



# TIEMS WORKSHOP

## Rome, 2012

# THE ROLE OF WEATHER AND CLIMATE FORECASTING

Vinicio Pelino  
Weather Service  
Italian Air Force

# The threat

9/11



Fatalities **2.976**

Damage **\$27.3 Billion**

Katrina



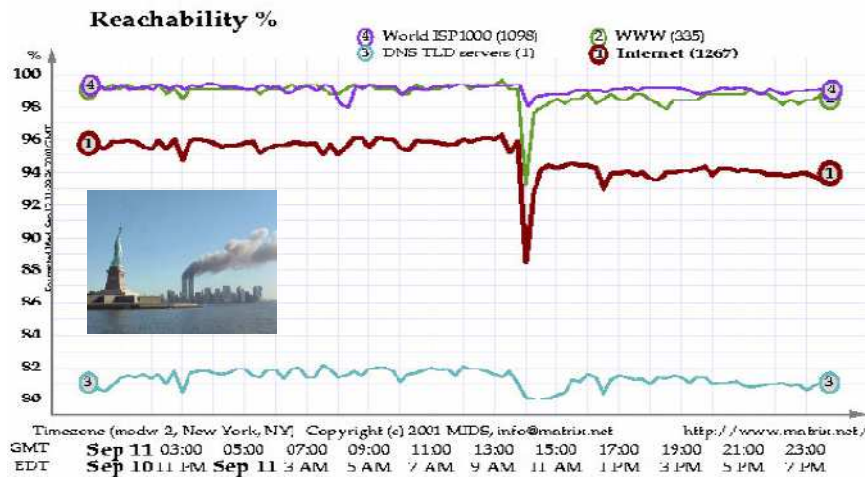
Fatalities **1.833**

Damage **\$108 Billion**

**Leon Panetta: *Environment is becoming a national security concern***

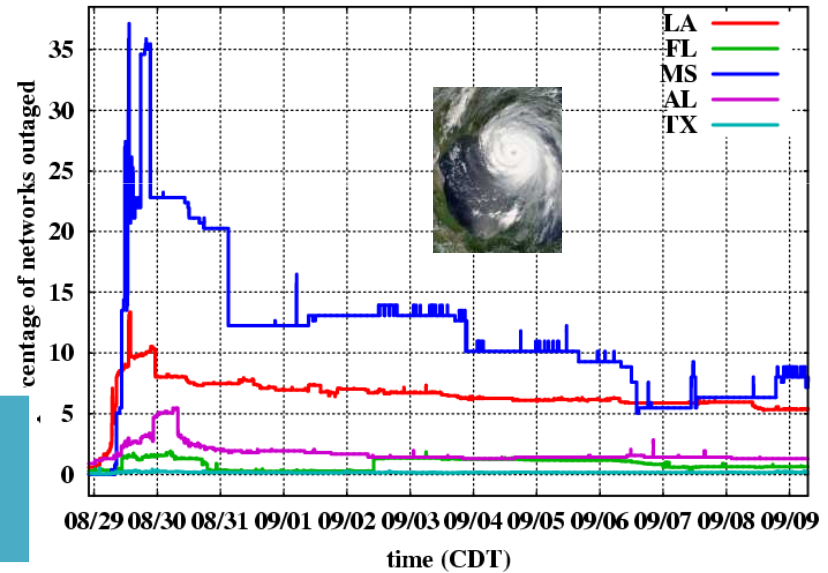
*Source: Homeland Security News Wire Published 8 May 2012*

# Impact on Internet Infrastructure



Reachability of four representative sets of Internet hosts on September 11, 2001.

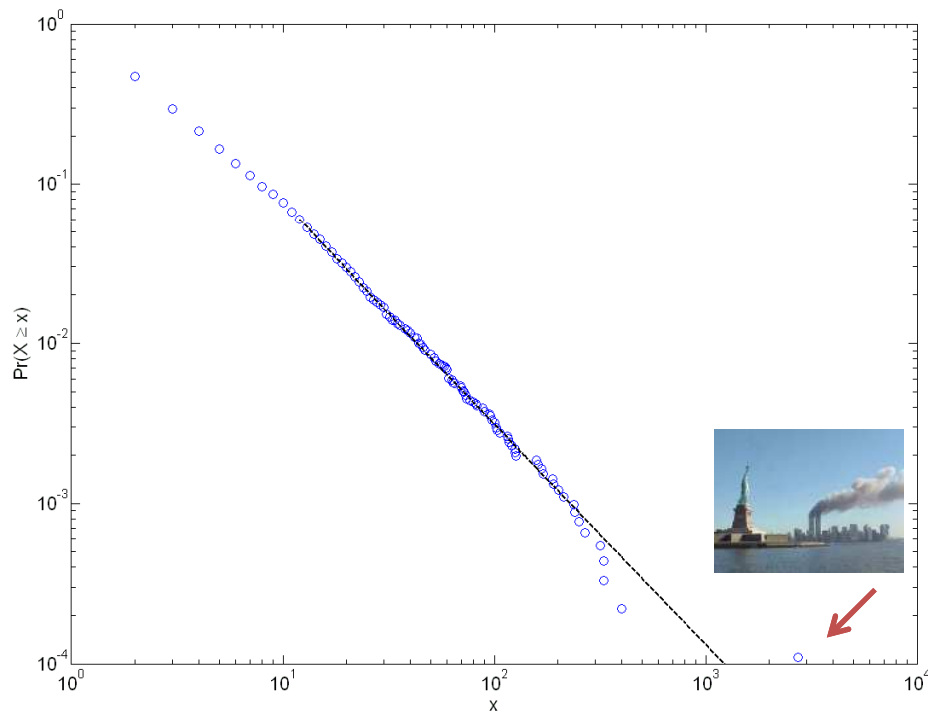
SOURCE: Matrix NetSystems, Inc.



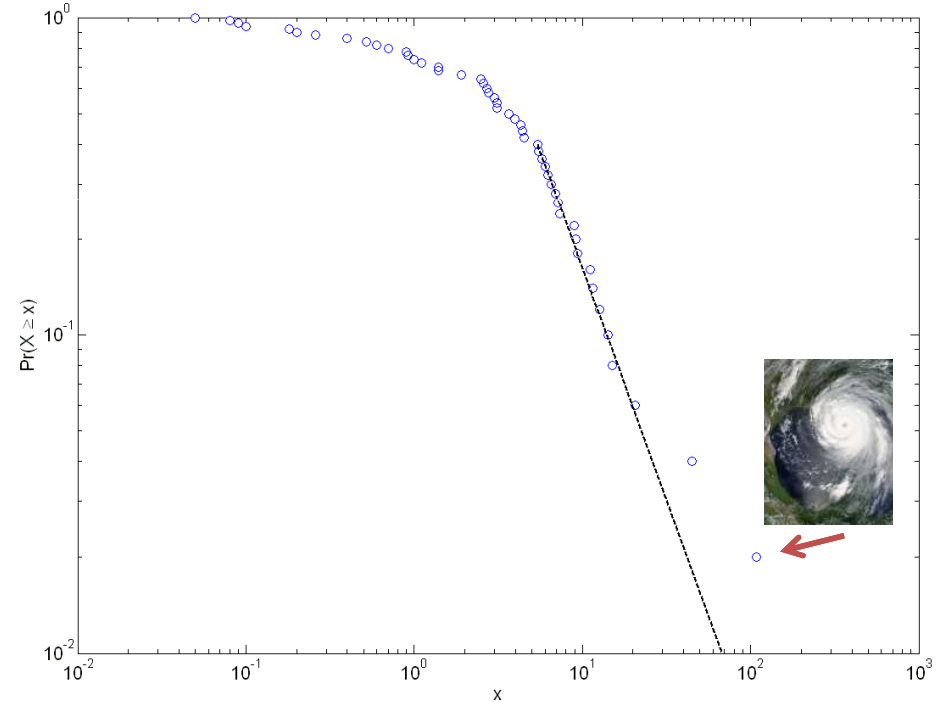
Percentage of outaged, globally routed networks by state in the affected region over the entire 10-day period since Katrina's landfall. Note the early recovery followed by extended outages, especially in Louisiana and Mississippi.

SOURCE [www.renesys.com](http://www.renesys.com)

## Distribution of terroristic attacks by deaths since 1968



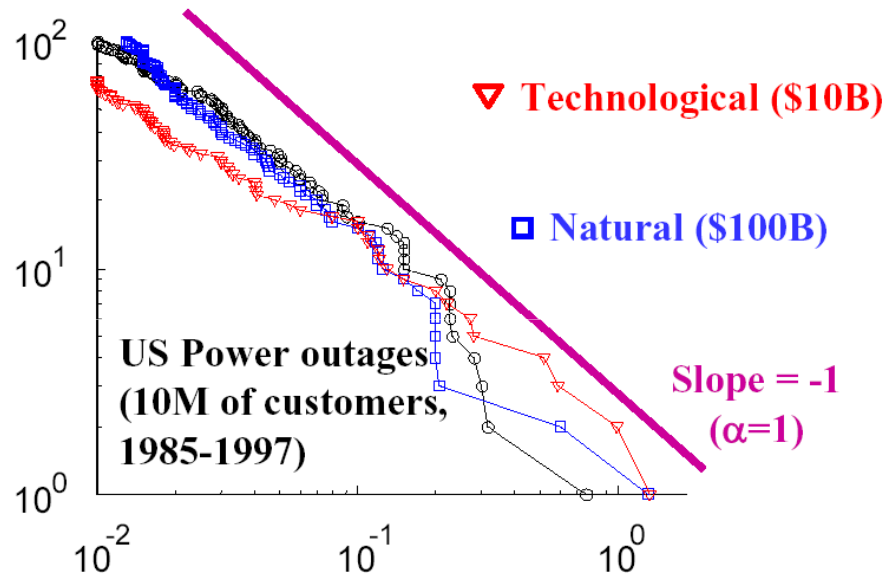
## The 94 costliest mainland United States tropical cyclones



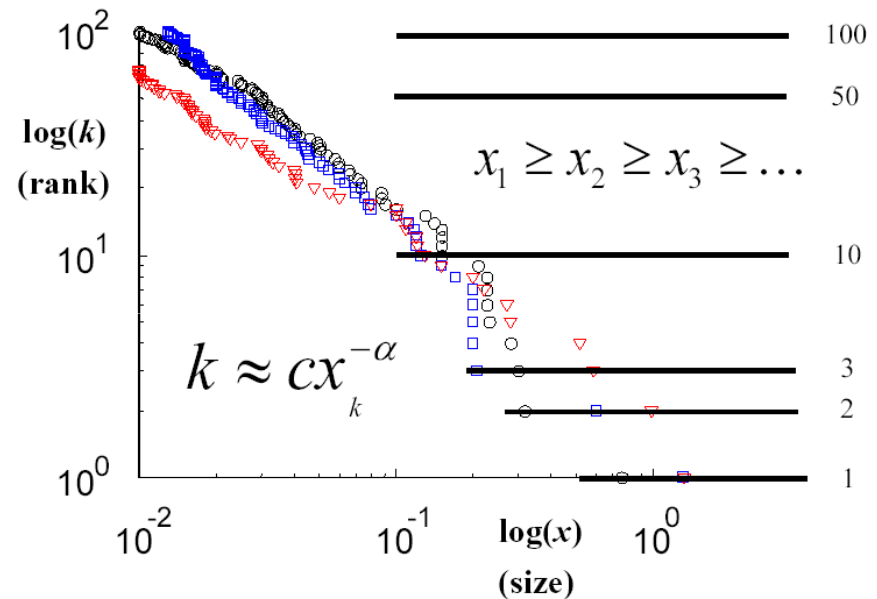
Inflation adjusted cost  
(In billion 2004 USD)

# Complex systems paradigm

20<sup>th</sup> Century's 100 largest disasters worldwide



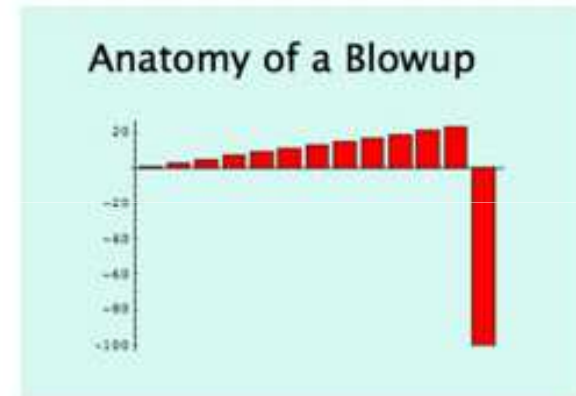
Raw data, *not* statistical



***The typical behavior is much smaller than the worst case, and the worst case is very, very bad***

Source: Proceedings of a Workshop on Statistics on Networks, NAP 2007

# 'black swan' events



**Figure 1** My classical metaphor: A Turkey is fed for a 1000 days—every days confirms to its statistical department that the human race cares about its welfare "with increased statistical significance". On the 1001<sup>st</sup> day, the turkey has a surprise.

The Bertrand Russell's turkey

**rare**      **unexpected**      **strong impact**



GIORDANO  
BRUNO  
Nolano.

De l'infinito vniuerso  
et Mondi.

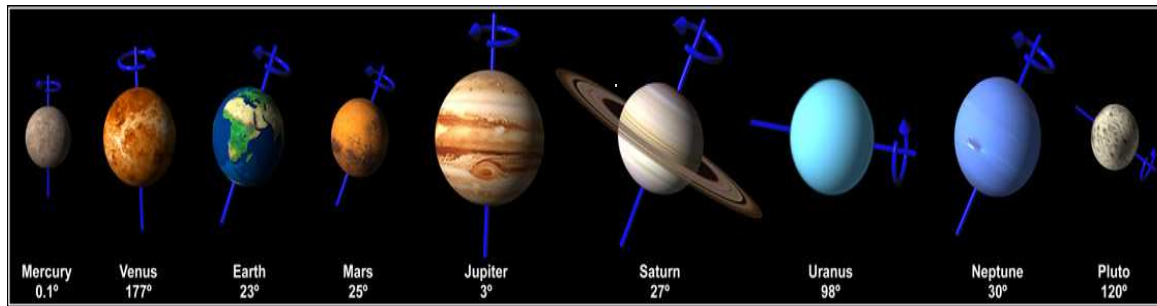
All' illustrissima Signor di  
Mauuflistio.



Stampato in Venetia.  
Anno, M. D. LXXXIII.

# COMPARATIVE PLANETARY CLIMATOLOGY

*There are countless suns and countless earths all rotating around their suns in exactly the same way as the seven planets of our system . . . The countless worlds in the universe are no worse and no less inhabited than our Earth*

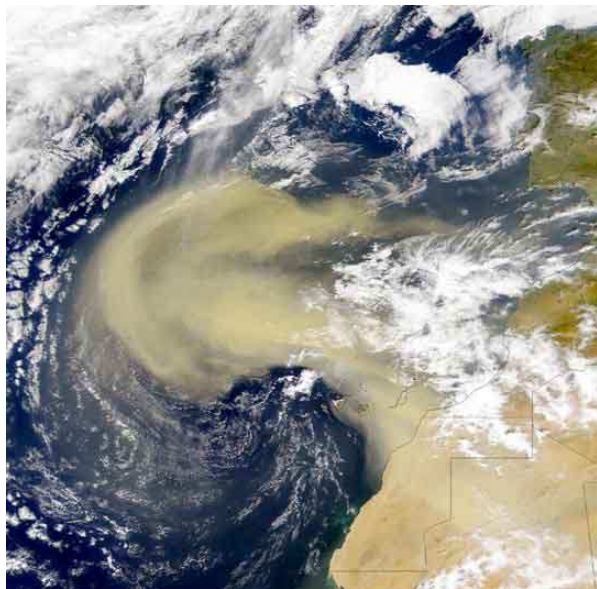


*The best of possible Worlds?*

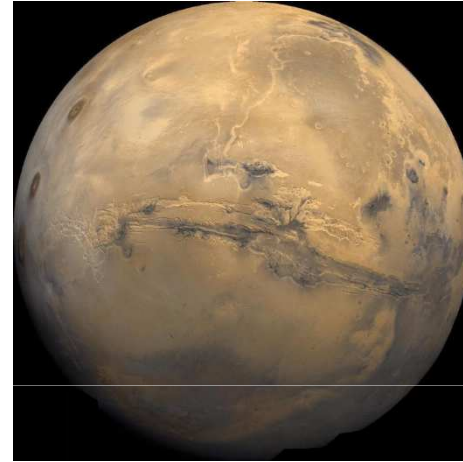


# SAND STORMS

Earth

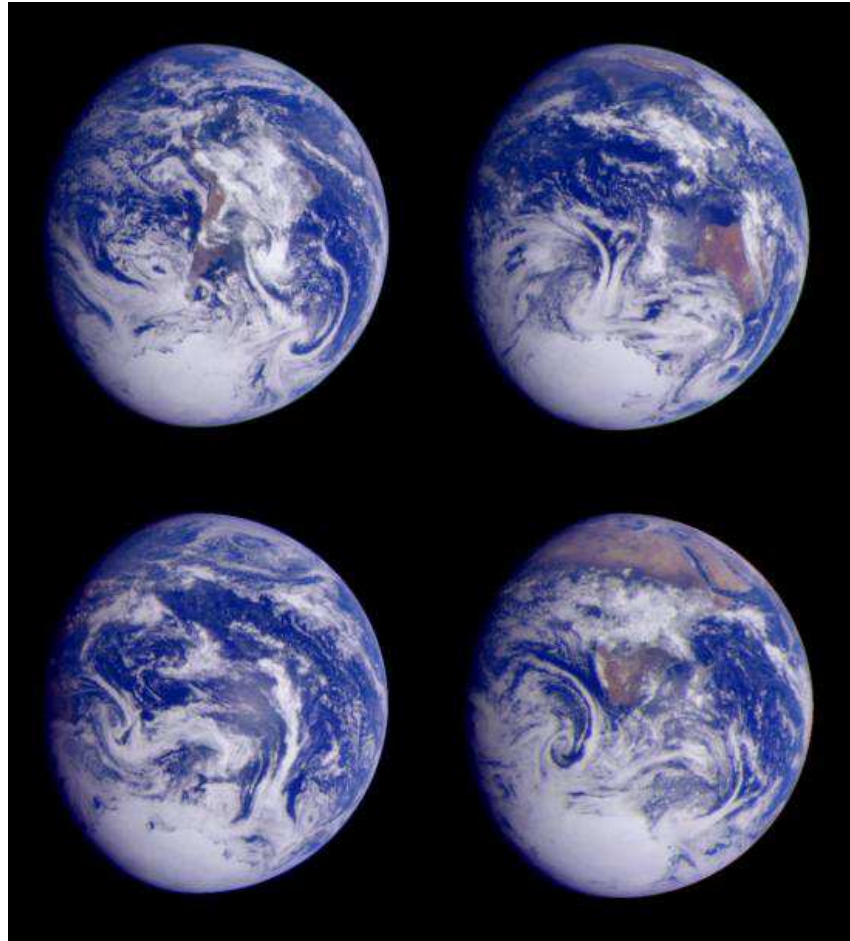


Mars



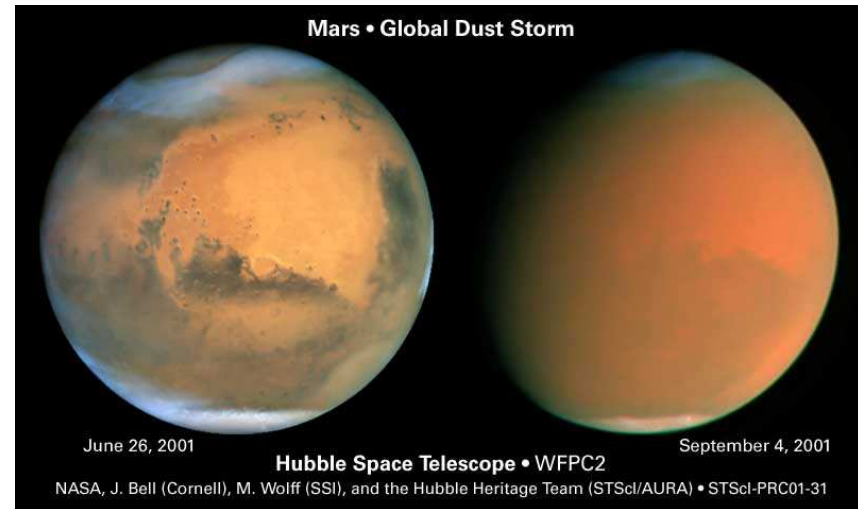


# 2 months later...



...The dissolved storm

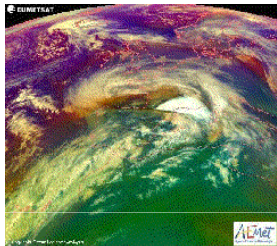
## The perfect storm...



# Limited area storms



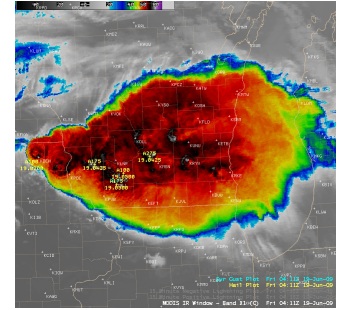
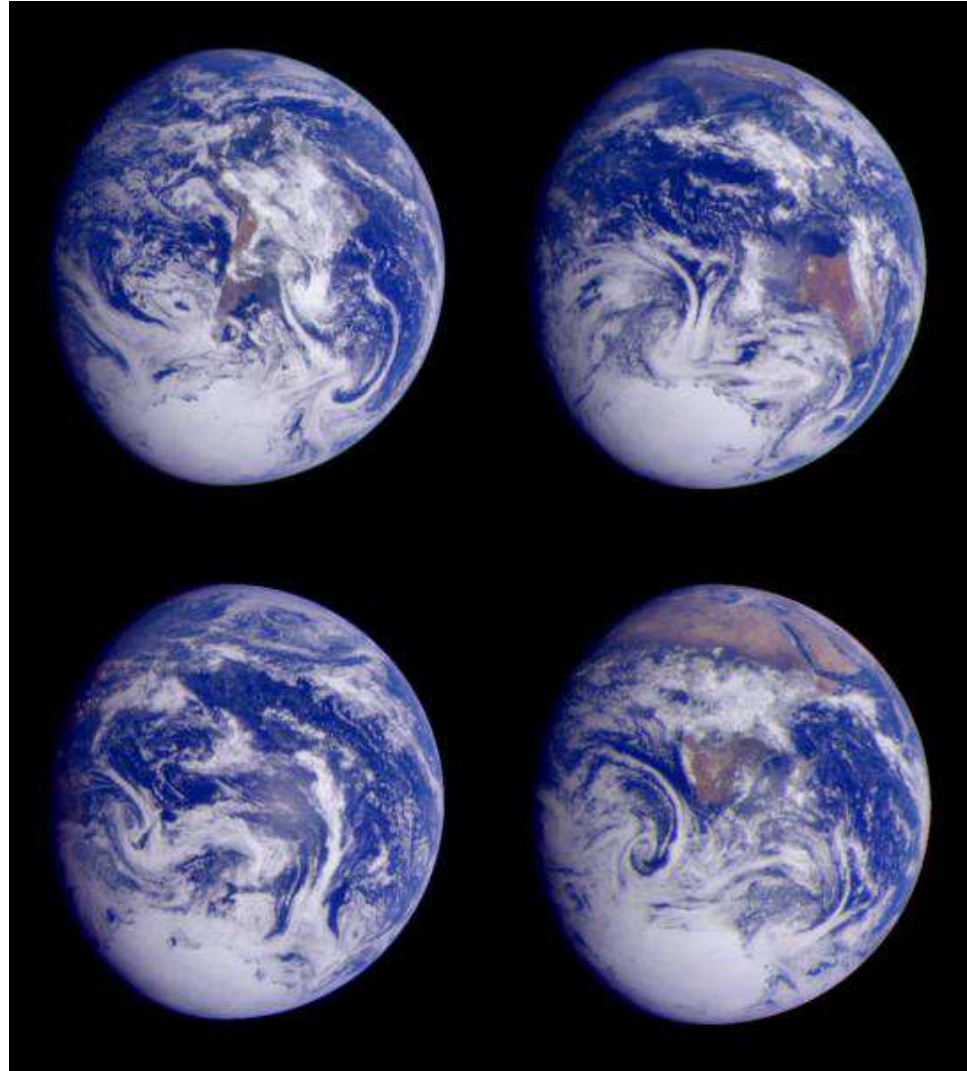
Hurricanes



wind storms



Tornado



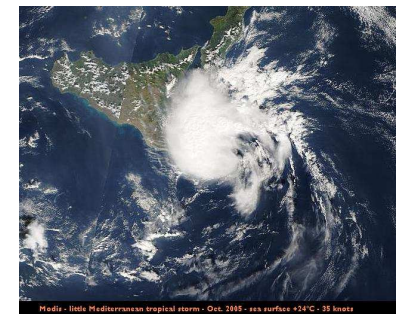
Mesoscale convective systems



funnel clouds



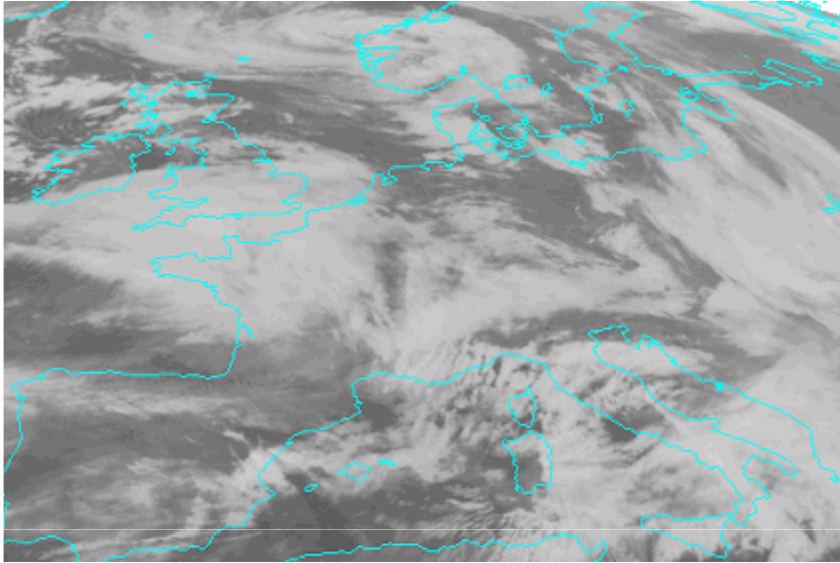
supercells



Medicanes



# and their predictability



- "Lothar" - deep low-pressure system which hit N. France on December 26 1999.
- • 110 mph winds recorded in Paris; 100 people killed across Europe.
- • 4000 trees uprooted in the Palais de Versailles (Paris) alone.
- • **Automated forecasting systems failed to forecast its severity.**

Lothar Winter storm  
Christmas 1999  
Central Europe



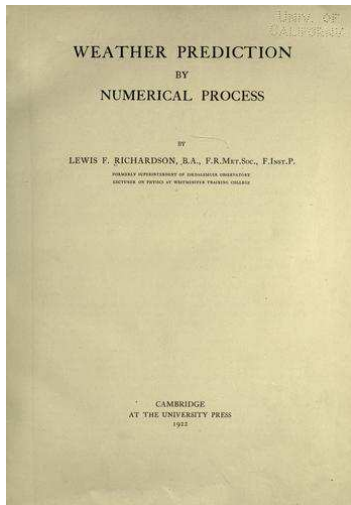
35 million euros of damage to Versailles (gardens and roof)

# A crash course on predictability

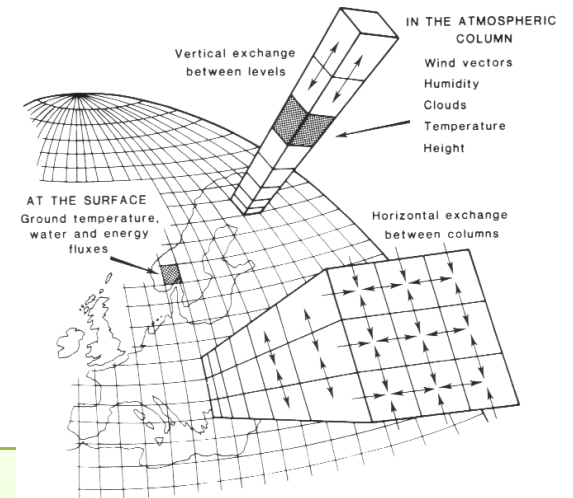


*Predictability is to Prediction  
as Romance is to sex*

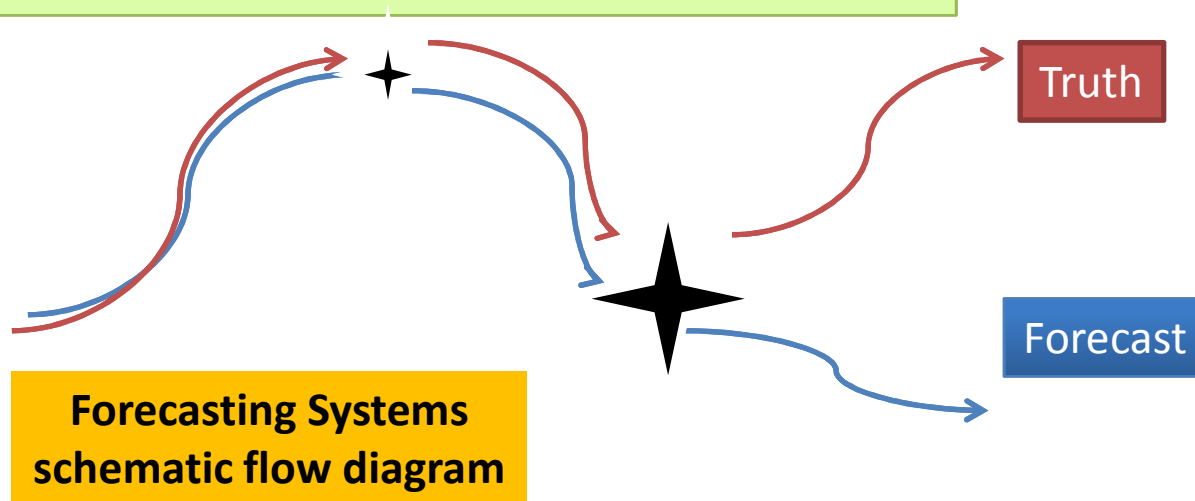
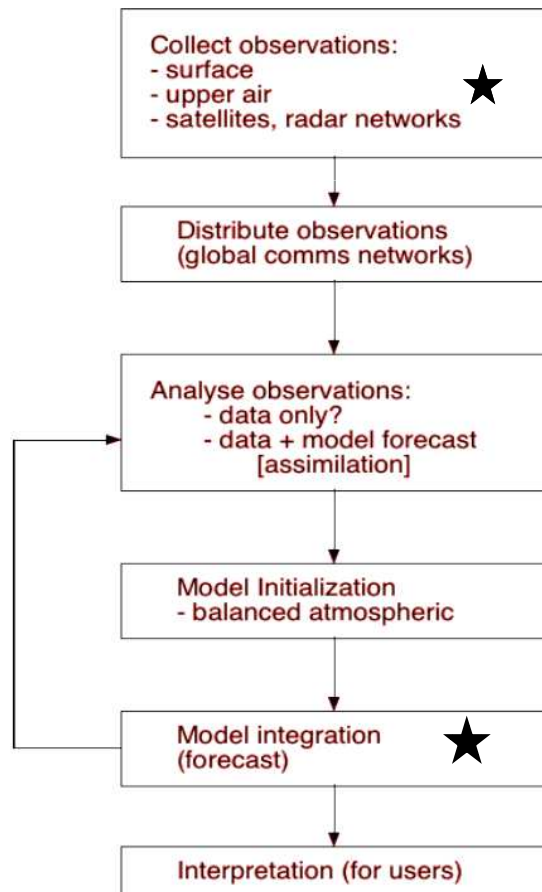
*K. Miyakoda 1985*



# Numerical Weather Predictions



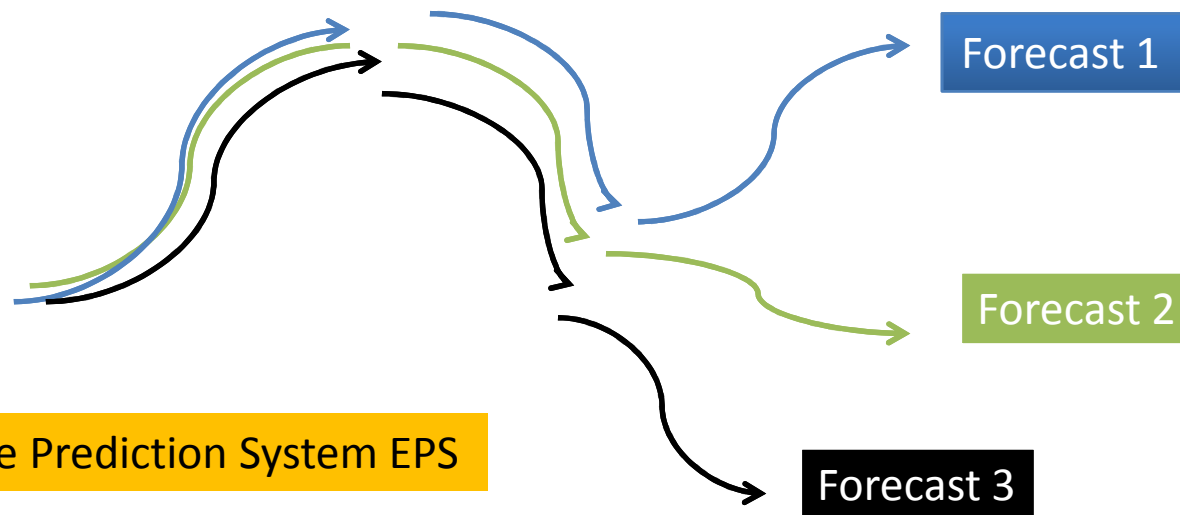
- We create models to simulate the atmosphere
- Instabilities increase forecast errors
- The models need initial conditions (today's analysis)
- Initial conditions have errors
- Errors grow because of instabilities and model error





# Ensemble forecasts

- We create ensembles of forecasts to simulate the uncertainty of the forecasts. **We need to include:**
  - **Uncertainties** in the initial conditions (today's analysis errors)
  - **Uncertainties** in the models (model errors or deficiencies)

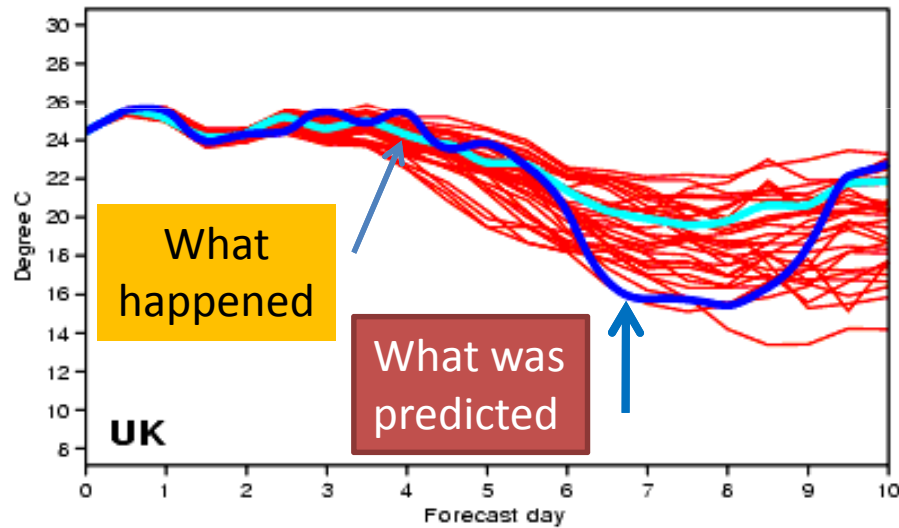


# The London Temperature Forecast



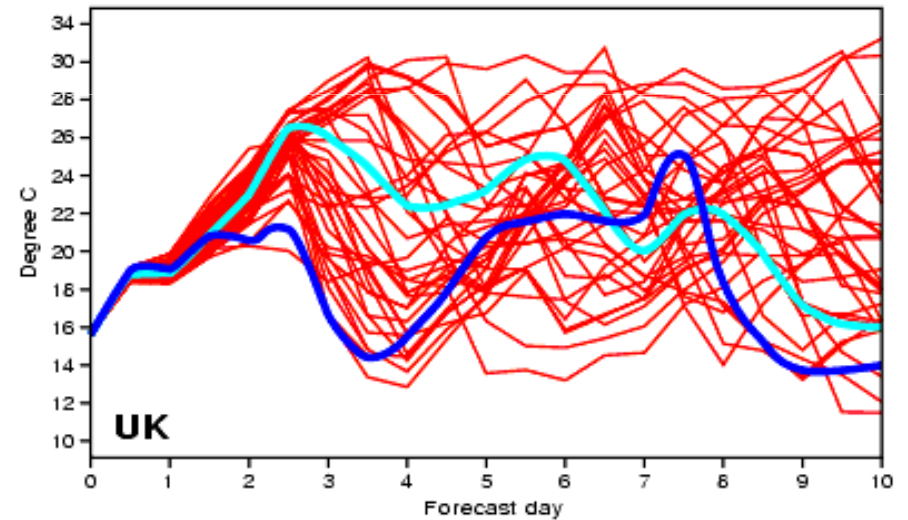
ECMWF ensemble forecast - Air temperature  
Date: 26/06/1995 London Lat: 51.5 Long: 0

Control Analysis Ensemble



ECMWF ensemble forecast - Air temperature  
Date: 26/06/1994 London Lat: 51.5 Long: 0

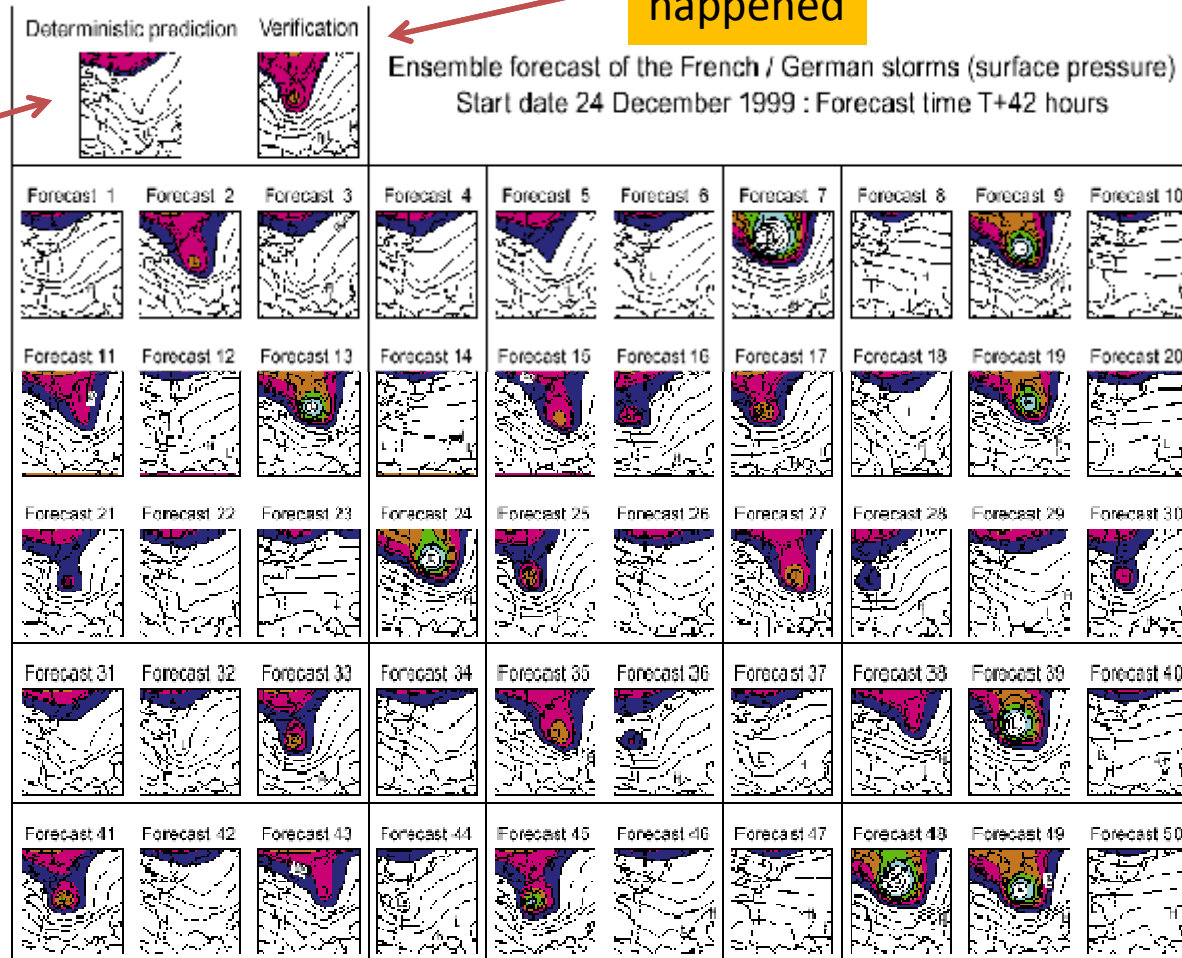
Control Analysis Ensemble



*Prediction is very difficult, especially about the future.  
N.Bohr*

# Back to Lothar

What happened



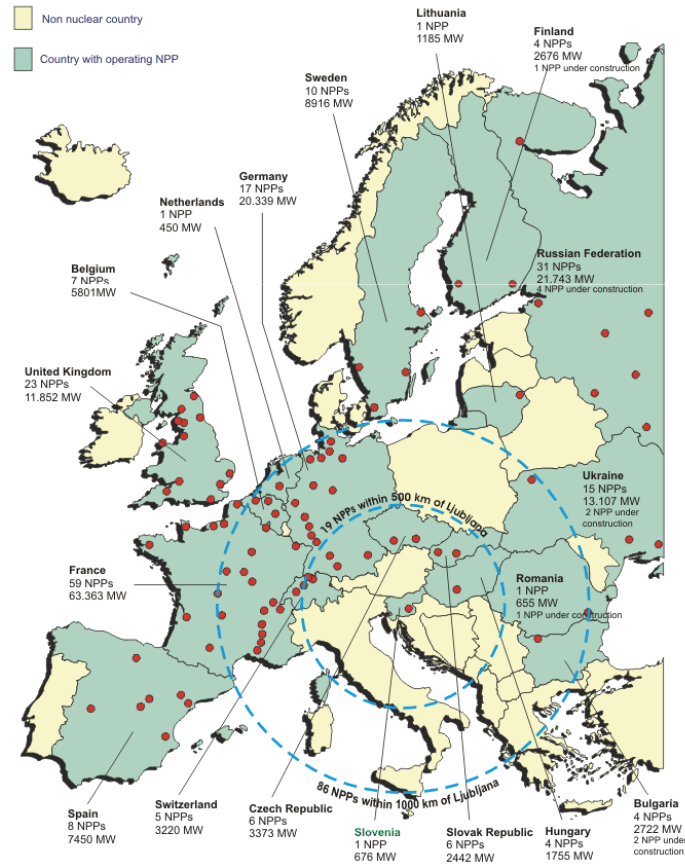
What was predicted

EPS

# Nuclear events

## Nuclear Power Plants in Europe

Copyright © ICJT 2006  
www.icjt.org



Status as 24 of August 2006 as reported to IAEA.

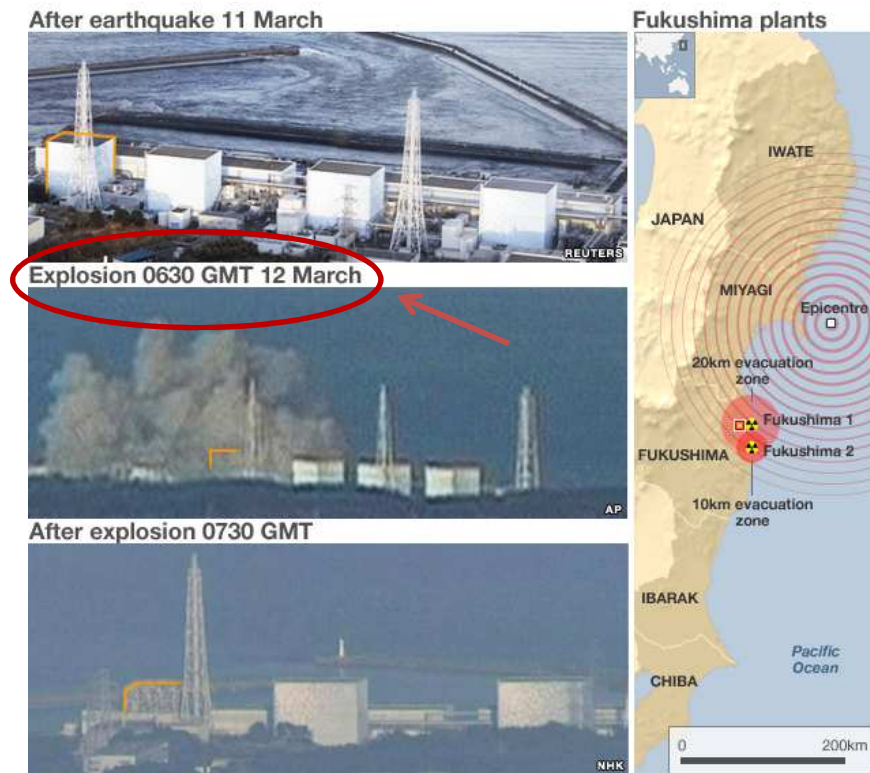
Each indicated location can represent several reactors.

# The Fukushima Event: Timeline

source: <http://www.iaea.org/newscenter/news/2011/fukushimafull.html>

## Explosion Reactor 2

**12/03/2011 0630 UTC**



## 1° Message Emercon AIEA

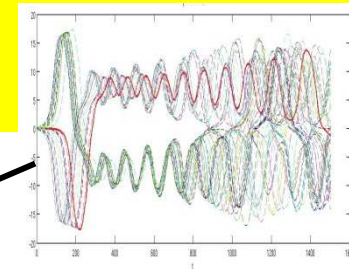
**14/03/2011 11.40 UTC**

```
Nuovo Documento di testo.txt
WNXX01 IAEA 141840
Subject: EMERCON GENF
-----
EMERCON      EMERCON  GENERAL EMERGENCY
-----
MESSAGE #    1
-----
Reporting STATE: IAEA
Reporting competent authority: IAEA IEC
Name of Contact Person: Emergency Response Manager
-----
Installation name: Fukushima Daiichi UNIT 2
Installation type: BWR
Normal Power: 2381 MW thermal
Co-ordinates(Latitude = Deg . Decimal) Lat: 37. 4206 degrees
N
              (Longitude = Deg . Decimal) Long: 141.0329 degrees
E
-----
Emergency class: General Emergency
Emergency class declared at: 2011/03/14 11:40 UTC
Information VALID at: 2011/03/14 18:15 UTC
-----
Actual or projected release to environment: Unknown
Release to atmosphere: yes
Effective release height: <1km
Actual or projected release times:
Start time: 03/14 11:40 UTC
End time: 03/15 11:40 UTC
Meteorology at mm/dd hh:mm UTC:
wind from ___ degrees
wind speed: ___ metres/second
Pasquill stability class: A/B/C/D/E/F
Local precipitation: no
-----
End of message
```

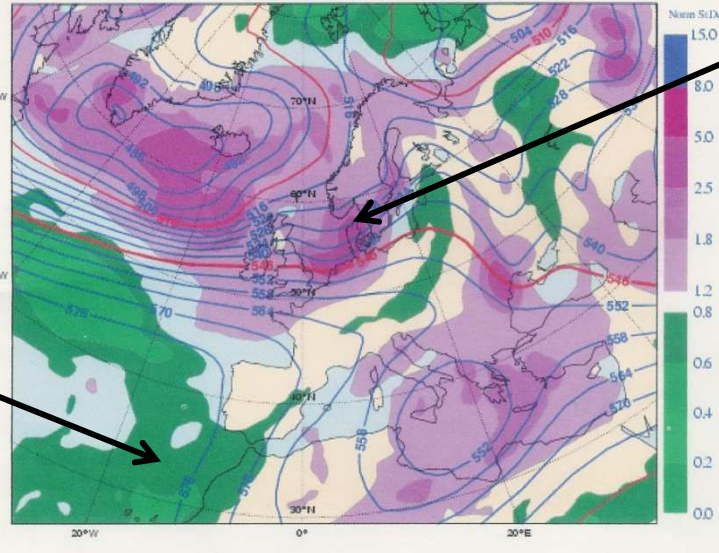


*In any moment of decision the best thing you can do is the right thing,  
the next best thing is the wrong thing,  
the worse thing you can do is nothing*

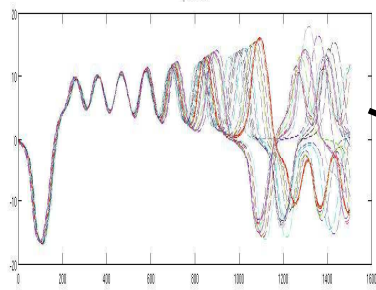
*T. Roosevelt*



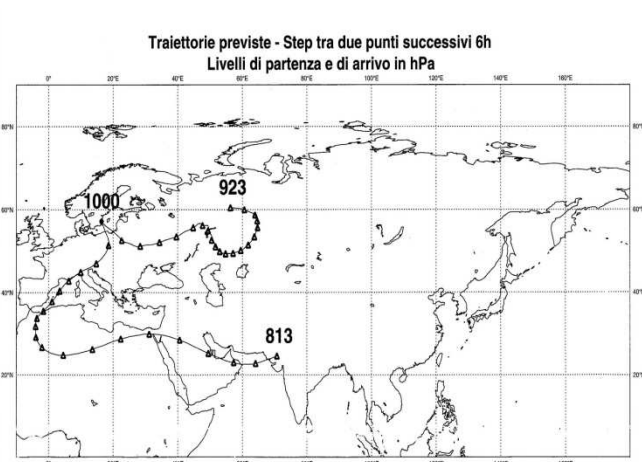
Wednesday 2 February 2011 12UTC ECMWF Forecast t+24 VT: Thursday 3 February 2011 12UTC  
500hPa Geopotential Ensemble Mean and Normalised Standard Deviation (shaded)



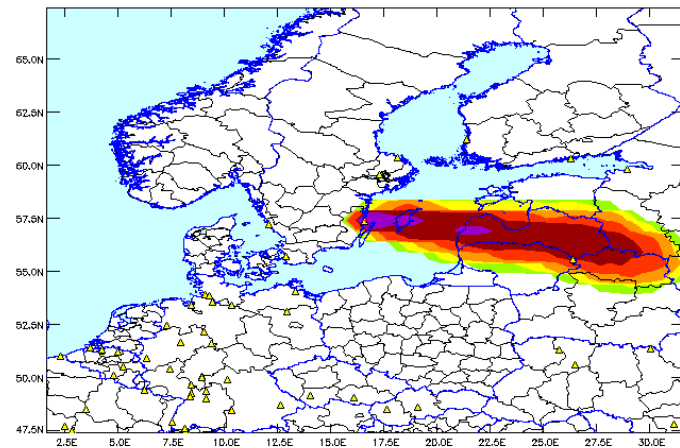
Predictability Map



## Trajectories Model



## Dispersion Model

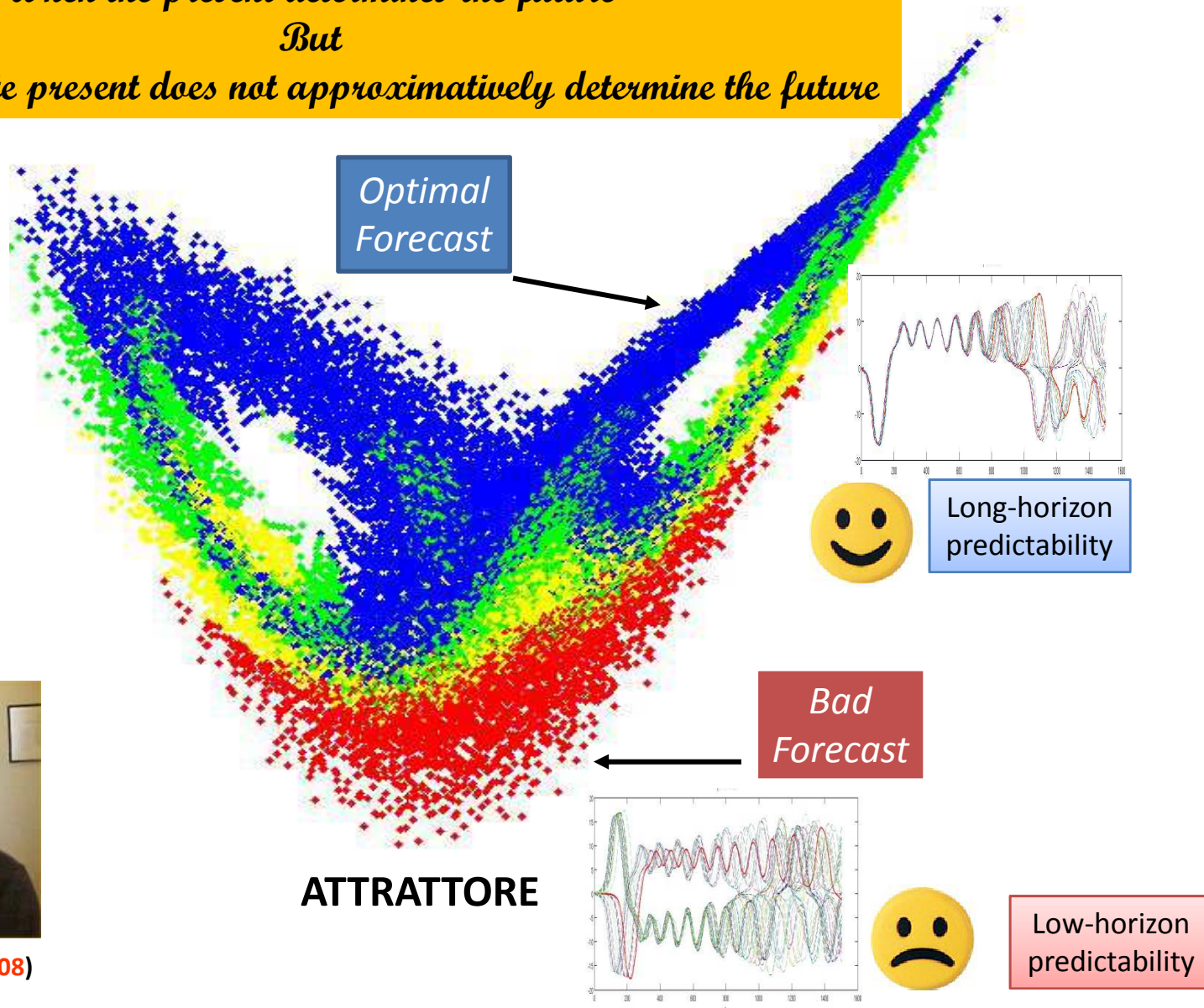


# Forecasting in a chaotic world

*When the present determines the future*

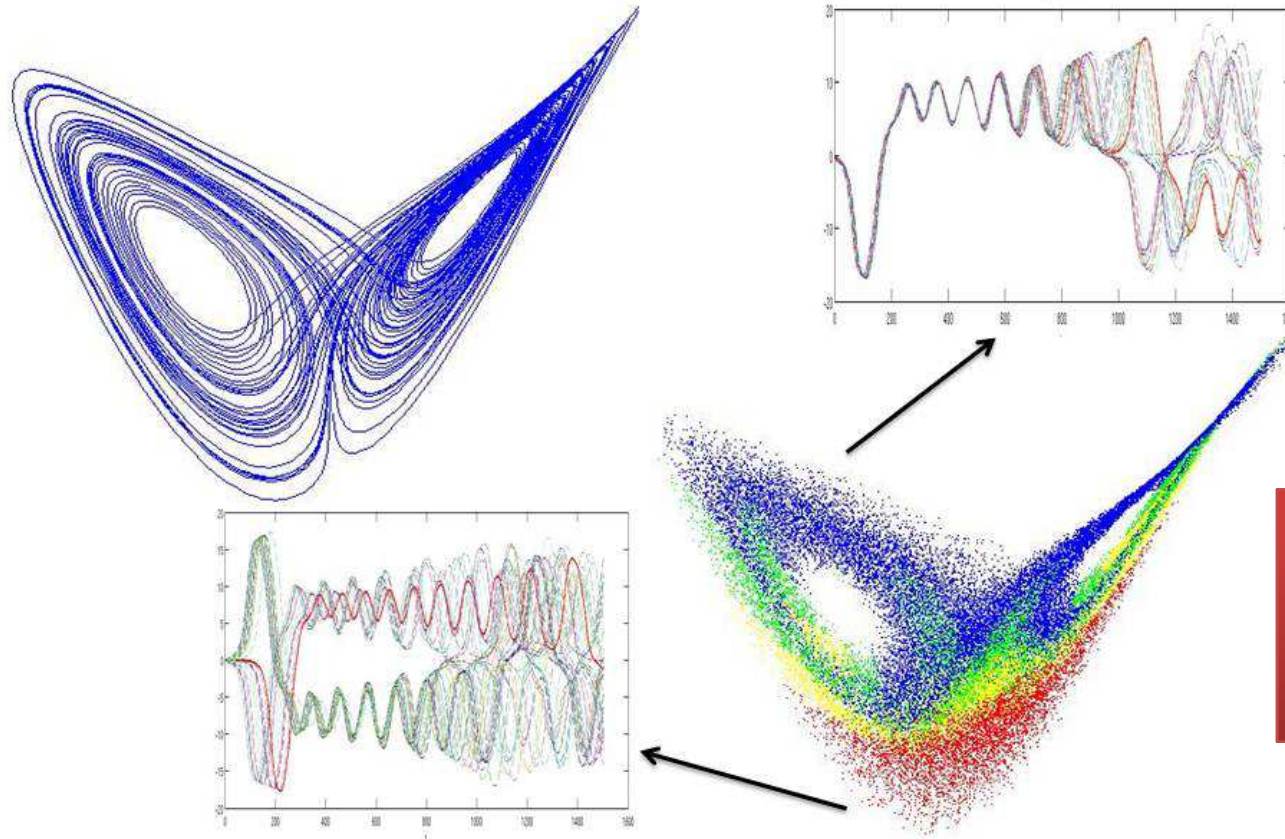
*But*

*The approximate present does not approximately determine the future*



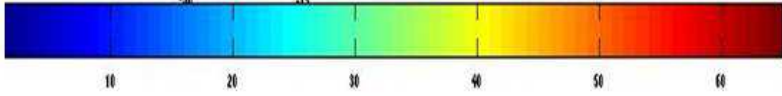
E.Lorenz, (1917,2008)

# A dynamical system approach to Meteorology and Climatology



**Weather  
Trajectories  
on  
the Attractor**

**Climate**  
Global dynamics and statistics  
of  
the Attractor



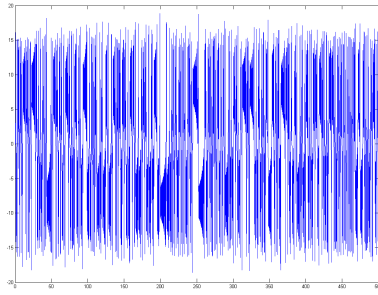


# climate in in a chaotic world

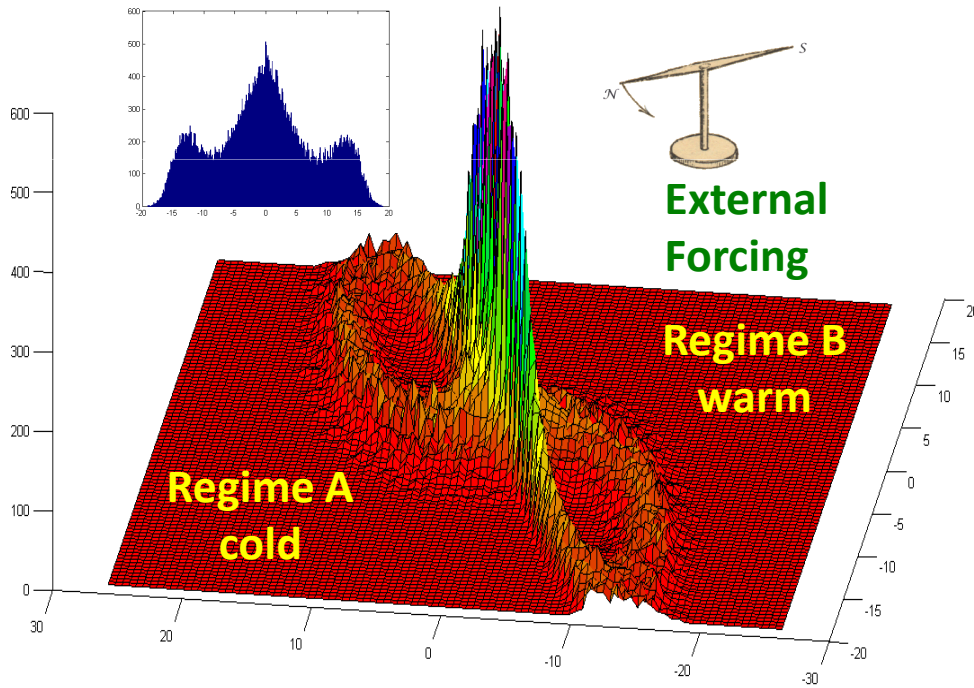
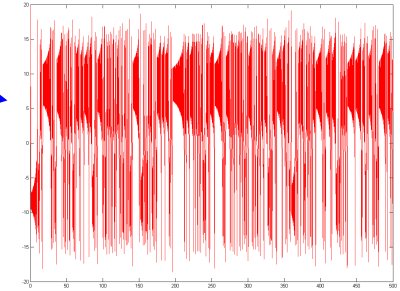
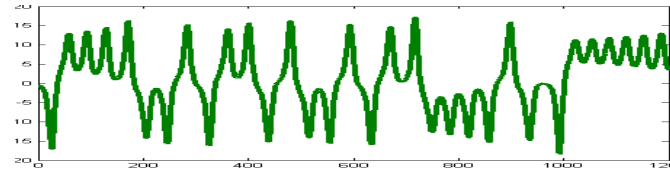


A => warm

B => cold



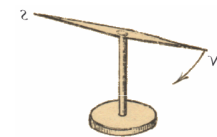
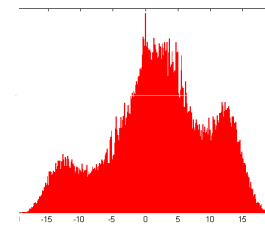
Climate variability  
*always working*



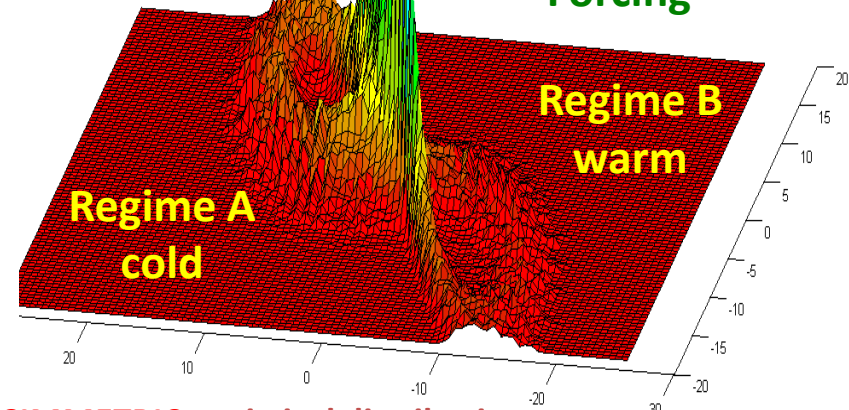
External  
Forcing

SIMMETRIC statistical distribution

Climate  
Oscillation



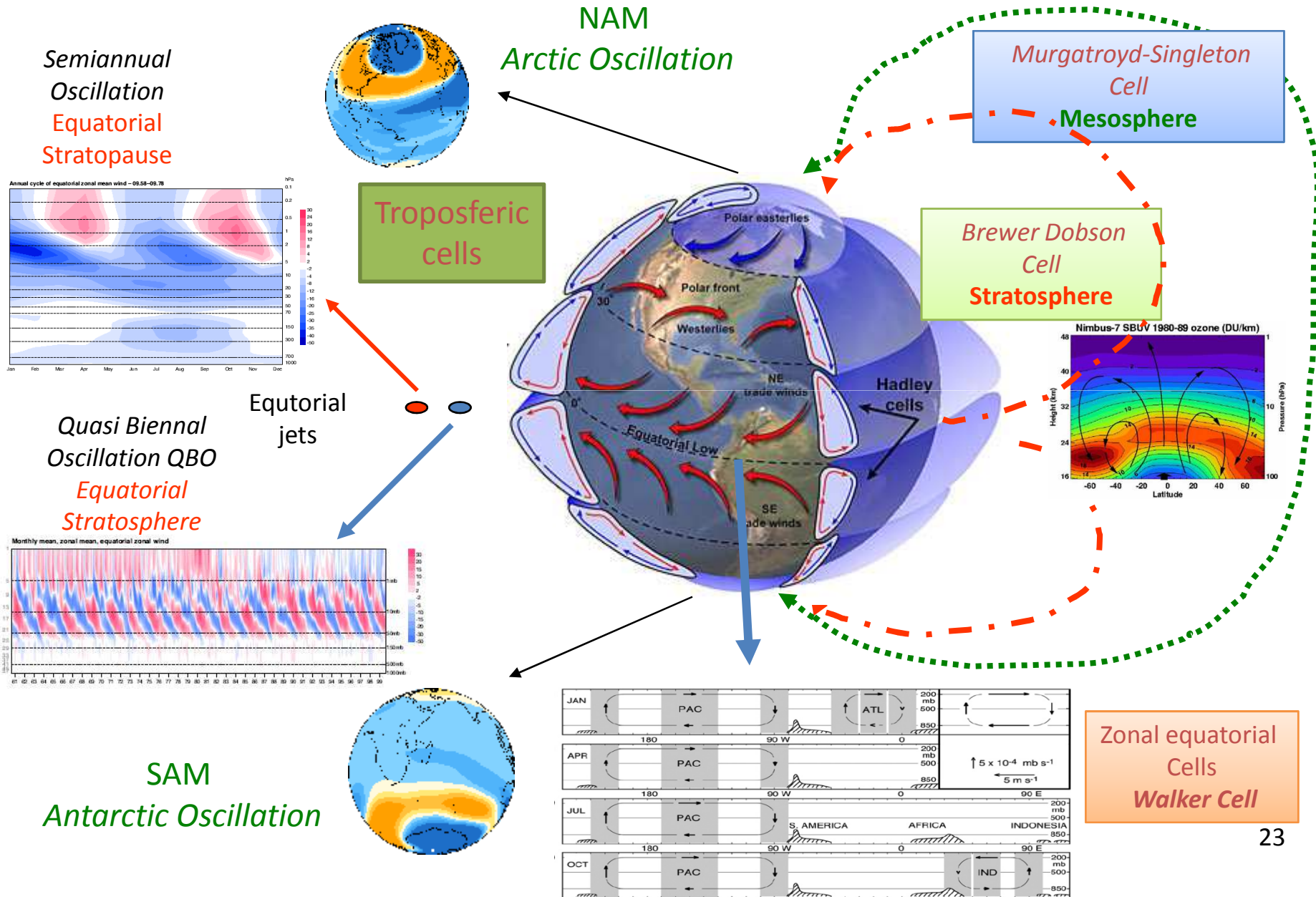
External  
Forcing



ASIMMETRIC statistical distribution

Climate  
Change

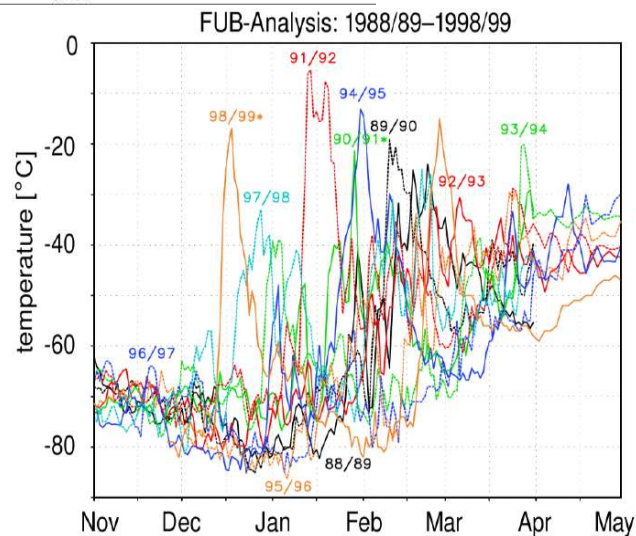
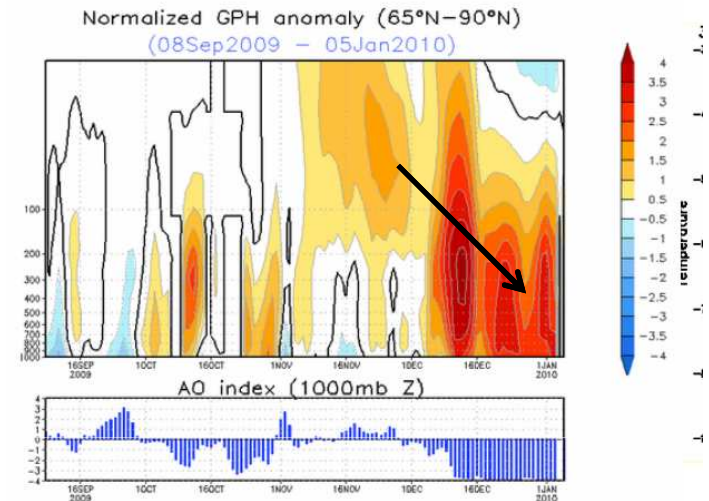
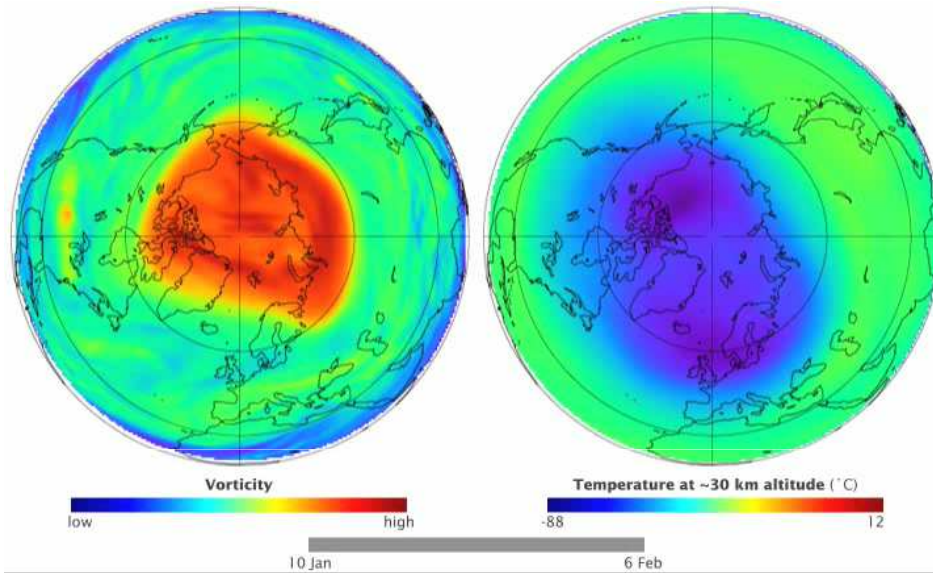
# Complexity: the Atmosphere



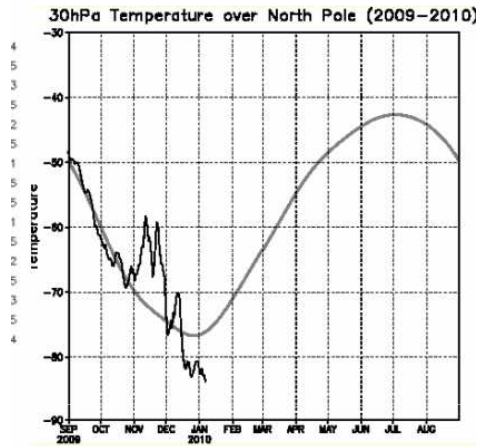


# Stratosphere-Troposphere interaction

## Stratospheric Sudden Warming



# Example impact: Feb 2009 weather



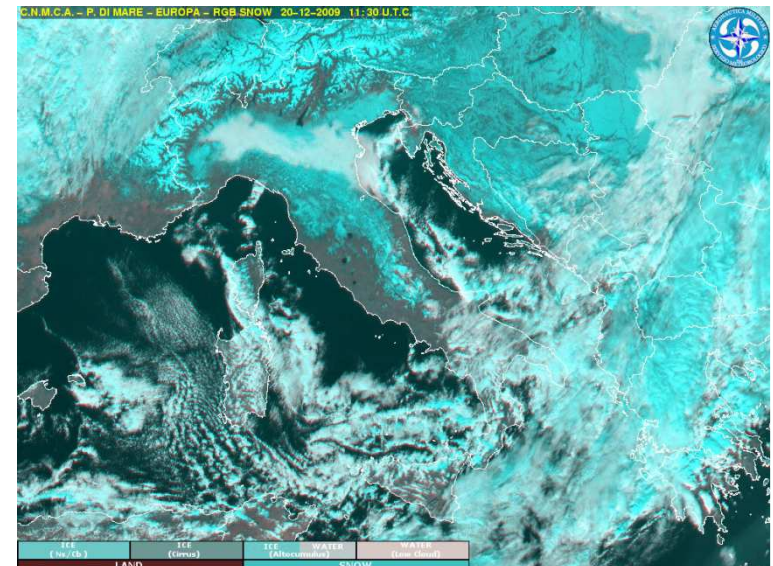
London 5 Feb 2009



Widespread disruption to London transport services early Feb 2009

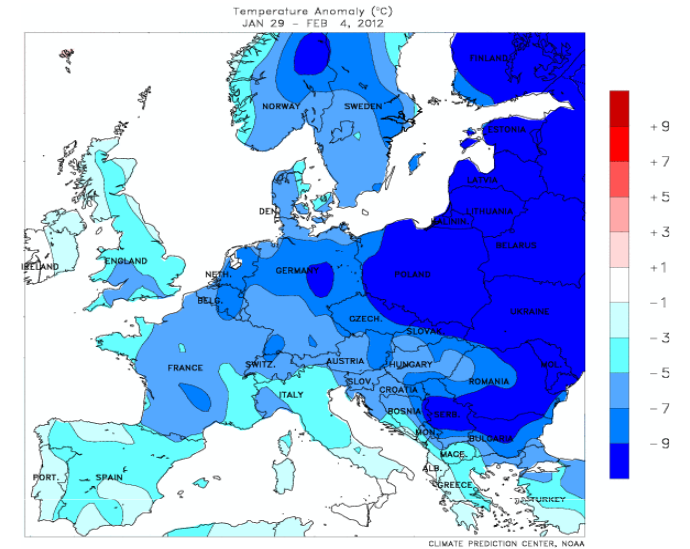
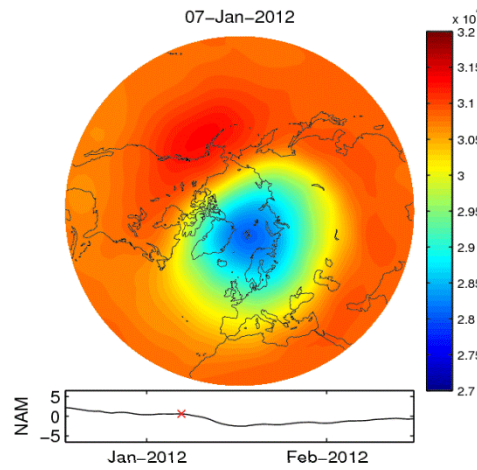
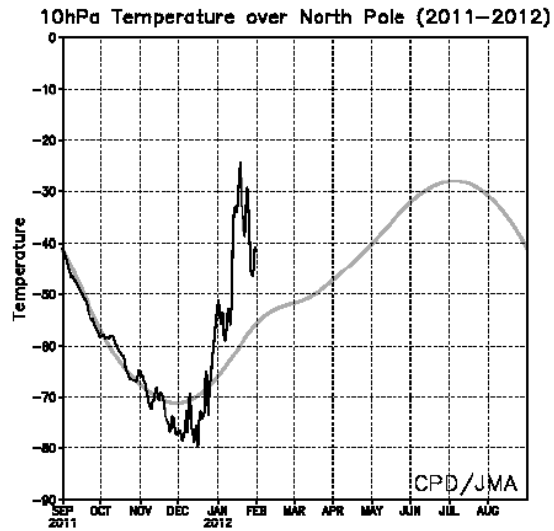
One of the main problems during the period of heavy snow in February was the dwindling supply of salt held by local authorities. We heard that local authorities had placed their usual orders for salt before the winter....when local authorities ordered more stock, the suppliers "could not respond and deliver".  
*Commons Select Transport Committee Report on Feb 2009*

© Crown copyright Met Office





# 2012 European Cold Wave



Roma, Italy

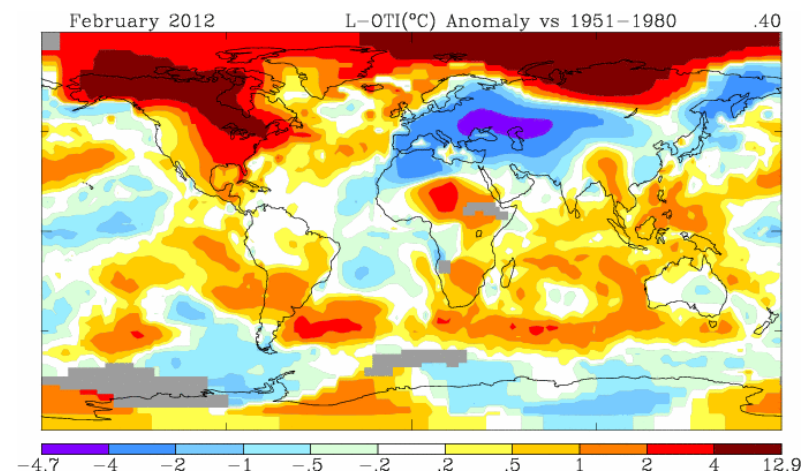
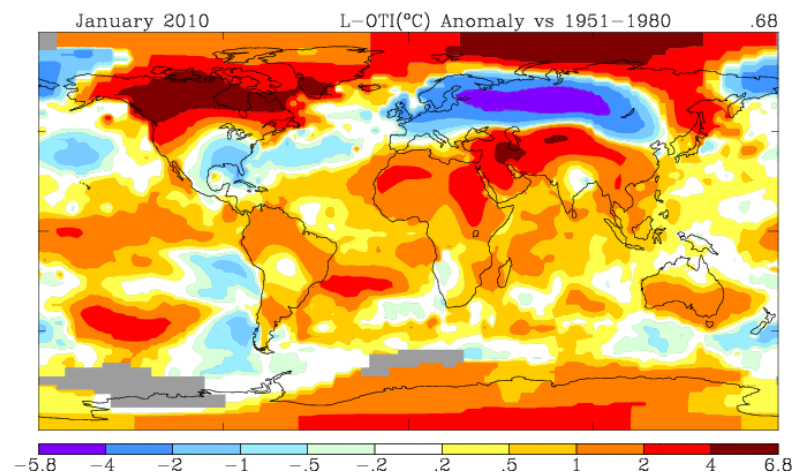
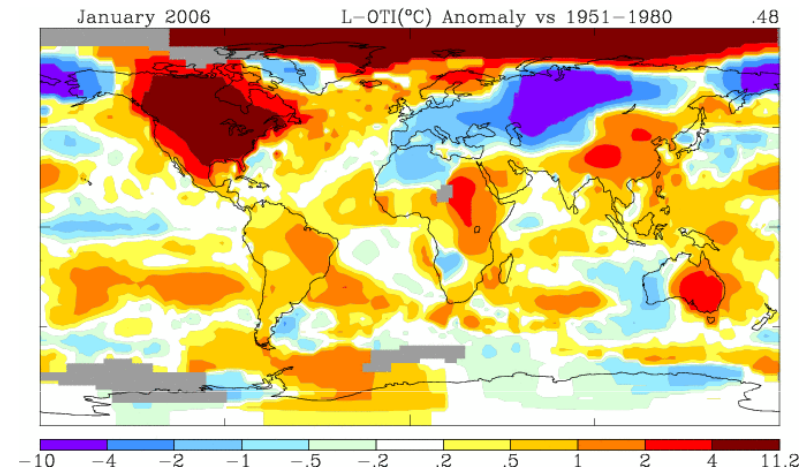
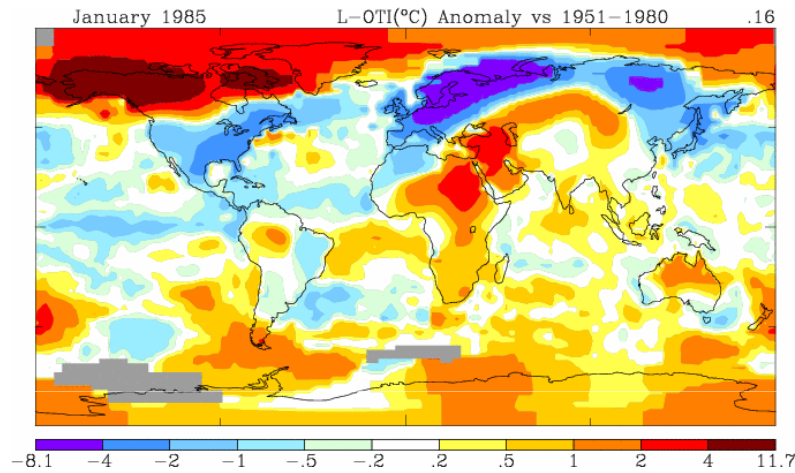


Senj, Croatia



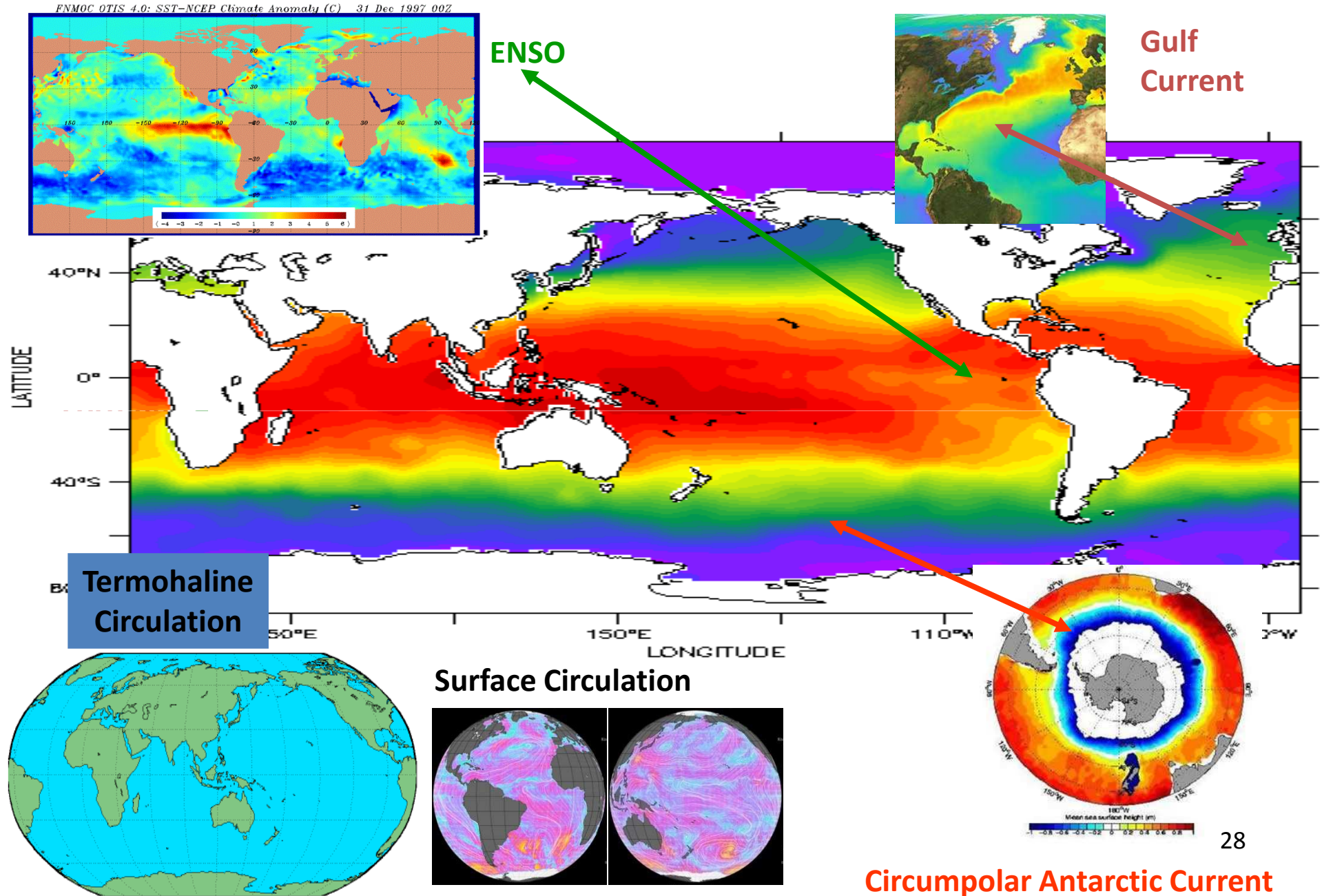
Damme, Belgium

# Cold Waves due to Stratospheric Sudden Warming



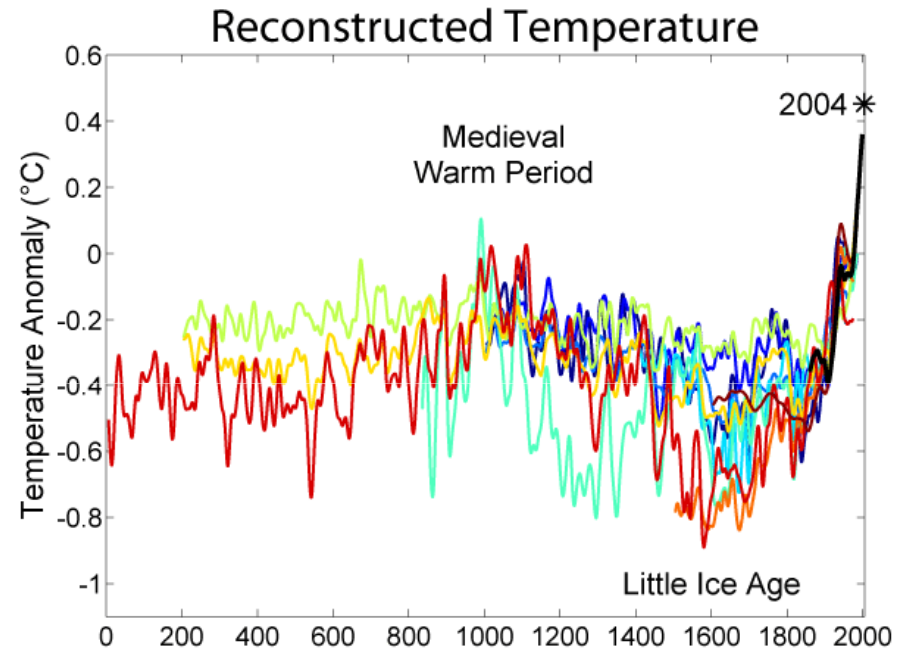
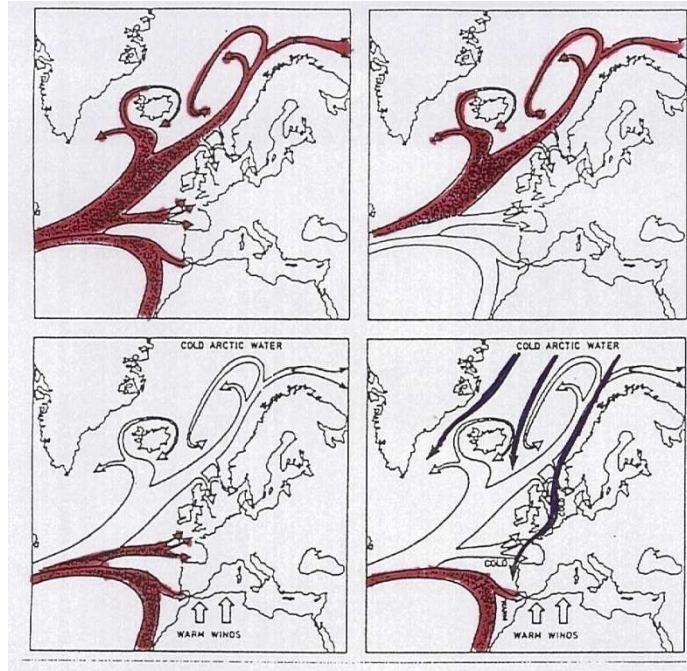


# Complexity:the Ocean





# The Little Ice Age



*Make your plans to fit the circumstances*  
*Gen. G. Patton*



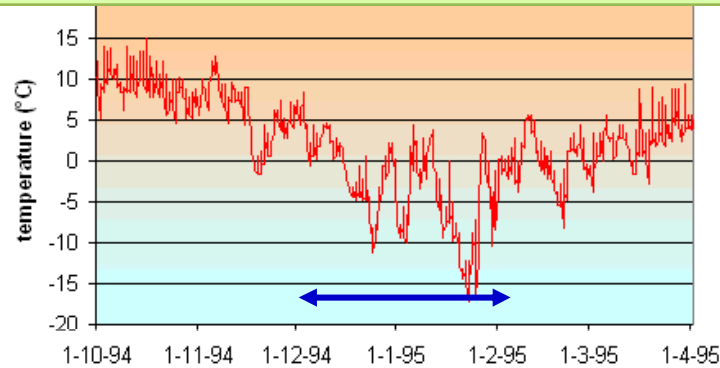




# La marine hollandaise est à nous!

## January 23, 1795

Temperatures registered in the Netherlands during Gen. Pichegru campaign 794-1795  
source KNMI

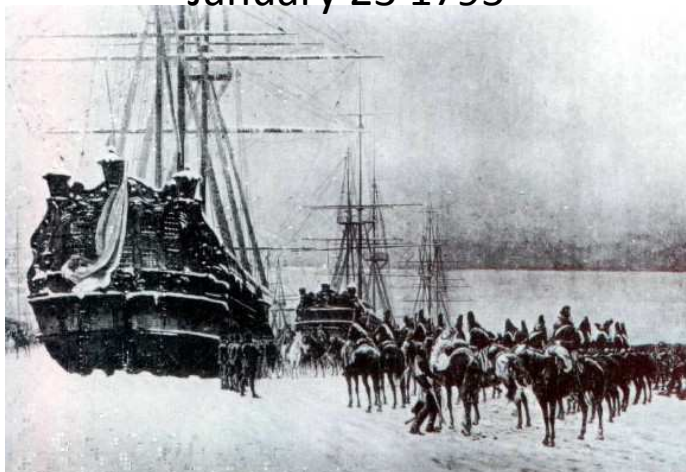


Dutch Fleet Position

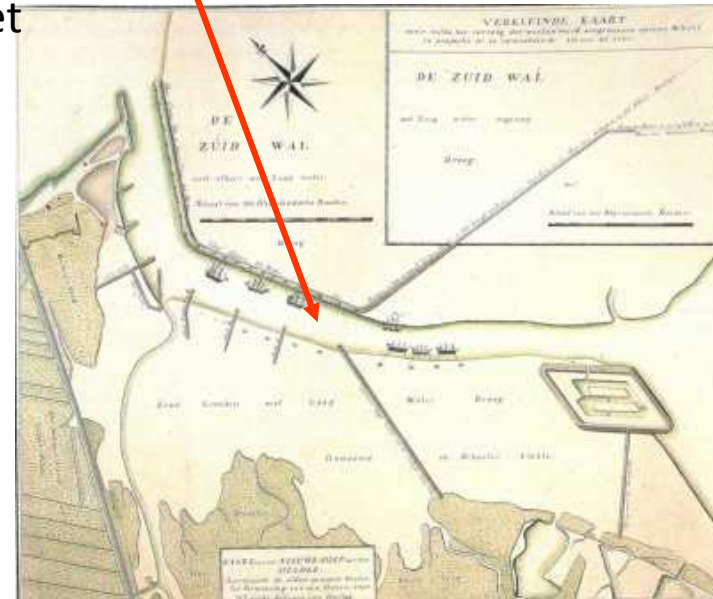


Gen. Pichegru 1761-1804

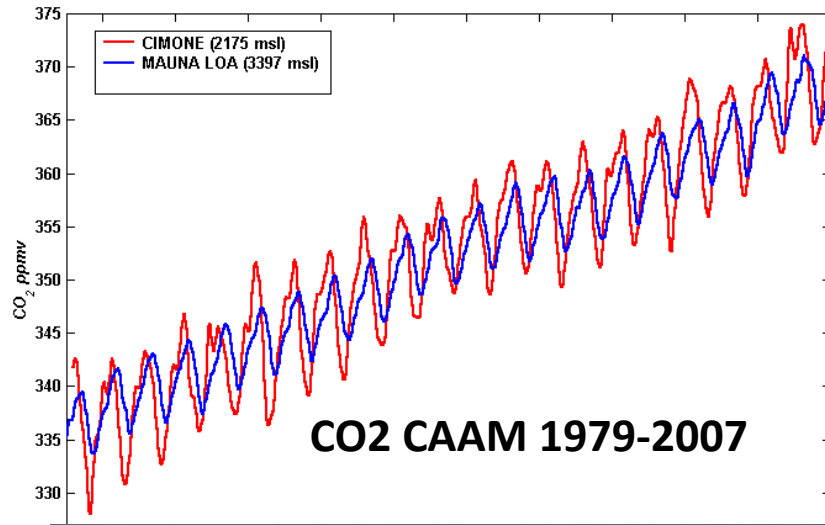
A Squadron of the 8° Hussars captures the Dutch fleet  
January 23 1795



Musée de l'Empéri (Salon de provence)



# The breath of GAIA



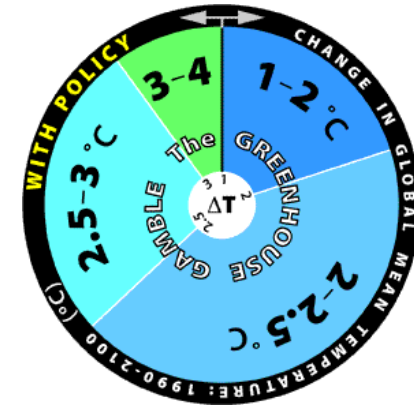
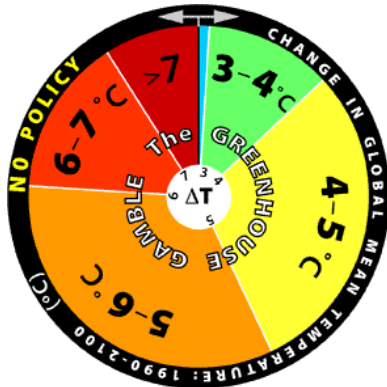
Monte Cimone Obs.



Mauna Loa Obs.



# The Greenhouse Gamble wheels



The roulette-style spinning wheels depict the estimated probability, or likelihood, of potential temperature change (global average surface temperature) over the next 100 years. The face of each wheel is divided into colored slices, with the size of each slice representing the estimated probability of the temperature change in the year 2100 falling within that range.

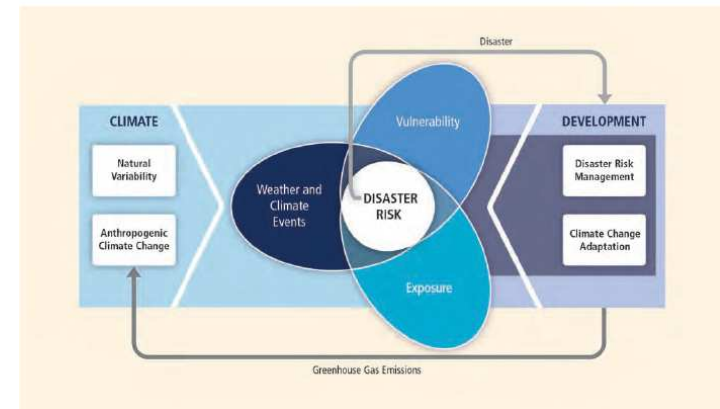
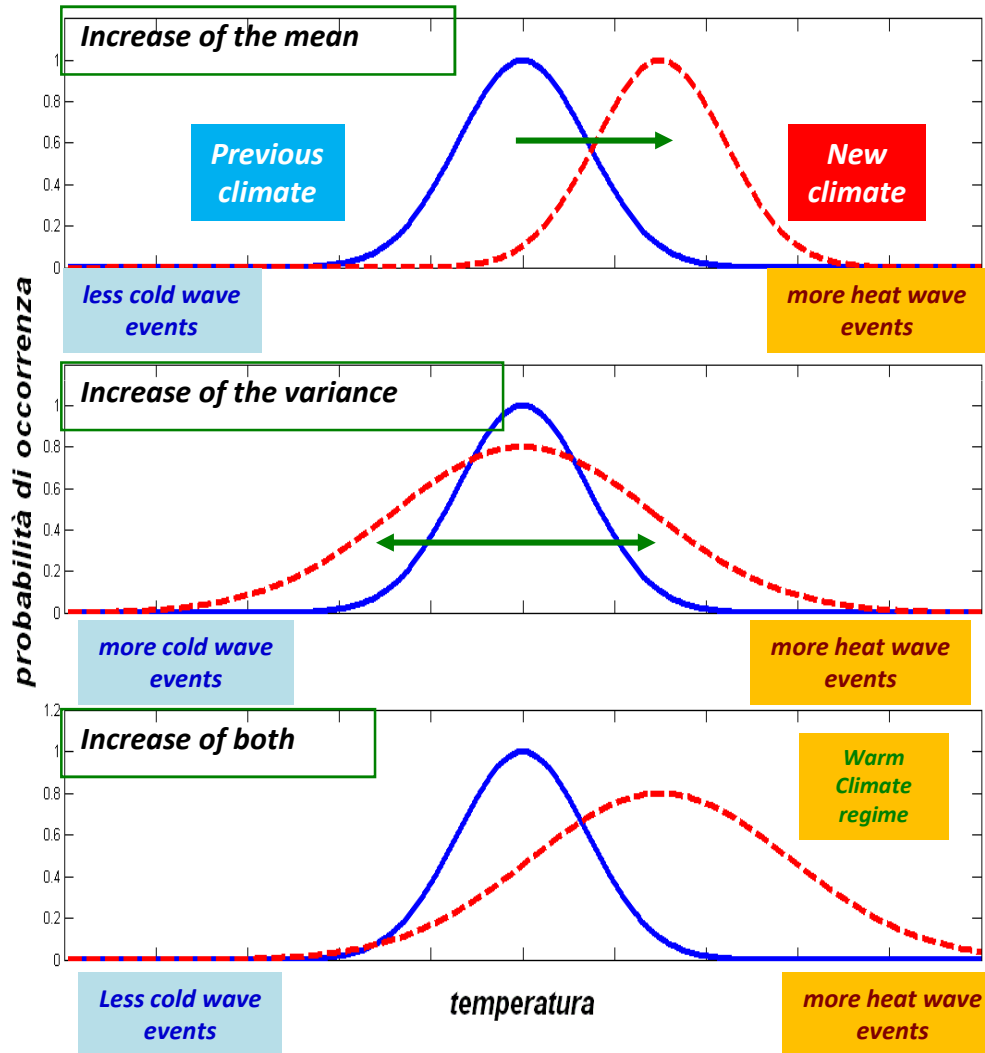
The Greenhouse Gamble wheel on the left is the "no policy" or reference case, in which it is assumed no action is taken to try to curb the global emissions of greenhouse gases. The median value of the "no policy" wheel, or the temperature at which there is a 50% chance of falling above or below that level (even odds) is 5.2 °C.

The Greenhouse Gamble wheel on the right is the "with policy" case, which assumes that policies are enacted to limit cumulative emissions of greenhouse gases over the century to 4.2 trillion metric tons, measured in CO<sub>2</sub>-equivalent. The median warming level (even odds) is 2.3 °C.

<http://globalchange.mit.edu/focus-areas/uncertainty/gamble>

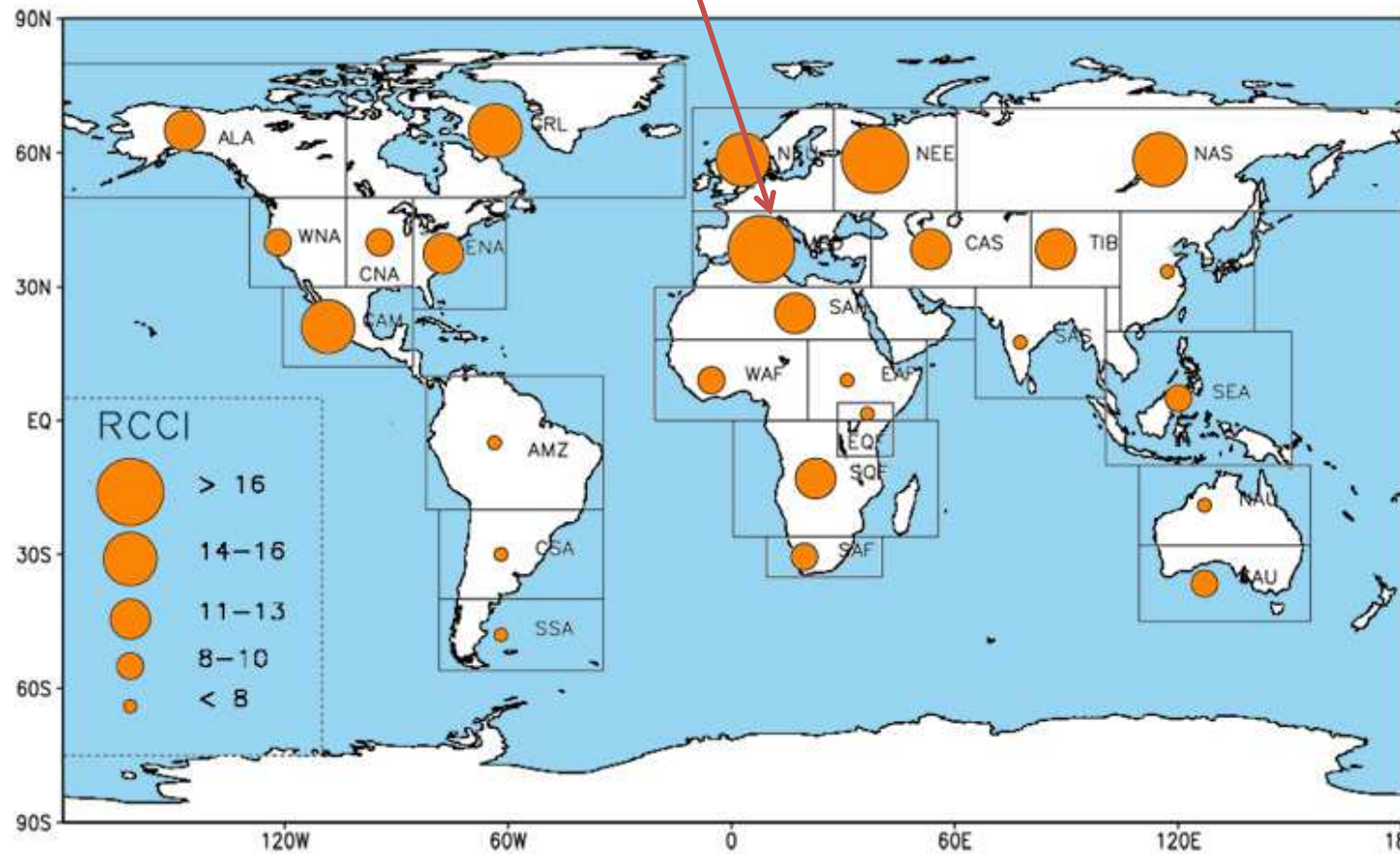
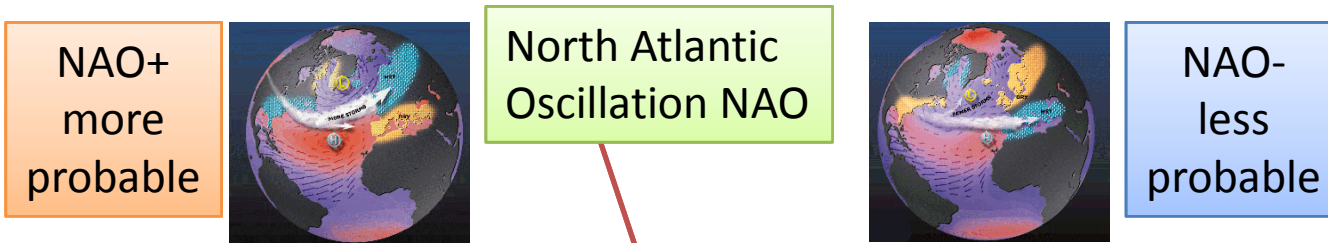
# A PRAGMATIC VIEW OF CLIMATE CHANGE

**Risk=Threat x Vulnerability**



**Vulnerability:** The propensity or predisposition to be adversely affected.

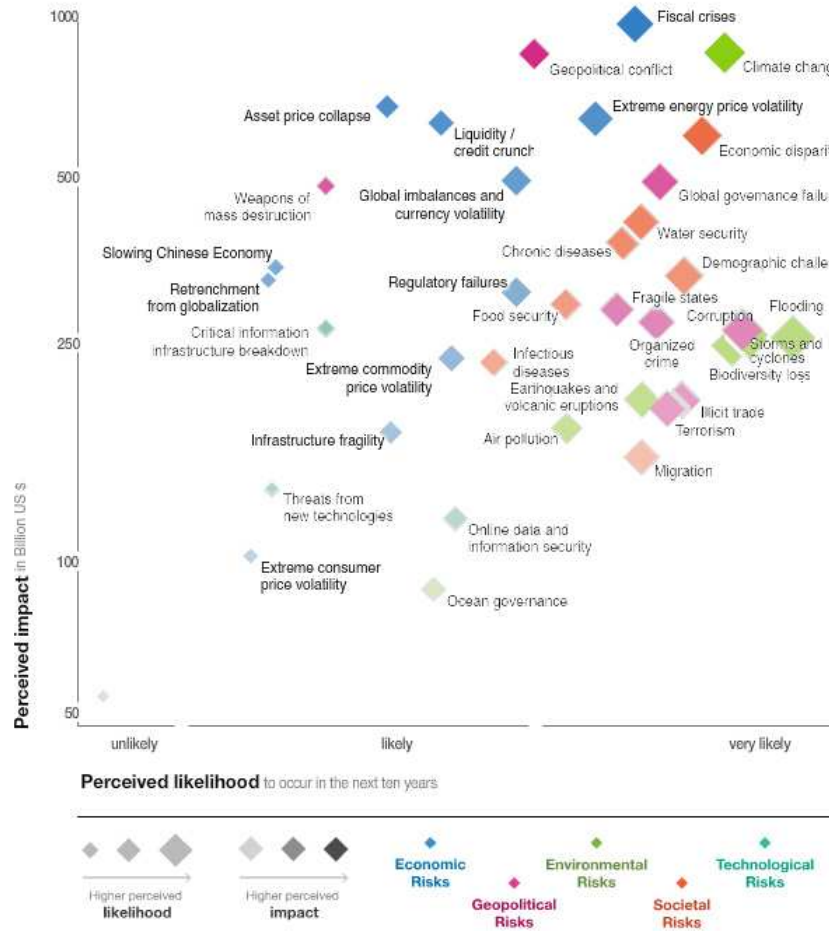
# THE HOT SPOTS RISK MAP



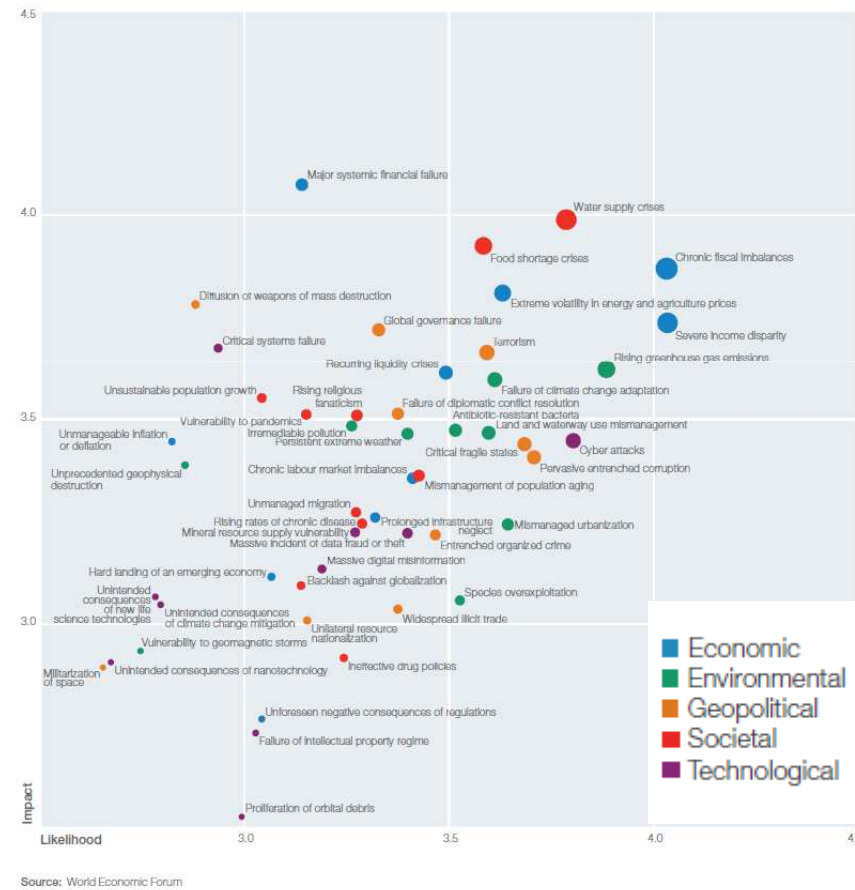
RCCI: Regional Climate Change Index

Source: ICTP Trieste

# The World Economic Forum Risk Map



2011

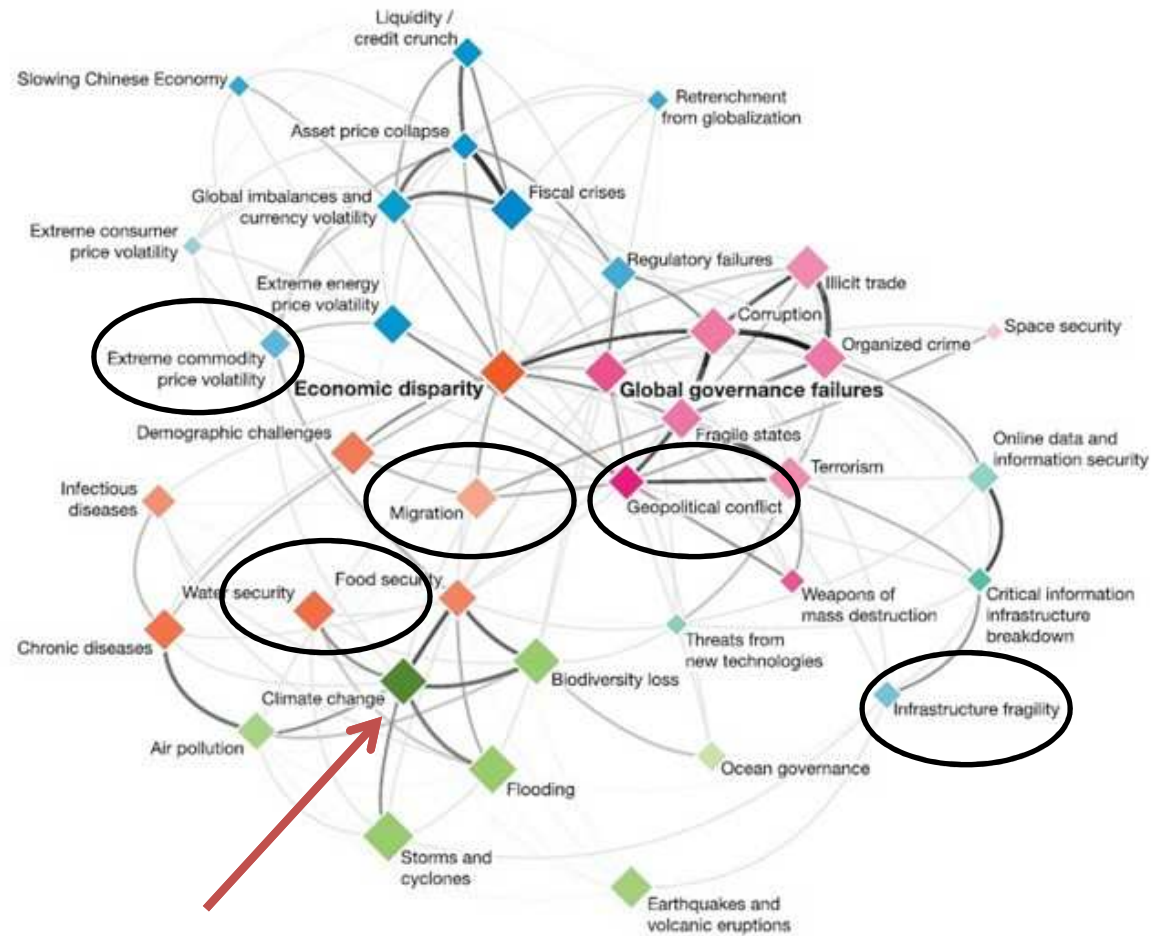


2012

Source: WEF



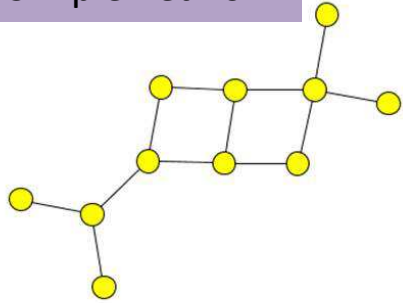
# Interconnections



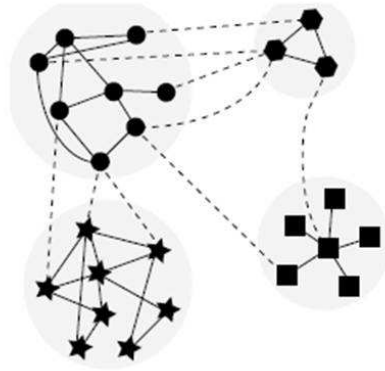
Source: WEF

# and their fragility

Simple network

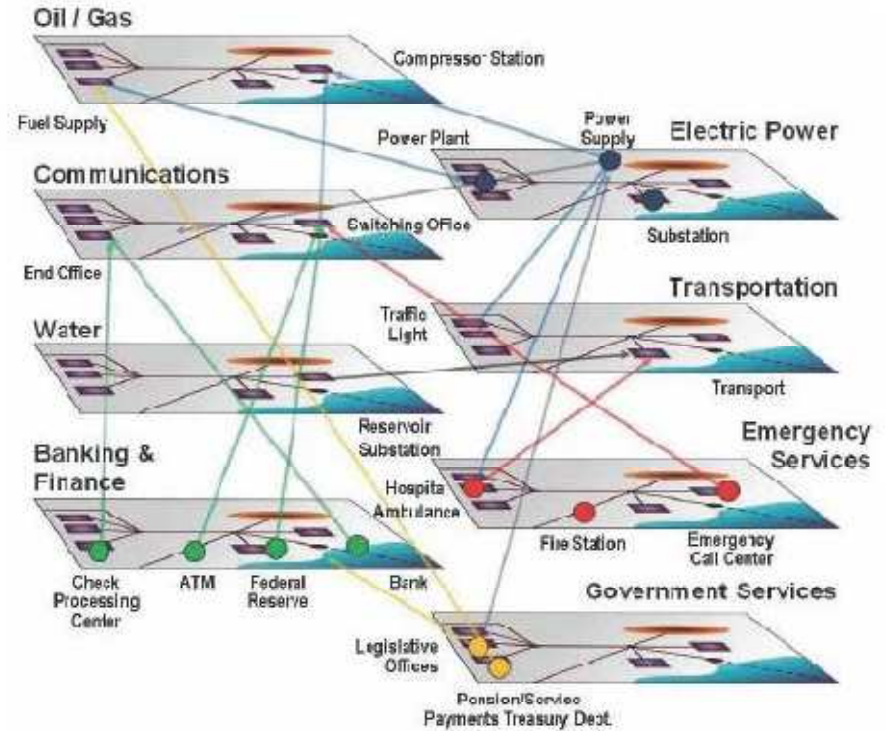
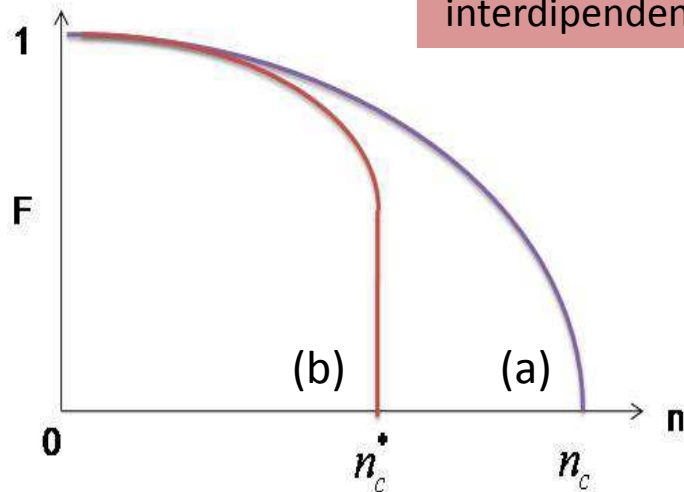


(a)



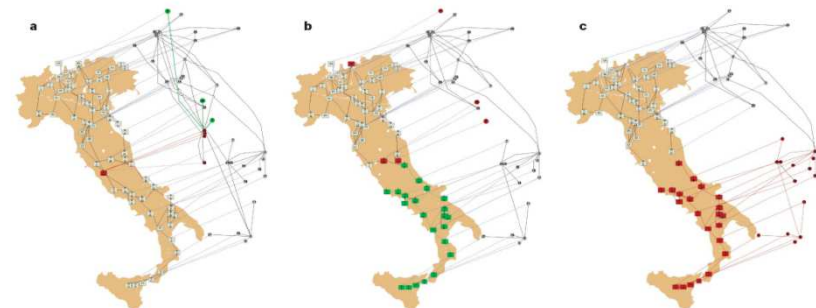
(b)

interdependent network



Italy's blackout del 23/09/2003

Internet control network  
Scada comm.



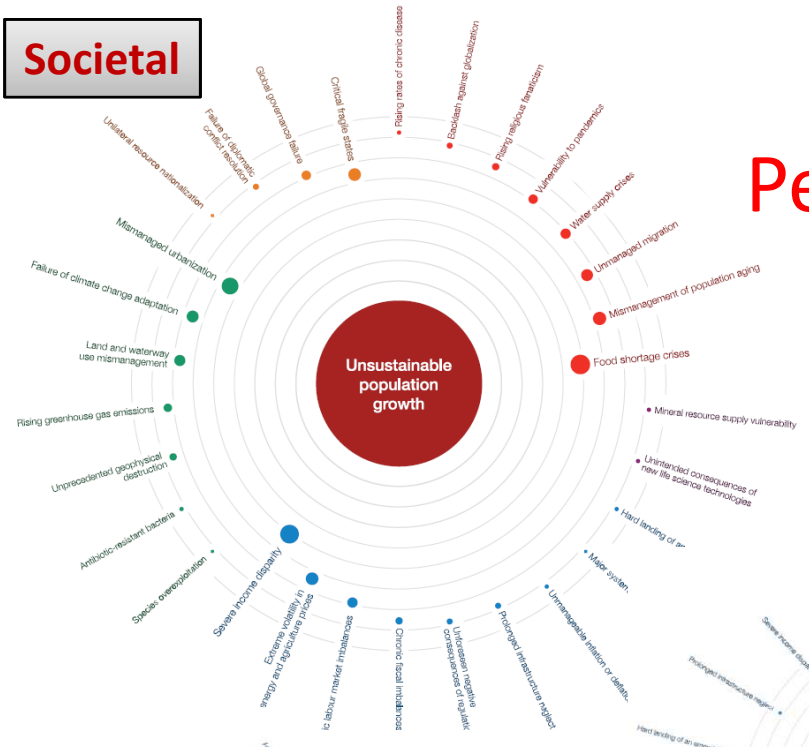
Power network

S.V. Buldrev, R. Parshani, G. Paul, H.E. Stanley & H. Havlin. *Catastrophic cascade of failures in interdependent networks*. Nature Vol. 464 (2010)

# Global Perception of The risk

**Societal**

**Technological**



**Geopolitical**

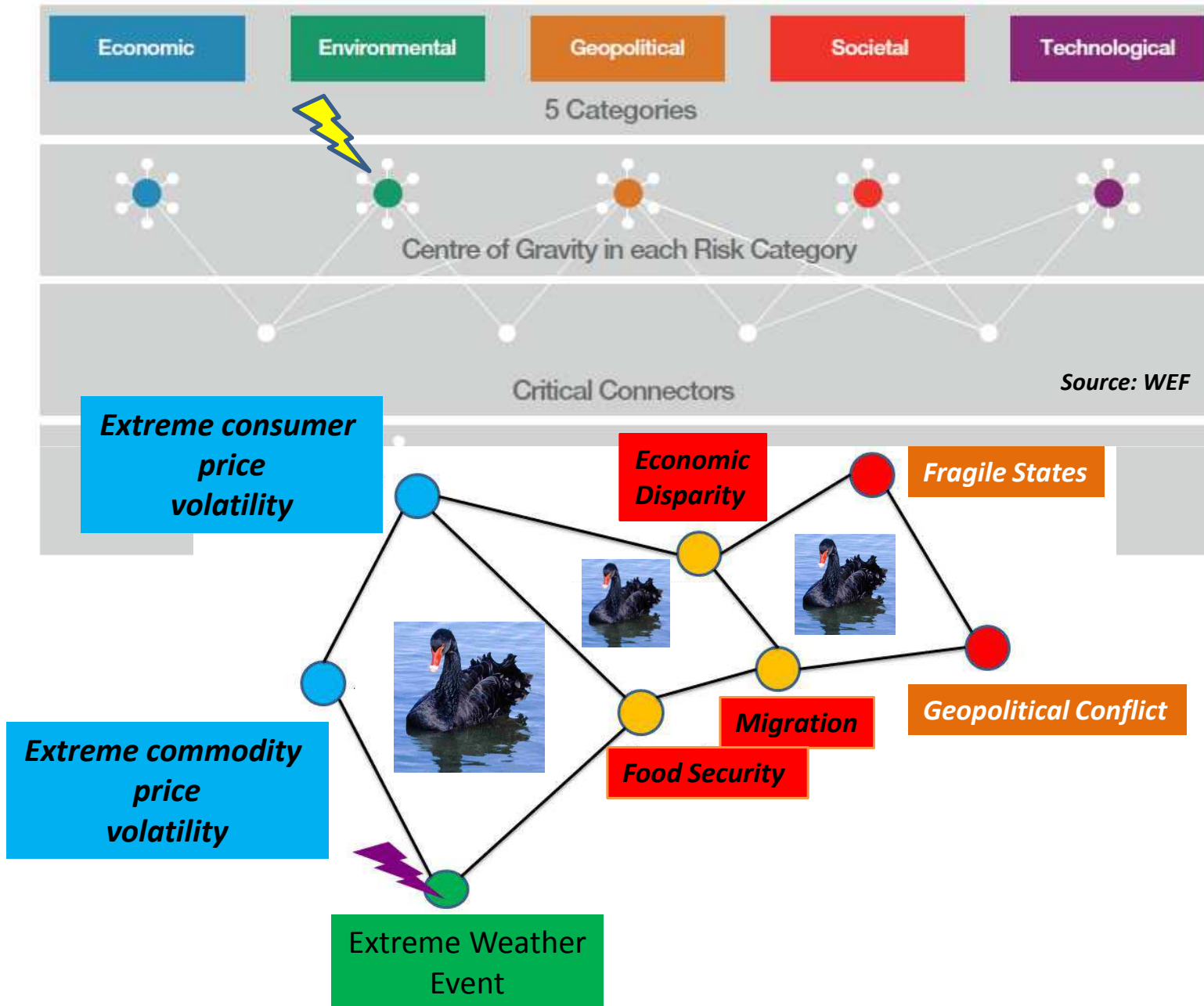
**Environmental**

**Chronic fiscal imbalances**

**Economic**

Source: WEF

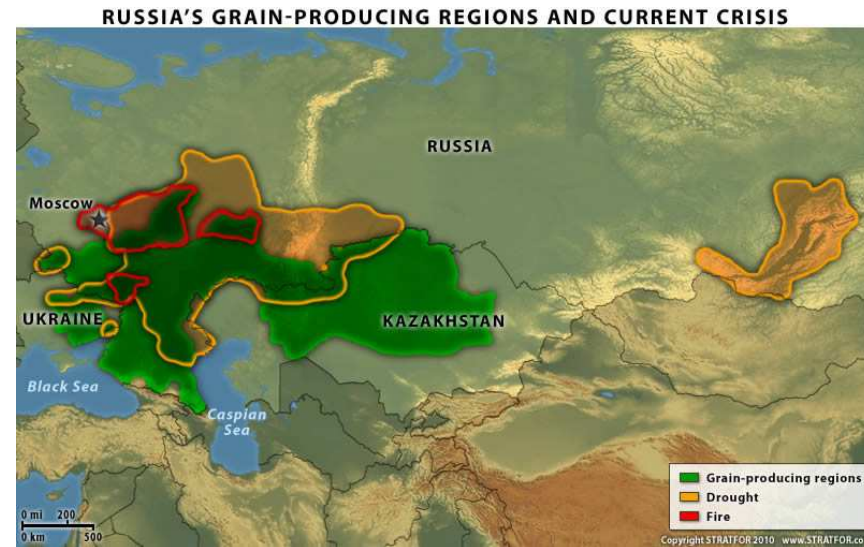
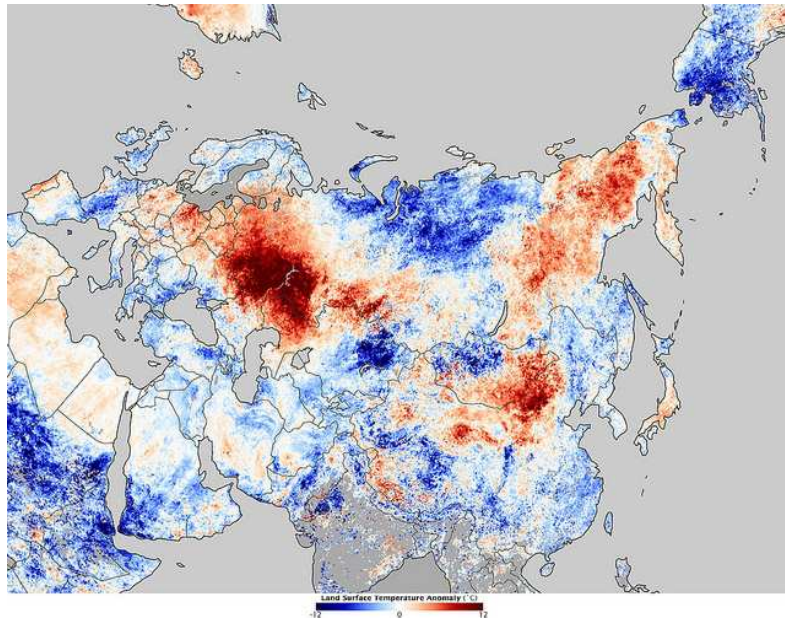
# An exercise of economic intelligence



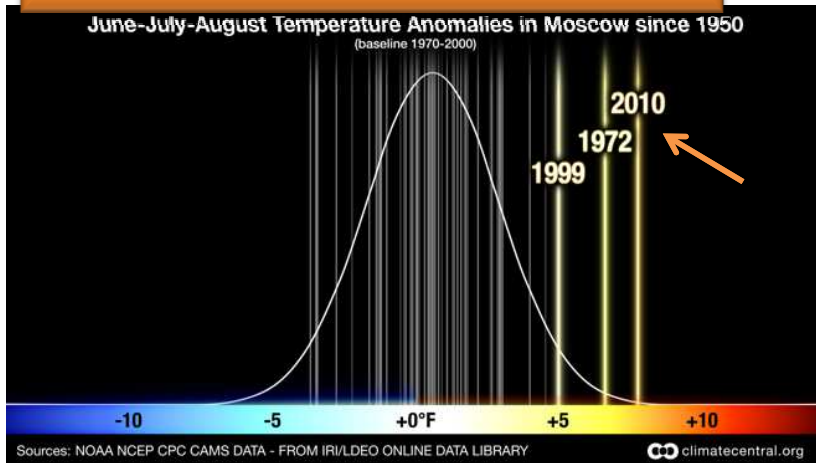


# the event: Heat Wave in Russia

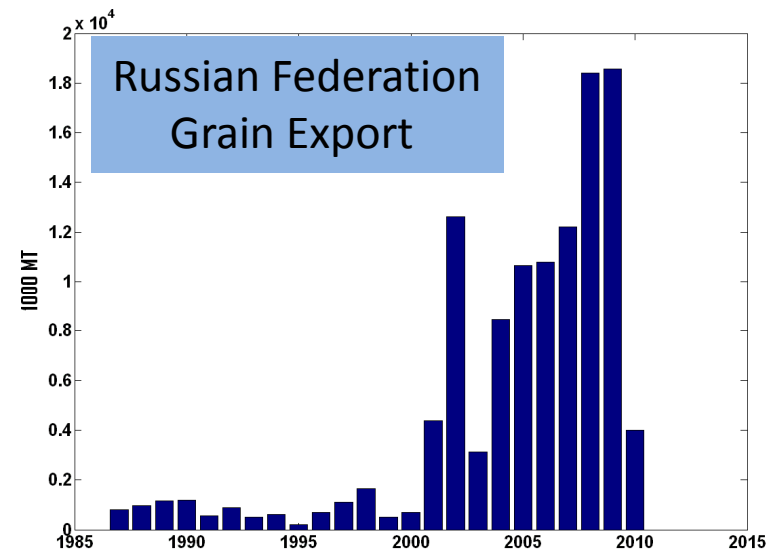
# the datum



## Eurasia: Temperature Anomalies June 2010 (rif. 1961-90)

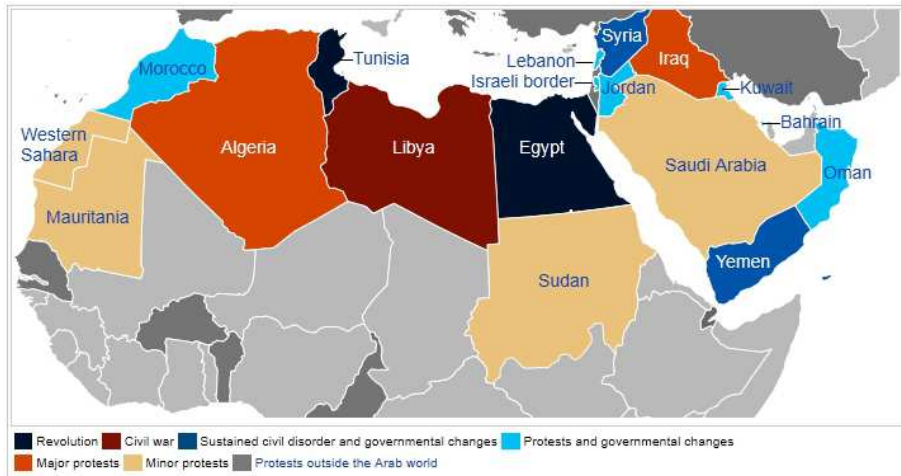


## Moscow: Temperature Anomalies



source: International Monetary Fund

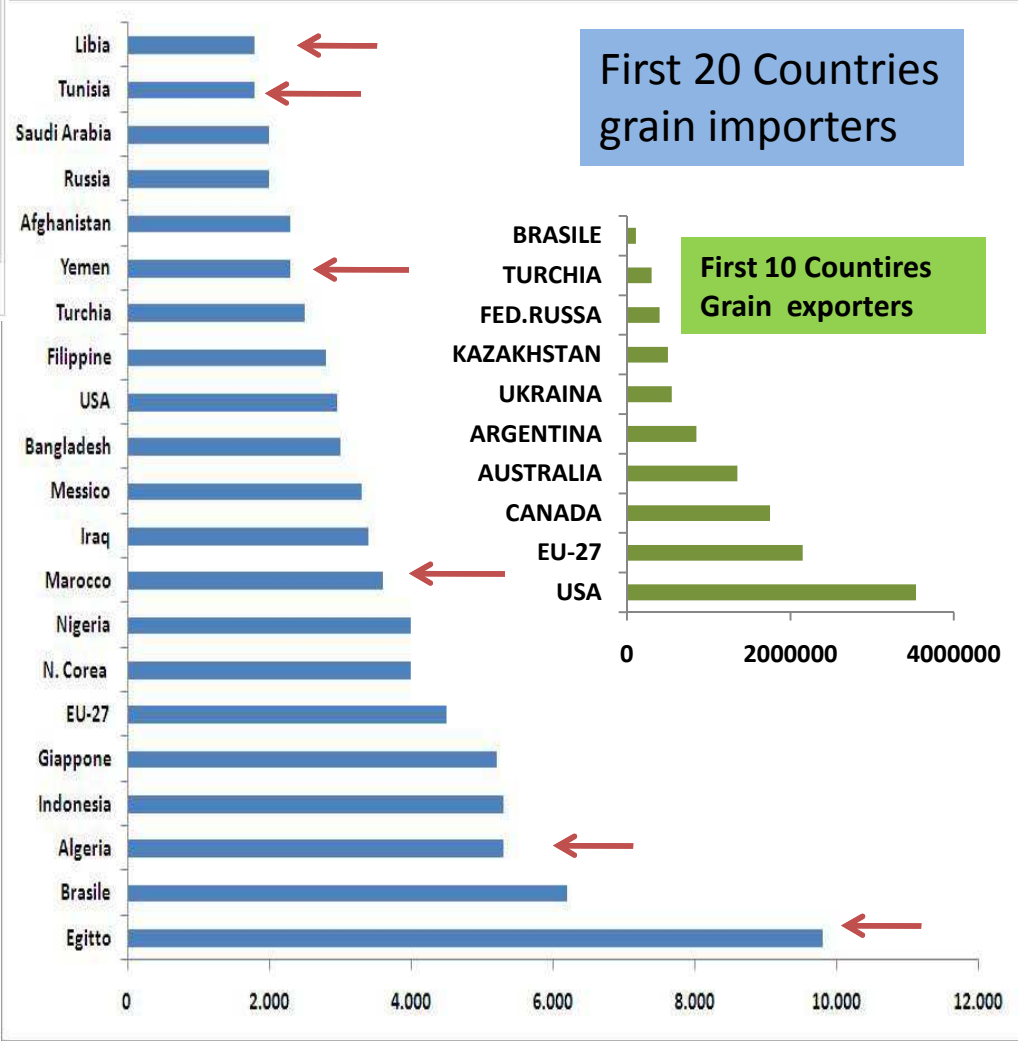
# The information



2007-2008  
beginning of the global financial crisis

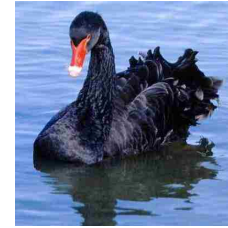


monthly price of wheat  
1980-2011



source <http://www.indexmundi.com/agriculture/>

# The Facts



**TUNISIA**



**EGYPT**



## **TUNISIA**

**Riesplode la rivolta del pane**

**"Uccisi cinquanta manifestanti"**

**La polizia ha aperto il fuoco sulla folla a Tala.**

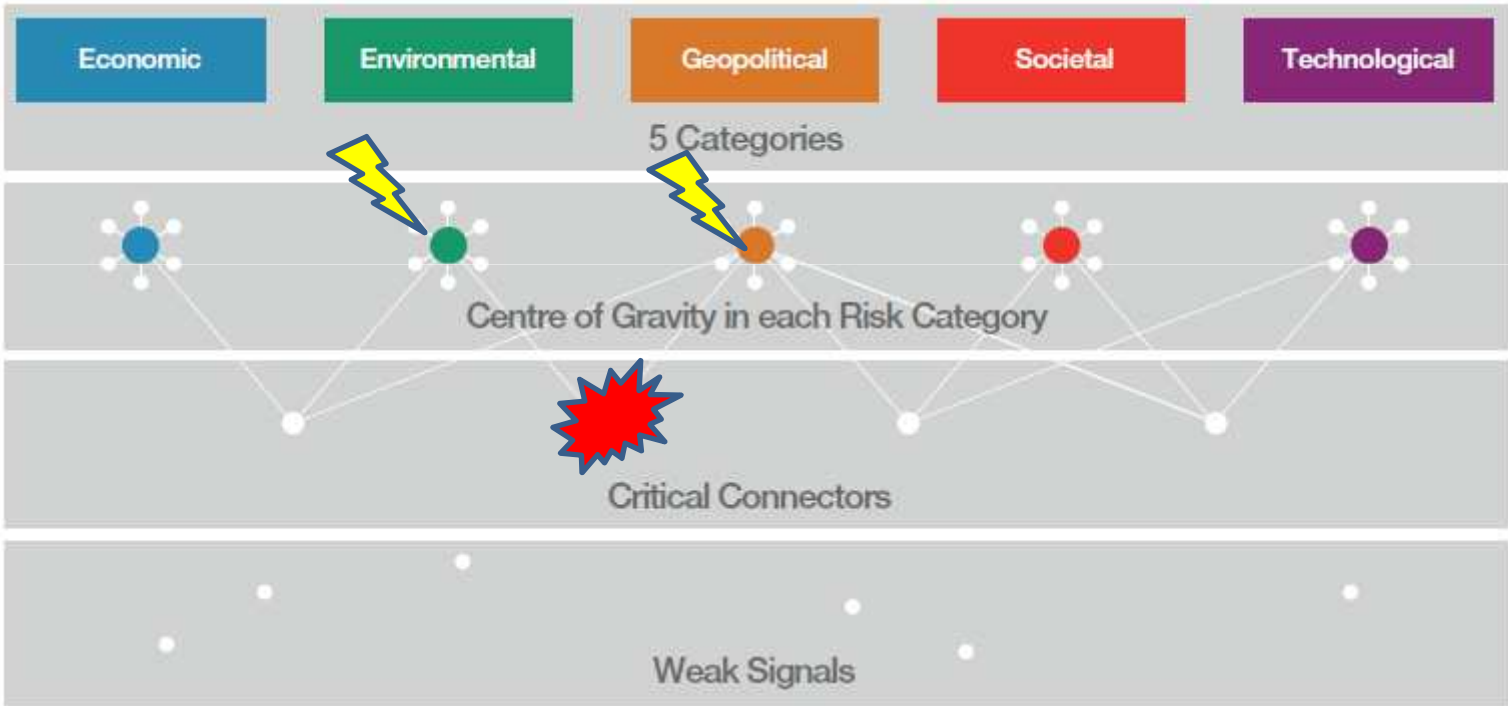
**La protesta contro il caro vita continua anche in Algeria, dove negli ultimi giorni quattro persone sono state uccise e circa 800 persone, tra le quali 300 agenti, sono rimaste ferite**

***La Repubblica 09 gennaio 2011***



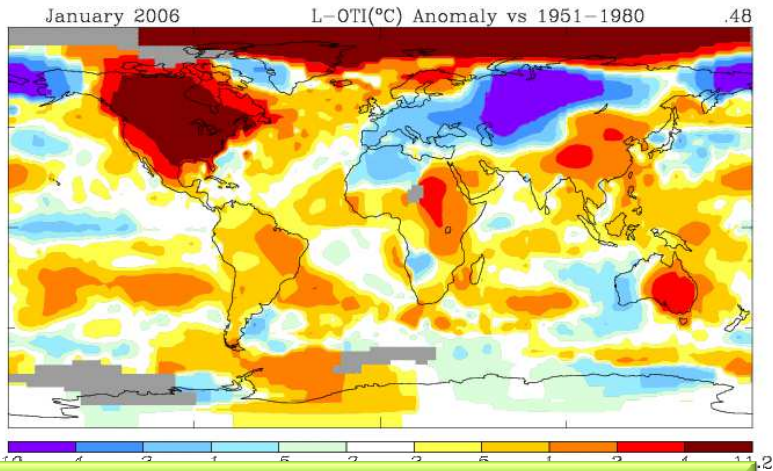
**ALGERIA**

# a lesson learned





# Environmental



# The Winter 2006 Cold Wave

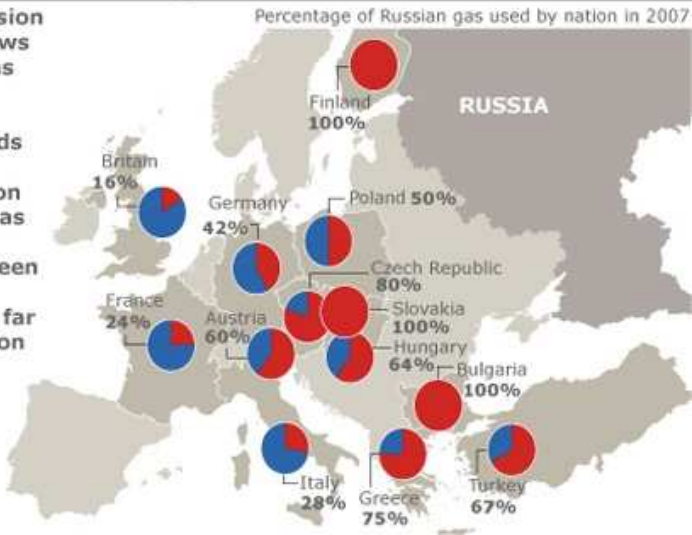
# Geopolitical



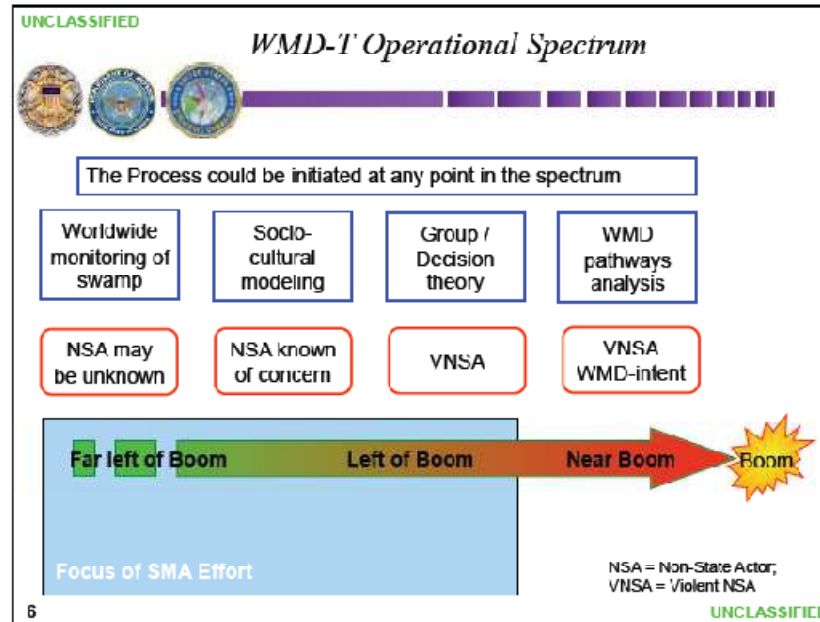
# The Russia-Ukraina Crisis

## Dependence on Russian gas

Russia's decision to cut gas flows to Ukraine has once again highlighted Europe's needs to reduce its dependence on Russian gas, as the pricing dispute between Moscow and Kiev appears far from resolution



# Left of boom...



WMD-T-> Weapons of Mass Destruction-Terrorism



Strategic Planning

Decision Making

Climatology:  
Search for Hot Spots

Network Analysis  
on  
Risk impact

Meteorology:  
EPS Forecasting