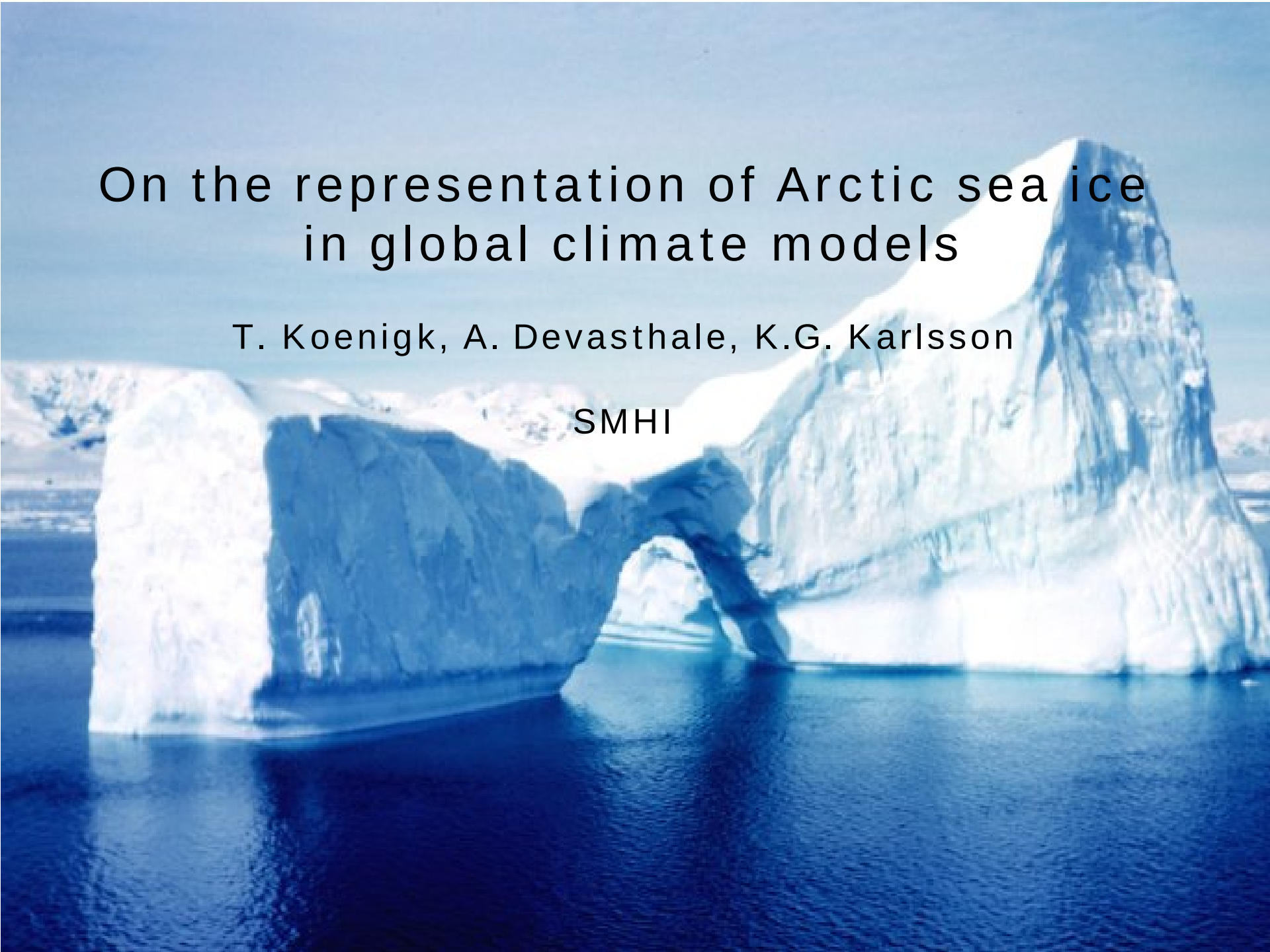

On the representation of Arctic sea ice in global climate models

T. Koenigk, A. Devasthale, K.G. Karlsson

SMHI

Summer sea ice is reduced!

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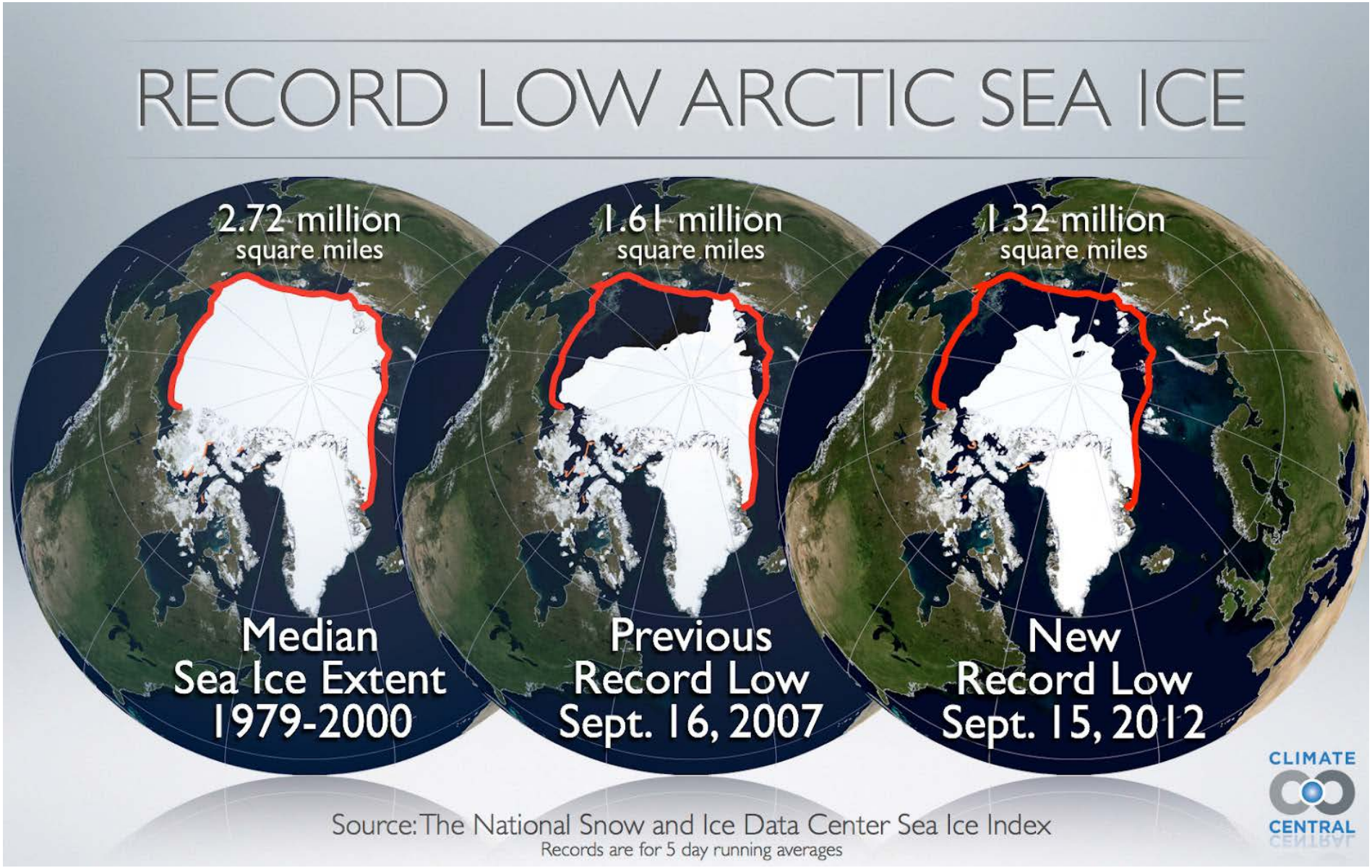

Arctic sea ice extent in CMIP5 models

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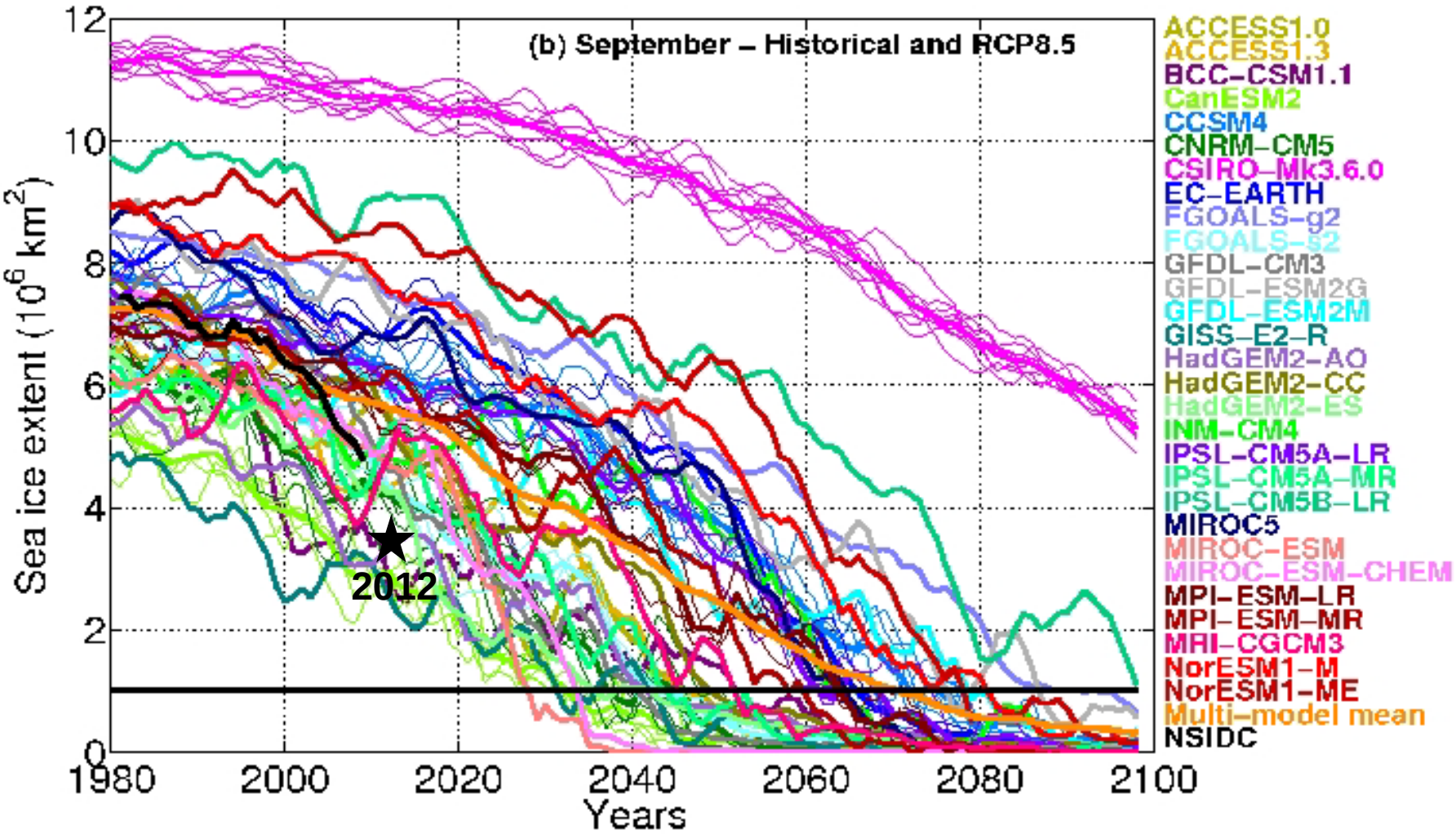

Massonnet et al. 2012

Why is there such a spread among models?
What is the role of sea ice albedo for the spread?

Model and data

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Models:
Historical simulations from 21 CMIP5 models.
All data interpolated on 2° x 2°.

Observations:
Surface albedo product from CM-SAF: CLARA-A1-SAL
Sea ice concentration from OSI-SAF
Surface temperature from ERA-interim reanalysis data

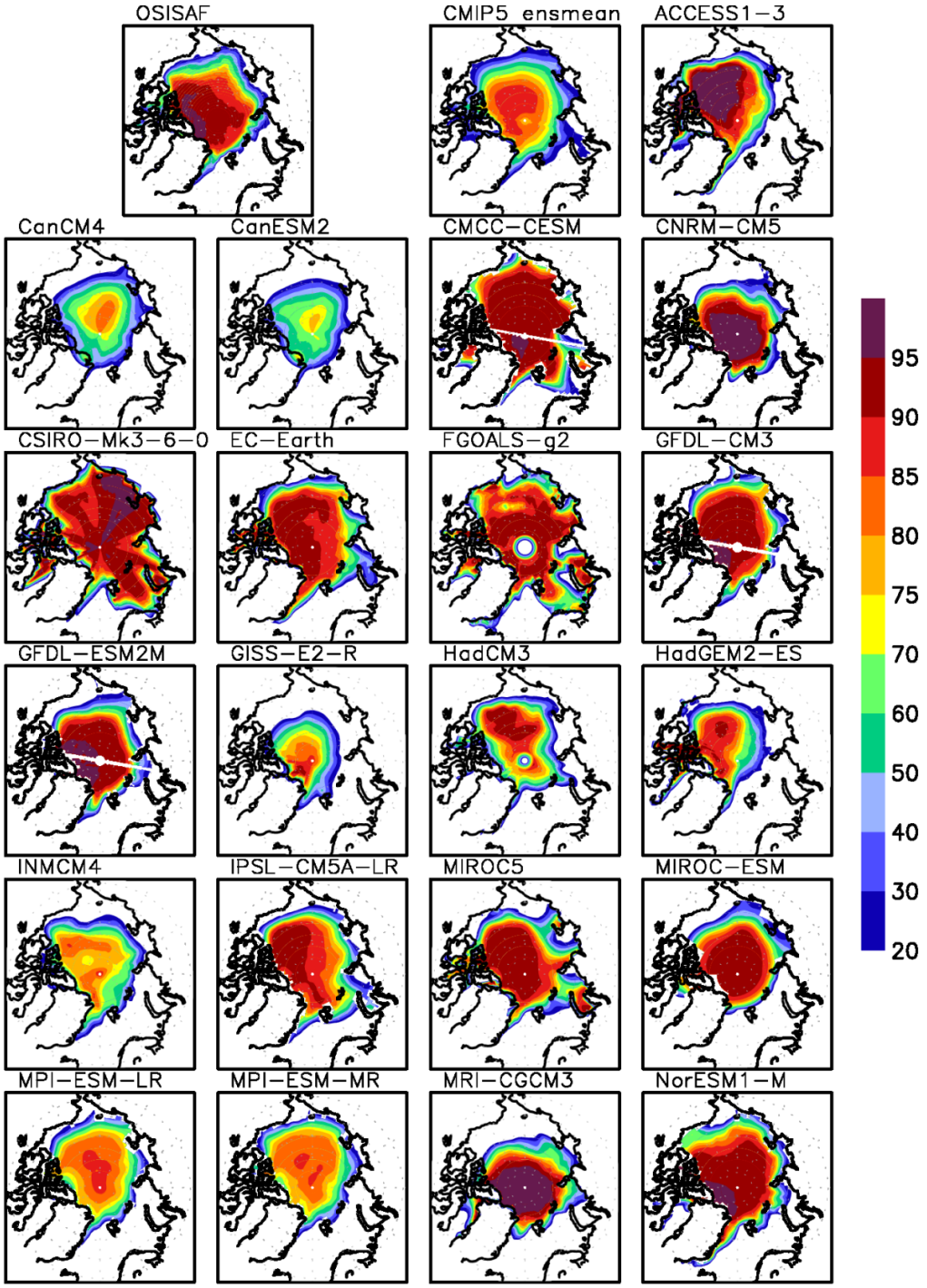
Time period:1982-2005

Method:
Surface albedo in the models was calculated from downward and upward surface solar radiation.
Sea ice albedo was calculated by taking the ice concentration in each grid box into account:

$\alpha_{surf} = \alpha_{ice} \cdot A_{ice} + \alpha_{water} \cdot (1 - A_{ice})$
$\alpha_{water} = 0.07$

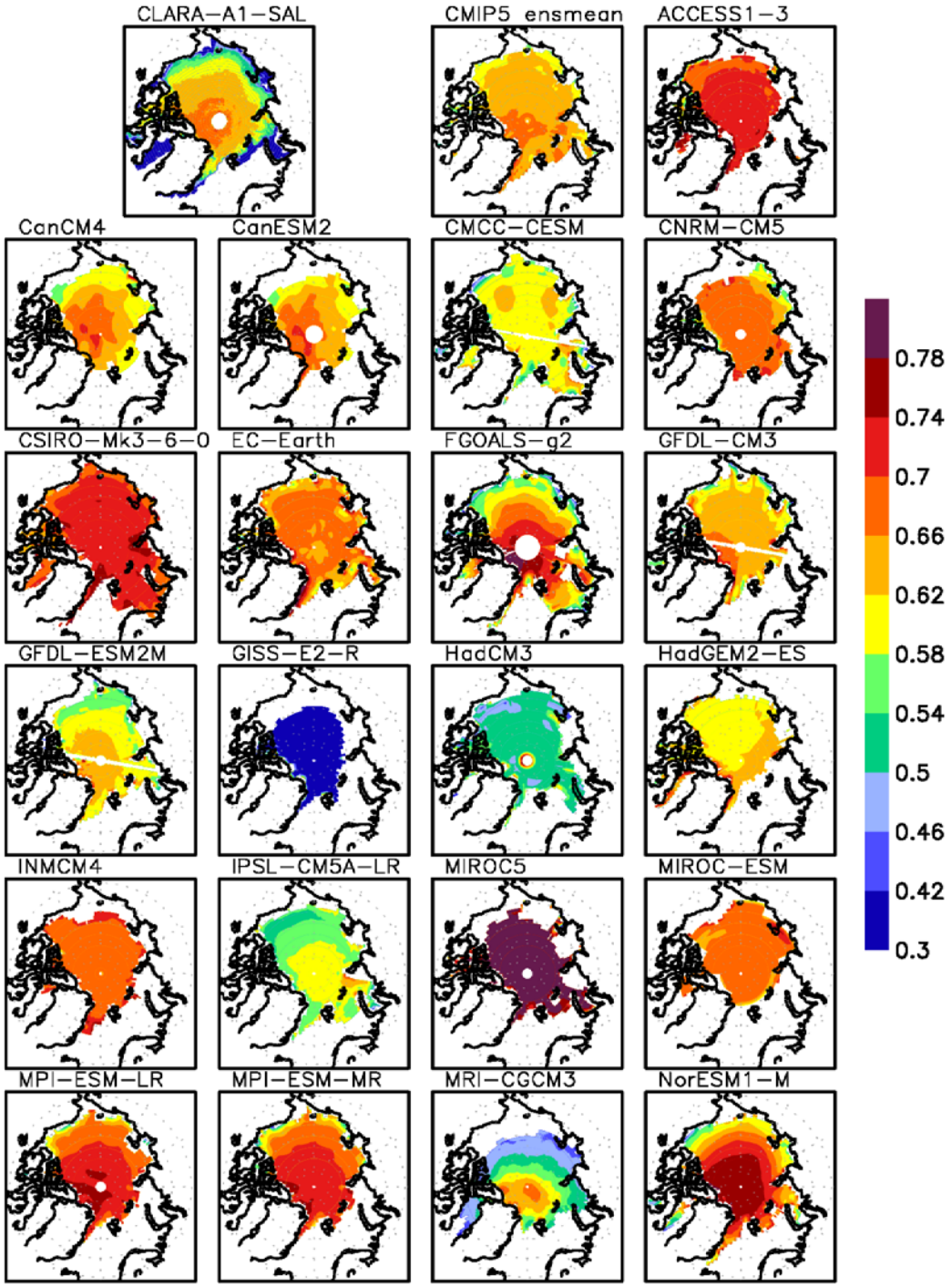
Sea ice concentration in September

Average 1982-2005



Surface ice albedo
JJA mean

Average 1982-2005



Sea ice albedo trend, 1982-2005

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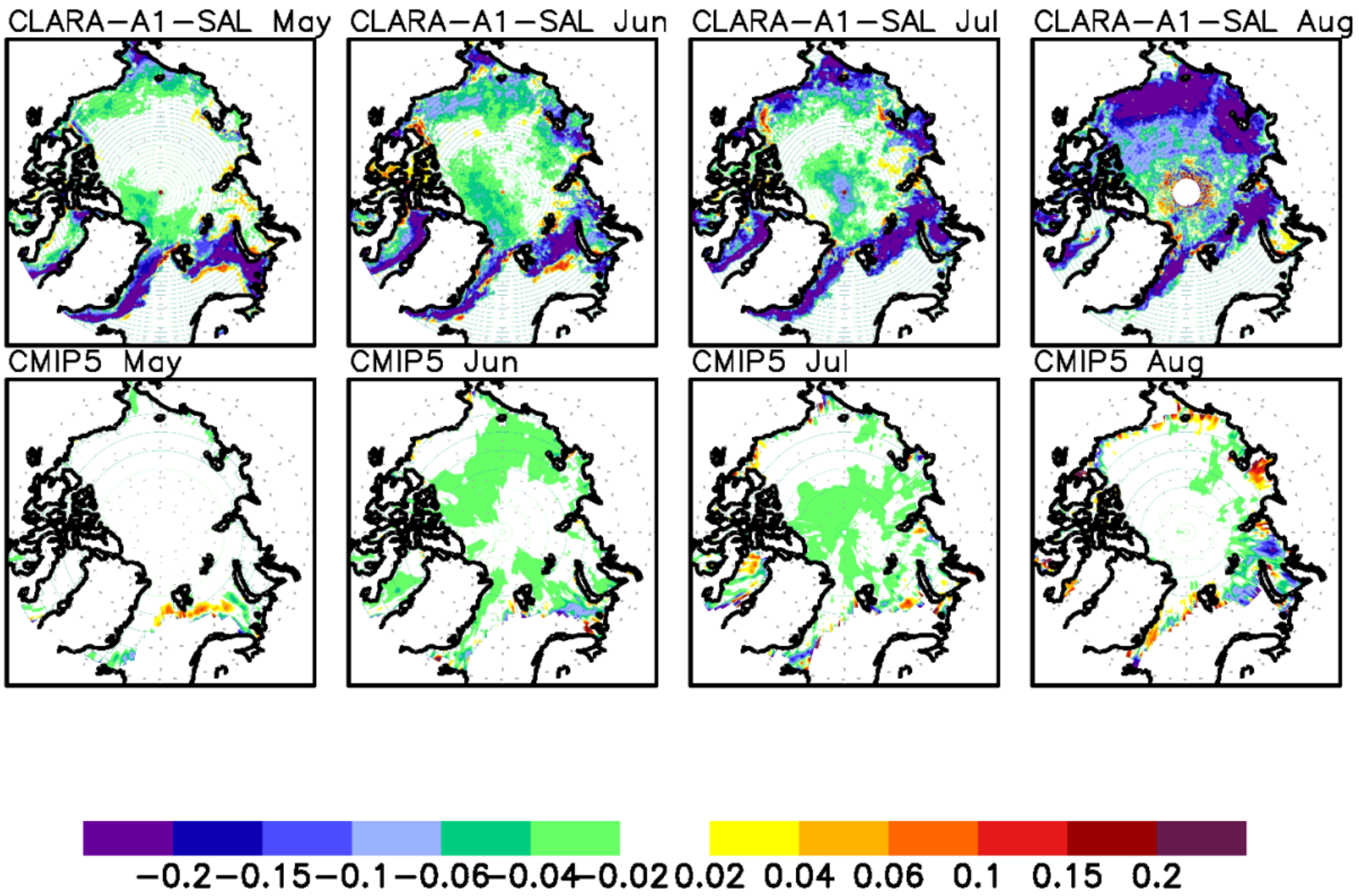

Time evolution

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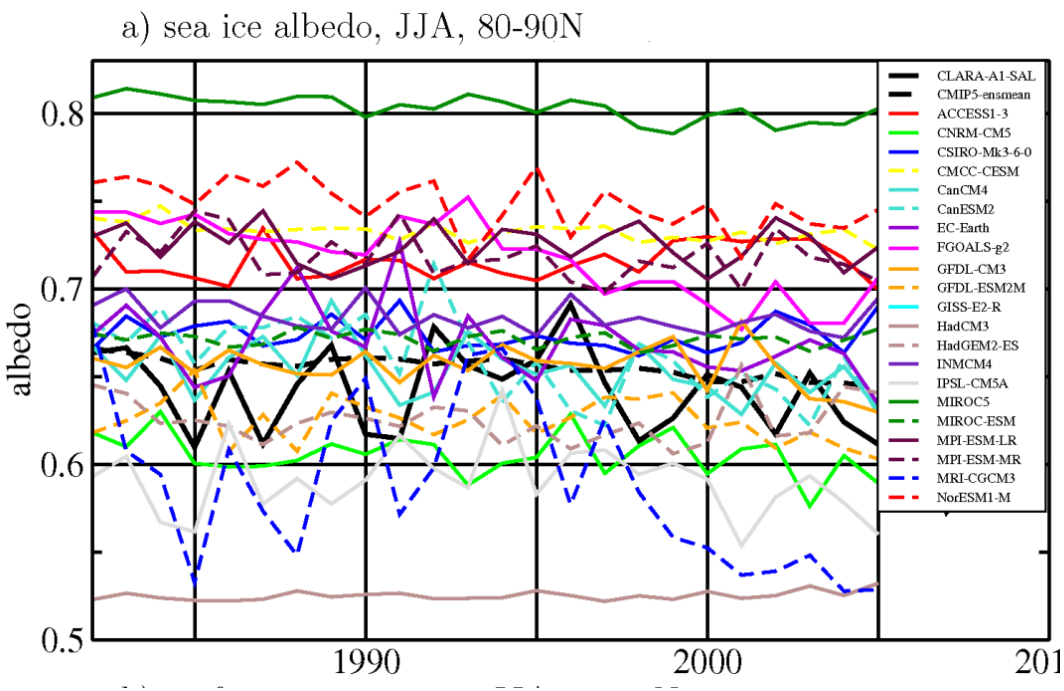
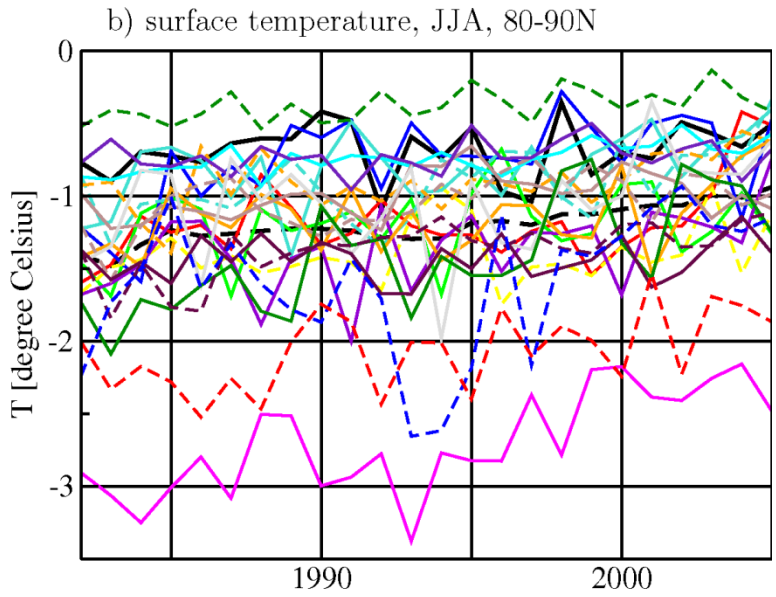
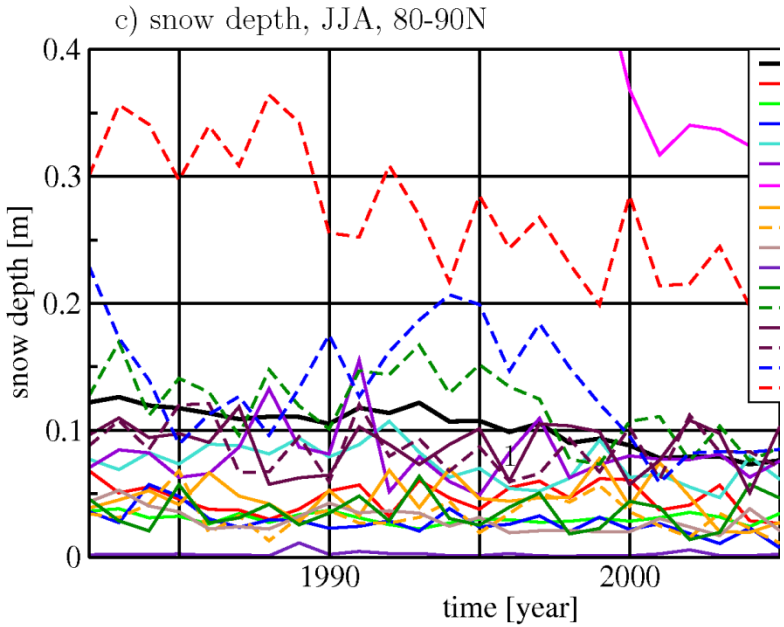
Average 80°N-90°N







black solid: CLARA-A1-SAL
black dashed: CMIP5-mean

Impact of temperature and snow on albedo

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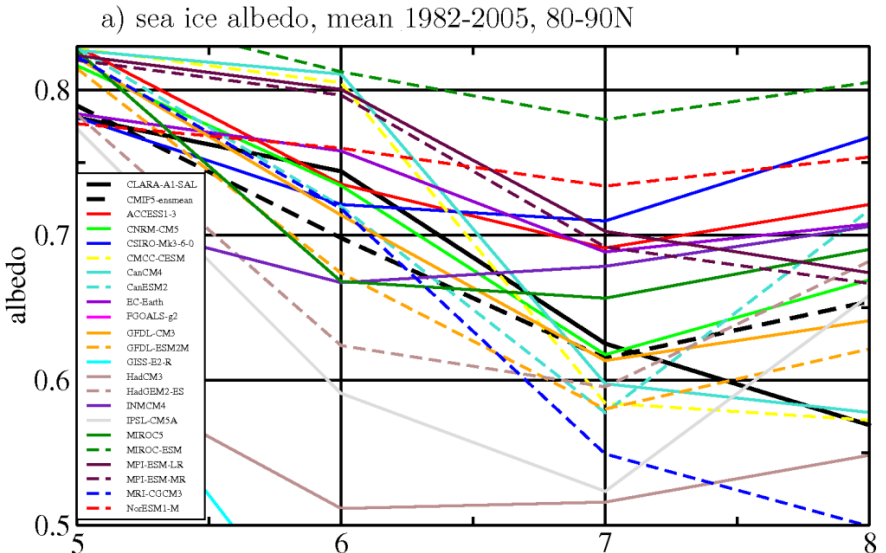
Correlation ice albedo – surface temperature; 80°N-90°N

Correlation coeff.	May	June	July	August
CMIP5 mean	-0.33	**-0.74**	**-0.45**	**-0.51**
CLARA/ ERAint	**0.53**	**-0.43**	-0.23	-0.38

Correlation ice albedo – snow depth; 80°N-90°N

Correlation coeff.	May	June	July	August
CMIP5 mean	0.31	**0.74**	**0.45**	**0.70**

Summer evolution of ice albedo



black solid: CLARA-A1-SAL
black dashed: CMIP5-mean

Conclusions

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We find a strong spread in ice albedo across CMIP5 models.

Variations in surface temperature and snow on ice are responsible for a large part of the albedo variations.

The correlation between ice albedo and surface temperature seems to be too strong in most CMIP5 models.

Temporal evolution of albedo throughout the summer is not well reproduced. Melting and refreezing start too early.

Spatial ice albedo patterns are too uniform and albedo too high along the ice edges

→ Underestimated ice-albedo feedback along ice edges in the models during summer

Implementing melt ponds to EC-Earth

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Comparison with CLARA-A1-SAL shows that the sea ice albedo in EC-Earth2.3 (CMIP5) was too high:

To improve the ice albedo, the melt pond parameterization of Koltzow et al. (2007) has been implemented:

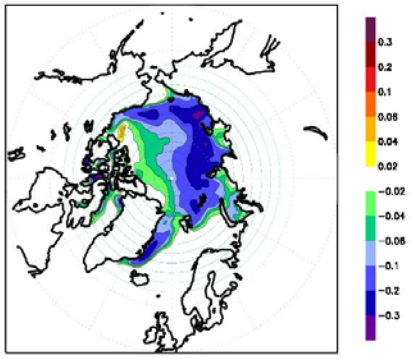
Melt pond fraction = *0.11 * (2 + Ts)* *for Ts > -2 C*

Albedo of melt ponds = *0.36 - 0.1 * (2 + Ts)*

CTRL: 350-year PD-simulation with EC-Earth

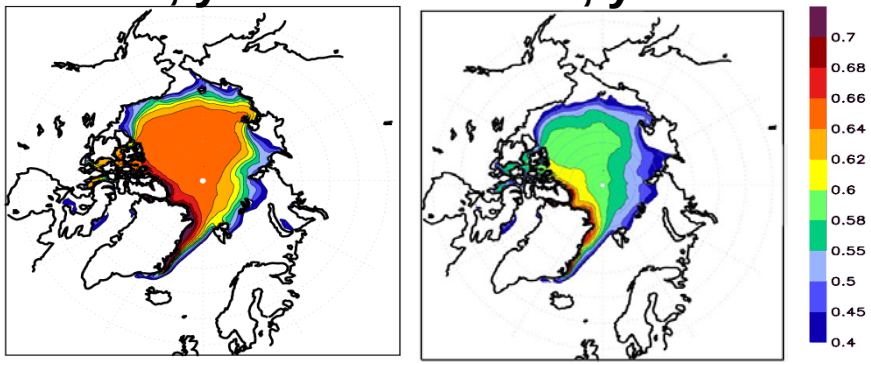
MELT: 80-year PD-simulation started from year 250 of CTRL with new albedo-scheme

Ice conc: MELT-CTRL

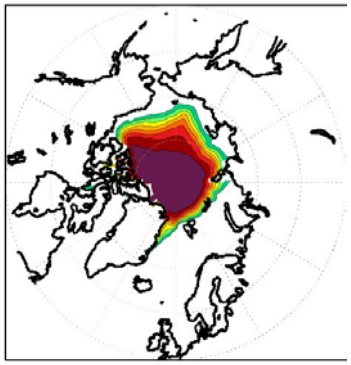


Summer (JJA) ice albedo

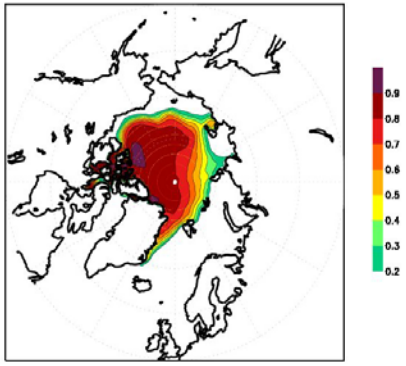
CTRL, y 281-330 **MELT, y 31-80**



Ice concentration Sep OSI-SAF



Ice conc Sep MELT



Satellite data for climate modelling

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Model evaluation and development:

- Long time series – 30 years and more
- Consistent data sets – to evaluate processes
- Uncertainties (realistic, consistent across different products)

Climate prediction:

- Initial conditions, assimilation
- Uncertainties – to create ensemble members

Atmosphere modelling:

- Lower boundary conditions (SST, ice concentration)

Future needs (wishes from a sea ice modeller):

- Reliable ice thickness data
- Melt pond fraction
- Snow thickness on ice
- Surface roughness, ice deformation

Introduction of melt ponds to the sea ice albedo scheme in EC-Earth v2.3

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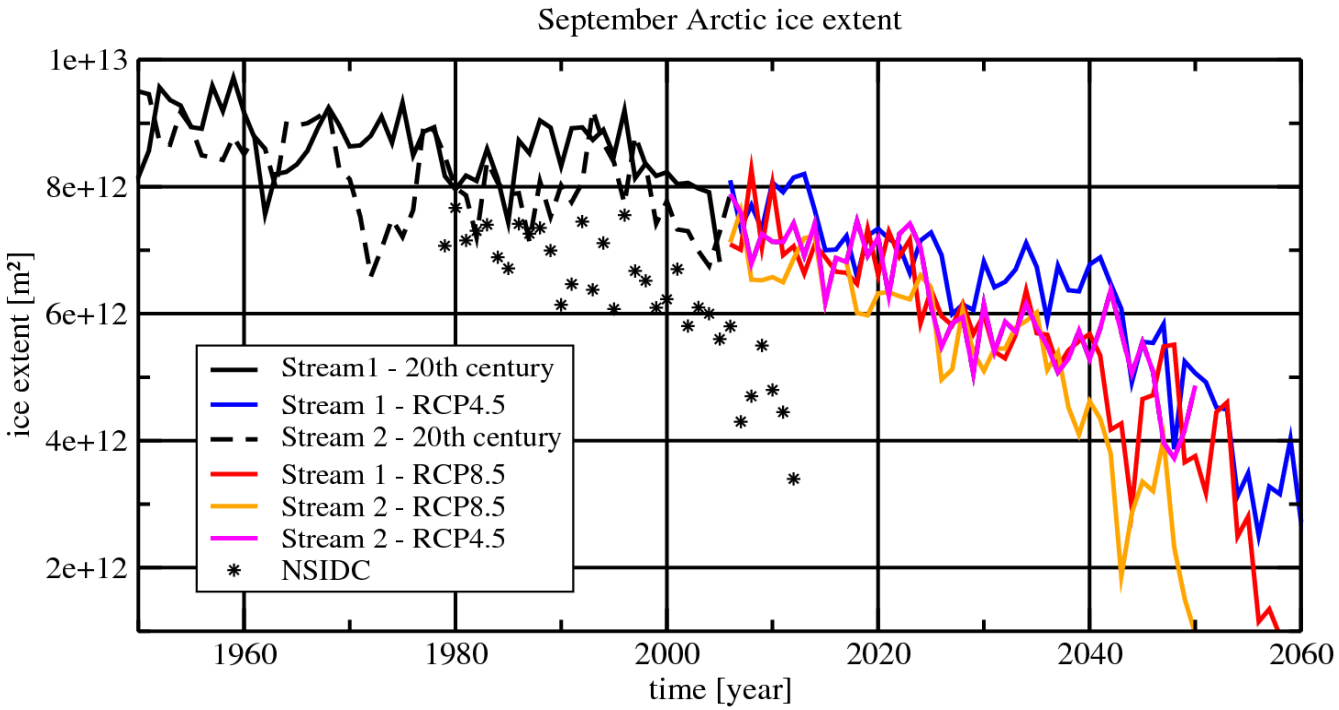
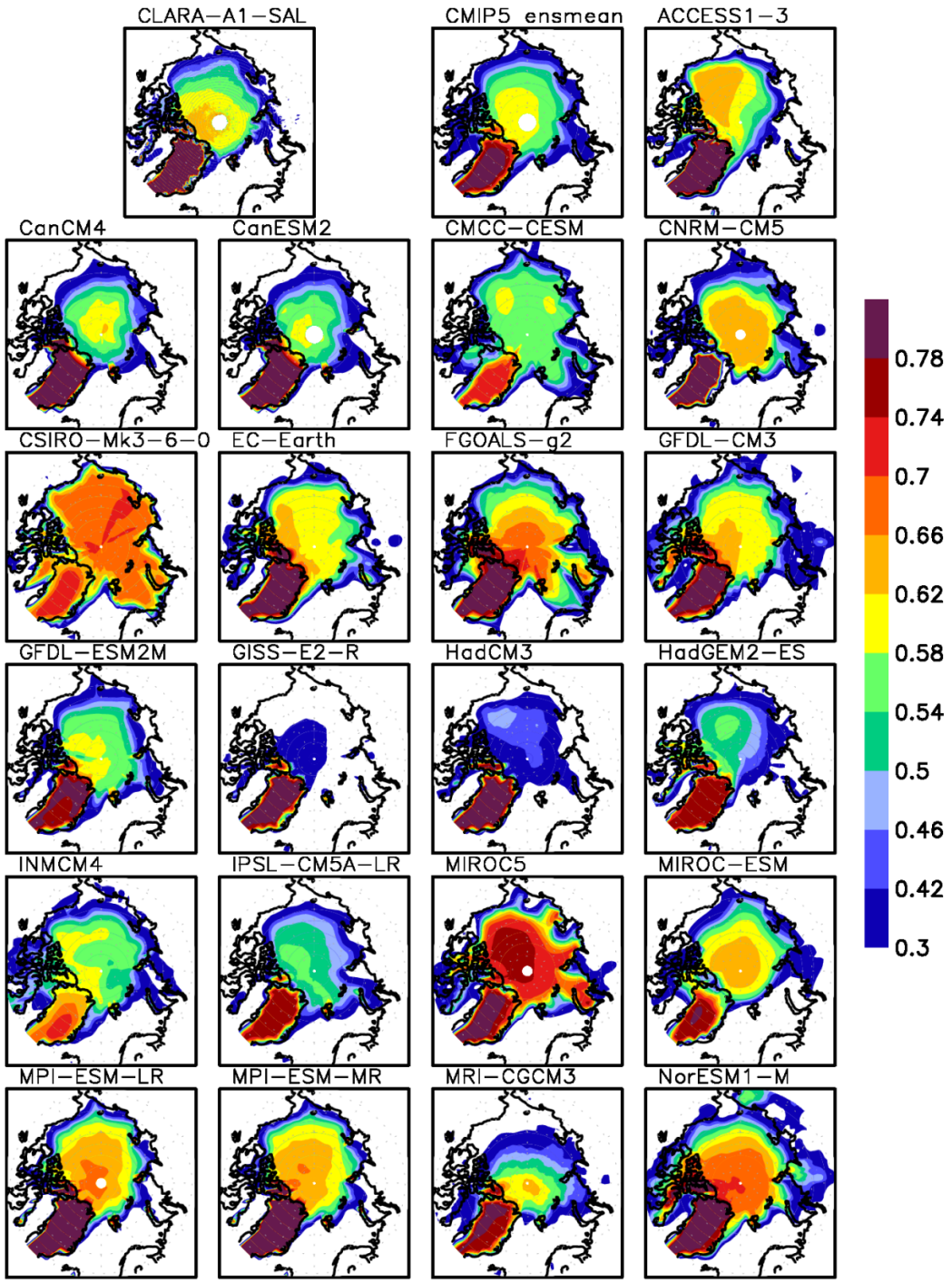
Historical and Future Scenario Simulations
Stream 1: EC-Earth2.3: 1850-2005, RCP4.5, RCP8.5 2006-2100
Stream 2 EC-Earth2.3 + melt ponds: 1950-2005, RCP4.5, RCP8.5 2006-2050



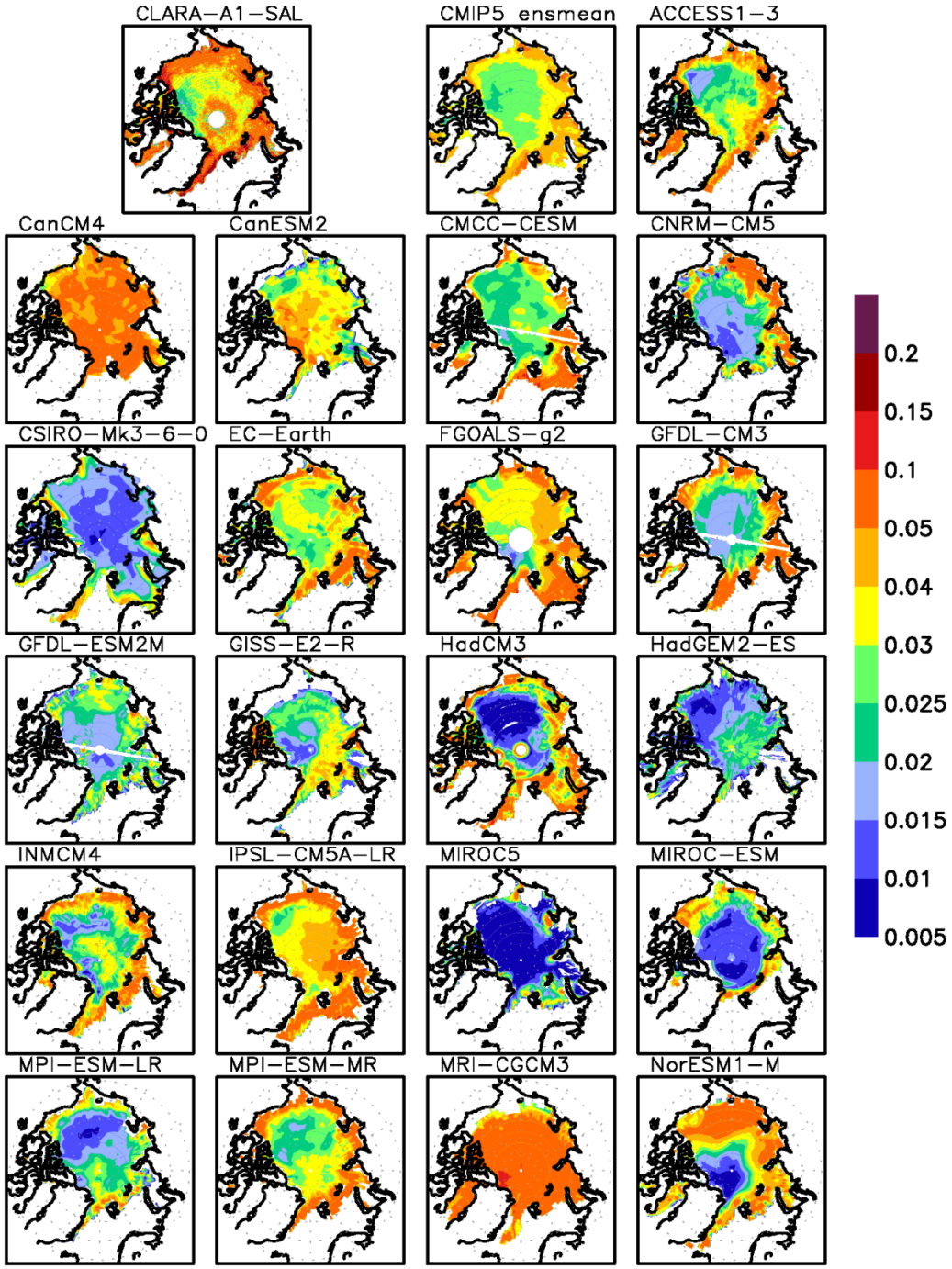
Results:
Melt ponds reduce summer ice albedo in EC-Earth and lead to a more realistic albedo.

Sea ice extent and volume are reduced in 20th and 21st century simulations but still strongly overestimate observations.

Surface albedo
JJA mean
Average 1982-2005

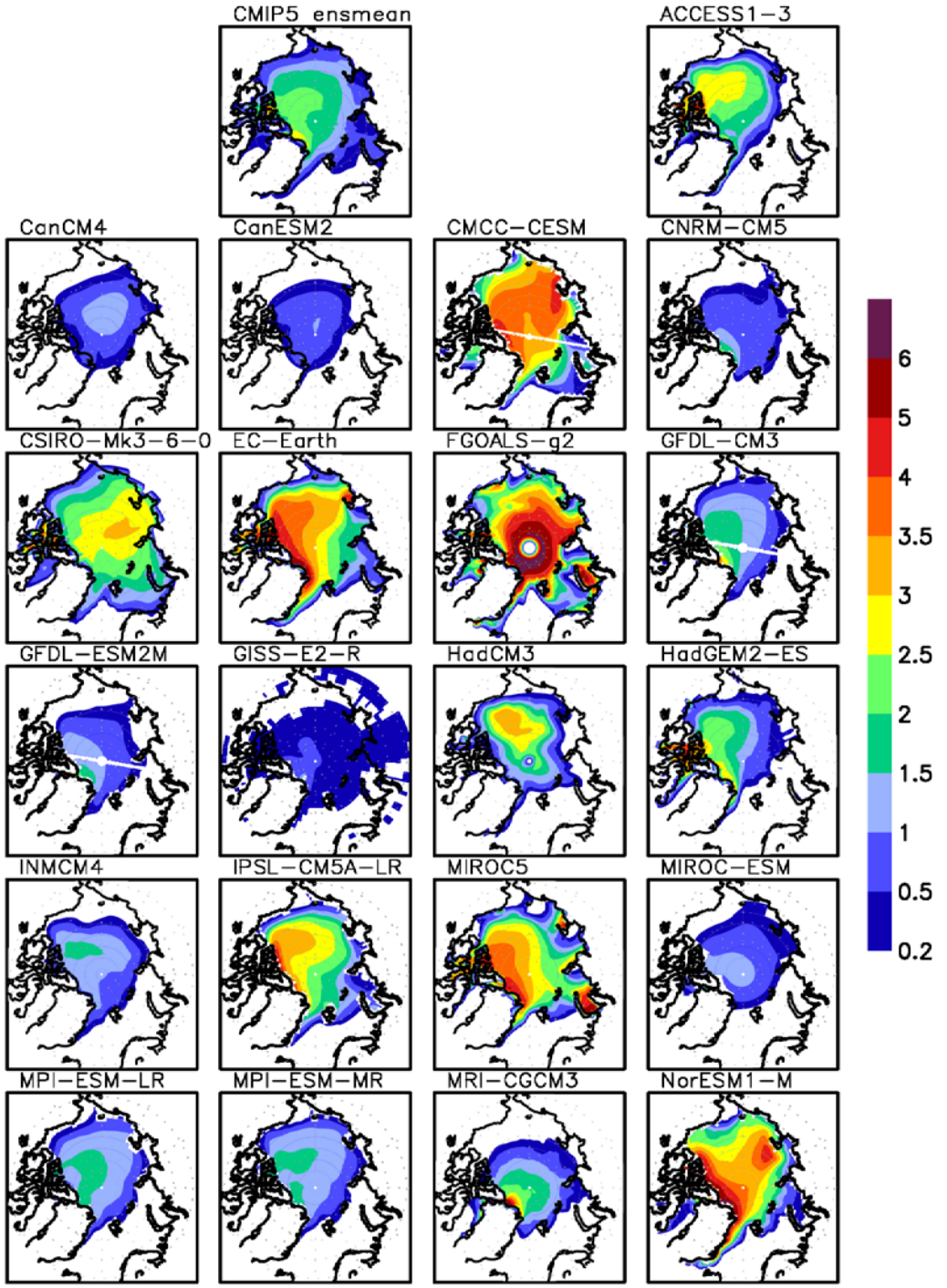


Standard deviation of summer sea ice albedo 1982-2005



Sea ice thickness
in September

Average 1982-2005



Relation ice albedo – net solar radiation