SBIR Phase II - High Resolution Wind Forecasts Using Multi-Sensor Satellite Surface Characterization Data

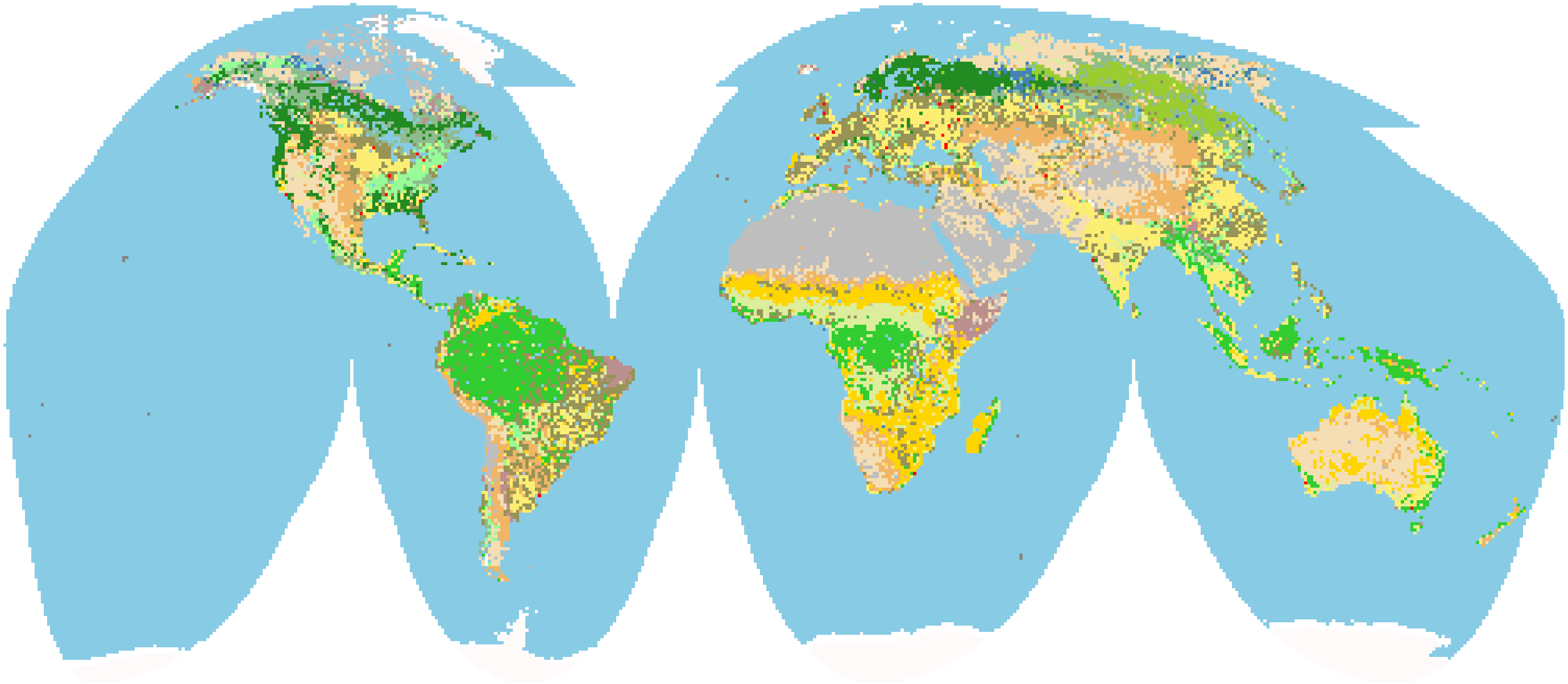
Task 1:

Research/access/implement additional datasets

- *Investigate the availability of additional high-resolution surface characteristic datasets for numerical forecast models*
    - *NDVI (to derive vegetation characteristics) (USGS)*
    - *Sea surface temperatures (Navy, NOAA/CIRES, NOAA/NESDIS)*
    - *Soil characteristics (STATSGO for US, Digital Soil Map of the World - 5 min)*

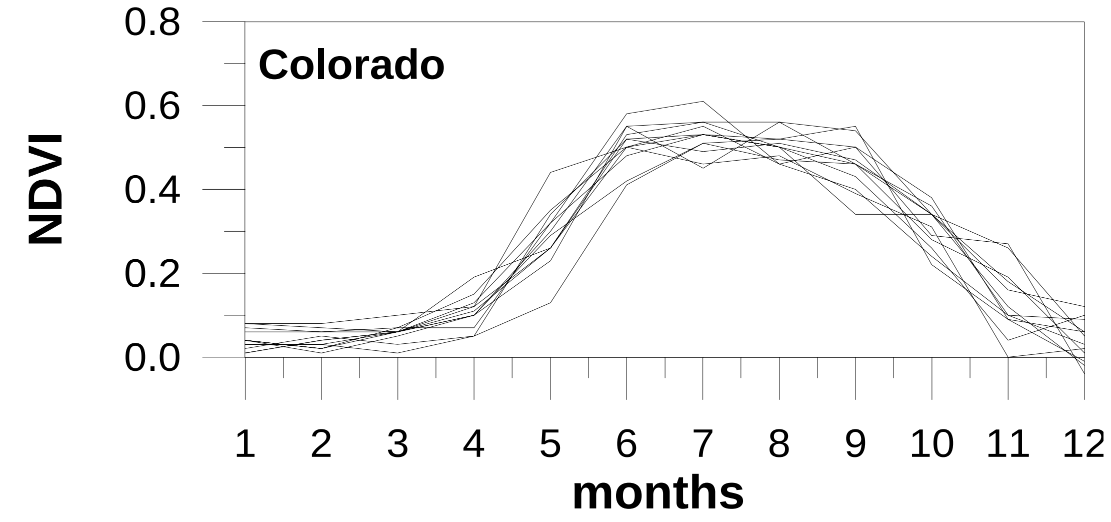
- *Implement and test the datasets*
- *Validate the impact on accuracy by repeating the forecast tests we performed in the Phase I project*

Normalized Difference Vegetation Index - NDVI

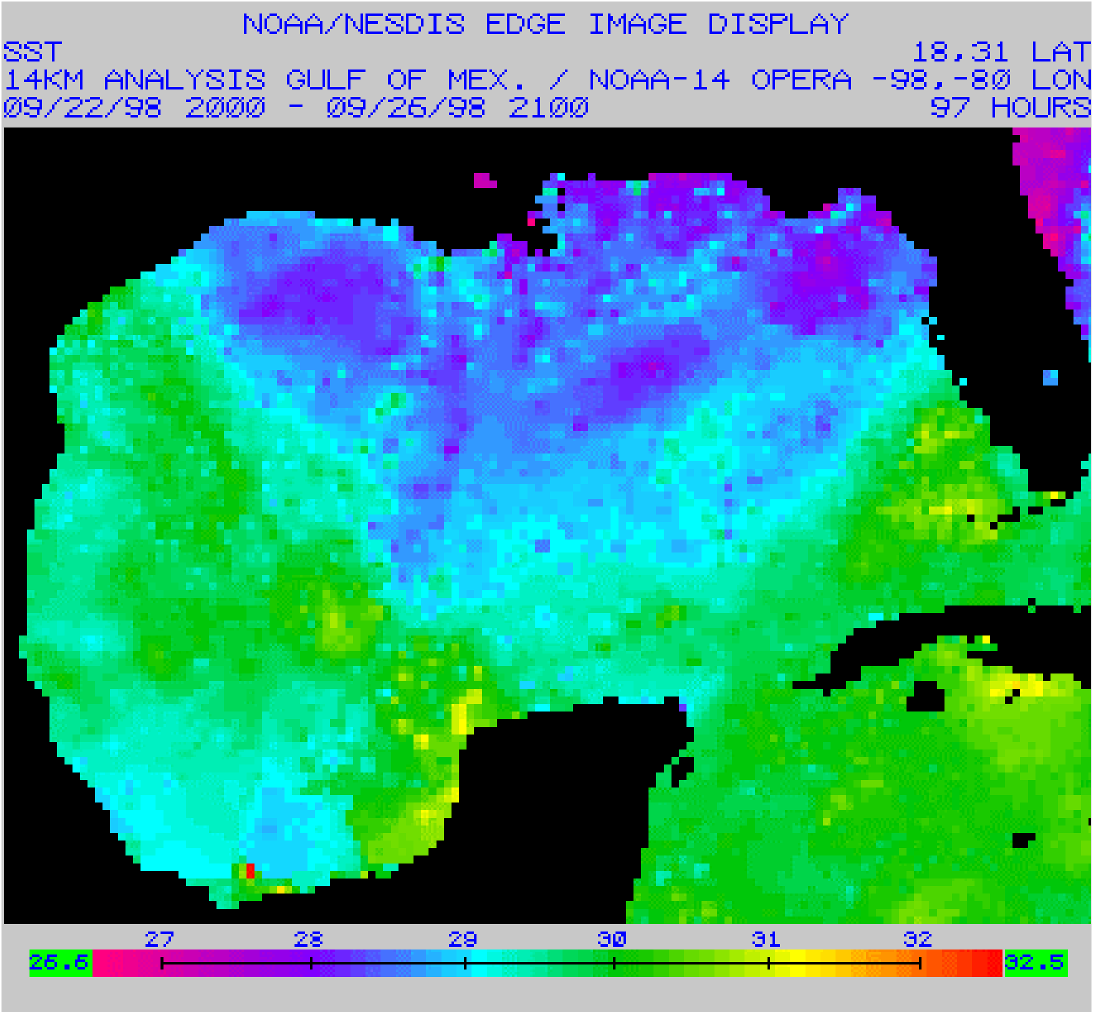


- Global 1 km data from USGS
- Monthly - April 1992 through March 1993
- Captures first-order seasonal effects
- Replaces ad-hoc BATS scheme currently used (TSEASN)

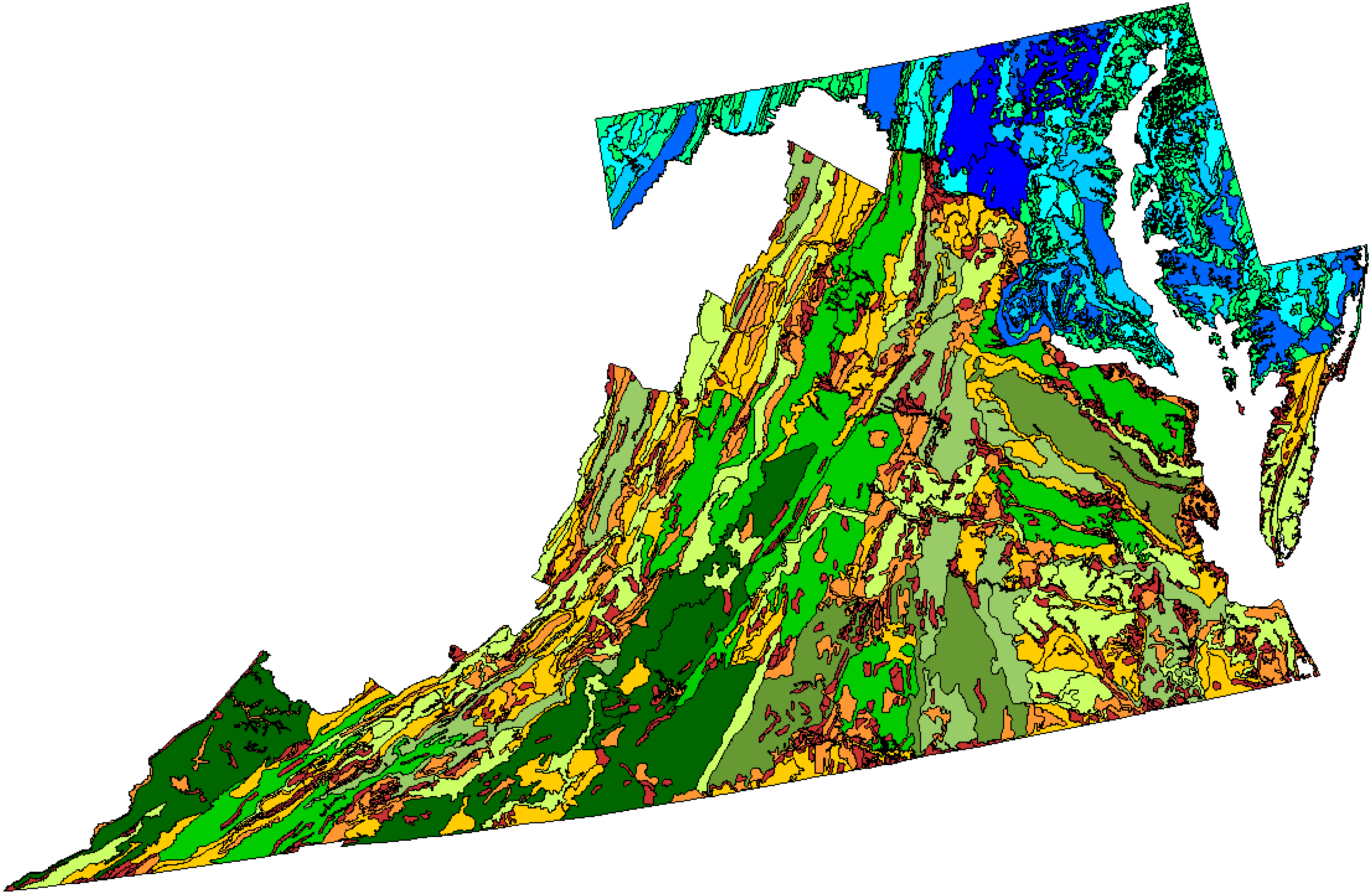
Monthly composites of NDVI for Colorado: Years: 1982-1993.



Sea Surface Temperature for the Gulf of Mexico



STATSGO Soil Data



Task 2:

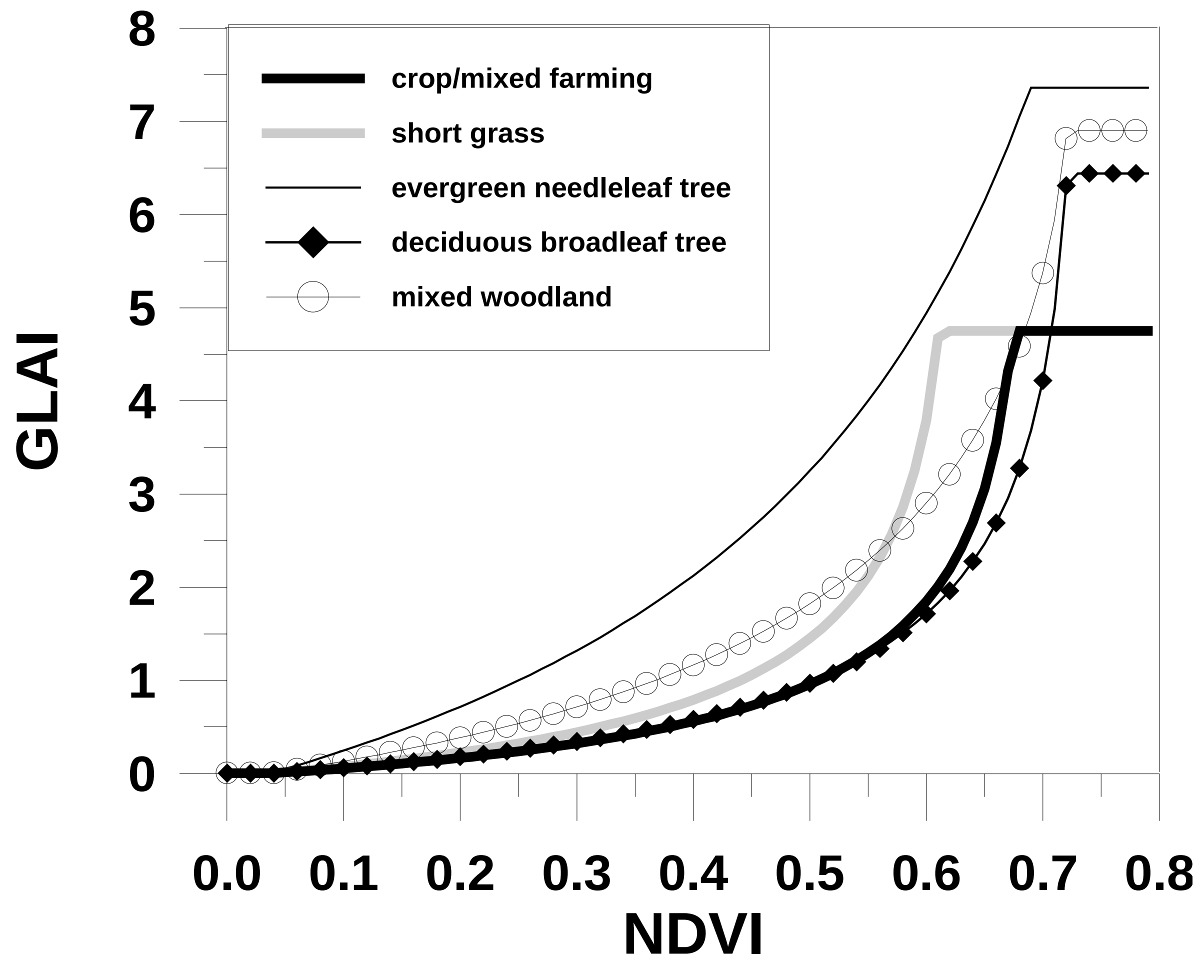
Testing/validation of NDVI conversion schemes

- *Fully implement the technique we explored in the Phase I project to convert NDVI data to the vegetation characteristics used by a numerical model.*
- *Use the USGS historical NDVI dataset for the source of the input.*

NDVI to LAI scheme

- Based on Seller's implementation for SiB2
- Technique:
  - Calculate FPAR directly from NDVI data
  - Calculate green LAI, L_G, from FPAR
  - Use L_G in RAMS' current land surface parameterization to calculate canopy resistance and latent heat flux.
- Requires three sets of data:
  - Spatial distribution of NDVI data with appropriate resolution
  - Spatial distribution of vegetation classes
  - Morphological, physiological, and optical parameters assigned to each vegetation class.
- Additional parameters characterizing vegetation were adopted from the SiB2 parameterization

Computed LAI_G Versus NDVI for Several Vegetation Classes



Task 3:

Investigation of surface roughness, topography definition, and differencing schemes

- *Explore three numerical techniques for enhancing the treatment of topography in a numerical forecast model:*
    - *subgrid topography roughness scheme*
    - *reflected envelope orography scheme*
    - *better numerics for handling steep topography*

- *Implement, test, and validate these schemes in both ideal situations and in real-world forecast tests*

Task 4:

Research, develop, and implement aspects of the "diabatic initialization" problem

- *Explore numerical techniques for treating "diabatic initialization" (including quantitative cloud information in the initial fields of a numerical model)*
- *Implement and test both a stratiform and convective scheme, along with a "dynamic initialization" scheme*
- *Validation will be performed on two Florida convective cases and two East Coast CONUS stratiform cases, which we will identify in conjunction with DTRA*

Diabatic initialization

- The problem: When a model is initialized, cloud fields are not included at all on a “cold start”. Even if run on an assimilation cycle, relies on accuracy of cloud forecasts.
- Diabatic initialization techniques attempt to start model with information from observed clouds fields. Provides condensate and latent heating fields (hence the term, *diabatic*).
- We will implement a stratiform cloud technique and a “*cumulus inversion*” scheme.
- Will also require dynamic initialization technique because of heating
- We will implement either adiabatic backward-and-forward model integration (Matsuno, 1966) or digital filter (Lynch and Huang, 1992).
- Other techniques:
    - Normal modes (more appropriate for large scale)
    - 4-D Variational schemes-adjoint (not enough resources, computer and ours, to consider)

Task 5:

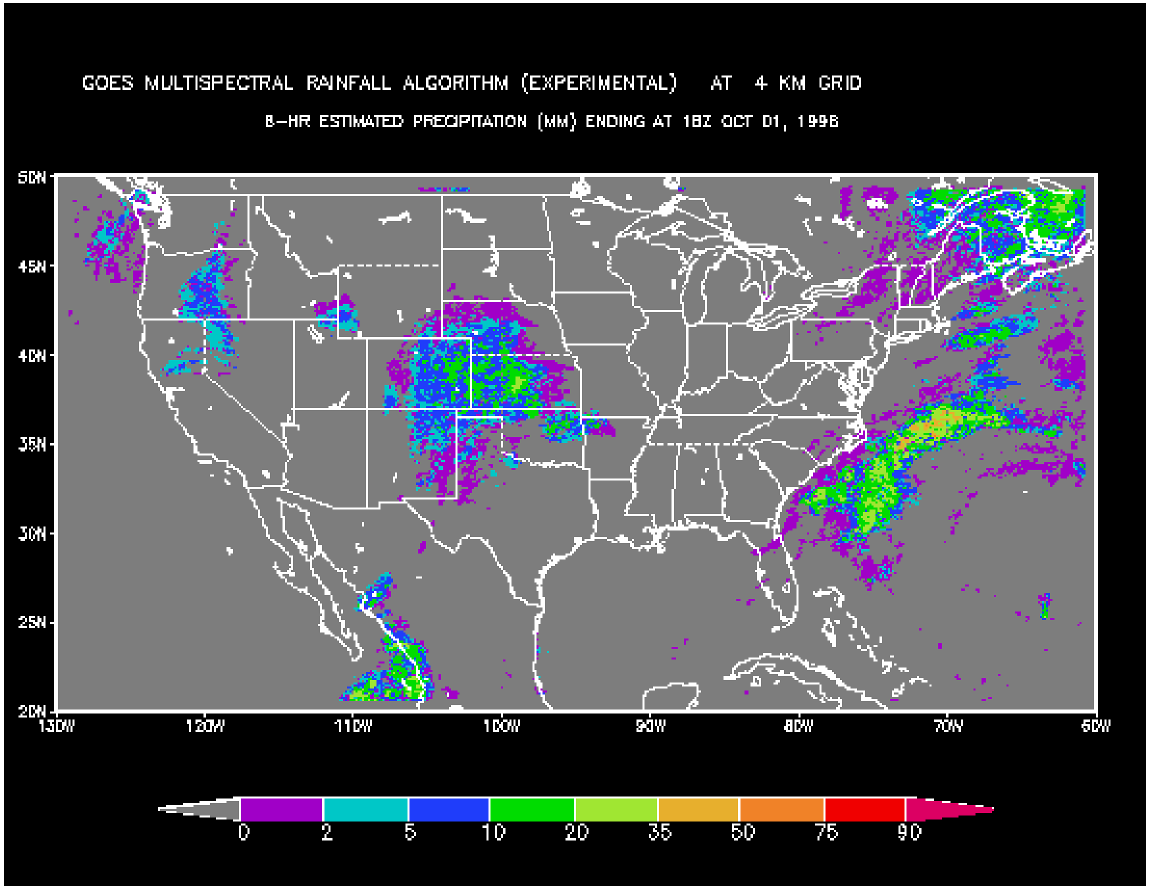
Modify/test/validate Antecedent Precipitation Index (API) scheme for worldwide use

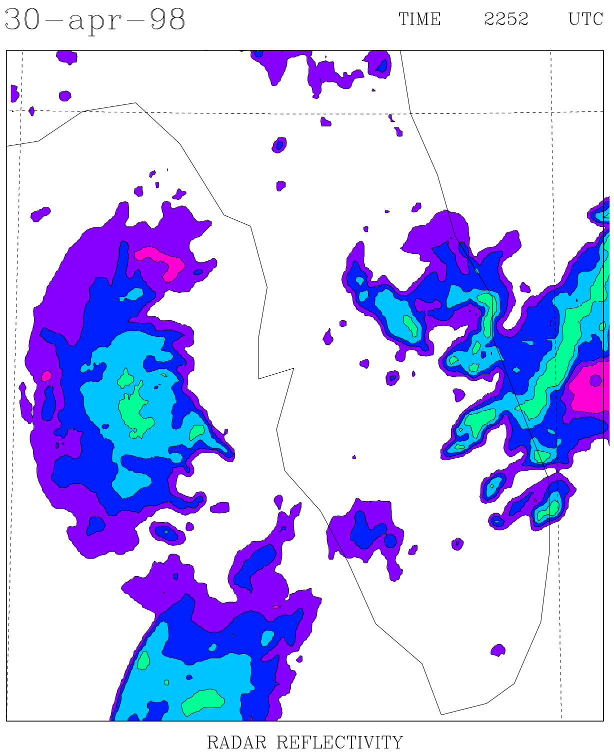
- *Fully implement, test, and validate an Antecedent Precipitation Index (API) scheme for global application to better initialize the important quantity of soil moisture*
- *API scheme developed under NASA funding for KSC will be extended to allow for inclusion of several different precipitation data inputs*
- *Validate the API scheme by using Florida and East Coast CONUS cases (using different types of precipitation data input such as NEXRAD, satellite, direct observation, etc.*

Antecedent Precipitation Index - API

- “Stripped-down” RAMS with only soil/vegetation schemes executed
- All atmospheric parameters specified from previous forecast
- Precipitation data specified from observations/radar/satellite
- Example:
  - → 0000 UTC forecast time on the 30th
  - → Back up to 0000 UTC on the 29th
  - → Run RAMS in API mode for 24 hours
  - → Initial soil moisture field available for 0000 UTC on 30th
- Can be combined with soil moisture assimilation

Precipitation Data Sources





Task 6:

Urban data collection for Washington, D.C. and implementation of urban canopy scheme

- *Explore techniques to better model the effect that urban areas have on meteorological circulations in and around large cities*
- *Implement an urban canopy scheme to account for:*
    - *increased surface roughness characteristics*
    - *changes in albedo*
    - *heat capacity*
    - *anthropogenic heat sources*
- *Explore several sources of data to use for implementing such schemes with focus on Washington, D.C. for our development, test, and validation efforts*
- *Configure and run a real-time forecast cycle for Washington, producing forecasts with and without the new urban capabilities*

Parameterization of urban canopy layer

- Urban canopy layer- the lowest layer of the atmosphere containing buildings, urban blocks, other man made structures as well as tall vegetation

- Current parameterization: through roughness parameter

- Goal of new parameterization:
    - to simulate a mean flow and turbulence within the canopy layer
    - to include dynamic effect of the urban area on a larger scale flow

- Approach consistent with the Mellor-Yamada turbulence parameterization option used in RAMS

- Based on Yamada (1982) forest canopy parameterization

- Same approach can be used for urban and vegetation canopies

Parameterization of urban canopy layer

- Modeling approach: analogous to flow in porous media
  - additional drag terms in the equation of motions within the canopy:

$$\frac{dU}{dt} - fV = \frac{1}{<\rho>}\frac{\partial p}{\partial x} + \frac{\partial}{\partial z}K_M\frac{\partial U}{\partial z} - \eta C_d a(z)U|U|$$

$$\frac{dV}{dt} + fU = \frac{1}{<\rho>}\frac{\partial p}{\partial y} + \frac{\partial}{\partial z}K_M\frac{\partial V}{\partial z} - \eta C_d a(z)V|V|$$

  - additional drag related production term in the equation for turbulent kinetic energy:

$$\frac{dE}{dt} = \frac{\partial}{\partial z}K_e\frac{\partial E}{\partial z} + P_S + P_B - \varepsilon + P_D$$

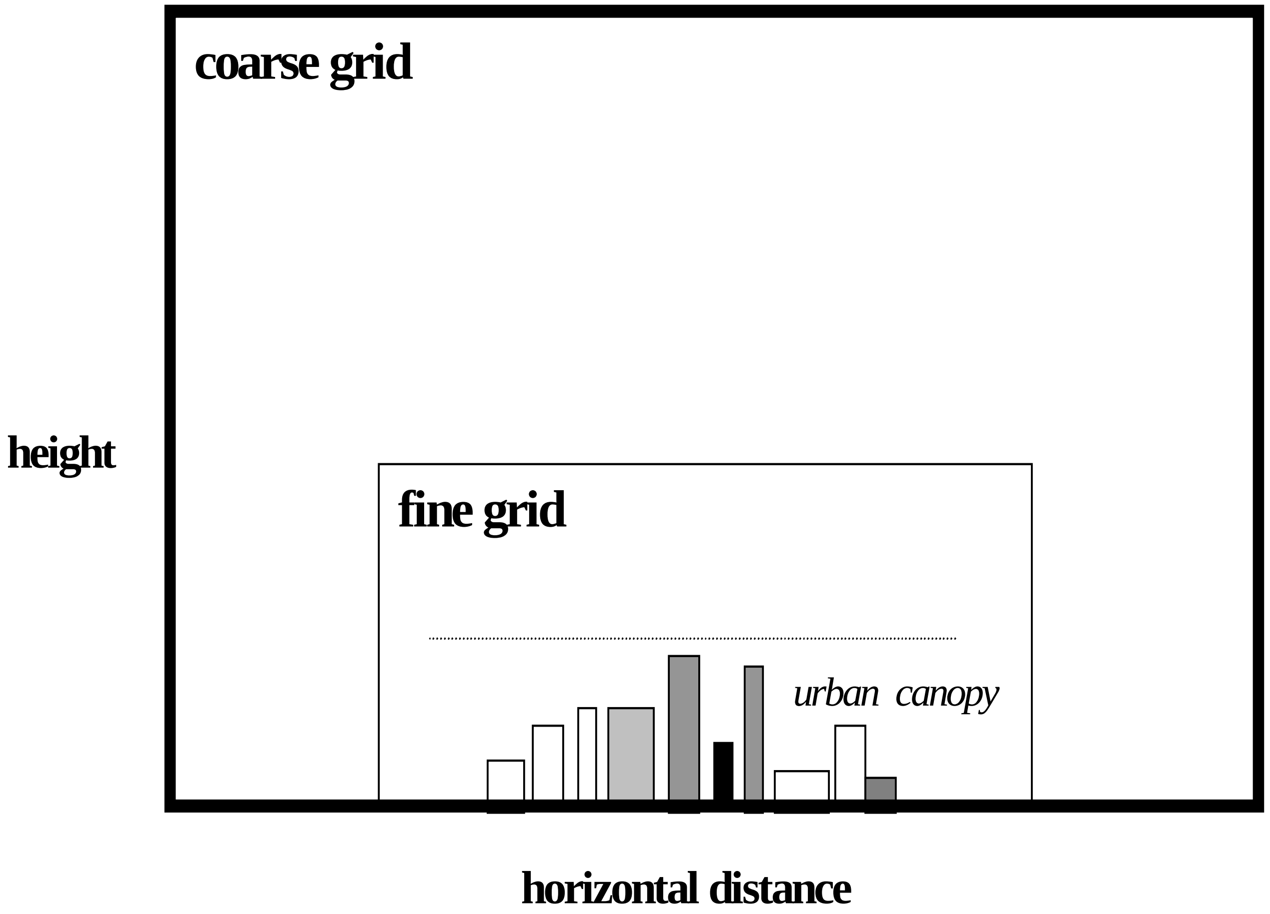
$$P_D = \eta C_d a(z)(|U^3| + |V^3|)$$

- Computer implementation:
  - Requires higher vertical model resolution within the canopy layer
  - Vertical nesting capabilities can be used over areas of interest

- Input data: spatial distributions of canopy height, density of canopy elements, a(z)

- Drag coefficient, C_D, dependent on shape of canopy elements (e.g., area of buildings facing the flow)

The Urban Canopy Concept



Ensemble Project

- Funded by DTRA
- Multi-model, multi-realization ensembles
- RAMS, MM5, COAMPS, OMEGA
- Goal: understand/measure uncertainty in meteorological-dispersion simulations

Ensemble Project

Task 1. Explore methods of initially perturbing the analyzed fields and determine the minimum number of forecasts required.

- Determine the best method of creating the ensemble to improve transport predictions and provide error estimation.
- Determine if re-balancing the fields will improve the transport forecast results.
- Determine the effect of computed forecast resolution on the resultant ensemble forecast skill.
- Determine number of members required for ensemble.

Ensemble Project

Task 2. Support, accumulate, and document available and ongoing forecasts including run parameters, input data, and output files.

- Develop a standard index and presentation format that will be used to document forecasts.
- Archive forecast data.

Ensemble Project

Task 3. Generate an ensemble of individual model meteorological forecasts to measure meteorological uncertainty.

- Create ensemble forecasts to supplement the forecasts in Task 2 using methods developed in Task 1.
- Create additional ensemble forecasts to supplement those initiated in Task 2 in areas/regimes not considered.

Ensemble Project

Task 4. Analyze and evaluate the resultant ensemble forecasts for accuracy and ability to represent the potential forecast variation.

- Combine the individual model ensembles to create a net ensemble.
- Produce a mean forecast from the ensemble fields.
- Produce probability maps—plots showing the probability of occurrence of a specified value.
- Compare with observations.

High-resolution Local Forecasting

Several projects dealing with various aspects:

- Providing 0-12 day hourly forecasts
- Emergency response at KSC
- Forecasts for special programs
  - Dispersion tests - White Sands
  - Counter proliferation drills
  - Demonstrations for utilities
- Local requirements (e.g, ski forecasts)
- Helps drive development of MOCCA