Combining precipitation fields on the basis of radar data and mesoscale model output products in nowcasting systems of Hydrometcenter of Russia

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Systems of two types for mesoscale deterministic and probabilistic nowcasting have been developed and operationally run at the Hydrometcenter of Russia over the past few years. The first type systems are built on the numerical weather prediction (NWP) output products adjusted to the latest ground observations. The second type systems are oriented on precipitation forecasting based on the DMRL-S radar data combined with the NWP output products. Description of these systems and their verification results, starting from the meteorological support of the Sochi Olympic Games in 2014, are overviewed in [Kiktev et al., 2017, Kiktev et al., 2019].

One of the well known and challenging problems for developing precipitation nowcasting systems lies in combing spatial areas pertaining to principally different sources and exhibiting diverse and hardly comparable spatiotemporal scales. In the context of the precipitation nowcasting system implemented at the Hydrometcenter of Russia this problem is aggravated by the fact that the Lagrangian extrapolation block of the "seamless" forecasting, i.e. the STEPS model [Bowler et al., 2006], starts with individual radars with a further formation of a unified field that covers the whole forecast area. It is here necessary: to take into account the circular radar surveys distribution over the forecast region, to transform those areas to quasi-rectangular fields (two dimensional arrays), to mark off or data fill the areas with missing values, keeping in mind evolutionary details over the forecast period, to recalculate intensity values in the overlapping zones, etc. The very-short-term forecasting interval (extending the two hour nowcasting period up to six hours) produces a similar problem of merging the unified radar field with the NWP output field.

Since the end of 2019 the precipitation nowcasting area with 9 DMRL-C radars covering the Central federal district (CFD), has been broadened to the European territory of Russia covered by 28 DMRL-S radars. By that time, a new STEPS version [Pulkkinen et al., 2019] had been adapted, which provided means to solve different extrapolation problems and to get around the difficulties in constructing composite fields.

In the first half of 2020 new testing of the Lagrangian block of the nowcasting system together with the calculation package for combining heterogeneous fields was initiated. Computational experiments in combining radar data with the NWP products over the CFD in 2-km resolution area have started, with precipitation estimates flowing from twelve DMRL-S, and forecast fields – from the COSMO model [Rivin et al, 2015]. The forecasts are generated at 10-min intervals as in the operational nowcasting system, and at 10-min refreshing intervals, as the radar sensing data flow in. Parallel testing of probabilistic nowcasting on the one-kilometer grid is performed.

Figure 1 demonstrates very clear differences between two combination methods: the previous scheme generates a fatal "shock" effect from radar field borders when by the 70th minute the forecast flow runs into a "void" square left by the malfunctioning Vnukovo radar, whereas no such effect is observed in the new scheme. Other differences in location and intensity are accounted for by differing optical flow forecasting variants.

Figure 2 shows synchronized precipitation intensity fields (mm/h) (a) in the unified radar observation field, (b) in the NWP forecast field, and (c) in the combined radar and NWP field at the 90 min lead-time. The merging of fields and the forecast quality may be considered quite satisfactory if the synchronized unified radar field is considered the "observational truth".

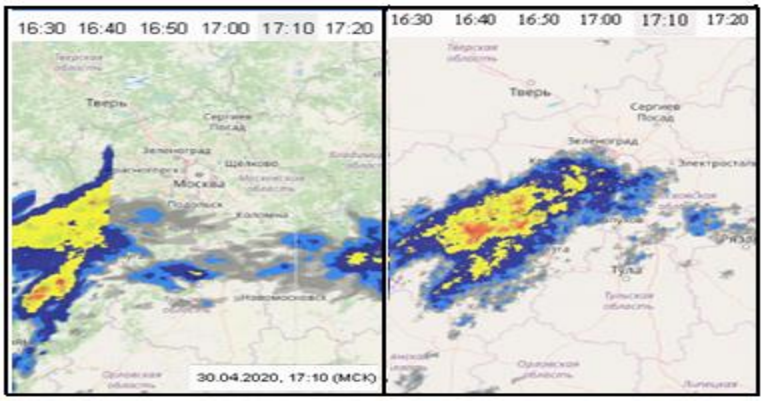

Figure 1. Forecast flow impingement against a “void” area left by the malfunctioning Vnukovo radar in the previous scheme (left), and in the new scheme (right), at 70 minutes lead-time.

a) b) c)

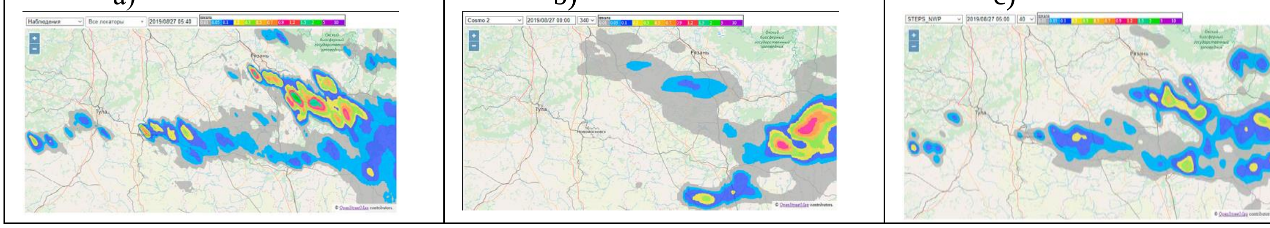

Figure 2. Examples of precipitation intensity forecast fields for synchronized time moments (panels left to right): radar observation field (a); numerical COSMO model forecast (b); blended forecast at 90 min lead-time (c).

References

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