Application of WRF-ARW Model to Short-Range Squalls Prediction in Transbaikalia Region of Russia

Eugenie Verbitskaya, Stanislav Romanskiy

Far Eastern Regional Hydrometeorological Research Institute (Russia) ✉ sromanskiy@khbr.meteorf.ru

1. Introduction

Squall is a sudden onset of strong winds with speeds increasing to 20-30 m/s for one minute or more. Swirling motion of air with a horizontal axis of rotation takes place in a squall (fig. 1) [1,2].

More than 30 squalls, including *severe events* whose wind speed increased to a value of 25 m/s and above, observed in Transbaikalia region of Russia on warm season (from May to September) yearly (tab. 1). Majority of these occurrences had a frontal origin.

Table 1. **Total amount of marked squalls in Transbaikalia**

Year / Wind speed	2010	2011	Total
20-24 m/s	28	22	50
≥ 25 m/s	4	1	5

The Advanced Research Weather Research and Forecasting Model (WRF-ARW) [3] was applied as the prognostic base for prediction of squalls.

Aims of the research

- To estimate WRF-ARW capabilities to predict convective severe weather events including squalls in Transbaikalia region of Russia.
- To develop a method for definition squalls using model prognostic data.
- To understand a general impact of intrinsic physical parameterizations to squall origin in the model.

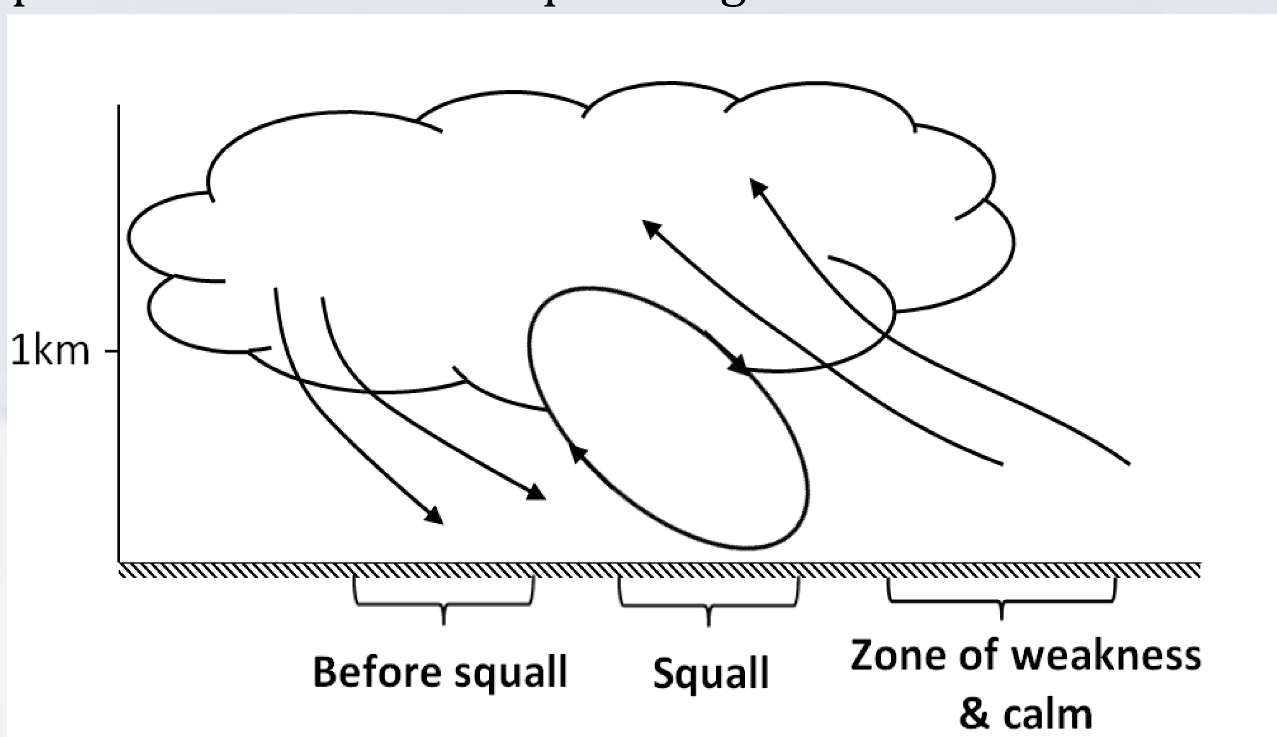

Fig. 1. **Wind direction in a squall**

Model specifications

Forecast area consists of *two nested domains with 9 km and 3 km* grid resolutions. External domain covers roughly 2500 km x 2000 km region centered on lake Baikal (fig. 2). Forecast period is up to 30 h. 4 different variant of WRF-ARW configurations were created and run for 25 representative cases from 2010. There were 21 observed squalls in these occasions. For each case, 2 various pairs of *surface and planetary boundary layers* parameterizations (Mellor–Yamada–Janjic (MYJ) and Yonsei University (YSU) schemes) and two scheme *of feedback (fb)* were involved. A treatment of convection (Kain-Fritsch scheme) was always switched off inside inner domain. Model had 27 vertical levels. 0.5° GFS forecasts filled initial and boundary data.

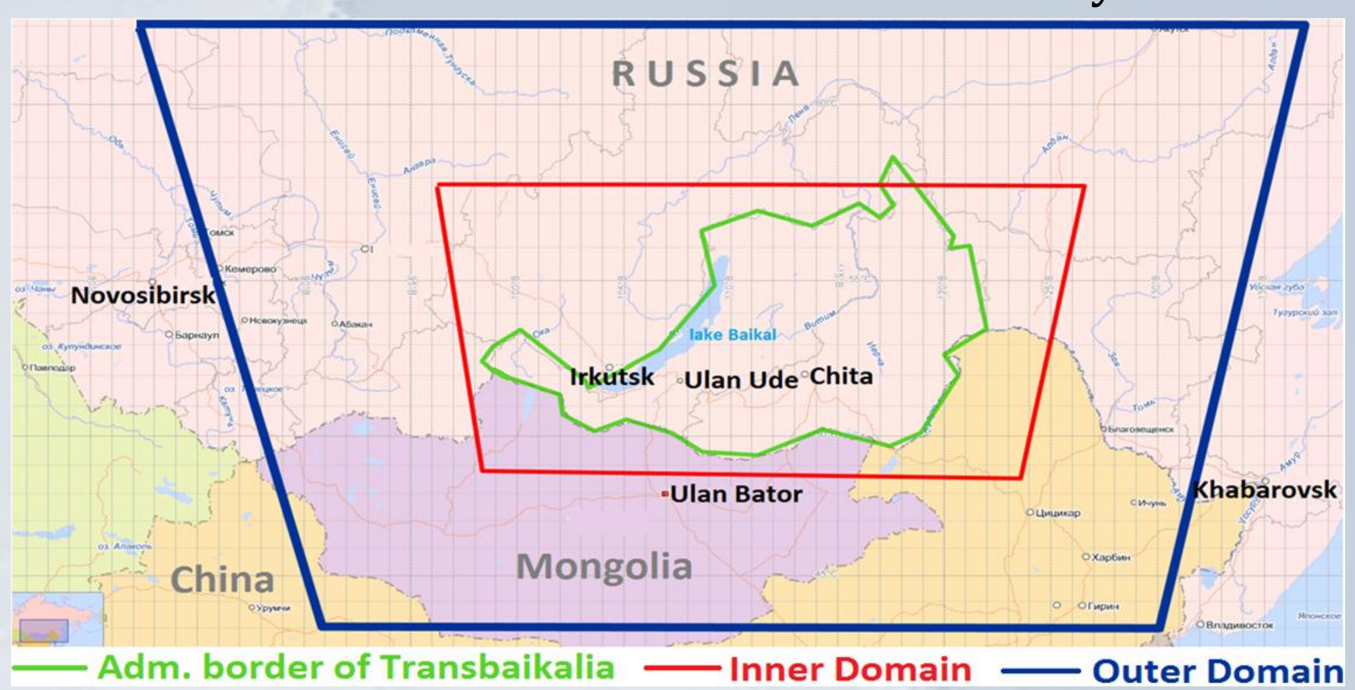

Fig. 2. **Nested domains of WRF-ARW**

2. Methodology

Model data, such as wind speed at a height of 10m ($\boldsymbol{M}_{10}$) and at the nearest to ground vertical model level ($\boldsymbol{M}_0$), vertical velocity of wind at heights up to 250 m ($\boldsymbol{W}_k$, k=1,2,3), has been analyzed every model minute within inner domain. We considered that *squall has happened* if parameter $\boldsymbol{V}_1$ (1) has reached the threshold value $\boldsymbol{V}_0$ within a circle of 30 km radius $\boldsymbol{\rho}$ centered about observing site for one minute or more.

$$V_1 = F_{V_0,\rho}\left(M_{10}, M_0, W\right). \qquad (1)$$

$\boldsymbol{W}, \boldsymbol{M}_0, \boldsymbol{M}_{10}$ is related to the nearest mesh point to weather station.

First of all, we compared results with observed data (tab. 2). We drawn hourly maps of $\boldsymbol{V}_1$ to understand how this parameter has represented a movement of squall lines.

3. Results

Table 2. **Comparison with observed squalls, V_0=21 m/s**

	YSU+no fb	YSU + fb	MYJ + no fb	MYJ + fb
Hits	7	7	7	6
Misses	14	14	14	15
False alarms	8	9	24	35

MYJ scheme has overstated wind speed if a deep convection has place that means nonexistent squalls might appear.

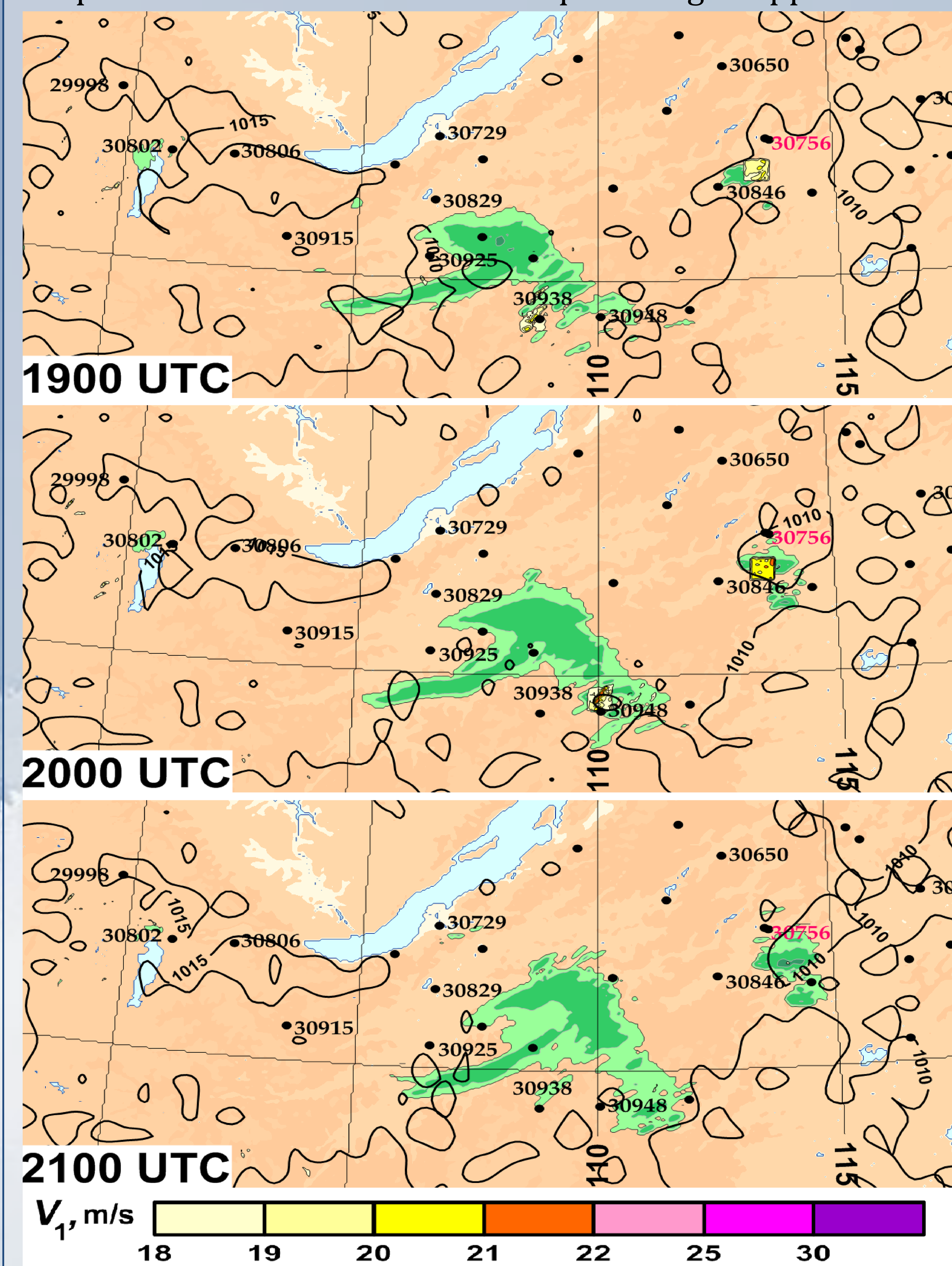

Fig. 3. **Maps of V_1 on 27.07.2010, Model conf. is MYJ+no fb**

Forecasting of squalls in mesh points

We present here only a representative sample of our forecast experiences to show a movement and accuracy of location of squall lines. Satisfactory forecast on 27.07.2010 is presented on fig. 3. Shades of green indicates zones of precipitation. Squall was marked on station 30756 (Chita) at 2057 UTC, wind speed reached a value of 24 m/s. Distance between squall line and observing site is near 50 km. Value of parameter $\boldsymbol{V}_1$ is near 21 m/s. But unmarked squall was produced near station 30938. Probably it was a "false alarm". Weather pattern was determined by a movement of occluded front.

In addition, method has to include information about gradient of surface pressure, tendency of surface potential temperature and vertical wind velocity at heights up to 1km.

4. Conclusion

- WRF-ARW had abilities to predict squalls. But the model required a special configuration. Parameterizations of surface and planetary boundary layers influenced to position and appearance time of squalls. Grid resolution of model domain had to provide a capability to generate convective outbreaks directly without using any type of convective parameterization.
- A method to define squalls in the model as a function of horizontal and vertical wind speed has been developed.
- Observed squalls were divided into 7 different classes based on analysis of weather patterns. Some cases, i. e. origin of squalls as a result of movement of arctic cold fronts, was predicted more precisely than others.
- Model squalls was compared with observation data from 2010. Current work is checking quality of the method for squalls prediction on the independence representative sample of squalls that have been marked during 2011.

References: [1] Wakimoto R. M., 1982: The life cycle of thunderstorm gust fronts as viewed with dopler radar and rawinsonde data. *Mon. Wea. Rev.*, **110**, 1060—1082. **[2]** Peskov B. E. et al., 2009: Conditions for formation and short-range forecasting of severe squalls. *Russian Meteorology and Hydrology*, **34**, 5—15. **[3]** Skamarock W. C., Klemp J. B., 2007: A time-split nonhydrostatic atmospheric model for research and NWP applications. *J. Comp. Phys.*, special issue on environmental modeling, pp. 3465—3485.