Statistical predictability of Arctic sea ice volume anomalies: identifying predictors and optimal sampling locations

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APPLICATE Context

WP5 – Improved predictive capacity
Task 5.2.4 – Empirical statistical models for benchmarking

WP4 – Support for Arctic observing system design
Task 4.2.3 – Optimal sampling

Clustering WP5 and WP4:
Using the empirical statistical model developed in WP5 for supporting an optimal sampling strategy in WP4

Motivating questions:

(1) What is the predictability skill of different pan-Arctic predictors, such as SIV, SIA, OHT, SIT, SIC, SST and Ice Drift, for predicting SIV anomalies?

(2) How does model resolution impact the statistical predictability of SIV anomalies?

(3) What are the best *in situ* locations for sampling predictor variables in order to optimize the statistical predictability of SIV anomalies?

Building the empirical statistical models for predicting Sea Ice Volume anomalies (no trend; no seasonal variability)

6 different model outputs from PRIMAVERA project:

- HadGEM3-LL
- HadGEM3-MM
- ECMWF-LR
- ECMWF-HR
- AWI-LR
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PRIMAVERA

Docquier et al., 2018 (under review)

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Several predictors:

SIV: Sea Ice Volume
SIA: Sea Ice Area
OHT: Ocean Heat Transport
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SIC: Sea Ice Concentration
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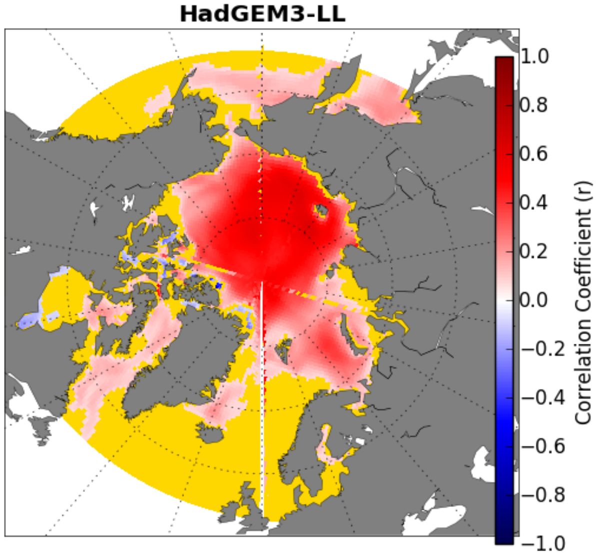
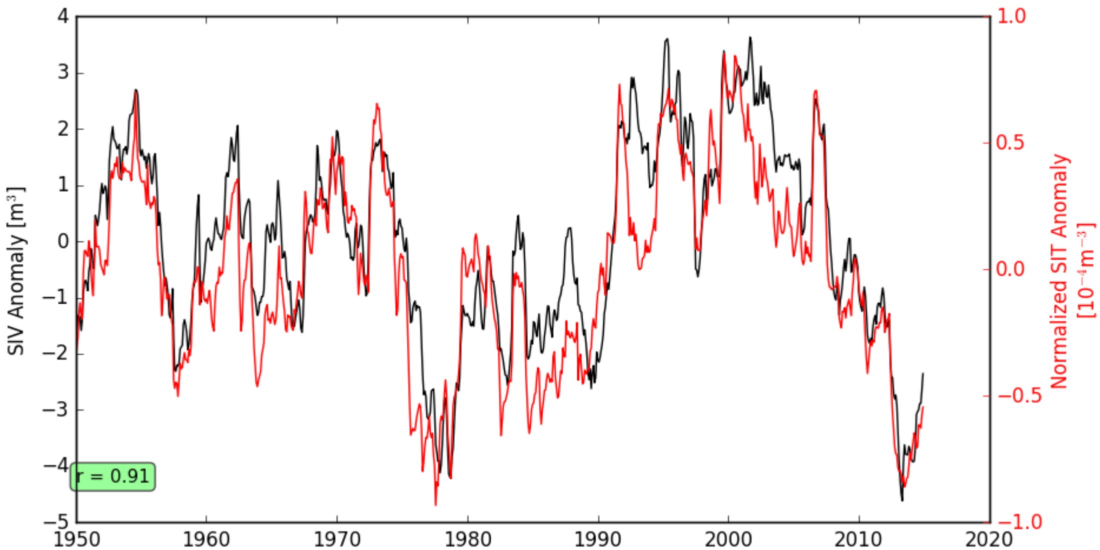
Correlation Maps:

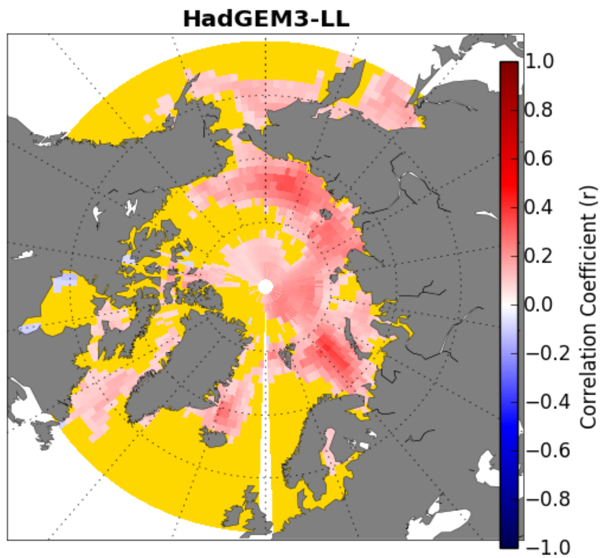
To take the best advantage of the correlations between predictors and predictand, the Pan-Arctic averages are normalized by the correlation maps

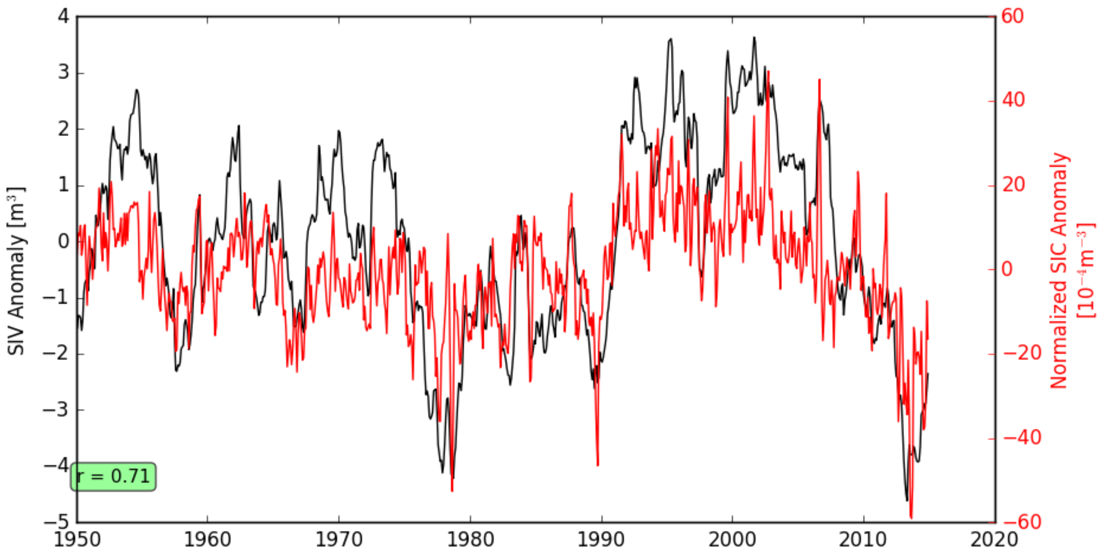
Correlation Map
SIV Anomaly *vs.* SIT Anomaly at every grid-point





Correlation Map
SIV Anomaly *vs.* SIC Anomaly at every grid-point





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Long-term time series (1950-2014)

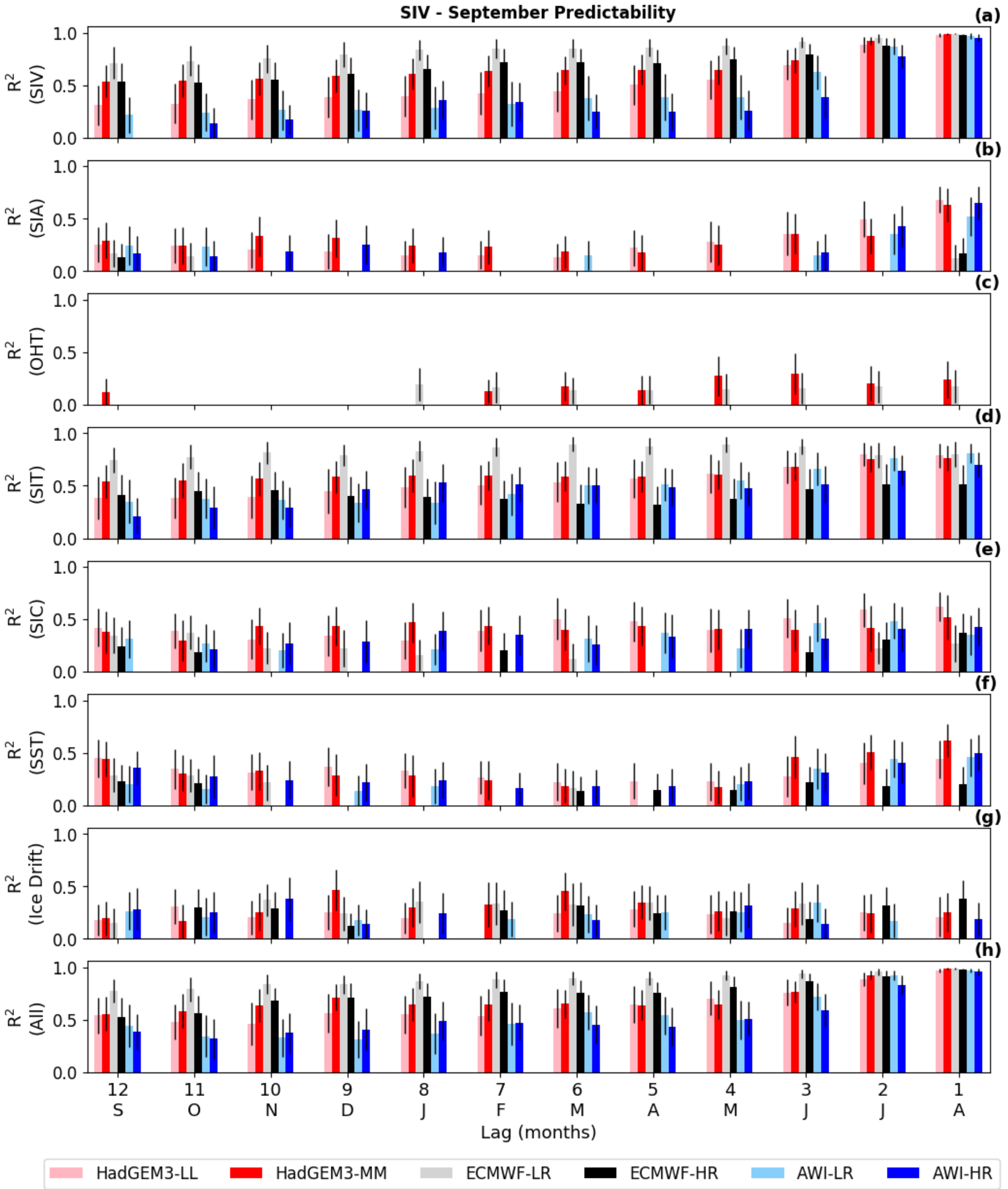
- 80% of the data are used to set the Multiple Linear Regression Model

- 20% of the data are used to calculate the errors

1000 repetitions – Monte Carlo

Statistical predictability
Pan-Arctic SIV anomaly

Figure: Statistical predictability of the **September SIV Anomaly** from 1 to 12 preceding months



Predictors:

a) Sea Ice Volume itself (a)
b) Sea Ice Area (b)
c) Ocean Heat Transport (c)
d) Sea Ice Thickness (d)
e) Sea Ice Concentration (e)
f) Sea Surface Temperature (f)
g) Sea Ice Drift (g)
h) All predictors (h)

Determining optimal sampling locations in order to infer the Sea Ice Volume Anomalies.

Predictors:

Sea Ice Thickness (mooring)

Sea Surface Temperature (mooring)

Sea Ice Drift (mooring)

Sea Ice Concentration (satellite)

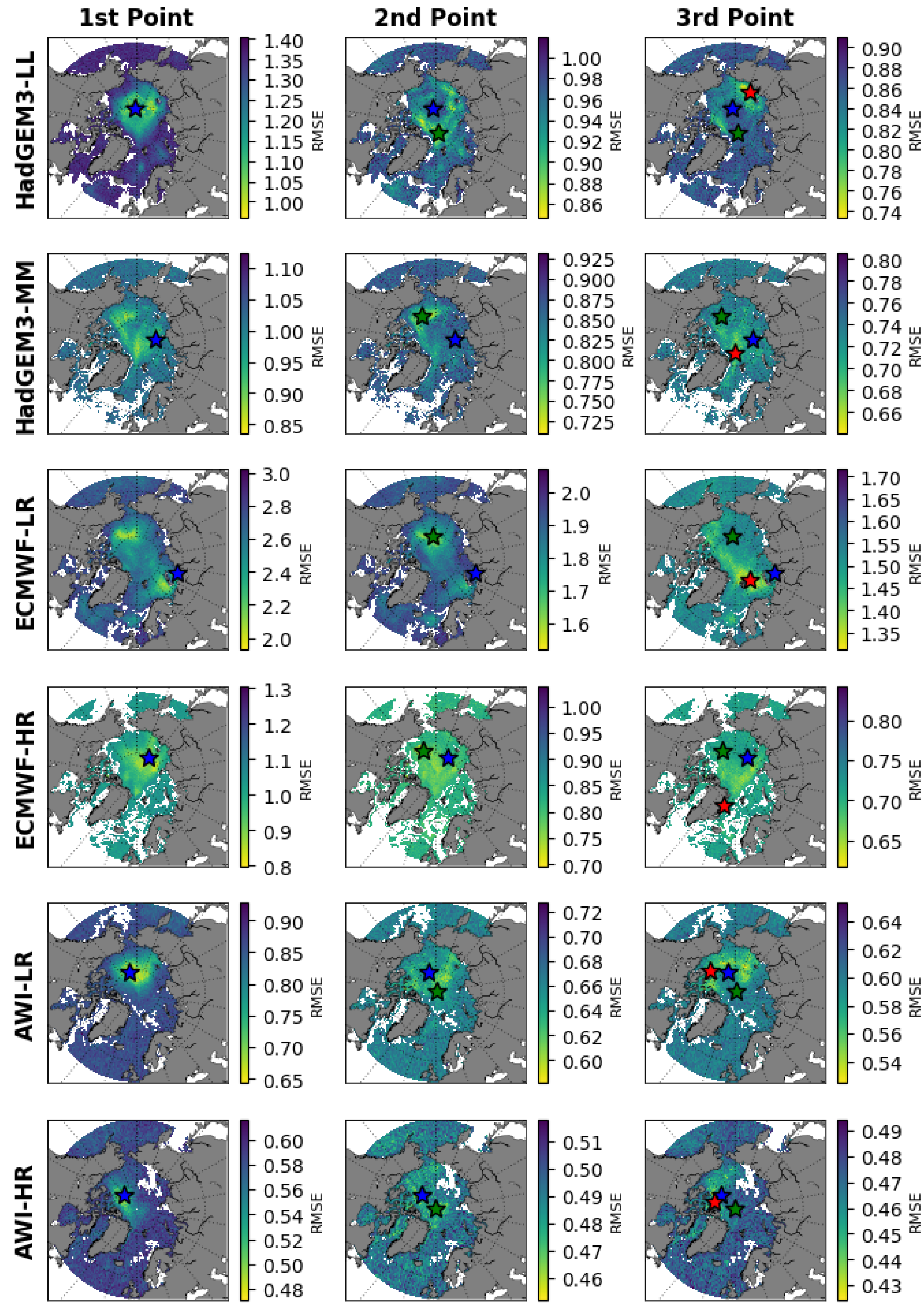
~~Ocean Heat Transport~~

~~Sea Ice Volume~~

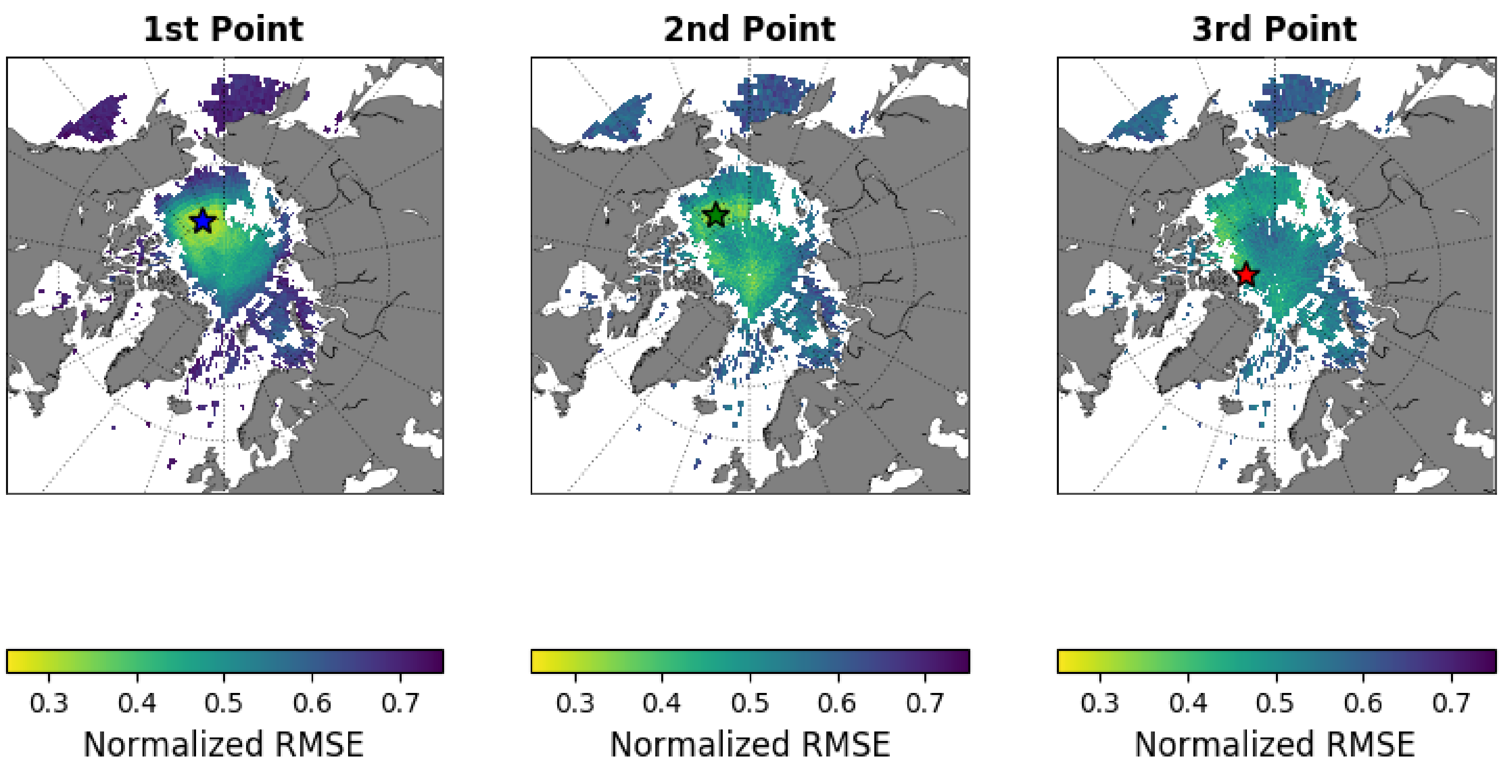
~~Sea Ice Area~~

Using correlation maps to determine which predictors will be used

The **optimal locations** are placed at the grid points where the predictor parameters provide best estimation of the SIV Anomaly (**minimum RMSE**)

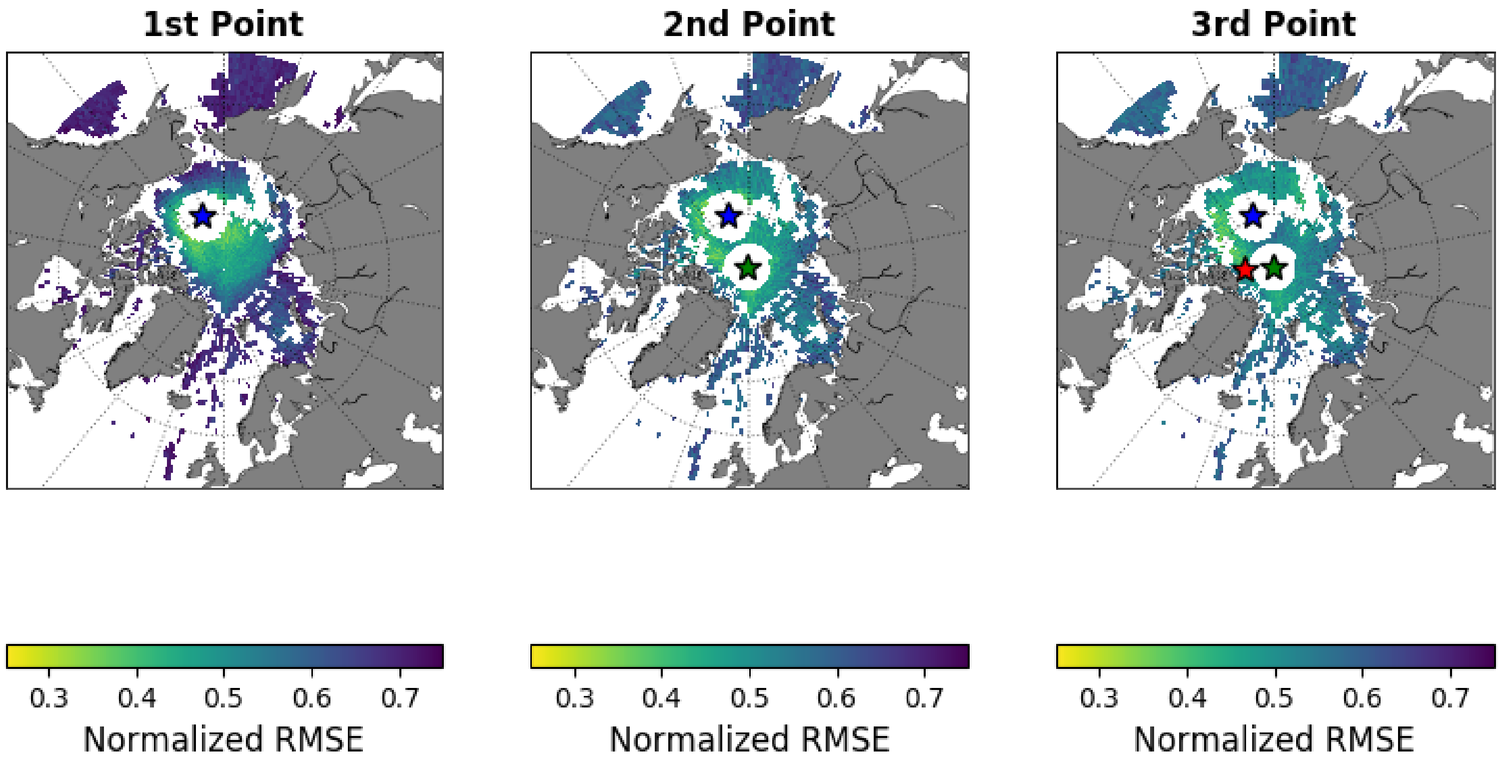


Optimal locations for the ensemble



Problem: proximity between 1st and 2nd locations

Optimal locations for the ensemble



Taking advantage of the length scales presented by
Ponsoni et al. 2018, The Cryosphere (under discussion)

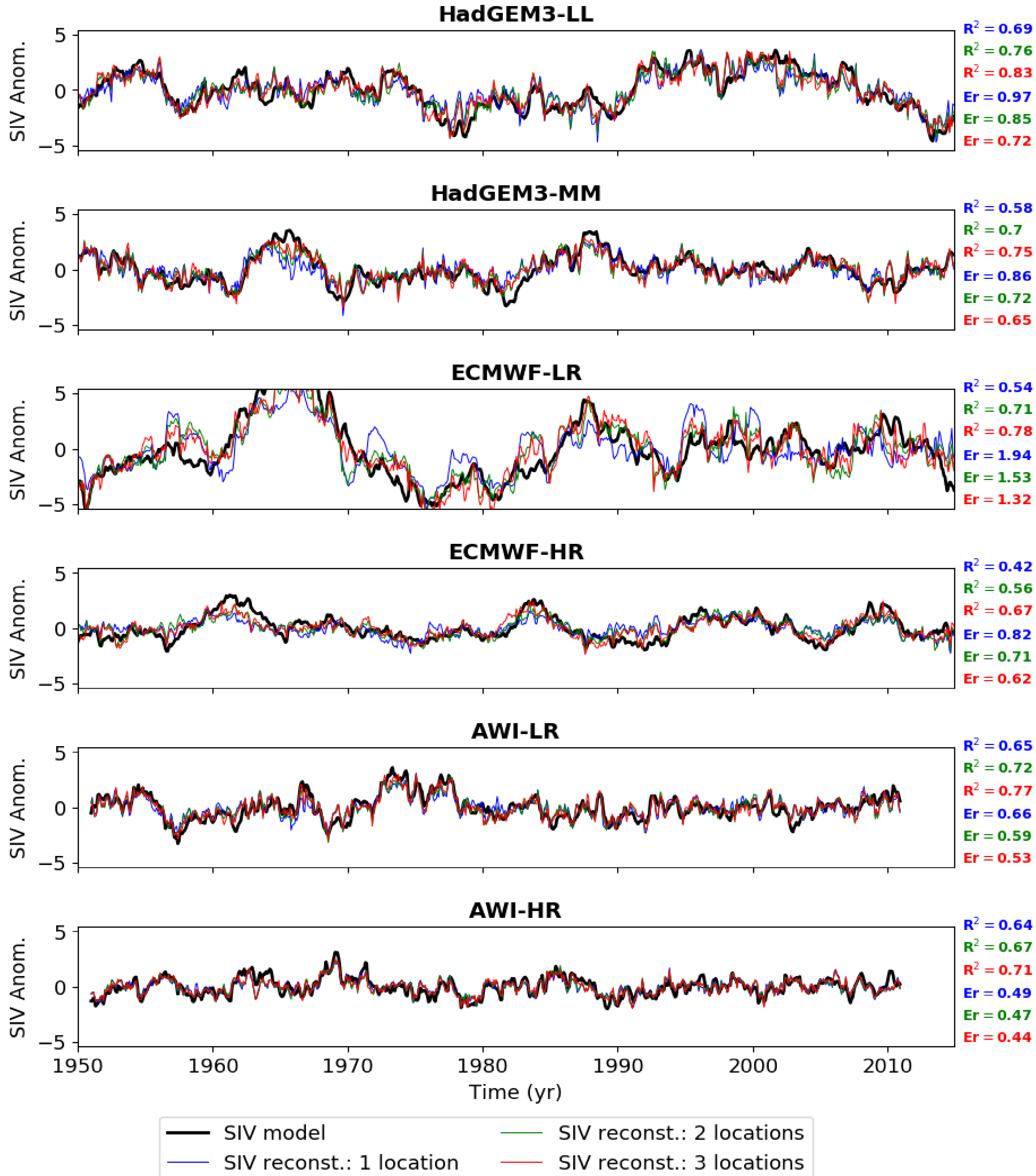
Reconstructed Sea Ice Volume Anomaly according to the empirical model and the optimal locations

Predicted SIV Anomaly:

- 1 optimal location
R^2: 0.42 – 0.69

- 2 optimal locations
R^2: 0.56 – 0.76

- 3 optimal locations
R^2: 0.67 – 0.83



Back to the motivating questions:

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(2) How does model resolution impact the statistical predictability of SIV anomalies?

For the models used in this work, the versions with finer horizontal resolution are best predictors in terms of RMSE, while models with coarser resolution are best predictors in terms of R2.

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(3) What are the best *in situ* locations for sampling predictor variables in order to optimize the statistical predictability of SIV anomalies?

The optimal locations are model-dependent. Nevertheless, for all model outputs, 3 optimal locations are already enough for explaining ~70% of the SIV Anomaly variance.

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