



**Federal Service for Hydrometeorology  
and Environmental Monitoring**



**VOEIKOV  
MAIN GEOPHYSICAL  
OBSERVATORY**

*Since 1849*

# Adaptation to CC in the Arctic: Roshydromet's prospective

Vladimir Kattsov

# Roshydromet's Climate Centre

<http://cc.voeikovmgo.ru>



Климатический центр Росгидромета

**World Energy Outlook 2018**

Опубликован очередной ежегодный прогноз мирового энергетического развития от Международного энергетического агентства (МЭА) - World Energy Outlook (WEO) 2018

24-я Конференция ООН по климату в Катовеце

Пресс-релиз ВМО к открытию 24-й Конференции сторон РКИК

Четвертый национальный доклад о климате США

Второй доклад США о состоянии углеродного цикла

Прогноз развития мировой энергетики МЭА

Шестая сессия Комитета по управлению Межправительственного совета по климатическому обслуживанию

Снижение риска стихийных бедствий

Изменение климата в 21 веке

Изменение климата России в 21 веке

ОЦЕНОЧНЫЙ ДОКЛАД  
ОБ ИЗМЕНЕНИЯХ КЛИМАТА И ИХ ПОСЛЕДСТВИЯХ  
НА ТЕРРИТОРИИ РОССИЙСКОЙ ФЕДЕРАЦИИ

Том I. Изменения климата

ФЕДЕРАЛЬНАЯ СЛУЖБА ПО ГИДРОМЕТЕОРОЛОГИИ И МОНИТОРИНГУ ОКРУЖАЮЩЕЙ СРЕДЫ (РОСГИДРОМЕТ)

2008

ВТОРОЙ ОЦЕНОЧНЫЙ ДОКЛАД РОСГИДРОМЕТА  
ОБ ИЗМЕНЕНИЯХ КЛИМАТА  
И ИХ ПОСЛЕДСТВИЯХ  
НА ТЕРРИТОРИИ РОССИЙСКОЙ ФЕДЕРАЦИИ

ФЕДЕРАЛЬНАЯ СЛУЖБА ПО ГИДРОМЕТЕОРОЛОГИИ И МОНИТОРИНГУ ОКРУЖАЮЩЕЙ СРЕДЫ (РОСГИДРОМЕТ)

2014

ФЕДЕРАЛЬНАЯ СЛУЖБА ПО ГИДРОМЕТЕОРОЛОГИИ И МОНИТОРИНГУ ОКРУЖАЮЩЕЙ СРЕДЫ (РОСГИДРОМЕТ)

КЛИМАТИЧЕСКИЙ ЦЕНТР РОСГИДРОМЕТА

**ДОКЛАД  
О КЛИМАТИЧЕСКИХ РИСКАХ  
НА ТЕРРИТОРИИ  
РОССИЙСКОЙ ФЕДЕРАЦИИ**

ФЕДЕРАЛЬНАЯ СЛУЖБА ПО ГИДРОМЕТЕОРОЛОГИИ И МОНИТОРИНГУ ОКРУЖАЮЩЕЙ СРЕДЫ (РОСГИДРОМЕТ)

КЛИМАТИЧЕСКИЙ ЦЕНТР РОСГИДРОМЕТА

**ИЗМЕНЕНИЯ  
КЛИМАТА АРКТИКИ:  
МЕСТО КЛИМАТИЧЕСКОЙ НАУКИ  
В ПЛАНИРОВАНИИ АДАПТАЦИИ**

Новости

- 26.12.2018 Путин: Парижское соглашение по климату не несет угрозы России
- 24.12.2018 Ольга Добровидова: Оставьте физику физикам
- 17.12.2018 Ъ: Конференция ООН не смогла договориться о механизме сокращения выбросов
- 13.12.2018 Россия подтвердила выполнение обязательств по снижению выбросов
- 09.12.2018 Ъ: РФ демонстрирует климатическую активность, не взирая на санкции

Изменение климата России в 21 веке

Республика Крым  
Температура у поверхности, °C

2011-2030	2041-2060	2080-2099
1.2	2.7	5.1

Сценарий: RCP 6.5  
Временной период: 2080-2099  
Озон: Год  
Россия: 7.6 °C  
Выберите регион

Карты архивные, вер:13. Обновить Ресурс: находится в разработке. © Оценочный центр Росгидромета

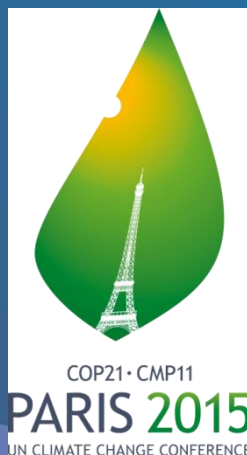
© 2013-2019 Главная геофизическая обсерватория имени А.И. Воейкова

# Adaptation to CC is being recognized internationally not less important than mitigation





**CLIMATE  
DOCTRINE  
OF THE RUSSIAN  
FEDERATION**

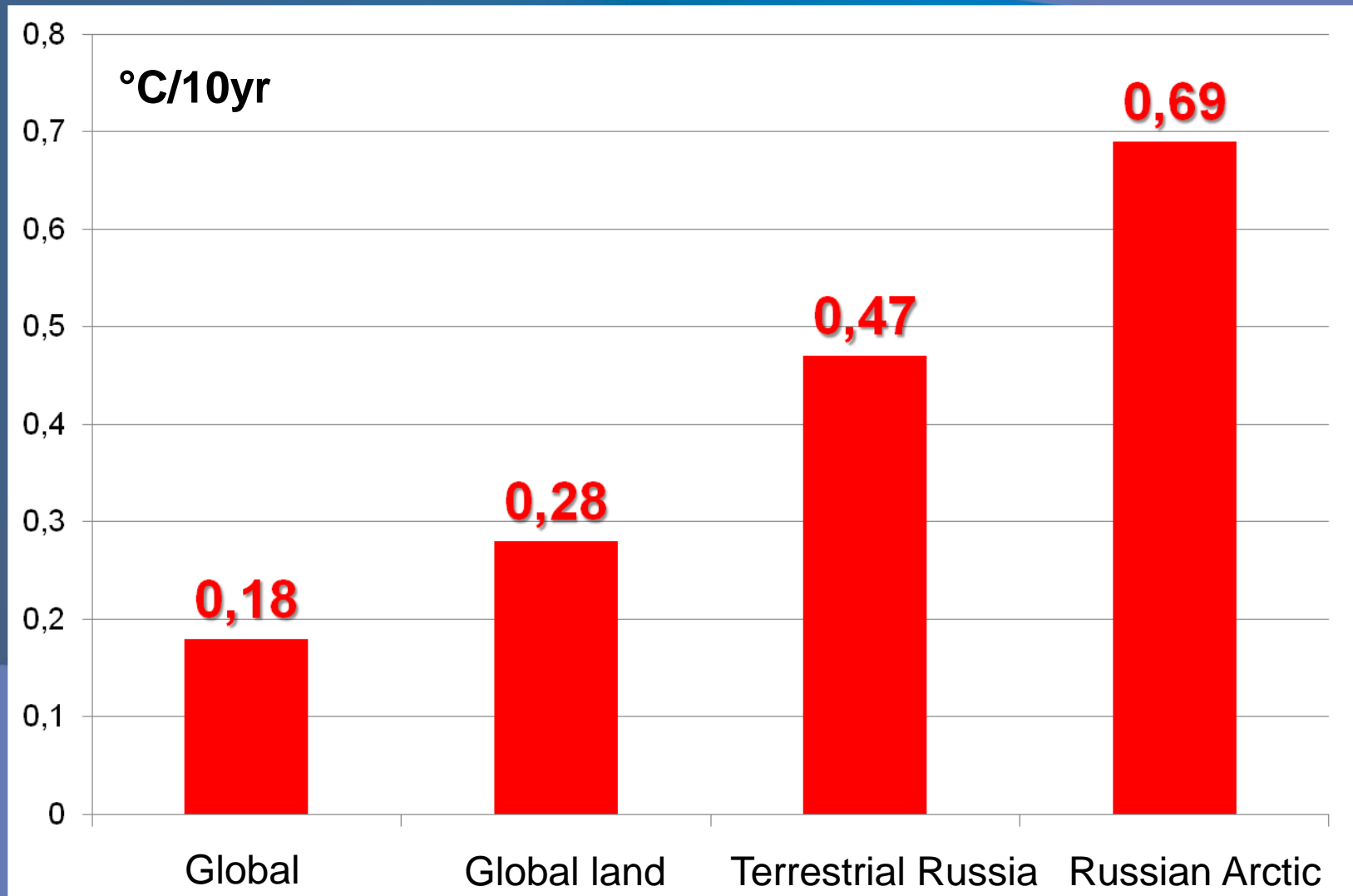


**CLIMATE CHANGE  
ADAPTATION PLAN  
OF THE RUSSIAN  
FEDERATION**



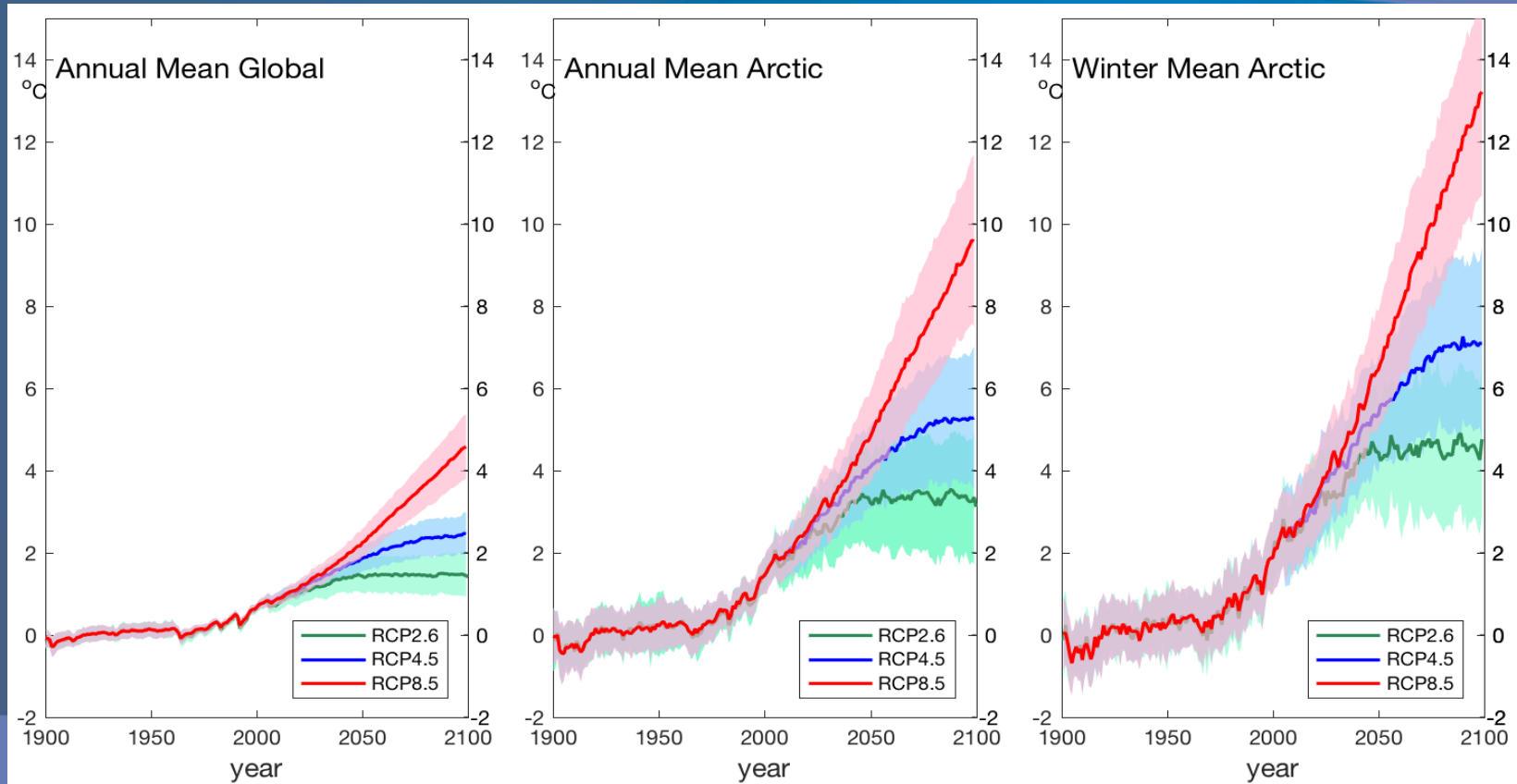
Arctic is becoming one of most visible objects (and subjects) for near- and long-term strategies of adaptation to current and expected CC.

# Roshydromet: Warming since mid-1970s through 2018





# Arctic amplification: through the 21<sup>st</sup> century

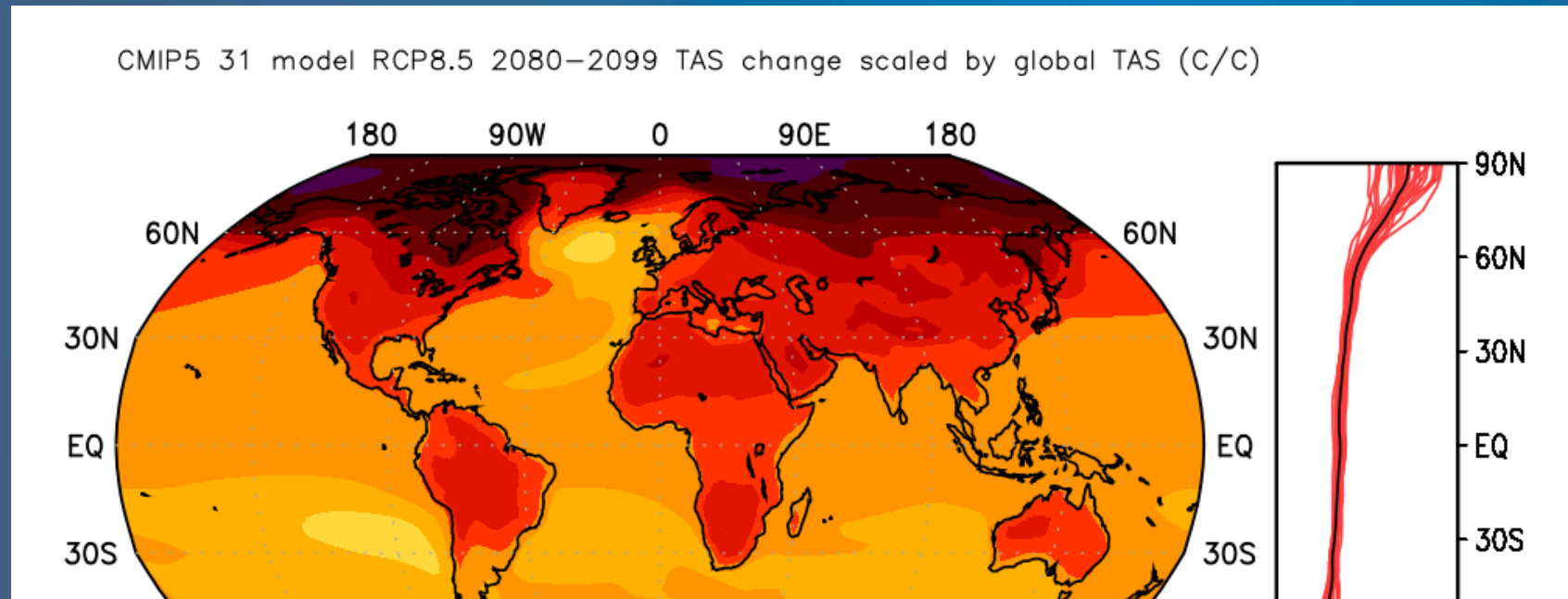


Overland et al., 2018 (Polar Science. accepted):

<https://www.sciencedirect.com/science/article/pii/S1873965218301543?via%3Dihub>

# Arctic amplification: the causes and consequences still to be explored

CMIP5 projections  
(by late 21<sup>st</sup> century, RCP8.5)

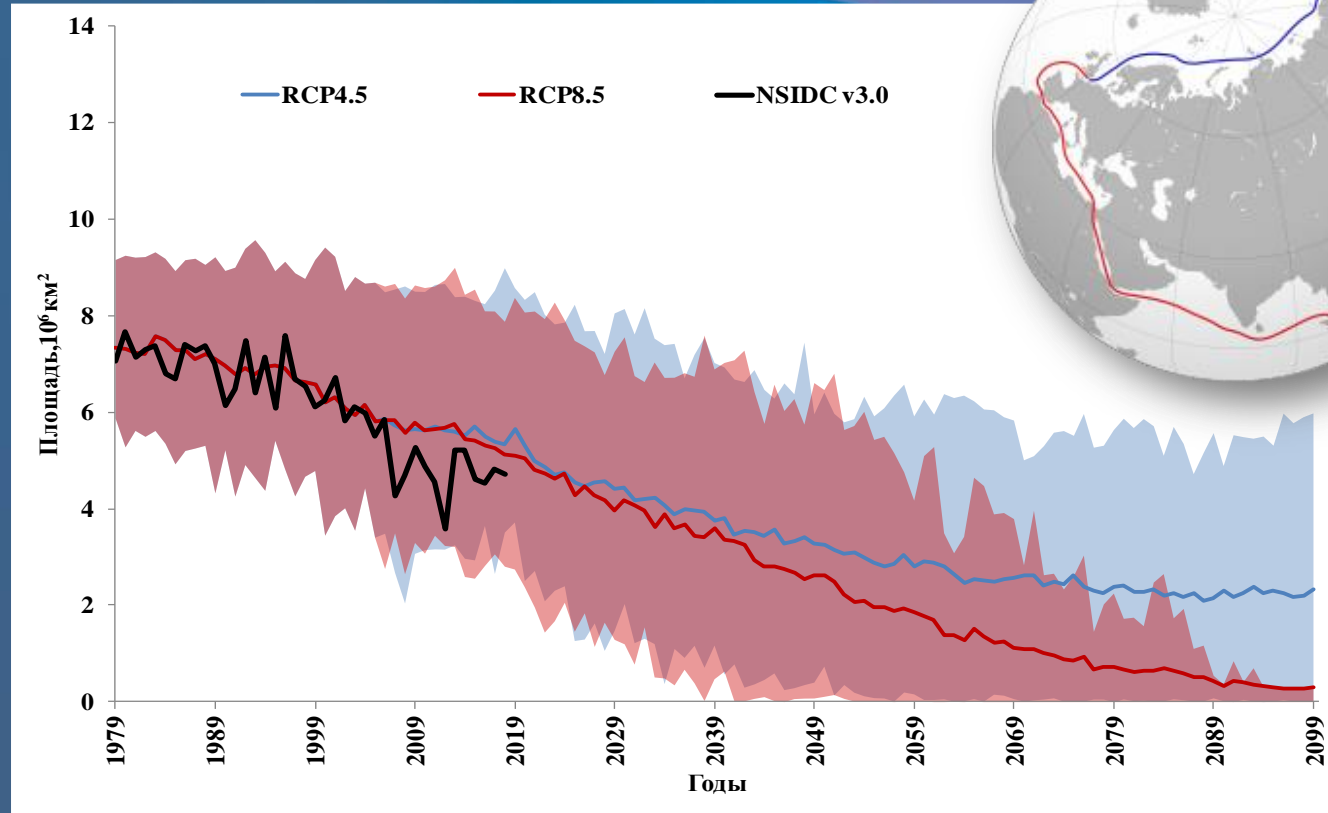


## Open questions:

**What are the relative roles of local sea ice and remote sea surface temperature changes in driving polar amplification, and how does the global climate system respond to changes in Arctic sea ice?**



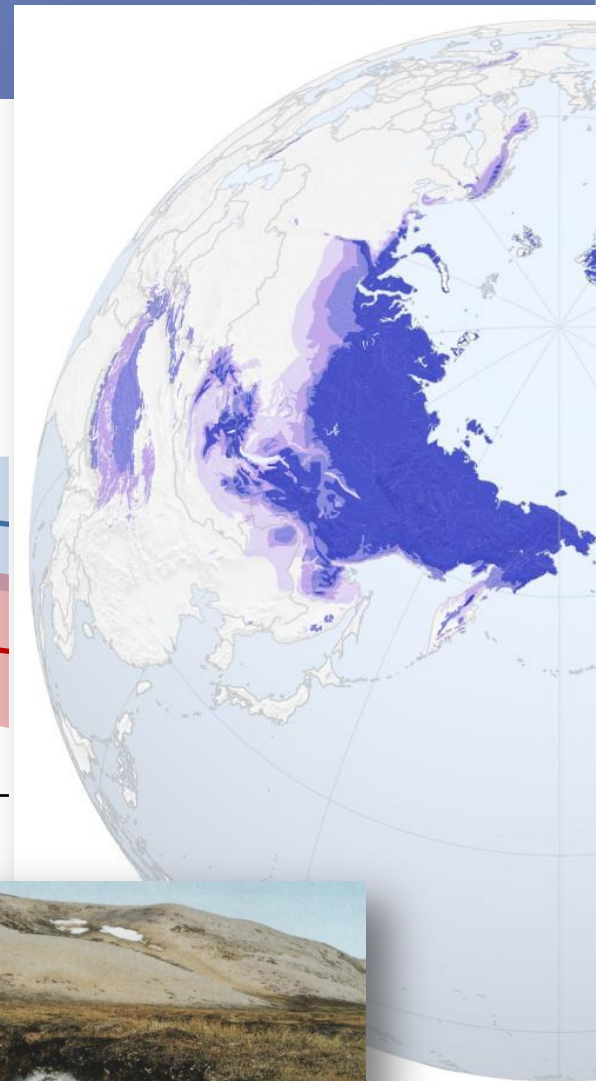
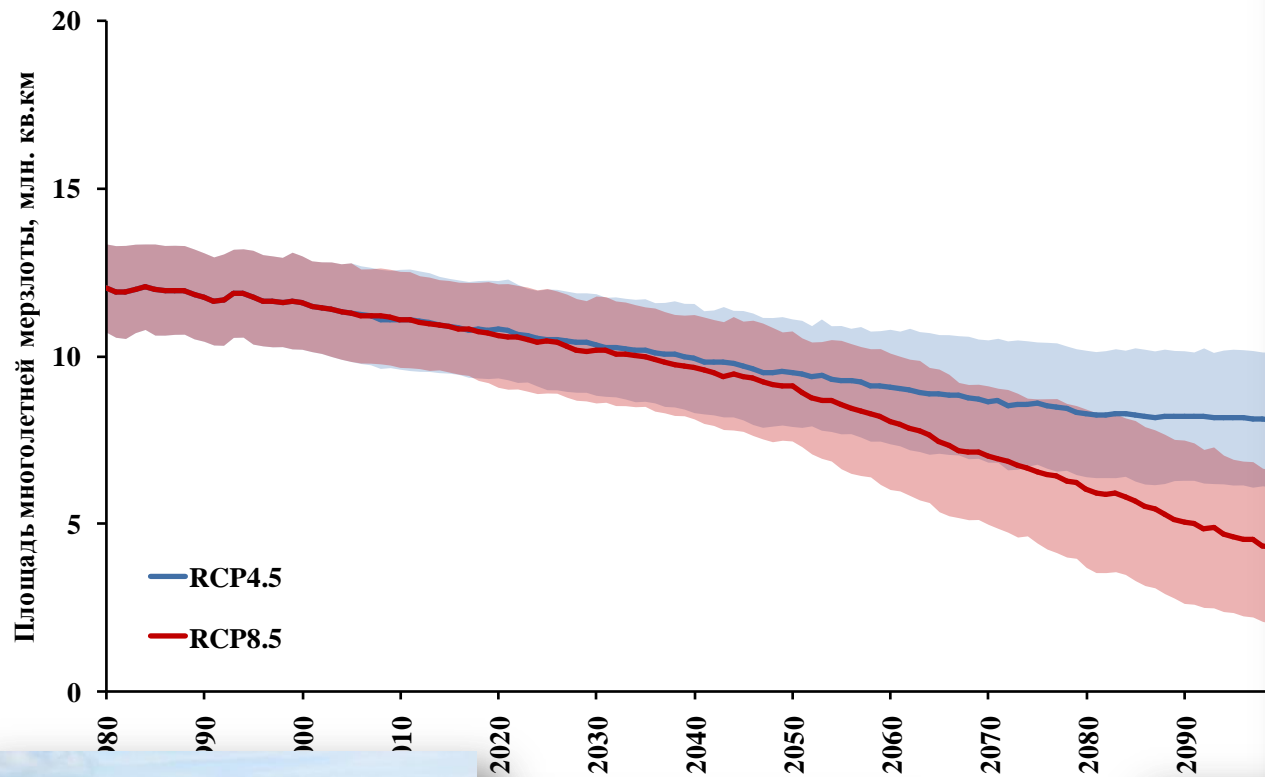
# Sea-ice extent in September over 1979-2099: 30 CMIP5 models RCP8.5/4.5 against updated observation (1979-2018)



## An open question:

The prospect of an “*ice-free Arctic Ocean*”: how soon the sea ice in the Arctic may become essentially seasonal?

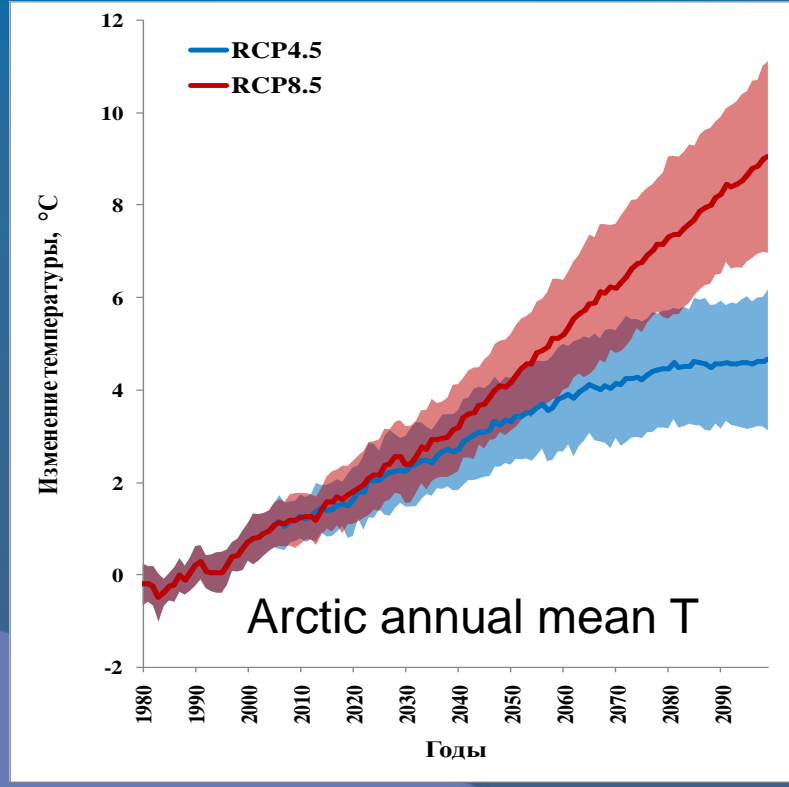
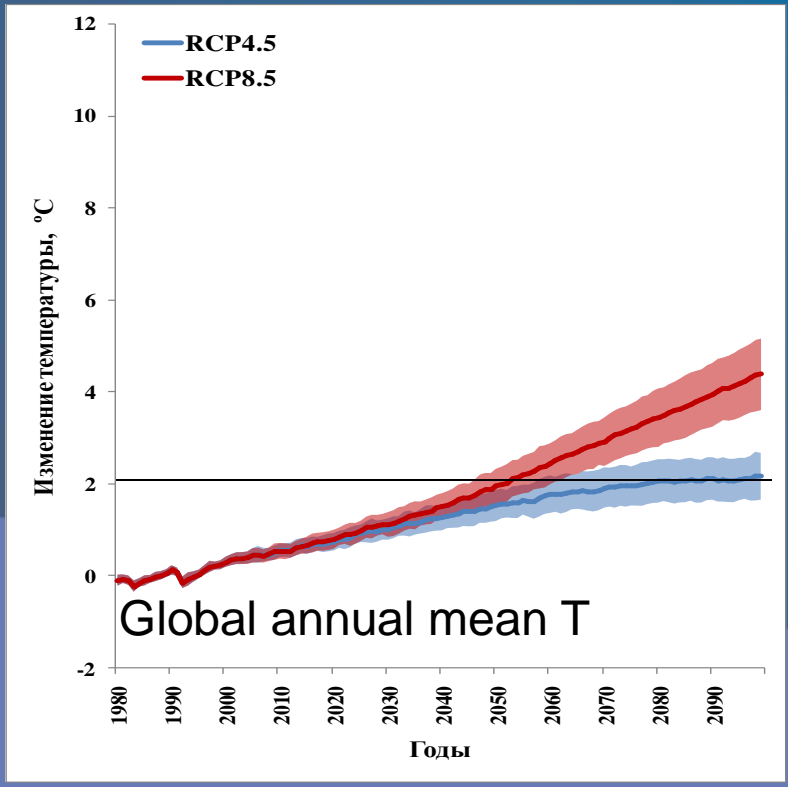
# Subsurface permafrost extent over 1980-2099: 28 CMIP5 models RCP8.5/4.5 Russian territory



## An open question:

Can a warming Arctic become a significant obstacle to achieving Paris Agreement's CC mitigation targets – e.g. the “below 2°C”?

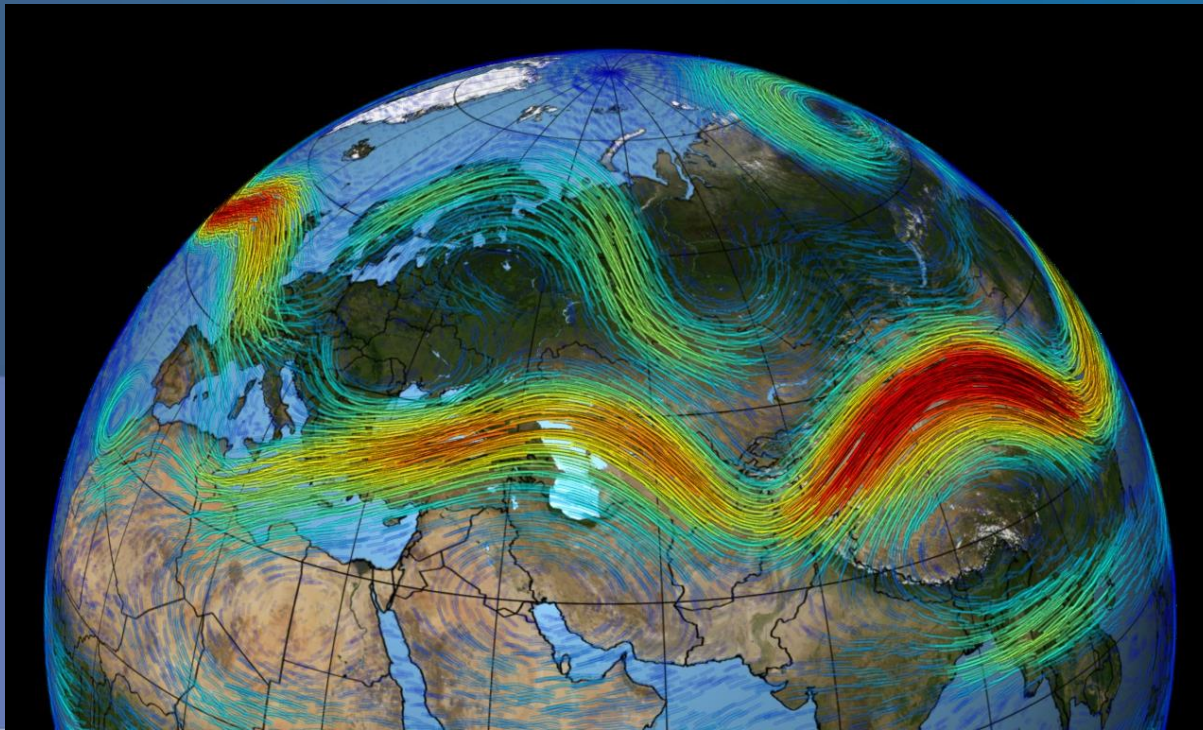
T, °C



# Reshuffles at the “kitchen of weather”: How CC will affect high-impact weather in the Arctic and beyond?

## An open question:

To what extent recent extreme heat and cold waves, floods and droughts may be connected with the warming of the Arctic?





Some other open questions:

Consequences of the Arctic Ocean freshwater budget changes for the *global THC*: how soon and how significantly the increased export of freshwater from the Arctic can affect the deep water formation in the Northern North Atlantic?

The role of ice-sheet (Greenland) dynamics in amplification of ice sheets' contribution to the *global SLR*: are the state-of-the-art SLR projections still too conservative?

The relative role of *short-lived climate forcers* (SLCF), particularly black carbon, in the Arctic warming: how to improve its quantification?

*Polar predictability* on time scales from a season through a decade. A particular intriguing question: what happens to predictability in the Arctic climate system with shrinking of cryosphere?

Etc.

So, while achievements of climate science  
are encouraging...

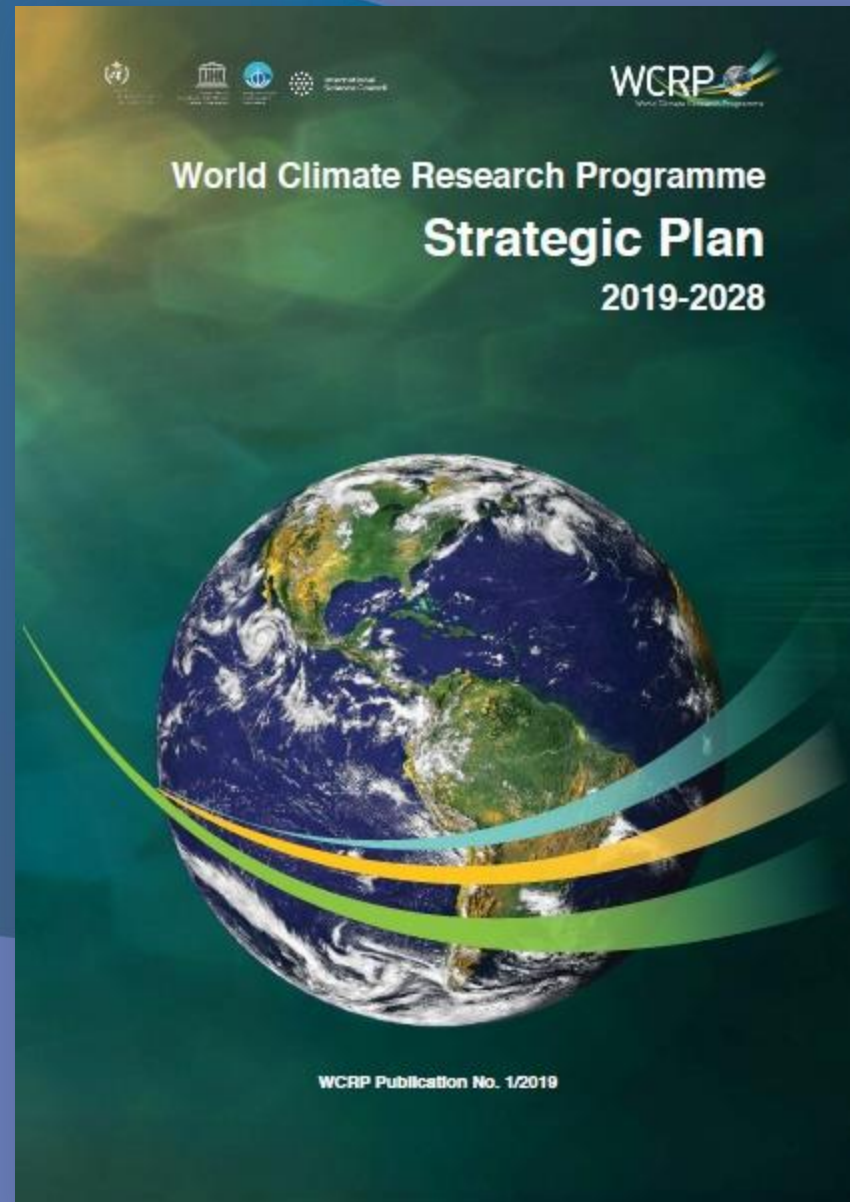
Knowledge gaps are challenging credibility of projections



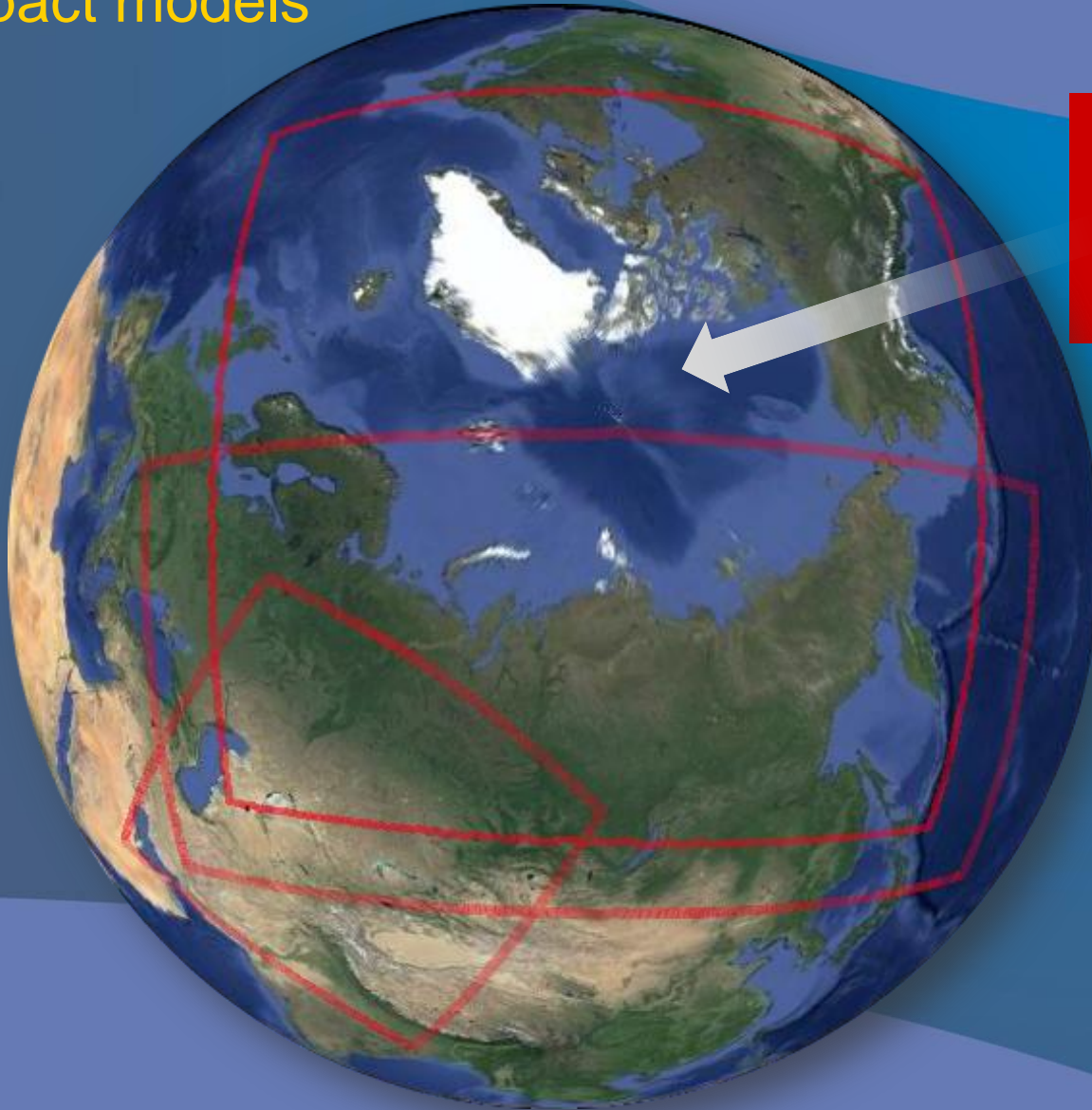
# Arctic as a cross-cut of the World Climate Research Programme's Grand Challenges

<https://www.wcrp-climate.org/grand-challenges/grand-challenges-overview>

- ✓ Melting Ice and Global Consequences
- ✓ Clouds, Circulation and Climate Sensitivity
- ✓ Carbon Feedbacks in the Climate System
- ✓ Weather and Climate Extremes
- ✓ Water for the Food Baskets of the World
- ✓ Regional Sea-Level Change and Coastal Impacts
- ✓ Near-term Climate Prediction



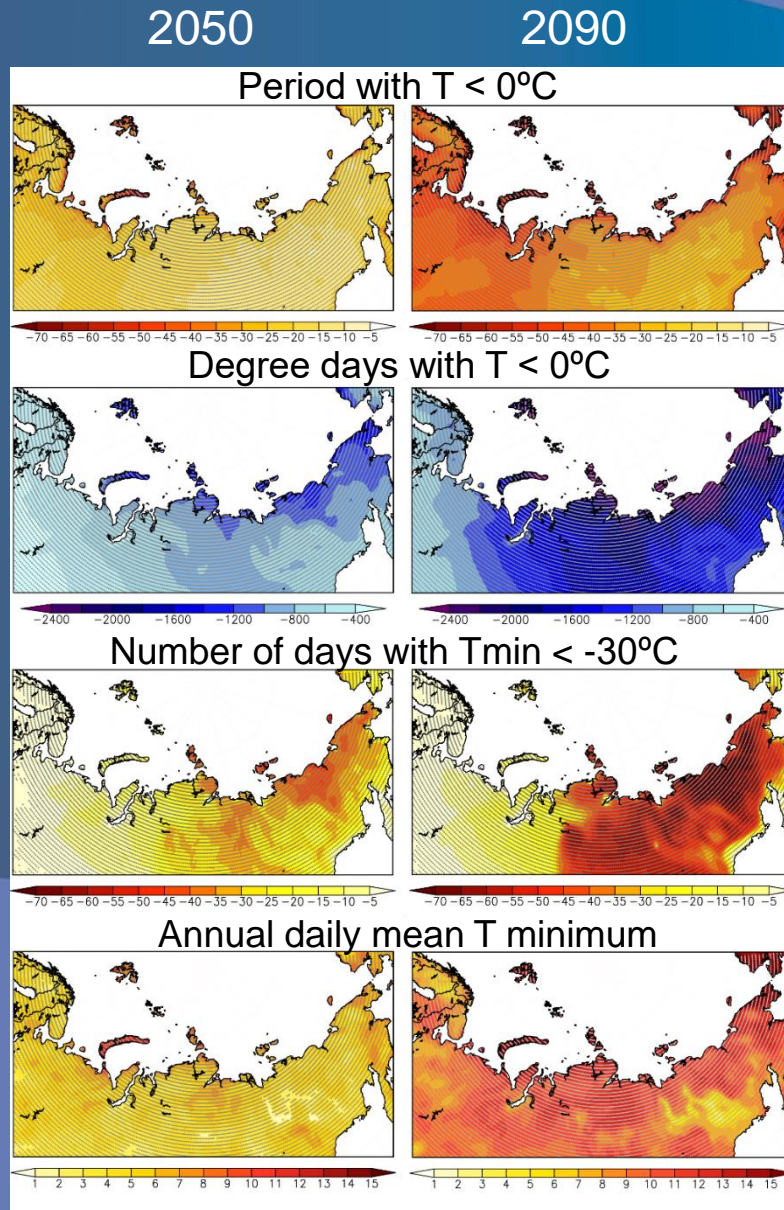
# High resolution CC modeling to provide input into the impact models



**Pan-Arctic RCM**  
**(301×301) 50 km**



# MGO RCM (Arctic-CORDEX) mid- and late 21<sup>st</sup> century vs late 20<sup>th</sup> century (RCP8.5)



Laying of  
pipes and  
drilling

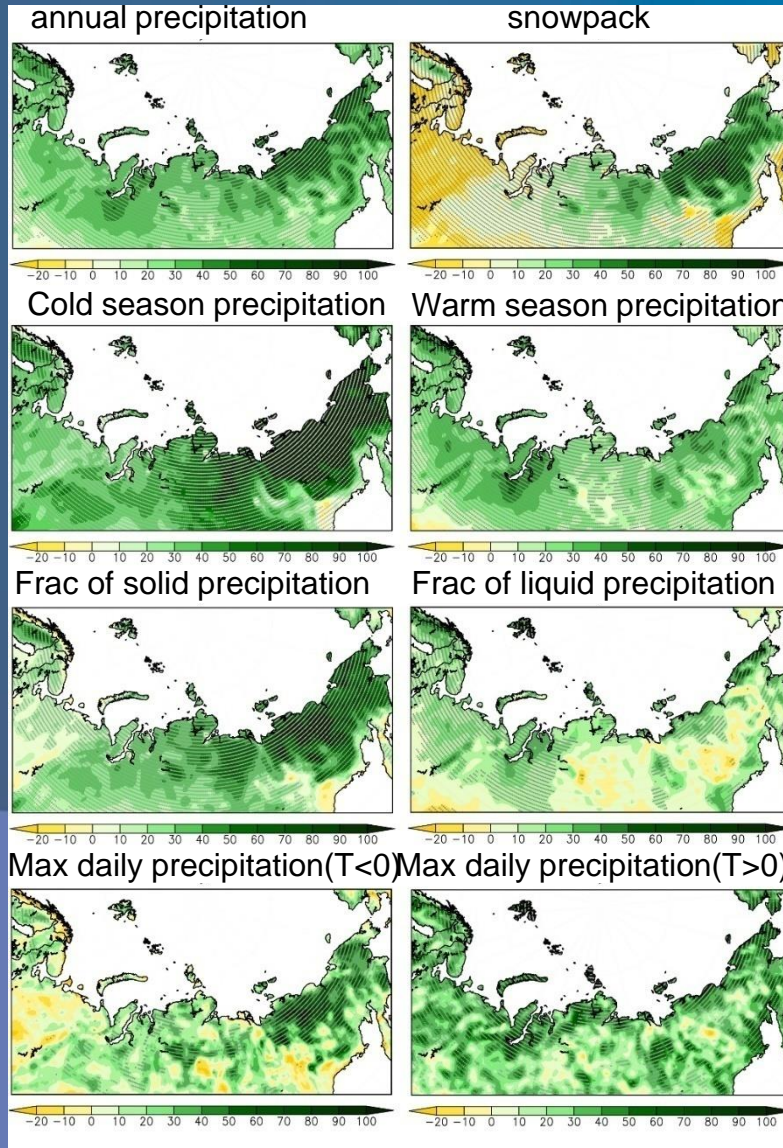
Equipment  
downtime,  
personnel idle  
time and  
operating  
costs

Solidity  
characteristics  
and “wet  
works” in  
construction

# MGO RCM (Arctic-CORDEX) mid- and late 21<sup>st</sup> century vs late 20<sup>th</sup> century (RCP8.5)



## Changes in humidification by 2090



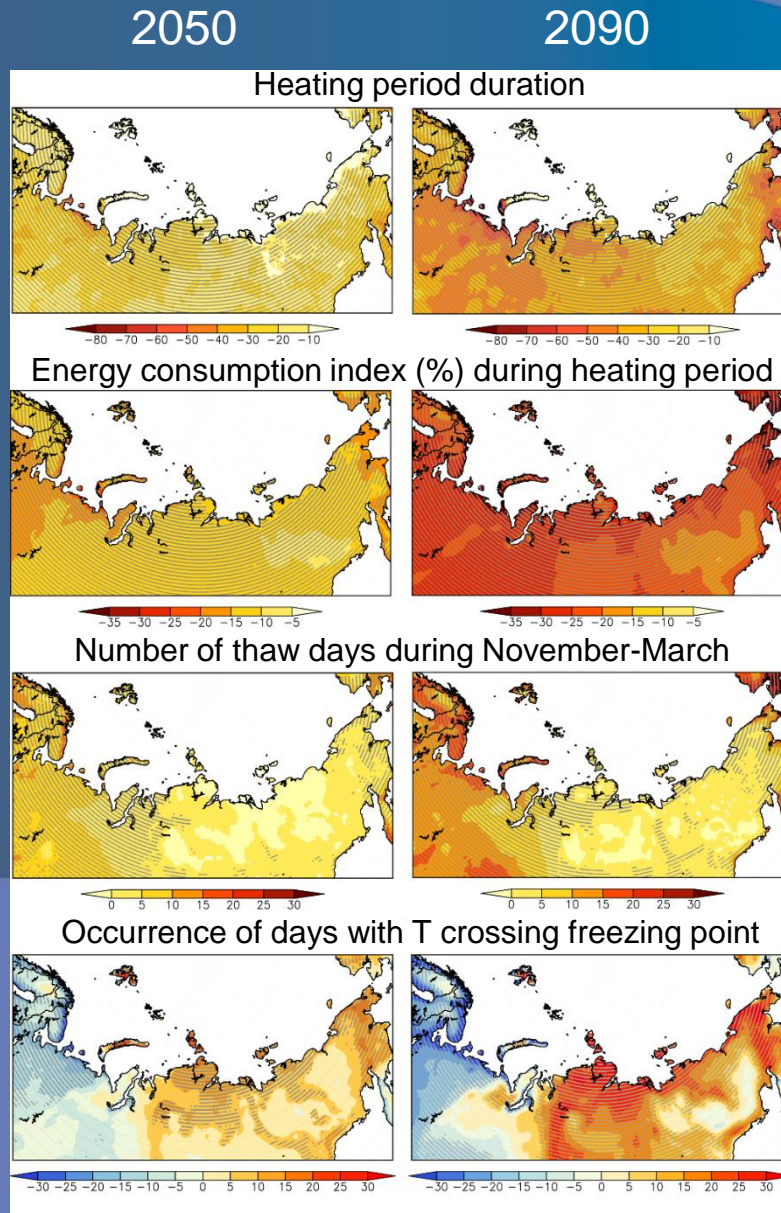
Oil and gas production facilities and machinery, especially for offshore operations and port's inshore facilities

Corrosion resistant characteristics

Efficiency of roadway network



# MGO RCM (Arctic-CORDEX) mid- and late 21<sup>st</sup> century vs late 20<sup>th</sup> century (RCP8.5)

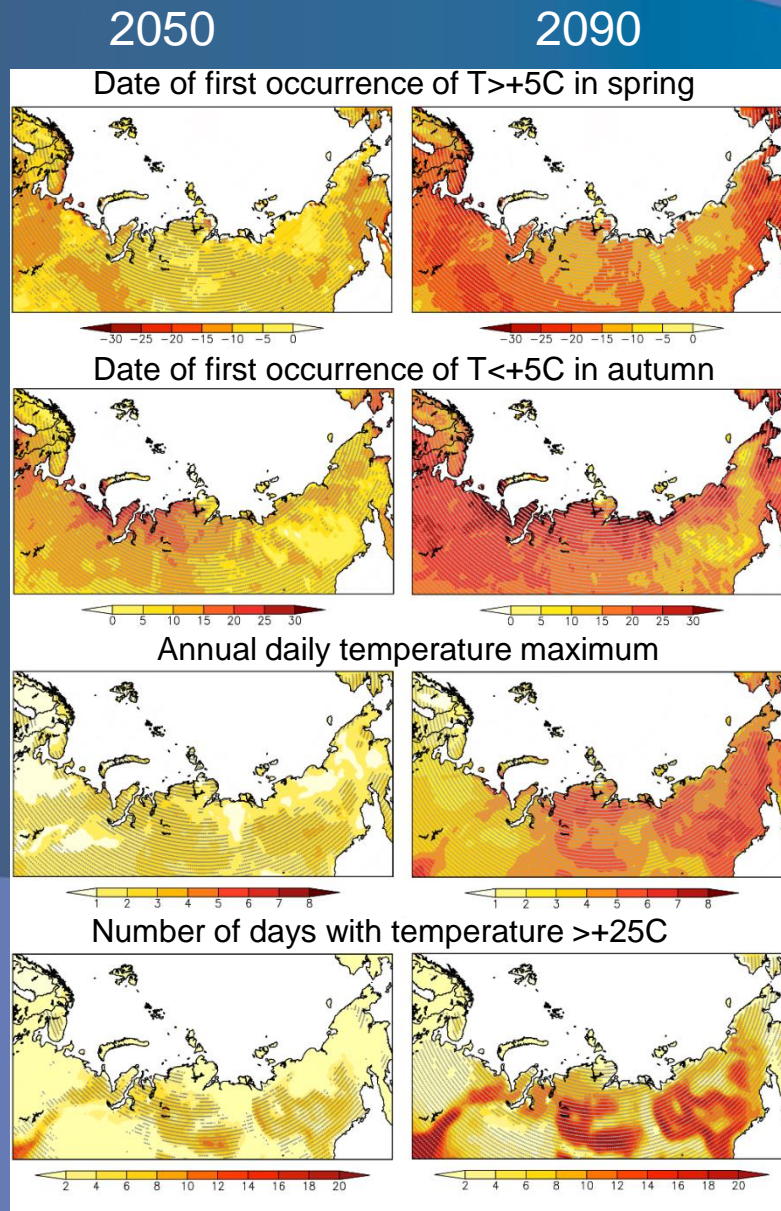


Reliability of  
heat supply  
systems and  
optimization of  
their  
functioning

Efficiency of  
transport  
infrastructure



# MGO RCM (Arctic-CORDEX) mid- and late 21<sup>st</sup> century vs late 20<sup>th</sup> century (RCP8.5)



Port  
infrastructure

Biological  
productivity

Forestry and  
wood  
transportation

# Extreme weather events keep holding top positions in global risk ratings

2017	2018	2019
Extreme weather events	Extreme weather events	Extreme weather events
Large-scale involuntary migration	Natural disasters	Failure of climate-change mitigation and adaptation
Major natural disasters	Cyber-attacks	Natural disasters
Large-scale terrorist attacks	Data fraud or theft	Data fraud or theft
Massive incident of data fraud/theft	Failure of climate-change mitigation and adaptation	Cyber-attacks



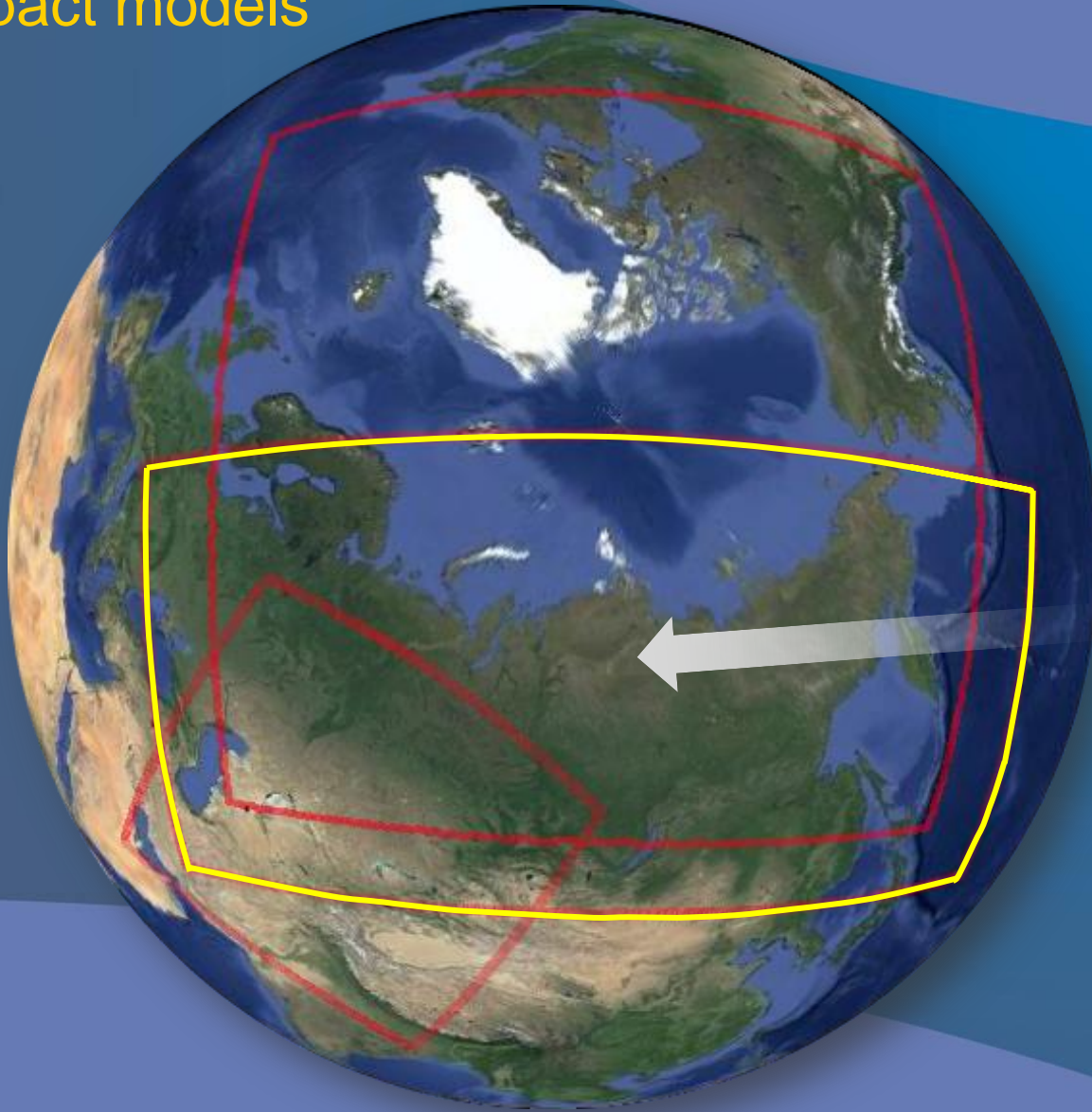
Insight Report

## The Global Risks Report 2019 14th Edition

In partnership with Marsh & McLennan Companies and Zurich Insurance Group



# High resolution CC modeling to provide input into the impact models

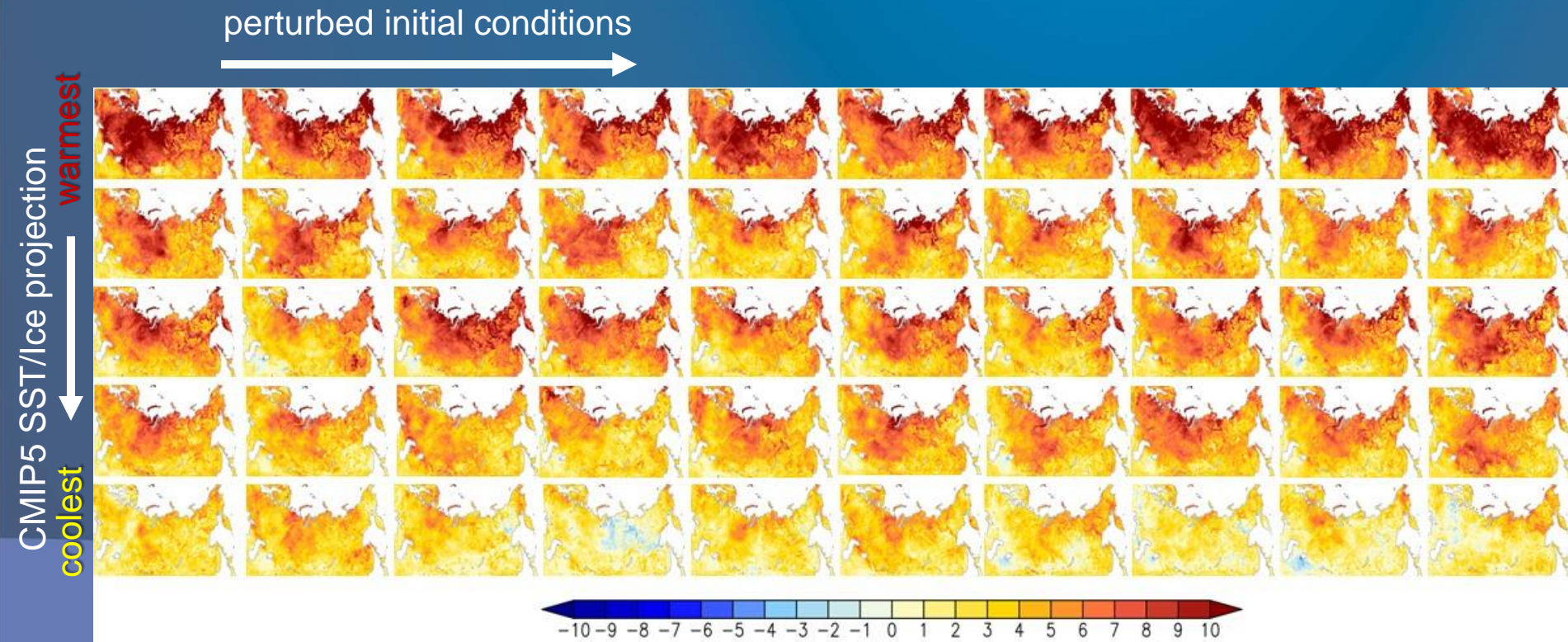


Northern Eurasia  
(381×183) 25 km



# Large ensembles of projections to tackle natural climate variability and discern regional changes in the near through long term

MGO RCM 50-member ensemble (25 km) late 21<sup>st</sup> vs late 20<sup>th</sup> century (RCP8.5)

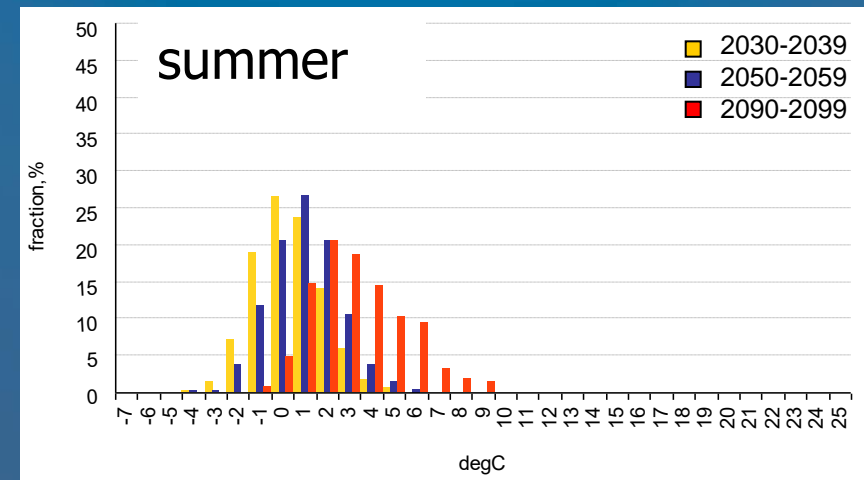
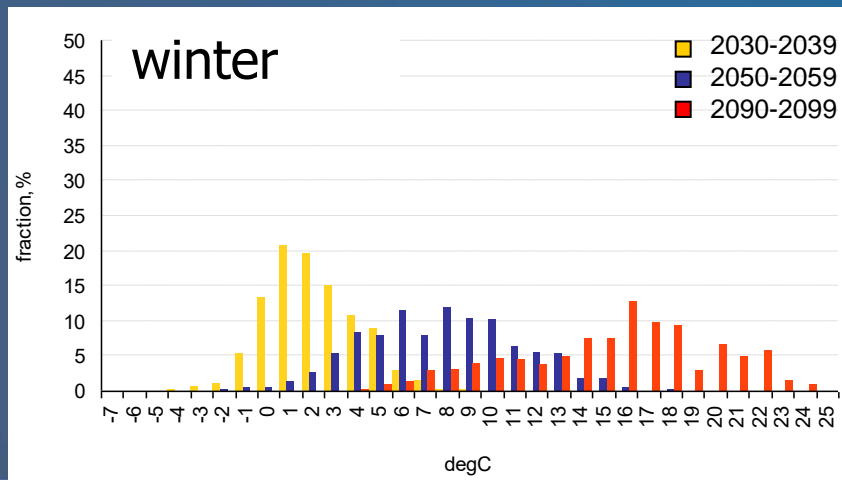


Changes ( $^{\circ}\text{C}$ ) in annual  $T_{\min}$  by 2055 relative to 1995:  
effects of unforced climate variability and global ocean forcing

# Large ensembles of projections to tackle natural climate variability and discern regional changes in the near through long term

MGO RCM 50-member ensemble (25 km) 21<sup>st</sup> vs late 20<sup>th</sup> century (RCP8.5)

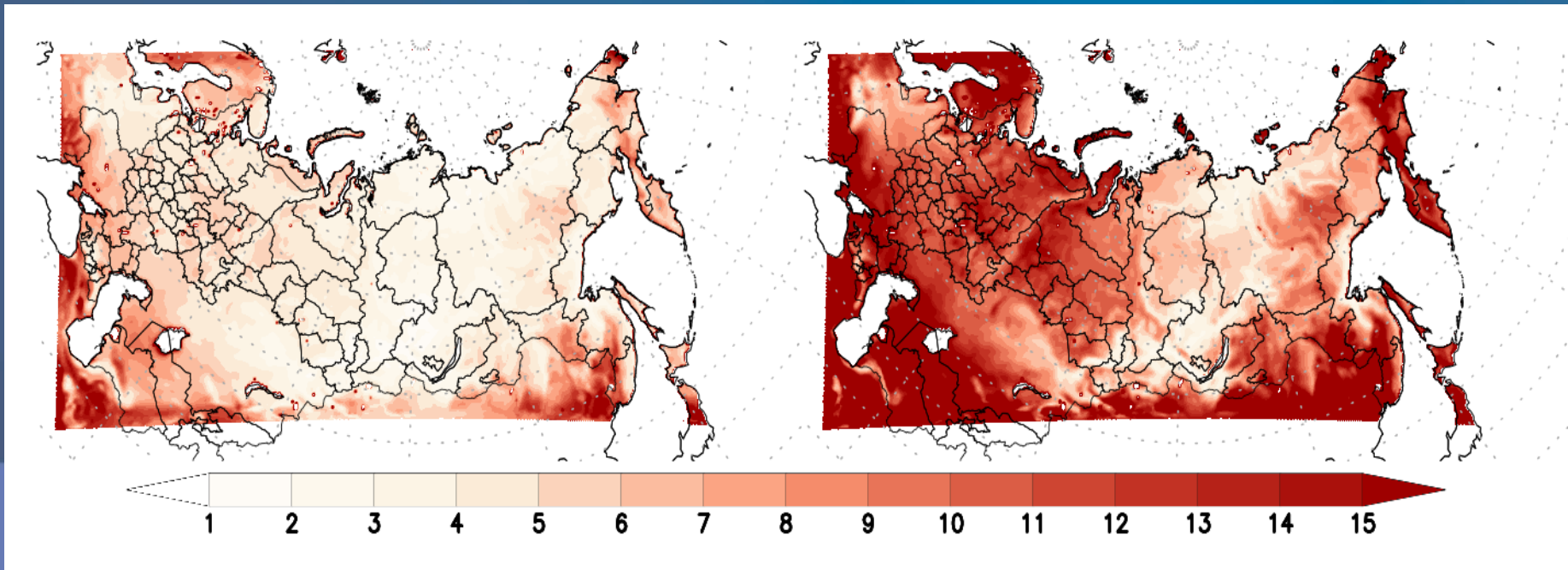
## T PDF change (°C) at Taymyr peninsula, Russian Arctic (RCP8.5)



# Large ensembles of projections to tackle natural climate variability and discern regional changes in the near through long term

MGO RCM 50-member ensemble (25 km) 21<sup>st</sup> vs late 20<sup>th</sup> century (RCP8.5)

## Heat wave duration change (days) vs 1990-1999 (RCP8.5)



2050-2059

2090-2099

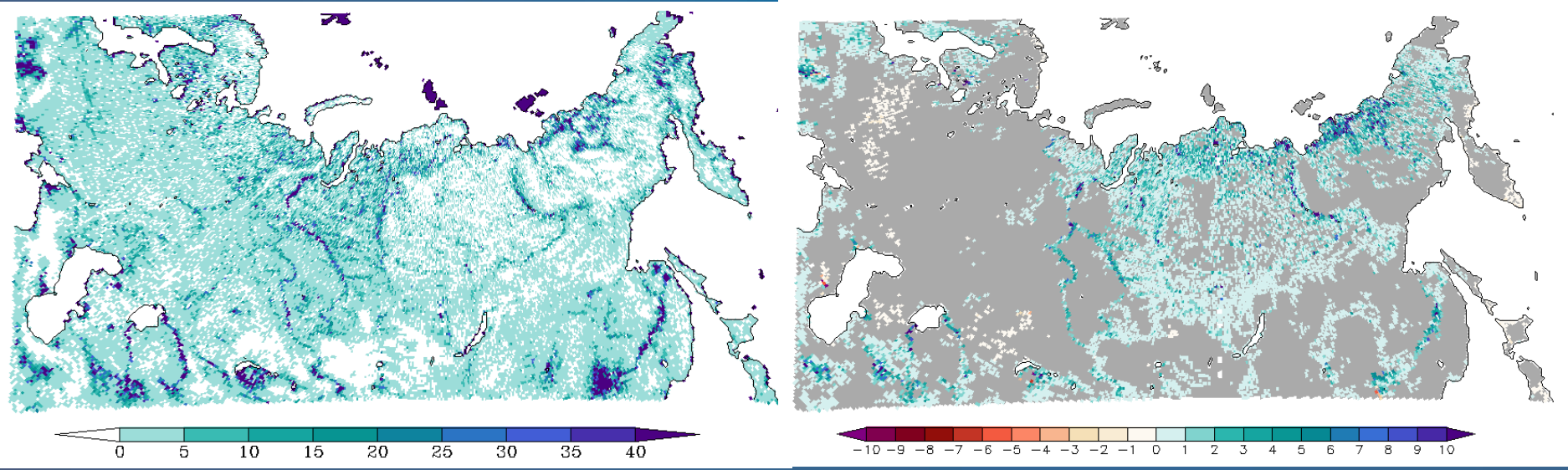




# Large ensembles of projections to tackle natural climate variability and discern regional changes in the near through long term

MGO RCM 30-member ensemble (25 km) 21<sup>st</sup> vs late 20<sup>th</sup> century (RCP8.5)

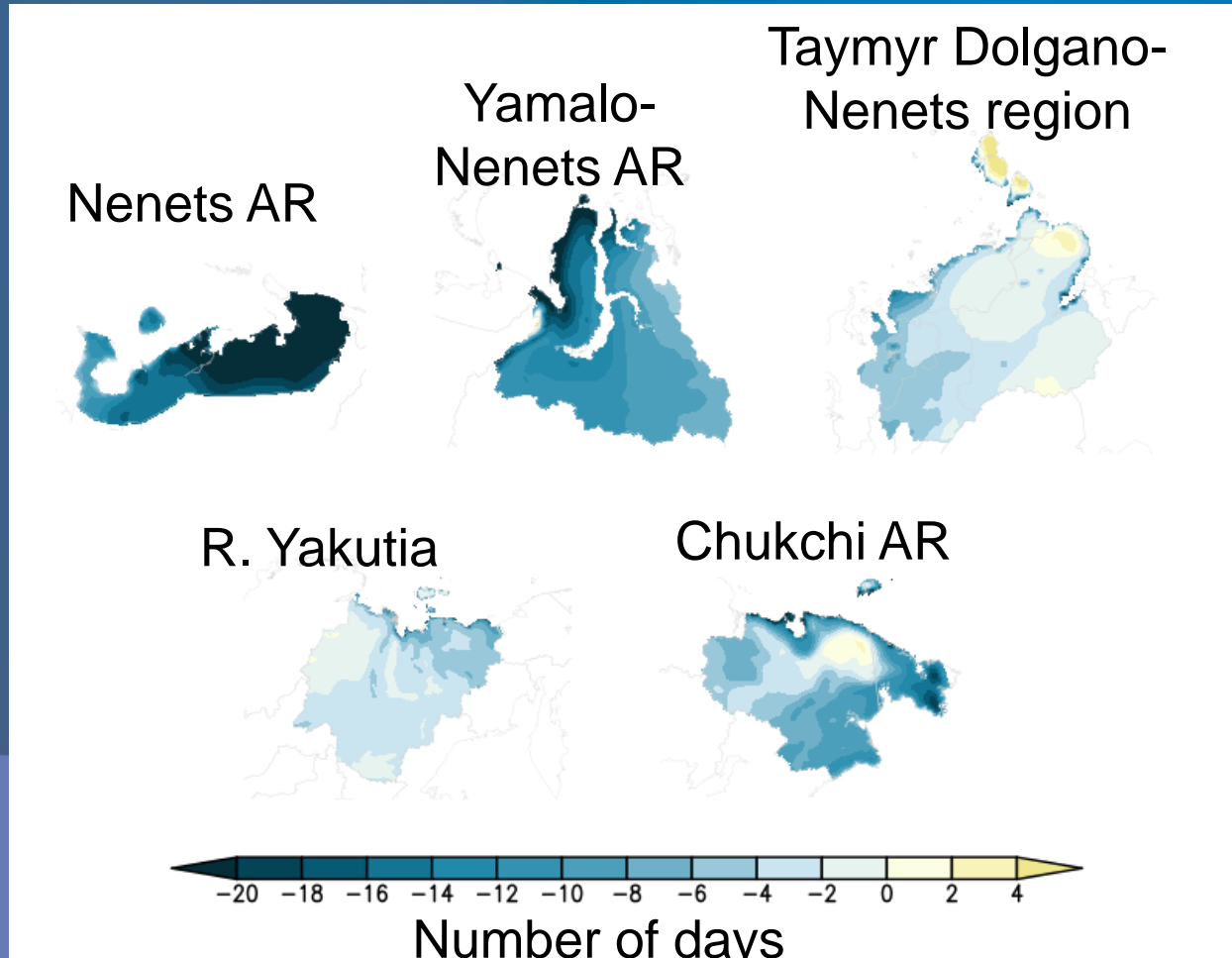
## Floods



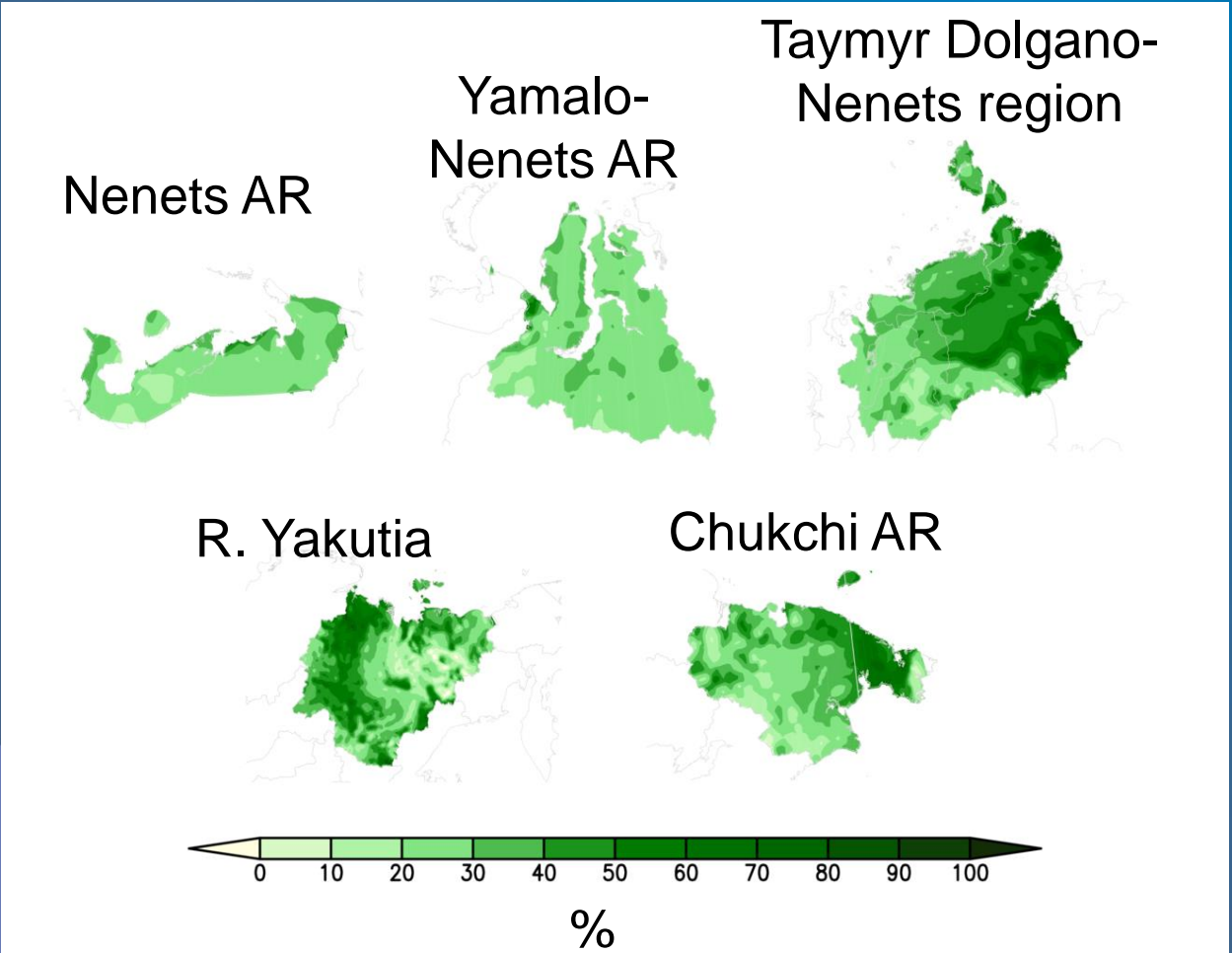
Simulated max yearly flooded area, 1990-99  
(% of  $0.25^\circ \times 0.25^\circ$  grid cell area)

Its projected change by 2050-59

# Changes in the number of days with intraday T crossing 0°C in May-June by 2050-59 (RCP8.5) 50 ensemble members



# Changes in maximum precipitation over 5 consequent days (%) in July-September by 2090-99 (RCP8.5) 50 ensemble members



It is necessary to learn to take the best possible decisions on adaptation to CC. Having in mind the very high cost of erroneous decisions, particularly in the Arctic, it is necessary to invest in enhancing observations and scientific research aimed at minimising uncertainties of CC projections and quantifying corresponding impacts.

The science community is faced by a big work on making use of opportunities provided by modern technologies. In particular, an intensive progress is urgently needed in developing methods and techniques that provide interpretation and proper use of climate monitoring and modelling results for application (proactive adaptation).

# Thank you!

## Acknowledgements:

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