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COMMISSION FOR BASIC SYSTEMS
OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS

INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

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Development of Climate Indicators

(Submitted by GCOS Secretariat)

Summary and Purpose of Document

This paper discusses the GCOS lead process to identify a core set of climate change indicators to be used as a basis for reporting climate change to the public. The set of climate indicators agreed upon by the scientific community is presented.

ACTION PROPOSED

The third session is invited to note the information provided

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Appendices: A. Historic Indicators following discussions by GCOS science panels

DISCUSSION

Introduction

In accordance with the GCOS implementation plan (GCOS-200) GCOS aims to identify a core set of climate change indicators to be used as a basis for reporting climate change to the public. The need to inform the public on the range of climate impacts beyond temperature is clear and a small, limited, number of global indicators should, as a set, demonstrate the range and speed of climate change. Many different bodies are already presenting different sets of climate indicators. Here the aim is not to replace these sets of indicators but to identity a core set of 5-10 indicators that could be used to report on the general state of the climate to a broad audience. There are in general two types of indicator, those describing the physical state of the climate system and its historical development, also sometimes called lagging indicators, and those looking at future impact, risk and adaptation, so-called leading indicators. Here indicators of the former type are identified; further work will be needed to consider the latter.

The latest GCOS Implementation Plan was presented to the UNFCCC in November 2016. The UNFCCC encouraged all parties of international organizations to implementing this plan, which includes the development of these two types of climate indicators. The need for climate indicators and appropriate criteria for them was also discussed in papers at the GCOS Science Conference, Amsterdam, March 2016.

Two meetings held by GCOS in Geneva have agreed that climate indicators should meet the following criteria:

- 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: 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.

Outcome of the meetings can be found in GCOS-206.

1. The two meetings hosted by GCOS proposed indicators in the following groups: temperature & energy; atmospheric composition; ocean; cryosphere; land use/vegetation change; extremes and human impacts. Whilst a single indicator for most of these groups could be identified, subsidiary indicators providing additional information were also identified.

The GCOS science panels discussed the need for indicators and their intended audience. They agreed that it was clear climate indicators are for informing the general public and not for scientists and should not be confused with the ECVs.

The presentation of these indicators, and how they convey the message of climate change needs further thought: more local information may help highlight changes.

The OOPC agreed with the list but felt strongly that ocean heat content to be called “ocean warming” and expressed in °C should be a main climate indicator. It was agreed that the term ocean heat content may not be readily understood, however its importance and relevance is clear. There is also the possibility of expressing this as an equivalent atmospheric warming. Several groups are able to update 0-700m and 0-2000m ocean warming rates on an annual basis. For example, this is done routinely as part of the BAMS State of the Climate reports, which are issued once a year by NOAA (https://www.ncdc.noaa.gov/bams).

AOPC agreed on the following climate indicators: surface temperature, ocean heat content, sea level, CO2 and arctic ice extent. Extreme events are interesting but difficult to define.
AOPC and TOPC agreed that deforestation should not be an indicator as its relationship to climate change is too complicated but there was a desire to see some land-based indicator, and suggestions included total area of permafrost, seasonal indicators, like for example phenology, desertification, greenness. The indicators agreed so far miss the changing seasonal signals. However, while indicators related to phenology are very useful at a local and regional level, given the regional differences in phenology they were unlikely to provide an easily understood indicator.

TOPC also noted that glacier mass balance, based on the world glacier monitoring service (wgms) reference glaciers would also be a good indicator, but this overlaps with the ice and snow coverage. It was suggested to talk to COPERNICUS for additional ideas.

The Global Cryosphere Watch (GCW) discussed if one indicator is enough for cryosphere; e.g. seaice extent and area of land covered by snow and ice. Other possibilities are glacier mass balance, sea ice extent, snow cover. The meeting agreed that Arctic and Antarctic ice should be reported separately as this would avoid cherry-picking and be more transparent. The responses of sea ice in the Arctic and Antarctic are different and have differing seasonality.

The agreed list of historical indicators can be found in Appendix A

2. Next steps

The indicators described in this document will be considered by the GCOS Steering Committee in May 2017 to be promoted as a single minimal set that describes climate changes that have occurred up to the present time. These will be presented to the WMO EC and discussed with the IPCC.
The GCOS secretariat will hold further meeting and discussions to better understand the needs for indicators of future risk and adaptation and to propose specific indicators. The aim will be to present specific proposals to the GCOS Steering Committee in October 2017.

Appendix A: Historic Indicators following discussions by GCOS science panels (references in endnotes)

Topic	Headline Indicator	Baseline	Subsidiary Indicators	Notes	Availability
Temperature and Energy	Global surface temperature	Pre-industrial temperatures	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
	Ocean Warming: 0-2000m ocean warming (how to express tbd))	data from 1970 onwards	0-700m ocean warming – has the advantage of a much longer time series.	Is "Ocean Warming" the best phrase to use? What units to express it in? (suggestions include: Wm-2 relative to Earth's surface area (what does this mean SE???); and ocean warming in °C and include conversion to equivalent atmospheric warming?)	Reconstructed gridded products from various institutes (e.g.CSIRO, NOAA) and Argo-based products are available - http://www.argo.ucsd.edu/Gridded_fields.html
Atmospheric composition	Atmospheric CO2 (ppm)	Pre-industrial	Methane, N20, hydrogenated greenhouse gases	While mole concentrations are measured this not widely understood: talk about concentrations for wide understanding	GAW
Oceans	Sea Level Rise	1870	Ocean Acidification,	Reconstructed from a combination of tide gauges and satellite altimetry	CSIRO & others
Cryosphere	Arctic and Antarctic Sea Ice Extent separately	1980	Arctic and Antarctic sea ice extent	The hemispheres must be reported separately, differences in behaviour & timing could misrepresent the change. Often the annual changes in the two hemispheres offset each other to some degree. Reports in terms of minimum, maximum or rate of change could be more relevant when reporting to the public.	Regularly reported by a number of agencies (e.g. National Snow and Ice Data Center, JAXA-National Institute for Polar Research, etc
	Area of land covered by snow and ice, for the N and S Hemispheres,	1980 (selected for consistency with the sea ice)	Snow and ice anomaly trackers	Snow Anomaly trackers: Near real-time tracking of NH SWE from GlobSnow (FMI) and the CMC daily snow depth analysis (ECCC)	reported by a number of agencies (e.g. National Snow and Ice Data Center; ECCC; not available for SH
Extremes	Heatwaves			Heatwave magnitude index[1]	WMO CCI
	Extreme Rainfall			As 95% percentile of rainy days >1mm[2]	
	Drought			GPCC Drought Index[3] (based on SPI and SPEI)	

[1] Heat wave magnitude index: -Russo, S.; Dosio, A.; Graversen, R. G.; Sillmann, J.; Carrao, H.; Dunbar, M. B.; Singleton, A.; Montagna, P.; Barbola, P.; Vogt, J. V. (2014) *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.
or alternatively see
Coumou D. and Robinson A.(2013) *Historic and future increase in the global land area affected by monthly heat extremes*, 2013 Environmental Research Letters, Volume 8, Number 3

[2] Karl, T.; Nicholls, N.; Ghazi, A. (1999) *Clivar/GCOS/WMO workshop on indices and indicators for climate extremes workshop summary*. Weather Clim. Extrem. 1999.
and
Albert Klein-Tank; Francis W. Zwiers; Xuebin Zhang (2009) *Guidelines on Analysis of extremes in a changing climate in support of informed decisions for adaptation*. Clim. Data Monit. 2009, 72.
And see:
http://www.eea.europa.eu/data-and-maps/indicators/precipitation-extremes-in-europe-3/assessment/#indicator-definition

[3] M. Ziese, U. Schneider, A. Meyer-Christoffer, K. Schamm, J. Vido, P. Finger, P. Bissolli, S. Pietzsch, and A. Becker *(2014) The GPCC Drought Index – a new, combined and gridded global drought index*, Earth Syst. Sci. Data, 6, 285–295, 2014 www.earth-syst-sci-data.net/6/285/2014/ doi:10.5194/essd-6-285-2014