Commercial Implementation of WRF with Efficient Computing and Advanced Data Assimilation

Brent Shaw*, Richard Carpenter, Phillip Spencer, and Zach DuFran

Weather Decision Technologies, Inc.

Norman, OK

*bshaw@wdtinc.com

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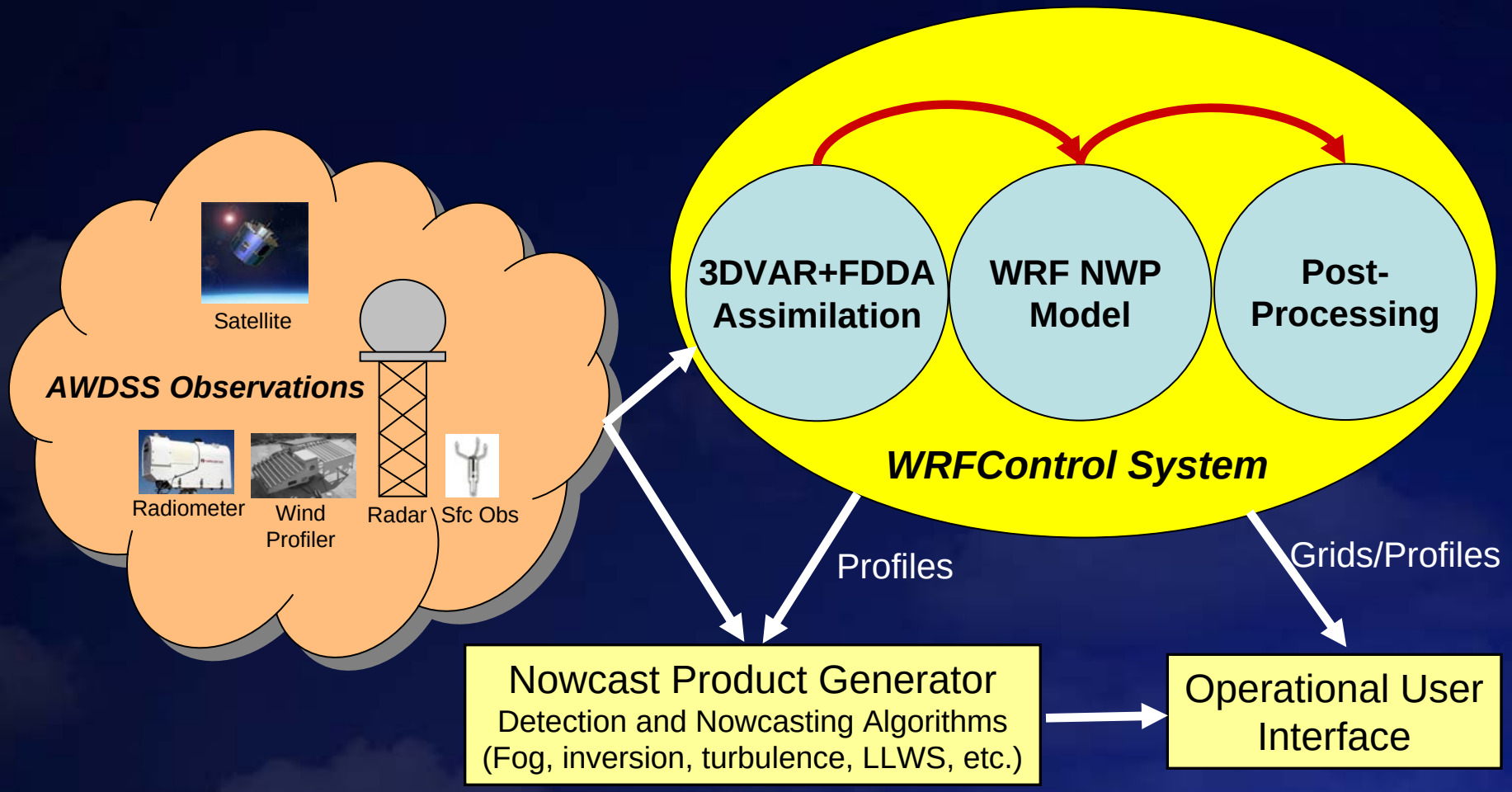
Motivation

- Dubai International Airport Project
  - Incorporate WRF in the Aviation Weather Decision Support System (AWDSS)
  - Need for an *operationally reliable* turn-key system that can run without an on-site NWP expert
  - Incorporation of data assimilation and rapid refresh
- Refresh of WDT's internal infrastructure
  - Replacement of older WRF+ADAS system
  - Hardware nearing end-of-life
- Develop a shared code base for deployable and internal WRF-based systems

System Components

- Public WRF Components
  - WRF Domain Wizard
  - WPS
  - WRF-Var
  - WRF-ARW Version 2.2.1 with FDDA
  - WRF Post Processor (from WRF-NMM Distribution)
- WDT Components
  - WRFControl Package
  - WRF Management Portal
  - Custom Post-Processing and Plotting
- High-Performance Linux Cluster
  - Built and managed with ROCKS, using Sun Grid Engine (SGE) for job control and Ganglia for system monitoring

AWDSS WRF Integration



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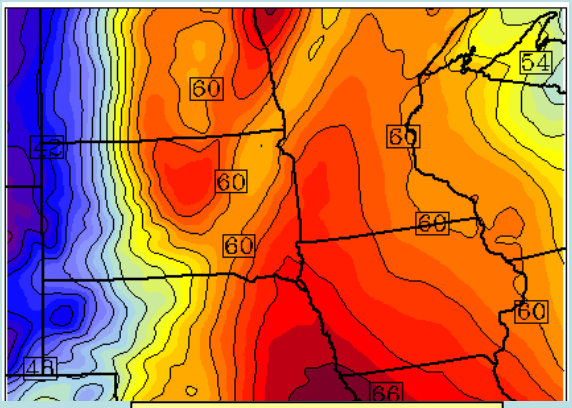
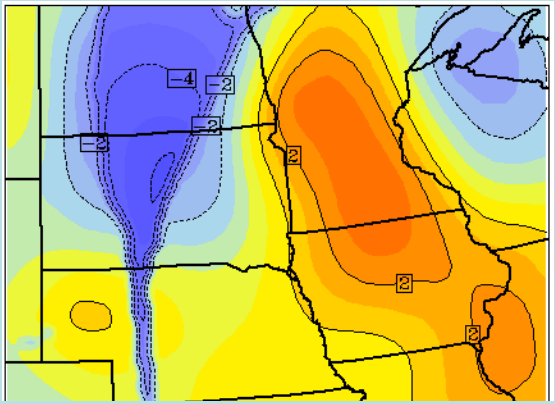
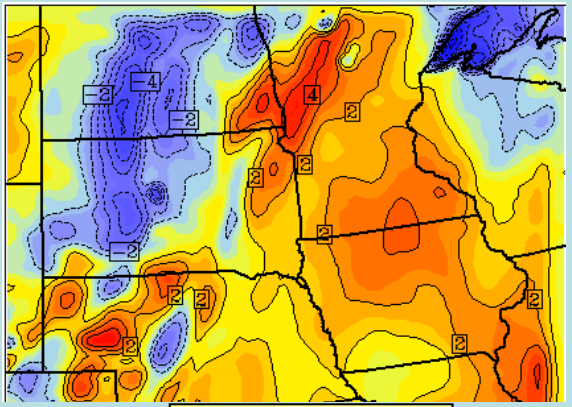
Data Assimilation: 3DVAR+FDDA Initialization



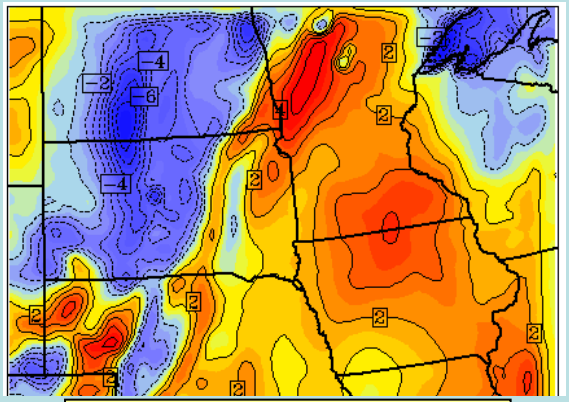
COLD Initialization



3DVAR - COLD



FDDA - COLD

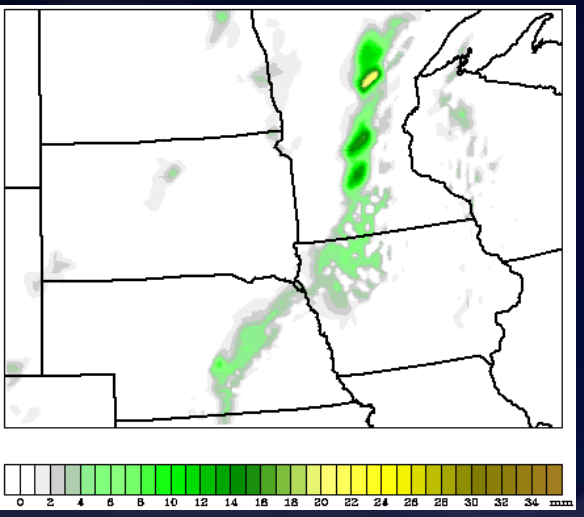


(3DVAR+FDDA)- COLD

Comparison of 1200Z, 24 Sep 2007 WRF Initialization
2 m Dewpoint Temperature

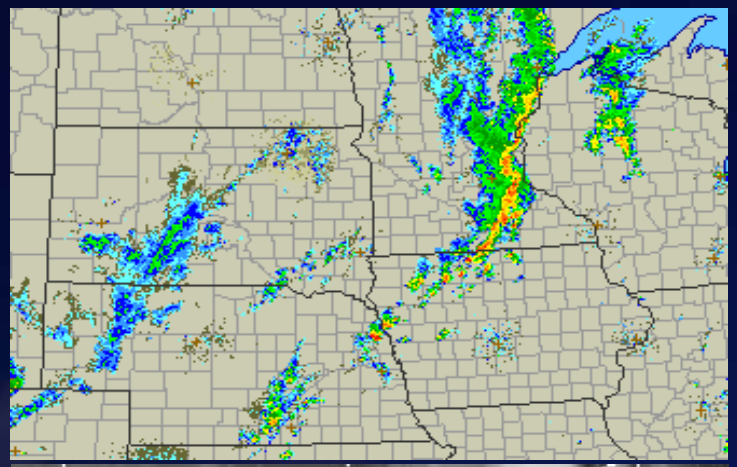
- **COLD**
  - **Initialized from GFS forecast at 12Z**
- **3DVAR**
  - **3DVAR analysis from GFS forecast + obs**
- **FDDA**
  - **3-h Forecast initialized at T-3 with GFS, nudged with obs**
- **3DVAR+FDDA**
  - **Initialized with 3DVAR at T-3, FDDA from T-3 to T**

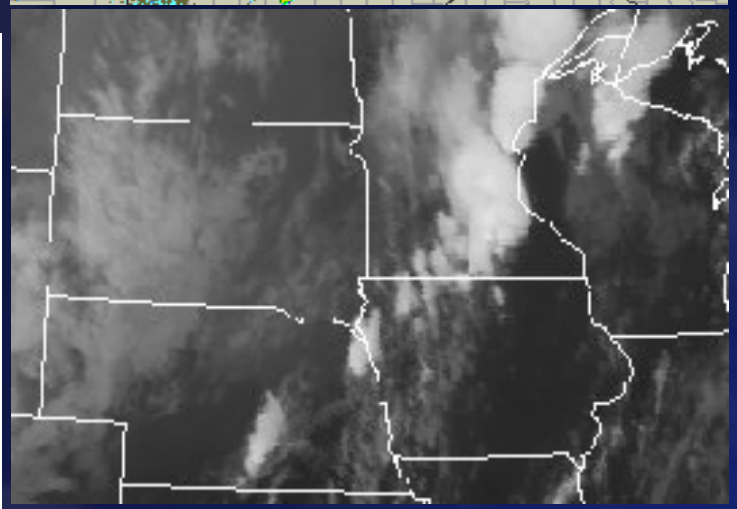
11-h Forecast of Valid 2300Z/24 Sep 2007
Total Precipitation from 2200-2300Z

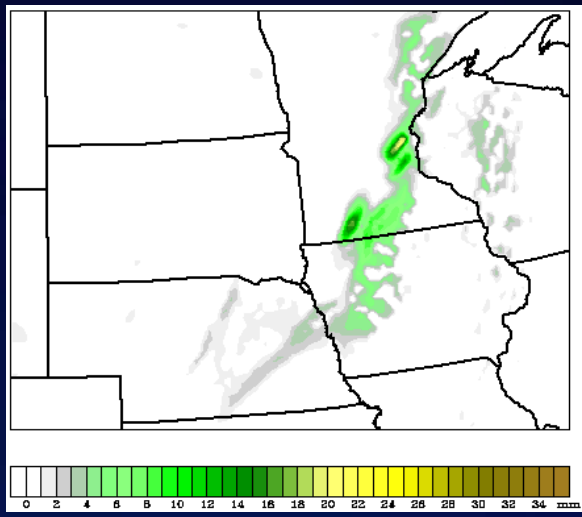


COLD

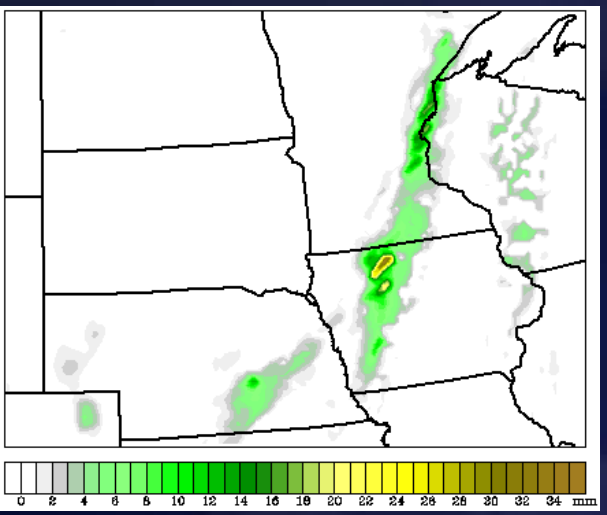
Radar/IR Satellite at 2300Z



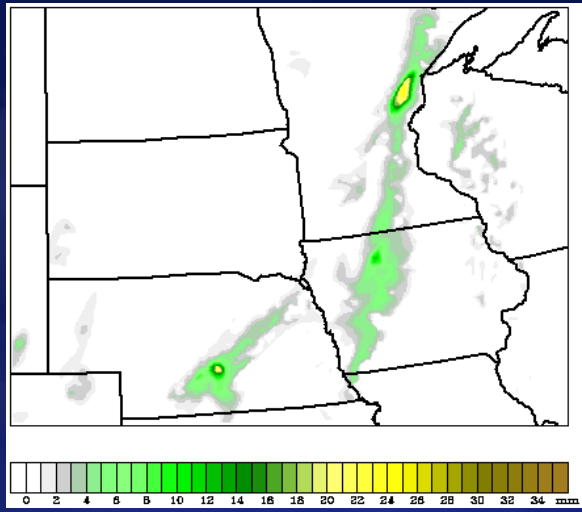




3DVAR



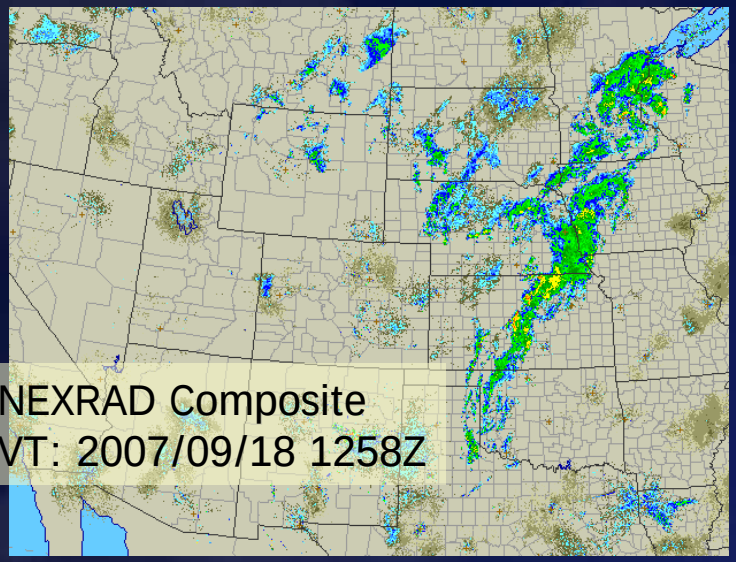
FDDA

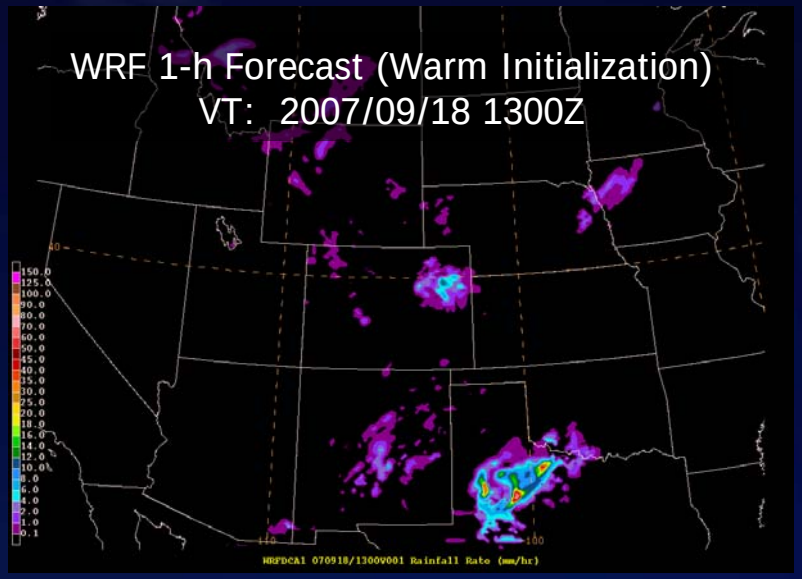


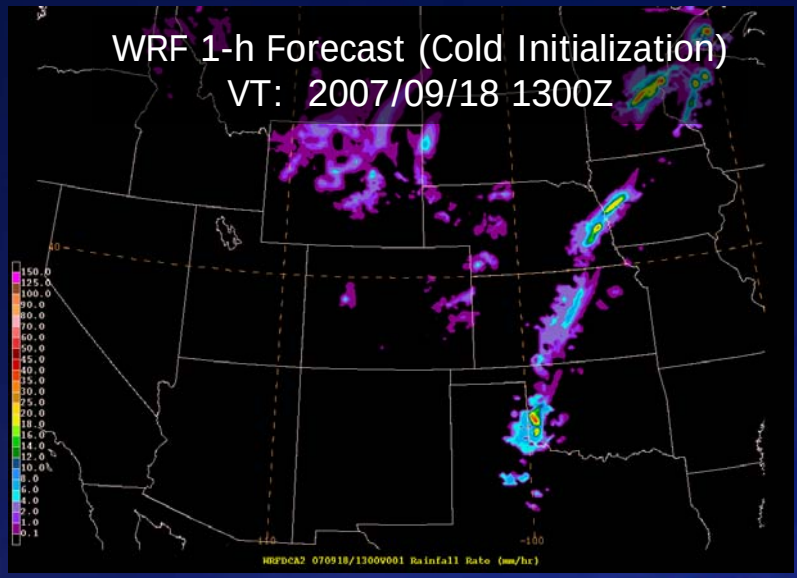
3DVAR+FDDA

Data Assimilation Issues

- **Cycling of 3DVAR Problematic**
- **Numerous Data Formats**
- **Observation QC in FDDA**
- **Availability of Documentation**
  - I/O Formats
  - Obs. Types and Usage
  - GenBE Code







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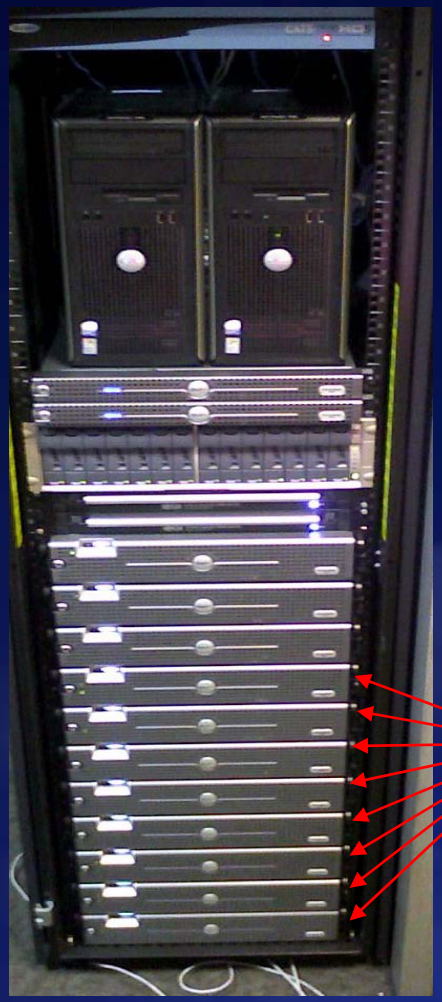
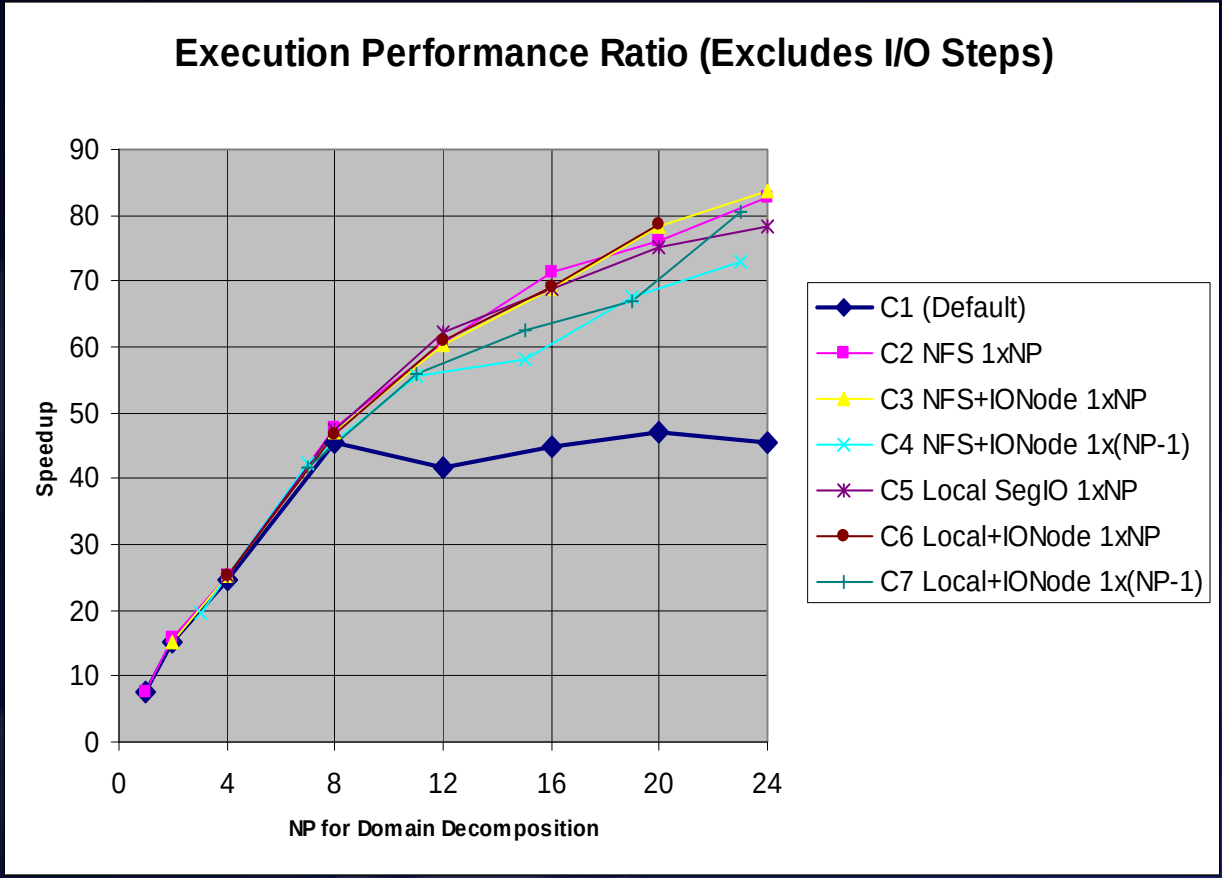
Computational System

- Linux Cluster
  - 2 dual-core AMD Opteron CPUs per node
  - 8 GB RAM per node
  - Dual power supplies
  - High-availability network attached storage
- ROCKS Cluster Software
  - Built with Red Hat Linux
  - Sun Grid Engine (SGE) Job Management
  - Ganglia Web Monitor
- PGI Fortran and Gnu C Compilers
- Functional Partitioning for Reliability
  - Primary/backup headnode
  - Separate queues for serial vs. parallel jobs
- **No single point of failure**



Optimizing Parallel WRF Performance

System Tuning on Small Clusters without Interconnect



Key Results

Decomposition matters!

MPICH2 better than MPICH1

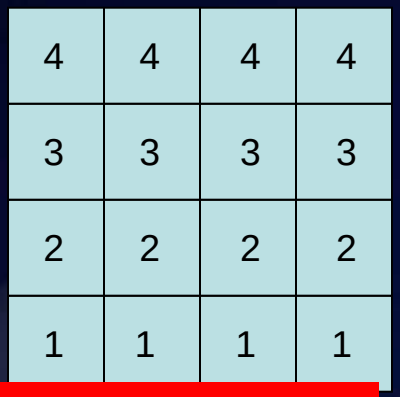
OpenMPI may be even better

Multi-core systems present new challenges

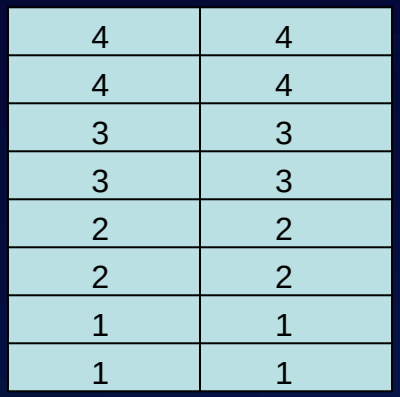
NOTE: All issues above are mitigated if high-speed interconnect is used!

Optimizing Parallel WRF Performance

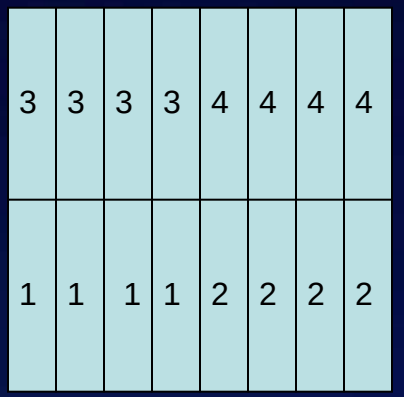
Decomposition Tuning via NPROC_X and NPROC_Y



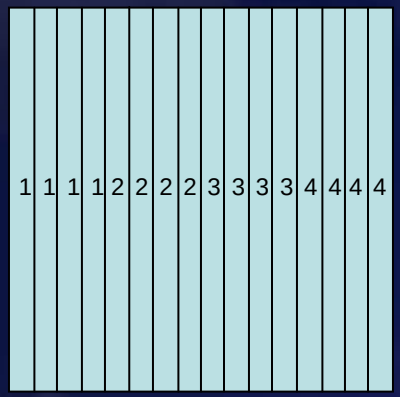
Inter-node Interfaces: 30
Performance Ratio: 25.0



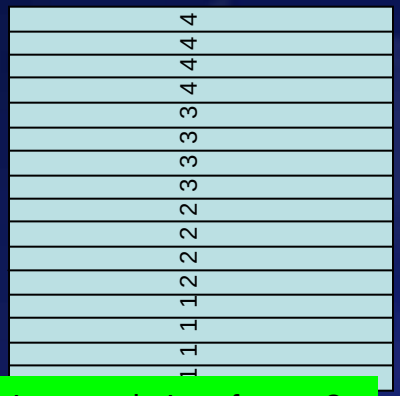
Inter-node Interfaces: 12
Performance Ratio: 27.6



Inter-node Interfaces: 24
Performance Ratio: 31.8



Inter-node Interfaces: 3
Performance Ratio: 29.4



Inter-node Interfaces: 3
Performance Ratio: 33.4

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Operationalization

- Efficiency
  - Computational system optimizations
  - Separation/parallelization of WPS ungrib process
- Reliability
  - Elimination of single failure points
    - Enterprise-class servers and OS
    - Dual head nodes using SGE “shadow master”
    - Extra compute nodes
    - NetApp file server
  - Fault tolerance
    - Handling of missing data, 3DVAR problems, etc.
    - Dynamic resource allocation via SGE to handle failed servers
    - Configurable e-mail alerting levels
- Usability
  - Turn-key system with flexible user configuration options
  - Web-based WRF Management Portal
  - Standardized output formats for easy integration into operations

WRF Management Portal

Powered By WDT

Home | Configure Domains | Schedule | Monitor WRF | Launch IDV | Browse: Work Data Logs | Monitor Cluster | Cluster Info (ROCKS)

26 Oct 2007 18:35:37 UTC
Oct 26, 2007 1:35:37 PM

Portal User Guide

- Creating Forecast Domains
- Scheduling Forecasts
- Monitoring Forecasts
- View Output

WRF Reference

- WRF ARW Users Guide
- WRF ARW Technical Document
- WRF Model Homepage
- WRF Namelist
- Description of Forecast Products
- Selecting the Grid Spacing
- Troubleshooting WRF
- Technical Support
- Version history

Home

Launch Domain Wizard

All currently configured WRF domains for this system are shown below. Click on the thumbnail images to see the full resolution domain map.

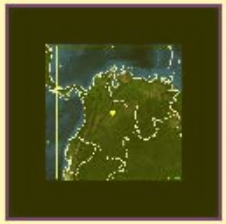
To add a new domain, or to change or delete an existing domain, please click on the link above to launch the WRF Domain Wizard, ensuring that you complete the "Run Geogrid" step for each domain you edit. Click here to see the correct Domain Wizard settings

Note: *Any changes made may take up to 10 minutes after the "Run Geogrid" step is completed before being made effective.*

Configured WRF Domains

Name	Projection	Standard Lon	TrueLat1	TrueLat2
Carib	Mercator	-70.0	17.0	0.0

Nest	Center Lat	Center Lon	Grid Spacing	Nx	Ny	Nz	Time Step
d01	17.00	-70.00	12.0 km	288	224	36	72.0 sec



Name	Projection	Standard Lon	TrueLat1	TrueLat2
Colombia	Mercator	-72.0	5.0	0.0

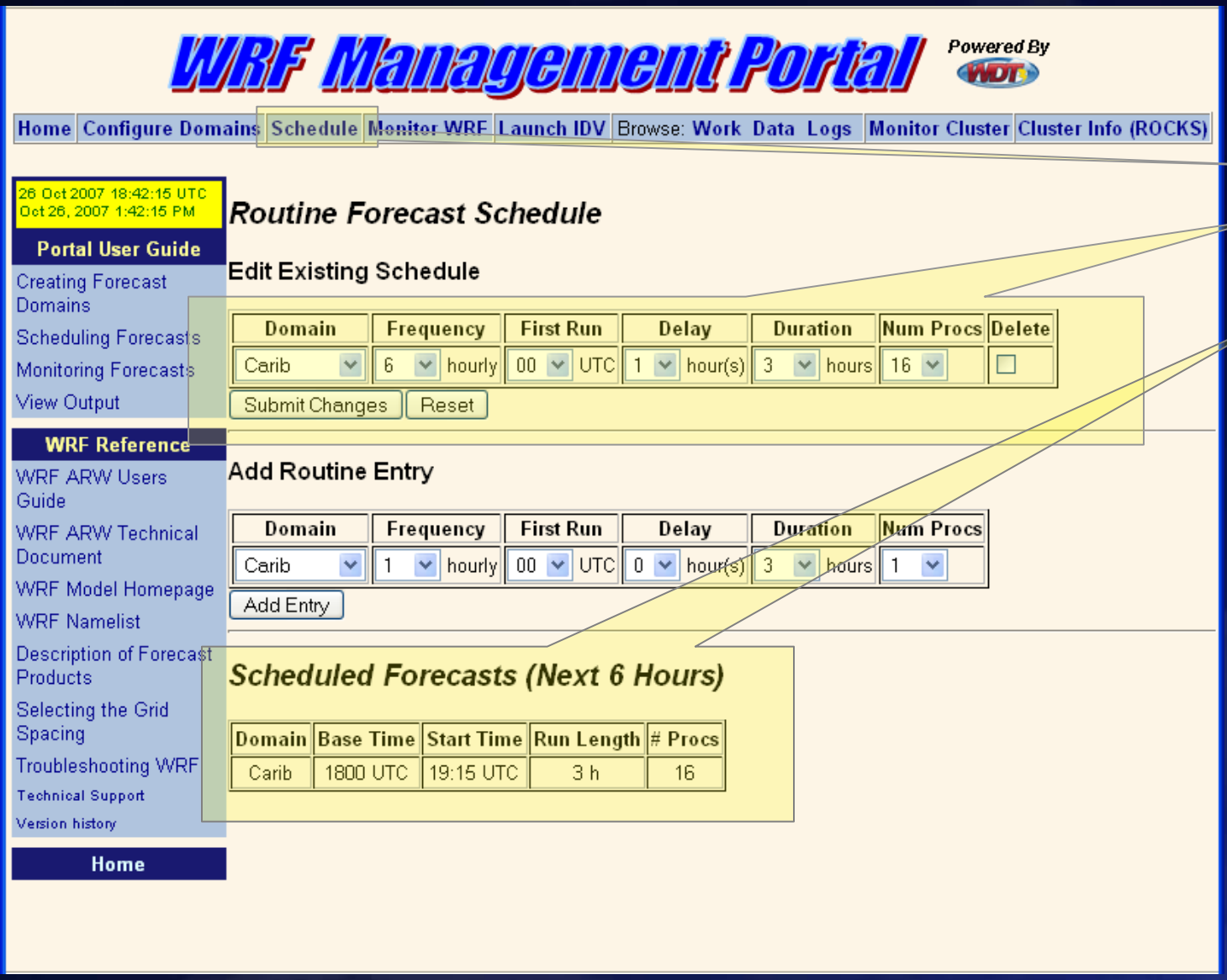
Nest	Center Lat	Center Lon	Grid Spacing	Nx	Ny	Nz	Time Step
d01	5.00	-72.00	12.0 km	193	193	36	72.0 sec

Standard

Configure Domains

Domain Wizard

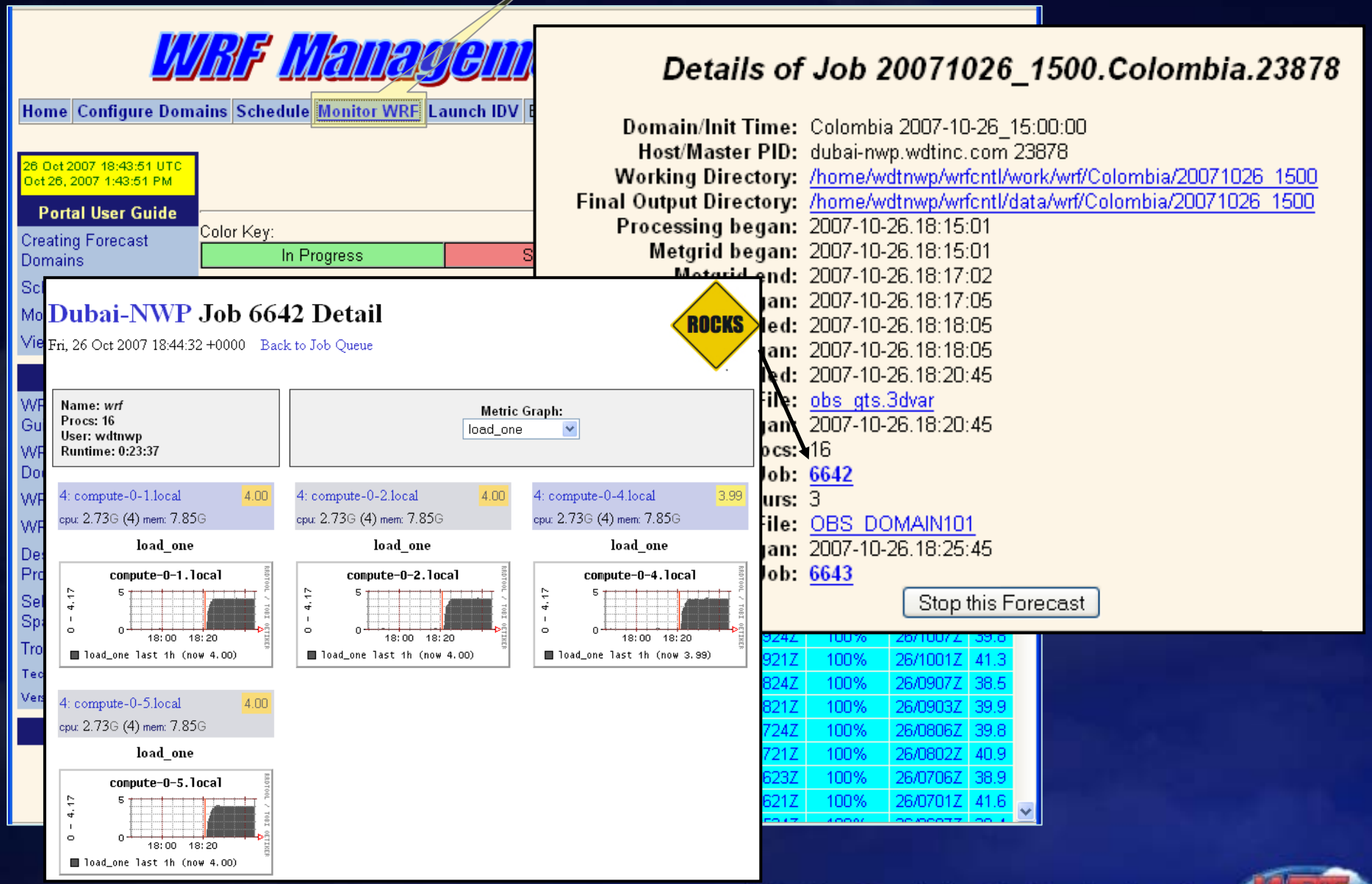
Summary of Configured Domains



Scheduler

After adding, entries appear on schedule

WRF Monitor



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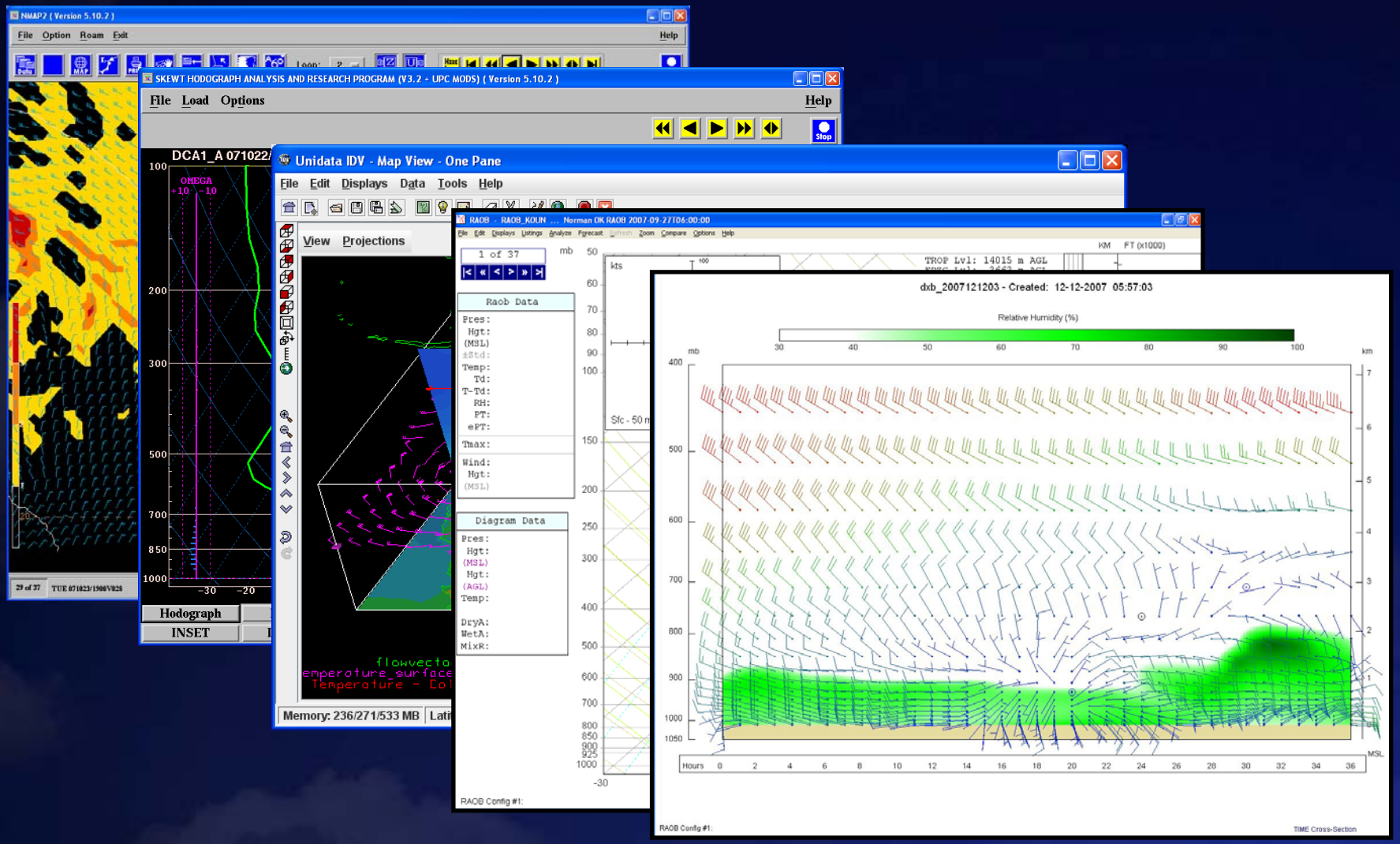
Post-Processing and Integration



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Future Plans

- WDT Internal System Implementation
  - Hourly update CONUS 0-9 h forecast (10 km)
  - 6-hourly CONUS 0-72 h forecast (10 km)
  - 6-hourly Europe 0-72 h forecast (10 km)
- Test and upgrade to WRF v3.0
- Radiance and Radar Assimilation
- Address Cycling (Digital Filter?)
- Automate 3DVAR GenBE
- New Post-processing (GRIB-2)
- Deliverable Systems

Community Recommendations

- Add/Improve Documentation
  - I/O Format Specifications for 3DVAR & FDDA
  - Explanation of observation usage/limitations
  - Optimizing
- Continue Software Architecture Improvements
  - Liberal use of inline comments
  - Integration of related software packages
  - Other decomposition options?