# Error growth on intra-daily timescales

# The importance of the daily cycle in variability

**Åke Johansson**
**SMHI**

# Error growth

In chaotic systems the uncertainty in a forecast increases ***exponentially*** with time.

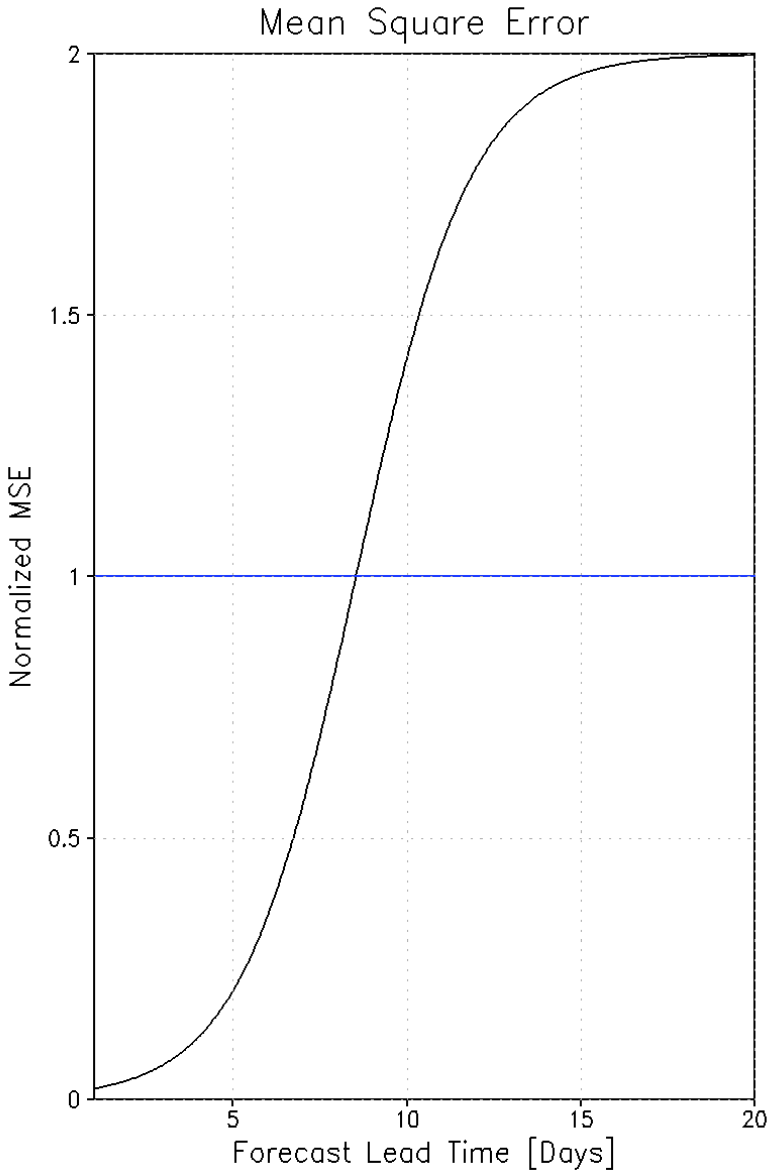
However, the uncertainty can not grow for ever and have an upper limit which is equal to the difference between two random states.

Lorenz proposed as a prototype error growth model a logistic curve

$$y = \frac{e^t}{e^t + 1}$$

which has been found very appropriate for NWP.

# Logistic equation error growth

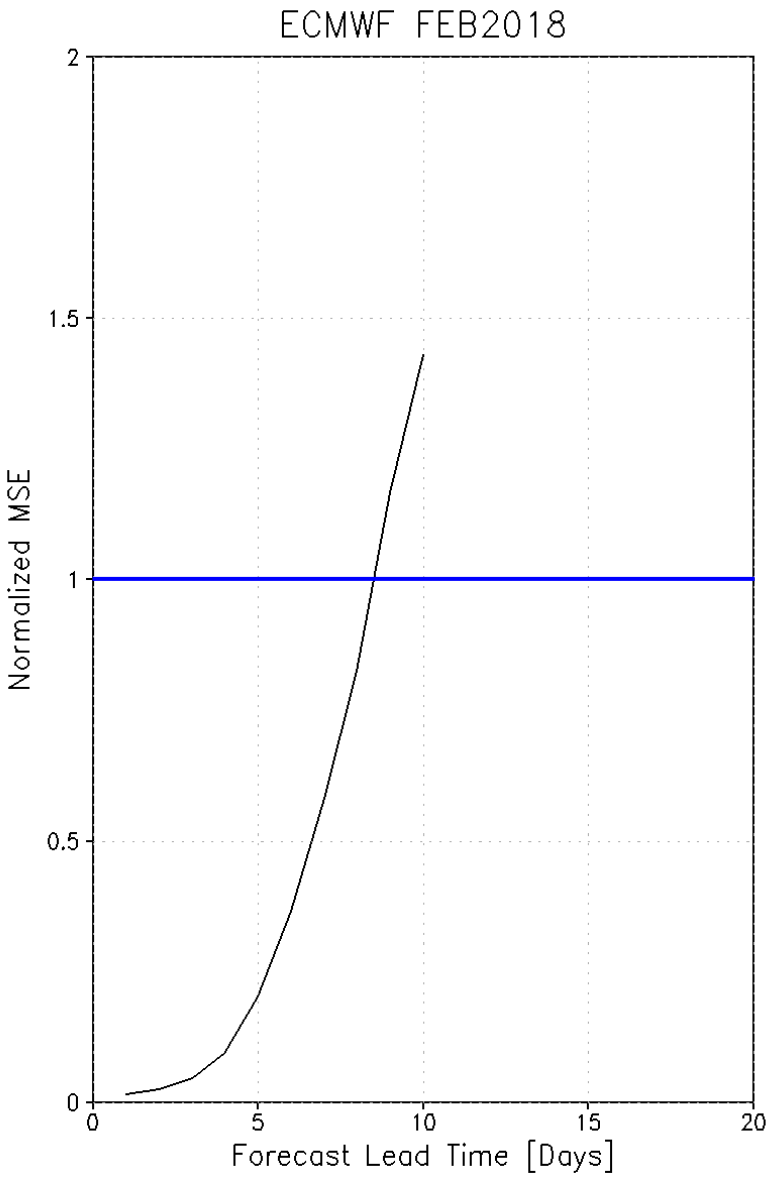



**Two parameters**

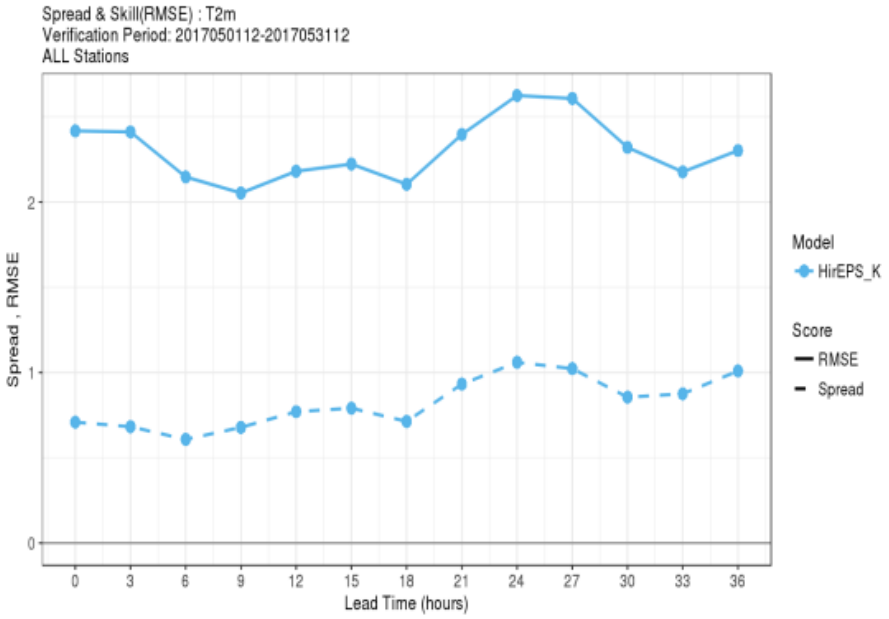
- **Growth rate**
- **Initial error**

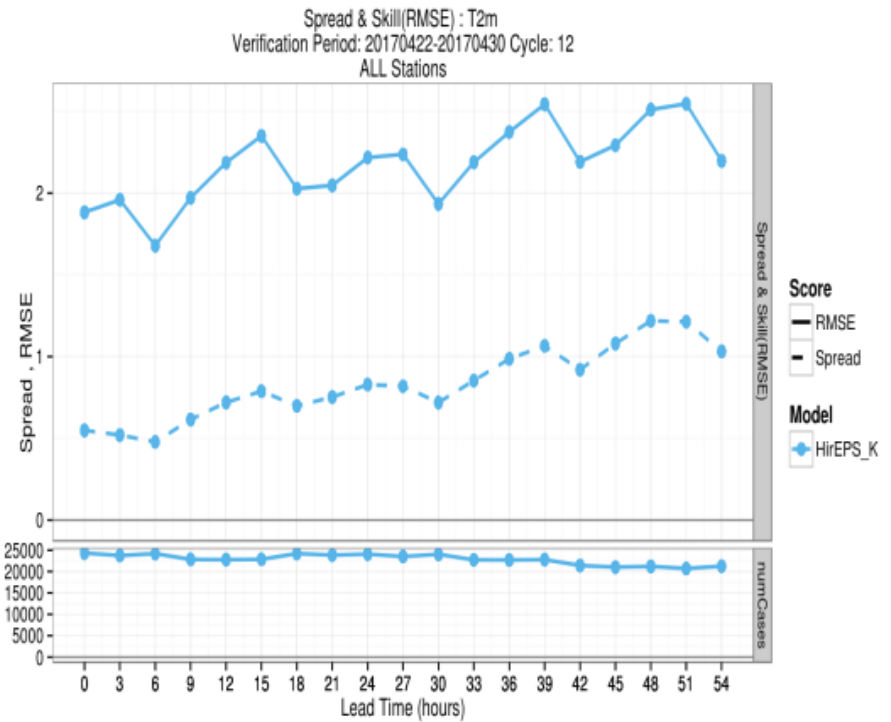
# Real NWP error growth

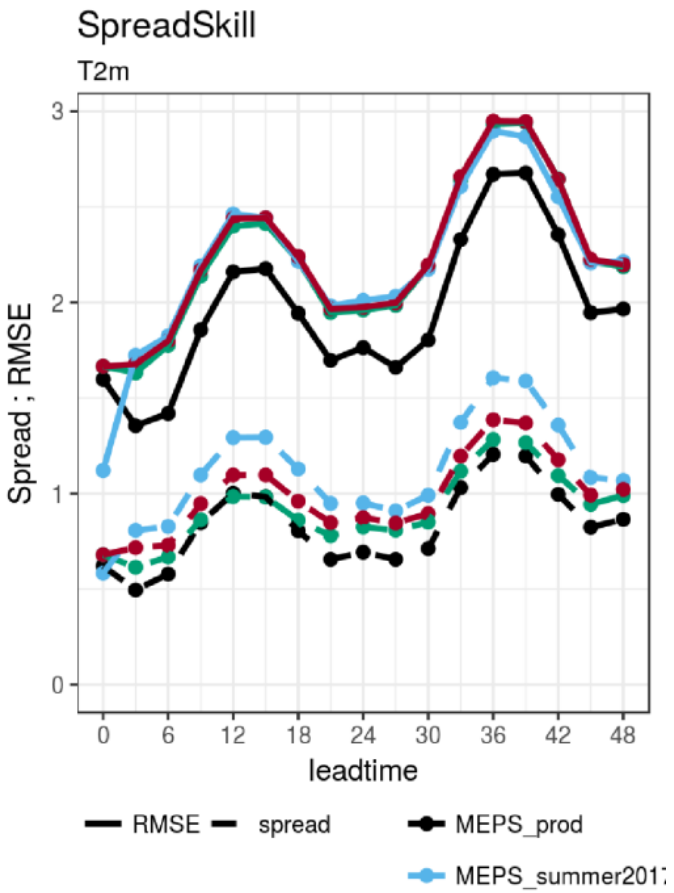
**ECMWF HRES**




**Z500 NHEM ET 00 UTC FEB2018 Against Obs 24 48 .. 240**


Spread & Skill(RMSE) : T2m
Verification Period: 20170501 12-2017053112
ALL Stations
Spread , RMSE
Lead Time (hours)
Model
HirEPS_K
Score
RMSE
Spread


Spread & Skill(RMSE) : T2m
Verification Period: 20170422-20170430 Cycle: 12
ALL Stations
Spread , RMSE
Spread & Skill(RMSE)
numCases
Lead Time (hours)
Score
RMSE
Spread
Model
HirEPS_K


SpreadSkill
T2m
Spread ; RMSE
leadtime
RMSE
spread
MEPS_prod
MEPS_summer201

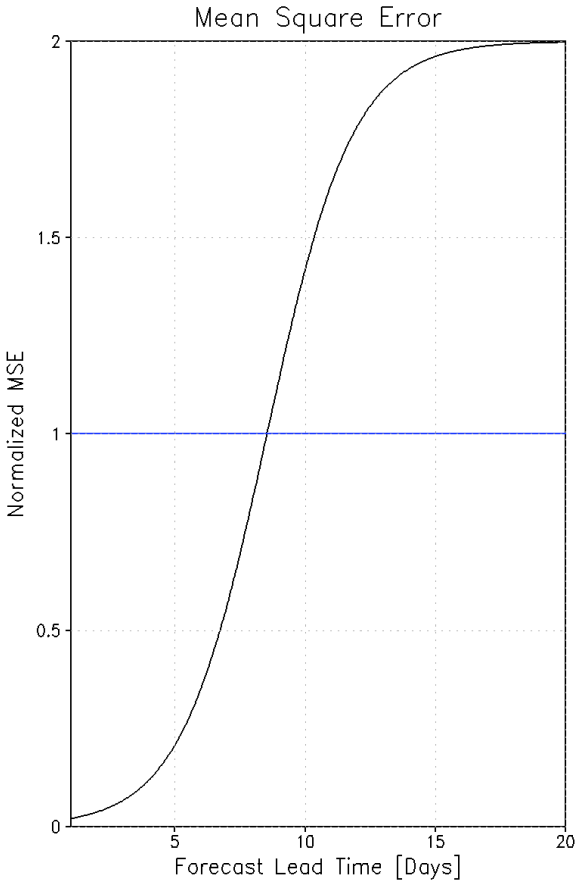
# Hypothesis

The error at the verification time is scaled by the climatological variance at this specific point in the

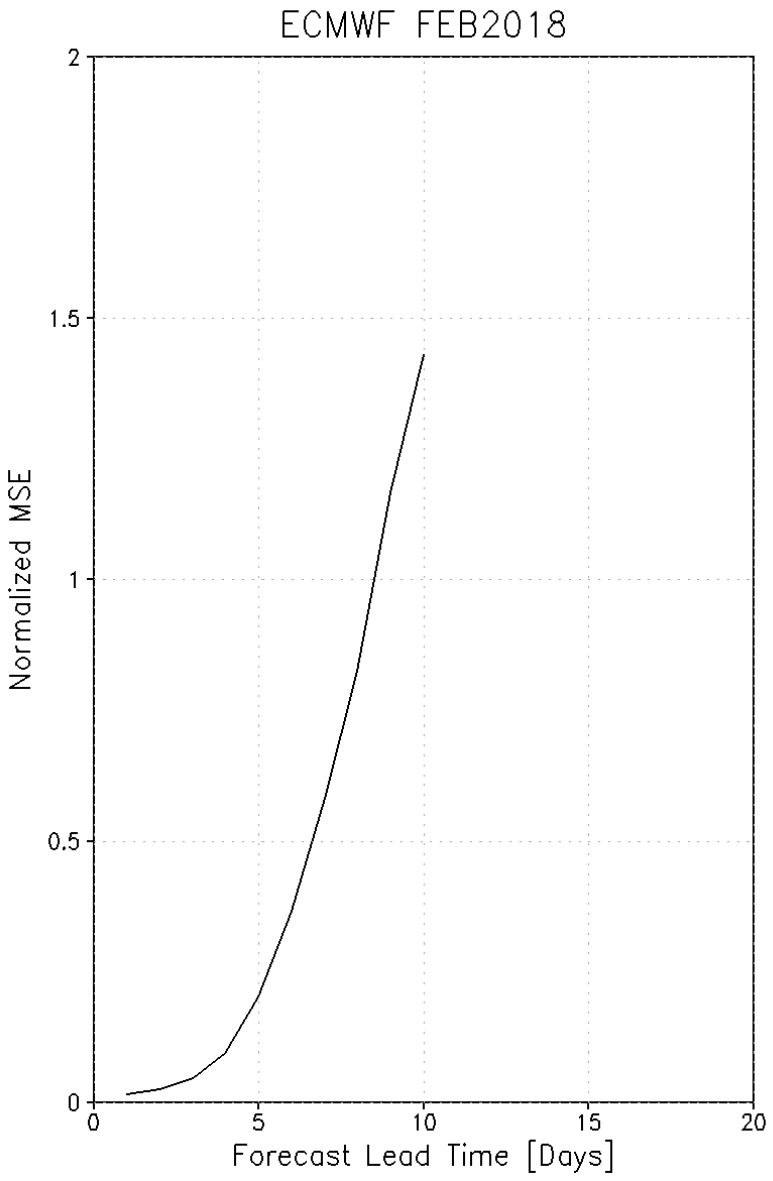
- Yearly cycle
- Daily cycle

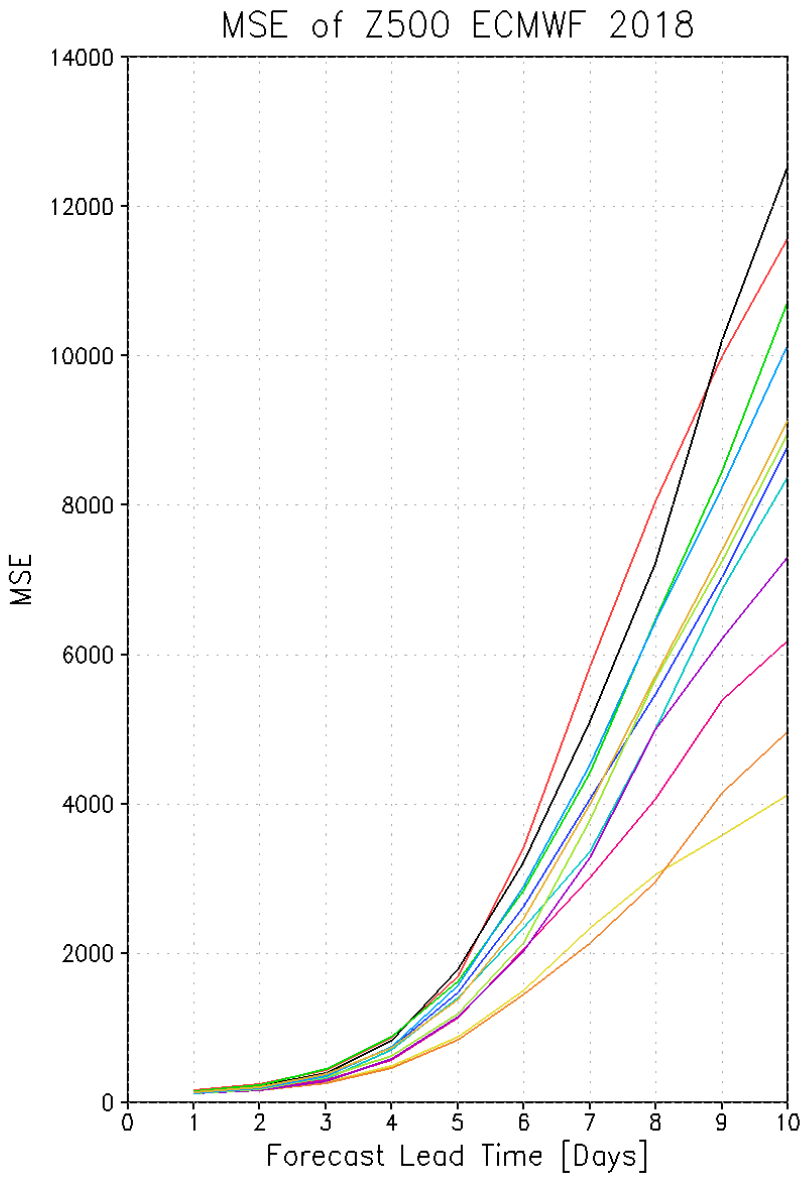
# The saturation value varies with

- Time of year
- Time of day



# ECMWF error growth



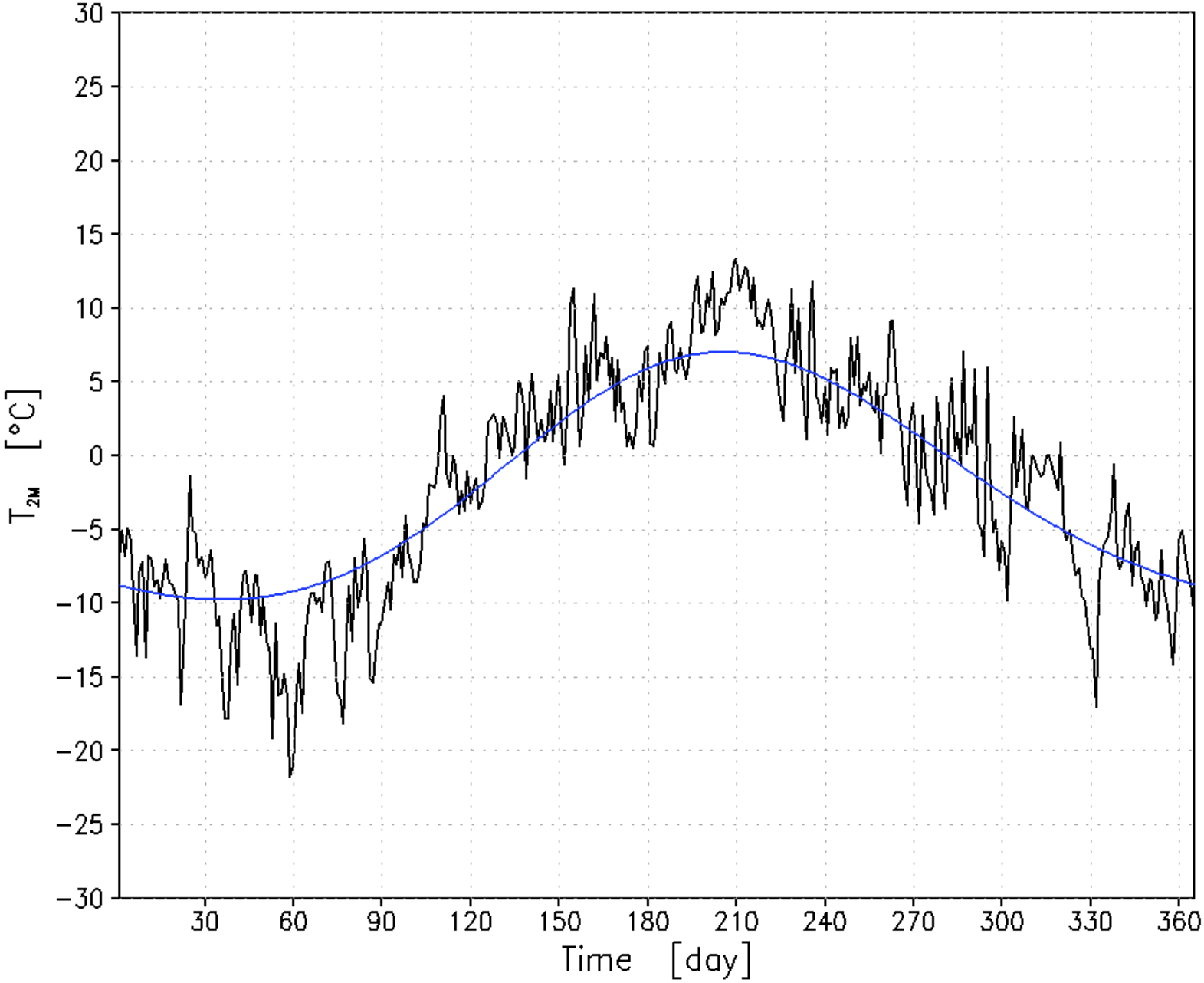



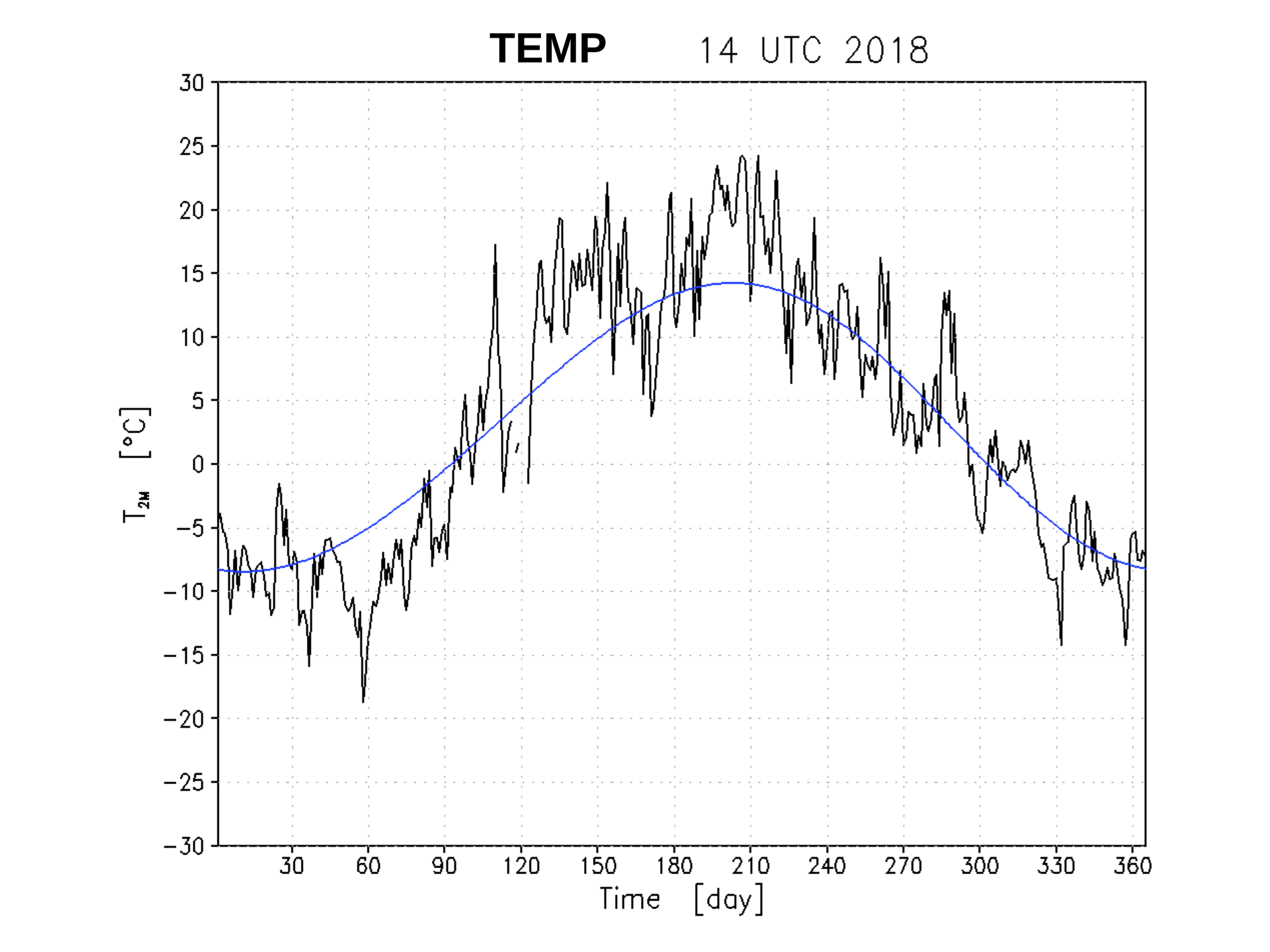
# Variability in the Atmosphere

- Yearly Cycle
- Daily Cycle
- ”Weather”

# Length of a Year

| | |
|---|---|
| Tropical year | 365.24219 days |
| Anomalistic year | 365.25964 days |


TEMP
00 UTC 2018
30
25
20
15
10
5
0
−5
−10
−15
−20
−25
−30
T2M [°C]
30
60
90
120
150
180
210
240
270
300
330
360
Time [day]


TEMP
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T2M [°C]
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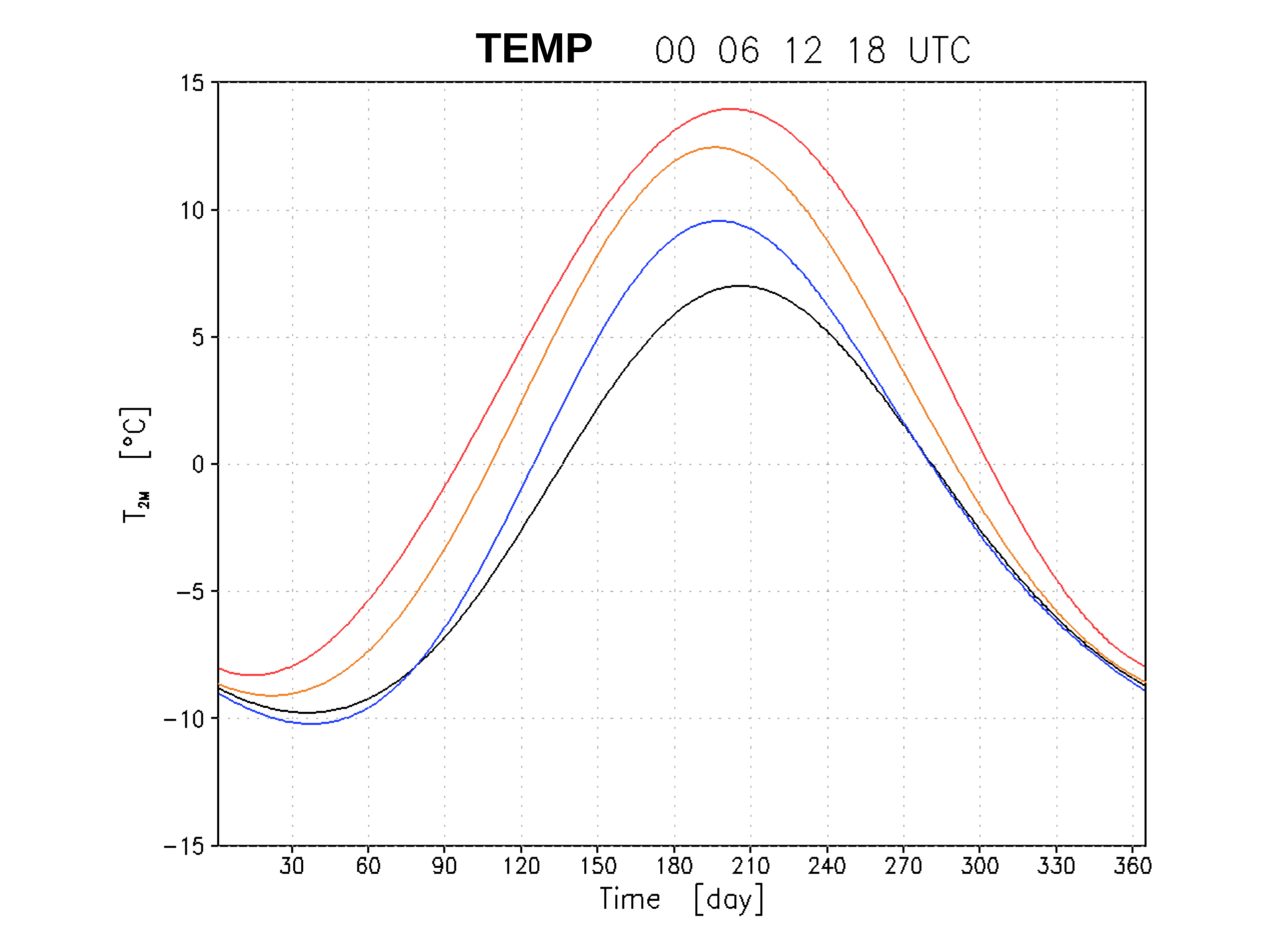
Time [day]


TEMP
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T2M [°C]
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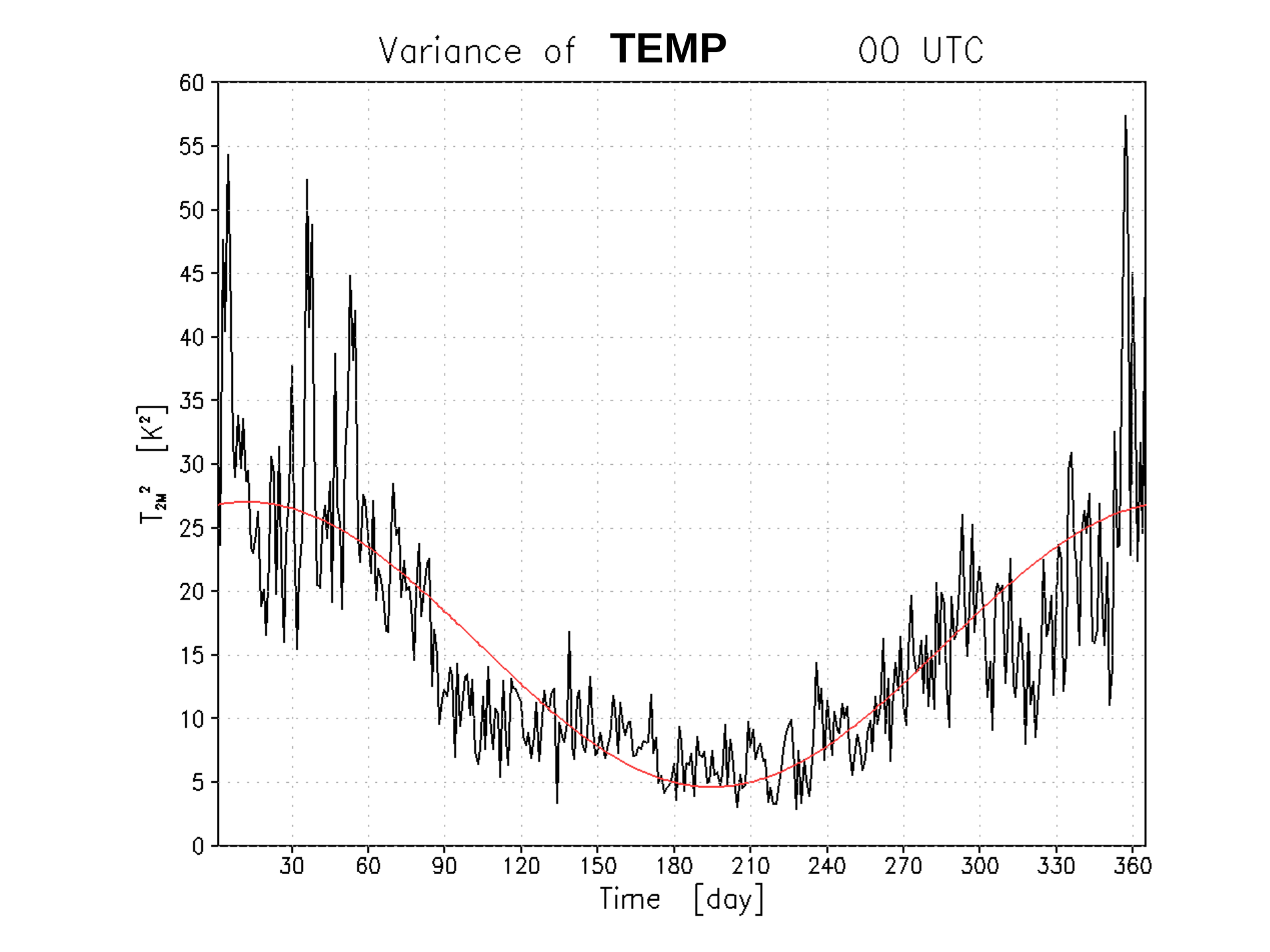
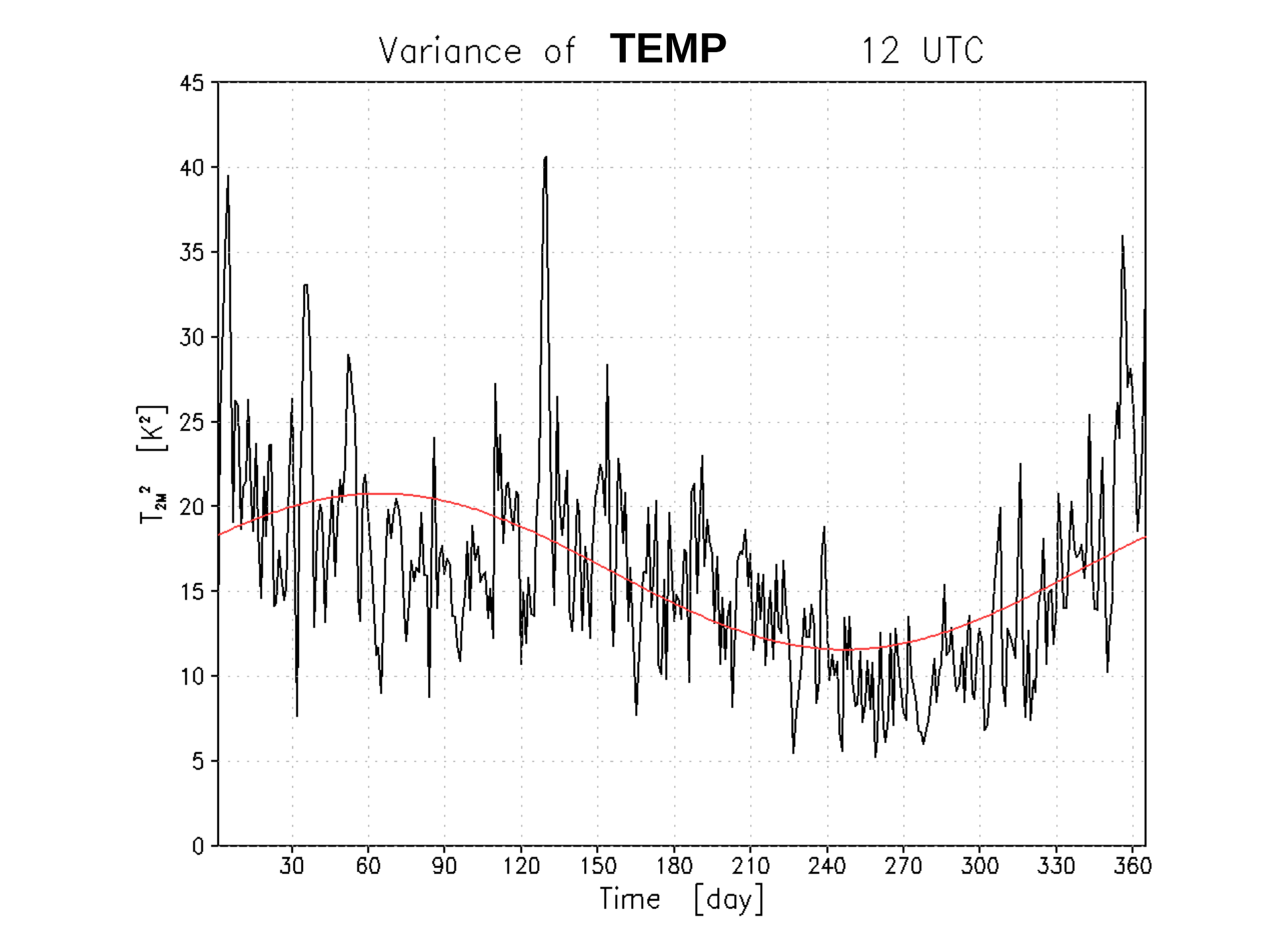
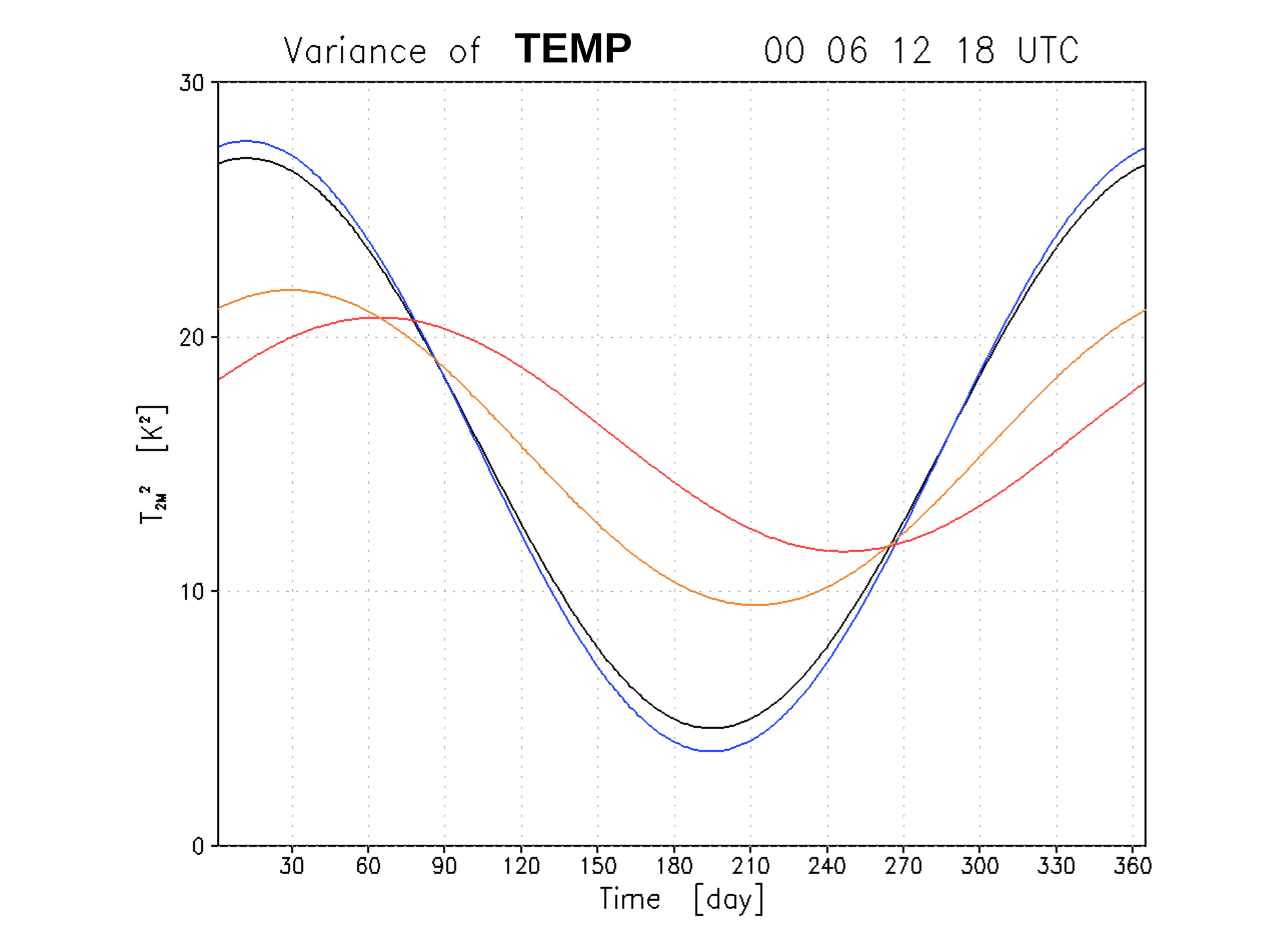
Time [day]


Variance of TEMP 00 UTC
60
55
50
45
40
35
30
25
20
15
10
5
0
$T_{2M}^2$ [K²]
30
60
90
120
150
180
210
240
270
300
330
360
Time [day]


Variance of TEMP 12 UTC
45
40
35
30
25
20
15
10
5
0
$T_{2M}^2$ [K²]
30
60
90
120
150
180
210
240
270
300
330
360
Time [day]


Variance of TEMP
00 06 12 18 UTC
30
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$T_{2M}^2$ [K²]
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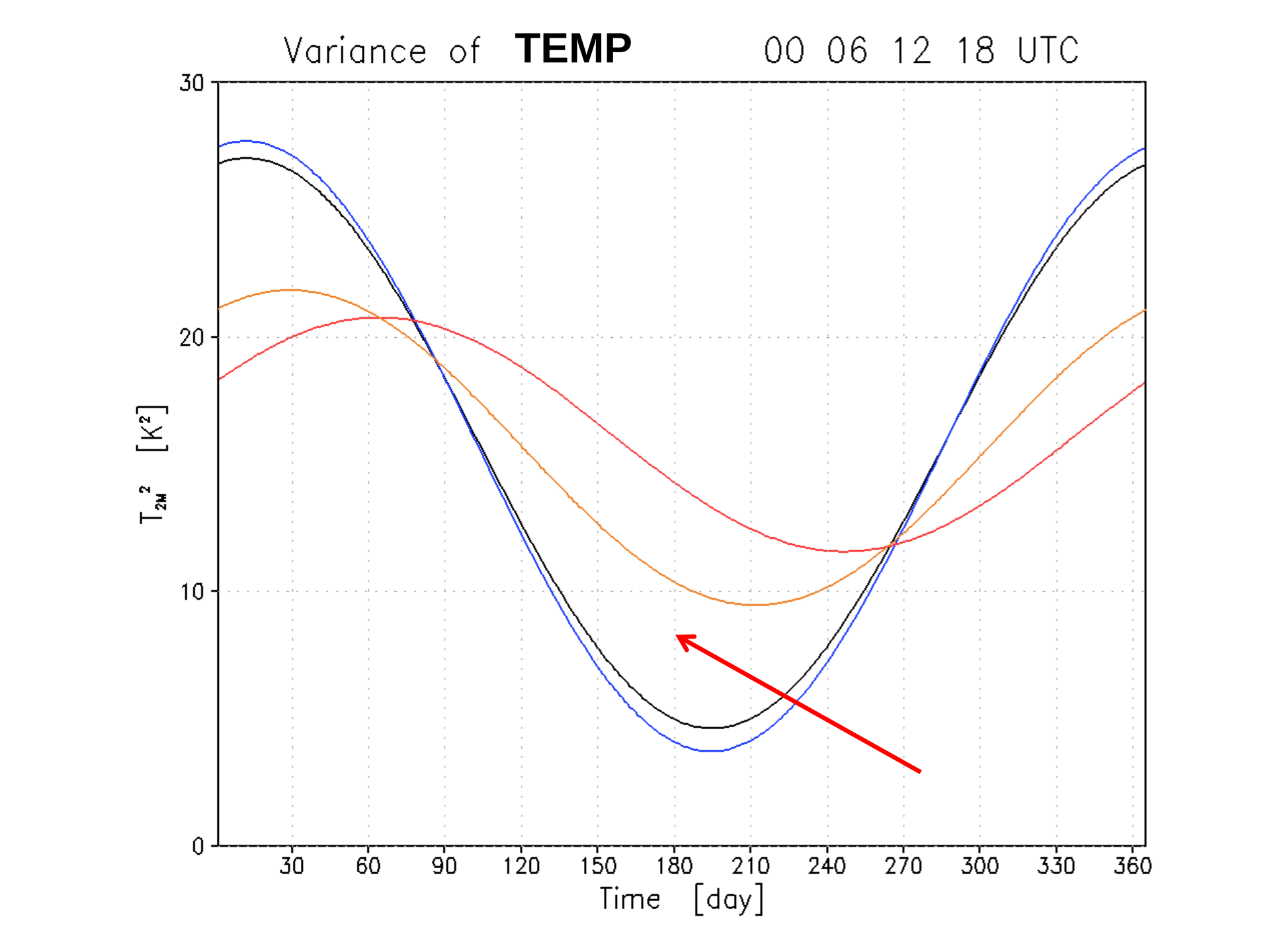
330
360
Time [day]


Variance of TEMP
00 06 12 18 UTC
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$T_{2M}^2$ [K²]
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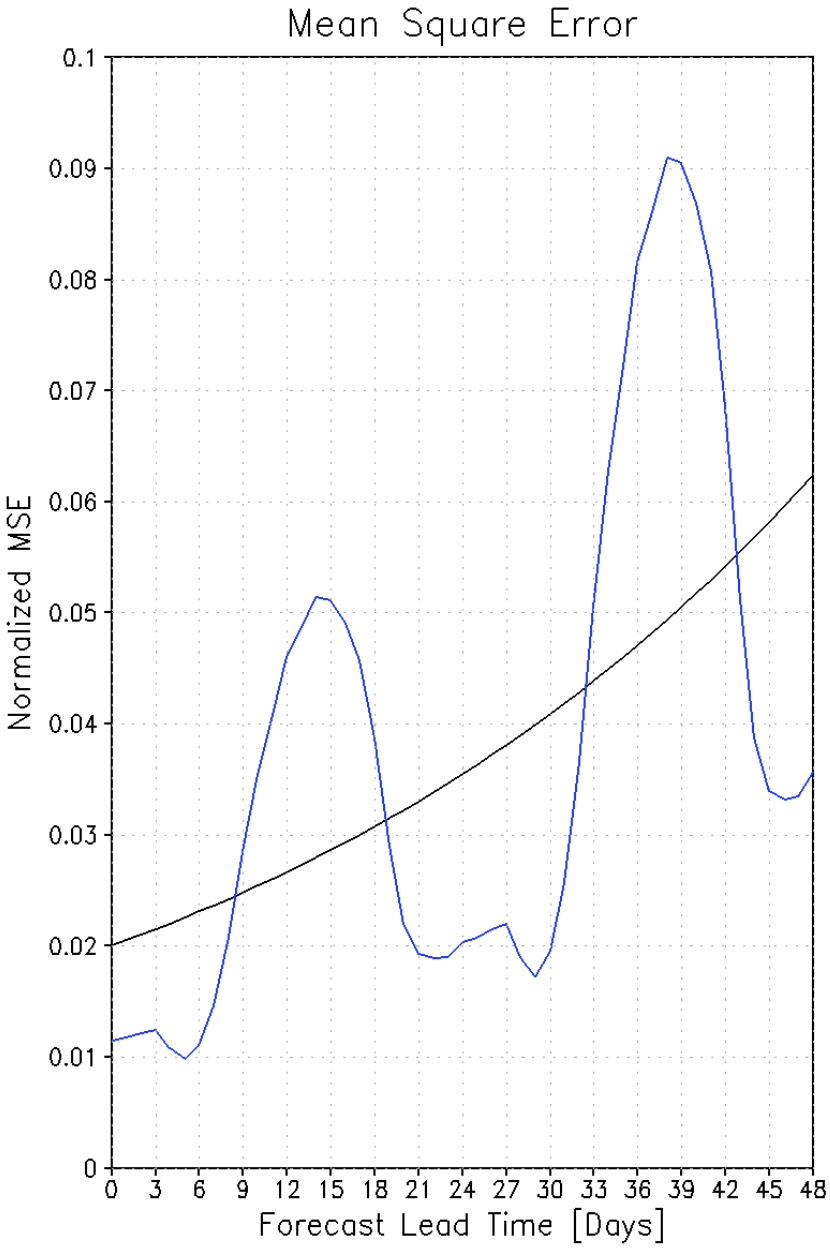
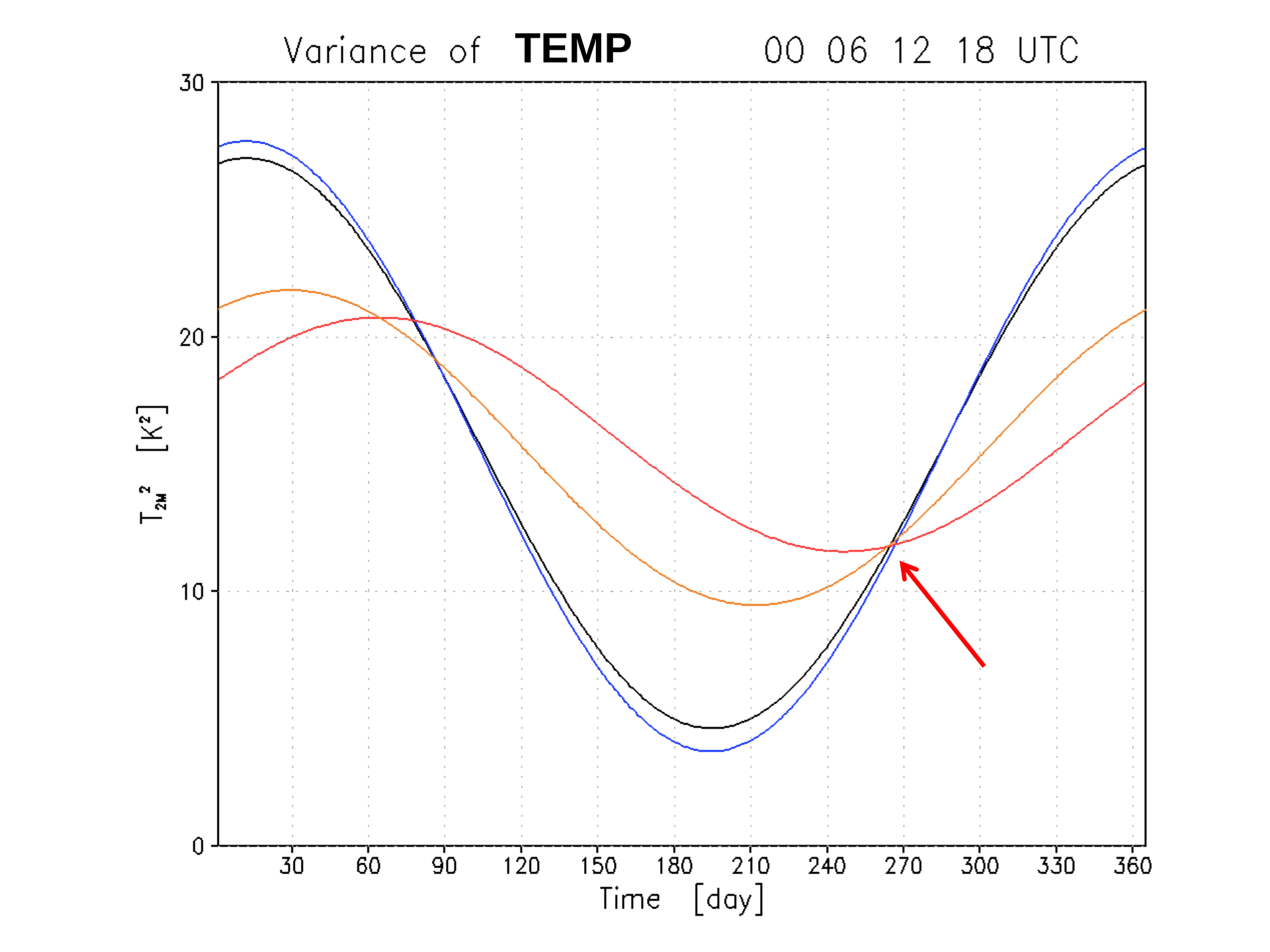
Time [day]


Mean Square Error
Normalized MSE
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
Forecast Lead Time [Days]

1 JUL


Variance of TEMP
00 06 12 18 UTC
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$T_{2M}^2$ [K²]
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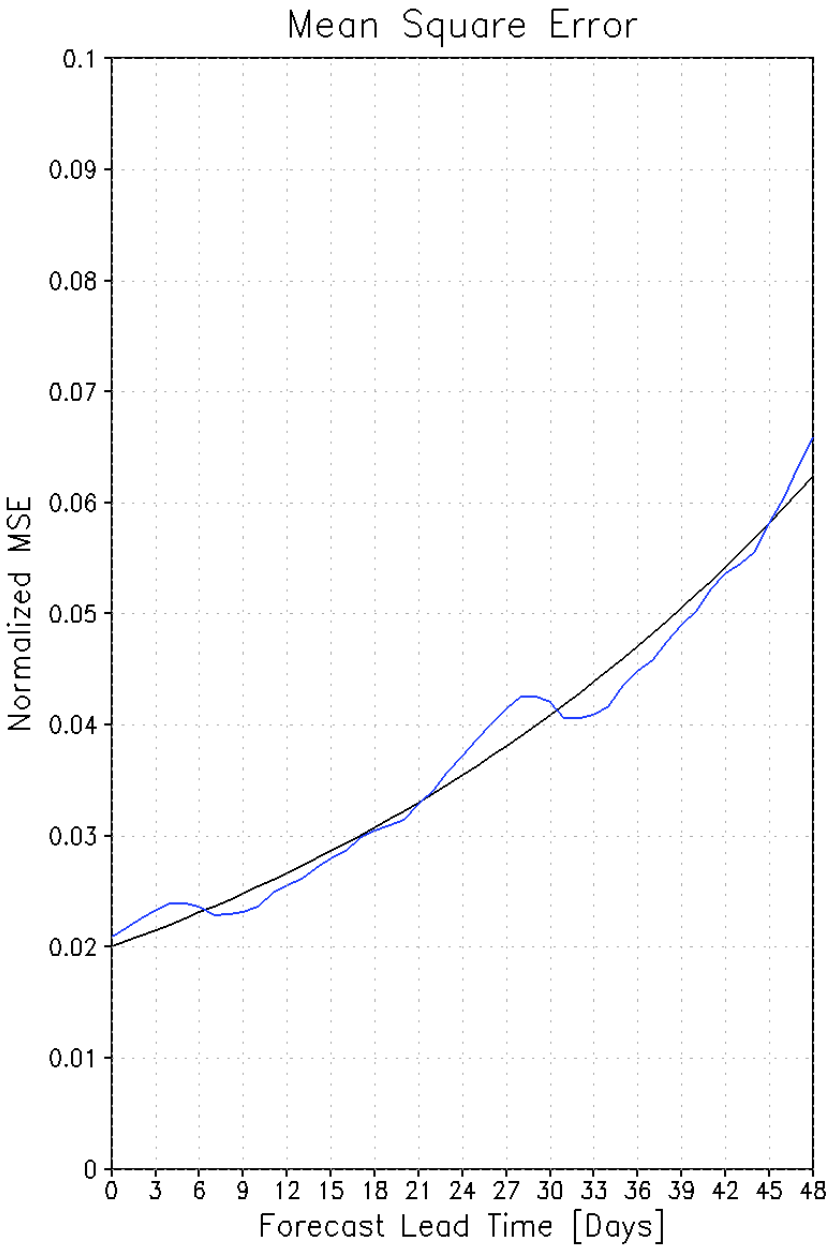
Time [day]


Mean Square Error
Normalized MSE
0.1
0.09
0.08
0.07
0.06
0.05
0.04
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0.02
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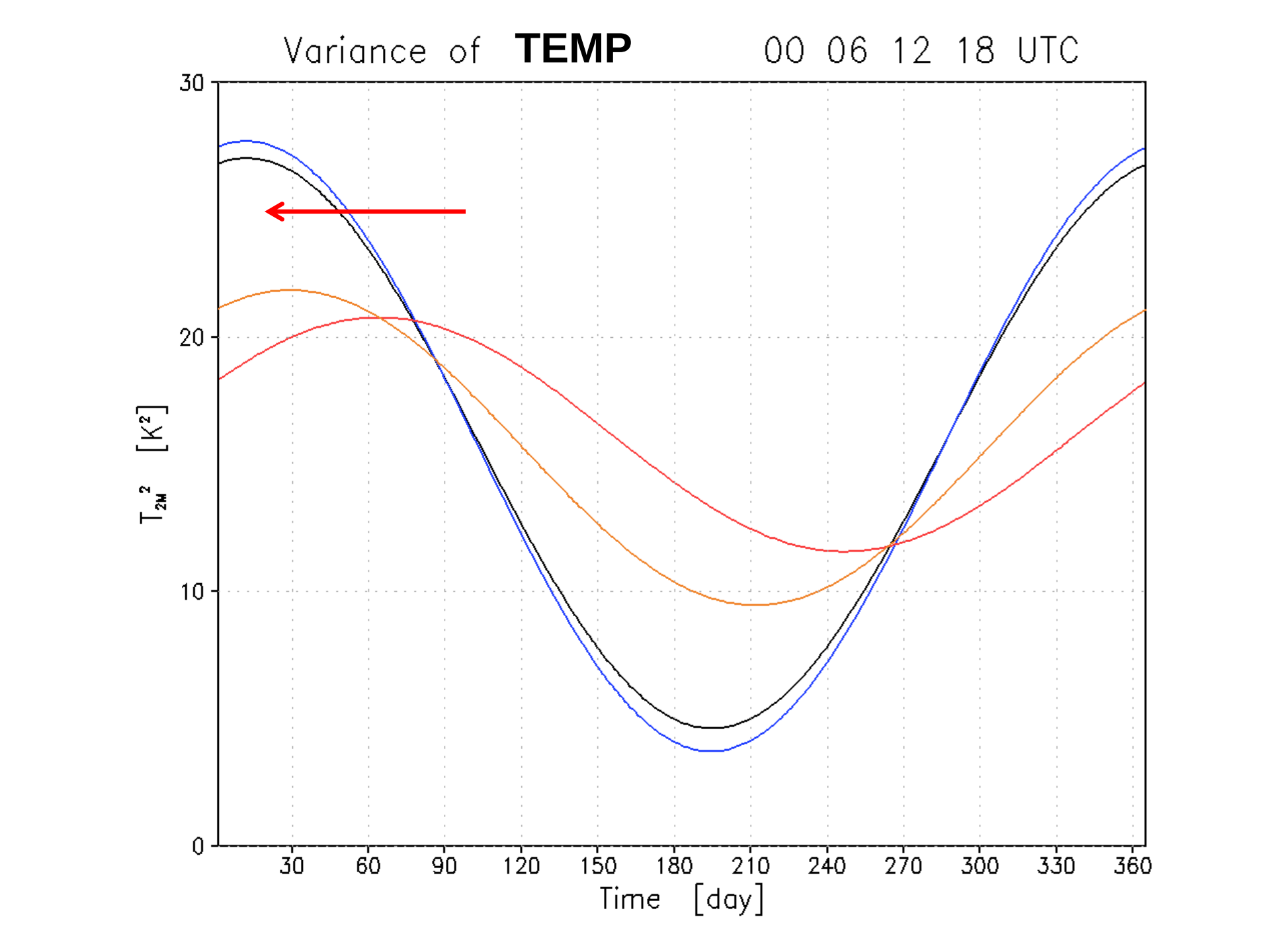
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
Forecast Lead Time [Days]

25 SEP


Variance of TEMP
00 06 12 18 UTC
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20
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$T_{2M}^2$ [K²]
30
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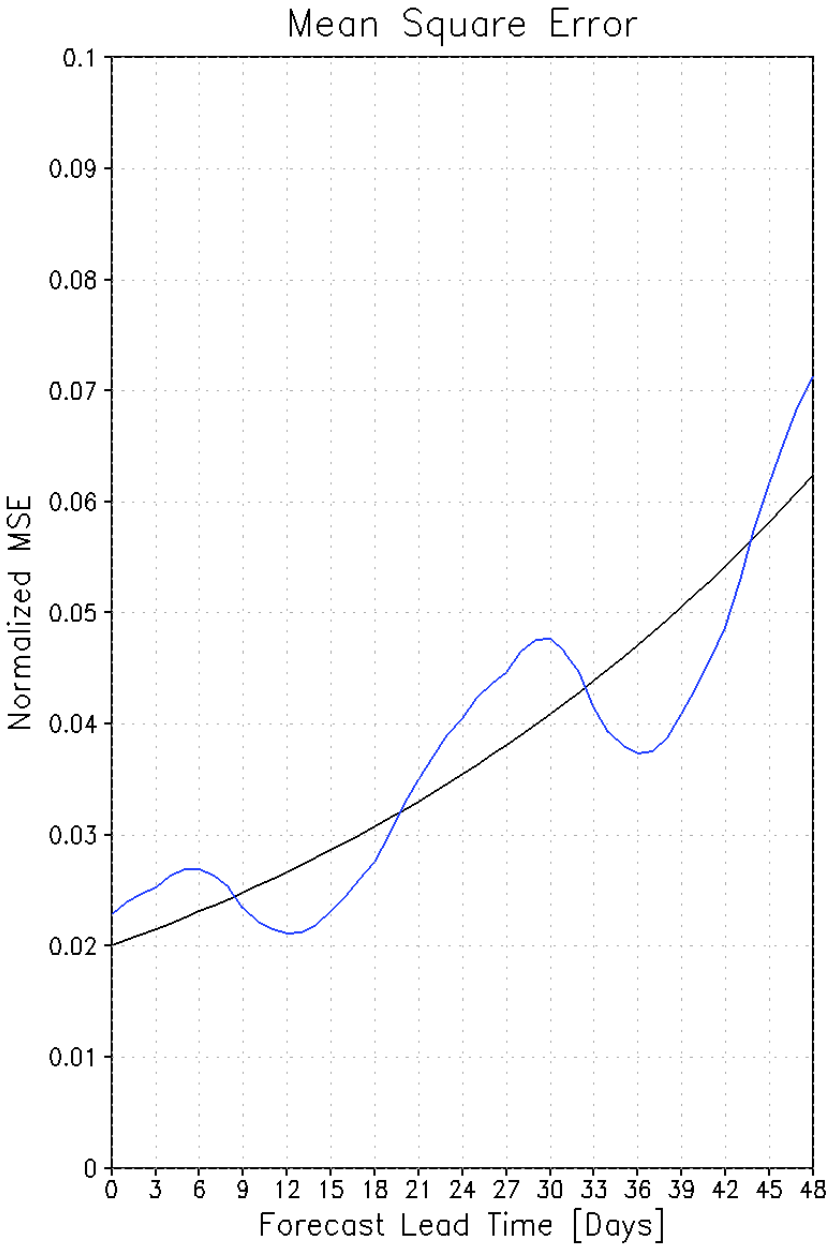
Time [day]


Mean Square Error
Normalized MSE
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48
Forecast Lead Time [Days]

15 JAN

# Conclusions

- The error magnitude at the verification time is critically dependent on the climatological variance at the time of day and time of year
- To make errors comparable they have to be normalized by appropriately defined climatological variances
- Therefore VARIANCE(stn,variable,day,hour) has to be calculated and used in the verification