Cloud Computing Applications in Support of Earth Science Activities at Marshall Space Flight Center

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Currently, the NASA Nebula Cloud Computing Platform is available to Agency personnel in a pre-release status as the system undergoes a formal operational readiness review. Over the past year, two projects within the Earth Science Office at NASA Marshall Space Flight Center have been investigating the performance and value of Nebula's "Infrastructure as a Service", or "IaaS" concept and applying cloud computing concepts to advance their respective mission goals. The Short-term Prediction Research and Transition (SPoRT) Center focuses on the transition of unique NASA satellite observations and weather forecasting capabilities for use within the operational forecasting community through partnerships with NOAA's National Weather Service (NWS). SPoRT has evaluated the performance of the Weather Research and Forecasting (WRF) model on virtual machines deployed within Nebula and used Nebula instances to simulate local forecasts in support of regional forecast studies of interest to select NWS forecast offices. In addition to weather forecasting applications, rapidly deployable Nebula virtual machines have supported the processing of high resolution NASA satellite imagery to support disaster assessment following the historic severe weather and tornado outbreak of April 27, 2011. Other modeling and satellite analysis activities are underway in support of NASA's SERVIR program, which integrates satellite observations, ground-based data and forecast models to monitor environmental change and improve disaster response in Central America, the Caribbean, Africa, and the Himalayas. Leveraging SPoRT's experience, SERVIR is working to establish a real-time weather forecasting model for Central America. Other modeling efforts include hydrologic forecasts for Kenya, driven by NASA satellite observations and reanalysis data sets provided by the broader meteorological community. Forecast modeling efforts are supplemented by short-term forecasts of convective initiation, determined by geostationary satellite observations processed on virtual machines powered by Nebula.

This presentation will provide an overview of these activities from a scientific and cloud computing applications perspective, identifying the strengths and weaknesses for deploying each project within an IaaS environment, and ways to collaborate with the Nebula or other cloud-user communities to collaborate on projects as they go forward.

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Supported Projects

Cloud computing activities support two projects within the Earth Science Office at NASA's Marshall Space Flight Center in Huntsville, Alabama:

The NASA Short-term Prediction Research and Transition (SPoRT) Center, which integrates unique NASA satellite and weather forecast modeling capabilities into the operational weather forecasting community.

NASA's SERVIR Program, which integrates satellite observations, ground-based data, and forecast models to improve disaster response in Central America, the Caribbean, Africa, and the Himalayas.

Cloud Resources

Cloud computing projects employ hardware provided through "Infrastructure as a Service" (IaaS) concepts available through:

- NASA's Nebula Cloud Computing Platform
- Amazon's Elastic Compute Cloud (EC2)

IaaS provides virtualized hardware platforms supporting various software packages required for projects associated with SPoRT and SERVIR.

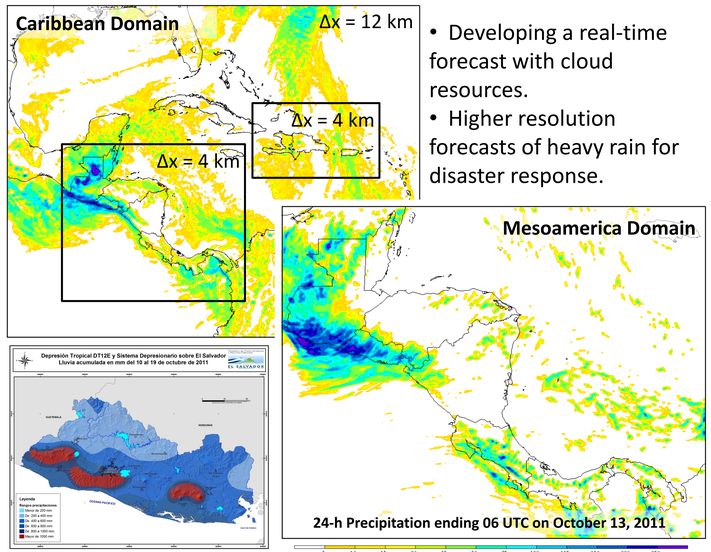
Benefits of Cloud Computing

- IaaS provides flexibility to spin up new hardware for short-term projects that do not require the procurement of specialized hardware.
- The use of a shared resource pool increase the efficiency of IT dollars.
- Allows for exploration or "sandbox" systems that can be used to define requirements before purchase.

Risks and Mitigation

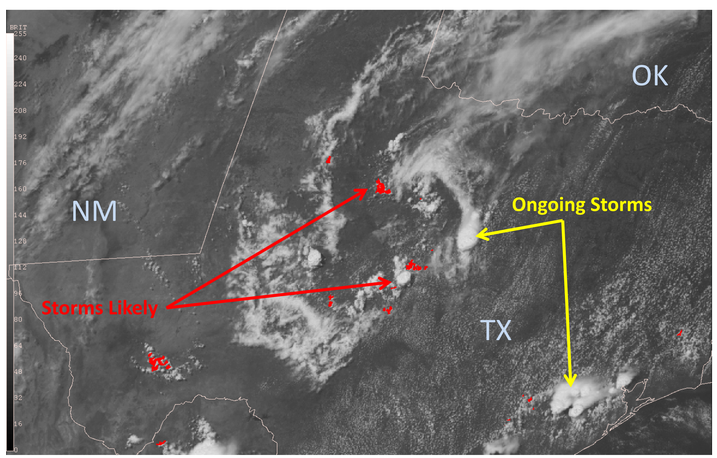
- Virtual machines can result in the loss of progress and data if not handled carefully. This is mitigated by the use of external "elastic" storage and versioning of machine images.
- Acceptance of cloud computing may be slow among users more comfortable with their local hardware. To increase acceptance, we have provided seminars and basic instructions on use.

Real-Time Weather Forecasts for Central America



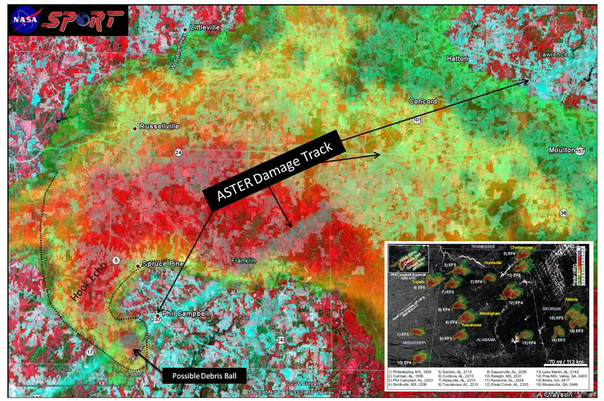
- Developing a real-time forecast with cloud resources.
- Higher resolution forecasts of heavy rain for disaster response.
- Forecast models can improve prediction of extremely heavy rainfall events, such as those from Tropical Depression 12-E in October 2011.
- Here, a single day forecast during the period highlights heavy rains in El Salvador due to the offshore depression and local topography.

Real-Time Satellite Imagery to Detect New Thunderstorms



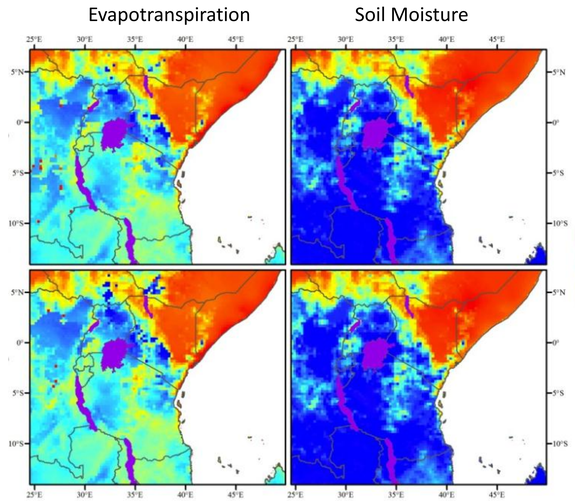
- Satellite imagery monitored to improve prediction of thunderstorms.
- System is imaged and can be deployed to additional coverage areas.
- Currently being developed for use on the NASA Nebula system.

Tiling of High Resolution Imagery



- Following severe weather events of April 27, 2011, ASTER and MODIS imagery were used to assist in damage surveys.
- Cloud resources were used as a "sandbox" to test high resolution image tiling for display in GIS and Google Earth.

Hydrologic Modeling to Monitor Floods and Droughts



- By operating the NOAA CREST model in the cloud, provides flexibility to deploy hydrologic models for areas of interest.
- Use of cloud resources avoids maintenance costs of local hardware or maintaining resources at distant SERVIR nodes.
- Imaging the configuration allows for the deployment of additional model domains on new virtual systems.

Summary

- Several activities are underway at Marshall Space Flight Center that use cloud computing resources.
- Currently, these projects use "Infrastructure as a Service" concepts available from either the NASA Nebula Cloud Computing Environment or the Amazon Elastic Compute Cloud (EC2).
- Although each project has been envisioned as a prototype, continued development will produce machine images for continued use.
- In order to determine the effectiveness of cloud computing resources, each project must balance the cost of cloud resources versus the cost of procurement and long-term maintenance.

Future Work

Real-Time Weather Forecasts

- Benchmarks of cloud resources against permanent hardware to determine costs.
- Developing model verification techniques and data dissemination strategies for the region.

Real-Time Satellite Imagery

- Deploying the convective storms algorithm over the Central America domain using GOES data.
- Determining the cost-effectiveness of a cloud solution versus the purchase of new hardware.

High Resolution Satellite Image Tiling

- Development of machine images to launch software on an as-needed basis in response to additional severe weather events.
- Determining if web mapping capabilities can be supported in a cloud environment t.

Hydrologic Modeling

- Verification of hydrologic models against available data in East Africa
- Maintenance of the current system and creating images coincident with software upgrades.

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