**Project overview**

**Innovative disaster prevention system for oil/gas spill**

Numerical prediction of diffusion and drifting of spilled oil/gas
- Fluid dynamics, chemical process
- Multi-scale, multi-physics

Data transfer  Data assimilation

Autonomous tracking and monitoring oil/gas plume

SOTAB-I Robot  SOTAB-II Robot

Project Web: http://www.naoe.eng.osaka-u.ac.jp/~kato/project/en/

**Objective of present study**

- Numerical modeling of oil/gas spill in deep water.
- Implementation of methane hydration considering convective mass and heat transfer.
- Investigation of drop size effect on spilled region.

**Numerical model**

**Methane gas**
- Lagrangian control volume + Lagrangian particle tracking
- Conservations of momentum, heat, and mass
- Bubble size distribution
- Gas dissolution
- Gas separation from plume
- Bubble breakup and coalescence
- Hydrate formation, dissociation
- Hydrate dissolution

**Crude oil**
- Lagrangian particle tracking
- Conservation of momentum
- Droplet size distribution

**Conclusions**

- Oil/gas spill behavior was simulated by using a Lagrangian approach.
- Effect of convective mass and heat transfer on methane hydration was successfully considered with Ranz-Marshall equation.
- Small oil drop raise slowly and diffused in horizontal direction by sea current.

**Results and discussion**

**Validation of numerical code**

**Kinetics of hydrate formation**

\[
\frac{dn}{dt} = K \cdot 4\pi r^2 \cdot \psi \left(f_{\text{dis}} - f_{\text{eq}}\right)
\]

Chen & Yapa (2002):
- \(K = \text{const.}, \quad \Psi = 38\)

Present model:
- Ranz-Marshall eq.
- \(Sh = 2 + 0.65Sc^{1/3}Re^{1/2}\)
- \(Nu = 2 + 0.6Pr^{1/3}Re^{1/2}\)
- \(\Rightarrow K = f(Re), \quad \Psi = 1\)

- Simulated extent of spilled oil/gas well agreed with experiment.
- Methane hydration decreased the rising velocity of methane.
- Convective mass and heat transfer affected methane hydration immediately after blowout.

**Oil spill simulation in GOM with the Prinston Ocean model (POM)**

**Vertical distribution of oil droplet**

- Horizontal distribution of oil droplet
- Motion of small oil droplets was strongly affected by sea current.
- Around the the Macondo well, oil spilled in the east-west direction.
- High accuracy prediction requires a proper ocean model.