

# Observational evidence for interhemispheric hydroxyl parity

September 11 2014

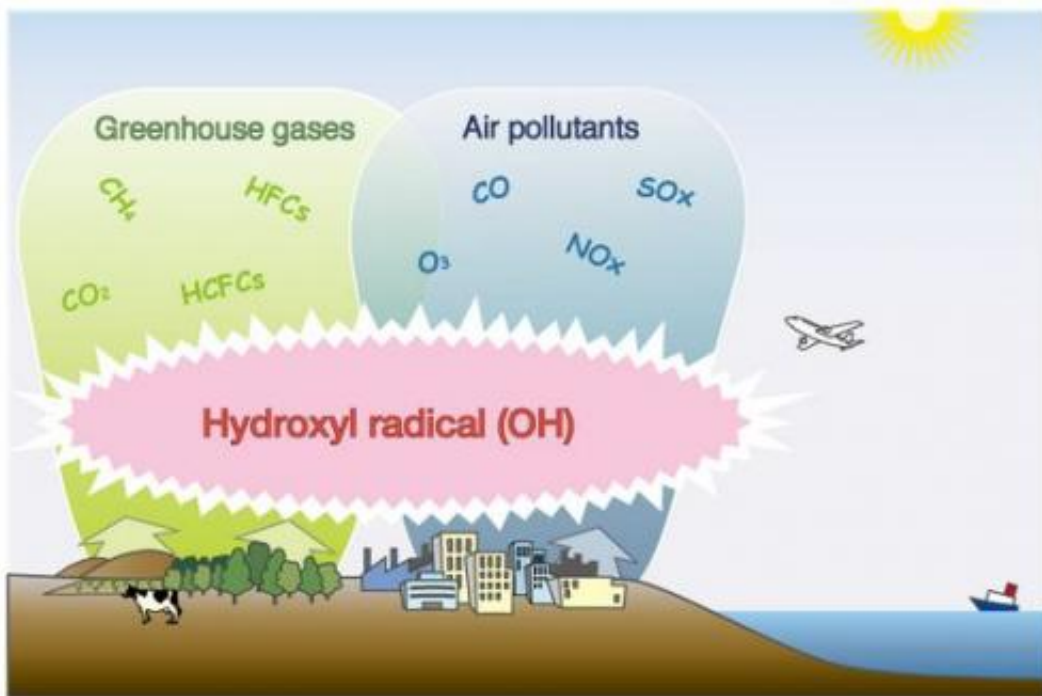


Figure 1: Role of OH in removal and production of greenhouse gases and air pollutants emitted from the biospheric and anthropogenic activities on the earth's surface.

A new study published today in *Nature* based on observational data and modeling shows that surprisingly the self-cleansing power of the atmosphere does not differ substantially between the Northern and the Southern Hemisphere. Up to now model simulations generally showed higher levels of hydroxyl (the dominant "bleaching agent" of the

atmosphere that oxidizes many pollutants) in the Northern Hemisphere (NH). This seemed logical in view of the massive amounts of nitrogen oxides emitted by traffic, domestic heating and industry in the NH. These nitrogen oxides act as catalysts that promote the formation of ozone (ozone smog) and subsequently hydroxyl.

The new study models the global distribution of the hydroxyl radical (OH), a highly reactive species responsible for keeping the Earth atmosphere clean using [measurements](#) from aircraft and remote observing stations (Figure 1). OH controls the removal and formation of air pollution species and greenhouse gases in the troposphere at altitudes up to ~10-15 km.

Dr. Prabir Patra and his colleagues at the Department of Environmental Geochemical Cycle Research within the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) have estimated that the NH/SH ratio of OH concentration is close to 1. OH is very hard to measure across the globe given its very short lifetime (~1 second), its very low concentration, and its high variability. This has prevented a direct validation of model-simulated OH distributions, and indirect methods to gauge OH are called for. The new study uses measurements of methyl chloroform ( $\text{CH}_3\text{CCl}_3$ ), an entirely man made chemical but with emissions now limited by the Montreal Protocol, that is chiefly removed from the atmosphere by OH. Methyl chloroform measurements from two ground-based observation networks operated by the international Advanced Global Atmospheric Gases Experiment (AGAGE) and the U.S. National Oceanic and Atmospheric Administration (NOAA), as well as from the High-performance Instrumented Airborne Platform for Environmental Research Pole-to-Pole Observations (HIPPO) campaign are used in combination with JAMSTEC's atmospheric chemistry-transport model (ACTM) (Figure 2).

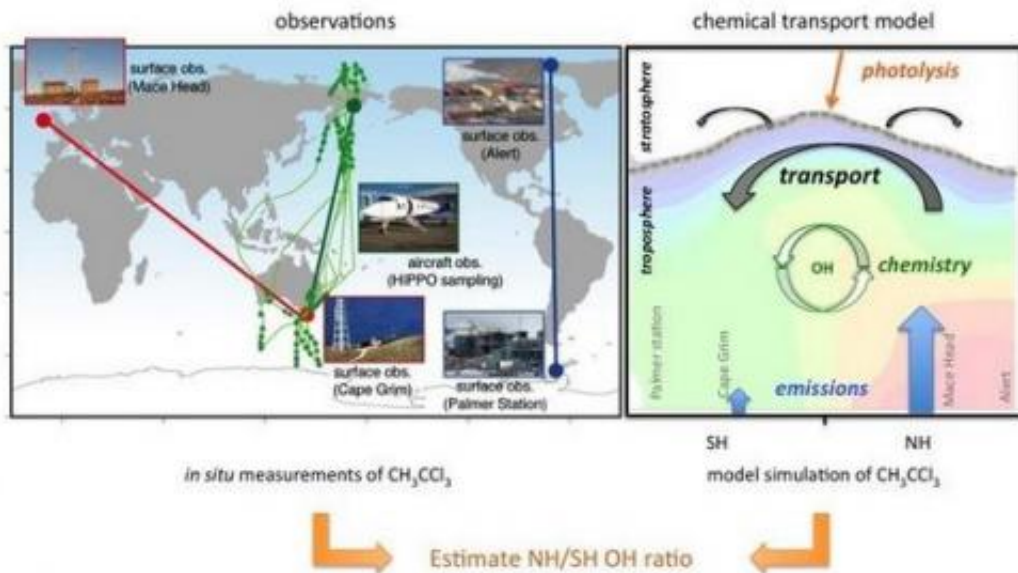


Figure 2: Materials and methods used in deriving NH/SH ratio of OH concentrations from the measurements (left) and modelling the chemistry-transport-emissions (right) of  $\text{CH}_3\text{CCl}_3$ .

Although state-of-the-art chemistry-transport models predict that the OH concentration in the NH is ~28% (13–42%) higher than in the SH, the present detailed study derives a NH/SH OH ratio of  $0.97 \pm 0.12$  (Figure 3). Uncertainties about the relative abundance of OH in the two hemispheres have persisted since the early 1990s due to uncertainties about how much  $\text{CH}_3\text{CCl}_3$  was actually released into the [atmosphere](#) and also due to imperfections in interhemispheric transport in models used to estimate OH concentrations.

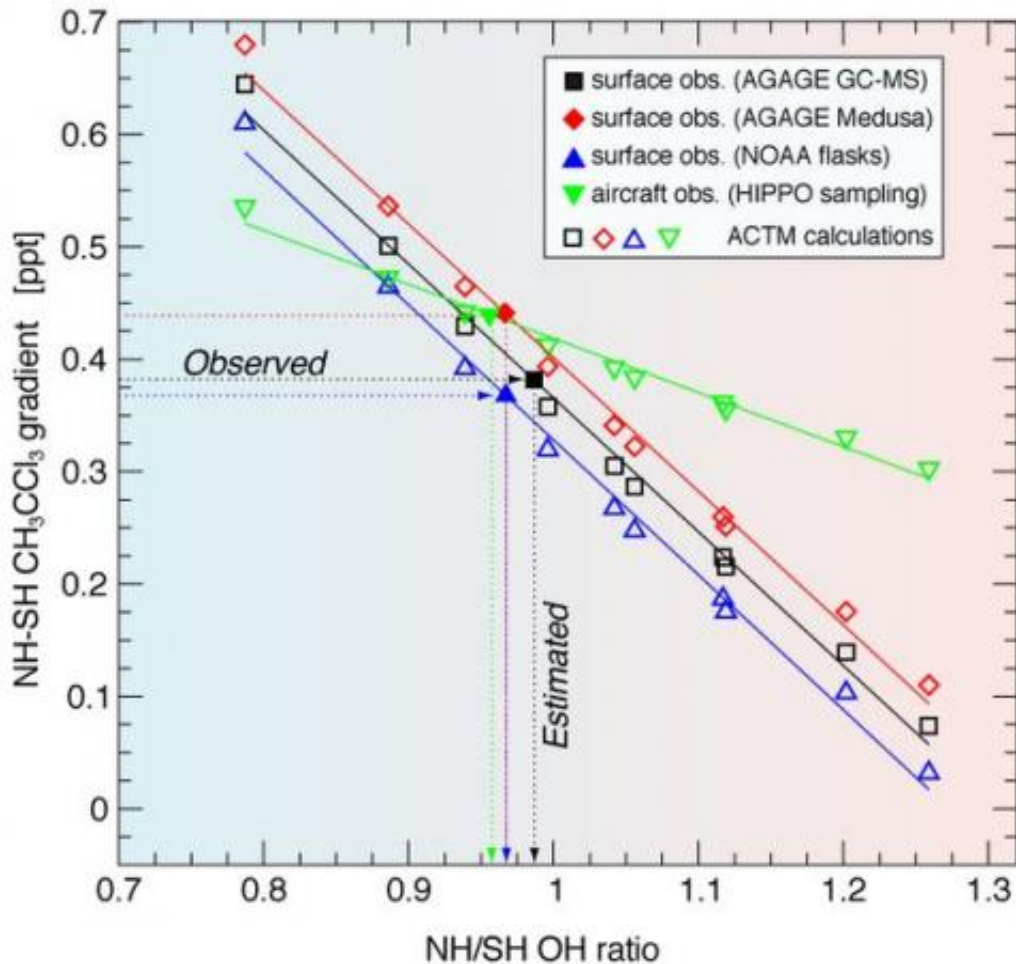


Figure 3: Estimation of NH/SH ratio of OH concentration from the observed north-south gradients in CH<sub>3</sub>CCl<sub>3</sub> concentrations from two surface measurements networks and aircraft campaigns

Dr. Carl Brenninkmeijer of Max Planck Institute for Chemistry (Germany), who first estimated this ratio in 1992, says "this result puts a finger on a wound in our understanding or at least proper description of the oxidative capacity of the troposphere." This study suggests that top-down emission estimates of reactive species, such as methane and carbon monoxide, in key emitting countries in the NH that are based on a NH/SH OH ratio larger than 1 may have been overestimated. For

example, inverse modeling studies with relatively high OH in the NH require unrealistically large CH<sub>4</sub> emissions in the NH to counterbalance OH removal. The authors conclude "chemical reactions simulated by the models may be incomplete and further research is needed to investigate how global/hemispheric OH responds to the wide range of human influences and to improve our ability to predict Earth's environmental change."

**More information:** "Observational evidence for interhemispheric hydroxyl parity." P. K. Patra, et al. Observational evidence for interhemispheric hydroxyl-radical parity. P. K. Patra, M. C. Krol, S. A. Montzka, T. Arnold, E. L. Atlas, + et al. *Nature* 513, 219-223 [DOI: 10.1038/nature13721](https://doi.org/10.1038/nature13721)

Provided by JAMSTEC

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