Table 1 Summary list of feedback loops

Feedback	Effect of climate change	Effect on climate change	+/–
20 physical feedback loops			
1. Planck†	↑ Temperature	↑ Heat loss (radiation)	–
2. Water vapor†	↑ Increasing water vapor content	↑ Greenhouse effect	+
3. Sea ice albedo*†	↑ Sea ice melting or not forming	↓ Albedo	+
4. Ice sheets*†‡	↑ Glacier & ice sheet melting/instability	↓ Albedo	+
5. Sea level rise‡	↑ Sea levels	↓ Albedo (↑ coastal submergence)	+
6. Snow cover†	↓ Snow cover	↓ Albedo	+
7. Clouds†	Δ Cloud distribution & optical properties	Δ Cloud albedo & greenhouse effect	+
8. Dust†	Δ Dust aerosol abundance	Δ Albedo & greenhouse effect	?
9. Other aerosols†	Δ Atmos. aerosol conc.	Δ Albedo & greenhouse effect	?
10. Ocean stratification	↑ Ocean stratification	↓ Carbon uptake by ocean	+
11. Ocean circ.*	↓ Ocean circ.	Δ Surface temperature	?
12. Solubility pump†	↑ Atmos. CO_2 levels	↓ CO_2 absorption by ocean	+
13. CH_4 hydrates*‡	↑ CH_4 hydrate dissociation rates	↑ Release of CH_4 into atmos.	+
14. Lapse rate†	Δ Temp.-altitude relationships	↓ Global mean temperature	–
15. Ice-elevation‡	↓ Ice sheet/glacier elevation	↑ Glacier & ice sheet melting, ↓ albedo	+
16. Antarctic rainfall‡	↓ Ice sheet extent, ↑ precipitation	↓ Albedo, ↑ deep ocean warming	+
17. Sea ice growth	↓ Sea ice thickness, ↓ insulation	↑ Thin ice growth rate	–
18. Ozone†	Δ Atmos. circ.	↓ Tropical lower stratospheric ozone	?
19. Atmos. reactions†	Δ Atmos. chem. reaction rates	Δ Greenhouse effect	?
20. Chem. weathering‡	↑ Chemical weathering rates	↑ CO_2 taken out of atmosphere	–
21 biological feedback loops			
21. Peatlands†	↑ Drying and fire, ↓ Soil carbon	↑ Release of CO_2 into atmos.	+
22. Wetlands†	↑ Wetlands area (↑ precipitation)	↑ CO_2 seq., ↑ CH_4 emissions	+
23. Freshwater	↑ Aquatic plant growth rates	↑ CH_4 emissions	+
24. Forest dieback*	↑ Amazon and other forest dieback	↓ CO_2 seq., Δ albedo	+
25. Northern greening	↑ Boreal forest area, Arctic vegetation	↑ CO_2 seq., ↓ albedo	+
26. Insects	Δ Insect ranges and abundances	↓ CO_2 seq., Δ albedo	+
27. Wildfire†	↑ Fire activity in some regions	↑ CO_2 emissions, Δ albedo	+
28. BVOCs†	Δ BVOC emission rates	↓ Greenhouse effect, ↑ tropospheric O_3	–
29. Soil carbon (other)	↑ Loss of soil carbon	↑ CO_2 emissions	+
30. Soil nitrous oxide†	Δ Soil microbial activity	↑ Nitrous oxide emissions	+
31. Permafrost*†	↑ Permafrost thawing	↑ CO_2 and CH_4 emissions	+
32. Soil and plant ET	↑ ET from soils and plants	↓ Latent heat flux	+
33. Microbes (other)	↑ Microbial respiration rates	↑ CO_2 and CH_4 emissions	+
34. Plant stress	↑ Thermal stress, ↑ droughts	↑ Plant mortality, ↓ CO_2 seq.	+
35. Desertification	↑ Desert area	↓ CO_2 seq., Δ albedo	+
36. Sahara/Sahel greening*	↑ Rainfall in Sahara and Sahel	↑ CO_2 seq. by vegetation	–
37. CO_2 fertilization	↑ CO_2 conc., ↑ NPP	↑ Carbon uptake by vegetation	–
38. Coastal productivity	↑ Coastal ecosystem degradation	↓ Coastal ecosystem carbon seq.	+
39. Metabolic rates	↑ Phytoplankton respiration rates	↑ CO_2 released into atmos.	+
40. Ocean bio.	↑ Ocean CO_2, ↑ acidification, ↑ temp.	Δ Ocean carbon sink	?
41. Phytoplankton-DMS†	Δ Plankton DMS emissions	Δ Cloud albedo	?

Loops are divided into two categories: physical (loop numbers 1–20) and biological (loop numbers 21–41). The rightmost column shows the loop direction ("+": reinforcing, "-": balancing, "?": uncertain). Feedback loops that involve potential tipping elements are marked with asterisks (*; see supplemental experimental procedures). As a rough indicator of feedbacks that are more likely to be at least partly included in some climate models, loops that are covered in Figure TS.17 (feedbacks overview) or 5.29 (biogeochemical feedbacks) of IPCC[4] are marked with daggers (†). Many of these feedbacks will have significant effects on Earth's climate, but others are more speculative and possibly negligible. Feedback impacts operate on time scales ranging from short (e.g., months/years) to very long (e.g., millennia); feedbacks we believe to be exceptionally slow are marked with double daggers (‡). Symbols indicate increasing (↑), decreasing (↓), and changing (Δ), and abbreviations correspond to circulation (circ.), concentration (conc.), temperature (temp.), atmospheric (atmos.), chemical (chem.), sequestration (seq.), biogenic volatile organic compounds (BVOCs), ozone (O_3), evapotranspiration (ET), biological pump (bio.), and dimethyl sulfide (DMS). See supplemental experimental procedures and Table S1 for complete loop descriptions, grouping order, limitations (e.g., overlapping loops and uncertain tipping elements), and selected references.