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Methanesulphonic acid from Talos Dome ice core as a marker of past periodicity of Ross Sea ice extent and southern hemisphere atmospheric circulation mode

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This work contributes to the understanding of variation in methanesulphonic (MSA) concentration in an ice core drilled during the 1996-97 Antarctic Campaign at the coastal plateau site of Talos Dome (East Antarctica) as function of sea ice extent in Ross Sea sector and southern hemisphere atmospheric circulation mode.
Unperturbed stratigraphy and high ice thickness make Talos Dome a promising site for deep ice coring, which started in December 2004 and reached a depth of 1619.2 m, which is a few meters above the bedrock, in December 2007. This ice core record is assumed to cover the previous 120 kyr. In preparation of the deep drilling, an 89 m firn core (TD96) was drilled at the dome culmination in November 1996 and, in this work, the results obtained from this firn core are reported.
MSA stratigraphy from TD96 core was compared with anomalies of the satellite-measured sea ice extension (1973-1995) in the Ross Sea and Wilkes Land oceanic sector. In spite of the sparseness of sea ice data, the MSA maxima fit with many positive sea ice anomalies in the Ross Sea. This evidence suggests that marine biogenic activity enhanced by large sea ice cover is an important, but not exclusive, factor in controlling MSA concentration in snow precipitation at Talos Dome. Other than source intensity, differences in regional atmospheric transport mechanisms affect the arrival of MSA-rich aerosol at Talos Dome. To clarify the role of transport processes in bringing biogenic aerosol to Talos Dome, a spectral analysis was applied to the MSA, SOI (South Oscillation Index), and SAM (Southern Annular Mode) record. Synchronicity or phase shift between the chemical signature and atmospheric circulation modes were tested. The variations in the MSA profile have a periodicity of 6.9, 4.9, 3.5, and 2.9 years. The 6.9 and 2.9 year periodicities show a strong positive correlation and are synchronous with corresponding SOI periodicity. This variability could be related to an increase in MSA source intensity (by dimethylsulphide from phytoplanktonic activity) linked to the sea ice extension in the Ross Sea area, but also to an increased strength in transport processes. Both of these factors are correlated with La Niña events (SOI positive values). Furthermore, SAM positive values are related to an increased sea ice extension in the Ross Sea sector and show two main periodicities 3.3 and 3.8 years. These periodicities determine the MSA variability at 3.5 years. However, the effect of intensification of the polar vortex and the consequent reduction in transport process intensity, which reduce the delivery of air masses enriched in MSA from oceanic areas to Talos Dome, makes the effect of the SAM on the MSA concentration at Talos Dome less active than the SOI. In this way, snow deposition at the Talos Dome records larger MSA concentration by the combined effects of increased source emissions and more efficient transport processes. The MSA record from Talos Dome can therefore be considered a reliable proxy of sea ice extension when the effect of changes in transport processes in this region of Antarctica is considered. Over the previous 140 years, these conditions occur with a periodicity of 6.9 years.