UNIVERSITEIT
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UNIVERSITY

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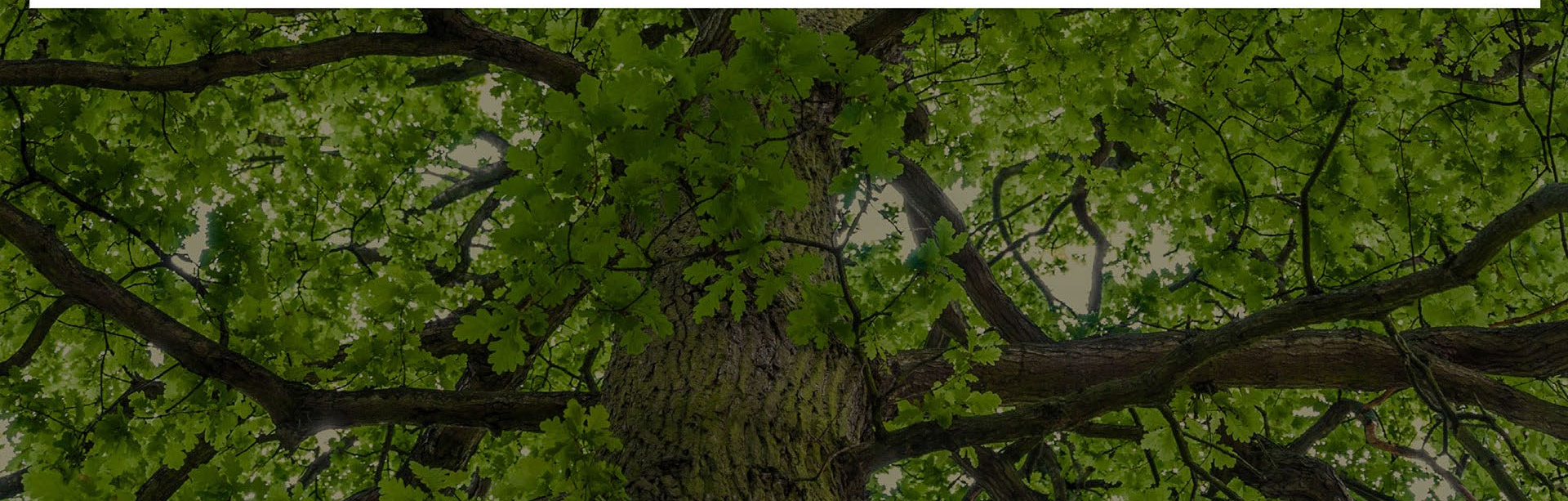
forward together · saam vorentoe · masiye phambili

Postgraduate Opportunities

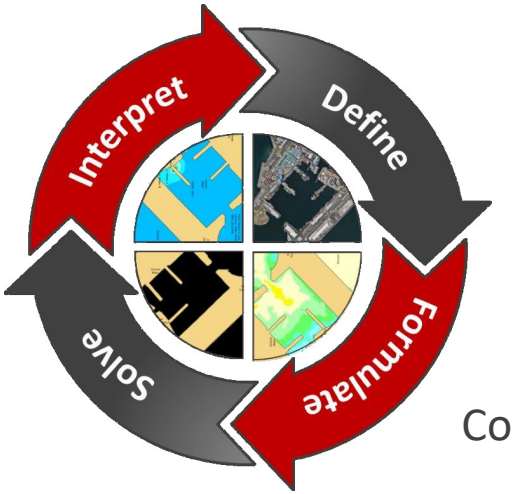
Applied Mathematics



Applied Mathematics

The division of Applied Mathematics at Stellenbosch University focuses on research in numerical analysis and scientific computing, computer vision and machine learning, fluid dynamics and modelling, and applied discrete mathematics.

Our mission is to formulate and solve problems in all walks of life by making use of mathematical skills in an innovative way.

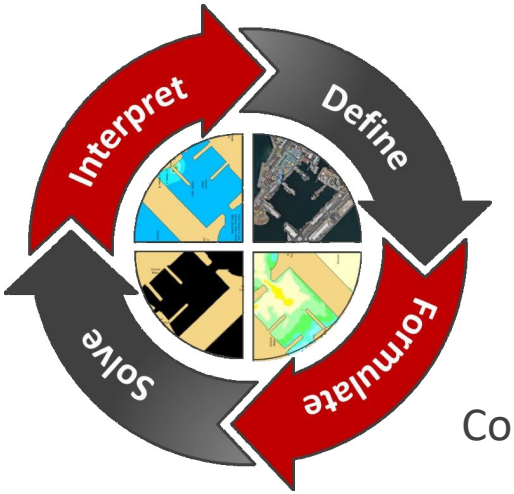


Contact: appliedmaths@sun.ac.za

Postgraduate Opportunities

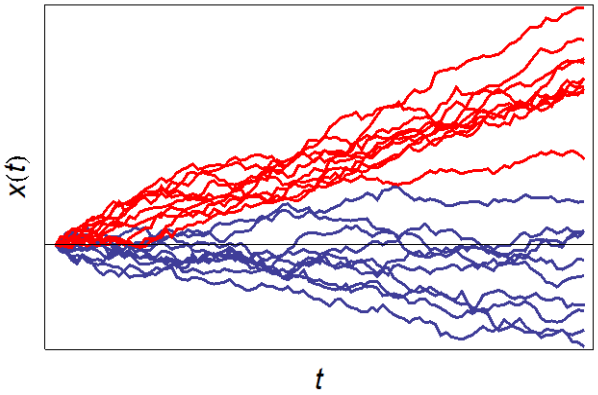
- BSc Honours in Applied Mathematics
  - Prerequisites: 60% average for 3rd-year Applied Maths modules
- MSc in Applied Mathematics
  - Prerequisites: BSc Honours or B.Eng degree
- PhD in Applied Mathematics

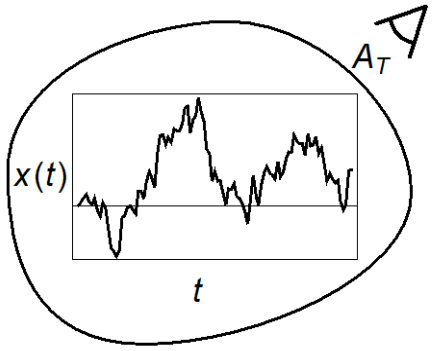
Research Projects

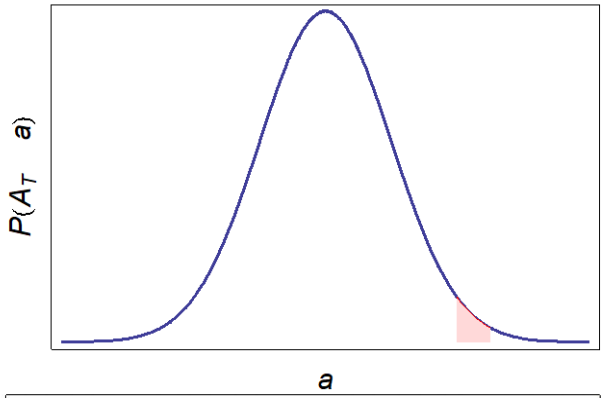


Contact: appliedmaths@sun.ac.za

Stochastic modelling – Hugo Touchette

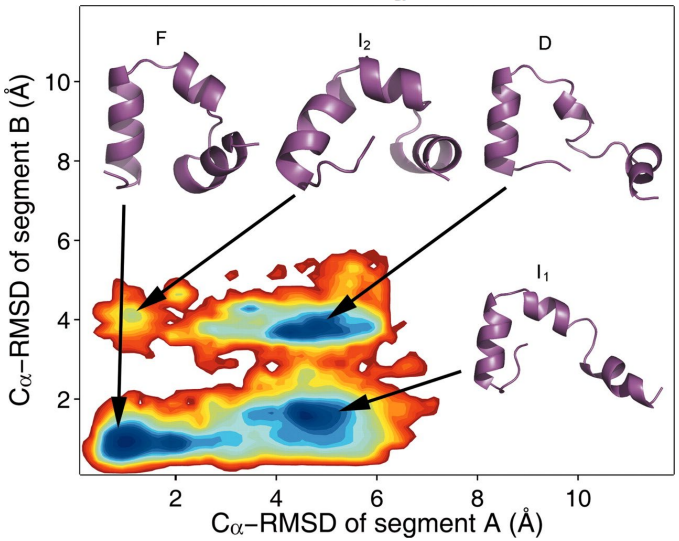






Topics

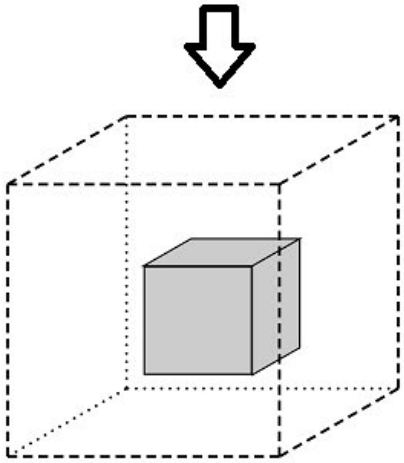
- Noisy systems (Markov processes)
- Estimation and prediction (learning)
- Simulations and sampling
- Rare transitions (crashes, change points)
- Physics applications



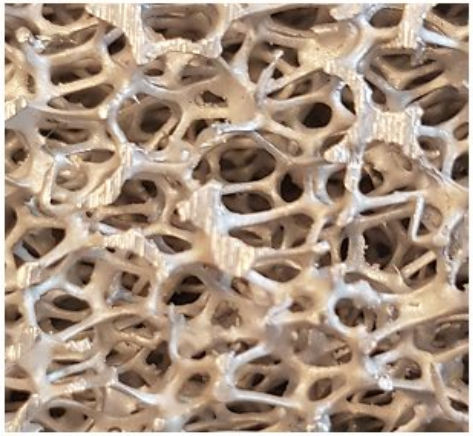
Contact: htouchette@sun.ac.za

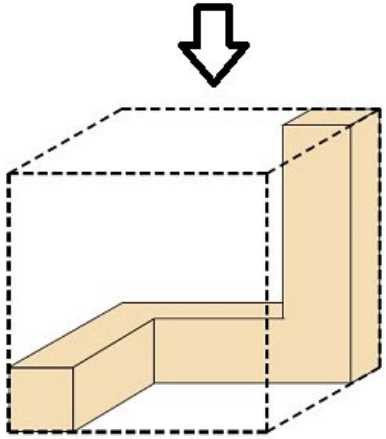
Flow through Porous Media – Dr S Fidder

Granular Porous Medium

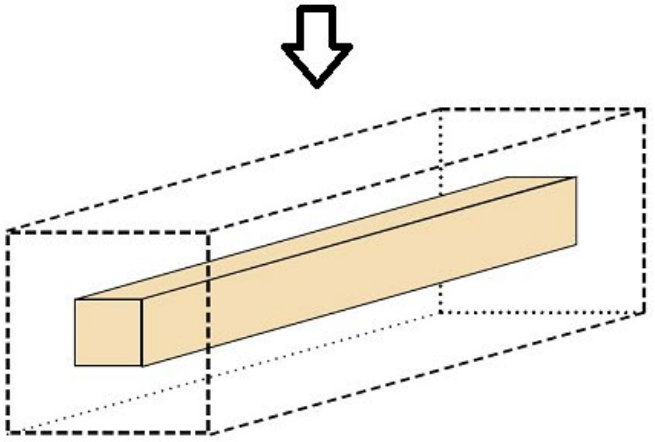


Metal Foam





Fibrous medium

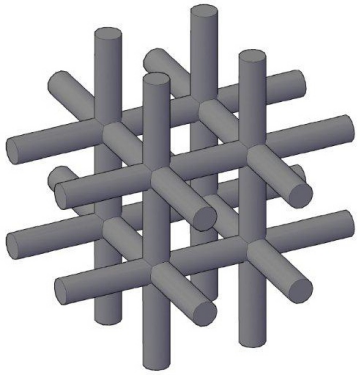


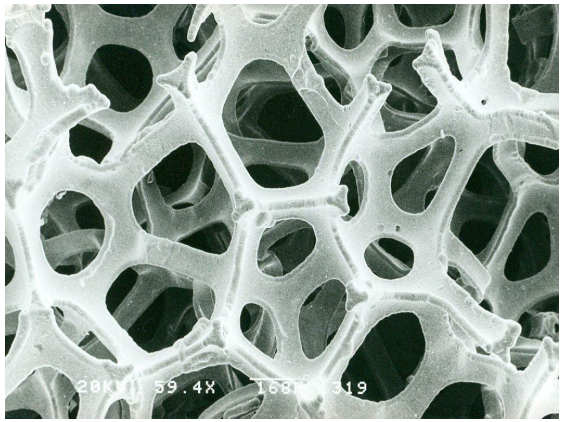
Geometric Models Representative of Average Medium Geometry

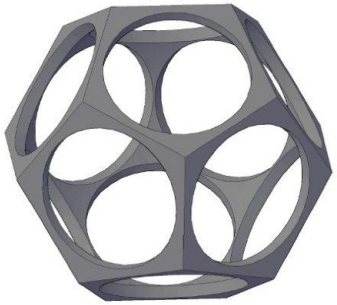
Contact: fidder@sun.ac.za

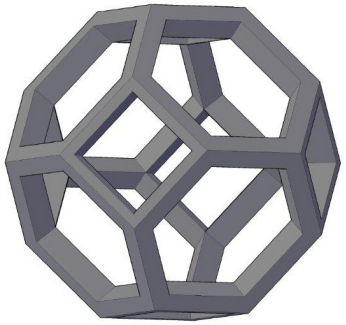
Flow through Porous Media – Dr S Fidder

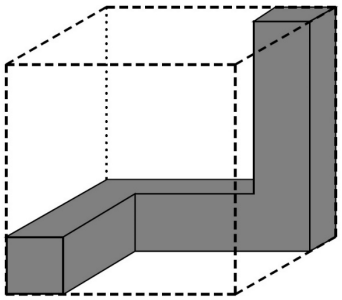
Geometric models for metal foams











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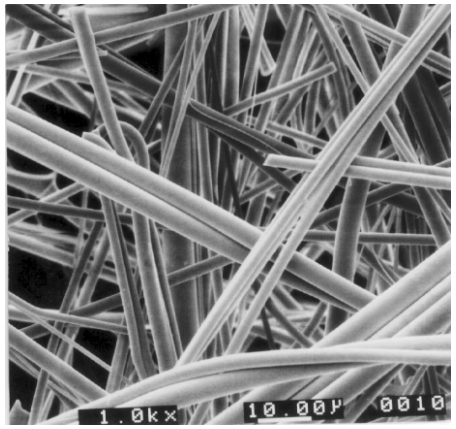
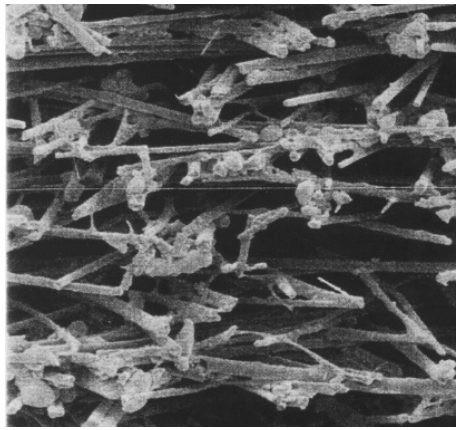
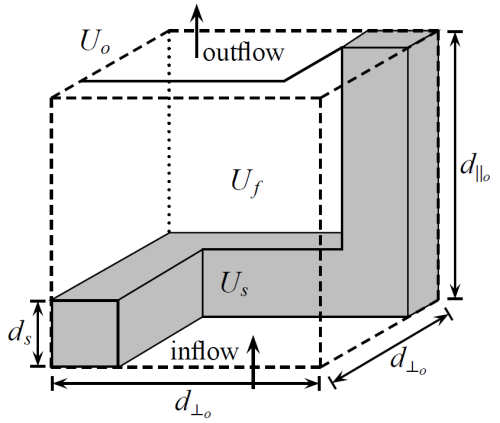
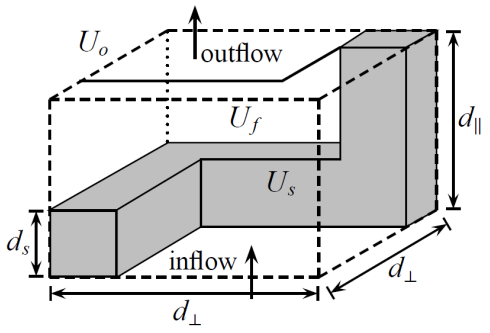
Flow through Porous Media – Dr S Fidder

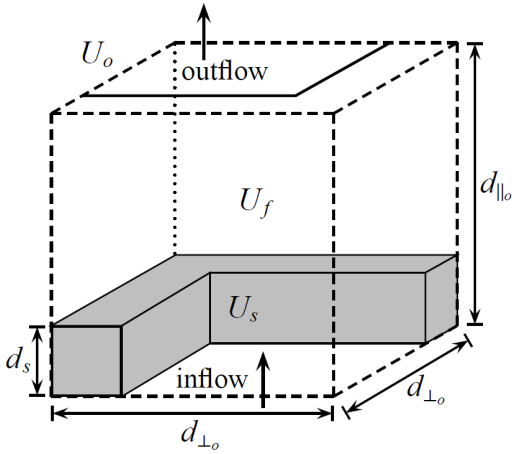
AIR FILTRATION

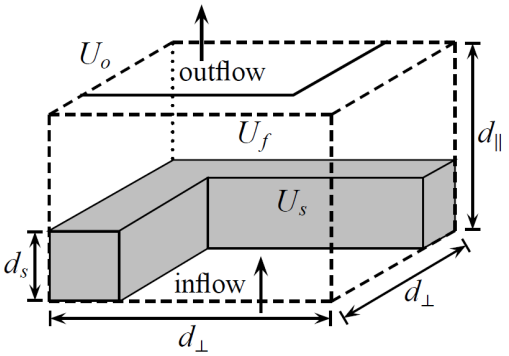












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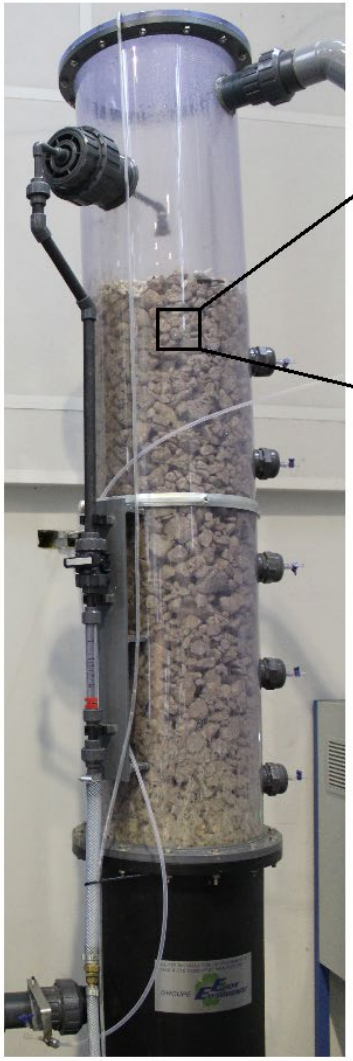
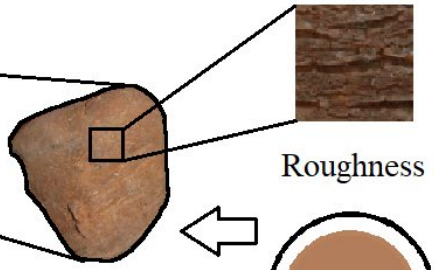
Flow through Porous Media – Dr S Fidder

BIOFILTRATION

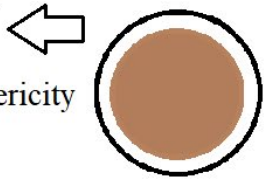


Biofilter

Packing material

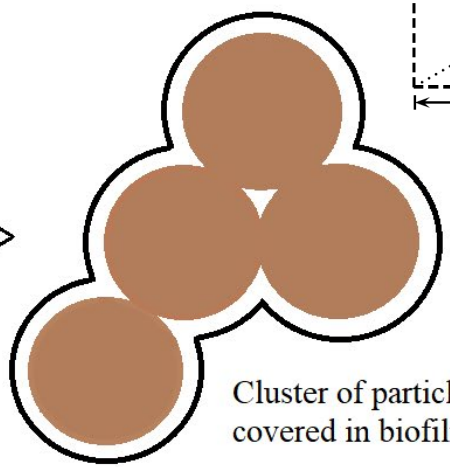


Roughness

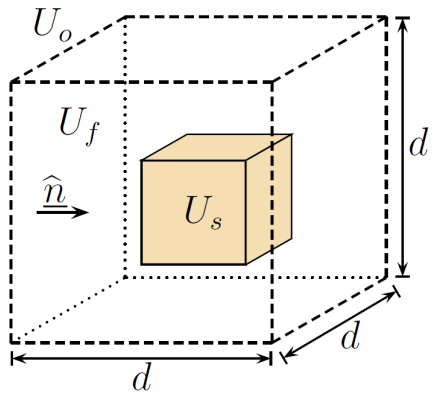


Sphericity

Particles in contact



Cluster of particles covered in biofilm



Contact: fidder@sun.ac.za

Concluding remarks

Advantages of our models

- Physically adaptable
- Based on sound physical principles – no empirical curve fitting parameters

Outputs delivered from our models to date

- 15 MSc and PhD theses
- 40 journal papers

Contact: fidder@sun.ac.za

Possible future work

- Non-Newtonian flow combined with anisotropic geometry
- Taking particle size distributions into account
- Predict the formation factor in electrical conduction
- Accounting for the accumulation of solid material at the intersection of struts in the foam model
- Numerical flow simulations
- Etc.

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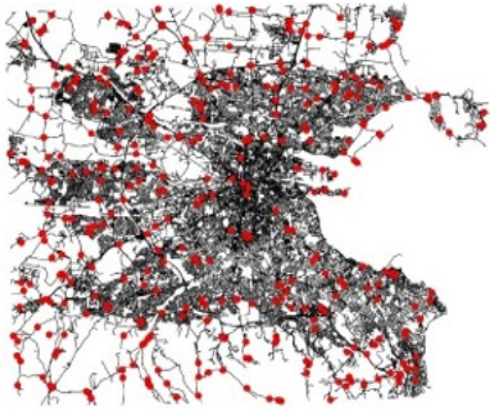
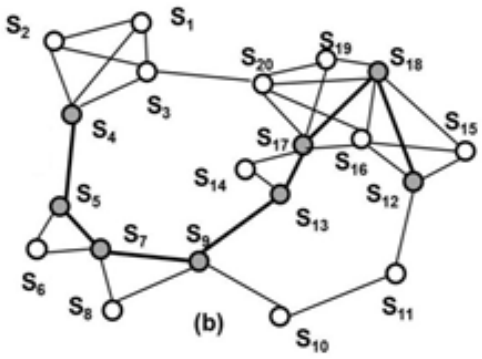
Graph theory – Riana Roux

Domination in graphs

What are we modelling?

- Facility location problems
- Network protection

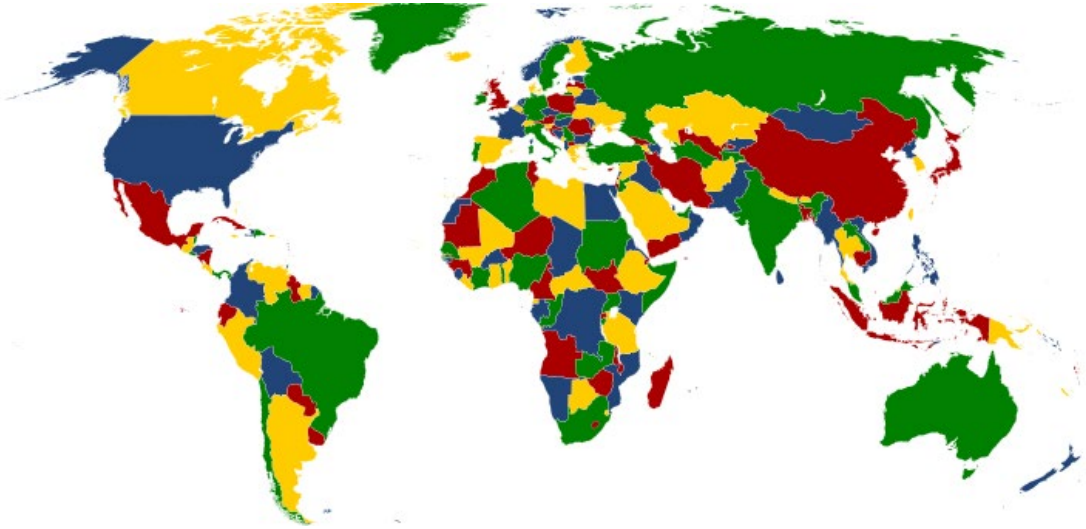




Colouring a graph

What are we modelling?

- Scheduling
- Register allocation

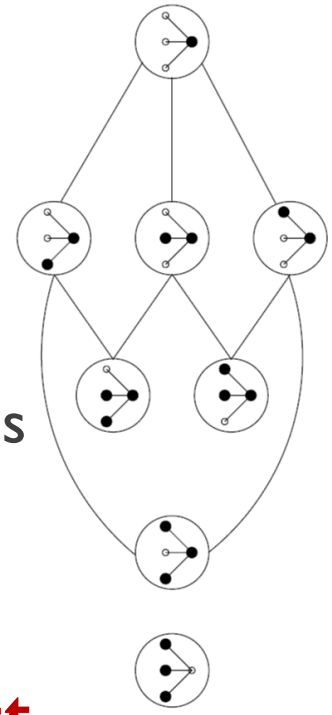


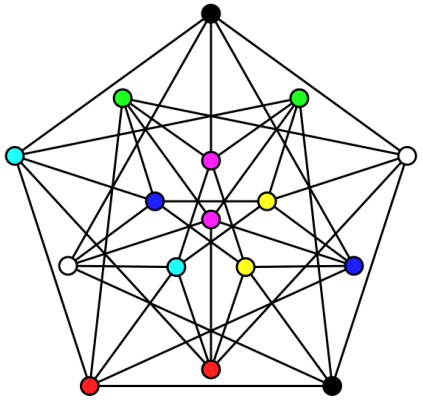
Contact: rianaroux@sun.ac.za

Graph theory – Riana Roux

Research topics

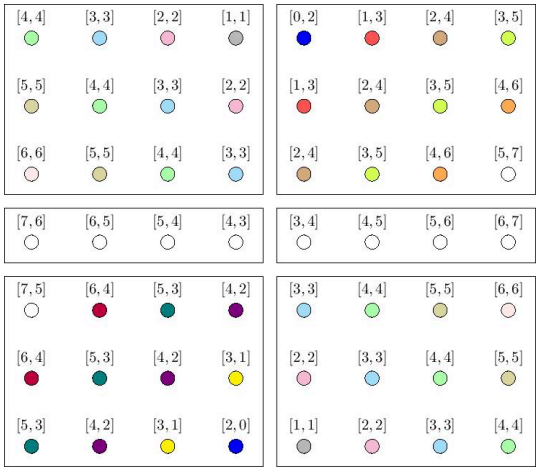
- Reconfiguration problems
- Effects of changes in a graph
- Complexity results
- Structural properties of graphs
- Games on graphs





Graph parameters of interest

- Exponential and broadcast domination
- Equitable and consecutive colourings
- Ramsey colourings



Contact: rianaroux@sun.ac.za

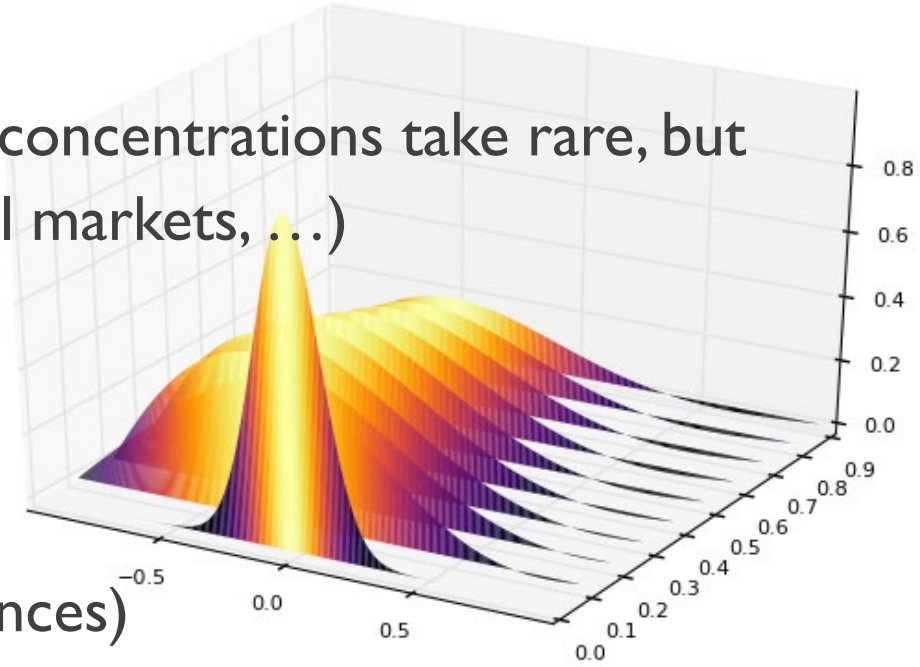
Numerical methods for fractional differential equations – Nick Hale

Fractional differential equations (FDEs)

FDEs are playing an ever-increasing role in the mathematical modelling of real-world phenomena.

"Super-diffusion": processes where concentrations take rare, but large jumps (e.g., epidemics, financial markets, …)

"Anomalous diffusion": processes with a 'memory', (e.g., neural synapse responses and DNA sequences)



Contact: nickhale@sun.ac.za

Software for numerical solution of differential equations – Nick Hale

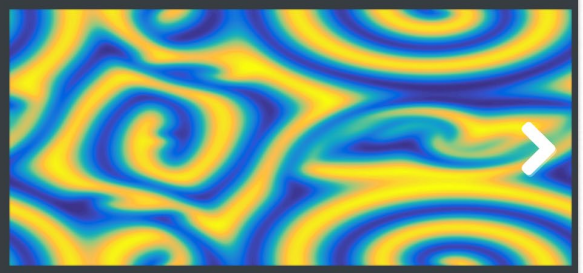
Chebfun (www.chebfun.org)

- Well-written codes for numerical solution of DEs
- Automatic discretisation and grid refinement

Applications:

- Numerical function approximation and optimisation
- ODEs and PDEs on rectangles, spheres, and disks
- ODE eigenvalue problems

```
% Create operator for Ginzburg-Landau proble
m
d = 20*[-1.2 3.2 -1 1];  tspan = [0 46.5];
S = spinop2(d,tspan); S.lin = @(u) lap(u);
S.nonlin = @(u) u - (1+1.5i)*u.*(abs(u).^2);
% Set initial condition, solve PDE, plot
S.init = chebfun2(@(x,y) ...
    (1i*x+y).*exp(-.03*(x.^2+y.^2)), d);
u = spin2(S, 128, 1e-1, 'plot', 'off');
plot(real(u))
```



Contact: nickhale@sun.ac.za

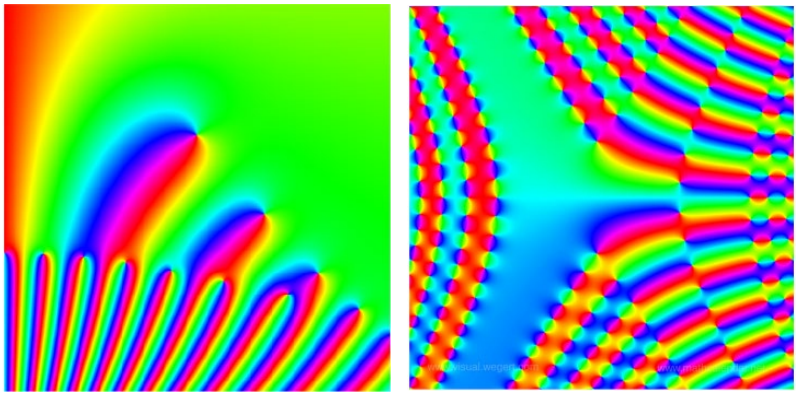
Computation of special functions

Special functions

Certain special mathematical functions are ubiquitous in scientific and engineering investigations, e.g.,

$$w(z) = \frac{i}{\pi} \int_{-\infty}^{\infty} \frac{e^{-t^2}}{z - t}\, dt, \qquad u''(z) = 2\,u^3 + z\,u$$

- w(z) is the plasma dispersion function, and occurs in astrophysics and spectroscopy.
- u(z) is a Painleve function, and occurs in the computation of a certain probability distributions

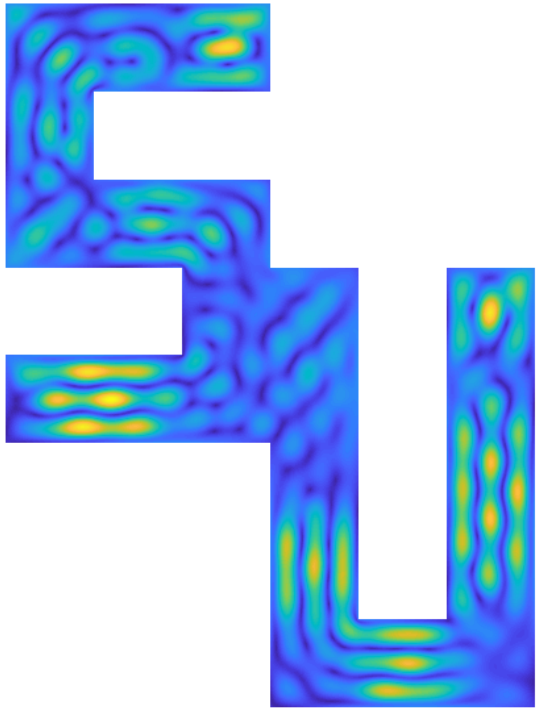


Contact: weideman@sun.ac.za

Other topics in Numerical Analysis and Scientific Computing – Nick Hale

Other topics

- Spectral methods for ODEs and PDEs
- Fast large-scale numerical linear algebra
- Spectral deferred correction methods
- Radial basis function methods
- Function approximation
- Numerical complex analysis
- Computation of matrix functions
- Fast transforms and special functions



Contact: nickhale@sun.ac.za

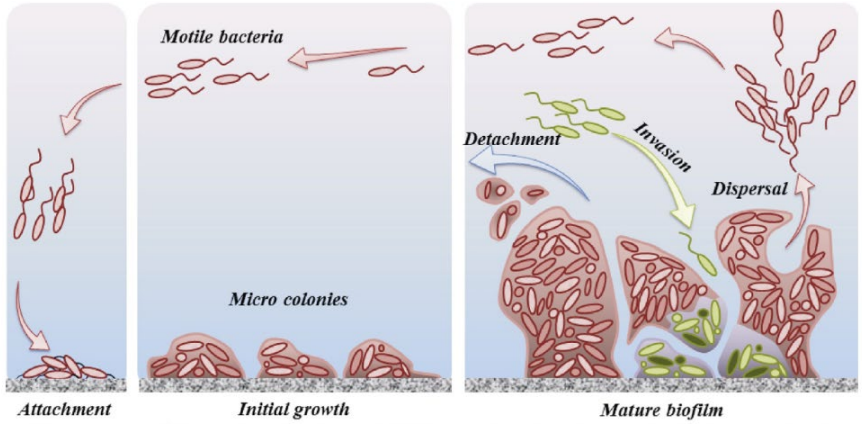
Modelling Biofilms– Andie de Villiers

Multiphysics, multiscale modelling

Fluid-Structure Interaction

Fluid mechanics

Structure mechanics
- Viscoelastic
- Detachment?



D'acunto et al. (2019)

Growth modelling

Solving the equations:
- Finite Element Method
- High Performance Computing

Contact: andiedevilliers@sun.ac.za

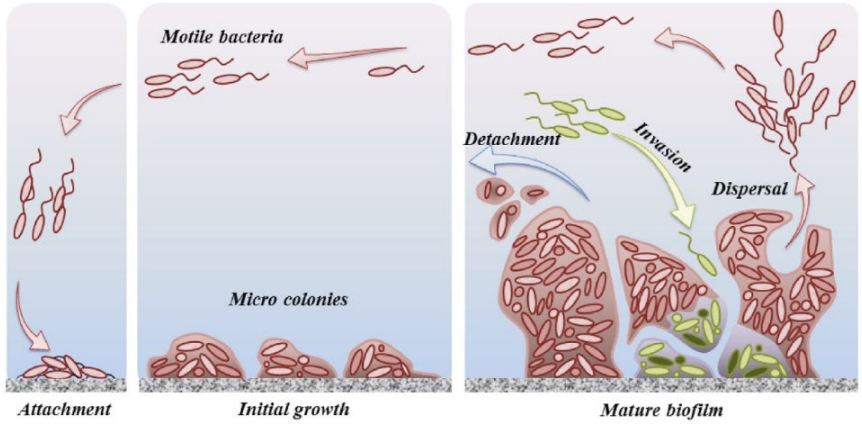
Modelling Biofilms– Andie de Villiers

Multiphysics, multiscale modelling

Fluid-Structure Interaction

Fluid mechanics

Structure mechanics
- Viscoelastic
- Detachment?



D'acunto et al. (2019)

Continuum hydrodynamica time-scale

micro scale (bacteria) longer timescale

Growth modelling

Solving the equations:
- Finite Element Method
- High Performance Computing

Contact: andiedevilliers@sun.ac.za

Modelling Biofilms– Andie de Villiers

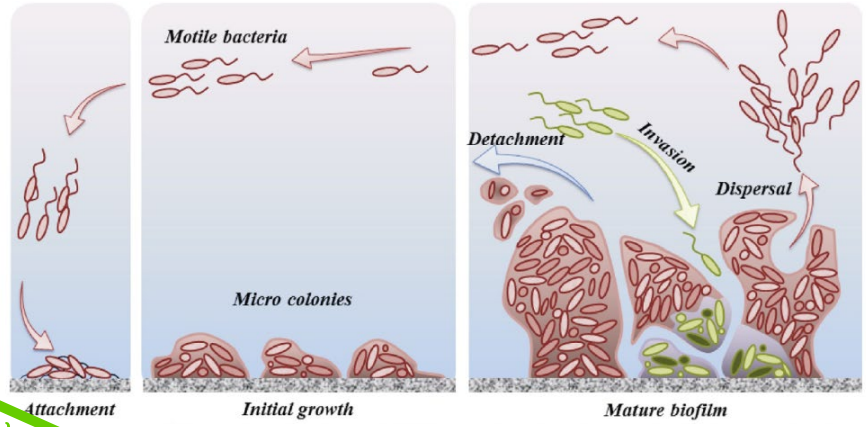
Multiphysics, multiscale modelling

Fluid-Structure Interaction → Fluid mechanics

stress, deformation

altered flow patterns

Structure mechanics
- Viscoelastic
- Detachment?



D'acunto et al. (2019)

nutrients (+)
biocides (−)
antibiotics (−)
concentration

structure, strength

porosity influence nutrient concentration

Growth modelling

Solving the equations:
- Finite Element Method
- High Performance Computing
  (use clusters / Parallel computing)

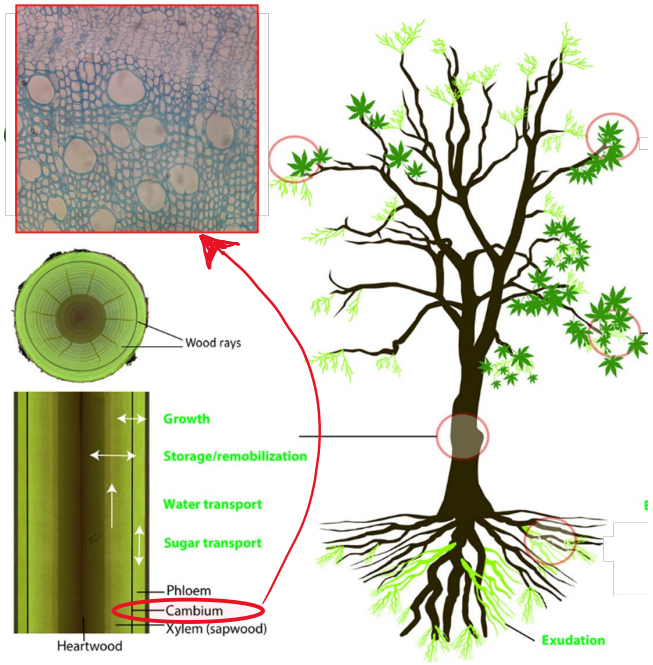
Contact: andiedevilliers@sun.ac.za

EucXylo - David Drew, Andie de Villiers

EucXylo

The Hans Merensky Chair in
Advanced Modelling of *Eucalyptus* Wood Formation
at Stellenbosch University

Funding Available for PhD and Masters students

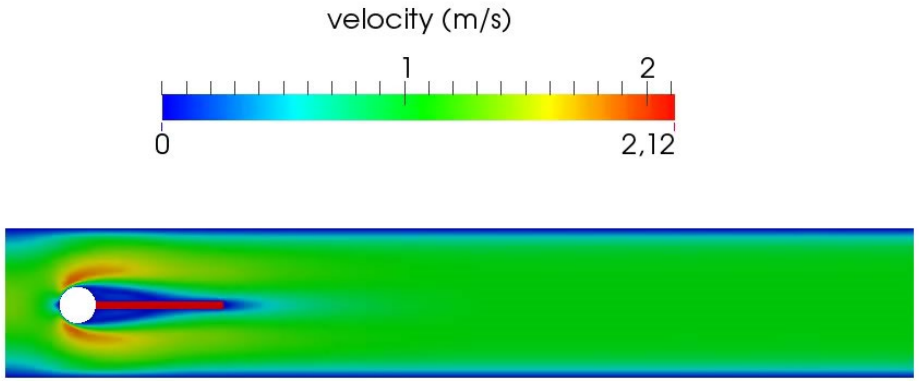


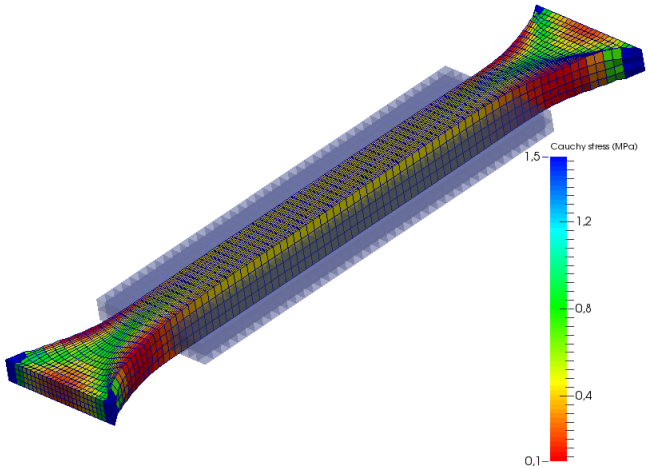
Multiscale, Multiphysics modelling

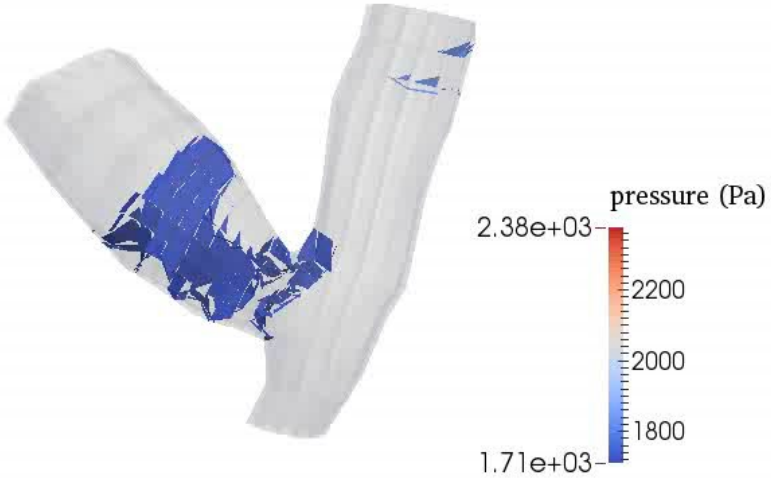
- Plant-, tissue- and cell-level
- Cell mechanics
- Plant fluid mechanics
- Growth modelling

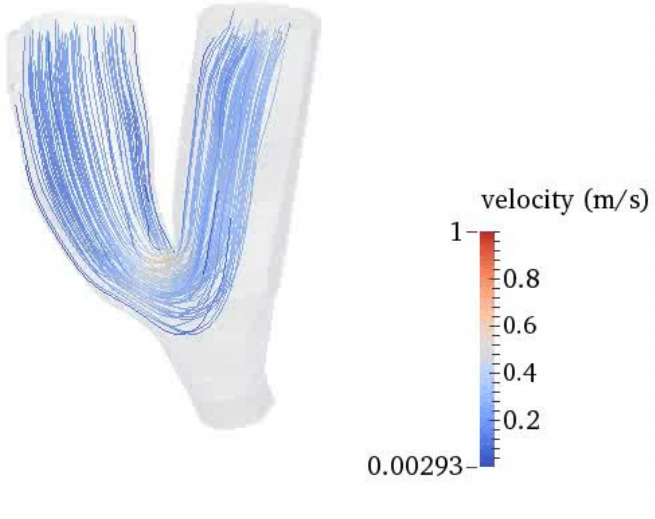
Contact: drew@sun.ac.za
andiedevilliers@sun.a.za

Other topics - Andie de Villiers



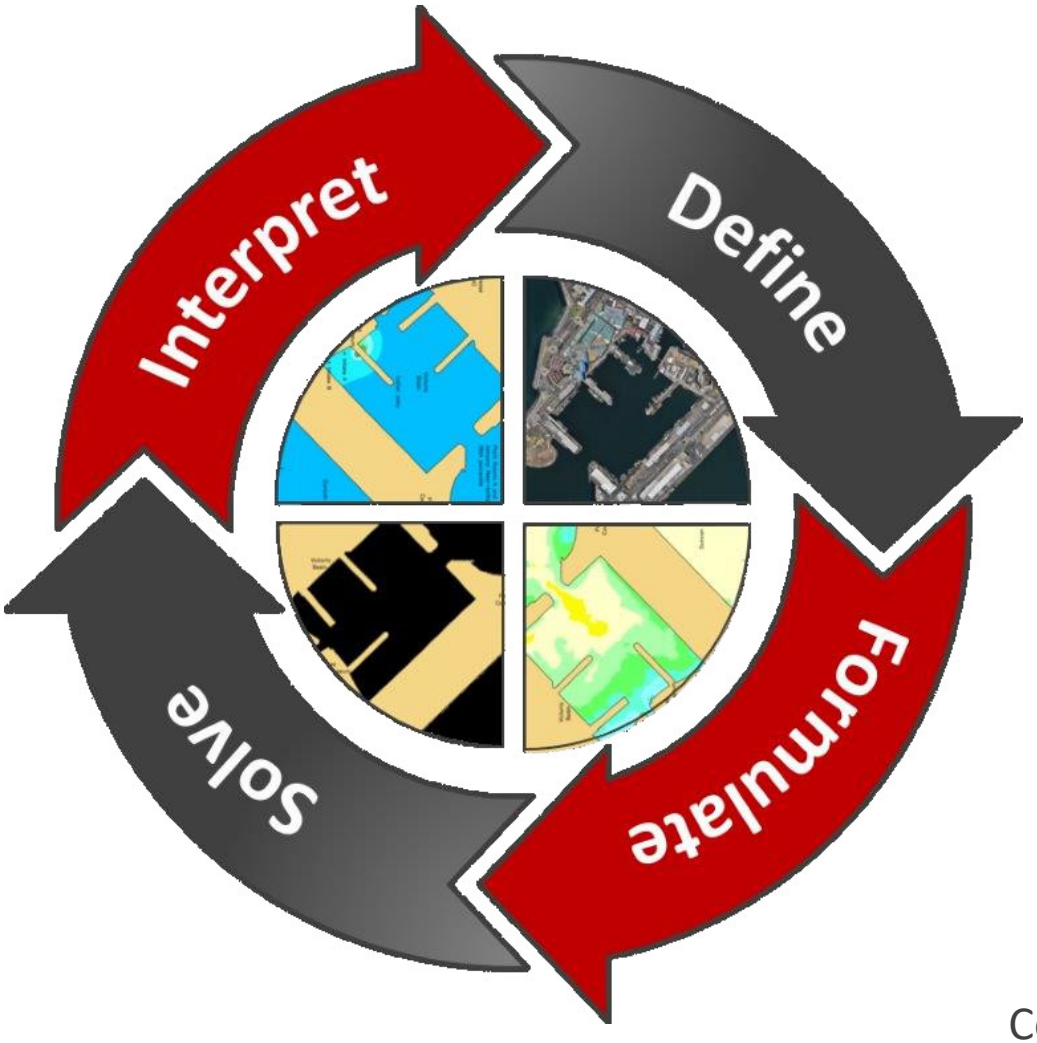






Contact: andiedevilliers@sun.ac.za

Questions?



Contact: appliedmaths@sun.ac.za