Changing Jet-Stream Waviness Assessed Using Self-Organizing Maps (SOMs)

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Abstract

A Self Organizing Maps (SOMs) approach is used to diagnose changing meridional (north/south) wave amplitude in the 500-hPa geopotential height field of the northern hemisphere during the “Arctic amplification (AA) era” of 1995-2012 relative to 1948-1990. The total change in wave amplitude is separated into contributions from (1) changing frequency of occurrence (FOC) of patterns identified by the SOM algorithm, (2) changing cluster-mean amplitudes for each SOM pattern, and (3) a combination of the two. We find an overall increase in amplitude that results primarily from an increase in cluster-mean wave amplitude, augmented by an increased frequency of high-amplitude patterns. These results support the hypothesis by Francis & Vavrus (2012) and the new analysis by Francis & Vavrus (2015).

What are Self-Organizing Maps (SOMs)?

The Self Organizing Maps (SOM) algorithm employs an artificial neural network through an unsupervised training process to:

- Determine representative patterns in the input data, typically daily maps of a well-behaved variable
- Organize similar data records into clusters or nodes that form a 2D matrix of representative patterns
- Our SOM training uses 66 years of daily 500-m contours of the 500 hPa field in the northern hemisphere obtained from the NCEP/NCAR Reanalysis.
- Other variables (e.g., meridional wave amplitude) can then be mapped onto the Master SOM for further analysis.

The Master SOM

Mean and Changing: Frequency of Occurrence (FOC) and Amplitudes

Frequency of Occurrence (FOC), days

Change in FOC, frac. of 1948-1990 mean

Cluster-mean wave amplitude (lat)

Dynamic contribution: A1 ± A2

Amplitude contribution: FOC1 ± A2

Total SOM-integrated contributions

What about the future?

Daily 500 hPa contours from simulations by CMIP models can also be mapped to the SOM to investigate future changes in wave strength. Historical runs (1970-2005) can be compared to amplitudes from NCEP Reanalysis data (1948-1990) to assess models' realism. Each layer in the bar represents one SOM cluster; its height corresponds to its FOC (%) and color indicates cluster-mean amplitude. Models have fairly realistic distributions; GFDL is most similar to NCEP. In the future (2070-2099, RCP 8.5), all 4 models project increased FOC of nodes with largest amplitudes, with an overall shift toward a wavier flow.

References:

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