TORERO motivation
The primary objective of TORERO was to study the release and transport of halogenated gases and oxidized VOCs in the Eastern Tropical Pacific during the season of high biologic productivity. Many halogenated gases, also called very short-lived species (VSLs; t < 6 mo.), are emitted from the ocean and can impact marine boundary layer (MBL) O₃ as well as stratospheric O₃ due to convection to the UTLS. Despite efforts to quantify these species, uncertainties remain as to the regional distribution of sources and sinks of these compounds and their impact on MBL chemistry.

Figure 1. Flight tracks of the 17 research flights flown from Antofagasta, Chile and San Jose, Costa Rica, 19-Jan to 29-Feb-2012.

Organohalogen measurements
Several VSLs were measured in situ using GC/MS on board the NCAR/NSF GV using the NCAR Trace Organic Gas Analyzer (TOGA), and from the NOAA RV Ka’imimoana by the University of York.

Figure 2. Observations of DMS and several organohalogens during three TORERO flights in both oligotrophic (RF05) and nutrient-rich environments.

Marine Boundary Layer Organohalogens
Figure 3. TOGA data from the MBL (< 500 m) and U. of York data on surface maps of MODIS sea surface temperatures (SST) and Chlorophyll-a (Ch-a).

Ratios of pairs of halogenated species, i.e., CHBr₃/CH₂Br₂, are indicators or MBL influence.
τ₃₀₃ ≈ 1 min
τ₉₀₃ ≈ 1 week
τ₉₀₂ ≈ 4 hours
τ₌₃ ≈ 1 day

Figure 4. RAQMS model curtain plots showing MBL exposure, with observed CHBr₃/CH₂Br₂ ratios.

Comparison with WACCM/CAM-chem
Model output from the global CAM-chem chemistry-climate model, with recently integrated observations of very short-lived (VSL) halocarbons and reactive iodine and bromine species (Saiz-Lopez et al., 2012), are compared against several of the VSLs observed by TOGA during TORERO.

Figure 5. CAM-chem modeled and observed VSLs from three TORERO flights.

Summary
- VSL emissions from the east-tropical Pacific Ocean are tied to factors involving SST and biologically active chlorophyll-a production, but differ from DMS.
- MBL ship- and aircraft-based observations of most VSLs are in good agreement.
- Ratios of VSLs are indicators of recent influence of MBL air to the free troposphere and of aging within the free troposphere.
- Initial comparisons of observations to WACCM/CAM-chem model output show reasonable agreement with CHBr₃, CH₂Br₂ and CH₂ClI.