Integrated Environmental Health Impact Assessment on Air Pollution and Climate Change in Mediterranean Areas

ICTP

23 - 27 April 2018
Trieste, Italy

Further information:
http://indico.ictp.it/event/8343/
smr3250@ictp.it

# Consequences (sanitary and economic incl. buildings, agriculture, biodiversity...) of living and breathing in the Mediterranean


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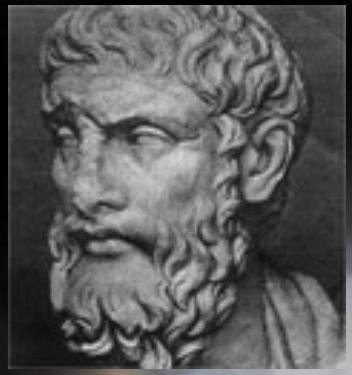
Inserm
Institut national de la santé et de la recherche médicale

EPAR: EPidemiology of Allergic and Respiratory Diseases

NO COI

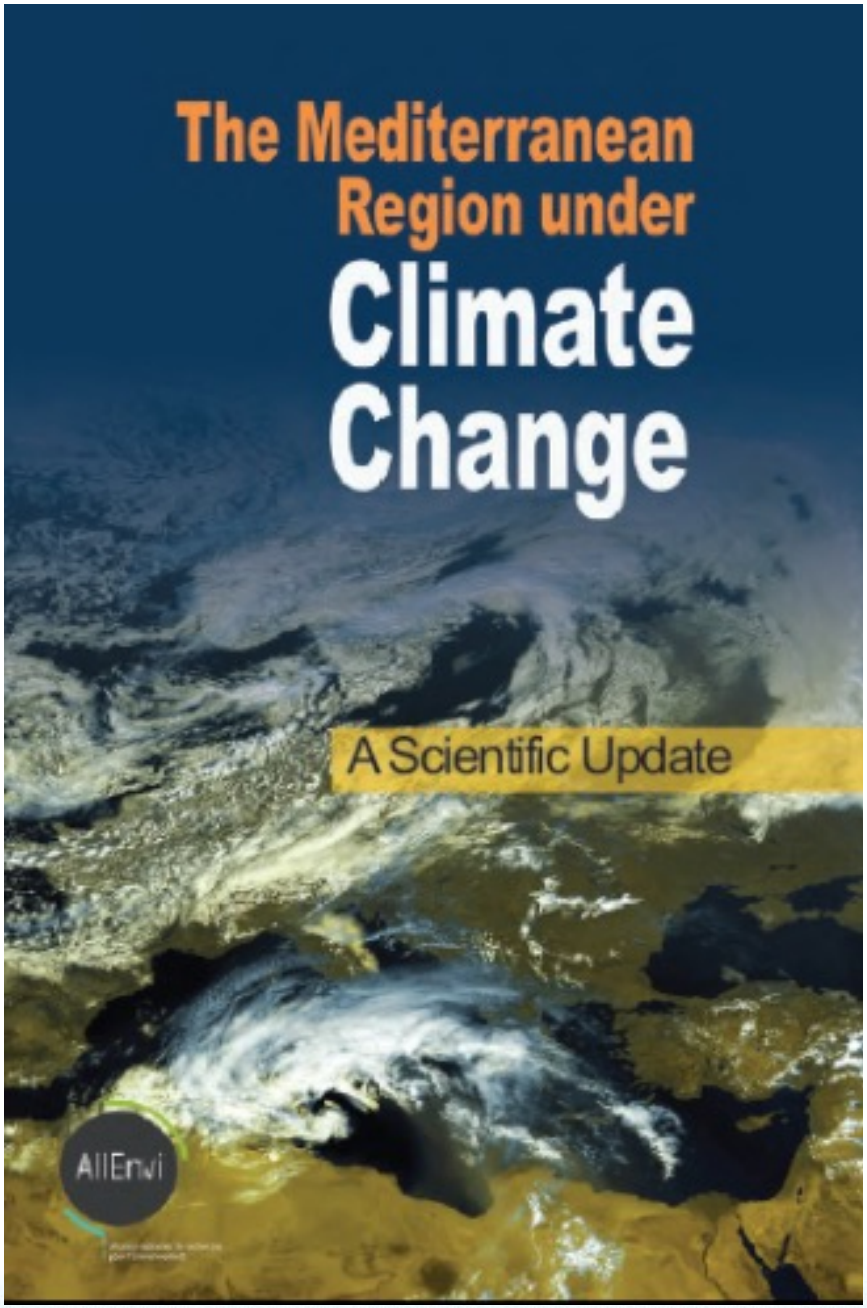


About 2500 years ago, Hippocrates made noteworthy observations about the influence of climate on public health. He believed that people living in cities with different climate may suffer from different diseases. Hippocrates also observed that abrupt climatic changes or unusual weather conditions affect public health, especially the incidence and severity of various infectious diseases …..

# How and What do we know about the impact of CC on lung health?

**Four types of evidence from:**

- **Observational research**
- **Experimental research**
- **Modeling (Projections, HIA…)**
- **More recently: Data mining, Machine learning**


The Mediterranean Region under
Climate Change
A Scientific Update
AllEnvi


**CC slang:**

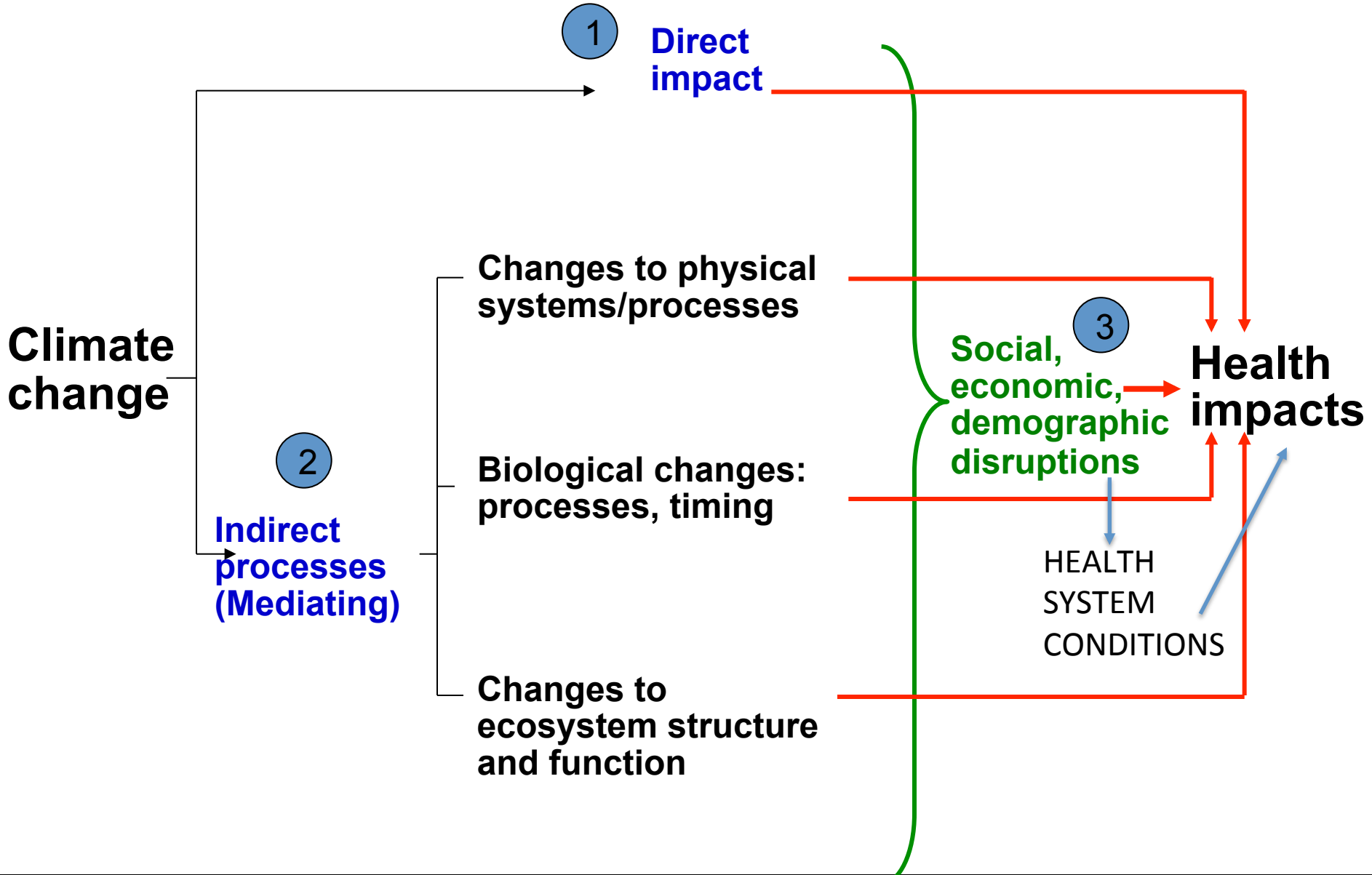
**Virtually certain/ Likely/ To be further confirmed**

# CLIMATE CHANGE: TRENDS OF CLIMATIC VARIABLES

| | ACTUAL CHANGES | | FUTURE SCENARIOS |
|---|---|---|---|
| Phenomenon[a] and direction of trend | Likelihood that trend occurred in late 20th century (typically post 1960) | Likelihood of a human contribution to observed trend[b] | Likelihood of future trends based on projections for 21st century using SRES scenarios |
| Warmer and fewer cold days and nights over most land areas | *Very likely*[c] | *Likely*[e] | *Virtually certain*[e] |
| Warmer and more frequent hot days and nights over most land areas | *Very likely*[d] | *Likely (nights)*[e] | *Virtually certain*[e] |
| Warm spells / heat waves. Frequency increases over most land areas | *Likely* | *More likely than not*[f] | *Very likely* |
| Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas | *Likely* | *More likely than not*[f] | *Very likely* |
| Area affected by droughts increases | *Likely* in many regions since 1970s | *More likely than not* | *Likely* |
| Intense tropical cyclone activity increases | *Likely* in some regions since 1970 | *More likely than not*[f] | *Likely* |
| Increased incidence of extreme high sea level (excludes tsunamis)[g] | *Likely* | *More likely than not*[f, h] | *Likely*[i] |

IPCC, 2007

# Pathways in the effects of Climate Change on Health



# How does climate change affect health?

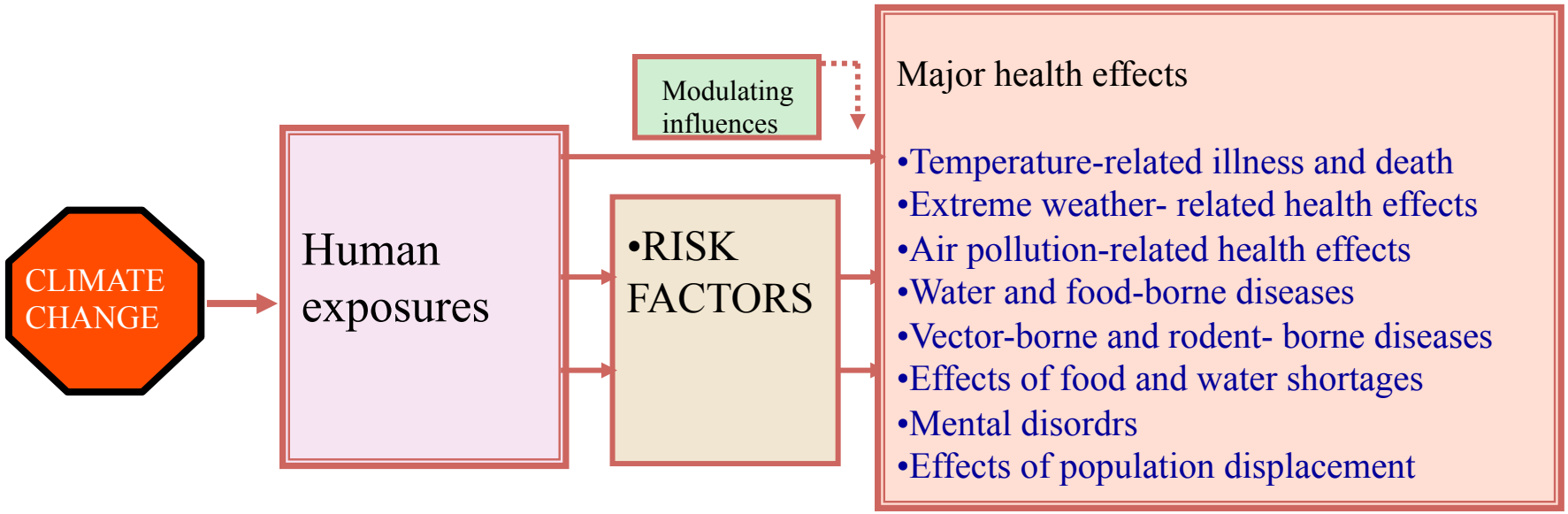
# CLIMATE CHANGE UNDERMINES THE ENVIRONMENTAL DETERMINANTS OF HEALTH

Without effective responses, climate change will compromise:

- **Air quality** (see below)
- **Water quality and quantity**: Contributing to a doubling of people living in water-stressed basins by 2050.
- **Food security**: In some African countries, yields from rain-fed agriculture may halve by 2020.
- **Control of infectious disease**: Increasing population at risk of malaria in Africa by 170 million by 2030, and at risk of dengue by 2 billion by 2080s.
- **Protection from disasters**: Increasing exposure to coastal flooding by a factor of 10, and land area in extreme drought by a factor of 10-30.

# CLIMATE CHANGE CONNECTS TO MANY HEALTH OUTCOMES

Expectations are mainly for changes in frequency or severity of health risks




Based on Patz et al, 2000

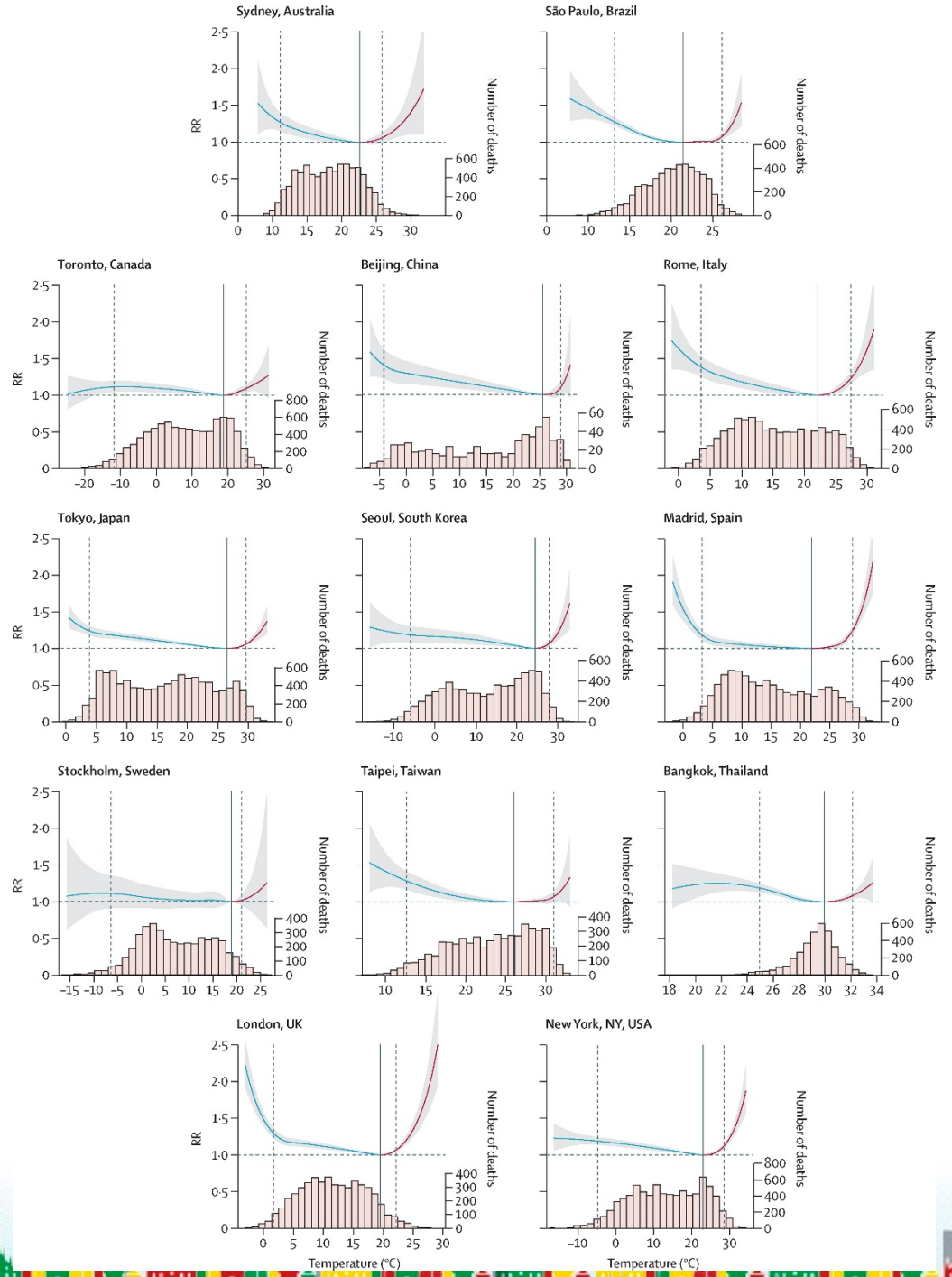
# MORTALITY RISK ATTRIBUTABLE TO HIGH AND LOW AMBIENT TEMPERATURE

**Exposure–response associations in representative cities of 13 countries, with related temperature distributions**

**OF NOTE: Africa is missing**

Extreme cold and hot temperatures were responsible for 0·86% (0·84–0·87) of total mortality.

7·71% (95% empirical CI 7·43–7·91) of mortality was attributable to non-optimum temperature






The Lancet DOI: (10.1016/S0140-6736(14)62114-0)

# A joint ERS/ATS policy statement: what constitutes an adverse health effect of air pollution? An analytical framework

George D. Thurston[1], Howard Kipen[2], Isabella Annesi-Maesano[3], John Balmes[4,5], Robert D. Brook[6], Kevin Cromar[7], Sara De Matteis[8], Francesco Forastiere[9], Bertil Forsberg[10], Mark W. Frampton[11], Jonathan Grigg[12], Dick Heederik[13], Frank J. Kelly[14], Nino Kuenzli[15,16], Robert Laumbach[2], Annette Peters[17], Sanjay T. Rajagopalan[18], David Rich[19], Beate Ritz[20], Jonathan M. Samet[21], Thomas Sandstrom[11], Torben Sigsgaard[22], Jordi Sunyer[23] and Bert Brunekreef[13,24]

Eur Respir J 2017; 49: 1600419

| Consideration |
| --- |
| 1. Fatality |
| 2. Persistence of effect |
| 3. Population risk |
| 4. Susceptibility |
| 5. Medical/functional significance |

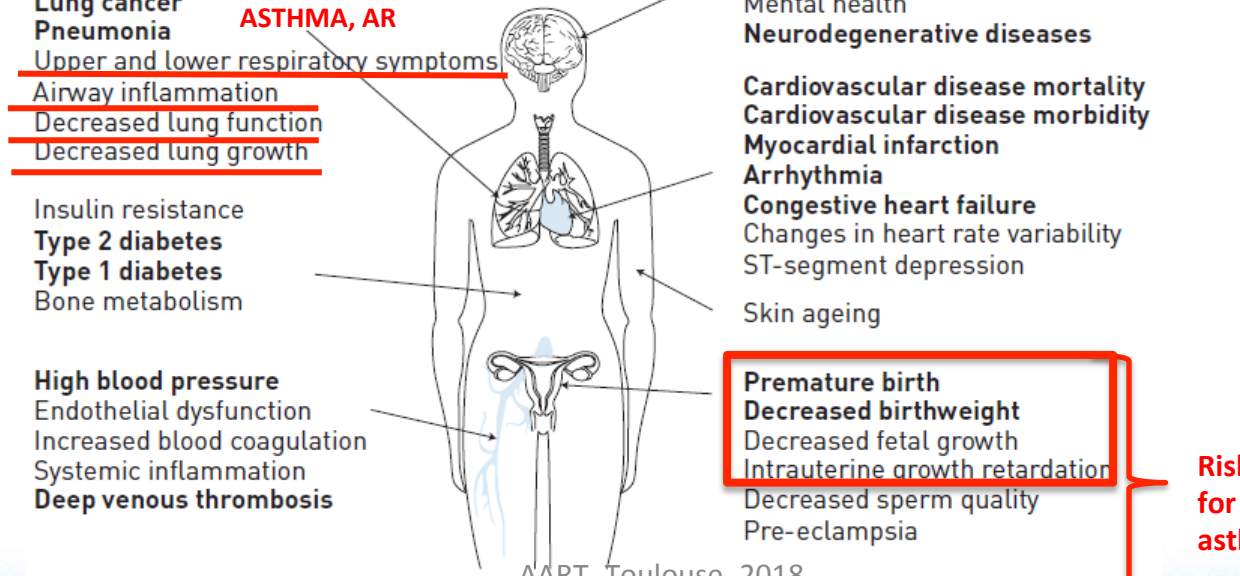



FIGURE 1 Overview of diseases, conditions and biomarkers affected by outdoor air pollution. Updated based on [31]. Bold type indicates conditions currently included in the Global Burden of Disease categories.

# Biomarkers of adverse allergic and respiratory health effects

Increased levels of markers of airway inflammation (*e.g.* PMNs or inflammatory cytokines in BAL or sputum)
Increased levels of markers of airway injury or inflammation in exhaled breath (*e.g.* increased acidity of exhaled breath condensate or increased $F_{ENO}$ in asthmatics)
Increased levels of blood markers of lung injury (*e.g.* 8-isoprostanes, club cell secretory protein)
Imaging evidence for lung injury or reduced lung volume
Reduced pulmonary gas exchange (*e.g.* $D_{LCO}$, $D_{LNO}$, $P_{aO_2}$, pulse oximetry)
Increased airways responsiveness to nonspecific challenge
Increased airways hyperresponsiveness in asthmatic patients

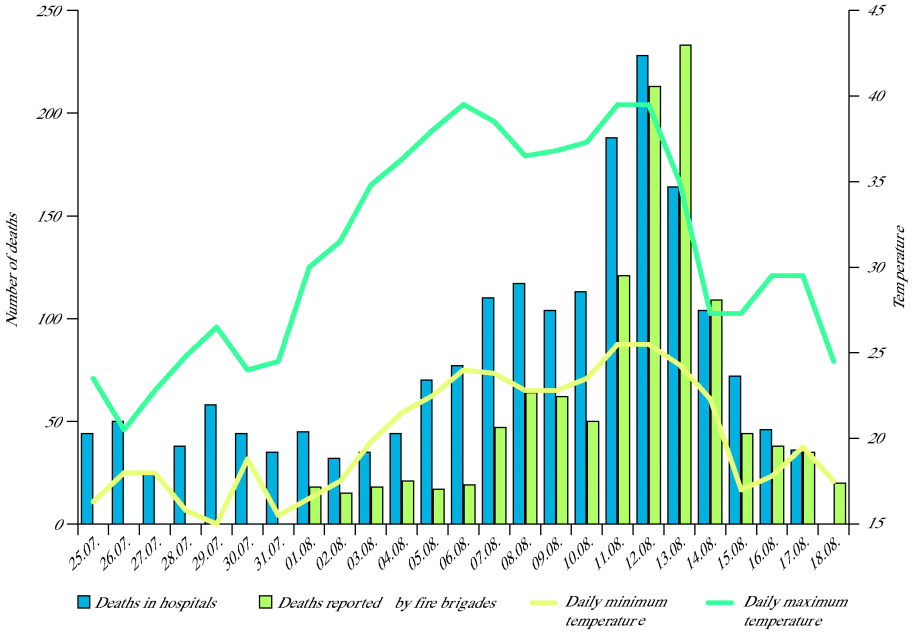
PMN: polymorphonuclear leukocyte; BAL: bronchoalveolar lavage; $F_{ENO}$: exhaled nitric oxide fraction; $D_{LCO}$: diffusing capacity of the lung for carbon monoxide; $D_{LNO}$: diffusing capacity of the lung for nitric oxide; $P_{aO_2}$: arterial oxygen tension.

# SOME OF THE LARGEST DISEASE BURDENS ARE CLIMATE-SENSITIVE

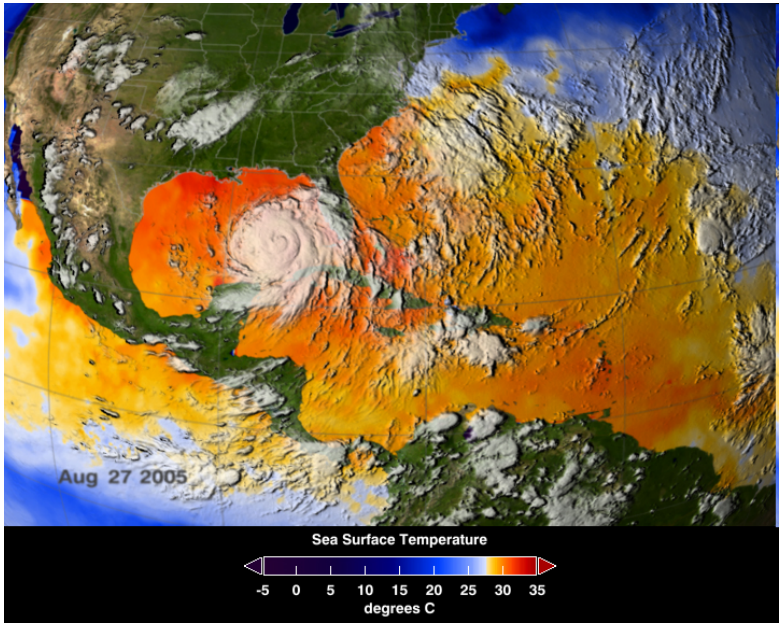
- **Each year:**
  - Undernutrition kills 3.5 million.
  - Diarrhoea kills 2.2 million.
  - Malaria kills 900,000.
- - Extreme weather events kill 60,000.

WHO estimates that the climate change that has occurred since the 1970s already kills over 140,00 per year.

# WEATHER-RELATED DISASTERS KILL THOUSANDS IN RICH AND POOR COUNTRIES

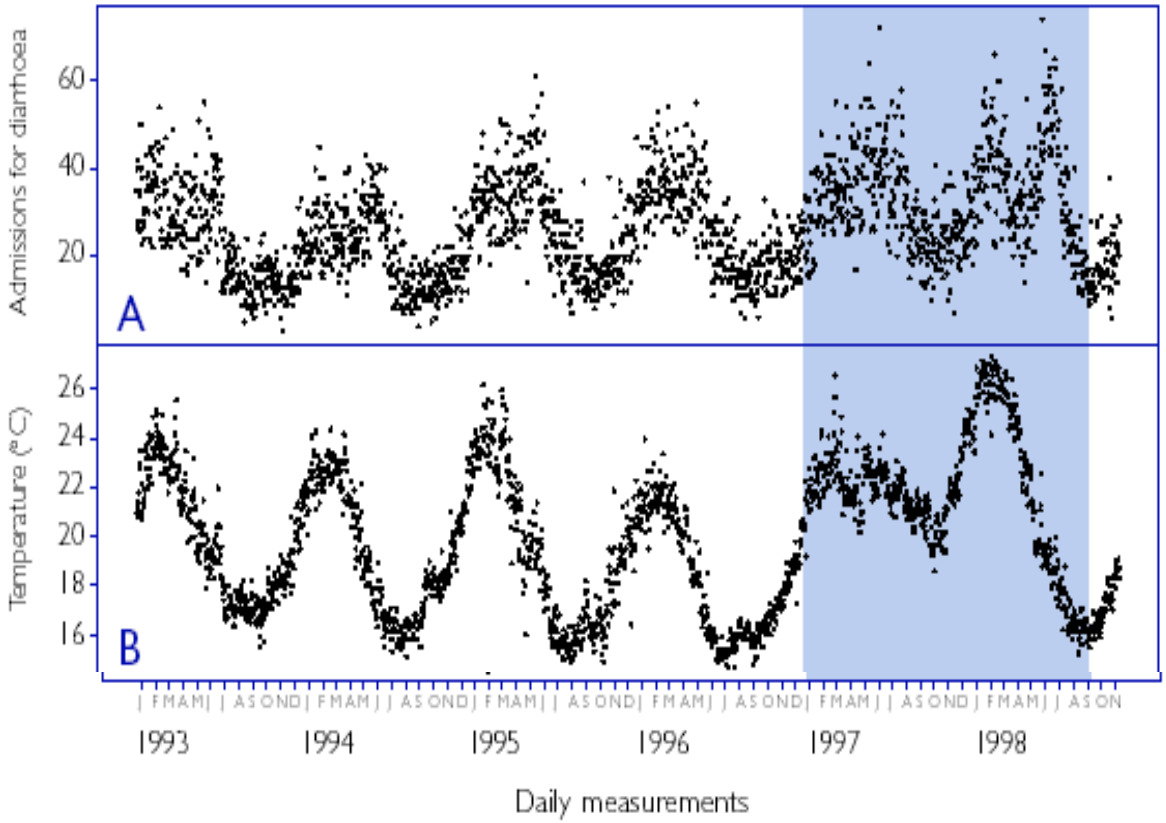



Deaths During Summer Heatwave.
Paris Funeral Services (2003)




Hurricane Katrina, 2005

# INCREASES IN DISEASES OF POVERTY MAY BE EVEN MORE IMPORTANT

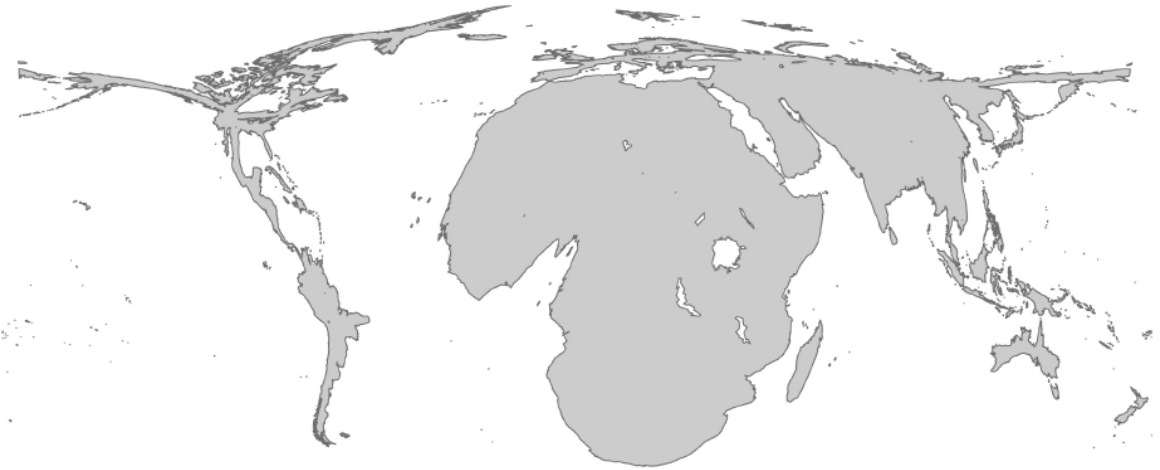



Diarrhoea is related to temperature and precipitation. In Lima, Peru, diarrhoea increased 8% for every $1^0$C temperature increase.

(Checkley et al, Lancet, 2000)

# HEALTH IMPACTS ARE UNFAIRLY DISTRIBUTED

Cumulative emissions of greenhouse gases, to 2002



WHO estimates of *per capita* mortality from climate change, 2000

Map projections from
Patz et al, 2007; WHO, 2009.

# THE CASE OF ALLERGIC AND RESPIRATORY DISEASES

Eur Respir J 2009; 34: 295–302
DOI: 10.1183/09031936.00003409
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ERS POSITION STATEMENT

## Climate change and respiratory disease: European Respiratory Society position statement

J.G. Ayres, B. Forsberg, I. Annesi-Maesano, R. Dey, K.L. Ebi, P.J. Helms, M. Medina-Ramón, M. Windt and F. Forastiere, on behalf of the Environment and Health Committee of the European Respiratory Society#

ABSTRACT: Climate change will affect individuals with pre-existing respiratory disease, but the extent of the effect remains unclear.

The present position statement was developed on behalf of the European Respiratory Society in order to identify areas of concern arising from climate change for individuals with respiratory disease, healthcare workers in the respiratory sector and policy makers. The statement was developed following a 2-day workshop held in Leuven (Belgium) in March 2008.

Key areas of concern for the respiratory community arising from climate change are discussed and recommendations made to address gaps in knowledge. The most important recommendation was the development of more accurate predictive models for predicting the impact of climate change on respiratory health.

Respiratory healthcare workers also have an advocatory role in persuading governments and the European Union to maintain awareness and appropriate actions with respect to climate change, and these areas are also discussed in the position statement.

AFFILIATIONS
For affiliations, please see the Acknowledgements section, and #For members of the Environment and Health Committee of the European Respiratory Society, please see the Acknowledgements section.

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## Climate change and respiratory diseases

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@ERSpublications
Climate change represents a threat to respiratory health by acting on respiratory diseases or risk factors http://ow.ly/v6JEl

# Projections of the effects of climate change on allergic asthma: the contribution of aerobiology

L. Cecchi[1,*], G. D'Amato[2,*], J. G. Ayres[3,*], C. Galan[4], F. Forastiere[5,*], B. Forsberg[6,*], J. Gerritsen[7], C. Nunes[8,*], H. Behrendt[9,*], C. Akdis[10,*], R. Dahl[11] & I. Annesi-Maesano[12,*]

Allergy, 2010

## Climate Change, Migration, and Allergic Respiratory Diseases: An Update for the Allergist

*Gennaro D'Amato (Chair), MD, Menachem Rottem, ●●●, Ronald Dahl, ●●●, Michael Blaiss, ●●● Erminia Ridolo, ●●●, Lorenzo Cecchi, ●●●, Nelson Rosario, ●●●, Cassim Motala, ●●●, Ignacio Ansotegui, ●●●, Isabella Annesi-Maesano, ●●●, for the WAO Climate Change, and Migration and Allergy Special Committee*

WAO journal, 2011

D'Amato *et al. World Allergy Organization Journal* (2015) 8:25
DOI 10.1186/s40413-015-0073-0

WAO WORLD ALLERGY ORGANIZATION *journal*

REVIEW Open Access

## Meteorological conditions, climate change, new emerging factors, and asthma and related allergic disorders. A statement of the World Allergy Organization

doi: 10.1111/cea.12709
*Clinical & Experimental Allergy*, 1–7


REVIEW

## Thunderstorm-related asthma: what happens and why

G. D'Amato[1], C. Vitale[2], M. D'Amato[2], L. Cecchi[3,4], G. Liccardi[1], A. Molino[2], A. Vatrella[5], A. Sanduzzi[2], C. Maesano[6] and I. Annesi-Maesano[6]

# CLIMATE CHANGE: TRENDS OF HEALTH EFFECTS

Temperature
Humidity
Rainfall
Barometric pressure
…

Climate change

Human activities

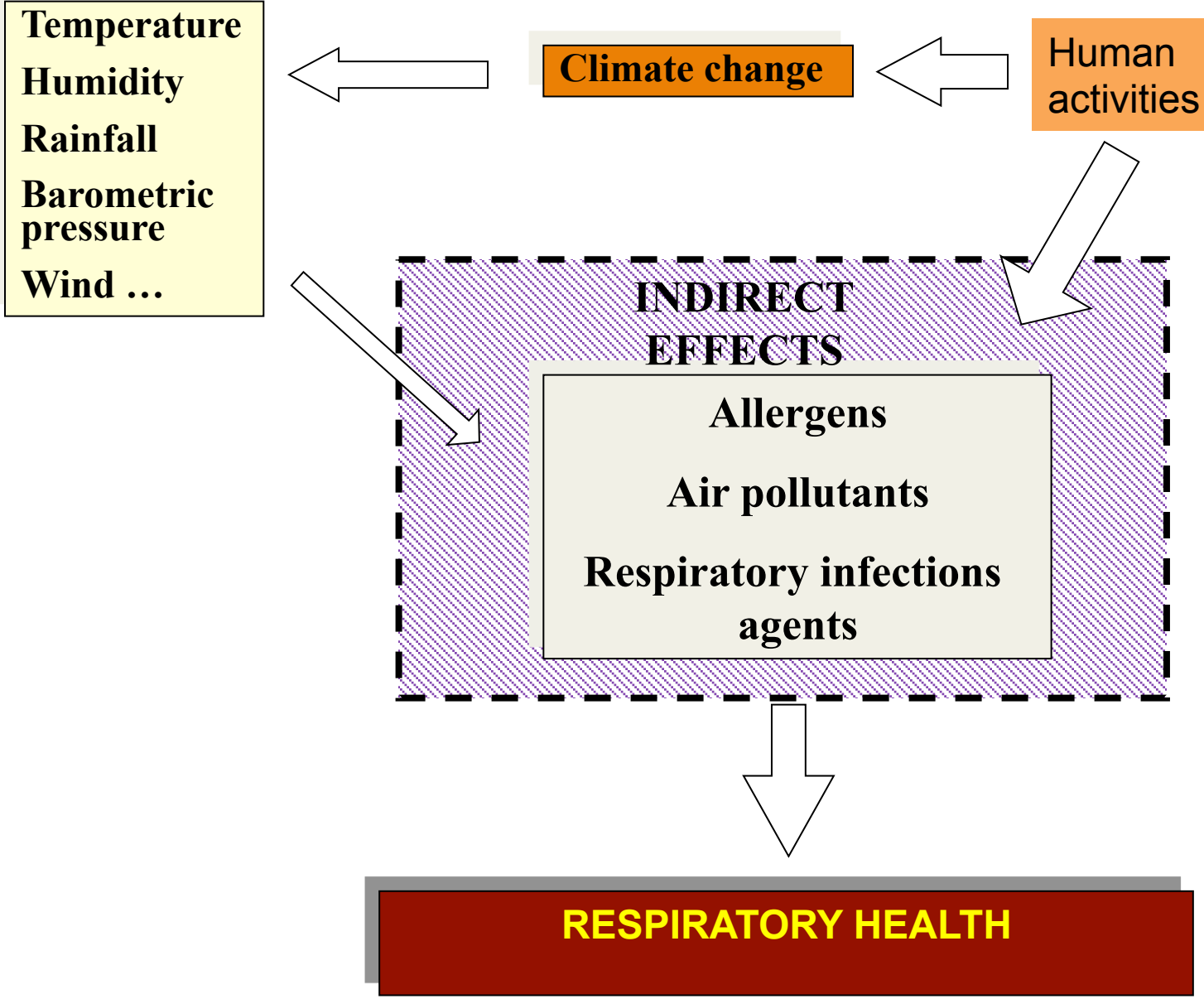
DIRECT EFFECTS

- **Virtually certain**
  - Increased asthma and COPD morbidity with cold temperature
  - Increased COPD mortality with cold temperature
  - Increased asthma and rhinitis morbidity and development with humidity
- **Likely**
  - Increased asthma and rhinitis development with cold temperature
  - Increased risk of asthma and rhinitis morbidity with rainfall
- **To be further confirmed**
  - Effect of high temperature and barometric pressure on pneumothorax (Alifano, Chest 2005)

**RESPIRATORY HEALTH**

**Observed direct effects:** effects on both morbidity and mortality

# Climate change: TRENDS OF HEALTH EFFECTS




**Observed indirect effects:** effects on morbidity and mortality

# CLIMATE CHANGE: TRENDS OF AIR POLLUTION

- **Virtually certain**
  - **Increased outdoor ozone level due to**
    - Increasing temperatures
    - Windiness and stagnant air conditions
    - Urbanization
    - Affecting natural sources of air pollutant emissions (→biogenic VOCs)
  - **Increased outdoor PM level due to**
    - Increasing emissions from
      - fossil fuel-fired power plants due to demand for electricity for cooling (due to temperature increase)
      - Urbanization and traffic
    - Increasing natural sources of air pollutant emissions
      - Wildfire smoke induced by drought and heat
      - Desertification → Sand storms

- **Likely**
  - Removal by precipitation of PM level at local level

- **To be further confirmed**
  - Increase of indoor air pollutants

Likely (in some zones)

Desertification

Likely

Sand storm

Likely

Wildfire

Virtually certain

Urbanization and trafic

Virtually certain

Industry in developing countries

# CLIMATE CHANGE: IMPACT ON CHEMICAL AIR POLLUTION AND CONSEQUENCES ON RESPIRATORY HEALTH

**Outdoor**

- ozone (overall increase in concentrations in high-income countries, but with wide regional differences)

→ **Ozone related mortality increase for 2051–2060 up to 27.3% for a 40 ppb threshold**

Australia Department of Health, 2016

- PM (local and transboundary increase in concentrations)

→ **Increased all-causes mortality and respiratory mortality and morbidity**

**Indoor**

- Biomass use and other air pollutants (VOCs)
  - Europe: 30% of fine PM from biomass burning

→ **Increased all-causes mortality and respiratory mortality and morbidity for biomass**

**But no robust projections**

# Effects of two $PM_{10}$ sources: Anthropogenic and Saharan dust

Percent increase (95% CI) in mortality and hospital admissions associated with 10 μg/$m^3$ increase in anthropogenic/desert $PM_{10}$: Results of two-pollutant models

| Outcome | Lag | Anthropogenic $PM_{10}$ | | | Desert $PM_{10}$ | | |
|---|---|---|---|---|---|---|---|
| | | % IR (95% CI) | $I^2$ | $X^2$ p value | % IR (95% CI) | $I^2$ | $X^2$ p value |
| **Mortality** | | | | | | | |
| Natural | 0-1 | **0.53 (0.23, 0.83)** | 32 | 0.147 | **0.66 (0.27, 1.06)** | 0 | 0.748 |
| Cardiovascular | 0-5 | 0.47 (-0.39, 1.33) | 46 | 0.045 | **1.10 (0.15, 2.05)** | 0 | 0.766 |
| Respiratory | 0-5 | **2.43 (0.94, 3.95)** | 41 | 0.073 | 1.28 (-0.42, 3.01) | 0 | 1.000 |
| **Hospital admissions** | | | | | | | |
| Cardiovascular, age 15+ | 0-1 | 0.36 (-0.02, 0.75) | 59 | 0.016 | 0.23 (-0.30, 0.76) | 0 | 0.503 |
| Respiratory, age 15+ | 0-5 | **0.67 (0.14, 1.19)** | 21 | 0.266 | 0.67 (-0.48, 1.83) | 10 | 0.352 |
| Respiratory, age 0-14 | 0-5 | **1.76 (0.60, 2.94)** | 24 | 0.235 | **2.38 (0.09, 4.71)** | 9 | 0.363 |

Stafoggia et al, EHP 2015

# CLIMATE CHANGE: TRENDS OF POLLUTION

- **Virtually certain**
  - **Increased outdoor ozone level**
    - Increasing temperatures
    - Windiness and stagnant air conditions
    - Urbanization
    - Affecting natural sources of air pollutant emissions (→biogenic VOCs)
  - **Increased outdoor PM level**
    - Increasing emissions from
      - fossil fuel-fired power plants due to demand for electricity for cooling (due to temperature

Desertification

ustry in develo countries

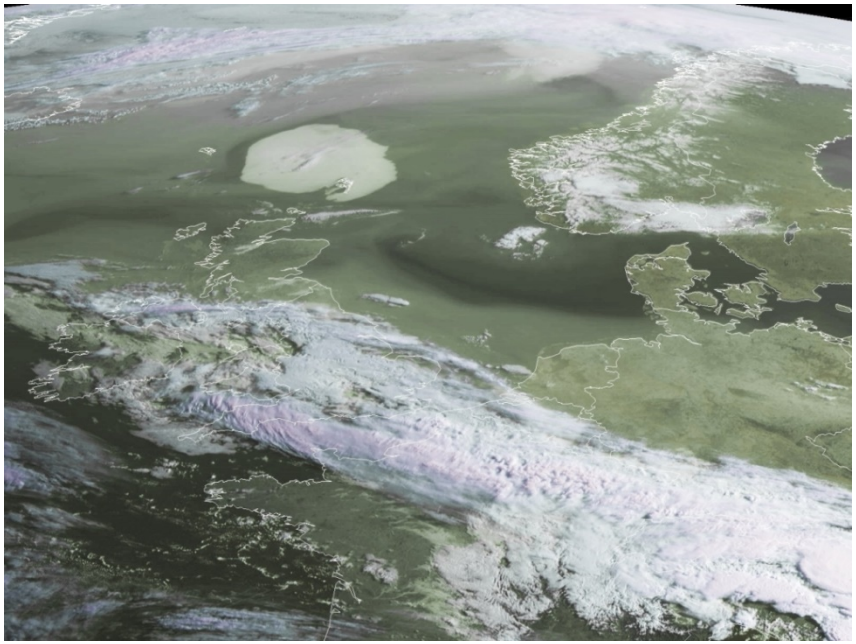
ldfire

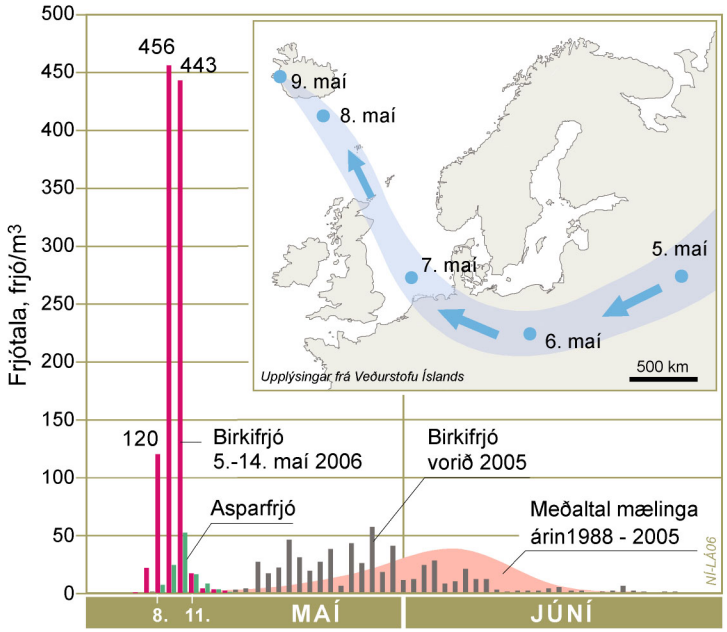
d storm

**Increased pollen and molds**

- Precipitations and flood responsible → molds proliferation
- Changes in temperature and humidity → Increased pollen production, longer pollen season, larger distribution ‘transport), increased potency of airborne allergens (also due to air pollution exposure), rainfall and plants

# LONG DISTANCE TRANSPORT OF BIRCH POLLEN






**EUMETSAT pictures first time a pollen (and ash) cloud**

# DURATION AND ANTICIPATION OF POLLEN SEASON

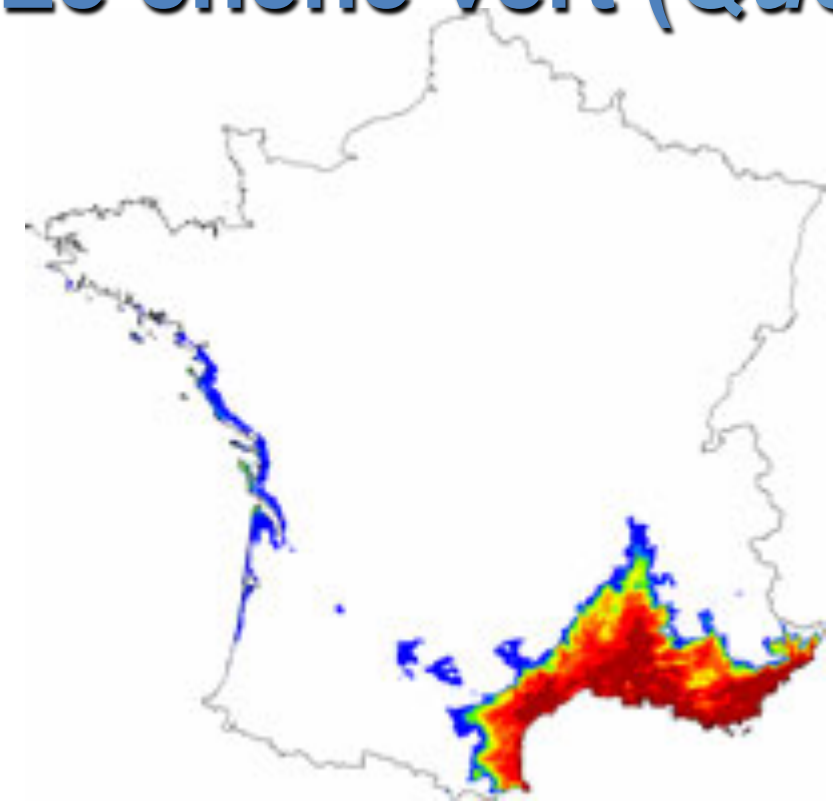
**The average first flowering date of 385 British plant species has advanced by 4.5 days during the past decade compared with the previous four decades: 16% of species flowered significantly earlier in the 1990s than previously, with an average advancement of 15 days in a decade**


Fitter AH & Fitter RSR Rapid change in flowering time in British plants. Science, 2002

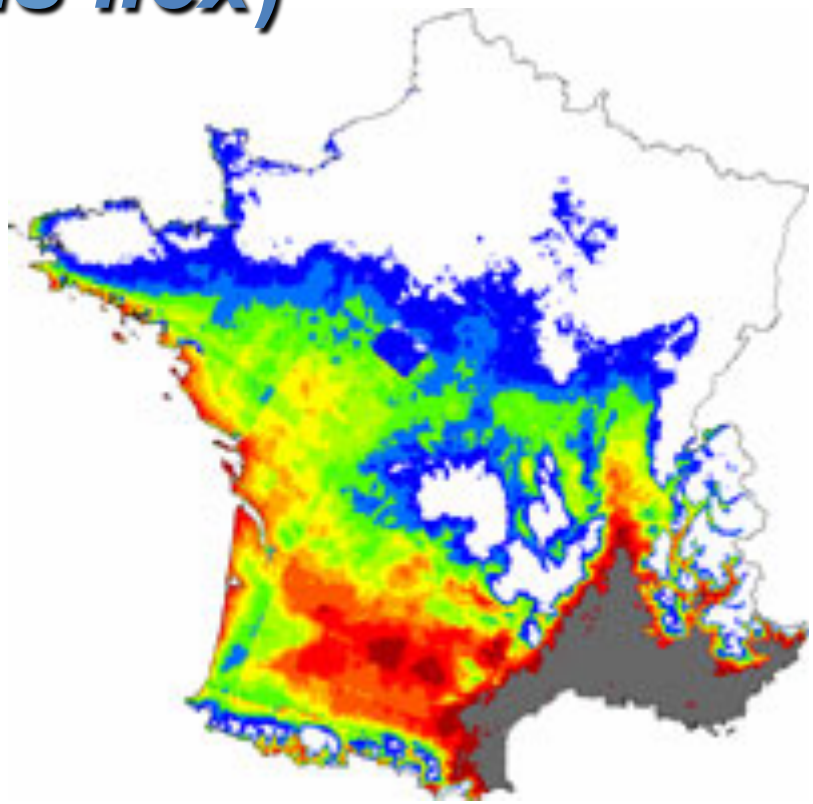
**International Phenological Gardens in Europe (69-42 ° N, 10 ° W-27 ° E): ↳ flowering season longer of 10.8 days in average**

A. Menzel, P. Fabian, *Nature,* 1999
P.J. Beggs, H.J. Bambrick, *Environ Health Perspect,* 2005
A. Menzel, *Int J Biometeorol,* 2006

# Le chêne vert (*Quercus ilex*)



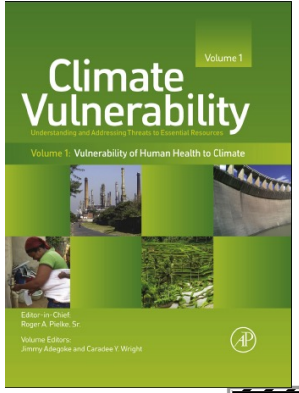
Aujourd'hui



En 2100

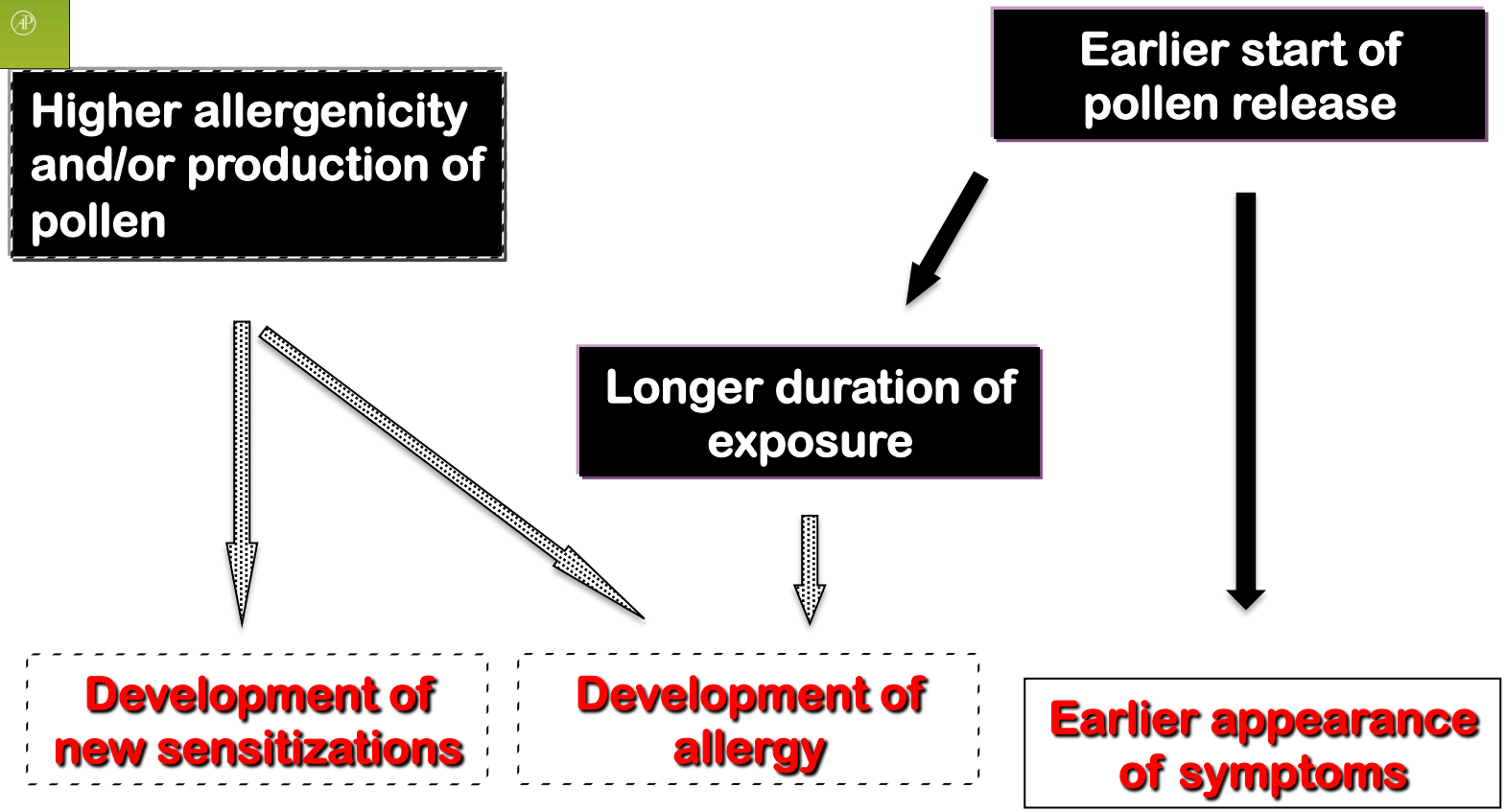
Due to climate changes.

Same trends for *Olea*, *Pinus halepensis*, *Pinus pinea*, *Cupressus sempervirens*...




# HEALTH IMPACT OF POLLEN VARIATIONS

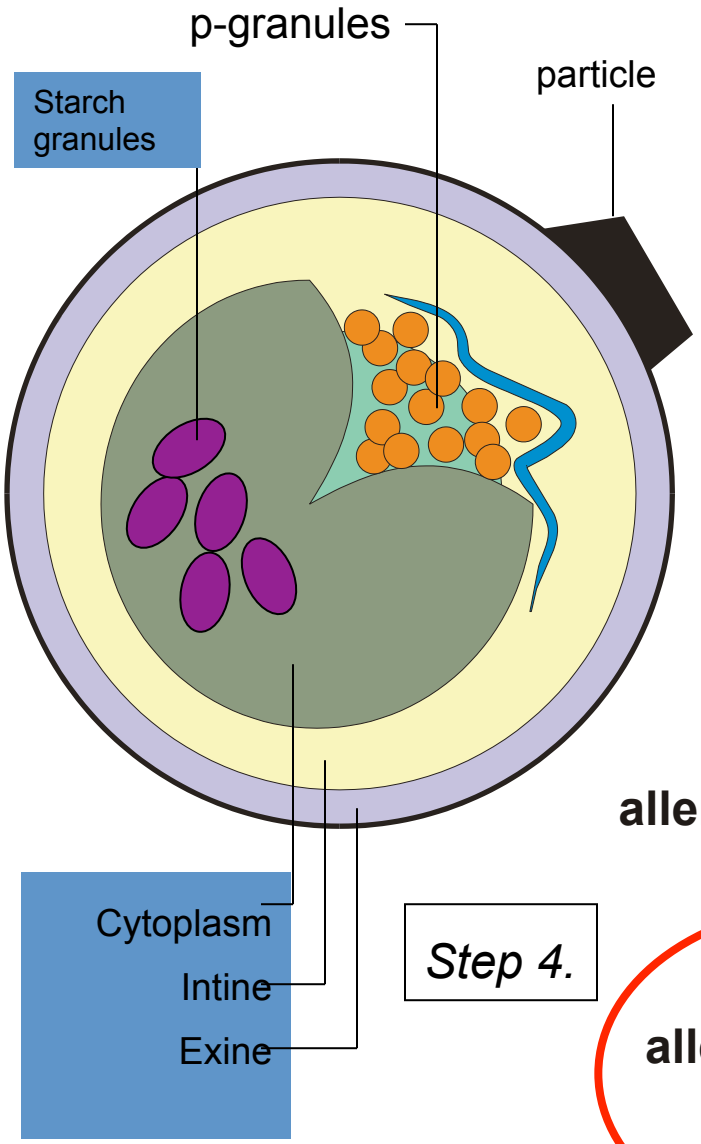
## Cecchi, D'Amato, Annesi-Maesano




Observed (solid arrows) and projected (dotted arrows) effects of climate change on pollen allergy

# New phenomena

# Ambient Pollen - Particle Interaction




*Step 1.* **Agglomeration induced by organic substances**

*Step 2.* **local preactivation of pollen**

**+ humidity**

*Step 3.* **allergen release**

**allergenic extrusions < 1 µm**

**adsorption of allergens to pollen bound particles**

*Step 4.*

**allergenic aerosol** ↔ **particulate matter as allergen carrier**

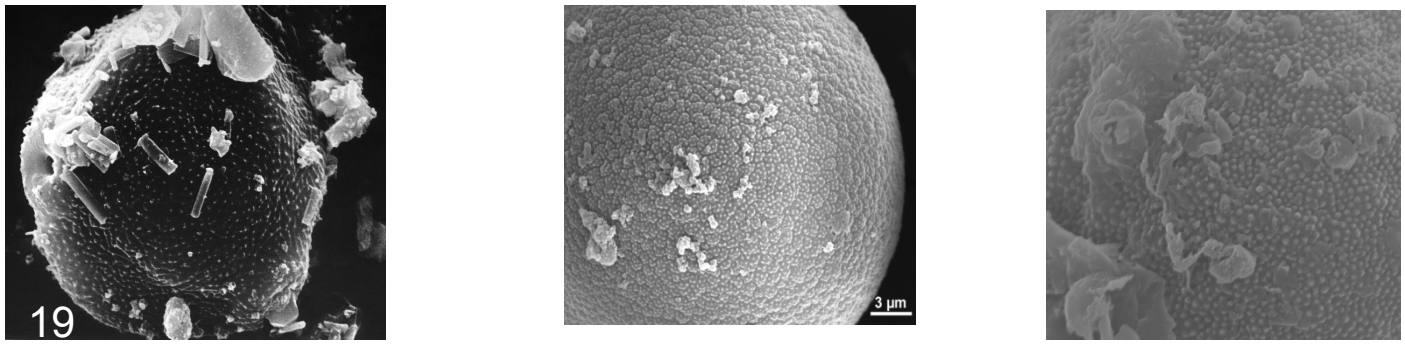
*Behrendt and Becker, Curr Opin Immunol 2001; 13(6):709-715*

# INTERACTION BETWEEN POLLEN, MOLDS AND POLLUTAnts

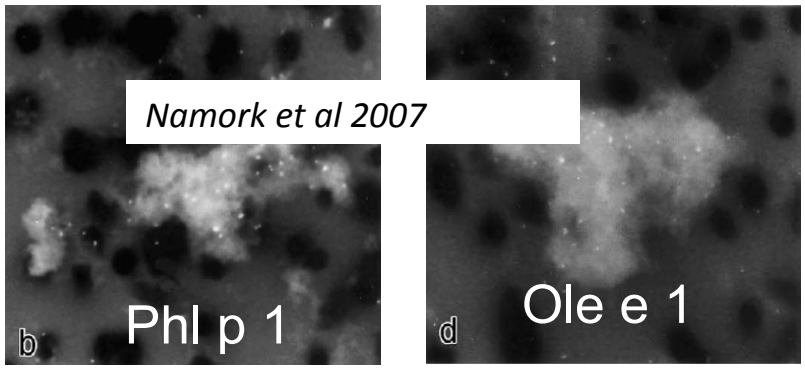
**particulate matter as allergen carrier**

1

PM




$PM_{2,5}$




*Namork et al 2007*

Allergens from pollens, latex and also beta-glucans may be bound to and, hence, transported by the combustion particles in ambient air as shown by the immunogold labelling visualised in the backscatter electron imaging mode, showed tha

*Motta et al 2006*

# Interaction between pollen, molds and pollutants

2

Traffic-related pollutants can trigger the release of allergen-containing granules from grass pollen, and increase the bioavailability of airborne pollen allergens. *(Motta et al 2006)*

❑ Modifications of the pollen morphology following exposure to pollutants

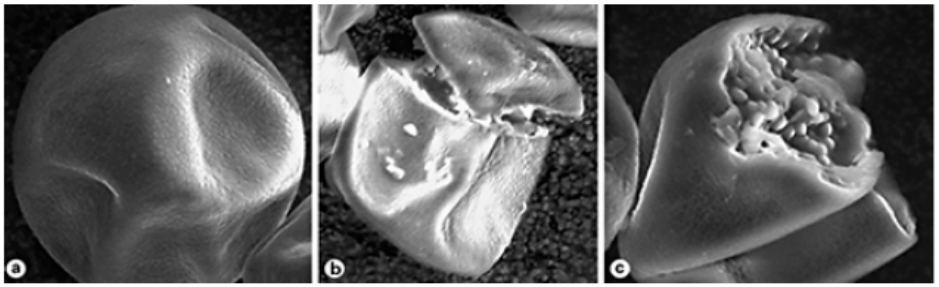


**Fig. 1.** Examples of damaged pollen grains. Treatment of pollen samples to air or pollutants can induce structural damage of the grains. **a** Intact pollen. ×7,540. **b** Pollen damaged following treatment to 50 ppm $NO_2$. ×3,000. **c** Pollen damaged following treatment to 0.7 ppm $O_3$. PCG can be seen inside the broken grain. ×6,000.

❑ Modifications of PCG release following exposure to pollutants

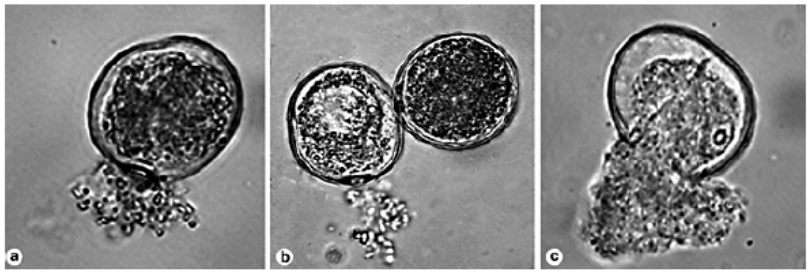


**Fig. 2.** Release of PCG following contact of pollen grains with water. PCG are expelled from the grain via the pore (**a**, **b**). Only a small proportion of the grains release their cytoplasm, and the remaining grains stay intact (**b**: intact grain on the right). However, in the fragile pollen, PCG release can also occur through breaks of the exine (**c**). ×400.

**PCG: Pollen** cytoplasmic granules **PCG**

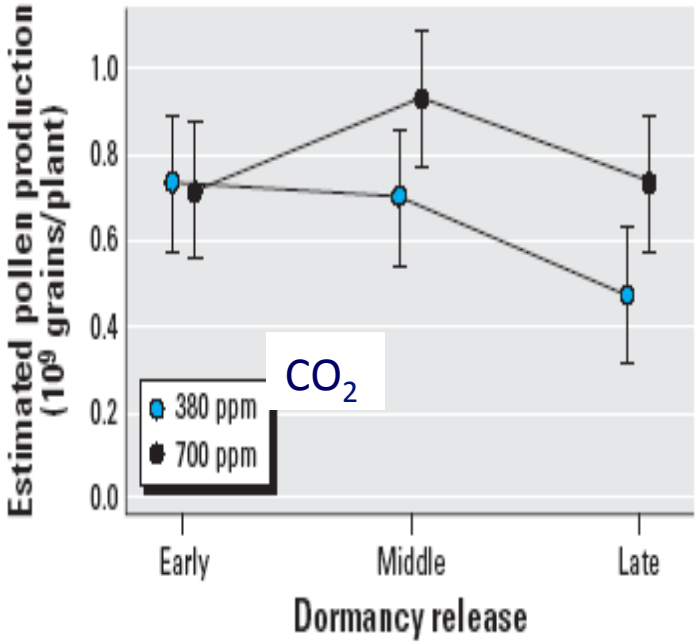
# *Ambrosia artemisiifolia* L.: Effect of $CO_2$ on pollen and allergen production

## Interaction of the Onset of Spring and Elevated Atmospheric $CO_2$ on Ragweed (*Ambrosia artemisiifolia* L.) Pollen Production

*Christine A. Rogers,[1] Peter M. Wayne,[2] Eric A. Macklin,[3] Michael L. Muilenberg,[1] Christopher J. Wagner,[1] Paul R. Epstein,[4] and Fakhri A. Bazzaz[5]*

[1]Department of Environmental Health, Harvard School of Public Health, Boston, Massachusetts, USA; [2]New England School of Acupuncture, Watertown, Massachusetts, USA; [3]New England Research Institutes, Watertown, Massachusetts, USA; [4]Center for Health and the Global Environment, Harvard Medical School, Boston, Massachusetts, USA; [5]Organismic and Evolutionary Biology, Harvard University, Cambridge, Massachusetts, USA

Environmental Health Perspectives • VOLUME 114 | NUMBER 6 | June 2006 

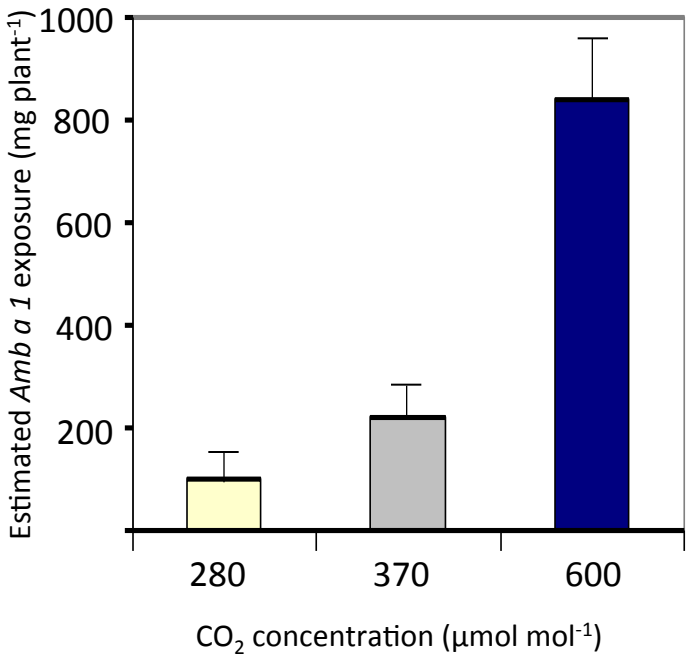



***Research Note:***

**Increasing Amb a 1 content in common ragweed (*Ambrosia artemisiifolia*) pollen as a function of rising atmospheric CO2 concentration**

*Ben D. Singer, Lewis H Ziska, David A. Frenz, Dennis E. Gebhard and James G. Straka*

*Functional Plant Biology 2005;32:267-70*






Greenhouse conditions !

***Changes are also occurring in the amount, intensity, frequency and type of precipitation as well as the increase of extreme events, like heat waves, droughts, floods and hurricanes and thunderstorms***

Celenza, **BMJ 1996;312:604-607**

# THUNDERSTORM-ASTHMA: WHICH EVIDENCE?

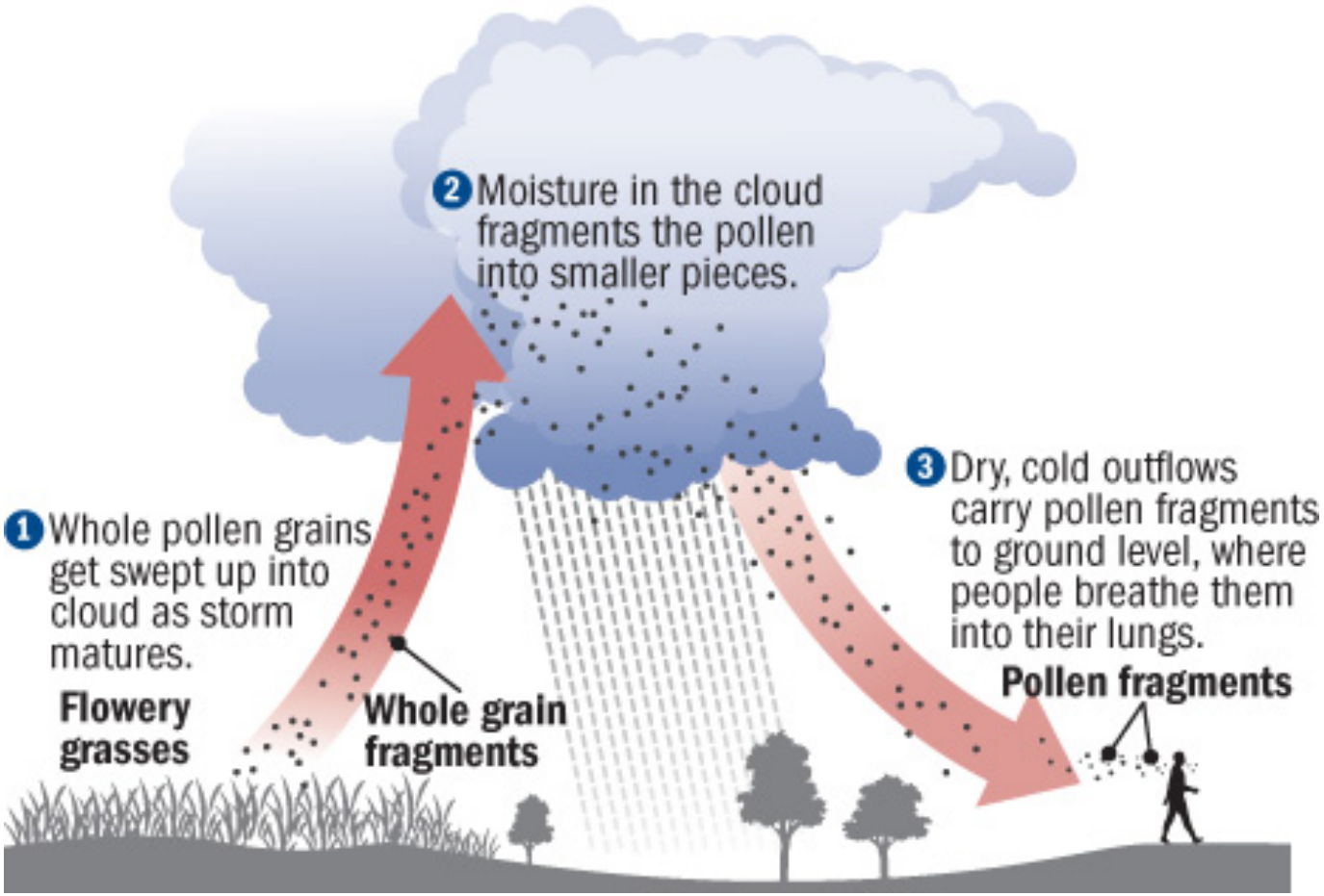
| Year | Country | Evidences |
|---|---|---|
| 1983 | **UK** | 26 sudden cases of asthma attacks in relation to thunderstorms |
| 1992 | **Australia** | Late spring thunderstorms in Melbourne can trigger epidemics of asthma attacks (five to 10-fold rise) |
| 1997 | **UK** | Asthma or other airways disease hospital visits. 640 cases who attended during a 30-h period on June 1994, nearly 10 times expected number |
| 1992 - 2000 | **Canada** | 18970 hospital ED asthma visits among children 2–15 yrs of age<br>Summer thunderstorm activity was associated with an OR of 1.35 (95% CI 1.02–1.77) relative to summer periods with no activity |
| 1993-2004 | **USA** | 215832 asthma ED visits; 24350 of these visits occurred on days following thunderstorms.<br>Significant association between daily counts of asthma ED visits and thunderstorm occurrence.<br>Asthma visits were 3% higher on days following thunderstorms. |
| 2000 | **Australia** | Asthma visits during thunderstorms<br>History of hay fever and allergy to rye grass are strong predictors for asthma exacerbation during thunderstorms in spring |
| 2001 | **Australia** | The incidence of excess hospital attendances for asthma during late spring and summer was strongly linked to the occurrence of thunderstorm outflows |
| 2002 | **UK** | A case–control study of 26 patients presenting to Cambridge University Hospital with asthma after the thunderstorm.<br>Alternaria alternata sensitivity is a compelling predictor of epidemic asthma in patients with seasonal asthma and grass pollen allergy and is likely to be the important factor in thunderstorm-related asthma |
| 2004 | **Italy** | Six cases of thunderstorm-related asthma because of pollen (Paretaria) |
| 2010 | **Italy** | 20 cases of thunderstorm-related asthma because of pollen (olive tree) |
| 2010<br>2016 | **Australia** | • Epidemics of "thunderstorm asthma" that occurred in Melbourne during spring<br>• Approximately 8,500 people sought hospital treatment on November 21, 9 deaths |

| THUNDERSTORM-ASTHMA: EVIDENCE-BASED KNOWLEDGE |
| --- |
| There is a link between asthma epidemics and thunderstorms |
| There is a close temporal association between the start of the thunderstorm and the onset of epidemics |
| Asthma epidemics related to thunderstorms are limited to pollen seasons |
| There are not high levels of gaseous and particulate components of air pollution during thunderstorm-related asthma outbreaks |
| Subjects with pollen allergy who stay indoors with the window closed during thunderstorms are not involved |
| There is a major risk for subjects who are not receiving anti-asthma treatment but subjects with allergic rhinitis and without previous asthma can experience severe bronchoconstriction |
| Non allergic subjects arenot involved in thunderstorm-related asthma |

Partly based on Hill's criteria

D'Amato, Annesi-Maesano CEA 2017

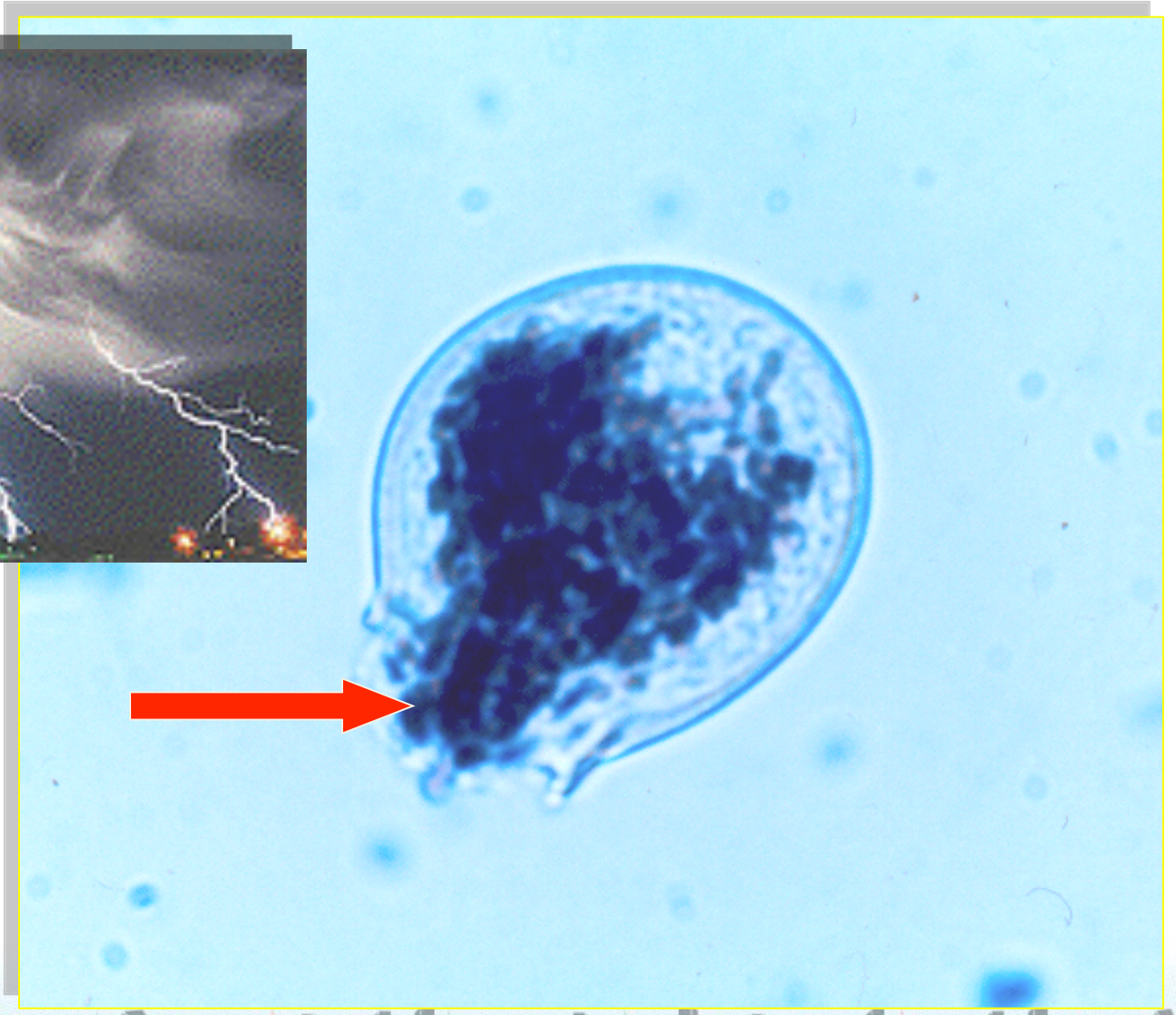
# Thunderstorm-asthma

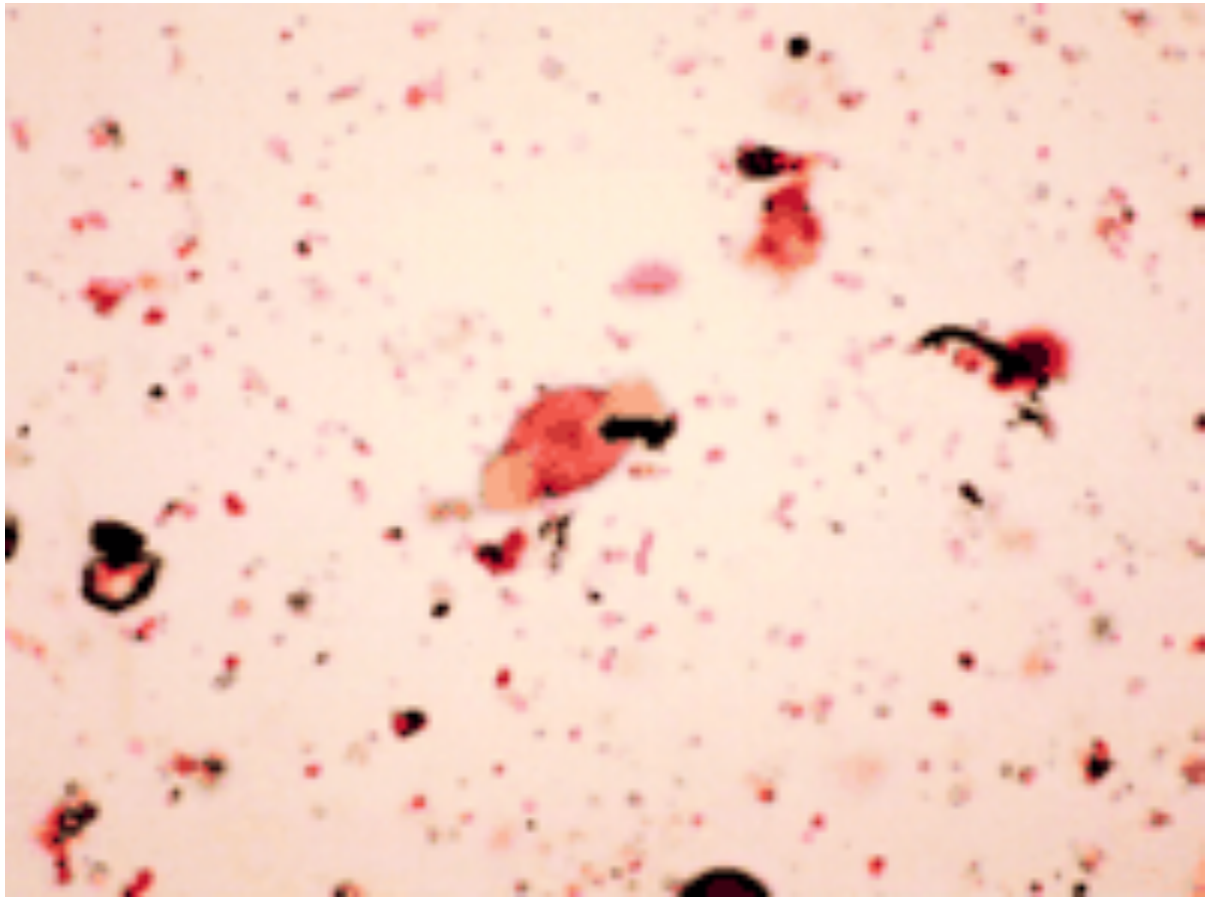



D'Amato, Annesi-Maesano CEA 2017

# GRASS POLLEN GRAIN BURSTS BY OSMOTIC SHOCK AND RELEASES STARCH GRANULES

Thunderstorm





“The arrival of a thunderstorm accompanied
by a large increase in the concentration of ruptured pollen grains”

Marks G.B. et al. Thorax 2001; 56:468-471

# Some projections

# RAPID URBANISATION

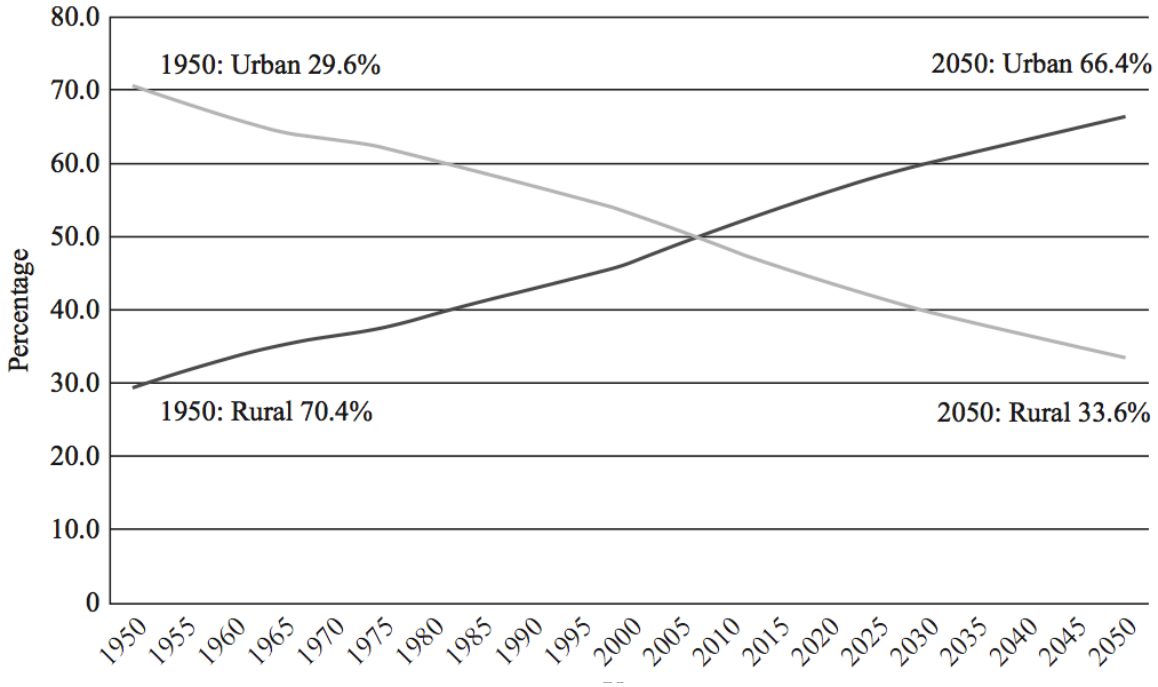



*Figure: Percentage of world population living in urban and rural areas 1950– 2050.*

*Data source:*

United Nations (2014). *World urbanization prospects: the 2014 revision*, Department of Economic and Social Affairs, Population Division CD-ROM Edition.

# RAPID URBANISATION

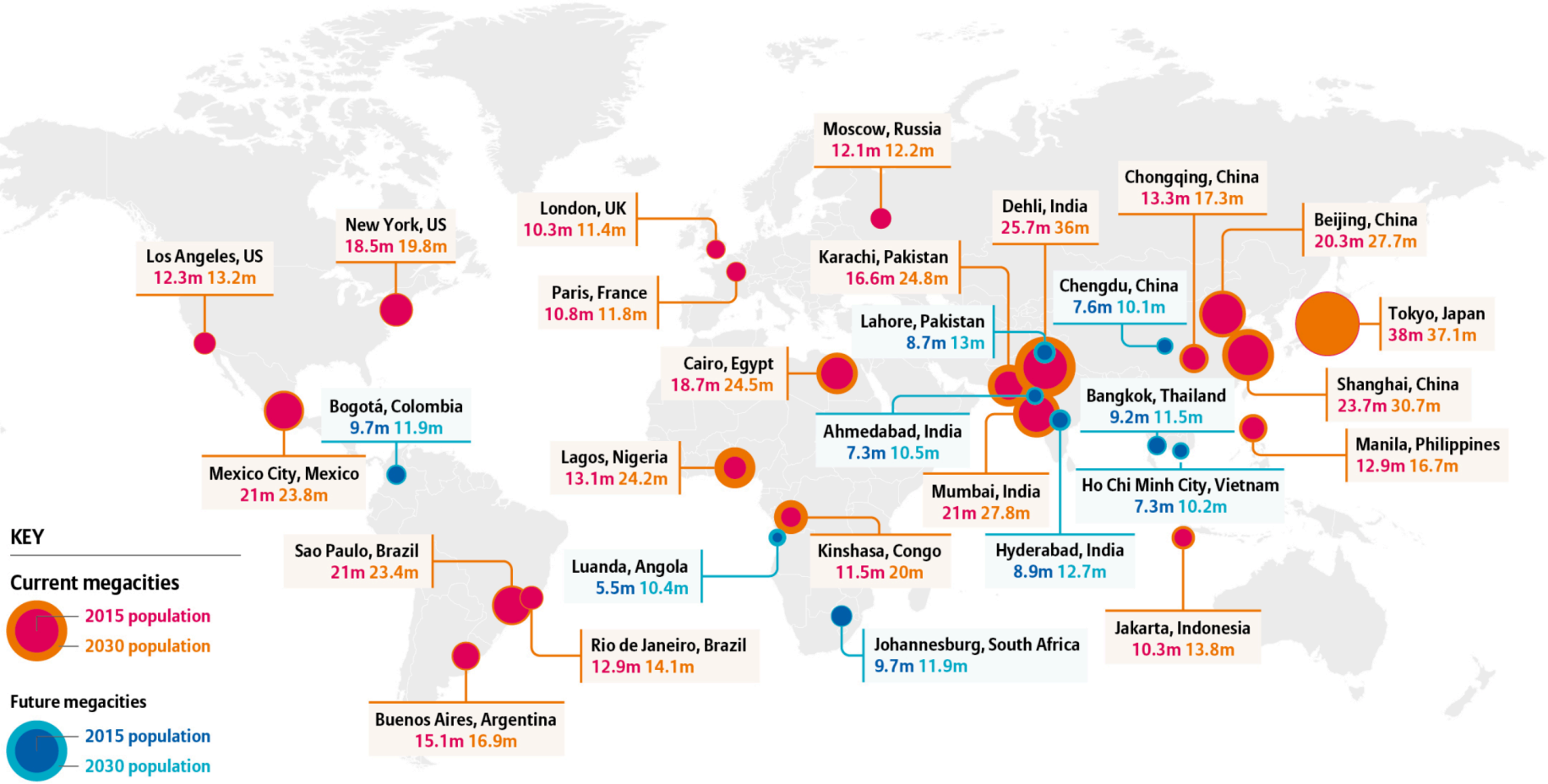



*Figure: Selected current and future mega-cities 2015–30*

*Source:* Allianz (2015). *The mega city of the future is smart*.
Available - https://www.allianz.com/en/press/news/studies/151130_the-megacity-of-the-future-is-smart/, accessed 24 Oct. 2017.

# CONSEQUENCES OF RAPID URBANIZATION

- *Impacts of urban growth on mobility and transport infrastructure*
  - **Traffic congestion (jam)**
    - → **Health care access limited**
  - **Air pollution ($CO_2$ and micropollutants emission)**
- *Impacts of urban growth on health*
  - ***Adverse health effects (morbidity, mortality)***
    - → ***Asthma, rhinitis, eczema increase***
  - ***Psychological health impacts due to noise and other stress sources***
  - ***Road crashes and injuries***

*"He inhaled a breath of humid morning breeze and let in nitrogen, oxygen, argon, xenon & radon, steam, carbon monoxide, nitrogen dioxide, tetra-ethyl lead, benzene, some mould spores, a bacteria fleet, anonymous body hair, a pigeon ectoparasite, anemophilous pollen, a drop of sulphur dioxide flown from a distant factory, and a particle of dust carried by the night sirocco.*

*In other words he breathed air of the city"*

(Stefano Benni "*Achille piè veloce*", Mondadori, Italy, 2003)

**Table 1 | Premature mortality related to $PM_{2.5}$ and $O_3$ for the population <5 and ≥30 years old**

| WHO region | Year | Population ($\times 10^6$) | Mortality attributable to air pollution (deaths $\times 10^3$) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | $PM_{2.5}$ | | | | | $O_3$ | Total |
| | | | ALRI < 5 yr | IHD ≥ 30 yr | CEV ≥ 30 yr | COPD ≥ 30 yr | LC ≥ 30 yr | COPD ≥ 30 yr | |
| Africa | 2010 | 809 | 90 | 55 | 77 | 11 | 2 | 2 | 237 |
| | 2050 | 1,807 | 158 | 185 | 262 | 38 | 5 | 12 | 660 |
| Americas | 2010 | 930 | 0 | 44 | 8 | 4 | 7 | 5 | 68 |
| | 2050 | 1,191 | 0 | 75 | 15 | 7 | 11 | 11 | 119 |
| Eastern Mediterranean | 2010 | 602 | 56 | 115 | 86 | 12 | 5 | 12 | 286 |
| | 2050 | 1,021 | 66 | 321 | 246 | 37 | 13 | 40 | 723 |
| Europe | 2010 | 867 | 1 | 239 | 95 | 13 | 27 | 6 | 381 |
| | 2050 | 886 | 1 | 307 | 156 | 18 | 37 | 11 | 530 |
| Southeast Asia | 2010 | 1,762 | 64 | 327 | 250 | 124 | 15 | 82 | 862 |
| | 2050 | 2,332 | 104 | 865 | 807 | 419 | 48 | 227 | 2,470 |
| Western Pacific | 2010 | 1,812 | 19 | 299 | 794 | 209 | 107 | 35 | 1,463 |
| | 2050 | 1,861 | 16 | 413 | 1,120 | 309 | 155 | 57 | 2,070 |
| World | 2010 | 6,783 | 230 | 1,079 | 1,311 | 374 | 161 | 142 | 3,297 |
| | 2050 | 9,098 | 346 | 2,166 | 2,604 | 828 | 270 | 358 | 6,572 |

Regions are defined by the World Health Organization, see Extended Data Table 1. Results for 2050 are based on a business-as-usual scenario.

Lilielend,

Lilieveld, Nature 2015

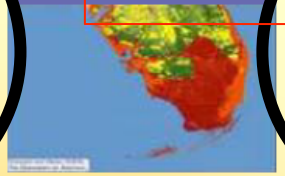
# CONSEQUENCES OF INTERNETT

**76 Millions of tons of $CO_2$ produced by Internet in 2002**
**830 millions of ton in 2016**
**…**

# THE CLIMATE CHANGE CONUNDRUM

# THE CLIMATE CHANGE CONUNDRUM: Environmental risks have become increasingly inter-dependent and complex!


Indoor and outdoor air pollution

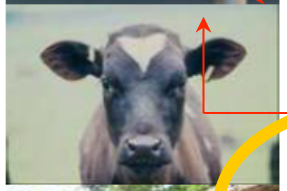



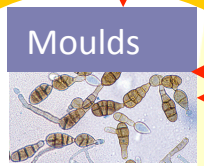


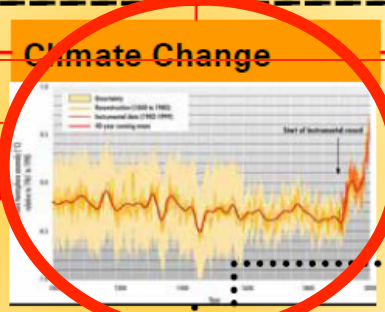





Pollen

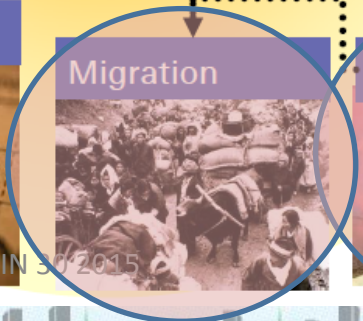











**Allergic and respiratory diseases among others**

# The climate change conundrum: Environmental risks have become increasingly inter-dependent and complex!


Indoor and outdoor air pollution

GHG emissions

Storms

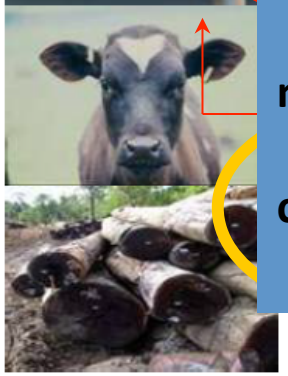
Flood

Sea level

Drought

Ecosystems

**Greater effects in susceptible individuals (with respiratory co-morbidity, in elderly…) and in vulnerable individuals (in those living closer to risk factor sources and areas…)**



GHG regulation

Energy security

UN Climate Change Conference 2007 Bali - Indonesia

Investments

Migration

Conflict

Health effects

**Allergic and respiratory diseases among others**

# **Environmental Refugees** UN projection

- By 2020: up to 50 million people escaping effects of environmental deterioration.
  - order-of-magnitude increase vs. 2005
- Inevitable spectrum of health risks – physical, nutritional, infectious, mental, and conflict situations

# Social Inequities due to Climate Change

- Agricultural production
- Freshwater availability
- Sea-water innundation
- Intergenerational equities

# Crop Susceptibility to Climate Change

1) Abiotic effects

- Crop development and yield impacted by (exp):
temperature changes

precipitation changes

2) Biotic effects

- impact agricultural productivity (exp) :

pest pressures

availability of pollination services

# Climate Change effects on Production

Aggregate Effects transcend individual agro-ecosystems:

Agriculture is complex system linked to climate by temp., precip., solar radiation, and atmospheric gas composition.

Soil and water resources are impacted by same issues and represent key components of the system.

# Climate Change effects on Soil Resources

Soils provide ecosystem services:

- Nutrient cycling & delivery of nutrients for food and fiber production;
- Flood mitigation thru filtration and water reservoir
- Structure to support plants – multi element
- $CO_2$ sequestration & uptake of GHG in surface and organic layers

# SOIL EROSION EFFECTED BY CC

- Studies of field edge effects indicate major factors are:

  1) Rainfall:

     a) intensity – Hi I, short D > Low I, long D

     b) increase $CO_2$ may lead to plant growth and ground cover – lower splash and higher infiltration,

  But higher intensity may increases erosion overall.

- 2) Snow and Winter processes - increased erosion when melt water flows over thawed soil on top of frozen soil.
- 3) Wind – erosion by wind impacted by velocity, soil moisture content, surface roughness, vegetation. Primary areas: Great Plains

Dust storm near Lubbock, Texas

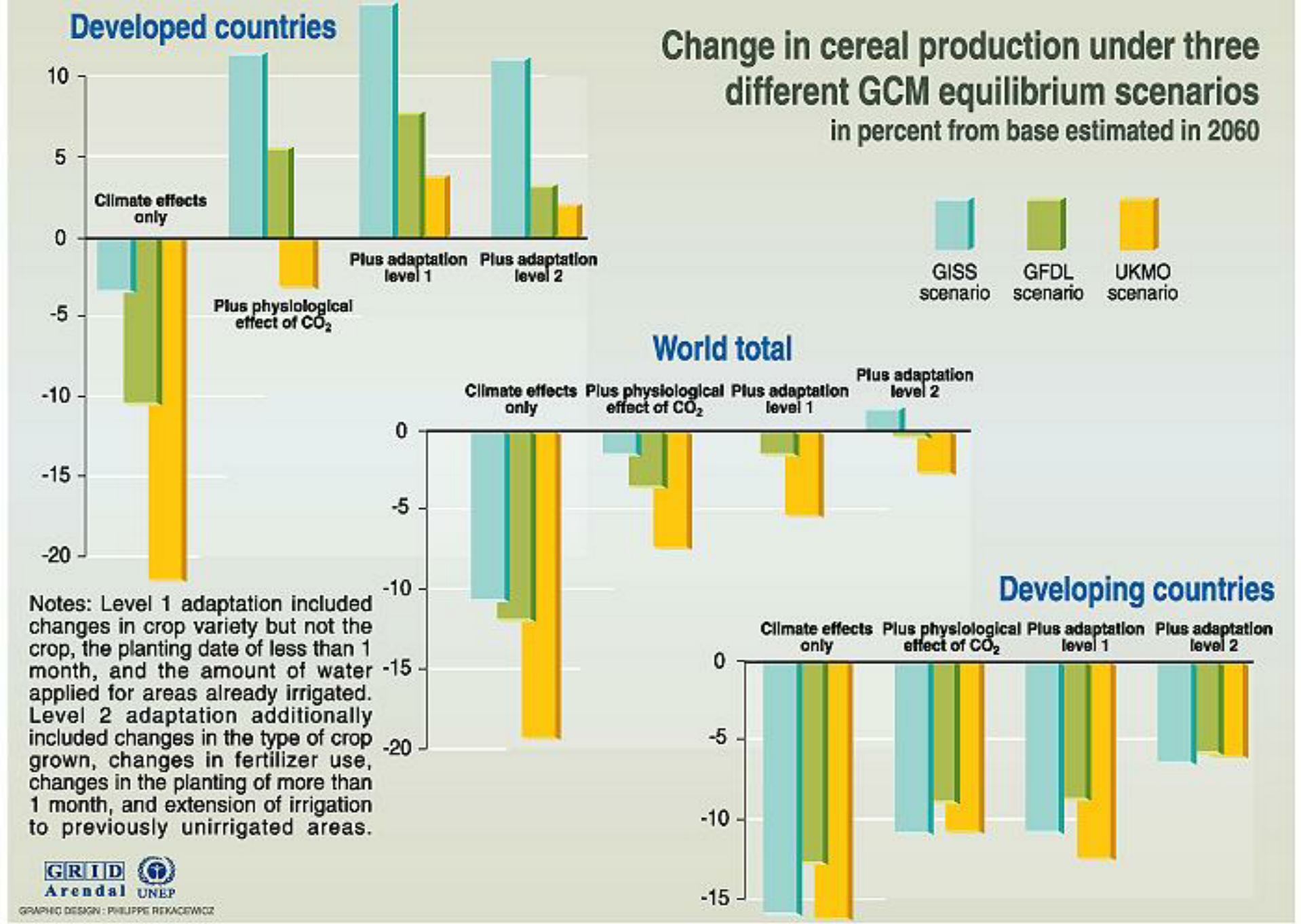
http://www.newswise.com/images/uploads/2012/05/7/duststorm.JPG

# Changing Production and Effects on Erosion

- Changes in temperature and ppt. are changing the types of crops planted, dates of planting, harvest and tillage and crop management.
- Mixed messages with regard to soil erosion – most studies show an increase in soil erosion (decreasing fertility), but the opportunities for increased management coupled with the varying temporal and spatial scales, may result in new models that will more accurately reflect shifts in ecosystem characteristics.

# Change in cereal production under three different GCM equilibrium scenarios

in percent from base estimated in 2060



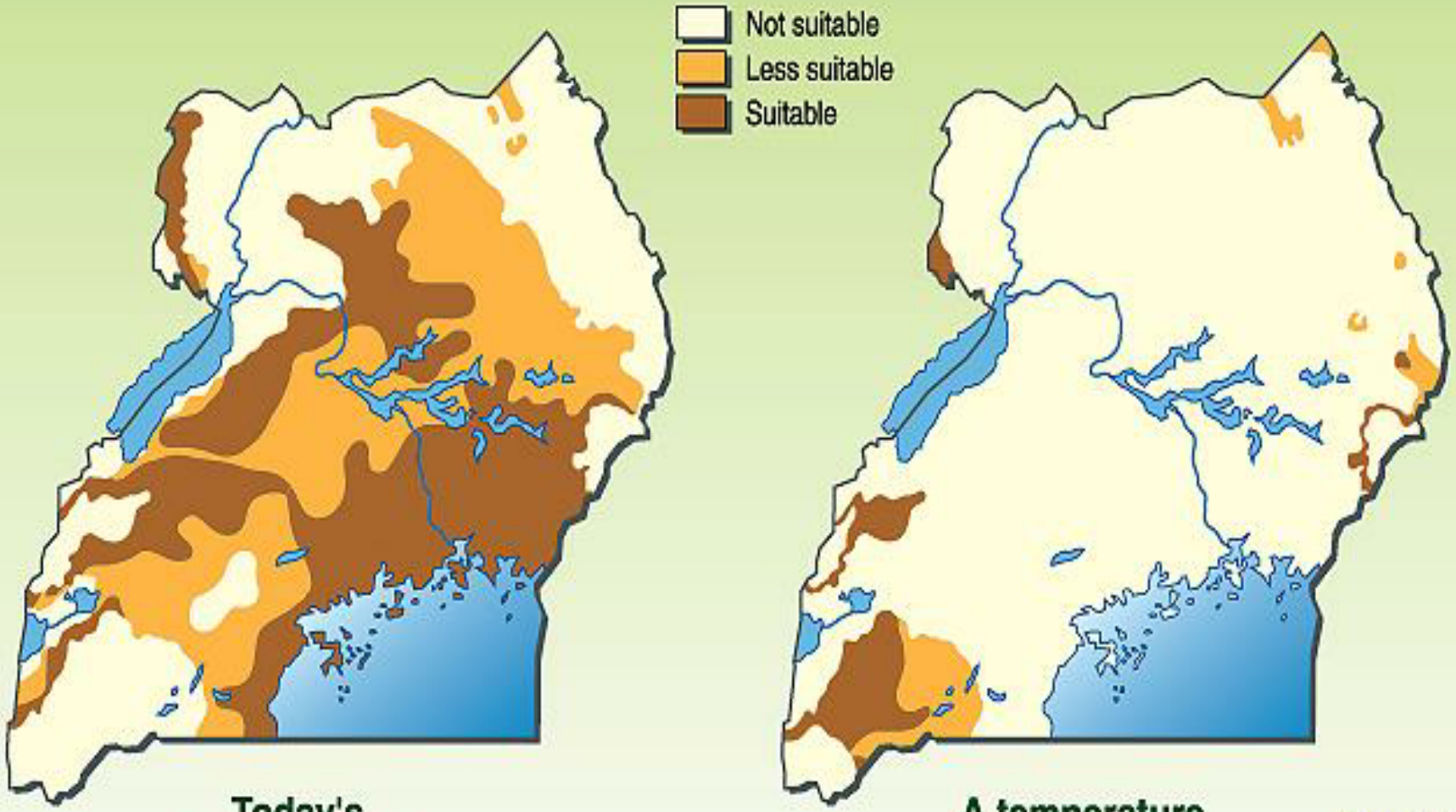

Notes: Level 1 adaptation included changes in crop variety but not the crop, the planting date of less than 1 month, and the amount of water applied for areas already irrigated. Level 2 adaptation additionally included changes in the type of crop grown, changes in fertilizer use, changes in the planting of more than 1 month, and extension of irrigation to previously unirrigated areas.

GRID Arendal UNEP

GRAPHIC DESIGN : PHILIPPE REKACEWICZ

Source: Climate change 1995, Impacts, adaptations and mitigation of climate change: scientific-technical analyses, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

# Impact of temperature rise on robusta coffee in Uganda

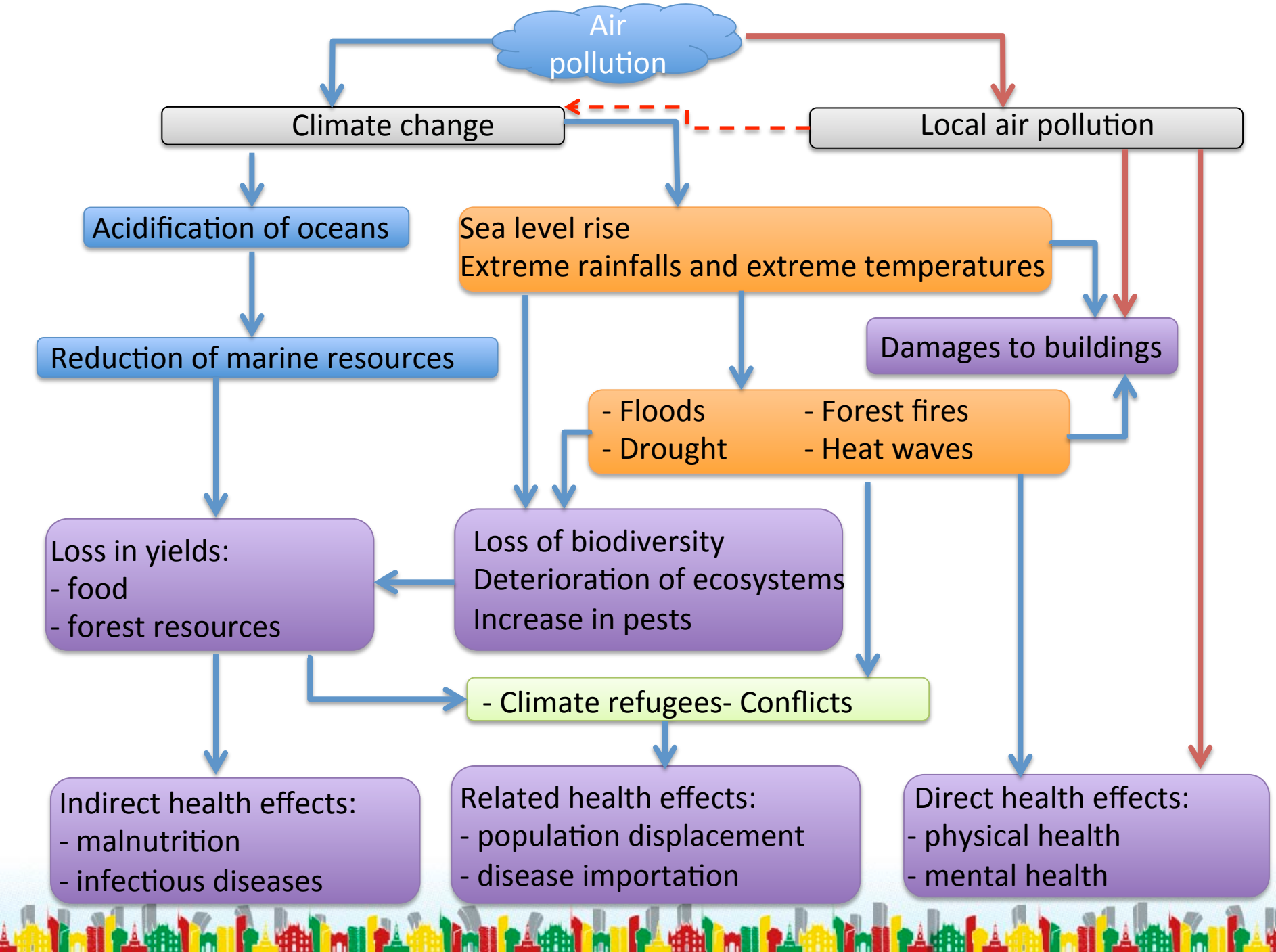



Source: Otto Simonett, Potential impacts of global warming, GRID-Geneva, case studies on climatic change. Geneva, 1989.

# Impact on US Agriculture (speculations)

- The US is a large enough country at a high enough latitude that it will have regional winners and losers
- Areas now marginal for agriculture may become less suitable
- Some areas now having abundant water but limited growing seasons may be winners
- Areas with good soils and robust climate, like Iowa, may be impacted less
- The US Midwest may experience more variability from year to year, which would make agricultural yields more variable (flooding, water-logging, drought)
- Changes in consumption and agricultural production in other nations may affect US agriculture more than changes to US climate
- Environmental refugees?

# SOME COSTS


Air pollution
Climate change
Local air pollution
Acidification of oceans
Sea level rise
Extreme rainfalls and extreme temperatures
Damages to buildings
Reduction of marine resources
- Floods
- Drought
- Forest fires
- Heat waves
Loss in yields:
- food
- forest resources
Loss of biodiversity
Deterioration of ecosystems
Increase in pests
- Climate refugees- Conflicts
Indirect health effects:
- malnutrition
- infectious diseases
Related health effects:
- population displacement
- disease importation
Direct health effects:
- physical health
- mental health

Preliminary data showed a potential 30% rise within next decade in medical costs for allergic diseases and asthma as climate change impacts continue to rise at the same rate

Bielory L et al.Curr Allergy Asthma Rep. 2012.

# RESEARCH CHALLENGES

# The initial definition of the exposome

**"The Exposome (Chris Wild, CIRC):** The totality of exposure an individual is subjected to from conception to death…"

Health and disease are influenced by the genome and the exposome.

WE NEED GOOD DATA! DATA HAVE TO BE RECORDED!

# To learn more

# JACI 2018

Mechanisms of allergic diseases

## External exposome and allergic respiratory and skin diseases

**Lorenzo Cecchi, MD,[a,b] Gennaro D'Amato, MD,[c,d] and Isabella Annesi-Maesano, MD, PhD, DSc[e]** *Florence, Prato, and Naples, Italy, and Paris, France*

**Allergies are complex diseases that result from interactions between multiple genetic and environmental factors. However, the increase in allergies observed in the past decades is explained exclusively by environmental changes occurring in the same period. Presently, the exposome, the totality of specific and nonspecific external environmental exposures (external exposome) to which a subject is exposed from preconception**

*Abbreviations used*
AD: Atopic dermatitis
$CO_2$: Carbon dioxide
GHG: Greenhouse gas
HDM: House dust mite
$NO_2$: Nitrogen dioxide
$O_3$: Ozone

# Exposome involvement in allergy

Epigenome

Genome

**Gene-Environment interactions**

***Specific external environment***

*In utero* smoking
Chemical air pollutants
Biocontaminants (viruses…)
Allergens (pollen, molds, pets, hymenoptera…)
Diet
Drug
Consumer products

***Non specific external environment***

*Climate*
External biodiversity (greenspaces….)
Urban environment
Mobility, excercise
Social dimension

**EXTERNAL EXPOSOME**

***« Omics »***

Transcriptomics
*Adductomics*
Metabolomics
Proteomics
….
…

PROTEIN
Amino Acids
DNA

**INTERNAL EXPOSOME**

- Skin → atopic dermatitis, eczema, urticaria
- Eyes → allergic rhinoconjonctivis
- Nose, upper airways → allergic rhinitis
- Lung, Airways → asthma
- Gastrointestinal (GI) system, throat, heart, tongue, skin… → food allergy
- Hives, rash, fever, runny nose, lower airways… → drug allergy
- Tongue, lung, GI and central system… → anaphylactic shock (food allergy, drug allergy, venom (hymenoptera, triatominae…)

**TARGETED ORGANS AND MAJOR DISEASES**

**Annesi-Maesano**
**Adapted from JACI 2018**

# INTERACTIONS ARE IMPORTANT!

# External exposome and allergic respiratory and skin diseases

Lorenzo Cecchi, MD,[a,b] Gennaro D'Amato, MD,[c,d] and Isabella Annesi-Maesano, MD, PhD, DSc[e] *Florence, Prato, and Naples, Italy, and Paris, France*

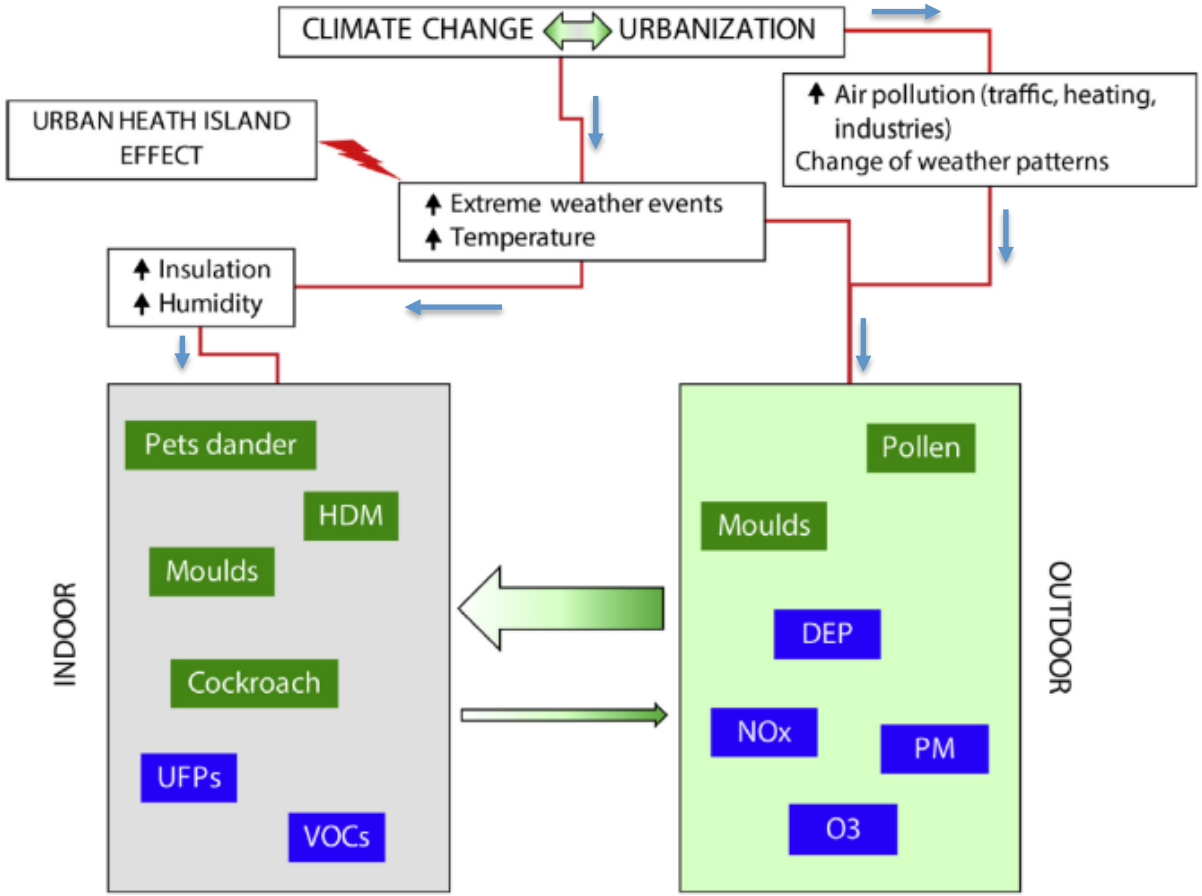



**FIG 2.** Indoor and outdoor exposures to aeroallergens and air pollutants and environmental factors affecting their production and concentrations. *NOx*, Nitrogen oxides; *UFPs*, ultrafine particles; *VOCs*, volatile organic compounds.

# Summary

- Mediterranean climate is changing:
  - Increases in temperature
  - Increases in high dew point temperatures
  - Increases in extreme precipitation events
- Climate changes will likely increase:
  - Particulate matter
  - Formation of ozone
  - Pollen and mold
- Certain populations are at greater risk from exposure to pollution and allergens, especially those with existing respiratory and cardiovascular conditions, the elderly, and children
- Public health awareness, education and coordinated mitigation planning with other agencies can reduce the health impacts

# PERSPECTIVES FOR THE MEDITERRANEAN BASIN

# Rationale

- In 2014, WHO has released new evidence that ambient air pollution and climate change are among the most important risks to health in Eastern Mediterranean becoming one of the top priorities (Health Strategy and Action Plan 2014-9).
- Projections indicate that it will even be a bigger problem in the future overpassing the impact of drinking poor quality water.

# Take home messages

- Climate change impacts respiratory health in several ways. Some locations (developing countries and Mediterranean area due to its specificity in terms of pollen, air pollution, migrants, refugiees) and some individuals (vulnerable and susceptible) are at higher risk
- Projections indicate worsening of the situation if actions are not taken
- Needs for accessing existing archives of data → open access data
- Needs for prevention/mitigation/adaptation recommendations
- Other investigations are needed
- including exposome


MERCI!

isabella.annesi-maesano@inserm.fr