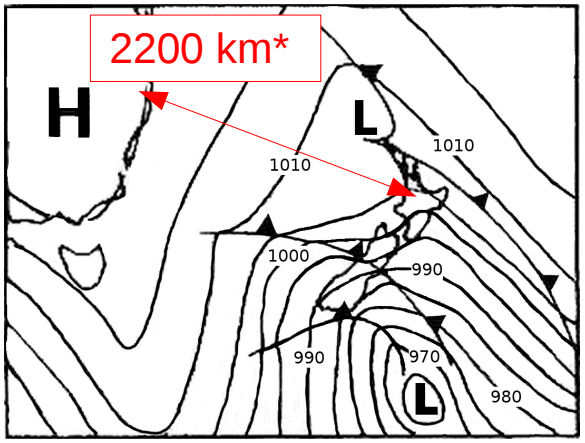
Downscaling** a reanalysis for July 1996 "Big Freeze" in Southern NZ



* Sydney to Auckland

**with NOAA/NWS Sci. & Training Resource Center (STRC)
"Environmental Modeling System" (EMS): WRF-ARW core

eas372_downscaling_BigFreeze.odp
JDW, EAS UAlberta
Last mod. 27 Mar. 2014

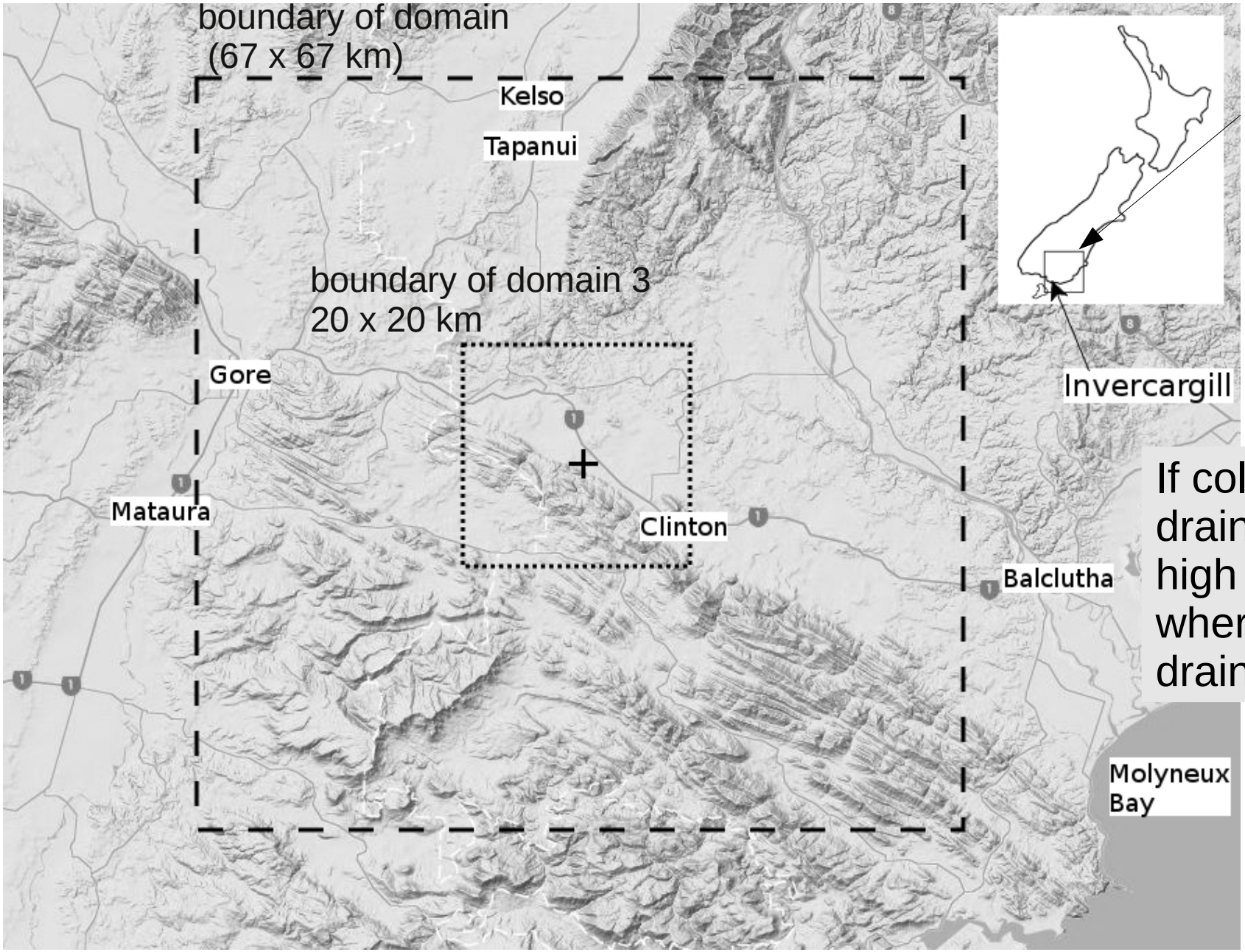
Downscaling a reanalysis (NCEP II) for July 1996 "Big Freeze" in Southern NZ

Downscaling a reanalysis (NCEP II) for July 1996 "Big Freeze" in Southern NZ

- Invercargill
- Gore
- Blaclutha

Downscaling a reanalysis (200 km => 20 km), valid 06 NZST 4 July 1996

- Nested subdomains of successively finer resolution, finest spans 20 x 20 km
- Reanalysis gives initial and b/conditions for domain 1 (i.e. coarsest domain, 200 x 200 km)



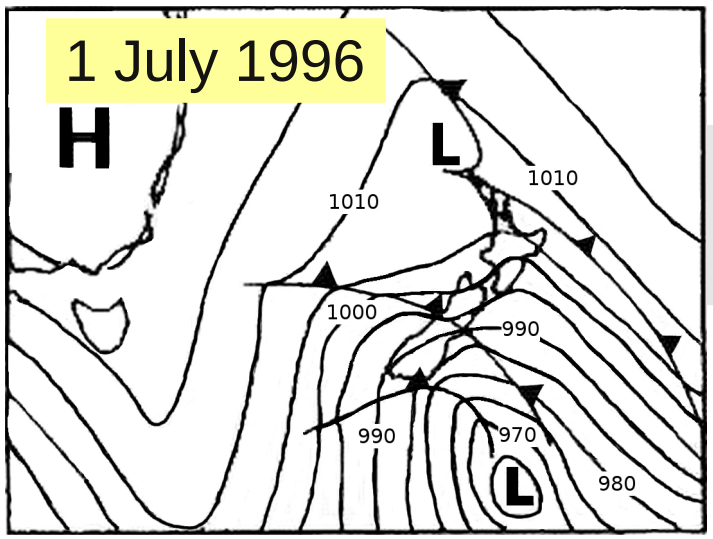
Observations – daily minimum temperatures (normals blue)

(Tap. – Tapanui, Bal. – Balclutha, Inv. – Invercargill)

		T_{min}				T_{max}			
Location		Tap.	Gore	Bal.	Inv.	Tap.	Gore	Bal.	Inv.
July normals	*61 – 90,** 71 – 00	1.3*	1.0**	1.0*	1.1*	8.6*	8.2**	9.2*	9.6*
30 Jun (GMT)	1 Jul (NZST)	-1.9	-0.2	0.3	0.9	9.1	6.9	8.3	6.3
1 Jul (GMT)	2	-2.9	-5.4	-1.1	-4.0	2	2.4	3.2	3.9
2	3	-13.5	-10.5	-6.3	-8.0	5	1.2	3.5	1.5
3	4	-15.3	-10.5	-6.5	-9.0	-0.6	-2.7	3.1	1.7
4	5		-9.6	-4	-7.3	0.9	-1.0	2.8	1.7
5	6	-10.2	-8.5	-5.5	-7.9	5.2	1.0	8.4	2.6
6			-9.8	-6.2	-7.6		-0.9	3.2	1.8
7		-11.7	-8.6	-6.3	-9.0	3.5	-1.0	3.8	2.8
8			-9.0	-6.2	-7.6	3.5	2.2	7.1	4.3
9		-10.2	-6.7	-1.3	-7.0	4.1	1.2	7.9	4.4
10		-1.2	-0.9	1.7	-0.3	7.9	3.2	8.7	6.9
11	12	-3.4	-2.9	-1.0	-3.9	5.9	3.8	6.6	6.6
12	13	-9.0	-4.0	-3.5	-5.0	7.2	4.4	6.4	6
13	14	-8.2	-4.0	-3.2	-4.9	3.2	0.9	3.0	4.3
14	15	-2.0	0.5	-1.6	0.0	7.5	6.1	5.8	7.9
15 Jul	16 Jul	3.7	2.9	-3.0	2.8	7.6	5.4	7.1	6.9

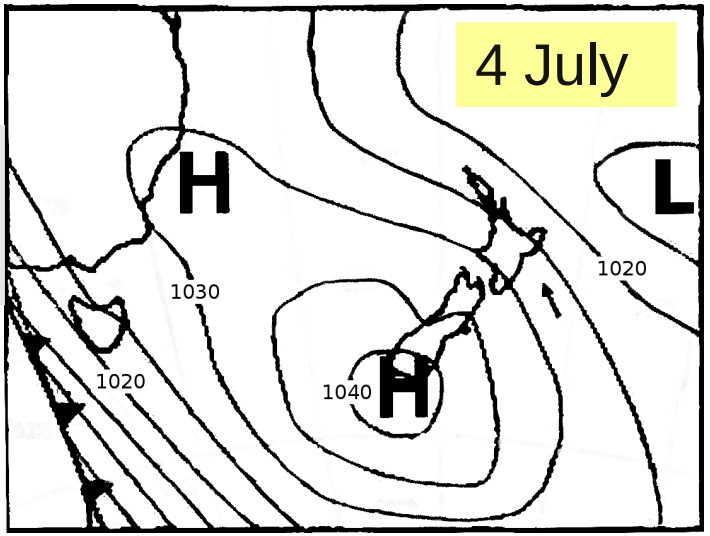
- -9°C set Invercargill's record low temperature (1905 – 2012)
- two weeks of hard frosts
- trees and birds killed

Nature of a “reanalysis” and comparison with NZMS analyses of the time

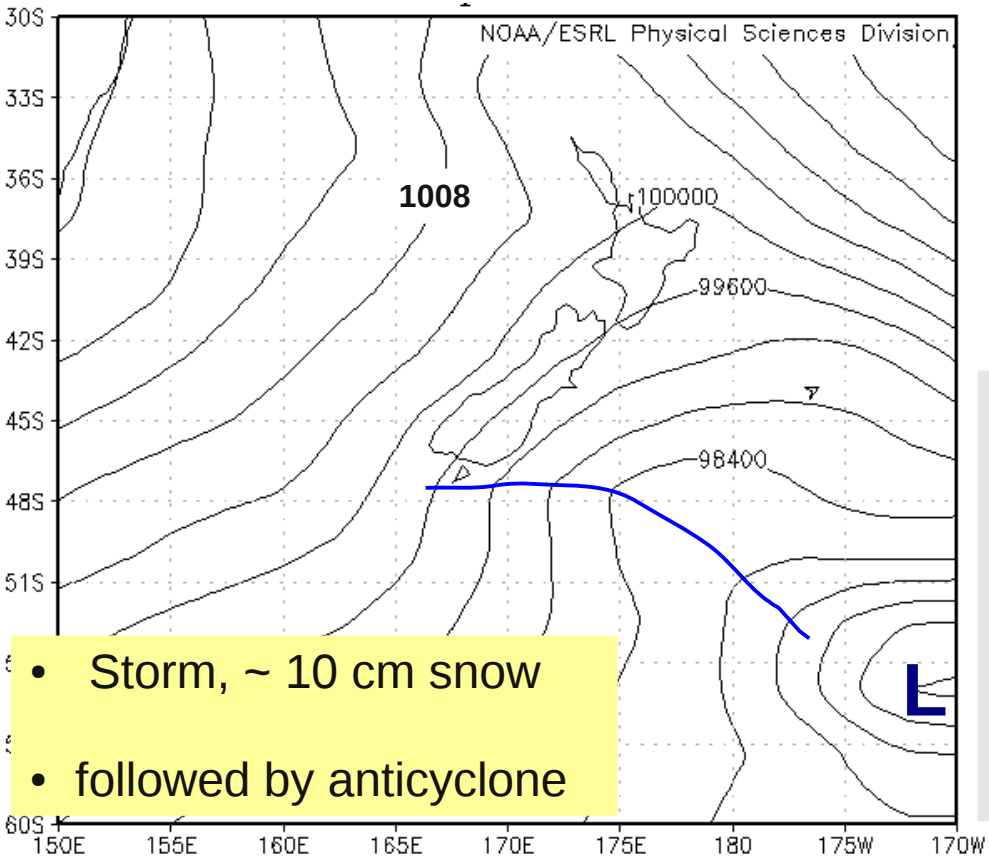


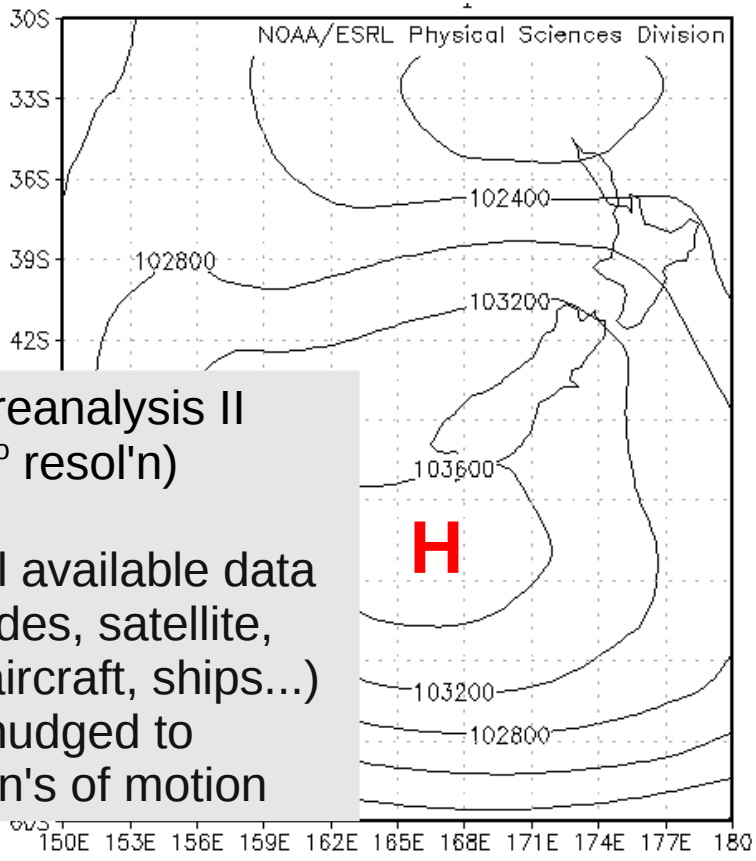
Otago Daily Times

NZMS “noon forecast”



compare





- Storm, ~ 10 cm snow
- followed by anticyclone

NCEP reanalysis II
(2.5^{o} resol'n)

- ingests all available data (radiosondes, satellite, surface, aircraft, ships...)
- gridded, nudged to satisfy eqn's of motion

WRF-EMS (Weather Research & Forecasting – Envir. Mdlg System)

- domain – regional
- horizontal grid spacing – configurable
- vertical grid – terrain following, grid spacing configurable

- dynamics
- parameterizations
- coordinates
- numerics
- initialization

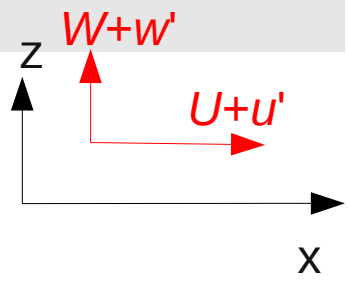
- non-hydrostatic

- as must all NWP models, "parameterizes" sub-grid-scale processes

- provision of initial and boundary conditions automated

Zonal momentum equation (in Cartesian *x,y,z* coord. system)

$$\frac{\partial U}{\partial t} + U\frac{\partial U}{\partial x} + V\frac{\partial U}{\partial y} + W\frac{\partial U}{\partial z} = \frac{-1}{\rho}\frac{\partial P}{\partial x} + f\,V + F_u$$



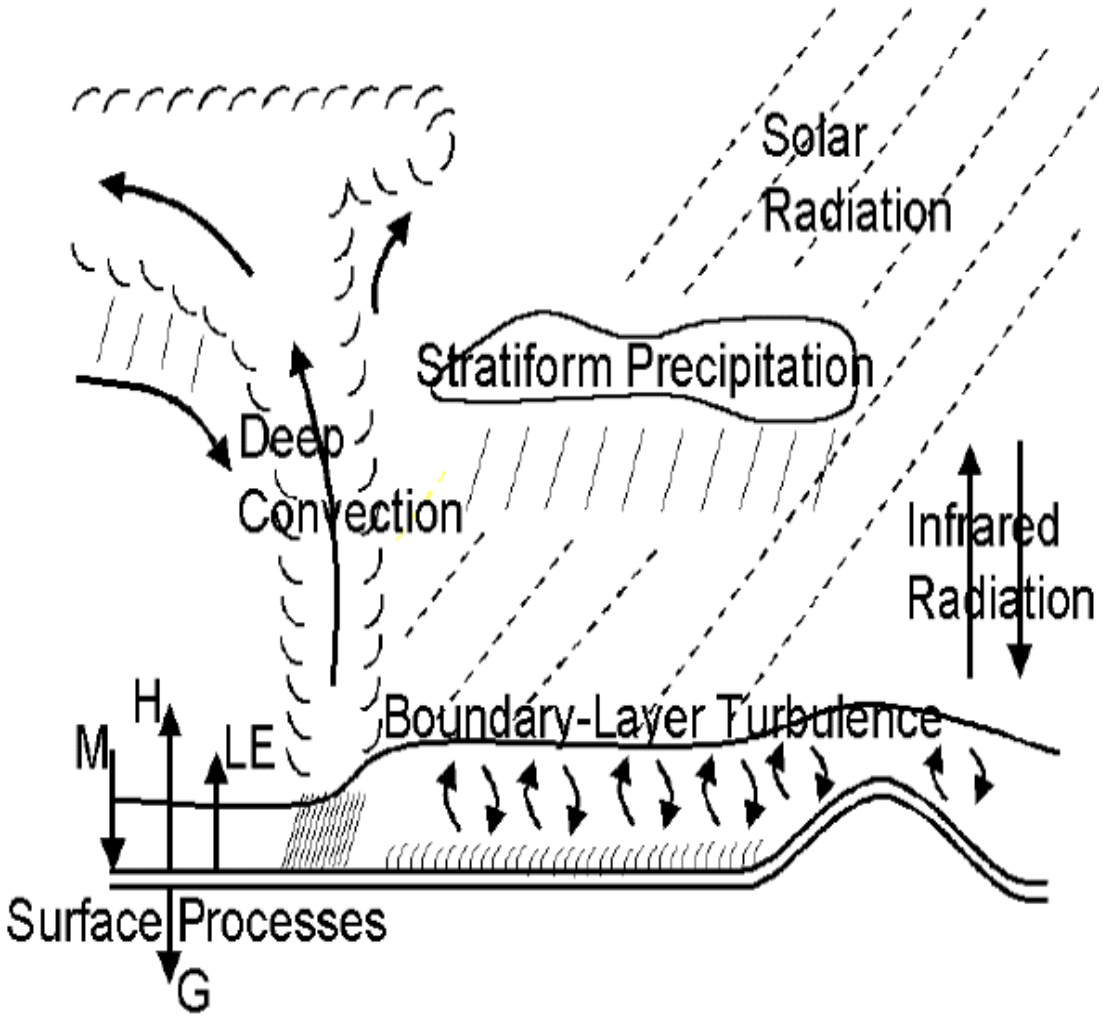
non-linearity

friction: influence of unresolved scales

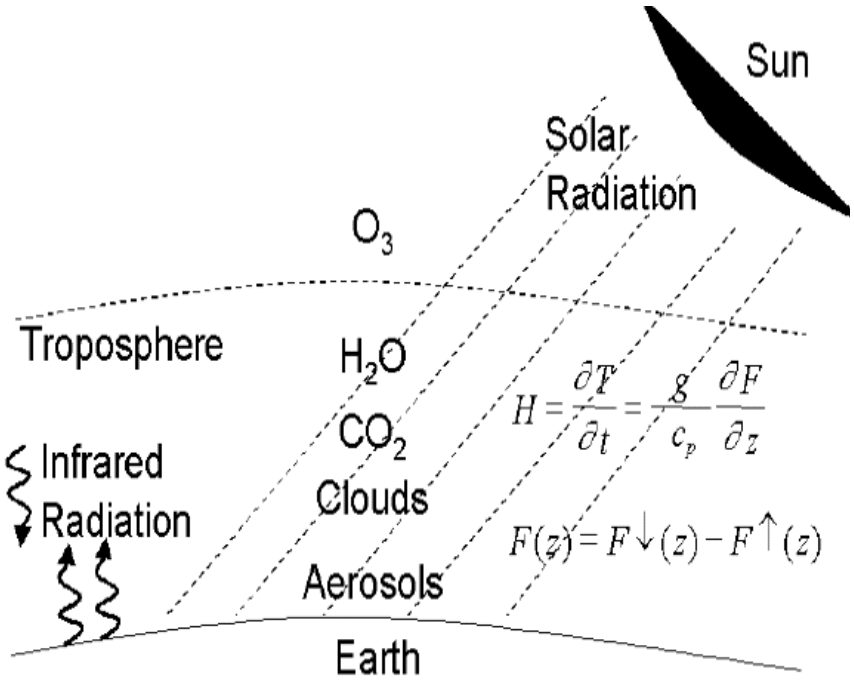
Friction – divergence of unresolved momentum flux, parameterized as eddy diffusion

$$F_u = -\frac{\partial \overline{u'u'}}{\partial x} - \frac{\partial \overline{v'u'}}{\partial y} - \frac{\partial \overline{w'u'}}{\partial z} \rightarrow \frac{\partial}{\partial z}\left[K(z)\frac{\partial U}{\partial z}\right]$$

Overview of Physical Processes* that are parameterized



* including effects of unresolved (sub-grid scale) motion



Thanks to Stephane Belair (Cdn Meteorol. Centre) for permission to use this sketch

16 December 2013 - Tis the season, welcome the EMS "EMS Just Keeps on Giving" release!

NEWR EMS

http://strc.comet.ucar.edu/software/newrems/

What is it?

Who's Using?

Recent News

Release Issues

User Guide

FansFAQ

EMS Forums

List Archives

Benchmarks

Register Me!

Some questions you may be asking yourself

STRC EMS - What is it?

The NOAA/NWS Science and Training Resource Center (STRC) Environmental Modeling System (EMS) is a complete, full-physics, state-of-the-science numerical weather prediction (NWP) package that incorporates dynamical cores from both the National Center for Atmospheric Research (NCAR) Advanced Research WRF (ARW) and the National Center for Environmental Predictions' (NCEP) non-hydrostatic mesoscale model (NMM) releases into a single end-to-end forecasting system. All the capability of the NCEP and NCAR WRF models are retained within the EMS; however, the installation, configuration, and execution of each core has been greatly simplified to encourage their use throughout the operational, private, and University forecasting and research communities.

Nearly every element of an operational NWP system has been integrated into the EMS, including the acquisition and processing of initialization data, model execution, output data processing, and file migration and archiving. Even tools for the display of the model output are provided. Real-time forecasting operations

Please keep in mind that *all* EMS activities are conducted by a single, sleep-deprived person. This includes testing, package design, development, support, research, computer maintenance, EMS real-time data server upkeep, web site development (or lack thereof), DVD burning, labeling, and mailing. And those activities represent a fraction of the work-related responsibilities! So be kind and understanding as nothing gets done as quickly as it should, and some things not at all.

Downscaling NCEP II reanalysis to obtain high resolution (200 m) fields

(Δt = 10 sec)

Reanalysis 18 NZST 3 July

6 hours

Reanalysis 00 NZST 4 July

6 hours

06 NZST 4 July

Downscaled fields valid at this time

initial and boundary conditions for: Domain 1 which covers 200 x 200 km with resolution 2 km

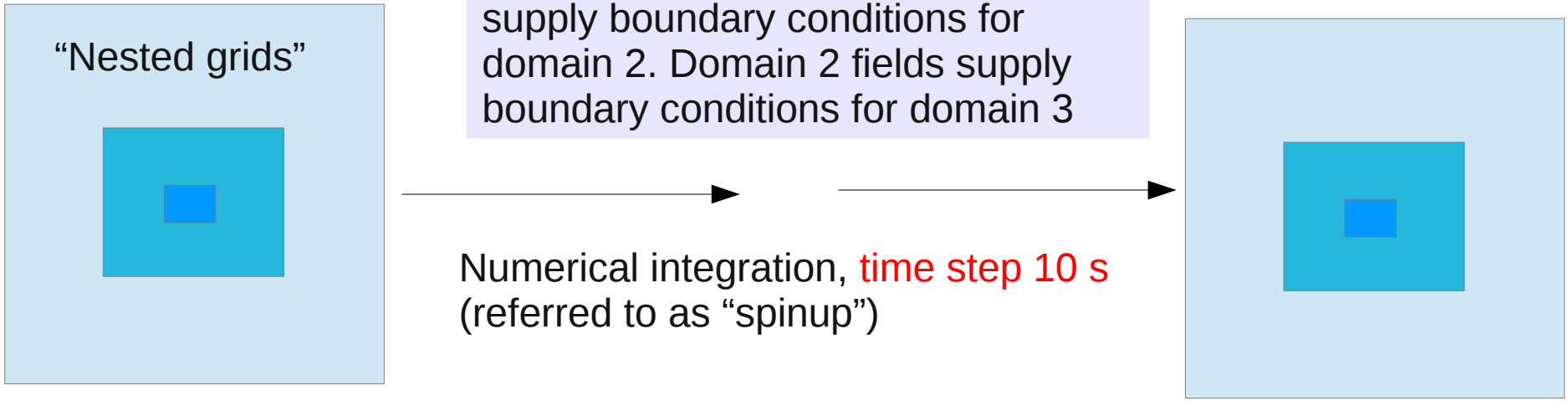
Linear interpolation

boundary conditions

Downscaling was performed using "WRF-EMS" with the ARW core

Reanalysis provides init. & b/conds for Domain 1. Domain 1 fields supply boundary conditions for domain 2. Domain 2 fields supply boundary conditions for domain 3

Fields on refined (nested) grids – resolution of finest grid 220 m



Numerical integration, time step 10 s (referred to as "spinup")

Configuration of WRF for 12 hr downscaling simulation – emphasis the ABL

- default shortwave and longwave radiation schemes
- convection & precip. schemes off (dry, stable, mid-winter, anticyclonic system)
- Yonsei Univ. (YSU) ABL scheme: a *K*-profile method,

$$K(z) = \frac{k_v \, u_* \, z}{\varphi(z/L)} \left[1 - \frac{z}{\delta}\right]^2$$

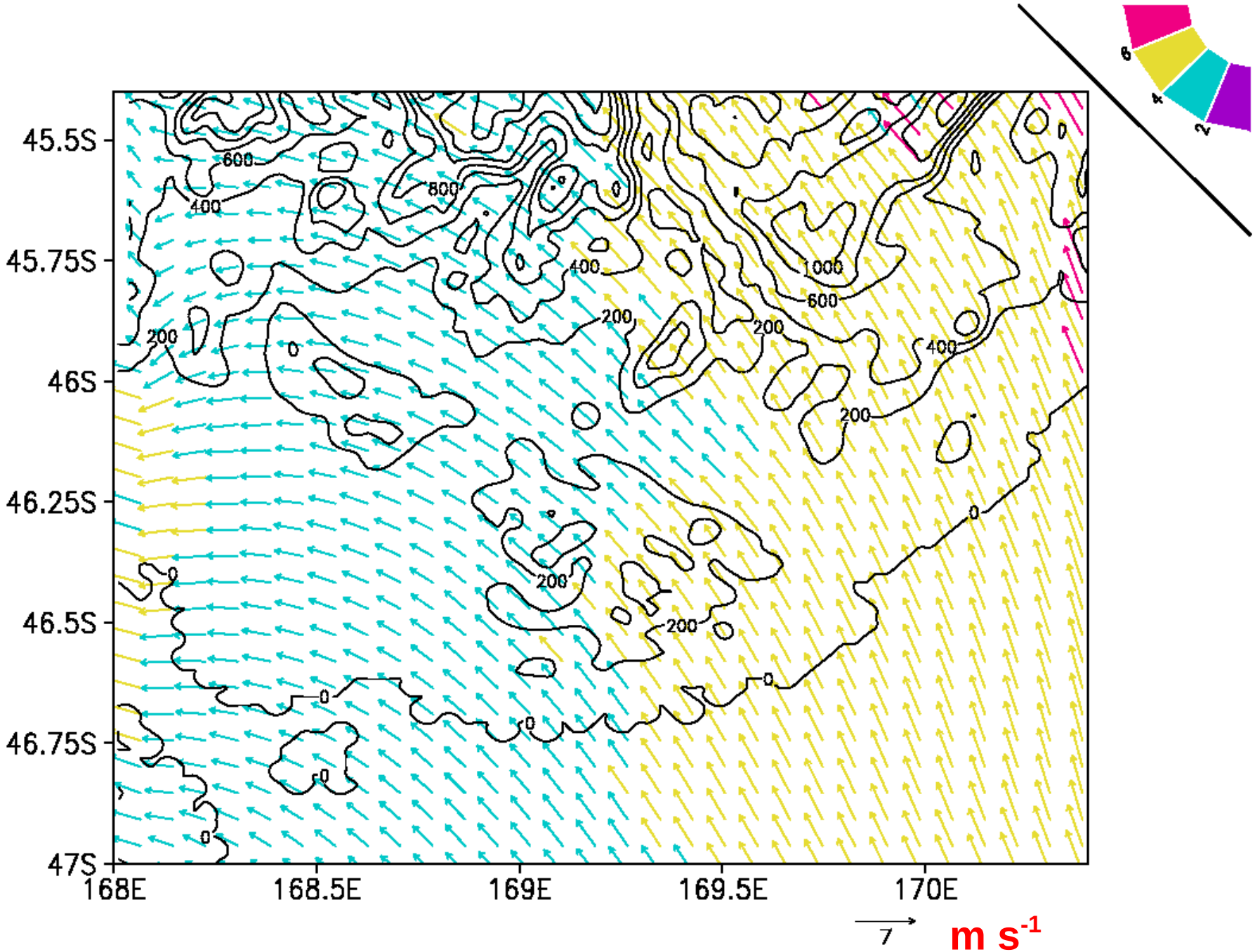
- NOAA land surface model: soil temperature and moisture in four layers, fractional snow cover, and frozen soil physics. Vegetation effects included. Predicts snow cover and canopy moisture. Diagnoses skin temperature T_{sfc} and uses emissivity. Provides heat and moisture fluxes to the lowest model level (e.g. U_a, T_a, ...), using the bulk transfer formulation

$$Q_{H0} = \rho \, c_p \, \alpha \, U_a \left[T_{sfc} - T_a\right]$$

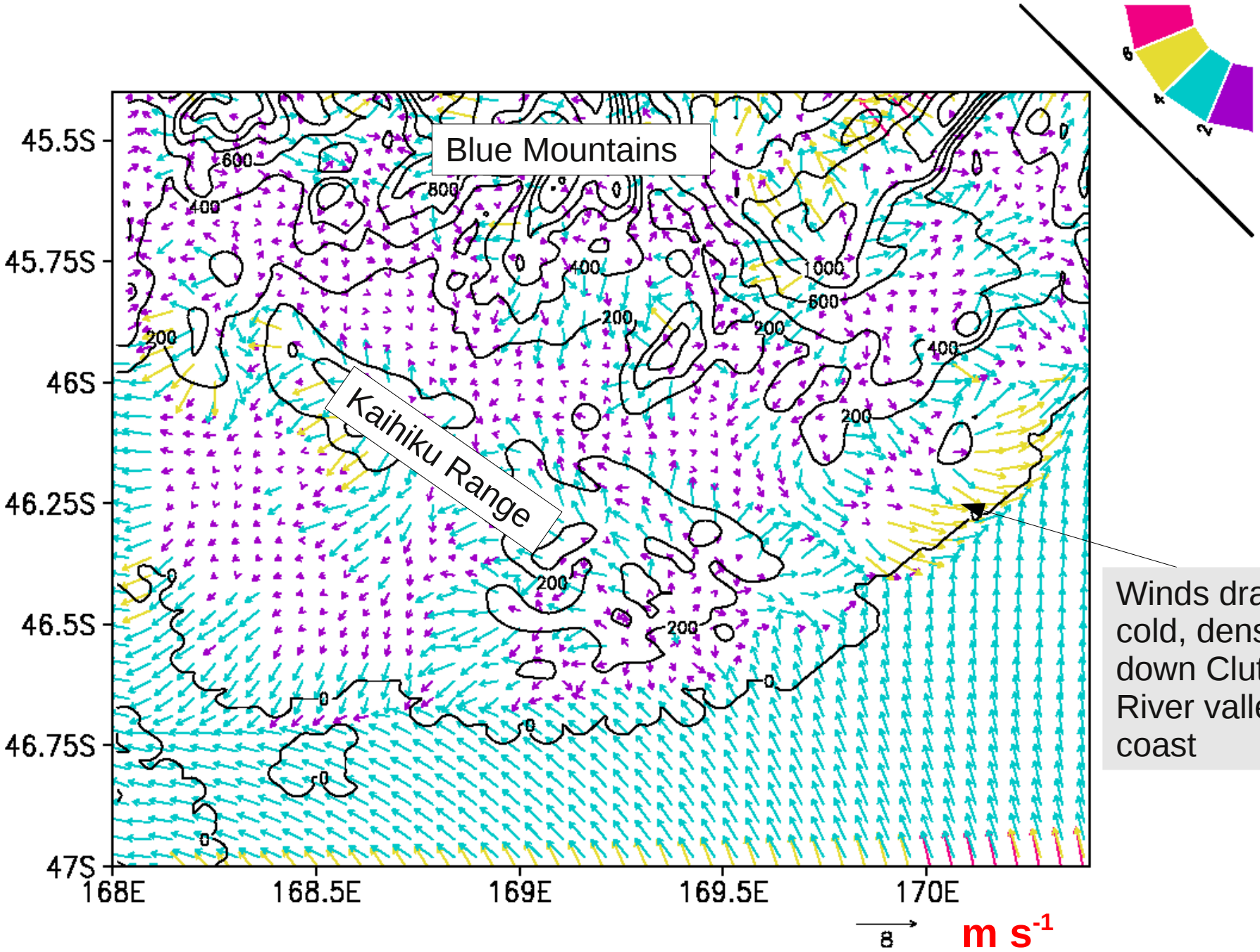
(coefficient α tuned to be consistent with Monin-Obukhov similarity theory)

- 59 σ levels, $\Delta\sigma = 0.002$ below $\sigma = 0.966$. Lowest levels 8, 23, 38 m AGL.

Wind (850 hPa) on domain 1 (2 km resolution) – 6 am 4 July 96

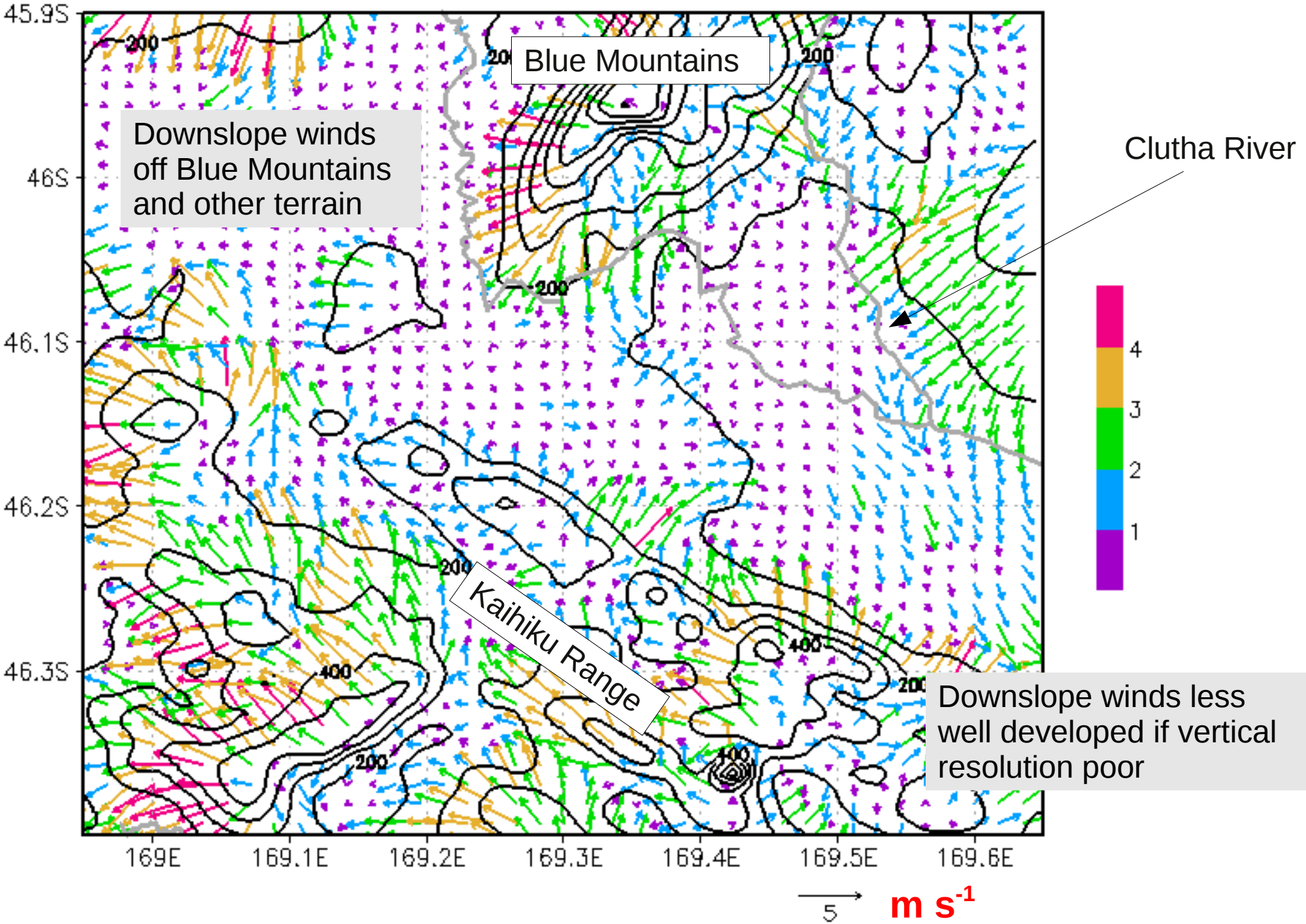


Wind (10 m AGL) on domain 1 (2 km resolution) – 6 am 4 July 96

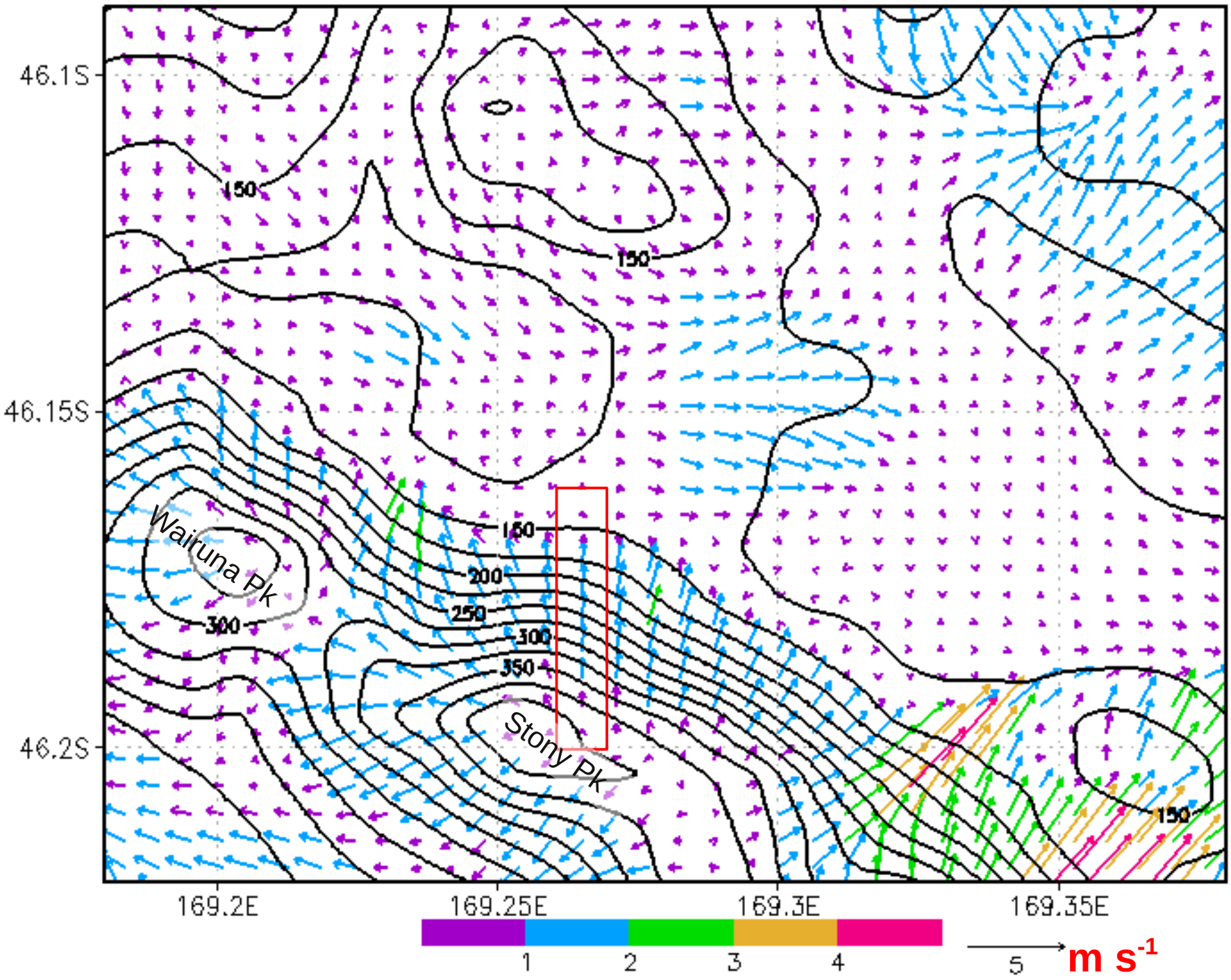


Winds draining cold, dense air down Clutha River valley to coast

Wind (10 m AGL) on domain 2 (660 m resolution) – 6 am 4 July 96

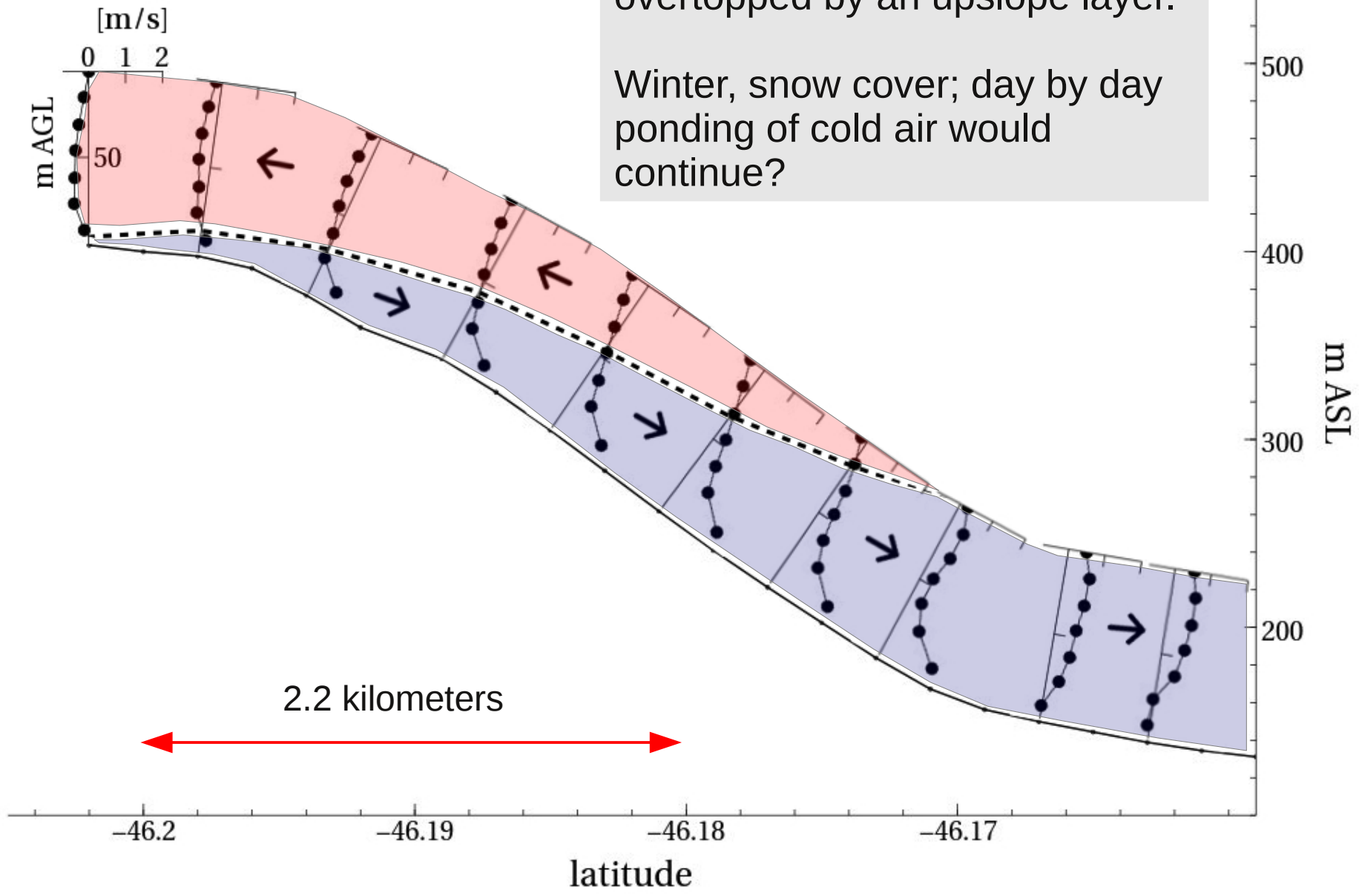


Wind (10 m AGL) on domain 3 (220 m resolution) – 6 am 4 July 96



Profiles of the up/downslope wind component on a transect down Stony Pk

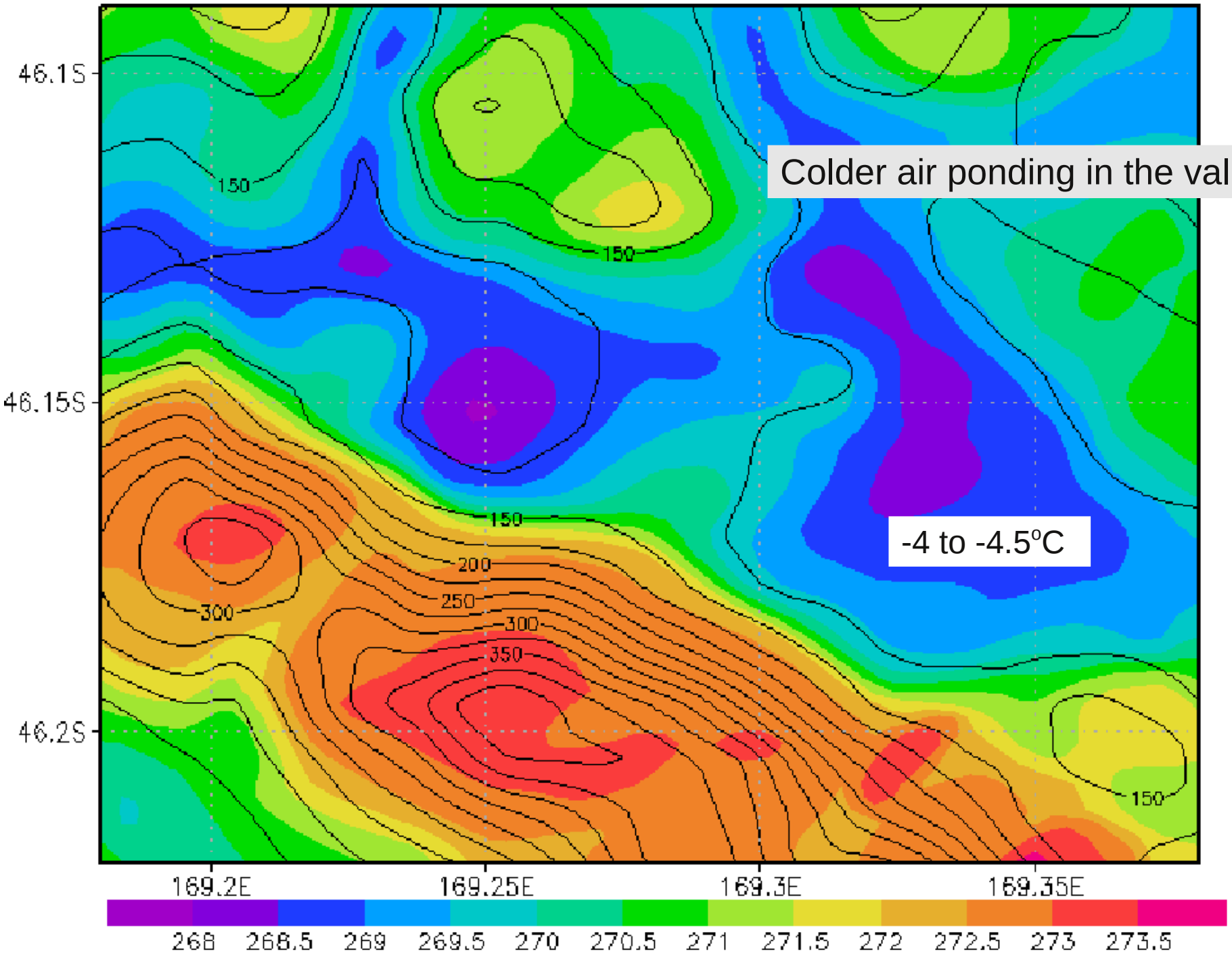
Stony Peak



Shallow cold air drainage layer, overtopped by an upslope layer.

Winter, snow cover; day by day ponding of cold air would continue?

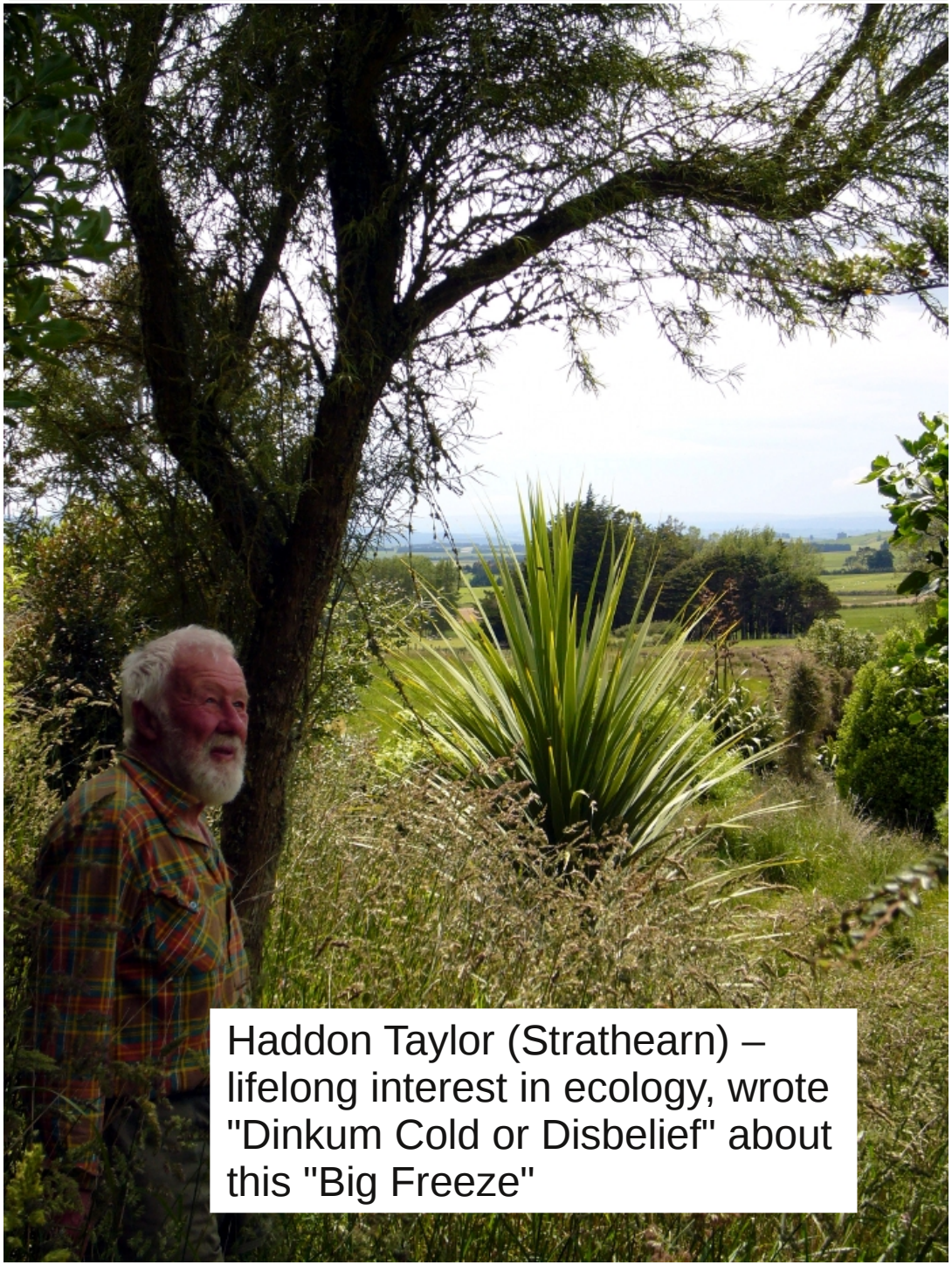
Potential temperature (2 m AGL) on domain 3 (220 m) – 6 am 4 July 96



Colder air ponding in the valley

-4 to -4.5°C

Conclusion



Haddon Taylor (Strathearn) – lifelong interest in ecology, wrote "Dinkum Cold or Disbelief" about this "Big Freeze"

- WRF solution not grid-independent (NWP solutions rarely if ever are)
- Finer resolution near ground accentuates drainage winds
- Hydrostatic solutions similar
- If “driven” by alternative reanalyses (e.g. European ECMWF) outcome similar

JDW hang gliding at Strathearn 1974