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Radiative forcing of aerosols over the Arctic from the August 2017 Canadian and Greenlandic wildfires

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Extended and intense wildfires occurred in Northern Canada and, unexpectedly, on the Greenlandic West coast during summer 2017. The thick smoke plume emitted into the atmosphere was transported to the high Arctic, producing one of the largest impacts ever observed in the region. Evidence of Canadian and Greenlandic wildfires was recorded at the Thule High Arctic Atmospheric Observatory (THAAO, 76.5°N, 68.8°W, www.thuleatmos-it.it) by a suite of instruments managed by ENEA, INGV, Univ. of Florence, and NCAR. Ground-based observations of the radiation budget have allowed quantification of the surface radiative forcing at THAAO.

Excess biomass burning chemical tracers such as CO, HCN, H2CO, C2H6, and NH3 were measured in the air column above Thule starting from August 19 until August 23. The aerosol optical depth (AOD) reached a peak value of about 0.9 on August 21, while an enhancement of wildfire compounds was detected in PM10. The measured shortwave radiative forcing was -36.7 W/m2 at 78° solar zenith angle (SZA) for AOD=0.626.

MODTRAN6.0 radiative transfer model (Berk et al., 2014) was used to estimate the aerosol radiative effect and the heating rate profiles at 78° SZA. Measured temperature profiles, integrated water vapour, surface albedo, spectral AOD and aerosol extinction profiles from CALIOP onboard CALIPSO were used as model input. The peak aerosol heating rate (+0.5 K/day) was reached within the aerosol layer between 8 and 12 km, while the maximum radiative effect (-45.4 W/m2) is found at 3 km, below the largest aerosol layer.

The regional impact of the event that occurred on August 21 was investigated using a combination of atmospheric radiative transfer modelling with measurements of AOD and ground surface albedo from MODIS. The aerosol properties used in the radiative transfer model were constrained

by in situ measurements from THAAO. Albedo data over the ocean have been obtained from Jin et al. (2004). Backward trajectories produced through HYSPLIT simulations (Stein et al., 2015) were also employed to trace biomass burning plumes.

The radiative forcing efficiency (RFE) over land and ocean was derived, finding values spanning from -3 W/m2 to -132 W/m2, depending on surface albedo and solar zenith angle. The fire plume covered a vast portion of the Arctic, with large values of the daily shortwave RF (< -50 W/m2) lasting for a few days. This large amount of aerosol is expected to influence cloud properties in the Arctic, producing significant indirect radiative effects.