First Joint workshop to (re)formulate open research questions of joint interest “Tipping Elements in the Climate System, with a Focus on the North Atlantic”

Picture 1 Seasmoke. Courtesy of Hans Jensen (DMI)

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About this document

Deliverable: D6.1 First Joint workshop to (re)formulate open research questions of joint interest: "Tipping Elements in the Climate System, with a Focus on the North Atlantic"
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Summary for publication

The first joint workshop on areas of common interest was held on 18-19 September 2017 at Wolfson College, Oxford (UK). The focus of the workshop was tipping elements in the climate system, with a focus on the North Atlantic. Blue-Action is focused on Arctic and high latitude changes. Therefore, the high number of tipping elements in this region and their potentially large impact on Northern Hemisphere climate is of particular interest and concern to Blue-Action scientists. The workshop was organised by the Blue-Action project to link Blue-Action scientists with experts outside the project. Key areas of research and actions for future collaboration were identified.

Work carried out

The workshop was organised by Didier Swingedouw (CNRS-University of Bordeaux), Gerard McCarthy (NOC /Maynooth University) and Sybren Drijfhout (SOTON/ KNMI), all Blue-Action scientist. The workshop was held over two days in Oxford, back to back with the Joint Science Meeting ACSIS - OSNAP – RAPID Understanding Change and Variability in the North Atlantic Climate System1.

Motivation

"Tipping points" in the climate system commonly refers to a critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system. "Tipping Elements" of the climate system refers to the large-scale components of the Earth System that may pass a tipping point.

Global assessments based on expert elicitation of tipping points are presented in Lenton et al. (2008). A quantitative assessment of the tipping points that are present in the state-of-the-art climate models used in the Intergovernmental Panel for Climate Change (IPCC) was provided by Drijfhout et al. (2015). The results of Drijfhout et al. (2015) focus attention on the high latitude North Atlantic and the Arctic ocean as regions containing a high number of tipping elements.

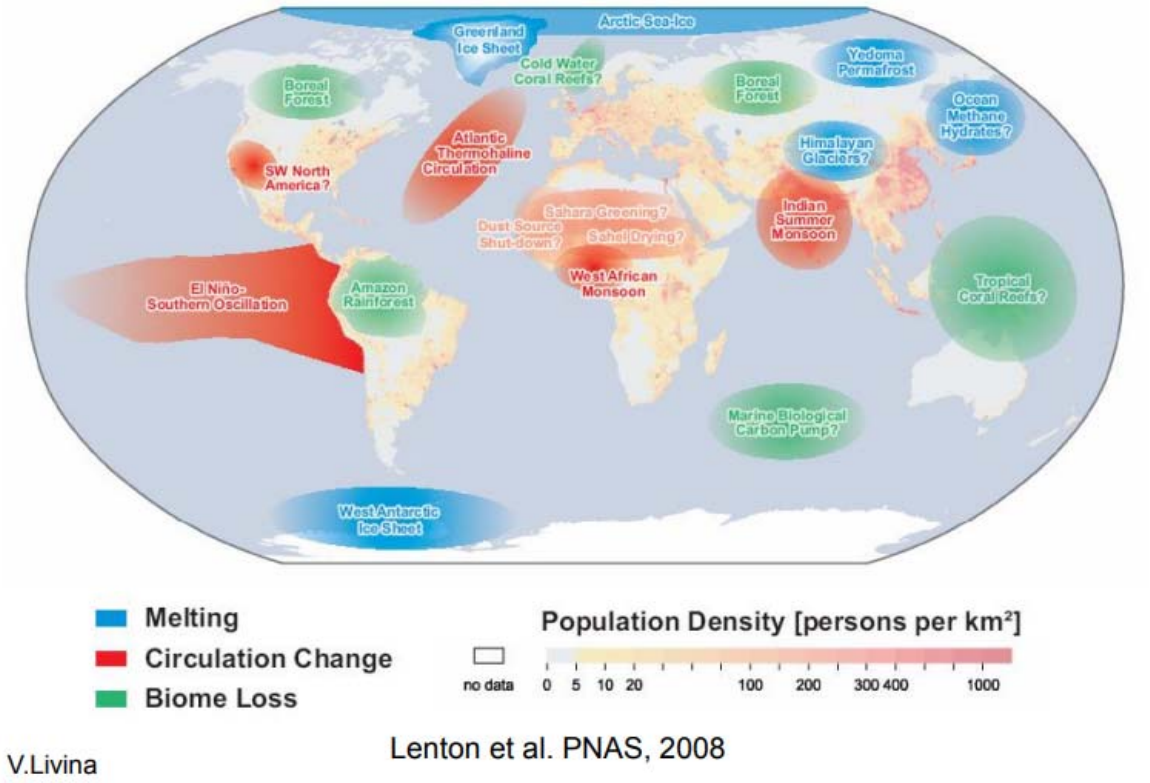
Blue-Action is focused on Arctic and high latitude changes. Therefore, the high number of tipping elements in this region and their potentially large impact on Northern Hemisphere climate is of particular interest and concern to Blue-Action scientists.

A number of skills and expertise gaps were identified by Blue-Action scientists. As a result of this, the workshop was organised to address these gaps and connect the missing expertise with the Blue-Action project.

Contents

A catalogue of identified tipping points and tipping elements were presented (Lenton et al., 2008; Drijfhout et al., 2015) with particular focus on the North Atlantic.

[1] The RAPID event took place on 19-21 September 2017, Oxford
http://www.rapid.ac.uk/aor17/programme.php



Picture 2 Tipping elements in the Earth's climate system, Ref: Lenton et al. 10.1073/pnas.0705414105 in the presentation of Valerie Livina (NPL)

The Atlantic Meridional Overturning Circulation (AMOC) which encompasses the Thermohaline Circulation of the Atlantic has long been identified as a tipping element in the climate system (Stommell, 1961). Recent work has highlighted the potential for abrupt change due to convective collapse in the subpolar North Atlantic (Sgubin et al., 2017[2]). These two tipping elements are within the scope of expertise of the Blue-Action community.

Discussion expanded to areas of expertise not present in the Blue-Action consortium. Paleoclimate data were discussed as the best observational evidence for abrupt climate change. Dansgaard-Oescher oscillations (Daansgaard et al., 1993) are abrupt changes in climate during the last ice age. Collapses and recoveries of the AMOC are frequently cited as the driver of these oscillations (Broeker, 2010). New high-resolution proxies for Dansgaard-Oescher oscillations are becoming available (Landais, personal communication). These high-resolution proxies are useful for understanding the events in greater detail and early detection of these events.

Early warning indicators of abrupt climate change are possible using mathematical analysis. Typical early warning signals arise from slowing oscillations prior to a change in state of the system that are indicated by increased autocorrelations (Livina and Lenton, 2007; Boulton et al., 2013).

Three areas of tipping point analysis were highlighted:

- anticipation,
- detection, and
- forecasting of tipping (Livina et al., 2013).

[2] This peer-reviewed article acknowledges explicitly the Blue-Action project, and it is in open access.

Emerging techniques such as machine learning have also seen useful application to the detection of tipping points. In addition to mathematically-derived early warning signals, the physical precursors of tipping points were also discussed such as deep density changes for detection of AMOC change (Baehr et al., 2008).

The representation of abrupt changes in climate models was discussed. The state-of-the-art CMIP5 models are often thought of as too stable (Valdes, 2011) and the models that do show abrupt changes are often dismissed as unreliable. Emerging results from the next iteration of the coupled model intercomparison project, CMIP6, were thought to be promising for improving the simulation of instabilities in the climate system.

Attendees

	Name	Institution	Country
1.	Didier Swingedouw*	University of Bordeaux	France
2.	Gerard McCarthy*	NOC /Maynooth University	UK
3.	Sybren Drijfhout*	SOTON/ KNMI	Netherlands
4.	Pedro Antonio Gutiérrez	University of Cordoba	Spain
5.	Pablo Ortega	BSC	Spain
6.	Andreas Born	University of Bergen	Norway
7.	Martin Widmann	University of Birmingham	UK
8.	Karin Margretha Larsen*	Havstovan	Faroe Islands
9.	Christophe Cassou	CERFACS	France
10.	Jon Robson	University of Reading	UK
11.	Penny Holliday*	NOC	UK
12.	Javier Sánchez Monedero	University of Cordoba	Spain
13.	Steffen Olsen*	DMI	Denmark
14.	Valerie Livina	NPL	UK

* Blue-Action scientists

Main results achieved

A structure for further work was outlined:

- The value of the quantitative approach for analysis of tipping points in climate models pioneered by Drijfhout et al. (2015) was acknowledged and should form the basis for analysis of the next iteration of CMIP6 models
- The need for a model-based process understanding of tipping elements and their associated tipping points was acknowledged
- The value of observations for validation and constraint of simulations was emphasised
- The development of early warning indicators and physical precursors was seen as a key bridge to the utility of further work
- The assessment of the associated societal impacts and delivery of the information to policy-makers and stakeholders was seen as a key outcome of further work

Future Work

It was agreed that the lines of communication established by this clustering workshop would remain open and the potential for collaboration on an upcoming Horizon 2020 Call on "Addressing knowledge gaps in climate science, in support of IPCC reports" would be explored.

Impact

The exchange of knowledge at workshop contributes directly to the following expected impacts of Blue-Action (Section 2.1.1 Expected impacts of the programme, DoA, Part B):

- Improve the capacity of climate models to represent Arctic warming and its impact on regional and global atmospheric and oceanic circulation
- Improve capacity to predict the weather and climate of the Northern Hemisphere, and make it possible to better forecast of extreme weather phenomena
- Contribute to a robust and reliable forecasting framework that can help meteorological and climate services to deliver better predictions, including at sub-seasonal and seasonal time scales

Lessons learned and Links built

A special link has been built for a collaboration with Valerie Livina (NPL), who has been invited to join the annual meeting of Blue-Action in Bologna and to cooperate further with the teams at the event breakout sessions. Valerie Livina delivered a presentation on the "Tipping point analysis of geophysical data" and presented the Tipping point toolbox.

Contribution to the top level objectives of Blue-Action

Blue-Action is focused on Arctic and high latitude changes. Therefore, the high number of tipping elements in this region and their potentially large impact on Northern Hemisphere climate is of particular interest and concern to Blue-Action scientists.
This deliverable contributes to the achievement of all the objectives and specific goals indicated in the Description of the Action, part B, Section 1.1: http://blue-action.eu/index.php?id=4019:

- Objective 1 Improving long range forecast skill for hazardous weather and climate events
- Objective 2 Enhancing the predictive capacity beyond seasons in the Arctic and the Northern Hemisphere
- Objective 3 Quantifying the impact of recent rapid changes in the Arctic on Northern Hemisphere climate and weather extremes
- Objective 5 Optimizing observational systems for predictions
- Objective 6 Reducing and evaluating the uncertainty in prediction systems
- Objective 8 Transferring knowledge to a wide range of interested key stakeholders: A number of skills and expertise gaps were identified by Blue-Action scientists. As a result of this, the workshop was organised to address these gaps and connect the missing expertise with the Blue-Action project.

References (Bibliography)

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Dissemination and exploitation of Blue-Action results

Dissemination activities

Type of dissemination activity	Title	Date and Place	Estimated buget	Type of Audience	Estimated number of persons reached
Organisation of a workshop	Tipping Elements in the Climate System, with a Focus on the North Atlantic	18-19 September 2017 at Wolfson College, Oxford (UK)	See form C of the partners involved.	Scientific Community (higher education, Research)	15

Peer reviewed articles

Title	Authors	Publication	DOI (if available)	Publication Status (in preparation, under review, accepted)	Open Access
Abrupt cooling over the North Atlantic in modern climate models	Giovanni Sgubin, Didier Swingedouw, Sybren Drijfhout, Yannick Mary & Amine Bennab	NATURE COMMUNICATIONS | 8:14375 |	DOI: 10.1038/ncomms14375 |www.nature.com/naturecommunications	Published	Open Access: green journal. Link to the publisher version of the paper: http://www.nature.com/articles/ncomms14375

Uptake by the targeted audiences

- As indicated in the Description of the Action, the audience for this deliverable is *for t*he general public (PU) is and is made available to the world automatically via https://cordis.europa.eu/
- The contents of the workshop are for a scientific audience. Key presentations of the workshop can be found in the redmine of the project https://code.mpimet.mpg.de/issues/8093
- The peer-reviewed article of Sgubin et al., 2017 is in green OA available: Link to the publisher version of the paper: http://www.nature.com/articles/ncomms14375
- The contents of the workshop have been widely disseminated to the Blue-Action community and the Arctic Cluster at the annual meeting of Blue-Action