Dynamics of Atmosphere and Wind Energy During Dust Storms

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The contemporary wind erosion of the agricultural lands manifests in different forms: dust storms, dust squalls, blowing of soil with snow in winter. Dust storms are the most active factor of the contemporary formation of relief in the steppe zone. That's why we can consider the intensity of the process according to their geographical spreading and repetition.

The probability of the beginning of dust storms in the steppe districts of the Northern Caucasus and the Nizhneye Povolzhye, Western Kazachstan is approximately the same. According to the data (available) we notice annually from 2 to 26 days with dusts storm in the steppe of the Eastern - European plain.

The beginning of dust storms is often found in Salsk steppes, on the Black Lands of Kalmikiya, in Zavolzhiye, on the plains of the Don River, and on the Eastern mountainside of Stavropol Hills (10-15 days). The annual recurrance of dust storms in Western Siberia and Northern Kazachstan is approximately the same as in the European steppes (1-34 days). The recurrance of dust storms begins on light chestnut soils (according to its mechanical soil composition) of the Kulundinsk steppe, on the Southern chernozem plains of the Priirtish and Kokchetav Hills, and on usual chernozem soils of the Aleiskaya steppe. We notice 15-20 days with dust storms here annually. But there are essential regional peculiarities in the character of the manifestation of dust storms. It is conditioned by natural and climatic differences and antropogenic structure of this process. Wind speed and duration of influence on the extensive surface are the main climatic conditions of intensity of the wind erosion process.

The beginning of strong dust storms with considerable territorial spreading in the steppes of the Eastern-European plains is connected with the steady processes of the blockade (disturbance Western air mass movement). The great anticyclone starts to develop over the Middle Povolzhye, the South of the Urals and the Western Kazachstan. This anticyclone remains in place for a long period (in some years to 1-1.5 months). The speed of the wind achieves the power of a storm and hurricane, 18-23, 29-34 m/s and more during such processes.

The strengthening of wind and beginning of strong dust storms in the Western Siberia and the Northern Caucasus are conditioned by the frontal processes in the system of cyclones. These processes are more dynamic in time. That is why the strengthening of wind is short and the drifting of soil is not as important as in the Northern Caucasus.

Weather processes with opposite signs are caused not only by different directions of the wind during dust storms (in the steppes of the Nizhneye Povolzhye and the Northern Caucasus - eastern and south-eastern, in the steppes of the Western Siberia and the Northern Caucasus - Western and South-western), but they are essentially different from the speed regime of wind in the time of dust storms. In the Nizhneye Povolzheye and Northern Caucasus, the speed of wind during dust storms in general is higner than in Western Siberia and dust storms are a longer meteorogical phenomena. The most probable speed is 14-16 m/s in the European region, and in the steppes of Siberia and Kazachstan, the dust storm winds have speeds of 7-12 m/s.

The very important index of wind regime during dust storms is the speed of the wind of different probabilities. So we have a question: What speed do we plan for? When we choose, for

example, the sizes of interrow distances during creation the system of defensive forest lines. Evidently, for this purpose we have to accept the speed of wind of 20% probability during dust storms. Since strong dust storms take place approximately once every 5 years. In the districts of the Northern Caucasus and the Nizhneye Povolzhye the speed during wind erosion is 13-32 m/s, in the Western Siberia and in the Northern Kazachstan – only 12-22 m/s.

So the main difference in climatic dependence of wind erosion is in reference to the probability of the beginning of long periods with strong wind and magnificent dynamic loading on the extensive surface. We can show a calculation of the energy of the air current which influences the surface of soil during the wind erosion period (April, May, June) as a kinetic energy of moving body. We have to take into consideration two conditions:

1) The speed of wind from critical for zonal soil to maximum possible (speed);

2) The duration of wind in every gradation of speed.

The destructive energy of current **E** will correspond to the difference of energies with a given speed $\mathbf{V}_i$; in the definite diapason and the critical speed $\mathbf{V}_{cr}$. The mathematical dependence for the calculation of the energy current which is the cause of wind erosion after appropriate carrying, will be as follows:

$$E = r\frac{St}{2}(V_i^3 - V_{cr}^3) = 0.625(V_i^3 - V_{cr}^3)t \cdot S$$

V – Wind speed

V_i – Wind speed in diapason from critical for zonal types of soil to maximum possible

V_{cr} – Critical Wind speed

where ρ air density (1.25 kg/m^3)

S – diametrical sector (m^2) through which the air transfers for the time t(s).

The energy of wind reaches the largest limit on the open plains of the Western Pricaspian and Yergeninsk Hills in the zone of joining air currents (179* 10^6- 640*10^6 j/m^2 * month). The most powerful dynamic influence takes place in the regions. There regions are considered to be the centers of beginning of dust storms and are characterized by the highest recurrance of storms during the year (Table 1).

Table 1. Energy of air current (j/m^2*mon.) in the period of dust storms

n/n	Meteorological station	Average energy			During strong dust storms
		April	May	June	
	Northern Caucasus and Nizhneye Povolzhye				February 1969
1	Elton	179*10^6	169*10^6	99*10^6	596*10^6
2	Kotelnikovo	76	57	16	360
3	Zavetnoye	338	304	112	1933
4	Gigant	122	58	11	1379
5	Utta	230	231	89	623
6	Elista	640	515	259	1406
7	Tichoretsk	109	68	19	2957
8	Armawir	98	35	22	3293
9	Arsgir	93	108	10	1436
10	Alexandrovskoye	57	34	24	119
	Average in the region	180*10^6	149*10^6	62*10^6	1348*10^6
	Western Siberia and Northern Caucasus				May 1974
1	Cherlak	51*10^6	49*10^6	39*10^6	39*10^6
2	Kupino	217	240	91	669
3	Aleiskaya	154	103	51	179
4	Kulunda	293	265	150	166
5	Petropavlovsk	213	207	104	151
6	Kustanai	138	90	72	237
7	Kziltu	464	355	250	314
8	Yesil	211	150	183	146
9	Celinograd	78	81	46	50
10	Pavlodar	154*10^6	157*10^6	58*10^6	753*10^6
	Average in the region	199*10^6	173*10^6	105*10^6	270*10^6

In the Asian regions of dust storms, the energy of wind as a climatic condition of beginning of wind erosion has approximately the same level as in the European regions. The largest limit is 150-464*10^6 j/m^2 and it is the characteristic feature for the plains which are situated near the Kokchefav Hills and the Northern-Eastern regions of Kazachstan Little Hills (the steppes of Priirtishya, Kulundinskaya plain, Barabinskaya lowland).

The given facts show that the climatic index of the energy of wind is practically the same in this and the region of wind erosion. The main difference is that during the processes of blockade in the European steppes, the dynamic loading on the extensive surface grows from 20-100 times, to 1500-3000*10^6 j/m^2 month.

For example, during the strong dust storms in the Northern Caucasus in February 1969, the destruction of soil took the character of catastrophe.

In the Asian region, the weather conditions of such energetic potential take place only on a few days and nights. The cyclones are displaced quickly in space, and the energy of air current disperses and exceeds the climatic index by 2-3 times, but it is not enough for strong destruction of soil on most of the land.

When we regard the contemporary aeolian formation of relief in the steppe zone, such topics as the spatial migration of materials, the direction moving of particles from mountain soil during strong dust storms and deposition from 2 phase current[1], and accumulation on the extensive surface are very important. In conformity with spatial arrangement of pressure formations which determine conditions of beginning of strong winds one can make up wind erosion zones of the modern relief in the steppe zone:

1) zone of predominant blowing (zone of wind erosion);
2) zone of carrying over the aeolian material;
3) zone of accumulation of particles of mountain soil during weakness of air current.

Blowing of soil takes place in the zone of joining currents with sharp increase of speed and turbulence. This zone is situated in the South of the East-European plain (the Western Pricaspii, the Nizhneye Povolzhye, plains of the Eastern Precaucasus (Drawing 1). The transformation of soil together with raising it from extensive surface and accumulation of the greatest fraction occur in the limits of storm zone (500 – 700 km wide). It extends to 1.5 – 2 thousand km from the Pricaspii through the plains of the Central and Western Precaucasus and the Salsk steppes, the plains of the Nizhnii Don and the Eastern Ukraine.

Reduction of wind speed and the power of air current and deposition of small particles on the extensive surface take place in the zone of carrying over where the processes of accumulation of aeolian material are predominant. In space this zone corresponds to the Southern and Western regions of Ukraine, Zakarpatiye, Baltic countries, Nechernozemiye. For example during the winter dust storms (1969) the deposition of dust was observed in the South of Ukraine, Moldowa, Netherlands, Sweden.

If we refer to palaeogeographical conditions of formation of mountain rocks in the South of the Russian plain (according to aeolian hypothesis) during the Ice age, we can consider that at present the opposite process aeolian of migration of substance takes place - from the zone of formation of rock substance to the sand plains and centers of ice fields.

In the Asian region, the manifestation of aeolian formation of relief in the active zone of blowing is more dynamic and more extensive in space. The blowing and transformation of dust takes place mainly from the extensive surface of dry steppes of the Ishim-Irtish and the Ob-Irtish interrivers. The dust falls out in the forest regions of the South - Eastern part of the West Siberia.

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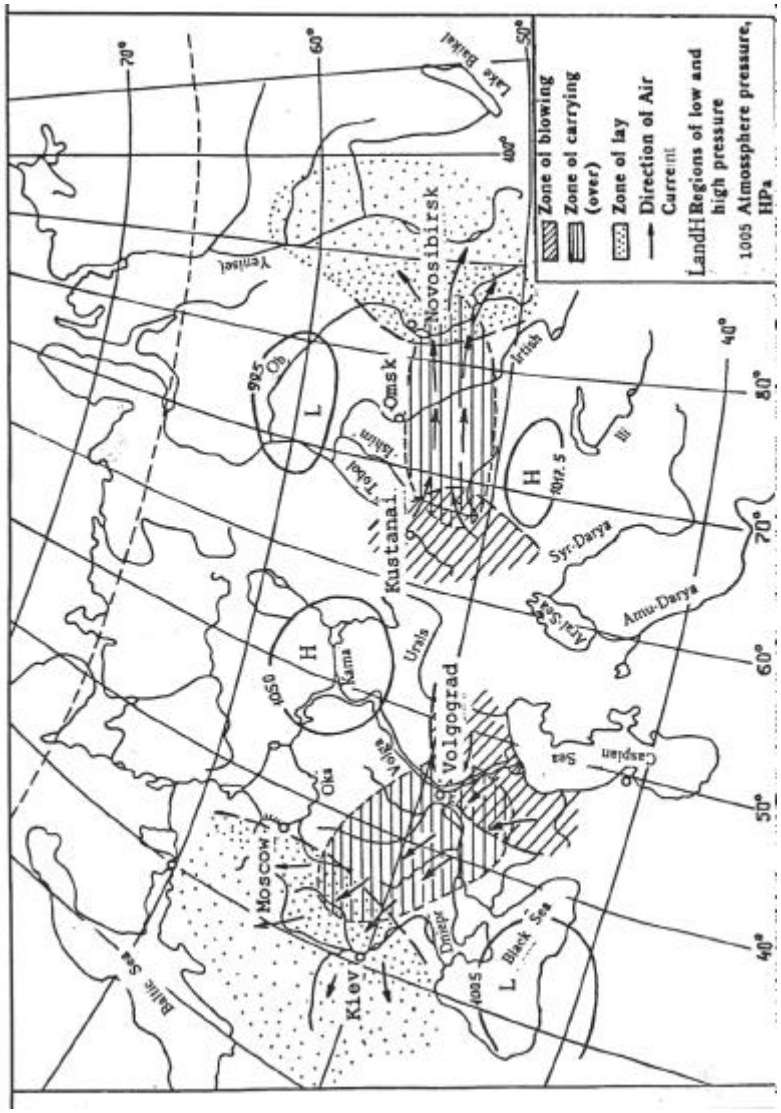
[1] Air current with soil particles

Different speeds of wind and duration of its influence on the extensive surface and unequal erodibility of surface and the destructive power of air current determine different speeds of removal of aeolian material from the field of active soil erosion. Small parts of soils (from 2-3 to 20-22 t) from 1 hectare are carried out of the steppe provinces of the Nizhneye Povolzhye and the soil of the Northern Caucasus lose from 3-5 to 25-38 t, and the soils of the Western Siberia - from 7-10 to 40-60 t and more. These facts testify that the contemporary exodynamic processes on the steppe soil are very active and the reduction of the natural fertility results in general degradation of natural anthropogenic landscapes of steppe ecosystems.



Drawing 1. Exodynamic Zones of Modern Wind erosion of the Eastern-European and the Western -Siberian Plains.

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