Weather & Climate Information for Heat Health Management Systems: Users Perspective

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GLOBAL HEAT HEALTH
INFORMATION NETWORK

Who Uses Weather & Climate Information ?

Value Chain Linking Climate Knowledge to Action

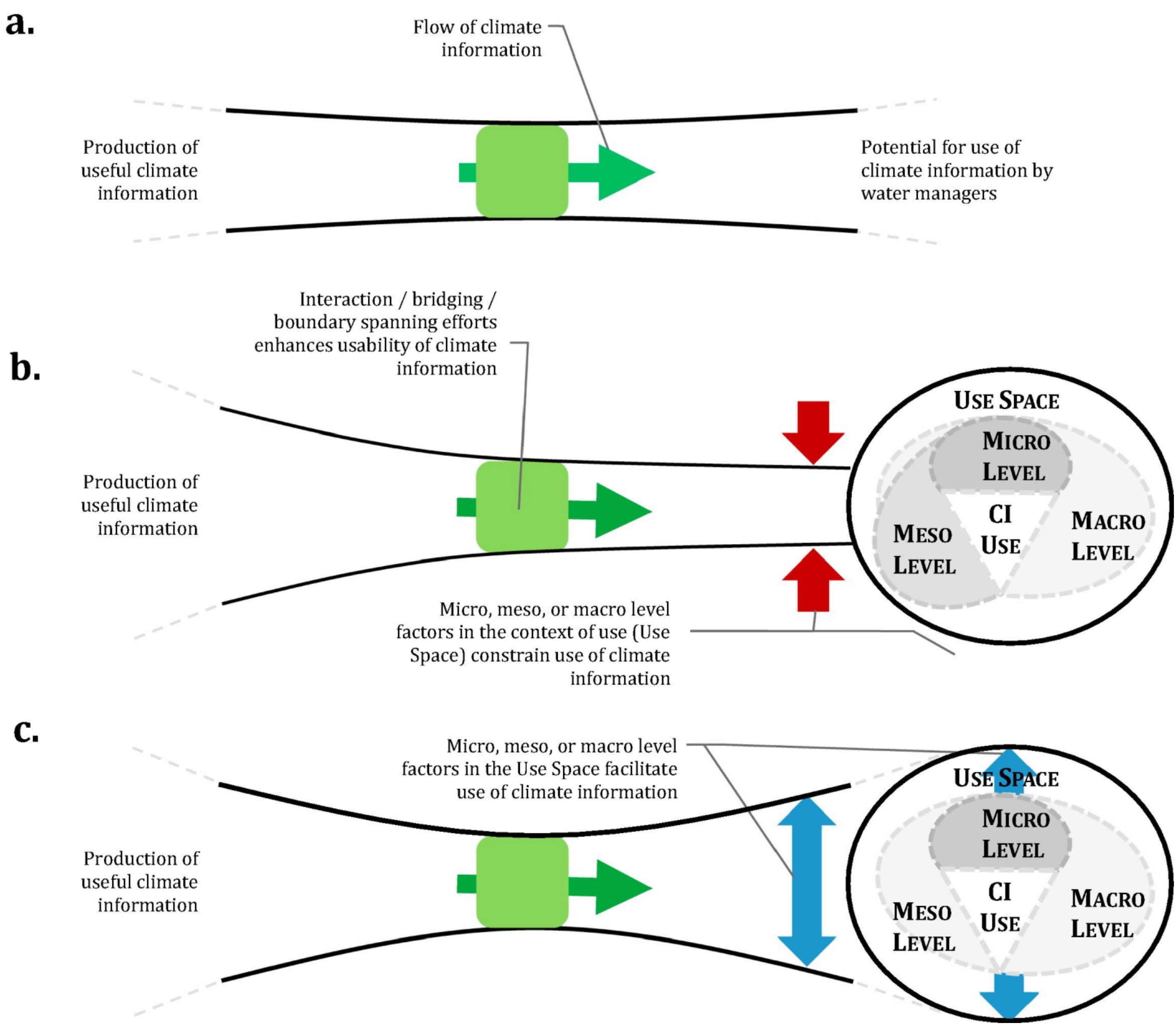
Source: https://www.wmo.int/gfcs/saly-coordination-workshop

Drivers of and barriers to climate information (CI) use at the micro to macro levels

	Micro level factors	Meso level factors	Macro level factors
Drivers of CI use	Feeling at risk or experiencing climate-related risks Valuing research and scientific collaborations and reliable. Having CI related educational background· Perceived responsibility. More recently employed and working on the front lines	In the public eye and accountable. Organizational leadership and a culture of innovation· A focus on long-term planning· Having a flexible decision making process· Believing climate issue (heat) is a problem and a priority for the organization· Larger risk management organizations with technical and human capacity	State elected leaders' direct or indirect actions· Local elected boards and council members supportive actions·· National level policy (e.g. HHAPs), building codes etc.
Barriers to CI use	Skepticism or politicization of climate-related risks. Lack of perceived responsibility. Longer tenure employee working higher up in the organizational hierarchy or only working part-time	Not in the public eye or not accountable More conservative organization with measured approach to innovation A focus on long-term planning that creates path dependency. Inflexible decision making process Believing climate issue (heat) i not a priority Smaller risk management organizations without sufficient technical and human capacity·	State elected leaders' direct or indirect actions· Local elected boards and council members unsupportive Politicization of climate issue (heat) Little support of/progress with research informed heat policy negotiations

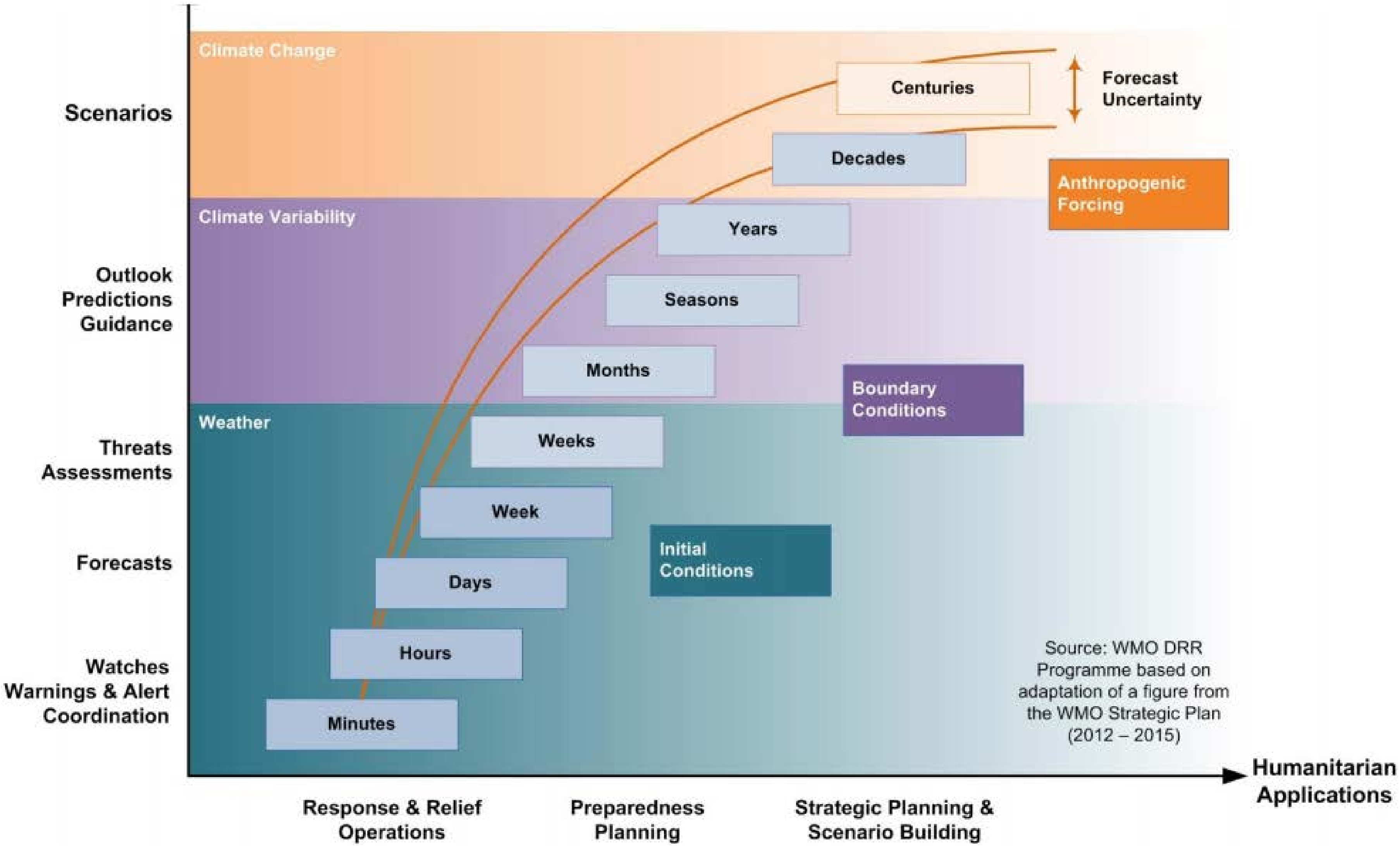
Source (modified from) : Flagg and Kirchoff (2018) Climate Risk Management, Volume 20, 2018, Pages 1-10

A conceptual model for bridging the knowledge-action gap



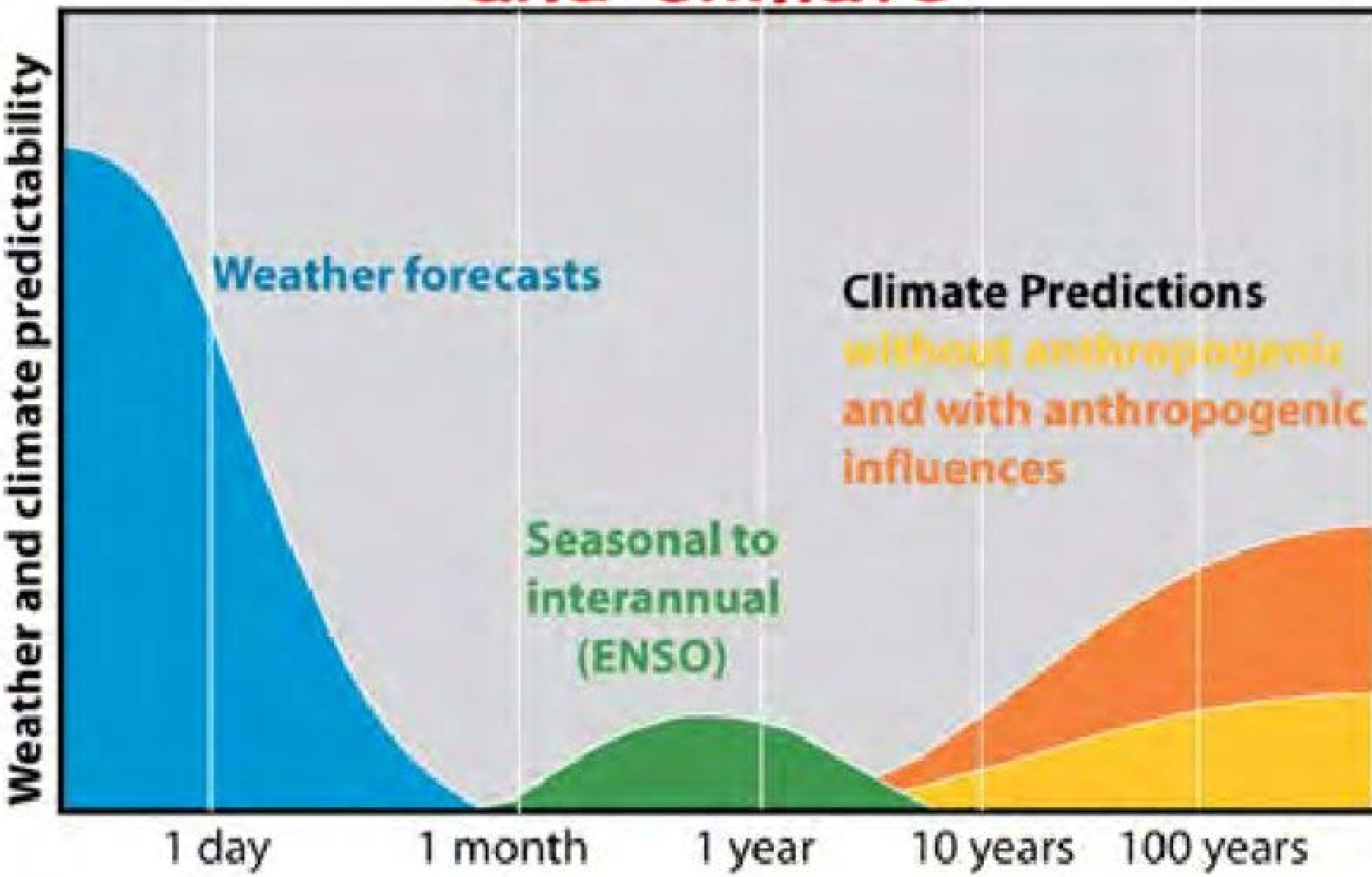
Source: Flagg and Kirchoff (2018) Climate Risk Management, Volume 20, 2018, Pages 1-10

Climate Information Time Scales



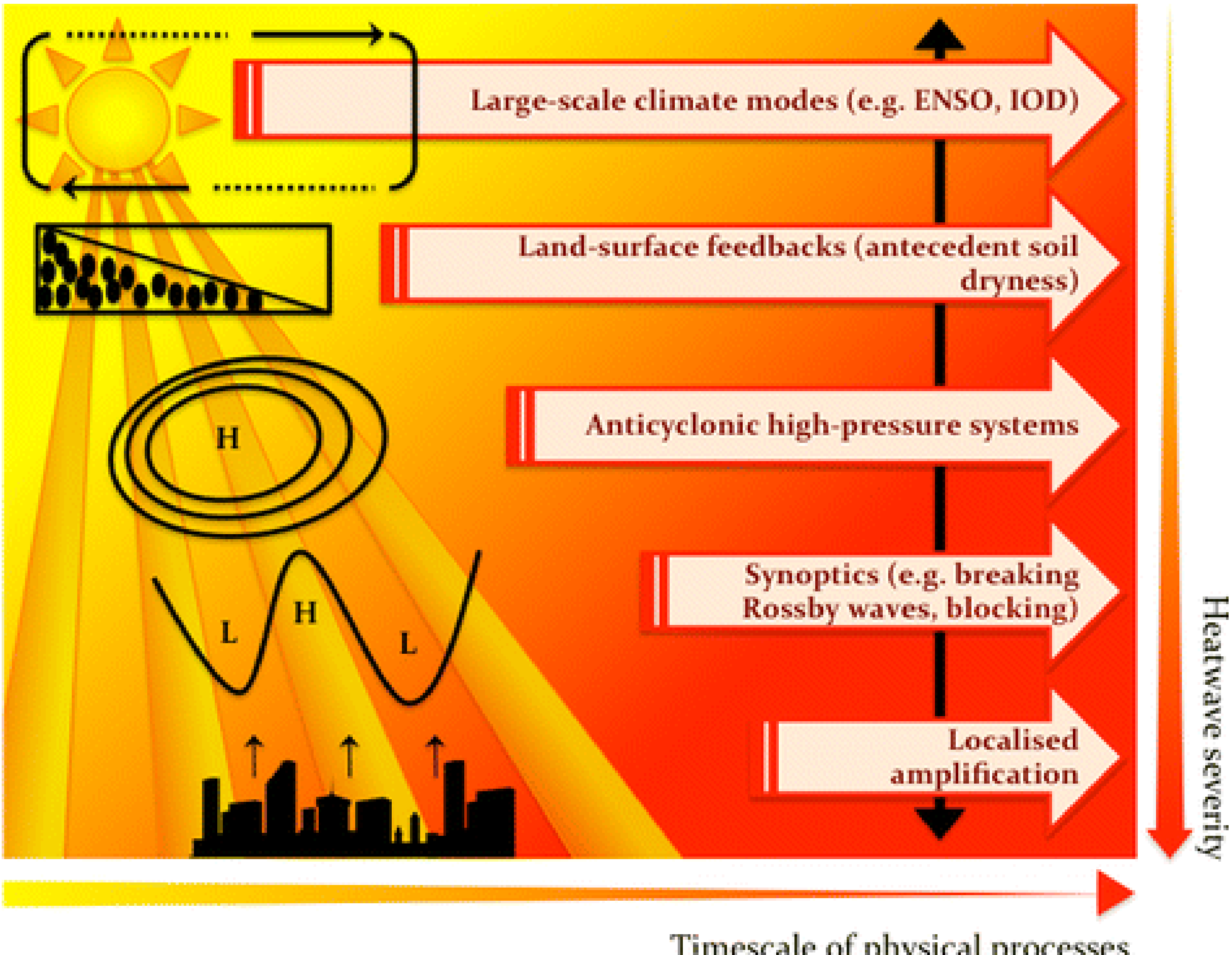
Source: https://www.newsecuritybeat.org/2015/10/climate-data-critical-fragile-conflict-affected-states-heres/

Predictability of weather and climate



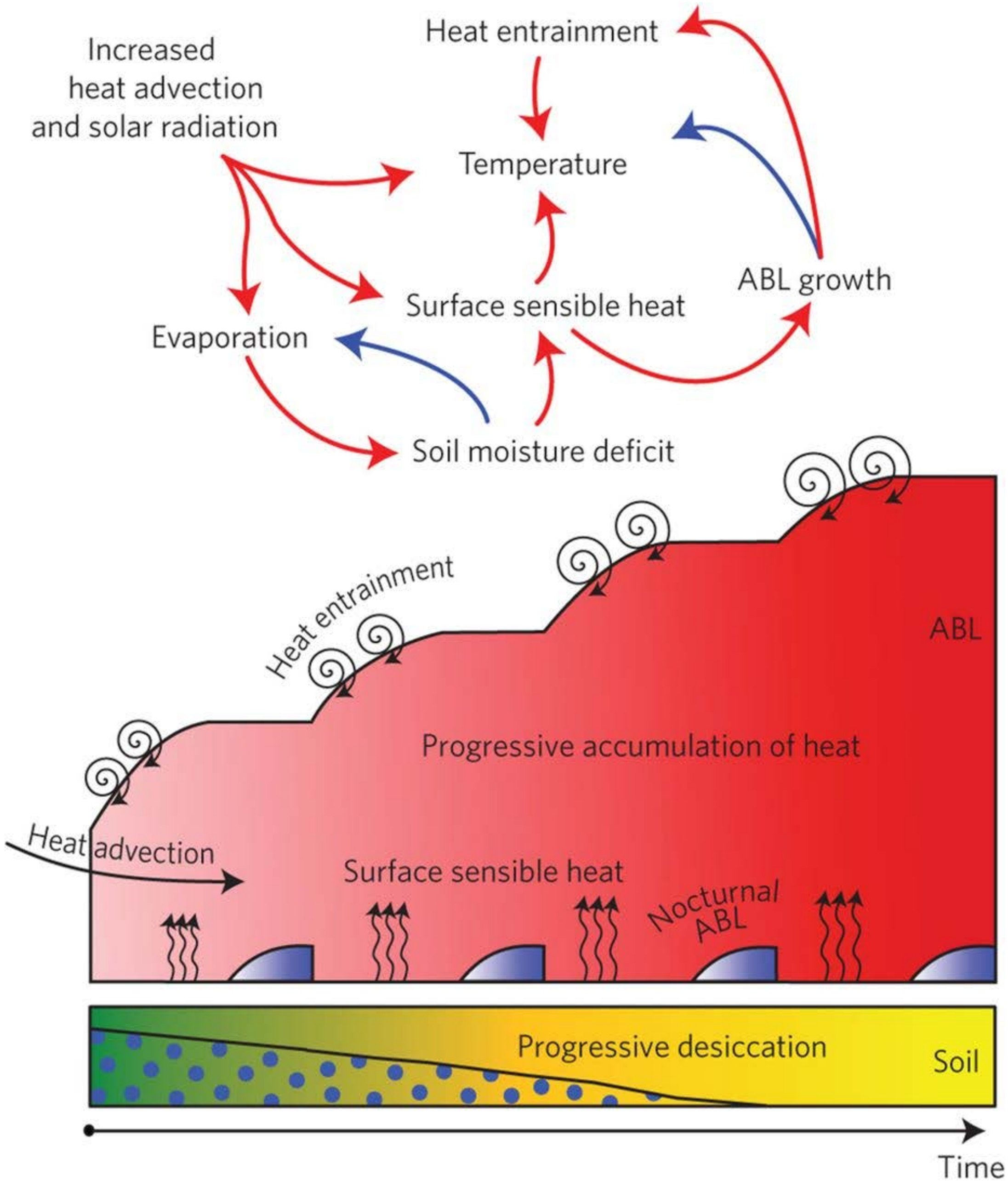
https://www.researchgate.net/figure/Predictability-of-weather-and-climate-models-high-on-the-short-time-scales-and-in-the_fig1_51992235

Physical Drivers of Heatwaves – Knowledge for Forecasting



Source: Perkins et al. 2016 Climatic Change Volume 139, Issue 1, pp 101–114

Land – Atmosphere Feedbacks and Mega-Heatwaves

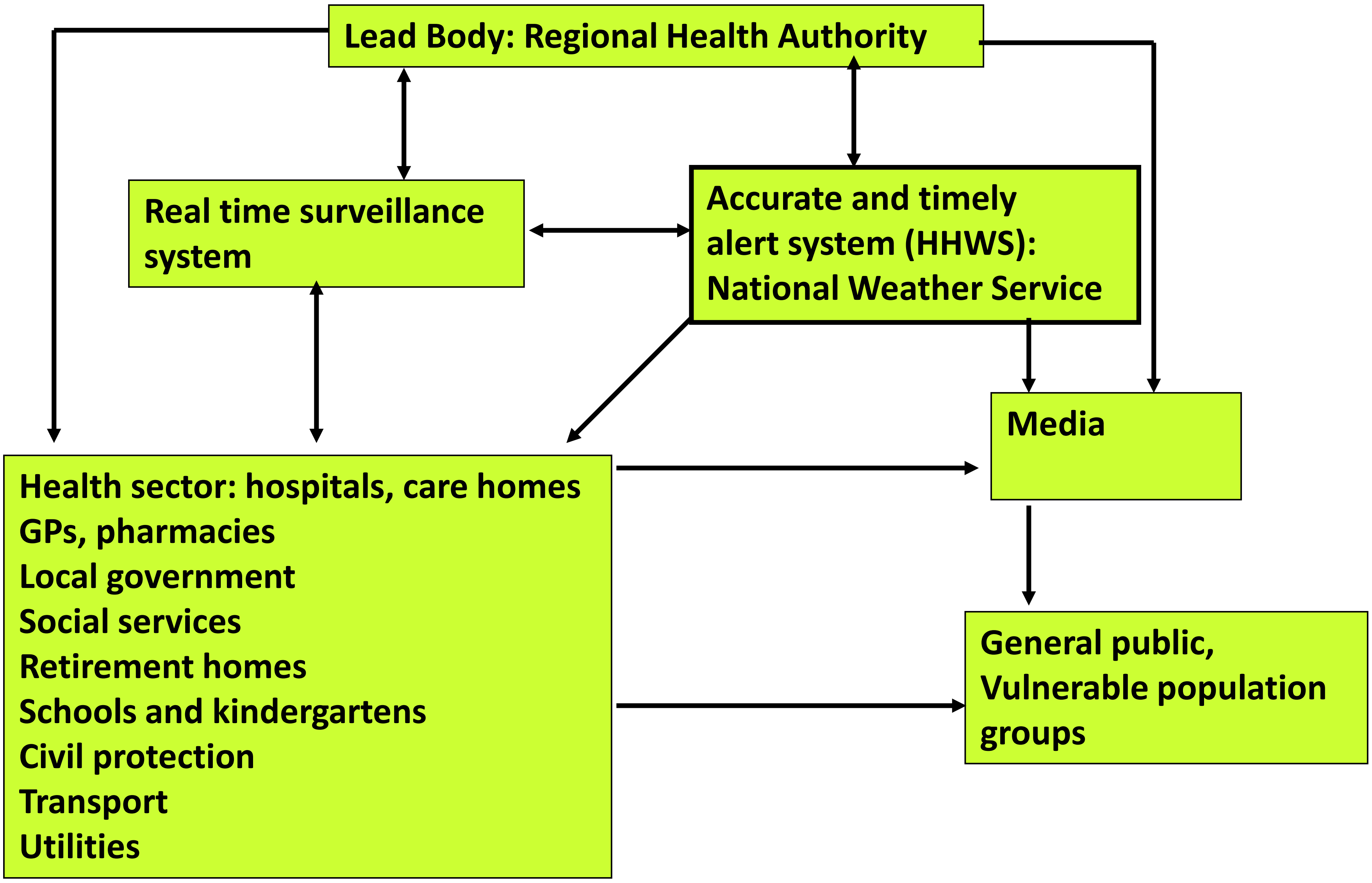


Source: Miralles et al. 2014 Nature Geoscience, Volume: 7 Issue: 5 Pages: 345-349

Geographical Scales for Climate Information ?

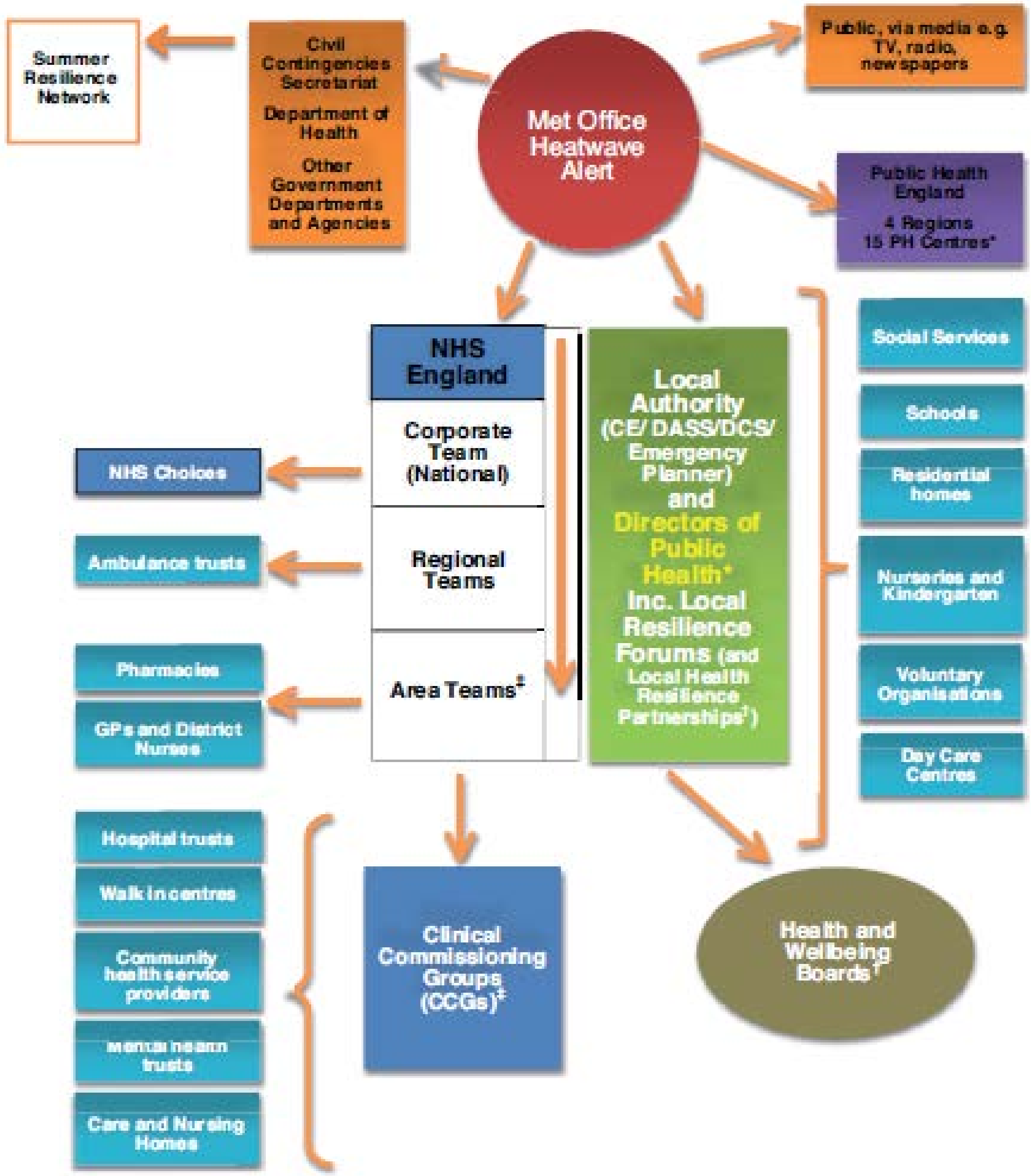
- Global
- World Regional (e.g. East Asia)
- Nation State (e.g. China)
- Regional (e.g. Southern China)
- Administrative Region (e.g. Hong Kong)
- Locality (e.g. Hong Kong Island)
- Neighbourhood (e.g. Sai Ying Pun)
- Street (e.g. Pok Fu Lam Road)
- Household
- Personal

Possible Flow of Information Between Lead Agency and Other Actors in Heat Plan



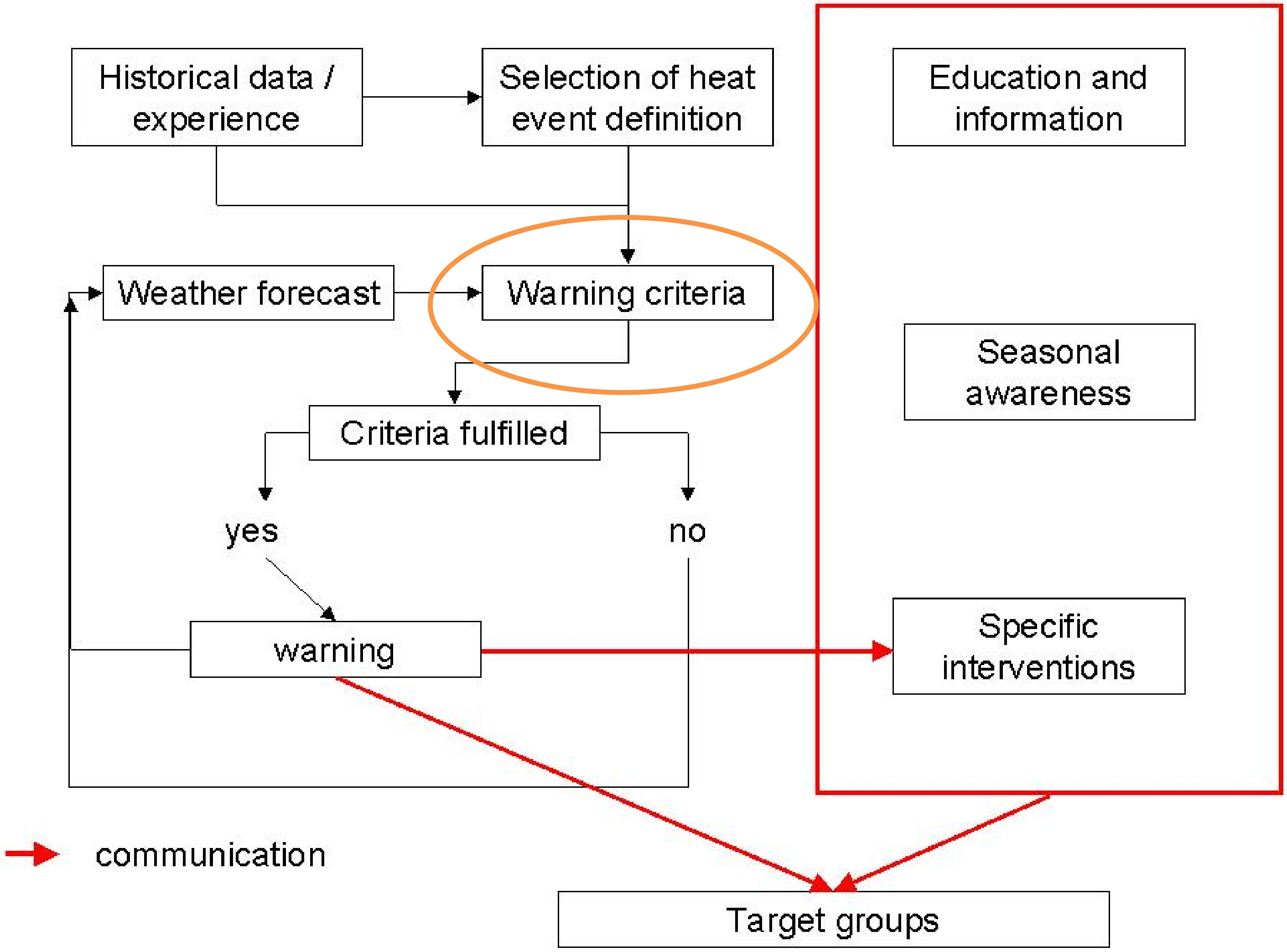
Source:G.R. McGregor, P. Bessemoulin, K. Ebi and B. Menne (eds.) (2015) WMO Heatwaves and Health: Guidance on Warning-System Development WMO-No. 1142

England HWP: Cascade of Heat Wave Alerts



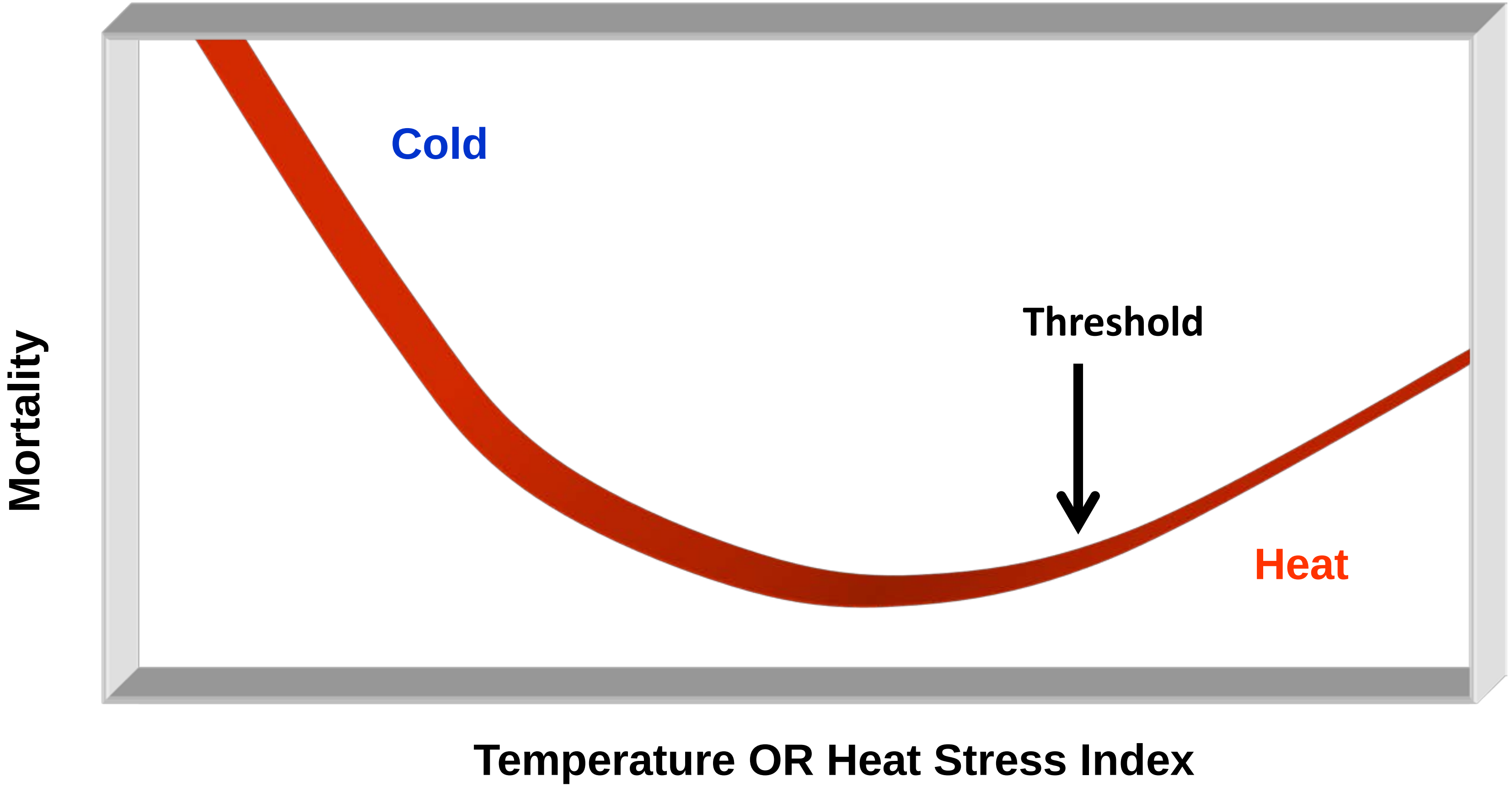
Source: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/711503/Heatwave_plan_for_England_2018.pdf

Operation of a Typical HHWS



Source:G.R. McGregor, P. Bessemoulin, K. Ebi and B. Menne (eds.) (2015) WMO Heatwaves and Health: Guidance on Warning-System Development WMO-No. 1142

Relationship between cold, heat and mortality



Keatinge et al., 2000: British Med. J.

Thresholds (Apparent Temperature ºC)

PHEWE PROJECT RESULTS :

Effect of summer temperature on total mortality, city threshold and % variation of mortality for 1°C increase in maximum apparent temperature

(Biggeri et al, 2007, submitted)

City	Threshold	95%*CI*		% Variation	95%*CI*	
Northern-Continental	23.3	22.5	24.0	1.84	0.06	3.64
Mediterranean	29.4*	25.7*	32.4*	3.12	0.60	5.72
Athens	32.7	32.1	33.3	5.54	4.30	6.80
Barcelona	22.4	20.7	24.2	1.56	1.04	2.08
Budapest	22.8	21.9	23.7	1.74	1.47	2.02
Dublin	23.9	20.7	27.1	-0.02	-5.38	5.65
Helsinki	23.6	21.7	25.5	3.72	1.68	5.81
Ljubljana	21.5	15.0	28.0	1.34	0.32	2.37
London	23.9	22.6	25.1	1.54	1.01	2.08
Milan	31.8	30.8	32.8	4.29	3.35	5.24
Paris	24.1	23.4	24.8	2.44	2.08	2.80
Praha	22.0	20.4	23.6	1.91	1.39	2.44
Rome	30.3	29.8	30.8	5.25	4.57	5.93
Stockholm	21.7	18.2	25.3	1.17	0.41	1.94
Turin	27.0	25.2	28.9	3.32	2.53	4.13
Valencia	28.2	23.7	32.7	0.56	-0.35	1.47
Zurich	21.8	16.5	27.0	1.37	0.49	2.25

A selection of operational Heat–Health Systems showing the varying nature of system structure, heat-event definition and type of threshold used for triggering warnings

(Source: Heatwaves and Health: Guidance on Warning-System Development
G.R. McGregor, P. Bessemoulin, K. Ebi and B. Menne (eds.) WMO-No. 1142
World Meteorological Organization and World Health Organization, 2015)

Country	Threshold	Thresholds based on historical mortality	Excess mortality forecast	Duration of heat event included	Seasonality or adaptation included	Regionally variable thresholds	Human expertise
Australia (Queensland)	AT			2 days		✓	✓
Belarus	T						
Belgium	Tmax/Tmin/Ozone			3 days			
Canada (Toronto region)	Airmass	✓	✓	✓	✓	✓	✓
Canada (Montreal)	Tmax/Tmin			✓			
Canada (all others)	Humidex			✓			
China (Hong Kong)	NET						
China (Shanghai)	Airmass	✓	✓	✓	✓		✓
France	Tmax/Tmin	✓		3 days		✓	✓
Germany	PT			2 days	✓	✓	✓
Greece	Tmax			✓			
Hungary (Budapest only)	Tmean	✓					
Italy	Airmass/Tapp	✓	✓	✓	✓	✓	
Republic of Korea	Airmass	✓	✓	✓	✓	✓	✓
Republic of Korea (Seoul*)	Airmass	✓	✓	✓	✓	✓	✓
Latvia	Tmax			✓			
Netherlands	Tmax			✓			
Poland	Tmax/Tmin						
Portugal	Tmax	✓	✓	✓		✓	✓
Romania	ITU						
Slovenia	Forecaster						✓
Spain	Tmax/Tmin	✓				✓	✓
Switzerland	HI						
United Kingdom (England and Wales)	Tmax/Tmin			✓		✓	
USA (synoptic**)	Airmass	✓	✓	✓	✓	✓	✓
USA (all others)	HI			2 days		✓	✓

Common Heat Indices Used in Research and Practice

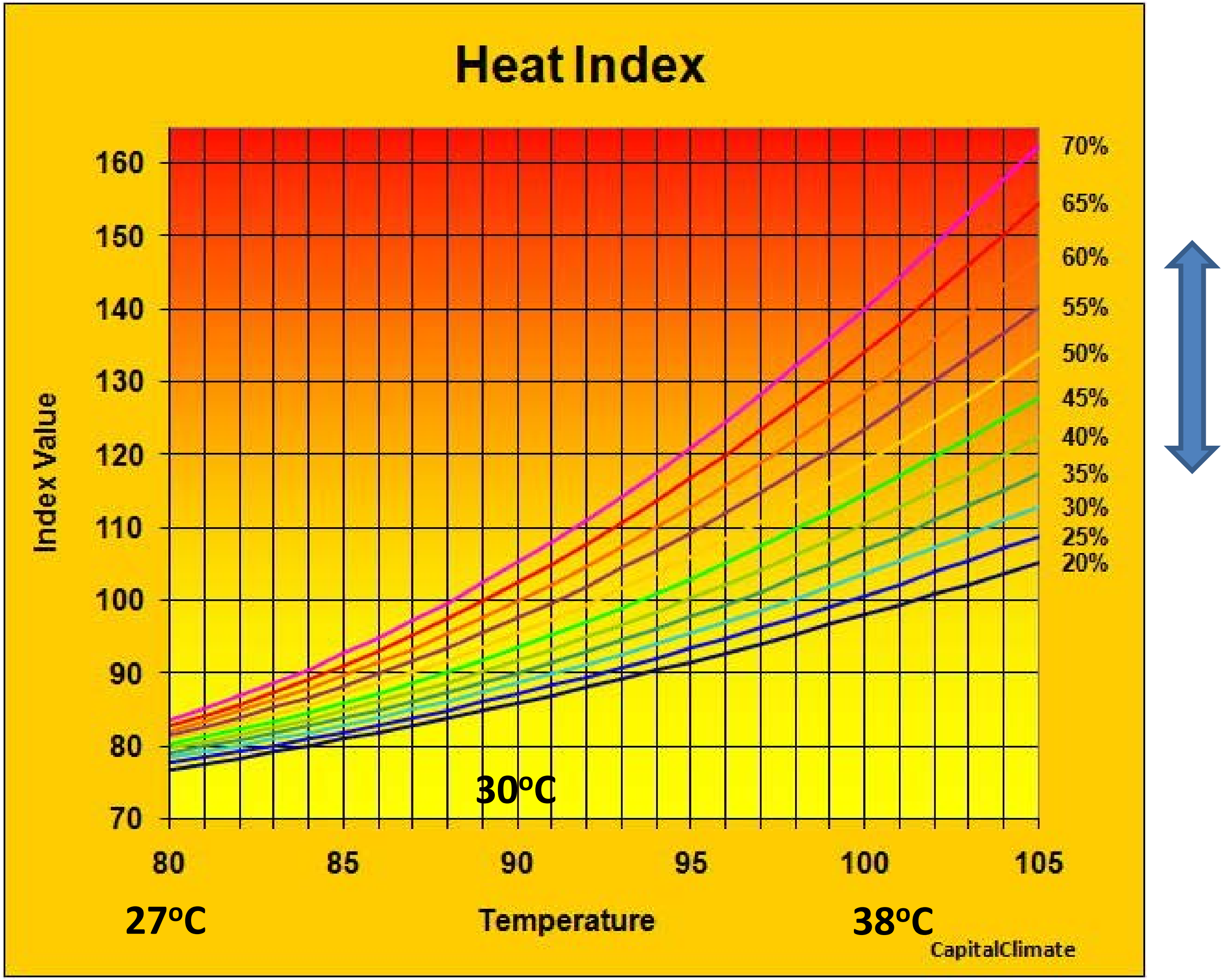
(Source: McGregor & Vanos (2017) Heat: A Primer for Public Health Researchers. *Public Health.* 161:138-146. doi: 10.1016/j.puhe.2017.11.005)

Table 3 – Common heat indices used in research and practice worldwide.

Index	Type and main inputs	Scale/Units	Main application(s) & notes
Simplified heat budget models (direct and empirical)			
Heat index	Direct index, yet empirically derived in its conception.[54] T_a, RH.	°F	Heat wave warnings and guidance, USA.[63] Full population; relative thresholds for vulnerable.
Humidex	Direct index, yet empirically derived. T_a, VP	°C	Heat wave warning and guidance, Canada.[55] Full population; relative thresholds for vulnerable.
Net effective temperature (NET)	Direct. T_a, RH, V	°C	Heat wave warning and guidance, China.[64]
Wet-bulb globe thermometer (WBGT)	Direct. T_w, T_a, T_g	°F/°C	Exertional heat stress and illness; military, athletes, active populations, occupational heat exposure.[58,65]
Wet bulb temperature (T_w)	Direct. T_w.	°F/°C	Classic heat illness; $T_w > 35$ °C cited as limits of habitability for human adaptation to heat.[66] No set warnings thresholds for general population.
Complex heat budget models (rational)			
Physiological equivalent temperature (PET)	Rational. T_a, T_{mrt}, RH, V, M_{act}	°C	Thermal comfort, urban design.[67] Applied to general population.
COMfort FormulA (COMFA)/ COMFA	Rational. T_a, NR, VP, V, M_{act}, I_{cl}. Utilizes Eq. (1).	W/m^2	Thermal comfort, urban design, heat stress prediction sedentary/active (COMFA).[17,68] Applied to general population; can be age-specific.
Man-ENvironment heat EXchange model (MENEX)	Rational. T_a, NR, RH, V, M_{act}, I_{cl}. Utilizes Eq. (1).	W/m^2	Thermal comfort, urban design, heat stress during exercise.[69]
Heat Stress Index (HSI)	Rational. VP, T_a, V, M_{act}. Ratio required to reach maximum evaporation.	Scale from 0 to 100 ($HSI = E_{req}/E_{max}$)	Heat stress prediction, classic and exertional.[70] General population.
Standard effective temperature (SET)	Rational. T_a, T_{mrt}, RH, V, M_{act}, I_{cl}. Utilizes Eq. (1).	°C	Two-node method represents skin temperature and wettedness.[71]
Thermal work limit (TWL)	Rational. T_a, NR, VP, V.	W/m^2 or METs	Occupational and exertional heat stress.[49]
Universal Thermal Comfort Index (UTCI)	Rational. T_a, T_{mrt}, RH, V, M_{act}, I_{cl}	°C	Physiologically-based thermal comfort.[26,72,73]
Apparent temperature	Rational. T_a, T_{mrt}, RH, V, M_{act}, I_{cl}	°C	Assessment of hot/humid weather; thermal comfort; clothing.[54,74]
Other			
Physiological Strain Index (PSI)	Empirical. Requires physiological inputs of heart rate and BCT.	Strain (0–10)	Clinical studies, exercise/active individuals.[75]
Environmental Stress Index (ESI)	Empirical. SR, RH, T_a	°C	Exercise (athletic, military, occupational).[21]
Discomfort Index (DI)	T_w, T_a	°F	Human (dis)comfort required for air conditioning for sedentary individuals.

Rational indices are utilized within research, whereas direct and empirical are used more in practice and by the public.
Abbreviations: T_a, air temperature; RH, relative humidity; VP, vapour pressure; V, wind speed/ventilation; T_{mrt}, mean radiant temperature; NR, net radiation; I_{cl}, clothing insulation; M_{act}, metabolic activity; SR, solar radiation.

Heat Index Sensitivity to Relative Humidity Prediction



Forecast Type

Probabilistic forecasting relies on different methods to establish an event occurrence/magnitude **probability**.

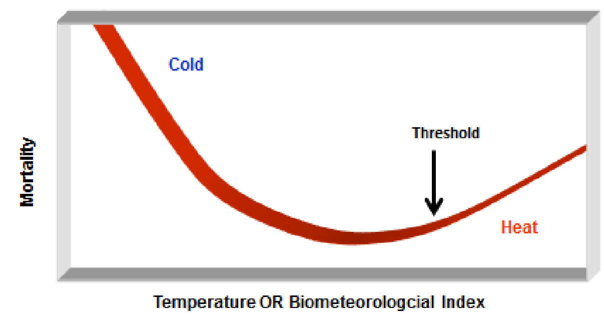
e.g. tomorrow = 75% probability Tmax > 35°C

Deterministic forecasting: definitive information on the occurrence (occur/not occur) or magnitude (size) of an same event

e.g. tomorrow Tmax = 36°C;

tomorrow > 35°C (yes/no)

Relationship between cold, heat and mortality



Keatinge et al., 2000: British Med. J.

Users Worry About Forecast Quality Attributes

- Reliability
- Accuracy
- Skill
- Resolution
- Sharpness
- Uncertainty

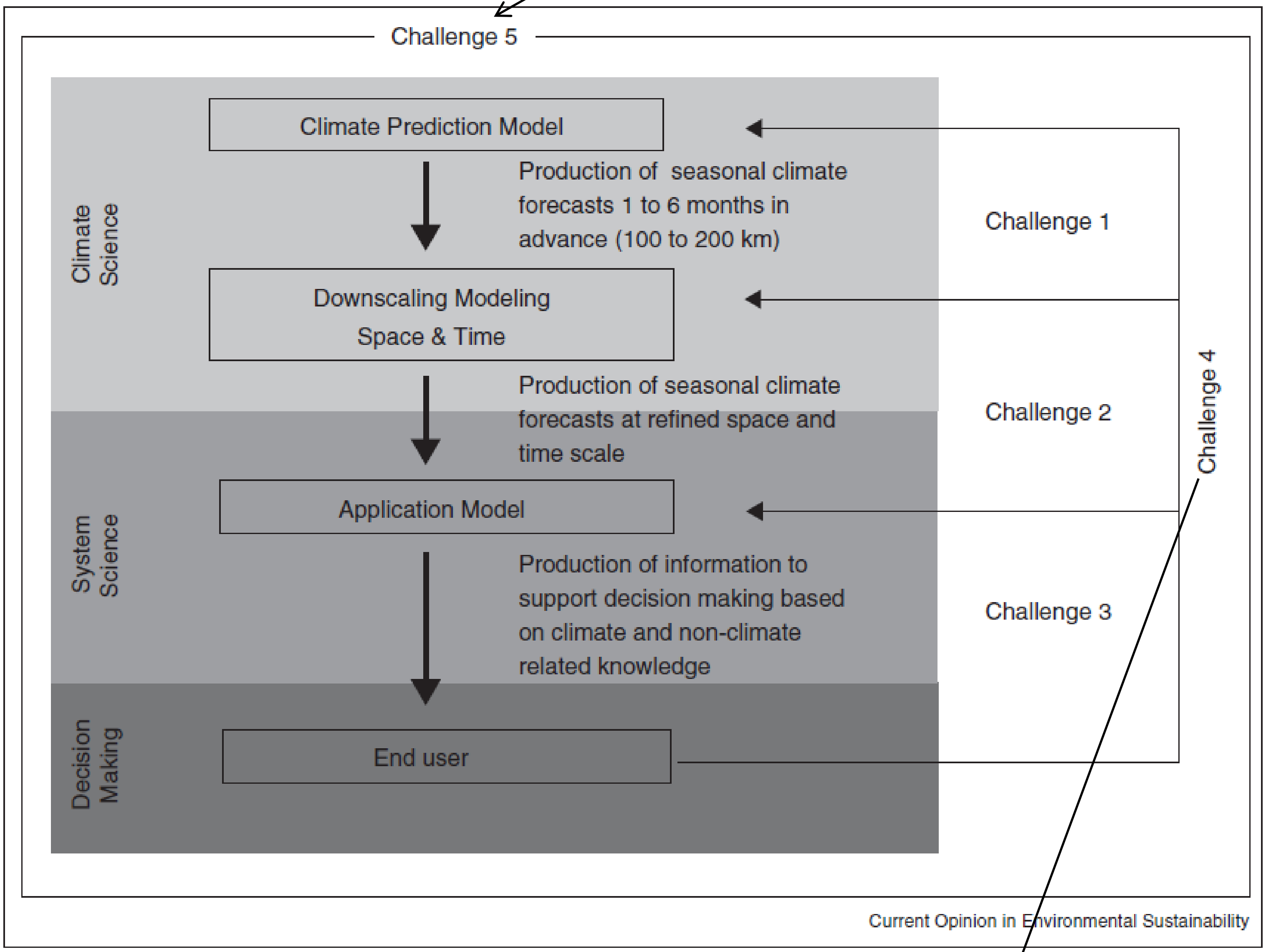
→

Trust in the forecast

Challenges for integrating seasonal climate forecasts in user applications

(Source: https://www.cptec.inpe.br/pesquisadores/caio.coelho/Coelho_and_Costa_2010.pdf)

Design and implement the whole system.



Stimulate feedback provision by the end user to system and climate scientists for improving the forecasting process

Some Specifics

- Heat prediction products 3-4 weeks in advance (but this timescale characterized by a small signal, large noise and low predictability)*

- Development of user-friendly interactive tools for heat outlooks e.g. (i) probabilistic outlooks for tercile categories, (ii) outlooks tailored to user risk profile.

- Explore possibility of S2S heat forecasts (dynamical-statistical) so as to provide decision support services to the heat-health community.

- Understand consistency of relationship between large scale modes of climate variability (e.g. El Niño, NAO, SAM, PDO, PNA, IOD) and anomalous heat at range of time and space scales.

***** due to the decaying influence of atmospheric initial conditions and marginal influence from boundary conditions such as sea surface temperature, soil moisture, sea ice

Where/how do People Want to Access Climate Information?

Phone's default weather app

Social media

Local TV news

A specific website or app

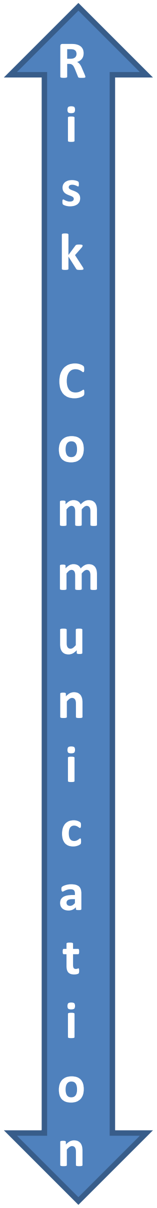
The Weather Channel or equivalent

Internet search

Newspaper

Radio weather

Newsletter (electronic, printed)



Thankyou