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Dust concentration in San Jorge Gulf and adjacent shelf (Patagonia, Argentina)

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Abstract

Patagonia is the major source of aeolian dust into the southern part of the Atlantic Ocean and Argentinean shelf. However, to the best of our knowledge there are no direct measurements in these regions. The objective of this study is to analyze, for the first time, the spatial distribution of dust concentration in San Jorge Gulf and adjacent shelf (43ºS-48ºS). Dust concentration was measured on 74 stations on an oceanographic survey conducted on board of the R/V Puerto Deseado between October 28th and November 8th of 2017. Measurements were conducted with a particle counter (PCE-PCO 1) and the concentration of particles in the air (particles per liter: p/l) was evaluated in six classes of particle sizes: 0.3 µm, 0.5 µm, 1.0 µm, 2.5 µm, 5.0 µm and 10 µm. Additionally, data of relative humidity and air temperature were obtained. Particle concentrations varied inversely to particles sizes: the highest concentration was observed for smaller particles and the lowest concentration was observed for higher particles (mean concentration for 0.3 υm: 18500 p/l; 0.5 µm: 7030 p/l; 1.0 µm: 1750 p/l; 2.5 µm: 390 p/l; 5.0 µm: 80 p/l; 10 µm: 44 p/l). The highest concentration of particles was measured between 46ºS and 48ºS, while the lowest concentration was measured between 43ºS and 45ºS.

Keywords: Mineral aerosol, Particle matter, San Jorge Gulf

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1. Introduction

Aeolian processes (erosion, transport, and deposition of sediments by wind) are the main cause of dust emissions in arid and semiarid regions. Dust affects almost all aspects of the biosphere playing an important role in the lithosphere-atmosphere-ocean system (Ravi et al., 2011). The most studied effects of dust are focused on regional and global climate, biogeochemical cycles and human health as well [e.g., Goudie & Middleton, 2006; Field et al., 2010]. Dust particles can influence climate by modifying the radiative balance of the Earth due to the absorption or dispersion of solar radiation (Kaufman et al., 2002). Also, dust particles modify physical properties of clouds causing a decrease in the precipitation regime due to the increase of condensation nuclei (Kaufman et al., 2002). Additionally, dust have direct influence on biogeochemical cycles of aquatic environments either by increasing the primary productivity through the input of nutrients (Lam & Bishop, 2008; Johnson et al., 2010) or by decreasing it through the input of deleterious material to some organisms (Balseiro et al., 2014).

Arid regions of North Africa and the Arabian Peninsula (dust belt) are well known to be dominant sources of dust worldwide (Washington et al., 2003; Mahowald et al., 2005). On the contrary, dust sources in the Southern Hemisphere are considerably less active than those in the Northern Hemisphere, and the most active regions are located in Argentina, southern Africa and Australia (Maher et al., 2010). In Argentina, the most active region is Patagonia. This region is characterized by a huge glacial outwash plain with fluvioglacial channels with low vegetation coverage, ranging between 60% and 10% (Bertiller & Bisigato, 1998). The climate of this region is semiarid, with a precipitation regime below 300 mm-y and relative humidity below 20% and is influenced by strong westerly winds throughout the year (Satyamurty et al., 1998; Remedio, 2013). Such conditions, make Patagonia one of the terrain-types acting as a major source of windblown mineral aerosols towards the Atlantic Ocean (Pye, 1989a). Even, dust particles are transported long distances influencing at least 420.000 Km^2 of the South Atlantic Ocean (SAO) reaching, probably, the Antarctic Peninsula (Gaiero, 2007; McConnell et al., 2007; Crespi-Abril et al., 2016). Patagonian emissions are the product of the activity of thousands of small enclosed basins each one acting as a particular source of dust with its own particular dynamics (Maher et al. 2010). These characteristics of Patagonia lead to a high variability in the patterns of dust emissions (Crespi-Abril et al., 2018). Dust flux from Patagonia towards SAO, fluctuates between 0.2 and 7 $g*m^{-2}*month^{-1}$, depending on the location and season (Gaiero et al., 2003; Gaiero, 2007). It is worth to mention that all estimations reported in the region are based on measurements over the continental ground, which may lead to an overestimation due to processes of local particles resuspension and deposition. In this context, the objective of this study is to analyze the spatial distribution of dust concentration over the San Jorge Gulf and adjacent shelf (43ºS-48ºS).

2. Materials and methods

The studied area is located between 43ºS and 48ºS over the Argentine Shelf (Figure 1). This area was surveyed on board of the R/V ARA Puerto Deseado. A total of 74 stations were sampled between October 28 and November 8 of 2017. Particle concentration was estimated at six different sizes (0.3 μm, 0.5 μm, 1.0 μm, 2.5 μm, 5.0 μm and 10 μm) using a particle counter PCE-PCO 1. At each station, three measurements of particle concentrations were performed. Mean particle concentration was expressed as number of particles per liter of air (p/l). Complementary data of wind intensity, relative humidity and air temperature were recorded at each station. To analyze the spatial distribution, data was interpolated with kriging algorithm using of QGIS software. Additionally, a correlation analysis was conducted among the concentrations of dust particles of different sizes.

3. Results and discussion

Dust is a combination of particles of different sizes that have been suspended from the topsoil by wind. Although the proportion of each size class in one dust event depends mainly on the emitting source, there is a relation among the relative concentration of each class (Pye, 1989b). In the present study, a strong positive correlation between different size classes was observed (Table 1). Particle concentrations varied inversely to particles sizes: the highest concentration was observed for smaller particles and the lowest concentration was observed for higher particles (Table 2). In this sense, smaller particles have longer period of residence in the atmosphere and are transported longer distances from the continent (Maher et al., 2010). Dust mobilization is a highly complex process that depends mostly on atmospheric conditions and this leads to a high spatial and temporal variability of dust concentration. In the present study, the meteorological conditions (wind intensity, relative humidity, and air temperature) presented small variability during the studied period (Table 2).

Regarding the spatial distribution, the different size classes presented a similar pattern among stations (Fig. 2). The highest concentration of particles was measured in the southern part of San Jorge Gulf between 46ºS and 48ºS. On the other, the lowest concentration was measured in the northern part between 43ºS and 45ºS and in the central part of San Jorge Gulf between 45º39'S and 46º12'S (Fig. 2). However, this pattern may change depending on environmental conditions such as wind intensity and soil moisture that affect dust emissions dynamics of the sources. Several sources, such as Colhue Huapi and Deseado River basins, that emit dust into the gulf were detected based on remote sensing observations (Crespi-Abril et al., 2016), but their emissions are variable.

4. Concluding remarks

These are the first measures of dust concentration conducted over sea surface on the San Jorge Gulf and adjacent shelf, and to the best of our knowledge this is the first time these measurements are conducted in the Argentinean continental shelf. The spatial distribution was very heterogeneous suggesting a heterogeneous deposition rate over the sea surface.

The data presented in this study can be used to calibrate aerosol concentrations estimated by remote sensing algorithms, and certainly is a starting point to be used as background for future studies.

5. Tables

Table 1. Pearson's correlation index between different the concentration of dust particles at each size class (μm)

	0.3	0.5	1	2.5	5	10
PM0.3	1	0.87	0.91	0.96	0.93	0.87
PM0.5		1	0.98	0.80	0.80	0.59
PM1.0			1	0.88	0.88	0.7
PM2.5				1	0.98	0.94
PM5.0					1	0.94
PM10						1

Table 2. Particle matter concentration expressed in number of particles per liter o fair (p/l) at different sizes (0.3,μm, 0.5μm, 1.0μm, 2.5μm, 5.0μm and 10μm), and meteorological parameters recorded during the sampling period

Measurement	Mean	Standard Deviation
0.3 (p/l)	18500	23263.5
0.5 (p/l)	7030	6964.8
1.0 (p/l)	1750	1851.9
2.5 (p/l)	390	549.9
5.0 (p/l)	80	103.2
10 (p/l)	44	90.2
Relative humidity(%)	70.85	10.7
Air Temperature (ºC)	12	2.2
Wind intensity (m/s)	7.8	1.7

6. Figures

Fig. 1. Location of San Jorge Gulf and adjacent shelf and the Colhue Huapi and Deseado River basin (major sources of dust)

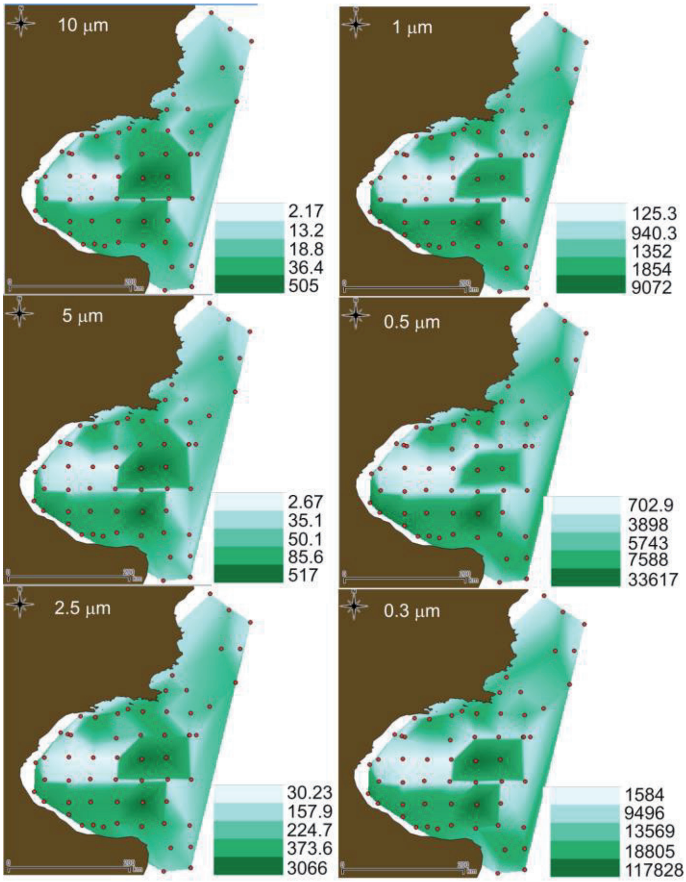

Fig. 2. Spatial distribution of dust concentration (number of particles per litre of air) of different size classes (µm) over the San Jorge Gulf and adjacent shelf

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