Observational and modeling evidence for lake-land breeze at Lake Taihu
Outline

- Background
- Observation characteristic of Lake Breeze
- WRF/lake model Validation
- Simulated Lake breeze
- On-going Work
Background
Surface temperatures were extracted from nighttime thermal infrared imagery of 167 large inland water bodies distributed worldwide beginning in 1985 for the months July through September and January through March.

Results indicate that the mean nighttime surface water temperature has been rapidly warming for the period 1985–2009 with an average rate of $0.045 \pm 0.011 \degree C \text{ yr}^{-1}$ and rates as high as $0.10 \pm 0.01 \degree C \text{ yr}^{-1}$.

Global assessment shows 95% of lakes are warming, Lakes in North America and northern Europe warming more rapidly, Lake water temperatures warming more rapidly than air temperatures, Lakes are good indicators of climate trends.

China’s Lake

Lake number decreased from 2928 to 2693
Lake area reduced from 91019.6 km² to 81414.6 km²
Newly formed / discovered lake 191
Disappeared lake 243
Hulun Lake is shrinking

Ma et al., 2010, China’s lakes at present: Number, area and spatial distribution, SCIENCE CHINA Earth Sciences
Observation characteristic of Lake Breeze
Sites: 16 meteorological stations around Lake Taihu and 4 flux and microclimate stations over the Lake.

Observed data from Jun 1, 2012 to Aug 31, 2012
(Sills, et al. 2011, ACP)
Lake breeze identification

(Sills, et al. 2011, ACP)

• rapid shift in wind direction to onshore wind (may be accompanied by rapid change in wind speed, sharp decrease in temperature and dew point within 20 km of shore)
• gradual inland penetration of onshore winds
• quasi-parallel to shore
• gradual inland penetration of above, or quasi-stationary
• The Border Air Quality and Meteorology Study (BAQS-Met) (Sills, et al. 2011, ACP)
### Sills, et al., 2011

<table>
<thead>
<tr>
<th></th>
<th>June 2007 Days</th>
<th>June 2007 %</th>
<th>July 2007 Days</th>
<th>July 2007 %</th>
<th>August 2007 Days</th>
<th>August 2007 %</th>
<th>Total Days</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huron Shore</td>
<td>28</td>
<td>93%</td>
<td>29</td>
<td>94%</td>
<td>19</td>
<td>66%</td>
<td>76</td>
<td>84%</td>
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<tr>
<td>Erie Shore</td>
<td>27</td>
<td>90%</td>
<td>27</td>
<td>87%</td>
<td>20</td>
<td>69%</td>
<td>74</td>
<td>82%</td>
</tr>
<tr>
<td>St. Clair Shore</td>
<td>26</td>
<td>87%</td>
<td>29</td>
<td>94%</td>
<td>20</td>
<td>69%</td>
<td>75</td>
<td>83%</td>
</tr>
<tr>
<td>Shores of All Lakes</td>
<td>26</td>
<td>87%</td>
<td>26</td>
<td>84%</td>
<td>16</td>
<td>55%</td>
<td>68</td>
<td>76%</td>
</tr>
<tr>
<td>Shore of Any Lake</td>
<td>29</td>
<td>97%</td>
<td>30</td>
<td>97%</td>
<td>22</td>
<td>76%</td>
<td>81</td>
<td>90%</td>
</tr>
</tbody>
</table>

### Lake breeze Frequency on Taihu

<table>
<thead>
<tr>
<th></th>
<th>June 2012</th>
<th>July 2012</th>
<th>August 2012</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two shore</td>
<td>36.6%</td>
<td>12.9%</td>
<td>32.25%</td>
<td>34.78%</td>
</tr>
<tr>
<td>Four Shore</td>
<td>30%</td>
<td>9.67%</td>
<td>22.58%</td>
<td>22.82%</td>
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</tbody>
</table>
WRF/lake Model Validation
Shallow Lake Land Surface Model

CLM4-LISSS is an improved version of CLM4 Lake developed by scientists at the National Center of Atmospheric Research and the Lawrence Berkeley National Laboratory (Oleson et al. 2004; Subin et al. 2012a and b)

A tuned version for shallow lake (Deng et al, Journal of Hydrometeorology, 2012)
Numerical Case

- WRFV3.3.1
- 3 nested domains 27-9-3 (km)
- Mellor – Yamada – Janjic TKE PBL scheme
- Noah land surface model
- UTC 2012.6.1.00----UTC 2012.7.1.00
- Validation – BFG & DS flux site data
Simulation Domain
Simulation result compared with BFG observation data
Simulation result compared with DS observation data
Simulated Lake breeze on Taihu
Air Temperature (2m) difference from 09:00 to 12:00 on Jun 15, 2012
Air Temperature (2m) difference from 13:00 to 16:00 on Jun 15, 2012
Air Temperature (2m) difference from 17:00 to 20:00 on Jun 15, 2012
Wind vector and wind direction from 09:00 to 10:00 on Jun 15, 2012
Wind vector and wind direction from 11:00 to 12:00 on Jun 15, 2012
Wind vector and wind direction from 13:00 to 14:00 on Jun 15, 2012
Wind vector and wind direction from 15:00 to 16:00 on Jun 15, 2012
Wind vector and wind direction from 17:00 to 18:00 on Jun 15, 2012
Wind vector and wind direction from 19:00 to 20:00 on Jun 15, 2012
Observed Wind barb from 09:00 to 12:00 Jun 15, 2012
Observed Wind barb from 13:00 to 16:00 Jun 15, 2012
Simulated and observed lake breeze frequency comparison in June 2012

<table>
<thead>
<tr>
<th></th>
<th>Observation</th>
<th>WRF/lake</th>
<th>WRF/default</th>
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<tbody>
<tr>
<td>Days</td>
<td>9</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Frequency</td>
<td>30%</td>
<td>33%</td>
<td>53%</td>
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On-going work

• More observation date for model validation, including Modis TS data and meteorology station data. Analyzing the statistical characteristic.
• Simulation and analysis from July 1 to August 31
• Some sensitivity test for urban influence, etc.
THANK YOU!