The role of troposphere-stratosphere coupling

Strong discussion of late winter development

Time delay between models and reanalysis: within weeks depending on model and point in time

Stratospheric westerly winds massively reduced (in ERA)

Challenge: Representation in models

Challenge: Mechanisms?

Possible Troposphere signal reaching the troposphere

Sea ice decline statistically correlates with

The role of

Sea ice concentration

Sea level pressure

September (HadISST data)

Following winter (ERA-Interim)

Arctic-midlatitude linkages Coupled Patterns 1979-2015

Sea ice concentration

Sea level pressure

September (HadISST data)

Following winter (ERA-Interim)

Arctic-midlatitude linkages AGCM model experiments

AGCM For Earth Simulator (AFES, T79/L56)

2 model runs with 60 perpetual years each

CNTL: High ice conditions as observed from 1979-1983

NICe: Low ice conditions as observed from 2005-2009

Only sea ice is different between both runs

ECHAM6 (T63/L95) with similar boundary conditions

2 model runs with 12 perpetual years each

Comparison with ERA-Interim

High ice (1979/80 - 1999/00)

Low ice (2000/01 - 2013/14)

Arctic sea ice concentration maps SON

Polar cap zonal wind change - Zonal wind [m/s] average 65°N-85°N

High ice 1979/80 - 1999/00

Low ice 2000/01 - 2013/14

Polar cap zonal wind change - Zonal wind [m/s] average 65°N-85°N

High ice 1979/80 - 1999/00

Low ice 2000/01 - 2013/14

Polar cap regional conditions as observed from 2005

AFES/ECHAM6: surface warming related to sea ice alone

Strong significant warming of polar stratosphere in late winter; but weaker signal in ECHAM6

Polar vortex weakening?

Very good agreement between AFES and reanalysis in winter (and autumn)

Sea ice decline statistically correlates with changes in circulation patterns

Shifts of “centers of action”

similar to negative (NAO) pattern

Observed changes involve tropo- and stratosphere

Challenge: Mechanisms?

Challenge: Representation in models?

Meridionalization – Interim sea ice is different between both runs

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High ice (1979/80 - 1999/00)

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Polar vortex weakening?

Very good agreement between AFES and reanalysis in winter (and autumn)

Clear indication of stratospheric vortex weakening in February

Stratospheric westerly winds massively reduced (in ERA-Interim and AFES)

Signal reaching the troposphere

Waver signal in ECHAM

Time delay between models and reanalysis: within weeks depending on model and point in time

Enhanced upward propagation of planetary waves in autumn and early winter

Disturbing the polar vortex, leading to a vortex weakening

Vertical wave propagation is reduced in February due to the vortex weakening in ERA-Interim and AFES model simulation

Consistency of datasets indicates clear impact of sea ice changes

ERA-Interim is more disturbed in early winter → Impact of additional processes

Conclusions & Outlook

Troposphere-stratosphere interaction play a crucial role for the atmospheric response to present-day sea-ice reduction

AGCMs with realistically prescribed sea-ice reduction are able to simulate the observed signal of mid-latitude linkages

Strength of the signal is model-dependent (e.g. in AFES stronger than ECHAM6)

Potential for future studies

Sensitivity of the model response with respect to

boundary forcing (e.g. turbulent surface fluxes)

representation of stratospheric processes (e.g. stratospheric chemistry)

Possible change of underlying mechanisms under stronger than present-day sea-ice reduction (Nakamura et al. 2016)

Discussion of autumn to winter development

Interaction between synoptic and planetary scales

See poster by Handorf et al.

Discussion of late winter development

How is the stratospheric signal translated into the tropospheric negative (NAO) anomaly

References


The ERA-Interim data were obtained from the ECMWF web site (http://data.ecmwf.int/)

The APE6 simulations (Nakamura et al. 2015) were performed on the Earth Simulator at the Japan Agency for Marine-Earth Science and Technology.

Merged Hadley/NCEP/NCAR SST and IC data were obtained from the Climate Data Guide (https://climatedataguide.ucar.edu/)

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