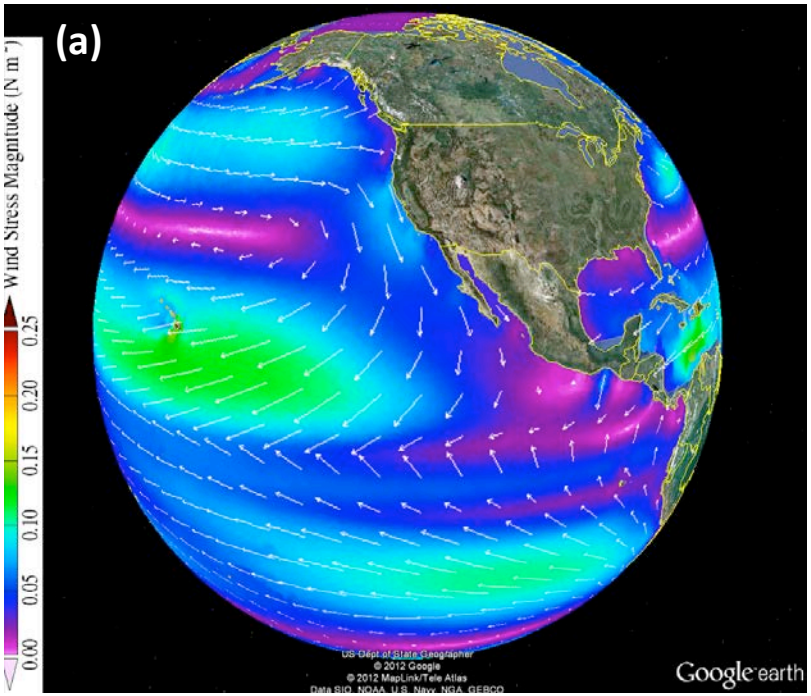
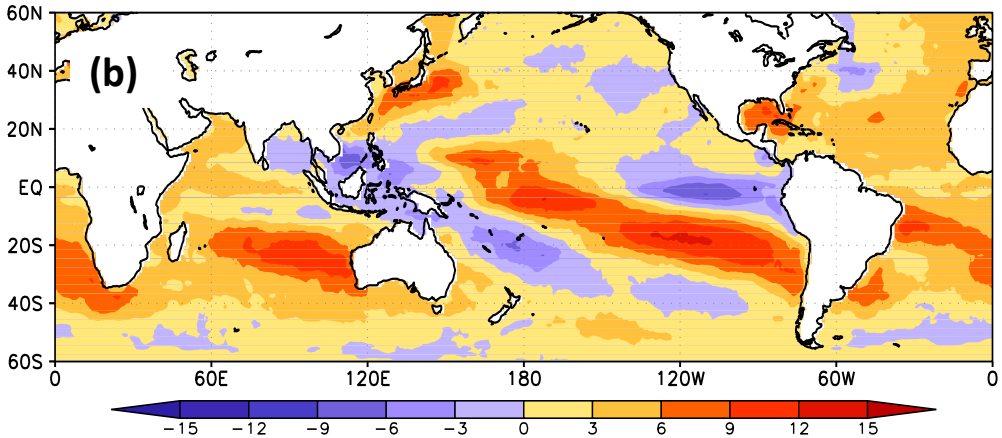
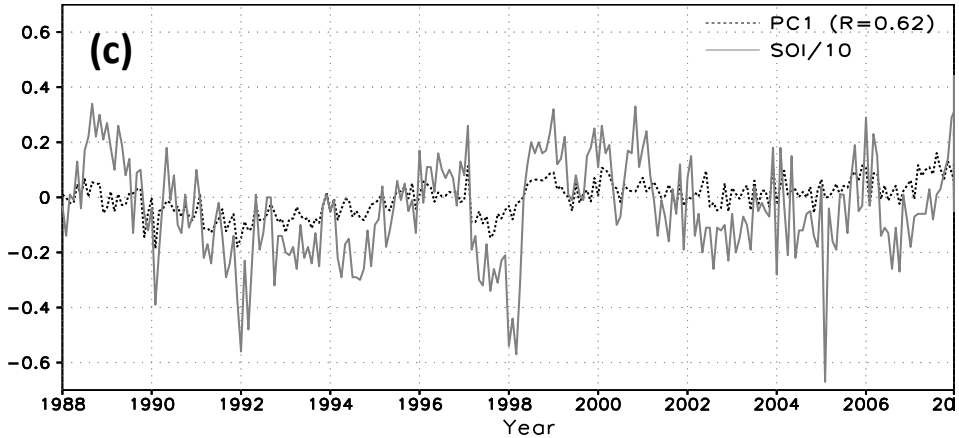
Upgraded Global Air-sea Turbulent Fluxes from GSSTF datasets and Their Climate Applications

Chung-Lin Shie (UMBC/JCET/612), Long S. Chiu, and Si Gao







Surface wind stress from the GSSTF3 yearly climatology is shown in (a). A climate application to GSSTF2c is show in (b-c), where an empirical orthogonal function (EOF) is applied to latent heat flux. The first EOF (EOF1), shown in (b), follows the El Niño Southern Oscillation (ENSO) mode. In (c) its associated time series (principal component PC1) is shown along with the well-correlated Southern Oscillation Index (SOI).

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References:

Gao, S., L. S. Chiu, and C.-L. Shie, 2013: Trends and Variations of Oceanic Evaporation: Results from GSSTF2c Dataset, *Geophysical Research Letter*, Vol. 40, Issue 2, 380–385. doi: 10.1029/2012GL054620

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Shie, C.-L. and coauthors, 2009: A note on reviving the Goddard Satellite-based Surface Turbulent Fluxes (GSSTF) dataset, *Advances in Atmospheric Sciences,* Vol. 26, No. 6, 1071-1080. doi: 10.1007/s00376-009-8138-z

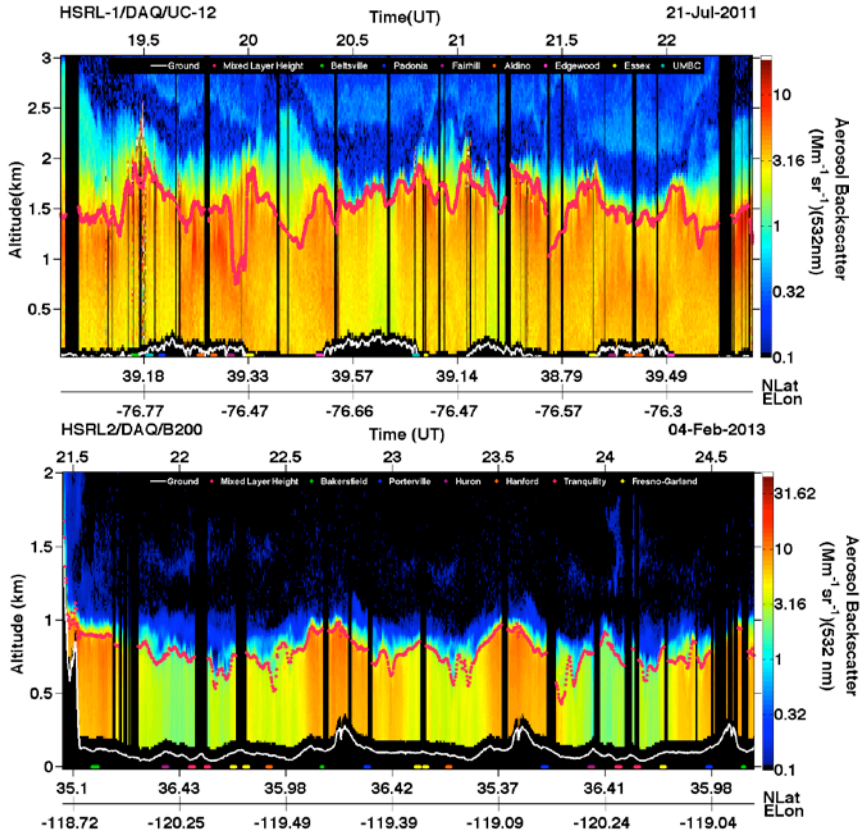
Data Sources: The global daily, monthly and climatological (July 1987-Dec 2008) air-sea turbulent fluxes in GSSTF2c (1.0^{o}x1.0^{o}) (Shie et al. 2011) and GSSTF3 (0.25^{o}x0.25^{o}) (Shie et al. 2012) datasets distributed by NASA GES DISC.http://disc.sci.gsfc.nasa.gov/daac-bin/DataHoldingsMEASURES.pl?PROGRAM_List=ChungLinShie

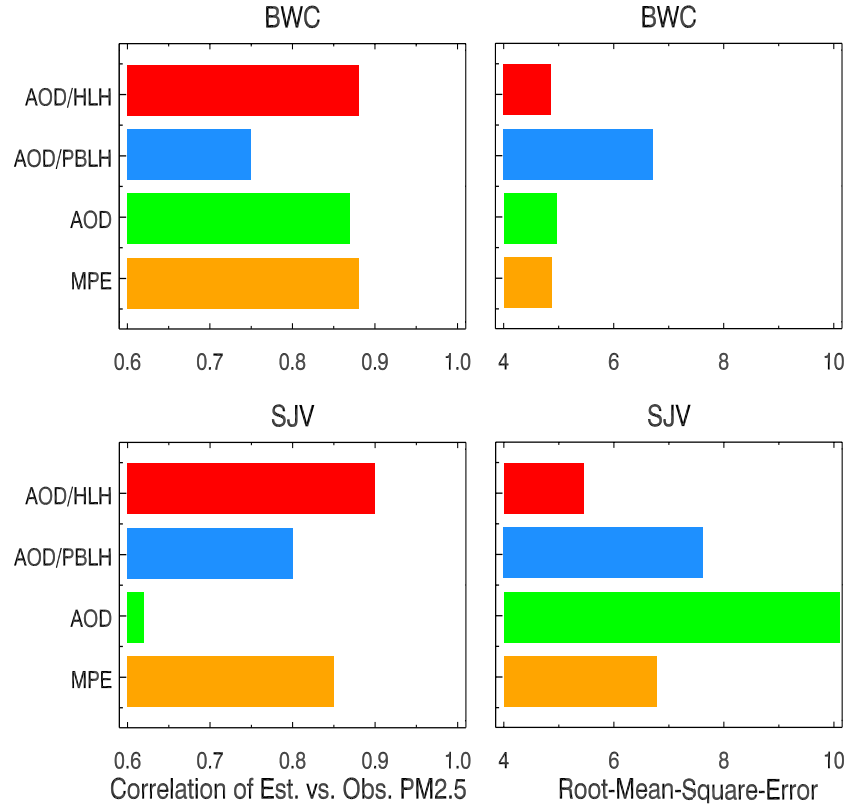
Technical Description of Figures:
An example of surface wind stress (vectors) and its magnitude (shades; units in N m^{-2}) in the GSSTF3 yearly climatology (1998-2008) is shown in (a). The maximum wind speed and stress are located in the trade wind belts and extratropical storm track regions, while the minimum wind speed and stress are located in the weak wind areas of the intertropical convergence zone (ITCZ), South Pacific convergence zone (SPCZ), the tropical Indian Ocean, and under subtropical highs. (Figure is produced with help from Andrey Savtchenko at GES DISC.) Meanwhile, in (b-c) a statistic data analysis, using an empirical orthogonal Function (EOF), has been applied on non-seasonal latent heat flux (LHF) in the GSSTF2c Dataset for the period 1988–2008. The first EOF (EOF1) is shown in (b). It has a variance of 5.6% and follows the conventional El Niño Southern Oscillation (ENSO) mode. The associated time series principal component (PC1; dotted line) of non-seasonal LHF is also shown (c). The Southern Oscillation Index (SOI) divided by 10 (solid line) is also shown here with PC1, and correlation between PC1 and SOI is 0.62.

Scientific significance, societal relevance, and relationships to future missions: About two-thirds of global precipitation, mainly attributable to air-sea surface latent and sensible heat fluxes, falls in the tropics. This provides about three-fourths of the energy driving global atmospheric circulation via Hadley cells. Accurate global sea surface fluxes measurements are therefore crucial to understanding the global water and energy cycles. Oceanic evaporation is a major component of the global oceanic fresh water flux and is particularly useful for predicting oceanic circulation and transport. Remote sensing is a valuable tool for global monitoring of these flux measurements. The GSSTF algorithm has been developed and applied to remote sensing research and applications for two decades. GSSTF2c and GSSTF3 are two recently improved and upgraded datasets using the corrected SSM/I brightness temperature (TB) by removing artificial temporal trend due to the Earth incidence angle (EIA) decease found among the SSM/I sensors. C.-L. Shie (PI of the GSSTF project) plans to further develop the GSSTF algorithm and extend its application to the GPM mission for producing the associated air-sea turbulent fluxes by using the available related parameters such as TB, SST, surface wind speed (U) and specific humidity (Q) retrieved from GPM.

Remote Sensing of $PM_{2.5}$ with Airborne HSRL Measurements during DISCOVER-AQ Field Campaigns

Allen Chu, JCET/UMBC and NASA GSFC and HSRL Team, NASA LaRC





Processing HSRL aerosol backscattering measurements during DISCOVER-AQ field campaigns to derive aerosol optical depth (AOD), PBLH (Planetary Boundary Layer Height), and HLH (Haze Layer Height). Linear approximations were developed to estimate surface $PM_{2.5}$ (Particulate Matter with diameter less than 2.5 μm) and compare with $PM_{2.5}$ measurements in Baltimore-Washington Corridor (BWC, MD) and San Joaquin Valley (SJV, CA) by normalizing AOD with PBLH and HLH. MPE (Mean PBL Extinction) is used to serve as the baseline for the linear approximations.

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References: 2013 AGU Fall Meeting (Chu, D. A. et al., 2013. Multi-sensor Approach on Air Quality Application and Assessment Using Measurements in DISCOVER-AQ as a Testbed, A24C-7).

Data Sources:
Airborne HSRL (High Spectral Resolution Lidar) measurements of DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) over BWC (Baltimore-Washington Corridor, Maryland July 2011) and SJV (San Joaquin Valley, California, January-February 2013). The HSRL team is based at NASA Langley Research Center (Co-PIs: Rich Ferrare, John Hair, and Chris Hostetler). The details can be found on http://science.larc.nasa.gov/hsrl/.

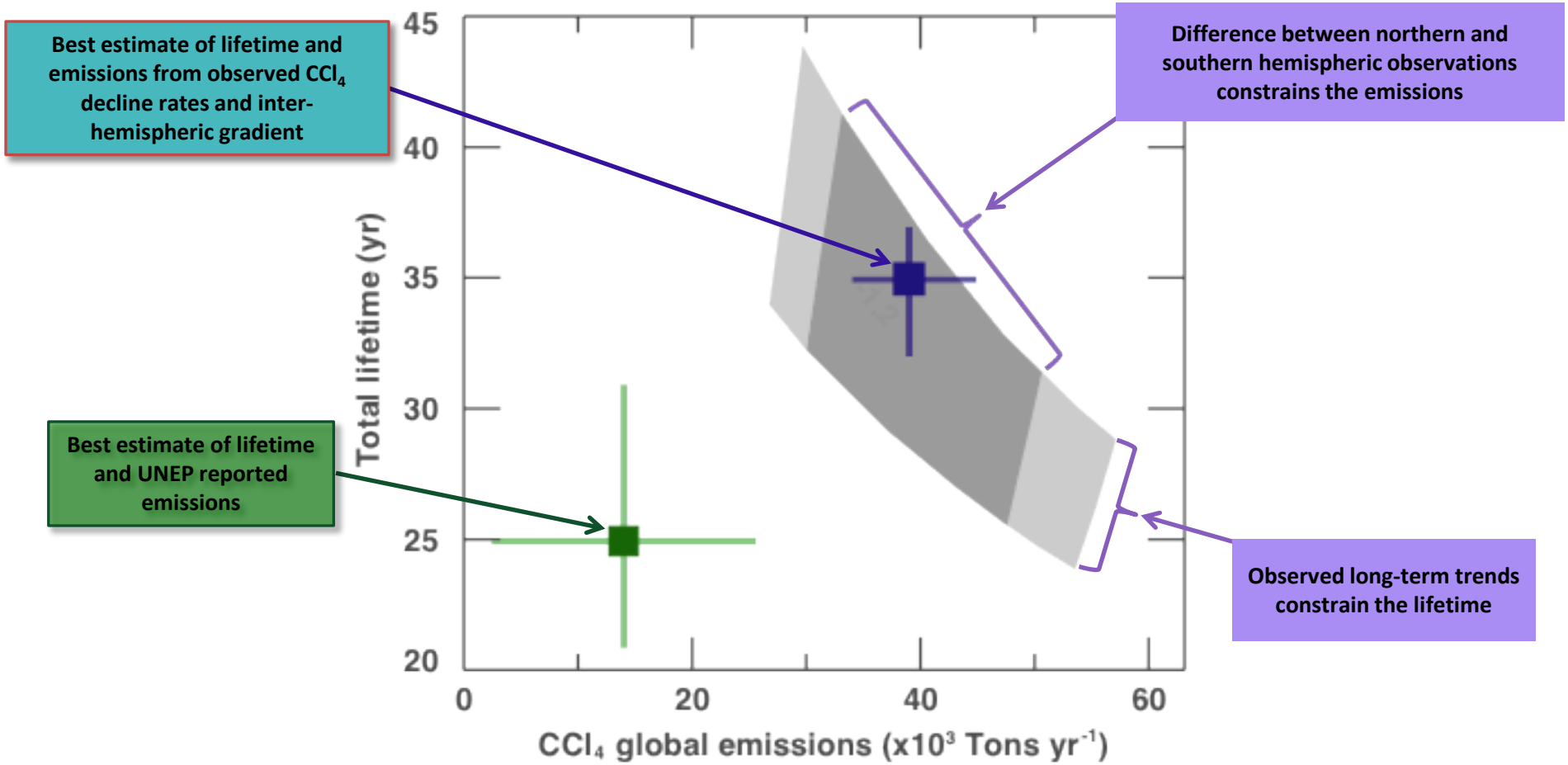
Technical Description of Figures:
Left panels*:** Selected HSRL aerosol backscattering images on July 21, 2011 and February 4, 2013 to show the examples of maximum AOD in BWC, Maryland (top) and SJV, California (bottom) respectively. ***Right panels: Correlation and RMSE (Root-Mean-Square-Error) of estimated versus observed $PM_{2.5}$ by the linear approximations of AOD/HLH and AOD/PBLH as well as AOD and MPE during DISCOVER-AQ of the entire campaign period over BWC (July 2011) and SJV (January 16 – February 4, 2013), respectively, where MPE serves as the baseline reference for the linear approximations.

Scientific significance, societal relevance, and relationships to future missions:
Satellite remote sensing covers a large area. The application of satellite retrieval products become an important tool to evaluate public heath effects by air pollutants. DISCOVER-AQ is a NASA Earth Venture class mission to better understand the scientific challenges associated with the use of Earth-observing satellites for measuring air quality. As far, three field deployments have completed in BWC (Baltimore-Washington Corridor, Maryland) in July 2011, SJV (San Joaquin Valley, California) in January-February 2013), and HMR (Houston Metropolitan Region) in September 2013. The last field deployment takes place in the Denver Metropolitan in July-August 2014. The results shown are part of the comparative study of estimated $PM_{2.5}$ over DISCOVER-AQ campaigns with airborne HSRL measurements by linear approximations. HLH (Haze Layer Height) is developed based upon PBLH and scale height assuming exponential decrease in extinction with altitude above PBLH. The MPE (Mean PBL extinction) calculated by the fractional AOD within PBLH over PBLH serves as the baseline for the linear approximations of AOD/HLH and AOD/PBLH. The normalization of AOD (aerosol optical depth) by HLH results in the best $PM_{2.5}$ estimate compared to surface $PM_{2.5}$ observations (correlation ~0.88-0.9 and RMSE ~4-6 mg/m^3). The results were presented in 2013 AGU Fall Meeting (Chu, D. A. et al., 2013. Multi-sensor Approach on Air Quality Application and Assessment Using Measurements in DISCOVER-AQ as a Testbed, A24C-7.). The results are applicable to the development of future satellite mission, such as GEO-CAPE of the Decadal Survey.

Solving the CCl_4 budget mystery using surface observations

Qing Liang (614) and Paul Newman (610), NASA/GSFC and USRA/GESTAR

Carbon tetrachloride (CCl_4) is a major ozone depleting substance and greenhouse gas in our atmosphere. CCl_4 levels increased up to about 1990 and are now in decline, but at a much slower rate than can be expected. There appears to be an unknown source that is mainly in the Northern Hemisphere.



1. The near-zero CCl_4 emissions from UNEP reported production and feedstock and the 25-year lifetime ***do not match*** the observed decline and inter-hemispheric gradient (IHG).
2. Based on the observed IHG, global trend, and the linear dependence of IHG on global annual emissions*:* we deduce that the ***mean global emissions during 2000-2012 are 39x10^3 Tons/yr with a 35-year total lifetime*** (Liang et al., 2014).

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References:

Liang, Q., P. A. Newman, J. S. Daniel, S. Reimann, B. Hall, G. Dutton, L. J. M. Kuijpers, Constraining the Carbon Tetrachloride (CCl_4) budget using its global trend and inter-hemispheric gradient, Geophys. Res. Lett., 41, doi:10.1002/2014GL060754, 2014.

Data Sources: Model simulations for CCl_4 are conducted using the NASA Goddard 3-D chemistry climate model, GEOSCCM. Monthly mean surface observations of CCl_4 from the the Advanced Global Atmospheric Gases Experiment (AGAGE) network and the National Oceanic and Atmospheric Administration – Global Monitoring Division (NOAA-GMD) network.

Technical Description of Figures:

Graphic 1: Our model results show that there is a strong linear dependence of interhemispheric gradient on global annual emissions, thus the observed IHG can be used to derive emissions quantitatively. We use the AGAGE and NOAA-GMD observed IHG for CCl_4 to derive its global emissions and the observed global trend to derive the corresponding lifetime. The dark gray shading outlines the range of emissions and CCl_4 lifetime that can be reconciled with the observed inter-hemispheric gradient and global trend for CCl_4, using the current best estimate of Northern Hemisphere emission fraction (EF_n) of 0.94.The light gray shading outlines the lower to upper limit estimates for emissions and lifetime based on a reasonable range estimate of 0.88-1.00 for EF_n. The green square symbol shows the current best estimate for CCl_4 lifetime (the vertical bar indicates 1-σ uncertainty) and the upper limit bottom-up potential emissions from the UNEP reported production and feedstock uses for 2007-2012 (horizontal bar indicates 1-σ variance).

Scientific significance, societal relevance, and relationships to future missions: CCl_4 is a major anthropogenic ozone-depleting substance and greenhouse gas and has been regulated under the Montreal Protocol. Current bottom-up emissions, estimated based on reported production and feedstock usage, were zero after 2007. The near-zero bottom-up emissions cannot be reconciled with the observed slow decline of atmospheric concentrations (~ 1 % per year) and the inter-hemispheric gradient for CCl_4. Our 3-D model simulations suggest the observed inter-hemispheric gradient (1.5$\pm$0.2 ppt for 2000-2012) is primarily caused by ongoing current emissions, while ocean and soil losses and stratosphere-troposphere exchange together contribute a small negative gradient (~0 - –0.3 ppt). Using the observed CCl_4 global trend and inter-hemispheric gradient, we deduce the mean global emissions for the 2000-2012 period are 39 (34-45) Gg/yr (~ 30% of the peak 1980s emissions) and a corresponding total lifetime of 35 (32-37) years. Results from this work point to the need for a more accurate bottom-up estimate of CCl_4 emissions as well as re-evaluation of the current CCl_4 best estimate lifetime of 25 years to a needed much longer lifetime of 35 years.