

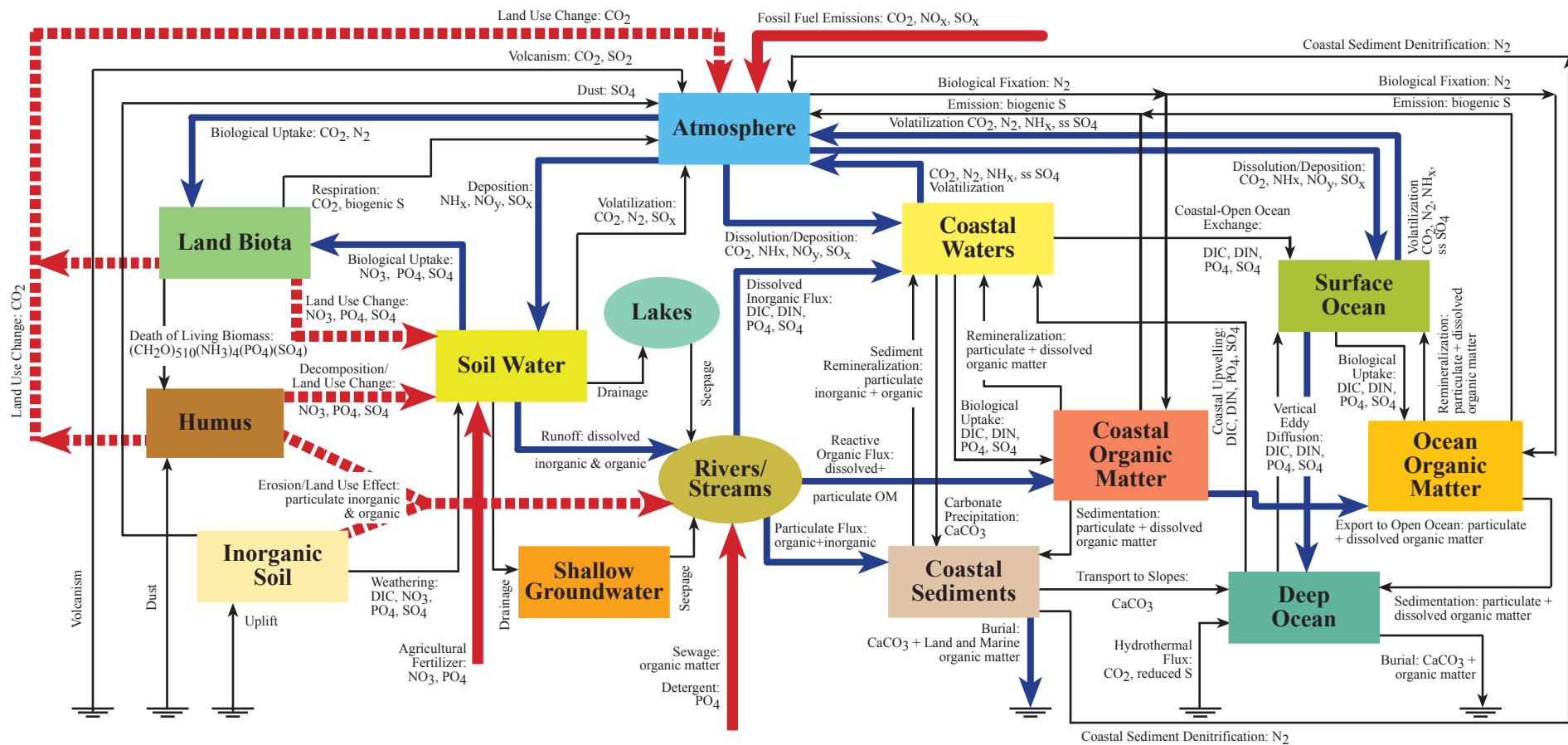
Global Biogeochemical Cycles: Feedbacks and Climate Change

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Terrestrial Ocean a Tmosphere Ecosystem Model (TOTEM)

- **Four domains of land, ocean, sediments, and atmosphere involving 13 reservoirs**
- **Cycles of C, N, P, & S are coupled via biogeochemical processes**
- **Process-based equations using**
 - **Gas exchange kinetics**
 - **Michaelis-Menten type kinetics**
 - **Zeroth- and first-order kinetic equations**
 - **Non-linear formulations**



Questions

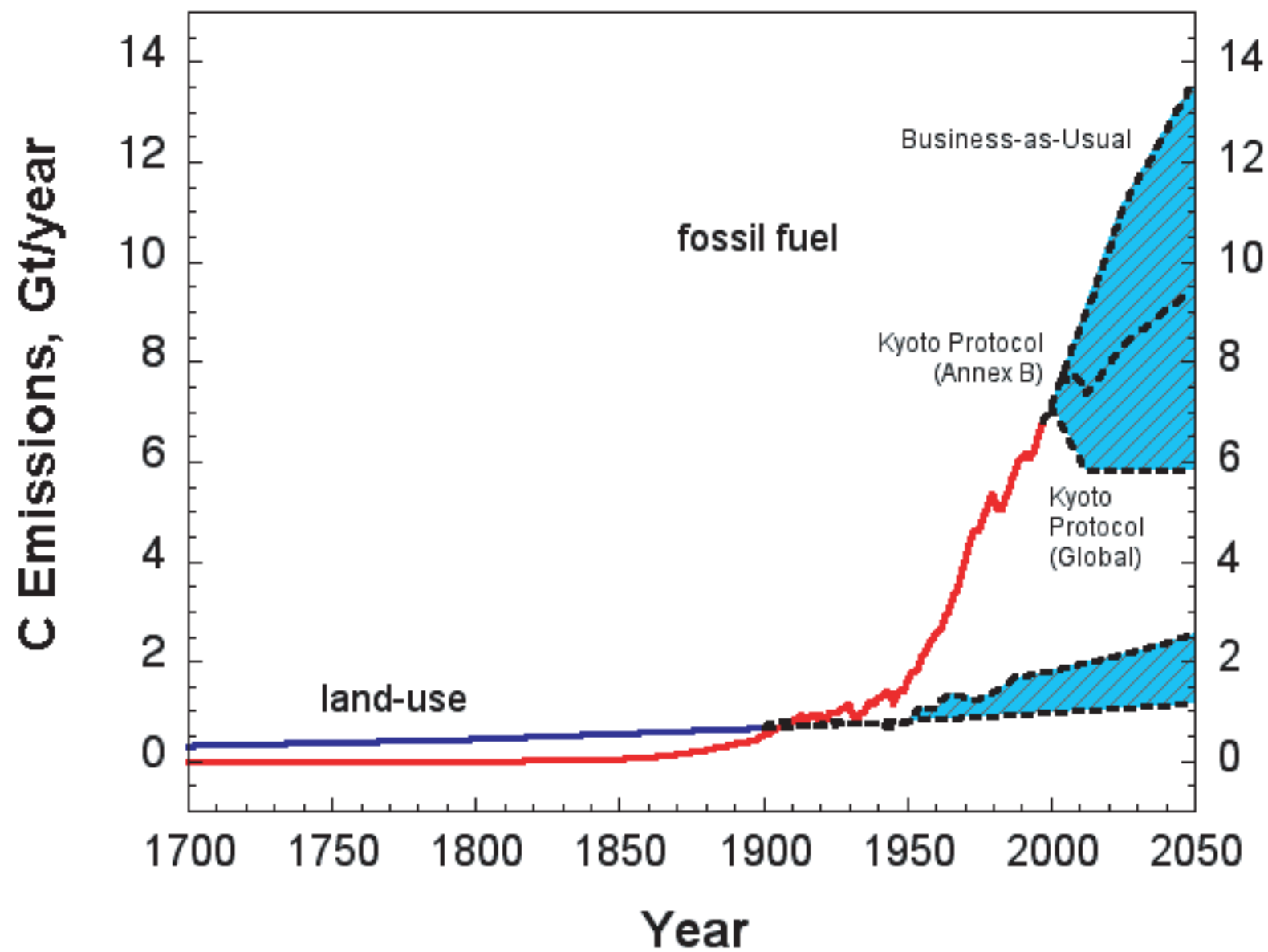
- **Where has all the anthropogenic CO₂ released to the atmosphere in recent centuries gone? Is there a Missing Sink?**

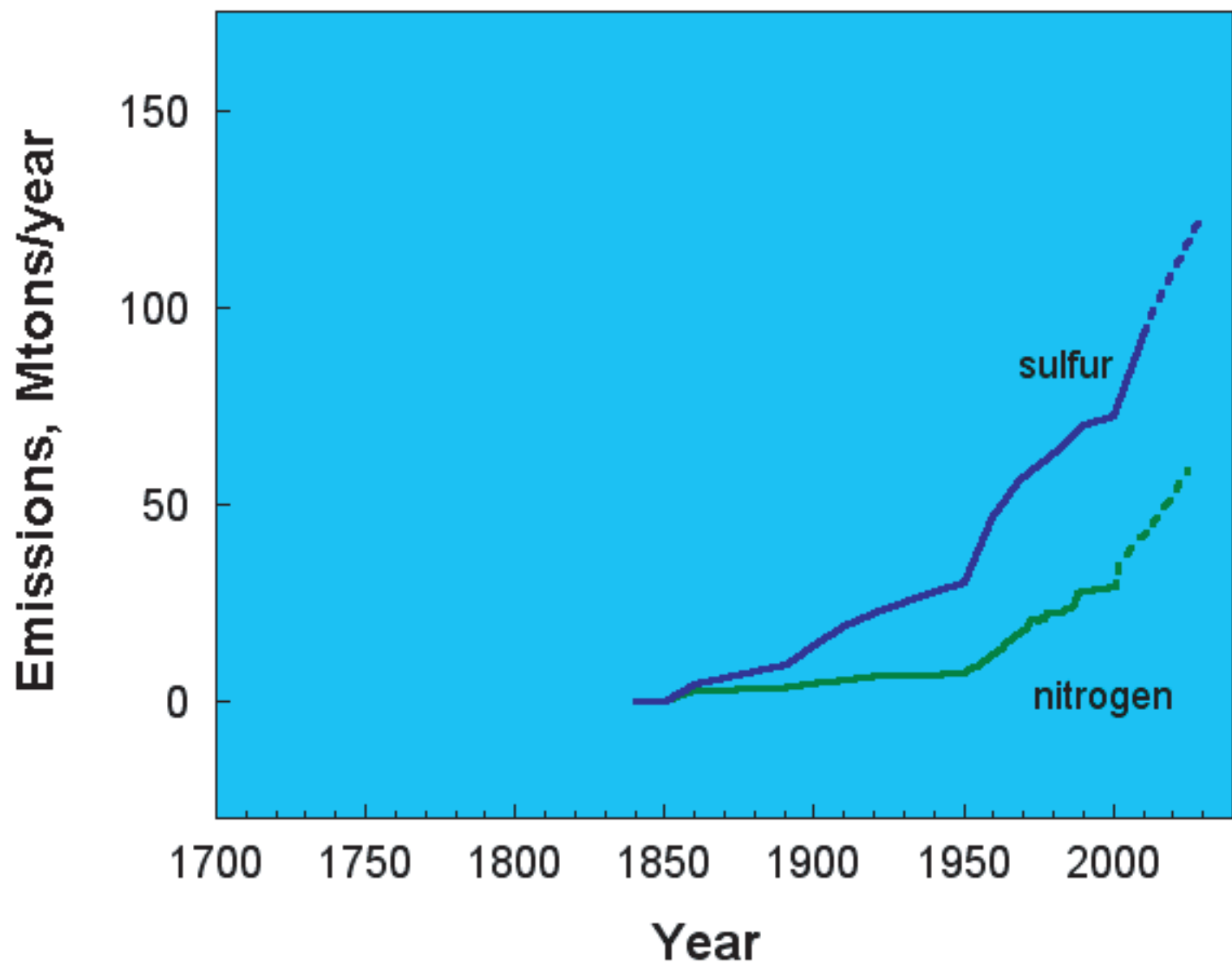
Questions

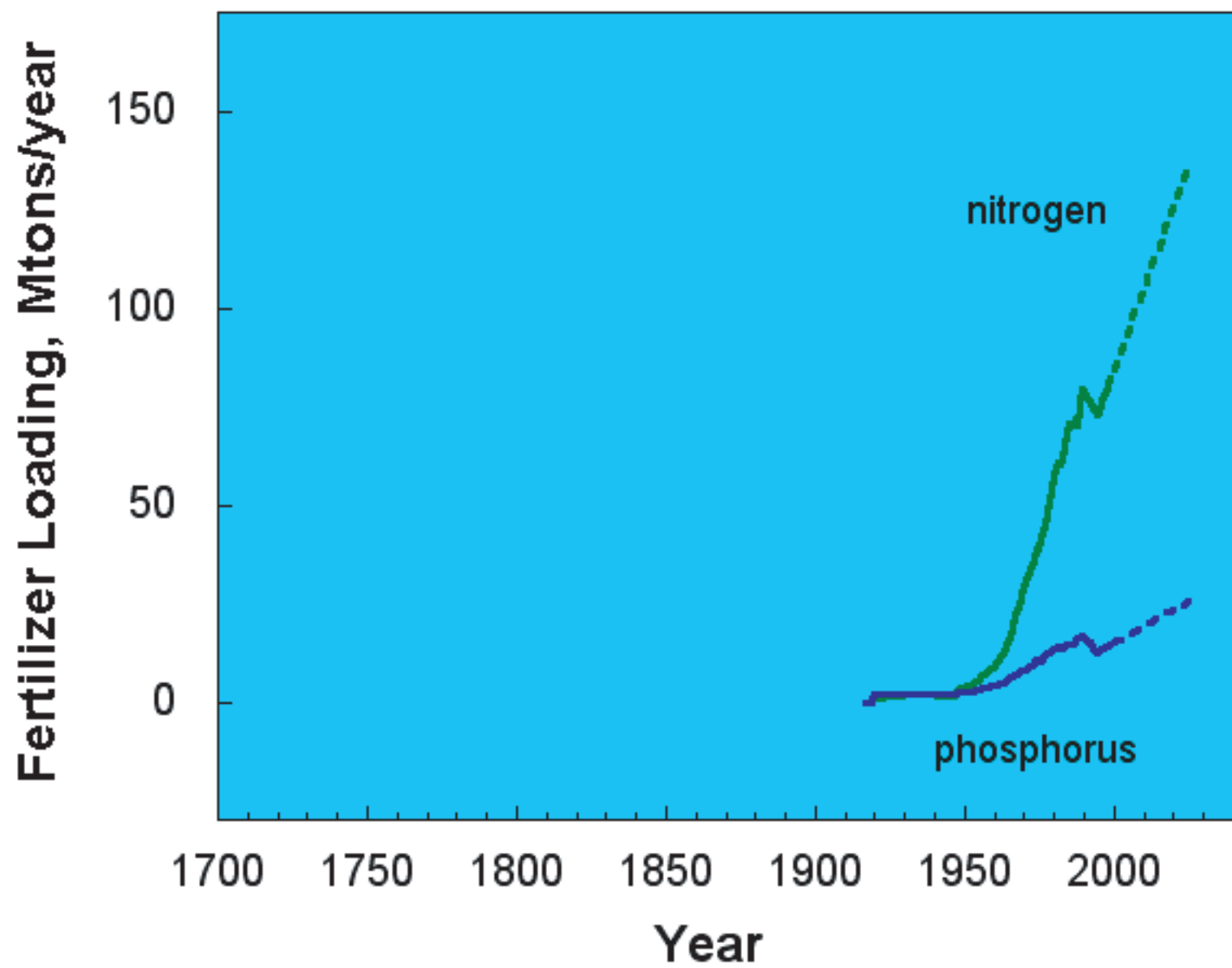
- **How will the Kyoto Protocol, if fully implemented, affect future atmospheric CO₂ levels?**

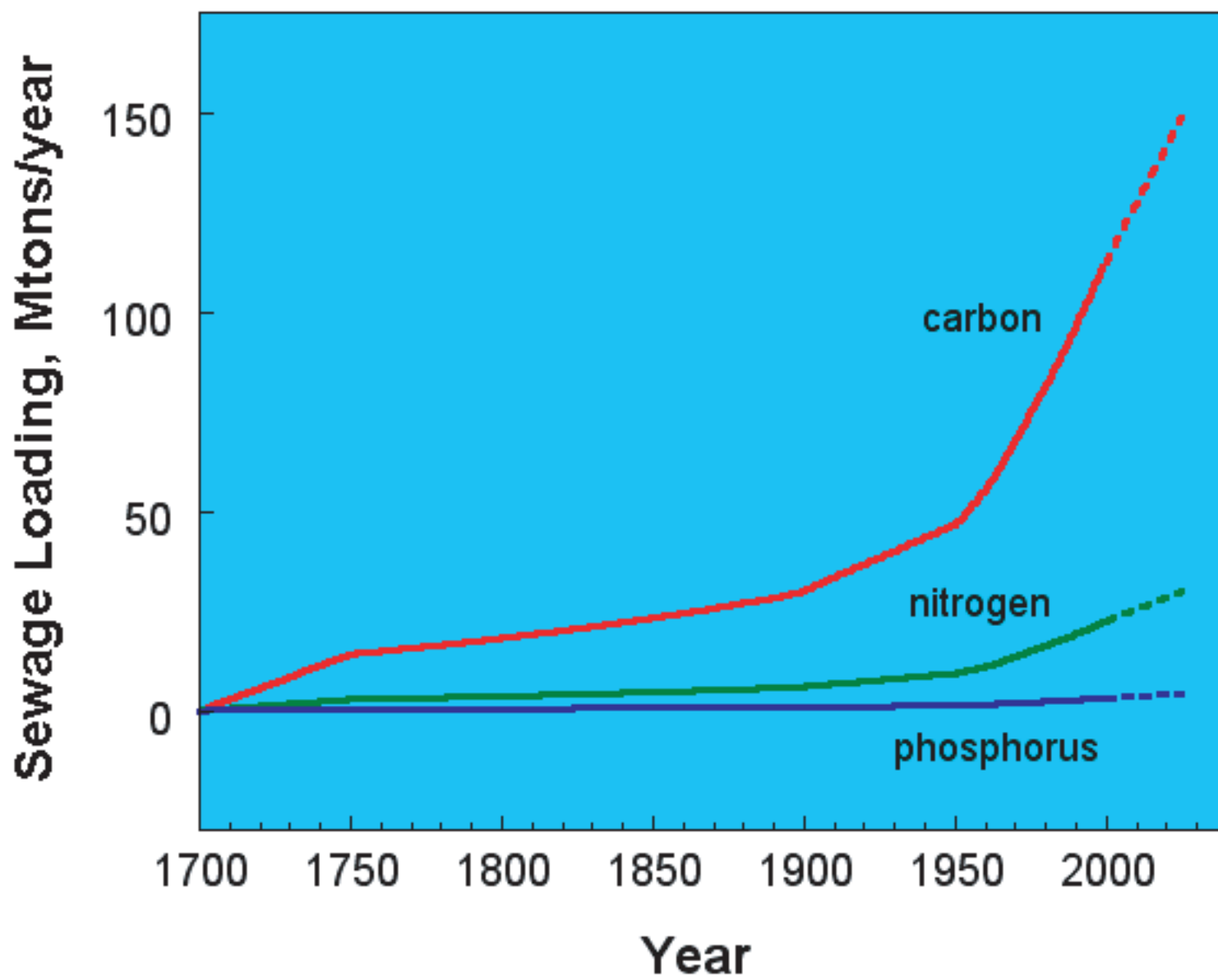
Questions

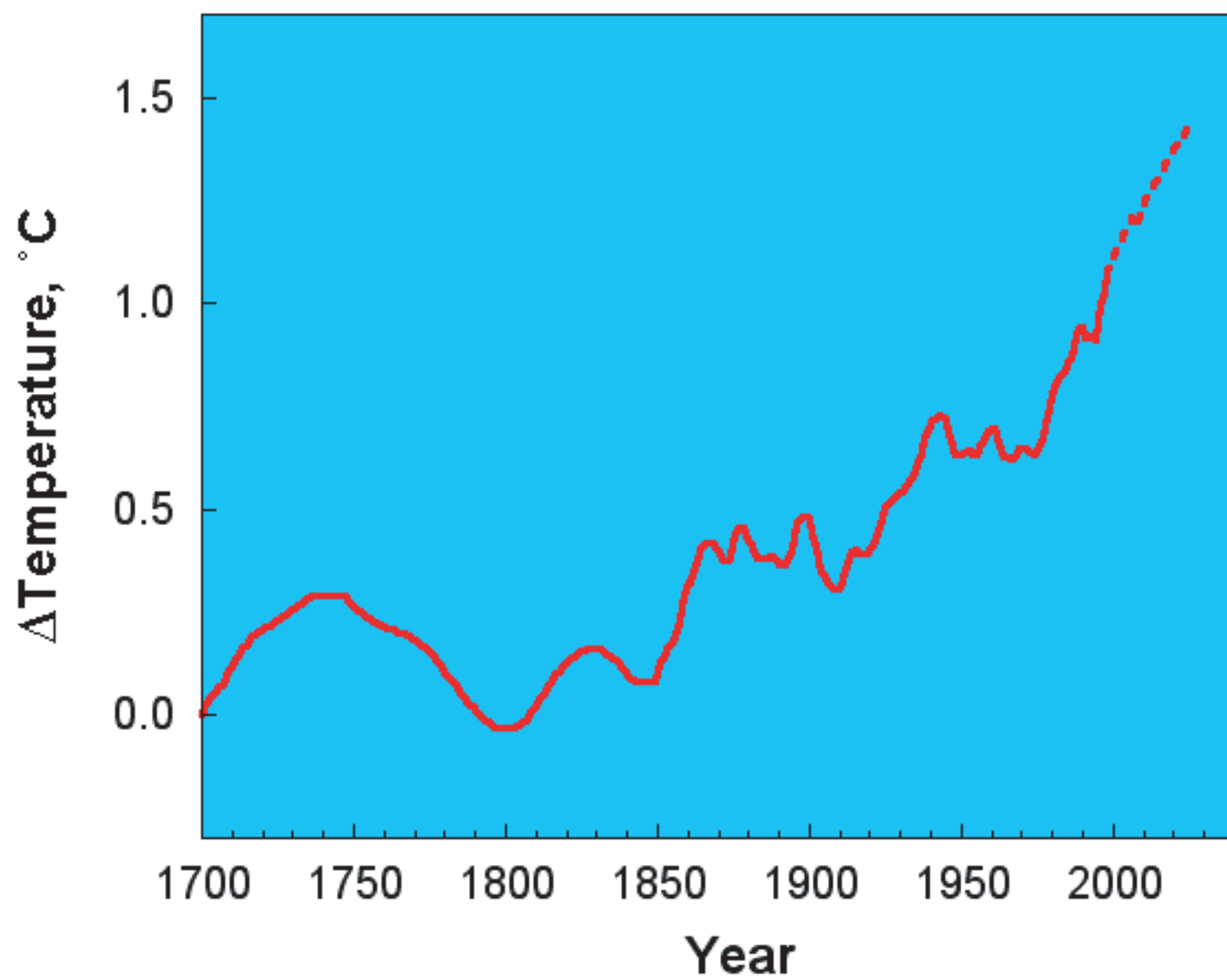
- **How will future changes in the thermohaline circulation pattern of the ocean affect the carbon balance in the oceans?**
- **How will changes in atmospheric CO₂ affect carbonate saturation state Ω and biological carbonate production in the global coastal ocean?**

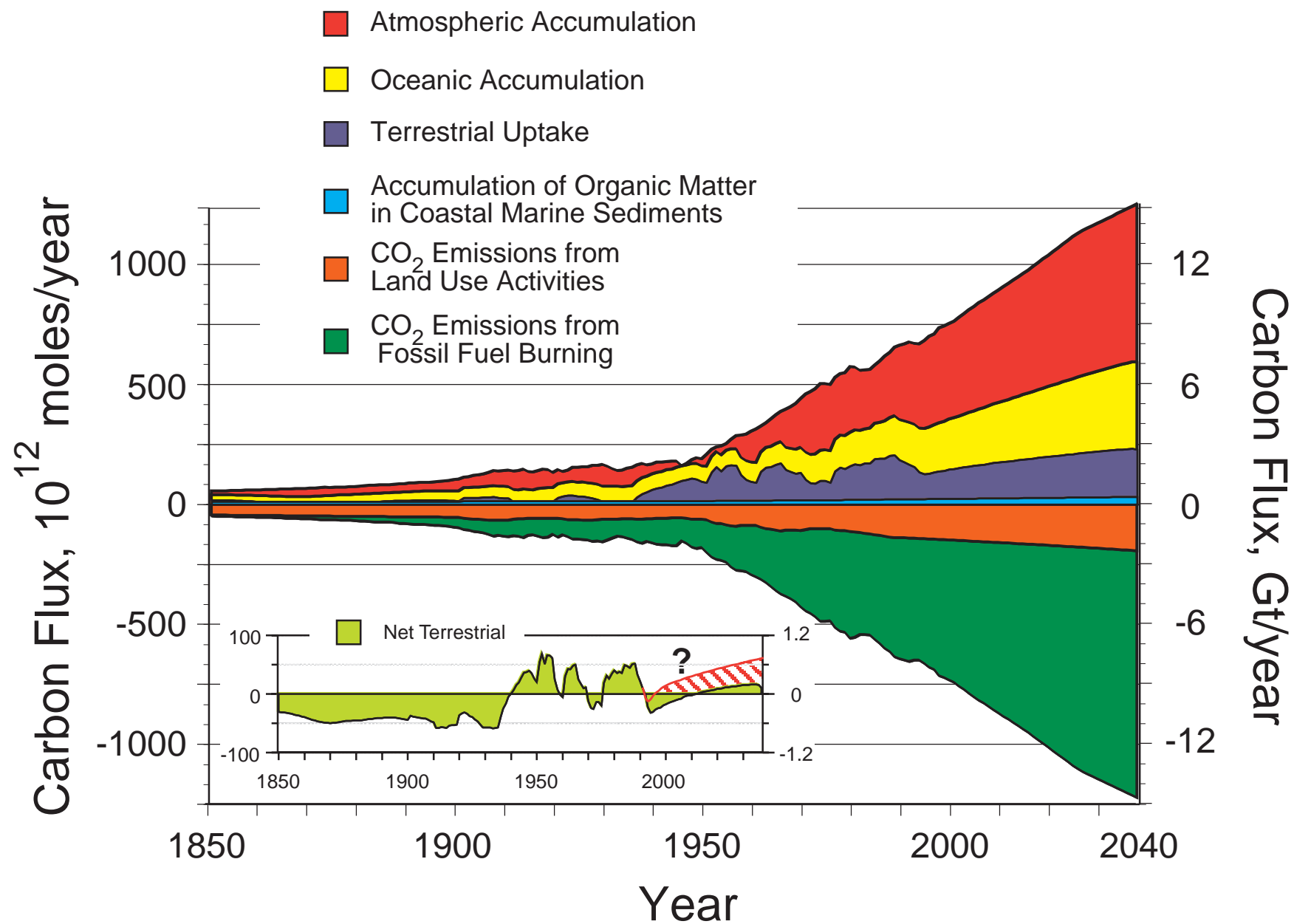


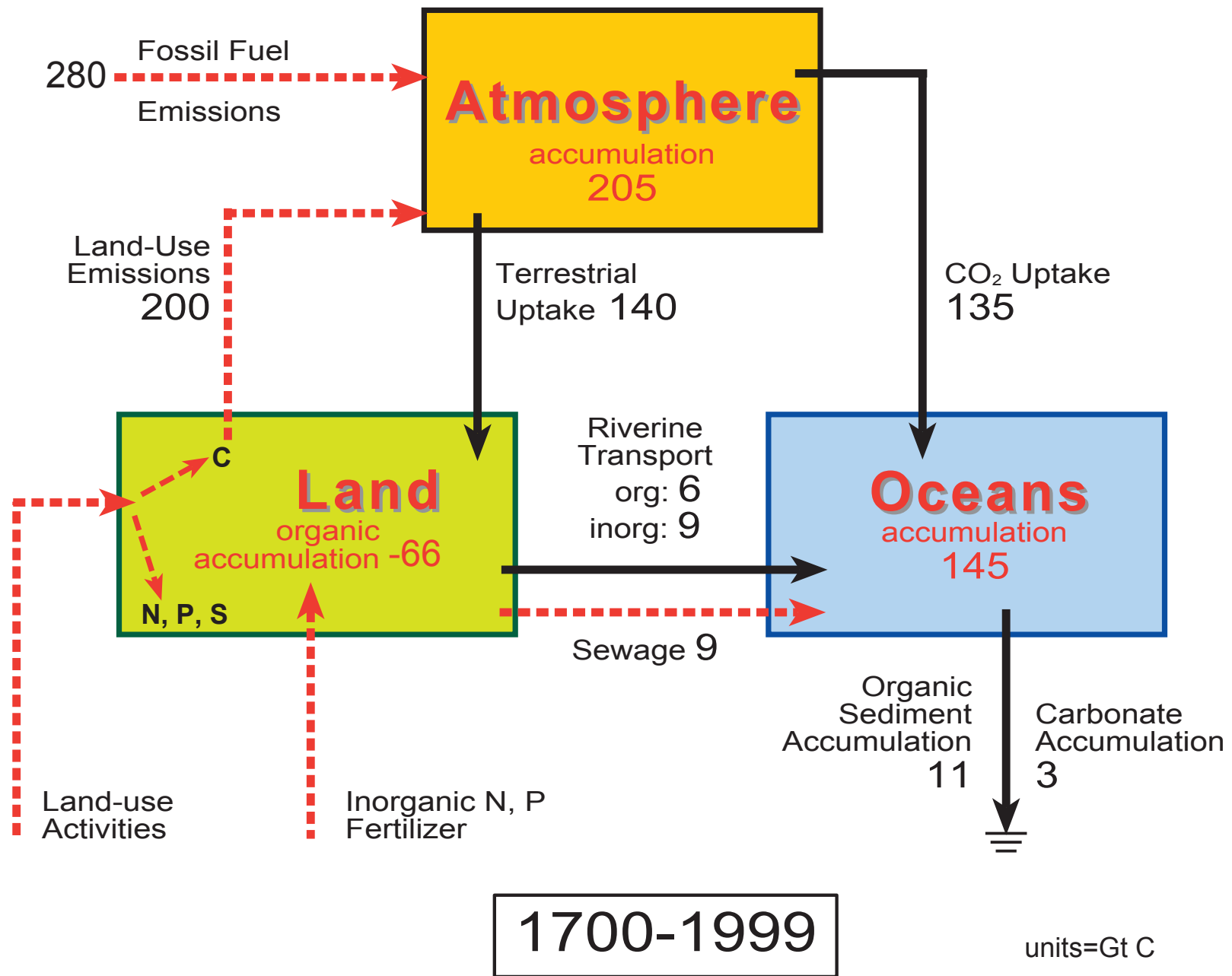


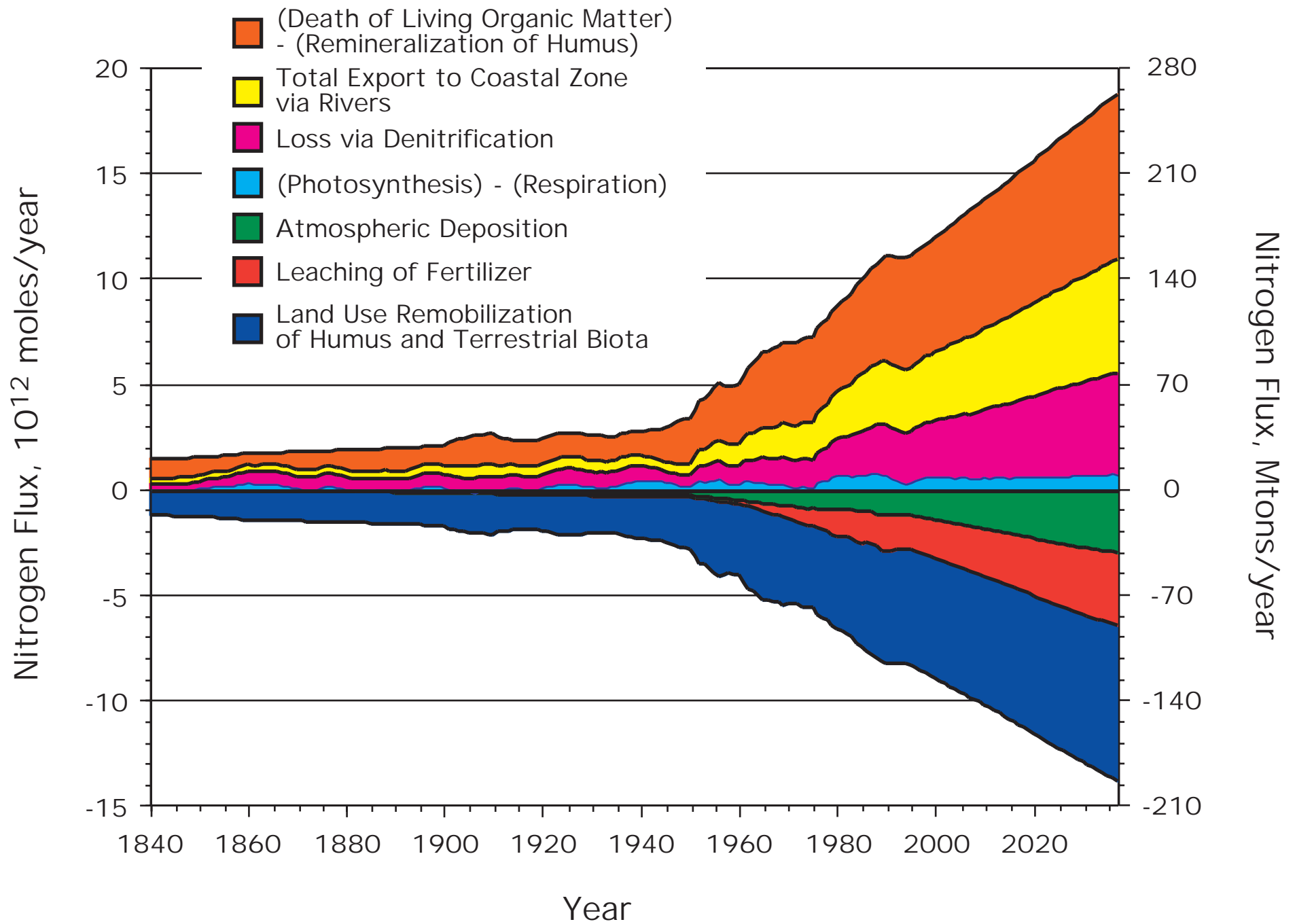


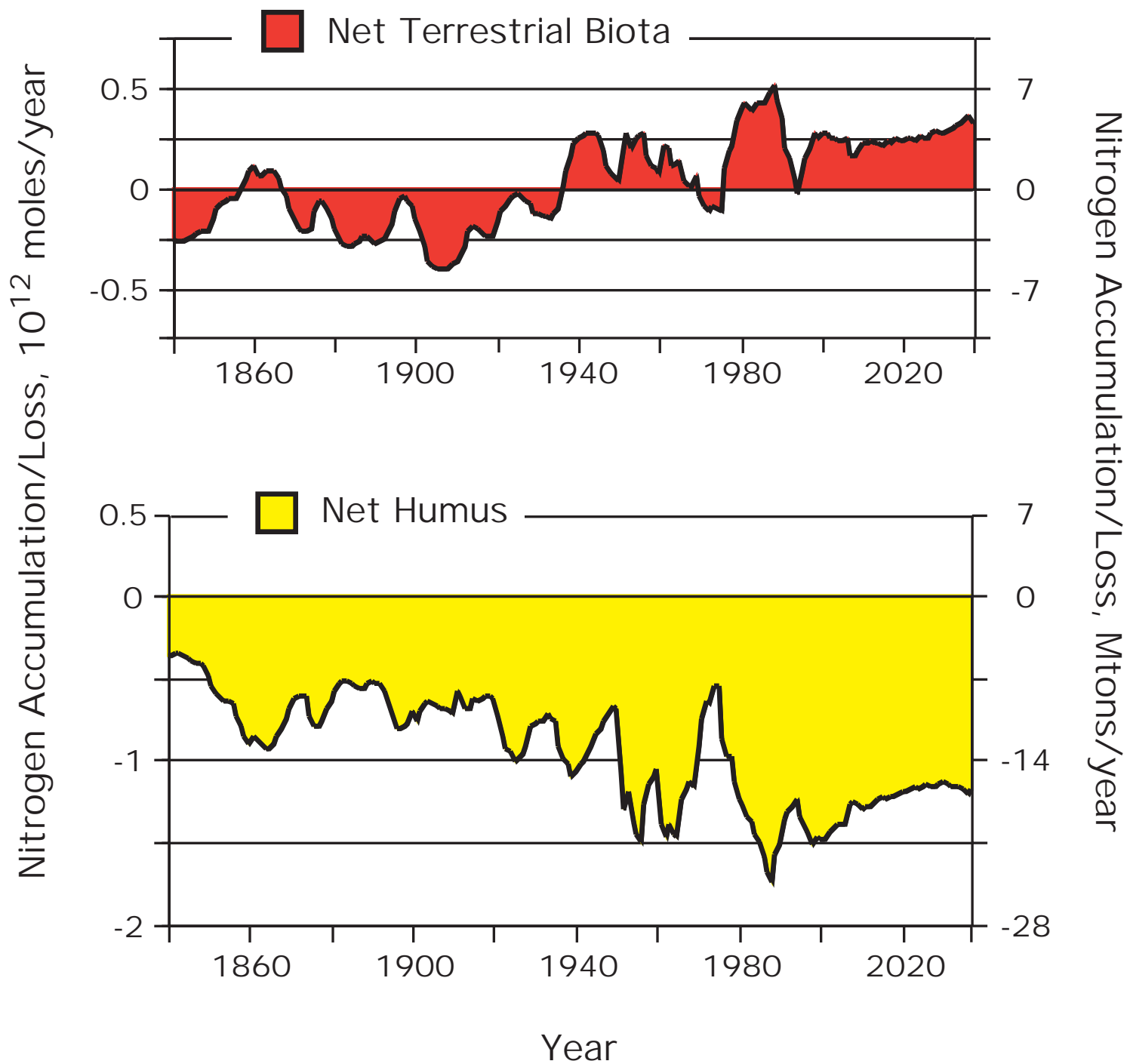


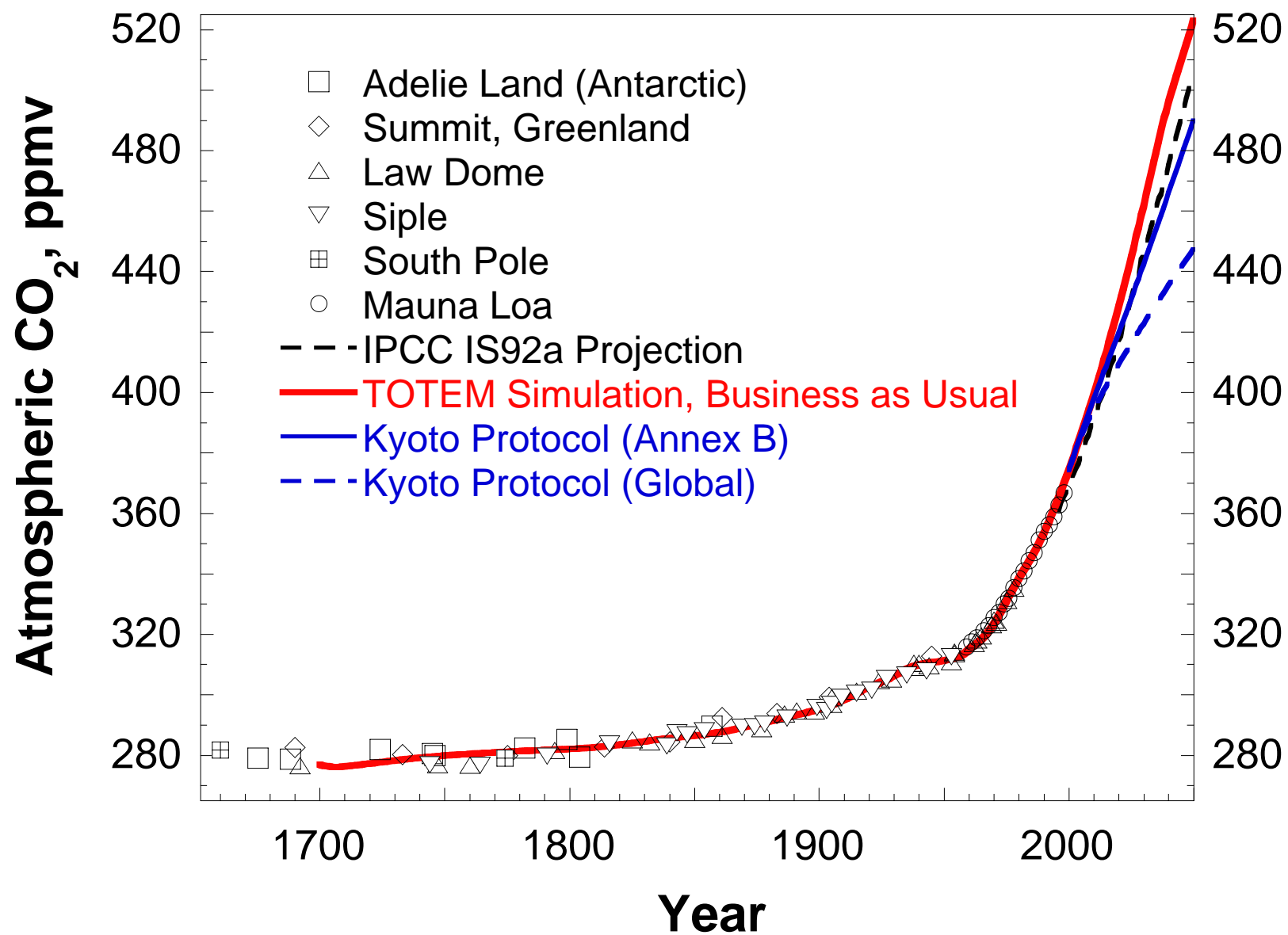




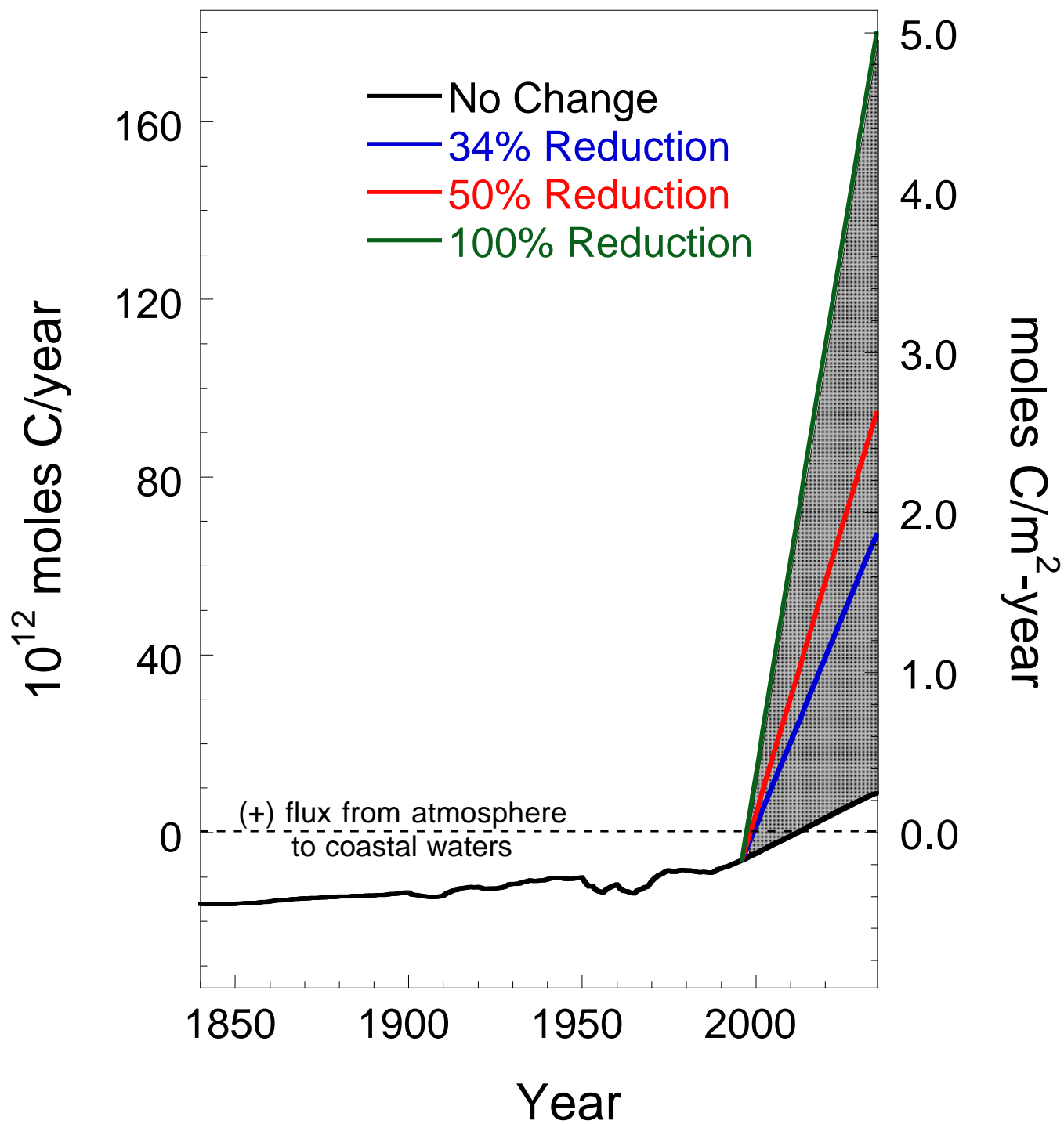




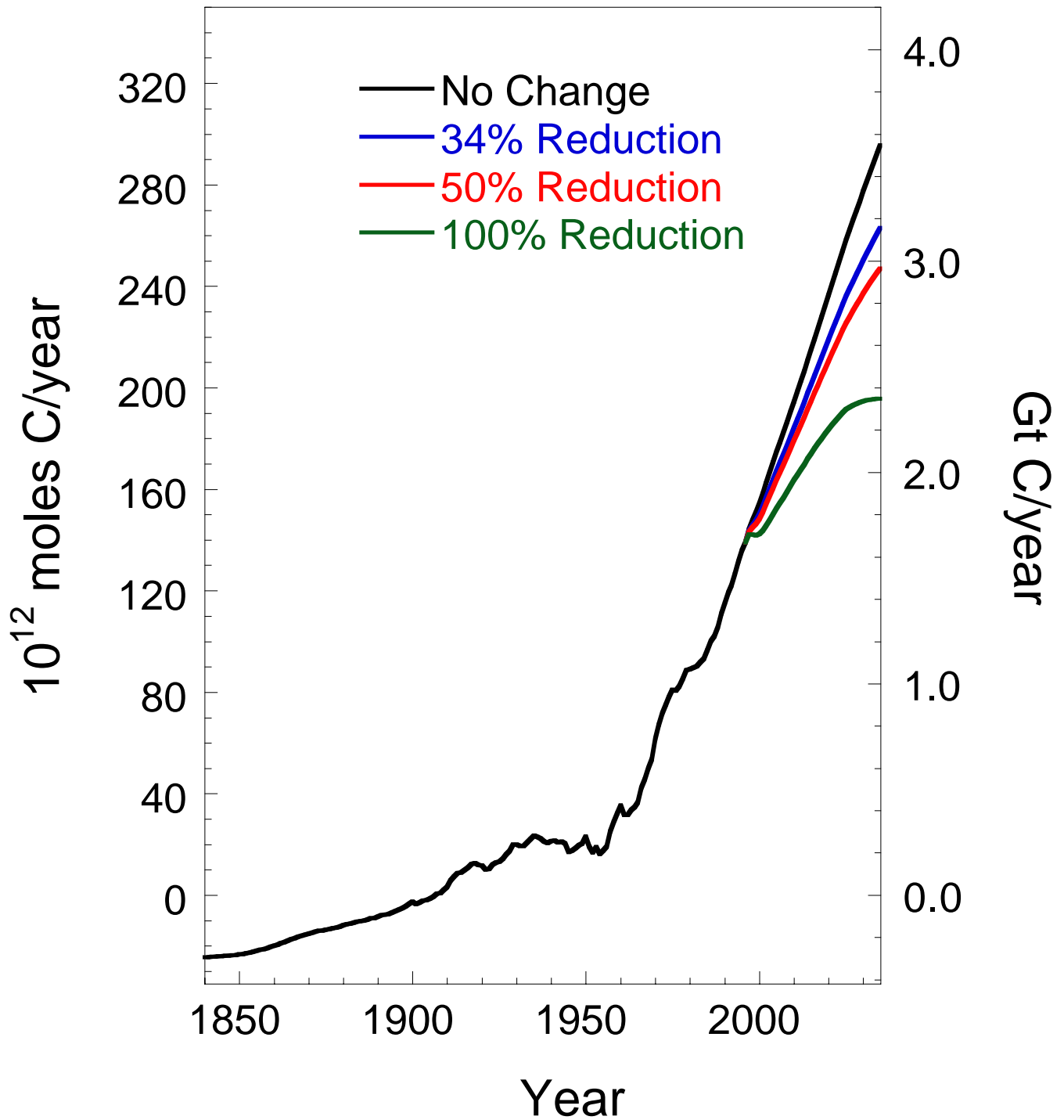


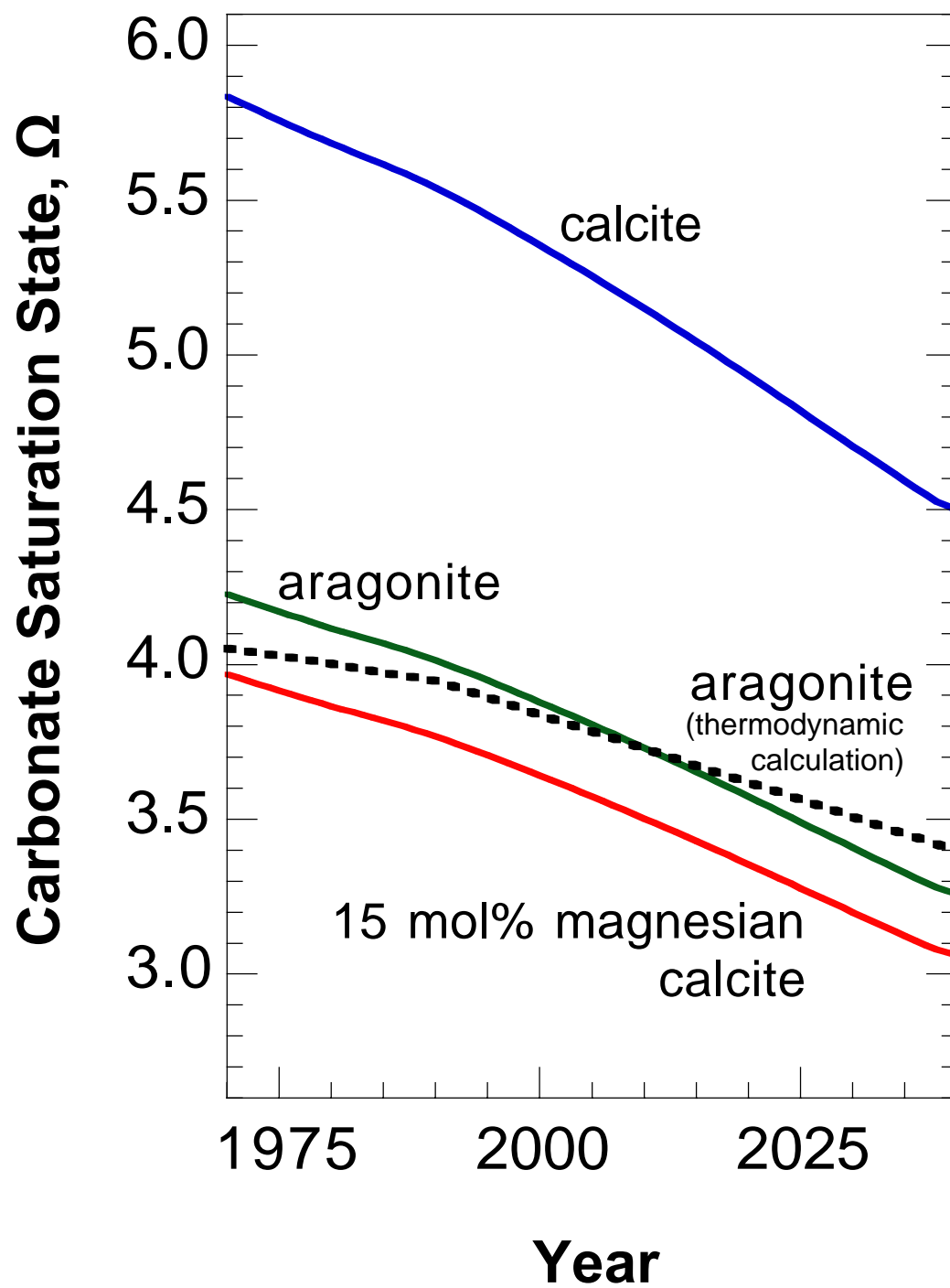


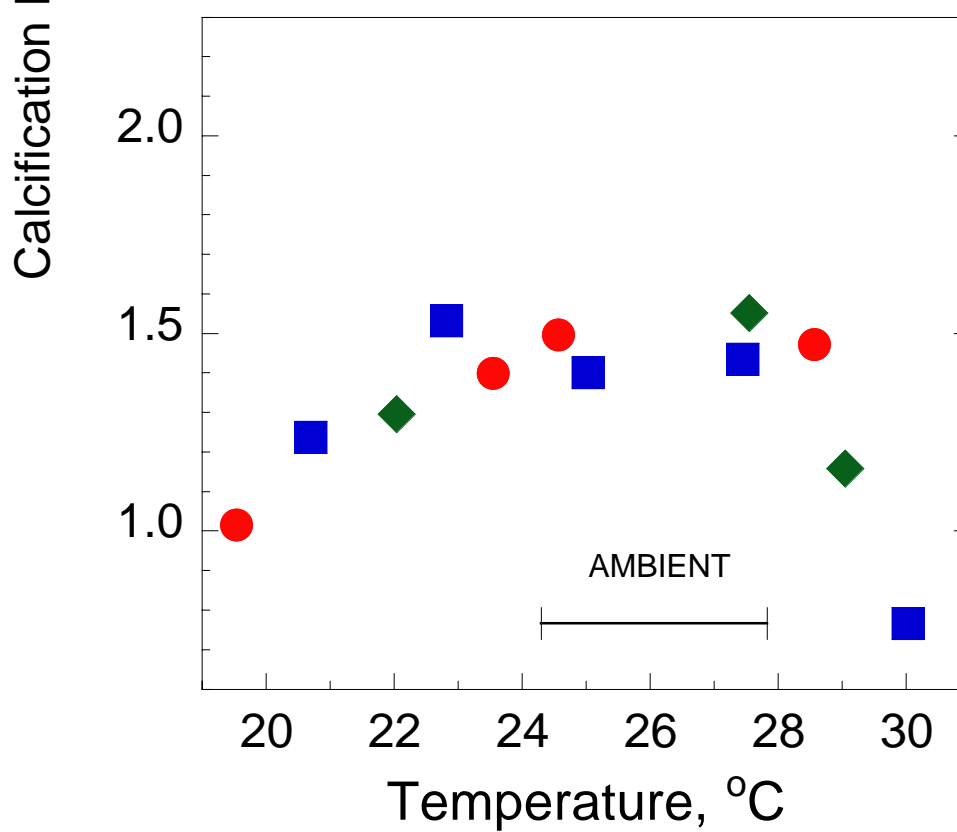
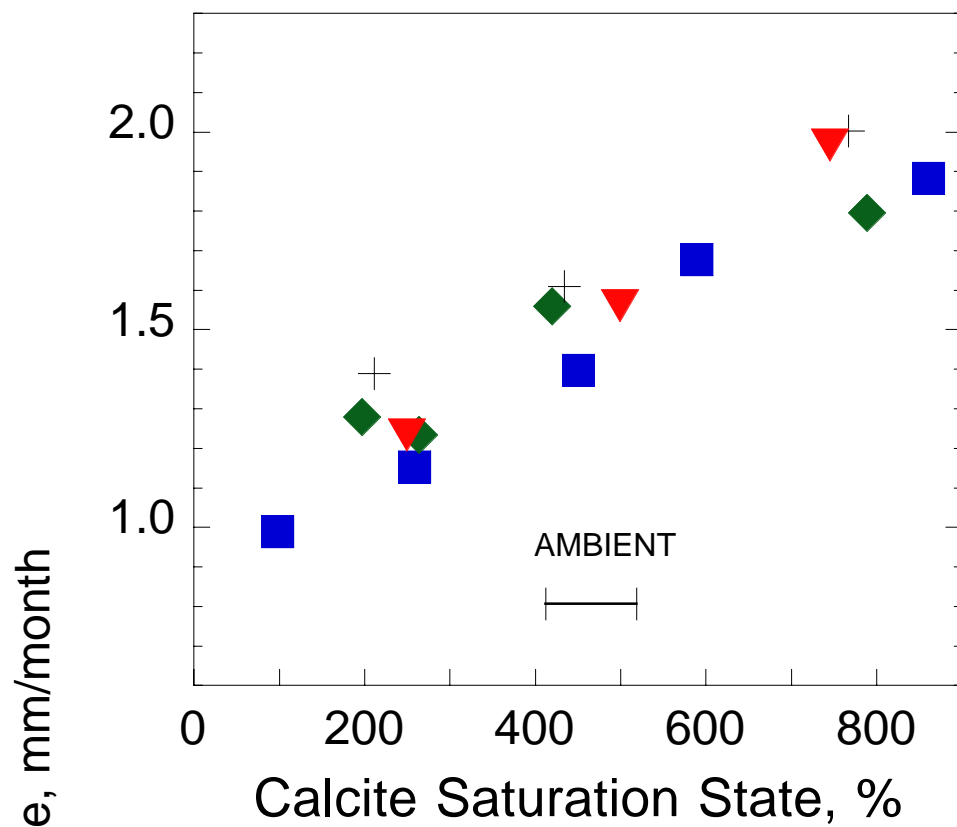
Coastal Ocean-Atmosphere Flux



Total Ocean-Atmosphere Flux







Summary

- **There is no “missing sink.” Anthropogenic CO₂ is mainly stored in the atmosphere and in the open ocean; the gain of C from the enhanced terrestrial photosynthetic uptake is less than the loss from deforestation and other land-use activities.**

Summary

- **CO₂ fertilization of terrestrial biota is partially supported by nutrients mobilized and relocated during land use activities.**
- **Increasing consumption of terrestrial organic C and carbonate precipitation in the coastal zone counteracts and weakens its ability to act as a greater sink for anthropogenic CO₂**

Summary

- **The coastal ocean has recently become a net sink for anthropogenic CO₂ owing to the rise in atmospheric CO₂**
- **Fertilizer use, erosion, and sewage discharges have doubled fluxes of N and P to coastal waters stimulating biological productivity and carbon storage**

Summary

- **Adherence to the Kyoto protocol by most of the industrialized nations in terms of regulating fossil fuel emissions could have a substantial effect on the rate of atmospheric CO₂ growth during the early part of the 21st century.**

Summary

- **Weakening of the oceanic thermohaline circulation reduces the CO₂-sink strength of the surface ocean while enhancing that of the coastal ocean.**

Summary

- **An increase in atmospheric CO₂ leads to a lower supersaturation state Ω of coastal ocean water with respect to calcite and aragonite, which may result in lower rates of carbonate storage in shallow oceanic areas.**