Notes: don’t need to mention the re-gridding of the UCI data and the manual shifting through UCI data to find longitude and latitude coordinates. Only include relevant information

**1/ Air archive (how the values were obtained)**

The observed annually averaged ethane mixing ratio is calculated using data from the Oregon Graduate Institute (OGI, 1982-1987), University of California – Irvine (UCI, 1984- 2009), and the National Oceanic and Atmospheric Administration Earth System Research Laboratory Global Monitoring Division (NOAA, 2005- 2015).

**2/ Simulation modeling**

**3/ Data analyses**

The ethane mixing ratio has a very large seasonal cycle with the maximum ratio occurs in March and the minimum ratio occurs in September. The UCI data is only available in March, June, September, and December, which correspond to the maximum, minimum and the inflections of the seasonal cycle. We defined each of the 4 months as a season and only the aforementioned months are examined from NOAA and OGI. The UCI data is distributed from latitude 50° S to 75° N, so we constrained the analyses to those latitudes.

**3.1/ Global Analysis**

**3.1.1/ Observed data**

The Earth’s atmosphere is divided into 5 latitudinal bands: 50°S - 30°S, 30°S - 0°, 0° - 30°N, 30°N - 50°N, 50°N - 75°N. The data in each band is deseasoned by removing the average seasonal cycle calculated over an averaging window of multiple years at monthly resolution (Fig?). A Gaussian fit is applied to the deseasoned data to obtain to the standard deviation (σ) (how to refer to the Coyote algorithm?) of the latitudinal band (Fig. xx). We removed data that is 3σ away from the mean.

The annual latitudinal band average, , is calculated as the average of all four seasonal means in one year.

(E1)

The uncertainty, of each latitudinal band is the propagation of error from the standard error of each season resulted in the following

(E2)

where SEseason is the standard error of each season, which is calculated as

(E3)

n is the number of samples in a season.

The annual hemispheric means, is calculated from the weighted mean of the latitudinal bands as following for the northern hemisphere

(E4)

with the weights are determined using the sine of the latitudes

(E5)

For the southern hemisphere, the mean is calculated as

(E6)

and for the weights

(E6)

The uncertainty of the annual hemispheric mean, is calculated as the propagation of uncertainty from each latitudinal band :

(E7)

N is the number of bands for of a hemisphere.

The mixing ratio in the northern hemisphere is 3-4 times higher than the mixing ratio in the southern hemisphere (cite), thus global mixing ratio gradient is sensitive to the changes in the emissions of the northern hemisphere. To compare the ethane mixing ratio gradient with different emission scenarios without the influence of the northern hemisphere, we defined the Interhemispheric Ratio (IHR) as the quotient of the Northern Hemispheric Mean (NHM) over the Southern Hemispheric Mean (SHM). We expect that the IHR can also eliminate the bias in the absolute calibration differences that might exist between different sampling networks. The uncertainty of the IHR, , is the propagation of uncertainty from the hemispheric means’ uncertainties; the result is as follow

(E8)

**3.1.2/** **Simulated data**

The simulated mixing ratio to use for the global analysis is built from the GEOS-Chem data structure output using the spatial and temporal parameters of the observed data from each network; consequently, the simulated data will have the same location and time span as the observed data. There are 6 simulated data sets corresponding to 6 emission scenarios. Each simulated data set goes through the same calculations as the global observed data analysis except for the uncertainty calculations (need to justify not using uncertainty calculations or should it be in the discussion section?)

Fig. xx shows the observed NHM, SHM and the IHR as discrete data points and the simulated data as continuous lines. To compare the trends of the observed ethane mixing ratio and the simulated mixing ratio, we normalized the data over the time period within a sampling network; Fig. xx shows the normalized data.

**3.2/ 2-site analysis**

**3.2.1/ Observed Data**

We used the observed ethane data from Barrow, Alaska, USA (71.3°N, 156.6°W) and Cape Grim, Tasmania, Australia (40.7°S, 144.7°E) to represent the ethane mixing ratio in the Northern Hemisphere and the Southern Hemisphere. The UCI network does not have data for the Cape Grim site, so in order to get a consistent time series with the Barrow site, we used UCI data between latitude 38°S to 46°S to represent Cape Grim for the UCI network. (How to justify the use of the latitude bound?)

The 2 sites are deseasoned using the same technique as the global analysis. The same data filtering algorithm is also applied to each site where data larger than 3σ are removed.

Similar to the global analysis, the annual mean of each site, , is also calculated as the average of the mean of each season.

(E9)

The uncertainty of the annual mean, , is the propagation of error from the standard error of each season.

(E10)

The Interhemispheric Ratio (IHR) of the 2-site analysis is defined as the quotient of the annual means of the Barrow site over the Cape Grim site. The uncertainty of the IHR, , is the propagation of uncertainty from the annual uncertainties of each site. The result is similar to the equation E8 where Barrow represents the Northern Hemisphere and Cape Grim represents the Southern Hemisphere.

(E11)

Fig. xx shows the time series of the annual ethane IHR resulted from the 2-site analysis and the annual means of the Barrow site and the Cape Grim site. Fig. xx shows the same time series but normalized over individual data network.

**3.2.2/ Simulated Data**

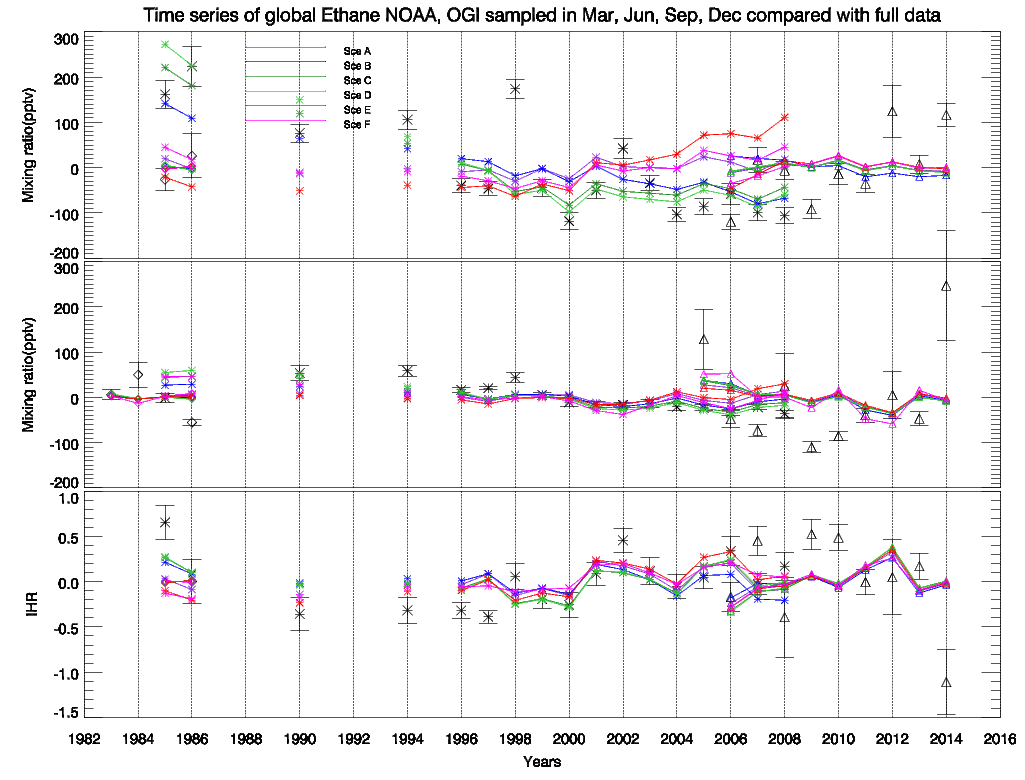
**4/ Sensitivity**

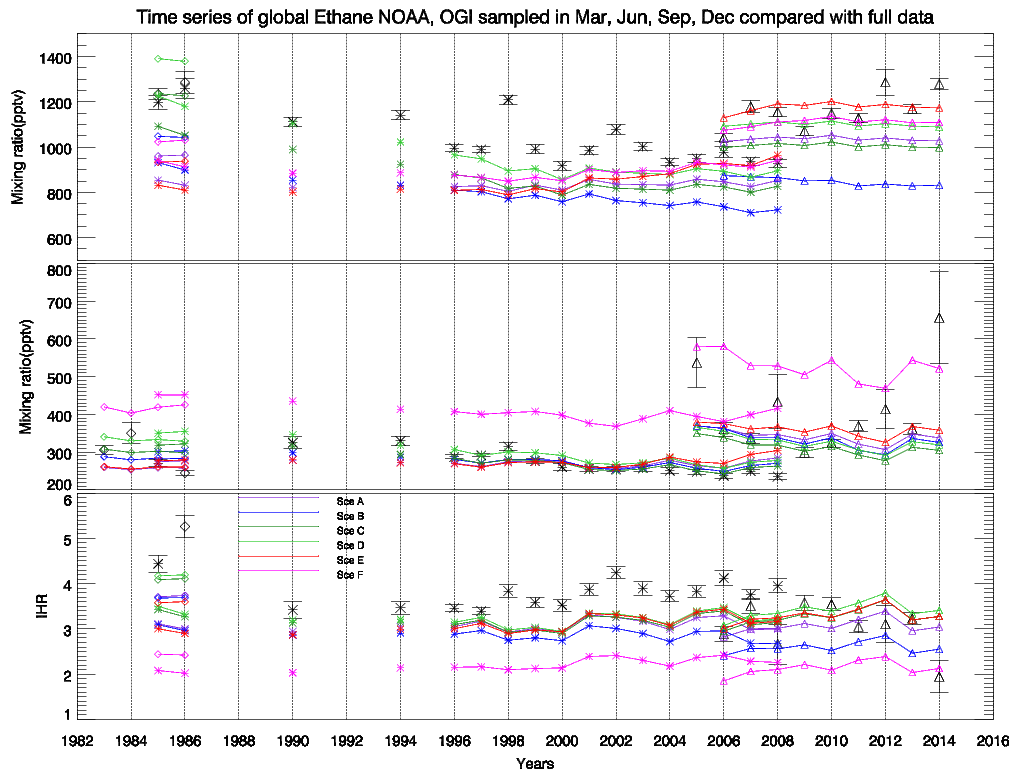
**4.1/ Observed data sensitivity**

**4.2/ Simulated data sensitivity**

**References**

**Figures**

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