Data Assimilation Experiments of Tsukuba Tornado on May 6, 2012 with the Nested-LETKF System

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The Case

Three tornadoes were generated in 2012/5/6, about 12:30 JST.

Seko et al. (2013)
- Two tornadoes were reproduced in the data assimilation experiment. However, the sites of the south tornado shifted about 10 km north.

Yamauchi et al. (2012)
- The south tornado was observed by MRI Doppler Radar.

This Study

Doppler wind observed by MRI Radar is assimilated and the impact of the assimilation is clarified.
The tornado was observed well by MRI-Radar.

⇒ The tornado was observed well by MRI-Radar.
**Experimental Design**

**About Nested NHM-LETKF**

**Outer-LETKF**
- 12 members
- 15km grid

**Inner-LETKF**
- 12 members
- 1.875km grid

Downscaling Experiments
- 13 members (12 + analysis)
- 1.875km and 350m grid

※Operational observation:
Surface (pressure), Radiosondes (wind, humidity, temperature),
Planes (wind, temperature) and Wind profiler radar (wind)

<table>
<thead>
<tr>
<th>Grid Interval</th>
<th>Initial Time</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer LETKF</td>
<td>15 km 5/3 09:00JST</td>
<td>Operational observation data of JMA (every 1 hour) are assimilated.</td>
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</tbody>
</table>
| Inner LETKF   | 1.875 km 5/6 03:00JST | **CTL:** Only operational observation data of JMA (every 10 minutes) are assimilated.  
**VR:** Doppler wind data is also assimilated |
| Downscaling Experiments | 1.875 km 350 m 5/6 10:00JST | Initial and boundary conditions are analysis of the inner LETKF in both CTL and VR. |
Color: Mixing ratio of water and ice (g/kg, z*=20m)
Arrows: Horizontal wind (m/s, z*=20m)
Red Point: High relative vorticity area (>0.03/s, z*=20m)

⇒ The vortex was generated at south edge of precipitation area.
The south vortex in VR is stronger and the path shifts to the south.
What Decides **Strength** of the Vortex

**Increment**

$Q_{v_{low}} \text{ (VR-CTL)}$

**Correlation**

Vmax v.s. $Q_{v_{low}} \text{ (VR)}$

Low-level moisture increases near the genesis point of the vortex.

The vortex becomes stronger.

$Q_{v_{low}}$: Mixing Ratio of Moisture ($z^* = 20m$)

Calculated with 13 VR members (12 + analysis)

[g kg$^{-1}$] in 10:00 JST
Correlation Analysis

What Decides **Strength** of the Vortex

Movement of Cumulus

Genesis of the Vortex
Correlation Analysis

What Decides **Strength** of the Vortex

**Low-level Moisture** makes the convection easy to be formed.

**Movement of Cumulus**

**Genesis of the Vortex**
**Correlation Analysis**

**What Decides the Path of the Vortex**

**Increment**

SReH (VR-CTL)

**Correlation**

L140 v.s. SReH (VR)

Calculated with 13 VR members (12 + analysis)

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**SReH** decreases at the south of precipitation area and increases at the path of precipitation area.

The vortex path shifts to the south.
What Decides the **Path** of the Vortex

**Correlation Analysis**

- **Movement of Cumulus**
- **SReH** makes the vortex move to the right in the direction of flow.
- Low-level southerly wind advects the vortex to the north.
The south vortex became close to real because low-level moisture and SReH were corrected.

⇒ Correction of wind and moisture at low level is effective to reproduce vortices.

Higher resolution LETKF, more members, more observations (Ground Observation, Reflectivity, Dual-pol information of Radar and so on)

⇒ to improve the accuracy of the reproduction
⇒ to clarify the genesis mechanism of tornadoes