AUSTRAL SUMMER INSTITUTE – VII (ASI-VII)

2 – 26 January 2007

Universidad de Concepción (UDEC) – Woods Hole Oceanographic Institution (WHOI) – Fundación Andes (FA) Cooperative Program

I. Introduction

The Seventh Austral Summer Institute (ASI VII) was held at the Marine Biology Station of the Oceanography Department of the University of Concepción, in Dichato, and at the Main Campus of the University of Concepción, from January 2 through January 26, 2007.

ASI-VII was devoted to: **Methane biogeochemistry and geophysics & Remote Sensing and Ocean-Land interaction.**

Methane biogeochemistry and geophysics consisted of four courses:

1) Methane: Microbes, Biomarkers & Carbon Cycle (January 2 – 5, 2007)
2) Methane hydrates (January 8 – 12, 2007)
3) Sediment diagenesis & biology (January 15 – 19, 2007)
4) Methane turnover & seeps (January 22 – 26, 2007)

Remote Sensing and Ocean-Land interaction consisted of two courses:

1) Connecting land and the ocean (January 3 – 12, 2007)
2) Remote sensing & bio-optics (January 16 – 26, 2007)

ASI-VII was developed as part of the UDEC-WHOI-FA cooperative project.

Graduate and advanced undergraduate students in the areas of Marine Sciences and Oceanography, academics, post-doctorates, and professionals interested in the areas of Marine Geology and Geophysics were all invited to apply.

II. Announcements and Applications

Publicity for the Austral Summer Institute VII (ASI-VII) included national and international mailings (letter of invitation, program, application form and poster), e-mails (letter of invitation and program), and a Web page at http://www.udec.cl/oceanoudec/oceanografia

Information on ASI-VII was also posted on the following websites:

http://www.udec.cl/congresos/ (UDEC)

http://copas.udec.cl/eng/education/courses/asi7.pdf (FONDAP COPAS)

http://www.conicyt.cl/cgi-bin/w3-msql/agenda/sigue.html?id=1302 (CONICYT)

http://www.ocean-partners.org/POGOsponsopps.htm (POGO)

http://www.eula.cl/ (EULA)

http://www.ciep.cl/not/noticias2.php?id=28 (CIEP)

http://www.cona.cl/boletines/2006/boletin0706/02jul06.html (CONA)

http://www.comisionunesco.cl/Unesco/ListaNoticias.jsp# (IOC UNESCO)

Applicants were required to fill out an application form, write a letter of intent, and provide a brief CV.

Applicants for the Austral Summer Institute VII (ASI-VII) totaled 97. 49 of them were from Chile, 5 were from Argentina, 17 were from Brazil, 3 were from Colombia, 2 were from Costa Rica, 2 were from Egypt, 2 were from Germany, 1 was from India, 1 was from Japan, 1 was from Kenya, 1 was from Mauritius, 4 were from Mexico, 5 were from Peru, 1 was from Scotland, 1 was from Uruguay, 1 was from the USA and 1 was from Venezuela.

III. Participants and Lecturers

Methane biogeochemistry and geophysics

22 students were accepted for the course **Methane: Microbes, Biomarkers & Carbon Cycle.** 10 students were from Chile, 5 were from Brazil, 4 were from Mexico, 1 was from Scotland, 1 was from Germany and 1 was from Peru.

19 students were accepted for the course **Methane Hydrates**. 8 were from Chile, 4 were from Brazil, 4 were from Mexico, 1 was from Scotland, 1 was from Germany and 1 was from Peru.

21 students were accepted for the course **Sediment diagenesis & biology.** 10 were from Chile, 4 were from Brazil, 4 were from Mexico, 1 was from Scotland, 1 was from Germany and 1 was from Peru.

16 students were accepted for the course **Methane turnover & seeps**. 8 were from Chile, 2 were from Brazil, 4 were from Mexico, 1 was from Scotland and 1 was from Peru.

REMOTE SENSING AND OCEAN-LAND INTERACTION

14 students were accepted for the course **Rivers: Connecting land and the ocean.** 10 were from Chile, 3 were from Brazil and 1 was from Peru.

14 students were accepted for the course **Remote sensing & bio-optics**. 9 were from Chile, 3 were from Brazil, 1 was from Argentina and 1 was from Peru.

The participant roster is included at the end of this report.

Eleven lecturers participated in ASI-VII.

	Methane biogeochemistry and geophysics	
	Name	**Affiliation**
1	Dr. Kai-Uwe Hinrichs	RCOM, University of Bremen, Germany
2	Dr. Antje Boetius	Max Planck Institute for Marine Microbiology, Germany
3	Dr. Gerald Dickens	Rice University, USA
4	Dr. Richard Behl	California State University, Long Beach, USA
5	Dr. Gerhard Bohrmann	RCOM, University of Bremen, Germany
6	Dr. Jeffrey Chanton	Florida State University, USA
7	Dr. Lisa Levin	Scripps Institution of Oceanography, USA
8	Dr. Guillermo Alfaro	GEA, University of Concepcion, Chile
9	Dr. Jean Whelan	Woods Hole Oceanographic Institution, USA

	Remote sensing and ocean-land Interaction	
	Name	**Affiliation**
10	Dr. John Milliman	The College of William & Mary, VIMS, USA
11	Dr. Ajit Subramaniam	Lamont Doherty Earth Observatory at Columbia University, USA

IV. **Course contents**

METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

1) Methane: Microbes, Biomarkers & Carbon Cycle

Dr. Antje Boetius: Microbial ecology of methane turnover
Dr. Gerald Dickens: Carbon cycle and climate change
Dr. Kai-Uwe Hinrichs: Biomarkers in methane biogeochemistry

Methane biogeochemistry –Intro (What is methane? Global budgets, sources and sinks, principal reactions leading to methane) (AB, KH)

Methane in the marine environment (Methane solubility? How do we measure methane concentrations? Where do we find methane? General types of gas deposits (thermogenic versus biogenic) (JD, K Sources and sinks of methane in the ocean (CO_2 reduction, acetate fermentation, methylotrophy, thermogenesis, AOM, aerobic oxidation) (AB, KH)

Isotopic compositions of reactants and products in biogeochemical processes involving methane (KH)

Methanogens and methanotrophs, diversity, function and distribution (AB)

Metabolism and physiology of methanogens and anaerobic methanotrophs (AB)

Lipid biomarkers of methanogens and methanotrophs (KH)

Inorganic geochemistry of gas systems, cold seeps and mud volcanoes: what else is produced and consumed along with gas and microbes (JD, AB)?

Gas hydrates: what are they, where do they occur, and how do we detect them and quantify their abundance? How much is there? (JD)

Microbial ecology of ecosystems harboring anaerobic methanotrophs: cold seeps and subsurface environments (AB, KH)

Paleoceanography and methane:

1 How can we find old sites of methane venting? How we can examine past changes in seafloor methane fluxes? (JD)

The Paleocene/Eocene thermal maximum and other massive carbon injection events (JD)

The Clathrate Gun Hypothesis: pros and cons (KH, JD)

New questions and hypotheses in marine methane research: closing discussion (AB, JD, KH)

2) Methane Hydrates

Dr. Richard Behl: Methane hydrates and climate change: Evaluating the clathrate gun hypothesis

This seminar examined the role of methane and marine methane hydrates in Late Quaternary climate change. Was methane - an extremely powerful greenhouse gas on short time scales - an active or passive participant in past episodes of abrupt climate change? What is the evidence - for and against - for instability of methane hydrates contributing to the character of Late Quaternary climate change? What is impact of existing paradigms within different disciplines of Earth Science on our perception of the workings of the Earth System? This seminar will cover:

The Nature of Quaternary Climate Change
CO_2, Methane, and Climate
Methane Sources and Sinks
Two World Views: Terrestrial and Marine proxies
The Wetland Methane Hypothesis
The Clathrate Gun Hypothesis
Testing the Two Hypotheses
Marine Evidence
Ice Core Evidence

Alternate Hypotheses
Significance and Implications
Remaining Open Questions

Dr. Gerhard Bohrmann: Methane hydrates in marine sediments – formation, detection and relevance.

Clathrates: cages and crystal structures; guest molecules
Stability and phase boundaries
Seismic evidence for gas hydrates
Empirical predictions of methane hydrate stability
Gas hydrate stability zone (GHSZ) in marine sediments and permafrost
Gas transport and hydrate precipitation
Fabric of natural gas hydrates: deep and shallow hydrates
Gas hydrates and pore water anomalies
Gas hydrate and seafloor venting, AOM, precipitates
Gas hydrates and submarine slope failures and economic perspective
Drilling gas hydrates and quantification of gas hydrates
Global estimates of gas hydrates
Gas hydrates and submarine slope failures and economic perspective

Recent interest in gas hydrates emerges from the awareness that hydrate deposits may play significant roles in global and regional processes with societal and economic significance. A global hydrate assessment, although still uncertain, suggests that methane hydrates might represent an important future energy. In addition, other important hydrate questions that have attracted attention include: 1) Is there a feedback between methane hydrate stability and climate? 2) What is the role of methane hydrate in the carbon cycle? and 3) How much does gas hydrate contribute to seafloor stability on continental slopes? The purpose of this lecture is to summarize some of the fundamentals of our current understanding of gas hydrate in marine sediments, its interactions with the environment, and recent findings from ongoing research programs that illustrate key aspects of gas hydrate dynamics.

3) Sediment diagenesis & biology

Dr. Jeffrey Chanton: Diagenesis and pore water chemistry

Sequence of electron acceptors that serve as oxidants for organic matter diagenesis, their reaction products and their fate. Typically referred to as biogeochemical zonation, a suite of compounds serve the microbial degradation of organic matter. These compounds are used in a sequence governed by their energy yield. Their reduced forms then go on to interact in the sediments resulting in the overall process of sedimentary diagenesis.

Reaction-diffusion models of this process were introduced and discussed.

Dr. Lisa Levin: Biology and ecology of methane seeps

Lectures on seep biology covered a range of topics in the areas of biogeography, adaptation, symbiosis, evolution, community ecology and food web structure. Linkages among sediment biogeochemical conditions, microbes and animals were discussed. We highlighted the diversity of tools and

techniques available to study biological processes. Examples were drawn from seeps in the Pacific, Atlantic, Gulf of Mexico and Indian Oceans and from Chile in particular.

4) Methane turnover & seeps

Dr. Guillermo Alfaro: Mineral and energy: Resources of the ocean bottom: Comparison with ancient cases.

Geología de los fondos marinos. Desde la Deriva de los Continentes a la Tectónica de Placas. Se entregará una visión histórica de los conceptos geológicos relevantes que llevaron a la actual visión de la geología global y de los fondos oceánicos. Se partirá con una visión de la Tierra en el universo y se terminará con una radiografía de lo que son los fondos oceánicos hoy.

2.- Los recursos minerales y energéticos asociados a los fondos marinos.

2.1.- *Recursos Energéticos*:

a.-Los hidratos de metano. Génesis, exploración, aspectos económicos. Riesgos asociados. Importancia en la secuestración de CO2. El cambio geopolítico que ellos implican. Los Estados Unidos de América: ¿Un nuevo emirato árabe? La situación particular de Chile: ¿Cuándo se incorporarán a la matriz energética?
b.- Hidrocarburos líquidos en cuencas "marinas". El Golfo de México y el Mar del Norte. El caso de Chile
c.- Carbones en la Plataforma Marina

2.2.- *Recursos minerales.*

a.- Sulfuros polimetálicos masivos
b.- Costras cobaltíferas y elementos asociados
c.- Nódulos de manganeso
d.- Placeres litorales: oro, diamante, estaño. ¿Qué hay en los fondos marinos de Tierra del Fuego? Historia de un descubrimiento
e.- Mineralización hidrotermal en el Mar Rojo
f.- Efectos en el medio al explotar con métodos actuales

3.- "El presente es la clave del pasado". Las ofiolitas y mineralización asociada (cromitas, sulfuros polimetálicos, asbesto). Un fondo de océano pretérito que podemos caminar: El Macizo de Troodos (Chipre) y la Cordillera de la Costa del sur de Chile.

4.- Terreno. Visita a rocas del Manto Superior y corteza oceánica de 280 millones de años. Lanalhue-Lleu Lleu-Tirúa- Centinela. Se verán rocas ultramáficas serpentinizadas y cromititas formadas bajo la Discontinuidad de Mohorovicic (límite corteza-manto).

Dr. Jean Whelan: Natural oil and gas seeps in the ocean-potential effects on chemistry, biology and geology of the ocean and atmosphere.

A number of areas have now been identified in the ocean floor where gas and/or oil naturally vent vigorously into the water column, particularly in ocean margins. This course will describe a number of shallow and deep water areas around the world where these venting processes have been observed along with the potential mechanisms of venting and sources of the hydrocarbons. An introduction to gas and oil formation and migration in ocean sediments will be presented. The potential influences of these vents on local biota, gas hydrates (large potential energy resource), seafloor stability, mud volcanoes, tsunamis, and as a possible "deep sediment source of metal discharge to the ocean" were summarized.

The potential for utilization of these hydrocarbons as a "deep biosphere" food source were discussed.

REMOTE SENSING AND OCEAN-LAND INTERACTION

1) Dr. John Milliman: Rivers: Connecting land and the ocean. Processes and problems

- Runoff, Erosion and Delivery to the Coastal Ocean

- Fluvial Discharge of Fresh Water
  - Precipitation and Evapotranspiration
  - Discharge and Runoff
- Sediment Delivery
  - Factors Controlling Substrate Erosion
  - Regional and Global Sediment Fluxes
- Dissolved Solids
  - Factors Controlling Chemical Weathering
  - Regional and Global Dissolved-Solid Fluxes

- Temporal Variability

- Periodicity in Flow
  - Seasonal
  - Short-term Climatic Cycles
  - Long-term Change
- Events
  - Supply-related Events
  - Transport-related Events

- Human Impacts

- Watershed Land-use
- River Control
- Case Histories

- Future Fluvial Delivery to the Coastal Ocean

2) Dr. Ajit Subramaniam: Use of Remote Sensing and Bio-Optics for Coastal Water Quality Monitoring

Remote sensing techniques can be used to monitor coastal water quality and satellite based sensors can be a very cost effect method for collecting environmental data. Once placed in service, satellites provide regular, regionally synoptic data that can complement conventional shipboard surveys by filling the gaps between surveys. Regional synoptic data can help distinguish between nearfield and farfield effects and separate local production from that advected into the region. Satellite sensors can also be a continuous source of information for decadal scale monitoring of the dynamics of natural and anthropogenic changes in the ecosystem, often providing baseline data for "before" and "after" conditions.

The course will cover the various types of remote sensing measurements and in-situ bio-optical instruments and their application to coastal water quality monitoring. The students will be taught the basic principles of bio-optics to understand and interpret satellite data and how to validate it with in-situ data. The course will also provide a brief introduction to the use of Geographical Information Systems (GIS) to understand spatial distribution of water quality data using ArcView GIS software. The course will be taught in a "hands on" manner and the students will be shown data sources and tools to manipulate satellite data in laboratory exercises. They will be taught how to use SeaDAS, a software package developed at NASA, to process ocean color data from raw level 1A to final products. They will make field measurements of bio-optical parameters and validate satellite data. The students were expected to participate in a term project for the final class grade that would require the processing, analysis, display, and interpretation of ocean color and moored bio-optical data. The students will form two person teams for a total of six projects similar to those suggested below. The students are encouraged to come prepared with ideas and validation datasets for projects, especially if they have extensive validation datasets or a clear application in mind. Validation datasets include multiyear (1998-present) time series measurements of biooptical parameters such as chlorophyll concentration, total suspended solids concentration, water clarity (Secchi depth) etc.

1) Evaluation of ocean color algorithms for water quality monitoring in coastal waters using in-situ data.
2) Preparation of time-series data from moored sensors, comparision with in-situ evaluation data sets to aid in decision support systems (Hovmoller plots, "movie loops").

AUSTRAL SUMMER INSTITUTE VII (ASI-VII)

Announcement

AUSTRAL SUMMER INSTITUTE VII (ASI-VII)

Methane Biogeochemistry and Geophysics & Remote Sensing and Ocean-Land Interaction
January 2 – January 26, 2007

Universidad de Concepción – Woods Hole Oceanographic Institution - Fundación Andes Cooperative Program and UNESCO IOC Chair in Oceanography

The Department of Oceanography and the FONDAP COPAS Center are pleased to announce the **Austral Summer Institute VII (ASI-VII)** to be held at the University of Concepción in January 2007. ASI-VII will be devoted to the topics of **Methane Biogeochemistry and Geophysics & Remote Sensing and Ocean-Land Interaction**.

Graduate, advanced undergraduate students and professionals in the areas of marine biology and ecology, oceanography, environmental microbiology or related fields are invited to apply. Fundación Andes will cover room, board, and national transportation costs for selected Chilean citizens and graduate students in Chilean graduate programs. Additional funding is being sought to cover expenses for other participants.

Applications for **ASI-VII** must include: 1) a complete copy of the application form, 2) a current copy of the applicant's *curriculum vitae* (summarized to 2 pages) with educational and work histories, and 3) a brief (one page) letter of intent indicating the scientific interests of the applicant and how s/he hopes to benefit from participating in this activity. Interested persons could apply for either the entire **Methane Biogeochemistry and Geophysics**, or one/some of the modules; or the entire **Remote Sensing and Ocean-Land Interaction**, or one of the modules (see enclosed information or http://www.udec.cl/oceanoudec/oceanografia/.

The applications (in English) can be sent by e-mail, fax, or mail and **must be received no later than Saturday September 30th 2006.** The tuition fee is US$ 250 and fellowships are available for qualified participants. The selection of applicants is highly competitive, and special attention is paid to the applicant's potential as a future scientist and his/her academic achievements to date. Maximum capacity is 15 students.

For additional information and application forms, please contact:

Ms. Mónica Sorondo
Departamento de Oceanografía
Universidad de Concepción
Casilla 160-C, Concepción, Chile
http://www.udec.cl/oceanoudec/oceanografia/
E-mail: asi@udec.cl, Tel.: (56) (41) 203557 Fax: (56) (41) 207254

Dr. Silvio Pantoja G.
UNESCO-IOC Chair and UDEC/WHOI/FA Project Director
Department of Oceanography
University of Concepción

Application Form

AUSTRAL SUMMER INSTITUTE VII (ASI-VII)

METHANE BIOGEOCHEMISTRY AND GEOPHYSICS & REMOTE SENSING AND OCEAN-LAND INTERACTION

January 2 – January 26, 2007

Universidad de Concepción (UDEC) – Woods Hole Oceanographic Institution (WHOI) – Fundación Andes (FA) Cooperative Program – UNESCO IOC Chair in Oceanography

1. Name:

_____

Last *first* *middle*

2. Address for Reply _____
Phone Number: _____ **Fax Number** _____
E-mail: _____

3. Are you a Chilean citizen? _____ YES _____ NO

4. Record of Education

Undergraduate School:

_____
Name of School

Numbers of years completed:

_____

Field:

_____

Name of Degree: _____

Dates Attended: From: _____ To: _____

Date Degree Granted/Expected: _____

Graduate School (if applicable):_____
Name of School

Numbers of years completed: _____ Field: _____
Name of Degree: _____
Dates Attended: From: _____ To: _____
Date Degree Granted/Expected: _____

Post-Doctoral, Faculty, Professional Information (if applicable):

_____

Name of School / Institution / Company

Position Held: _____

Number of Years in that Position: _____

5. **Certifications and Diplomas**: _____

_____

6. **Honors and Awards**: _____

_____

7. Please mark all applicable boxes:

METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

Biomarkers, carbon cycle & microbial ecology (January 2 – January 5)

☐ Microbial ecology of methane turnover
Carbon cycle and climate change
Biomarkers in methane biogeochemistry

Methane hydrates (January 8 – January 12)

☐ Methane hydrates and climate change: Evaluating the clathrate gun hypothesis
Methane hydrate in marine sediments - formation, detection and relevance

Sediment diagenesis & biology (January 15 – January 19)

☐ Diagenesis and pore water chemistry
Biology and ecology of methane seeps

Methane turnover & seeps (January 22 – January 26)

☐ Mineral and energy: resources of the ocean bottom: Comparison with ancient cases
Natural oil and gas seeps in the ocean- potential effects on chemistry, biology, and geology of the ocean and atmosphere

REMOTE SENSING AND OCEAN-LAND INTERACTION

Rivers: Connecting land and the ocean (January 3 – January 12)

☐ Rivers: Connecting land and the ocean. Processes and problems

Remote sensing & bio optics (January 16 – January 26)

☐ Use of remote sensing and bio-optics for coastal water quality monitoring

In case you apply to more than one course, please indicate priorities.

Financial Support (in US$)

Expenses	US$	Available by Student	Requested from UDEC
Tuition			
Transportation			
Food & Lodging			
TOTAL			

Please enclose a current copy of your *curriculum vitae* (summarized to 2 pages) with educational and work histories, and a brief (one page) letter of intent indicating the scientific interests of the applicant and how s/he hopes to benefit from participating in this activity.

"I declare that the information presented above is true and correct to the best of my knowledge and I understand that any misinformation, voluntary or otherwise, can be grounds for the rejection of my application. Furthermore, I authorize the University with which I am affiliated/my place of employment to release information on my status as a student/academic/professional."

Date: _____ Applicant's Signature:_____

Program

AUSTRAL SUMMER INSTITUTE VII (ASI VII)
METHANE BIOGEOCHEMISTRY AND GEOPHYSICS & REMOTE SENSING AND OCEAN-LAND INTERACTION

METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

Methane: Microbes, Biomarkers & Carbon Cycle, January 2 – 5

Lecturer	Institution	Topic
Dr. Antje Boetius	Max Planck Institute for Marine Microbiology, Germany	Microbial ecology of methane turnover
Dr. Gerald R. Dickens	Department of Earth Science, Rice University, USA	Carbon cycle and climate change
Dr. Kai-Uwe Hinrichs	RCOM, University of Bremen, Germany	Biomarkers in methane biogeochemistry

Methane hydrates, January 8 –12

Lecturer	Institution	Topic
Dr. Richard J. Behl	California State University, Long Beach, USA	Methane hydrates and climate change: Evaluating the clathrate gun hypothesis
Dr. Gerhard Bohrmann	RCOM, University of Bremen, Germany	Methane hydrate in marine sediments - formation, detection and relevance

Sediment diagenesis & biology, January 15 –19

Lecturer	Institution	Topic
Dr. Jeffrey Chanton	Department of Oceanography, Florida State University, **USA**	Diagenesis and pore water chemistry
Dr. Lisa Levin	Scripps Institution of Oceanography, **USA**	Biology and ecology of methane seeps

Methane turnover & seeps, January 22 –26

Lecturer	Institution	Topic
Dr. Guillermo Alfaro	Instituto de Geología Económica Aplicada, University of Concepción, **Chile**	Mineral and energy: Resources of the ocean bottom: Comparison with ancient cases
Dr. Jean Whelan	Woods Hole Oceanographic Institution, **USA**	Natural oil and gas seeps in the ocean- potential effects on chemistry, biology, and geology of the ocean and atmosphere

REMOTE SENSING AND OCEAN-LAND INTERACTION

Lecturer	Institution	Topic
Dr. John Milliman	The College of William & Mary, **USA**	Rivers: Connecting land and the ocean. Processes and problems
Dr. Ajit Subramaniam	Lamont Doherty Earth Observatory at Columbia University, **USA**	Use of remote sensing and bio-optics for coastal water quality monitoring

PARTICIPANT ROSTER: AUSTRAL SUMMER INSTITUTE VII (ASI-VII)

METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

Methane: Microbes, Biomarkers & Carbon Cycle, January 2 – 5

	Name	Affiliation	E-mail
1	Leslie Abarzúa	Center of Biotechnology, University of Concepción, CHILE	leabarzu@udec.cl
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METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

Methane Hydrates: January 8 – 12, 2007

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18	Sam Wilson	Dunstaffnage Marine Laboratory, Scottish Association for Marine Science, SCOTLAND	sam.wilson@sams.ac.uk
19	Marcos Yukio Yoshinaga	Oceanographic Institute, University of São Paulo, BRAZIL	yoshinaga@io.usp.br

METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

Sediment diagenesis & biology: January 15 – 19, 2007

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METHANE BIOGEOCHEMISTRY AND GEOPHYSICS

Methane turnover & seeps: January 22 – 26, 2007

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REMOTE SENSING AND OCEAN-LAND INTERACTION

Rivers: Connecting land and the Ocean January 3 – 12, 2007

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REMOTE SENSING AND OCEAN-LAND INTERACTION

Remote sensing & bio optics, January 16-26

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