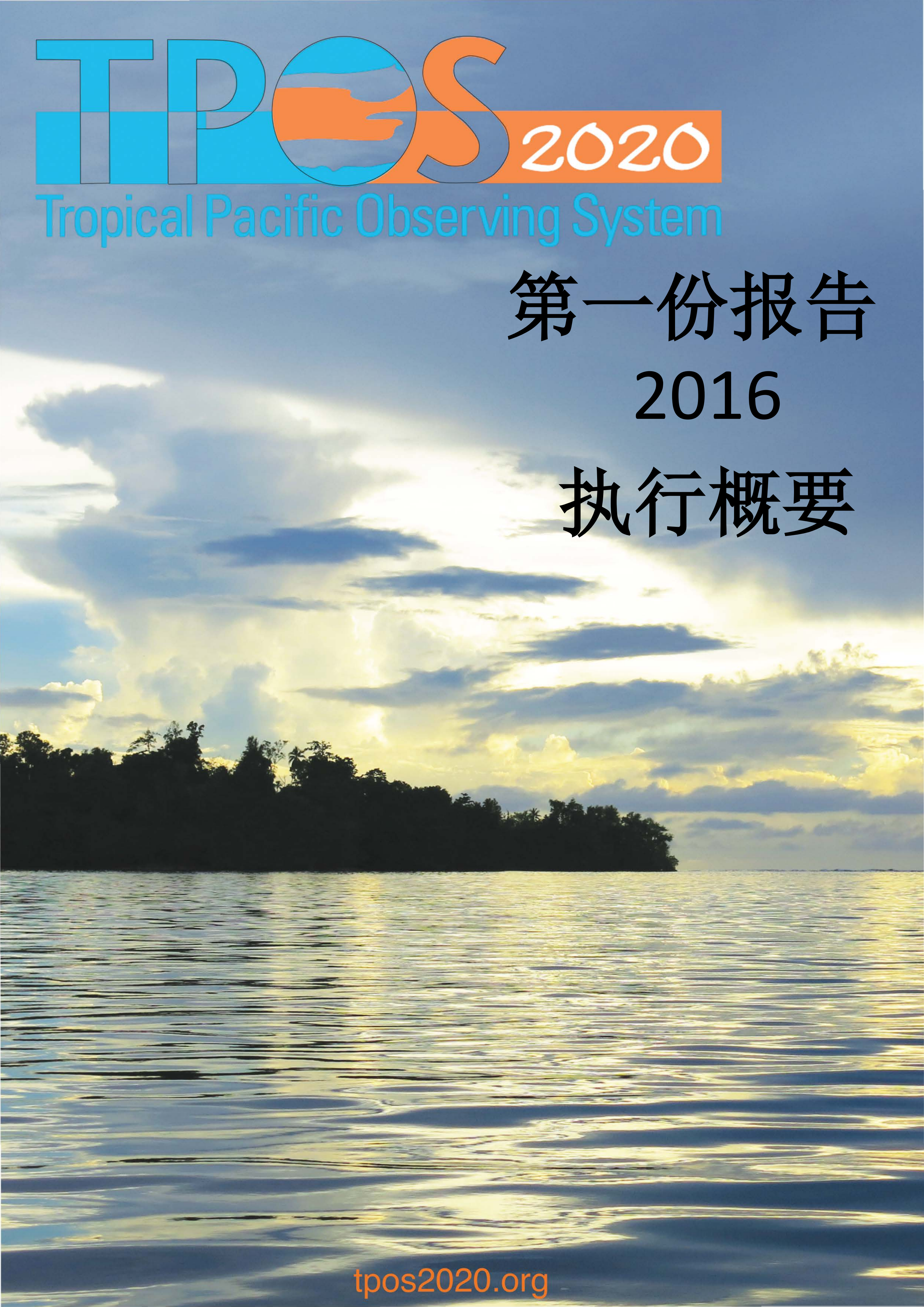
TPOS 2020

Tropical Pacific Observing System

第一份报告

2016

执行概要



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First Report of TPOS 2020 | TPOS 2020 第一份报告
Executive Summary | 执行概要
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Executive Summary

执行概要

TPOS 2020 (Tropical Pacific Observing System 2020 project) is a once in a generation opportunity to enhance and redesign international observations of the tropical Pacific. Variability of this strongly coupled atmosphere-ocean system reverberates across the global climate and provides a principal source of interannual climate predictability extending worldwide.

热带太平洋观测系统 2020 计划（Tropical Pacific Observing System 2020 project, 简称 TPOS 2020）为提升和重新设计热带太平洋国际观测系统提供了一个极为难得的契机。热带太平洋海-气耦合系统的变化能强烈影响全球气候，是预测世界范围内年际尺度气候变异的关键所在。

The principal driver of the project is an identified significant risk to El Niño – Southern Oscillation (ENSO) predictions and associated services due to the deterioration of the tropical moored buoy array (TMA) in the Pacific in 2012-2014. The TPOS network aims to mitigate this risk as well as to accelerate advances in the understanding and prediction of tropical Pacific variability and its profound consequences to multiple sectors, ranging across agriculture, marine ecosystems, human health and disaster preparedness, around the globe. In response to other science drivers, especially climate, TPOS 2020 will continue key observational records, intensify monitoring of key upper ocean/surface atmosphere parameters and phenomena, include ocean biogeochemistry and expand to both the eastern and western boundary regions.

促成此计划的主因是热带太平洋锚系阵列（tropical moored buoy array, 简称 TMA）在 2012-2014 年的严重退化，因为这会给厄尔尼诺-南方涛动（El Niño – Southern Oscillation, 简称 ENSO）的预测工作和相关业务带来巨大风险。TPOS 观测网旨在降低这种风险，并进一步认知和预测热带太平洋气候变异及其在农业、海洋生态系统、人类健康、防灾减灾等领域的全球影响。针对其他科学因素，特别是气候，TPOS 2020 将延续关键观测记录，强化对上层海洋及海面大气重要参数和现象的监测，增加海洋生物地球化学方面的内容，并向太平洋东、西边界区域扩展。

This Report lays out the rationale and plans for the first step of the redesign and enhancement of the TPOS. It aims to provide sponsors with a means to justify and defend current and future investments in both sustained and experimental observations in the Tropical Pacific. This report focuses on the fundamental and core contributions to the sustained observing system (herein referred to as the Backbone of the TPOS) and is organized around five key functions [1.3][1]:

[1] Section references from the main Report are given in square brackets

[1]方括号内数字表示总体报告中对应的章节

本报告阐述开展 TPOS 2020 计划的理由，并给出重新设计和改进 TPOS 的初步方案。其目的是为经费资助方提供依据，用以证明和解说为什么应该在现在及未来对热带太平洋的持续性和实验性观测进行投资。本报告聚焦于持续性观测系统（简称 TPOS 骨干系统）的基本和核心贡献，围绕五个主要功能展开 [1.3][1]：

(1) Provide data in support of, and to evaluate, validate and initialize, ENSO prediction and other forecasting systems and to foster their advancement;
(2) Provide observations to quantify the evolving state of the surface and subsurface ocean;
(3) Support integration of satellite and in situ approaches including calibration and validation;
(4) Advance understanding and modelling of the climate system in the tropical Pacific, including through the provision of observing system infrastructure for process studies; and
(5) Maintain and extend the tropical Pacific climate record.

(1) 为评估、验证及初始化 ENSO 预测和其他预报系统，并促进其发展，提供数据支撑；
(2) 为定量表征海洋表层及次表层的状态变化提供观测数据；
(3) 为整合卫星和现场观测方法提供支撑，包括数据定标；
(4) 推进对热带太平洋气候系统的认识与模拟，包括为过程研究提供基础观测设施；
(5) 维持并扩展热带太平洋的气候观测记录。

The redesign builds on the foundations of the 1985-1994 Tropical Ocean – Global Atmosphere (TOGA) program and the many innovations and enhancements since that era [2.2, 2.3]. The many public benefits stemming from ENSO monitoring and prediction and its supporting scientific research remain a primary motivation for the TPOS. The network also provides a foundation for improved weather and ocean forecasts, as well as climate and marine environmental monitoring services. Such public good services demand a reliable, effective sustained TPOS [2.1, 2.2, 2.4]. This Report outlines both the initial recommendations and actions to meet the demands of 2020 and beyond [5, 7].

TPOS 的重新设计是基于 1985-1994 年间的热带海洋-全球大气计划（TOGA）以及之后对其观测系统的大量更新和改进 [2.2, 2.3]。基于 ENSO 监测和预测及相关科学研究的许多公共利益，仍然是 TPOS 的主要动机。TPOS 观测网也会为改进天气与海洋预报以及气候与海洋环境监测提供基础。这些公共服务需要可靠、有效且持续的 TPOS [2.1, 2.2, 2.4]。本报告概述 TPOS 2020 计划的初步建议与措施，以满足 2020 年前后的需求 [5, 7]。

The TPOS has been highly successful in the 20 years since TOGA [2.5], providing a foundation for improved understanding and for developing the many services that have emerged over that period [2.4]. TPOS 2020 revisits requirements while taking account of science issues, and new understanding that has come to the fore, and the greater sophistication of the analyses, modelling, and prediction systems as well as services that are now in place or being developed [3.1]. The TPOS design is reconsidered to take advantage of advances in new technology, both satellite and in situ, and to deliver increased efficiency, effectiveness and reliability, refocusing observations on the needs of the coming decades. The requirements are first developed for Essential Ocean and Climate Variables and, to the extent possible they are characterized in terms of spatial and temporal sampling, regime dependencies, accuracy, quality and the need for continuity, as appropriate [3.1.1, 3.1.2, 3.1.3]. The requirements are also driven by the need to sustain and improve the climate record [3.2].

TPOS 在 TOGA 之后的 20 年中取得了很大的成功 [2.5]，为提高认识和发展服务项目提供了基础 [2.4]。TPOS 2020 在重新审视需求时，考虑到了新的科学问题和科学认知，以及分析、模拟、预报系统和各种服务项目的更加复杂化 [3.1]。TPOS 的重新设计将利用卫星和现场观测新技术的发展，提供更高的效率、有效性和可靠性，以满足未来几十年的需要。我们首先对基本的海洋和气候变量提出要求，尽可能地明确这些变量的时空取样率、系统依赖性、精度、质量和连续性 [3.1.1, 3.1.2, 3.1.3]。提出这些要求也是因为我们需要维持和改进气候资料 [3.2]。

New targets for improved understanding and model development include the ocean mixed layer and the surface fluxes that interact with it; the diurnal cycle; equatorial ocean-atmosphere coupled physics; the Pacific boundary regions; and biogeochemistry, especially the large air-sea carbon fluxes [3.3]. These requirements will be met by a combination of sustained and experimental networks.

为了提高认知和发展模式，新的研究对象包括海洋混合层和与其相互作用的海-气通量；日变化；赤道海-气耦合物理机制；太平洋边界区域；生物地球化学，特别是海-气碳通量 [3.3]。这些需要将通过结合持续性和实验性的观测网来实现。

The new TPOS 2020 approach lessens the reliance on any single platform and harvests some of the efficiencies available from recent technological developments [7.6]. Key regimes will be observed comprehensively for the first time, delivering benefits to coupled model development, better system-wide gridded products and understanding more generally. TPOS enhancements will enable much needed improvements to operational modelling systems, improvements that have proved elusive.

TPOS 2020 的新方案会减少对任何单一平台的依赖，并获益于最新技术进展所提供的高效率 [7.6]。关键的海洋与气候系统将首次得到全面的观测，为耦合模式发展、更好的网格化产品和更广泛的认知提供帮助。TPOS 的强化将使得解决业务化模式系统改进的难题成为可能。

Principles are developed to guide the design for the new Backbone and its implementation [4, 7.1]. These include a coherent joint consideration of satellite and in situ platforms, exploiting their capabilities to reduce uncertainty in the climate record of the tropical Pacific [5] and introducing Pilot projects and Process studies [6] that will inform further refinement of TPOS during and after the conclusion of the Project in 2020.

我们制定了新骨干系统设计及实施的指导原则 [4,7.1]。 这些原则包括对卫星和实测平台的统一考虑，以利用它们各自的特长减少热带太平洋气候数据的不确定性 [5]；同时引入试点项目和过程研究 [6]，为计划实施期间及 2020 年计划结束以后 TPOS 的进一步完善提供支撑。

The next section of this Summary outlines the ocean variable **requirements** and the associated **recommendations** for the observing system, while the following section “Implementation” focuses on key **actions**. The order in which recommendations and actions are stated here does not imply priority, and in some cases differs from their order in the main text of the report.

下面的“需要与建议”部分给出对海洋变量的需要和对观测系统的相关建议，接下来的“实施方案”部分则侧重于计划实施的关键措施。这里列出的建议和措施不分先后，在某些情况下可能与它们在报告书全文中出现的顺序不同。

To the extent it is possible at this stage in TPOS 2020, the Report includes estimates of the cost against significant items. The Recommendations and Actions are feasible and implementable, but proper costing will only be possible after deeper dialogue with those responsible for implementing the TPOS.

在 TPOS 2020 现阶段许可的范围内，报告书包括了对重要项目的成本估算。这里给出的建议和措施都是可行且可实施的，但只有与负责实施 TPOS 的相关人员进行更深层次的交流之后，才能进行适当的成本核算。

REQUIREMENTS AND RECOMMENDATIONS

需要与建议

Climate change monitoring and detection requires stringent accuracy, duration, and continuity which flow through all the essential climate variables. Delivering such a climate record demands appropriate redundancy and resiliency against failures of the system components that might otherwise cause damage [3.2.1].

气候变化的监测和探测对所有的基本气候变量都提出了严格的精度、长度和连续性要求。为了提供这样的气候记录，观测系统需要有适当的重复配置和恢复能力，以防止仪器故障可能造成的损失 [3.2.1]。

❑ TPOS requires unbiased accurate ***surface wind/wind stress***[2] with good spatial and temporal coverage, including in high rain regions and low- and high-wind regimes. It is important to maintain long time series of in situ winds for inter-calibration and to underpin the climate record, especially in the equatorial Pacific and strong convection and precipitation areas [3.1.1.2, 3.2.1, 5.1]. Monitoring frontal and other small-scale processes requires that vector wind fields resolve gradients at scales no larger than 50km [3.3.2]. Surface currents are also needed to reconcile differences between scatterometer and in situ winds [see Recommendation 11]. TPOS 2020 recommends:

❑ TPOS 需要无系统性偏差的、精确的、时空覆盖率高的***表面风速/风应力***[2] 观测，包括在强降水、弱风和强风条件下的观测。维持长时间序列的实测风对于资料相互校准和确保气候记录非常重要，在赤道太平洋、强对流和降水区域尤其如此 [3.1.1.2，3.2.1，5.1]。监测锋面和其

[2] The Essential Climate/Ocean Variables are shown in ***bold italics***

*基本的气候 / 海洋变量用**粗斜体**表示*

他小尺度过程，需要在不大于 50 公里的尺度上分辨矢量风的梯度 [3.3.2] 。还需要表层海流来调解卫星散射计和实测风之间的差异 [见建议 11]。TPOS 2020 建议：

Recommendation 1 A constellation of multi-frequency scatterometer missions and complementary wind speed measurements from microwave sensors to ensure broad-scale, all-weather wind retrievals over 90% of the tropical Pacific Ocean every 6 hours for the next decade and beyond, with different equatorial crossing times to capture the diurnal cycle.

建议 1：用一组卫星多频散射计的矢量风观测，辅以微波传感器的风速观测，确保在未来十年甚至更长的时间里获得每 6 小时的全天候大尺度风场，覆盖 90%以上的热带太平洋。这些卫星要具有不同的赤道穿越时间，以捕获风场的日变化。

Recommendation 2 In situ vector wind measurements, with particular emphasis on extending the in situ based climate data records, and inter-calibrating different satellite wind sensors especially in the equatorial Pacific and in tropical rainy areas.

建议 2：实地观测矢量风，特别注重延长实测气候数据资料，并以赤道太平洋和热带降水区为重点，对不同的卫星测风传感器进行交叉定标。

❑ Unbiased and accurate high-resolution long-term ***sea surface temperature (SST)*** sampling is required, with particular focus on persistently cloudy and rainy regions and sharp horizontal gradients in the cold tongue region. Ideally, for improved understanding of processes near the surface, sampling should resolve the diurnal cycle and thus be able to characterize near-surface temperature profiles in regions where diurnal variability is large [3.1.1.1, 3.3.1, 3.3.2, 5.2]. TPOS 2020 recommends:

❑ 需要无系统性偏差的、精确的、高分辨率的长期***海表温度（SST）***观测，特别注意持续多云和多雨的区域以及冷舌区的强水平梯度。为了更好地认知近表面过程，理想的采样频率应能分辨日变化，在日变化大的区域获得海洋近表层温度的垂直剖面 [3.1.1.1, 3.3.1, 3.3.2, 5.2] 。TPOS 2020 建议：

Recommendation 3 Sustaining satellite measurements of SST, using infrared sensors for higher spatiotemporal sampling; passive microwave sensors filling gaps under clouds; and the diversity of satellite and in situ platforms contributing to inter-calibration.

建议 3：维持现有的 SST 卫星观测，使用红外传感器进行高时空分辨率的资料采集；用被动微波传感器弥补云下面的空白；用各类卫星传感器和实测平台进行数据的交叉校准。

Recommendation 4 Maintenance of the current level of in situ SST observations and improvement of drifter SST quality. Both will contribute to satellite SST calibration and validation, as well as providing an independent reference dataset for the SST climate record. Specifically target convective and rainy areas for SST ground truth, while keeping SST in situ measurements on moorings in the equatorial region.

建议 4：维持现场 SST 观测的现状，改进漂移浮标 SST 的质量。这两者都将有助于卫星 SST 的定标，并为 SST 气候记录提供独立的参考数据。特别要在维持赤道区域 SST 锚系观测的同时，针对对流和降水区获取 SST 实测资料。

❑ High-accuracy broad-scale ***sea surface height (SSH)*** sampling is required for climate as well as smaller scale (to sub-mesoscale) for initialization of ocean prediction models. Ocean mass (gravity or bottom pressure) sampling should be maintained [3.1.2.1，3.1.2.2，3.3.4，5.3]. TPOS 2020 recommends:

❑ 需要高精度、大范围的***海面高度（SSH）***观测，用以为海洋预报模式的初始化提供气候及较小尺度（至次中尺度）的数据。应当维持海水质量（重力或海底压力）的观测 [3.1.2.1, 3.1.2.2, 3.3.4, 5.3]。TPOS 2020 建议：

Recommendation 5 Continuation of the high-precision SSH measurements via the Jason series of satellite altimeters for monitoring large-scale SSH, and the continuing development of wide-swath altimetry technology to measure meso- and submesoscale SSH variations that are particularly energetic in crucial regions including the western boundary.

建议 5：继续通过 Jason 系列卫星高度计获取高精度的 SSH 测量，并开发宽幅高度计技术，以观测在西边界等关键区域特别活跃的中尺度和次中尺度 SSH 变化。

Recommendation 6 Maintenance of in situ tide gauge measurements for the calibration and validation of satellite SSH, upgraded with global navigation satellite system referencing, and complemented by sustained temperature and salinity profile measurements (see below).

建议 6：维持用于卫星 SSH 定标的验潮站观测，并通过全球导航卫星系统对之进行升级，辅以持续的温、盐垂直剖面观测（见下文）。

Recommendation 7 Continuation of ocean mass measurements to complement satellite SSH and profile-derived steric height measurements, and in situ bottom pressure sensors to help calibrate and validate satellite-derived estimates.

建议 7：继续利用海水质量测量来辅助卫星 SSH 观测和基于温盐剖面的比容高度计算，继续使用海底压力传感器来帮助校准和验证基于卫星观测的估算。

❑ Satellite ***precipitation*** measurements, evaluated against in situ data across diverse climate regimes are required. Rain-rate and collocated wind speed and direction sampling is particularly important in the convective regions of the western equatorial Pacific and under the Inter-Tropical and South Pacific Convergence Zones [3.1.1.2, 3.1.1.5, 5.4]. TPOS 2020 recommends:

❑ 需要卫星***降水***观测，并在不同气候条件下用实测数据对其进行验证。尤为重要的是赤道西太平洋、热带辐合带和南太平洋辐合带对流区域的降雨和同一位置上的风速和风向观测 [3.1.1.2, 3.1.1.5, 5.4] 。TPOS 2020 建议：

Recommendation 8 Continuation and enhancement of international collaboration for precipitation-measuring satellite constellations to sustain the spatiotemporal sampling of precipitation measurements in the tropics.

建议 8：继续并加强降水观测卫星系列的国际合作，以维持热带降水观测的时空覆盖率。

Recommendation 9 Continuation and expansion of open-ocean in situ precipitation measurements for the evaluation and improvement of satellite-derived products, especially for providing a long-term climate record.

建议 9：继续并增加降水的海上现场观测，用以评估和改进各种卫星产品，特别是用来提供降水的长期气候资料。

❑ Broad-scale ***sea surface salinity (SSS)*** sampling is required, with sufficient resolution to characterize sharp salinity fronts in the equatorial zone [3.1.1.6]. For understanding key processes and phenomena, higher-resolution salinity sampling is particularly important in the west Pacific warm pool and in frontal regions [3.3.1, 3.3.2, 5.5]. In situ and satellite measurements together provide complementary observations of SSS to meet TPOS needs. In situ measurements provide accurate near-surface salinity measurements. Argo provides coverage on larger space scales; tropical moorings provide high-frequency measurements, Voluntary Observing Ships (VOS) provide high spatial resolution measurements along tracks and a long climate data record. Satellites provide SSS with near uniform sampling that resolves gradients, as well as better coverage in coastal oceans and marginal seas. TPOS 2020 recommends:

❑ 需要大尺度的***海表盐度***（sea surface salinity，简称 SSS）观测，并使其有足够的分辨率来表征赤道区域的强盐度锋面 [3.1.1.6]。为理解关键过程和现象，在西太平洋暖池和锋区的高分辨率盐度观测尤为重要 [3.3.1，3.3.2，5.5] 。现场观测和卫星观测相结合能提供互补的 SSS 数据，以满足 TPOS 的需要。Argo 提供较大空间尺度的覆盖，热带锚系提供高频测量，而志愿船（VOS）则提供沿航迹的高空间分辨率测量和长期气候记录。卫星的 SSS 观测在空间上近于均匀，可用来分辨梯度，也能更好地覆盖近岸海区和边缘海。TPOS 2020 建议：

Recommendation 10 Continuity of complementary satellite and in situ SSS measurement networks, with a focus on improved satellite accuracy.

建议 10：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。

❑ ***Surface current*** (speed and direction) is required with a high spatial and temporal resolution, especially in the equatorial band, to facilitate the assimilation and synthesis of satellite and in situ wind measurements [3.1.1.2]. Time-series of equatorial ***subsurface currents*** are widely used in model validation and development and will continue to be needed for future model data assimilation [3.1.3.2]. For improved understanding of processes and phenomena, TPOS 2020 identifies requirements for enhanced vertical resolution of current measurements to resolve near-surface shear; meridional sampling near the equator to resolve the circulation; and improved monitoring of other key circulation elements such as low-latitude western boundary currents and intermediate depth currents [3.3.1, 3.3.3, 3.3.4.1, 3.3.4.2, 5.6]. TPOS 2020 recommends:

❑ 需要具有高时空分辨率的***表层海流***（包括速度和方向）观测，特别是赤道区域的观测，以便于同化和融合卫星和实测风场 [3.1.1.2]。 赤道***次表层海流***的时间序列已广泛用于模式验证和开发，并将继续为未来的模式数据同化所需 [3.1.3.2]。为了更好地认知过程和现象，TPOS 2020 认为需要增强海流观测的垂向分辨率，用以获得近海面的流场切变；需要增加赤道附近的经向观测，用以分辨海洋环流；需要改进对其他关键环流分量的监测，如低纬度西边界流和中层海流 [3.3.1，3.3.3，3.3.4.1，3.3.4.2，5.6]。TPOS 2020 建议：

Recommendation 11 Continuation of technological developments to measure ocean surface currents remotely, and improved in situ measurements of surface and near-surface currents, particularly near the equator, and to collect co-located measurements of wind and surface currents; and

建议 11：继续开发测量表层海流的遥感技术，改进表层和近表层海流的现场观测，特别是赤道附近的观测，并获取风场和海表流场的同位观测；而且

Recommendation 19 Maintenance and, potentially, augmentation of the sampling depth range of current profiles on the existing equatorial moorings, and enhancement of the meridional resolution of velocity along targeted meridians by additional moorings near the equator.

建议 19：维持并尽可能增加现有的赤道锚系对流场剖面的观测深度，并增加特定经向断面上赤道附近的锚系数量，以提高这些断面上海流的经向分辨率。

❑ Air-sea carbon dioxide (CO_2) flux requirements are partially addressed by the existing high-quality sea surface partial pressure of CO_2 (***p*CO₂** → $\boldsymbol{pCO_2}$) sampling. These observations quantify the seasonal to interannual variability in CO_2 fluxes impacted by ENSO and advance understanding of natural variability in the context of human-induced change [3.1.1.4, 3.3.5]. TPOS 2020 recommends:

❑ 需要对海-气二氧化碳（CO_2）通量进行测量，而现有的高质量海表 ***CO_2 分压***（pCO_2）观测能部分地满足这一需要。这些观测能量化 ENSO 影响下 CO_2 的季节到年际变化，并提高我们对人类活动背景下自然变率的认识 [3.1.1.4，3.3.5] 。TPOS 2020 建议：

Recommendation 12 Continuation of high-frequency, moored time series and broad spatial scale underway surface ocean pCO_2 observations across the Pacific from 10°S to 10°N.

建议 12：维持对海表 pCO_2 的高频锚系时间序列以及太平洋 10°S-10°N 之间的大范围走航观测。

❑ Broad-scale surface ***ocean color*** measurements are required, with sufficient resolution to diagnose regime boundaries and with sufficient accuracy to diagnose seasonal changes. There is an additional requirement for in situ sampling for chlorophyll-a to validate remotely-sensed ocean color measurements [3.1.1.4, 5.7]. TPOS 2020 recommends:

❑ 需要对***海洋水色***进行大范围观测，并使其具有足够的分辨率来诊断不同系统间的边界，以及足够的精度来诊断季节变化。此外，还需要对叶绿色-a 进行现场取样，以验证卫星遥感水色观测 [3.1.1.4, 5.7]。TPOS 2020 建议：

Recommendation 13 Continuation of advocacy for ocean color satellite missions with appropriate overlap to facilitate inter-calibration for measurement consistency. In situ measurements of chlorophyll-a and optical properties for the validation of satellite ocean color measurements are required.

建议 13：继续推动海洋水色系列卫星，并使不同卫星有一定的重复观测，以交叉校准观测的一致性。现场观测叶绿素-a 和其他光学变量，用以验证海洋水色的卫星观测。

❑ Understanding seasonal biogeochemical processes requires measurements at semi-annual timescales, spanning the tropical Pacific from 10°S to 10°N, augmented by high-frequency observations at selected sites [3.3.5]. In order to properly understand CO_2 dynamics, one needs to understand variations in ***oxygen***, which is consumed at depth during the recycling of organic matter (e.g., phytoplankton) produced at the surface. Expanding oxygen minimum zones have fundamental implications for marine life. TPOS 2020 recommends:

❑ 需要针对季节性生物地球化学过程，在热带太平洋 10°S－10°N 间进行半年时间尺度的观测，并辅以特定站点的高频观测 [3.3.5]。为了正确理解 CO_2 的调控机理，需要了解***溶解氧***的变化，因为海洋表层有机物 （如浮游植物）的再循环过程会在海洋深层消耗溶解氧。日益扩张的低氧区对海洋生命有根本性影响。TPOS2020 建议：

Recommendation 14 From 10°S to 10°N, observations of subsurface biogeochemical properties are required including chlorophyll concentration, particulate backscatter, oxygen and nutrients. Enhanced focus is needed for the eastern edge of the warm pool and the east Pacific cold tongue.

建议 14：在 10°S－10°N 间，观测海洋次表层的生物地球化学变量，包括叶绿素浓度、颗粒反向散射、溶解氧和营养盐。特别注重暖池东边界和东太平洋冷舌区的观测。

❑ Comprehensive sampling both of the state variables needed to estimate turbulent ***heat fluxes*** (SST, air temperature, humidity, wind and surface currents), and of the ***radiative fluxes*** (downwelling solar radiation, downwelling longwave radiation, emissivity) is needed in the full range of climatic/weather regimes and key oceanic regimes [3.1.1.3, 5.8]. These are essential to evaluate and improve atmospheric reanalyses, satellite-based surface flux estimates, and coupled data assimilation systems, and to improve our understanding of the exchanges between the atmosphere and ocean in these different regimes. TPOS 2020 recommends:

❑ 需要对气候／天气系统和关键海洋系统进行全方位观测，包括估算湍***热通量***所需的状态变量（SST、大气温度、湿度、风场、海面流场）以及***辐射通量***（向下短波辐射、长波辐射、放射率）[3.1.1.3，5.8]。这对评估和改进大气再分析资料、基于卫星的海表通量估算和耦合数据同化系统至关重要，对进一步认知各类系统中的海-气交换不可或缺。TPOS 2020 建议：

Recommendation 15 In situ observations of state variables needed to estimate surface heat and freshwater fluxes should be enhanced in key regions. These include the west Pacific warm pool, along the equator, and on several meridional lines extending from the SPCZ and seasonal southern ITCZ, across the equator through the northern hemisphere ITCZ.

建议 15：针对估算热通量和淡水通量所需的状态变量，在以下关键区域加强现场观测：西太平洋暖池、赤道，以及从 SPCZ 和季节性南半球 ITCZ，跨赤道至北半球 ITCZ 的若干条经线。

❑ TPOS 2020 supports efforts to increase the number of surface drifters and moorings measuring ***sea level pressure*** [3.1.2.4, 7.4.1].

❑ TPOS 2020 支持增加用于测量***海平面气压***的表面漂移浮标和锚系 [3.1.2.4, 7.4.1]。

❑ Sea surface waves (***sea state***) change surface stress at low wind speeds and are important for coastal sea level and related impacts. A few permanent directional wave buoys in the Tropical Pacific would complement and validate satellite wave data [3.1.2.3].

❑ 表面波（***海况***）在低风速条件下能改变海表风应力，对沿岸海面涨落及相关影响至关重要。在热带太平洋布设几个永久性的波浪浮标，将辅助和验证表面波的卫星观测 [3.1.2.3]。

❑ Broad-scale sampling of ***subsurface temperature and salinity*** is required, with enhanced resolution through the tropics (approximately 2° x 2° resolution), and better meridional spacing (100 km) and increased vertical resolution (10m or finer) in the equatorial region. Stable and accurate deep profiles are required. An additional target is to resolve near-surface salinity stratification, especially in the Warm Pool region, at its eastern edge and under persistent rain bands.

❑ 需要对海洋***次表层温度和盐度***进行大范围观测，在整个热带地区提高分辨率（约 2° x 2°），并在赤道地区增加经向分辨率（100 公里）和垂向分辨率（10 米或更高）。需要稳定和精确的深水剖面观测。此外还需要针对近表层的盐度层结，特别是在暖池区、暖池东边界及持续降水区，开展高分辨率测量。

For improved understanding of phenomena and processes, finer vertical resolution is required above 100m depth. Sampling within 2°S-2°N should be sufficient to resolve meridional gradients. Profiles in the west-central equatorial region should resolve phenomena at timescales no longer than 5 days [3.3.1, 3.3.2, 3.3.3, 3.3.4.1].

为了更好地认知现象和过程，需要在 100m 以上的深度范围内增加垂向分辨率。在 2°S-2°N 之间要有足够的观测，以分辨出经向梯度。而赤道太平洋西部和中部的剖面观测，应分辨出时间尺度在 5 天以下的现象 [3.3.1，3.3.2，3.3.3，3.3.4.1]。

Better resolution of the physical fields will aid interpretation and modeling of biogeochemical processes. Most of the platforms used for enhanced temperature and salinity can accommodate in situ biogeochemical observations [3.3.5].

增加对物理变量的分辨率将有助于对生物地球化学过程的解释和模拟。大部分用于温、盐加密观测的平台也适用于生物地球化学变量的现场观测 [3.3.5]。

The diversity of ENSO and its future changes will require sampling of the tropical Pacific environment to follow ENSO's spatiotemporal patterns and underpin improved ENSO prediction and model forecast skills.

为了认知 ENSO 的多样性及其在未来的变化，需要对热带太平洋环境进行观测，以便追踪 ENSO 的时空分布特征，为提高 ENSO 预测及模拟能力提供支撑。

TPOS 2020 recommends [4, 5.9]:

TPOS 2020 建议[4, 5.9]：

Recommendation 16 A combination of fixed-point moorings, profiling floats and lines/sections from ships to meet the sustained requirement for subsurface temperature and salinity observations. Integration through data assimilation and synthesis is needed to produce the required gridded fields;

建议 16：通过结合定点锚系、剖面浮标及走航断面观测，满足对次表层温、盐的持续观测需要。通过资料同化和融合来提供网格化数据产品；

Recommendation 17 Enhancing meridional resolution of temperature and salinity in the equatorial zone through a mix of (a) additional moorings near the equator and (b) targeted enhancement of Argo profiles in the equatorial zone (approximately doubling density);

建议 17：通过（a）增加靠近赤道的锚系数量和（b）有针对性地增加赤道区域的 Argo 浮标数量（大致翻倍），提高赤道区域温、盐的经向观测分辨率；

Recommendation 18 Enhancing vertical temperature and salinity resolution from the TMA via additional upper ocean sensors on moorings from the top of the thermocline to the surface, and returning Argo profiles at 1 dbar resolution from 100 dbar to the surface (or as close as practical); and

建议 18：通过在海表至温跃层之间增加 TMA 锚系上的传感器，及回传 Argo 浮标从 100 dbar 至海表（或尽可能接近海表）1 dbar 分辨率的剖面，提高温、盐观测的垂向分辨率；

Recommendation 20 Doubling the density of Argo temperature and salinity profile observations through the tropics (10ºN - 10ºS), to deliver improved signal-to-noise ratios (better than 4:1) at weekly timescales, starting with the western Pacific and the equatorial zone.

建议 20：在热带（10ºN－10ºS）加倍 Argo 温、盐剖面观测的密度，以改善周时间尺度上的信噪比（优于 4:1），这一建议可从西太平洋和赤道区域开始实施。

❑ Other existing in situ components should continue to be supported. These include the surface drifter network; underway data collected from Voluntary Observing Ships and Ships of Opportunity (including ancillary measurements on service vessels); high-resolution expendable bathythermograph transects; deep, long regular hydrographic transects (known as GO-SHIP); fixed-point reference sites under OceanSITES; and tide gauges for calibration and monitoring sea level change [3.1.1.1, 3.1.1.3, 3.1.1.4, 3.1.1.6, 3.1.2.4, 3.1.3]. TPOS 2020 recommends:

❑ 应继续资助其他已有的现场观测，包括表面漂移浮标网、志愿船及机遇船观测（包括锚系维护航次的辅助观测）、高分辨率 XBT 断面、深层次长期重复水文断面（GO-SHIP）、OceanSITES 定点参考观测站，以及用于校准和监测海表平面变化的验潮站 [3.1.1.1, 3.1.1.3, 3.1.1.4, 3.1.1.6, 3.1.2.4, 3.1.3]。TPOS 2020 建议：

Recommendation 21 Continued support for in situ observations from drifters, ships, tide gauges and reference mooring sites.

建议 21：继续支持基于漂移浮标、船舶、测潮站、参考锚定站位的现场观测。

❑ Modelling and data assimilation are fundamental elements of the TPOS design and critical for delivering integrated products of value to stakeholders, including predictions and synthesized gridded fields. We outline work to provide additional guidance for the TPOS 2020 design, identify the causes of coupled model biases, and assess the influence of observational data on ocean analyses and other products [3, 4, 6.1.6, 6.1.7, 7.5]. TPOS 2020 recommends:

❑ 数值模拟和数据同化是 TPOS 设计的基本要素，也是向有关方面提交集成产品的关键，这些产品包括预报及综合网格数据。这方面的工作可以为 TPOS 2020 设计提供进一步的指导，确定耦合模式产生偏差的原因，并评估观测资料对海洋再分析及其他产品的影响 [3, 4, 6.1.6, 6.1.7, 7.5]。TPOS 2020 建议：

Recommendation 22 A coordinated program of (a) data assimilation studies to assess the effectiveness of the TPOS 2020 Backbone design, and (b) studies on the utilization and influence of observational data among an appropriate subset of ocean analysis systems.

建议 22：设立一个协调项目，（a）通过数据同化研究来评估 TPOS 2020 骨干设计的有效性；（b）通过一部分适当的海洋分析系统来研究观测数据的使用和影响。

IMPLEMENTATION

实施方案

This report provides advice to sponsors on near-term implementation actions with respect to platforms and other technical aspects, consistent with the above requirements and recommendations. The focus on the near-term generally precludes specific actions related to satellites; the reader is referred to the recommendations for relevant guidance.

本报告根据上述需要和建议，向资助方提供关于观测平台和其他技术的短期实施方案。近期的重点不包括与卫星有关的具体措施，请读者参考其他相关的指导性建议。

It is critical that all recommendations and actions from TPOS 2020 are subject to careful consideration prior to implementation, taking account of existing stakeholder commitments, capacity and capability. The transition from the TPOS as it exists now to its future configuration must be managed and coordinated effectively to maintain data streams for operational forecasting, to ensure continuous climate records, and to take account of changes to sampling methods. [3.2, 7.1 and sections of 7.7]. Ongoing assessment of the transition is required so that risks are properly managed.

在 TPOS 2020 计划实施之前，所有的建议和措施都需要经过仔细斟酌，要考虑到现有利益相关方的承诺、承受力及能力。从 TPOS 目前状态到未来布局的过渡，必须在有效的管理和协调下，维持业务化预报所需的数据流，确保连续的气候记录，并考虑观测方法的变更 [3.2，7.1 及部分 7.7]。需要对 TPOS 过渡进行不断的评估，以便妥善应对风险。

There are a number of existing mechanisms available to facilitate such a process, and TPOS 2020 partners can contribute advice and guidance. There are also opportunities to use regional mechanisms. [7.7.1, 7.7.2, 7.7.3]

有一些现成的机制可用来促进这一过渡，TPOS 2020 的合作伙伴也可以提供建议和指导。此外，也有机会利用一些区域性机制 [7.7.1, 7.7.2, 7.7.3]。

Action 15 In consultation with key stakeholders, including GOOS, JCOMM, WMO/WIGOS and GCOS, a transition process should be initiated, including the creation of a TPOS 2020 Transition and Implementation Group, for overseeing implementation of TPOS 2020 Recommendations and Actions.

措施 15：应与 GOOS，JCOMM，WMO / WIGOS 和 GCOS 等主要利益相关方协商，启动过渡程序，包括设立 TPOS 2020 过渡和实施组，以监督 TPOS 2020 建议和措施的执行。

❑ The most pressing action is to address the decline of the TMA in the west; the response here focuses on restoring the most critical capabilities and on seeking sustained commitments [1.2, 7.2, 7.4.3].

❑ 目前最紧迫的任务是解决西太平洋 TMA 减少的问题；我们认为重点是恢复 TMA 最关键的功能并寻找持续性的投资 [1.2, 7.2, 7.4.3]。

Action 1 Six TMA sites in the western Pacific within 2°S to 2°N should be maintained or reoccupied.

措施 1：应维持或恢复布放在西太平洋 2°S－2°N 之间的六个 TMA 站点。

Action 2 Argo deployments should immediately be doubled equatorward of 10° in the west (especially outside the TMA-occupied region) to maintain subsurface temperature and salinity sampling and compensate for the declining TMA.

措施 2：应立即在西太平洋 10°S－10°N 范围内（特别是 TMA 之外的区域）将 Argo 的布放数量加倍，以保证对次表层温、盐的观测，补充因 TMA 减少而造成的资料缺失。

❑ Enhanced Argo profiling throughout the tropical region (10°S - 10°N) is recommended [Recommendations 17, 20]. The deployments would target a density of one profile every 5 days per 3x3 square or, equivalently, one profile per 2.1x2.1 degree square every 10 days. The increase would be staged, building on experience in the west. Near the equator the higher-frequency TMA sampling remains critical and complements the excellent vertical resolution provided by Argo [Recommendations 18, 19; 7.4.3].

❑ 建议在整个热带区域（10°S－10°N）增加 Argo 剖面观测 [建议 17, 20]。目标是在每 3°x3°范围内每 5 天获取一个剖面，这也相当于在每 2.1°x2.1°范围内每 10 天获取一个剖面。Argo 的全面增加将在西太平洋实施经验的基础上分阶段进行。在赤道附近，TMA 的高频观测仍然重要，可以补充 Argo 的高垂向分辨率观测 [建议 18，19；7.4.3]。

Action 3 Argo float deployments should be doubled over the entire tropical region 10°S-10°N, and return increased upper ocean vertical resolution.

措施 3： Argo 浮标的数量在整个热带区域（10°S-10°N）应该加倍，并提供高垂向分辨率的上层海洋观测数据。

❑ The ocean scales of variability, background noise (e.g eddies and synoptic weather effects) and different phenomena (tropical instability waves and barrier layers) vary across the tropical Pacific. Refinements of deploying and missioning a float array may deliver further benefits to the TPOS [3, 5.9].

❑ 热带太平洋具有各种尺度的海洋变化、背景噪声（如涡旋和天气效应）和其他各种现象（热带不稳定波和障碍层）。改善剖面浮标阵列的布设可以进一步提升 TPOS 的功能[3, 5.9]。

Action 4 Through the TPOS 2020 Backbone Task Team and the Argo Steering Team, further explore how to optimize float deployments and missions to better deliver to TPOS goals.

措施 4：通过 TPOS 2020 骨干系统工作组和 Argo 指导组，进一步探索如何优化浮标的布放和任务设置，以便更好地实现 TPOS 的目标。

❑ TPOS 2020 concludes there is a strong case for beginning the transition of the TMA from its present grid structure between 8°S and 8°N, to one with more capable moorings that sample the varied regimes of the tropical Pacific [3.1.1.3] and captures the basin-scale variability in the surface and subsurface fields [3.1]. Any such change would be carefully implemented to maintain climate records and assessed according to the Global Climate Observing Principles. Actions 5 and 6 would begin these changes.

❑ TPOS 2020 有充足的理由认为，TMA 应该从其现有的 8°S－8°N 之间的网格结构，过渡为一个观测能力更强的锚系浮标网，以便观测热带太平洋的各种海洋/气候系统 [3.1.1.3]，并捕获表层及次表层海盆尺度的变化 [3.1]。任何此类调整都需谨慎执行，以保持气候资料的完整性，并需要根据全球气候观测条例（Global Climate Observing Principles）进行评估。措施 5 与措施 6 将开始这些调整。

Present sampling capability in the near-equatorial region does not meet scale requirements demanded by the sharp meridional gradients across the equator [3.1.3, 3.3.3, 3.4, 5.9.1; Recommendation 17]. Given the capabilities of available platforms, the most effective way to do this would be to increase the meridional resolution of enhanced fixed-point sampling spanning the equator at one or few selected longitudes.

目前在赤道附近的观测能力不能满足跨赤道经向梯度急剧变化的尺度需求 [3.1.3, 3.3.3, 3.4, 5.9.1; 建议 17]。考虑到现有观测平台的能力，最有效的方法应当是沿着一个或若干个特定的经度，增加跨赤道的定点观测密度。

Action 5 Moorings at 1°S and 1°N at selected longitudes should be added to enhance the resolution of near-equatorial dynamics. Enhancement of instrumentation on all moorings spanning 2°S and 2°N at these longitudes should be targeted, including velocity profiles as feasible.

措施 5： 沿着特定的经度，在 1°S 和 1°N 处增加锚系，以提高对近赤道动力过程的分辨率。在这些经度上，争取加 强 2°S 和 2°N 间 锚系上的仪器设备，尽可能获得流速剖面。

❑ Given the ability of Argo to deliver high-resolution profiles (Action 3), and of scatterometers and models to capture the trade winds [3.1.1.2, 5.1], there is now the possibility to refocus the TMA towards other priorities.

❑ 鉴于 Argo 已能提供高分辨率剖面观测（措施 3），而散射计和数值模式已能较好地给出信风风场 [3.1.1.2，5.1]，现在可以将 TMA 用于观测其他优先级更高的变量。

Action 6 A staged reconfiguration of the TMA should emphasize enhancement in key regimes.

措施 6：TMA 的分阶段重新设置应当强调对一些关键系统的强化观测。

❑ We recommend more complete surface flux measurements in particular regimes, with corresponding enhanced sampling in the mixed layer [3.1.1.3, 5.8; Recommendation 15]. Fixed-point (mooring) measurements are particularly well suited to these tasks because of their ability to target regimes and to sample the high frequencies (diurnal) of these processes.

❑ 我们建议对一些特定系统进行更完整的海表通量观测，并在混合层中进行相应的加密观测 [3.1.1.3, 5.8; 建议 15]。由于定点锚系能针对特定系统进行高频率（昼夜）的过程观测，它们特别适合此类任务。

Action 10 All equatorial mooring sites should be upgraded to flux moorings.

措施 10：赤道上的所有锚系都应升级为具有通量观测能力的锚系。

❑ The existing TMA, limited within 8° of the equator provides only partial coverage of key climatic regimes [3.1] and generally does not have adequate sampling to determine all key flux terms.

❑ 现有的 TMA 局限于 8°S－8°N 之间，仅覆盖了部分的关键气候系统 [3.1]，其观测一般不足以满足估算所有关键通量的要求。

Action 11 Meridional lines of flux sites should be extended from the equator to intersect both the South Pacific and Intertropical Convergence Zones in the west, and across the Intertropical Convergence Zone, the cold tongue and the seasonal southern Intertropical Convergence Zone in the east and central Pacific.

措施 11：布放通量观测站点的经向线，在西太平洋应当从赤道延伸至南太平洋辐合带及热带辐合带，在中、东太平洋则应穿过热带辐合带、冷舌区及季节性的南太平洋热带辐合带。

❑ Reduction of horizontal coverage away from these key regimes should be accompanied by assessments of impacts on subsurface fields, surface fluxes (including wind stress), and underway and ancillary data collection, especially for pCO2 data [7.4.4.2, 7.4.6]. The earlier Actions 1 and 2 for the western Pacific will provide a valuable reference for the actions here.

❑ 在远离这些关键气候系统的地方可减少观测的水平覆盖，但应充分评估其对次表层变量、海-气通量（包括风应力）及走航和补充数据收集的影响，特别是对 pCO_2 数据的影响 [7.4.4.2, 7.4.6]。前面针对西太平洋的措施 1 与措施 2，将为这里的措施提供有价值的参考。

We note significant differences in surface wind and flux products within the tropical region and a paucity of studies on the impact of TMA surface meteorological data in weather prediction and associated reanalysis products, and in coupled models [3.1, 4].

值得注意的是，热带海面风场与海表通量的各类产品仍存在显著的差异，而且很少有人研究 TMA 海面气象数据对天气预报、再分析产品和耦合模式的影响 [3.1, 4]。

Action 7 Promote and support sensitivity and impact studies of wind and wind vector data inputs on operational analysis and reanalysis and specialized wind stress products, including their application to climate change detection. The effectiveness of rain metadata flags and various approaches to cross-calibration of scatterometers should also be considered.

措施 7： 提倡并支持对风速和风矢量数据应用的敏感性和影响研究，包括对业务化分析和再分析、专用风应力产品及其在气候变化信号检测中的应用。还应考虑卫星元数据中降水标志（rain metadata flags）和各种散射计交叉校准方法的有效性。

Action 8 Renew and help coordinate efforts to understand the sensitivity and diagnose the impact of TMA air-sea flux variables in weather prediction, atmospheric reanalyses and coupled models, including through existing activities focused on the impact of observations.

措施 8：更新并协调对 TMA 海-气通量数据的敏感性和影响研究，诊断这些数据对天气预报、大气再分析及耦合模式的作用，这也包括利用现有的针对观测数据影响的研究工作。

Also see Action 13 below.

参见后面的措施 13。

❑ Vandalism of TMA buoys has been a recurrent problem, particularly for the 95°W TAO mooring line, which resulted in reduced measurements during the recent 2015-16 El Niño. Regional involvement would be valuable to sustain sampling of this important regime.

❑ TMA 锚系浮标常常被破坏，这一问题沿 95°W 的 TAO 锚系线特别严重，以至减少了 2015-16 厄尔尼诺时期的观测资料。周边国家的参与将有助于维持这一重要区域的观测。

Action 9 The Transition and Implementation Group (see section 7.7) should initiate discussion with TPOS stakeholders on sustainable solutions for the distinct implementation problems of the western and eastern Pacific regions, especially for the needed TMA contributions.

措施 9：过渡和实施组（见 7.7 节）应针对西太平洋和东太平洋区域面临的突出问题，特别是急需的对 TMA 的贡献，启动与利益相关方的讨论，提出可持续的解决办法。

❑ Risks arise from the refocusing of the TMA, particularly for surface flux variables, some of which have no present alternative to buoy measurements. To mitigate these risks, Voluntary Observing Ships and other in situ systems should be encouraged to enhance focus on these variables. New technology and improvements in the testing and calibration of reanalysis and weather products offer additional routes to meeting surface flux requirements [7.4.6].

❑ TMA 的重新聚焦会带来一定的风险，特别是对一些与海-气通量相关的变量，目前没有可以替代浮标的其它观测。为了减少这些风险，应鼓励志愿船和其他现场观测系统加强对这些变量的测量。此外，新的观测技术以及在测试和校准再分析和天气资料方面的进步，也为满足海表通量的需求提供了另外的途径。

Action 13 To mitigate risks in meeting surface flux requirements associated with changes in the TMA, TPOS 2020 seeks (a) enhanced sampling by the Voluntary Observing Ship Climate Fleet and other in situ systems for flux variables, (b) support for relevant new technology developments, and

(c) encourages efforts to improve the realism of reanalysis and possibly real-time Numerical Weather Prediction flux products through output correction/flux adjustment techniques.

措施 13：为减少因改变 TMA 而无法满足通量观测需要的风险，TPOS 2020 寻求（a）增强志愿船和其他现场观测系统对通量变量的观测，（b）支持相关新技术的开发，（c）鼓励通过模式输出校正/通量调整方法来改进再分析产品，并尽可能地改进实时数值天气预报的通量产品。

❑ Biogeochemical and ecosystem requirements, recommendations and actions will be a major focus for TPOS 2020 in subsequent Reports. In this Report the societal relevance and utility of established sustained and experimental biogeochemical systems is emphasized [2.6.7, 3.3.5]. Opportunistic use of existing platforms, such as moorings, floats and research and servicing vessels is a key strategy. Maximizing the use of mooring servicing cruises in particular is a critical component for Backbone biogeochemical observations. Service ships should continue underway measurements for pCO_2 to ensure continuity in the record of CO_2 flux, to serve as validation for moored measurements and new technologies, and to provide context for spatial variability between moored observations. Mapping the extent of the eastern Pacific oxygen minimum zone is also an early action that can be taken by TPOS [3.3.5].

❑ 对生物地球化学和生态系统观测的需要、建议和措施将是 TPOS 2020 后续报告中的重点。 在本报告中，我们强调已有的持续性和实验性生物地球化学观测系统的社会作用和用途 [2.6.7,3.3.5]。一个重要策略是借用锚系、浮标、科考船和服务船等现有观测平台。对锚系服务航次的最大化利用，是生物地球化学观测骨干系统的关键组成部分。锚系服务船应继续进行走航 pCO2 测量，以确保 CO2 通量资料的连续性，并用于验证锚系观测和新技术，同时为锚系间的空间变化提供环境背景。普查东太平洋溶解氧最低区的影响范围，也是 TPOS 马上可以采取的一个措施 [3.3.5]。

Action 12 Underway pCO_2 observations should be continued or reinstated on all mooring servicing vessels and the present network of moored pCO_2 measurements should be maintained and possibly extended. Measurements of dissolved oxygen from the surface to about 1500m should be made on ships where practical, and oxygen sensors should be considered on each mooring.

措施 12：继续或恢复所有锚系服务航次对 pCO_2 的走航观测，维持并尽量扩大现有的锚系 pCO_2 观测网。应当尽可能对表层至 1500 米深度的溶解氧开展航次观测，还应当考虑在每一个锚系上增加溶解氧传感器。

❑ Several Pilot and Process Studies, as well as on-going work being led by TPOS 2020 Task Teams, are outlined in this report. Some of these studies are precursors needed to further guide sampling strategies, test and improve delivery, cost and suitability for sustained implementation. Others target improved understanding of phenomena and processes [3.3], some of which are partly or wholly addressed by the recommendations and actions above.

❑ 本报告概述了由 TPOS 2020 各个工作组牵头的正在进行的工作以及若干试点项目和过程研究。其中一些研究是为了进一步指导观测策略，并测试和改进观测系统的数据提交、成本

核算和适宜性。其他研究则是为了提高对现象和过程的认知水平 [3.3]，有些已经部分或完整地包括在上述建议和措施中。

In addition to the project initiatives recommended below, several groups around the Pacific are already engaged in research projects exploiting recent technical developments that point to additional monitoring opportunities for TPOS 2020 [7.5.2].

除了后面提到的项目倡议外，太平洋周边的几个研究团队已经开始了一些研究项目，以利用最近的技术进展为 TPOS 2020 带来更多的机会 [7.5.2] 。

New technology is also considered, because it provides opportunities for broader engagement in the development of TPOS and for introducing efficiencies and/or enhancing relevance and impact of the observing system.

我们还需要考虑新技术，因为它为 TPOS 的发展提供更广泛的参与度，并为提高观测系统的效率和/或增强其作用提供手段。

Recommended projects and supported initiatives include [6.1, 6.2, 10]:

建议的项目和已获资助的初始项目包括 [6.1,6.2,10]：

Pilot Studies/Programs for the Backbone

Observing Western Boundary Current Systems: A Pilot Study [6.1.1]
Eastern Pacific equatorial-coastal waveguide and upwelling system [6.1.2]
Determining the critical time and space scales for biogeochemistry in TPOS [6.1.3]
Direct measurements of air-sea fluxes, waves, and role in air-sea interaction [6.1.4]
Pilot Climate Observing Station at Clipperton Island for the Study of East Pacific ITCZ [6.1.5]
Assessing the impact of changes in the TPOS Backbone [6.1.6]
Comparison of analyses and utilization of TPOS observations [6.1.7]

试点研究/骨干系统项目

观测西边界流系统：试点研究 [6.1.1]
东太平洋赤道-沿岸波导及上升流系统 [6.1.2]
确定 TPOS 计划中生物地球化学研究的时空尺度 [6.1.3]
直接观测海-气通量、波浪及其在海-气相互作用中的角色 [6.1.4]
为研究东太平洋 ITCZ 在 Clipperton 岛建立的试点气候观测站 [6.1.5]
评估调整 TPOS 骨干系统所带来的影响 [6.1.6]
比较 TPOS 观测资料的分析和使用 [6.1.7]

Process studies

Pacific Upwelling and Mixing Physics [6.2.1]
Air-sea interaction at the northern edge of Western Pacific warm pool [6.2.2]

Air –Sea Interaction at the Eastern Edge of Warm Pool [6.2.3]
Eastern Pacific ITCZ/warm pool/cold tongue/stratus system [6.2.4]

过程研究

太平洋上升流与混合的物理机制 [6.2.1]
西太平洋暖池北边界的海-气相互作用 [6.2.2]
暖池东边界的海-气相互作用 [6.2.3]
东太平洋的热带辐合带/暖池/冷舌/层云系统 [6.2.4]

Examples of funded new technology projects

- Profiling Floats Equipped with Rainfall, Wind Speed, and Biogeochemical Sensors (NOAA) [10.2.1]
- Autonomous Surface Vessels as Low-Cost TPOS Platforms (NOAA) [10.2.2]
- Flux surface glider experiment (JAMSTEC) [10.2.3]
- Enhanced ocean boundary layer observations on NDBC TAO moorings (NOAA) [10.2.4]
- Development and Testing of Direct (Eddy Covariance) Turbulent Flux Measurements for NDBC TAO Buoys (NOAA) [10.2.5]

已获资助的新技术项目举例

- 载有降水、风速及生化参数传感器的剖面浮标 (NOAA) [10.2.1]
- 作为经济型 TPOS 观测平台的自动海面航行器 (NOAA) [10.2.2]
- 海表通量滑翔器（glider）实验 (JAMSTEC) [10.2.3]
- NDBC TAO 锚系上加密的海洋边界层观测 (NOAA) [10.2.4]
- 发展并测试 NDBC TAO 浮标上湍流通量的直接测量 (涡相关法) (NOAA) [10.2.5]

Action 14 Through the TPOS 2020 Resources Forum, the TPOS 2020 Transition and Implementation Group, and through links to research programs and funders, support should be advocated for Pilot Studies and Process Studies that will contribute to the refinement and evolution of the TPOS Backbone.

措施 14：通过 TPOS 2020 资源论坛、TPOS 2020 过渡与实施小组以及与各研究计划和资助方之间的沟通，应当提倡支持有助于改善和发展 TPOS 骨干系统的试点研究和过程研究。

This is the first in a sequence of Reports by TPOS 2020. The initial recommendations and actions begin a process of transformation and change to an observing system that will be more capable, more resilient and more effective. The integrated design lessens the reliance on any single platform, and its implementation harvests some of the efficiencies available from recent technological developments. Broadscale ocean and surface conditions will be more accurately tracked. Key regimes will be observed comprehensively, delivering a clearer ongoing description of the evolving tropical Pacific climate and guiding coupled model development. TPOS enhancements will enable much needed improvements to operational modelling systems, addressing the scientific challenges of coming decades.

本报告是 TPOS 2020 系列报告的第一部。这里提出的初步建议与措施开启了提升观测系统能力、持续力及效率的改革进程。综合性的设计降低了对任何单一平台的依赖性，其实施将受益于最新技术发展提供的高效率。我们将更准确地监测大尺度的海洋及海面状况，更全面地观测关键的海洋/气候系统，更清楚地描述演变中的热带太平洋气候，并为耦合模式的发展提供指导。TPOS 系统的改进不但能满足业务化模式系统的需求，也能应对未来几十年的科学挑战。

Subsequent Reports will include refinements arising from evolving technology and additional insights gained from Pilot and Process studies. Biogeochemistry and ecosystem observations, and their interpretation in the context of improved physical-system observations, will be a major focus. The value of all TPOS observations is increased by integration through assimilation and syntheses, so future designs will address needs from advanced model parameterizations and changes that increase the effectiveness of data assimilation systems.

此后的报告将包括不断发展的新技术带来的改善，以及试点项目和过程研究带来的新认知。生物地球化学和生态系统观测，以及对这些观测在改进了的物理系统观测背景下的阐释，将是后续报告的主要关注点。通过数据同化与融合，TPOS 观测系统的价值会进一步提高。因此，今后的设计将会着眼于发展先进的模式参数化并提高数据同化系统效率的需求。