



## Rapid transport of East Asian pollution to the deep tropics

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**Abstract.** Anthropogenic emissions from East Asia have increased over recent decades. These increases have led to changes in atmospheric composition as far afield as North America under the prevailing westerly winds. Here we show that, during Northern Hemisphere (NH) winter, pollution originating in East Asia also directly affects atmospheric composition in the deep tropics. We present observations of marked intra-seasonal variability in the anthropogenic tracer perchloroethene ( $C_2Cl_4$ ) collected at two locations in Borneo (117.84° E, 4.98° N and 118.00° E, 4.22° N) during the NH winter of 2008/2009. We use trajectories calculated with the Numerical Atmospheric-dispersion Modelling Environment to show that the observed enhancements in  $C_2Cl_4$  mixing ratio are caused by rapid meridional transport, in the form of “cold surges”, from the relatively polluted East Asian land mass. In these events air masses can move from  $\sim 35^\circ$  N to Borneo in 4 days. We then present data from the Monitoring Atmospheric Composition and Climate reanalysis which suggest that air masses high in  $C_2Cl_4$  may also contain levels of the pollutants carbon monoxide and ozone that are approximately double the typical “background” levels in Borneo. In addition to strengthening the meridional transport from the

north, cold surges can enhance convection in Southeast Asia, and further trajectory calculations indicate that the polluted air masses can subsequently be lifted to the tropical upper troposphere. This suggests a potentially important connection between midlatitude pollution sources and the very low stratosphere.

### 1 Introduction

The rapid growth of East Asian economies over recent decades has led to enhanced emissions of various pollutants, including ozone ( $O_3$ ) precursors (e.g. Granier et al., 2011) and halocarbons (e.g. Wan et al., 2009). The emitted pollutants are known to be transported eastward by the prevailing midlatitude winds, and plumes have been observed at the edge of East Asia (e.g. Akimoto et al., 1996; Tanimoto et al., 2008) and over the Pacific (e.g. Liu et al., 2003; Hudman et al., 2004). East Asian pollution has also been shown to affect atmospheric composition further afield, leading to increased  $O_3$  in both western North America during Northern Hemisphere (NH) spring (Cooper et al., 2010) and Hawaii