Possible interactions between some solar activity indicators for the last two solar cycles

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Data

The CME data are taken from SOHO/LASCO CME catalog and the maximum CME speed index are calculated as daily values. Then the monthly values were produced.

The ISSN data are taken from the WDC-SILSO, Royal Observatory of Belgium, Brussels, as a monthly mean values. Here we used the second version ISSN data.

Hα flare index (FI) data are taken from Bogazici University Kandilli Observatory as daily values. Then, monthly average values were calculated.

F10.7 data are downloaded from NASA OMNIWeb system as a daily values and the monthly values were calculated.

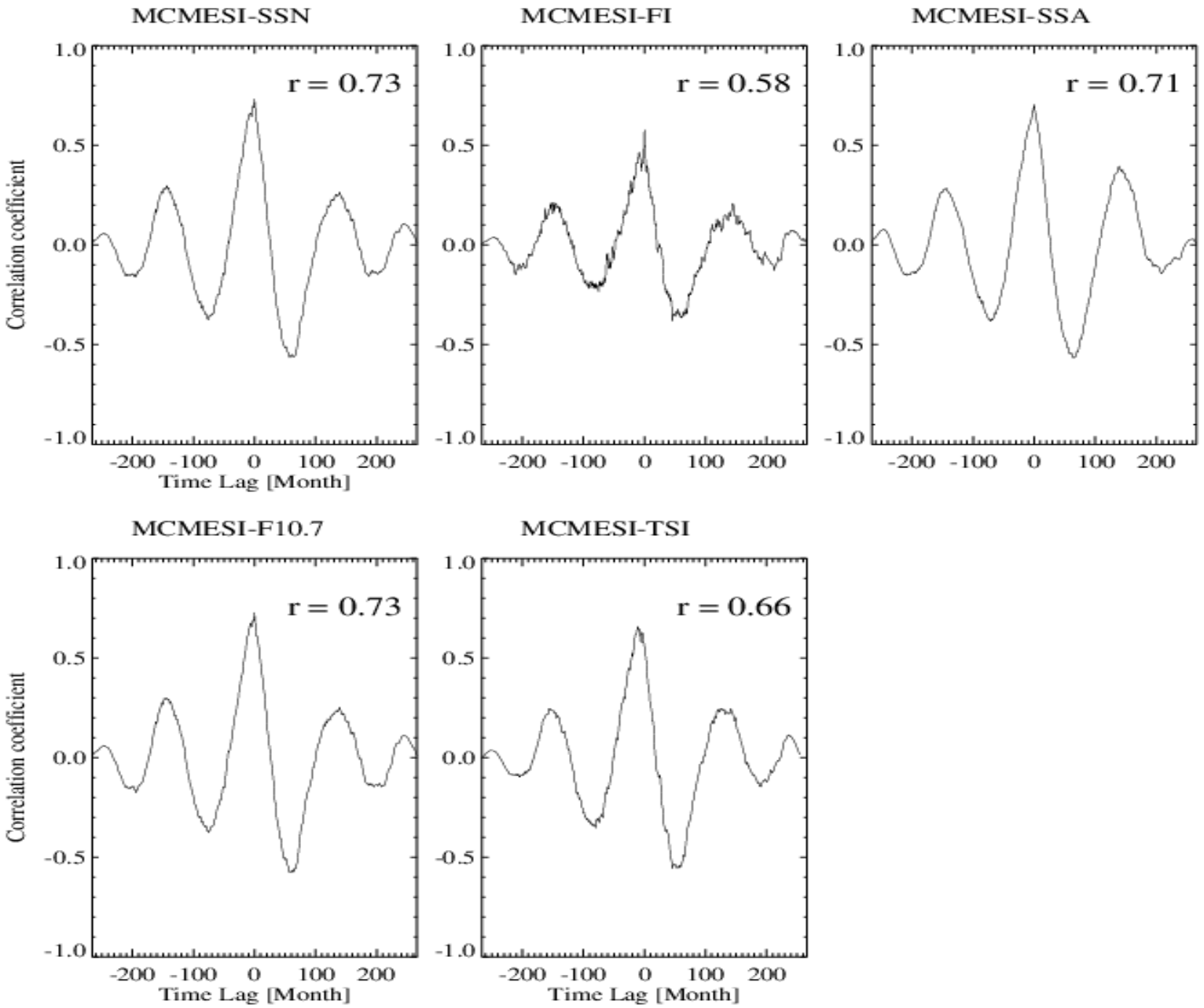
SSA data are taken from Debrecen Photoheliographic Data (DPD) sunspot catalogue as a daily data, then the monthly values were calculated.

The TSI data are taken from ftp://ftp.pmodwrc.ch/pub/data/irradiance/composite as a daily values and the monthly values were calculated.

METHOD

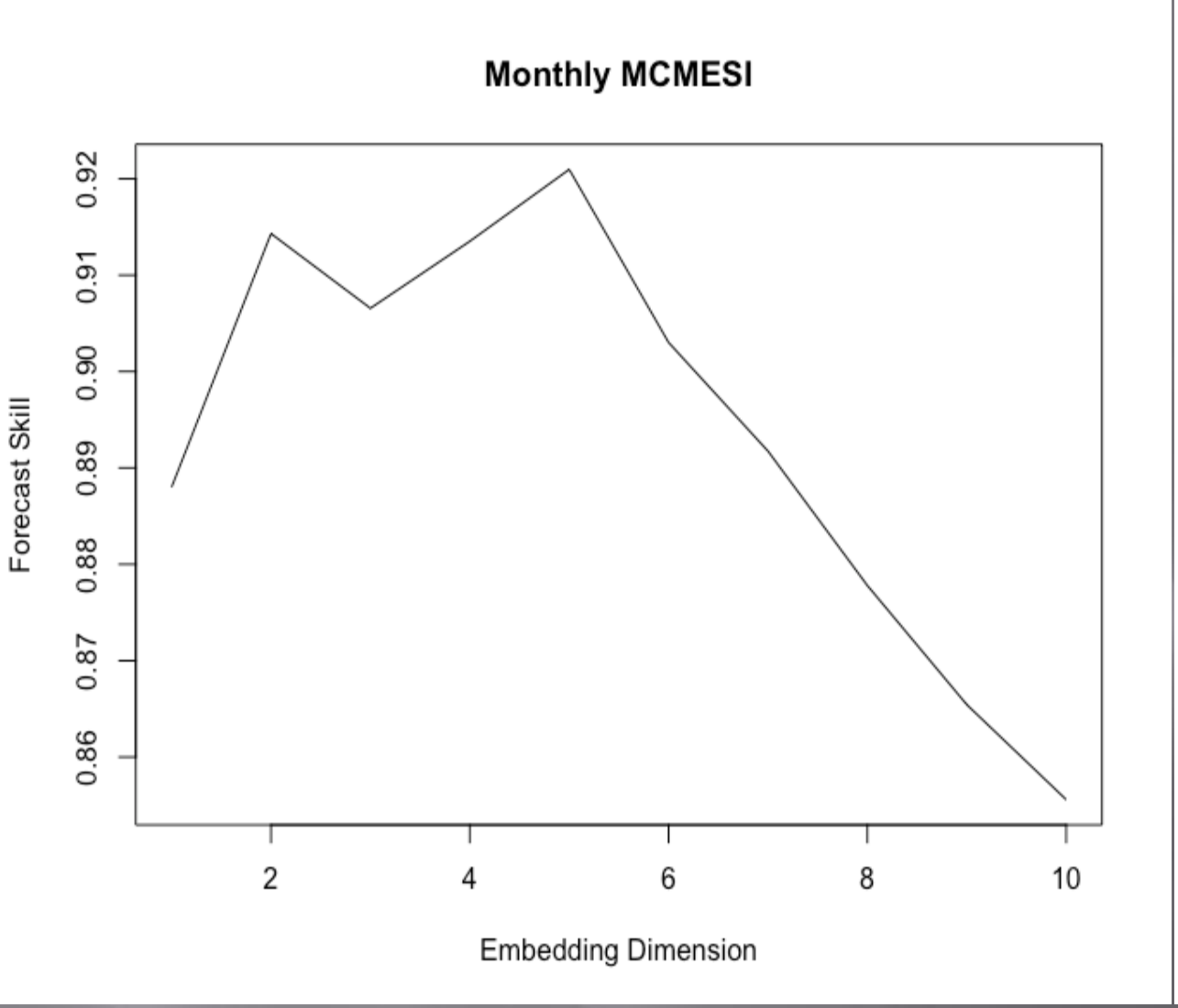
To investigate the linear relationship between the MCMESI and other solar activity indicators (ISSN, SSA, FI, F10.7 and TSI) cross-correlation analysis method was used.

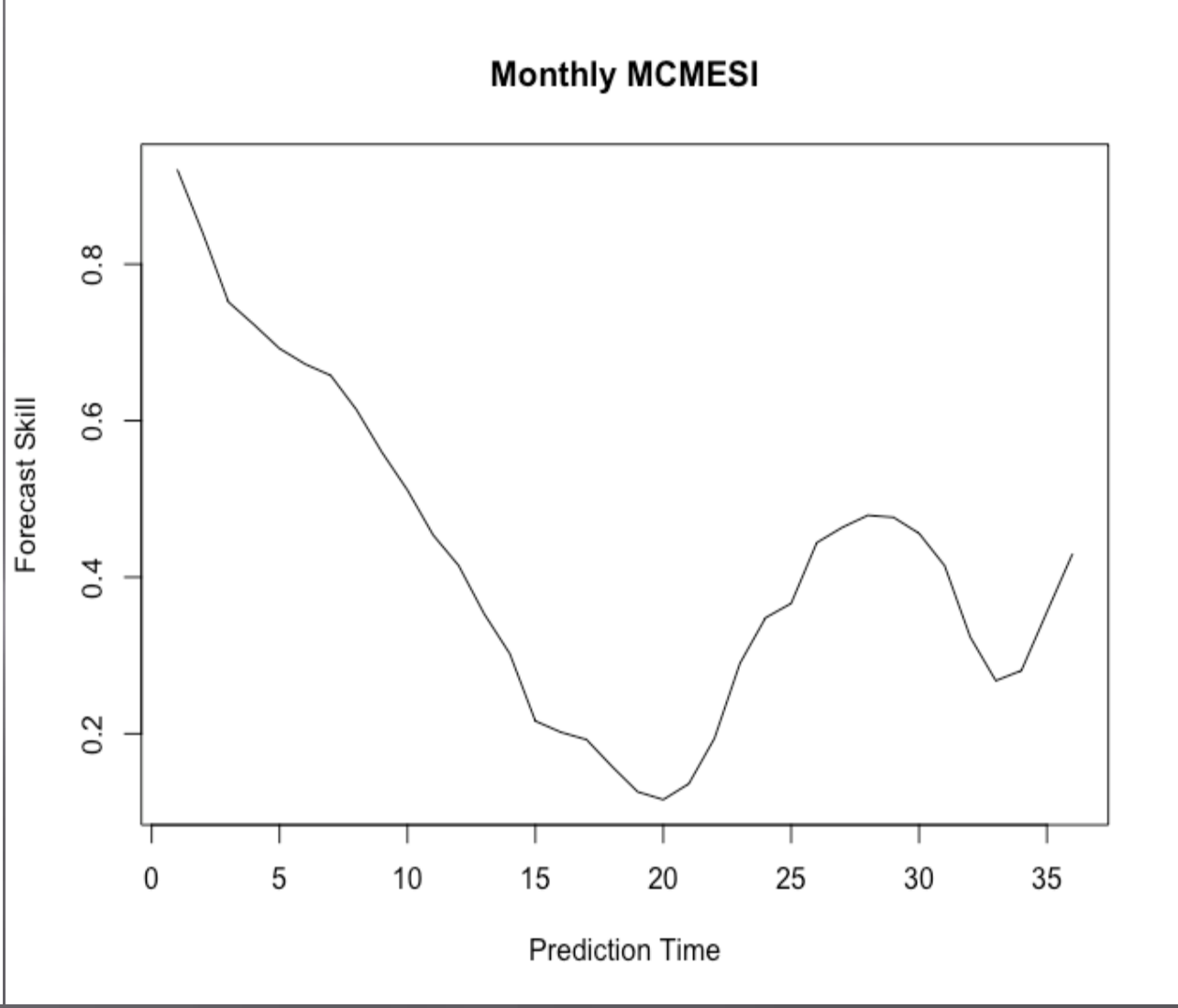
The method gives the highest correlation between two data sets by taking into account time delay.

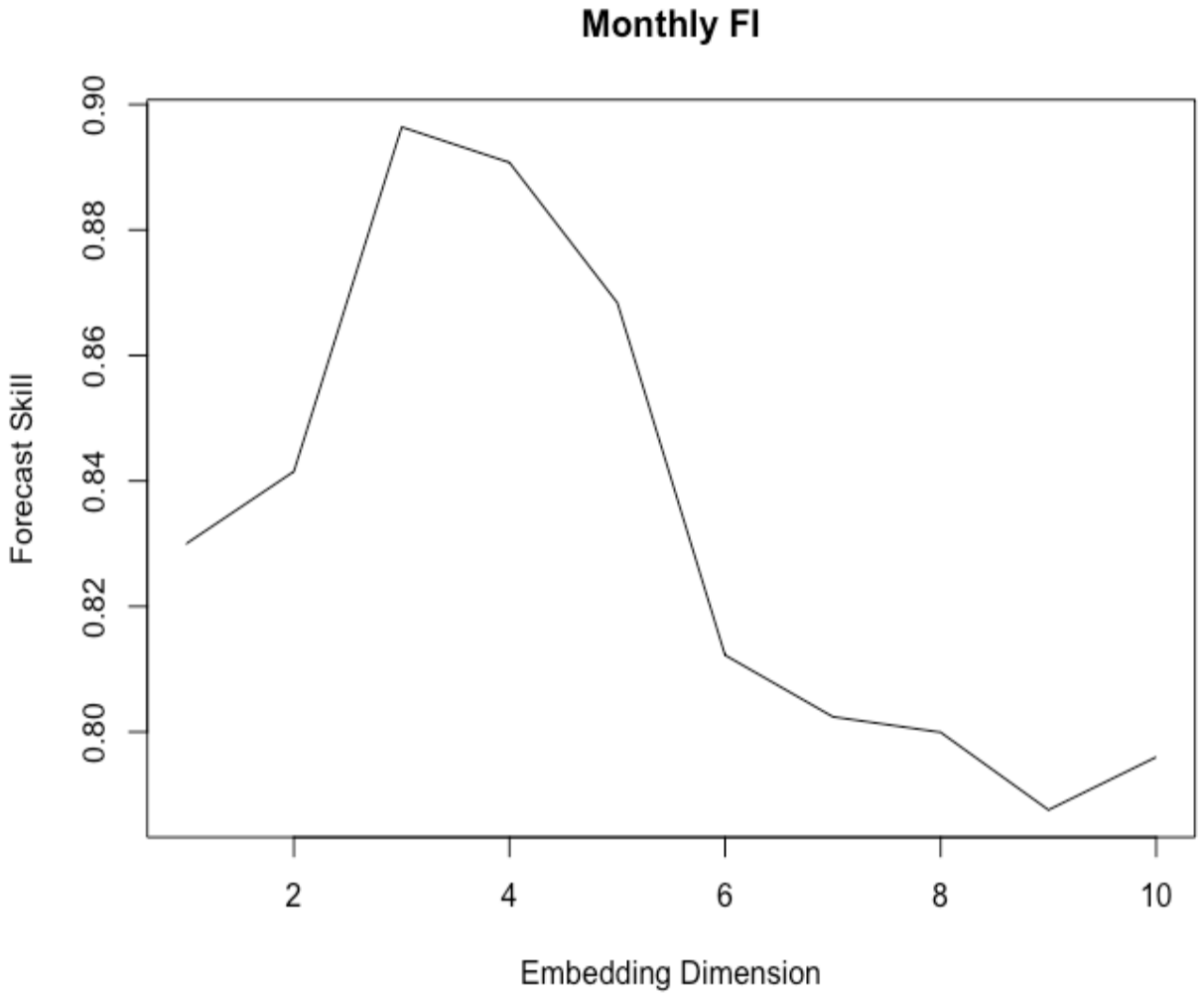


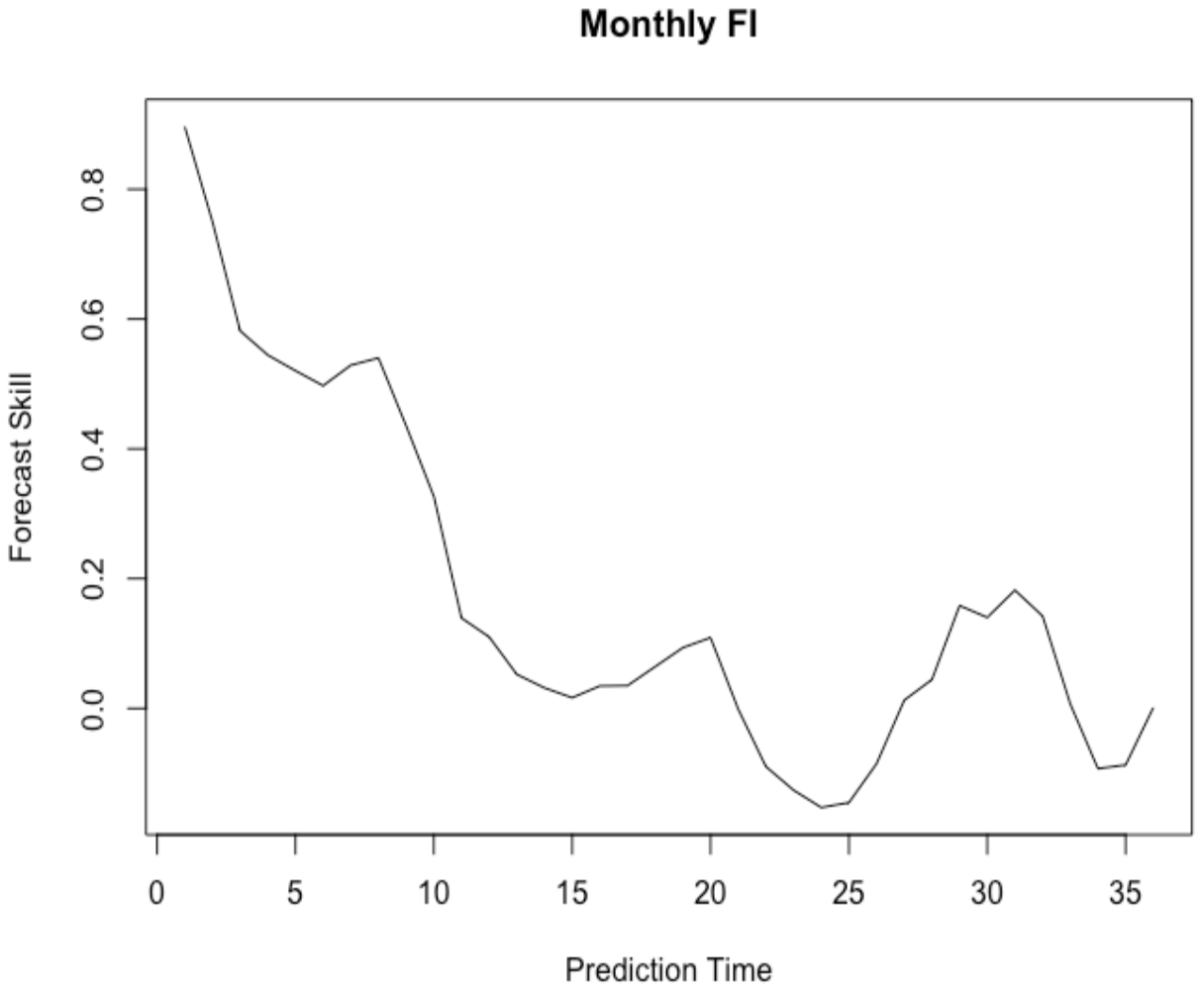
Cross correlation analysis results between the MCMESI and all other solar indices used in this study.

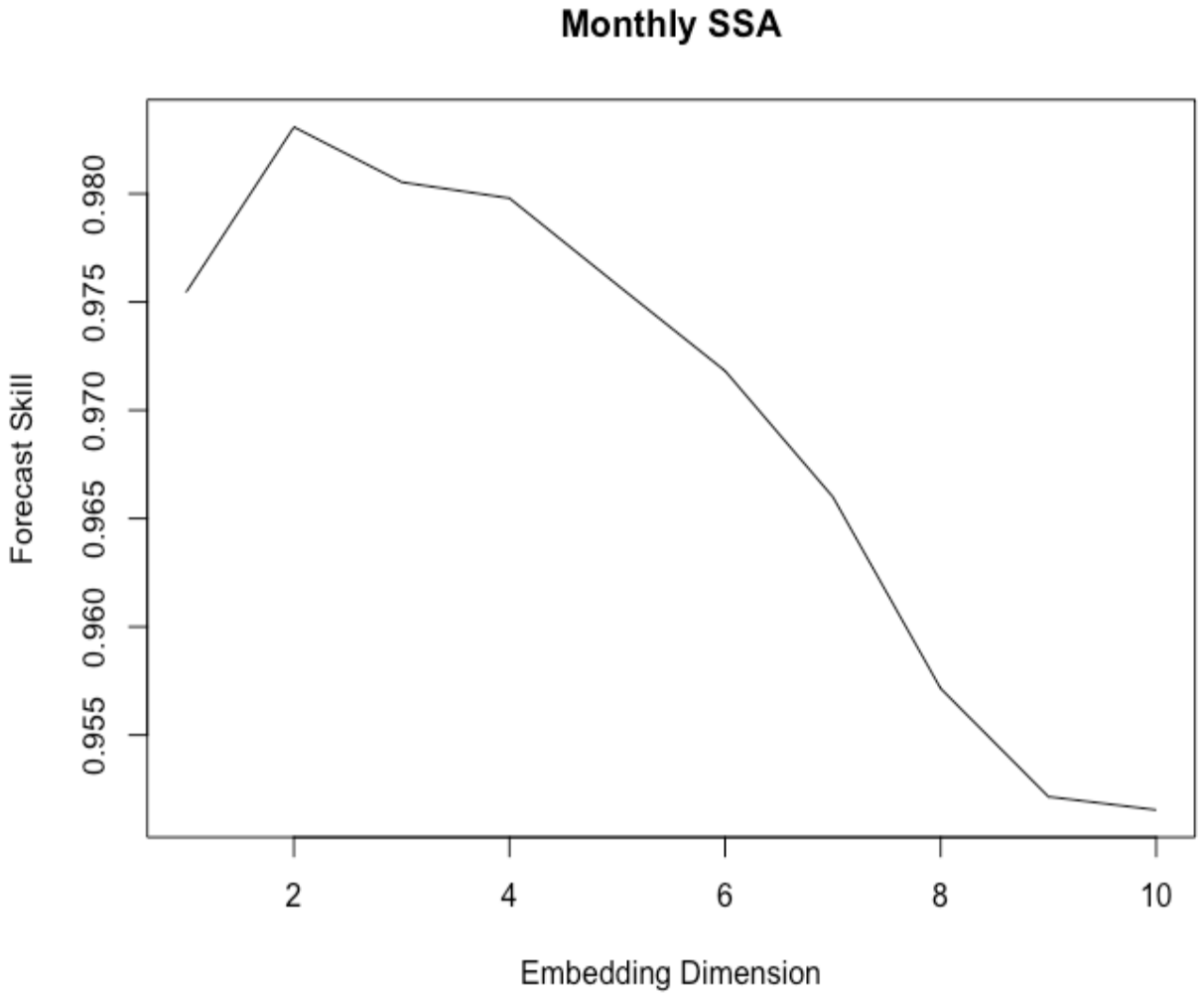
For the possible non-linear interaction between the MCMESI and the other indicators Convergent Cross Mapping (CCM) analysis method were used. This method can distinguish causality from correlation. For the causality, correlation is not necessary nor sufficient. To apply CCM method we should first determine the embedding dimension of each variable. The embedding dimension can be determined by using the prediction performance of the simplex projection. Then, by using this embedding dimensions, two data sets can be used for CCM analysis and possible causalities can be obtained by determining how well local neighborhoods on two studied variables' reconstructions will correspond to each other.

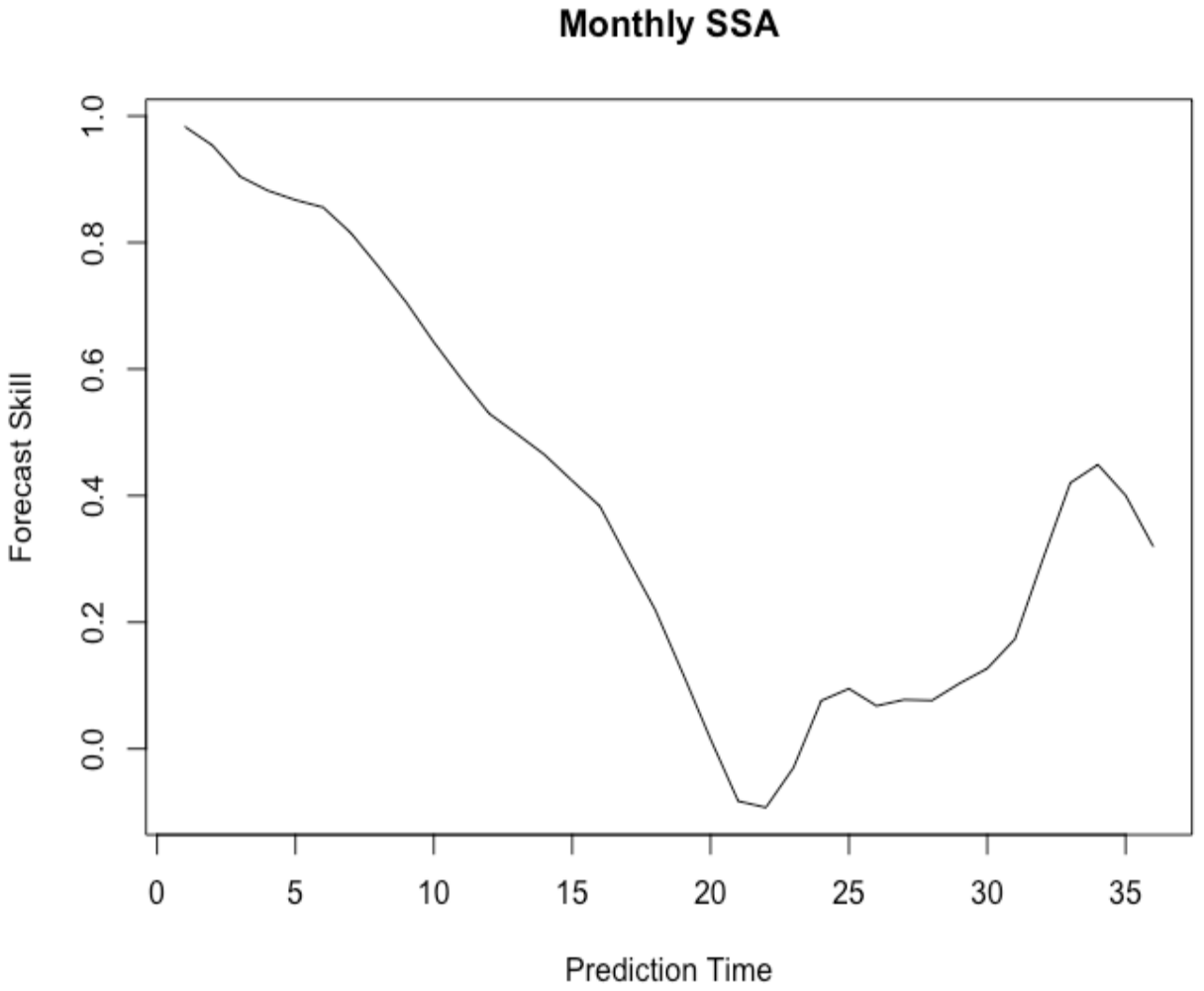

Monthly MCMESI
Forecast Skill
0.86
0.87
0.88
0.89
0.90
0.91
0.92
2
4
6
8
10
Embedding Dimension

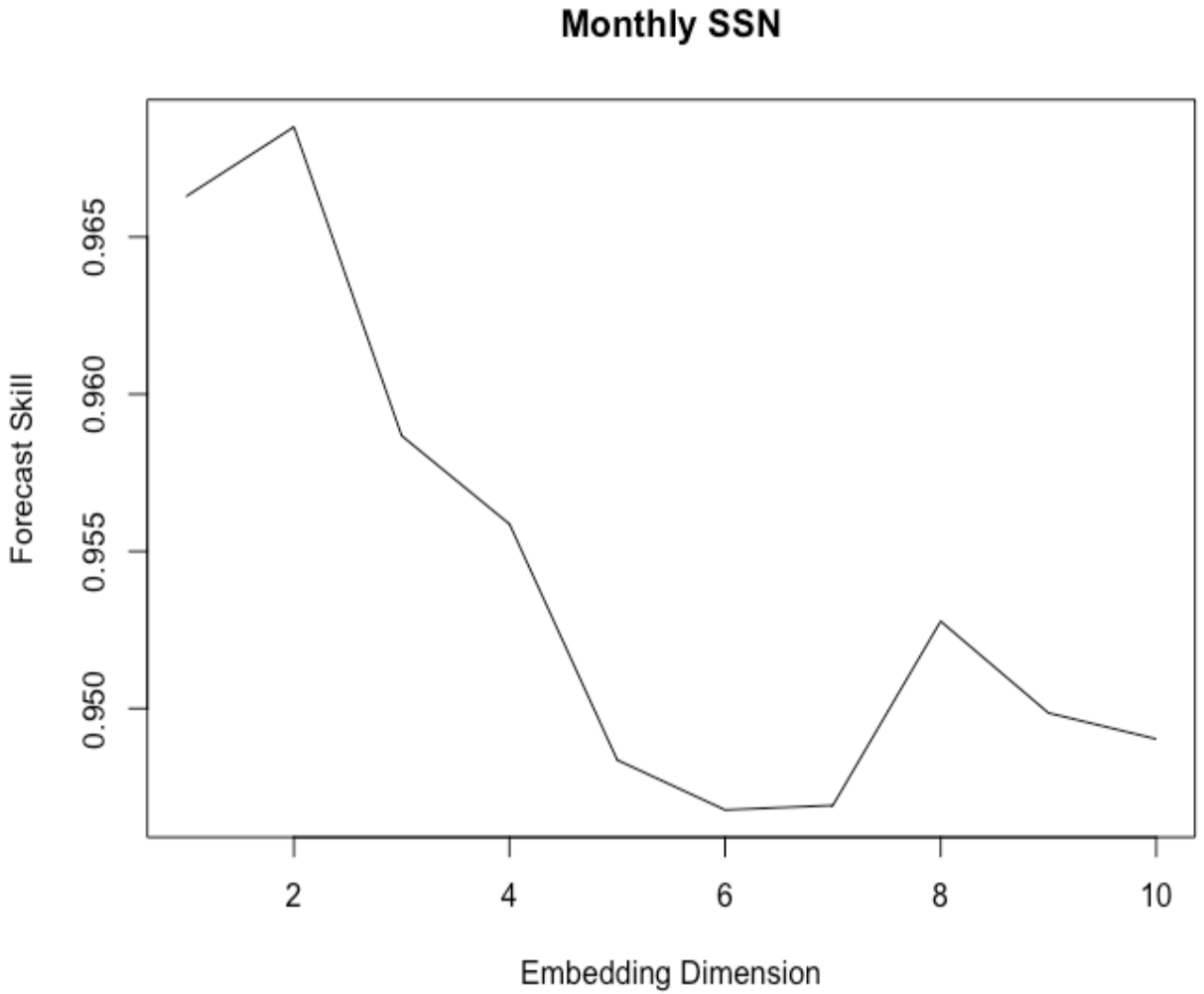

Monthly MCMESI
Forecast Skill
0.2
0.4
0.6
0.8
0
5
10
15
20
25
30
35
Prediction Time

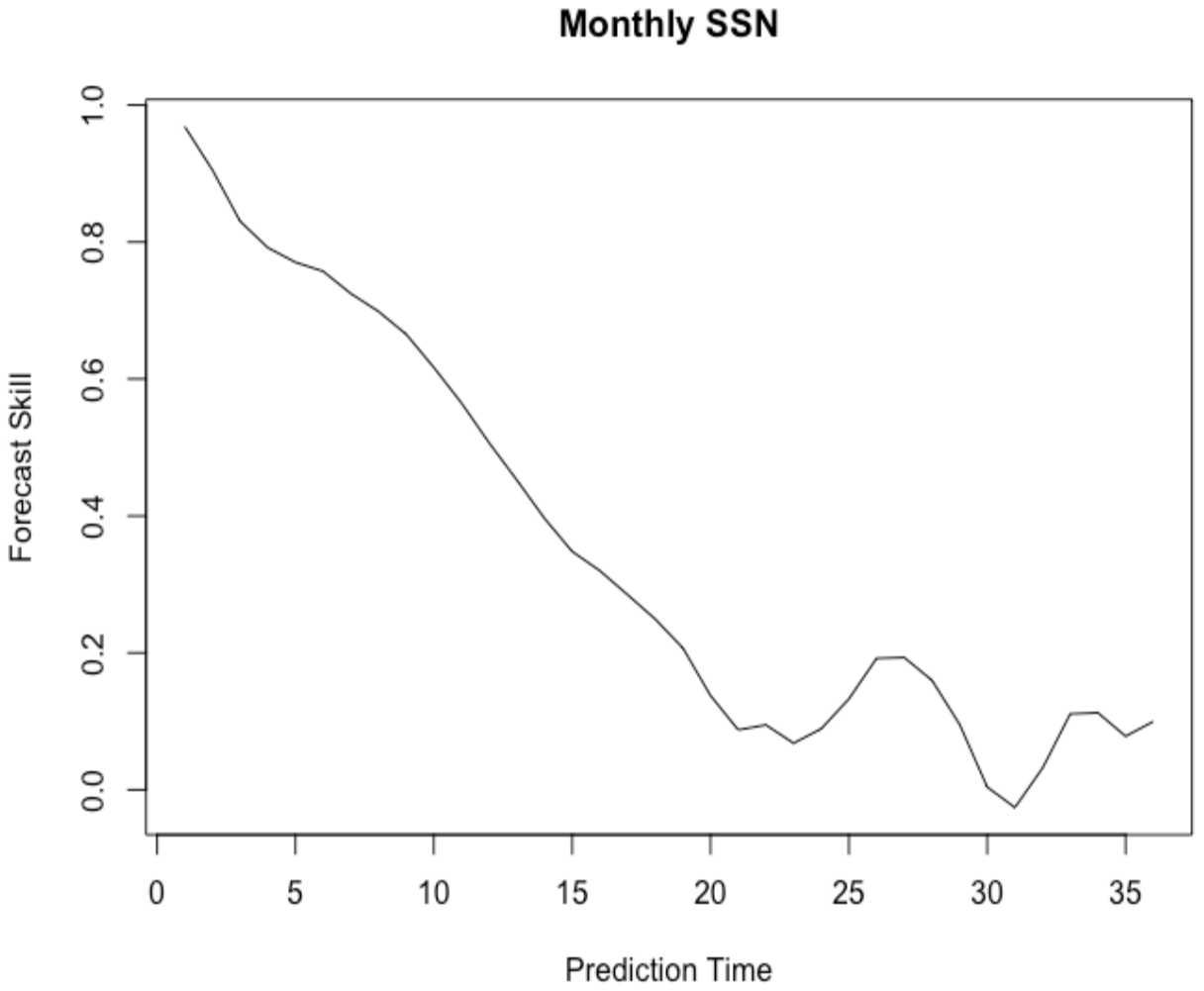

Monthly FI
Forecast Skill
0.80
0.82
0.84
0.86
0.88
0.90
2
4
6
8
10
Embedding Dimension

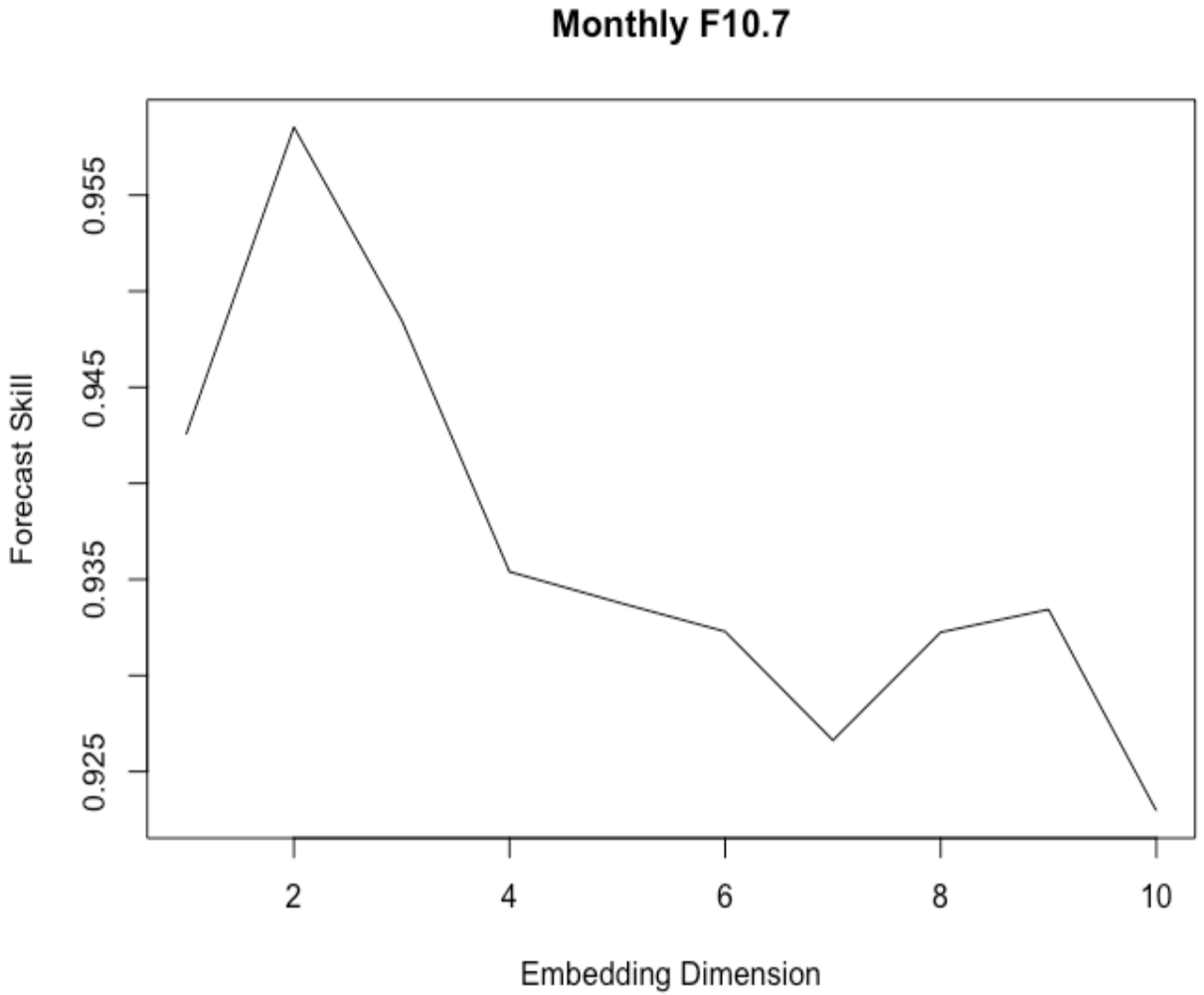

Monthly FI
Forecast Skill
0.0
0.2
0.4
0.6
0.8
0
5
10
15
20
25
30
35
Prediction Time

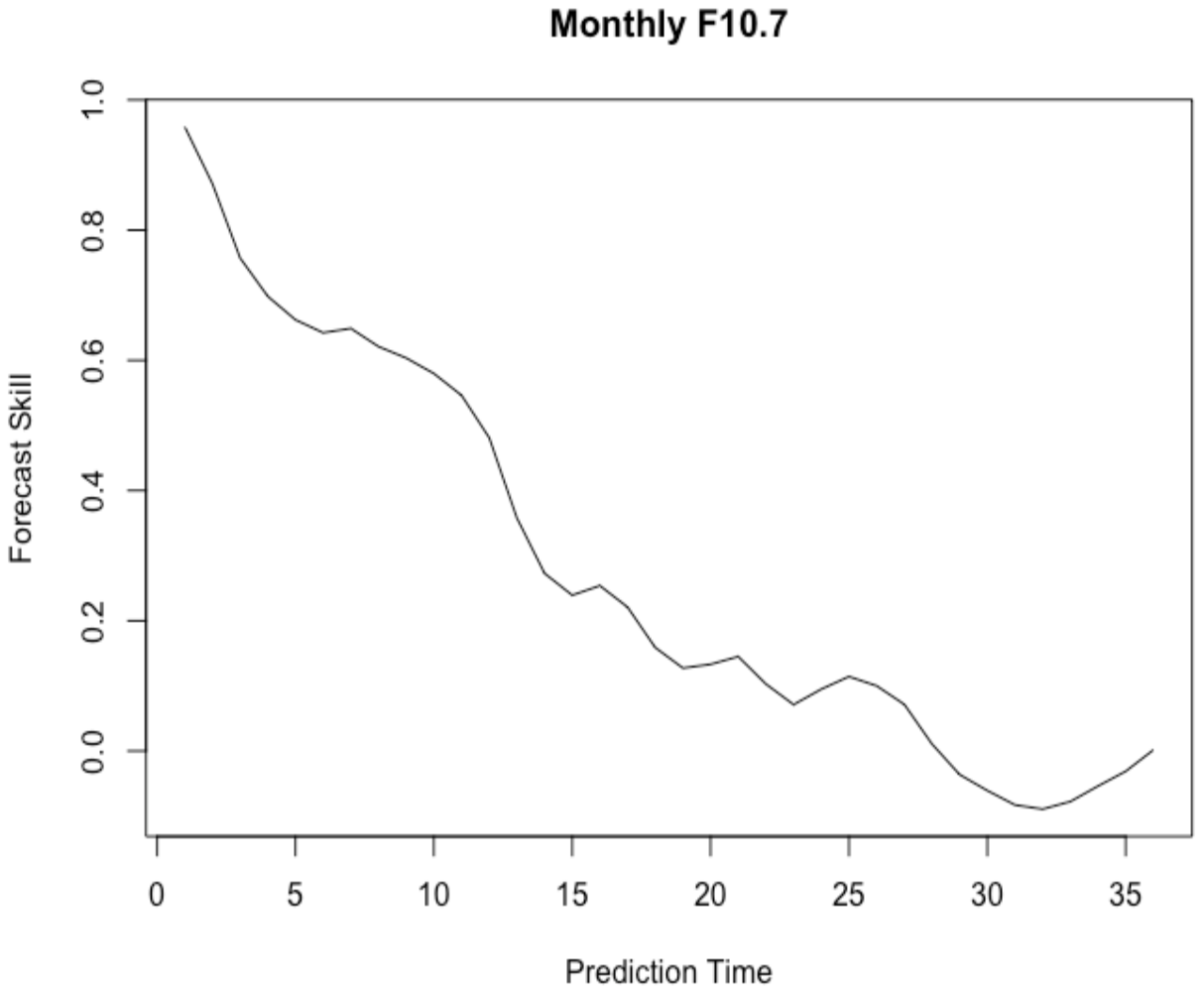

Monthly SSA
Forecast Skill
0.955
0.960
0.965
0.970
0.975
0.980
2
4
6
8
10
Embedding Dimension

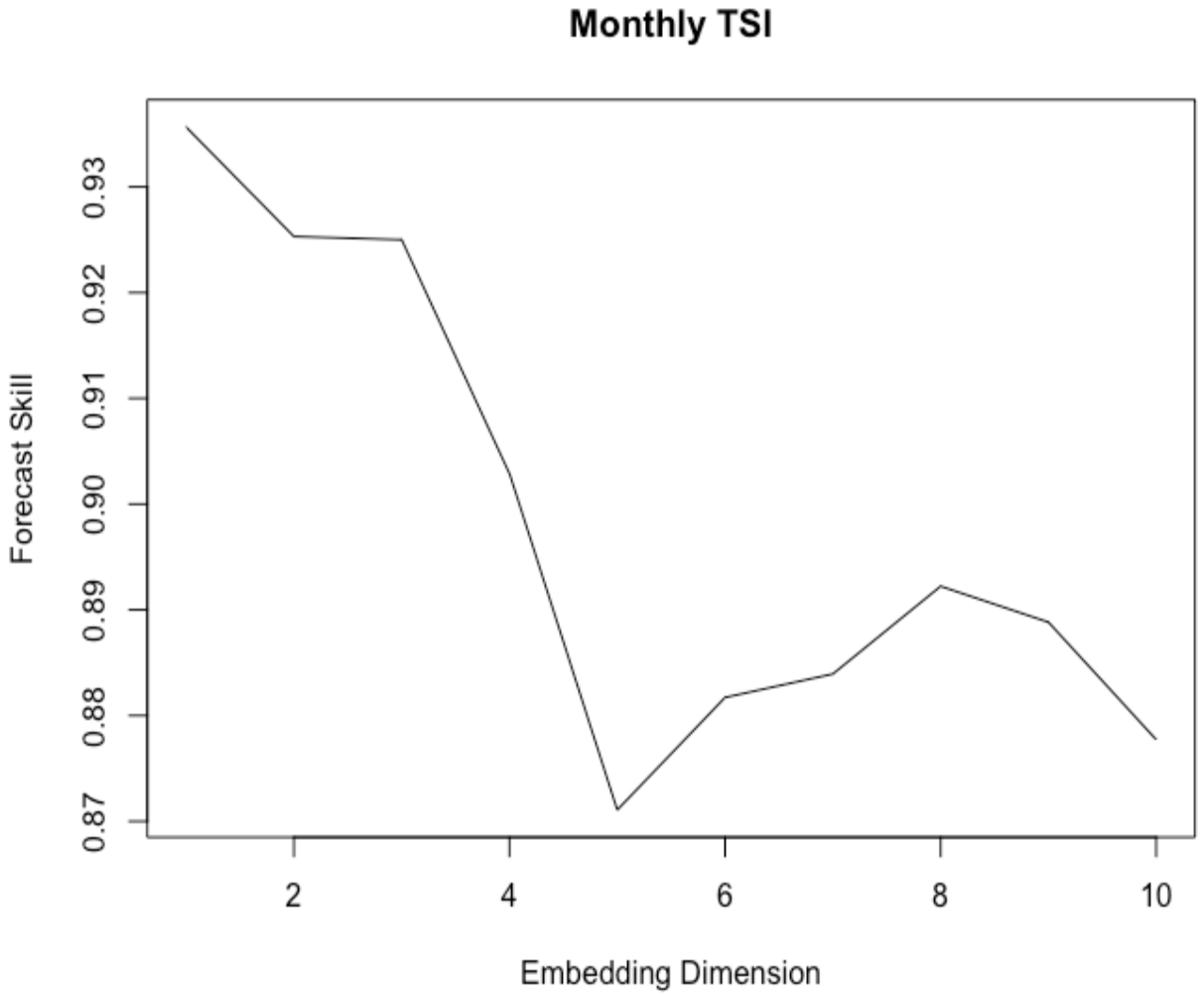

Monthly SSA
Forecast Skill
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
Prediction Time

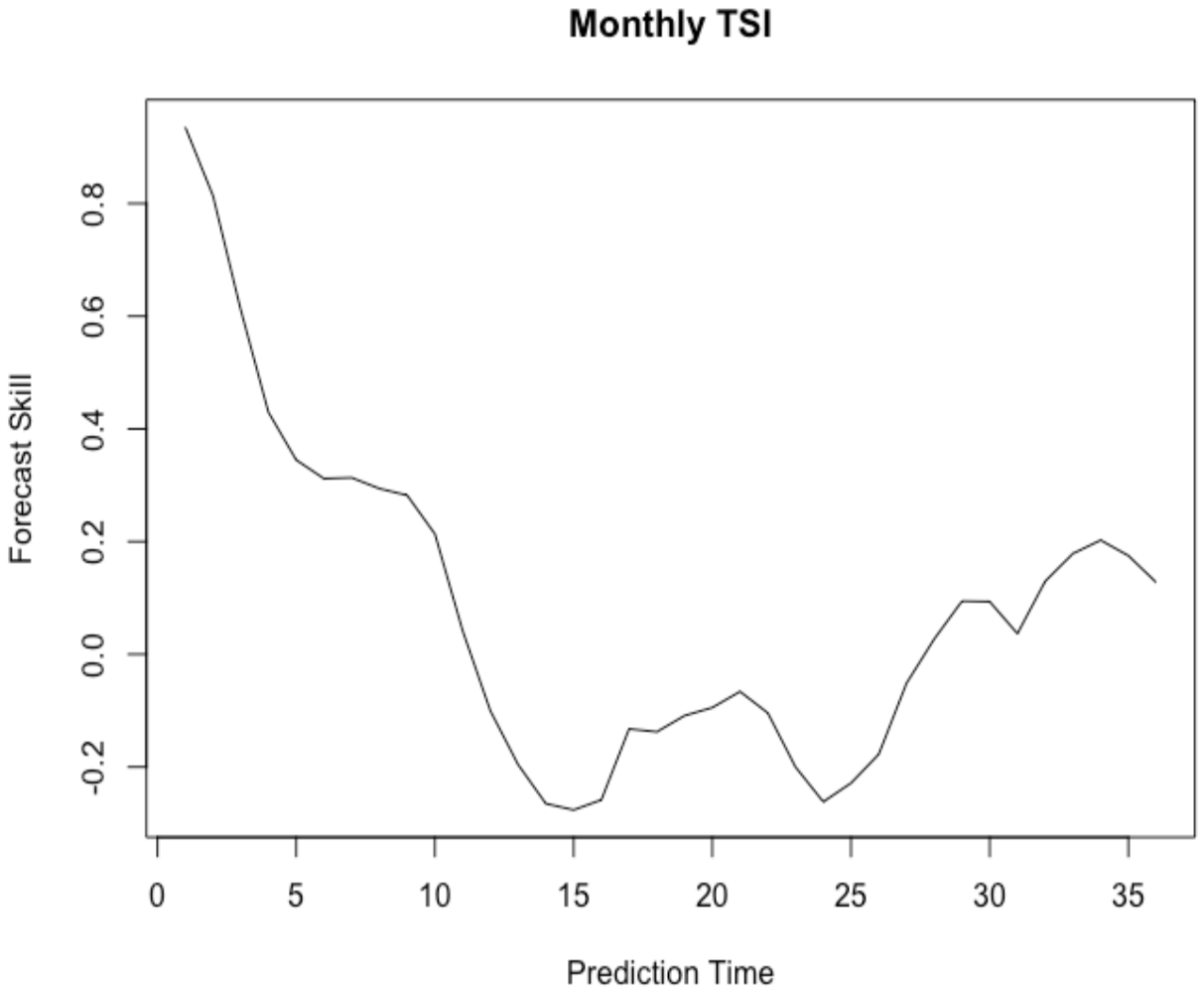

Monthly SSN
Forecast Skill
0.950
0.955
0.960
0.965
2
4
6
8
10
Embedding Dimension

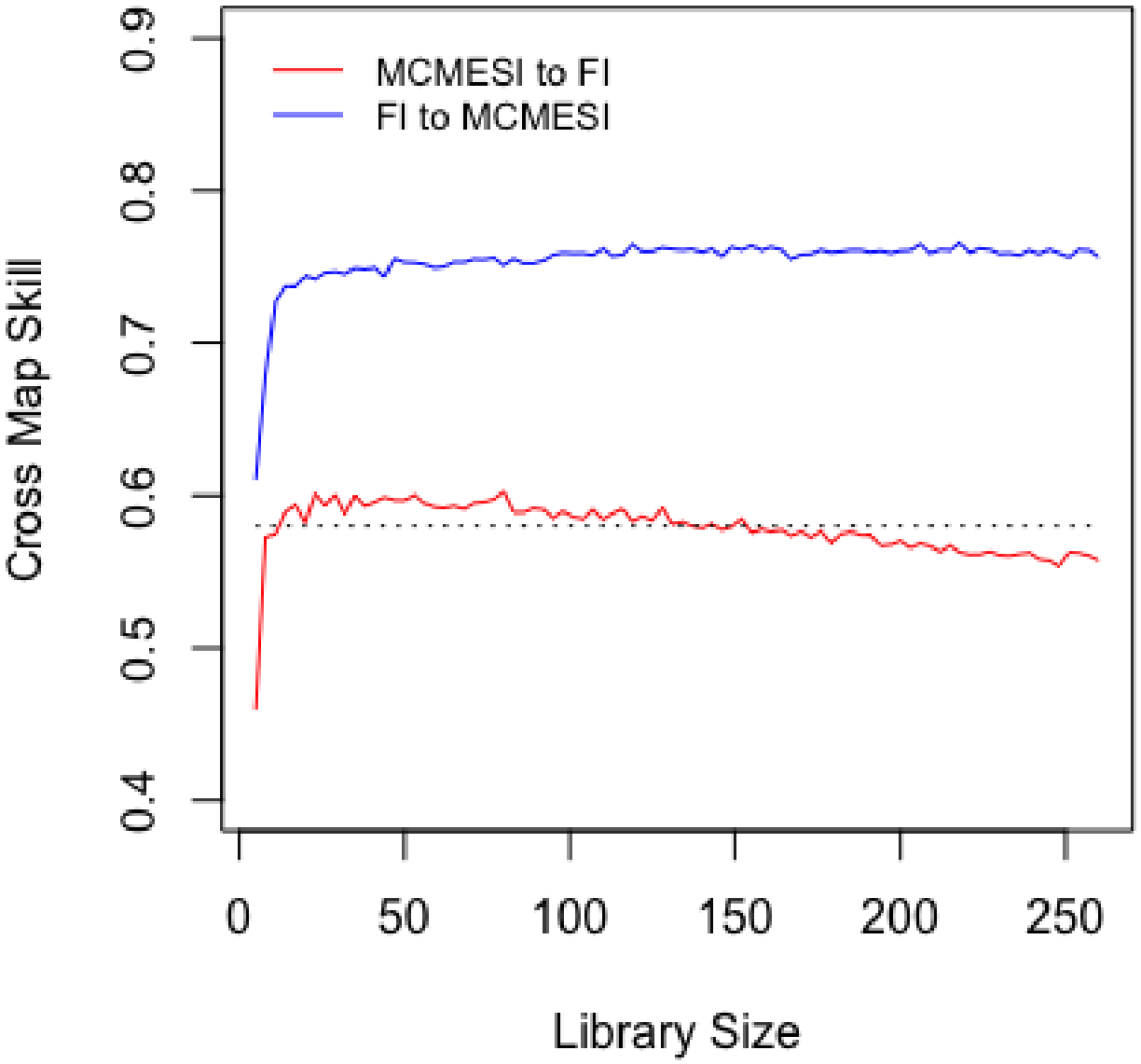

Monthly SSN
Forecast Skill
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
Prediction Time


Monthly F10.7
Forecast Skill
0.925
0.935
0.945
0.955
2
4
6
8
10
Embedding Dimension

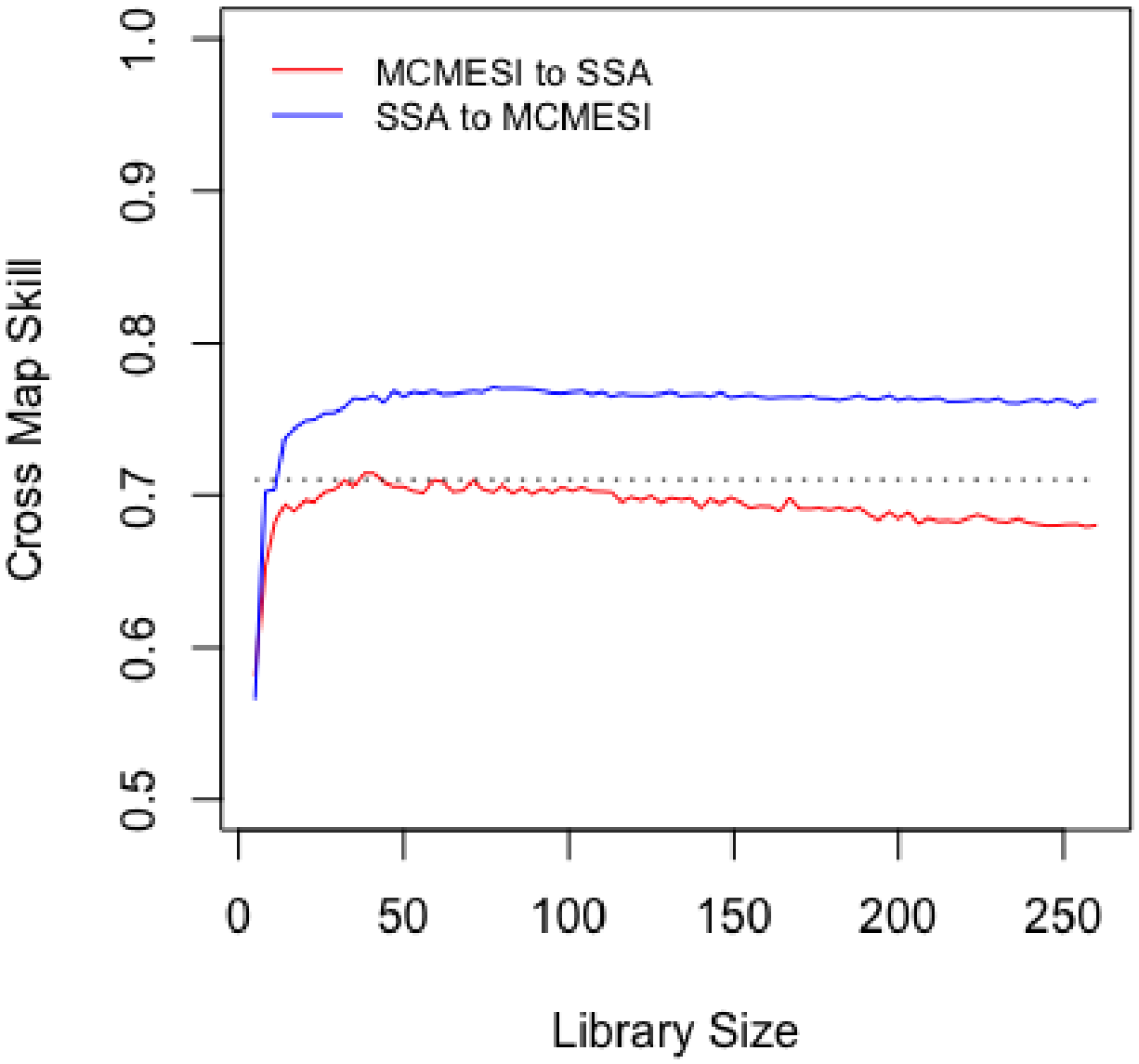

Monthly F10.7
Forecast Skill
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
30
35
Prediction Time


Monthly TSI
Forecast Skill
0.87
0.88
0.89
0.90
0.91
0.92
0.93
2
4
6
8
10
Embedding Dimension

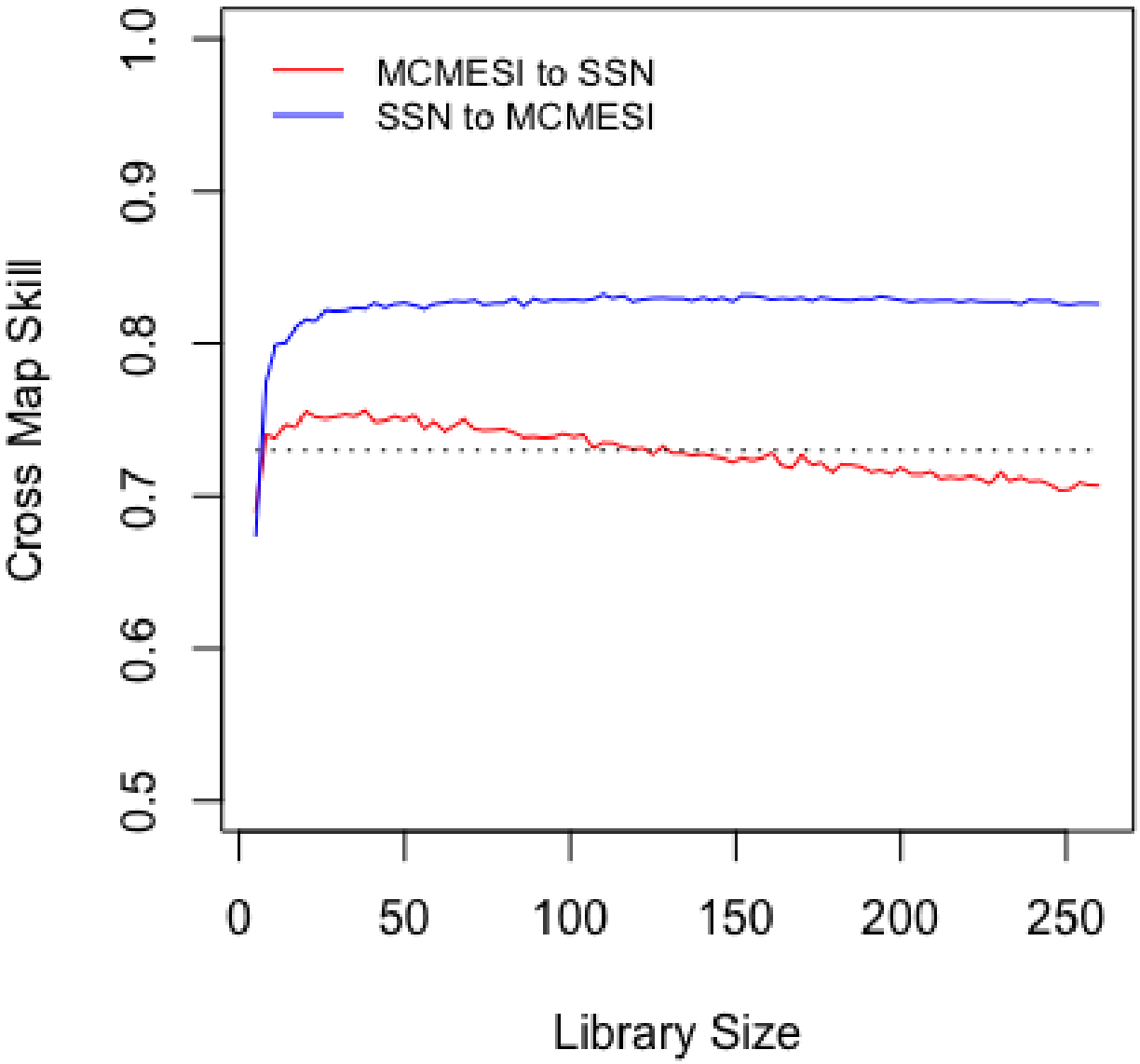

Monthly TSI
Forecast Skill
-0.2
0.0
0.2
0.4
0.6
0.8
0
5
10
15
20
25
30
35
Prediction Time



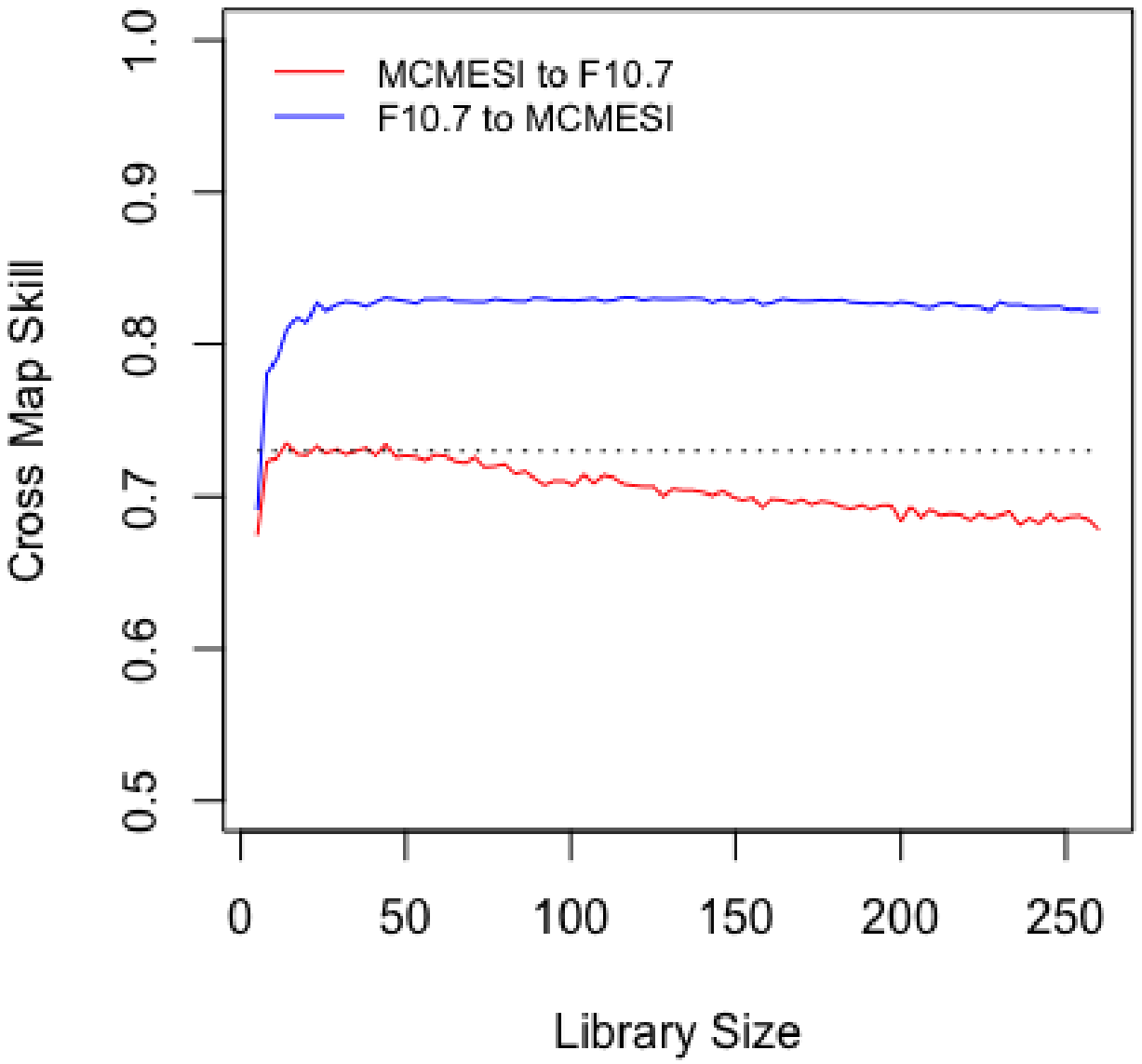
- MCMESI variations could cause FI variations
- Asymetrical unidirectional coupling
- FI have nearly no effect on MCMESI in the long term



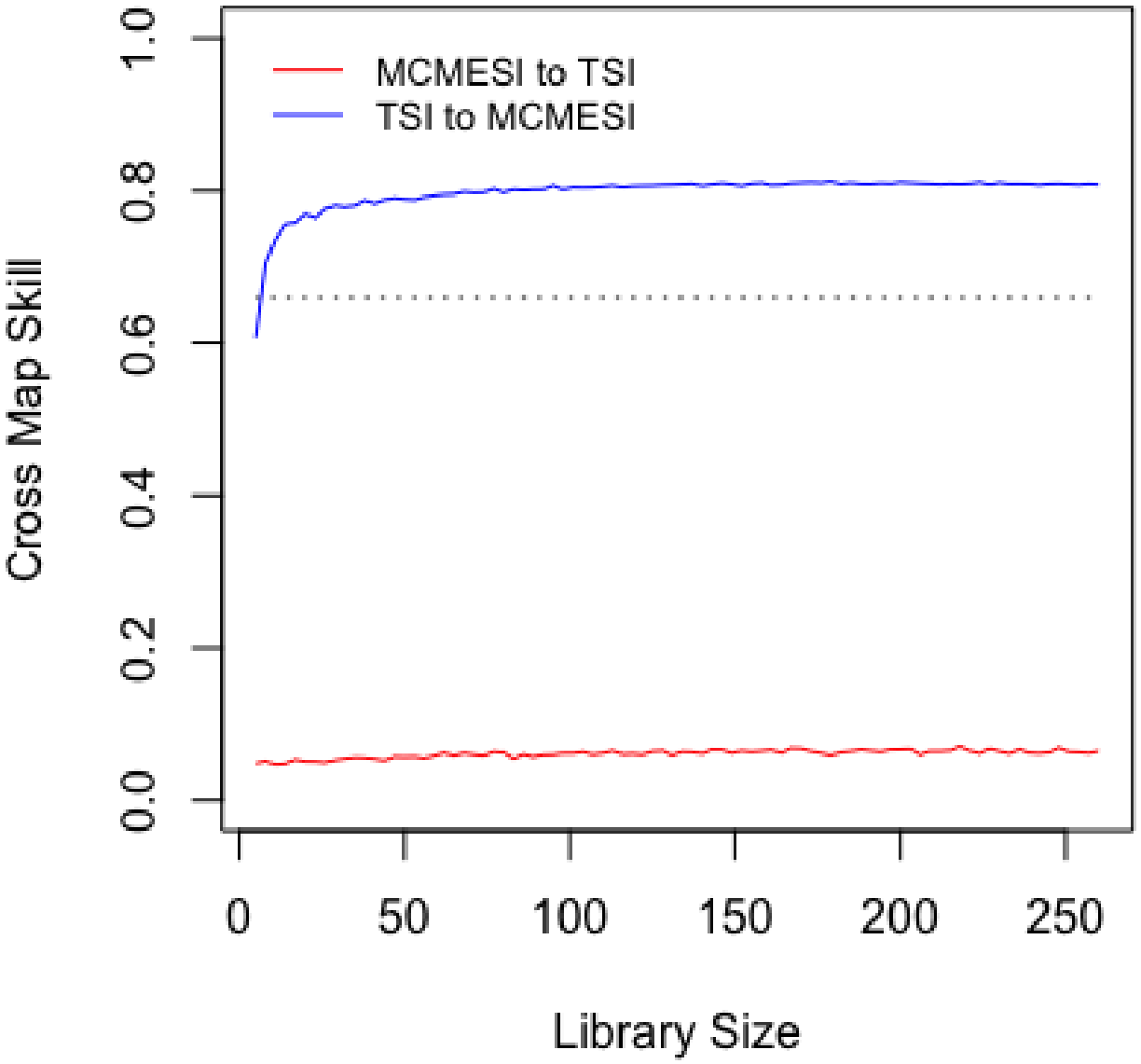
- MCMESI Dynamics are more sensitive to the states of SSA than vice versa
- There is a synchonized variation



- MCMESI Dynamics are more sensitive to the states of SSN than vice versa.
- Variations in SSN, cause MCMESI to change



- MCMESI Dynamics are more sensitive to the states of F10.7 than vice versa.
- Variations in F10.7, cause MCMESI to change



- TSI Dynamics are insensitive to the states of MCMESI but the reverse is not true
- So TSI corresponds to external forcing or there is an incomplete information flow from MCMESI to TSI

CONCLUSİONS

- ✓ 1. The most complicated data are the MCMESI which has the highest embedding dimension (E = 5)
- ✓ Forecast skills decrease with increasing time in a short duration. This indicate that all data sets used in this study can be approximated by deterministic chaos rather than stochastic process.
- ✓ CCM results indicate that there are no bidirectional coupling in the long term (more than one cycle). Because one of the CCM curve always under the level of correlation coefficient.
- ✓ In contrast, for the short term there are synchronized relation between two variable.
- ✓ TSI behave differently than other data sets used; it has the weakest coupling with the MCMESI

THANKS FOR YOUR ATTENTİON

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