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Observed seasonal cycles in tropospheric ozone at three marine boundary layer locations and their comparison with models

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Observational data have been used to define the seasonal cycles in tropospheric ozone at the surface at three marine boundary layer (MBL) locations at Mace Head in Ireland, Trinidad Head in the USA and at Cape Grim in Tasmania. Least-squares fits of a sine function to the observed monthly mean ozone mixing ratios allowed ozone seasonal cycles to be defined quantitatively, as follows: y = Y0 + A1 $\sin(\theta + \varphi 1)$ + A2 $\sin(2\theta + \varphi 2)$, where Y0 is the annual average ozone mixing ratio over the entire set of observations or model results, A1 and A2 are amplitudes, $\varphi 1$ and $\varphi 2$ are phase angles and θ is a variable that spans one year's time period in radians. The seasonal cycles of fourteen tropospheric ozone models, together with our own STOCHEM-CRI model, at the three MBL stations were then analysed by fitting sine curves and defining the five parameters: Y0, A1, $\varphi 1$, A2, $\varphi 2$. Compared to the fundamental term: A1 $\sin(\theta + \varphi 1)$, all models more accurately reproduced the observed second harmonic terms: A2 $\sin(2\theta + \varphi 2)$. This accurate agreement both in amplitude and phase angle suggested that the term arose from a cyclic phenomenon that was well predicted by all models, namely, the photochemical destruction of ozone. Model treatments of the fundamental term were in many cases far removed from the observations and it was not clear why there was so much variability across the tropospheric ozone models.