DSM2 Sediment Transport Module

DSM2 User Group and CWEMF sponsored
Technical Advisory Committee Meeting
January 13, 2010

Jamie Anderson, Ph.D., P.E.

Department of Water Resources
Modeling Support Branch
Bay-Delta Office

Thanks for the refreshments

California Water and Environmental Modeling Forum Conference

- Feb 22-24, 2010
- Asilomar near Monterey
- STM update in DSM2 session
- http://cwemf.org

Agenda

- Welcome and Introductions
- Questionnaire
- Project Overview
  Jamie Anderson, DWR
- Project Progress
  Jamie Anderson, DWR and
  Fabian Bombardelli, UCD
- Issues for TAC Input
  Fabian Bombardelli, UCD
- Discussion and wrap up

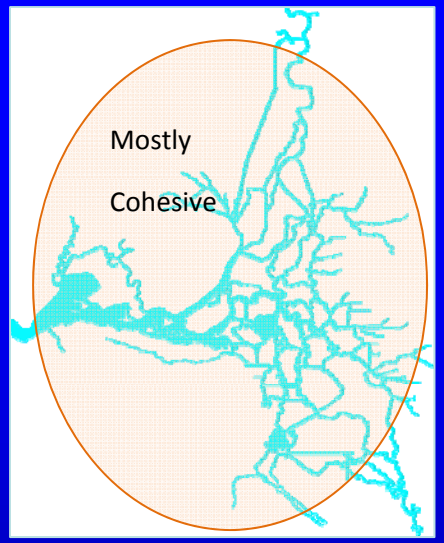
Web site for materials:
http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/stm/stm.cfm

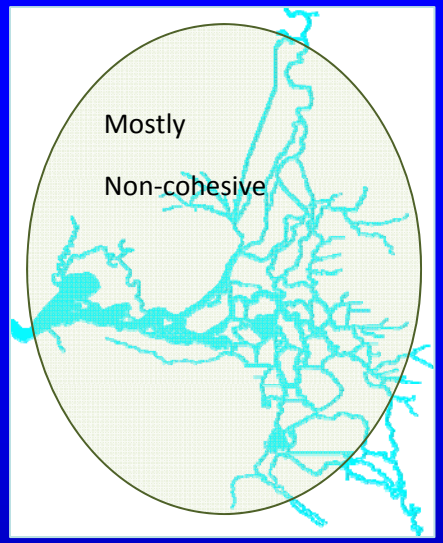
- Name
- Affiliation
- Interest / experience with sediment transport

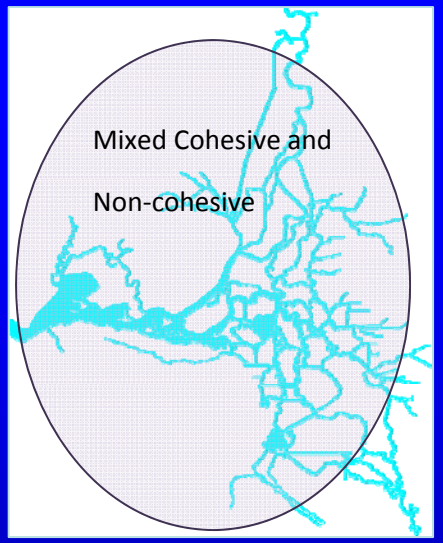
Questionnaire

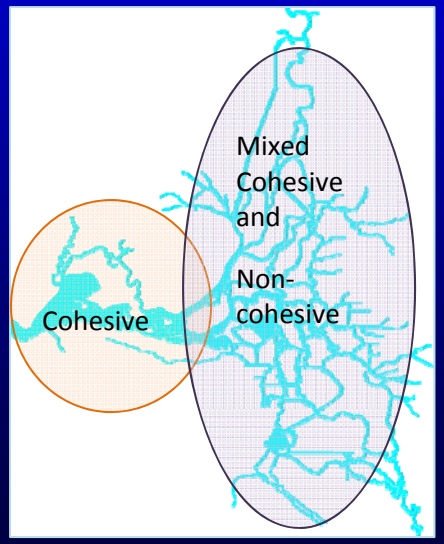
- What features are important to you for the Sediment Transport Model and its application to the Delta?
- Do you know of any data sets or Delta sediment transport studies that you think that the model development team should investigate?
- Is there anything else that you would like us to know and/or consider when developing STM?

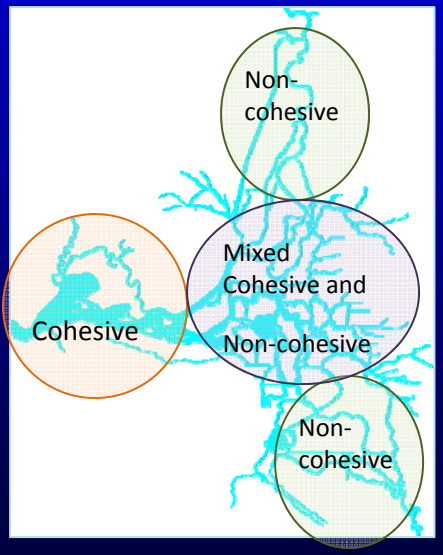
Questionnaire: Sediment in Delta

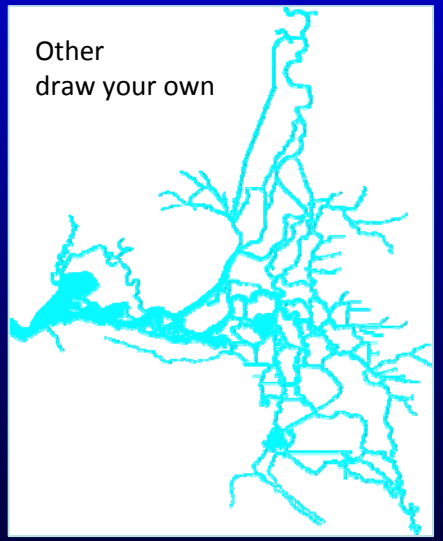












Issues Related to Sediment Transport in the Delta

- Dredging
- Levee failures
- Marsh restoration
- Turbidity / fish migration
- Mercury/heavy metal transport
- Channel bed level changes
  - Erosion
  - Deposition

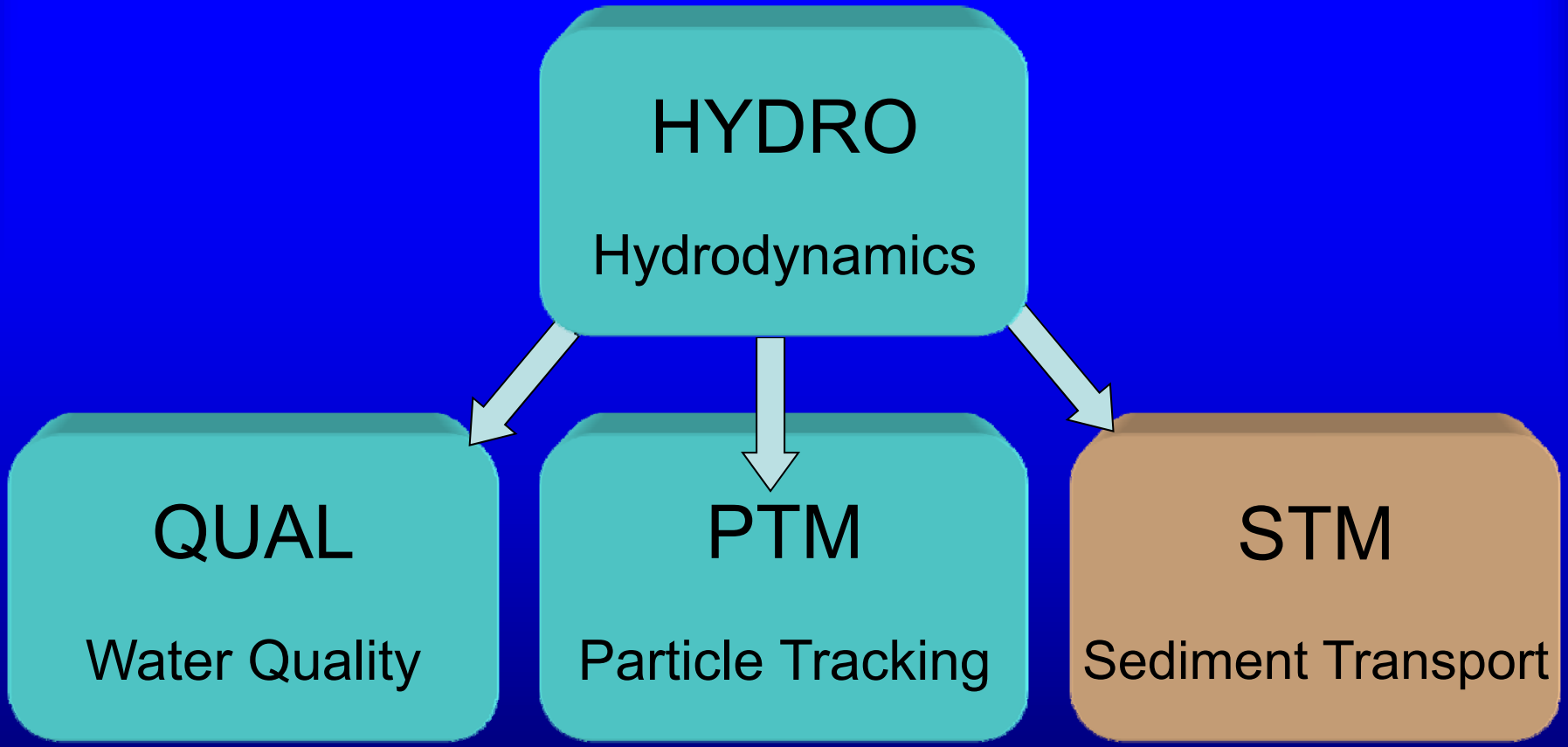
Contract to Develop STM

- 2 year MACHRO contract with UC Davis
- PI Fabian Bombardelli Civil & Env. Engineering
  - Graduate student Kaveh Zamani (modeling)
  - Graduate students Jamie Kohne & Joseph Waltz (data)*
- Project products
  - Web site with available sediment data in the Delta
  - Sediment Transport Module (STM) for DSM2
    - Suspended sediment and bed load
    - Multiple sediment class sizes
    - One-dimensional model

STM=Sediment Transport Module

*supported by another funding source

DSM2 Sediment Transport Module



STM Project Deliverables

- Establish Technical Advisory Committee
  - Meet twice a year
- 1-D sediment transport code-STM
- Website with available Delta sediment data
- Documentation
  - Progress reports
  - Complete code documentation and user manual
  - Journal articles
- Training on how to use STM

STM=Sediment Transport Module

STM Code Development Plan

- Flexible, modular design
- Separate input/output routines to aid in generalization to other codes
- Generalize Eulerian transport that could be adapted to other constituents

STM=Sediment Transport Module Eulerian=fixed frame of reference

Why did we create a new transport code instead of using QUAL?

- QUAL is a moving frame of reference (Lagrangian) model
- STM is a fixed frame of reference (Eulerian) model
  - Compatibility with other Eulerian codes/methods
  - Clean slate, develop testable code
  - Separate sources from transport
    - Sediment is one of the sources, but model could be applied to other sources as well
  - Sharing resources with a companion project
  - Future benefits
    - Could incorporate baroclinic term from HYDRO (couple HYDRO and transport)
    - Could be used for salinity based operating rules

STM Code Development Plan

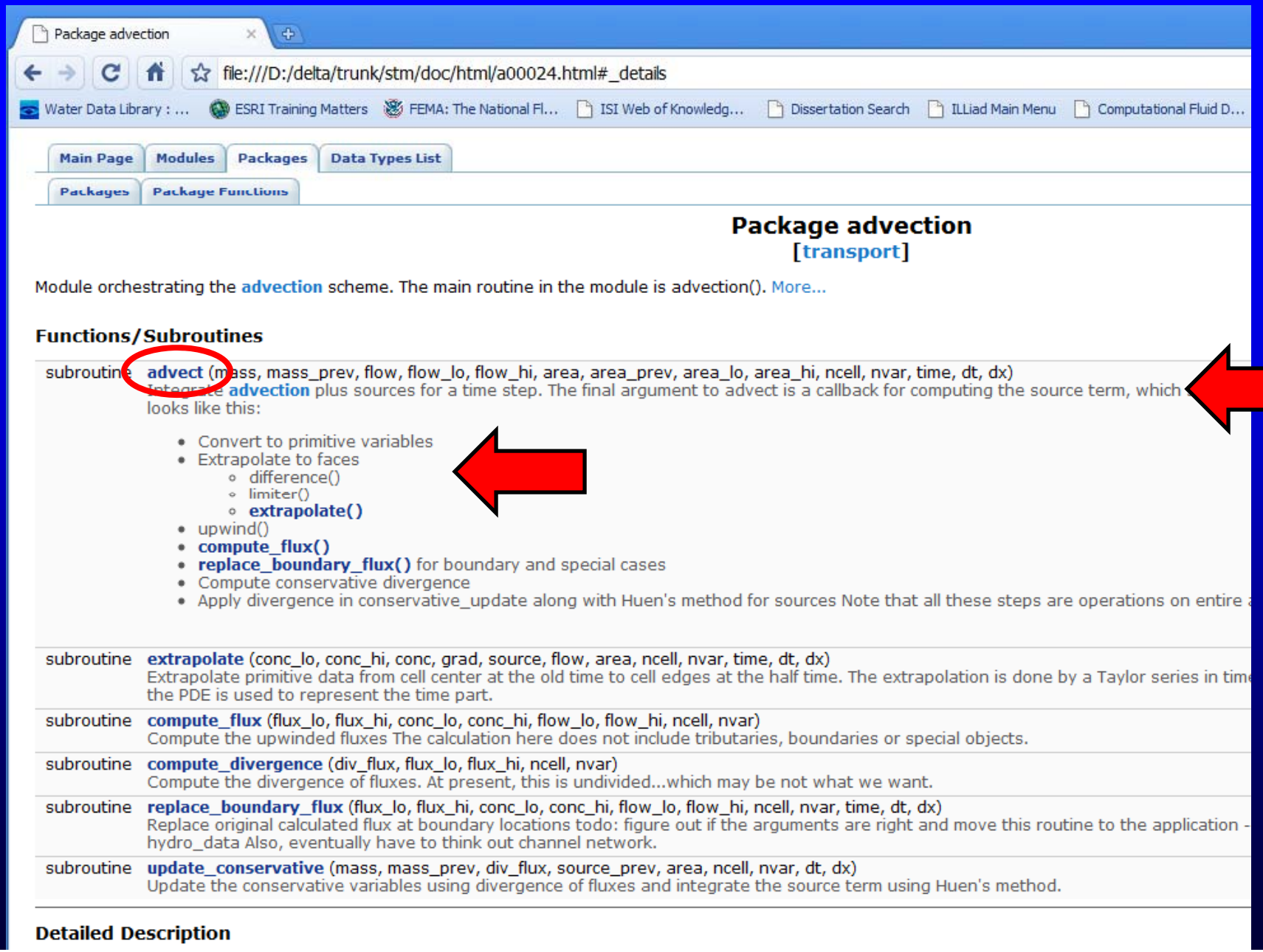
- Flexible, modular design
- Separate input/output routines to aid in generalization to other codes
- Generalize Eulerian transport that could be adapted to other constituents
- Self-documenting code using Doxygen

STM=Sediment Transport Module Eulerian=fixed frame of reference

Self-Documenting Code using Doxygen

```
!> Integrate advection plus sources for a time step.
!> The final argument to advect is a callback for computing the source term,
!> which should conform to the source_if interface
!> The algoritm looks like this:
!>    - Convert to primitive variables
!>    - Extrapolate to faces
!>        - difference()
!>        - limiter()
!>        - extrapolate()
!>    - upwind()
!>    - compute_flux()
!>    - replace_boundary_flux()   for boundary and special cases
!>    - Compute conservative divergence
!>    - Apply divergence in conservative_update along with Huen's method for sources
!>   Note that all these steps are operations on entire arrays of values -- this ke
subroutine advect(mass,      &
                  mass_prev,&
                  flow,      &
                  flow_lo,   &
                  flow_hi,   &
                  area,      &
                  area_prev,&
                  area_lo,   &
                  area_hi,   &
                  ncell,     &
                  nvar,      &
                  time,      &
                  dt,        &
                  dx)
```

Self-Documenting Code using Doxygen

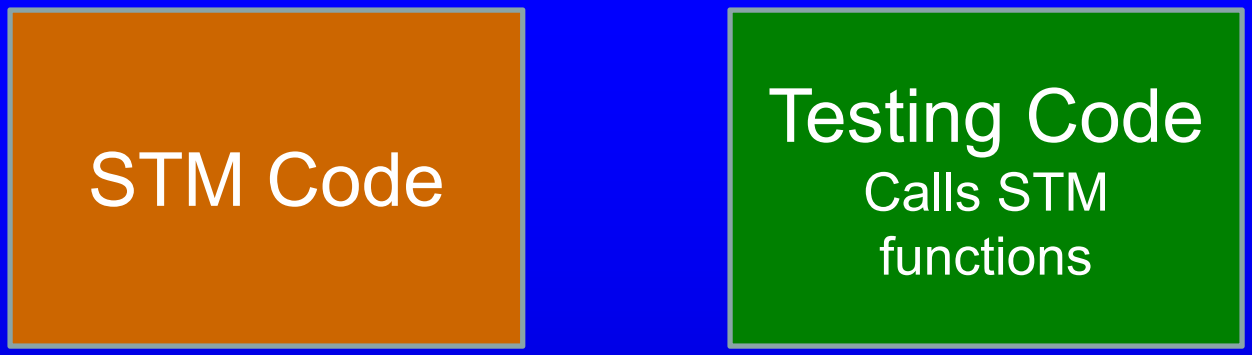


STM Code Development Plan

- Flexible, modular design
- Separate input/output routines to aid in generalization to other codes
- Generalize Eulerian transport that could be adapted to other constituents
- Self-documenting code using Doxygen
- Companion testing routines

STM=Sediment Transport Module Eulerian=fixed frame of reference

STM Code Testing



- Each function in STM has companion testing code
- Code and analytical tests
- Test wide range of scenarios
- Produce report of pass/fail result for all tests
- Run tests regularly,
  in future automatic daily running of tests

STM=Sediment Transport Module

Fortran Unit Test Framework (FRUIT)

- Unit testing
  - a software verification and validation method in which a programmer tests if individual units of source code

- FRUIT

  - open source

  - written in Fortran 95

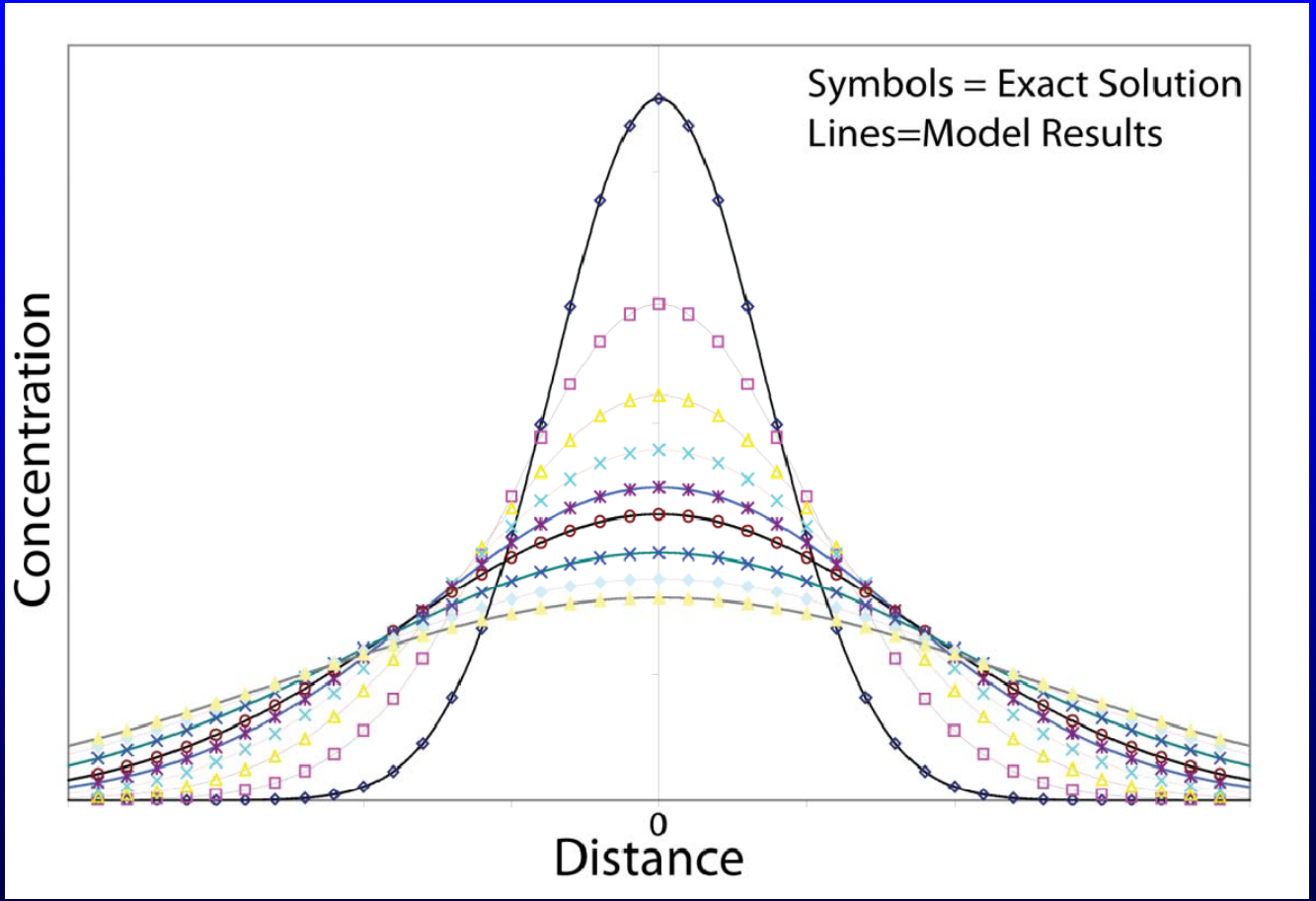
  - has assertion (true/false pass/fail), fixture, setup, teardown, report, spec generation, driver generation

Code Tests

- Test all functions in the code
- Provide input with known output, call code function ⇨ pass/fail
- Test common and more importantly uncommon uses of that function
- Example: Gradient
  - High value to low value, low value to high value
  - Low value to low value, high value to high value
  - End of channels
  - Positive and negative values, mixture of values

Analytical Test: Diffusion of one unit of mass

Symmetrical C=1/ΔX at X=0 c=0 everywhere else

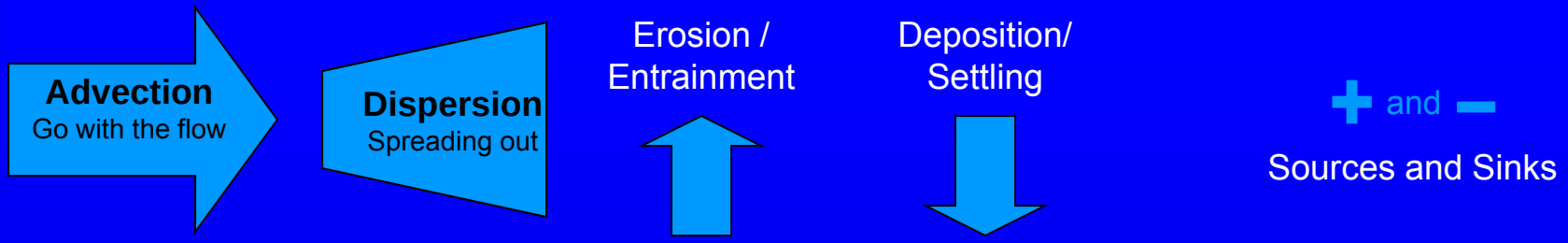


STM Code Development Plan

- Flexible, modular design
- Generalize Eulerian transport that could be adapted to other constituents
- Self-documenting code using Doxygen
- Companion testing routines
- Assistance with code development from DWR staff
  - lead by Kevin Kao
    guidance from Eli Ateljevich and Nicky Sandhu
  - version control
- Training on use of the model

STM=Sediment Transport Module Eulerian=fixed frame of reference

Sediment Transport Processes



Advection | Dispersion | Erosion | Deposition | Source/Sink | Tributaries

Progress to Date: Single Channel

Advection | Dispersion | Erosion

Next step: Complete single channel model

Advection | Dispersion | Erosion | Deposition | Source/Sink | Tributaries

Next step: Extend model to a channel network

Highlights from TAC July 2009: Code

- Initial STM plan
  - Suspended sediment
  - Single sediment particle size
  - Deposition only
  - STM runs after DSM2 HYDRO and doesn't provide info to HYDRO
- Revised STM plan after TAC
  - Suspended sediment
  - Ability for multiple sediment particle sizes, use 2 initially
  - Deposition and erosion
  - STM runs after DSM2 HYDRO and doesn't provide info to HYDRO
- Deposition dominates over longer time scales, but on a tidal timescale, both erosion and deposition are important
- Resolving bed forms would not be possible in STM due to the spatial scale of DSM2
- STM may never need to be integrated with HYDRO because bed changes in the Delta are typically small relative to the depth and flow

Highlights from TAC July 2009: Data

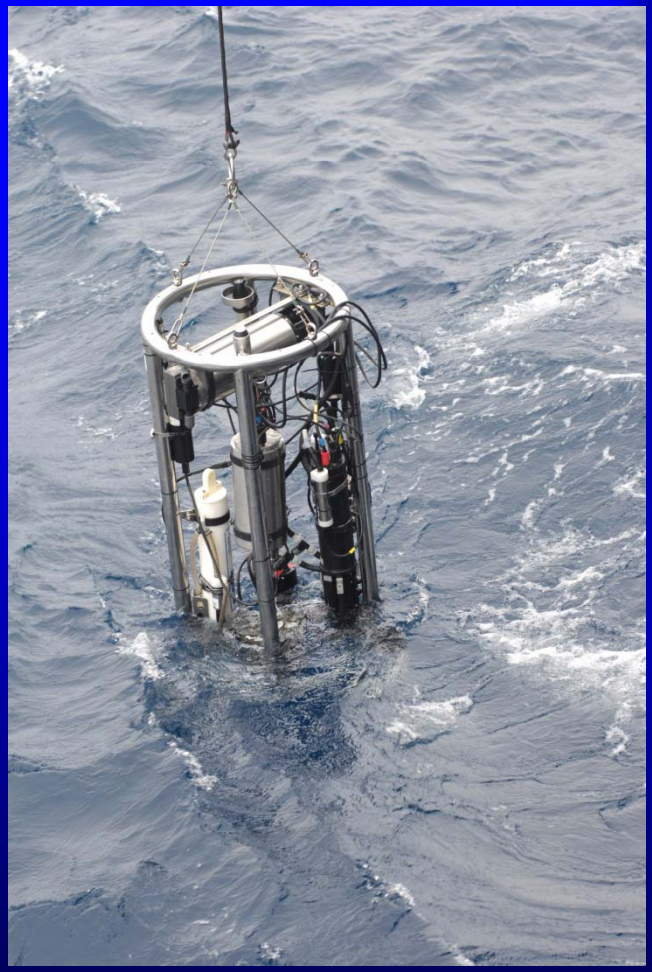
- TAC members provided feedback on available field data sets
- Partial data sets can be tricky. Where, when and how the data were collected is essential for putting the data in perspective, especially in a tidal system (spring/neap, ebb/flood)
- It is important to identify data needs and strategies for dealing with data deficiencies.
- Rick Oltmann from USGS looked at flow and sediment data around 2000 and found relating the data to be very challenging and frustrating.

Available Field Data

What data do we need?

What data are available?

How do we deal with any data deficiencies?



- Compiled by Jamie Kohne and Joseph Waltz at UCD
- Report and links will be posted on the web

Technical Details


Thank You!
Jamie Anderson
jamiea@water.ca.gov
916-654-5455
Fabian Bombardelli
fabianbombardelli2@gmail.com
530-752-0949
Photo by Ralph Finch Jan 4, 2006