Supplement of

A new lightning scheme in Canada's Atmospheric Model, CanAM5.1: Implementation, evaluation, and projections of lightning and fire in future climates

Whaley et al.
Correspondence to: Cynthia Whaley (Cynthia.whaley@ec.gc.ca)

Author

Norm McFarlane, John Scinocca

Theoretical formulation

The basic definition of CAPE is as follows:

$$CAPE = \int_{zb}^{zt} \frac{g(T_v^{(p)} - \bar{T_v})}{\bar{T_v}} dz \qquad (1)$$

The integrand in this formula is the buoyancy ($B^{(p)}$)of a parcel of air which undergoes undiluted adiabatic ascent between the base level (z_b) and uppermost level (z_t) may be reached by moists onvection. This level is typically the level of nuetral buoyancy (LNB) for conditionally unstable atmospheric column.

The virtual temperature (T_v) is defined using a standard approximation as $T_v \simeq T[1 + (\frac{1}{\epsilon} - 1)r_v - r_c] \simeq T(1 + .61r_v - r_c)$, where $\epsilon \simeq .622$ is the ratio of the gas constants for dry air (R_d) and water vapour (R_v). (ref: {AMS Glossary of Meteorology; http://glossary.ametsoc.org/wiki/Virtual_temperature}). The remaining quantities in the above formulae are defined as follows:

$r_v, r_c = r_l + r_i$: respectively mixing ratios of water vapour and condensed [liquid (r_l) plus solid (r_i)] water.

$g(= 9.8m/s^2)$: acceleration due to gravity.

z_b, z_c : respectively the base and top levels of the convective layer.

$T_v^{(p)}$: the virtual temperature associated with a parcel of air lifted adiabatically from the base level (z_b) taking into accout the effects of condensation and latent heat release. The ascent is assumed to be reversible (i.e. all of the condensate generated in the ascent is carried upward with the parcel).

$\bar{T_v}$: the virtual temperature of the background (mean state) air (evuated from input values of the background temperature and water vapour mixing ratio).

Figure S0: CanAM's CAPE calculation from code documentation.

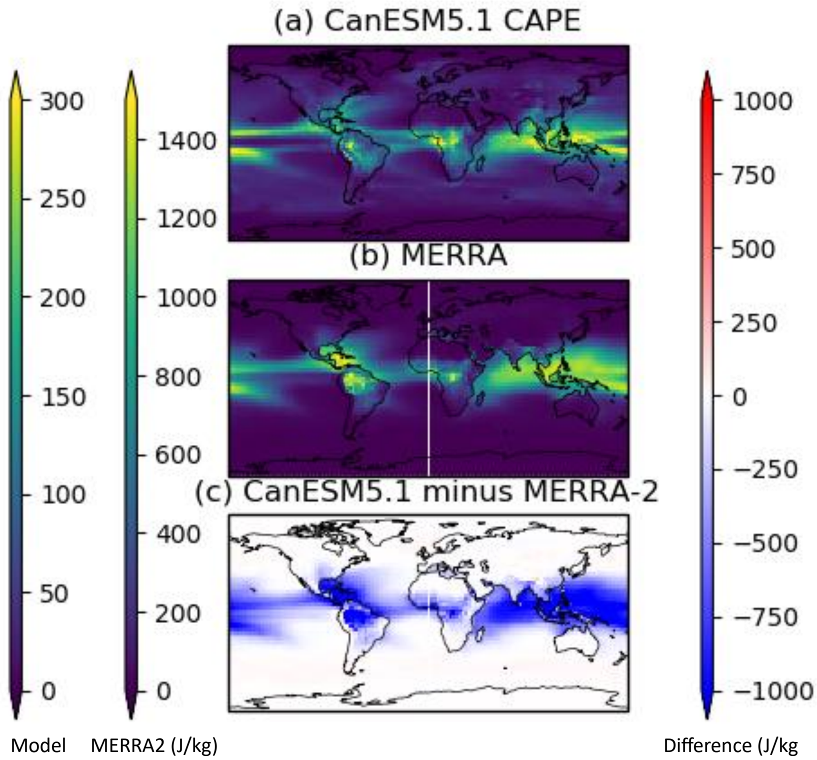

Figure S1: 2017-2019 annual mean of CAPE from (a) CanESM5.1 (left-most color bar), (b) derived by MERRA-2 reanalysis (middle color bar), and (c) their differences (right color bar) – all in J/kg. Note the different scales for the top two panels to highlight the range in values.

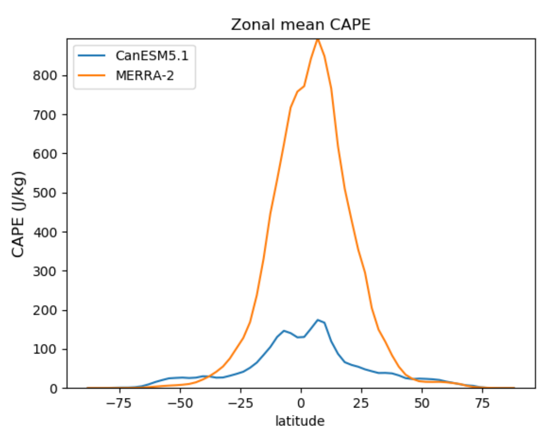

Figure S2: 2017-2019 annually averaged zonal mean CAPE from MERRA-2 (orange) and CanESM5.1 (blue).

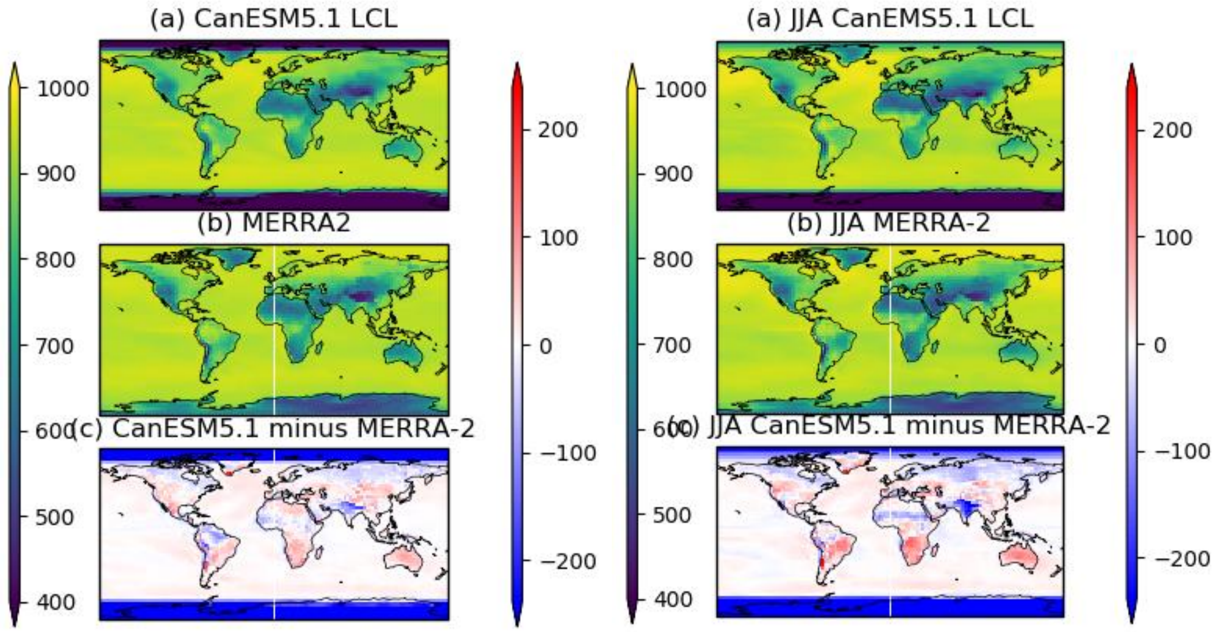

Figure S3: 2017-2019 (left) Annual mean, and (right) summertime (JJA) mean of LCL from (a) CanESM5.1 and (b) derived by MERRA-2 reanalysis, and (c) their differences (all in hPa).

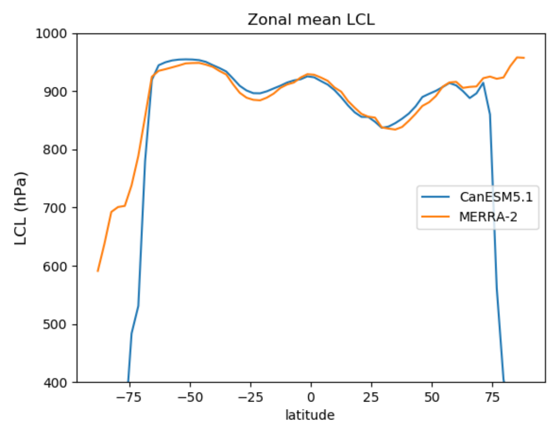

Figure S4: 2017-2019 annually averaged zonal mean LCL from MERRA-2 (orange) and CanESM5.1 (blue).

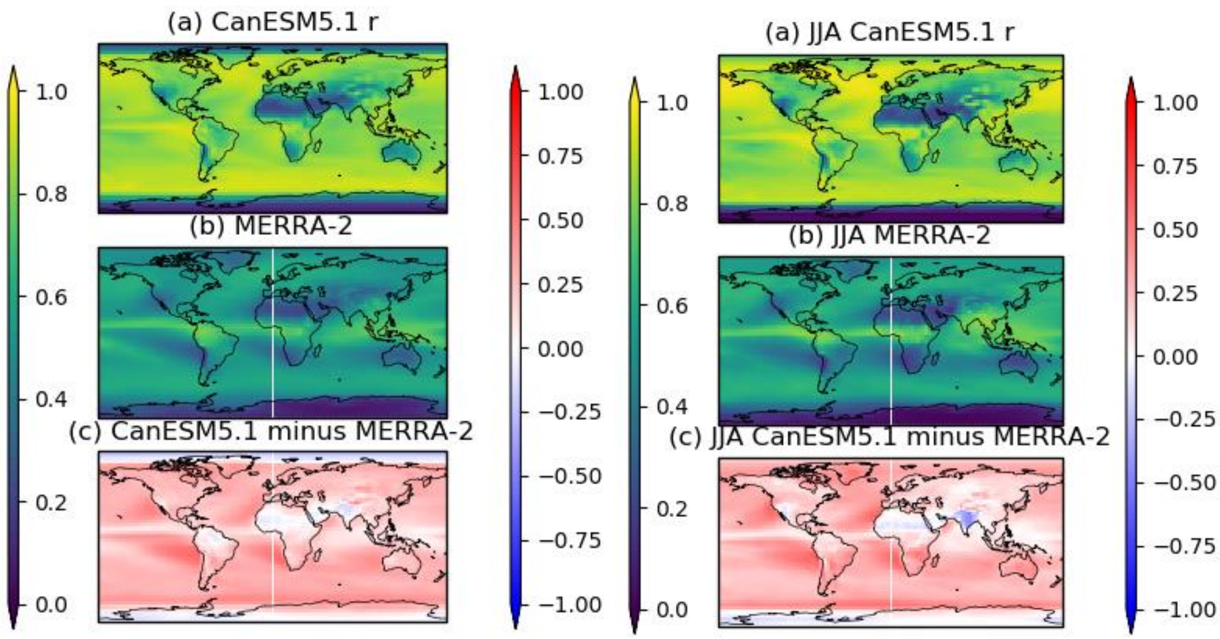

Figure S5: 2017-2019 (left) annual mean and (right) summertime (JJA) mean r from (a) CanESM5.1 and (b) derived by MERRA-2 reanalysis, and (c) their differences (unitless fractions).

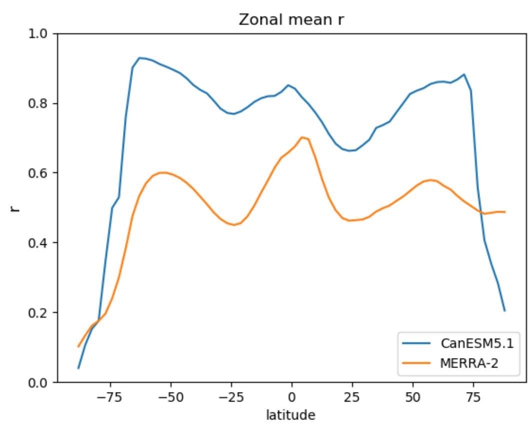

Figure S6: 2017-2019 annually averaged zonal mean r from MERRA-2 (orange) and CanESM5.1 (blue).