Compatibility of High Resolution Terrain with High Resolution Model Grid

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Motivation

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Modelers intuitively want to use the highest resolution terrain possible; but may not always good - high resolution terrain may generate noise and increase computing instability.

Effective resolution of ARW WRF is 7Dx (Skamarock 2004); Thus terrain features < 7 Dx in WRF may generate forcing or noise not resolved by model.

Solution to this problem: smooth terrain but many ways to do this.

Methodology

Smooth terrain using a more objective method: discrete wavelet transform (DWT).

Wavelet transform: a process akin to local Fourier transform (basis function with compact support).

This study tested different number of DWT passes to smooth/remove certain Dx terrain features in WRF to evaluate model sensitivity to underlying terrain in the finest nest.

Methodology

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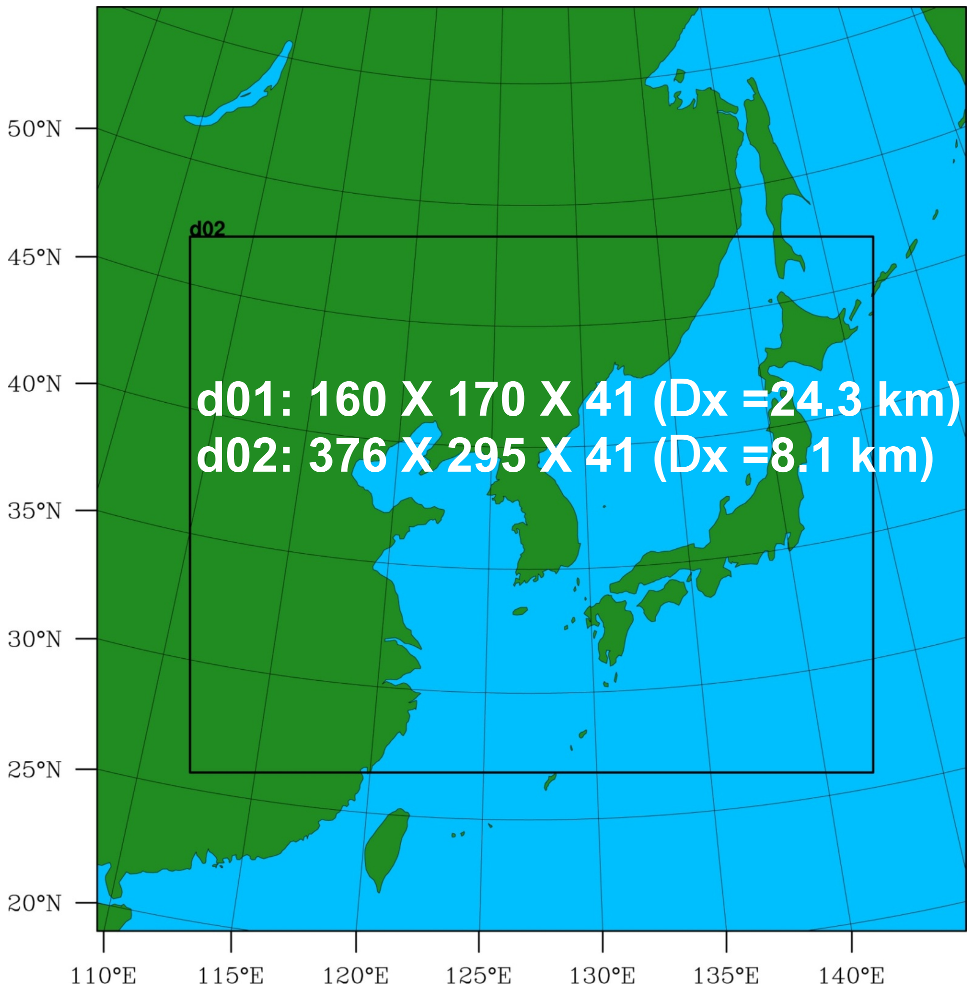
Area of study: East Asia with a focus on the complex terrain of the Korean Peninsula.

Model: WRF-based RTFDDA

Focus on near surface atmospheric variables and boundary layer kinetic energy spectrum (1.5 km AGL) using Skamarock's (2004) methodology.

Grid Setup

NCAR



Cold start: initialized with **GFS** grid (1.0° X 1.0°) on **0000 UTC 24 Dec 2010** and ran for 48-h with data assimilation using **NCAR WRF3.4-RTFDDA**. Data including MADIS, WMO obs, AMDAR, NCEP STG 1/12 deg SST.

Experimental Design

	# passes DWT (d02)	comments
db0	0	original terrain
db1	1	removes 2Dx terrain features
db2	2	removes 4Dx terrain features
db3	3	removes 8Dx terrain features

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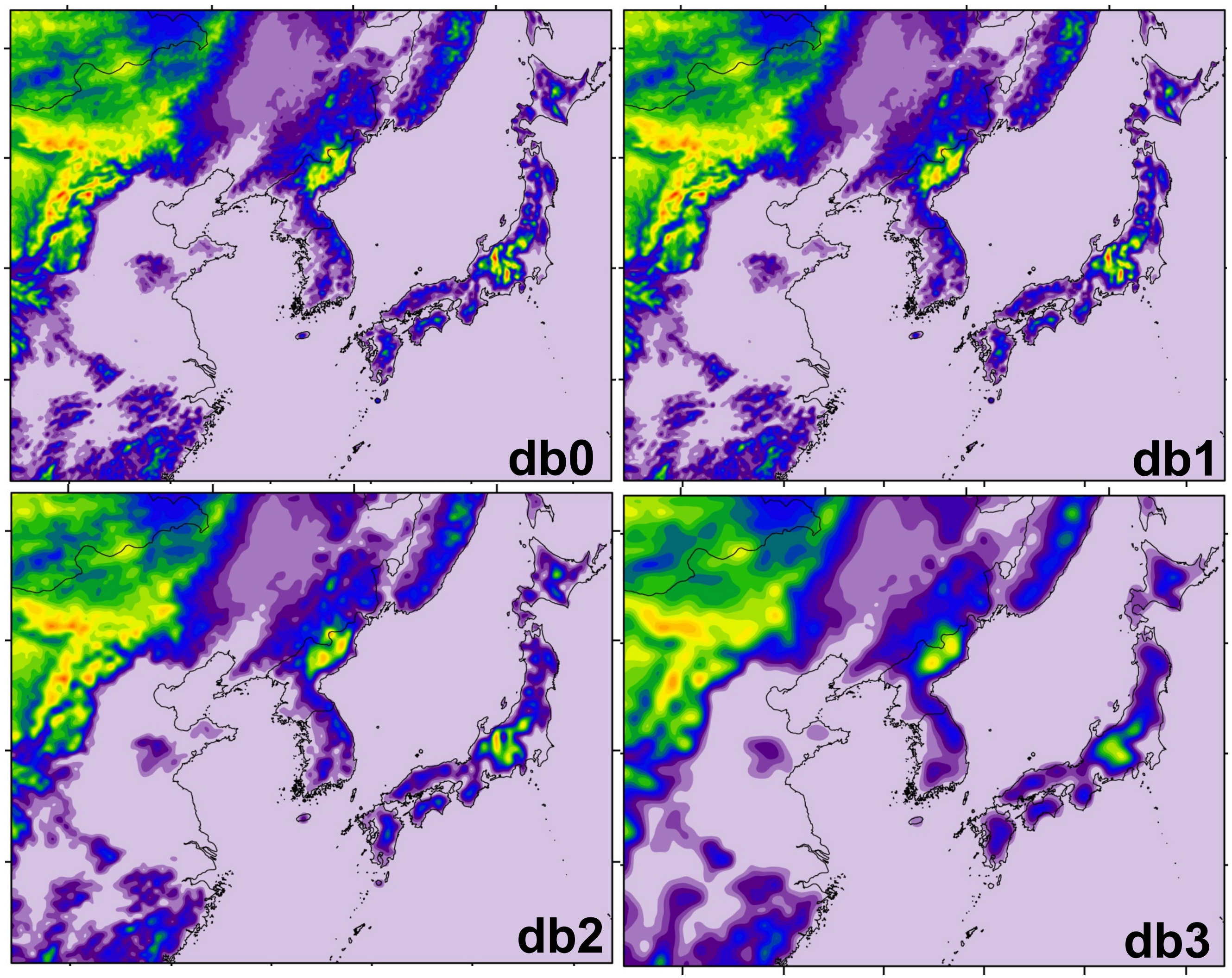
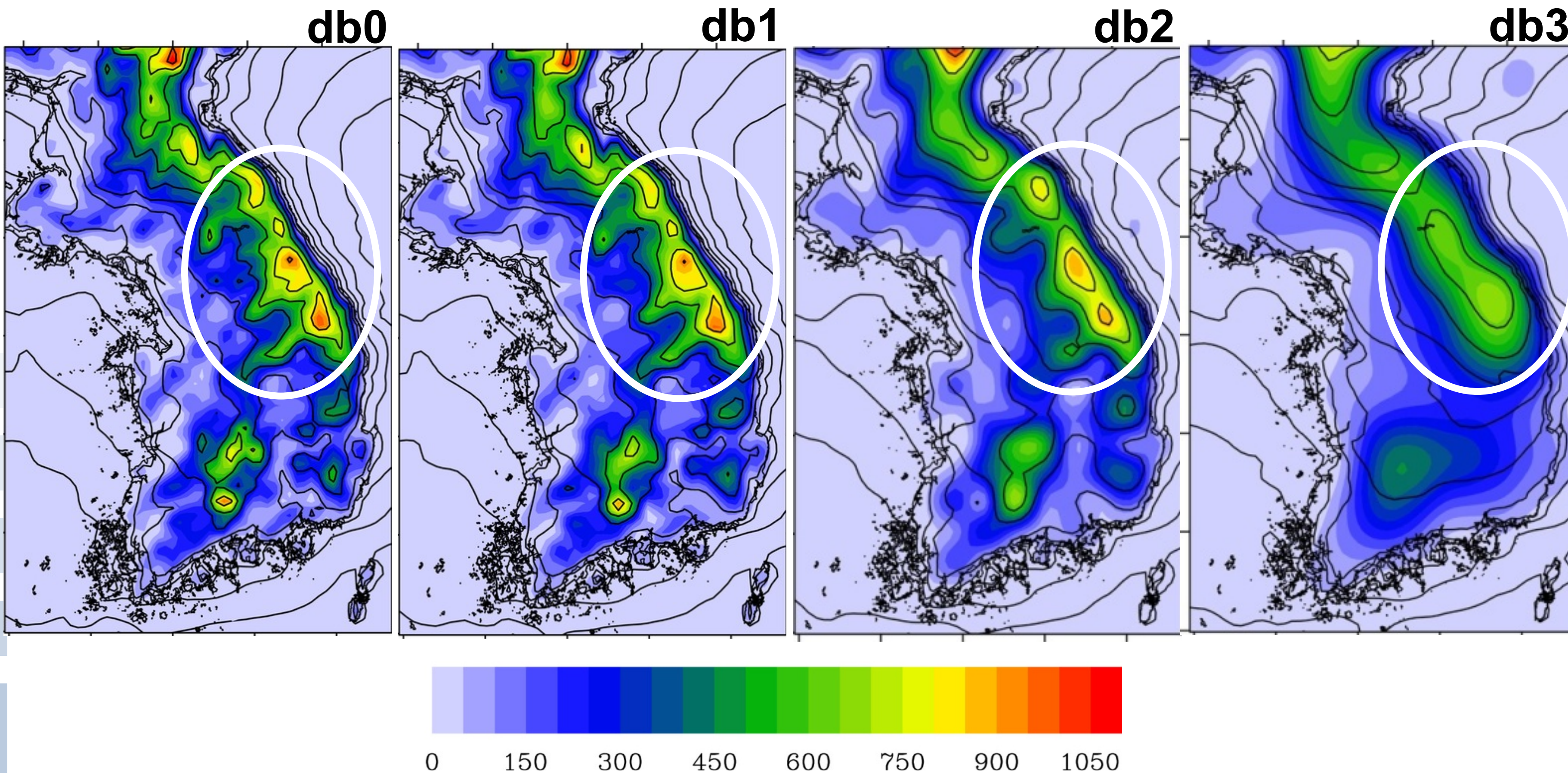
Wavelet Filtering of d02 Terrain



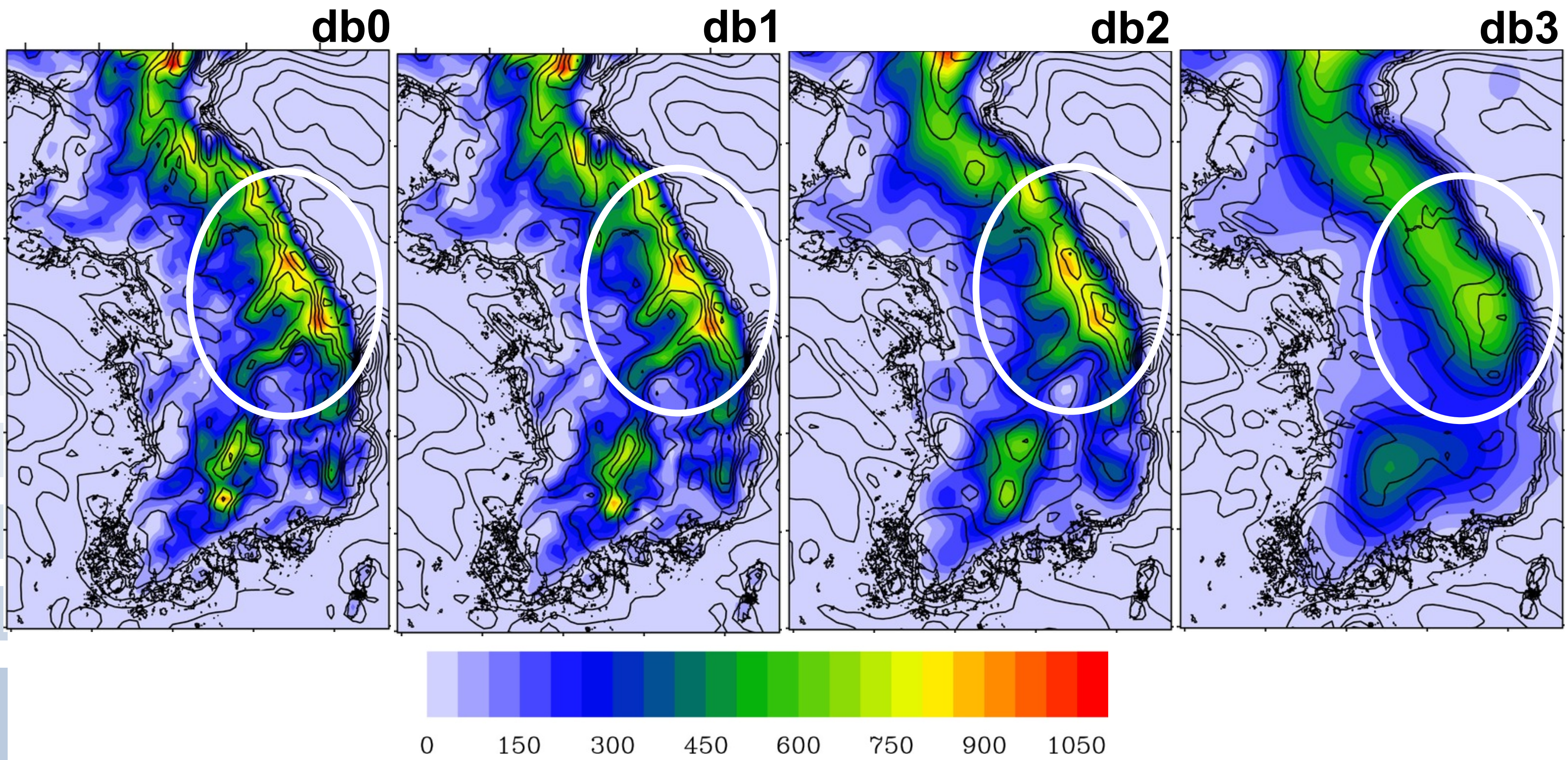
d02 2-m Temperature Analysis: 25/12



Nighttime temperature became higher for mountain peaks in smoothed terrain due to reduction of heights of the mountain peaks. **Note: Seoul local time is UTC + 9 hours.**

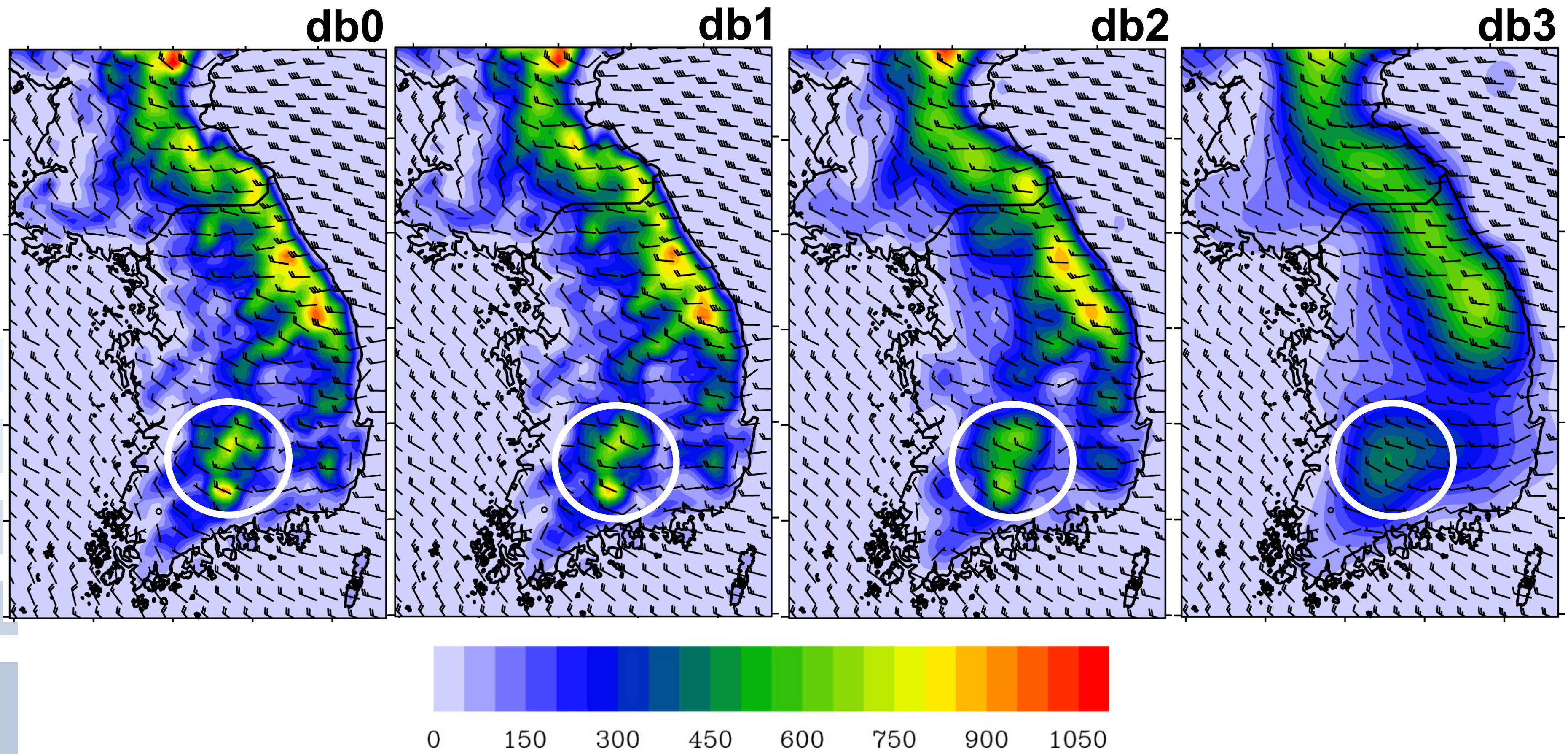
d02 10-m Wind Speed Analysis: 25/12

NCAR



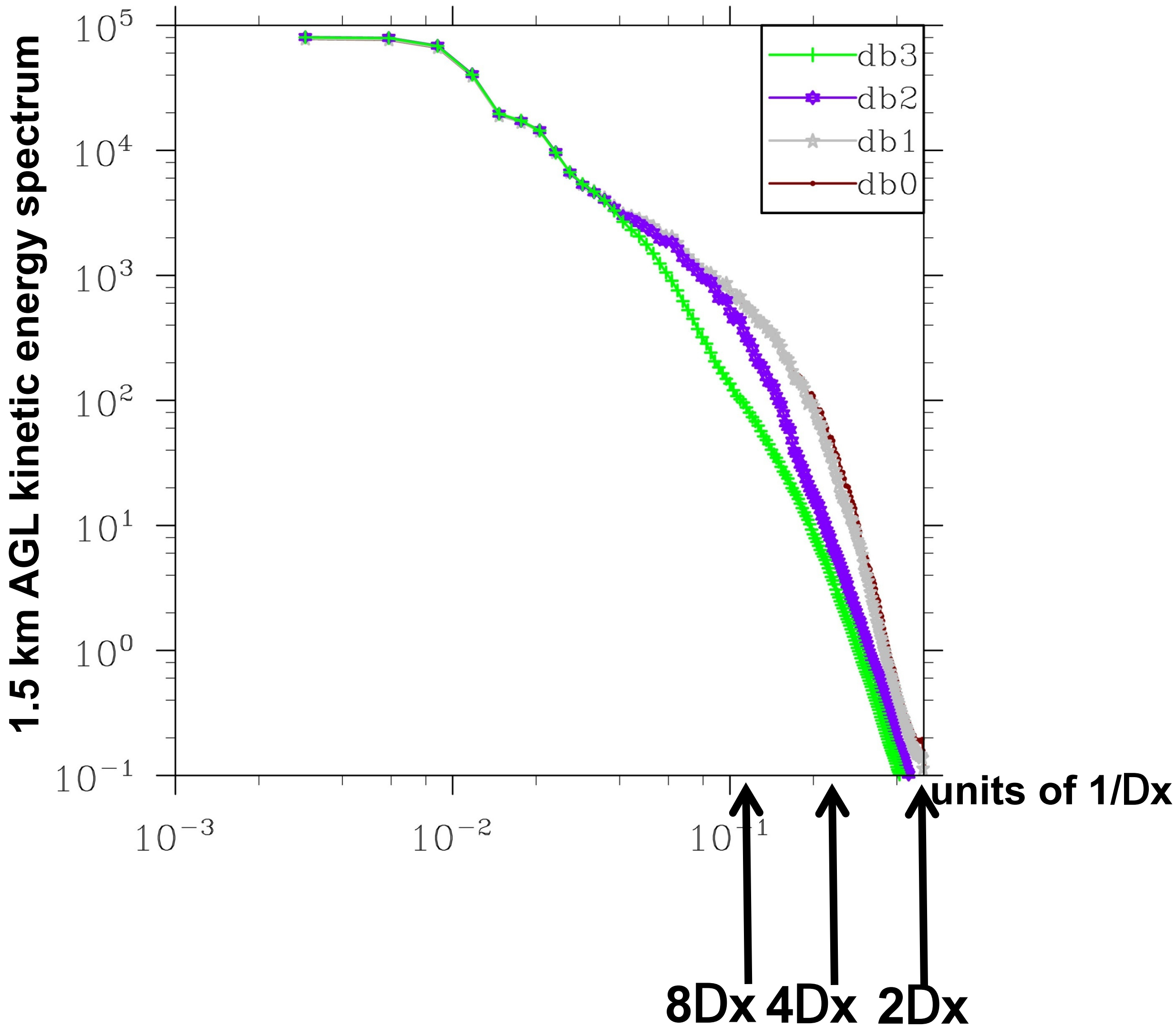
Reduction of wind speed over mountain peaks with smoothing. **Note: Seoul local time is UTC + 9 hours.**

d02 10-m Wind Barb Analysis: 25/12



As number of wavelet passes increased, the two mountain peaks in the circle became one. The channeling effect disappeared.

1.5 km AGL KE Spectrum



db1 (1-pass wavelets) filtered out noise somewhat but not as much as db2 and db3. db3 filtered out too much noise above 8 Dx. db2 may be an optimal.

d02 Near Surface Cumulative Error Statistics

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	T (°C)		qv (g kg^{-1})		ws (m s^{-1})		wd (°)	
Experiment	**BE**	**MAE**	**BE**	**MAE**	**BE**	**MAE**	**BE**	**MAE**
db0	0.37	1.50	0.24	0.37	1.08	2.17	2.83	26.59
db1	0.34	1.50	0.24	0.37	1.10	2.19	2.76	26.74
db2	0.28	1.51	0.24	0.37	1.21	2.27	3.93	27.25
db3	0.19	1.54	0.24	0.37	1.41	2.38	5.05	27.94

Note that with increasing wavelet filtering the 2-m temperature BE decreased, while the wind speed and direction BE and MAE increased.

Summary

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- Wavelet smoothing reduced heights of mountain peaks, warmer nighttime temperature and reduced wind speed at these peaks.
- Smoothing obliterated channeling effects.
- Analysis temperature BE was reduced with increased smoothing while temperature MAE remained almost unchanged with smoothing.
- Both wind speed and wind direction BE and MAE increased with smoothing due to loss of detailed terrain features necessary to represent flow over complex terrain.
- 2-pass DWT (removing 4Dx terrain features) appeared to be optimal
- **Future work**: single domain runs with higher resolution