

GEFSv12 North Atlantic Oscillation Indices

Zachary D. Lawrence (zachary.lawrence@noaa.gov), Dillon Elsbury (dillon.elsbury@noaa.gov)

Overview

This document provides details about the North Atlantic Oscillation (NAO) indices for the GEFSv12 reanalysis and reforecast datasets. More details about the GEFSv12 reanalysis and reforecasts can be found from [Hamill et al., 2021](#) and [Guan et al., 2022](#), respectively.

Methodology

The NAO indices are computed using simple Empirical Orthogonal Function (EOF) analysis of 500 hPa geopotential height (*Z500*) fields.

The NAO pattern is defined from the first EOF of *Z500* anomalies in the 20-90N latitude, 90W-40E longitude region using GEFSv12 reanalysis data. Because the primary NAO pattern is known to vary seasonally, the NAO indices are derived using monthly-varying EOF1 loading patterns. The twelve different EOF1 loading patterns are determined from pooling together all the monthly *Z500* anomalies for the three months centered on the month in question between 2000-2019. For example, the January EOF1 pattern is determined from the 2000-2019 December, January, and February months.

The daily NAO indices are then computed by projecting daily *Z500* anomalies onto these patterns (see Figure 1), where the appropriate pattern to project onto is chosen by the month of the given date. For the GEFSv12 reforecasts, the daily *Z500* anomalies are determined by removing the lead-dependent climatology of *Z500* as described by [Pegion et al., 2019](#) (see Appendix B).

As a last step, the GEFSv12 reanalysis NAO index time series is normalized by subtracting the time mean (mean = 0.00086208) and dividing by the standard deviation (std dev = 1.47893798). For consistency, these values are used to similarly transform the GEFSv12 reforecast NAO indices, though this does not guarantee the reforecast indices have zero mean and unit variance when considering all initializations and lead times.

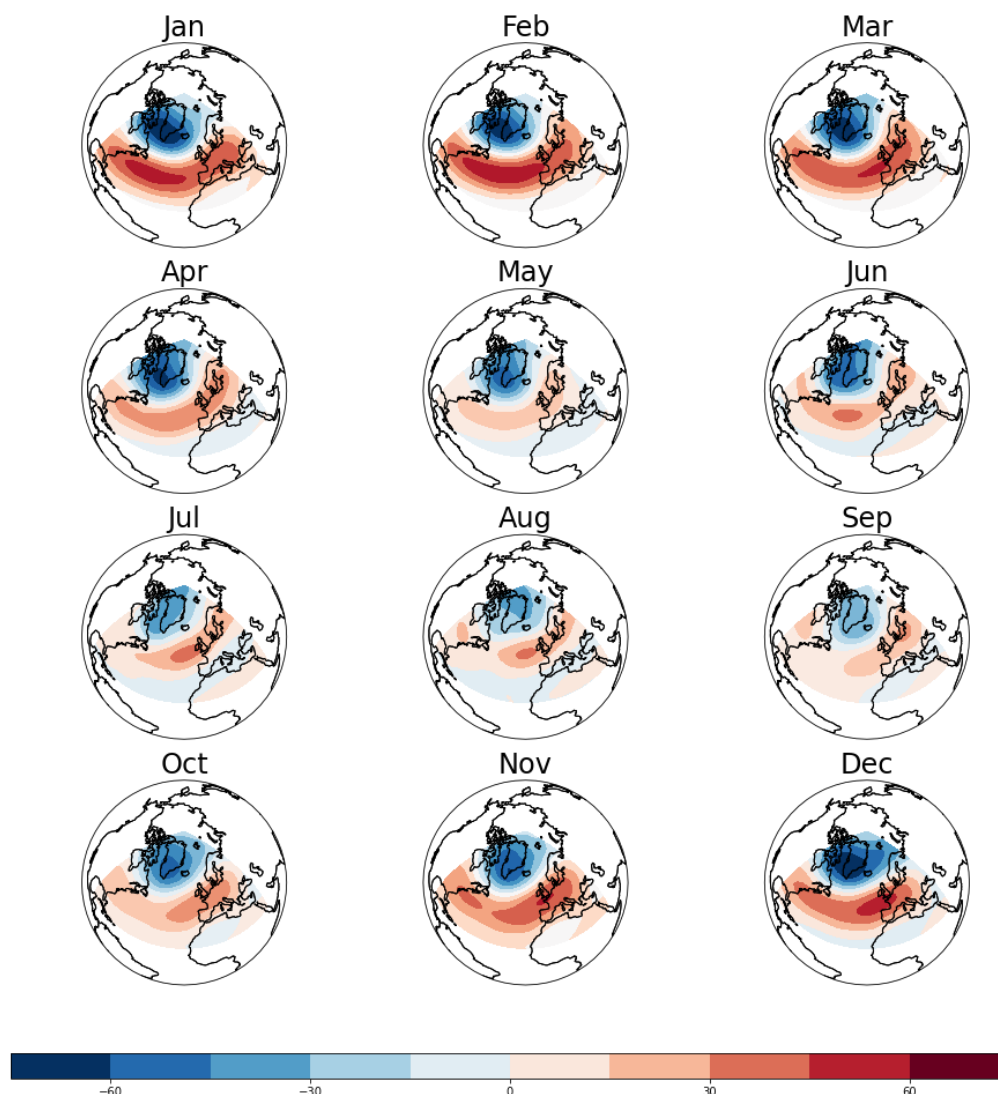


Figure 1. The monthly-varying EOF1 loading patterns derived from the GEFSv12 reanalysis Z500 data.

Additional Notes

The GEFSv12 reforecast NAO indices have NaNs for some ensemble members and some lead times around 7-10 days. This is because there were missing grib records in some of the 1-10 day files archived on the [Amazon Web Services bucket for the GEFSv12 data](#).

The GEFSv12 reforecast NAO indices span lead times from days 0 to 35. Since these are determined from daily mean Z500 anomalies, it should be noted that “day 0” for the GEFSv12 reforecasts only consists of forecast hours 6, 12, and 18. Similarly “day 35” consists only of forecast hour 840 (a single timestep), which is the limit of the forecasts.

References

- Guan, H., Zhu, Y., Sinsky, E., Fu, B., Li, W., Zhou, X., Xue, X., Hou, D., Peng, J., Nageswararao, M. M., Tallapragada, V., Hamill, T. M., Whitaker, J. S., Bates, G., Pegion, P., Frederick, S., Rosencrans, M., & Kumar, A. (2022). GEFSv12 Reforecast Dataset for Supporting Subseasonal and Hydrometeorological Applications, *Monthly Weather Review*, 150(3), 647-665, <https://journals.ametsoc.org/view/journals/mwre/150/3/MWR-D-21-0245.1.xml>
- Hamill, T. M., Whitaker, J. S., Shlyueva, A., Bates, G., Fredrick, S., Pegion, P., Sinsky, E., Zhu, Y., Tallapragada, V., Guan, H., Zhou, X., & Woollen, J. (2022). The Reanalysis for the Global Ensemble Forecast System, Version 12, *Monthly Weather Review*, 150(1), 59-79, <https://journals.ametsoc.org/view/journals/mwre/150/1/MWR-D-21-0023.1.xml>
- Pegion, K., Kirtman, B. P., Becker, E., Collins, D. C., LaJoie, E., Burgman, R., Bell, R., DelSole, T., Min, D., Zhu, Y., Li, W., Sinsky, E., Guan, H., Gottschalck, J., Metzger, E. J., Barton, N. P., Achuthavarier, D., Marshak, J., Koster, R. D., Lin, H., Gagnon, N., Bell, M., Tippet, M. K., Robertson, A. W., Sun, S., Benjamin, S. G., Green, B. W., Bleck, R., & Kim, H. (2019). The Subseasonal Experiment (SubX): A Multimodel Subseasonal Prediction Experiment, *Bulletin of the American Meteorological Society*, 100(10), 2043-2060, <https://journals.ametsoc.org/view/journals/bams/100/10/bams-d-18-0270.1.xml>

Output of 'ncdump -h GEFSv12_Reanalysis_NAO.nc'

```
netcdf GEFSv12_Reanalysis_NAO {
dimensions:
    time = 7305 ;
variables:
    int64 time(time) ;
        time:units = "days since 2000-01-01 00:00:00" ;
        time:calendar = "proleptic_gregorian" ;
    float nao(time) ;
        nao:_FillValue = NaNf ;
        nao:long_name = "North Atlantic Oscillation (NAO) Index" ;
        nao:description = "Computed by projecting daily mean Z500
            anomalies onto monthly-varying EOF1 patterns of monthly
            Z500 anomalies in the region of 20-90 latitude, 90W-40E
            longitude. The EOF patterns are determined from pooling
            together the three months centered on the month in
            question (e.g., the Jan EOF1 pattern comes from DJF
            months; the May EOF1 patterns comes from AMJ; etc.)" ;

// global attributes:
        :source = "GEFSv12 Reanalysis (obtained from
ftp.emc.ncep.noaa.gov/GEFSv12/reanalysis/FV3_reanalysis/)" ;
        :contact = "Zachary Lawrence (zachary.lawrence@noaa.gov);
Dillon Elsbury (dillon.elsbury@noaa.gov)" ;
}
```

Output of 'ncdump -h GEFSv12_Reforecast_NAO.nc'

```
netcdf GEFSv12_Reforecast_NAO {
dimensions:
    init = 1043 ;
    lead = 36 ;
    member = 11 ;
variables:
    int64 init(init) ;
        init:long_name = "Initialization Date" ;
        init:standard_name = "forecast_reference_time" ;
        init:units = "days since 2000-01-05 00:00:00" ;
        init:calendar = "proleptic_gregorian" ;
    int64 lead(lead) ;
        lead:units = "days" ;
        lead:long_name = "Days from initialization" ;
    float nao(init, member, lead) ;
        nao:_FillValue = NaNf ;
        nao:long_name = "North Atlantic Oscillation (NAO) Index" ;
        nao:description = "Computed by projecting daily mean Z500
            anomalies onto monthly-varying EOF1 patterns from the
            GEFSv12 reanalysis valid for the region of 20-90
            latitude, 90W-40E longitude. The Z500 anomalies are
            determined by removing the GEFSv12 lead-dependent
            climatology." ;
    int64 member(member) ;
        member:long_name = "Ensemble Member" ;
    int64 valid_time(init, lead) ;
        valid_time:units = "days since 2000-01-05 00:00:00" ;
        valid_time:calendar = "proleptic_gregorian" ;

// global attributes:
        :source = "GEFSv12 Reforecasts (obtained from
https://registry.opendata.aws/noaa-gefs-reforecast/)" ;
        :contact = "Zachary Lawrence (zachary.lawrence@noaa.gov);
Dillon Elsbury (dillon.elsbury@noaa.gov)" ;
}
```