International Training Course on Sand & Dust Storms

9-12 October 2011, Tehran, IR of Iran

Impacts of Sand & Dust Storms On Agriculture

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Disclaimer

This presentation contains:

No equations.

No modeling

No description of any instrument……

Or your money back !!!

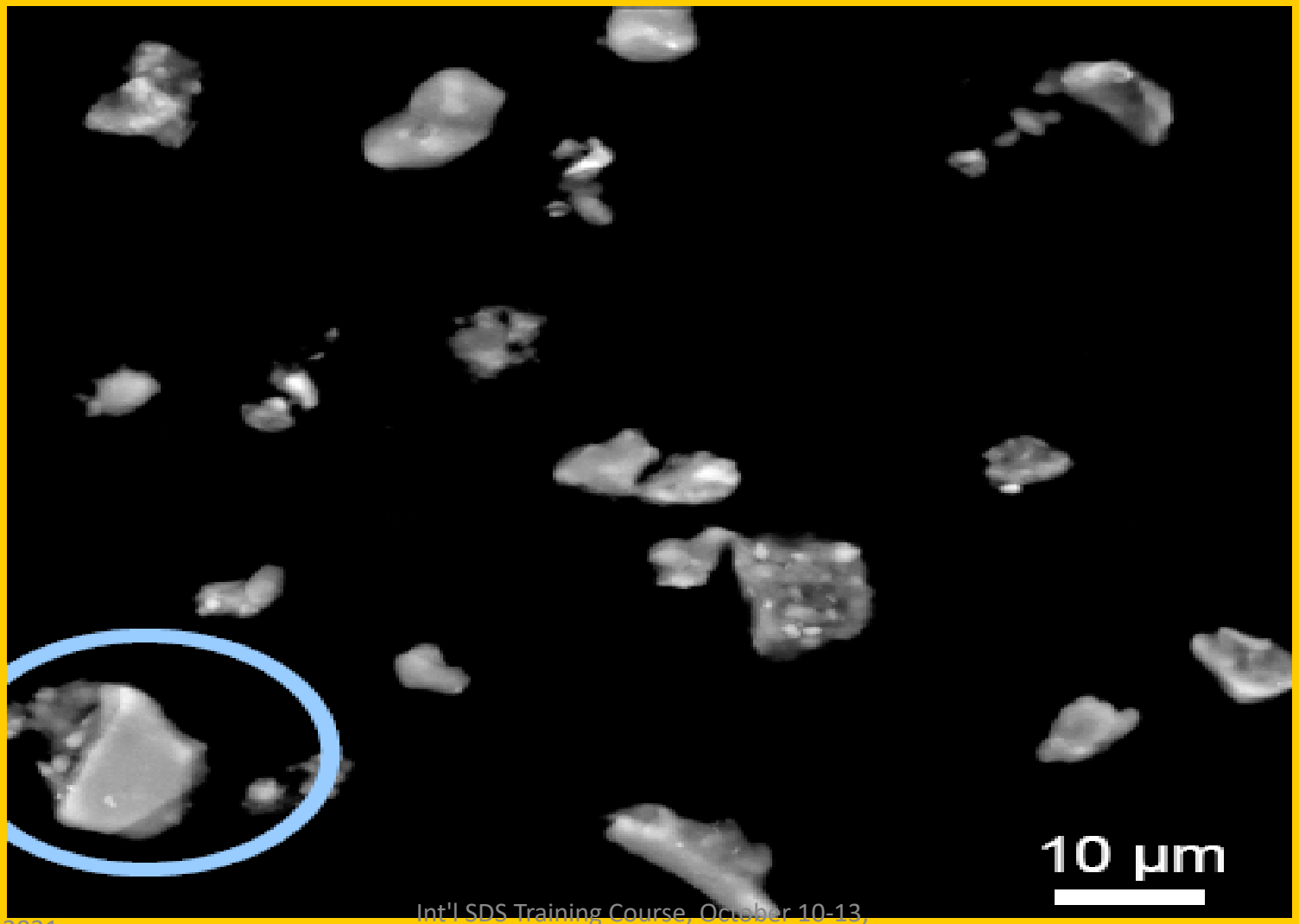
SDS can, sometimes, be wild

Sequences…

Block sun, diffuse light

28 May 2021

Microscopic view...



Basic facts SDS

Size: ~ 100 µm or less

Concentrations: can be 6000 µg/m3

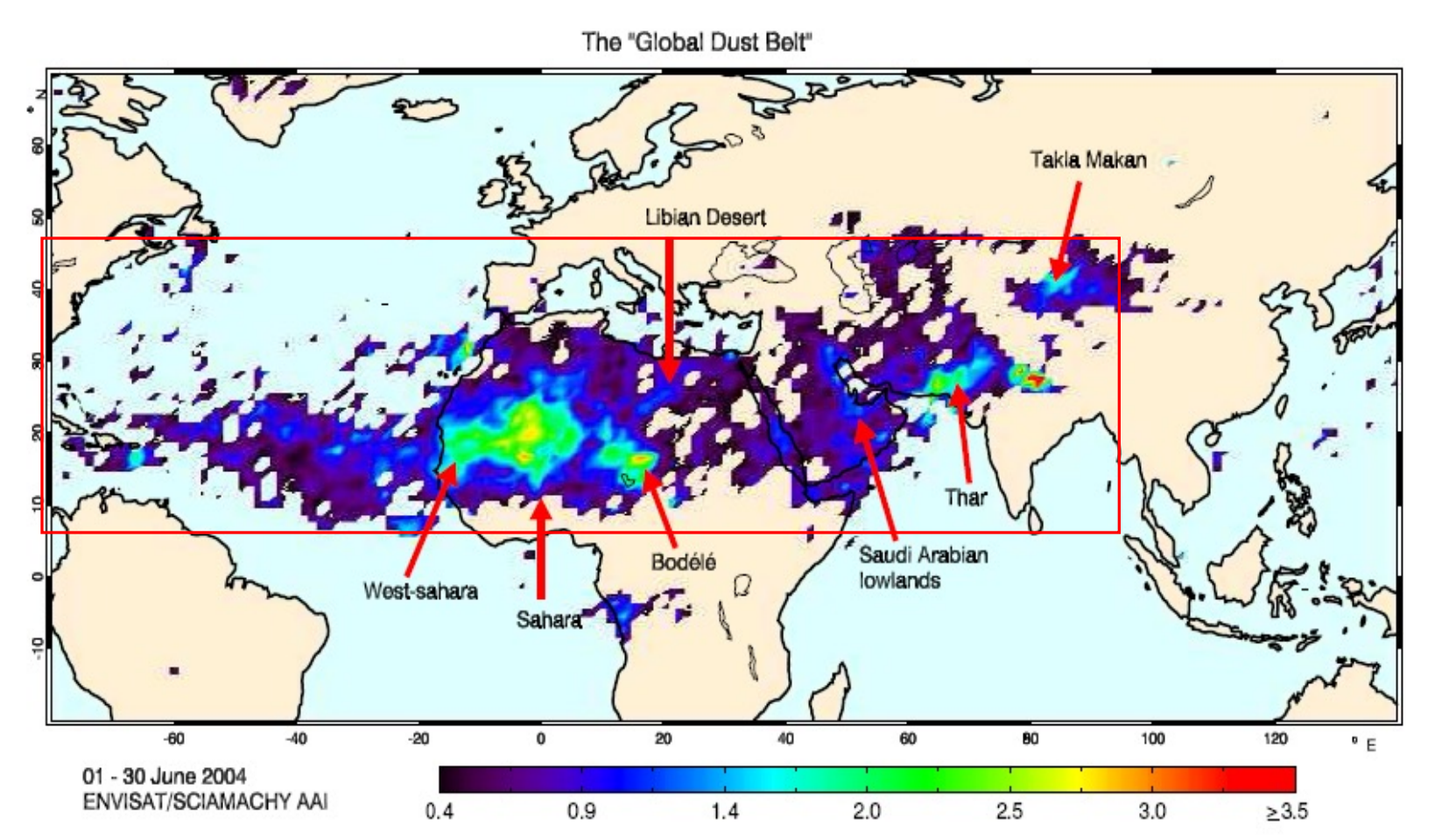
Ascent: Up 10 km high

Coverage: 100s km^2

Life time: 4-7 days

Intercontinental transport

Global Sources of SDS



Sahara, Sahel, Arabian Peninsula, Thar desert (Middle East), Aral Sea (Central Asia), Taklamakan desert (China), Gobi Desert (China/Mongolia), Lake Eyre Basin (Australia)

(de Graaf, 2006)

Main Dust sources Affecting the Region

Tigris and Euphrates rivers basin

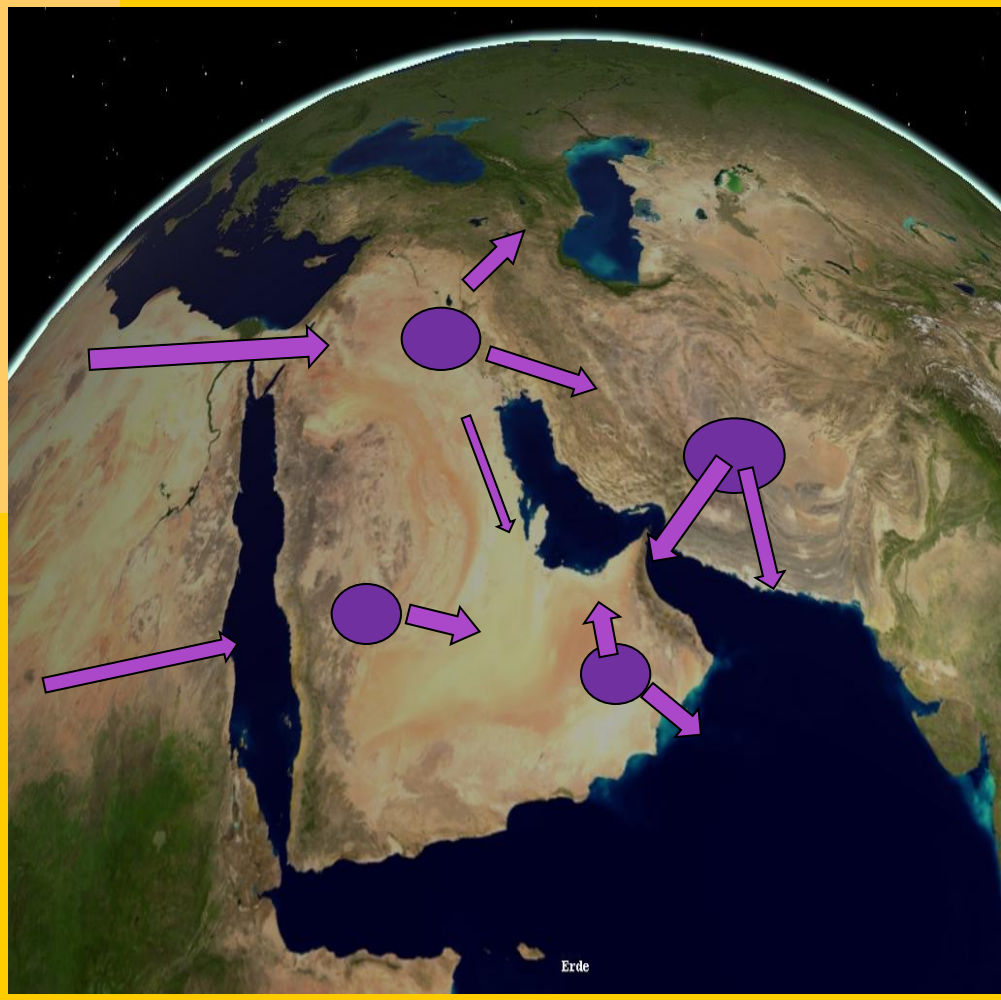
Sistan Basin & Baluchistan

East of Alhejaz Mountains

Southwest Alhajar Mountains

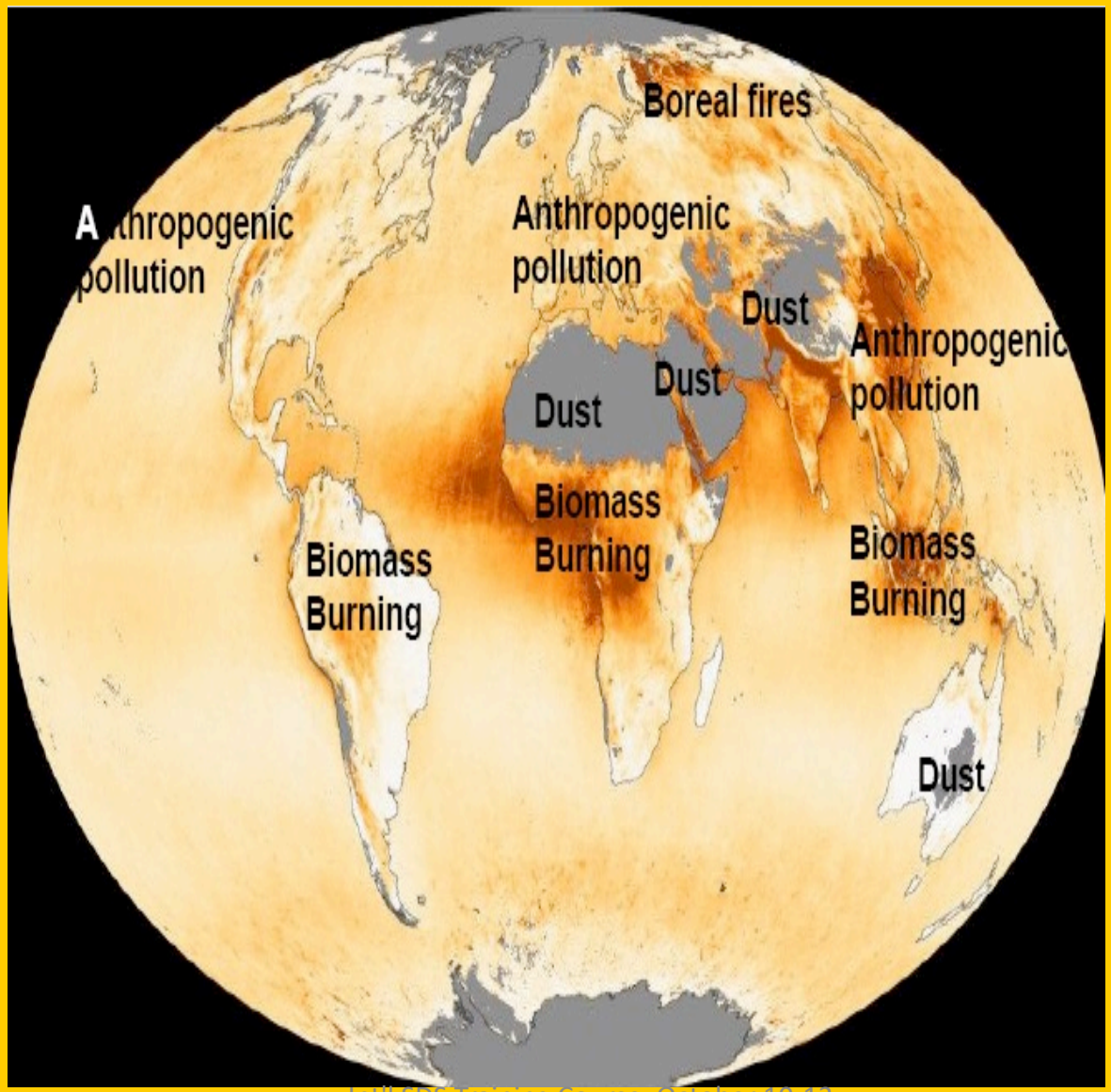
Sahara Desert

Oman Met service



Typical Sandstorm effecting central Egypt & north western Saudi Arabia

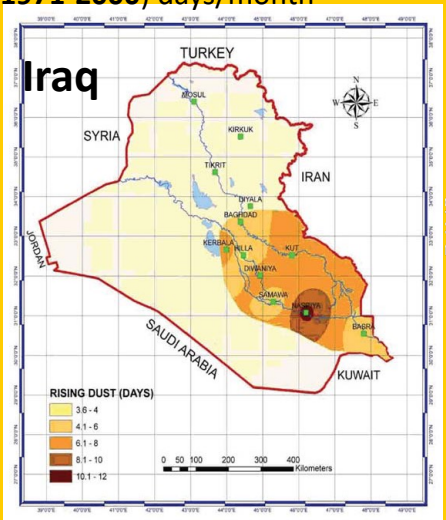
non-desert sources…

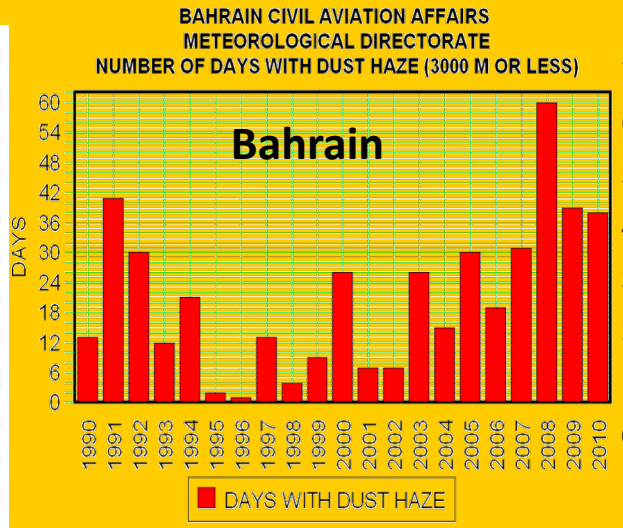


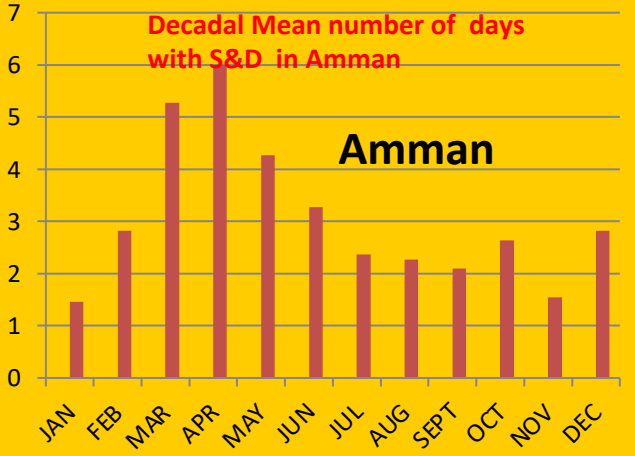
How much dust there is ?

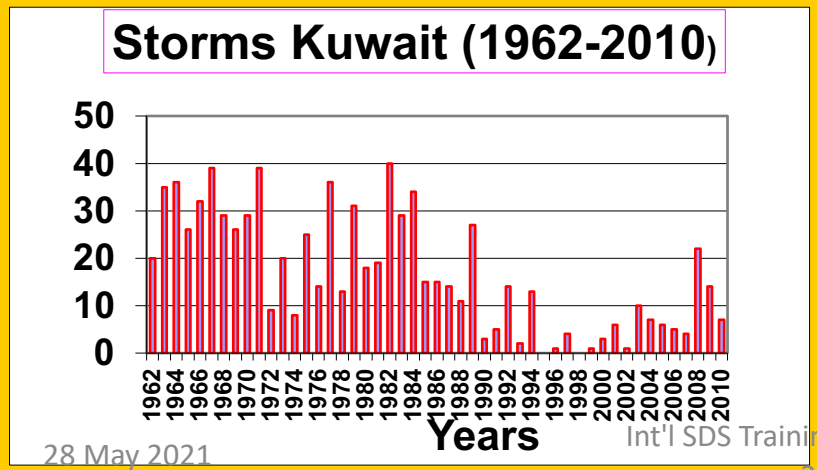
Frequency… Regional examples

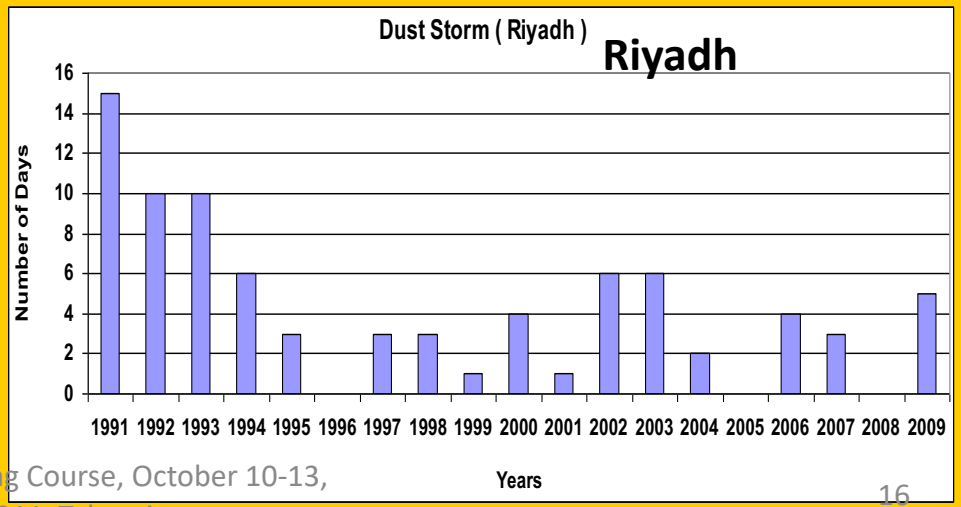
Rising Dust (Days) distribution over Middle & southern Iraq
(**1971-2000**) days/month











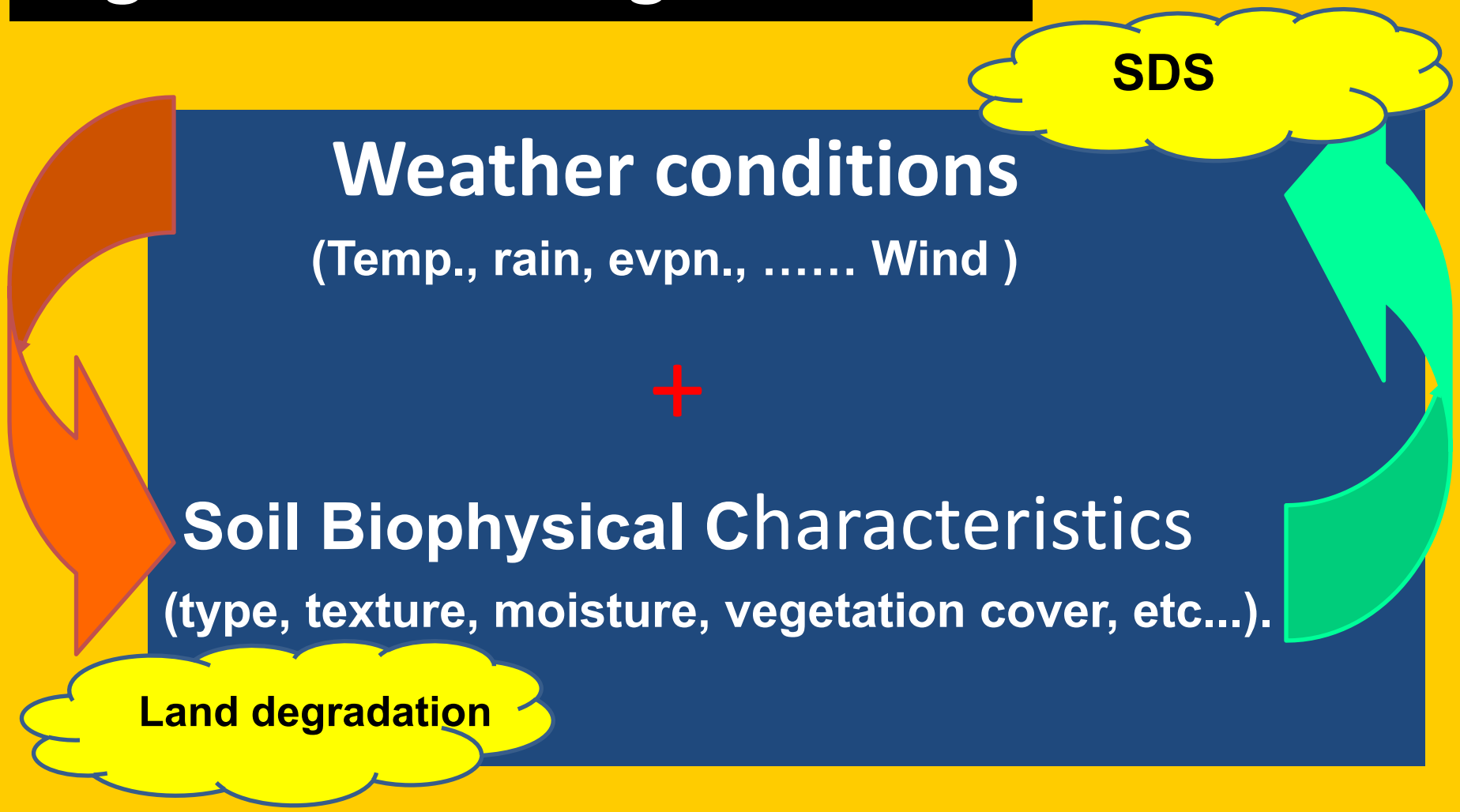
Comfort & Health

Road blocker

SDS .. A bit of history

Cambyses II (son of Syros the Great), lost 50,000 strong men of his army in the way to Siwa Oasis (west of Cairo) in 542 BC

SDS needs….
Right climate… Right surface



Impact of Sand & dust storms on Agriculture

1. Immediate Impact on ag. Systems:

i. **Plant & Crop's yield** (Iran 2009);

ii. **Operators, systems & infrastructure;**

iii. **Livestock** diseases, productivity (milk, honey..)

iv. **Marine life** (+ ve impact)

2. Wind erosion (removal of top soil)

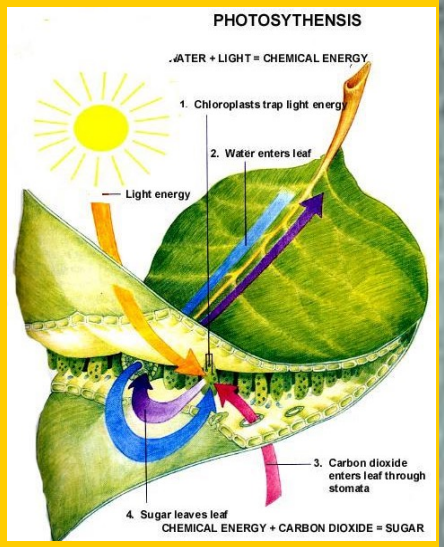
Land Degradation

Sand Blasting

i. Blasting of leaves

light

6CO2 +	12H2O		C6H12O6 +	6O2 +	6H20
Carbon	Water		Sugar	Oxygen	Water



Timing Scenarios of wind blasting Growing Stages …

1. Emerging plants

Total loss

2. Early growing season

Minor damage

3.Flowering

Loss of flowers

4.Maturity & harvesting

Major damage

ii. Impacts on irrigation systems: Regional examples

iv. Impact of SDS on marine life

Marine life: Groups

Benthos: plants and animals living on the sea bottom fixed (sponges and corals), creeping (crabs, snails) and others: seaweeds ;

Nekton swimming animals that can move freely and that are capable of migration from one place to another

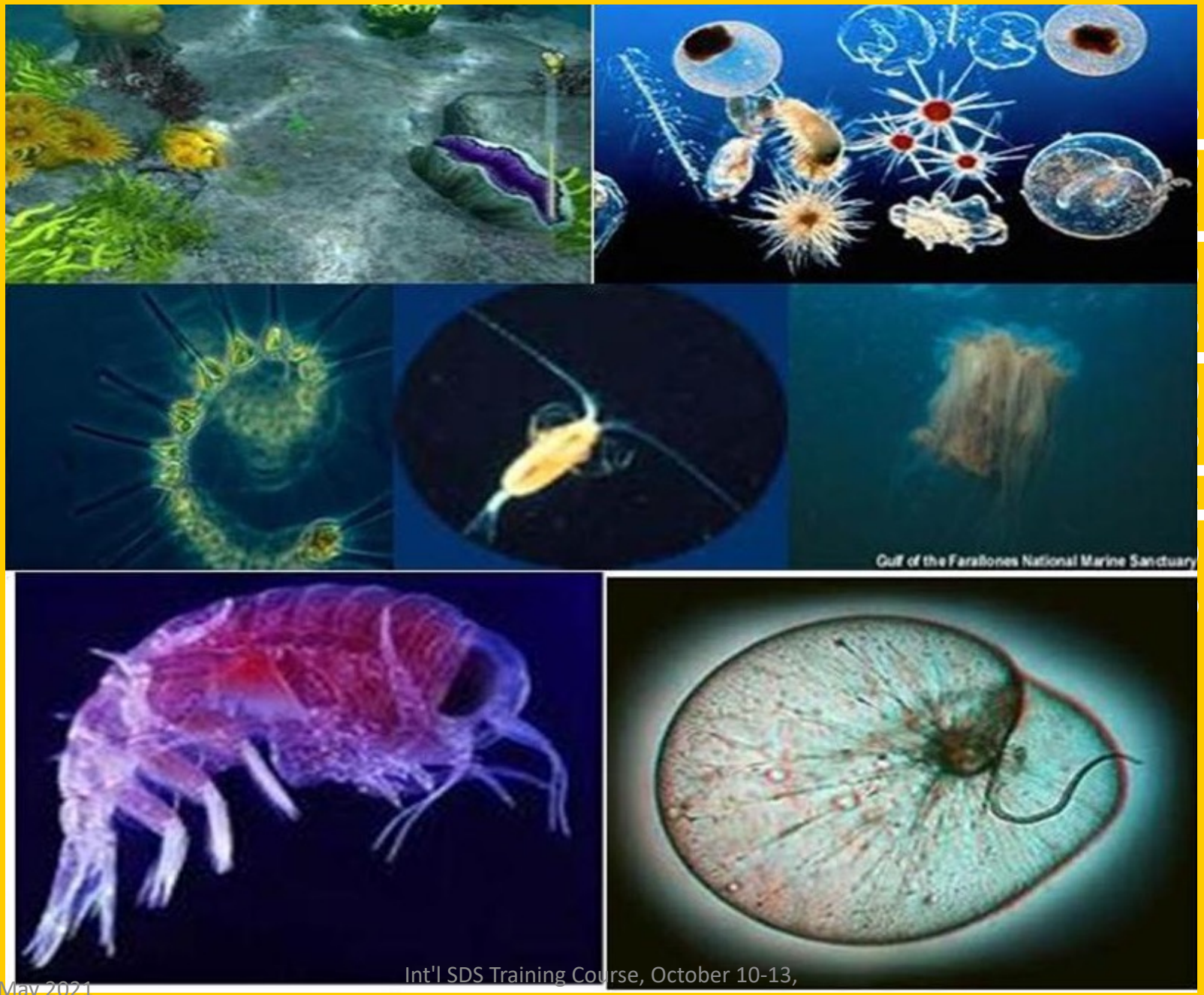
Plankton floating and drifting *(photic zone, 140 m)*

Meet the Plankton….

Aquatic organisms: Plants (phytoplankton) or animals (zooplankton);

Most abundant life form on earth after bacteria;

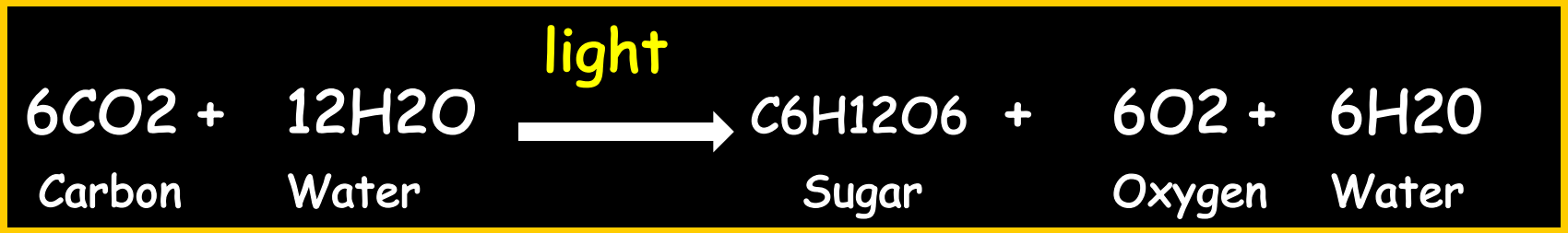
Different Size: microbes to giant jellyfish (meters) .


Gulf of the Farallones National Marine Sanctuary

Why we care about them ..

- **Major source of food production** "grass" of aquatic habitats….. Base in food chain;
- **Consume aquatic bacteria** (cleaners of oceans);
- **Generate 50% of world's O_2, Sink of CO_2 ;** Oceans' **Invisible Forest**;
- Major Climate **controllers** (past-present).

Iron & Photosynthesis



Iron is necessary for photosynthesis as an **enzyme cofactor** in plants (Fe deficiency .. chlorosis and necrosis)

Iron & Oceans

Facts:

Dust flux into oceans = 1 BT/yr

Fe = ~3.5%

Dust storms provide oceans with much needed iron

Iron deficiency in Oceans (Joseph Hart 1930)

Iron seeding concept: 16 tankers of Fe particles.. $b 20, John Martine 1991)

Dust storms can be useful fertilizers…

dedicated for SDS haters….

Amazon rain forest: receives from Sahara/Sahel dust 2.5 and 0.2 kg $ha^{-1}y^{-1}$ of K and P & 1-4 kg of phosphate ha^{-1} y^{-1};

Saharan dust is the most important parent material for clay-rich soils on Caribbean islands;

Dust from China is major component of alkali ice crystals which neutralize acid rain in Japan;

Bergametti et al 2008, ***(Swap et al., 1992) , (Muhs et al., 1990***

2. Wind erosion of Soil

Erosion $\propto V^3$

Simple dynamics

High Wind → Removal of topsoil →

Loss of vital nutrients (Potassium & Phosphorous) →

Decrease in crop productivity:

Threshold wind speed @ 15 cm above ground for soil erosion as a function of soil texture

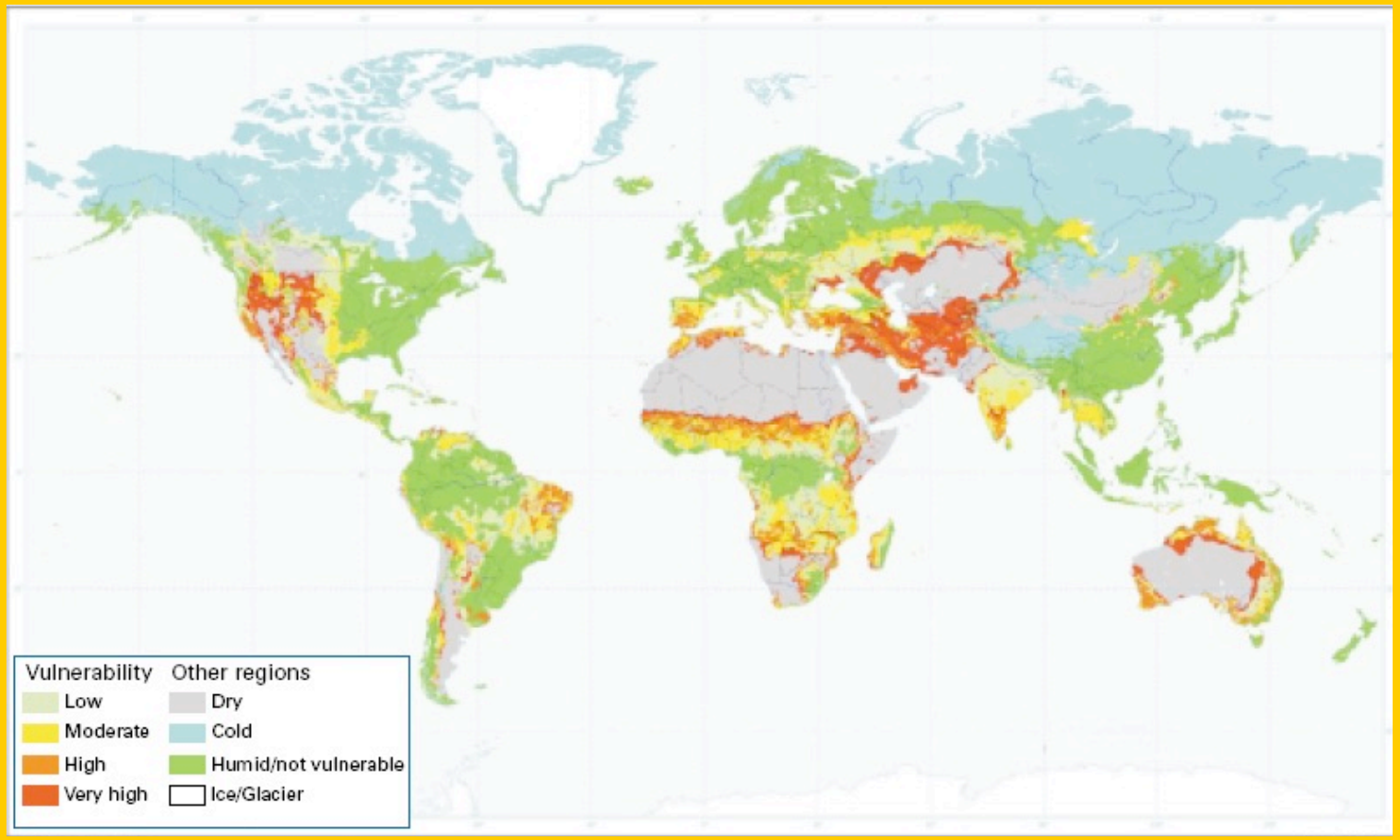
CAgM

Soil	Wind Speed m/s
Sandy	2-3
Sandy with Loam	3-4
Slight Loamy	4-6
Very Loamy	5-7
Loam	7-9

Land Degradation
Mitigation /Adaptation Measures

1. **Reduce wind** (shelter) : biological & mechanical wind breakers
2. **Ag. practices:** tillage, water harvesting, Protect surface,….
3. **Legislations & Policies ….**

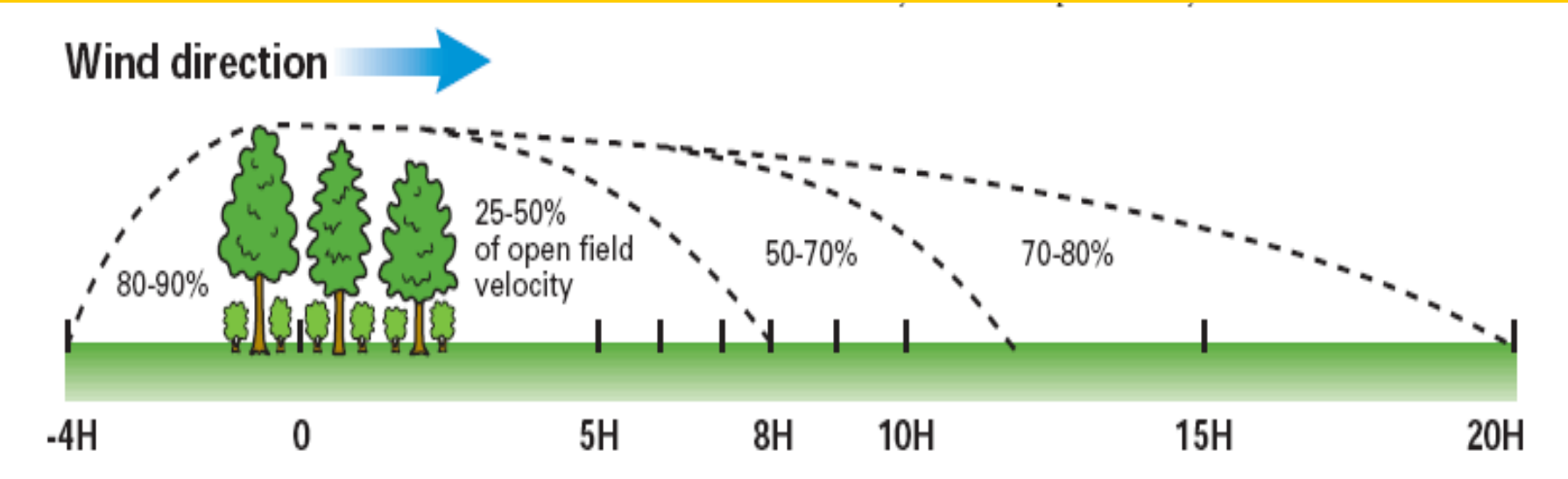
Regions vulnerable to land degradation….33%



Wind breaks

Sheltering effect

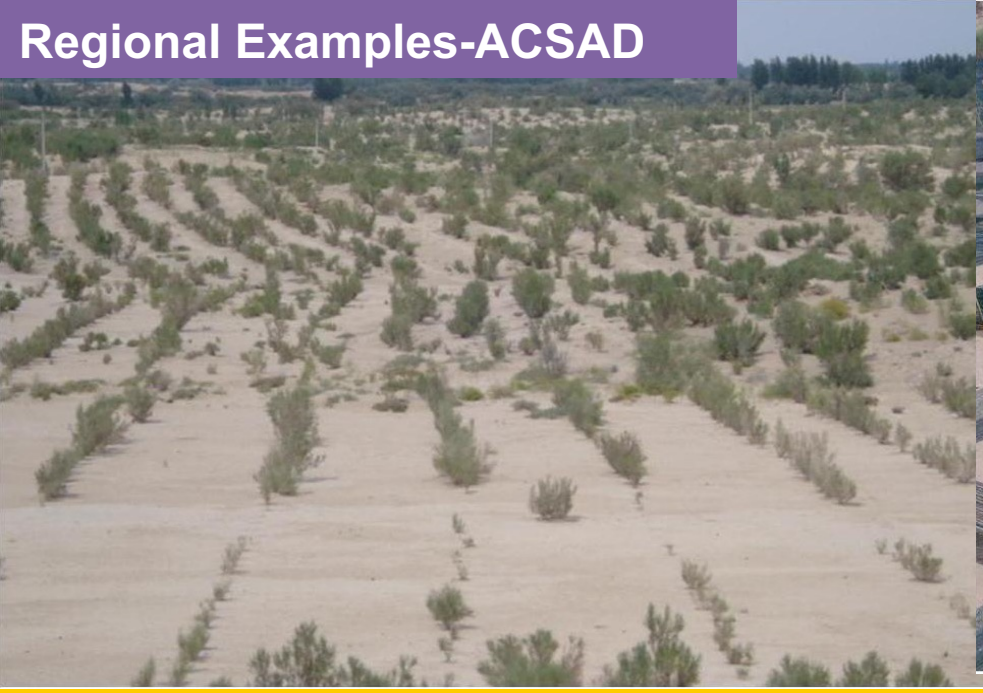
Iowa State



Distance from windbreak	5H	10H	15H	20H	25H	30H
% reduction in wind speed	78%	66%	35%	14%	10%	4%

Wind breakers: the higher, the more efficient

Regional Examples-ACSAD



Saudi Arabia, Ihsaa

Egypt

Regional Examples
Wind breakers

Saudi Arabia: wind breakers

Regional examples

Regional examples: Local Material

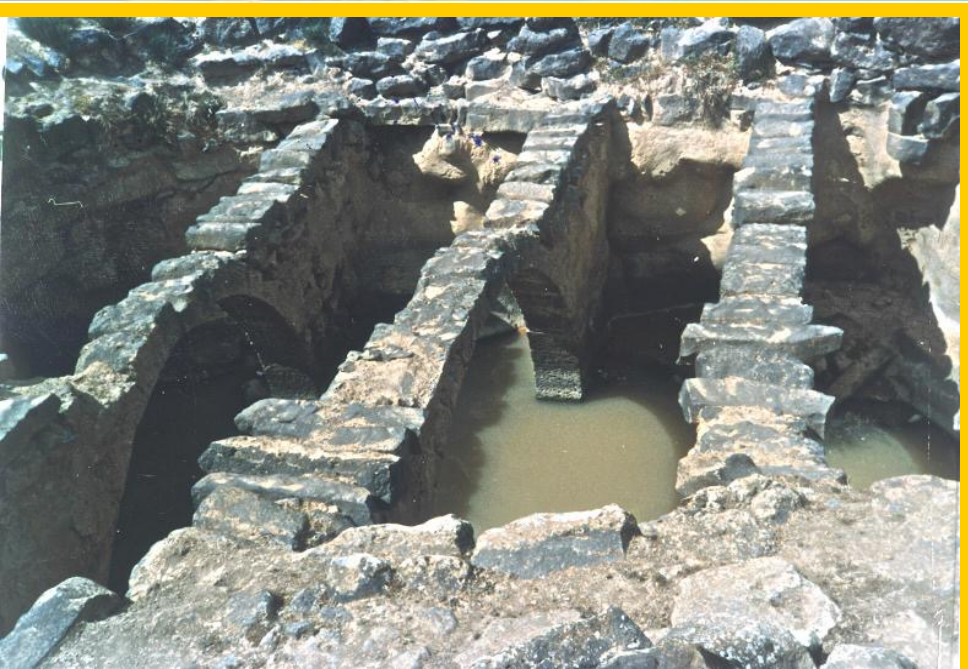
Measures on the ground…..Cover your soil !!

Morocco: plant residuals

Libya: chemicals

Tunis: chemicals

Resources Management: Innovative & Indigenous



Unique Engineering, Yemen

الصهاريج

Aden Tanks, Yemen

Thank you

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Part I

Definitions

American Met. Society

1. **Airborne Particulates**
   (Solid Particles suspended in the air)

i. Larger particles

>100 µm

Terminal velocities > 0.5 m s^{-1} and fall out quickly.

Include hail, snow, graupel, insect debris, room dust, soot aggregates, coarse sand, gravel, and sea spray

ii. Medium-size particles

1 -100 µm;

Sedimentation velocities > 0.2 m h^{-1} and settle out slowly;

Fine ice crystals, pollen, hair, large bacteria, windblown dust, fly ash, coal dust, silt, fine sand, small dust.

iii. Small particles

<1 *μm*;

Slow fall (days to years.. Stability)

Wet deposition OR Dry deposition;

viruses, small bacteria, soot, oil, metallurgical fumes, smoke, tobacco smoke, clay, and fumes.

Meteorologists description ….

2. Storm

Disturbed state of the atmosphere, especially as affecting the earth's surface, implying severe and possibly destructive weather.

3. Dust

Solid materials suspended in the air as irregular & microscopic particles;

Give tan/gray color to distant objects. Pale sun's disk.

Is not a stable component of the atmosphere, it eventually settle down

Block sun, diffuse light

28 May 2021

4. Sand

suspended particles of soil mixed with the air in the atmospheric boundary layer during strong winds;

Prevalent in deserts (no moisture, no plants).

6. Sand Storm

A strong wind carrying sand through the air;

Best developed in desert regions;

Large to medium particle (1000 µm);

10 -15 M high.

Visibility criteria…

Both forms of erosion are manifestations of desertification.

Chepil and Woodruff (1963) proposed empirical models for calculating wind aggressivity, or the wind index:

$$C = V^3 / 2.9 (PE)^2,$$

where:

C is wind aggressivity;

V is wind speed;

P is precipitation;

ETR is evapotranspiration; and

PE – ETR = E, which is precipitation efficiency.

Water erosion is measured by loss of soil per unit area, per unit of time. This value is a function of total precipitation, the empirical coefficient of proneness to soil erosion, slope gradient (the basis of erosion), agrotechnical coefficients and other parameters.

Contemporary methods for assessing and mapping desertification have been

Impacts of SDS: Summary

- **Human Health & Comfort**

  Respiratory: asthma

  Infections: meningitis/Africa, valley fever/ America's;

  Eyes: Irritation

- **Transportation (air, ground, marine..)**
- **Industrial activities** (out doors works, shipping, oil production, Precision Manufacture Industry, etc..);
- **Weather and Climate;**
- **Agriculture:**

Health Impacts

Potential dust mechanisms include:

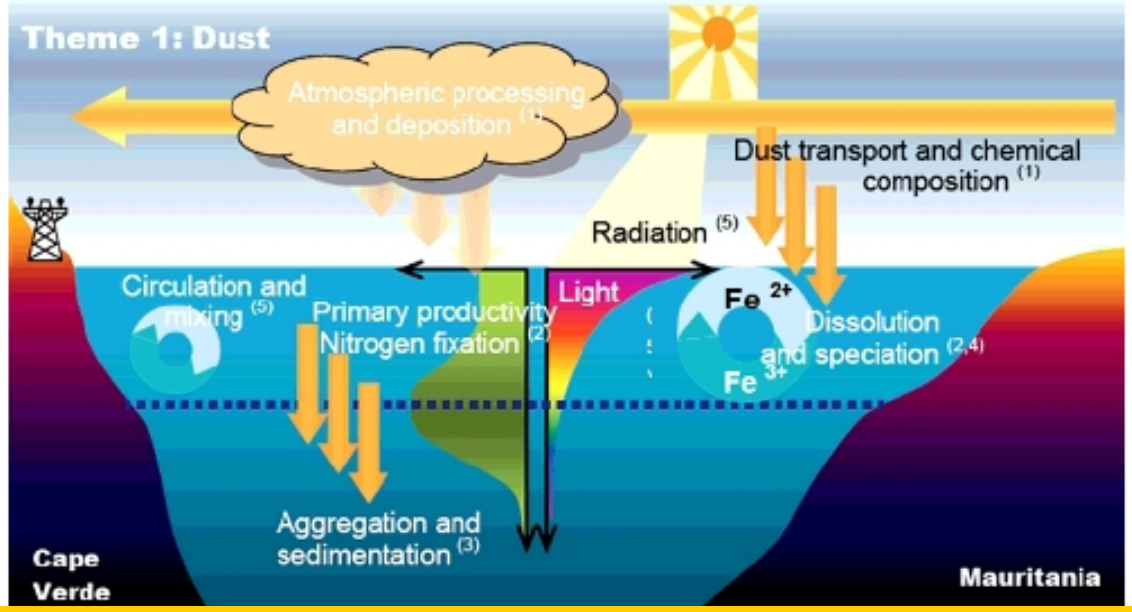
I. Impact on fluid dynamics of airborne transmission
II. Physical damage to epithelial cells of naso-pharynx
III. Impacts on preceding viral infection
IV. Enhanced activation of bacteria through high iron content
V. Impact on human behaviour, crowding, reduced ventilation
VI. Through impact on other climatic variables e.g. absolute humidity and temperature

- *Could be confounded with other factors which affect the above*

Role of Iron

UNIVERSITY OF LEEDS

- "Iron Hypothesis" formulated by John Martin: Despite high levels of nutrients (e.g. nitrate, phosphate) certain Ocean areas show less bio-productivity, i.e. phytoplankton growth [Martin et al., 1988]
- In ocean ecosystems, iron acts as controlling factor for marine life (e.g. phytoplankton growth) in high-nitrate, low chlorophyll (HNLC) regions [e.g. Mahowald et al., 2005]
- Dust fertilises tropical rain forest [Koren et al., 2006]



http://sopran.pangaea.de