Climate Models as Guidance for the Design of Observing Systems

The Case of Polar Climate and Sea Ice Prediction

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VIDEO HERE :
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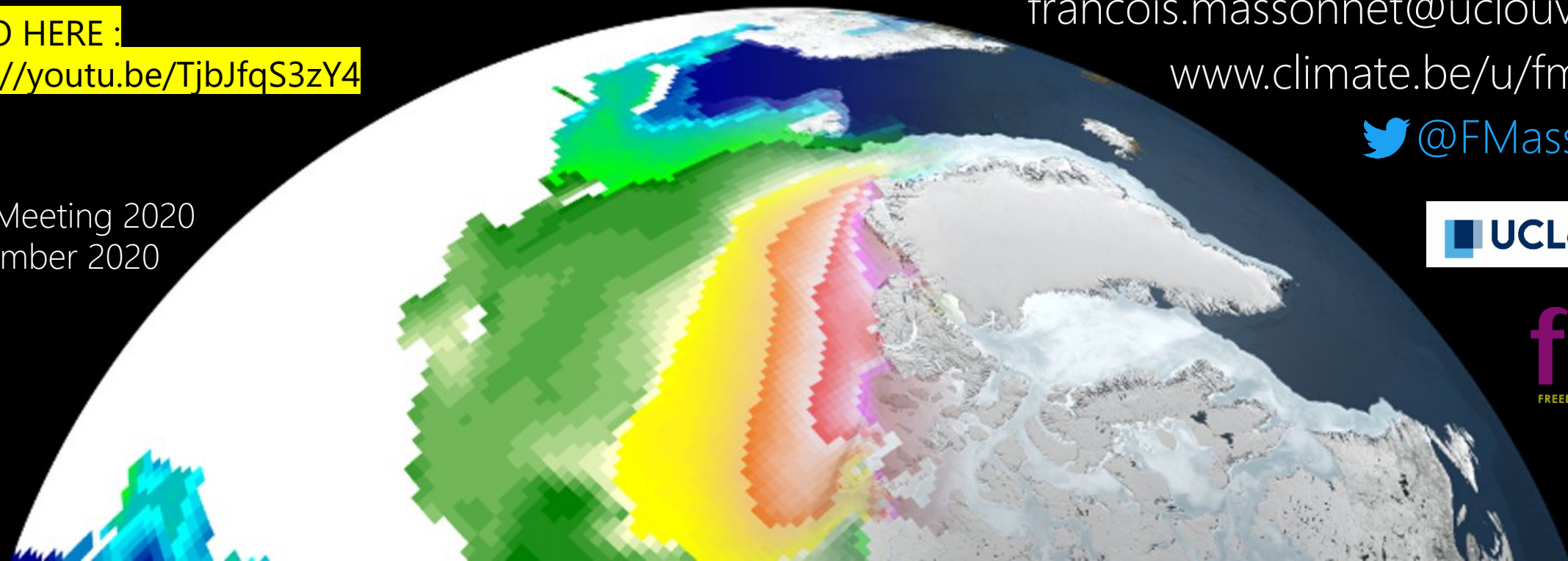

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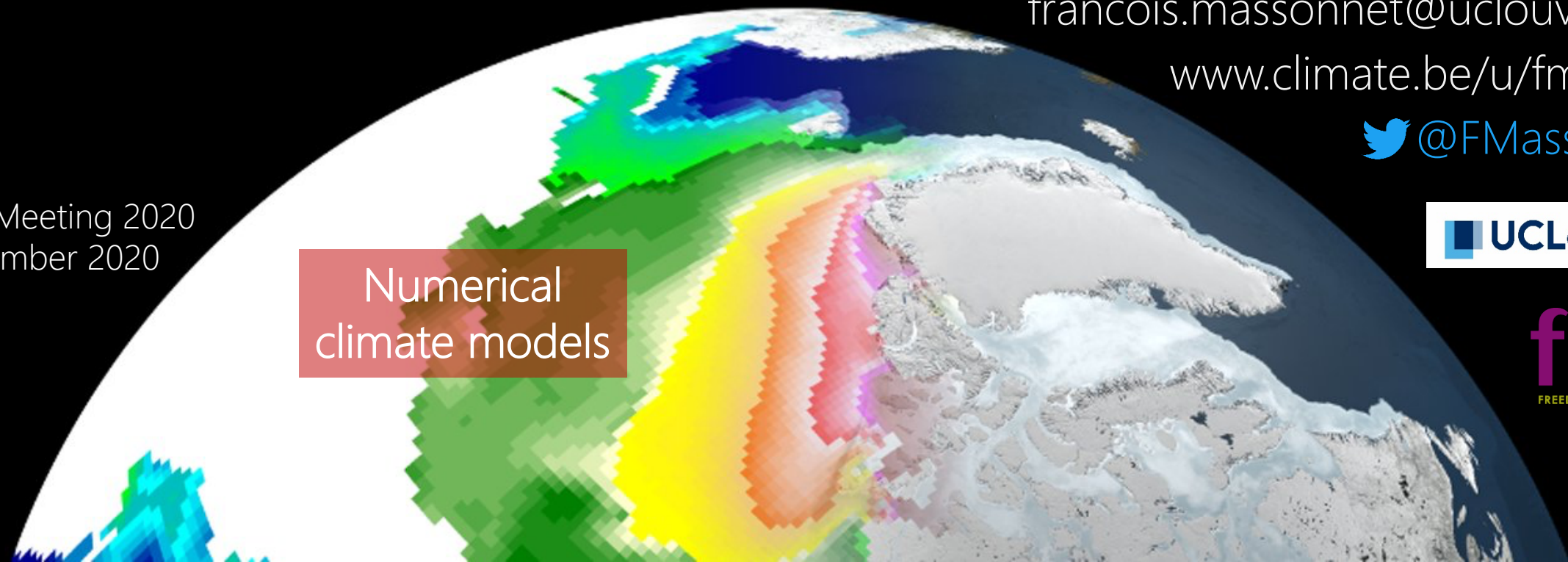

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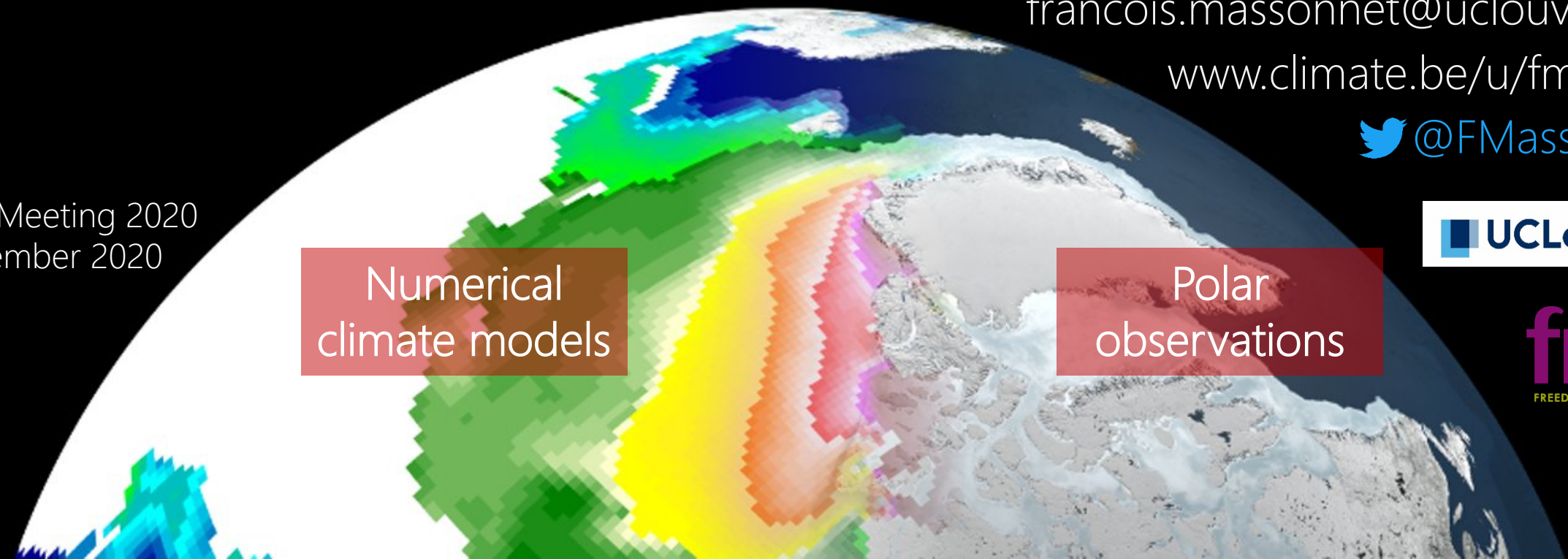

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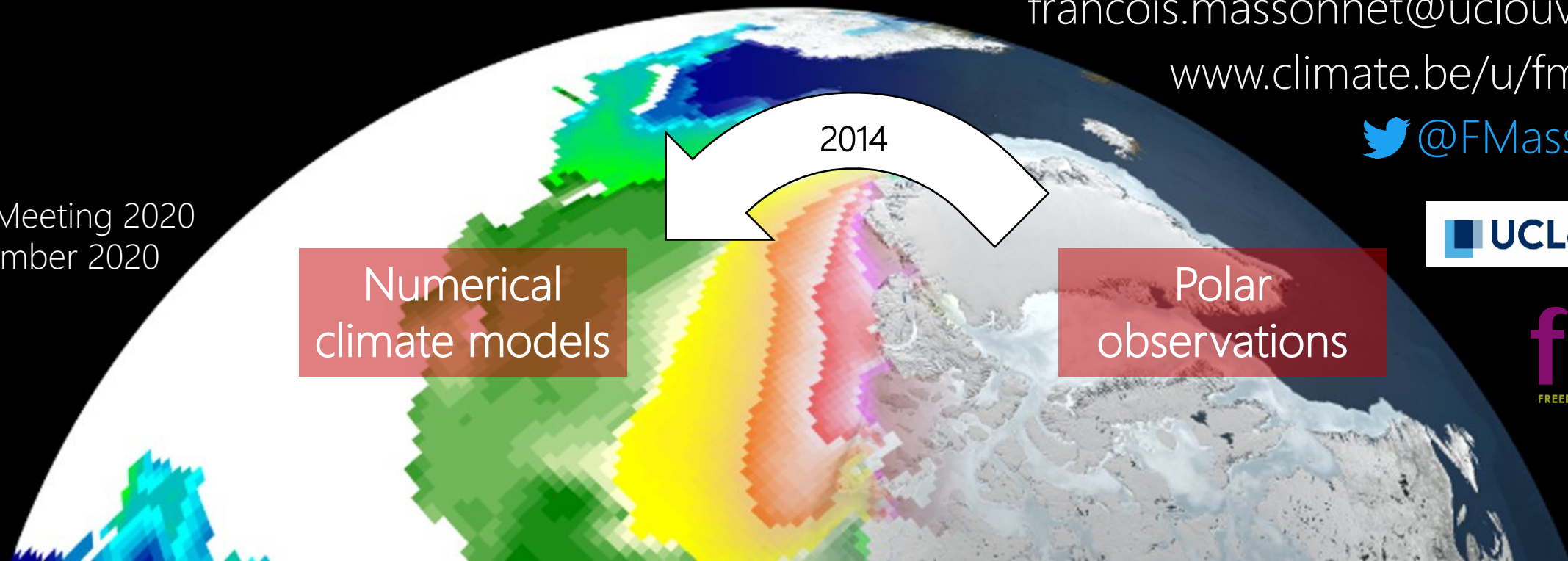

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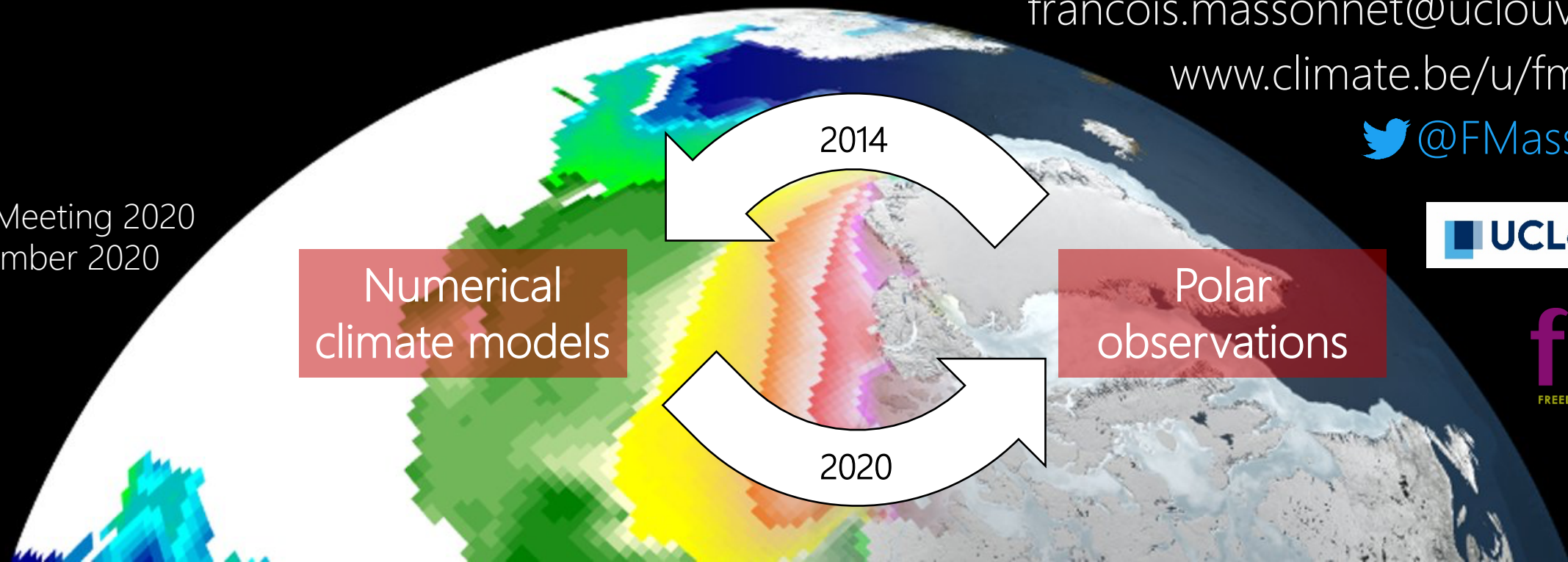

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Hypothesis

"Climate models are invaluable opportunities to imagine, design and optimize the polar observing system for the next decade"

Objectives

Review cases, based on concepts inherited from numerical weather prediction, of how models can be used to improve the polar observing network in a prediction context, with a focus on sea ice

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1. Observing System (Simulation) Experiments
2. Satellite emulators
3. Emergent constraints for long-term projections
4. Evaluation of observational products
5. Strategic deployment of in-situ sampling stations

1. Observing System (Simulation) Experiments (OS(S)Es)

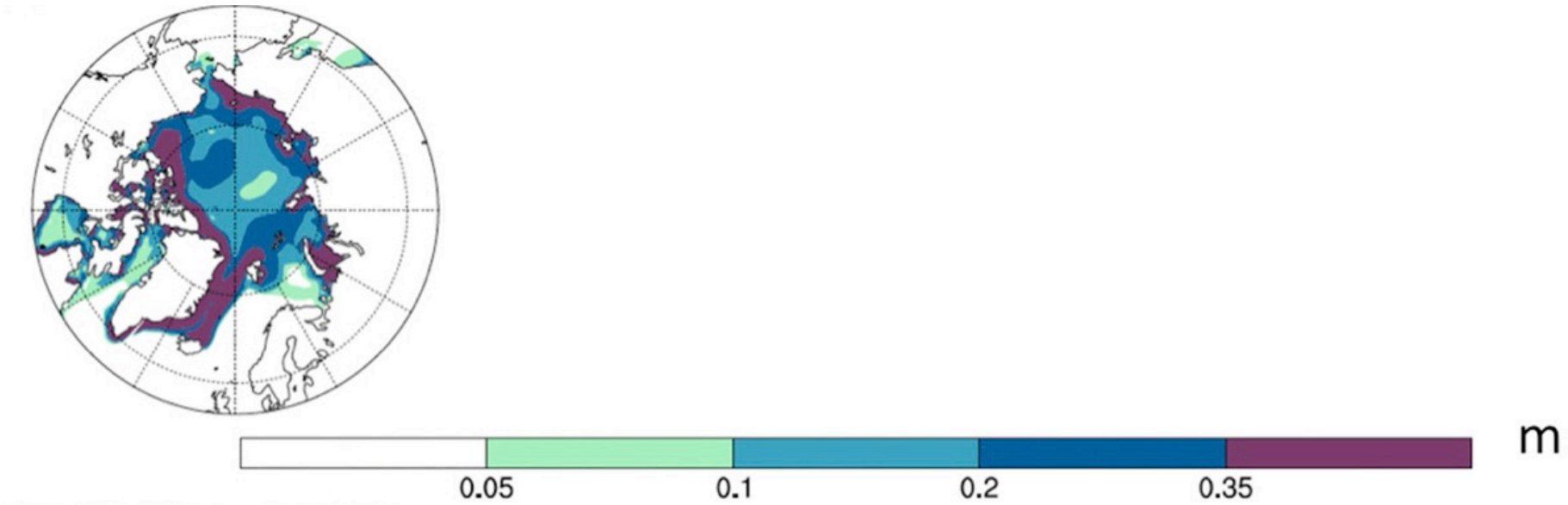
The idea Climate models can be used to test the influence that an existing type of observations, or a hypothetical new type of observations, have on prediction skill.

The approach Observations are **added, degraded, sub-sampled, or removed** from a **data assimilation scheme** of a climate prediction system

Observing Simulation System Experiments tell us what observations make the most impact on prediction skill

Root mean square error of 2001-2003 sea ice thickness
(CICE5 sea ice model + slab ocean + atmospheric forcing)
Reference: one model realization.

No assimilation



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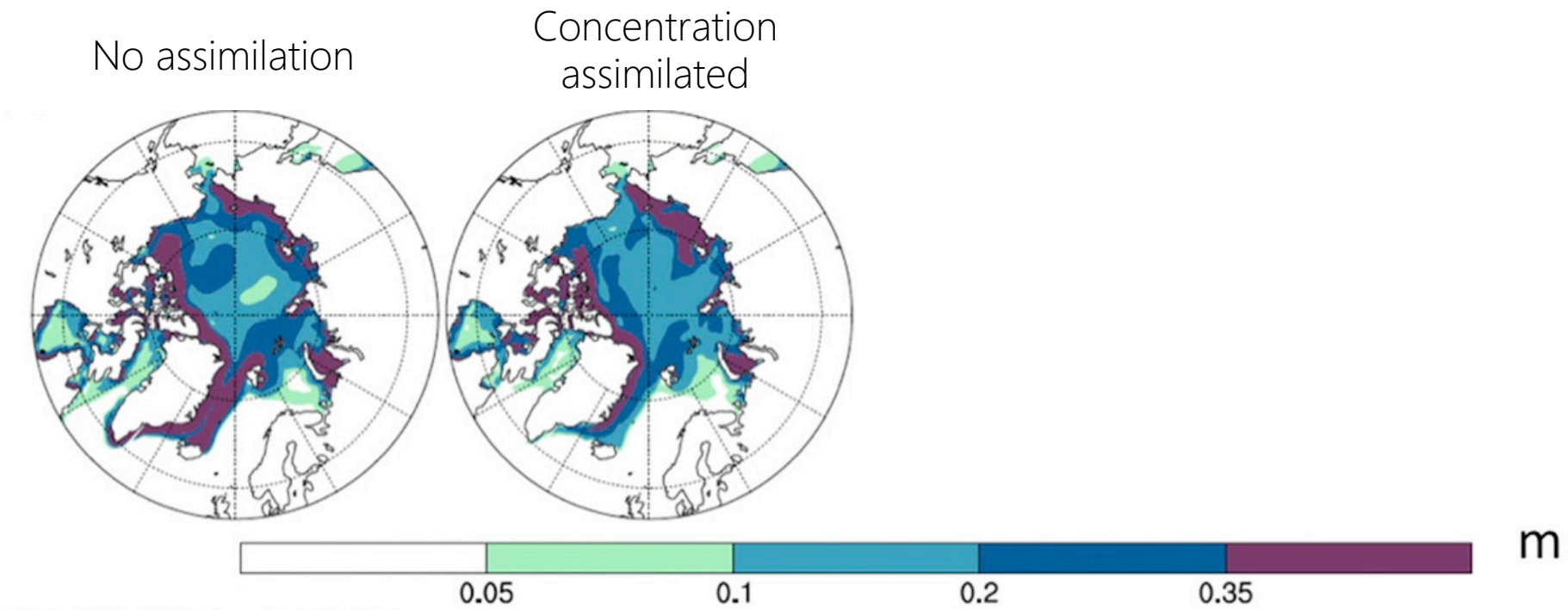

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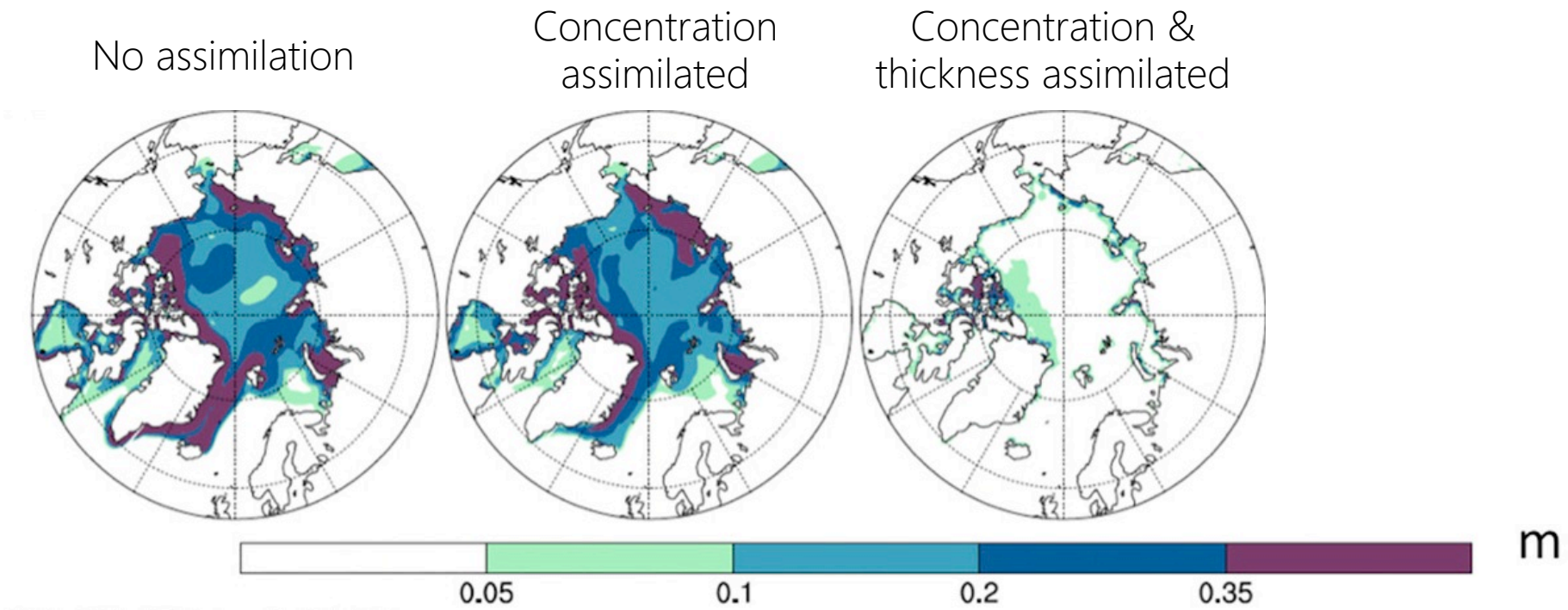

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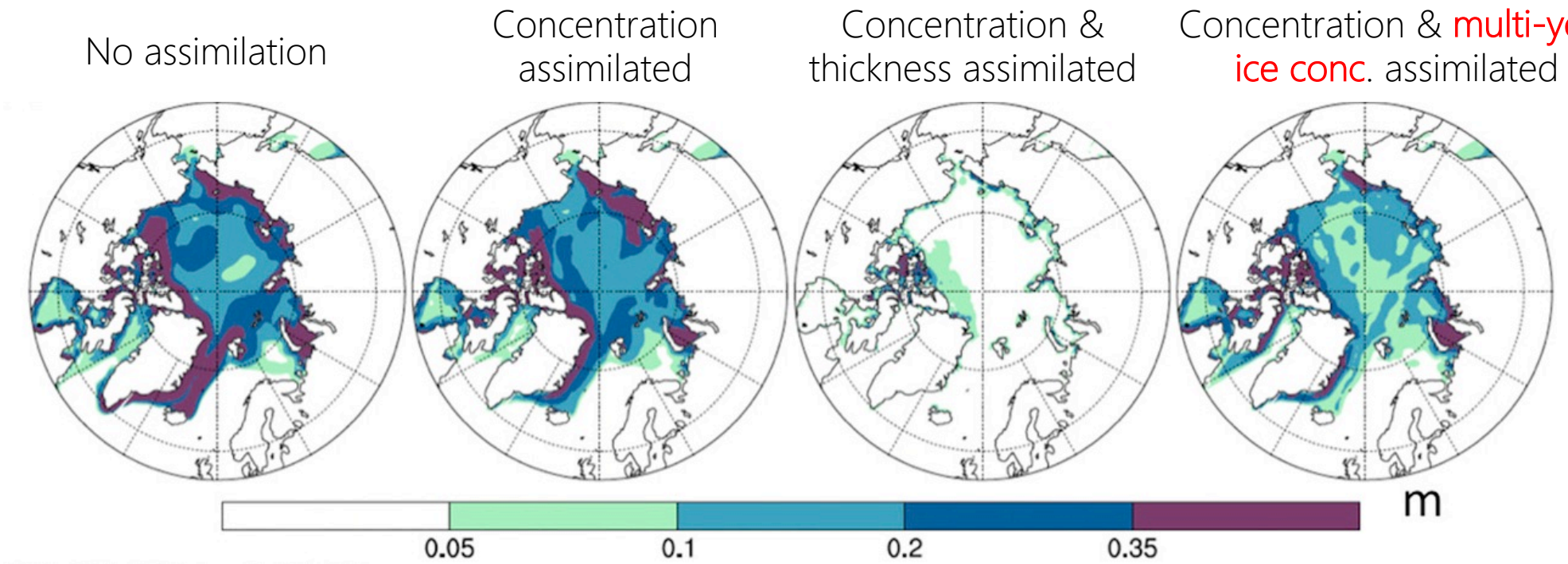

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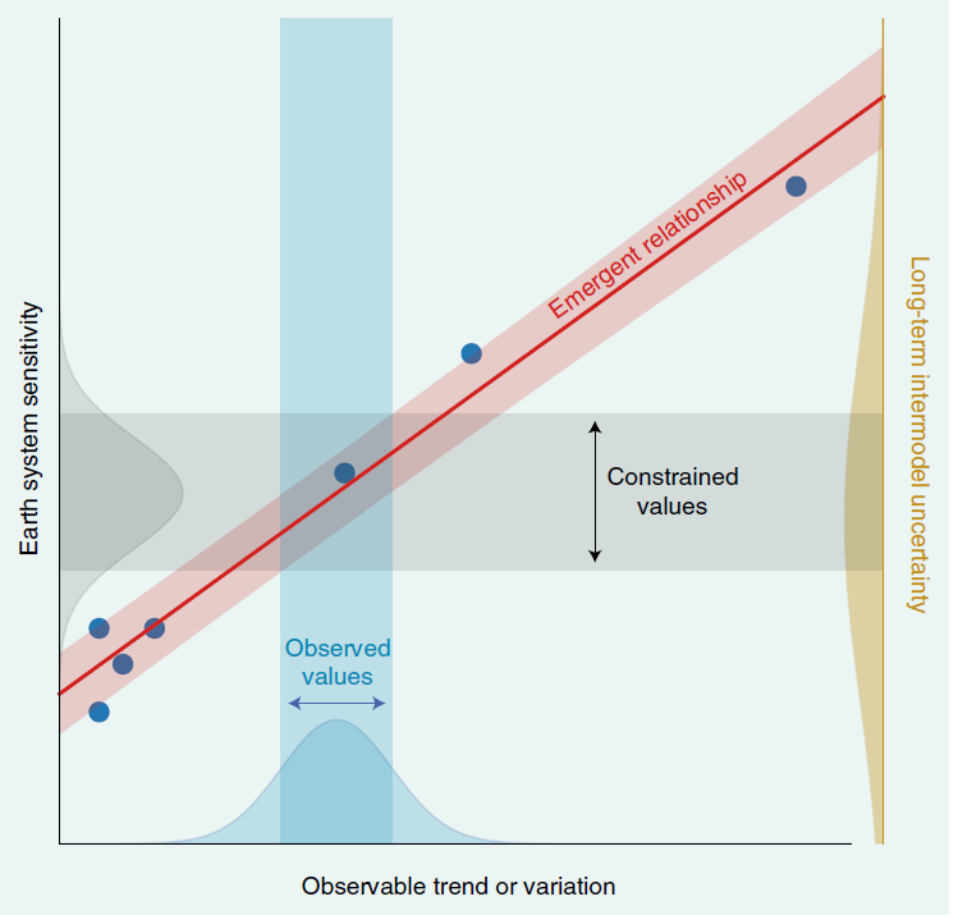
3. Emergent constraints for long-term projections

The idea

Climate models can be used to identify the observational gaps that, if filled, would allow reducing uncertainty in projected changes thanks to improved model evaluation and selection.

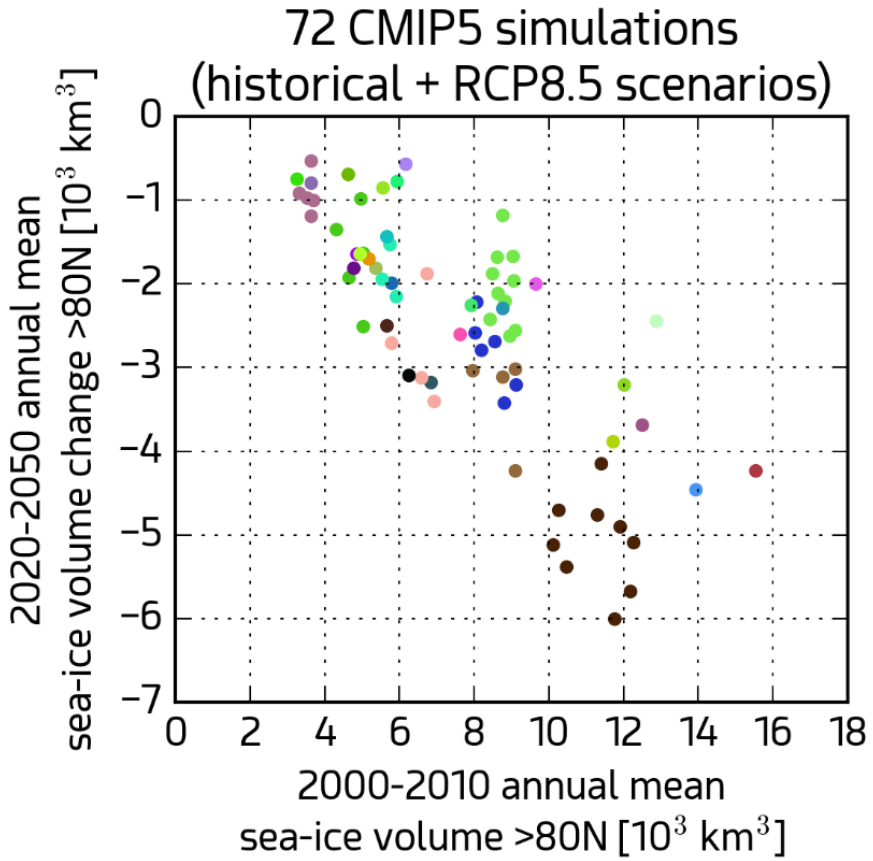
The approach

From model runs, identify relationship between observable and policy- or climate-relevant projected changes that can be understood on physical grounds.



Eyring, V., et al.. (2019). Taking climate model evaluation to the next level. *Nature Climate Change*, *9*(2), 102–110. https://doi.org/10.1038/s41558-018-0355-y

Present-day central Arctic sea ice volume provides a theoretical constraint on projected loss, but observational uncertainty is too large to apply it



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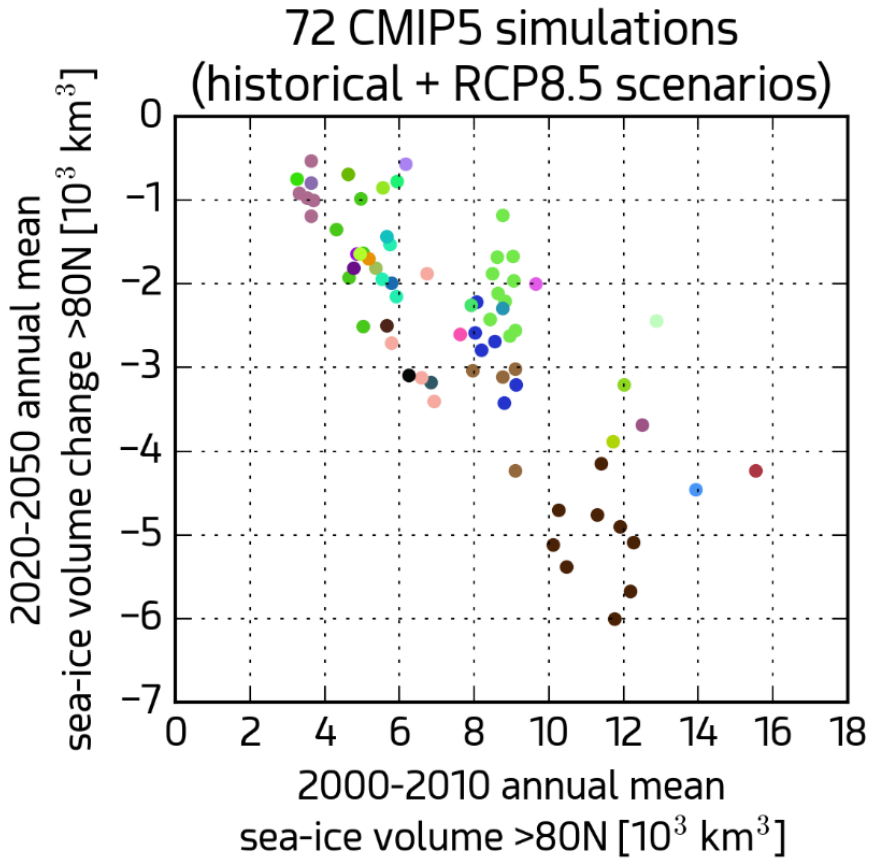

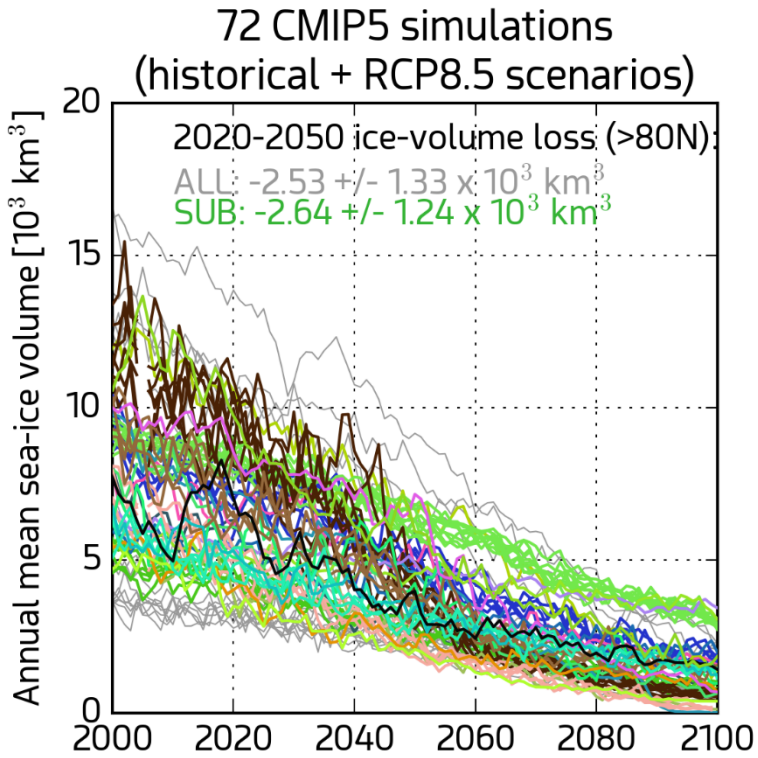

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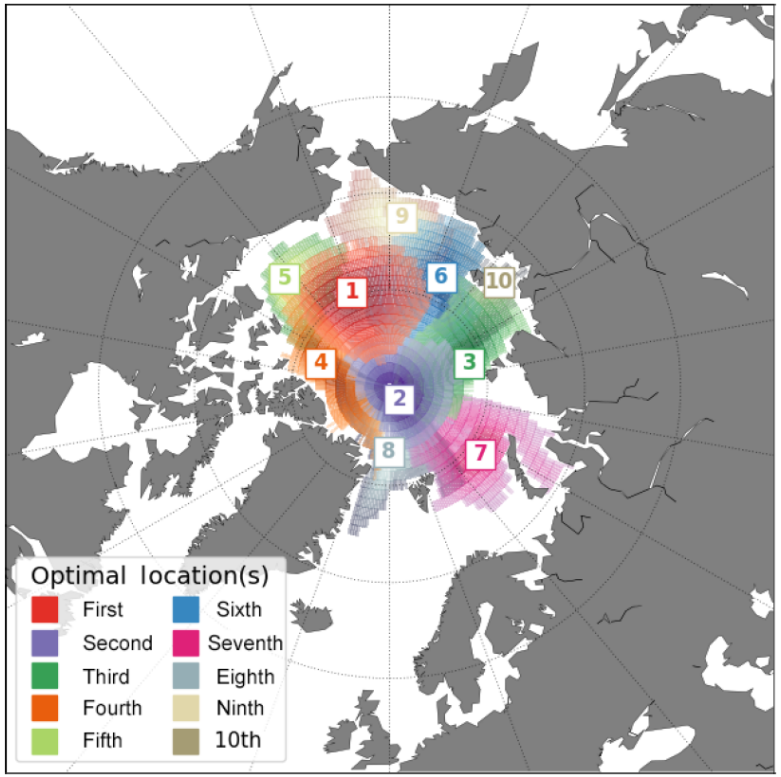
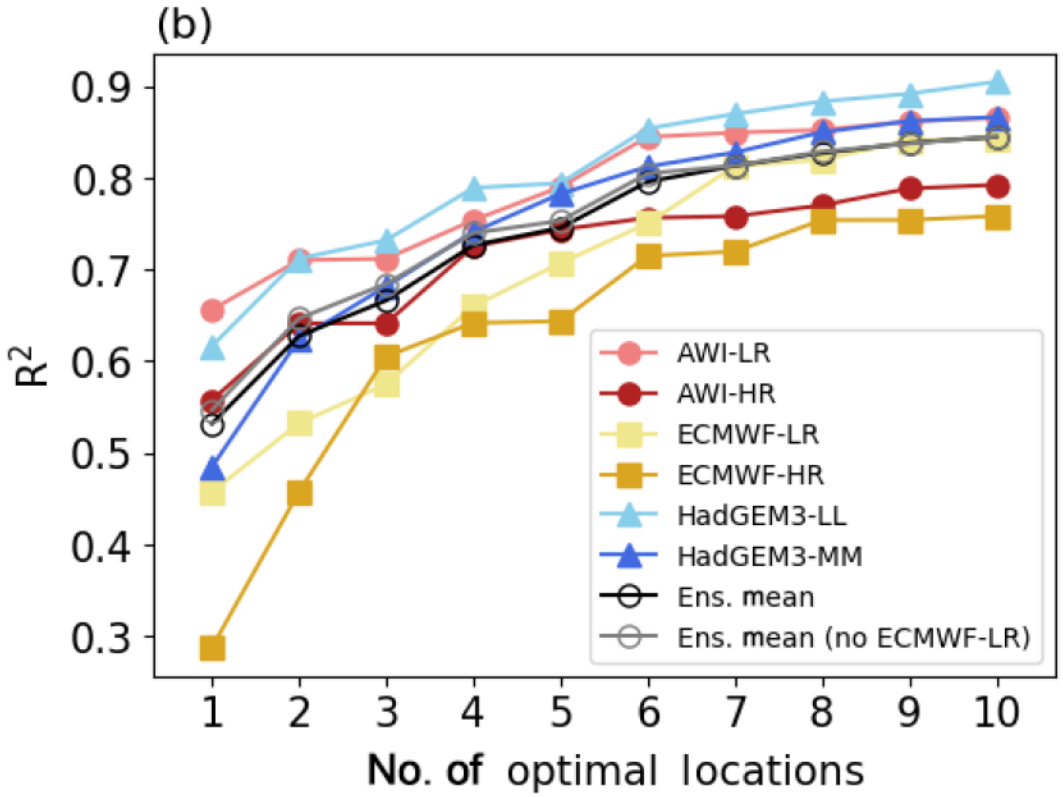
5. Strategic deployment of in-situ sampling sites

The idea Study the spatiotemporal variability of geophysical fields (e.g., sea ice thickness) in numerical models to derive optimal locations of sampling

The approach Correlate the model's large-scale unobservable with the model's local observables

The knowledge of sea ice thickness at a handful of discrete locations can reconstruct sea ice volume anomalies (according to models)





Ponsoni, L., Massonnet, F., Docquier, D., Achter, G. V., & Fichefet, T. (2020). Statistical predictability of the Arctic sea ice volume anomaly: Identifying predictors and optimal sampling locations. *The Cryosphere*, *14*(7), 2409–2428. https://doi.org/10.5194/tc-14-2409-2020

Conclusion

1. We have at least three “observational data” open questions:
    1. Do we (modelers) make optimal use of the existing observational datasets?
    2. Are today’s observation fit for answering tomorrow’s science questions in tomorrow’s polar regions?
    3. Can we (modelers) give recommendations to develop cost-effective networks for the coming decade – a crucial one.

Conclusion

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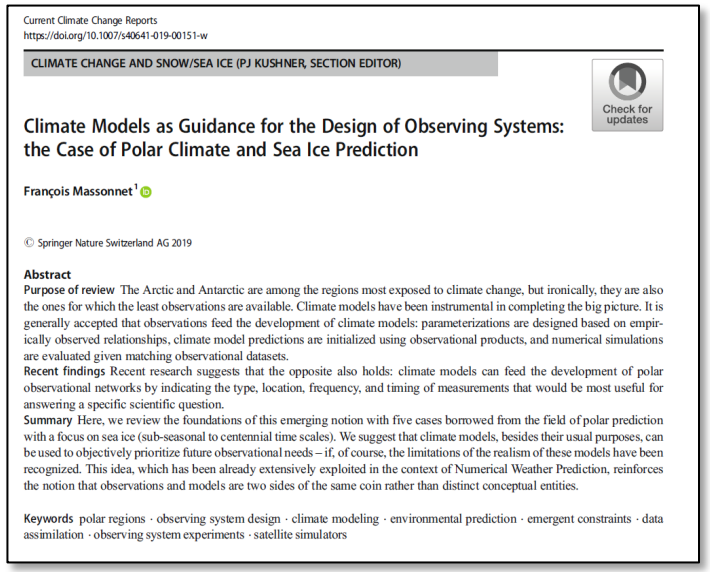
    2. Are today’s observation fit for answering tomorrow’s science questions in tomorrow’s polar regions?
    3. Can we (modelers) give recommendations to develop cost-effective networks for the coming decade – a crucial one.

2. In three of the five cases given here, the concepts find their origin the **numerical weather prediction (NWP) community**. Never hesitate to knock on the door of your NWP colleagues – you’ll be amazed by what they can help you!

Want to go further?

Review article 👇



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CLIMATE CHANGE AND SNOW/SEA ICE (PJ KUSHNER, SECTION EDITOR)

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Climate Models as Guidance for the Design of Observing Systems: the Case of Polar Climate and Sea Ice Prediction

François Massonnet[1]

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Abstract

Purpose of review The Arctic and Antarctic are among the regions most exposed to climate change, but ironically, they are also the ones for which the least observations are available. Climate models have been instrumental in completing the big picture. It is generally accepted that observations feed the development of climate models: parameterizations are designed based on empirically observed relationships, climate model predictions are initialized using observational products, and numerical simulations are evaluated given matching observational datasets.

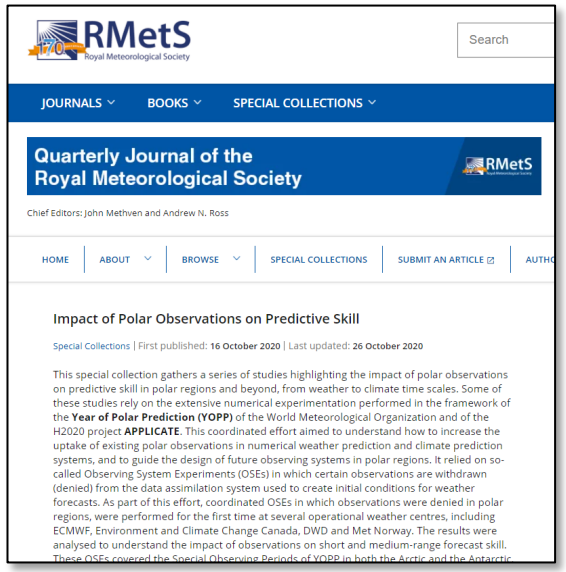
Recent findings Recent research suggests that the opposite also holds: climate models can feed the development of polar observational networks by indicating the type, location, frequency, and timing of measurements that would be most useful for answering a specific scientific question.

Summary Here, we review the foundations of this emerging notion with five cases borrowed from the field of polar prediction with a focus on sea ice (sub-seasonal to centennial time scales). We suggest that climate models, besides their usual purposes, can be used to objectively prioritize future observational needs – if, of course, the limitations of the realism of these models have been recognized. This idea, which has been already extensively exploited in the context of Numerical Weather Prediction, reinforces the notion that observations and models are two sides of the same coin rather than distinct conceptual entities.

Keywords polar regions · observing system design · climate modeling · environmental prediction · emergent constraints · data assimilation · observing system experiments · satellite simulators

Massonnet, F. (2019). Climate Models as Guidance for the Design of Observing Systems: The Case of Polar Climate and Sea Ice Prediction. Current Climate Change Reports. https://doi.org/10.1007/s40641-019-00151-w

Special collection: impact of polar observations on prediction skill



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Impact of Polar Observations on Predictive Skill

Special Collections | First published: 16 October 2020 | Last updated: 26 October 2020

This special collection gathers a series of studies highlighting the impact of polar observations on predictive skill in polar regions and beyond, from weather to climate time scales. Some of these studies rely on the extensive numerical experimentation performed in the framework of the **Year of Polar Prediction (YOPP)** of the World Meteorological Organization and of the H2020 project **APPLICATE**. This coordinated effort aimed to understand how to increase the uptake of existing polar observations in numerical weather prediction and climate prediction systems, and to guide the design of future observing systems in polar regions. It relied on so-called Observing System Experiments (OSEs) in which certain observations are withdrawn (denied) from the data assimilation system used to create initial conditions for weather forecasts. As part of this effort, coordinated OSEs in which observations were denied in polar regions, were performed for the first time at several operational weather centres, including ECMWF, Environment and Climate Change Canada, DWD and Met Norway. The results were analysed to understand the impact of observations on short and medium-range forecast skill. These OSEs covered the Special Observing Periods of YOPP in both the Arctic and the Antarctic

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GOALS & OBJECTIVES
The goal of APPLICATE is to develop enhanced predictive capacity for weather and climate in the Arctic and beyond, and to determine the influence of Arctic climate change on Northern Hemisphere mid-latitudes, for the benefit of policy makers, businesses and society.

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