Sensitivity of heavy rainfall simulations to mountain heights: a windward case of the Southern Alps

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The Joint Annual R&D Workshop and 6th Momentum®UK Partnership Convective Scale Workshop

Climate, Freshwater & Marine Science

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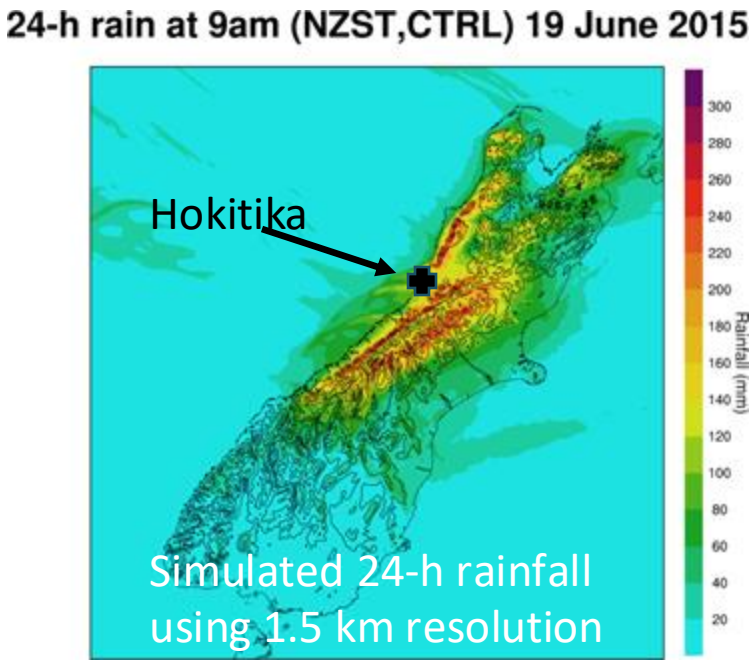
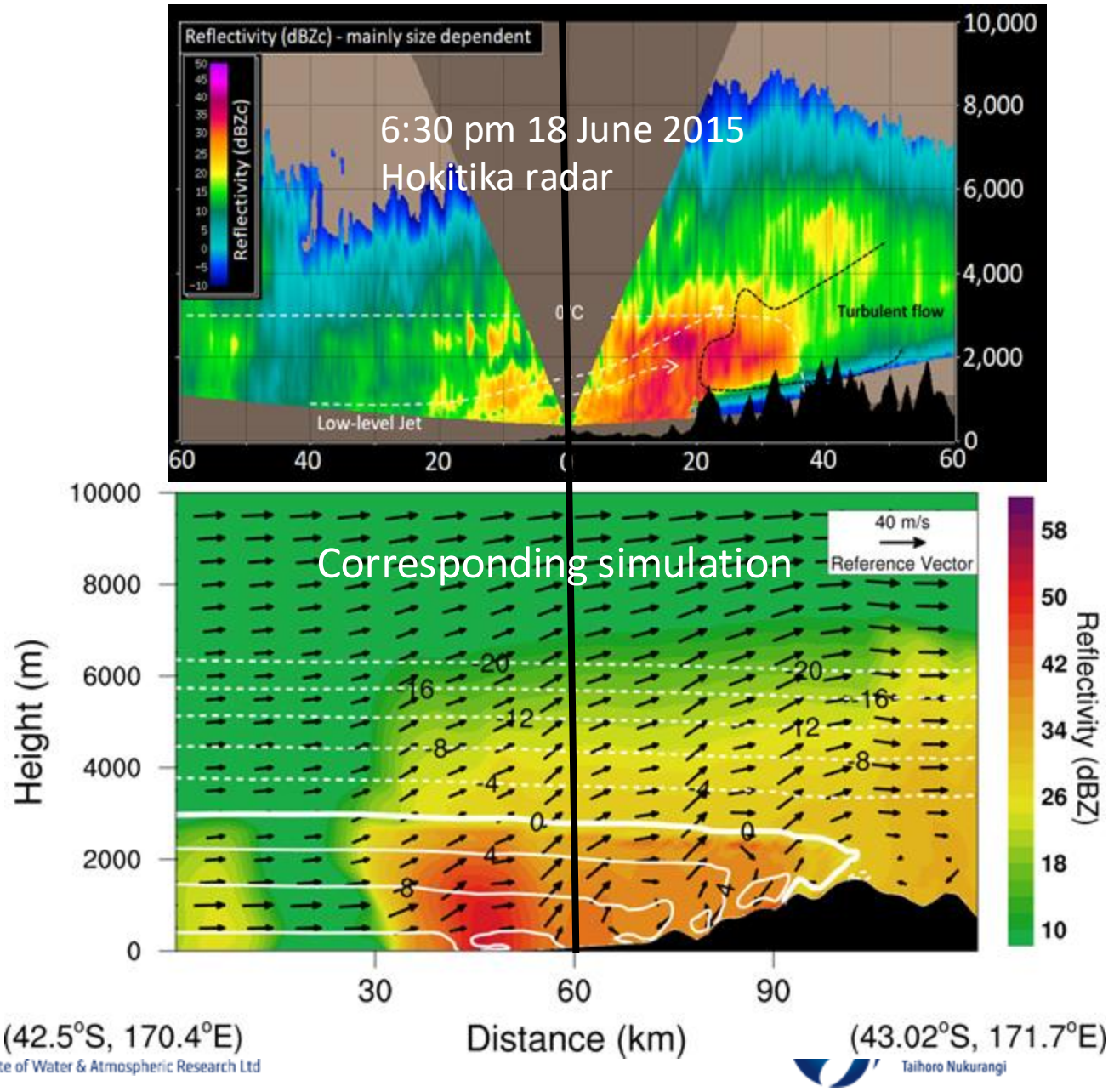
1. Introduction



Hokitika OBS: 211.3 (mm)
CTRL(RAL1M):140.2 (mm)

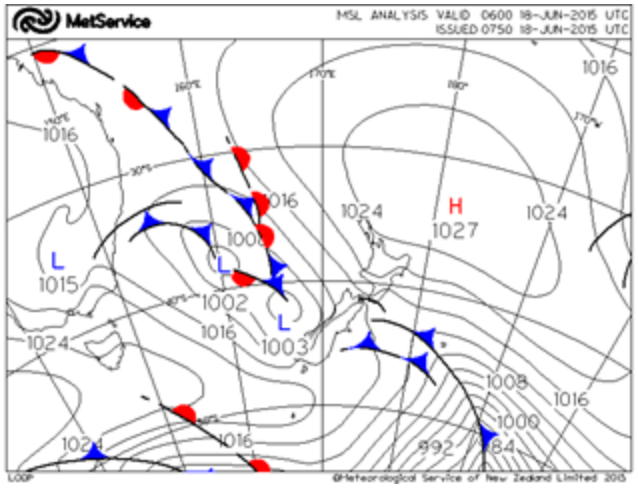
What caused the errors in this heavy rainfall?

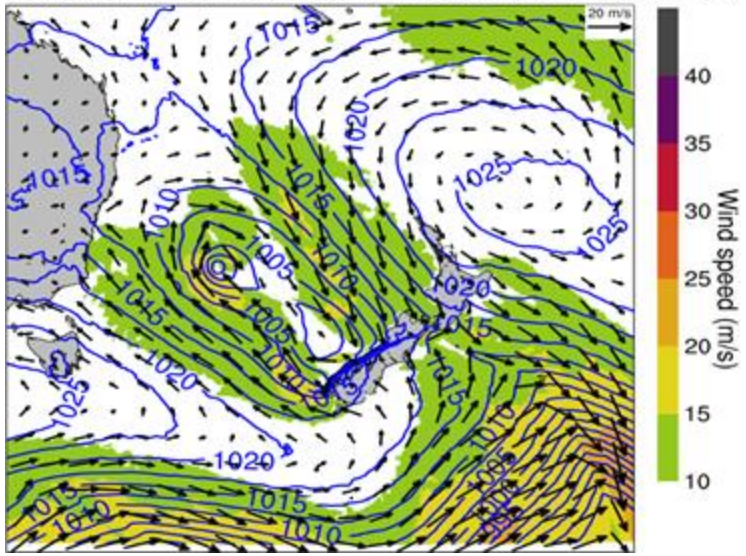


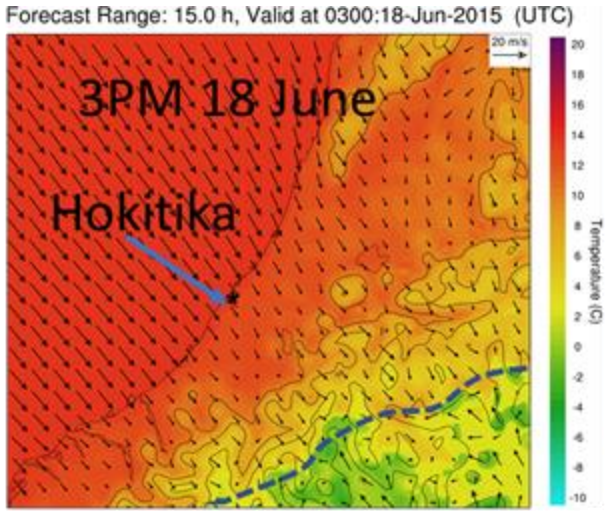
1. Introduction

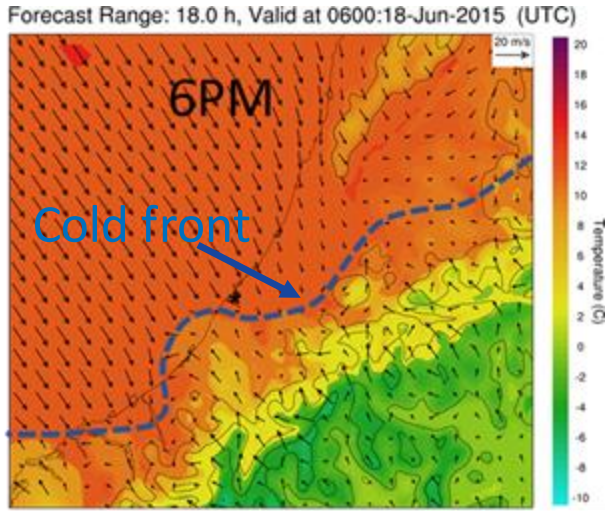
Major factors caused this heavy rainfall:

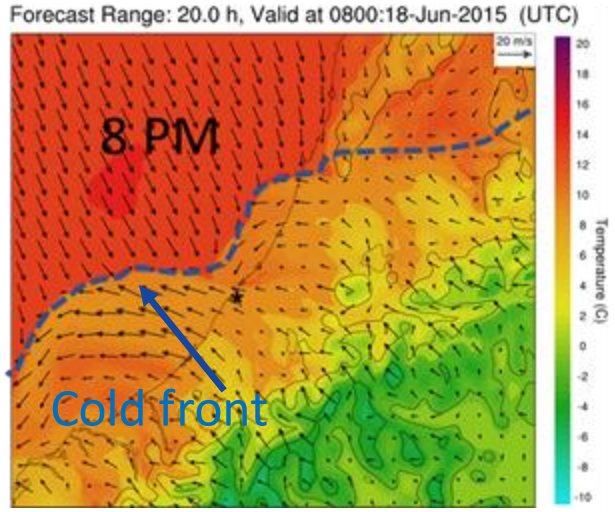
Front lifting enhanced by orographic lifting.

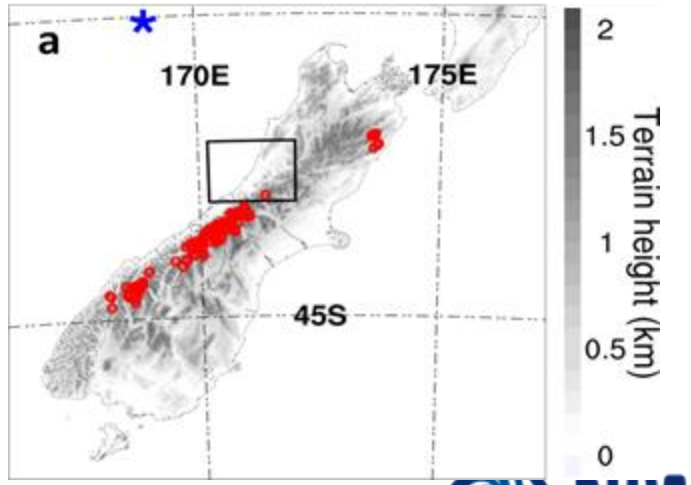












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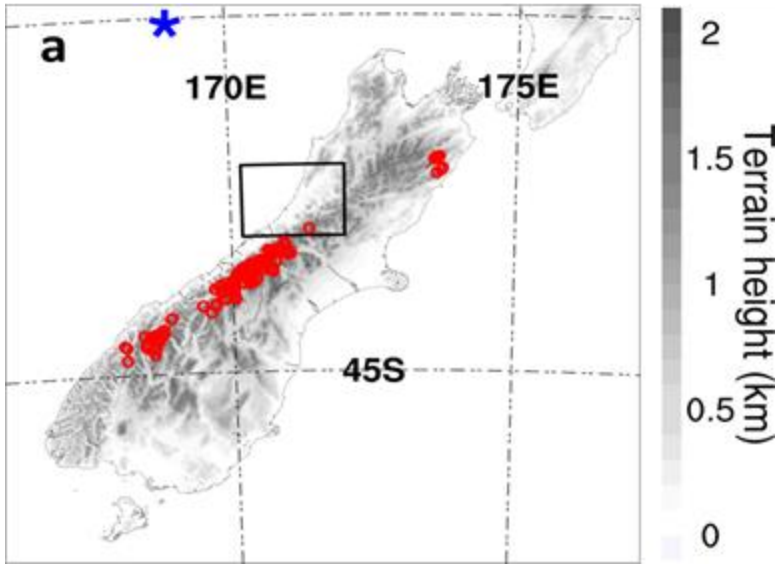
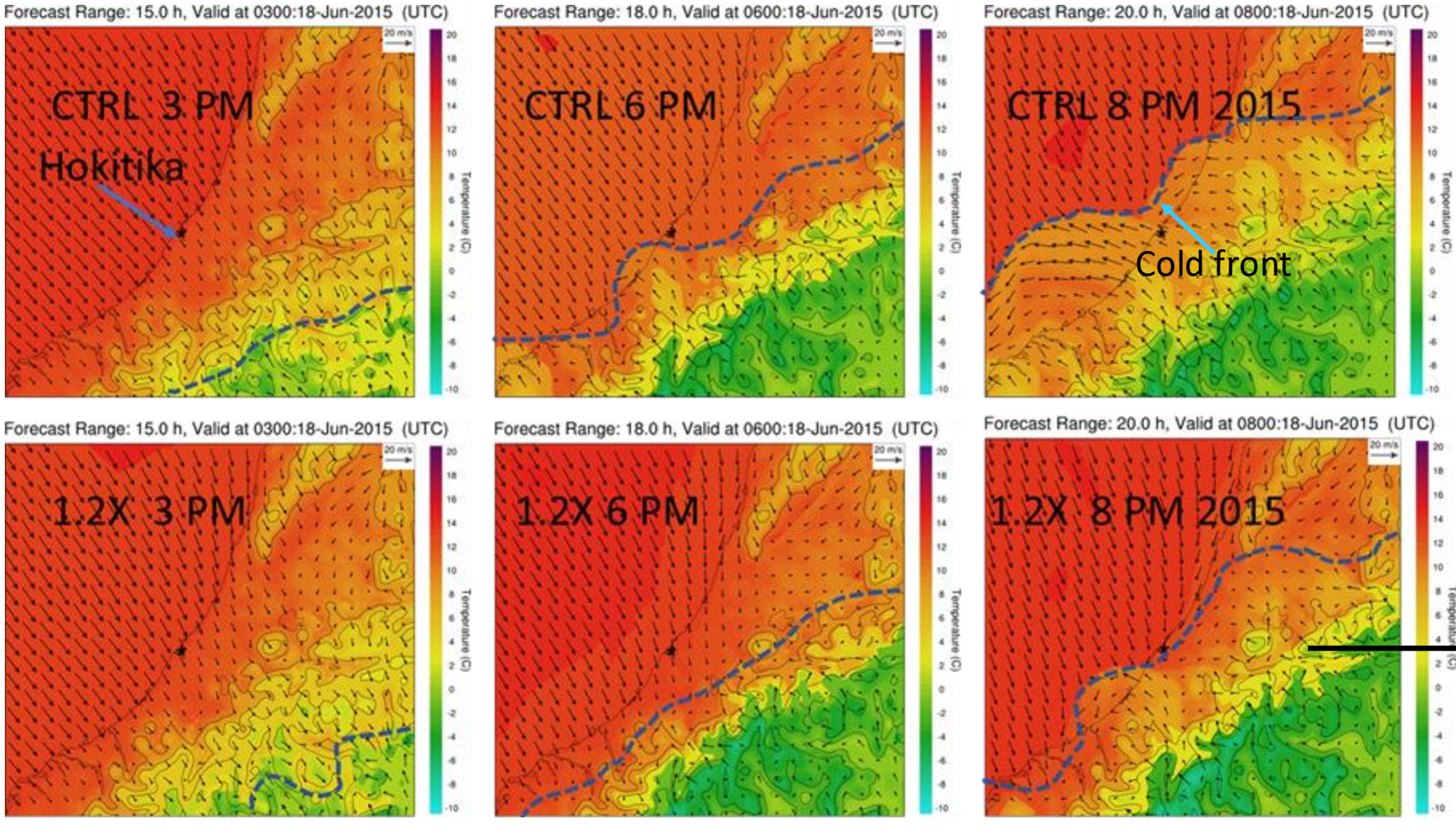
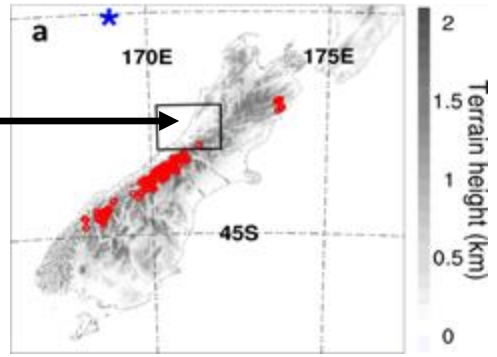


For 103 tallest mountains of the South Island, the mean height is ~2650 m
For CTRL, the terrain was created from raw terrain data with ~1 km resolution, corresponding height: ~1800 m

Hypothesis for the large rainfall errors:
Weaker mountain dynamical forcing due to a lower terrain.

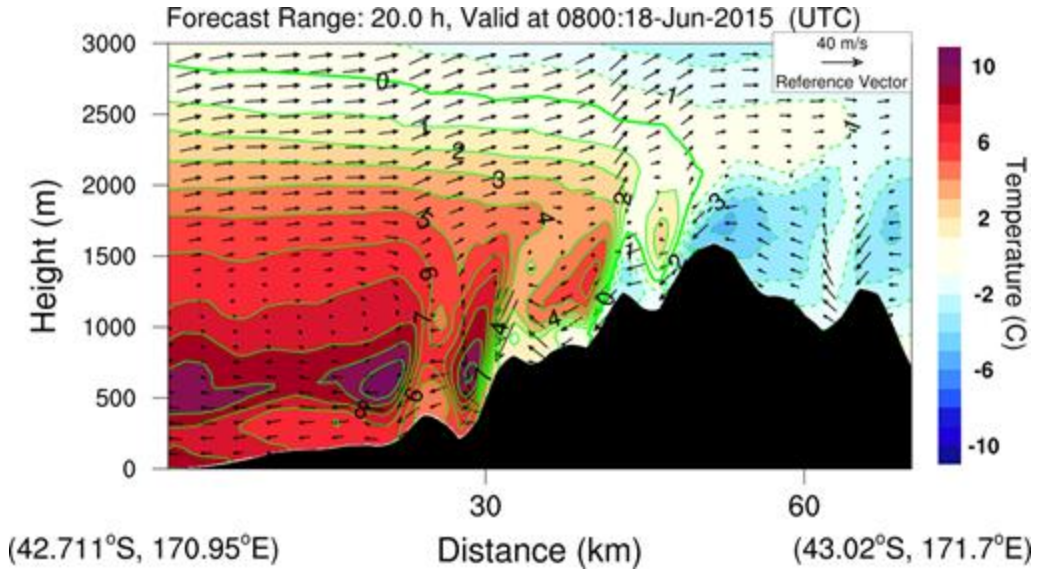
EXP	Description	h (m)	
CTRL	Using the original terrain data generated by the nesting suite of UM	1800	1.21
1.1X	Increasing the terrain height by 1.1 times of the terrain of CTRL	1980	1.11
1.2X	Increasing the terrain height by 1.2 times of the terrain of CTRL	2160	1.01
1.3X	Increasing the terrain height by 1.3 times of the terrain of CTRL	2340	0.94
1.4X	Increasing the terrain height by 1.4 times of the terrain of CTRL	2520	0.61



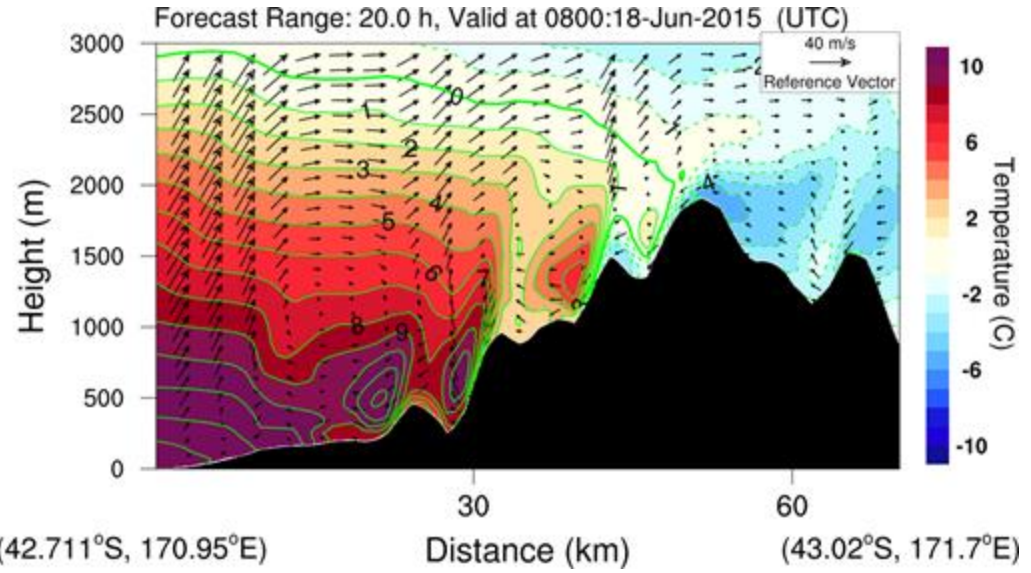


The movement of the cold front is slower for a higher terrain

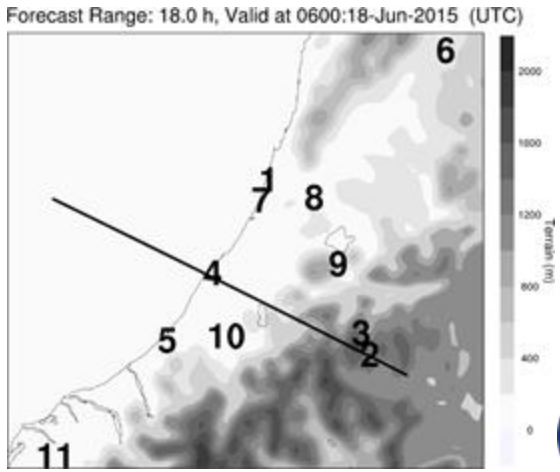
CTRL 8PM



1.2X 8PM



For a higher terrain, the cold air on the west side is shallower, and the intensity of the cold front is weaker regarding cold air wind speed.



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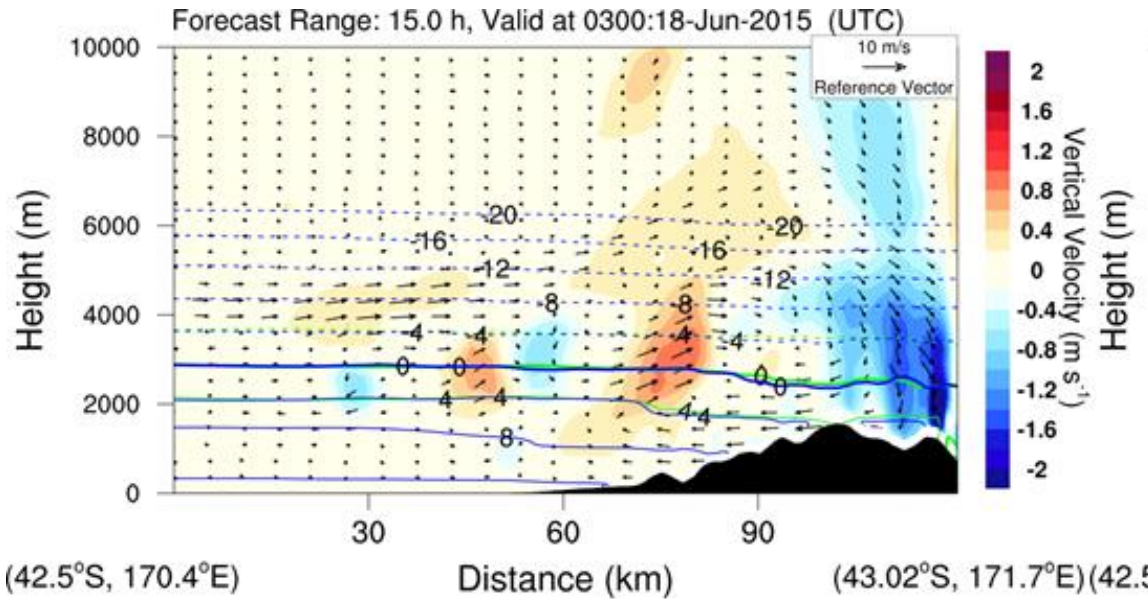
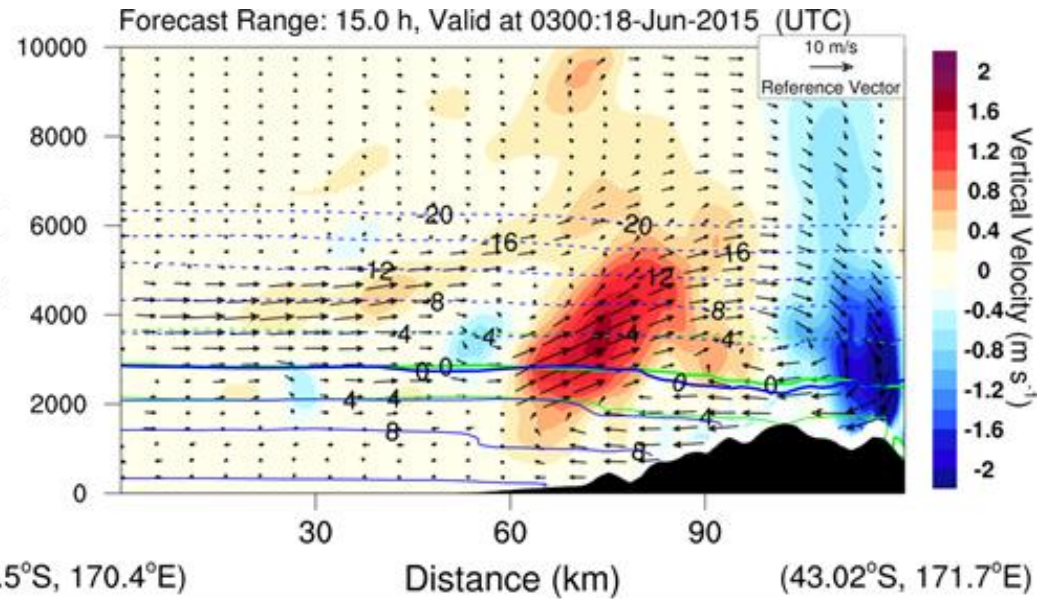
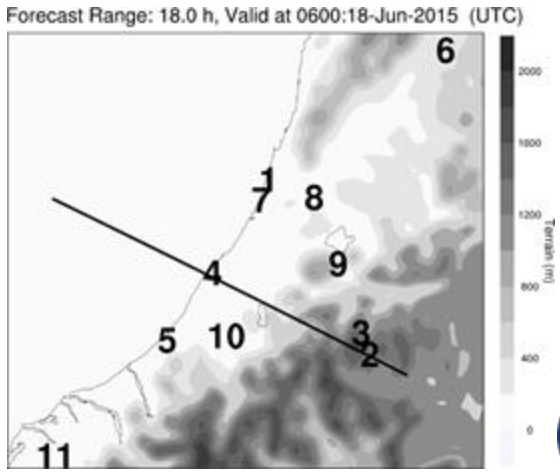
1.2X – CTRL 3PM

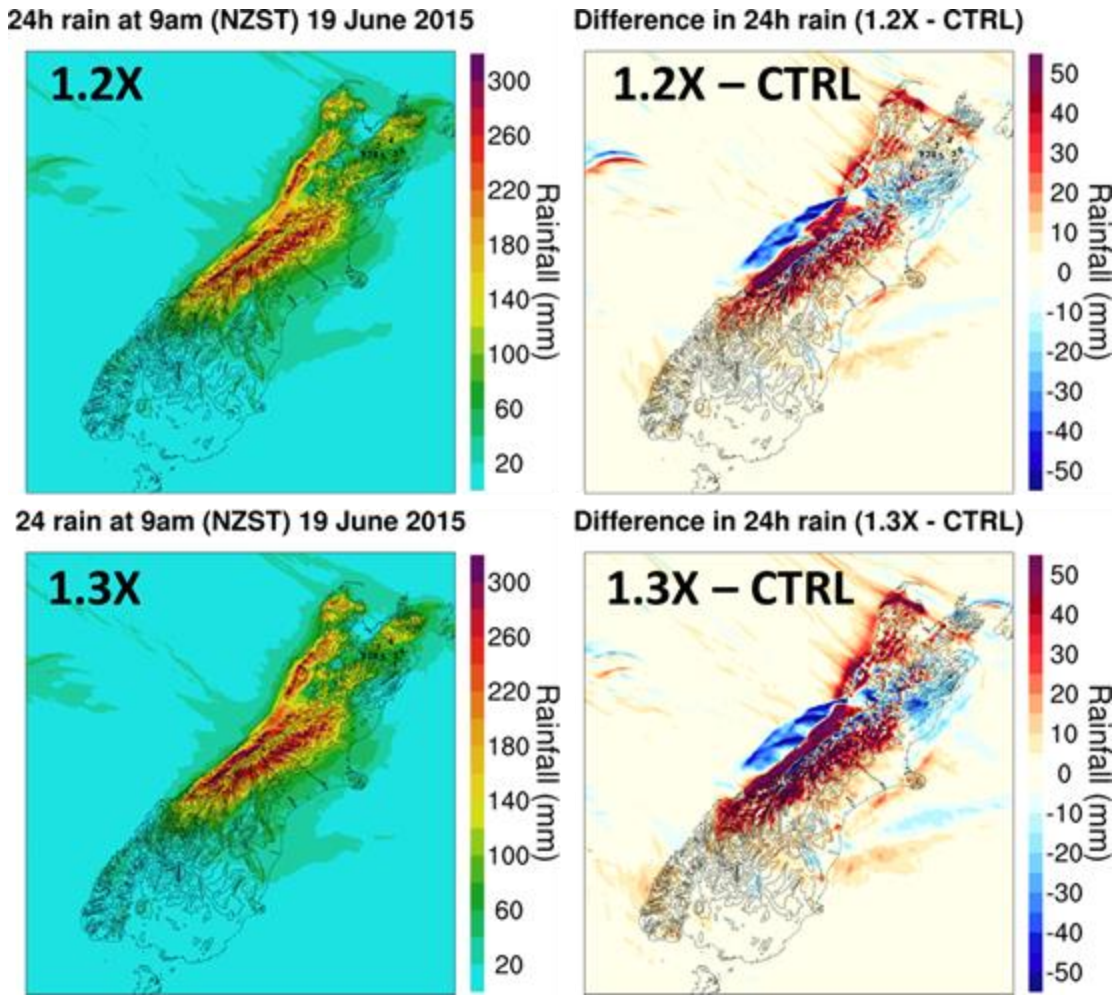


1.3X – CTRL 3PM

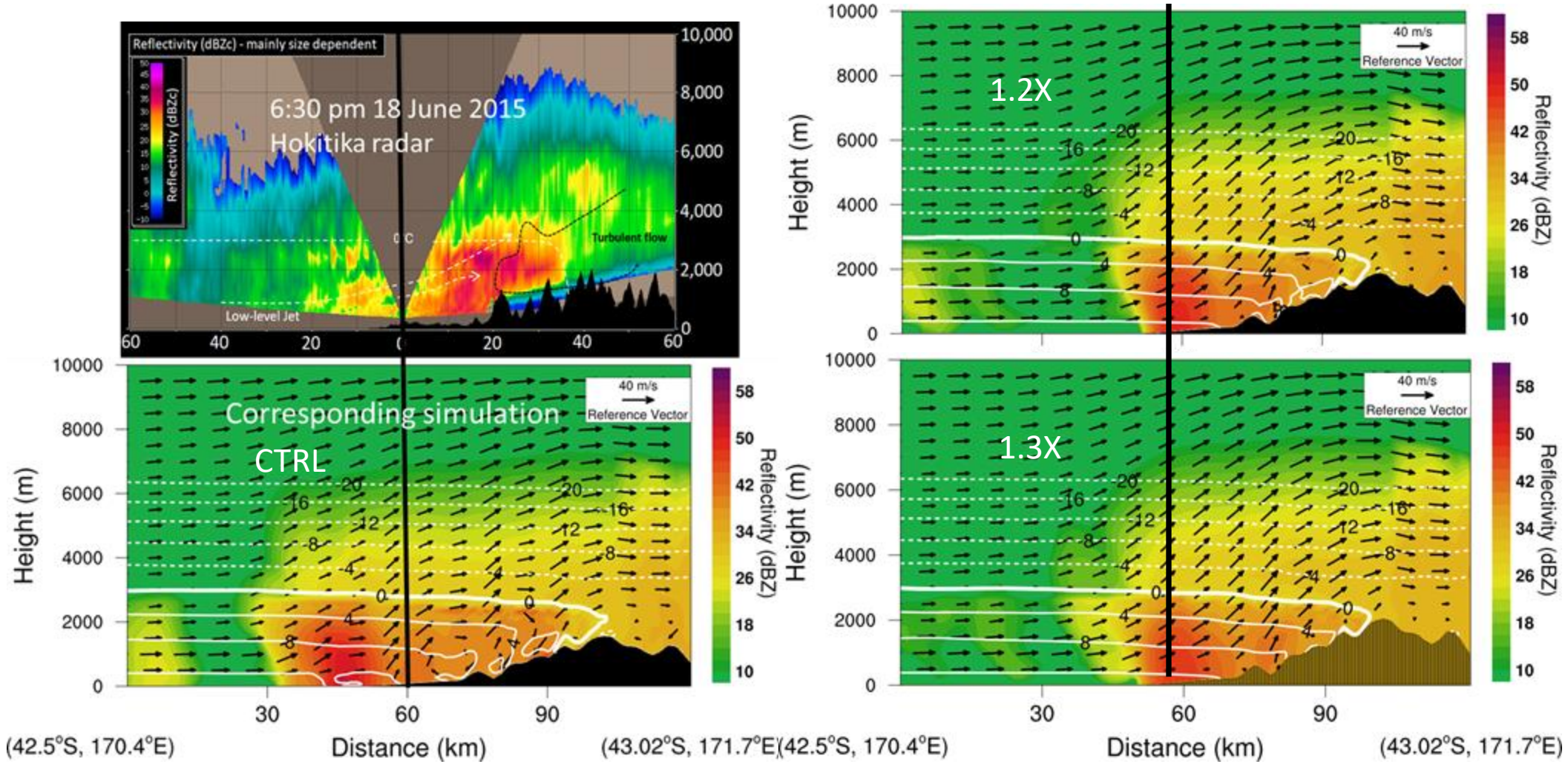


Orographic lifting is stronger for a higher terrain

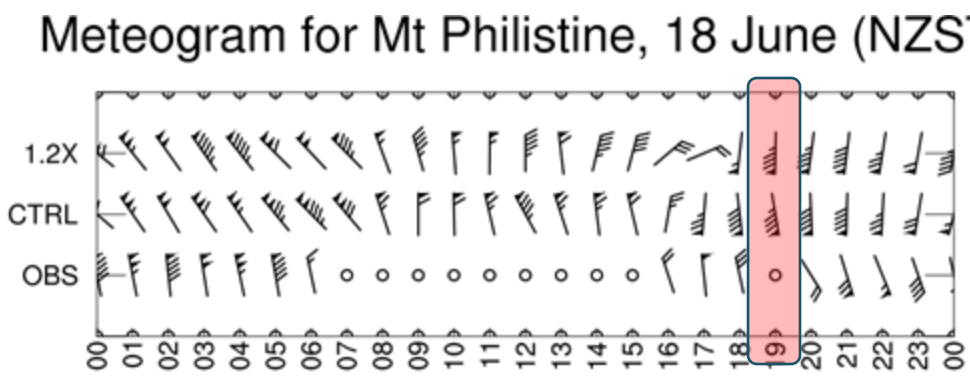


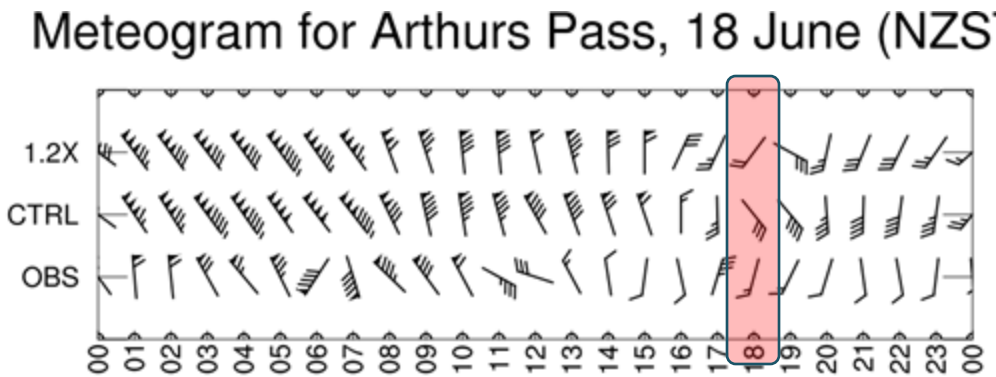


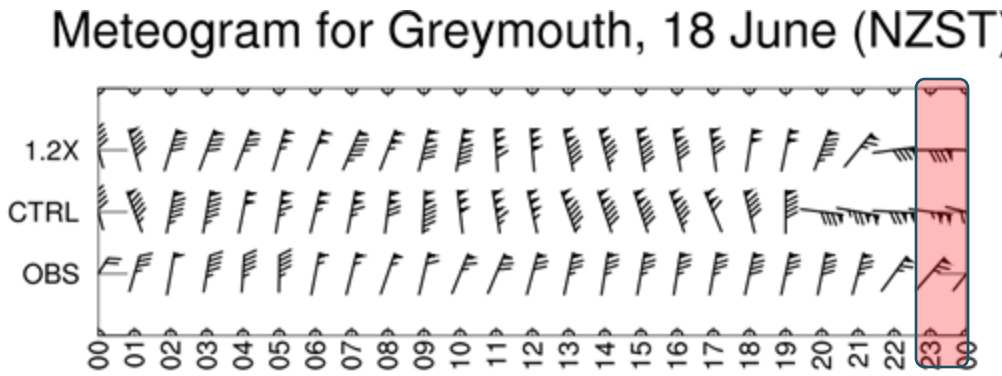
For a higher terrain, less rainfall offshore and more rainfall over land

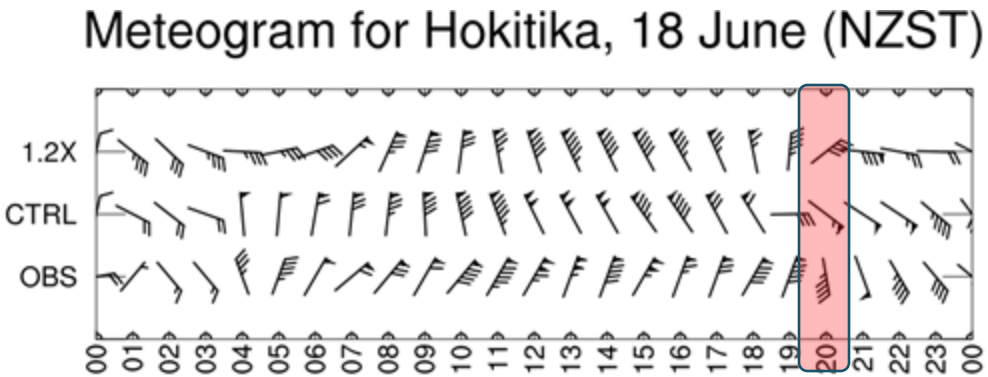


The location of the heaviest rainfall is closer to OBS for a higher terrain



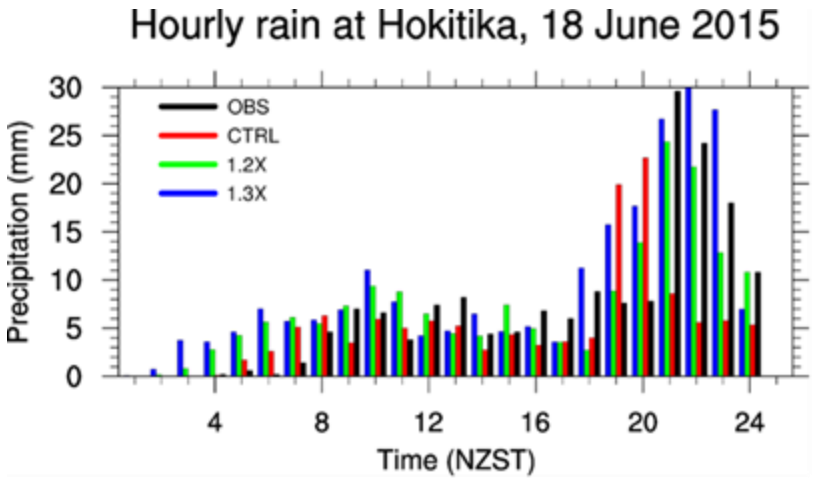


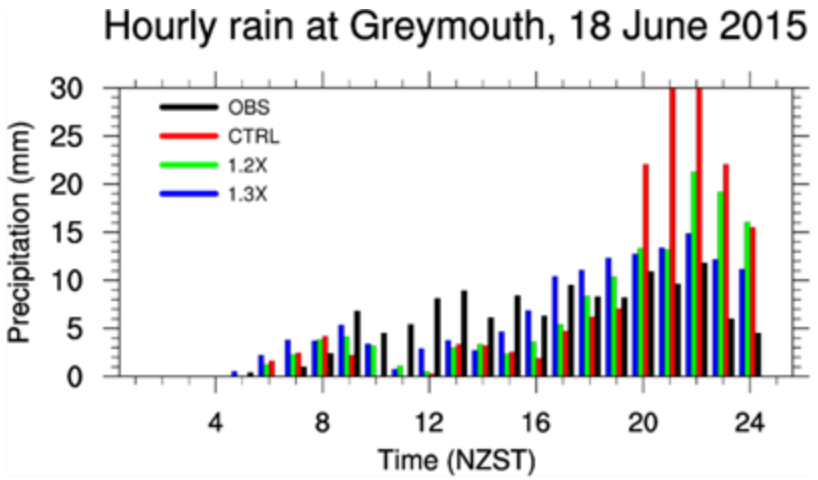


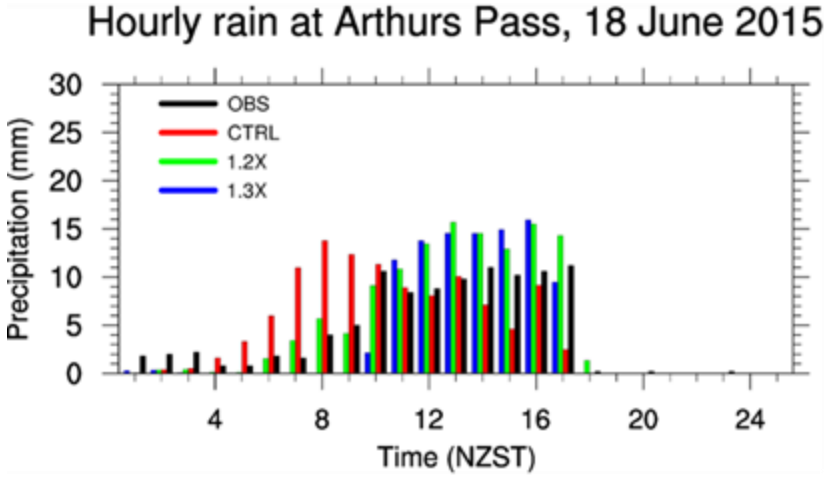


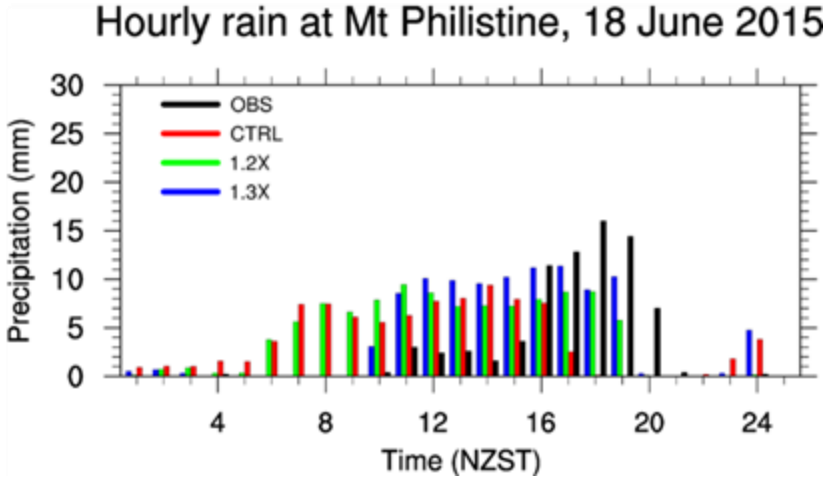
The pink bars denote the arrival time of the cold front at stations.

For a higher terrain, the arrival time of the cold front at stations is closer to OBS than CTRL

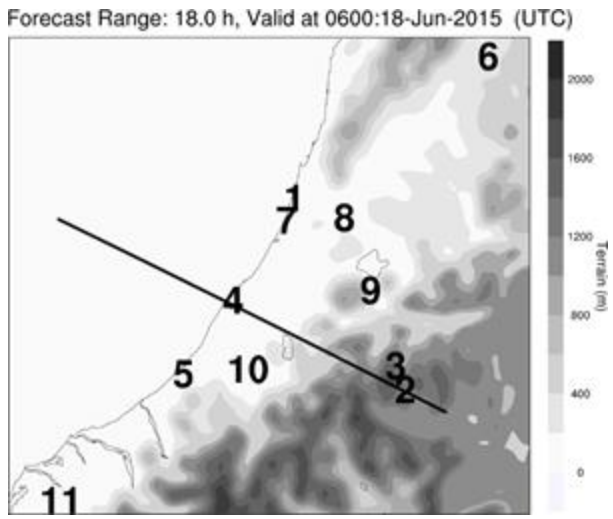








For a higher terrain, the hourly rainfall matches OBS better than CTRL regarding time and intensity



Distribution of stations

Daily rainfall observations (OBS) and simulations valid at 0900 NZST 19 June

Station No.	Sta. Name	OBS	1.4X	1.3X	1.2X	1.1X	CTRL
1	Greymouth	144.4	136.0	144.0	151.9	206.6	186.2
2	Arthurs Pass	81.0	130.2	113.7	123.0	114.1	82.3
3	Mt Philistine	163.0	107.6	113.4	107.7	93.4	87.5
4	Hokitika	211.3	167.6	197.7	178.4	144.7	140.2
5	Ross	188.5	240.2	184.0	133.0	121.6	106.5
6	Reefton	82.8	94.0	105.9	102.3	102.7	97.2
7	Paroa	144.9	139.6	156.9	216.2	171.7	118.6
8	Kokiri	180.6	177.2	178.8	171.2	156.3	147.9
9	Inchbonnie	327.9	210.8	248.9	247.0	247.0	231.8
10	Kowhitirangi	265.3	250.1	226.2	200.7	164.9	149.3
11	Lower Whataroa	274.7	180.7	169.9	192.8	139.4	113.8
MAE (mm)			42.2	33.6	48.2	63.2	66.1

MAE is smaller for a higher terrain, except for 1.4X, implying the way to raise terrain in this study is not a good way, need to use high quality data like SRTM 100m.

1

Summary

- This heavy rainfall was caused by cold front lifting enhanced by orographic lifting.
- Weaker mountain blocking in CTRL caused stronger and faster cold front, leading to large errors in the heavy rainfall simulation.
- With higher terrain, better simulation of the cold front and orographic lifting, thus, better heavy rainfall simulation.

Next steps:

- Using SRTM 100m data to create the terrain file.
- Turning on the sub-grid gravity wave drag scheme.
- Rerun this rainfall case for comparisons.

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Thanks!

Any questions?