

Summary of Repository Contents

Title: Dataset associated with "Skillful all-season S2S prediction of U.S. precipitation using the MJO and QBO"

Purpose: This repository provides supplemental information in support of Nardi et al. (2020), cited below. For detailed information regarding the model and analyses, please refer to Nardi et al. (2020).

Date Last Modified: 25 October 2019

Abstract: Although useful at short and medium-ranges, current dynamical models provide little additional skill for precipitation forecasts beyond Week 2 (14 days). Here, we apply an empirical model that uses the Madden-Julian oscillation (MJO) and quasi-biennial oscillation (QBO) as predictors to forecast anomalous (i.e., categorical above- or below-normal) weekly precipitation at Weeks 3 through 6 (15-42 days) across the contiguous U.S. and Alaska during all seasons. In almost all regions and seasons, the model provides "skillful forecasts of opportunity" for 20-50% of all forecasts valid Weeks 3 through 6. We also find that this model skill is correlated with historical responses of precipitation, and related synoptic quantities, to the MJO and QBO. Finally, we show that the addition of the QBO as a predictor increases the frequency of skillful forecasts of opportunity over most of the contiguous U.S. and Alaska during all seasons.

Contact: For questions regarding this repository, please contact Kyle M. Nardi at kyle.nardi18@alumni.colostate.edu or kmn182@psu.edu.

License information or restrictions placed on the data:

The material is open access and distributed under the terms and conditions of the Creative Commons Attribution International License (<https://creativecommons.org/licenses/by/4.0/>).

For any relevant license information or restrictions related to the model input data, please refer to the individual model input data sources. These data sources are provided in Nardi et al. (2020), which is cited at the end of this document.

Recommended data citation:

Nardi, K. M., C.F. Baggett, E.A. Barnes, E.D. Maloney, D.S. Harnos, and L.M. Ciasto, 2020. Dataset associated with "Skillful all-season S2S prediction of U.S. precipitation using the MJO and QBO." Colorado State University. Libraries. <https://hdl.handle.net/10217/195747>

Format of data files: All data files are in Network Common Data Form (NetCDF) 4 format (*.nc4). Recommended file viewers include Ncview and Panoply:

Ncview: http://meteora.ucsd.edu/~pierce/ncview_home_page.html

Panoply: <https://www.giss.nasa.gov/tools/panoply/>

Location where data were collected: Details regarding model input data coverage can be obtained through the data sources listed in Nardi et al. (2020).

Time period during which data were collected: Model input data cover a 39-year period from 1 January 1979 through 31 December 2017.

File Information: This repository contains 264 files, which account for approximately 50 MB in total storage space. Three types of files exist in the repository:

1. Files containing skill and “skillful forecast of opportunity” data for each forecast region. These files are labelled **foo_lat_lon.nc4**, where *lat* and *lon* refer to the latitude and longitude coordinates of the central grid cell of each region. These files show model skill scores with MJO phase on the vertical axis and lead time on the horizontal axis. Skill is defined using the Heidke Skill Score (HSS). For more information about how to interpret these files, please refer to Figure 1 in Nardi et al. (2020). In addition, the definition of skillful forecasts of opportunity is derived from Nardi et al. (2020). This repository contains 262 files of this nature, with each file representing a unique region.
2. A file containing skill scores in map form. This file is labelled **HSS_map.nc4** and depicts the model’s HSS within each region under particular conditions (see variables and dimensions described below).
3. This README file, labelled **README.pdf**.

Definitions of acronyms, site abbreviations, or other project-specific designations used in the data file names or documentation files: We use the abbreviation **foo** to describe skillful forecasts of opportunity (see Nardi et al. 2020). We also use other common abbreviations for Heidke Skill Score (**HSS**), the Madden-Julian oscillation (**MJO**), and the quasi-biennial oscillation (**QBO**). Additional acronyms related to the institutions providing the input data and model code can be found in Nardi et al. (2020).

Variable information: The **foo** files contain the following variables:

HSS: Heidke Skill Score; dimensions = (season, predictor, MJO_QBO category, MJO phase, lead); should be viewed with MJO phase on vertical axis and lead time on horizontal axis; positive values imply more skill than a random model; see the citations below for additional information about the version of HSS used here

fcsts_opportunity: binary indicators of the presence of a skillful forecast of opportunity (1 = yes, 0 = no); dimensions = (season, predictor, MJO_QBO category, MJO phase, lead); should be viewed with MJO phase on vertical axis and lead time on horizontal axis

The **HSS_map** file contains the following variables:

HSS_map: map of HSS values for precipitation forecasts over the contiguous U.S. and Alaska; dimensions = (season, MJO_QBO category, MJO phase, lead, latitude, longitude); should be viewed in latitude/longitude space

fcsts_opportunity_map: map of binary indicators of the presence of a skillful forecast of opportunity (1 = yes, 0 = no) over the contiguous U.S. and Alaska; dimensions = (season, predictor, MJO_QBO category, MJO phase, lead, latitude, longitude); should be viewed in latitude/longitude space

Descriptions of the dimensions are below:

season: the 3-month season in which forecasts are initialized (see Nardi et al. 2020 for further information about the seasons); there are four values for season (0 = winter/DJF, 1 = spring/MAM, 2 = summer/JJA, 3 = fall/SON)

predictor: the combination of predictors used by the model; for **foo** files, there are two values for predictor (0 = MJO only, 1 = MJO and QBO); for the **HSS_map** file, there is only one value for predictor (0 = MJO and QBO)

MJO_QBO category: if the predictors are the MJO and QBO, then category refers to the QBO phase (0 = easterly, 1 = westerly, 2 = combined easterly and westerly); if the MJO is the only predictor, then category is the same for all three values

MJO phase: categorical MJO phase; ranges from 1 to 8

lead: lead time in units of days; forecasts are valid for the 5-day period beginning on the given lead day (input data are initially smoothed using 5-day forward running mean); for example, a lead day 6 implies the 5-day period ranging from 6 to 10 days following forecast initialization; 43 values representing 43 different overlapping 5-day periods starting at days 0 through 42

latitude: latitude in units of degrees North; ranges from 22.5 to 72.5 degrees North; resolution of 2.5 degrees

longitude: longitude in units of degrees East; ranges from 182.5 to 295 degrees East; resolution of 2.5 degrees

Here is the result of a Linux “ncdump” command for a sample file:

```
$ ncdump -h foo_239.75_47.25.nc4
netcdf foo_239.75_47.25 {
dimensions:
    season = 4 ;
    MJO\ index = 1 ;
    predictor = 2 ;
    MJO_QBO\ category = 3 ;
    MJO\ phase = 8 ;
    lead = 43 ;
```

```

variables:
    byte lead(lead) ;
        lead:description = "first day in forward 5-day running mean
forecast" ;
        lead:units = "days since initialization" ;
    byte MJO\ index(MJO\ index) ;
        MJO\ index:description = "MJO index used to make predictions" ;
    byte predictor(predictor) ;
        predictor:description = "combination of climate variability
patterns used as predictors" ;
    byte MJO_QBO\ category(MJO_QBO\ category) ;
        MJO_QBO\ category:description = "if QBO is a predictor, the phase
of the QBO; if MJO only, there is no difference in category" ;
    byte MJO\ phase(MJO\ phase) ;
        MJO\ phase:description = "MJO phase (1-8)" ;
    byte season(season) ;
        season:description = "3-month running season during which
forecasts are initialized" ;
    float HSS(season, MJO\ index, predictor, MJO_QBO\ category, MJO\ phase,
lead) ;
        HSS:description = "Heidke Skill Score (HSS) for each phase/lead
combination" ;
    float fcsts_opportunity(season, MJO\ index, predictor, MJO_QBO\
category, MJO\ phase, lead) ;
        fcsts_opportunity:description = "binary indicator of forecast of
opportunity for each phase/lead combination; 1 = yes, 0 = no" ;

// global attributes:
    :history = "Created by Kyle M. Nardi in support of manuscript
titled \"Skillful all-season S2S prediction of U.S. precipitation using the
MJO and QBO\". Please direct questions to knardi@rams.colostate.edu." ;

```

Uncertainty, precision, and accuracy of measurements

Environmental or experimental conditions: For uncertainty and precision related to the model input data, please refer to the data sources listed in Nardi et al. (2020). For uncertainty related to the empirical model's design, please refer to the citations listed at the end of this document.

Method(s): Model input data were collected through the published data sources listed in Nardi et al. (2020). These sources also provide detailed information regarding how the dataset was initially created. These model input data were formatted by Kyle M. Nardi and Cory F. Baggett at Colorado State University using NCL 6.4 and Python 2.7 programming languages. Preexisting model code was obtained by Kyle M. Nardi from Bryan D. Mundhenk and Cory F. Baggett at Colorado State University. Model code was modified and implemented by Kyle M. Nardi in NCL 6.4 using Colorado State University's computing resources. Analysis of model output was performed by Kyle M. Nardi using Python 2.7.

Quality assurance and quality control that have been applied: Please refer to the data sources listed in Nardi et al. (2020) for information regarding quality control of model input data. Model performance has been tested by Kyle M. Nardi and Cory F. Baggett.

Citations:

Nardi, K.M., C.F. Baggett, E.A. Barnes, E.D. Maloney, D.S. Harnos, and L.M. Ciasto, 2020: Skillful all-season S2S prediction of U.S. precipitation using the MJO and QBO, *Wea Forecasting*, <https://doi.org/10.1175/WAF-D-19-0232.1>

Mundhenk, B., E.A. Barnes, E.D. Maloney and C.F. Baggett, 2018: Skillful Empirical Subseasonal Prediction of Landfalling Atmospheric River Activity using the Madden-Julian Oscillation and the Quasi-biennial Oscillation. *npj Climate and Atmospheric Science*, <https://doi.org/10.1038/s41612-017-0008-2>

Johnson, N. C., D. C. Collins, S. B. Feldstein, M. L. L'Heureux, and E. E. Riddle, 2014: Skillful Wintertime North American Temperature Forecasts out to 4 Weeks Based on the State of ENSO and the MJO. *Weather Forecast.*, 29, 23–38, <https://doi.org/10.1175/WAF-D-13-00102.1>