Integrating model and data over the Southern Ocean (SO) at the Last Glacial Maximum to better understand the sea-ice cover

F. Lhardy¹ (fanny.lhardy@lsce.ipsl.fr), N. Bouttes¹, D.M. Roche¹,², X. Crosta¹

1. Model-data comparison: sea-surface temperatures and sea ice

PI

PMIP4 P1.1
PMIP T1.1
PMIP P1.1
PMIP P1.1 windyc3
Warm PMIP2
New PMIP2
Cold PMIP2

Simulation

PI
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PMIP T1.1
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Topography

Semi-automated bathymetry

Sensitivity experiment

+0.6 Sv around Antarctica
x3 wind tension on ice
parametrization of the sinking of brines
modified albedo profiles

Inverse methodology:
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RMSE = 3.1

a

c

e

Fig. 1: Global mean temperature anomaly (°C).

Grey bar - estimate of Annan and Hargreaves [2013]

2. Deep ocean circulation: streamfunctions

A set of simulations displaying contrasting climates (due to different boundary conditions and experimental setting)

What would be the associated impact on deep ocean circulation?

RMSE = 3.6

b

d

Fig. 2: Austral winter (a) and summer (b) SSTs in a model vs data diagram. 1:1 line - perfect model-data agreement with WOA SST data. Marker color - latitude of the grid cell found nearest the core coordinates.

Fig. 3: Winter (c) and summer (d) sea-ice edges. Data points - sea-ice concentration (%) from Schweitzer [1995].

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Fig. 5: Streamfunctions in the Atlantic (North of 32°S) and Southern Ocean (South of 32°S).

2. Deep ocean circulation: streamfunctions

- Systematic (and consistent) biases in regional and seasonal patterns of the SO:

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1. Model-data comparison: sea-surface temperatures and sea ice

- Cold PMIP2
- Warm PMIP2
- New PMIP2
- PMIP P1.1
- PMIP P1.1 windxy3
- PMIP P1.1 br0.8
- PMIP P1.1 PI
- PMIP P1.1 and ET

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A set of simulations displaying contrasting climates (due to different boundary conditions and experimental setting)

Inverse methodology:
What surface conditions should be simulated in the SO to agree well with the proxy data?

RMSE = 4.2

Systematic (and consistent) biases in regional and seasonal patterns of the SO:

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1. Model-data comparison: sea-surface temperatures and sea ice

RMSE = 3.8

2. Deep ocean circulation: streamfunctions

SU
d
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RMSE = 4.2
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2015-18
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Fig. 6: Semi-automated bathymetry simulation +0.6 Sv around Antarctica
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1. Model-data comparison: sea-surface temperatures and sea ice

Fig. 1: Global mean temperature anomalies (°C) across PMIP2 models.

- Cold PMIP2
- Warm PMIP2
- New PMIP2

Table: Simulation comparison

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1. Model-data comparison: sea-surface temperatures and sea ice

PMIP4 T1.1

Inverse methodology:
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A set of simulations displaying contrasting climates (due to different boundary conditions and experimental setting)

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- SST
- Sea Ice
- RMSE = 4.0

- SST
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2. Deep ocean circulation: streamfunctions

- Atlantic
- Southern Ocean
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