SPHERA v.8.0 documentation

1. Description and references

SPHERA v.8.0 (RSE SpA) is free research software (FOSS) based on the SPH ("Smoothed Particle Hydrodynamics") method, which represents a mesh-less Computational Fluid Dynamics technique for free surface and multi-phase flows.
So far, SPHERA has been applied to represent: several types of floods (and landslides) with transport of solid bodies and bed-load transport; sloshing tanks;…
With Copyright 2005-2015 (RSE SpA -formerly ERSE SpA, formerly CESI RICERCA, formerly CESI-), SPHERA has been developed for RSE SpA (hereafter RSE, unique owner of the patrimonial rights of SPHERA) by the following authors (SPHERA author list): Andrea Amicarelli, Antonio Di Monaco, Sauro Manenti, Elia Bon, Daria Gatti, Giordano Agate, Stefano Falappi, Barbara Flamini, Roberto Guandalini, David Zuccalà.
The main numerical developments featuring SPHERA (so far) are listed in chronological reverse order:

- 3D SPH numerical scheme for the transport of solid bodies in free surface flows. Reference: Amicarelli et al. (2015, CAF):
  Amicarelli A., R. Albano, D. Mirauda, G. Agate, A. Sole, R. Guandalini; 2015; A Smoothed Particle Hydrodynamics model for 3D solid body transport in free surface flows; Computers & Fluids, 116:205–228, DOI 10.1016/j.compfluid.2015.04.018
- 3D SPH numerical scheme for a boundary treatment based on discrete surface and volume elements, and on a 1D Linearized Partial Riemann Solver coupled with a MUSCL (Monotonic Upstream-Centered Scheme for Conservation Laws) spatial reconstruction scheme. Reference: Amicarelli et al. (2013, IJNME):
  Amicarelli A., G. Agate, R. Guandalini; 2013; A 3D Fully Lagrangian Smoothed Particle Hydrodynamics model with both volume and surface discrete elements; International Journal for Numerical Methods in Engineering, 95, 419–450, DOI: 10.1002/nme.4514.
- SPH numerical scheme for a 2D erosion criterion. Reference: Manenti et al. (2012, JHE):
  Manenti S., S. Sibilla, M. Gallati, G. Agate, R. Guandalini; 2012; SPH Simulation of Sediment Flushing Induced by a Rapid Water Flow; Journal of Hydraulic Engineering ASCE 138(3): 227-311.
- 3D SPH numerical scheme for a boundary treatment based on volume integrals, which are numerically computed outside of the fluid domain (semi-analytic approach). Reference: Di Monaco et al. (2011, EACFM):
  Di Monaco A., Manenti S., Gallati M., Sibilla S., Agate G., Guandalini R., 2011; SPH modeling of solid boundaries through a semi-analytic approach; Engineering Applications of Computational Fluid Mechanics, 5, 1, 1–15.

Other major numerical developments are available in SPHERA (i.e. 3D erosion criterion also with mixture-fixed bed interactions; bed-load transport), but their validation only refers to a manuscript submitted to an International Journal.
Since its SPHERA v.7.0 branches, SPHERA has being developed under a Git repository (GitHub web site). Its current version contains the folders of Table 1.1.
The email address to contact the first author of SPHERA is: andrea.amicarelli@rse-web.it .
SPHERA is free software released under the GNU General Public License (Free Software Foundation).

Folder	Description
(main folder)	License file (GNU-GPL license).
doc	Documents on SPHERA registration at SIAE. Present documentation file.
src	SPHERA source code (with makefile)
bin	SPHERA executable files compiled with gfortran/ifort for run/debug executions
input	Input files for validated test cases (Sec.8). A template for the main input file with comments.

Table 1.1. Folders in SPHERA Git repository.

Test case	Reference for detailed descriptions
2D_erosional_dam_break_SPHERA_demo	(simple test case, rough resolution)
2jets_plate_DBSPH_high_res	Amicarelli et al. 2013 (IJNME)
2jets_plate_DBSPH_low_res	Amicarelli et al. 2013 (IJNME)
2jets_plate_SASPH_low_res	Amicarelli et al. 2013 (IJNME)
Archimede	(simple test case, rough resolution)
asymmetric_wedge_20deg_light	Amicarelli et al. 2015 (CAF)
asymmetric_wedge_20deg_medium	Amicarelli et al. 2015 (CAF)
body-body_impact_asymmetric	Amicarelli et al. 2015 (CAF)
body-body_impact_low_vel	Amicarelli et al. 2015 (CAF)
body-body_impact_symmetric	Amicarelli et al. 2015 (CAF)
body-boundary_impact	Amicarelli et al. 2015 (CAF)
body-boundary_impact_low_vel	Amicarelli et al. 2015 (CAF)
dam_break_2_bodies	Amicarelli et al. 2015 (CAF)
dam_break_2D_demo	(simple test case, rough resolution)
dam_break_multi-body	Amicarelli et al. 2015 (CAF)
jet_body-plate	Amicarelli et al. 2015 (CAF)
jet_plate_DBSPH	Amicarelli et al. 2013 (IJNME)
jet_plate_DBSPH_low_res	Amicarelli et al. 2013 (IJNME)
jet_plate_SASPH_low_res	Amicarelli et al. 2013 (IJNME)
symmetric_wedge_20deg_light	Amicarelli et al. 2015 (CAF)
symmetric_wedge_20deg_medium	Amicarelli et al. 2015 (CAF)
water_box_free_surface	(simple test case, rough resolution)
water_tank-body	(simple test case, rough resolution)

Table 1.2. Input files in SPHERA GitHub repository.

This documentation file is intended to provide only additional and updated material, beyond the other SPHERA GitHub repository files and the associated papers on International Journals (indexed by Web of Science or Scopus; cited above).

2. Theory

Please refer to SPHERA main references (Sec.1). The release of further documentation is in progress and coming soon.

3. Installation

SPHERA files are distributed on a dedicated Git repository on GitHub (in case of need, please refer to SPHERA contact email address of Sec.1).
SPHERA executable files are released for Linux OS. The only mandatory argument of the executable file (in the command line) is the name of the main input file (with no format extension ".inp").

4. Official SPHERA users

Official SPHERA users contribute to the validation of the official releases of SPHERA (please refer to SPHERA GitHub repository; in case of need, do not hesitate to contact the email address of Sec.1).
SPHERA official users have already provided all the following items, which are collected on SPHERA Git repositories (and web sites):

- reference input files of a validation test case;
- declaration to give RSE the patrimonial rights of their SPHERA input files to be used only under GNU-GPL license;
- reference to their publication on International Peer-Reviewed Journals associated to SPHERA (indexed by Web of Science or Scopus);
- eventual and useful information on SPHERA bugs.

Official SPHERA users will usually take advantage of:

- keeping the authorship (i.e. the moral rights) of her/his input files and the freedom to use, modify and redistribute them in any other free software, under the GNU-GPL license;
- free ordinary support from RSE on SPHERA use under official collaborations;
- credits on SPHERA GitHub repository with their affiliations, publications and test cases;
- SPHERA input files sent by official SPHERA users (under GNU-GPL license) will be regularly updated for the next code releases (if the test case will be considered relevant for a generic code release);
- a wider result dissemination;
- using a Computational Fluid Dynamics Free and Open-Source Software, whose results have been already published on several International Peer-Reviewed Journals indexed on Scopus and Web of Science (Sec.1).

However, RSE SpA can arbitrarily decide to stop providing the services described above at any time and without any notice as these services are not due.

5. SPHERA support and teaching activities

RSE's support for non-official SPHERA users and for non-official SPHERA authors are available on demand and may be provided with fee.
RSE's teaching activities on SPHERA are available on demand and may be provided with fee.

6. SPHERA developers/authors

Software developers/authors officially contribute to the numerical developments of SPHERA (please refer to SPHERA GitHub repository and the email address of Sec.1). SPHERA authors have already provided all the following items, which are collected on SPHERA GitHub repository and web site:

- the modified or new program units she/he proposes for the official releases of SPHERA;
- declaration to give RSE the patrimonial rights of their SPHERA program units to be used by RSE only under GNU-GPL license;
- the same items requested from official SPHERA users (Sec.4).

SPHERA developers will usually take advantage of:

- SPHERA program units authored by SPHERA developers (under GNU-GPL license) will be regularly updated for the next code releases (if these files will be considered relevant for a generic code release);
- keeping the authorship (i.e. the moral rights) of her/his program units and the freedom to use, modify and redistribute them in any other free software, under the GNU-GPL license;
- free ordinary support from RSE (on SPHERA development and use) under official collaborations;
- credits on SPHERA web site and GitHub repository as SPHERA authors, with their affiliations, publications and the developed program units;
- contributing to the development of a Computational Fluid Dynamics Free and Open-Source Software, whose results have been already published on several International Peer-Reviewed Journals indexed on Scopus and Web of Science (Sec.1);
- the same advantages available for official SPHERA users (Sec.4).

However, RSE SpA can arbitrarily decide to stop providing the services described above at any time and without any notice as these services are not due.
RSE is responsible for selecting or refusing any modification (as proposed by SPHERA developers) to any official release of SPHERA.
SPHERA developers follow the basic rules on Fortran 95 coding, adhere as much as possible to SPHERA file format and respect the following style formatting rules:

1) Please use the subroutine labels at the beginning of the subroutine (title and description) and of each subroutine section (modules, declarations, explicit interfaces, allocations, initializations, statements, deallocations).
2) Please use Fortran 95 standard and portable procedures to be compiled with both gfortran and ifort.

3) A generic program unit has to be named as the associated file (without file extension) to have simpler dependencies in the makefile. As a consequence, one file is allowed per program unit and vice versa.
4) Please write since the first column of each line.
5) Please use 3 spaces for indentation.
6) Please use 1 blank space only before and after any mathematical operator in the Right Hand Side of each assignment and when a blank space is clearly convenient in terms of readability. Otherwise, blank spaces are used only for indentation (and within comments). For example, “endif” and “enddo” better replace “end if” and “end do”. Further, no blank space is present between a procedure and its arguments (e.g. write(*,*)).
7) For readability and printability, do not write beyond column 80. Here the symbol “&” is put for a new line.
8) Please follow this variable order for declarations: parameters, “inout” variables, local variables, external functions. For each of the previous variable set, please following the following sub-order: scalars, 1D arrays 1D, …, nD arrays. Provided the same dimensionality, variable declarations follow this “sub-sub-order”: “logical”, “integer”, “double precision”, “character”, derived types.
9) A comment begins with “! <capitol letter>“ (there is a space after “!”).
10) Any logical expression is written within brackets (e.g.”(a==b).and.(c==d)”).
11) Automatic indentation is allowed only with blank spaces instead of tabs (but the makefile).
12) No multiple statements on a line (do not use “;” as a statement separator).
13) Do not go to a new line with “&” under the section “declarations”.
14) Keywords are written in lower case letters (e.g.: do,if,…).
15) Comments are written in UK English.

7. Doxygen guide

The release of further documentation is in progress and coming soon.

8. User guide

SPHERA repository contains a sequence of input files, whose associated test cases are either reported on International Journal papers or represent analogous simplifications (Table 1.2). Please refer to SPHERA main references (Sec.1). The release of further documentation is in progress and coming soon.

9. FAQ

So far, no additional information is relevant.

10. Previous versions (not tracked on SPHERA Git repository)

Table 12.1 reports information on SPHERA v.7.0 files and their relationship with SPHERA v.8.0 program units.

11. SPHERA acknowledgments

SPHERA has been entirely financed by the Research Fund for the Italian Electrical System (for “Ricerca di Sistema -RdS-”), at different stages:

- ✓ under the second period of RdS (2003-2005), where CESI SpA was the only beneficiary of the Research Fund for the Italian Electrical System;
- ✓ under the Contract Agreement between CESI Ricerca SpA and the Italian Ministry of Economic Development for the of RdS period 2006-2008, in compliance with the Decree of 8 March 2006;
- ✓ under the Contract Agreement between ERSE and the Ministry of Economic Development-General Directorate for Energy and Mining Resources (for the of RdS period 2009-2011) stipulated on 29 July 2009 in compliance with the Decree of 19 March 2009.
- ✓ under the Contract Agreement between RSE SpA and the Italian Ministry of Economic Development for the of RdS period 2012-2014, in compliance with the Decree of November 9, 2012.

“We acknowledge the CINECA award under the ISCRA initiative, for the availability of High Performance Computing resources and support.” In fact, SPHERA validation has also been financed by means of the following instrumental funding HPC projects:

- ✓ HSPHMI14 - High performance computing for Lagrangian numerical models to simulate free surface and multi-phase flows (SPH) and the scalar transport in turbulent flows (MIcromixing); June 2014 – March 2015; Amicarelli A., G. Agate, G. Leuzzi, P. Monti, R. Guandalini, S. Sibilla; HPC Italian National Research Project (ISCRA-C2); competitive call for instrumental funds;
- ✓ HPCEFM15 - High Performance Computing for Environmental Fluid Mechanics 2015 (Italian National HPC Research Project); instrumental funding based on competitive calls (ISCRA-C project at CINECA, Italy); 2015

- in progress; Amicarelli A., A. Balzarini, S. Sibilla, G. Agate, G. Leuzzi, P. Monti, G. Pirovano, G.M. Riva, A. Toppetti, E. Persi, G. Petaccia, L. Ziane, M.C. Khellaf.

12. SPHERA registration

SPHERA v.8.0 Copyright is registered ("Registro pubblico speciale per i programmi per elaboratore, SIAE", Italy).

Program unit (SPHERA v.7.0)	First author (SPHERA v.7.0)	SPHERA 8.0 folder	SPHERA v.8.0 file	subroutine(s)/ function(f)/ module(m)/ main(p)	Notes
CancelOutgoneParticles_2D	n.a.	BC	CancelOutgoneParticles.f90	s	
CancelOutgoneParticles_3D	n.a.	BC	CancelOutgoneParticles.f90	s	
FindFrame	n.a.	BC	Sphera_Tools.f90	s	
FindLine	n.a.	BC	Sphera_Tools.f90	s	
GenerateSourceParticles_2D	Di Monaco	BC	GenerateSourceParticles.f90	s	
GenerateSourceParticles_3D	Di Monaco	BC	GenerateSourceParticles.f90	s	
IsParticleInternal2D	n.a.	BC	Sphera_Tools.f90	f	
IsParticleInternal3D	n.a.	BC	Sphera_Tools.f90	f	
NormFix	n.a.	BC	Sphera_Tools.f90	s	
NumberSectionPoints	n.a.	BC	Sphera_Tools.f90	f	
PreSourceParticles_2D	Di Monaco	BC	GenerateSourceParticles.f90	s	
PreSourceParticles_3D	Di Monaco	BC	GenerateSourceParticles.f90	s	
VelLaw	n.a.	BC	Sphera_Tools.f90	s	
CalcPre	n.a.	BE_Mass	Sphera_Tools.f90	s	with commented subroutine on Mach check
inter_EqCont_2D	n.a.	BE_Mass	Inter.f90	s	
inter_EqCont_3D	n.a.	BE_Mass	Inter.f90	s	
inter_SmoothPres	Di Monaco	BE_Mass	Inter.f90	s	
PressureSmoothing_2D	Di Monaco	BE_Mass	PressureSmoothing.f90	s	
PressureSmoothing_3D	Di Monaco	BE_Mass	PressureSmoothing.f90	s	
diffumorris	n.a.	BE_Momentum	Sphera_Tools.f90	s	
inter_EqMoto	n.a.	BE_Momentum	Inter.f90	s	
inter_SmoothVelo_2D	Di Monaco	BE_Momentum	Inter.f90	s	
inter_SmoothVelo_3D	Di Monaco	BE_Momentum	Inter.f90	s	
viscomon	n.a.	BE_Momentum	Sphera_Tools.f90	s	
viscomorris	n.a.	BE_Momentum	Sphera_Tools.f90	s	
Body_dynamics_output	Amicarelli	Body_Transport	Body_dynamics.f90	s	
body_particles_to_continuity	Amicarelli	Body_Transport	Body_dynamics.f90	s	
body_pressure_mirror	Amicarelli	Body_Transport	Body_dynamics.f90	s	
body_pressure_postpro	Amicarelli	Body_Transport	Body_dynamics.f90	s	
body_to_smoothing_pres	Amicarelli	Body_Transport	Body_dynamics.f90	s	
body_to_smoothing_vel	Amicarelli	Body_Transport	Body_dynamics.f90	s	
Gamma_boun	Amicarelli	Body_Transport	Body_dynamics.f90	f	
Input_Body_Dynamics	Amicarelli	Body_Transport	Body_dynamics.f90	s	
RHS_body_dynamics	Amicarelli	Body_Transport	Body_dynamics.f90	s	
mixture_viscosity	Amicarelli	Constitutive_Equation	Granular_flows.f90	s	
viscapp	Di Monaco	Constitutive_Equation	Sphera_Tools.f90	s	

adjacent_faces_isolated_points	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
BC_wall_elements	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
DBSPH_find_close_faces	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
DBSPH_IC_surface_elements	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
DBSPH_inlet_outlet	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
DBSPH_kinematics	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
Gradients_to_MUSCL	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
Gradients_to_MUSCL_boundary	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
Import_ply_surface_meshes	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
semi_particle_volumes	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
viscomon_wall_elements	Amicarelli	DB_SPH	BC_wall_elements.f90	s	in drafts.f90
viscomorris_wall_elements	Amicarelli	DB_SPH	BC_wall_elements.f90	s	in drafts.f90
wall_elements_pp	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
wavy_inlet	Amicarelli	DB_SPH	BC_wall_elements.f90	s	
compute_k_BetaGamma	Amicarelli	Erosion_Criterion	Granular_flows.f90	s	
fixed_bed_slope_limited	Amicarelli	Erosion_Criterion	Granular_flows.f90	s	
MohrC	Manenti	Erosion_Criterion	Crit_Erosion.f90	s	in drafts.f90
Shields	Manenti	Erosion_Criterion	Crit_Erosion.f90	s	
area_quadrilateral	Amicarelli	Geometry	Granular_flows.f90	s	
area_triangle	Amicarelli	Geometry	Granular_flows.f90	s	
dis_point_plane	Amicarelli	Geometry	Body_dynamics.f90	s	
distance_point_line_2D	Amicarelli	Geometry	Body_dynamics.f90	s	
distance_point_line_3D	Amicarelli	Geometry	Body_dynamics.f90	s	
IsPointInternal	n.a.	Geometry	Sphera_Tools.f90	f	
line_plane_intersection	Amicarelli	Geometry	Granular_flows.f90	s	
LocalNormalCoordinates	Di Monaco	Geometry	Sphera_Tools.f90	s	
Matrix_Inversion_2x2	Amicarelli	Geometry	Body_dynamics.f90	s	
Matrix_Inversion_3x3	Amicarelli	Geometry	Body_dynamics.f90	s	
MatrixProduct	n.a.	Geometry	Sphera_Tools.f90	s	
MatrixTransposition	n.a.	Geometry	Sphera_Tools.f90	s	
point_inout_polygone	Amicarelli	Geometry	Body_dynamics.f90	s	
quadratic_equation	Amicarelli	Geometry	Granular_flows.f90	s	
reference_system_change	Amicarelli	Geometry	Body_dynamics.f90	s	
three_plane_intersection	Amicarelli	Geometry	Body_dynamics.f90	s	
Vector_Product	n.a.	Geometry	Sphera_Tools.f90	s	
vector_rotation	Amicarelli	Geometry	Body_dynamics.f90	s	
GeneratePart	n.a.	IC	Sphera_Tools.f90	s	
initialization_fixed_granular_particle	Amicarelli	IC	Granular_flows.f90	s	
SetParticleParameters	Amicarelli	IC	Sphera_Tools.f90	s	
SetParticles	n.a.	IC	Sphera_Tools.f90	s	
SubCalcPreIdro	Agate	IC	Sphera_Tools.f90	s	
AggDens	n.a.	Interface_Dispersion	Sphera_Tools.f90	s	in drafts.f90
inter_CoefDif	n.a.	Interface_Dispersion	Inter.f90	s	in drafts.f90
inter_SmoothVF	Manenti	Interface_Dispersion	Inter.f90	s	in drafts.f90
check_files	n.a.	Main algorithm	Sphera_Main.f90	s	in sphera.f90
Gest_Dealloc	n.a.	Main algorithm	Sphera_Tools.f90	s	
Gest_Trans	n.a.	Main algorithm	Sphera_Tools.f90	s	

Loop_Irre_2D	Di Monaco	Main algorithm	Loop_Irre.f90	s	
Loop_Irre_3D	n.a.	Main algorithm	Loop_Irre.f90	s	
sphera	n.a.	Main algorithm	Sphera_Main.f90	p	in sphera.f90
AdM_User_Type	Di Monaco	Modules	AdM_User_Type.f90	m	New name: Hybrid_allocation_module
ALLOC_Module	n.a.	Modules	Alloc_Module.f90	m	New name: Dynamic_allocation_module
BoundIntegralTab_Module	Di Monaco	Modules	BoundIntegralTab_Module.f90	m	New name: SA_SPH_module
diagnostic_module	n.a.	Modules	Diagnostic_Module.f90	m	New name: I_O_diagsnostic_module
english_writime2	n.a.	modules	Sphera_Tools.f90	m	New name: I_O_ENG_module
files_entities	n.a.	Modules	Files_Entities.f90	m	New name: I_O_file_module
GLOBAL_Module	n.a.	Modules	Global_Module.f90	m	New name: Static_allocation_module
italiano_writime2	n.a.	modules	Sphera_Tools.f90	m	New name: I_O_ITA_module
language_writime2	n.a.	modules	Sphera_Tools.f90	m	New name: I_O_language_module
time_usertype	n.a.	Modules	Time_UserType.f90	m	New name: Time_module
CalcVarLength	n.a.	Neighbouring_Search	Sphera_Tools.f90	s	
CellIndices	n.a.	Neighbouring_Search	Sphera_Tools.f90	f	
CellNumber	n.a.	Neighbouring_Search	Sphera_Tools.f90	f	
CreaGrid	n.a.	Neighbouring_Search	Sphera_Tools.f90	s	
InterFix	n.a.	Neighbouring_Search	Inter.f90	s	
OrdGrid1	n.a.	Neighbouring_Search	Sphera_Tools.f90	s	
ParticleCellNumber	n.a.	Neighbouring_Search	Sphera_Tools.f90	f	
SearchforParticleZone_3D	Di Monaco	Neighbouring_Search	Sphera_Tools.f90	s	
w	Di Monaco	Neighbouring_Search	Boundaries.f90	f	
calc_pelo	n.a.	Post-processing	Sphera_Tools.f90	s	
CalcVarp	n.a.	Post-processing	Sphera_Tools.f90	s	
CreateSectionPoints	n.a.	Post-processing	Sphera_Tools.f90	s	
GetVarPart	n.a.	Post-processing	Sphera_Tools.f90	s	
Memo_Ctl	n.a.	Post-processing	Sphera_Tools.f90	s	
Memo_Results	n.a.	Post-processing	Sphera_Tools.f90	s	
Print_Results	n.a.	Post-processing	Sphera_Tools.f90	s	
result_converter	n.a.	Post-processing	Sphera_Tools.f90	s	
s_ctime	n.a.	Post-processing	Sphera_Tools.f90	s	
s_secon2	n.a.	Post-processing	Sphera_Tools.f90	s	
start_and_stop	Agate	Post-processing	Sphera_Tools.f90	s	
sub_Q_sections	Amicarelli	Post-processing	Granular_flows.f90	s	
Update_Zmax_at_grid_vert_columns	Amicarelli	Post-processing	Granular_flows.f90	s	
write_Granular_flows_interfaces	Amicarelli	Post-processing	Granular_flows.f90	s	
write_h_max	Amicarelli	Post-processing	Granular_flows.f90	s	
writime2	n.a.	Post-processing	Sphera_Tools.f90	s	
defcolpartzero	n.a.	Pre-processing	Sphera_Tools.f90	s	
diagnostic	Agate	Pre-processing	Sphera_Tools.f90	s	
Gest_Input	n.a.	Pre-processing	Sphera_Tools.f90	s	
Init_Arrays	n.a.	Pre-processing	Sphera_Tools.f90	s	
ModifyFaces	n.a.	Pre-processing	Sphera_Tools.f90	s	
ReadBedLoadTransport	Amicarelli	Pre-processing	ReadInputFile.f90	s	
ReadBodyDynamics	Amicarelli	Pre-processing	ReadInputFile.f90	s	
ReadCheck	n.a.	Pre-processing	ReadInputFile.f90	f	
ReadDBSPH	Amicarelli	Pre-processing	ReadInputFile.f90	s	

ReadInput	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputBoundaries	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputControlLines	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputControlPoints	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputControlSections	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputDomain	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputDrawOptions	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputExternalFile	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputFaces	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputGeneralPhysical	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputLines	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputMedium	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputOutputRegulation	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputParticlesData	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputRestart	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputRunParameters	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputTitle	n.a.	Pre-processing	ReadInputFile.f90	s
ReadInputVertices	n.a.	Pre-processing	ReadInputFile.f90	s
ReadRestartFile	n.a.	Pre-processing	ReadInputFile.f90	s
ReadRiga	n.a.	Pre-processing	ReadInputFile.f90	s
ReadSectionFlowRate	Amicarelli	Pre-processing	ReadInputFile.f90	s
AddBoundaryContribution_to_CE2D	Di Monaco	SA_SPH	AddBoundaryContribution.f90	s
AddBoundaryContribution_to_CE3D	Di Monaco	SA_SPH	AddBoundaryContribution.f90	s
AddBoundaryContributions_to_ME2D	Di Monaco	SA_SPH	AddBoundaryContribution.f90	s
AddBoundaryContributions_to_ME3D	Di Monaco	SA_SPH	AddBoundaryContribution.f90	s
AddElasticBoundaryReaction_2D	Di Monaco	SA_SPH	AddBoundaryContribution.f90	s
AddElasticBoundaryReaction_3D	Di Monaco	SA_SPH	AddBoundaryContribution.f90	s
BoundaryMassForceMatrix2D	Di Monaco	SA_SPH	Boundaries.f90	s
BoundaryMassForceMatrix3D	Di Monaco	SA_SPH	Boundaries.f90	s
BoundaryPressureGradientMatrix3D	Di Monaco	SA_SPH	Boundaries.f90	s
BoundaryReflectionMatrix2D	Di Monaco	SA_SPH	Boundaries.f90	s
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CompleteBoundaries3D	Di Monaco	SA_SPH	Boundaries.f90	s
ComputeBoundaryDataTab	Di Monaco	SA_SPH	Boundaries.f90	s
ComputeBoundaryIntegralTab	Di Monaco	SA_SPH	Boundaries.f90	s
ComputeBoundaryVolumeIntegrals_P0	Di Monaco	SA_SPH	Boundaries.f90	s
ComputeKernelTable	Di Monaco	SA_SPH	Boundaries.f90	s
ComputeSurfaceIntegral_WdS2D	Di Monaco	SA_SPH	Boundaries.f90	s
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DefineBoundaryFaceGeometry3D	Di Monaco	SA_SPH	Boundaries.f90	s
DefineBoundarySideGeometry2D	Di Monaco	SA_SPH	Boundaries.f90	s
DefineBoundarySideRelativeAngles2D	Di Monaco	SA_SPH	Boundaries.f90	s
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EvaluateBER_TimeStep	Di Monaco	SA_SPH	Boundaries.f90	s
FindBoundaryConvexEdges3D	Di Monaco	SA_SPH	Boundaries.f90	s
FindBoundaryIntersection2D	Di Monaco	SA_SPH	Boundaries.f90	s
FindCloseBoundaryFaces3D	DI Monaco	SA_SPH	Boundaries.f90	s

FindCloseBoundarySides2D	Di Monaco	SA_SPH	Boundaries.f90	s	
GridCellBoundaryFacesIntersections3D	Di Monaco	SA_SPH	Boundaries.f90	s	
InterpolateBoundaryIntegrals2D	Di Monaco	SA_SPH	Boundaries.f90	s	
InterpolateTable	Di Monaco	SA_SPH	Boundaries.f90	s	
IWro2dro	Di Monaco	SA_SPH	Boundaries.f90	f	
J2Wro2	Di Monaco	SA_SPH	Boundaries.f90	f	
JdWsRn	Di Monaco	SA_SPH	Boundaries.f90	f	
SelectCloseBoundarySides2D	Di Monaco	SA_SPH	Boundaries.f90	s	
WIntegr	Di Monaco	SA_SPH	Boundaries.f90	f	
GetToken	n.a.	strings	Sphera_Tools.f90	f	
lcase	n.a.	strings	Sphera_Tools.f90	f	
ltrim	n.a.	strings	Sphera_Tools.f90	f	
Euler	Amicarelli	Time_Integration	time_integration.f90	s	
Heun	Amicarelli	Time_Integration	time_integration.f90	s	
inidt2	n.a.	Time_Integration	Sphera_Tools.f90	s	
rundt2	n.a.	Time_Integration	Sphera_Tools.f90	s	
stoptime	n.a.	Time_Integration	Sphera_Tools.f90	s	
time_integration	Amicarelli	Time_Integration	time_integration.f90	s	
time_integration_body_dynamics	Amicarelli	Time_Integration	time_integration.f90	s	
KeyDecoderCheck	Agate		KeyDecoderCheck.f90	s	Erased permanently
sloshing_tank_control_points	Amicarelli		DB-SPH_hard_coding.f90	s	Erased permanently

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