REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	08/26/98	PROGRESS 10/1/97-9/30/98

4. TITLE AND SUBTITLE

Local Measurements of the Air-Sea Gas Transfer Rates

5. FUNDING NUMBERS

N000149410050

6. AUTHOR(S)

Bernd Jaehne

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

The Regents of the University of California
Scripps Institution of Oceanography
Physical Oceanography Research Division
9500 Gilman Drive, La Jolla, CA 92093-0210

8. PERFORMING ORGANIZATION REPORT NUMBER

94-1022

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Available to public

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Please see attached sheet

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

DTIC QUALITY INSPECTED 1

14. SUBJECT TERMS

15. NUMBER OF PAGES

5

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

UNIVERSITY OF CALIFORNIA, SAN DIEGO UCSD

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

SCRIPPS INSTITUTION OF OCEANOGRAPHY
OFFICE OF CONTRACT AND GRANT ADMINISTRATION

9500 GILMAN DRIVE
LA JOLLA, CALIFORNIA 92093-0210

File: ONR-G

September 2, 1998

Chief of Naval Research (3)
Attn: Dr. Ron Ferek, Code 322MM
Ballston Tower One
800 North Quincy Street
Arlington, Virginia 22217-5660

Director, Naval Research Laboratory (1)
Attn: Code 2627
Washington, DC 20375

Office of Naval Research (1)
Attn: ONR OOCC1, Mr. William McCarthy
Ballston Tower One
800 North Quincy Street
Arlington, VA 22217-5660

Veronica Lacey (1)
Office of Naval Research
San Diego Regional Office
4520 Executive Drive, Suite 300
San Diego, California 92131-3019

Defense Technical Information Center (2)
8725 John J. Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218

SUBJECT: Progress Technical Report
ONR Grant Number N00014-94-1-0050
Principal Investigator: Bernd Jaehne

Enclosed is the progress technical report and SF298 for the above referenced grant.

Sincerely,

Nancy Wilson

Nancy Wilson
Manager, Contracts and Grants, SIO

Enclosure

Air-Water Gas Transfer in Coastal Waters

Bernd Jaehne and Jochen Klinke
Physical Oceanography Research Division 0230
Scripps Institution of Oceanography
La Jolla, CA 92093-0230
phone: (619) 534-6860 or 8209, fax: (619) 534-8509
E-mail: bjaehne@ucsd.edu and jklinke@ucsd.edu
Award#: N00014-94-1-0050

LONG-TERM GOALS

The long-range objective of this project is threefold: a) the investigation of the mechanisms of air-water gas transfer by field measurements, b) the development of novel instrumentation for insitu measurements of the gas transfer rate and the parameters controlling it, and c) the solution of the long-standing problem of a physically-based parameterization of the air-sea gas transfer rate.

OBJECTIVES

In interdisciplinary field experiments the influence of wind forcing, short wind waves, and surfactants on the air-sea gas transfer is studied in coastal waters. The measurements include the air-sea gas transfer rate with a temporal resolution in order of minutes using heat as a proxy tracer, the air friction velocity, water currents and turbulence, air and water temperatures, visible and IR radiative fluxes, the visco-elastic properties of surface films, and wave number-frequency spectra of short wind waves. The measurements of the air-sea gas exchange rate with our instruments were combined with concentration measurements of carbon dioxide and dimethyl sulfide in the sea and the atmosphere, and direct flux measurements of carbon dioxide using the eddy correlation technique.

APPROACH

Using heat as a proxy tracer, the transfer rate is measured locally and with a temporal resolution of less then a minute. This technique offers an entirely new approach to measure air-sea gas fluxes of arbitrary gases and simultaneously to observe the micro turbulence at the ocean interface. Two independent techniques have been developed and successfully applied during field experiments. Both techniques use extended image sequences of the ocean surface temperature with and without artificial heating. The active technique estimates the time constant of heat transfer from the temporal decay of a heated spot at the ocean surface. Measuring the spatiotemporal temperature distribution on top of the aqueous mass boundary layer, heat patterns could be observed that directly revealed the horizontal structure of surface-near turbulence. Together with a physical modeling of the underlying transfer processes the passive technique allowed to compute transfer rates directly from the surface temperature distribution without artificial heating. The active heat spot-tracking and the passive statistical method deliver consistent results.

This project is conducted in cooperation with Dr. Erik Bock, Dr. Nelson Frew, and Dr. James Edson from WHOI and Dr. Tetsu Hara from the University of Rhode Island. The field experiments include two major components. One experiment took place in July 1997 with partial support from the NSF CoOP program. Additional longer-term measurements are planned in the year 1999 to fill in gaps in the range of conditions in the vicinity of the new SIO Marine Observatory, a platform about a mile off the Scripps Pier.

WORK COMPLETED

During the recent CoOP East Coast experiment from July 1 to July 18, 1997, the CFT instrument was used for the second time in the field. The cruise started from coastal waters at Martha's Vineyard sound south of Cape Cod, MA, leading to several Gulf Stream transects halfway to the Bermuda islands. Although no high wind speeds were encountered (maximum 8.4 m/s) the experimental conditions include a large variability in physicochemical surface conditions ranging from coastal waters with high surfactant concentrations up to very clean, deep blue waters close to the Bermuda islands. Measurements could be taken on 15 days in total. A first evaluation of the data showed that it will be possible to get good data from measurements at up to 10 days. Details are contained in the following table. The last column indicates the estimate of the quality of the data and additional comments.

CFT boom conditions, CoOP 97

JD	Time (UT)	Wind (m/s)	Conditions/patterns
188	01:25:34 - 02:52:00	0.0 - 0.9	Fair, high humidity, no waves
188	09:17:10 - 11:25:50	0.7 - 1.9	Fair, sky reflexes visible
189	01:32:07 - 02:15:39	4.0 - 4.3	Bad, foggy
190	02:47:26 - 05:33:30	1.0 - 3.1	Good, low fluorescence TOPEX crossing
191	00:08:42 - 03:02:40	6.3 - 8.3	Good, sky reflexes
192	10:12:14 - 13:16:45	1.5 - 2.7	Rain
193	09:21:42 - 13:49:13	2.0 - 4.7	Excellent, clear sky, frequent surface renewal visible
194	00:18:41 - 00:45:45	4.7	Excellent, clear sky
194	08:12:34 - 11:25:18	2.5 - 4.1	Good, foggy, small scale structures, surface renewal visible
194	18:43:31 - 19:53:12	4.5 - 5.3	Fair, daytime, sun reflexes, TOPEX crossing
195	08:50:50 - 11:16:03	4.9 - 5.8	Bad, foggy, sky reflexes
196	09:31:20 - 13:05:45	4.9 - 6.3	Bad, high humidity, sky, reflexes
197	00:53:43 - 03:08:55	4.7 - 5.8	Fair, high humidity
198	00:40:50 - 05:25:41	6.7 - 8.4	Fair, clear sky, reflexes
199	00:44:26 - 02:01:50	6.7 - 7.2	Bad, clear sky, reflexes

Wind wave spectra from the scanning laser slope gauge measured and evaluated from the WHOI/URI group are available for 6 of the 10 conditions for the same time periods.

RESULTS

The main data evaluation period will be from October 1998 through June 1999. During this period Dr.Erik Bock will be a visiting scientist at Heidelberg University and work together with Dr. Haussecker and the PI on the data.

Some preliminary results are already available:
1. The rates at low wind speeds are significantly higher as predicted by the empiric relationships based on laboratory data. This is not surprising. At low wind speeds there is still a residual turbulence in the ocean, which is not present in the laboratory facilities.
2. The data rather support surface renewal models of the than turbulent eddy models. Surface renewal is directly observable in the IR image sequences showing surface patches washed away statistically even at low wind speeds (Haussecker et al., 1998).
3. The surface velocity field derived from infrared image sequences clearly shows convergence and divergence zones that violate the two-dimensional continuity equation and thus also indicate the importance of surface renewal (Jaehne et al., 1998).

IMPACT/APPLICATIONS

We envision that the methods developed so far in this research project are only the beginning of a new interdisciplinary research area that merges chemistry, applied optics, fluid mechanics, and image processing techniques to gain an unprecedented insight into the mechanisms of small-scale air sea interaction processes (Jaehne, 1995; Jaehne and Haussecker, 1998).

RELATED PROJECTS

The activities in this project are closely related to the NSF CoOP project "Air-Sea Gas Exchange in Coastal Waters." Both projects focus on the air-sea gas exchange at the interface and thus support each other. In cooperation with the image processing group of the PI at the Interdisciplinary Center for Scientific Computing (University of Heidelberg, Germany), new algorithms are being developed for the local analysis of the surface flow image sequences from the IR image sequences within a research unit funded by the German Science Foundation (DFG) (Jaehne, 1997a and b; Jaehne et al, 1998; Haussecker and Jaehne, 1998).

PUBLICATIONS

Jaehne, B., Impact of Quantitative Visualization and Image Processing on the Study of Small-Scale Air-Sea Interaction, Proceedings Air-Water Gas Transfer, Selected Papers, 3rd Intern. Symp. on Air-Water Gas Transfer, edited by B. Jaehne and E. Monahan, AEON, Hanau, pp. 3-12, 1995.

Jaehne, B., Practical Handbook on Digital Image Processing for Scientific Applications, CRC-Press, Boca Raton, FL, USA, 1997a.

Jaehne, B., Digital Image Processing - Concepts, Algorithms, and Scientific Applications, 4th completely revised edition, Springer, Berlin, 1997b.

Haussecker, H., and B. Jaehne, A tensor approach for precise computation of dense displacement vector fields, Proc.\ Mustererkennung 1997, Braunschweig, 15--17. September 1997, E. Paulus und F. M. Wahl (eds.), Informatik Aktuell, Springer, Berlin, 199--208, 1977.

Jaehne, B., and H. Haussecker, Air-Water Gas Exchange, Annual Review of Fluid Mechanics, 30, 443-468, 1988.

H. Haussecker, U. Schimpf, and B. Jaehne, Air-sea gas transfer and the dynamics and patterns of the ocean surface micro turbulence, abstract submitted to the OS18 Special Session Dynamics of the Ocean Surface Mixed Layer, at the AGU Ocean Science Meeting, San Diego, USA, February 9-13, 1988.

U. Schimpf, J. Klinke, H. Haussecker, and B. Jaehne, Novel instrumentation for synergetic studies of short wind waves, surface micro turbulence and air-sea gas transfer, abstract for poster submitted to the OS26 Special Session Recent Advances in Ocean and Fresh Water Science Instrumentation, at the AGU Ocean Science Meeting, San Diego, USA, February 9-13, 1988.

Jaehne, B., H. Haussecker, H. Spies, D. Schmundt, and U. Schurr, Study of dynamical processes with tensor-based spatiotemporal image processing techniques, Computer Vision (ECCV'98), Proc. Vol. II, H. Burkhardt and B. Neumann (eds.), Lecture Notes in Computer Science 1407, Springer-Verlag, Berlin, pp. 322-335, 1998.

Haussecker, H., and B. Jaehne, Tensor-based image sequence processing techniques for the study of dynamical processes, invited paper, International Symposium on Realtime Imaging and Dynamic Analysis, Hakodate, Japan, June 2-5, 1998.

Haussecker, H., U. Schimpf, and B. Jaehne, 1998. Measurements of the air-sea gas transfer and its mechanisms by active and passive thermography, Proc. IGARSS98, Seattle, July 1998.

Jaehne, B., H. Haussecker, and P. Geissler (eds.), Handbook of Computer Vision and Applications (3 volumes, approx. 2500 pages), Academic Press, 1999, in press.

AWARDS

DAGM Award 1997 for the contribution ``A tensor approach for precise computation of dense displacement vector fields", by H. Haussecker and B. Jaehne.