Remote Sensing and Sea-Truth Measurements of Methane Flux to the Atmosphere (HYFLUX project)

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Executive Summary of HYFLUX Program Work

On 1 October 2008, Texas A&M University - Corpus Christi began work on the National Energy Technology (NETL) funded project Remote Sensing and Sea-truth Measurements of Methane Flux to the Atmosphere (HYFLUX). This portion of the project was Budget Period 1. Project management activities during Quarter 1 were dedicated to completing the project management plan and setting up sub-contracts with Scripps Oceanographic Institution, University of California, Santa Barbara, University of Southern Mississippi, and Texas A&M University-College Station. Discussions in relation to planning for the upcoming cruise were completed by email and conference call among the project investigators at the conclusion of Quarter 2. During Quarter 3, preparation for the seaturth cruise was the major focus of effort for all investigators. During Quarter 4, the investigators completed the seaturth cruise, curated the samples and data collected during the cruise, and submitted a report describing the results of the cruise.

Phase 2, budget period 2 for the project was initiated on 1 October 2009. Figure 1 shows a Gantt style chart outlining tasks during the quarterly period October through December 2010. This is the tenth and last scheduled quarter of the project. During budget period two, work on the project had been largely over-shadowed by response to the Gulf of Mexico oil spill particularly for MacDonald, Garcia-Pineda, and Leifer. Kastner was also involved. Consequently, there was a diversion of effort away from project tasks that is being redressed as the project comes to a close. A no-cost extension of project deadlines was requested and has been allowed by DOE NETL managers.

Project investigators are now engaged in final reporting and development of publications for the fieldwork and remote sensing components of the program. A series of conference calls among the investigators has focused attention on the final report with associated publications. Because
each of the disciplinary groups, i.e., remote sensing, air-sea flux, water column, bubble flux, and carbonate sequestration, has approached the question of methane flux from hydrate formations separately, care must be taken to coordinate the results into a coherent presentation.

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Progress, Results, and Discussion

The following is the working outline of the final report. Specific project tasks that will be addressed in each section are indicated in underlined italics.

HYFLUX Final Report Outline

1. Introduction

1.1 Methane flux to mixed zone and atmosphere
Background on methane fluxes from marine seeps
Shallow Seeps
Deepwater Seeps

1.2 Gas hydrate in the Gulf of Mexico
Gas hydrate occurrence on continental margins is predominantly in the form of disseminated deposits at the base of the GHSZ. Focused flow conduits occur in margins where tectonic processes including plate boundaries and diapirism force fluids through stratigraphic traps. Where gas hydrate occurs: well-studied examples include Hydrate Ridge, Black Sea, and Gulf of Mexico.

1.3 Formation of seafloor carbonates and chemosynthetic communities

2. Methods and Materials

2. 1 Remote sensing Task 9
2.1.1 Goals of HYFLUX project
2.1.2 Remote Sensing Background
   Theory of remote sensing oil with SAR
   Previous results of Remote Sensing Inventory
   The Texture Classifying Neural Network Algorithm (TCNNA)

2.2 Field Study Methods Task 6
2.2.1 Study Site Description
   MC 118
   GC 600
   GC 185

2.2.2 Bubble visualization Task 11
2.2.3 Water Column Sampling and Analysis Task 12
2.2.4 Sea-Air Flux Measurement Task 13
2.2.5 Sediment Collection Task 14

2.3 Analytical methods (Tasks 12, 13, 14)
   Water column
   Pore fluids
   Carbonate
   Bubble propagation numerical modeling
   Estimates of methane oxidation
   Sea-air flux calculations
   Diffusive methane flux estimates

3 Results
3.1 Remote Sensing Inventory of Gas Hydrate Tasks 9, 10
   3.1.2 SAR image archive processed
   3.1.3 Regional assessment of GH in Gulf of Mexico
   3.1.4 Abundance and distribution of oil & gas seep in Gulf of Mexico
      Comparison of MC118, GC600, and GC185 sites in remote sensing results
      Comparative regional flux of oil and gas
   3.1.6 Results from Black Sea and West African Margin
   3.1.5 Gulf of Mexico seep database

3.2 Methane flux to water column Tasks 11, 12
   3.2.1 Bubble size emission distributions, plume fluid dynamics, bubble
      hydrate skin effects
   3.2.2 Water column CH$_4$ distribution
   3.2.3 Hydrocast grids (CTD) and spatial extent of saturation anomalies
   3.2.3 Stable isotopes $\delta^{13}$C-CH$_4$

3.3 Sea-Air Methane Fluxes Task 13
   3.3.1 Results
      MC118
      GC600
      GC185

3.4 Authigenic carbonate formation and cycling of methane-derived carbon in
   gas-hydrate-bearing sediments Task 14
   3.4.1 Modeling AOM and carbonate precipitation rates
4 Integration and discussion

4.1 Spatial and temporal variation in fluxes
   Evidence from Remote Sensing Results
   Evidence from Sea-Air Measurements
   Site-to-Site comparisons

4.2 Comparison of Gulf of Mexico hydrate system to other regions

4.3 Gas hydrate CH$_4$ sources and fluxes
   Discussion of factors affecting water column profiles, importance of hydrate skins, importance of plume processes, importance of oil
   Discussion of importance of stratification, particularly pycnocline
   Discussion of fresh water lensing (fresher surface waters)
   Detailed discussion of CH$_4$ distribution in the upper 100 m
   Estimation of extent of methane oxidation
   Numerical modeling implications for seepage over a range of Gulf depths
   Comparison between 2003 and 2009 results at GC 185
   Diffusive CH$_4$ flux estimates to the atmosphere
   Possible impacts of Climate Change on hydrate stability and methane flux
   Comparison between Sea-Air and water column flux measurements - difficulty in measuring methane flux from hydrate systems.

5. Literature Cited

6. Appendices
   Remote Sensing Data (FSU)
   Water sample data (Scripps, UW, FSU)
   Carbonate data (TAMUCC)
   Bubble flux data (UCSB)
   Sea-air data (TAMU)

Presentations and publications (Task 14)
Four principal publications for the peer-reviewed literature are being developed based on the results described above with anticipated submission in 2011. Additional student publications may be forthcoming at future dates. The titles and authorship is as follows:

Title: Methane fluxes to the atmosphere from deep hydrocarbon seeps in the northern Gulf of Mexico
Authorship: L. Hu, S. Yvon-Lewis, J. Kessler, I. MacDonald
Submitted to: Earth and Planetary Science Letters

Title: Methane emissions from 550-1200 m seeps in the Gulf of Mexico
Authorship: E. Solomon, M. Kastner, I. Leifer, I. MacDonald, J. Chanton
For submission to: Limnology and Oceanography or Global Biogeochemical Cycles
Title: Natural oil and gas sources in the Gulf of Mexico: Quantification by satellite remote sensing
Authorship: I. MacDonald and O. Pineda-Garcia
For submission to: Nature Geoscience

Title: Rates of carbonate precipitation in gas hydrate sediments of the Gulf of Mexico
Authorship: T. Naehr, R. Shapiro, W. Ussler III, and M. Kastner
For submission to: Marine Chemistry or Chemical Geology

Conclusion
The HYFLUX project has completed its project phase and is entering its reporting period.
Cost Status

Figure 2  Expenditures by Quarter. Cumulative projected costs (upper panel) and cost status as of Quarter 2, 2011.
Milestone Status
No Milestones achieved during this reporting period.

Problems or Delays
A no-cost extension of the project was granted. Final reporting will be completed prior to 29 August 2011.
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