

東北地方における冷夏の  
アンサンブルダウンスケール予報実験

東北大学 福井 真

# はじめに

## ヤマセによる局地的影響を予報するために

- 複雑な地形、局地循環、雲を陽に表現  
⇒ 力学的ダウンスケール(DS)
  - 力学的DSの予報誤差を考慮した予報
    - 力学的DSによる予報誤差  
← 領域モデルの不完全性 & 境界値の誤差
    - 境界値の誤差  
← 全球モデルの不完全性 & 初期値の誤差
- ⇒ 全球アンサンブル予報の利用

# 目的

アンサンブルダウンスケールシステムを構築し、高解像度の中期予報を行うことを目指す。

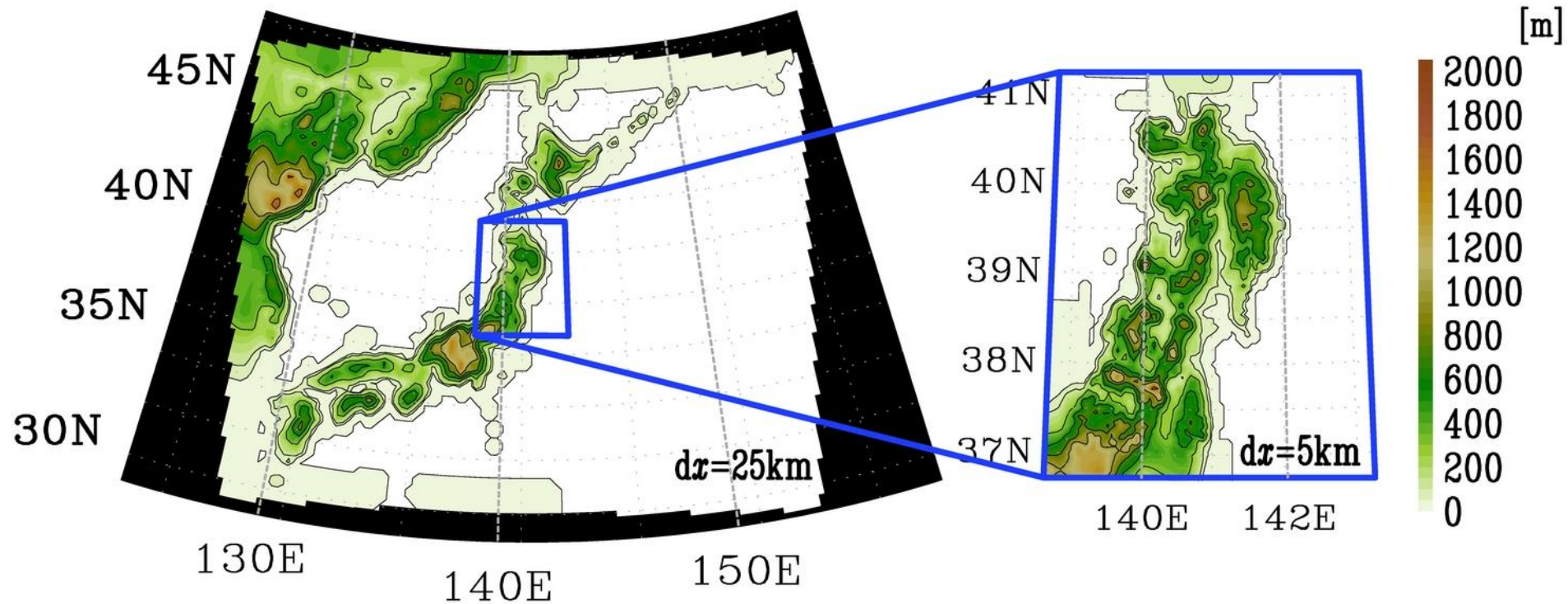
2003・04年夏季事例に対し、全球アンサンブル予報に力学的ダウンスケールを行い、その有効性を示す。

# 計算設定

使用モデル	気象庁非静力学モデル (JMA-NHM) (Saito et al. 2007)	
水平解像度(格子数)	25km (100×70)	5km (80×80)
初期値・境界値	1ヶ月アンサンブルハインドキャスト* (水平解像度1.25度)	水平解像度25kmへの ダウンスケール結果
メンバー数	9	
計算期間	2003・04年 6/20, 6/30, 7/10, 7/20 を初期値とした14日間	
時間間隔	40s	20s
鉛直格子	50層 (20-904m) 地形に沿うハイブリッド座標	
積雲対流	Kain-Fritschスキーム	
SST	NGSST(Guan and Kawamura, 2004) (初期日に固定)	
乱流クロージャー	Improved Mellor-Yamada Level3 (Nakanishi and Niino, 2004,2006)	

\*気象庁気候情報課より提供

# 計算領域



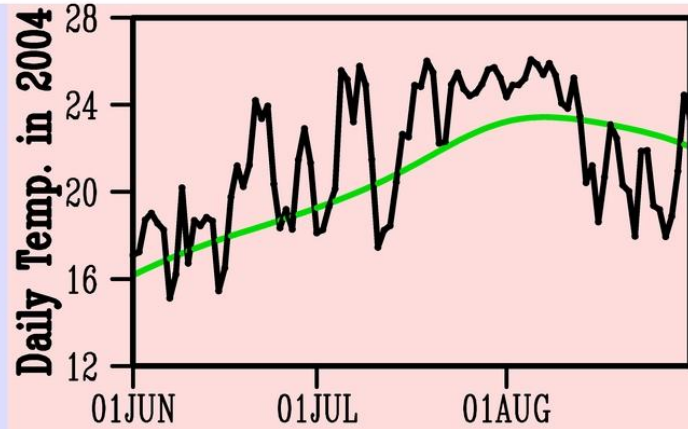
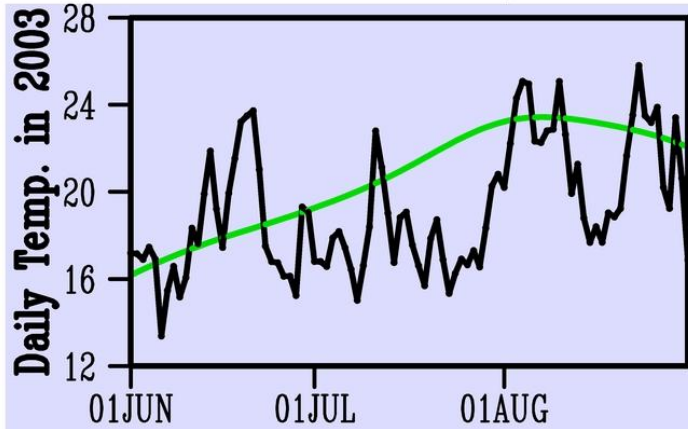
水平解像度5kmの計算領域内のAMeDAS(158 地点) に対して検証

# 対象期間

## Daily Temperature in Miyagi Pref. [°C]

— daily mean

— climate



宮城県内AMeDAS(仙台・駒ノ湯・川渡・築館・米山・志津川・古川・大衡・鹿島台・新川・塩竈・江ノ島・白石・亘理・丸森・気仙沼)の気温の平均  
 平年値は期間1979-2010の平均

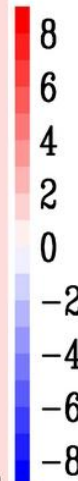
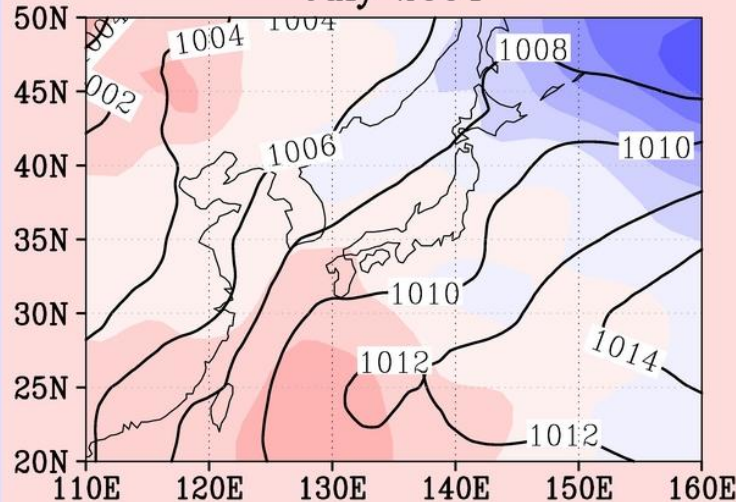
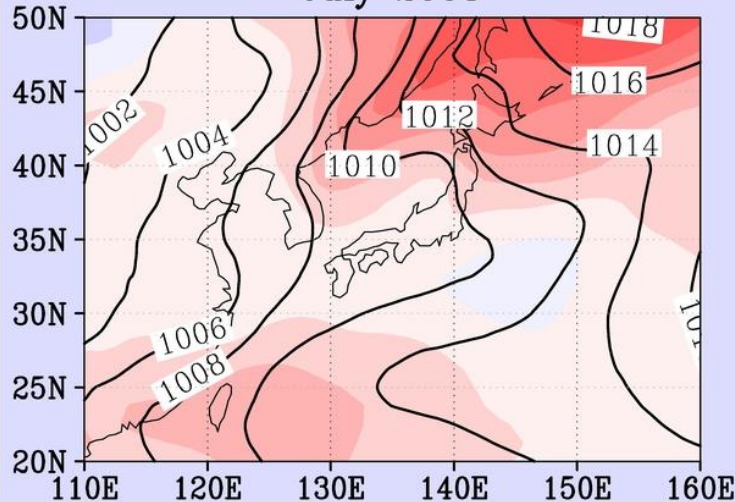
## Monthly mean Psea & its Anomaly [hPa]

Contours : Monthly mean Psea

Shades : Psea Anomaly

July 2003

July 2004



# 誤差の成分について

$$\langle x_j \rangle \equiv \frac{1}{M} \sum_{i=1}^M x_{i,j} \quad : \text{Areal - Mean of } j\text{-th Member's } x$$

$$L_{i,j} \equiv x_{i,j} - \langle x_j \rangle \quad : \text{Locality of } j\text{-th Member's } x \text{ at } i\text{-th Station}$$

$$\bar{x}_i \equiv \frac{1}{N} \sum_{j=1}^N x_{i,j} \quad : \text{Ensemble Mean of } x \text{ at } i\text{-th Station}$$

$$E_{i,j}^2 = (x_{i,j} - x_i^{\text{obs}})^2$$

$$= (\langle x_j \rangle - \langle x^{\text{obs}} \rangle)^2 + (L_{i,j} - L_i^{\text{obs}})^2 + 2(L_{i,j} - L_i^{\text{obs}})(\langle x_j \rangle - \langle x^{\text{obs}} \rangle)$$

$$\langle E_j^2 \rangle = (\langle x_j \rangle - \langle x^{\text{obs}} \rangle)^2 + \langle (L_{i,j} - L_i^{\text{obs}})^2 \rangle$$

$$\overline{\langle E^2 \rangle} = \underbrace{\left( \overline{\langle x \rangle} - \langle x^{\text{obs}} \rangle \right)^2}_{\text{アンサンブル平均のAreal-Mean誤差}} + \underbrace{\frac{1}{N} \sum_{j=1}^N \left( \langle x_j \rangle - \overline{\langle x \rangle} \right)^2}_{\text{Areal-Meanのスプレッド}} + \underbrace{\frac{1}{M} \sum_{i=1}^M \left( \bar{L}_i - L_i^{\text{obs}} \right)^2}_{\text{アンサンブル平均のLocality誤差}} + \underbrace{\frac{1}{M \cdot N} \sum_{i,j} \left( L_{i,j} - \bar{L}_i \right)^2}_{\text{Localityのスプレッド}}$$

アンサンブル平均  
のAreal-Mean誤差

Areal-Mean  
のスプレッド

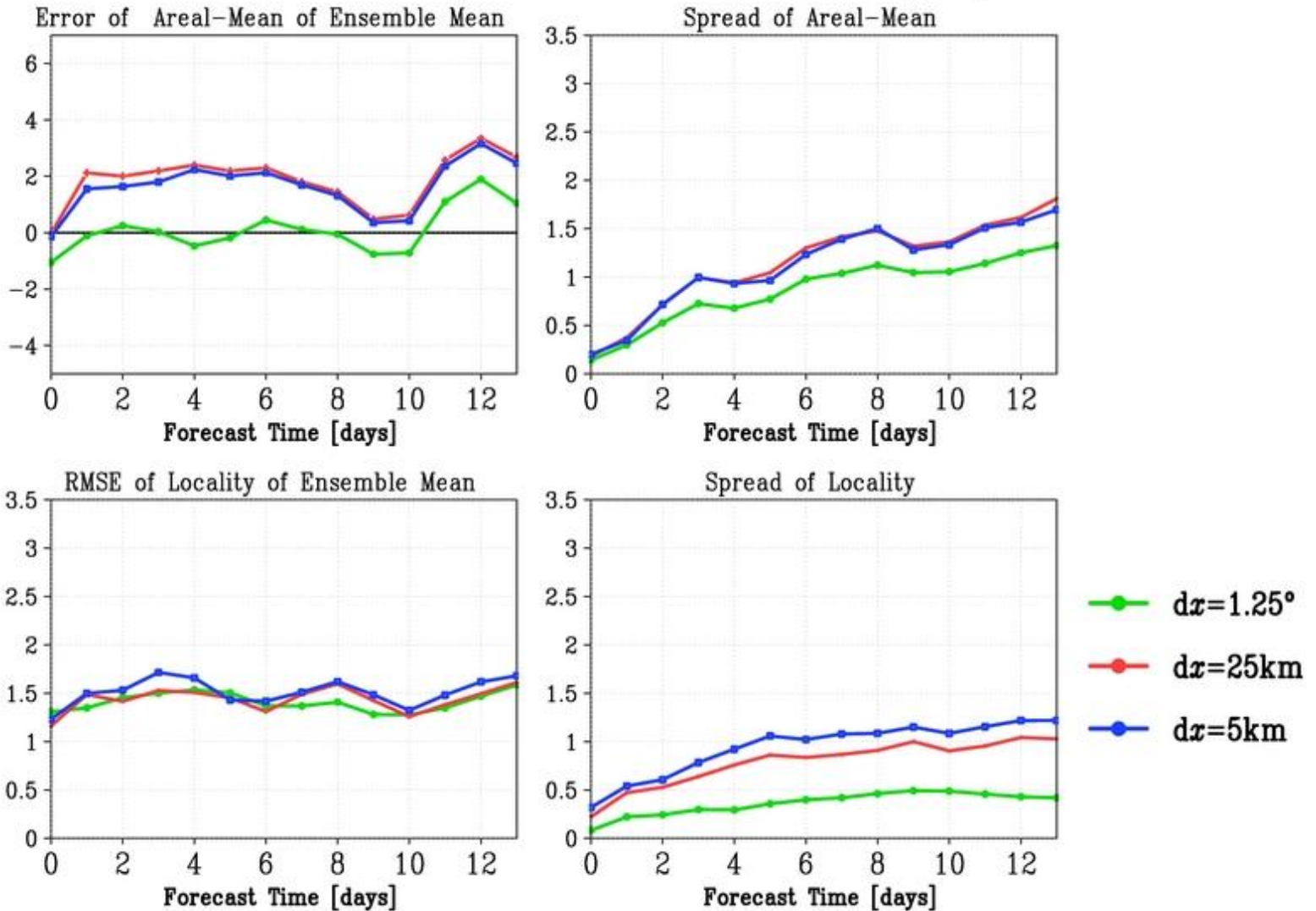
アンサンブル平均  
のLocality誤差

Localityの  
スプレッド

# 日最低気温 (at 03JST)

before bias correction

## Minimum Temperature in Tohoku [°C]

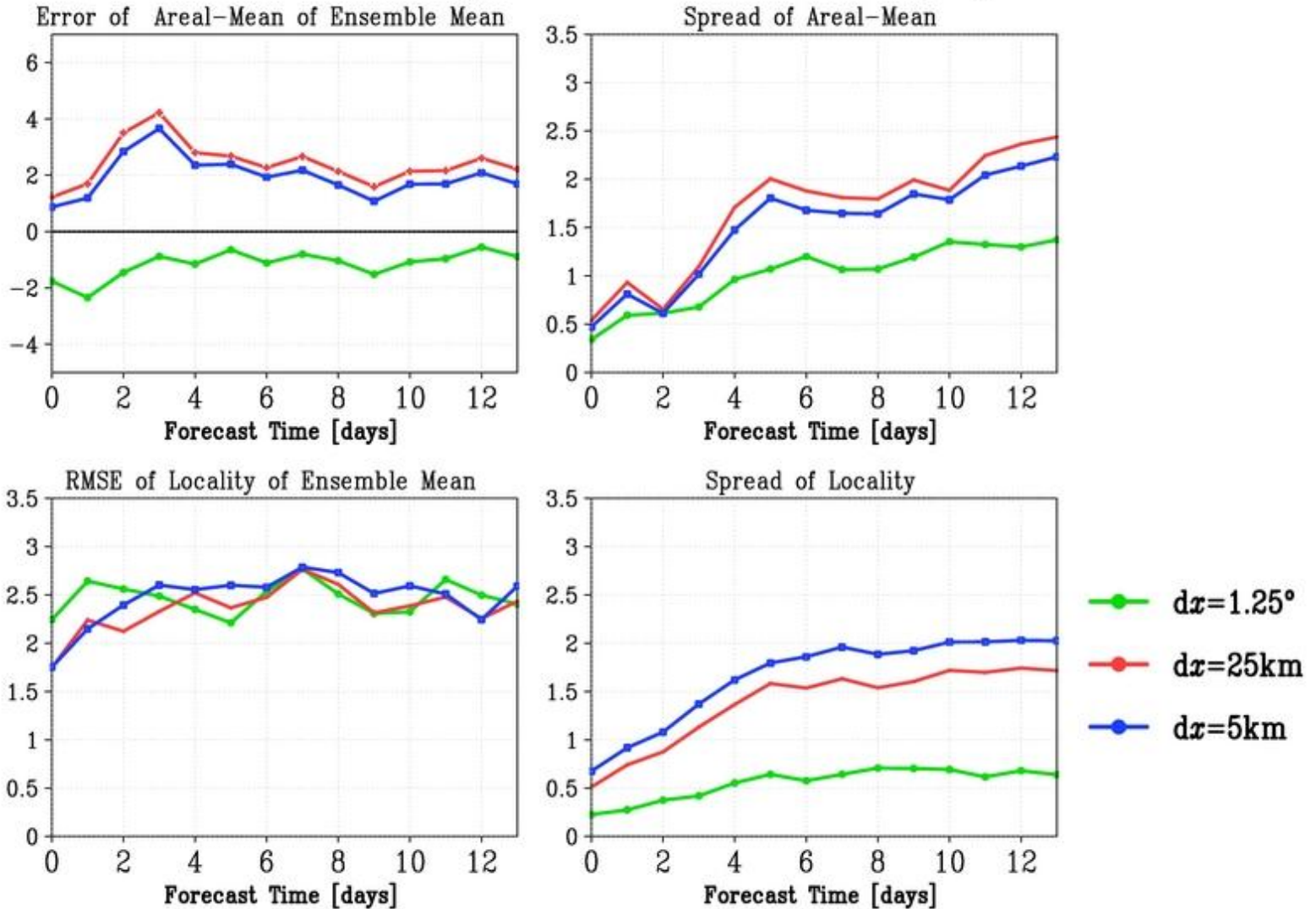




# 日最高気温 (at 15JST)

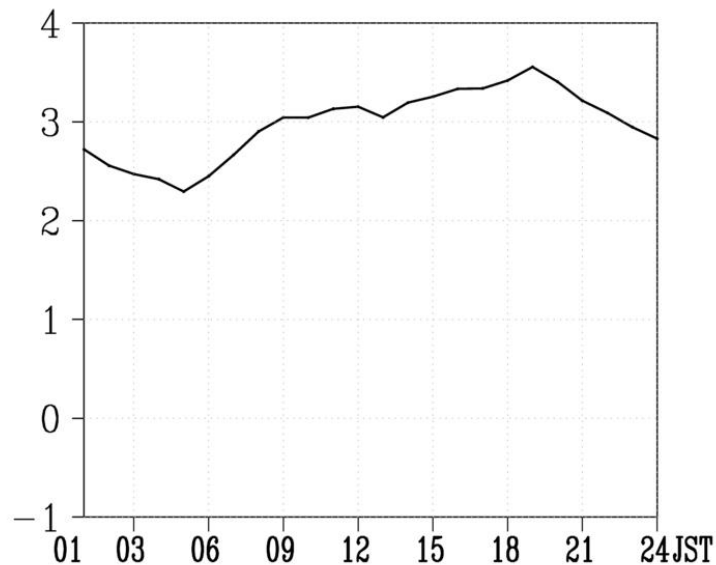
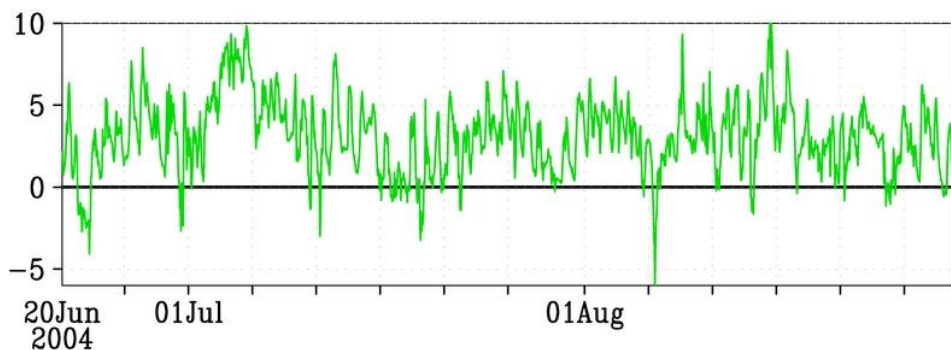
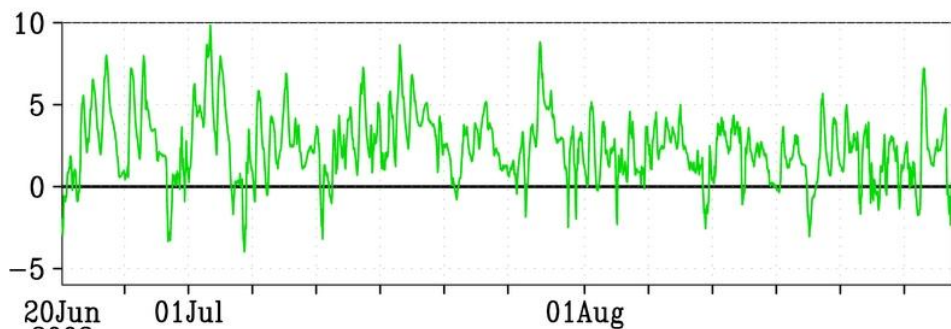
before bias correction

## Maximum Temperature in Tohoku [°C]



# バイアス

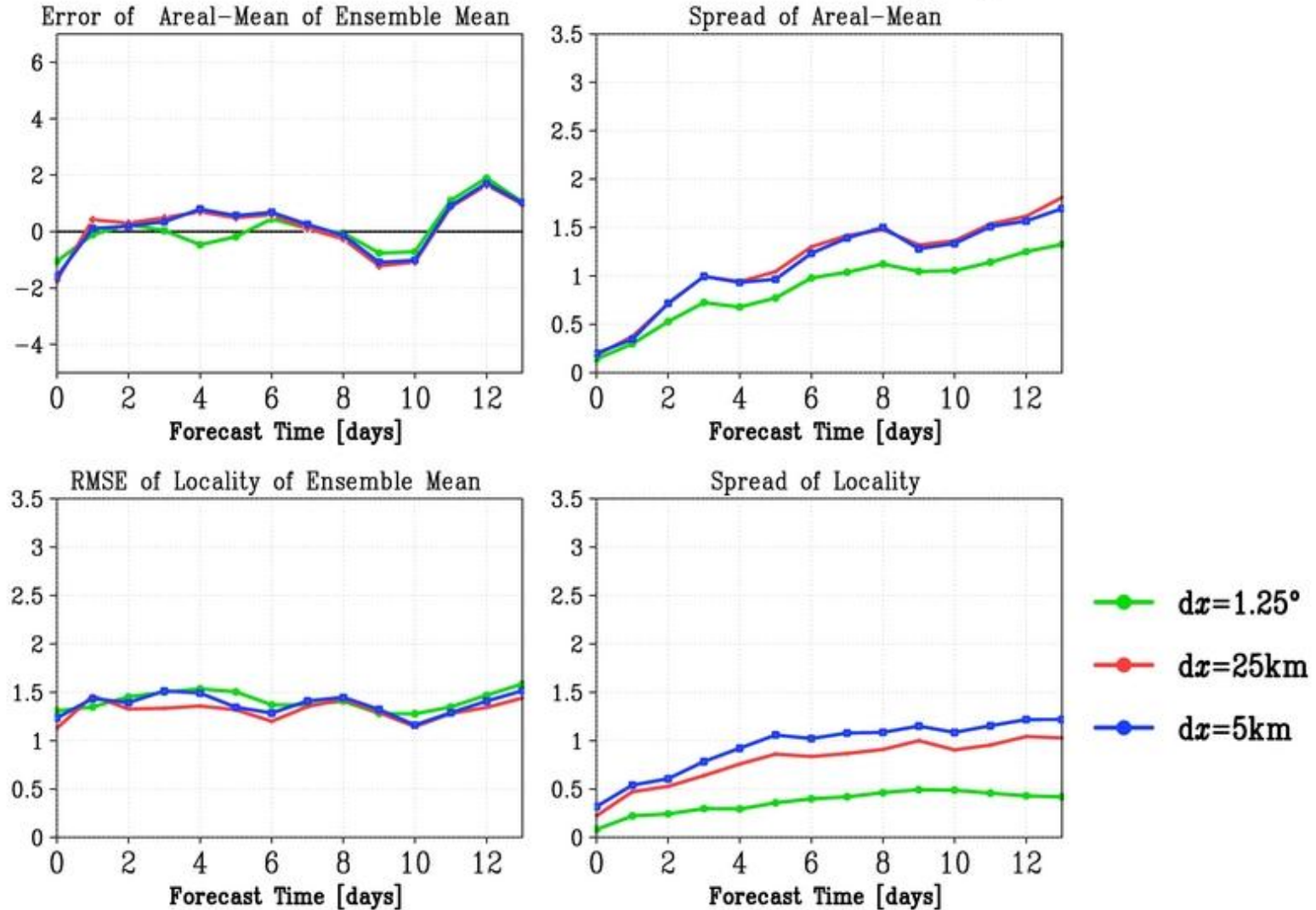
- 再解析データJRA-25(Onogi, 2007)を完全境界とみなしたDS
- 期間は、2003・04年の6/20～8/31(冷夏・暑夏を網羅)
- ある地点・ある時間帯における期間平均したDS結果と観測結果の差をその地点・その時間帯のバイアスとする。



# 日最低気温 (at 03JST)

after bias correction

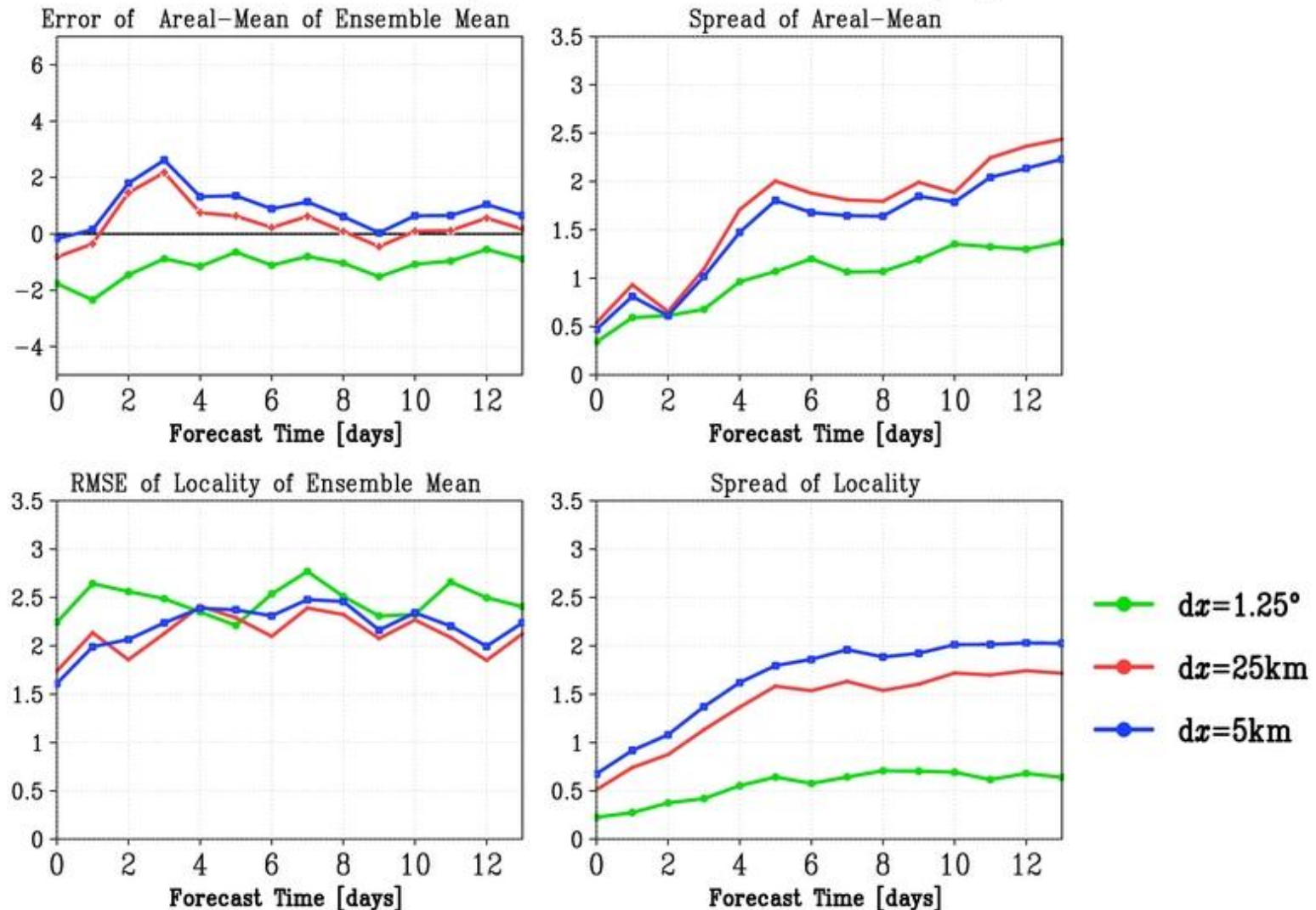
## Minimum Temperature in Tohoku [°C]



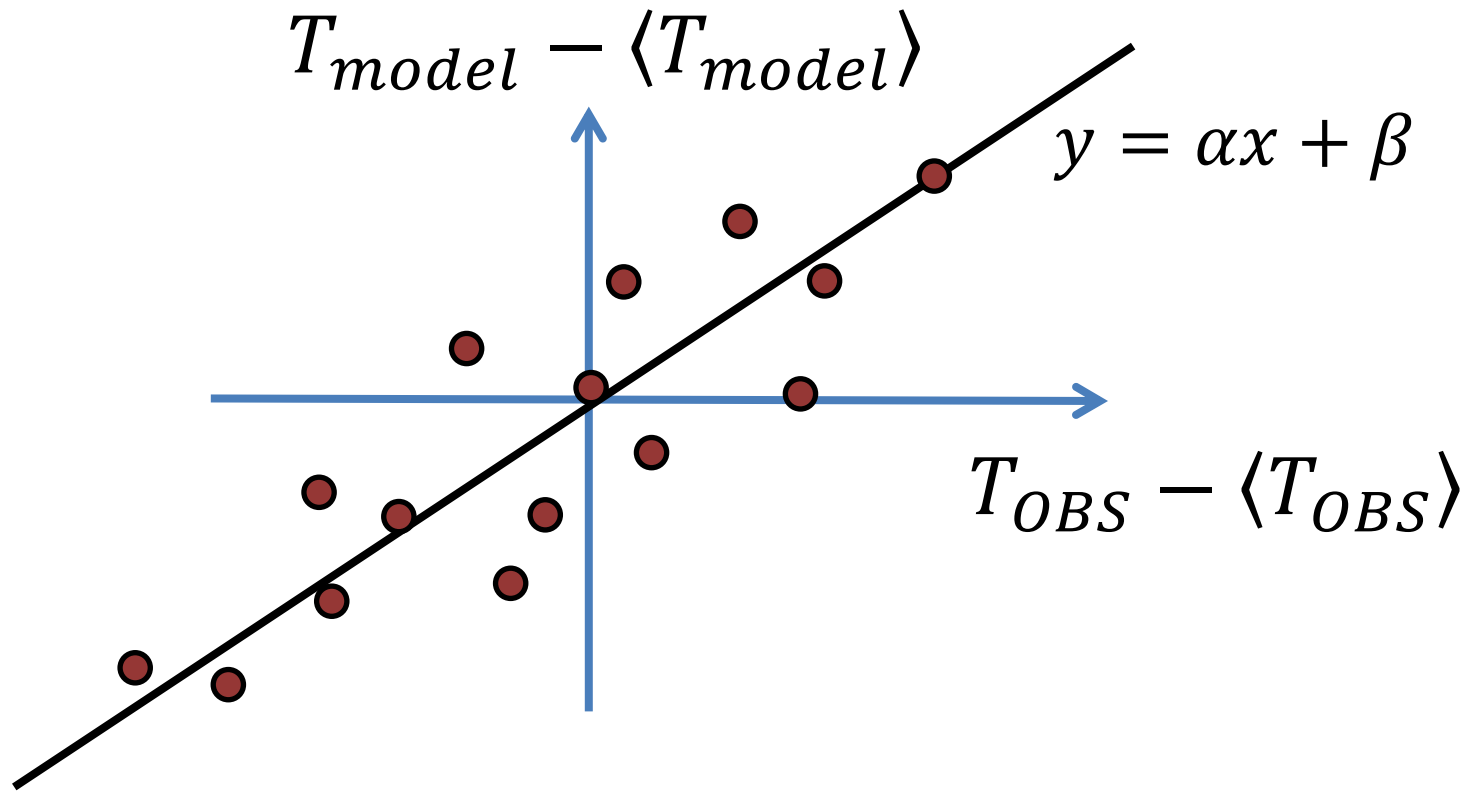
# 日最高気温 (at 15JST)

after bias correction

## Maximum Temperature in Tohoku [°C]



# 予報時間毎、全地点、8ケース



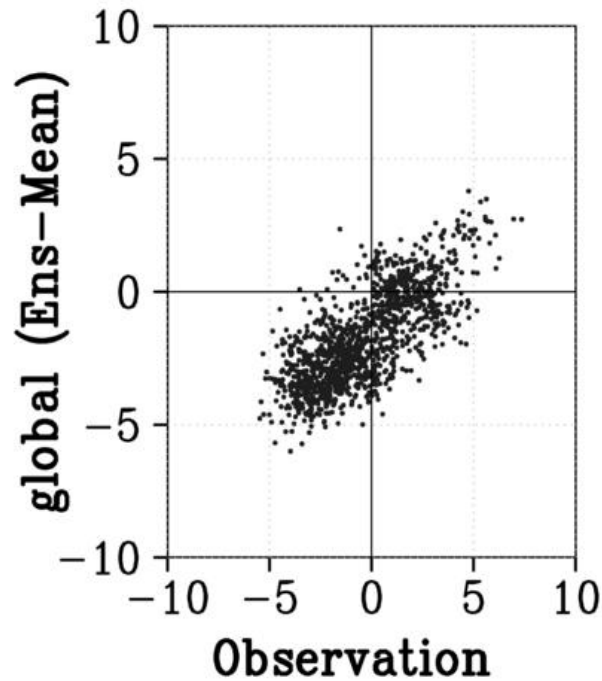
$T_{model}$ : 気温のモデル値 (アンサンブル平均)

$T_{OBS}$ : 気温の観測値

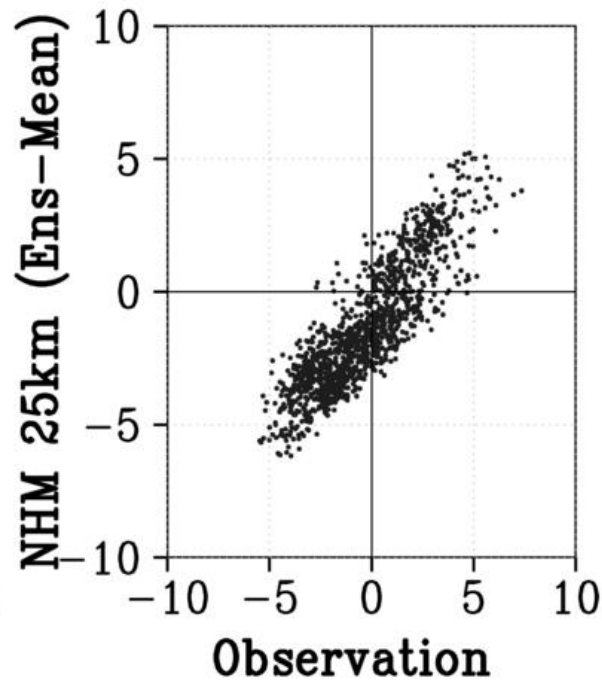
$\langle x \rangle$ : 気候値 (2003・04年6/20～8/31の平均)

# Daily Mean Temperature Anomaly (FT=1days)

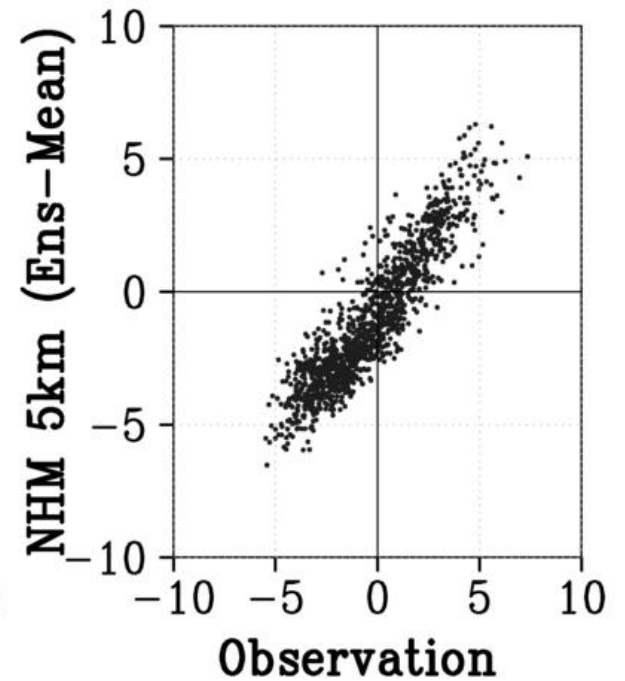
Cor=0.74  $y=0.54x-1.53$



Cor=0.87  $y=0.84x-1.14$



Cor=0.91  $y=0.93x-0.77$

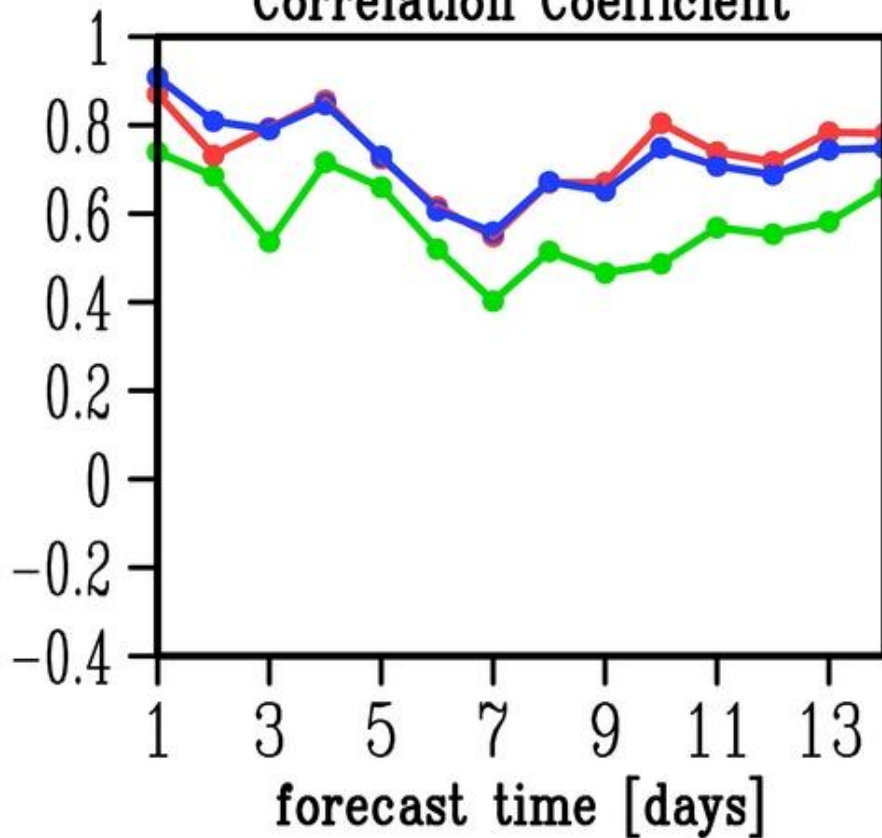


# 日平均気温 (03, 09, 15, 21JST)

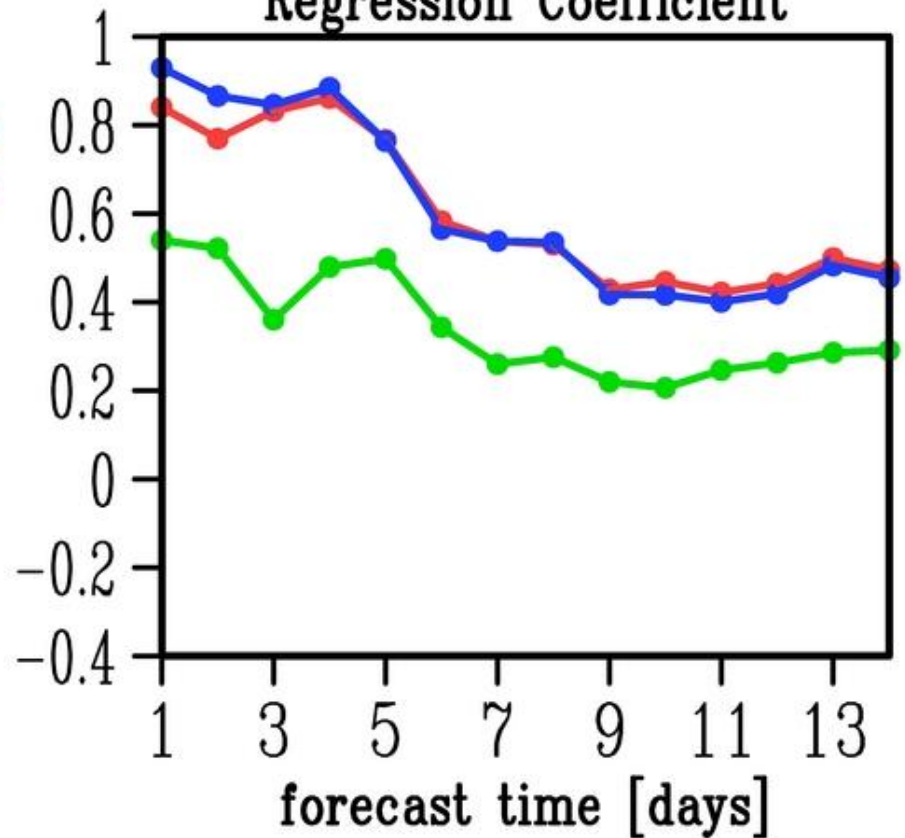
## Daily Mean Temperature Anomaly Model VS Observation

— global    — NHM\_25km    — NHM\_5km

Correlation Coefficient



Regression Coefficient

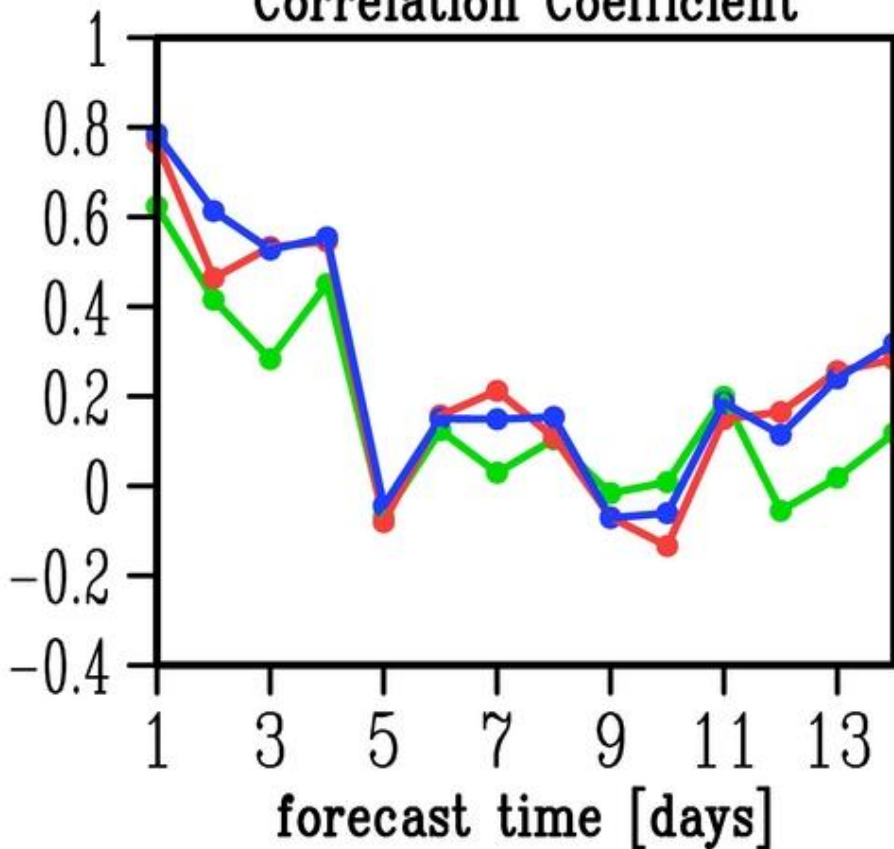


# 気温日較差 (15 - 03JST)

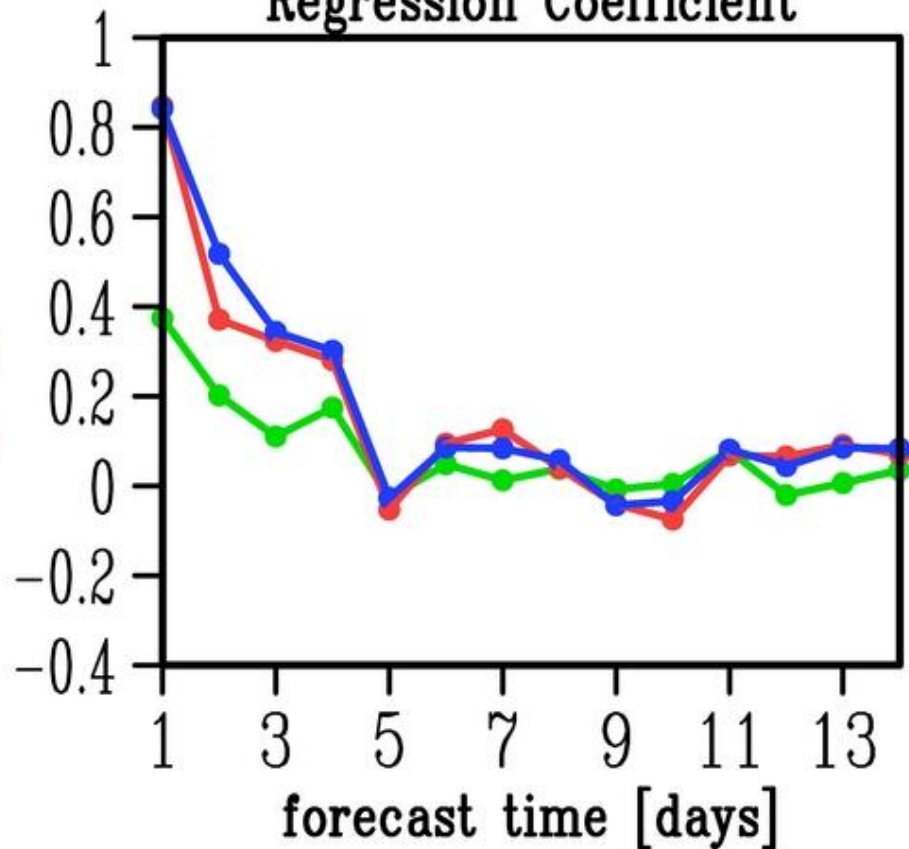
## Diurnal Temperature Range Anomaly Model VS Observation

— global — NHM\_25km — NHM\_5km

Correlation Coefficient



Regression Coefficient



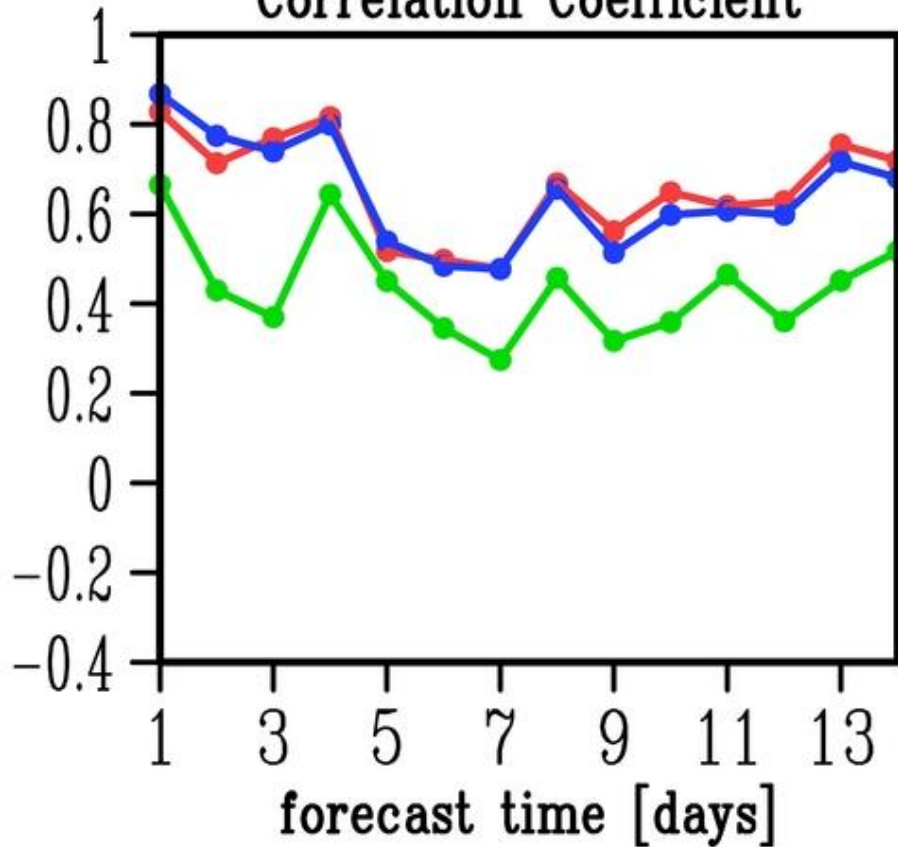


# 最高気温 (at 03JST)

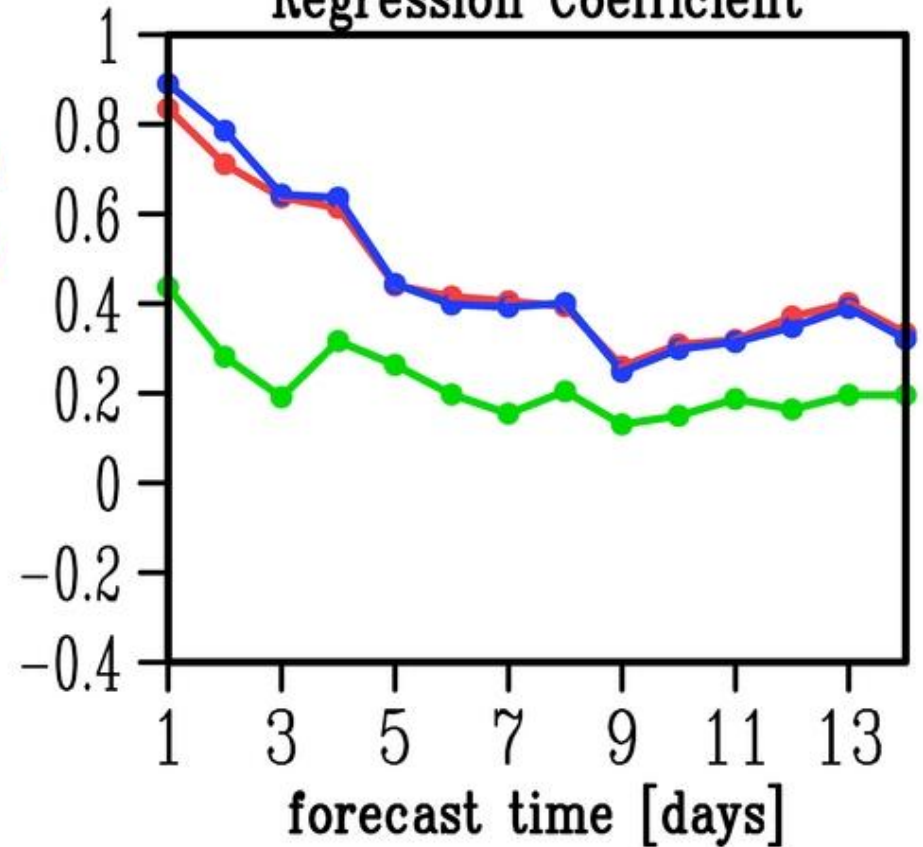
## Daily Maximum Temperature Anomaly Model VS Observation

— global — NHM\_25km — NHM\_5km

Correlation Coefficient



Regression Coefficient

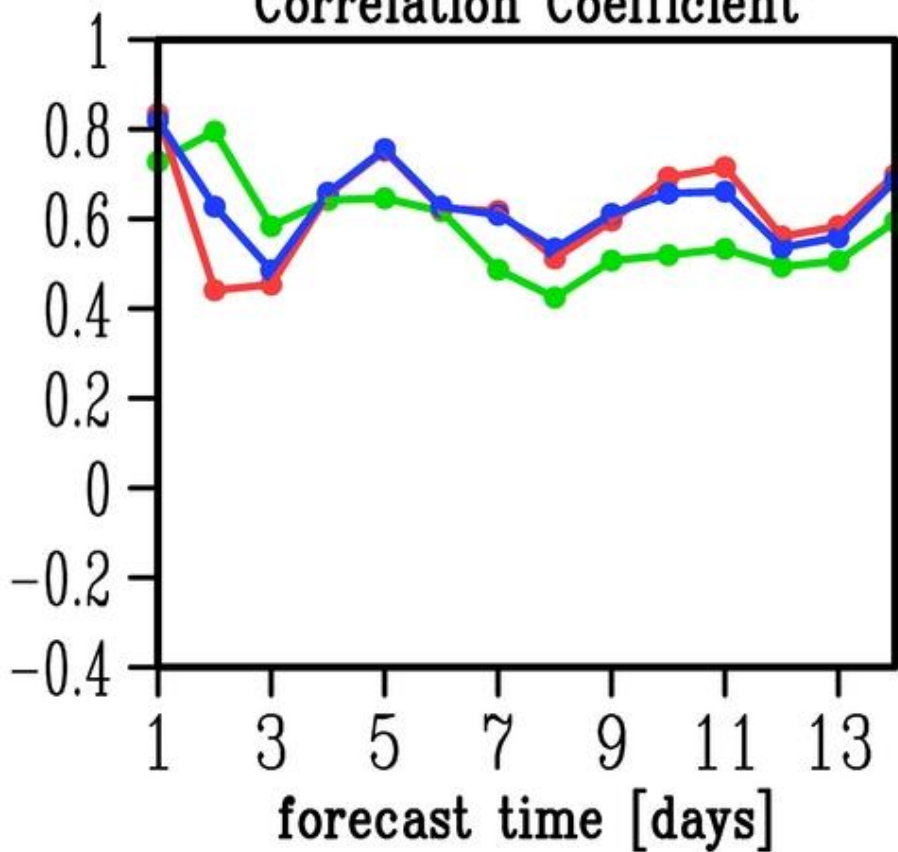


# 最低気温 (at 03JST)

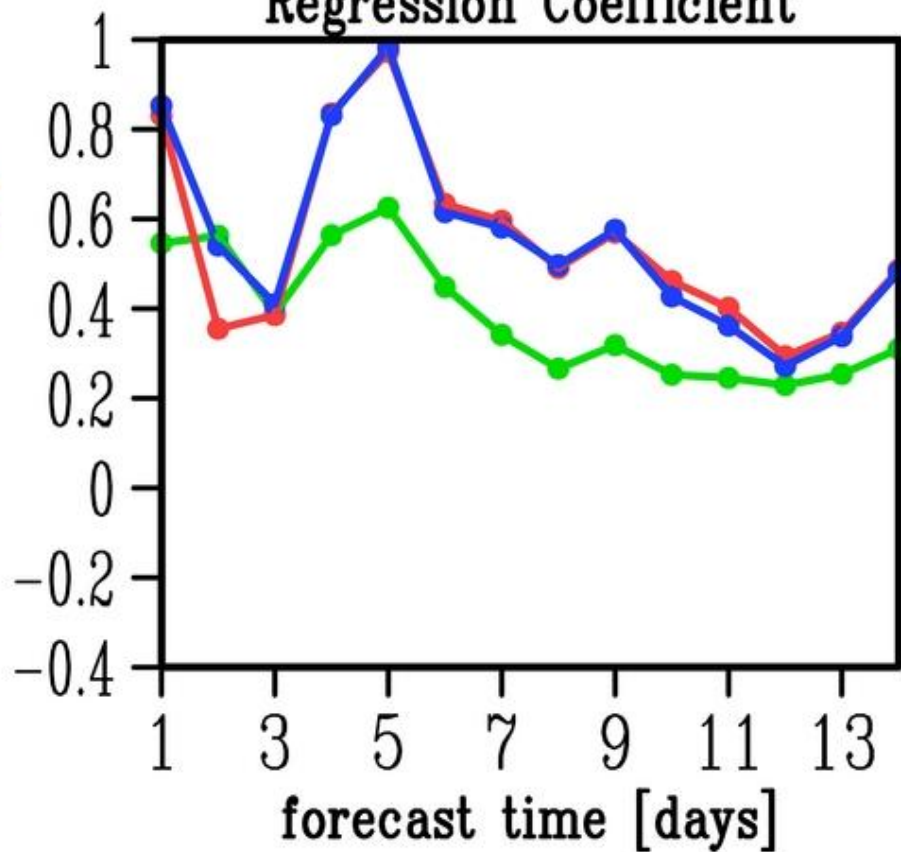
## Daily Minimum Temperature Anomaly Model VS Observation

— global — NHM\_25km — NHM\_5km

Correlation Coefficient



Regression Coefficient



# まとめ

- DS ( global → 25km )

スプレッドが大きくなる

予報時間4～5日まで、アドバンテージ

- DS ( 25km → 5km )

地域性のスプレッドが大きくなる

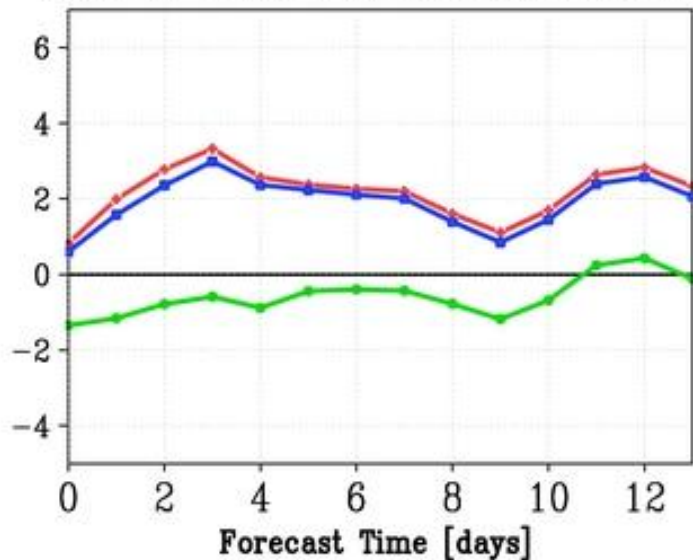
予報時間2日まで、アドバンテージ



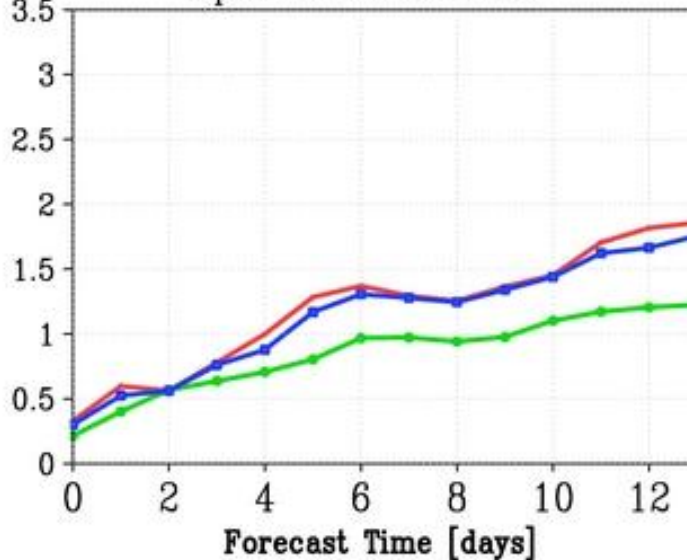
**before bias correction**

# Daily Mean Temperature in Tohoku [°C]

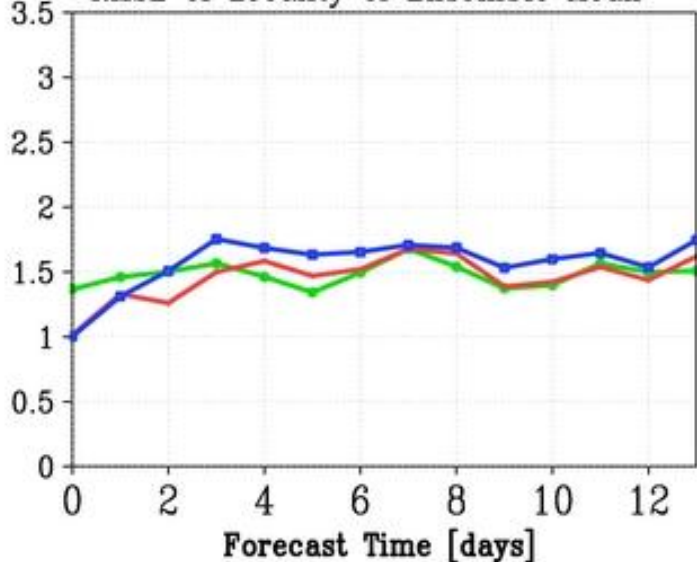
Error of Areal-Mean of Ensemble Mean



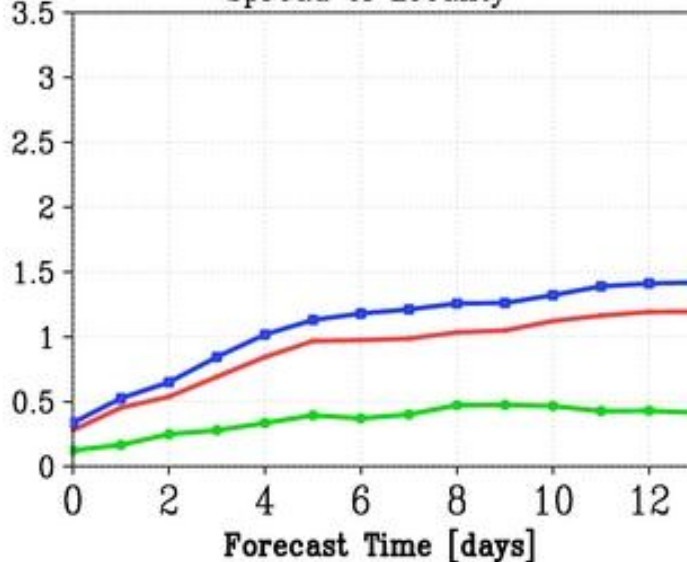
Spread of Areal-Mean



RMSE of Locality of Ensemble Mean



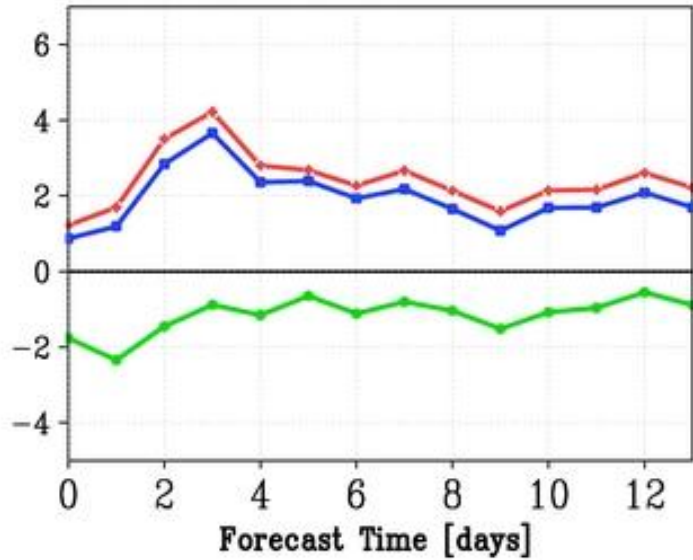
Spread of Locality



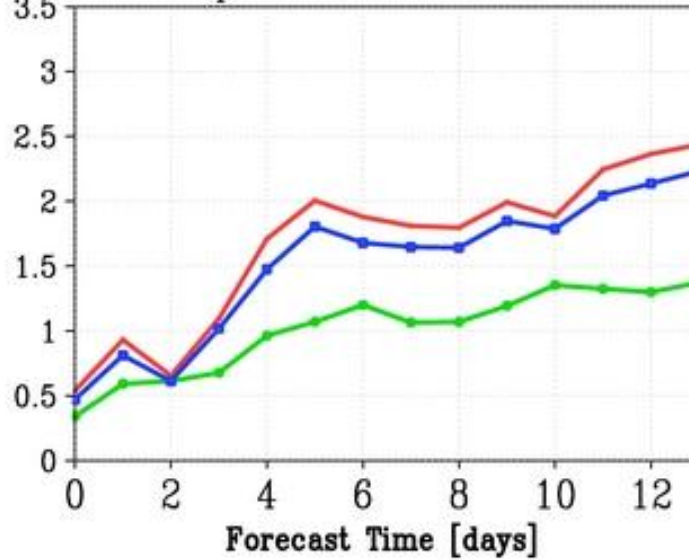
- dx=1.25°
- dx=25km
- dx=5km

# Maximum Temperature in Tohoku [°C]

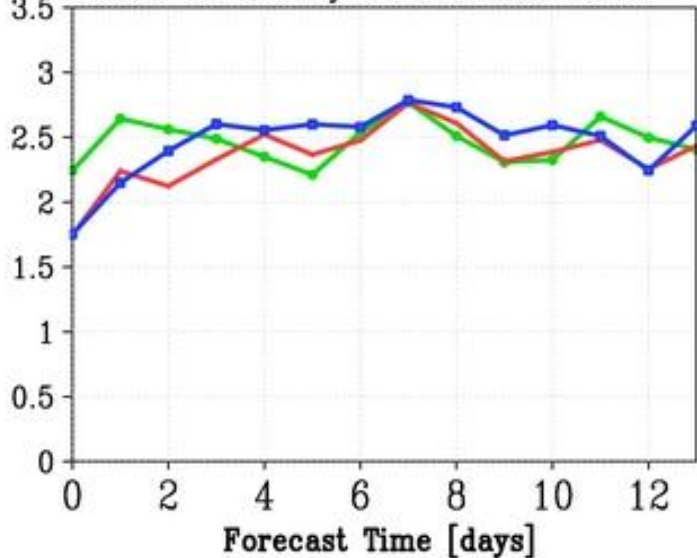
Error of Areal-Mean of Ensemble Mean



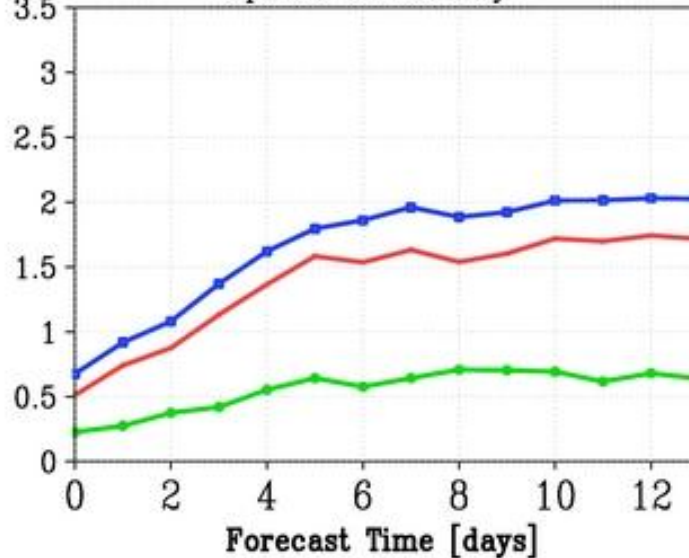
Spread of Areal-Mean



RMSE of Locality of Ensemble Mean



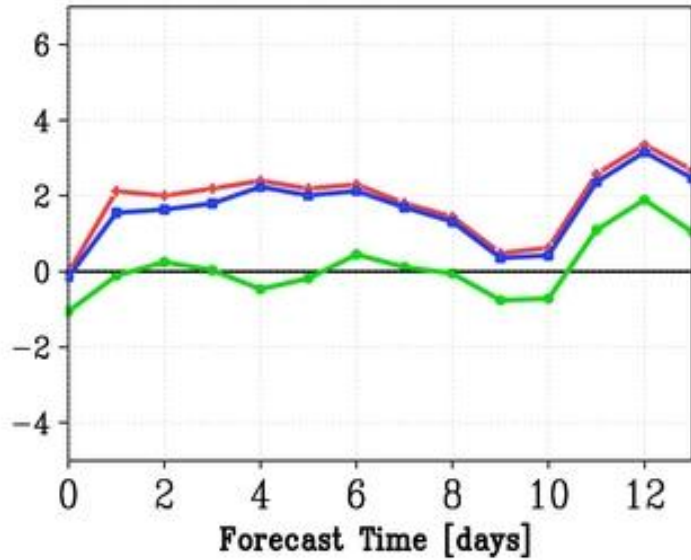
Spread of Locality



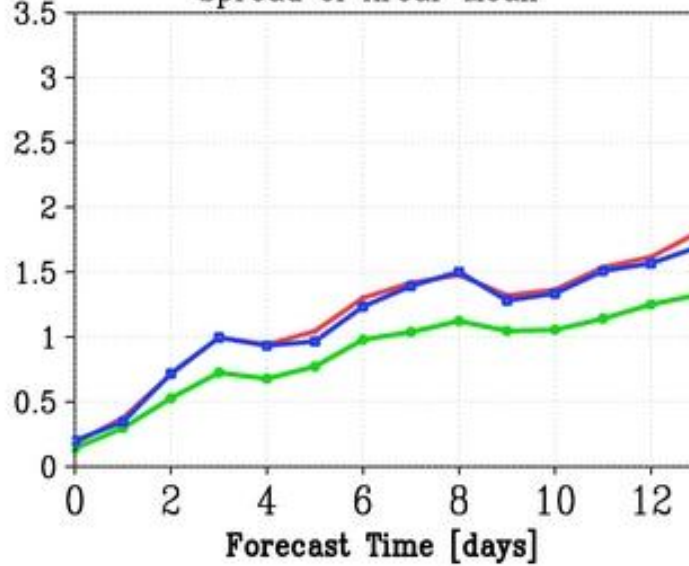
- dx=1.25°
- dx=25km
- dx=5km

# Minimum Temperature in Tohoku [°C]

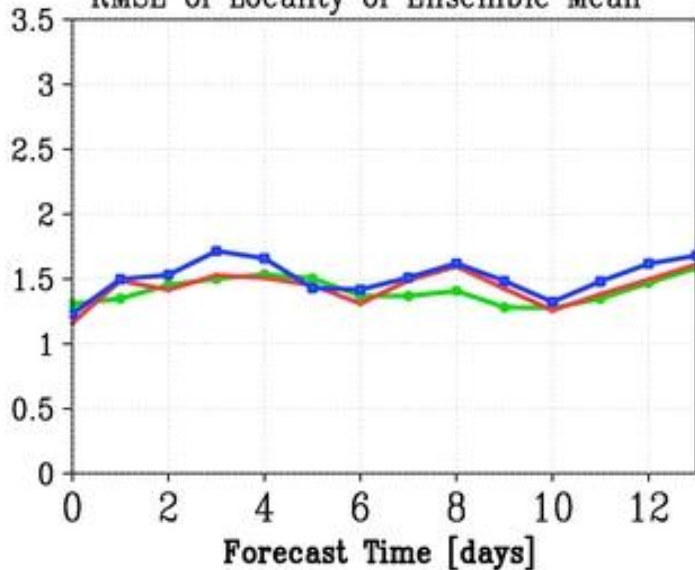
Error of Areal-Mean of Ensemble Mean



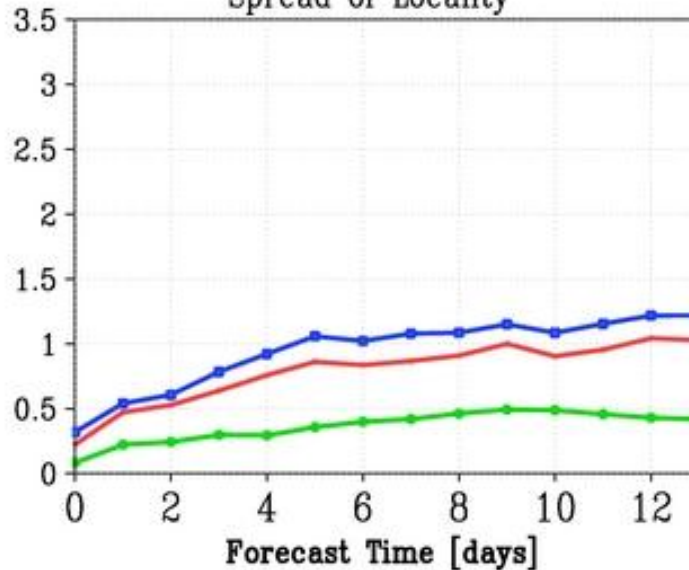
Spread of Areal-Mean



RMSE of Locality of Ensemble Mean



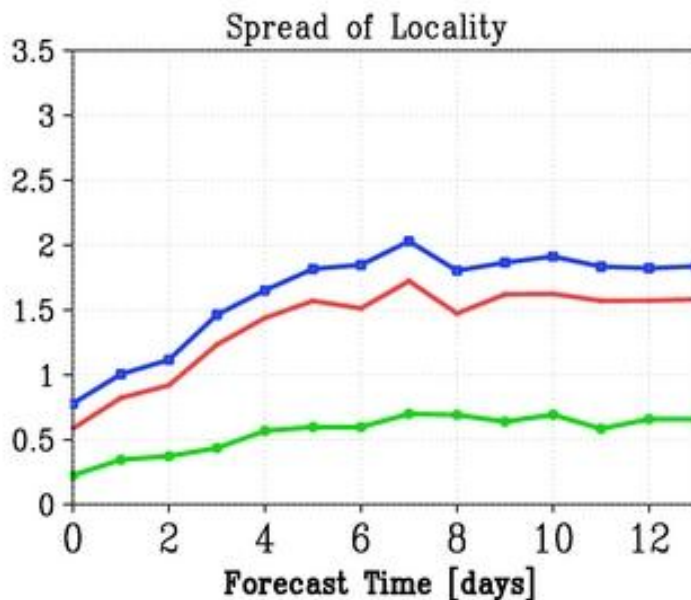
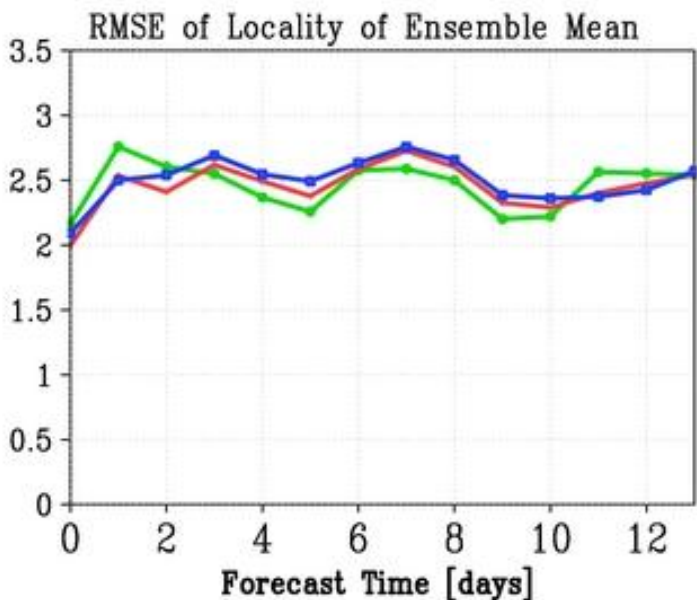
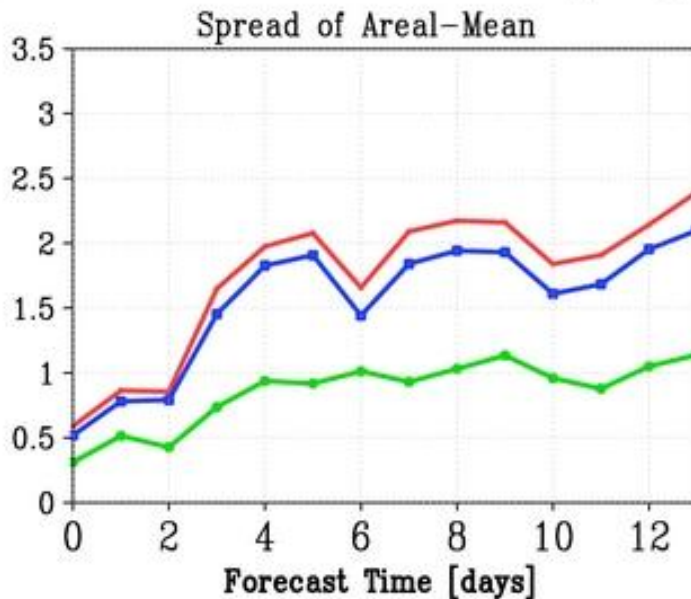
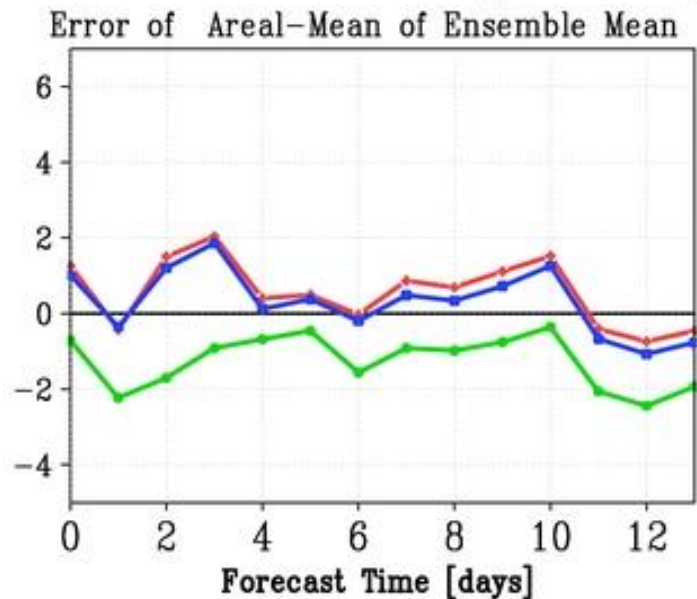
Spread of Locality



- dx=1.25°
- dx=25km
- dx=5km



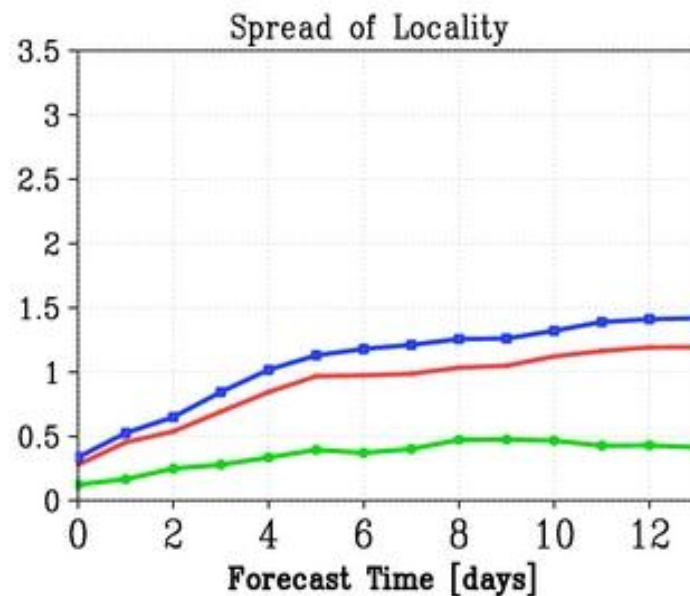
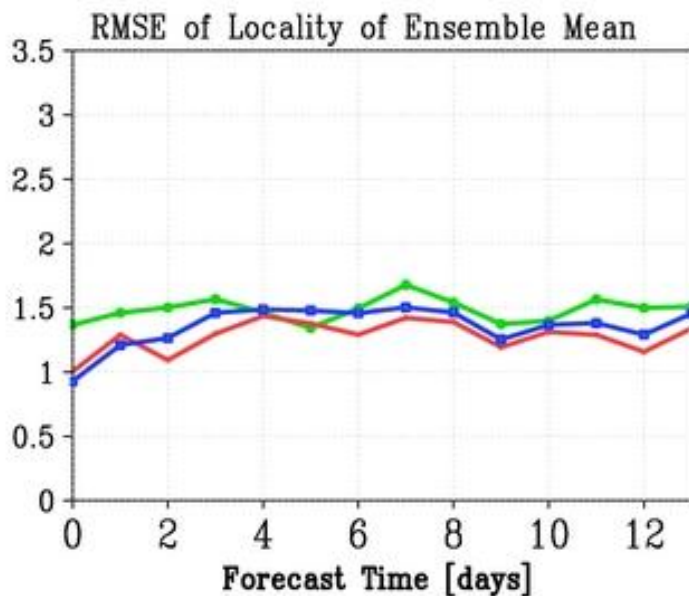
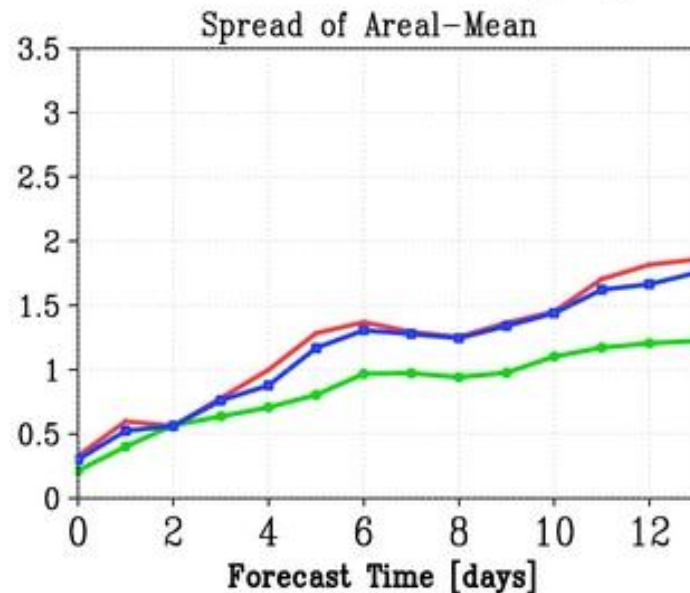
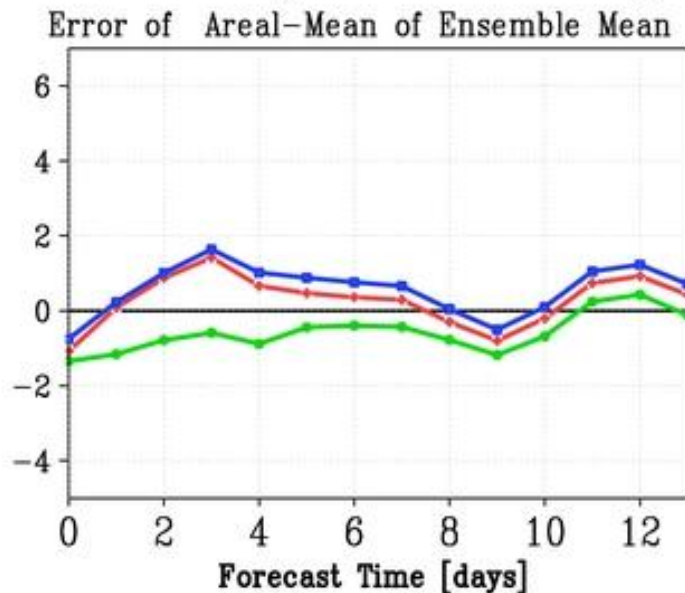
# Diurnal Range Temperature in Tohoku [°C]



- $dx=1.25^\circ$
- $dx=25\text{km}$
- $dx=5\text{km}$

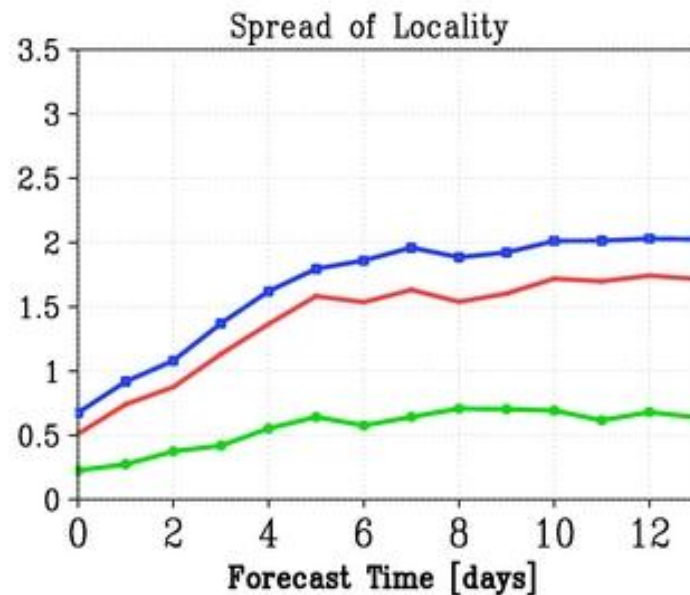
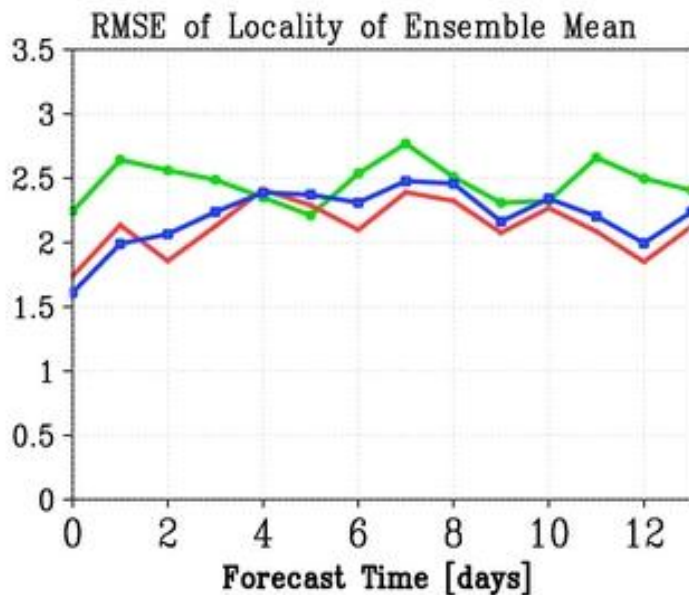
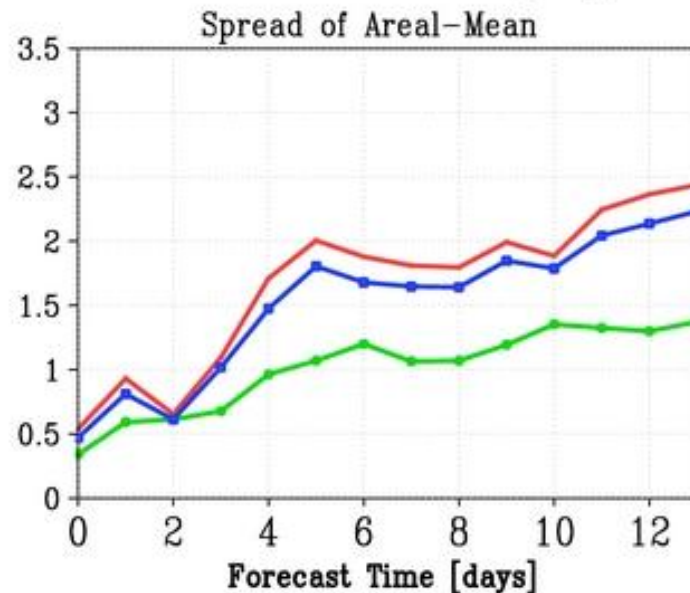
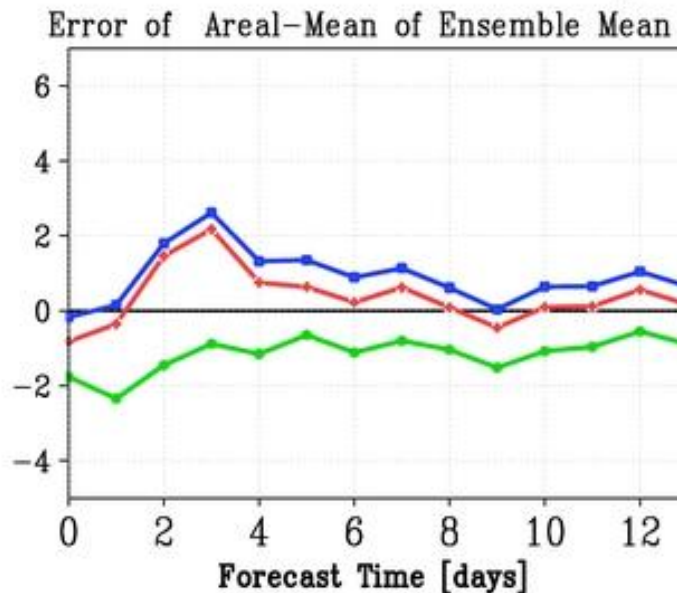
after bias correction

# Daily Mean Temperature in Tohoku [°C]



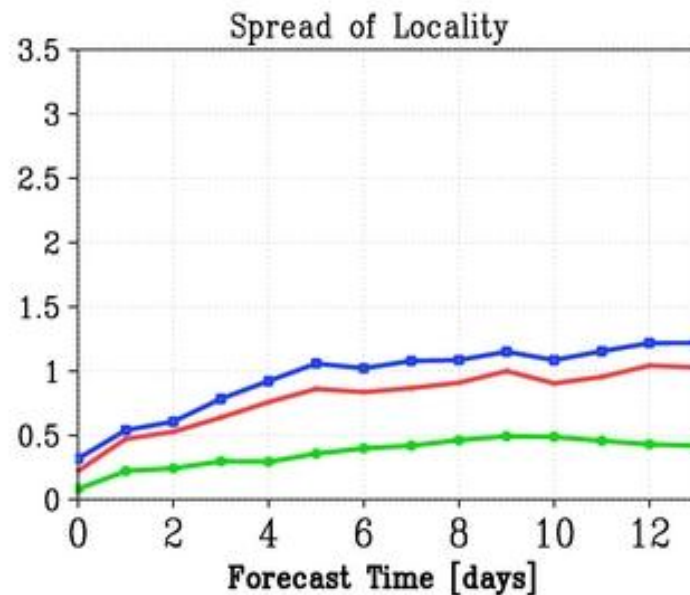
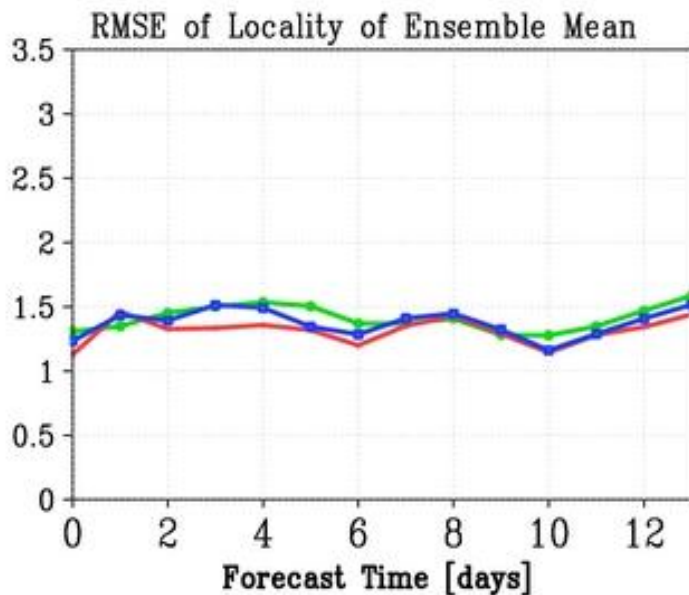
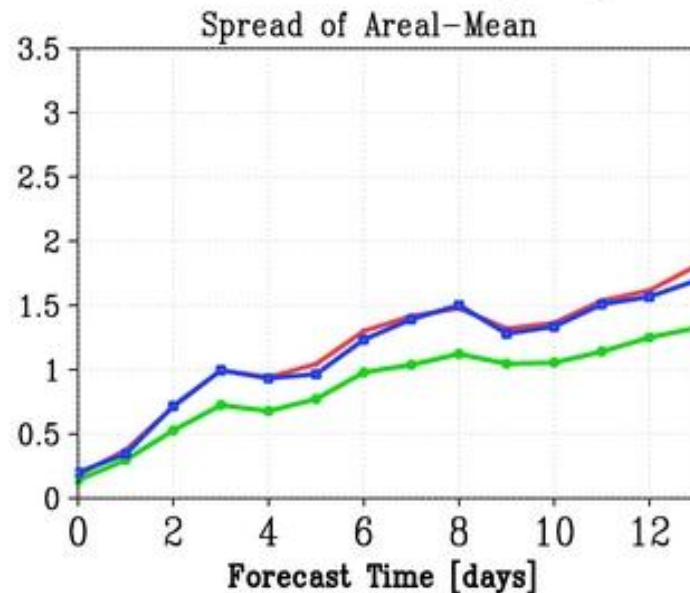
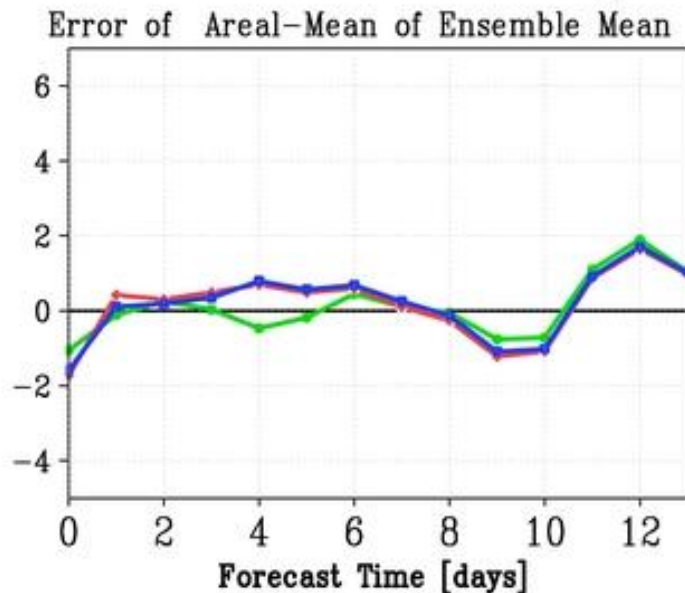
- dx=1.25°
- dx=25km
- dx=5km

# Maximum Temperature in Tohoku [°C]



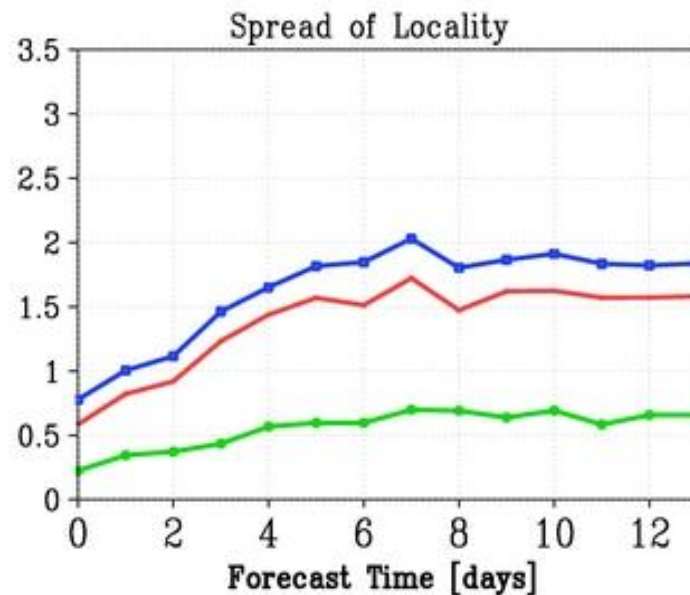
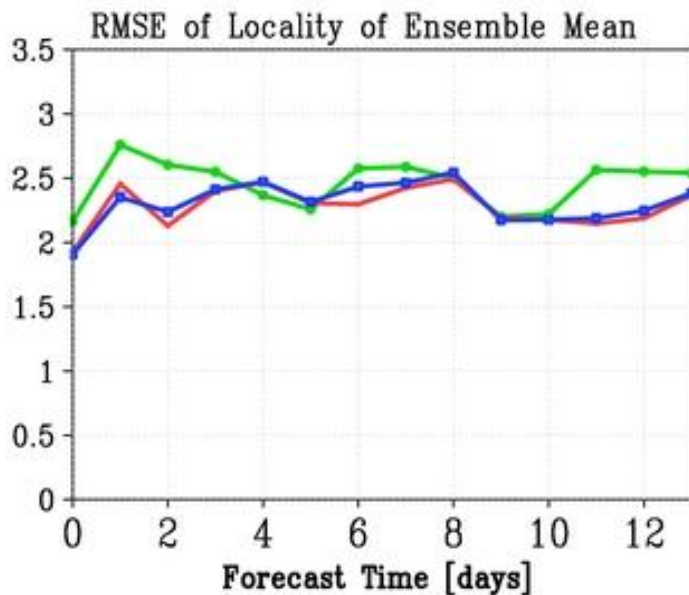
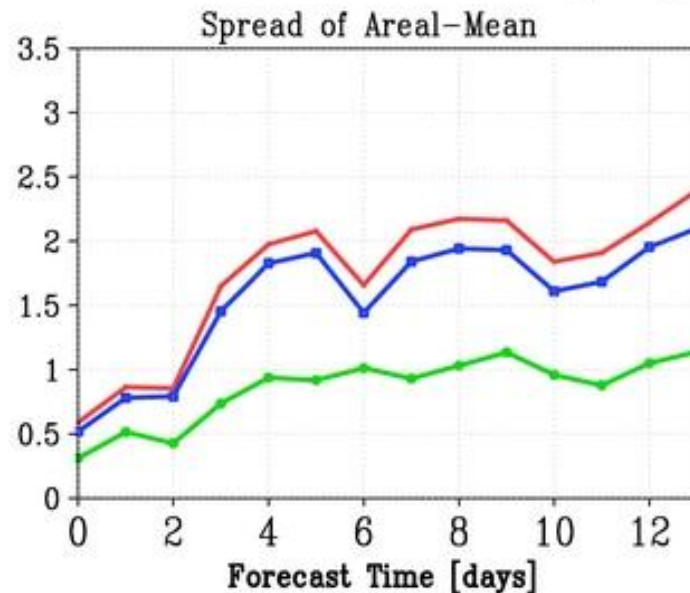
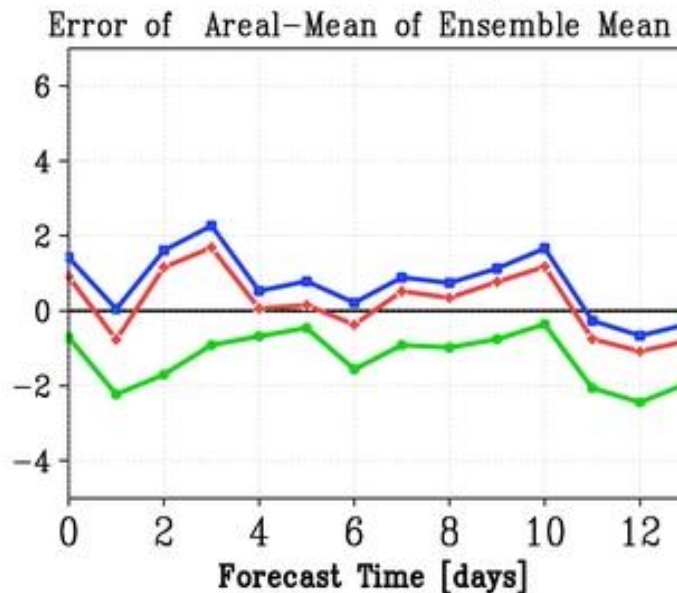
- dx=1.25°
- dx=25km
- dx=5km

# Minimum Temperature in Tohoku [°C]



- $dx=1.25^\circ$
- $dx=25\text{km}$
- $dx=5\text{km}$

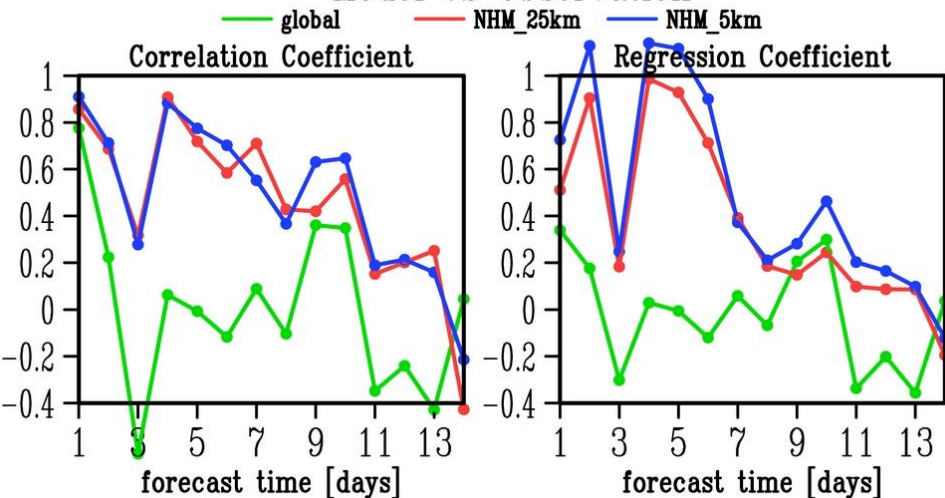
# Diurnal Range Temperature in Tohoku [°C]



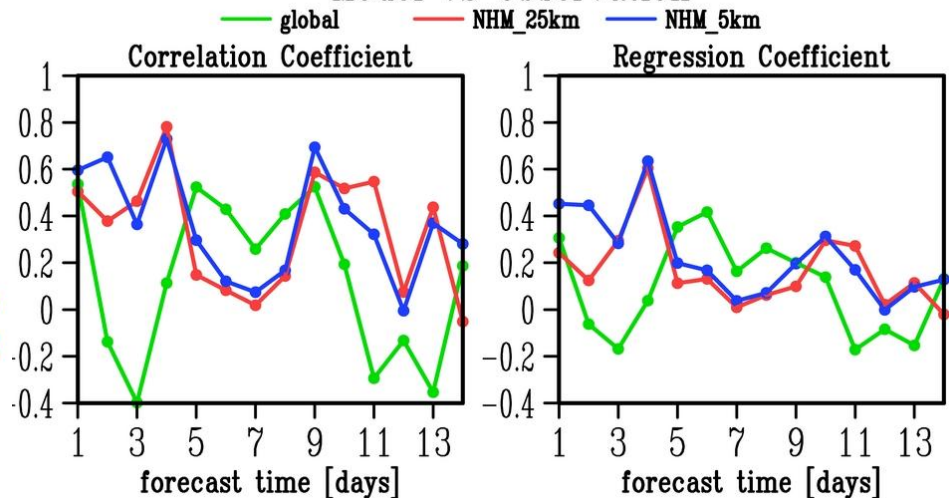
- $dx=1.25^\circ$
- $dx=25\text{km}$
- $dx=5\text{km}$



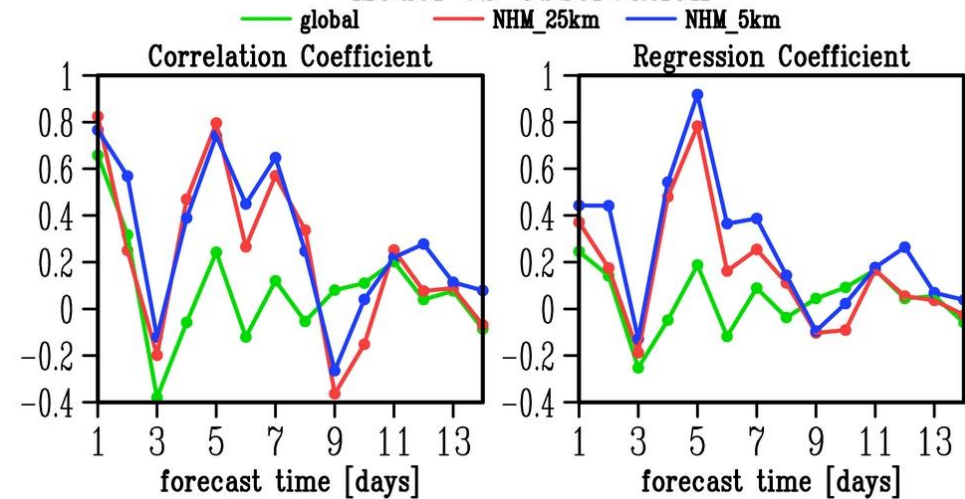
### Daily Mean Temperature Anomaly (20030620) Model VS Observation



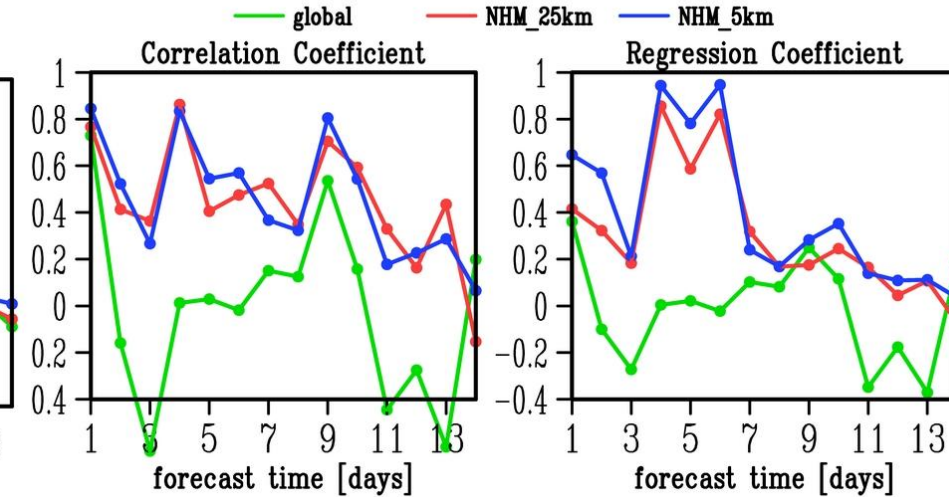
### Diurnal Temperature Range Anomaly (20030620) Model VS Observation



### Daily Minimum Temperature Anomaly (20030620) Model VS Observation

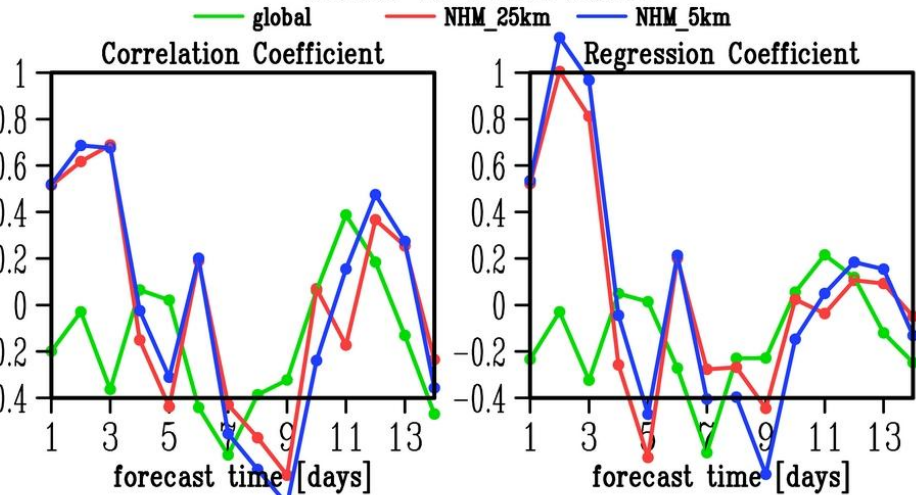


### Daily Maximum Temperature Anomaly (20030620) Model VS Observation

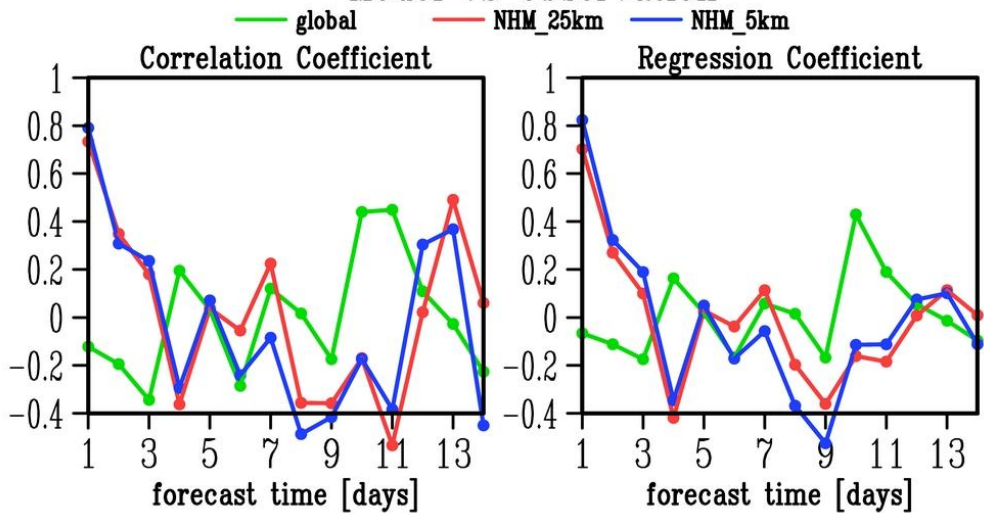




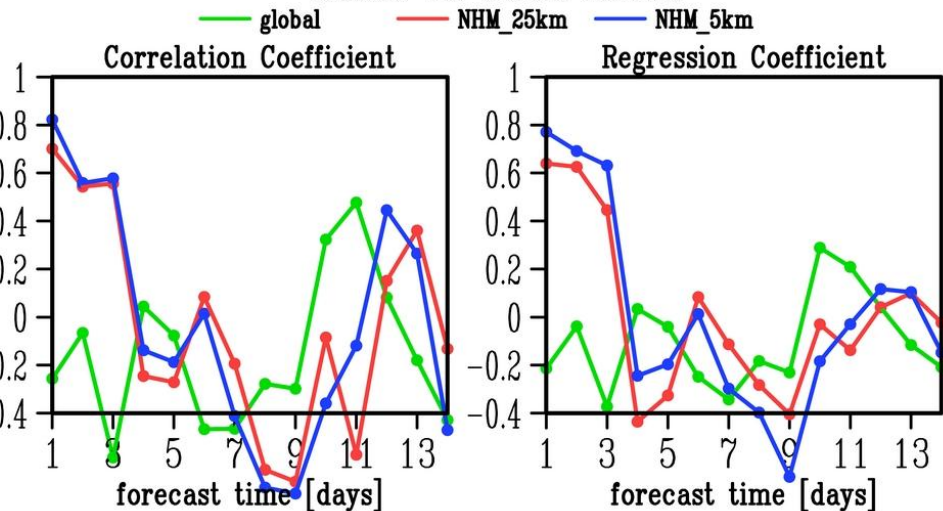
### Daily Mean Temperature Anomaly (20030630) Model VS Observation



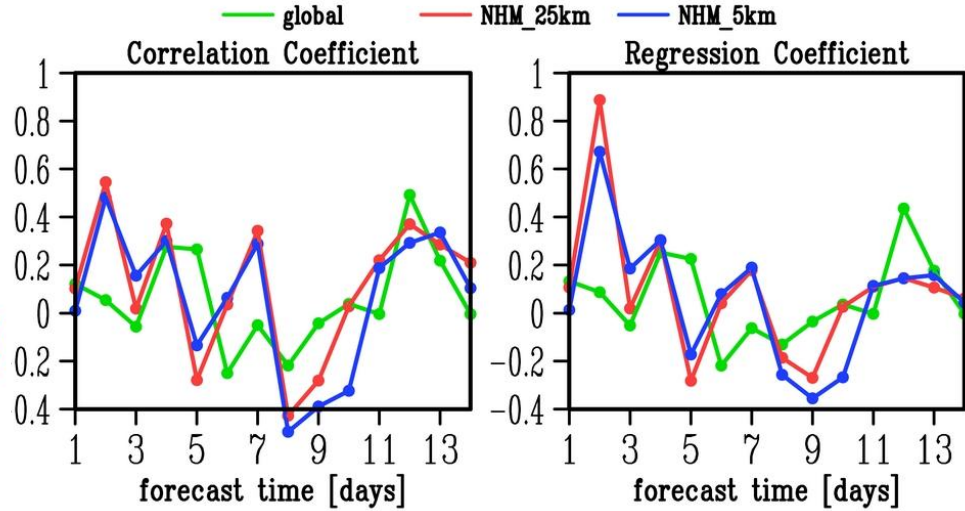
### Diurnal Temperature Range Anomaly (20030630) Model VS Observation



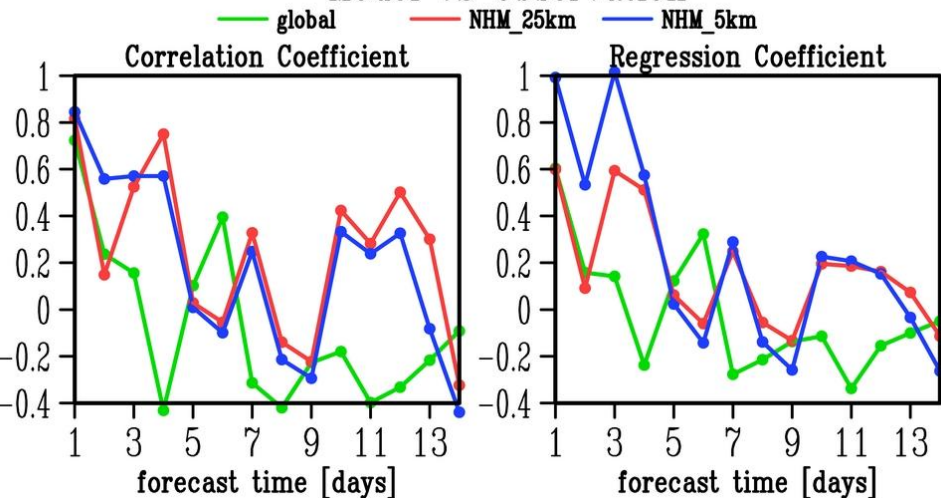
### Daily Maximum Temperature Anomaly (20030630) Model VS Observation



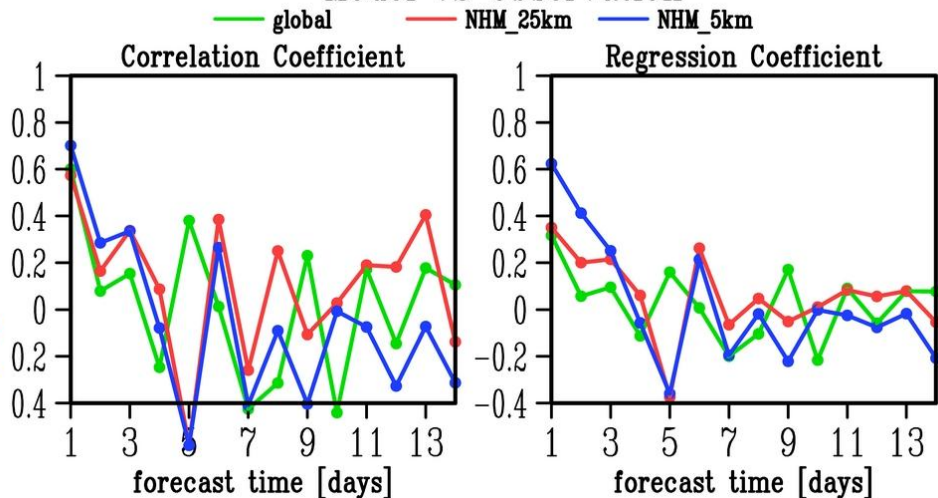
### Daily Minimum Temperature Anomaly (20030630) Model VS Observation



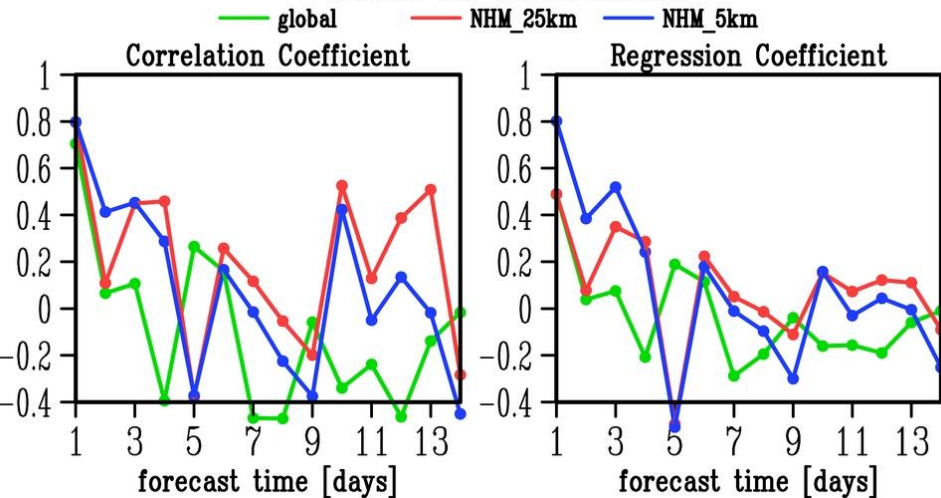
### Daily Mean Temperature Anomaly (20030710) Model VS Observation



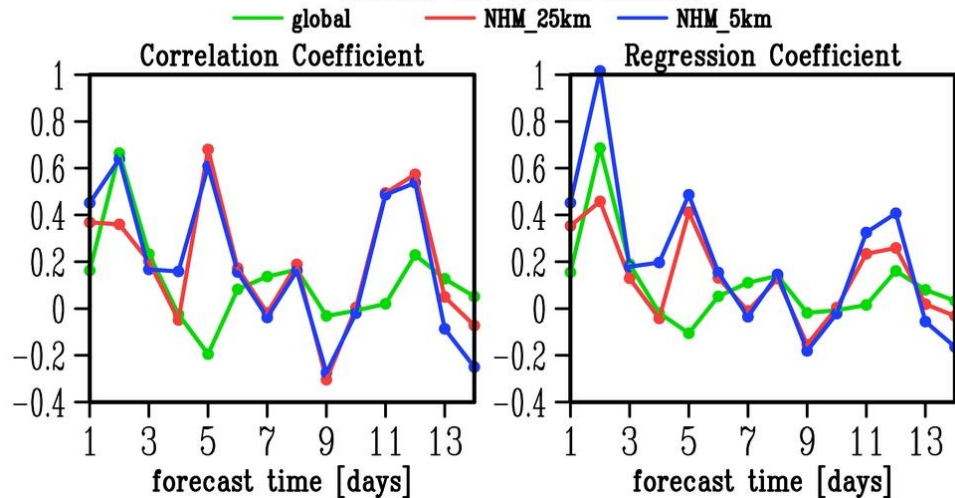
### Diurnal Temperature Range Anomaly (20030710) Model VS Observation



### Daily Maximum Temperature Anomaly (20030710) Model VS Observation



### Daily Minimum Temperature Anomaly (20030710) Model VS Observation

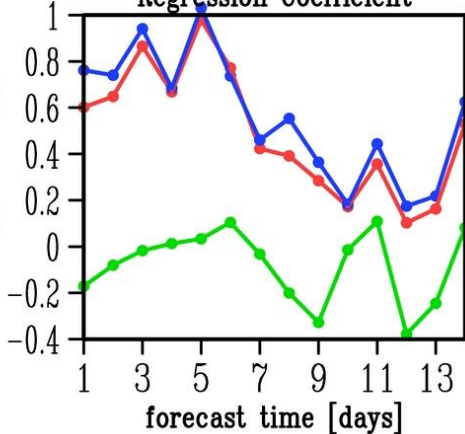
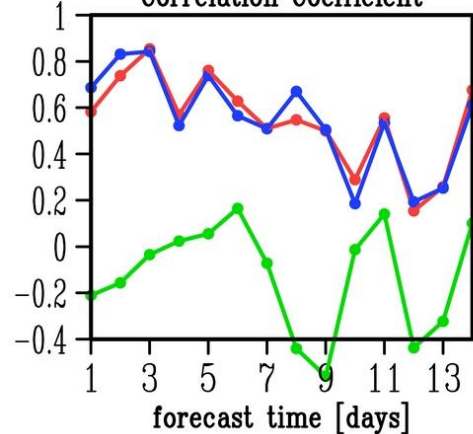


### Daily Mean Temperature Anomaly (20030720) Model VS Observation

— global — NHM\_25km — NHM\_5km

#### Correlation Coefficient

#### Regression Coefficient

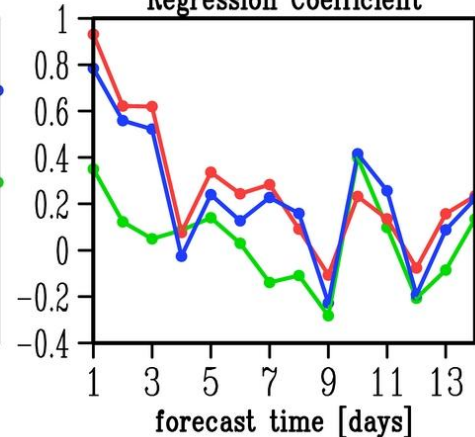
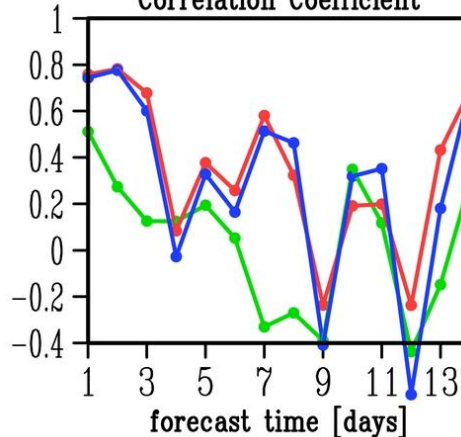


### Diurnal Temperature Range Anomaly (20030720) Model VS Observation

— global — NHM\_25km — NHM\_5km

#### Correlation Coefficient

#### Regression Coefficient

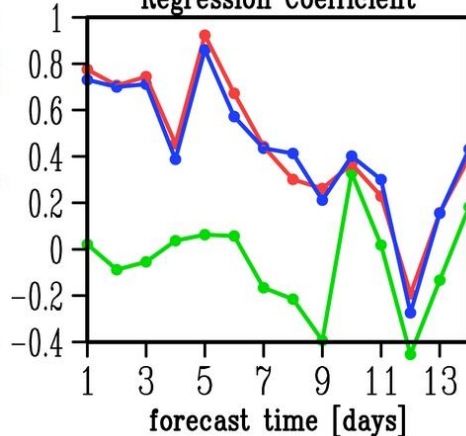
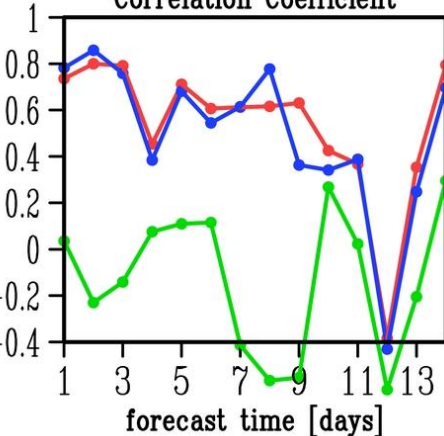


### Daily Maximum Temperature Anomaly (20030720) Model VS Observation

— global — NHM\_25km — NHM\_5km

#### Correlation Coefficient

#### Regression Coefficient

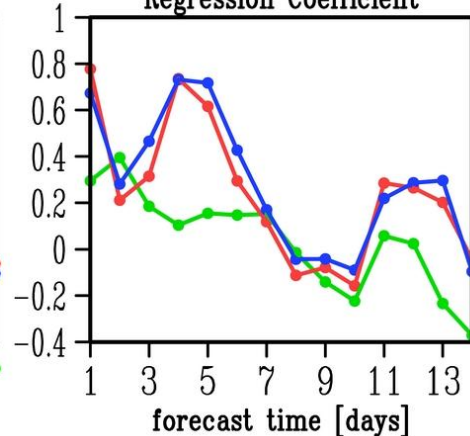
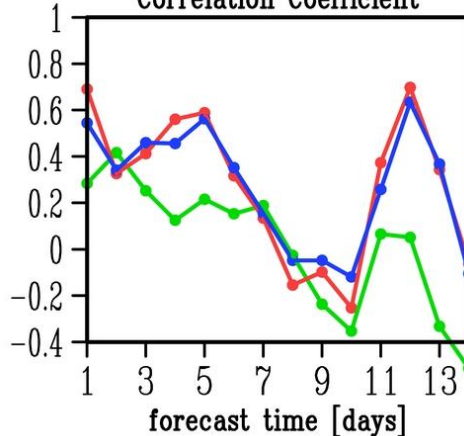


### Daily Minimum Temperature Anomaly (20030720) Model VS Observation

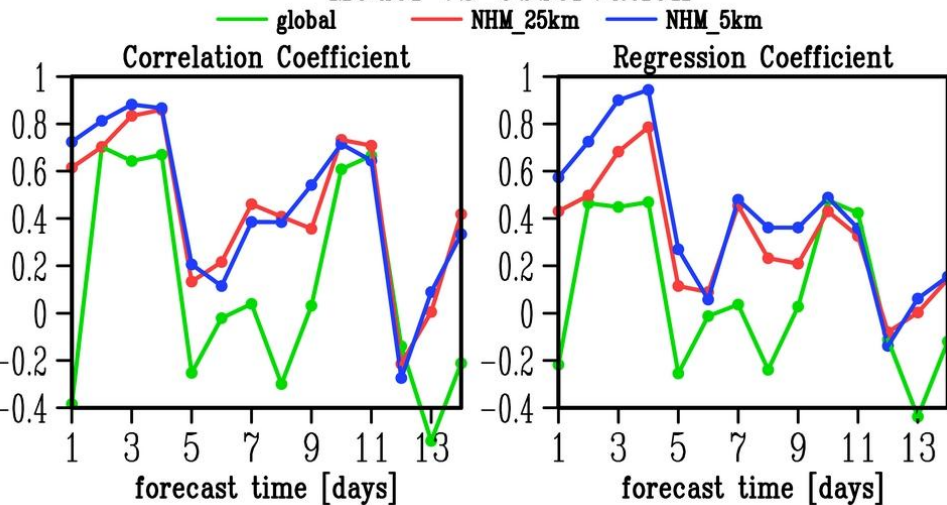
— global — NHM\_25km — NHM\_5km

#### Correlation Coefficient

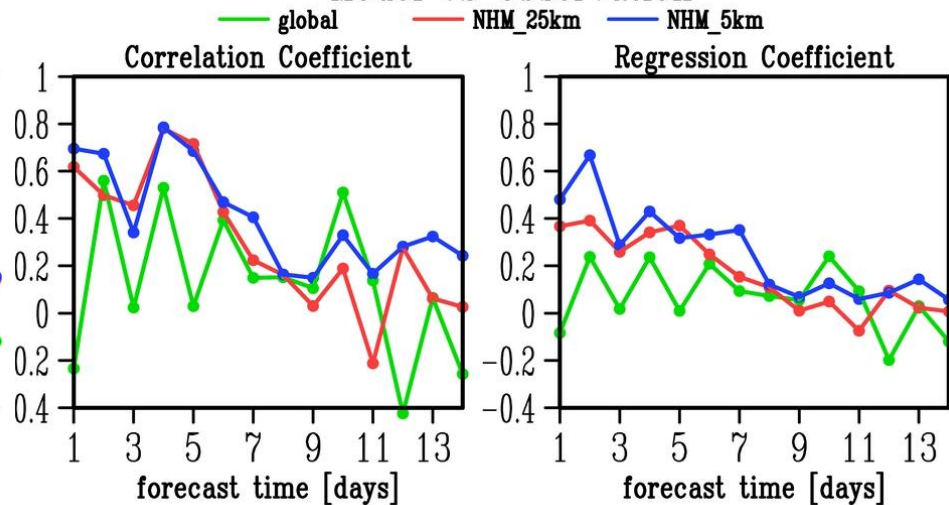
#### Regression Coefficient



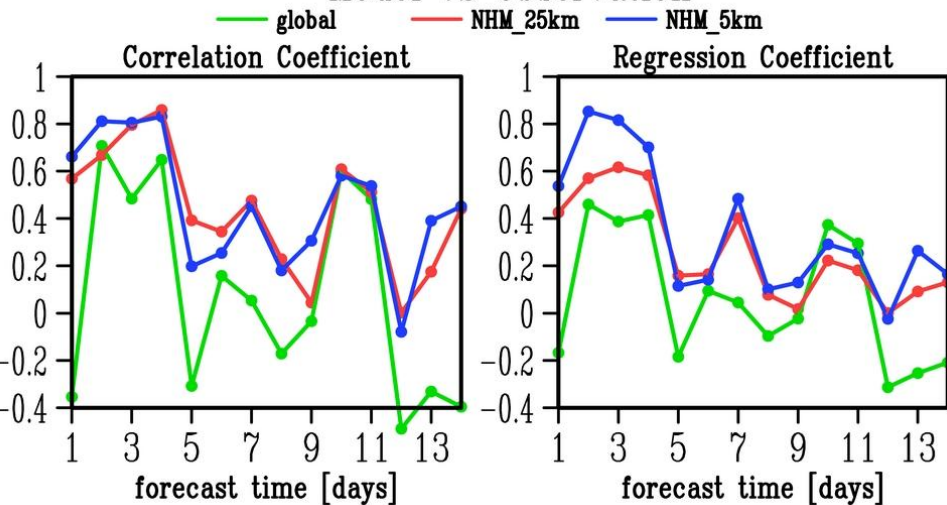
### Daily Mean Temperature Anomaly (20040620) Model VS Observation



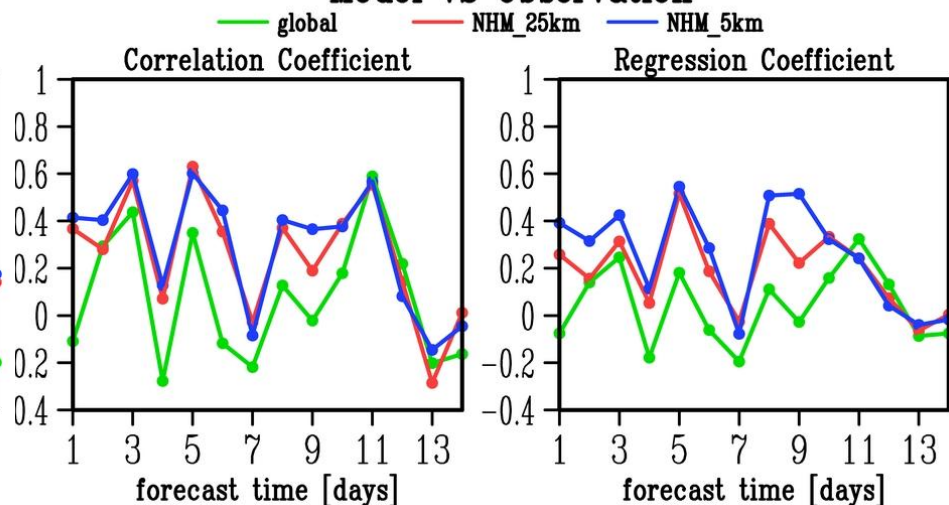
### Diurnal Temperature Range Anomaly (20040620) Model VS Observation



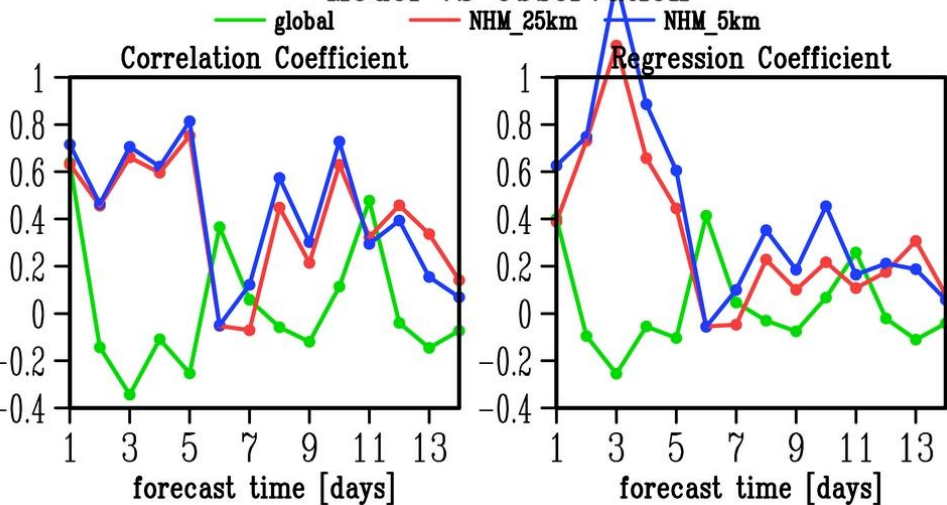
### Daily Maximum Temperature Anomaly (20040620) Model VS Observation



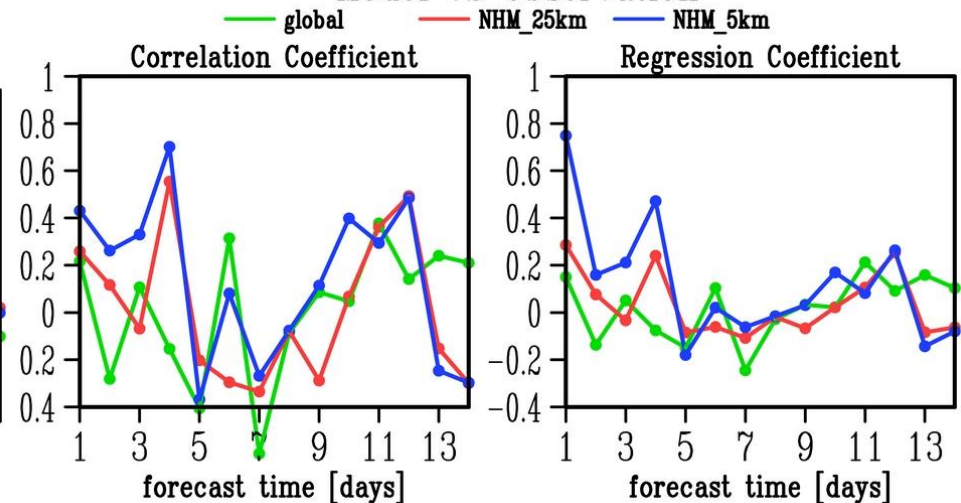
### Daily Minimum Temperature Anomaly (20040620) Model VS Observation



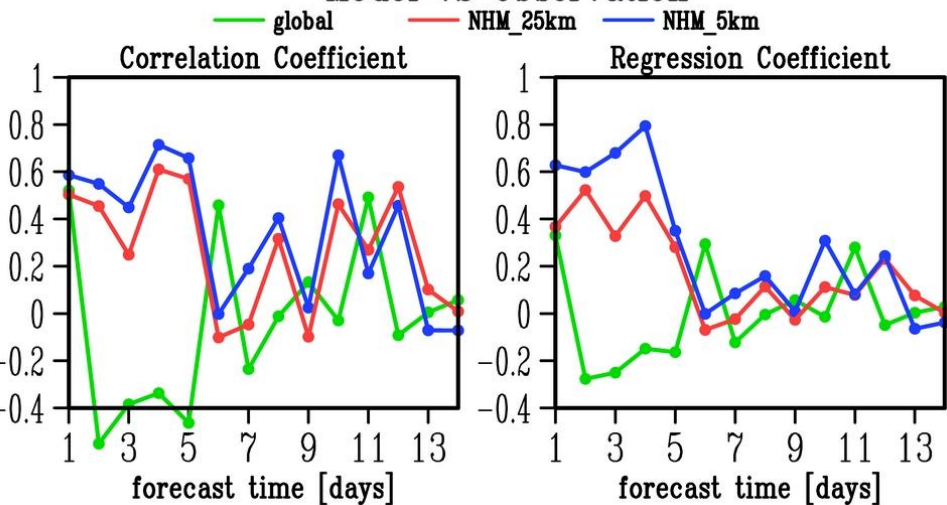
### Daily Mean Temperature Anomaly (20040630) Model VS Observation



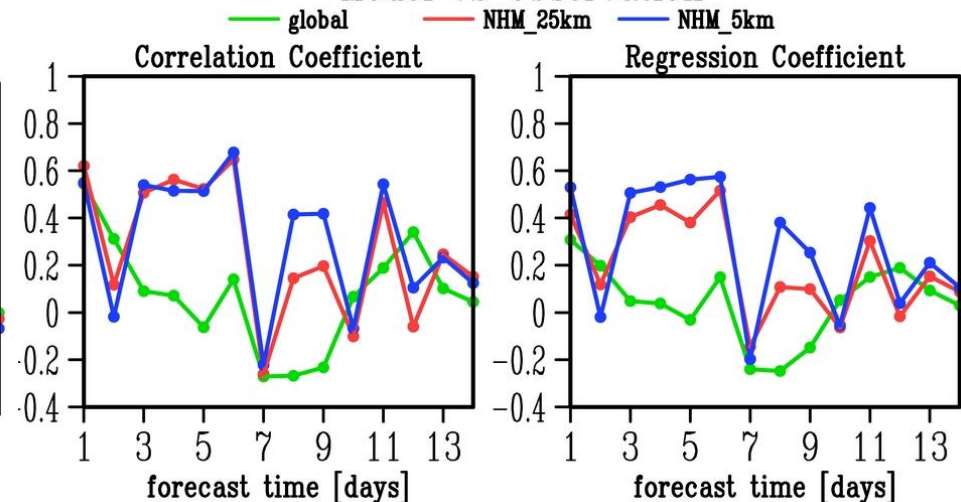
### Diurnal Temperature Range Anomaly (20040630) Model VS Observation



### Daily Maximum Temperature Anomaly (20040630) Model VS Observation

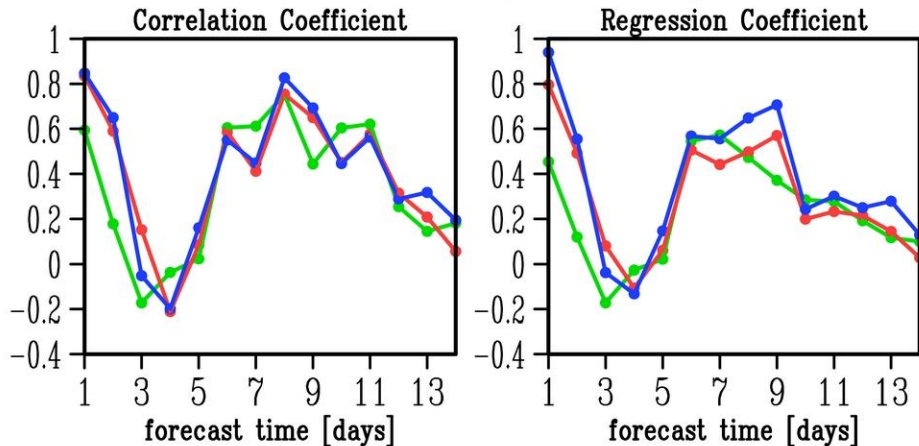


### Daily Minimum Temperature Anomaly (20040630) Model VS Observation



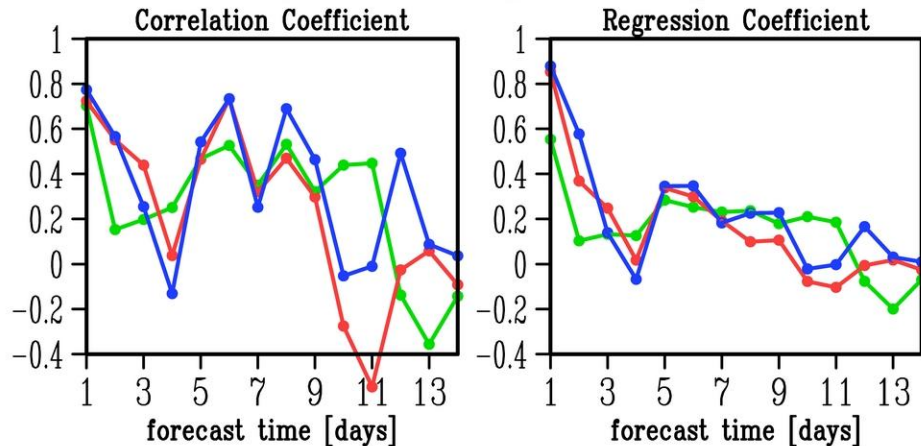
### Daily Mean Temperature Anomaly (20040710) Model VS Observation

— global — NHM\_25km — NHM\_5km



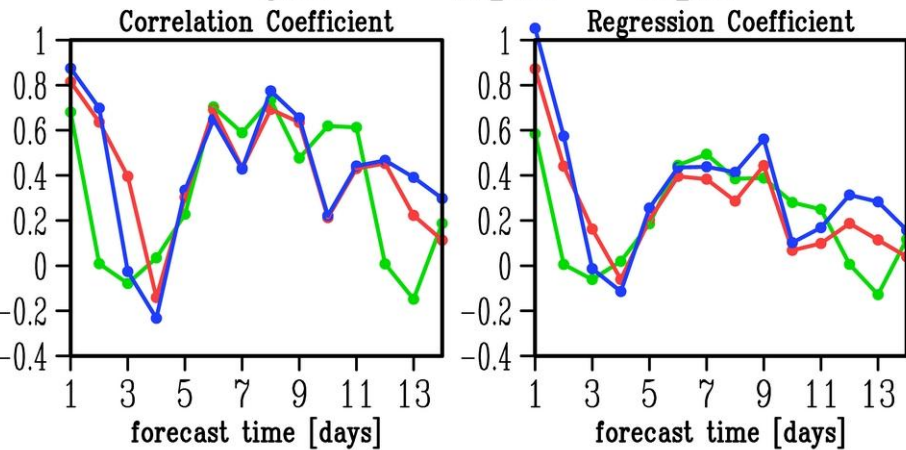
### Diurnal Temperature Range Anomaly (20040710) Model VS Observation

— global — NHM\_25km — NHM\_5km



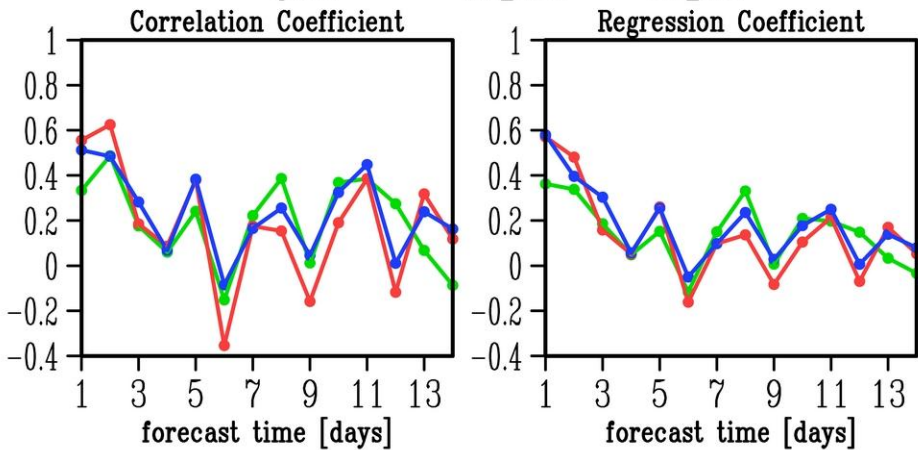
### Daily Maximum Temperature Anomaly (20040710) Model VS Observation

— global — NHM\_25km — NHM\_5km

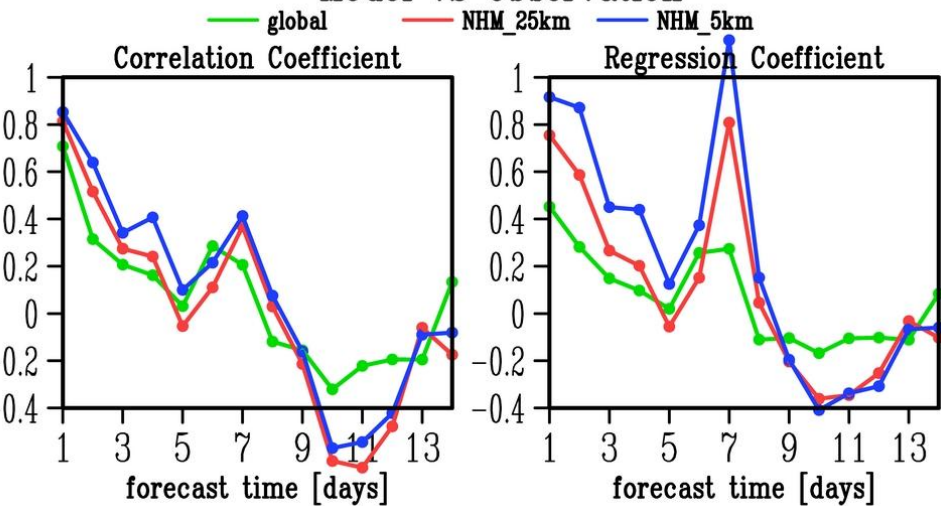


### Daily Minimum Temperature Anomaly (20040710) Model VS Observation

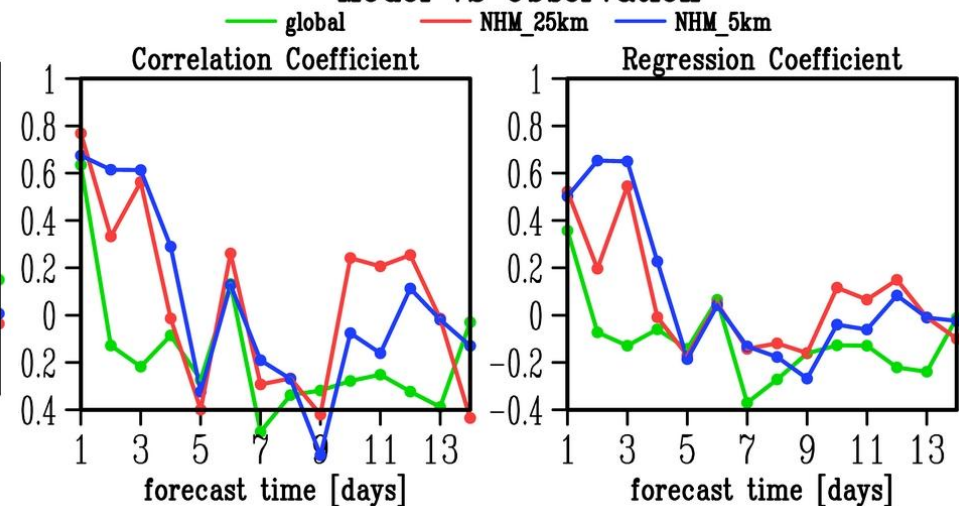
— global — NHM\_25km — NHM\_5km



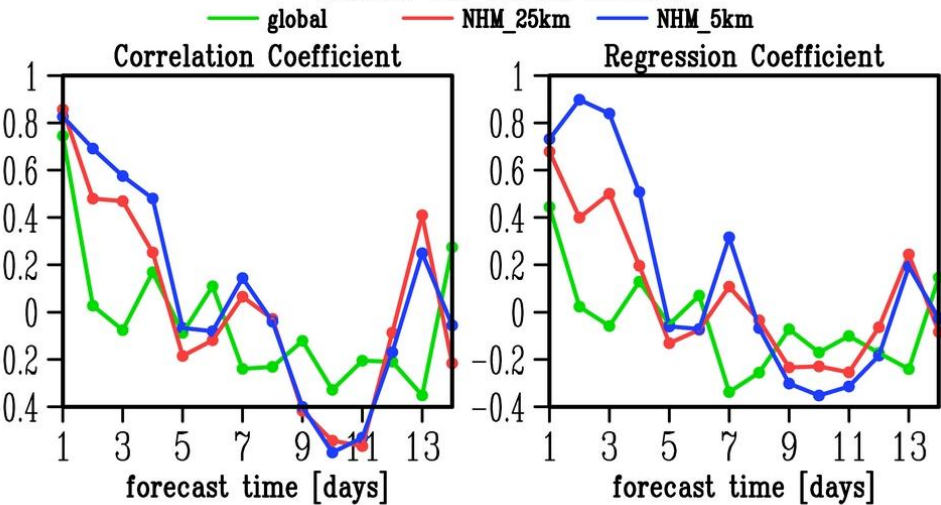
### Daily Mean Temperature Anomaly (20040720) Model VS Observation



### Diurnal Temperature Range Anomaly (20040720) Model VS Observation



### Daily Maximum Temperature Anomaly (20040720) Model VS Observation



### Daily Minimum Temperature Anomaly (20040720) Model VS Observation

