International Scientific Journal
Journal of Environmental Science
http://environment.scientific-journal.com/

Local disturbances and wind field distribution modeling in Georgia

Marika Tatishvili, Inga Samkharadze
Institute of Hydrometeorology of Georgian Technical University
Tbilisi, Georgia
marika.tatishvili@yahoo.com

Abstract— The wind is one of most important meteorological element used both in science and energetic industry. However its origin and nature isn't well understood yet. The Sun, together with the Earth's motion along its orbit, govern changes in the solar–terrestrial environment on time scales ranging from minutes to glacial cycles. The quasi-steady flow of the solar wind is also modified by coronal mass ejections (CME) and cause geomagnetic storms with subsequent impacts on Earth. The energetic particle precipitation (EPP) leads to the modification of the ionosphere and neutral atmosphere. Observations have suggested that energetic particle forcing may affect wave propagation, zonal mean temperatures, and zonal winds in the Northern Hemisphere. Wind direction and value in atmosphere surface layer is depending on local geographic conditions and thus it is manifold. The meteorological observation data, Earth Observing System Satellite data are used to conduct statistical analysis in order to identify wind parameters. For this reason wind flow mathematical model for local area also was developed.

Keywords— Local atmospheric processes, **w**ind field modeling, wind velocity repeatability

Introduction

In Georgia due to complex orographic conditions and influence of the black Sea there exist most of Earths climatic types, from marine wet subtropical climate in west Georgia and steppe continental climate in east Georgia up to eternal snow and glaciers in high mountain zone of Great Caucasus, and also approximately 40% of observed landscapes. The Georgian relief may be characterized by three sharply expressed orographic elements: Caucasus- in north, in south – Georgian south upland and lowland or intermountain depression located between those two risings. This one begins from The Black Sea shore namely Kolkheti Lowland triangle and spreads up to eastern Georgia like **a** narrow strip. Between those two uplands small scaled orographic elements can be allocated. Such complicated relief has definite influence on air masses motion in atmosphere lower layers. Mainly west and eastern atmospheric processes prevailed over Georgian territory. Current geodynamics and orographic properties of Georgia play an important role in formation of weather various patterns. Such complex relief conditions the formation and evolution of various scaled circulation systems and heterogeneous spatial distribution of meteorological elements. This is verified by the fact, that such important parameter as wind annual distribution has diverse type, with sharply expressed spatial inhomogeneities.

The weather and climate driven factor is solar irradiance. The variations in the Sun's magnetic flux control the amount of cosmic rays impinging on the atmosphere. Cosmic rays produce ionizations and the ions form nuclei for cloud formation. Cloud cover has a great effect on global temperature, but this area is still poorly understood and not addressed in climate models. Meteorological effects resulting from fluctuations in the solar wind are presently poorly represented in weather and climate models. Geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth. These storms result from variations in the solar wind that produces major changes in the currents, plasmas, and fields in Earth's magnetosphere[1]. The largest storms that result from these conditions are associated with solar coronal mass ejections (CME) where a billion tons or so of plasma from the sun, with its embedded magnetic field, arrives at Earth. CMEs typically take several days to arrive at Earth. The correlation between geomagnetic storms and meteorological elements (temperature, precipitation, wind) have been determined for Georgian region using meteorological observation and NASA's Solar Dynamics Observatory and NOAA Space Weather Prediction Center data. It is obvious that weather pattern formation is greatly depended on eruptions and Earth magnetic field variations [2]. The conducted analysis has shown that wind reach extreme values during geomagnetic disturbances.

Study area and methods

Wind velocity repeatability is presented on map 1 [3]. As it is evident from the map there exist some local areas with strong winds.

One of such area is near Gori and this location has been chosen for construction first wind power plant

The station works smoothly and its efficiency is 54%, which is a high rate for such a station. Since the Kartli wind power station has been moving from the test drive to electricity generation regime, it has never stopped functioning, the energy generated by the power plant has been fully delivered to Georgia's electricity system (5.5 million kW) since December 1, and it provided 10 572 kilowatt hours energy. The wind power is the essential and most important precondition for producing electricity.

The power plant requires a wind speed of at least 3 m / sec to start generating energy, and its further development is directly proportionate to the wind speed. According to the current year

December data, the efficiency of Kartli wind power generation is 54%, which is one of the best indicators in the world

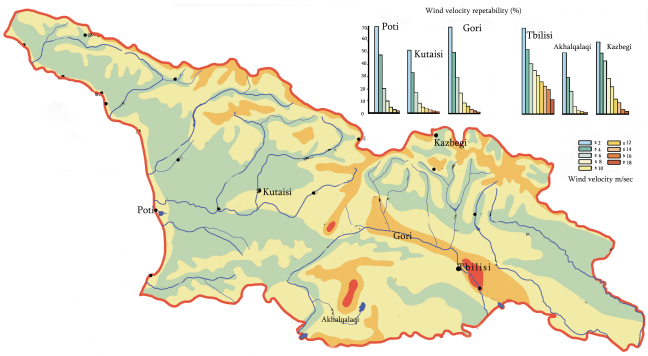


Fig.1. Wind field distribution in Georgia

. The total power of Kartli power plant is 20.7 megawatt, it consists of 6 units with a 3.45-megawatt turbine (turbine model: V117-91.5HH).

Fig.2. Wind power plant Kartli

Wind is particularly air masses horizontal and vertical motion caused by temperature and pressure gradient. Due to Earth motion wind is enforced by Coriolis force. In middle latitudes dominate motion caused by pressure gradient, parallel to isobars. The influence of friction and orography on air masses motion is important, as they resist motion and force it to replace toward low pressure area. Wind direction and velocity at atmosphere surface layer depends on local geographical conditions.

The equation for air mass horizontal motion may be written as following:

$$\frac{du}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + lv + \frac{\partial}{\partial z}(k\frac{\partial u}{\partial z}); \frac{dv}{dt} = -\frac{1}{\rho}\frac{\partial p}{\partial y} - lu + \frac{\partial}{\partial z}(k\frac{\partial v}{\partial z}) \quad (1)$$

Results

Except Gori there are a lot of windy regions in Georgia such as: Kutaisi, Tbilisi and Telavi, the notable is that those regions have different thermal and dynamical conditions. Wind observation 50 year period (1960-2014) data for Kutaisi have been processed and divided by 5m/sec interval gradation beyond 15m/sec. It may be concluded that 1 gradation wind occurs mainly in February-March and second gradation occurs mainly in January-March.

Wind maximal velocity variability by month has sinusoidal character; wind maximal values were detected in February-March and minimal in July (Fig.3, 4)

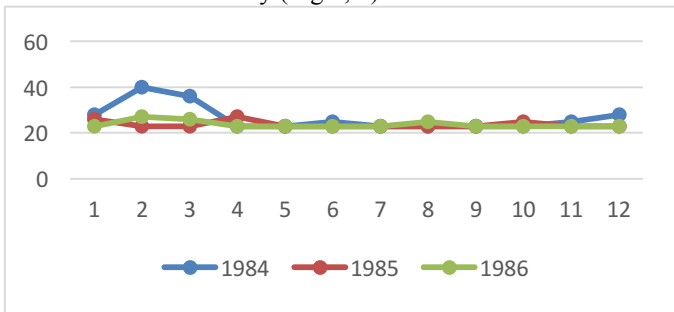


Fig.3. Wind maximal velocity distribution by years (1984-86)

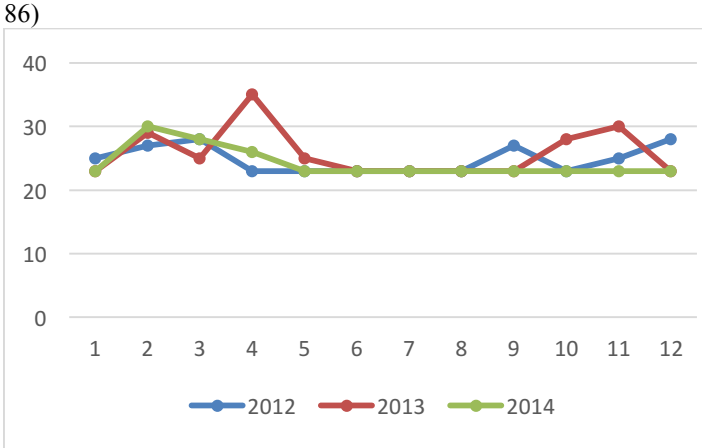


Fig.4. Wind maximal velocity distribution by years (2012-2014)

To understand wind extreme velocity character 1984-2014 year data had been treated and results are presented on fig.5. It has sinusoidal character and its maximal value reaches 40m/sec. It is remarkable that wind extremes lower threshold for last years has been increased.

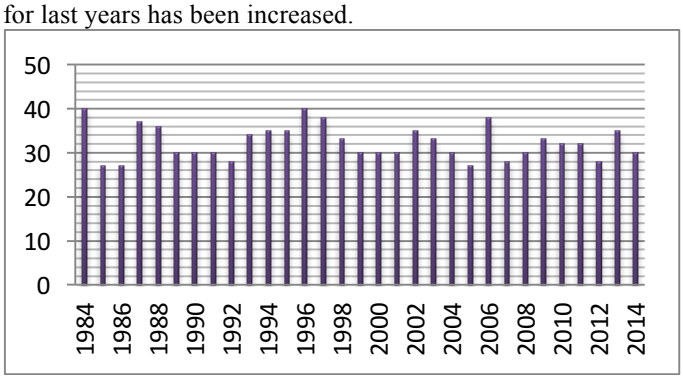
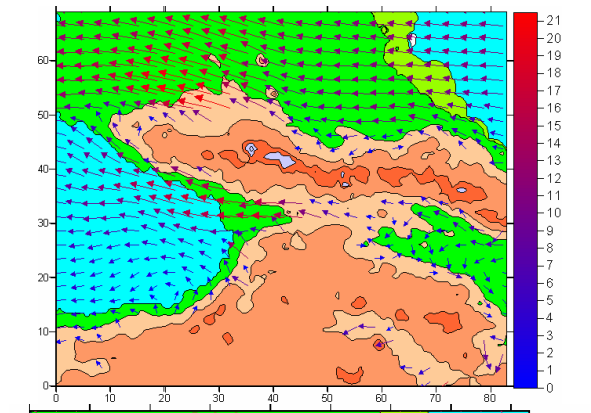
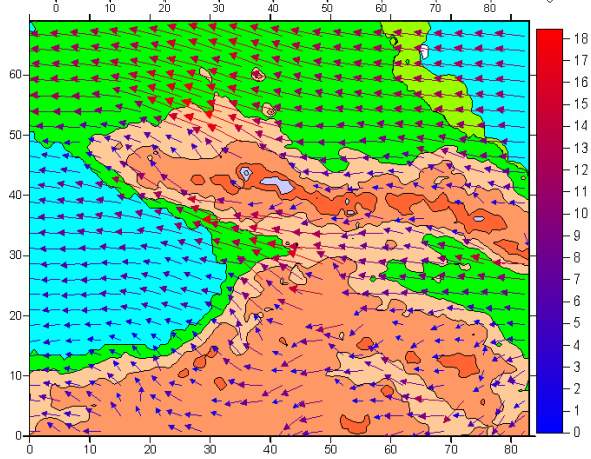


Fig.5. Wind maximal velocity (>25m/sec) distribution for Kutaisi region (1984-2014)

Three dimensional non-stationary local atmospheric process hydrodynamical model has been created for temperature, precipitation and wind field distribution [4]. Below is presented wind flow evolution for various elevations (100,200m).

WIND FLOW, Z = 1000M





WIND FLOW, Z = 2000 M

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