Conference paper

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Climatology of transport and deposition of atmospheric substances of different intensity on the southern Primorye territory by using the meteorological reanalysis data and observations at EANET monitoring station

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Abstract: The article presents an analysis of air masses and precipitation transport to the area of EANET monitoring station in Russian Primorsky Krai (Primorskaya) during the warm seasons (June–October) for the period 2013–2018. The relative contributions of chemical compounds transfer from marine or continental regions were defined. The probability of sulfate and nitrate concentration values in precipitation was calculated separately in line with backward trajectory sectors. Obtained information is used for estimating contributions of marine and continental sources into wet deposition fluxes onto the Russian Far East areas.

Keywords: Aerosols; atmospheric deposition; atmospheric precipitation; chemistry and climate; nitrogen oxides; precipitation pollution; Russian Far East; snow cover; sulfate; trajectories.

Introduction

The territories of the coastal regions in the temperate latitudes of East Asia are under the influence of atmospheric transfers of air masses, which are formed over surfaces fundamentally different in properties: sea (oceanic), providing slightly different moisture content throughout the year, the same composition of salts dissolved in rainwater; and continental (of vast inland areas with a variety of conditions: from forest landscapes to dry regions of deserts and mountain plateaus, as well as extending transitional zones of coastal plains and rainforests), with significant differentiation of moisture content, air temperature and levels of the main chemical mixture compounds in atmospheric precipitation. This also occurs in characteristics of the aerosols, which are being monitored in the areas remote from anthropogenic sources and far from urbanized areas. Atmospheric aerosols in sea air masses,

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formed as a result of drying spray, parts of sea foam, evaporation of wind-blown droplets, contain mainly sodium chloride with presence of sulfates, potassium and magnesium cations, as well as organic substances [1]. Calcium and ammonium salts prevail in aerosols and sediments of continental origin, however they contain sulfate- and nitrate-anions, and also carbonates (bicarbonates), chlorides as well as some organic compounds formed in forest ecosystems [2, 3]. Assessment of the contributions to the total amount of deposition of chemicals in coastal areas arrived from fundamentally different source areas is not only one of the interesting scientific problems of monitoring environmental pollution [4], but it will also make possible to evaluate indirectly the role of atmospheric transport from the sea surfaces in the formation of the biological component of aerosols, in particular, the remains of the life of marine plants, mushrooms, as well as the spread of spores and other reproductive biomaterial.

Research objectives

The aim of the research is to analyze the ratio of the pathways of precipitation to the observation area and the contributions of these directions (from the sea and from the continent) to the frequency and average concentration of sulfur and nitrogen compounds in precipitation and wet deposition onto the underlying surface, using measurement data at the EANET Primorskaya station [5]. In order to further use the obtained information for the study and assessment of mass analysis of biological material of marine and continental origin, the period was limited to warm season months, when the presence of bioaerosols (including those in the precipitation composition) is the most possible (from June to October for the south of Primorsky Krai).

During the study we solved the following tasks: (1) re-analyzing the arrival path of each precipitation case using the backward trajectory of air mass movement; (2) grouping of these trajectories by directional sectors (for calculating the contributions of transport of marine or continental nature); (3) using the data of daily measurements of the chemical composition of precipitation (CCP) at the station, calculating the frequency of the concentration values of sulfates and nitrates for each of the directions (sectors) in the warm season (June–October) for the period 2013–2018.

Methods and materials

The Lagrangian hybrid model HYSPLIT of the Air Resources Laboratory NOAA, USA, was applied to calculate the atmospheric transport path as a trajectory of air volume floating, taking into account the vertical movements [6]. Whole HYSPLIT model is not only an interactive program for calculating trajectories using a databank of re-analysis of wind fields and other meteorological elements for the Northern Hemisphere, but also a software tool for modeling the transport and dispersion of pollutants in the atmosphere, their chemical transformation and deposition. For many years HYSPLIT continues to be one of the most widely used long range atmospheric transport and dispersion models in atmospheric physics and environmental studies [7].

Calculations of backward 3-day long trajectories were done for each day of warm seasons in all years of 2013–2018 for the point of monitoring area – EANET Primorskaya station (43.62° N and 132.23° E), not far from the town of Ussuriisk, Primorsky Krai [8]. The grouping of trajectories was carried out into 4 sectors of prevailing directions: marine – mainly from the east, southeast and south, originated from water area of the of the Pacific Ocean basin and its seas; and of 3 types of continental ones – from the southwest along the coastal zone with capturing areas of the Korean Peninsula, another – the wide range of western pathways from regions of China, and the last is from the northwest and north passed regions of Russia.

The data on precipitation chemical composition of daily samples at the EANET station were used to evaluate the frequency characteristics of concentration values of different intervals for sulfates and nitrates in precipitation that came from the sectors of grouped transport directions.

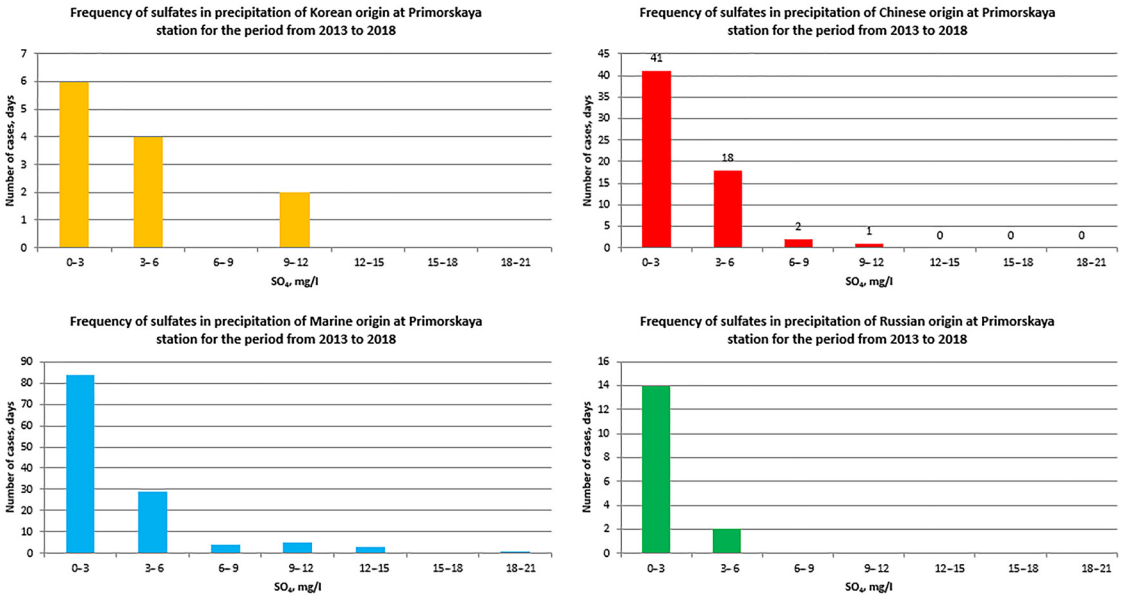

Fig. 1: Frequency distribution of sulfate level concentrations in precipitation for the sectors of trajectories at Primorskaya station from June to October in 2013–2018.

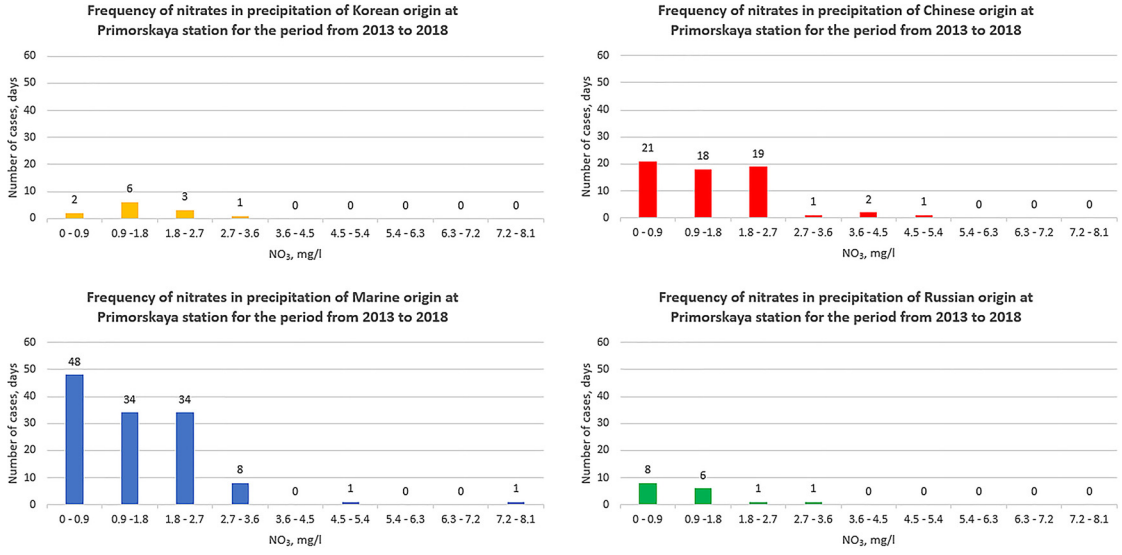

Fig. 2: Frequency distribution of nitrate level concentrations in precipitation for the sectors of trajectories at Primorskaya station from June to October in 2013–2018.

Results

In general, the trajectories of marine origin in warm seasons are 38–48 % for EANET Primorskaya station, however, taking into account that there were no precipitation for 60–62 % of days the share of marine transport for the days with precipitation increases to 45–65 % varying year to year. Among the continental directions, especially for days with precipitation, the number of transfers from the regions of China prevails – up to 23–39 %.

Analysis of the distribution of CCP value intervals showed that sulfate concentrations of less than 3 mg/L are the most frequent for the rains of marine origin, and they cover together with the interval up to 6 mg/L more

than 90 % of cases (Fig. 1). The same is typical for the continental transfers from China and Russia, but the contribution of intervals of more than 3 mg/L was higher.

For nitrate concentrations, a significantly prevail interval was not disclosed in rainwater either of marine origin, or continental ones: values less than 3 mg/L (more than 90 % of cases) are almost evenly distributed within this interval, leaving only a small number of higher concentrations not higher than 5 mg/L (Fig. 2).

The obtained characteristics of the concentration level repeatability by sectors of air mass transfer were used for detailed calculations of oxidized sulfur and nitrogen fluxes with precipitation onto surface. The estimates demonstrated that despite the transport of air with precipitation of marine origin predominates their relative contribution to the wet atmospheric deposition sum is not the major one. This allows us to conclude that the share of organic substances of marine origin will not also be decisive for coastal areas, but this outcome requires verification by experimental observations.

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Measurement data of EANET are provided by the Network Center for EANET (EANET Data on the Acid Deposition in the East Asian Region), https://monitoring.eanet.asia/document/public/index (Accessed: 01.12. 2019).

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