Measuring "weather whiplash" events in North America: An increased frequency linked with rapid Arctic warming?

Jennifer Francis (Woodwell Climate Research Center), Natasa Skific (Rutgers University), Steve Vavrus (University of Wisconsin), and Judah Cohen (AER, Inc.)

What is Weather Whiplash?

Our definition: *An abrupt shift from one persistent set of weather conditions to another very different set, often from one extreme to another.*

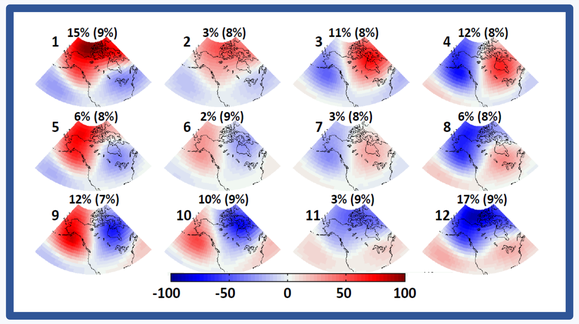
For example:

Drought	<=>	Stormy period
Heatwave	<=>	Long cold spell
Calm, drizzle	<=>	Breezy and clear

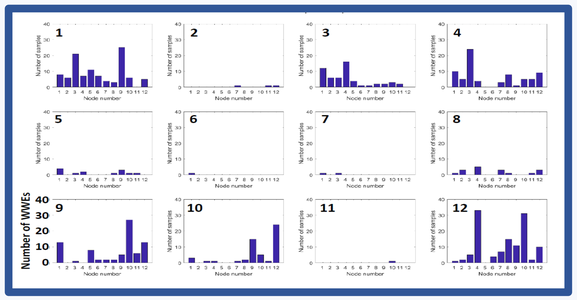
For example…

Our new approach:

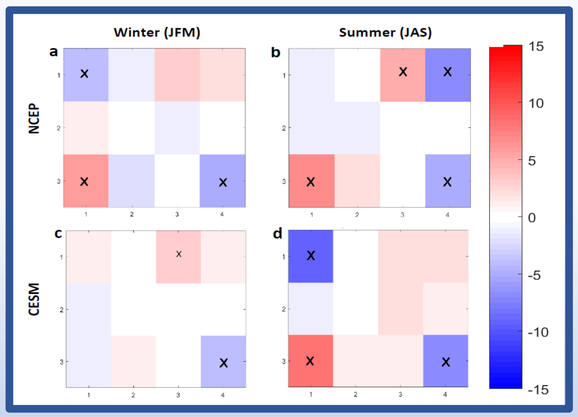
- Find characteristic atmospheric patterns in 72 years of daily 500 hPa height anomalies over North America, using NCEP reanalysis output and the Self-Organizing Maps (SOMs) clustering algorithm. Map 10 CESM runs to SOM.
- Find cases when the atmosphere gets "stuck" in one pattern for 4 or more consecutive days: long-duration events (LDEs)
- Track which pattern the atmosphere jumps to 2 days after the LDE
- If the pattern is sufficiently different (i.e., it did not jump to an adjacent pattern), a weather whiplash event (WWE) is identified



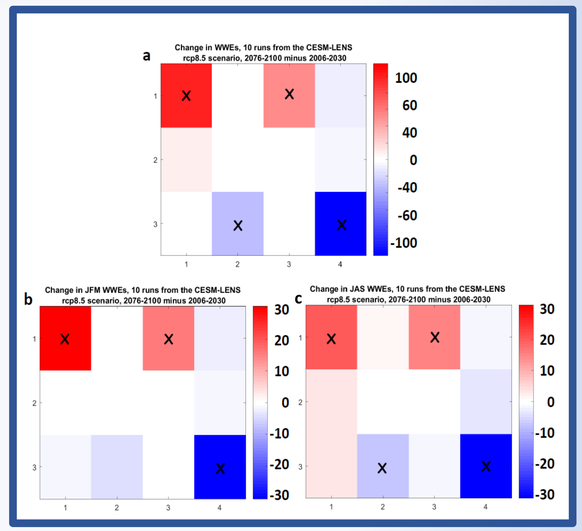
SOM matrix of characteristic patterns in 500 hPa height anomalies (m, shaded), based on daily fields from 1948-2019. Percentages indicate pattern frequency in winter (JFM) and summer (JAS).



Distributions of days (y-axis, see node #9) of node number 1-12 (x-axis) corresponding to 2 days following an LDE in each node during winter (JFM).



NCEP vs CESM: Changes in total number of WWEs from 1979-1989 to 1995-2005, JFM and JAS. X(x) indicates 95% (90%) confidence. Boxes correspond to node placement in SOM matrix above.



Projected changes in the total number of WWEs from 2006-2030 to 2076-2100 in (a) all months, (b) JFM, and (c) JAS based on 10 runs of CESM forced with RCP 8.5 scenario.

Take-Aways:

- Abrupt shifts from one persistent anomalous weather regime to another are disruptive to all manner of human activities and ecosystems.
- Changes in WWEs over time are more robust in future model RCP scenario 8.5 projections than during past decades.
- Increasing WWEs are projected for patterns with positive height anomalies in high latitudes (warm Arctic), while WWEs are projected to decrease for patterns with negative Arctic anomalies.
- A persistent episode of strong Arctic warming (e.g., node #1) is likely to be followed by a more amplified upper-level circulation pattern (#3).
- Mapping temperature and precip extremes to each node (not shown), we find WWEs originating in #1 and #3 are likely to jump between these two nodes, resulting in repetitious cold spells in midlatitudes and fluctuating wet/dry periods in west-central regions.

Francis, J.A., N. Skific, S.J. Vavrus, and J. Cohen, Measuring "weather whiplash" events in North America: A new large-scale regime approach. *J. Geophys. Res.-Atmos.*, in revision.