Environment Canada Environnement Canada

Canada

14th INTERNATIONAL WORKSHOP ON WAVE HINDCASTING AND FORECASTING - 5th COASTAL HAZARDS SYMPOSIUM

Projected changes in the Arctic Ocean wave climate using the CMIP5 simulations

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Key west, November 13th 2015

wallpaper.com

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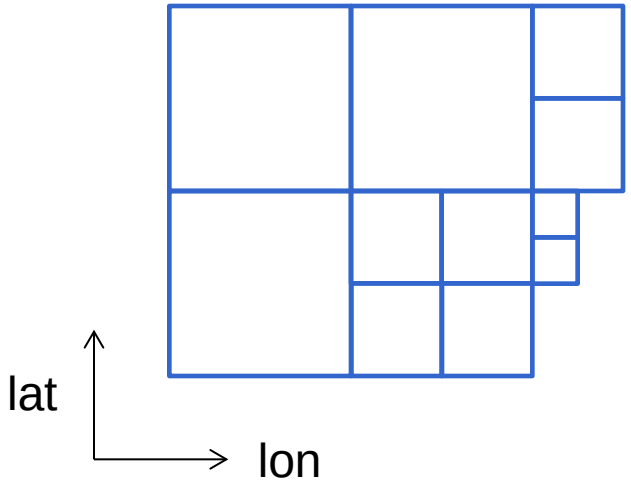
Introduction

- Climate change: **global warming** → Arctic
- Changes in Arctic wave climate — factors:
  - Ice retreat → **New** open water areas
  - Ice retreat → **Fetch** increase:
    - More fully developed sea states (not fetch limited)
    - Wind sea might even develop into swell
  - Changing surface **winds** → Wave forcing
- **Impacts**: coastal erosion, shipping, acceleration of ice retreat — feedback
- Wave modelling in the Arctic is **challenging**: CFL restriction at high lat, pole singularity, ice-wave interactions, etc

Wave model setup

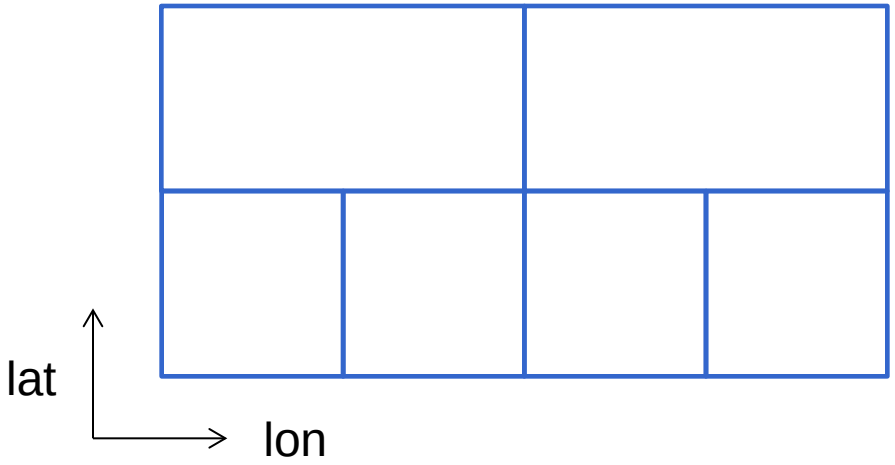
- WAVEWATCH III 4.18
- **SMC grid** - resolution:
  - Global: 50-100km
  - Arctic: 12-25km
- Forcing: 10m wind (w) & sea ice concentration (sic)
- Physics: ST4
- Ice: IC0 (25%,75%)
- Output: mean wave parameters Δt=1h
- Parallelization: 514 MPI tasks

SMC grid: features



Multi resolution grid

Increase spatial resolution at desired locations (near coast and/or specific areas)

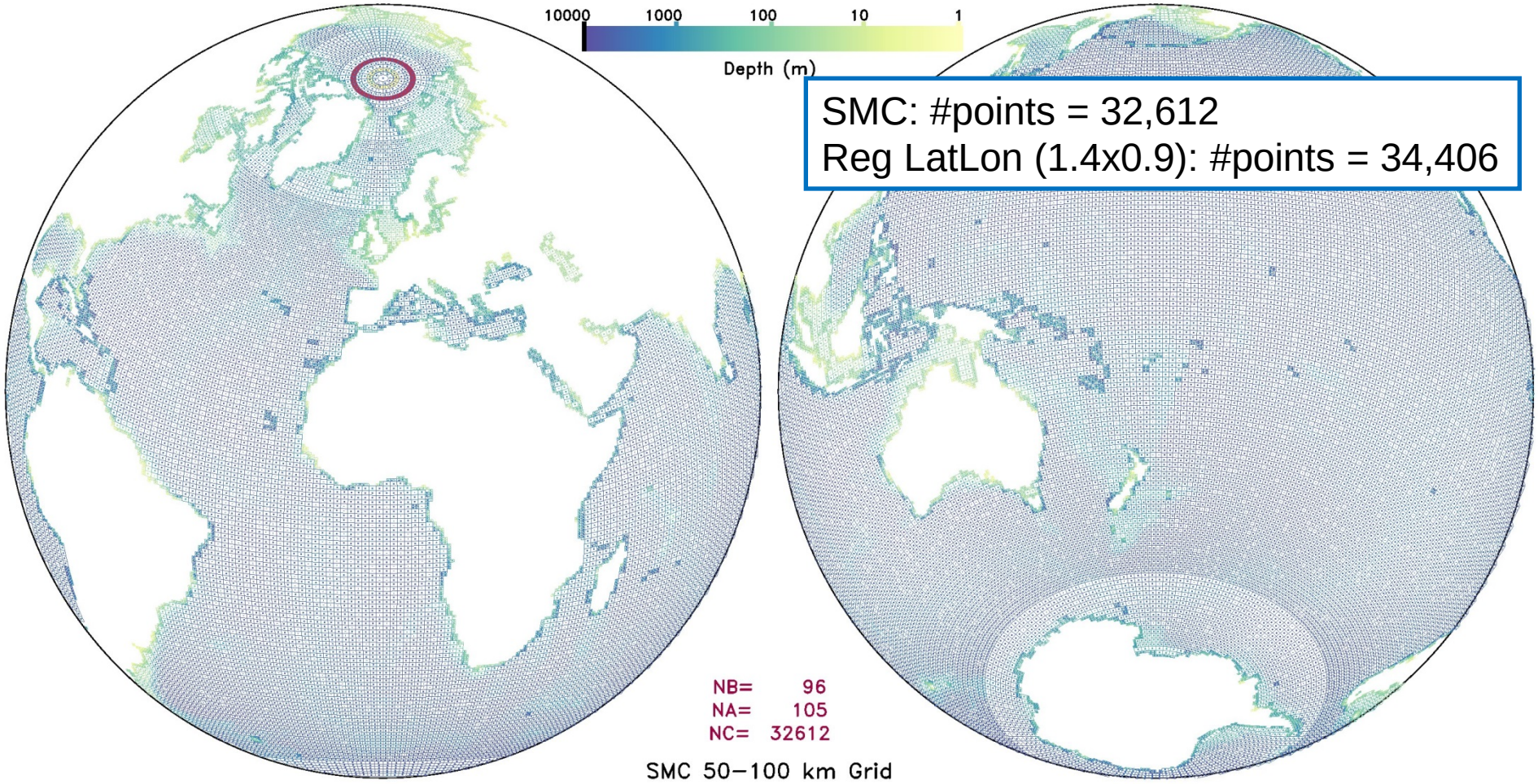


Arctic

Cell merging at high latitudes: relaxes CFL restriction

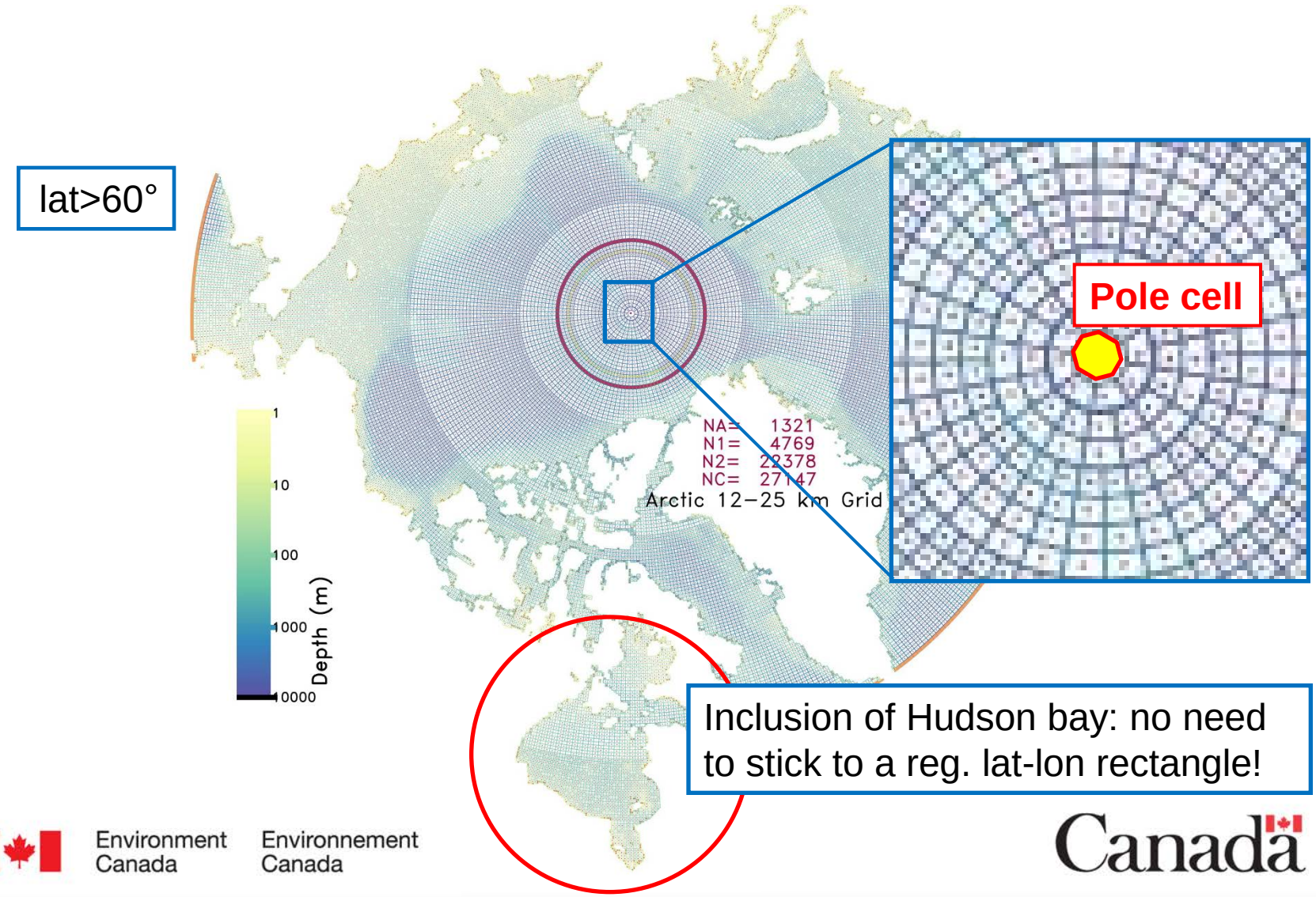
Polar cell is introduced

SMC grid: 50-100km GLOBAL grid

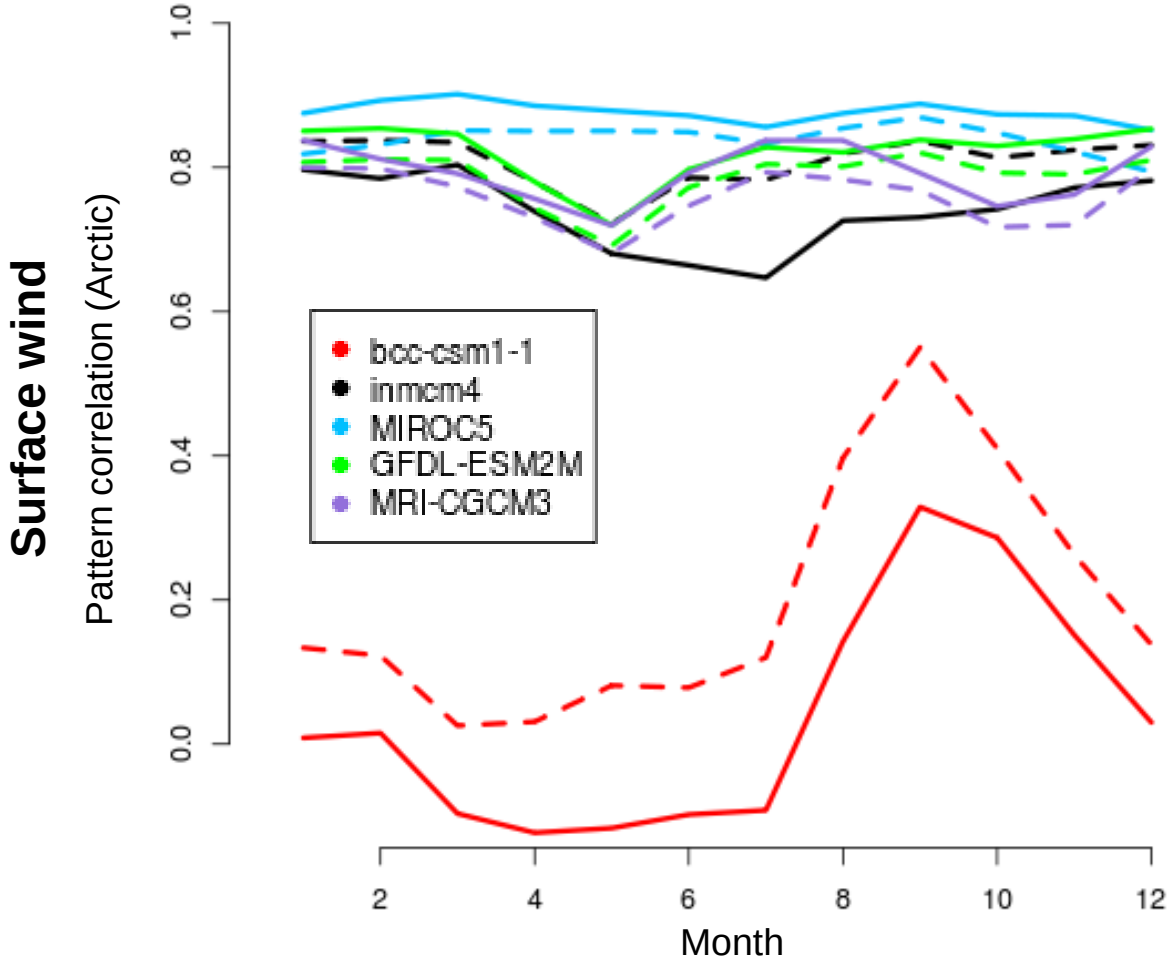


SMC: #points = 32,612
Reg LatLon (1.4x0.9): #points = 34,406

SMC grid: 25-50km ARCTIC grid



Forcing: CMIP5

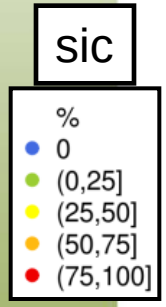


(compared to ERA interim)

Forcing: MIROC5 - ice

RCP 4.5

1979-2005	2026-2045	2081-2100
March	March	March
September	September	September



Forcing: MIROC5 - ice

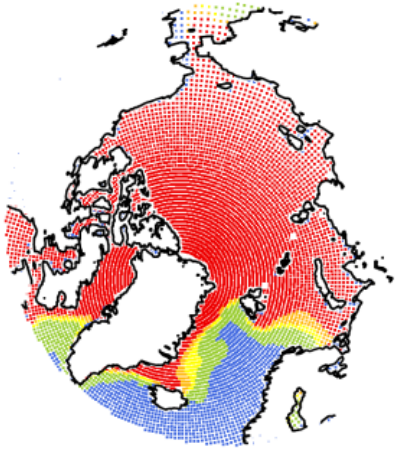
RCP 8.5

1979-2005

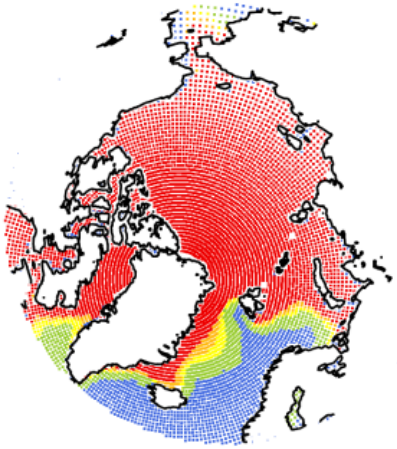
2026-2045

2081-2100

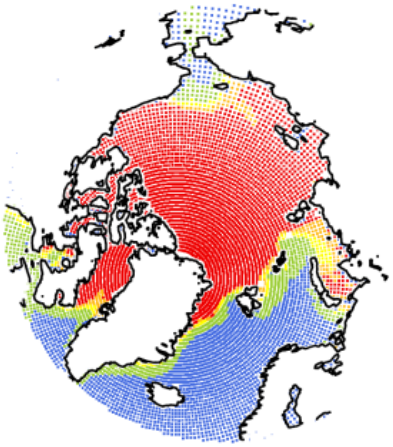
March



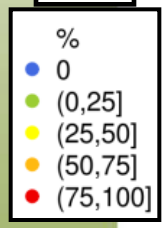
March



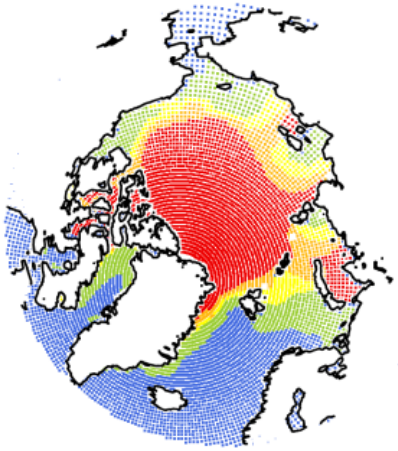
March



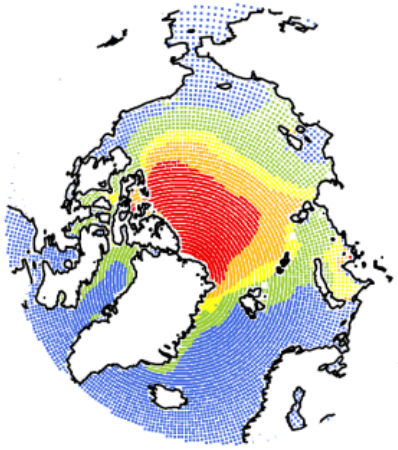
sic



September



September



ICE FREE!

September

Forcing: MIROC5 - wind

RCP 4.5

1979-2005

2026-2045

2081-2100

March

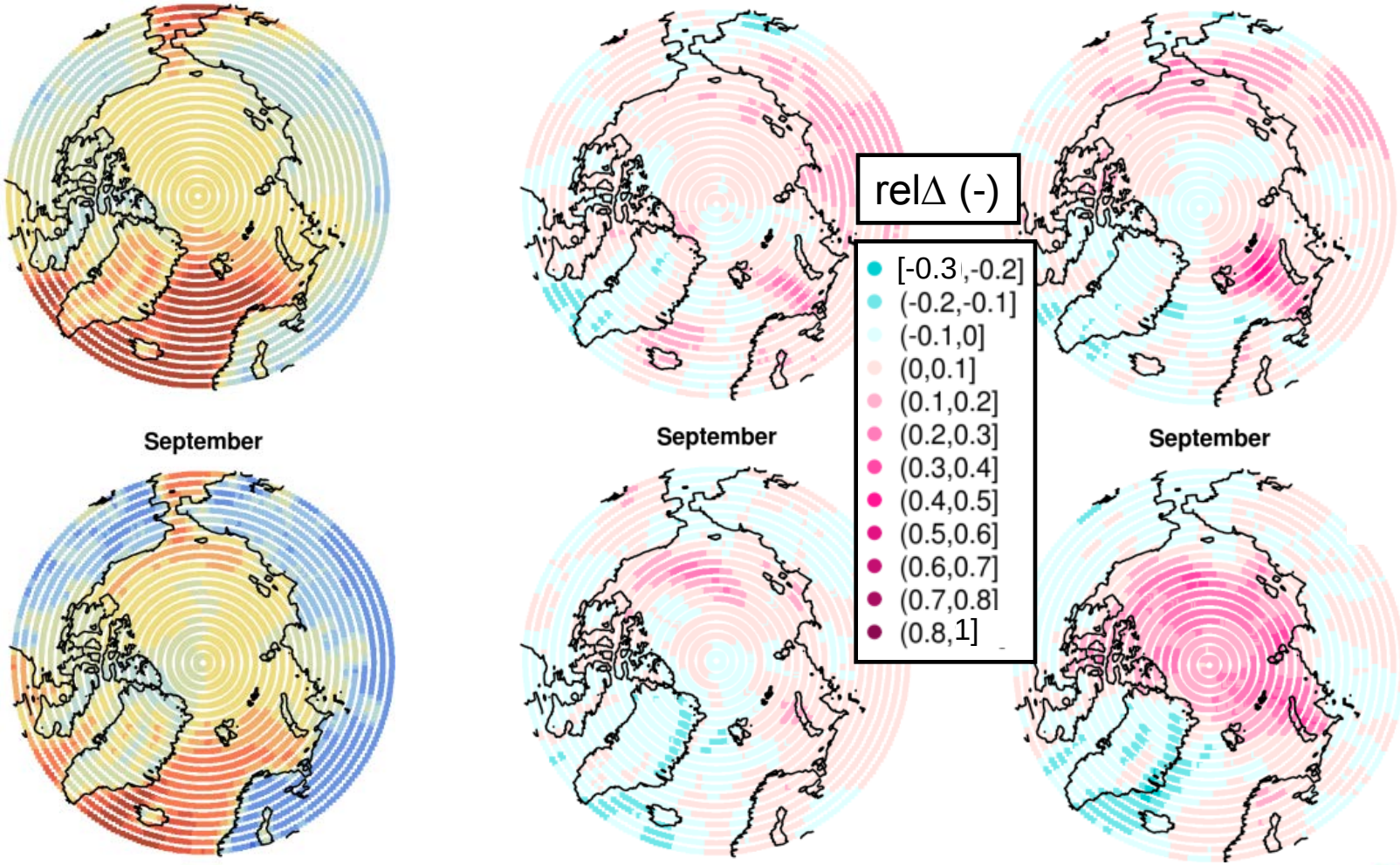
September

w50

m/s
0
(0,1]
(1,2]
(2,3]
(3,4]
(4,5]
(5,6]
(6,7]
(7,8]
(8,9]
>9

relΔ (-)

[-0.3,-0.2]
(-0.2,-0.1]
(-0.1,0]
(0,0.1]
(0.1,0.2]
(0.2,0.3]
(0.3,0.4]
(0.4,0.5]
(0.5,0.6]
(0.6,0.7]
(0.7,0.8]
(0.8,1]



Forcing: MIROC5 - wind

RCP 8.5

1979-2005

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(0.4,0.5]
(0.5,0.6]
(0.6,0.7]
(0.7,0.8]
(0.8,1]

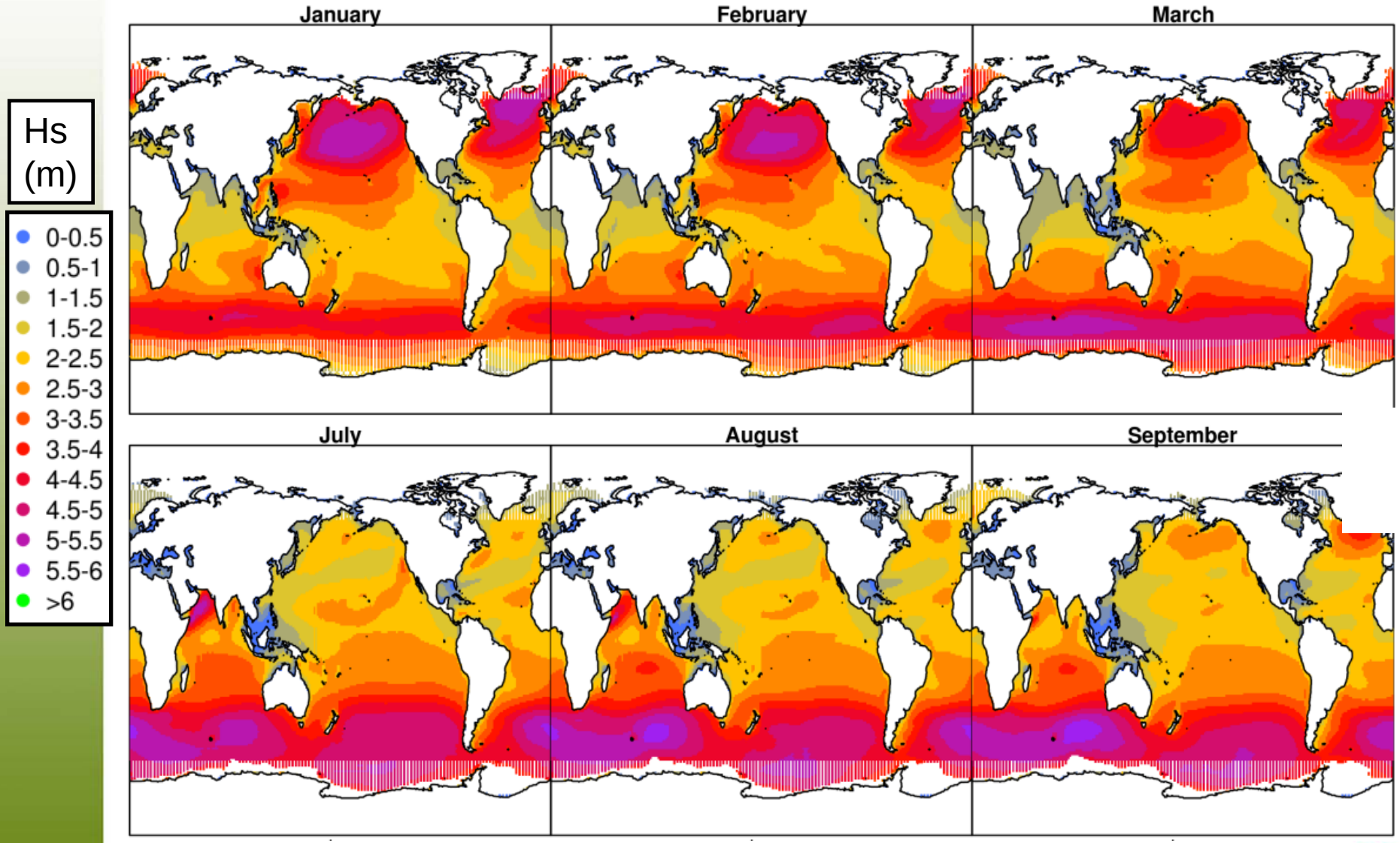
~60%
~4 m/s

~40%
~3 m/s

Feedback
Ice – wind

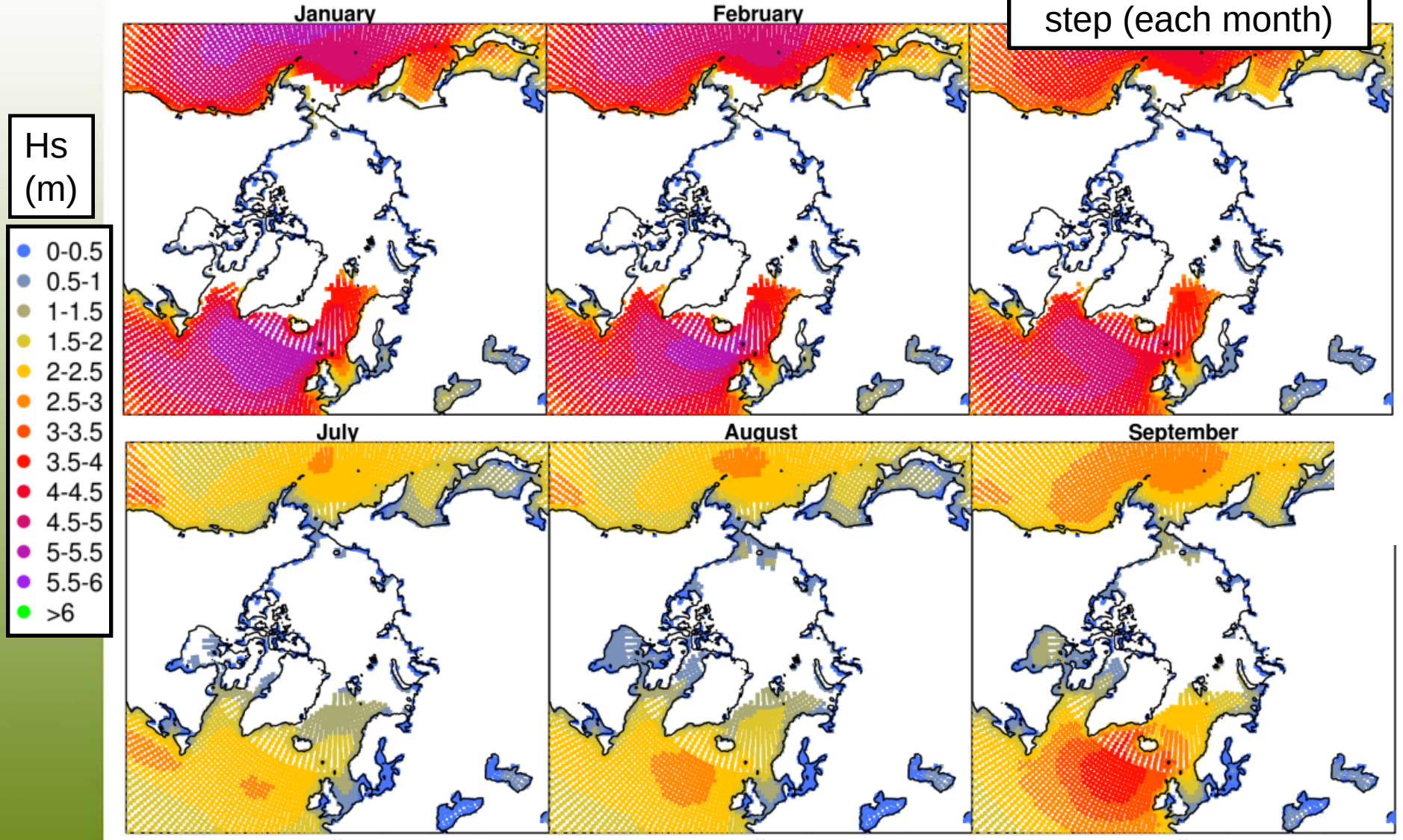
ICE FREE
& HIGHER SPEED!

Mean Hs 1979-2005 (ref)

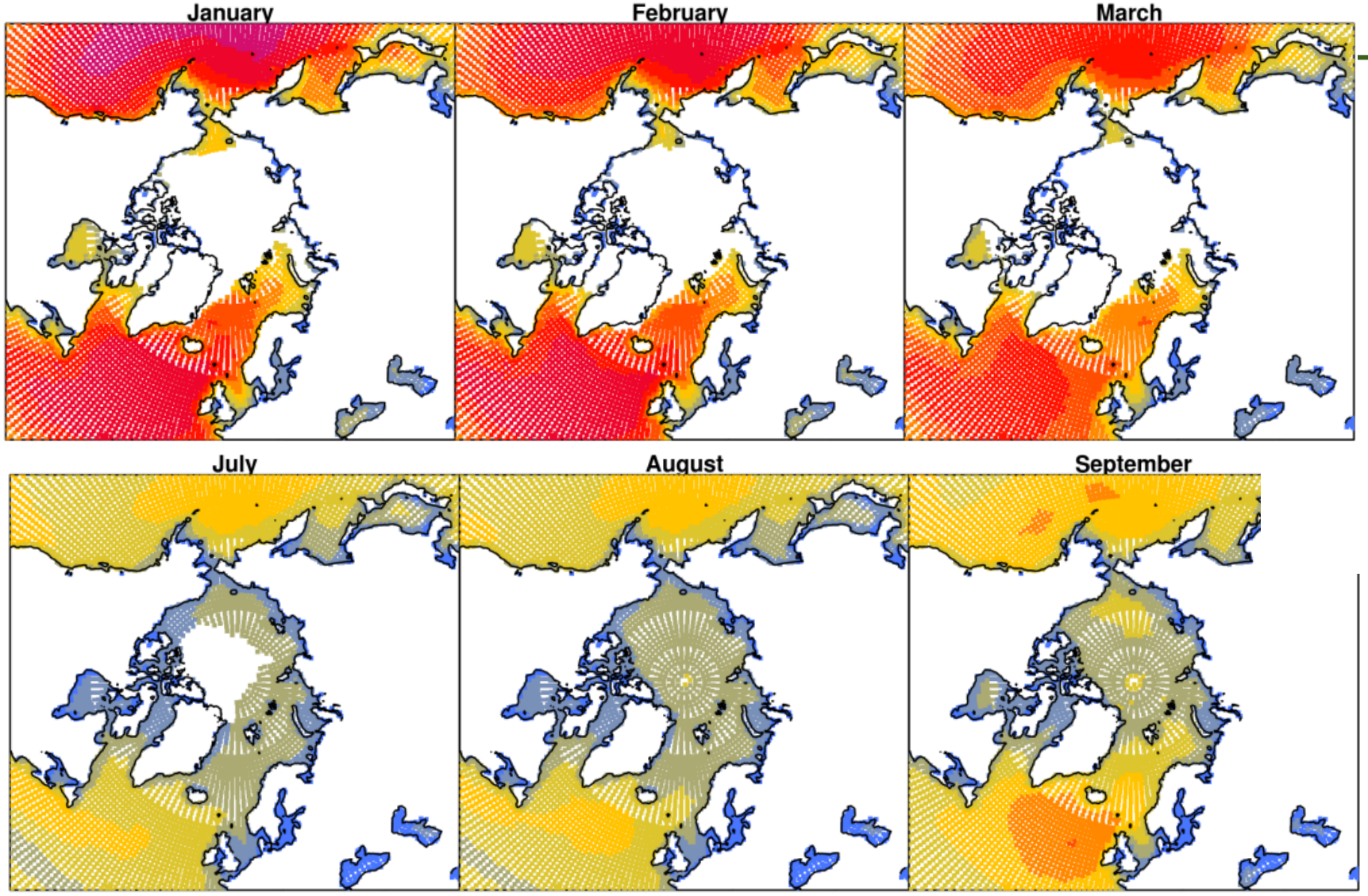


Mean Hs 1979-2005 (ref)

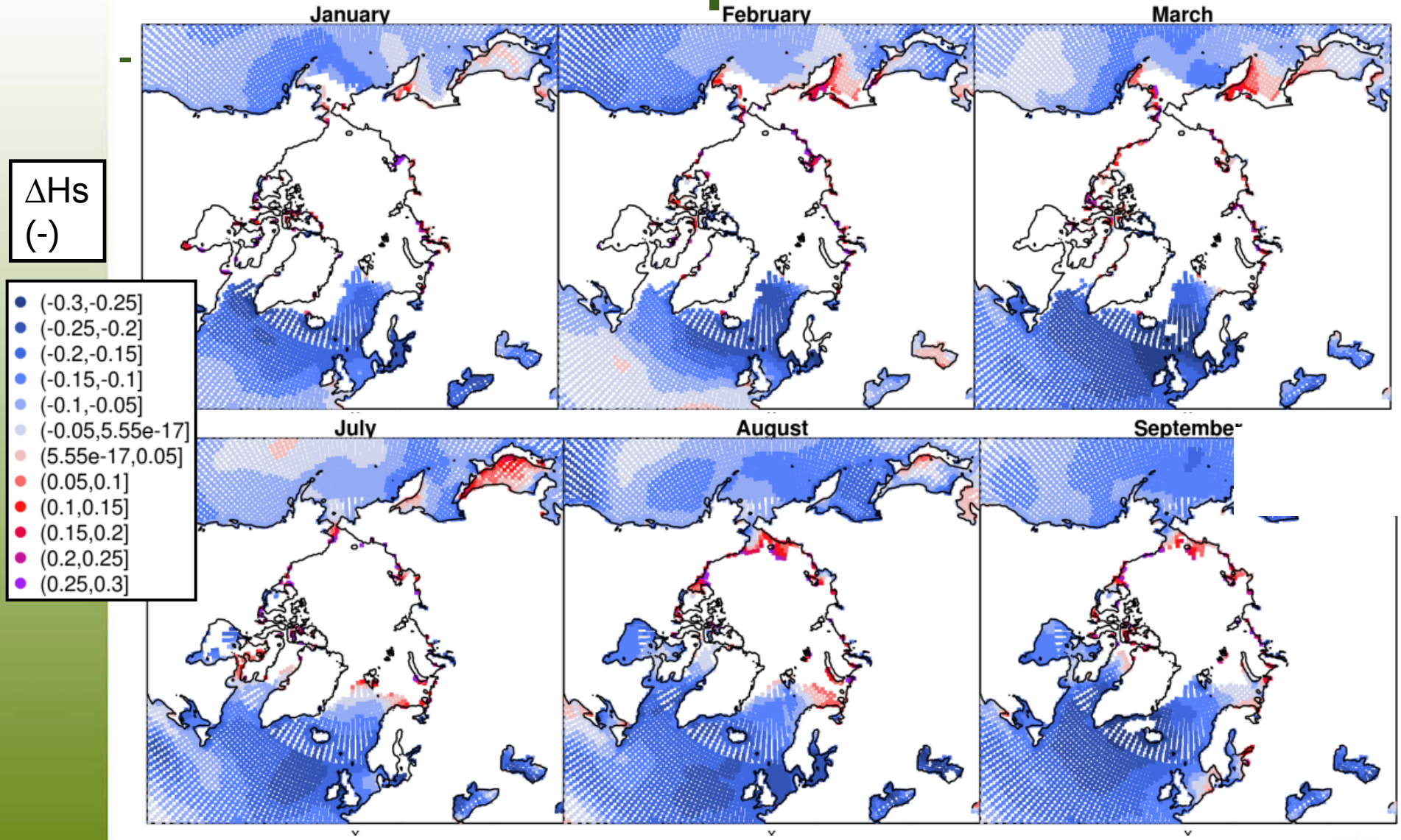
Mean computation: Waves every time step (each month)



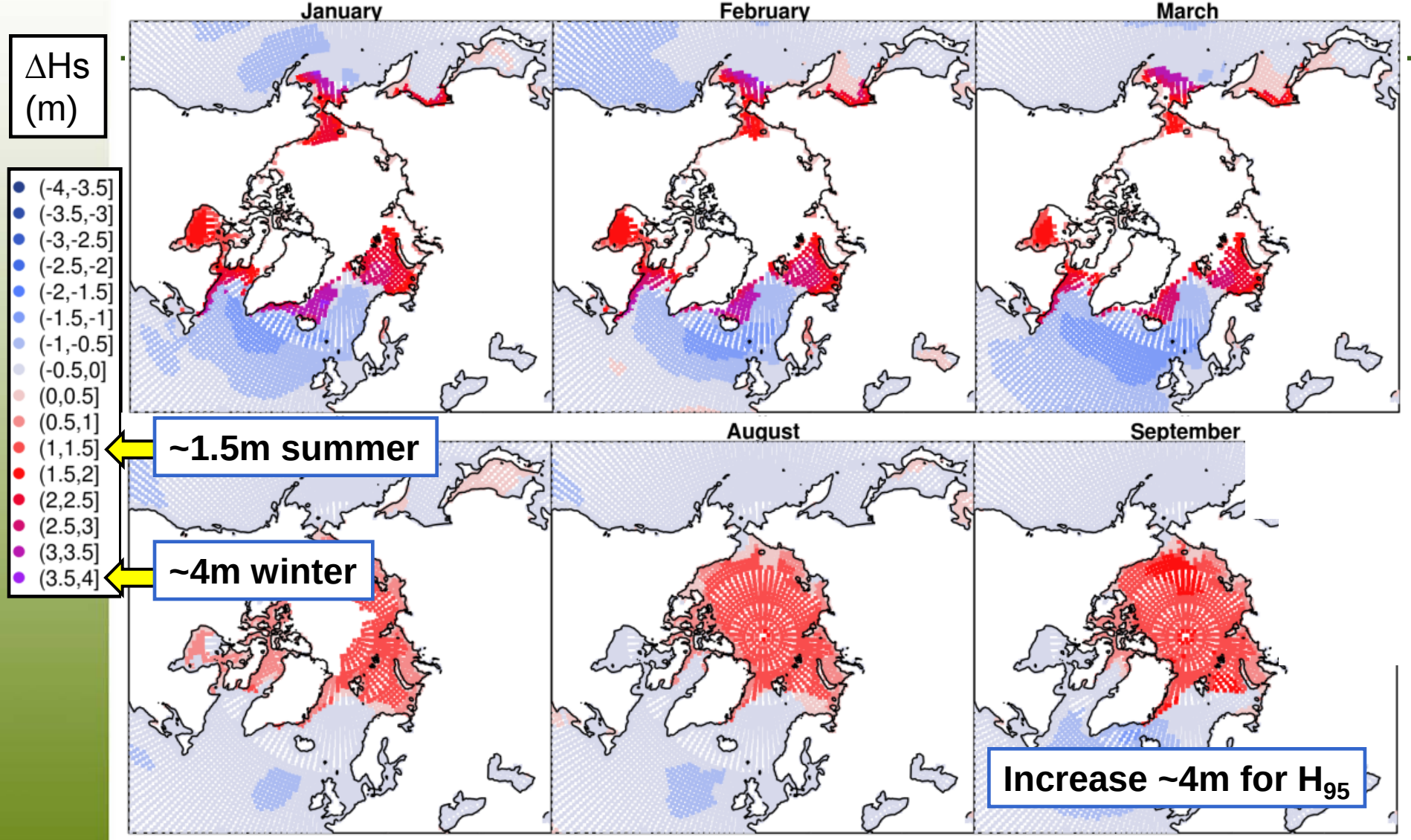
Mean Hs rcp8.5 2081-2100



Rel Δ mean Hs rcp8.5 2081-2100



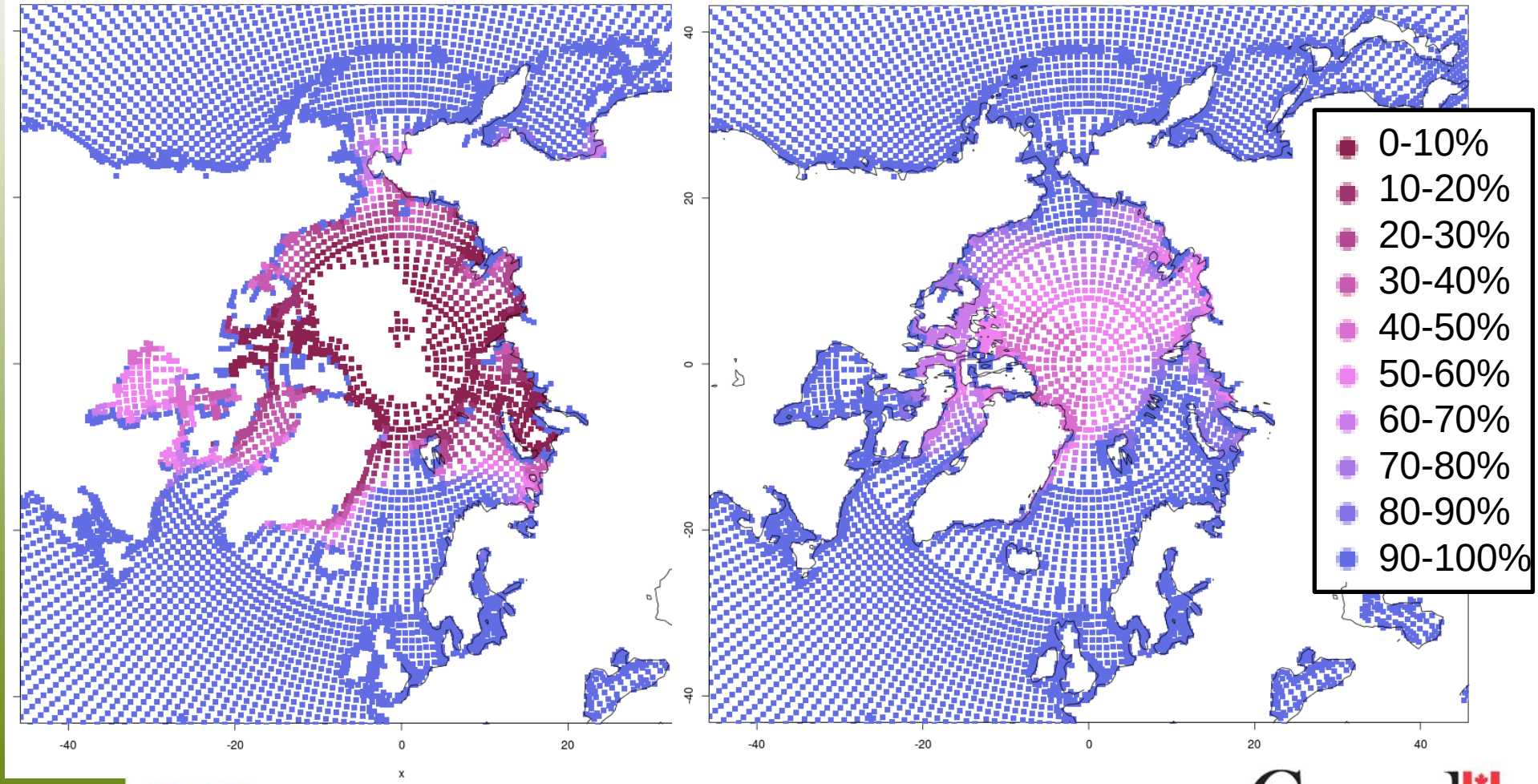
Abs Δ mean Hs rcp8.5 2081-2100



Annual % time with waves (<75% sic)

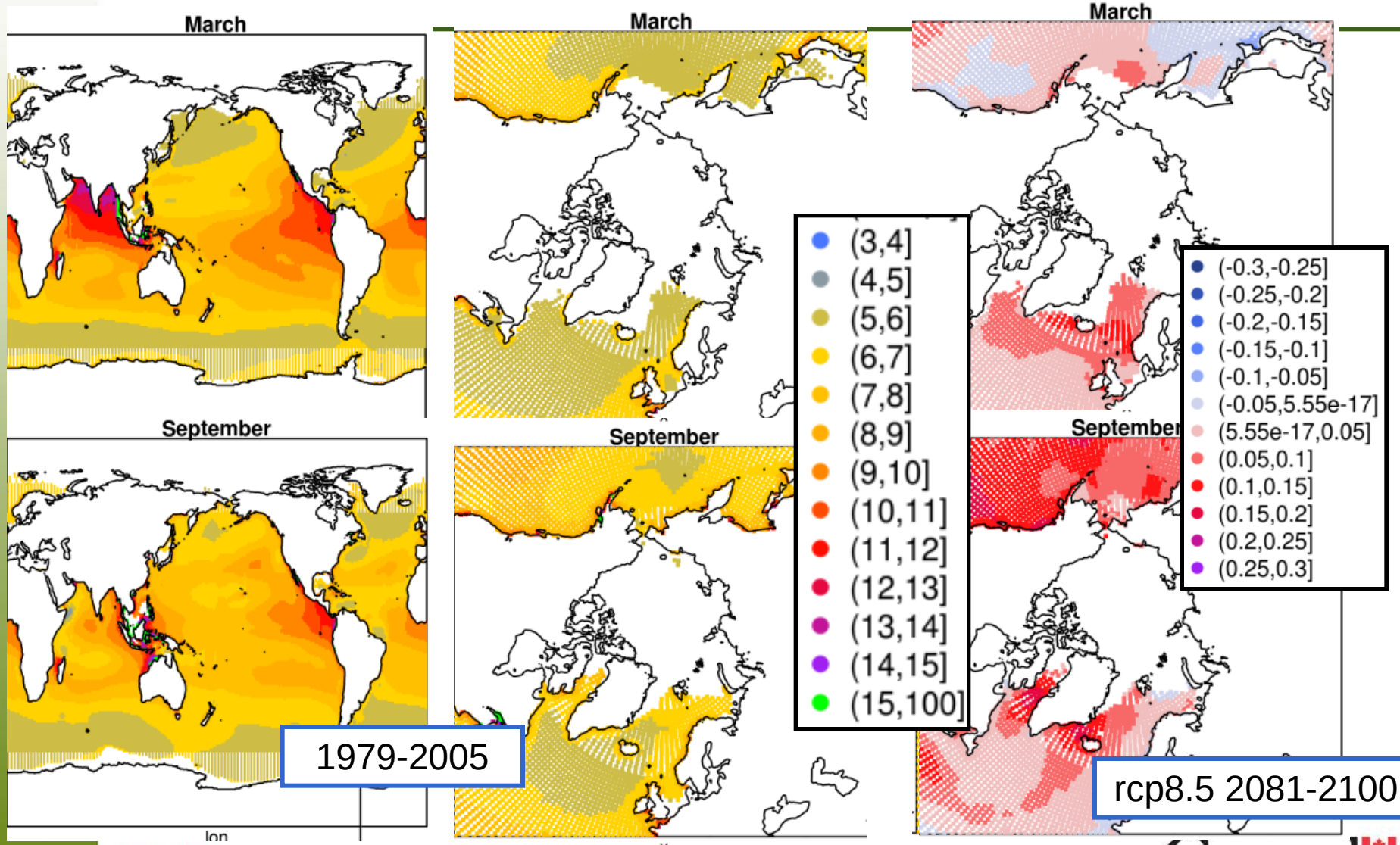
1979-2005

rcp8.5 2081-2100



Results: swell – mean α

$$Tp \sim \alpha \sqrt{H_s}$$



1979-2005

rcp8.5 2081-2100

Summary

- SMC grid: convenient to model waves in the Arctic
- Preliminary results with MIROC5 (rcp 8.5 2081-2100):
  - Mean Hs tends to generally decrease in areas with already existing wave climate BUT
  - New areas of wave climate with up to **1.5m** in **summer** (almost ice free) and up to **4 m in winter**
  - Almost half year → waves entire Arctic (<75% sic)
  - Increase swell conditions
- Future work:
  - More model combinations
  - “Test” ice formulation

Acknowledgements

- SMC grid: Dr. Jian-Guo Li

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- Sponsored by WMO

THANK YOU!