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Progress report on thesis research: wind energy

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Outline

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Research Significance

Wind energy resources in various region depend on local density of wind energy and annual cumulative hours of available wind energy, and wind energy resources are greatly affected by topography. Wind energy resources are abundant in china. Such as the southeast coast and its islands, Inner Mongolia and Northern Gansu, are the major wind energy resources in china.

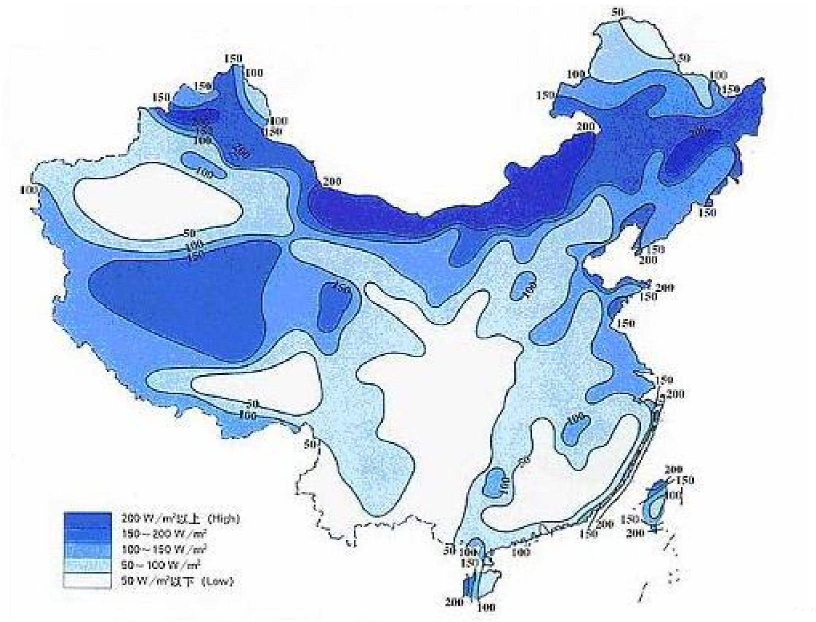


Fig 1 The wind energy resource distribution map

For the continuous expansion of wind power plants, the wind energy resource assessment and wind power forecasting, are becoming more and more important .

Present Research

Wind resource assessment and wind power forecasting are targeted to the very small scale, which is a specific wind farm or a wind turbine. Wind farm scale is about a few square kilometers, the turbine is at 100 m level. And most of wind farms are in complex terrain conditions in remote areas. The atmospheric motion on the wind farm is impacted not only by the regional atmospheric circulation, but also by local small-scale environment. And a single meso-scale meteorological model or computational fluid dynamics model cannot meet the requirements of wind energy development.

In this paper, two advanced numerical simulation tools, meso-scale atmospheric model (WRF) and computational fluid dynamics model (Fluent), are combined to asssess wind energy resources finely.

Methodology

The Poyang Lake area in China is Wind energy seasonal utilization area, and wind energy resources are abundant in winter. The numerical simulation of wind field in Poyang Lake area is made by taking a gale process in 2010 in the winter of December as an example.

- Using WRF model to simulate the meteorological field in Poyang Lake area from 13 to 16 , December, 2010.
- Based on the boundary conditions provided by the WRF simulation results, the numerical simulation of wind field and turbulent flow field near the jishan site (1.8km×1.8km) and zaohu site (3.6km×3.6km) is performed by using Fluent.

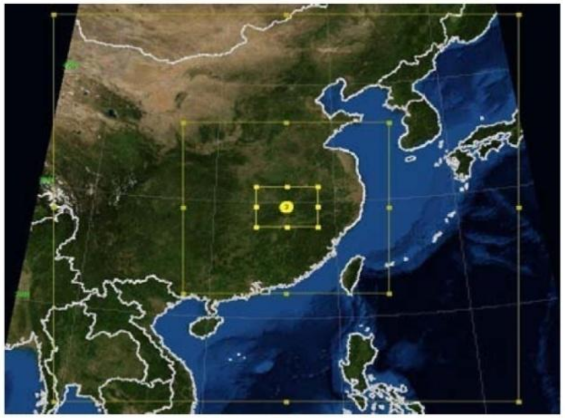


Fig 2 WRF simulation grid area of Poyang Lake

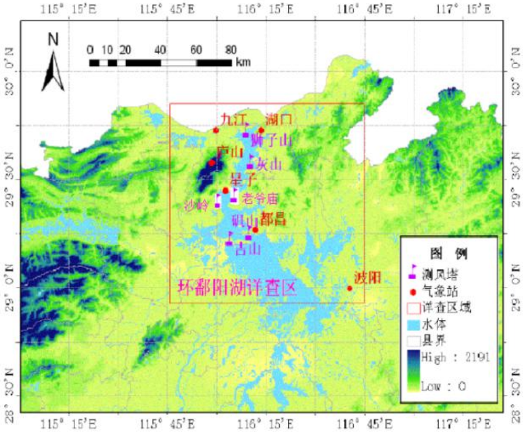


Fig 3 Simulated region and locations of observation towers

Technical route

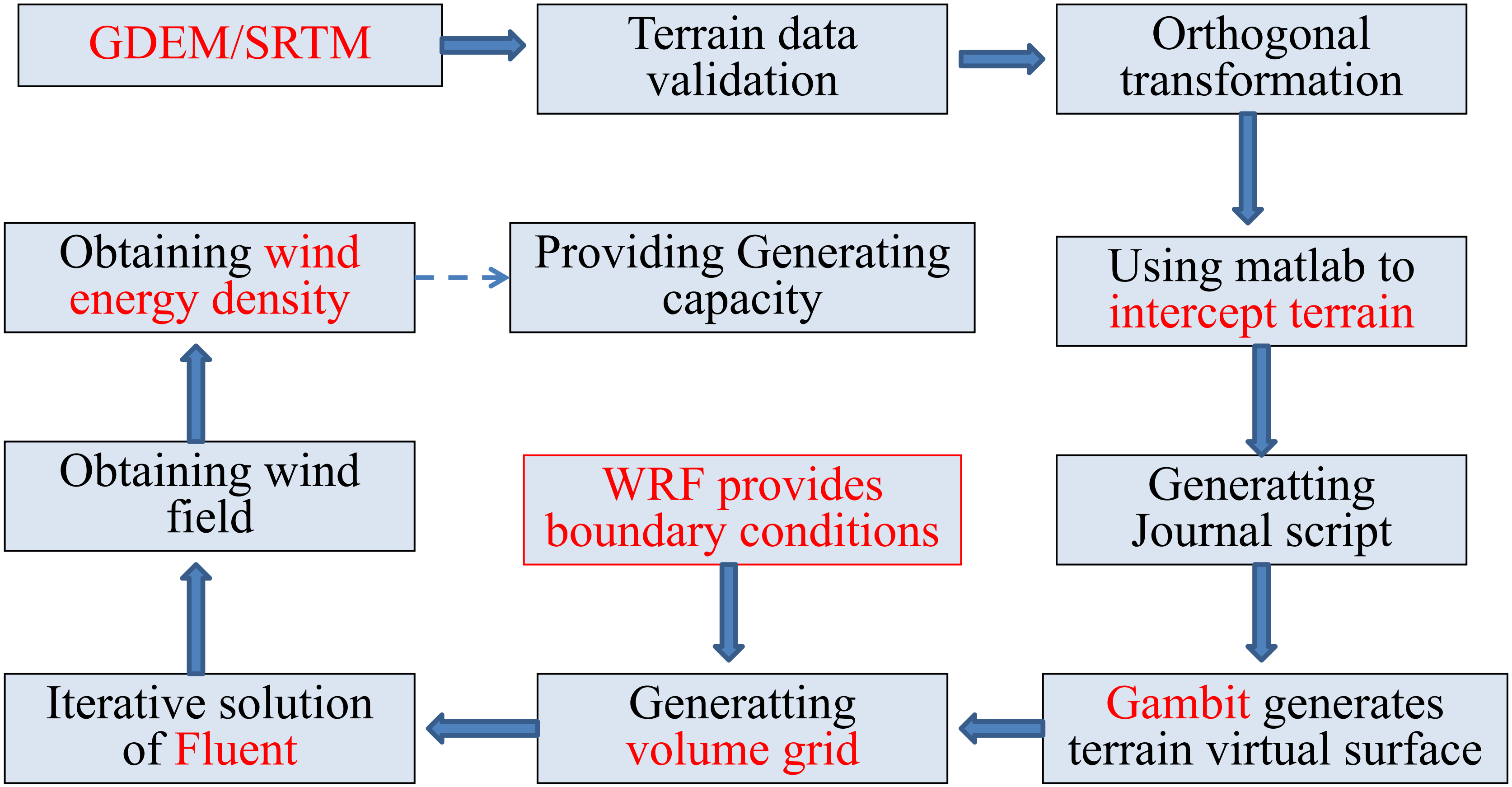
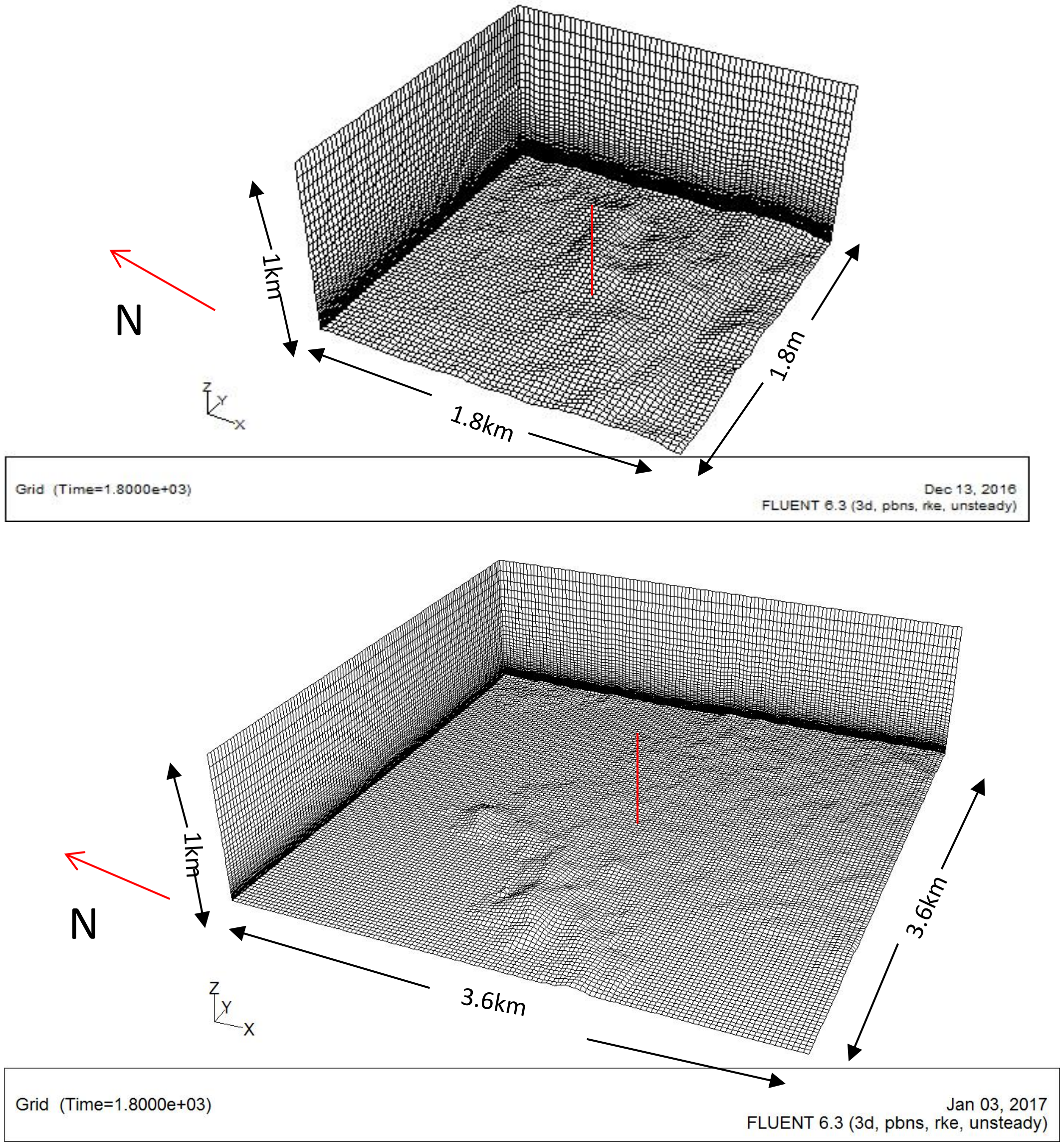


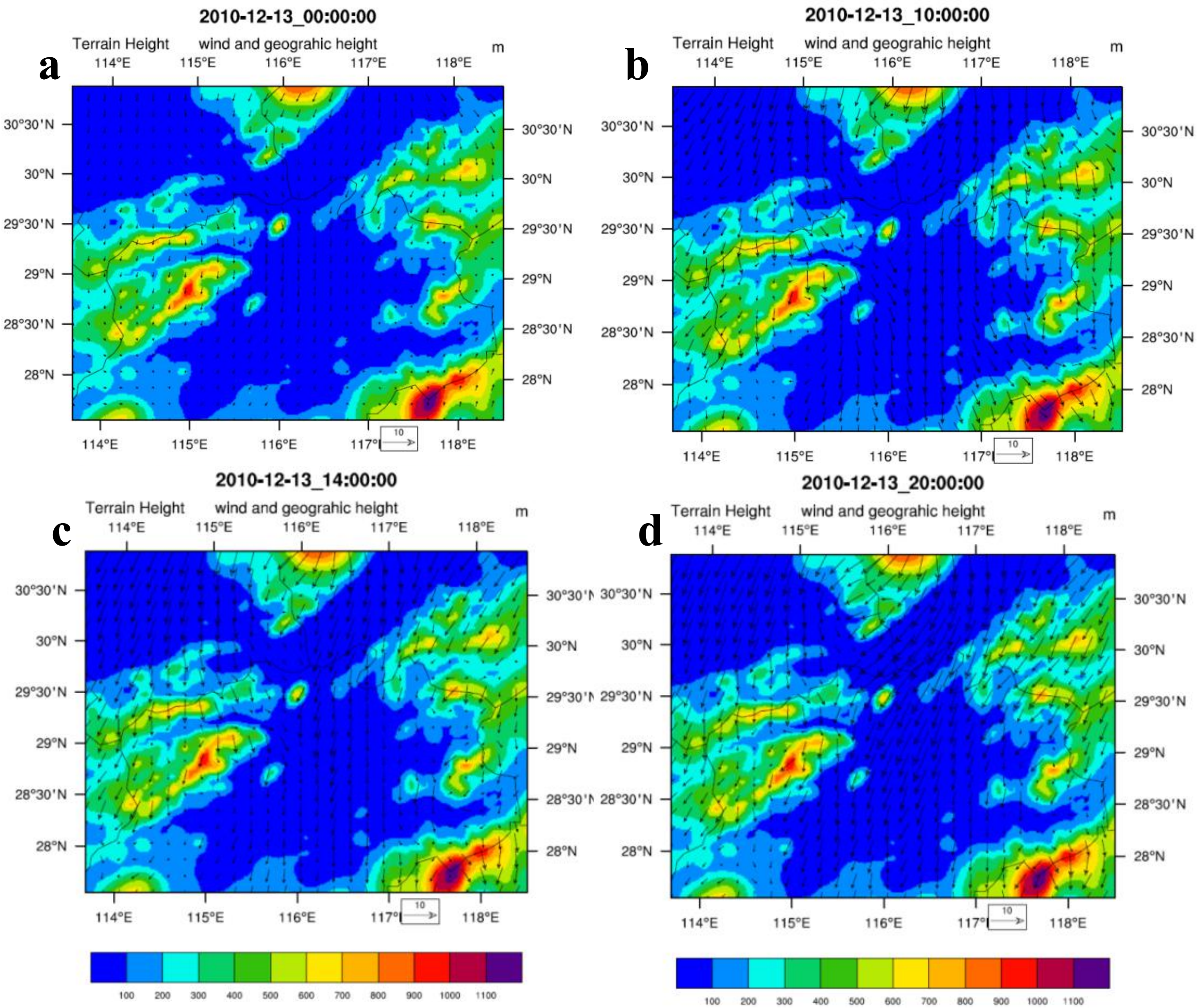
Fig 4 Technical route of WRF frives Fluent



The two pictures is volume grid of jishan (up) and zaohu (down) site produced by Gambit. The red line respresents site location.

Fig 7 The volume grid of jishan (up) and zaohu (down) site

Result and Discussion



The dark blue part represents water.

Fig 5 The surface wind field in Poyang Lake simulated by WRF at 0 h (a), 10h (b), 14h (c) and 20 (d) in 15d

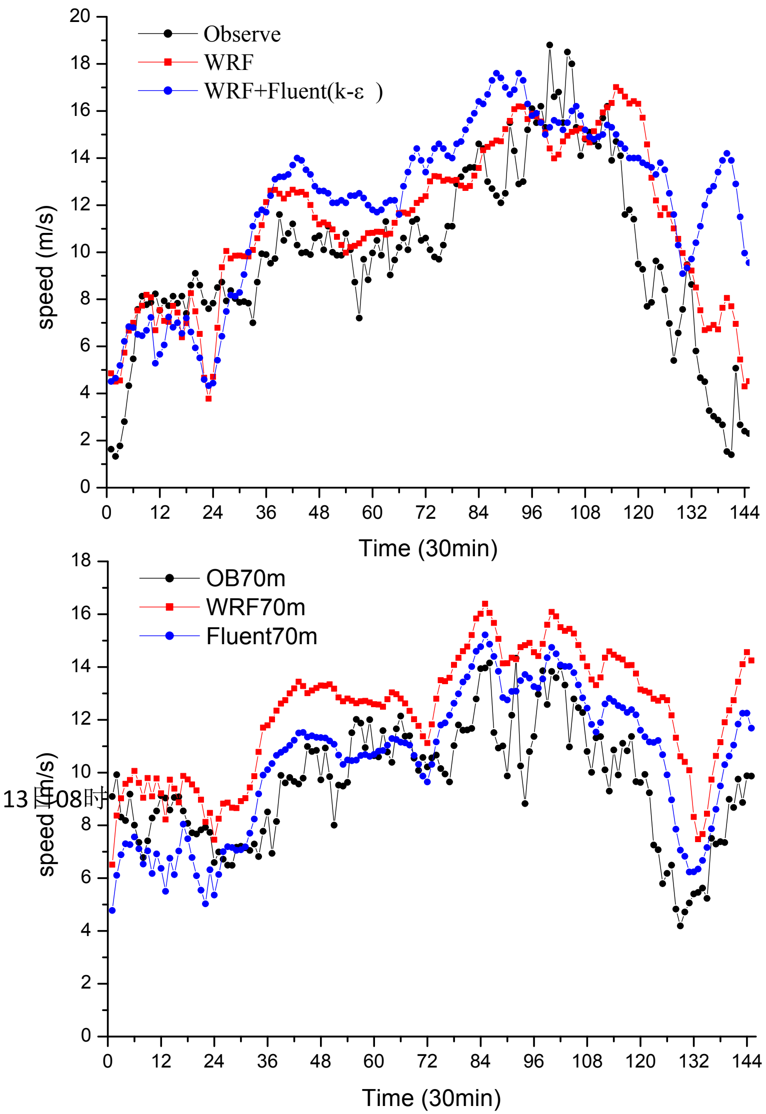


Fig 6 Comparison between simulated and observed speed at 70m height in jishan(up) and zaohu(down) site during simulated time period

The simulated includes WRF (red line) and WRF+Fluent(blue line). The simulated period is three days.

Table 1 Statistical analysis between simulated and observed speed at 70m height in jishan and zaohu site during simulated time period

	Error of simulated (WRF)and measured values			Error of simulated (WRF+Fluent) and measured values		
Site	BIAS	RMSE	R^2	BIAS	RMSE	R^2
Jishan	1.360	2.140	0.830	2.247	3.139	0.637
Zaohu	2.675	1.629	0.747	0.801	1.719	0.769

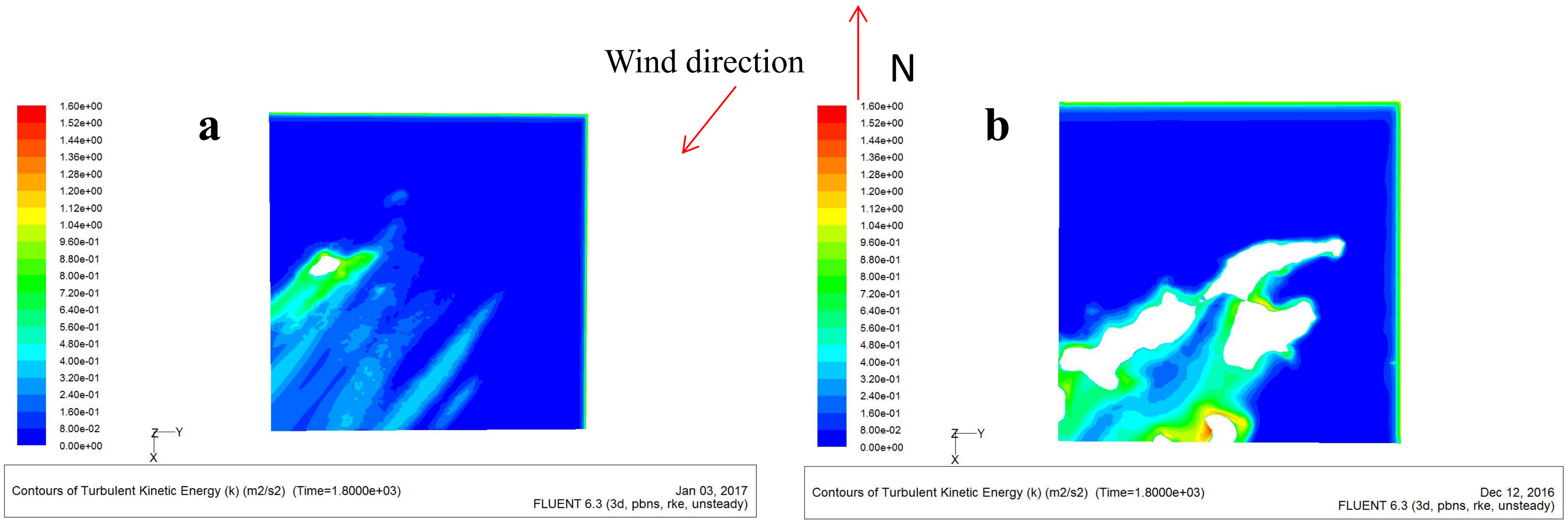


Fig 8 The simulated turbulent intensity at 70m height in zaohu (a) and jishan (b) site at 10h in 15d by fluent

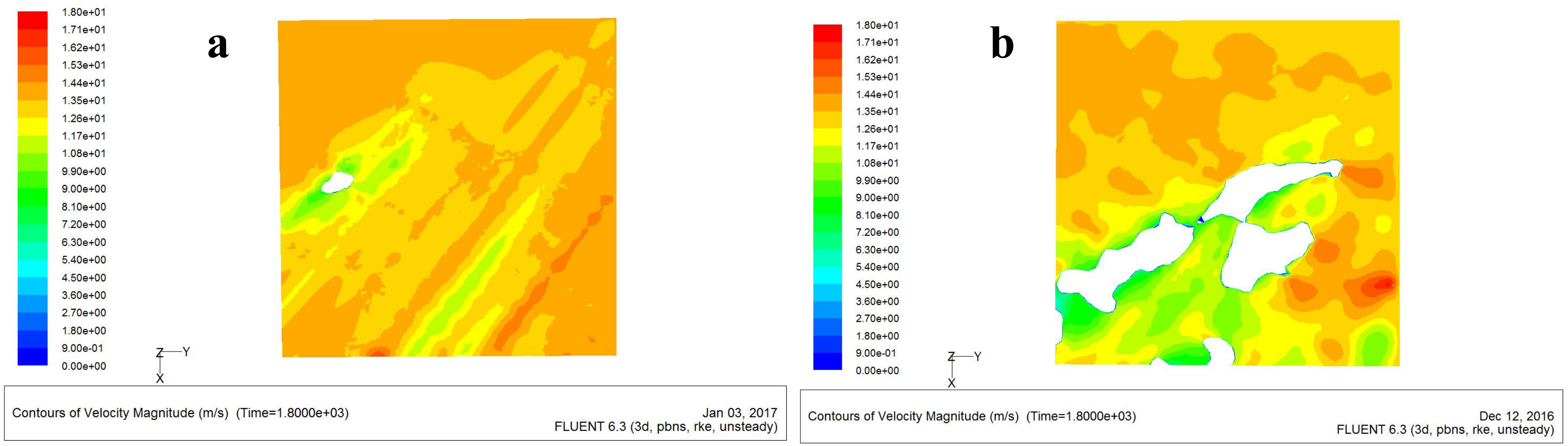


Fig 9 The simulated speed at 70m height in zaohu (a) and jishan (b) site at 10h in 15d by fluent

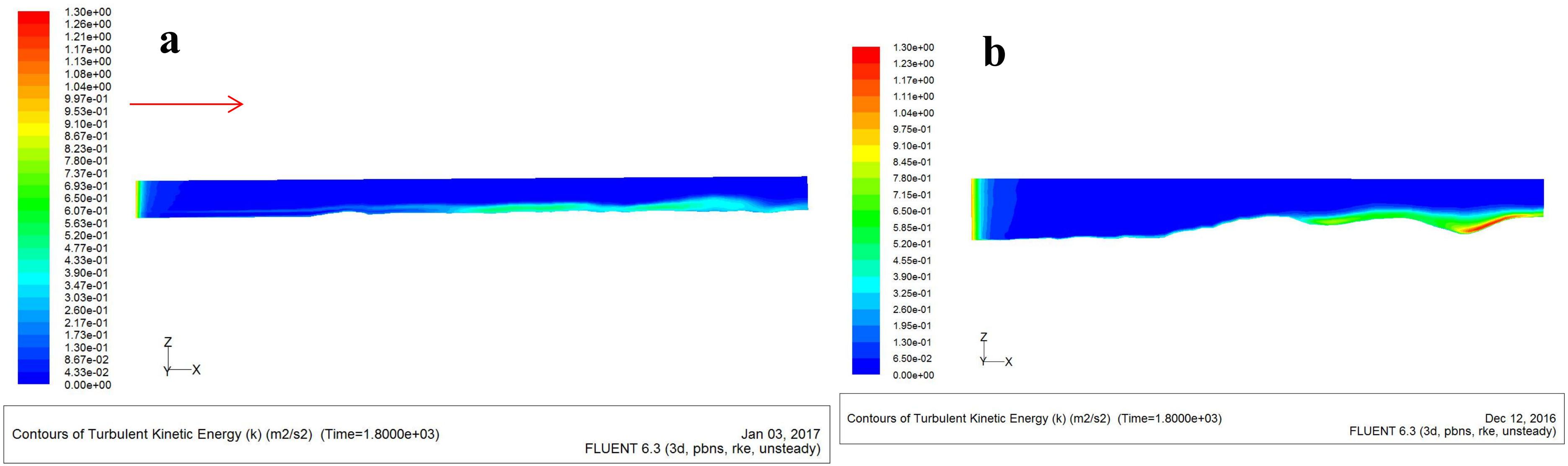


Fig 10 The simulated turbulent intensity at 70m height in zaohu (a) and jishan (b) site at 10h in 15d by fluent

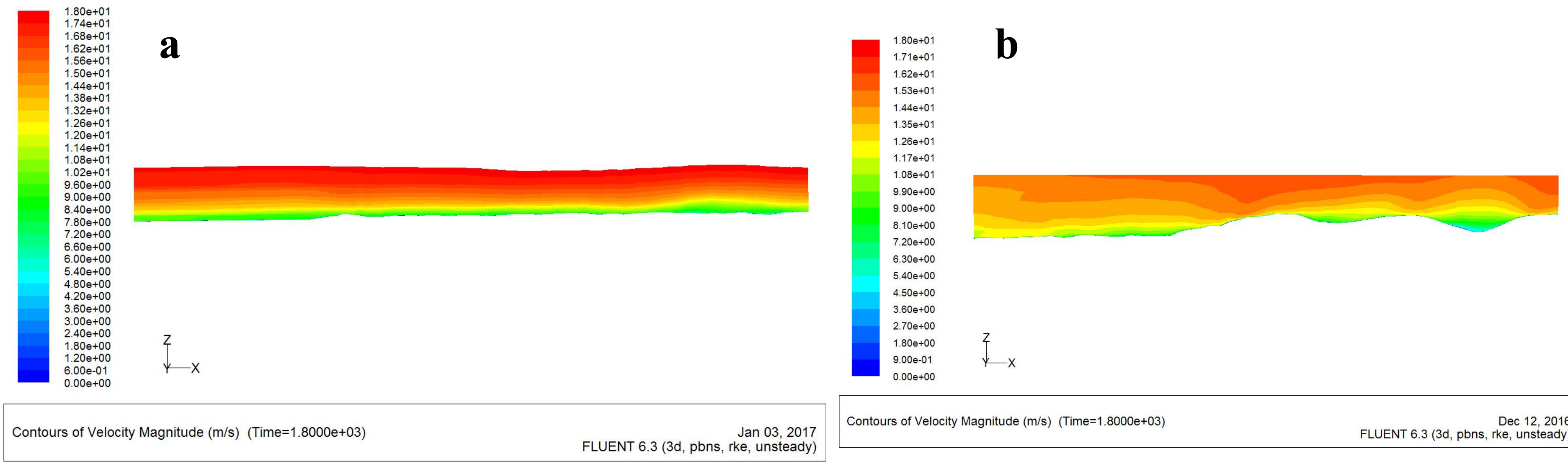


Fig 11 The simulated turbulent intensity at 70m height in zaohu (a) and jishan (b) site at 10h in 15d by fluent

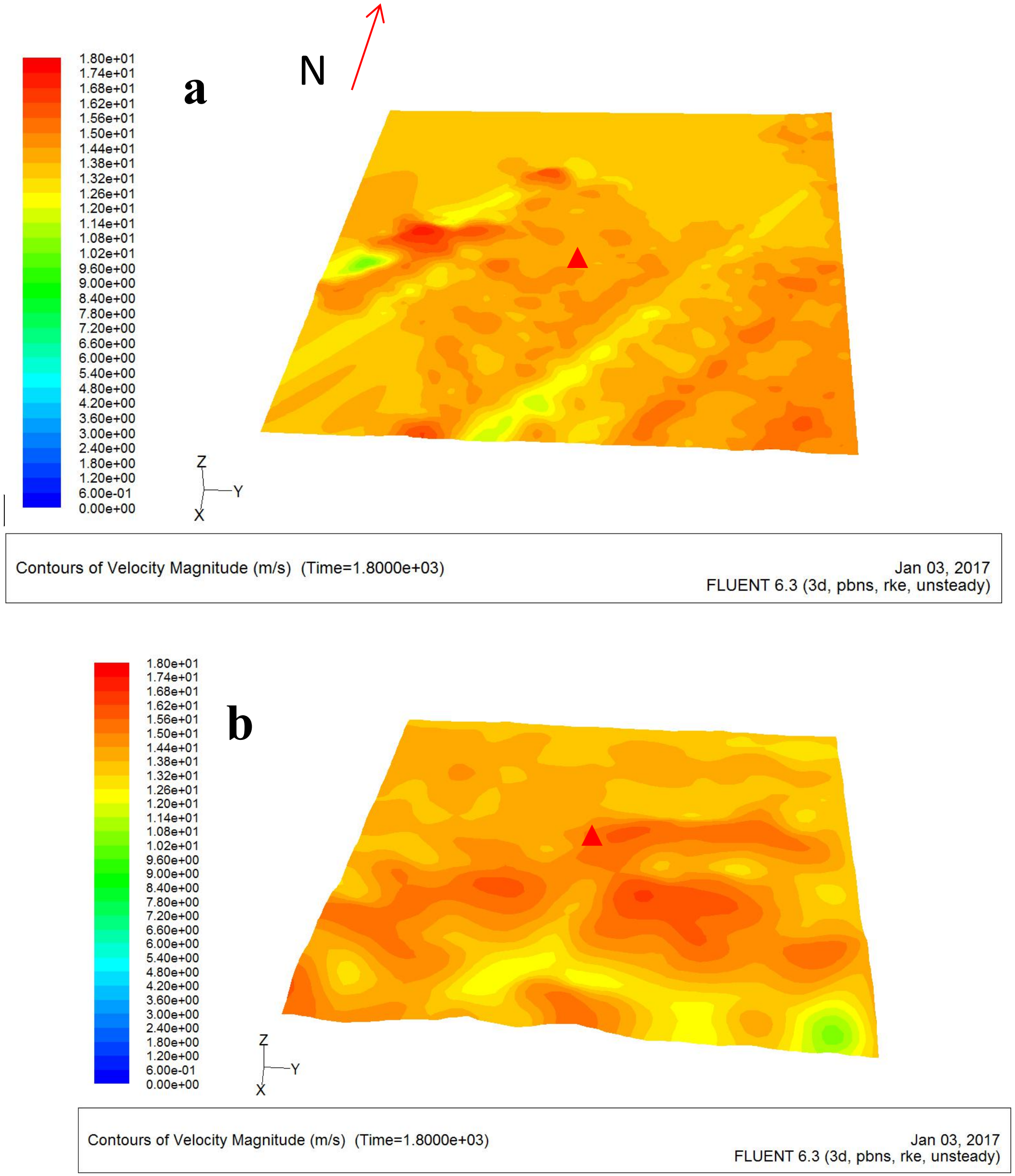


Fig 12 The simulated speed over 70m height above ground in zaohu (a) and jishan (b) site at 10h in 15d by fluent

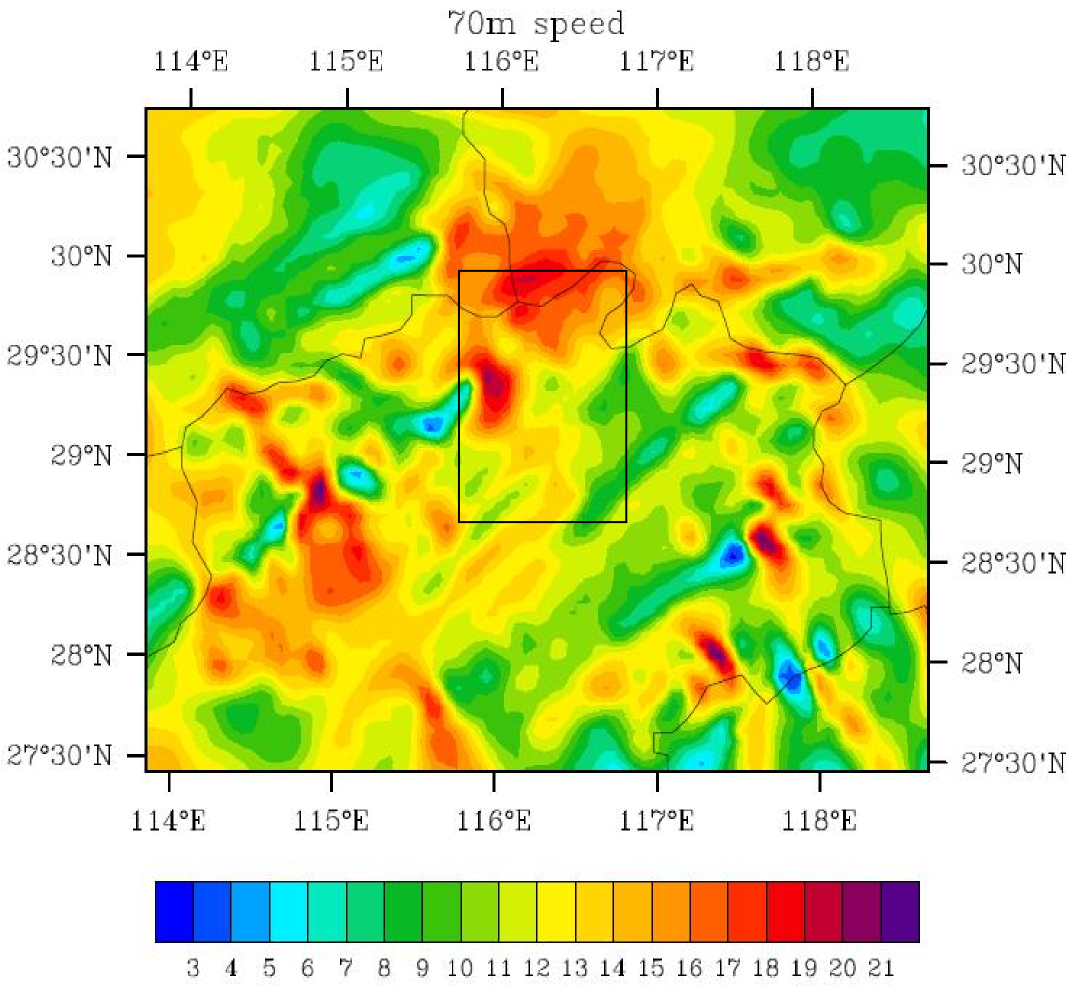


Fig 13 The simulated speed over 70m height above ground in in Poyang Lake at 10h in 15d by WRF

Conclusion

- The advantage of the CFD model (Fluent) is that it can reflect the influence of many small-scale topographic effects on wind speed, is to simulate the separation and rotation of the flow after terrain, is to simulate the turbulent scale of atmospheric movement, it is the output of the wind speed change range greater than WRF, the rate of change (frequency) faster than WRF. The advantage of WRF in the mean motion of the mesoscale atmospheric simulation. Using a single site and hourly average simulation results to compare WRF and CFD, and can not be a good display of the advantages of CFD model.
- This method (WRF+Fluent)is a one-way coupling, WRF driven Fluent, WRF prediction is the basis of Fluent forecast. When the WRF prediction error is large, Fluent can not be completely corrected.

- It can be seen from the analysis of Figure 6 that the simulation results of WRF coupling Fluent to high speed process are good, which is significant for the development of wind energy resources.
- Although the WRF coupling Fluent and WRF direct output of the simulated wind speed is roughly the same, However, Fluent can give the fine scale wind field information as shown in Figure 12, which WRF cannot do.

Thank you