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Influence of Stratospheric Circulation on the Predictability of the Tropospheric Northern Annular Mode

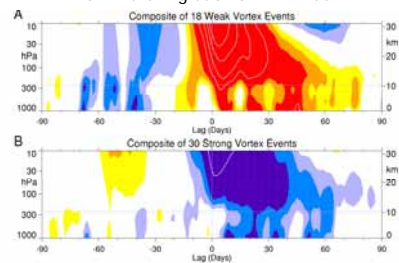
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Downward Migration of NAM index



Baldwin and Dunkerton(1999,2001)

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Stratospheric Influence on Tropospheric Forecast Skill

Baldwin et al. (2003)
Statistical prediction of the monthly-mean AO(t+1;1000hPa) with a forecast period beginning after 10 days by a linear regression model which uses the present value of the NAM(t) at one level between 1000 and 100 hPa:
 $AO(t+1) = B0 + B1 * NAM(t) +$



The 150-hPa NAM predicts the monthly-mean AO better than the AO itself. Downward migration of the NAM variation

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Aim of Our Study

Examine **stratospheric influence on the forecast skill** of the tropospheric circulation using **operational 1-month ensemble forecast dataset provided by the JMA**

Influence of **stratospheric NAM variation** on the forecast skill of tropospheric NAM index

5-winter (2001/02-2005/06; DJF) archive of the JMA 1-month ensemble forecasts

Forecast skill of upper tropospheric NAM index for a lead time from 4 to 11 days tends to be better when **negative NAM anomaly (easterly wind anomaly) is observed in the stratosphere** at the initial time of forecast

Forecast skill of tropospheric circulation over the North Atlantic region is significantly improved

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Data

1-month forecast dataset of JMA ensemble prediction system

Resolution: T106L40 hybrid coordinate

Top Boundary: 0.4 hPa

Ozone: specified by zonal-mean climatological value

SST: constant SST anomaly at the initial time

Integration Period: 34 days

Number of Ensemble: 13 members

Perturbation Method: BGM(Breeding of Growing Mode)

Initialization Date: Every Wednesday and Thursday

Interval of Stored Data: Daily (2.5° x 2.5°)

5 winter seasons: 2001/02 - 2005/06

5 X 26 = 130 forecasts

7-day averaged ensemble-mean forecasts

JMA Global Analysis (GANAL) dataset (1.25° x 1.25°)

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Northern Hemisphere Annular Mode(NAM)
Baldwin and Dunkerton (2001)

NAM index:

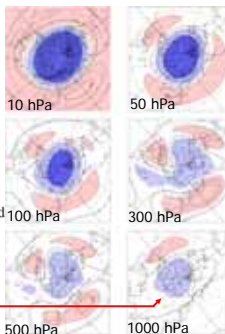
$$\frac{\|Z \cdot r\|}{\|r\|^2}$$

Z: Z anomaly; r: Regressed field

ERA-40 monthly mean Z

Nov.-Apr. 1957-2002

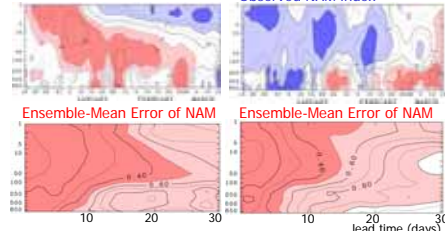
Arctic Oscillation (AO)



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Observed NAM & Ensemble-Mean Forecast Error of NAM

03/04 Winter: Observed NAM index
04/05 Winter: Observed NAM index

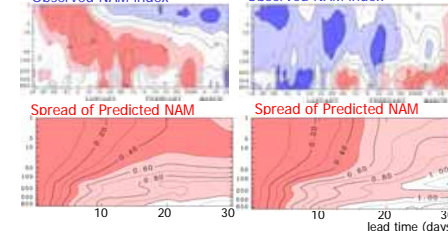


Prediction skill of the 7-day averaged NAM index for 03/04 winter is better than that for 04/05 winter

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Observed NAM & Spread of the Predicted NAM

03/04 Winter: Observed NAM index
04/05 Winter: Observed NAM index



Spread of the predicted 7-day averaged NAM index in the troposphere for 03/04 winter is also smaller than that for 04/05 winter

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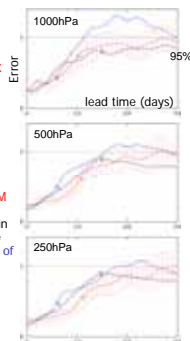
Dependence of Ensemble-Mean Forecast Error of Predicted NAM Index on the Initial NAM Index at 50 hPa

Classified based on NAM index at 50hPa at the initial time of forecast

p: NAM@50hPa > 1: 18 forecasts
n: NAM@50hPa < -1: 43 forecasts
0: others: 69 forecasts

Predicted NAM index error for negative NAM case is significantly smaller than positive NAM case for lead time from 4 to 11 days in the upper troposphere, which suggests the stratospheric influence on the forecast skill of the prediction of the troposphere

For extended-range period, the error of predicted NAM for positive case becomes significantly large even in the lower troposphere

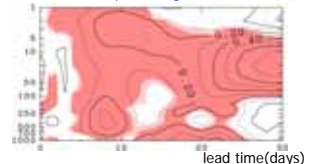


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Dependence of Ensemble-Mean Forecast Error of Predicted NAM Index on the Initial NAM Index at 1000hPa

Classified based on NAM index at 50hPa at the initial time of forecast

Error difference of p-n with significance level 95(90)%

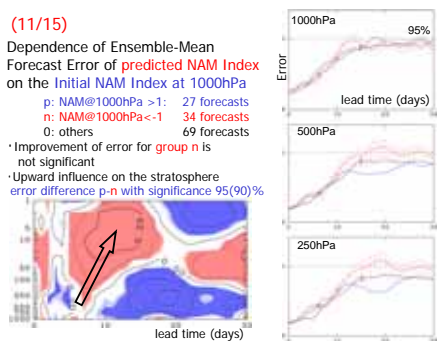


Prediction skill of tropospheric NAM anomaly for extended-range forecast would be improved when negative NAM anomaly is observed at 50hPa

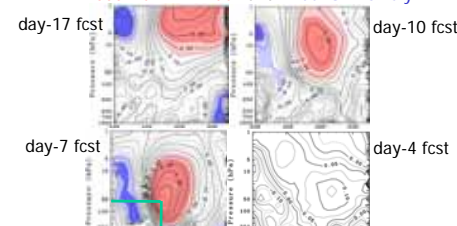
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Dependence of Ensemble-Mean Forecast Error of predicted NAM Index on the Initial NAM Index at 1000hPa

p: NAM@1000hPa > 1: 27 forecasts
n: NAM@1000hPa < -1: 34 forecasts
0: others: 69 forecasts
Improvement of error for group n is not significant
Upward influence on the stratosphere error difference p-n with significance 95(90)%

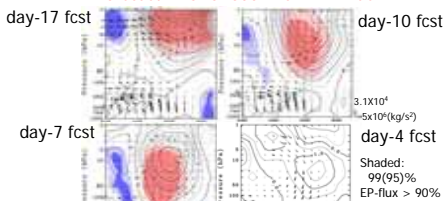


(12/15) Correlation between Forecast Error of Predicted 500hPa NAM Index and Initial U Anomaly



High correlated region gradually migrates downward from upper to lower stratosphere, but does not penetrate into troposphere

(13/15) Regressed Initial U & WN1 E-P flux w.r.t. Forecast Error of 500-hPa NAM Index

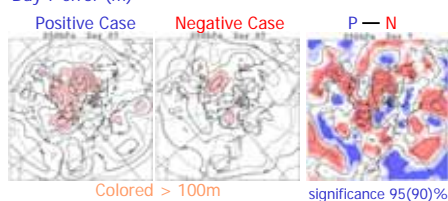


When the forecast error of 500-hPa day-7 NAM index is large, westerly anomaly prevails in the lower stratosphere associated with equatorward & downward propagation of anomalous WN1 activity

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Dependence of Ensemble-Mean Forecast Error of Predicted Z250 on the Initial NAM Index at 50 hPa

Day 7 error (m)



Forecast error of Z250 over the North Atlantic for positive NAM case is significantly larger than that for negative NAM case

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Summary

- Forecast skill of the 7-day averaged ensemble-mean upper tropospheric NAM index for a lead time from 4 to 11 days tends to be better when the negative NAM index is observed in the stratosphere
- Influence of tropospheric NAM anomaly at the initial time on the forecast skill of tropospheric NAM index is insignificant
- When the extended-range forecast error of the tropospheric NAM index is large, westerly anomaly prevails in the stratosphere associated with suppressed upward and enhanced equatorward propagation of WN1 activity
- The impact of the stratospheric state on the forecast error of the troposphere could be well understood in the framework of regional mode (NAO), rather than annular mode variability