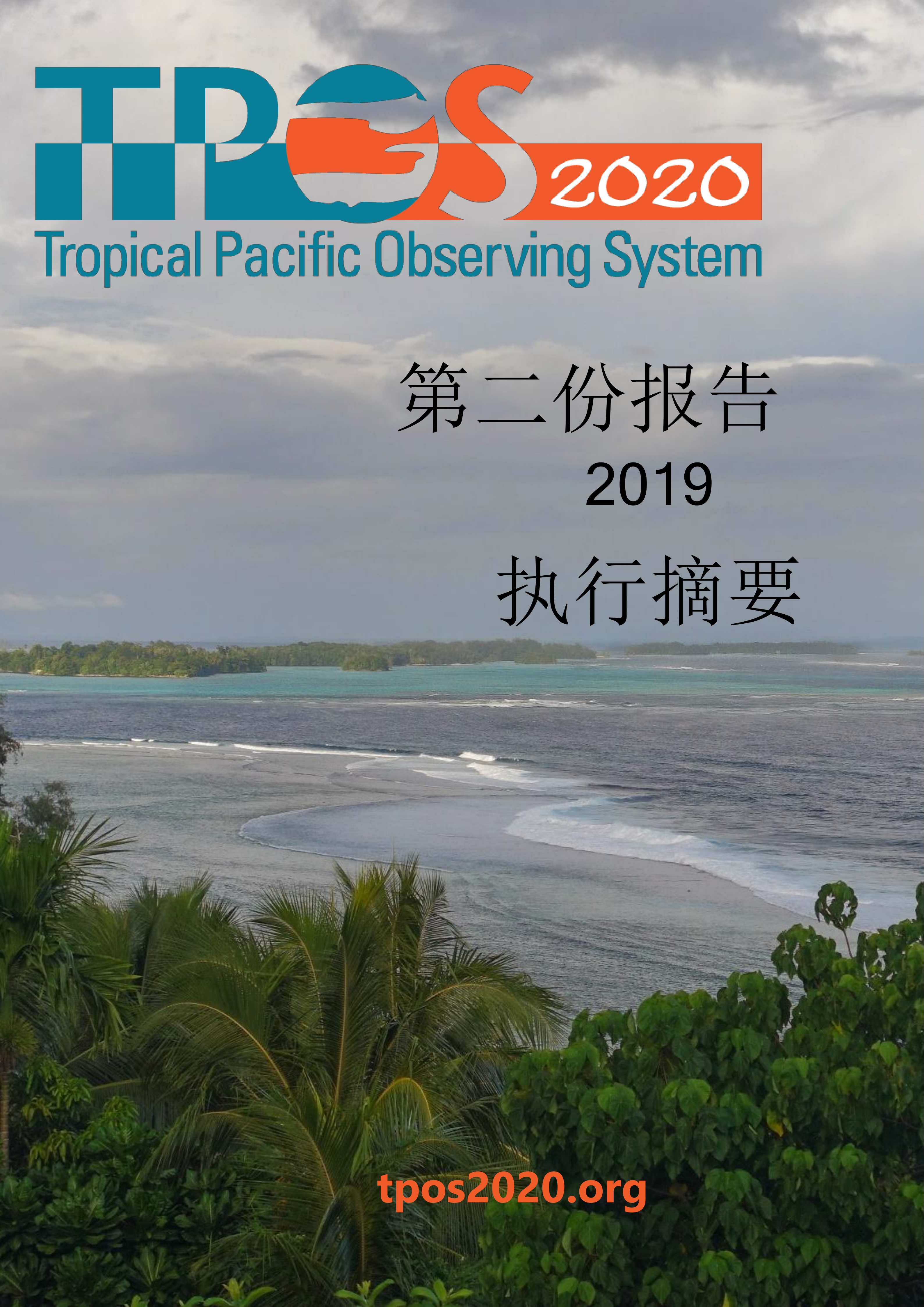
TPOS 2020
Tropical Pacific Observing System

第二份报告

2019

执行摘要



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Second Report of TPOS 2020第二份报告

May 2019 | 2019年5月

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全部作者及审稿人名单详见附录 C。以上列出的作者的所属单位见下一页。以上作者按章节顺序列出。

This report is GOOS-234, PMEL contribution number 4911 and a JISAO contribution.

此份报告编号为GOOS-234，PMEL 4911，JISAO。

Please use the following citation for the full report:

请按以下格式引用报告全文：

Kessler, W.S., S. E. Wijffels, S. Cravatte, N. Smith, and Lead Authors, 2019: Second Report of TPOS 2020. GOOS-234, 268 pp. [Available online at http://tpos2020.org/second-report/.]

Citation for the Executive Summary only:
执行概要引用：

Kessler, W.S., S. E. Wijffels, S. Cravatte, N. Smith, and Lead Authors, 2019: Executive Summary. Second Report of TPOS 2020. GOOS-234, pp. i-xiv [Available online at http://tpos2020.org/second-report/.]

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Executive Summary
执行概要

This Second Report of the Tropical Pacific Observing System 2020 Project (TPOS 2020[1]) builds on the analysis and conclusions of the First Report, informed by new evidence and/or fresh perspectives on priorities. The report provides further elaboration and refinement of the recommendations and updated or new actions where appropriate, together with additional detail and recommendations in areas not covered in the initial report. Recommendations for a redesigned moored array, that remained fuzzy in the First Report, are now detailed.

这是热带太平洋观测系统 2020 计划（Tropical Pacific Observing System 2020 project, 简称 TPOS 2020[1]）的第二份报告，是以第一份报告的分析和结论为基础编制的，并考虑了新发现的证据和对相关优先事项的新看法。与第一份报告相比，本报告对相关建议、已有措施的新动态或新采取的措施作出了更详细的阐述，并进一步完善，同时补充了第一份报告中未涉及的领域，进行了详细说明并提出相关建议。第一份报告中对热带太平洋锚系阵列的重新设计没有提出明确建议，在本报告中作了详细阐述。

This Second Report provides a major revision and more comprehensive update for two of the major foci of TPOS 2020, biogeochemical and ecosystem Backbone observations and the eastern Pacific. The western Pacific was revisited in the TPOS OceanObs'19 community white paper and this report includes an analysis of requirements arising from the complex scale interactions from weather to climate over the western Pacific Ocean. Additional consideration of air-sea fluxes and the planetary boundary layers in the tropical Pacific are also included in this report.

生物地球化学观测骨干系统和东太平洋是TPOS 2020计划的两个主要关注焦点，本报告对此作了大规模的修订并进行了全面更新。在TPOS OceanObs'19行业白皮书对西太平洋进行了重新审视。本报告对西太平洋天气与气候之间复杂的相互作用要求作出了分析。此外，本报告还对热带太平洋海气通量和行星边界层进一步进行了探讨。

TPOS 2020 sponsors specifically requested further consideration of requirements arising from monsoon and subseasonal timescales; severe storms and any special ocean observing requirements; observations related to Indo-Pacific exchanges; and any requirements emerging from the new class of coupled numerical weather prediction models. This report, supported by the Community White Paper on the TPOS published for OceanObs'19 (Smith et al., 2019; hereafter TPOS OceanObs'19), represents a substantial, but not yet complete, response to this charge.

TPOS 2020计划的赞助商特别要求进一步考虑季风和次季节性时间尺度的要求；强烈风暴和其他特殊的海洋观测要求；与印度太平洋交换有关的观测；以及新一类耦合数值天气预报模型中出现的所有要求。本报告得到了为OceanObs'19发布的TPOS行业白皮书（Smith等，2019；以下简称为“TPOS OceanObs'19”）的支持，是对这些要求的实质性响应，但尚不完善。

New Areas of Review
新研究领域

Three new topics are reviewed in this Second Report:

本报告包括以下三个新的研究领域：

- coupled models for subseasonal to interannual predictions;
- observational requirements for coupled weather and subseasonal timescales; and
- TPOS data flow and access (see later in this Summary).

- 用于季节性到年际性预测的耦合模型；
- 对耦合天气和次季节性时间尺度的观测要求；
- TPOS数据流和访问（请参阅本摘要的后面部分）。

All three areas were touched on in the First Report but here we provide a deeper review and associated recommendations and actions.

第一份报告也提及了这三个领域，在本报告中我们作出了更深入的研究，并提出了相关建议，介绍了作出的相关行动。

Coupled models for subseasonal to interannual predictions

用于季节性到年际性预测的耦合模型

The review is based on a survey of operational seasonal-to-interannual prediction centers; a US CLIVAR workshop aimed at bridging the knowledge gap between sustained observations and data assimilation for TPOS 2020, including consideration of the models that underlie that process; and the published literature. The First Report noted there is an urgent need to improve the skill, effectiveness and efficacy of the modeling systems that are critical to realizing the impact of an improved TPOS. This report provides further analysis of the main systematic errors but finds that translating that information into model developments to reduce biases has proven difficult and that systematic approaches are not in place. [2.3, 2.4, 2.5][2]

本项研究基于对季节到年际预测中心的调查，在美国开展的旨在弥合TPOS 2020持续观测与数据同化之间的知识空白（包括考虑该过程背后的模型）的气候变化及可预报性（CLIVAR）项目，以及已发表的相关文献。第一份报告指出迫切需要提高建模系统的技能、效率和有效性，因为这对改进TPOS的影响至关重要。本报告进一步分析了存在的主要系统误差，但发现将这些信息转化为模型开发以减少偏差存在困难，并且没有系统性的方法。

We propose building from the experiences of the numerical weather prediction community and the Coupled Model Intercomparison Project (CMIP) to establish such a systematic approach, with a regular cycle of three parallel lines of development: (a) an agreed community-planned set of experiments; (b) studies based on a set of common diagnostics and metrics; and (c) a series of process studies to bridge the observations and modeling communities. [***Action 2.1***; 2.7]

我们建议根据数值天气预报行业和耦合模型比对项目（CMIP）的经验建立起这种系统性的方法，并按照一定时间周期同时从三个方面入手：（a）商定后发起基于行业的系列测试；（b）进行基于同一套诊断和指标的研究；（c）开展旨在促使观察与建模进行对接的系列研究。[***措施 2.1***、*2.7*]

[1] “TPOS” alone refers to the observing system; “TPOS 2020” refers to the project.
[1] “TPOS”是指观测系统。“TPOS 2020”是指本项计划。

[2] Unless indicated otherwise, the [] references are to sections in the Second Report.

[2] 除非另有明确说明，否则[]内引用的均是指第二份报告。

The community survey indicated a cycle of around five years might be workable, with a timetable for planning, commitment, execution and publication, and concluded by an independent assessment of progress. This report concludes that without such a commitment to a systematic process, the seasonal-to-interannual prediction community may never realize its full potential, nor that of TPOS observations. [2.7]

相关人员调查表明，从提出包括规划、承诺、执行和发布在内的时间表，到通过独立的评估得出结论，大约需要五年的时间。本报告认为，如果缺乏这种系统过程研究，季节到年际预测可能永远无法发挥其全部潜力，对TPOS观测也同样如此。[2.7]

Recommendation 2.1. Establish a systematic and planned cycle of work among the participants in seasonal prediction, including (i) a planned and systematic cycle of experimentation; (ii) a coordinated set of process and/or case studies, and (iii) routine and regular real-time and offline system evaluation. An independent assessment should occur across all elements every five years. [2.7]

建议2.1：在季节性预测参与者之间建立起系统性的和计划性的工作周期，包括（i）一个计划性的和系统性的实验周期；（ii）一套协调性的过程和/或案例研究，以及（iii）日常的和定期的实时和离线系统评估。每五年一次对所有要素进行独立评估。[2.7]

We provide two additional recommendations to promote innovative observing system sensitivity experiments and reanalyses to guide the evolution of the observing system.

此外，我们还提供了另外两项建议，以促进创新性的观测系统灵敏度实验的开展和进行重新分析，并指导观测系统的升级发展。

Recommendation 2.2. Increase support for observing system sensitivity and simulation experiments to identify observations that constrain models most effectively and have high impact on forecasts. Correspondingly, development of infrastructure for exchanging information about data utilization and analysis increments should be supported. [First Report; 3.3.3.2, 6.1.6]

建议2.2：加大对系统灵敏度观测和模拟实验的支持，以确定能以最有效的方式约束模型并对预测具有重大影响的观测。相应地，也应支持用于数据使用和分析增量的信息交换用途的基础设施开发。[第一份报告；3.3.3.2、6.1.6]

Recommendation 2.3. Increase support for the validation and reprocessing of ocean and atmospheric reanalyses; conduct TPOS regional reanalyses and data reprocessing to guide observing system refinement and to enhance the value of TPOS data records. [2.7]

建议2.3：加大对进行海洋和大气再分析的验证和再处理的支持；进行TPOS区域再分析和数据再处理，以指导观测系统的改进并提高TPOS数据记录的价值。[2.7]

Observational requirements of coupled weather and subseasonal prediction

耦合天气和次季节性预测的观测要求

The science around coupled weather and subseasonal prediction is advancing rapidly and several recent publications have reviewed progress and considered ocean observation needs in a general way. Key processes include heat and water fluxes in and between the atmospheric and oceanic boundary layers. At a general level, the First Report included a trend toward requirements with enhanced spatial resolution and finer temporal resolution, specifically to capture features such as fronts and the diurnal cycle and to avoid aliasing in air-sea flux estimates [First Report; Chapter 3]. The conclusion drawn in this report is that further research is required before we can be more specific or detailed in terms of essential variable spatiotemporal requirements; such research is underway. [***Recommendation 3.3***]

耦合天气和次季节性预测的研究发展迅速，最近的刊物发表了该方面的发展报告，并以整体方式探讨了海洋观测需求。关键过程包括大气和海洋边界层内部和他们之间的热量和水通量。第一份报告在总体上提出对提高空间分辨率和时间分辨率的趋势要求，特别是为捕获锋面和日循环等特征，并避免错误识别海-气通量预测[第一份报告；第3章]。本报告得出的结论是，只有通过进一步研究，我们方能了解基本的变更时空要求。目前这一研究正在进行之中。[***建议3.3***]

Two process studies are supported, one focused on the eastern edge of the west Pacific warm pool, and the other on equatorial upwelling and mixing.

支持开展了两项研究，其中一项研究专注于西太平洋暖池的东部边缘，另一项专注于赤道上升流区域和混合区域。

Observations of sea surface temperature and salinity must be complemented by observations of near-surface winds, ocean surface waves, surface currents and vertical structure in the ocean mixed layer if we are to constrain/initialize processes in models on monthly and shorter timescales. The high temporal resolution of the Tropical Moored Buoy Array (TMA) and the move toward measuring more complete flux variables aligns with such needs and we conclude will almost certainly benefit coupled data assimilation and coupled model development.

如果我们需要在月度甚至更短的时间尺度上约束/初始化模型中的过程，则必须进行海面温度和盐度观测，同时观察近海表风、海洋表面波、表面海流和海洋混合层的垂直结构。提高热带太平洋锚系阵列（Tropical Moored Buoy Array, 简称 TMA）的时间分辨率并对更加完整的通量变量进行测量与这些要求相一致，我们认为这些措施必然会有利于耦合数据的同化和耦合模型的开发。

The following recommendations would advance these goals:

以下建议有助于实现这些目标：

Recommendation 3.1. Where feasible and practical, promote observing approaches that jointly measure the ocean and marine boundary layers, and air-sea flux variables, principally to support model development, as well as testing and validation of data assimilation methods and systems. [3.3.3.1, 3.3.3.2, 7.2.1.1]

建议3.1：在切实可行的情况下，应当采取共同测量海洋和海洋边界层以及海-气通量变量的观测方法，其目的主要是支持模型开发以及进行数据同化方法和系统的测试和验证。[3.3.3.1、3.3.3.2、7.2.1.1]

Recommendation 3.2. Encourage and promote process studies that will improve the representation of key processes and allow further testing of the ability for observations to constrain the coupled system; to address biases in observations and models; and to improve CDA observation error estimates. [3.2, 3.3.1, 3.3.2].

建议3.2：鼓励和促进开展旨在改进关键过程的表示并有利于用于约束耦合系统的观测能力的进一步研究的过程研究；解决观测和模型中存在的偏差；并改善CDA观测误差估计。[3.2、3.3.1、3.3.2]

The international Subseasonal-to-Seasonal project hindcast and real-time database is supporting research and model development. Studies on initialization of an intraseasonally-varying ocean are being supported, including sensitivity to ocean observation, and provide insight on common errors that need to be addressed. One subproject aims to provide ocean outputs from the forecast models for analysis.

支持该项研究和模型开发的有国际次季节性到季节性的项目后报和实时数据库。得到支持的项目有对海洋在季节内变化的初始化研究，包括对海洋观测的敏感性研究，这些研究提出了对经常出现的需要处理的许多错误的看法。此外还有旨在通过预测模型提供海洋相关输出数据的子项目。

Recommendation 3.3. Promote and engage with the Working Group on Numerical Experimentation-WCRP Subseasonal-to-Seasonal subproject on Ocean Initialization and Configuration. [3.4]

建议3.3：促进和参与数值实验工作组-WCRP海洋初始化和配置的次季节到季节子项目。[3.4]

Requirements: The First Report Reprised and Extended
要求：重新编制并扩展第一份报告

Biogeochemical and ecosystem Backbone observations

生物地球化学和生态观测骨干系统

We report on further refinement of biogeochemical (BGC) and ecosystem observational requirements, including estimates of critical time and space scales, and the implications for the Backbone. Key processes that drive variability in biogeochemistry and ecosystem and thus determine biogeochemical requirements are: (i) the response to long-term climate change; (ii) seasonal to decadal variability of the tropical Pacific biological pump; (iii) seasonal to decadal variability of the tropical Pacific CO_2 flux and implications for the global carbon cycle ; (iv) the upper ocean carbon budget, including carbon export below the mixed layer and sources of anthropogenic carbon for upwelled water; and (v) volume and nutrient fluxes into the Equatorial Undercurrent.

我们报告了生物地球化学（BGC）和生态系统观测要求的完善情况，包括关键时间和空间尺度的估计，以及对骨干系统的影响。推动生物地球化学和生态系统变化并因此确定生物地球化学要求的关键过程为：（i）对长期气候变化的响应；（ii）热带太平洋生物泵的季节性至年代际的变化；（iii）热带太平洋二氧化碳通量的季节性到年代际的变化以及对全球碳循环的影响；（iv）海洋上层碳排放预算，包括混合叉层以下的碳输出以及造成海平面上升的人为碳排放源头；（v）赤道暗流的流量和营养物质通量。

This phenomenological basis permits an analysis of relevant biogeochemical Essential Ocean Variable (EOV) measurements, including for oxygen, nutrients (e.g., nitrate, phosphate and silicate), inorganic carbon, particles, chlorophyll and transient tracers. We considered new analyses of space and time decorrelation scales of some of these variables which may allow characterization of seasonal to interannual variability, including for oxygen minimum zones.

这些基于现象学的证据有助于对相关的生物地球化学基本海洋变量（EOV）测量进行分析，包括氧气、营养素（例如硝酸盐、磷酸盐和硅酸盐）、无机碳、颗粒、叶绿素和瞬态示踪剂。我们考虑采用有助于对季节性到年际的变化（包括氧气含量最低的区域）进行表征的空间和时间去相关尺度的新的分析办法。

These advances, along with TPOS 2020 pilot projects (Saildrone® and BGC-Argo) and further input from the community have led to refinement and extension of the conclusions from the First Report. The main points are:

这些进展以及TPOS 2020试点项目（Saildrone®和BGC-Argo）的开展以及对本行业的进一步投入，共同带来相对于第一份报告的结论的进一步完善和扩展。主要有：

- Maintain and extend the pCO_2 climate record [4.3.1; First Report, Rec. 12; ***Action 7.6***]
- Address the broader goals of the Biogeochemical Argo community through 31 BGC-Argo float deployments per year in the 10°N to 10°S band.

- 维护和扩展pCO_2气候记录[4.3.1；第一份报告，建议12、***措施7.6***]
- 在10°N至10°S范围内，每年31次部署BGC-Argo浮标，实现BGC-Argo更广泛意义上的目标。

Recommendation 4.1. TPOS 2020 recommends a target of 124 BGC-Argo floats with biogeochemical sensors (specifically nitrate, dissolved oxygen, pH, chlorophyll fluorescence, particulate backscatter and downwelling irradiance) for the 10°N-10°S band. [4.3, 4.4]

建议4.1：TPOS 2020建议在10°N-10°S范围内使用生物地球化学传感器（特别是硝酸盐、溶解氧、pH、叶绿素荧光、颗粒反向散射和下行辐照度）部署124个BGC-Argo浮标。[4.3、4.4]

- Re-institute CTD and bottle sampling on mooring servicing cruises - CTDs should be performed to 1000 m along each TMA line.

- 在锚系维护航次中重新进行CTD和采样瓶瓶取样，CTD沿每条TMA线下方至1000米。

Recommendation 4.2. TPOS 2020 recommends CTDs with dissolved oxygen and optical sensors (chlorophyll fluorescence, particulate backscatter, transmissometer) and water samples (at a minimum for chlorophyll and nutrients) should be performed to 1000 m along each TMA line by servicing cruises, at every degree of latitude between 8°N and 8°S and every 0.5° between 2°N and 2°S at a frequency of at least once per year. Twice per year sampling is optimal and could be augmented by GO-SHIP and other ships of opportunity. [4.3.2, 4.4; ***Recommendation 7.3***]

建议4.2：TPOS 2020推荐使用带有溶解氧的CTD和光学传感器（叶绿素荧光、颗粒反向散射、透射仪），并在8°N至8°S、2°N至2°S之间的每个纬度，以至少每年

一次的频率，通过维护航次沿每条TMA线提取水样（至少包括叶绿素和营养素）。最好每年两次采样，并最好通过GO-SHIP和可行的其他船只。[4.3.2、4.4；建议7.3]

- Continued coverage of satellite ocean color and CO_2 observations [4.2.5, 4.3.1, First Report, Rec. 13]
- Develop a coordinated and long-term observation strategy for the low-latitude western boundary current region [4.4, 7.4.5.1; TPOS OceanObs'19]
- Continue pilot studies for technology development to expand autonomous capabilities – especially for Oxygen Minimum Zones [4.3, 9.2.5, 9.2.3]
- Promote process studies to understand the impact of El Niño and long-term change on carbon export and ecosystems [4.1.1, 4.3, 4.4]

- 通过卫星对海洋水色和二氧化碳进行观测[4.2.5、4.3.1，第一份报告，建议13]
- 为低纬度西部边界流域制定协调的长期观测策略[4.4,7.4.5.1；TPOS OceanObs'19]
- 继续进行技术开发试点研究，以扩大自主能力，特别是对于氧气含量最低的区域[4.3、9.2.5、9.2.3]
- 推进过程研究，以了解厄尔尼诺现象和长期变化对碳输出和生态系统的影响[4.1.1、4.3、4.4]

Eastern Pacific observing system

东太平洋观测系统

The eastern Pacific region has high societal impact and is among the most problematic for climate modeling, as oceanic processes, low-cloud physics, and tropical deep convection have complex interactions in this region. The sharp property gradients of the eastern Pacific form a key distinction from the rest of the basin and a major challenge to both observing and modeling. The Second Report revisits the phenomenological basis and requirements of the region, including the coastal waveguide, and extends the discussion of atmospheric processes and observations to the extent they are relevant for an integrated approach to the TPOS. We map a course for addressing outstanding science questions through both engagement with regional efforts, as well as pilot and process studies.

东太平洋地区的社会影响很大，是气候模拟中最棘手的地区之一。海洋过程、低矮的云层和海洋深对流在这一地区存在十分复杂的相互作用。东太平洋地区复杂的地形使其与该流域范围内的其他区域截然不同，进行观测和建模都存在很大的困难。第二份报告重新审视了该地区的现象学证据和要求，包括沿海波导，对大气过程和观测的讨论进行的扩展，形成可用于TPOS的综合方法。通过参与区域性工作以及试点项目和过程研究，我们绘制了解决这些突出科学问题的航线。

The following provide the overarching scientific motivation for an eastern Pacific observing system:

以下为东太平洋观测系统提供了总体性的科学的激励机制：

- Monitoring and predicting the El Niño-Southern Oscillation, including the evolution in understanding of tropical instability waves, the influence of tropical Atlantic SST, and the nature and spread of convection in the region;
- Understanding and addressing ocean model biases, including Kelvin wave dissipation processes, systematic errors in the vicinity of upwelling and the equatorial thermocline, and modelling of interaction with coastal upwelling dynamics;
- Understanding atmospheric and coupled model biases through a focused effort to better observe cold tongue and Inter-tropical Convergence Zone dynamics and associated cloud feedbacks, including the atmospheric thermodynamic and dynamic vertical structure; and
- Oxygen minimum zone dynamics and equatorial and coastal upwelling that brings cold nutrient-rich waters toward the surface resulting in phytoplanktonic blooms (see also the biogeochemistry discussion above).

- 监测和预测厄尔尼诺-南方涛动，包括了解热带不稳定波的演变、热带大西洋海表温度的影响以及该区域对流的性质和扩散；
- 了解和处理海洋模型偏差，包括开尔文波消散过程、上升流和赤道温跃层附近的系统性误差以及与沿岸上升流动力学相互作用的模拟；
- 加大观测力度，观测冷舌和热带辐合带动力学及相关的云反馈，包括大气热力学和垂直结构，以便了解大气和耦合模型偏差；
- 氧气含量最低区域的动力学以及将营养丰富的寒冷海流抬升至表面导致浮游植物大量繁殖的赤道和沿岸上升流（参见以上的生物地球化学讨论）。

Recommendation 5.1. The existing TMA line along 95°W should be maintained and updated to full-flux sites. [7.3.1]

建议5.1：保留当前沿95°W的TMA线，并扩展到全部通量基地。[7.3.1]

Recommendation 5.2. Increase Argo density for the eastern Pacific as soon as possible. A coordination of South American countries to execute the doubling of Argo will be required. [***Recommendation 4.1*** and ***Action 7.9***].

建议5.2：尽快提高东太平洋的Argo密度。需要协调南美国家以实现Argo数量的加倍。 [建议4.1和措施7.9]。

TPOS 2020 reaffirms its support for pilot projects to evolve and strengthen observing capability in the region. The equatorial-coastal waveguide and upwelling system (***Action 5.2***) and Inter-tropical Convergence Zone/cold tongue/stratus system (***Action 5.3***) pilot studies are reaffirmed as high priority. A third pilot on atmospheric monitoring from eastern Pacific islands is recommended to test our ability to monitor: (a) vertical profiles of atmospheric winds, temperature and moisture variability; (b) surface conditions in the near-offshore region; and (c) atmospheric vertical structure and cloud radiative forcing in the core stratus deck region (***Action 5.4***).

TPOS 2020再次确定其支持旨在发展和加强该地区的观测能力的试点项目。再次将赤道-沿海波导和上升流系统（***措施***5.2）和热带辐合带/冷舌/层云系统（***措施***5.3）试点研究视为需要优先处理的重点项目。建议建立第三个东太平洋岛屿大气监测试点，以测试我们

在以下方面的监测能力：（a）大气风、温度和湿度变化的垂直剖面；（b）近海区域的表面状况；（c）核心层平面区域的大气垂直结构和云辐射强迫作用（***措施***5.4）。

One of the motivations for revisiting the eastern Pacific in this report was to enable and generate greater regional activity. Several opportunities are identified, including (a) enhanced data sharing and cooperation, to include improved transmission and quality of data, using regional mechanisms where appropriate, (b) direct participation in profiling float enhancements, (c) participation in a regional reanalysis project that would better resolve processes and fields relevant to Eastern Pacific stakeholders, and (d) assistance to establish collaborative frameworks so that greater regional value could be obtained from their observing efforts (***Action 5.1***). [5.2]

本报告重新审视了东太平洋区域，其中一个目的是为了促成更大范围的区域性活动。包括以下几种可能的活动：（a）加强数据共享和合作，包括改进数据的传输和质量，并在需要时采取区域性机制，（b）直接参与分析增强的浮标方案，（c）参与区域再分析项目，以更好地解决与东太平洋利益相关方有关的进程和领域，（d）协助建立协作性框架，以便从其观测工作中取得更大的区域价值（***措施5.1***）。[5.2]

Recommendation 5.3. A pilot study along 95°W installing dissolved oxygen sensors to 200 m and an ADCP is recommended at the equator, with additional dissolved oxygen and current sensors on 2°N and 2°S if at all possible. [5.1.4]

建议5.3：沿95°W开展试点研究，安装溶解氧传感器至200m，并建议在赤道处使用ADCP。如果可能，在2°N和2°S处也安装溶解氧传感器和电流传感器。[5.1.4]

Recommendation 5.4. TPOS 2020 recommends planning and execution of a reanalysis project for the eastern Pacific, making use of past and current data sets, as well as hydrographic sections between the Galapagos Islands and the coast. This reanalysis effort should include high-resolution regional atmospheric products that resolve important coastal winds, and ensembles for estimating uncertainty. [5.2]

建议5.4。 TPOS 2020建议规划和执行东太平洋再分析项目，使用历史的和现在的数据集，以及在加拉巴哥群岛和海岸之间的水道测量数据。该重新分析工作应包括可用于解析重要沿海风的高分辨率的区域大气产品以及估算不确定性的集合。[5.2]

TPOS 2020 strongly encourages stakeholders to advocate for and support an eastern Pacific focus for the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), given the benefits will be relatively large for this region (***Action 5.5***).

TPOS 2020强烈鼓励利益相关方倡导并支持在东太平洋地区重点关注“联合国海洋科学促进可持续发展十年”计划（2021-2030），因为该地区的受益将相对较大（***措施***5.5）。

Tropical Pacific decadal variability and long-term trends

热带太平洋年代际变率和长期趋势

Consultations after the publication of the First Report strongly encouraged TPOS 2020 to revisit the requirements arising from decadal variability, long-term climate trends and the climate record. This report provides a comprehensive update, including a review of historical studies of decadal variability; implications from global climate change and other external-forcing for tropical Pacific climate; and an analysis of modeled and observed past changes in the El Niño-Southern Oscillation and potential future changes. [6.1.2-6.1.5]

第一份报告发布后各方展开的磋商让TPOS 2020强烈感受到需要重新审视由于年代际变率、长期气候趋势和气候记录带来的新要求。本报告对此作了全面的更新，包括对年代际变率的历史研究的回顾、全球气候变化和其他外部强迫作用对热带太平洋气候的影响、对厄尔尼诺-南方涛动的模拟和观察到的过去变化的分析以及对潜在的未来变化的预测。[6.1.2-6.1.5]

Key findings include the need for better observational constraints for estimates of surface heat fluxes, and for improved understanding of the subsurface circulation, thermal structure, and heat budget of the upper ocean along the equator; and the need for sustained reliable observations and reanalyses of both the on- and off-equatorial winds and air-sea fluxes. Long-term sustained monitoring and high-quality reanalyses are highlighted as priorities. [6.1.6] We also discuss the potential role of TPOS for better calibrating and understanding paleo-proxy data records, a topic that should be considered for the coming years.

主要结论包括需要更佳的观测约束以估算地表热通量，以及需要更好地了解沿赤道的上层海洋的地下环流、热结构和热量预算；需要对赤道风和非赤道风和海气通量进行的持续可靠观测和重新分析。重点是需要进行长期持续监测和高质量再分析。 [6.1.6] 此外，我们还探讨了TPOS用于更好地校准和理解古代理数据记录方面的潜在可能，这是未来几年应该考虑的一个主题。

We stress the challenge of detecting multi-decade signals and the importance of maintaining a reference set of longstanding, continuous climate records, with quantified uncertainties, that can bridge any future changes in the observing system and confirm or refute any shifts that may coincide with the introduction of observing system or data processing changes. Such references must have enough coverage and sufficient quality and reliability to (1) detect and identify small dec-cen signals, (2) enable cross-checks for consistency, and (3) be able mitigate risks from unexpected failures of individual elements. [6.1.6]

我们强调了数十年进行信号检测的困难性以及保留长期连续气候记录参考数据的重要性。通过这些记录量化的不确定性，可用于预测观测系统未来可能发生的变化，并确认或推翻可能与观测系统的介绍或数据处理变化发生的不一致情况。这些参考必须具有足够的覆盖面，并具有足够的质量和可靠性，以便（1）检测和识别微弱的十进制信号，（2）能够进行交叉检查以确保一致性，以及（3）能够降低个别元素导致的意外故障风险。[6.1.6]

The Northwestern Pacific Ocean

西北太平洋

The TPOS OceanObs'19 Community White Paper provided recommendations for a low-latitude western Pacific boundary current monitoring system, including consideration of the Indonesian Throughflow. This report supplements that work with an analysis of complex interactions over a range of timescales in the northwestern Pacific Ocean, including stochastic forcing of El Niño and involvement in the delayed-action oscillator and discharge-recharge mechanisms.

TPOS OceanObs'19行业白皮书就低纬度西太平洋边界海流监测系统提供了建议，包括将印度尼西亚通流考虑在内。本报告对此作了补充，分析了西北太平洋一系列时间尺度上的复杂相互作用，包括厄尔尼诺现象的随机强迫作用以及延迟作用振荡器和补排机制的介入。

The boreal summer intraseasonal oscillation, an elemental part of the Asian summer monsoon system, provides one example of potentially predictable signals on subseasonal to seasonal timescales in the northwestern Pacific Ocean, with likely far-reaching impacts (e.g., extreme rainfalls and droughts) of significant societal relevance for the region. The region also hosts the most intensive typhoon/cyclone hot spot according to observations over the last fifty years. Improved understanding may allow typhoon prediction to be extended beyond seven days.

北方夏季季内振荡是亚洲夏季风系统的一个基本组成部分，这是西北太平洋次季节到季节时间尺度上潜在可预测信号的一个例子。它可能带来严重的影响（如极端降雨和干旱），与该地区具有明显的社会相关性。根据过去五十年的观察，该地区还拥有最密集的台风/飓风热点。提高对这一现象的理解可以使台风预测延长至七天以上。

An enhanced observing capability is needed to meet requirements in the northwestern Pacific Ocean arising from these complex scale interactions and their associated links between the tropics and subtropics. These enhancements are proposed as part of the evolution of the Backbone.

由于这些复杂的尺度相互作用及其与热带和亚热带之间的相关联系，需要提高观测能力以满足西北太平洋的观测需要。已经提议骨干系统的改进包括提高这些方面的观测能力。

Air-sea fluxes and the planetary boundary layers

海-气通量和行星边界层

One purpose of the Backbone is to provide in situ time series for comparisons with satellite-based measurements and validating gridded synthesis products, including for those of wind stress and air-sea heat and water fluxes. The Second Report discusses how the TPOS might better support these goals.

骨干系统的其中一个用途是提供现场的时间序列数据，用于与卫星观测数据进行比较和对网格合成产品进行验证，包括对风应力和海-气热和水通量产品的验证。第二份报告讨论了TPOS如何更好地支持这些目标。

Wind stress

风应力

The First Report design takes advantage of the revolution in broadscale wind estimation over the ocean enabled by space-based scatterometers, but combined with and complemented by in situ measurements, particularly from moorings. If space-based vector wind sampling could be increased and better spread across the diurnal cycle, the outlook is for greatly improved wind estimation. However, some questions remained about the differences between wind estimates from moorings and satellites, about errors in blended gridded wind products, and about the best approach to monitoring decadal-scale variability and detecting climate change. An Annex to the Second Report is devoted to these issues and to errors arising from sampling (space and time). Further research is needed to better understand these errors in gridded wind products and the impacts of sampling differences between satellite and buoy winds (***Action 6.1***). There are also outstanding issues around directional dependence of buoy and scatterometer wind differences (***Action 6.3***).

第一份报告的设计利益于采用基于空间的散射仪所获得的海洋大规模风速估算数据，以及现场测量数据，尤其是锚系设备。如果可以加大基于空间的矢量风的采样并在日

周期以更佳的方式加以部署，则可以极大地改善风的估算。但是，锚系设备数据与卫星数据的风力估算之间存在差异、混合网格风产品存在误差以及如何以最佳方式数十年持续进行变化监测和气候变化检测等问题仍然没有解决。第二份报告专门讨论了这些问题和抽样（空间和时间）带来的错误。目前需要进一步进行研究，以便更好地了解网格化风产品存在的这些误差以及卫星和浮标风之间的采样差异的影响（***措施***6.1）。浮标的方向依赖和散射仪风速差异也存在突出问题（***措施***6.3）。

The First Report noted the many different approaches to producing gridded wind products (including uncertainty estimates), ranging from reanalysis products to specialized blended products using wind observations from different scatterometers and in situ data. The effect of surface currents remains an issue. Dedicated analyses have been started (as discussed in Annex A of the Second Report) to better document error sources from both moorings and satellites, to understand their differences, and distinguish the issues of measurement versus sampling errors (***Action 6.2***).

第一份报告指出生产网格风产品的许多不同方法（包括不确定性估算），从再分析产品到使用不同散射仪和现场数据的风观测的专业混合产品。表面海流的影响仍然没有得到很好理解。已开始进行专门分析（如第二份报告附件A所述），以更好地记录锚系与卫星的误差来源、了解它们之间存在的差异并区分测量与采样误差的问题（***措施***6.2）。

Heat and moisture fluxes

热量和水分通量

In the First Report, it was noted that the satellite-based estimates of heat and moisture flux variables were either non-existent or subject to large uncertainties. The Second Report revisits this assessment based on recent progress in these efforts.

在第一份报告中指出，基于卫星的热量和湿度通量变量估算要么不存在，要么存在很大的不确定性。第二份报告以这些研究的最新进展情况为依据对此作了重新审视。

For radiative fluxes, the report analyses studies that have looked at the bias and standard deviation of satellite derived downwelling shortwave and longwave products with encouraging results. There remain uncertainties that need to be better quantified and understood. The pathways for progress include more in situ radiation data, together with the development of standards that ensure their measurements and processing led to the highest possible quality. They also include the deployment of some highly instrumented Super Sites (section 7.4.7) in selected regions.

对于辐射通量，本报告对卫星导致的下行短波和长波产品的偏差和标准偏差的研究作了分析，结果令人鼓舞。仍有不确定因素需要得到更好地量化和理解。改进途径包括获取更多的现场辐射数据，以及制定相关标准以确保以最高质量进行测量和处理。此外，还可以在选定区域部署几个装备精良的超级站点（第7.4.7节）。

Satellite products of turbulent fluxes relying on surface state variables and bulk algorithms have also been continuously improved, even if satellite retrievals of near-surface temperature and humidity need further refinement. Documented errors in these variables have regional and regime dependencies, for example in the vicinity of large-scale atmospheric convergence/ divergence fields and associated cloud properties. In situ data sites within each of these regimes (with meridional extensions) will help improve near-surface temperature and humidity estimates.

Additional measurements at "Super Sites" such as in situ directly measured fluxes using direct correlation flux observations and atmospheric boundary layer temperature and humidity profiles would also provide guidance for improving satellite retrievals.

近地表温度和湿度的卫星检索尚需进一步改进，但依赖于表面状态变量和体积算法的湍流通量的卫星产品也在不断得到改进。这些变量中的记录错误具有区域和制度依赖性的特点，如在大规模大气辐聚/辐散场和相关云特性附近。在每个该类区域内的现场数据站点（经向扩展）有助于改善近地表温度和湿度的估计。在"超级站点"加大测量，例如以直接相关通量观测方式现场直接测量的通量和大气边界层温度和湿度分析，也有助于改进卫星检索。

Freshwater fluxes

淡水通量

As in Recommendation 9 from the First Report, increasing the number of in situ rain gauges would provide better statistics for satellite comparisons. The TPOS community should continue discussion with the satellite and in situ precipitation experts to examine to what extent and in what regions increased rain gauge density would be of value, and whether additional measurements (for instance a Super Site with radar) could be incorporated (***Action 6.4***).

如在第一份报告的建议9所述，增加现场雨量计的数量可为进行卫星比较提供更好的统计数据。TPOS人员应当进一步与卫星和现场降水专家进行讨论，以探讨加大雨量计部署密度的程度和部署的区域，以及是否需要进行额外的测量（例如配备雷达的超级站点）（***措施6.4***）。

Other considerations

其他考虑因素

The Second Report reaffirms the importance of surface currents for improving surface fluxes; the evaporation rate, and latent and sensible heat fluxes depend on the wind speed relative to the ocean current.

第二份报告重申了表面海流对改善表层通量的重要性；并重申蒸发速率、潜热和显热通量取决于相对于洋流的风速。

The Second Report confirms the priority placed on the requirement for more extensive measurements of the full suite of flux variables which are currently only made at a few sites on the equator. It also confirms the priority to extend surface sampling across the tropical convergence zones and into the subtropical trade wind regime and other key regimes. [6.5]

第二份报告确认需要优先考虑对全套通量变量进行更广泛的测量，而目前仅在赤道上的几个地点进行测量。此外，还确认需要优先考虑将表面采样扩展到热带辐合区以及亚热带贸易风系统和其他关键区域。[6.5]

The Second Report also reaffirms the increased requirements for mean sea level pressure measurements based on recent sensitivity experiments. Near the equator, where rapid divergence can hinder effective sampling from drifters, sensors on the TMA (5°S – 5°N) could help meet the requirement.

第二份报告还重申了根据最新的敏感性实验对平均海平面气压进行测量的迫切需要。

在赤道附近，快速辐散会阻碍漂移浮标进行有效采样，但采用TMA（5°S-5°N）传感器可以帮助满足此要求。

The Backbone Observing System
骨干观测系统

The Second Report updates, and as necessary modifies, the Backbone observing system recommendations provided in the First Report, taking advantage of recent consultation and feedback, new dedicated studies and technical progress, and results from recent pilot studies. We recap the design and multiple functions of the Backbone and more fully explain some of the reasoning behind the Backbone recommendations where the First Report left uncertainty, or where issues have been raised subsequent to the publication of the initial Report.

对于第一份报告中提出的骨干观测系统建议，第二份报告基于最新的咨询和反馈、新开展的专门研究和技术进步以及最新的试点研究所取得的结果，作了更新，并在必要时作了修改。我们回顾了骨干观测系统的设计和多种功能，并更全面地解释了骨干观测系统建议背后的一些原因，无论是由于在第一份报告留有的不确定性，或者是由于在第一份报告发布后新出现的问题。

In general, the recommendations of the First Report remain valid, with the underlying logic and evidence strengthened by the review. The major changes remain renewal and reconfiguration of the mooring array, and a doubling of Argo sampling in the tropical zone (10°N – 10°S), now including BGC-Argo sensors on 1/6th of the floats.

总体而言，第一份报告的建议仍然有效，研究所强调的基本逻辑和证据仍然存在。主要变化仍然是锚系阵列的更新和重新配置问题，以及热带地区（10°N-10°S）的Argo（现在其1/6的Argo浮标为BGC-Argo）采样如何加倍的问题。

The reconfiguration of the tropical moored buoy array is now described in greater detail, including tiered parameter suites (7.3.1.1), and a refocused spatial configuration that maintains and enhances the focus on the equator while retaining a grid-like structure for detecting and validating basin-wide decadal and longer-term flux changes (7.3.2; Figure 7.4). The 3 tiers include a widely deployed and enhanced base level (Tier 1), with some that will include rainfall, pressure and mixed layer salinity (***Action 7.1***); a velocity-enhanced mooring that will be deployed at select sites/lines (Tier 2) (***Action 7.2***); and a small number of very highly instrumented "Super Sites" (Tier 3).

本报告更详细地阐述了热带锚系浮标阵列的重新配置问题，包括分层参数套件（7.3.1.1）和重新划分的工作空间部署，在保持并进一步聚焦在赤道的前提下，建立起一个网格状的结构，以用于检测和验证海盆尺度的年代际和长期通量变化（7.3.2；图7.4）。划分为三层次，包括部署范围广泛并加强的基础层（第1层），部分包括降雨、压力和混合层盐度（***措施7.1***）；在部分地点/线路部署的速度增强锚系（第2层）（***措施7.2***）；以及装备极为精良的少量"超级站点"（第3层）。

Consistent with identified requirements and priorities, the new moored array design focuses on [7.3.1]:

1) expanding the sampled surface meteorological regimes through poleward extension of some meridional spines;
2) markedly expanding the spatial coverage of variables for heat and water flux estimates,

adding short and longwave radiation to Tier 1, and rainfall (***Action 6.4***);
3) complementing (2), resolving near surface and mixed layer diurnal variability across the domain (denser vertical resolution of temperature in the upper 50m);
4) systematically measuring near surface currents;
5) expanding surface barometric pressure measurements;
6) better resolving the near equatorial flow field in the central Pacific; and
7) sustaining and enhancing pCO_2 measurements.

与确定的要求和需要优先处理的事项一样，新的锚系阵列设计侧重于以下几个方面[7.3.1]：

1）通过经向向上扩展的方式扩大表层气象的采样区域；
2）显著扩大用于热量和水通量估算的变量的空间覆盖范围，第1层增加短波和长波辐射，以及降雨（***措施6.4***）；
3）作为以上第（2）方面的补充，研究整个区域的近表层和混合层昼夜差异性（上方50m更密集的垂直温度分辨率）；
4）系统性地测量近海表海流；
5）扩大表面气压测量；
6）更好地研究中太平洋近赤道流场；
7）继续进行并加强pCO_2的测量。

Recommendation 7.1. TPOS 2020 recommends the adoption of and support for a refocused design for the tropical moored buoy array, with a three-tiered approach to instrumentation. These comprise the Tier 1 baseline with enhanced surface and upper ocean measurements over the existing array; Tier 2 with added velocity observations in the mixed layer; and Tier 3, an intensive Super Site that might be used in a campaign mode. [7.3.1].

建议7.1： TPOS 2020建议对热带锚系浮标阵列的部署重点进行重新设计，并采用划分为三个层次的办法。第一层为基础层，加强表面和上层海洋的测量；第二层加强在混合层的速度观测；第三层为在集中部署超级站点。[7.3.1]

The exact location of the moorings poleward of 8°S under the South Pacific Convergence Zone needs to be further explored, in consultation with community experts and regional partners (***Action 7.3***).

需要与行业专家和区域合作伙伴协商，进一步探讨南太平洋辐合带8°S锚系极点的确切位置（***措施7.3***）。

Tier 2 sites, in consultation with community experts to specify the priority sites (***Action 7.2***), will include an upward looking near-surface ADCP, measuring velocity in the upper 50m. The "Super Site" concept is still in development but will include additional instruments to provide more detailed or specialized information to refine the observing strategy and take advantage of technological advances. [7.4.7]

第二层站点需要与行业专家协商确定优先站点的位置（***措施7.2***），包括近海表ADCP以测量海洋上层50米的速度。"超级站点"概念仍处于开发阶段，可以配备其他工具，以提供更详细或专业的信息，完善观测策略并充分使用最新技术。[7.4.7]

Full implementation of the TPOS design will deliver many gains, but also raises the potential for losses; such is inevitable in a process of redesign and reprioritization but is nevertheless regrettable, particularly with respect to some historical off-equatorial mooring sites. This is already the case in the western Pacific, although the new design aims to redress and minimize the loss. The gains and losses are described in detail [7.3.2, 10], including mooring coverage (Figure 7.5), rainfall sampling (Figure 7.6), decadal and longer-term wind (Figure 7.7) and latent heat flux (Figure 7.8) changes, and radiation and evaporation regimes (Figure 7.9). Subsurface impacts from changes to Argo and mooring sampling are also presented (Figures 7.10-15). A full summary is included. [7.3.3]

全面实施TPOS设计可带来许多好处，但也会提高发生损失的风险。在重新设计和重新确定优先次序的过程中不可避免会发生损失，特别是对于一些历史的远离赤道的锚系地点。在西太平洋已经出现了这种情况，尽管新设计的目的就是为纠正并尽量减少损失。本报告详细描述了可带来的好处和可能造成的损失[7.3.2,10]，包括锚系覆盖范围（图7.5）、降雨采样（图7.6）、年代际和长期风场（图7.7）和潜热通量（图7.8）等的变化以及辐射和蒸发方式（图7.9）等。本报告还提出Argo和锚系取样变化引起的次表层影响（图7.10-15）。并提供了完整的摘要。[7.3.3]

Progress with Implementation
实施进展

Progress with implementation since the First Report has been very encouraging and TPOS 2020 has achieved significant buy in. We provide a schematic update of the status of the main Backbone Essential Ocean Variables which shows around half are in a satisfactory state (requirements met adequately or better), but for the remainder there is considerable work to do. For wind, and building on Recommendation 1 from the First Report, TPOS 2020 must drive further dialogue with agencies to explore ways to improve data availability and the diurnal spread of sampling by vector wind measuring satellite missions if the TPOS requirements are to be met (***Action 7.4***, 7.4.1, First Report, Rec. 1). For sea surface salinity, the community must continue to highlight the ongoing need and benefits of follow-on satellite missions (***Action 7.5,*** First Report Rec. 10). Underway measurements of pCO_2 fall short of requirements and TPOS 2020 must act to establish measurements on all mooring servicing vessels and promote pilots of pCO_2 measurements from autonomous underway vehicles (***Action 7.6***; 4.3.1; First Report, Rec. 12).

自第一份报告发布以来各项措施的实施取得了非常令人鼓舞的进展，TPOS 2020已经取得了显著的进步。我们示意性更新了对骨干观测系统而言十分重要的主要海洋变量的状态，其中大约一半处于令人满意的状态（各项要求得到充分满足甚至超出预期）。但对于其他方面，还有很多的工作需要做。对于风变量，根据第一份报告的建议1，TPOS 2020必须推动与各机构的进一步对话，以探索为满足TPOS要求，通过矢量风测量卫星任务提高数据可用性和采样的昼夜扩散的方法（***措施7.4***、***7.4.1***，第一份报告建议1）。对于海表面盐度，必须继续强调后续卫星任务的持续需求和益处（***措施7.5***，第一份报告建议10）。正在进行的pCO_2测量不符合要求，TPOS 2020必须采取措施，对所有锚系维护航次进行测量，并促进水下自主机器人进行pCO_2测量（***措施***7.6；4.3.1；第一份报告建议12）。

The First Report included recommendations and actions to enhance Argo coverage in the TPOS region; the Second Report reaffirms this strategy and priority. Around 20% of that enhancement is in place currently. This report provides further analysis of deployment strategies and stresses the need for greater international participation.

第一份报告对在TPOS地区加强Argo覆盖范围提出建议和措施，第二份报告重申了这一

战略和优先事项。目前增强部分约20%已经到位。本报告进一步分析了部署战略，并强调需要进一步加强国际参与。

To address requirements in the western and northwest Pacific Ocean, the TPOS 2020 project has convened discussions with key stakeholders. China has outlined plans to contribute moorings and other capability to address these needs, including to track monsoon and typhoon development over the northwestern Pacific Ocean [the so-called Ding "丁" array; 6.2.2, 7.2.1.3]. In-principle support for maintaining the TAO part and the remaining 3 TRITON moorings has been provided by the National Oeanic and Atmospheric Administration (NOAA) and the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), respectively. We reprise and update the incomplete action from the First Report:

为应对西太平洋和西北太平洋区域的相关要求，TPOS 2020项目已经与主要利益相关方进行了讨论。中国已经制定了计划，以提供锚系和其他能力以满足这些需求，包括跟踪西北太平洋的季风和台风发展[所谓的 “丁”阵列； 6.2.2、7.2.1.3]。国家海洋和大气管理局（NOAA）和日本海洋地球科学和技术局（JAMSTEC）分别同意原则上提供对维护TAO部分和剩余3个TRITON锚系设备的支持。对第一份报告中没有完整阐述的措施，作了重申并更新：

- *The TMA sites in the western Pacific within 2°S to 2°N should be maintained or reoccupied.*
- *应当保持或重启用用西太平洋2°S至2°N的TMA站点。*

These are core sites, and all should be supported.

这些是核心站点，都应该得到支持。

The Second Report outlines a staged implementation approach [7.4.4; Figure 7.19; TPOS OceanObs'19], with ongoing assessment through to full maturity. Many elements will evolve with global implementation, but with recognition of and advocacy from the TPOS community. Others will require specific actions from the TPOS community, and these are discussed in more detail in the report. The actions, including reconfiguration of the moored array, will need to be carefully coordinated since no single player is able to respond to all requirements. Resource limitations are inevitable but through a cooperative implementation strategy and plan, the TPOS community can jointly meet most requirements and together enjoy the benefits of the whole TPOS.

第二份报告概述了分阶段实施方法[7.4.4；图7.19；TPOS OceanObs'19]，以持续评估至最后。许多要素随着全球范围的实施也将出现变化，但需要得到TPOS行业的认可和支持。 其他方面需要TPOS采取具体的措施，报告中对此作了更详细的讨论。没有单独的机构或个人能够响应所有要求，因此需要仔细协调这些措施，包括重新配置锚系阵列。资源限制不可避免，但通过合作实施战略和计划，TPOS行业可以共同努力以满足大多数要求，并共享整个TPOS所带来的益处。

Several specific actions are highlighted:

- In preparation for TMA-wide usage, Tier 1 ‘full flux’ moorings from all contributing operators should be piloted, intercompared and assessed, and agreement reached on where salinity, rainfall, and barometric pressure are most needed in addition to the core measurements. Instrument calibration and quality control procedures should be further developed, agreed and documented. [***Action 7.7***]

- A pilot of enhanced thermocline velocity measurements at established sites at 140 °W, 2 °N/S should be planned, and if successful, extended to include the new sites at 1°N/S. [***Action 7.8***]
- Argo float deployments should be doubled over the entire tropical region 10°S-10°N, starting immediately in the western Pacific, followed by the eastern Pacific and extending to the entire region, building to a total annual deployment rate of 170/year.

报告中着重阐述了以下几项具体措施：

- 为准备大面积使用TMA，需要所有参与者进行第一层次的“全通量”锚系测试、相互比较和评估。除需要测量的关键指标外，还需要就哪里最需要进行盐度、降雨和气压的测量达成一致。此外，还需要进一步制定、约定和记录相关的设备校准和质量控制程序。 [***措施7.7***]
- 应当计划在140°W、2°N/S的既定地点加强温跃层速度测量。如果成功实施，则应扩展，包括1°N / S的新站点。 [***措施***7.8]
- 部署在整个热带地区10°S-10°N的Argo浮标应增加一倍，从西太平洋开始，然后是东太平洋，并扩展到整个地区，部署的速度为每年170 个浮标。

Of these, 31 should be equipped with biogeochemical sensors. [***Action 7.9***; ***Recommendation 4.1***]

- TPOS 2020 should develop and detail whole-of-system assessment activities, describing them in the final TPOS report (or earlier). Part of the assessment should include examining the tradeoffs between the number of sites versus the ability to maintain continuous records. [***Action 7.10***]
- For each specialized data stream or platform, ensure the creation of an engaged team of experts to oversee sensor management, develop quality control (QC) procedures and guide the delayed-mode QC for the TPOS data streams. [***Action 7.11***; ***Recommendation 8.3***]

其中，31个浮标应当配备生物地球化学传感器。 [***措施7.9***；***建议4.1***]

- TPOS 2020应制定并详细说明整个系统的评估活动，并在TPOS最终报告（或更早）中对其进行说明。评估内部应包括检查站点数量与维持连续记录的能力之间是否能实现平衡。 [***措施7.10***]

- 对于每个专业数据流或平台，应当创建一个专家团队负责传感器管理的监督，开发质量控制（QC）程序并就TPOS数据流的延迟质量控制进行指导。[***措施7.11***；***建议8.3***]

The draft schedule attempts to synchronise actions and harmonise actions and assessments, but this will need to be revisited regularly.

计划草案旨在实现行动的同步并进行行动和评估的协调，但需要定期重新检查。

TPOS needs to be proactive to ensure the climate record and our ability to detect change is at least maintained, if not enhanced.

TPOS应当积极确保相关的气候记录得到保存，并且我们检测变化的能力至少得到保持（如果没有增强的话）。

Recommendation 7.2. To ensure that the TPOS observing platforms collect the accurate and interoperable measurements required to detect small [climate or "dec-cen"] signals, a series of actions should be taken, beginning before the rollout and continuing during implementation, to assess the performance and impact of the proposed platform/sensor changes. [7.2.1.2, 7.4.4]

建议7.2：为确保TPOS观测平台收集用于检测微弱[气候或"dec-cen"]信号所需的准确且可互操作的测量值，还需要采取一系列措施（从推出之前开始并在实施期间继续），对拟议平台/传感器的性能和变化的影响进行评估。 [7.2.1.2、7.4.4]

Updates are provided for all Pilot Studies and Process Studies proposed in the First Report [7.4.5, 7.4.6; Figure 7.20].

在本报告中，对第一份报告的[7.4.5、7.4.6；图7.20]提出的试点研究和过程研究作了更新。

The concept of a Super Site is to provide multi-year specialized and more comprehensive data sets, using a larger and/or more complex suite of measurements than the Backbone observing system offers. TPOS 2020 should further develop and articulate the concept, including possible approaches to determination of appropriate times, locations, and measurements. [***Action 7.12***]

超级站点这一概念旨在使用比骨干观测系统更大和/或更复杂的测量套件提供多年的专业化的更全面的数据集。TPOS 2020应当进一步发展和阐明这一概念，包括找到用于确定适当时间、地点和测量方式的方法。 [***措施7.12***]

Several additional actions and recommendations flow from the review of the First Report.

在本报告中新提出的多个措施和建议是在对第一份报告进行重新检查后提出的。

For sea surface temperature, Recommendation 3 from the First Report remains valid but additional emphasis is needed on the mix of observations and processing needed to properly resolve the diurnal cycle, incorporating remote microwave measurements, visible–near infrared sensing data, and in situ data at various depths near the surface. [First Report Rec. 3; ***Action 7.13***; 7.5.1]

对于海面温度，第一份报告中的建议3仍然有效，但需要就以下多个方面进一步加强观测和处理：日循环、远程微波测量、表面附近各个深度的可见近红外传感数据和现场数据。 [***第一份报告建议3；措施7.13；7.5.1***]

The First Report recommendation for sea surface salinity might be misleading, and so has been updated:

Updated First Report Recommendation 10*: Continuity of complementary satellite and in situ SSS measurement networks, with a focus on improved satellite accuracy to augment the spatial and temporal sampling of SSS.*

第一份报告中关于海面盐度的建议可能具有误导性，因此在本报告中作了如下更新：

第一份报告的建议10在此更新如下：*维持互补的卫星和实测 SSS 观测网，重点提高卫星观测的精度，以增强SSS的空间和时间采样。*

Further progress has been made in relation to the First Report recommendation on surface currents (Recommendation 11). Two missions are now in the planning phase which are, in the view of TPOS 2020, potential game-changers with direct measurements of total surface currents, a requirement that has been highlighted with respect to surface wind stress and surface fluxes. [7.5, 9.3.1]

在第一份报告中提出表层海流的建议已经取得新进展（建议11）。目前有两项尚处于规划阶段但可能改变TPOS 2020的游戏规则的任务。在这两项任务中，对所有表层海流进行直接测量，这是已经在表层风应力和表层通量方面强调过的一项要求。[7.5、9.3.1]

The importance of other in situ capabilities, while recognized in the First Report (Recommendation 21), was not sufficiently highlighted. Thus, a new recommendation from TPOS 2020 is:

尽管在第一份报告（建议21）中也提及其他现场能力的重要性，但并未充分强调。 因此，TPOS 2020提出以下建议：

> ***Recommendation 7.3.*** Improvement of dedicated capacities on servicing ships to allow repeated ancillary measurements. Underway measurements such as Shipboard Acoustic Doppler Current Profiler measurements, *p*CO2 and sea surface salinity should be systematically acquired. [7.5; ***Recommendation 4.2***]

> ***建议7.3***：提高服务船舶的专业能力，以便重复进行辅助测量。目前已经正在进行的测量能力如船载声学多普勒电流分析仪测量、*p*CO2和海面盐度等应当做到具有系统性。[7.5；***建议4.2***]

TPOS 2020 continues to advocate for Pilot and Process Studies that will contribute to the refinement and evolution of the TPOS Backbone. [First Report, Action 14]

TPOS 2020在本报告中继续倡导进行有助于TPOS骨干网的改进和发展的试点研究和流程研究。 [第一份报告，措施14]

Additional Areas of Review
其他审查领域

TPOS data flow and access

TPOS数据流和访问

The Second Report proposes that data management should be considered alongside observations in the requirement determination process and that the architecture of our data systems requires greater clarity. We continue to advocate for the necessaryinvestment:

第二份报告建议在需求确定过程数据管理应当与观察结果一并考虑，并建议我们的数据系统架构应当更加清晰。 我们继续倡导在以下方面的投资：

> ***Recommendation 8.1.*** As an underlying principle, around 10% of the investment in the TPOS should be directed towards data and information management, including for emerging and prototype technologies. [First Report, 8.1, 8.2]

> ***建议8.1***：作为一项基本原则，TPOS投资中约有10%应当用于数据和信息管理，包括用于新兴技术和原型技术。 [第一份报告，8.1、8.2]

This report concludes a distributed approach to data systems promotes agility and efficiency, particularly if the distributed services are built upon commonly used standards and conventions.

This report outlines a generalized system that takes advantage of other developments in this area. An important benefit is that the scientists and/or data providers are abstracted from the need to understand the formats required for real-time distribution. The ultimate aim is to have a virtual one-stop set of web services for all TPOS data, suitable for research, production, services, public and privately funded activities or other ad hoc use. [8.3]

本报告总结了一种用于提高数据系统的敏捷性和效率的分布式方法，特别是对于分布式服务是建立在常用的标准和惯例之上的情况。本报告概述了一种利用这一领域的其他发展成果的广义系统。其中一个优点是科学家和/或数据提供者无需理解实时分发所需的格式。其最终目标是为所有TPOS数据提供虚拟的一站式Web服务，并适用于研究、生产、服务、公共和私人资助的活动或其他临时用途。[8.3]

This report identifies two other areas where TPOS should be proactive. First, the likely introduction of new partners, particularly for the tropical moored buoys, and new technologies, argues for a TPOS data management plan, initially spanning all TMA contributions and data modes. The second area is around delayed-mode data, data archeology, re-processing and re-analysis. Re-processing for reanalysis is now mainstreamed, to take advantage of knowledge that was not available in real-time, and/or to exploit improved techniques. One foci for TPOS 2020 is the western Pacific where there is a large cache of data that is for now "lost" to the wider scientific community, and likely to be "found" only through a major international collaborative effort (***Action 8.1***) aimed at retrieving and re-processing such data into a form that is FAIR (findable, accessible, interoperable, reusable).

本报告确定了TPOS应当积极处理的其他两个方面。首先是是否可以引入新的合作伙伴，特别是在热带锚系浮标和新技术方面，就TPOS数据管理计划进行讨论，最初涵盖所有TMA和数据模式。其次是关于延迟模式数据、数据考古、重新处理和重新分析。如今，重新分析重新处理已成为主流，以利用实时无法获得的知识和/或充分利用后续改进的技术。TPOS 2020应当关注的其中一个焦点是西太平洋，因为这里存有的大量数据并不为更广泛的科学界所知，并且可能只有通过旨在为进行检索并将这些数据重新处理为可查找、可访问、可互操作、可重用（findable, accessible, interoperable, reusable，简称FAIR）形式时，通过国际合作方式（***措施8.1***）才能“找到”。

Recommendation 8.2. Data stewardship and the engagement of all TPOS 2020 stakeholders in data management must be a central platform in the sustainability of the TPOS. The FAIR Principles should be adopted as a basis for TPOS engagement. [8.4]

建议8.2：数据管理以及让TPOS 2020的所有利益相关方参与数据管理必须作为实现TPOS可持续性的中心平台。应采用FAIR原则，作为TPOS参与的基础。[8.4]

Recommendation 8.3. TPOS 2020 should develop a project around the management of all TMA data including, to the extent possible, recovery and re-processing of other relevant mooring data. [8.4]

建议8.3：TPOS 2020应当发起旨在对所有TMA数据（包括其他相关锚系数据的恢复和重新处理，范围应当尽可能广泛）进行管理的项目。[8.4]

TPOS 2020 supports the global community in its endeavor to establish global information and management systems that will provide cost-effective ways to increase and improve accessibility, interoperability, visibility, utility and reliability; endeavors that will benefit TPOS data, for current TPOS stakeholders and beyond.

TPOS 2020支持全球各界努力建立起全球信息和管理系统，实现以经济有效的方式提高和改善可访问性、互操作性、可见性、实用性和可靠性。同时也支持对于TPOS的利益相关者甚至在在更广泛的范围内均有益于TPOS数据所作出的努力。

Recommendation 8.4. TPOS 2020 should develop a pilot project, in conjunction with the WMO Information System effort, to explore the global distribution of TPOS data in near-real time. [8.5]

建议8.4：TPOS 2020应联合WMO信息系统共同发起一个以近乎实时的方式探索TPOS数据的全球分布的试点项目。[8.5]

Emerging technologies

新兴技术

This report discusses the current state of a selection of emerging technologies that are of potential future relevance to TPOS and introduces an evaluation mechanism to assess readiness and guide integration of new observation techniques/platforms into the Backbone. The discussion includes:

1. NOAA Saildrone®[3] experiments;
2. Wave Glider® experiments;
3. PRAWLER profiler;
4. Ocean gliders;
5. Biogeochemistry, biology, and ecosystems technology;
6. Water isotope observations - applications and technology;
7. Remote sensing of ocean surface currents;
8. Global Navigation Satellite System radio occultations;
9. Microwave and infrared-laser occultations; and
10. Global Navigation Satellite System scatterometry.

本报告讨论了一系列在未来可能与TPOS有关系的一系列新兴技术的当前发展情况，并介绍了旨在评估其是否可用及用于指导将新的观测技术/平台整合到骨干观测系统的评估机制。其中包括：

1.NOAASaildrone®[3]实验；

2.WaveGlider®实验；

3. PRAWLER分析器；

4.海洋滑翔机；

5.生物地球化学、生物学和生态系统技术；

[3] Saildrone and Wave Glider are trademark names; hereafter referred to without ®

[3] Saildrone和Wave Glider是商标名称，下文出现时不再带®

6.水同位素观测的应用和技术；

7.遥感海洋表层水流；

8.全球导航卫星系统无线电掩星；

9.微波和红外激光掩蔽；

10.全球导航卫星系统散射测量。

Technological innovations were also discussed in the First Report and elsewhere in this report.

在第一份报告和本报告的其他部分也讨论了技术创新。

The proposed evaluation framework is an adaptation of that given in the Framework for Ocean Observing, simplified and adjusted for application to potential Backbone contributions (a Backbone readiness level). Preliminary assessments are provided for the emerging technologies discussed in the report, together with an assessment of the Technical Readiness Level.

拟议的评估框架是对海洋观测框架的评估框架的修改，作了简化和调整以适用于可能的骨干观测系统用途（骨干观测系统可用级）。对报告中讨论的新兴技术作了初步评估，同时对其技术可用级进行评估。

The report acknowledges that further work is required to ensure the framework can be applied in a consistent manner (e.g., improved documentation) and to determine whether it will meet stakeholder/TPOS sponsor needs. The assessments also need to be extended to cover other potential technologies (***Action 9.1***).

本报告承认，为确保能以一致的方式使用该框架（例如，文件改进），并确定其是否符合利益相关者/ TPOS赞助商的需求，还需要进一步的努力。此外，对其他潜在技术也需要进行评估（***措施9.1***）。

The report emphasizes that such a framework only provides guidance, and decisions on adoption of new techniques and technology will need to consider other factors, such as roadblocks to/assistance for user uptake, availability of suitable data management facilities, and of course cost and effectiveness. Likewise, the relative impact of potential technologies must factor in actual and prospective model and assimilation sensitivity.

报告中强调，该框架只提供指导，是否采用新方法和新技术需要考虑其他因素如用户的使用困难、如何帮助他们开始使用、是否有可用的数据管理设施以及成本和效益等。此外，潜在技术的相对影响必须考虑到实际的和预期的模型和同化敏感性。

> ***Recommendation 9.1.*** That the Backbone Readiness Level framework be further developed and refined by TPOS 2020 before adoption. [9.4]
>
> ***建议9.1***：在采用之前，TPOS 2020应当进一步开发和完善骨干观测系统可用级的框架。[9.4]

Next Steps
后续措施

The work of implementing the new observing system for the next decades is just gaining momentum. Although the TPOS 2020 project will finish at the end of that year with a final report, much of the implementation of the changes proposed here will just be getting under way. We note the need for additional investment in order to move from where TPOS is today toward the full implementation of this plan [10]. Results of piloting new technology discussed in Chapter 9, and the process studies in Chapters 2 and 3 and in 7.4.6, will become clear over the next few years; these will need evaluation to determine their lessons and readiness for the Backbone.

在未来几十年实施新观测系统是一个漫长的过程，目前才刚刚起步。在发布最终报告之日，也将时是TPOS 2020项目完成之时，但对于实施报告中所述的变更，目前还只是处于进行过程。我们注意到需要加大投资才能将TPOS从目前所处位置向前推进，直至本计划最终完成[10]。对于第9章所讨论的新技术以及第2章、第3章和7.4.6所讨论的过程研究的结果，在未来几年才能知道是否富有成效。为此需要进行评估，以吸取教训和评估其是否可用于骨干观测系统。

The actions and recommendations of this report already point to substantive issues that will need to be included in the Final Report. More will emerge as TPOS 2020 stakeholders and the TPOS 2020 Resource Forum consider the implications from this report.

本报告中提出的措施和建议已经涉及一系列将在最终报告中探讨的实质性问题。在本报告发布后，随着项目的进展，TPOS 2020的利益相关者和TPOS 2020资源论坛也会考虑除此外的其他措施和建议。

As the system evolves, maintenance of the climate record will be an essential consideration. Coordination of the interlocking networks will require regular consultation among the implementing partners.

随着系统的发展，气候记录的保留将是一个必不可少的考虑因素。联锁网络的协调需要各参与的合作伙伴定期进行协商。

For all these reasons, the need for appropriate governance, and for scientific advice, will continue past this project's sunset; the mechanisms for these are under discussion with our sponsors (TPOS OceanObs'19) and among the international organizations that set the framework for observing systems such as the TPOS (***Action 10.1***).

由于所有这些原因，在本项目完成后需要继续探讨如何进行治理和听取科学的建议等问题。这些机制目前正与我们的赞助商TPOS OceanObs'19以及为TPOS（***措施10.1***）等观测系统设定框架的国际组织进行讨论。