Evolution and tracks of tropical cyclones in 2016 in the Pacific Ocean.

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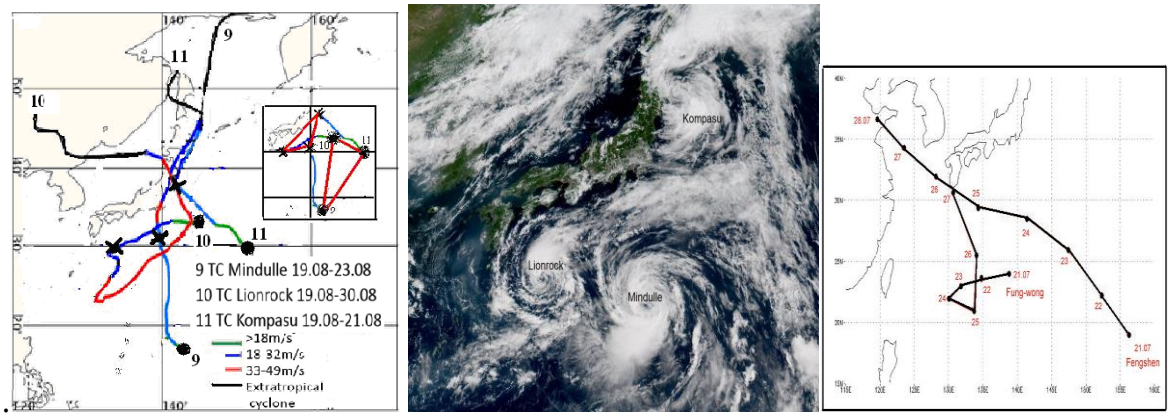
The evolution and motion of a series of tropical cyclones (TC) in 2016 in the Pacific Ocean are investigated in this work. Cases of triple interaction of TCs and the influence of a polar front (PF) on them are considered. The dynamics of groups of real tropical cyclones is compared with the behaviour of perfect cyclonic vortices in experiments with a numerical model. Variants of explanation of the origination of loops, zigzags and sharp turns in the cyclones tracks are suggested.

From August 19 a group of vortices constituted by three tropical cyclones – Tropical Storm (TS) Mindulle, TS Lionrock N10 and Tropical Depression (TD) Kompasu – moved synchronously on the Pacific Ocean north-eastern water area. The tracks of the TCs included sharp turns and loops (Fig.1a).



1a 1b 1c

Fig.1. a/ The tracks of TCs Mindulle, Lionrock, Kompasu from 19 to 30 August 2016. Black circles show the moments of the beginning of the interaction of cyclones, crosses show the moments of the end of their interaction. The inset shows some parts of the tropical cyclones during their interaction. It can be seen that the triangle between the three centers of the cyclones turned counterclockwise and is significantly smaller at the end of the cyclones interaction compared with such triangle in the beginning of their interaction. It bears evidence of strong interaction of the tropical cyclones;
1b/ satellite image of the cyclones Mindulle, Lionrock, Kompasu 2016-08-21 000Z (visible range). Cloud structures connecting the vortices are distinctly visible;
1c/ the trajectories of the TCs Fung Wong and Fengshen in July 2002.

In this area of the ocean such situations are observed rather often. One of such examples: the trajectory of the TC Fung Wong described a loop during its interaction with the TC Fengshen, which was similar to the loop of the TS Lionrock trajectory (Fig. 1c). A loop forms in the trajectory of a weak tropical cyclone under the influence of the circulation of a stronger vortex.

The interaction and rotation of the TCs under investigation in a cyclonic orbit lasts till the moment when a polar front (PF) approaches them from the north-west. Between August 20 18:00 and August 21 0 hours 2018 Kompasu settles on the PF that approached it well closely and, under its influence, sharply turns (almost a 90º turn) in the north-eastern direction (Fig. 1a). Then it merges with the PF and quickly moves in the north-eastern direction in the flow of PF.

Less than in 24 hours Mindulle also turns north-eastwards (on August 21, at 12:00) in the direction to closely approached PF, for some time it describes the trajectory of Kompasu that passed further (Fig. 1a) and, on August 22, approximately in 02:00, it also settles on the PF that approached it from the east side, and "tears up" it. Then Mindulle begins to move to the north-north-east direction at a great velocity following the steering flow, that is, the northern part of the PF.

A series of numerical experiments using a barotropic model of the atmosphere based on the "shallow water" equations was carried out. The investigation dealt with the behaviour of a group of perfect distributed vortices (in a rotating field) located in a way analogous to the location of real TCs. As a result of calculations the patterns of the evolution of the vorticity fields ($10^{-5}c^{-1}$) and the tracks of the interacting vortices were obtained (Fig. 2).

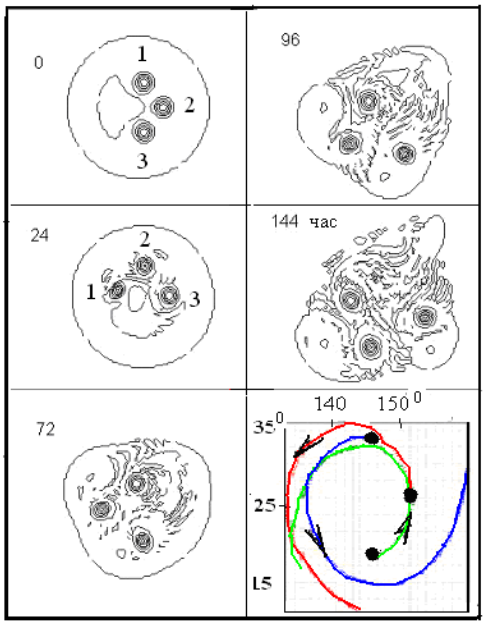


Fig. 2. Patterns of the evolution of the vorticity fields ($10^{-5}c^{-1}$) and tracks of the interacting vortices. The integration time is 144 hours.

Conclusions

1. The interaction of the vortices with one another and with other baric formations can lead to meandering and loop-like motion of these vortices.

2. Based on the experiments using a numerical model and the data from satellites the explanation of the motion of tropical cyclones under investigation is found. A numerical experiment with a group of three perfect distributed vortices substantiated the hypothesis about the cause of the loop-like motion of the TS Lionrock. The strange trajectory of Lionrock was successfully explained by its interaction with two TCs (Mindulle and Kompasu) which existed simultaneously with the first one.

3. On the basis of satellite data it was shown that the action of a polar front on the motion of the TCs Mindulle and Kompasu had interrupted the interaction between these TCs and the TS Lionrock.