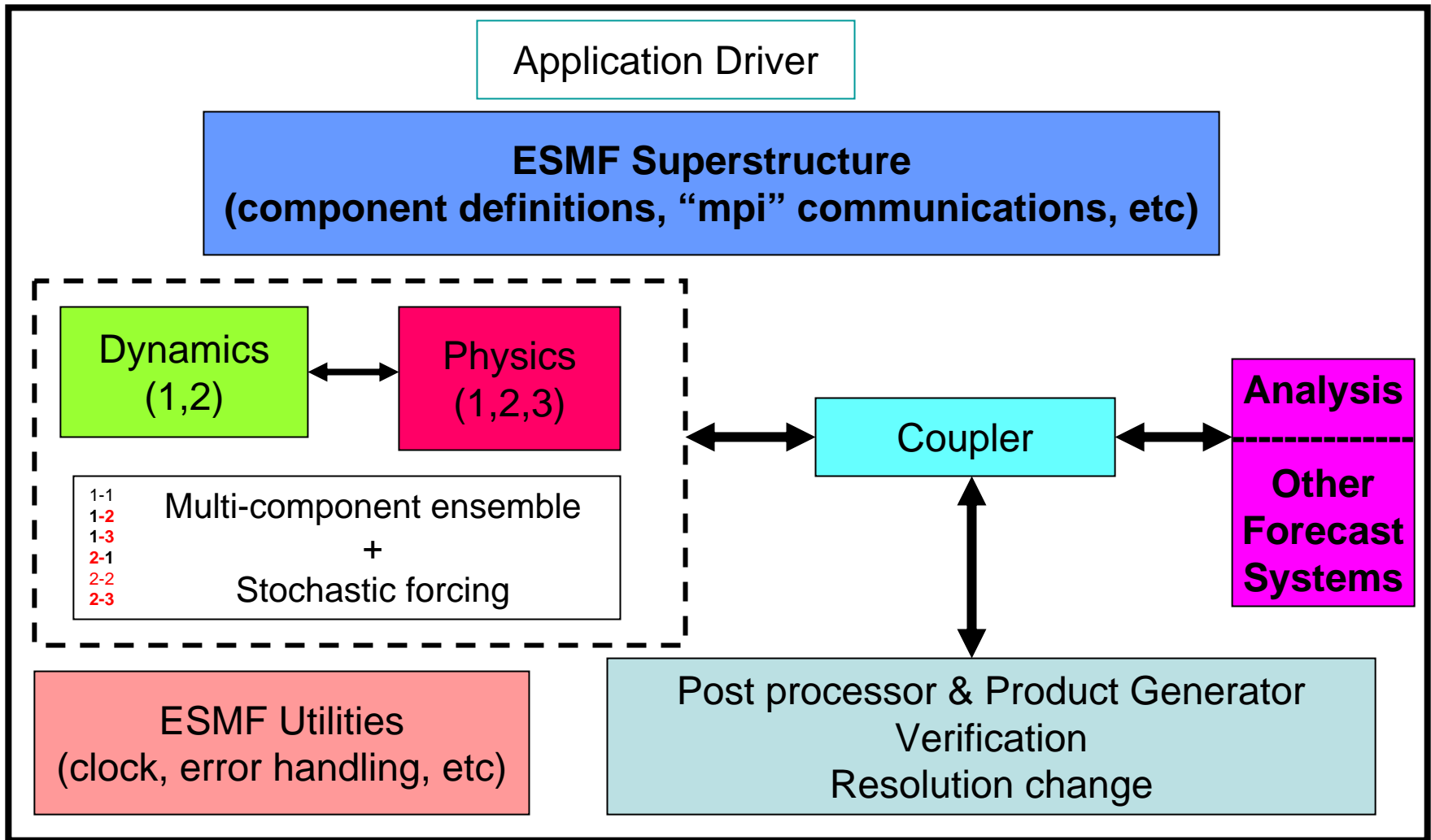# Progress on Future NCEP Production Suite

EMC Senior Staff

Overview

- **National Environmental Modeling System (NEMS)**
- **Evolution of the NCEP Production Suite**
- **Visit to the UK Met Office**

National Environmental Modeling System (NEMS)
(uses standard ESMF* compliant software)

Application Driver

**ESMF Superstructure
(component definitions, "mpi" communications, etc)**

Dynamics
(1,2)

Physics
(1,2,3)

1-1
1-2
1-3
2-1
2-2
2-3
Multi-component ensemble
+
Stochastic forcing

Coupler

Analysis

**Other
Forecast
Systems**

**ESMF Utilities
(clock, error handling, etc)**

Post processor & Product Generator
Verification
Resolution change

* Earth System Modeling Framework (NCAR/CISL, NASA/GMAO, Navy (NRL), NCEP/EMC), NOAA/GFDL

2, 3 etc: NCEP supported thru NUOPC, NASA, NCAR or NOAA institutional commitments

Components are: Dynamics (spectral, FV, NMM, FIM, ARW, FISL, COAMPS…)/Physics (GFS, NRL, NCAR, GMAO, ESRL…)

Planned NEMS Capabilities

- Components and capabilities of the NEMS infrastructure
  - Configuration control
    - Domain
    - Resolution (horizontal, vertical)
    - Standardized fixed field generation (WPS - topography, land use, etc)
    - Tracer definition
  - Observations ingest, formatting, QC, etc libraries
  - Nesting (static and moving, telescoping, 1-way, 2-way)
  - Concurrent ensemble execution (single executable, multiple members)
  - Data assimilation (3D-var and advanced techniques)
  - In-core updating for analysis increments and boundary conditions
  - Model dynamics and physics including
    - Atmosphere
    - Ocean
    - Land surface and hydrology
    - Air Quality and trace gases
  - Post-processor and product generator
  - Standard operational verification
  - Documentation for operational and research users

Planned NEMS Capabilities (cont)

- Modeling Research
  - Global and regional
  - Institutionally supported components
    - Atmosphere
      - **GFS (NCEP)**
      - **NOGAPS (Navy)**
      - **FV (NASA, GFDL)**
      - **NMM (NCEP)**
      - **ARW (ESRL, NCAR, AFWA)**
      - **COAMPS (Navy)**
      - **FIM (ESRL)**
      - **FISL (NCEP)**
    - Ocean
      - **MOM4 (GFDL)**
      - **HYCOM (NCEP, Navy)**
    - Land surface and hydrology
      - **Noah (NCEP)**
      - **VIC (Princeton, U. Wash)**
      - **MOSAIC (NASA)**
      - **Sacramento (OHD)**
      - **Smirnova LSM (ESRL)**
    - Air Quality and trace gases
      - **CMAQ (EPA, ARL)**
      - **GOCART (NASA)**
      - **NAAPS (Navy)**

> Under construction
> Will include in future

Planned NEMS Capabilities (cont)

- **Operational Models (NCEP only)**
  - Global Forecast System
    - **GFS**
  - Global Ensemble (GENS, NAEFS)
    - **GFS**
  - North American (NAM)
    - **NMM**
  - Short-range Ensemble (SREF)
    - **NMM**
    - **ARW**
    - Physics diversity
  - High Resolution Window (HRW)
    - **NMM**
    - **ARW**
  - Air Quality (AQ)
    - **CMAQ**
  - Land Surface & Hydrology (LIS)
    - **Noah**
  - Rapid Refresh (RR) Ensemble
    - **ARW Dynamics + GSD physics**
    - **NMM dynamics + NCEP physics**
  - Hurricane (HUR)
    - **NMM for hurricanes**
    - **HYCOM + Wavewatch**
  - Seasonal Climate Forecast (CFS)
    - **GFS for climate**
    - **MOM4**

> Will include in Operational NEMS

Community-based Development

- **Strategy and roles:**
  - **Focus on <u>single component</u> instead of entire model system**
  - **<u>Collaborative</u>, not competitive**
  - NCEP/EMC
    - Maintains <u>primary components</u> for each part of Production Suite and <u>for each application</u>
    - Supports ESMF applications in operations
    - In collaboration with community
      - Integrates new ESMF-based components into operations
      - Performs final testing and preparation of upgrades of supported components in operations
  - **<u>Collaborators</u>**
    - Provide
      - Component upgrades to be tested in operational setting
      - Institutional support for their contributed components
      - Diversity and expertise complementary to operations
    - Work through DTC, JCSDA, CTB, etc.
- **Examples of current and potential collaborators**
  - **OAR/GSD**
    - Model enhancements
    - Aviation applications, including products and physics component
  - **NASA-(GMAO, HSB)**
    - Data assimilation (atmosphere, ocean, land)
    - Finite-volume (FV) model
    - Physics (aerosol, land surface)
    - ESMF-based components (e.g. physics)
  - **NRL**
    - Aerosol physics and analysis
    - ESMF-based model structure (atmosphere, ocean)
    - Physics component
    - Operational ensemble generation and processing
  - **NMFS**
    - Fishery ecosystems

  - **NCAR**
    - ARW dynamics
    - Physics components
  - **NWS/OHD**
    - Land & Hydrological models for
      - Streamflow
      - Flash floods
    - Precipitation analysis
  - **NOS**
    - Dynamic storm surge
    - Coastal ecosystems
    - Water quality
  - **Universities**
    - Specific physics upgrades

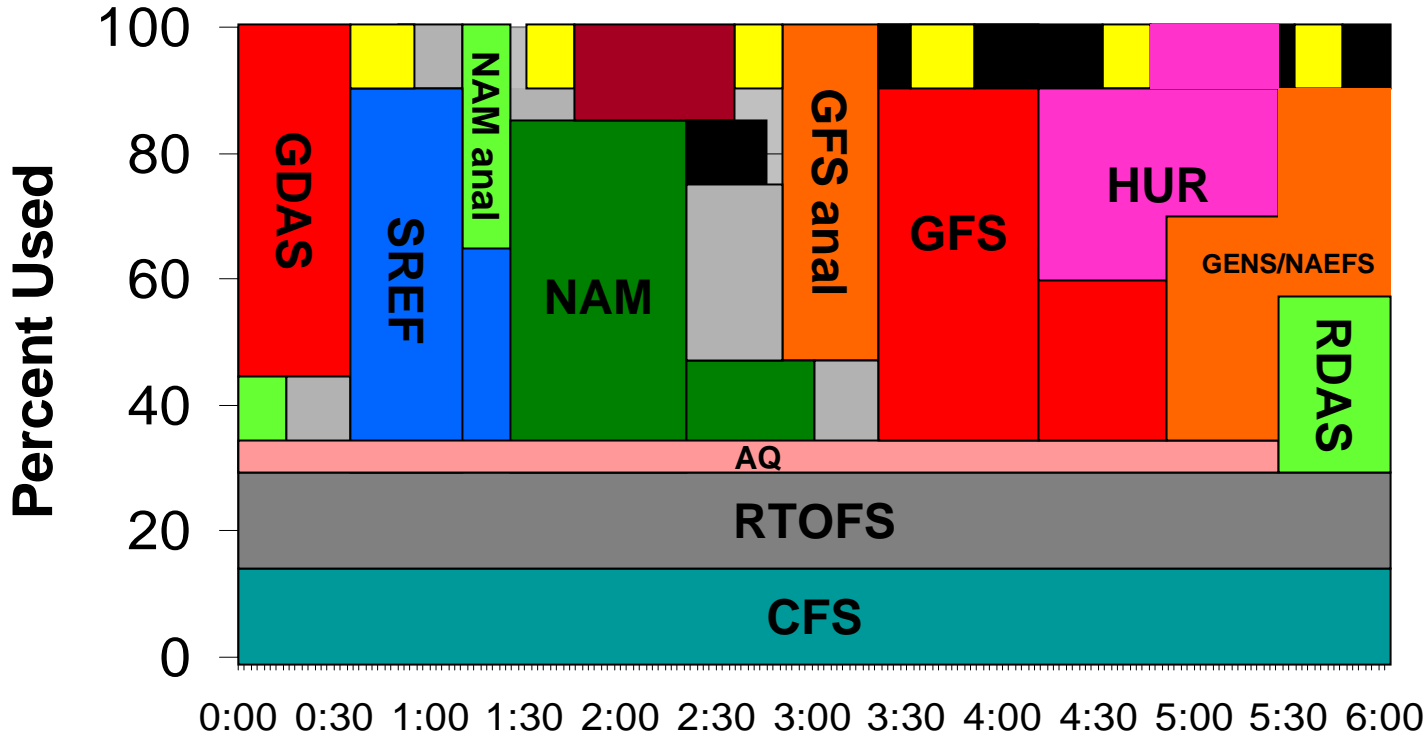# Criteria for Inclusion in NEMS

- Research
  - Adherence to ESMF standards
  - Institutional support for code
  - Participation in system evolution
- Operations
  - Research criteria plus:
  - Standard "Transition to Operations" criteria
    - NCEP: http://www.emc.ncep.noaa.gov/
      - Forecast performance benefits
      - IT compatibility
      - Efficiency
      - Sustainability
    - AMOP (Navy)
    - AFWA IPT process (USAF)

NCEP Production Suite
Weather, Ocean, Land & Climate Forecast Systems

Current - 2007

Data processing
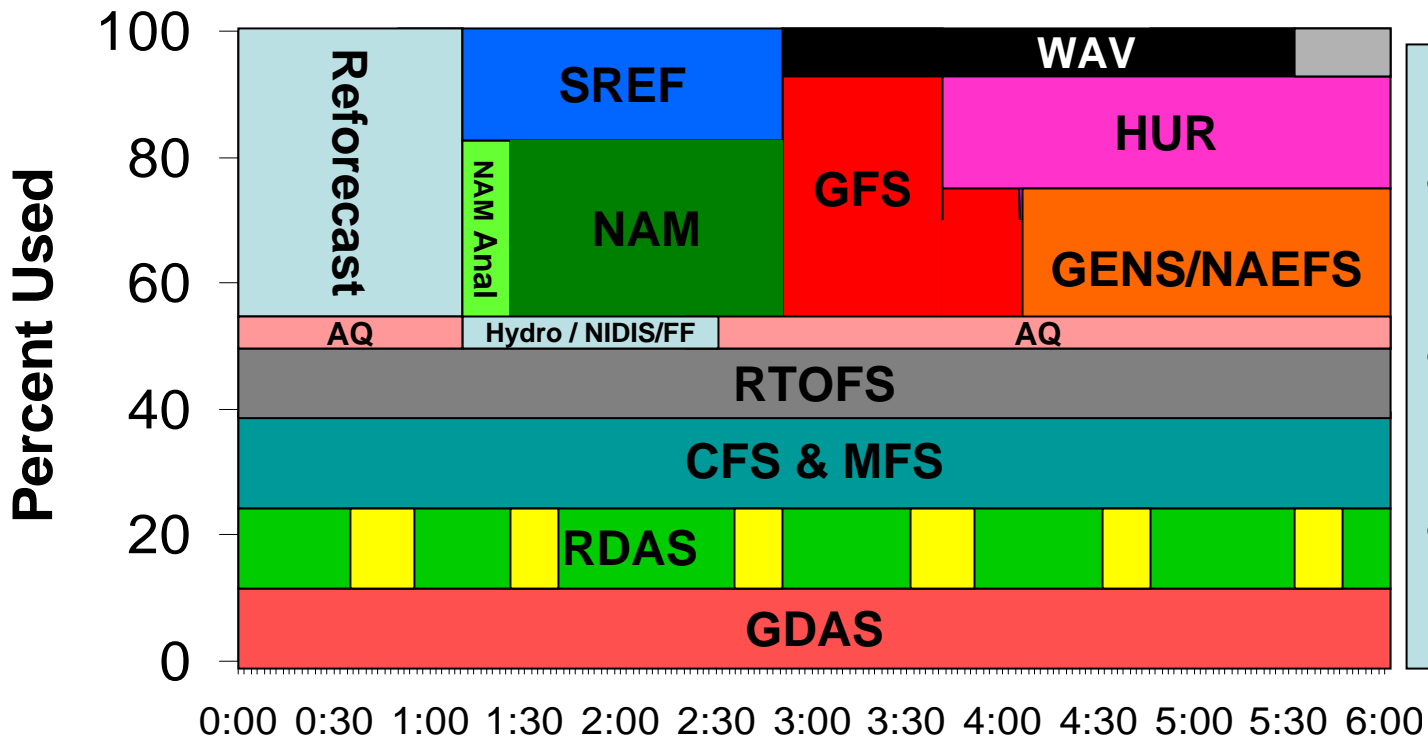
NCEP Production Suite
Weather, Ocean, Land & Climate Forecast Systems

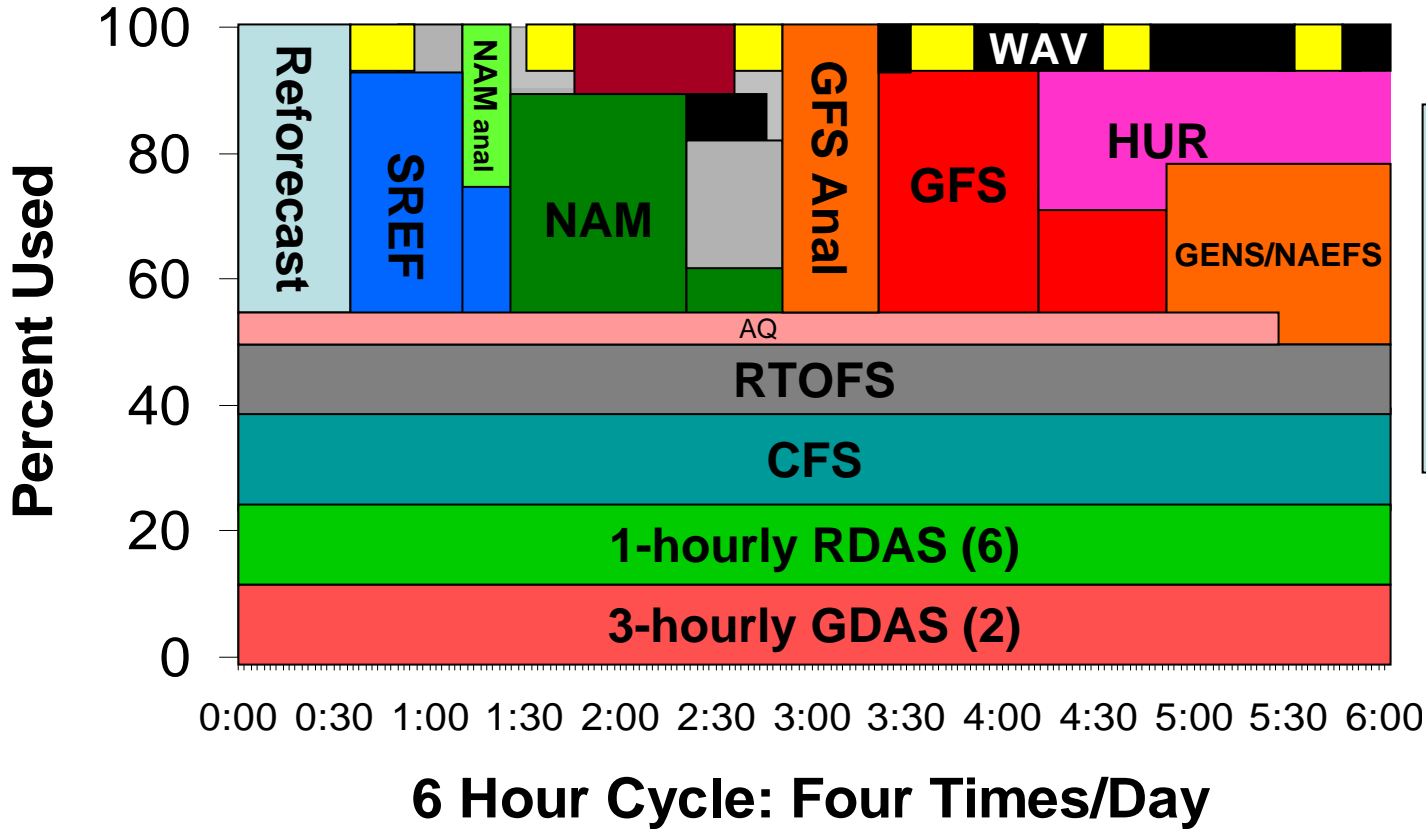**Next Generation Prototype Phase 3**

Computing factor: 27

Reforecast

SREF

NAM Anal

NAM

WAV

GFS

HUR

GENS/NAEFS

AQ

Hydro / NIDIS/FF

AQ

RTOFS

CFS & MFS

RDAS

GDAS

Percent Used

100 · 80 · 60 · 40 · 20 · 0

0:00 0:30 1:00 1:30 2:00 2:30 3:00 3:30 4:00 4:30 5:00 5:30 6:00

6 Hour Cycle: Four Times/Day

Added
• Flash flood products
Moved
• SREF concurrent to NAM
Expanded
• Reforecast capability

NCEP Production Suite
Weather, Ocean, Land & Climate Forecast Systems

Next Generation Prototype Phase 1

Computing factor: 3

Percent Used

100

80

60

40

20

0

Reforecast

SREF

NAM anal

NAM

AQ

GFS Anal

GFS

WAV

HUR

GENS/NAEFS

RTOFS

CFS

1-hourly RDAS (6)

3-hourly GDAS (2)

0:00 0:30 1:00 1:30 2:00 2:30 3:00 3:30 4:00 4:30 5:00 5:30 6:00
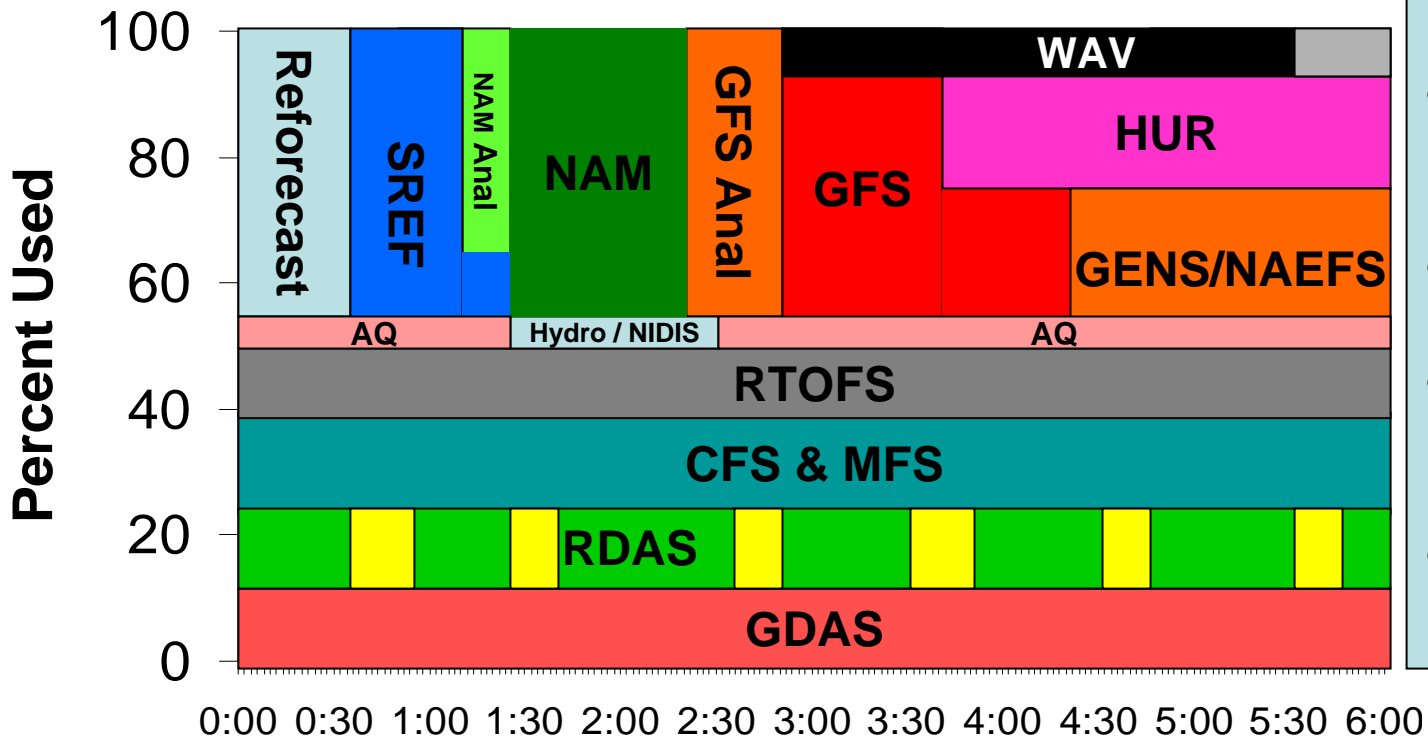
6 Hour Cycle: Four Times/Day

Added
• 1-Hourly RDAS
• 3-Hourly GDAS
• Reanalysis/ Reforecast

NCEP Production Suite
Weather, Ocean, Land & Climate Forecast Systems
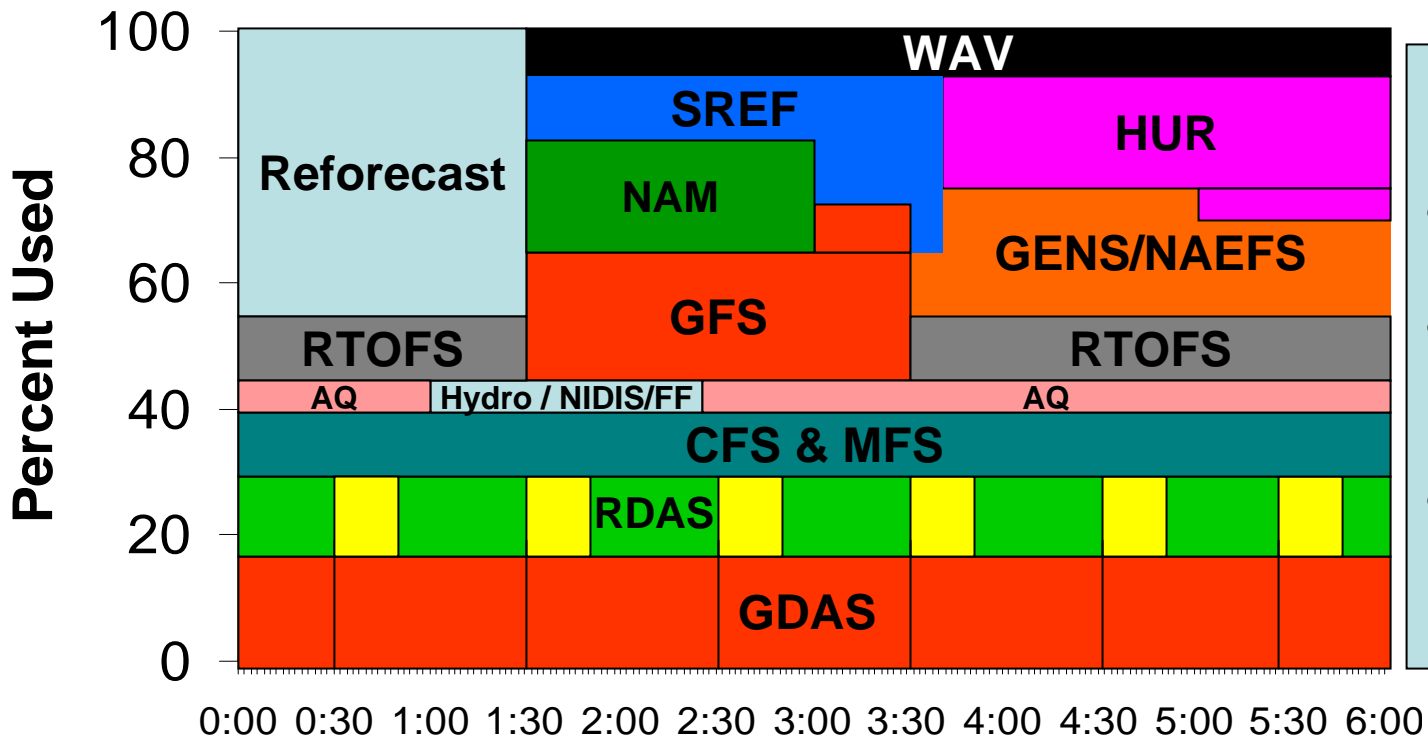
Next Generation Prototype
Phase 4

Computing factor: 81

Added
• Hourly GDAS
Moved
• GFS concurrent to NAM & SREF
Expanded
• Hurricane capability (hires)

Percent Used

WAV
SREF
NAM
HUR
GFS
GENS/NAEFS
RTOFS
RTOFS
Reforecast
AQ
Hydro / NIDIS/FF
AQ
CFS & MFS
RDAS
GDAS

100
80
60
40
20
0

0:00 0:30 1:00 1:30 2:00 2:30 3:00 3:30 4:00 4:30 5:00 5:30 6:00

6 Hour Cycle: Four Times/Day

NCEP Production Suite
Weather, Ocean, Land & Climate Forecast Systems

Next Generation Prototype Final Phase
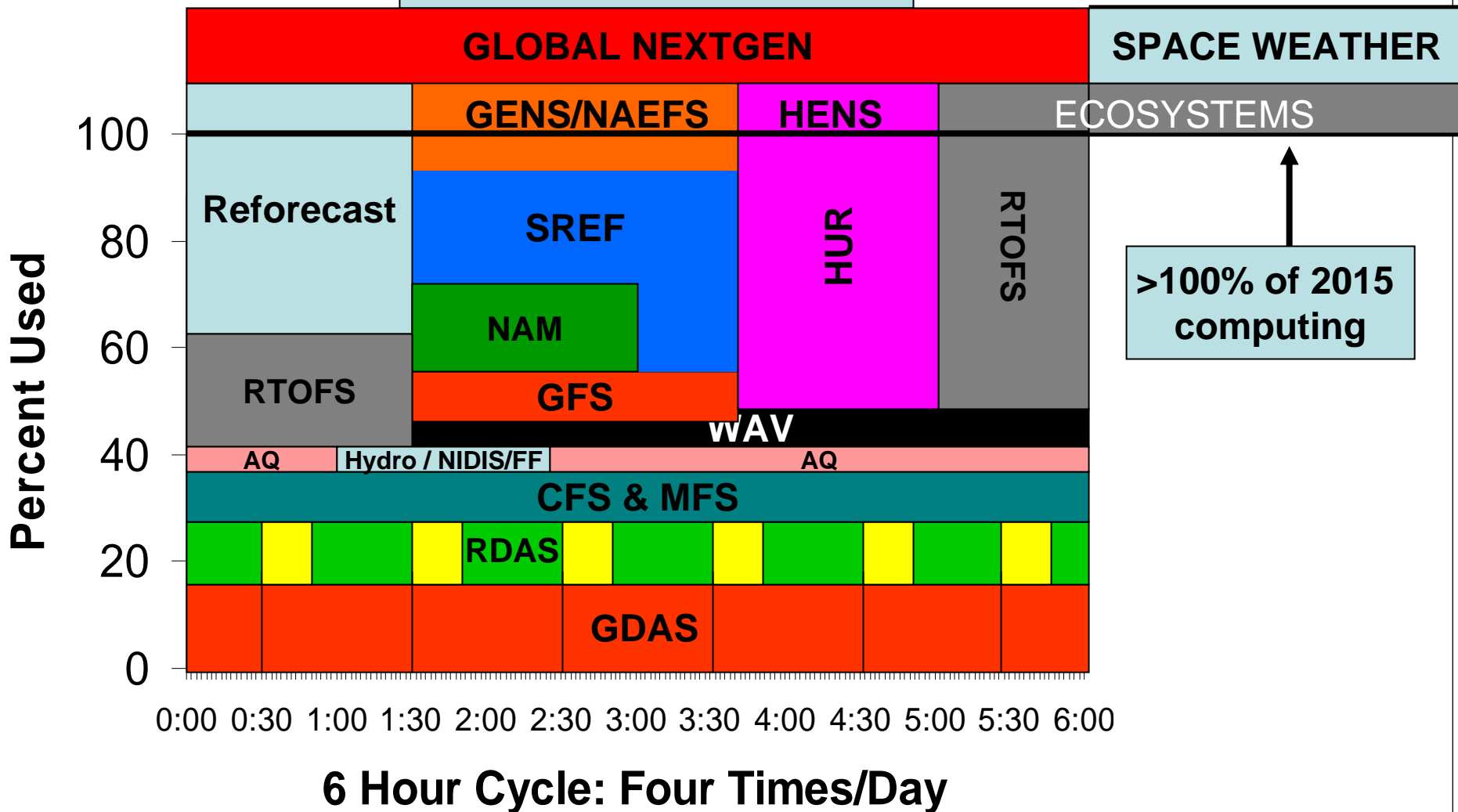
Computing factor: > 240

GLOBAL NEXTGEN

SPACE WEATHER

GENS/NAEFS

HENS

ECOSYSTEMS

Reforecast

SREF

HUR

RTOFS

>100% of 2015 computing

NAM

GFS

RTOFS

wAV

AQ

Hydro / NIDIS/FF

AQ

CFS & MFS

RDAS

GDAS

Percent Used

0 20 40 60 80 100

0:00 0:30 1:00 1:30 2:00 2:30 3:00 3:30 4:00 4:30 5:00 5:30 6:00

6 Hour Cycle: Four Times/Day