The Role of Scenarios in the Cambridge Risk Framework : A Freeze Event

Dr Gary Bowman

Application of System Shock: Supply Network Disruptions

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Risk Studies

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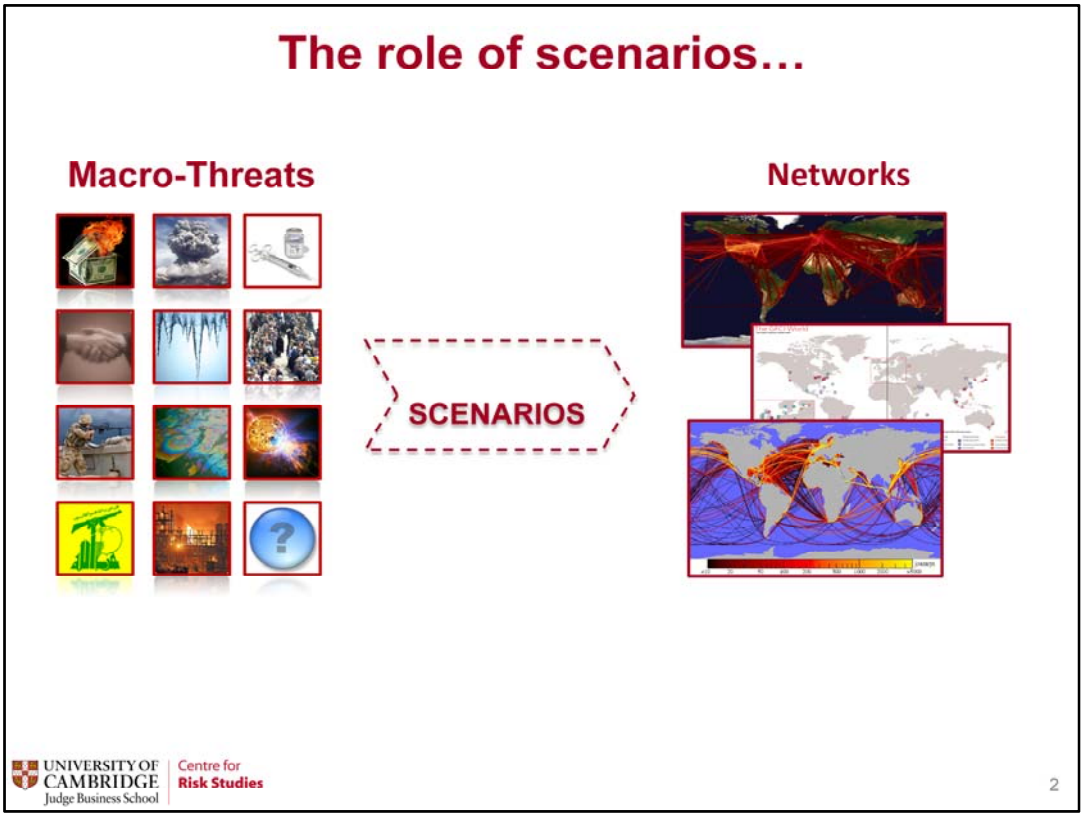
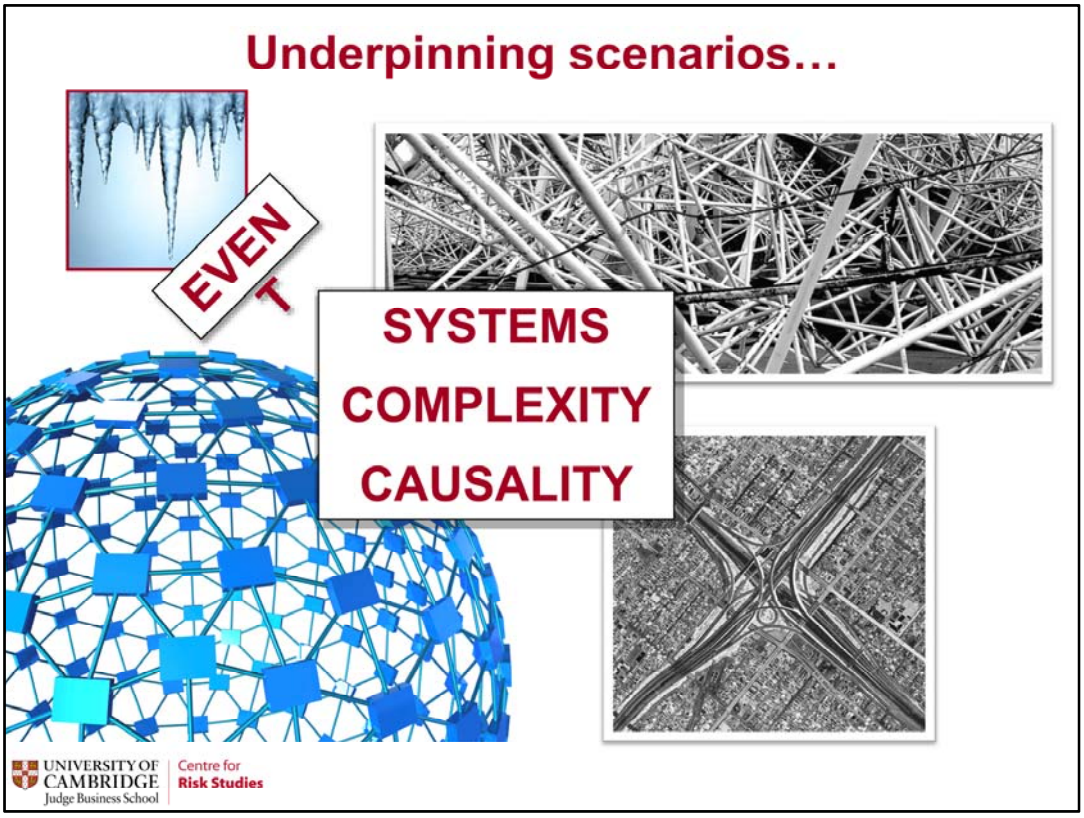


Scenarios to connect the two in a tractable way; and in doing so we can learn more about the individual threats, and in the way they affect and are changed by the networks with which they interact.



And this was the original intention behind scenarios

Now used by…..

We're using scenarios in a broadly similar way

Taxonomy of Macro Threats

A framework for categorising socio-economic threats and collecting structured data

1 Financial Shock
1.1 Asset Bubble
1.2 Financial Irregularity
1.3 Bank Run / Credit Default
1.4 Sovereign Structural Failure
1.5 Market Volatility

2 Trade Dispute
2.1 Labour dispute
2.2 Trade Sanctions
2.3 Tariff Wars
2.4 Nationalization
2.5 Cartel Pressure

3 Geopolitical Conflict
3.1 Conventional War
3.2 Asymmetrical War
3.3 Nuclear War
3.4 Civil War
3.5 External Force

4 Political Violence
4.1 Terrorism
4.2 Separatism
4.3 Civil Disorder
4.4 Assassination
4.5 Organized Crime

5 Natural Catastrophe
5.1 Earthquake
5.2 Windstorm
5.3 Tsunami
5.4 Flooding
5.5 Volcanic Eruption

6 Climatic Catastrophe
6.1 Drought
6.2 Freeze Event
6.3 Heat Wave

7 Environmental Catastrophe
7.2 Oceanic Circulatory System Change
7.3 Atmospheric System Change
7.4 Pollution Event
7.5 Wildfire

8 Technological Catastrophe
Accident
8.2 Industrial Accident
8.3 Infrastructure Breakdown
8.4 Technological Accident
8.5 Cyber-Catastrophe

9 Disease Outbreaks
9.1 Human Epidemics
9.2 Animal Epidemics
9.3 Plant Epidemics

10 Humanitarian Crisis
10.1 Famine
10.2 Water Supply Failure
10.3 Population Migration
10.4 Welfare System Failure

11 Externalities
11.1 Meteorite
11.2 Space Weather

12 Other Shock

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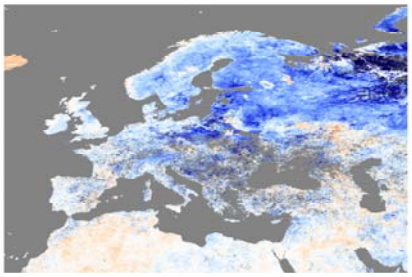
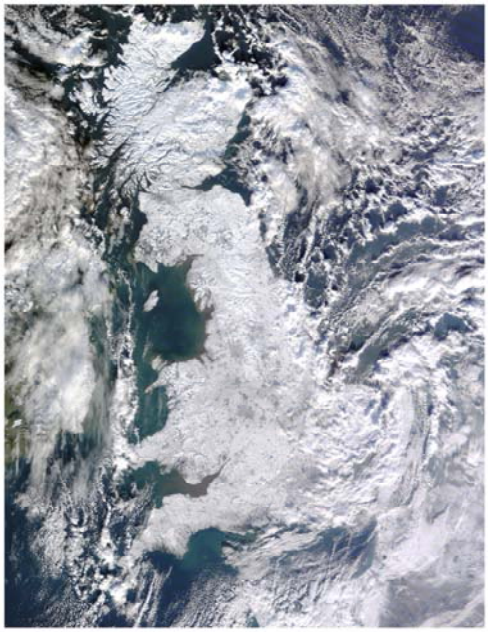
6 Climatic Catastrophe

6.1 Drought
6.2 Freeze Event
6.3 Heat Wave

6.2 Freeze Event





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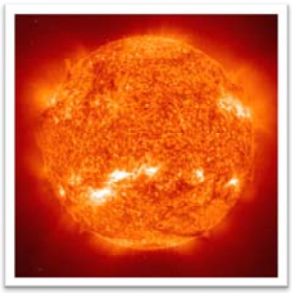
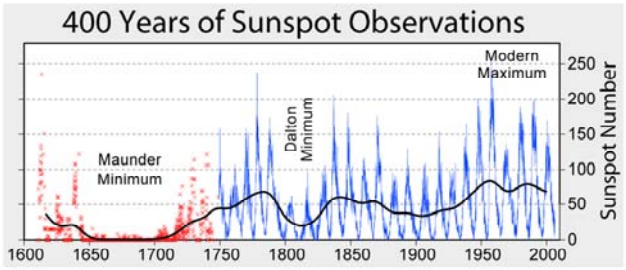
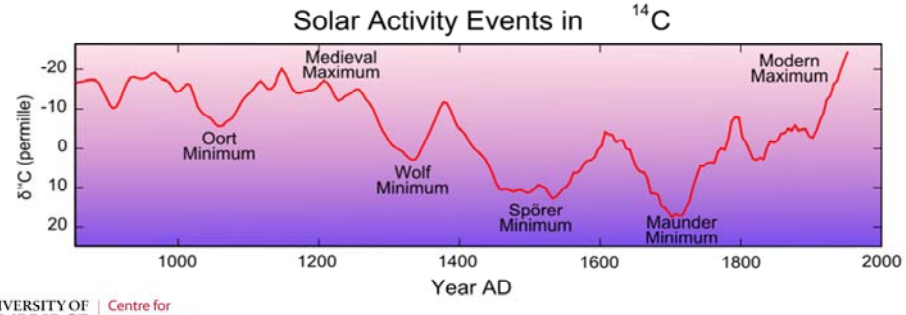
Causes of Freeze: Solar Activity







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Causes of Freeze: Volcanic Activity

VEI	Description	Tephra Volume (m^3)	Plume Height (km)	Frequency	Examples
0	Gentle	< $1x10^4$	< 0.1	Constant	Kīlauea,
1	Effusive	> $1x10^4$	0.1 – 1	12 / 1	Stromboli Nyiragongo (2002)
2	Explosive	> $1x10^6$	1 – 5	1 / 1	Sinabung (2010)
3	Explosive	> $1x10^7$	3 – 15	1 / 5	Soufriere Hills (1995)
4	Cataclysmic	> $1x10^8$	0 – 25	1 / 10	Eyjafjallajokull (2010)
5	Cataclysmic	> $1x10^9$	> 25	1 / 100	Vesuvius (79CE) St Helens (1980)
6	Paroxysmal	> $1x10^{10}$	> 25	1 / 500	Krakatoa (1883) Pinatubo (1991)
7	Colossal	> $1x10^{11}$	> 25	1 / 1000	Thera (1600BCE) Tambora (1815)
8	Colossal	> $1x10^{12}$	> 25	1 / 100,000	Yellowstone (640,000BP)

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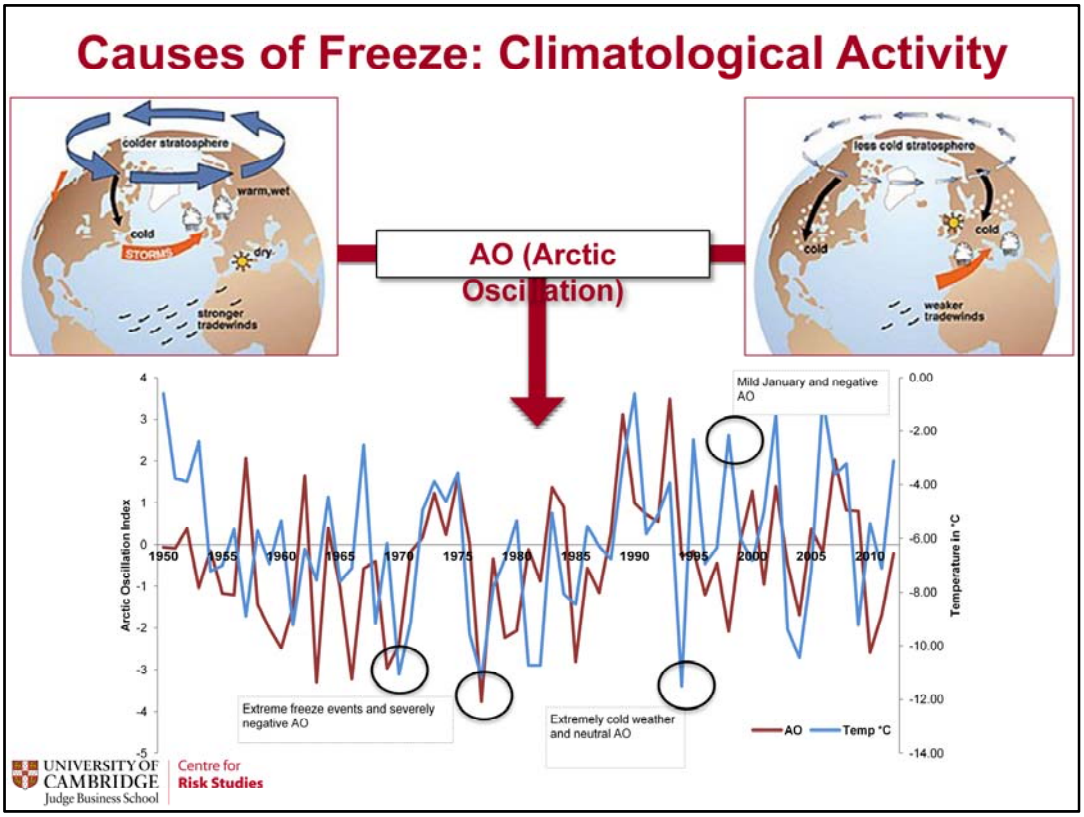
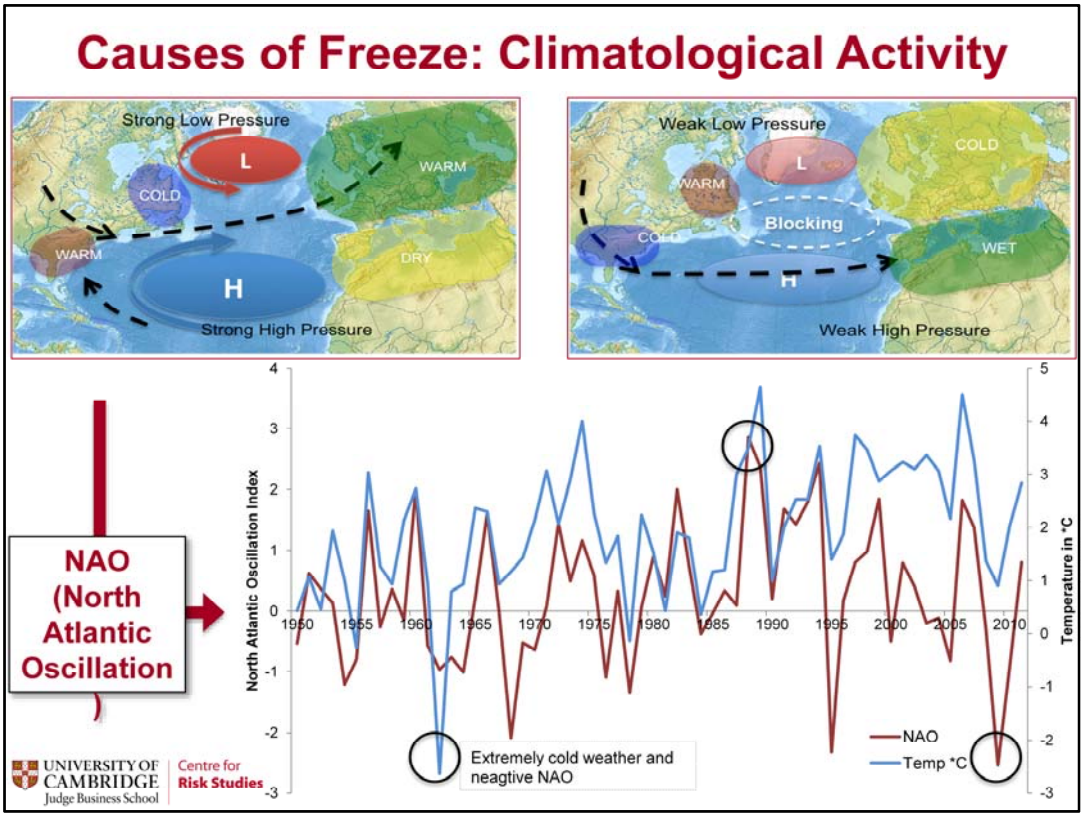
Causes of Freeze: Volcanic Activity

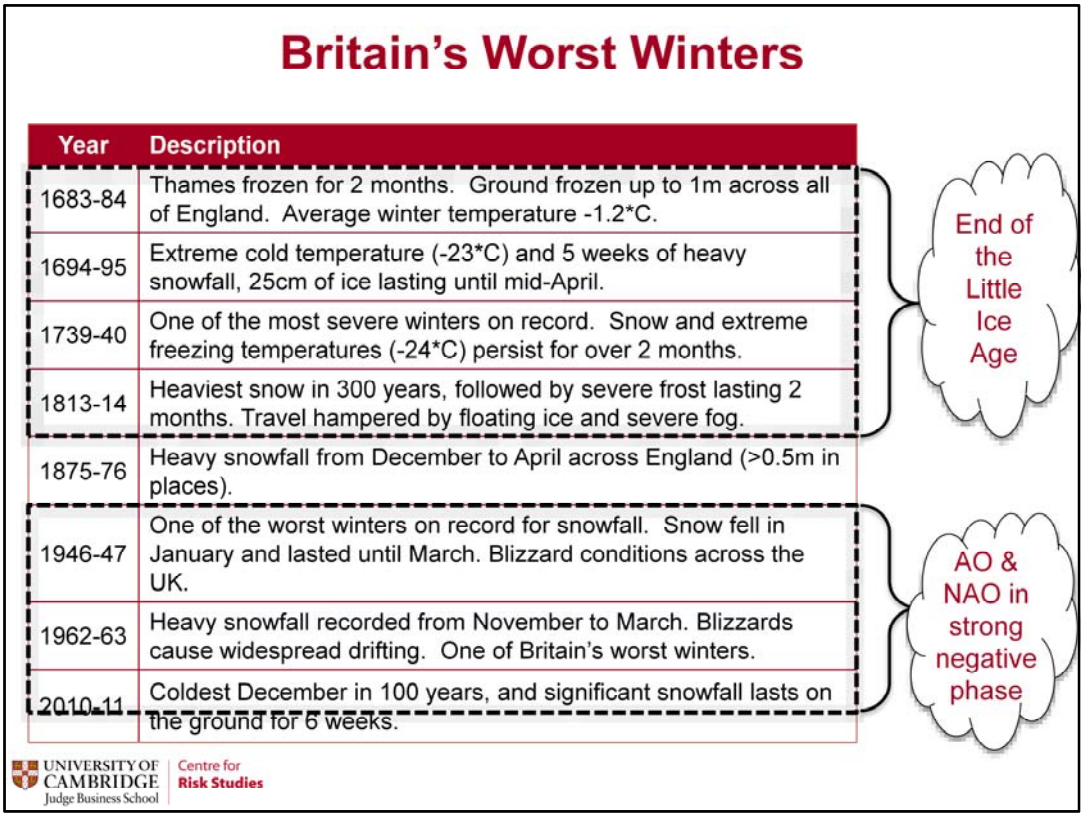
Year	Volcano	Description
535	Krakatoa Tierra Blanca Joven Rabual	It is speculated that one of these volcanoes erupted with a VEI >6. Historical reports note the lack of sunlight, the dense fog (tephra), and failure of crops. Scientific data from marine sediment supports a massive volcanic eruption.
1315	Kaharoa	The great European famine was triggered by a universal crop failure in 1316. Millions of deaths due to famine and disease were noted across the whole of Northern Europe. The period was marked further by the increase in criminal activity and social unrest, culminating in rebellion against the church and state.
1600	Huaynaputina	Russia experienced its worst ever famine between 1601 and 1603, with a third of its citizens dying, as exceptionally cold winters decimated agriculture across Northern and Eastern Europe and Asia.
1815	Tambora	Colossal eruption creates a layer of volcanic fog that caused significant global temperature drop and thus widespread crop failure during 1816, known as the Year without a Summer.
1883	Krakatoa	Global temperatures decreased significantly in the four years after the eruption. The winters of 1887 and 1888 were particularly bad as record snowfall was recorded worldwide.
1991	Pinatubo	For 2-3 years following the eruption, global temperatures dropped. In 1992 and 1993 North America experienced two of the worst winter storms in recorded history.



Patterns in Arctic sea-level pressure variations are captured on an index called Arctic Oscillation (AO), which is related to the degree of penetration of cold air into middle latitudes and gages the strength of the Polar Vortex (see Figure 1). When surface pressure in the Artic is low, AO is said to be in a positive phase, resulting in a strong (west-to-east) jet stream that contains Arctic air in the polar region, and keeps Northern Europe relatively mild with increased precipitation. Conversely, when surface pressure is high, AO is said to be in a negative phase, resulting in weaker zonal and trade winds that allows cold, Arctic air to penetrate south into the middle latitudes (e.g., the United States and Northern Europe). Despite stochastic fluctuations, AO has become a fairly accurate weather predictor.

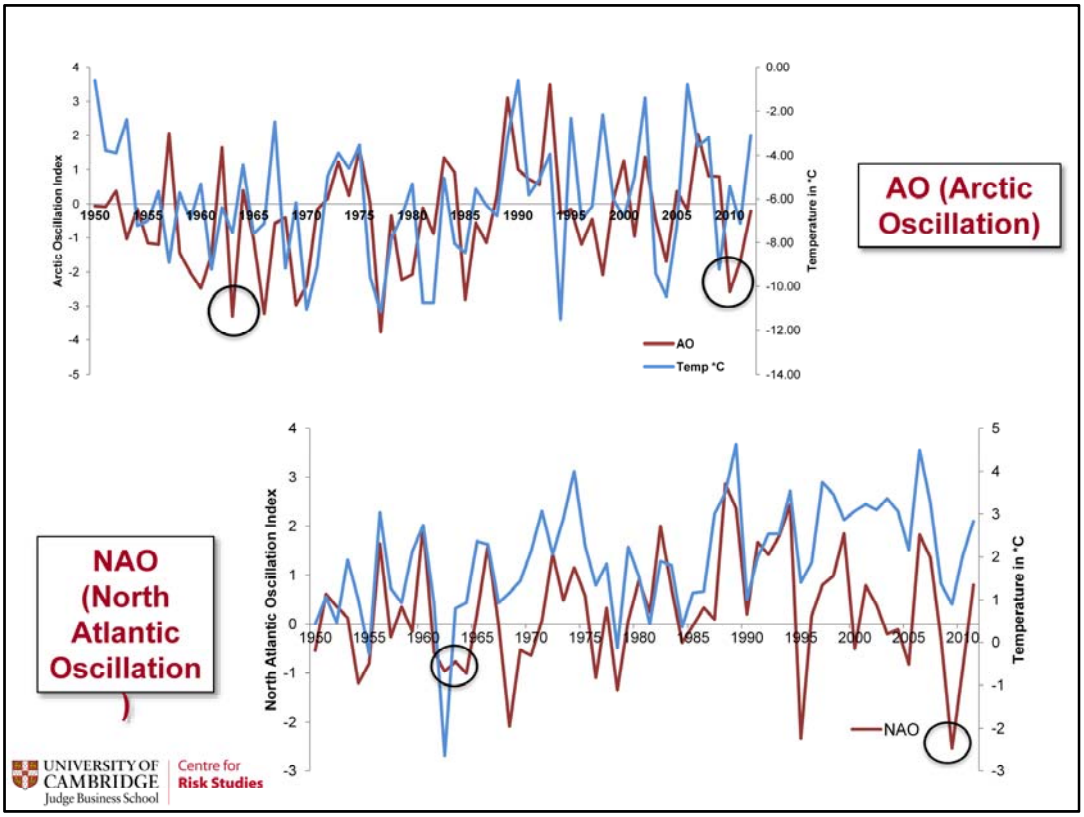


Related to AO is North Atlantic Oscillation (NAO), an index used to capture the variations in sea-level atmospheric pressures between permanent weather systems in the Azores and Iceland (see Figure 3). The subtle movements of the Icelandic low pressure system and the Azores high pressure system determines the strength and direction of winds and storms in the North Atlantic. When the pressure difference between the two points is large, the NAO is considered to be in a positive phase (NAO+), and, conversely, when the pressure difference is very small the NAO is considered negative (NAO-). Typically, NAO+ results in strong westerly winds, bringing mild, wet winters to Europe. Conversely, in a low index, westerly winds are suppressed, bringing cold air from the Arctic to Northern Europe and forcing storms and wetter weather to southern Europe and North Africa. Similar effects are evident in North America. In a positive phase, warm air is pulled from the south-west up the eastern United States and southeast of Canada; in a negative phase, warm air is pulled west causing freezing arctic air from the Polar Vortex to extend as far south as Florida.



17th Century full of terrible winters. Skating on the Thames was a pretty regular occurrence (although it was wider and shallower then). It wasn't uncommon for snowfall and frosts to last for 6-8 weeks.
1739-1740 One of the worst periods for Ireland – 20% excess mortality, summers were poor too – massive crop and agriculture failure lead to famine, increased prices, social unrest and rioting.

1800s had much greater temperatures than 1700 but also greater snowfall


Arctic Oscillation Index
Temperature in °C
AO
Temp °C
AO (Arctic Oscillation)
NAO (North Atlantic Oscillation)
North Atlantic Oscillation Index
Temperature in °C
NAO
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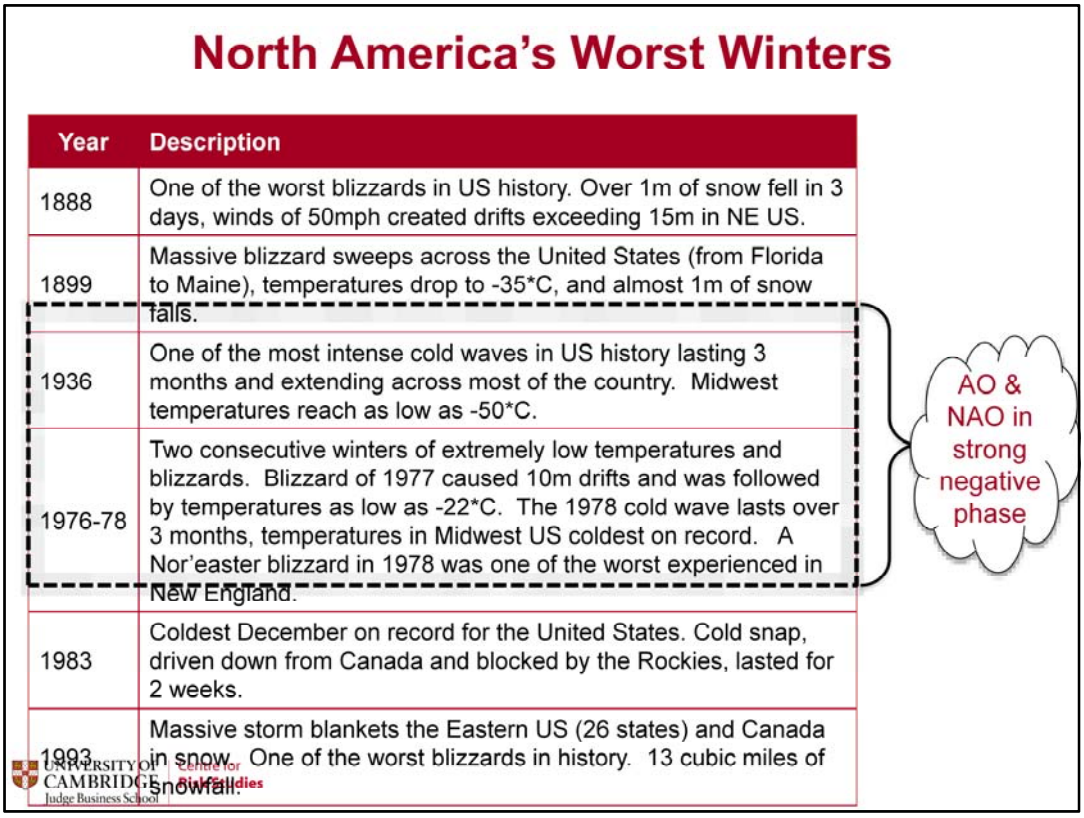
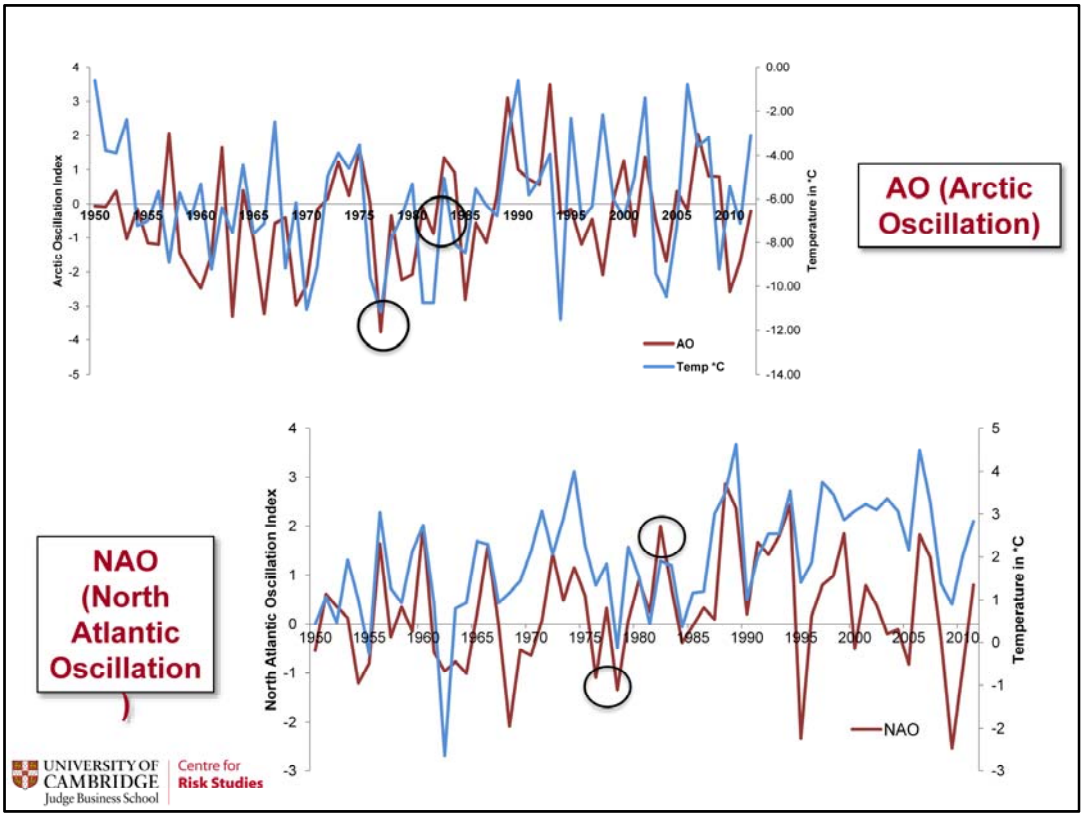


Extreme weather tends to be storm related – northeasters – gulf low pressure moving northeast meeting arctic air over them midwest and great plains.

1993 sheer weight of snow – some 27 billion tonnes collapsed factory roofs

These are all location dependent – New England refers to 78 as worst because it stopped traffic / shutdown activity


AO (Arctic Oscillation)
Arctic Oscillation Index
Temperature in °C
AO
Temp °C
NAO (North Atlantic Oscillation)
North Atlantic Oscillation Index
Temperature in °C
NAO
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Developing a Freeze Index

TEMPERATURE

DURATION

PRECIPITATION

WIND SPEED

NESIS Scale

RSI

Category	NESIS Value	Description
1	1.0 – 2.499	Notable
2	2.5 – 3.99	Significant
3	4.0 – 5.99	Major
4	6.0 – 9.99	Crippling
5	+ 10.0	Extreme

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Northeast Snow Impact Scale – Only two storms have registered a 5 on this scale – 1993 & 1996 – In over 120 years of data (so we have some benchmarks on how severe a 1 in 100 event would be.

Developing a 1 in 100 Freeze Event

Historically Negative NAO

NORTHERN EUROPE – ZONE:	A	B	C
TEMPERATURE	-5*C	-10*C	-20*C
DURATION	7 wks	7 wks	7 wks
PRECIPITATION	<10cms	<50cms	>50cms
WIND SPEED	Strong	Gales	Gales

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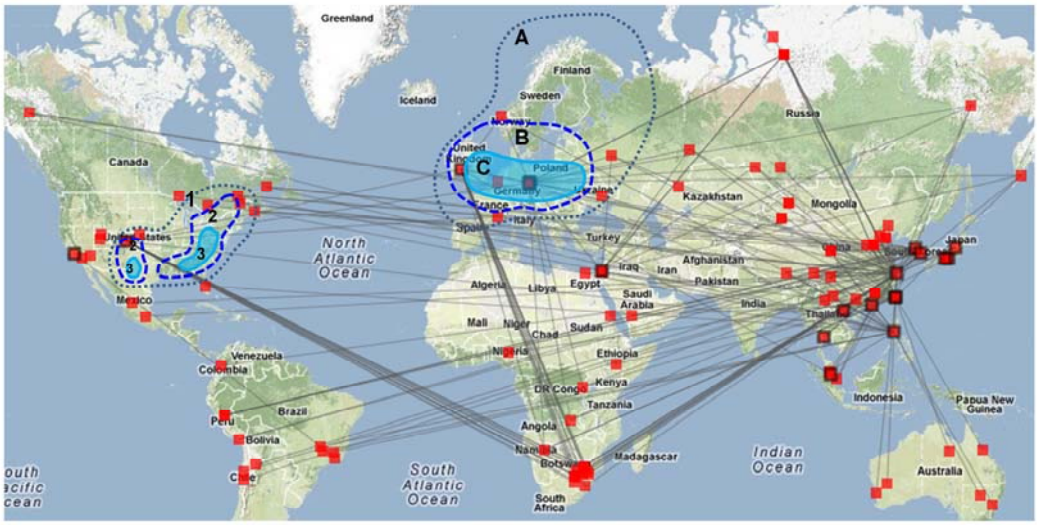
Freeze Event 1-in-100



Developing a 1 in 100 Freeze Event

Historically Negative NAO

NORTH AMERICA – ZONE:	1	2	3
TEMPERATURE	-10*C	-15*C	-25*C
DURATION	4 wks	4 wks	4 wks
PRECIPITATION	10cms/day	20cms/day	30cms/day
WIND SPEED	Strong	Gales	Hurricane

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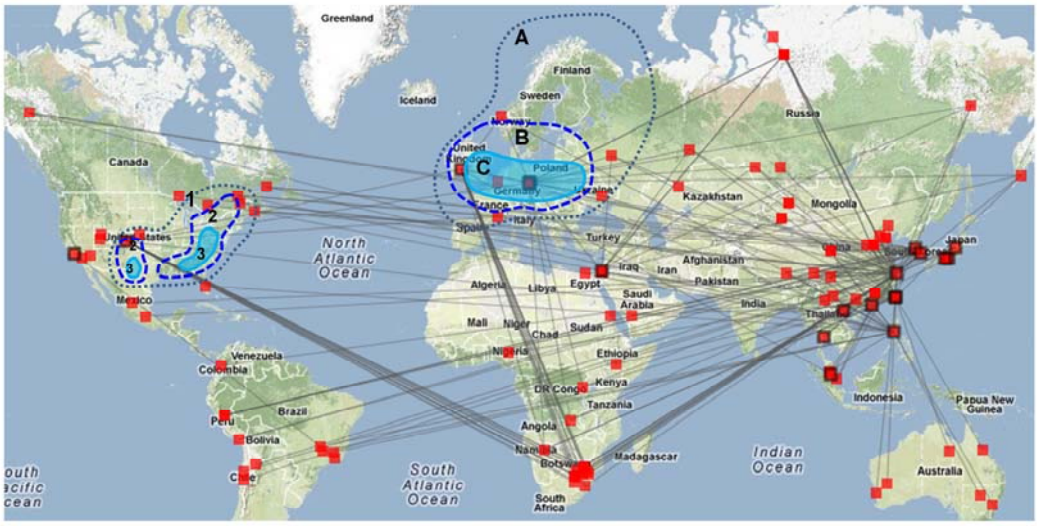
Freeze Event 1-in-100



December 12, 2012

THE DAILY NEWS

www.dailynews.com THE WORLD'S FAVOURITE NEWSPAPER - Since 1879

Travel Chaos as Europe Freezes

The Worst Freeze in 100 years has brought European travel to a halt as blizzard conditions and record low temperatures cause airports closures and flight cancellations across the continent.

Approximately 500,000 passengers have been left stranded, as airports struggle to clear runways and de-ice planes. Rail lines have been similarly disrupted, with queues at London terminals stretching for hundreds of metres. Concern is growing too for drivers stranded in their vehicles on blocked roads. Emergency services have been trying to reach stranded vehicles as blizzard conditions made sections of the A1 north of Stevenage impassable. Similar conditions on the M6, and a serious accident at the Stafford junction, have created havoc for commuters and emergency services.

With the severe weather expected to continue for several weeks, shares in the FTSE 100 dropped 2.3% as fears grow of a weak Christmas retail performance, increased energy costs, and continued disruption to business processes. British Airways, which dropped 6%, have cancelled *(see page4)*.

1 in 100 Freeze Event Impact

NORTHERN EUROPE			
Factor	**Zone A**	**Zone B**	**Zone C**
Human	5%	10%	15%
Economic	-0.2% GDP	-0.5% GDP	-1.0%
Industry Activity	15%	20%	25%
Transportation			
Road	10%	25%	50%
Rail (delays)	12% (40%)	20% (60%)	30% (80%)
Air Travel	10%	20%	30%
Sea Travel	5%	10%	25%

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Human cost – 10% equals about 45,000 extra deaths. Industry activity derived from building industry, small business statistics and traffic data

House of commons transportation report & Begg report

Road - laying salt on roads and pavements helps prevent ice forming and snow lying but is largely ineffective against deep snow and does not work at temperatures below -8˚C.95 The UK is reliant on salt imports (to supplement limited domestic supply)

Sea Travel disrupted by several port closures (and blockage of routes into ports)

Key Considerations for Supply Chains

At what point (node) does the Freeze disrupt:

- Transportation (Input / Output)
- Production (Labour supply)

- ….and how severe is the disruption?

- Perhaps more specific and detailed scenarios can be used help approximate delays and failures

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Very simplified just now, but perhaps as we progress on this exceptionally ambitious project, we can work on developing more detailed scenarios to explore the impact of specific delays or node failures on supply chains.