Design of an Oil Spill Model Using Modern Software Design Principles & Associated Field Studies

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Outline

• Model Design--Software Concepts
• 2001-2002 Field Studies at the Lock Lake tidal marsh
  – Significant Flow and Transport Features
  – Preliminary Simulations of Lock Lake
• Conclusions
Oil Spill

Volatilization

Oil Slick

Emulsified Oil

Dispersed Oil

Dissolution
Object Oriented Structure

• Natural alignment with Problem Definition
  – Polymorphism: Slicks vs. droplets
  – Inheritance: Multiple droplets, e.g.

• Vast improvement over serial languages:
  • Flexibility
  • maintainability
  • testing
  • QA/QC
  • Cost is in Additional Design Time
EPA’s Research Object-Oriented Oil Spill Model ---- ERO³S
Model Structure

- Input Parameter Values
- I/O Controls
- Graphics Routines
- Input data
- Results
- Nonlinear Equation Solver
- "Oil Slick"
- Solver Test
- I/O Spec & Results
- Inputs, Parameters
- Results
- RK Explicit Differential Equation Solver
- RKF1(2), ..., RKF 4(5), DP5(4)...

I/O Spec & Results

Input data

Results
Main Screen

EPA Research Object Oriented Oil Spill Model (ER03S)

About ER03S
ER03S
EPA's Research Object-Oriented Oil Spill Model
Ecosystems Research Division
National Exposure Research Laboratory
Office of Research and Development
United States Environmental Protection Agency
Athens, Georgia
October, 2000

Run  Resume  Pause  Stop

Select Model/Test Problem
- Viscous/Inertial Oil Slick
- Ext. Fay Equation Oil Slick
- Fehlberg Test Problem
- Euler Test Problem

Run  Resume  Pause  Stop
Input

EPA Research Object Oriented Oil Spill Model (ERO3S)

- **Crude**: Alaska North Slope
- **Leak Rate**: 1000.0 gal/day
- **Leak Duration**: 10.0 day
- **Simulation Duration**: 15.0 day
- **Wind Speed**: 1.0 knot
- **Current Speed**: 0.0010 m/s

Buttons:
- Run
- Resume
- Pause
- Stop
Lock Lake Tidal Marsh Study

- Gain understanding from studying field site
  - Component of model design
  - We have observed phenomena we could not have guessed
  - What data are critical for model-based studies?

- Test site for hypothesis testing
  - What would be the impact of an oil spill? Emulsified fuel spill?

- Parameter estimation from field studies
  - Measure dispersion coefficients
Lock Lake Tidal Marsh

- Small tidal marsh on south shore of Long Island
- Cooperative study between
  - US EPA, NYSDEC, Temple University
- Study transport in a setting influenced by
  - Tides, ground water discharge, freshwater inflows
Stilling Well Data

• Do predicted and observed tides match?
  – (Sandy Hook, NJ or Montauk Point, NY + time lag and height correction?)

• How much does response lag in the marsh?
  – Approximately 20 minutes at Dunton Lake
  – Is this data reproduced by the model?
Marsh Water Levels (9-2001)
Marsh Water Levels (10-2001)
Aquifer Connection
East Inlet Salinity & Temperature

Outlet Parameters 10-25-2001

Salinity (ppt)/Temperature (°C)

Time

- Salinity
- Temperature
Conclusions

• Lock Lake field study provides insight into transport behavior and contributes to model design
  – Preliminary Lock Lake data indicate
    • maximum propagation distance into marsh
    • mixing with fresh water
  – Inverted salinity profiles indicate fresh water inflows
  – Spring with abrupt salinity transition
Conclusions

• Preliminary model results correspond to observations
  – limited propagation distance into marsh
  – sensitivity analysis indicates topography controls flow

• Continuing work to link oil slick model to the flow model
2002 Field Work

- Long term logging of water levels, temperature and salinity in marsh
- Tracer study to generate testing data
  - Direct estimates of dispersion coefficients
  - Test data for water level model
  - Verification (or not) of transport hypothesis based on inlet data
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