# Northern Hemisphere Cyclone Locations and Characteristics from NCEP/NCAR Reanalysis Data, Version 1

## USER GUIDE

**How to Cite These Data**

As a condition of using these data, you must include a citation:

Serreze, Mark. 2009. *Northern Hemisphere Cyclone Locations and Characteristics from NCEP/NCAR Reanalysis Data, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/XEPCLZKPAJBK. [Date Accessed].

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National Snow and Ice Data Center

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# 1 DETAILED DATA DESCRIPTION

## 1.1 Format

Data are provided in a tab-delimited ASCII text file that contains cyclone locations and characteristics. Table 1 lists the column headings* and data field descriptions for the file.

Table 1. Column Headings and Descriptions

| Column Heading | Units (where applicable) | Description |
|---|---|---|
| dday | -- | Julian day of year on the quarter hour (1.00, 1.25, 1.75, 2.00...366.75) |
| rec_num | -- | Cyclone system record number (ignore this variable) |
| year | -- | 2-digit year |
| month | -- | 1- or 2-digit month |
| day | -- | 1- or 2-digit day |
| hour | -- | 1- or 2-digit hour (0, 6, 12, 18 = 0000, 0600, 1200, 1800 UTC) |
| num_daily_sys | -- | Total number of daily cyclone systems |
| num_grid_pts | -- | Number of grid points defining central pressure of a given system |
| prev_day_skip_flag | -- | Flag to indicate if previous day(s) were skipped (1 = yes, 0 = no) |
| cent_pressure | hPa | Cyclone central pressure |
| laplacian | $mPa/km^{-2}$ | Local laplacian of pressure system (a measure of cyclone system intensity) |
| distance | m | Distance traveled from last observation (-999 indicates the previous day was skipped or this is a cyclogenesis event) |
| press_tend | hPa/6h | Pressure tendency from last observation (-999 indicates the previous day was skipped or this is a cyclogenesis event) |
| lat | degrees North | Latitude of system center |
| lon | degrees East | Longitude of system center |
| EASE_grid_row | -- | EASE-Grid row |
| EASE_grid_col | -- | EASE-Grid column |
| cyclogen_flag | -- | Flag indicating cyclogenesis event (1 = yes, 0 = no) |

| Column Heading | Units (where applicable) | Description |
|---|---|---|
| cyclol_flag | -- | Flag indicating cyclolysis event (1 = yes, 0 = no) |
| sys_nu | -- | System number during given year |

*Column headings are not available in the yearly data files.

## 1.2 File and Directory Structure

Data are available on the HTTPS site in the following directory:

https://daacdata.apps.nsidc.org/pub/DATASETS/atmosphere/nsidc0423_cyclone_ncep_ncar_reanalysis/

There are nine files within this directory: one time series file for the years 1958 to 2008 and eight yearly files for 2009 through 2016.

## 1.3 File Naming Convention

The time series file from 1958 to 2008 is named: ncepstorms_1958_2008.txt. The yearly data files for 2009 to 2016 are named according to the following convention and as described in Table 2.

**Naming Convention**: ncepstorms_YYYY.txt
**Example**: ncepstorms_2009.txt

Table 2. File Naming Convention

| Variable | Description |
|---|---|
| ncep | National Centers for Environmental Prediction (NCEP) |
| storms | Cyclone storm systems |
| YYYY | Last 4-digit year of time series |
| .txt | Indicates this is an ASCII text file |

## 1.4 File Size

The time-series file is approximately 150 MB, and the yearly files are approximately 3 MB each.

## 1.5 Volume

The total volume of this data set is approximately 174 MB.

## 1.6 Spatial Coverage

Spatial coverage is the Northern Hemisphere.

Southernmost Latitude: 0° N
Northernmost Latitude: 90° N
Westernmost Longitude: 180° W
Easternmost Longitude: 180° E

### 1.6.1 Spatial Resolution

The spatial resolution of this data set is 250 km.

### 1.6.2 Projection and Grid Description

Prior to identification of cyclone centers, the input SLP data were interpolated from the NCEP/NCAR 2.5° x 2.5° grid to a 250 x 250 km version of the NSIDC EASE-Grid (Armstrong and Brodzik 1995). This is a lower-resolution form of the same equal-area projection being used at NSIDC for re-gridding passive microwave satellite data. The interpolation (based on Cressman weights) is necessary for compatibility with the algorithm search logic for identifying system centers and promotes flexibility when applying the algorithm to SLP fields other than the NCEP/NCAR Reanalysis. However, the interpolation has the undesirable effect of smoothing the fields.

## 1.7 Temporal Coverage

Temporal coverage for this data set spans 01 January 1958 to 31 December 2016. Data were subsetted from the NCEP/NCAR Reanalysis time series, which provides global coverage from 1948 to the present. Due to fewer upper-air data observations made during the first decade of the time series, only data from 1958 to 2016 have been used for this data set (Kistler et al. 2001).

### 1.7.1 Temporal Resolution

For the purposes of this data set, data originating from the NCEP/NCAR Reanalysis time series were analyzed four times per day at six-hour intervals.

## 1.8 Parameter or Variable

Parameters include the position and central pressure of each cyclone, the distance the center of the cyclone traveled, whether the observation represents a cyclogenesis or cyclolysis event, the local Laplacian of the SLP at each cyclone center, and the SLPT at each cyclone center.

### 1.8.1 Parameter Description

The cyclone position, or cyclone system center, is provided in latitude and longitude coordinates, and the cyclone central pressure is provided in hectopascals (hPa). The distance each cyclone center traveled is provided in kilometers. Cyclogenesis and cyclolysis represent the first and last appearance of a closed 1-hPa isobar, respectively.

See Serreze et al. 1997 for a description of the local Laplacian and SLPT parameters:

The local Laplacian parameter is proportional to the geostrophic relative vorticity and, unlike cyclone central pressure, provides an index of cyclone intensity largely independent of changes in the background pressure field (Murray and Simmonds 1991). In turn, SLPT provides a useful index of synoptic development (Sanders and Gyakum 1980), provided that the decrease in cyclone central pressure is not embedded within a region of generally falling or rising pressure and the storm maintains an approximately constant size through the 6-hr analysis period (Roebber 1989). Following Roebber (1984), all SLPT values were adjusted by latitude using the relationship in Equation 1:

$$SLPT_{adj} = SLPT \sin \Phi_{ref} / \sin \Phi \quad \textbf{(Equation 1)}$$

where Φref is a reference latitude of 60° N and Φ is the latitude of the SLPT observation. This accounts for the latitudinal variation in geostrophic wind for a unit pressure gradient. The choice of the reference latitude is arbitrary; 60° N was chosen here, following Sanders and Gyakum (1980) and Serreze (1995).

Table 3 provides a brief description and the units of each parameter.

Table 3. Parameter Description and Units

| Parameter Name | Description | Units |
|---|---|---|
| Cyclone Position | Latitude and longitude of cyclone system center | degrees |
| Cyclone Central Pressure | Pressure at the center of the cyclone system | hPa |
| Distance Cyclone Center Traveled | Distance the cyclone center traveled since it was initially tracked | km |
| Cyclogenesis/Cyclolysis | Cyclogenesis and cyclolysis represents the first and last appearance of a closed 1-hPa isobar, respectively | -- |
| Local Laplacian of SLP | A measure of intensity of sea level pressure at the cyclone center | $mPa/km^{-2}$ |
| SLPT | Sea level pressure tendency at each cyclone center, as determined between subsequent central pressure values | $hPa\ (6\ h)^{-1}$ |

### 1.8.2 Sample Data Record

Figure 1 displays a partial sample of the `ncepstorms_1958_2008.txt` file.

| dec_day | rec_num | year | month | day | hour | num_daily_sys | num_grid_pts | prev_day_skip_flag | |
|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1003.95 | 11.58 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 997.70 | 12.13 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 993.97 | 4.89 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 996.14 | 11.36 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 987.21 | 12.66 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1013.79 | 11.54 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1017.52 | 9.44 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1020.36 | 19.18 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1007.57 | 25.58 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1000.55 | 8.31 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1003.67 | 12.44 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 986.57 | 15.97 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1009.12 | 10.73 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 995.11 | 4.79 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1004.89 | 9.67 -999.00 -999.00 |
| 1.00 | 1 | 58 | 1 | 1 | 0 | 16 | 1 | 1 1004.89 | 5.06 -999.00 -999.00 |
| 1.25 | 2 | 58 | 1 | 1 | 6 | 15 | 1 | 0 1000.77 | 11.15 462.02 -3.17 |
| 1.25 | 2 | 58 | 1 | 1 | 6 | 15 | 1 | 0 995.34 | 8.95 236.93 -2.36 |
| 1.25 | 2 | 58 | 1 | 1 | 6 | 15 | 1 | 0 990.56 | 8.27 586.73 -3.41 |

Figure 1. Partial Sample Data Record

# 2 SOFTWARE AND TOOLS

Data are accessible with any text editor or Web browser.

## 2.1 Quality Assessment

Serreze and Barrett 2008 outline several screening steps that users of this data set may wish to consider. These include discarding cyclones that remained stationary during their system life cycle, such as remained within the same grid cell, and discarding cyclones that lasted less than one day and thus comprised less than four 6-hr charts. As most spurious systems appear due to a reduction in surface pressure to sea level over high or complex topography, these screening steps eliminated those systems. These screening steps also tended to eliminate most mesoscale features, such as those in the range of 10 to 1000 kilometers.

Another potentially useful screening is to verify that a cyclone had deepened sometime during its life cycle. Serreze and Barrett 2008 retained only cyclones with a minimum total of 2 hPa SLP change over their life cycle. Though these steps helped limit analysis to most robust cyclone systems, some spurious systems may still remain, particularly over Greenland (Serreze and Barrett 2008).

# 3 DATA ACQUISITION AND PROCESSING

## 3.1 Theory of Measurements

Prior to the early 1950s, prevailing views of the Arctic atmospheric circulation remained largely speculative. Interest in the Arctic atmospheric circulation stems from recognition of the importance of atmospheric variability in driving anomalies in the circulation, extent, concentration, and thickness of the sea ice cover (Walsh and Chapman 1990). Such anomalies, through atmospheric feedbacks, may have potentially significant impacts on regional and hemispheric climates. In light of this interest, this data set provides Arctic cyclone characteristics based on results from an automated cyclone detection and tracking algorithm applied to a 50-year record (1958-2008) of daily NCEP/NCAR reanalysis of sea level pressure.

## 3.2 Data Acquisition Methods

NCEP/NCAR Reanalysis source data were acquired from the Physical Sciences Division (PSD) of the Earth System Research Laboratory (ESRL), a part of the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado USA. For access to the original source data, visit the NOAA ESRL Reanalysis Datasets at PSD Web page.

## 3.3 Derivation Techniques and Algorithms

The following is adapted from Serreze et al. 1997.

The current detection and tracking algorithm is largely identical to that published in Serreze 1997. The two major components of the algorithm are:

1. A detection threshold to determine how many systems are identified in a given SLP chart
2. A nearest neighbor analysis of the positions of cyclone systems to track the movement of systems

Cyclones are identified using a series of search patterns, testing whether a grid point SLP value is surrounded by grid point values at least 1 hPa higher than the central point being tested. Starting on the first 6-hr chart (Chart 1), each cyclone is ascribed a number. A grid array is then centered over each system on the next 6-hr chart (Chart 2). If a cyclone on Chart 1 falls within a given array, the Chart 2 cyclone at the center of the array is taken to be a continuation of the Chart 1 system. This immediately tracks stationary or slow-moving cyclones. It is possible that two or more Chart 1 systems could fall within the same array, but this was rarely observed. The minimum distances from all remaining untracked systems on Chart 2 are then determined with respect to the remaining numbered systems on Chart 1. Typically, two or more untracked Chart 2 systems have their

minimum distance with respect to the same Chart 1 system. The number of the Chart 1 system is carried over to the closest Chart 2 system, provided the minimum distance between them is less than a specified limit, and several other screening steps involving the 6-hr SLPT at the cyclone centers for a candidate pairing and the direction of system motion are satisfied. Otherwise, the Chart 2 system is taken as new (cyclogenesis), and successively more distant Chart 2 systems are tested in the same manner, up to the distance limit. At the end of the search process, all remaining Chart 1 systems that could not be paired with a Chart 2 system are considered to have filled (cyclolysis). The process is then repeated for each subsequent pair of charts. If any chart is missing, all systems on the next available chart are taken as new and numbered accordingly. (Serreze et al. 1997)

### 3.3.1 Data Source

The NCEP/NCAR Reanalysis time series data were used as source data to derive this data set. The NCEP/NCAR Reanalysis source data set includes an assimilation of land surface, rawinsonde, ship, pibal, aircraft, satellite, and various other data within a global weather model. For complete documentation regarding the sensors, platforms, and methods used as a basis for this data set, refer to the NCEP-NCAR 50-Year Reanalysis: Monthly Means CD-ROM and Documentation paper.

### 3.3.2 Processing Steps

A FORTRAN program was used to apply an algorithm that identifies and tracks cyclones using gridded SLP analyses as a basis. Each cyclone identified is ascribed a unique number which is maintained throughout the life history of the system from cyclogenesis to cyclolysis. The output variables include the following: the position of each cyclone; the cyclone number, year, month, day, and hour of each observation; cyclone central pressure; the local Laplacian of SLP at the cyclone center (a measure of intensity); pressure tendency (as determined between subsequent central pressure values); and whether the system represents a cyclogenesis or cyclolysis event, based on the first and last observation. All cyclone numbers are reset at 01 January 0000Z of each year, where Z indicates Zulu Time Zone/UTC. The program was originally developed by Mark Serreze at the University of Colorado for application to 12-hr NMC fields for the entire Northern Hemisphere. The present version was subsequently modified for application to 6-hr Northern Hemisphere fields from the NCEP/NCAR Reanalysis data set. The logic of the algorithm is further explained in Serreze 1997.

Prior to identification of cyclone centers, the input NCEP/NCAR SLP arrays are interpolated to a 250 x 250 km version of the NSIDC EASE-Grid (Armstrong and Brodzik 1995). This is a lower-resolution form of the same equal-area projection being used at NSIDC for re-gridding passive microwave satellite data. The interpolation (based on Cressman weights) is necessary for compatibility with the algorithm search logic for identifying system centers and also promotes

flexibility when applying the algorithm to SLP fields other than the NCEP/NCAR Reanalysis. Of course, the interpolation has the undesirable effect of smoothing the fields, but it avoids the problem of strong convergence of meridians at high latitudes.

The distance and pressure tendency thresholds for cyclone tracking were altered for use with 6-hr as opposed to 12-hr analyses. The parameter sets work well with the NCEP/NCAR analyses, but would need to be adjusted for use with other SLP fields. The most important threshold is set by the variable maxdist. For the NCEP/NCAR data used here, it is set to 800 km, meaning that the total allowable distance a cyclone can move between six-hour intervals is 800 km (133 km/hr). While seemingly too fast (a speed of 100 km is about the upper limit one could ever imagine for cyclone motion), this allows for center jumps to be tracked. Further, since data are only at specific grid points, there are only a finite number of possible distances a cyclone can move (the distances are quantized). The maxdist and other distance thresholds were adjusted to account for this; and, as noted in Section 2.1 Quality Assessment, the user may wish to screen the data to eliminate short-lived and/or spurious cyclone systems.

### 3.3.3 Error Sources

The NCEP/NCAR Reanalysis time series data were used as source data to derive this data set. For a list of errors with the NCEP/NCAR Reanalysis data, visit the NCEP/NCAR Reanalysis Problems List Web page.

## 3.4 Sensor or Instrument Description

The NCEP [formerly the National Meteorological Center (NMC)]/NCAR Reanalysis source data includes an assimilation of land surface, rawinsonde, ship, pibal, aircraft, satellite, and various other data within a global weather model. A partial list of some of the sensors and data sources used in the NCEP/NCAR Reanalysis is provided in Table 4. For complete documentation regarding the sensors used as a basis for this data set, refer to the NCEP-NCAR 50-Year Reanalysis: Monthly Means CD-ROM and Documentation paper.

Table 4. Examples of Data Sources/Sensors used in NCEP/NCAR Reanalysis Data

| Example Data Type | Example Data Source and/or Sensor(s) | Description |
|---|---|---|
| Rawinsonde | NCEP Global Telecommunication System (GTS) data | The main source for the rawinsonde data, a global collection of upper-air observation data. Also includes pibal and aircraft data. |

| Example Data Type | Example Data Source and/or Sensor(s) | Description |
|---|---|---|
| Surface Marine Data | Comprehensive Ocean-Atmosphere Data Set (COADS) data | Among other data, includes data from ships, drifting buoys, fixed buoys, pack-ice buoys, and near-surface data from ocean station reports, such as Expendable Bathythermographs (XBTs). |
| Aircraft Data | NCEP Global Telecommunication System (GTS) data | The main source for the aircraft data, a global collection of upper-air observation data. Also includes pibal and rawinsonde data. |
| Surface Land Synoptic Data | Air Force Global Telecommunication System (GTS) data | The main source for the surface land synoptic data, a global collection of surface data. |
| Satellite Sounder Data | TIROS Operational Vertical Sounder (TOVS) sensors:<br>High Resolution Infrared Radiation Sounder (HIRS)<br>Microwave Sounding Unit (MSU)<br>Stratospheric Sounding Unit (SSU) | The TOVS suite of sensors provides global measurements used in weather forecasting, such as the vertical distribution of temperature and moisture in the atmosphere. |
| Surface Wind Speed Data | Special Sensor Microwave Imager (SSM/I) | SSM/I data were used with the Kransopolsky (Krasnopolsky et al. 1995) algorithm which resulted in wind speeds closer to buoy data, and coverage under cloudy conditions. Measurements include SSM/I wind speed, total precipitable water, and other parameters. (Kalnay et al. 1996) |
| Satellite Cloud Drift Wind Data | Geostationary Meteorological Satellite (GMS) data | The GMS program is a series of satellites operated by the Japan Meteorological Agency (JMA). The Visible and Infrared Spin Scan Radiometer (VISSR), the primary instrument aboard GMS, collects visible and infrared images of Earth and its cloud cover. |

# 4 REFERENCES AND RELATED PUBLICATIONS

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## 4.1 Related Data Collections

ARCSS Data

# 5 CONTACTS AND ACKNOWLEDGMENTS

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# 6 DOCUMENT INFORMATION

## 6.1 Publication Date

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## 6.2 Date Last Updated

20 May 2021