Multi-resolution Nested Dust Forecast System Feasibility Study

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Project Background

✓ Public Health Applications

- Public Health Applications in Remote Sensing (PHAiRS - NASA REASoN): 2003-2008
- Adding NASA Earth Science Results to EPHTN via the NM/EPHT System (ENPHASYS - NASA DECISIONS): 2008-2011

Interoperability Development & Testing

 NASA GIO/PHAiRS Project Interoperability and High Performance Computing Test/Demonstration: 2007-2008

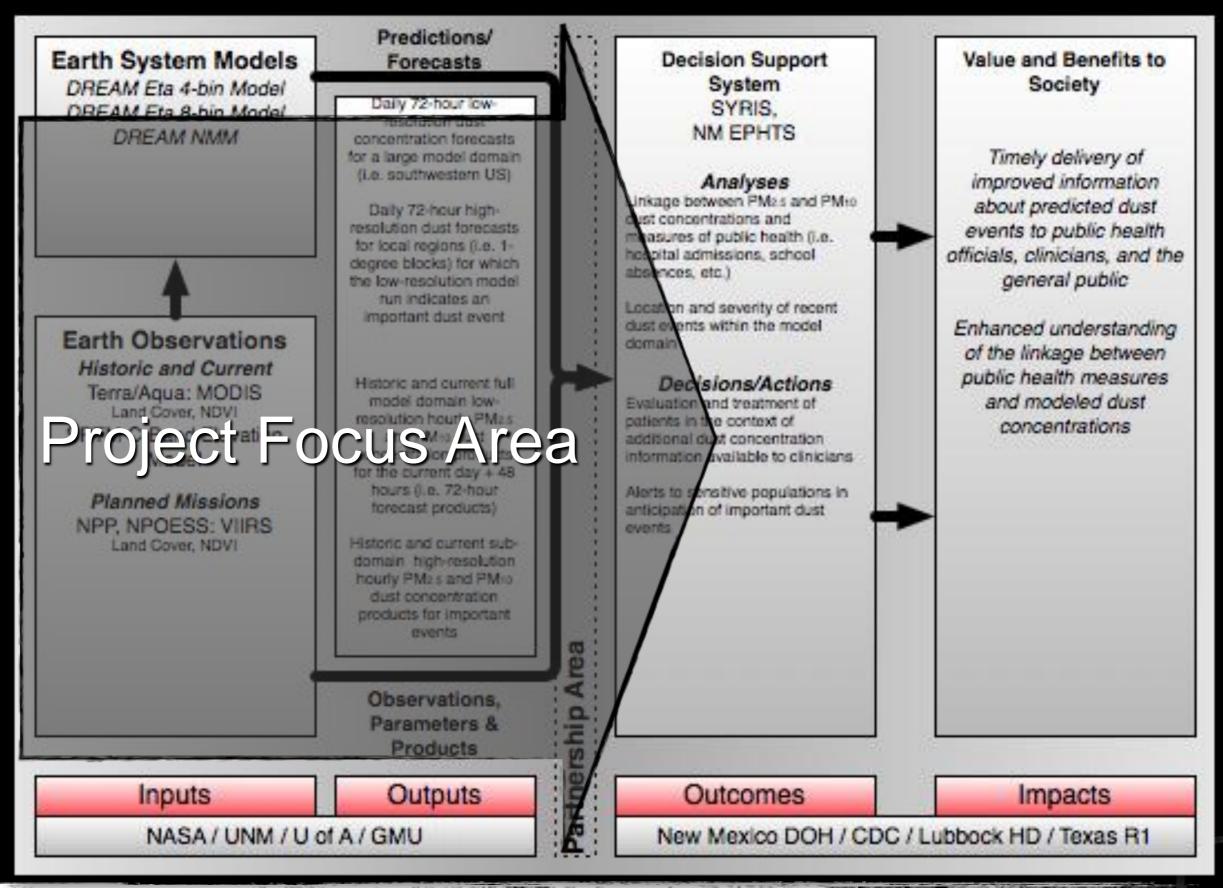


Goals

- ✓ Work with existing modeling cores (DREAM ETA-8, DREAM NMM)
- Modify model pre- and post-processors to support OGC and REST data transfer
- Develop algorithm for automated generation of dust forecast area(s) of interest
- Evaluate and report on performance characteristics of the nested model system



Integrated System Solution Diagram





NASA

Feasibility Testing

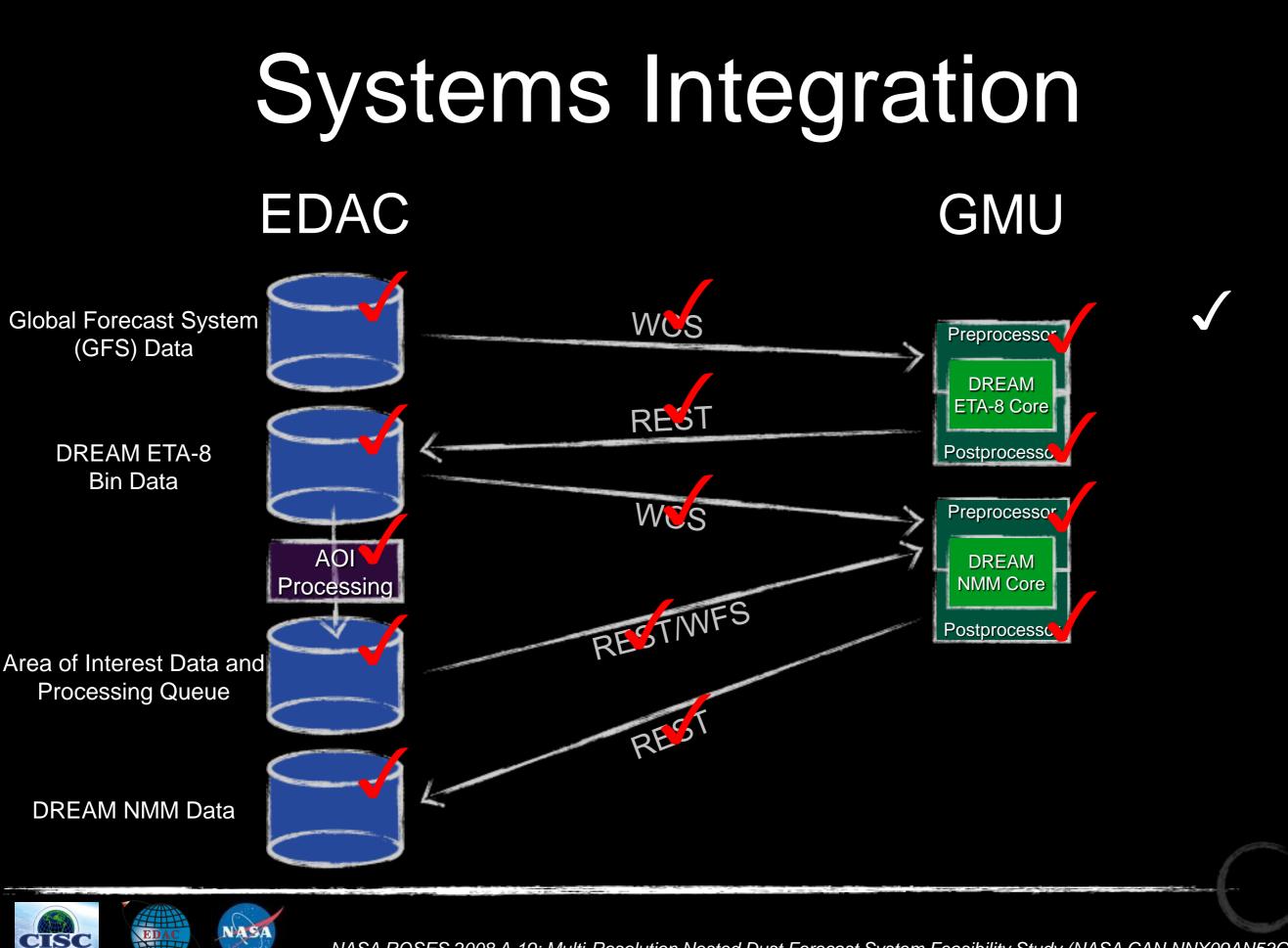
- Systems Integration
 - Model pre- and post-processor implementation
 - Data management and storage
 - Appropriateness of implemented service standards
- ✓ Performance
 - Comparison of performance (time-to-delivery) of nested model vs. dedicated large domain/high-resolution model runs

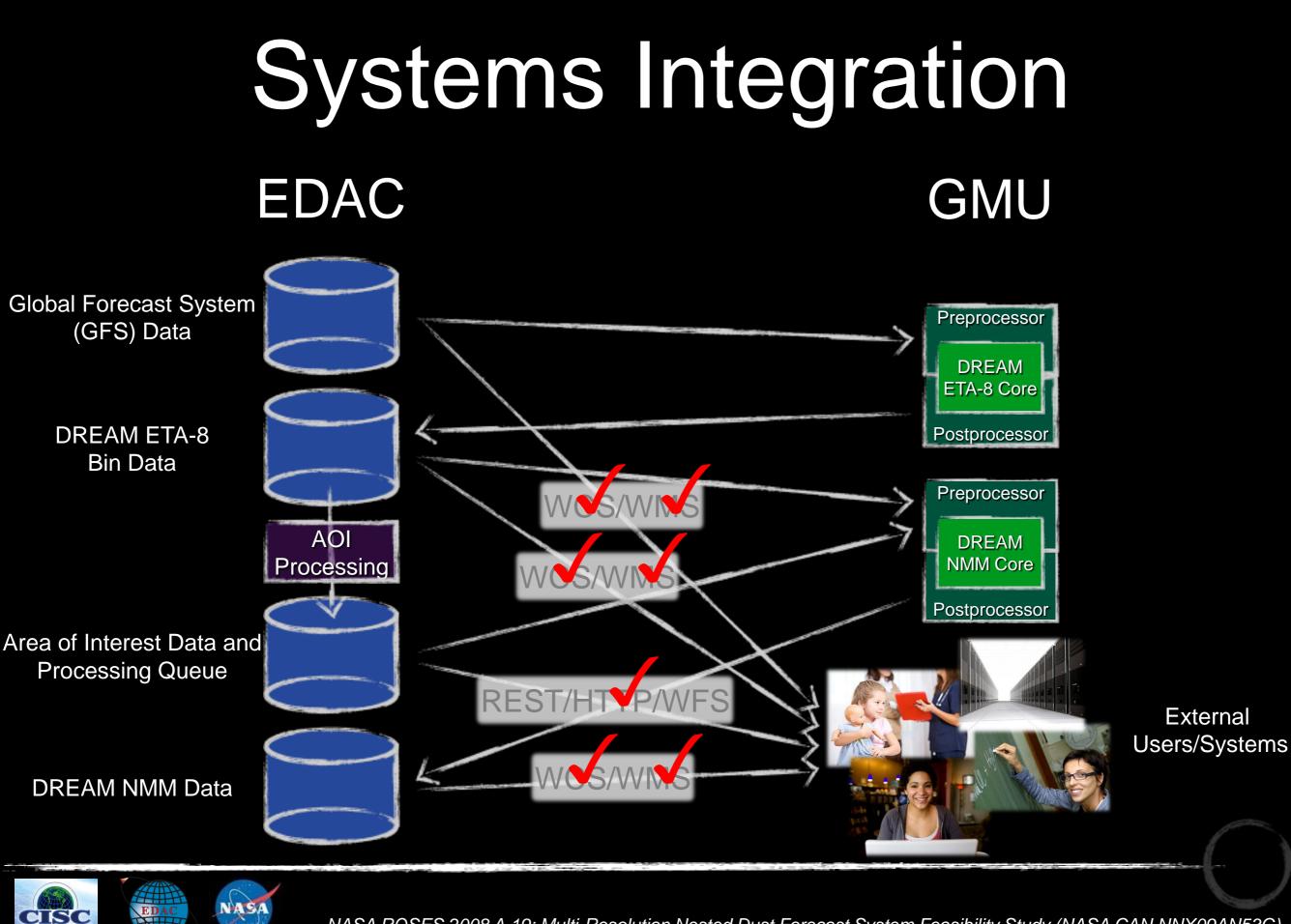


Timeline









What Do These Components Look Like?



OGC/HTTP/OPeNDAP – THREDDS (EDAC/GMU)

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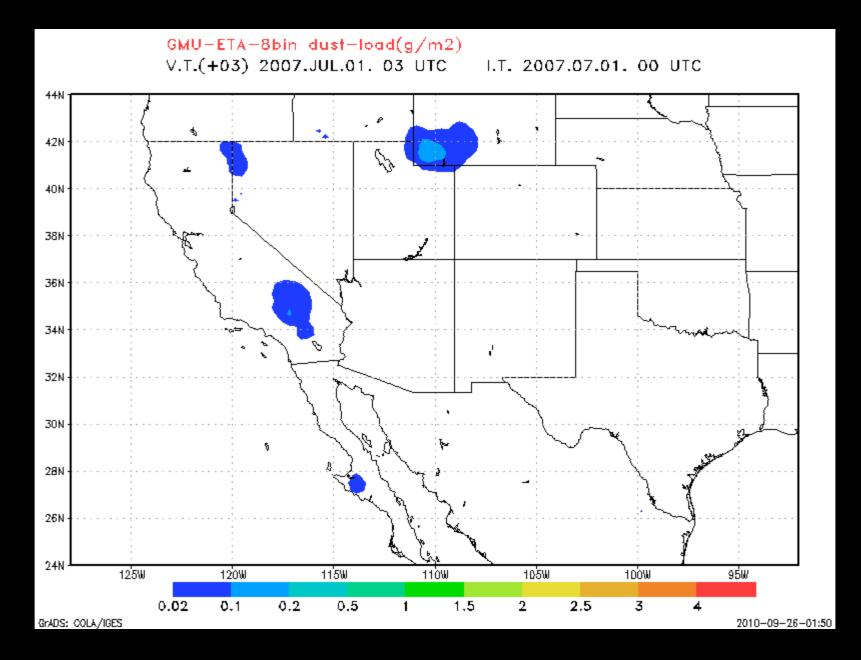


REST Data Upload Services (EDAC/GMU)

Multi-resolution Nested Dust Forecast System - M	ozilla Firefox	
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Multi-resolution Nested Dust *		-
	Multi-resolution	
	ested Dust Forecast System	
ETA-8bin AOI NMM-DUS	T Information Help	
REST-style Web Services	Client for Dust Output	
Send HTTP GET, POST, PUT and DELETE requests to R	EST resources	
HTTP Method: POST		
Date 2007-07-01 Model Eta-8bin		
HTTP URL: http://cischpc.gmu.edu/thredds/fileServer/eta/e	ta.20070701.nc	
WCS URL: http://cischpc.gmu.edu/thredds/wcs/eta/eta.200	70701.nc	
WMS URL: http://cischpc.gmu.edu/thredds/wms/eta/eta.20	070701.nc	
OPENDAP URL: http://cischpc.gmu.edu/thredds/dodsC/et	a/eta.20070701.nc	
send		



DREAM ETA-8 Model



2007-07-01



Identified Areas of

Matrix Processing of NetCDF Model Output

Generation of AOI Raster mask (GeoTiff)

Vectorization of discreet AOIs from raster

Generation of AOI vector files (KML, GeoJSON)

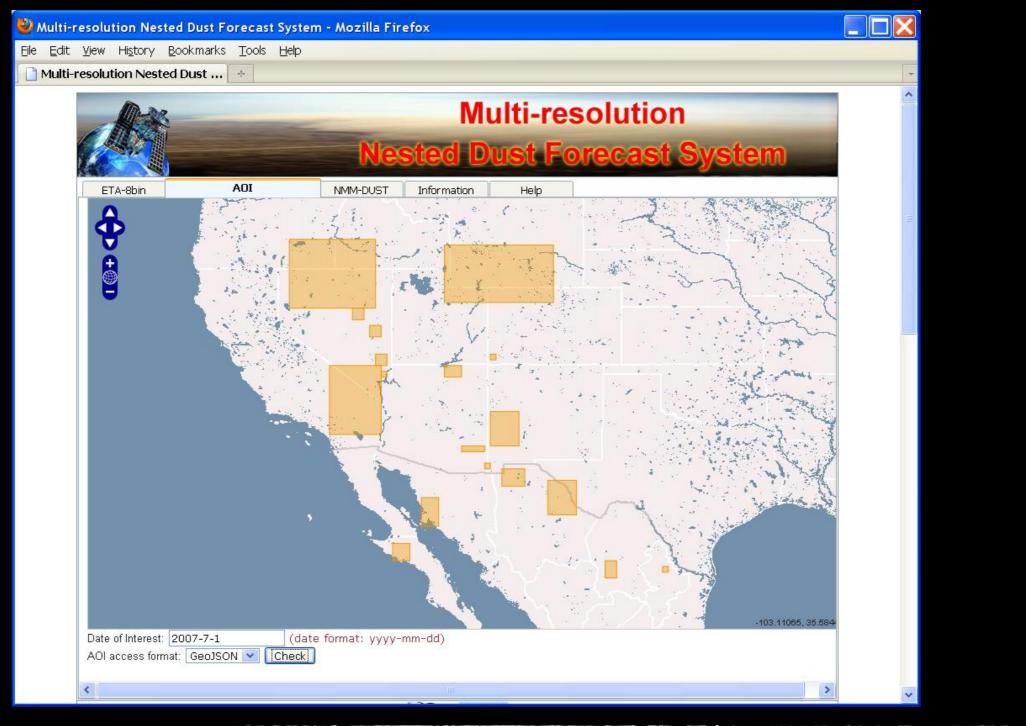
Publication of vector files via HTTP

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es	Name	Last modified	Size Description	Elet	Name	Last modified	Size Description
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Labels Places	2009-12-22 bbox.geojson	22-Sep-2010 15:43	915		2009-12-22 bbox.km	22-Sep-2010 15:43	1.7K
Panoramio Roads	2009-12-23.geojson	22-Sep-2010 15:49	50		2009-12-23.kml	22-Sep-2010 15:49	170
3D Building	2009-12-23 bbox.geojson	22-Sep-2010 15:49	45	× 1 3	2009-12-23 bbox.km	22-Sep-2010 15:49	155
Ocean Street View	2009-12-24.geojson	14-Sep-2010 11:06	50	1 2	2009-12-24.kml	14-Sep-2010 11:06	170
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	2009-12-26.geojson	14-Sep-2010 11:07	50	2	The second s	14-Sep-2010 11:07	
	2009-12-26 bbox.geojson	14-Sep-2010 11:07	45		2009-12-26 bbox.km	14-Sep-2010 11:07	155

2007-07-01, 72-hour forecast, 3-hour time step, dl (dust loading, gm/m²),1*10⁻⁷ base threshold, 8 aggregate threshold



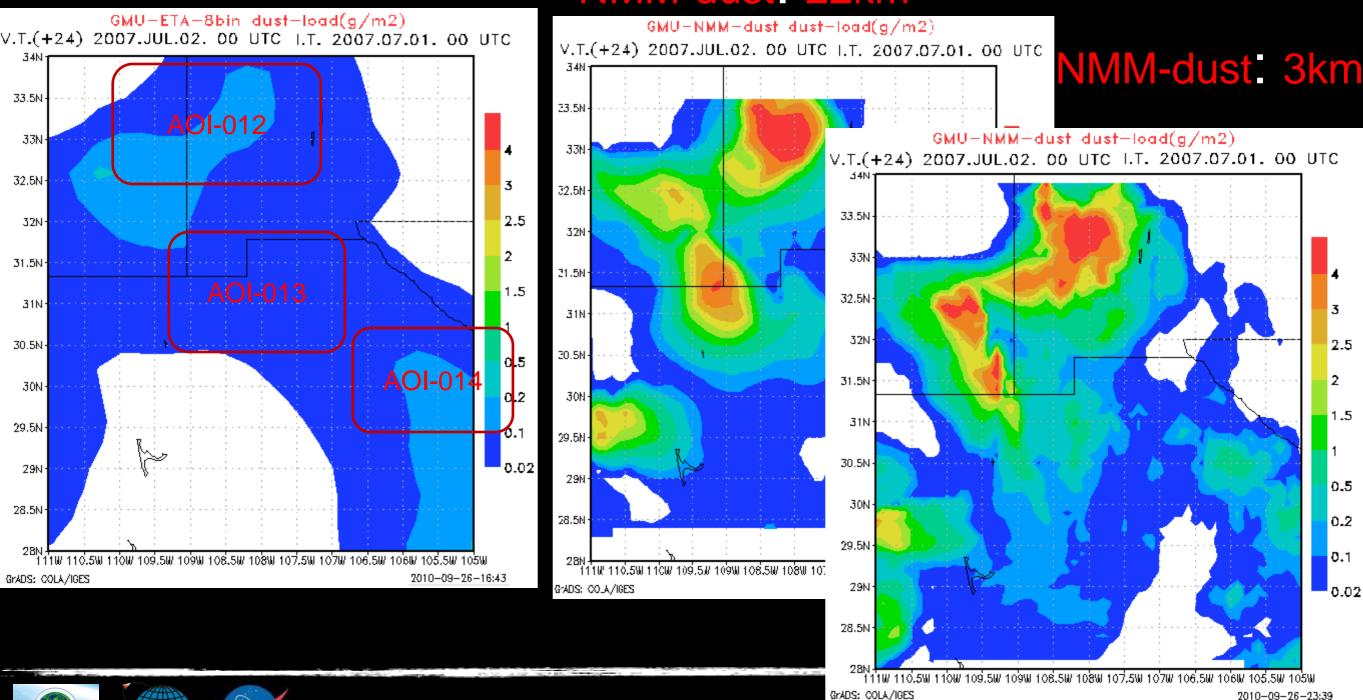
AOI Access Client(GeoJson/KML)





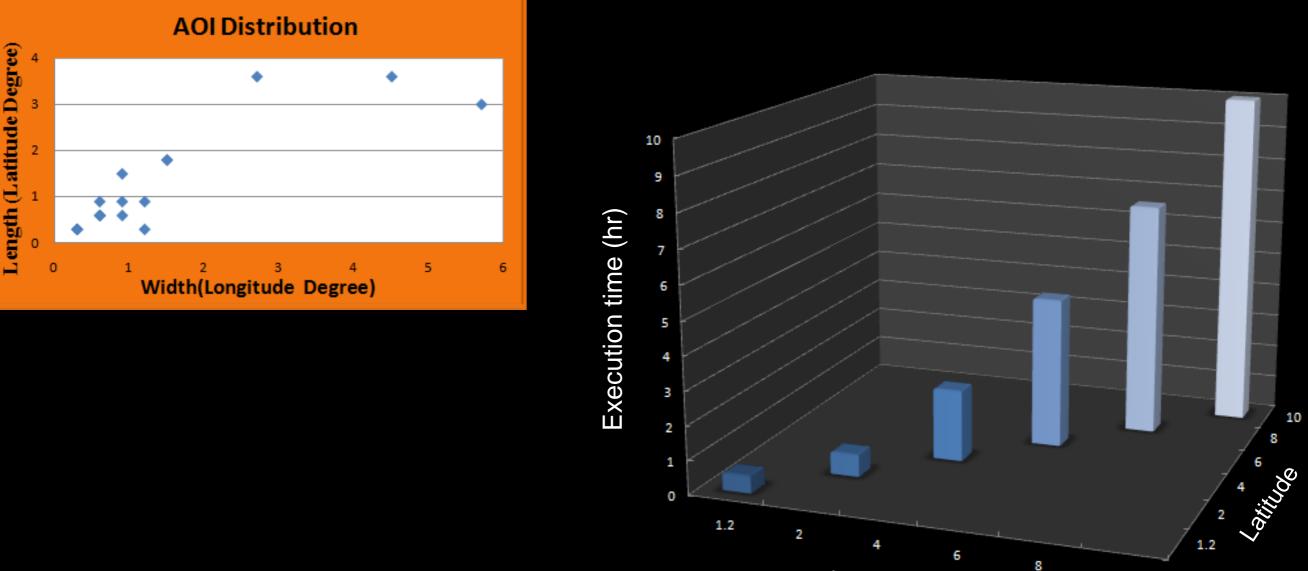
NMM Model

ETA-8bin: 50km



NMM-dust 22km

Performance



Longitude

10



Performance Comparison

Nested Running

- Retrieve initialization data from EDAC:1.5 mins
- Run ETA model: 20 mins
- Push ETA model output to EDAC: 4.5 mins
- AOI analysis: ~4.4 seconds
- Retrieve initialization data from EDAC for NMM : 3.9 mins
- Retrieve AOI data from EDAC for NMM: 30 s
- Execute NMM for each AOI
 - Depends on the AOI domain size
 - AOI 012: around 48 mins
- Push NMM outputs to EDAC: 1.5 mins per AOI output

NMM-Dust Only

- Retrieve initialization data from EDAC: 2.45 min
- Execute NMM
 - Depends on the size of domain
 - Cannot execute full domain
 - 10*10 degree : 12.7 hours with 8 CPU



Performance Comparison

		serial	parallel
retrieve ETA initialization data	0:01:32	0:01:32	0:01:32
run ETA model	0:20:00	0:20:00	0:20:00
push ETA output to data server	0:04:37	0:04:37	0:04:37
AOI Analysis	0:00:04	0:00:04	0:00:04
retrieve NMM initialization data	0:03:50	1:09:00	0:03:50
retrieve AOI data for NMM model run	0:00:30	0:09:00	0:00:30
execute NMM model for all AOIs	5:55:00	5:55:00	2:08:00
push NMM output to data server	0:01:30	0:27:00	0:01:30
		8:06:13	2:40:03



Feasibility Analysis

Systems Integration

- Model pre- and post-processor implementation
 - ✓ Relatively straightforward process
 - Challenge posed by models that require re-compilation to change model domain or other execution parameters
- Data management and storage
 - Simple file system approach works well
 - Separation of model execution from file storage allows for optimization for modeling independent of storage capacity
 - Need to develop more structured data management system (i.e. data registry & management utilities) in move towards operationalization
 - Appropriateness of implemented service standards
 - WCS is very effective in supporting data subsetting prior to network transfer (i.e. parameter extraction from large model products)
 - ✓ WMS remains useful for quick visualization of products in a variety of platforms, but for the modeling activity is not key
 - For this application, WFS seems like overkill, simple HTTP access to GeoJSON data files is sufficient for delivery of AOIs in a compact data model to remote systems
 - REST exchange remains useful for flexible transfer of data products between systems where the OGC services don't have a standard request-response model





Feasibility Analysis

- Performance
 - ✓ With all components now in place, performance testing is under way
 - ✓ Different geographic resolution will require different time to simulate.
 - ✓ One time of higher resolution (e.g., 4x4->2x2) will need 8-10 times more computing time
 - ✓ NMM model execution at high resolution (3km) remains computationally and time intensive, but smaller domains are more feasible
 - Different domain size will require different operation time.
 - Most sub-domain size is within 2x2 degrees, which can be processed within one hour for 3X3 km²
 - ✓ Given long execution times for NMM model, network latency for transfer of initialization parameters and outputs is a small fraction of total execution time.
 - About 1-2 minutes for transfer data between two sites (UNM & GMU)
 - More dynamic parameters, such as soil moisture, should be assimilated into the model and implementation of this additional modeling capacity would require increasing computing power (potentially provided by cloud computing)



Follow-on/Related Opportunities

Operationalization

- Develop AOI generation service
- Develop processing queue that tracks which AOIs have been processed for publication of un-executed AOIs as a feed (e.g. ATOM or RSS)
- Enable time-enabled WMS for more efficient access and use
- Auto-mosaic/overlay of time-enabled WMS for low- and highresolution model outputs within a single service
- Integration with other modeling systems.
 - Soil Moisture from Hydrologic Models for Model Initialization (NASA EPSCoR Proof of Concept Project)
 - Community Multi-Scale Air Quality (CMAQ) model (ENPHASyS Project)
- Extension of on-demand high-resolution model execution into public/private cloud
- Automated air-quality alerts based upon AOI system



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