MATHEMATICAL MODELLING OF SUBSEA DISPERSANT INJECTION

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ABOUT ME

- PHD IN MATHS AT UNIVERSITY OF OXFORD
- IN COLLABORATION WITH BP

- KNOWLEDGE TRANSFER POSTDOC: OXFORD + BP
- APPLY MODELS TO MAKE A PRACTICAL TOOL FOR SUBSEA DISPERSANT INJECTION
- EXTENSION WORK IN BP

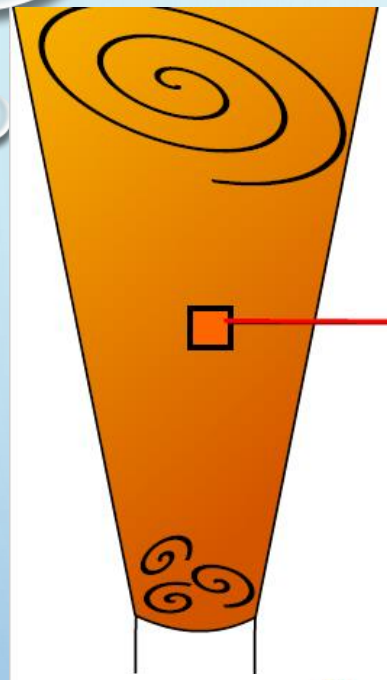
BACKGROUND AND CONTEXT

- WANT TO INCREASE DROPLET BREAKUP: REDUCE VOLUME OF LARGE OIL DROPS AND PRODUCE SMALLER OIL DROPS
- DISPERSANT INJECTED TO BREAK UP DROPS

BACKGROUND AND CONTEXT

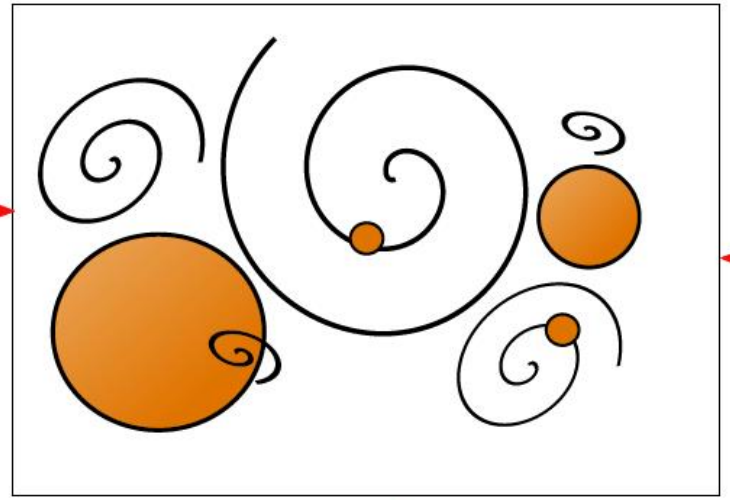
- CURRENTLY, A DEFINED CONCENTRATION OF DISPERSANT IS APPLIED
- CAN WE DO BETTER?
- ASSESS CHANGING CONDITIONS AND PREDICT
  - WHERE TO INJECT DISPERSANT?
  - HOW MUCH DISPERSANT TO APPLY?
  - EFFICIENCY LOSS OF SUB-OPTIMAL DISPERSANT APPLICATION?

MODEL OVERVIEW

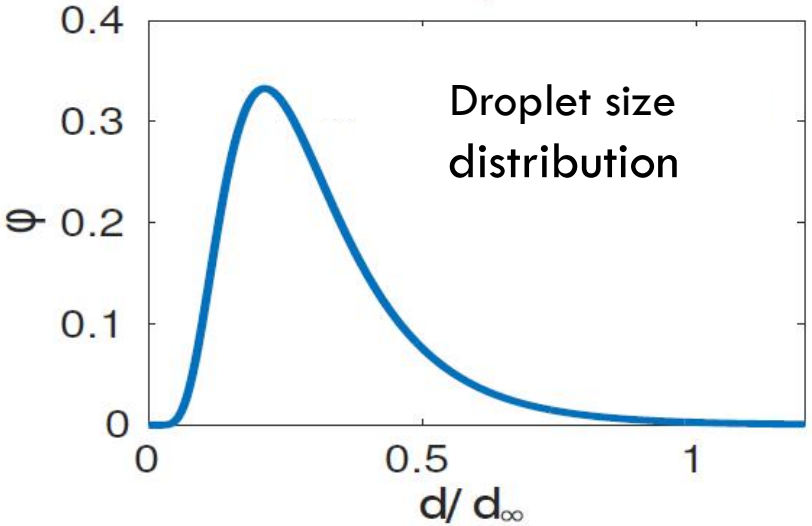


Turbulent jet

Oil drops



Dispersant



MATHEMATICAL MODEL

ASSUMPTIONS

- OIL IS NOT VISCOUS: APPROX. < 5 CST
- NO GAS
- FITTED TO SMALL-SCALE EXPERIMENTS

WHY USEFUL?

- SIMPLE AND UNIVERSAL
- CORRECT - COMPARES WELL WITH SMALL-SCALE SINTEF EXPERIMENTS.
- MODELS VARIATION OF SURFACE TENSION IN JET (UNLIKE OTHER MODELS). ALLOWS INVESTIGATION INTO CHANGING DISPERSANT APPLICATION

MIDAS TOOL (MODEL OF IDEAL DISPERSANT APPLICATION: SUBSEA)

- SIMPLE USER INTERFACE
- ENABLES EXPLORATION OF DIFFERENT DISPERSANT APPLICATIONS AND THEIR EFFECT ON THE EFFICIENCY OF DROPLET BREAKUP
- OPEN SOURCE
- PROOF OF CONCEPT

Input
- Oil spill parameters e.g. flow rate
- Dispersant parameters

MIDAS
- Computes variation of drop size distribution with height

Output
- Efficiency of droplet breakup

UI Figure

MIDAS | Single case study | Injection height | Dispersant concentration

MIDAS (Model for Ideal Dispersant Application: Subsea)

MIDAS predicts the efficiency of subsea dispersants and how this varies with dispersant amount and injection height.

SINGLE CASE STUDY:

First type in input values.

Click "Go!" to calculate dispersant efficiency for the case corresponding to your inputed parameters.

Calculations may take up to 1 minute and once complete a message box saying "Done!" will appear.

The average drop size with and without dispersant are displayed, and the drop size distribution is plotted. There is also an option to see relevant drop sizes which can be fed into the OSCAR far-field model.

INJECTION HEIGHT:

Type in input values.

Click "Go!" to see how drop size varies with the injection height. Calculations may take 2-5 minutes.

DISPERSANT CONCENTRATION:

Again type in input values.

Click "Go!" to see how drop size varies with the amount of dispersant injected. Calculations may take 2-5 minutes.

MIDAS assumes there is no gas. In general, the oil is assumed to a light oil which is not very viscous (with viscosity less than approximately 5 CSt) e.g. Oseberg blend. It should be used in consultation with an SME. Hold for legal disclaimer.

UI Figure

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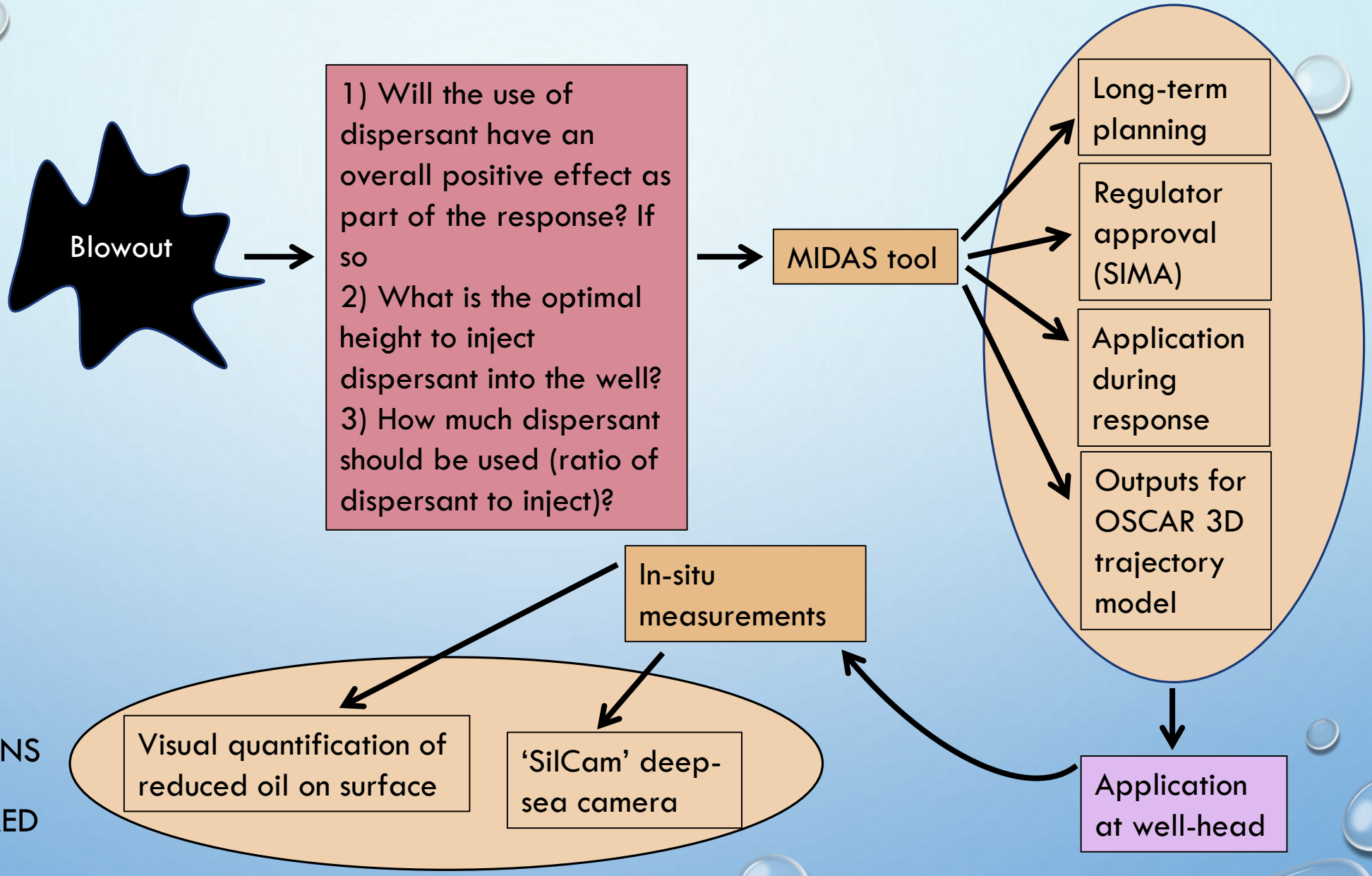
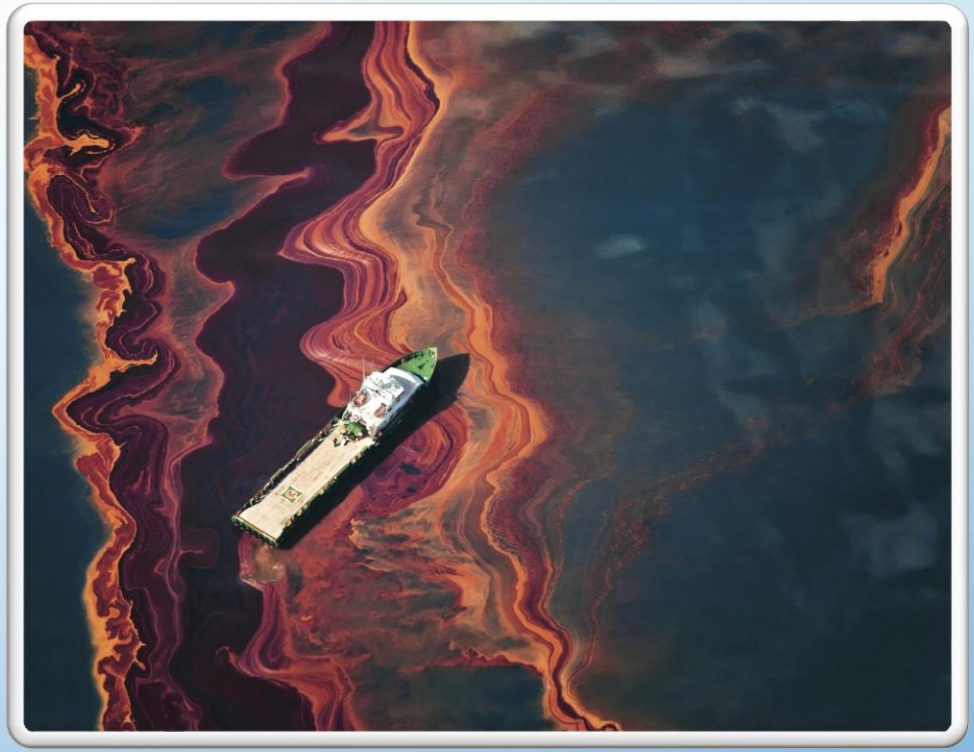
WHERE DOES MIDAS TOOL FIT?



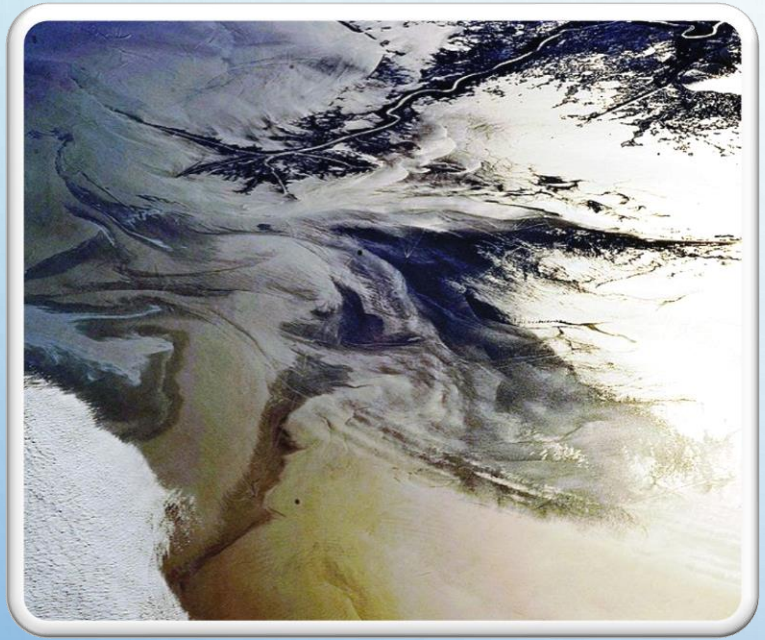
- OPEN CONVERSATIONS
- MAKE MORE INFORMED DECISIONS

CONCLUSIONS

- INJECT DISPERSANT CLOSE TO THE DISCHARGE POINT.
- IF NOT POSSIBLE, PAST A CERTAIN HEIGHT CONSIDER WHETHER DISPERSANT SHOULD BE ADDED AT ALL.
- INCREASING DISPERSANT CONCENTRATION CAUSES DROPLET BREAKUP
- THIS MAY HAVE DIMINISHING RETURNS PAST A CRITICAL CONCENTRATION



FURTHER WORK



- CAN THE SAME APPROACH BE USED FOR MORE VISCOUS OILS?
- WHAT EFFECT, IF ANY, WILL GAS HAVE ON DISPERSANT EFFECTIVENESS?
- TEST AND VALIDATE AGAINST REAL-WORLD SCENARIO.

TRY IT OUT YOURSELF!

EMAIL YOUR INTEREST TO ANDREW.TUCKER@BP.COM