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Robust optimisation of cargo loading and ship scheduling in tidal areas

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Until now, works in the field of tide routing (i.e. optimisation of cargo loading and ship scheduling decisions in tidal ports and shallow seas) have omitted the uncertainty of sea levels predictions. However, from the harmonic tide forecasts to the outputs of ensemble prediction systems, sea level predictions are not perfectly reliable. Consequences for the maritime industry are significant: current solutions to tide routing may be robust through the introduction of arbitrary slack but they are not optimal. Given the financial implications at stake for every additional centimetre of draft but also the dramatic effects of a grounding, an investigation of tide routing from the perspective of risk analysis seems necessary.

Considering the journey of a bulk carrier between two ports, a shipping decision model is designed to compute cargo loading and scheduling decisions, given the time series of the sea level point forecasts in these ports. Two procedures based on particle swarm optimisation and Monte Carlo simulations are used to solve the shipping net benefit constrained optimisation problem. The outputs of probabilistic risk minimisation are compared with those of net benefit maximisation. Our technique is assessed on a realistic case study between two British ports with 54-hour-ahead sea level predictions provided by the British Oceanographic Data Centre. Results show that only the decision taking into account the stochastic dimension of sea levels is robust in real port and weather conditions. Further, we investigate the sensitivity of the shipping decision computed by the model to both the risk metric (minimax regret, mean-risk, worst-case) and the representation of the sea level forecast uncertainty (from a statistical modelling based on historical data to an imprecise probability approach).