Ethane (C2H6) is a hydrocarbon that is emitted during the process of oil and natural gas production, leakage in mining, storage and distribution, along with biofuel use and biomass burning (Xiao et al., 2008). Methane (CH4), which is co-emitted with ethane from these sources, is a greenhouse gas that is 34 times more potent per unit of mass than CO2 (including feedback) over a time horizon of 100 years (Intergovernmental Panel on Climate Change, 2013). The major contributor to the anthropogenic sources of methane and ethane is fugitive emissions from oil and natural gas production. Horizontal drilling and hydraulic fracturing provide better access to oil and gas reservoirs that would otherwise be unprofitable using conventional methods, thus providing some economic advantages. However, besides some environmental impacts of horizontal drilling and hydraulic fracturing, recent increases of these activities can potentially increase the rate of fugitive emission of methane into the atmosphere. Natural gas is a promising transition to clean, climate-friendly energy sources because combustion of natural gas produces less CO2 than coal in electricity production (U.S. Energy Information Administration, 2011), although this scenario can only be achieved if the leakage rate of natural gas delivery from wells to plants is not above the 3.2% estimated threshold (Alvarez et al., 2012). Bottom-up accounting of ethane fugitive emissions is challenging, in part because leakage rates vary widely across production fields and distribution networks. For the above reasons, the climate mitigation achieved by transitioning from coal to natural gas will be undermined if leakage rates are high. To that end, a good understanding of the methane fossil fuel trends is required. Despite that, there is disagreement among the scientific community on the fossil fuel emission trends of the last four decades.

Bottom-up and top-down studies that were done on both ethane and methane produced different conclusions on the temporal trend of fugitive fossil fuel emissions. Surface air sampling and analysis showed a global decline of -6.8 ± 0.6 p.p.t.v yr-1 in ethane mixing ratio from 1986 to 2010 (Simpson et al., 2012). Ethane mixing ratio in the high latitude northern hemisphere declined faster compared to the southern hemisphere mixing ratio. The authors calculated that this required an annual global decline in ethane emissions of 3.0 ± 0.4 Tg yr-1 from 1986 to 2010. The authors attributed the decline to a decrease in fugitive fossil fuel emission of about 3.4 - 4.2 Tg yr-1 from 1985 to 2000, along with small increases in the other ethane sources. Firn air analysis by Aydin et al. (2011) yielded a scenario where anthropogenic emission decreased 5-6 Tg yr-1 during 1980-2000, biomass burning emissions rose from less than 1 Tg yr-1 in 1950s to ~3 Tg yr-1 by 2000, and then a decline of 2 Tg yr-1 after 2000. However, inverse modeling analyses of isotopic methane indicate that CH4 fugitive fossil fuel emissions remained nearly constant during the 1980s and 1990s and increased by 20 Tg yr-1 from 2000 to 2009 (Rice et al. 2016). This work compares those emissions hypotheses against multi-decadal surface ethane measurements from 1982 to 2015 to determine the emission scenario that most likely has occurred for the last four decades.

The emissions hypotheses of ethane were tested using the three-dimensional chemical-tracer model GEOS-Chem. The results of the simulations were compared to the analyzed surface air measurements latitudinally and temporally to infer the fossil fuel emission trend that fits to the observed ethane data best. Since ethane anthropogenic emissions occur mainly in the middle-to-high northern latitudes (Fig. 1a), biomass burning emissions in the tropics (Fig. 1b), and biofuel emissions in the low northern latitudes (Fig. 1c), the change in the latitudinal distribution of atmospheric ethane over time can help determine the trends in the different ethane sources.