Relating Winter Weather to Societal Impact

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PURPOSE: Method For Generating Impact Forecasts

- **PHASE ONE**: Local Winter Storm Scale (LWSS) → Create winter storm climatology for historical perspective.
- **PHASE TWO**: Rooney Disruption Index (RDI) → Provide a quantitative link between meteorology and societal impact.

WHY WINTER STORMS?

"Winter storms paralyze cities and regions for days and cost **billions of dollars** in cleanup and lost productivity…"

–NWS Strategic Plan 2020

…Introduction to Disruption

- **Intrinsic Disruption** : Pure meteorology, the potential for an event to cause societal disruption.
  - Saffir-Simpson Scale (1974)
- **Societal Susceptibility** : How vulnerable society is to a phenomenon (winter storms).
  - Scharfenberg (2011)
- **Realized Disruption** : Actual resulting socioeconomic impact.

Intrinsic Disruption + Societal Susceptibility = Realized Disruption.

  - Rooney (1967)

National Weather Service Strategic Plan 2020 Focus: Impact-based Decision Support Services

- Better understand the impact forecasts have on society → focus NWS resources
  - Provide decision assistance to core partners (FAA, DOT) during ***High Impact Events***
- ***High Impact Event*** = A meteorological event that causes realized disruption.
  - Examples: Squall line, blizzard, light freezing rain at rush hour

The Winter Storm Problem

- Precipitation Type and Amount
- Wind (during and after event)
- Temperature (during and after event)
- Timing is everything
  - Wed. Jan 26, 2011 evening "commute"
  - Event revealed society can still be caught by surprise → Need tool to communicate details.

PHASE ONE: Local Winter Storm Scale

- LWSS (pronounced "Lewis")
- Developed with Dr. Steven G. Decker (Rutgers)
- Measures *intrinsic disruption (METEOROLOGY ONLY)* at a single location
- Uses METARs and storm spotter data as input
- Represent complex situation with single value

GOAL → Provide a **winter storm climatology** for placing storms into **historical perspective →** **Allows for comparison of events separated by time and/or space**

STORM ELEMENTS

Sustained Wind [kt]	Wind Gust [kt]	Storm Total Snowfall [in]	Storm Total Icing [in]	Minimum Visibility [mi]

Storm Element Value (descriptor)
0 (Nuisance)
1 (Minimal)
2 (Substantial)
3 (Major)
4 (Major)
5 (Extreme)
6* (Extreme)

BIN VALUE / LWSS CATEGORY

* Last bin is for extrapolation of extreme values

STORM ELEMENTS

BIN VALUE / LWSS CATEGORY

Storm Element Value (descriptor)	Sustained Wind [kt]	Wind Gust [kt]	Storm Total Snowfall [in]	Storm Total Icing [in]	Minimum Visibility [mi]
0 (Nuisance)	0	0	0	none	10
1 (Minimal)	7	13	2	T	3
2 (Substantial)	11	17	4	0.1	1
3 (Major)	17	22	10	0.25	0.5
4 (Major)	22	30	15	0.5	0.25
5 (Extreme)	27	41	20	0.75	0.125
6* (Extreme)	34	48	25	1.0	0

NOTE: Values shown are Lowest value for each Bin, except for Visibility

STORM ELEMENTS

BIN VALUE / LWSS CATEGORY

Storm Element Value (descriptor)	Sustained Wind [kt]	Wind Gust [kt]	Storm Total Snowfall [in]	Storm Total Icing [in]	Minimum Visibility [mi]
Weighting Factor	20%	15%	50%	30%	15%
0 (Nuisance)	0	0	0	none	10
1 (Minimal)	7	13	2	T	3
2 (Substantial)	11	17	4	0.1	1
3 (Major)	17	22	10	0.25	0.5
4 (Major)	22	30	15	0.5	0.25
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PHASE ONE: Local Winter Storm Scale

METHOD DESCRIPTION

1.) For a single station, analyze all METARs over the period of time when precipitation is falling, drifting, or blowing.

2.) Obtain the **Storm Elements** by noting the maximum sustained wind speed, wind gust, and minimum visibility during this period and obtain storm total snowfall and icing data for the same location.

3.) Place **Storm Elements** into the appropriate BIN and interpolate to calculate the **Storm Element Scores**.

4.) Multiply the **Storm Element Score** by the appropriate **Weighting Factor** and sum to obtain the **LWSS** score.

PHASE ONE: LWSS Examples

Storm Element	Observation	SES	SES x WF
Sus. Wind	17 kts	3.00	0.600
Wind Gust	23 kts	3.11	0.467
Snowfall	2.9 in.	1.45	0.725
Icing	none	0.00	0.000
Visibility	0.5 mi.	3.00	0.450
LWSS = 2.242 (Substantial Disruption)			

1/19/2002 – 1/20/02 KEWR

Storm Element	Observation	SES	SES x WF
Sus. Wind	23 kts	4.20	0.840
Wind Gust	35 kts	4.46	0.669
Snowfall	19.5 in.	4.90	2.450
Icing	0.18 in.	2.53	0.759
Visibility	0.25 mi.	4.00	0.600
LWSS = 5.305 (Extreme Disruption)			

2/9/2010 – 2/11/2010 KBWI
SNOWMAGEDDON

LWSS Category Value					
0 (Nuisance)	1 (Minimal)	2 (Substantial)	3 (Major)	4 (Major)	5 (Extreme)

PHASE ONE: LWSS - Highlights

- Measures **POTENTIAL** for winter storms to deliver societal impact (*intrinsic disruption*)
  - Meteorology Only
  - Similar to Saffir-Simpson scale
- Weighting Factor sums to **1.30** to reward ice storms; no icing = sums to 1.00
- A unique value exists for every point
  - Spatial variability for each storm!
    → Complements NESIS
- Does NOT account for Realized Disruption

PHASE TWO: Realized Disruption Scale

- Rooney Disruption Index (RDI) - Derived from Rooney (1967)
- Measures ***realized disruption*** for
  - Highways
  - Local Roads
  - Railways
  - Manufacturing
  - School Operations
  - Public Functions
  - Power Outages
  - Airways
  - Retail

<u>GOALS</u> → 1.) Provide climatology of socioeconomic impact for historical perspective

2.) Build regression relationship with LWSS values for forecasting of RDI.

PHASE TWO, Goal 1.): Rooney Disruption Index

METHODOLOGY

1.) Identify events where LWSS is calculated.

2.) Collect all relevant socioeconomic impact data for each event and categorize using RDI Rubric.

PHASE TWO, Goal 2.): LWSS/ RDI Relationship

METHODOLOGY

1.) Perform regression using LWSS values to predict the RDI values

2.) Reveal societal susceptibilities by investigating the relationship under differing circumstances.

PHASE TWO, GOAL 2.): LWSS and RDI Relationship Study Example

- Study at single location
  - (Newark, NJ; KEWR)
  - **Isolate variations in societal susceptibility**
- 15 cold seasons (10/1/1995 – 3/31/2010)
- Resulted in database of 309 events
  - Apply LWSS and RDI to each
    - OMIT STORMS WITH NO PRESS MENTION (RDI = 0)
    - Results in database of 136 events
  - **Investigate relationship…**

As intrinsic disruption increases, societal impact increases

(NOTE: RDI=0 cases omitted)

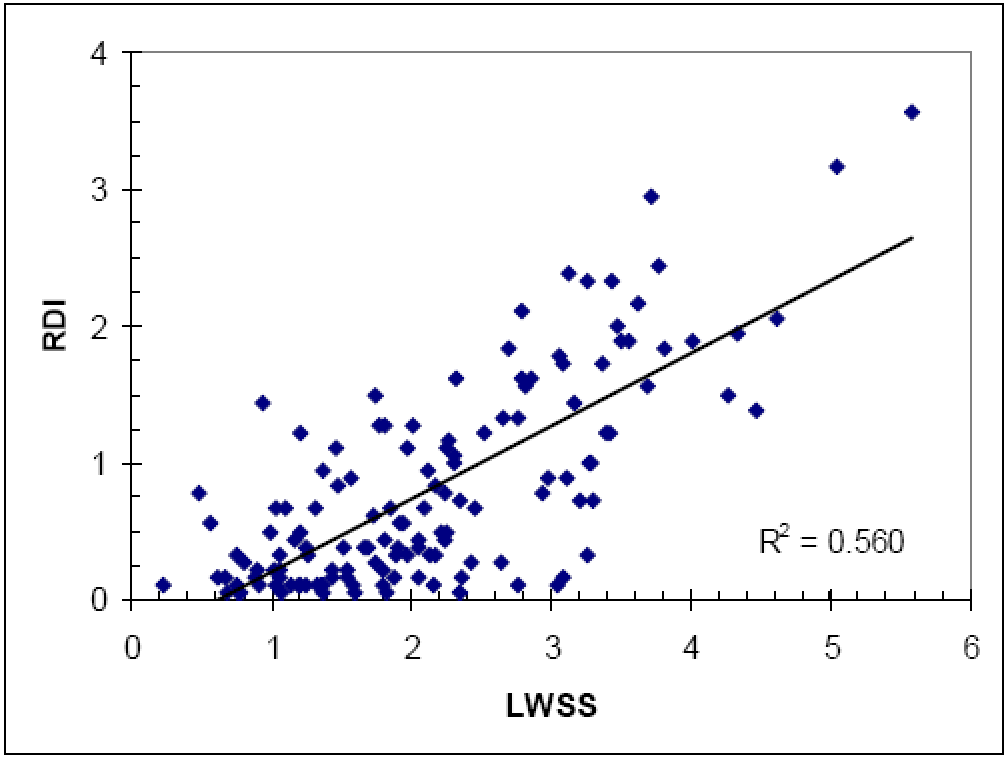


FIG. 2. Scatterplot of LWSS and RDI values, including the linear best fit and its associated coefficient of determination (R^2). Storms with no press mention (RDI = 0) are not included.

Relationship is not perfect

(→ ***Societal Susceptibility*** is present)

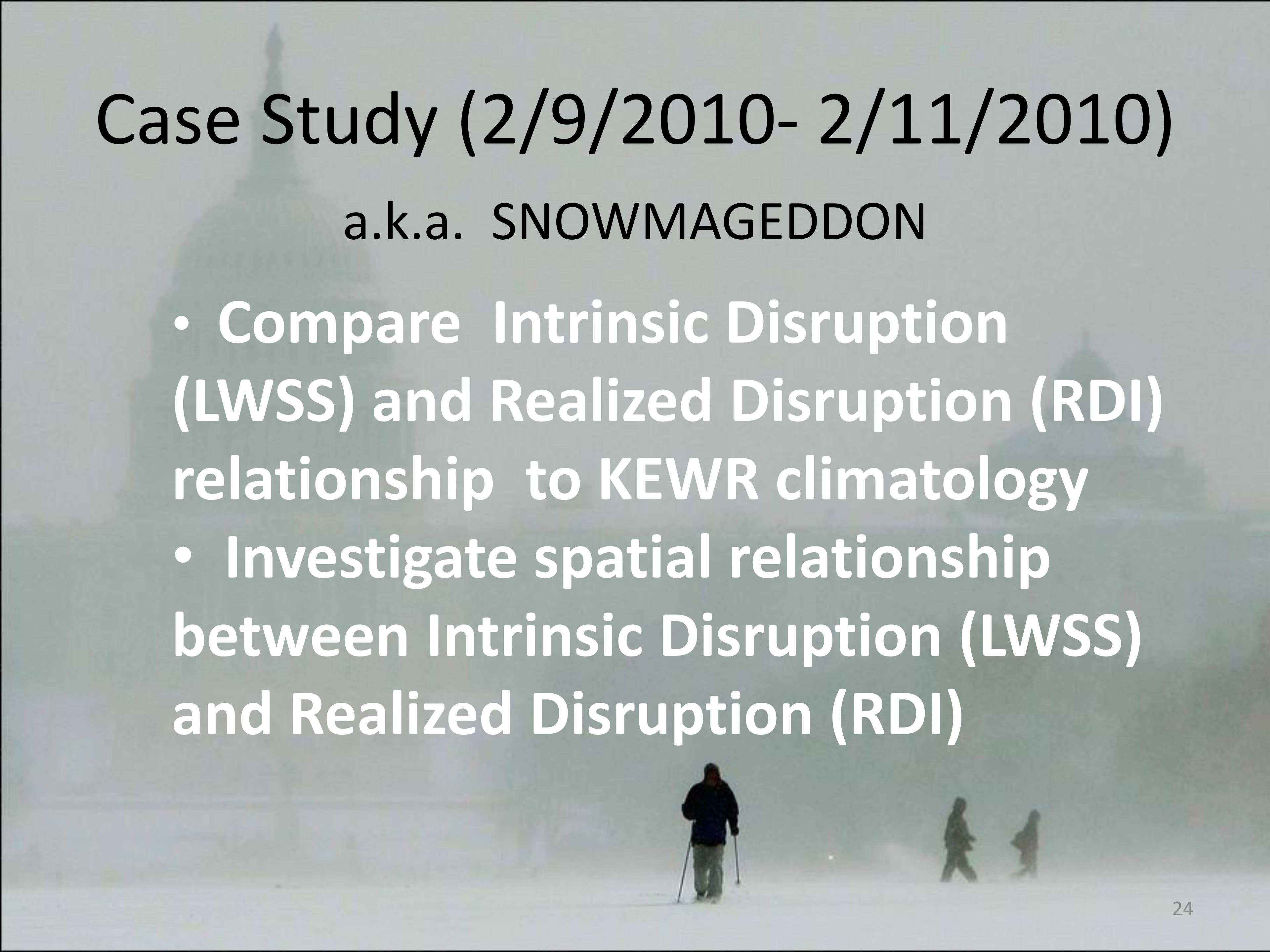
PHASE TWO, GOAL 2.): Summary of Analysis

- ‘MAJOR’ winter storms always had an impact
  - When LWSS > 3, RDI > 0
- Storms occurring on non-holiday weekdays (weekends/ holidays) have more (less) realized disruption.
- Storms occurring < 2 days after the previous event have more realized disruption.
- Storms occurring outside of the ‘peak season’ display a weaker LWSS/ RDI relationship.
  - Non-LWSS factors have more influence
- **Can now provide Impact forecasts directly…**

POSSIBLE TEXT PRODUCTS

Assume expected LWSS value of 4.0…

Societal Element	ASSUME: Storm occurs in peak season RDI = 2.0	ASSUME: Storm occurs in mid October on a weekday RDI = 3.0
Roadways	Increased accidents, traffic **slowed**, **speed restrictions** on highways	Increased accidents, traffic **stopped**, some **stranded vehicles**
Railways	Rail delays up to **four hours**	Rail delays up to **twelve hours**
Airports	**Light** flight **cancellations**	**Several** flight **cancellations**
Schools	Closing of **some** suburban schools, **minor** attendance drops for urban schools	Closing of **most** suburban schools, **major** attendance drops for urban schools
Electrical Utility Operations	Widespread **brief** power **interruptions**	**Widespread** power **outages**



Case Study (2/9/2010- 2/11/2010)

a.k.a. SNOWMAGEDDON

- **Compare Intrinsic Disruption (LWSS) and Realized Disruption (RDI) relationship to KEWR climatology**
- **Investigate spatial relationship between Intrinsic Disruption (LWSS) and Realized Disruption (RDI)**

Snowmageddon relative to KEWR climatology

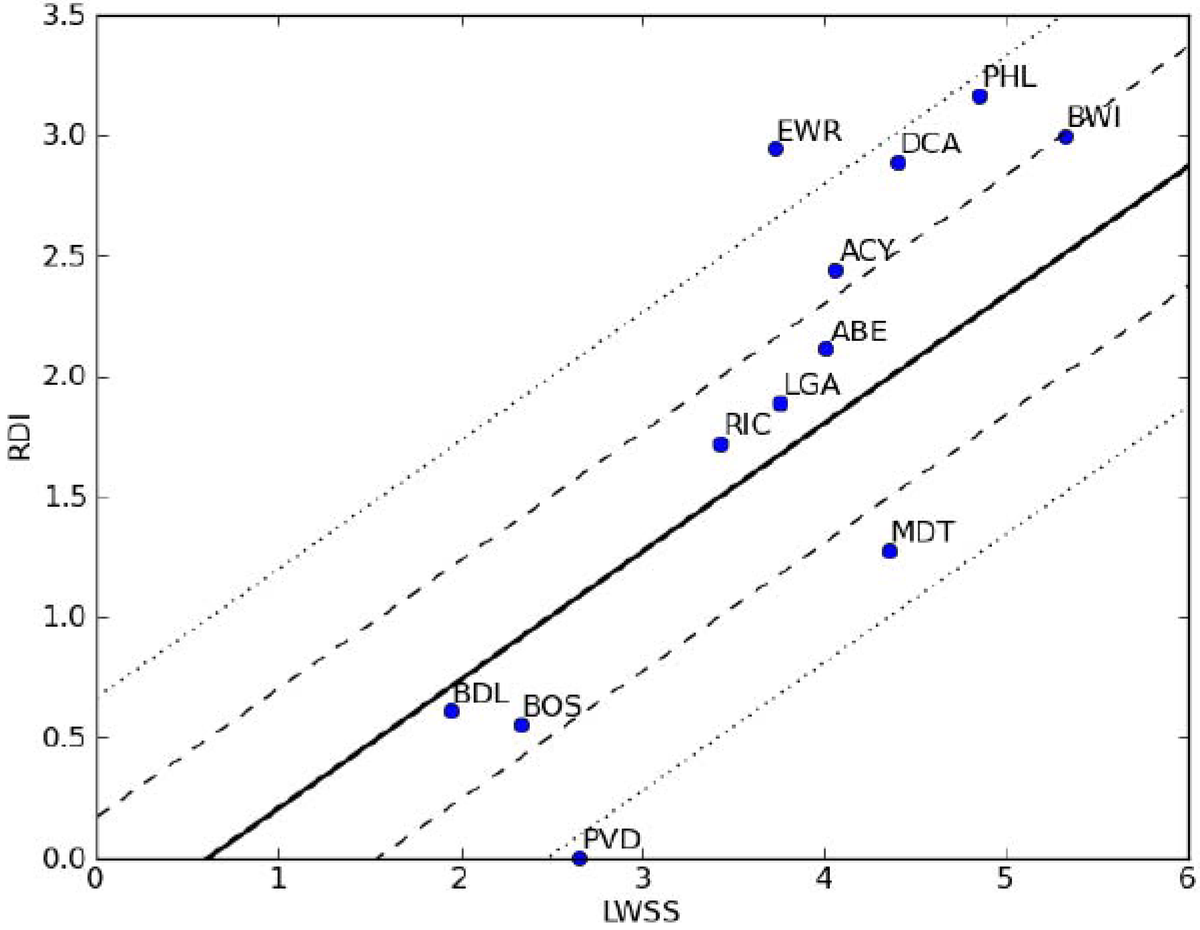
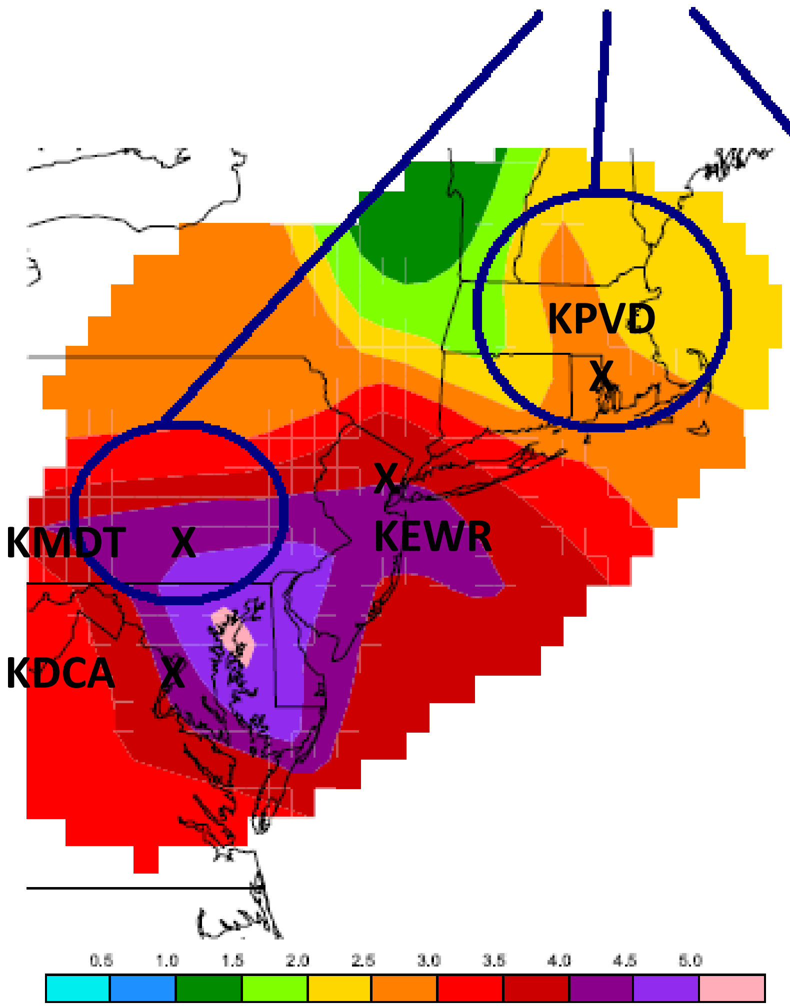


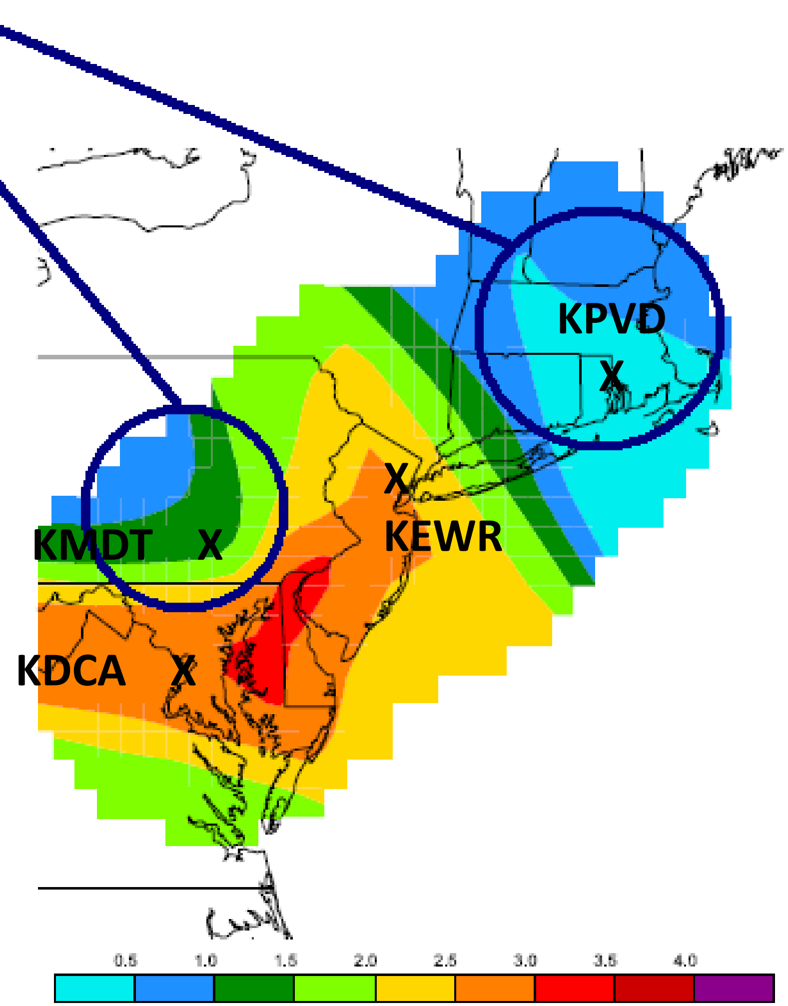
FIG. 8. Scatterplot of LWSS and RDI values at various locations affected by the 9–11 February 2010 winter storm. The best-fit line from Fig. 2 is also included, as are lines representing one (dashed) and two (dotted) standard errors above and below the best-fit line.

Snowmageddon Intrinsic Disruption (LWSS) and Realized Disruption (RDI) Spatial Comparison

LWSS Overestimates RDI Value



Intrinsic Disruption (LWSS)



Realized Disruption (RDI)

REMEMBER: ONLY CALIBRATED FOR KEWR!!!!

Conclusions

- LWSS provides estimate of intrinsic disruption (meteorology) for a single location
- RDI provides estimate for realized disruption (socioeconomic impact) for a single location
- A relationship between LWSS and RDI can be exploited to create Impact Based forecasts
- New calibration is needed for each station
  - Allows for intricate localized knowledge of societal susceptibility

Future Work

- Development of LWSS/ RDI relationship for all locations where impact forecasts are desired
  - **WFO Memphis, TN** has agreed to carry out development for selected stations
  - (Any other interested WFOs, please contact me!)
- Develop Real-time LWSS to track intrinsic disruption
  - Aid in short term forecasts and decision making
  - Already in development and experimental form
  - Relate RT-LWSS to ‘real time’ Realized Disruption Data

THANK YOU FOR LISTENING

- Questions?
- Comments?
- **Any interested WFOs out there?**
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