Inclusion of Antarctic sea-ice emissions and sea-salt aerosol recycling of bromine into the global CAM-Chem chemistry-climate model

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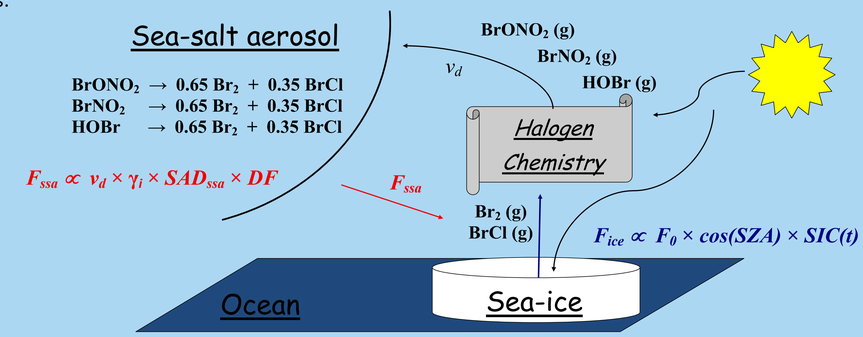
POLAR MODULE IN CAM-CHEM

A halogen polar module has been coupled to the global CAM-Chem chemistry climate model[1], including the following processes:



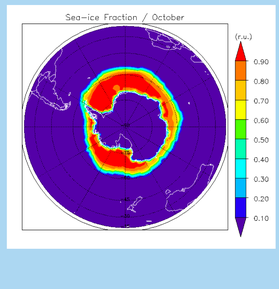
• ***F_{ice}*:** The inorganic bromine source from sea-ice has a 2-fold dependence on both solar zenith angle (*SZA*) and local sea-ice cover (*SIC(t)*). The surface flux (F_0 = 1.0 × 10^9 molec cm^{-2} s^{-1}) has been scaled to reproduce observations over coastal Antarctica.

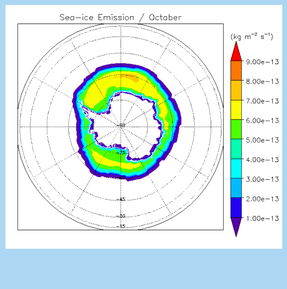
• ***F_{ssa}*:** The sea-salt recycling scheme considered is based on the uptake of halogen species in sea-salt aerosols[2] (SAD_{ssa}). A time-dependent depletion factor (*DF(Lat,t)*) has been used[3]. Improved sea-salt recycling efficiency over fresh sea-ice regions is considered.

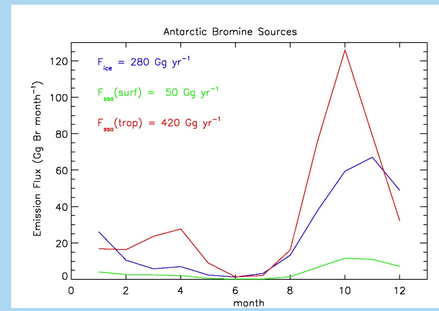
BROMINE EMISSIONS FROM SEA-ICE

The Antarctic sea-ice bromine source presents a strong seasonality with maximum values in October/November, as a compromise between SIC and incident radiation. In October, the incident radiation at high latitudes is smaller, so the greater emission fluxes appear in the outer portion of the sea-ice edge.

The sea-ice flux (F_{ice} = 280 Gg Br yr^{-1}) is the predominant source of bromine and controls halogen chemistry in the Antarctic boundary layer (F_{ssa}*(surf)* = 50 Gg Br yr^{-1}), but the tropospheric aerosol contribution (F_{ssa}*(trop)* = 420 Gg Br yr^{-1}) surpass the sea-ice flux strength.





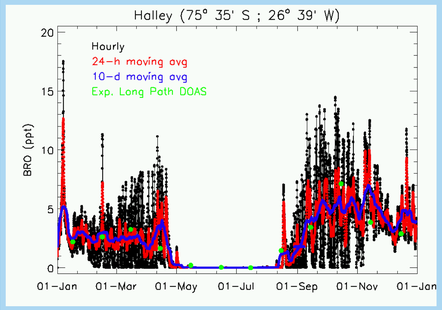


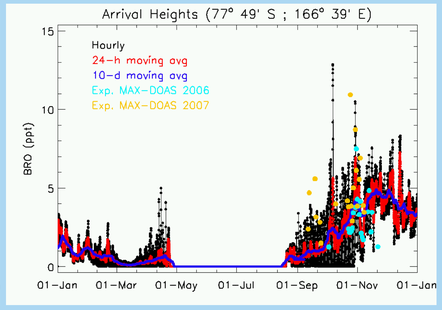
The tropospheric sea-salt recycling flux follows the sea-ice flux shape, but shows two distinct shifts: the maximum F_{ssa}*(trop)* occurs in October before the maximum F_{ice}, and the relative F_{ssa}*(trop)* enhancement is maximized in April. This highlights the F_{ssa} dependence on the chemical partitioning as well as the seasonality of sea-salt aerosol production and DF efficiency.

RESULTS

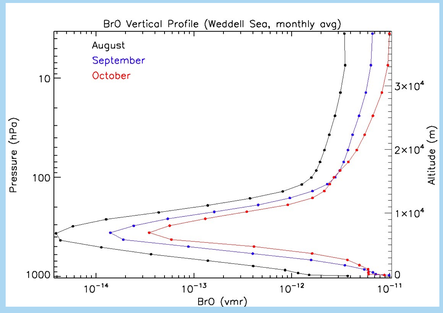
Surface

The modeled surface hourly variation of BrO has been compared with measurements at two different Antarctic sites. 24 h (red) and 240 h (blue) moving averages are also shown in order to compare with the 10-day moving averages reported at Halley (Long-Path DOAS)[4]. There is a good agreement both in the boundary layer concentrations for the entire year and the springtime maximum BrO. Even when the MAX-DOAS measurements performed at Arrival Heights in 2006-2007[5] are more sparse, the modeled values lie within measurements range showing a similar tendency.





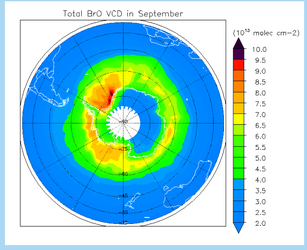
Vertical Profile

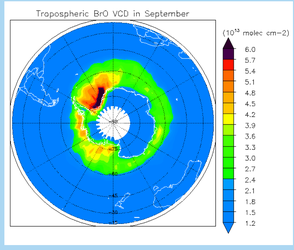


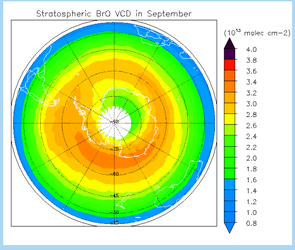
The monthly average BrO Vertical profile above the Weddell sea region shows two independent contributions from the troposphere and stratosphere. Model results indicate that BrO abundance in the Free Troposphere can not be neglected in the satellite BrO retrievals. Recycling of bromine over sea-salt aerosol is the dominant factor controlling the Tropospheric BrO VCD.

Vertical Column Density (VCD)

The modeled springtime BrO total columns are in agreement with BrO VCDs measurements from GOME2 and SCIAMACHY. The polar BrO cloud distribution is coincident with the Antarctic monthly sea-ice coverage, with springtime maximum values over the Weddell and Ross seas. The Tropospheric VCD presents a clear regional distribution, highlighting the importance of fresh sea-ice/halogen interactions. In general, modeled Total VCDs are smaller than retrieved with greater differences in the southern ocean and mid-latitudes background, which might be due to the absence of other bromine sources reaching the polar free troposphere (eg., VSLs) or by the uncertainties in the AMF used for the retrieval.







FUTURE DEVELOPMENT

- Include Iodine sources in the polar module
- Address the role of halogen-VSL sources from the sea-ice and ocean at high-latitudes
- Expand the polar module to the North Hemisphere

6. REFERENCES:

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