Lagrangian analysis of the Chao Phraya River estuarine circulation

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Outline

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- Materials and methods
  - The model and study domain
  - Lagrangian Particle Tracking
- Results
  - Model validation
  - Transit times
  - Dispersion and diffusivity of the Chao Phraya River estuarine circulation
- Conclusions

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Background

- Chao Phraya River
  - Main fresh water supply in the middle region of Thailand
  - agriculture, industry and waterworks
  - Tidal influent salt water intrusion
- The United Nation Sustainable development goal (SDG) 2030 Agenda
  - 6 : conservation and sustainable use of management of water and sanitation
  - 14 : the oceans, seas, and marine resources

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The model and study domain

SCHISM

- Semi-implicit Cross-scale Hydroscience Integrated System Model
  - Modified from SELFE model
  - Open-source
  - Semi-implicit Finite-Element and Finite-Volume method
  - Based on Naiver-Stokes equations

$$\nabla \cdot \mathbf{u} + \frac{\partial w}{\partial z} = 0, \ \ (\mathbf{u} = (u, v))$$

$$\frac{D\mathbf{u}}{Dt} = \mathbf{f} - g\nabla\eta + \frac{\partial}{\partial z}\left(\nu \frac{\partial \mathbf{u}}{\partial z}\right)$$

http://ccrm.vims.edu/schismweb/

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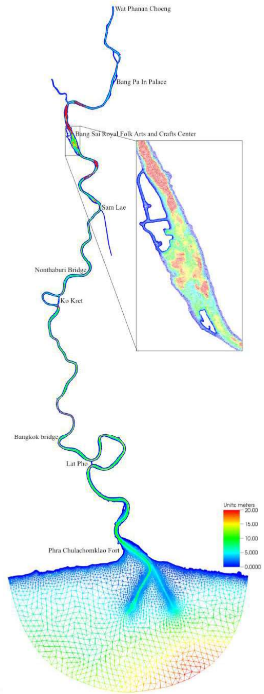
The model and study domain

Domain

- Lower Chao Phraya River
  - Approximately 150 kilometers from Amphoe Phra Nakhon Si Ayutthaya to Chao Phraya River mouth plus 20 km into the upper Gulf of Thailand
  - 176,959 elements and 97,401 nodes in total
- Scenario

Scenario No.	Scenario	
	Upstream water discharge (cms)	Water supply canal
1	80	Open
2	90	Open
3	100	Open
4	800	Open
5	1,500	Open
6	2,840	Open
7	3,700	Open
8	100	Closed



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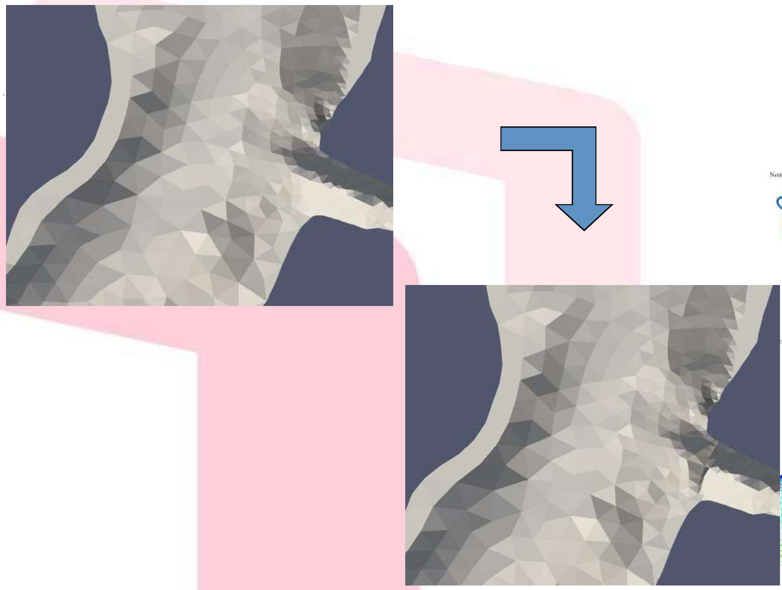
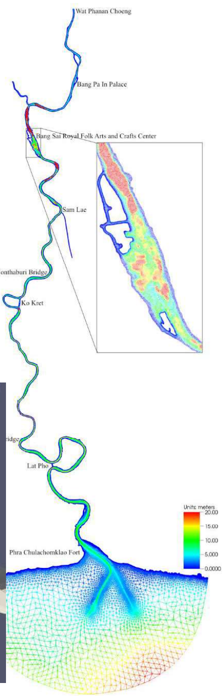
The model and study domain

Scenario





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Lagrangian Particle Tracking

- Lagrangian Particle Track (LPT)
  - Tracing virtual particle movement
  - Offline type

$$\frac{d\boldsymbol{X}}{dt} = \boldsymbol{v}(\boldsymbol{X}(t), t)$$

Lagrangian Particle Tracking

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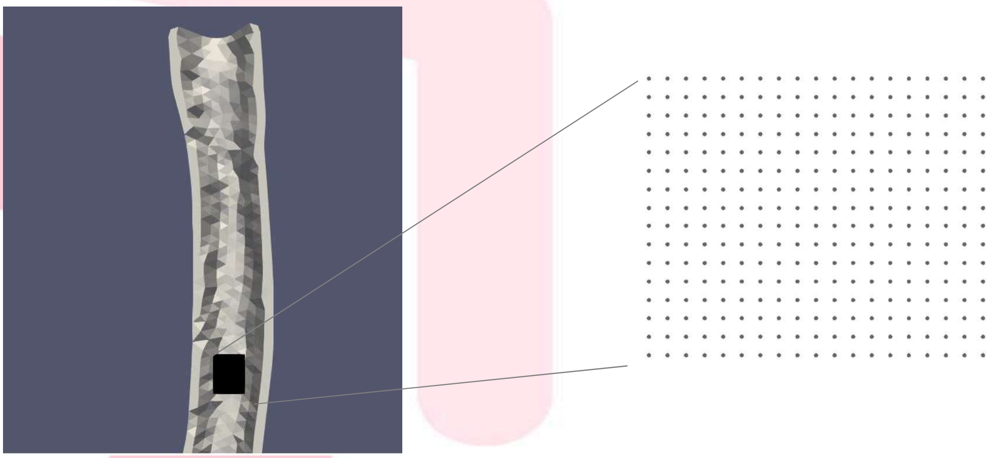


Lagrangian Particle Tracking

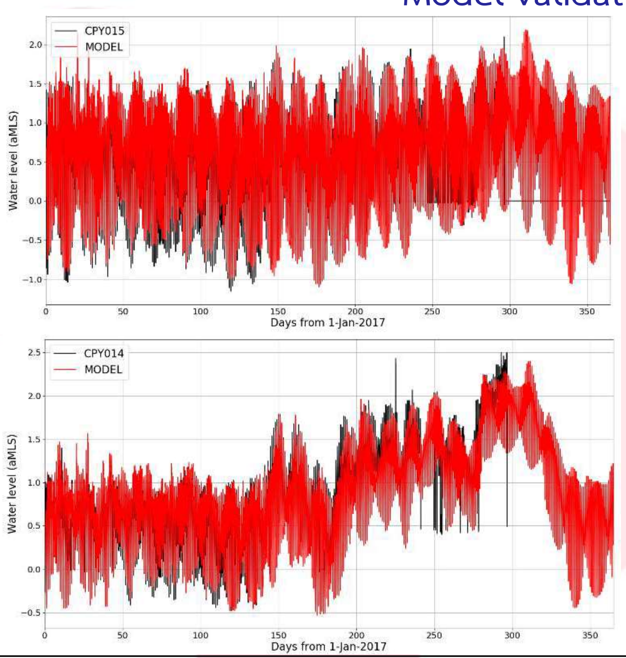
- Transit times
  - Total time particle spend between release point and sea
- Dispersion and Diffusivity
  - Particle dispersion and its rate of change
  - single-particle diffusivity and double-particle diffusivity

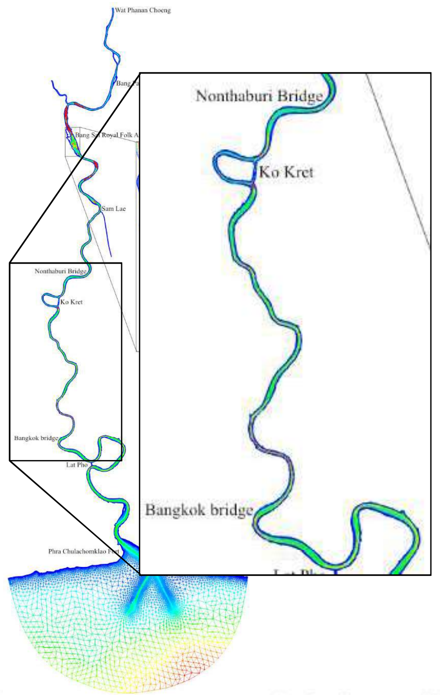
$$\kappa(t) \equiv \frac{1}{2}\frac{d}{dt}\langle \boldsymbol{X}^2(t)\rangle$$

$$\kappa_R(t) \equiv \frac{1}{2}\frac{d}{dt}\langle \boldsymbol{r}^2(t)\rangle = \frac{1}{2}\frac{d}{dt}\left\langle \sum_{m\neq n}\left[\boldsymbol{X}^{(m)}(t) - \boldsymbol{X}^{(n)}(t)\right]^2\right\rangle$$

RESULTS

Model validation

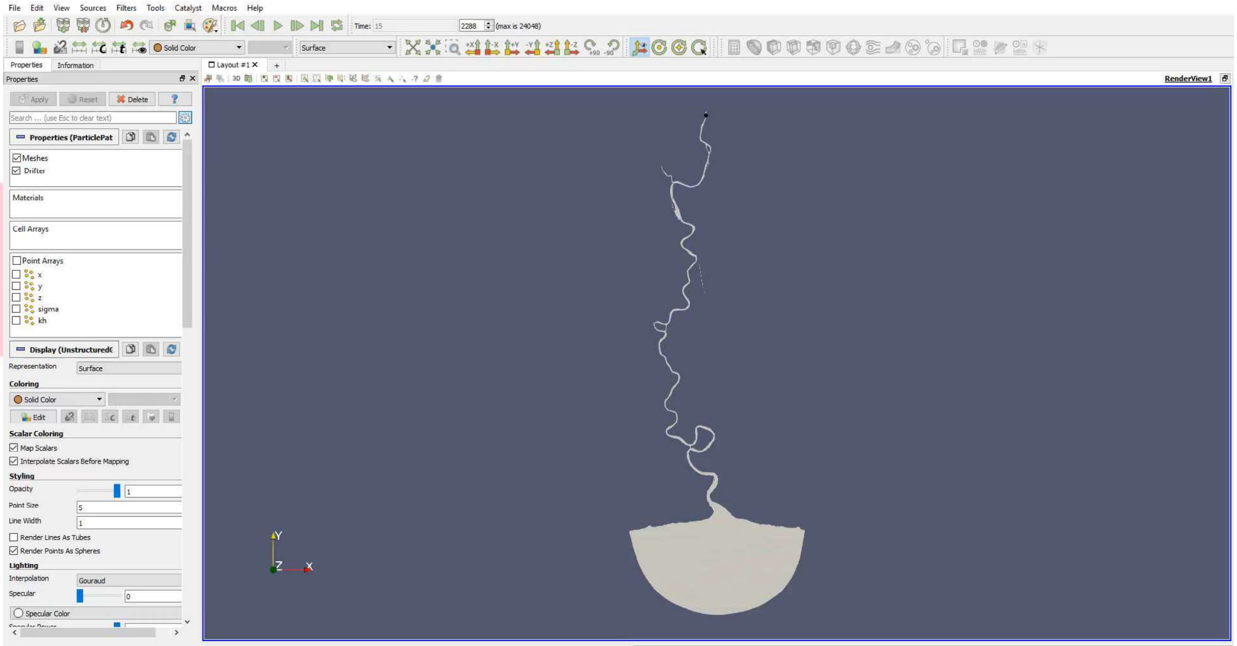




Large Scale Simulation Research

RESULTS

a member of NSTDA



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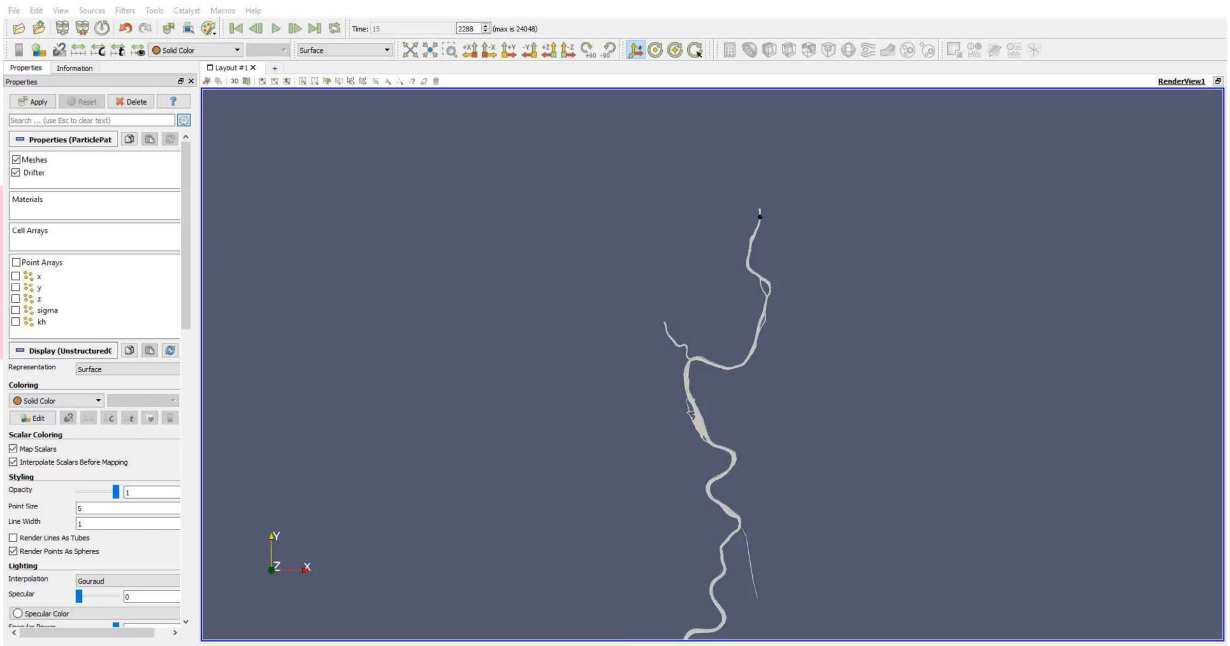
Large Scale Simulation Research

RESULTS

a member of NSTDA



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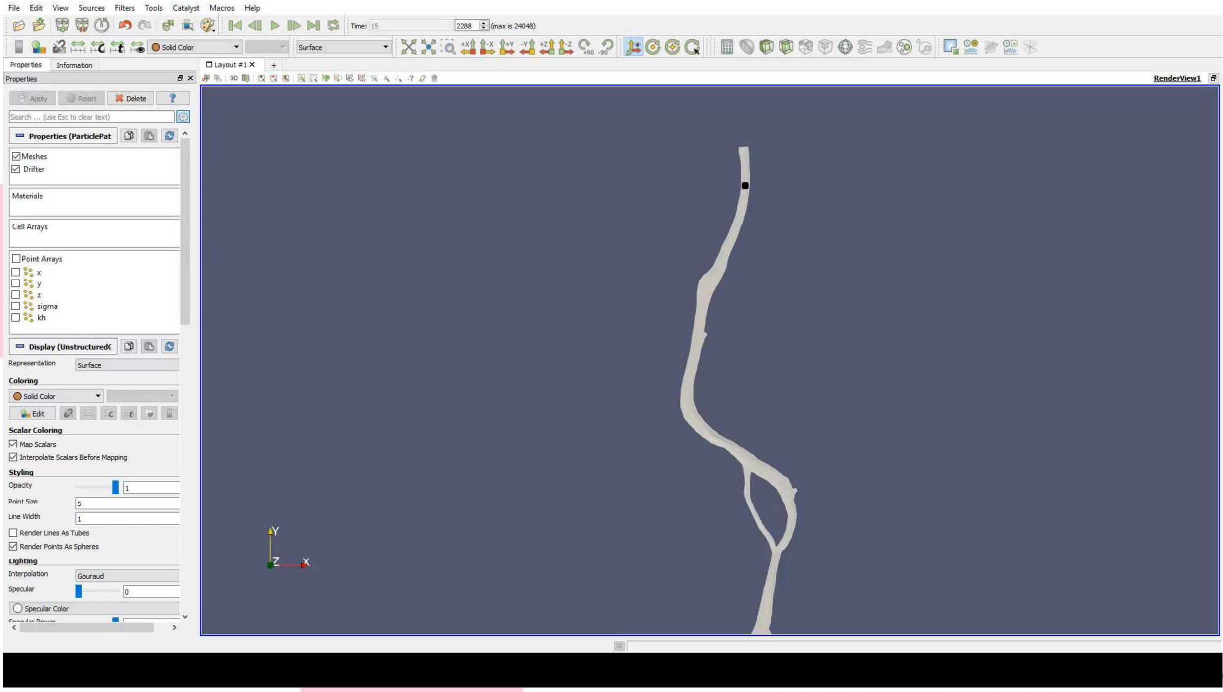
Large Scale Simulation Research

RESULTS

NECTEC
a member of NSTDA



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Large Scale Simulation Research

RESULTS

NECTEC
a member of NSTDA

Transit times

Scenario No.	water discharge	Transit times (days)			
		Sam Lae	Pak Kred	Lat Pho	River mouth
1	80	14	19.7	32.5	61
2	90	13	16.2	31	49
3	100 (open)	11.8	15.9	28.9	45
8	100 (closed)	12	15.1	23.8	32
4	800	1.9	2.5	3.9	6
5	1,500	1.15	1.5	2.3	3.8
6	2,840	0.76	0.98	1.4	1.8
7	3,700	0.63	0.85	1.1	1.6

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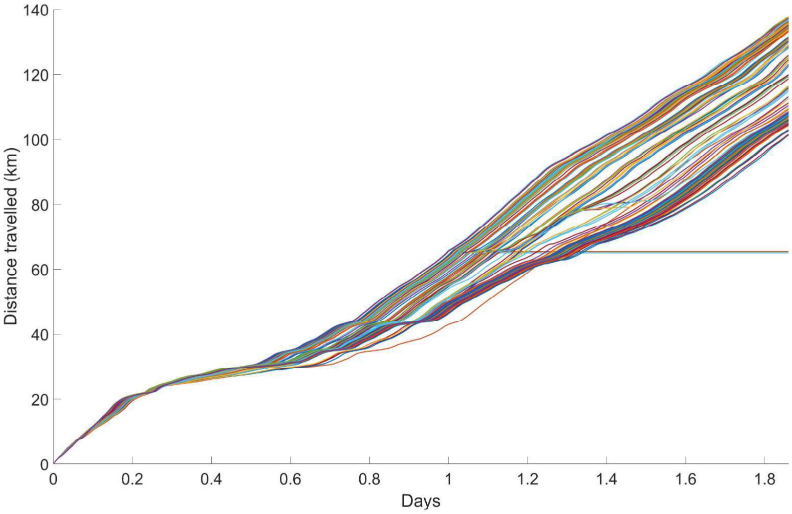
RESULTS

Transit times

- Rainy season



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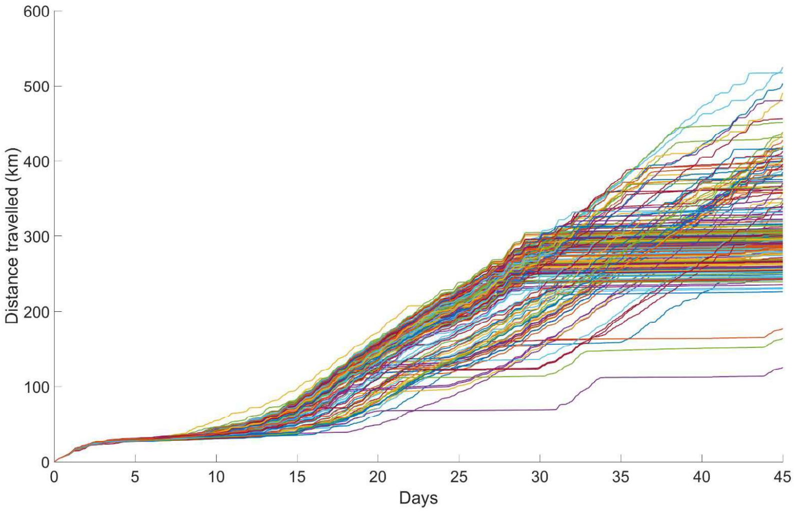
RESULTS

Transit times

- Dry season



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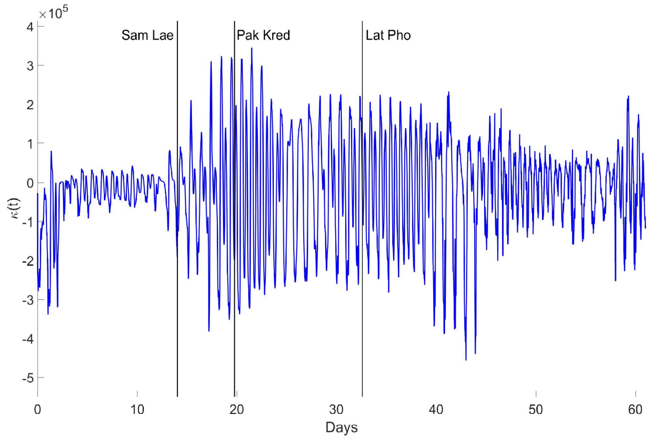
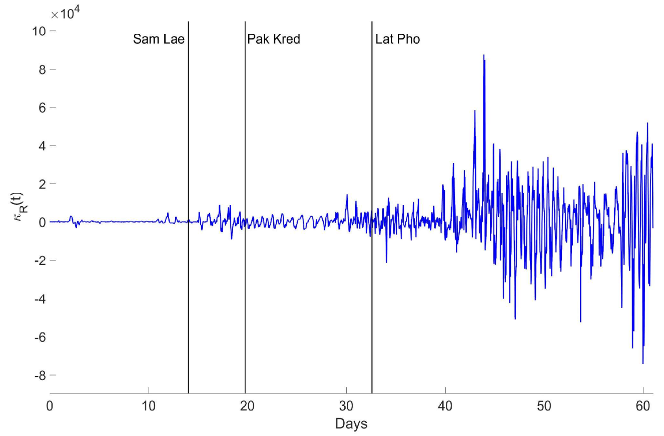
RESULTS

Dispersion and diffusivity

- 80 cms water discharge case





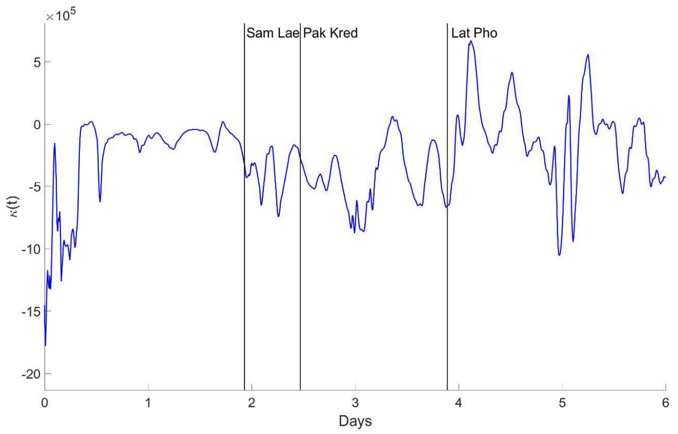
single

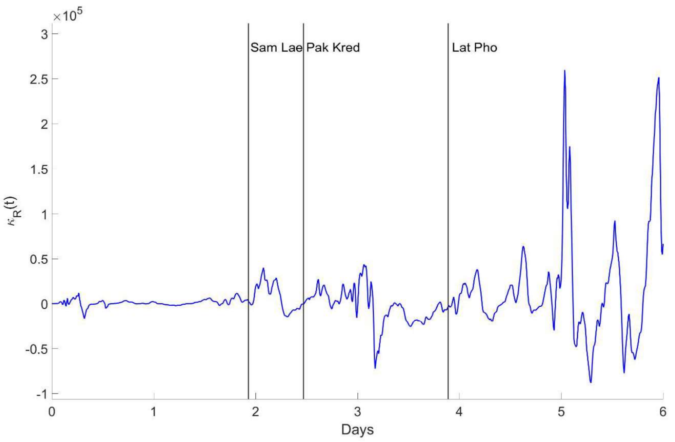
double

RESULTS

Dispersion and diffusivity

- 800 cms water discharge case





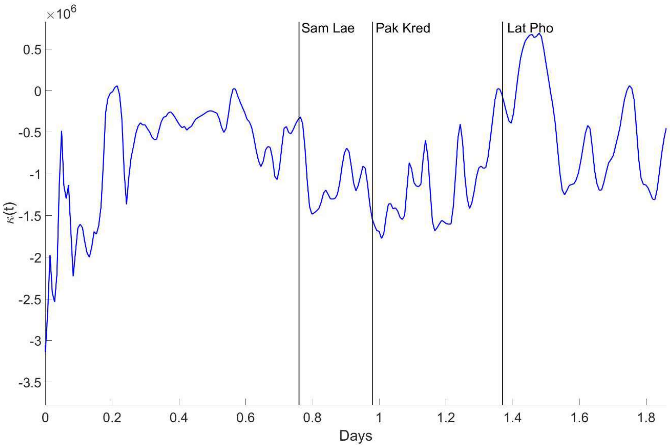
single

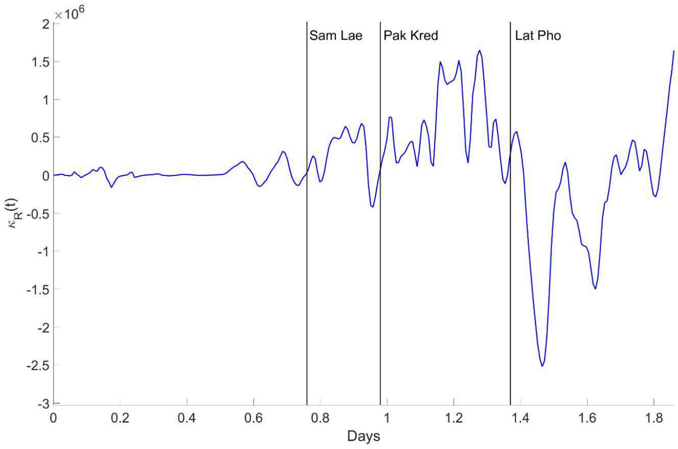
double

RESULTS

Dispersion and diffusivity

- 2,840 cms water discharge case





single double

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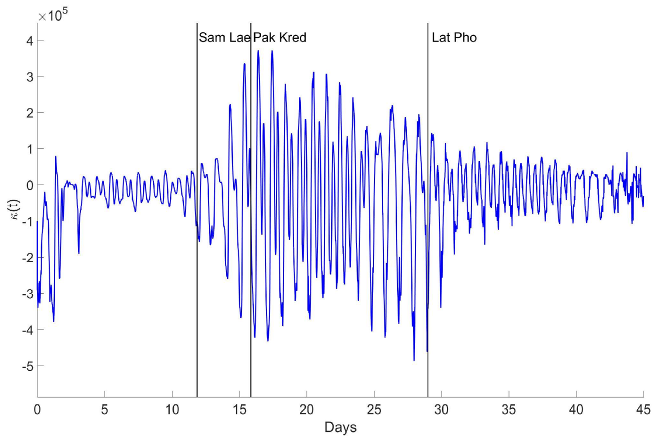
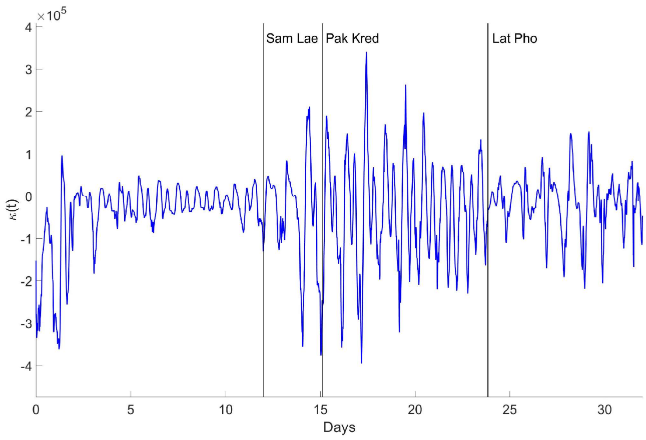
RESULTS

Dispersion and diffusivity

- 100 cms water discharge case : single-particle diffusivity





Normal Closed Canal

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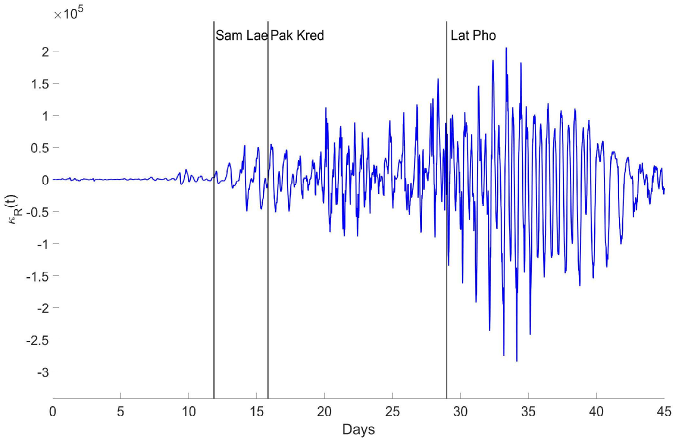
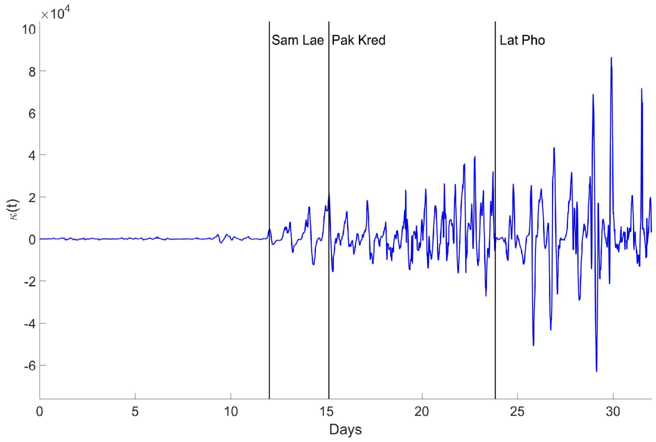
RESULTS

Dispersion and diffusivity

- 100 cms water discharge case : double-particle diffusivity



Normal



Closed Canal

Conclusions

- Use SCHISM to simulate the Chao Phraya River
  - Created 8 scenario according to history
- Applied Lagrangian Particle Tracking algorithm and analyze
  - Transit time change inversely to the amount of the upstream water discharge
  - Total traveled distance in dry season is significantly longer than in rainy season
  - Changing of particle movement affect by tide
  - Particle move more independently from each other near the river mouth