NWP System and Computing at NCMRWF for Weather Guidance

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Our Mission

- To provide accurate location specific medium range weather forecasts in quantitative terms to farmers, Numerical Weather Prediction (NWP) guidance to partners/user agencies on high impact weather, and customized forecast products for other applications.

Objectives

- Development of global and regional scale NWP models for Medium Range Weather Forecasts
- Set-up a state-of-the-art supercomputing infrastructure
- To issue location specific weather forecast to the farmers
- Set-up agro-meteorological advisory service (AAS) units, in each of the 127 agroclimatic zones of the country
- Set-up a stable/fast dedicated communication network between NCMRWF and AAS units

Models at NCMRWF

NWP Models

Global Models

T-80/L18

T-170/L28

Meso-scale Models

MM5 [Nested 90, 30, 10 km resolution]

Eta [48km resolution]

Ocean Wave Model

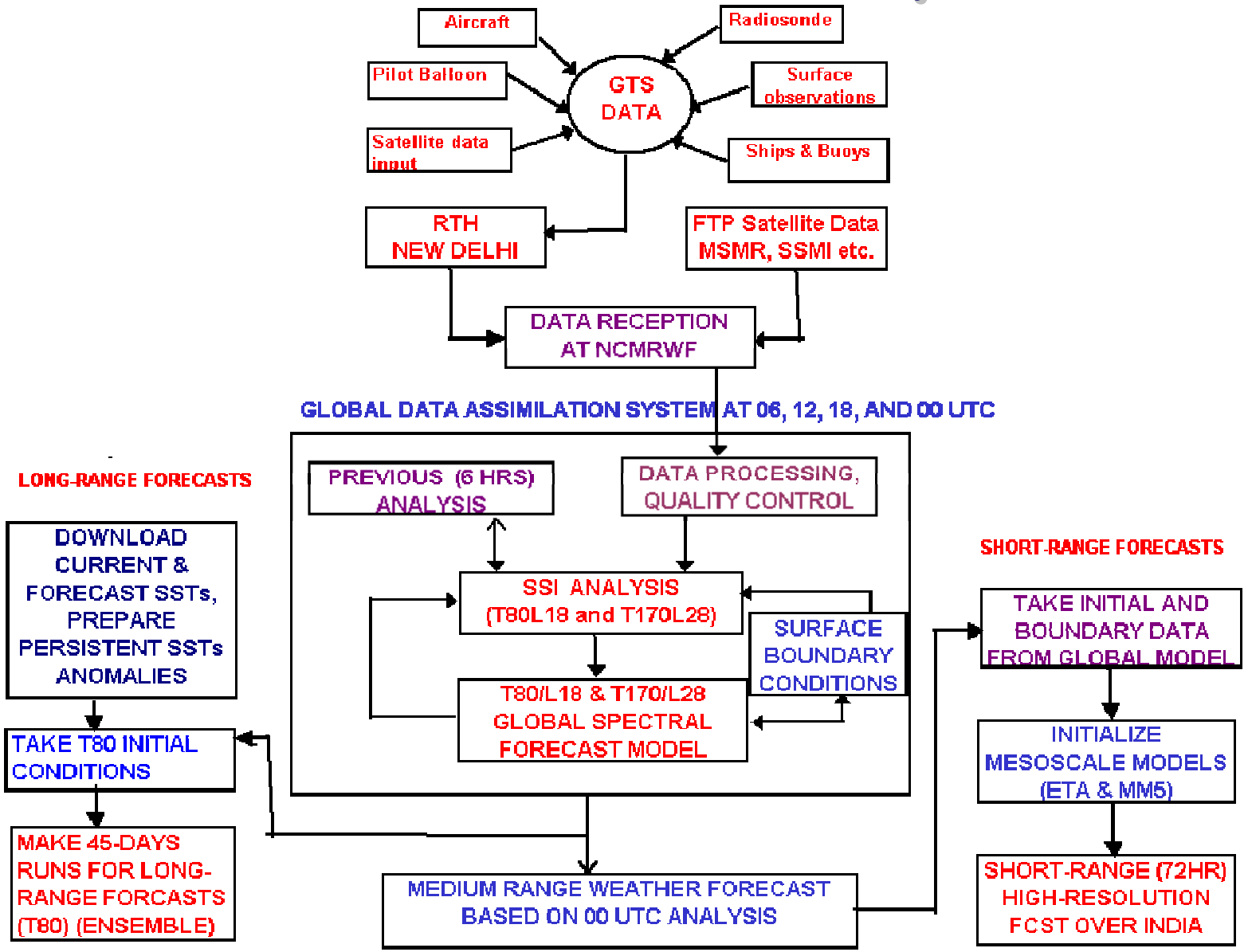
WAVEWATCH-III at 1 deg.for global ocean

Crop-weather models

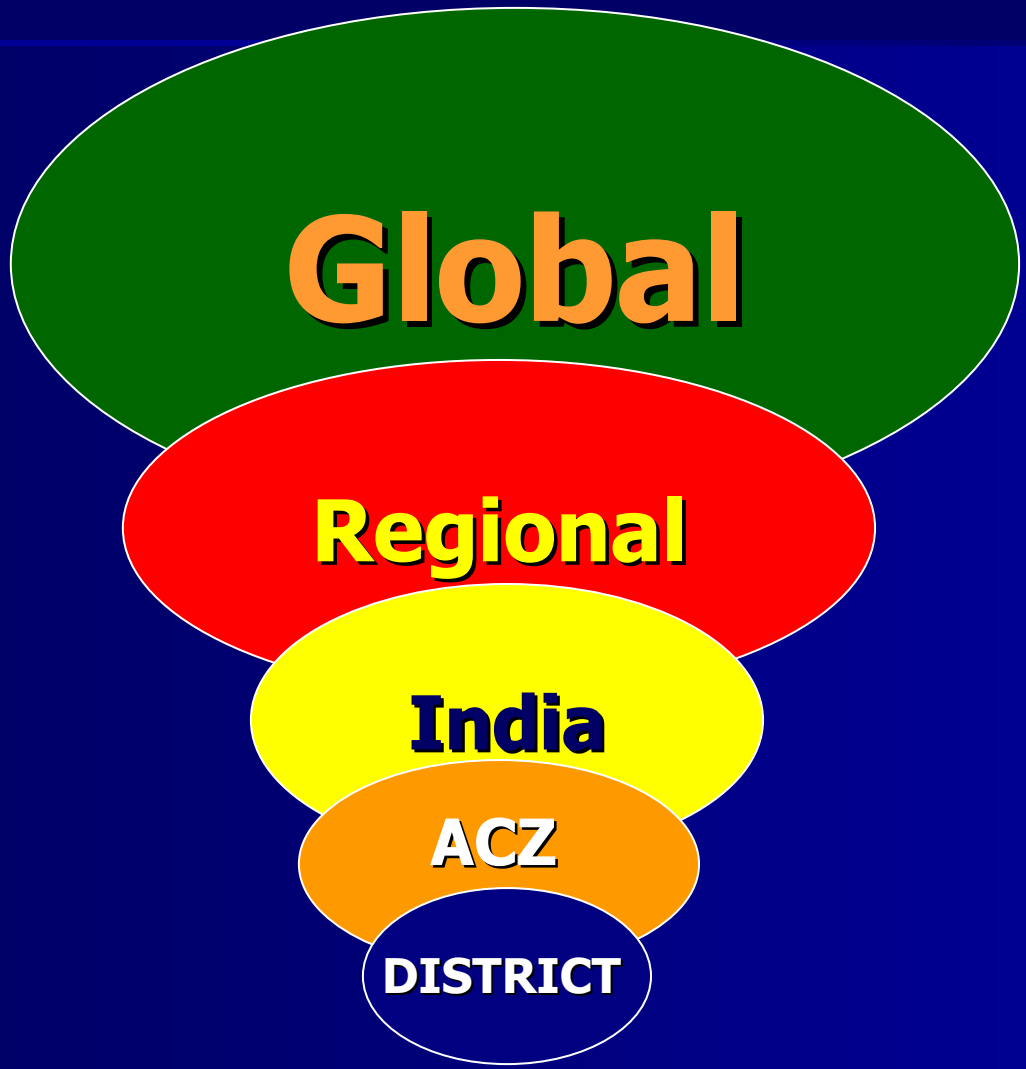
CERES Model for cereals

CROPGROW model for legumes

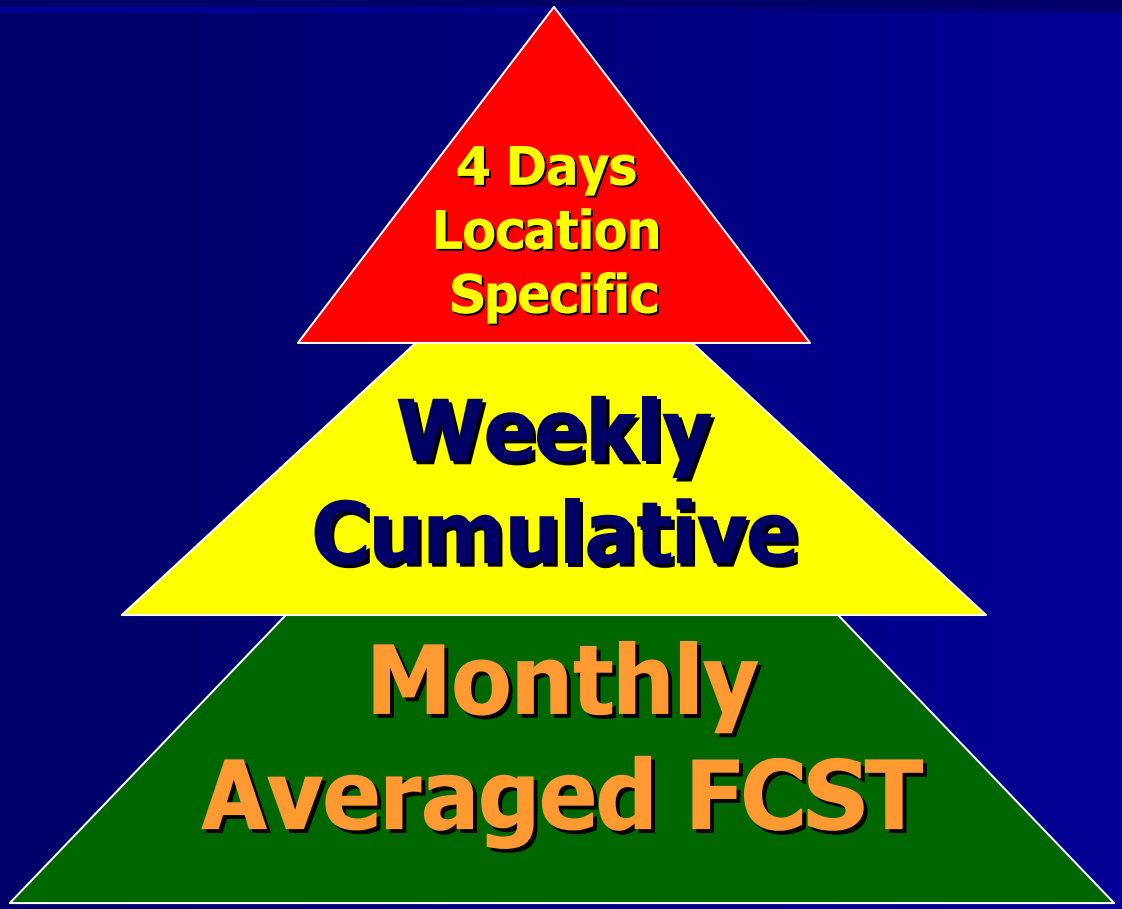
Weather Forecast System



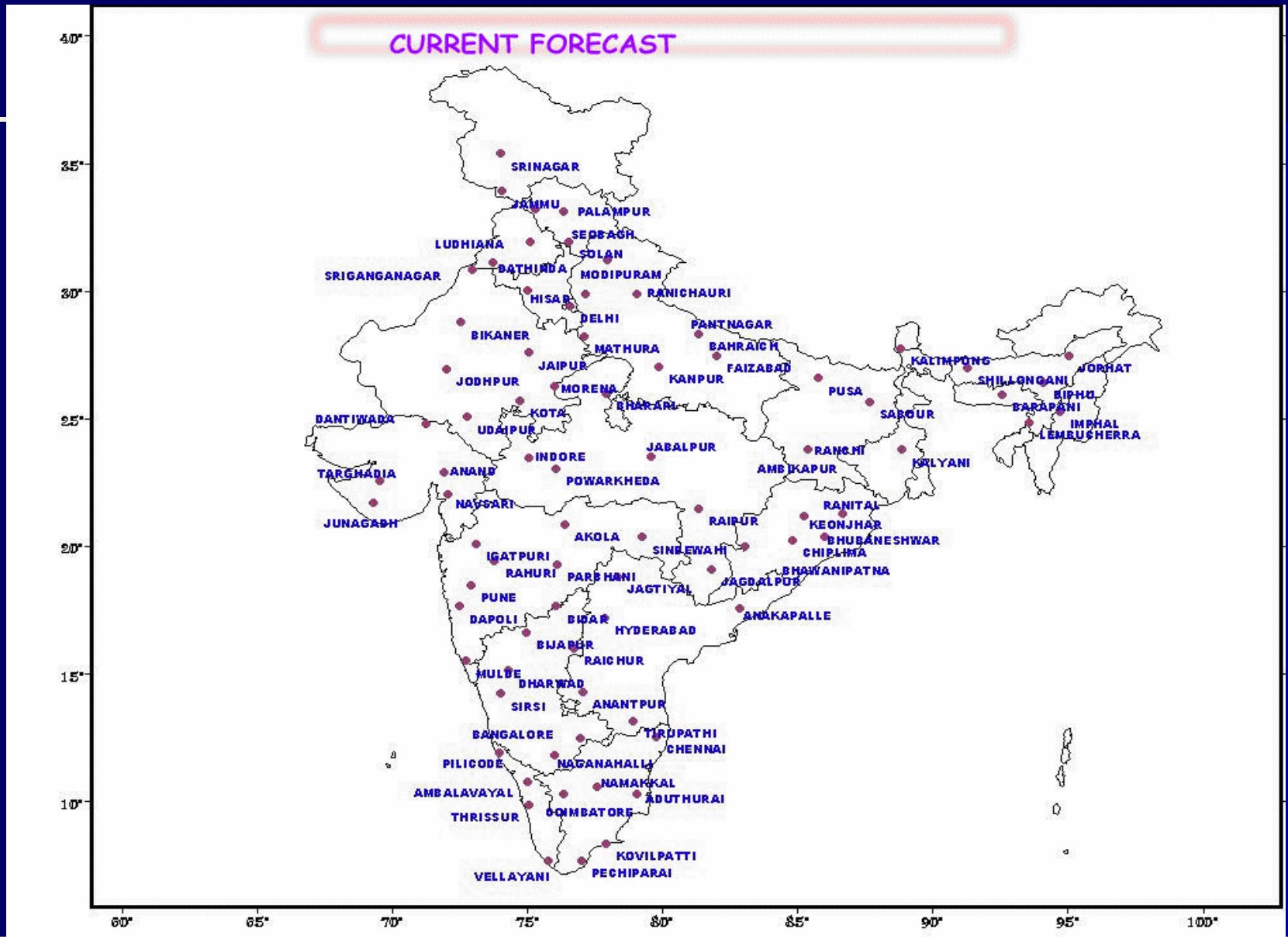
NCMRWF'S Forecasts are available in all spatial scales



NCMRWF'S Forecasts are produced from Day to Monthly Scales



NETWORK OF AGROMET ADVISORY SERVICE (AAS) UNITS OF NCMRWF



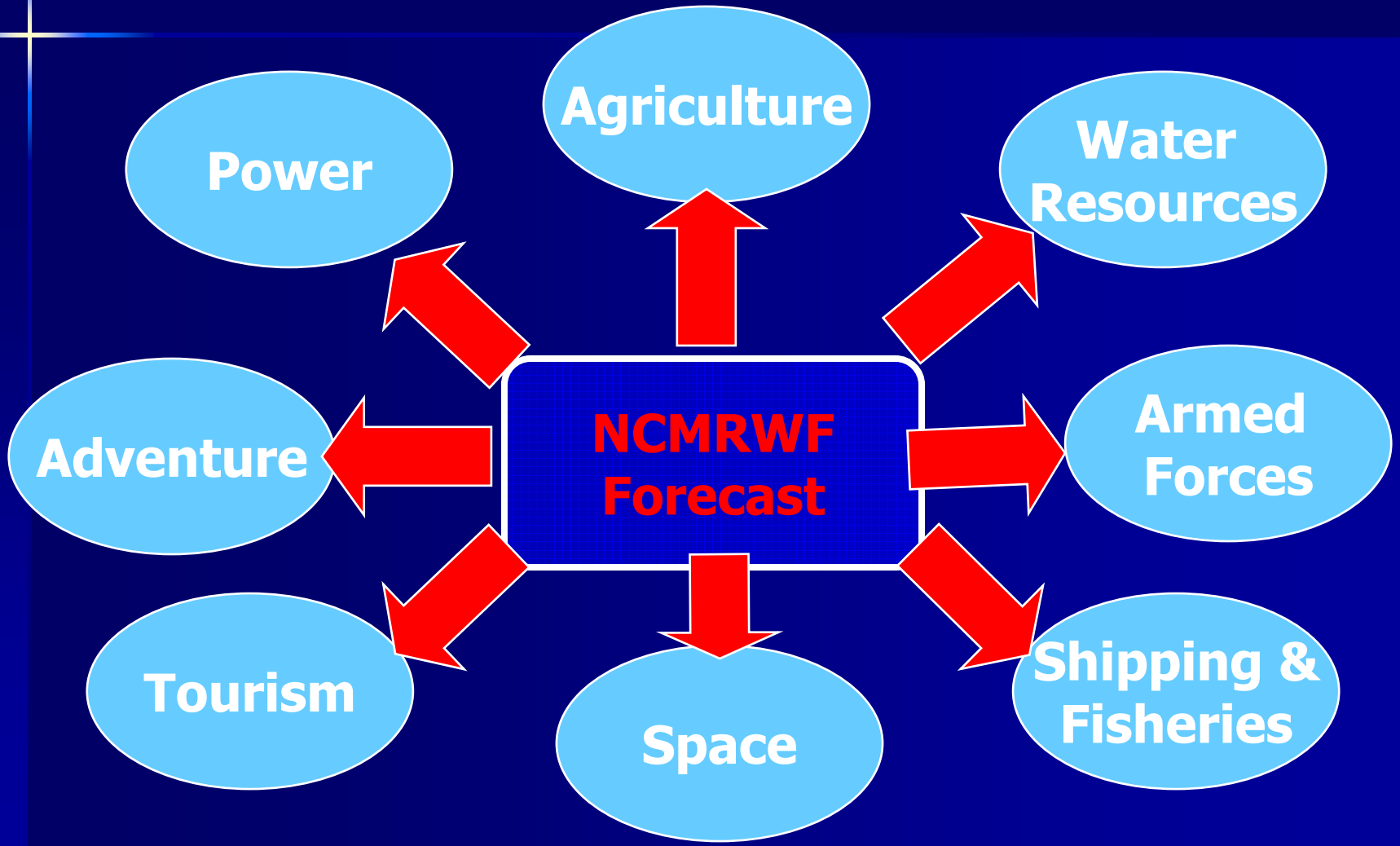
NCMRWF FORECAST PRODUCTS DISSEMINATED TO AAS UNITS

- 24 HR PRECIPITATION (MM)
- AVERAGE CLOUDINESS (OKTA)
- AVERAGE WIND SPEED (KMPH) AT 10 FT HEIGHT
- PREDOMINANT WIND DIRECTION (DEG.) AT 10 FT HEIGHT
- MAXIMUM TEMP. TREND (DEG. C) AT 4.5 FT HEIGHT
- MINIMUM TEMP. TREND (DEG. C) AT 4.5 FT HEIGHT

Frequency of Forecast	:	Twice-a-week
Dissemination	:	On Tuesday and Friday
Period covered	:	4 days

- WEEKLY CUMULATIVE RAINFALL (mm)l

Forecast to different Sectors



Major Weather Systems Affecting Indian Sub-continent

Monsoon (June-Sept)	Monsoon Depression/ Low Onset Vortex Mid-Tropospheric Cyclone Off-Shore Vortex
Pre/Post Monsoon (Mar-May) (Oct-Dec)	Tropical cyclone Thunderstorm/ Duststorm Hailstorm/ Tornado Easterly Wave Heat wave
Winter (Jan-Feb)	Western Disturbance Fog, Cold Wave

Medium Range Prediction during Monsoon-2004

Date of Issue of Forecast	Forecast for Next week	Verification based on IMD's reports
28 June	Monsoon is expected to revive during 30 June-2 July,04. Rainfall activity may increase over Peninsular India. NE States/ Himalayan Foot Hills to witness decrease in rainfall. No further advancement of Monsoon till 3 July,2004.	There had been revival of monsoon due to formation of a low pressure area. But no further advancement of monsoon took place.
05 July	Monsoon Low over Chattisgarh is expected to weaken after 48 hours and move northward through UP without moving to NW India. There are indications of monsoon going into weak phase once again after 8 July,2004 with excessive rains predicted over NE States and sub-dued rains in Central India	Monsoon low weaken and did not move to NW India. Monsoon moved into Weak Phase by 7 July.Excessive rains occurred in NE States
12 July	Model predictions suggest possibility of revival of monsoon by 16 July but not of a classical Type.	Monsoon revived around 15 July. But revival remained a weak type.
19 July	Monsoon is once again going into a Break Phase and Model predictions do not indicate revival in next 5 days. Rainfall deficiency in distressed zone may grow further during this week.	Monsoon once again went into Weak phase. No revival was observed till 23 July. Deficiency grown substantially in many zones.

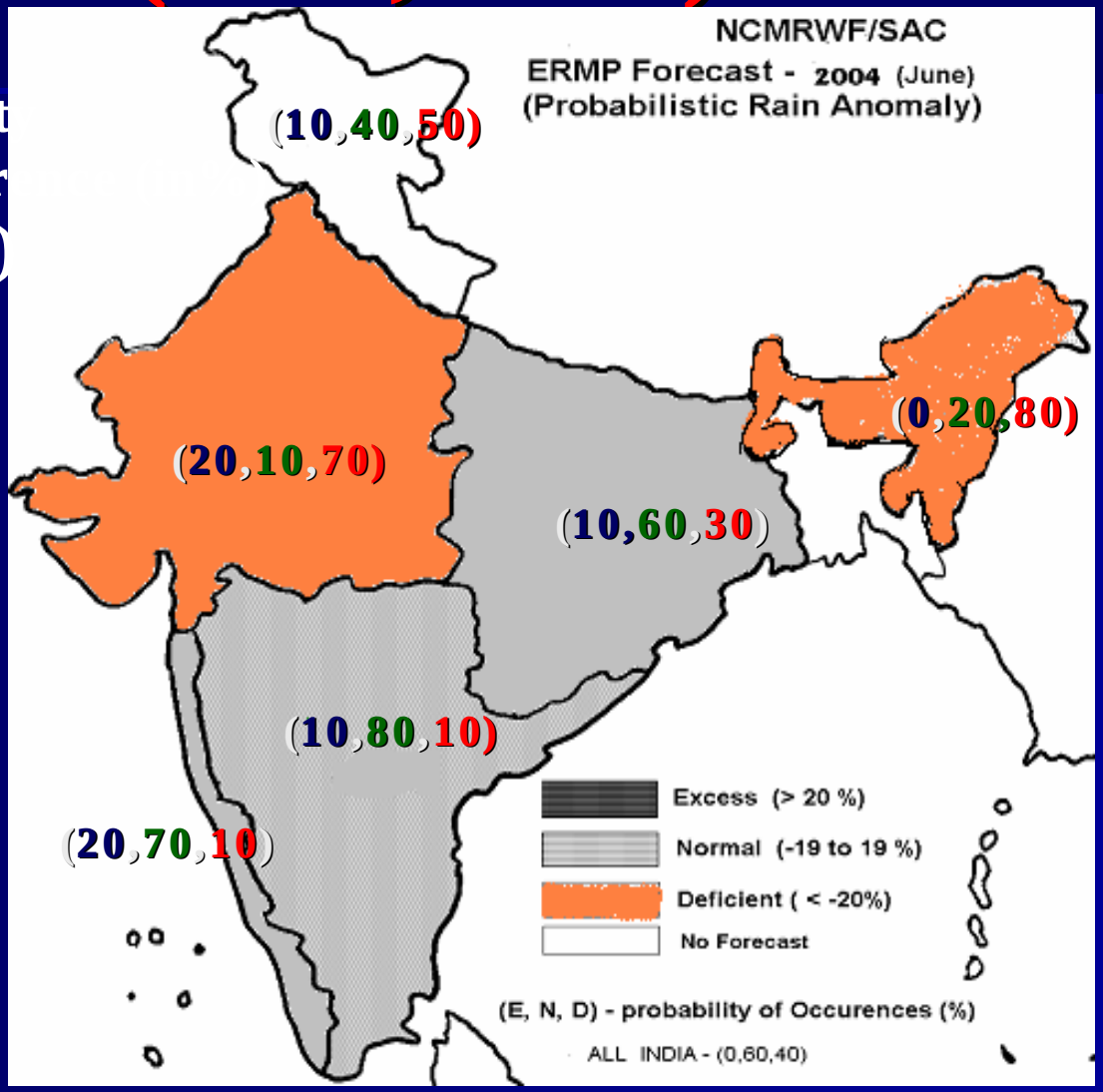
DynamicExtended-Range Prediction System at NCMRWF

Dynamical Forecasts using Global Atmospheric Model at T80L18 Resolution, and predicted and/or persistent Surface Boundary Conditions (SSTs).

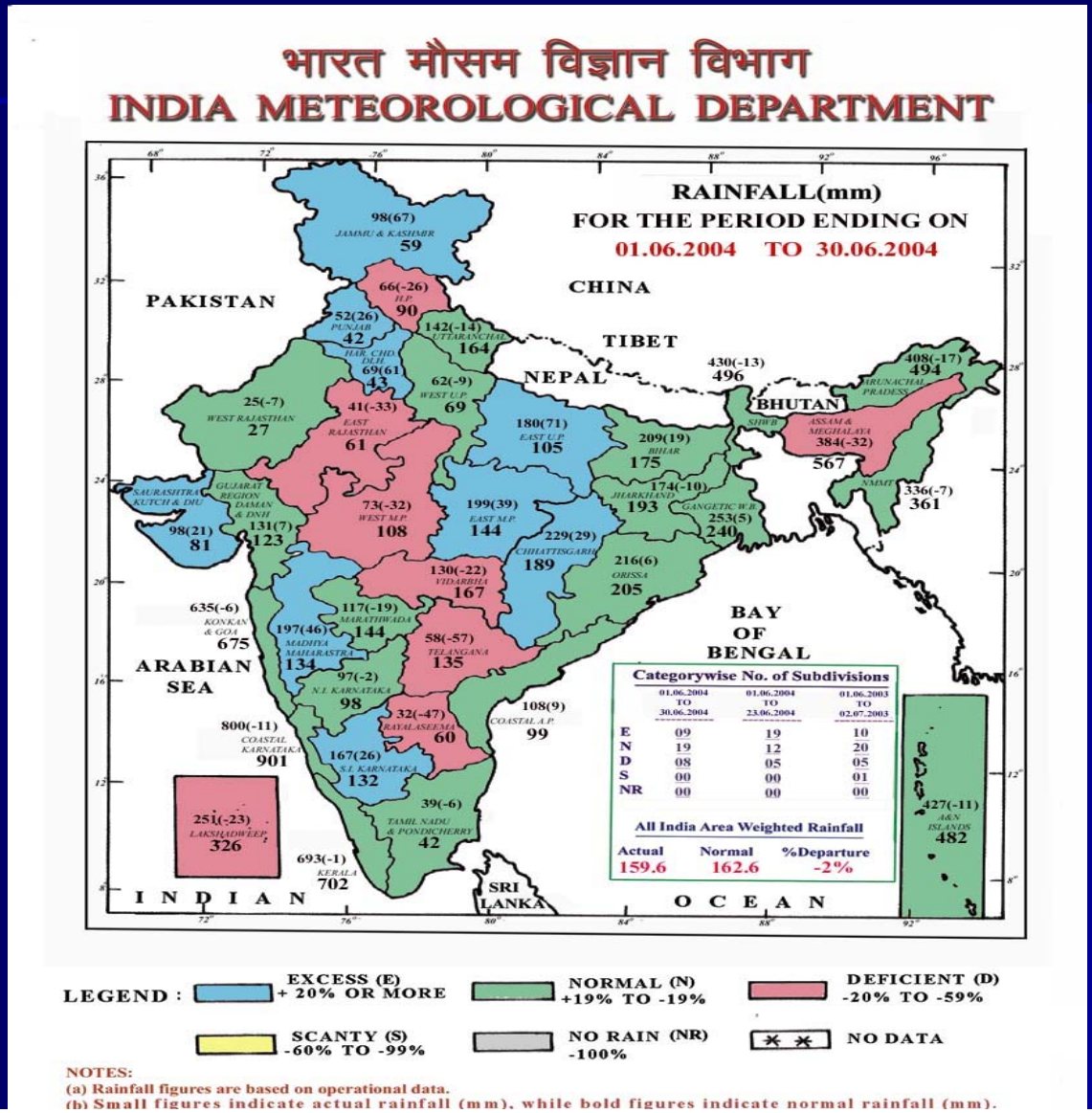
Extended Range Forecast (June,2004)

Probabilit
of Occurr
(E, N,D)

E- Excess
N-Normal
D-Deficient



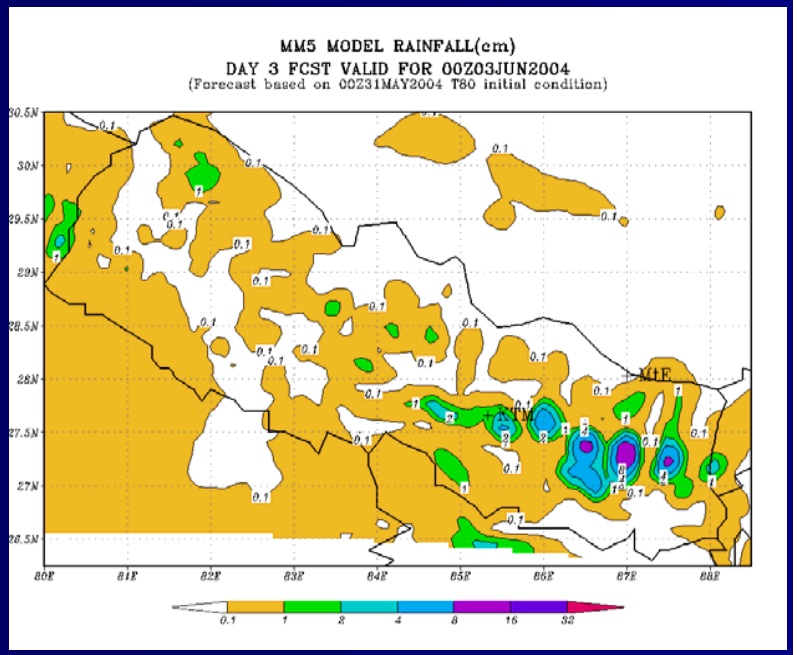
Observed Rainfall distribution June,2004



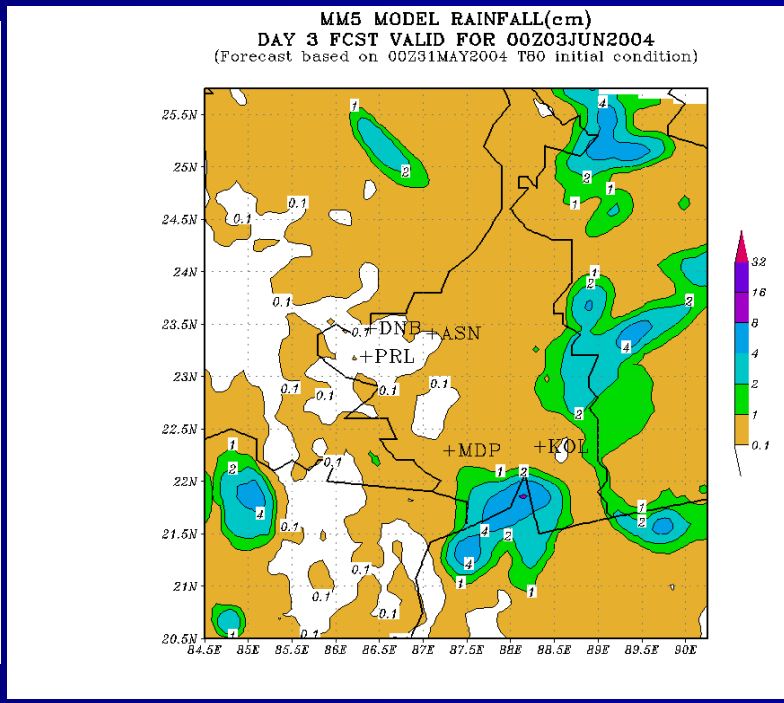
Very High Resolution Forecast

(For prediction of Localized Weather Events)

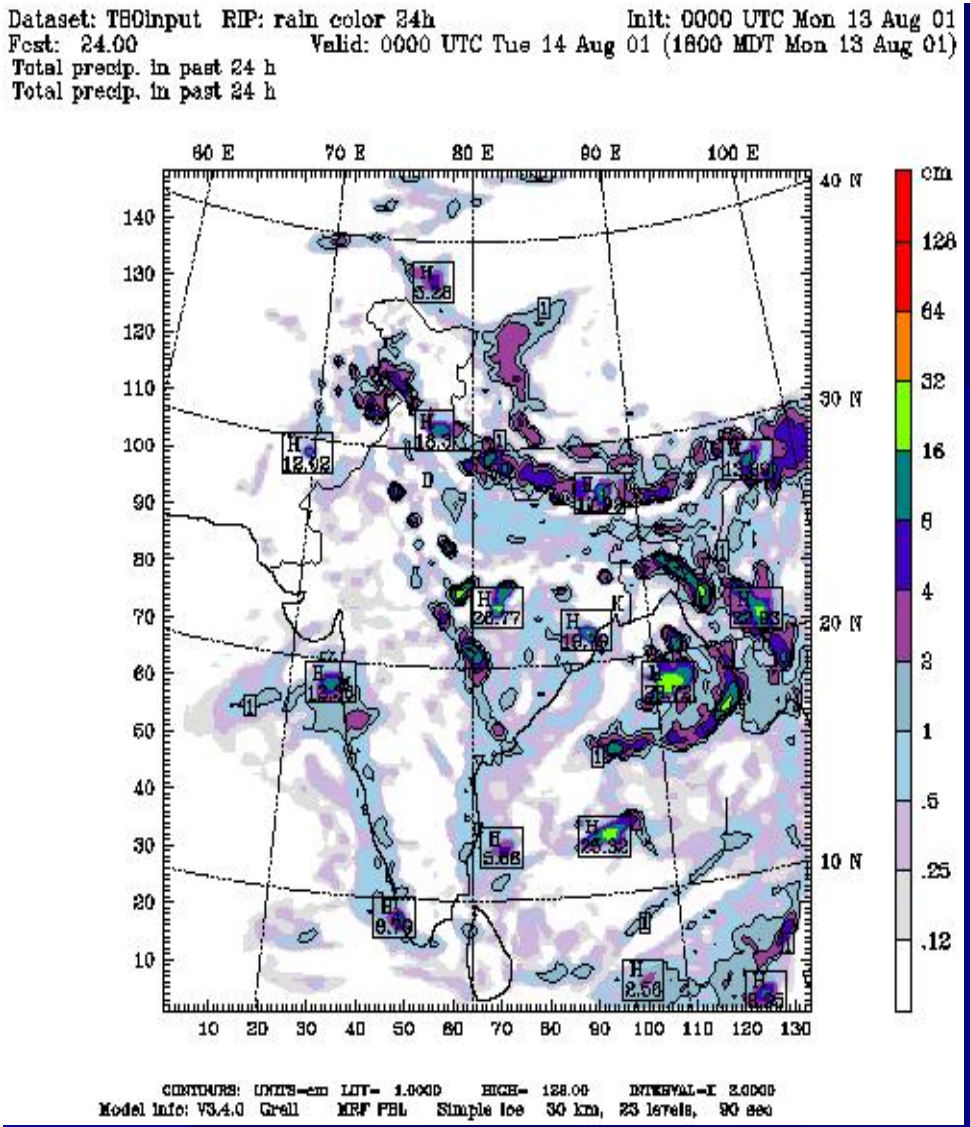
MM5 10 km Rainfall Forecast for Central Himalaya

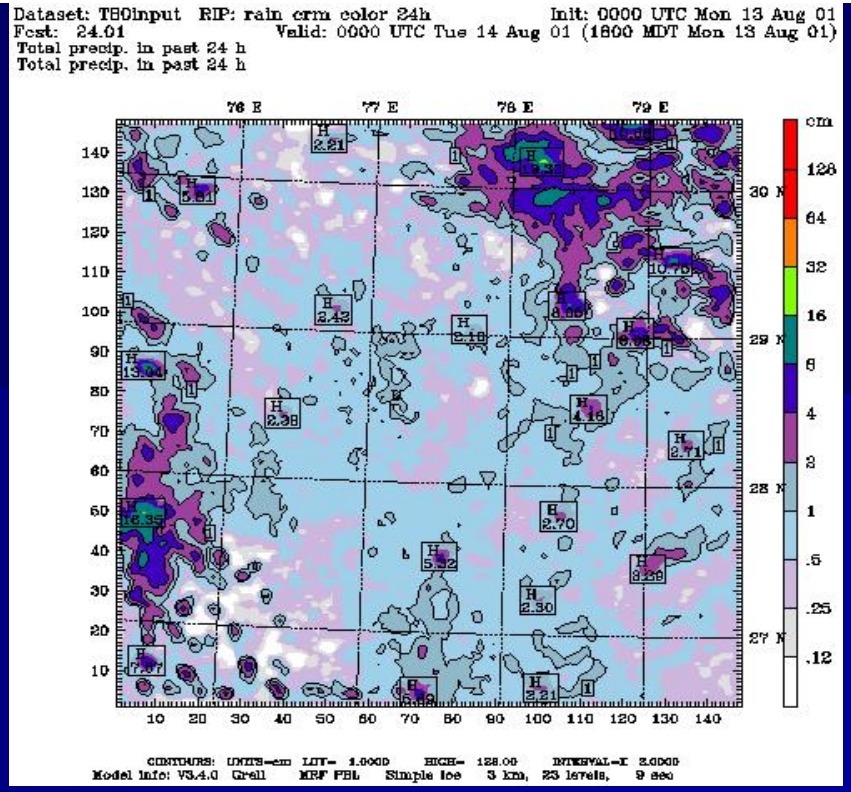


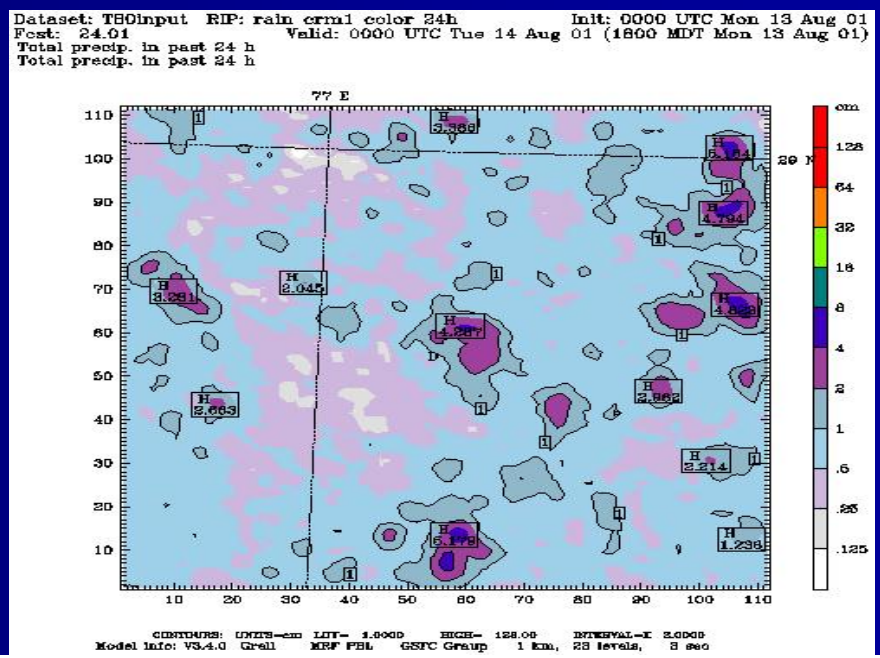
MM5 10 km Rainfall Forecast for West Bengal & Adj. areas



Observed Rainfall (cm) over Delhi
03Z 14 August, 2001







30 km, 3 km, 1km MM5 Rain forecast for 14 Aug 2001

Computing Resources

- Dec-Alpha Cluster (Anupam Alpha)
- Origin Cluster
- Cray SV1
- Param

ANUPAM-ALPHA System

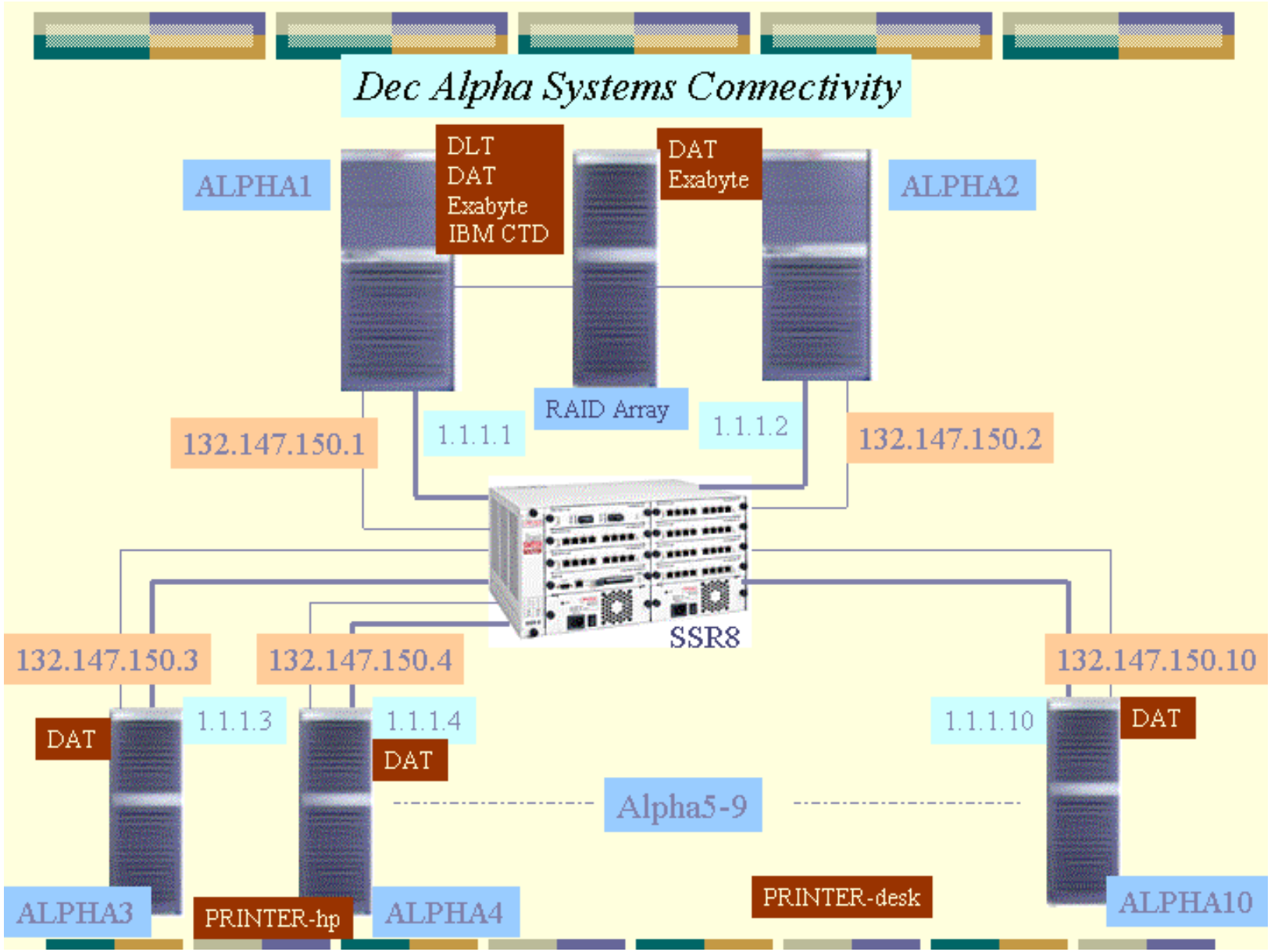
Indigenously developed Parallel Processing Computer.

2 Nos. DEC-ALPHA Servers AS4100 @600MHz each with Memory of 1GB each & 8MB Cache.

9 Nos. DEC-ALPHA Work Stations @600MHz each with Memory of 512MB each & 4MB Cache

Inter-Node communication: Gigabit Ethernet Smart Switch Router.

Anupam-Alpha system



Cray SV1

24-Processors
1.2 GFlops per processor
8 GB Main Memory
800GB Disk.

Softwares available on Cray

- CF90 Programming
- Environment for unlimited users.
- C++
- DMF
- IMSL LIBRARY(fortran 77/90 and C)

Origin Cluster Configuration

Origin cluster

2 Servers(4-cpu each) Origin200@255MHz , Memory 1 GB each

3 Servers (1cpu) Origin200@270MHz, Memory 512 MB each

1 Server (1cpu) Origin200@180MHz, Memory 512 MB each

4 Workstations O2@200MHz, Memory 512 MB each

IBM 3490

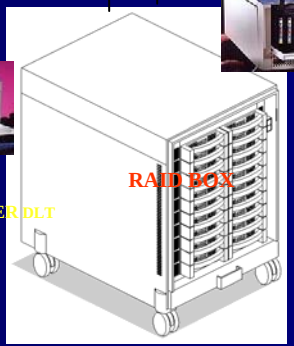
ADMINISTRATION WORK STATION

AUTOLOADER DLT

craysgi1_fddi
1 CPU ORIGIN 200

CRAYSGI1
1 CPU ORIGIN 200

AUTOLOADER DLT



RAID BOX

AUTOLOADER DLT

craysgi2_fddi
1 CPU ORIGIN 200

CRAYSGI\2
1 CPU ORIGIN 200

craysgi3_fddi
1 CPU ORIGIN 200

CRAYSGI13
1 CPU ORIGIN 200

9TRACK SPOOLER
TAPE DRIVE

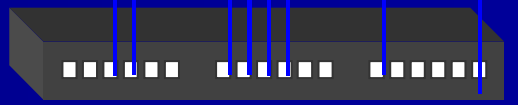
LINK TO LAN

O200-2
4 CPU ORIGIN 200

ORIGIN VAULT

O200-3
4 CPU ORIGIN 200

O200-1
1 CPU ORIGIN 200



PARAM SYSTEM

Model is PARAM 10000

2 Sun Ultra Sparc-II Servers
(4-CPU each)
@300 MHz
Memory 1 GB each
MYRINET switch

Network Servers

Modem

2 mbps Leased Line

V.35

WWW

PDNS

FTP

Mail

SDNS

SERVER-DELL POWER EDGE 1300

Archival Details/DAY

T80	643.6 MB
T170	936.8 MB
MM5	233 MB
ETA	70.1 MB
MISC	500MB

MEDIA DETAILS

- DAT,DLT,CDROM,EXABYTE drives are available in the center.
- Data is archived in various Media.
- For operational purpose usually DLT media is used.
- When a specific data set is prepared for an outside agency, data is sent in DAT / DLT/ CDROM.
- Data is also sent using the FTP public outgoing area, were it can be accessed by the outside agency.

Types of data distributed

- Boundary and initial condition fields to partners for running regional/meso-scale models
- Post processed model output
- Observation ,Analysis and Forecast

Data Visualisation Tools

- MAGICS
- GrADS
- GMT
- GIS
- NCAR Graphics
- Other Public Domain Software

ARMEX ATMOSPHERIC DATA CENTRE
NCMRWF - IITD - IMD

Objectives of Data Centre

- Processing, quality control and archiving conventional and non-conventional data of atmospheric and oceanographic observations collected during ARMEX period

- Storing gridded analysis prepared by Operational Analysis Forecasting system of NCMRWF, gridded satellite data (viz INSAT, METEOSAT, SSMI, TRMM) during ARMEX period

- Assimilation of ARMEX observations using NCMRWF

Operational MRF is more challenging in India

- Major part of the country falls in tropics. Systematic errors overwhelm signal very fast.
- There are concerns regarding quantity and quality of data available for defining initial conditions
- Severely limited computing resources

Future Road Map of Modeling Activity at NCMRWF

Model Resolution
T340L60

Ensemble Runs

Meso-Scale
10km over the entire
Indian Region
1 km models for
Clouds

Use of more
Satellite Data
Direct Radiance
Assimilation

Real-time Seasonal
Prediction

Climate Variability
and Change
AMIP-type Runs

Future Plans for R&D

- **ASSIMILATION of all types of Satellite data in the analysis system.**
- **Implementation of 4-D VARIATIONAL ASSIMILATION SYSTEM for improvement of Model Analysis.**
- **Implementation of MULTI-MODEL ENSEMBLE PREDICTION SYSTEM**
- **Implementation of ADVANCED MESO-SCALE FORECASTING SYSTEM (WRF,MM5,ETA,etc)**
- **OCEAN-ATMOSPHERE COUPLED MODEL for monthly/seasonal prediction.**
- **AEROSOL TRANSPORT, DIFFUSION MODELLING and ENVIRONMENT EMERGENCY RESPONSE.**
- **Regional Scale CLIMATE CHANGE MODELS Scenario/Impact Studies.**
- **CROP WEATHER & PEST/LOCUST MODELLING.**
- **SPONSORING RESEARCH/ Training/ Education At Universities/ Institutions**

Infrastructure upgradation Plans

(a) Procurement of Param Padma
(b) Upgradation of Cray SV1
(c) Upgradation of Anupam
(d) Web-based Data Service
(e) Upgradation ILL capacity

PARAM Padma

- Indigenously developed Cluster computing solution for HPC Applications
- Recognized as a Top500 HPC system world wide in June 2003
- Based on Cluster computing principles
- Built from Integration of Common Off the Shelf (COTS) Components
- Delivers Supercomputing performance by interconnecting with PARAMNet
- PARAMNet is the low latency and high bandwidth SAN network developed by C-DAC
- Delivers 2.5 Gbits/sec Full Duplex bandwidth with < 10 microseconds latency.

PARAM Padma

- Supports applications based on professional Unix and Linux
- At present it is certified for AIX and Linux and will be done on Solaris very soon
- By supporting above Operating Systems, PARAM technology becomes more or less Vendor independent
- Supports Parallel Development tools and Parallel File System (PFS)
- Proven Platform running applications for Scientific Modeling

Proposed PARAM Padma Configuration to NCMRWF

- Proposed 16 Node, 4 CPU / Node based PARAM Padma running on AIX Operating System
- Based on the high performance Power 5 Processor technology of IBM
- Dual PARAMNet interconnectivity for Fail over
- Parallel software development environment
- Fiber channel based network centric architecture with 5 TB Storage with Parallel File System(PFS) support and 10 TB High Speed Tape Backup
- Provides balanced performance and I/O for high data intensive applications.
- Applications like T80, T170, T126 and MM5 Weather codes are running successfully

PARAM Padma Compute Cluster Layout

PARAM Padma HPC Cluster based on 4 way Power 5 Systems

Compute Nodes connected through PARAM Padma System Area Network and Gigabit Ethernet

Graphics Workstations

Specifications

- Compute Nodes:
- Configuration :16 Nos. of 4 Way SMP
- No. of Processors :64 (Power 5 processors with min. 1.6 GHZ speed)
- Aggregate Memory :128 GB
- Internal Storage :1.1 Terabyte
- Operating System :AIX 5L
- Aggregate Peak Computing :~ 300 GFLOPS

Specifications

- Networks:
  - Primary : PARAMNet-II @ 2.5 Gbps Full Duplex
  - Backup : Gigabit Ethernet @ 1 Gbps Full Duplex
- External Storage:
  - Storage Array : 5 TeraBytes
  - Tape Library : 10 TeraBytes

- System Software:
- C-DAC's HPCC Suite of System Software including:
  - KSHIPRA
  - C-MPI
  - C-PFS
  - F90 IDE
  - PARMON
  - PCF 90
  - DIVIA
  - RMS
  - METRIC Advisor

Key Features – PARAMNet -II

- Ultra low latency and high bandwidth
- Non-blocking configuration allows multilevel switches to connect upto 1024 compute hosts
- VIA Standard Compatible
- Diverse platform Support AIX/Solaris/Linux/Windows
- Mechanically compact (1U Height, 19” Rack Mountable)
- Highly Scalable
- State-of-the-art Technology

Installation Plan

Phase-1: Planning & Preparation	➢ Application requirement collection, analysis ➢ Configuration details and site detail collection and analysis. ➢ Site readiness and sign-off ➢ Solution definition including disk space allocation layouts and pin-out diagrams ➢ Detailed solution sign-off	This activity happens in parallel to Hardware order and delivery. It will complete before hardware is delivered at the site.
Phase – 2 Hardware Installation and configuration	➢ Checking of products delivered for completeness ➢ Preparation and power-on testing of products delivered ➢ Basic installation and configuration of ➢HPC Server ➢Storage Array ➢Tape library ➢Workstation Installation(if any) ➢ SAN fabric ➢ Software installations	This is the first activity after hardware is delivered. Makes use of solution definition documents prepared during the planning phase.

Installation Plan

Phase-3 Storage consolidation and integration	➢ **HPC Server Configuration** ➢ **Configuration of storage box based on disk layout details** ➢ **Allocations and access of disk space** ➢ **Usage of applications from new storage box**	Integration of HPC Server with Storage Array and Tape Library in the SAN Environment.
Phase-4 Backup integration	➢ **Configuration of tape library, testing of tape library and necessary software** ➢ **Define and test backup policy**	Integration of SAN storage and File servers will be done in parallel.
Phase-5 Management software integration and tuning	➢ **Integrate management software and tune for error trapping and activation of corrective measures**	This activity occurs in parallel to Phase-4.
Phase-6 Acceptance Testing	➢ **Demonstration of implementation meeting acceptance parameters / tests** ➢ **Demonstration to be done by C-DAC, verification to be done by NCMRWF**	At the end of phase-5, system is ready for acceptance testing to be done jointly by C-DAC and NCMRWF.

CRAY X1

A 800 MHz clock

Peak Cache Bandwidth of 76.8 Gbps/CPU

16 processor (4 nodes)

Memory of 128 GB

Raid of 2 TB

Peak Memory bandwidth of 38.4 Gbps/CPU

Peak performance of 12.8 Gflops per CPU

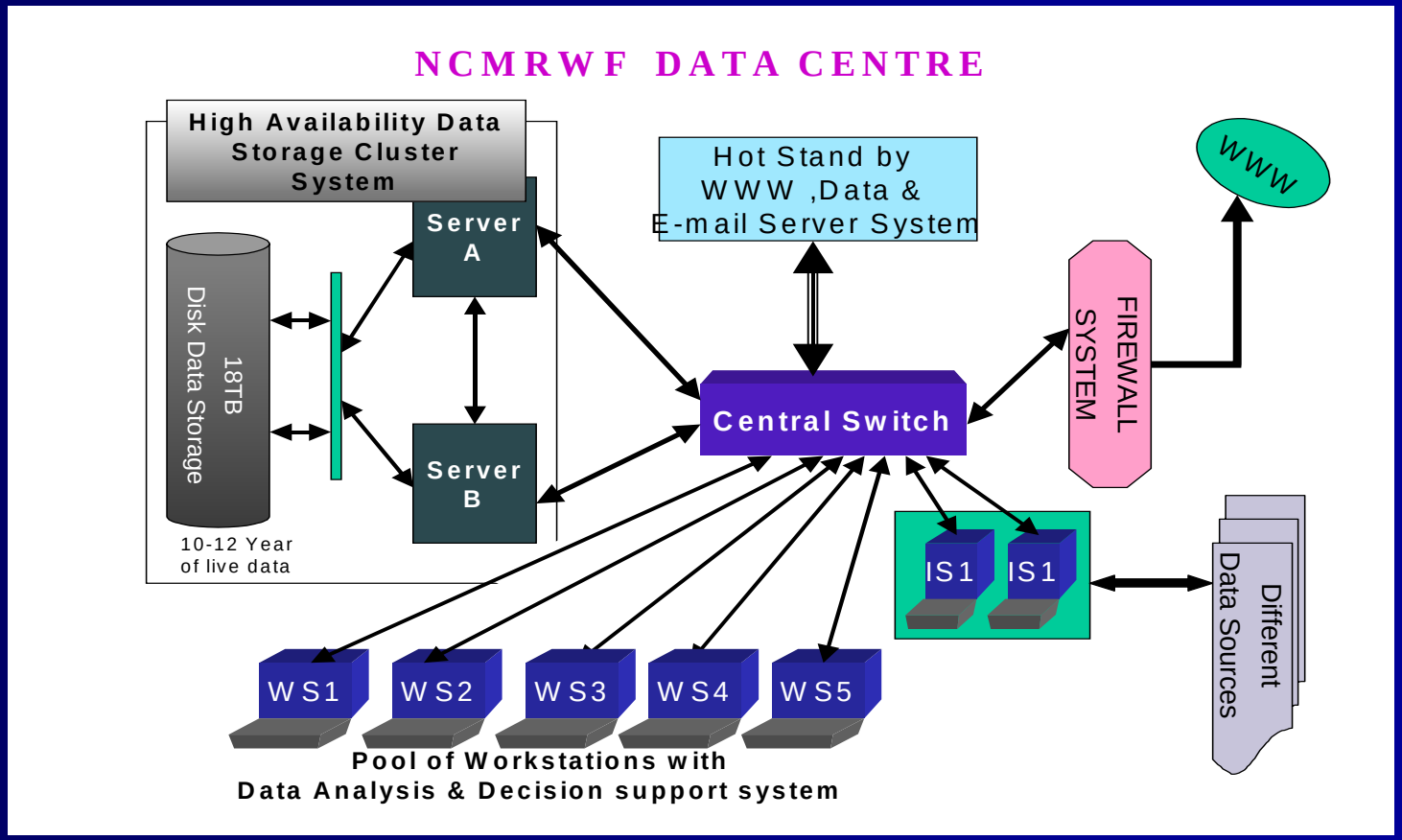
X1 to X1e upgrade by 2006 with 600Gflops peak

ANUPAM-Xeon/128

- Processor Servers :64 Dual Xeon
- Speed :2.4 GHz
- Peak Performance :202 Gflops
- Memory/processor :2GB
- Interconnect Tech. Coherent Interface(SCI) : Scalable
- OS : LINUX

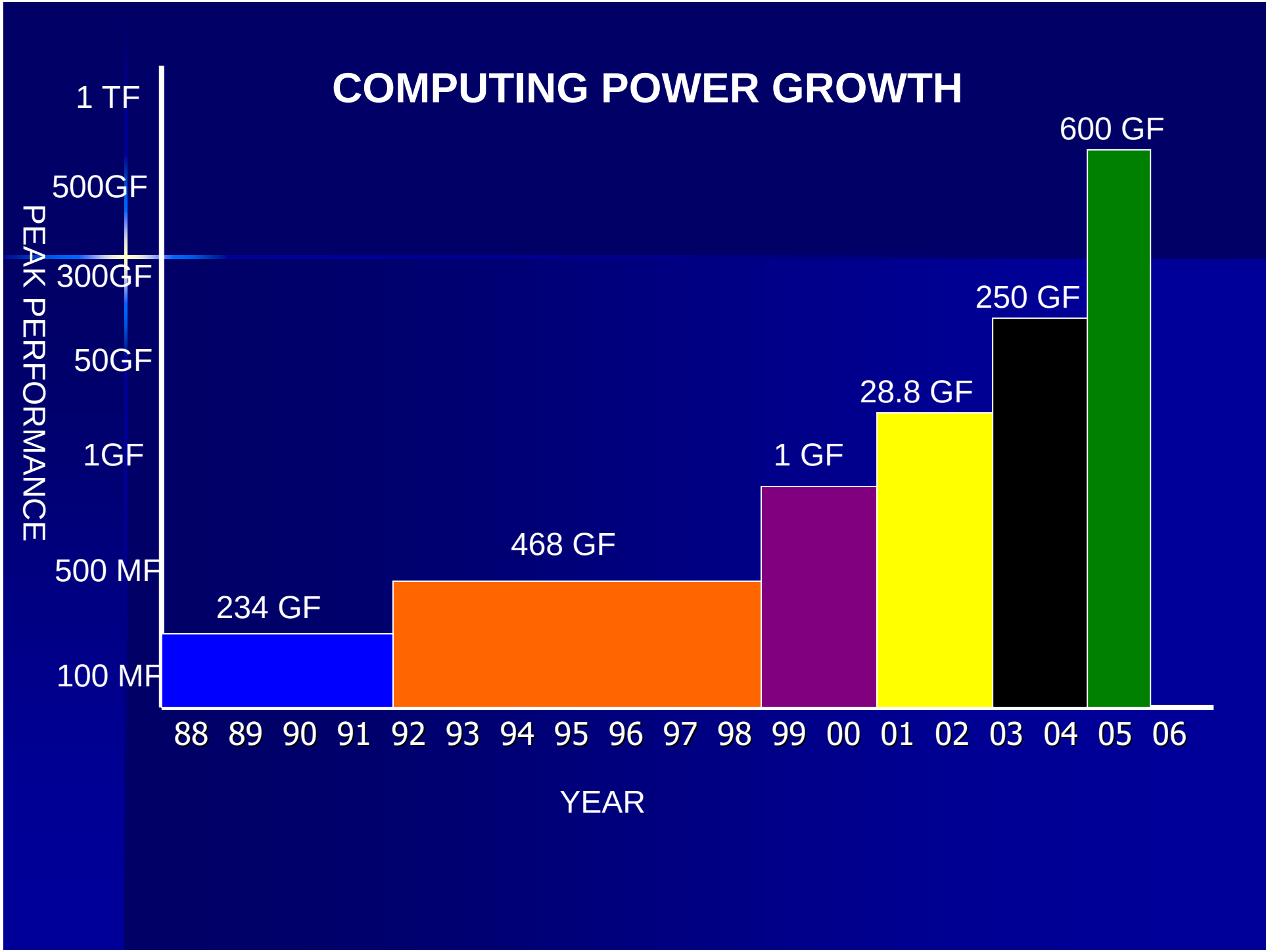
Anupam-Xeon/128

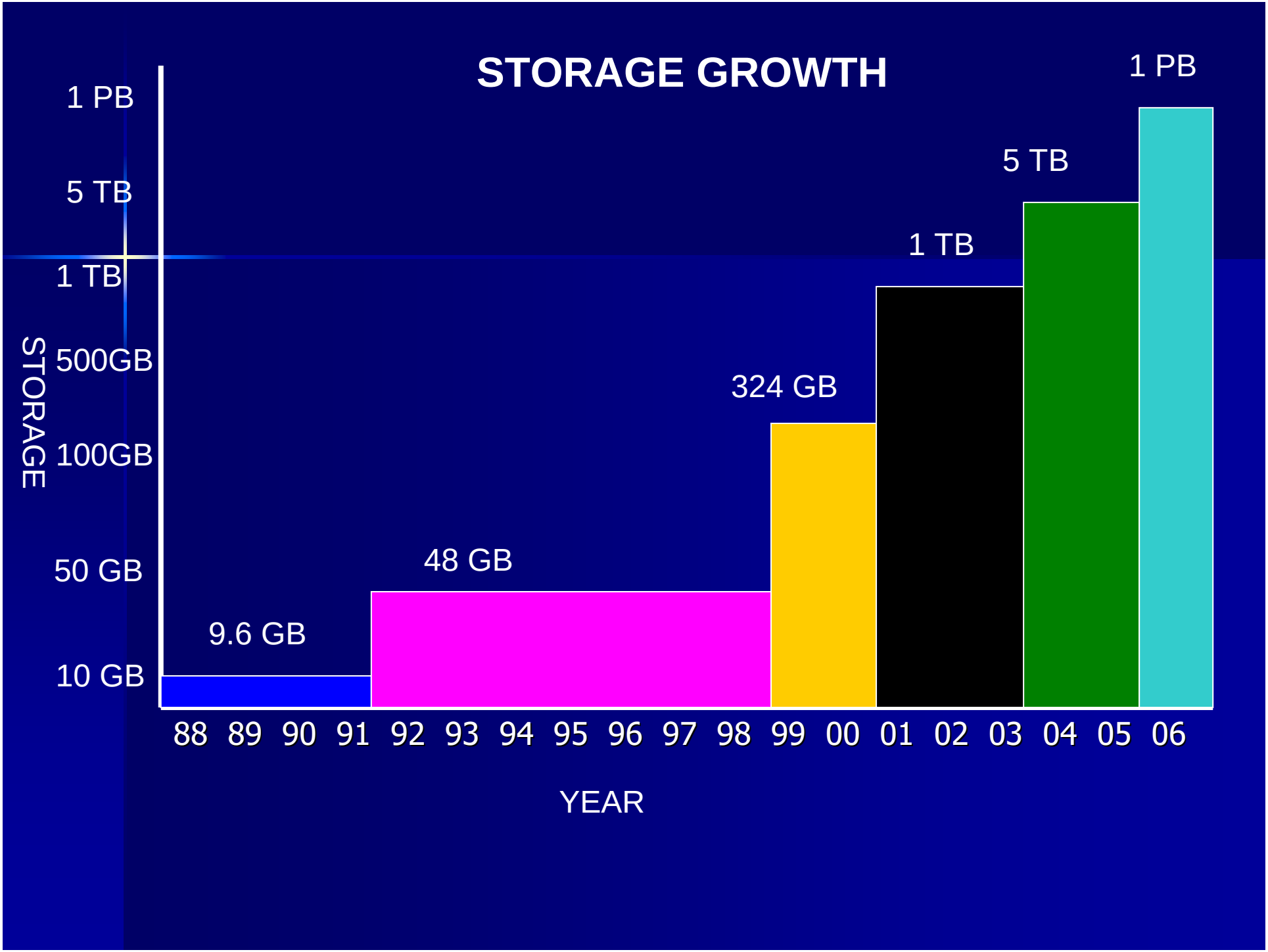
Data Handling System



Data Centre Hardware

- Two RISC based servers in clustered mode (1,00,000 tpm_c expandable to 2,00,000 tpm_c)
- Two RISC based application server(50,000 tpm_c expandable to 1,00,000 tpm_c)
- Two RISC Web (25,000 tpm_c expandable to 50,000 tpm_c)
- Storage array (5TB online and 15TB near on-line)
- Tape Library (32 LTO drives scalable to 80 drives, maximum of 100TB)/ Inexpensive disk
- 2mbps ILL/associated infrastructure


COMPUTING POWER GROWTH
1 TF
500GF
300GF
50GF
1GF
500 MF
100 MF
PEAK PERFORMANCE
234 GF
468 GF
1 GF
28.8 GF
250 GF
600 GF
88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06
YEAR


STORAGE GROWTH
1 PB
5 TB
1 TB
500GB
100GB
50 GB
10 GB
STORAGE
9.6 GB
48 GB
324 GB
1 TB
5 TB
1 PB
88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06
YEAR

Near Future Plans...

Param Padma	16 Nos of 4 way 64 p5 processor 128 GB Aggregate memory 1.1 TB Internal Storage 5 TB Storage Array 10 TB Tape Library
Cray X1	16 processor @ 800 MHz 64 GB Memory 38.4 GB/s Memory Bandwidth
Web-based Data Service	
ILL	Increase the Leased Line capacity to 32 Mbps

Thank You

NCMRWF NEW CAMPUS AT NOIDA