Improving CFS Precipitation and 2m Temperature Anomaly Outlooks from Week-1 to Week-6 with Machine Learning

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NOAA Center for Weather and Climate Prediction

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Outline

- **Motivation**
- **NN Basic**
- **Preliminary Results**
- **Summary**

Motivation

Demand for S2S P & T2m Fcst Steadily Increasing

Problem: Low Forecast Skill

Post-Processing:

Data Sets

$\{ (f_1, f_2, \ldots\ldots, f_n)_p, \ O_p \}_{p=1,2,\ldots\ldots N}$

Where

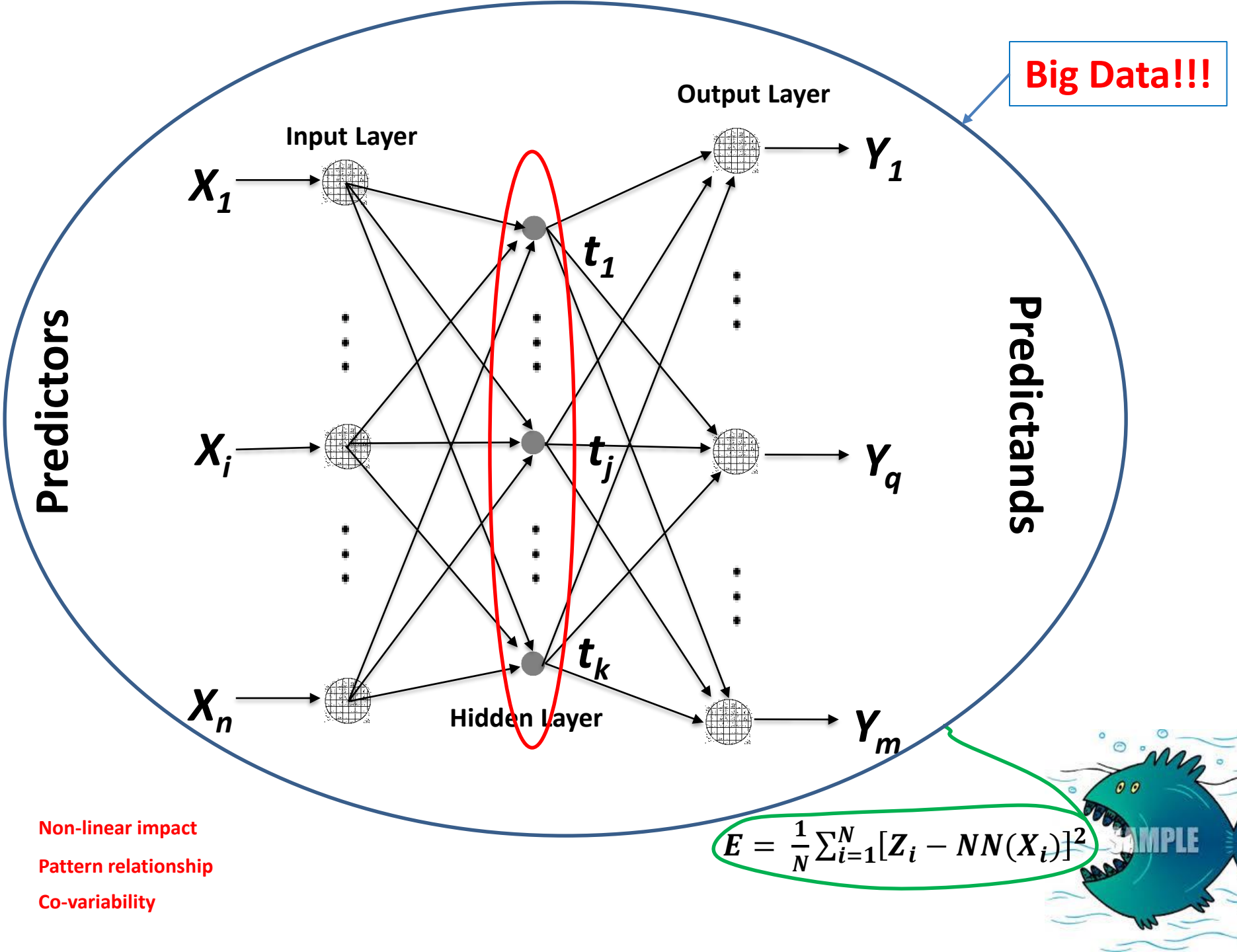
$f_1, f_2, \ldots\ldots, f_n$ **-- predictors:** 1999-2019 daily BC **CFSv2** Week 1-6 P & T2m **fcsts**, ……

O_p **-- predictands:** 1999-2019 daily Week 1-6 **P** & **T2m Obs**

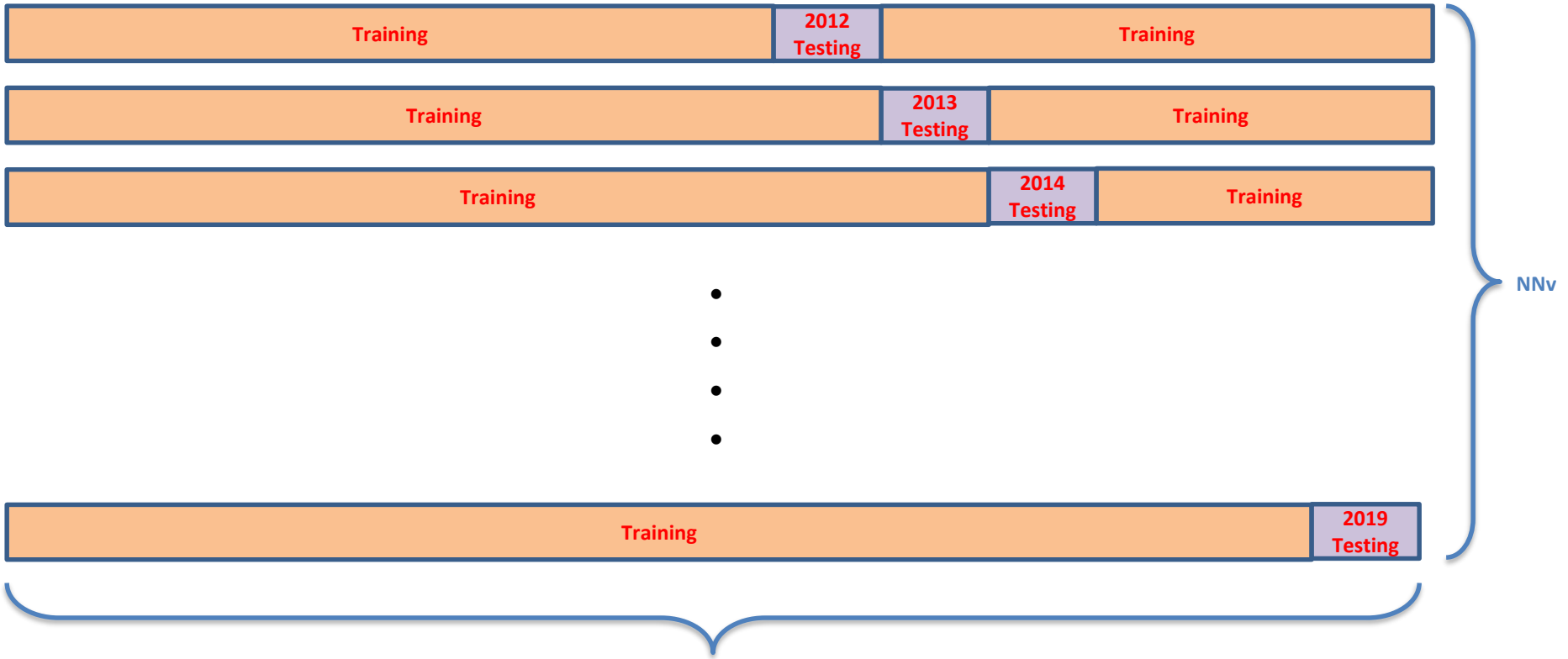
Mapping: $O = M(F)$

Traditional method: MLR -- MOS

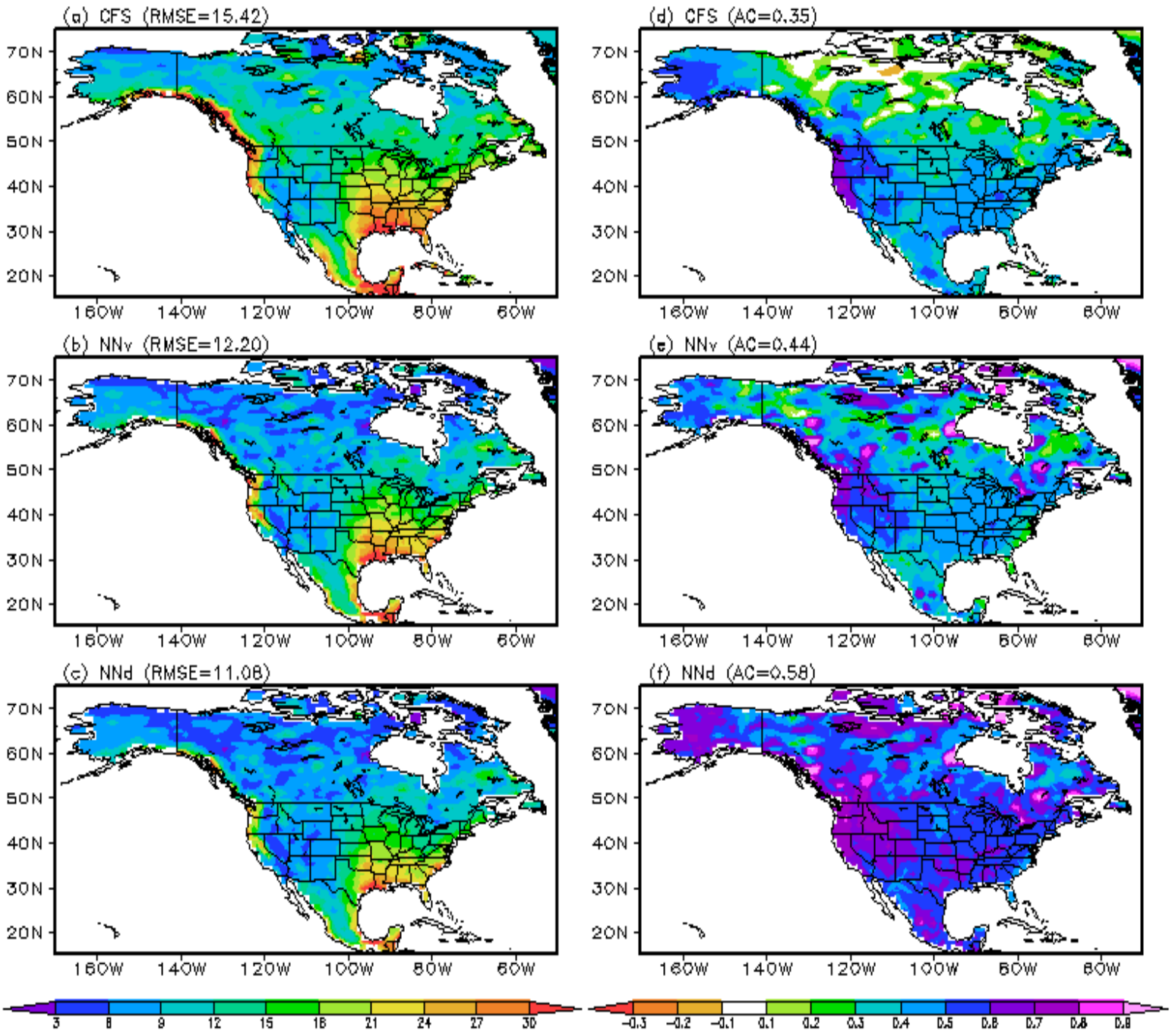
Can AI or Machine Learning beat BC CFS?


Big Data!!!
Output Layer
Input Layer
X_1
X_i
X_n
t_1
t_j
t_k
Y_1
Y_q
Y_m
Predictors
Predictands
Hidden Layer
$E = \frac{1}{N}\sum_{i=1}^{N}[Z_i - NN(X_i)]^2$
Non-linear impact
Pattern relationship
Co-variability

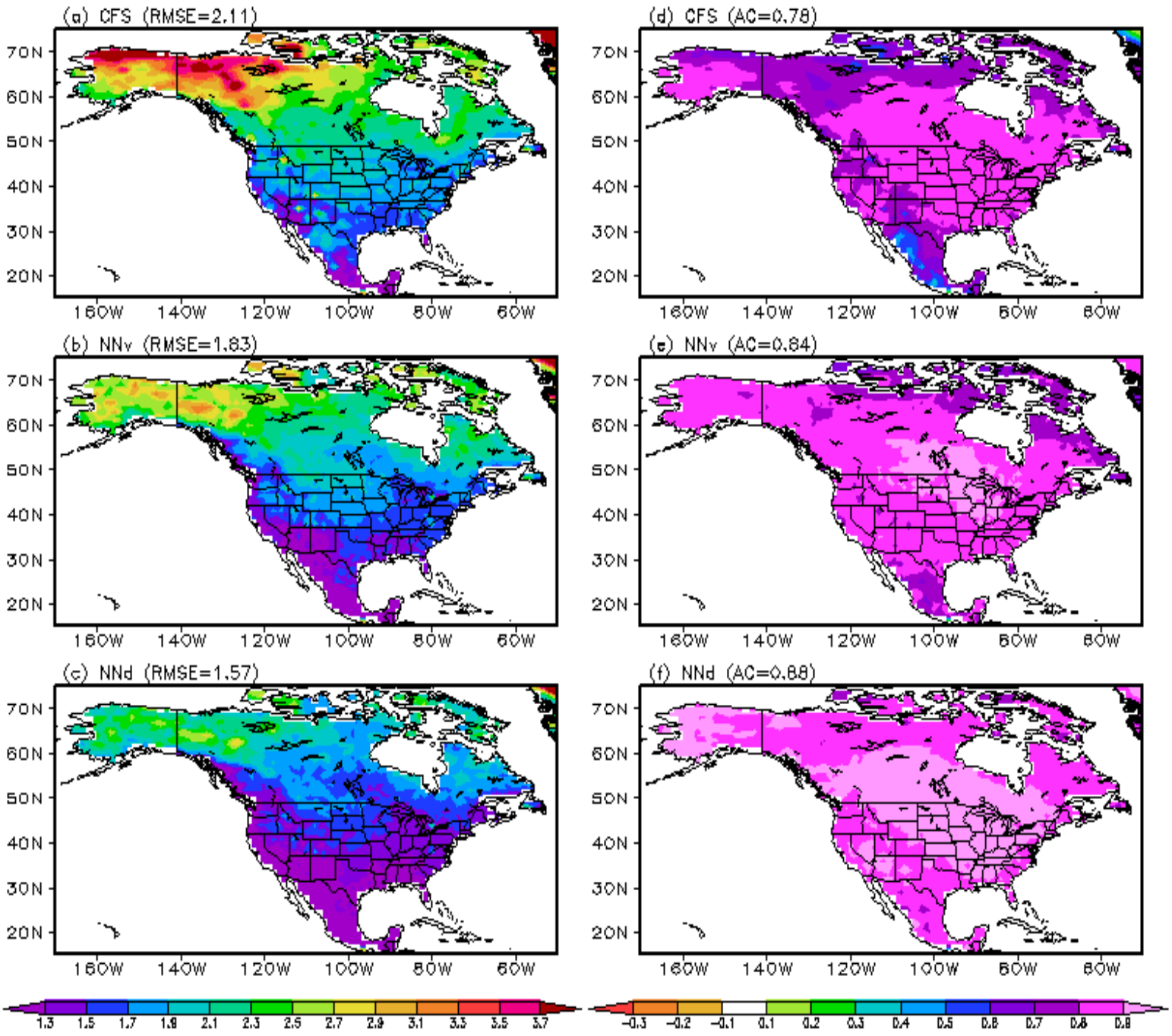
8 Years Cross-Validation



1999 – 2019 daily Week 1-6 forecasts = 6 x 7670 daily samples over North America



CFS: Bias corrected
NNv: Yearly Cross-Validation
NNd: Dependent Fcst



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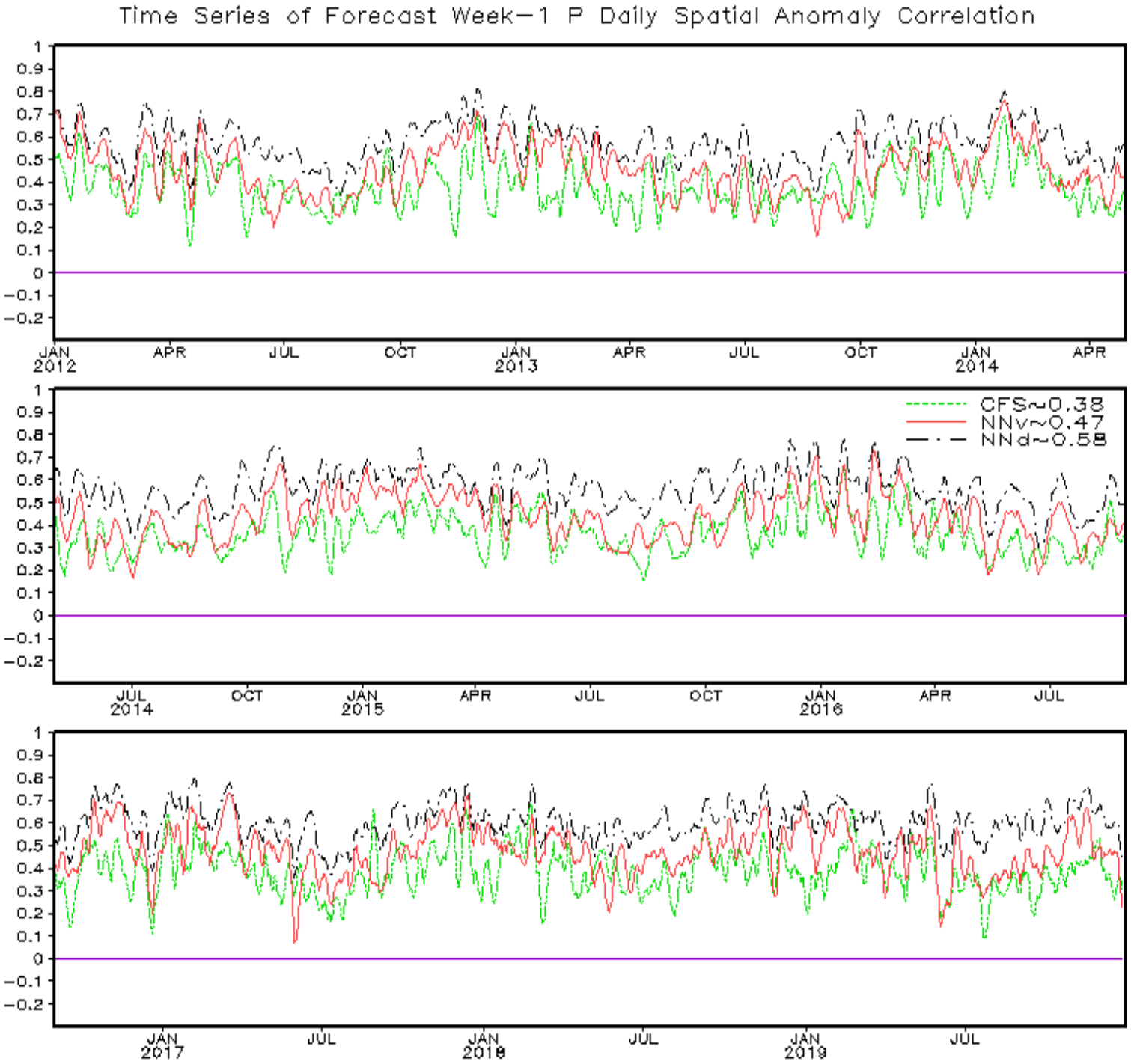

North American Domain

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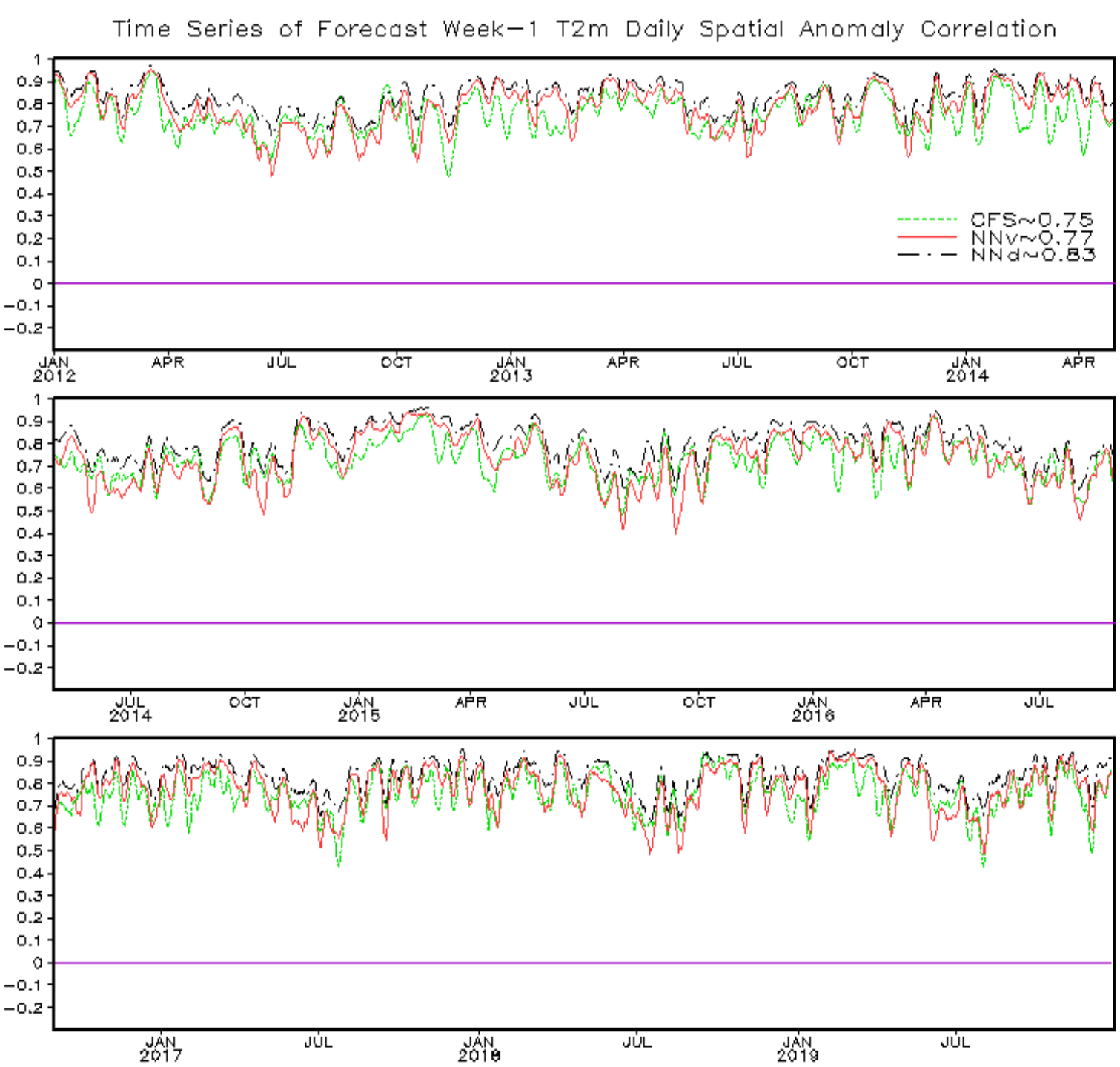

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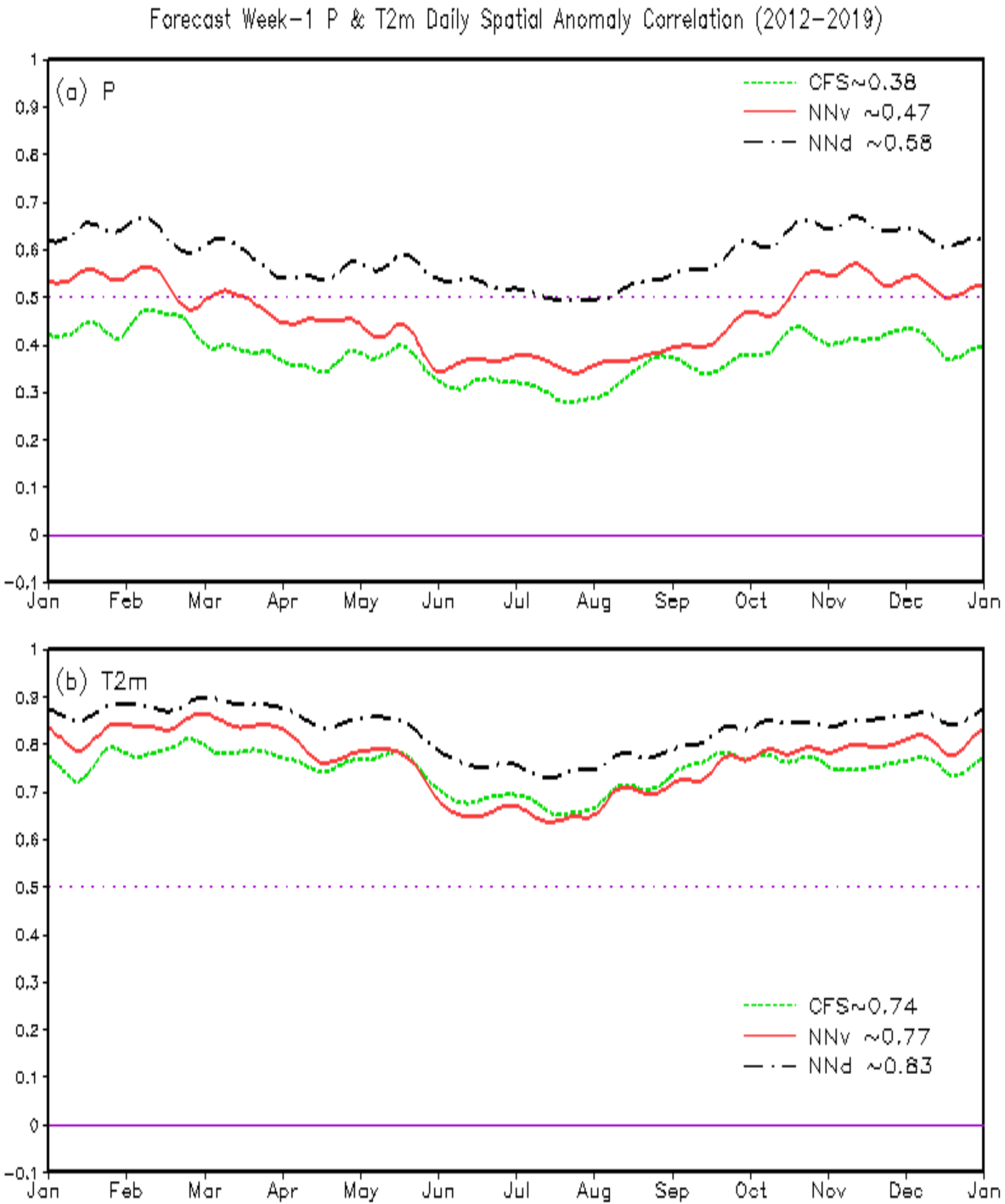

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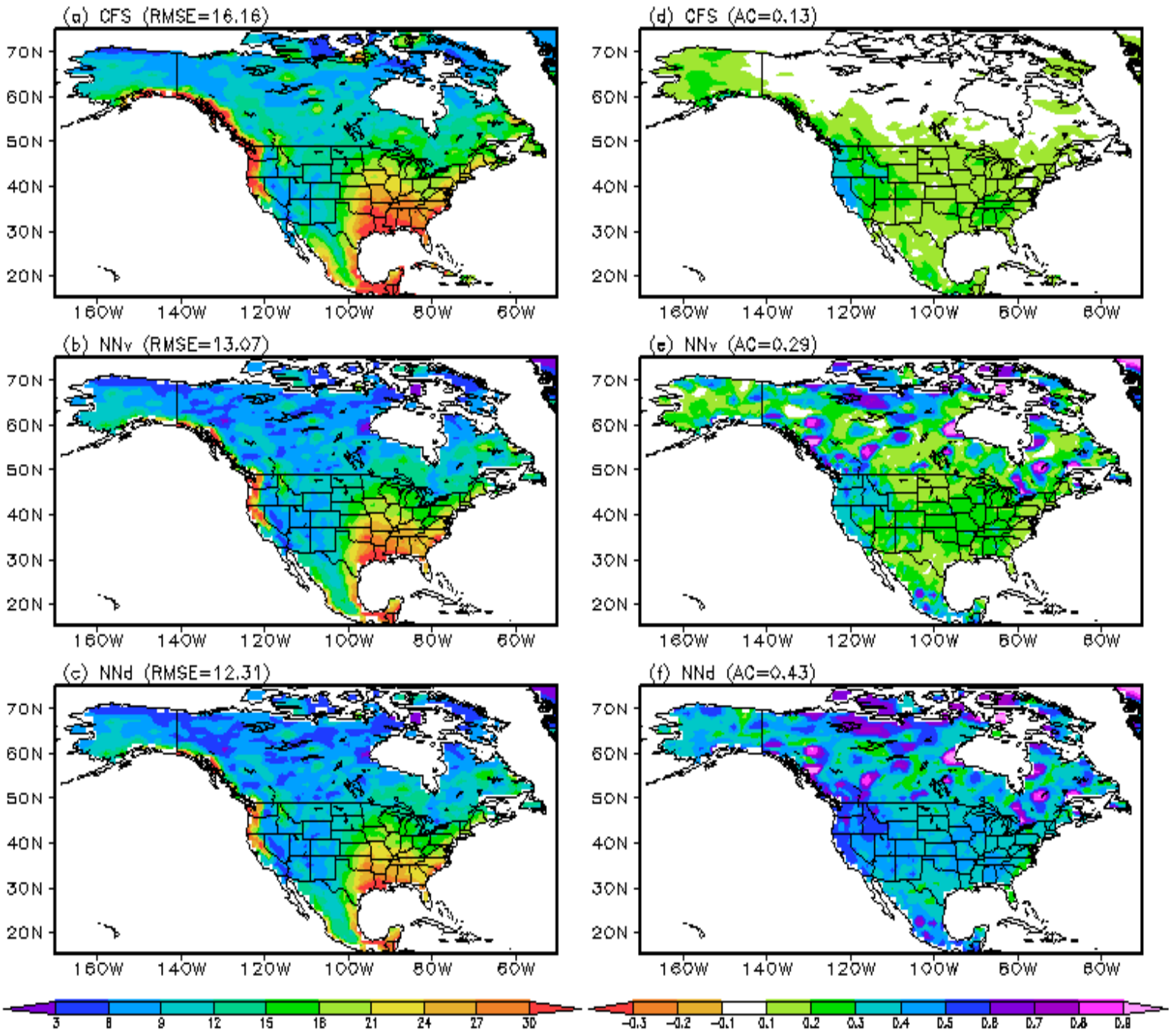

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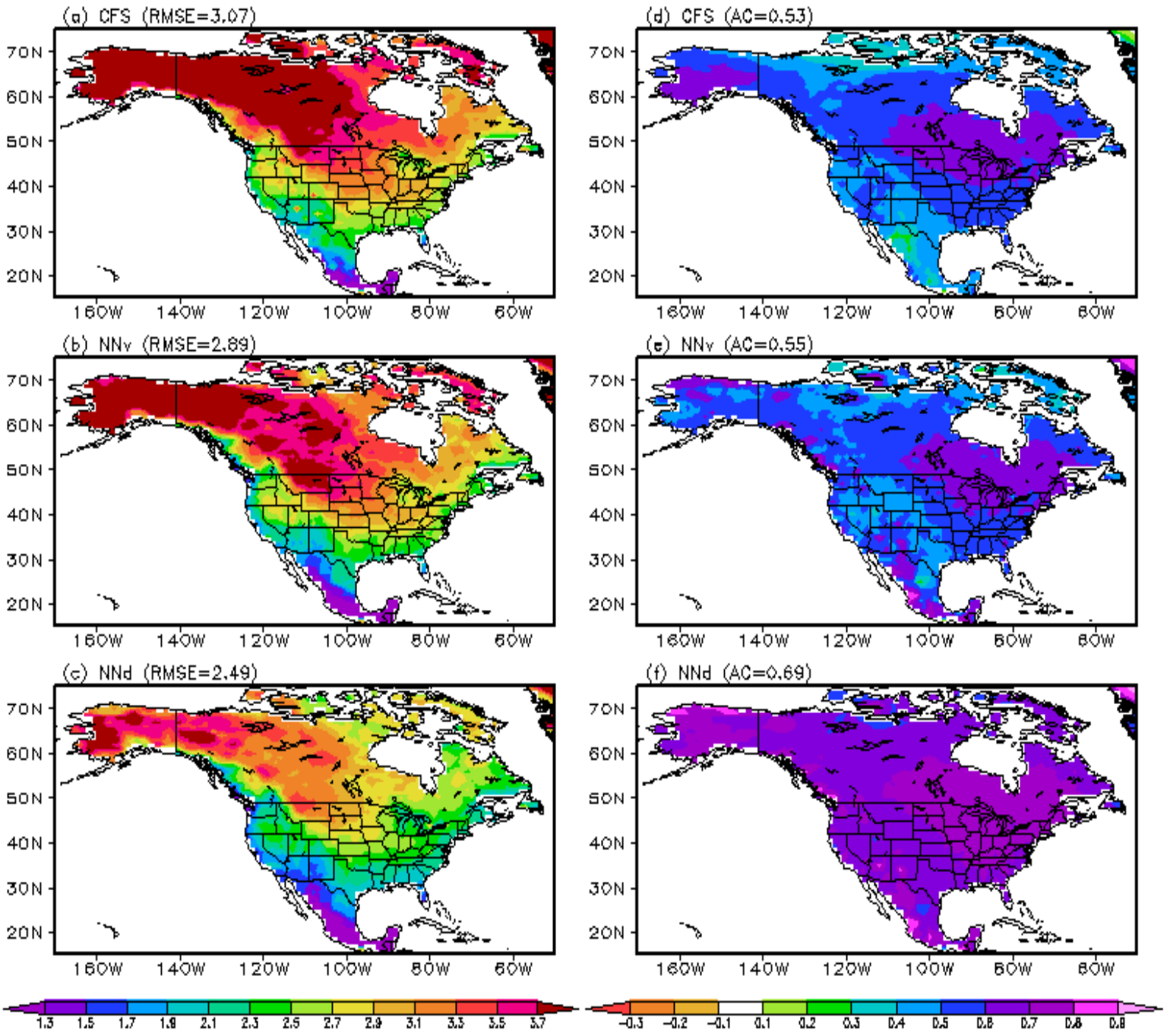

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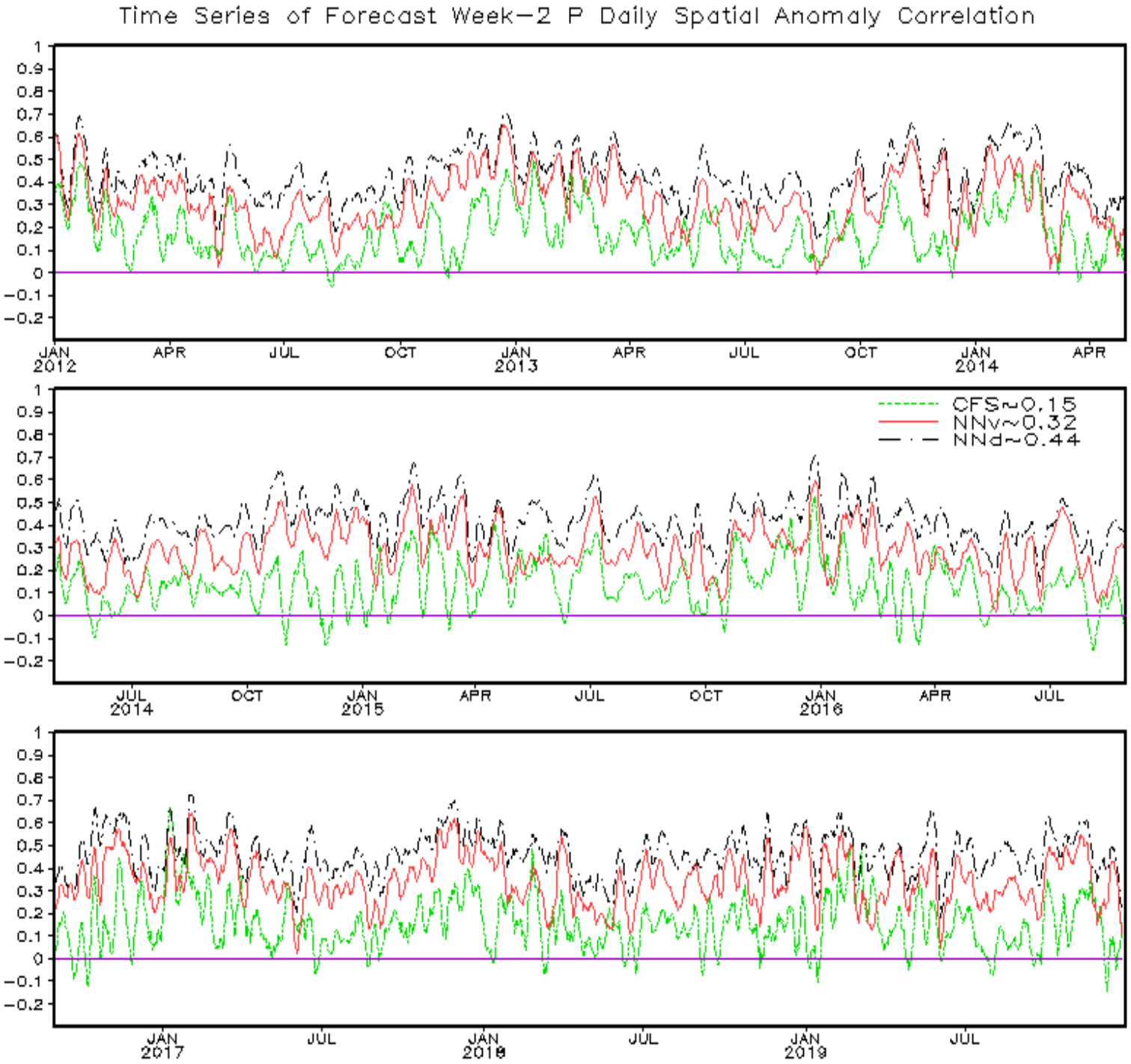

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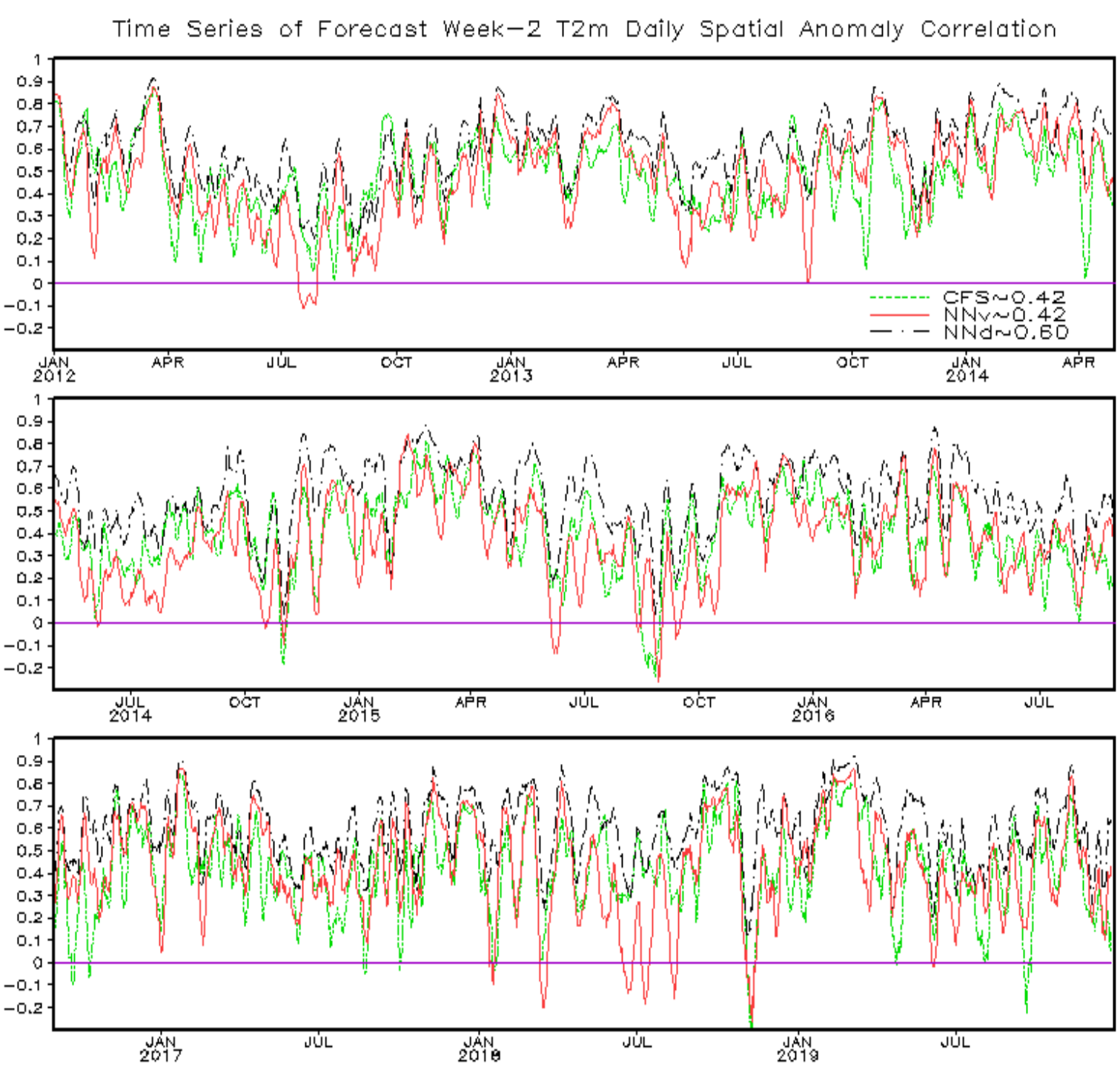

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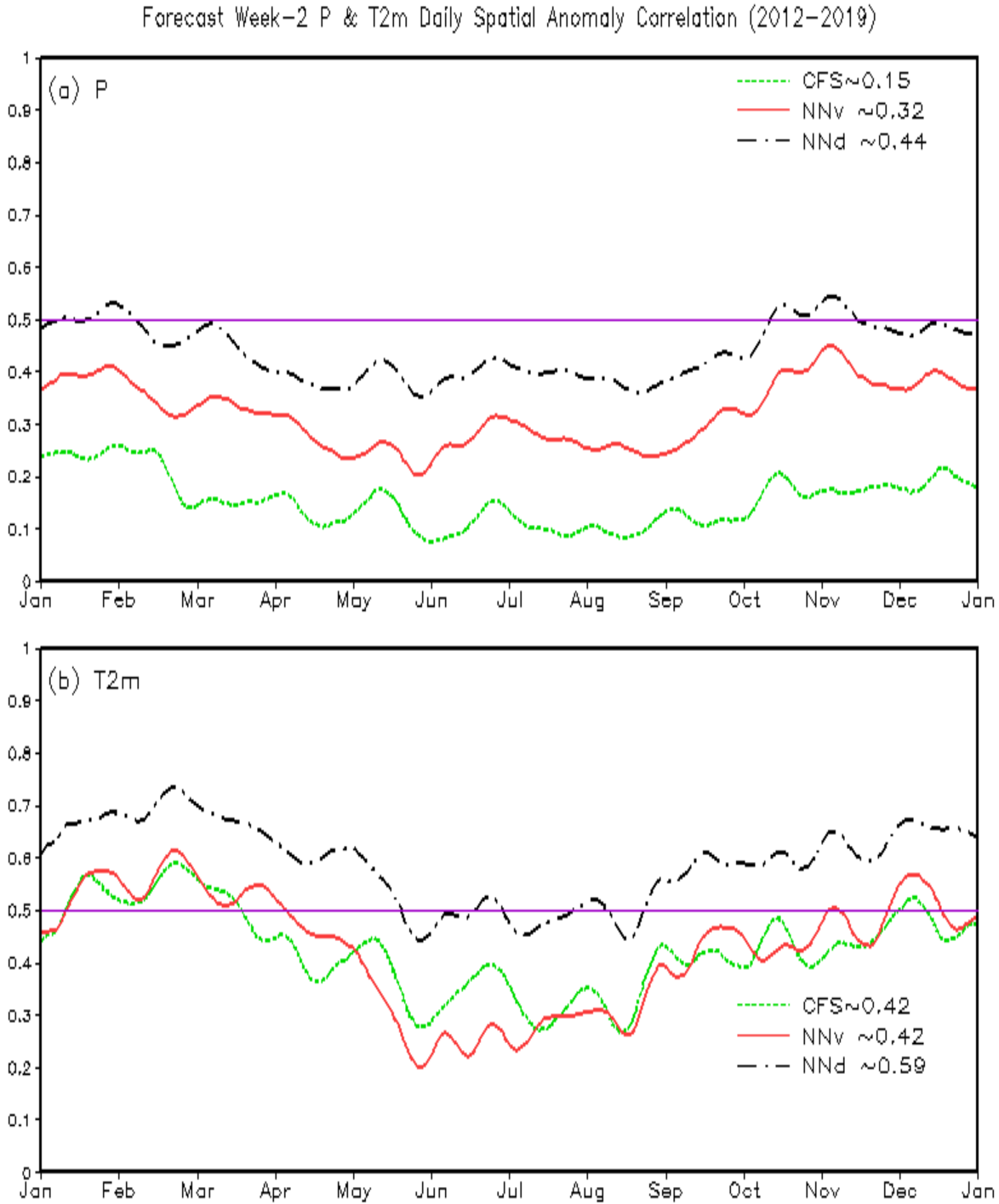

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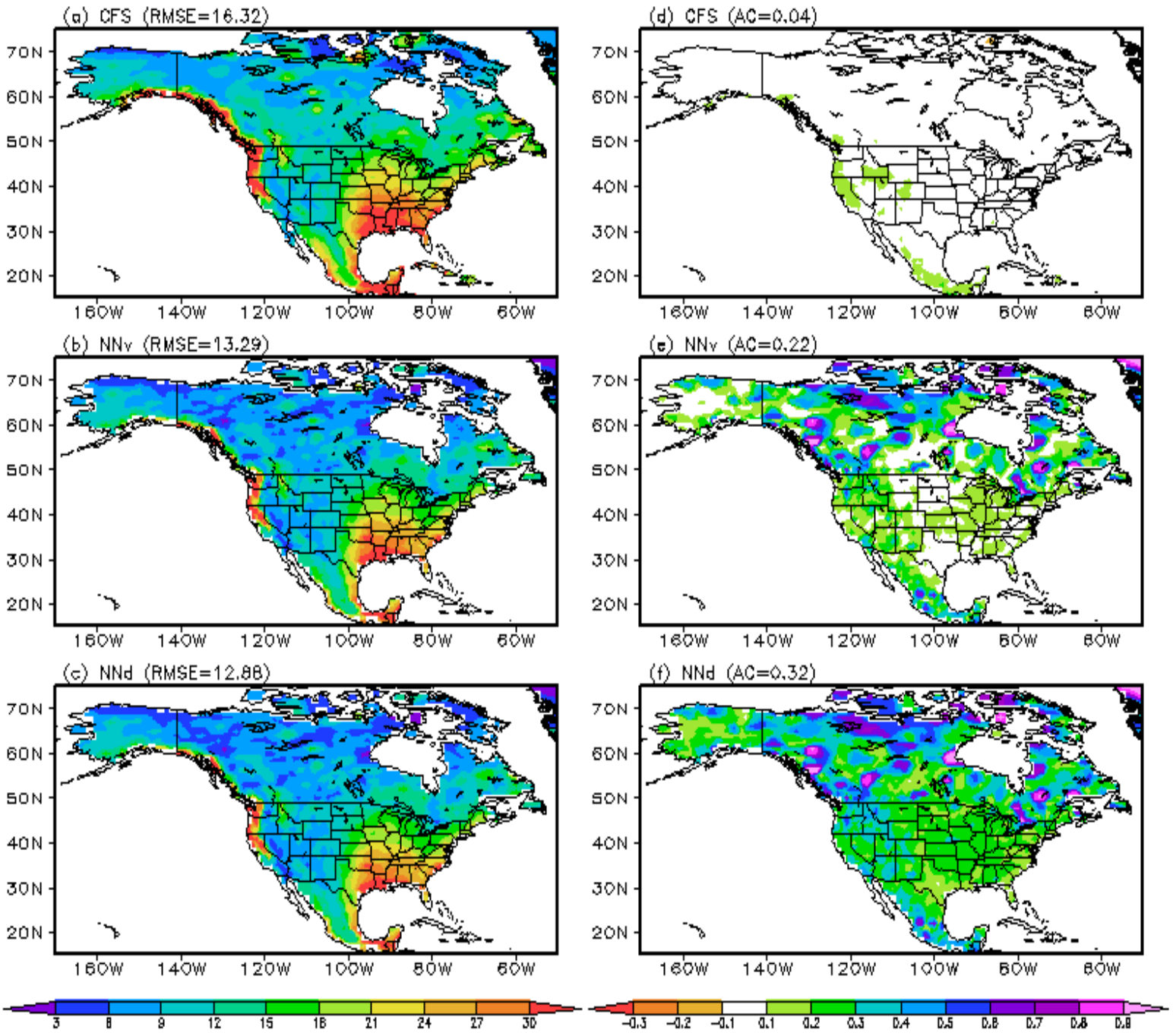

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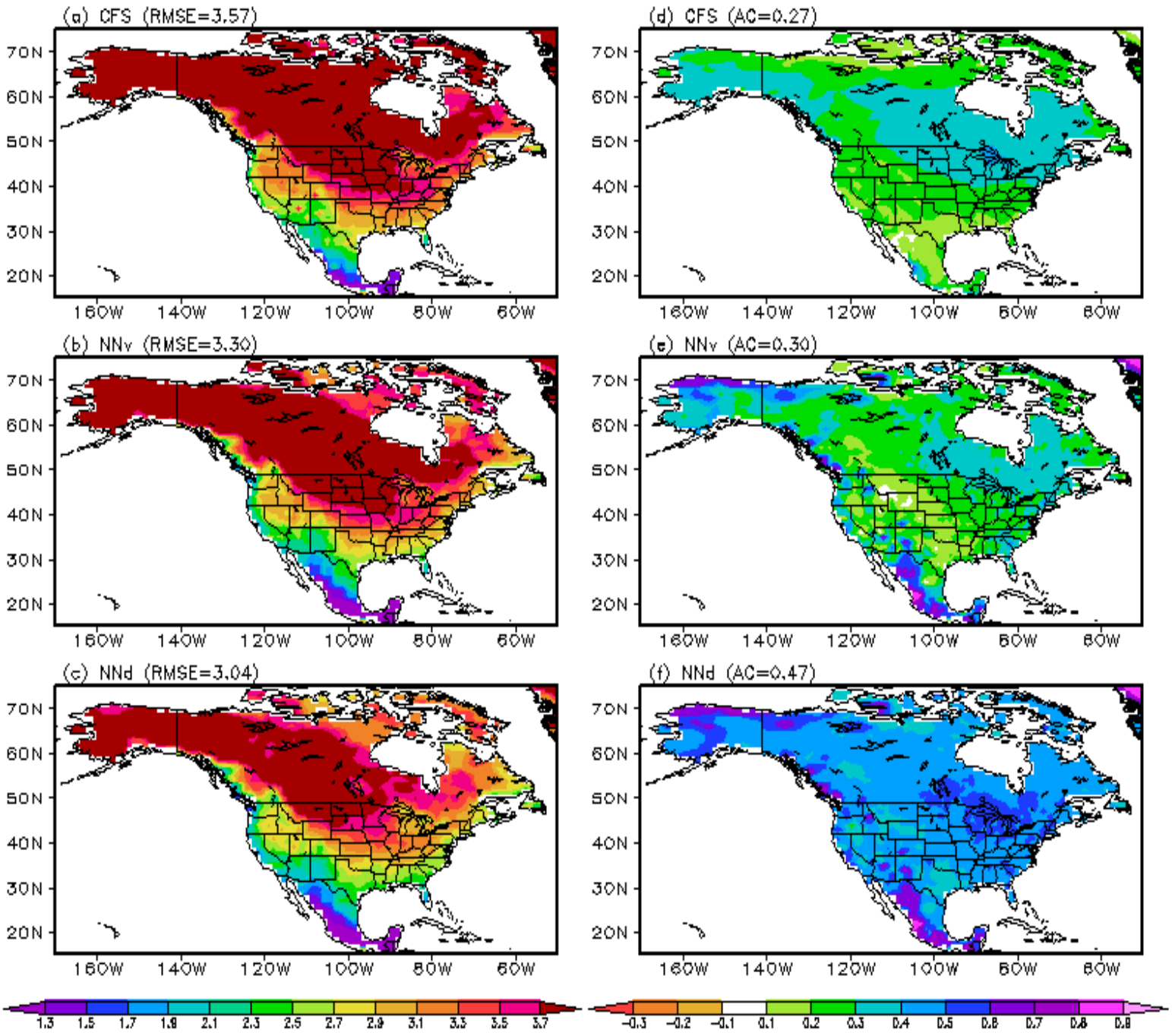

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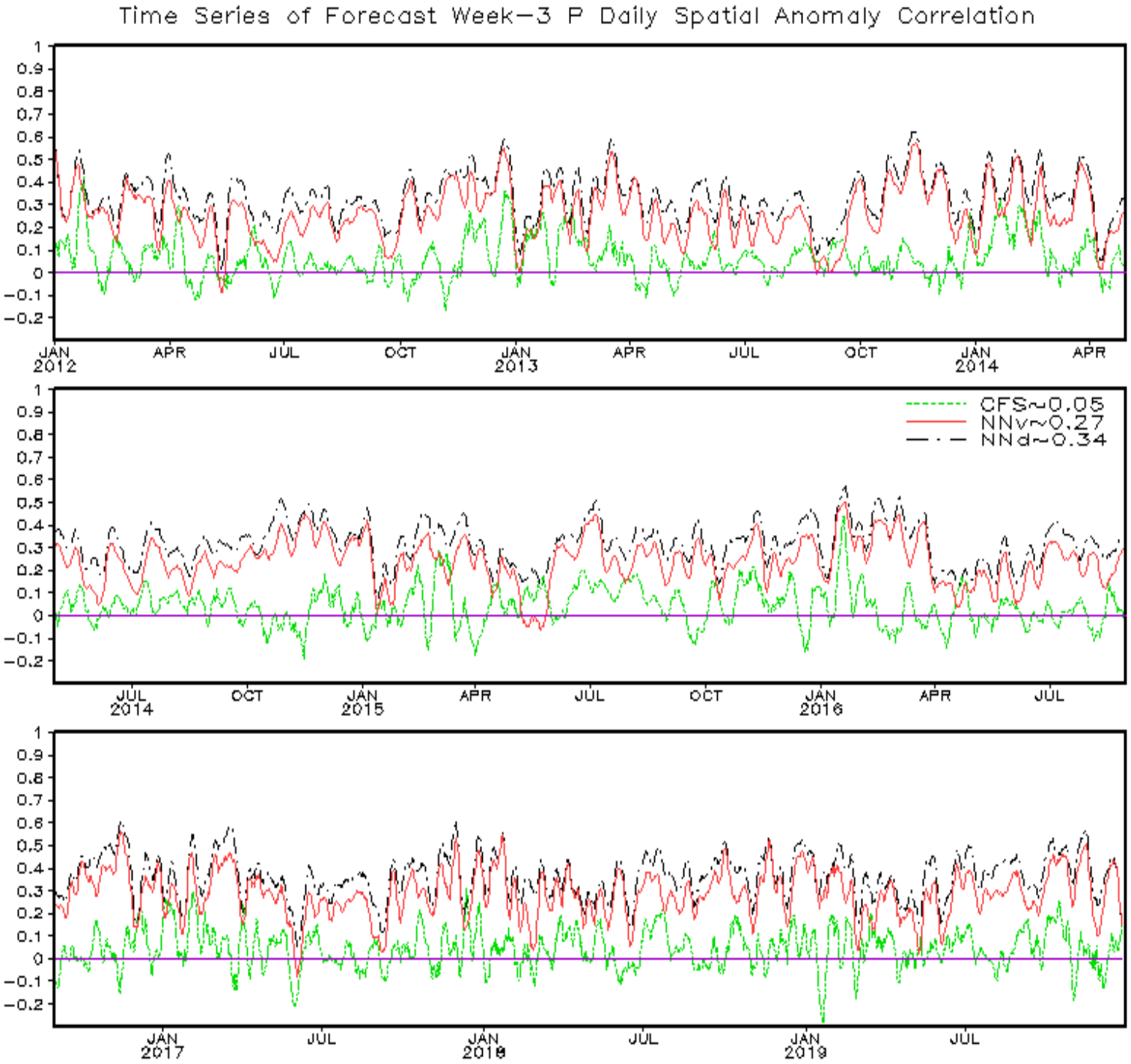

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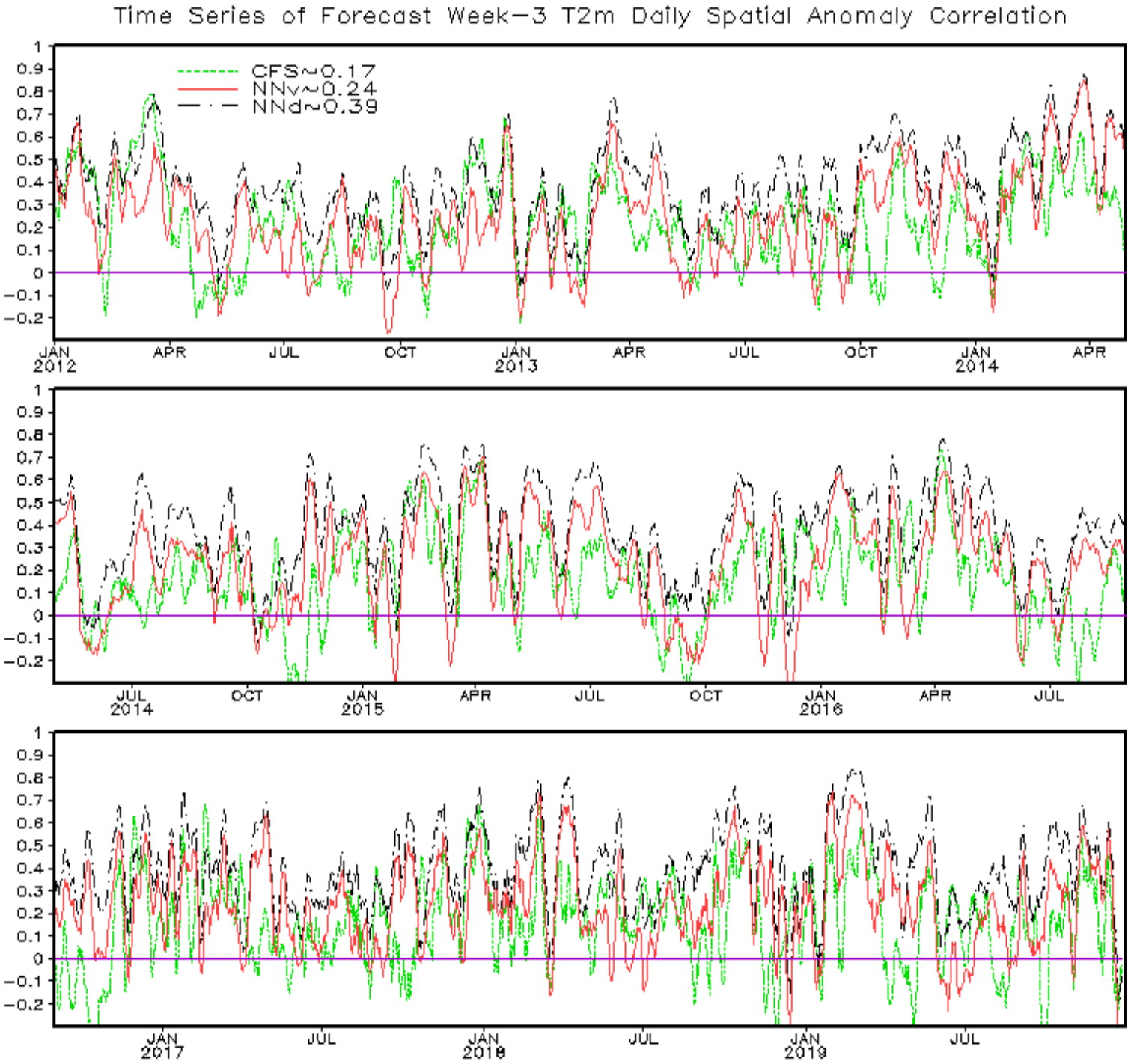

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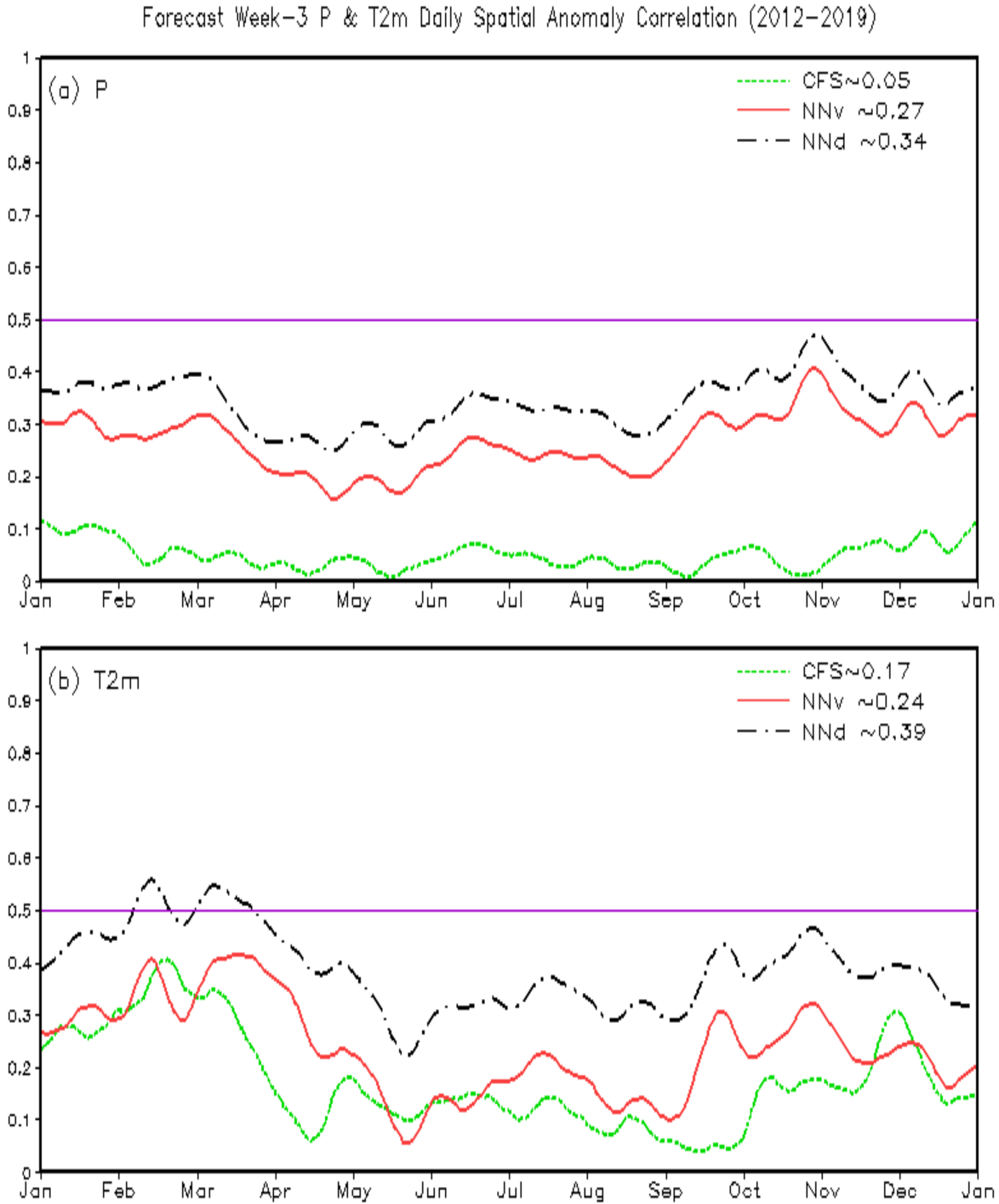

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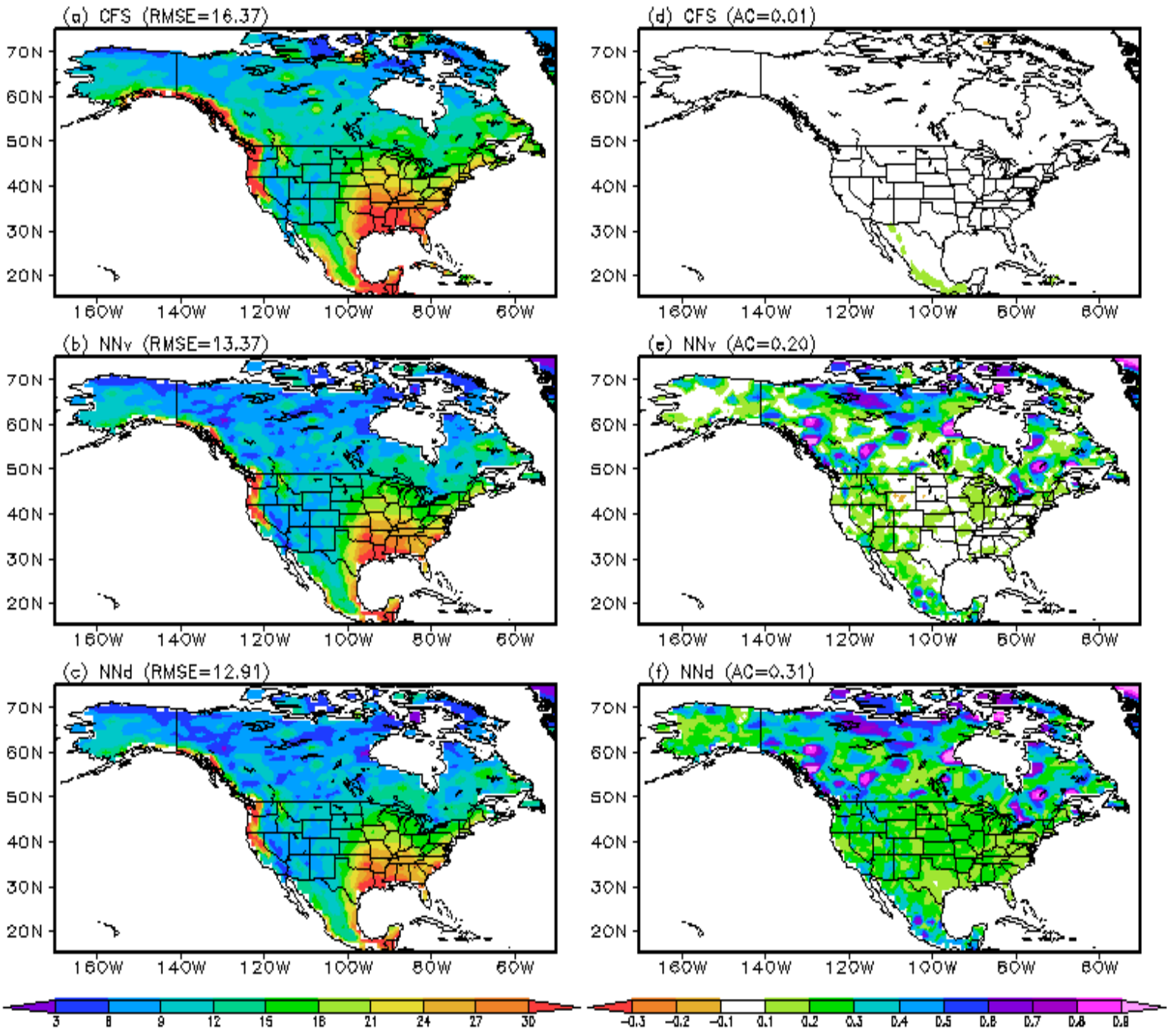

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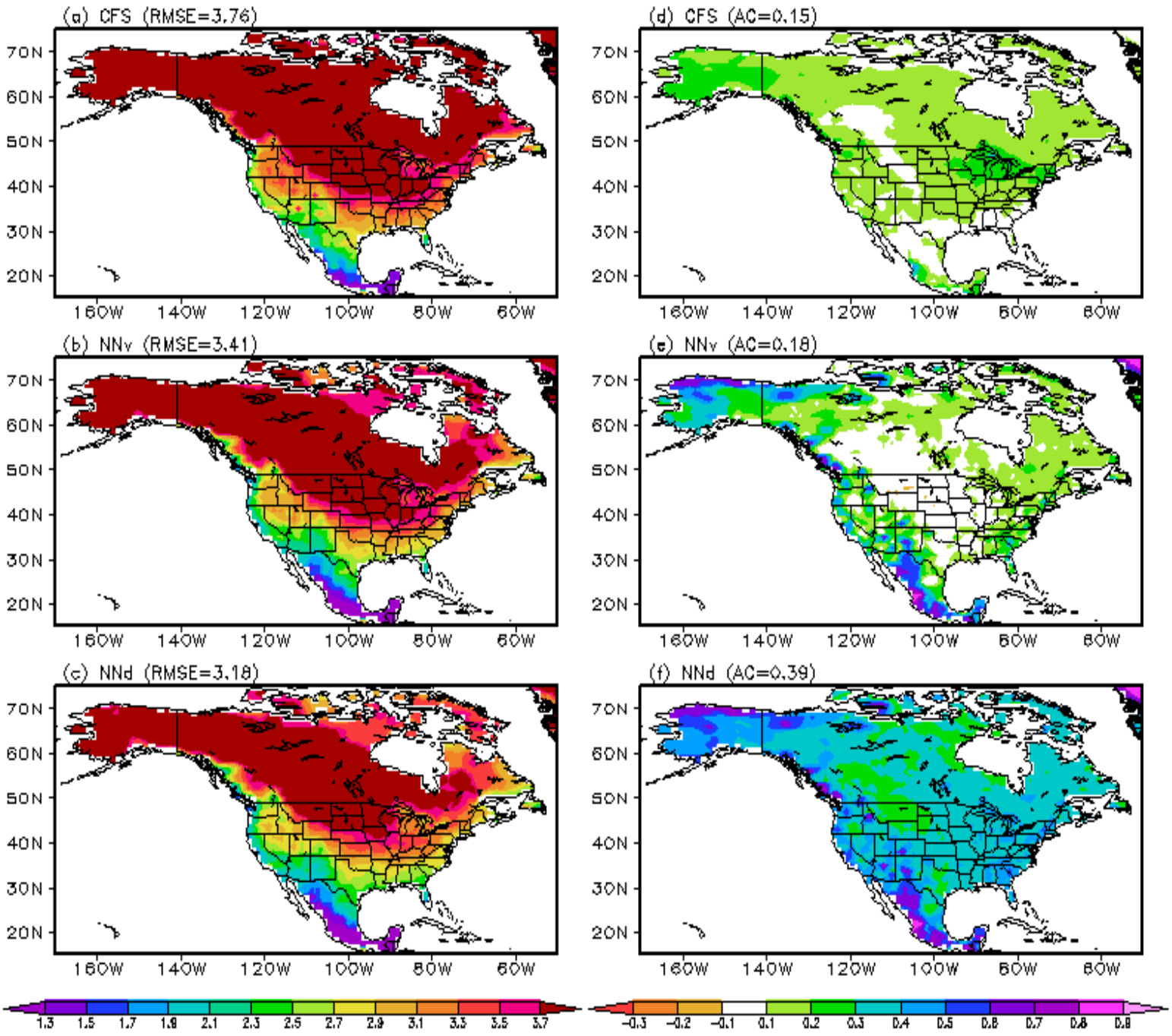

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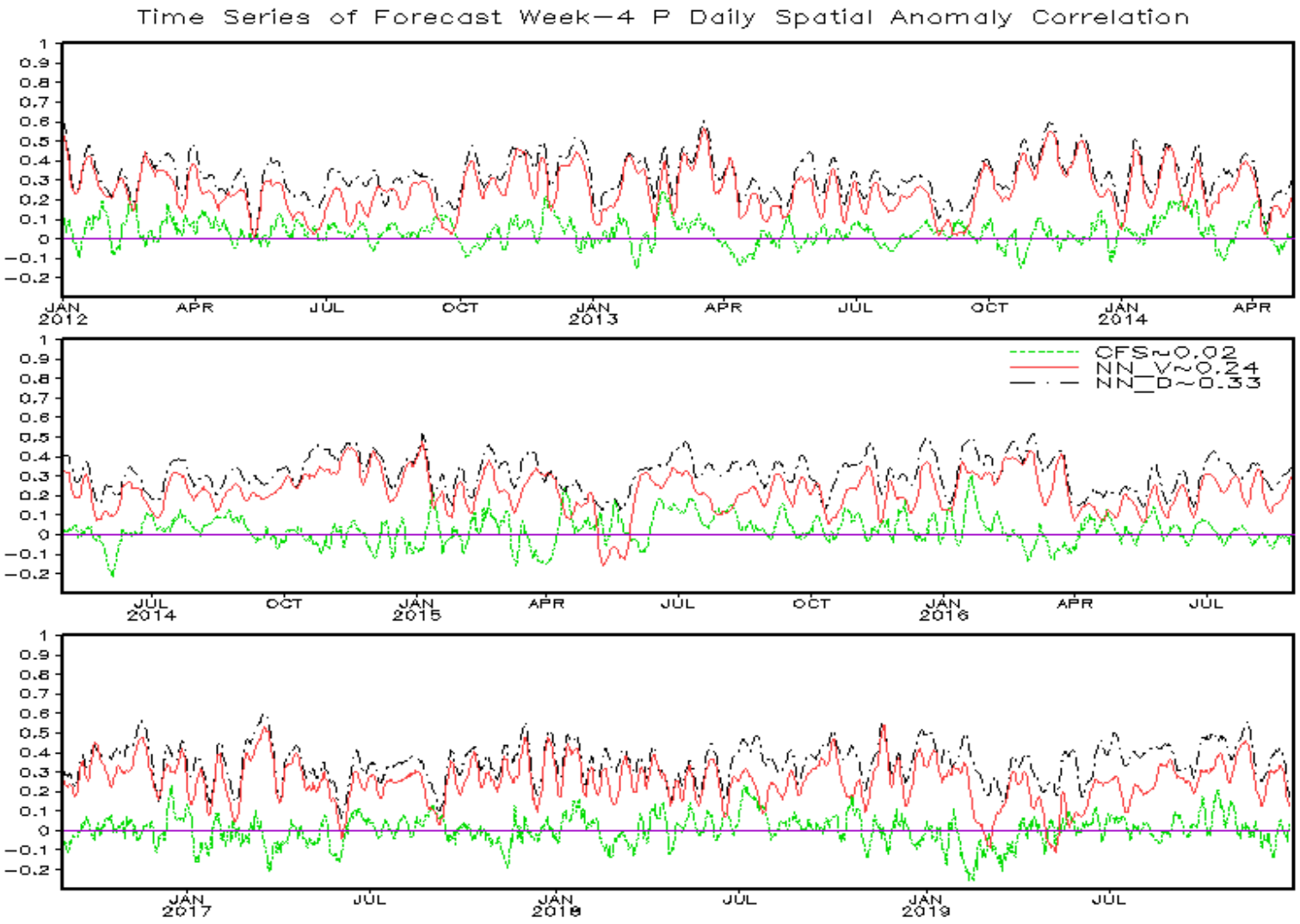

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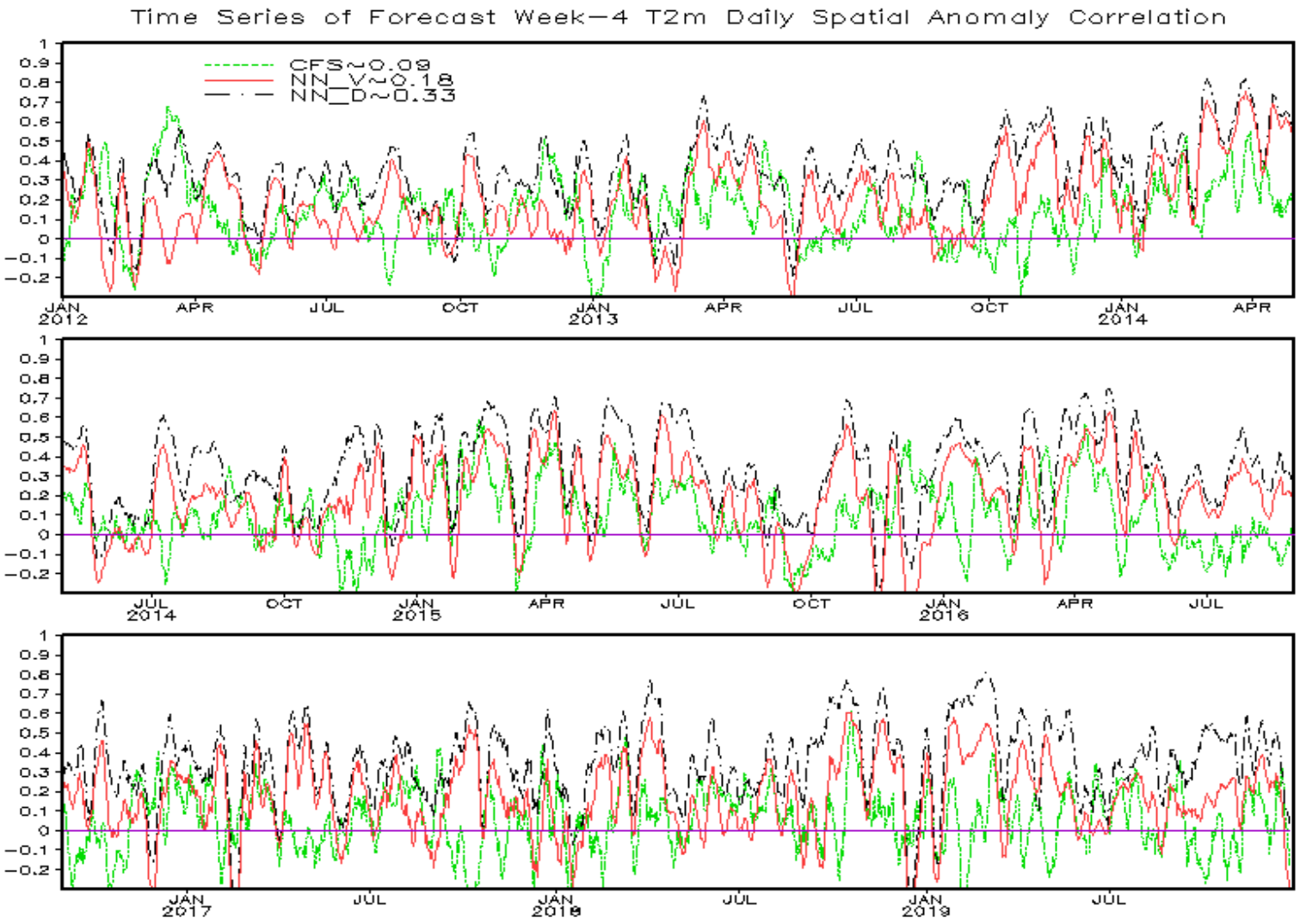

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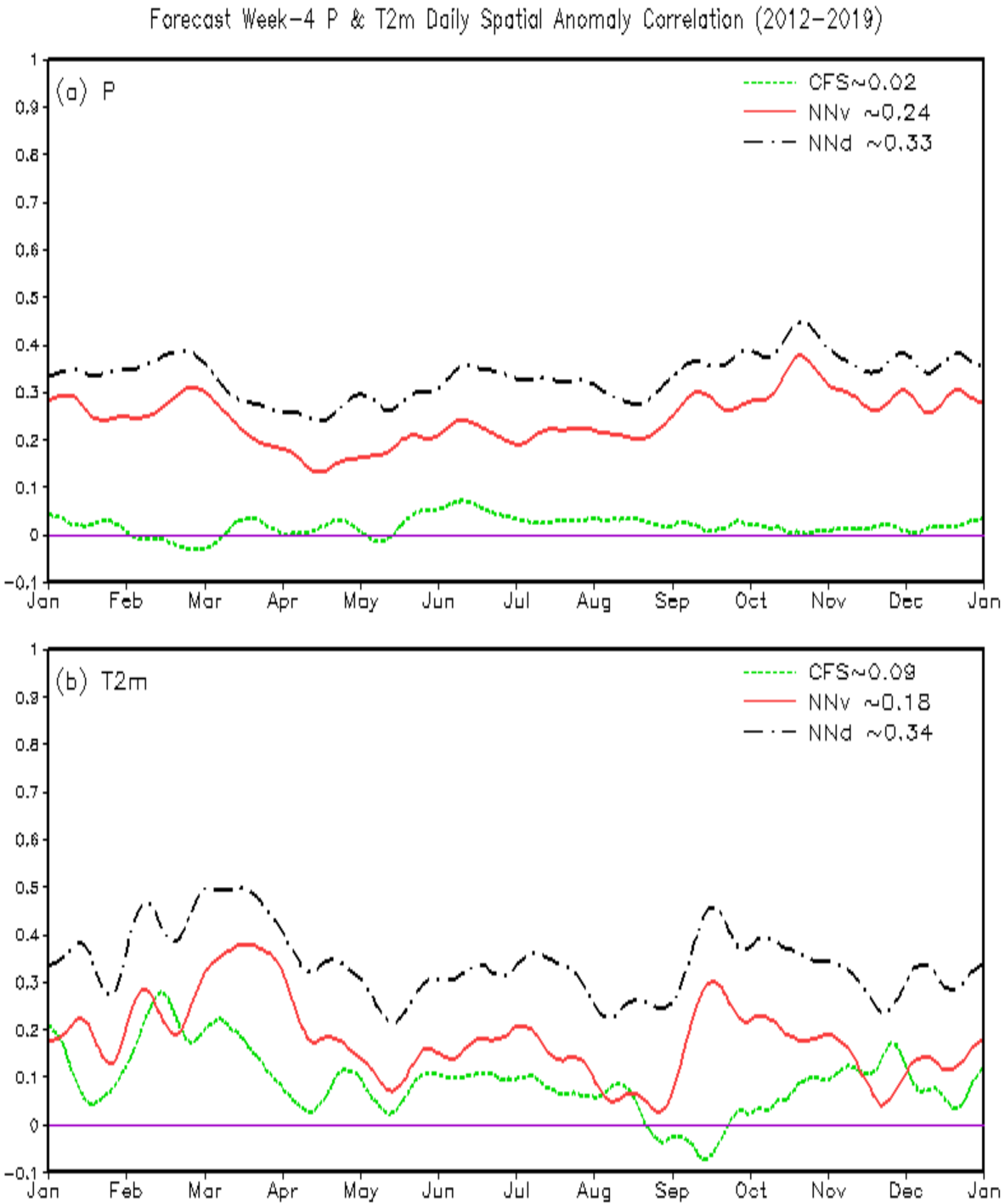

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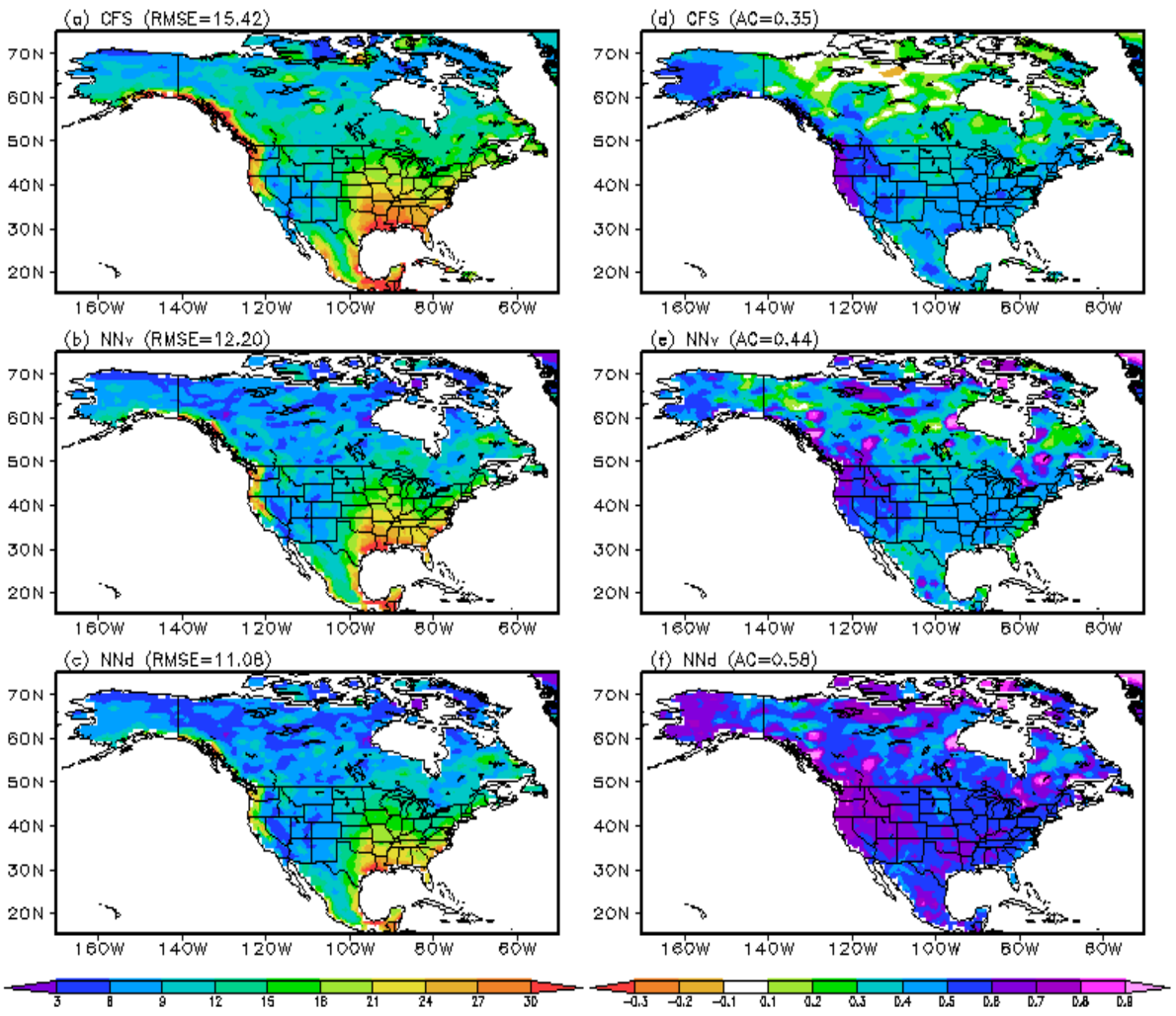

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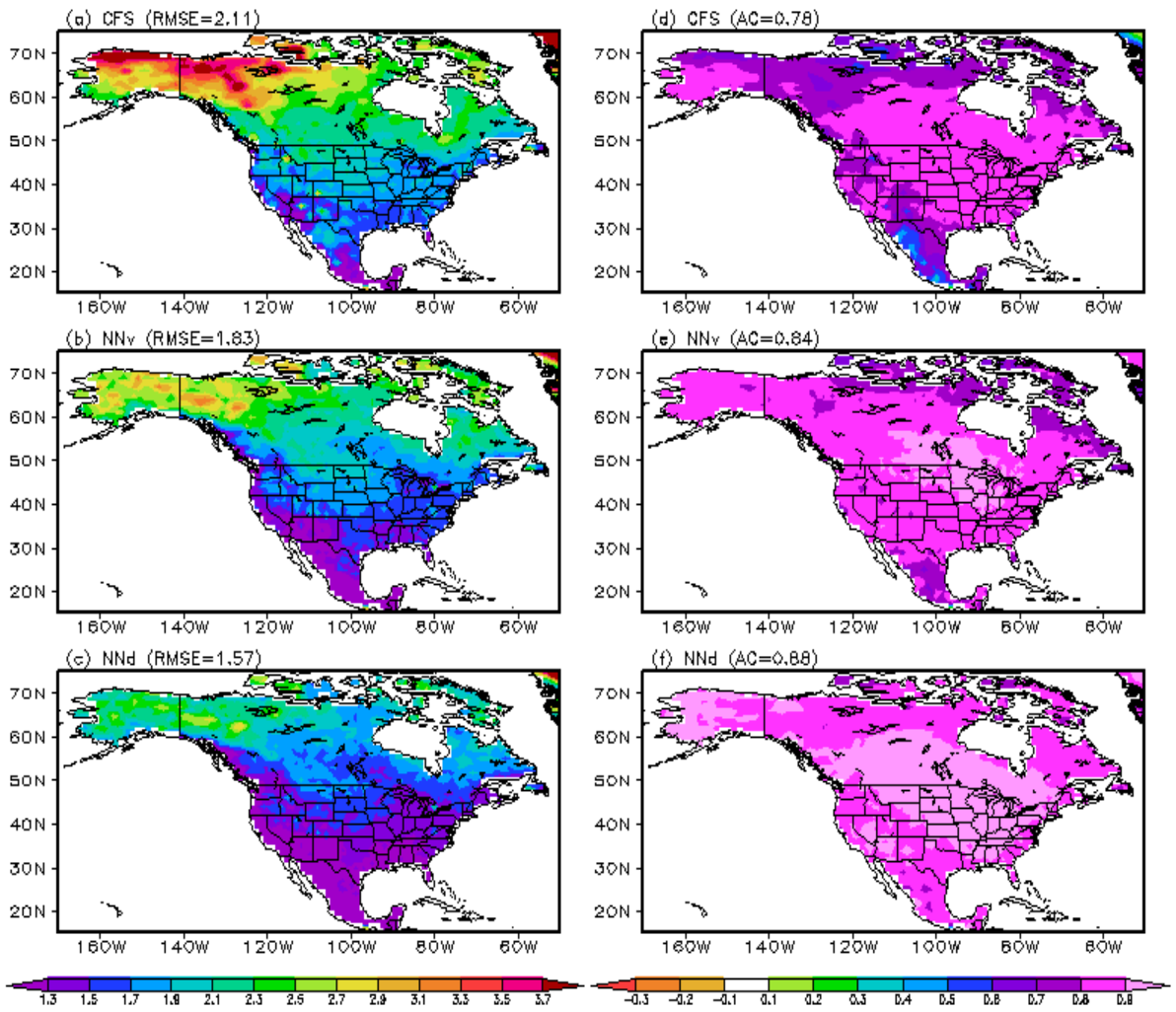

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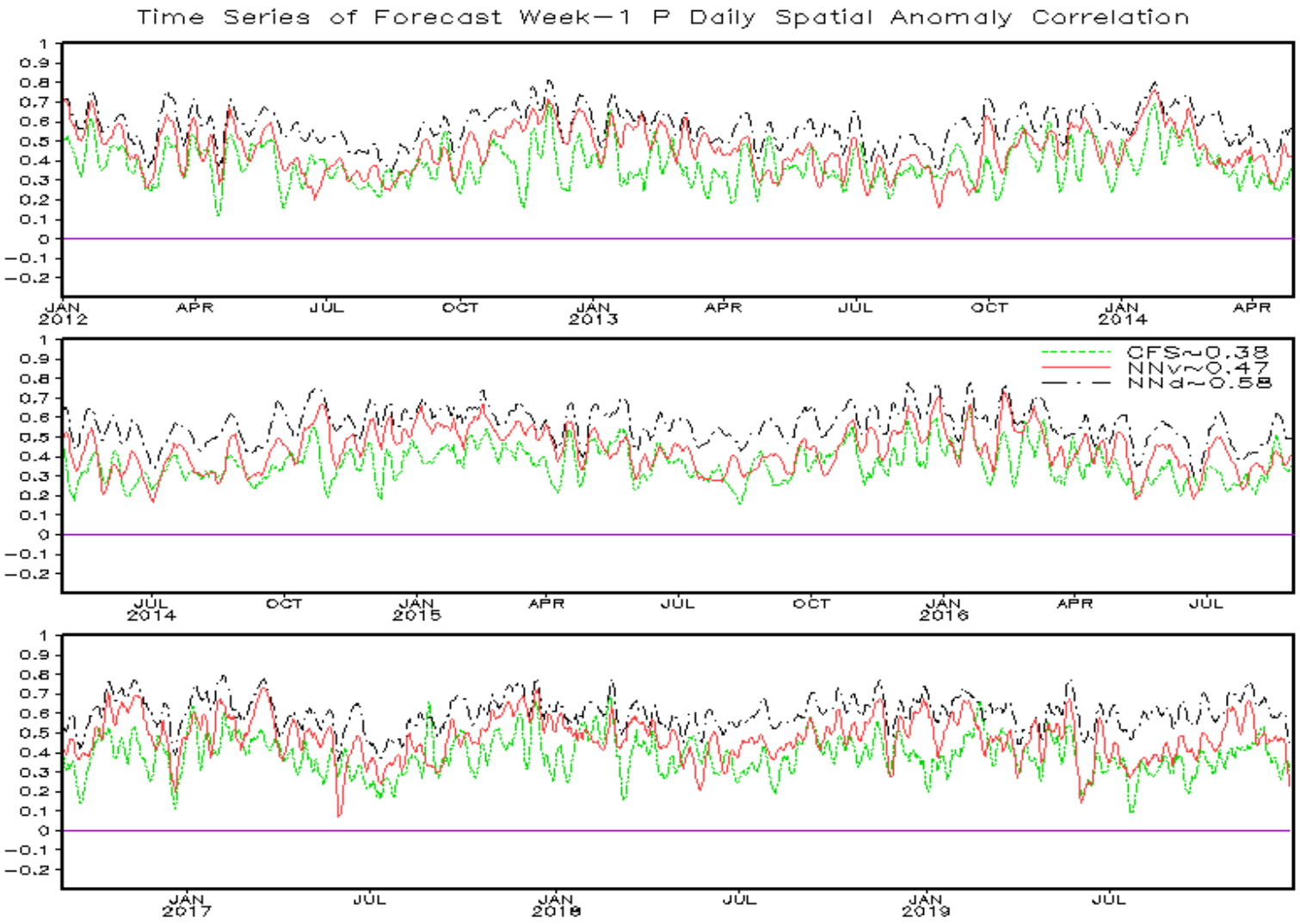

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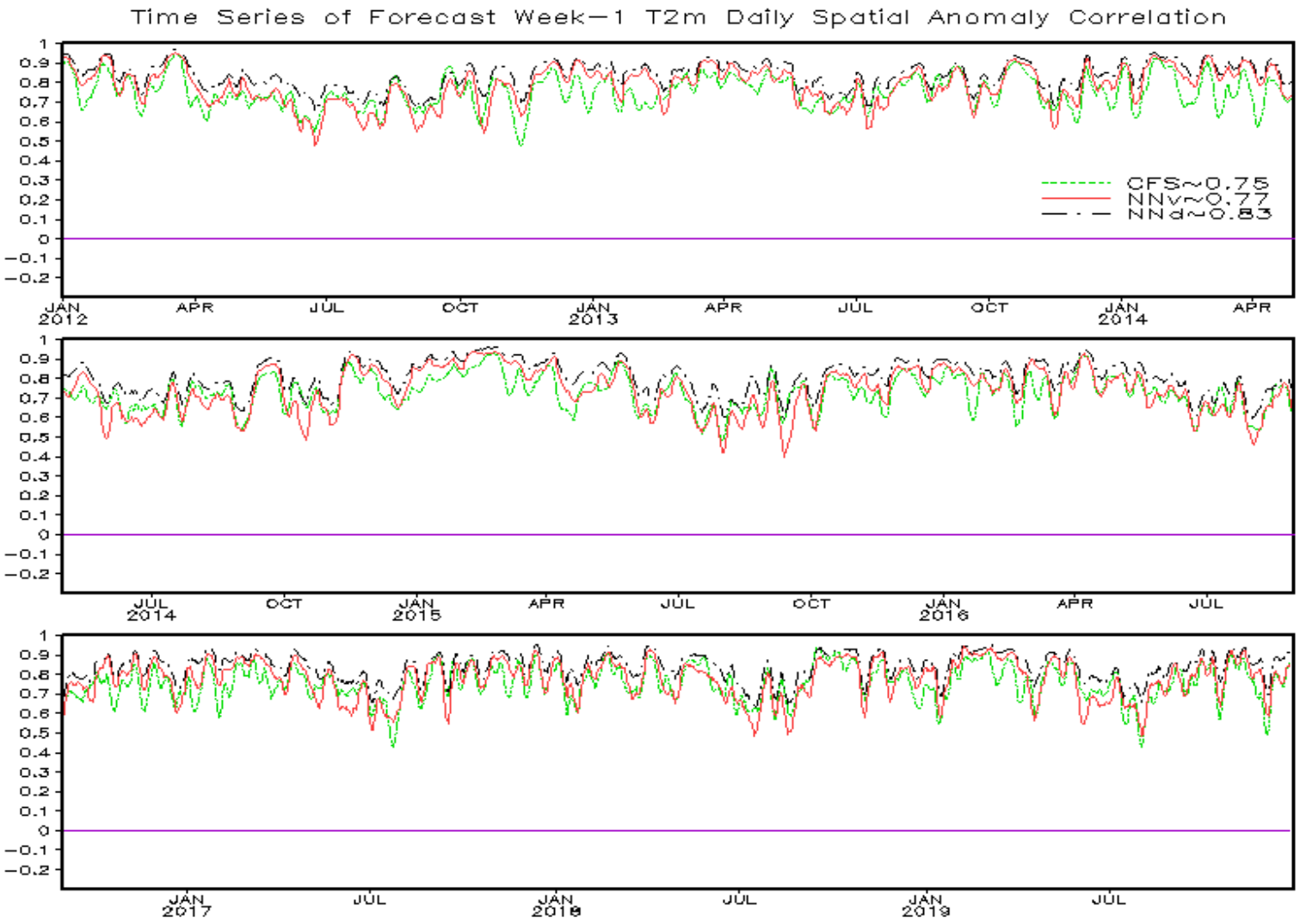

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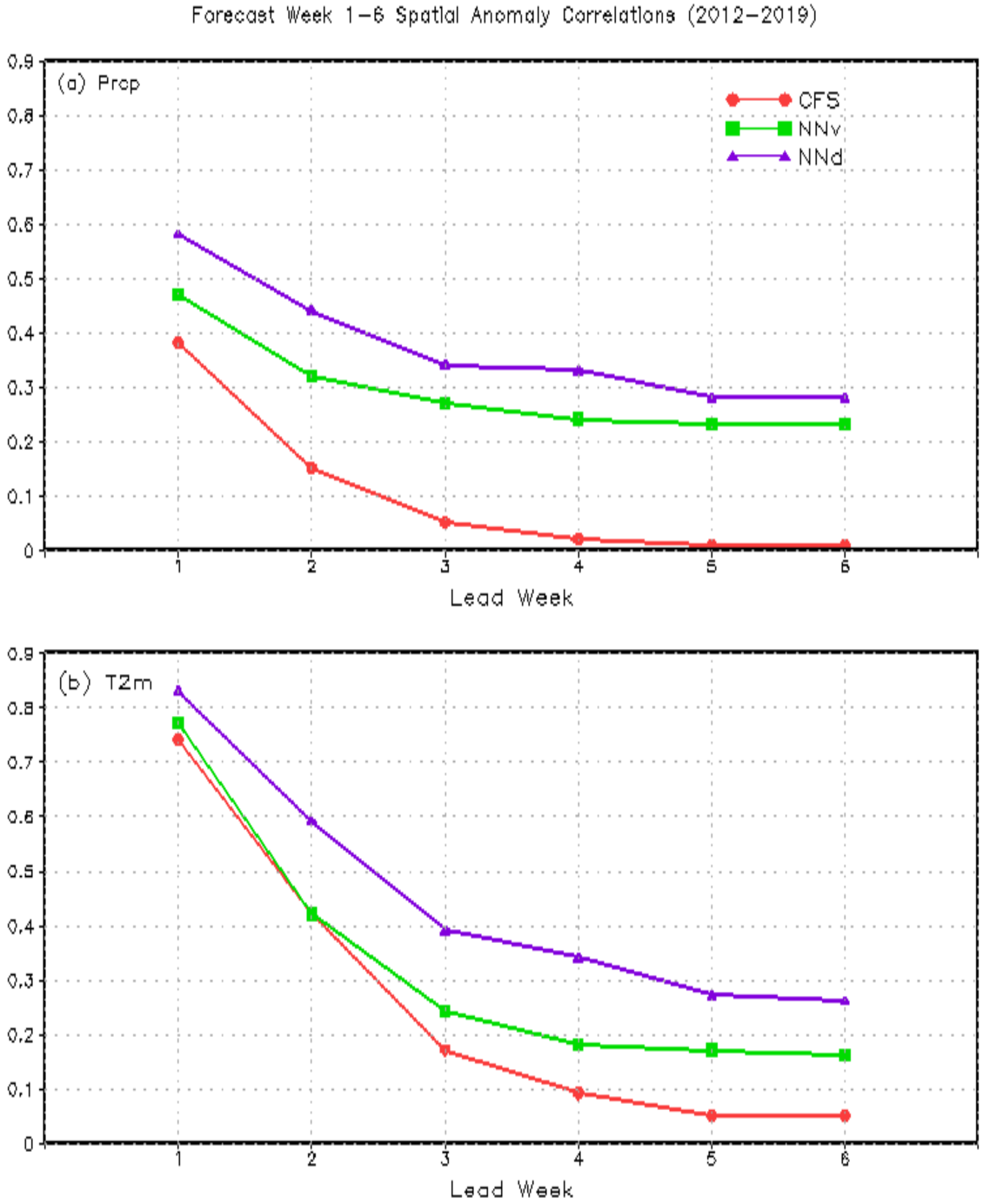

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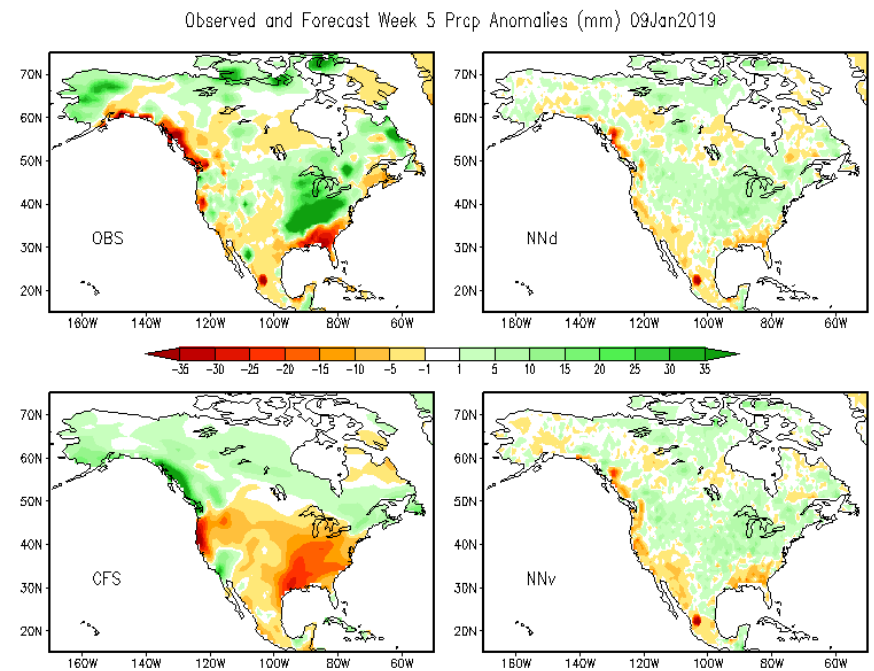
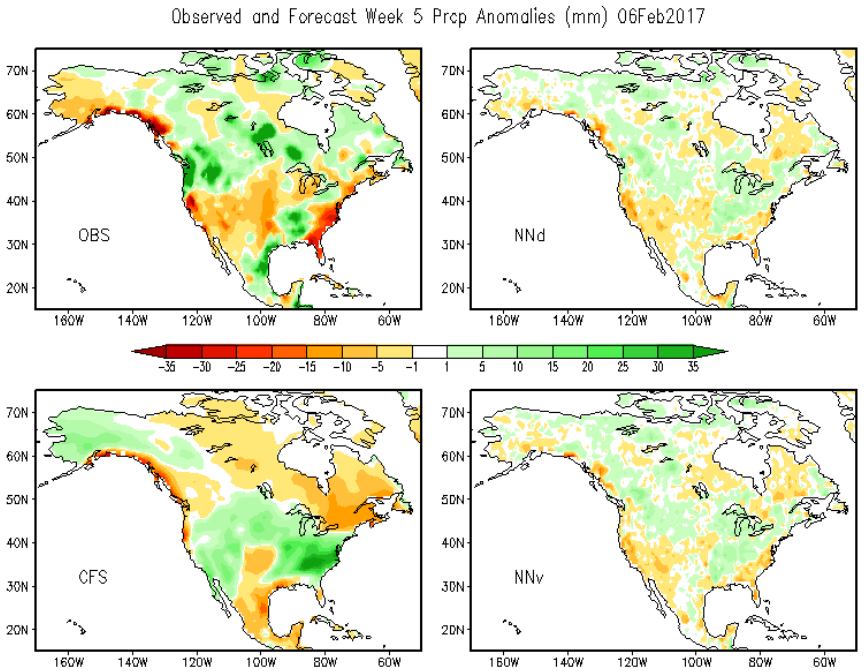
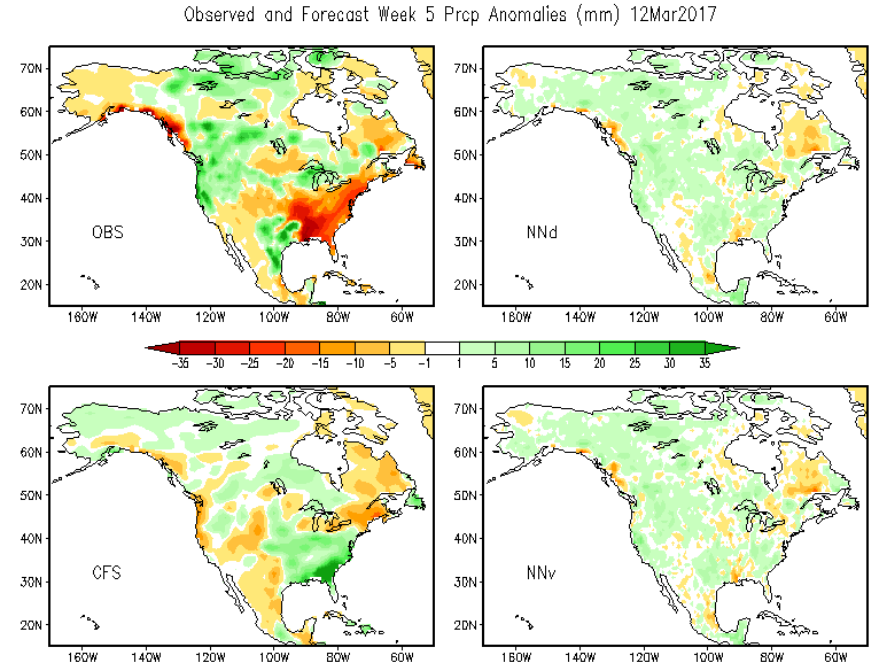
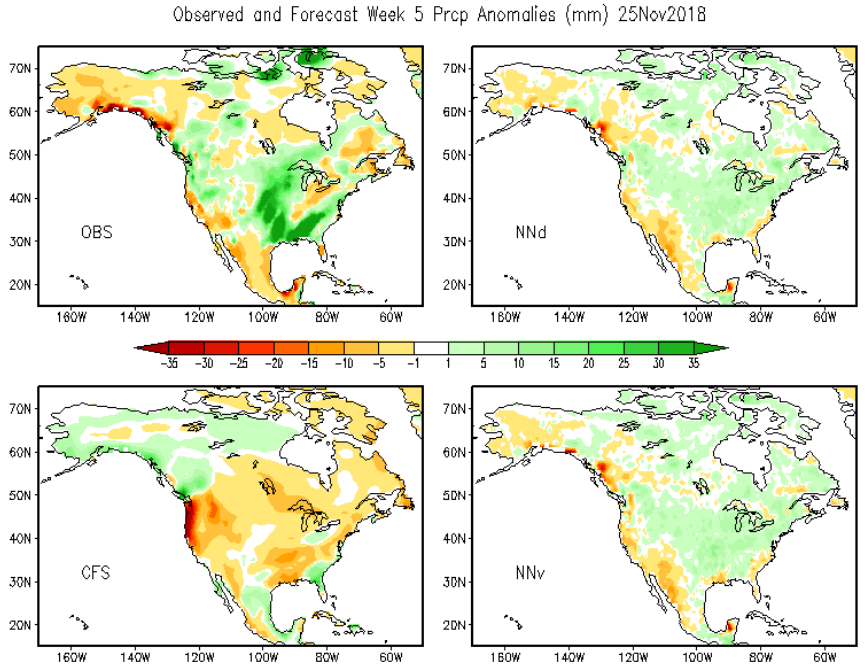
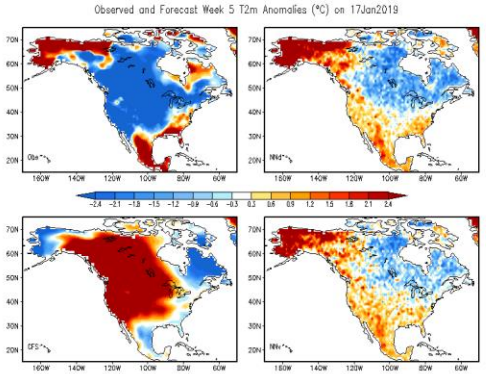


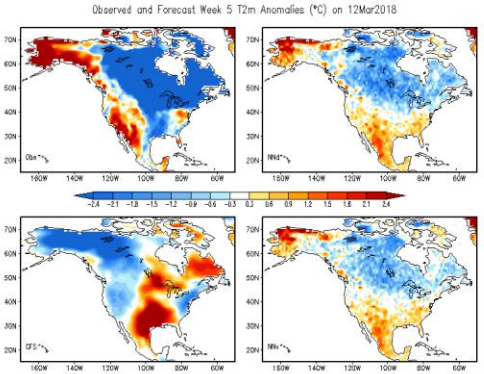


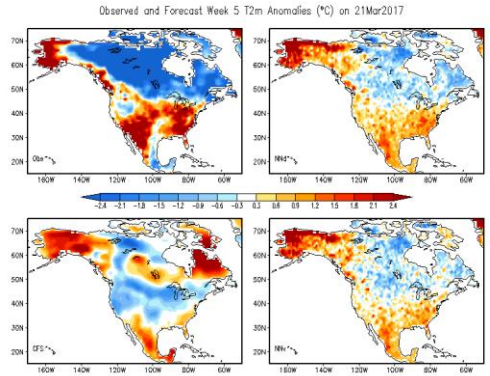
Week-5 Prcp Forecasts

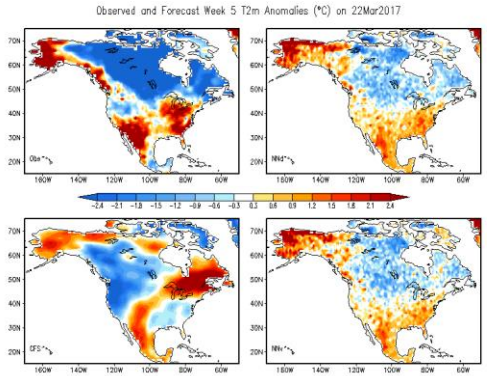


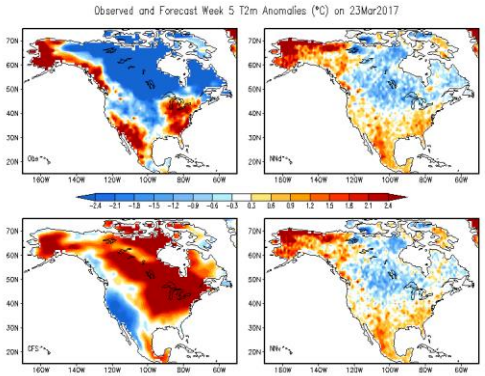




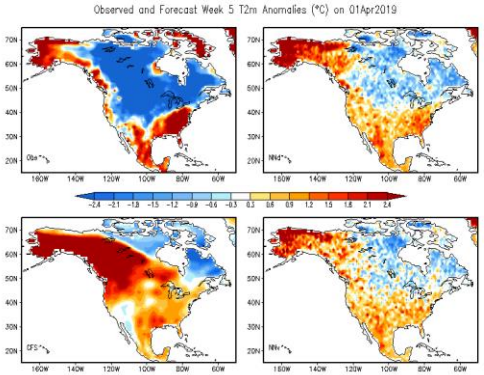


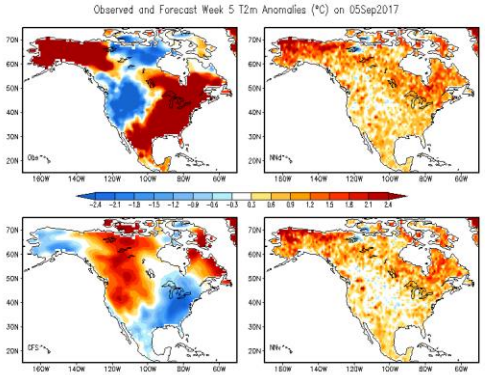


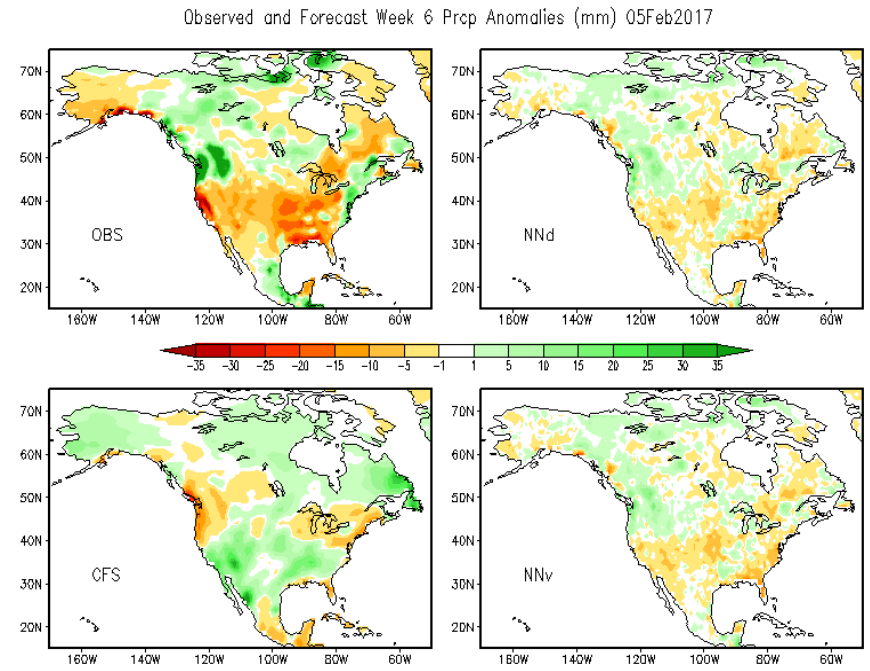


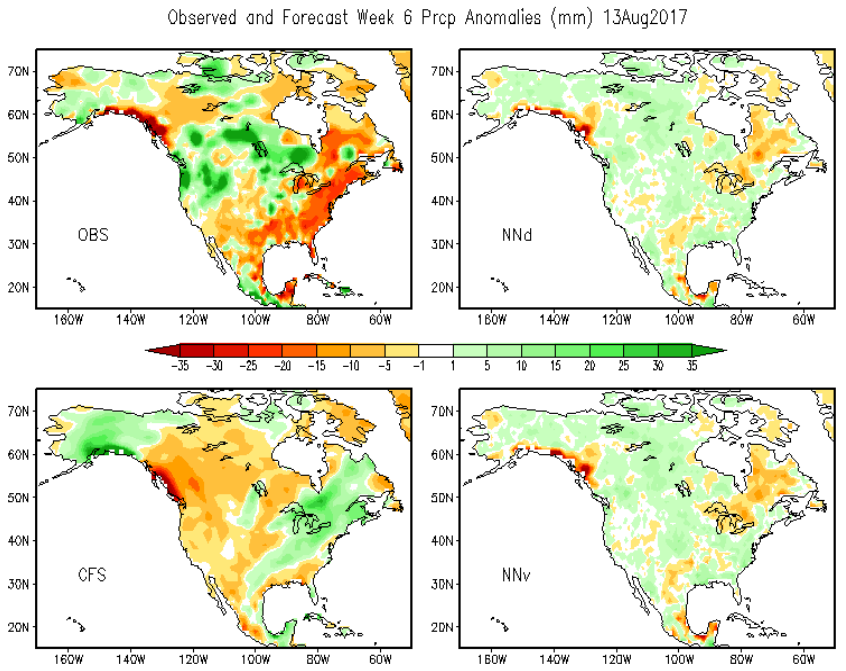


Week-5 T2m Forecasts

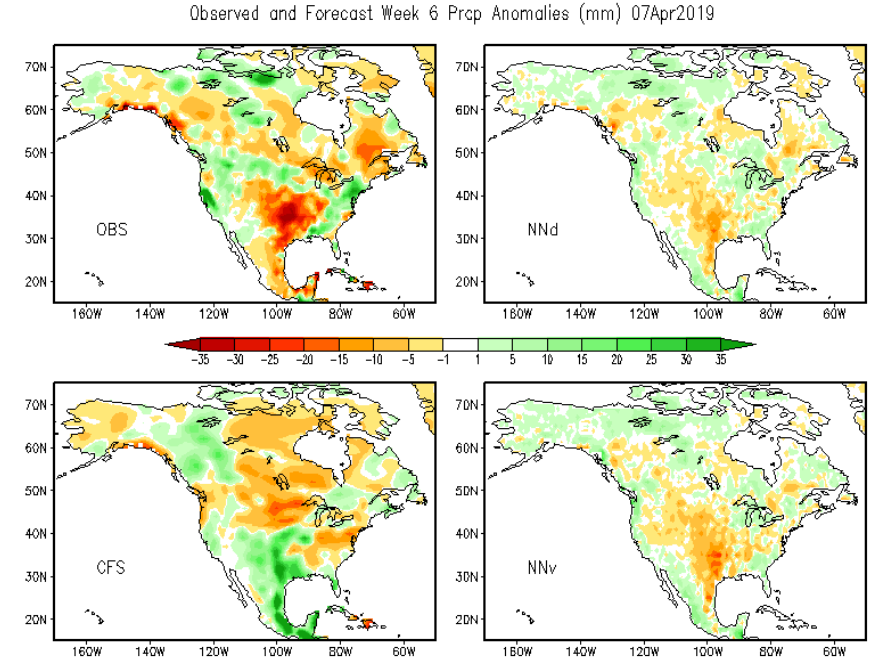


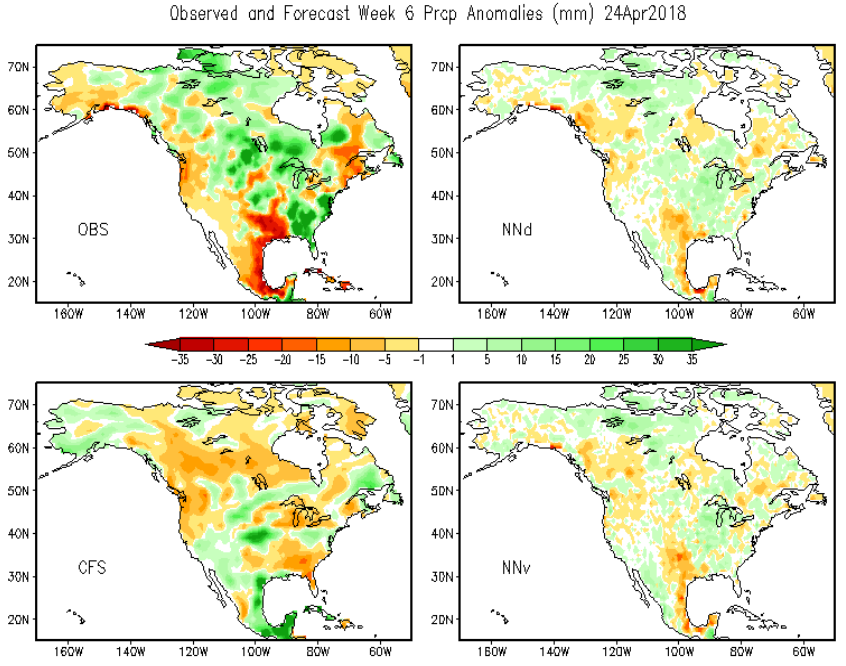


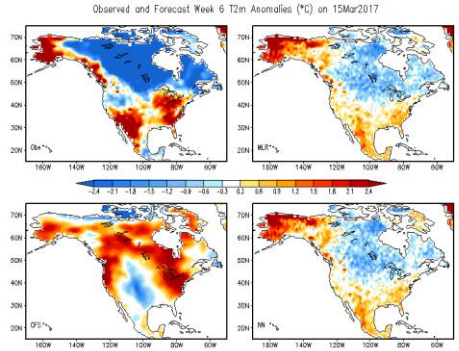


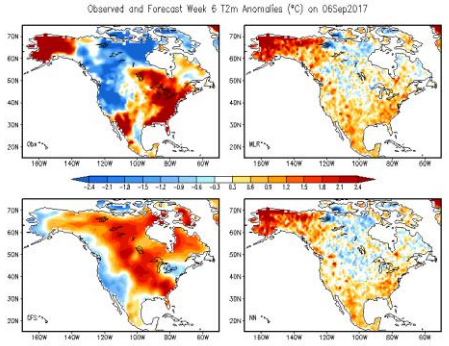


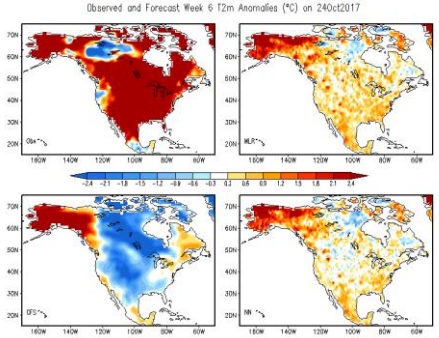
Week-6 Prcp Forecasts

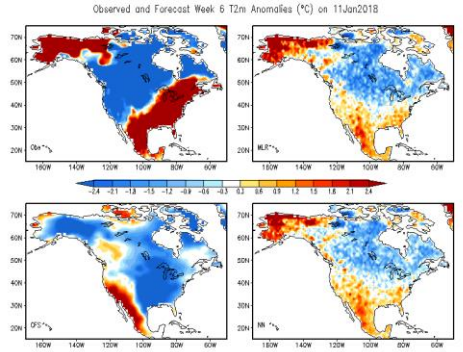


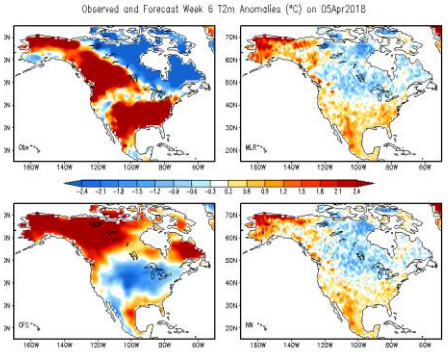


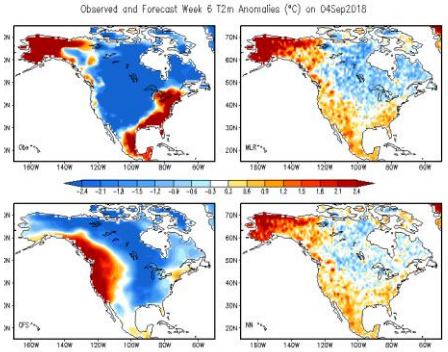


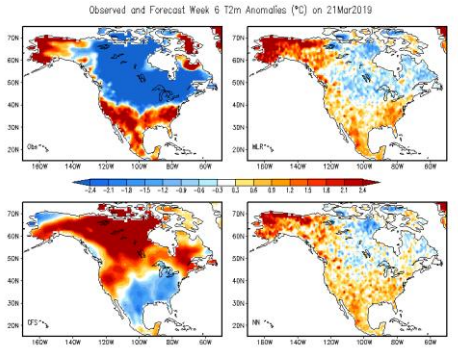




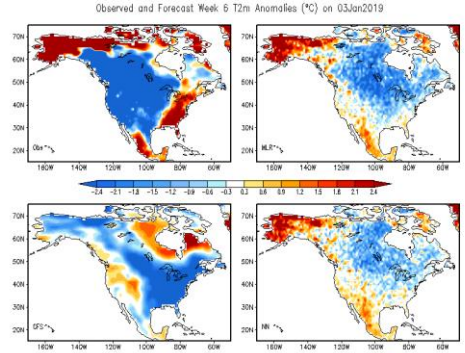


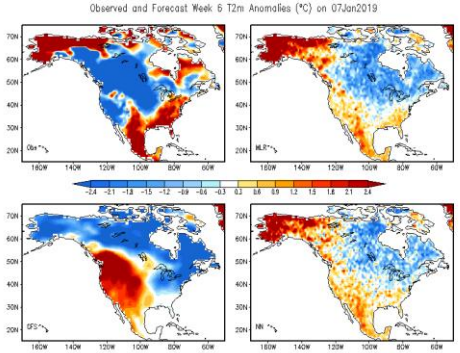


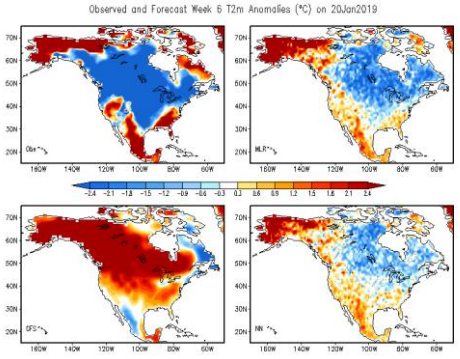


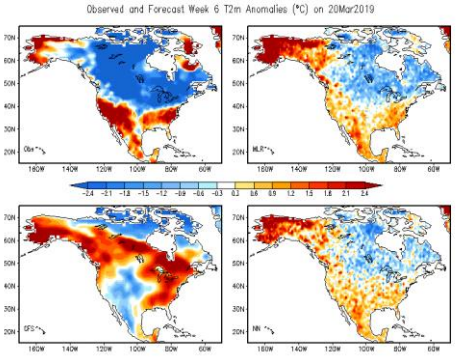


Week-6 2m Temperature Forecasts









Summary

1. **NN advantages**

   Flexible nonlinear tool & Easy to handle BIG DATA

2. **Unique & beneficial NN architectures: account for**

   Non-Linear Impact, Pattern Relationship, Co-Variability

3. **NN Significantly Improves CFS Week 1-6 P & T2m Fcsts**

   more sophisticated info hidden behind multiple dimensional big data can be extracted by NN

4. **NN can perform more complicated corrections**

   by reversing incorrect forecast patterns, hardly done by traditional MLR

5. **Forecast skills in Week 3-6 ranges have similar tendency**

   good forecasts in Week 3 tend to be good up to Week 6