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Aerosol nucleation over oceans and the role of galactic cosmic rays

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Abstract. We investigate formation of sulfate aerosol in the marine troposphere from neutral and charged nucleation of H_2SO_4 and H_2O . A box model of neutral and charged aerosol processes is run on a grid covering the oceans. Input data are taken from a model of galactic cosmic rays in the atmosphere, and from global chemistry and transport models. We find a weak aerosol production over the tropical oceans in the lower and middle troposphere, and a stronger production at higher latitudes, most notably downwind of industrial regions. The strongest aerosol production however occurs in the upper troposphere over areas with frequent convective activity, in particular in the tropics. This finding supports the proposition by which non-sea salt marine boundary layer aerosol in tropical regions does not form in situ, but nucleates in the upper troposphere from convectively lifted and cloud processed boundary layer air rich in aerosol precursor gases, from where it descends in subsiding air masses compensating convection. Convection of boundary layer air also appears to drive the formation of condensation nuclei in the tropical upper troposphere which maintains the stratospheric aerosol layer in the absence of volcanic activity. Neutral nucleation contributes only marginally to aerosol production in our simulations. This highlights the importance of other mechanisms, including charged binary and ternary, and neutral ternary nucleation for aerosol formation. Our analysis indicates that the variation of ionization by galactic cosmic rays over the decadal solar cycle does not entail a response in aerosol production and cloud cover via the second indirect aerosol effect that would explain observed variations in global cloud cover. We estimate that the variation in radiative forcing resulting from a response of clouds to the change in galactic cosmic ray ionization and subsequent aerosol production over the decadal solar cycle is smaller than the concurrent variation of total solar irradiance.

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