# EMBRACER

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## Earth System Feedback Research Centre

### Background

EMBRACER is a consortium of 5 Dutch universities | institutes funded by NWO, the Dutch Research Council. EMBRACER combines observations & modelling of the carbon- & water cycles at atmosphere-land-ocean-ice-biosphere interfaces to study climate change & feedback mechanisms.

### Aim

Fundamental understanding and quantification of complex feedback mechanisms in the climate system, triggered by ongoing greenhouse gas emissions and warming, on timescales of decades to millennia to enable reliable long-term climate projections.

## 4 FEEDBACK THEMES

### Atmosphere Land Biosphere

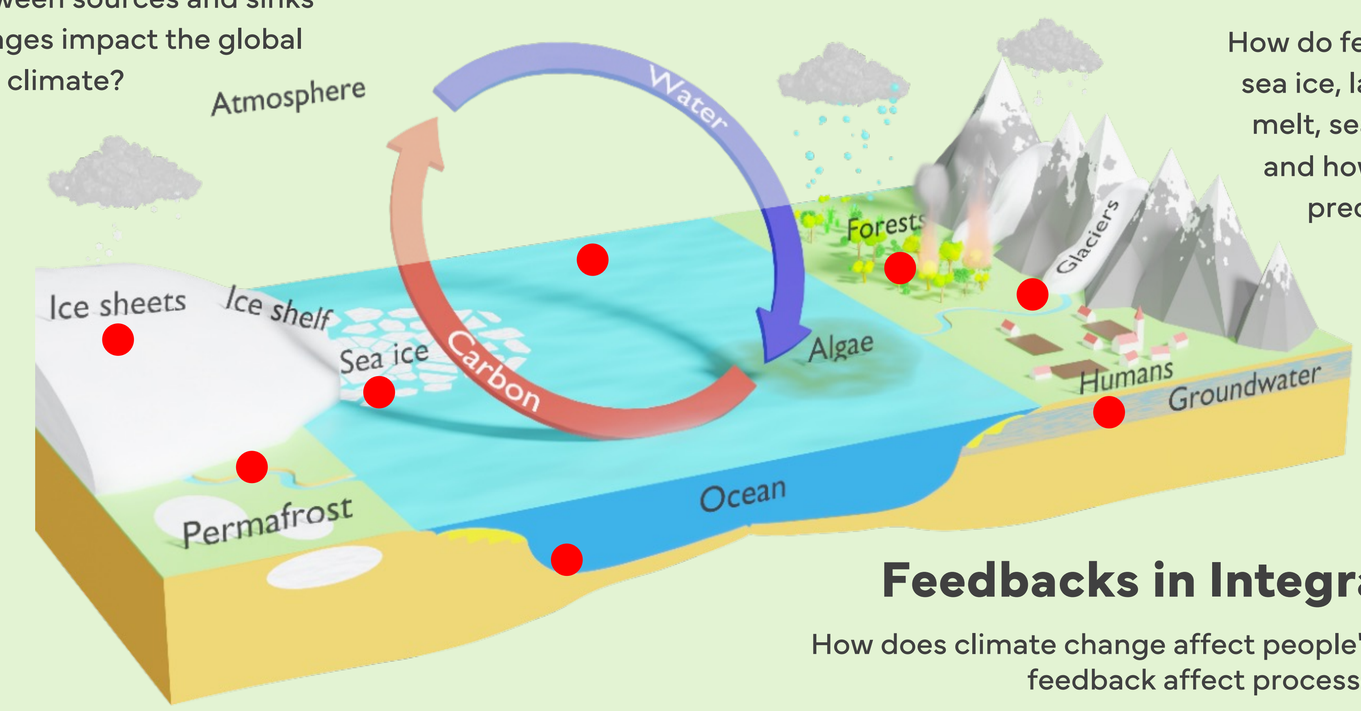
How can major land carbon reservoirs like permafrost soils, tropical forests, and peatlands shift between sources and sinks of $CO_2$ and $CH_4$, and how do these changes impact the global carbon cycle in a warming climate?

### Ice Ocean Atmosphere

How do feedbacks between the atmosphere, sea ice, land ice, and ocean impact land ice melt, sea level rise, and ocean circulation, and how can we reduce uncertainties in predicting these slow processes?

### Ocean Biosphere

How will physical, chemical, and biological feedbacks alter future ocean carbon uptake, and what will change when atmospheric carbon stabilizes or declines?




### Feedbacks in Integrated Systems

How does climate change affect people's choices, and how does this feedback affect processes in nature?

## 8 SYNERGY PROJECTS

### Atmosphere Land Biosphere

#### C release from Greenland tundra

Examine $CO_2$ and $CH_4$ release from Greenland tundra permafrost, quantifying lateral carbon transfer to downstream ecosystems and its potential offset by increased productivity.

#### Effects on Amazonian vegetation and resilience

Assess the impact of drought, human activity, and $CO_2$ fertilization on vegetation resilience and shifts (e.g., tropical forests to savannas, peatlands to croplands). How do vegetation fires affect carbon storage, particularly during extended droughts?

### Ice Ocean Atmosphere

#### Past ice-ocean interactions

Use sediment records to reconstruct land ice volume, meltwater, sea ice extent, and subsurface ocean temperatures. Evaluate past ice-ocean interactions during key periods (e.g., glacial-interglacial cycles, Miocene/Pliocene Climatic Optimum) and the magnitude of feedbacks in recent history.

#### Ice sheet mass balance processes

Enhance modern climate models by evaluating ice sheet mass balance processes in Greenland and Antarctica. Monitor AMOC strength to improve understanding of future ice sheet collapse and sea level rise.

### Integrated Systems

#### Human-driven changes in H2O and C cycles

Focus on tracking water from glaciers in High Mountain Asia through rivers and agricultural floodplains to the Indian Ocean. This involves comprehensive fieldwork, remote sensing, coupled land-atmosphere modeling, socioeconomic data, and machine learning to understand human-driven changes in water and carbon cycles.

#### Role of reservoirs and wetlands in watersheds

Investigates the role of reservoirs and wetlands in watersheds affected by human activity, focusing on their impact on greenhouse gas emissions in nearby coastal systems.

### Ocean Biosphere

#### Marine carbonate dynamics and biological C pump

A Lagrangian approach will track individual water parcels over multiple timescales, from ocean acidification (weeks) to sediment dissolution (millennia), to study marine carbonate dynamics and the biological carbon pump's response to changes in circulation and stratification.

#### C cycling during recovery from past-carbon perturbation

Utilize geological archives (e.g., ocean sediment cores) and paleoclimate models to examine carbon cycling during the recovery from past carbon perturbations, such as the Neogene-Quaternary global cooling.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