A New Climatology for Investigating Storminess Influences on the Extratropics

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Overview

What is this MCMS?
MCMS stands for the MAP Climatology of Mid-Latitude Storminess dataset. Mid-latitude storminess in this case means the area confined to the sea level pressure (SLP) depression around a mid-latitude baroclinic cyclone (or just cyclone). MCMS rests on two operations: 1) finding and tracking cyclones and 2) objectively delineating the area under each cyclone’s influence (storminess). These operations are elaborated below.

Why make MCMS?
Because cyclones are a primary weather-maker outside the tropics as well as a specific process that can be isolated in both observations and model results. Cyclone activity strongly shapes the distribution many quantities on both climatic and meteorological scales. Today’s climate models can in principle resolve basic cyclone features but they are unlikely to represent other key features such as fronts very well (Naud et al, 2010). Indeed, mid-latitude storm clouds are a key source of inter-model spread in climate sensitivity (Williams and Tselioudis 2007).

Who might MCMS and for what?
The MCMS provides a detailed assessment of the areas under the influence of mid-latitude cyclones and those that are not. The temporal-spatial variability of storminess can be used to give phenomenological context or act as a screen for weather sensitive data. MCMS data will be made available for a variety of reanalysis products (e.g., NCEP Reanalysis I and II, ERA-40, ERA-Interim, MERRA). The software for working with this MCMS data will also be made available, as will the source code to allow the create of new MCMS datasets from climate model output or other numerical analyses.

Our Approach

Center Finding
MCMS uses the most popular method for locating cyclones; as depressions in the sea level pressure (SLP) field. At its most basic level this means scanning the SLP field for local minima in a time independent manner and then refining the list of potential cyclones with additional criteria. This process ignores some open-wave cyclones which is why MCMS alters the conventional minima finding method to exclude only SLP maxima and then apply extra scrutiny to isolate likely cyclones. MCMS also employs a unique method for limiting the effects of SLP noise in over high or steep topography which allows for the retention of more cyclones over these areas that conventional methods do.

Center Tracking
With the centers now identified we then attempt to associate them into cyclone tracks via nearest neighbor and other similarity arguments. For this MCMS defines a dissimilarity score for each potential connection. This score is based on a preference for connections with relatively small changes in track course, SLP and position. A connection is made for the connection with the lowest dissimilarity score. Multiple potential connections are rare events (~5% of cases), which mean that the primary searching process of MCMS was projected. The final composites are centered over New York City for scale. The data comes from the NCEP/NCAR Reanalysis II (Northern Hemisphere, NDJFM, 1979-2011).

Example of MCMS Filtering:
MCMS data can be used to contextualize or screen by the presence or absence of cyclonic activity. Here we show various views of recent cyclonic activity near a fictitious ARM site in New York City (NYC). In the control area, darker shades more activity.

Example of MCMS Compositing:
Composite a) shows the climatological likelihood that a given point in the composite domain is classified as a center. Composite b) shows the climatological likelihood that a given point in the composite domain falls within the storminess area of a cyclone other than the one being composed.

Example of MCMS Attribution:
To encourage these works MCMS data from several reanalysis efforts will be made publically available (e.g., NCEP Reanalysis I and II, ERA-40, ERA-Interim, MERRA). MCMS data files come in the form of specially formatted plain text files.

Defining Storminess
The method described in this section, which we call attribution, delineates the region of influence around any given cyclone. This is done with the idea that a cyclone’s area of influence or “storminess” is bound by the unique set of concentric sea level pressure (SLP) contours surrounding that cyclone. MCMS labels this area as a cyclone’s attributed or ATT contours. When the outermost closed contour encloses more than one cyclone a new storminess label is applied to the shared contours (ATTs).

An example of this process is shown below along with the associated kept and discarded cyclone centers. It is interesting to note that while the benefit of the discarded center databases it would not be apparent that MCMS detected a cyclone within the closed 1008 hPa contour found in the lower right of the figure. Because MCMS saves this information we not only know that MCMS properly detected this center, but that it was discarded because that system eventually merges with the stronger system to its northeast and the resulting track is too short for retention.

Example of MCMS Filtering: Figure 1 (Salma) shows the initial SLP contours along with the associated kept (black squares) and discarded cyclone centers (orange open circles).

About the MCMS datasets and software:
Users can freely modify, improve and extend the MCMS toolset and are encouraged make these changes available to the wider community. Please are already under way to improve MCMS operations at polar latitudes, to accommodate very high resolution numerical input and to allow center-finding with alternative fields such as vorticity.

References

Naud, C.M., A.D. Del Genio, M. Bauer & W. Kovari 2010: Cloud Vertical Distribution With alternative fields such as vorticity. Circulation Model.