

# The oceans in the climate system

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## Motivation

Water covers around 70% of the surface of our 'Blue Planet'. Consequently, the oceans are very important for the global climate. In the climate system, oceans store and transport heat, thereby the oceans have a balancing/ compensating effect throughout the annual cycle with a warming effect in winter and a cooling effect in summer. Moreover, the oceans are the major source for atmospheric water vapour and, as a result, strongly influence the precipitation patterns on Earth. Additional important processes by which the oceans impact the climate include the uptake and storage of carbon dioxide as well as the formation of sea ice. In comparison to the atmosphere, where weather patterns take place on timescales of days and weeks, the oceans are a relatively inertial element of the climate system. As a consequence, climate variability, that occurs on timescales of years to decades, are often related to interactions between the oceans and the atmosphere.

The following experiments with the Monash Simple Climate Model (MSCM) can help to understand the effects of the oceans on near-ground air temperature.

## Model setup for the experiments

Depending on the user, the MSCM can be used in different levels of difficulty:

The standard version has 11 processes that can be switched on and off manually (see next page). However, some processes like diffusion or advection of water vapour and heat are not comprehensible for every user. Likewise, the term model correction is hard to grasp for non-professionals. Thus this version is rather suitable for advanced users (e.g. students or people with a strong background in climate physics).

The basic version combines several processes from the standard version under one generic term so that the number of the processes that can be switched on and off reduces to 6 (see next page). The model correction, although not visible, is switched on, if the water cycle is switched on. This basic version is suitable for users without previous knowledge in climate physics.

The experiments discussed here result in the same model performance for the standard as well as the basic version, because the processes not shown in the basic version are still incorporated in the model. Therefore, the experiments are outlined and explained only once in the section 'Model results and observations'.

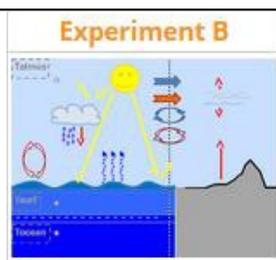
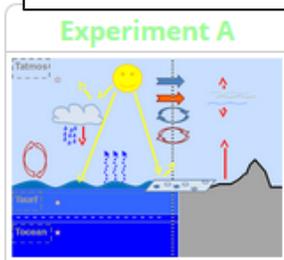
Processes switched ON in experiment A:  
**All processes**

Processes switched ON in experiment B:  
**All processes except 'Oceans'**

Following months will be compared:  
**January** (Northern winter/ southern summer) and **July** (Northern summer/ southern winter)

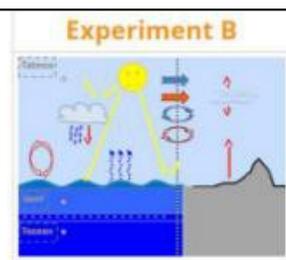
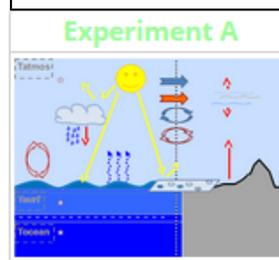
### Standardversion

### Basic version



- Ice-albedo
- Clouds
- Oceans
- Atmosphere
- Diffusion of heat
- Advec. of heat
- CO<sub>2</sub>
- Hydrological cycle
- Diff. of W. Vapor
- Advec. of W. Vapor
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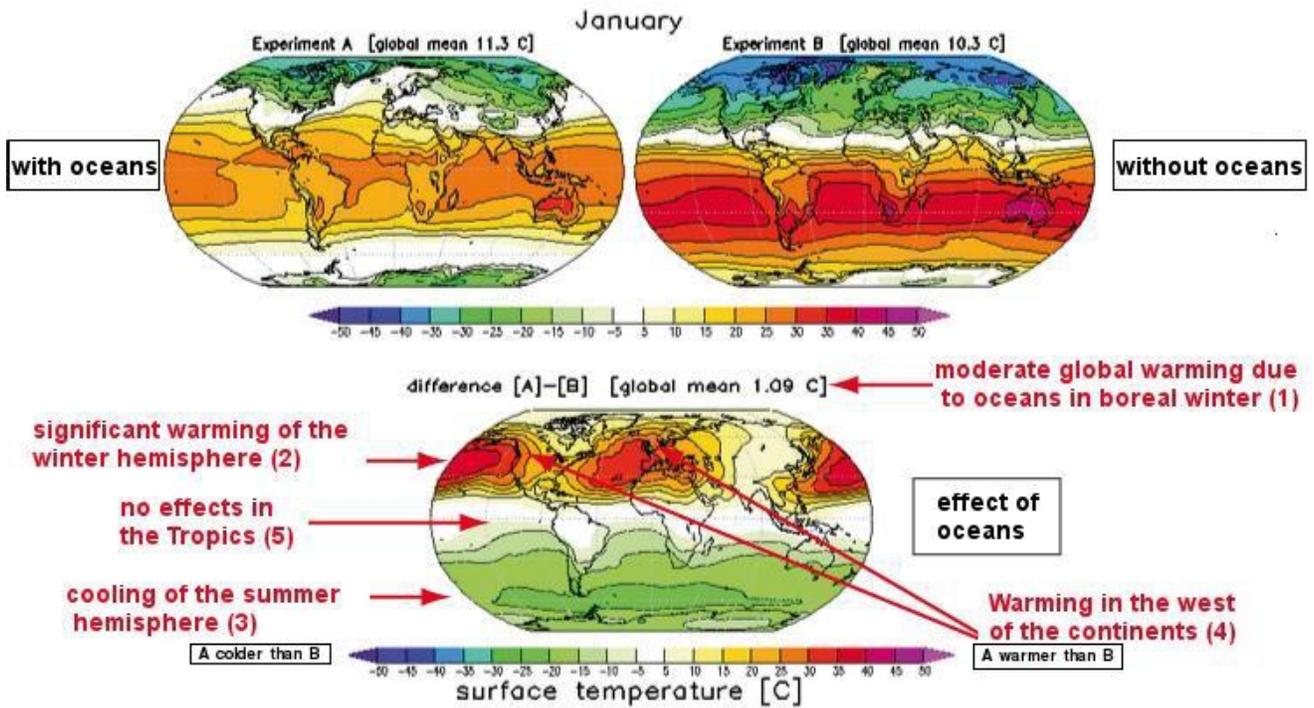


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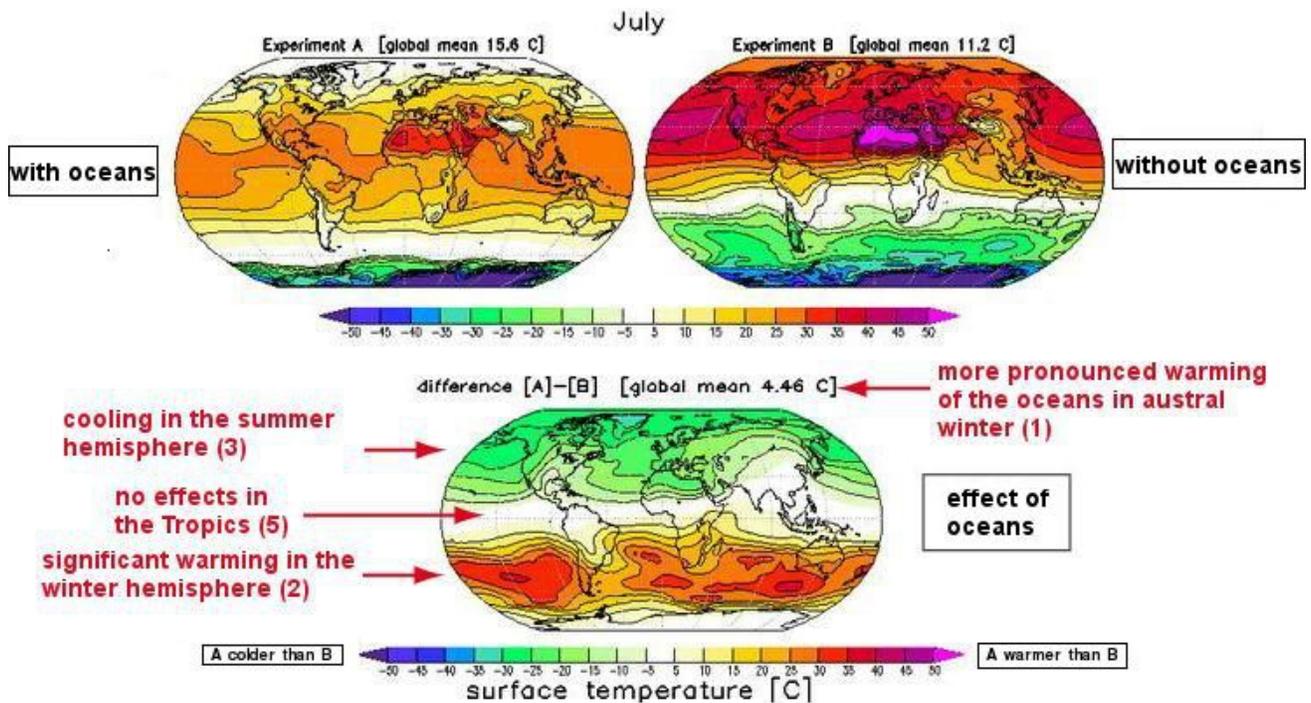
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# Model results and observations

## JANUARY



## JULY



## Physical background and explanation of the model results

Within the MSCM, oceans are represented by their function as heat storage. The transport of heat in the oceans is not simulated within MSCM. However, the impact of the oceans on temperature are also noticeable due to the transport of heat in the atmosphere.

### Global observations

	Observation	Explanation
(1)	Global warming that is more pronounced in austral than in boreal winter.	Due to their low albedo and their big heat capacity, the oceans store a substantially bigger fraction of the solar energy than land surfaces. This way, the oceans have a warming effect on the atmosphere on average. Compared to boreal winter, the heat emission is stronger in austral winter because the area covered by oceans is considerably larger in the Southern Hemisphere than in the Northern Hemisphere.

### Regional observations

	Observation	Explanation
(2)	Oceans lead to a pronounced warming in the winter hemisphere.	The oceans function as a large heat storage, that takes up and stores energy in summer, and subsequently release it to the atmosphere again in winter.
(3)	Oceans have a cooling effect in the summer hemisphere.	Oceans are an inertial element of the climate system and only heat up very slowly in summer. Therefore, they have a cooling effect in the summer hemisphere.
(2+3)	Oceans balance out seasonal variations.	Owing to their heat capacity, oceans have a cooling effect in summers and a warming effect in winters, thereby reducing the annual cycle of the temperature.
(4)	Oceans significantly influence the temperatures in the edges of the continents in mid- to high latitudes.	The transport of heat in the atmosphere in the mid- to high latitudes is strongly influenced by westerly winds. Consequently, the impact of the oceans on the temperature is also noticeable in the temperature over land. This effect declines with the increasing distance to the coast.
(5)	Oceans have only a small impact on temperatures in the Tropics.	In the Tropics, the annual cycle is rather weak. Therefore, the heat capacity of the oceans hardly impacts the temperature.

**Helpful articles to work on the exercises:**

Article	Topic
<a href="#">Ocean in the climate system</a>	The role of the ocean in the climate system, currents, interactions between ocean and atmosphere
<a href="#">Sea ice</a>	Processes of sea ice formation and melting, effects of sea ice on interactions between ocean and atmosphere, isolation effect of sea ice
<a href="#">Warming of the ocean</a>	Impacts of climate change on the energy stored in the oceans