

Economic Assessment of Hydro-Met Services and Products: A Value Chain Approach

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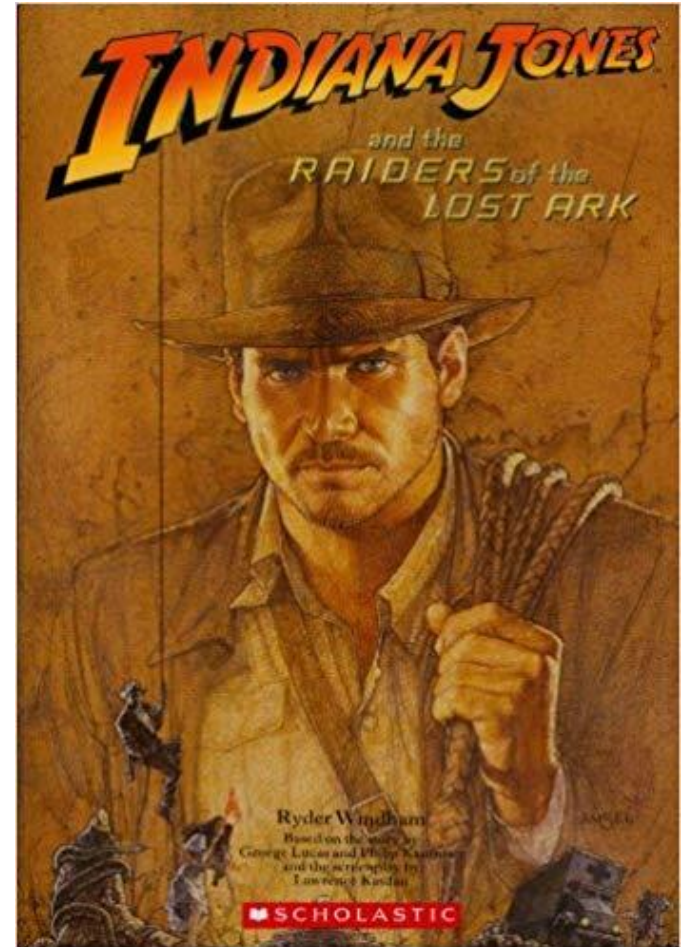
August 21, 2019

Before I begin ...

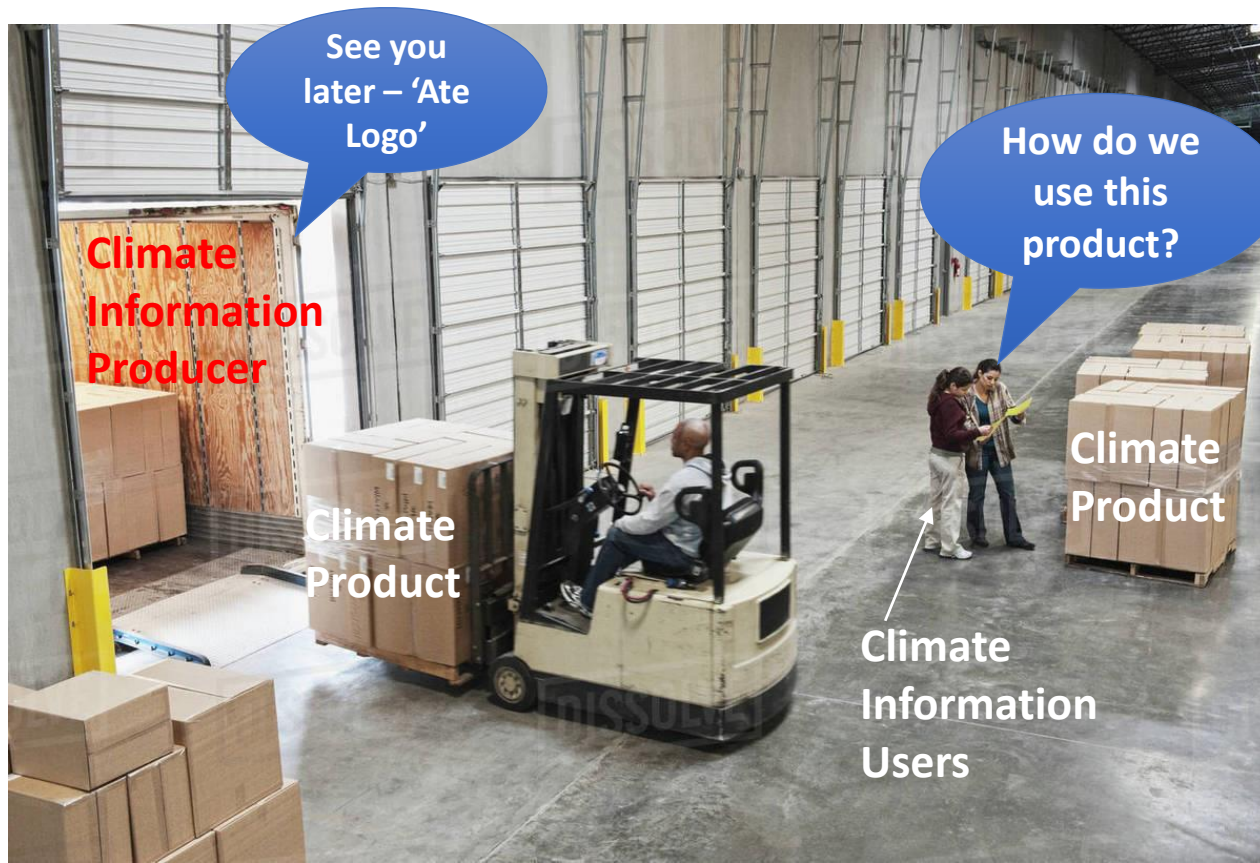
- Thank you APEC and all involved!
- First ... an apology to all those in line for coffee yesterday morning ...
- Second ... a note on introverts ...
- A second apology ... and a thought about Glenn's talk yesterday ...

**The creation,
communication, and
use of climate
information ...**

***... with thanks (and
apologies) to Glenn
McGregor for loaning me his
“warehouse slide”***



Provision of Climate Information – Avoid the ‘Loading Dock’ Approach

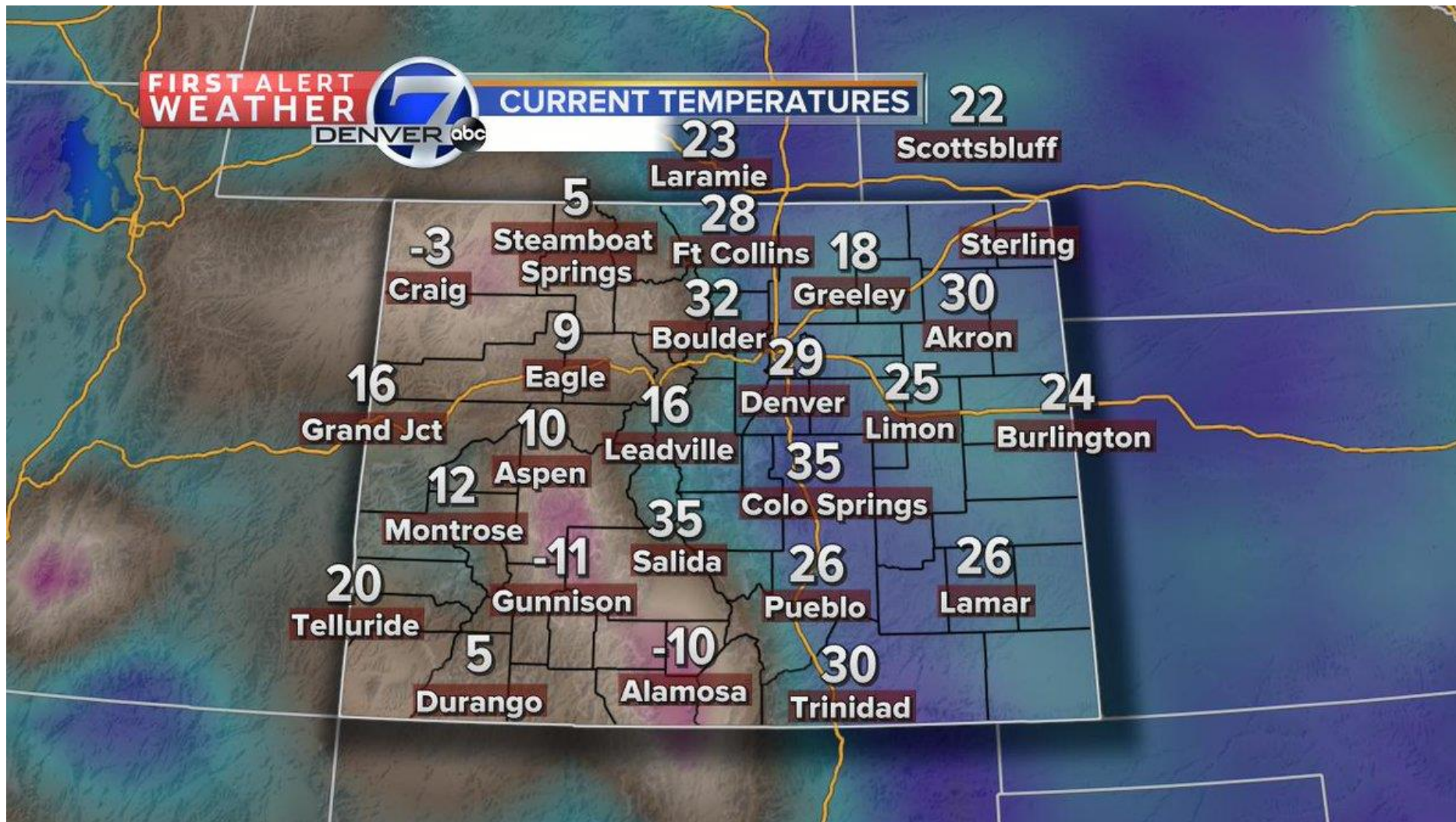


A man in a blue uniform is pushing a wooden crate on a dolly. The crate has a warning label that reads "TOP SECRET ARMY INTEL 9906763 DO NOT OPEN!". The scene is set in a warehouse or storage area with wooden walls.

TOP SECRET
ARMY INTEL 9906763
DO NOT OPEN!



Again ... before I start ... thoughts about climate change ...



Gunnison – winter 2017/18 – summer 2018

One of lowest snowfalls on record

- hurt the ski industry
- wildfires all summer
- low water levels in reservoir hurt agriculture including hay and ranching
- some of the best fishing in years – no where for the fish to hide!
- Gunnison Valley Observatory – smoke caused very poor viewing at the observatory



Gunnison – winter 2018/19 – summer 2019

One of highest snowfalls on record

- great for skiing!
- Reservoir levels rebounded! Some of the worse fishing in years – possibly so much vegetation in reservoir from the prior year the fish weren't biting
- amazing hay yields – but prices likely to plunge due to oversupply!
- Flooding in rivers closed many rivers to white water rafting
- huge energy production at the dams
- wildflowers everywhere and extreme hot weather elsewhere in the country led to significant tourism in the county summer 2019



Gunnison and climate change

- Weather is the connection for many people to the idea and reality of climate change
- Locals
 - blame bad winter on climate change
 - Good winter is “back to normal”
- Very local effects
 - most people are local – not global
- “Climate change” leads to positive and negative socio-economic impacts
 - Changes in skiing and fishing recreation
 - Changes in agricultural output may be opposite of price changes and profits
- Understanding use of information, communication, decisions, outcomes and economic impacts ... that is what this talk is about
- ...

Again ... before I start ... my thoughts about climate change ...

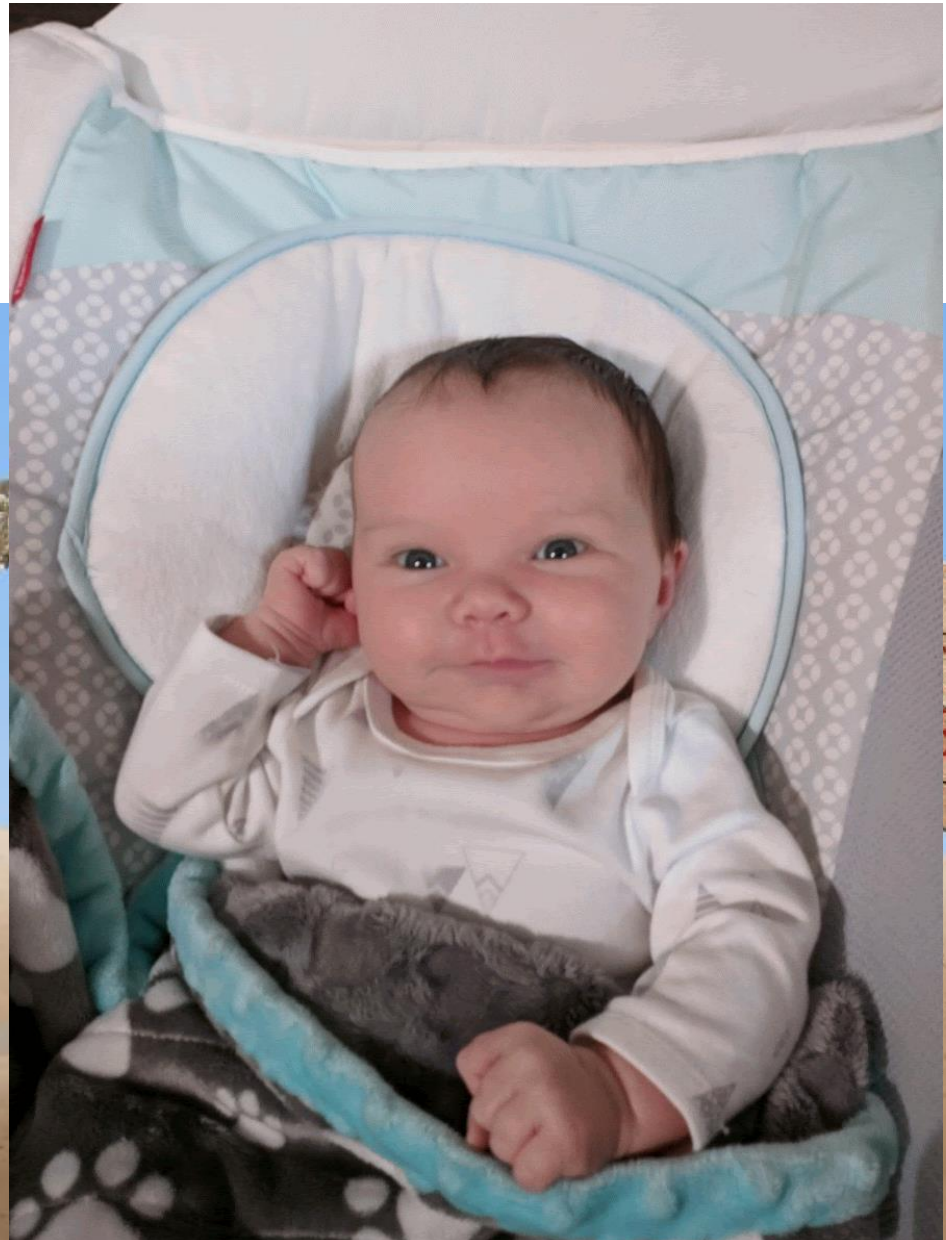
I am not a climate expert

I am not a climate denier by any means

I am not also very much a climate activist

I may have been a climate ostrich!

But ... like a “local” I believe I am experiencing climate change – and will experience negative social and economic impacts before I die ...



Is climate change really a socio-economic problem?

Sharing our planet: Issues involving the global commons

1. Global warming

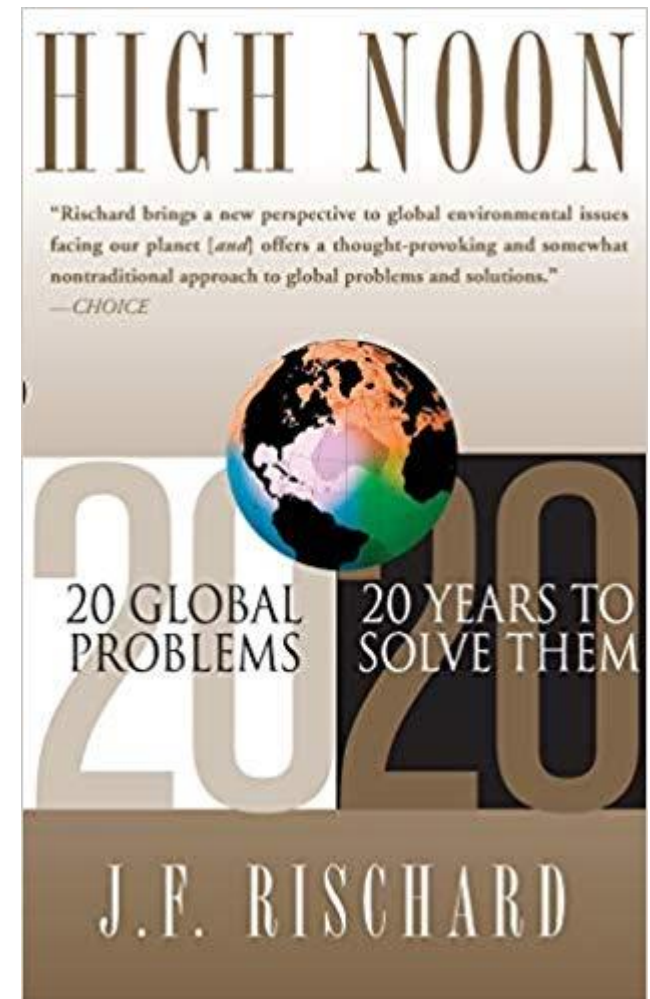
2. Biodiversity and ecosystem losses
3. Fisheries depletion
4. Deforestation
5. Water deficits
6. Maritime safety and pollution

Sharing our humanity: Issues requiring global commitment

1. Massive step-up in the fight against poverty
2. Peacekeeping, conflict prevention, combating terrorism
3. Education for all
4. Global infectious diseases
5. Digital divide
6. Natural disaster prevention and mitigation

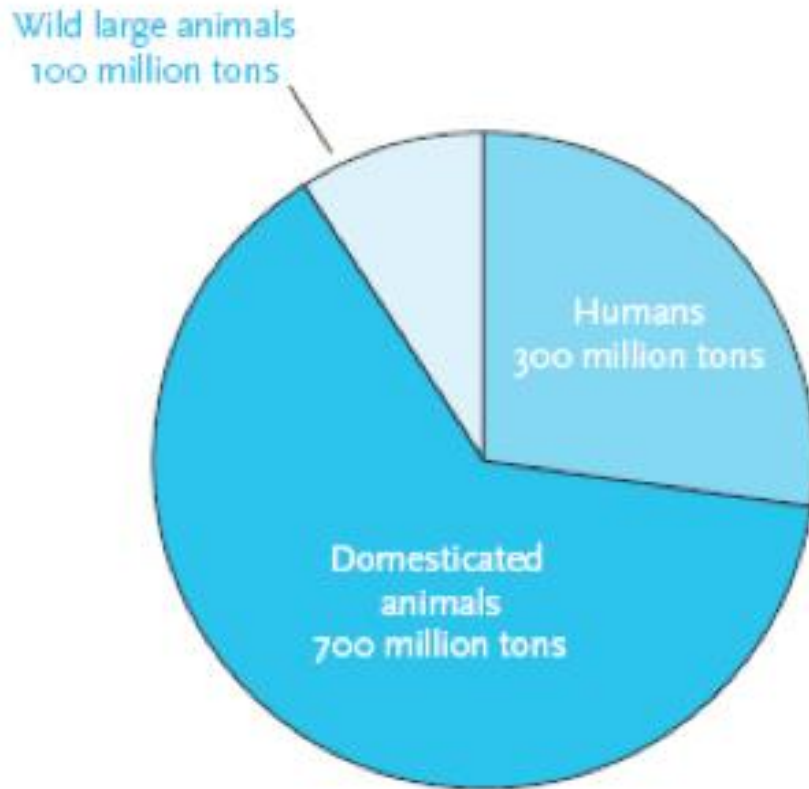
Sharing our rule book: Issues needing a global regulatory approach

1. Reinventing taxation for the 21st century
2. Biotechnology rules
3. Global financial architecture
4. Illegal drugs
5. Trade, investment and competition rules
6. Intellectual property rights
7. E-commerce rules
8. International labor and migration rules



Written in 2003

Is climate change really the socio-economic problem?



11. Pie chart of global biomass of large animals.

#1 NEW YORK TIMES BESTSELLER

Yuval Noah Harari

New York Times Bestselling
Author of *Sapiens*



Homo Deus

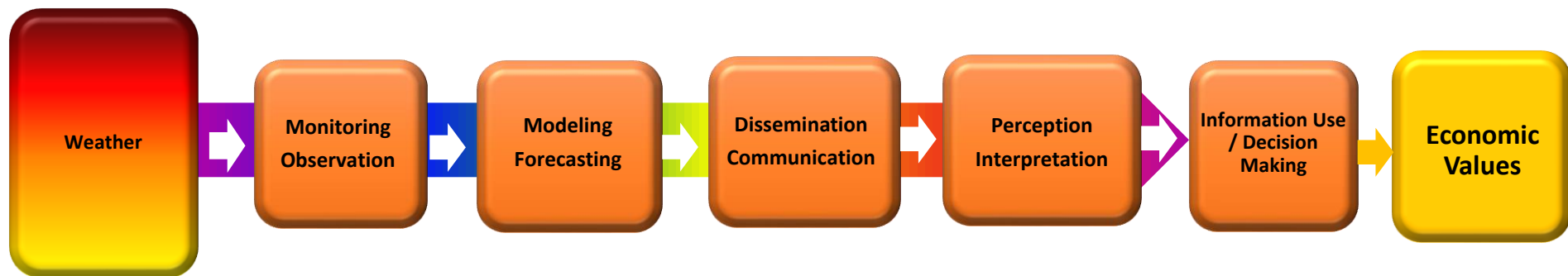
A Brief History
of Tomorrow

"Provocative. . . . The handiwork of a gifted thinker."

—NEW YORK TIMES

Objectives

Discuss some of the work I've been doing on economics and weather and the conceptual framework of the “*Weather Information Value Chain*” that is important to connecting the weather with the economics discussion



Outline

- Why Economics?
- Economic Valuation Methods
- ***Weather Information Value Chain***
 - Valuation methods
- “What to Value?” ... and some examples
 - Economic impact of weather
 - Value of current weather data and information
 - Value of current weather forecasts
 - Value of improved weather forecasts
 - Value of research to improve forecasts
 - Value of improving dissemination / comprehension / use / decision making / response ...
- Recommendations

Why economics?

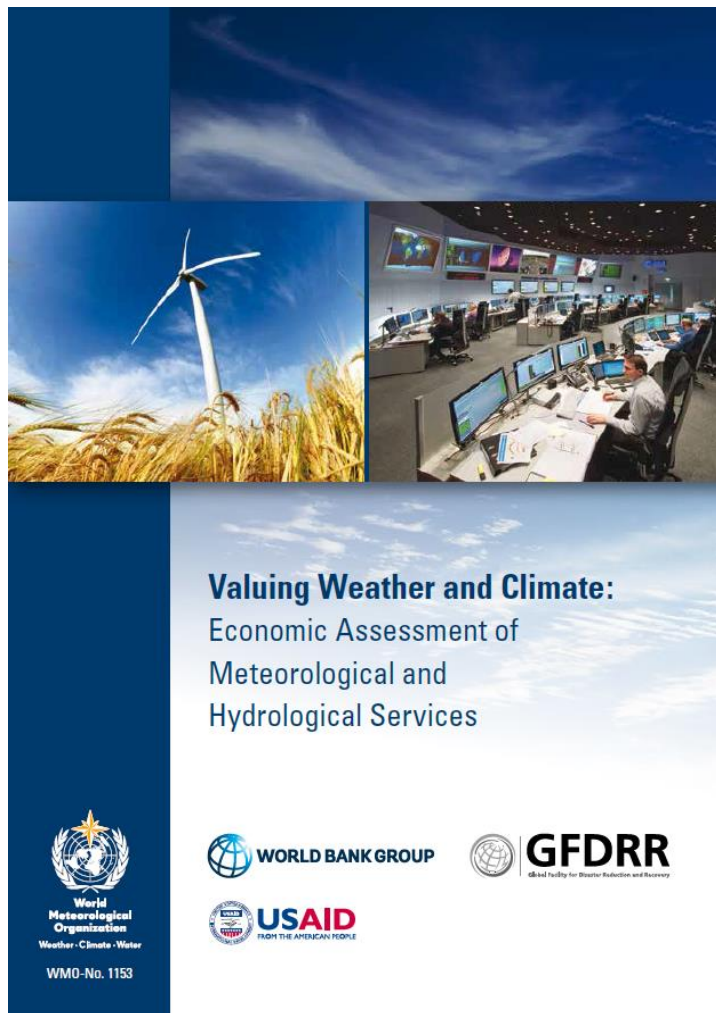
- ❖ Program evaluation / program justification
 - Validating the provision of basic met/hydro services
 - Validating past and current investments in specialized met/hydro services
 - Justifying new investments in met/hydro services
- ❖ Determining the value of NMHSs to user goals
- ❖ Prioritization or reallocation of resources
- ❖ Study of human behavior / decision making

❖ WMO, WBG, GFDRR & USAID. 2015. *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*. World Meteorological Organization, World Bank Group, Global Facility for Disaster Reduction and Recovery, and United States Agency for International Development, WMO No. 1153, Geneva, Switzerland.

<https://www.gfdr.org/valuing-weather-and-climate-economic-assessment-meteorological-and-hydrological-services>



What is the value of weather, water, and climate information?



WMO, WBG, GFDRR & USAID. 2015. *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services*. World Meteorological Organization, World Bank Group, Global Facility for Disaster Reduction and Recovery, and United States Agency for International Development, WMO No. 1153, Geneva, Switzerland.

<https://www.gfdr.org/valuing-weather-and-climate-economic-assessment-meteorological-and-hydrological-services>

What is the value of weather information?

SEB Study	Geographic Location	Sectors	Benefits Methods/Measures	Benefit/cost ratio
Contingent valuation study of the public weather service in the Sydney metropolitan area (Anaman et al., 1998)	Sydney, Australia	Households	Willingness-to-pay survey of households	4:1
Economic value of current and improved weather forecasts in the United States household sector (Lazo and Chestnut, 2002)	United States	Households	Willingness-to-pay (WTP) survey of households	4:1 +
Benefits of Ethiopia's Livelihoods, Early Assessment and Protection (LEAP) drought early warning and response system (Law, 2012)	Ethiopia	Households	Quantification of avoided livelihood losses and decreased assistance costs	3: 1 to 6:1
Success of the United States National Weather Service (NWS) Heat Watch/Warning System in Philadelphia (Ebi et al., 2004)	Philadelphia, Pennsylvania	Households/elderly	Regression analysis to determine lives saved; application of the U.S. EPA's Value of a Statistical Life estimate	2,000:1 +
The benefits to Mexican agriculture of an El Niño/ Southern Oscillation (ENSO) early warning system (Adams et al., 2003)	5-state region in Mexico	Agriculture	Change in social welfare based on increased crop production with use of improved information	2:1 to 9:1
The value of hurricane forecasts to oil and gas producers in the Gulf of Mexico (Considine et al., 2004)	Gulf of Mexico	Oil drilling	Value of avoided evacuation costs and reduced foregone drilling time	2:1 to 3:1
Economic efficiency of NMHS modernization in Europe and Central Asia (World Bank, 2008)	11 European and Central Asian countries	Weather-dependent sectors	Sector-specific and benchmarking approaches to estimate avoided losses	2:1 to 14:1
Benefits and costs of improving met/hydro services in developing countries (Hallegatte, 2012)	Developing countries	National level and weather-sensitive sectors	Benefits-transfer approach to quantify avoided asset losses, lives saved, and total value added in weather-sensitive sectors	4:1 to 36:1
Avoided costs of the FMI met/hydro services across economic sectors (Leviäkangas and Hautala, 2009)	Finland	Key economic sectors	Quantification of avoided costs and productivity gains; Also used impact models and expert elicitation	5:1 to 10:1
Social economic benefits of enhanced weather services in Nepal – part of the Finnish–Nepalese project (Perrels, 2011)	Nepal	Agriculture, transport, and hydropower	Need something on benefits measured or methods	10:1
Economic and social benefits of meteorology and climatology (Frei, 2010)	Switzerland	Transport, energy, aviation, agriculture, households	Benefits transfer, expert elicitation, decision modelling	5:1 to 10:1
Socioeconomic evaluation of improved met/hydro services in Bhutan (Pilli- Sihvola et al., 2014)	Bhutan	National level	Benefits transfer, expert elicitation, cardinal rating method	3:1

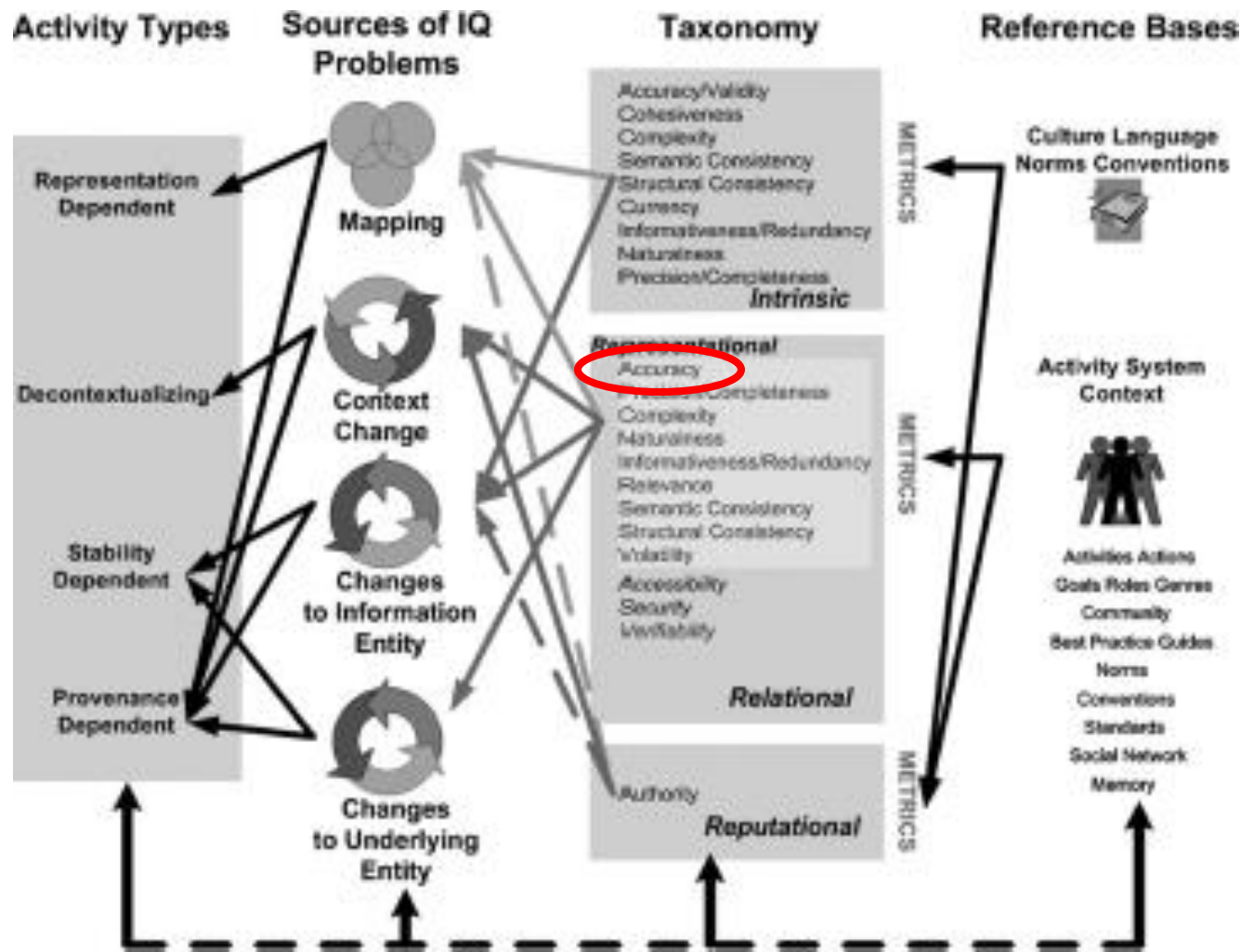
Value of Information

- Theoretical economic framework for “value of information” – VOI
 - “amount a decision maker would be willing to pay for information prior to making a decision”
- Decision-making under uncertainty

Laxminarayan, Ramanan; Macauley, Molly K., eds. (2014-09-21). *The Value of Information: Methodological Frontiers and New Applications in Environment and Health* (2012 ed.). New York. Springer. [ISBN 9789400798083](#).

Quality of Information

- How do we measure information quality?
- It is much more multi-dimensional than we normally consider!



Economic valuation methods

Sector Specific / Benchmarking / Expert Elicitation

Non-market valuation techniques

- Stated preference methods
- Revealed preference methods

Economic decision modelling

- Decision analysis
- Equilibrium models
- Econometric models

Avoided cost/damage assessments

- including avoided mortality and morbidity impacts

Benefits transfer (BT)

Economic valuation methods

Sector Specific / Benchmarking / Expert Elicitation

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**Back of the
envelope ...**

Economic valuation methods

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Benefits transfer (BT)

Primary methods ...

Economic valuation methods

Sector Specific / Benchmarking / Expert Elicitation

Non-market valuation techniques

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Economic decision modelling

- Decision analysis
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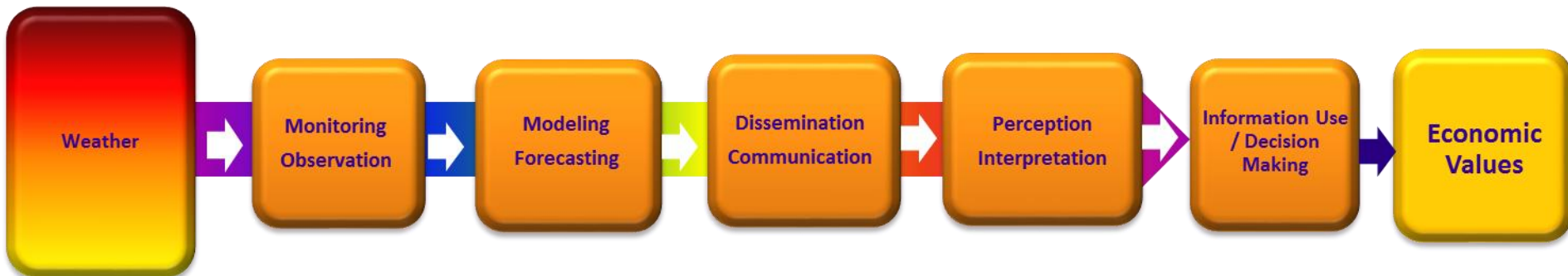
Benefits transfer (BT)

Secondary methods ...

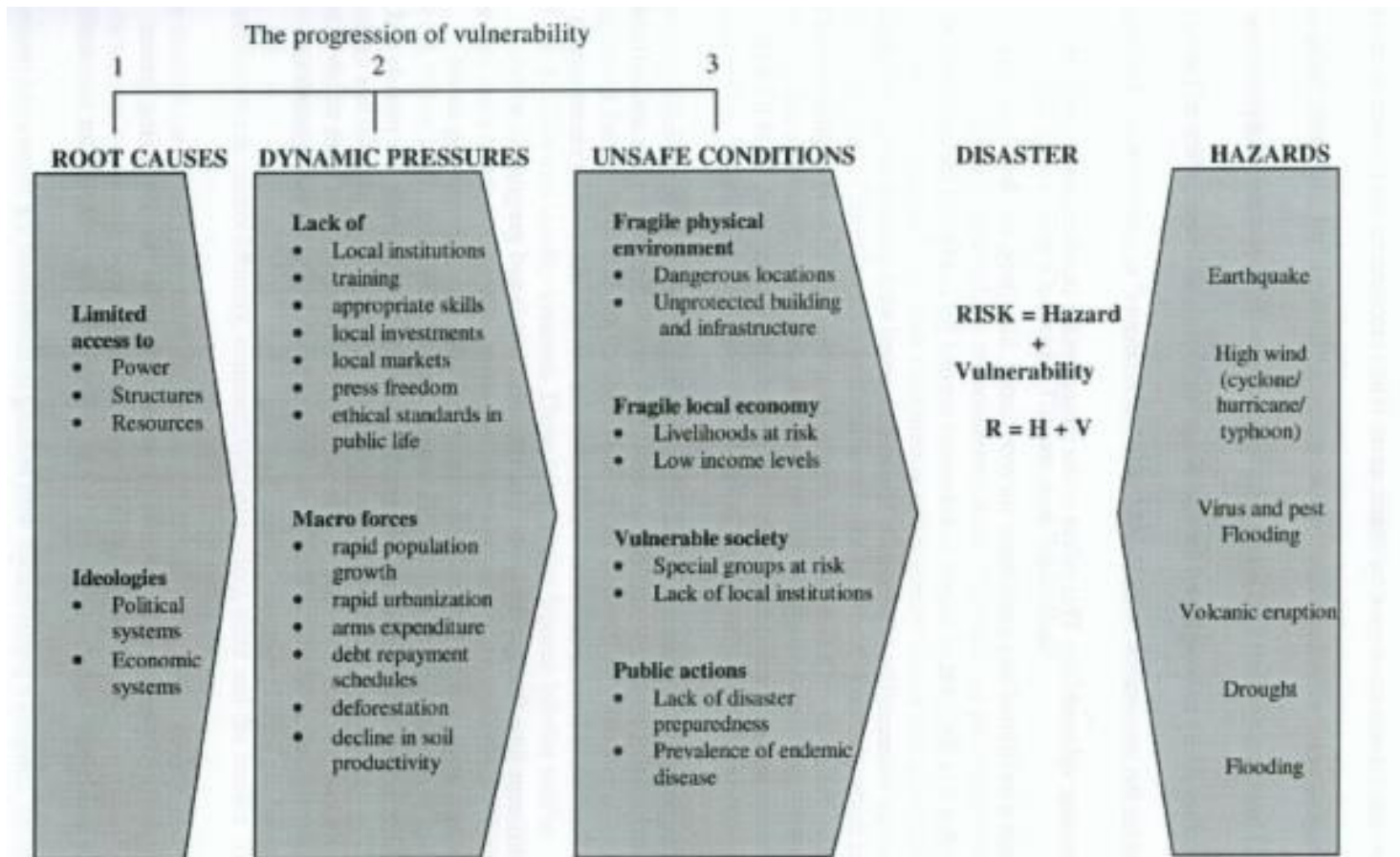
Weather Information Value Chain – *What?*

“...tracing the information flow end-to-end from geospatial data acquisition system to decisions by end users...”

- What is the weather information value chain?
 - Conceptual model of the value creation process
 - Emphasize this is ***not*** linear in the real world!
 - End-to-end-to-end



Context - Weather Information Value Chain



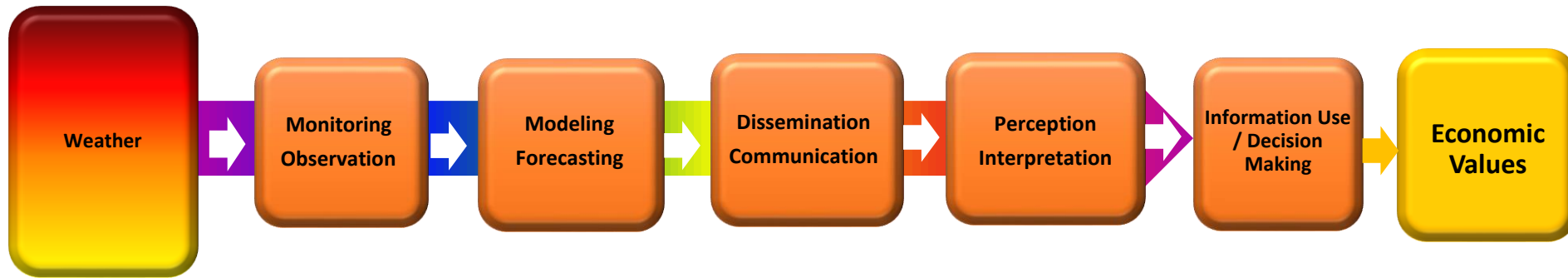
Pressure and Release Model of vulnerability to disasters

Blaikie, P., T. Cannon, I. Davis & B. Wisner. (1994). *At Risk: Natural hazards, People's vulnerability, and disasters*. London, Routledge.

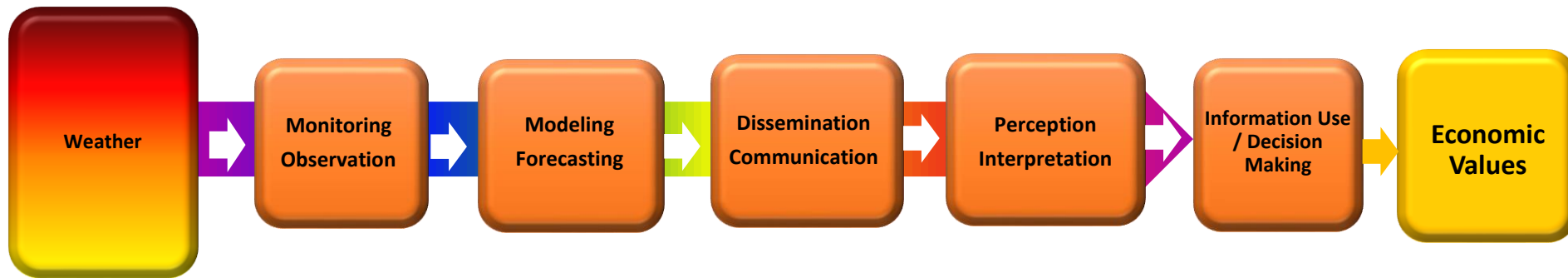
Weather Information Value Chain - *Why?*

- Use economic concepts to explicate mapping of the value of information from creation to valuation
 - Stakeholders (Agents)
 - Objectives
 - Resources
 - Constraints
- Tie information to value so value estimates are valid and reliable
- Explicate how user-relevant information can drive product and service development
- Detail potential contributions of other social sciences – to evaluating the chain and to enhancing value

Weather Information Value Chain



Weather Information Value Chain

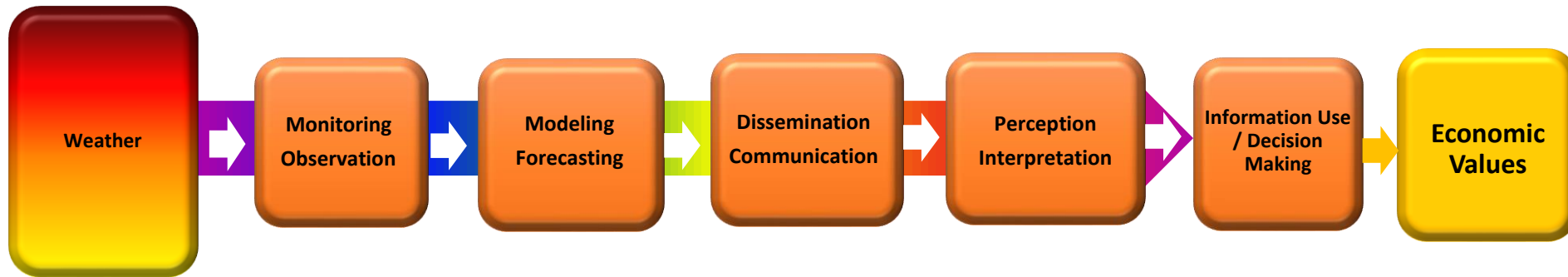


Weather ...

... and water

... and climate

Weather Information Value Chain



Observations

Satellites

Radar

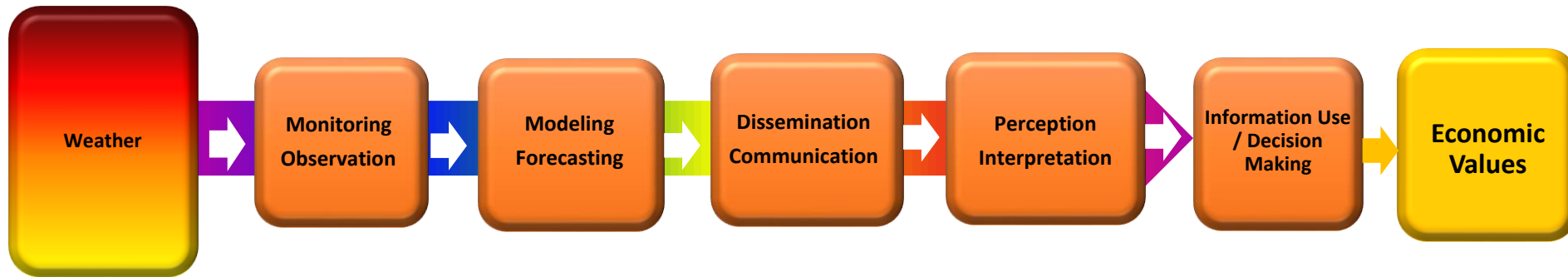
Ground stations

...

Your car ...

Your cell phone ...

Weather Information Value Chain



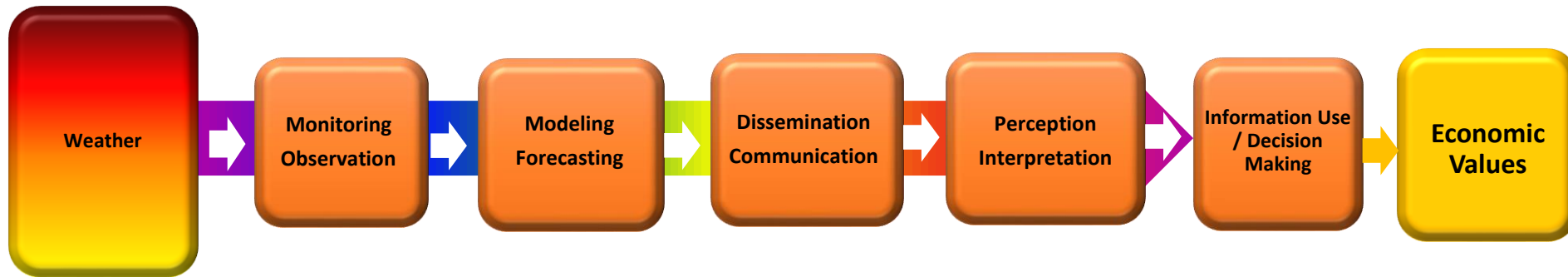
Modeling

Numerical Weather Prediction

Nowcasting

Climate models

Weather Information Value Chain



Forecasting

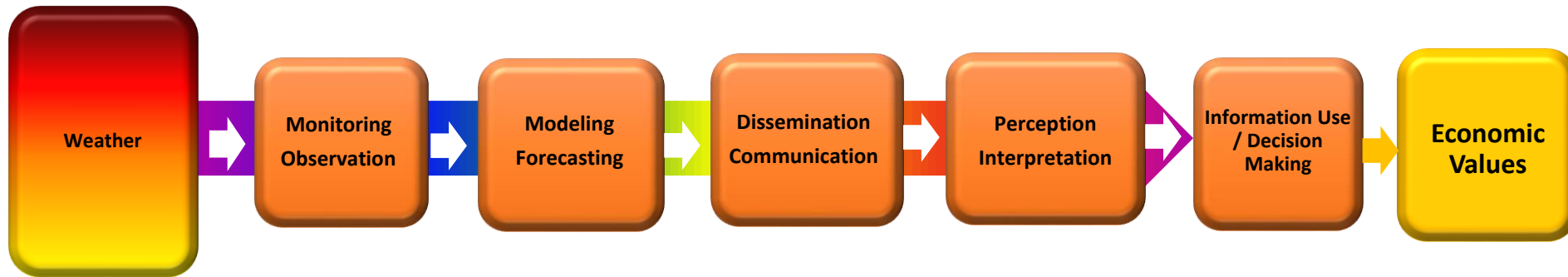
Weather forecast

Seasonal forecasts

Climate forecasts

Watches and warnings

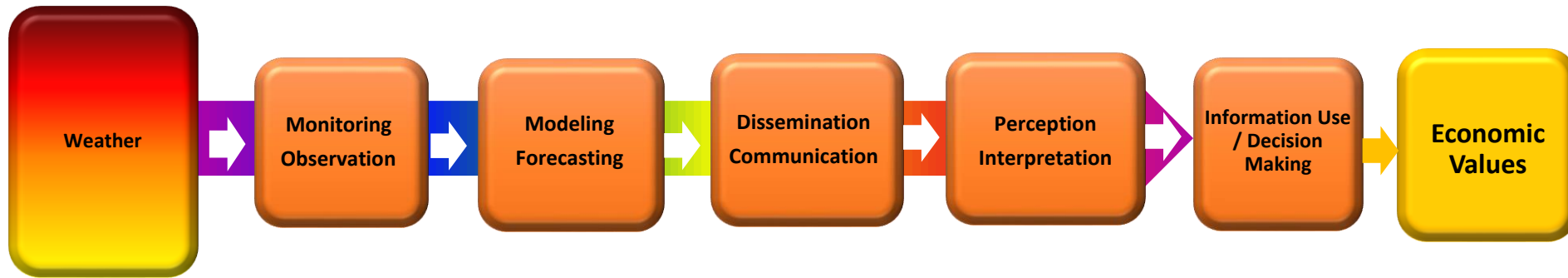
Weather Information Value Chain



Dissemination

Internet
Television
Radio
Telephone
Newspapers
Sirens
Word of mouth

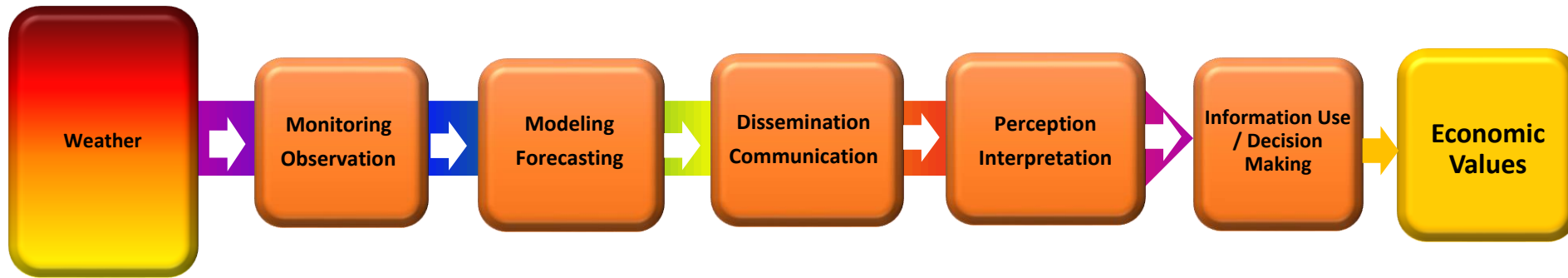
Weather Information Value Chain



Communication

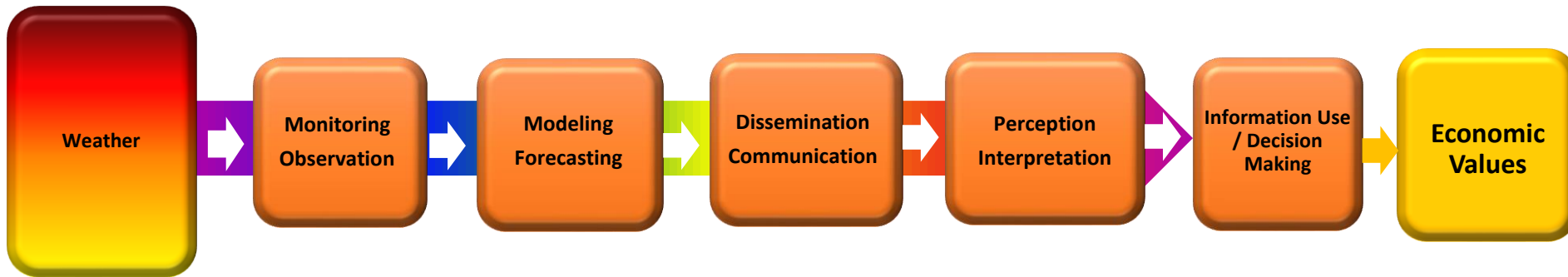
Format
Content
Detail
Uncertainty

Weather Information Value Chain



**Perception /
Interpretation**
Threat
Impacts
Probability
Reliability / trust
...

Weather Information Value Chain



Decisions

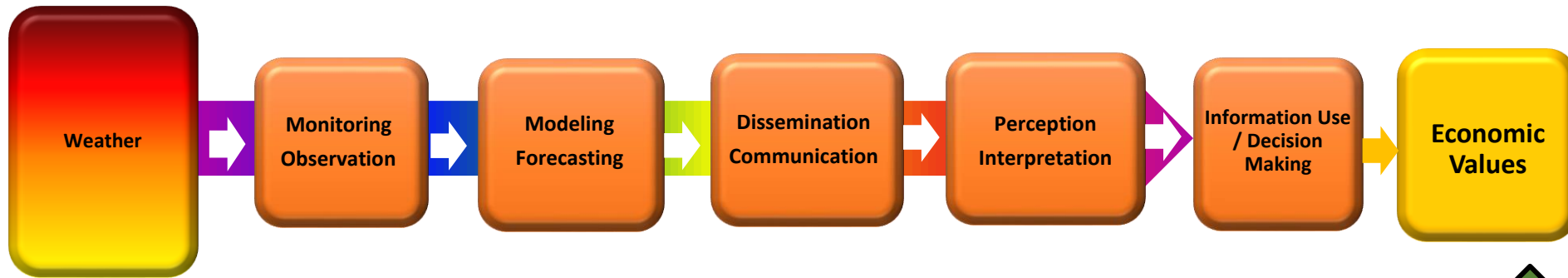
Run / hide

Buy / sell

Sunglasses / coat

...

Weather Information Value Chain



Decisions

Run / hide

Buy / sell

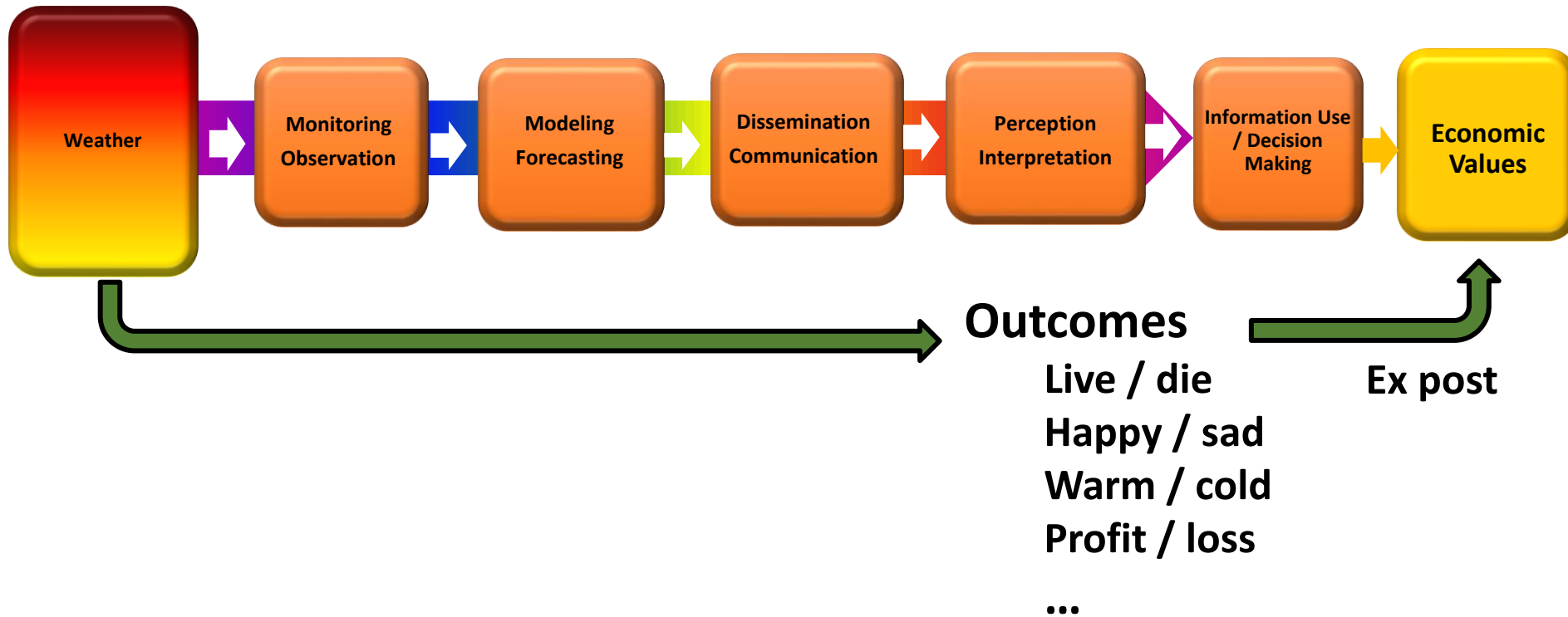
Sunglasses / coat

...

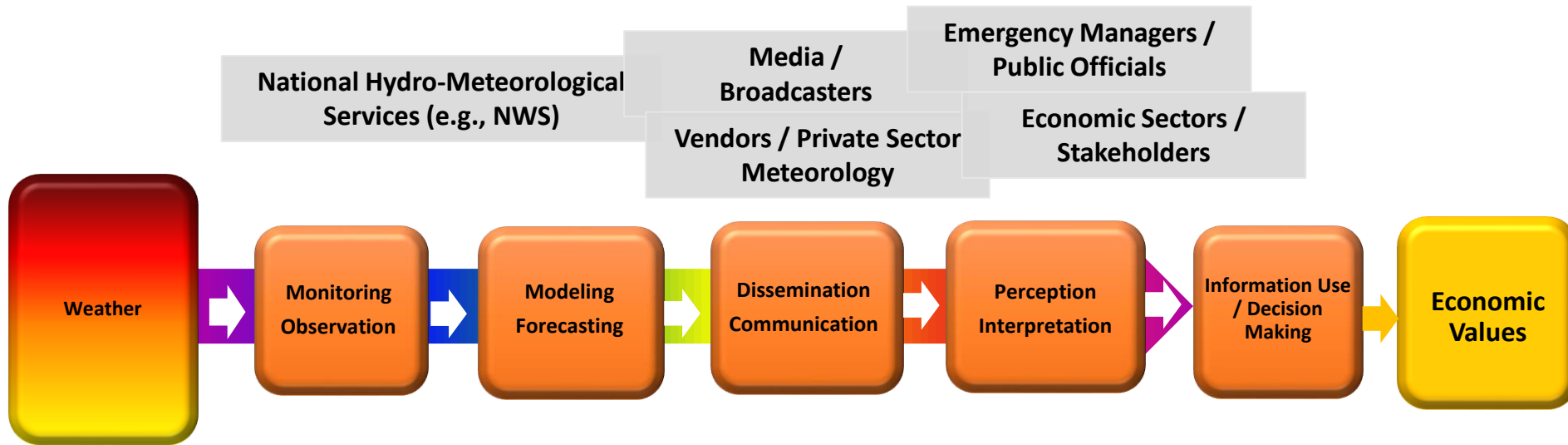
Subject to objectives,
resources, constraints

Ex ante

Weather Information Value Chain



Weather Information Value Chain

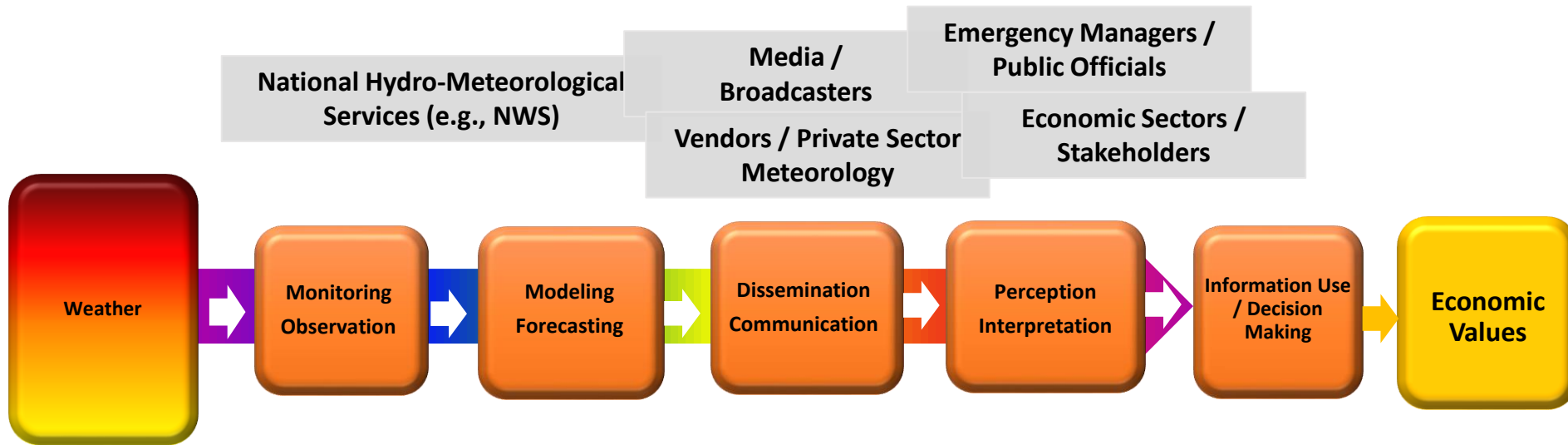


Each stakeholder, agent, and decision maker has his or her own set of:

- objectives
- resources and
- constraints

that frame their transformation or use of information

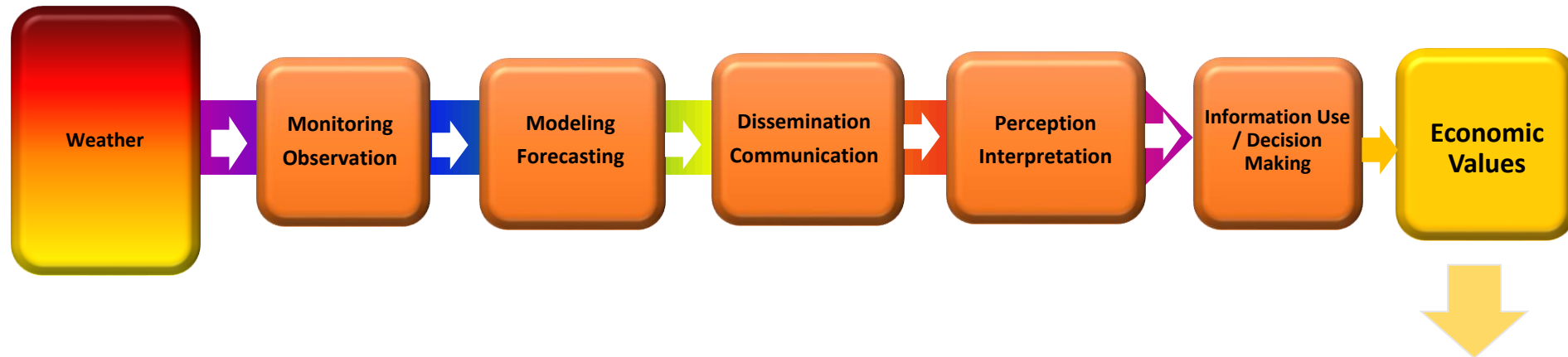
Weather Information Value Chain



Economic values are the result of a complex process

- Ultimately value of information is a function of the ability of decision makers to receive, understand, and act on information on uncertain future events.
- Have to be able to tell the story end-to-end to derive valid benefit estimates.

Valuation Methods



Valuation is at the end of the chain so valuation methods ultimately depend on the decisions and potential outcomes being evaluated

- Morbidity / mortality (VSL)
 - Reduced costs
 - Reduced damages
 - Increased profits
- Improved welfare (WTP)

What to value?

- Value of “Weather” and “Weather Information”
 - Economic impact of weather
 - Value of current weather data and information
 - Value of current weather forecasts
 - Value of improved weather forecasts
 - Value of research to improve forecasts
 - Value of improving dissemination / comprehension / use / decision making / response ...

What to value?

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Melissa Dell, Benjamin F. Jones, and Benjamin A. Olken (2014)
“What Do We Learn from the Weather? The New Climate–
Economy Literature?”

Journal of Economic Literature 2014, 52(3), 740–798

<http://dx.doi.org/10.1257/jel.52.3.740>

- literature review socio-economic impacts of weather
- primary focus on panel data analysis
- not really “causal” analysis other than in the “econometric” sense of causality
- significant and complex impacts of weather on:
 - *economic – aggregate output*
 - *agriculture*
 - *labor productivity*
 - *industrial and services output*
 - *health and mortality*
 - *energy*
 - *conflict and political stability*
 - *crime and aggression*
 - *growth and development*

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United States Economic Sensitivity to Weather Variability

- What is the variability in sectoral Gross State Product (GSP) related to weather variability?
- Empirical modeling using historical economic and weather data

Lazo, J.K., M. Lawson, P.H. Larsen, and D.M. Waldman. June 2011 “United States Economic Sensitivity to Weather Variability.” *Bulletin of the American Meteorological Society*. 92.

Data

Economic Data - state x year x sector

Gross State Product (dependent variable)

Production Inputs

- Capital (K) - dollars
- Labor (L) - hours
- Energy (E) – BTUs

Weather Data - state x year

Temperature Variability

- CDD : Cooling Degree Days: $(T - 65)$ on a given day
- HDD : Heating Degree Days: $(65 - T)$ on a given day

Precipitation

- P_Tot: Precipitation Total (per square mile)
- P_Std: Precipitation Standard Deviation

i = state 48
j = sector 11
t = year 1977-2000 = 24 years
48 x 11 x 24 = 12,672 “observations”

Modeling

transcendental logarithmic production function

$$\ln Q_{it} = \alpha + \delta t + \sum_{k=1}^N \beta_k \ln X_{kit} + \frac{1}{2} \sum_{k=1}^N \sum_{l=1}^N \gamma_{kl} \ln X_{kit} \ln X_{lit} + \varepsilon_{it}$$

Q – Gross State Product

t – year (1977-2000)

X – economic & weather inputs (K, L, E, Temp, Precip)

i – 48 states

Econometric Methods

- Panel data – time series – AR(1)
- Heteroskedasticity
- Fixed Effects
- Covariance calculations for marginal effects

Analysis

- Estimated a model for each sector (11 models) using 24 years data
- Set K, L, E to recent 5 year average
- Ran 70 years of weather data (HDD, CDD, P_{tot} , P_{sdev}) through model
- Aggregated by:
 - Sector
 - State
 - Nationally

Sector sensitivity estimates

Sector	Heating Degree Days	Cooling Degree Days	Total precipitation	Precipitation standard deviation
Agriculture		-0.19	0.28	-0.12
Communications	0.13	0.06		0.17
Construction		0.06		0.26
FIRE (finance, insurance, and real estate)	0.15	0.06	0.54	-0.08
Manufacturing	0.18		0.49	-0.22
Mining	0.25		-3.52	1.10
Retail trade	0.04	0.03		0.13
Services	0.04		0.33	-0.05
Transportation				0.15
Utilities		0.08		-0.28
Wholesale trade	0.10	0.02	-0.19	0.02

Economic Impact of Weather

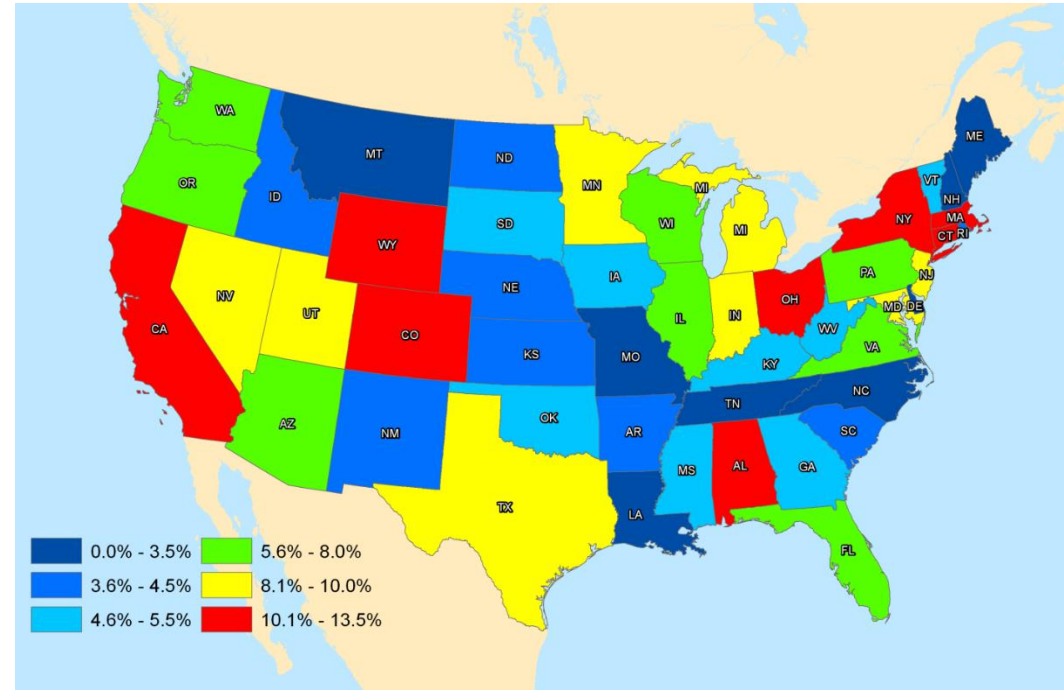
What is the variability in sectoral Gross State Product (GSP) related to weather variability?

Empirical modeling using historical economic and weather data

Findings:

- All sectors and all states show significant economic sensitivity to weather variability
- U.S. GDP varies by up to \$485 billion a year (2008) — about 3.4% — owing to weather variability

Did not look at causal relationship – purely statistical analysis



What to value?

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Value of current weather **data and information**

- Continuity of data critical to use in analysis
- Important for climate change assessment
- Important for use in applications
 - Index based insurance
- Question of temporal overlap of satellites to “align” quality of observational data
 - increased overlap increased cost
 - Increase overlap – increased accuracy
 - What is the economic benefit of increased accuracy of data set

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Value of current **weather forecasts**

Lazo, J.K., R.E. Morss, and J.L. Demuth. 2009. "300 Billion Served: Sources, Perceptions, Uses, and Values of Weather Forecasts." *Bulletin of the American Meteorological Society*. 90(6):785-798

Public survey

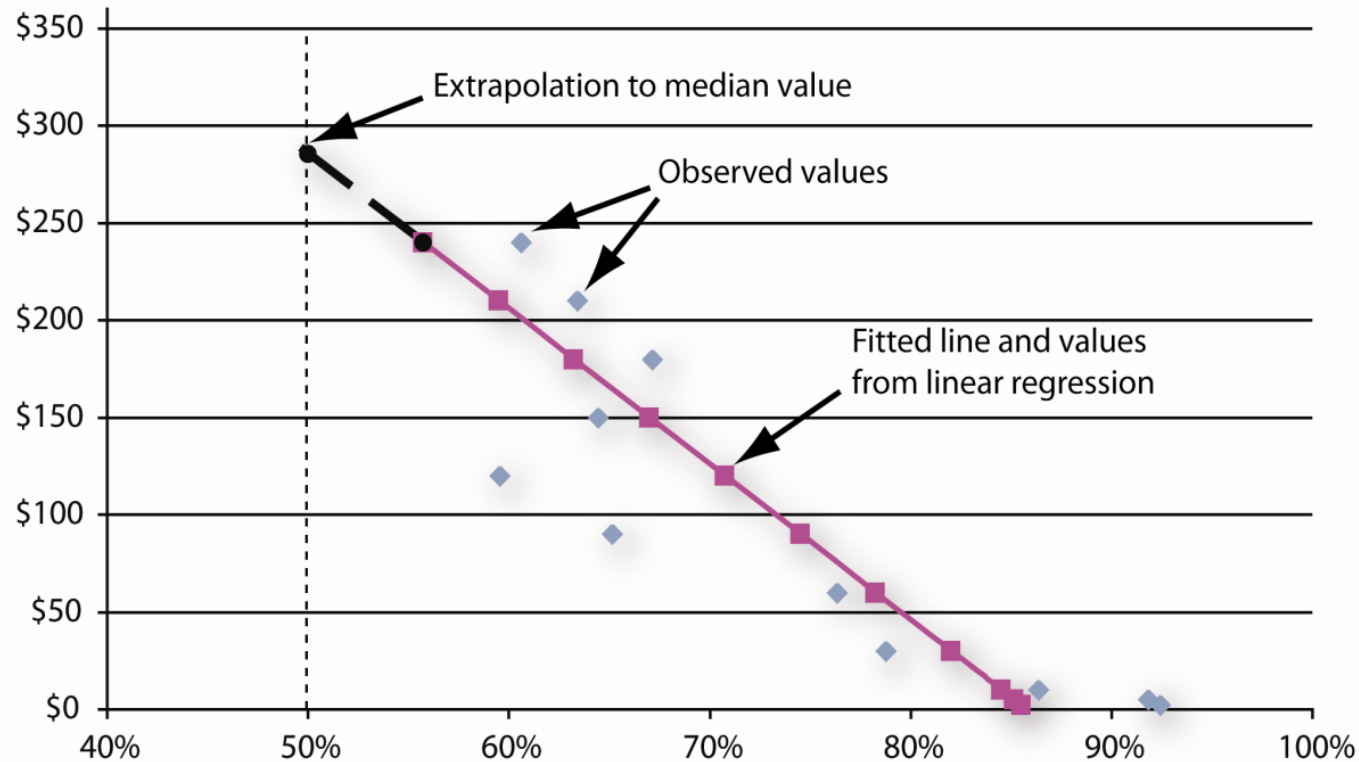
- online nationwide, web-based, controlled-access sample of U.S. households in November 2006
- 1520 complete survey responses
- 3.6% indicated they do not use weather forecasts
- analysis $n = 1465$

Value of current weather forecasts

All of the activities of the National Weather Service (NWS) are paid for through taxes as a part of the federal government. This money pays for all of the observation equipment (such as satellites and radar), data analysis, and products of the NWS (including all the forecasts, watches, and warnings). Suppose you were told that every year about \$N of your household's taxes goes toward paying for all of the weather forecasting and information services provided by the NWS. Do you feel that the services you receive from the activities of the NWS are worth more than, exactly, or less than \$N a year to your household? *Please select only one option.* The value inserted for N randomly inserted from 2, 5, 10, 30, 60, 90, 120, 150, 180, 210, 240.

- Worth more than \$N a year to my household
- Worth exactly \$N a year to my household
- Worth less than \$N a year to my household

Value of current weather forecasts



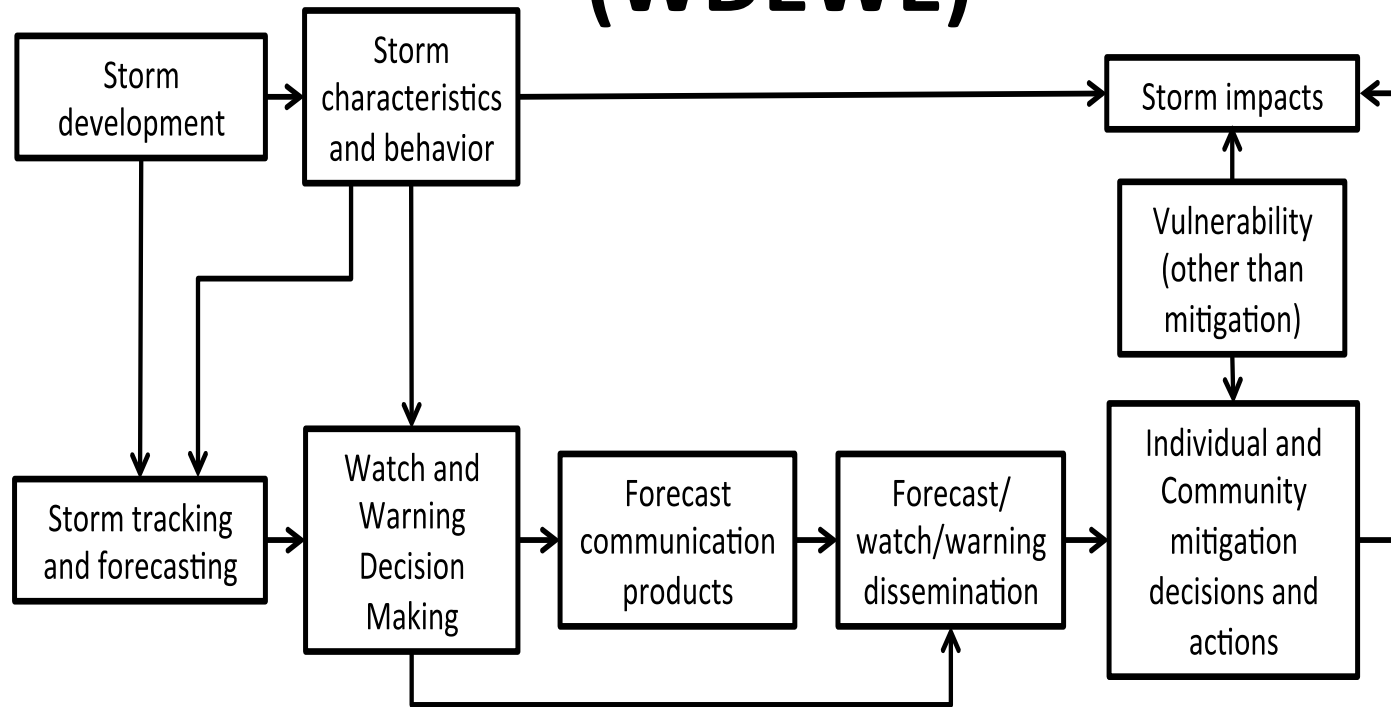
- value of current wx information ~\$286 / household / year
- ~114,384,000 households in US (2006)
- \$31.5 billion total per year value to U.S. households
- U.S. public and private sector meteorology costs of \$5.1 billion/ yr
- benefit-cost ratio of 6.2 to 1.0

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Value of improvements ... of particular interest to NMHS and agencies advocating investments in NMHS

Warning Decisions Extreme Weather Events (WDEWE)



In depth mental model interviews with key stakeholders

- Forecasters
- Broadcasters
- Emergency managers
- General public

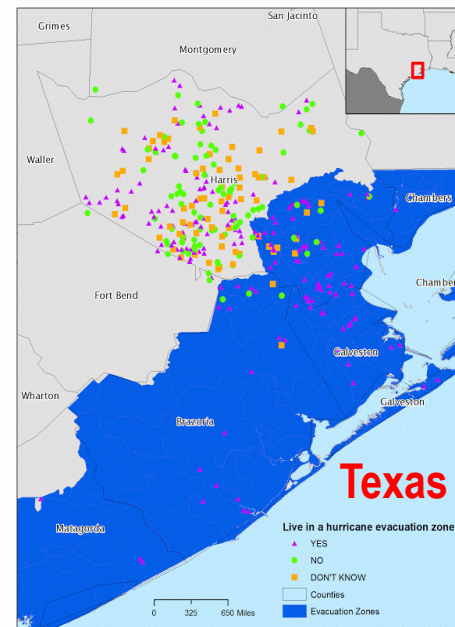
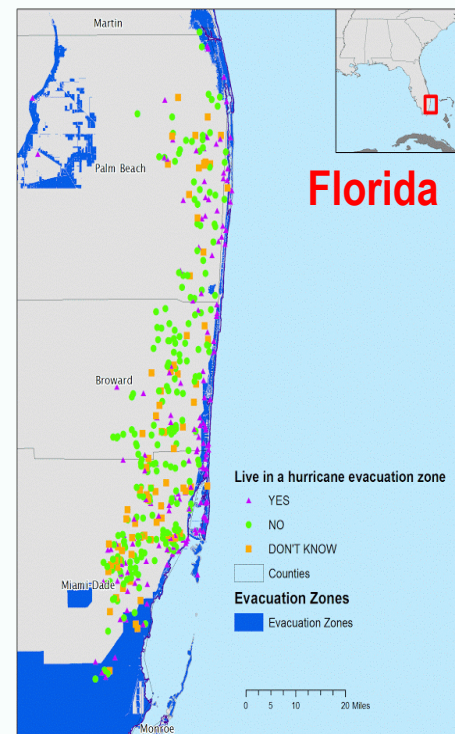
Survey of general public

Public Survey – Methods

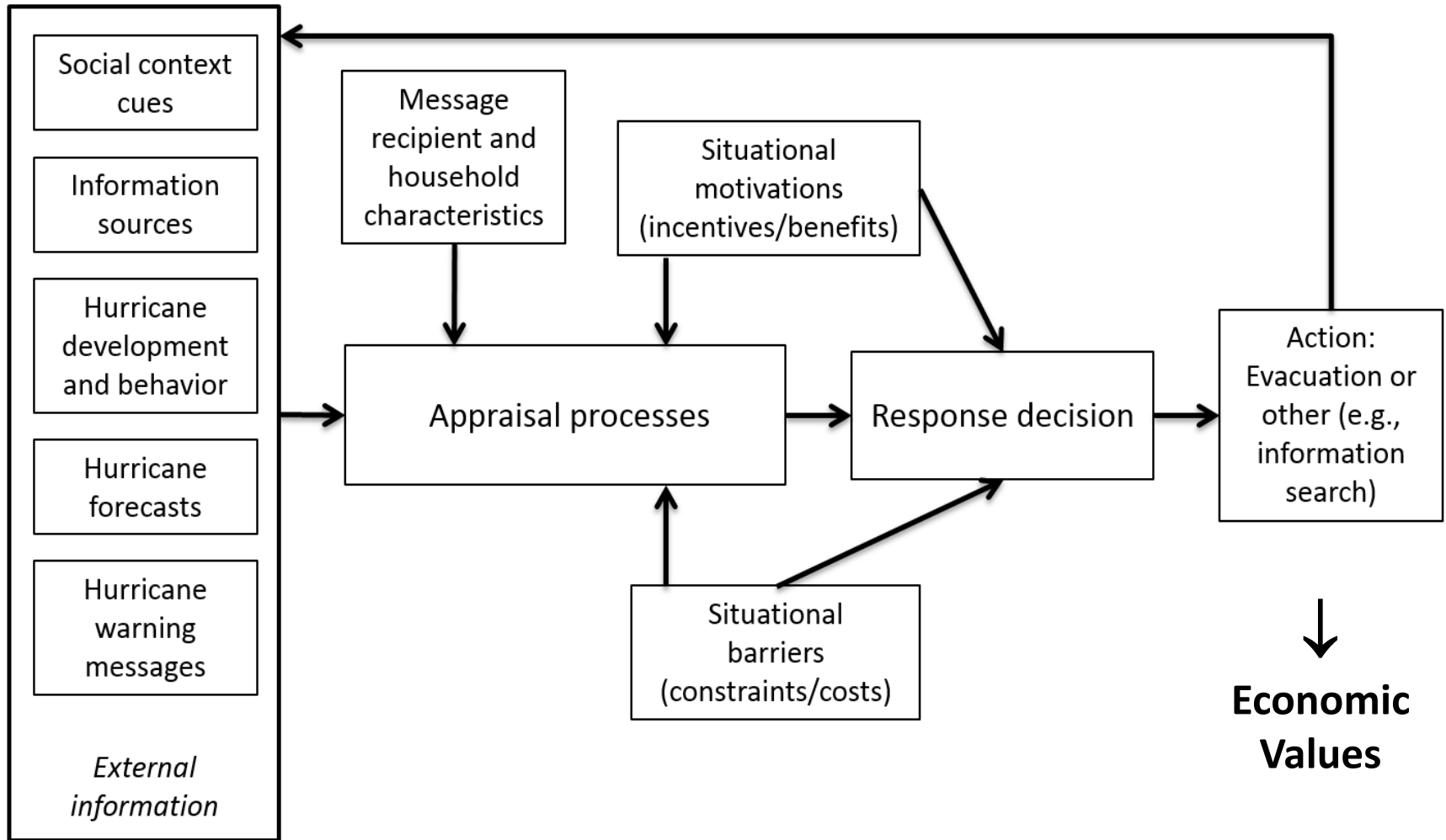
- Survey development and pre-testing
 - Mental models interviews with forecasters, broadcasters, emergency managers, and public
 - Prior hurricane-related survey work
 - Risk communication literature (e.g., psychometric paradigm)
 - Cultural theory (Leiserowitz, Douglas and Wildavsky)
 - Pre-tested with one-on-ones and small sample online
- Implementation
 - Online survey – available in Spanish
 - Knowledge Networks (KN) KnowledgePanel®
 - May 4-24, 2012
 - N=804 (61.6% of those invited to the survey)
 - 457 in the Miami-Dade area
 - 347 in the Galveston-Houston area
 - Missing values on some variables replaced with mean or median as appropriate (<1% of data points)

Respondents' Socio-Demographics (n=804)

Characteristic	Mean
Age (Years)	47.11
Total Yrs in Hurricane Vulnerable Area	25.29
Education (Years)	13.67
Income (Thousands)	66.50
Dummy Variables	
Male	46.6%
Own Residence	68.4%
Children in House	36.8%
Took Survey In Spanish	18.7%
Single Family House – Detached	55.4%
All state-level data weighted to be representative of the areas sampled at the state level, and totals weighted to be representative of all areas sampled.	



WDEWE – Value Chain



WDEWE – Choice Question

Q25 Please indicate which Program you would prefer if you had to choose.

Accuracy of Current Forecasts		Program D ▼	Program E ▼
Landfall location	within 50 miles	25 miles	No change
Maximum wind speed	within 15 miles per hour	No change	7 mph
Flooding from rainfall	detected 50% of the time	No change	No change
Storm surge information	no separate storm surge information	No change	Separate storm surge information
Increase in Annual Cost to Your Household		\$12 per year	\$24 per year
I would prefer (check one box)		Program D <input type="checkbox"/>	Program E <input type="checkbox"/>

Q26 Would you prefer to keep forecast accuracy the way it is now (current levels of accuracy) with no increased costs to your household or the Program (D or E) you chose above at the cost indicated?

- Keep forecast accuracy the way it is now with no increased costs to my household.
- Undertake the program (D or E) chosen above at the cost indicated.

- **11 total choice questions for each individual x 804 = 8,844**
- **n for models = 8,733**

Choice Set Attributes and Levels

Attribute	Description	Current Level	Improved Level
Landfall location	Forecasters predict where a hurricane will make landfall. Currently, two days before landfall, forecasts of the hurricane landfall location are accurate to within about 50 miles. Hurricane-force winds typically extend from 35-75 miles from the center of the storm, depending on the size and intensity of the hurricane.	50 miles	25 miles
Maximum wind speed	Forecasters predict what the maximum sustained wind speeds will be when a hurricane makes landfall. Currently, two days before landfall, forecasts of maximum sustained wind speed are accurate to within plus or minus 15 miles per hour.	15 mph	7 mph
Inland flooding from rainfall	Significant rainfall from hurricanes can cause inland flooding which can include flash floods. This is different from coastal flooding that is caused by storm surge. Inland flooding can be a threat hundreds of miles from the coast. Currently forecasters are able to accurately predict 50% of these inland flooding events.	50%	75%
Storm surge information	Hurricane warnings are based on forecasts of maximum sustained wind speeds and thus do not necessarily include information about the potential risk of storm surge. The depth of storm surge can vary considerably for any given category of hurricane. Currently, forecasters do NOT issue separate warnings for hurricane storm surge. If forecasters DID issue separate storm surge warnings, they would give specific information about the storm surge threat.	No separate storm surge information	Separate storm surge information
Cost	No current additional cost	No current additional cost	\$6 per year \$12 per year \$24 per year \$36 per year

WDEWE – Modeling Framework

$$U_{ij} = \beta' x_{ij} + \varepsilon_{ij}, \quad i = A, B; \quad j = 1, \dots, 8$$

Random Utility Model (RUM)

- ε assumed independent, identically distributed, mean zero normal random variables, uncorrelated with x_{ij} , with constant unknown variance σ
- Under these assumptions, the probability of choosing program 1, for example, is:

$$P_{ij}^1 = P(U_{ij}^1 > U_{ij}^2) = \Phi \left[\beta' (x_{ij}^1 - x_{ij}^2) / \sqrt{2\sigma_\varepsilon} \right]$$

- univariate standard normal cumulative distribution function
- Probit model for dichotomous choice

WDEWE – Econometric Modeling

	Model 1	Model 2	Model 3	Model 4
Parameter	Est.	Est.	Est.	Est.
Landfall	0.27 ***	0.27 ***	0.27 ***	0.27 ***
Max Wind Speed	0.07 ***	0.07 ***	0.07 ***	0.07 ***
Flooding	0.11 ***	0.11 ***	0.11 ***	0.11 ***
Storm Surge Warning (SSW)	-0.04 **	-0.31 ***	-0.67 ***	-0.64 ***
Cost	-0.04 ***	-0.04 ***	-0.04 ***	-0.04 ***
SSW * Education		0.01 **	0.01	0.01
SSW * Children In Household		0.09 **	0.08 **	0.07 *
SSW * Own Residence		0.08 **	0.09 **	0.11 ***
SSW * Evac Likelihood – Order			0.06 ***	0.05 ***
SSW * Information Accuracy			0.04 *	0.03
SSW * Sources Factor Official			0.03 *	0.03 *
SSW * House Vulnerable to Surge				0.07 ***
SSW * Perceived Evacuation Zone				0.04
Percent Concordant	67.9	68.0	68.3	68.4
Max-rescaled R-Square	0.18	0.193	0.19	0.19

WDEWE – Econometric Modeling

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SSW * Education * Education			0.08 **	0.07 *
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SSW * Education * Education * Education * Education * Education * Education * Education				0.07 ***
SSW * Education * Education * Education * Education * Education * Education * Education * Education				0.04
Percent Concordant	67.9	68.0	68.3	68.4
Max-rescaled R-Square	0.18	0.193	0.19	0.19

WTP for improving accuracy of landfall forecasts from ±50 miles to ±25 miles is \$6.75 per year per household

What to value?

- Value of “Weather” and “Weather Information”
 - Economic impact of weather
 - Value of current weather data and information
 - Value of current weather forecasts
 - Value of improved weather forecasts
 - **Value of research to improve forecasts**
 - Value of improving dissemination / comprehension / use / decision making / response ...

Value of research to improve forecasts: Windshear warnings

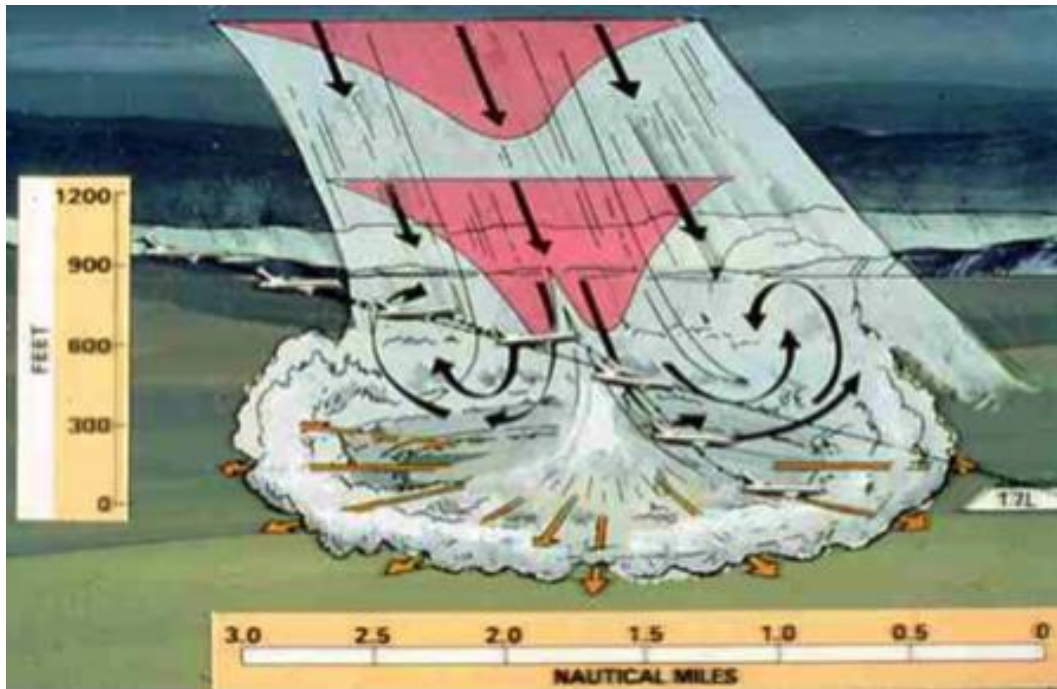
- 1.Problem
- 2.Research
- 3.Products
- 4.Solution
- 5.Result
- 6.Valuation



August 3rd 2016, Boeing 777-300, Emirates EK521 crashed at
Dubai International Airport

Windshear Warning

1. Problem

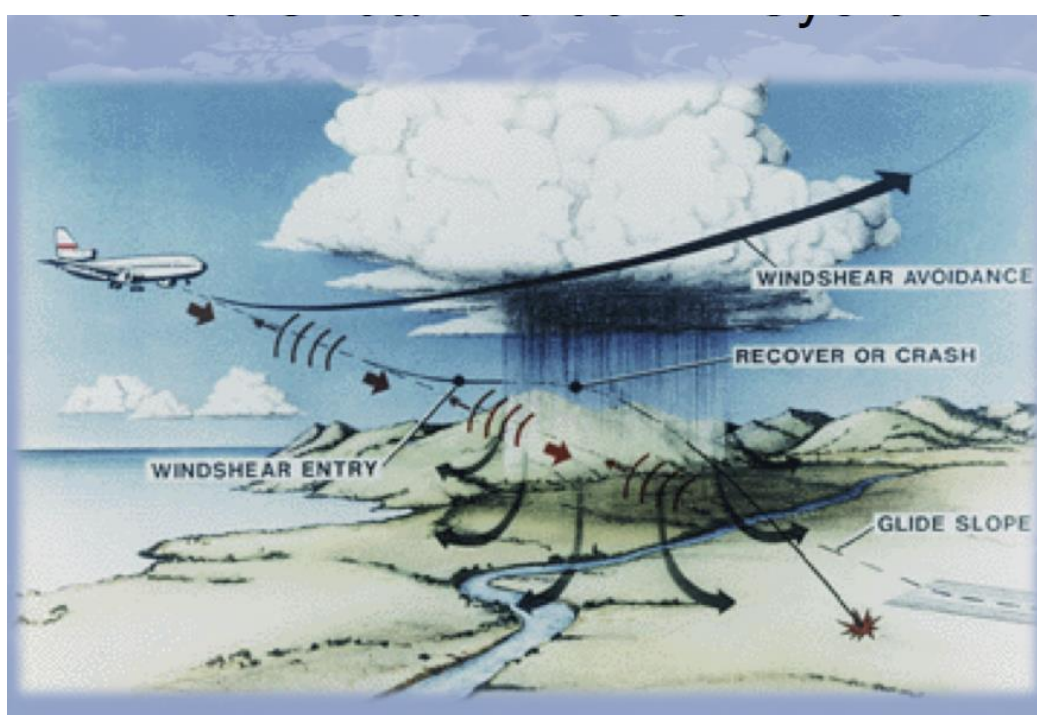


- Windshear is any rapidly changing wind event
- A pilot flying into downburst will detect increased speed due to headwind and may decelerate
- As he crosses into other side he rapidly decelerates due to tailwind ...
- ... and may crash
- 1973-1985 about 400 fatalities in windshear related accidents in U.S. – about 33 a year.

Windshear Warning

1. Problem

2. Research



- Scientists recognized downdraft as a potential atmospheric phenomena
- 1982 – NCAR, U. Chicago, FAA – began research to prove or disprove the theory that microbursts existed
- Began to develop windshear detection and warning systems
 - Langley Research Center
 - FAA
 - NCAR
 - Lincoln Labs

Windshear Warning

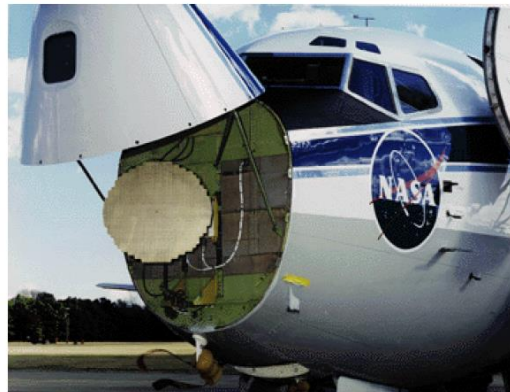
1. Pilot training – windshear recognition
2. Airborne detection
3. Ground based detection and warning systems



TDWR



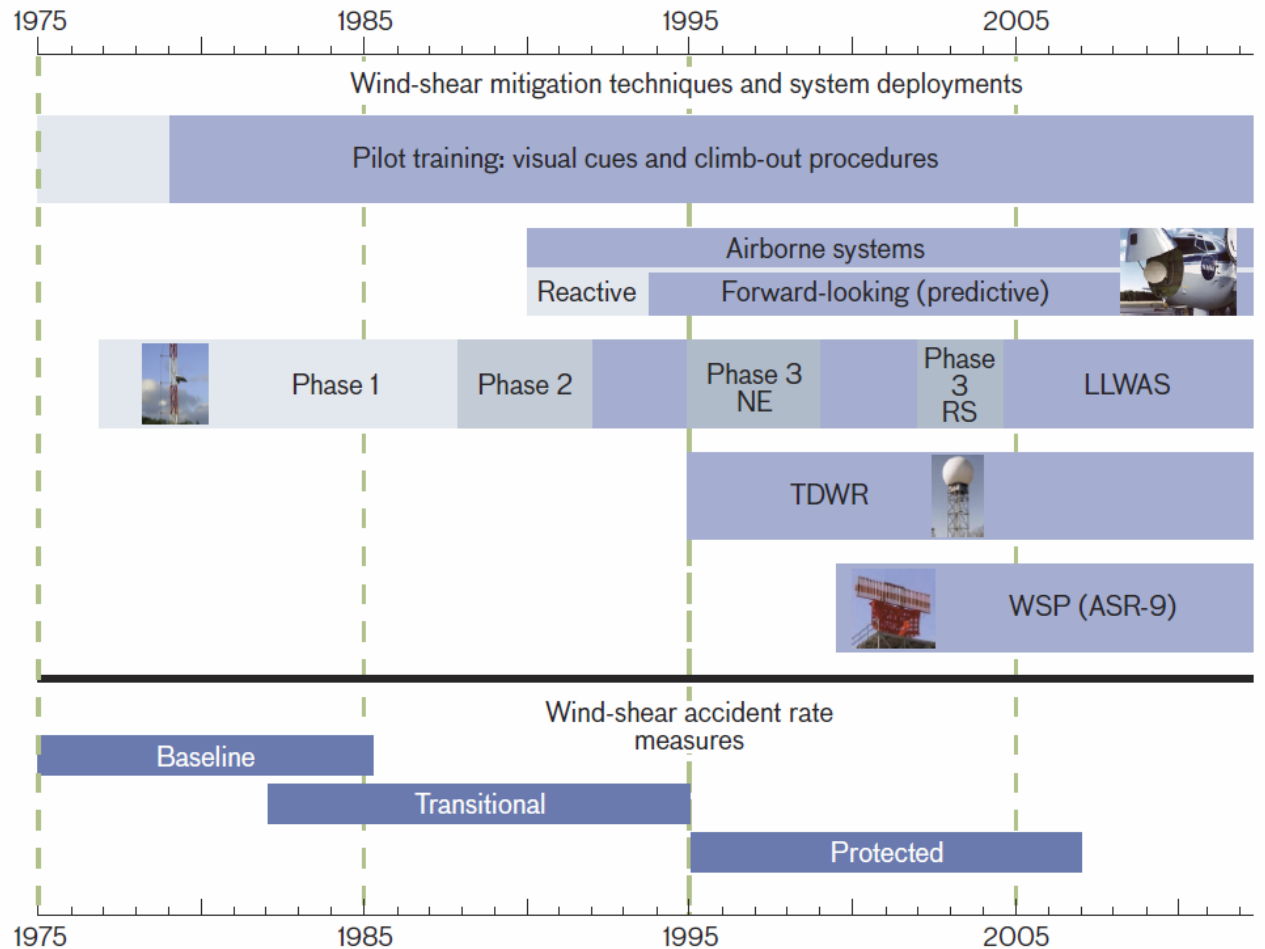
ASR-9



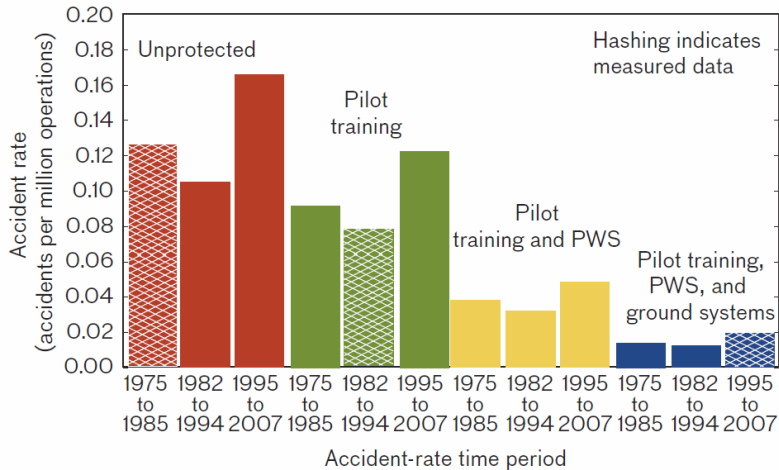
LLWAS

Windshear Warning

- 1. Problem
- 2. Research
- 3. Products
- 4. Solution
- 5. Result
- 6. Valuation



Windshear Warning



Time Period	Fatalities	Average per year
1973-1985	400	33.3
1985-present	0	0

FIGURE 14. A comparison of measured and mitigation-adjusted accident rates permits the “filling out” of the entire chart. The bars with hatching are the measured accident rates. Modeling the other protection conditions from the measured data provides estimates of accident rates for all possible mitigations in each time period.

Hallowell, R.G. and J.Y. N. Cho. 2010. Wind-Shear System: Cost-Benefit Analysis. Lincoln Laboratory Journal. 18(2):47-68

5.Result

6.Valuation

Windshear Warning Valuation

1.Problem

2.Research

3.Products

4.Solution

5.Result

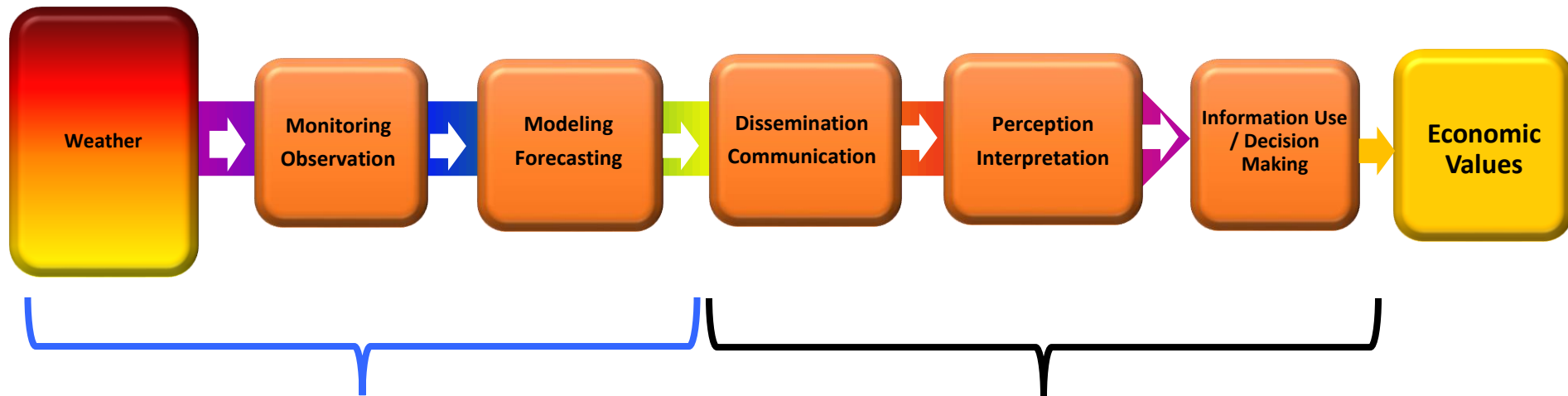
6.Valuation

Time Period	Fatalities	Average per year
1973-1985	400	33.3
1985-present	0	0
Statistical lives saved		33.3
VSL		\$6.0 M/life
Benefit		\$200,000,000/yr

What to value?

- Value of “Weather” and “Weather Information”
 - Economic impact of weather
 - Value of current weather data and information
 - Value of current weather forecasts
 - Value of improved weather forecasts
 - Value of research to improve forecasts
 - **Value of improving dissemination / comprehension / use / decision making / response ...**

Value of improving dissemination / comprehension / use / decision making / response ...



Applications discussed so far all fall in this end of the value chain with respect to initial creation of benefits

Significant potential for value creation without any change or improvement of hydro-met information!!!

Recommendations I

- do not just focus on “extremes”
 - these may not translate into economic extremes
 - economic extremes may occur from minor climatological changes
- evaluate contribution of behavioral economics to weather information process
- need a critical review and consolidation of the existing economic literature on hydro-met services
- need more primary valuation studies
 - to support future Benefits Transfer (BT) efforts
- agencies funding studies should require that studies are “BT-useable”
 - enhance quality and transparency of the study
 - enhance value of study as resource in future BT applications

Recommendations II

- all major investments or changes in hydro-met services should undertake economics analysis
 - going through the process of an economic analysis increases understanding and awareness of the value process underlying any product or service
- fully characterizing the ***Weather Information Value Chain*** should be fundamental part of benefits studies
 - ensure that economic estimates are reliable and valid
- better characterizing any aspects of the ***Weather Information Value Chain*** will help the information creators better understand user needs and create societal value

Finally ... on a positive note about climate change ...

... the challenges humankind has overcome have been astronomical ...

... I believe that regardless of how many more climate conferences we attend and vent about the lack of meaningful action ...

... at some point, a threshold will be crossed where enough of the “right public” will demand a solution ...

... and there will be a viable way forward.

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Weather Information Value Chain



Thank You!

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