CLIVAR Research Focus Proposal

Title: Tropical basin interaction

Acronym: TBI

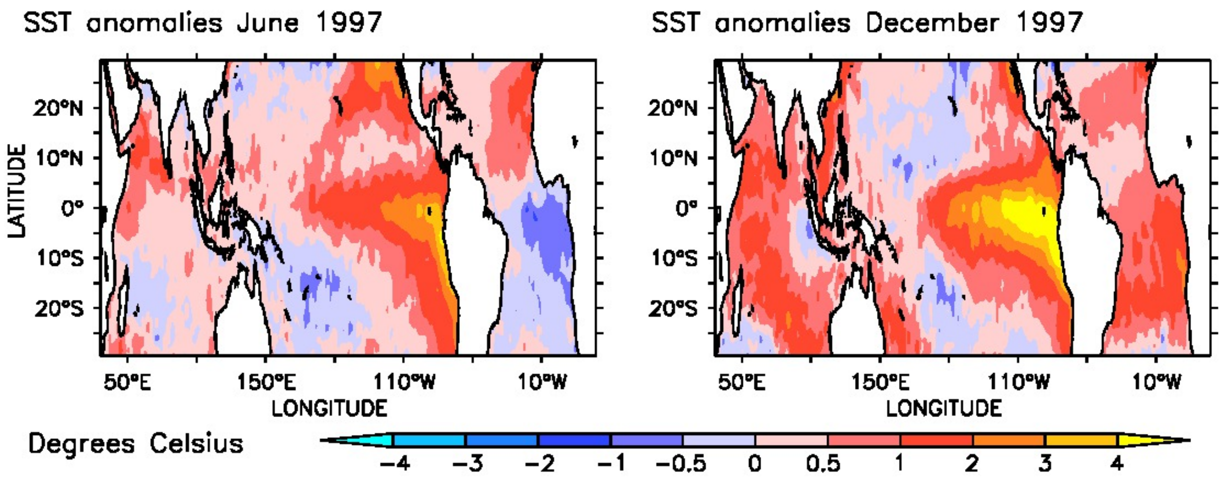

Figure 1. The development of the 1997 event appears influenced by the conditions in the Atlantic during boreal summer. The representation of this interaction and that with the Indian Ocean is thought to be important for predictability in the tropics. Notable are also the same-signed SST anomalies in tropical Pacific and Atlantic during the mature El Niño, which only occurs during a few events. Data: HadISST.

Synopsis

This RF shall drive a paradigm shift toward the recognition that tropical basin interaction (TBI) is of central importance for both understanding and predicting climate variability. We aim to create a consensus on the mechanisms underlying TBI and how these contribute to predictability, and we will spur research on how these interactions are affected by low-frequency climate variability and long-term climate change. This will be achieved by using existing numerical simulations and observations, but also by coordinating new climate model experiments and by compiling new paleo proxy data. The RF will arrange workshops, conference sessions, and summer schools, and will produce several community papers.

1. Scientific Background and Rationale (max. 1500 words)

Scientific background

Interaction between the Pacific, Atlantic, and Indian Ocean basins (also referred to as "interbasin interaction" or just "basin interaction") is increasingly recognized as a key factor in understanding climate variability on interannual to decadal timescales (Wang 2006, Rodriguez-Fonseca et al. 2009, Izumo et al. 2010, Ding et al. 2012, Ham et al. 2013, Chikamoto et al. 2015, Kucharski et al. 2015, McGregor et al. 2018, Cai et al. 2019, Wang 2019, Keenlyside et al. 2020). While it has long been known that El Niño-Southern Oscillation (ENSO) has far-reaching influences across the globe (Klein et al. 1999), it was commonly understood that these influences mostly operated in one direction, from the Pacific to other ocean basins and surrounding continents. More recent results, however, indicate that both the Atlantic and Indian Oceans may in turn influence the tropical Pacific in profound ways (see Fig. 1 for one particular example) and that they contain internal patterns of variability that are partly independent of ENSO.

The tropical Indian and Atlantic Oceans are found to act as thermal capacitors to ENSO, storing energy and then releasing it with a delayed influence on ENSO that may enhance its predictability (Xie et al., 2009; Wang et al., 2017; Fig. 2). El Niño events typically cause warming that begins in boreal summer in the southwest Indian Ocean, transforming into an Indian Ocean Dipole (IOD) event and an Indian Ocean Basin (IOB) mode in the following seasons (Xie et al., 2002; Du et al., 2009). The associated diabatic heating affects the circulation over the tropical Pacific (Xie et al., 2002; Yang et al., 2007; Annamalai et al., 2010; Luo et al., 2010) and contributes to the demise of the El Niño event (Kug and Kang, 2006; Dommenget et al., 2006). In addition, an oceanic pathway can contribute to the transition to La Niña (Zhou et al., 2015). The warming of the north tropical Atlantic in boreal spring following an El Niño event likewise can contribute to the demise of the event (Dommenget et al., 2006; Ham et al., 2013). Studies show that this two-way interaction with the other basins leads to ENSO variability with a more biennial character (Kug and Kang, 2006; Dommenget et al., 2006; Jansen et al., 2009), and that these feedbacks act as a delayed negative feedback, enhancing the predictability of ENSO (Dommenget and Yu, 2017).

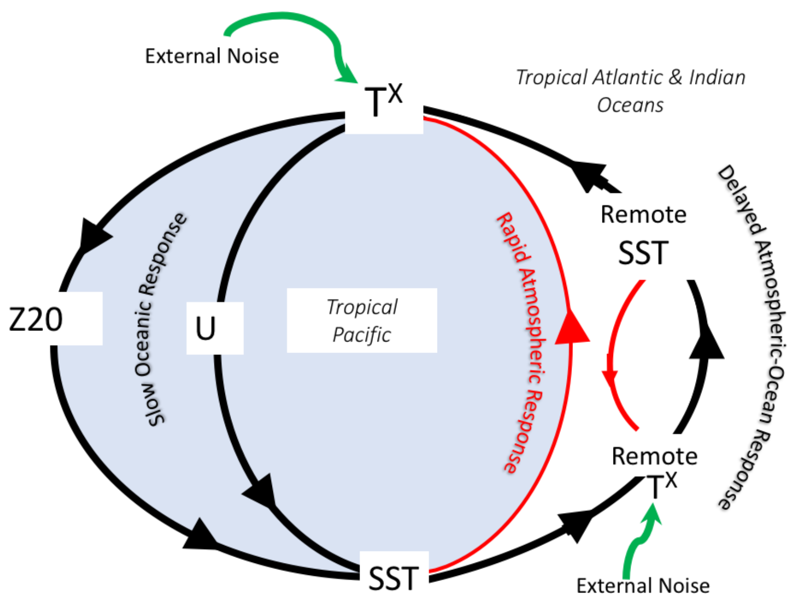

Figure 2: Schematic of tropical basin interaction. The classical ENSO dynamics are captured by the blue shading. Tropical Pacific climate variability affects the other two tropical ocean basins, which in turn feedback onto the tropical Pacific. The basin interaction contributes to a delayed feedback loop that can alter the predictability of ENSO. Figure is from Keenlyside et al. 2020.

On interannual timescales, it has been suggested that tropical Atlantic variability in boreal spring and early summer may contribute to the development or even initiation of ENSO events in the following months (Rodriguez-Fonseca et al. 2009, Ham et al. 2013). While SST anomalies in the tropical Atlantic are of smaller amplitude and spatial extent than those associated with ENSO, they tend to peak in boreal spring and early summer, which is the crucial period for determining the fate of ENSO events. Variability in the equatorial Atlantic is dominated by the so-called Atlantic Niño, which typically develops in spring and peaks in early summer. Warm events are associated with an eastward shift of convection and changes in the Walker circulation. Evidence suggests that this leads to easterly wind anomalies over the equatorial Pacific, which can contribute to the development of a Pacific La Niña event (Rodriguez-Fonseca et al. 2009). Likewise, warming in the northern tropical Atlantic has been associated with Rossby wave activity that forces easterly wind anomalies over the western and central equatorial Pacific in boreal spring (Ham et al. 2013). This picture, however, is complicated by the influence of ENSO on the Atlantic, with ENSO typically developing in boreal spring and early summer as well. ENSO is well known to influence the northern tropical Atlantic (Enfield and Mayer 1997) though its influence on the equatorial Atlantic is inconsistent (Chang et al. 2006, Lübbecke and McPhaden 2012, Tokinaga et al. 2019). Indeed, one of the great puzzles of Atlantic-Pacific basin interaction is why the two super El Niños of 1982 and 1997 had opposite impacts on equatorial Atlantic SST (Chang et al. 2006; see right panel in Fig. 1, where both the tropical Atlantic and Pacific are marked by warm SST anomalies during the 1997-98 El Niño).

The Indian Ocean also contains intrinsic variability that can independently influence ENSO. In particular, it has been suggested that IOD events may contribute to the development of ENSO. In particular, conditions resembling a negative IOD event tend to precede El Niño events by 5 seasons (Kug and Kang, 2006). This SST pattern can drive westerly wind anomalies in the western Pacific in the following spring, favouring the development of an El Niño event (Kug and Kang, 2006). Furthermore, it has been shown that the IOB mode can accelerate the decay (Kug and Kang 2006), or limit the growth (Dong and McPhaden 2018), of ENSO events.

While the study of inter-basin interaction is interesting in its own right, a crucial question is whether there are any practical benefits for seasonal predictions. Izumo et al. (2010) found that accounting for IOD variability enables skilful statistical predictions of ENSO events 14 months in advance, through providing additional information during the critical boreal spring period. Likewise, experiments with fully coupled climate models show that Indian Ocean conditions prior to the El Niño onset affect El Niño prediction (Luo et al., 2010; Zhou et al., 2019); in particular, constraining SST in the Indian Ocean to the observed climatology significantly deteriorated the predictions of the 1994, 1997/98 and 2006/7 events for forecasts initiated prior to boreal spring. Similarly, it has been shown that knowledge of tropical Atlantic SST enhances the prediction of ENSO in models of varying complexity, including statistical models (Jansen et al. 2009), intermediate complexity models (Frauen and Dommenget 2012), and full GCMs (Keenlyside et al. 2013). Much more work remains to be done, however, to quantify the potential benefit of basin interaction to seasonal prediction skill.

On longer timescales, there is evidence that tropical Atlantic warming over the last few decades contributed to the eastern Pacific trade wind strengthening and SST cooling that roughly lasted from 1998-2013 and that played a part in the temporary deceleration of the global surface temperature increase (McGregor et al. 2014; Li et al. 2016). These low-frequency changes may also modulate the strength of the tropical basin interaction on seasonal to multi-annual timescales (e.g., Martin-Rey et al. 2014). Research suggests that the Atlantic has become a more active player during the recent period, but whether this is related to global warming or reflects internal climate variability is unknown (Cai et al. 2019).

The Indian Ocean also contributed to modulating global climate change. The Pacific trade wind strengthening mentioned above resulted in enhanced ocean heat transport from the Pacific to the Indian Ocean, cooling the Pacific and warming the Indian Ocean, and thereby influencing the rate of global temperature change (Collins et al. 2019). The rapid warming in the Indian Ocean in recent decades has been suggested to strengthen the Atlantic Meridional Overturning Circulation (AMOC), thereby compensating for the recent slowdown in the circulation due to increasing greenhouse gas emissions (Hu et al. 2019). These results underscore the importance of understanding the basin interactions.

How decadal variability and trends in the Pacific, Atlantic, and Indian Oceans covary, impact each other, and modulate basin interaction on seasonal to multi-annual timescales, all under the background of greenhouse-gas induced warming is a key emerging question of active research. Research in this area is much needed, as the climate prediction community seeks to realize prediction skill beyond ENSO. TBI has also the potential to enhance ENSO prediction, by mitigating the spring predictability barrier (Izumo et al. 2010; Luo et al. 2010; Chikamoto et al. 2015; Luo et al. 2017; Zhou et al. 2019). Enhancing climate prediction on seasonal to multi-annual timescales is further required to meet the rapidly growing demand for climate services focused on the more immediate future.

Previous activities

The PREFACE project (https://preface.w.uib.no) has highlighted the important role of the Atlantic in inter-basin connections and the potential to enhance prediction skill of ENSO. The project deepened our understanding of some of the mechanisms, but coordinated experiments on tropical inter-basin interaction were not conducted and remain a pressing need to investigate the robustness and overall importance of tropical Atlantic variability in ENSO prediction.

Two recent workshops organized by Lixin Wu and Wenju Cai in 2018 synthesized the current understanding of, and raised awareness for, pan-tropical basin interaction on interannual to decadal timescales, with the results published in a recent review paper (Cai et al. 2019). While this review suggests several pathways and mechanisms for tropical basin interaction, it also highlights the need for a more detailed and quantitative understanding of the underlying pathways and mechanisms. In particular, the following two issues were raised: 1) There is increasing observational and modeling evidence suggesting that teleconnections are modulated on decadal timescales and that they may change under global warming, but the underlying mechanisms need to be understood better and robustness has to be established. 2) Climate model biases, particularly those in the tropical Atlantic (McGregor et al. 2018), hamper modeling efforts to elucidate basin interaction. Thus, understanding the influence of model biases on teleconnections and feedbacks, as well as eventually reducing them, is a high priority.

Rationale

The purpose of the present proposal for a CLIVAR RF is to invigorate research on the topic of tropical basin interaction on seasonal to multi-annual timescales. Building on the outcome of previous projects and research activities, we aim to foster coordinated research that clarifies the mechanisms underlying tropical basin interaction on these timescales, examines the robustness of previous findings, and identifies the requirements for monitoring these connections. To achieve this, we will promote the analysis of available large-ensemble and multi-model numerical experiments, coordinate dedicated numerical experimentation, and enhance and utilize paleo proxy archives.

We focus on understanding tropical basin interactions on multi-annual and shorter timescales, because these interactions can be of huge importance for seasonal and multi-annual prediction and they have not been studied in a coordinated fashion. It also makes for an achievable five-year project. We will not focus on interactions on decadal timescales, as these have received attention under the WCRP Decadal Climate Prediction Project and the CLIVAR Decadal Climate Variability and Predictability (DCVP) Working Group. However, we will consider the modulation of tropical basin interaction by slowly evolving basic state changes since these may affect the decadal modulation of ENSO characteristics (e.g., Levine et al, 2017). Thus, while the RF is not dedicated to decadal variability and climate change, the outcomes should be relevant to those research areas as well.

A wealth of simulations already exists for analysis of TBI. Immediate progress can be made through analysis of CMIP6 experiments (preindustrial, historical, and future, and DCPP tropical Pacific and North Atlantic pacemaker experiments), large initial condition and decadal prediction ensembles, multi-model seasonal predictions (NMME[1], CHFP[2]), and subseasonal predictions (S2S[3], NMME SubX[4]). RF-TBI will provide a platform for the discussion and analysis of these experiments. We note that none of these existing model archives, however, addresses the specific topic of TBI on seasonal to multi-annual timescales, and experimental setups are not adequate to assess related contributions to predictability.

Multi-model coordinated experiments, including pacemaker experiments, are an excellent way to investigate both the mechanisms and the robustness of tropical basin interaction. General Circulation Model (GCM) output affords detailed analysis of mechanisms at high temporal resolution, while the multi-model ensemble experiments under controlled conditions allow assessment of the robustness of the results. Furthermore, even though climate models are subject to biases, particularly in the tropical Atlantic (Richter et al. 2014), the extent of such biases varies considerably across models. This, together with the possibility of overriding SST

[1] https://www.cpc.ncep.noaa.gov/products/NMME/
[2] https://www.wcrp-climate.org/wgsip-chfp
[3] http://s2sprediction.net/
[4] http://cola.gmu.edu/subx/

biases in pacemaker experiments, provides an opportunity to study the influence of GCM biases on tropical basin interaction.

RF-TBI aims to coordinate multi-model standard and hindcast (i.e., retrospective pacemaker prediction) experiments that are needed to quantify the impact of tropical basin interaction. In these experiments, SSTs in one basin are constrained to observations or climatology and the respective impacts on variability and prediction skill are examined. In contrast to standard pacemaker experiments, hindcast pacemaker experiments provide a practical measure of inter-basin influences while at the same time revealing to what extent individual ocean basins contribute to prediction skill in others.

RF-TBI will also promote the analysis of TBI through proxy data in order to provide a model independent assessment of the robustness of TBI and their potential multi-decadal modulation. This is important as models suffer from biases and sensitivity tests are always subject to some degree of inconsistency. Proxy data, such as those derived from coral records, provide an invaluable opportunity to study long-term changes in tropical basin interaction. A network of annual resolution coral proxy records for SST exists in the different tropical basins for at least the last 400 years (Tierney et al. 2015). Seasonal-resolved corals from the Pacific have been shown to capture ENSO diversity (Freund et al. 2019). Corals have also been used to study interactions between ENSO and the Indian Ocean (Timm et al. 2005). Multi-proxy reconstructions of Atlantic multi-decadal variability could similarly be used to study interannual variability and its modulation.

Recent reviews of the tropical observing system (TPOS2020, TAOS, IndOOS) have not focused on interbasin connections. It is unclear which observations would be optimal for monitoring tropical interbasin connections for enhancing seasonal to multi-annual prediction although continuation of successful long time series observations in all three ocean basins is essential. Observations are also critical to the calibration of proxy data. The RF-TBI will aim to deliver the tools required to assess the effectiveness of the current observing system in capturing teleconnections, and to provide information that can guide the future development of the observing system.

2. Terms of Reference (max. 250 words)

Our main goal is to elucidate the complex two-way interactions between the tropical basins and to quantify the benefit to climate prediction. We will initiate and facilitate research activities with a focus on seasonal to multi-annual variability and predictability, thus complementing the CLIVAR DCVP RF. More specifically, our aims are as follows.

- To promote analysis of existing GCM simulations, coordinate bespoke standard and hindcast pacemaker experiments, and foster analysis of novel monthly resolved coral proxy data.
- To host workshops to stimulate, coordinate, and synthesize research on TBI, and to design appropriate pacemaker experiments.

- To provide a concrete and robust estimate of the prediction skill associated with TBI; in particular, to quantify the tropical Atlantic and Indian Ocean contribution to prediction skill in the tropical Pacific.
- To assess how common model biases affect TBI, and identify the implications for climate predictions and climate change projections.
- To identify factors underlying low-frequency modulation of TBI and how they affect the decadal modulation of ENSO.
- To raise awareness of TBI through dedicated conference sessions.
- To write review papers to consolidate understanding of TBI.
- To host summer schools to get the future generation of researchers involved and strengthen capacity.
- To make output of the coordinated experiments freely available in order to invigorate research activities across the community.
- To deliver input on observational system requirements for monitoring TBI.
- To report annually to CLIVAR on progress of the RF-TBI

3. Relevance to CLIVAR Science Plan (max. 100 words)

RF-TBI will improve understanding the ocean's role in climate variability through new knowledge of interactions among climate in the three tropical basins on seasonal and longer-timescales. New analysis of available simulations and new coral-proxy data, and the development and evaluation of bespoke pacemaker experiments will deliver better understanding of the drivers of climate predictability in the three regions. This will lead to improved regional climate predictions and future projections, and knowledge required for optimizing the observing system. Joint multi-model, observational, and proxy-data analysis are needed to achieve rapid progress, and this requires combining national and multinational efforts, and scientists at different career stages.

4. Working Plan (max. 1000 words)

Our work plan consists of four core activities: (A) analysis of existing numerical experiments, (B) coordinating new targeted GCM experiments, (C) enhancing and analyzing paleo proxy archives and leveraging existing observations, and (D) capacity strengthening and outreach activities.

<u>(A) Analysis of existing numerical experiments</u>

We will promote analysis of available coordinated experiments to make initial progress on understanding TBI and their impact on predictability. Long-term pre-industrial control simulations from both CMIP5 and CMIP6 allow the assessment of low-frequency modulation of basin interaction, as well as examining the impact of mean state biases on basin interaction.

The recent DCPP component C experiments can be used to assess contributions of tropical Pacific and North tropical Atlantic in TBI. The large initial condition ensemble experiments (e.g., CESM-LE), large initial condition prediction experiments (e.g., CESM-DPLE), and new CMIP6 experiments can help assess robustness of TBI. Contributions of TBI to seasonal prediction skill can be further assessed in existing hindcast experiments (e.g., NME or CHFP). We will also promote analysis of data available at operational centers (e.g., Jeff Knight indicated availability of simulations from the Hadley Centre).

(B) GCM coordinated experiments

We will invite modeling centers to perform a set of coordinated experiments using state-of-the-art coupled Land-Ocean-Atmosphere GCMs. The aim is to obtain a representative sample of current major climate models.

The following description of the coordinated experiments is meant to serve as a basis for further discussion. If supported, one of the first tasks of the RF will be to hold a workshop in which climate researchers and modeling experts will discuss the detailed experiment design. Experiments will be prioritized into two tiers. This prioritization is aimed to encourage active participation because it will allow modeling centers with relatively limited resources to focus on a limited set of experiments. Several team members and other researchers have already expressed interest in contributing experiments (Richter: SINTEX-F, Keenlyside: NorESM, Koll: IITM-NCEP CFSv2, Li: CESM1; Yu Kosaka: GFDL CM 2.1; Gokhan Danabasoglu: CESM2; Yoshimitsu Chikamoto: CESM1). Tier 1 will consist of control, and standard and hindcast pacemaker experiments. These are essential for the investigation of inter-basin connections and therefore considered to be the minimal requirement for participation in the coordinated experiments. There will be pacemaker experiments with SST constrained (by restoring or more advanced approaches) to observation in the tropical Pacific, tropical Atlantic, and tropical Indian Oceans. For each ocean basin, the restoring region will cover the whole width of the basin and extend from 20S-20N, with 10-degree buffer zones extending poleward. The core integration period will be 1958 to present. The ensemble size should be 10 or greater. The initial conditions for the hindcast experiments will be taken from the control experiment with global SST restoring. Simple SST nudging initialization technique can yield skillful predictions of interannual variability in the tropics (Luo et al. 2008), though more sophisticated initialization techniques based on data assimilation can likely improve on this. The advantage of the SST nudging technique is that it is relatively easy to implement. We therefore hope that this will encourage groups to participate even if they do not have data assimilation tools at their disposal. In order to keep the computational burden low hindcasts will be initialized for only one or two calendar months per year.

Tier 2 adds experiments that explore the influence of model biases on teleconnections in both a pacemaker and a hindcast setting. These are considered highly desirable but not mandatory to the project. Further experiments may examine some detailed aspects, such as case studies for certain years and the influence of model biases on prediction skill.

Pacemaker experiments can be problematic because SST restoring can lead to inconsistencies with the surface heat fluxes. Alternative experiment designs will be discussed at the planned workshop and decisions will be made after carefully evaluating the pros and cons of each.

(C) Leveraging observational and proxy data, including the enhancement and analysis of coral proxy data

Using observations to disentangle the directionality of complex basin interaction is challenging because only one realization is available and the data record is relatively short. One angle of attack that has received relatively little attention is the analysis of subseasonal data. At these short time scales the oceanic response to atmospheric forcing is relatively weak, allowing for the analysis of atmospheric teleconnection mechanisms in isolation. One specific example would be the impact of individual convective events in the northern tropical Atlantic on the eastern tropical Pacific. Existing satellite data and reanalysis products can be leveraged to perform such an analysis, while existing model output can be used to corroborate observation-based findings. On the basis of this analysis, targeted GCM experiments can be designed, which provides linkage to the modeling component of the RF. We therefore aim to foster research activities in this area.

Proxy data provide another avenue for disentangling complex basin interaction because they provide centuries long time series at up to monthly resolution. The mean state in each tropical basin is subject to low-frequency natural climate variations, such as the Interdecadal Pacific Oscillation (IPO; Power et al. 1999) and the Atlantic Multidecadal Variability (AMV; e.g. Ting et al. 2013). Analysis of long-term climate records allows for the assessment of how these mean state changes influence basin interaction. Furthermore, such records can be used to assess the ratio of internal basin variability relative to Pacific ENSO, and to evaluate model performance in representing teleconnections, linking again to the modeling component of the RF. Coral proxy data is available from all three tropical ocean basins (PAGES2k Consortium, 2017; https://www.ncdc.noaa.gov/paleo/study/21171). Currently undersampled regions are the tropical Atlantic and the tropical Indian Ocean. Ongoing independently funded research projects will provide novel unpublished data from key sites in the tropical Indian and Atlantic Ocean that capture the Indian Ocean Dipole and ENSO-related anomalies at seasonal resolution.

Further basin interaction topics that will be addressed through a combination of observation-based data and model experimentation include the atmospheric heat and moisture transport across the Central American isthmus and its impact on the cross-basin salinity gradient (e.g. Richter and Xie 2010), the leakage of the Agulhas Current into the Atlantic Ocean (e.g. de Ruijter et al. 1999), and the oceanic salinity and heat fluxes through the Indonesian Throughflow (ITF; e.g. Sprintall et al. 2014). Assessment of ITF transport and its impact on TBI is particularly challenging because high oceanic resolution is required to properly represent the relevant currents and because even reanalysis products differ widely in their transport estimates (Lee et al. 2010).

(D) Capacity strengthening and outreach

Strengthening capacity shall be achieved through (1) arranging a summer school at the ITCP in Trieste involving students and lecturers from all over the world, and (2) by including material from RF-TBI in other summer schools and lectures. Such material will be made available through the CLIVAR RF website.

Outreach and dissemination activities will include chairing conference sessions, and including material in public lectures.

Timeline (assuming a start date of January 2020):

2020

- Hold workshop to synthesize current understanding, motivate analysis of available simulations, raise awareness of available and new coral-proxy data, and to finalize experiment design.
- Foster observational studies of basin interaction, with a focus on subseasonal time scales.
- Form task teams for performing coordinated experiments, and for analyzing existing simulations and new coral-proxy data; ensure concrete goals and plans identified.
- Begin Tier 1 experiments.

2021

- Finish all Tier 1 experiments. First analysis of the results.
- Host online meetings or conference side events to discuss results of team activities

2022

- Conduct all Tier 2 experiments. Detailed analysis of the experiment results.
- Hold workshop to prepare an overview paper of RF-TBI.
- Prepare Tier 1 experiments for publication (check consistency, build infrastructure). Make Tier 1 experiments publicly available by the end of the year.
- Hold a summer school in which students are actively introduced to new results, and new data for climate analysis.

2023

- Publish Tier 2 experiments. Hold workshop or conference session on tropical basin interaction.

2024

- Synthesize results obtained from the coordinated experiments, observational analyses and other activities. Write a review paper.

5. Deliverables (max. 250 words)

- Workshops to stimulate, coordinate, and synthesize research on TBI, and to design and analyze appropriate pacemaker experiments.
- Set of GCM experiments conducted by several modeling centers made freely available via a repository similar to that set up PCMDI (explore the possibility of adding the output to the CMIP6 archive).

- Network of seasonally enhanced coral-proxy data expanded to the tropical Atlantic and Indian Oceans.
- A summer school to stimulate interest in the next generation of scientists.
- Overview papers and individual papers on assessments of TBI contribution to variability and predictability, factors causing TBI to change in time, and understanding of how TBI are impacted by model biases.
- Special sessions at international conferences and meetings to raise awareness of TBI.
- Input on observational system requirements for monitoring TBI.

6. Leadership and Suggested Membership (10-12 members)

This RF brings together scientists with different competences, are at various stages of their careers, and are from diverse backgrounds, as listed below. The areas of expertise include basin interaction (Chang, Jia, Kucharski, Li, Okumura, Rodrigues, Rodriguez-Fonseca, Stuecker, Taschetto, Wang), observational analysis (McPhaden, Tokinaga), proxy data (Hetzinger, Pfeiffer, Okumura), seasonal to decadal climate prediction (Bates, Chang, Keenlyside, Richter), climate change (Koll, Tokinaga), and climate model biases (Chang, Keenlyside, Richter).

Members:

1) **Ingo Richter** (co-chair) is a Senior Scientist and Deputy Group Leader at the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) in Yokohama, Japan. He is an expert in tropical Atlantic variability, GCM biases, and seasonal prediction, and will contribute to the coordinated experiments with one of the JAMSTEC seasonal prediction models.
2) **Noel Keenlyside** (co-chair) is a Professor at the Bjerknes Centre for Climate Research in Bergen, Norway. He has wide ranging expertise in interannual and decadal climate variability and its prediction, and has led several large European research projects. He will contribute to the coordinated experiments with one or two models available at the University of Bergen. He is a member of CLIVAR Climate Dynamics and Atlantic Region panels.
3) **Susan Bates** is a Project Scientist in the Climate and Global Dynamics (CGD) Laboratory of the National Center for Atmospheric Research (NCAR) at Boulder, CO, USA. She has extensive experience with model simulations and will provide linkage to the CGD modeling group at NCAR and to the CLIVAR Atlantic Region Panel, of which she is a member.
4) **Ping Chang** is a Professor at Texas A&M University in College Station, TX, USA. He has made important contributions to tropical climate variability, particularly regarding the tropical Atlantic and its link to ENSO, and also has extensive modeling experience.

5) **Fan Jia** is an Associate Professor at the Institute of Oceanology in Qingdao, China. He has worked on the western tropical Pacific and its link to the tropical Atlantic, and how this link might change under global warming.
6) **Steffen Hetzinger** is a Research Scientist at the GEOMAR Helmholtz Ocean Research Centre in Kiel, Germany. He is an expert in coral proxy records, including studies on the linkage between the North Atlantic and Pacific. He brings tropical Atlantic coral-proxy competence.
7) **Roxy Koll** is a Climate Scientist at the Indian Institute of Tropical Meteorology. He is an expert in Indian Ocean and monsoon variability and change, and teleconnections to ENSO. He is a co-chair of the CLIVAR Indian Ocean Region panel and a Lead Author of the IPCC Special Report on Ocean and Cryosphere in a Changing Climate.
8) **Fred Kucharski** is a Research Scientist at the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy. He has worked extensively on basin interaction and was involved in some of the pioneering studies on Atlantic influences on the Pacific and Indian Oceans. He will contribute to the modeling efforts with the SPEEDY model, a simplified GCM.
9) **Xichen Li** is an Associate Professor at the Institute of Atmospheric Physics of Beijing University in Beijing, China. He has published important work on the link between the tropical Atlantic and Pacific.
10) **Michael J. McPhaden** is a Senior Scientist at the NOAA/Pacific Marine Environmental Laboratory in Seattle, WA, USA. He has played a key role in the observational networks of all three tropical ocean basins, is the current chair of the Tropical Moored Buoy Implementation Panel, and an ex-officio member of the CLIVAR Pacific and Indian Ocean Regional Panels.
11) **Yuko M. Okumura** is a Research Scientist at the Jackson School of Geosciences, University of Texas, Austin, TX, USA. In addition to her work on two-way basin interaction and her work on ENSO diversity, she has expertise in proxy records.
12) **Miriam Pfeiffer** is a Professor of Paleontology at the University of Kiel, Germany. She has done extensive work on coral proxy records, including teleconnections in the tropics on interannual and decadal time scales. She brings competence on Indian Ocean coral-archives.
13) **Regina Rodrigues** is a Professor in the Physical Oceanography Department of the Federal University of Santa Catarina in Santa Catarina, Brazil. In addition to her expertise in tropical Pacific impacts on South America and the Atlantic, she will provide linkage to the CLIVAR Atlantic Region Panel.
14) **Belen Rodriguez-Fonseca** is a Professor in the Department of Geophysics and Meteorology at the Complutense University of Madrid, Spain. Her 2009 paper in GRL was one of the first to suggest an Atlantic influence on ENSO. Since then she and her group have been very active in Atlantic-Pacific basin interaction and its decadal modulation.
15) **Malte Stuecker** is an Assistant Professor at the Oceanography department and International Pacific Research Center at the University of Hawaiʻi at Mānoa. He has participated in many basin interaction studies and has particular expertise in ENSO impacts on the Indian Ocean and the role of biases in basin interactions.

16) **Andréa S. Taschetto** is a Senior Researcher at the University of New South Wales in Sydney, Australia. She made important contributions to the understanding of ENSO impacts on the Atlantic and Indian Oceans, and their combined effect on Australian weather patterns. She will contribute to the coordinated experiments.
17) **Hiroki Tokinaga** is a Professor at Kyushu University in Kasuga, Japan. He is specialized in observational analysis and has published important work on tropical circulation changes over the last century and on ENSO effects on the equatorial Atlantic. He is the PI of an ongoing 4-year project on tropical basin interaction between the Pacific and Atlantic (Co-PIs: Ingo Richter, Yu Kosaka) funded by the Japan Society for the Promotion of Science.
18) **Chunzai Wang** is a Professor at the South China Sea Institute of Oceanology in Guangzhou, China. He has done important work on global inter-basin interactions and is currently PI of a large national 5-year project on three-ocean interactions and climate variability.

7. Relationship with other CLIVAR and WCRP activities as well as other international programs (max. 100 words)

The co-chairs of the CLIVAR Climate Dynamics and Atlantic, Pacific and Indian Ocean Region Panels support RF-TBI, which includes several current panel members (Bates, Keenlyside, Koll, Rodrigues). We will coordinate with these panels to foster research on regional impacts of TBI.

RF-TBI focuses on interannual variability in the tropics and is thus distinct from WCRP DCPP and CLIVAR DCVP. Nevertheless, we will seek interaction with these groups as our activities will also contribute to a better understanding of decadal variability and predictability. Proposed research will also require cooperation with WCRP-WGSIP, WCRP-CHFP, and US CLIVAR large ensemble project.

8. Key References (max. 10 most relevant publications)

Annamalai, H., S. Kida, and J. Hafner, 2010: Potential impact of the tropical Indian Ocean–Indonesian Seas on El Niño characteristics. *J. Climate,* **23**, 3933-3952.

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