



High Performance Computing System Market Outreach Session

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Pakistan Meteorological Department

Introduction:

National Meteorological & Hydrological Service of Pakistan responsible for providing meteorological services throughout Pakistan to wide variety of interest and for numerous public activities and projects which require climatic information.

PMD's Services

- Meteorology
- Hydrology/Drought/Seismology
- Agro-Meteorology
- Aviation Meteorology
- Marine Meteorology
- Glaciology (Glacier Monitoring)
- Climatology/Astronomy
- Research and Development

Multi-Hazards Early Warning

- Heavy Rain Warning System
- Flood Early Warning System
- Earthquake & Tsunami Early Warning System
- Cyclone Early Warning System
- Heat Wave & Marine Early Warning System
- GLOF Early Warning System
- Drought Monitoring & Early Warning System
- Fog, Smog, Dust/Thunderstorm, Visibility Warning

Financing Arrangements of the Project

Financing Arrangement

Financer	World Bank IDA, Credit No. 7333-PK
Project Title	Integrated Flood Resilience and Adaptation Project (IFRAP) Component-II: Strengthening Hydromet and Climate Services
Implementation Agency	PMD through Project Implementation Unit PIU-PMD
Project Duration	04 Years
Committed Financing by WB	US\$ 40 million (Phase-I)

Overview of Project

Objective: Strengthen hydromet and climate services in Pakistan through technological modernization and capacity building.

Main Components:

- **Modernization of Hydromet Services:**
 - **Procurement & Installation:**
 - 300 Automatic Weather Stations (AWS), including 50 with Agromet sensors.
 - 5 Radars: 2 S-Band (Gwadar, Lahore), 2 C-Band (D.I. Khan, Cherat), 1 X-Band (Quetta).
 - 3 Mobile Radars: X-Band
 - High Performance Computing System for Numerical Modelling and Improved Forecast
 - **Civil Works:**
 - Construction of radar towers, AWS installation structures and rehabilitation/construction of HPC Building
- **Institutional Strengthening & Capacity Building:**
 - Upgrading PMD's core infrastructure, including the Institute of Meteorology & Geophysics (IMG), Met. Workshop, and Climate Data Processing Centre (CDPC).
 - Transitioning to a service-oriented department with enhanced forecasting capabilities (public weather services, early warnings, agromet services).

Key Procurement and Implementation Areas

- **High Performance Computing System:**
 - Procurement and implementation of an HPC system for enhanced weather predictions.
 - Data Assimilation: Integrating observations from multiple sources to improve forecast accuracy.
 - Data Center: Centralized infrastructure for storage, processing, and management of large-scale weather and climate data.
 - Prediction System: Use of HPC for real-time numerical weather predictions (NWP), Hydrological Modelling, and Climate model simulations for reliable and accurate forecast.

Scope of Procurement

PMD's High Performance Cluster Computing (HPCC) Facility

PMD's 1st Generation HPCC (2006)

- Peak Performance **~0.2 TFLOPS**
- Compute Nodes **09**
- Total No. of Cores **18**
- Total Data Storage Capacity **12TB**

PMD's 2nd Generation HPCC (2009)

- Peak Performance **~1.7 TFLOPS**
- Compute Nodes **32**
- Total No. of Cores **256**
- Total Data Storage Capacity **50TB**

PMD's 3rd Generation HPCC (2019)

- Peak Performance **~22 TFLOPS**
- Compute Nodes **24**
- No. of Cores **672**
- Data Storage Capacity **72 TB**



Prioritized Objectives of New HPC Procurement:

- Convection-Permitting High resolution (~1-3 KM) regional forecast Models
- Ensemble Prediction system for Probabilistic Weather Forecast
- Multi-model simulations to have improved Weather Forecast Guidance System
- Data Assimilation System to ingest local observations and have improved localized high impact weather forecast.
- Seasonal Forecasting using Dynamically Downscaled Models
- Hydrological Modelling
- A real-time air quality forecasting system
- Future Climate Change Projections

(Note: The wish list is extensive, but we will prioritize the objectives based on the actual available resources from the HPC.)

Proposed HPC system

The HPC System shall be sized to meet the minimum benchmark requirements of the PMD with

- **CPU nodes** \geq **9000 cores**
- **GPU nodes** $>$ **272 TFLOPS** Peak Performance - Double Precision (FP64)
- **Total Storage** \sim **3.5 PB**
- **Racks (42 U)** \leq **3 Racks**
- **Peak Power** \sim **100KW**

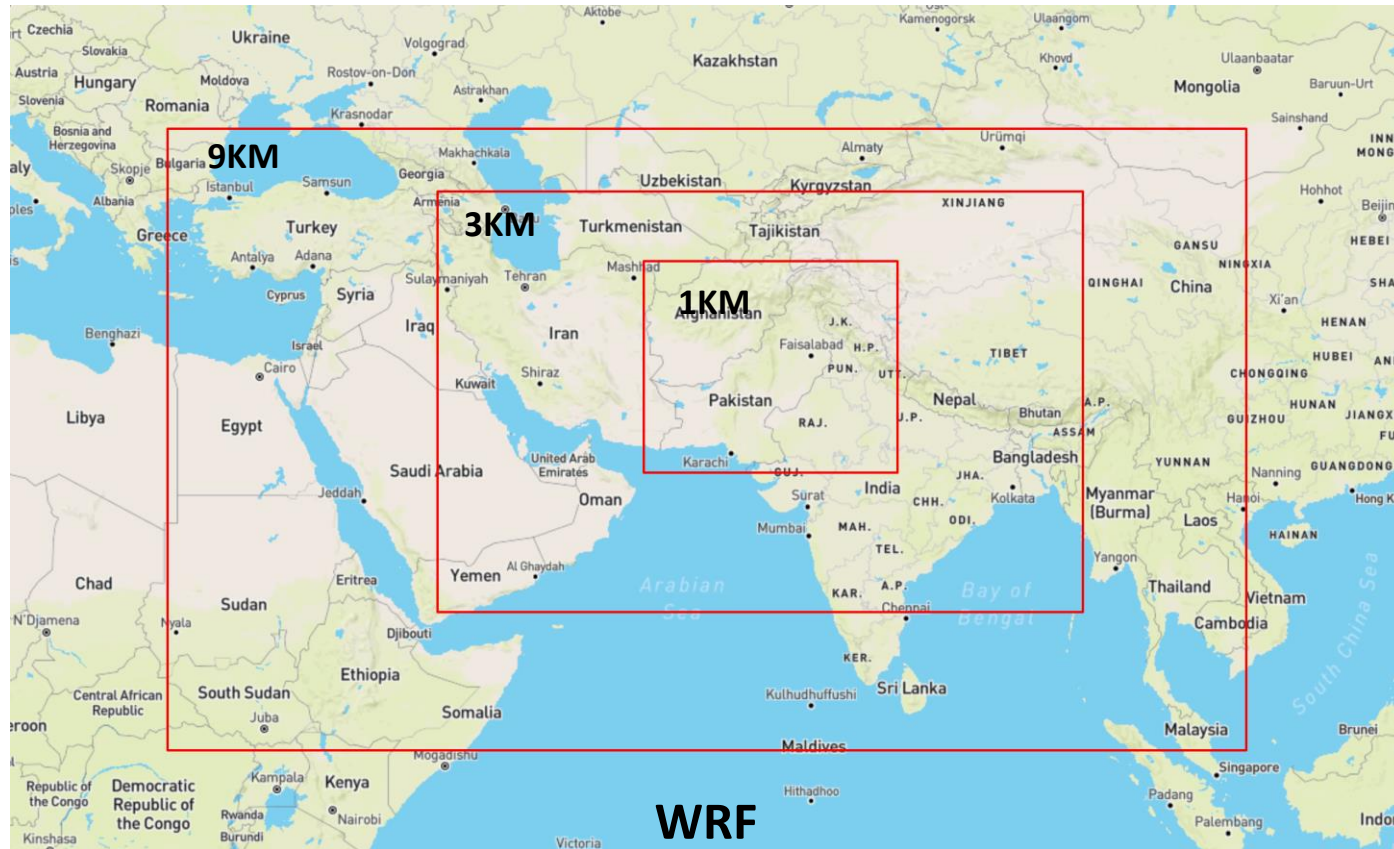
The number of nodes and types of processors on each node shall be determined on the basis of the performance of a set of application and synthetic benchmark tests and will be offered by the bidder in their proposal.

Proposed HPC system

- **The Solution will consist of :**

- HPC Login, Management and CPU based Compute Nodes
- GPU nodes for data analytics, visualization and GPU-based Forecast Models
- Implementation of Data Assimilation System and High-Resolution Regional Forecast Models
- High-Speed InfiniBand/Ethernet/Management Network
- Fast Parallel Access Data Storage & Object Storage
- Complete Software Stack for Cluster Management, Data Processing, Analytics & Visualization
- Redundant Power Backup and Cooling Infrastructure with Direct Liquid Cooling for Servers
- Comprehensive Trainings

Operational NWP Benchmarking Tentative Specifications



WRF

Nested 9km/3km/1km

9km Domain: 7-days forecast with 6-h intervals

3km Domain: 5-days forecast forecast with 3-h intervals

1km Domain: 2-days forecast with 1-hr intervals

All nested simulations should be completed within 60 – 120 minutes

ICON Model

6.5km/2.5km/1km

6.5km Domain: 7-days forecast with 6-h intervals

2.5km Domain: 5-days forecast forecast with 3-h intervals

1km Domain: 2-days forecast with 1-hr intervals

Simulations should be completed within 60 – 120 minutes

Forecast Models:

Models/Products Deployments:

WRF: Weather Research and Forecasting (WRF) Model with Data Assimilation System

Nested: 9 Km, 3Km, 1km

ICON: Icosahedral Nonhydrostatic Weather and Climate Model

Nested: 6.5 Km, 2.5 Km, 1km

WRF-Chem, WRF-Hydro

As per demand

Seasonal Prediction System

Monthly

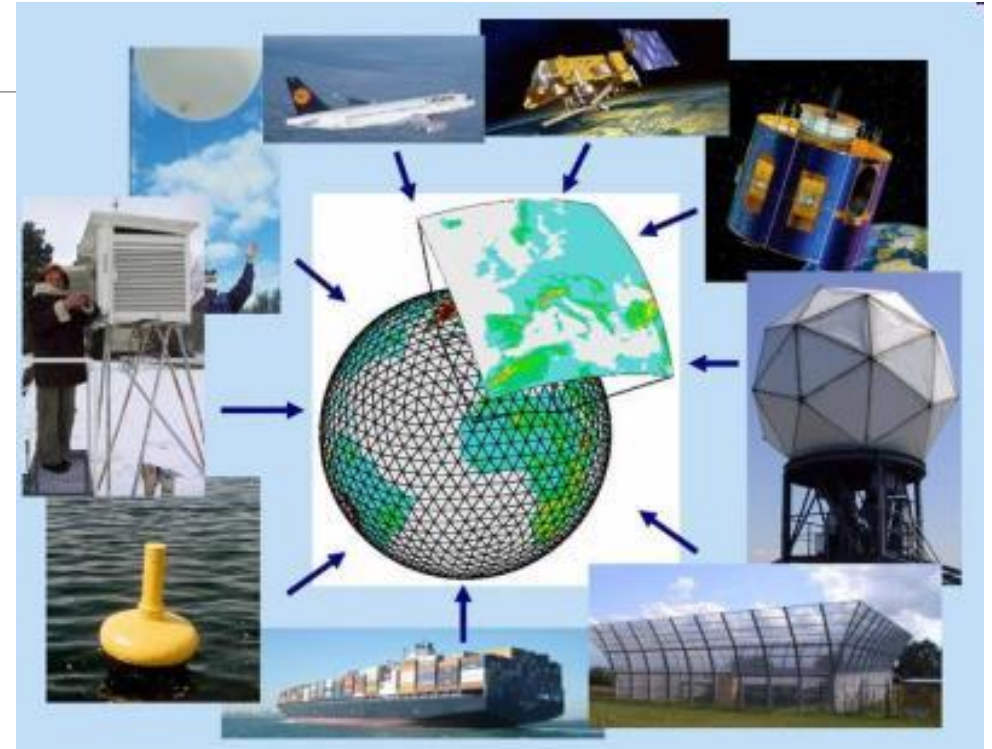
Climate Models

Ad hoc basis, as per research needs

Data Assimilation System:

• Data Assimilation System

- Commission Data Assimilation for WRF/ ICON models.
- Integrate data from RADAR, AWS, Satellite, Wind Profiler, etc.
- Pre-process and normalize data for model compatibility.
- Assimilate data into models for better forecasting.
- Ensure real-time processing with optimized HPC performance.
- Improve forecasting accuracy with integrated data sources.



Source: deutscher wetterdienst

Specialized Trainings:

- **Comprehensive OEM training** for all components of the solution including servers, storage, HPC Cluster manager, workload manager, and other software components.
- **Data center environment management** onsite training including Hardware, Cooling and Power.
- On-site training for **HPC Hardware/software maintenance and operation** after HPC installation and commissioning.
- **Data Assimilation System** (Land-surface and Upper Air meteorological data, RADAR, Satellite etc.) Deployment & Operation.
- Comprehensive **NWP training** WRF, ICON and WRF-Hydro models installation/operation:
- **NWP forecast verification and evaluation** system at an internationally renowned atmospheric modelling center.

Q&A Session



THANKS

