

ETKF rescaling scheme for HIRLAM

Application to Ensemble Forecasting

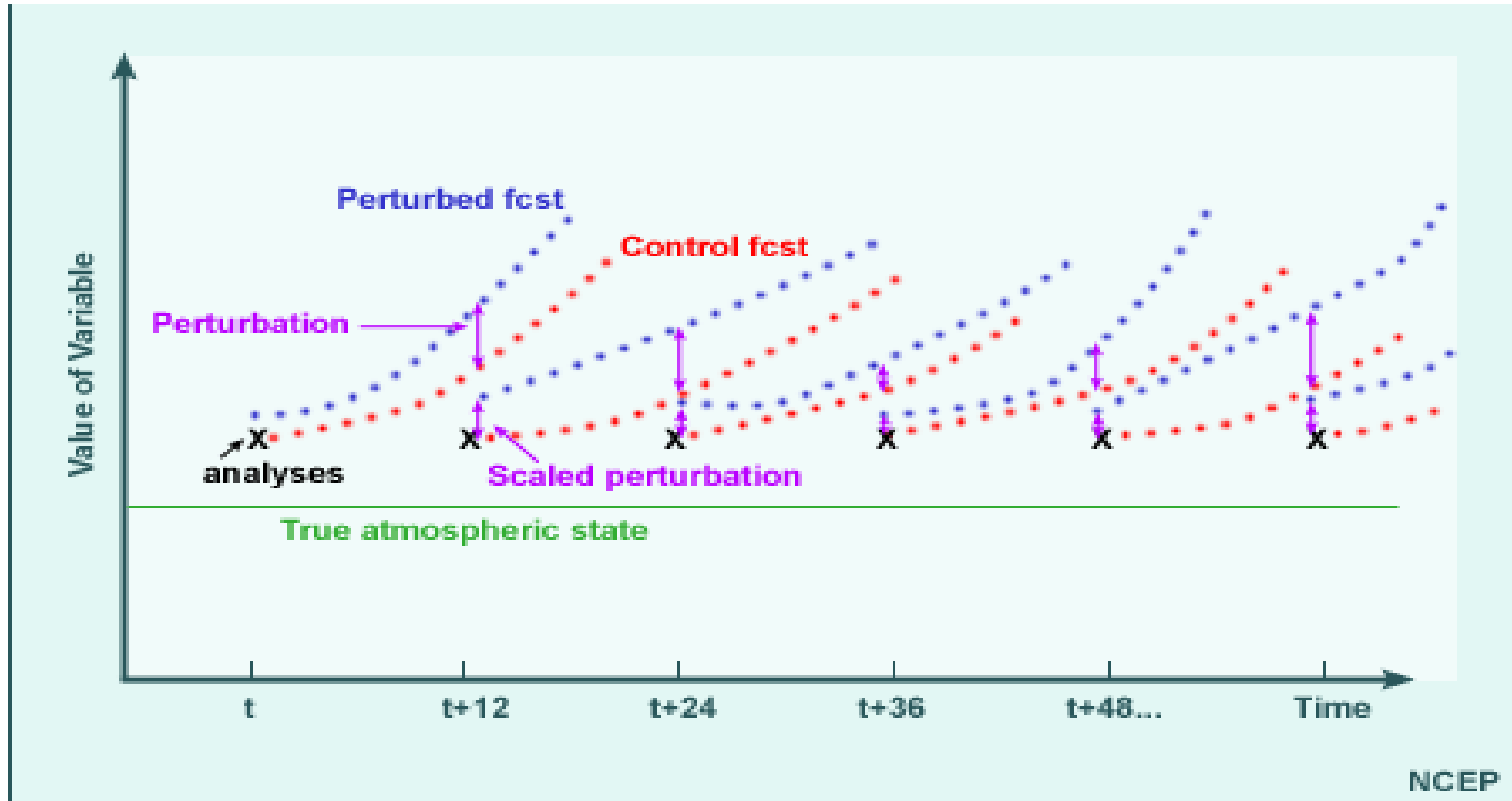
Åke Johansson, Jelena Bojarova, Nils Gustafsson, Ole Vignes

Acknowledgements

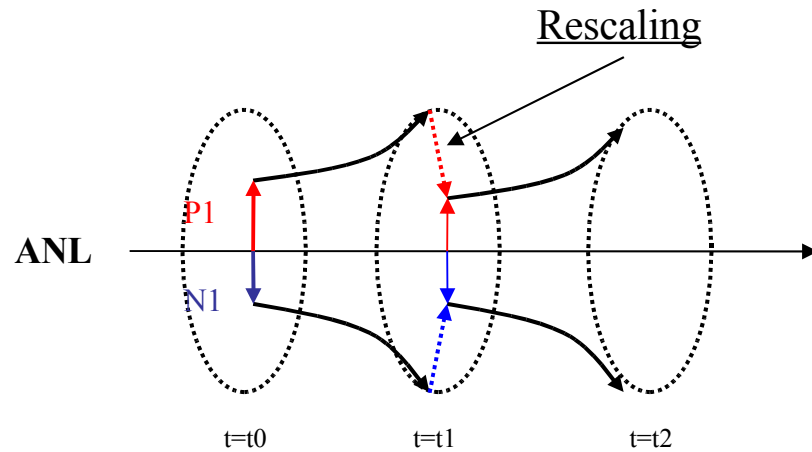
Trond Iversen
Kai Sattler

ETKF vs TEPS

The Breeding technique



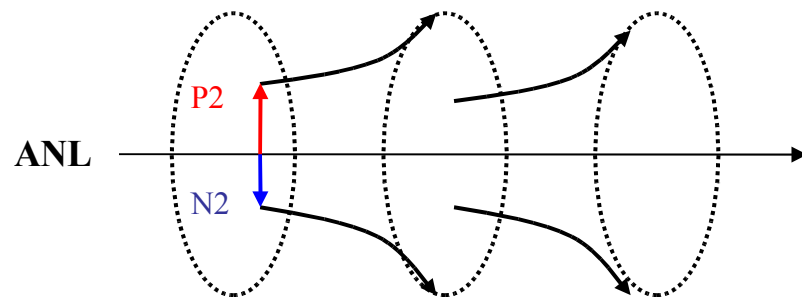
Bred Vector (Old)



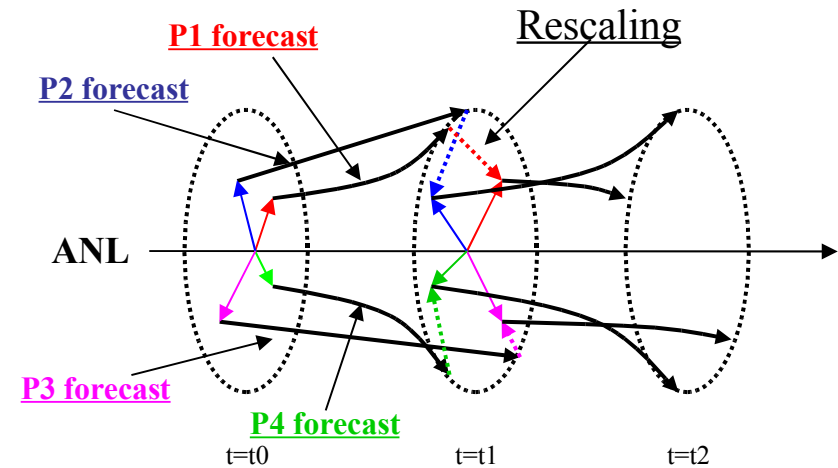
$P\#, N\#$ are the pairs of positive and negative

$P1$ and $P2$ are independent vectors

Simple scaling down (no direction change)



Ensemble Transform with Rescaling (Current)



$P1, P2, P3, P4$ are orthogonal vectors

No pairs any more

To centralize all perturbed vectors (sum of all vectors are equal to zero)

Scaling down by applying mask

Transformation Matrix

$$\mathbf{T} = \mathbf{C}(\mathbf{\Gamma} + \mathbf{I}^{\mathbf{K} \times \mathbf{K}})^{-1/2}$$

Bishop et al. 2001

where

$$\left\{ \begin{array}{l} [\mathbf{Z}^f \mathbf{H}^T \tilde{\mathbf{H}} \mathbf{Z}^f] \\ \mathbf{K} \times \mathbf{M} \quad \mathbf{M} \times \mathbf{P} \quad \mathbf{P} \times \mathbf{M} \quad \mathbf{M} \times \mathbf{K} \\ \\ \tilde{\mathbf{H}} = \mathbf{R}^{-1/2} \mathbf{H} \end{array} \right.$$

ETKF vs TEPS

**Dependence
on
of Observations**

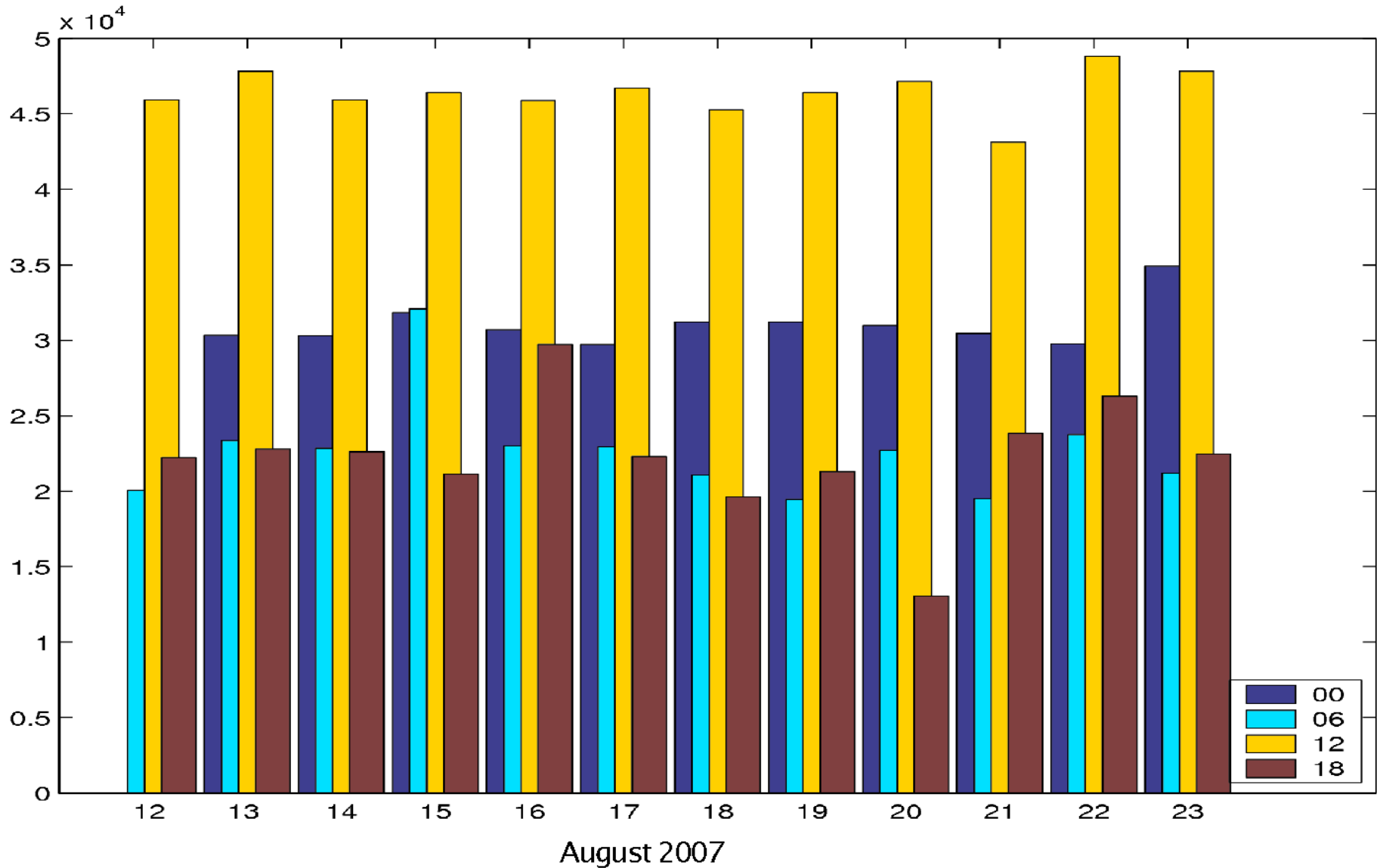
ETKF vs TEPS

**Dependence
on
of Observations**

No Satellite Data

Total amount of assimilated observations

Large variations with cycle



EXPERIMENTS

EXPERIMENTS

12 – 24 AUG 2007

EXPERIMENTS

12 – 24 AUG 2007



16 – 24 AUG 2007

EXPERIMENTS

12 – 24 AUG 2007



16 – 24 AUG 2007

CIS branch SEP 2008

EXPERIMENTS

12 – 24 AUG 2007



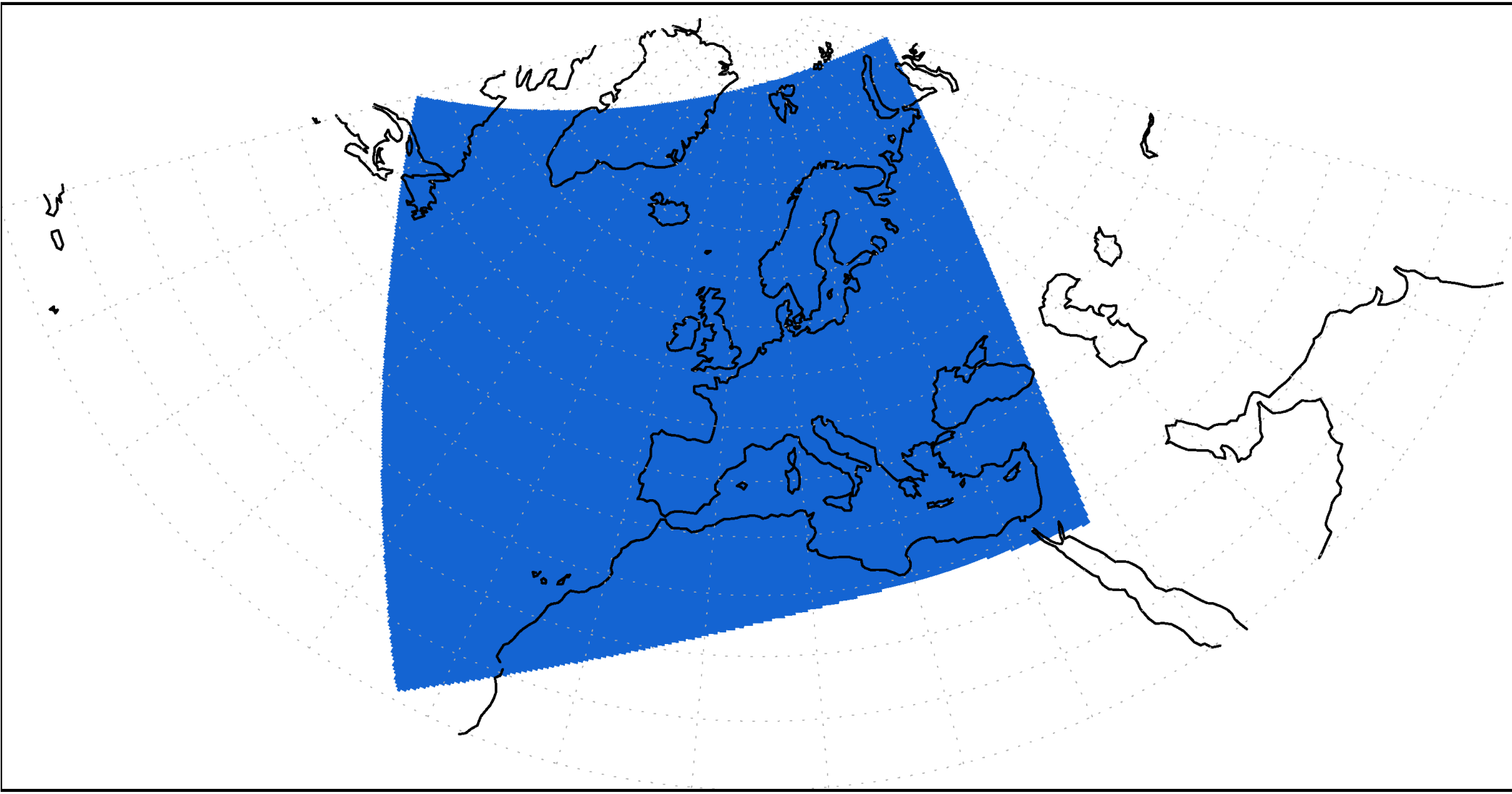
16 – 24 AUG 2007

CIS branch SEP 2008

EPS 71 $0.2^\circ \times 0.2^\circ$ L40

EPS71

306 X 260 points 0.2 X 0.2 NLEV=40 DT=6 min



EXPERIMENTS

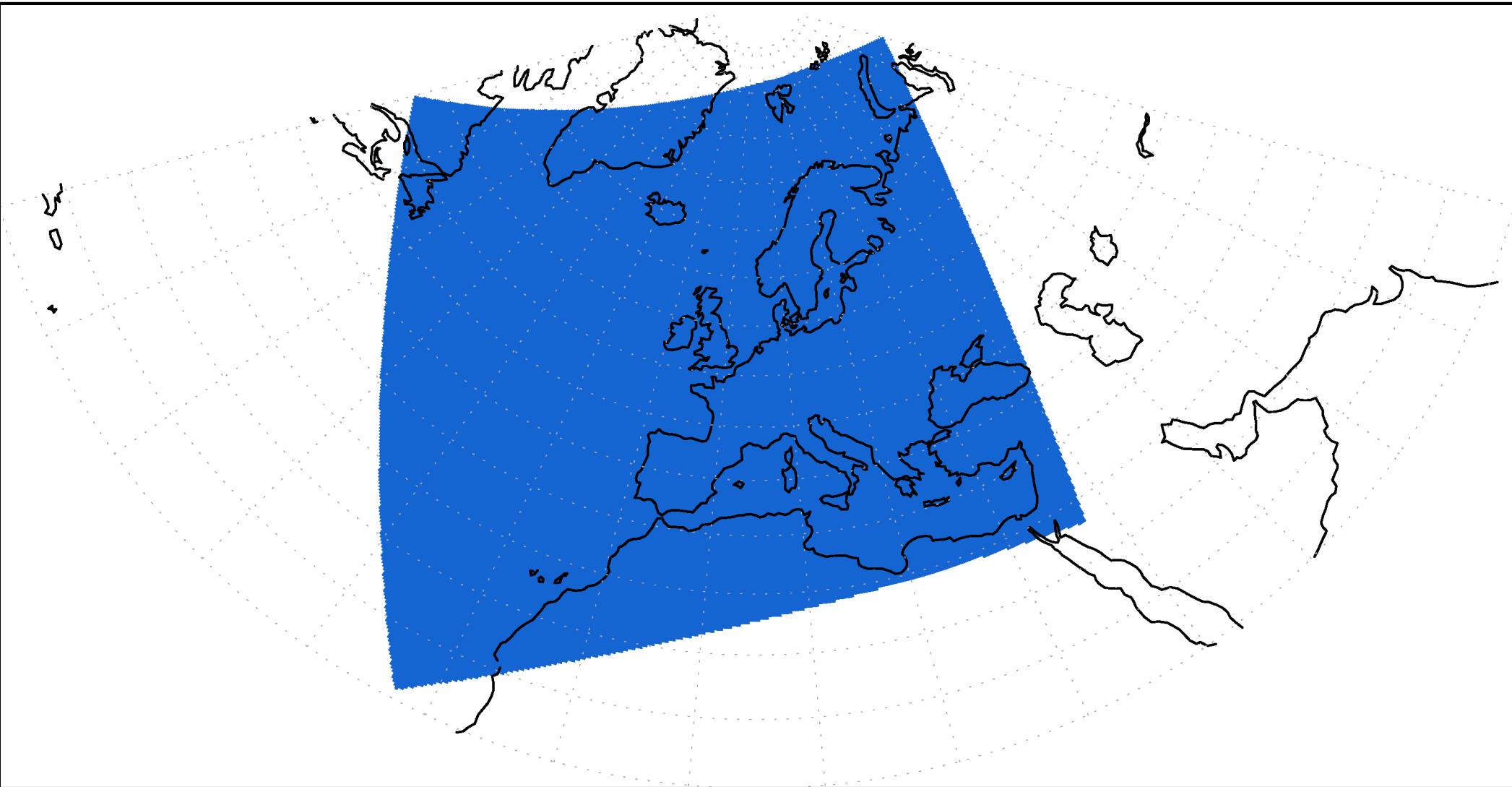
ETKF

20% TEPS

80% ETKF

EPS71

306 X 260 points 0.2 X 0.2 NLEV=40 DT=6 min



EXPERIMENTS

ETKF

20% TEPS

80% ETKF

TEPS

100% TEPS

0% ETKF

MSE

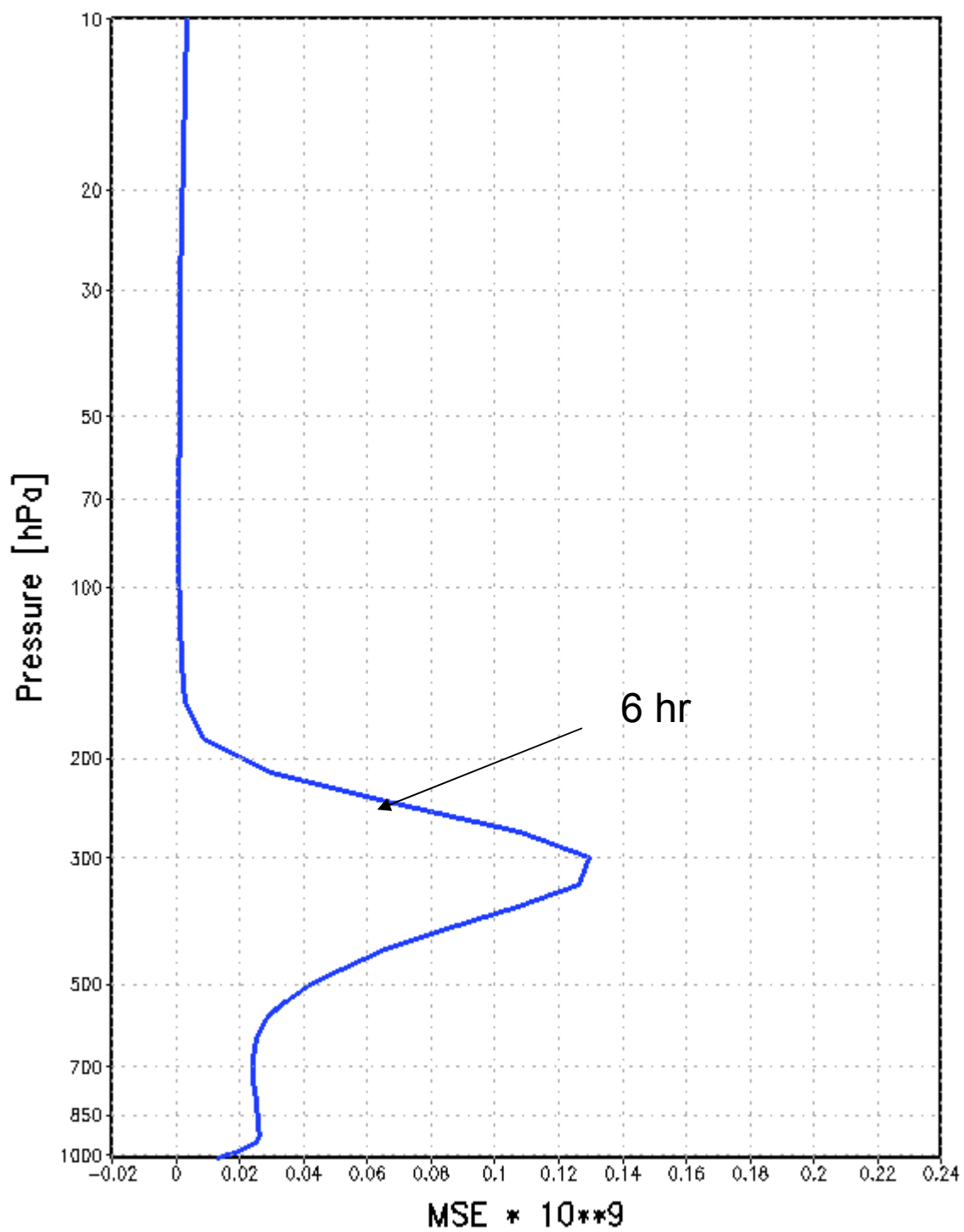
of Control forecast

ETKF

VORTICITY

12 UTC

EPS71

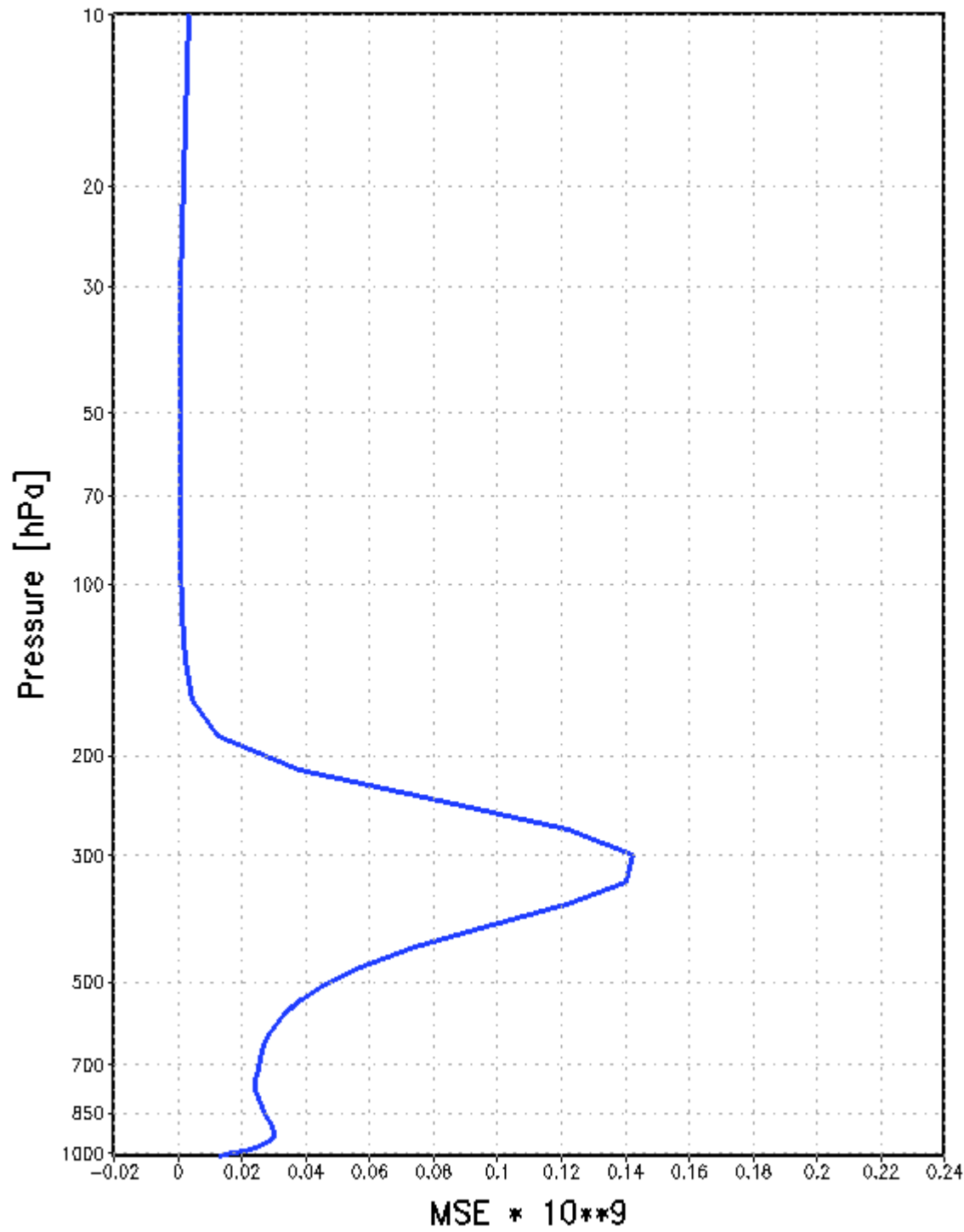


ETKF

VORTICITY

00 UTC

EPS71

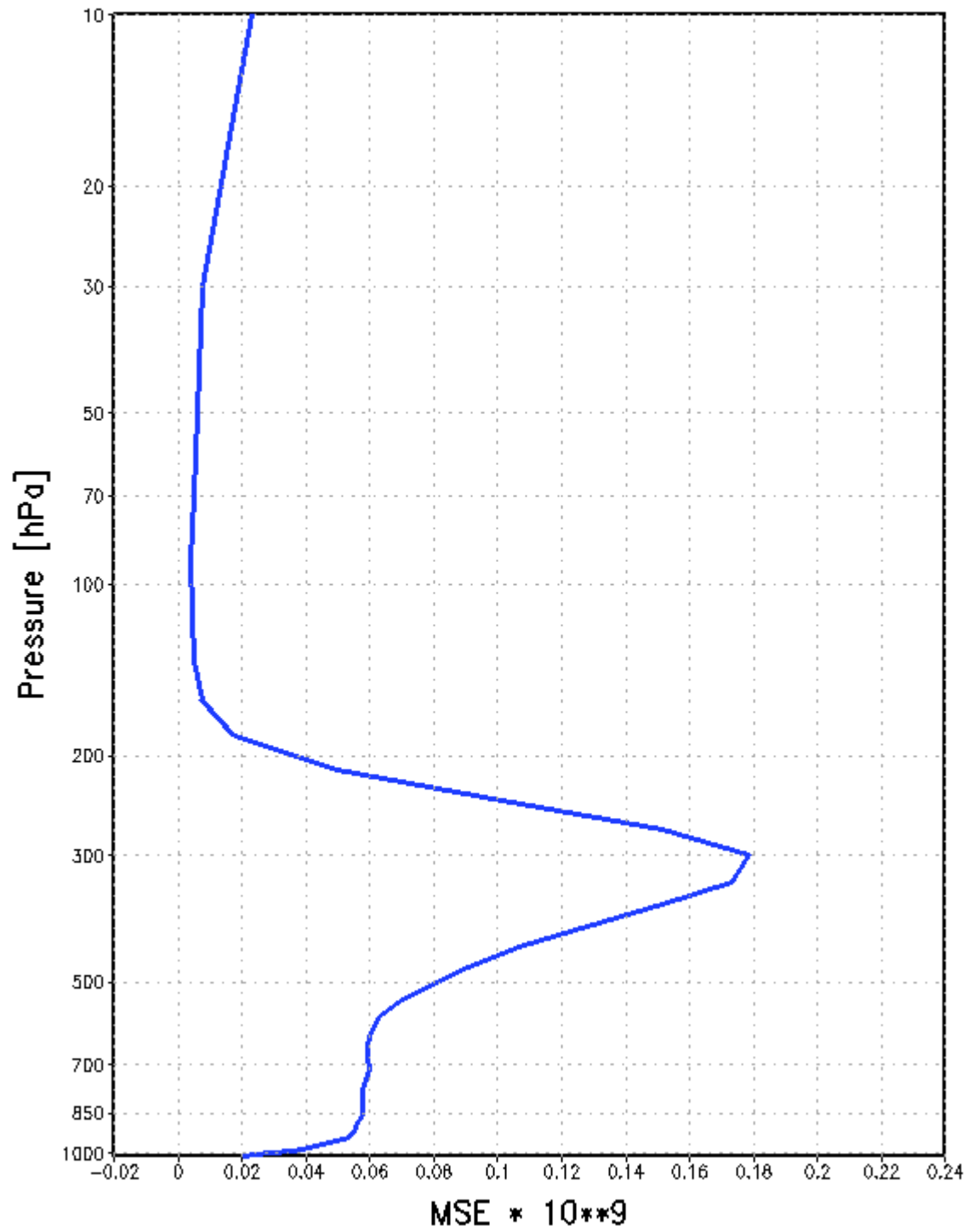


ETKF

VORTICITY

18 UTC

EPS71

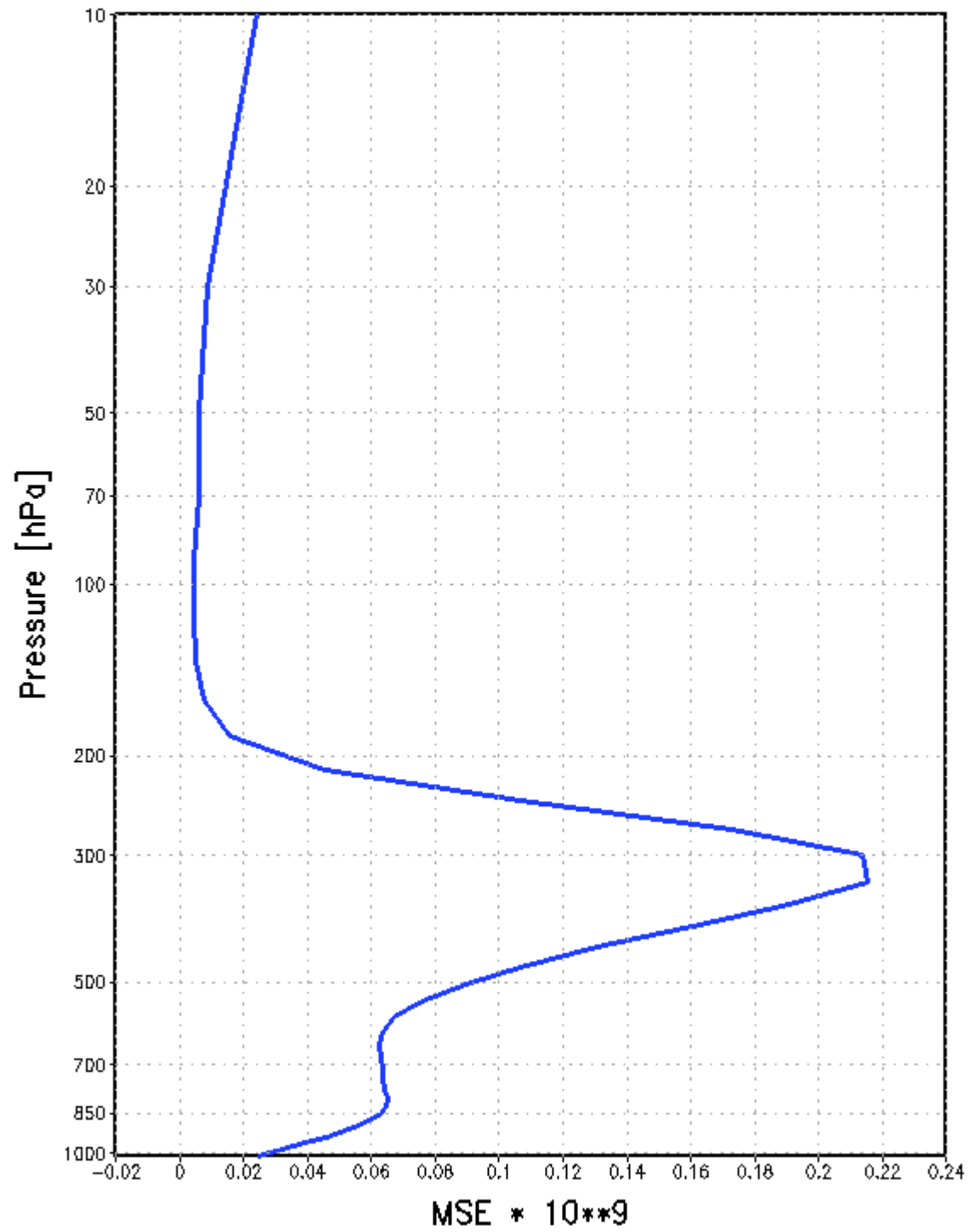


ETKF

VORTICITY

06 UTC

EPS71



SPREAD

among

perturbed members

VORTICITY

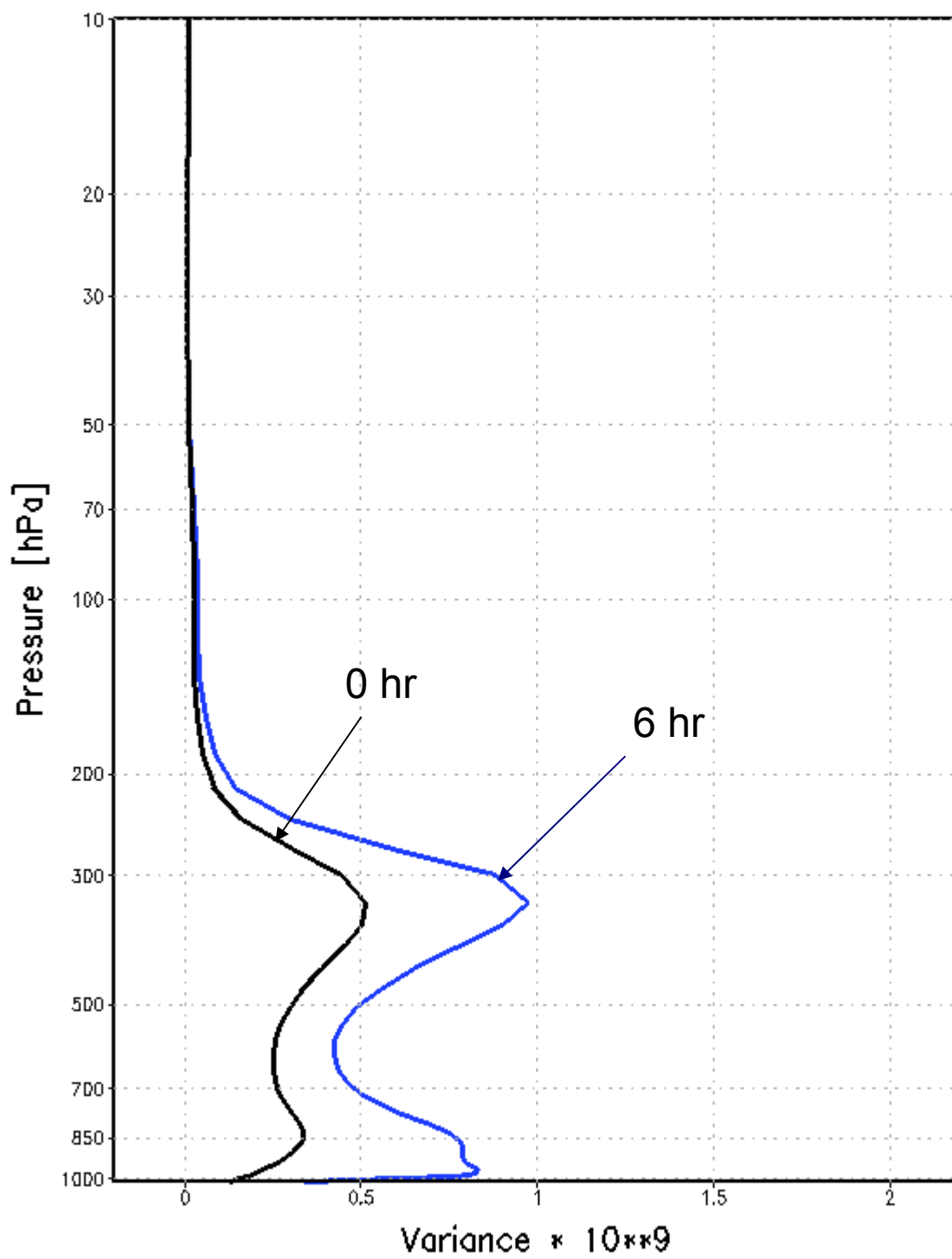
ETKF

ETKF

VORTICITY

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EPS71

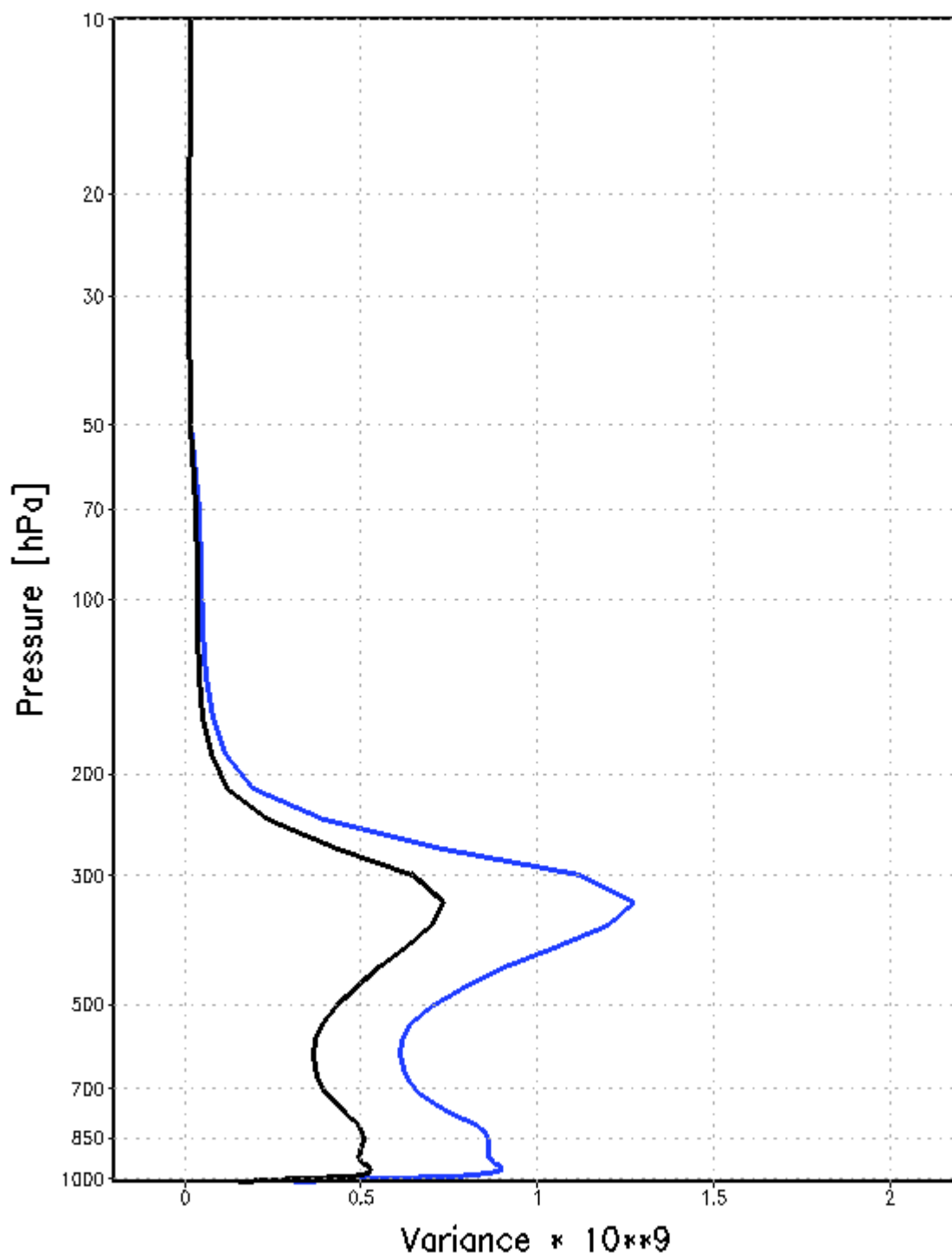


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00 UTC

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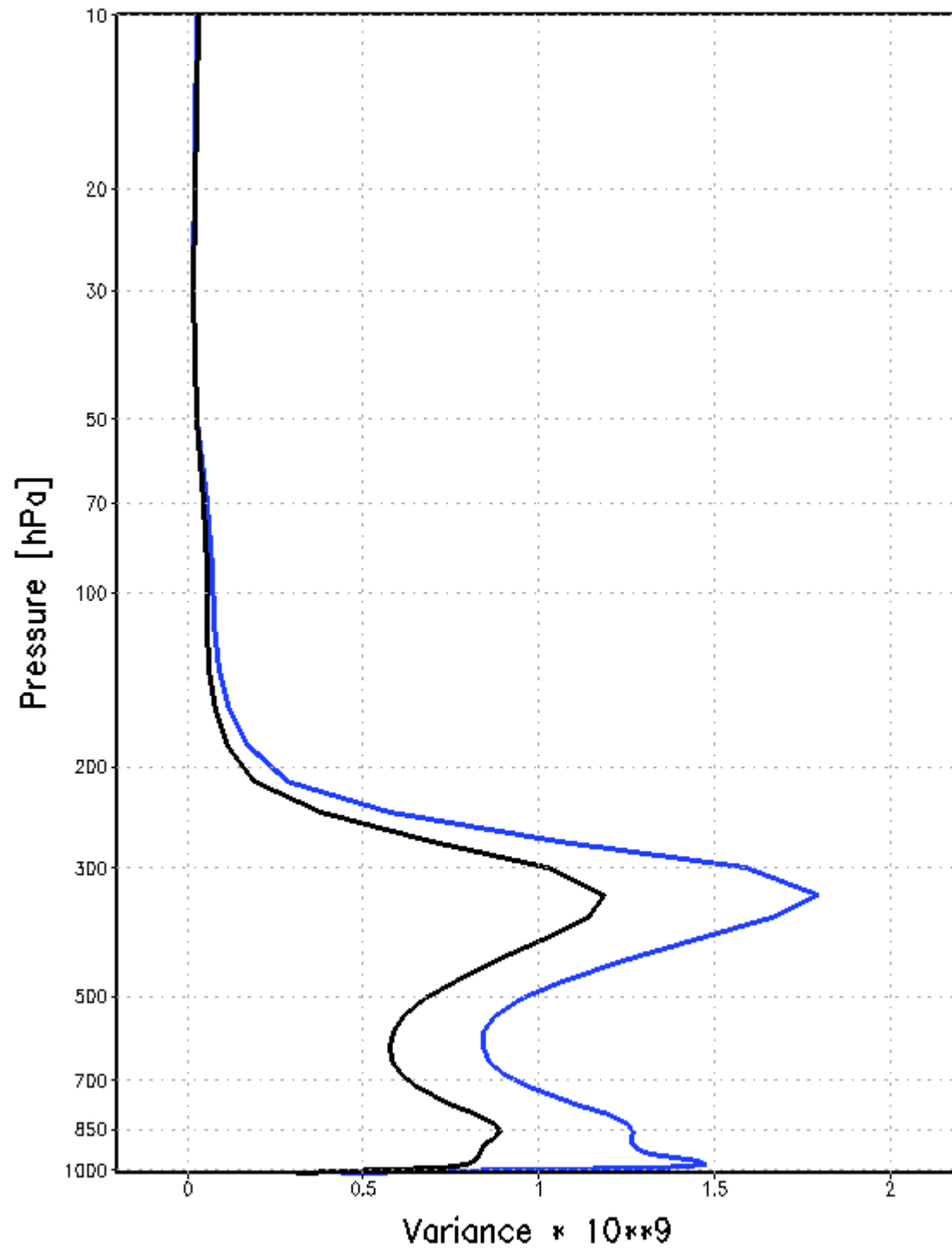


ETKF

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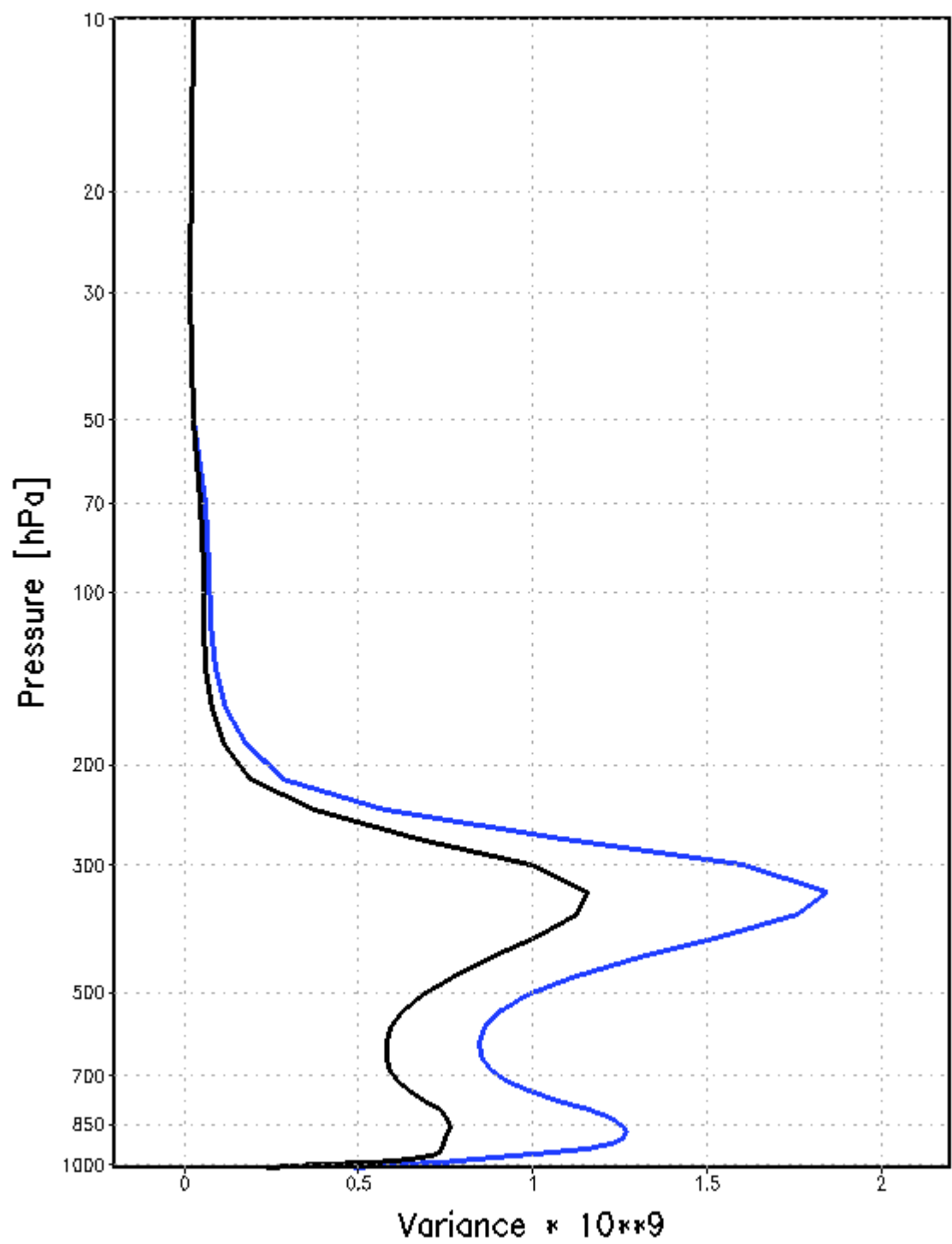


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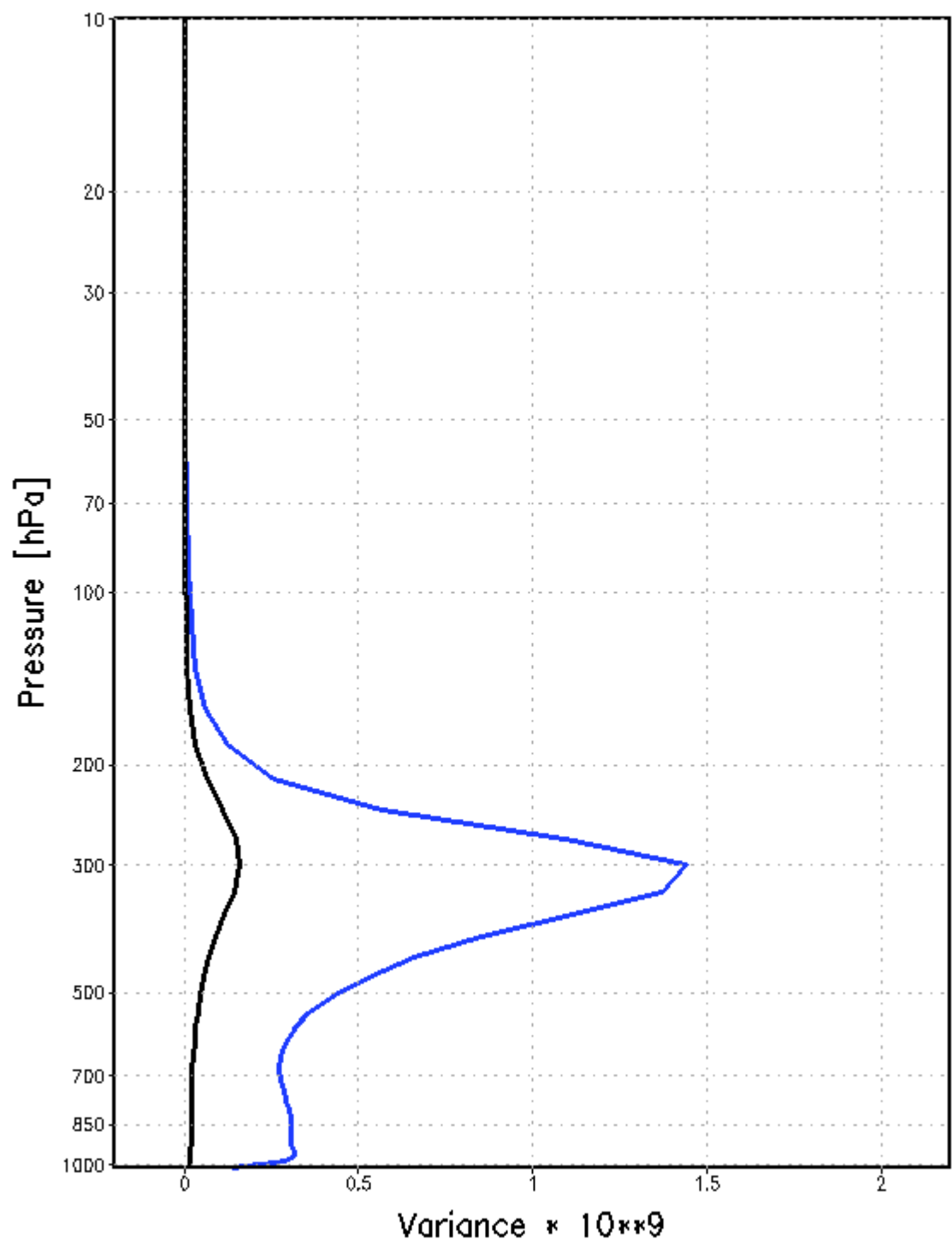
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EPS71



VORTICITY

TEPS

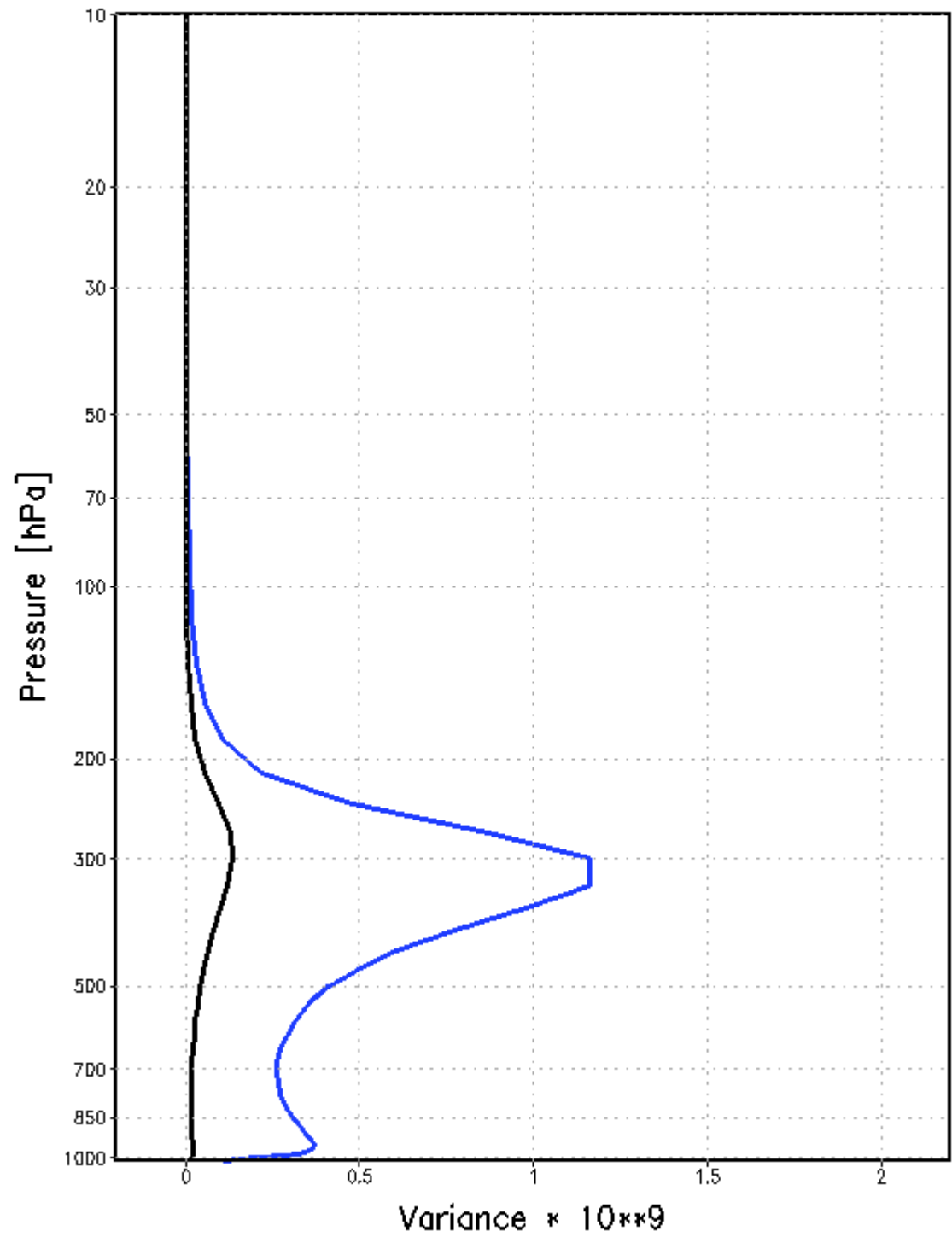


TEPS

VORTICITY

00 UTC

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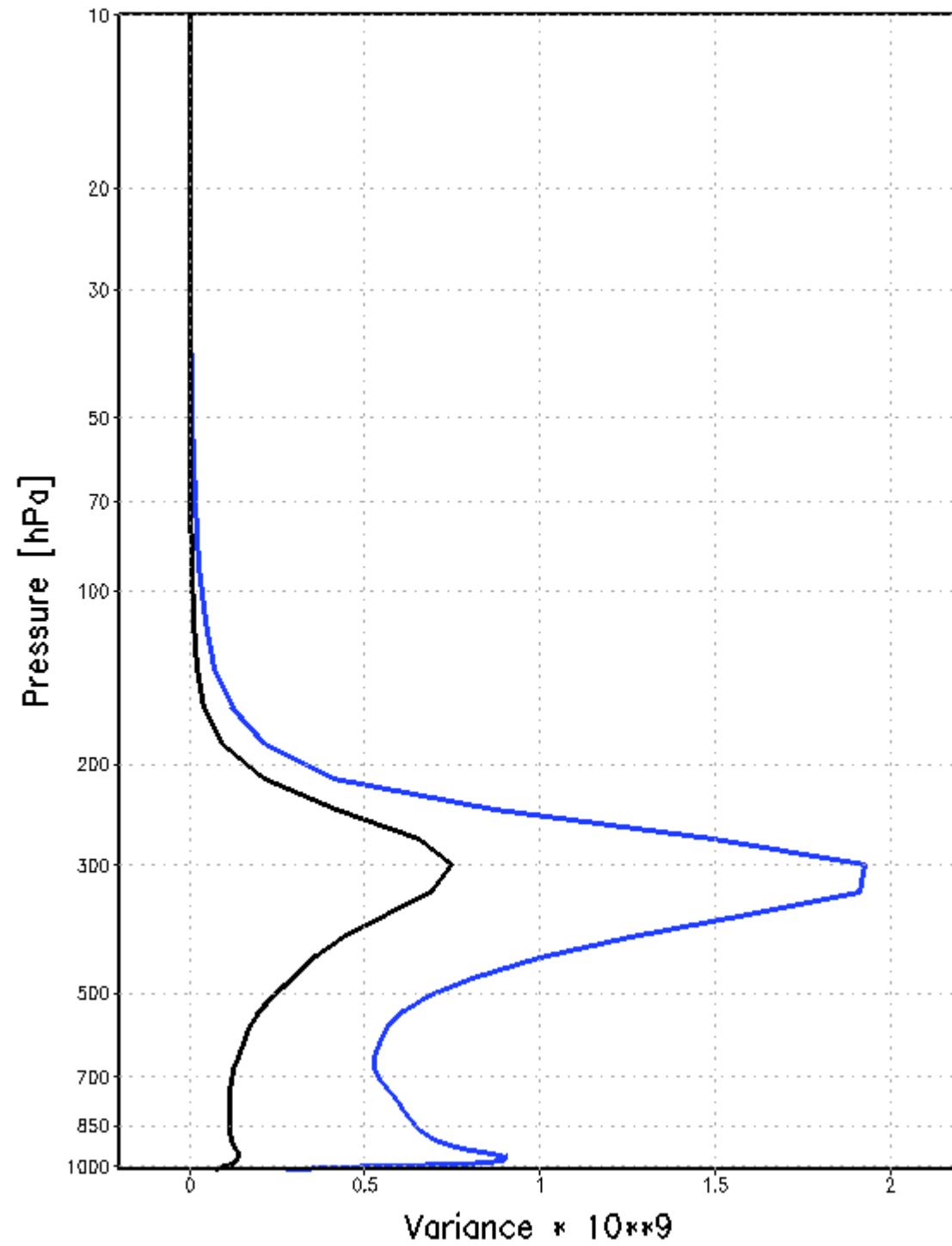


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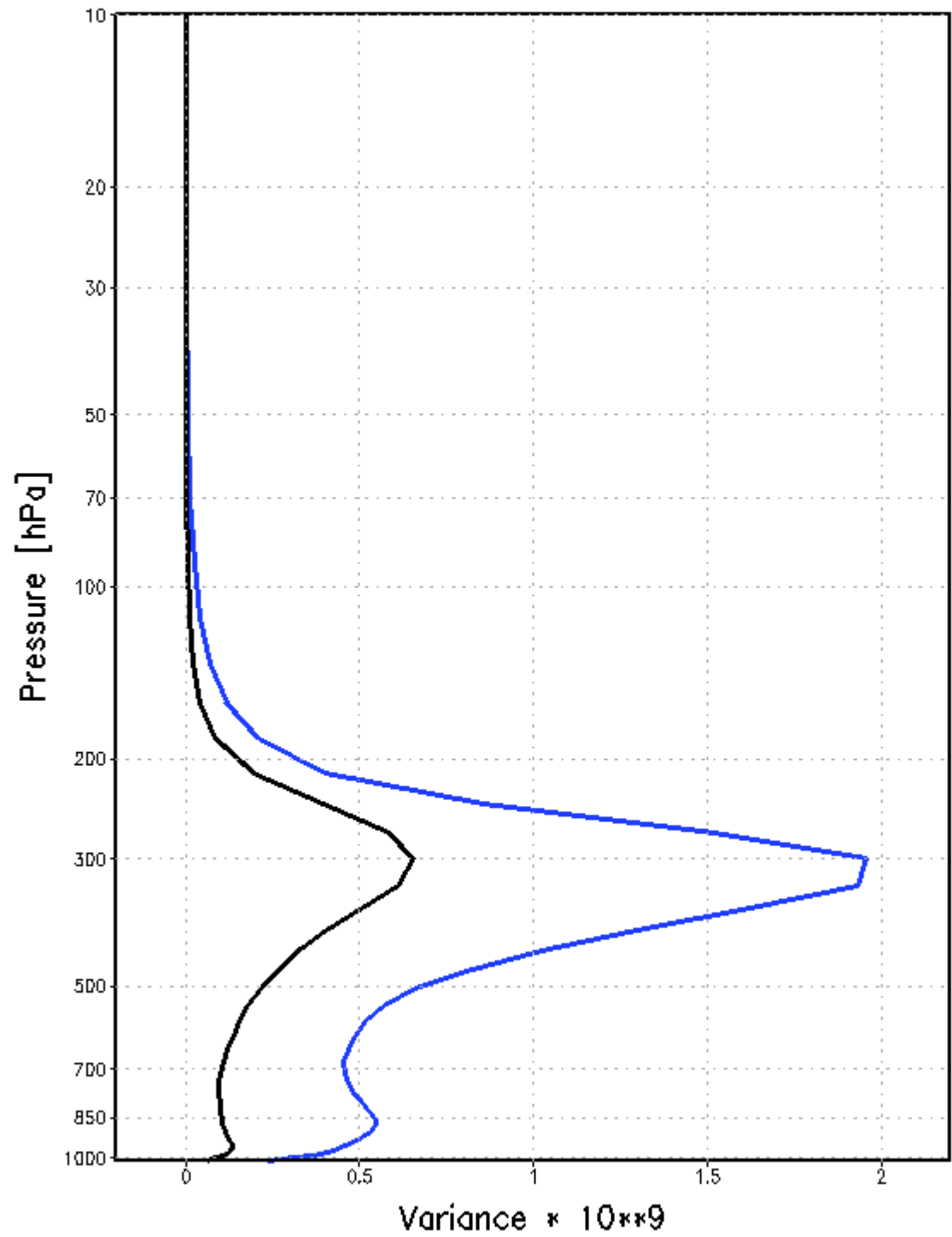


TEPS

VORTICITY

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EPS71



VORTICITY

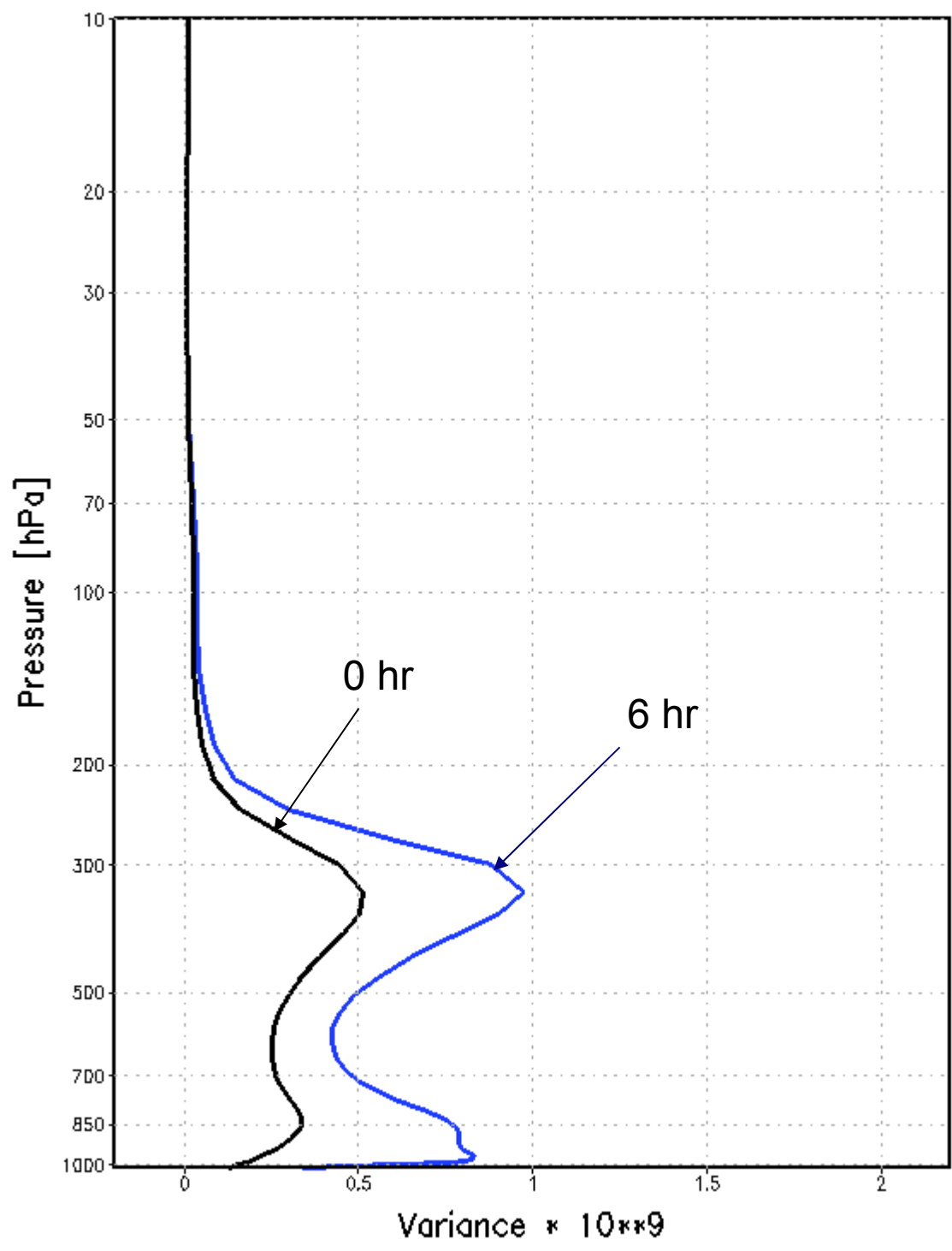
ETKF vs TEPS

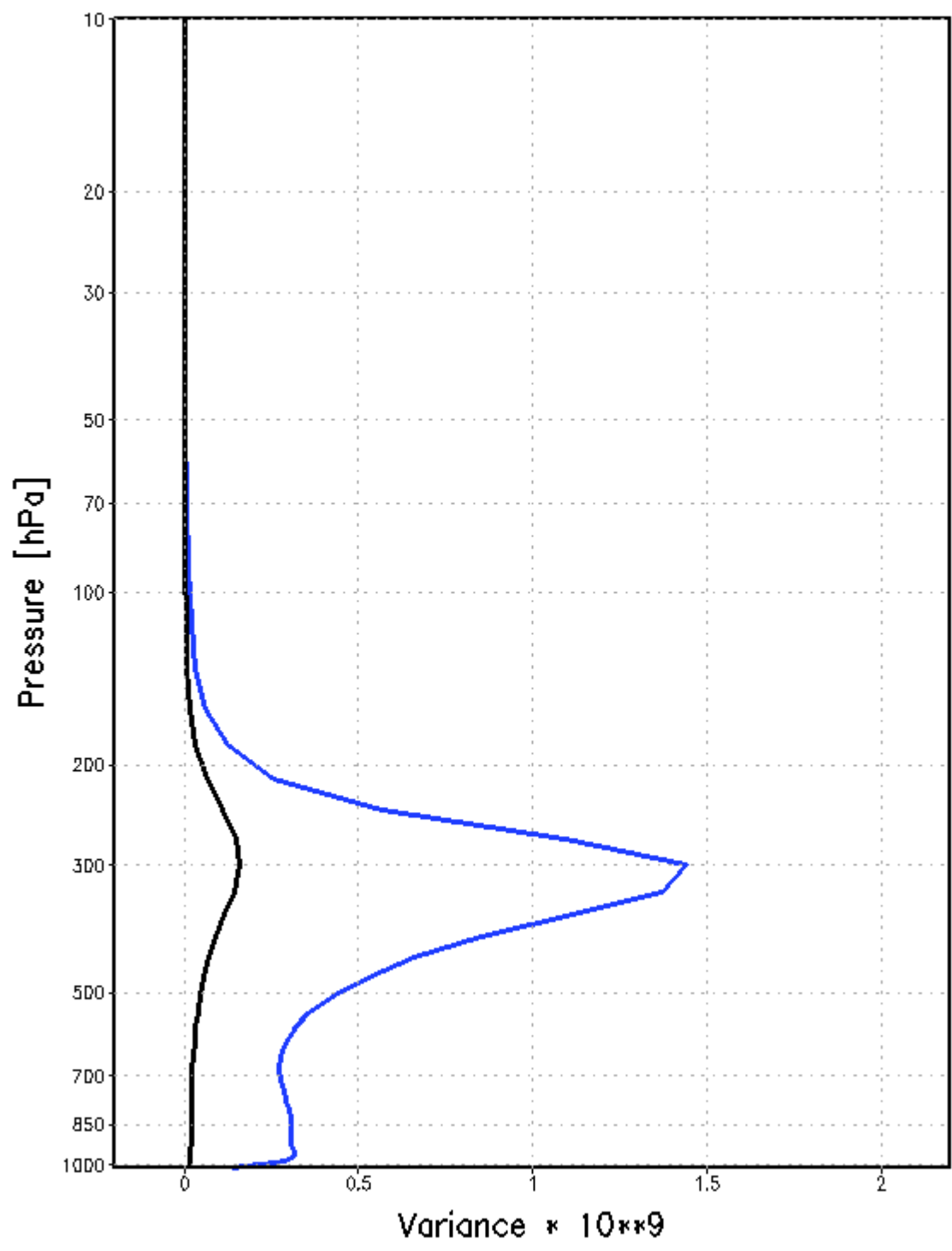
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VORTICITY

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EPS71



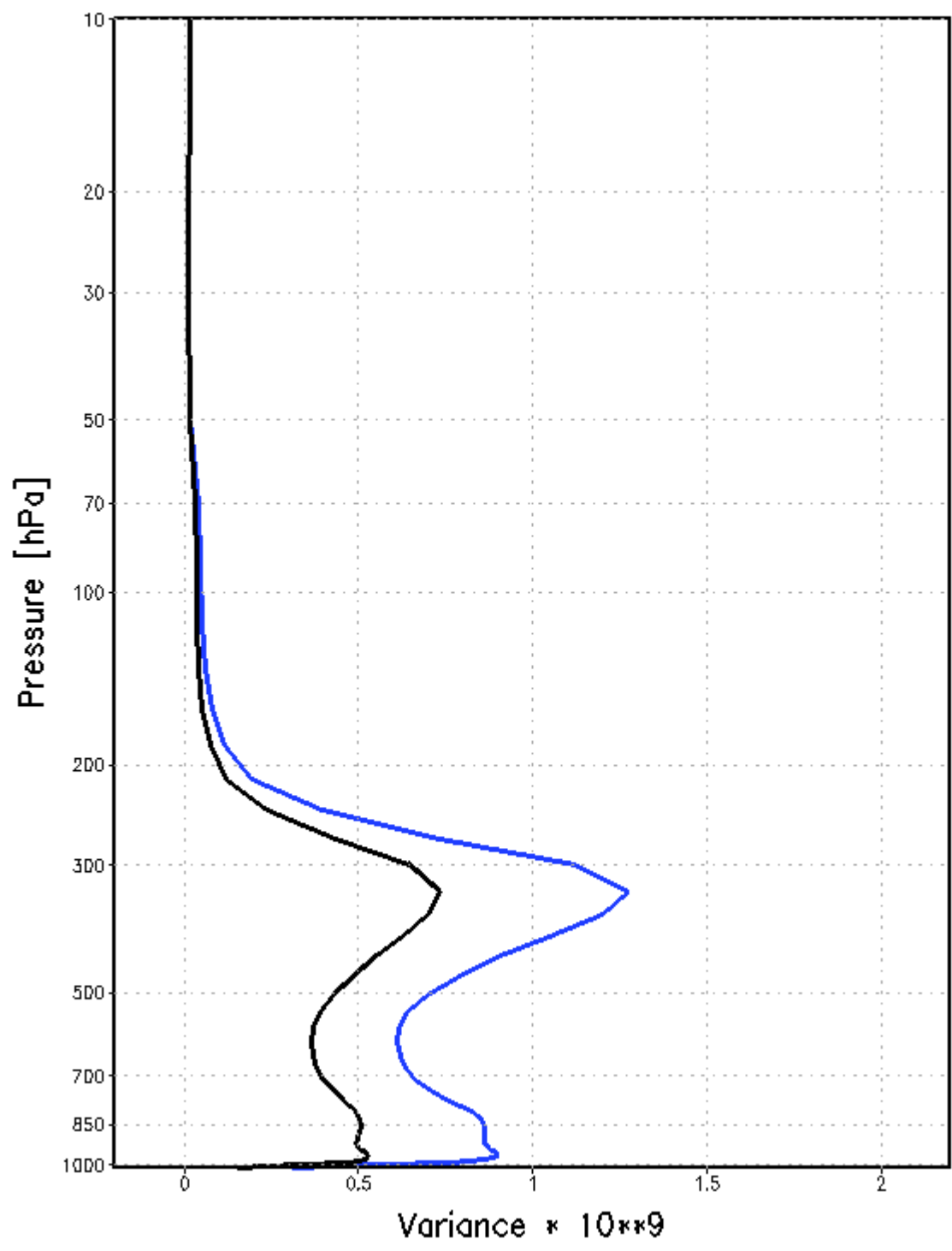


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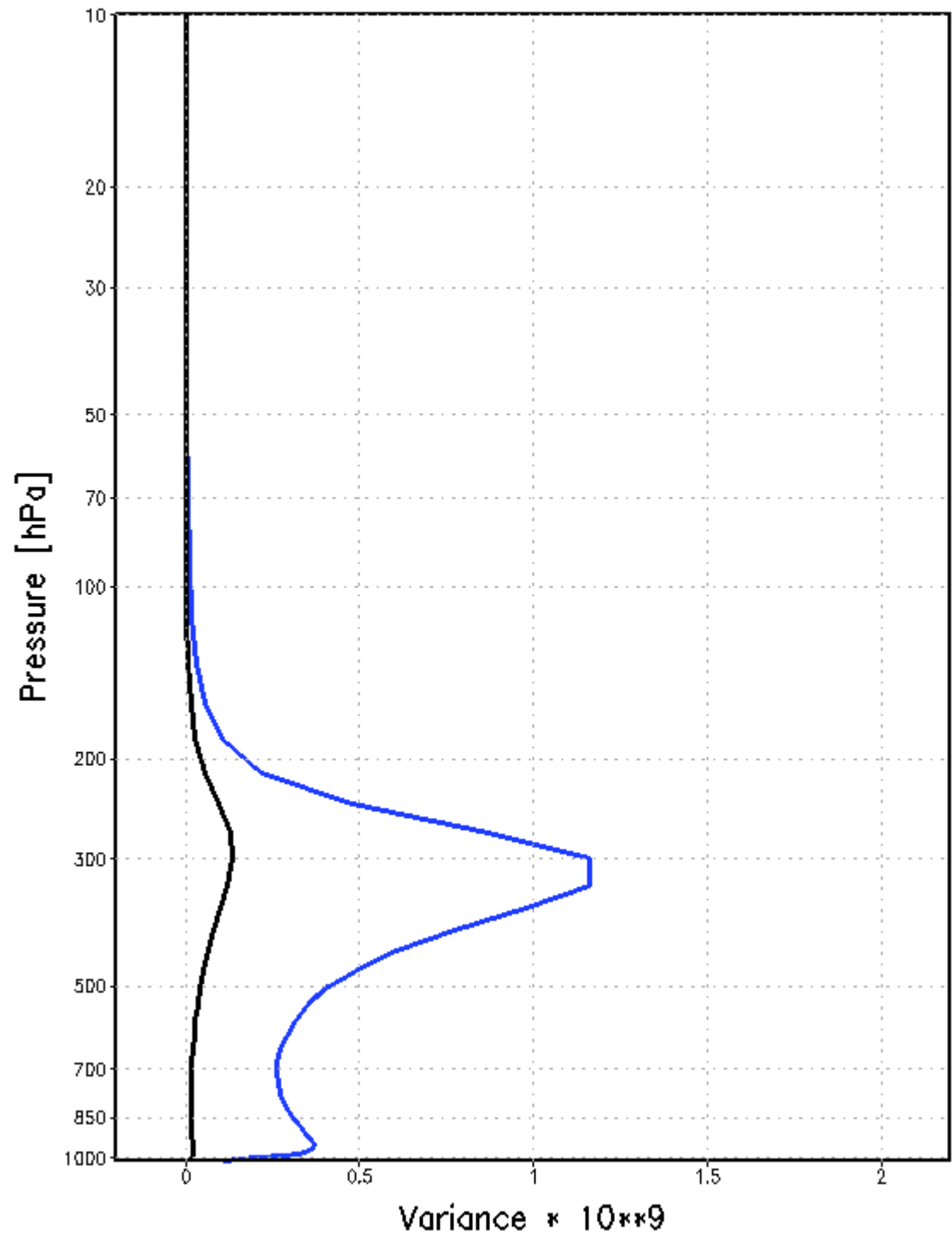


TEPS

VORTICITY

00 UTC

EPS71

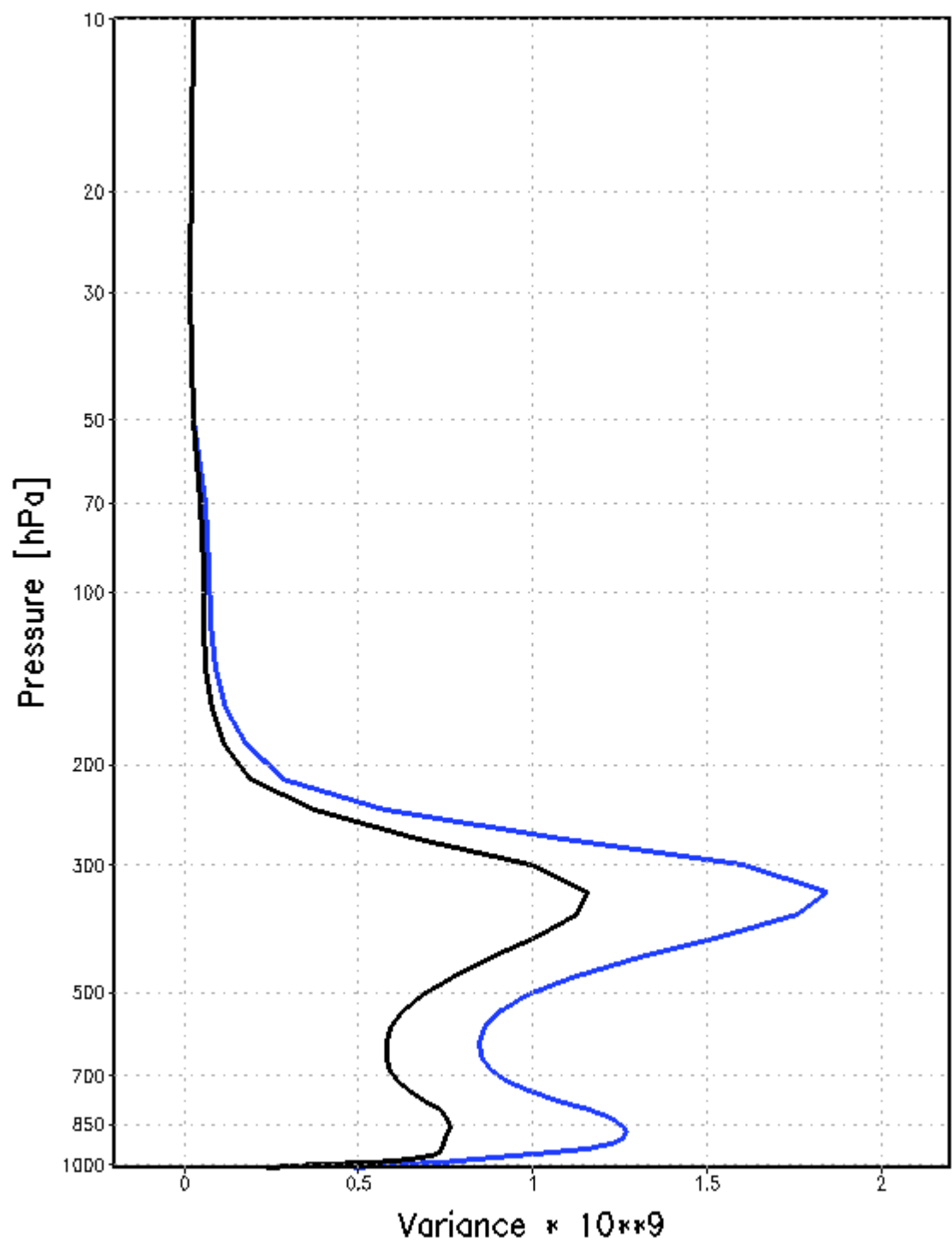


ETKF

VORTICITY

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EPS71

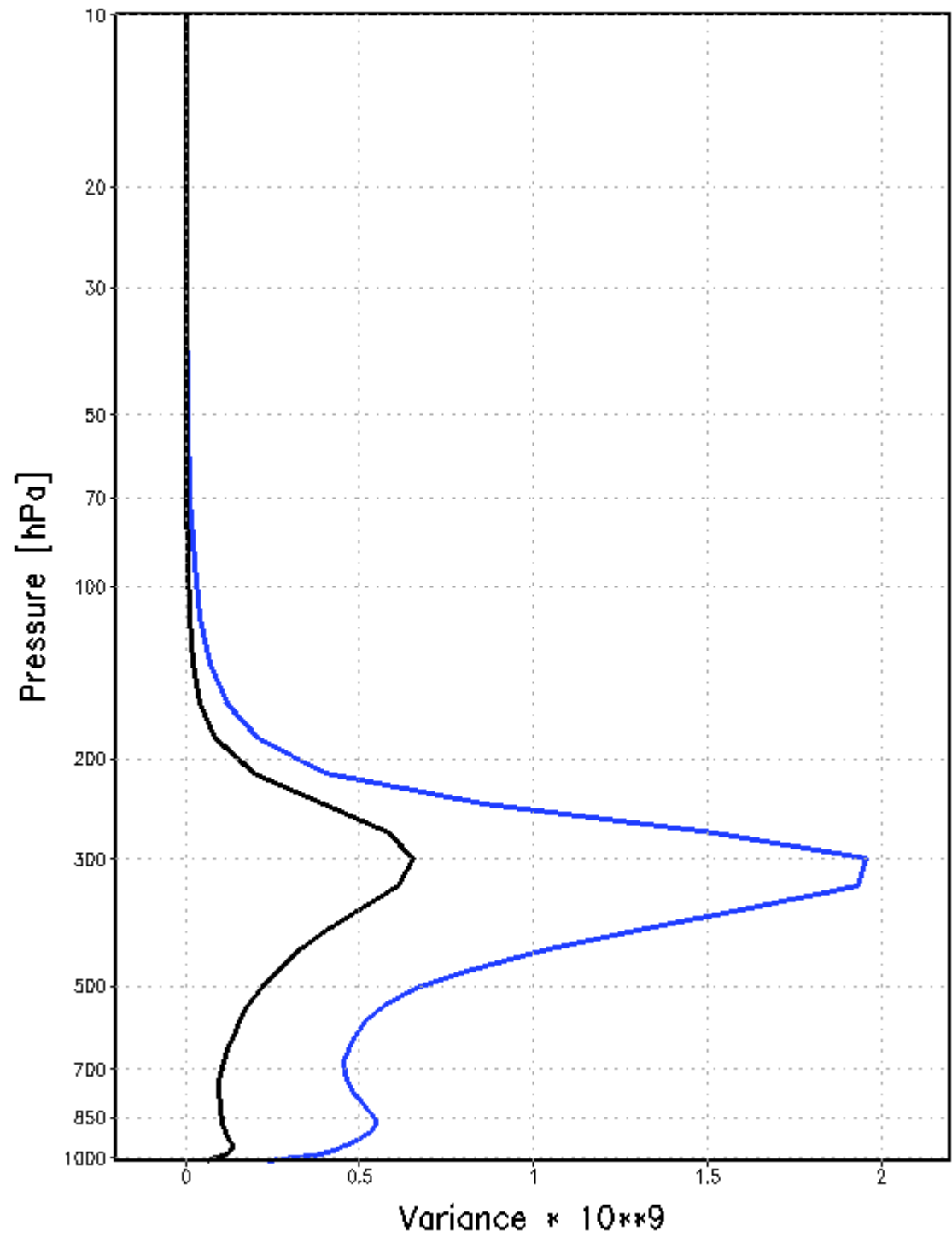


TEPS

VORTICITY

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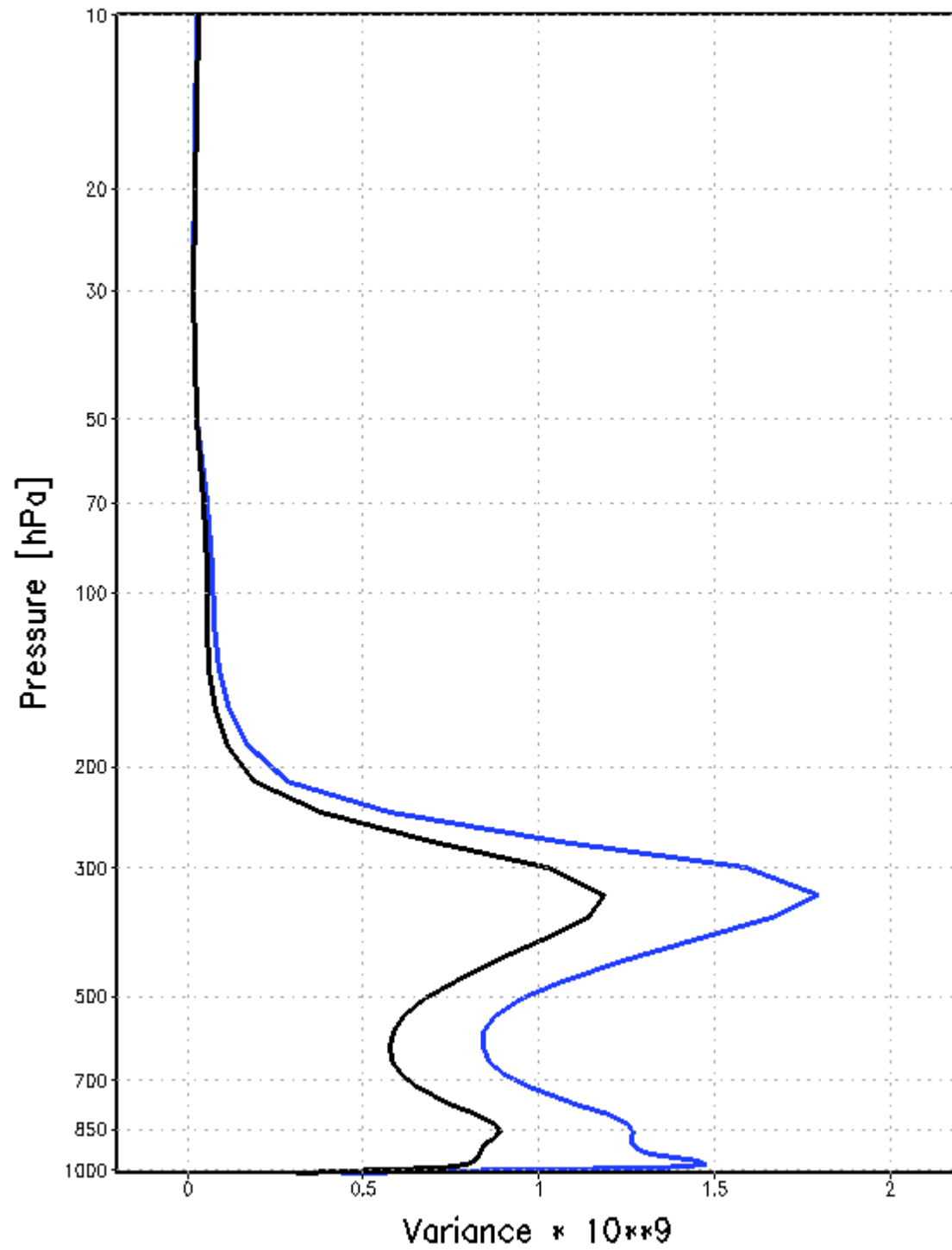


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VORTICITY

18 UTC

EPS71

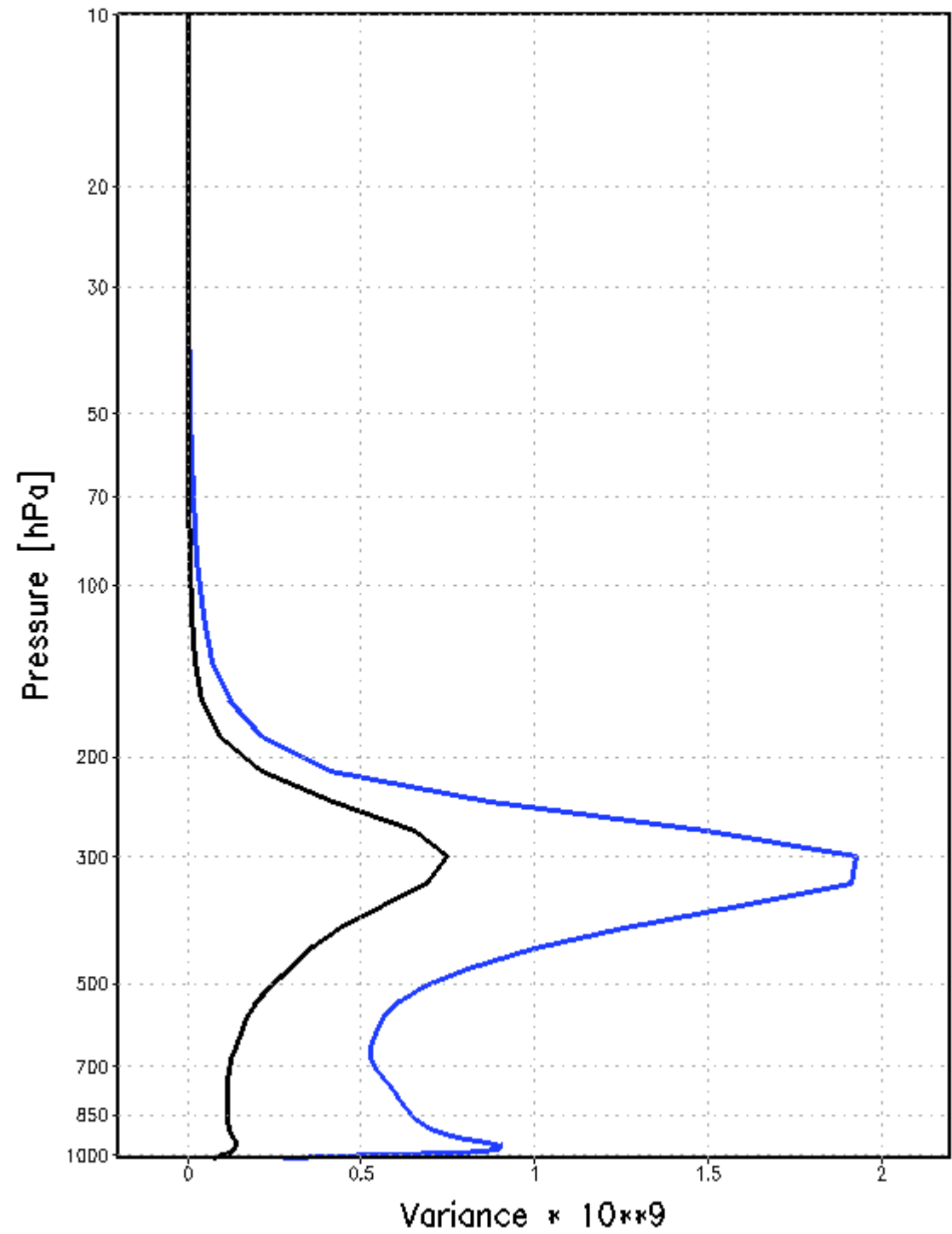


TEPS

VORTICITY

18 UTC

EPS71



VORTICITY

ETKF vs TEPS

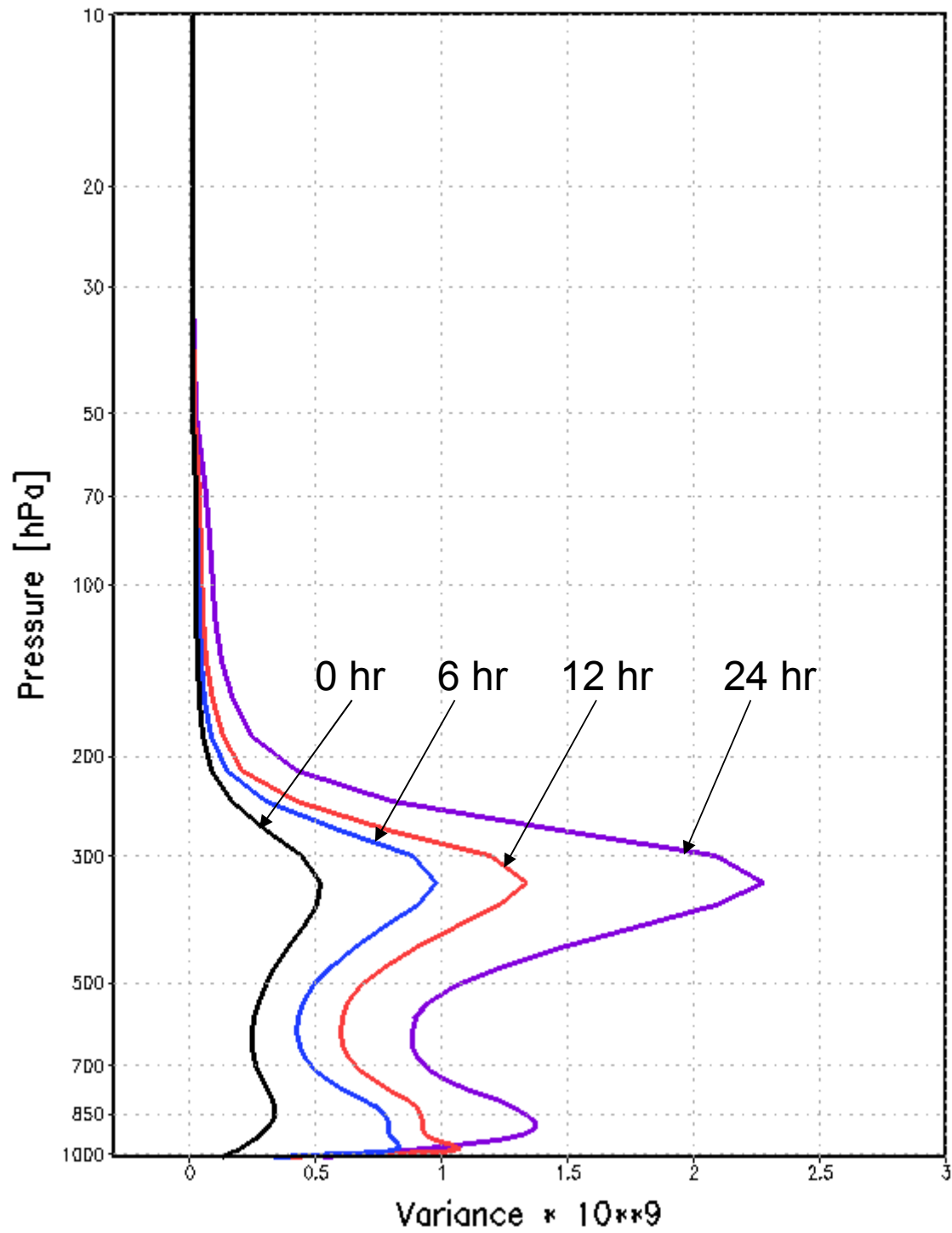
12 and 00 UTC

ETKF

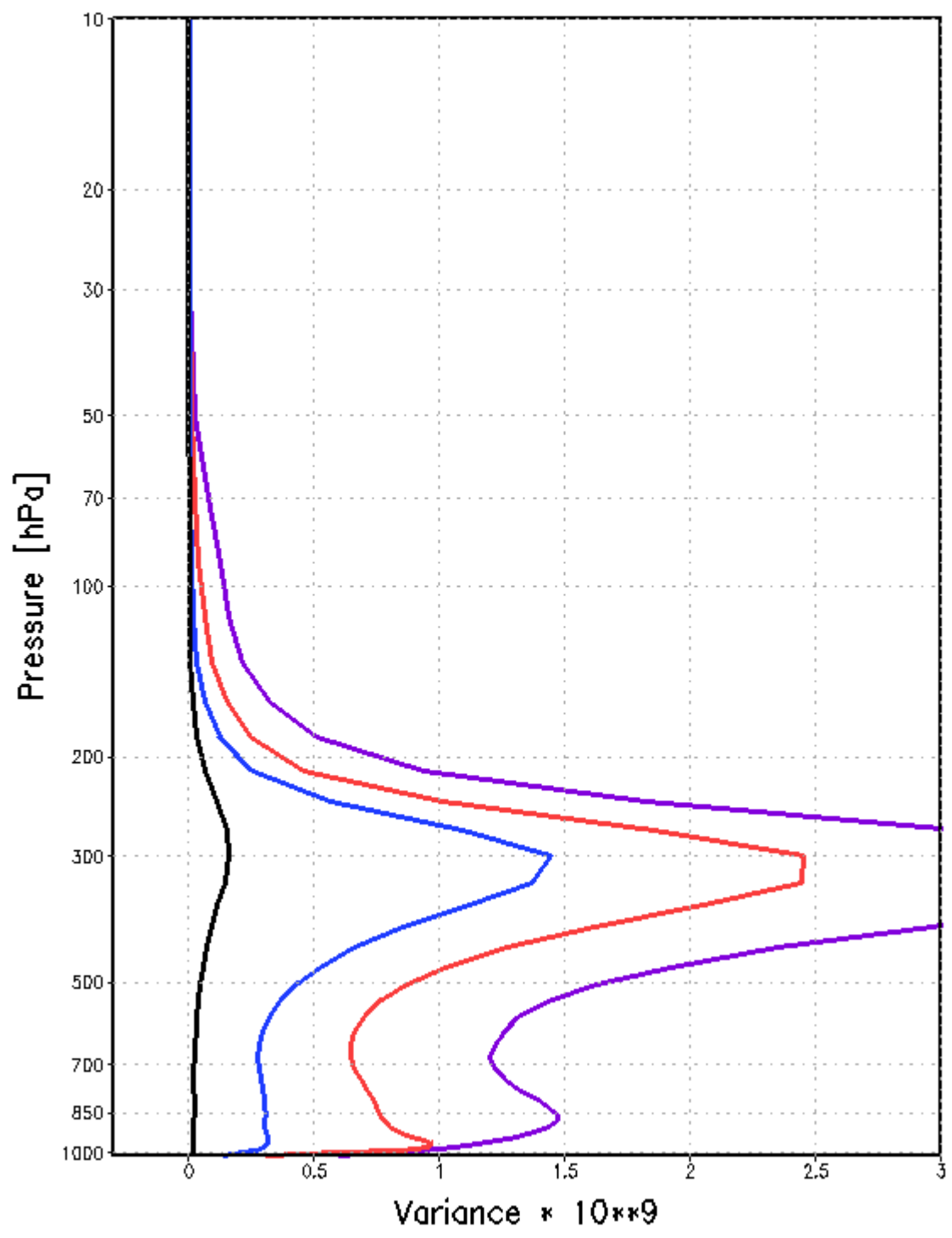
VORTICITY

12 UTC

EPS71



TEPS VORTICITY 12 UTC EPS71

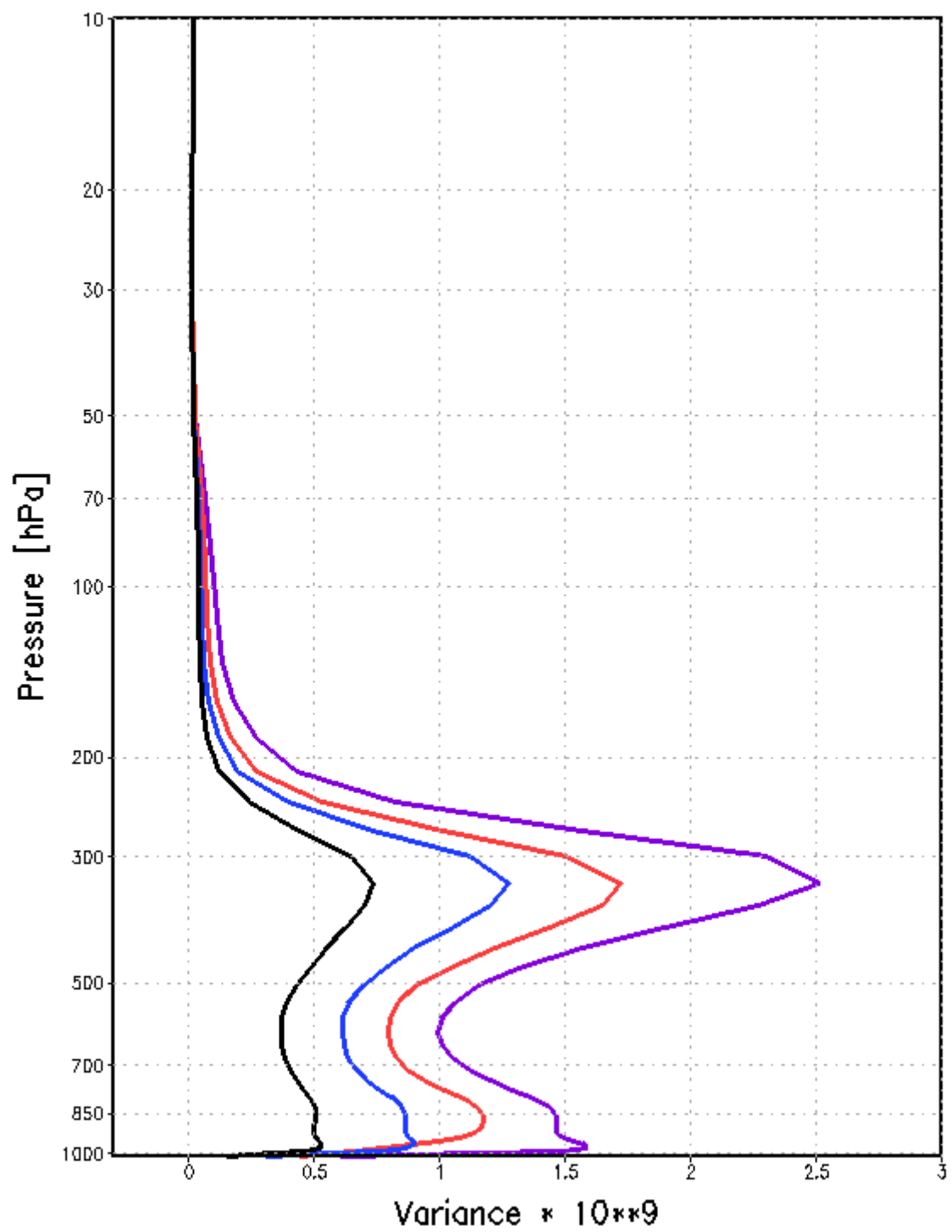


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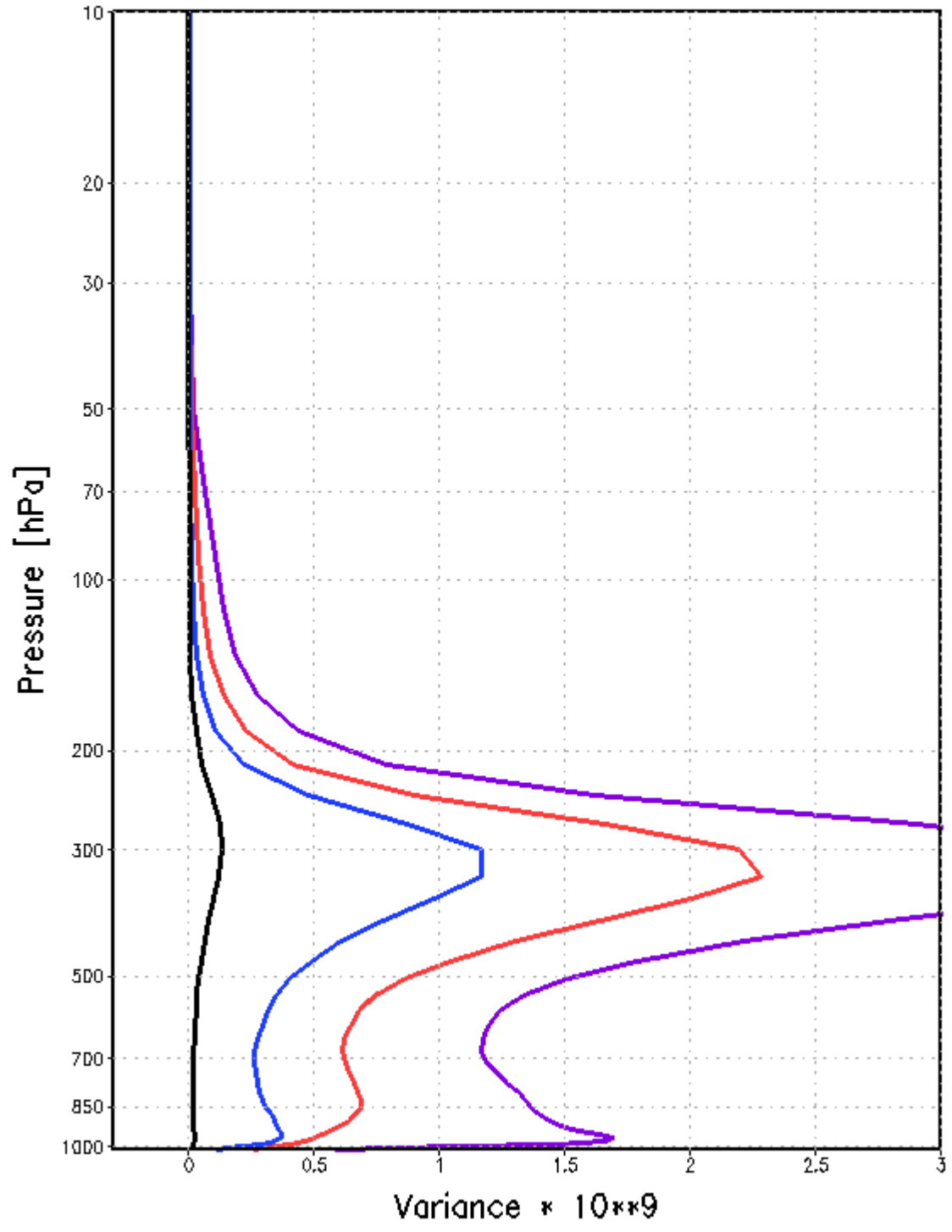
VORTICITY

00 UTC

EPS71



TEPS VORTICITY 00 UTC EPS71



MSE

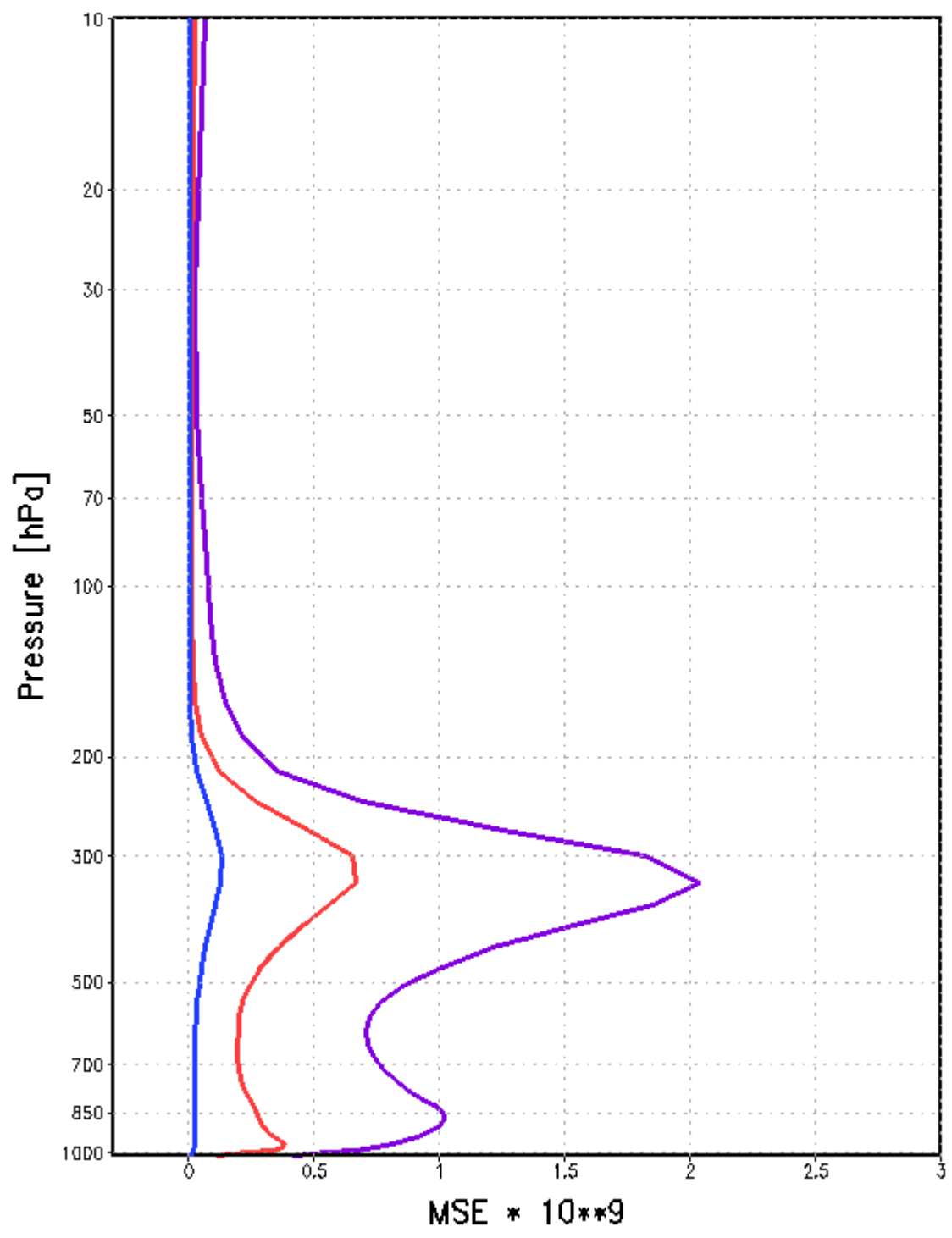
of Control Forecast

vs

SPREAD

among perturbed members

CTRL VORTICITY 12 UTC EPS71

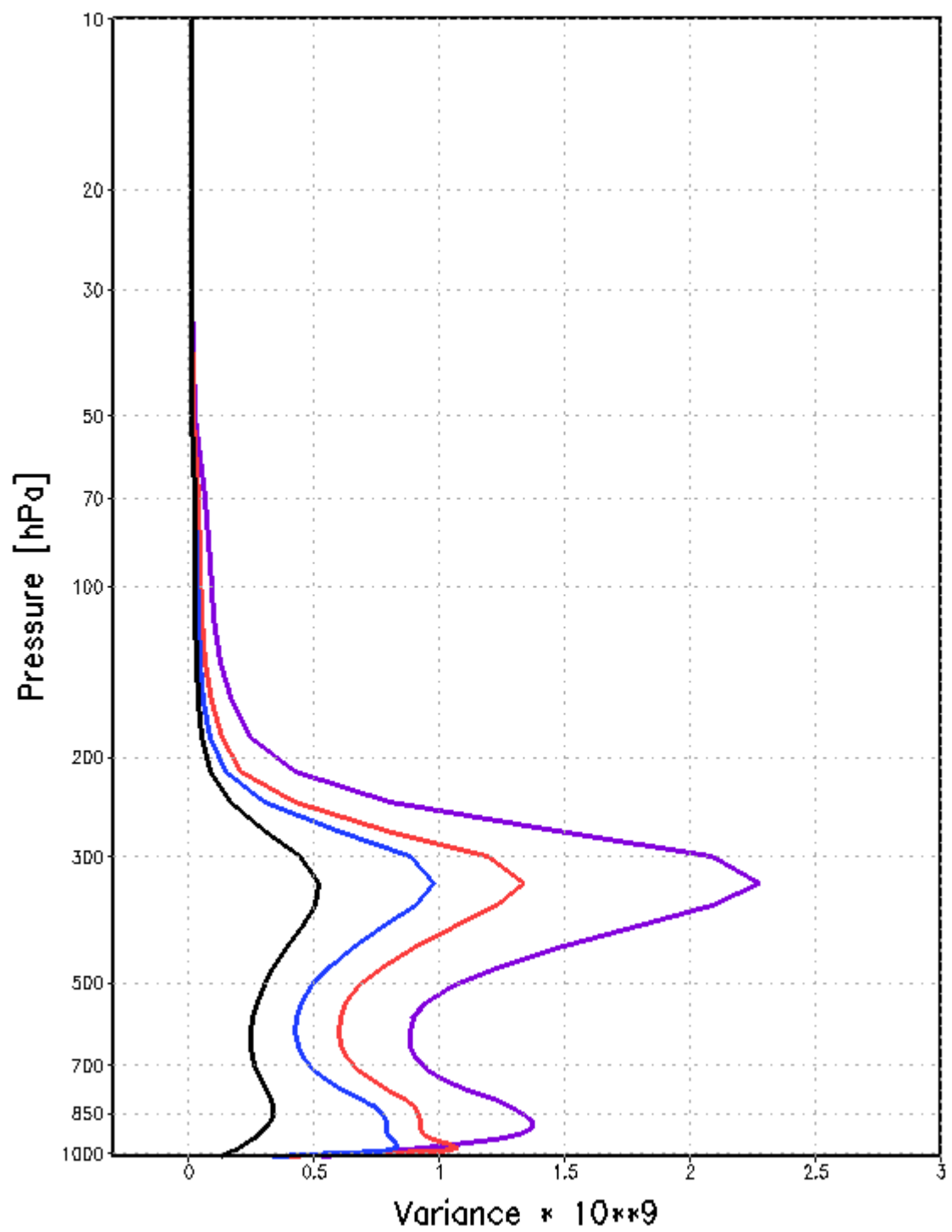


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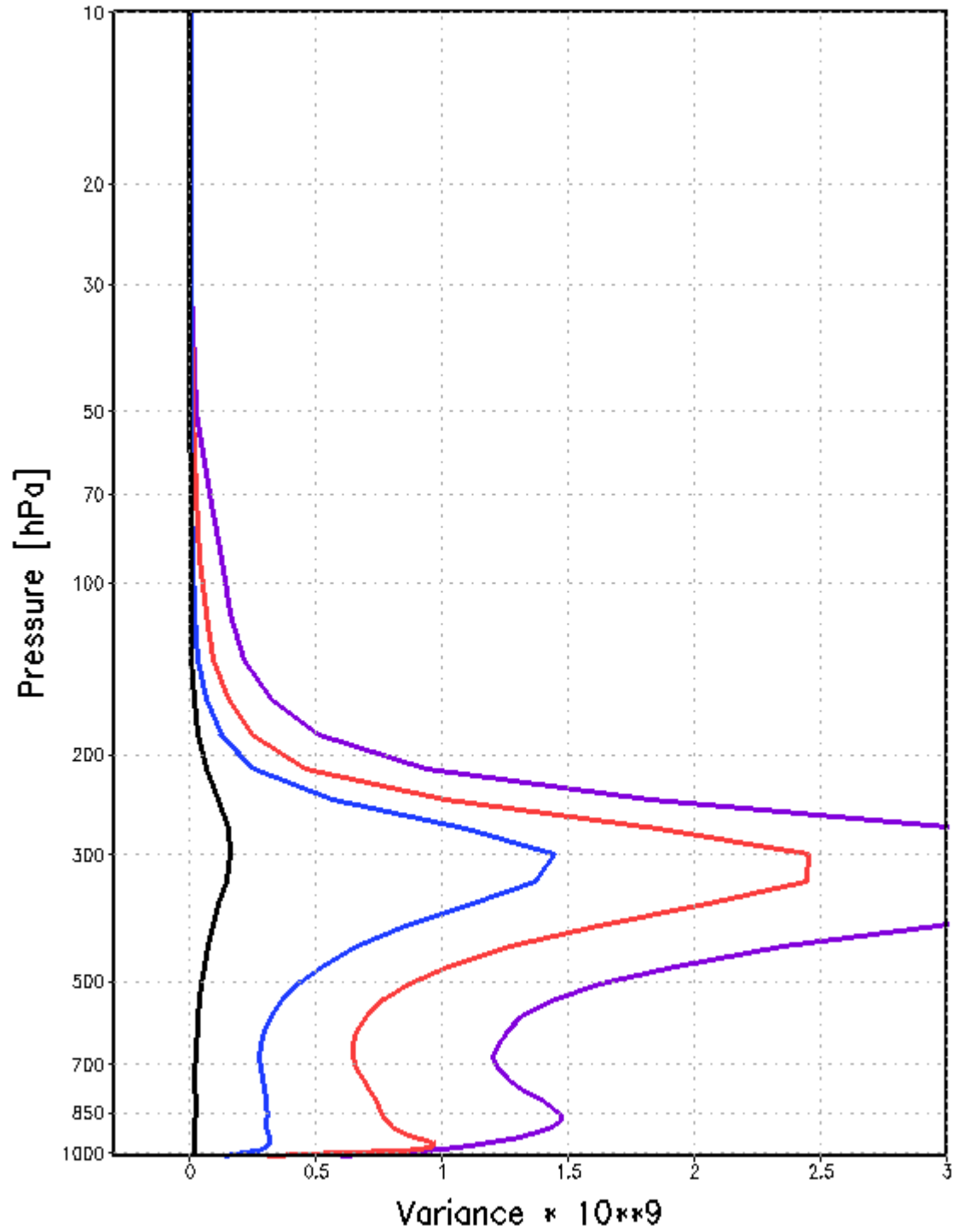
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EPS71



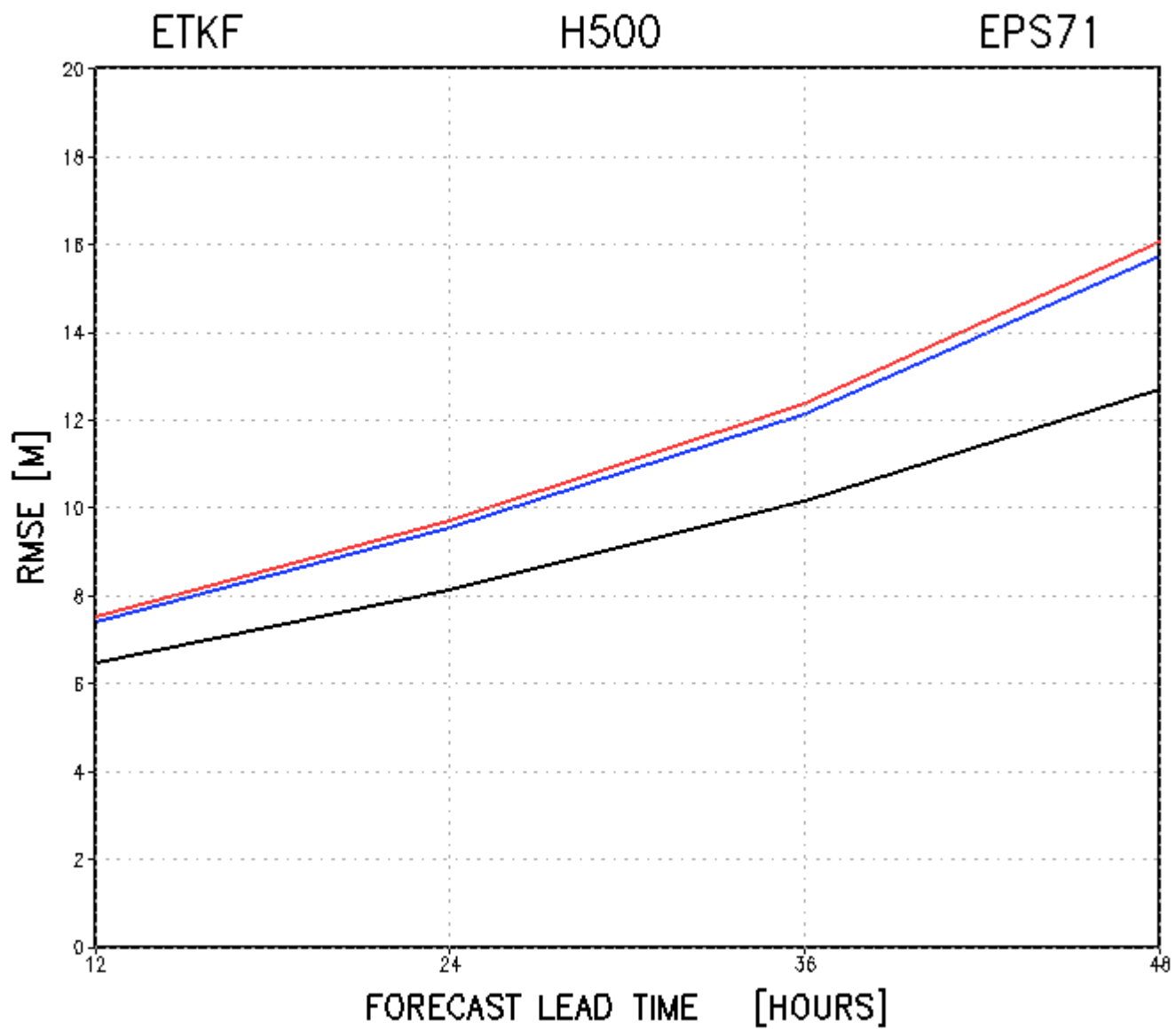
TEPS VORTICITY 12 UTC EPS71



MSE

among

perturbed members



VORTICITY

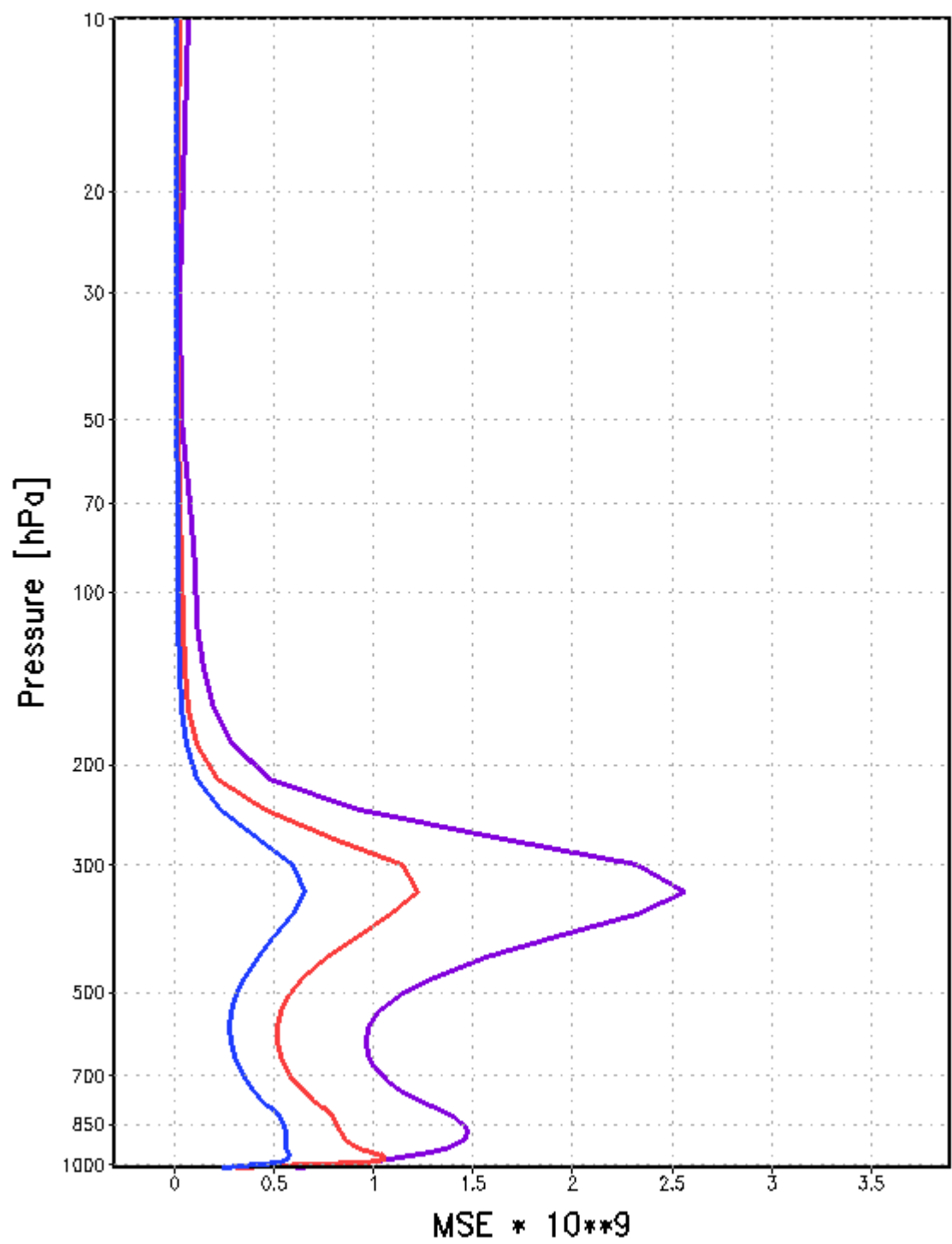
ETKF vs TEPS

ETKF

VORTICITY

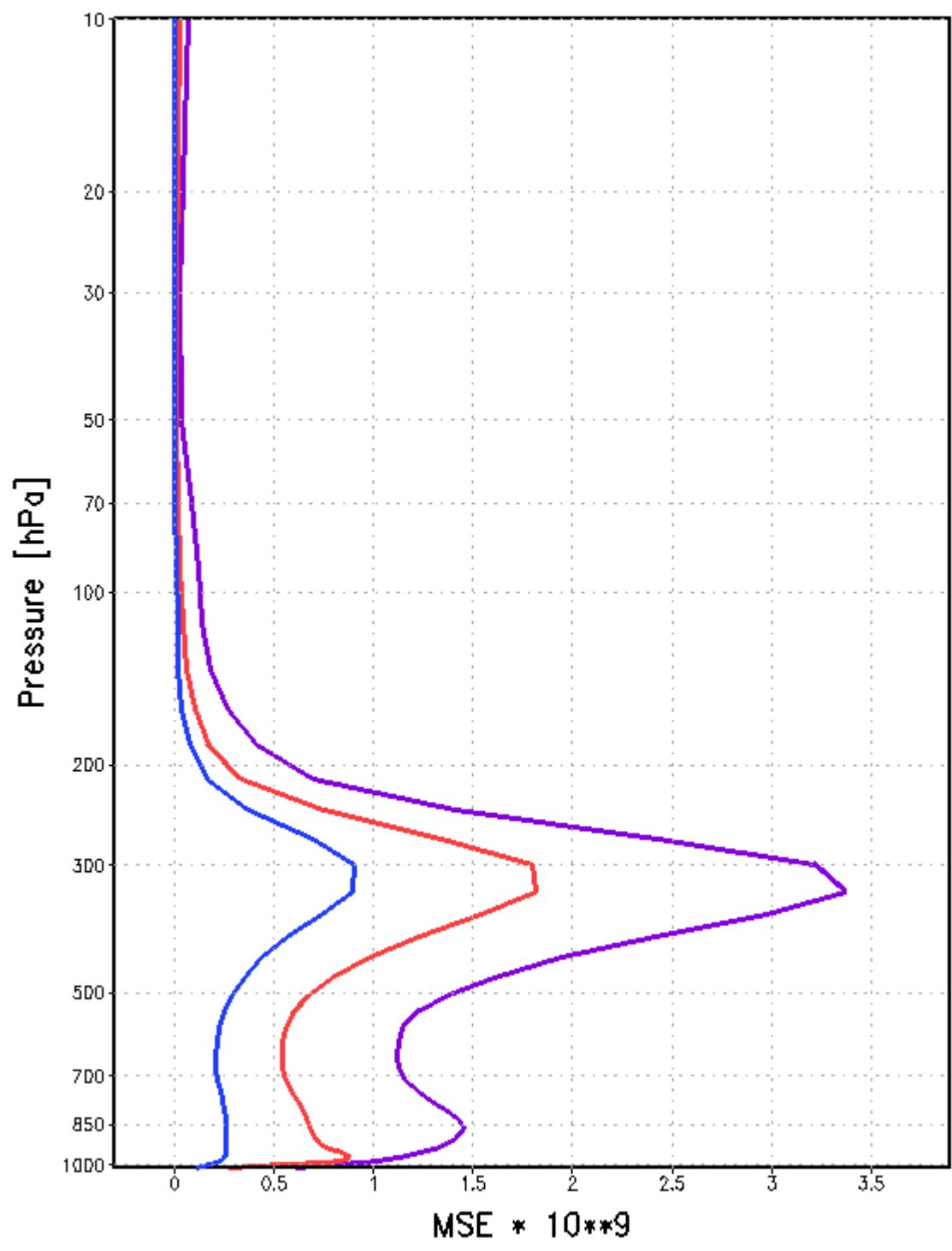
12 UTC

EPS71



MSE * 10**9

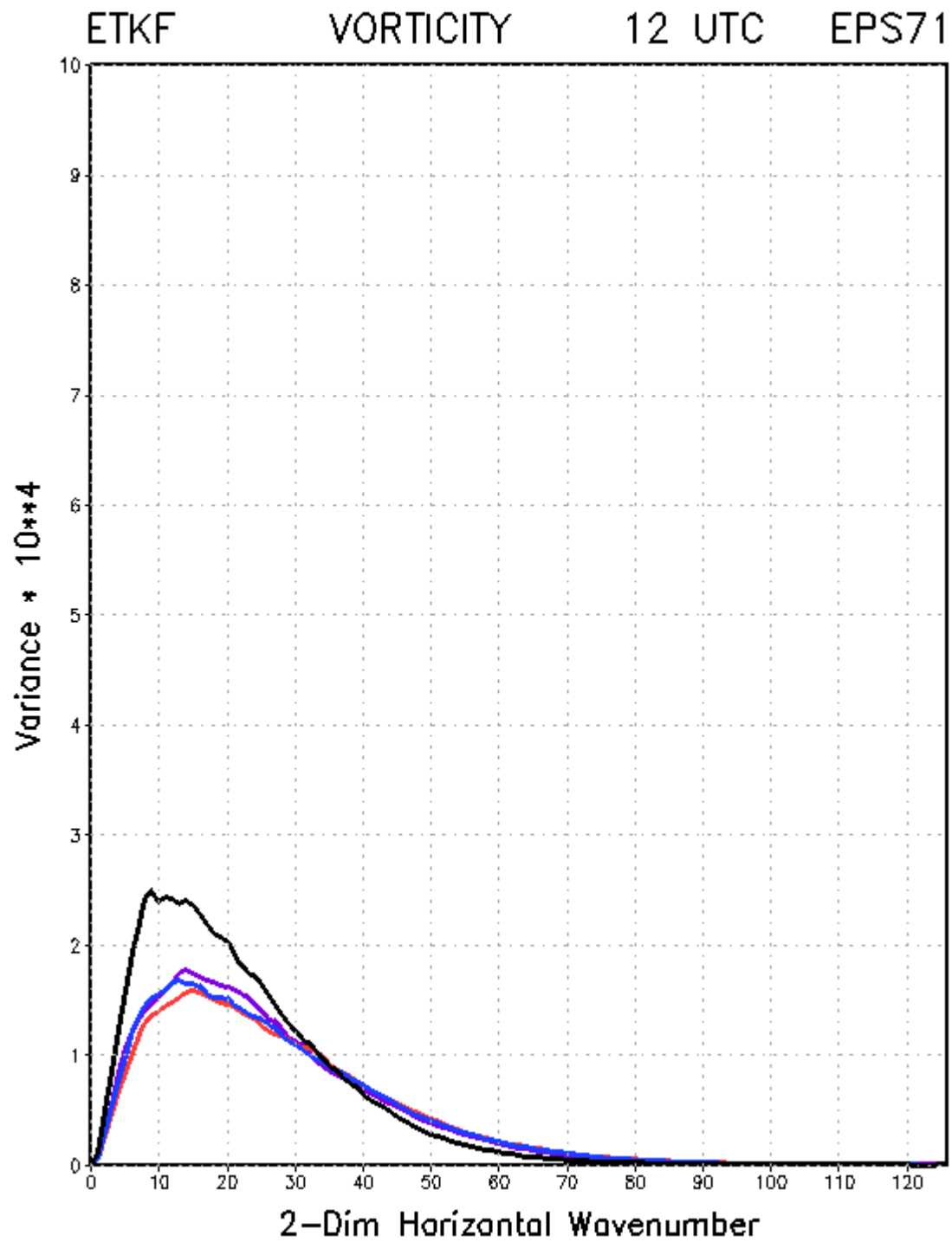
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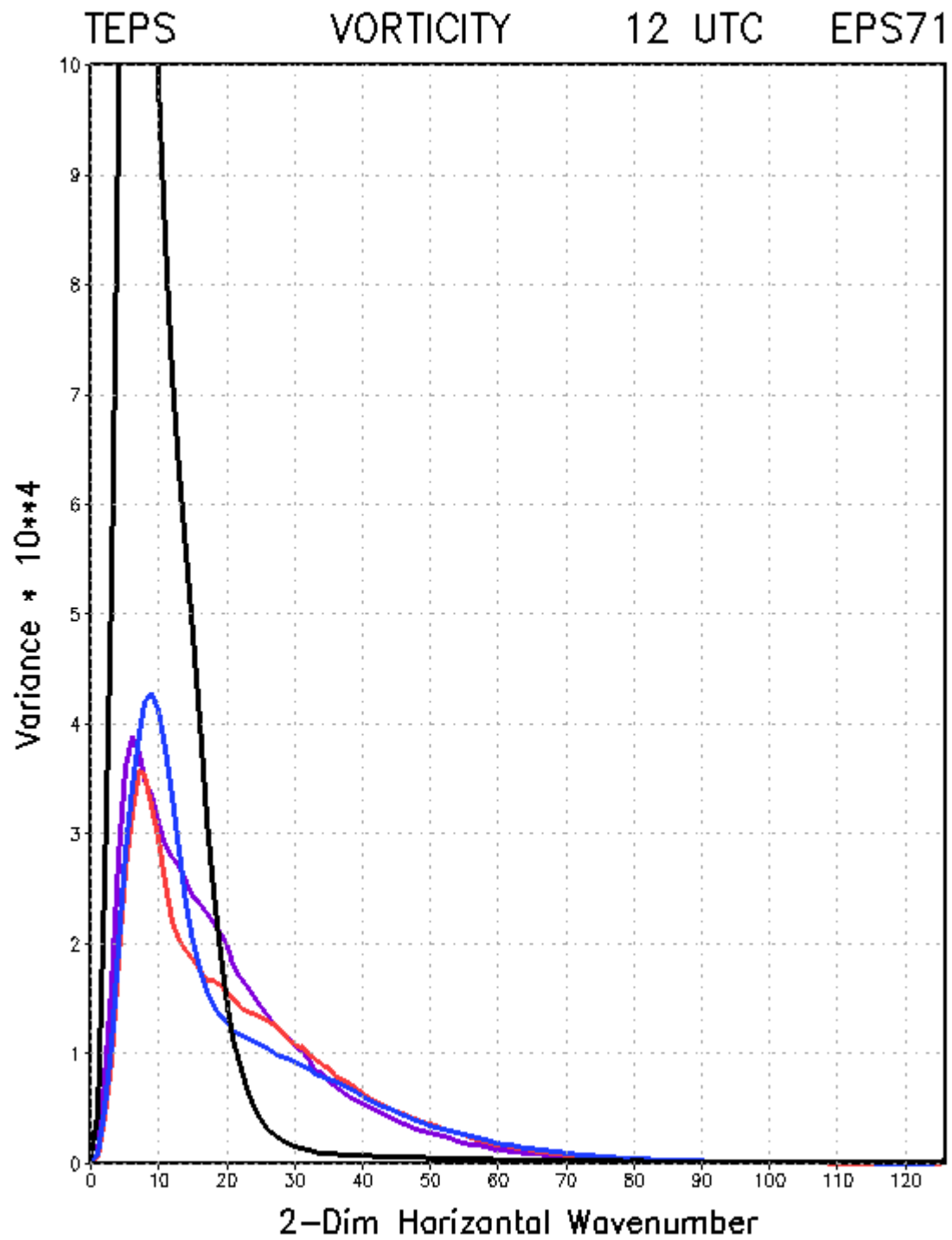


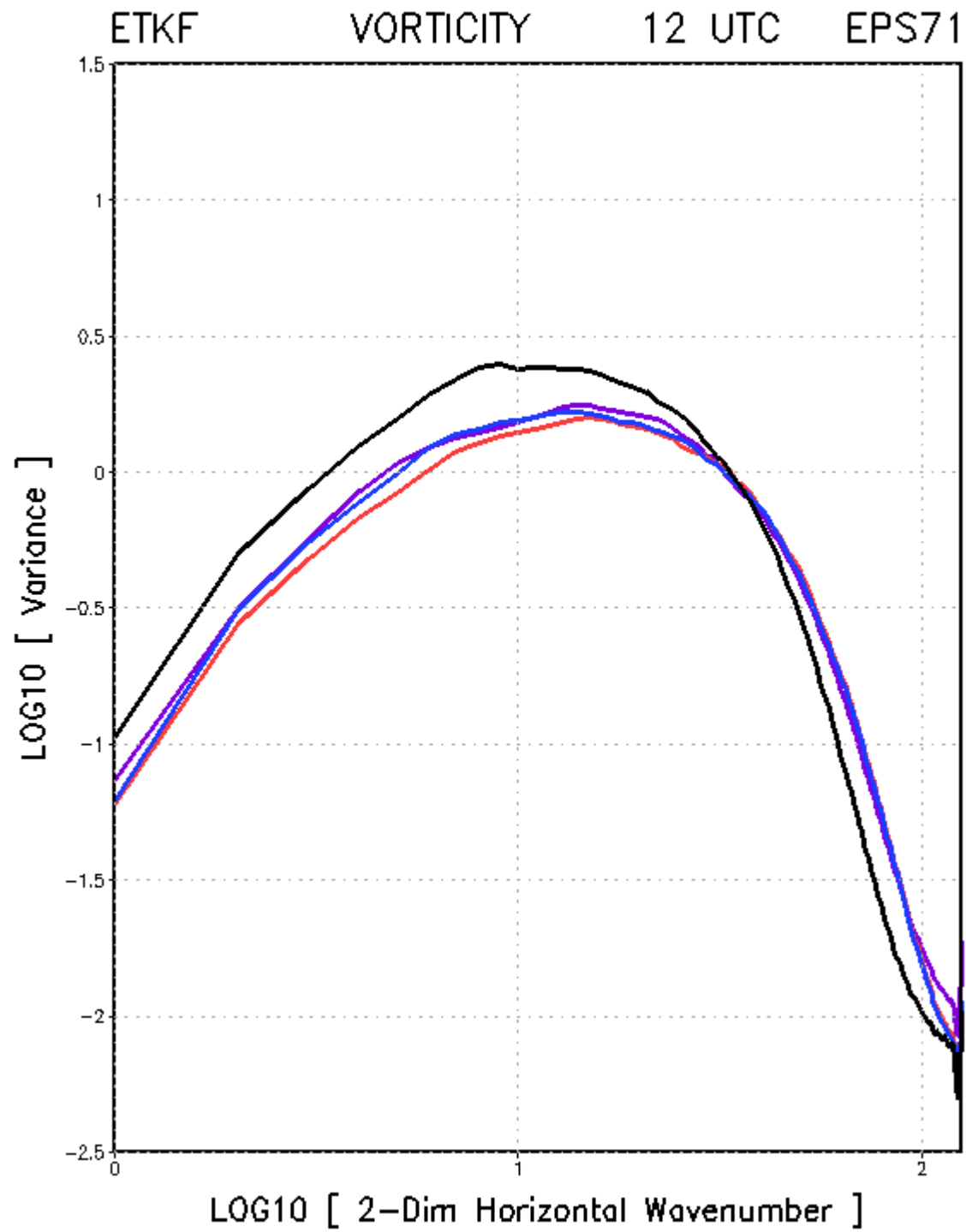
SPECTRA

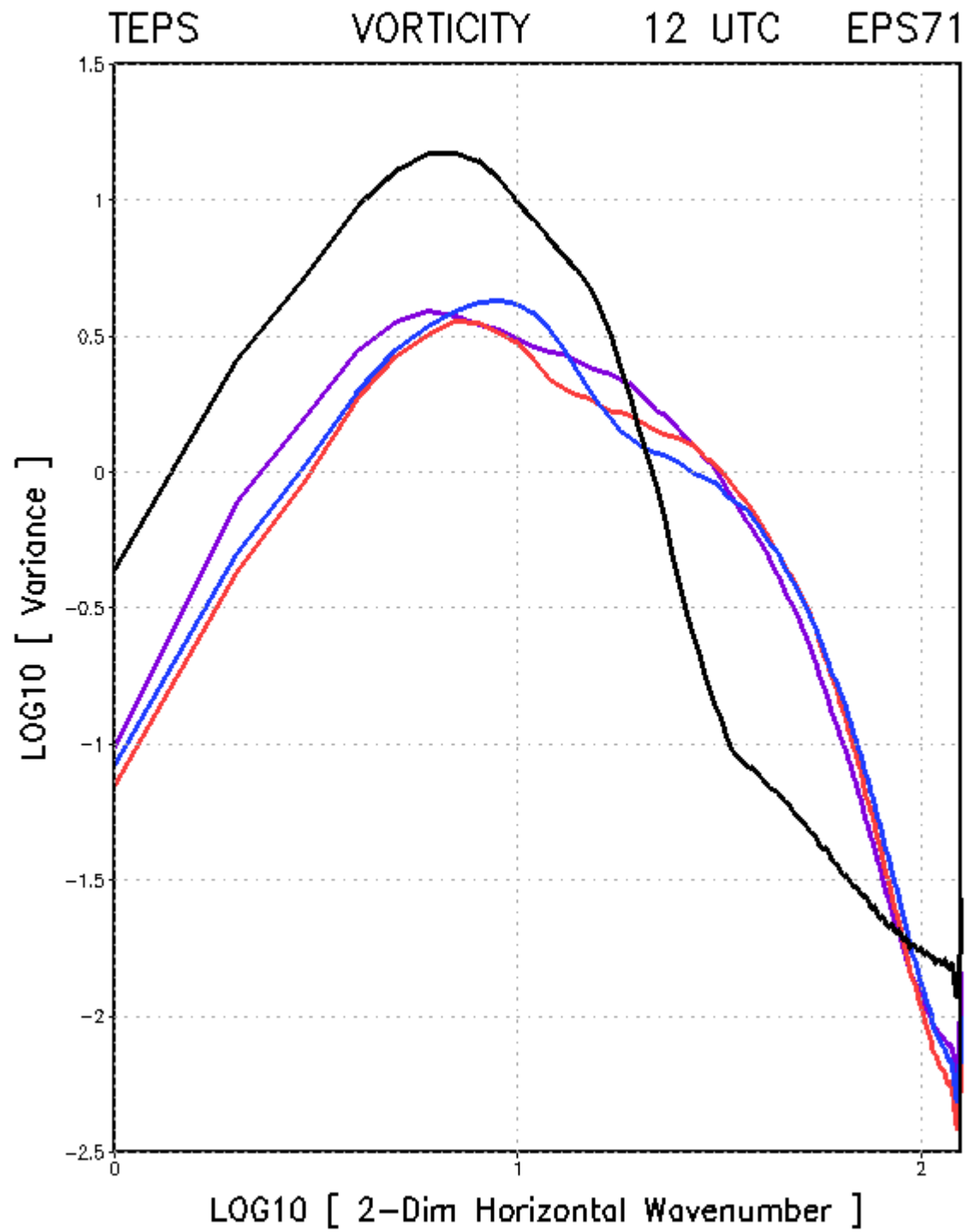
of

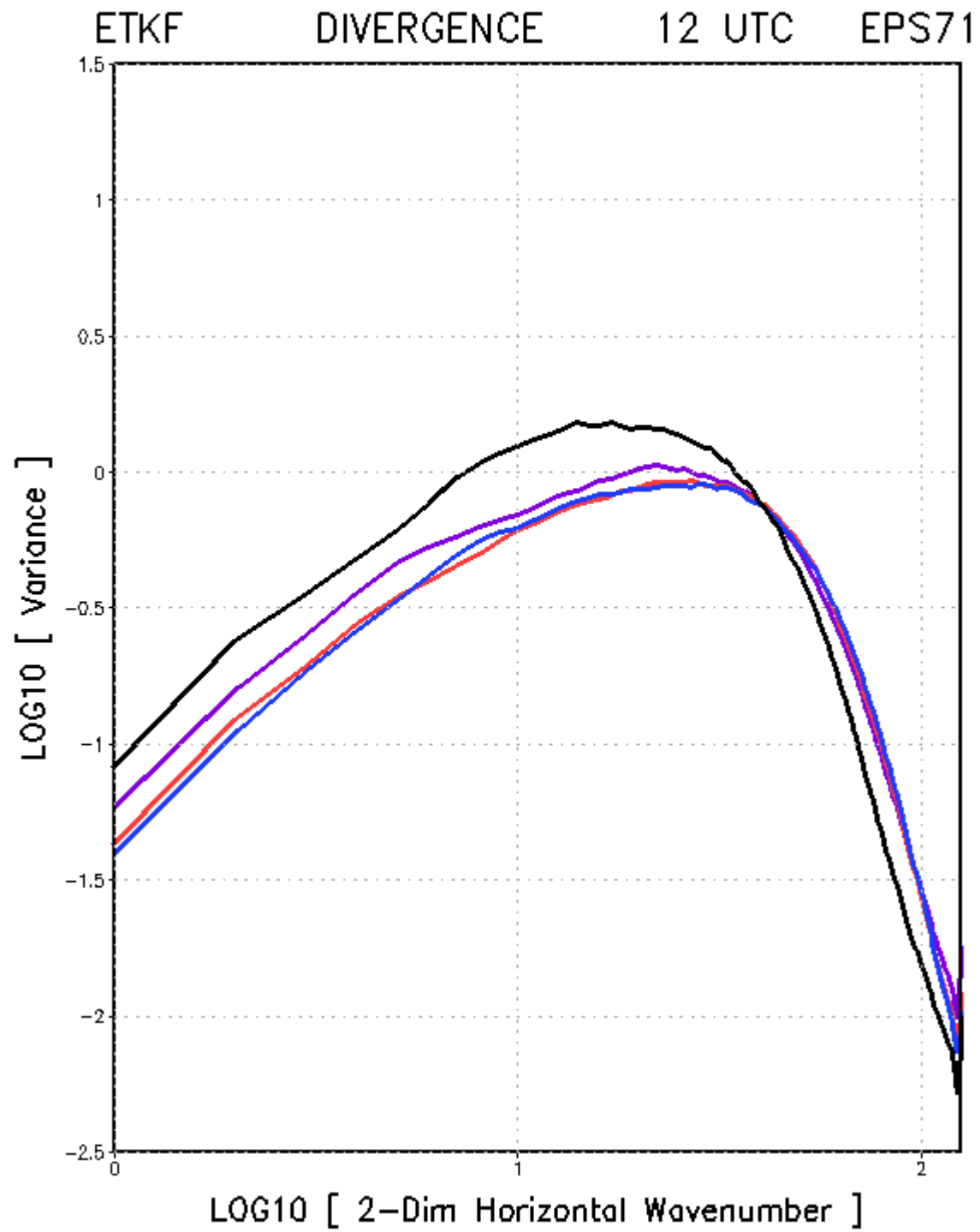
perturbed members

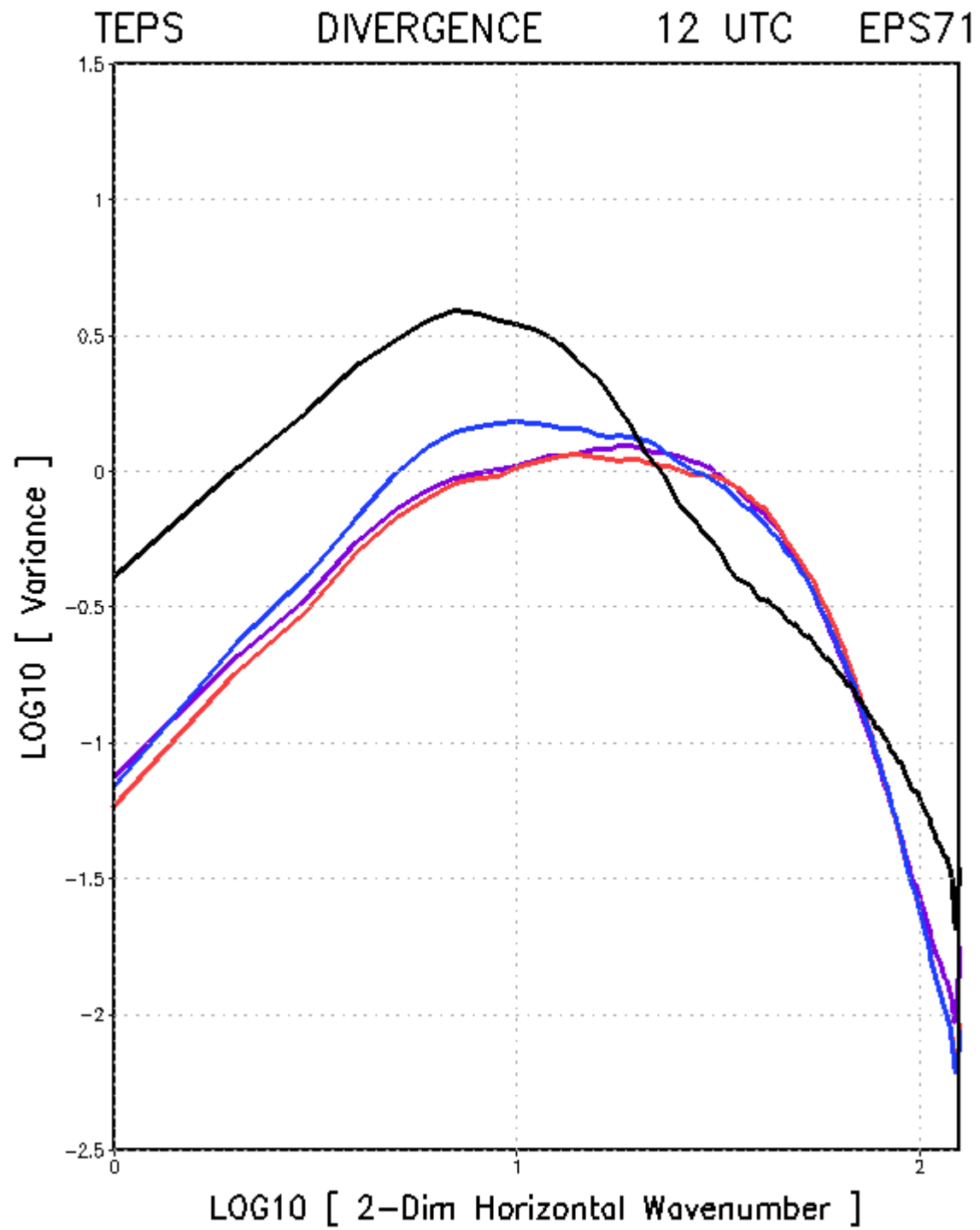




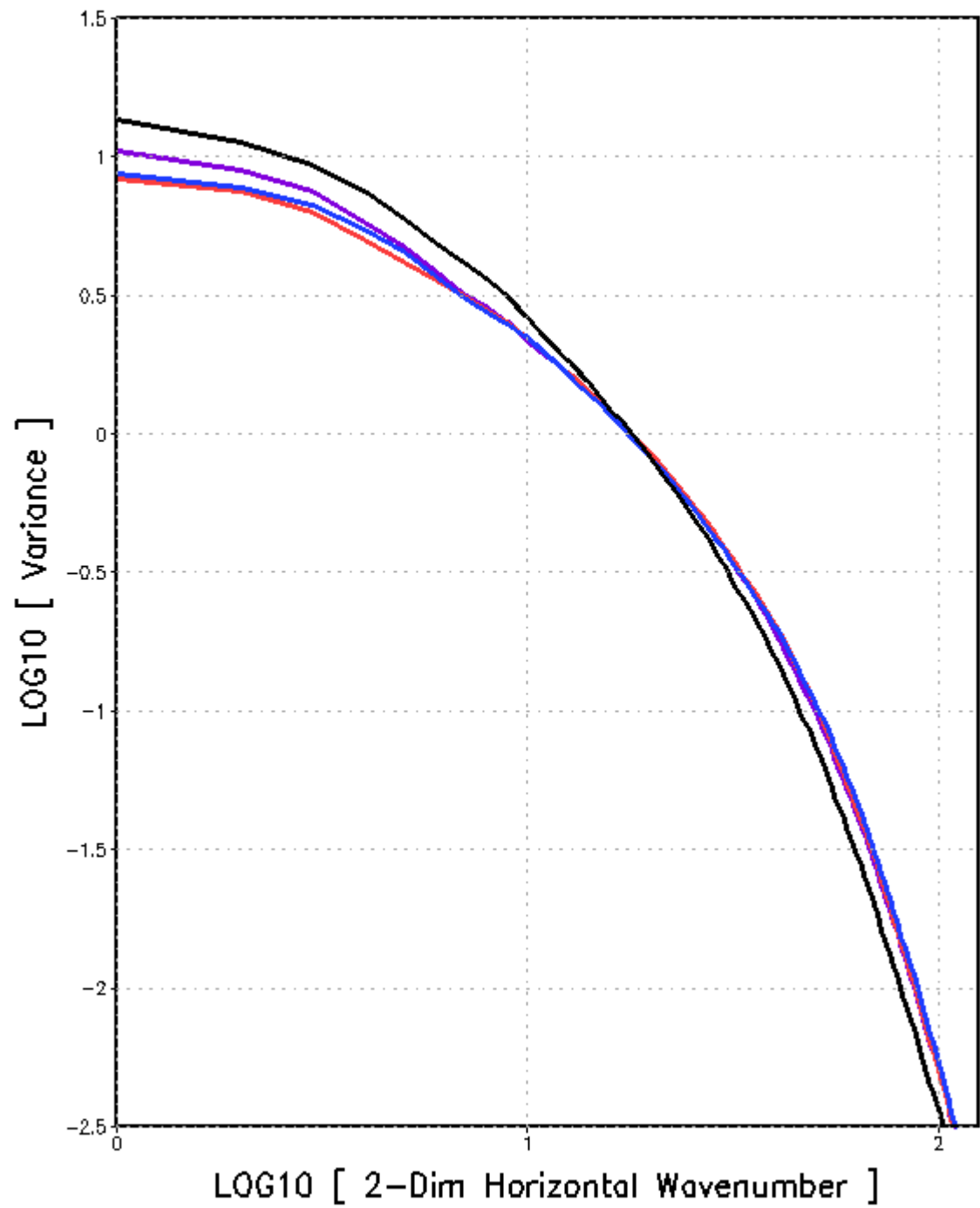


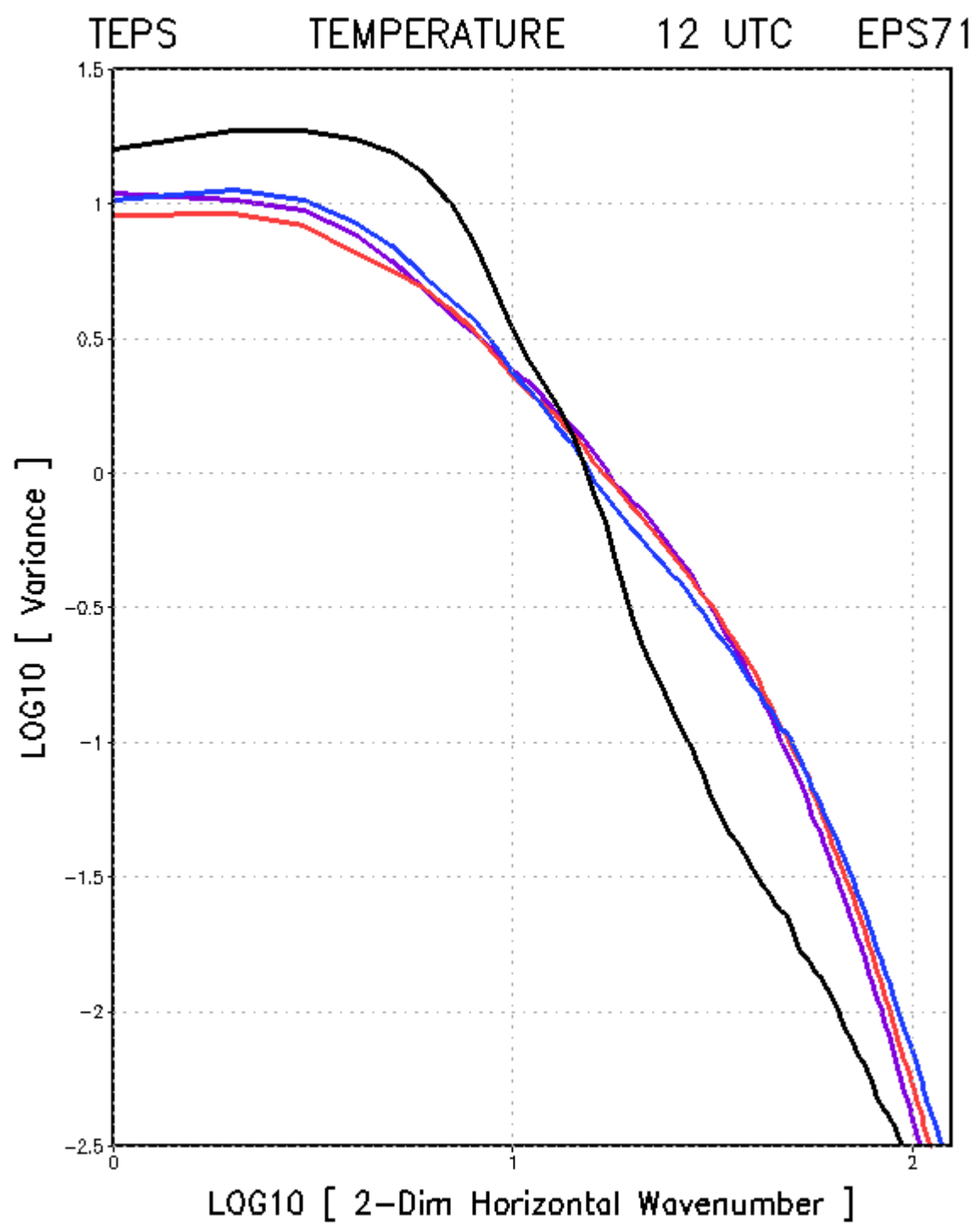




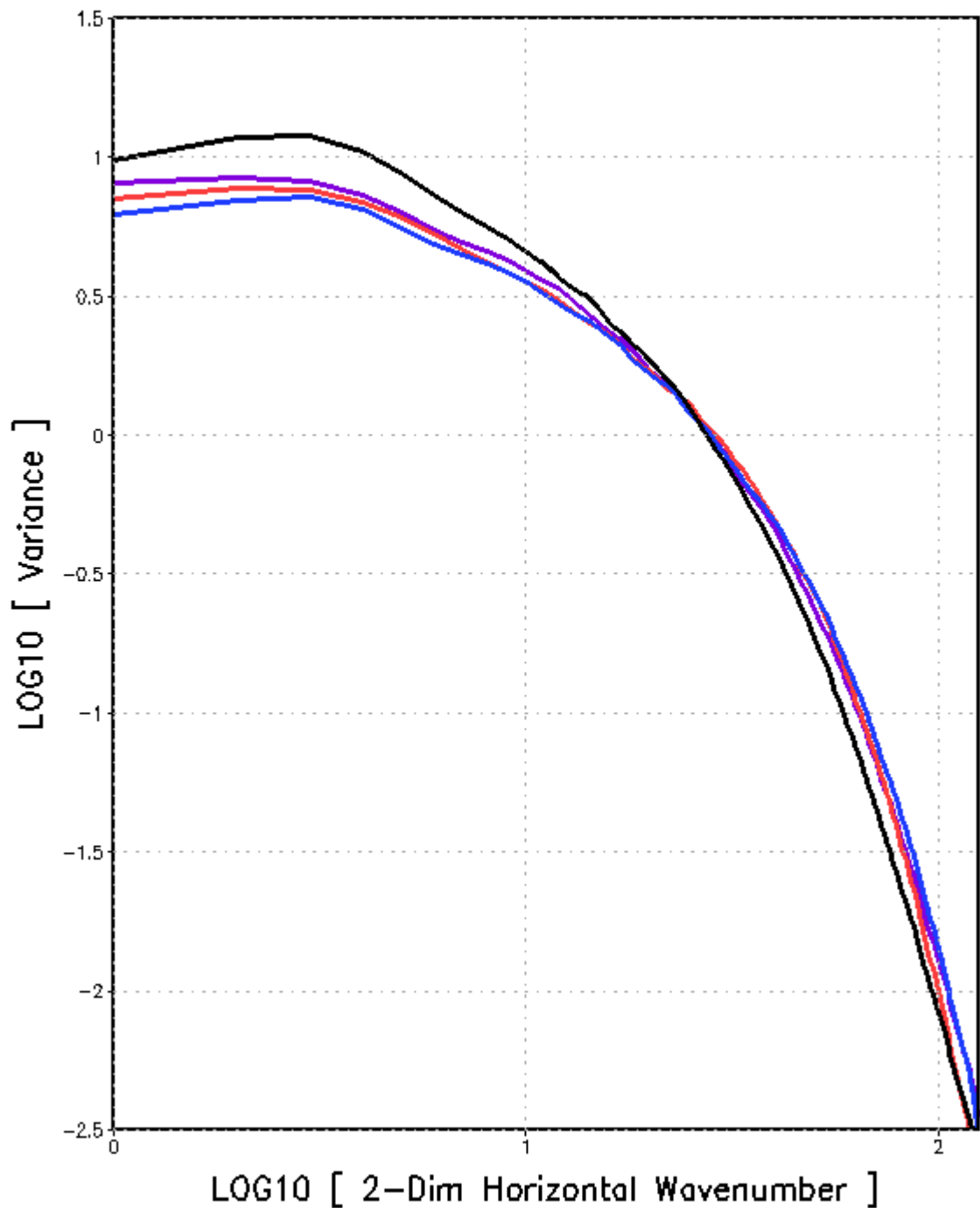


ETKF TEMPERATURE 12 UTC EPS71





ETKF SPECIFIC HUMIDITY 12 UTC EPS71



TEPS SPECIFIC HUMIDITY 12 UTC EPS71

