# INTRODUCTION

This second edition of *Numerical Modeling of Water Waves* describes the technological revolution that has occurred in numerical modeling of water waves during the last decade. A CD-ROM with many of the FORTRAN codes of the numerical methods for solving water wave problems and computer animations of the problems that have been solved using the codes is included with the book. Several PowerPoint presentations describing the modeling results are on the CD-ROM. It will be called the NMWW CD-ROM in the rest of the book.

The objective of this book is to describe the numerical methods for modeling water waves that have been developed primarily at the Los Alamos National Laboratory over the last four decades and to describe some examples of the applications of these methods. Some of the applications of the numerical modeling methods were performed while the author was working at the Joint Institute for Marine and Atmospheric Research at the University of Hawaii, some as Mader Consulting Co. research projects, and the rest as a Fellow of the Los Alamos National Laboratory.

Although the two- and three-dimensional numerical methods for modeling water waves had been available in the 1980's for several decades, they had seldom been used. A major obstacle to their use was the need for access to large and expensive computers. By the 1980's, inexpensive personal computers were adequate for many applications of these numerical methods.

In this book, the basic fluid dynamics associated with water waves are described. The common water wave theories are reviewed in Chapter 1. A computer code called *WAVE* for personal computers that calculates the wave properties for Airy, third-order Stokes, and Laitone solitary gravity waves is available on the NMWW CD-ROM.

The incompressible fluid dynamics model used for shallow water, long waves is described in Chapter 2. A computer code for personal computers using the shallow water model is called *SWAN* and is available on the NMWW CD-ROM. The *SWAN* code is used to model the 1946, 1960 and 1964 earthquake generated Hilo, Hawaii tsunamis, the 1964 Crescent City, California tsunami and the 1994 underwater landslide generated Skagway, Alaska tsunami.

The two-dimensional incompressible Navier-Stokes model used for solving water wave problems is described in Chapter 3. A computer code for personal computers using the two-dimensional Navier-Stokes model is called *ZUNI* and is available on the NMWW CD-ROM. The *ZUNI* code is used to model tsunami wave propagation and flooding. It is also used to model the effect of underwater barriers on tsunami waves.

The three-dimensional incompressible Navier-Stokes model for solving water wave problems of any type is described in Chapter 4. The equations used in the computer code called *SOLA-3D* are described and the FORTRAN code is on the NMWW CD-ROM. The *SOLA-3D* code is used to model the 1975 Hawaiian tsunami and the 1994 Skagway tsunami by water surface cavities generated by underwater landslides.

It is surprising that most academic and government modelers of water waves have chosen to use shallow water or other incompressible models of limited validity for modeling water waves and not use the incompressible Navier-Stokes model since the first edition of this book was published. The severe limitations of the shallow water model are described in Chapter 5.

The generation of water waves by volcanic explosions, conventional or nuclear explosions, projectile and asteroid impacts require the use of the compressible Navier-Stokes model. The numerical models and codes for solving such problems have recently become available as part of the Accelerated Strategic Computer Initiative program. A computer code for solving one, two and three dimensional compressible problems called *SAGE, NOBEL or RAGE* is described in Chapter 6 and some of its remarkable capabilities are presented. These include modeling of the KT Chicxulub asteroid impact and the modeling of the largest historical tsunami which occurred July 8, 1958, at Lituya Bay, Alaska. The modeling of the Lituya Bay impact landslide generated tsunami and the flooding to 520 meters altitude is described.

A color videotape (VTC–86–4) lecture featuring computer generated films of many of the applications discussed in this book is available from the Los Alamos National Laboratory library. Several web sites have been established that contain additional information and computer movies of the problems described in this book. The major sites are http://www.mccohi.com and
http://t14web.lanl.gov/Staff/clm/tsunami.mve/tsunami.htm.

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