Simple assessments of the benefits from early warning systems and stronger hydro-meteorological systems

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Measuring the value of weather forecasts

I produce a forecast, what is its value?

Answer:

It depends on who uses it, and for what type of use.

Corollary:

One cannot measure the value or quality of a forecast independently of its user. (we need one measure for each user)

Meteorological factors influence the economy

- Agriculture
- Energy and electricity production
- Tourism
- Water management
- Construction
- Transportation
- Trade
- Everyday life

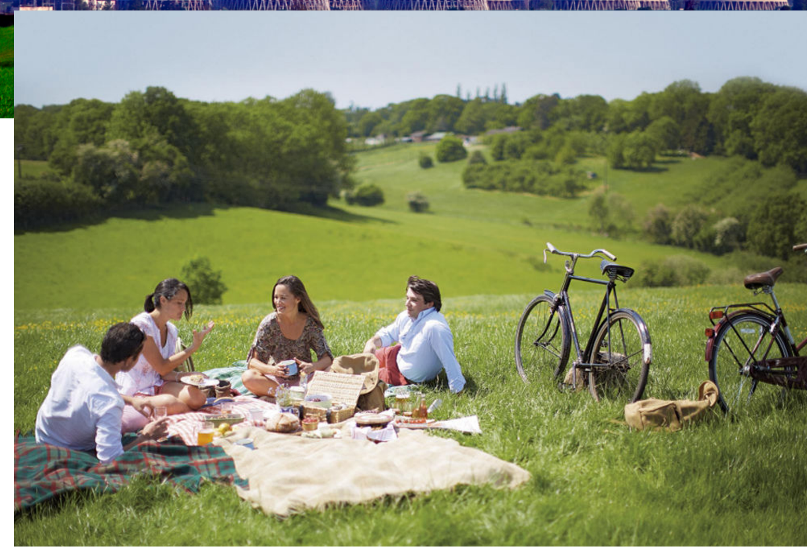
- Natural disasters

Complexity of the assessment

- Multiplicity of timescales
  - Observations
  - Nowcasting
  - Short-term forecasts (up to 10 days)
  - Seasonal forecasts (up to 6 months)
  - Climate forecasts (decades, centuries)

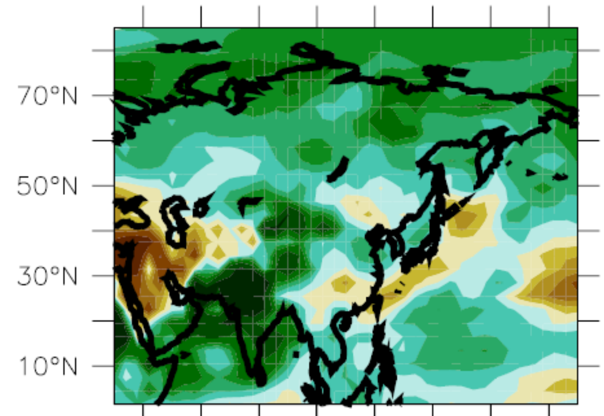
- Multiplicity of actors
  - Households
  - Industries
  - Public organizations

- Multiplicity of use
  - Safety of goods and persons
  - Production optimization
  - Private use

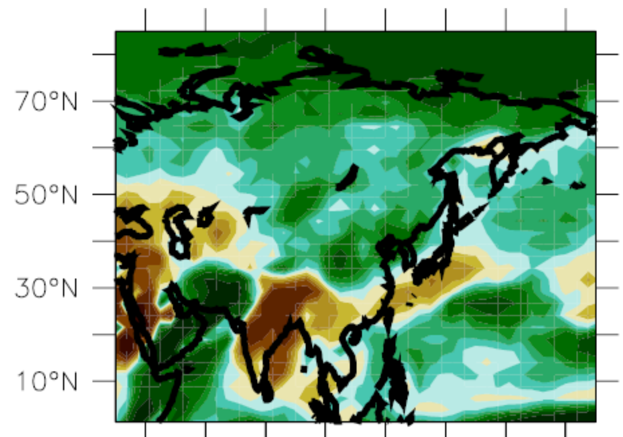


Climate data and information also key for infrastructure design

- **Infrastructure design requires also anticipation**:
    - Water management infrastructure (lifetime: up to 200 years);
    - Energy production and distribution infrastructure (up to 80 years);
    - Transportation infrastructure (50 to 200 years) ;
    - Natural disaster protections (50 to 200 years);
    - Urbanism, housing and architecture (25 to 150 years).
- These infrastructures represent more than 200% of GDP in developed countries.
- In **developing countries**, these infrastructures are currently being built and it is crucial to take climate change into account.



The GISS model



The IPSL model

A framework to assess the values of hydromet information needs to start from how it is used….

Time scale / Use	Safety (avoided economic and human losses)	Economic activity optimization	Private use	National security
Observation				
Now-casting (hours)				
Short-term forecasts (days)				
Medium- to long-term forecasts (10 days to seasons)				
Climate and decadal forecasts (decades and more)				
Knowledge				

Why a full assessment is out of reach....

Economic losses: how much can we save with early warning systems?

½-hr warning (1)	2-hrs warning (2)	4-hrs warning (3)	> 4-hrs warning (4)
Color television (console) Color television (portable) Stereo equipment Smallest electric appliances Vacuum cleaner Personal effects	Carpet sweeper Larger appliances, such as microwaves, blenders, toaster ovens Items in cupboards Expensive clothing Curtains and drapery Vehicles Additional personal effects	Largest appliances, such as dryer and refrigerator Bookcases Dining table and chairs and other furniture Food Some carpet Additional clothing and personal effects	Appliances such as dishwasher, oven, freezer, and washer Kitchen utensils Central heating system Piano Dressers Beds Linoleum/tiles

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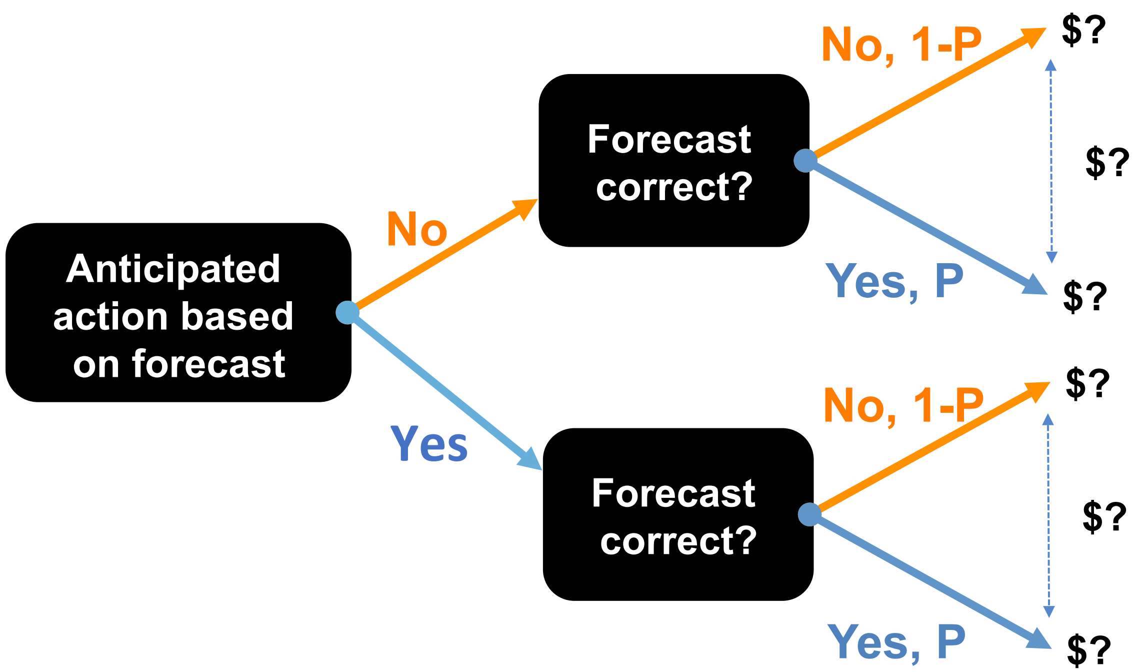
Economic losses: how much can we save with early warning systems?

Depth (ft) (1)	Mitigation time, hrs 0 (2)	1 (3)	6 (4)	12 (5)	24 (6)	36 (7)	48 (8)
-3	0	0	0	0	0	0	0
-2	0	0	0	0	0	0	0
-1	0	0	0	0	0	0	0
0	10	8	6	5	4	4	4
1	17	15	12	11	9	9	8
2	23	21	17	16	13	11	11
3	29	26	22	21	16	15	14
4	35	32	27	27	23	20	19
5	40	37	33	32	27	25	23
6	45	42	36	36	31	27	25
8	55	51	44	43	38	33	30
10	60	55	48	46	40	35	31
15	60	55	48	47	40	35	31
20	60	55	48	47	40	35	31

The economic value does not increase linearly with the lead time (nor with the quality of the forecast)

Imperfect forecasts are difficult to use....



When to evacuate a city (or move the piano)?

- We need to consider the expected cost of different scenarios

	No flood	Flood
Do nothing	$ 0	$ -100
Early action	$ -10	$ -50

- When is it better to act early?

Cost(Action) → Px50+(1-P)x10=10+40P

Cost(NoAction) → Px0+(1-P)x100=100P

If P > 16%, the authority should go for the evacuation

The best "prediction" depends on the cost of various actions

	No flood	Flood
Do nothing	$ 0	$ -100
Early action	$ **-10**	$ -50

When is it better to evacuate?

Cost(Action) → Px50+(1-P)x10=10+40P

Cost(NoAction) → Px0+(1-P)x100=100P

Warning if P > 16%

	No flood	Flood
Do nothing	$ 0	$ -100
Early action	$ **-20**	$ -50

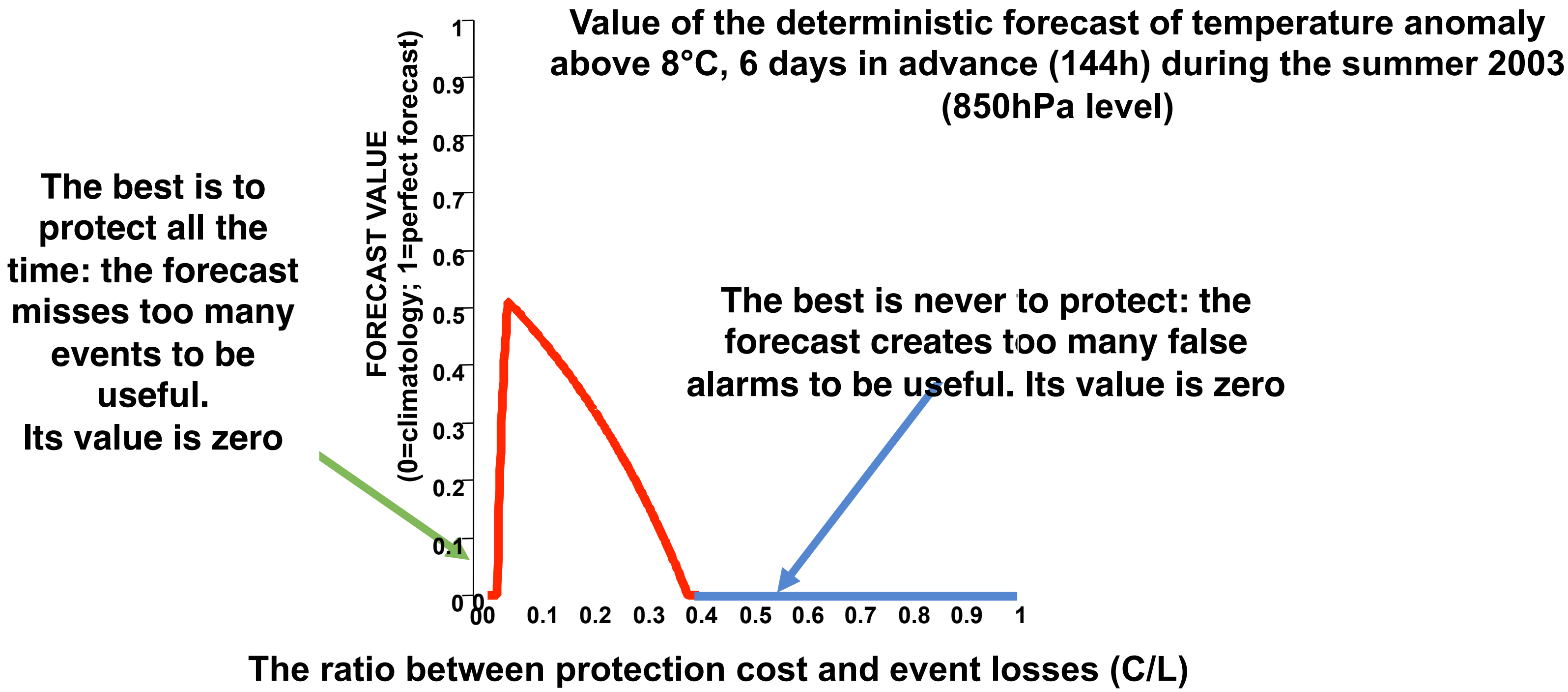
When is it better to evacuate?

Cost(Action) → Px50+(1-P)x20=20+30P

Cost(NoAction) → Px0+(1-P)x100=100P

Warning if P > 29%

The value of a forecast depends on the cost and benefit of early action



And we have to account for human behavior…

Reason	Escambia	Charlotte
Thought I could ride it out	53.6	27.2
Storm was predicted to hit elsewhere	1.8	25.6
Was not aware hurricane was coming	0.0	4.1
Concerned about leaving pets	8.3	6.1
Concerned about leaving house unattended	8.3	5.7
Had no place to go	1.8	2.0
Had no transportation	1.2	1.2
Medical condition prevented evacuation	4.2	3.7
Job did not permit leaving	6.8	2.9
Did not have enough time	0.0	4.9
Other	14.0	16.6

Fleeing The Storm(s): An Examination of Evacuation Behavior During Florida's 2004 Hurricane Season

STANLEY K. SMITH and CHRIS MCCARTY

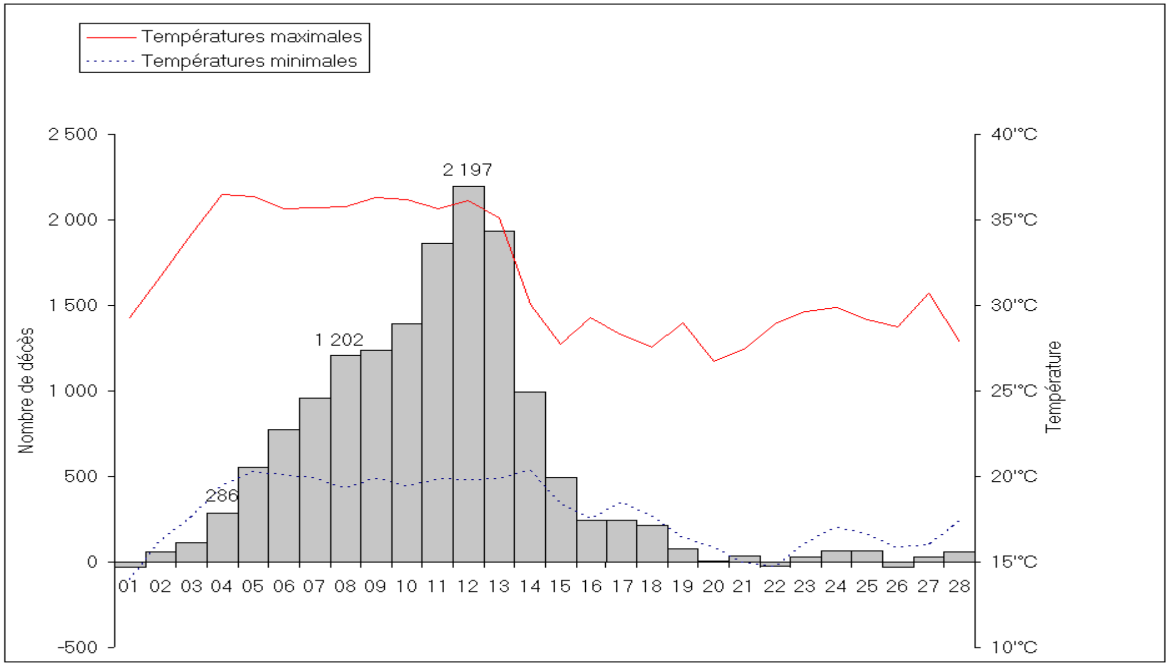
Can we do a simple assessment?
The case of France

Assessment of economic benefits

- **An assessment of economic losses avoided thanks to early warning systems:**
  - Flood and storm losses could be reduced by 25% in 50% of the cases (or 50% in 75% of the cases) = between 140 million and 840 million EUR per year
- **Private use of weather information**
  - In the US, median estimate of US$109 per year and per household, with 86% of households ready to pay more than $10 and 80% more than $32.
  - Assuming French people ready to pay 20-80 EUR per year = 500 million to 2 billion EUR per year
- **Economic optimization**
  - Large annual value added in sensitive sectors:
    - Agriculture: 34 billion Euros ;
    - Agro-business: 28,2 milliards Euros;
    - Energy : 32,5 billion Euros;
    - Construction : 69,7 billion Euros ;
    - Transport : 64.0 billion Euros.
  - Assuming between 0.1% and 1% in gains: benefits between 220 million and 2.2 billion EUR
- **Infrastructure design**
  - 200% of GDP in infrastructure. If inappropriate design requires a 1% annual retrofit after 2050, then it will cost 30 billion EUR per year post 2050
  - Equivalent to a net prevent cost of 3 billion EUR per year (7% discount rate)
  - Gains thanks to climate projections between 3 and 30% leads to benefits between 100 million and 1 billion EUR per year.

How to account for human losses? Can we use a “statistical value of a human life” ?

Additional deaths observed on a daily scale during August 2003, and maximum daily temperature.



- Floods, storms, avalanche, heat waves
- Fishermen
- Commercial aviation
- Leisure aviation, sailing, hiking
- Technological/nuclear incident

Assuming 100 to 500 lives are saved every year, and using the French value (1 million EUR per life) leads to between 100 and 500 million EUR per year

Back of the envelope calculation. The case of France

Time horizon	Sector		Minimum	Likely
Short to medium term	Safety	Persons	200	2 250
		Assets	140	850
	Private use		500	2 000
	Optimisation de Production		220	2 200
Seasonal			0	0
Climate change			100	1 000
Knowledge spill-overs			?	?
TOTAL			1 160	8 300

Benefits between 1.2 and 8.3 billion EUR per year, i.e. 4 to 30 times the annual cost.

What about the marginal cost?

Can we use this assessment to assess the benefits from providing the same level of service in developing countries?

Potential global benefits from improved early warning systems

	GDP (million USD)	Potential (European-like) benefits		Ratio of current vs potential benefits	Estimation of actual benefits		Benefits from improved services	
		Low estimate	Likely estimate		Low estimate	Likely estimate	Low estimate	Likely estimate
Low income	413,000	12	69	10%	1	7	11	62
Lower middle income	4,300,000	122	714	20%	24	143	97	572
Upper middle income	15,300,000	433	2,542	50%	217	1,271	217	1,271
High income	43,000,000	1,217	7,145	100%	1,217	7,145	-	-
TOTAL	63,013,000	1,784	10,470		1,459	8,565	**324**	**1,904**

Potential co-benefits from better hydromet information for economic optimization….

	GDP (million USD)	Potential (European-like) benefits		Ratio of current vs potential benefits	Estimation of actual benefits		Benefits from improved services	
		Low estimate	Likely estimate		Low estimate	Likely estimate	Low estimate	Likely estimate
Low income	413,000	103	1,033	10%	10	103	93	929
Lower middle income	4,300,000	1,075	10,750	20%	215	2,150	860	8,600
Upper middle income	15,300,000	3,825	38,250	50%	1,913	19,125	1,913	19,125
High income	43,000,000	10,750	107,500	100%	10,750	107,500	-	-
TOTAL	63,013,000	15,753	157,533		12,888	128,878	**2,865**	**28,654**

Overall, a very good investment, provided that it is done efficiently

Type of benefits	Annual benefits (million USD)		Annual cost (million USD)	Benefit-cost ratio	
	Minimum	Maximum		Minimum	Maximum
Reduced asset losses from disasters	300	2,000	1,000	4	35
Reduced human losses from disasters	700	3,500			
Other economic benefits	3,000	30,000			
Total	4,000	35,500			