Supplementary information

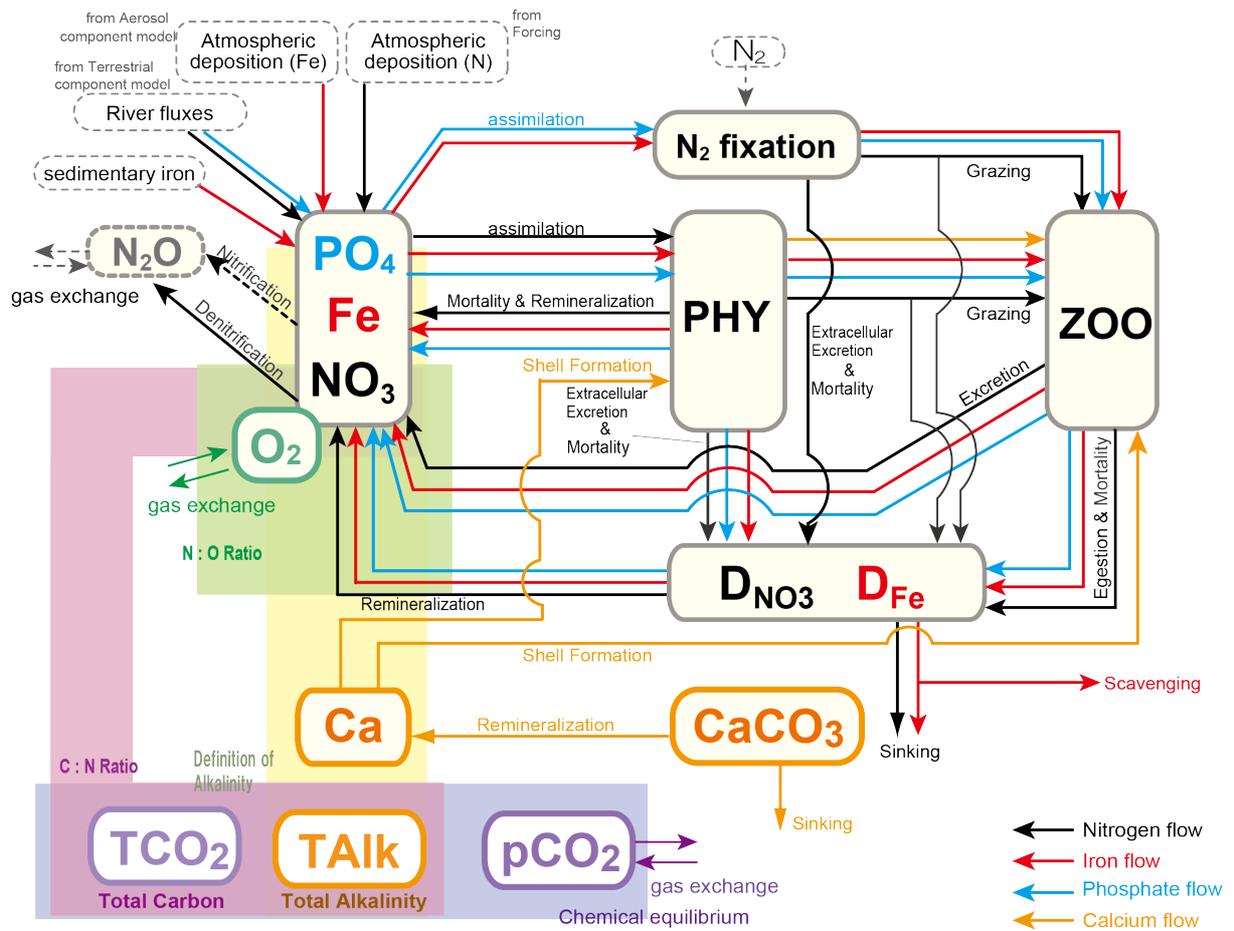
2085

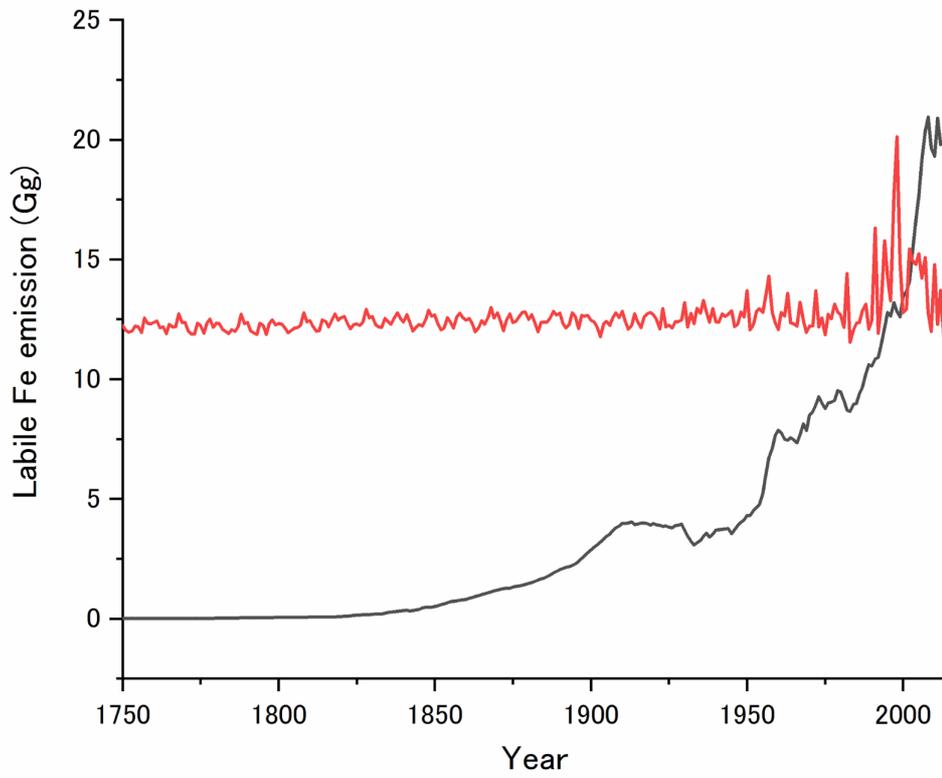
Supplementary Figure 1

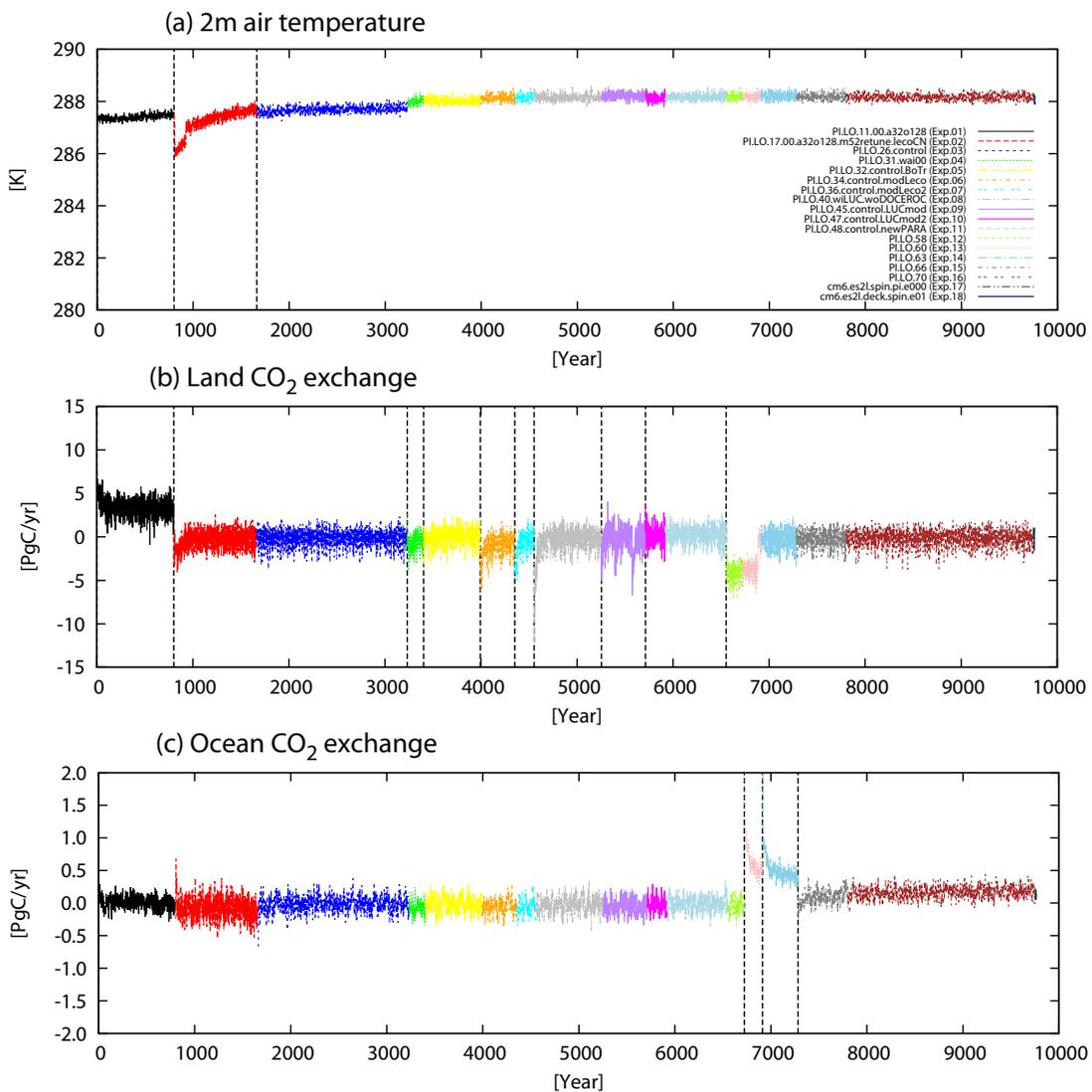
Structure of nitrogen pool and flow in the land ecosystem component model. Boxes colored green, red, and blue represent vegetation N, soil organic N, and inorganic N, respectively. Arrows indicate internal N flow within land ecosystem (black), N flow into ecosystem (orange), and N flow out of ecosystem (cyan). Bold characters represent the names of N cycle processes/pools and the italic text indicates variable names.

2090

Supplementary Figure 2

Distributions of (a) vegetation types used for VISIT-e (b) crop fraction (%) in 1850, and (c) crop fraction (%) in 2014.
Vegetation types are based on MODIS vegetation cover category: 1 = evergreen needleleaf forest, 2 = evergreen broadleaf forest, 3 = deciduous needleleaf forest, 4 = deciduous broadleaf forest, 5 = mixed forest, 6 = closed shrubland, 7 = open shrubland, 8 = woody savanna, 9 = savanna, 10 = grassland, 11 = permanent wetland, and 12 = desert. Cropland is not included in the vegetation map, but it is simulated as one of the model tiles, the areal fraction of which follows CMIP6 forcing (LUH2 (Ma et al., 2019); http://luh.umd.edu).

Supplementary Figure 3

2105   Schematic of biogeochemical compartments and flows in OECO-v2.

Supplementary Figure 4

2110   Historical emissions of labile Fe from biomass burning (red lines) and fossil fuel and biofuel combustion (black lines) during 1750–2014.

Supplementary Figure 5

History of MIROC-ES2L development and the spin-up presented by changes in (a) global mean 2 m air temperature, (b) atmosphere–land CO_2, and (c) atmosphere–ocean CO_2 flux (for CO_2 flux, positive means uptake). Colors represent experimental sets in development phases. Spin-up started at January 2017 (Exp. 01, black line) with a fully integrated system (i.e., physical core plus biogeochemical components). Spin-up ended at January 2019 after a series of final phase spin-up (Exp. 15, 16, 17, and 18 colored gray, brown, green, and blue, respectively). All simulations performed in this study were initiated from the endpoint in the plots. Vertical dashed lines represent the time at which part of the initial conditions of MIROC-ES2L was replaced by that created by the offline component models. For example, at year 7283, the initial condition of ocean biogeochemistry was replaced by that created by the offline OECOv2 spin-up after 3000 years with majorly updated source code. After the beginning of Exp. 15 (gray line, started at year 7283), continuous spin-up was performed by MIROC-ES2L for 2483 years with minor source code modifications.

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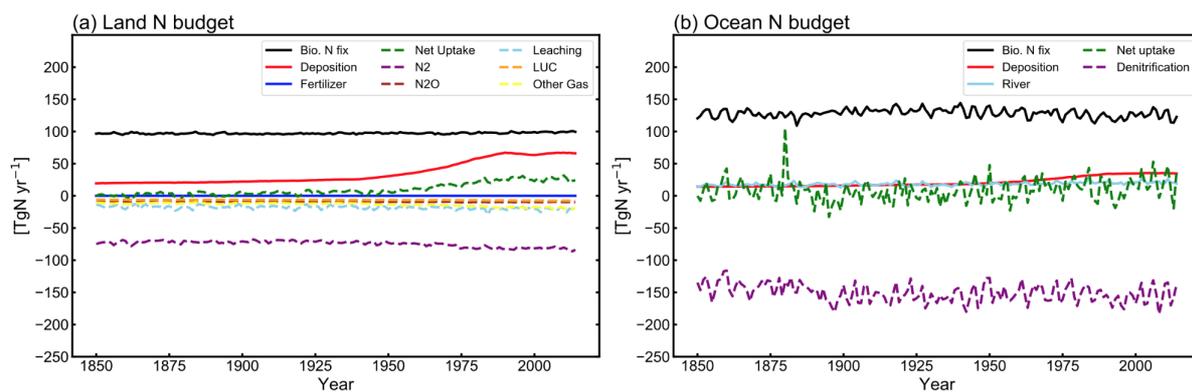
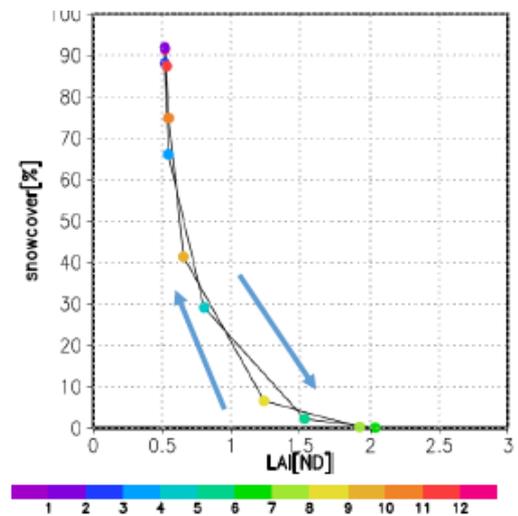
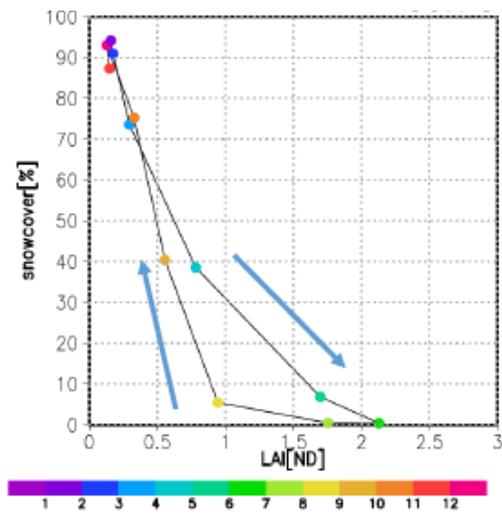

Supplementary Figure 6

Same as Fig. 4 but for HIST-NOLUC simulation.

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Supplementary Figure 7

Annual cycle of relationship between snow fraction (Y-axis) and LAI (X-axis) in the northern high-latitude land region based on 2000–2014 climatology. Colored dots indicate monthly mean snow fraction and LAI averaged for 50°–80°N. Left panel is derived from MODIS data and the right panel is derived from a historical run of MIROC-ES2L.

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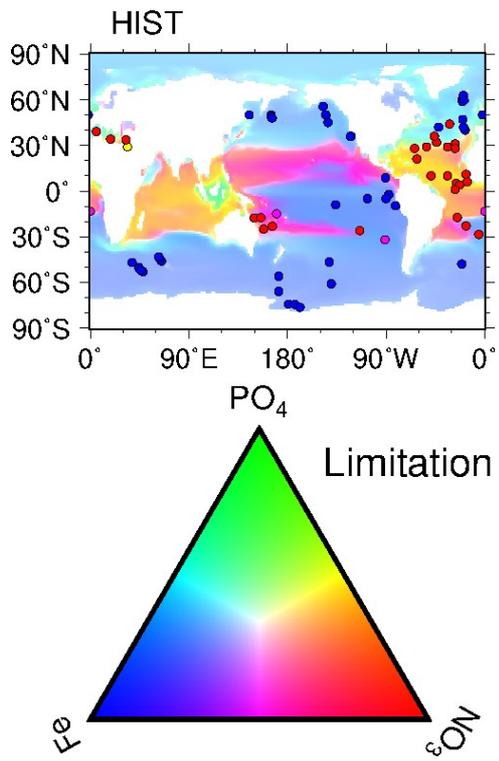
Supplementary Figure 8

2145   Same as Fig. 15 but for the HIST simulation.