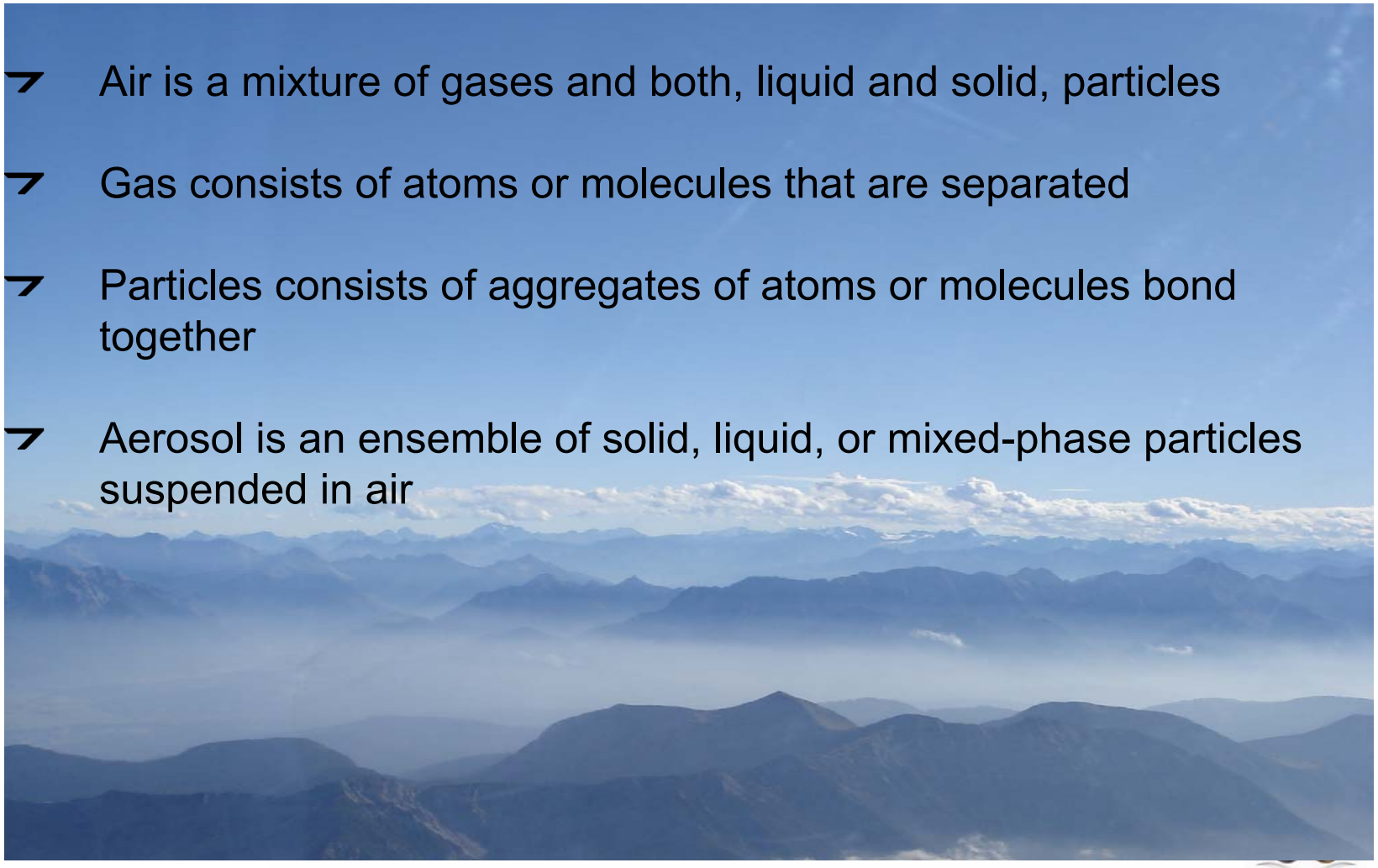
Introduction to Air Pollution

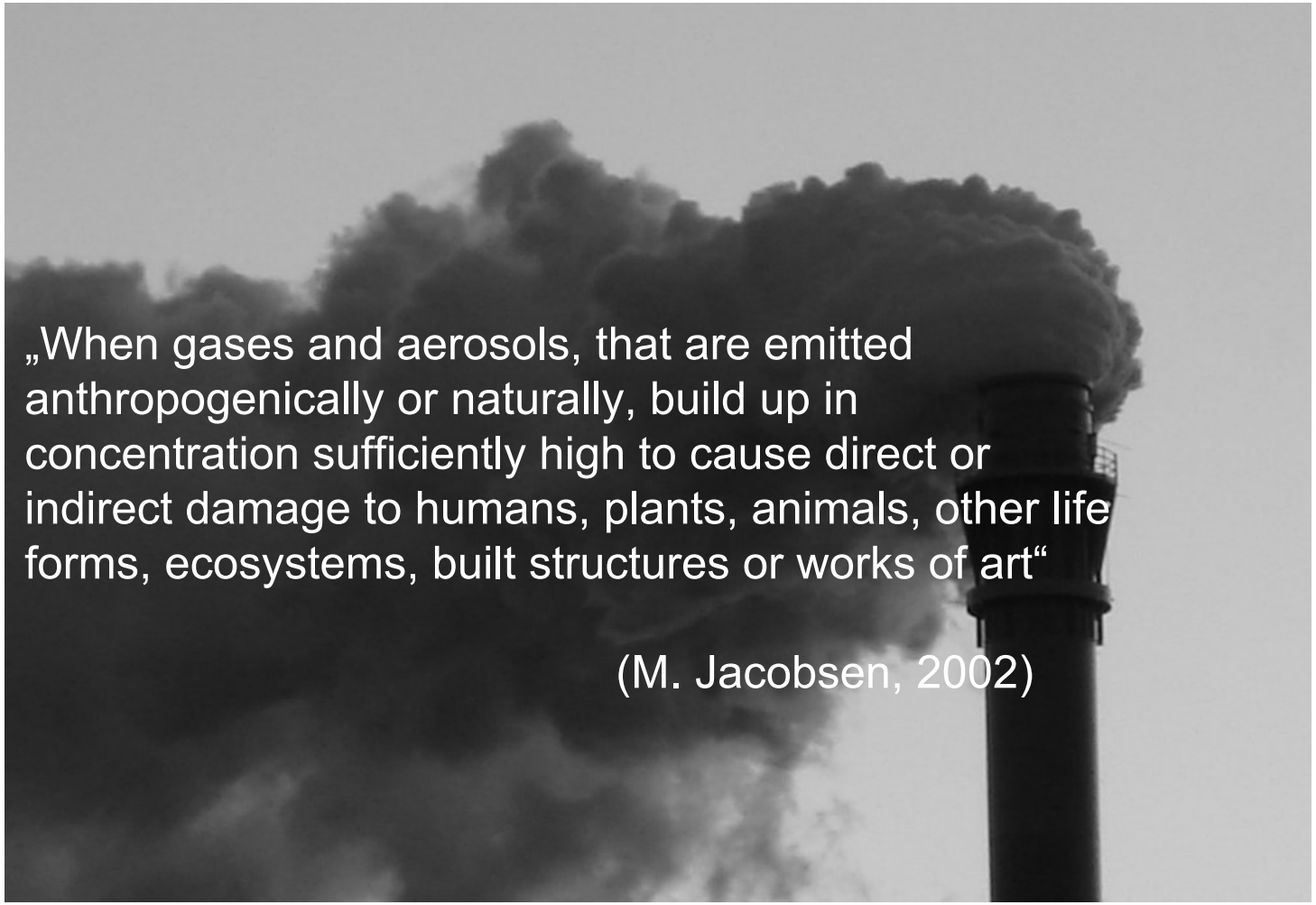
Thilo Erbertseder
DLR

What is Air?



- Air is a mixture of gases and both, liquid and solid, particles
- Gas consists of atoms or molecules that are separated
- Particles consists of aggregates of atoms or molecules bond together
- Aerosol is an ensemble of solid, liquid, or mixed-phase particles suspended in air

What is Air Pollution?



Why care about air pollution?

- Atmospheric pollutions affects us all
- It affects the air we breath in
- It affects our health and our environment

Why care about air pollution?

1907

1962

Photo courtesy Schmidt-Thomsen

Air Pollution – natural and man-made

Natural sources:

Volcanoes, fumaroles, natural fires and desert dust

Anthropogenic sources:

Burning wood, clearing land (dust),

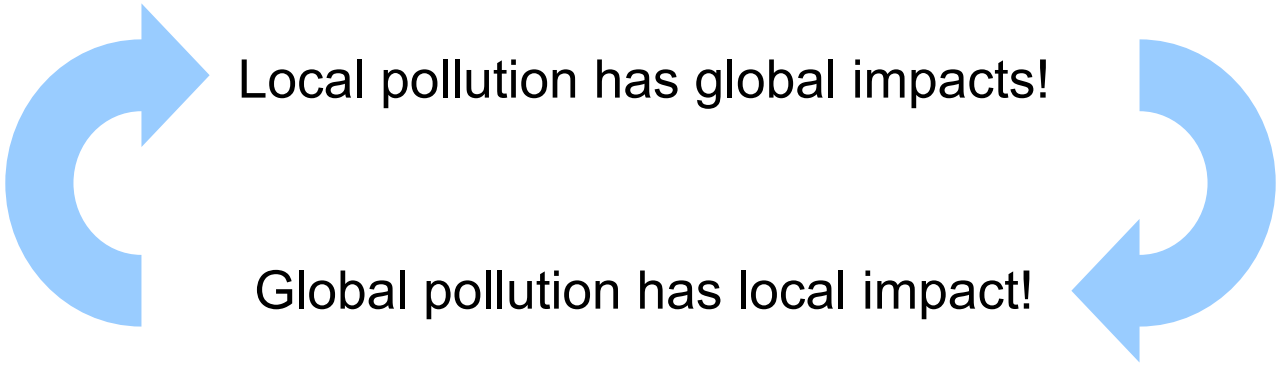
Burning of coal, oil, gasoline, kerosene, diesel, alcohol fuels, natural gas

Waste and release of chemicals

Why is air quality monitoring and forecasting so complicated?

- It is not only the directly emitted pollutants that can be hazardous.
  - Pollutants can react with each other and produce harmful smog in the cities
  - Pollutants can be dispersed into buildings and alongs streets affecting whole city areas
  - Pollutants can travel across boundaries, continents and around the world
  - Pollutants can harm our fragile climate system

If there was only one slide in this training…



Air …

- Air is not owned privately, it is common property owned by all individuals
- As a result has historically been polluted without limit (tragedy of commons)

Two ways of limiting air pollution

- Voluntarism
- Government intervention

Intervention against air pollution an economic market?

Intervention has proven to be effective and can take the form of

- setting up economic markets for the rights to emit pollution
- Limiting emissions from specific sources
- Requiring certain emission control technologies
- Setting limits on pollution concentrations
- Allowing any emission reduction method to meet those limits

→ Intervention stimulates the development of environmental technologies → Economoic push

The regulatory air pollutants

→ Late discovery, since more difficult to observe and isolate than liquids or solids

NO2	Nitrogen Dioxide,	1774, Priestley
CO	Carbon Monoxide	1774, Priestley
SO2	Sulfur Dioxide	1774, Priestley
O3	Ozone	1840, Schönbein

Chemical reactions

→ Many pollution problems today are exacerbated by atmospheric chemical reactions

→ Reactions initiated by sunlight, lightning, temperature changes, molecular collisions

Chemical reactions

→ Gas-phase chemical reactions can divided into **2 groups**:

→ **Photolysis reactions**

→ unimolecular:

$NO_2 + h\nu \rightarrow NO + O \quad \lambda < 420\ nm$

→ **Chemical kinetic reactions**

→ bimolecular

$CH_4 + OH \rightarrow CH_3 + H_2O$

Carbon Monoxide

- Tasteless, colorless and odorless gas
- Sources:
  - Incomplete fossil fuel combustion mainly from tranportation (cars, ships, …)
  - Biomass burning and wildfires
  - Photolysis and kinetic reactions
  - Plants and biologial activity in oceans
- Sinks:
  - Kinetic reaction to CO2
  - Transfer to soils and ice
  - Dissolution in ocean water (CO insoluble)

Carbon Monoxide: Health Effects

- Harmful short-term healht effects
- Exposure to 300 ppm for 1 hour causes headaches
- Exposure to 700 ppm for 1 hour causes death
  (On freeways and tunnels up to more than 100 ppm)
- It dissolves in blood and replaces oxygen as an attachment to hemoglobin. Thus it causes suffocation
- Effects mainly reversible. Following acute exposure individuals mayexpress neurologic symptoms

Ozone

- Colorless gas, with pungent sweet smell (>0.02ppm) (greek *ozein:* to smell)
- Sources:
  - Chemical reaction of O and O2
- Sinks:
  - Photolysis
  - Kinetic reaction
  - Transfer to soil and ice
  - Dissolution in water
- No direct emission of ozone!
- Importance of precursor / ozone building substances

Ozone: Health Effects

- Headaches at Volume Mixing Ratios > 0.15 ppm
- Chest pain at VMR > 0.25 ppm
- Sore throat and cough at VMR > 0.30 ppm
- Most polluted cities 0.50 ppm in the afternoon!
  Average polluted city 0.15 ppm
- Ozone decreases lung function for more than hour after exposure to 0.30 ppm and accelerates aging of lung tissue
- Affects people with asthma, chronocal bronchitis
- Reduces growth of animals and plants, deteriorates organic materials, paints, coatings, rubber, ttextiles

Sulfur Dioxide

- Colorless gas with a taste at levels > 0.3 ppm, and strong odor > 0.5 ppm
- Sources:
  - Fossil fuel combustion from coal-fired power plants, cooking gas stoves
  - Mineral ore processing
  - Volcanic eruptions
  - Chemical manufactoring
- Sinks:
  - Dissolution in cloud drops and ocean water
  - Kinetic reaction to H2SO4
  - Transfer to soils and ice

Sulfur Dioxide: Health Effects

- Both SO_2 and H_2SO_4 are water soluble
- Absorbed in mucous membrane of the nose and respiratory tract
- Harm of lungs
- Bronchicolar restrictions and respiratory infections at VMR > 1.5 ppm

Nitrogen Dioxide

- Brown gas with strong odor
- Strongly related to production of Nitric Oxide (NO)
- Sources:
  - Fossil-fuel combustion
  - Biomass burning
  - Lightning
  - Denitrification in soils and plants
  - Photolysis and kinetic reactions
- Sinks:
  - Kinetic reaction
  - Dissolution in ocean water
  - Transfer to ocean and ice

Nitrogen Dioxide: Health Effects

- Harm of lungs
- Increase in respiratory infections
- Children and astmatics affected more
- Increases allergic response
- Acute bronchitis at VMR > 25 ppm
- Death at VMR > 100 ppm
  In polluted cities up to 0.25 ppm

Particulate Matter

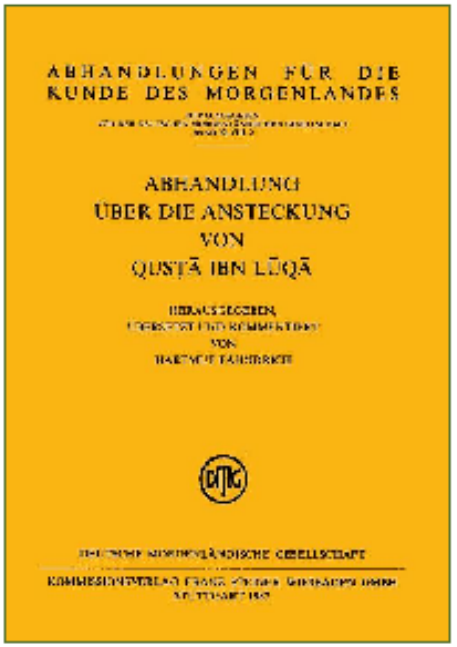
- All kinds of organic and anorganic particles
- Sources
  - Nucleation, condensation
  - Fossil-fuel emissions
  - Biomass emissions
  - Industrial processes
  - Sea spray
- Sinks:
  - Dry and wet deposition (wash out, rain out)

Particulate Matter: Health Effects

- Hazardeous ultra fine particles (< 0.1µm in diameter
- Pulmonary deseases
  - Decrease of lung function
  - Black lung desease (coal workers)
  - asthma
- Cardiovascular deseases
- Arteriosclerosis
- Increase of death rates after exposure to PM proven

Air Pollution in Saudi Arabian Heritage

- Qusta ibn Luqa (9th to 10th century)
- His „*Medical regimes to the pilgrims to Mecca*“ is a traveller health guide, especially written for a pilgrim to Mecca
- He assigns 2 causes of widespread illnesses
  - Surroudning air
  - Infection



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Surrounding air differs greatly according to different effects on it. Those are either from the earth or from the sky. The earth factors include: [i] vapors ascending from forests and swamps, [ii] other ground humidities such as the smoke ascending from mountains and furnaces, [iii] other dry bodies which emit smoke when they are burned, corpses and [iv] other spoiled things which emit bad fumes and stinky odors when heated by the sun and nature. Heavenly factors include: extreme heat in summer and extreme cold in winter. These factors cause common illnesses that overwhelm most people. The most obvious cause is air spoilage which results from these factors.

الهواء المحيط يختلف اختلافا كبيرا، على قدر
اختلاف التأثرات التي تحدث فيه: إما من الأسباب
الأرضية كالبخارات التي ترتفع من السباخ
والغياض وسائر الرطوبات الأرضية كالأدخنة التي
ترتفع من الجبال والأتاتين وغيرها من الأجرام
.اليابسة التي إذا عملت فيها النار انقادت منها دخانا
وكجثث القتلى وغيرها من الأشياء العفنة التي إذا
فعلت فيها الحرارة الشمسية والطبيعية أحدثت منها
بخارات رديئة وروائح منتنة. وإما من أسباب
سمائية، كالحر المفرط في الصيف والبرد المفرط
في الشتاء كان كثيرا ما يعرض للناس أمراض
مشتركة تعم أكثرهم، يكون أظهر حدوثها عن فساد
الهواء بما يعرض فيه من هذه الأحداث

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Air Pollution in Saudi Arabian Heritage

- Al-Tamini (10th century)
- Voluminous treaty on air pollution
  - Description of polluted air types in the Islamic World and the relation to weather
  - Diseases resulting from air pollution
  - Types of incenses to treat air pollution
- Work was among lost Arabic writings until the 1970s!

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