Supplementary information to "European atmosphere in 2050, a regional air quality and climate perspective under CMIP5 scenarios" by A. Colette et al.

1 Sensitivity of biogenic emission to the choice of meteorological forcing

1.1 The biogenic emission module of CHIMERE

Biogenic emissions for the six species relevant to CHIMERE (isoprene, α-pinene, β-pinene, limonene, ocimene, and NO) are based on the MEGAN model version 2.04 (Guenther et al., 2006). As described in (Bessagnet et al., 2008; Menut et al., 2013). For each grid cell a species-specific reference emission rate E_0 is modulated according to environmental conditions to produce the instantaneous emission:

$$E = E_0 \times \gamma_{LAI} \times \gamma_{AGE} \times \gamma_T \times \gamma_{PPFD}$$

Annual reference emissions for each species (E_0) factors are static and refer to the years 2000-2001.

The variation of monthly emission activity is due to changes in the leaf area index (LAI), which also drives leaf age changes in order to represent the fact that biogenic emissions peak several weeks after the onset of photosynthesis and decrease with the aging of the leaves. For the full expression of γ_{LAI} and γ_{AGE} the reader is referred to equations 15-19 in (Guenther et al., 2006). The LAI database is given as a monthly mean product derived from satellite (MODIS) observations for the year 2000.

The meteorological modulation is included in the hourly emission activity that is the product of two correction factors: γ_T (function of temperature) and γ_{PPFD} function of photosynthetic photon flux density (PPFD, directly related to the incoming short wave radiation). The expression of γ_T for isoprene is given in equation 14 of (Guenther et al., 2006) and reported here for convenience:

$$\gamma_T = E_{opt} \frac{C_{T_2} \exp(C_{T_1} x)}{C_{T_2} - C_{T_1}(1 - \exp(C_{T_2} x))}$$

where:

$$\begin{aligned} x &= \left(\frac{1}{T_{opt}} - \frac{1}{T} \right) \Big/ 0.00831 \\ T_{opt} &= 313 + 0.6\,(T_{day} - 297) \\ E_{opt} &= 1.75 \exp(0.08\,(T_{day} - 297)) \\ C_{T_2} &= 200 \\ C_{T_1} &= 80 \end{aligned}$$

and T_{day} is the daily temperature. The expression of γ_{PAR} is given in equations 11-13 of (Guenther et al., 2006) and also reported here for convenience:

$$\gamma_{PPFD} = \cos(SZA)\left[2.46\left(1 + 0.0005\,\varphi(PPFD_{day} - 400)\right) - 0.9\varphi^2\right]$$

where SZA is the Solar Zenith Angle, φ is the above canopy PPFD transmission, and $PPFD_{day}$ is the daily photosynthetic photon flux density.

1.2 Sensibility of the biogenic modulation factors to the meteorological forcing

Using the equations provided in Section 1.1, it is possible to quantify the impact a given difference in surface temperature or incoming short wave radiation on the modulation of biogenic emissions. We used the daily average meteorological variables computed with the downscaled GCM-historical and ERA-hindcast to assess the impact of the meteorological driver on biogenic emissions.

The maps of γ_T and γ_{PAR} are given in Figure 1 for the GCM-historical and ERA-hindcast forcing as well as the difference, in the last row. Over land surfaces of Western Europe, the difference between the

γ_{PAR} obtained with the GCM-historical and ERA-hindcast driver is -0.074, while this value is only -0.035 for $\gamma_{T,}$ hence the statement on a sensitivity to incoming radiation 216% or about twice as large as the sensitivity to temperature.

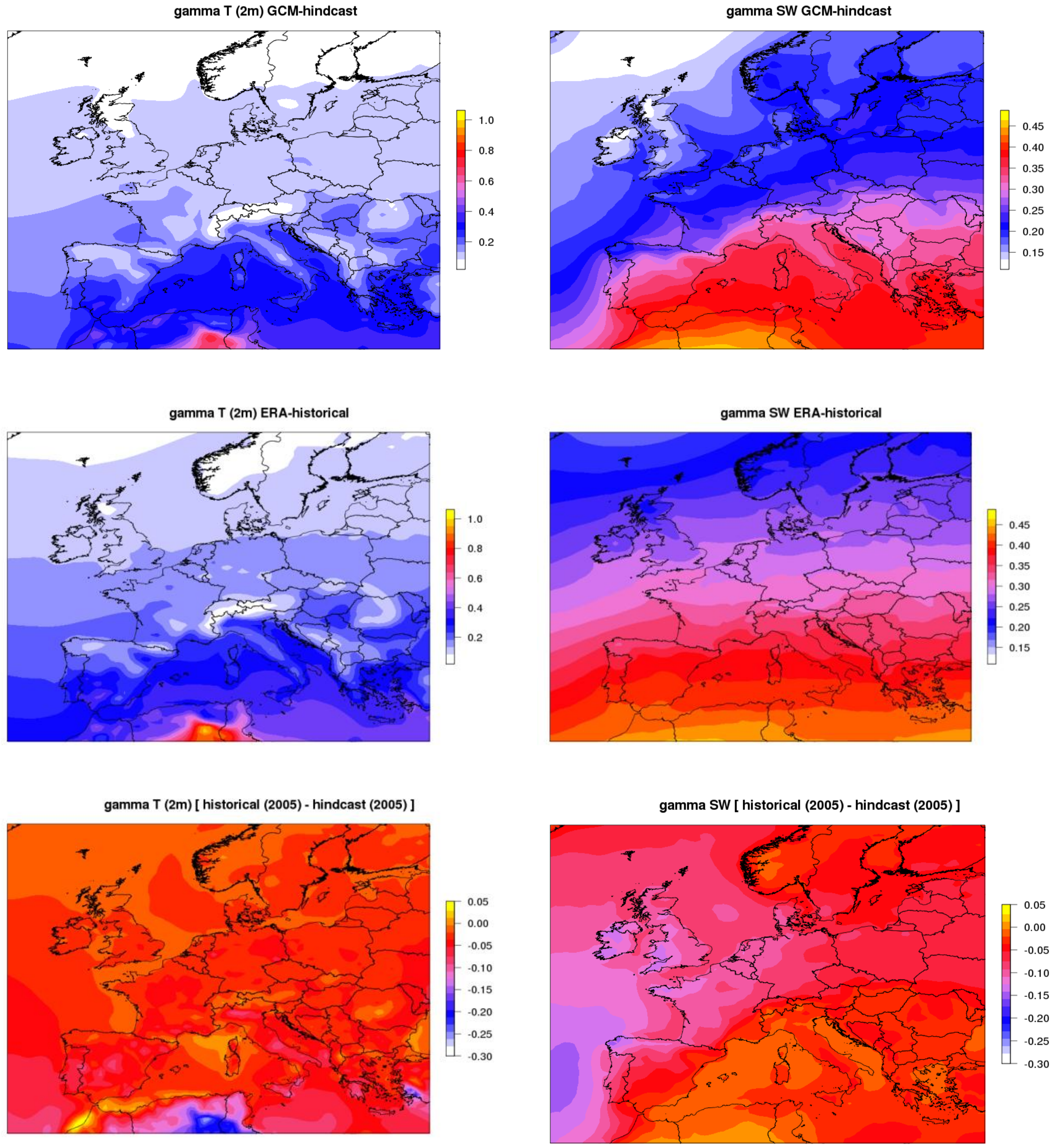

Figure 1 : Map of the modulation factors attributed to surface temperature (T2m, left) and to incoming short wave radiation (SW, right), when using the GCM-historical or ERA-hindcast meteorological driver. The last line provides the difference between the first two.

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