Mid-latitude Storminess: A New Dataset

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MCMS
The MAP Climatology of Mid-Latitude Storminess

Overview

What is this MCMS?

MCMS stands for the MAP Climatology of Mid-latitude Storminess dataset (see http://gcss-dime.giss.nasa.gov/mcms/mcms.html). 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. 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. 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 6-hourly 50-year long 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 your data.

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 (based on the 8 neighbors of each grid, see red matrix in Figure 1) and then refining the list of potential cyclones with additional criteria (e.g., local SLP laplacian, regional screen based on zonal wavenumber). This process ignores some open-wave cyclones (center C in Figure 1 for example) as a result (to be fixed).

With the centers now identified we can then attempt to associate them into tracks in a time dependent manner. In essence, the idea is to connect current and past centers via nearest neighbor and other similarity arguments. Cyclone tracking is treated as a separate process and product (not shown here for brevity)

Continue to "**Defining Storminess**" →

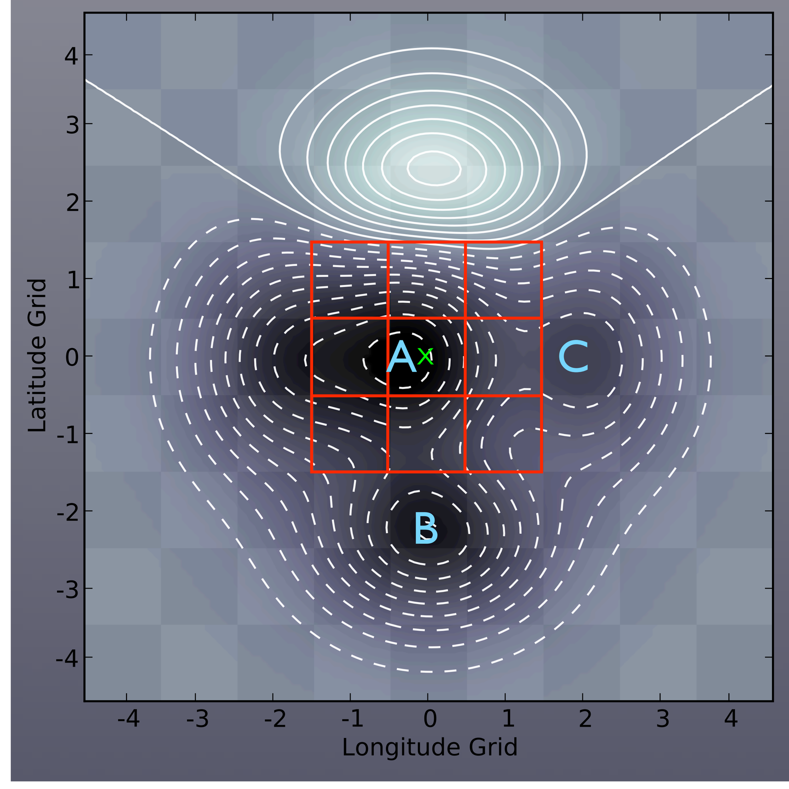
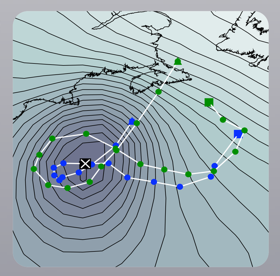


Figure 1: Synthetic SLP field (grey shading with darker lower, dashed contours below mean pressure) with the model grids underlaid (squares). Three low pressure centers are shown (A,B,C). An example local search is also shown (red grid centered on green X).

Application/Examples

Example of MCMS Attribution: The 1991 Halloween Nor'easter, also known as the Perfect Storm, at peak intensity 12:00 UTC on 30 October. Shown are the current centers (white Xs), with the entire lifetime or track of each system shown as white lines with blue dots). The SLP field (grey shaded contours with darker being lower values) is also shown. The so-called "attributed" model grids (red dots) represent the largest set of closed SLP contours around each center that contain just that center. Sometimes an additional set of grids, the so-called "stormy" grids (yellow dots), is needed to represent the closed SLP contours enclosing multiple centers.

a)


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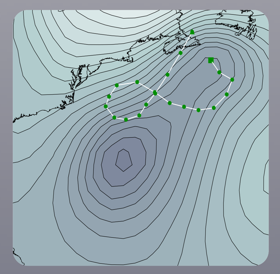

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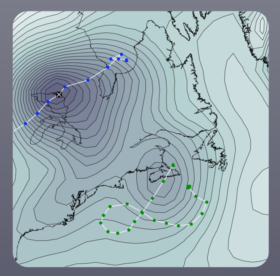
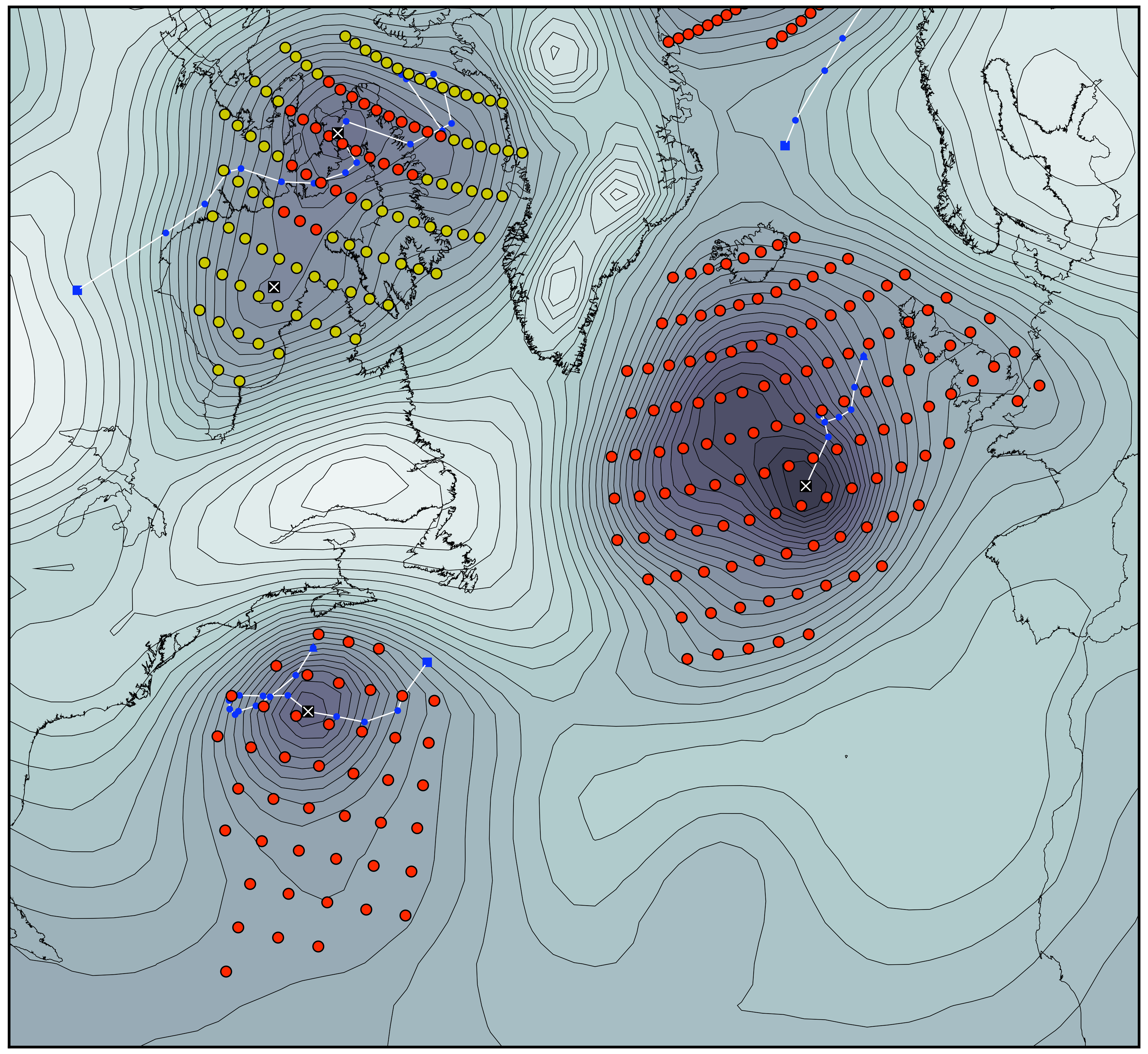


Shown to the left are some comparisons with the National Hurricane Center "Best Track" for the southern most system (shown as white lines with green dots in inset a).

Inset a) shows the largest track discrepancy. Whether the systematic differences come from the limitations of the 6 hourly 2.5°x2.5° latitude-longitude grid of the NCEP/NCAR reanalysis SLP field or in how the "best track" positions are made is unclear. Note that the MCMS center does lie in the center of the SLP minima.

Inset b) show that the beginning of the MCMS track is delayed because the NCEP/NCAR reanalysis SLP field lacks a closed low in the early stages of this storm.

Insert c) shows that the MCMS track ends prematurely compared to the "best track" because the MCMS system incorporated the weaker low center into the large and deeper system to the west.



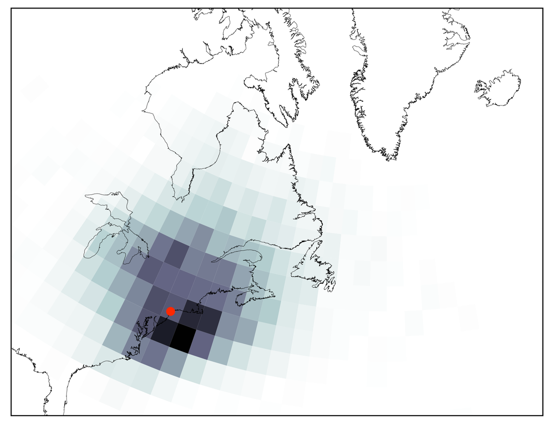
Example of MCMS Filtering: MCMS data can be used to contextualize or screen by the presence or absence of cyclone activity.

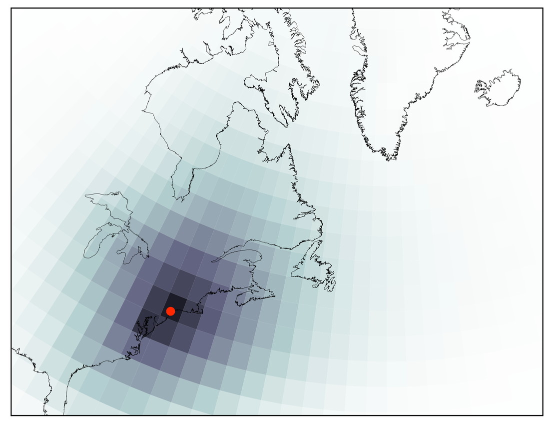
Here we show various views of recent cyclone activity near a fictitious ARM site in New York City (NYC red dot, years 1979-2007, darker shades more activity).

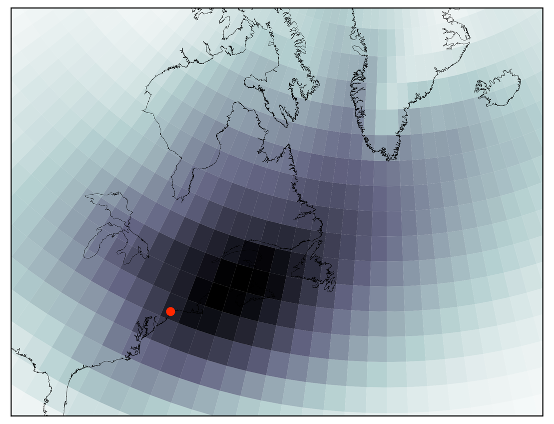
The uppermost panel counts only the centers of cyclones whose center or attributed grids pass over NYC. Note how the center count peaks over the storm tracks.

The middle panel uses a whole storm count. That is, it counts both the attributed grids and the centers. Note how this count peaks over the city and extends further out.

The bottom panels is a whole storm count as before but includes the whole track of all storms that passed over NYC at any point. Note how the count peak is to the north of NYC.







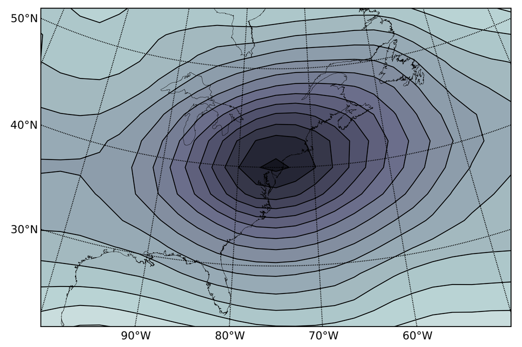
Example of MCMS Compositing: MCMS data can be used to create cyclone-centric composites of various data.

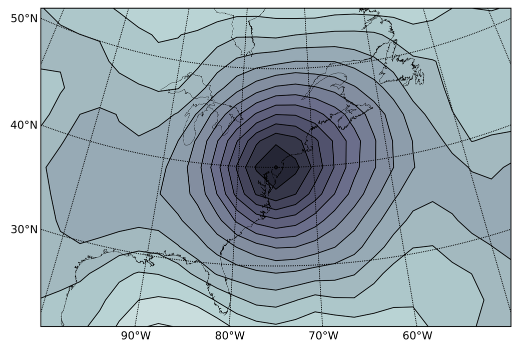
Here we composite the Northern Hemisphere DJF SLP field. For comparative purposes the final results are projected (Lambert Conformal) as if it was centered over New York City.

The leftmost panel shows the mean SLP composite when it is accrued using a fixed 60° longitude by 30° latitude box around each cyclone. In this case grids are treated without regard to their physical size.

The rightmost panels shows exactly the same information except the composite was accrued after each cyclone was projected to a common reference point (New York City) so that the relative size and shape of each cyclone was taken into account.

The next stage of this sort of work, now in testing, is to use the attributed and stormy grids as a screen during the compositing. This will help to reduce the contamination, or double counting, that occurs when two or more cyclones are present within a given composite frame.





Our Approach Cont.

Defining Storminess

The method described in this section, which we call attribution, delineates the region of influence around any give 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 (Wernli and Schwierz (2006) describe an analogous method). Our method works in the grid space with a recursive search algorithm that stops at downward inflections in the SLP field.

Our method accounts for the smooth nature of the original SLP field but is not tied. That is, attribution searches can also be done on discontinuous fields such as precipitation. When the process is complete we will have separated the current SLP field into model grids uniquely associated with a center (what we call attributed grids) and the remaining grids which are presumably unconnected to any center (see Figure 2).

All this is fairly straight forward for the ideal case of a simple isolated cyclone. Cyclones however, sometimes express themselves as complex cyclone families in which multiple systems share the same contours (~13% of NCAR/NCEP reanalysis cyclones are of this type). Our scheme accommodates these situations as well, a unique quality of MCMS, which allows us to disentangle these situations and make clearer composites and other analyses than traditional methods allow.

MCMS dataset is currently available for the last 50 years of the NCEP/NCAR Reanalysis. The examples to the right are all drawn from this dataset.

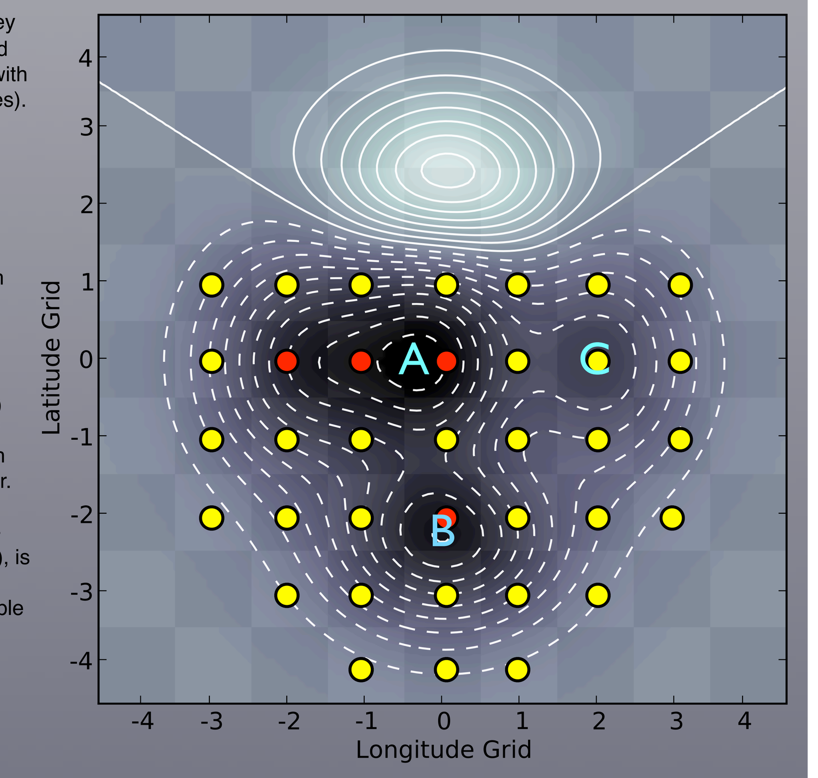
The MCMS source code and data are available at our site (written in Python, http://gcss-dime.giss.nasa.gov/mcms/mcms.html).

Figure 2: Synthetic SLP field (grey shading with darker lower, dashed contours below mean pressure) with the model grids underlaid (squares).

Three low pressure centers are shown (A,B,C). Two of these centers (A,B) have closed SLP contours and thus seen as independent systems. The other center (C) is an open SLP system and is not classified as a cyclone center.

Centers A and B have so-called "attributed" model grids (red dots) which represent the largest set of closed SLP contours around each center that contain just that center.

An additional set of grids, the so-called "stormy" grids (yellow dots), is needed to represent the closed SLP contours enclosing the multiple centers (A,B) as well as the open center (C).



References

Wernli, H. & Schwierz, C. (2006). Surface Cyclones in the ERA-40 Dataset (1958–2001). Part I: Novel Identification Method and Global Climatology. *Journal of the Atmospheric Sciences*, *63*, 2486-2507.

Williams, K. D. & Tselioudis, G. (2007). GCM intercomparison of global cloud regimes: