REIMAGINING HISTORY

COUNTERFACTUAL RISK ANALYSIS

'Intelligence without imagination: a deadly combination'
Nassim Nicholas Taleb

Dr. Gordon Woo
Catastrophist

17 November 2017

RMS™

History, harmless history,
where everything unexpected
in its own time is chronicled on
the page as inevitable.

The terror of the unforeseen
is what the science of history
hides.

Philip Roth,
The Plot against America (2004)

Counterfactual political risk scenario

In October 1938, Charles Lindbergh was presented by Goering with the Service Cross of the German Eagle for his contributions to aviation.

Disaster: an unfavorable aspect of a star

The past cannot be changed.

Hazard analysts treat the past as fixed.

This is an anthropocentric viewpoint.

A new perspective on catastrophe risk

‘The report provides another excellent new lens into managing risk.’

Amlin

Counterfactual Underwriting

The Economist

October 21, 2017

History: the same word as story

German:	Geschichte
Icelandic:	Saga
French:	Histoire
Italian:	Storia
Spanish:	Historia
Catalan:	Història
Portuguese:	História
Norwegian:	Historie
Danish:	Historie
Greek:	Ιστορία

Imagination in catastrophe risk modeling

Catastrophe risk modeling is still in its infancy.

Modelers need to be more imaginative.

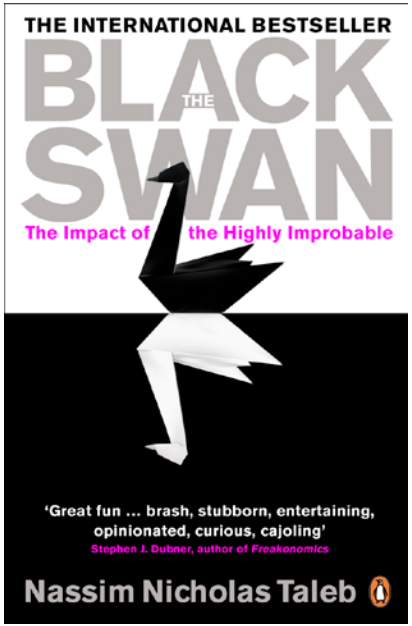
We need to exercise counterfactual thinking, and imagine the past as being other than it actually was.

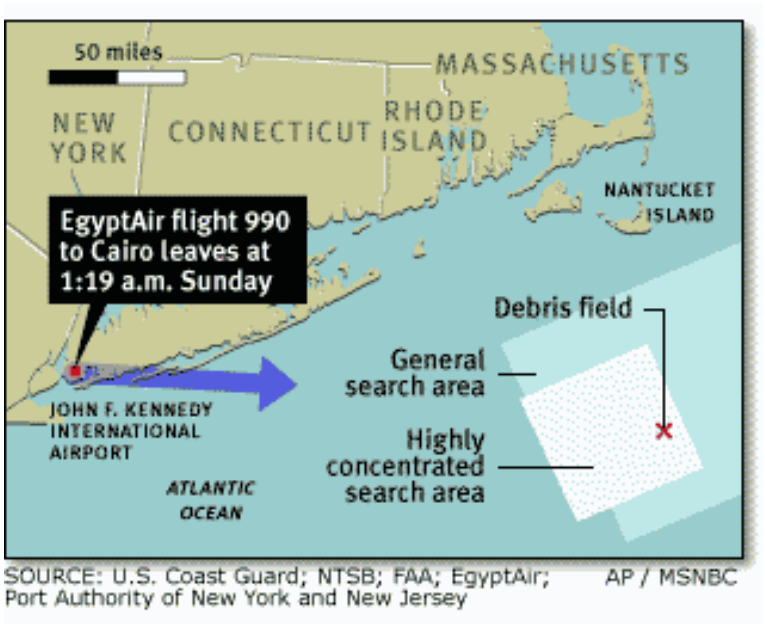
'Children pretend so much because they are learning so much.'

Alison Gopnik, Berkeley

Counterfactual thinking to counter a failure of imagination

*'Think of the terrorist attack of September 11, 2001: had the risk been **reasonably conceivable** on September 10, it would not have happened.'*





On October 31, 1999, Gameel Al Batouti, crashed EgyptAir Flight 990 en route from JFK to Cairo.

His last words were:
'I trust in Allah'.

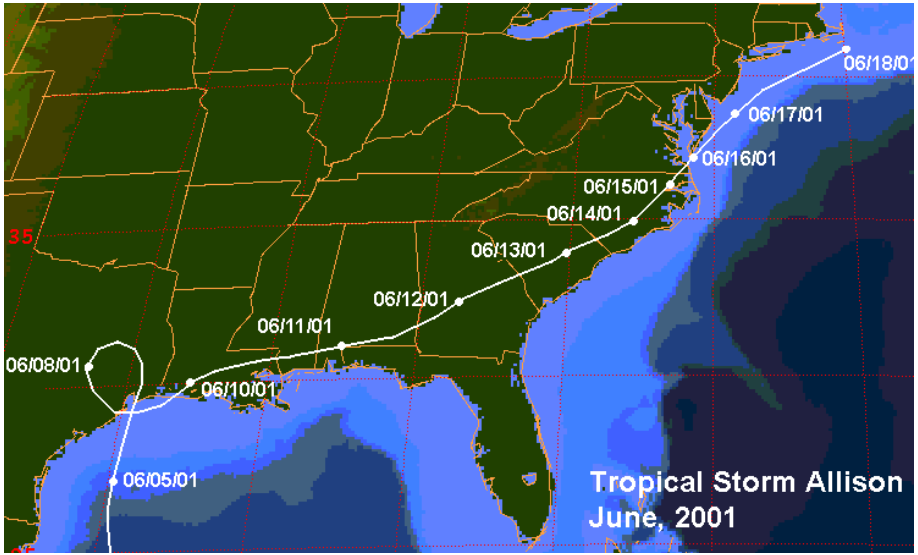
Germanwings Flight 9525: March 24, 2015

Andreas Lubitz crashed Germanwings Flight 9525 killing 150 on board.

On November 29, 2013, a Mozambique Airlines plane flying from Maputo to Luanda in Angola crashed, killing 33 on board.

In January 2015, an Alitalia pilot threatened to crash his plane and kill 200 passengers if his wife left him.

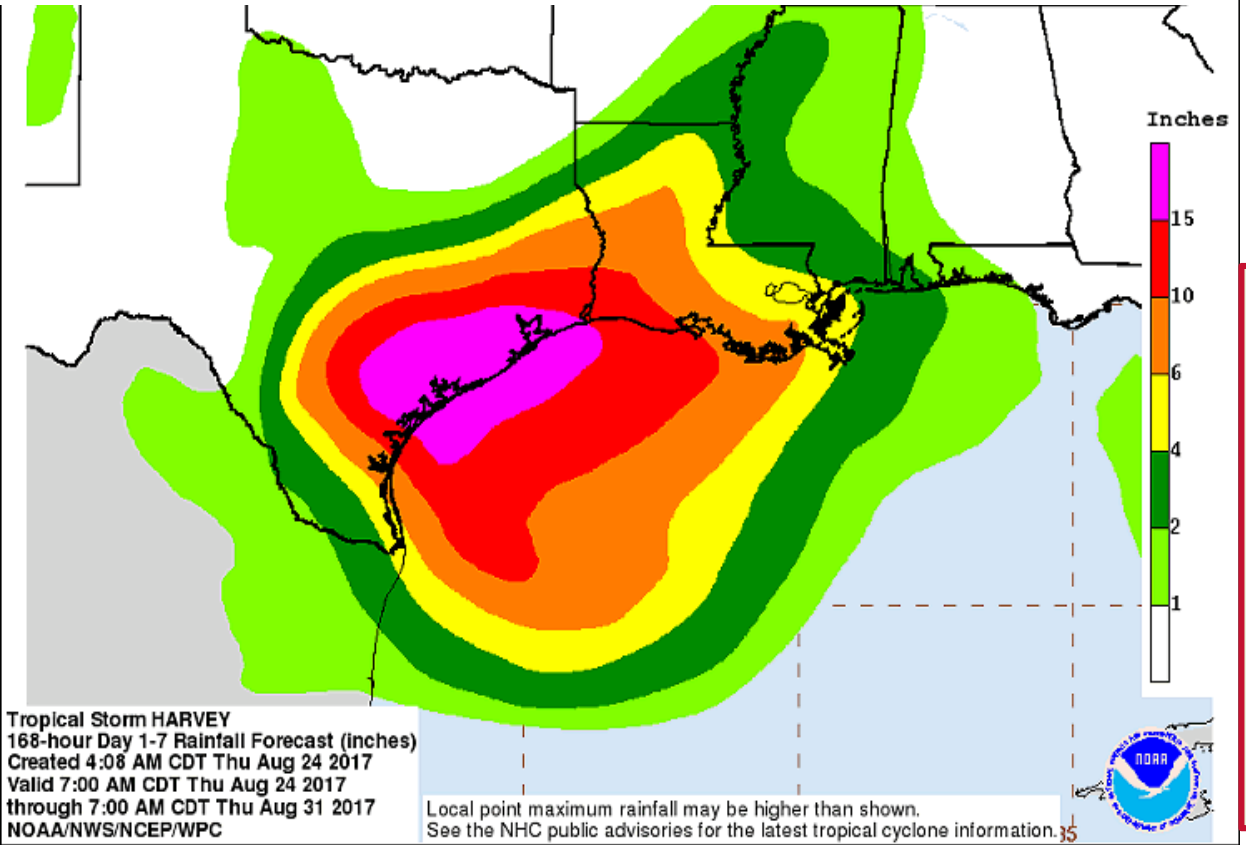
Comparison of Allison (2001) and Harvey (2017)



Harvey set a record for rainfall in the continental USA: 51.88 inches in Cedar Bayou, East of Houston. In 2001, Allison rainfall reached 38 inches.

What was the chance that the Allison rainfall might have approached this record?

Large stochastic variation in rainfall potential of Hurricane Harvey



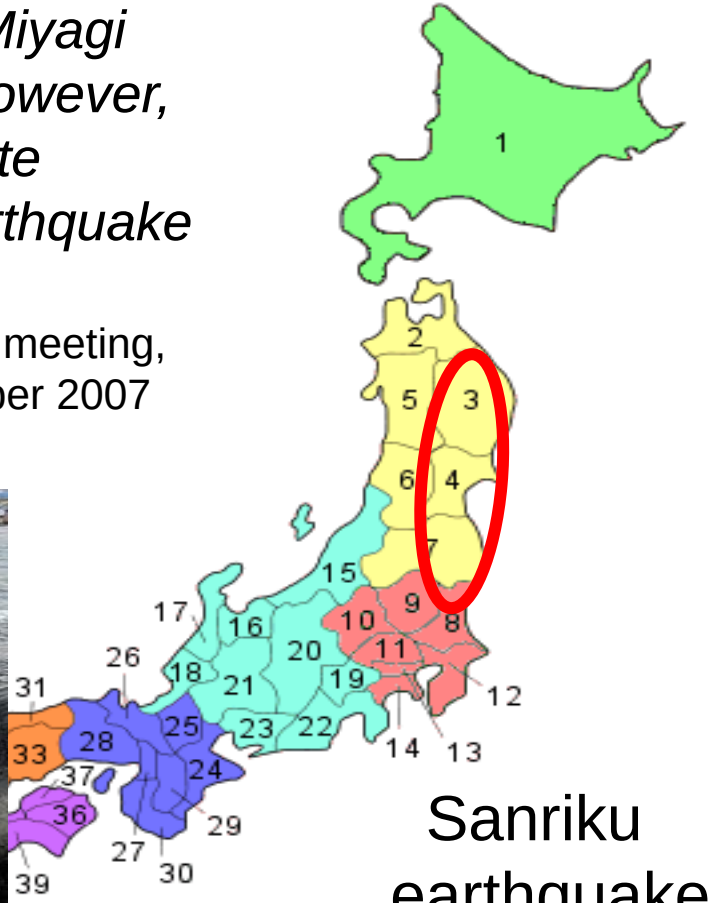
The rainfall forecast for Harvey on Thursday, August 24, before landfall, was significantly lower than for Tropical Storm Allison in June 2001.

The most aggressive forecasts, which call for more than 20 inches of rain to fall in isolated areas, fall short of Allison's 38-inch output.

HoustonPress.com

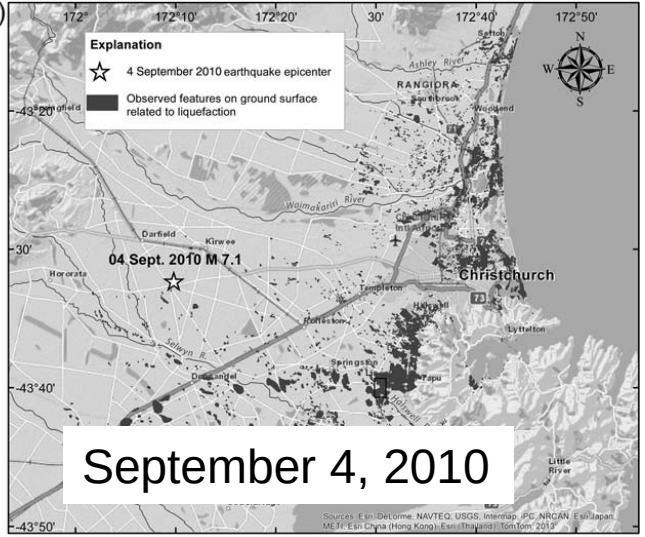
‘Traces of tsunami damage were found from Miyagi Prefecture (4) to Fukushima Prefecture (7). However, researchers found evidence of damage in Iwate Prefecture (3), leading them to believe the earthquake might have measured around magnitude 9.’

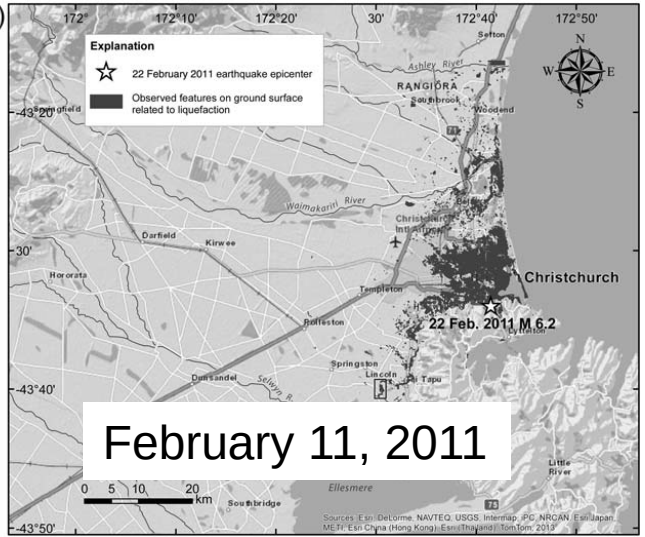
Japan Society of Engineering Geology meeting,
Osaka, 12 October 2007



Sanriku earthquake 869

Liquefaction insurance loss surprise





The total economic loss due to the Canterbury earthquakes is estimated at NZ$30 billion and about half of that loss (or NZ$15 billion) can be attributed to liquefaction.

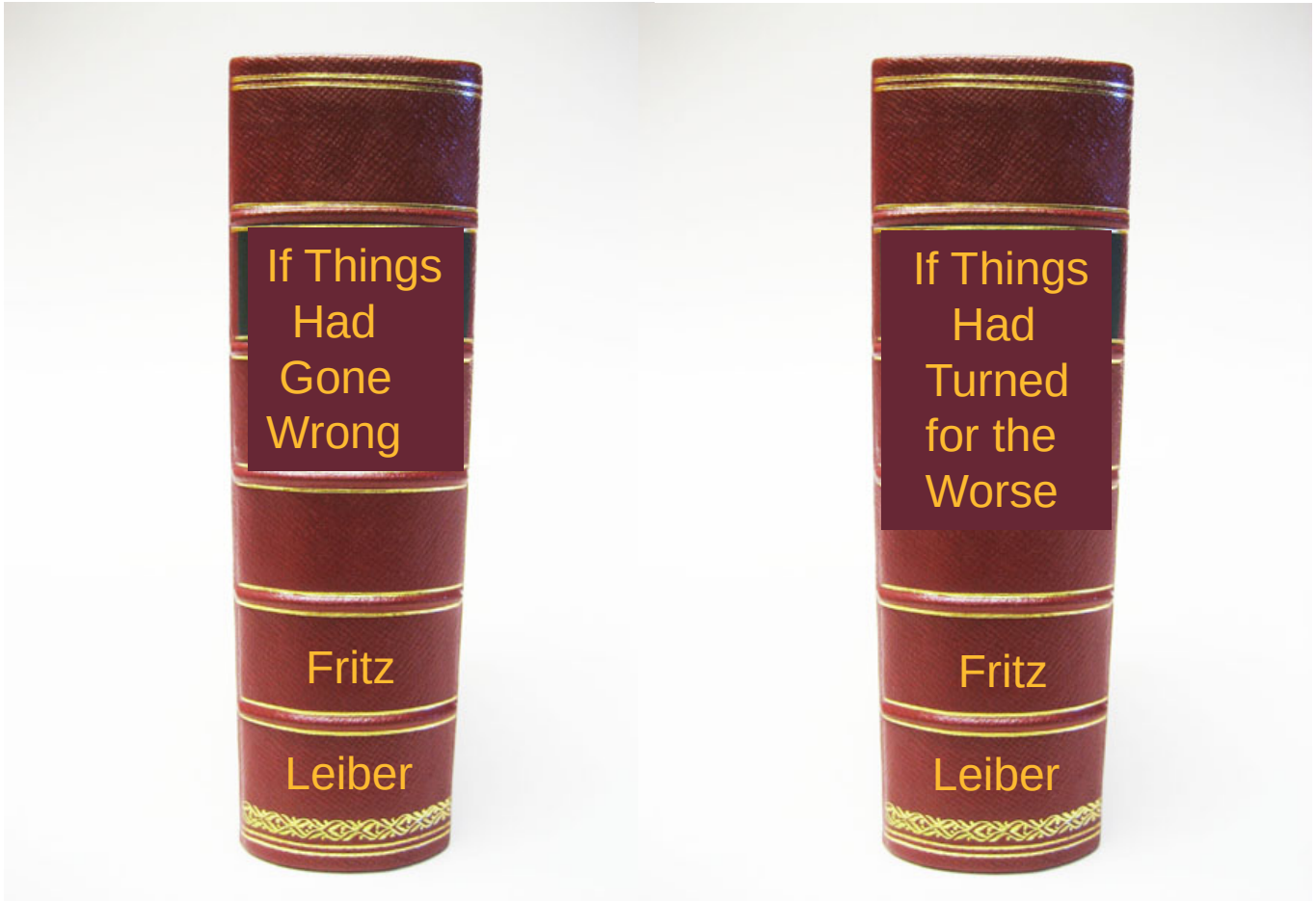
60,000 residential buildings were affected by liquefaction, 20,000 were severely affected, and more than 8000 were abandoned.

Misko Cubrinovski
University of Canterbury, Christchurch

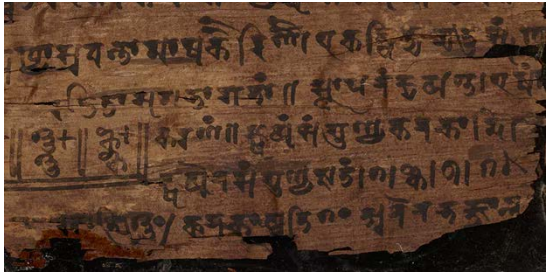
Earlier strong evidence of high liquefaction loss potential in Christchurch, NZ

In the M7.1 Darfield, NZ, earthquake of September 4, 2010, liquefaction caused extensive damage to residential houses and other infrastructures through lateral spreading, ground subsidence, and differential settlements.

Downward counterfactuals



The meaning of zero



Bakhshali manuscript:
3rd or 4th century

May 2017
WannaCry Ransomware losses to major US corporations

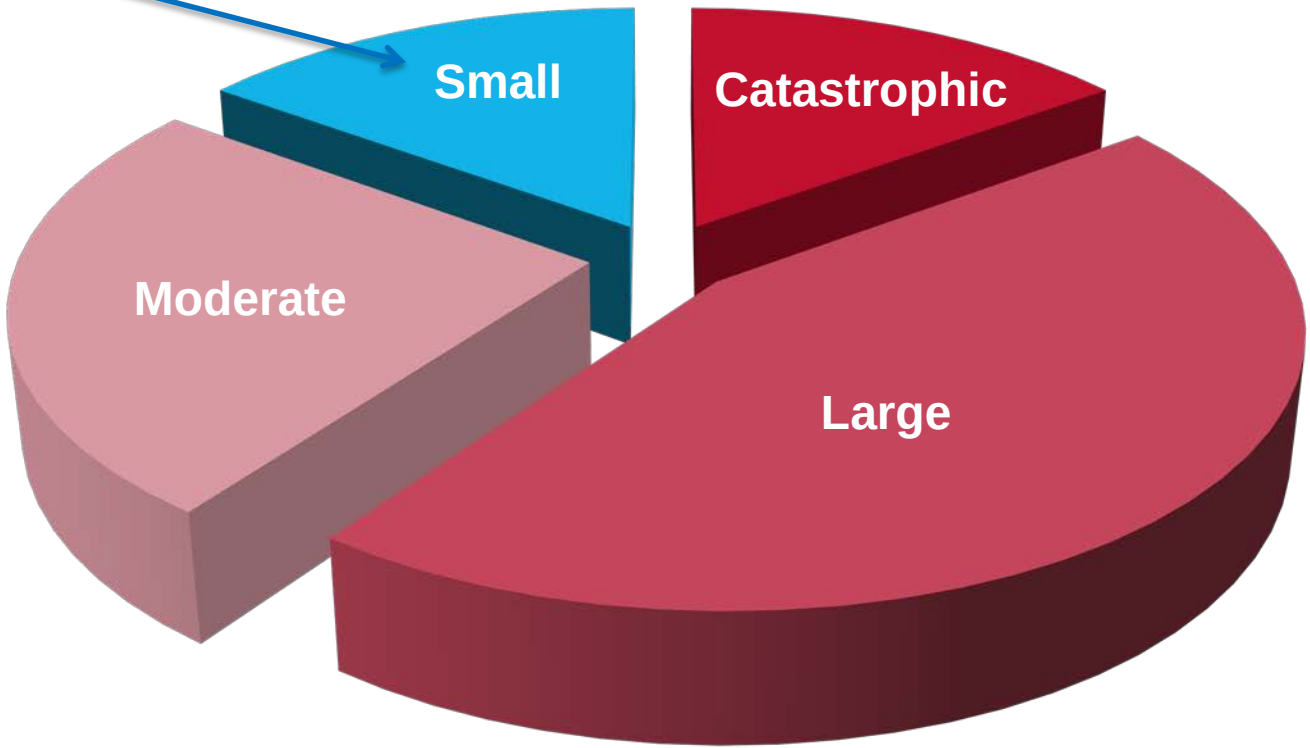
July 2017
Aviation losses at San Francisco airport

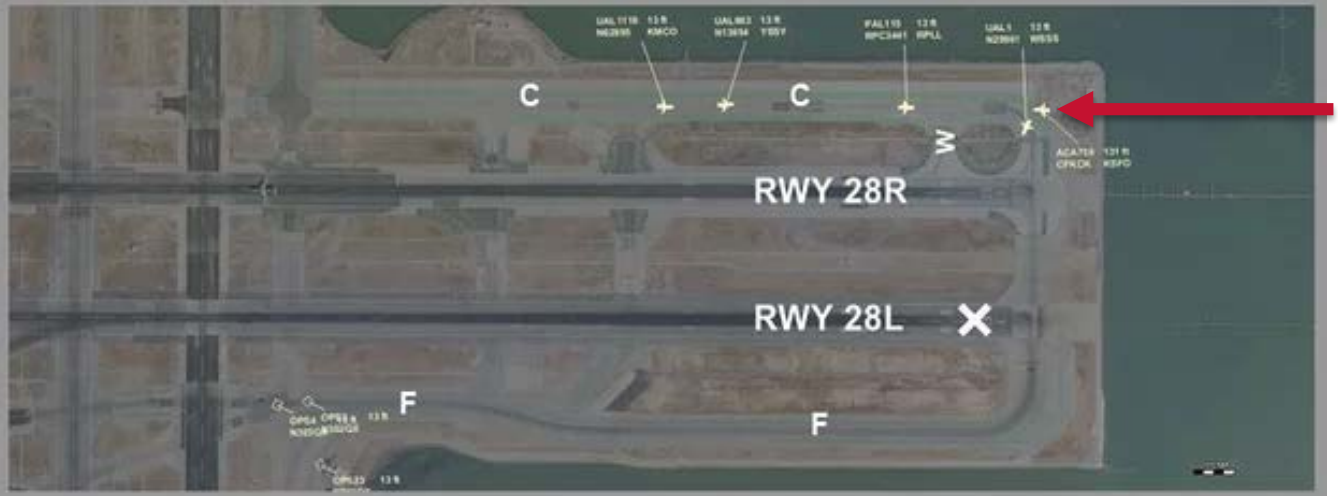
August 2017
Property losses from Barcelona terrorist attack

September 2017
Hurricane Irma losses to Florida cat bonds rated by S&P

Potential for outcome bias

Fortunate historical hazard and loss outcome





UAL1 (23:56:04): he's on the taxiway.

Counterfactual air disaster scenario July 7, 2017 at SFO

The Air Canada pilots mistook the taxiway for the runway next to it, and flew the AC759 jet to just 18m above ground, before pulling up 5 seconds from crashing.

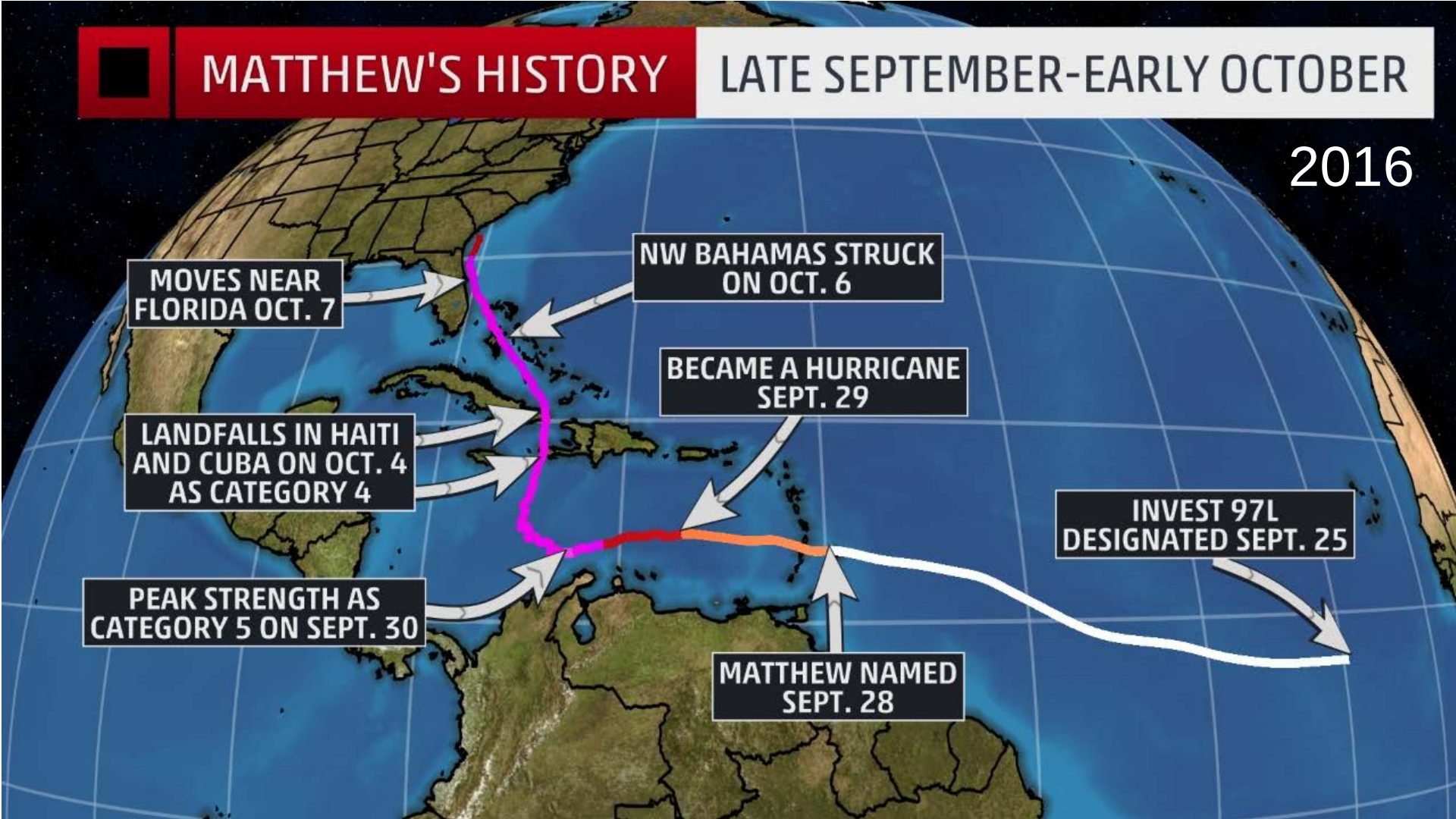
This was almost the worst ever civil aviation disaster.

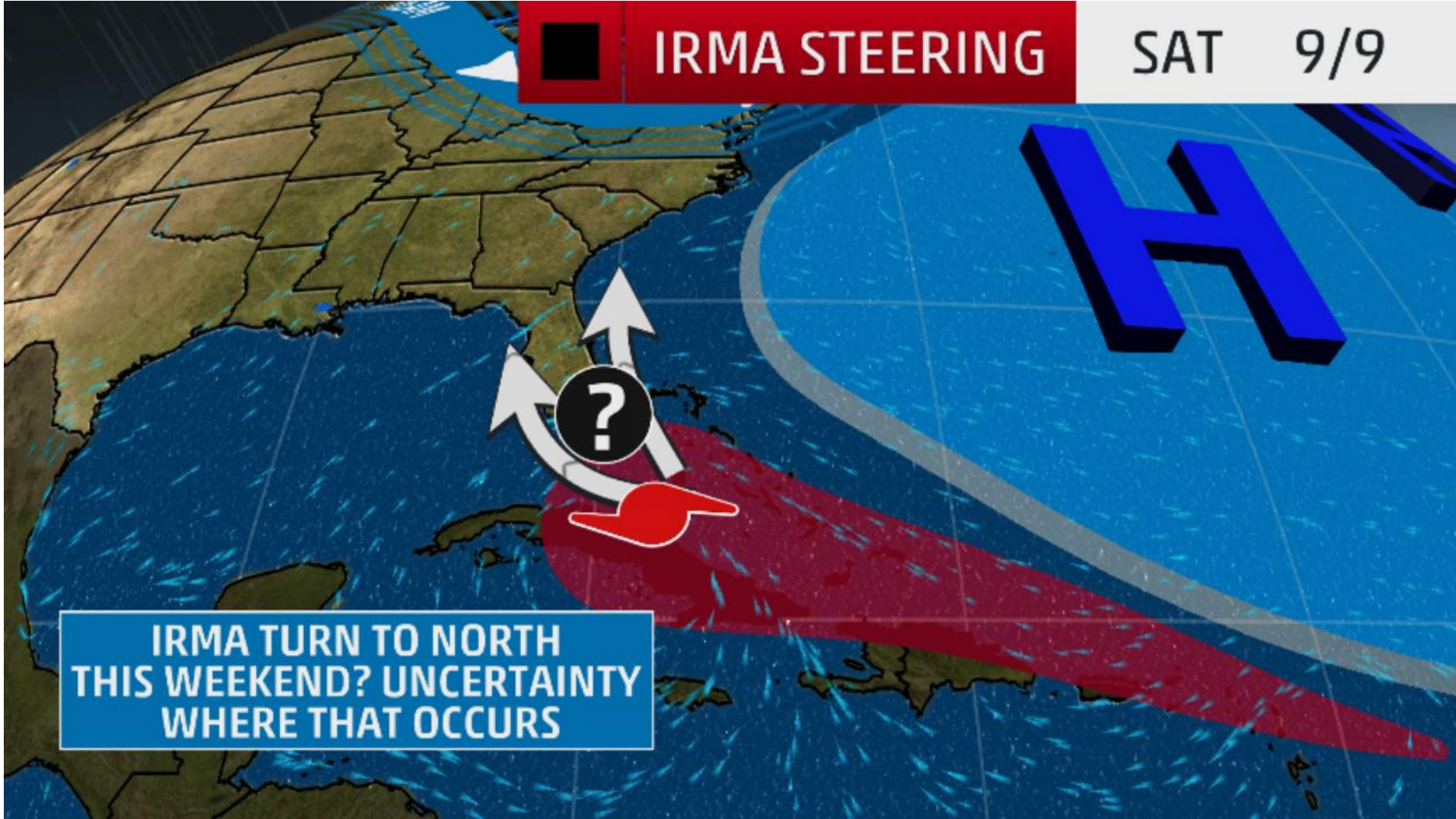
Lower San Fernando Dam

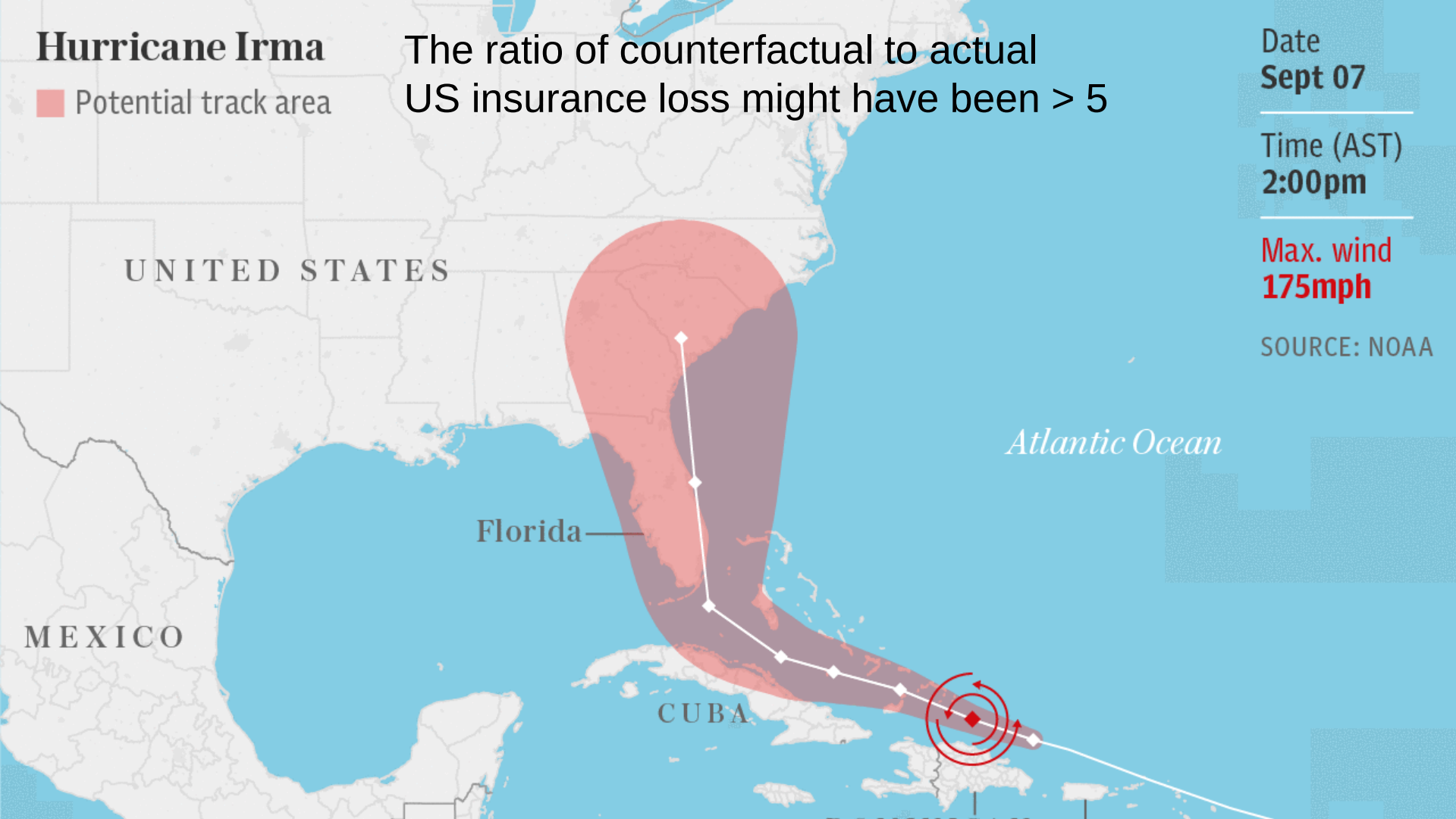
February 9, 1971

M6.7

Counterfactually, had the reservoir been at its maximum height, (or a strong aftershock occurred), water would have overtopped and eroded the dam, and flooded the valley with millions of tons of water. 100,000 might have been killed.


MATTHEW'S HISTORY
LATE SEPTEMBER-EARLY OCTOBER
2016
MOVES NEAR FLORIDA OCT. 7
NW BAHAMAS STRUCK ON OCT. 6
BECAME A HURRICANE SEPT. 29
LANDFALLS IN HAITI AND CUBA ON OCT. 4 AS CATEGORY 4
INVEST 97L DESIGNATED SEPT. 25
PEAK STRENGTH AS CATEGORY 5 ON SEPT. 30
MATTHEW NAMED SEPT. 28


IRMA STEERING
SAT 9/9
H
?
IRMA TURN TO NORTH
THIS WEEKEND? UNCERTAINTY
WHERE THAT OCCURS


Hurricane Irma
Potential track area
The ratio of counterfactual to actual
US insurance loss might have been > 5
Date
Sept 07
Time (AST)
2:00pm
Max. wind
175mph
SOURCE: NOAA
UNITED STATES
Atlantic Ocean
Florida
MEXICO
CUBA

Barcelona: August 17, 2017

Terrorist van rammed pedestrians on the most famous promenade in Spain. The original plot involved three gas-laden vehicle bombs targeting the port and the cathedral as well. A TATP explosion in the bomb factory ended what would have been the biggest terrorist attack against the western alliance since 9/11.

≡ EL PAÍS CATALUÑA

ANDALUCÍA CATALUÑA C. VALENCIANA GALICIA MADRID PAÍS VASCO MÁS COMUNIDADES TITULARES »

ATENTADO EN BARCELONA ›

Un atentado terrorista en Barcelona provoca al menos 13 muertos

Una furgoneta ha atropellado a una multitud en La Rambla. Los Mossos d'Esquadra relacionan el atentado con la explosión ayer de una casa en Alcanar

JESÚS GARCÍA | ALFONSO L. CONGOSTRINA | ORIOL GÜELL | REBECA CARRANCO

Barcelona - 18 AGO 2017 - 16:57 CEST

El Estado Islámico (ISIS, en sus siglas en inglés) golpeó ayer el corazón de **Barcelona** y dejó al menos 13 muertos y más de 100 heridos en el **atentado** más grave que sufre España desde el 11-M y el primero yihadista desde entonces. A las 16.50 horas, una furgoneta se lanzó contra los centenares de personas que se encontraban en La Rambla. Los Mossos confirmaron que se trata de un atentado coordinado. El autor material del atropello masivo se dio a la fuga y paradero desconocido. La policía catalana ha detenido a dos personas. Una de ellas es Driss Oukabir, que pr alquiló el vehículo. La otra, cuya identidad se ignora, fue detenida en Alcanar (Tarragona), donde los Mossos junto a otras personas, estaba preparando un artefacto explosivo.

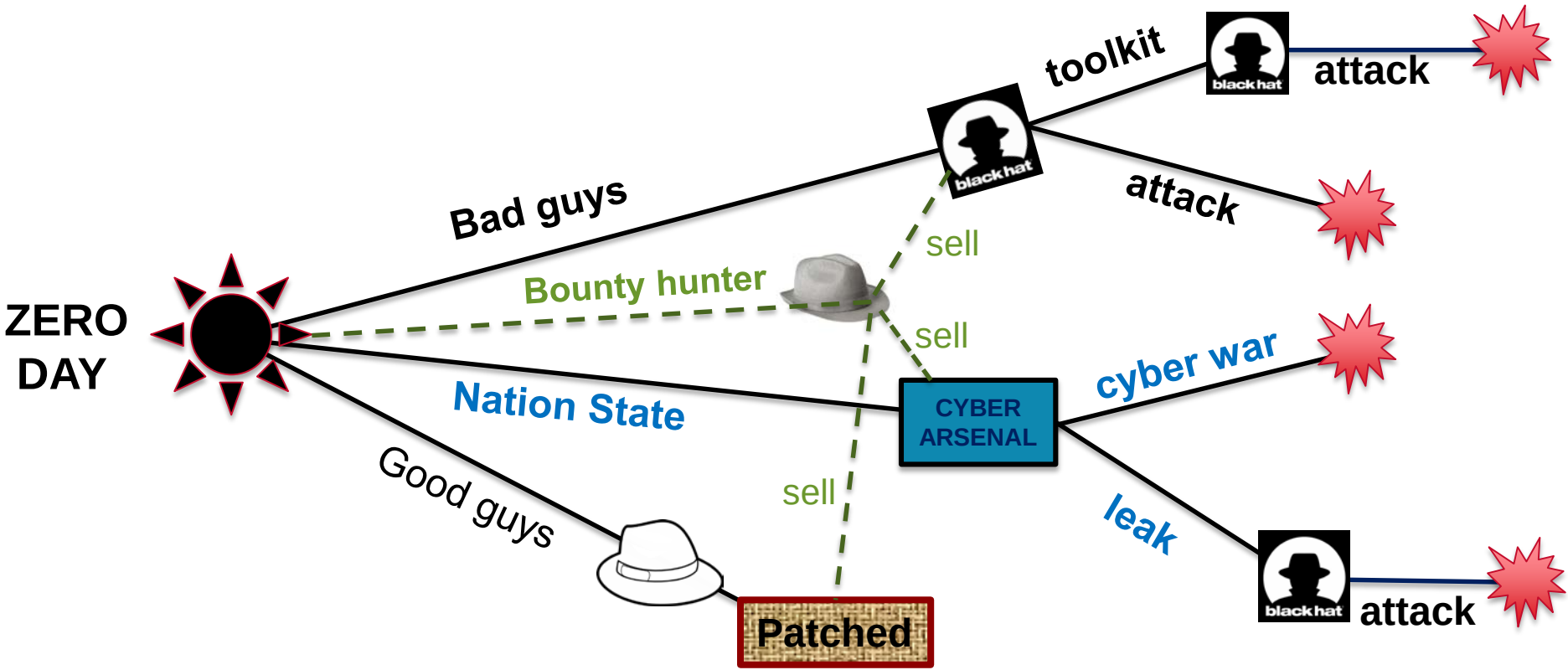
Human dimension to the SWIFT heist

Malware was planted on the computer systems of the Bangladesh Bank. The North Korean Lazarus Group has been linked with this heist.

On February 4, 2016, **$81m** was stolen from the Bangladesh Bank and was laundered in the Philippines casino industry. Another $20 million was recovered due to a Sri Lanka bank query: '*Foundation*' being misspelt as '*Fandation*'.

Counterfactually, another $850m might have been lost, but for a fluke coincidence of the name 'Jupiter', that resulted in orders being blocked by the New York Fed.

Counterfactual event tree for zero days



Ransomware on a Cherokee Jeep

‘The Jeep vulnerability was discovered by ethical researchers.

But imagine if that exploit was done by a cybercriminal where all those Jeeps were impacted with ransomware.’

Steve Grobman
Intel Security CTO

Timeline to May 12, 2017, WannaCry attack

These two events could have happened three months earlier.

January 7

Shadow Brokers posted screenshots taken from Equation Group's 2013 Windows Ops disk.

February 14

Microsoft cancels Patch Tuesday for the first time

March 14

Microsoft Patch of Eternal Blue

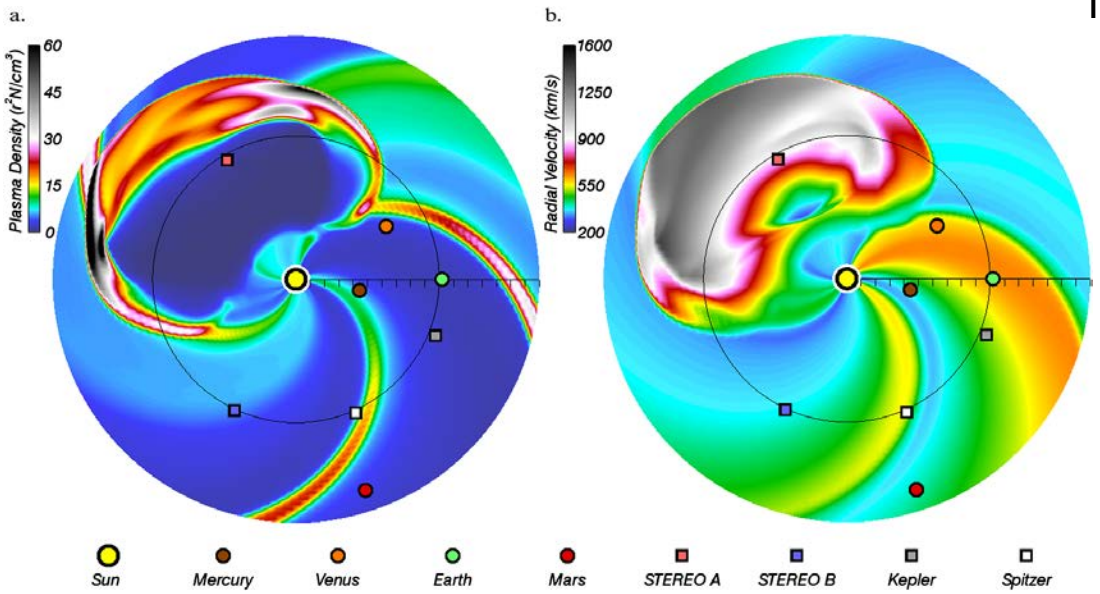
April 8

Contents of the 2013 Window Ops disk released the day after U.S. cruise missile attack on Syria

May 12

WannaCry Ransomware attack

Solar storm near miss July 23-24, 2012

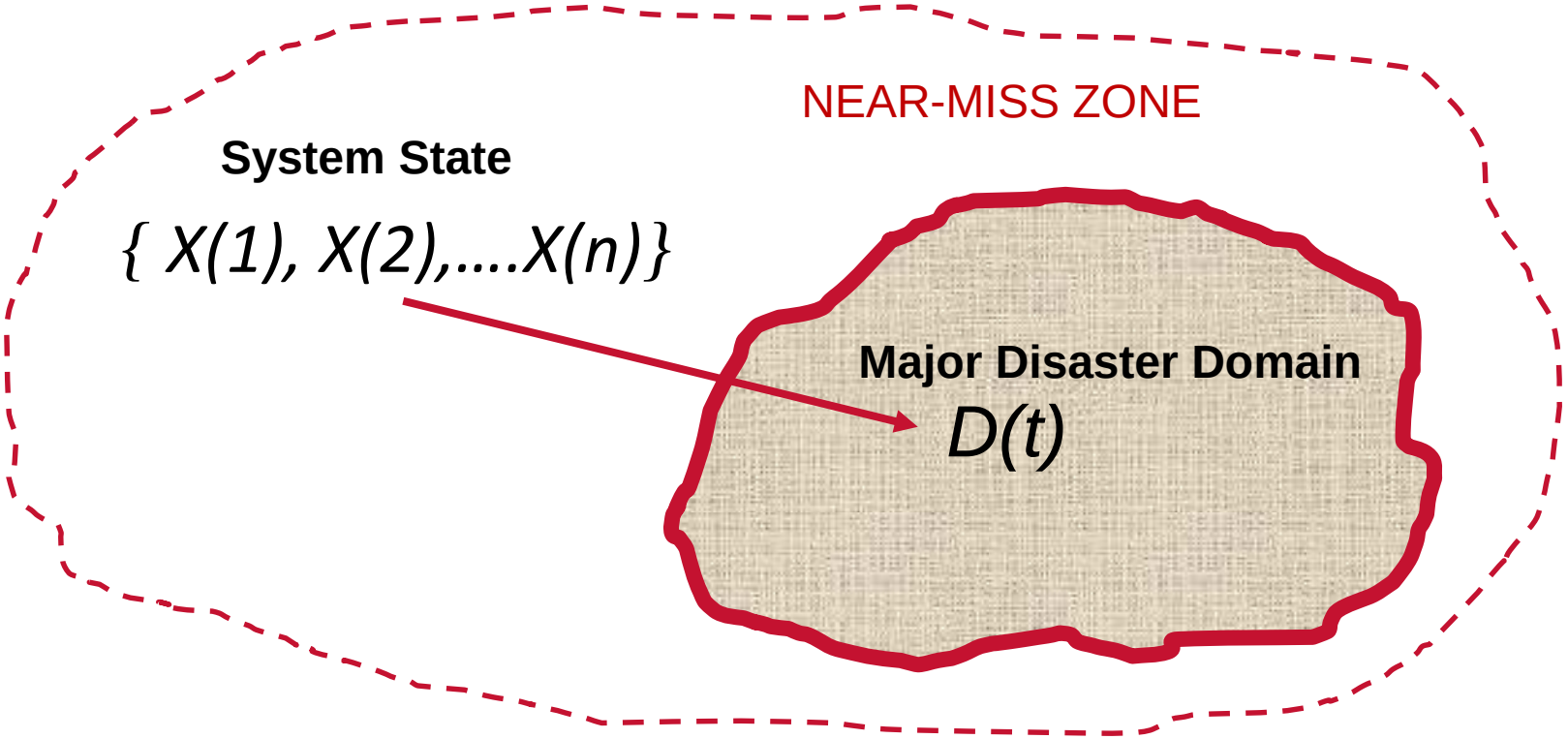


Baker et al., Space Weather, 2012

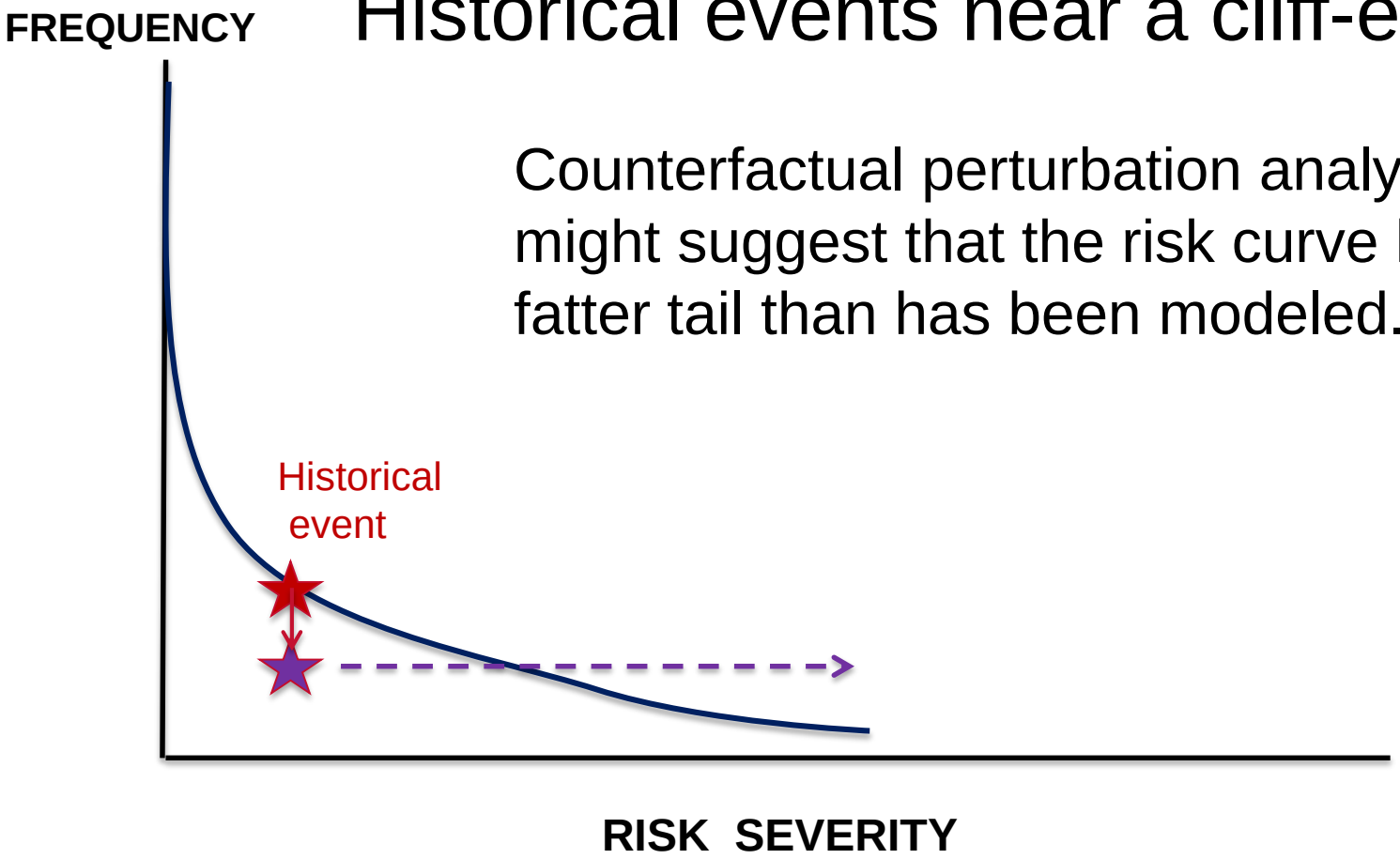
The regions of the Sun near its equator rotate every 25 days, so nine days earlier the ignition spot of the CMEs was pointed directly at Earth. The counterfactual chance of a 1859 Carrington-like event was about 4%.

The opening ceremony of the London Olympics was on July 27, 2012. Satellite coverage might have been severely impaired.

Perturbation of a system state into a dangerous domain



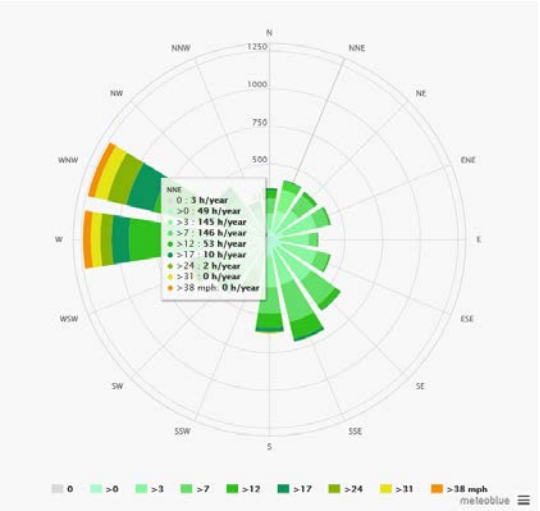
Historical events near a cliff-edge



Counterfactual perturbation analysis might suggest that the risk curve has a fatter tail than has been modeled.

Fukushima nuclear accident March 2011

Had the winds been less favourable, the exclusion zone around the site would have been larger.



Based on wind rose data for Fukushima, there was about an even chance of the wind blowing the radioactivity inland.

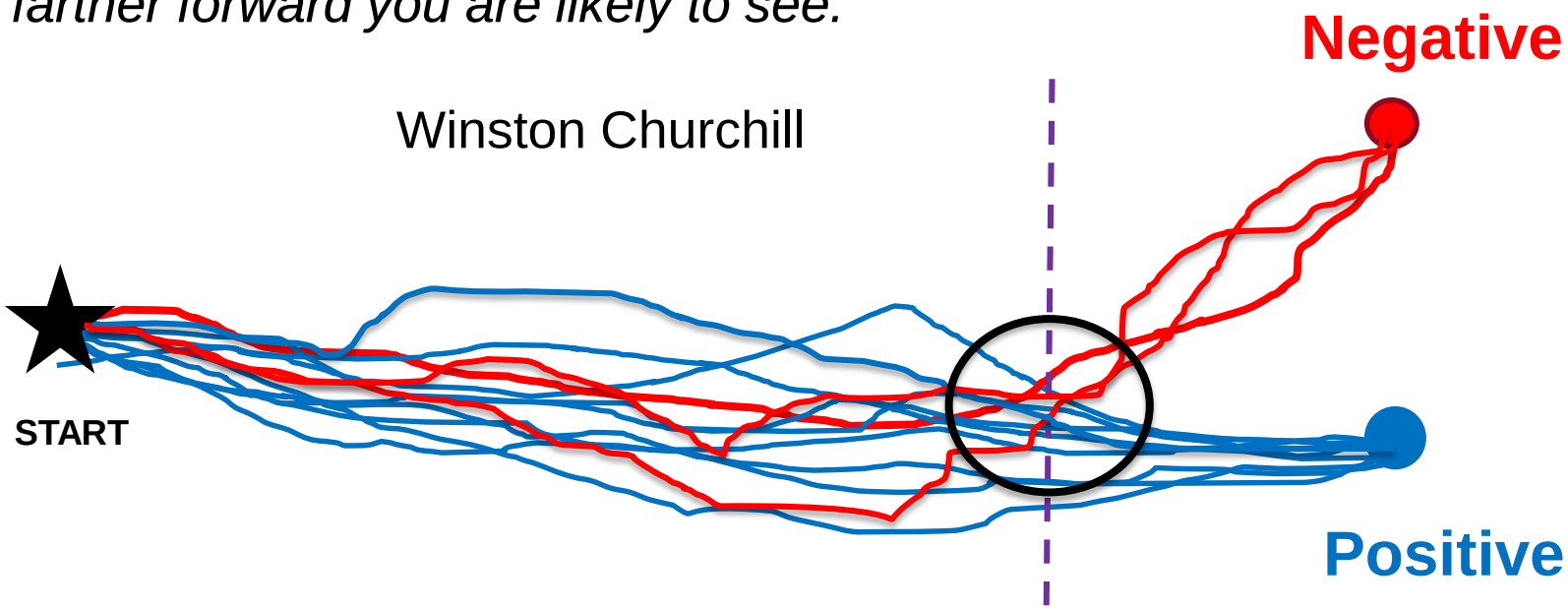
Perturbations towards fatter tails

- A small change to the potency of a hazard event might leverage a massive cliff-edge impact.
- A minor random dynamical perturbation might trigger a nonlinear system change, especially if the system is in a critical state.
- A change in the time of occurrence or spatial footprint could amplify loss considerably.
- A small perturbation to the direct loss might trigger a cascade of indirect loss.

Stochastic forensics

‘The farther back you can look,
the farther forward you are likely to see.’

Winston Churchill



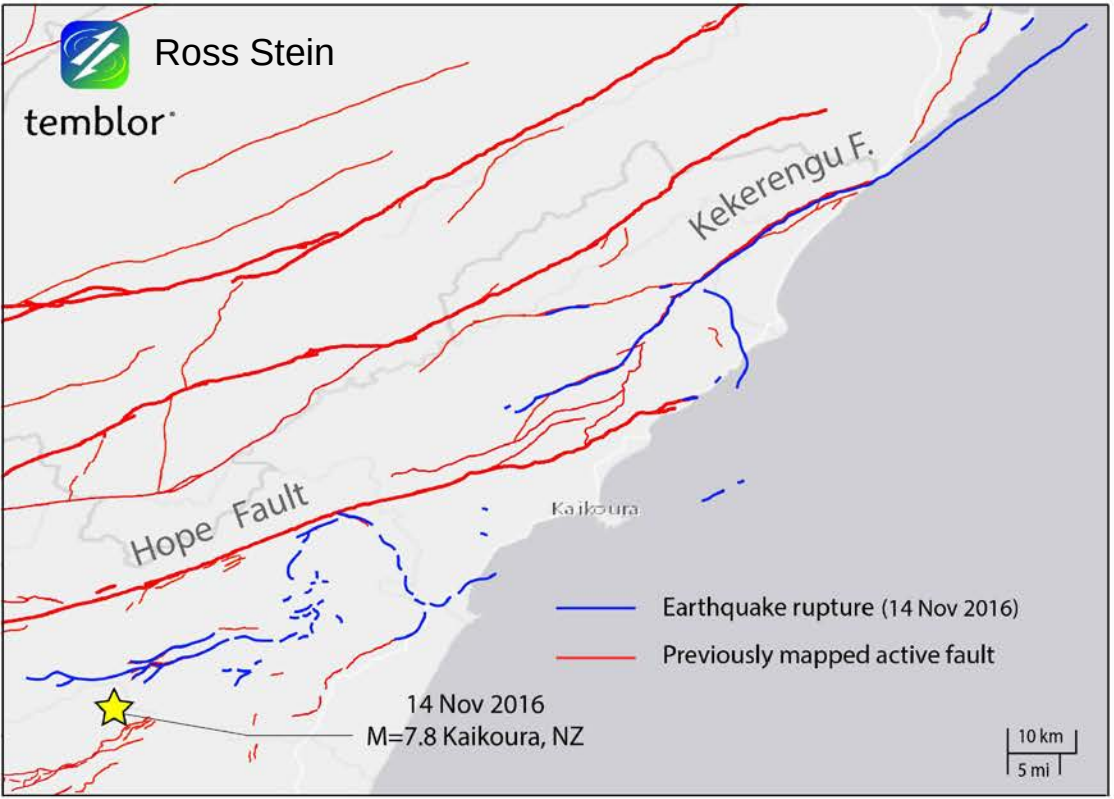
Stochastic forensic questions

Probabilistic answers are needed
for these historical questions of inference:

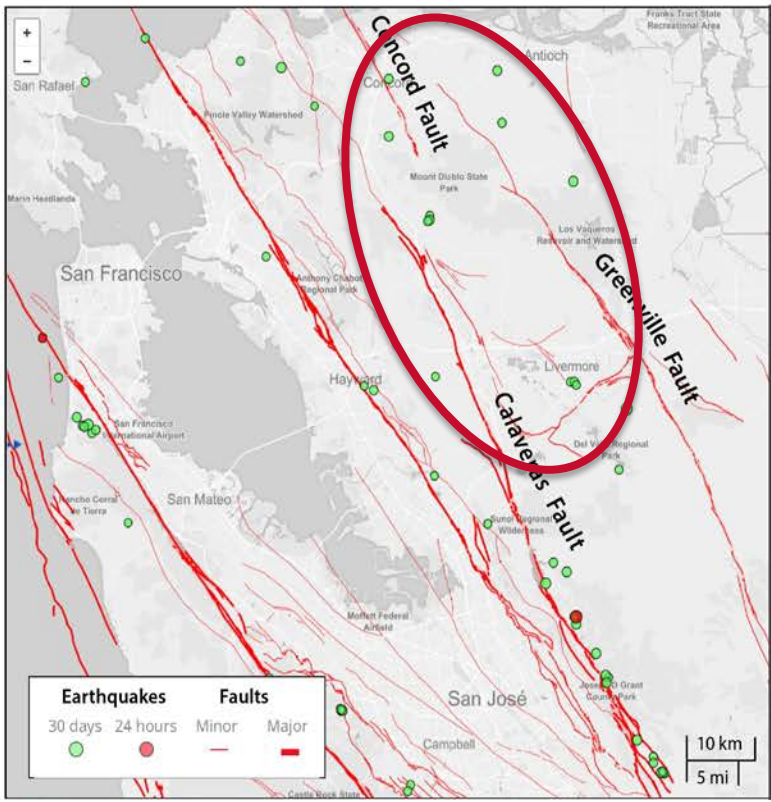
- What was the underlying cause of the event?
- What was the location and size of the event?
- How could it have been worse?
- What was the linkage with other events?

Stochastic fault rupture geometry

New Zealand



San Francisco Bay area



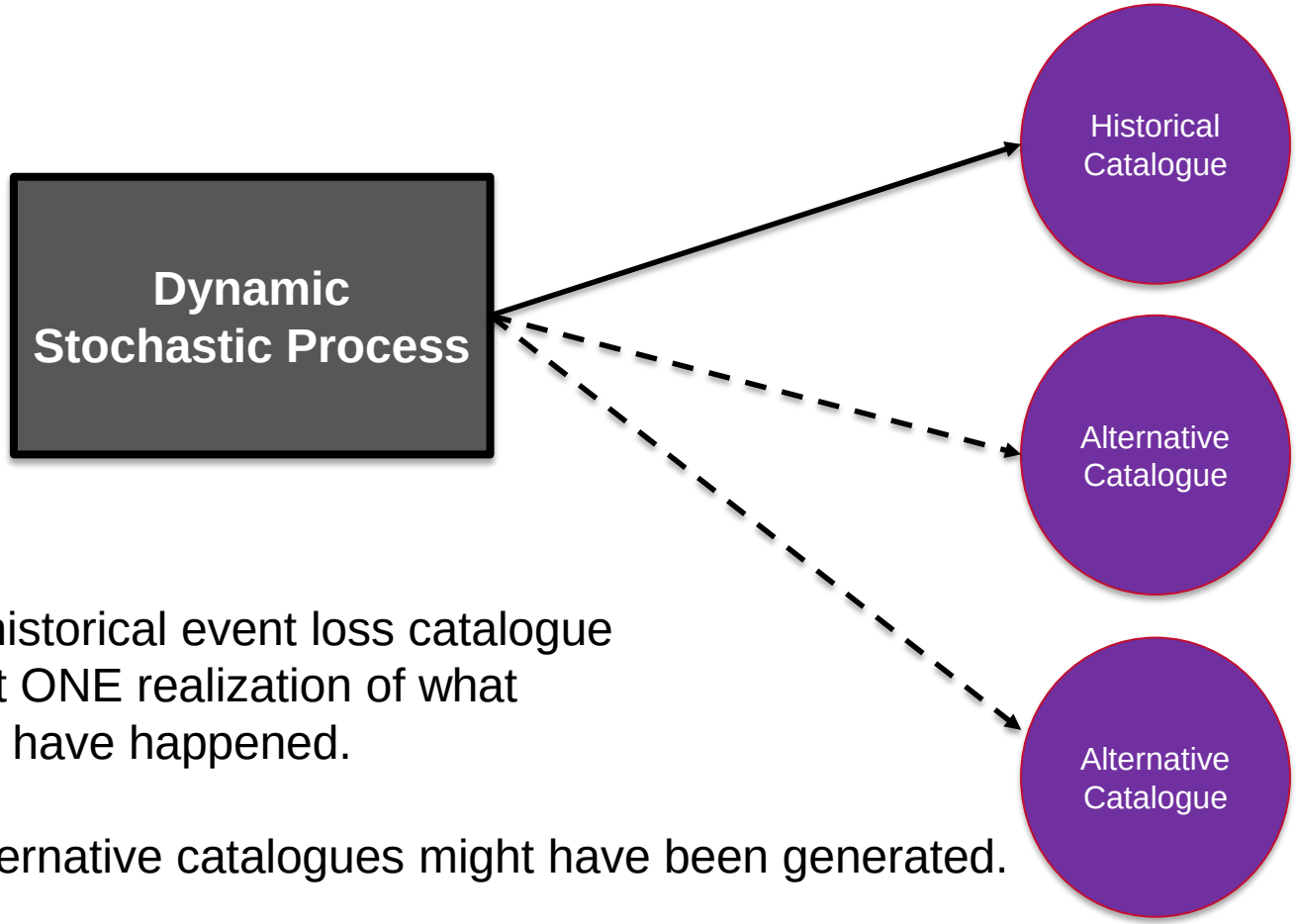
Stochastic forensics of the MH370

Stochastic modeling of the past

'There is an infinitude of pasts, all equally valid'

André Maurois

Focusing more on the process than the events

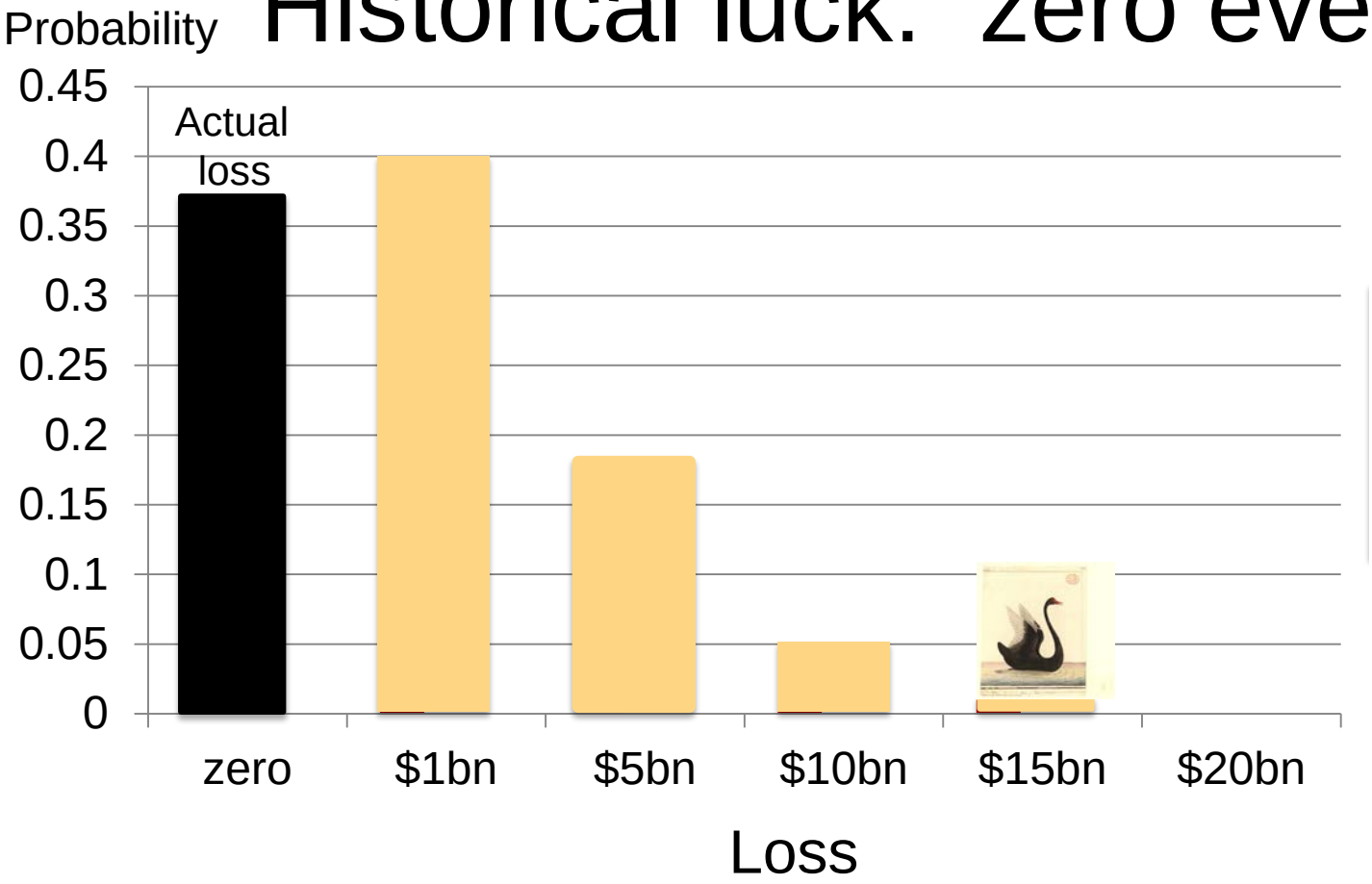


The historical event loss catalogue is just ONE realization of what could have happened.

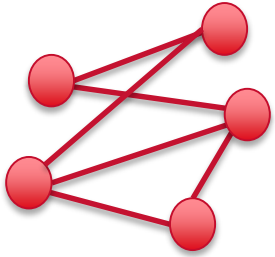
....Alternative catalogues might have been generated.

Stochastic event sets could be benchmarked against these alternative catalogues.

Historical luck: zero event loss



Alternative terrorism loss catalogues



Terrorist cell

A planned attack against the US Bank (Library Tower in L.A.), the tallest building in western USA, was interdicted in early 2002 with the arrest of a key Al Qaeda operative in Asia.

Routledge
Taylor & Francis Group

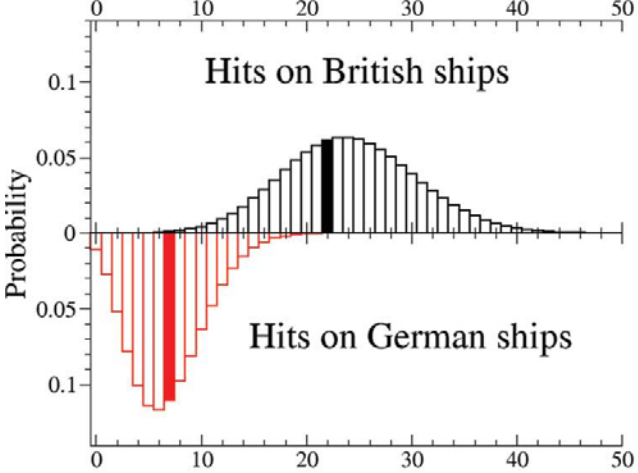
Historical Methods: A Journal of Quantitative and Interdisciplinary History

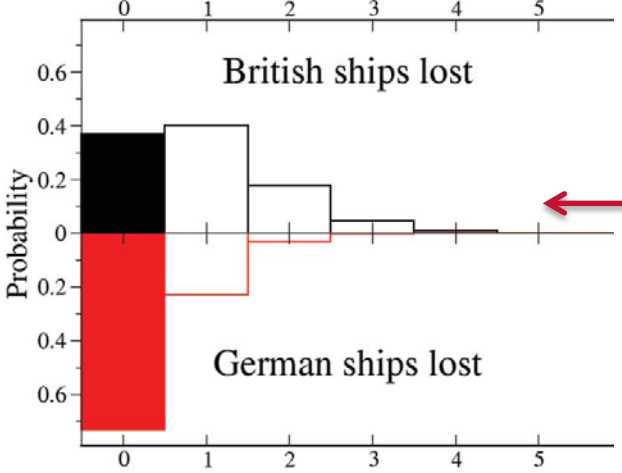
ISSN: 0161-5440 (Print) 1940-1906 (Online) Journal homepage: http://www.tandfonline.com/loi/vhim20

2016

Weighing the fog of war: Illustrating the power of Bayesian methods for historical analysis through the Battle of the Dogger Bank

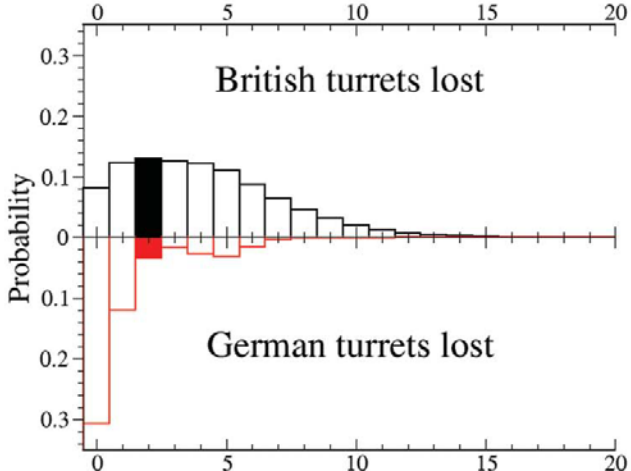
Niall MacKay, Christopher Price & A. Jamie Wood





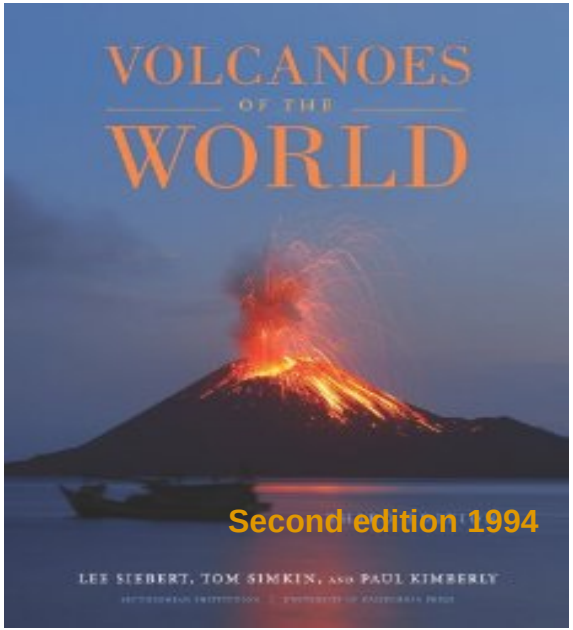
The British navy was fortunate: the expected result would have been the destruction of at least one ship, and possibly as many as three.

Results from Approximate Bayesian Computation



The belief of military historians that this was a squandered British victory on January 24, 1915 - IS FALSE.

Learning more from history



'Episodes not leading to eruption may be under-reported, or not reported at all, by local observatories.

Such a bias can result in incorrect estimation of probabilities that a given episode of unrest will lead to an eruption.'

Moran and Newhall (2011)

Soufrière Hills (Montserrat)	16.72 N	62.18 W	Stratovolcano	Castle Peak	**1630**

Montserrat volcano hazard before July 1995

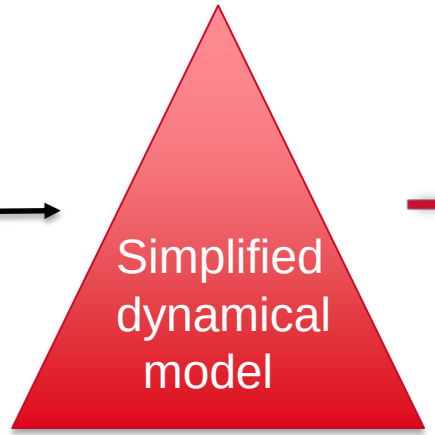
Volcano-seismic activity had damaged buildings in the 1890s, 1930s and 1960s.

The crisis in the mid-1930s raised fears of a potential major eruption.

A build-up of sporadic seismic activity peaked with a Magnitude 6.2 earthquake on November 10, 1935.

Bayesian modeling of volcano dynamics

Prior input parameter distributions for dynamic variables



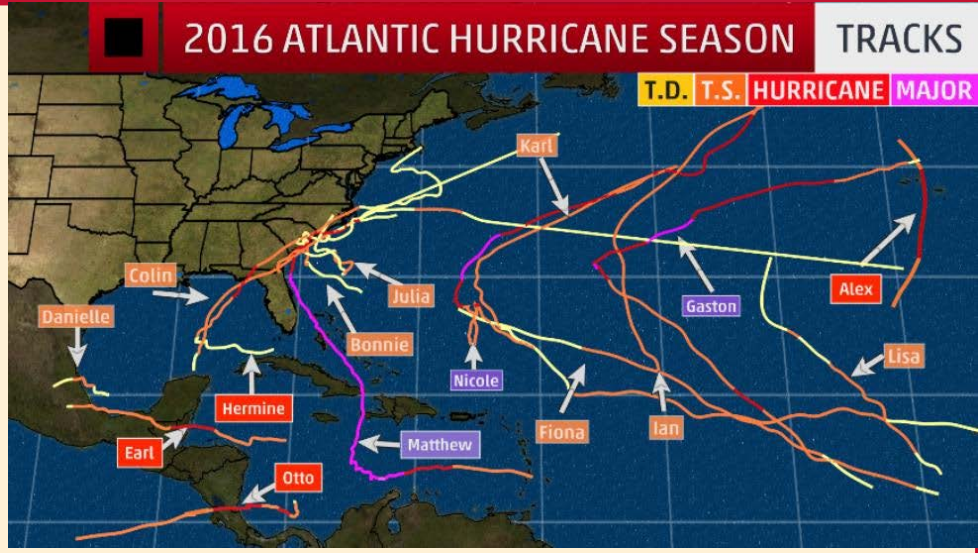
Excess magma and fluid pressures

Posterior parameter distributions are obtained by updating using data from the unrest characteristics of the volcano.

The aim is to capture the uncertainty in the stochastic processes, so highly elaborate geodynamic volcano modeling is not necessary.

Use of ensemble hurricane forecasts

Start with the ensemble forecasts of Tropical Cyclones worldwide from the ECMWF Integrated Forecasting System (IFS) since 2008.

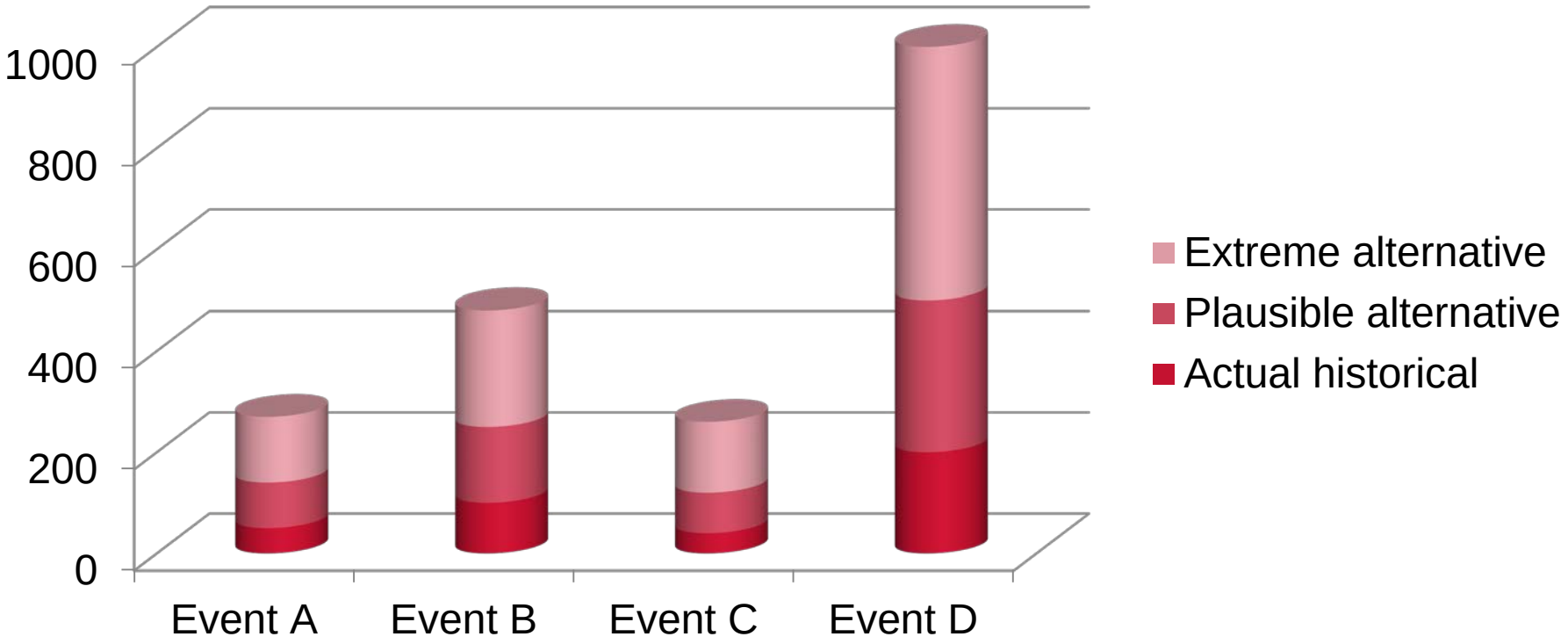


Take all ensemble members from each of the available forecasts when they cross a line in the Atlantic that means they have a fairly good chance of making landfall in the US.

For each of the ensemble members, calculate the loss associated with each event from the windspeed at landfall. *There will of course be times that actual historical events will disappear from our loss history, while other non-events will become events in the ensemble record.*

Tom Philp, XLCatlin

Gauging the volatility of historical losses



Counterfactual loss estimation

Counterfactual analysis of the j'th historical event would generate a table of counterfactual losses $C_1(j), C_2(j), C_3(j)...$

with associated probability estimates: $p_1(j)$, $p_2(j)$, $p_3(j)...$

PML tail risk from NSA cyber weapon release

Annual frequency of NSA cyber arsenal release ~ 1/10 .

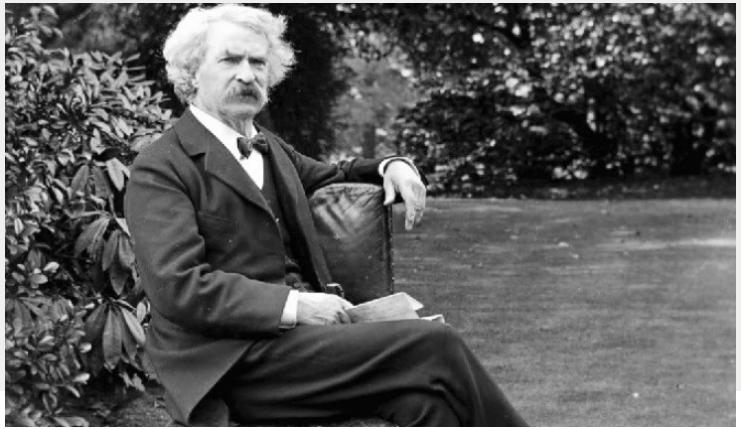
Edward Snowden
Harold Martin

Counterfactually, ten times as many Windows 7 computers might have been infected, and the insurable economic loss would have been in the range $3 to $6 billion.

Chance that Eternal Blue might have been released before being patched by Microsoft ~ 1/20.

Counterfactual **D**isaster **S**cenarios

‘*History doesn’t repeat itself,*
but it does rhyme.’
Mark Twain



Counterfactual scenarios are rooted in actual occurrences, and are intrinsically realistic.

Compared with future events, the highest resolution for a catastrophe risk scenario is achievable for recent historical events.