A High-Level Overview of The Consortium for Advanced Research on Transport of Hydrocarbon in the Environment (CARTHE)

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Processes Affecting Transport in Deep Water Oil Blow-Outs:

- Hurricanes and storms
- Atmospheric advection
- Evaporation
- Precipitation
- Mixing
- Wind
- Wave mixing
- River outflow
- Tides/surges
- Land deposition & sediment mixing

Oil Fate
- Weathering
- Biodegradation
- Buoyancy
- Multi-phase plume
- Settling

Plume
- Ocean current advection
- Mixing

Air-Sea

Coastal
Our Main Goal:

To accurately predict the fate of hydrocarbons released into the environment, thereby guiding risk management and response efforts to minimize damage to human health, the economy and the environment.
This goal will be achieved through:

(A) Interconnection of a number of state-of-the-art hydrodynamic models across a vast range of spatial and temporal scales of motions caused by different physical processes;

(B) A dedicated set of in-situ and laboratory experiments designed for model evaluation and parameterization;

(C) Uncertainty analysis to assess model performance and solution space.
Summary of CARTHE’s Innovative Aspects and Team Members:

- Buoyant plume modeling through Large Eddy Simulation (LES): Özgökmen, Poje (CUNY), also Fischer (ANL).

- Near-surface wind/wave driven Langmuir circulation modeling (Zha, UM) and a three-phase air-sea-oil model (Soloviev, NOVA).

- Coupled ocean-wave-atmosphere modeling systems with extensive experience in tropical storms: Chen, Donelan (UM), Jacobs (NRL prediction group)

- Atmospheric LES model for small-scale feedback to ocean models: Zhu, FIU

- Connectivity across shelf break to land fall using coastal (Dawson, UT Austin) and surf zone models (Reniers, UM; MacMahan, NPS)
• **Expertise in 2D and 3D transport analysis using theory (Dewar, FSU) and Lagrangian Coherent Structures (LCS): Haza, Olascoaga, Griffa (UM), Kirwan, Lipphardt, Huntley (UD)**

• **In-situ dispersion (UM PIs), near-surface turbulence (Bogucki, TAMU-CC) and bottom oil (Rosenheim, Tulane) observations**

• **Laboratory experiments of air-sea interaction at ASIST and SUSTAIN salt water tank facilities (Haus, UM)**

• **Novel uncertainty quantification tools: Iskandarani, Srinivasan, Mariano (UM), Restrepo, Venkataramani (UA)**
Buoyant Plume Model: (Özgökmen, Poje, Fischer)
LES of a plume interacting with mixed layer flows (Özgökmen, Fischer)
Multiphase Air-Sea Interface Model
Including Hurricane Conditions (Soloviev, NOVA)

- 1000-fold density difference between air and water is handled
- Will be extended to include a third phase, namely oil. 
Ocean-Wave-Atmosphere Coupled Model: Forecast of Hurricane Katrina (Chen, Donelan, UM)
Example of CARTHE work initiated

- 16 ensemble members have been initiated starting at the DWH event time.
- A constant inflow of contaminant is injected into each member by a simple 2D surface dispersion model.
- The results show the possibility of three main possible paths.
- Two paths (black arrow) follows the observed trajectory.
- One other paths (red arrow) shows that forecasts errors could lead to incorrect application of resources if the error information is not accounted for.

Ensemble average of concentration injected at DWH site:

NOAA analysis of observed oil position
- Evaluation against satellite-observed spill extents provided by NOAA NESDIS.
- Overlap of 60% of observed spill, even a full week into the simulation.
- Research thrust: improve circulation and transport in the nearshore including 3D and biogeochemical effects.
Near-shore Model - Transport in the Surfzone Using Delft3D and Experiments: (Reniers, UM; MacMahan, NPS)
A Transport Analysis Tool – Lagrangian Coherent Structures (UM and UD PIs): *To Identify Transport Barriers in Time-Dependent Velocity Fields*

2D LCS:

“Forbidden zones” in the GoM circulation area (left panel, Olascoaga);

Application of 2D LCS to understand areas of uncertainty caused by chaotic regions for the DWH spill using the intersection of backward (red, stretching) and forward (blue, uncertainty) in time transport barriers (right panel, Huntley, Kirwan, Lipphardt).
3D LCS (Özgökmen and LLNL): computed from ~100 million particles releases

Important to understand how vertical motions in eddies and waves influence transport
Why Do We Need A Lagrangian Dispersion Experiment?

- Which turbulent features control the transport?
- Are the long-living, slow mesoscale features enough to compute transport?
- Or, rapidly-evolving, smaller submesoscale transport barriers are needed?
Hypothesis-I: energetic and slowly-evolving turbulent features in control, data-assimilating OGCMs would be adequate to give good predictions

Hypothesis-II: rapidly-evolving small scales dictate relative dispersion at submesoscales, parameterizations for submesoscale processes would be needed in OGCMs
Multi-Scale Drifter Deployment Module and A-Priori Error Analysis

~100-200 drifters will be deployed near the DWH site; never been done at this scale

positions and dispersion can be accurately measured to to quantify both model evaluation and parameterization
Project Timeline:

- **Year 1:**
  - Idealized studies of transport within individual components
  - Historical reconstruction of DWH event from OGCM hindcasts
  - Coupled modeling
  - Lagrangian dispersion experiment

- **Year 2:**
  - Integration of modeling components
  - Quantification of submesoscale transport
  - Model evaluation and submesoscale parameterization
  - Surfzone experiments and laboratory tank results

- **Year 3:**
  - Effect of extreme events (hurricanes) on oil dispersion
  - Uncertainty quantification and hazard maps
Management Structure:

**Steering Committee**

T. Öztokmen (RSMAS), Director

D. Bogucki (Texas A&M)
S. Chen (RSMAS)
C. Dawson (U. Texas, Austin)
W. Dewar (Florida State)
G. Jacobs (NRL Cenennis)
A. D. Kirwan, Jr. (U. Delaware)
J. MacMahan (NRL Monterey)
A. Poje (CUNY Staten Island)
J. Restrepo (U. Arizona)
B. Rosenheim (Tulane)
A. Soloviev (Nova)
P. Zhu (Florida Intl.)

**Observations**

B. Haus (RSMAS)

**Models**

G. Jacobs (NRL Stennis)

**Uncertainty**

M. Iskandarani (RSMAS)

**Outreach**

A. Mariano (RSMAS)

**Atmosphere/Waves**

D. Bogucki
A. Griffin
J. MacMahan
J. Olausonaga
B. Rosenheim

S. Chen
M. Donelan
P. Zhu

**Ocean**

A. D. Kirwan, Jr.
A. Haza
H. Huntley
B. Lipphardt
T. Öztokmen
A. Poje
A. Soloviev
G. Zha

C. Dawson
W. Dewar
A. Reniers

A. Mariano
J. Restrepo
A. Srinivasan
S. Venkatarama

All Co-PIs

CARTHE Kick-off Meeting: 17-18 November, 2011, at UM
• THANKS VERY MUCH FOR THIS GREAT OPPORTUNITY!!!

• We are looking forward to establishing close ties with other GRI consortia.