

# Environmental Hydraulics in the New Millennium: Historical Evolution and Recent Research Trends

Xianglai Zeng <sup>1</sup>, Carlo Gualtieri <sup>2</sup>, Haifei Liu <sup>1</sup> and Dongdong Shao <sup>1,3,\*</sup>

Table S1. ISEH concept List.

ISEH Concept List					
model	depth	compared	scale	fluid	momentum
flow	hydraulic	vegetation	dispersion	sea	deposition
experimental	wave	mixing	energy	values	three-dimensional
simulation	bed	large	boundary	work	watershed
river	equations	tidal	areas	estuary	load
sediment	observed	shear	region	performance	material
velocity	concentration	stress	structures	scheme	coupled
measurements	flood	obtained	discussed	including	suspended
data	characteristics	bottom	environmental	available	open-channel
developed	distribution	studied	maximum	comparison	breaking
numerical	current	density	ratio	computational	describes
effect	based	hydrodynamic	analyzed	slope	calibrated
present	quality	agreement	structure	monitoring	mathematical
method	analysis	physical	groundwater	volume	fine
turbulent	jet	approach	ecological	secondary	dikes
paper	design	management	plume	application	kinetic
discharge	applied	coastal	performed	open	k-ε
different	time	layer	horizontal	buoyant	fate
processes	due	carried	reservoir	control	stochastic
field	conducted	natural	flume	drainage	solved
investigated	basin	profiles	range	series	supercritical
transport	vertical	free	roughness	size	incipient
conditions	parameters	main	wind	predict	
channel	proposed	shallow	spatial	runoff	
surface	number	length	scour	two-dimensional	
system	order	laboratory	calculated	evolution	

Table S2. EFMC Concept List.

EFMC Concept List					
Reynolds	predicted	downstream	entrainment	better	jump
LES	sediment	significant	environmental	potential	behind
Froude	number	temperature	initial	impacts	thickness
Lagrangian	experiments	main	buoyancy	tested	growth
Finally	compared	dissipation	particular	transfer	ground
Richardson	case	due	higher	secondary	bore
3d	structures	urban	analytical	accuracy	deep
2d	particles	interactions	distance	transverse	k-epsilon
TKE	shear	building	internal	empirical	elements
RAMS	profiles	discharges	low	stability	components
Numerical	concentrations	kinetic	larger	form	information
Re	dispersion	hydraulic	front	features	test
RANS	relative	system	computational	relationship	turbidity
Ri	parameter	wake	derived	grid	breaking
SGS	distribution	atmospheric	properties	scalar	collected

Experiments	paper	complex	increase	importance	lock
Doppler	plume	order	erosion	width	stepped
Experimental	fluid	terms	longitudinal	aspect	patches
PIV	energy	presence	vortices	scheme	open-channel
RNG	stress	bottom	shape	events	play
Analysis	jet	development	carried	rectangular	subsurface
Navier-stokes	based	vortex	general	uniform	pollution
Fr	large	ambient	induced	environment	governing
Further	characteristics	speed	upper	pollutant	rigid
Herein	bed	strong	several	estimate	aeration
Co2	rate	applied	previous	force	large-eddy
Due	vegetation	tidal	drag	finite	spillway
RANS	analysis	maximum	various	coupled	sensible
Eulerian	flux	size	quality	wide	emergent
Schmidt	value	function	temporal	gradient	jumps
Despite	methods	levels	statistics	theoretical	solved
Gaussian	studies	stratification	tunnel	validated	solving
WRF	showed	mass	coherent	detailed	humidity
Smagorinsky	processes	constant	dense	rivers	residence
Non-boussinesq	height	slopes	friction	regimes	negatively
UBL	obtained	open	two-dimensional	problem	usage
Several	region	pressure	volume	variation	intensities
flow	dynamics	evolution	scour	forcing	skimming
models	proposed	zones	street	steady	curved
turbulence	depths	diffusion	exchange	formation	acoustic
velocity	horizontal	lower	areas	free-surface	plays
simulations	solutions	respect	magnitude	meteorological	solitary
different	performance	free	phase	accurate	crossflow
measurements	provide	theory	streamwise	resolution	stochastic
layer	direction	three-dimensional	principle	plane	quadrant
boundary	motion	sources	wall	stable	closures
effect	coefficient	work	standard	mechanisms	incipient
numerical	agreement	local	generated	analyzed	baffles
present	density	interface	discussed	large-scale	vortical
data	ratio	comparisons	increasing	calculated	optical
field	including	role	lateral	diffusivity	stably
surface	gravity	heat	behavior	air-water	spherical
observed	roughness	circulation	canyon	technique	waveform
current	influence	upstream	degrees	suspended	permeability
experimental	range	natural	transition	types	aircraft
conditions	air	stratified	account	settling	impinging
wind	laboratory	coastal	submerged	literature	sub-grid
channel	length	health	thermal	patch	excellent
mixing	similar	buoyant	simple	law	mechanics
investigated	patterns	canopy	addition	dimensionless	chute
time	approaches	shown	regime	instantaneous	planetary
transport	shallow	hydrodynamic	period	closure	spillways
scale	considered	eddy	series	integral	two-equation
wave	momentum	fluctuations	physical	flume	probes
equations	conducted	propagation	intensity	velocimetry	obstructed
vertical	spatial	increases	available	image	