DETERMINING FUGITIVE DUST EMISSIONS FROM WIND EROSION

Presented by

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PROJECT TEAM

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OUTLINE

- Project Background & Overview
- Literature Review
- Wind Tunnel Studies
- Agricultural Considerations
- Data Sources
- Estimation Methodology
- Program Development
- Summary

BACKGROUND AND OVERVIEW OF PROJECT

- **WRAP Objectives**
- **Overall Objective to Compile PM10 and PM2.5 Emission Factors and Inventories From Windblown Dust for the Western Region**
- **Develop General Methodology to Facilitate Future Revisions and Control Strategy Development**
- **Develop Integrated SMOKE Processing Modules for PM10 and PM2.5 Emissions Modeling**

BACKGROUND AND OVERVIEW OF PROJECT

- Develop PM10 and PM2.5 Emission Inventory Applicable to the Western Region
- Ensure Consistency With 36-km MM5 Meteorology and BELD3 Databases
- Develop General Methodology to Facilitate Future Revisions and Control Strategy Development
- Develop Integrated SMOKE Processing Modules for PM10 and PM2.5 Emissions Modeling

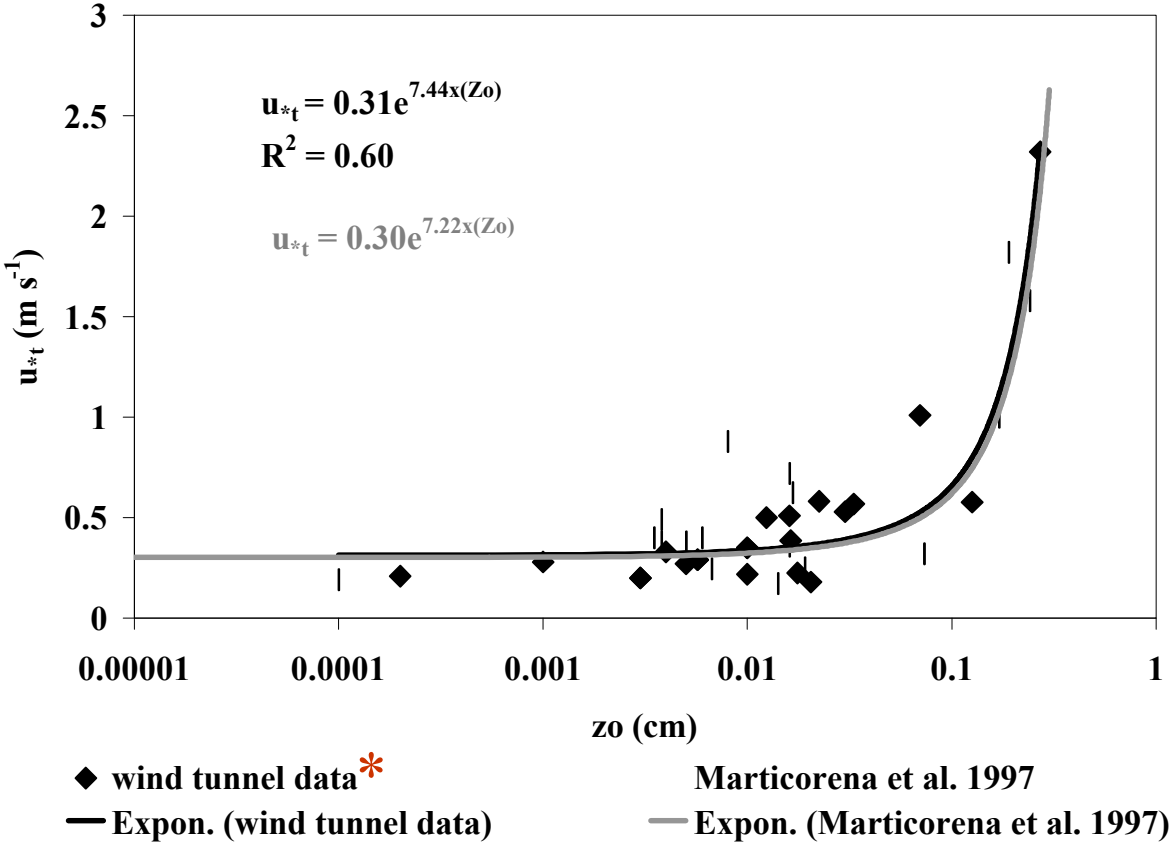
OVERVIEW OF TECHNICAL APPROACH

- Categorize Vacant Land Types
- Identify Wind Tunnel Emission Factors
- Develop Meteorological Data
- Develop Threshold Wind Velocities, Wind Events, Precipitation Events
- Develop Inventory Specific Emission Factors
- Apply Emission Factors to Vacant Land Categories

LITERATURE REVIEW

- Portable field wind tunnels have been used to investigate particle entrainment thresholds, emission potentials, and transport of sediment by wind.
- Major contributions of information on: 1) thresholds from Gillette et al. (1980), Gillette et al. (1982), Gillette (1988), Nickling and Gillies (1989), 2) emission fluxes from Nickling and Gillies (1989), James et al. (2001), Columbia Plateau PM_{10} Program (CP^3), Houser and Nickling (2001).
- Key information has also come from dust emission modeling (e.g., Alfaro et al., 2003) and desert soil characterization studies (e.g., Chatenet et al., 1996).

WIND TUNNEL STUDY RESULTS: Thresholds



*(Gillette et al., 1980; Gillette et al., 1982; Gillette, 1988; Nickling & Gillies, 1989)

Comparison between modeled relationship of threshold friction velocity and aerodynamic roughness length and wind tunnel data.

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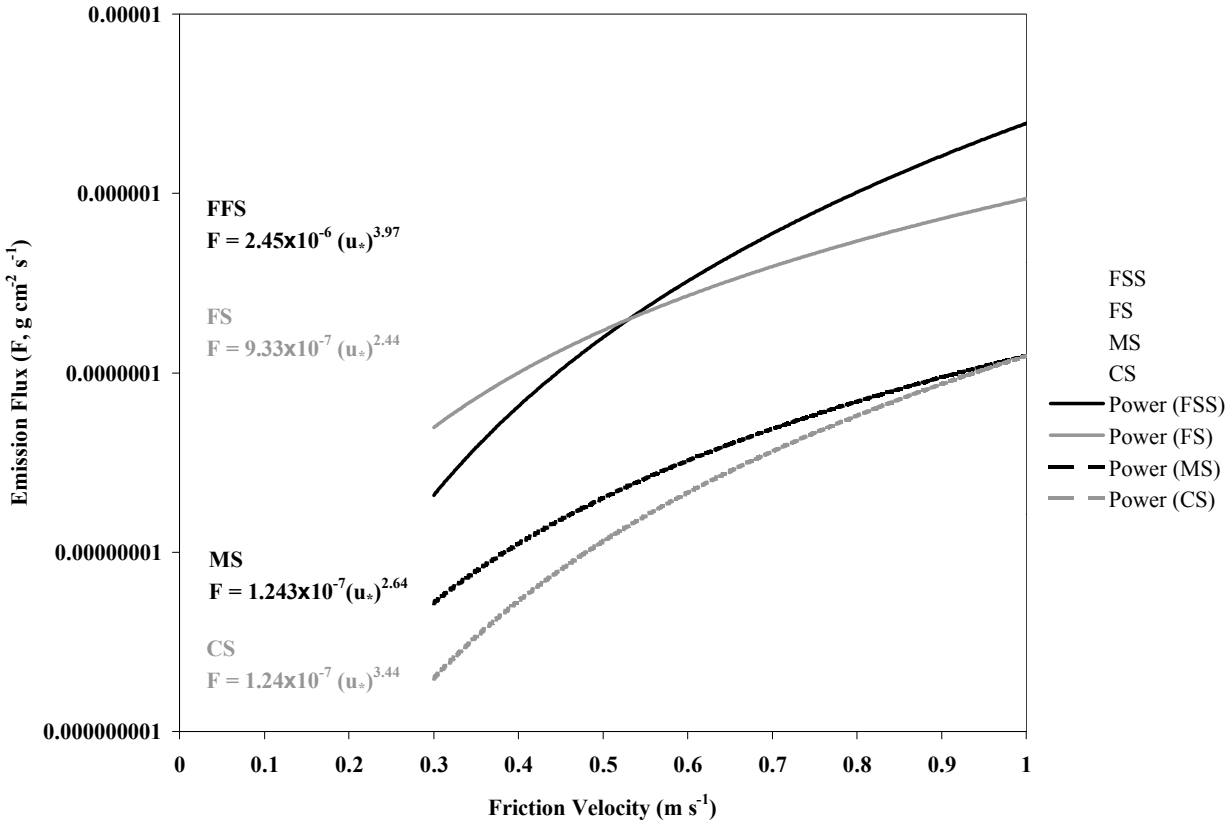
WIND TUNNEL STUDY RESULTS: Emissions



The emission flux as a function of friction velocity predicted by the Alfaro and Gomes (2001) model constrained by the four soil geometric mean diameter classes of Alfaro *et al*. (2003).

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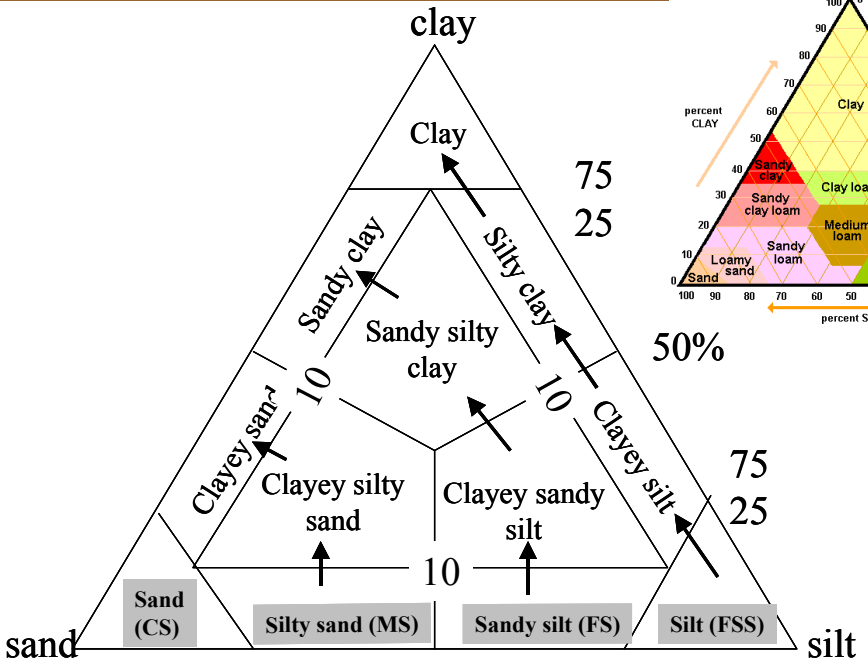
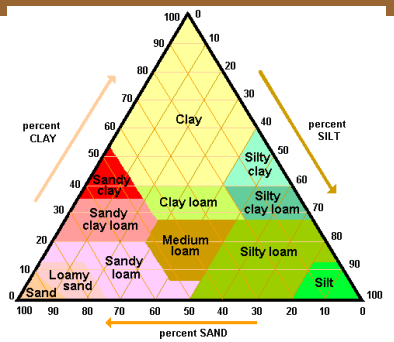
WIND TUNNEL STUDY RESULTS: Emissions as a function of texture.





Relations between the soil types deduced from aggregate size distributions of various desert soils and soil textural categories (Chatenet *et al*. 1996). The "gray" highlighted textural classes indicate the 4 sediment types; the arrows indicate the pathways linking these types to the other textures. These can be linked to the North American soil texture triangle.

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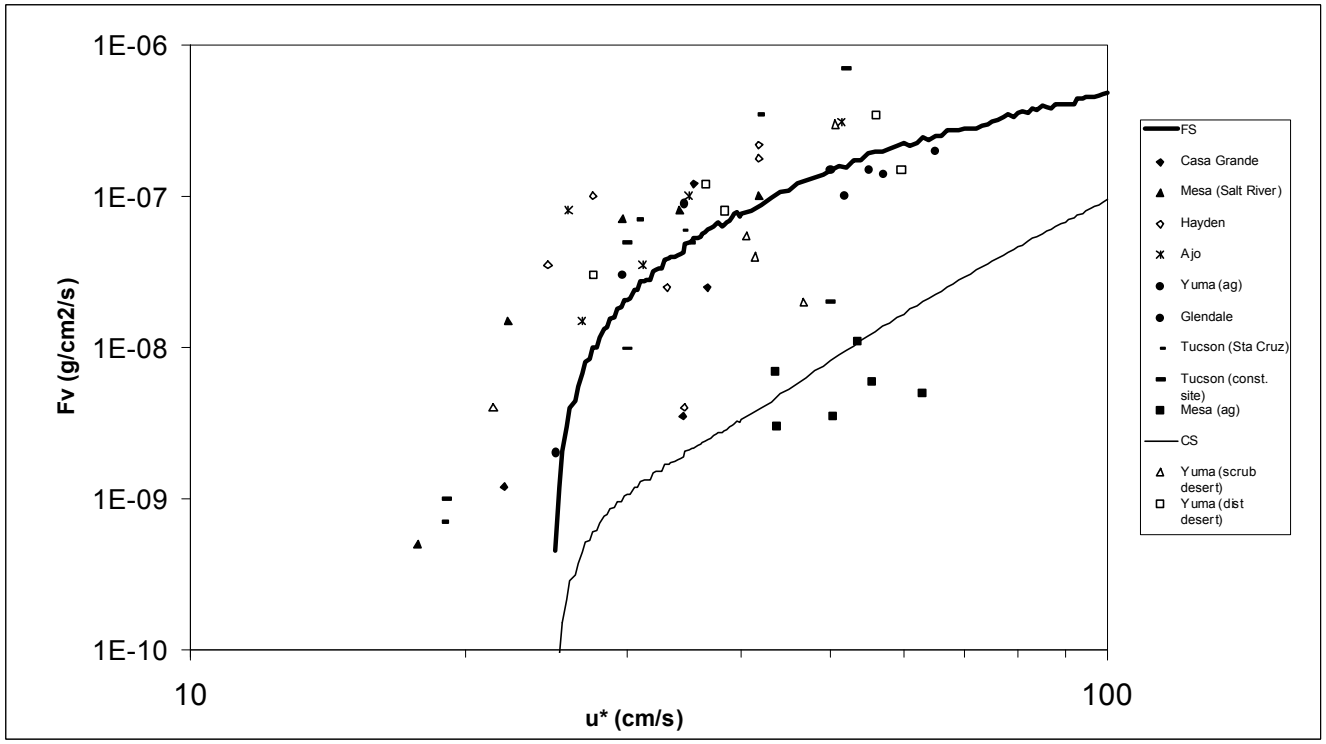
WIND TUNNEL STUDY RESULTS: Emissions



Comparison between model relationship for FS and CS sizes and the wind tunnel data of Nickling and Gillies (1989). Ten (out of 13) sites have a dust production potential similar to the FS model and one site (Mesa agricultural) is closely aligned with the CS model (after Alfaro *et al.*, 2003).

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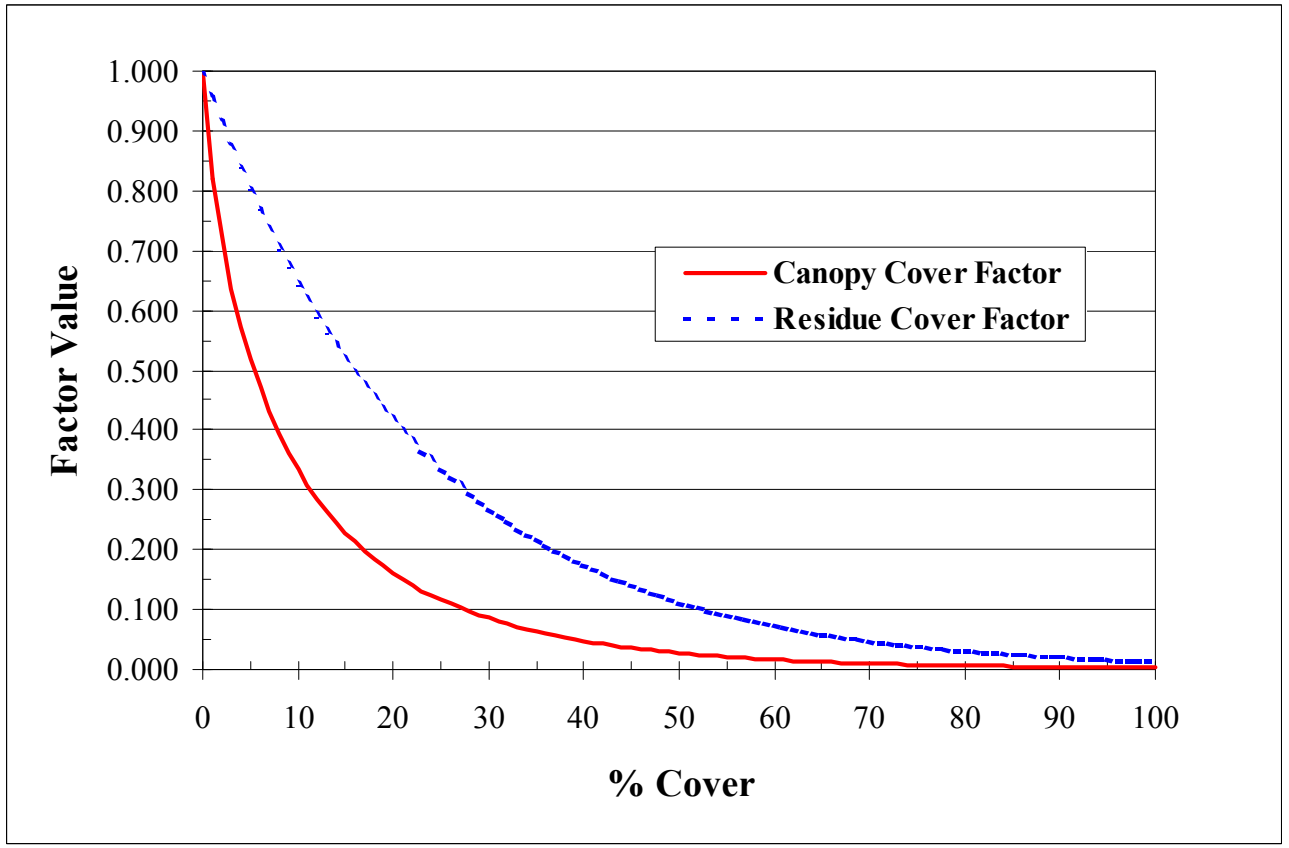
AGRICULTURAL CONSIDERATIONS

- **Non-climatic factors significantly decrease soil loss from agricultural lands**
- **Similar approach to CARB, 1997**
- **Seven "adjustment" factors simulate these effects:**
  - Bare soil within fields
  - Bare borders surrounding fields
  - Long-term irrigation
  - Short-term irrigation
  - Crop canopy cover
  - Post-harvest vegetative cover (residue)
  - Post-harvest replanting (multi-cropping)

Canopy Cover and Residue Cover Adjustment Factors



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AGRICULTURAL ADJUSTMENT FACTOR DEVELOPMENT

- **New regional data collected for WRAP project:**
  - Crop calendars with growth curves from Revised Universal Soil Loss Equation (RUSLE2) model
  - Residues remaining after harvest due to conservation tillage practices from Purdue's Conservation Technology Information Center (CTIC)
  - Irrigation events from crop budget databases
- **Factors applied by county/crop type, crop management zones (CMZs)**

DATA SOURCES

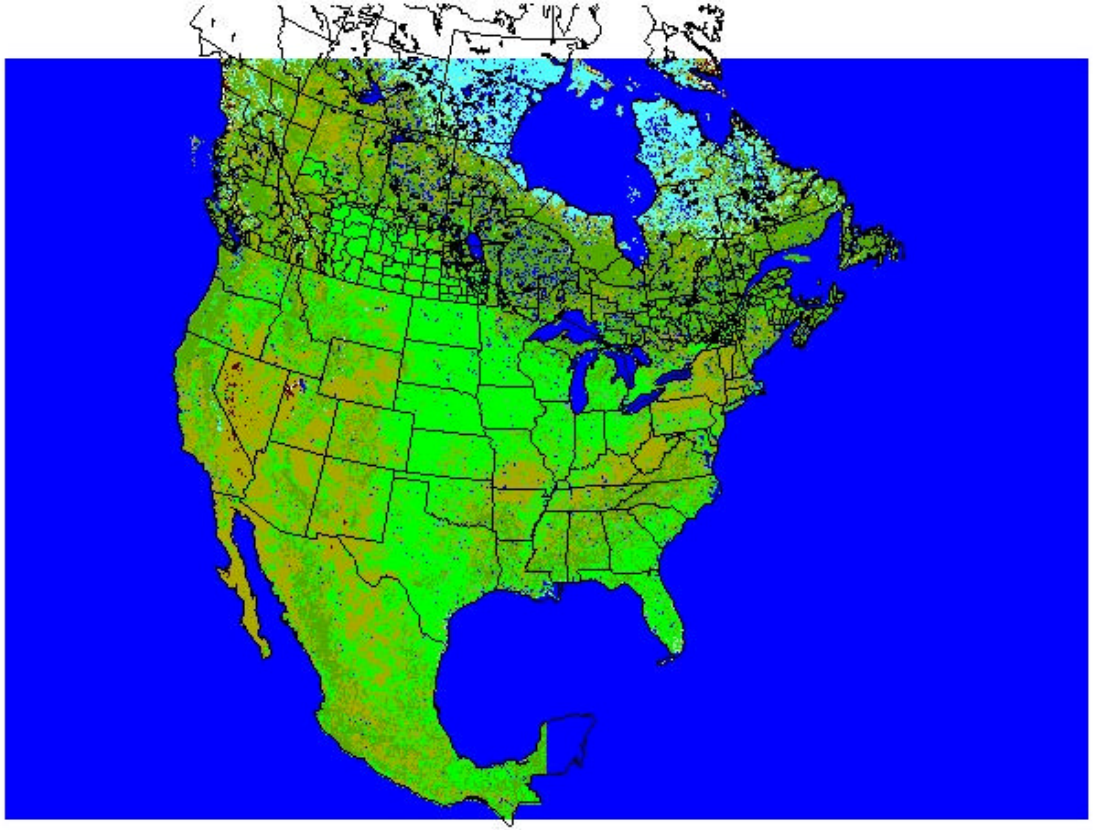
- **Land Use/Land Cover (LULC)**
  - Biogenic Emission Landcover Database (BELD3)
  - North American Land Cover Characteristics (NALCC)
- **Soils Characteristics**
  - State Soil Geographic Database (STATSGO)
  - Soil Landscape of Canada (SLC_V2)
  - International Soil Reference and Information Centre
- **Meteorological Data**
  - 1996 MCIP 36-km (Friction Velocity, Precipitation)

LAND USE/LAND COVER DATA

- **BELD3 LULC Data**

Summary	Total Area (Acres)	%	% excluding water
Urban	6,781,771	0.26%	0.34%
Agriculture	531,231,552	20.54%	26.35%
Shrub/grassland	720,022,464	27.84%	35.71%
Forest	741,902,639	28.69%	36.80%
Barren	5,801,931	0.22%	0.29%
Wetlands	681,383	0.03%	0.03%
Tundra	9,096,875	0.35%	0.45%
Snow&Ice	603,210	0.02%	0.03%
Water	569,829,853	22.04%	
Total	2,585,951,680	100.00%	
Total excluding water	**2,016,121,827**		**100.00%**

BELD3 USGS Land Use/Land Cover



- Urban Land
- Agricultural Land
- Shrub/Grassland
- Forest land
- Water Bodies
- Wetlands
- Barren Lands
- Tundra
- Snow & Ice

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SOIL CHARACTERISTICS

U.S. soil texture	Chatenet (1996) Soil Texture (from Chamley, 1987)	Chatenet (1996) Groupings
sand	sand	CS
loamy sand	sand	CS
sandy loam	silty sand	MS
sandy clay loam	clayey sand	MS
sandy clay	clayey sand	MS
(medium) loam	clayey silty sand	MS
clay loam	clayey silty sand	MS
silty loam	clayey sandy silt	FS
silty clay loam	clayey silt	FFS
silt	silt	FFS
silty clay	silty clay	FFS
clay	sandy clay	FS
	(10-50% sand, 75-50% clay)	
clay	sandy silty clay	FS
	(10-45% sand, 12-45% silt,	
	35-75% clay)	

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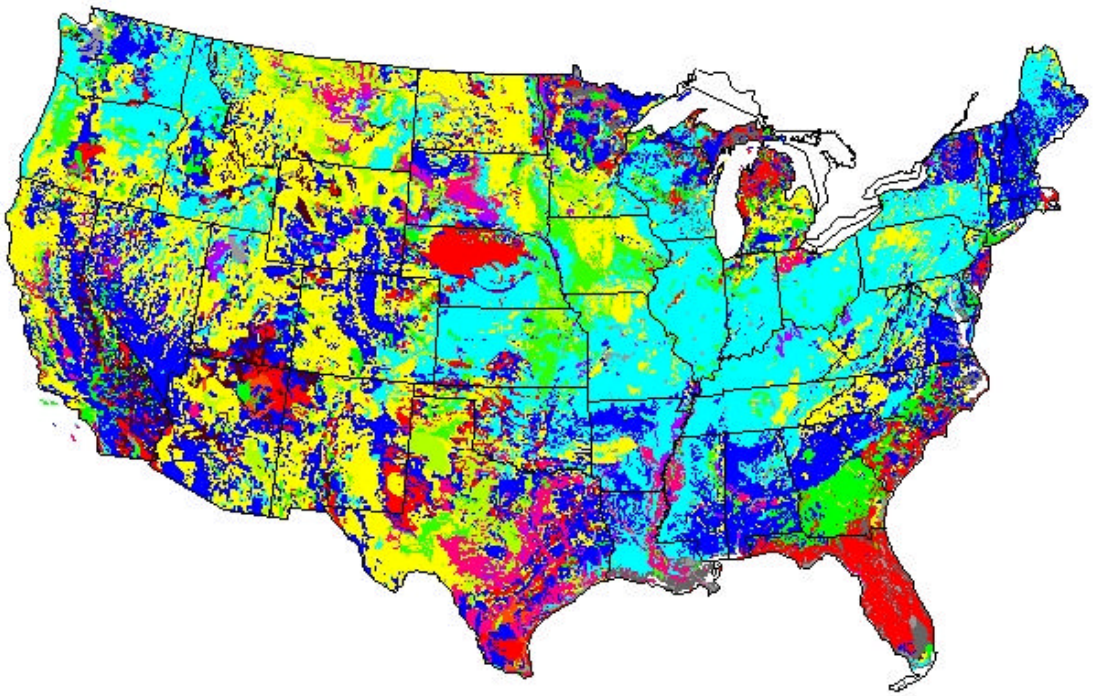
STATSGO Soils Texture Class



- ND No data
- S Sand
- LS Loamy sand
- SL Sandy loam
- SIL Silt loam
- SI Silt
- L Loam
- SCL Sandy clay loam
- SICLSilty clay loam
- CL Clay loam
- SC Sandy clay
- SIC Silty clay
- C Clay
- OM Organic materials
- W Water
- BR Bedrock
- O Other

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METEOROLOGICAL DATA

- **1996 MM5/MCIP**
  - 1996 Annual, hourly, gridded meteorology
  - 36-km horizontal resolution
  - Hourly friction velocities
  - Hourly precipitation rates

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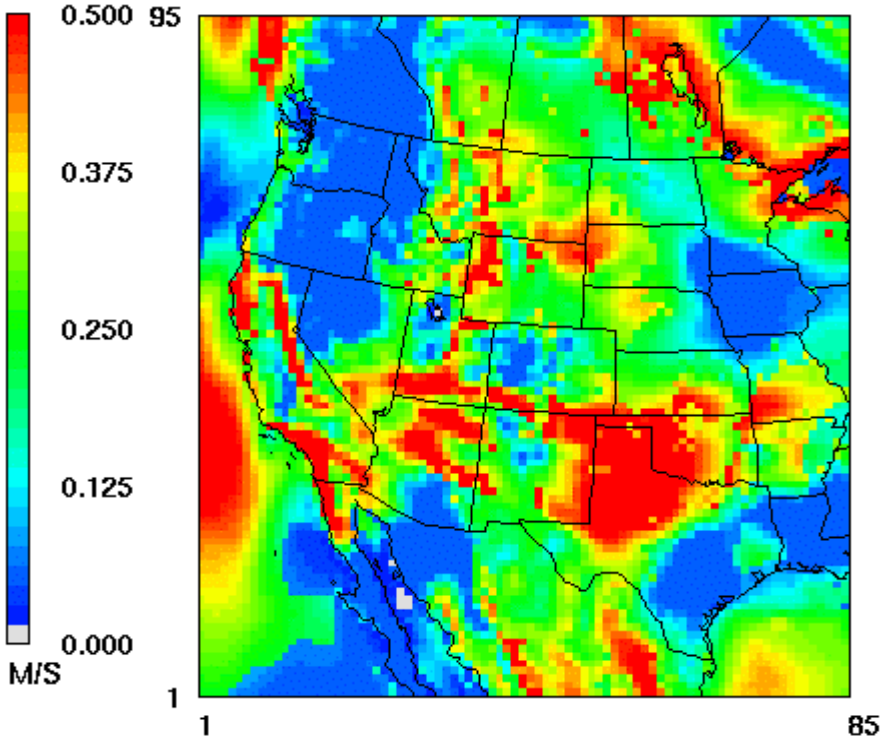
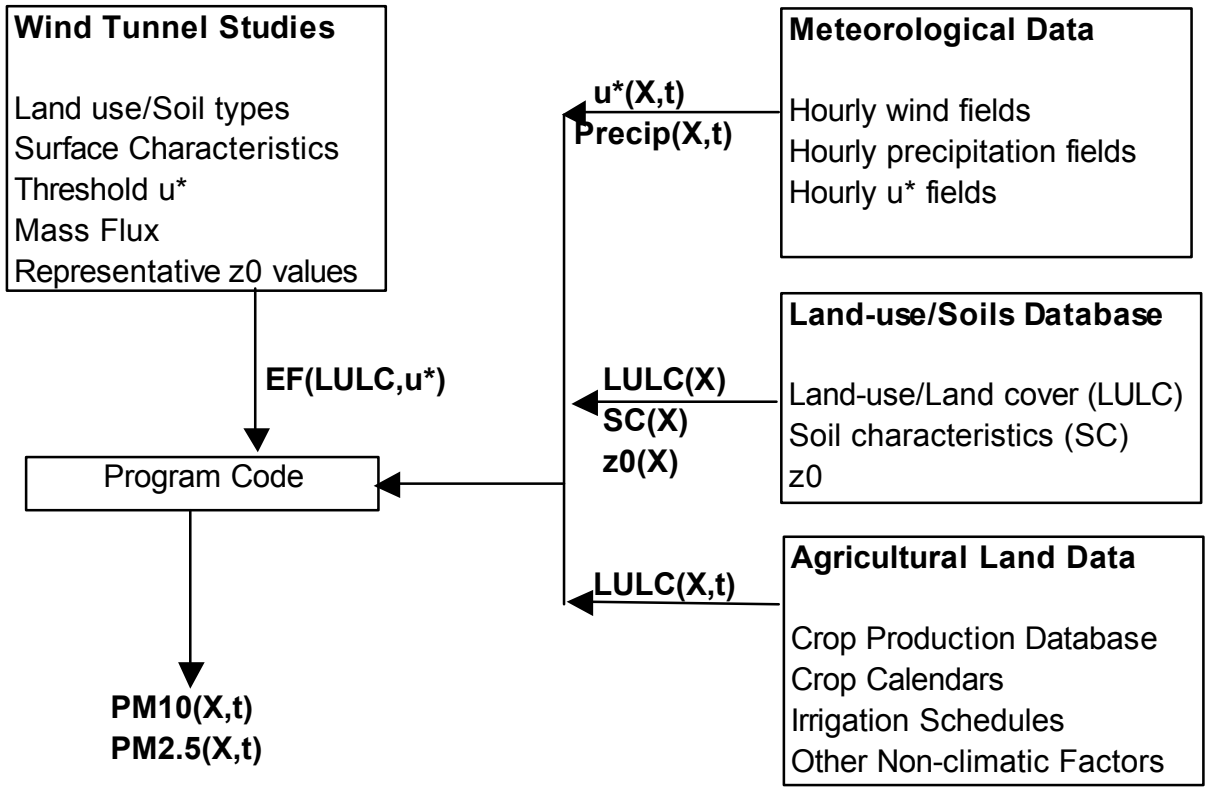
Friction Velocity

January 1, 1996



ESTIMATION METHODOLOGY



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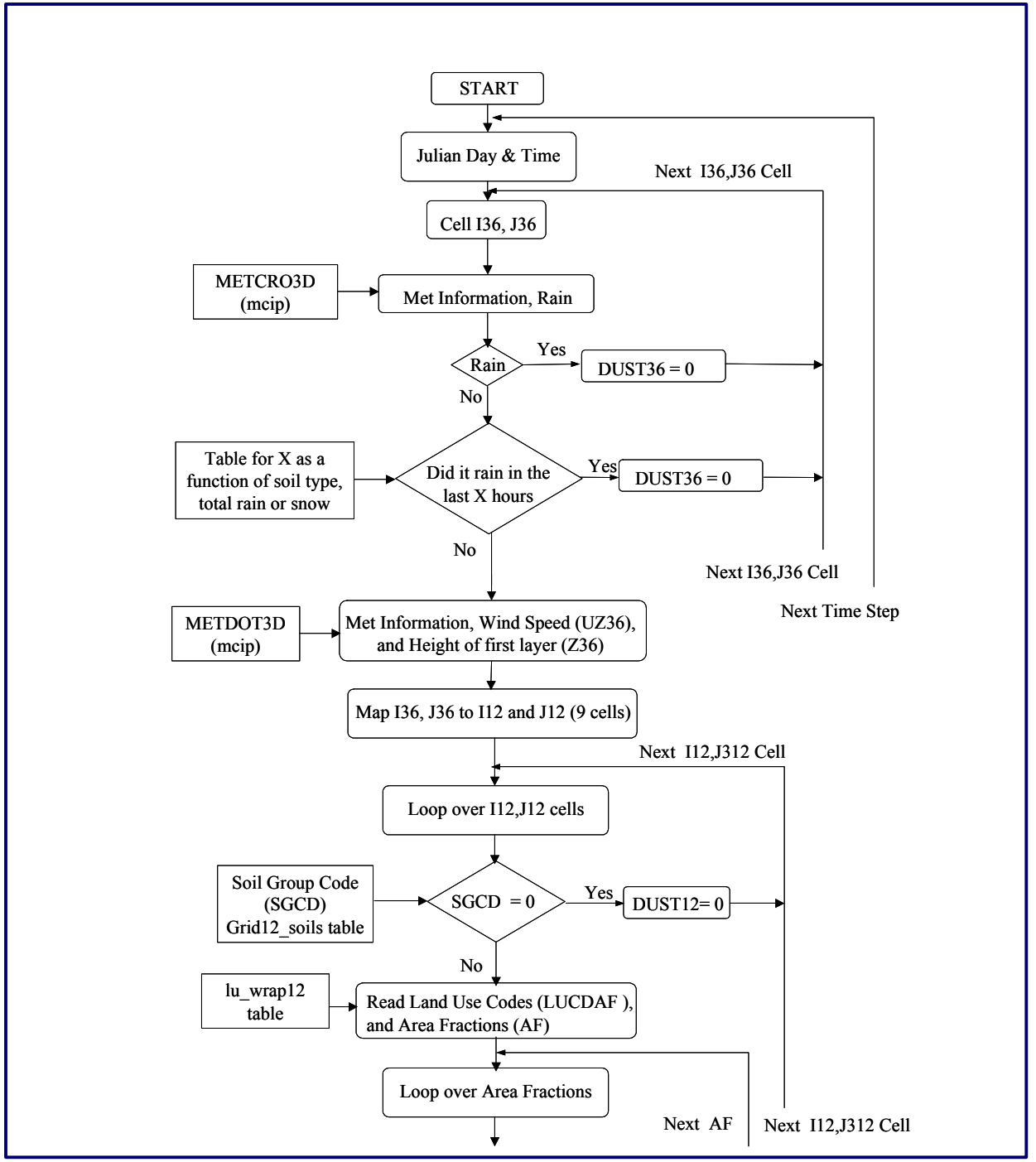
PROGRAM DEVELOPMENT



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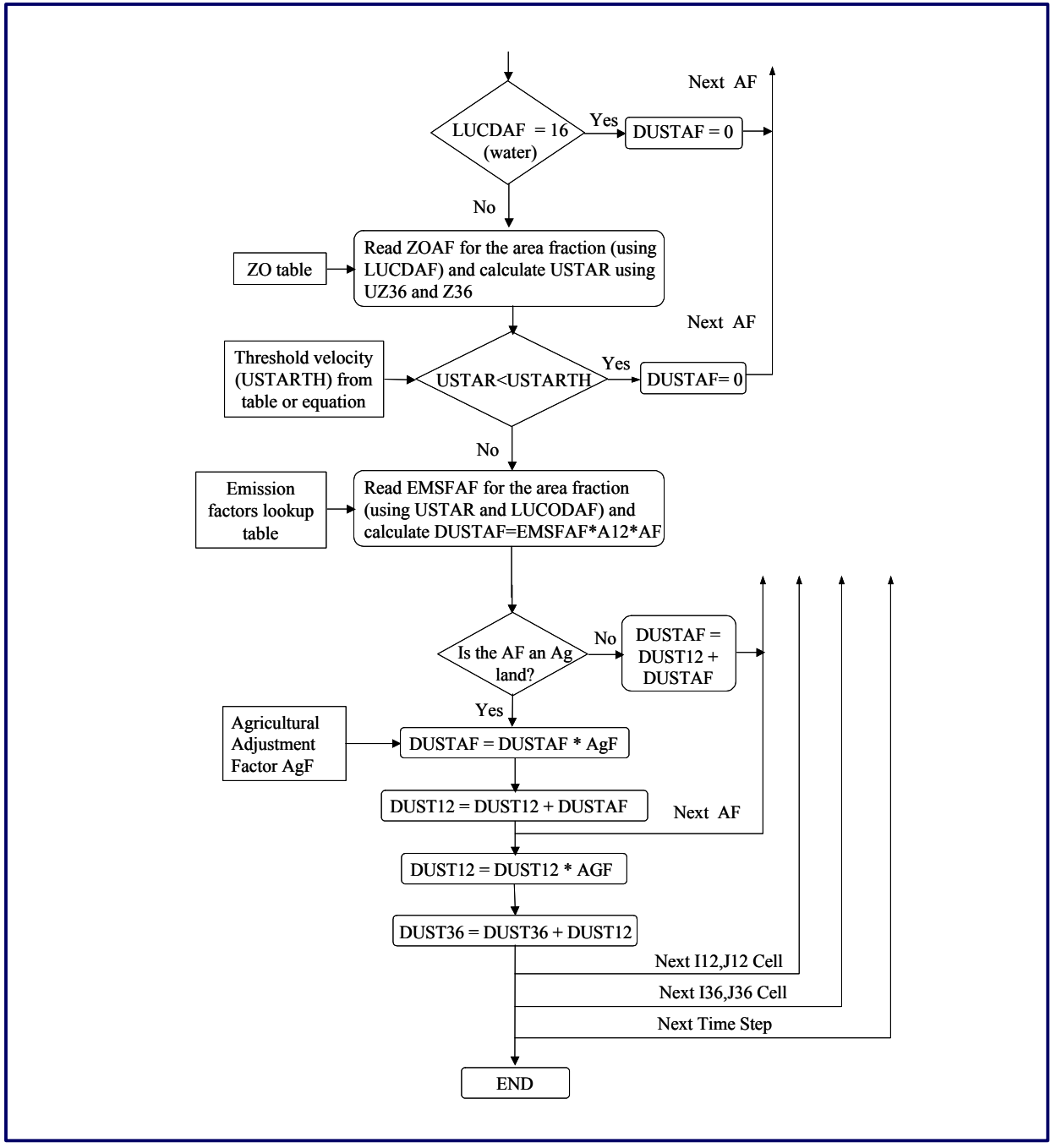

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SUMMARY

- Windblown dust emissions represent a significant portion of PM10 and PM2.5 emissions
- Applicable wind tunnel study results identified and evaluated
- Development of appropriate data sets
- Incorporation of non-climatic effects for agricultural lands
- Development of general emission estimation methodology
- Development of SMOKE compatible processing code