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Computational Insights into Wind Patterns and Albatross Mortality

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As technology advances, field researchers increasingly apply sophisticated computational methods to study biological systems, enabling insights across individual, population, and ecosystem scales that were previously challenging to obtain through traditional observational approaches. The present study focused on the impact of wind patterns on sub-Antarctic Marion Island's ecology, combining extensive field observations, wind tunnel experiments, and numerous computational fluid dynamics (CFD) simulations (using both ANSYS Fluent and Siemens Star-CCM+). The initial phase of the project involved simulating wind flow across Marion Island (ca. 330 km²) and the adjacent Prince Edward Island. This was a time-consuming task due to the scale and complexities of modelling atmospheric flow, even with access to the resources at the CHPC. The resulting wind data have informed various ecological studies on Marion Island, particularly in phase two of this research, which focused on understanding grey-headed albatross crash-landings around an inland breeding site in relation to local wind patterns.

Field observations of crash sites on Marion Island showed that most grey-headed albatross crashes occurred during departure flights, where low altitude and variable wind vectors pose risks. To complete an aerodynamic investigation a wing geometry was constructed using a combination of wind tunnel testing, 3D scanning and photographs of grey-headed albatrosses in flight. The extensive aerodynamic investigation was completed using CFD analyses of the generated geometry in gliding flight, incorporating over 350 simulations with a fine 3D mesh. The simulated aerodynamic loads showed that these birds can generate lift up to nine times their weight at high airspeeds and positive angles of attack. Under prevailing westerly winds near the inland breeding site, high cross-winds combined with moderate downdrafts create downforces (negative lift) comparable to the bird's weight, leading to high-impact crashes that are often fatal.

Given the albatross's low natural mortality rate, the current level of wind-related deaths is concerning. This study provides rare insight into how on-land wind patterns affect seabirds and highlights the need for ongoing monitoring of changing conditions.

Student or Postdoc?

Email address

Co-Authors

CHPC User

CHPC Research Programme

Workshop Duration

Primary author: Ms SCHOOMBIE*, Janine (University of Pretoria)

Co-authors: Prof. SMITH, Lelanie; Prof. CRAIG, Ken (University of Pretoria)

Presenter: Ms SCHOOMBIE*, Janine (University of Pretoria)

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