Some approaches to detecting human influence on extremes

Francis Zwiers
Pacific Climate Impacts Consortium
University of Victoria, Victoria, Canada
Approaches for D&A on extremes

- Apply standard machinery
  - To indices of annual extremes
    • Hegerl et al 2004, J Climate
    • Christidis et al 2005, GRL
  - To suitably transformed annual extremes
    • Min et al 2011, Nature
  - To parameters of fitted extreme value distributions
    • Brown et al 2008, JGR
    • Christidis et al 2010, submitted

- Cast problem directly within framework of extreme value theory
  • Zwiers et al, 2010, in press, J Climate
1. D&A applied directly to indices

- Hegerl et al, 2004
  - Model-model assessment of potential detectability

- Christidis et al, 2005
  - Used Hegerl et al temperature indices
  - Applied standard approach
  - Detected human influence in 3 of 4 indices globally

Scaling factor on HadCM3 **ALL**, **ANT**, and **GHG** responses fitted to observed temperature extremes (1950-1999)
2. D&A on transformed extremes

• Min et al 2011

• Annual maxima of 1-day (RX1D) and 5-day (RX5D) precipitation accumulations

• Fit GEV distributions (to obs and each model simulation separately) and transform to near Uniform

• Apply standard D&A approach
PI Trends (RX1D; 1951-1999)

OBS

Models

ANT

ALL
Detection results – 1951-1999

- **ANT** detectable for both RX1D and RX5D
- **ALL** detectable only for RX1D and less robustly
- **ANT** scaling factors near 2-3
  - → model responses to **ANT** underestimated
3. D&A on GEV parameters

• Brown et al, 2008
  • Fit GEV distributions to annual temperature extremes
  • Include time as a covariate
  • Describe observed extremes
  • Show trend in location parameter inconsistent with internal variability
• Christidis et al, 2010
  • Apply standard D&A technique to trends in location parameter
  • Able to detect anthropogenic influence in all 4 temperature extremes indices
Scaling Factors: TXx location parameters

Christidis et al, 2010, submitted
4. D&A in GEV framework

\[ Y \mid X \sim GEV(X\beta, \Sigma, \Xi) \]

- **Y**: Space-time vector of annual extremes
- **X**: Space-time signal matrix (one column per signal)
- **\beta**: Vector of scaling factors
- **\Sigma**: Vector of scale parameters
- **\Xi**: Vector of shape parameters

Note that these are vectors.
Results: Global

- **TNN**: Coldest night
- **TXN**: Coldest day
- **TNX**: Warmest night
- **TXX**: Warmest day
Implied change in waiting times (1990’s vs 1960’s)

Global Land (GLA)

TNn
Coldest night

TXn
Coldest day

TNx
Warmest night

TXx
Warmest day
Considered four approaches
Have not assessed which approach results in most efficient detection
Ability to model spatial dependence in extremes remains limited
Thus detection on suitably transformed data or on EV distribution parameters currently remains preferable
Nevertheless, advantages to further developing detection approaches within EVT framework
Should be able to calculate FAR directly
Potentially a constraint on projections of future extremes
The End

Photo: F. Zwiers