A Premise for and Thoughts Underpinning the B2B Initiative

Version 7

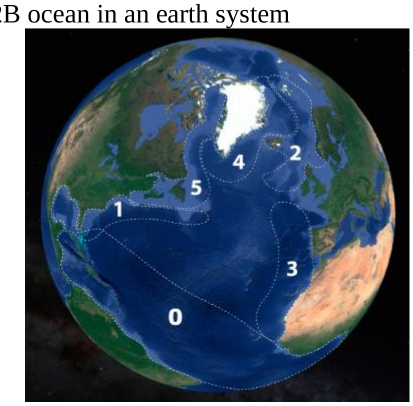
The Joint B2B North Atlantic-Arctic Ocean Science Strategic Framework [1]

Preamble: The North Atlantic-Arctic Ocean Science Initiative (B2B) is designed to respond to the unprecedented and fundamentally different world where the scientific evidence suggests that oceanic and coastal changes are accelerating at rates exceeding those in other regions on the planet. This region of 20 nations, interconnected by the North Atlantic-Arctic Ocean[2], contains one the most active trade routes in the world, hosts one of the world's important fisheries and key multinational geopolitical and socio-economic agreements activities that are directly linked to the regions coastal margins. The region is increasingly affected by global and local changes in the Earth's climate system that drive the melting land-based ice that already contribute 40% of the global mean sea level rise. In this context, the World Economic Forum (WEF)[3] suggests that:

The 20 nations (from the Florida to Spain) all have coastal borders that have direct access to the ocean in this North Atlantic-Arctic region, including Belgium, Bermuda, Canada, Denmark/Greenland/Faroe Island, Estonia, Finland, France, Germany, Iceland, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Russia, Spain, the Svalbard Archpelago, Sweden, the United Kingdom and the United States.

> "*We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving all stakeholders of the global policy, from the public and private sectors to academia and civil society*".

The B2B is Designed to be a *Strategic Framework* for Research and Education Projects: The B2B Initiative is proposed as a "***strategic framework***" to host scientific and scholarly "***evidence-based***" and "***use-inspired***" [4] projects that a) through developing both the observational capability, the process understanding and the numerical modelling, aim to improve the forecasting of the physics, dynamics and biology of the B2B ocean in an earth system framework, thereby reducing risk in current day's marine operations including fisheries, and b) to address the emerging patterns of climate, environmental, technological and socio-economic change. The speed of these changes has no historical precedent as they are disruptive and foretell of unprecedented transformations of the socio-economic, physical, digital, and biological spheres of societies, affecting both the public and the private interests. In summary, the B2B provides a "***strategic framework***" within which projects develop their analyses of the scientific, organizational, legal and socio-economic issues where the nature of ***use-inspired*** science should contribute to improving existing, relevant ***science-to-policy decision-making value cycles***, rather than to historical institutional thinking.



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[1] **This is not necessary the title for the effort, it is simply a working title to get the conversations moving**. Another title might be the Joint North Atlantic-Arctic Ocean Region Study (JNAORS), and our Norwegian science colleagues at the University of Tromsø, Norway's Arctic University, **suggested that we call this B2B: From Bermuda to Bear Island in Svalbard.**

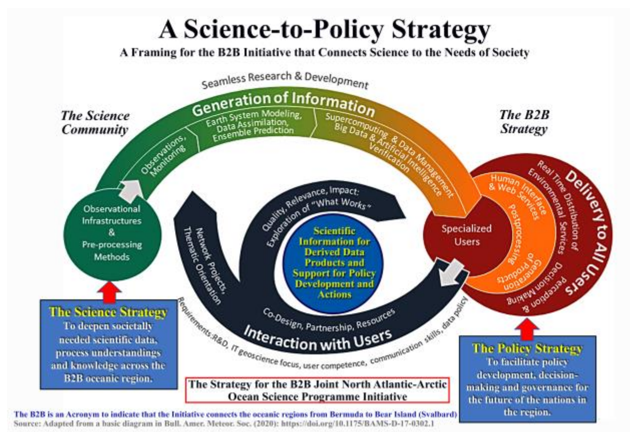
[2] Benway, H. M., E. Hofmann, M. St. John (2014). Eos Trans. AGU 95(35),317, DOI: 10.1002/2014EO350007. ***Building international research partnerships in the North Atlantic-Arctic System: An international planning workshop for a North Atlantic-Arctic science program***. This international planning workshop was the first step in fostering the development of a large multidisciplinary research program focused on the coupled North Atlantic-Arctic system that will facilitate partnerships among U.S., European Union (EU), and Canadian scientists. The workshop, which was jointly supported by the U.S. National Science Foundation (NSF) and the EU, convened expertise in marine biogeochemistry, biodiversity, ecosystem dynamics, paleoceanography, ocean physics, etc. to establish the interdisciplinary framework for a large international research initiative that will examine key components of the North Atlantic-Arctic system (e.g., Atlantic Meridional Overturning Circulation, or AMOC, spring bloom timing, biological carbon pump, ecosystem structure as well as their dynamics, etc.) and associated sensitivities to circulation and climate changes. https://www2.whoi.edu/site/northatlanticarcticsystem/

[3] **The World Economic Forum's posits a 21st century** "*Fourth Industrial or Knowledge Revolution*" that is increasingly founded on "cyber-physical systems" that involves entirely new capabilities for people and machines. (https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution/).

[4] **Use-inspired" research** consists of scientific investigation whose rationale, conceptualization, and research directions are driven by the potential use to which the knowledge will be put. https://www.nap.edu/read/12015/chapter/5

The 21st century scientific agenda is evolving from numerous sources[3], B2B seeks to address at least these four major themes within the six Core Regions of the North Atlantic-Arctic oceanic region:

- **Improve the analysis and forecasting of the ocean state on all time scales and including changing climate, both globally and locally**: Focused on the dynamic interaction between the actions of societies and the global climate system, by addressing the ocean state and its forecasting and projection in an earth system framework as a continuum in time and space – and ask questions like: How can risks be reduced in current marine operations? How are the Earth's massive ice sheets changing? How fast will sea level rise and affect coastal regions around the world? What are the impacts on rainfall, extreme weather events, flooding and drought? How do changes in ecosystems and their services affect humankind? How do changes in landscapes and water resources impact humankind's future? What are the consequences for important oceanic (e.g., fisheries) and marine systems (e.g., coastal wetlands, estuaries, and coral reefs) from higher levels of CO_2 from the consequential increases in ocean acidification?
- **Changes in Relevant Socio-Economic Systems**: Humankind is nested in global-scale socio-economic changes (e.g., the globalization of many aspects of modern civilization) that affects business and governance over a wide range of foundational issues essential to us, the origins of which range from population increases, demographic shifts to the availability of energy, food and water.
- **Challenges that Impact Human Health and Societal Well-being**: The health of humans and of civil societies are affected by changes in ocean state extremes and in increasing temperatures and precipitation, with consequences such as enhanced risk of waterborne and foodborne diseases and allergies, and the proliferation of insects that spread diseases like Zika, West Nile, dengue and Lyme disease into new territories. Extreme weather and climate-related natural disasters (e.g., floods and draughts) are affecting vulnerable populations, such as the elderly, children and lower-income communities.



- **Geopolitical Realities, Governance Issues and Treaties** determine the evolvement of **(a)** economic, environmental and social disruptions that are likely to continue to accelerate, **(b)** global knowledge-based socio-economic societies, **(c)** new management and operating models, **(d)** a greater demand for transparency and accountability, and **(e)** the expectation for returns on financial and programmatic investments**.**

A New Expectation for the B2B Strategic Framework: This B2B Strategic Framework is emerging in ways that create new expectation for the scientific community from public and private funders in particular on three major aspects[5] (Additional Material in Appendix I):

- **Implement Foundational Basic and Use-inspired Research and Education:** Research and related technology research that contributes to both improved understanding of fundamental earth system processes, adaptation strategies and practices and mitigation changes, *all of which facilitates effective policy and decision making*,
- **Conduct Research and Education Projects that are Explicitly Focused on Adapting to the Climate and Environmental Change:** A program that addresses these four[6] elements that: (a) Improves the quality, accessibility, and usability of climate hazard and risk information essential to adaptation efforts, (b) Increases investment in adaptation-focused research, development, and demonstration from both governmental and

[5] **Examples:**(1) EU's Europe Horizon: A research and innovation initiative to increase the effectiveness of funding addressing clearly defined targets of societal interest from research on adaptation to climate change affecting societal transformation to climate-neutral and smart cities (https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en) and (2) **Sweden's MISTRA** program that invests in research aimed at solving key environmental problems and promoting Sweden's future sustainable development and competitiveness: https://www.mistra.org/en/.

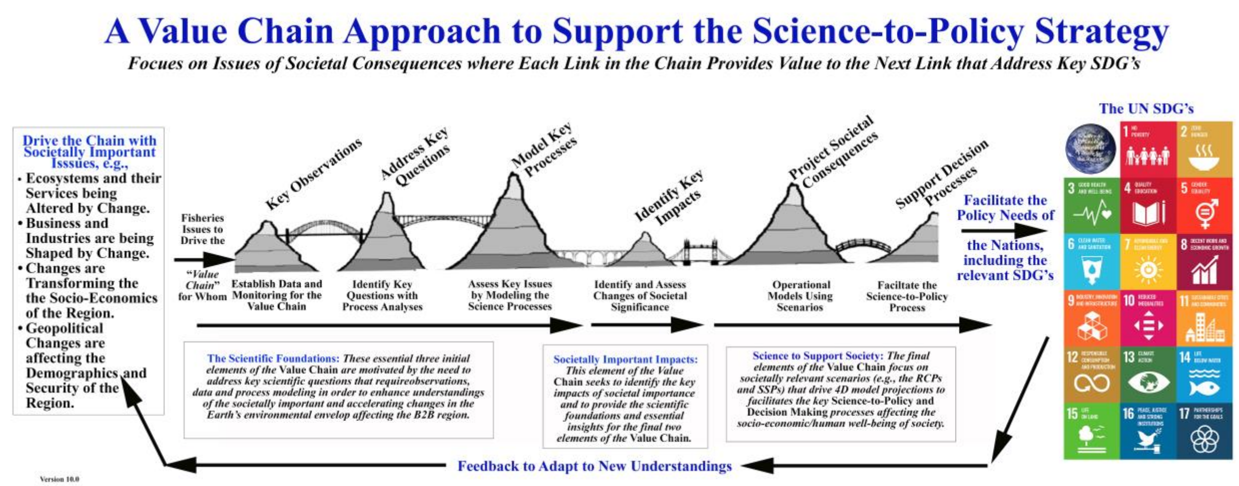
[6] https://issues.org/perspective-adapting-to-global-warming-four-national-priorities/

private sources, (c) Develops the means to identify the public and private economic costs of adaptation, and (d) Strengthens policies and plans related to adaptation at all levels of society, and

- **Initiate Research and Education that Supports Key Mitigation Realities:** The research and education community need to focus on use-inspired ways to reduce local GHG emissions to fulfil national emission reduction commitments. Further, focus aspects of use-inspired projects that have the potential to lead to economically viable renewable, alternate and/or more efficient energy systems, geoengineering or other adaptive technologies and practices that are socio-economically acceptable.

Planning and Organizing for the B2B Strategic Framework: It is essential to develop interest in and support among key individuals and scientific organizations within the B2B region to continue to develop the B2B and to explore how to fund the B2B Initiative.

To develop and implement the B2B initiative further, the B2B Advisory Planning Committee is exploring innovative methodologies,[7] one of which is to structure the B2B Strategic Framework as a ***Value Chain [8],*** which explicitly facilitates[9] the "*Science-to-Policy Strategy*"[10]. In this graphic of the ***Value Chain*** each link in the chain provides value to the next link in ways that ultimately maximizes the beneficial outcomes for society. Note also the feedback to earlier stages in the chain as experience grows, transforming it to a value cycle.



The ***value chain*** strategy is proposed as a methodology to implement the ***Strategic Framework*** in which the graphical presentation suggests five elements: **(1)** What are the societal relevant drivers, **(2)** Address the three elements of the relevant science, **(3)** Identifies the key impacts to drive the Science-to-Policy Chain , **(4)** The next two elements are designed to explicitly facilitate the policy/decision-making/societal well-being needs of societies in the B2B region, and **(5)** The set of overarching policy and decision-making needs of the nations, cultures, industries/businesses/NGO's etc. in the region.

The B2B ***Strategic Framework***, nested in this ***value chain strategy*** is to improve the four-dimensional (4D) near real time analysis and operational forecasting of physics, dynamics and biogeochemistry systems in the

Issues with Consequences that Drive the Value Chain Strategy

- **Arctic Life Changes are Transforming the Socio-Economics of the Region**
- **Atmospheric and Ocean Temperatures are Increasing at Rates Exceeding the Global Mean**
- **Ecosystems and their Services are Altered by Change**
- **Energy Sources and Societal Demands are Changing National Policies and GHG Emissions**
- **Extreme Weather Events are Accelerating Flooding and Droughts**
- **Fisheries and Aquaculture Industries are being Shaped by Change**
- **Geopolitical Changes are Transforming Demographical and Security Issues**
- **Indigenous Cultures and their Livelihoods are being Impacted**
- **Land Ice Is Melting Changes Water Supplies and Increases Sea Levels**
- **Natural Resources Are Being Developed with Socio-Economic Implications**
- **Ocean Circulation Changes have Implications for the Euro-Arctic Nations**
- **Permafrost Is Thawing affecting the Civil Infrastructure and GHG Emissions**
- **Pollutants are Increasing in the Environment Impacting the Well-Being of Society**
- **Sea Ice Melting is Opening Seaways and Changing the Coastal Regions**
- **Shipping & Tourism are Increasing with Navigational and Port Implications**

[7] Lazo, J. K., R. S. Raucher, T. J. Teisberg, C. J. Wagner and R. F. Weiher, 2009*: Primer on Economics for National Meteorological and Hydrological Services*. University Corporation for Atmospheric Research, Boulder,

[8] The *Value Chain Strategy* is discussed in *A Value Chain Approach to Optimising Early Warning Systems*: https://www.undrr.org/publication/value-chain-approach-optimising-early-warning-systems

[9] *From Science to Policy and Society: Enhancing the Effectiveness of Communication*, Front. Mar. Sci., 14 September 2016 | https://doi.org/10.3389/fmars.2016.00168

[10] Laing, M. & Walter, J. (2018). *Policy influence: tactics and strategies for researchers*. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.

B2B region by supporting the policy and decision-making interests of the nations and their societies such as listed here. It is important to note that to reach many of the SDGs as well as solving the list of issues that drive the value cycle strategy, ocean state forecasting is required both on short timescales (days-weeks) and longer (years, decades, centuries) i.e. both as an initial value problem and as a boundary value problem.

Appendix I

An Elaboration of What B2B Could Become

Øystein Hov, (Former Director of Research at the Norwegian Meteorological Institute and Past President (2013-2019) of WMO Commission for Atmospheric Sciences)

Understanding, analyzing and forecasting wind, waves, currents, tides, storm surges, sea ice – the support structure for marine activities in the Atlantic rim states

How can B2B improve the four-dimensional near real time analysis and forecasting of physics, dynamics and biogeochemistry of the B2B region ("the backend"). By specialized post-processing of the information from the continuously evolving storage in the backend, specific applications and user needs can be addressed like:

- Characterization of living conditions for marine life (management of fisheries),
- Fishing industry – weather and marine conditions, supply and delivery lines
- Aquaculture – environmental conditions
- Ship lanes, trade routes – winds, currents, icing conditions, harbors
- Search and rescue operations
- Operating conditions for coastal industry and business
- Sea ice conditions
- Military and civilian security

Storm surges, tides

- Sea level rise

Historically all Atlantic rim states have implemented *elaborate operational support functions of the marine state including weather* to protect their economic and security interests in "this region of 20 nations, interconnected by the North Atlantic-Arctic Ocean, which contains one the most active trade routes in the world, one of the most important world fisheries, contains globally significant socio-economic activities in the coastal margins, businesses and industry that are directly linked to the coastal margins of the North Atlantic-Arctic region, herein called the B2B region. Further, global and local changes in the climate system are accelerating land-based ice melting, adds substantial to global sea level changes along with changes in weather and climate extremes that increasingly are controlled by ocean processes that affect global natural systems. This forms the basis upon which to develop the B2B research."[11]

The marine operational support functions often have a long history. They are usually mandated in national legislation which regulates their organization, mission and funding (in support of safety of ship lanes and transport at sea, search and rescue, harbor access, light houses, aqua culture, fisheries including supply and delivery structures, offshore industry, military and civilian security, leisure activities, environmental pollution, coastal erosion including storm surge preparedness, tidal flows, sea level rise etc.).

[11] Quoted from an earlier B2B Premise Document

To underpin these support functions, specialized observational programmes are often in operation on a routine basis where observations flow in to be analyzed and exploited for specific service purposes, often in combination with numerical modelling and with local highly skilled, user informed experience built into the service provision.

Going around the Atlantic states there are dozens of specialized institutions that together cover a very substantial capacity in risk management of local or national maritime operations, and often with long service histories which seen as a whole also provide significant elements of the recent 50-100 years of change in regional climate, marine biological resources and biogeochemical cycles.

This support structure may be characterized as not optimally integrated. Observational programs, model systems and post-processing procedures and capacities as well as data flow and storage are not standardized and balanced among the individual institutions, which often do their work in separation being mandated according to specific purposes, and for specific limited regions, and supported by the budgeting and political control structures which vary a lot from state to state ("a collection of legacy systems").

This support structure is traditionally marked by a lack of *lateral perspective* which means it is allowed to specialize and advance in the specific missions, while the encouragement to cross boundaries into adjacent themes or geographical domains has been absent and is in some countries prohibited by law. This has meant that quality advancement – and risk management improvements - have been slower than necessary, hence the term *lack of lateral perspective*.

The coupling of the routine support structure for marine operations and the science community varies a lot from country to country, from institution to institution and from topic to topic, at times significant self protection mechanisms are at work and has evolved over very long periods of time. A milestone of long-lasting detrimental effect has in my view been Vannevar Bush's report *Science, the Endless Frontier* in June 1945 which in a top-down way separated science and applications in the US up to this day. In the footsteps of this separation has evolved a bottom-up academic tradition where applications of science are underfunded and considered to be inferior and second class and to be left with engineers and routine oriented wage earners. During the last two-three decades academia has been increasingly exposed to market forces and competitiveness for funding at the same time as the separation of science and applications has been maintained. As a consequence the mutual interest and respect between science and operations is weaker than it ought to be, meaning that opportunities for societal risk reduction and value creation remain under explored.

Large value can possibly be created by breaking new land (high risk science). While "adding fertilizer to already high yield fields" usually only creates marginal new value. Breaking new land means that barriers established in science, between science and services/society/operations, between geographical regions, institutions, government ministries and international agencies, need to be reduced wherever they prevent knowledge-based evolution to take place.

Recommendations:

- In my view B2B should analyze the scientific, organizational, legal and financial status of backend-frontend systems in operation in the Atlantic rim countries for the range of applications suggested above. The analysis may provide an estimate of what can be gained by allowing the combined science-backend-frontend-user community to work in a value cycle mode dictated by the nature of the issues rather than the historical institutional thinking. How can a value cycle approach like this enhance the understanding of the physical, dynamical and living B2B marine environment, translate the understanding into applications to risk reduction and value creation (innovation), and allow the user experience to feed into further research? The role of the scientist is to take part in the curiosity driven development of any segment of the value cycle, both in a

fundamental and in rather applied ways (This is "Cycles of invention and discovery"-thinking of Narayanamurti and Odumosu, Harvard University Press 2016).

- As a consequence B2B will not become a traditional research programme, it will first of all become a framework which needs to interact with and influence a system of countries, governments, regions, institutions, cultures and science disciplines which all may state that their goal in a broad sense is risk reduction in the marine sector, but where too modest steps are taken to realize the inherent potential when one allows the goal itself, and not only the institutional thinking, to define the approach for how to reach it.[12]
- To do this B2B needs to enter into science diplomacy and represent lateral thinking. B2B would need to assess the current situation within "the B2B region and B2B topics". This assessment would need to cover science, user and service interaction, governance nationally and internationally, the education systems.[13] The societal risk value at stake should be quantified to characterize the gains (in terms of economy and sustainability) that could be possible.
- The direction the EU framework programmes, now Horizon Europe, takes is to activate the full value cycle and emphasize that this is a requirement for innovation. The EU is a major funder and is therefore strongly bound by political and legal constraints and compromises which a "penniless" B2B is not. B2B is without funding or political capacity and is only constrained by intellectual capacity. That can be a significant advantage, however, if the right people and institutions are involved in its planning and execution.
- An assessment along these lines could end up with long lists of barriers in the current mode of operation, and in a number of warnings saying that more can be lost than gained (due to structural defense mechanisms) at least in the short term (decadal scale) by attempting large scale restructuring. Principles underpinned by facts therefore need to be an important outcome of the assessments and recommendations, which should address:
  - the need for balanced, interoperable observation systems for the earth system compartments influencing the marine compartment. The FAIR principles for data stewardship need to be invoked.
  - removing the barriers between routine observations, research observations and field experiments by realizing that embedding the research observations into the framework of routine observational capacity, near real time data flow, data assimilation and model analysis/forecasts can actually add significant information content as well as guidance for further research steps. Existing operational marine services usually derive from state-of-the-art science and with dedicated research efforts underpinning it. Essential components are observational systems, near real time data flow, data assimilation, model calculations, data storage, together called the "backend" of an operational system. Special user informed applications - the "frontend" – rely on the harvesting of data from the backend storage which is continuously being updated. Both the post-processing modelling capability in the frontend and in the backend, model generalize the observational data in a manner which retain as much as possible of the observed characterization of the state at a given time or region. The frontend and backend models can also provide diagnostics tailored for specific research questions. And being operational means that the frontend and backend model capabilities over time can provide high quality climatologies both related to climate and biodiversity/living resources. This should be a part of the *research infrastructure* in B2B. The other parts are existing routine observational capabilities related to the ocean as well as

[12] A recent example is the response of the health service to the covid19 crisis. The hospitals in the National Health Service in the UK "shuffled responsibilities acting as parts of wider networks rather than as stand alone institutions. Health care must be based on the needs of the population, not the design of the institution" (The Economist 5 December 2020 p. 28)

[13] Most university curricula are disciplinary and in depth focused. This needs to be retained but complemented by a strong "lateral thinking" requirement in science, organization, governance, economics, environmental protection and sustainability

existing research instrumentation and carriers of such instrumentation with their human and institutional capacities.

- Through so-called data denial experiments both the backend and frontend models can identify parameters or regions which are under-observed and where observational investment would be of special value, and redundancies can be identified in the observational capabilities where adding more would only add marginally to the quality of the analysis or forecasting. The conclusion of an assessment could in my view be a recommendation to associate B2B strongly to one or several regional or global operational centres for forecasting/analysis (like NCEP, Copernicus Marine Environmental Monitoring Service CMEMS, ECMWF, or one or more of most advanced national weather centres in Asia or Europe) (*The B2B research infrastructure)*.
- the need for seamless earth system model development and operational use
- the need for operational value cycles where application experience is fed back into the discovery and translation parts of the cycle, and the expansion of such cycles to broader and broader applications (including socio economics, culture, law).

➢ Consequences for higher education: A need to foster the lateral thinkers' perspective alongside the indepth disciplinary focus

➢ Consequences for innovation: In my view the removal of the barrier between science and services opens for significant innovation when the informed user meets the expert scientist on an equal footing.

➢ To attract interest to this approach from key contributors in the science community, the B2B framework would need to contain research projects. These should provide substance to the broad transformational vision of the B2B framework. To provide a critical mass to pursue these rather idealistic goals with many barriers beyond the science community, one would need a very visible and nonpartisan sponsor and protector with strong symbolic authority, like National Academy of Sciences with its president. In my view Paul Wassmann's contributions to B2B planning are helpful building stones for research projects within the B2B framework.

The Growth of the Earth System Perspective in Science

There is now a rapid growth in *seamless prediction* which considers all compartments of the Earth system as well as disciplines of the weather–climate–water–environment enterprise value cycle (monitoring and observation, models, forecasting, dissemination and communication, perception and interpretation, decision-making, end-user products) to deliver tailor made weather, climate, water and environmental information covering minutes to centuries and local to global scales.

The grand challenge of accelerating advances in Earth system observation, analysis, and prediction capabilities was postulated by Shapiro et al. (2010).[14] In this context seamless prediction was introduced for sub-seasonal to seasonal prediction to span the boundary between weather and climate (Brunet et al. 2010).[15] These authors extended the use of seamless beyond the realm of atmospheric predictions to include the consideration of biophysical, medical, and socioeconomic factors pertinent to successful decision making.

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[14] Melvyn Shapiro, Jagadish Shukla, Gilbert Brunet, Carlos Nobre, Michel Béland, Randall Dole, Kevin Trenberth, Richard Anthes, Ghassem Asrar, Leonard Barrie, Philippe Bougeault, Guy Brasseur, David Burridge, Antonio Busalacchi, Jim Caughey, Deliang Chen, John Church, Takeshi Enomoto, Brian Hoskins, Øystein Hov, Arlene Laing, Hervé Le Treut, Jochem Marotzke, Gordon McBean, Gerald Meehl, Martin Miller, Brian Mills, John Mitchell, Mitchell Moncrieff, Tetsuo Nakazawa, Haraldur Olafsson, Tim Palmer, David Parsons, David Rogers, Adrian Simmons, Alberto Troccoli, Zoltan Toth, Louis Uccellini, Christopher Velden and John M. Wallace (2010) An Earth-system Prediction Initiative for the 21st Century. BAMS 91, 1377-1388.

[15] Brunet, G., S. Jones and P. Ruti, editors (2015) Seamless prediction of the Earth system from minutes to months. The collection of White Papers from the World Weather Open Science Conference in Montreal, Canada 16-21 August 2014. WMO-No. 1156, Geneva.

The Growth in High Quality Service Provision

There is now a strong growth in high quality service provision for all parts of the earth system. This takes place in a myriad of institutions and organizational settings nationally and internationally, and in the public and private and hybrid sectors. There is a willingness of private investors in many places because the value of risk reduction in e.g. marine operations is significant and underexploited. The channels for private investments have often been too narrow and the governmental services have been allowed to grow over generations without being really challenged. Here is a large potential.

Acknowledgement:

The suggestions above are influenced by experience from World Meteorological Organization and 20 years of involvement there, through chairing Global Atmospheric Watch (GAW) 2000-2013 and being president of the Commission for Atmospheric Sciences 2013-2020. Steps are taken between IOC (UNESCO) and WMO to couple the atmosphere and the ocean in the type of framework outlined here. Similar efforts also pertain to atmosphere and hydrology (through WMO, IHP of UNESCO and IAHS of ISC).