Hydrodynamic modeling the coastal surface currents for the water pollution problems.

Shnaydman V.A.
Department of Environmental Sciences,Rutgers University-Cook college
14 College Farm Road, New Brunswick, NJ, 08901 USA
e-mail: Volf@envsci.rutgers.edu
Tarnopolskiy A.G.
Department of Geophysical Hydrodynamics, Ecological University,
Lvovskaya 15, Odessa, Ukraine,
e-mail: geophys@ogmi.farlep.Odessa.ua

A three-dimensional, time-dependant, baroclinic model for the coupled atmospheric and coastal shelf boundary layers (thereafter ABL and SBL, correspondingly) is applied to study polluted effluents (mostly oil residues) transport (1,2). One such application stands alone for it is essentially a study of the backward chronology of a pollution event.

The coupled ABL and SBL model was used to reconstruct the current and property fields for the entire pollution episode with known external forcing factors. Since the pollutant was positively buoyant, only surface currents were of interest, although the model provided the multilayered picture.

The coupled ABL and SBL model allows implementation of a two-step procedure to obtain the surface currents. At the first step the ABL model with given pressure field is transformed to use the actual surface winds instead of the geostrophycal ones. This transformation is needed to solve the backtracking of the source on the basis of information of the actual winds. Then the ABL modeling is used to determine the turbulent flux of momentum through the water surface. At the second step the Reynolds stresses obtained were used in the SBL modeling for quantitative description of the atmospheric dynamical forcing. The atmospheric motions form the turbulent flux of momentum which goes into formation of the drift currents and the deviation of the free surface from equilibrium value due to the wind impact, breaking the surface waves. The SBL modeling takes into account the parts of the atmospheric turbulent momentum fluxes that form separately currents and wind waves, the creation of pure “wind drift” that then goes into formation of what is perceived as the geostrophycal currents, the flux of kinetic turbulent energy due to waves collapse.

The important SBL hydrodynamics mechanism is the vertical turbulent exchange which is described by the two-equation scheme (turbulent kinetic energy and dissipation rate).

The comparison with observations in the study area shows a good agreement between simulated and measured surface currents velocities.
We show an example of application the two-step procedure to backtrack the source of the oil plume which allowed the authorities to correct the wrong conclusion of the source location. The plume was detected at noon (May 9,1996) near the Odessa South Seaport. The well-defined plume moved from east to west what allowed to conclude that the plume was released by the tanker located in the eastern side of South Seaport. But the chemical test didn't confirm this conclusion. The detail analysis of the meteorological information showed that the wind directions were changed during the period between 12:00 May 8 and 12:00 May 9. This information is given in the table where Vs is the module, Ds is the direction of the wind over the land and sea properly, Vc and Dc are the module and the direction of the surface current vectors. The backward trajectory is computed on the basis of calculated currents allowing detection of the polluted plume. This trajectory is directed from west to east from 12:00 ET to 22:00 ET May 9, from east to west from 22:00 ET May 9 to 10:00 ET May 8 and then before 10:00 ET May 8 turned to east. The trajectory's behavior clearly indicated that the source is located near the point of the trajectory at 10:00 ET May 8. where the distance between the plume and the coast was the smallest. Actually the source of the oil slick turned out to be the power station located on the coastal area.

t, ET	12	15	18	21	00	03	06	09	12
				Land					
Vs, m/s	**3**	**4**	**4**	**2**	**3**	**2**	**2**	**2**	**2**
Ds, deg.	**3 45**	**3 45**	**45**	**45**	**270**	**270**	**225**	**180**	**90**
				Sea					
Vs, m/s	**5,4**	**7,2**	**7,2**	**3,6**	**5,4**	**3,6**	**3,6**	**3,6**	**3,6**
Ds, deg.	**30**	**30**	**30**	**30**	**255**	**255**	**210**	**165**	**75**
				Sea					
Vc, cm/s	**7,6**	**14,5**	**14,5**	**4,0**	**9,8**	**7,0**	**6,0**	**5,7**	**3,8**
Dc, deg.	**346**	**348**	**354**	**355**	**210**	**220**	**190**	**150**	**45**

1.Berkovich, L.V., Tarnopolskiy, A.G., Shnaydman, V.A.: 1997,'A Hydrodynamic Model of the Atmospheric and Oceanic Boundary Layers', Russian Meteorology and Hydrology 7, 22-31
2 Shnaydman, V.A., Tarnopolskiy,A.G.: 1999, "Conception of the Investigation of Anthropogenic Forcing on the Sea Environment", Dokl. NAS of Ukraine 2,204-208.