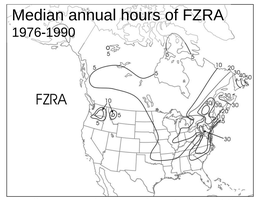
A Synoptic- and Planetary-Scale Analysis of Widespread North American Ice Storms

Christopher McCray, John Gyakum, and Eyad Atallah
McGill University - Montréal, Québec, Canada

1. Introduction and motivation

- Freezing rain (FZRA) can have devastating impacts. For example, the January 1998 ice storm brought **upwards of 100 mm** of ice accretion to portions of southeast Canada[1].
- Predicting the placement and duration of FZRA remains an important forecasting challenge[2].
- Relatively few studies have examined synoptic- and planetary-scale patterns leading to ice storms.
- By identifying patterns that allow FZRA to persist, we hope to better understand and forecast these conditions.

Ice storm damage in Montreal during Jan. 1998 ice storm (Photo credit: City of Montreal)

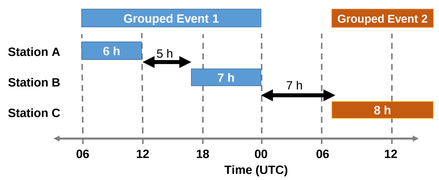


Median annual hours of FZRA from 1976-1990 (Fig. 2 in Cortinas et al. 2004[3])

2. Data and event identification

Datasets
- Surface station observations (NOAA ISD) – 1979-2016
- NCEP Climate Forecast System Reanalysis (CFSR)/CFSv2

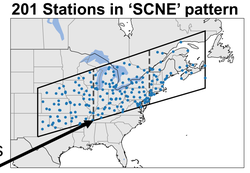
Event definitions
- **Freezing rain event duration**
  - Hours of freezing rain at a given station separated by no more than 24 hours
- **Long-duration (LD) freezing rain event**
  - Freezing rain event with a duration of 6+ hours
- **Grouped LD freezing rain event**
  - Grouping of all long-duration events among all stations that occur within 6 hours of each other
  - This produces temporally and spatially coherent events



Example of grouping technique for three stations observing LD events

- **'South Central-Northeast' (SCNE) event**
  - Grouped event for which:
    - At least **2/3** of LD FZRA hours fell within polygon at right
    - At least **5%** of stations in each third of the polygon observed a LD event (thirds denoted by dashed lines)

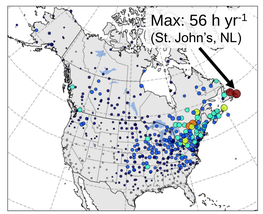
201 Stations in 'SCNE' pattern



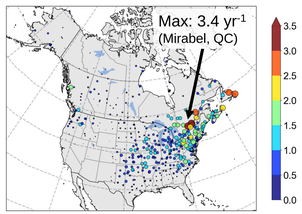
Stations used to identify the largest recurring pattern of LD FZRA

3. Climatology of freezing rain and long-duration events (1979-2016)

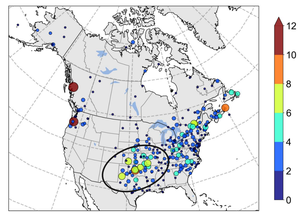
Median annual hours of FZRA (1979-2016)



Mean annual long-duration events



Number of 18+ hour freezing rain events

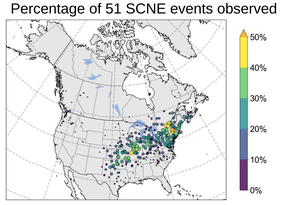


- **FZRA/LD events** most common in **NE US/SE Canada**
- **99th percentile** of event durations is 18 hours
- **18+ hour events** are relatively frequent over **South Central U.S.**
- What conditions support these climatological patterns?

4. The South Central-Northeast (SCNE) Ice Storm Pattern

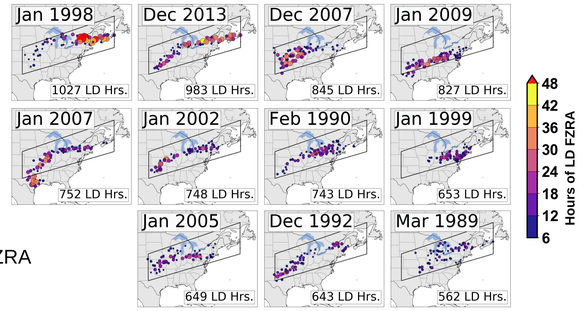
51 grouped cases meet **SCNE criteria**
- These cases include…
  - **15** of the top 20 grouped events
  - 29 of top 50
  - **36%** of all **18+ h events**
  - **49%** of all **24+ h events**
- Median SCNE grouped event duration: **3.8 days**

Percentage of 51 SCNE events observed

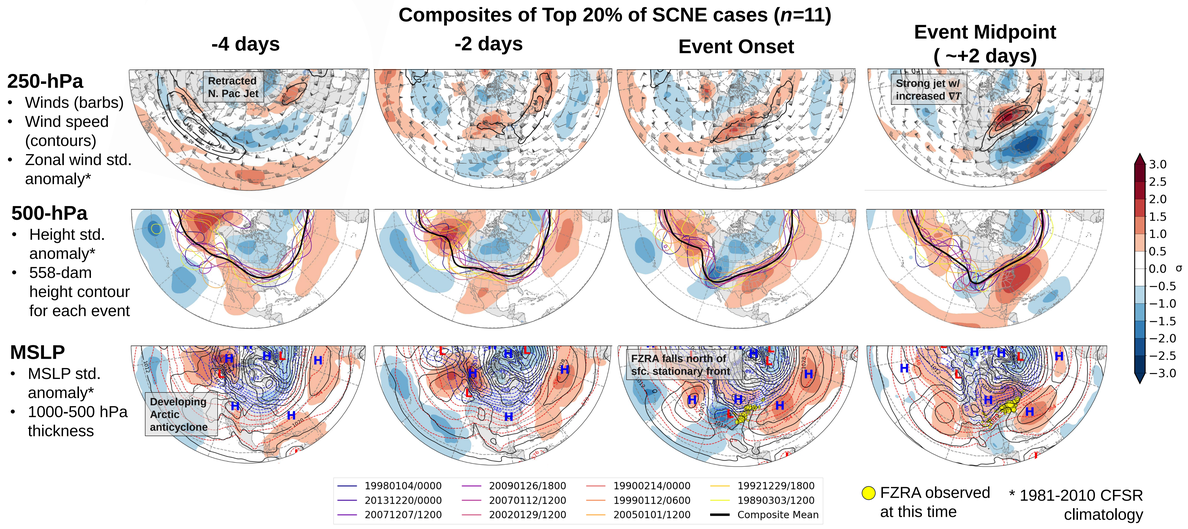


We composite the **top 20%** of SCNE events based on total LD FZRA hours to understand the conditions leading to these severe cases

Top 20% of SCNE cases based on total LD FZRA hours



Composites of Top 20% of SCNE cases (*n*=11)

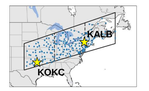


FZRA observed at this time

* 1981-2010 CFSR climatology

5. Thermodynamic environments

Observed soundings for *all* SCNE events that affected KOKC and KALB (not just top 20%)



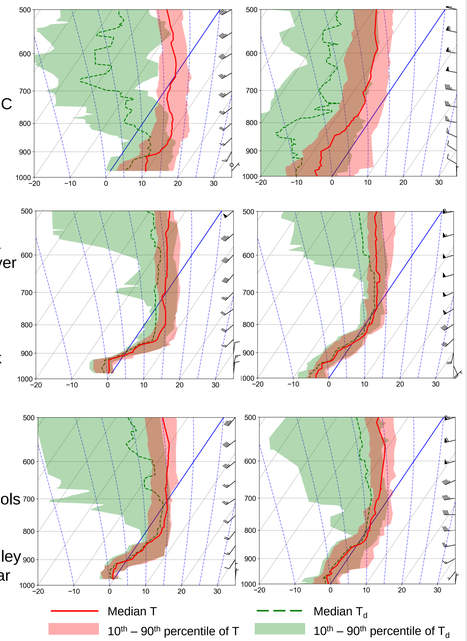
KOKC – Oklahoma City (*n*=12)

KALB – Albany, NY (*n*=20)

Onset -24 h
- KOKC
  - T_{sfc} > 0°C
- KALB
  - T_{sfc} often < 0°C

Event Onset
- KOKC
  - Low-level CAA
  - Deep warm layer aloft
- KALB
  - T_{sfc} steady
  - Mid-level WAA develops weak warm layer

Event End
- KOKC
  - T_{sfc} remains below 0°C
  - Warm layer cools
- KALB
  - Cold layer confined to valley
  - T_{sfc} rises to near or above 0°C



6. Summary and conclusions

- Freezing rain is **most common** over the NE U.S. and SE Canada, but many **very long duration** (18+ h) events also occur over the **U.S. Southern Plains.**
- The **South Central-Northeast (SCNE)** pattern produces severe LD FZRA events over a >3000 km-wide region.
- FZRA falls in deformation zone between Arctic, Atlantic highs
- Slow-moving, large half-wavelength trough/ridge pattern
- Over the **Southern Plains**
  - Cold air from Arctic anticyclone undercuts warm air in place prior to event onset
  - Surface CAA allows FZRA to persist for many hours
- Over the **NE U.S./ SE Canada**
  - Warm air overruns surface-based cold air in place at onset
  - Surface cold air is eroded by latent heat release, WAA

References

1. Gyakum, J. R., and P. J. Roebber, 2001: The 1998 Ice Storm—Analysis of a Planetary-Scale Event. *Mon. Wea. Rev.*, 129, 2983–2997.
2. Reeves, H. D., K. L. Elmore, A. Ryzhkov, T. Schuur, and J. Krause, 2014: Sources of Uncertainty in Precipitation-Type Forecasting. Wea. Forecasting, 29, 936–953.
3. Cortinas Jr., J. V., B. C. Bernstein, C. C. Robbins, and J. Walter Strapp, 2004: An Analysis of Freezing Rain, Freezing Drizzle, and Ice Pellets across the United States and Canada: 1976–90. *Wea. Forecasting*, 19, 377–390.

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Additional questions?

E-mail Christopher.McCray@mail.mcgill.ca
Website www.cdmccray.com
Twitter @McCrayWX