

Damage Survey in the Surrounding Area of the Capsizing Accident of the Cruise Ship ‘Dongfangzhixing’ on 1 June 2015

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Outline

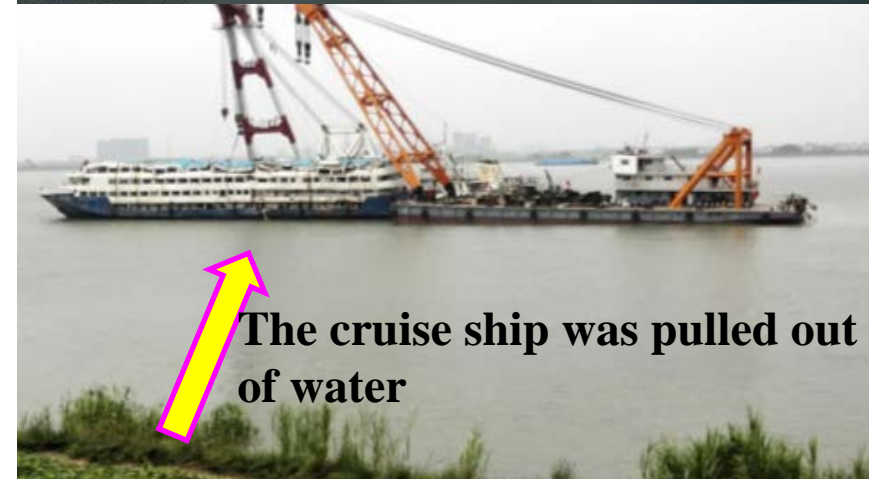
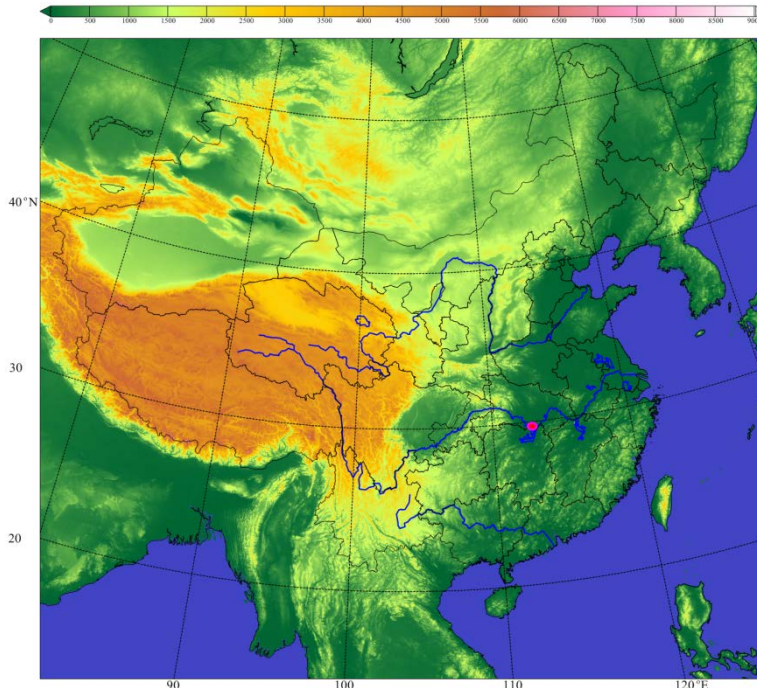
- **1 Introduction**
- **2 Damage Survey**
- **3 Tornado/Mesovortex, Microburst, and Multi-scale Characteristics**
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- **Acknowledgements**

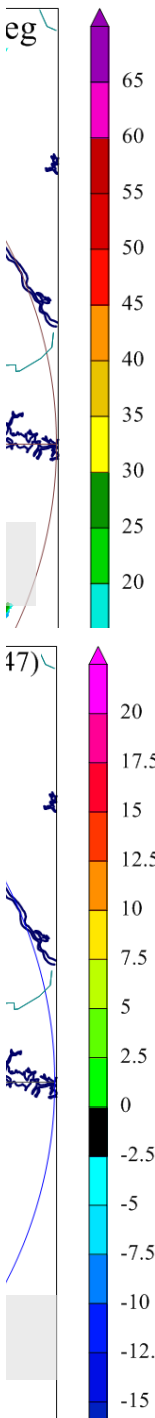
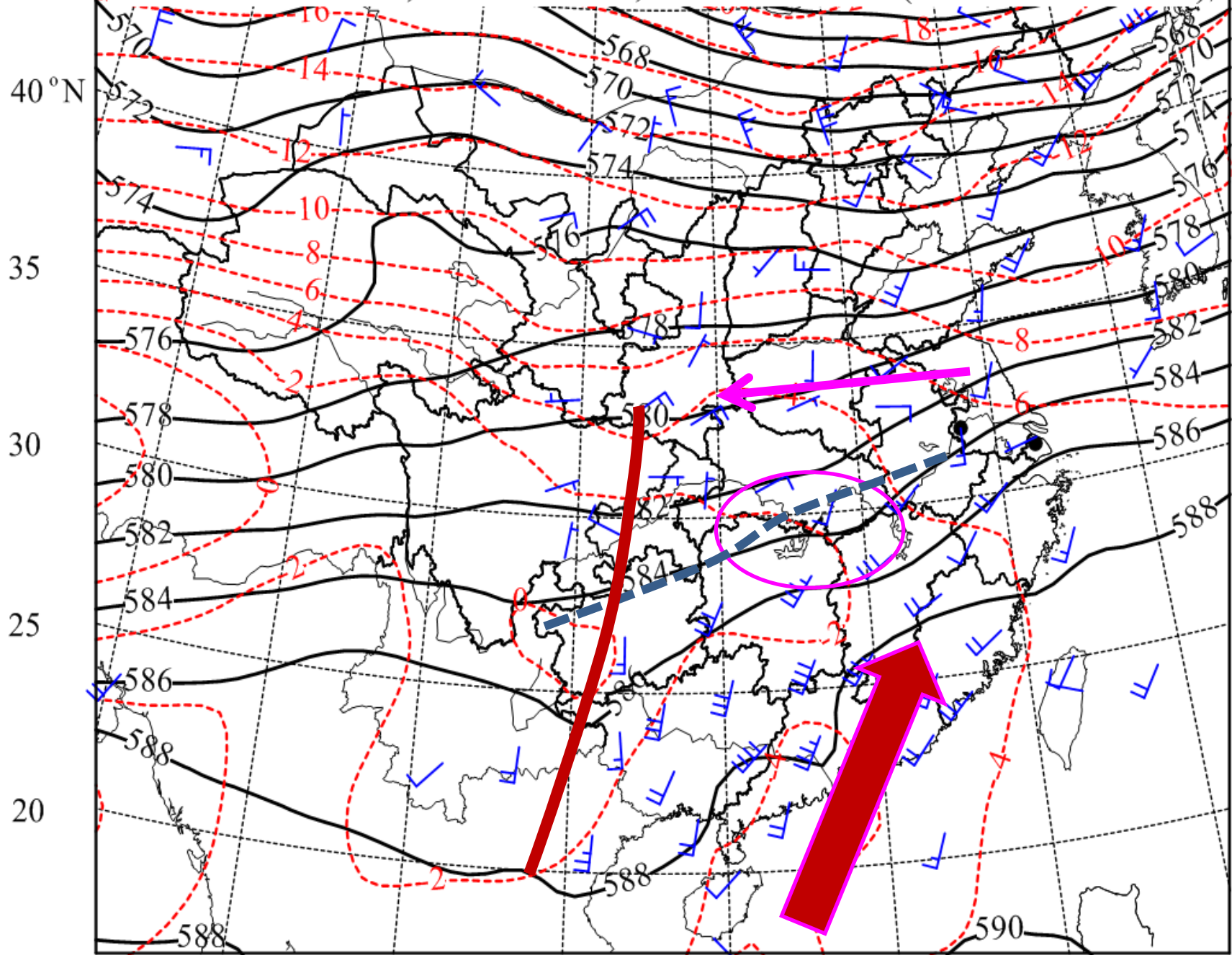
1 Introduction

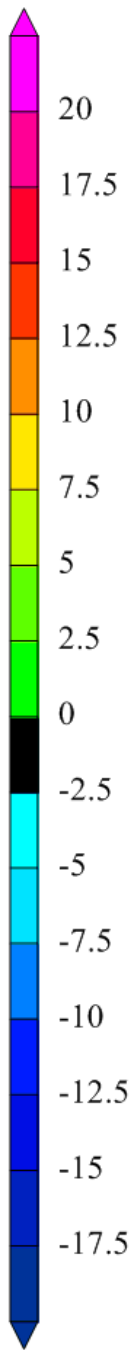
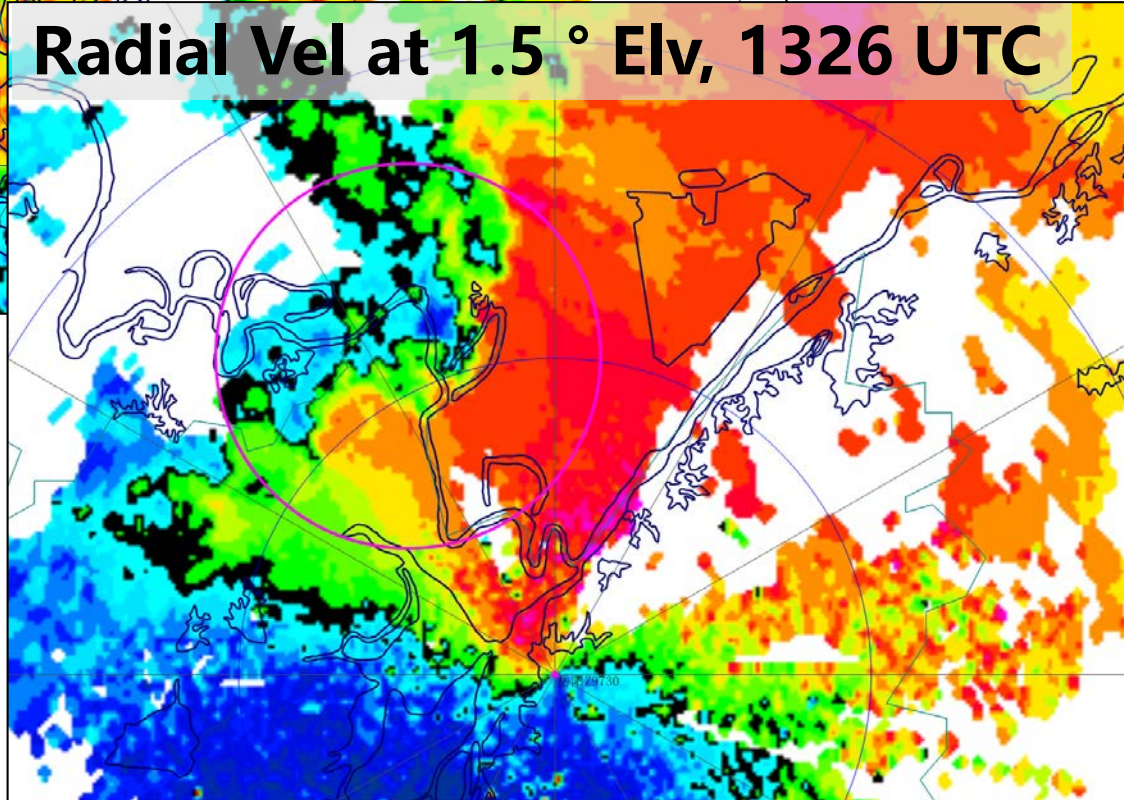
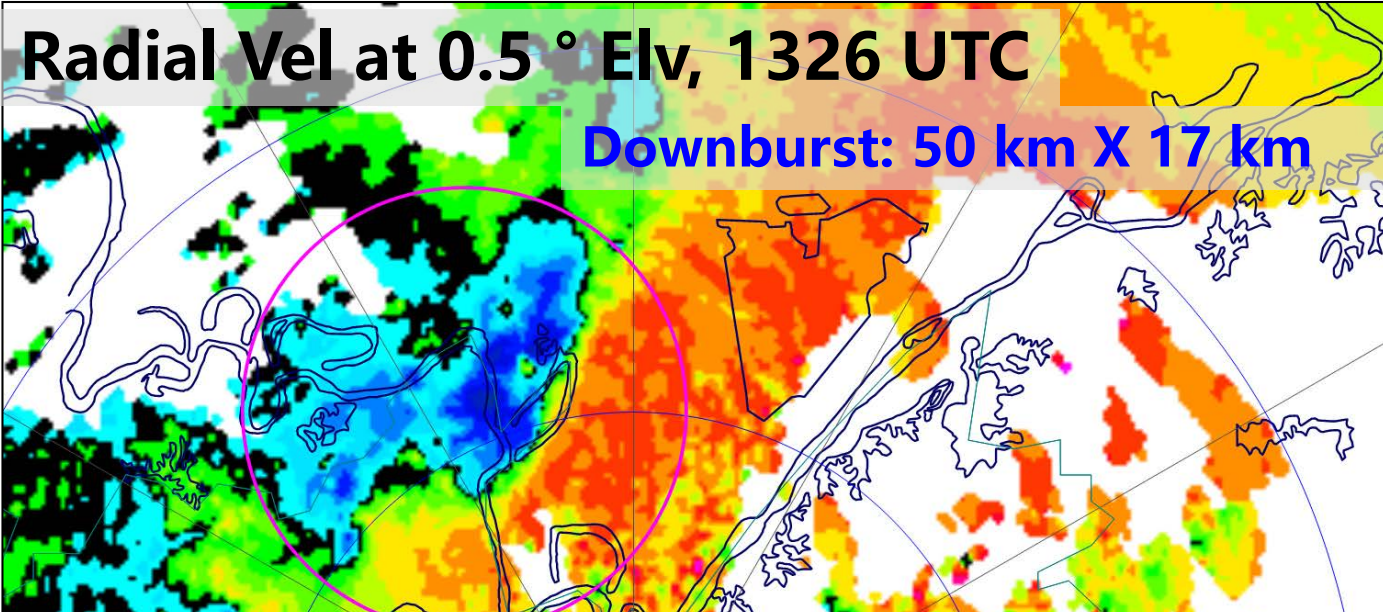
◆ At about 2131 LST (Local Standard Time; $LST = UTC + 0800$) on 1 June 2015, **“Dongfangzhixing” (Oriental Star)**, a cruise ship on its way to **Chongqing from Nanjing** with 454 people on board, capsized on the Yangtze River in Jianli County, Hubei Province, China, **causing 442 deaths**.

◆ An extensive damage survey was performed in the disaster area on both sides of the Yangtze River **on two separate occasions: 2–5 June and 10–14 June**.



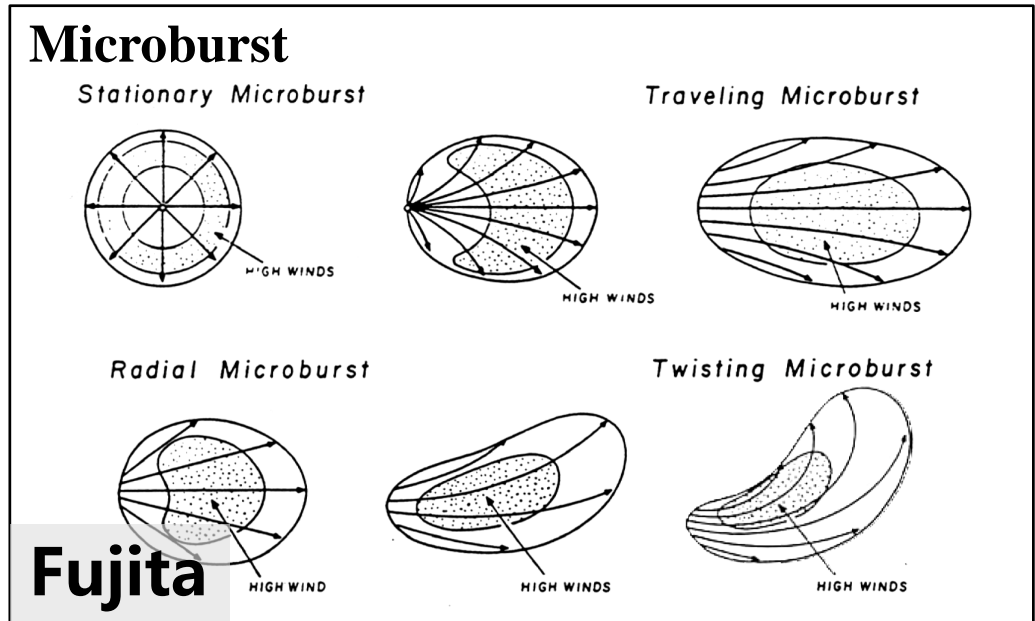
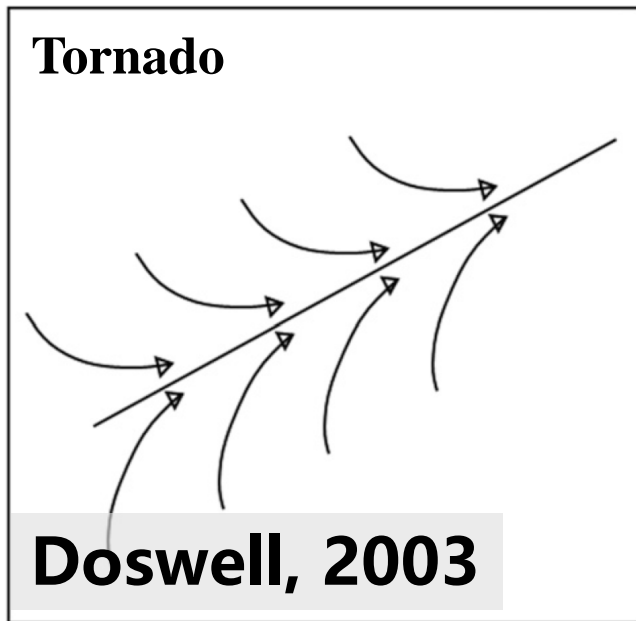
2015060112 UTC, 500 hPa H T, 850 hPa Wind (Full barb = 4 m/s)





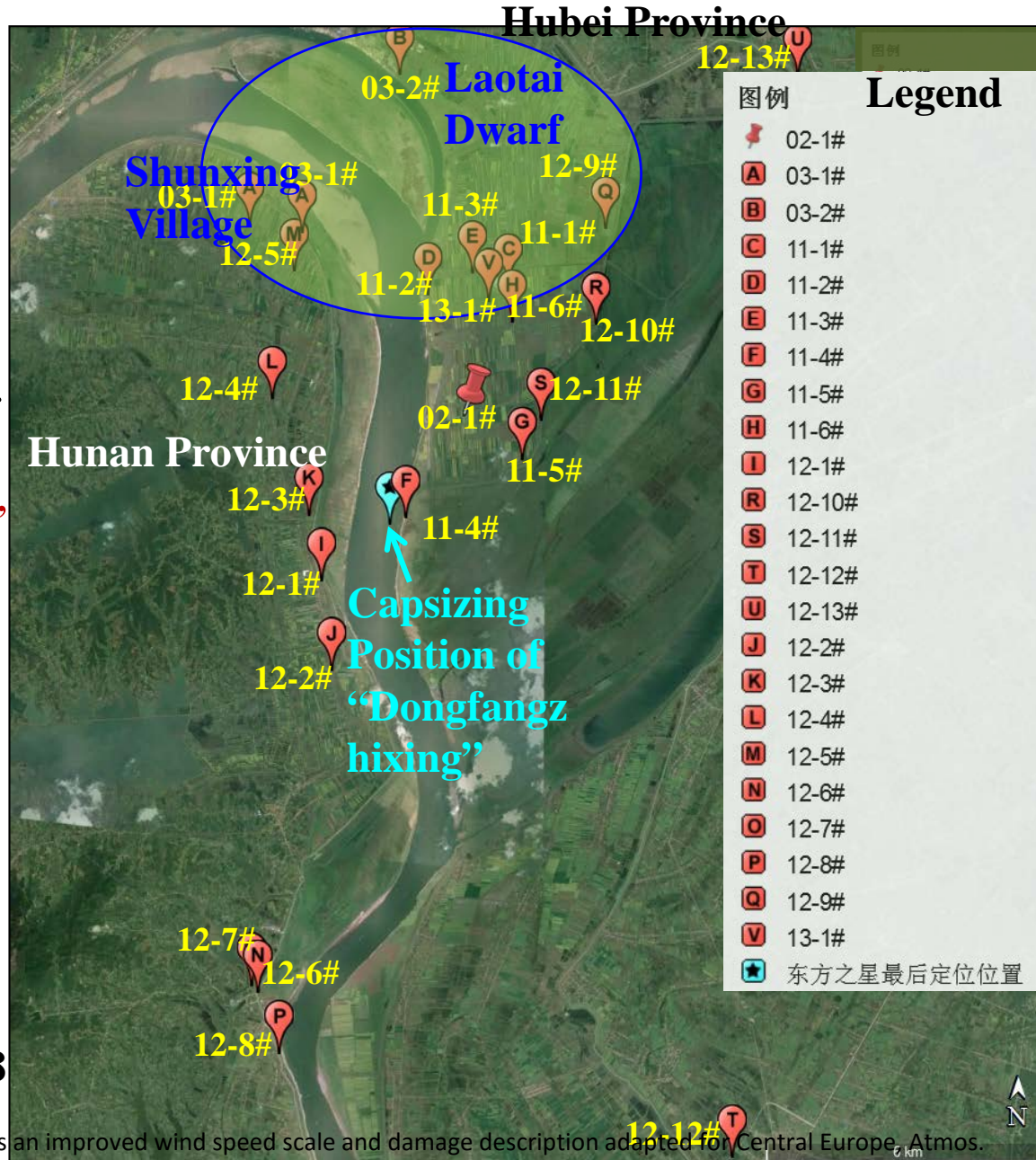
There are some issues need to address:

- ◆ What caused the accident? Tornado or Microburst produced by the QLCS?
- ◆ Was there a tornado in the vicinity of the accident?
- ◆ What intensities were the high winds caused by the QLCS?
- ◆ How strong were the high winds causing the cruise ship capsized?



2 Damage Survey

- The position, type, direction, diameter, and damage of all accessible fallen trees were recorded using **rulers, cameras, compasses, and GPSs**. *Two drones* were also used to take photos and videos.
- It was found that the damage was **mainly in the form of bent, snapped or uprooted trees**. Although bent corns and slightly peeled roofs were also observed, they were highly infrequent and hard to rate,
- so the wind speed was estimated using the damaged trees only and according to the **Enhanced Fujita (EF) scale with an uncertainty* of about 18 $m s^{-1}$** .



*Feuerstein B, Groenemeijer P, Dirksen E et al (2011) Towards an improved wind speed scale and damage description adapted for Central Europe. Atmos. Res., 100, 547–564

FUJITA SCALE			DERIVED EF SCALE		<i>OPERATIONAL EF SCALE</i>		
F Number	Fastest 1/4-mile (mph)	3 Second Gust (mph)	EF Number	3 Second Gust (mph)	<i>EF Number</i>	<i>3 Second Gust (mph)</i>	<i>3 Second Gust (m/s)</i>
0	40-72	45-78	0	65-85	<i>0</i>	<i>65-85</i>	<i>29-37</i>
1	73-112	79-117	1	86-109	<i>1</i>	<i>86-110</i>	<i>38-49</i>
2	113-157	118-161	2	110-137	<i>2</i>	<i>111-135</i>	<i>50-60</i>
3	158-207	162-209	3	138-167	<i>3</i>	<i>136-165</i>	<i>61-73</i>
4	208-260	210-261	4	168-199	<i>4</i>	<i>166-200</i>	<i>74-90</i>
5	261-318	262-317	5	200-234	<i>5</i>	<i>Over 200</i>	<i>>90</i>

TREES (SOFTWOOD)

Typical Construction

- Softwood: Pine, Spruce, Fir, Hemlock, Cedar, Redwood, Cypress

DOD	Damage description	EXP	LB	UB
1	Small limbs broken (up to 1" diameter)	60	48	72
2	Large branches broken (1" – 3" diameter)	75	62	88
3	Trees uprooted	87	73	113
4	Trunks snapped	104	88	128
5	Trees debarked with only stubs of largest branches remaining	131	112	153

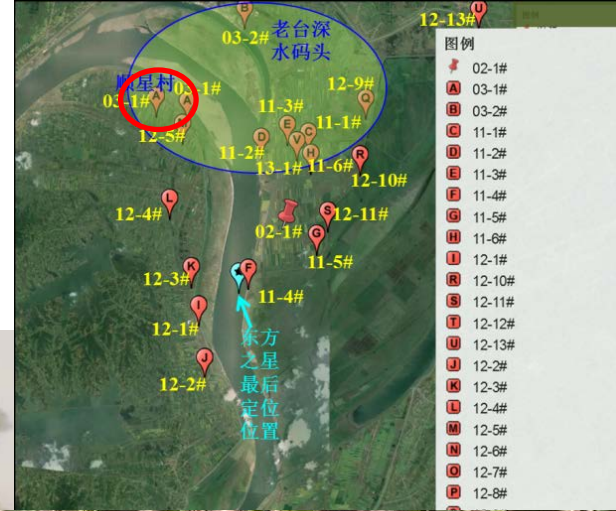
EF0
EF0-EF1
EF1-EF2
EF2-EF3

* DOD is degree of damage

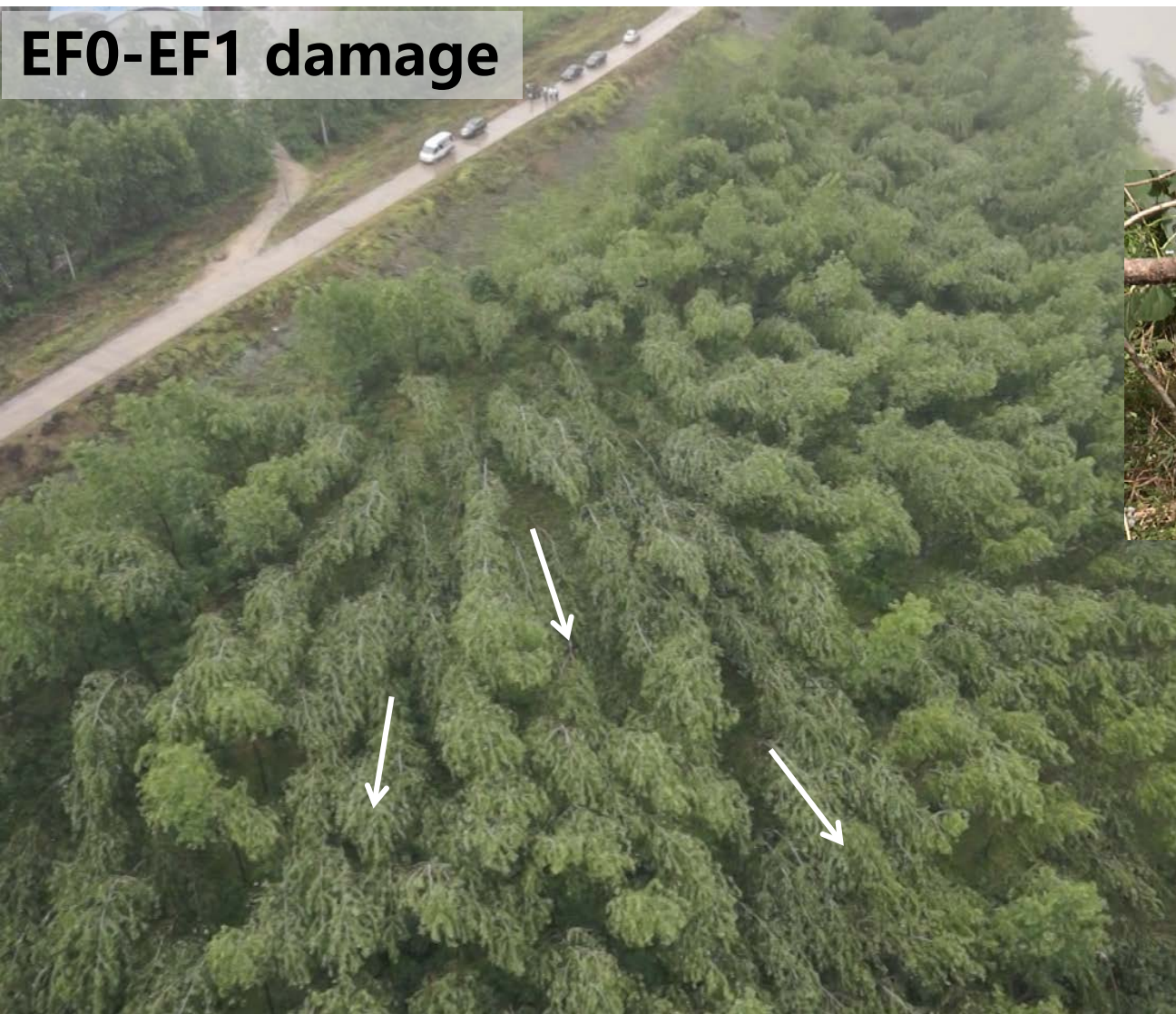
<i>EF Number</i>	<i>3 Second Gust (mph)</i>	<i>3 Second Gust (m/s)</i>
<i>0</i>	<i>65-85</i>	<i>29-37</i>
<i>1</i>	<i>86-110</i>	<i>38-49</i>
<i>2</i>	<i>111-135</i>	<i>50-60</i>
<i>3</i>	<i>136-165</i>	<i>61-73</i>
<i>4</i>	<i>166-200</i>	<i>74-90</i>
<i>5</i>	<i>Over 200</i>	<i>>90</i>

Shunxing Village, Huan Province, at the west side of the Yangtze River

Poplar (aspen) woods (SOFTWOOD)



EF0-EF1 damage



EF1 damage



Poplar trees

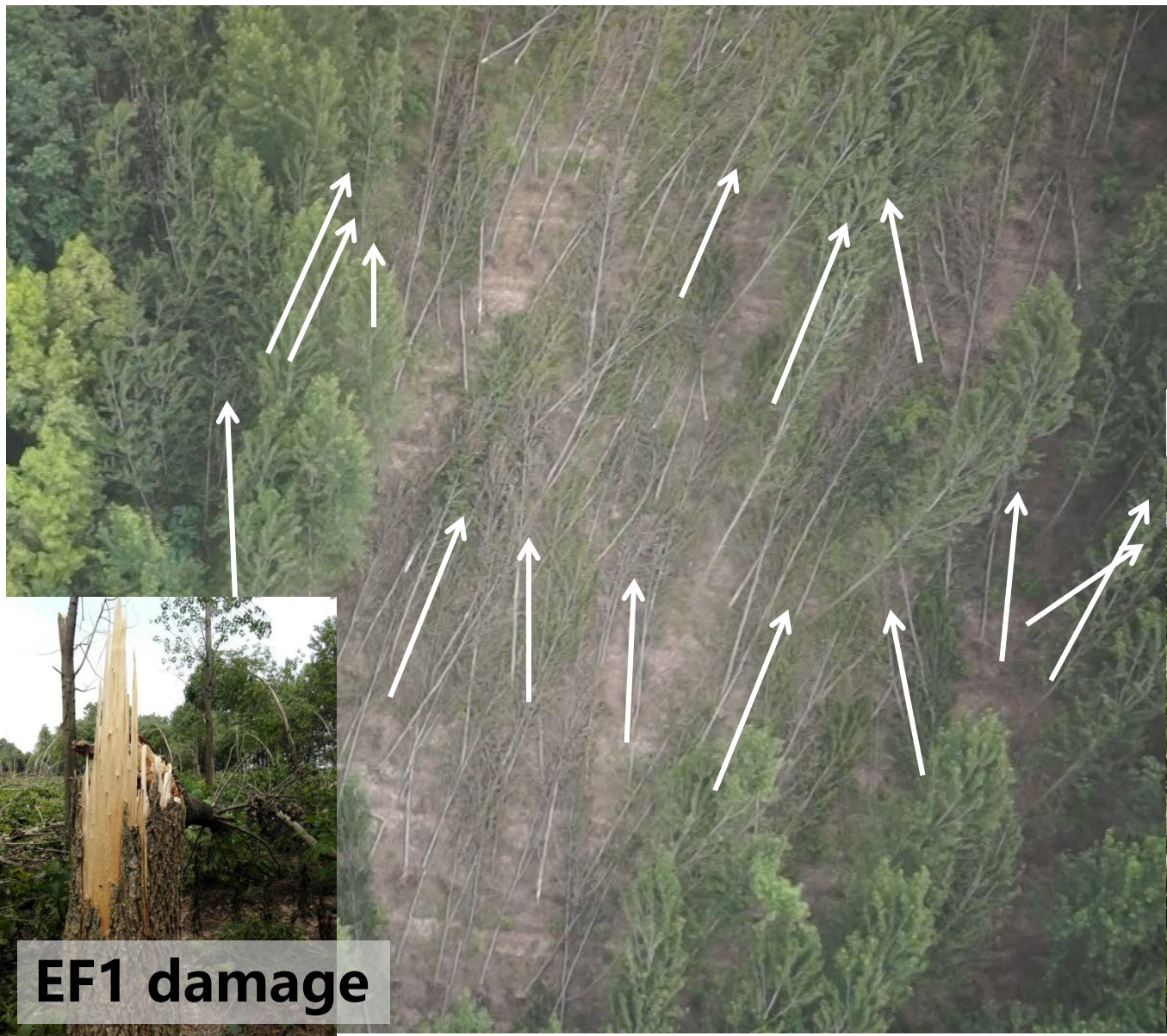
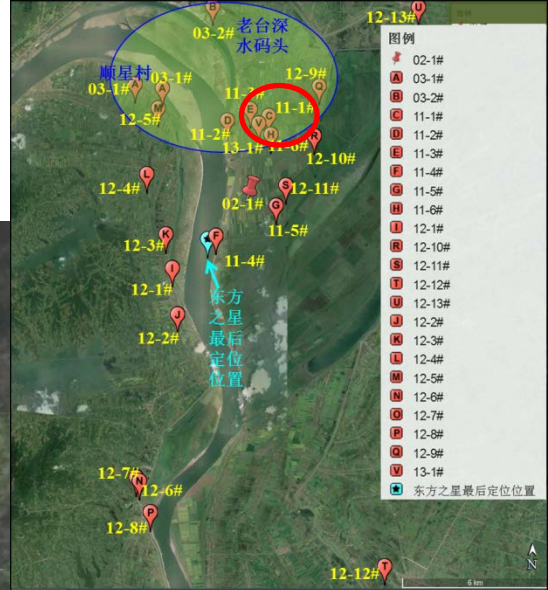
Fir trees



An aspen tree with a diameter of about 50 cm was snapped in Shunxing village, corresponding to an estimated wind speed of about 49 m s^{-1} (110 mph).

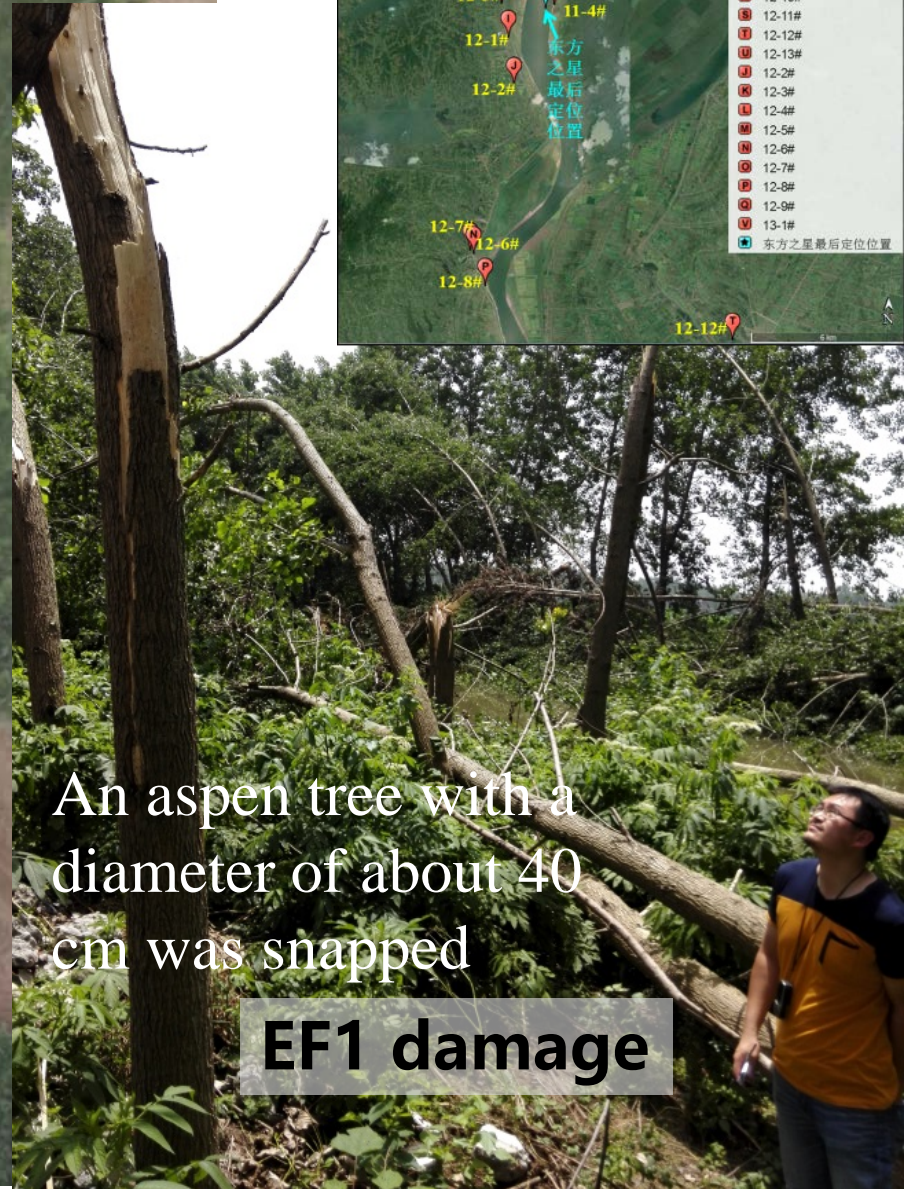
Woods near Sitai Village (11-1#) at the east side of the Yangtze River

The size of the damage area is about 200 m X 200 m



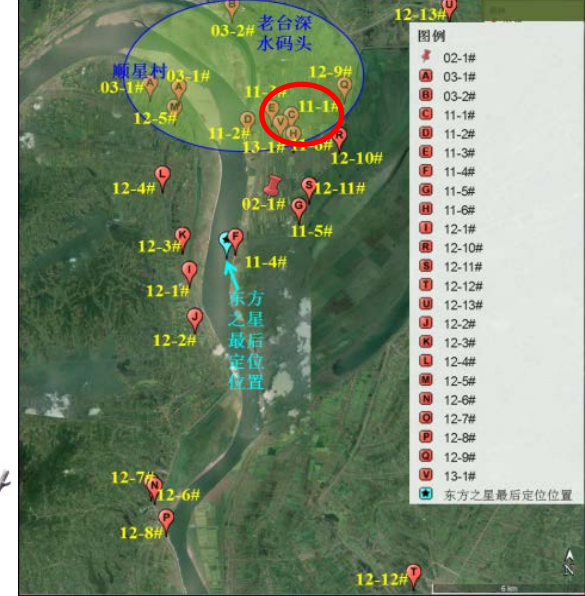
EF1 damage

EF1 damage



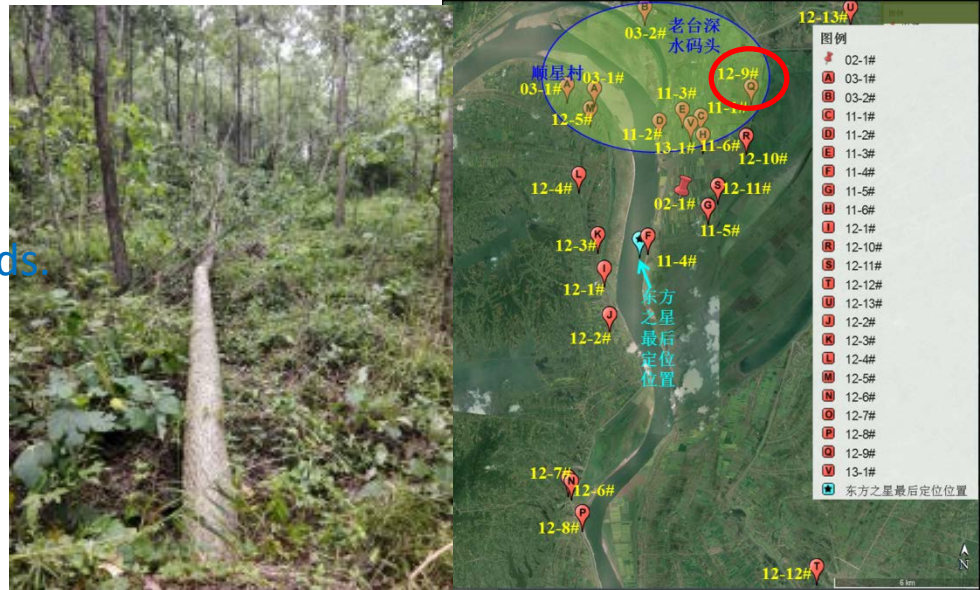
An aspen tree with a diameter of about 40 cm was snapped

EF1 damage



Woods Neighboring Xingouzi Village (12-9#)

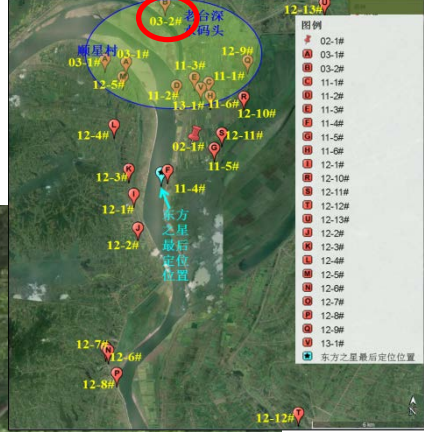
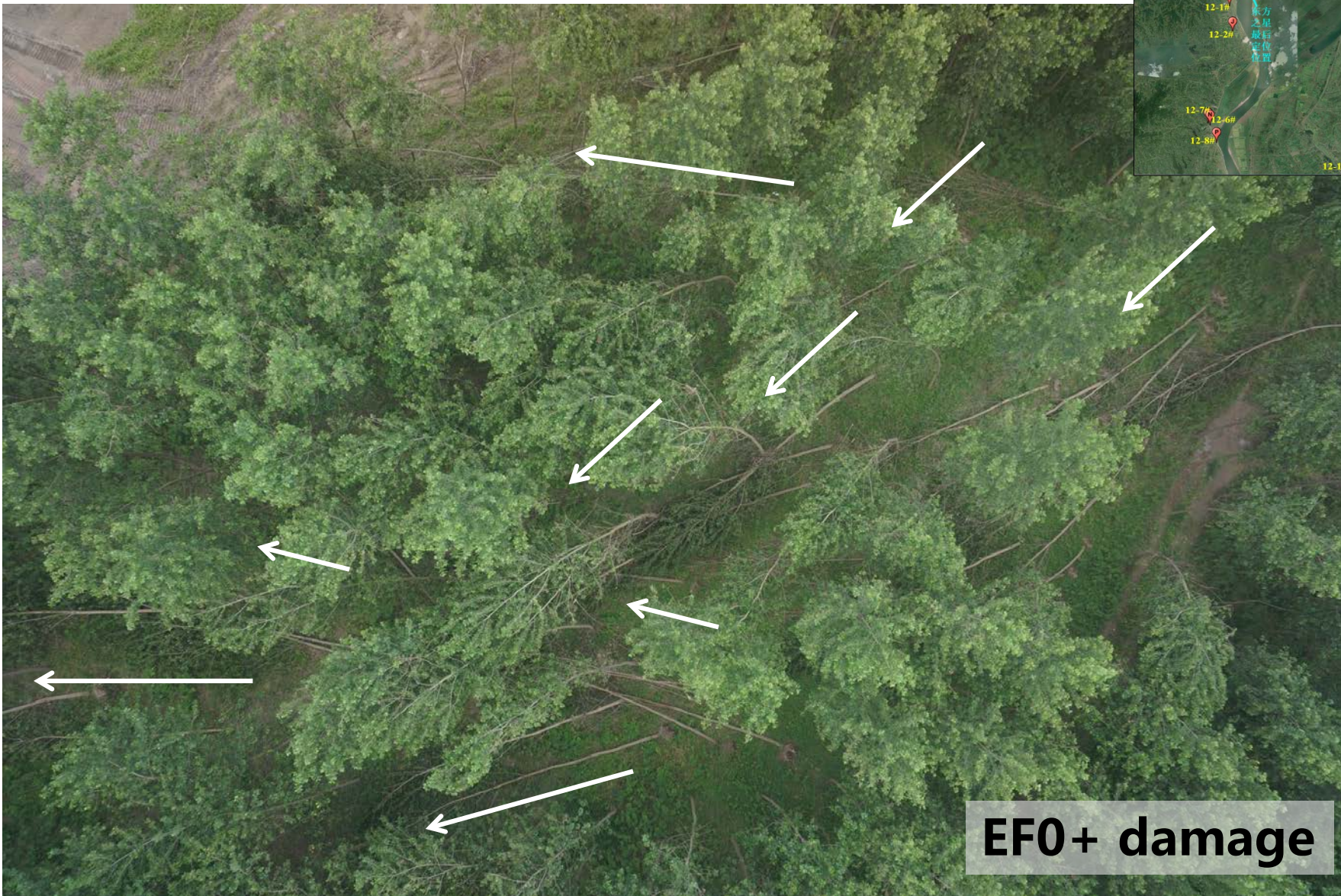
Many trees were bent and uprooted by the winds.



EF0+ damage



Laotai Dwarf (03-2#) , Hubei Province



EF0+ damage

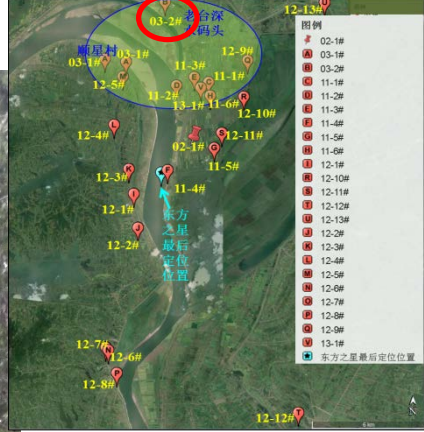
Laotai Dwarf (03-2#) , Hubei Province

EF0+ damage

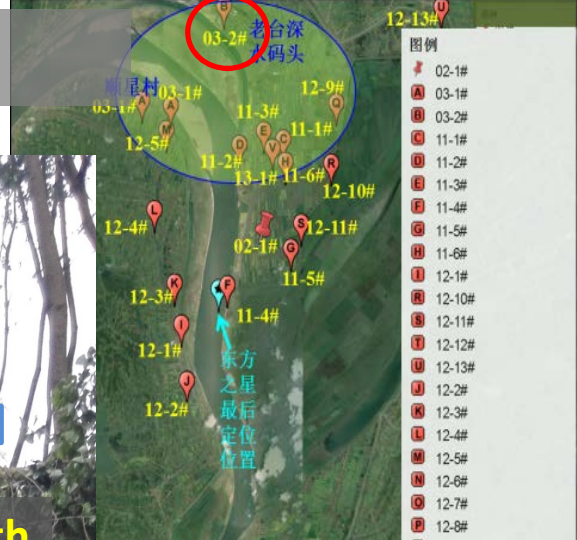


South east-south

East east-south



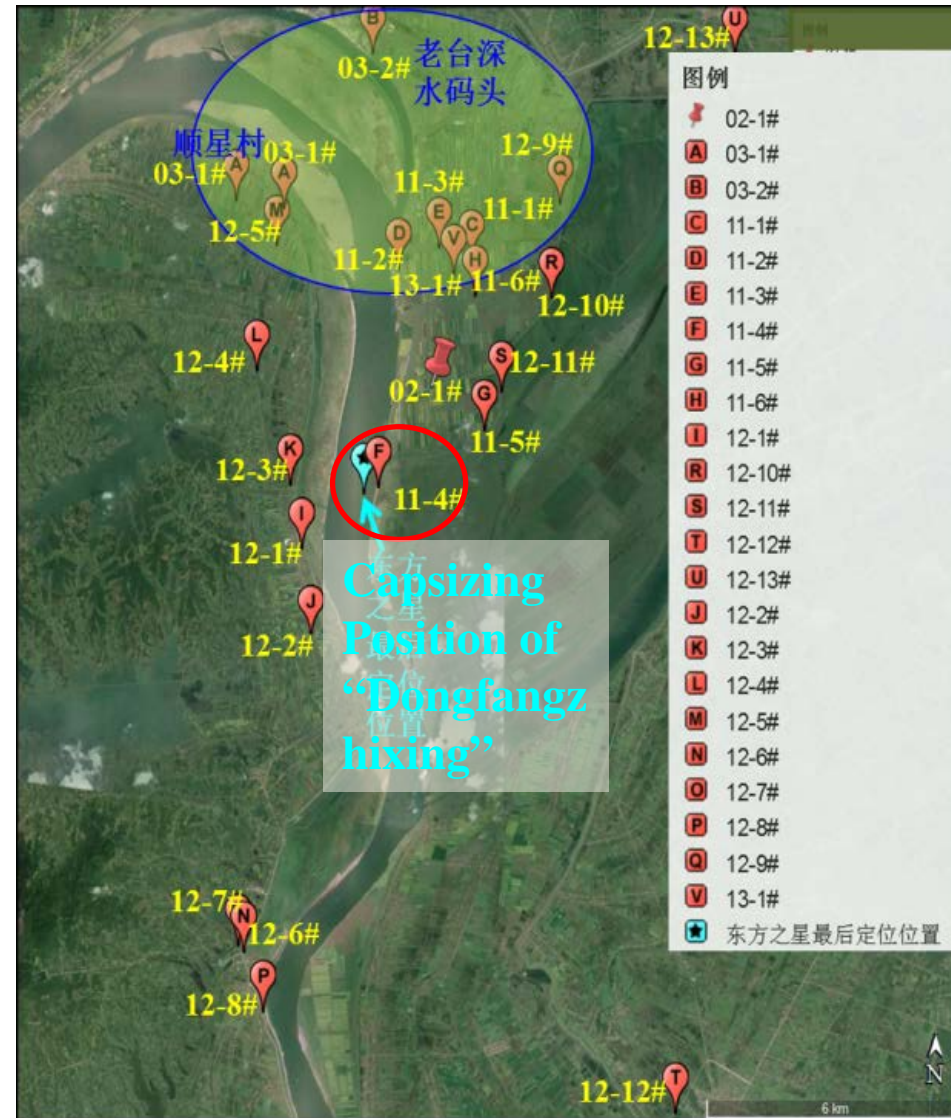
Laotai Dwarf (03-2#) , Hubei Province



EF0+ damage



- How strong were the high winds causing the cruise ship capsized?



East side neighboring
Capsizing
Position of
"Dongfangz
hixing"
(11-4#)



EF0 damage
(snapped dead tree)



EF1 damage

(snapped tree
with a diameter
of about 30 cm)



corresponding to an estimated wind speed of
about 49 m s⁻¹ (110 mph).

TREES (SOFTWOOD)

Typical Construction

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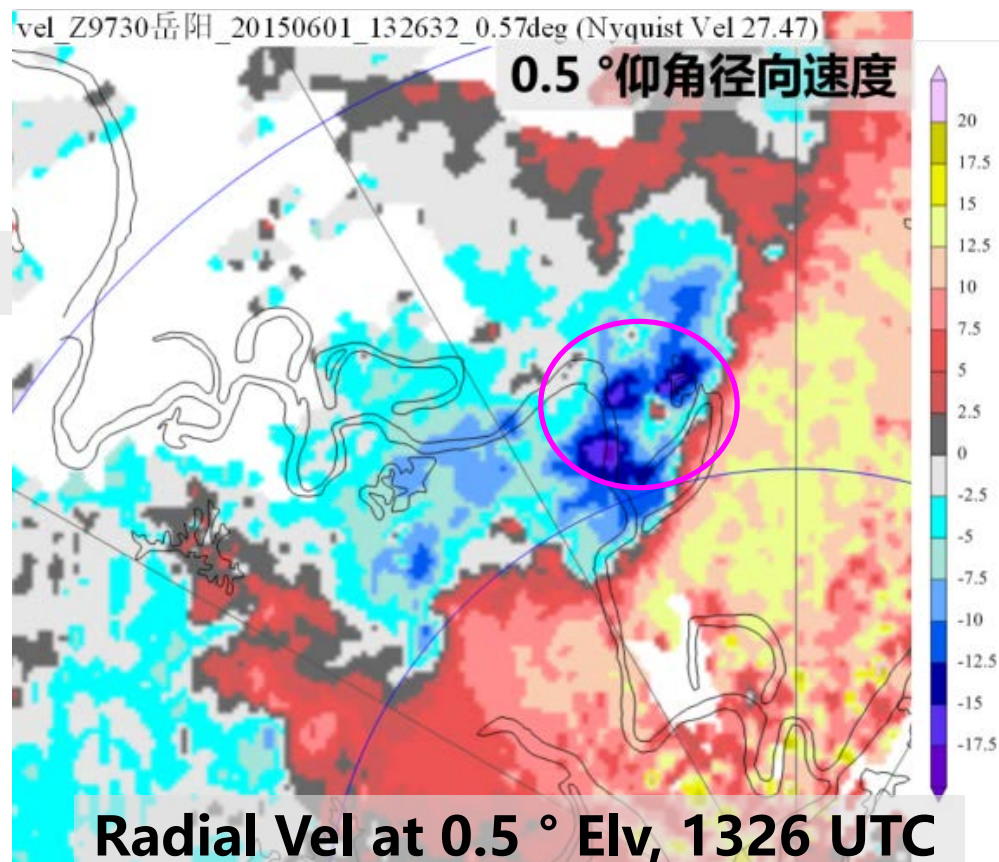
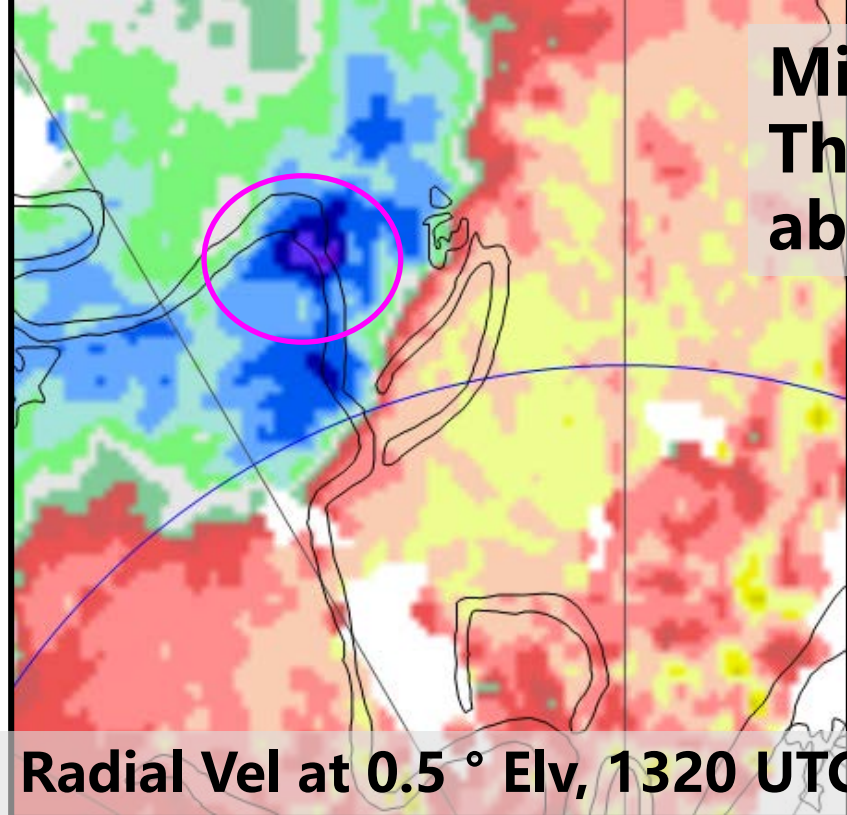
* DOD is degree of damage

EF0
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EF2-EF3

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Towards an improved wind speed scale and damage
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547-564



**Microburst was about 4km X 4km.
The intense inbound velocity is
about 19 m/s**



3 Tornado/Mesovortex, Microburst, and Multi-scale characteristic

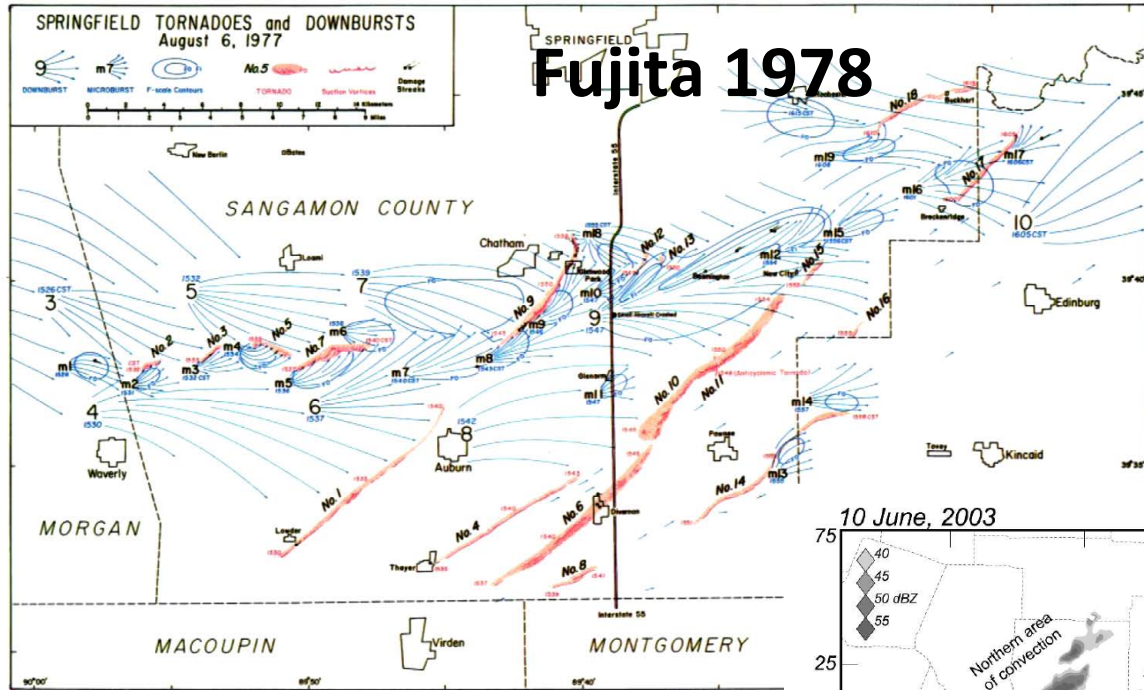


FIG. 8. Eighteen tornadoes, 10 downbursts, and 17 microbursts are depicted in this map. Apparently, eight tornadoes formed on the left side of microbursts. No traces of downbursts does. [From Fujita (1978).]

Atkins et al. (2005)

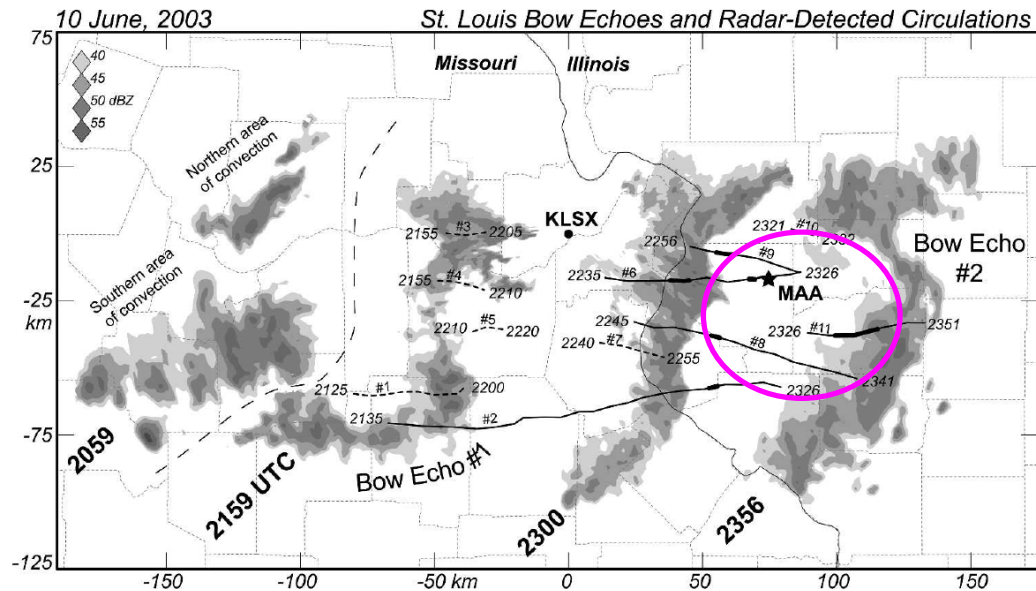


FIG. 5. Radar reflectivity data from the KLSX radar at 2059, 2159, 2300, and 2356 UTC. Solid and thick-dashed lines represent the locations of radar-detected tornadic and nontornadic mesovortices, respectively. Start and end times (UTC) for all mesovortices are also shown. Thick solid lines along the tornadic mesovortex paths represent the location of observed tornado damage. Thin-dashed lines are county boundaries. The long-dashed line separates the 2059 and 2159 UTC radar data.

EVOLUTION OF BOW ECHO

Proposed by FUJITA, 1979

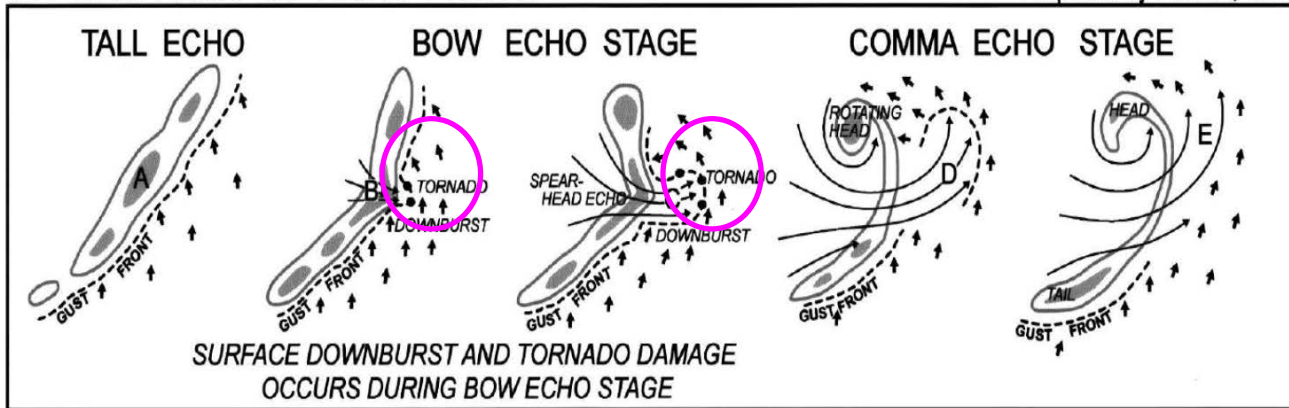
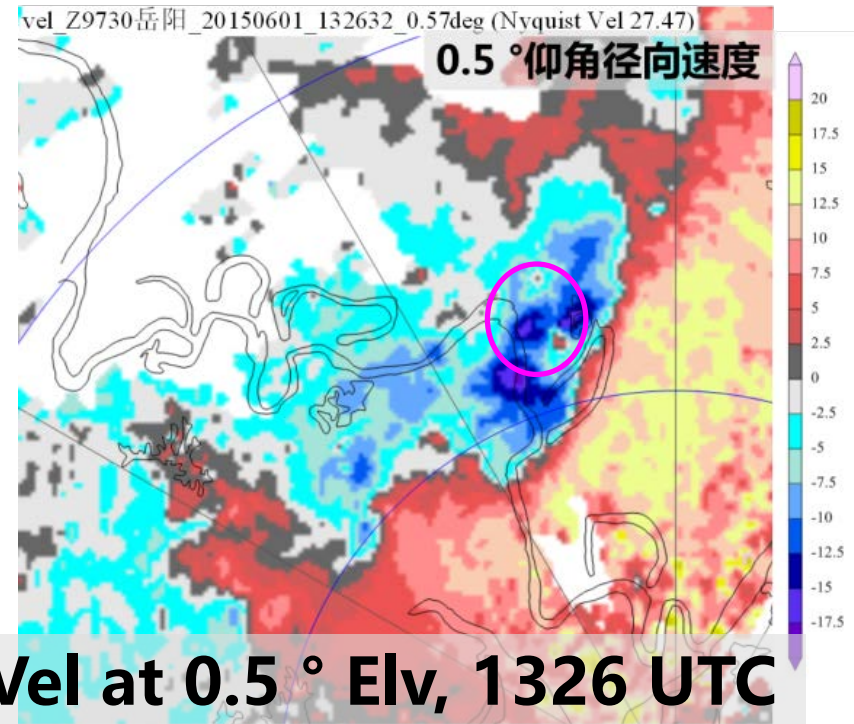
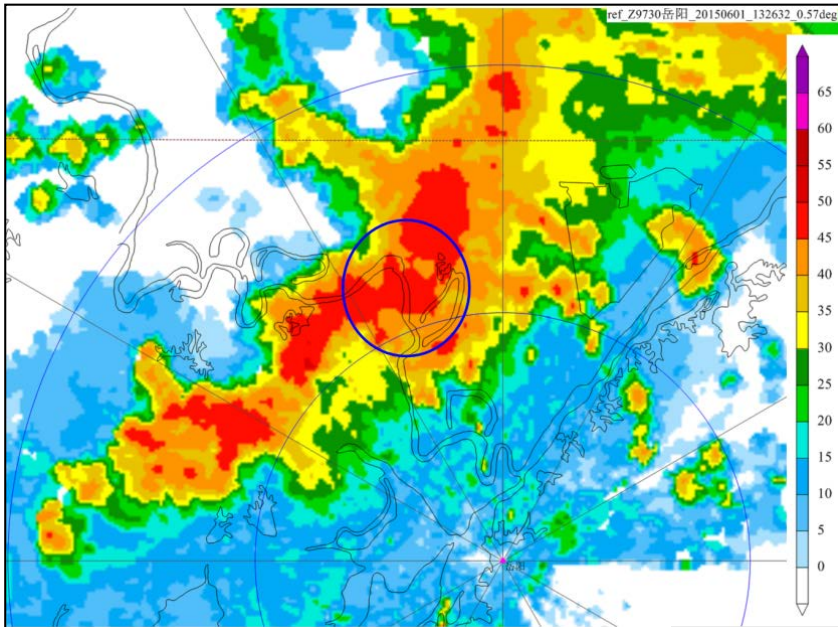


FIG. 1. Schematic diagram illustrating bow echo evolution. Figure adapted from Fujita (1979).



Multi-scale characteristic

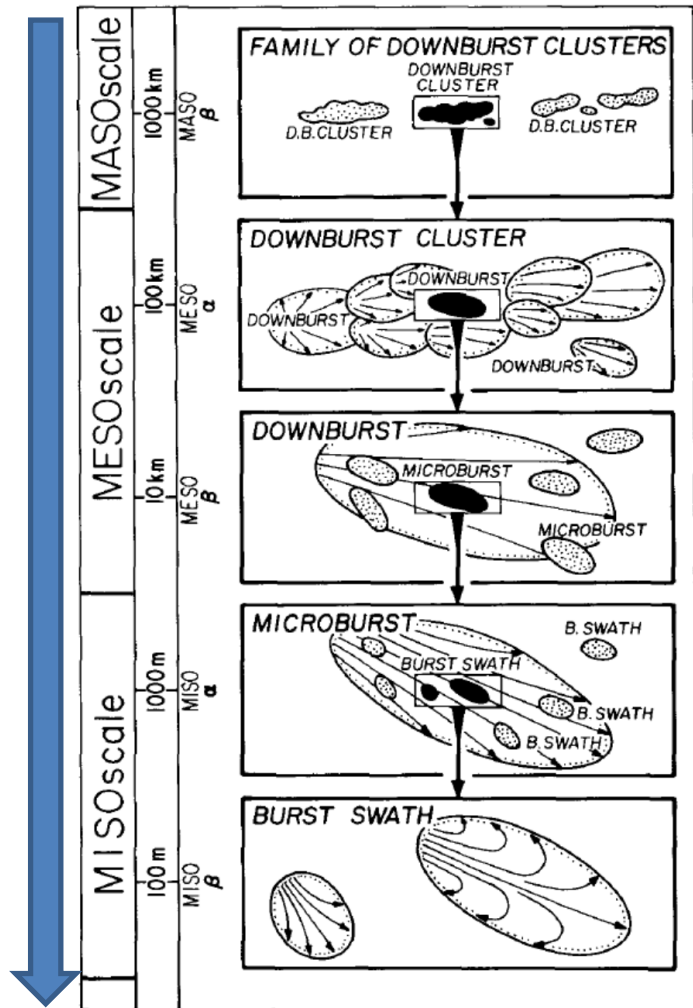
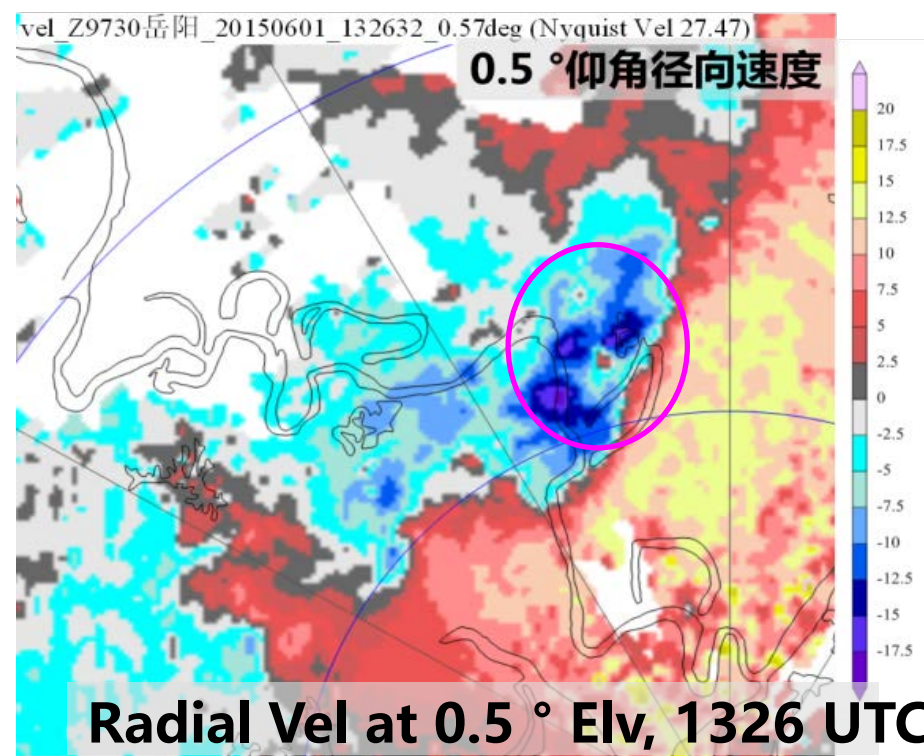


FIG. 1. Five scales of downburst damage patterns. A family of downburst clusters extends several hundred kilometers while a downburst cluster consists of a number of individual downbursts. Microbursts frequently occur without a parent downburst. A burst swath, particularly a long and narrow one, is characterized by damage typical of tornadoes.



4 Summary

- ❑ Nineteen damage positions were carefully surveyed.
- ❑ Downbursts produced by the QLCS caused widespread wind-damage.
- ❑ The most intense damage in the accident was rated as EF1. The wind speed causing the overturn of the cruise ship was at least Beaufort Scale 12, considering an uncertainty* of about 18 m s^{-1} in the estimation method.
- ❑ There was a mesovortex found in the QLCS.
- ❑ No apparent evidence shows there was a tornado in the vicinity of the accident area on 1 June 2015.

*Feuerstein B, Groenemeijer P, Dirksen E et al (2011) Towards an improved wind speed scale and damage description adapted for Central Europe, Atmos. Res., 100, 547–564

Acknowledgements

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- ✓ We express our appreciation to the China Portage Network, developed by Jiangsu Wurun United Shipping Internet Co. Ltd., and especially Guanghui Zhu and Yao Yu, for providing real-time locations of the ship.

Published Papers:

- Zheng, Y., F. Tian, Z. Meng, et al, 2016:
Survey and Multi Scale Characteristics of Wind Damage Caused by Convective Storms in the Surrounding Area of the Capsizing Accident of Cruise Ship “Dongfangzhixing”. **Meteorological Monthly**, 42(01):1-13. (In Chinese)
- Meng, Z., D. Yao, L. Bai, et al, 2016:
Wind estimation around the shipwreck of Oriental Star based on field damage surveys and radar observations. **Science Bulletin**, 61(4):330-337.

**Thank you
for your attention!**

谢谢！