Observations of a Quasi-Tropical Cyclone over the Black Sea

V. V. Efimov, S. V. Stanichnyi, M. V. Shokurov, and D. A. Yarovaya

Marine Hydrophysical Institute, National Academy of Sciences of Ukraine,
ul. Kapitanskaya 2, Sevastopol, Crimea, 99011 Ukraine

Received March 19, 2007

Abstract—A rare atmospheric phenomenon in the Black Sea region is described: a mesoscale cyclone with all main properties of tropical cyclones. The cyclone developed in the southwestern part of the sea and existed for about five days. General characteristics of the cyclone are presented along with its effect on thermodynamic structure of the sea upper layer.

INTRODUCTION

Tropical cyclones (TCs) are frequent enough in the tropical areas of the World Ocean and are often associated with catastrophic weather events. As a rule, tropical cyclones are smaller in size than midlatitude ones (about 200–300 km); strong winds (up to 100 m/s) and a cloud-free central area (an eye) are typical of them. Tropical cyclones originate and develop only over the warm sea, whose surface temperature, according to generally accepted estimates, should be not less than 27°C. Other typical features of TCs, differing from those of midlatitude cyclones with their larger scales, also exist [2–4, 11, 12].

When the satellite cloud images became available, it has been revealed that in the extratropical atmosphere, too, cyclonic eddies can arise, which can be classified as quasi-tropical for many of their features. First of all, they also exhibit axisymmetric space structure, they develop only over sea, and the main mechanism of their generation is the moist air lifting with release of large latent heat amount through condensation. The quasi-tropical cyclones of different origin arise from time to time over the Mediterranean Sea [5, 10, 14, 15, 17–20, 23–25]. In the polar areas, under conditions of cold air intrusions from the land to the sea, the polar lows develop, which also can be classified quasi-tropical [13, 21, 22].

By the end of September 2005, in the atmosphere over the southwest Black Sea, an intense mesoscale cyclone developed with all special features of a TC. The cyclone had an eye with a diameter not exceeding 300 km and exhibited almost axisymmetric structure. In the satellite images on September 25 and 26, the spiral cloud bands are clearly seen; the wind speed in the eddy area, after the QuikScat [28] satellite measurements, reached 20–25 m/s. Though this cyclone did not acquire the disastrous properties of a tropical hurricane, the hazardous weather with strong winds and surface waves caused stoppage of ships navigating to Istanbul. The cyclone was located, slightly wandering, over the southwest Black Sea since September 25 till September 29, then it moved southward and by September 30 left the Black Sea. Over land, the cyclone quickly decayed.

Consider the cyclone evolution basing on the data available. As a rule, the mesoscale atmospheric processes, and, in particular, evolution of the cyclone under study, are poorly documented with measurements. Apart from the satellite cloud images and wind measurements from QuikScat, no other high-resolution data are available. The operative NCEP/NCAR objective analysis data with 1° × 1° resolution are used as transmitted within the framework of international exchange [27]. Also, to study the structure of the cyclone in more detail, numerical experiments are carried out with the MM5 regional model; their detailed discussion has been presented in [1].

SYNOPTIC SITUATION

In Fig. 1a, the surface wind velocity and sea level pressure fields are displayed from the objective analysis data for 00:00 UTC of September 25. A high pressure area in the north, as associated with a blocking anticyclone, and a lower pressure zone over the Black Sea region can be seen. Also, despite of
rather coarse space resolution of the objective analysis, two small depressions with pressure about 1010 hPa can be noted over the Black Sea. The depression in the west part of the sea later gave rise to the quasi-tropical cyclone. The wind speed in the depression was about 10 m/s and the pressure in its center was 3 hPa lower than at its periphery. The surface wind distribution for the previous analysis time (18:00 UTC of September 24) does not show any cyclone center, and thus the structure in Fig. 1a can be considered as an initial stage of the cyclone origination over sea.

Determination of causes and of necessary and sufficient conditions for the tropical cyclone origination represents a problem which is not yet solved. It is known that only in one of ten cases tropical depressions develop to the stage of TC. For the Black Sea cyclone under study, a condition favoring its initial development is represented by a decreased atmospheric stability associated with cold air intrusion into the Black Sea region.

In Figs. 1c and 1d, the data on vertical stratification of the atmosphere at 00:00 UTC of September 25 in the western and eastern parts of the Black Sea are displayed. In fact, no radiosonde data are available; the displayed profiles are taken from the operative objective analysis. The thick dashed line shows height changes of temperature of the air parcel which is lifting from the sea surface, dry-adiabatically in the lower layer, up to the condensation level, and then moist-adiabatically. The thick solid lines show the profiles of air temperature (right) and dew point temperature (left). As it can be seen from Fig. 1c, from the 900 hPa level and almost up to the tropopause (above the 300 hPa level), the lifting parcel is warmer than the surrounding air. The atmospheric stratification is thus favorable for convection. As a measure of instability, convective available potential energy, CAPE, is used, which is represented by the area between the dashed and solid lines from the condensation level to the equilibrium level in Fig. 1c [9]. The CAPE distribution over the whole Black Sea area is presented in Fig. 1b. It can be seen that CAPE reaches high values over sea with a maximum of 1600 J/kg; in the eastern part of the sea, the CAPE values are larger than in the western one.