIWA:
  - Scientific collaboration on NWP and DA (i.e. focused research programme ready to contribute to, and to use Deepwave data);
  - Access to realtime AWS observing network data;
  - Opportunity to make use of additional observing systems and staff (Lauder upper air observations (Lidars & Radiosondes), Mobile DigiCORA, high elevation pressure measurements?);
  - Operational NWP model output:
    - NZCSM: Maps, site specific, CF NetCDF (2, 3 and 4D fields, model levels);
    - NZLAM: Maps, site specific, CF NetCDF (2, 3 and 4D fields, model levels).
  - Satellite data;
  - EcoConnect: Access to all relevant operational data.
- UK Met Office
  - Provide products from the deterministic global model (N768 (~17km), GA6.1, 80km top), 4 times per day. ENDGame dynamics has much improved explicit gravity wave representation;
  - Assist NIWA with the implementation of EndGame dynamics (GA6.1) in NZCSM for use in operations.

ENDGame UKV (1.5km resolution)

Lee waves over the UK. 08 UTC 12 June 2013

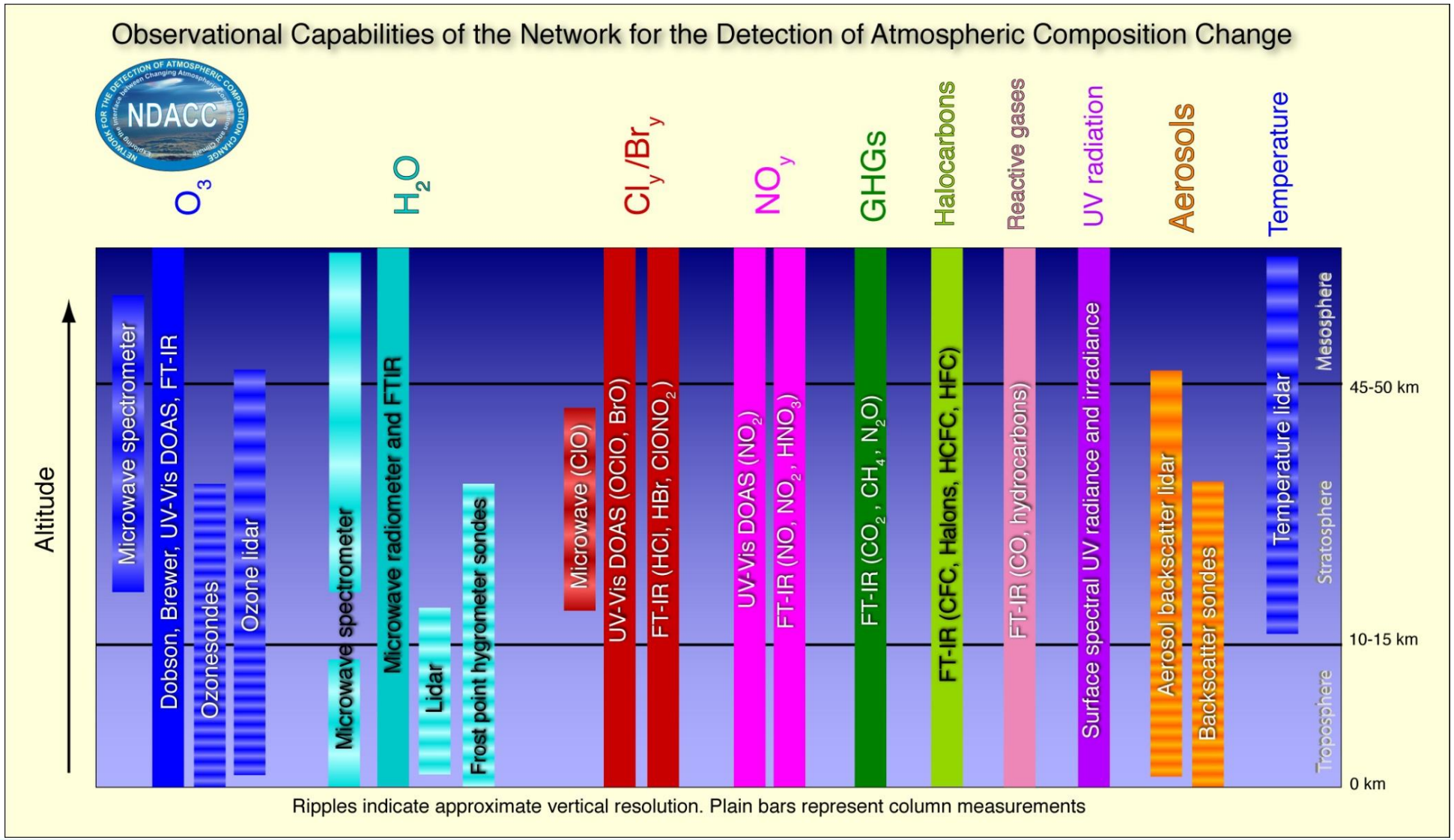




Data

- NIWA can provide (during the experiment):
  - NIWA Observing Network observations (~200) in real time;
  - Additional observations could be provided: high elevation pressure measurements, UT/UW data (BUFR format), Lidars (Lauder);
  - Satellite imagery (MODIS, AVHRR, and perhaps ViIRS);
  - Via EcoConnect GUI (and/or SOAP Webservices): Access to observational & forecast data:
    - Two and three dimensional fields (e.g. surface, standard levels, model levels, cross-sections,…);
    - Site specific (meteogram) observations and forecasts (UM Global, NZLAM, NZCSM – all MOS corrected);
    - Satellite imagery.
  - NZLAM and NZCSM output in CF compliant NetCDF format (surface, standard level and model levels) – probably with the ENDGame dynamical core.
- UK Met Office can provide (during the experiment):
  - UM Global N768L70 (~17 km resolution), ENDGame dynamical core (GA6.1) global output (80 km top) – Given agreement, these data could be made available via EcoConnect, and as CF NetCDF output for a suitable cut out.

Current Measurements at Lauder



Summary

- NZCSM is able to forecast mountain wave activity (with some skill) – will improve further when ENDGame dynamics are implemented.
- NIWA has a strong interest in participating in the Deepwave experiment:
  - Operational Support:
    - Provision of map and site specific forecasts:
      - NZCSM: 1.5 km, Unified Model (40 km top), 4× daily;
      - NZLAM: 12 km, Unified Model (80 km top), 4× daily.
    - EcoConnect – Access forecasts, AWS, Satellite imagery, … (GUI and SOAP Webservices).
    - Potential to use mobile DigiCORA upper air sounding system;
    - Potential to add air pressure sensors to Snow and Ice network stations (April maintenance flights);
  - Research:
    - Model validation, development (New Dynamics, ENDGame, physics) and intercomparison;
    - Data assimilation: Obs impacts;
    - Mountain waves and lee wind storms.
- UK Met Office has a strong interest in participating in the Deepwave experiment:
  - Operations support: Global forecasts, N768L70, ENDGame (GA6.1), 4× daily;
  - Research: Model validation & development, parametrization, etc.