A methodology for examining the relationship between teleconnections and extreme precipitation

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Extreme Precipitation Events

Question: Is it possible to make probabilistic forecasts of extreme precipitation and temperature events with 1-4 week lead times based on teleconnection patterns?

Definition: An extreme precipitation frequency time series at each grid point corresponds to the frequency of days, for each month, that the 90% threshold for precipitation is exceeded.

Method: Linear correlate extreme precipitation frequency time series with monthly teleconnection indices (NAO, AO, EA/WR, SCAND, ENSO).

Data: NCEP/NCAR precipitation data, NOAA/CPC teleconnection indices
NAO & EAWR vs Extreme Precipitation Frequency

(a) October – November

(b) December – January

(c) February – March
EAWR vs Extreme Precipitable Water and Dynamic Tropopause Pressure

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EAWR vs Extreme Precipitable Water and Dynamic Tropopause Pressure

- The NAO, AO, SCAND (EAWR) indices are negatively (positively) correlated with the frequency of extreme precipitation events in the western (eastern) Mediterranean.

- For the NAO, increase in extreme precipitation frequency associated with PV intrusions, wave breaking, and increased moisture.

- For the EAWR, increase in extreme precipitation frequency related only to PV intrusions and wave breaking.

- Teleconnections alter the frequency of extreme precipitation in the Mediterranean region through their impact on storm paths, and subsequently wave breaking and moisture transport.

- A similar approach can be adopted for North America.
NOAA/CPC 6-10 and 8-14 day forecasts

Can we use this probabilistic approach for extreme events?

Can this approach be used for 2-4 week lead times?
Data and Method

- **Data**: ERA-Interim 2m temperature
- Wheeler and Hendon MJO index (8 phases denote location of anomalous tropical convection)
- Niño 3.4 index (El Niño and La Niña events)
- **Method**: Forecast divided into 3 terciles
- Leave-one-year-out cross-validation 1-6 week forecasts
- North America is linked to the MJO and ENSO via *PNA-like teleconnection patterns*

Heidke skill score \( HSS=(H-E)(T-E) \times 100 \)

\( H \) = number of correct forecasts, \( T \) = total number of forecasts, \( E \) = \( T/3 \)
Heidke Skill Score averaged over North American continent
Heidke skill score based on the phase of the Wheeler and Hendon MJO index, ENSO, and linear trend
Probabilistic forecast based on the phase of the Wheeler and Hendon MJO index

2m Temperature, Heidke Skill Scores, 500-hPa Geopotential Height
Probabilistic forecast based on the phase of the Wheeler and Hendon MJO index and ENSO

2m Temperature, Heidke Skill Scores, 500-hPa Geopotential Height
Implications and Questions

• Can the same methodology (probabilistic forecasts that account for the MJO and ENSO phases) be applied to extreme events at lead times greater than one week?

• Other factors: Amplitude of MJO and ENSO, state of extratropical background flow, Arctic sea ice, stratospheric polar vortex
State of the Stratospheric polar vortex

- **Two types** of NAO+ and two types of NAO- events
  - NAO-:
    - OLR (MJO-related; phases 6, 7, 8) $\rightarrow$ PNA+ $\rightarrow$ NAO-
    - OLR (non-MJO) $\rightarrow$ PNA- $\rightarrow$ NAO- $\rightarrow$ MJO phases 7, 8
  - NAO+:
    - OLR (MJO-related; phases 2, 3, 4) $\rightarrow$ PNA- $\rightarrow$ NAO+ 
    - OLR (non-MJO) $\rightarrow$ PNA+ $\rightarrow$ NAO+ $\rightarrow$ MJO phases 3, 4, 5
Northern Annular Mode

PNA+ -> NAO-

MJO-related NAO-

Non-MJO NAO-

PNA- -> NAO-

MJO-related NAO+ 

Non-MJO NAO+

PNA- -> NAO+

PNA+ -> NAO+
Implications

• The midlatitude teleconnection response to the MJO is impacted by the state of the stratospheric polar vortex.
• Is it possible that probabilistic forecasts of extreme weather events can be improved by taking into account the stratospheric polar vortex?
SOM patterns, trend, and frequency of occurrence

Sea Ice/Global Mean Temp (GHG)

Global Mean Temp (GHG)

Sea Ice

6.5-7.5 day timescale for patterns
Lagged-correlations between Arctic sea ice and SOM frequency

Negative (positive) lags:
sea-ice leading (lagging) SOM frequency
Anomalous zonal wind associated with SOM patterns
Implications

• The midlatitude teleconnections show a large amplitude response to Arctic sea ice anomalies via the stratosphere.

• Is it possible that probabilistic forecasts of extreme weather events can be improved by taking into account Arctic sea-ice anomalies?
CONCLUSIONS

• Extreme precipitation events in the Mediterranean are closely linked to the NAO, EAWR and other teleconnection patterns. Is this the case for North America?

• **Questions** about probabilistic extreme weather forecasts?

• Useful probabilistic forecasts of 2m temperature with 1-4 week lead times can be obtained when the MJO and ENSO phases are taken into account. Can the same the method be applied to extreme weather events.

• The state of the stratospheric polar vortex influences the midlatitude teleconnection response to the MJO. Can probabilistic extreme weather forecasts be improved by including *stratospheric polar vortex* anomalies?

• Anomalies in Arctic sea ice appear to drive midlatitude teleconnections. Can probabilistic extreme weather forecasts be improved if *Arctic sea ice* is included.