

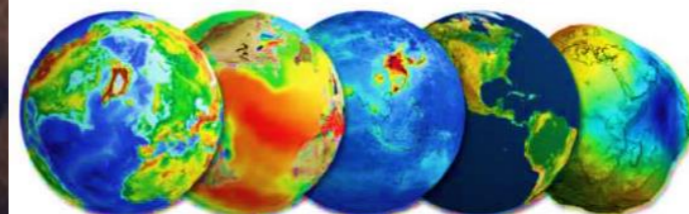
Space for Food Security

Pierre-Philippe Mathieu, ESA/ESRIN, Frascati, Italy.

pierre.philippe.mathieu@esa.int

Expo, Milano, 11 June 2015

Many thanks to F. Cecinati & colleagues

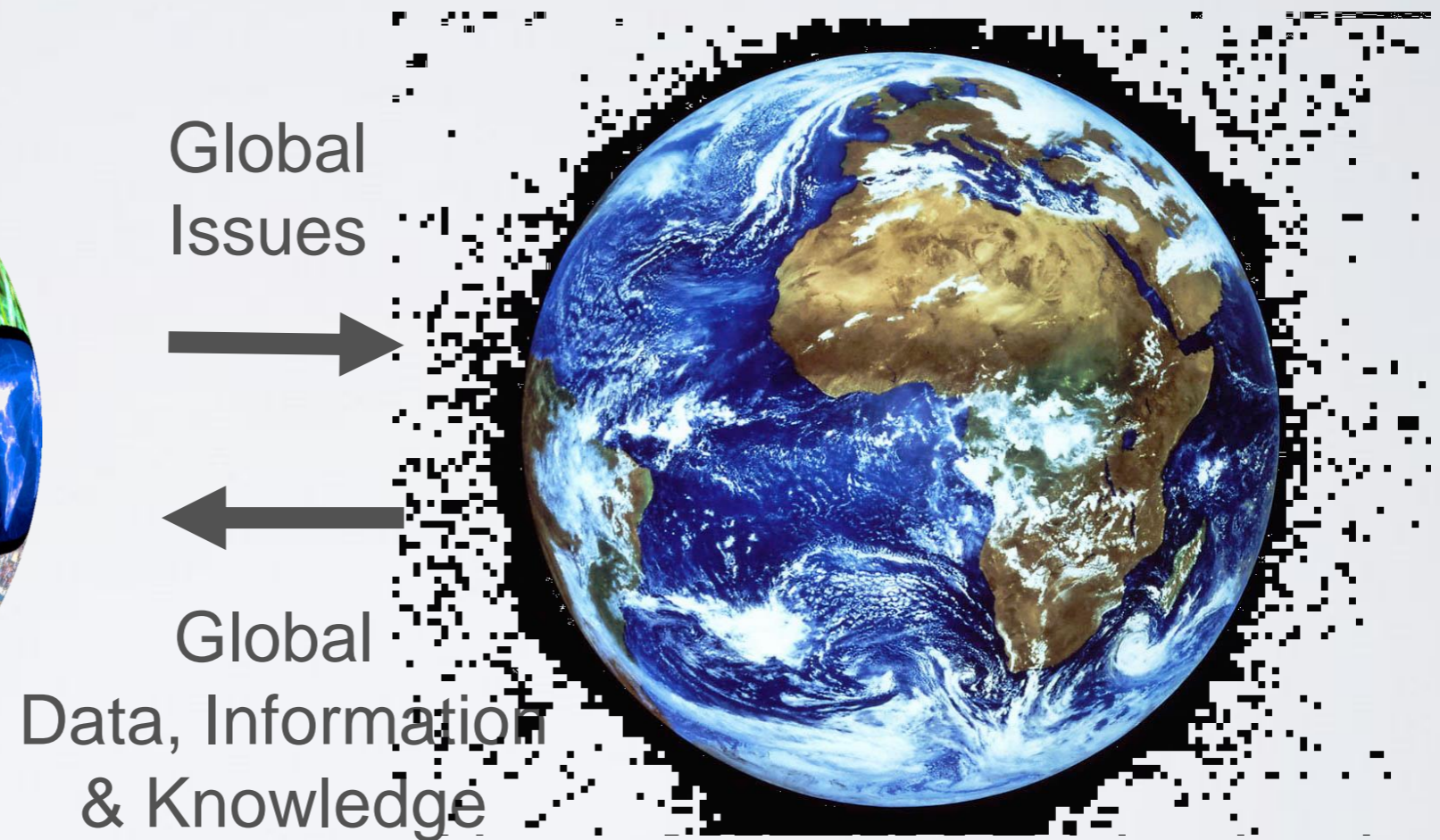


*... understanding our planet
... securing our environment
... benefiting our economy*

Planetary Challenges



Earth Observation Satellite data



A new era for global open data from space



COPERNICUS AND ITS 5 SENTINELS

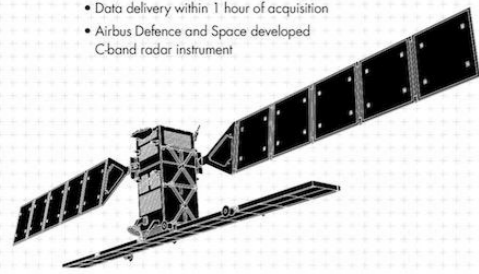
Observing our planet for a safer world. The European Earth Observation Programme Copernicus provides geo-information products and services based on satellite imagery.

- Known as **GMES** until 2012 - Global Monitoring for Environment and Security
- 30** Public and Private missions are also contributing data
- 16 years** of development and testing
- Five Sentinel-Missions** at the heart of the space component
- Civil Security.** Allowing early warning and crisis prevention in conflict and disaster areas
- Emergency Management.** Accurate and timely data for emergency plans and rescue for disaster management
- Land Surface Monitoring.** Geographical information on land cover, related variables and urban development
- Marine Environmental Monitoring.** Observations and forecasts on the state of the physical oceans and regional seas
- Climate Change Monitoring.** Helps to understand the reason for climate change, rising sea levels and melting ice caps
- Earth Atmosphere Monitoring.** Daily information on the global atmospheric composition and when Sentinel-4 is in service this will be hourly

SENTINEL-1A/1B



- **All-weather, day-and-night radar imaging satellite for land and ocean services**
- Able to "see" through clouds and rain
- Data delivery within 1 hour of acquisition
- Airbus Defence and Space developed C-band radar instrument

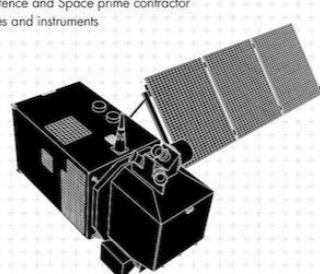


2014: Sentinel-1A
2015: Sentinel-1B

SENTINEL-2A/2B



- **Medium Res Multispectral optical satellite for observation of land, vegetation and water**
- 13 spectral bands with 10, 20 or 60 m resolution and 290 km swath width
- Global coverage of the Earth's land surface every 5 days
- Airbus Defence and Space prime contractor for satellites and instruments

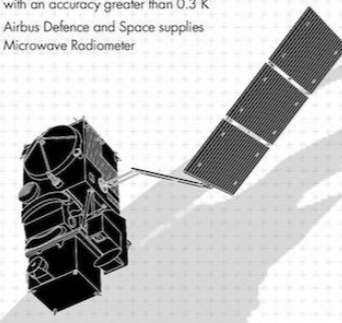


2014: Sentinel-2A
2015: Sentinel-2B

SENTINEL-3A/3B



- **Measures sea-surface topography with a resolution of 300 m, sea and land surface temperature and colour with a resolution of 1 km**
- Measures water vapour, cloud water content and thermal radiation emitted by the Earth
- Determines global sea surface temperatures with an accuracy greater than 0.3 K
- Airbus Defence and Space supplies Microwave Radiometer



2014: Sentinel-3A
2015: Sentinel-3B

SENTINEL-5P



- **Global observation of key atmospheric constituents, including ozone, nitrogen dioxide, sulphur dioxide and other environmental pollutants**
- Improves climate models and weather forecasts
- Provides data continuously during five-year gap between the retirement of Envisat and the launch of Sentinel-5
- Airbus Defence and Space prime contractor for satellite and TROPOMI instrument

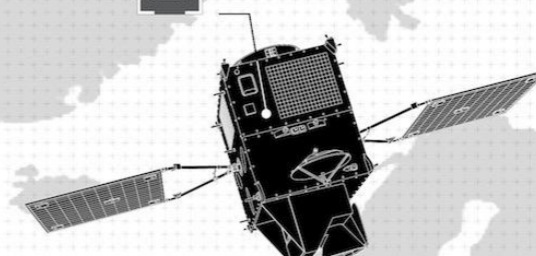


2015: Sentinel-5P

SENTINEL-4



- **Provides hourly updates on air quality with data on atmospheric aerosol and traces gas concentrations**
- Spatial sampling is 8 km and spectral resolution between 0.12 nm and 0.5 nm
- Airbus Defence and Space prime contractor for spectrometer
- Carried aboard EUMETSAT's Meteosat Third Generation (MTG) satellites

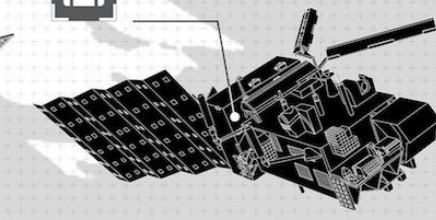


2020: Sentinel-4 with Meteosat-TG

SENTINEL-5



- **Measures air quality and solar radiation, monitors stratospheric ozone and the climate**
- Global coverage of Earth's atmosphere with an unprecedented spatial resolution
- Airbus Defence and Space prime contractor for instrument
- Carried aboard EUMETSAT's MetOp Second Generation satellites



2020: Sentinel-5 with MetOp-5G



3 April 2014

- C-Band Synthetic Aperture Radar Payload (at 5.405 GHz)
- Life time: 7 years design life time with consumables for 12 years
- Near-Polar sun-synchronous (dawn-dusk) orbit at 698 km.
- Repeat Cycle *12 days* repeat cycle (1 satellite)

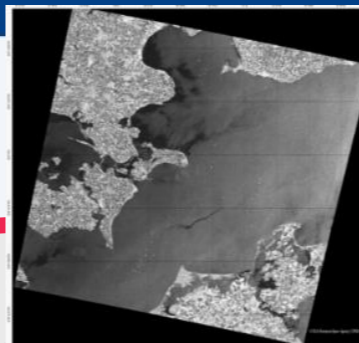
A wide range of applications



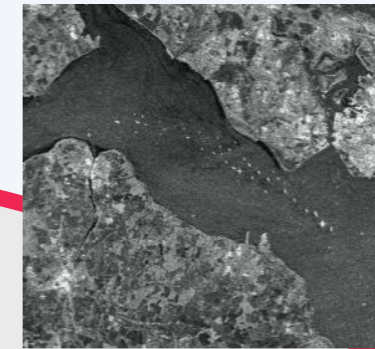
Arctic ice extent August 2009
(Credit: MyOcean)



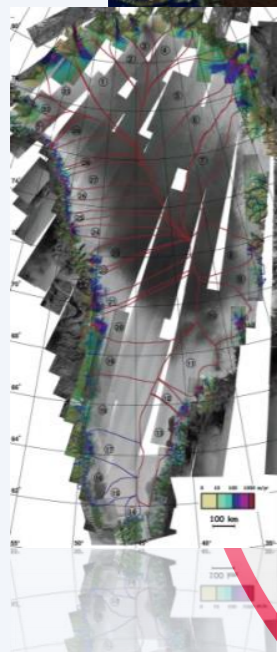
Larsen ice shelf loss between 2002 and 2009
(Credit: Polar View)



Oil spill detection and Surveillance
(Credit: EMSA)



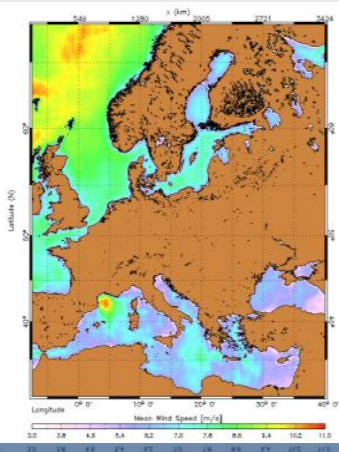
Ship detection
(Credit: ESA)



Acceleration of Greenland glaciers flow
(Credit: Rignot et Al)

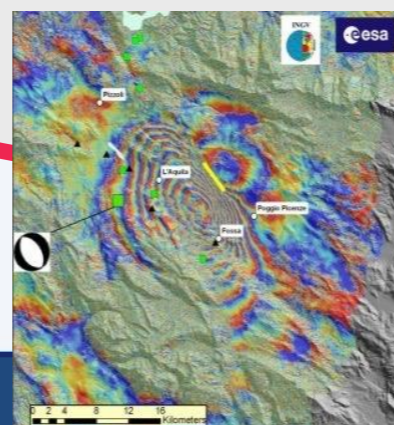
Emergency management: flooding
(Credit: SAFER, DLR)

Mean wind speed from 2005 to 2009
(Credit: CLS)

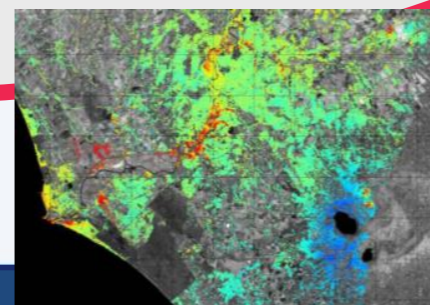


C-band SAR observations to support a wide range of applications

Earthquake analysis
(Credit: INGV)



Subsidence map 1992-2006
(Credit: TerraFirma)



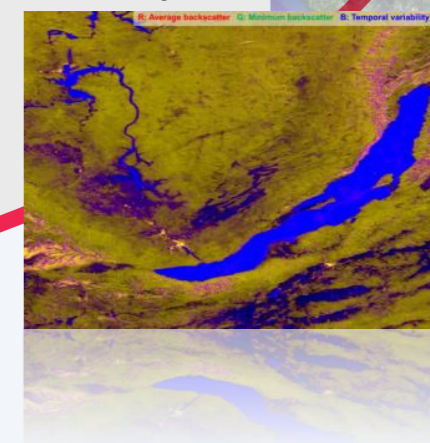
Crop Monitoring
(Credit: AgriSAR)



Land use
(Credit: ESA)



Forest monitoring
(Credit: Gamma)

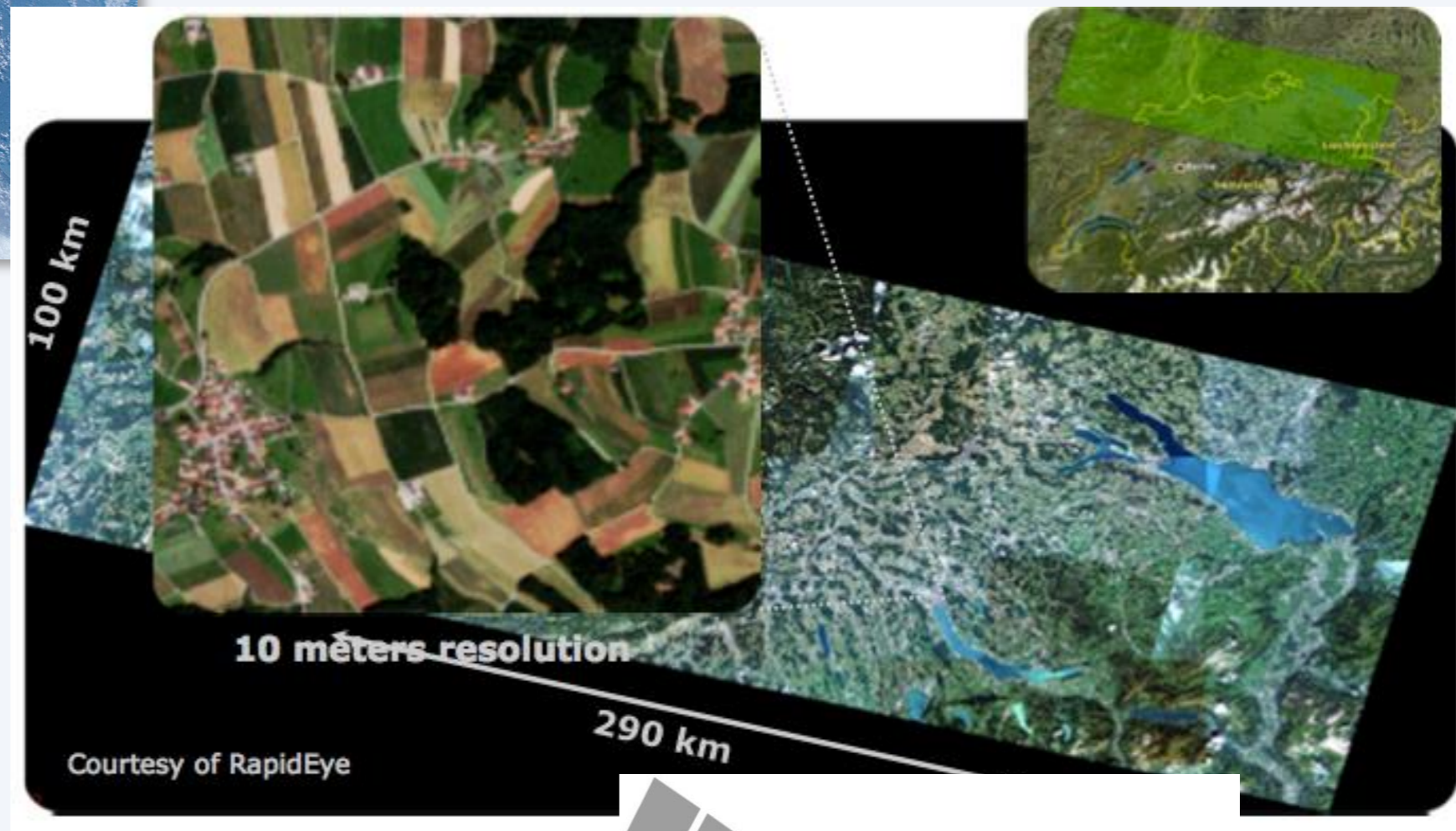


...and more

S-2 workhorse for agriculture



S-2 (13 spectral bands, 10-60m, 5d revisit 2sat)
Routine crop monitoring to better manage agriculture
and manage food security risks



THE CHALLENGE

SUSTAINABLE DEVELOPMENT



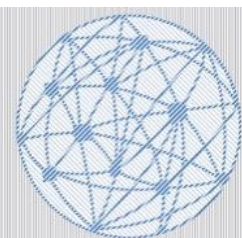
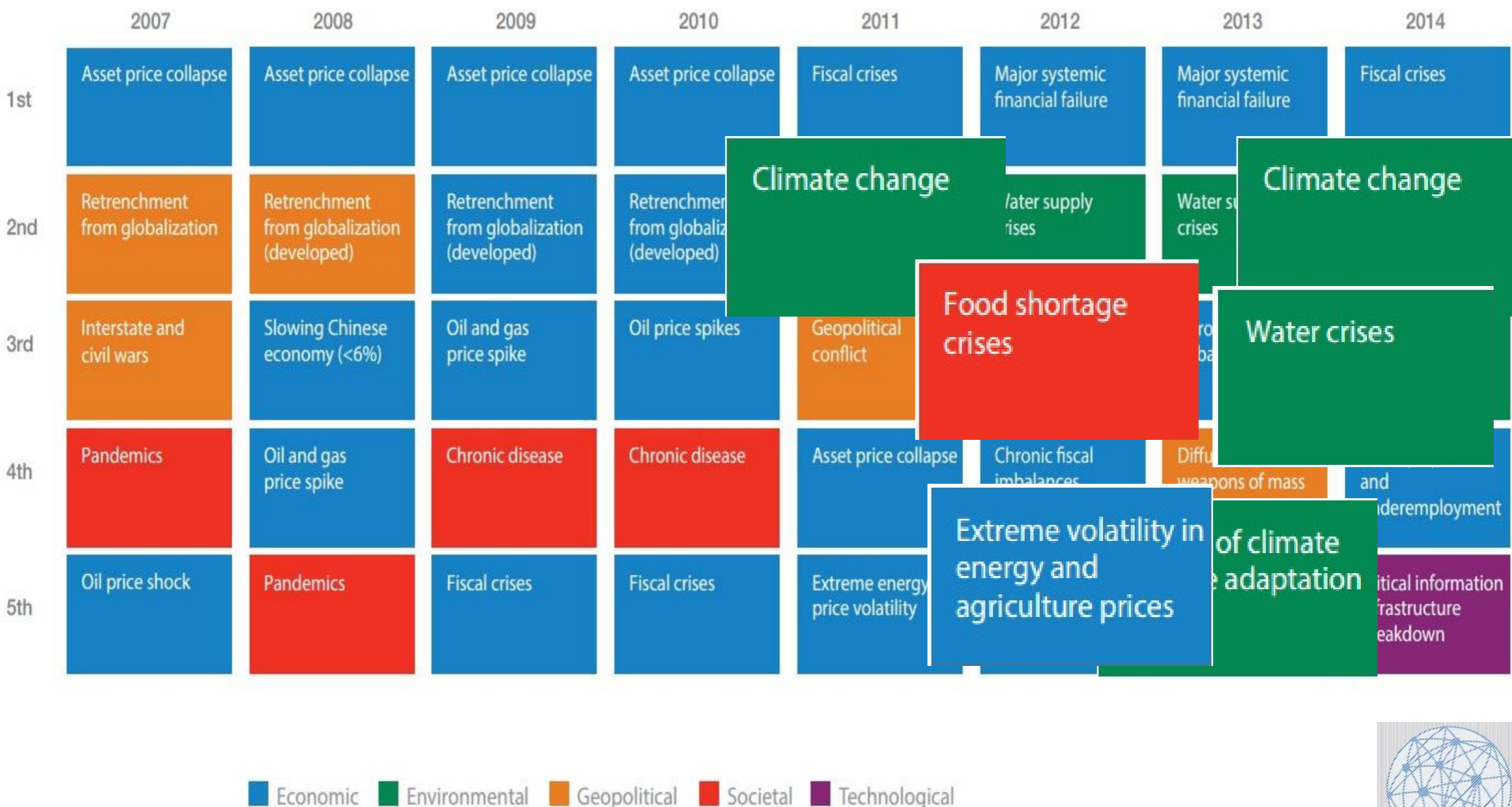
“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. “

Rome Declaration of The World Food Summit of 1996

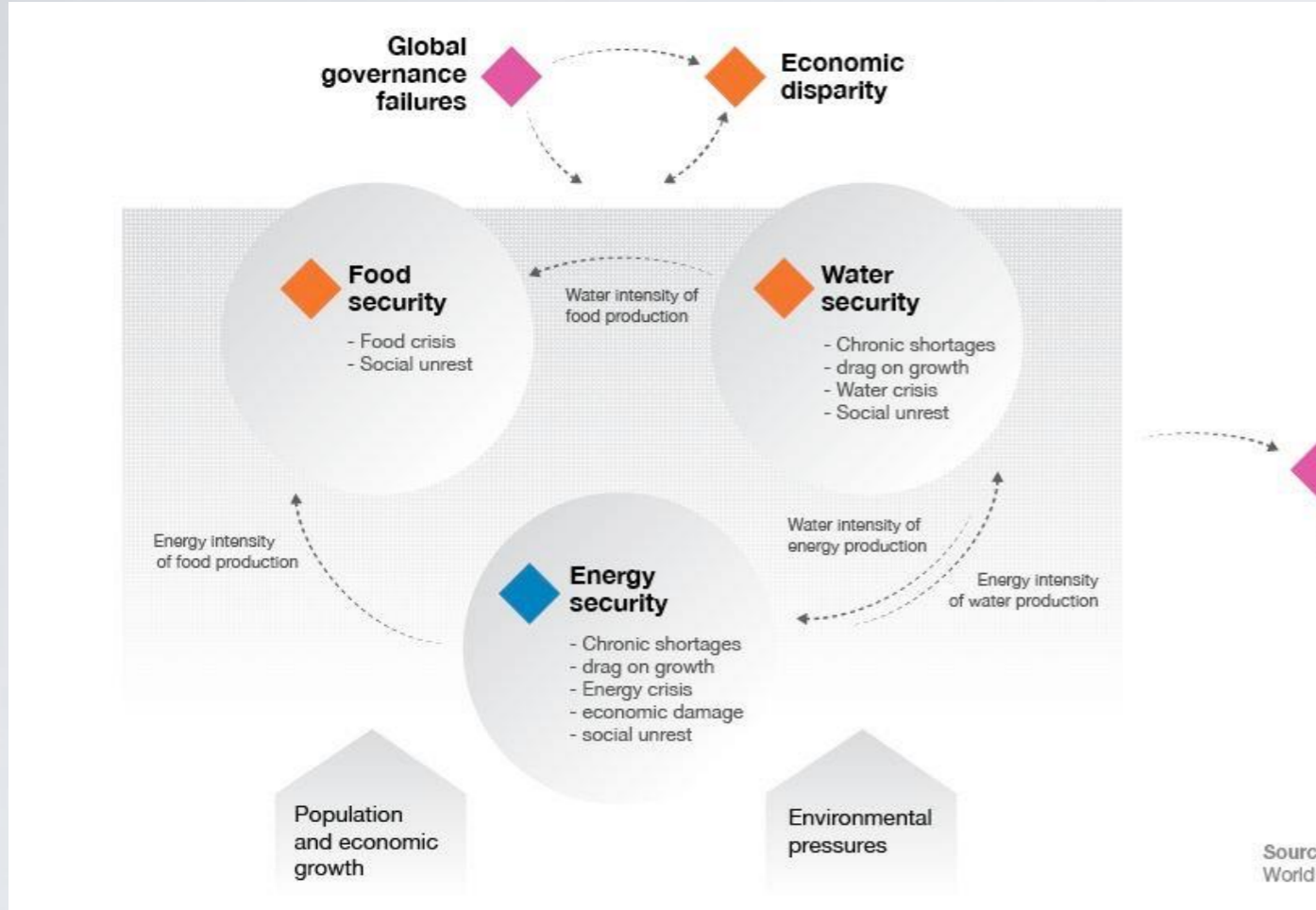


Global Risks as seen by WEF

Top 5 Global Risks in Terms of Impact



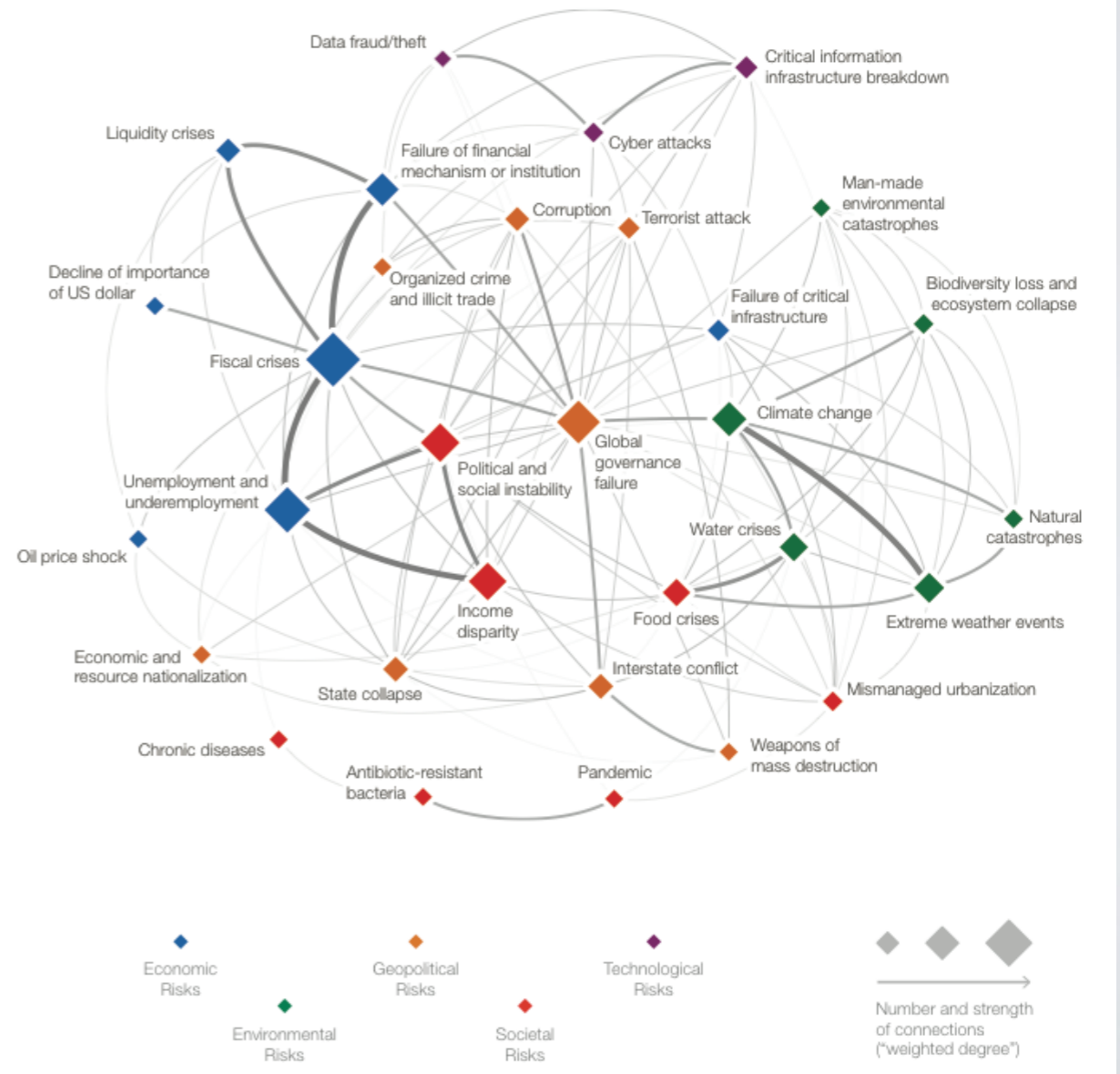
WEF, 2011, Risk in Focus



Source World I

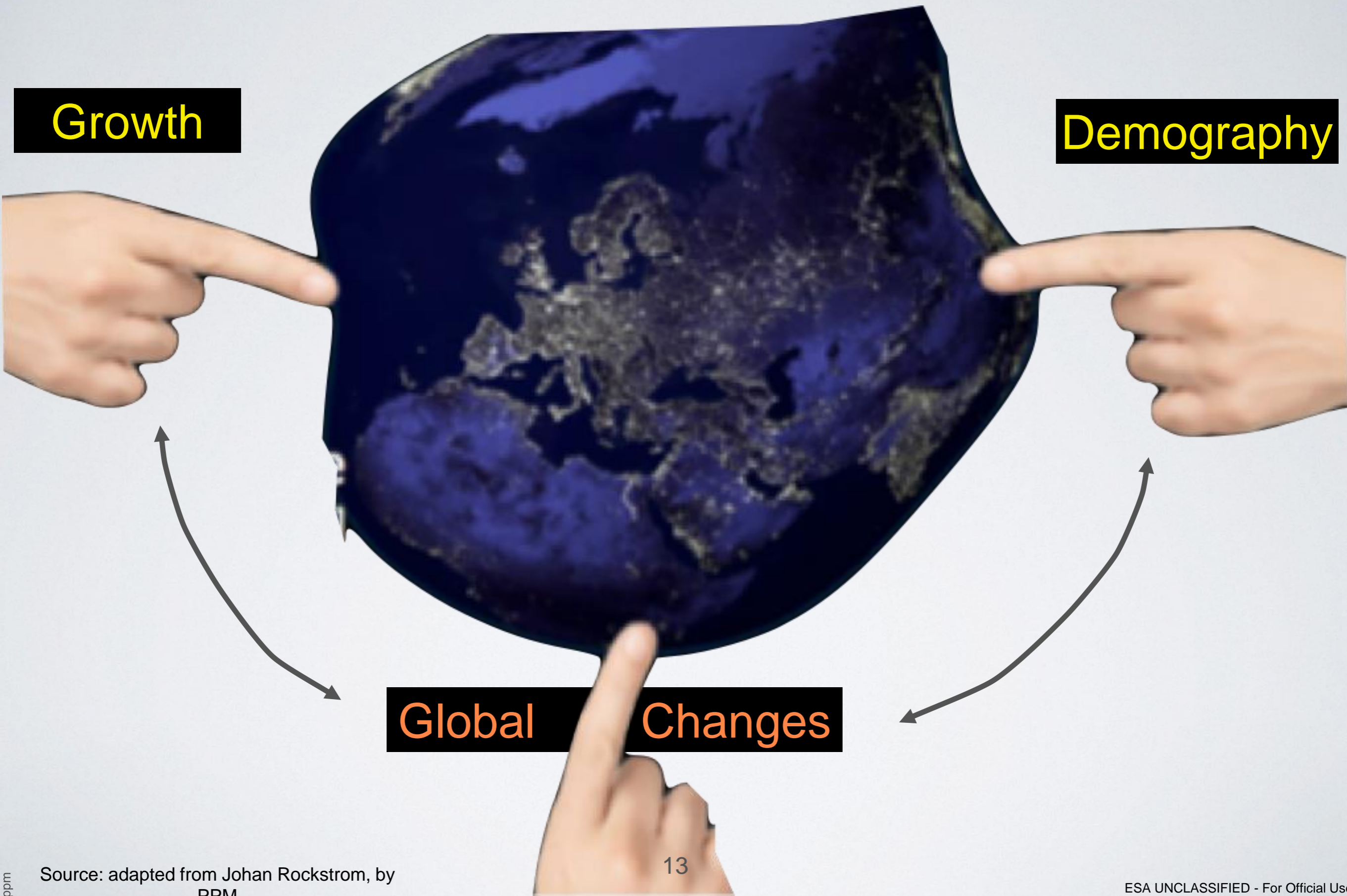
WEF, 2014, Risk in Focus

Figure 1.4: The Global Risks 2014 Interconnections Map

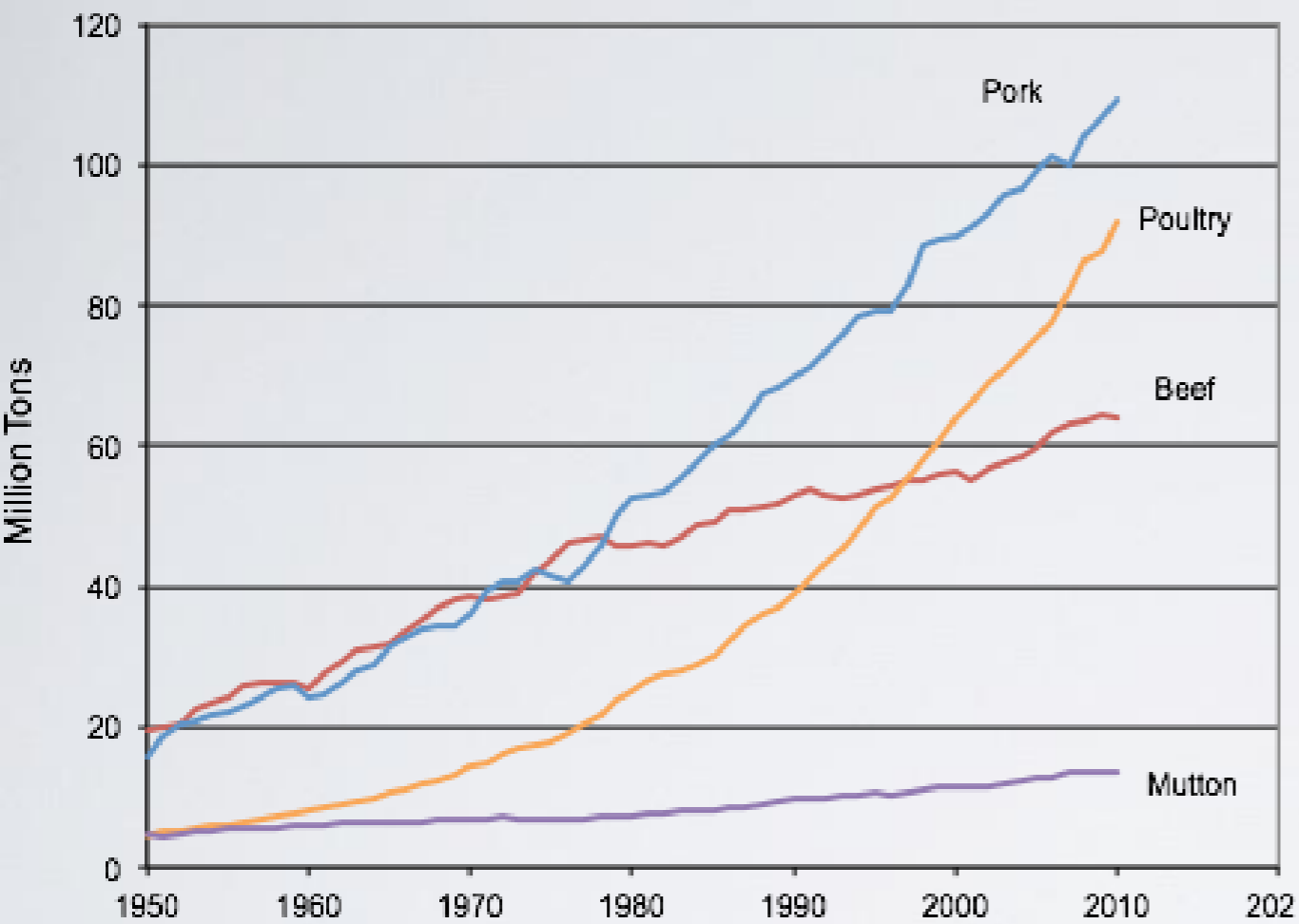


More crowded ...

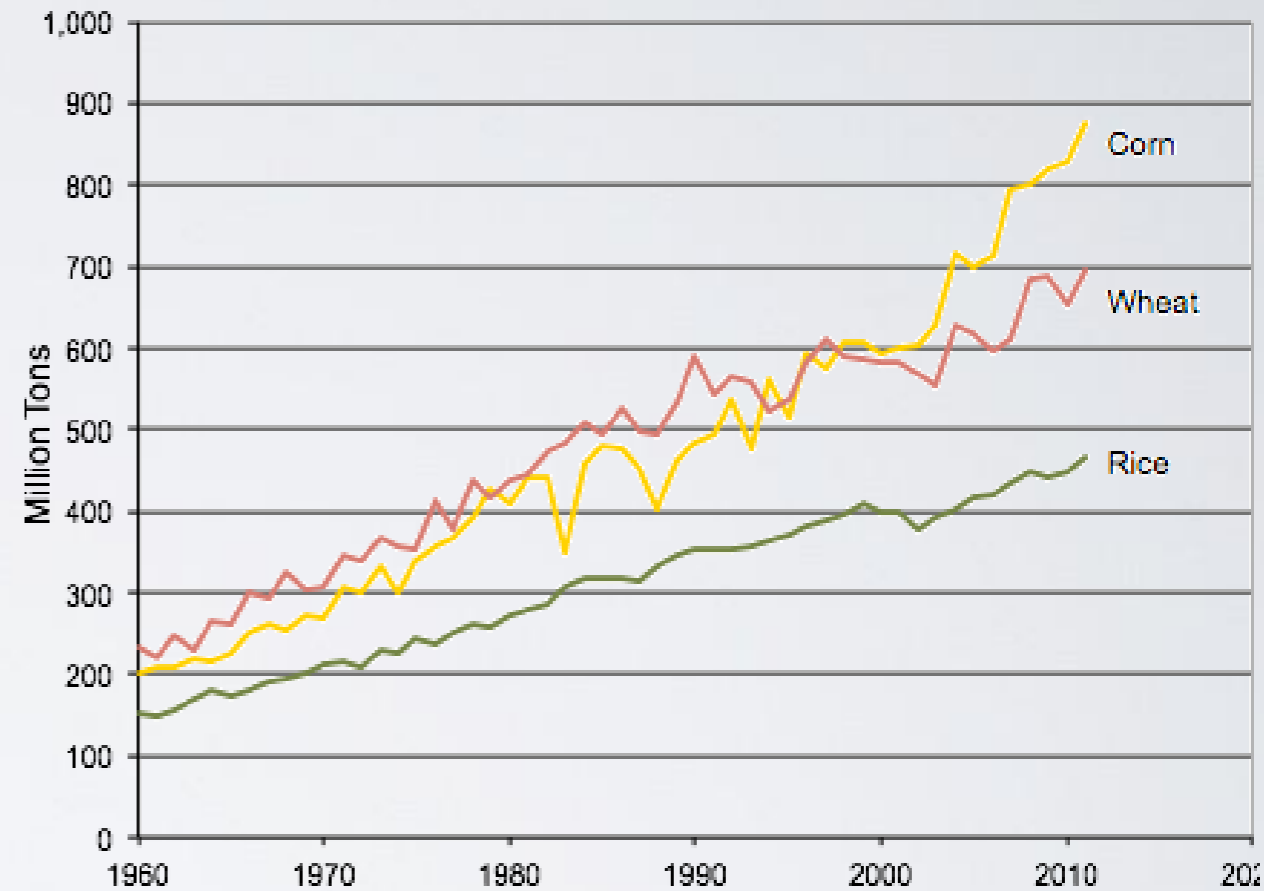
More Pressure ..



World Meat Production by Type, 1950-2010

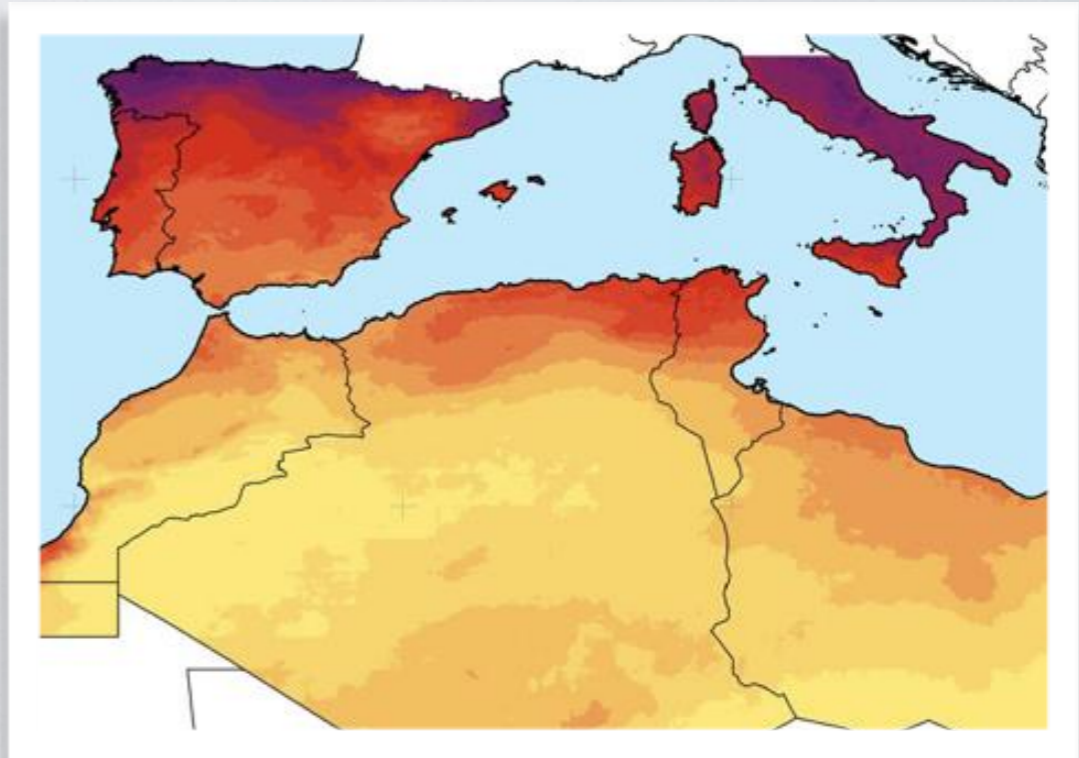
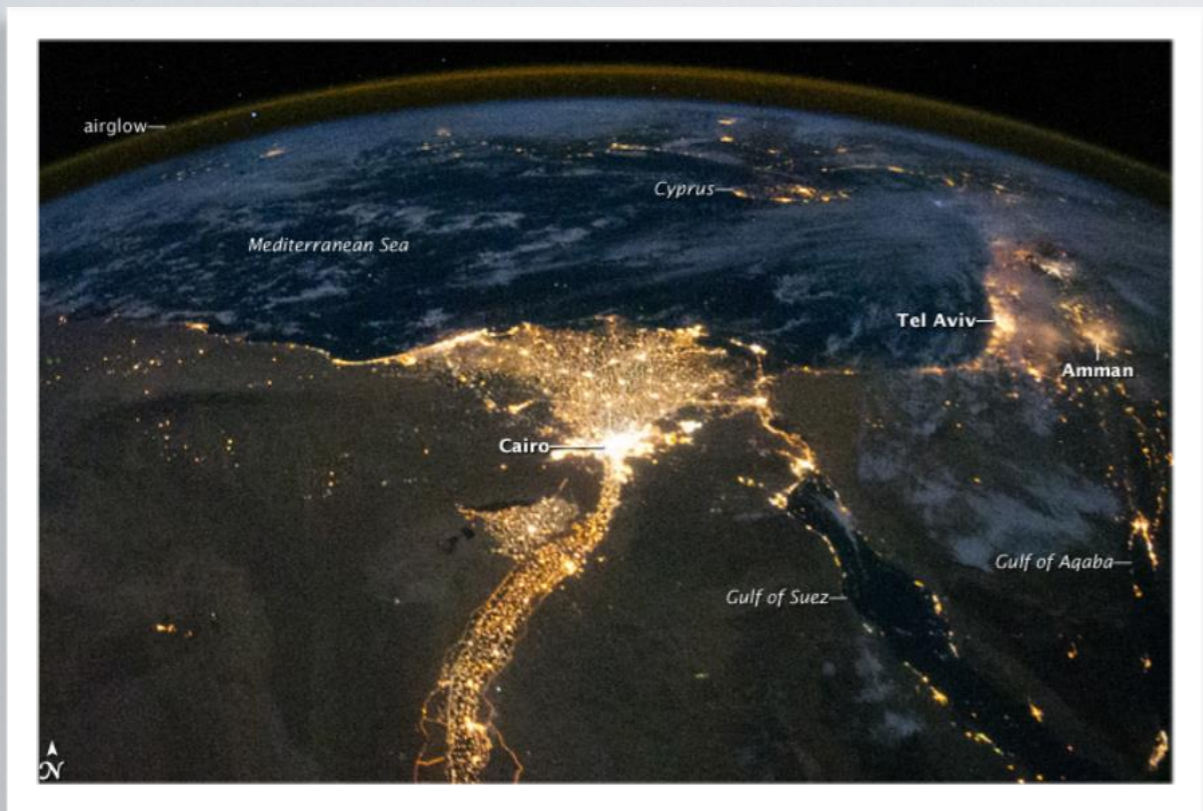


World Corn, Wheat, and Rice Production, 1960-2011



Changing Lifestyle & Consumption. Towards Western World Diet.

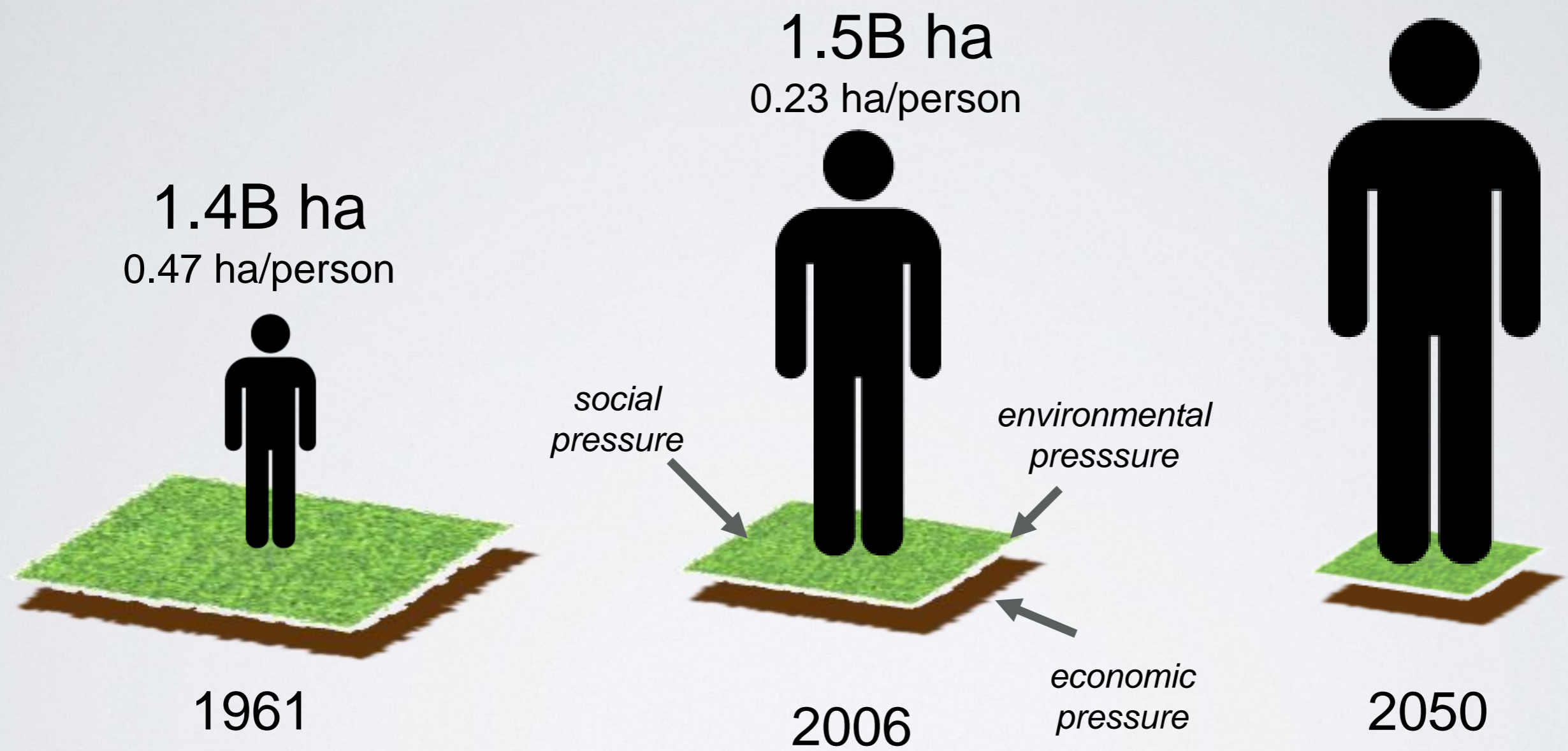
More Energy Demanding



Nicholas Stern The state of the climate — and what we might do about it

<p>50% The annual global energy demand has increased over the past 25 years</p>	<p>80% Energy demand met through fossil fuels today</p>	<p>40% The amount annual global energy demand could increase over the next 20 years</p>
--	--	--

ESA D



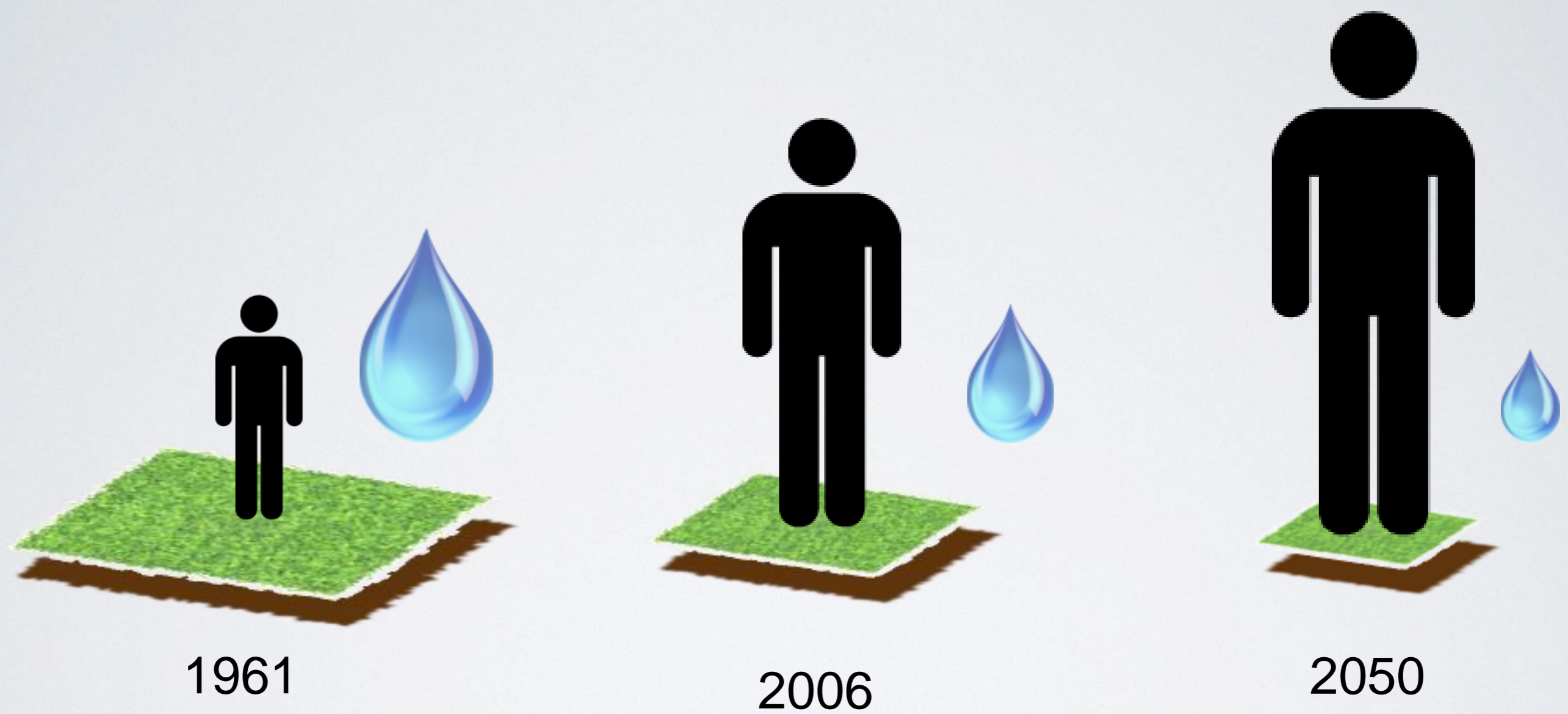
Majority of our **food** coming from 37% of our land

Image: Francesca Cecinatii, 2013

Source: Information Please® Database, 2007 Pearson Education, Inc.;

FAO, 2011, The state of the world's land and water resources for food and agriculture (SOLAW)

Water: 97% saline, 2% freshwater (ice), 1% drinkable



70% of water used for Irrigation (agriculture),
20% industrial production

Image: Francesca Cecinatii, 2013

Source: Information Please® Database, 2007 Pearson Education, Inc.;

FAO, 2011, The state of the world's land and water resources for food and agriculture (SOLAW)

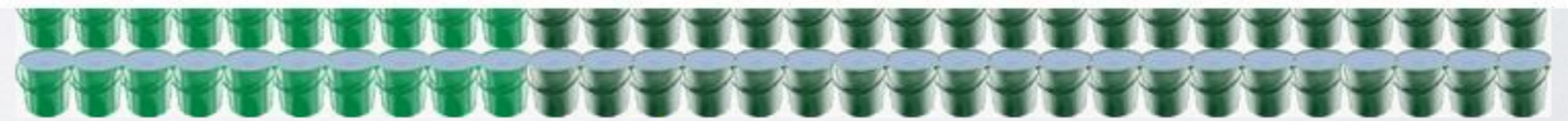
But we need much more water for food!



And we need water for energy!



3500 liters



1200 liters vegetarian 2300 liters meat

ne



Food security issues are water issues

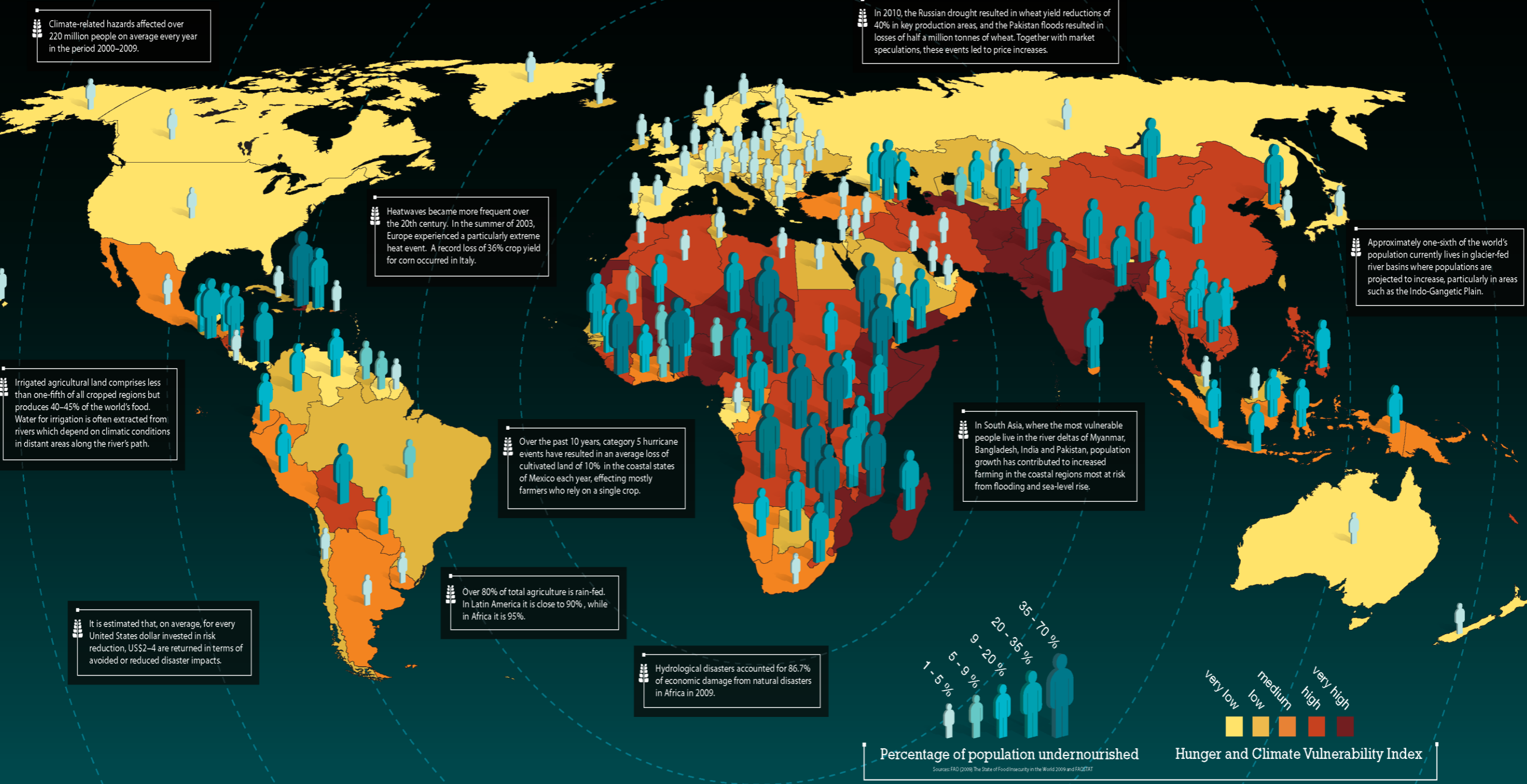
kg of ...?

maize: 900 l

beef: 16 000 l



Food insecurity and climate change



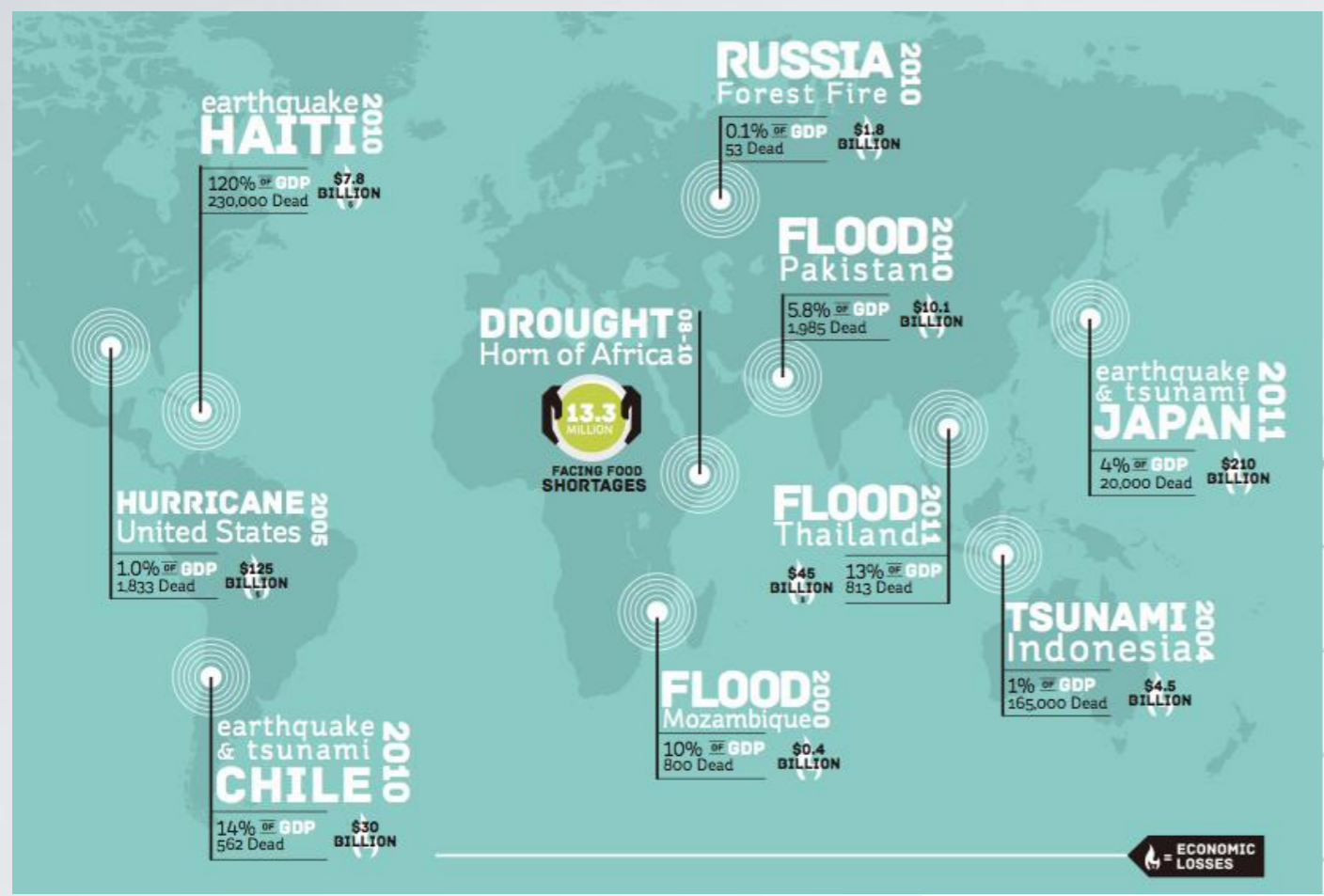


Source: Alessandro Grassani, LUZphoto http://www.luzphoto.com/story.php?titolo=bangladesh_grassani

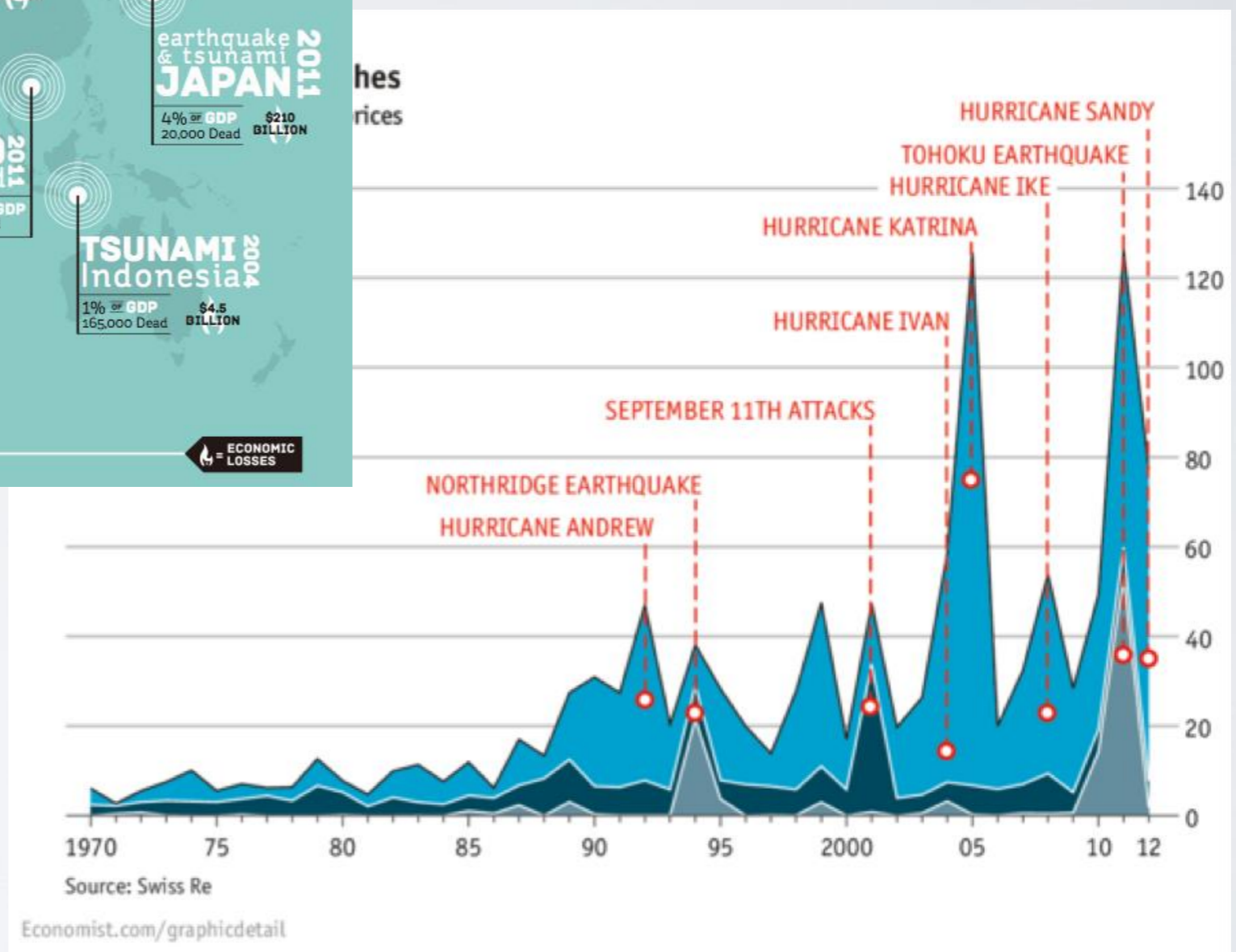
Source Study: <http://www.bis.gov.uk/assets/foresight/docs/migration/11-1116-migration-and-global-environmental-change>

Source Data: International Immigration Organisation

Disasters affecting everyone



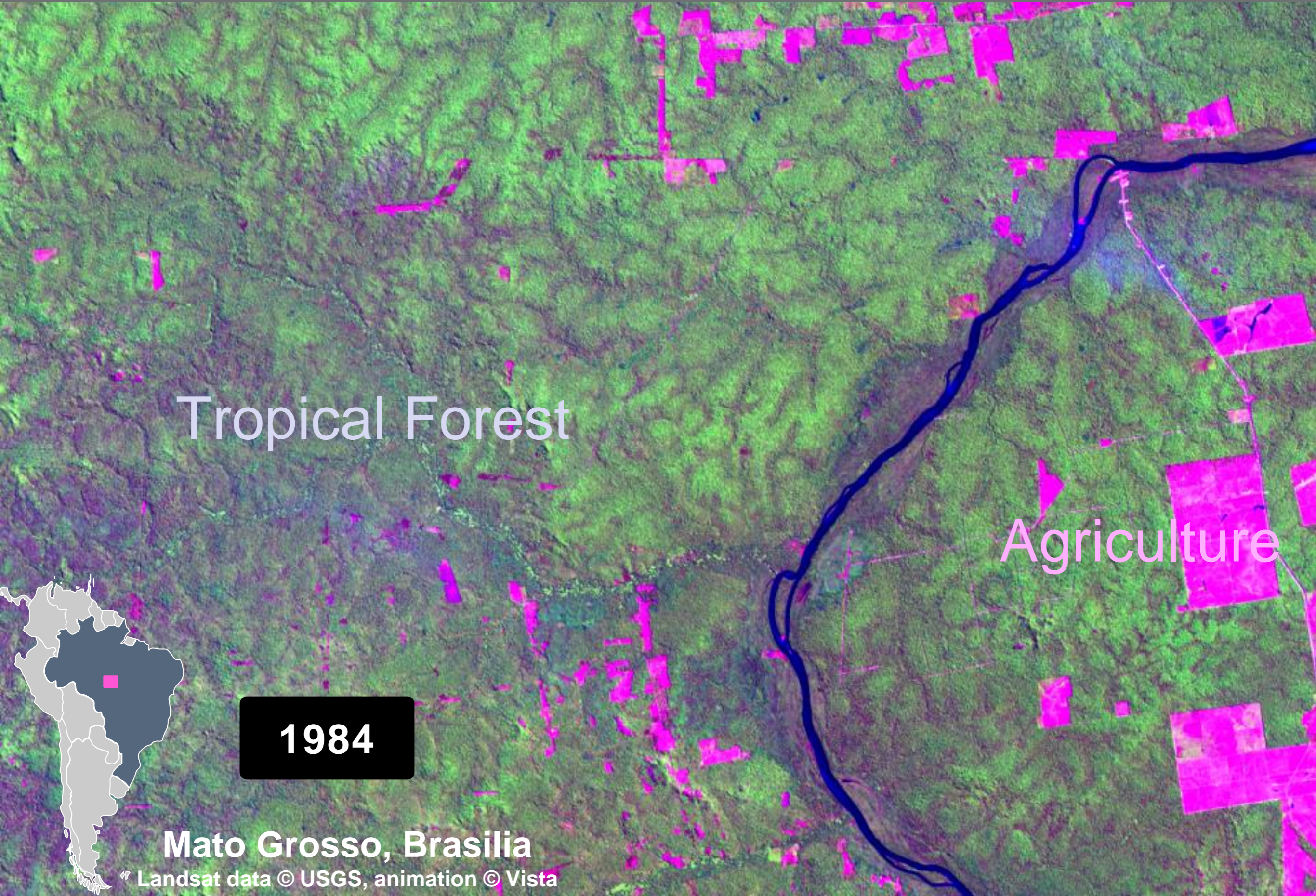
but they impact mostly the poor and vulnerable ...



If improved EO-based information and warnings could lead to a few % reduction in insured losses, this would be worth \$B to the global insurance industry.

***More Pressure on
limited natural
resources ...***

Human Footprint of Agriculture ...



Tropical Forest

Agriculture

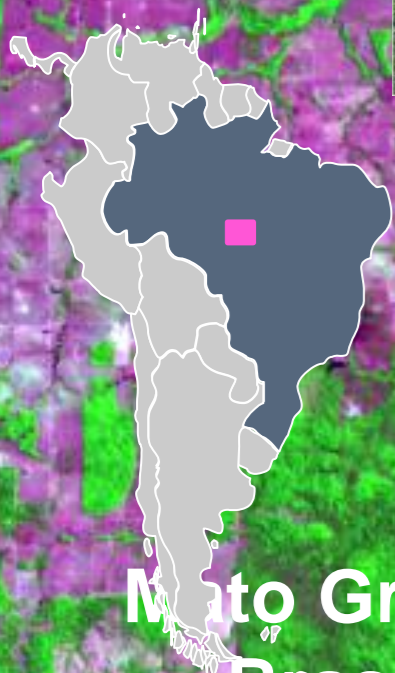
1984

Mato Grosso, Brasilia

Landsat data © USGS, animation © Vista

Human Footprint of Agriculture

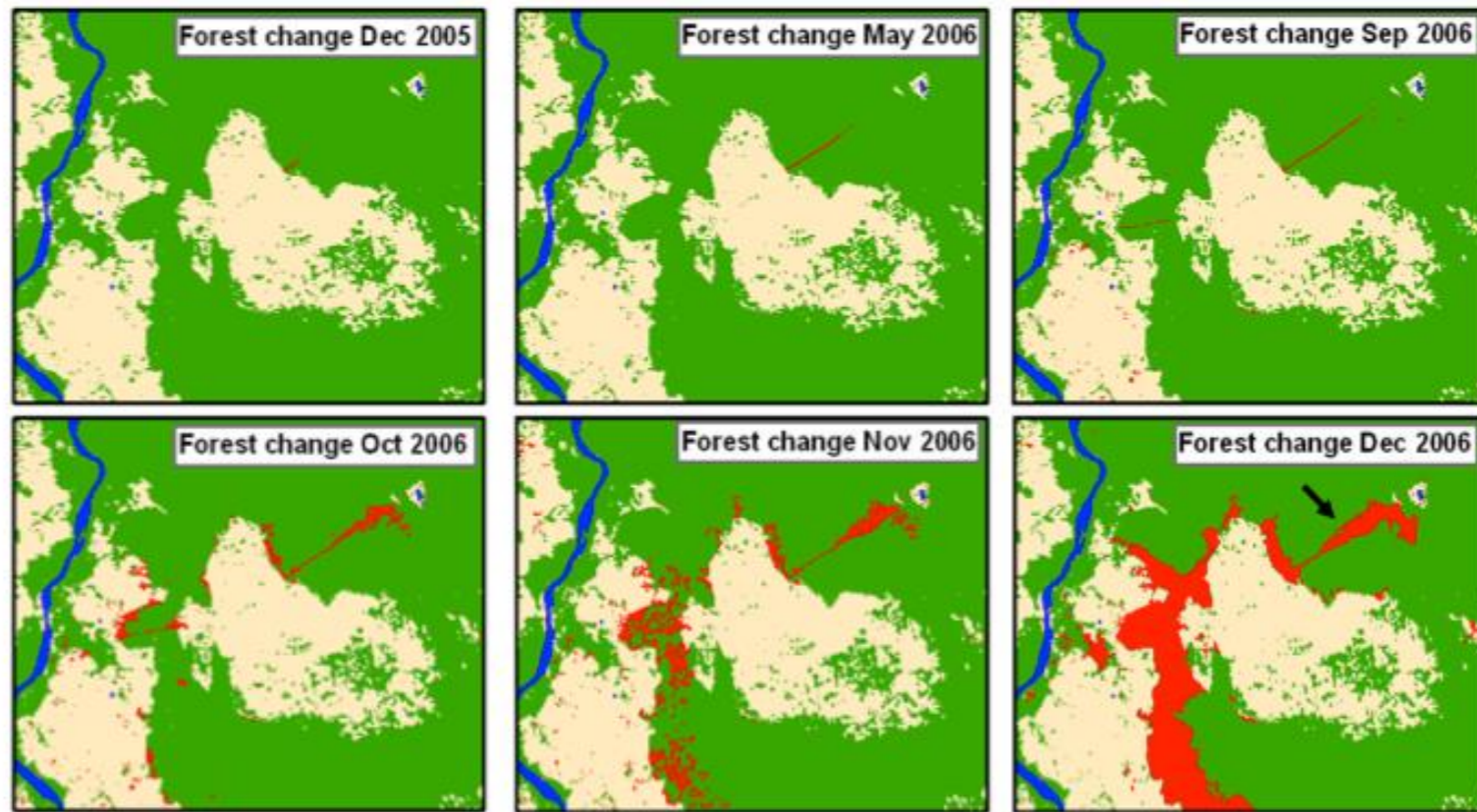
*“Already, we have cleared or converted more than **35 percent of the earth’s ice-free land surface for agriculture**, whether for croplands, pastures or rangelands.... Since the last ice age, nothing has been more disruptive to the planet’s ecosystems than agriculture.” Jonathan Foley, Uni Minnesota*



2011

LIBYA'S AL JAWF OASIS

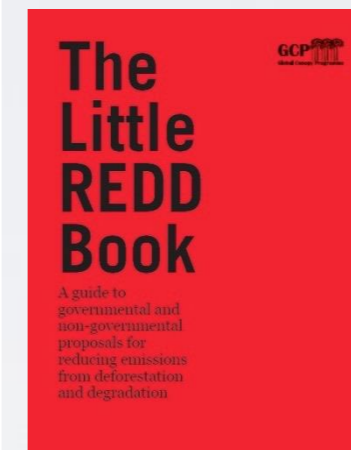




Dense ASAR time series in Borneo © Sarvision, Wageningen University

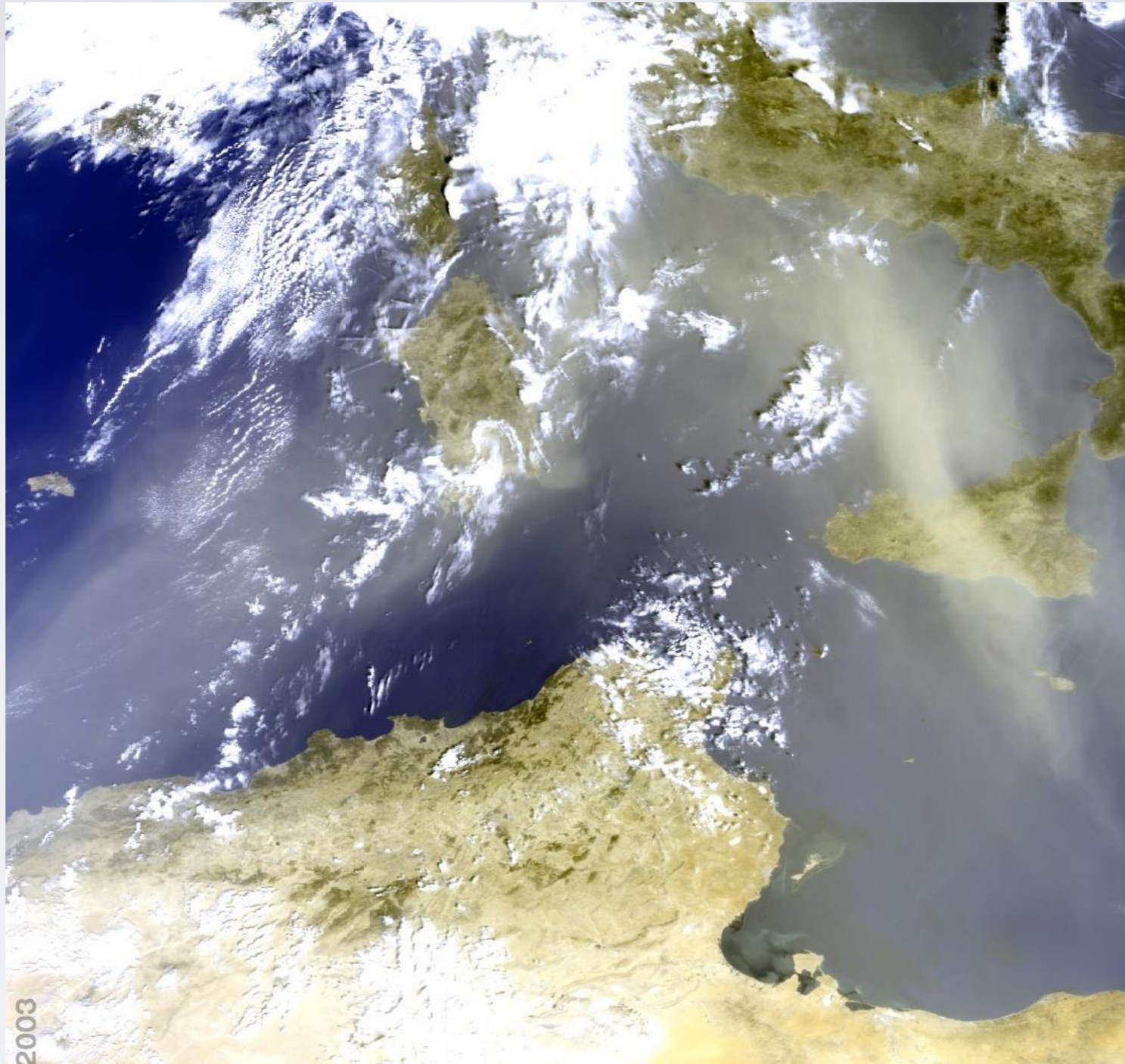


Certification of Sustainable Forest Management Practices

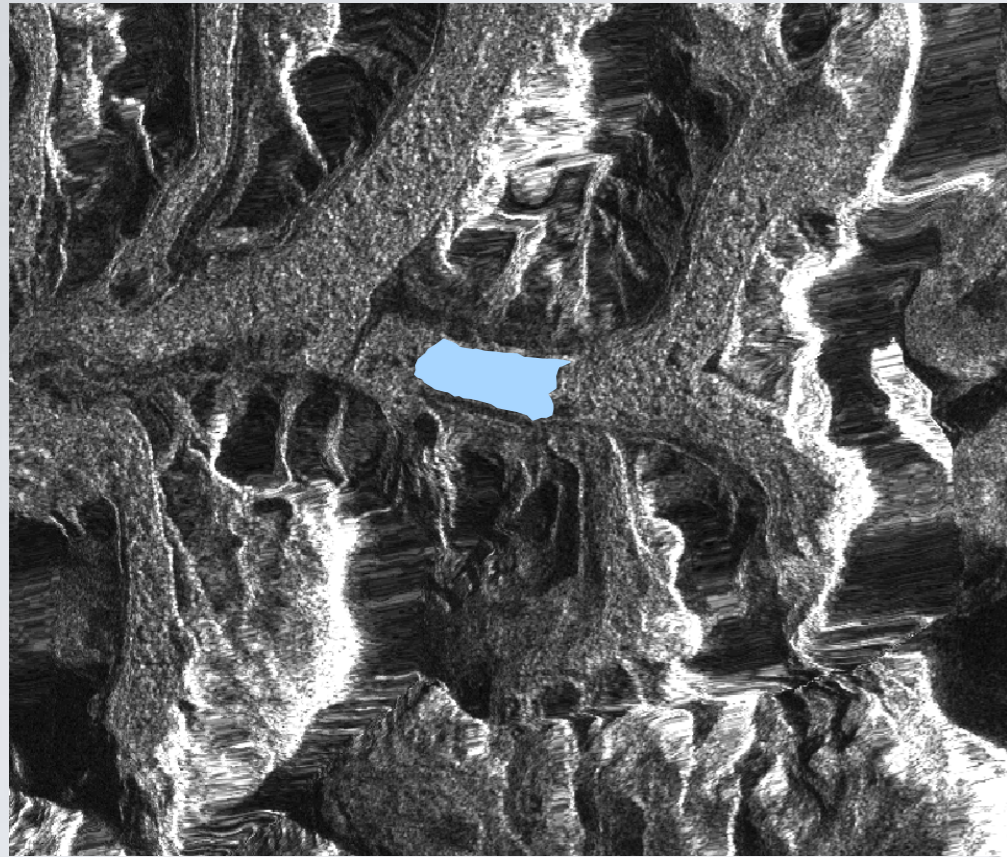


Reducing Emissions from Deforestation & Forest Degradation (UN-REDD+)

60% decline in species, large-scale deforestation (e.g. rate of deforestation of 13 Mha/yr. one stadium every 3 sec). Reasons: Timber, Agriculture, Energy. Issue of illegal logging, REDD.



Over- plowing & Over-grazing in parts of Africa, Asia, and the Middle East, transform productive cropland is turning into wasteland, and topsoil into dust. Emergence of new **Dust Bowls** (e.g. China, Sahel) and transboundary storms.

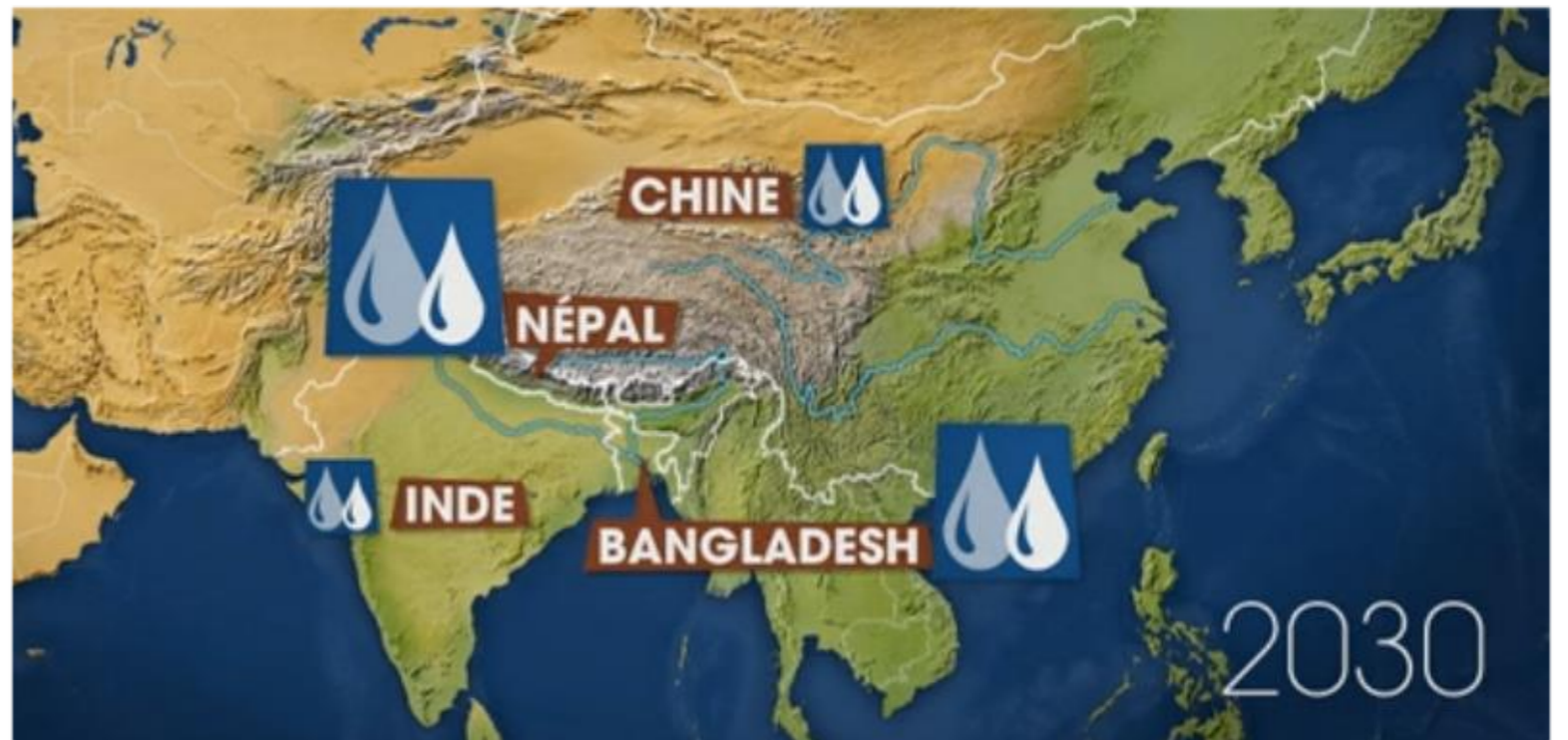


ENVISAT ASAR 09 Mar 2007 Lake Imia, Nepal

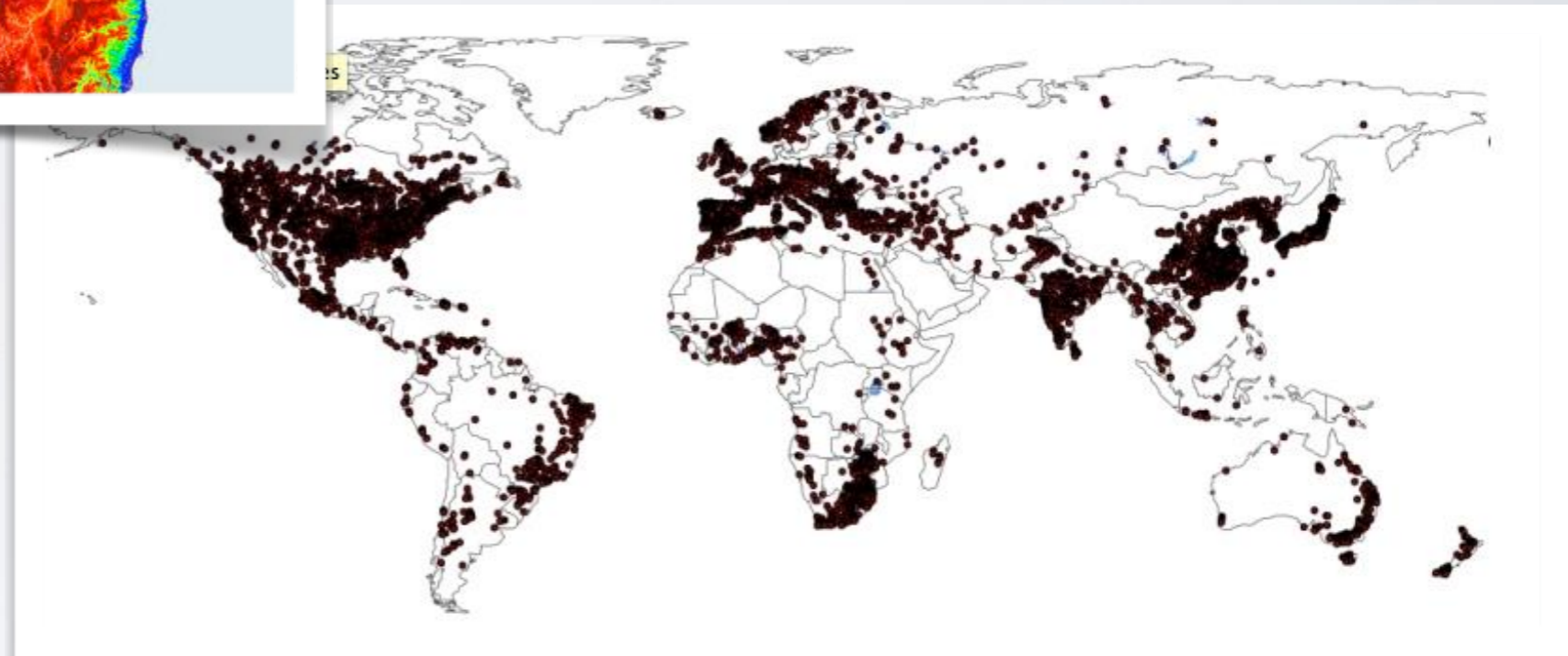
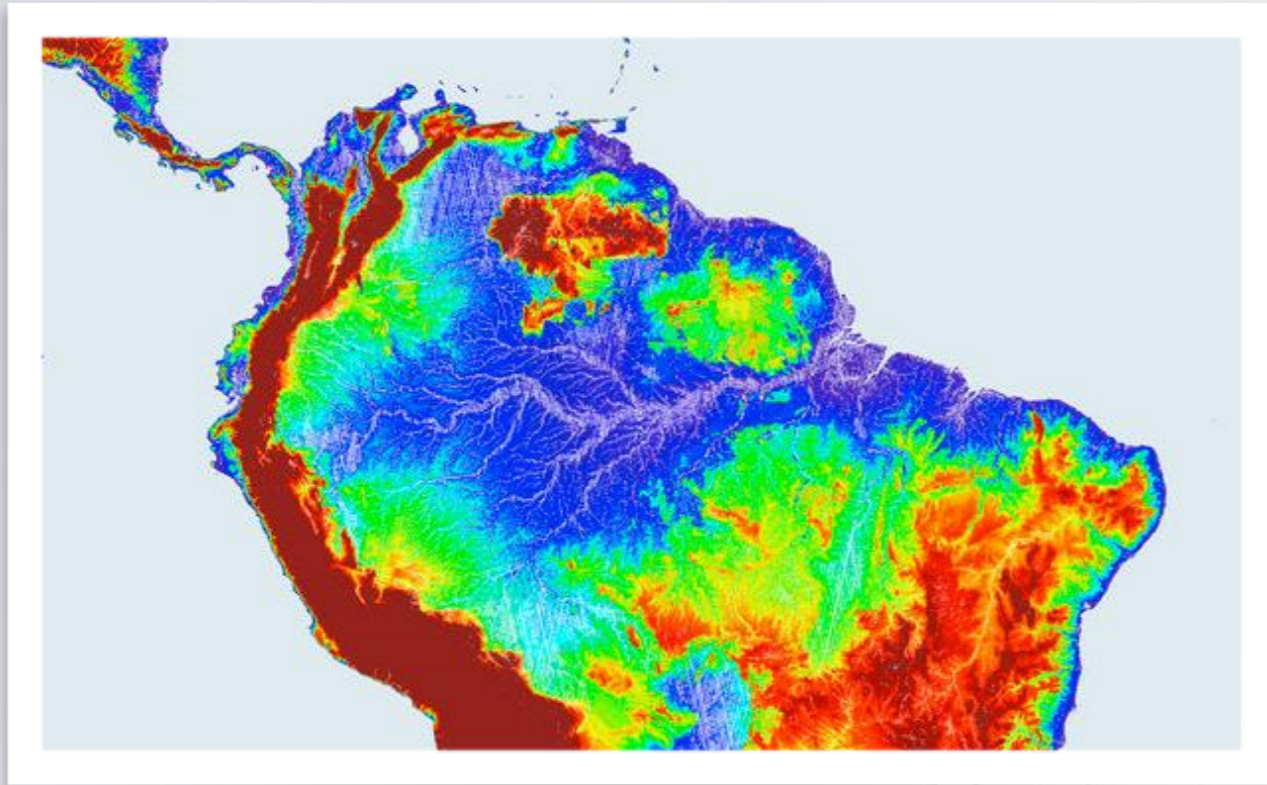


ESA GSE service on “Glacial Lake Outburst” delivered to “International Centre for Integrated Mountain Development” (ICMOD).

Himalayan glaciers alone store water used by more than a billion people. Scientists measure the volume of glaciers in “mm SLE” - the amount that sea levels would rise if the ice melted. ESA CCI Glacier Inventory in support of IPCC, also important to understand available water resources in Asia.



Estimated decrease of Water Availability in 2030



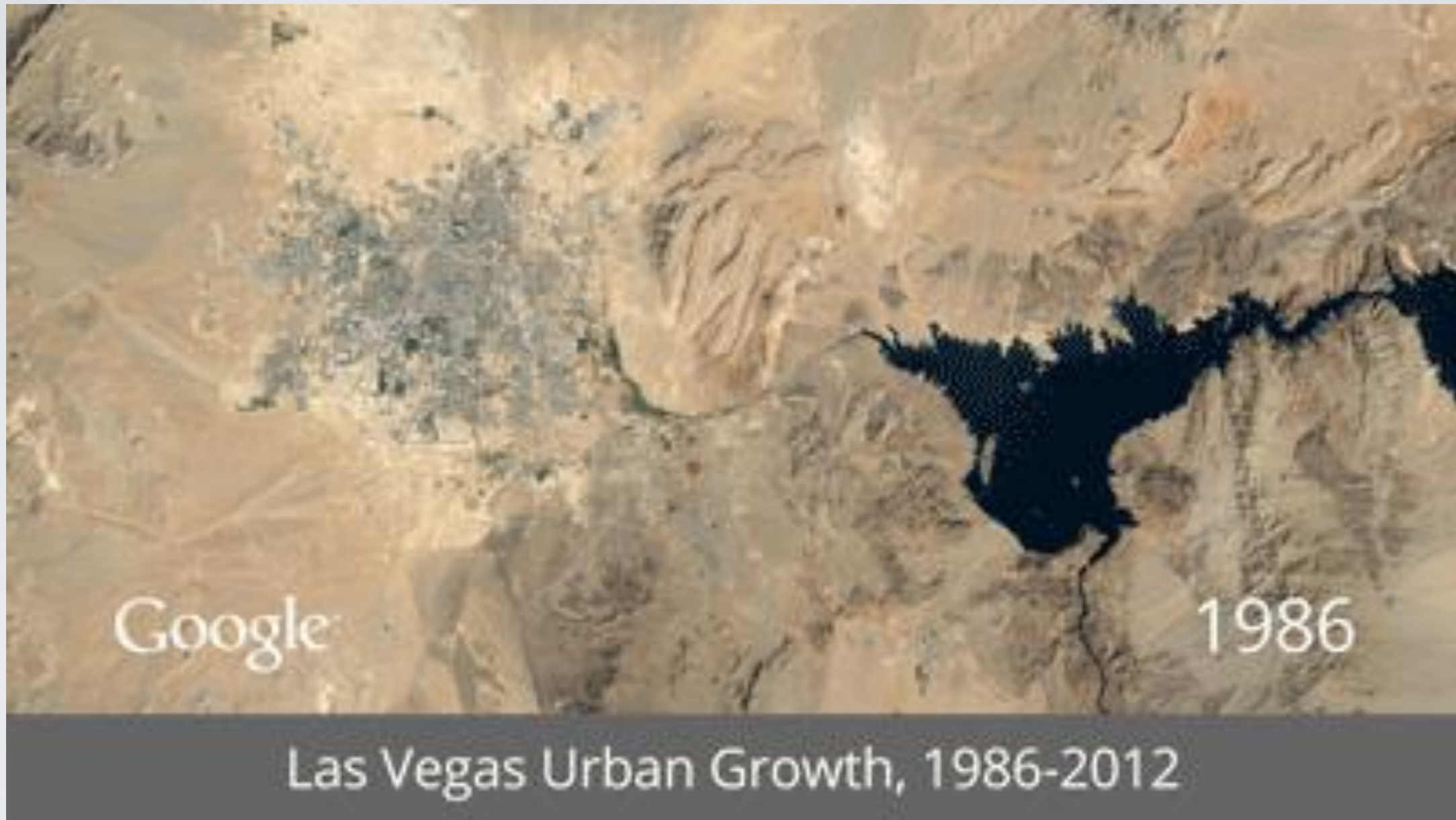
Rivers are the **arteries** of the water cycle, and significantly affected by man made activities, such as **dams** and **irrigation**.

Aquifers depletion as seen from space



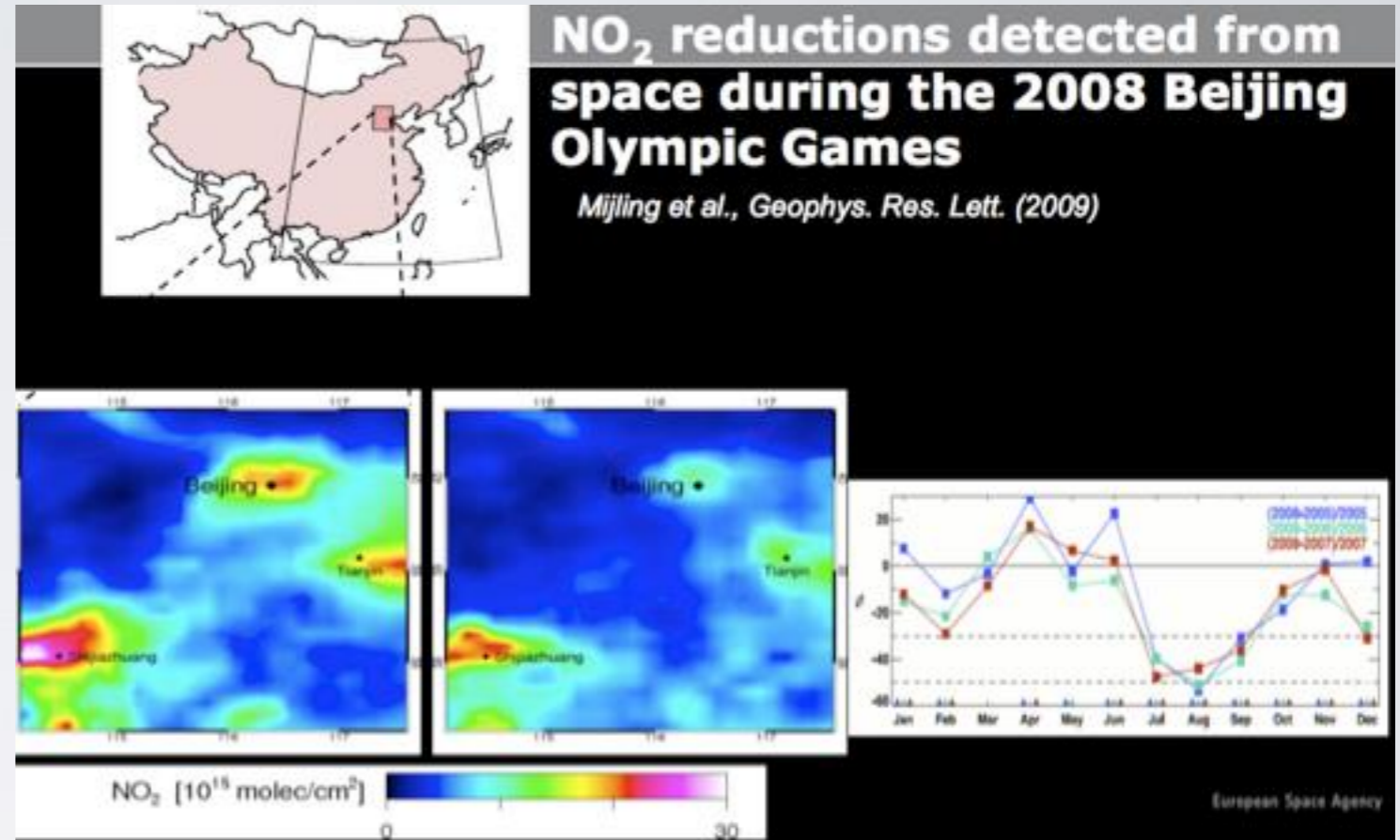
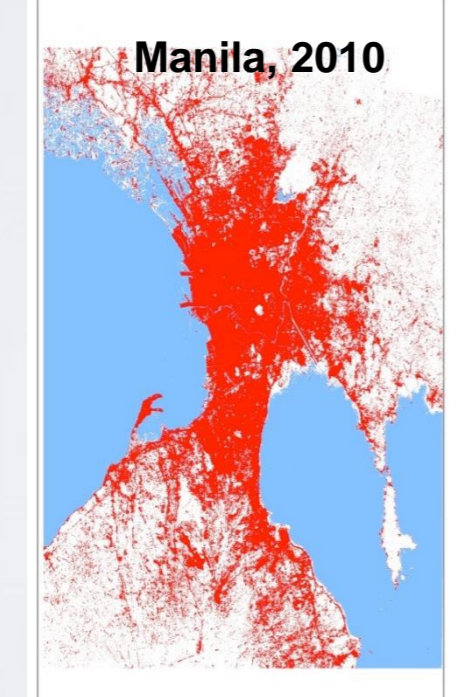
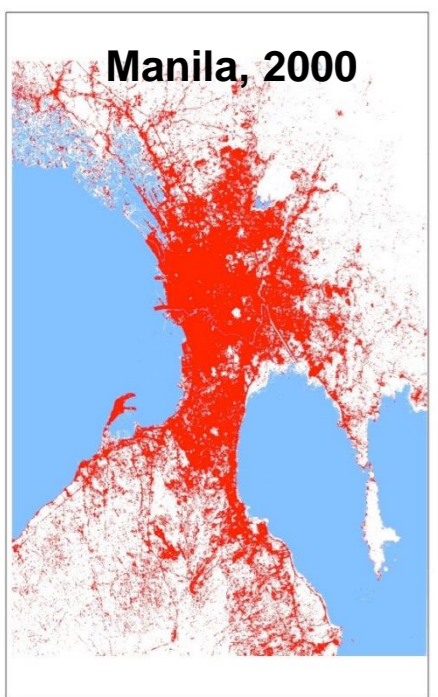
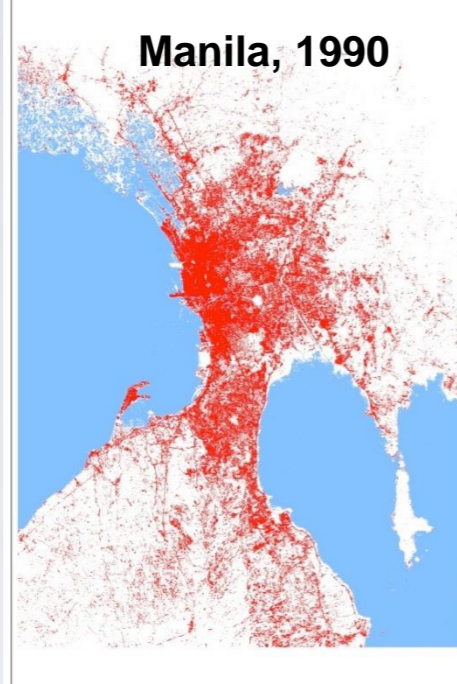
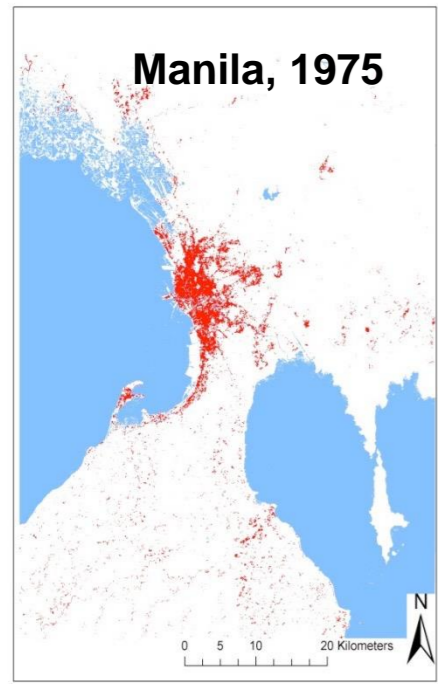
Gravity measurements from GRACE highlighting that, **water tables** have fallen in various countries, including China, India, and the United States, which together produce nearly half of the world's grain.

More urban ...



Cities will hold most of projected increased in humanity over the next decades. **Migration** from Rural to Urban, with about **3M** people moving to cities every **week** in **developing** countries (UN-Habitat).

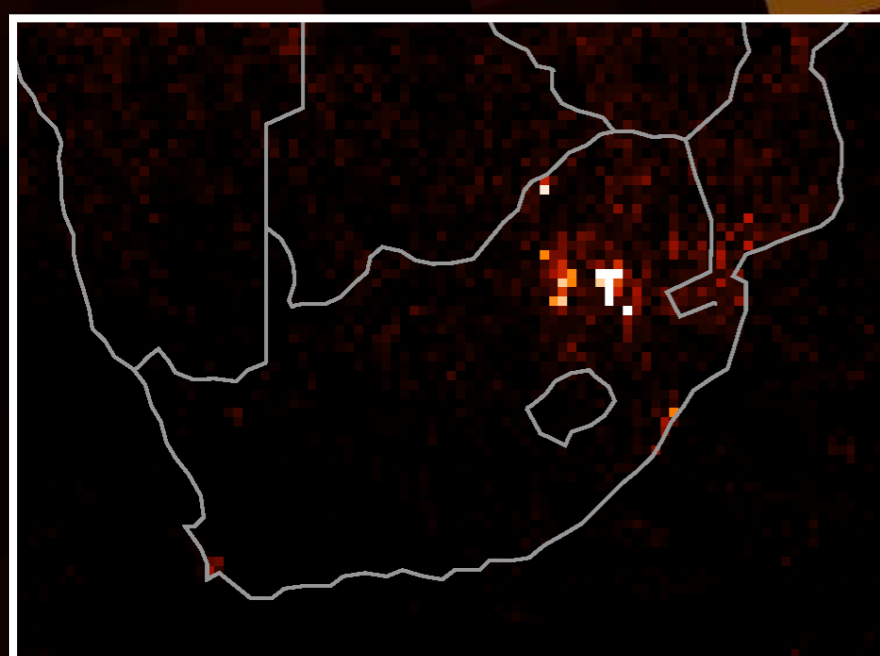
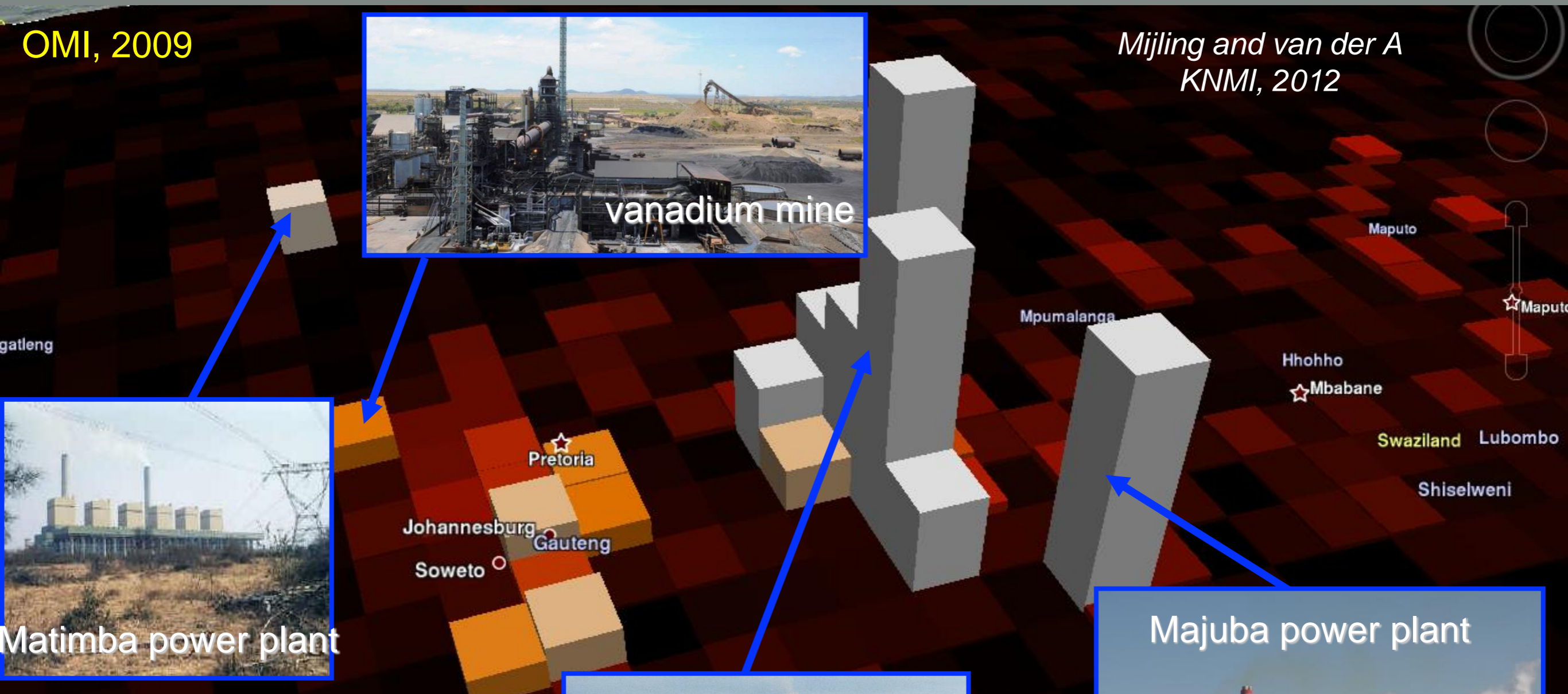
Mega-Cities, Mega-Pollution

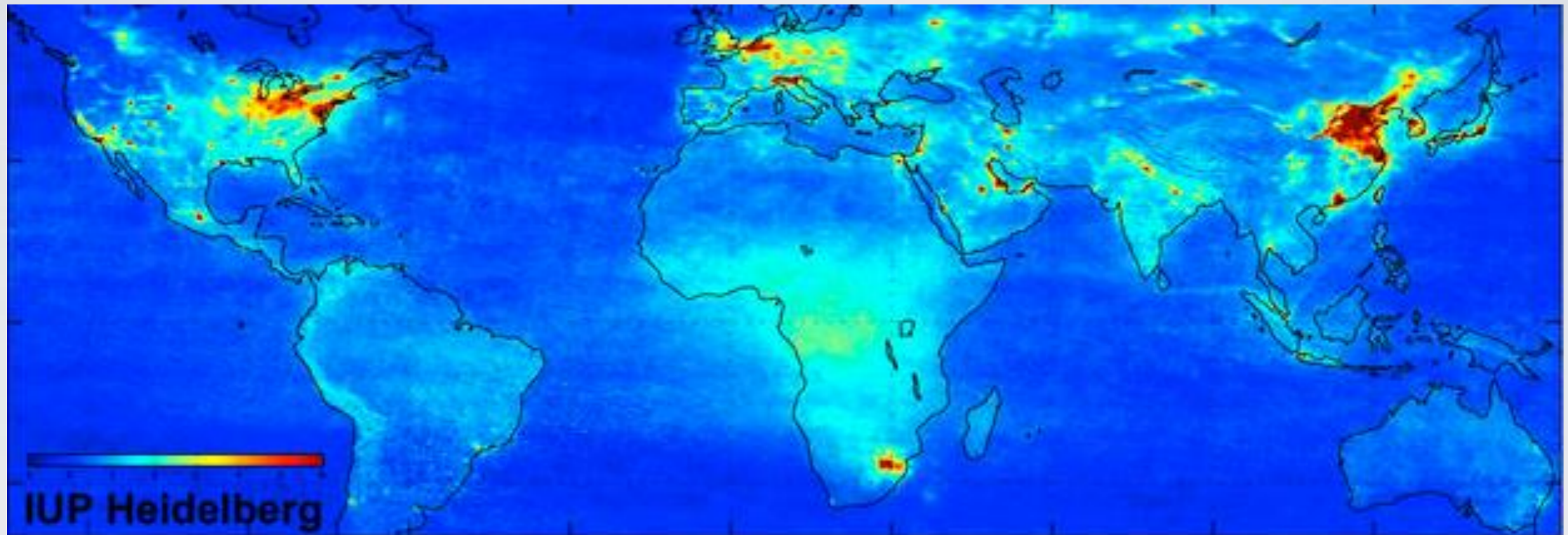


EO based NO₂ emissions South Africa

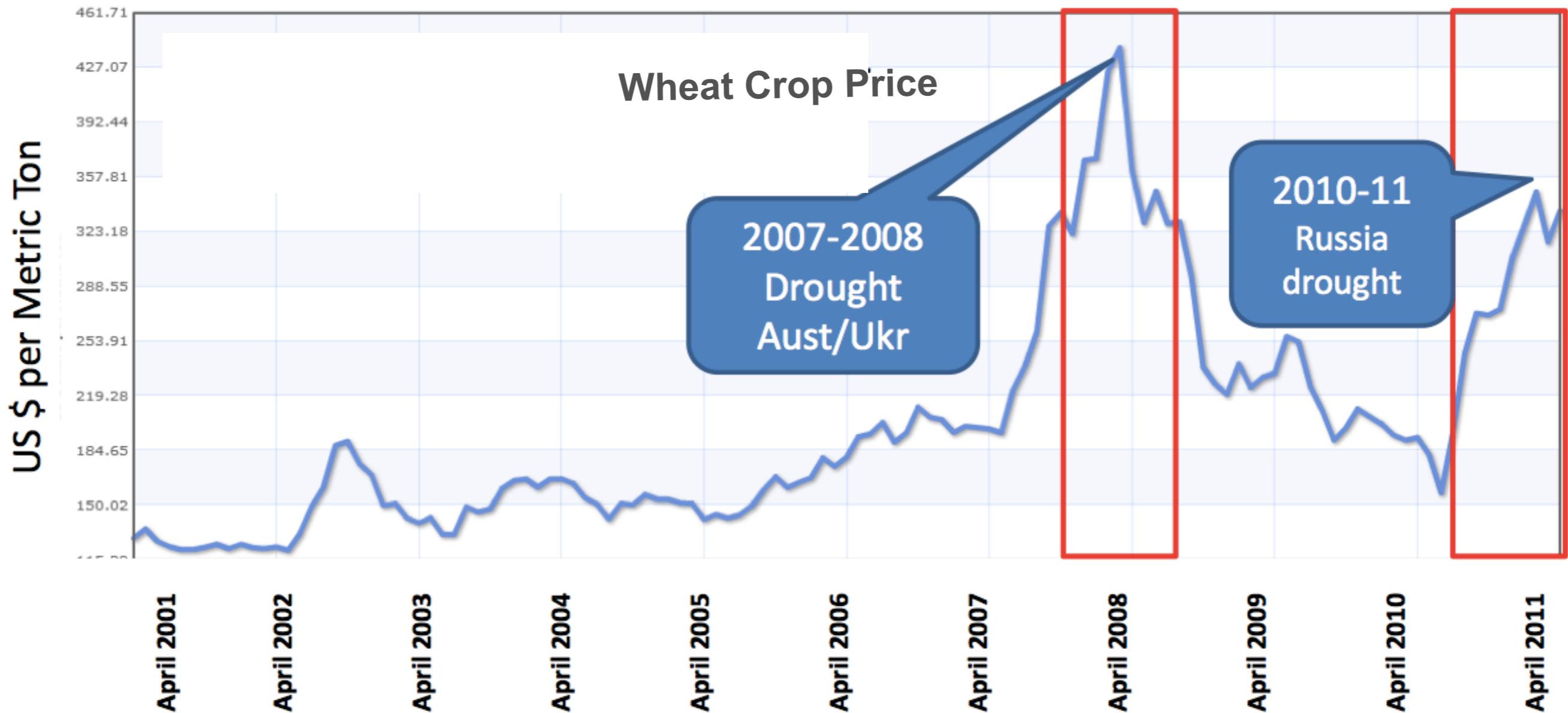
OMI, 2009

Mijling and van der A
KNMI, 2012

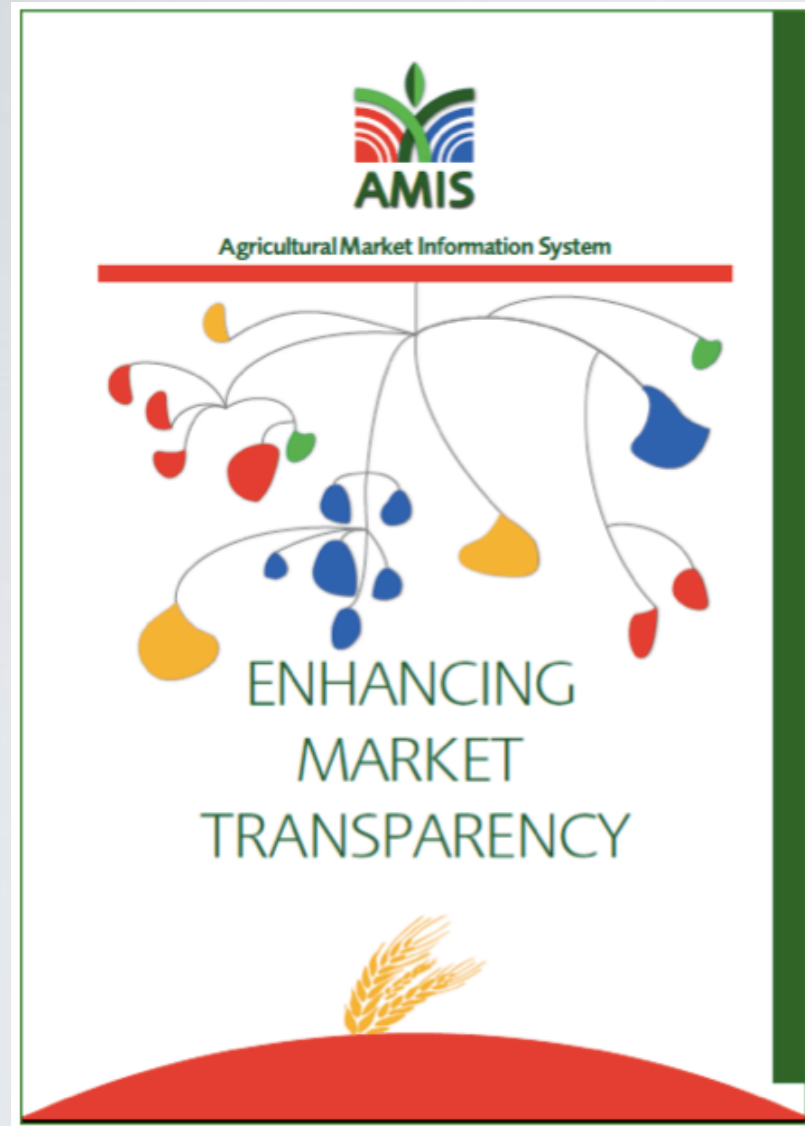




More volatile ...



Global food prices are increasingly **volatile** due to climate **extremes**, which alter global production patterns and exacerbate **hunger** in poorer countries. About **44M** people driven into **poverty** by rising food prices in the second half of 2010 (World Bank).

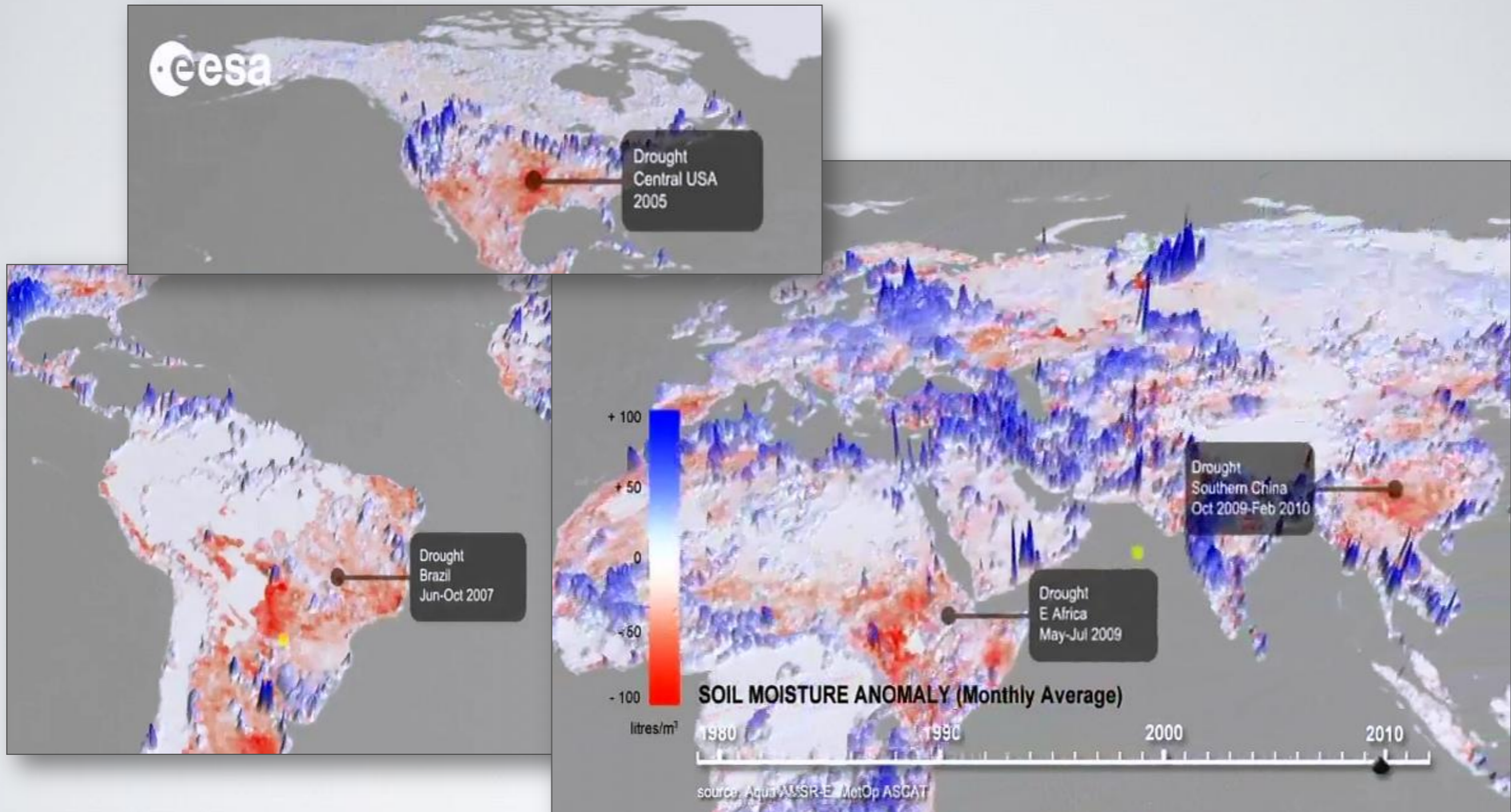


G20 Final Declaration

44. We commit to improve market information and transparency in order to make international markets for agricultural commodities more effective. To that end, we launched:

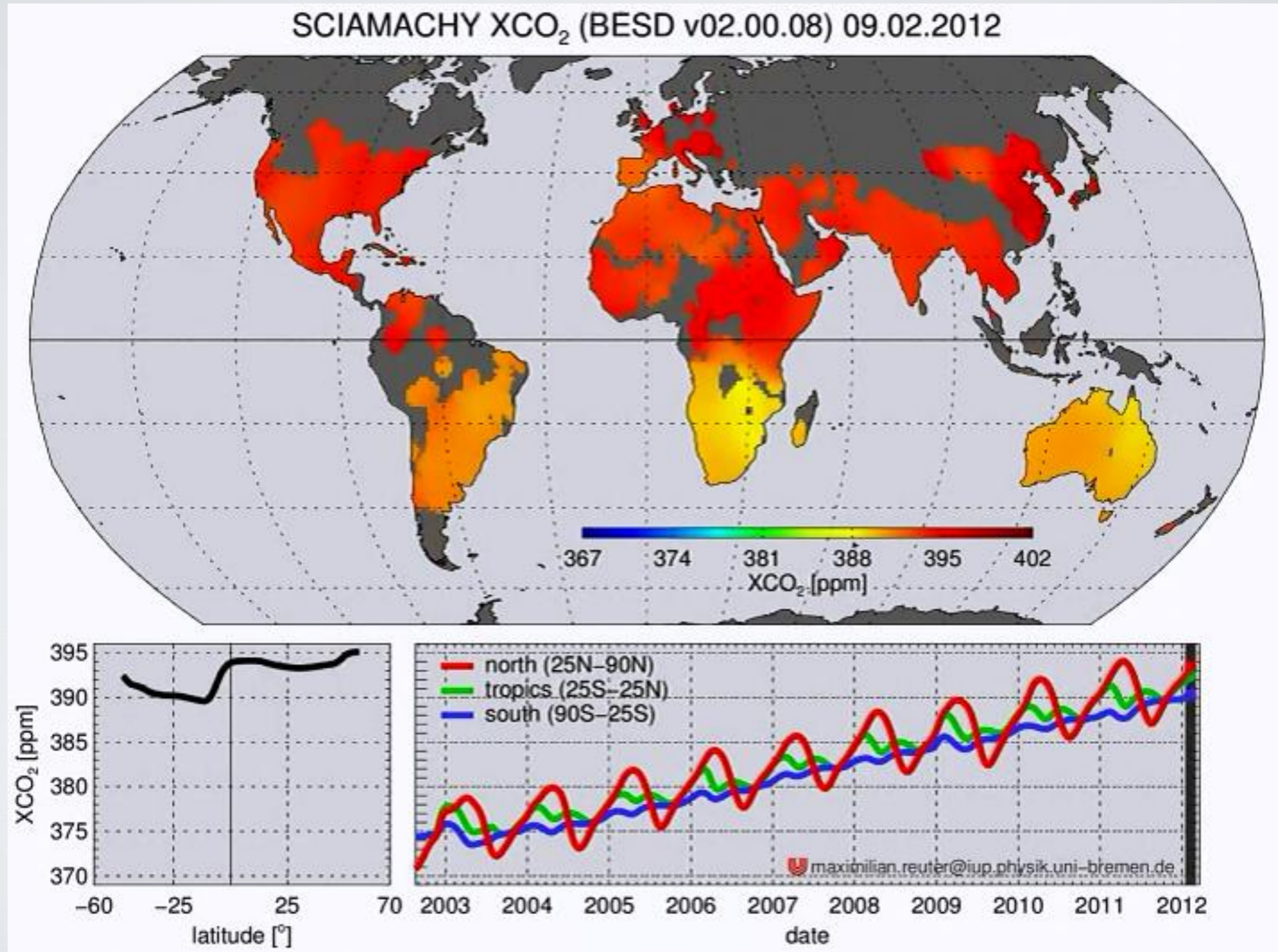
- The "Agricultural Market Information System" (AMIS) in Rome on September 15, 2011, to improve information on markets ...;
- The "**Global Agricultural Geo-monitoring Initiative**" (**GEO-GLAM**) in Geneva on September 22-23, 2011. This initiative will coordinate satellite monitoring observation systems in different regions of the world in order to enhance crop production projections and weather forecasting data.

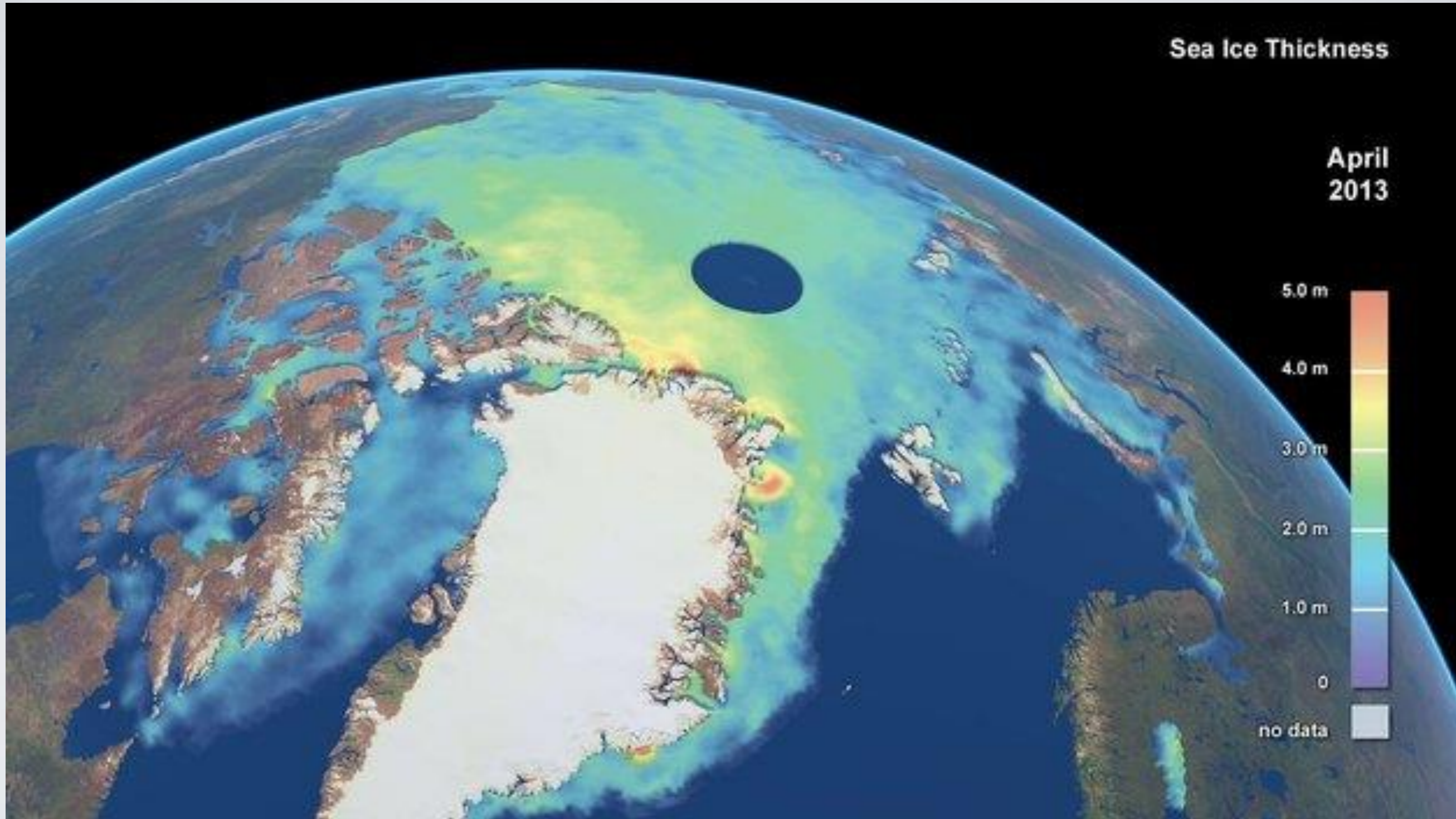
Global Framework for monitoring of agriculture and limit volatility.
EO from space has a key role to play. ESA is developing EO products to quantify food insecurity risks.



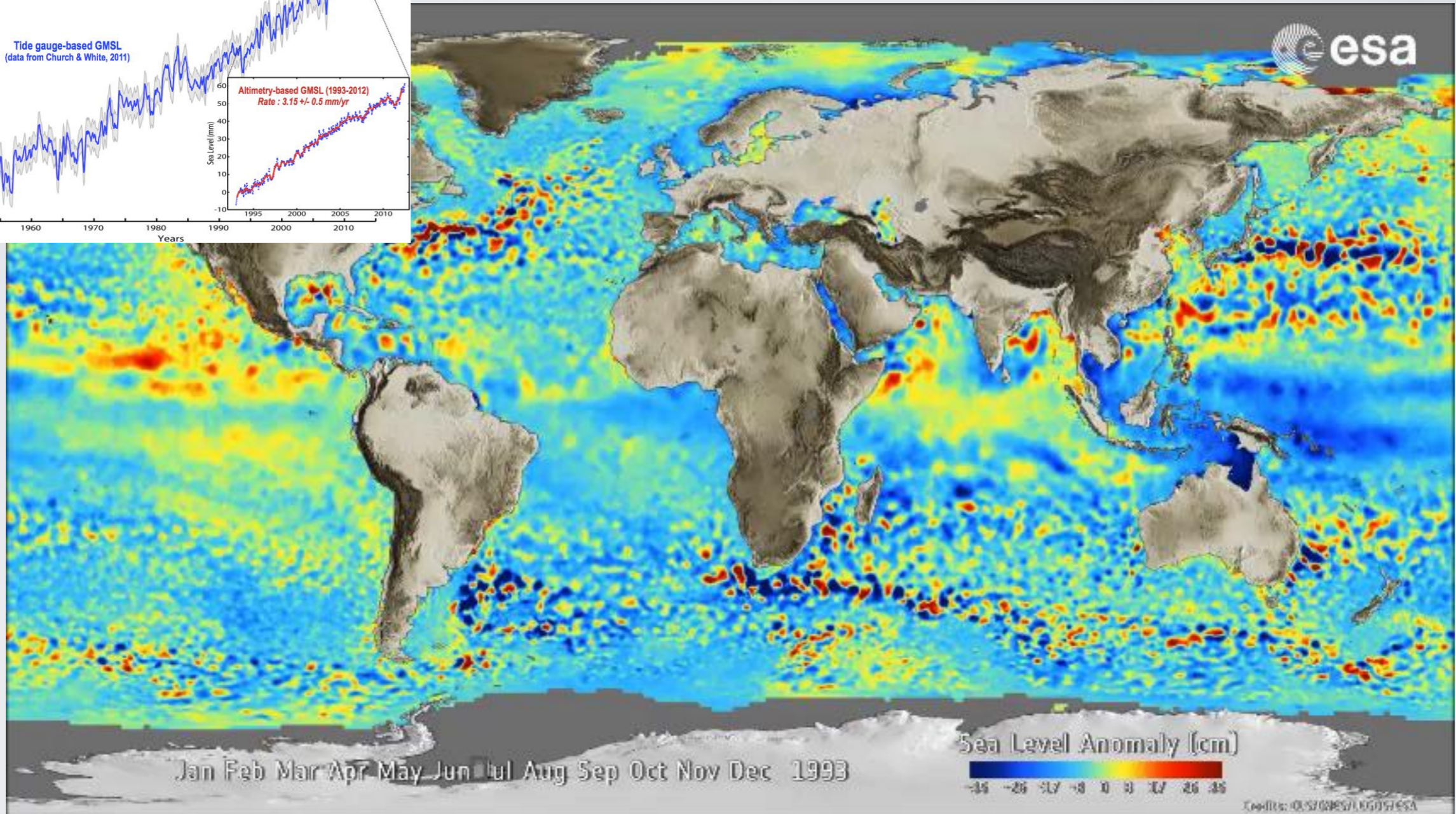
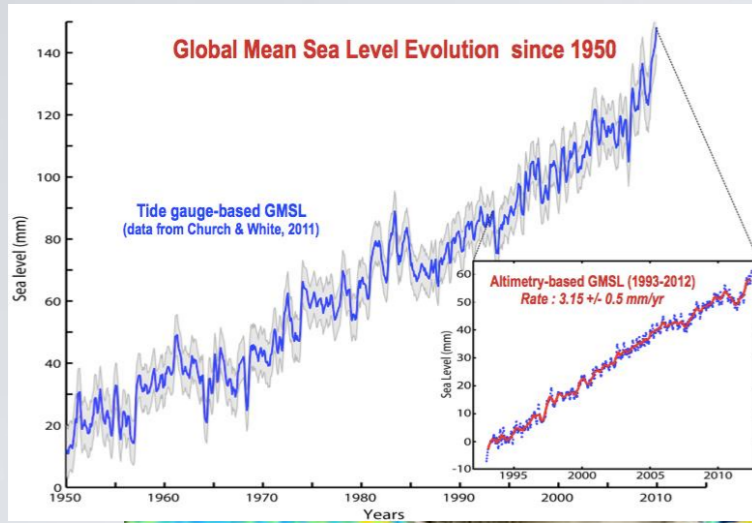
Improved Soil Moisture monitoring from space enables identification of **dry** conditions to support appropriate **actions** to avoid **food insecurity**.

***Warmer world,
Oceans rising high,
Turning sour ...***





Global Sea Level Rise from altimetry



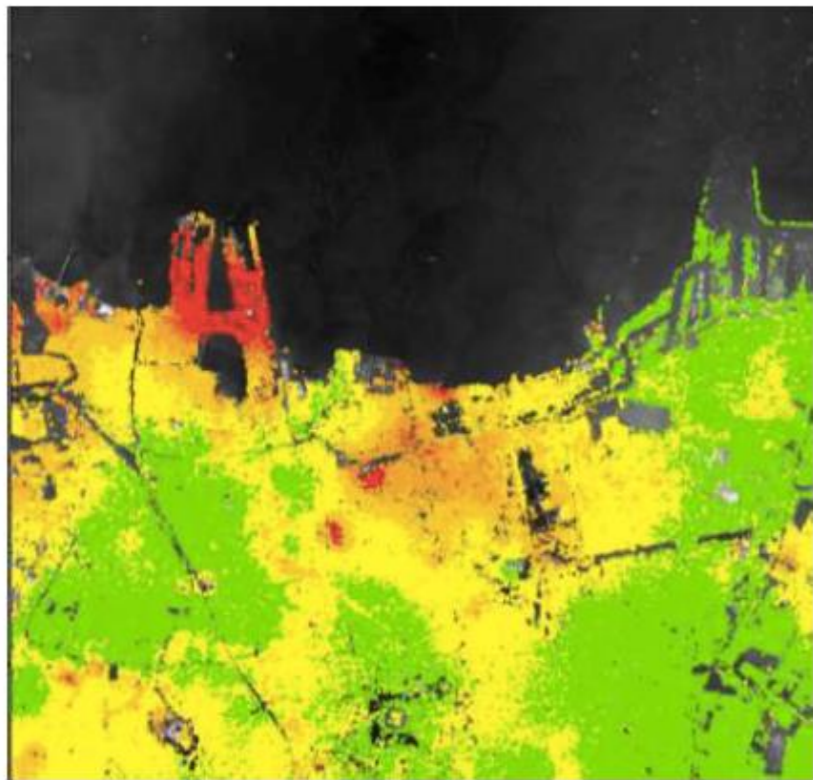


Figure (left): The map of subsidence derived from the analysis of ALOS PALSAR data (2007-2011). Credit: EOWorld project/Altamira Information, 2011 for ESA, World Bank.

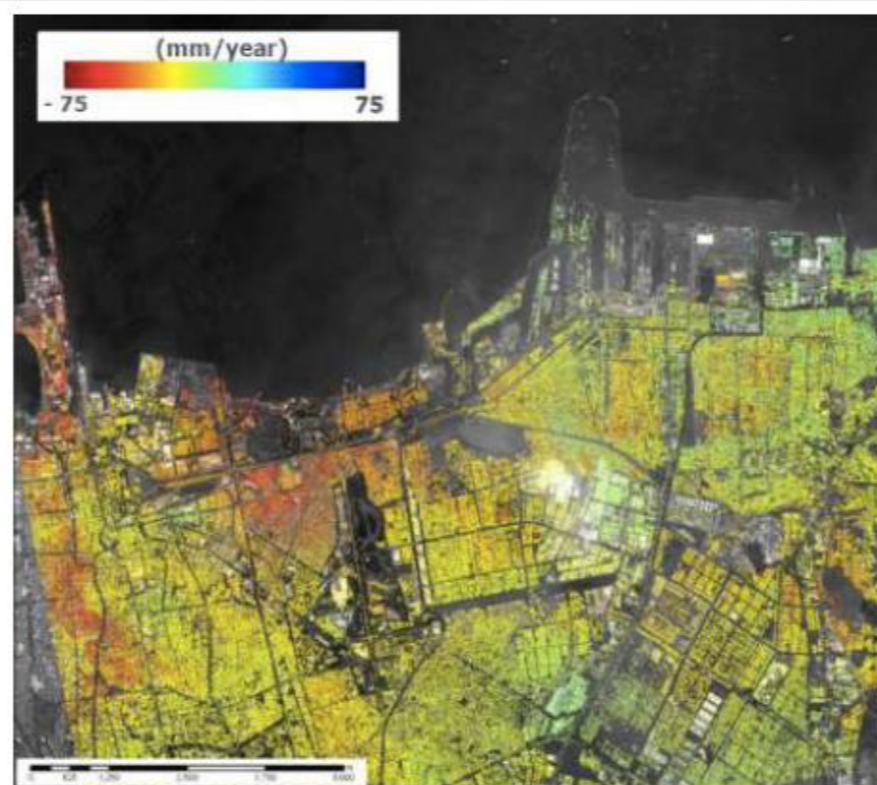
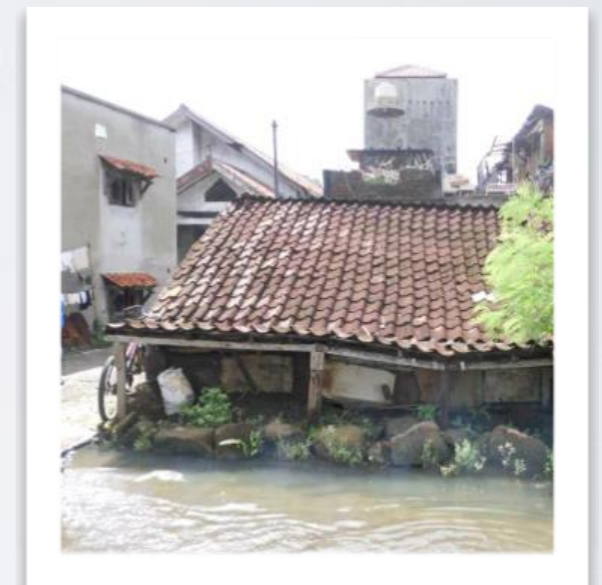
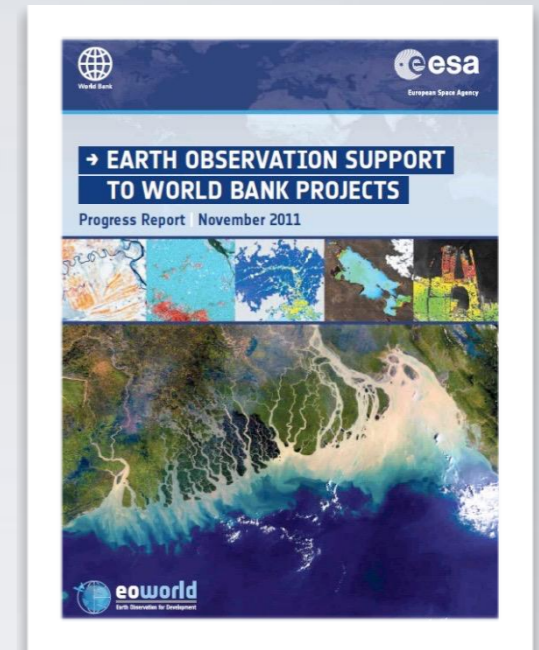


Figure (right). Deformation map in Jakarta Bay and harbor derived from the PSI analysis of VHR COSMO-SkyMed data (Oct. 2010 – Apr. 2011). Color scale between -75 (red) and 75 (blue) mm/year. Credit: EOWorld project/Altamira Information for ESA, World Bank.



Sinking cities: combination of subsidence (e.g. water pumping) monitored by **InSAR** and sea-level rise **SSH** help quantify **flood risk** in coastal mega-cities. Mega-deltas in Asia are the “rice bowls” to the world, their subsidence is a threat to food security.

Future Flood Losses in Major Coastal Cities

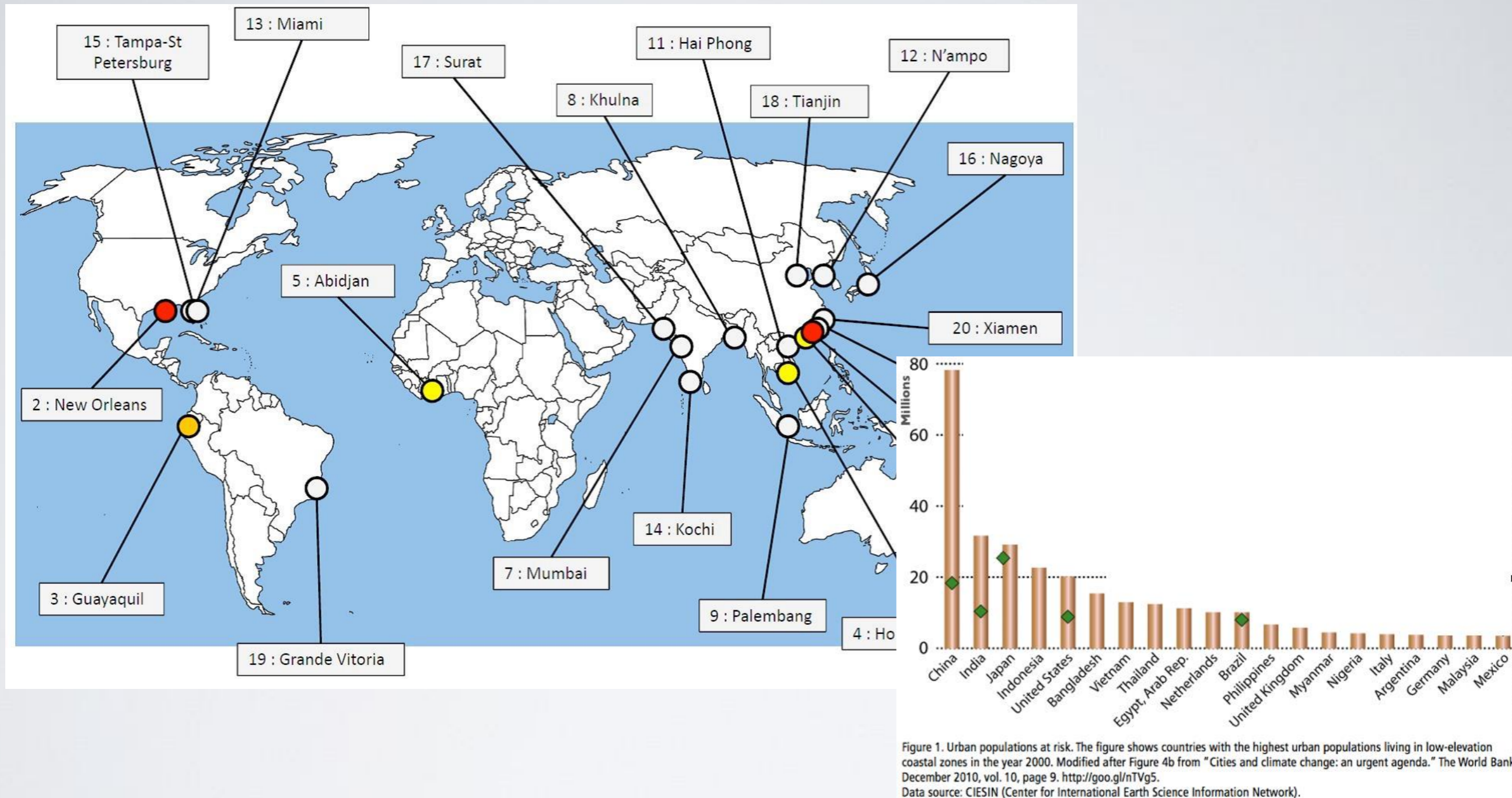
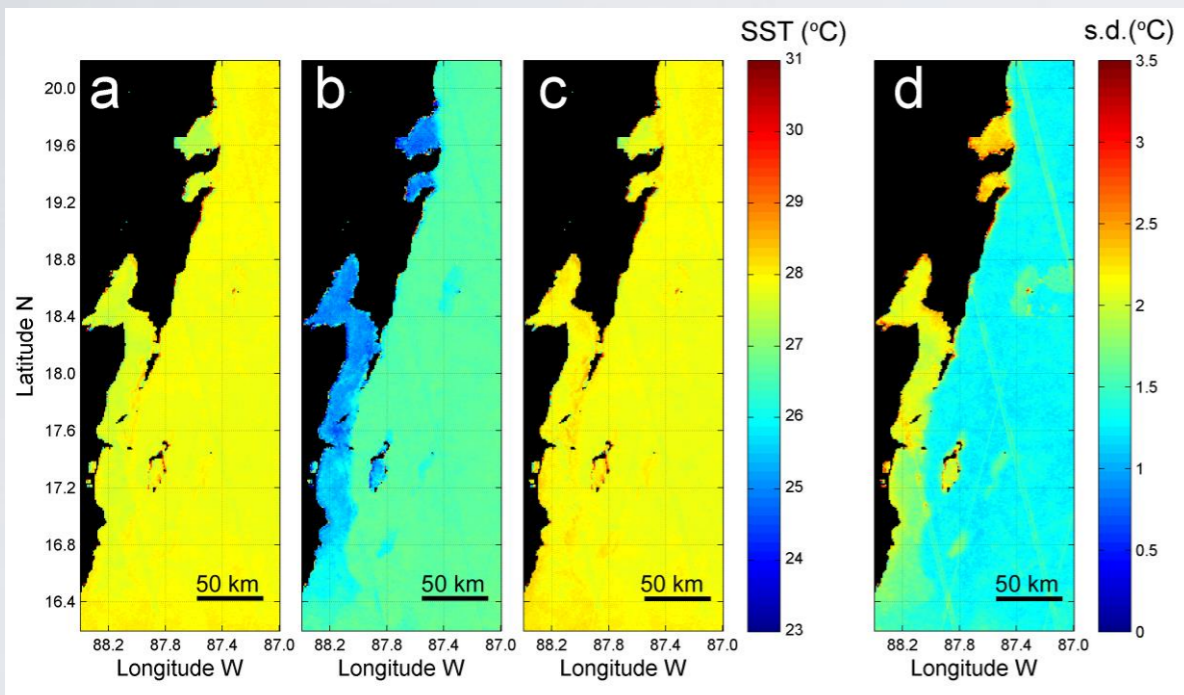


Figure 1. Urban populations at risk. The figure shows countries with the highest urban populations living in low-elevation coastal zones in the year 2000. Modified after Figure 4b from "Cities and climate change: an urgent agenda." The World Bank December 2010, vol. 10, page 9. <http://goo.gl/nTVg5>. Data source: CIESIN (Center for International Earth Science Information Network).

Flood damage in the world's major coastal cities may top **\$1 trillion** a year by **2050** due to rising seas and subsiding land, according to a new World Bank study in Nature Climate Change. More than 40% of these prodigious costs could fall upon just four cities – New Orleans, Miami and New York in the US and Guangzhou in China.

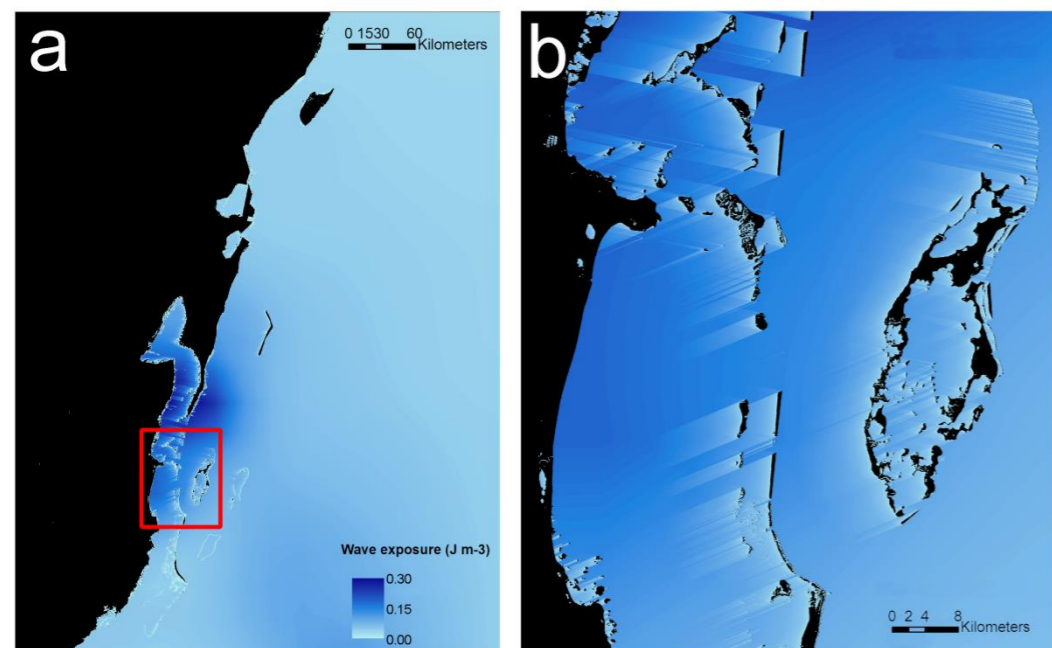
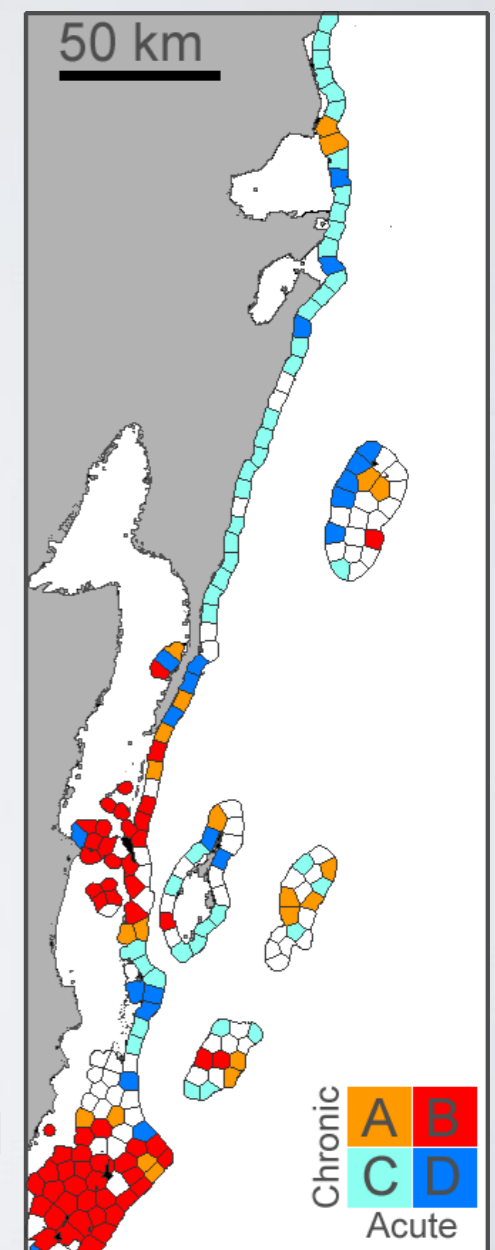
Impacts on Marine Ecosystems

- Health indicators : reef extent, reef roughness, coral and macro-algal cover, coral population structure, coral mortality, coral bleaching, coral diseases, herbivorous.
- Stress indicators : sedimentation, pollution, coastal development, over-fishing, ocean acidification, thermal stress



Improved **SST, SSH, OC, sea state**, monitoring to identify **suitable** sites for safely breeding **coral reefs**

Characterization of Thermal stress regime

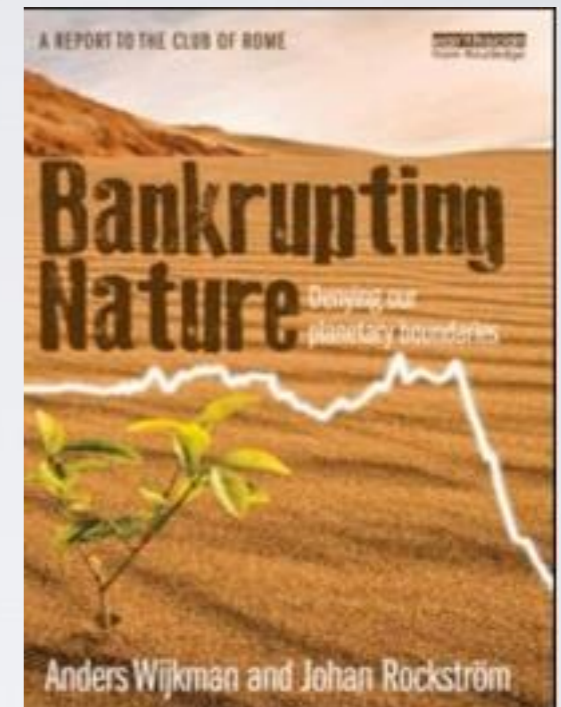


Wave exposure map (from shape of basin, wind-speed & direction (ERS Scatt))



←

An ecosystem service is defined as the benefit that people derive, either directly or indirectly, from a natural reserve. Earth observation can provide input to the valuations of ecosystem services by establishing baselines, monitoring the compliance of standards, spot checks of sustainable management practices and support environmental reporting (MetroVancouver)



TEEB – The Economics of Ecosystems and Biodiversity

Making Nature's Values Visible

***More Digital,
More Connected ...***



Election of the Pope
& the emergence of Mobile Phones
(now 6B cell phones, dramatic increase in Africa / Asia)



A young man with dark, curly hair, wearing a black leather jacket and dark pants, is the central figure. He has his mouth wide open in a shout and his arms raised high in a 'V' sign. He is surrounded by a crowd of people, some of whom are also raising their hands. The background shows a city street with buildings and trees. The overall atmosphere is one of excitement and protest.

THE OPPORTUNITY EO FUELING A DATA REVOLUTION

Moving from Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs)

A NEW GLOBAL PARTNERSHIP: ERADICATE POVERTY AND TRANSFORM ECONOMIES THROUGH SUSTAINABLE DEVELOPMENT

The Report of the High-Level Panel of Eminent Persons on
the Post-2015 Development Agenda May 2013



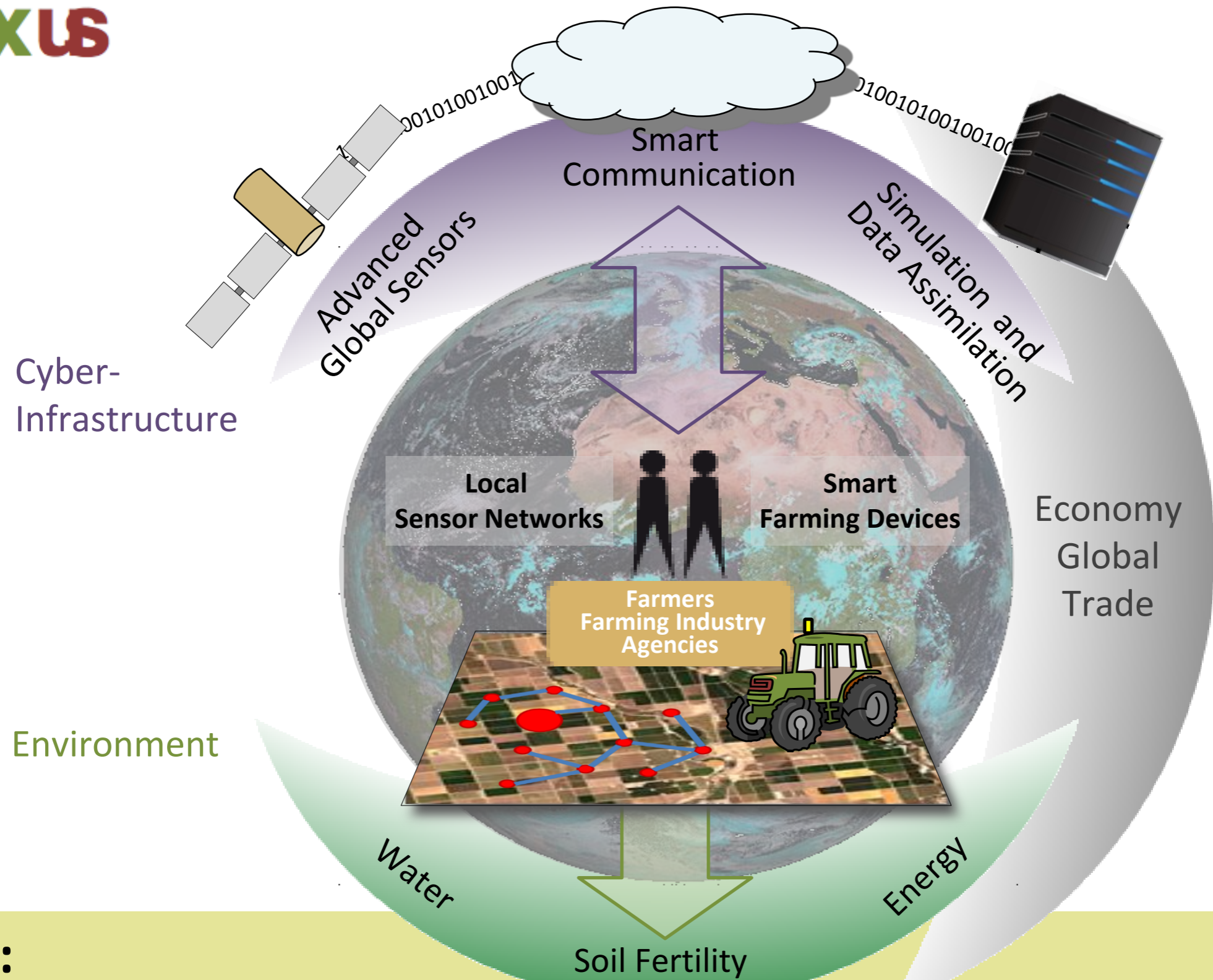
“We also call for a **data revolution** for sustainable development, with a new international initiative to improve the quality of statistics and information available to citizens. We should actively take advantage of new technology, crowd sourcing, and improved connectivity to empower people with information on the



July 2014



The Global Smart Farm of the Future



Vision:

Each farmer on the Globe will be part of an open cyber-environmental system which supports him in ensuring food security and sustainable agriculture

Monitoring Rice with Sentinel-1



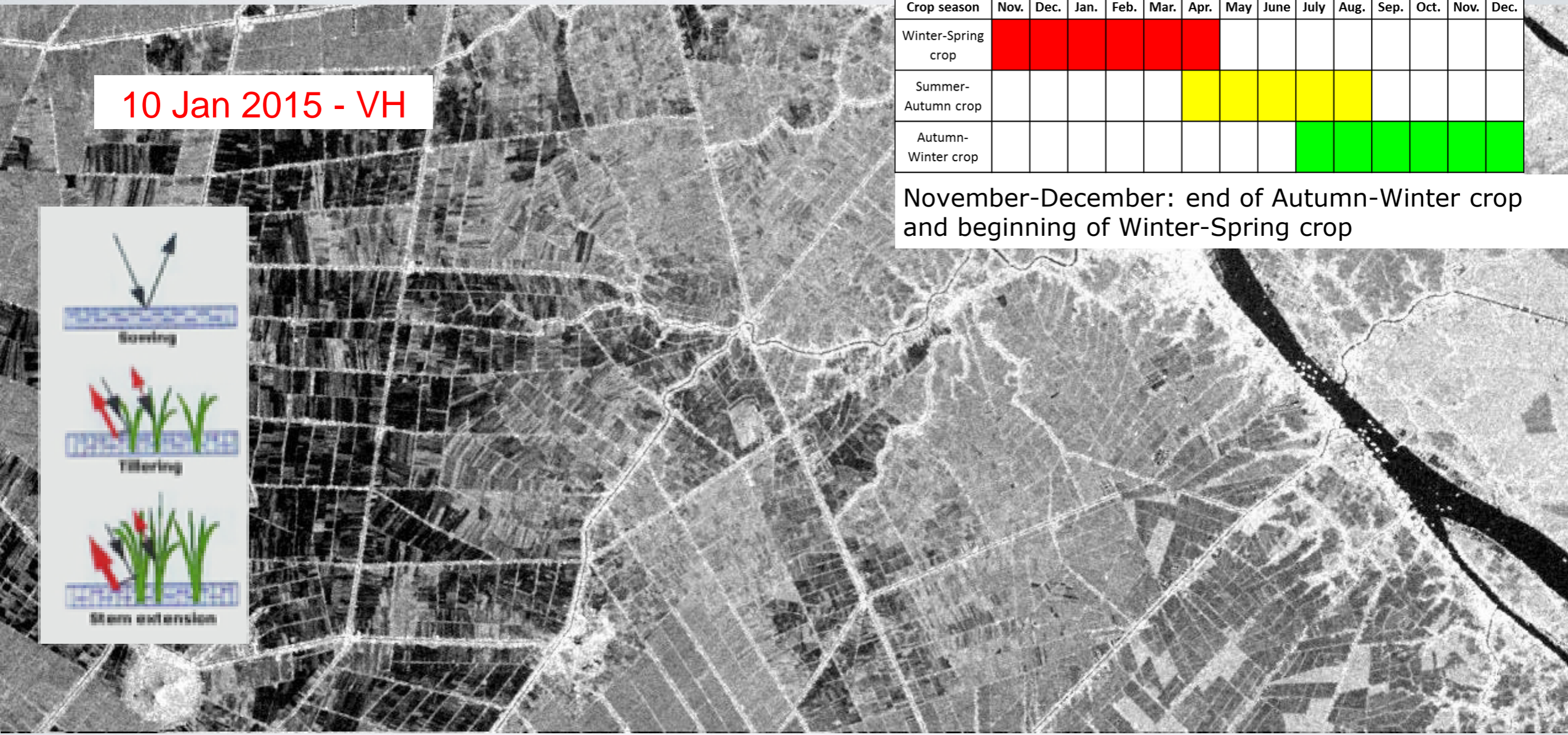
Sentinel-1 time series (Oct.2014-Jan.2015)
 GEOGLAM Asia-RICE Site: An Giang (Mekong River Delta, Vietnam)

Crop calendar

Crop season	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Winter-Spring crop	Red	Red	Red	Red	Red	Red								
Summer-Autumn crop						Yellow	Yellow	Yellow	Yellow	Yellow				
Autumn-Winter crop									Green	Green	Green	Green	Green	Green

November-December: end of Autumn-Winter crop and beginning of Winter-Spring crop

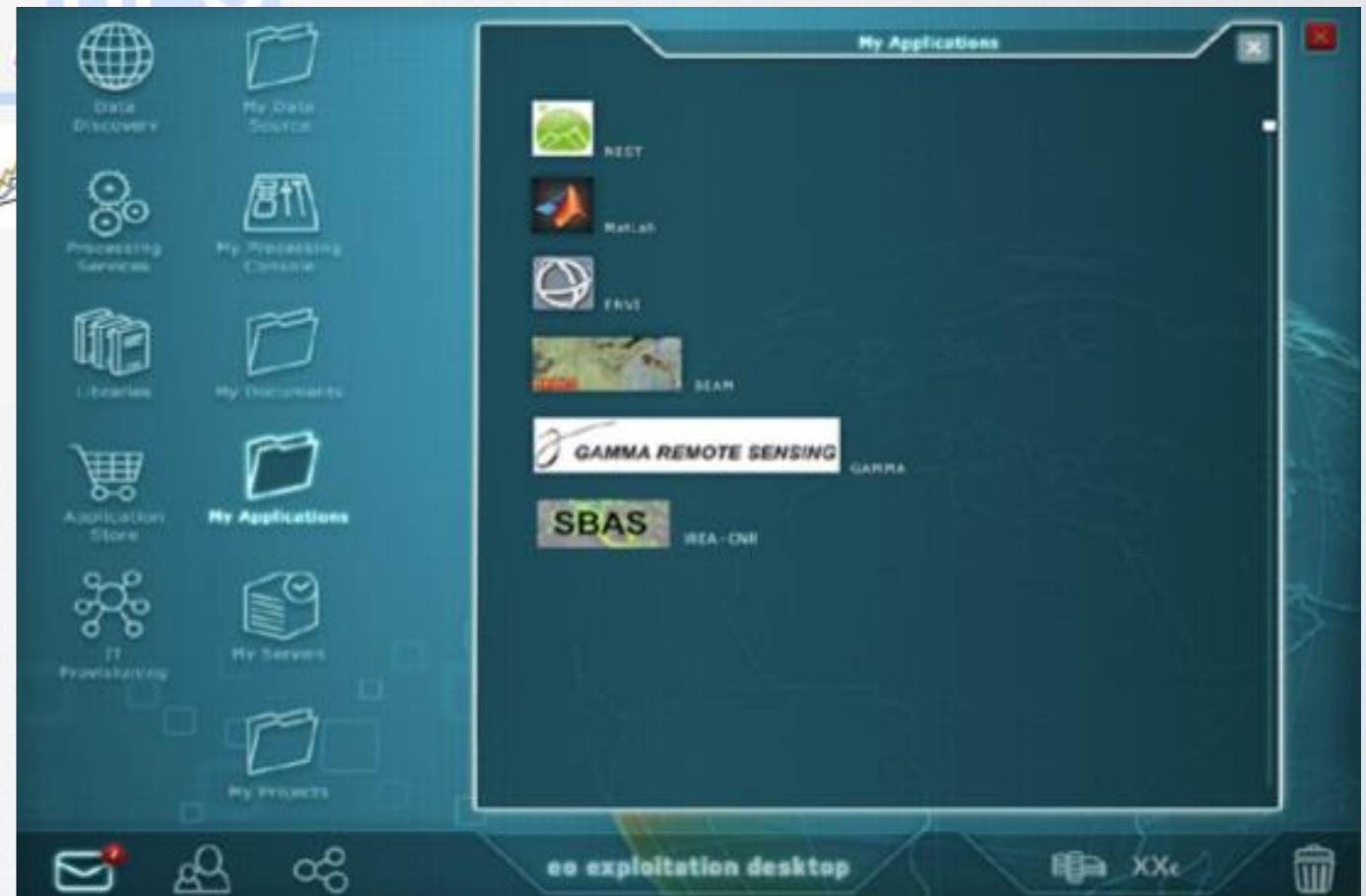
10 Jan 2015 - VH



Moving the Calculations to the data



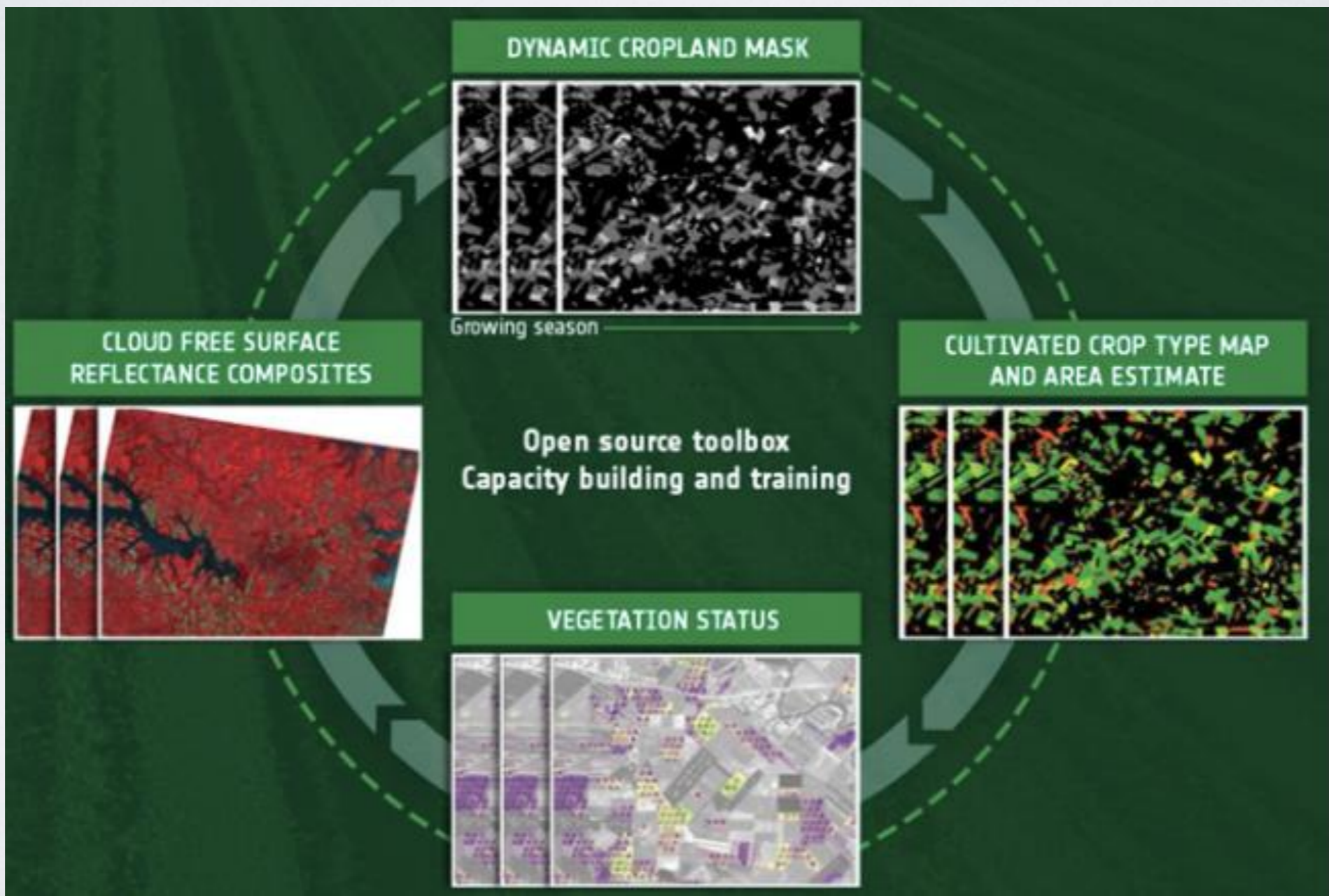
Data Gravity, and web services,
Geohazard Exploitation Platform



Development / Testing / Validation new Algos / Products



→ AGRICULTURE



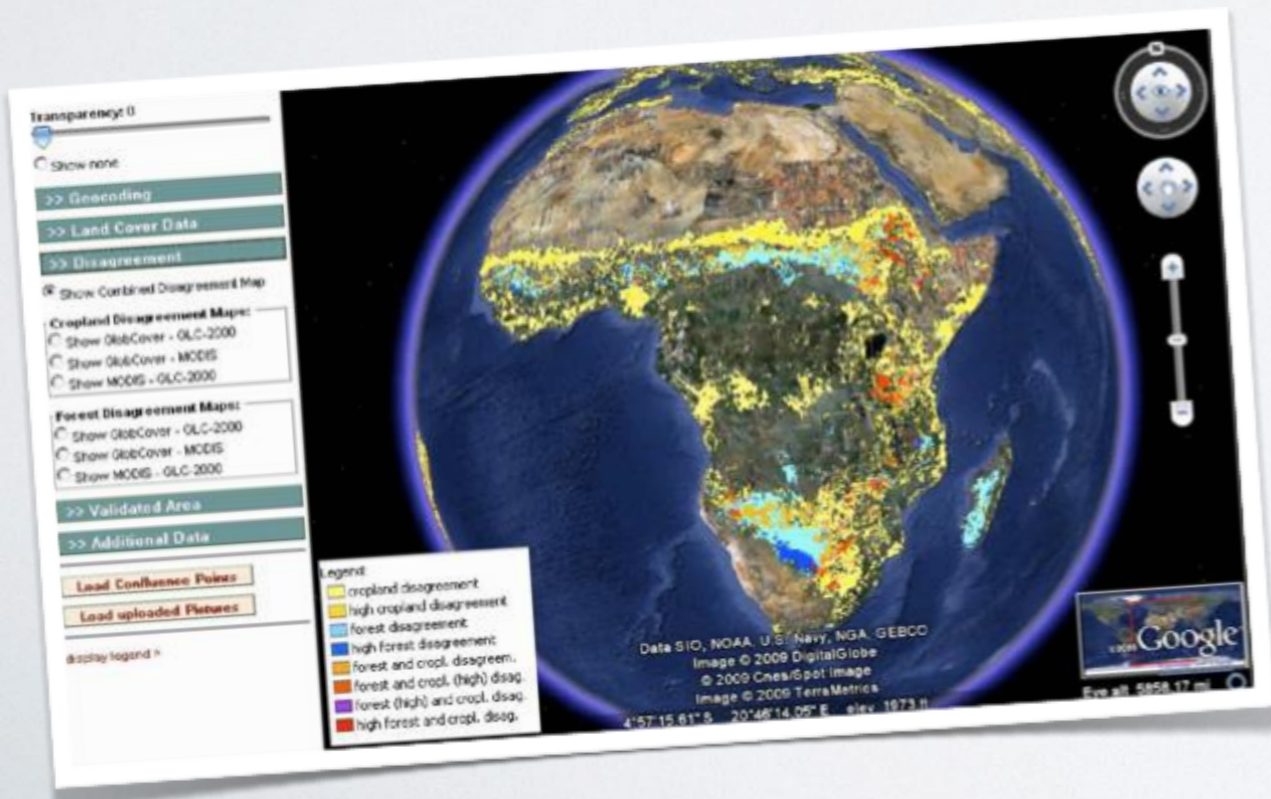
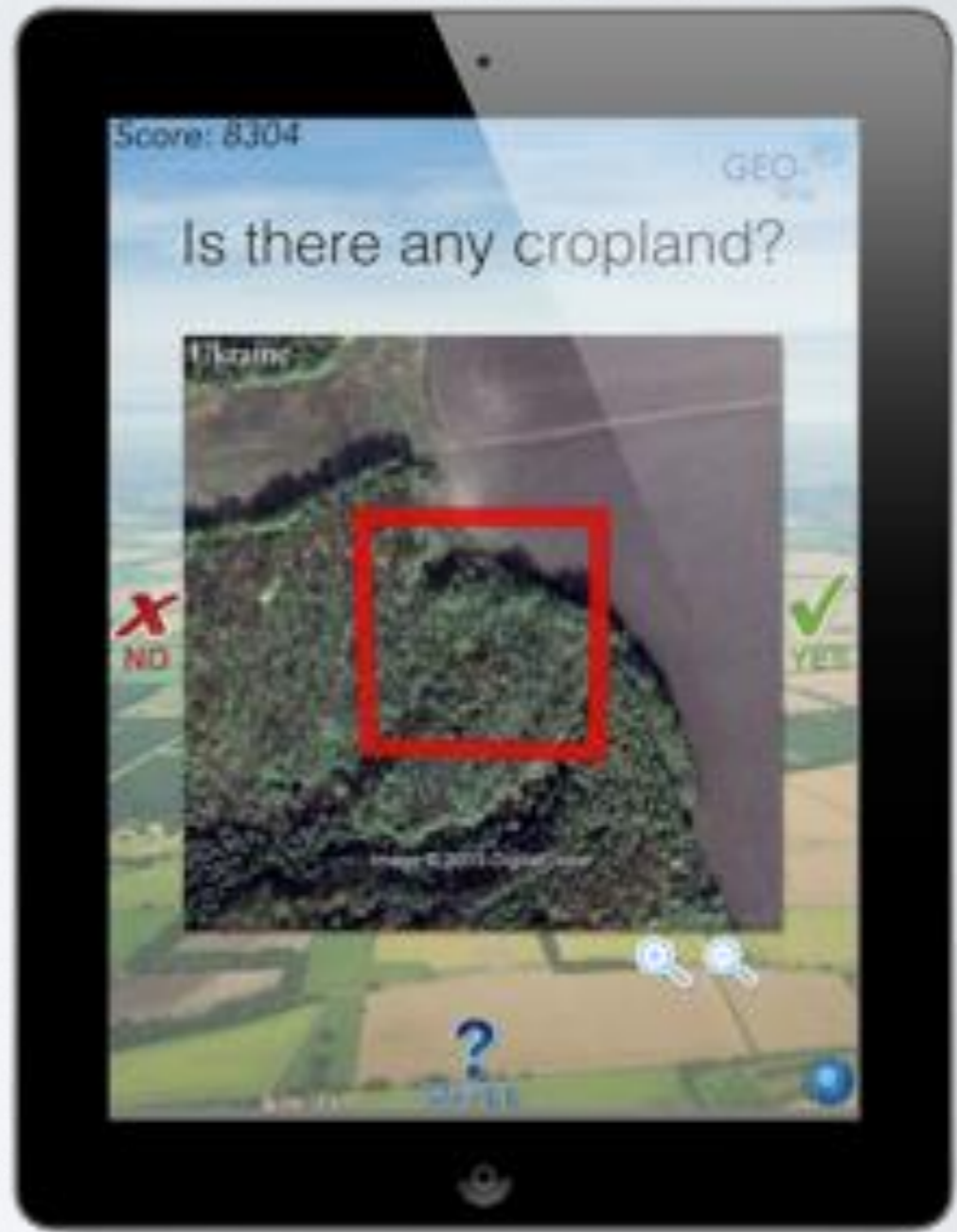
Project
UCL
Université catholique de Louvain



Key Users

-
-
-
-
-
-
-
-

Crowdsourcing ground truth and classification (EO Science 2.0)



Partnership with the Public Sector



English | Español | Français | عربي | Русский | 中文

THE WORLD BANK
Working for a World Free of Poverty

ABOUT | DATA | RESEARCH | LEARNING | NEWS | PROJECTS & OPERATIONS | PUBLICATIONS | COUNTRIES | TOPICS

TECHNOLOGY

Satellite Data Informs Development

A World Bank Group partnership with the European Space Agency is using satellites to gather a wide variety of information about climate change, water quality, coastal erosion, flooding, urban growth, and more. It has been particularly useful in conflict zones, where data can be difficult to gather.

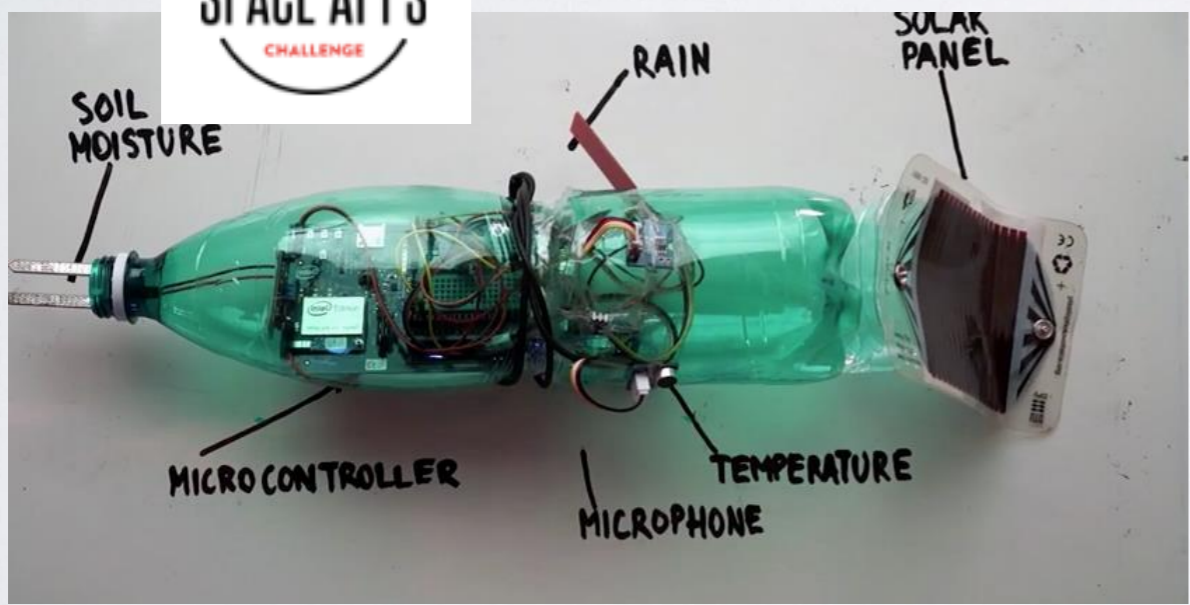
▶ Satellite Success Stories | Website

World Bank | esa
European Space Agency

→ EARTH OBSERVATION SUPPORT TO WORLD BANK PROJECTS

Progress Report | November 2011

eoworld
Earth Observations for Development



Opportunity to develop a **Innovation Pulse Lab @ ESRI** bringing together academia, private sector and regional actors to address Big Data issues for society and develop new applications.

Conclusions



What does all this mean for EO?

Ingredients:

- Agriculture is the largest employer on the Globe,
- Agriculture is a major sector of national economies (from >60% to 3% of GDP),
- Agriculture shows large productivity potentials,
- Agriculture is the economic sector with the largest environmental impact on the Globe,
- Productivity gains and environmental impacts are closely related to information science and technology used in farm management,
- Agriculture is and will remain the largest outdoor economic activity.

What is it that the Global Food System wants to know from EO?

Towards a Planetary Management System



Planetary
Boundaries

Citizen
Observatory

Early Warning

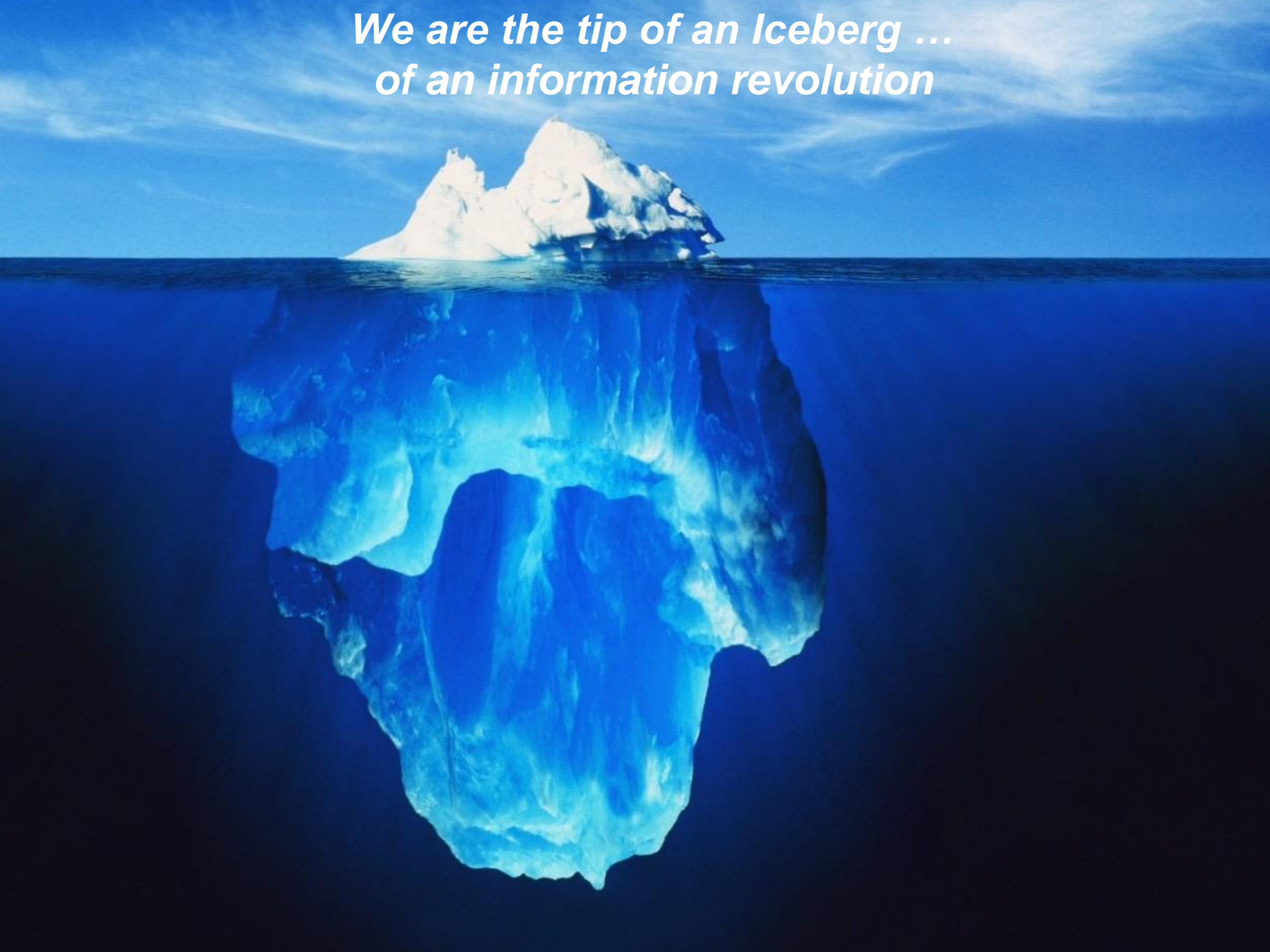
Monitoring

Attribution

Prediction



*We are the tip of an Iceberg ...
of an information revolution*



Thanks!

Current World Population:

7,127,758,356

