iLEAPS & Biosphere-Atmosphere-Society Index

Eleanor Blyth
iLEAPS IPO & NERC Centre for Ecology and Hydrology

https://we.tl/t-Dv2vIKWLyu

GEWEX SSG 2019. February 25th to 28th

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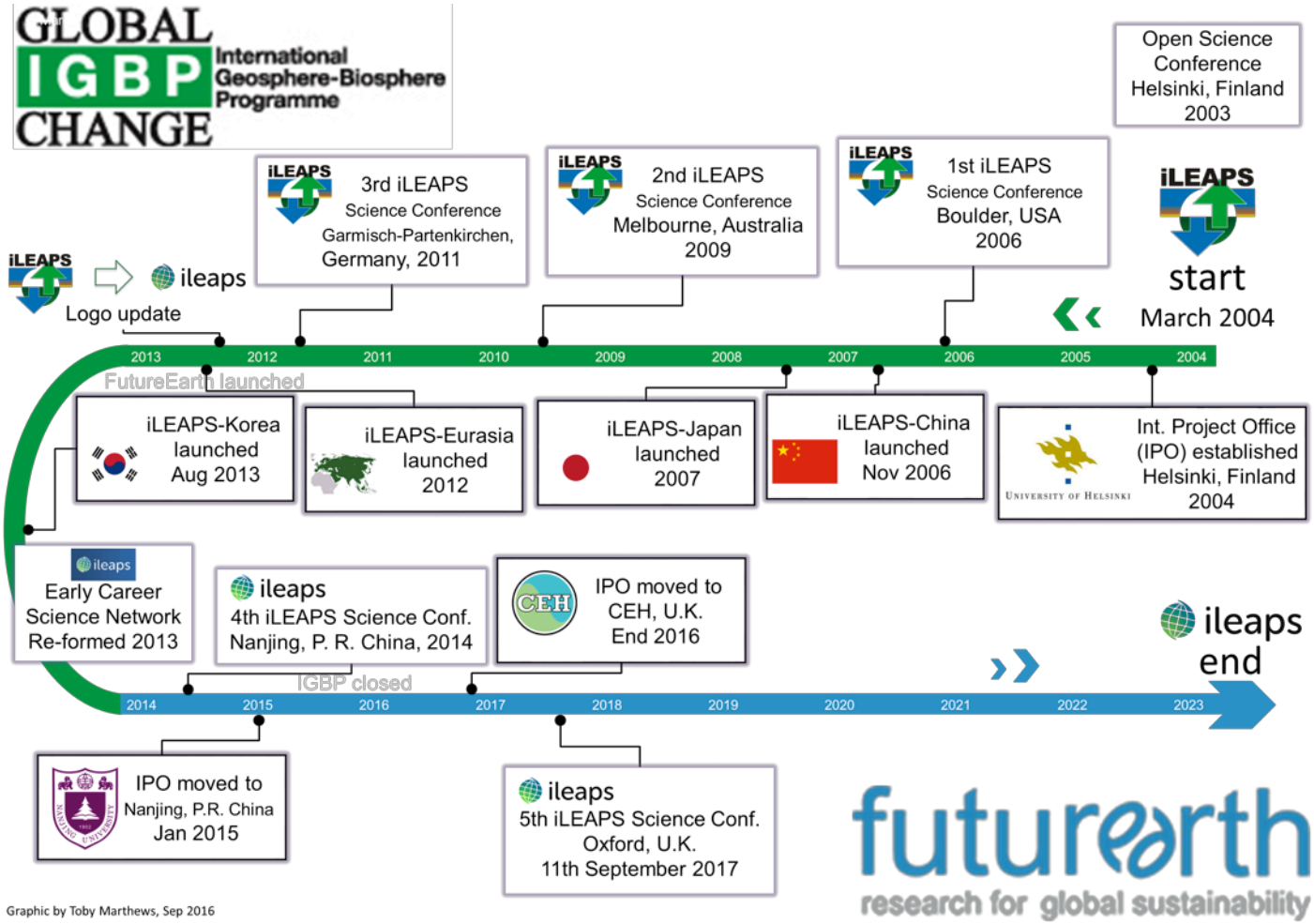
ileaps

Integrated Land Ecosystem - Atmosphere Processes Study



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Highlights of the first 10 years
Suni et al., 2015: Anthropocene

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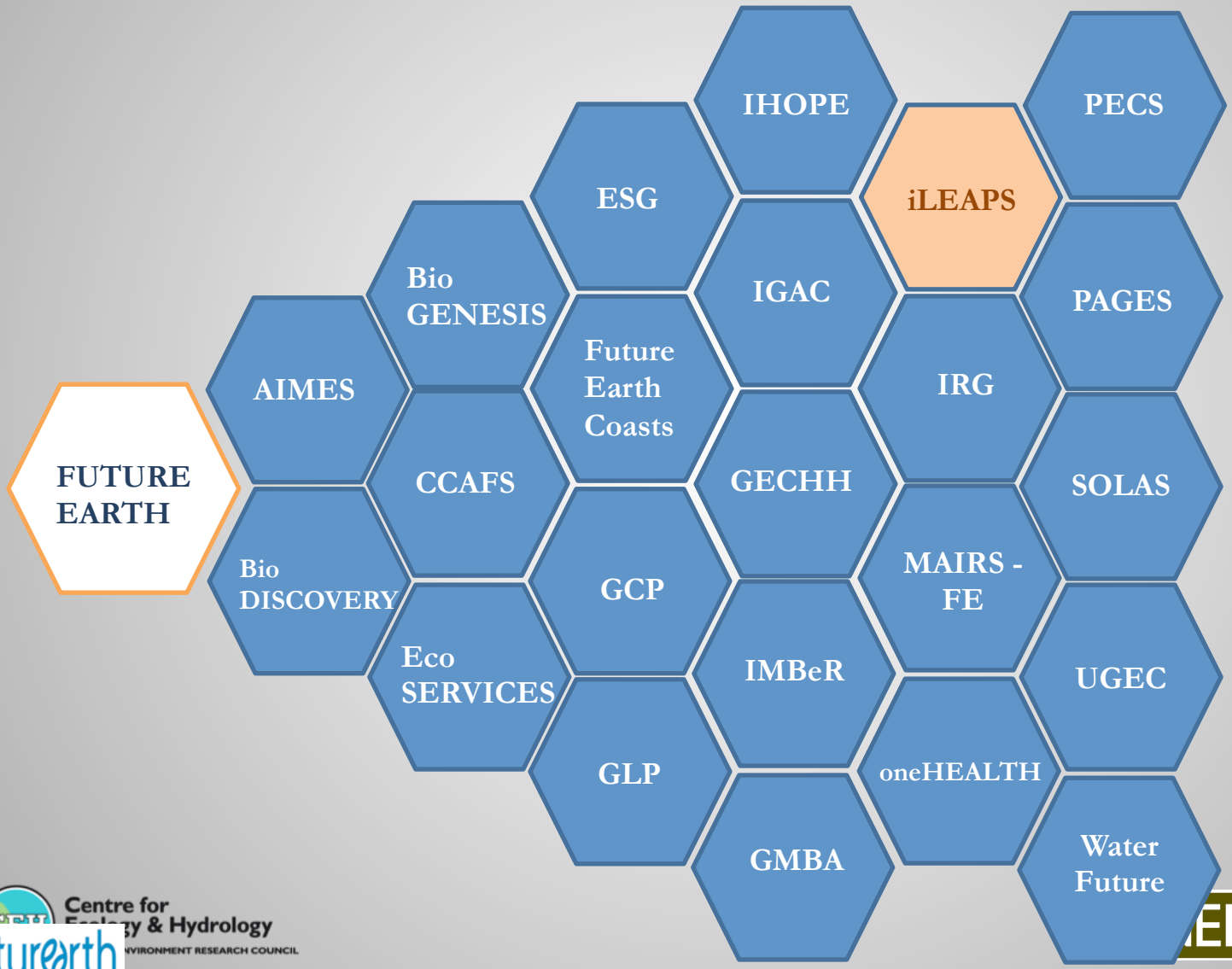
iLEAPS as a Future Earth Global Research Project



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futureearth
research for global sustainability

SCIENCE OF THE ENVIRONMENT
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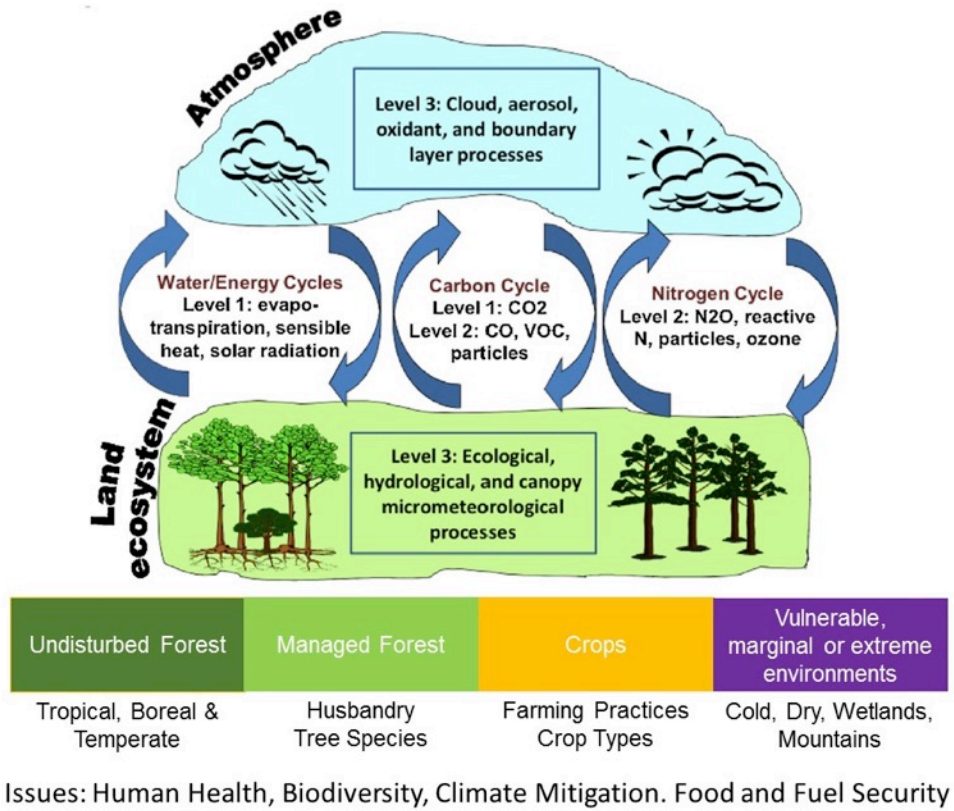
Mission Statement

iLEAPS fosters scientific excellence at the land-atmosphere interface and its impact on societal issues.

iLEAPS provides essential science that links biological, chemical and physical processes from local to global scales in the changing Earth system.

We focus on capacity building globally and preparing the next generation of leadership through ECS networks.



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Urban.

Societal issues: large, and increasing, percentage of humans live in cities. Air quality and heat affect health, especially in extreme conditions.

System: Trees and other ecosystems can be used to mediate the air quality and heat.

Managed Land.

Societal issues: Food and fuel requirements for increasing human population.

System: Downstream of cities can include high ozone levels which damage crops, deforestation affects carbon, water and heat exchanges with the atmosphere, carbon sequestration affected by management.

Forests

Societal issues: Biodiversity and global carbon.

System: Forests emit chemicals that affect the physical atmospheric system: rainfall, radiation diffusiveness. They respond to increased carbon dioxide in the atmosphere by conserving water.

Arctic and mountain regions

Societal issues: Rapid changes to the physical conditions due to warming. Global methane emissions.

System: Extensive wetlands in the Arctic are largest natural source of methane. Changes to climate affect vegetation. Permafrost thaw affects hydrology and carbon budgets. Longer growing season increases vegetation growth.

Arid and Semi-arid

Societal issues: Need for food and fuel.

System: Fires clear the vegetation for new growth and produce significant atmospheric particles. Vegetation has different strategies with high seasonal and inter-annual variability of rainfall. Bush encroachment changing the landscape.

iLEAPS Scientific Steering Committee

Co-Chairs	
Eleanor Blyth (Europe: UK):	Land surface in meteorological and hydrological models
Vinayak Sinha (Asia: India):	Atmospheric chemistry: VOCs & OH reactivity
Members	
Sally Archibald (Africa: South Africa)	Vegetation and fire ecology, adaptation of savanna ecosystems
Aijun Ding (Asia: China)	Atmospheric chemistry & air pollution – aerosols
*Silvano Fares (Europe: Italy)	Interaction between plant ecosystems and the atmosphere.
Tetsuya Hiyama (Asia: Japan)	Ecohydrology, hydrometeorology, human-natural interactions
Meehye Lee (Asia: S. Korea)	Atmospheric chemistry & air pollution – ozone, VOCs
Sebastian Leutzinger (New Zealand)	Global change impacts on plant communities
*Miguel Mahecha (Europe: Germany)	Extreme climate events & ecosystem-atmosphere interactions
*Ben Poultner (USA)	Global carbon & methane cycles
Sirkku Juhola (Europe: Finland)	Socio-economics, urban issues, adaptation of social systems
*David Odee (Africa: Kenya)	Tropical forestry & agroforestry systems
Allison Steiner (USA)	Atmospheric chemistry & land-surface processes
Xuemei Wang (Asia: China)	Atmospheric chemistry & air pollution
Ex Officio	
Garry Hayman (iLEAPS IPO, UK)	

International Project Office
- Eleanor Blyth
- Garry Hayman
- Victoria Barlow

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Membership

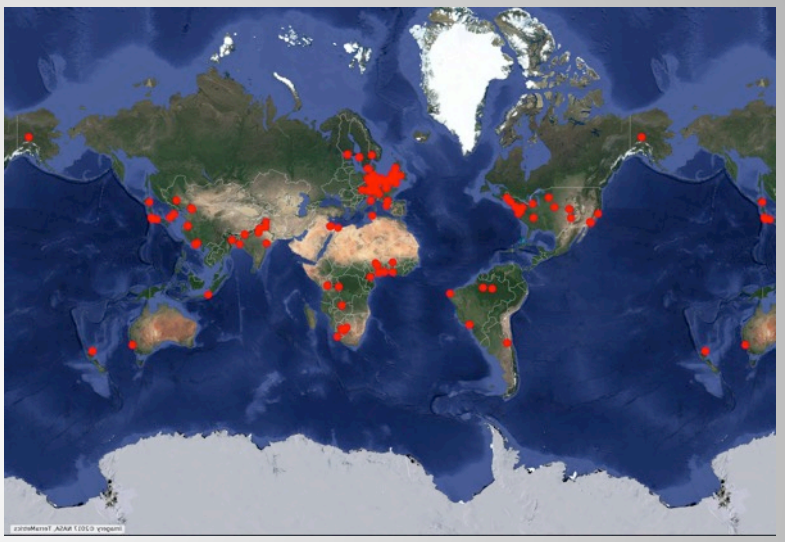
IPO moved from Nanjing (China) to CEH in 2017
Recruited a Project Officer October 2017
700 on our mailing list
275 attended the conference in September 2017
Wide range of geographical spread of attendees

Regional Project Offices:

iLEAPS-Korea – Meehye Lee
iLEAPS-Japan – Tetsuya Hiyama
iLEAPS-China – Xuemei Wang

We are actively organising an iLEAPS-India
We are aiming to build an iLEAPS-Africa

We have a very active Early Career Scientist Network



Map of conference attendees

Unfortunately reversed!

iLEAPS products and initiatives

Mature/Sponsored projects:

IBBI – Fire. ACPC – Aerosols and precipitation. iLAMB – integrated Land Model Benchmaking. GAIA – Atmospheric Chemistry. E3S: Extremes and Society

Teenage Projects:

CANEXMIP: Exploring ways to represent canopy processes in deposition

BASi: Biosphere Atmosphere Society index

New iLEAPS Initiatives:

Role of Methane and Permafrost in permitted emissions for 1.5 degrees warming

Ozone Impacts (with the International Ozone Commission)

Standardisation of non-GHG flux measurements

Using manipulation experiments to inform Earth System models

Exploring Nitrogen in Future Earth

iLEAPS: Using satellite data to create global indices

- ‘Hotspot’ analysis using the MPI Earth System Data Cube:
  a. Impact of ozone on crop and forest productivity – coincidence of EO derived ozone levels with where and when the crops are most vulnerable to damage
  b. Where does drought affect food production? – coincidence of spatial extent and timing of dry conditions that can affect food production
  c. Changes in vulnerable ecosystems – changes in the metric of biogeochemical shifts and vegetation structural changes that quantifies ecosystem state in the arctic and the semi-arid regions
- New Biosphere-Atmosphere-Society Index

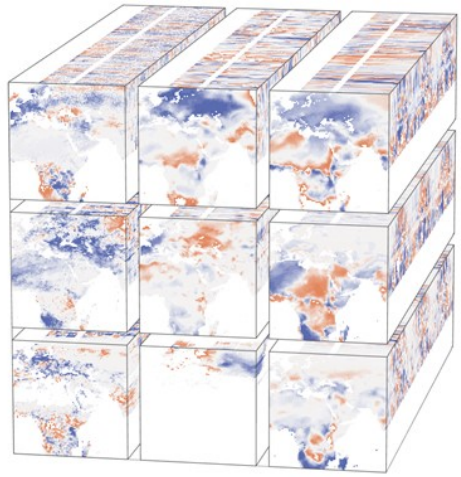


Figure 4: Schematic of the Earth System data cube.

Data product 1: Ozone and Crops

"Impact of ozone on crop and forest productivity – *coincidence of EO derived ozone levels with where and when the crops are most vulnerable to damage*"

- USDA page on the issue: https://www.ars.usda.gov/southeast-area/raleigh-nc/plant-science-research/docs/climate-changeair-quality-laboratory/ozone-effects-on-plants/ .

- Model studies of the impact of ozone on crop production and how these impacts will change into the future (van Dingenen et al., 2009; Avnery et al., 2011a, 2011b; Tai et al., 2014).

- Data Cube system currently has total column ozone product. Better to use 'tropospheric' ozone column.

- Combine with FAPAR, temperature, precipitation and a vegetation index

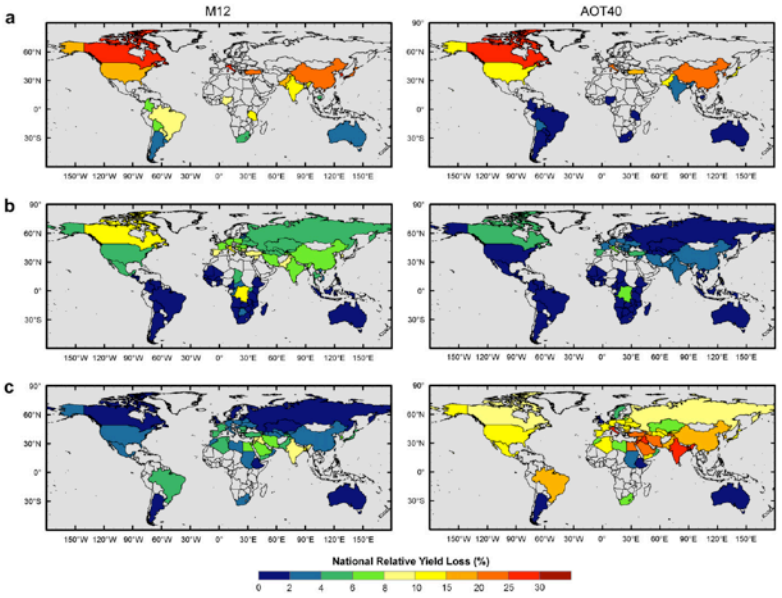


Fig. 4. National relative yield loss according to the M12 (left panels) and AOT40 (right panels) metrics for (a) soybean, (b) maize, and (c) wheat.

Taken from: Avnery et al., 2011a

Data product 2: Water and Food Stress

"Impact of water stress on crop and forest productivity – *coincidence of EO derived low soil moisture levels with where and when the crops are most vulnerable to damage*"

Could this be a simple combination of a water stress index and a reduction in GPP (or perhaps NPP) below a certain level?

Perhaps this could be combined with the OZONE product into a DAMAGE TO CROPLANDS product

Relate to Future Earth's Water, Food and Energy Nexus http://futureearth.org/future-earth-water-energy-food-nexus.

Data product 3: Ecosystem Vulnerability

"Changes in vulnerable ecosystems – *changes in the metric of biogeochemical shifts and vegetation structural changes (Heyder et al, 2011) that quantifies ecosystem state in the arctic and the semi-arid regions*"

Heyder et al., 2011: Risk of severe climate change impact on the terrestrial biosphere. Environ. Res. Lett., 6, 034036.

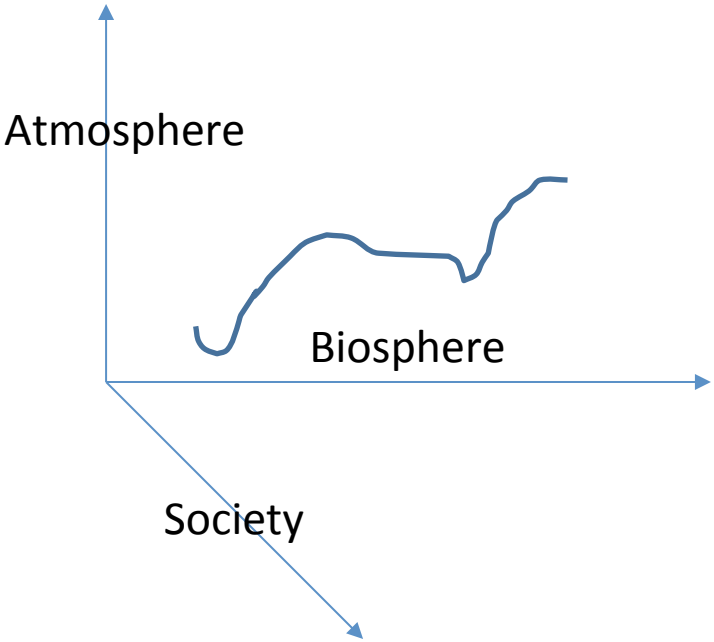
We envisage a global hotspots map highlighting vulnerability, possibly within an identified global set of 'marginal ecosystems'

Is it possible to assemble a defensible index here using only existing ESDC data?

Can this be linked to one of the various land-atmosphere coupling metrics listed on http://cola.gmu.edu/dirmeyer/Coupling_metrics.html .

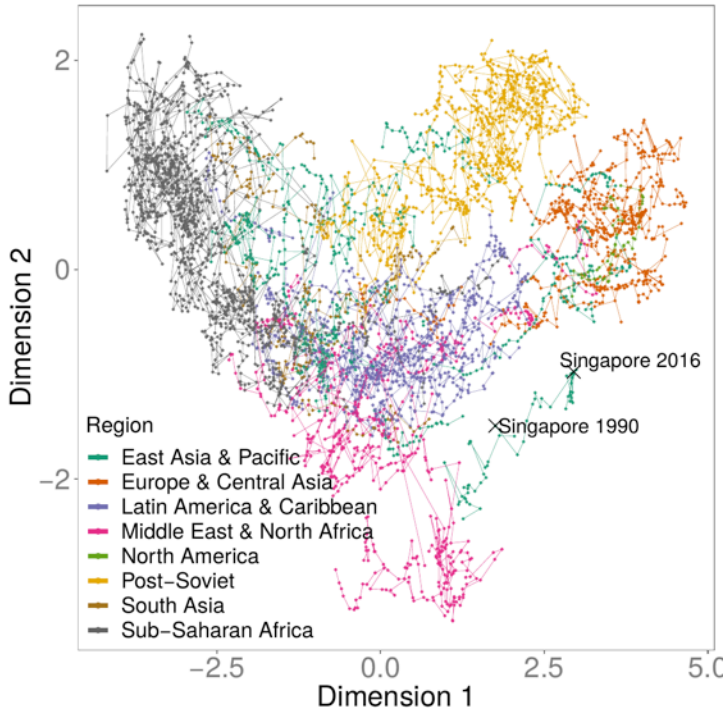
TRACKING CHANGES IN THE EARTH'S SYSTEM

Data driven approaches for the creation of indicators for monitoring changes in biosphere, atmosphere, and society



What is the major directions of biospheric and climatic co-variability, including fire, soil water stress, evapotranspiration, photosynthesis, crop productivity and land use change?

	Indicator	Describes	Created by
Society	Human Development Index (HDI)	Life expectancy, education, per capita income	United Nations Development Programme (UNDP, 2016)
	Multidimensional Poverty Index	Health, education, standard of living	
	Gender Development	HDI male vs. HDI female	
	Gender Inequality Index	Health, empowerment, labour market	
	Genuine Progress Index	Economic growth beyond GDP	Abstract concept (Kubiszewski et al., 2013)
	Global Footprint	Resources used	Global Footprint Network (McRae et al., 2016)
	Biocapacity indicators	Resources available	
	POLITY scores	Level of democracy	Center for Systemic Peace (Marshall and Elzinga-Marshall, 2017)
	Happy Planet Index	Long, happy, sustainable lives	New Economics Foundation (Helliwell et. a)
Biosphere	Normalized Difference Vegetation Index (NDVI)	Greenness of biomes	Copernicus Global Land Service (https://land.copernicus.eu/global/themes/vegetation)
	Vegetation Condition Index (VCI)	NDVI relative to previous times	
	Vegetation Productivity Index (VPI)	NDVI relative to previous times	
-	Drought and/or aridity indices??? Water quality???	-	-
Atmosphere	Multivariate ENSO Index (MEI)	Equatorial Pacific weather anomalies	National Oceanic and Atmospheric Agency (Wolter and Timlin, 2011; Barnston et al., 1987)
	North Atlantic Oscillation / Pacific - North American pattern (NAO/PNA)	PNA and NAO teleconnections	
Atmosphere	Air Pollution index (1-10)	Daily index to cover multiple air pollutants	UK examples but there are equivalents Air Quality https://uk-air.defra.gov.uk/air-
	UV Index (no risk, low, moderate, high, v. high, extreme)	Daily forecast of UV exposure	



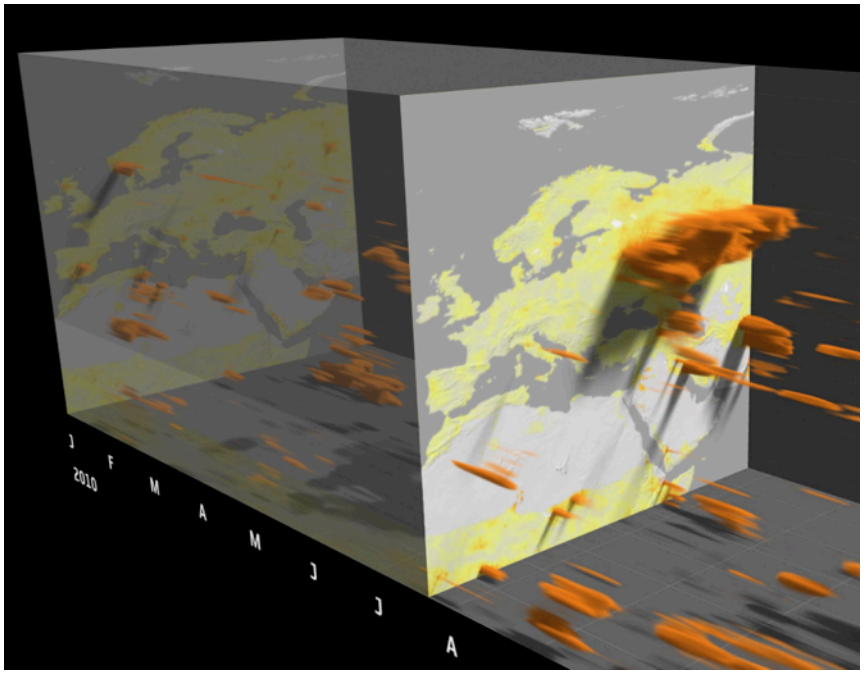
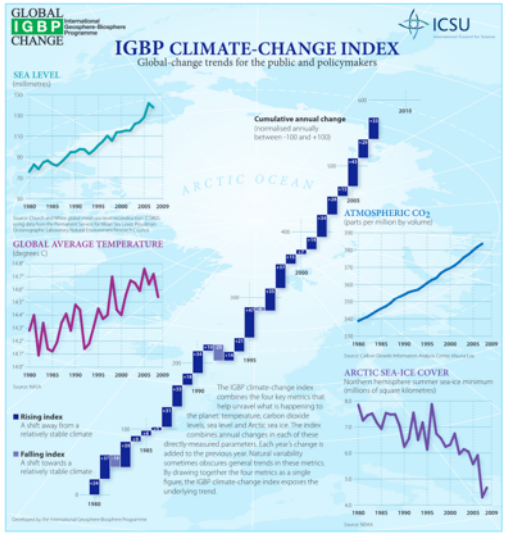


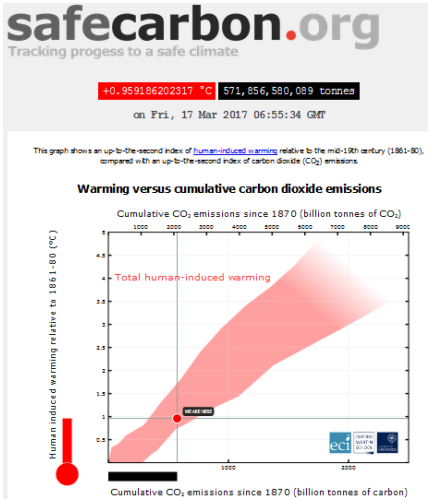
Figure 1a: Trajectories of change based on the WDIs (Kramer et al. sub.); each line is a trajectory of a 2D indicator of societies. b: Indicator of extremeness in the terrestrial biosphere based on the methods developed by Flach et al. (2017).

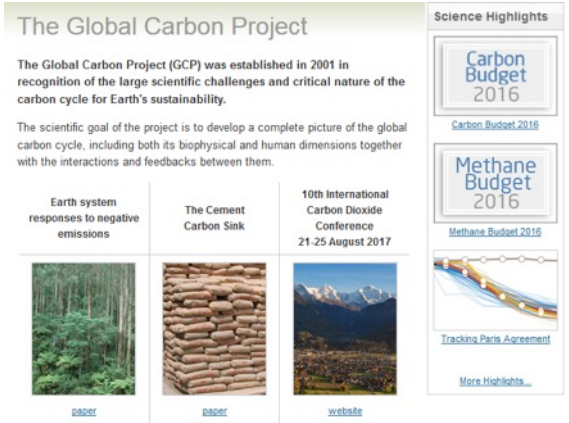
What could BASi look like?

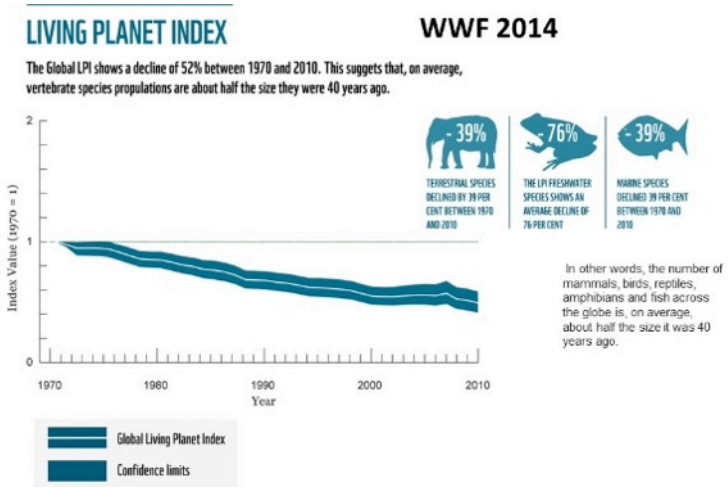
High-level product similar to the Annual Carbon and Methane budgets produced by the Global Carbon Project.

Also see SafeCarbon and the IGBP Climate-Change Index and the WWF Living Planet Index.









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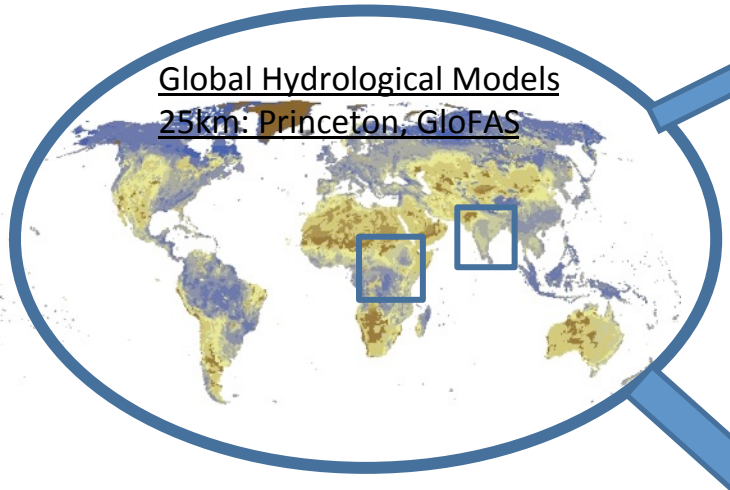
HydroSOS – Global Hydrological Status and Outlook System

Adopted by Commission for Hydrology in WMO



Global Hydrological Models
25km: Princeton, GloFAS

Downscaling
Data-filling

Regional Pilot Studies

India: 1km

Local catchment
Groundwater

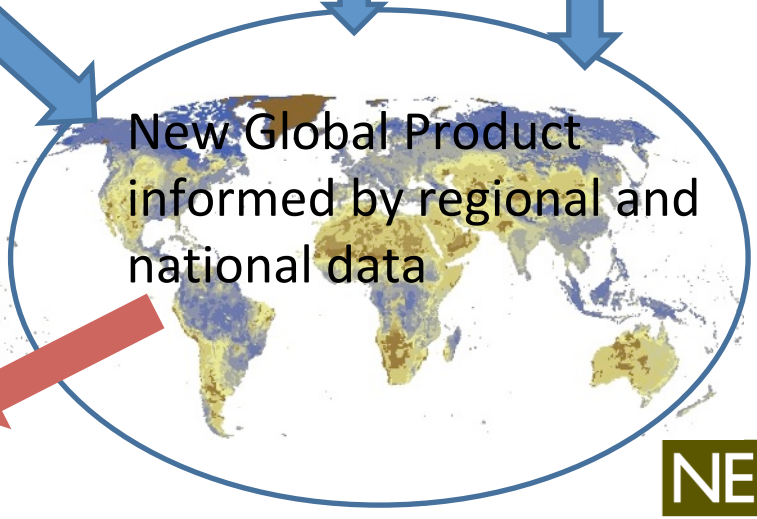
Lake Victoria: 1km

Local information
Abstractions etc

Climate and Hydrologic Services

National and Regional bodies

Common Data Protocols



New Global Product informed by regional and national data

Global stake-holders:
e.g. World bank

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Links between iLEAPS and GEWEX

1. Land Surface Modelling Summit – 2020 in Oxford
2. Use of Flux data. Include carbon fluxes in PLUMBER2.
3. Impact of CO2 fertilisation on the water cycle
4. Impact of the water cycle and extremes on the global carbon cycle
5. *Data science. How to analyse satellite data with societal data?*

iLEAPS & OZflux joint conference. Feb 2021. 9 to 12.

Auckland, New Zealand.