GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

THE GCOS INDICATORS OF CLIMATE CHANGE

GCOS Secretariat, WMO

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WMO UNESCO IOC ICSU International Council for Science UNEP

Rationale

The GCOS Implementation Plan 2016:

1. **Action G3: Development of indicators of climate change:**

Devise a list of climate indicators that describe **the ongoing impacts of climate change in a holistic way**. Consider the work of the WMO, IPCC and others. Indicators may include: heating of the ocean, rising sea level, increasing ocean acidity, melting glaciers and decreasing snow, changes in arctic sea ice, changes in vegetation characteristics and distributions and land cover changes.

2. **Action G4: Indicators for Adaptation and Risk:**

Promote definition of and research supporting the development of indicators **linking physical and social drivers** relating to exposure, vulnerability and improved resilience, in line with national requirements.

"A small number of vital signs and a narrative to go with, will maybe save the world (Chris Rapley)

2 Types of indicators:

Lagging / Historic indicators: ***Describe the physical state of the climate system and its historical development***.

Need is to identify a small set of essential climate indicators for the purpose of communication of climate change to date. Surface temperature is not the best indicator of climate change as it is a poor overall thermodynamic descriptor of the Earth's energy balance. A broader set of indicators would better describe and communicate the full range of physical climate change over the last 150 years.

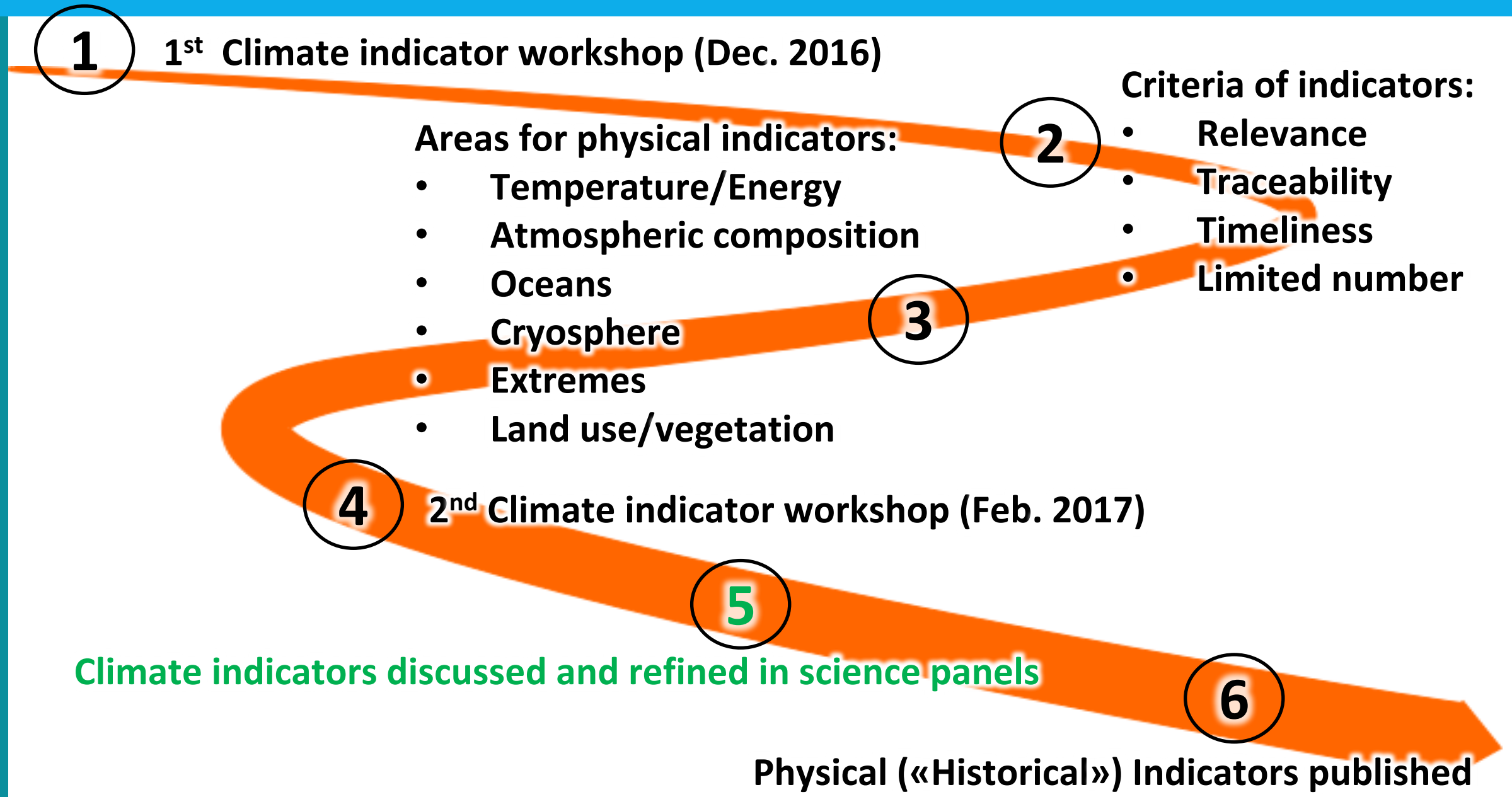
Leading / Future indicators: ***look at future impact, risk and adaptation***

Need to identify a set of indicators that can be used to inform management of climate change and its societal impacts in the future and which will help in assessing whether policy makers are making the right decisions in terms of mitigation and adaptation. Establishing a set of future indicators requires the involvement of a broader community, including socio-economic experts.

Existing climate change indicators

- Joint CCl/WCRP(Clivar)/JCOMM Expert Team On Climate Change Detection And Indices (ETCCDI): 37 indicators of extremes
- WCRP indicators
- WMO indicators
- Copernicus (C3S) indicators
- IGBP: Climate Change Index
- NASA: 5 vital signs
- EPA: 37 global/national indicators
- NOAA: 7 indicators
- NOAA/BAMS: State of Climate Report
- EEA: 48 indicators
- UNEP/GEO: Core indicators
- IPCC AR5: list of Climate Change Indicators (9)
- GERMANWATCH: Global climate risk indicators
- Notre Dame Global Adaptation Index
- Climate Change Health Indicators EPA
- Eurostat Climate Change and Energy indicators
- Briggs et al. 2015, Nature: 5 indicators
- …

The process towards physical indicators



Criteria for physical indicators

Relevance: **Each should be a clear, understandable indicator of global climate change, which has broad impact for a range of audiences. Some indicators will also have national and regional values.**

Representativeness: **Indicators as a package should provide a representative picture of changes to the earth system related to climate change.**

Traceability: **The Indicators should be calculated using an internationally agreed (and published) method.**

Timeliness: **Should be calculated regularly (at least annually) with a short lag between the end of the period and publishing the data.**

Limited number: **To allow clear, concise, communication the number of indicators should be limited to less than 10.**

Topic	Headline Indicator	Baseline	Subsidiary Indicators	Notes	Availability
Temperature and Energy	Global surface temperature	Pre-industrial temperatures	Ocean Heat Content, Top-of-the-atmosphere energy balance	The near surface temperature is important for political process, is a target of the Paris agreement, and is well understood by public. Need a more understandable name for top-of-the-atmosphere energy balance	NOAA, NASA, UK Met Office
Atmospheric composition	Atmospheric CO_2 (ppm)	Pre-industrial	Methane, N_2O, hydrogenated greenhouse gases	While mole concentrations are measures this not widely understood: talk about concentrations for wide understanding	GAW
Oceans	Sea Level Rise	1870	Ocean Acidification, Ocean Heat Content	Reconstructed from a combination of tide gauges and satellite altimetry	CSIRO
Cryosphere	Sea Ice Extent	???	Arctic and Antarctic sea ice extent	Arctic and Antarctic ice should be not reported in total as a single number and a second indicator would be needed for the terrestrial cryosphere	NASA
	Area of land covered by snow and Ice???	???			NASA
Land use/ vegetation	Deforestation (area per year). Urbanization?	Average of previous 10 years		Derived for satellite data time series using landsat/sentinel regular	???
Extremes	Heatwaves	Heatwave magnitude index	???	WMO CCI	NOAA
	Extreme rainfall Drought				

Indicators

Area	Indicator	Subsidiary indicator
Temperature/Energy	Global surface temperature	Ocean Heat Content, Top-of-the-atmosphere energy balance
Atmospheric Composition	Atmospheric CO_2 (ppm)	Methane, N_20, hydrogenated greenhouse gases
Ocean	Sea Level Rise	Ocean Acidification, Ocean Carbon
Cryosphere	Arctic Sea Ice Extent/ Antarctic Sea Ice Extent	Area of land covered by snow and Ice
Land use/vegetation	Deforestation	
Extremes	Heavy precipitation/ Heatwaves/Drought	

Open questions

1. **Is a common baseline possible and if yes, which?**
2. **Land use/vegetation: Is there a more suitable indicator for deforestation?**
3. **Extremes: What indicators should cover heatwaves, droughts and heavy precipitation? Are the proposed ones the best available for the global approach**
   - **Heatwaves: Heat Wave Magnitude Index** *(Russo et al.: Magnitude of extreme heat waves in present climate and their projection in a warming world. J. Geophys. Res. Atmos. 2014, 119, 12,500-12,512.)*
   - **Droughts: Standardized Precipitation and Evapotranspiration Index** *(Beguería, et al.: Standardized precipitation evapotranspiration index (SPEI) revisited: parameter fitting, evapotranspiration models, tools, datasets and drought monitoring. Int. J. Climatol. 2014, 34, 3001–3023).*
   - **Heavy Precipitation: 95% percentile of rain** *(Klein-Tank et al.: Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation. Clim. Data Monit. 2009, 72.)*

2nd Workshop on Indicators

3 Febraury 2017:

- Discuss outcome of previous meeting

- Defining a process for establishing the best future climate indicators: The key issues are how to provide advice for policy makers, society, how to go from science data to useful information, what is the best way forward and how to publish the information. The future indicators need to say how well a country is adapting: is it getting better or worse?

- ACTION: Hold a workshop to discuss future indicators. Discussions should cover: needs for indicators and target audiences, agree future steps to secure broad agreement on these headline indicators.

2nd Workshop on Indicators

Discussion:

- Planning for adaptation needs an understanding of future risk and how it may change: What would a one in a hundred-year storm look like in 100 years' time?
- Planning for future impacts needs an understanding now of worst-case scenarios, e.g. highest possible sea level rise, largest flood or biggest heat wave to guide planning decisions even if they are implemented over future decades.

Key issues:

- Many groups address climate risk management looking at extremes and the impacts of extremes. We should use this work and therefore we need to map out what already exists.
- Other communities, particularly interdisciplinary bodies, should be involved to get their perspectives.
- There needs to be a dialogue between observers, modellers and the adaptation and resilience community.
- Differing baselines is an issue for communications causing confusion and obscuring messages.

- For historic indicators, global indicators make sense. However, for the future ones, data should be more local and relevant. Local is important as it focusses on the population's concerns and so attracts people's attention. While the input may be global, the use is local.

Outlook: Impact indicators

1 **Types of indicators:**

- **Health**
- **Energy**
- **Economy**
- **Agriculture**
- **Water**
- **…?**

2 **Involve relevant communities (adaptation)**

3 **Present specific proposals to the GCOS Steering Committee in October 2017**

Main problems:

- Traceability: Not solely physical parameters but also information about the object, i.e. economy, health conditions, crops, population density, etc. → increases the degrees of freedom and makes indicators more arbitrary
- Representativeness vs. limited number: E.g. for health, many different effects take place → makes choice arbitrary
- Attribution: Difficult to separate vulnerability from the impact, e.g. floods

Thank you!

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