Temperature response measurements from eucalypts give insight into the impact of Australian isoprene emissions on air quality in 2050

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1. Australian distribution of eucalypt species used in this experiment

From Atlas of Living Australia, accessed 19.3.2020. [https://www.ala.org.au/](https://www.ala.org.au/)

Figure S1 clockwise from top left. *E camaldulensis*, *E tereticornis*, *E smithii*, *E. botryoides*.

The occurrences are unfiltered records and include points in arboreta or points over water bodies.
2 Condition of sapling eucalypt specimens.

The trees are ~1.5 m tall and have produced plenty of leaves prior to the experiment.

Figure S2 photograph of experimental set-up. Left *E. camaldulensis*, right *E tereticornis*
There are 5 or 6 replicates in each of the growing treatments. Figure S3 shows the variation in isoprene emission for each species, alongside the default MEGAN response.

Figure S3 Temperature response of normalised isoprene emission rate from four *Eucalyptus* species (a) *E. camaldulensis*, (b) *E. botryoides*, (c) *E. smithii* and (d) *E. tereticornis* grown under two different temperature regimes. Open circles (dotted lines) are current climate and filled circles (dashed line) are future climate. The solid line in each panel is the normalised isoprene emission calculated using default MEGAN values. Data are normalised to the isoprene emission rate measured at a leaf temperature of 303 K. Error bars (horizontal and vertical) are means ± one standard deviation of 4-6 replicate plants.

3 ESA to NCAR plant functional type classifications

Constructed for 2010, the ESA uses 36 land cover classes to describe global vegetation. These land cover classes have been processed to the NCAR plant functional types as required by MEGANv2.1 using similar methods as Emmerson et al. (2016). The ESA dataset also describes the percentage tree and shrub cover, so only minor estimation of tree/shrub/grass coverage is required (for example where the percentage of total trees is split between broadleaf evergreen and deciduous species). Any remaining ground is classed as bare soil and contains no vegetation. Table S1 gives the details of how each ESA land cover type has been split into the NCAR plant functional types (PFTs) as required by MEGAN.
Table S1. Relationship of ESA land cover types to NCAR PFTs, sorted according to boreal, temperate and tropical biomes. Not all land cover types are present in Australia.

| ESA land cover type                                      | NCAR Plant Functional Types          | Boreal   | Temperate | Tropical   |
|---------------------------------------------------------|--------------------------------------|----------|-----------|------------|
|                                                         |                                      | ≤-19 °C  | -19 °C ≤ X ≤ 15.5 °C | ≥15.5 °C   |
| 0  No Data                                              |                                      |          |           |            |
| 10 Cropland, rainfed                                    |                                      |          |           |            |
| 11 Herbaceous cover                                     | 90% Crop 10% Corn                   |          |           |            |
| 12 Tree or shrub cover                                  | 10% Corn                             |          |           |            |
| 20 Cropland, irrigated or post flooding                 | Bt Eg T                               |          |           | Bt Eg Tr   |
| 30 Mosaic cropland (>50%) / natural vegetation (tree, shrub, herbaceous) | 85% Crop                             |          |           |            |
|                                                         | 15% Sb Eg T                           |          |           |            |
|                                                         | Bt Eg T                               |          |           |            |
| 40 Mosaic natural vegetation (tree, shrub, herbaceous cover) (>50%) | Sb Eg T                              |          |           | Gs C3 W    |
|                                                         | 75% Bt Eg T                           |          |           | 75% Bt Eg Tr |
|                                                         | 25% Bt Dc T                           |          |           | 25% Bt Dc Tr |
| 50 Tree cover, broadleaved, evergreen, closed to open (>15%) | Bt Eg T                              |          |           | Bt Eg Tr   |
| 60 Tree cover, broadleaved, deciduous, closed to open (>15%) | Bt Dc B                              |          |           |            |
| 61 Tree cover, broadleaved, deciduous, closed (>40%)     | Bt Dc T                              |          |           | Bt Dc Tr   |
| 62 Tree cover, broadleaved, deciduous, open (15-40%)     | Bt Dc B                              |          |           |            |
| 70 Tree cover, needleleaved, evergreen, closed to open (>15%) | Nt Eg B                              |          |           | Nt Eg T    |
|   | Tree cover, needleleaved, evergreen, closed (>40%) |
|---|---|
| 71 | Tree cover, needleleaved, evergreen, open (15-40%) |
| 72 | Tree cover, needleleaved, deciduous, closed to open (>15%) |
| 80 | Tree cover, needleleaved, deciduous, closed (>40%) |
| 81 | Tree cover, needleleaved, deciduous, open (15-40%) |
| 82 | Tree cover, mixed leaf type (broadleaved and needleleaved) |
| 90 | 50% Nt Dc B |
| 90 | 50% Nt Eg B |
| 90 | 33% Nt Eg B |
| 90 | 33% Bt Eg T |
| 90 | 33% Bt Dc T |
| 90 | 50% Bt Eg Tr |
| 90 | 50% Bt Dc Tr |
| 100 | Mosaic tree and shrub (>50%) / herbaceous cover (<50%) |
| 100 | Sb Eg T |
| 100 | Bt Eg T |
| 100 | Gs C3 W |
| 100 | Bt Eg Tr |
| 110 | Mosaic herbaceous cover (>50%) / tree and shrub (<50%) |
| 110 | Sb Dc B |
| 110 | Sb Dc T |
| 110 | Sb Eg T |
| 120 | Shrubland |
| 120 | 34.5% Sb Eg T |
| 120 | 34.5% Sb Dc T |
| 120 | 25% Gs C3 Cl |
| 120 | 25% Gs C3 W |
| 120 | 50% Bt Eg T |
| 120 | 50% Bt Dc T |
| 120 | 50% Bt Eg Tr |
| 120 | 50% Bt Dc Tr |
| 121 | Evergreen shrubland |
| 121 | Sb Eg T |
| 122 | Deciduous shrubland |
| 122 | Sb Dc T |
| 130 | Grassland |
| 130 | Gs C3 Cd |
| 130 | Gs C3 Cl |
| 130 | Gs C3 W |
| 130 | 75% Bt Eg T |
| 130 | 75% Bt Eg Tr |
| 130 | 25% Bt Dc T |
| 130 | 25% Bt Dc Tr |
| 140 | Lichens and mosses |
| 140 | - |
| 140 | - |
| 150 | Sparse vegetation (tree, shrub, herbaceous cover) (<15%) |
| 150 | 10% Sb Eg T |
| 150 | 10% Sb Dc T |
| 152 | Sparse shrub (<15%) |
| Code | Description                                                                 | GS C3 Cl | GS C3 W |
|------|-----------------------------------------------------------------------------|----------|---------|
| 153  | Sparse herbaceous cover (<15%)                                              | Bt Eg T  | Bt Eg Tr|
| 160  | Tree cover, flooded, fresh or brackish water                                | Bt Eg T  | Bt Eg Tr|
| 170  | Tree cover, flooded, saline water                                           | Bt Eg T  | Bt Eg Tr|
| 180  | Shrub or herbaceous cover, flooded, fresh/saline/brackish water             | Sb Eg T  |          |
| 190  | Urban areas                                                                 | Sb Eg T  |          |
| 200  | Bare areas                                                                  |          |          |
| 201  | Consolidated bare areas                                                     |          |          |
| 202  | Unconsolidated bare areas                                                   |          |          |
| 210  | Water bodies                                                                |          |          |
| 220  | Permanent snow and ice                                                      |          |          |

Notes: B = Boreal, T = Temperate, Tr = Tropical.

Nt Eg = needleleaf evergreen tree, Nt Dc = needleleaf deciduous tree, Bt Eg = broadleaf evergreen tree, Bt Dc = broadleaf deciduous tree, Sb Eg = evergreen shrub, Sb Dc = deciduous shrub, Gs C3 = grass (can be Cd = cold, Cl = cool or W = warm depending on climatic zone).

## 4 Climate models used for 2050 temperature projections.

Surface temperature data for eight models considered in the Climate Model Intercomparison Project CMIP5 were downloaded for Australia. [https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/map-explorer/](https://www.climatechangeinaustralia.gov.au/en/climate-projections/explore-data/map-explorer/)

The eight models are: CanESM2, CNRM-CM5, ACCESS1.0, MIROC5, HadGEM2-CC, NorESM1-M, GFDL-ESM2M and CESM1-CAM5. The models were chosen to represent a wide range in climate projections and were judged to have performed well against 20th century observations.

The period December to February was chosen to correspond with the summer field campaigns used in this work. The change in seasonal temperature is calculated compared to the seasonal average between 1986 and 2005.

A range in warming is predicted by the eight models, with maximums ranging between 1.74°C and 3.83°C. For the purposes of this study, an average change in temperature was calculated from the ensemble. These delta temperatures were re-gridded to suit the four domains used by the C-CTM.
5 Variation in observed standard deviation.

Figure S4 shows how often the best performing model in terms of statistical $r^2$ fit, CC$_{\gamma T}$+LEF is within ±1 standard deviation of the isoprene observations. Note the colour of the CC$_{\gamma T}$+LEF run has changed to red here for visibility.

**Figure S4** Average diurnal timeseries in modelled and observed isoprene, showing ±1 standard deviation for the observations and CC$_{\gamma T}$+LEF run.

We calculate the percentage of modelled hours which are within ±1 standard deviation of the observed isoprene as follows:
Base run (CC$_{\gamma T}$+LEF run): Bringelly = 40% (90%); SPS1 = 89% (100%); MUMBA = 19% (33%).