Application of MM5 to study of air pollution in Christchurch, New Zealand – some problems of using MM5 with global analysis data

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Christchurch, New Zealand
Map of New Zealand and Christchurch region

- Australia
- Papua New Guinea
- Fiji
- New Caledonia
- New Zealand

Map showing the Christchurch region and surrounding areas.
Winter time pollution – Christchurch

“Common sense shows that there is a smog problem in Christchurch - through winter you can both see and smell it. This is what Vicki Buck meant when she said we don’t need science to prove this.” (Kelly, 1998:7)
Flow over and around the South Island

Convergence of Nor'easter and Nor'wester over the Canterbury Plains
Topographic factors and a conceptual model of near-surface airflow during winter smog episodes over Christchurch
Local topographic influences on airflow

- Flow over and around the Southern Alps
- Flow over and around Banks Peninsula
- Land and sea breezes
- Drainage winds from the Port Hills and Canterbury Plains
- Wind and stability effects of urban and rural areas
Input data:
NCEP Analysis (Global meteorological input fields)

MM5 versions 3.5.3 & 3.6.1

Eulerian dispersion modules of CAMx4

Data Assimilation, REGRID -> INTERPF
Nested grids and orography (grid 4)
4 grids with spatial resolution 27, 9, 3, 1 km
37 – 43 vertical levels (12 – 14 in lowest 500 m)
Simple ice/graupel explicit moisture schemes – Dudhia/Reisner
Grell cumulus parameterization (grids 1, 2)
MRF (grid 1 & 2) and Blackadar (grids 3 & 4)
PBL parameterization
Radiation cooling of atmosphere - RRTM
Multi-layer soil temperature model – bucket soil moisture scheme
Overview of the logical standing of the different methods of grid 4 initialization

Evaluation of the effects of Global Analysis data and FDDA analysis

**Experiment 4x1**
- 43 vertical levels
- Global Analysis
- grids 1-4 run: 72 h
- grid 4 run: 48 h (24 h spin-up)

**Experiment 4x2**
- 43 vertical levels
- Global Analysis
- grids 1-3 run: 72 h
- grid 4 run: 48 h (separately)

**Experiment 4x3**
- 43 vertical levels
- Global Analysis
- grid 1 run: 72 h
- grids 2-3 run: 72 h (separately)
- grid 4 run: 48 h (separately)
Modelled near-surface wind, experiment 4x1, grid 4:

a) 1700 NZST 4.08.2000 (41 h forecast)
b) 0000 NZST 5.08.2000 (48 h forecast)
Modelled near-surface wind, experiment 4x2, grid 4:
a) 1700 NZST 4.08.2000 (41 h forecast)
b) 0000 NZST 5.08.2000 (48 h forecast)
Modelled near-surface wind, experiment 4x3, grid 4:

a) 1700 NZST 4.08.2000 (41 h forecast)
b) 0000 NZST 5.08.2000 (48 h forecast)
# Model evaluation statistics: IOA, PCC, S-RMSE, U-RMSE, 1-7 August 2000

<table>
<thead>
<tr>
<th>EXPERIMENT</th>
<th>PCC</th>
<th>S-RMSE</th>
<th>U-RMSE</th>
<th>IOA</th>
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<tbody>
<tr>
<td><strong>Wind Speed (m/s)</strong></td>
<td></td>
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<tr>
<td>Experiments 4x1</td>
<td>0.62</td>
<td>0.85</td>
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<td>0.67</td>
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<td><strong>U-component (m/s)</strong></td>
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<td><strong>0.95</strong></td>
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<tr>
<td><strong>V-component (m/s)</strong></td>
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<td>0.85</td>
<td>0.92</td>
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<td>0.76</td>
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<tr>
<td>Experiments 4x3</td>
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<td>0.49</td>
<td><strong>0.76</strong></td>
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<tr>
<td><strong>Temperature (°C)</strong></td>
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<tr>
<td>Experiments 4x1</td>
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<td>1.49</td>
<td>1.52</td>
<td><strong>0.88</strong></td>
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<tr>
<td>Experiments 4x2</td>
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<td><strong>Relative Humidity (%)</strong></td>
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<td>5.41</td>
<td>5.82</td>
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</table>
Modelled near-surface wind, grid 4 (14h forecast):
a) 1400 NZST 23.07.2000 (scheme 4x3)
b) 1400 NZST 23.07.2000 (scheme 4x1)
Problems of using WRF following our MM5 experience

× We need a new multi-parallel computer for proper WRF utilisation and application
Conclusion

- The research has shown the ability of MM5 to reproduce air circulation for the Christchurch area (during winter time)

- As expected, there was permanent conflict between synoptic scale processes imported via the global analysis and local scale processes: this factor was investigated for more accurate MM5 evaluation over Christchurch

- We are currently examining the issues involved in replacing MM5 by WRF