OBJECTIVELY AND MANUALLY IDENTIFIED CHARACTERISTICS OF MID-LATITUDE STORMS: A COMPARISON FOR SIBERIAN REGION

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A comprehensive intercomparison of midlatitude storm characteristics is presented. Extratropical storm characteristics were derived from 16 reanalysis-based objective automated algorithms for cyclone identification and tracking from the IMILAST project and from the manual method based on an expert inspection of weather charts. The analysis was carried out for the Siberian region (50–80N, 60–110E) for two seasons (winter of 2007/08 and summer of 2008). Two ranking measures were used to evaluate similarity of objective algorithms with the manual method.

Large-scale atmospheric perturbations such as mid-latitude storms play an important role in the formation of weather regimes in many regions of the Earth and influence on the global climate by providing poleward energy transfer in the midlatitudes. For evaluation cyclonic activity, subjective methods based on manual expert inspections of synoptic charts were practiced for decades to evaluate cyclonic activity (e.g. (Mokhov et al., 1992)). Recently, several automated detection and tracking algorithms have been proposed to assess the variability of cyclonic activity (e.g. (Mokhov et al., 2009; Neu et al., 2013)).

Here, we present a comparative analysis of the main characteristics of extratropical cyclones from 16 objectively identified algorithms based on ERA-Interim reanalysis data and from manual inspection of synoptic charts for the Siberian region for summer and winter of 2008. The automated cyclone tracking and detection algorithms from the IMILAST database have been used in this paper with the same numbering as in Neu et al. (2013). To obtain information on cyclonic activity from surface observations, we carried out an expert evaluation of meteorological synoptic charts (following the method from (Podnebesnykh and Ippolitov, 2017)).

The comparative analysis was performed for December of 2007, January and February of 2008 (winter) and June, July, and August of 2008 (summer). In total, 514 synoptic charts were processed. We sampled ERA-Interim data to the available charts and analyze results from the same 514 fields. The analysis was restricted with the Siberian region from 60 E to 110 E and from 50 N to 80 N. The region is a good test field for the storm detection algorithms because of its various orography and the presence of the Siberian High (Chernokulsky et al., 2013).

The majority of the automated algorithms shows 1.5–3 times more cyclones and 3–5 times more tracks in the Siberian region than the manual method does (Fig.1). Most of algorithms agree
with the manual method on seasonal difference of cyclones and tracks (showing a storm number prevailing in summer compare to winter). All algorithms show about 1.5 times less the track presence time in the region (namely, storm lifetime in the limited area) compare to the manual method, but agree with the manual method on a seasonal difference showing more long-living storms in summer. A number of missing cyclones for half of algorithms do not exceed 10% of all manually detected cyclones. Nevertheless, several algorithms have missed up to 30–50% of cyclones. The algorithms rarely miss the whole tracks. We found that three topography-adjusted algorithms had missed a few summer storms developing over the elevated regions.

![Figure 1. Climatology of cyclones number for winter of 2007/08 (a, c) and summer of 2008 (b, d) for the manual method (a, b) and the objective algorithms mean (c, d) (except M06 method). Black dashed lines correspond to standard deviation between objective algorithms. The automated algorithms show a good agreement with the manual method for spatial distribution of cyclones and tracks number over the Siberian region. Spatial correlation coefficient for cyclone numbers between the objective algorithms and the manual method varies around 0.8–0.9 in summer and around 0.7–0.9 in winter for most of the algorithms (not shown). With a few exceptions, the automated algorithms demonstrate 1.5–3 higher spatial standard deviation of]
cyclones (and tracks) climatology than the manual method, which is associated with an overestimation of total cyclones (tracks) number by most of the objective algorithms. As the manual method, the automated algorithms place the main maximum to northwest and minimum to south of the region. However, the automated algorithms display the additional secondary maximum of cyclones and tracks over north-east of the Siberian region, which can be associated with an elevated orography (with the mean altitude of 500–800 m). The highest spread among the algorithms is noted over the elevated regions in the cold season.

We rank the objective cyclone identification algorithms as they relate to the manual method of identification. Two rankings were used. First ranking is based on intercomparison of objectively and manually obtained spatial patterns of cyclonic characteristics (frequency of cyclones), in particular, based on spatial correlation (r) and spatial deviation (σ) (normalized on σ of the manual method (\(\tilde{\sigma}\))). The skill score for the spatial pattern statistics (SPS) varies from zero (no agreement) to one (absolute agreement) and is written as follow:

\[
SPS = \frac{2(1+r)}{(\tilde{\sigma} + 1/\tilde{\sigma})^2}
\]

Second ranking estimates a forecast skill of automated methods. A cyclone derived by an objective algorithm is treated as a forecast, and a manually-detected cyclone is treated as an observation. The critical success index CSI (so called Gilbert Score) can be used:

\[
CSI = \frac{a}{a + b + c}
\]

where a (hits) is a count of cyclones identified both by the manual method and an objective algorithm, b (false alarms) is a count of cyclones identified only by an objective algorithm, and c (misses) is a count of cyclones identified only by the manual method. In an idealized case, forecast produce only hits. In practice, CSI varies from zero (no skillful forecast) to one (a perfect forecast).

In general, M13 and M08 algorithms can be treated as the closest ones to the manual method in both seasons for the Siberian region (Tables 1, 2).

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Table 1. The ranking of the automated algorithms based on the skill score for spatial pattern statistics of cyclone number (SPS). The rankings for the algorithms mean is shown compared with the overall ranking.
Table 2. The ranking of the automated algorithms based on the critical success index (CSI).

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References


