



SAHF STRATEGY FOR NUMERICAL WEATHER PREDICTION (NWP) 2030



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Foreword

The South Asian region continues to face increasing challenges arising from the growing frequency and intensity of weather and climate extremes. These impacts, amplified by rapid urbanization, population growth, and socio-economic vulnerabilities, underscore the urgent need to strengthen regional cooperation in weather and climate services. Reliable and timely forecasts are essential to safeguard lives, protect livelihoods, and support sustainable development across our nations.

This Regional Strategy for Numerical Weather Prediction (NWP) 2030 sets out a coherent and forward-looking framework to advance scientific, technical, and operational collaboration among National Meteorological and Hydrological Services (NMHSs) of South Asia. It provides a structured pathway for enhancing regional NWP capabilities, integrating emerging technologies, and optimizing resources to deliver more accurate, reliable, and actionable weather and climate information.

Grounded in three strategic pillars—*Impact, Science and Technology, and Research and Development*—the Strategy articulates clear goals and targeted actions to foster collective progress. It promotes data sharing, interoperability, and capacity development, while encouraging the adoption of innovative methodologies such as artificial intelligence, machine learning, and ensemble prediction techniques. By building on existing institutional strengths and enhancing regional partnerships, the Strategy aims to ensure that every Member country benefits equitably from scientific and technological advancements in numerical weather prediction.

The formulation of this Strategy exemplifies the spirit of cooperation and shared purpose that defines the South Asia Hydromet Forum (SAHF). It demonstrates our collective commitment to improving forecasting capabilities and strengthening resilience to hydrometeorological hazards through regional solidarity, technical excellence, and sustained partnership with the international community.

The Executive Council acknowledges with appreciation the contributions of members of the SAHF Working Group on NWP, technical experts, and partner institutions in developing this document. We also recognize the invaluable support of the World Bank's Resilient Asia Program, funded by the United Kingdom's Foreign, Commonwealth and Development Office (FCDO) under the Climate Action for a Resilient Asia (CARA) initiative, whose assistance has been instrumental in the preparation of this Strategy.

As Co-Chairs of the Executive Council, we reaffirm our commitment to the implementation of this Strategy and to strengthening cooperation among all Member States in pursuit of a safer, more resilient, and sustainable South Asia.

Co-Chairs, Executive Council, South Asia Hydromet Forum (SAHF)

The Context

As the impacts of weather extremes increase in frequency and severity in South Asia, it is essential that we can provide accurate forecasts and timely warnings that enable early action and response.

Weather forecasting generates significant societal benefits, which can be increased by improving accuracy and lead-time through better meteorological monitoring, modelling and computing. Numerical weather prediction (NWP) across timescales (from nowcasting to climate prediction) forms the basis of most weather and climate predictions and related products and services for decision-making on a day-to-day basis. Significant skill improvements have been accomplished through a combination of ever-increasing computing power, improved models with more accurate representation of atmospheric processes, new techniques and increasingly sophisticated algorithms that ingest ever-increasing volumes of observations into the models. The Ensemble Prediction Systems now operated by many advanced NWP centres use these models to quantify forecast uncertainty and indicate the range of possible future states of the atmosphere.

Developing, maintaining and operating an NWP capability is a major endeavour in terms of financial, scientific, technical and human resources. Many National Meteorological and Hydrological Services (NMHSs) are currently facing reductions in personnel and budget, which constraint their ability to implement, operate and sustain such systems. The typical NWP related issues in South Asia (and even elsewhere) include:

- Limited use of global and regional NWP;
- Limited understanding of EPS products;
- Run low resolution deterministic NWP (~9-30km), with no data-assimilation, nor the optimal parametrizations;
- Limited (or even no) capacity for weather prediction in complex terrain (mountain areas);
- Limited objective verification;
- No post-processing;
- Few NWP and ICT staff, but often very talent staff.

Under current Hydromet modernization projects in South Asia, there are a few NMHSs now with the ability to run deterministic NWP at higher resolution (~3-7km) in High Performance Computers (HPC); however, capacity building is still required for data assimilation. In addition, some of these investments are mostly for experiments as there is still limited (or even no) operational capacity to run models due to limited number of staff.

Drivers for regional strategy for NWP

- Under the influence of rapidly changing global warming regime, societies of south Asia in particular are facing an increase in the frequency and intensity of high-impact extreme weather and climate events. Differential incidence of such extremes together with exponential population growth and demographic shifts seen over the 21st century (e.g., urbanization, increase in coastal populations even after threatened by sea level rise) are increasing the detrimental socio-economic and built infrastructure losses.
- Incidental economic shocks that the Governments of South Asia are faced with have also enhanced demands for improved predictions of disruptive and potential high-impact weather events (preferably on kilometre scales) along with most representative projections of climate change at sub-national scale in support of climate resilient development planning.
- Innovations in observation, computing, networking, storage, data acquisition and communication technologies are expanding the possibilities of growing role for the private sector involving the weather and climate enterprise.

South Asia's Vision for Numerical Weather Prediction

In consideration of today's hydrometeorological service landscape, South Asia NMHSs are positioning "Full regional NWP integration, cooperation and innovation to ensure the safety and security of the people, and to realize contributions to economic sectors and society well-being" as its 2030 vision for NWP. This strategy focuses on non-Tropical Cyclone (TC) hazards, noting that TC and storm surges are well covered by RSMC New Delhi and INCOIS, respectively.

SAHF has been providing a cooperative knowledge transfer and capacity enhancement through fully leveraging accelerated advances in weather and climate forecasting with key actions needed across the public, private and academic sectors, as identified in this strategy and associated roadmap.

Pillars, goals and strategic actions for building the roadmap 2030

The overarching framework of this strategy consists of three main Pillars: Impact, Science and Technology, and Research and Development. This strategy establishes ten ambitious goals under these pillars (see **Figure 1**) aimed at enhancing regional NWP capabilities, complementing the national investments.

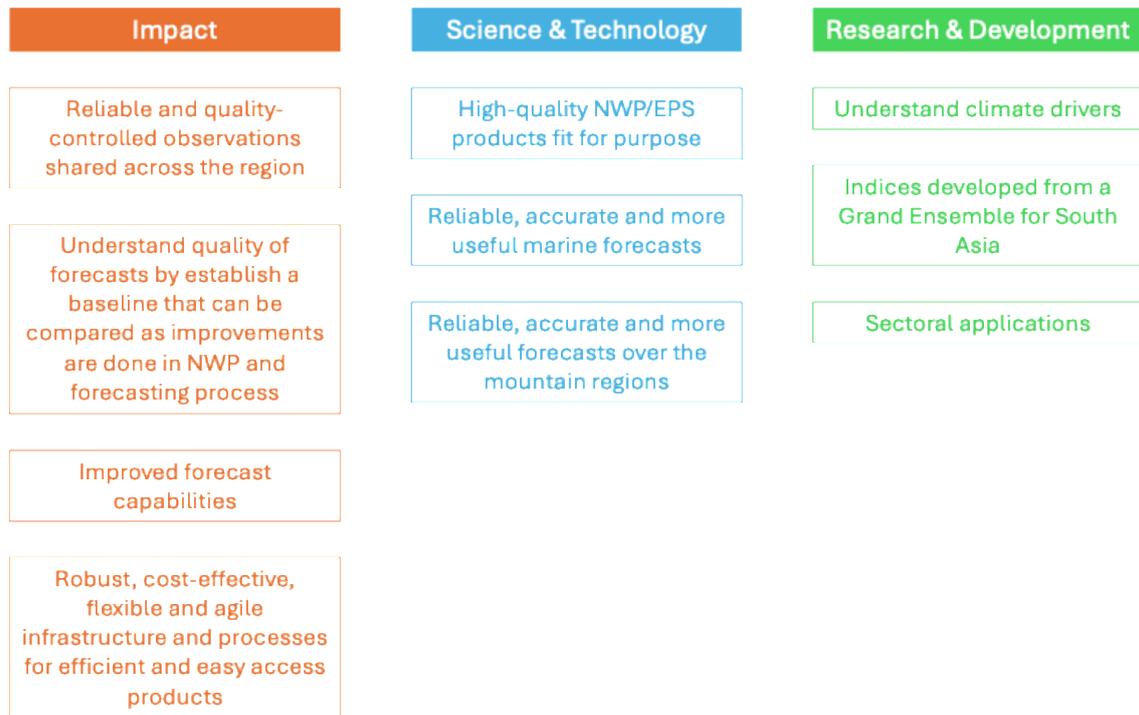


Figure 1 - Framework of the Regional NWP Strategy 2025-2030.

There are three main principles associated with this strategy. First, **collaboration within the region**, which is at the heart of everything we do. Second, **partnerships with the international community**, to support technical assistance for the implementation of activities and capacity building; as well as to fully taking advantage of and enhancing the existing service landscape. Third, **flexibility to account for uncertainties** associated with advances in science and technology.

PILLAR 1: IMPACT

Target 1: Making use of well-tested methodologies and tools in the region with the support of development partners.

Goal 1.1: Reliable and quality-controlled observations shared across the region [*Jointly addressed with the WG/OBS*].

Aim 1.1: To establish a South Asia Regional Basic Observation Network (RBON) for improving monitoring, forecasting and application services in the region.

Strategic Actions:

SA1.1.1: Establishing and implementing data-sharing agreements and protocols for a South Asia RBON.

SA1.1.2: Sharing data automatically via a regional platform compliant with WIS2.0.

SA1.1.3: Perform quality control of observations.

Goal 1.2: Quality of forecasts understood by establishing a baseline that can be compared as improvements are done in NWP and forecasting process.

Aim 1.2: To establish a common verification methodology across the SAHF countries for comparison of verification results for the same model in the various countries in order to defined target research for forecast improvements.

Strategic Actions:

SA1.2.1: Implementing forecast verification at NMHSs and reporting on a monthly basis.

SA1.2.2: Scaling-up the methods from point verification to extreme weather verification and expanding to other parameters (e.g. EFI, lightning flash, and ocean parameters).

Goal 1.3: Improved forecast capabilities.

Aim 1.3: To share, access and use all Limited Area Model data within the SAHF region, and implement High-resolution Rapid Refresh models across the region using the same methodology, with associated training, thereby building a regional workforce in the region for improved regional modelling and forecasting.

Strategic Actions:

SA1.3.1: Sharing all global models and LAM data through the regional platform.

SA1.3.2: Implementing country specific High-resolution Rapid Refresh (HRRR) models.

SA1.3.3: Enabling NWP support to WGs on IBF, climate services and hydrology.

SA1.3.4: provision and sharing of computing resources.

Goal 1.4: Improved operational forecasting through robust, cost-effective, flexible and agile infrastructure and processes for efficient and easy access products.

Aim 1.4: To make use of existing licence free forecaster workstations across the region and optimize provision and sharing of computing resources for regional computation and storage.

Strategic Actions:

SA1.4.1: Leveraging existing forecaster workstation in the region (e.g. DIANA, SMARTMET, METCAP+ and RIMES forecaster workstation) for visualization of NWP products by forecasters.

SA1.4.2: Further integrating the Severe Weather Forecasting Programme (SWFP) resources into the national forecasting processes.

SA1.4.3: Enhancing partnerships and collaborations for improved data access and capacity building / training on interpretation of forecasts, with a especial emphasis on the use of ensemble prediction systems.

PILLAR 2: SCIENCE AND TECHNOLOGY

Target 2: Applying methods and innovative ML/AI approaches for improving reliability and accuracy of general forecasts, marine forecasts and forecasts over the mountain regions.

Goal 2.1: High-quality NWP/EPS products fit for purpose.

Aim 2.1: To drive down systematic errors in regional models through collaborative efforts in forecast verification and using statistic methods and innovative ML/AI approaches.

Strategic Actions:

SA2.1.1: Driving down systematic model errors through bias correction and calibration of models using statistic methods and innovative ML/AI approaches.

SA2.1.2: Enhancing partnerships and collaborations with academia and research centres; attachment trainings.

Goal 2.2: Reliable, accurate and more useful marine forecasts

Aim 2.2: To enhance partnerships and collaborations within the region (coastal countries) to improve marine meteorology, including the engagement of INCOIS and academia.

Strategic Actions:

SA2.2.1: Improving marine meteorology, with engagement of INCOIS and WMO RSMCs covering the Indian Ocean.

SA2.2.2: Explore the engagement of other institutions (e.g. JMA, MRI, BoM, and others).

SA2.2.3: Enhancing partnerships and collaborations with academia and research centres; attachment trainings.

Goal 2.3: Reliable, accurate and more useful forecasts over the mountain regions.

Aim 2.3: To improve mountain meteorology through collaboration within and outside the region for the application of data-driven methods.

Strategic Actions:

SA2.3.1: Improving mountain meteorology through the application of data-driven methods.

SA2.3.2: Enhancing partnerships and collaborations with academia and research centres; attachment trainings.

PILLAR: RESEARCH AND DEVELOPMENT

Target 3: Studying the impacts of climate drivers and applying post-processing, big data and analytics for the development of sectoral applications and services.

Goal 3.1: Climate drivers understood.

Aim 3.1: To understand the impact of MJO, ENSO and IOD in the weather in South Asia.

Strategic Actions:

SA3.1.1: Studying the impact of MJO, ENSO and IOD in the weather in South Asia.

SA3.1.2: Developing case studies to understand the relationship between the climate drivers and the extreme weather events in the South Asia region.

Goal 3.2: Indices developed from a Grand Ensemble for South Asia.

Aim 3.2: To improve the capacity of forecasting severe and high-impact events through the development of a Grand Ensemble using the 3 existing Ensemble Prediction Systems (EPS) in the region.

Strategic Actions:

SA3.2.1: Using the 3 existing EPS available in the region (2 from India and 1 from ECMWF) and develop a Grand Ensemble for South Asia and derive indices (e.g. EFI).

SA3.2.2: Developing case studies based on extreme weather events in the South Asia region, highlighting how effectively NWP models predict these extreme events.

Goal 3.3: Sectoral applications developed [*Jointly addressed with the WG/IBF, WG/CS and WG/Hydro*].

Aim 3.3: To apply post-processing, big data and analytics for the development of sectoral applications and services.

Strategic Actions:

SA3.3.1: Developing sectoral applications through post-processing, big data and analytics from nowcasting to S2S in a seamless approach.

SA3.3.2: Establishing a research group in SKHub with TAG members as mentors to expedite weather and climate related research in South Asia.