HGB SIP Modeling Update MM5 Meteorology Modeling with Grell

Dick Karp
SETPMTC Meeting
February 18, 2009
Grell Cumulus Parameterization

- A model parameterization is used to account for a real physical phenomenon not resolved on the scale of the model grid size.
- Clouds are real, but generally smaller than the 108, 36, and 12 km grids, so a cumulus parameterization is needed.
- Cumulus parameterizations re-stabilize the atmosphere presumably as real clouds would.
- Typically, clouds become “resolved” at a grid cell size of 4 km or less, so cumulus parameterizations are not generally used at smaller grid scales.
• MM5 modeling on some of the episode days, with high and wide-spread 8-hour ozone, showed divergent surface winds due to strong vertical motion (e.g. starbursts)

• Some of these starbursts were coincident with the formation of clouds in the 4 km grid that were not evident in the satellite images

• Other meteorology researchers (e.g., John Nielsen-Gammon, Daewon Byun) have also noted problems with cloud formation and suggested applying the Grell cumulus scheme in the 4 km grid to see if it would alleviate the starburst and yield improved meteorological modeling
Wind and Cloud Map: Modeled versus Monitored  
May 27, 2005 1400 Hours
Wind and Cloud Map: modeled versus Monitored
June 23, 2005 1400 Hours
Wind and Cloud Map: Modeled versus Measured
August 2, 2005 1500 Hours

Layer 1 Horizontal Wind
MM5/CAMx: 2005sep07_sta_diagnostics_flddata_uvsst_alt8000_utk

Wind Speed (m/s) -

Layer 1 Horizontal Wind
MM5/CAMx: 2005sep07_sta_diagnostics_flddata_uvsst_alt8000_gre41

Wind Speed (m/s) -

Cloud Optical Depth (Layer 1)
MM5/CAMx: 2005sep07_sta_diagnostics_flddata_uvsst_alt8000_utk

Cloud Fract. -

Cloud Optical Depth (Layer 1)
MM5/CAMx: 2005sep07_sta_diagnostics_flddata_uvsst_alt8000_gre41

Cloud Fract. -

Legend:
- 0
- 0.01-0.09
- 0.10-0.19
- 0.20-0.29
- 0.30-0.39
- 0.40-0.49
- 0.50-0.59
- 0.60-0.69
- 0.70-0.79
- 0.80-0.89
- 0.90-0.99
- 1.00
- No Data
Wind and Cloud Map: Modeled versus Measured
June 8, 2006 1600 Hours
Wind and Cloud Map: Modeled versus Measured
August 17, 2006 1600 Hours

Layer 1 Horizontal Wind
MM5/CAMx 2006ep1a_eta_150km_inputs_uhst_utcsrfc Fletcher
August 13 - 27 2006

Layer 1 Horizontal Wind
MM5/CAMx 2006ep1a_eta_150km_inputs_uhst_utcsrfc_gr
August 13 - 27 2006

Cloud Optical Depth (Layer 1)
MM5/CAMx 2006ep1a_eta_150km_inputs_uhst_utcsrfc Fletcher
August 13 - 27 2006

Cloud Optical Depth (Layer 1)
MM5/CAMx 2006ep1a_eta_150km_inputs_uhst_utcsrfc_gr
August 13 - 27 2006
Wind and Cloud Maps: Modeled versus Measured
September 1, 2006 1500 Hours
MM5 with Grell Model Performance Evaluation

• Focus on episode days with high and wide-spread 8-Hour ozone
  – 2005ep0: May 27 and June 2, 2005
  – 2005ep1: June 21 and 22, 2005
  – 2005ep2: August 1 and 2, 2005
  – 2006ep0: June 8 and 14, 2006

• Focus on groups of monitoring sites representative of a common distance from the Gulf
  – Coastal Zone1: CLTA, MSTG, GALC
  – Ship Channel Zone2: MACP, DRPK, WALV
  – SE-Core Zone3: HCQA, HROC, HRM3, HCHV
  – NW-Core Zone4: SHWH, BAYP, HALC
  – Downwind Zone5: HNWA, CNR2

• Use graphical and statistical measures for the evaluation
  – Plume Trajectory Plots
  – Wind Speed and Wind Direction Metrics
HGB Ozone Monitoring Sites

<table>
<thead>
<tr>
<th>Site Code</th>
<th>Selected Site Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAYP</td>
<td>Bayland Park, Harris Co., TX</td>
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<tr>
<td>C35C*</td>
<td>Clinton, Harris Co., TX</td>
</tr>
<tr>
<td>CNR2</td>
<td>Conroe Relocated, Montgomery Co., TX</td>
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<td>DRPK*</td>
<td>Deer Park, Harris Co., TX</td>
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<tr>
<td>GALC</td>
<td>Galveston, Galveston Co., TX</td>
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<tr>
<td>H03H*</td>
<td>HRM-3, Haden Road, Harris Co., TX</td>
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<td>H08H</td>
<td>HRM Site 8, La Porte, Harris Co., TX</td>
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<td>H10H</td>
<td>HRM-10, Mt Belvieu, Chambers Co., TX</td>
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<td>H11H</td>
<td>HRM-11, Chambers Co., TX</td>
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<td>HALC</td>
<td>Aldine, Houston, Harris Co., TX</td>
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<td>HCHV*</td>
<td>Channelview, Houston, Harris Co., TX</td>
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<td>HCQA</td>
<td>Croquet, Houston, Harris Co., TX</td>
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<td>HNWA</td>
<td>NW Harris, Tomball, Harris Co., TX</td>
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<td>HOEA</td>
<td>Houston East, Houston, Harris Co., TX</td>
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<td>HROC</td>
<td>Houston Regional Office, Harris Co., TX</td>
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<td>HSMA</td>
<td>Swiss and Monroe,, Harris Co., TX</td>
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<td>HTCA</td>
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<td>LYNF*</td>
<td>Lynchburg Ferry, Harris Co., TX</td>
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<td>MACP</td>
<td>Manvel Croix Park, Brazoria Co., TX</td>
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<td>MSTG*</td>
<td>Mustang Bayou, Brazoria Co., TX</td>
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<tr>
<td>SBFP</td>
<td>Seabrook Friendship Park, Harris Co., TX</td>
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<tr>
<td>SHWH</td>
<td>Westhollow, Houston, Harris Co., TX</td>
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<tr>
<td>TXCT*</td>
<td>Texas City, Galveston Co., TX</td>
</tr>
<tr>
<td>WALV*</td>
<td>Wallisville Road, Harris Co., TX</td>
</tr>
</tbody>
</table>

* Sites with an auto-GC
Plume Trajectory Plots
May 27 and June 2, 2005, 0600 and 0900 Hours
Plume Trajectory Plots
June 21 and 22, 2005 0600 and 0900 Hours
Summary of 6 to 9 AM Plume Plot Trajectories

- May 27, 2005: Grell 6am trajectories compare slightly less favorably, but 9am Grell trajectories compare slightly more favorably with observed (no degradation).
- June 2, 2005: Both Grell and non-Grell 6 & 9am trajectories are quite similar, displaced to the west of observed trajectories (no degradation).
- June 21, 2005: Both Grell and non-Grell 6 & 9am trajectories are displaced to the southwest of observed trajectories, the 9am Grell even more so (somewhat degraded).
- June 22, 2005: Both Grell and non-Grell 9am trajectories are displaced to the south of observed trajectories, the 9am non-Grell slightly more to the south (somewhat improved).
- August 1, 2005: Both Grell and non-Grell 6am trajectories are displaced to the south of observed trajectories, the 9am non-Grell slightly more to the south (somewhat improved).
- August 2, 2005: Both Grell and non-Grell 6am trajectories compare favorably with observed trajectories, the 9am non-Grell slightly more to the northeast (somewhat improved).
- Overall Grell appears to provide a slight improvement in the 6 to 9 am plume plot trajectories, suggesting that using Grell in the 4 km grid does not compromise MM5 trajectory performance in the HGB area.
Wind Speed and Wind Direction Metrics
2005ep0: May 27 and June 2, 2005

2005ep0: May 27, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep0: June 2, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep0: May 27, 2005, Grell vs Non-Grell Wind Direction Metric

2005ep0: June 2, 2005, Grell vs Non-Grell Wind Direction Metric
Wind Speed and Wind Direction Metrics
2005ep1: June 21 and 22, 2005

2005ep1: June 21 and 22, 2005, Grell vs Non-Grell Wind Metric

2005ep1: June 21, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep1: June 21, 2005, Grell vs Non-Grell Wind Direction Metric

2005ep1: June 21, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep1: June 21, 2005, Grell vs Non-Grell Wind Direction Metric

2005ep1: June 22, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep1: June 22, 2005, Grell vs Non-Grell Wind Direction Metric
Wind Speed and Wind Direction Metrics
2005ep2: August 1 and 2, 2005

2005ep2: Aug. 1, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep2: Aug. 2, 2005, Grell vs Non-Grell Wind Speed Metric

2005ep2: Aug. 1, 2005, Grell vs Non-Grell Wind Direction Metric

# Wind Speed and Wind Direction Metrics

**2006ep0: June 8 and 14, 2006**

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Date</th>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>08/06</td>
<td>Wind Speed</td>
<td>Comparison of Grell vs Non-Grell Wind Speed Metric</td>
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<tr>
<td></td>
<td></td>
<td>14/06</td>
<td>Wind Direction</td>
<td>Comparison of Grell vs Non-Grell Wind Direction Metric</td>
</tr>
</tbody>
</table>

**Graphs:**

- **2006ep0: June 8, 2006 Grell vs Non-Grell Wind Speed Metric**
- **2006ep0: June 14, 2006 Grell vs Non-Grell Wind Speed Metric**
- **2006ep0: June 8, 2006 Grell vs Non-Grell Wind Direction Metric**
- **2006ep0: June 14, 2006 Grell vs Non-Grell Wind Direction Metric**

**Legend:**

- WS_nGrell
- WS_Grell
- WD_nGrell
- WD_Grell

**Geographic Zones:**

- Zone 1
- Zone 2
- Zone 3
- Zone 4
- Zone 5
- HGB-reg12

**Fraction of Hourly WS < 1.0 m/s**

- 0.00
- 0.10
- 0.20
- 0.30
- 0.40
- 0.50
- 0.60
- 0.70
- 0.80
- 0.90
- 1.00

**Fraction of Hourly WD < 30°**

- 0.00
- 0.10
- 0.20
- 0.30
- 0.40
- 0.50
- 0.60
- 0.70
- 0.80
- 0.90
- 1.00
Summary of Wind Speed and Wind Direction Performance

- May 27, 2005: Grell improves WS performance, with exception of zone 2 and degrades WD performance, with exception of zone 5
- June 2, 2005: Grell improves WS performance in only zones 4 and 5, but degrades WD performance in all zones
- June 21, 2005: Grell improves WS performance, but only improves WD performance in zone 2
- June 22, 2005: Grell improves WS performance, with exception of zone 1 and improves WD performance in only zones 2 and 5
- August 1, 2005: Grell improves WS performance in all zones and degrades WD performance, with exception of zone 5
- August 2, 2005: Grell improves WS performance, with exception of zone 4, and improves WD performance, with exception of zones 2 and 3
- June 8, 2006: Grell improves WS performance in zones 1 and 2, but degrades in zone 4, and improves the WD performance in zones 1 and 4, but degrades in zone 2
- June 14: Grell improves WS performance in all zones, except zones 1 and 5, and Grell WD performance is unchanged in all zones, except zone 5
- Overall Grell appears to improve WS performance, while degrading WD performance. Given the relative importance of WS and the larger monitoring error typically associated with WD measurements, the use of Grell in the 4 km grid does not appear to compromise MM5 wind performance in the HGB area
Conclusions

• Using the Grell cumulus scheme in the 4 km grid alleviates starbursts on some of the episode days with high and pervasive 8-hour ozone

• Performance measures for episode days with high and pervasive 8-hour ozone, focusing on selected monitors representing geographical zones in the HGB area, indicate the Grell cumulus scheme in the 4 km grid does not compromise MM5 model performance
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