

SuperIce - Super-resolution of sea ice thickness by combining machine learning and physical-based approach

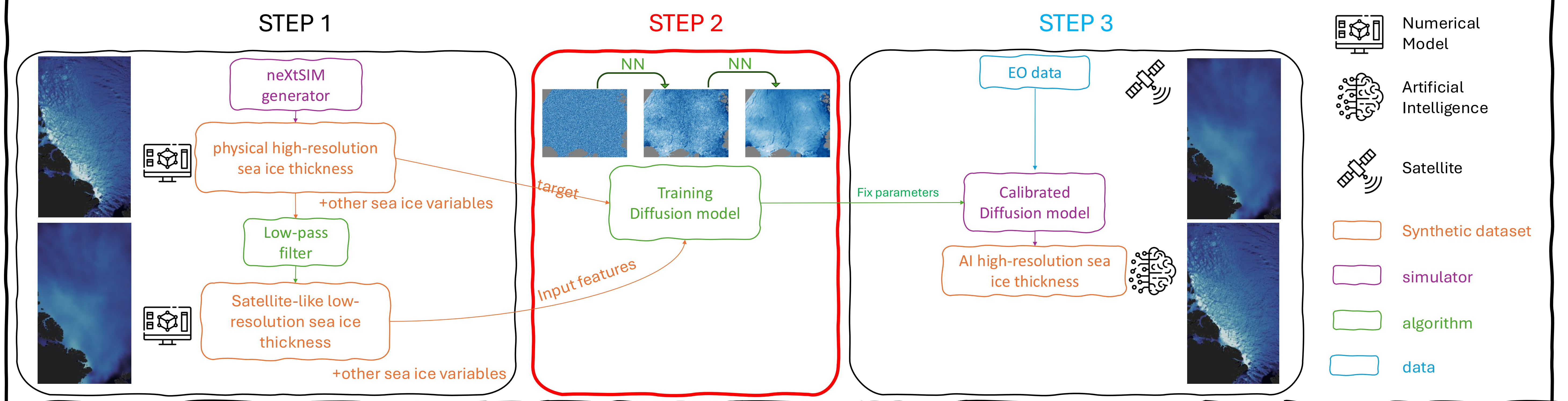


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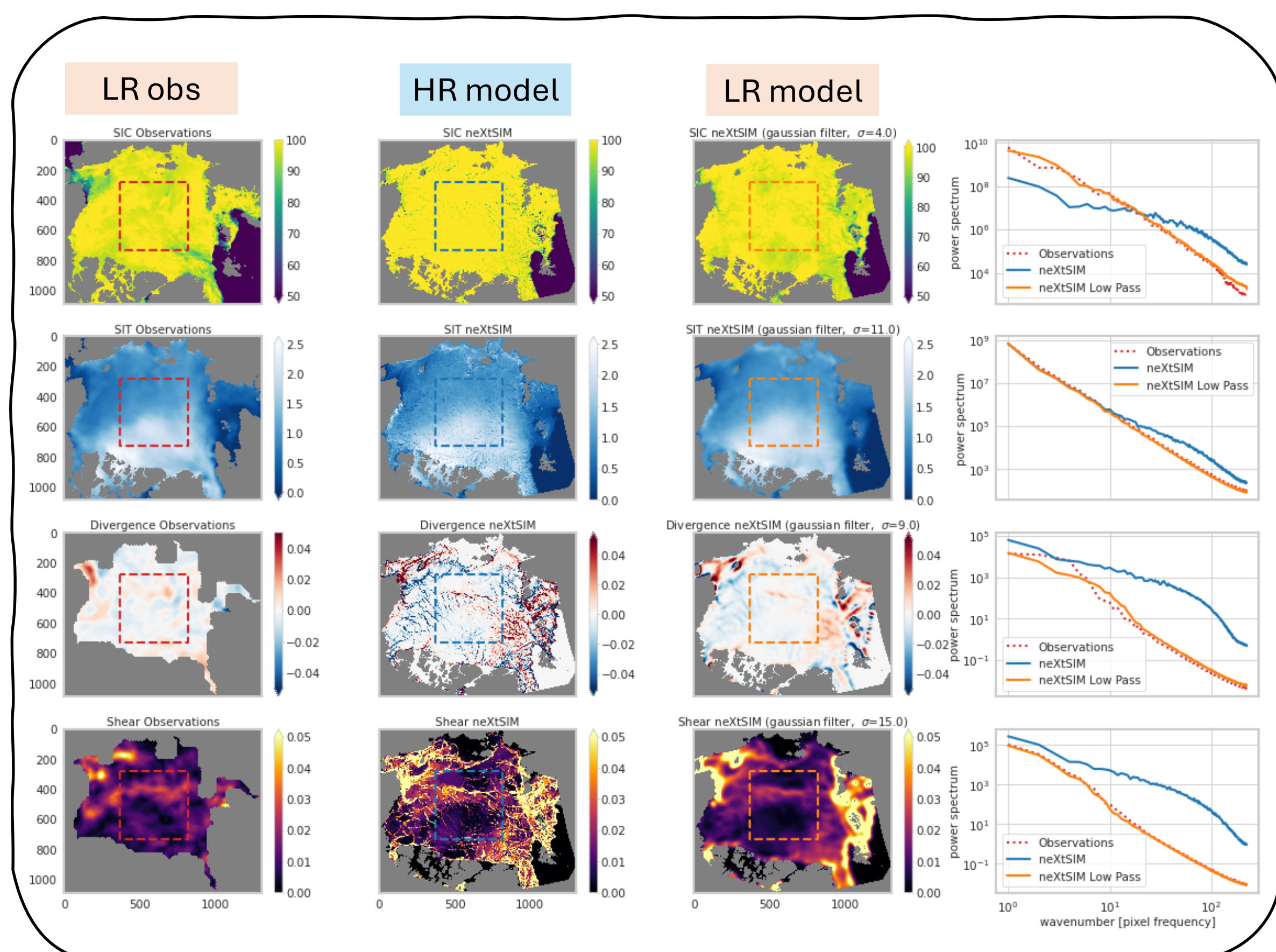


SuperIce project overview

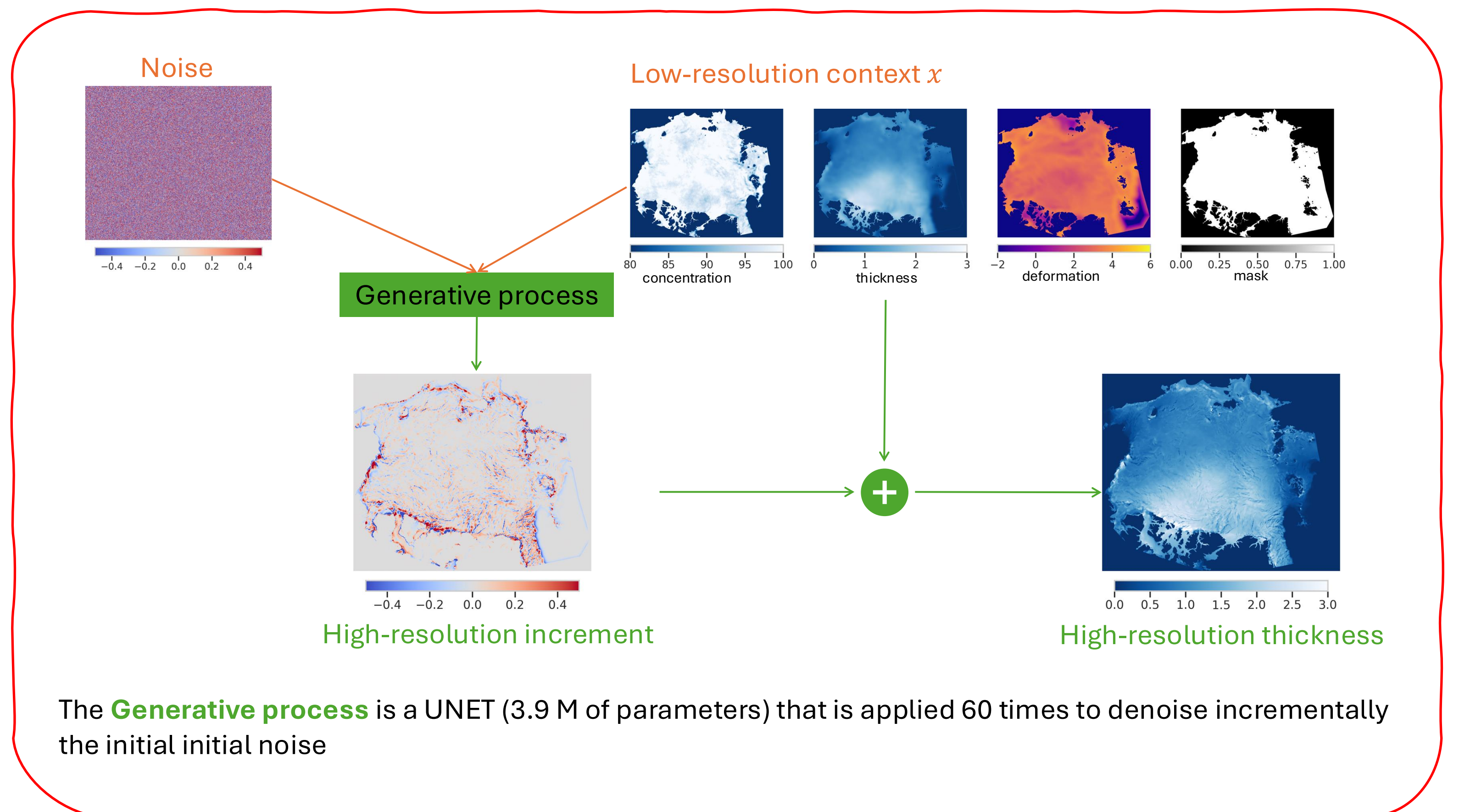
Motivation	<ul style="list-style-type: none"> ✓ Arctic Sea-ice thickness satellite observations have insufficient resolution ✓ It can degrade the initialization of seasonal forecast ✓ It leads to underestimate surface heat fluxes
Objective	✓ Produce high-resolution Sea-ice thickness product using a combination of physical modelling and artificial intelligence
Method	<ul style="list-style-type: none"> ✓ High-resolution simulation with the NeXtSIM sea-ice model ✓ AI super-resolution with diffusion models



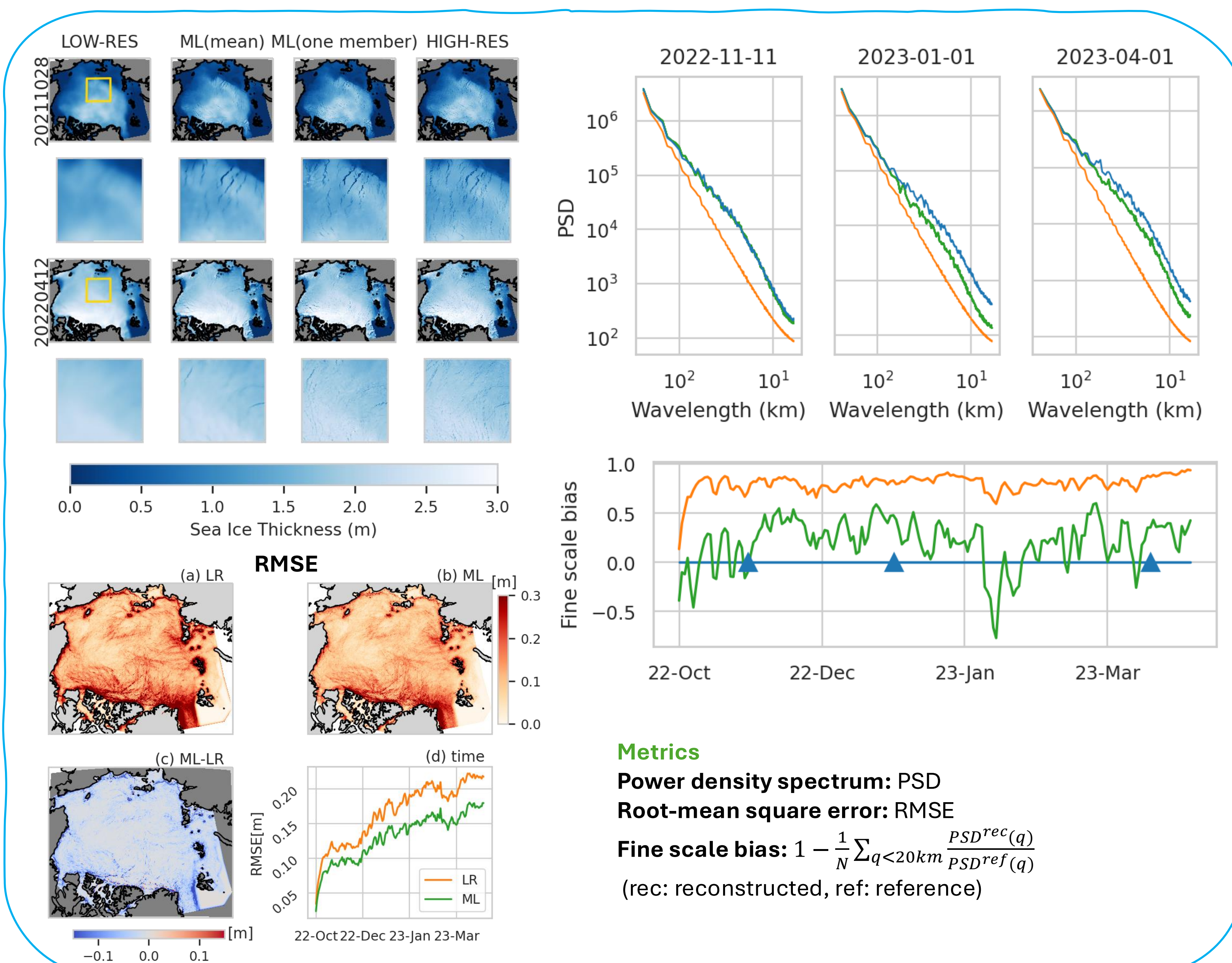
STEP 1: dataset constitution



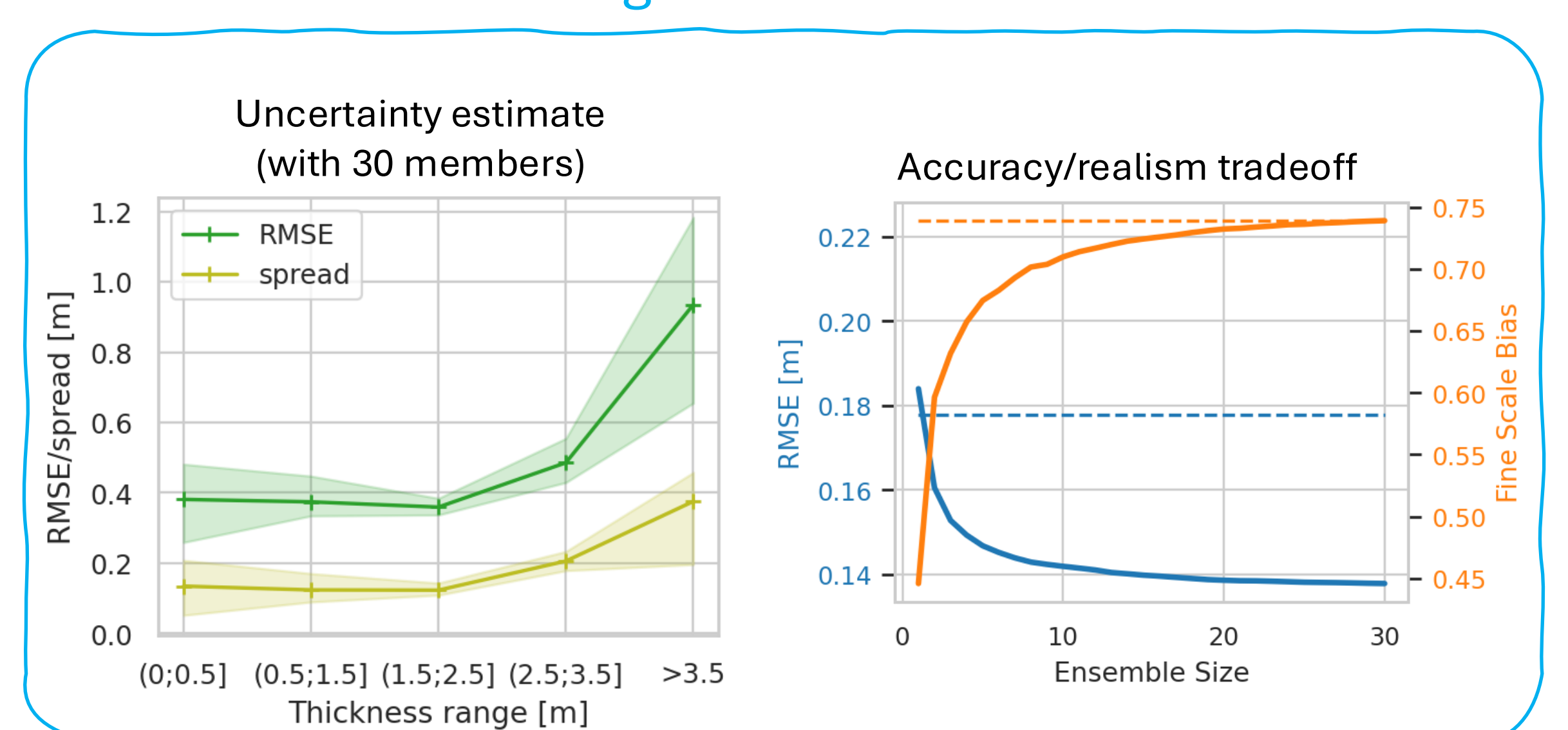
STEP 2: The algorithm



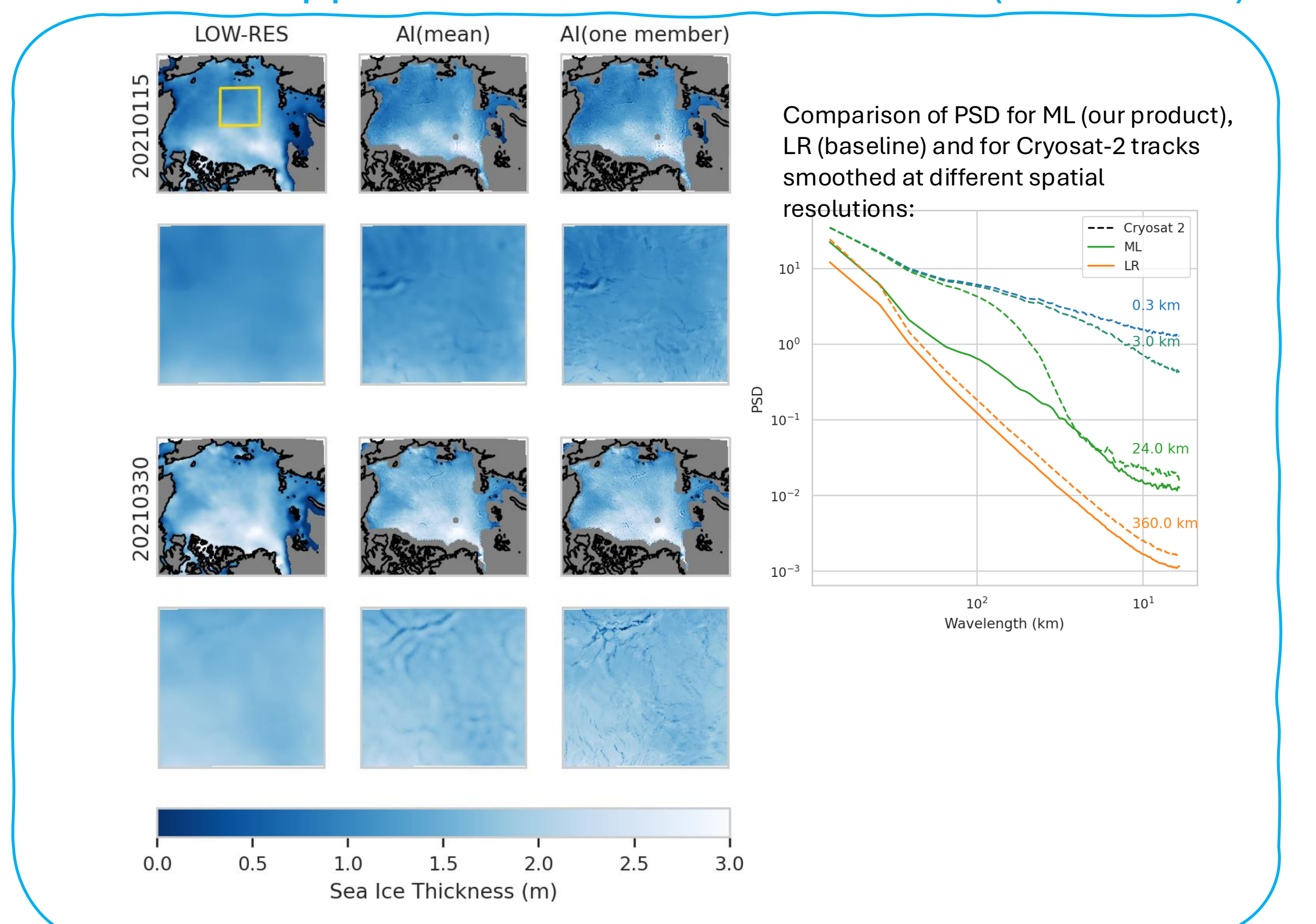
STEP 3a: Validation with model data



STEP 3b: Ensemble generation



STEP 3c: Application to real observations (CS2SMOS)



Conclusions

- ✓ **High-resolution enhancement:** A diffusion-based generative AI model upscales low-resolution Arctic sea ice thickness fields, improving accuracy by ~21% and capturing ~80% of sub-20 km variability.
- ✓ **Realistic and uncertain outputs:** The model produces realistic reconstructions and ensemble-based uncertainty estimates, and successfully recovers small-scale features while preserving large-scale structures in real observations.
- ✓ **Broad applicability and open data:** Applied to 2020–2023 simulated and observed Arctic data with outputs made public.

Download the data here: https://github.com/brajard/superice_data