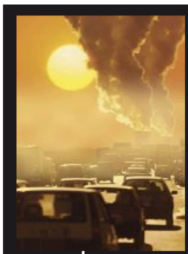
AVIESAN mini-symposium on Climate Change and Health, Paris, 6 July 2015



CLIMATE CHANGE AND HUMAN HEALTH

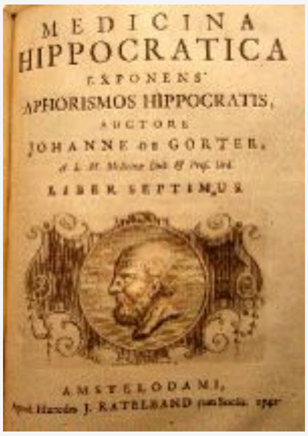
Rémy Slama, PhD
Senior Investigator
Inserm
Team of Environmental Epidemiology
Inserm and Univ. Grenoble Alpes joint research Center (IAB)
Grenoble

aviesan
alliance nationale
pour les sciences de la vie et de la santé

INSTITUT ALBERT BONNIOT

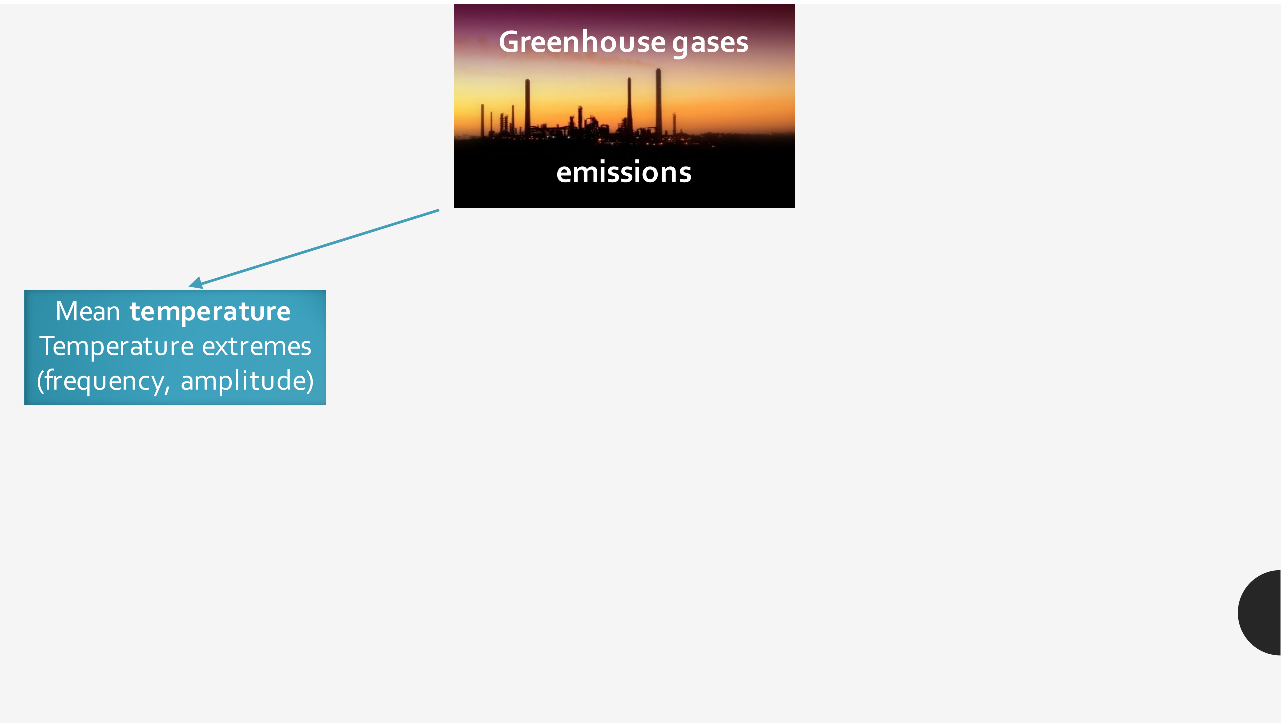
Inserm
Institut national
de la santé et de la recherche médicale

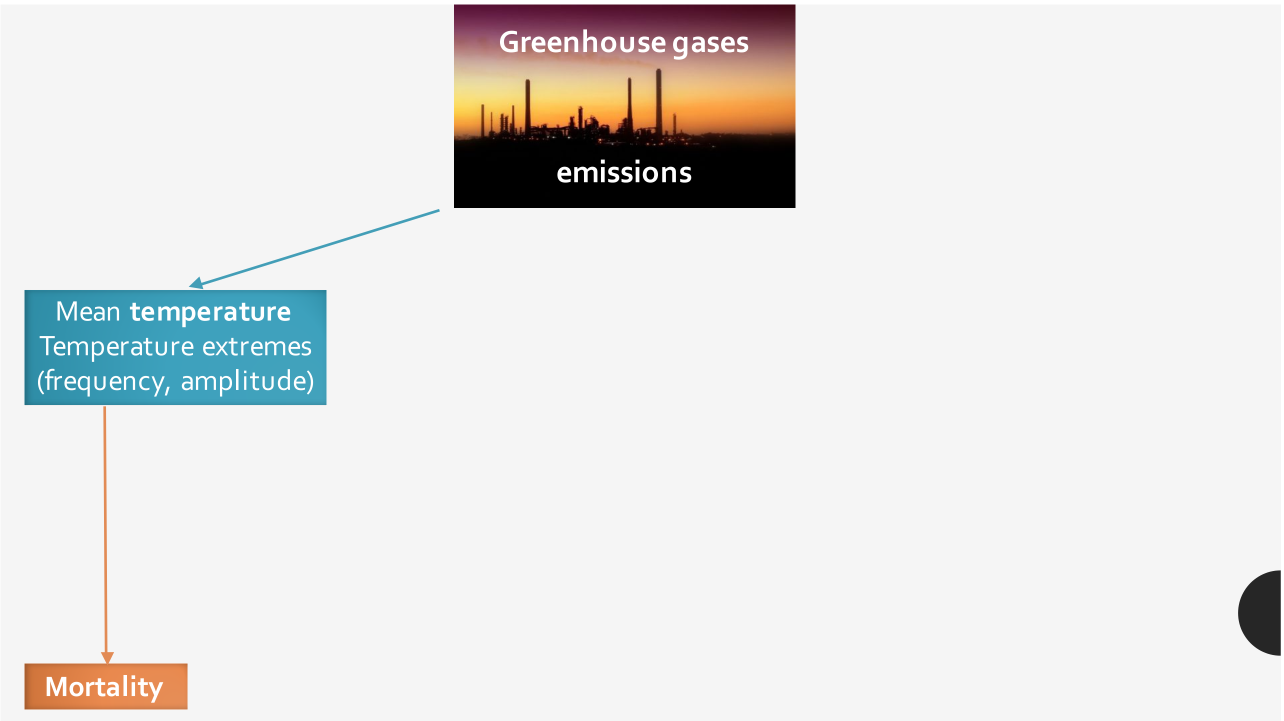
UNIVERSITÉ Grenoble Alpes


MEDICINA
HIPPOCRATICA
EXPONENS
APHORISMOS HIPPOCRATIS,
AUCTORE
JOHANNE DE GORTER,
LIBER SEPTIMUS
AMSTELODAMI,

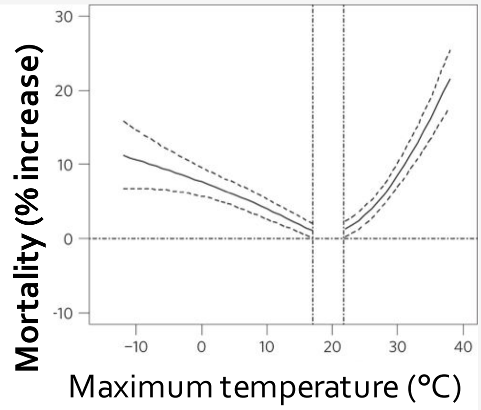
Whoever wishes to investigate medicine properly, should proceed thus: in the first place **to consider the seasons of the year**, and what effects each of them produces for they are not at all alike, but differ much from themselves in regard to their changes. **Then the winds, the hot and the cold**, especially such as are common to all countries, and then such as are peculiar to each locality.

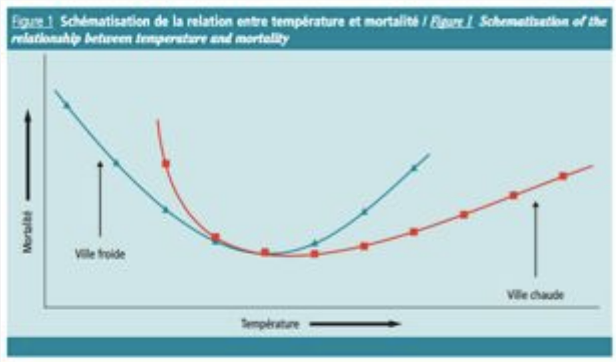
Hippocrates (ca. -460 to -370), *On Air, Water, Places*


Greenhouse gases
emissions
Mean **temperature**
Temperature extremes
(frequency, amplitude)


Greenhouse gases
emissions
Mean **temperature**
Temperature extremes
(frequency, amplitude)
Mortality

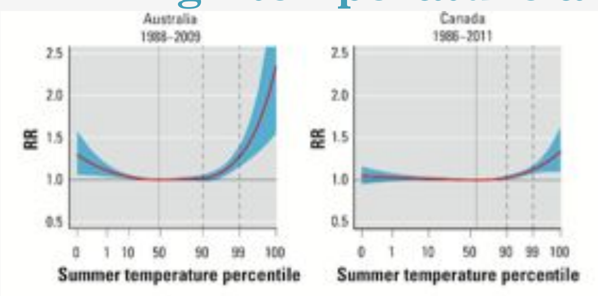
Temperature and mortality: *V-shape relation* *…depending on area*

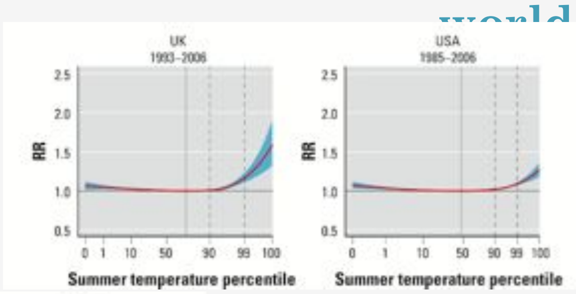


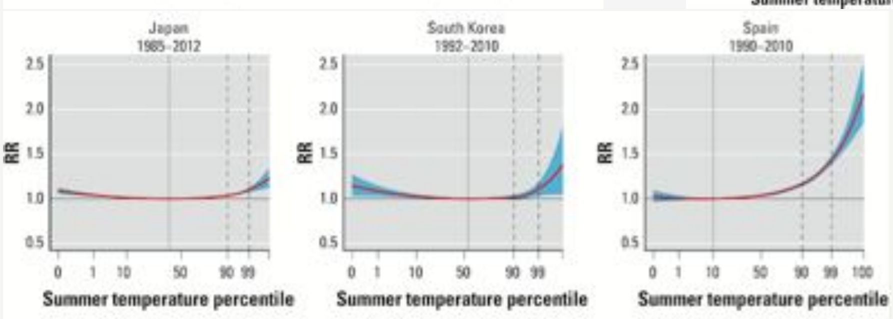


(Li, *Nature Climate Change*, 2013)

High temperature and mortality throughout the world

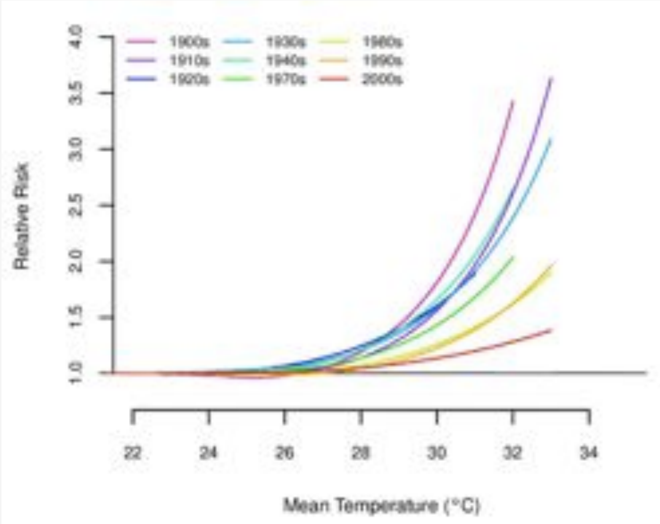






(Gasparrini, *EHP*, 2015)

High temperature and mortality: **any evidence of adaptation?** *The case of NY*



(Petkova, *Epidemiology*, 2014)

Temperature and mortality: **any evidence of adaptation?** *The French case*

Period	MST (°C)	MWT (°C)	Heat-wave days	Cold-spell days	MMT (°C)	Days > MMT days	RM25	RM25/18
P1: 1968–1981	17.6 ± 1.4	4.2 ± 1.8	6.8 ± 6.0	8.2 ± 2.4	17.5 ± 1.4	825 ± 228	1.19 ± 0.13	1.18 ± 0.12
P2: 1982–1995	18.6 ± 1.5	4.6 ± 1.8	5.8 ± 4.0	22.6 ± 3.5	17.8 ± 1.5	962 ± 243	1.15 ± 0.09	1.16 ± 0.08
P3: 1996–2009	19.2 ± 1.5	5.0 ± 1.7	16.7 ± 5.5	8.6 ± 2.9	18.2 ± 1.6	994 ± 262	1.14 ± 0.09	1.15 ± 0.08

Abbreviations: MMT, minimum mortality temperature; days > MMT, at a given period, sum on all squares of the number of days observed with a temperature above the MMT of the square at the given period; RM25, ratio of mortality at 25°C/mortality at MMT; RM25/18, ratio of mortality at 25°C/mortality at 18°C. Results were computed in the 211 squares with > 7,500 deaths and a U/J-shaped curve for all three periods. Mean summer temperature (MST) and mean winter temperature (MWT), respectively, are the mean temperatures observed during the months of June–August and December–February of the period considered.

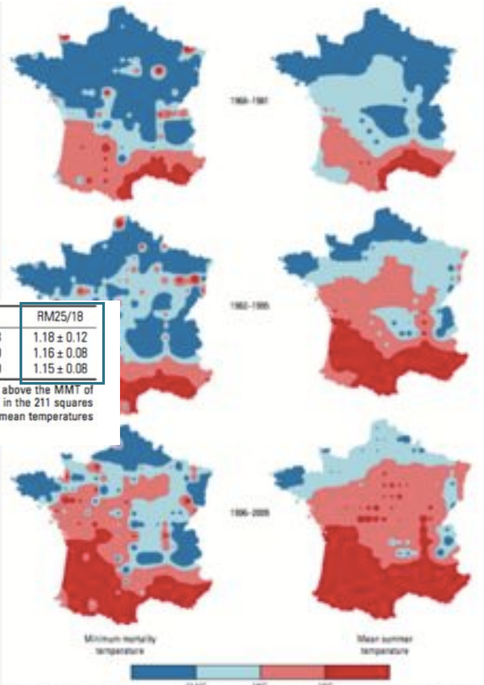
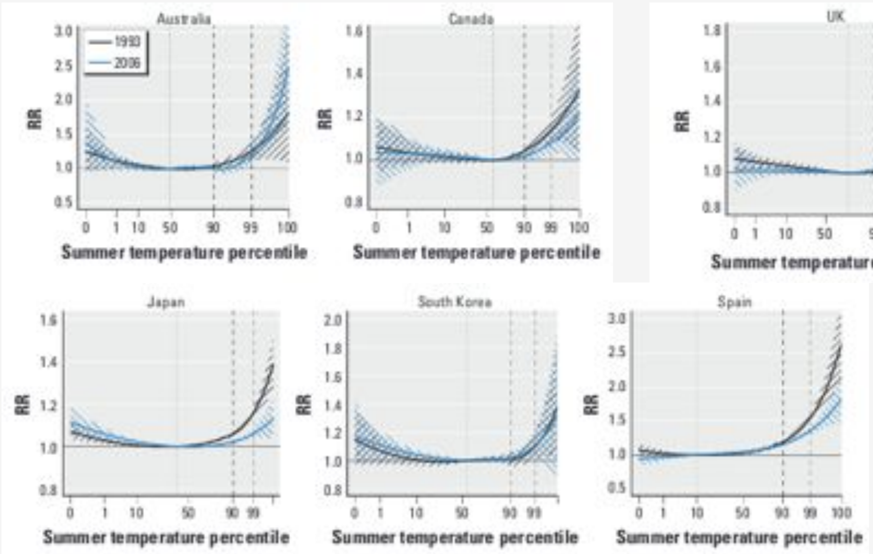


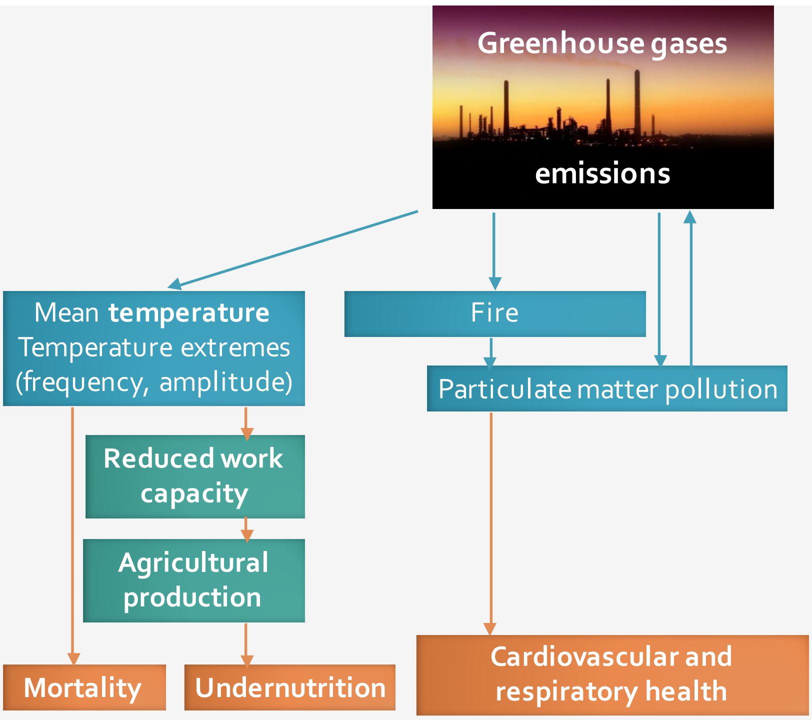
Figure 4. Variations of minimum mortality temperatures (MMT) and mean summer temperatures (MST) in France from 1968 through 2009. The maps were interpolated from the values observed at the centroids of

(Todd and Valleron, *EHP*, 2015)

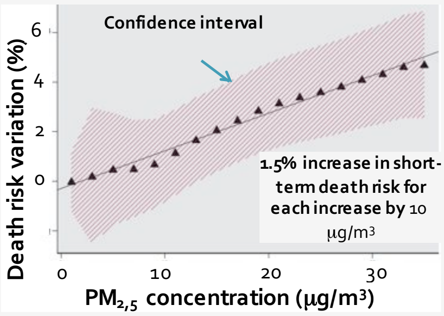
High temperature and mortality: any evidence of adaptation *worldwide?*



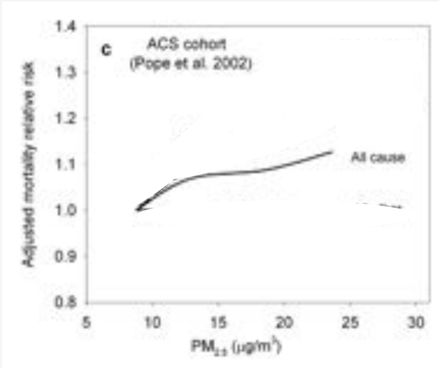
(Gasparrini, *EHP*, 2015)



Particulate matter (PM) are associated with mortality both on the short and long term



(Schwartz, *Env Health Perspect*, 2002)



For an increase by 10 µg/m³ in mean (yearly) $PM_{2.5}$ levels:

- Increase by 8% in all cause mortality risk
- Increase by 12% in risk of death by cardiovascular cause

See also Revihaap, WHO Europe, 2013

Combination of heat wave and fire – *The Moscow summer 2010 episode*

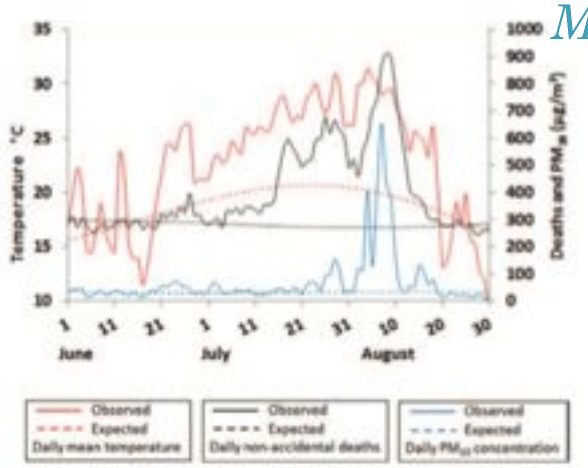
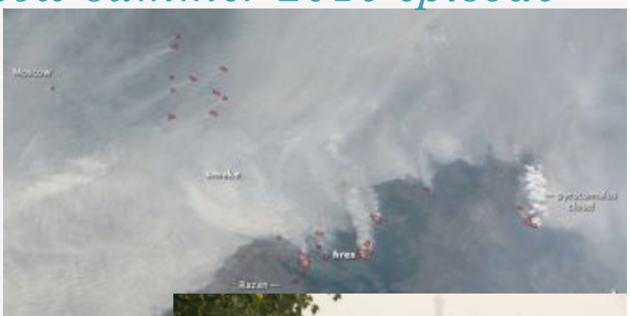
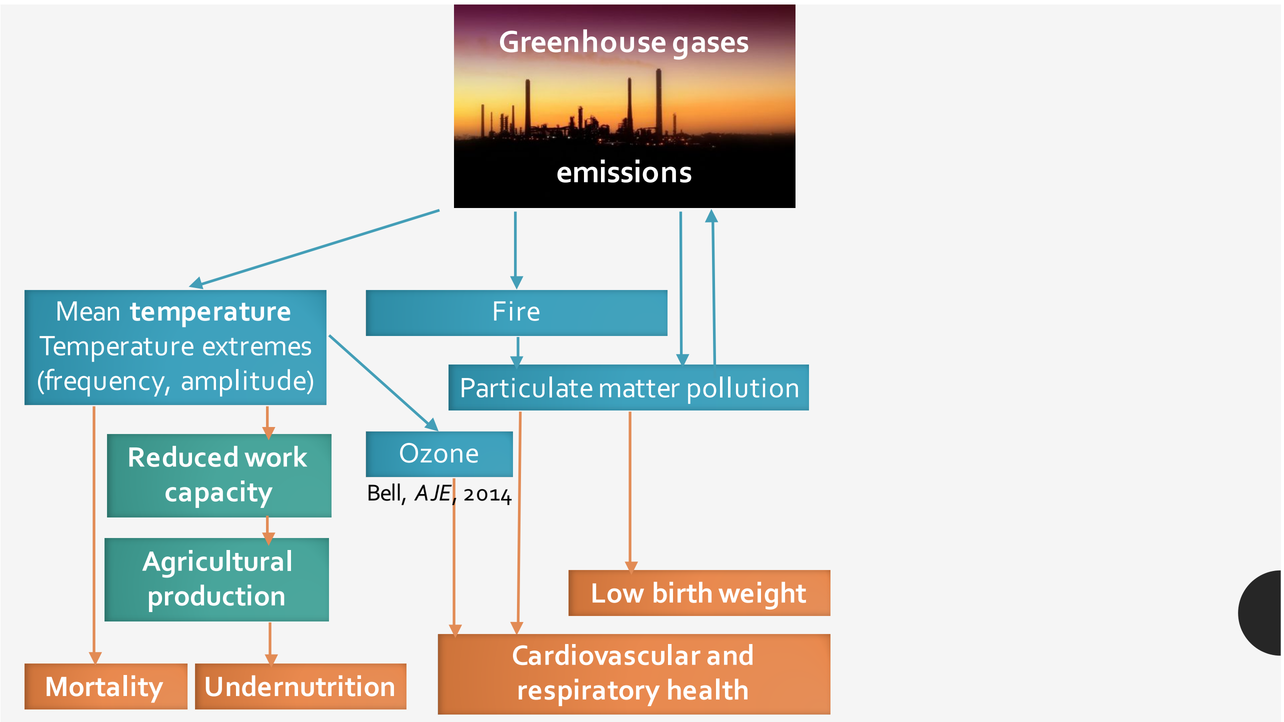


FIGURE 1. Daily nonaccidental deaths, mean temperature, and PM_{10} levels in Moscow during the summer of 2010. Solid lines show observed values; dashed lines, expected values.



44-day period.
11,000 deaths in excess, out of which possibly 2,000 attributable to interaction between heat and particulate matter.

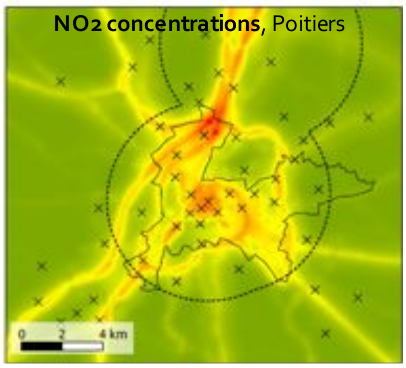
(Shaposhnikov, *Epidemiology*, 2015)



ESCAPE Project

The European Study of Cohorts for Air Pollution Effects (ESCAPE)

- Singleton births, 1994-2011
- ≈74,000 mother-child pairs, 24 centers, 14 cohorts, 12 countries
- Centralized analyses with individual data transfer from each cohort
- Analyses adjusted for smoking, gestational duration, sex, socio-economic status…
- *Health outcomes:* Preterm delivery (i.e. before 37 gestational weeks) and **low birth weight** (<2500g) among term births.
- Air pollution measurements followed by Land Use Regression (LUR) modelling (PM, NO2…)
- Air pollution effects were adjusted for meteorological factors, but not the other way round (Buckley, *Epidemiology*, 2014)



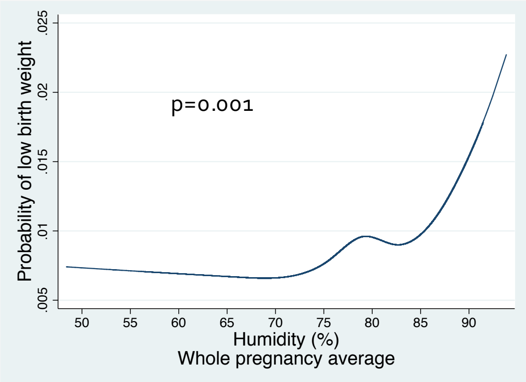
(Pedersen, *Lancet Resp Med*, 2014; Raaschou-Nielsen, *Lancet Oncol*, 2013; Eeftens, *EST*, 2013)

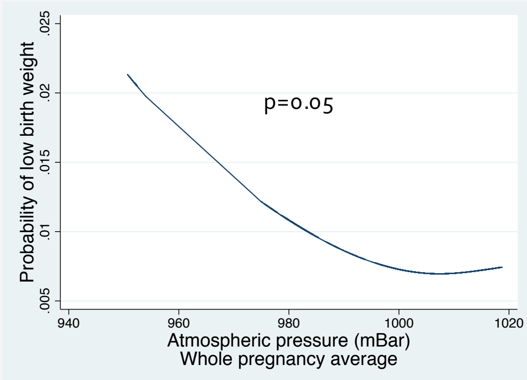
Meteorological conditions and low birth weight
56,532 births

Low birth weight risk was higher when humidity was high

…or atmospheric pressure low.

No evidence of association between temperature and low birth weight risk (p>0.3).





Restricted cubic spline models adjusted for gestational duration (3rd degree polynomial), maternal smoking, parity, infant sex, socio-economic status, center…

Atmospheric pollutants and low birth weight

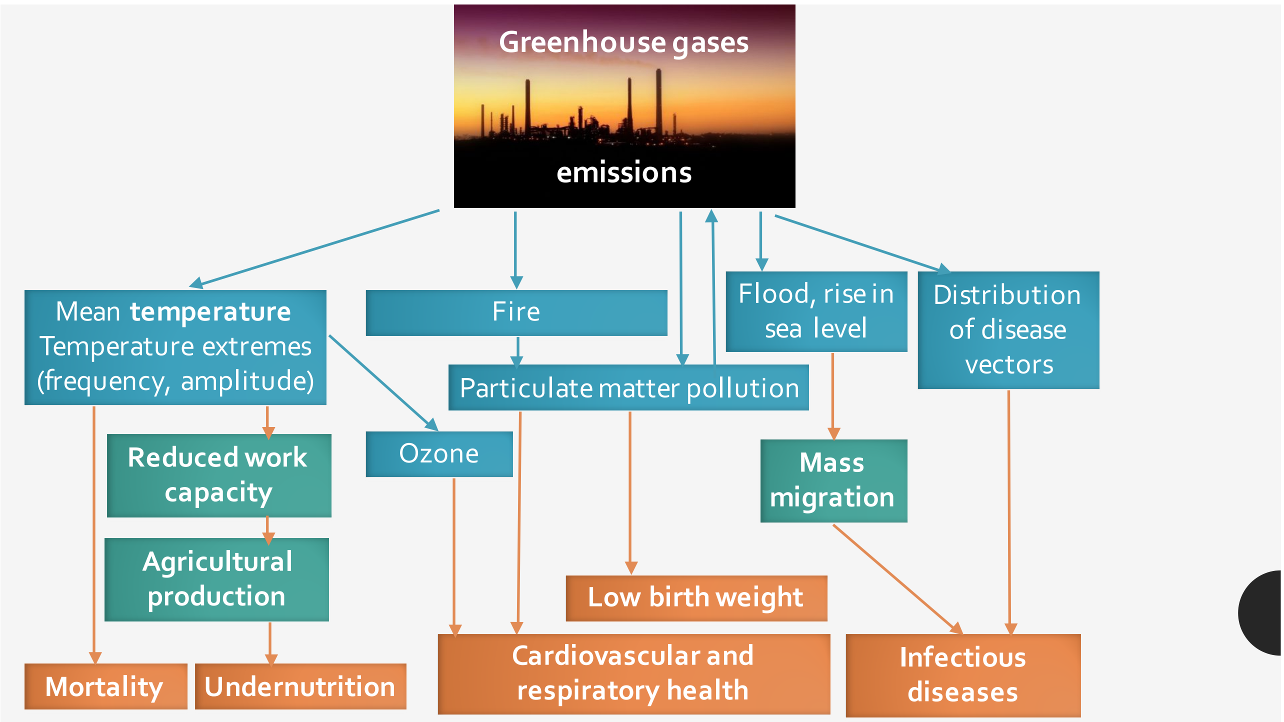
Pollutant	N births (cases)	OR low birth weight (95% CI)
PM2.5	48,326 (675)	**1.12** (1.01-1.24)
NO2	59,024 (1074)	**1.09** (1.00-1.19)

For each increase by 5 µg/m³ in PM2.5 pregnancy average and each increase by 10 µg/m³ in NO2

- Air pollution levels were generally below the current EU standard (25 µg/m³ yearly average)
- Increased risk of low birth weight associated with fine particulate matter (PM2.5) pregnancy exposure
- Weak effect *individually* but large *public health* impact given the widespread exposure

Models were adjusted for gestational duration (3rd degree polynomial), maternal smoking, parity, infant sex, socio-economic status, center **and meteorological conditions** (humidity).

(Pedersen, *Lancet Resp Med*, 2014)



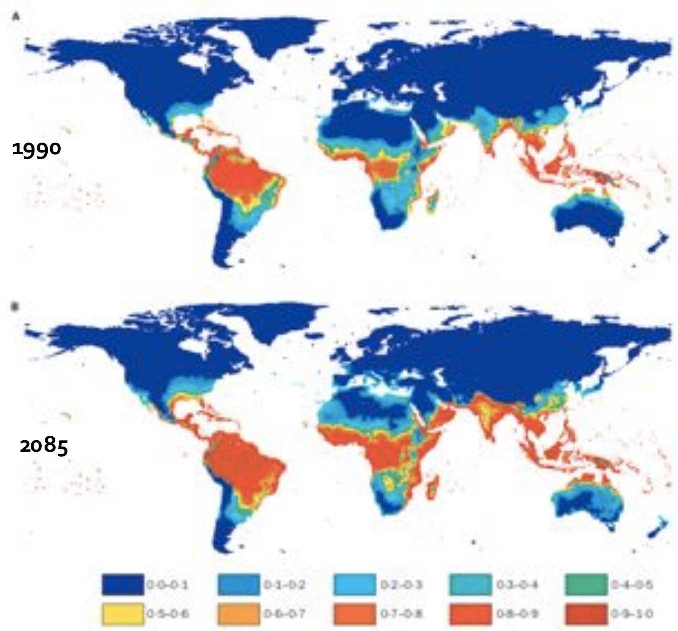


Figure 2: Estimated baseline population at risk in 1990 (A) and estimated population at risk in 2085 (B)

Dengue transmission (projections)

Malaria agent distribution

Ambroisia artemisiifolia pollen production

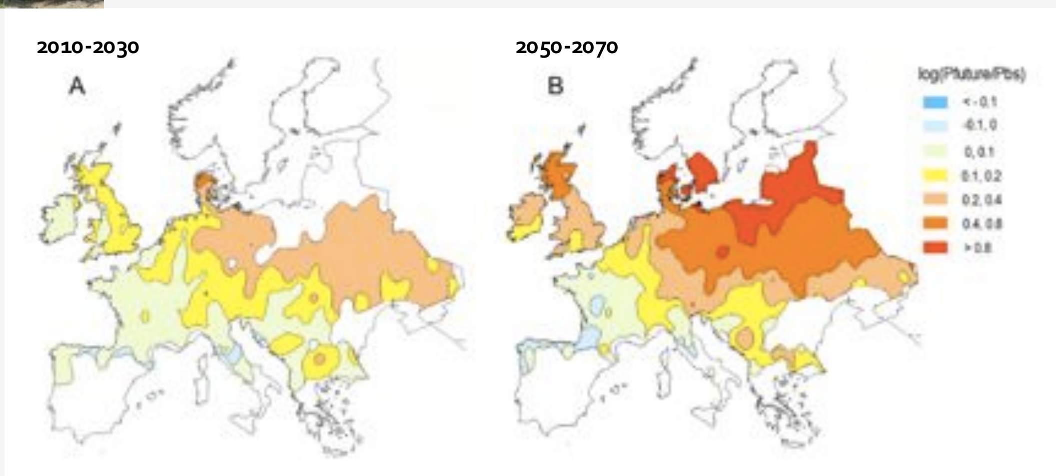
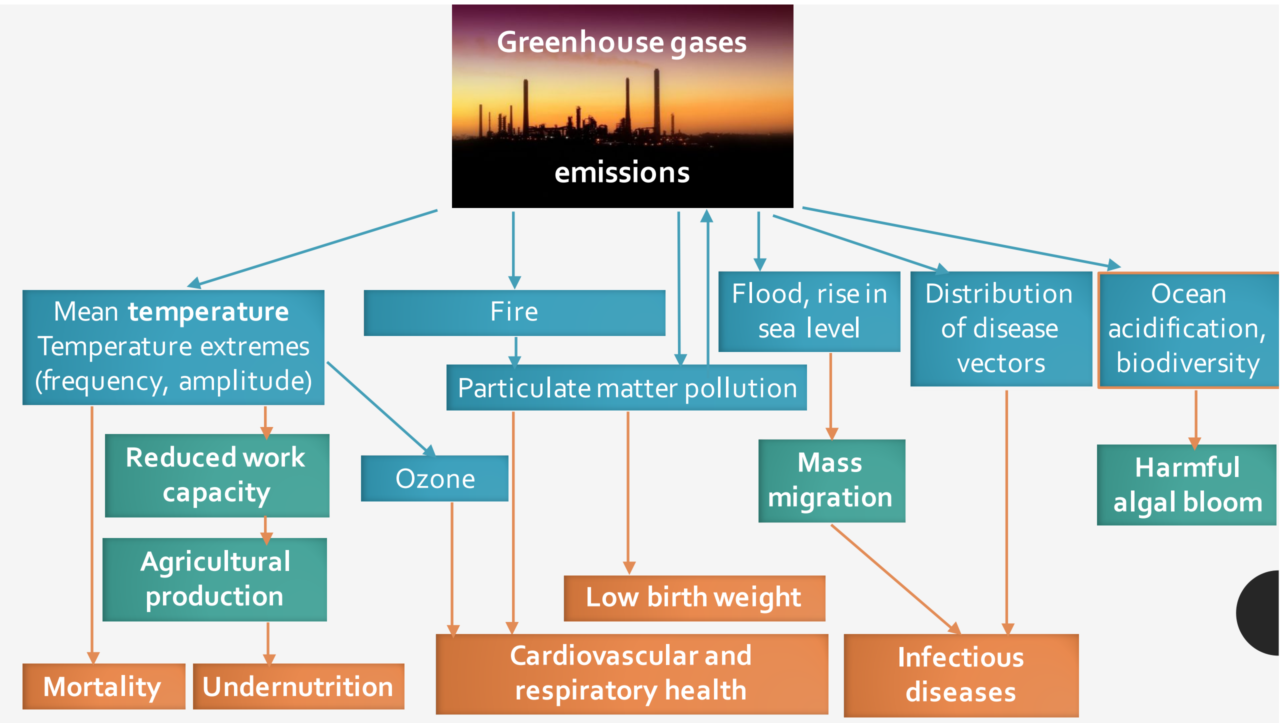


Figure 4. Logarithm of relative increase in *Ambrosia artemisiifolia* pollen production, Pfuture/Pbs, for the HadCM3 (A1B) scenarios. A

(Storkey, *Plos One*, 2014)



Harmful algae

- Algae proliferation on the French coasts, such as Ulva genus
- Recent episodes in France: Brittany, Antilles
- Proliferation results from various factors, including agriculture (phosphorous and nitrogen from fertilizers)
- Climate change also probably contributes to this proliferation (Zofia, *Ecol Lett*, 2015)
- Upon decomposition, algae emit toxic gases such as H_2S
- Concentrations may be very high locally, with levels able to kill mammalians

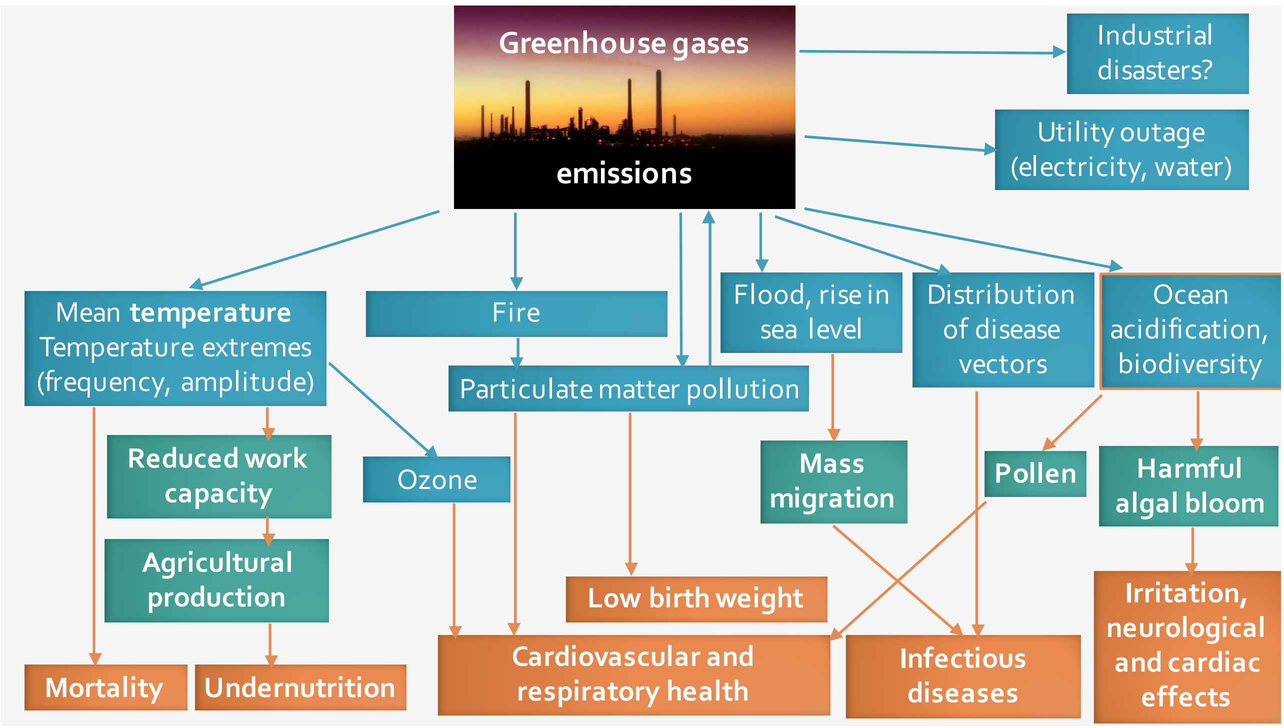
Table 1: List of substances emitted (or suspected of being emitted) into the air by green algae during decomposition

Substances observed during measurement campaigns		Suspected substances	
Name	**CAS number**	**Name**	**CAS number**
Hydrogen sulfide (H_2S)	7783-06-4	Sulfur dioxide (SO_2) *	7446-09-5
Dimethyl sulfide (DMS)	75-18-3	3-Dimethylsulfoniopropionate (DMSP)	7314-30-9
Methyl mercaptan	74-93-1	Acrylic acid	79-10-7
Dimethyl disulfide (DMDS)	624-92-0	Nitrous oxide (N_2O)	10024-97-2
Carbon disulfide (CS_2)	75-15-0	Acetic acid	64-19-7
Thioacetic acid	507-09-5	Lactic acid	50-21-5
Dimethyl sulfoxide (DMSO)	67-68-5	Sulfuric acid *	7664-93-9
Methanesulfonyl chloride	124-63-0	Sulfurous dioxide *	7782-99-2
Dimethyl trisulfide (DMTS)	3658-80-8	Ethanol	64-17-5
Dimethyl pentasulfide (DMPS)	7330-31-6	Acetamides	-
Dithiapentane	1618-26-4	Endotoxins	-
1,2,4-Trithiolane	289-16-7	* *suspected as traces*	
Dimethyl sulfone	67-71-0		
Ammonia (NH_3)	7664-41-7		
Urea	57-13-6		
Methane (CH_4)	74-82-8		
Acetaldehyde	75-07-0		
Formaldehyde	50-00-0		
Propionaldehyde	123-38-6		

During the discussions led by the CES concerning the work to characterise emissions, one expert also raised the possibility of the emission of phosphine (PH_3), whose toxicity is well documented, in view of the presence of phosphate. Such possible emissions could be investigated and characterised in future studies.

(Anses, 2011)

https://www.anses.fr/en/system/files/AIR2010sa0175RaEN.pdf



Conclusion

- Climate change is likely to impact human health by various pathways
- Challenges for risk assessment:
  - Many complex pathways
  - potential interactions with climatic or non-climatic (e.g., economic growth, health system resilience) factors
  - Non linear effects?

make it difficult to quantitatively predict the health burden

- Small risks may **interact** to strongly increase the risk of catastrophic outcomes
- **Adaptation** (of the wealthiest societies at least) may exist and be efficient up to a certain extent for some pathways
- **Co-benefits**: Conversely, some remedies against greenhouse gases emissions may be beneficial to health through various pathways (example of reduction of burning of fossil fuels)

Thank you very much for your attention