Bilingual

双语版

Acoustics Toolbox

声学工具箱

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内容提要

Acoustics Toolbox（声学工具箱）及其中的标准算例是 Michael B. Porter 近 40 年来的心血凝聚，用 Fortran、Matlab 以及 Python 等科学计算语言演绎了海洋水声传播的射线追踪、简正波和谱积分等演算方法的大量标准算例。本手册以双语版形式，可为希望深入海洋水声物理的同学和爱好者快速入门提供方便。

前　言

古有“阳春白雪”与“下里巴人”之论。上天难，下海更不易！想玩转 Acoustics Toolbox 更属不易——须有数学物理学科的功底、海洋科学的浸染、阵列信号处理学科的基础、英语以及科学计算语言的磨砺！怎么也得博士级别的水平才能够轻松驾驭吧！

好在大三的同学们和其他专业本科毕业的爱好者们都已经有些底子了，因此本双语版 Acoustics Toolbox（声学工具箱）正是为了让水声物理“飞入寻常百姓家”，让与海洋水声打交道的人们都能够较早（大三）、较容易（非本学科）地快速上手，从海洋声场传播入手，感悟真实海洋声场的绚烂特质及其和相关学科的交叉互动，为此领域的工作筑下感性的基础，为大家成为此领域的“明白人”插上稚嫩的羽翼。

快速上手方法：

1、在 64 位 windows 平台上，将 at.zip、atWin10_2018_7.zip 解压，并将解压后的文件夹添加在 64 位 matlab“设置路径”的“添加并包含子文件夹”。

2、在 64 位 matlab 平台上，逐句运行并品味.. at\tests\及其下各子文件夹中的 runtests.m 和 runtestsM.m 文件。感悟并品鉴 Michael B. Porter 以 40 年修炼的功力为我们奉上的声学工具箱标准算例大餐。

3、本双语手册随时提供参考，可提前看，可边玩边查看，随您所愿就好！

4、.. at\tests\中的算例运行完毕，我们再齐声赞叹：感谢！！！

…………

在此，我感谢包（青华）老师、林（俊轩）老师、惠（俊英）老师的悉心指导，也感谢吴老师、张老师言传身教的鼓励！更感谢 Michael B. Porter 先生近 40

年来孜孜不倦地在水声物理领域辛勤的耕耘！尤其感谢由 Free Software 凝聚起来的自由科学家社区中大家无私共享的精神！

最后，特别感谢能够展卷习玩 Acoustics Toolbox（声学工具箱）的每一位水声工作者！

目　　录

Acoustics Toolbox 声学工具箱

0 Source

0 溯源

本小节内容来源于网页：http://oalib.hlsresearch.com/Modes/AcousticsToolbox/

updated 27 September 2018

更新日期：2018 年 9 月 27 日

The Acoustics Toolbox is distributed under the GNU Public License.

声学工具箱根据 GNU 公共许可证分发。

Download

下载

at source code (zip file) for Mac, Linux, or Windows. Binaries are *NOT* provided.
at 用于 Mac、Linux 或 Windows 的源代码（zip 文件）。未提供二进制文件。
at Binaries (zip file) for Windows 10. (You'll need to merge these with the source code if you want to access the test cases and Matlab plotting routines)
at 用于 Windows 10 的二进制文件（zip 文件）。（如果想要运行测试算例和 Matlab 绘图程序，需要将它们与源代码合并）

Older copies. These include binary files; however, they are quite out of date and the binaries may well not work for your particular machine/architecture.

旧的拷贝。这些文件包括二进制文件；但是，它们已经非常过时，二进制文件很可能不适合您的特定的机器/体系结构。

at Mac OSX source code and binaries (dmg file)
at 在 Mac OSX 的源代码和二进制文件（dmg 文件）

at Mac OSX source code and binaries (zip file)
at 在 Mac OSX 的源代码和二进制文件（zip 文件）
at Linux source code and binaries
at 在 Linux 的源代码和二进制文件
at Windows binaries
at 在 Windows 的二进制文件

You will probably need to recompile for your machine. The Fortran2008 source code should be fully portable. The binaries were all produced using GFortran. They use dynamic link libraries so you need a compatible version of gcc and gfortran installed to use those binaries.

您可能需要为您的机器重新进行编译。Fortran2008 的源代码应该是完全可移植的。二进制文件都是使用 GFortran 生成的。它们使用动态链接库，因此需要安装兼容版本的 gcc 和 gfortran 才能使用这些二进制文件。

Compiling the package

编译程序包

The Fortran95 standard does not clarify whether record lengths are in bytes or words. For some compilers, e.g. the Intel Fortran you need to use a compiler switch making bytes the standard unit for record lengths. We use the free gfortran compiler. The free g95 compiler has also worked well in the past; however, I believe the current version of AT uses Fortran features not implemented in g95.

Fortran95 标准没有说明记录长度是以字节还是以字为单位。对于某些编译器，例如 Intel Fortran，您需要使用一个编译器开关，将字节作为记录长度的标准单位。我们使用免费的 gfortran 编译器。免费的 g95 编译器在过去也运行得很好；但是，我相信 AT 的当前版本使用了没有在 g95 中实现的 Fortran 特性。

The compilation is done using standard Makefiles that work under Unix, OS X, etc. We also use them under Windows with either the Cygwin system or MinGW, which provide a Unix-like environment under Windows. Cygwin and Mingw are also freely distributed.

编译是用在 Unix、OSX 等环境下工作的标准 Makefile 完成的。我们还在 Windows 下通过 Cygwin 系统或 MinGW（它们在 Windows 下提供类似 Unix 的环境）应用它们。Cygwin 和 Mingw 也是免费、自由分发的。

make clean # to remove old objects and executables

make clean # 删除旧对象和可执行文件

make install # to move the binaries to at/bin

```
make install # 将二进制文件移动到 at/bin
```

Running the package

运行程序包

We currently run the Acoustics Toolbox through Matlab using shell-escape commands to execute the binaries and a variety of Matlab scripts and functions (in at/matlab) to manipulate and display the output. If you don't have Matlab then you'll have to figure out your own graphics. In that case, the Matlab plot routines at least provide a good example of how to read the file formats.

目前，我们通过 Matlab 运行声学工具箱--使用 shell 转义命令执行二进制文件，运用各种 Matlab 脚本和函数（在 at/matlab 中）来操作和显示输出。如果您没有 Matlab，那么您就得设计自己的绘图法。在这种情况下，Matlab 绘图程序至少能为如何读取文件格式提供很好的示例。

The only challenge in this phase is to get the paths set up properly. When you call the Acoustics Toolbox through Matlab, you're using Matlab scripts. Those Matlab scripts use the Matlab 'which' command to find the location of the binaries within the Matlab search path. Therefore, Matlab has to have its path set to include the Acoustics Toolbox.

这个阶段唯一的挑战就是正确设置路径。当您通过 Matlab 调用声学工具箱时，您使用的是 matlab 脚本。这些 Matlab 脚本使用 'which' 命令在 Matlab 搜索路径中查找二进制文件的位置。因此，Matlab 必须设置包含声学工具箱的路径。

Here's an example of running kraken at the regular command line (rather than from inside Matlab):

下面是在常规的命令行（而不是在 Matlab 中）运行 kraken 的示例：

```
cd at/tests/Munk
kraken.exe MunkK
```

The 'cd' command above is hypothetical. You should cd to the directory where you've created the Acoustics Toolbox. If you get an error, the likely problem is that the path is not set properly. The following commands may be useful in tracking that down.

上面的 'cd' 命令是假设的。您应该 cd 到创建声学工具箱的目录。如果出现错误，问题可能是路径设置不正确。以下命令可能对跟踪这一点很有用。

```
printenv
which kraken.exe
```

If instead, you run the package through Matlab, start Matlab and make sure you have 'at' in your path. Check that by typing to following on the Matlab command line:

与此相反，您通过 Matlab 运行程序包--启动 Matlab，确保路径中有 'at' 。通过在 Matlab 命令行上输入以下内容来检查：

```
cd at/tests/Munk
kraken MunkK
```

If the above runs without error, then go to at/tests and type 'runtests' to execute a huge battery of test cases. If the above generates an error then it could be you don't have at/Matlab in your Matlab path.

如果以上运行没有错误，那么转到 at/tests，输入 'runtests' 来执行大量的测试算例。如果以上运行生成了一个错误，那么它可能是您的 Matlab 路径中没有 at/Matlab。

Incidentally, the test battery that you run by typing 'runtests' may fail somewhere unless you have a beefy computer - it generates a very large number of figures and consumes a lot of memory in the process. However, it's easy enough to restart the test battery at exactly the point where it overwhelms your system.

顺便说一句，如果您没有一台强劲的电脑，通过输入 'runtests' 来运行测试算例可能会在某个地方出现崩停 -- 它产生了大量的绘图，在此过程中消耗了大量的内存。不过，从您的系统被压垮的那一点又重启测试算例（在哪里跌倒，就从哪里爬起来）也非常容易。

MATLAB version of the Acoustics Toolbox

声学工具箱的 Matlab 版本

Note that at/Matlab includes versions of BELLHOP, KRAKEL, SCOOTER, and SPARC in Matlab (Kraken to come soon). The Matlab versions are typically much slower; however, they're much easier to use and modify. The Matlab version of SCOOTER has an optional Mex file (thanks to Paul Hursky) for the inner loop which is a tridiagonal solver. If you compile the Mex file, the Matlab SCOOTER runs about as fast as the Fortran one. The Matlab versions are not maintained as carefully as the Fortran versions and may not have the latest updates.

请注意，at/Matlab 在 Matlab 中包含了 BELLHOP、KRAKEL、SPARC 和 SPARC 的版本（Kraken 即将推出）。Matlab 版本通常要慢得多；不过，它们更容易使用和修改。Matlab 版本的 SCOOTER 有一个可选的 Mex 文件（感谢 Paul Hursky）用于内部循环，这是一个三对角解算器。如果编译 Mex 文件，Matlab SCOOTER 的运行速度与 Fortran 版本的运行速度一样快。Matlab 版本的维护不如 Fortran 版本那么仔细，可能没有最新的更新。

GUI Wrappers:

GUI 软件包

ACT: Matlab front-end providing a Graphical User Interface for the Acoustic Toolbox written by Alec Duncan from the Centre for Marine Science and Technology at Curtin University.

ACT: 以 MATLAB 为前端，提供的一个图形用户界面的声学工具箱。由 Curtin University（科廷大学）Centre for Marine Science and Technology（海洋科学和技术中心）的 Alec Duncan 编写。

Python Tools:

Python 工具：

AcousticPy: Runs the test cases for the Acoustic Toolbox and provides components to read and plot various files--- written by Orlando Rodríguez from the University of Algarve.

AcousticPy: 运行声学工具箱的测试算例，并提供组件来读取和绘制各种文件 --由 Algarve 大学 Orlando Rodríguez 编写。

arlpy, a Python interface to BELLHOP. Some of these tools may be useful for KRAKEN as well *(New September 2018)*

arlpy, 针对 BELLHOP 的 Python 界面. 其中一些工具对 KRAKEN 也有用*（2018 年 9 月更新）*

- (*Mandar Chitre, National University of Singapore*)
- （*Mandar Chitre, 新加坡国立大学*）

1 The Acoustics Toolbox

1 声学工具箱

The Acoustics Toolbox is a collection of acoustic models and related software for studying sound propagation in an ocean waveguide. Actually, the models have been structured to be suitable for general wave propagation problems; however, the ocean application is our main focus.

声学工具箱是研究声音在海洋波导中传播的声学模型和相关软件的集合。实际上，这些模型已构造成可适用于广泛的波传播问题；不过，海洋应用是我们关注的主要焦点。

The acoustic models in the package are:

该软件包中的声学模型如下：

- KRAKEN normal mode approach
- KRAKEN 简正波方法
- SCOOTER spectral integral (also know as wavenumber integration or the reflectivity method)
- SCOOTER 谱积分(也称为波数积分或反射率法)
- BOUNCE calculation of a reflection coefficient for a stack of layers
- BOUNCE 计算分层界面间的叠反射系数
- BELLHOP Gaussian beam tracing and ray tracing code
- BELLHOP 高斯波束追踪与射线追踪程序
- SPARC A spectral integral code that operates directly in the time domain.
- SPARC 在时域直接运算的谱积分程序

There are generally no limits on the dimensions that can be handled (up to virtual memory). The code uses dynamic allocation for virtually all arrays. There are a few exceptions. You will generally get a flag if for some reason any dynamic memory allocation fails or if you have exceeded an intrinsic limit in the code.

可以处理的数组维度通常没有限制（取决于虚拟内存）。程序对所有数组均动态分配内存。也有少数例外。一般情况下，如果由于某种原因，某次动态内存分配失败，或者超出程序内在限制，均将获得一个标志。

The following modules are part of the package.

以下各模块是程序包的各部分。

Group I: Mode Computations:

第一组：模式计算

- KRAKEN Solves for the modes and writes them to disk. Elastic media are allowed but material attenuation in an elastic medium is ignored.
- KRAKEN 解算模式并将它们写入磁盘。允许有弹性介质，但忽略弹性介质引起的衰减。
- KRAKENC A version of KRAKEN which finds the eigenvalues in the complex plane. KRAKEN uses perturbation theory to obtain imaginary parts of the eigenvalues while KRAKENC computes the complex eigenvalues exactly. KRAKENC runs about 3 times slower but is necessary for leaky mode computations or for including material attenuation in elastic media. Internally KRAKENC replaces elastic layers by an equivalent reflection coefficent. For this reason, you cannot use KRAKENC to look at fields within the elastic layers.
- KRAKENC 在复平面上解算特征值的 KRAKEN 版本。KRAKEN 利用微扰理论得到特征值的虚部，KRAKENC 则精确地计算复数特征值。KRAKENC 的运行慢了大约 3 倍，但对计算泄漏模式或弹性介质中的衰减是必然的。在 KRAKENC 内部，弹性层用等效反射系数代替。因此，不能用 KRAKENC 来查看弹性层中的声场。
- KRAKEL Analogous to KRAKENC but also computes elastic displacements and stresses for elastic media. KRAKEL is seldom used and tends to not be kept up-to-date.
- KRAKEL 类似于 KRAKENC，而且也计算弹性介质的弹性位移和应力。KRAKEL 很少使用，因此没能与时更新。

Group II: Basic Plotting Routines:

第二组：基本绘图程序

- PLOTSSP Plots the sound speed profile.
- PLOTSSP 绘制声速剖面。
- PLOTMODE Plots selected modes.
- PLOTMODE 绘制选定的模式。
- PLOTGRN Plots the Green's funtion for the depth separated wave equation for a particular source/receiver combination.
- PLOTGRN 绘制深度分离的波动方程中特定声源/接收机组合的格林函数。
- PLOTTRI Plots the triangular elements used for 3-D field calculations.
- PLOTTRI 绘制用于三维声场计算的三角形微元

Group III: Field Computations:

第三组：声场计算

- FIELD Computes fields on a vertical array over a specified range and for a series of source depths. Individual phones in the array may be displaced from the vertical. Range dependence is handled by either adiabatic or one-way coupled mode theory.

- FIELD 在设定的距离内为一系列深度的声源计算垂直接收阵上的声场。阵列中单个阵元可以偏离垂直方向。距离依赖可采用绝热或单向模式耦合理论予以处理。
- FIELD3D Computes field for a three-dimensionally varying SSP using adiabatic mode theory.
- FIELD3D 针对三维变化的 SSP，采用绝热模式理论计算声场。

Group IV: Plotting Routines that use Group III Program Output:

第四组：使用第三组程序的输出进行绘图的程序

- PLOTSHD Plots tranmission loss in plane or elevation, i.e. an (x,y) plot or an (r,z) plot.
- PLOTSHD 绘制水平面或俯仰面的传播损失，即(x，y)绘图或(r，z)绘图。
- PLOTRAYXY Plots the ray paths of the Gaussian beams generated during 3D field calculations.
- PLOTRAYXY 绘制在三维声场计算中产生的高斯波束的声线路径。

The various programs for computing fields (GROUP III) are only needed for PLOTSHD, or for special user programs (e.g. ambiguity surfaces).

第三组中计算声场的各种程序仅服务于 PLOTSHD 或特殊的用户程序（例如模糊曲面）。

The following extensions are used with these programs:

以下扩展名用于这些程序：

- .F90 The Fortran90/95 source code
- .F90 Fortran90/95 源代码
- .HLP A HeLP file documenting the module
- .HLP 模块的帮助文件
- .BAT A BATch file which runs the module
- .BAT 运行模块的批处理文件。

All user input in all modules is read using list-directed I/O. Thus data can be typed in free-format using space, tabs, commas or slashes as delimeters. Character input should be enclosed in single quotes like this: 'CHARACTER INPUT'. You will see the '/' character in a number of the input files. This terminates an input line causing the program to use default values.

所有模块的所有用户输入都采用列表导向的 I/O 进行读取。因此可以使用空格、制表符、逗号或斜线作为分隔符等格式自由地输入数据。字符输入须用单引号括

起来，就像：'CHARACTER INPUT'。您将在很多输入文件中看到 '/' 字符。该标记终止所在的输入行，并引导程序使用默认值。

Installation Notes

安装须知

There is a command file for each of the programs in this package which assigns necessary input files to the appropriate Fortran unit number used by that program. To simplify the installation, these command files make use of logical names for certain directories.

该程序包中每个程序都有一个命令文件，它可为该程序必需使用的输入文件分配适当的 Fortran 单元号。为了简化安装，这些命令文件对某些目录使用逻辑名称。

The following symbols and logical names for directories are used with the KRAKEN command files:

下列目录符号和逻辑名称与 KRAKEN 命令文件一起使用：

- AT: This is the Acoustics Toolbox directory which contains command files for running KRAKEN and other models in the toolbox.
- AT: 这是 AcousticsToolbox 目录，其中包含运行 KRAKEN 和工具箱中其他模型的命令文件。
- KRAK: The KRAKEN source code
- KRAK: KRAKEN 的源代码
- MISC: Miscellaneous scientific subroutines, e.g. root-finders, linear equation solvers, ...
- MISC: 各种科学子程序，比如寻根器，线性方程解算器，...
- GLOB: Global routines, that is, routines which operate on shade files. These routines operate on the output of a number of different propagation codes including KRAKEN, FSTFLD, BELLHOP, SCOOTER and SPARC.
- GLOB: 全局子程序，也就是基于渲染（shade）文件进行演算的子程序。这些子程序可以针对很多不同传播程序的输出进行演算，包括 KRAKEN、FSTFLD、BELLHOP、SCOOTER 和 SPARC 等。

2 Description of Environmental File

2 环境文件说明

The following can be repeated as many times as wanted in a single ENVFIL. KRAKEN and KRAKENC will generate a separate MODFIL for each case stopping when it detects an end-of-file.

以下内容可在单个 ENVFIL 中多次重复。KRAKEN 和 KRAKENC 会为每个算例生成单独的 MODFIL，当检测到文件结束时它就停止。

(1) - Title

(1) - 标题

Syntax:

TITLE

Description:

TITLE: Title of run enclosed in sinqle quotes.

语 法	*TITLE*	
说 明	TITLE	运算标题，须以单引号括起来。

(2) - Frequency

(2) - 频率

Syntax:

FREQ

Description:

FREQ: Frequency in Hz.

语 法	*FREQ*	
说 明	FREQ	频率，单位：Hz。

(3) - Number of Media

(3) - 介质分层数

Syntax:

NMEDIA

Description:

NMEDIA: Number of media.

语 法	*NMEDIA*	
说 明	NMEDIA	介质分层数

The problem is divided into media within which it is assumed that the material properties vary smoothly. A new medium should be used at fluid/elastic interfaces or at interfaces where the density changes discontinuously. The number of media in the problem is defined excluding the upper and lower half-space.

把要演算的问题划分为多层介质空间。在每层介质内部，假定介质的属性变化平滑。在流体/弹性界面或密度变化不连续的界面引入新的介质分层。问题中定义的介质分层数目不包括上半空间和下半空间。

BELLHOP is limited to one medium (NMEDIA=1) and actually ignores this parameter.

BELLHOP 限定为一层介质（NMEDIA=1），实际上是忽略此参数。

(4) - Top Option

(4) - 上端属性

Syntax:

TOPOPT

Description:

TOPOPT(1:1): Type of interpolation to be used for the SSP.

'C' for C-linear,
'N' for N2-linear (n the index of refraction),
'S' for cubic Spline,
'Q' for Quadrilatteral 2D SSP (BELLHOP only; reads the SSP from a file)
'H' for Hexahedral 3D SSP (BELLHOP3D only; reads the SSP from a file)
'A' for Analytic.
The user must modify the analytic formulas in ANALYT.FOR then re-compile and link.

TOPOPT(1:1)：SSP 插值方法	
选项	说　　明
C	C-线性插值
N	N2-线性插值(n 是折射率)
S	三次样条插值
Q	2D SSP 四边形插值（只用于 BELLHOP，从文件中读取 SSP）
H	3D SSP 六面体插值（只用于 BELLHOP3D，从文件中读取 SSP）
A	解析值 用户必须修改 ANALYT.FOR 中的解析公式，然后再编译和链接。

If your not sure which option to take, I'd suggest you use 'C'. The 'N' option is virtually identical to 'C'. It's provided to facilitate precise intermodel comparisons with codes that use a certain numerical technique that requires that type of interpolation.

如果不确定该选哪个选项，建议你采用'C'。'N'选项实际上与'C'相同。提供'N'是为了便于在模型之间进行精确比较。该模型应用了需要这类插值的数值技术。

Option 'S' is a little dangerous because splines yield a poor fit to certain kinds of curves, e.g. curves with sharp bends. If you insist on splines, you can fix a bad fit by dividing the water column into two 'media' at the bend.

选项'S'有点危险，因为样条插值对某些曲线拟合较差，比如带急弯的曲线。如果您坚持要用样条插值，可以在拐弯处将水体划分成两层介质来解决拟合不佳的问题。

Run PLOTSSP to check that the SSP looks the way you thought it should. Apart from potential typos, this will also show up fit-problems.

运行 PLOTSSP 来查验 SSP 是否看起来像你心中的模样。除了能查看潜在的排版问题，还能展示拟合可能出现的问题。

TOPOPT(2:2): Type of top boundary condition

'V' VACUUM above top
'A' ACOUSTO-ELASTIC half-space.
Requires another line with the halfspace parameters as described in block (4a).
'R' Perfectly RIGID
'F' Reflection coefficient from a FILE

TOPOPT(2:2)：上端边界条件类型	
选项	说　　明
V	顶端以上为真空
A	声学-弹性半空间。需要另起如表 4a 所描述的参数行。
R	完全刚性
F	从文件中读取反射系数。
S	用于“软层（Soft-boss）”Twersky 散射
H	用于“硬层（Hard-boss）”Twersky 散射
T	只用于“软层（Soft-boss）”Twersky 散射的幅度
I	只用于“硬层（Hard-boss）”Twersky 散射的幅度

These files for complicated, multi-layered media can be generated using BOUNCE. (Available in KRAKENC, SCOOTER, and BELLHOP. Not available in KRAKEN and SPARC.) For a Top Reflection Coefficient, the file should have the extension '.TRC'.

For KRAKEN/KRAKENC this option for tabulated reflection coefficients is somewhat experimental at this time. A complicated reflection coefficient may well cause problems for the mode-finder. Finally, a reflection coefficient tabulated only for real angles does not provide a good result for complex angles of incidence. This happens when the sediment sound speed is less than the water sound speed. In that case, the modes are evanescent in the upper part of the water column and therefore have a complex angle of incidence.

对于复杂的多层介质可用 BOUNCE 生成这些文件。(可用于 KRAKENC、SCOOTER 和 BELLHOP。KRAKEN 和 SPARC 不采用。)对于顶端反射系数，文件扩展名应该是'.TRC'。对于 KRAKEN/KRAKENC，列表反射系数选项有点实验性。复杂的反射系数很可能导致模式求解器出现问题。最后，仅对实数角度列表的反射系数对复数入射角并不能提供较好的结果。这发生在沉积层声速小于水层声速的时候。在此情况下，在水体上层，模式消失，因此有复数入射角。

'S' for Soft-boss Twersky scatter.
'H' for Hard-boss Twersky scatter.
'T' for Soft-boss Twersky scatter, amplitude only.
'I' for Hard-boss Twersky scatter, amplitude only.

The Twersky scatter options require another line as described in block(4b). Mnemonically, T, I options are one letter after S, H in the alphabet. Current wisdom is that option T is most appropriate for ice scatter.

Twersky 散射选项需要另添一行，如表(4b)所描述。助记符 T、I 选项是字母表中 S、H 之后的字母。当前的智慧是，选项 T 最适合计算冰散射。

For open ocean problems option 'V' should be used for the top BC. The Twersky options are intended for under-ice modeling.

对于开阔海洋问题，上端边界应该设置为'V'选项。Twersky 选项是专为冰层之下的模拟而设计的。

TOPOPT(3:3): Attenuation units.

'N' Nepers/m.
'F' dB/(kmHz)   (F as in Freq. dependent)
'M' dB/m   (M as in per Meter)

'm' dB/m (m as in per Meter) Scaled with frequency; quadratically, then linearly above fT
'W' dB/wavelength (W as in per Wavelength)
'Q' quality factor
'L' Loss parameter (a.k.a. loss tangent)

TOPOPT(3:3)：衰减所用单位	
选项	说 明
N	Nepers/m
F	dB/(kmHz)，F 指与频率相关（Freq. dependent）。
M	dB/m， M 指每米（per Meter）。
m	m 指每米。随频率缩放；再二次方，fT 之上呈线性。
W	dB/λ， W 指波长（Wavelength）
Q	品质因子
L	损失参量（又称损失切线）

KRAKEN ignores material attenuation in elastic media. (KRAKENC treats it properly). The option 'm' for attenuation is a new one designed to capture a power-law frequency dependence. You provide an attenuation in dB/m at the frequency specified above (FREQ). Then in a broadband run, with multiple frequencies that attenuation as automatically scaled according to the power that you specify. If you use this without doing a broadband run, then 'M' and 'm' will do the same thing, i.e. interpret your attenuation as dB/m at the given frequency.

KRAKEN 忽略弹性介质中的衰减，KRAKENC 对此处理得很好。衰减的“m”选项是一个新的选项，旨在捕获幂律频率依赖性。在上述指定的频率（FREQ）下，衰减单位为 dB/m。那么在宽带运行中，对于多频则根据您指定的幂律自动缩放衰减。如果不是针对宽带运行应用它，那么“M”和“m”将执行相同的操作，即在给定频率点衰减单位为 dB/m。

TOPOPT(4:4): Added volume attenuation.

'T' Thorp attenuation formula.
'B' Biological layer (fish)

TOPOPT(4:4)：添加体积衰减	
选项	说 明
T	Thorp 衰减公式。

B	生物层（鱼）

If you invoke this option, Thorp attenuation is added to the explicitly specified attenuation (ap, as).

如果引用此选项，Thorp 衰减将添加到指定的衰减(α_p,α_s)中。

TOPOPT(5:5): Altimetry option; Slow/robust root-finder.

'~' Read in a *.ati file containing the top altimetry. (BELLHOP only; '*' was used earlier and still works)
'_' Flat surface, i.e. no altimetry file. (BELLHOP only; this is the default if blank)
'.' As in: I want all the modes and I don't care how long it takes. Period.
The '.' option works only with KRAKENC, which sometimes has trouble finding a complete set of modes in the complex plane.

TOPOPT(5:5)：测高选项；缓慢/稳健的寻根器。	
选项	说　　明
'~'	从包含上端测高的*.ati 文件中读入数据。（仅用于 BELLHOP；过去使用是的'*'，至今仍有效)
'_'	水平海面，即没有测高文件。(仅用于 BELLHOP；如果为空，则为默认值。）
'.'	就像这样：我想算出所有的模式，并不在乎要花多长时间。
	'.' 选项仅用于 KRAKENC，有时 KRAKENC 在复平面上难以求解出完备的模式集。

TOPOPT(6:6): Single beam (BELLHOP only)

'I' Calculate only a single beam from the specified fan.
The actual beam number is specified after NBEAMS, under the section describing the beam fan.
' ' Default: trace all beams.

TOPOPT(6:6)：单波束（仅用于 BELLHOP）。	
选项	说　　明
'I'	只计算从特定扇面发出的单波束。
	在波束扇面描述部分，实际的波束号在 NBEAMS 之后设定。

' '	缺省值：跟踪所有波束。
B	宽带运行（当前只应用于 KRAKEN 和 SCOOTER） 当指定为多个频点时，选择“宽带运行”

Broadband run (currently implemented in KRAKEN and SCOOTER)
'B' Select a broadband run where multiple frequencies are specified

TOPOPT(7:7): Use 0 (zero) to disable stabilizing attenuation in SCOOTER

TOPOPT(7:7)	
选项	说　　明
0	在 SCOOTER 中，置为 0，禁用稳定衰减。

(4a) - Top Halfspace Properties

Syntax:

ZT CPT CST RHOT APT AST

Description:

ZT: Depth (m).
CPT: Top P-wave speed (m/s).
CST: Top S-wave speed (m/s).
RHOT: Top density (g/cm3).
APT: Top P-wave attenuation. (units as given by Option(3:3))
AST: Top S-wave attenuation. (" " " " " ")

表 4a　上半空间属性表		
语法	*ZT CPT CST RHOT APT AST*	
说明	ZT	深度（m）
	CPT	上半空间压缩波速（m/s）
	CST	上半空间切向波速（m/s）
	RHOT	上半空间密度（ g/cm^3 ）
	APT	上半空间压缩波衰减（单位由 Option(3:3)给出）
	AST	上半空间切向波衰减（单位由 Option(3:3)给出）

This line should only be included if TOPOPT(2:2)='A', i.e. if the user has specified a homogeneous halfspace for the top BC.

只有在用户设定上端边界条件为均匀半空间，即 TOPOPT(2:2)='A'的情况下，才包含此行。

(4b) - Twersky Scatter Parameters

Syntax:

BUMDEN ETA XI

Description:

BUMDEN: Bump density (ridges/km).
ETA: Principal radius 1 (m).
XI: Principal radius 2 (m).

表 4b Twersky 散射参数表		
语法	BUMDEN ETA XI	
说明	BUMDEN	凸起（bump）密度(脊/公里)
	ETA	主半径 1(m)
	XI	主半径 2(m)

This line should only be included when one of the Twersky-scatter options is selected.

只有在设置了某一 Twersky 散射选项时，才包括这一行。

(4c) - Biological Layer Parameters (for attenuation due to fish)

Syntax:

NBioLayers
Z1(1) Z2(1) f0(1) Q(1) a0(1)
Z1(2) Z2(2) f0(2) Q(2) a0(2)
.
.
.
Z1(NBioLayers) Z2(NBioLayers) f0(NBioLayers) Q(NBioLayers) a0(NBioLayers)

Description:

z1: Top of layer (m)
z2: Bottom of layer (m)
f0: Resonance frequency (Hz)
Q: Quality factor

a0: Amplitude

<table>
<tr><th colspan="3">表 4c　生物层参数（由鱼引起的衰减）</th></tr>
<tr><td>语法</td><td colspan="2">NBioLayers
Z1(1)　Z2(1)　f0(1)　Q(1)　a0(1)
Z1(2)　Z2(2)　f0(2)　Q(2)　a0(2)
.
.
.
Z1(NBioLayers)　Z2(NBioLayers)　f0(NBioLayers)　Q(NBioLayers)　a0(NBioLayers)</td></tr>
<tr><td rowspan="6">说明</td><td>NBioLayers</td><td>生物分层数目</td></tr>
<tr><td>z1</td><td>生物层顶端深度(m)</td></tr>
<tr><td>z2</td><td>生物层底端深度(m)</td></tr>
<tr><td>f0</td><td>共振频率（Hz）</td></tr>
<tr><td>Q</td><td>质量因子</td></tr>
<tr><td>a0</td><td>幅度</td></tr>
</table>

(5) - Sound Speed Profile

(5) - 声速剖面

Syntax:

NMESH SIGMA Z(NSSP)
Z(1)　CP(1)　CS(1)　RHO(1)　AP(1)　AS(1)
Z(2)　CP(2)　CS(2)　RHO(2)　AP(2)　AS(2)
.
.
.
Z(NSSP) CP(NSSP) CS(NSSP) RHO(NSSP) AP(NSSP) AS(NSSP)

Description:

<table>
<tr><td>语法</td><td colspan="2">NMESH　SIGMA　Z(NSSP)</td></tr>
<tr><td rowspan="3">说明</td><td>NMESH</td><td>内部离散化使用的网格点数。</td></tr>
<tr><td>SIGMA</td><td>界面 RMS 粗糙度。BELLHOP 和 SPARC 忽略此值。</td></tr>
<tr><td>Z(NSSP)</td><td>介质底端的深度(m)。</td></tr>
</table>

NMESH: Number of mesh points used in the internal discretization.

The number of mesh points should be about 10 per vertical wavelength in acoustic media. In elastic media, the number needed can vary quite a bit; 20 per wavelength is a reasonable starting point.

在声学介质中，网格点数目应每垂向波长取 10 点左右。在弹性介质中，所需数目可能更大：合理的起点是每波长取 20 点。

The number of mesh points used depends on the initial mesh and the number of times it is refined (doubled). The number of mesh doublings can vary from 1 to 5 depending on the parameter RMAX described below.

采用的网格点数取决于初始网格和精细化的倍数。根据后面的 RMAX 参数描述，网格点的倍数可从 1 到 5 不等。

If you type 0 for the number of mesh points, the code will calculated NMESH automatically.

如果输入的网格点数为 0，程序将自动计算 NMESH。

BELLHOP ignores this parameter as it's not relevant to its numerical technique.

BELLHOP 忽略此参数，因为它与数值技术无关。

SIGMA: RMS roughness at the interface (ignored by BELLHOP and SPARC)

Z(NSSP): Depth at bottom of medium (m).

This value is used to detect the last SSP point when reading in the profile that follows.

在读取下面的声速剖面时，该值用于检测最后一个 SSP 点。

<table>
<tr><th colspan="3">表 5a　声速剖面</th></tr>
<tr><td>语法</td><td colspan="2">Z(1)　CP(1)　CS(1)　RHO(1)　AP(1)　AS(1)
Z(2)　CP(2)　CS(2)　RHO(2)　AP(2)　AS(2)
.
.
.
Z(NSSP) CP(NSSP) CS(NSSP) RHO(NSSP) AP(NSSP) AS(NSSP)</td></tr>
<tr><td rowspan="2">说明</td><td>Z()</td><td>深度(m)</td></tr>
<tr><td>CP()</td><td>P 波速度(m/s)。</td></tr>
</table>

	CS()	S 波速度(m/s)。
	RHO()	密度（g/cm^3）。
	AP()	纵波衰减（单位由 Option(3:3)给出）
	AS()	横波衰减（单位由 Option(3:3)给出）

Z(): Depth (m).

The surface starts at the first depth point specified. Thus if you have say, XBT data which starts at 50 m below the surface, then you'll need to put in some SSP point at 0 m, otherwise the free-surface would be placed at 50 m giving erroneous results. The points Z(1) and Z(NSSP) MUST correspond to the depths of interfaces between media.

海面从给出的第一个深度点开始。因此，如果你说，XBT 数据是从海面以下 50m 处开始的，那么你必须在 0m 处设置一个 SSP 点，否则自由表面将置于 50m 处，从而导致错误的结果。Z(1)和 Z(Nssp)必须对应于介质之间的界面的深度。

If the attenuation units were specified with option letter 'm' and a broadband run is selected, then the attenuation is scaled with frequency. The scaling is based on the frequency to a power beta, up to a transition frequency, fT. Above fT, the scaling is linear with frequency. The parameters that control this are specified in the first line of this block using the syntax:

如果选择字母“m”指定衰减单位，并选择宽带运行，衰减则随频率进行缩放。缩放基于频率的幂 β，直到过渡频率 fT。在 fT 以上，缩放与频率呈线性关系。此操作的控制参数在此块的第一行中使用以下语法确定：

NMESH SIGMA Z(NSSP) beta fT

CP(): P-wave speed (m/s).
CS(): S-wave speed (m/s).
RHO(): Density (g/cm3).

Density variations within an acoustic medium are at present ignored.

目前，忽略声学介质的密度变化。

AP(): P-wave attenuation (units as given in Block 2)
AS(): S-wave attenuation (" " " " " ")

These lines giving the SSP should be omitted when the 'A' option is used (indicating that an analytic profile is supplied by a user written subroutine).

当采用选项'A'时，表示由用户编写的子例程提供“解析剖面”，这些给出 SSP 的输入行就应该省略。

The '/' character signals that the remaining data on the line is the same as in the previous line of SSP data. For the very first line the default or 'previous' line is:

字符'/'表示该行的其余数据与“前一行”的 SSP 数据相同。如果第一行（默认值）或“前一行”是：

0.0 1500.0 0.0 1.0 0.0 0.0

This block should be repeated for each subsequent medium.

后续每行介质参数均依此（为参照，）重复（省略的部分）。

Only KRAKEN, SCOOTER, and BOUNCE can use the shear wave information. SPARC and BELLHOP ignore it.

只有 KRAKEN、SCOOTER 和 BOUNCE 能用切变波信息。SPARC 和 BELLHOP 忽略切变波信息。

(6) - Bottom Option

(6) - 底端属性

Syntax:

BOTOPT SIGMA

Description:

BOTOPT(1:1): Type of bottom boundary condition.

'V' VACUUM below bottom.
'A' ACOUSTO-ELASTIC half-space.
Requires another line with the half-space parameters as described in Block (6a).

需要另起一行写明半空间参数。参见版块（6a）的说明。

'R' Perfectly RIGID.
'G' Grain size
'F' Reflection coefficient from a FILE

These files for complicated, multi-layered media can be generated using BOUNCE. (Available in KRAKENC, SCOOTER, and BELLHOP. Not available in KRAKEN and SPARC.) For a Bottom Reflection Coefficient, the file should have the extension '.BRC'. For KRAKEN/KRAKENC this option for tabulated reflection coefficients is somewhat experimental at this time. A complicated reflection coefficient may well cause problems for the mode-finder. Finally, a reflection coefficient tabulated only for real angles does not provide a good result for complex angles of incidence. This happens when the sediment sound speed is less than the water sound speed. In that case, the modes are evanescent in the upper part of the water column and therefore have a complex angle of incidence.

对于复杂的多层介质可用 BOUNCE 生成这些文件。(可用于KRAKENC、SCOOTER 和 BELLHOP。KRAKEN 和 SPARC 不采用。)对于底端反射系数，文件扩展名应该是'.BRC'。对于KRAKEN/KRAKENC，列表反射系数选项有点实验性。复杂的反射系数很可能导致模式求解器出现问题。最后，仅对实数角度列表的反射系数对复数入射角并不能提供较好的结果。这发生在沉积层声速小于水层声速的时候。在此情况下，在水体上层，模式消失，因此有复数入射角。

'P' Precaculated internal reflection coefficient from a FILE (available in KRAKENC and SCOOTER, not KRAKEN).

These files are generated using BOUNCE.

该文件由 BOUNCE 程序生成。

Option 'A' is generally used for ocean bottom modeling.

BOTOPT(2:2):

'~' Read in a *.bty file containing the bottom bathymetry. (BELLHOP only; '*' was used earlier and still works)
'_' Flat surface, i.e. no bathymetry file. (BELLHOP only; this is the default if blank)

SIGMA: Interfacial roughness (m).

<table>
<tr><td>语法</td><td colspan="3">BOTOPT　SIGMA</td></tr>
<tr><td rowspan="14">说明</td><td rowspan="13">BOTOPT</td><td colspan="2">BOTOPT(1:1)：底部边界条件类型</td></tr>
<tr><td>V</td><td>底端以下为真空（VACUUM）。</td></tr>
<tr><td rowspan="3">A</td><td>声学-弹性半空间（ACOUSTO-ELASTIC）。</td></tr>
<tr><td>需要另起一行写明半空间参数。参见版块（6a）的说明。</td></tr>
<tr><td>选项‘A’通常用于海底建模。</td></tr>
<tr><td>R</td><td>完全刚性（RIGID）。</td></tr>
<tr><td>G</td><td>颗粒大小。</td></tr>
<tr><td>F</td><td>从文件读取反射系数。需要一个扩展名为“.BRC”的底部反射系数文件。格式与顶端反射系数的格式相同。</td></tr>
<tr><td>P</td><td>预先计算好的内部反射系数文件，该文件由 BOUNCE 程序生成。(可用于 KRAKENC 和 SCOOTER。不可用于 KRAKEN)。</td></tr>
<tr><td colspan="2">BOTOPT(2:2)：测深文件选项</td></tr>
<tr><td>'~'</td><td>从包含底端测深的*.bty 文件中读入数据。（仅用于 BELLHOP；过去使用的'*'，至今仍有效)</td></tr>
<tr><td>'_'</td><td>水平海底，即没有测深文件。(仅用于 BELLHOP；如果为空，则为默认值。）</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>SIGMA</td><td colspan="2">界面粗糙度(m)。</td></tr>
</table>

(6a) - Bottom Halfspace Properties

(6a) - 底部半空间特性

Syntax:

ZB CPB CSB RHOB APB ASB

Description:

ZB: Depth (m).
CPB: Bottom P-wave speed (m/s).
CSB: Bottom S-wave speed (m/s).
RHOB: Bottom density (g/cm3).
APB: Bottom P-wave attenuation. (units as given by TOPOPT(3:3))
ASB: Bottom S-wave attenuation. ("   "   "   " " "   )

<table>
<tr><td colspan="3">表 6a　底部半空间属性</td></tr>
<tr><td>语法</td><td colspan="2">ZB　CPB　CSB　RHOB　APB　ASB</td></tr>
<tr><td rowspan="2">说明</td><td>ZB</td><td>深度（m）</td></tr>
<tr><td>CPB</td><td>海底 P 波速度（m/s）。</td></tr>
</table>

	CSB	海底 S 波速度（m/s）。
	RHOB	海底密度（ g/cm^3 ）。
	APB	海底纵波衰减（单位由 TOPOPT(3:3)给定）
	ASB	海底横波衰减（单位由 TOPOPT(3:3)给定）

This line should only be included if BOTOPT(1:1)='A', i.e. if the user has specified a homogeneous halfspace for the bottom BC.

只有当 BOTOPT(1:1)='A'，即用户将底部边界条件设定为均匀半空间时，才包括此行。

These lines should be contained in a separate '.BRC' file. This file is only required if BOTOPT(2:2)='F', i.e. if the user has specified that the bottom BC is read from a '.BRC' (Bottom Reflection Coefficient) file.

这些行应该包含在单独的'.BRC'文件中。只有当 BOTOPT(2:2)='F'，即用户指定从'.BRC'（底端反射系数）文件中读取底端边界条件（BC）时，才需要此文件。

For KRAKEN/KRAKENC this option for tabulated reflection coefficients is somewhat experimental at this time. A complicated reflection coefficient may well cause problems for the mode-finder. Finally, a reflection coefficient tabulated only for real angles does not provide a good result for complex angles of incidence. This happens when the sediment sound speed is less than the water sound speed. In that case, the modes are evanescent in the upper part of the water column and therefore have a complex angle of incidence.

对于 KRAKEN/KRAKENC，列表反射系数选项有点实验性。复杂的反射系数很可能导致模式求解器出现问题。最后，仅对实数角度列表的反射系数对复数入射角并不能提供较好的结果。这发生在沉积层声速小于水层声速的时候。在此情况下，在水体上层，模式消失，因此有复数入射角。

(6b) - Bottom Halfspace Properties from grain size

(6b) – 由颗粒尺寸确定的底部半空间特性

Syntax:

ZB MZ

Description:

ZB: Depth (m).

MZ:　Grain size (phi units).

表 6b　由颗粒尺寸确定的底部半空间属性		
语法	*ZB　MZ*	
说明	ZB	深度（m）
	MZ	颗粒尺寸（Φ）

This line should only be included if BOTOPT(1:1)='G', i.e. if the user has specified a homogeneous halfspace for the bottom BC defined by grain size. The bottom sound speed, attenuation, and density is calculated using formulas from the UW_APL High-Frequency handbook.

只有当 BOTOPT(1:1)='G'时，即用户设定海底边界条件是以颗粒尺寸来定义的均匀半空间时，才应该包括这一行。海底的声速、衰减和密度采用UW_APL 高频手册中的公式计算。

3 BELLHOP

Overview

概　述

BELLHOP computes acoustic fields in oceanic environments via beam tracing. The environment treated consists of an acoustic medium with a sound speed that may depend on range and depth.

BELLHOP 通过波束追踪计算海洋环境中的声场。所处理声学介质环境中的声速可能与距离和深度均相关。

A theoretical description may be found in:

理论描述可查阅以下文献：

> Michael B. Porter and Homer P. Bucker, ``Gaussian beam tracing for computing ocean acoustic fields," *J. Acoust. Soc. Amer*. **82**, 1349--1359 (1987).
>
> Michael B. Porter and Yong-Chun Liu, "Finite-Element Ray Tracing", Proceedings of the International Conference on Theoretical and Computational Acoustics, Eds. D. Lee and M. H. Schultz, pp. 947-956, World Scientific (1994).

The following programs are used with BELLHOP :

以下程序与 BELLHOP 一起使用：

BELLHOP Main program for doing Gaussian beam tracing

BELLHOP 高斯波束追踪的主程序

PLOTRAY Produces plots of central rays of beams

PLOTRAY 波束中心射线绘图

PLOTATI Produces plots of the altimetry

PLOTATI 绘制测高图

PLOTBTY Produces plots of the bathymetry

PLOTBTY 绘制测深图

ANGLES Given the source and receiver sound speeds, computes the angle of the limiting ray.

ANGLES 给定声源和接收器的声速，计算极限声线的角度

PLOTSSP Plots the sound speed profile

PLOTSSP 绘制声速剖面图

PLOTSSP2D Plots the range-dependent sound speed profile

PLOTSSP2D 绘制与距离相关的声速剖面图

BELLHOP produces pressure fields in the NRL standard format and can therefore be plotted using the MATLAB script, plotshd.m.

BELLHOP 以 NRL 标准格式生成声压场，因此可以使用 MATLAB 脚本 plotshd.m 绘制。

The steps in running the program are as follows:

程序运行步骤如下：

1. Set up your environmental file and run PLOTSSP to make sure the SSP looks reasonable.

1. 设置您的环境文件，运行 PLOTSSP，确保 SSP 看起来合理。

2. Do a ray trace. That is,

2. 来玩一次声线追踪吧，开始：

A. Run BELLHOP with the ray trace option to calculate about 50 rays.

A. 用“声线追踪”选项运行 BELLHOP，算出大约 50 条声线。

B. Run PLOTRAY to make sure you have the angular coverage you expect. Do the rays behave irregularly? If so reduce the step-size and try again.

B. 运行 PLOTRAY，确信角度覆盖了您期盼的范围。声线不规则吧？如果是这样，就减小步长，再来一次。

3. Re-run BELLHOP using the coherent, incoherent or semicoherent option for transmission loss. (Use the default number of beams.)

3. 采用相干、非相干或半相干选项重新运行 BELLHOP，得到传播损失。（采用默认波束数目。）

4. Run plotshd.m to plot a full range-depth field plot.

4. 运行 plotshd.m，绘制完整的距离-深度声场图。

5. Double the number of beams and check convergence.

5. 波束数目加倍，检查收敛情况。

Files:

	Name	Unit	Description
Input			
	*.ENV	1	ENVironmental data
Output			
	*.PRT	6	PRinT file
	*.RAY	21	RAY file
	*.SHD	25	SHaDe file

文 件	名称	单位	说 明
输 入	*.ENV	1	环境数据（ENVironmental data）
输 出	*.PRT	6	打印（反馈）文件（PRinT file）
	*.RAY	21	声线文件（RAY file）
	*.SHD	25	渲染文件（SHaDe file）

Sample Input (Environmental) File:

输入（环境）文件范例:

```
'Munk profile'        ! TITLE
50.0                  ! FREQ (Hz)
1                     ! NMEDIA
'SVN'                 ! SSPOPT (Analytic or C-linear interpolation)
51  0.0  5000.0       ! DEPTH of bottom (m)
    0.0  1548.52  /
  200.0  1530.29  /
  250.0  1526.69  /
  400.0  1517.78  /
  600.0  1509.49  /
  800.0  1504.30  /
 1000.0  1501.38  /
 1200.0  1500.14  /
 1400.0  1500.12  /
 1600.0  1501.02  /
 1800.0  1502.57  /
 2000.0  1504.62  /
 2200.0  1507.02  /
 2400.0  1509.69  /
 2600.0  1512.55  /
 2800.0  1515.56  /
 3000.0  1518.67  /
 3200.0  1521.85  /
 3400.0  1525.10  /
 3600.0  1528.38  /
 3800.0  1531.70  /
 4000.0  1535.04  /
 4200.0  1538.39  /
 4400.0  1541.76  /
 4600.0  1545.14  /
 4800.0  1548.52  /
 5000.0  1551.91  /
'V'  0.0
1                     ! NSD
1000.0 /              ! SD(1:NSD) (m)
2                     ! NRD
0.0 5000.0 /          ! RD(1:NRD) (m)
501                   ! NRR
0.0  100.0 /          ! RR(1:NR ) (km)
```

```
'R'                          ! Run-type: 'R/C/I/S'
51                           ! NBEAMS
-11.0 11.0 /                 ! ALPHA(1:NBEAMS) (degrees)
200.0   5500.0   101.0       ! STEP (m)   ZBOX (m)   RBOX (km)
```

Description of Inputs

输入说明

The first 6 blocks in the ENVFIL are common to all the programs in the Acoustics Toolbox. The following blocks should be appended for BELLHOP:

ENVFIL 的前 6 个版块对声学工具箱的所有程序都通用。BELLHOP 还附加以下几个版块：

(7) - SOURCE/RECEIVER DEPTHS AND RANGES

(7) - 声源/接收器的深度和距离

Syntax:

NSD
SD(1:NSD)
NRD
RD(1:NRD)
NR
R(1:NR)

Description:

NSD: The number of source depths
SD(): The source depths (m)
NRD: The number of receiver depths
RD(): The receiver depths (m)
NR: The number of receiver ranges
R(): The receiver ranges (km)

语 法	*NSD* *SD(1:NSD)* *NRD* *RD(1:NRD)* *NR*

	R(1:NR)	
说 明	NSD	声源深度的数目。
	SD()	声源深度。单位：m。
	NRD	接收器深度的数目。
	RD()	接收器深度。单位：m。
	NR	接收器距离的数目。
	R()	接收器距离。单位：km。

This data is read in using list-directed I/O you can type it just about any way you want, e.g. on one line or split onto several lines. Also if the depths or ranges are equally spaced then you can type just the first and last depths followed by a '/' and the intermediate depths will be generated automatically.

这些数据采用列表导向的 I/O 读取，因此可用任意方式写入，比如只写成一行或者拆成几行。此外，如果深度或距离的间距相等，那么就可以只写入第一个和最后一个深度或距离，后面跟着一个'/'，中间的深度值或距离值将自动生成。

You can specify a receiver at zero range; however, the BELLHOP field is singular there--- the pressure is returned as zero.

你可以在零距离处设置一个接收器；但是，BELLHOP 在那里的声场是奇异的----声压返回值为零。

Some of the subroutines that calculate the beam influence allow an arbitrary vector of receiver ranges; others require it to be equally spaced in range. In particular, only the following allow an arbitrary range vector:

计算波束影响的一些子程序容许任意的接收距离向量；另一些子程序则要求等间距的接收距离向量。特别注明一下：只有以下几项允许使用任意的接收距离向量：

'G' GeoHatCart
'B' GeoGaussianCart
CerveyRayCen

(8) - RUN TYPE

(8) - 运行类型

Syntax:

OPTION

Description:

OPTION(1:1): 'R' generates a ray file
'E' generates an eigenray file
'A' generates an amplitude-delay file (ascii)
'a' generates an amplitude-delay file (binary)
'C' Coherent TL calculation
'I Incoherent TL calculation
'S' Semicoherent TL calculation (Lloyd mirror source pattern)

OPTION(2:2): 'G' Geometric hat beams in Cartesian coordinates (default)
'g' Geometric hat beams in ray-centered coordinates
'B' Geometric Gaussian beams

OPTION(3:3): '*' read in a source beam pattern file
'O' don't (default)

OPTION(4:4): 'R' point source (cylindrical coordinates) (default)
'X' line source (cartesian coordinates)

OPTION(5:5): 'R' rectilinear grid (default)
'I' irregular grid

语 法	*OPTION*		
说 明	OPTION(1:1)	R	生成声线文件
		E	生成本征声线文件
		A	生成幅度-延时文件（ascii 码）
		a	生成幅度-延时文件（二进制）
		C	相干 TL 计算
		I	非相干 TL 计算
		S	半相干 TL 计算（Lloyd 镜声源模式）
	OPTION(2:2)	G	笛卡尔坐标系中的几何帽形波束（默认）
		g	射线中心坐标系中的几何帽形波束
		B	几何高斯波束
	OPTION(3:3)	*	读取声源波束模式文件
		O	不读取（默认）
	OPTION(4:4)	R	点源（圆柱形坐标系）（默认）
		X	线源（笛卡尔坐标系）
	OPTION(5:5)	R	直线网格（默认）
		I	不规则网格

The ray file and eigenray files have the same simple ascii format and can be plotted using the Matlab script plotray.m.

声线文件和本征声线文件具有相同简单的 ascii 格式，均可用 MATLAB 文件 plotray.m 绘制。

The eigenray option seems to generate a lot of questions. The way this works is that BELLHOP simply writes the trajectories for all the beams that contribute at a given receiver location. To get a useful picture you normally want to use a very fine fan, only one receiver location, and the geometric beam option. See the examples in at/tests.

“本征声线”选项似乎会产生很多问题。该选项的解算方法是，BELLHOP 简单地将对指定的接收器位置有贡献的所有波束的轨迹写出。要得到有用的图像，通常需要采用非常精细的扇面，且只针对一个接收器位置，并选择“几何波束”。可参见 at/test 中的范例。

The amplitude-delay file can be used with the Matlab script stackarr.m to 'stack the arrivals', i.e. to convolve them with the source spectrum and plot the channel response. stackarr.m can also be used to simple plot the impulse response.

幅度-延时文件可用 MATLAB 文件 stackarr.m 来“叠加到达声线”，即将它们与声源频谱相卷积，绘制出信道响应。stackarr.m 还可简单地用来绘制脉冲响应。

For TL calculations, the output is in the shdfil format used by all the codes in the Acoustics Toolbox and can be plotted using the Matlab script, plotshd.m. (Use toasc.f to convert the binary shade files to ascii format for use by plotshd.m or whatever plot package you're using.)

对于 TL 计算，声学工具箱中所有程序均采用 shdfil 格式进行输出，并使用 MATLAB 文件 plotshd.m 进行绘图。（可用 toasc.f 将二进制渲染文件转换为 plotshd.m 或您想用的任何绘图程序包所使用的 ascii 格式）。

The pressure field is normally calculated on a rectilinear grid formed by the receiver ranges and depths. If an irregular grid is selected, then the receiver ranges and depths are interpreted as a coordinate pair for the receivers. This option is useful for reverberation calculations where the receivers need to follow the bottom terrain. This option has not been used much. The plot routines (plotarr) have not been modified to accomodate it. There may be some other limitations.

声压场通常是在由接收器的距离与深度组成的直线网格点处计算的。如果选择不规则网格，那么接收器的距离与深度就被解释为接收器的位置坐标对。此选项对于混响计算很有用，因为接收器需要沿着海底

地形设置。此选项用得不多。绘图程序(plotarr)未对此作兼容性修改。可能还存在其他限制。

There are actually several different types of Gaussian beam options (OPTION(2:2)) implemented in the code. Only the two described above are fully maintained.

实际上，在程序中实现了几种不同类型的高斯波束(OPTION(2:2))。只有上述两项得到了充分的维护。

The source beam pattern file has the format

声源波束模式文件格式如下

NSBPPts
angle1 power1
angle2 power2
...

with angle following the BELLHOP convention, i.e. declination angle in degrees (so that 90 degrees points to the bottom). The power is in dB. To match a standard point source calculation one would used anisotropic source with 0 dB for all angles. (See at/tests/BeamPattern for an example.)

角度遵循 BELLHOP 规定，即倾斜角单位为度(°)，90°指向海底。功率单位为 dB。为匹配标准点源计算，使用各向同性声源，所有角度均为 0 dB（参阅 at/test/BeamPattern 范例。）

(9) - BEAM FAN

(9) - 波束扇面

Syntax:

NBEAMS ISINGLE
ALPHA(1:NBEAMS)

Description:

NBEAMS: Number of beams. (use 0 to have the program calculate a value automatically, but conservatively).
ISINGLE: If the option to compute a single beam in the fan is selected (top option), then this selects the index of the beam that is traced.
ALPHA(): Beam angles (negative angles toward surface)

For a ray trace you can type in a sequence of angles or you can type the first and last angles followed by a '/'. For a TL calculation, the rays must be equally spaced otherwise the results will be incorrect.

<table>
<tr><td>语 法</td><td colspan="2">NBEAMS ISINGLE
ALPHA(1:NBEAMS)</td></tr>
<tr><td rowspan="4">说 明</td><td>NBEAMS</td><td>波束数目。设为 0 时，程序会自动计算一个值。</td></tr>
<tr><td>ISINGLE</td><td>该选项计算扇面中的某一波束（顶端选项），其值设置为想要追踪的波束的索引。</td></tr>
<tr><td rowspan="2">ALPHA()</td><td>波束角（朝向海面为负角）</td></tr>
<tr><td>对于声线轨迹，你可以输入一系列角度，也可以输入第一个和最后一个角度，随后输入'/'。对于 TL 计算，声线必须等间距，否则结果会不正确。</td></tr>
</table>

(10) - NUMERICAL INTEGRATOR INFO

(10) - 数字积分器的信息

Syntax:

STEP ZBOX RBOX

Description:

STEP: The step size used for tracing the rays (m).
(Use 0 to let BELLHOP choose the step size.)
ZBOX: The maximum depth to trace a ray (m).
RBOX: The maximum range to trace a ray (km).

<table>
<tr><td>语 法</td><td colspan="2">STEP ZBOX RBOX</td></tr>
<tr><td rowspan="3">说 明</td><td>STEP</td><td>声线追踪步长（m）。（可设置为 0 让 BELLHOP 自己选择步长。）</td></tr>
<tr><td>ZBOX</td><td>声线追踪的最大深度（m）。</td></tr>
<tr><td>RBOX</td><td>声线追踪的最大距离（km）。</td></tr>
</table>

The required step size depends on many factors. This includes frequency, size of features in the SSP (such as surface ducts), range of receivers, and whether a coherent or incoherent TL calculation is performed. If you use STEP=0.0 BELLHOP will use a default step-size and tell you what it picked. You should then halve the step size until the results are convergent to your required accuracy. To obtain a smooth ray trace you should use the spline SSP interpolation and a step-size less than the smallest distance between SSP data points. Rays are traced until they exit the box (ZBOX, RBOX). By setting ZBOX less than the water depth you can eliminate bottom reflections. Make ZBOX, RBOX a bit (say 1%) roomy too make sure rays are not killed the moment they hit the bottom or are just reaching your furthest receiver.

所需步长取决于很多因素。包括频率、SSP 中的特征尺度（比如表面声道）、接收器距离、以及计算相干还是非相干 TL。如果设置 STEP=0.0，BELLHOP 将采用默认步长，并告诉您它选定的值。然后，您进行“步长减半”，直到结果收敛到所需的精度为止。要获得平滑的声线轨迹，应该设置 SSP 样条插值，并且步长要小于 SSP 数据点之间的最小间距。声线追踪只在（ZBOX, RBOX）范围内展开。通过设置 ZBOX 小于水深，您可以消除底部反射。要确保声线在到达底部或到达最远的接收器时不会被消除，须将 ZBOX、RBOX 范围设置得稍微大一点（比如 1%）。

Running BELLHOP

运行 BELLHOP

The main issue to be aware of is that ray tracing is very sensitive to environmental interpolation (both boundary and volume). The Gaussian beam options reduce that sensitivity significantly; however, one should still be attentive to this issue. The spline interpolation option to the SSP should be used with particular caution. In some cases, the spline fit is very smooth as desired; in other cases, the spline introduces large wiggles between ssp points, in its effort to produce a smooth curve. Use PLOTSSP to see how your fit looks.

需要注意的主要问题是声线追踪对环境（包括边界和水体）插值非常敏感。高斯波束选项大大降低了这种敏感性；但是，仍然应该注意这个问题。对 SSP 样条插值选项的使用应该特别小心。在某些情况下，样条拟合非常平滑；在其他情况下，样条插值虽然想努力生成平滑曲线，但却在 SSP 点之间引入了较大的摆动。注意使用 PLOTSSP 来查看拟合的结果看上去是否合理。

BELLHOP numerically integrates the ray equations to trace a ray through the ocean. To avoid artifacts at discontinuties in the SSP, the step size is dynamically adjusted to make sure a step always lands on an SSP point, rather than stepping over it. (The beam curvature needs to be adjusted at each such point.) It's better to not use more points to describe the SSP than necessary to capture the physics because BELLHOP will end up using lots of small steps to have each ray land on the SSP points. Similarly, BELLHOP uses the altimetry and bathymetry points to define segments in range, and adjusts the step size so that the rays land on each segment boundary.

BELLHOP 通过对射线方程进行数值积分来追踪在海洋穿行的声线。为了避免在 SSP 间断处出现伪影，步长大小将动态调整，以确保步子总是落在 SSP 点上，而

不跨越 SSP 点。（波束曲率在每个这样的点处也需要进行调整。）SSP 的点数只要足以抓住物理特征即可，最好不要用更多的点来描述。因为这样会让 BELLHOP 最终采用大量的小步子，来让每条声线都落在 SSP 点上。类似地，当 BELLHOP 使用测高和测深点来定义在距离上的分段时，也会调整步长，以让声线落在每段分段的边界。

BELLHOP has no direct capability for modeling elastic wave propagation; however, elastic boundaries can be treated using BOUNCE to generate an equivalent reflection coefficient.

BELLHOP 没有直接模拟弹性波传播的能力，但是，弹性边界可以用 BOUNCE 处理成等效的反射系数。

You can have BELLHOP use a range-dependent SSP by creating a separate SSPFIL containing that SSP data in a matrix form. (See Range-Dependent SSP File). The range-dependent SSPFIL is read if you select 'Q' (quadrilateral) for the SSP interpolation. The depths for the SSP points are read from the ENVFIL; the ranges are specified in the SSPFIL. See the example in at/tests/Gulf.

可以用 BELLHOP 来计算距离相关的 SSP，需要创建一个单独的 SSPFIL，它以矩阵形式来描述该 SSP 数据。(参见距离相关的 SSP 文件)。将 SSP 插值选项设定为'Q'（四边形），就读取这个与距离相关的 SSPFIL。SSP 点的深度从 ENVFILE 读取；距离在 SSPFIL 设定。参见 at/tests/Gulf 的范例。

BELLHOP will produce some artifacts for receivers very close the the surface or bottom, because a beam is essentially folded onto itself upon reflection. The zone of overlap (which depends on the fatness of the beam) is not treated with a lot of care. You can minimize such artifacts by making the beams narrow, which in turn can often be done by using lots of rays. If you want to explore some behavior of the field for a receiver on the bottom, you generally should offset it a little bit. Alternatively, you can use reciprocity and interchange the role of the source and the receiver; sources near the bottom are not a problem.

对于非常接近海面或海底的接收器，BELLHOP 会为产生一些伪像，因为波束反射时基本上折叠在自己身上的。重叠区域（取决于波束的胖度）没有经过仔细处理。你可以变窄波束让这种伪像效果最小，这可应用大量的声线来达成。如果你想探索接收器靠近海底的一些声场行为，通常应该稍微补偿一下。或者，您可以采用互易原理，交换声源和接收器的角色；声源靠近海底没有问题。

4 BELLHOP3D

Overview

概　述

BELLHOP3D computes acoustic fields in 3D oceanic environments via beam tracing. The environment treated consists of an acoustic medium with a sound speed that may depend on x, y, and z coordinates. Similarly, the surface and bottom boundaries may vary with x and y coordinates. It is patterned after the standard BELLHOP program, so more information about how to run it may be found in the BELLHOP documentation.

BELLHOP3D 通过波束追踪计算 3D 海洋环境中的声场。所处理的声学介质环境的声速与 x、y 和 z 坐标均有关。同样，海面和海底边界可能随 x 和 y 坐标的变化而变化。它是按照标准的 BELLHOP 程序设计的，因此关于如何运行的更多信息可以参阅 BELLHOP 文档。

The following programs are used with BELLHOP3D :

以下程序与 BELLHOP3D 一起使用：

BELLHOP3D Main program for doing Gaussian beam tracing

BELLHOP3D 高斯波束追踪主程序

PLOTRAY3D Produces plots of central rays of beams

PLOTRAY3D 波束中心射线绘图

PLOTBTY3D Produces plots of the bathymetry surface

PLOTBTY3D 绘制测深面

ANGLES Given the source and receiver sound speeds, computes the angle of the limiting ray.

ANGLES 给定声源和接收器的声速，计算极限声线的角度

PLOTSSP Plots the sound speed profile

PLOTSSP 绘制声速剖面图

PLOTSSP2D Plots the range-dependent sound speed profile

PLOTSSP2D 绘制与距离相关的声速剖面图

BELLHOP3D produces pressure fields in the NRL standard format and can therefore be plotted using the MATLAB script, plotshd.m.

BELLHOP3D 以 NRL 标准格式生成声压场，可以使用 MATLAB 脚本 plotshd.m 进行绘制。

The steps in running the program are as follows:

程序运行步骤如下：

1. Set up your environmental file and run PLOTSSP to make sure the SSP looks reasonable.

1. 设置您的环境文件，运行 PLOTSSP，确保 SSP 看起来合理

2. Do a ray trace. That is,

2. 来玩一次声线追踪，开始：

A. Run BELLHOP3D with the ray trace option to calculate about 50 rays.

A. 用“声线追踪”选项运行 BELLHOP3D，算出大约 50 条声线。

B. Run PLOTRAY3D to make sure you have the angular coverage you expect. Do the rays behave irregularly? If so reduce the step-size and try again.

B. 运行 PLOTRAY3D，确信角度覆盖了您期盼的范围。声线不规则吧？若如此，缩小步长，再试一次。

3. Re-run BELLHOP3D using the coherent, incoherent or semicoherent option for transmission loss. (Use the default number of beams.)

3. 采用相干、非相干或半相干选项重新运行 BELLHOP3D，得到传播损失。(采用默认波束数目。)

4. Run plotshd.m to plot a full range-depth field plot.

4. 运行 plotshd.m，绘制完整的距离-深度声场图。

5. Double the number of beams and check convergence.

5. 波束数目加倍，检查收敛情况

Files:

	Name	Unit	Description
Input			
	*.ENV	1	ENVironmental data
	*.SSP	40	Sound Speed Profile data (optional)
Output			
	*.PRT	6	PRinT file
	*.RAY	21	RAY file
	*.SHD	25	SHaDe file

文件	名称	单位	说　　明
输入	*.ENV	1	环境数据（ENVironmental data）
	*.SSP	40	声速剖面数据（可选）Sound Speed Profile data (optional)
输出	*.PRT	6	打印（回显）文件（PRinT file）
	*.RAY	21	声线文件（RAY file）
	*.SHD	25	渲染文件（SHaDe file）

Sample Input (Environmental) File:

输入（环境）文件范例:

```
'Munk profile'          ! TITLE
50.0                    ! FREQ (Hz)
1                       ! NMEDIA
'CVN'                   ! SSPOPT (Analytic or C-linear interpolation)
51   0.0   20000.0      ! DEPTH of bottom (m)
    0.0   1548.52   /
  200.0   1530.29   /
  250.0   1526.69   /
  400.0   1517.78   /
  600.0   1509.49   /
  800.0   1504.30   /
 1000.0   1501.38   /
 1200.0   1500.14   /
 1400.0   1500.12   /
 1600.0   1501.02   /
 1800.0   1502.57   /
 2000.0   1504.62   /
 2200.0   1507.02   /
 2400.0   1509.69   /
 2600.0   1512.55   /
 2800.0   1515.56   /
 3000.0   1518.67   /
 3200.0   1521.85   /
 3400.0   1525.10   /
 3600.0   1528.38   /
 3800.0   1531.70   /
 4000.0   1535.04   /
 4200.0   1538.39   /
 4400.0   1541.76   /
 4600.0   1545.14   /
 4800.0   1548.52   /
 5000.0   1551.91   /
  20000    1551.91 /
'A' 0.0
 20000.0   1600.00 0.0 1.8 0.8 /
1                  ! Nsx number of source coordinates in x
0.0 /              ! x coordinate of source (km)
1                  ! Nsy number of source coordinates in y
0.0 /              ! y coordinate of source (km)
```

```
1                  ! NSD
1000.0 /           ! SD(1:NSD) (m)
501                ! NRD
0 5000 /           ! RD(1:NRD) (m)
1001               ! NR
0.0   100.0 /      ! R(1:NR ) (km)
2                  ! Ntheta (number of bearings)
0.0 1.0 /          ! bearing angles (degrees)
'CG    3'          ! 'R/C/I/S'
51 6               ! Nalpha
-14.66 14.66 /     ! alpha1, 2 (degrees) Elevation/declination angle fan
11 46              ! Nbeta
-2   2 /           ! beta1, beta2 (degrees) bearine angle fan
100.0   100.0 100.0 20500.0      ! STEP (m), Box%x (km) Box%y (km) Box%z (m)
```

Description of Inputs

输入说明

The first 6 blocks in the ENVFIL are common to all the programs in the Acoustics Toolbox. The following blocks should be appended for BELLHOP:

ENVFIL 的前 6 个版块对声学工具箱的所有程序都通用。BELLHOP3D 还附加以下几个版块：

(7) - SOURCE/RECEIVER LOCATIONS (INCLUDING RANGES, DEPTHS, AND BEARINGS)

(7) - 声源/接收器位置（包括距离、深度和方位角）

Syntax:

NSx
Sx(1:NSx)
NSy
Sy(1:NSy)
NRD
RD(1:NRD)
NR
R(1:NR)
NTheta
THETA(1:NTheta)

Description:

NSD: The number of source depths
SD(): The source depths (m)
NRD: The number of receiver depths
RD(): The receiver depths (m)
NR: The number of receiver ranges
R(): The receiver ranges (km)
NTheta: The number of receiver bearings (radials)
THETA(): The receiver bearings (degrees)

<table>
<tr><td>语　法</td><td colspan="2">NSx
Sx(1:NSx)
NSy
Sy(1:NSy)
NRD
RD(1:NRD)
NR
R(1:NR)
NTheta
THETA(1:NTheta)</td></tr>
<tr><td rowspan="8">说　明</td><td>NSD</td><td>声源深度的数目。</td></tr>
<tr><td>SD()</td><td>声源深度。单位：m。</td></tr>
<tr><td>NRD</td><td>接收器深度的数目。</td></tr>
<tr><td>RD()</td><td>接收器深度。单位：m。</td></tr>
<tr><td>NR</td><td>接收机距离的数目。</td></tr>
<tr><td>R()</td><td>接收机距离。单位：km。</td></tr>
<tr><td>NTheta</td><td>接收器方位的数目（辐射状）。</td></tr>
<tr><td>THETA()</td><td>接收器方位。单位：度（°）。</td></tr>
</table>

This data is read in using list-directed I/O you can type it just about any way you want, e.g. on one line or split onto several lines. Also if the depths or ranges are equally spaced then you can type just the first and last depths followed by a '/' and the intermediate depths will be generated automatically.

这些数据采用列表导向的 I/O 读取，您可用任意方式写入，比如，写成一行或者拆分成几行。此外，如果深度或距离间距相等，那么可以只写入第一个和最后一个深度或距离，然后再写 '/'，中间的深度或距离将自动生成。

You can specify a receiver at zero range; however, the BELLHOP field is singular there--- the pressure is returned as zero.

你可以在零距离处设置一个接收器；但是，BELLHOP 在那里的声场是奇异的----声压返回值为零。

(8) - RUN TYPE

(8) - 运行类型

Syntax:

OPTION

Description:

OPTION(1:1): 'R' generates a ray file
'E' generates an eigenray file
'A' generates an amplitude-delay file (ascii)
'a' generate an amplitude-delay file (binary)
'C' Coherent TL calculation
'I Incoherent TL calculation
'S' Semicoherent TL calculation (Lloyd mirror source pattern)

OPTION(2:2): 'G' Geometric hat beams (default)
'B' Geometric Gaussian beams

OPTION(3:3): '*' read in a source beam pattern file
' ' don't (default)

OPTION(4:4): 'R' point source (cylindrical coordinates) (default)
'X' line source (cartesian coordinates)

OPTION(5:5): 'R' rectilinear grid (default)
'I' irregular grid

OPTION(6:6): '2' Nx2D run (default)
'3' 3D run

语 法	*OPTION*		
说 明	OPTION(1:1)	R	生成声线文件
		E	生成本征声线文件
		A	生成幅度-延时文件（ascii 码）
		a	生成幅度-延时文件（二进制）
		C	相干 TL 计算
		I	非相干 TL 计算
		S	半相干 TL 计算（Lloyd 镜声源模式）
	OPTION(2:2)	G	笛卡尔坐标系中的几何帽形波束（默认）

		B	几何高斯波束
	OPTION(3:3)	*	读取声源波束模式文件
		' '	不读取（默认）
	OPTION(4:4)	R	点源（圆柱形坐标系）（默认）
		X	线源（笛卡尔坐标系）
	OPTION(5:5)	R	直线网格（默认）
		I	不规则网格
	OPTION(6:6)	2	运行 Nx2D（默认）
		3	运行 3D

The ray file and eigenray files have the same simple ascii format and can be plotted using the Matlab script plotray.m.

声线文件和本征声线文件具有相同简单的 ascii 格式，均可用 MATLAB 文件 plotray.m 绘制。

The eigenray option seems to generate a lot of questions. The way this works is that BELLHOP simply writes the trajectories for all the beams that contribute at a given receiver location. To get a useful picture you normally want to use a very fine fan, only one receiver location, and the geometric beam option. See the examples in at/tests.

“本征声线”选项似乎会产生很多问题。该选项的解算方法是，BELLHOP 简单地将对指定的接收器位置有贡献的所有波束的轨迹写出。要得到有用的图像，通常需要采用非常精细的扇面，且只针对一个接收器位置，并选择“几何波束”。可参见 at/test 中的范例。

The amplitude-delay file can be used with the Matlab script stackarr.m to 'stack the arrivals', i.e. to convolve them with the source spectrum and plot the channel response. stackarr.m can also be used to simple plot the impulse response.

幅度-延时文件可用 MATLAB 文件 stackarr.m 来“叠加到达声线”，即将它们与声源频谱相卷积，绘制出信道响应。stackarr.m 还可简单地用来绘制脉冲响应。

For TL calculations, the output is in the shdfil format used by all the codes in the Acoustics Toolbox and can be plotted using the Matlab script, plotshd.m. (Use toasc.f to convert the binary shade files to ascii format for use by plotshd.m or whatever plot package you're using.)

对于 TL 计算，声学工具箱中所有程序均采用 shdfil 格式进行输出，并使用 MATLAB 文件 plotshd.m 进行绘图。（可用 toasc.f 将二进制渲染文件转换为 plotshd.m 或您想用的任何绘图程序包所使用的 ascii 格式）。

The pressure field is normally calculated on a rectilinear grid formed by the receiver ranges and depths. If an irregular grid is selected, then the receiver ranges and depths are interpreted as a coordinate pair for the receivers. This option is useful for reverberation calculations where the receivers need to follow the bottom terrain. This option has not been used much. The plot routines (plotarr) have not been modified to accomodate it. There may be some other limitations.

声压场通常是在由接收器的距离与深度组成的直线网格点处计算的。如果选择不规则网格，那么接收器的距离与深度就被解释为接收器的位置坐标对。此选项对于混响计算很有用，因为接收器需要沿着海底地形设置。此选项用得不多。绘图程序(plotarr)未对此作兼容性修改。可能还存在其他限制。

There are actually several different types of Gaussian beam options (OPTION(2:2)) implemented in the code. Only the two described above are fully maintained.

实际上，在程序中实现了几种不同类型的高斯波束(OPTION(2:2))。只有上述两项得到了充分的维护。

The source beam pattern file has the format

声源波束模式文件格式如下

```
NSBPPts
angle1   power1
angle2   power2
 ...
```

with angle following the BELLHOP convention, i.e. declination angle in degrees (so that 90 degrees points to the bottom). The power is in dB. To match a standard point source calculation one would used anisotropic source with 0 dB for all angles. (See at/tests/BeamPattern for an example.)

角度遵循 BELLHOP 规定，即倾斜角单位为度(°)，90°指向海底。功率单位为 dB。为匹配标准点源计算，使用各向同性声源，所有角度均为 0 dB（参阅 at/test/BeamPattern 范例。）

(9) - BEAM FAN

(9) - 波束扇面

Syntax:

NAlpha ISINGLE
Alpha(1:NBEAMS)
NBeta ISINGLE
Beta(1:NBEAMS)

Description:

NAlpha: Number of beams in elevation.(use 0 to have the program calculate a value automatically, but conservatively).
ISINGLE: If the option to compute a single beam in the fan is selected (top option) then this selects the index of the beam that is traced.
Alpha(): Beam elevation angles (degrees) (negative angles toward surface)
NBeta: Number of beams in azimuth (use 0 to have the program calculate a value automatically, but conservatively).
ISINGLE: If the option to compute a single beam in the fan is selected (top option) then this selects the index of the beam that is traced.
Beta(): Beam azimuth angles (degrees) (math convention with 0 degrees pointing along the x-axis)

语 法		*NAlpha ISINGLE* *Alpha(1:NBEAMS)* *NBeta ISINGLE* *Beta(1:NBEAMS)*
说 明	NAlpha	俯仰波束数目。设为 0 时，程序会自动计算一个值。
	ISINGLE	该选项计算扇面中的某一波束（顶端选项），其值设置为想要追踪的波束的索引。
	ALPHA()	俯仰波束角（朝向海面为负角）
	NBeta	方位波束数目。设为 0 时，程序会自动计算一个值。
	ISINGLE	该选项计算扇面中的某一波束（顶端选项），其值设置为想要追踪的波束的索引。
	Beta()	方位角（°）（数学惯例：0 度指向 x 轴）

For a ray trace you can type in a sequence of angles or you can type the first and last angles followed by a '/'. For a TL calculation, the rays must be equally spaced otherwise the results will be incorrect.

对于声线轨迹，你可以输入一系列角度，也可以输入第一个和最后一个角度，随后输入'/'。对于 TL 计算，声线必须等间距，否则结果会不正确。

(10) - NUMERICAL INTEGRATOR INFO

(10) - 数字积分器的信息

Syntax:

STEP Box%x (km) Box%y (km) Box%z (m)

Description:

STEP: The step size used for tracing the rays (m).
(Use 0 to let BELLHOP choose the step size.)
Box%x: The maximum distance in the x-direction to trace a ray (km).
Box%y: The maximum distance in the y-direction to trace a ray (km).
Box%x: The maximum distance in the z-direction to trace a ray (m).

语 法	*STEP ZBOX RBOX*	
说 明	STEP	声线追踪步长（m）。（设置为 0 让 BELLHOP 自己选择步长。）
	Box%x	沿 x 方向声线追踪的最大距离（km）。
	Box%y	沿 y 方向声线追踪的最大距离（km）。
	Box%z	沿 z 方向声线追踪的最大距离（m）。

The required step size depends on many factors. This includes frequency, size of features in the SSP (such as surface ducts), range of receivers, and whether a coherent or incoherent TL calculation is performed. If you use STEP=0.0 BELLHOP will use a default step-size and tell you what it picked. You should then halve the step size until the results are convergent to your required accuracy. To obtain a smooth ray trace you should use the spline SSP interpolation and a step-size less than the smallest distance between SSP data points. Rays are traced until they exit the box (Box%x, Box%y, Box%z). The box is defined with the source at the center of the coordinate system. Make the box a bit (say 1%) roomy too make sure rays are not killed the moment they hit the bottom or are just reaching your furthest receiver.

所需步长取决于很多因素。包括频率、SSP 中的特征尺度（比如表面声道）、接收器距离、以及计算相干还是非相干 TL。如果设置 STEP=0.0，BELLHOP 将采用默认步长，并告诉您它选定的值。然后，您进行“步长减半”，直到结果收敛到所需的精度为止。要获得平滑的声线轨迹，应该设置 SSP 样条插值，并且步长要小于 SSP 数据点之间的最小间距。声线追踪只在（Box%x, Box%y, Box%z）范围内展开。将声源置于坐标系统中心，然后定义范围。要确保声线在到达底部或

到达最远的接收器时不会被消除，须将范围设置得稍微大一点（比如1%）。

5 KRAKEN

Overview

概 述

KRAKEN is a normal mode program for range-varying environments in either cartesian (line sources) or cylindrical coordinates (point sources). The basic method is described in

KRAKEN 是一套简正波程序。适用于随距离变化的环境，采用笛卡尔坐标（线源）或圆柱坐标（点源）解算。以下文献对其基本方法中作了描述。

> Porter, Michael B. and Reiss, Edward L., "A numerical method for ocean-acoustic normal modes", JASA **76**, 244-252 (1984).
>
> Porter, Michael B. and Reiss, Edward L., "A numerical method for bottom interacting ocean acoustic normal modes", JASA **77**, 1760-1767 (1985).

Range-dependent solutions are obtained by using optionally adiabatic or coupled mode theory.

可选择绝热或者模式耦合理论来得到随距离变化的环境中的解。

KRAKEN is the main program. It takes an environmental file, computes the modes, and writes them to disk for use by other modules. A print file is also produced, echoing the user input.

KRAKEN 是主程序。它接受环境文件，计算模式，并将它们写入磁盘供其他模块使用。它还生成一个打印文件来回显用户的输入。

KRAKENC is a complex arithmetic version (hence the C in KRAKENC) of KRAKEN. By working in the complex domain, loss mechanisms such as ice scatter and material absorption may be included 'exactly' rather than perturbatively. In addition, leaky modes may be computed. The price of this non-perturbative treatment is a slowdown in speed by approximately a factor of 4. This factor principally represents the difference between complex and real arithmetic.

KRAKENC 是 KRAKEN 的复数算术版本（因此 KRAKENC 中有 C）。通过在复数域运行，诸如海冰散射、介质吸收等损失机制均可“精确”地算出，而不需采用微扰方法来处理。此外，还可以算出泄漏模式。这种用非微扰方法来解算的代价是速度减慢大约 4 倍。该因子也代表复数算法与实数算法之间的差别。

A further slow down by a factor of 2 or more may occur if the Twersky scatter option is used in KRAKENC. The calculation of the Twersky scatter function can require significant CPU time; enough to actually be a dominant part of the cost of computing the modes. KRAKEN incorporates the scatter perturbatively and is much less sensitive to the cost of Twersky scatter.

如果在 KRAKENC 中设置 Twersky 散射选项，速度则会进一步减慢 2 倍，甚至更多。Twersky 散射函数的计算需要占用大量的 CPU 时间；实际上，它占用了模式计算耗时的主要部分。KRAKEN 通过微扰方法处理散射，故对 Twersky 散射耗时不太敏感。

KRAKEN does not at allow for losses in elastic media due to material attenuation. Thus, for attenuating elastic media, KRAKENC should be used.

由于介质引起衰减，KRAKEN 不能计算弹性介质中的传播损失。因此，对于衰减的弹性介质，应该使用 KRAKENC 来计算。

Files:

	Name	Unit	Description
Input			
	*.ENV	1	ENVironmental data
	*.BRC	10	Bottom Refl. Coef. (optl)
	*.TRC	11	Top Refl. Coef. (optl)
	*.IRC	12	Internal Refl. Coef. (optl)

Output

*.PRT 6 PRinT file
*.MOD 20 MODe file

文 件	名称	单位	说 明
输 入	*.ENV	1	环境数据（ENVironmental data）
	*.BRC	10	底端反射系数（可选）（Bottom Refl. Coef. (optl)）
	*.TRC	11	顶端反射系数（可选）（Top Refl. Coef. (optl)）
	*.IRC	12	内部反射系数（可选）（Internal Refl. Coef. (optl)）
输 出	*.PRT	6	打印（反馈）文件（PRinT file）
	*.MOD	20	模式文件（MODe file）

Example Environmental File

环境文件示例

```
'FRAMIV Twersky S/S ice scatter'     ! TITLE
50.0                                 ! FREQ (Hz)
4                                    ! NMEDIA
'NSF'                                ! OPTIONS
0.0092  8.2  5.1                     ! BUMDEN (1/m)  ETA (m)  XI (m)
750  0.0  3750.0                     ! NMESH  SIGMA (m)  Z(NSSP)
    0.0  1436.0  0.0  1.03/          ! Z(m)  CP  CS(m/s)  RHO(gm/cm3)
   30.0  1437.4 /
   50.0  1437.7 /
   80.0  1439.5 /
  100.0  1441.9 /
  125.0  1444.6 /
  150.0  1450.0 /
  175.0  1456.1 /
  200.0  1458.4 /
  250.0  1460.0 /
  300.0  1460.5 /
  350.0  1460.6 /
  400.0  1461.0 /
  450.0  1461.5 /
  500.0  1462.0 /
  600.0  1462.9 /
  700.0  1463.9 /
  800.0  1464.8 /
  900.0  1465.8 /
 1000.0  1466.7 /
 1100.0  1467.0 /
 1200.0  1469.0 /
```

```
 1300.0  1469.5 /
 1400.0  1471.8 /
 1600.0  1474.5 /
 1800.0  1477.0 /
 2000.0  1479.6 /
 2500.0  1487.9 /
 3750.0  1510.4 /
35  0.0  3808.33
 3750.0  1504.6    0.0   1.50   .15  0.0
 3808.33 1603.07 /
35  0.0  3866.66
 3808.33 1603.07    0.0   1.533  .15  0.0
 3866.66 1701.53 /
35  0.0  3925.0
 3866.66 1701.53    0.0   1.566  .15  0.0
 3925.0  1800.0 /
'A'  0.0                   ! BOTOPT  SIGMA (m)
 3925.0  1800.0    0.0   1.60   .15  0.0
0.0  1504.0                ! CLOW  CHIGH (m/s)
300.0                      ! RMAX (km)
1                          ! NSD
100.0 /                    ! SD(1:NSD) (m)
1                          ! NRD
200.0 /                    ! RD(1:NRD) (m)
```

Description of Environmental File

输入文件说明

The first 6 blocks in the ENVFIL are common to all the programs in the Acoustics Toolbox. The following blocks should be appended for KRAKEN:

ENVFIL 的前 6 个版块对声学工具箱的所有程序都通用。KRAKEN 还附加以下几个版块：

(7) - Phase Speed Limits

(7) - 相速度界限

Syntax:
  CLOW CHIGH
Description:

CLOW: Lower phase speed limit (m/s).

CLOW will be computed automatically if you set it to zero. However, by using a nonzero CLOW you can skip the computation of slower modes. Mainly this is used to exclude interfacial modes (e.g.a Scholte wave). The root finder is especially slow in converging to these interfacial modes and when the source and receiver are sufficiently are far from the interface the interfacial modes are negligible.

如果将 CLOW 设置为零，程序会自动计算 CLOW。当然，若使用非零 CLOW，就可以跳过较慢模式的计算。这主要用于排除界面模式（例如 SCHOLTE 波）。要收敛到这些界面模式，寻根器运行得特别慢。当声源和接收器离界面足够远时，界面模式可以忽略。

<table>
<tr><td>语　法</td><td colspan="2">CLOW　CHIGH</td></tr>
<tr><td rowspan="2">说　明</td><td>CLOW</td><td>相速度下限(m/s)。</td></tr>
<tr><td>CHIGH</td><td>相速度上限(m/s)。</td></tr>
</table>

CHIGH: Upper phase speed limit (m/s).

The larger CHIGH is, the more modes are calculated and the longer the execution time. Therefore CHIGH should be set as small aspossible to minimize execution time.

CHIGH越大，计算的模式就越多，执行时间也越长。因此CHIGH应该设置得尽可能小，以便执行时间减到更短。

On the other hand, CHIGH controls the maximumray angle included in a subsequent field calculation-- ray paths are included which turn at the depth corresponding to CHIGH in the SSP. Thus a larger CHIGH means more deeply penetrating rays are included.

另一方面，CHIGH 控制着随后在声场计算中的最大射线角--其声线路径的反转深度对应于 SSP 中 CHIGH 的深度。因此，更大的 CHIGH 意味着声线的穿透深度更深。

Choice of CHIGH then becomes a matter of experience. In the far-field and at high-frequencies, rays travelling in the ocean bottom are severely attenuated and one may set CHIGH to the sound speed at the ocean bottom. Inthe near-field, low-frequency case, rays refracted in the bottom may contribute significantly to the field and CHIGH should be chosen to include such ray paths.

因此，CHIGH 的设定取决于经验。在远场和高频情况下，海底传播的声线会严重衰减，可以设置海底处的声速为 CHIGH。在

近场、低频情况下，海底折射的声线可能对声场贡献很大，设定 CHIGH 时，应须包含这些声线路径。

KRAKEN will (if necessary) reduce CHIGH so that only trapped (non-leaky) modes are computed.

必要时，可以减小 CHIGH，以便让 KRAKEN 只计算声道捕获（非泄漏）的模式。

KRAKENC will attempt to compute leaky modes if CHIGH exceeds the phase velocity of either the S-wave or P-wave speed in the half-space. Leaky mode computations are somewhat experimental at this time.

当 CHIGH 超过半空间中 S 波或 P 波的相速度时，KRAKENC 会尝试计算泄露模式。此时泄露模式的计算具有实验意义。

(8) - Maximum Range

(8) - 最大距离

Syntax:
RMAX
Description:
RMAX: Maximum range (km).

语　法	RMAX
说　明	最大距离(km)

This parameter should be set to the largest range for which a field calculation will be desired.

此参数应设置为想要计算声场的最远距离。

During the mode calculation the mesh is doubled successively until the eigenvalues are sufficiently accurate at this range. If you set it to zero, then no mesh doublings will be performed. You don't need to worry too much about this parameter-- even if you set it to zero the results will usually be reasonable.

模式计算期间，网格连续加倍，直到本征值在此距离上足够精确。如果把它设置为零，网格就不会加倍。毋需太担心此参数--即使将它设置为零，结果通常也会合理。

(9) - Source/Receiver Depths

(9) - 声源/接收器的深度

Syntax:

NSD

SD(1:NSD)

NRD

RD(1:NRD)

Description:

NSD: Number of source   depths.

SD(): Source   depths (m).

NRD: Number of receiver depths.

RD(): Receiver depths (m).

<table>
<tr><td>语　法</td><td colspan="2">NSD
SD(1:NSD)
NRD
RD(1:NRD)</td></tr>
<tr><td rowspan="4">说　明</td><td>NSD</td><td>声源深度的数目</td></tr>
<tr><td>SD()</td><td>声源深度(m)</td></tr>
<tr><td>NRD</td><td>接收器深度的数目</td></tr>
<tr><td>RD()</td><td>接收器深度(m)</td></tr>
</table>

This data is read in using list-directed I/O so you can type it just about any way you want, e.g. on one line or split onto several lines. Also if your depths are equally spaced then you can type just the first and last depths followed by a '/' and the intermediate depths will be generated automatically.

这些数据使用列表导向的 I/O 读取，因此可用任意方式写入，比如只写成一行或者拆成几行。此外，如果深度间隔相等，那么可以只写入第一个和最后一个深度，后面跟着一个‘/’，中间的深度值将自动生成。

CPU time is essentially independent of the number of sources and receivers so that you can freely ask for thousands of depths. However, for high-frequencies the storage for the mode files can be excessive.

CPU 时间基本上与声源和接收器的数量无关，因此可以随意设置数千个深度值。当然，对于高频，模式文件可能会占用较多的存储。

The source/rcvr depths are sorted and merged and then the modes are calculated at the union of the two sets of depths. Thus, it doesn't matter if you mix up source and receiver depths. Furthermore, you can leave out either the source or receiver specification (but not both simultaneously) simply by using a '/' for that line.

计算中会先对声源/接收器的深度进行排序和组合，然后再根据两组深度的组合来计算模式。因此，即使将声源/接收器深度混合也没关系。此外，仅在该行应用'/'，就能详细列出声源或接收器位置（但不能同时使用）。

Sources and receivers cannot be placed in a half-space.

声源和接收器不能放置在半空间。

If you are going to be doing a coupled-mode calculation then you must specify a large number of receiver depths spanning the entire column (down to the half-space). Fine sampling (about 10 points/wavelenght) is needed to calculate the coupling integrals accurately.

如果要进行模式耦合计算，就必须设定大量的接收器深度，并且贯穿整个水深（向下直到半空间）。耦合积分的精确计算需要精细的采样（大约 10 点/波长）。

How to run KRAKEN

运行 KRAKEN

Starting out for the first time? If the distribution does not have precompiled executables for your hardware, run the 'makefiles' to compile and link of the whole package.

1. Create the environmental file for your problem, following the directions in KRAKEN.HLP.

1. 遵照 KRAKEN.HLP 的说明，为您的问题创建环境文件。

2. Run KRAKEN (or KRAKENC) by typing

2. 输入以下命令，运行 KRAKEN（或 KRAKENC）

   KRAKEN filename

   where "filename" is the environmental file. (The process is the same under DOS or Linux.) The KRAKEN.HLP file details the differences between the KRAKEN and KRAKENC.

   其中"filename"是环境文件。（这个过程在 DOS 或 Linux 下是相同的。）KRAKEN.HLP 文件详细说明了 KRAKEN 和 KRAKENC 之间的区别。

3. Run FIELD to sum the modes and compute the complex pressure field:

3. 运行 FIELD，叠加模式，计算复数声压场：

FIELD filename

4. You now have several choices (all the GROUP II programs). These are run from inside MATLAB:

4. 您现在可做几项选择(所有第 II 组的程序)。在 MATLAB 平台上运行这些程序：

a. PLOTMODE to plot the modes.

a. PLOTMODE 绘制模式。

b. PLOTSSP to plot the sound speed profile.

b. PLOTSSP 绘制声速剖面

c. PLOTSHD to plot the pressure field as a function of range and depth.

c. PLOTSHD 绘制声压场，它是距离和深度的函数。

Once the modes are created by KRAKEN or KRAKENC you can run the above plot programs in any sequence or as often as you like.

一旦 KRAKEN 或 KRAKENC 算出模式，您就可以随心所愿：以任何顺序或者任意频次运行以上绘图程序。

Sample Print Out

打印输出范本

The print-out for this input is shown below. The version we run, has the complicated Twersky ice scatter model disabled since that part of the code has not been upgraded to Fortran95. Therefore the results do not actually include that effect of ice scatter loss.

此处展示了对输入的打印输出。我们运行的版本禁用了复杂的 Twersky 海冰散射模型，因为这部分代码还没有升级到 Fortran95。因此，结果实际上不包括海冰散射损失的影响。

KRAKEN- FRAMIV Twersky S/S ice scatter

Frequency = 20.00 NMedia = 4

N2-LINEAR approximation to SSP

Attenuation units: dB/mkHz

Twersky SOFT BOSS scatter model

Twersky ice model parameters:

Bumden = 0.920000E-02 Eta = 8.20 Xi = 5.10

Z AlphaR BetaR Rho AlphaI BetaI

(Number of pts = 750 RMS roughness = 0.00)

0.00	1436.00	0.00	1.03	0.0000	0.0000
30.00	1437.40	0.00	1.03	0.0000	0.0000
50.00	1437.70	0.00	1.03	0.0000	0.0000
80.00	1439.50	0.00	1.03	0.0000	0.0000
100.00	1441.90	0.00	1.03	0.0000	0.0000
125.00	1444.60	0.00	1.03	0.0000	0.0000
150.00	1450.00	0.00	1.03	0.0000	0.0000
175.00	1456.10	0.00	1.03	0.0000	0.0000
200.00	1458.40	0.00	1.03	0.0000	0.0000
250.00	1460.00	0.00	1.03	0.0000	0.0000
300.00	1460.50	0.00	1.03	0.0000	0.0000
350.00	1460.60	0.00	1.03	0.0000	0.0000
400.00	1461.00	0.00	1.03	0.0000	0.0000
450.00	1461.50	0.00	1.03	0.0000	0.0000
500.00	1462.00	0.00	1.03	0.0000	0.0000
600.00	1462.90	0.00	1.03	0.0000	0.0000
700.00	1463.90	0.00	1.03	0.0000	0.0000
800.00	1464.80	0.00	1.03	0.0000	0.0000
900.00	1465.80	0.00	1.03	0.0000	0.0000
1000.00	1466.70	0.00	1.03	0.0000	0.0000
1100.00	1467.00	0.00	1.03	0.0000	0.0000
1200.00	1469.00	0.00	1.03	0.0000	0.0000
1300.00	1469.50	0.00	1.03	0.0000	0.0000
1400.00	1471.80	0.00	1.03	0.0000	0.0000
1600.00	1474.50	0.00	1.03	0.0000	0.0000
1800.00	1477.00	0.00	1.03	0.0000	0.0000
2000.00	1479.60	0.00	1.03	0.0000	0.0000
2500.00	1487.90	0.00	1.03	0.0000	0.0000
3750.00	1510.40	0.00	1.03	0.0000	0.0000

(Number of pts = 35 RMS roughness = 0.00)

3750.00	1504.60	0.00	1.50	0.1500	0.0000
3808.33	1603.07	0.00	1.50	0.1500	0.0000

(Number of pts = 35 RMS roughness = 0.00)

3808.33	1603.07	0.00	1.53	0.1500	0.0000
3866.66	1701.53	0.00	1.53	0.1500	0.0000

(Number of pts = 35 RMS roughness = 0.00)

3866.66	1701.53	0.00	1.57	0.1500	0.0000
3925.00	1800.00	0.00	1.57	0.1500	0.0000

(RMS roughness = 0.00)
ACOUSTO-ELASTIC half-space
3925.00 1800.00 0.00 1.60 0.1500 0.0000

CLOW = 0.0000 CHIGH = 1504.0
RMAX = 300.0000000000000

Number of sources = 1
100.000

Number of receivers = 501

0.00000	7.85000	15.7000	23.5500	31.4000
39.2500	47.1000	54.9500	62.8000	70.6500
78.5000	86.3500	94.2000	102.050	109.900
117.750	125.600	133.450	141.300	149.150
157.000	164.850	172.700	180.550	188.400
196.250	204.100	211.950	219.800	227.650
235.500	243.350	251.200	259.050	266.900
274.750	282.600	290.450	298.300	306.150
314.000	321.850	329.700	337.550	345.400
353.250	361.100	368.950	376.800	384.650
392.500				

... 3925.00000

Mesh multiplier CPU seconds
--- Number of modes = 16
1 0.200E-01
--- Number of modes = 16
2 0.100E-01

I	K	ALPHA	PHASE SPEED	GROUP SPEED
1	0.8624469531E-01	-0.3393680437E-33	1457.060120	1442.191128
2	0.8582756287E-01	-0.2258264739E-34	1464.141611	1458.363347
3	0.8562779133E-01	-0.7903258864E-35	1467.557486	1459.982403
4	0.8545321184E-01	-0.2063707986E-29	1470.555681	1459.772119
5	0.8527102515E-01	-0.3869615292E-29	1473.697612	1460.007439
6	0.8510362497E-01	-0.3647388043E-26	1476.596399	1461.303669
7	0.8495175125E-01	-0.1793622439E-23	1479.236205	1462.170030
8	0.8479899358E-01	-0.3873153170E-21	1481.900915	1462.347048
9	0.8465055475E-01	-0.4836458160E-19	1484.499499	1461.666057
10	0.8450362764E-01	-0.4794435113E-17	1487.080610	1462.889869
11	0.8435766539E-01	-0.3328862832E-15	1489.653674	1463.381675
12	0.8421539792E-01	-0.1526837394E-13	1492.170188	1463.060233
13	0.8407682246E-01	-0.5076531997E-12	1494.629584	1463.714231

14	0.8393863717E-01	-0.1285683019E-10	1497.090141	1464.761578
15	0.8380272668E-01	-0.2261354744E-09	1499.518108	1465.064585
16	0.8366989890E-01	-0.2750609980E-08	1501.898625	1465.355728

If the program aborts in some way, examine the print file which is produced. Frequently an expected line has been omitted and the environmental file is therefore misinterpreted.

如果程序以某种方式中止，请查验生成的打印文件。经常是因为省略了预期的某行，就造成环境文件被曲解。

The message "FAILURE TO CONVERGE IN SECANT" occurs when KRAKEN requires more than 500 iterations to converge to a mode. Usually less than 20 iterations are needed but convergence to interfacial modes (Scholte or Stoneley waves) can be exceptionally slow,especially at higher frequencies. The simplest solution is to exclude interfacial modes by setting the lower phase-speed limit to the minimum p-wave speed in the problem. Alternately, you can increase the value of MAXNIT which controls the MAXimum Number of ITerations in the root finder.

当 KRAKEN 需要超过 500 次迭代才收敛到某个模式时，会出现"FAILURE TO CONVERGE IN SECANT（割线收敛失败）"的消息。通常只需不到 20 次迭代（就能收敛），但要收敛到界面模式（Scholte 波或 Stoneley 波）可能就会特别慢，特别是对于较高的频率。最简单的方案是将问题的相速度下限设置为 P 波速度的最小值，就排除了界面模式。或者，可以增加 MAXNIT 的值，该值控制寻根器的最大迭代次数。

***** Group speed *****

***** 群速度 *****

KRAKEN and KRAKENC compute group speed using the formula in Ch. 5 of Jensen, Kuperman, Porter, and Schmidt, Computational Ocean Acoustics. Note that this formula is only valid for acoustic problems (with no elasticity). It also does not address the role of interfacial or boundary scatter. In these cases, the value displayed is not reliable.

KRAKEN 和 KRAKENC 使用 Jensen、Kuperman、Porter 和 Schmidt 的《计算海洋声学》第 5 章中的公式计算群速度。请注意，此公式仅适用于声学问题（没有弹性）。也不涉及界面间或边界散射的作用。在此情况下，显示值并不可靠。

6 FIELD

6 声场计算

The FIELD program uses the modes calculated by KRAKEN and produces a shade file which contains a sequence of snapshots of the acoustic field as a function of range and depth. A snapshot is produced for every source depth specified by the user.

FIELD 程序应用 KRAKEN 算出的模式，生成一个渲染文件，该文件包含一系列声场快照，它是距离与深度的函数。也生成用户指定的每个声源深度的声场快照。

Files:

	Name	Unit	Description
Input			
	*.FLP	5	FieLd Parameters
	*.MOD	30-99	MODe files
Output			
	*.PRT	6	PRinT file
	*.SHD	25	SHaDe file

相关文件	名　称	单　位	说　　明
输　入	*.FLP	5	声场参数（FieLd Parameters）
	*.MOD	30-99	模式文件（MODe files）
输　出	*.PRT	6	打印文件（PRinT file）
	*.SHD	25	渲染文件（SHaDe file）

EXAMPLE AND DESCRIPTION OF FLP FILE

FLP 示例与说明

```
/,                      ! TITLE
'RA'                    ! OPT 'X/R', 'C/A'
9999                    ! M  (number of modes to include)
1                       ! NPROF
0.0                     ! RPROF(1:NPROF) (km)
501                     ! NR
200.0  220.0 /          ! R(1:NR)   (km)
1                       ! NSD
500.0 /                 ! SD(1:NSD)   (m)
1                       ! NRD
```

```
2500.0 /            ! RD(1:NRD)   (m)
1                   ! NRR
0.0 /               ! RR(1:NRR)   (m)
```

(1) - TITLE

Syntax:

TITLE

Description:

TITLE: Title to be written to the shade file.

If you type a /, the title is taken from the first mode file.

<table>
<tr><td colspan="2">（1） 标　　题</td></tr>
<tr><td>语 法</td><td>TITLE</td></tr>
<tr><td rowspan="2">说 明</td><td>此标题将被写入渲染文件。</td></tr>
<tr><td>如果输入 / ， 标题将取自第一个模式文件。</td></tr>
</table>

(2) - OPTIONS

Syntax:

OPTION

Description:

OPTION(1:1): Source type.

'R' point source

(cylindrical (R-Z) coordinates)

'X' line source

(cartesian (X-Z) coordinates)

OPTION(2:2): Selects coupled or adiabatic mode theory.

'C' Coupled mode theory.

'A' Adiabatic mode theory (default).

OPTION(3:3): Selects a source beam pattern

'*' Read in a source beam pattern file.

'O' Omnidirectional (default).

OPTION(4:4): Selects coherent or incoherent mode addition

'C' Coherent

'I' Incoherent

<table>
<tr><td colspan="4">（2）选　　项</td></tr>
<tr><td>语 法</td><td colspan="3">OPTION</td></tr>
<tr><td rowspan="5">说 明</td><td rowspan="3">OPTION(1:1)</td><td colspan="2">声源类型</td></tr>
<tr><td>R</td><td>点源(圆柱形(R-Z)坐标)</td></tr>
<tr><td>X</td><td>线源(笛卡尔(X-Z)坐标)</td></tr>
<tr><td rowspan="2">OPTION(2:2)</td><td colspan="2">选择耦合或绝热模式理论。</td></tr>
<tr><td>C</td><td>耦合模式理论</td></tr>
</table>

		A	绝热模式理论(默认)
	OPTION(3:3)	选择声源波束模式	
		*	从声源波束模式文件中读取
		O	全向（缺省）
	OPTION(4:4)	选择相干模式叠加或非相干模式叠加	
		C	相干
		I	非相干
若要选择“模式耦合”运行，您***必须***确保贯穿整个水体对模式进行精细采样（不包含半空间，如果有半空间的话），以便 **FIELD** 能够精确地计算耦合积分。这可以通过在运行 KRAKEN 时设置大数量的接收器深度（NRD）来完成。这个数目应该设置为大约 10 点/波长。			

For a coupled mode run you ***must*** be sure that the modes are finely sampled throughout the media (excluding the halfspaces if present) so that FIELD can accurately calculate the coupling integrals. This is done by using a large number of receiver depths (NRD) when you do the KRAKEN run. This number should be set to give about 10 points/wavelength.

(3) - NUMBER OF MODES

Syntax:
M
Description:
M: Number of modes to use in the field computation.
If the number of modes specified exceeds the number computed then the program uses all the computed modes.

（3） 模 式 数 目	
语 法	M
说 明	声场计算中使用的模式数目。
	如果设定的模式数目超过算得的数目，程序就用所有算出的模式。

(4) - PROFILE RANGES

Syntax:
NPROF RPROF(1:NPROF)
Description:
NPROF: The number of profiles, i.e. ranges where a new set of modes is to be used.
RPROF(): Ranges (km) of each of these profiles.
For a range independent problem there is only one profile and its range is arbitrary. Mode files must exist for each range of a new profile and be assigned in sequence to units 30,31,... The modes for

the last SSP profile are extended in a range-independent fashion to infinity so that RMAX can exceed RPROF(NPROF).
*** NOTE: RPROF(1) must be 0.0 ***

<table>
<tr><td colspan="3">（4）剖 面 的 距 离</td></tr>
<tr><td>语 法</td><td colspan="2">NPROF　RPROF(1:NPROF)</td></tr>
<tr><td rowspan="4">说 明</td><td>NPROF</td><td>剖面（亦即使用一组新模式的距离点）数目。</td></tr>
<tr><td rowspan="3">RPROF()</td><td>每个剖面观测所在的距离点位置(km)。</td></tr>
<tr><td>在与距离无关的问题中，就只有一个剖面文件，它的距离也是任意的。每个新剖面的距离点必须有一个模式文件，并按顺序依次命名，如 30，31，…。最后一组 SSP 的模式以与距离无关的方式扩展到无穷远，因此 RMAX 可以超过 RPROF(NPROF)。</td></tr>
<tr><td>*** 注意：RPROF(1)必须为 0.0 ***</td></tr>
</table>

(5) - SOURCE/RECEIVER LOCATIONS

Syntax:
NR
R(1:NR)
NSD
SD(1:NSD)
NRD
RD(1:NRD)
NRR
RR(1:NRR)
Description:
NR: Number of receiver ranges.
R(): The receiver ranges (km)
NSD: The number of source depths.
SD(): The source depths (m).
NRD: The number of receiver depths.
RD(): The receiver depths (m).
NRR: The number of receiver range-displacements.
Must equal NRD. (YES, IT IS REDUNDANT)
RR(): The receiver displacements (m).
This vector should be all zeros for a perfectly vertical array.

<table>
<tr><td colspan="2">（5）声源 / 接收器的位置</td></tr>
<tr><td>语 法</td><td>NR
R(1:NR)
NSD
SD(1:NSD)
NRD</td></tr>
</table>

	RD(1:NRD) NRR RR(1:NRR)	
说 明	NR	接收器距离的数目。
	R()	接收器距离(km)
	NSD	声源深度的数目
	SD()	声源深度(m)
	NRD	接收器深度的数目
	RD()	接收器深度(m)
	NRR	接收器距离-偏移的数目。
		必须等于 NRD。(对，该值多余)
	RR()	接收器偏移(M)。
		对于完全垂直的阵列，该向量全为零值。

The field is computed by stepping through the ranges, R(1:NR), and adding in the range displacements, RR() before computing the field on the array. Nonzero values are used to tilt ordistort the receiving array, thereby simulating the distortion which occurs on an array deployed in the ocean.

在计算阵列的声场之前，先将 R(1:NR)加上距离偏移 RR()，再通过步进算出声场。当接收阵列倾斜或扭曲时，该向量为非零值，从而可以模拟当海洋中部署的阵列发生扭曲时的声场。

The format of the source/rcvr info is an integer indicating the number of sources (receivers) followed by real numbers indicating the depth (range) of each receiver. Since this data is read in using list-directed I/O you can type it just about any way you want, e.g. on one line or split onto several lines. Also if your depths are equally spaced then you can type just the first and last depths followed by a '/' and the intermediate depths will be generated automatically.

声源/接收器信息的格式是一个整数，它表示声源（接收器）的数目。随后的实数表示每个声源/接收器的深度（距离）。由于这些数据采用表式 I/O 读取，所以您可以采用任何方式写入，比如，写成一行或拆成几行。此外，如果深度间隔相等，您可以只写入第一个和最后一个深度，随后写上‘/’，中间的深度就会自动生成。

7 FIELD3D

The FIELD3D program uses the modes calculated by KRAKEN and produces a shade file which contains a sequence of 2-D slices of the acoustic field. It is commonly used to compute a field in plan view, i.e. as a function of horizontal coordinates (x,y). It can also be used to compute the field on a vertical slice along any fixed bearing through the 3-D environment.

FIELD3D 程序应用 KRAKEN 算出的模式，生成一个渲染文件，该文件包含一系列二维声场切片。通常用该文件来计算声场的平面视图，此视图是水平坐标(x,y)的函数。也可用该文件来计算沿任何指定方位穿越三维环境的声场垂直切片。

FIELD3D uses a tiling of the ocean environment based on triangles. The terminology is taken from finite-elements. To define the triangles you must do the following:

Field3D 采用基于三角形平铺的海洋环境。此术语来自有限元。要定义三角形，必须进行以下操作：

(1) Lay out a grid of points (nodes) where you will construct environmental files for KRAKEN and solve for the modes. A rule-of-thumb is to pick points every 10 km but obviously a coarser spacing can be used in sites with less environmental change.

规划一批网格点(节点)，在这些节点您将为 KRAKEN 构造环境文件并计算模式。经验法则是每 10 公里取一个点。但是，很明显，在环境变化较小的站位，跨距较疏也可以。

(2) Assign a number to each of the nodes.

为每个节点分配一个编号。

(3) Form a triangulation of the nodes. That is, connect the nodes with lines such that the grid is divided into a number of triangles. This should be done with an eye towards keeping the area of the individual triangles uniform. All nodes should be a corner of at least one triangle. Each triangle is referred to as an element.

形成节点的三角剖分。也就是说，将节点用线连接起来，这样网格就被划分成大量的三角形。达成此点时，注意必须保持单个三角形区域内的均匀性。所有节点至少都应该是某三角形的一个角。每个三角形都称作基元。

There are algorithms for performing this step automatically and if you write one I would be glad to receive it. If instead you do this by hand you will rapidly discover the merits of using a regular grid.

有自动执行这个步骤的算法，如果您愿意写一个，我也会很乐意接受它。如果您动手做此事，很快您就会发现使用规则网格的优点。

(4) Assign a number to each of the elements.

为每个基元分配一个数字。

You now have the information required by FIELD3D to describe your triangulation. In the input file you first tell FIELD3D the coordinates of each node and the name of the file containing the modes at each node. You then tell FIELD3D how you connected the nodes to form a triangulation. This is done by specifying the node numbers which define the corners of each successive element (triangle).

现在,您已经具备了 FIELD3D 所需的描述您的三角剖分的信息。在输入文件中，首先告诉 FIELD3D 每个节点的坐标和包含此节点的模式的文件名称。然后告诉 FIELD3D 如何连接节点以形成三角剖分。这通过设定节点编号来实现，节点编号定义了每个连续基元（三角形）的角。

Files:

	Name	Unit	Description
Input			
	*.FLP	5	FieLd Parameters
	*.MOD	30-99	MODe files
Output			
	*.PRT	6	PRinT file
	*.SHD	25	SHaDe file

相关文件	名　称	单　位	说　　　明
输　入	*.FLP	5	声场参数（FieLd Parameters）
	*.MOD	30-99	模式文件（MODe files）
输　出	*.PRT	6	打印文件（PRinT file）
	*.SHD	25	阴影文件（SHaDe file）

EXAMPLE AND DESCRIPTION OF FLP FILE

FLP 示例与说明

```
'MUNK3D'                    ! TITLE
'STDFM'                     ! OPT
9999                        ! M (number of modes)
1                           ! Nsx
0.001                       ! Sx   coordinates of source (km)
```

```
1                                   ! Nsy
0.001                               ! Sy   coordinates of source (km)
1                                   ! NSD
1000.0                              ! SD(1:NSD) (m)
1                                   ! NRD
800.0                               ! RD(1:NRD) (m)
501                                 ! NR
0.0   100.0   501                   ! RMIN   RMAX (km)
19                                  ! NTHETA
0.0   360.0 /                       ! THETA(1:NTHETA) (degrees)
5                                   ! Number of SSP's (NSSP)
 100.0      0.0   'SCR:MUNKT0'      ! (x, y) i=1, NSSP (km)
    0.0   100.0   'SCR:MUNKT90'
-100.0      0.0   'SCR:MUNKT0'
    0.0  -100.0   'SCR:MUNKT270'
    0.0      0.0  'SCR:MUNKT0'
4                                   ! NELTS
5   1   2                           ! Nodes of corners
5   2   3
5   3   4
5   4   1
4.0    360.0   90                   ! ALPHA1   ALPHA2   NALPHA
500.0   160                         ! STEP   NSTEPS
0.3                                 ! EPMULT
```

(1) - OPTIONS

（1） 选 项			
语法	选 项		说 明
OPT	OPT(1:3)		计算类型。
		STD	(标准)用于 Nx2D 运行
		GBT	(高斯波束追踪)用于三维运行。
		PDQ	用于快速预览运行。
	OPT(4:4)		TESCHECK（镶嵌检查）标志
		T	执行镶嵌检查。
		F	省略镶嵌检查
	OPT(5:5)		波束类型。
		M	建议用'M'。
	OPT(6:6)		射线文件标志
		R	将水平平面内的射线路径轨迹文件写入磁盘
	OPT(7:7)		选择声源波束模式
		*	从声源波束模式文件中读取
		O	全向（缺省）

Syntax:

OPT

Description:

OPT(1:3): Type of caculation.

'STD' (Standard) for an Nx2D run.

'GBT' (Gaussian beam trace) for a 3D run.

'PDQ' For a fast preview run.

The 'STD' option neglects horizontal refraction but runs a lot faster. Avoid using the 'GBT' option: it requires some care to use properly. Option 'PDQ' runs about 3x as fast as 'STD' but is less accurate.

'STD'选项忽略水平折射，但运行速度快很多。避免使用'GBT'选项：它需要谨慎才能正确使用。选项'PDQ'运行速度比'STD'快 3 倍，但不太准确。

OPT(4:4): TESCHECK (tesselation check) flag.

'T' Perform the tesselation check.

'F' omit the tesselation check.

For all but the simplest setups the user will INVARIABLY make an error in setting up the triangulation. The first step to avoid this is to run PLOTTRI to get a plot of the triangulation. Even after that one should invoke this 'TESCHECK' option however for large problems some time can be saved by turning off this feature after the triangulation has been checked once.

除了最简单的设置，对于其他所有情形，用户在建立三角剖分时总是会出错。避免这种情况的第一步是运行 PLOTTRI 来对三角剖分进行绘图。即使在这样做了之后，我们还是应该启用'TESCHECK'选项。不过，对于较大型的问题，在完成一次三角剖分检查之后，关闭此功能可以节省一些时间。

OPT(5:5): Type of beams.

There are several types of Gaussian beams available. I suggest using 'M'. This option is ignored unless the Gaussian beam calculation has been selected.

现有数种高斯波束类型可用。我建议采用 'M'。除非选择高斯波束计算，否则此选项可以忽略。

OPT(6:6): Ray file flag.

Use 'R' to have a file of ray path trajectories (in the horizontal plane) written to disk for subsequent plotting using the PLOTRAYXY program. These rays show the horizontal refraction of individual modes. This option is ignored if you select a 'STD' or 'PDQ' run for then the ray paths are just straight lines.

采用'R'将(水平平面内的)射线路径轨迹文件写入磁盘，以便应用 PLOTRAYXY 程序进行后续绘图。这些射线展现了个别模式的水平折射。如果选择'STD'或'PDQ'运行，那么声线路径就只是直线，该选项即可忽略。

OPT(7:7): Selects a source beam pattern
'*' Read in a source beam pattern file.
'O' Omnidirectional (default).

(2) - NUMBER OF MODES

Syntax:
M
Description:
M: Number of modes to use in the field computation.

If the number of modes specified exceeds the number computed then the program uses all the computed modes.

（2） 模 式 数 目	
语 法	M
说 明	声场计算中使用的模式数目。
	如果指定的模式数目超过算得的数目，程序则将使用所有算得的模式。

(3) - SOURCE COORDINATES (x,y)

Syntax:
NSx
Sx(1:NSx)
NSy
Sy(1:NSy)
Description:
NSx: The number of source coordinates in x.
Sx(): x-coordinates of the sources (km).
NSy: The number of source coordinates in y.
Sy(): y-coordinates of the sources (km).

（3） 声 源 坐 标（x,y）		
语 法	NSx Sx(1:NSx) NSy Sy(1:NSy)	
说 明	NSx	声源 x 坐标的数目。
	Sx()	声源的 x 坐标（km）。
	NSy	声源 y 坐标的数目。

	Sy()	声源的 y 坐标（km）。

(4) - SOURCE/RECEIVER DEPTHS

Syntax:
NSD
SD(1:NSD)
NRD
RD(1:NRD)
Description:
NSD: The number of source depths.
SD(): The source depths (m).
NRD: The number of receiver depths.
RD(): The receiver depths (m).

（4） 声源 / 接收器的深度		
语 法	NSD SD(1:NSD) NRD RD(1:NRD)	
说 明	NSD	声源深度的数目
	SD()	声源深度(m)
	NRD	接收器深度的数目
	RD()	接收器深度(m)

(5) - RECEIVER RANGES

Syntax:
NR
RMIN RMAX
Description:
NR: Number of receiver ranges.
RMIN: First receiver range (km). MUST BE ZERO!
RMAX: Last receiver range (km).

（5） 接 收 器 的 距 离		
语 法	NR RMIN RMAX	
说 明	NR	接收器距离的数目
	RMIN	第一个接收器的距离(km)。必须为零！
	RMAX	最后一个接收器的距离(km)。

(6) - RADIALS

Syntax:
NTHETA

THETA(1:NTHETA)

Description:

NTHETA: Number of radials.

THETA(): Angles for each radial (degrees).

（6） 径 向 参 数		
语 法	NTHETA THETA(1:NTHETA)	
说 明	NTHETA	径向方位的数目
	THETA()	每个径向方位的角度(°)
对于完整的圆形（或圆盘）覆盖，绘图程序要求有一个重复的径向，例如 0°和 360°。		
您不能在单次运行中应用多个声源、多个接收器和多个方位：NSD、NRD 或 NTHETA 三者至少有一个必须是 1。		

For full circle (or disc) coverage our plotting program likes to have a repeated radial, say 0 and 360 degrees.

You cannot have multiple sources, receivers and bearings in a single run: at least one of NSD, NRD or NTHETA must be 1.

(7) - NODES

Syntax:

```
NNODES
X(1)       Y(1)       FILNAM(1)
X(2)       Y(2)       FILNAM(2)
 .
 .
 .
X(NNODES)   Y(NNODES)   FILNAM(NNODES)
```

Description:

NNODES: Number of nodes.

X(): X-coordinate of node (km).

Y(): Y-coordinate of node (km).

FILNAM(): Name of the mode file for that node.
Use the name 'DUMMY' to produce an acoustic absorber.

（7） 节 点	
语 法	NNODES X(1) Y(1) FILNAM(1) X(2) Y(2) FILNAM(2) . . .

<table>
<tr><td></td><td colspan="2">X(NNODES) Y(NNODES) FILNAM(NNODES)
RD(1:NRD)</td></tr>
<tr><td rowspan="5">说 明</td><td>NNODES</td><td>节点数目。</td></tr>
<tr><td>X()</td><td>节点的 X 坐标(km)。</td></tr>
<tr><td>Y()</td><td>节点的 X 坐标(km)。</td></tr>
<tr><td rowspan="2">FILNAM()</td><td>此节点的模式文件的名称。</td></tr>
<tr><td>用名字'DUMMY'来生成吸声器。</td></tr>
</table>

(8) - ELEMENTS

Syntax:

```
NELTS
NODE1(1)      NODE2(1)      NODE3(1)
NODE1(2)      NODE2(2)      NODE3(2)
 .
 .
 .
NODE1(NELTS)  NODE2(NELTS)  NODE3(NELTS)
```

Description:

NELTS: Number of elements. (<1500)
NODE1(): Number of node at first corner of the triangle.
NODE2(): " " " " second " " " "
NODE3(): " " " " third " " " "

In this fashion we define a tiling of triangular elements. The ordering of the elements is arbitrary.

<table>
<tr><td colspan="3">（8） 基 元 点</td></tr>
<tr><td>语 法</td><td colspan="2">NNODES
X(1) Y(1) FILNAM(1)
X(2) Y(2) FILNAM(2)
.
.
.
X(NNODES) Y(NNODES) FILNAM(NNODES)
RD(1:NRD)</td></tr>
<tr><td rowspan="4">说 明</td><td>NELTS</td><td>基元数目。</td></tr>
<tr><td>NODE1()</td><td>三角形第一个角的节点数。</td></tr>
<tr><td>NODE2()</td><td>三角形第二个角的节点数。</td></tr>
<tr><td>NODE3()</td><td>三角形第三个角的节点数。</td></tr>
<tr><td colspan="3">我们以这种方式定义了三角形基元的平铺。基元的排序是任意的。</td></tr>
</table>

(9) - GAUSSIAN BEAM INFO

Syntax:

ALPHA1 ALPHA2 NALPHA
STEP NSTEPS
EPMULT

Description:

ALPHA1: First angle for beam fan (degrees).
ALPHA2: Last " " " " "
NALPHA: Number of beams in fan.
STEP: Step size (m).
NSTEPS: Number of steps.
EPMULT: Epsilon multipler for beam initial conditions.

This Gaussian beam info can be omitted if the 'STD' option in block (1) is used.

（9） 高 斯 波 束 信 息		
语 法	ALPHA1 ALPHA2 NALPHA STEP NSTEPS EPMULT	
说 明	ALPHA1	波束扇面的第一个角(°)。
	ALPHA2	波束扇面的最后一个角(°)。
	NALPHA	扇面中的波束数目
	STEP	步距（m）
	NSTEP	步数
	EPMULT	波束初始条件用的 Epsilon 乘法器
如果模块(1)中使用 'STD' 选项，则可省略高斯波束信息		

Run time is roughly proportional to M * NTHETA * NR.

运行时间大致与 M*NTHETA*NR 成正比。

8 SPARC

SPARC (SACLANTCEN Pulse Acoustic Research Code) is an experimental time-marched FFP. It treats problems with broadband or transient sources, that is, pulses. The environmental file is patterned after that used for KRAKEN and SCOOTER. The mathematical basis and numerical algorithm is described in:

SPARC（SACLANTCEN 脉冲声学研究程序）是一套实验用的时间演进 FFP。它处理宽带或瞬态声源（即脉冲）问题。环境文件模板仿照 KRAKEN 和 SCOOTER 所用模板。其数学基础和数值算法在以下文献有详细描述：

> Michael B. Porter, "The Time-Marched FFP for Modeling Acoustic Pulse Propagation," *J. Acoust. Soc. Amer.* **87**, 2013--2023 (1990).

Files:

	Name	Unit	Description
Input			
	*.ENV	1	ENVironmental data
	*.STS	10	Source Time Series
Output			
	*.PRT	6	PRinT file
	*.GRN	20	GReen's function
	*.RTS	35	Receiver Time Series

文 件	名 称	单 位	说 明
输 入	*.ENV	1	环境数据（ENVironmental data）
	*.STS	10	声源时间序列（Source Time Series）
输 出	*.PRT	6	打印（反馈）文件（PRinT file）
	*.GRN	20	Green 函数
	*.RTS	35	接收器时间序列（Receiver Time Series）

EXAMPLE AND DESCRIPTION OF ENV FILE

ENV 文件示例与说明

```
'Munk profile'
5.0
2
'NVW S'
500   0.0   5000.0
    0.0   1548.52   0.0   1.0   0.0   0.0
```

```
   200.0   1530.29 /
   250.0   1526.69 /
   400.0   1517.78 /
   600.0   1509.49 /
   800.0   1504.30 /
  1000.0   1501.38 /
  1200.0   1500.14 /
  1400.0   1500.12 /
  1600.0   1501.02 /
  1800.0   1502.57 /
  2000.0   1504.62 /
  2200.0   1507.02 /
  2400.0   1509.69 /
  2600.0   1512.55 /
  2800.0   1515.56 /
  3000.0   1518.67 /
  3200.0   1521.85 /
  3400.0   1525.10 /
  3600.0   1528.38 /
  3800.0   1531.70 /
  4000.0   1535.04 /
  4200.0   1538.39 /
  4400.0   1541.76 /
  4600.0   1545.14 /
  4800.0   1548.52 /
  5000.0   1551.91 /
500   0.0   10000.0
   5000.0   1551.91   0.0   1.00   1.0 0.0
  10000.0 /
'R'   0.0
1500.0   1550.0
10.0                            ! RMAX (km)
1                               ! NSD
    250.0 /                     ! SD(1:NSD) (m)
26                              ! NRD
   0.0 5000.0 /                 ! RD(1:NRD) (m)
'PH'                            ! PULSE
 0.0   15.0                     ! FMIN   FMAX (Hz)
1                               ! NRR
   60.0   0.200 /               ! RR(1:NRR) (km)
6                               ! NTOUT
 1.0 3.0 5.0 10.0 20.0 30.0     ! TOUT(1:NTOUT) (s)
-0.1   0.9   0.0   0.0   0.0    ! TSTART (s)   TMULT   ALPHA   BETA   V (m/s)
```

The input structure is identical to KRAKEN except for additional option in line 4 and 4 additional lines at the end.

除了第 4 行的附加选项和末尾的 4 行之外，其输入结构与 KRAKEN 相同。

OPT(5:5): Type of calculation

'S' for Snapshot.

FIELDS must be run afterwards to convert the '.GRN' file to a '.SHD' file containing the pressure field. The shade file can then be plotted using PLOTSHD.

'R' for Range stack (horizontal array).

The time series is written in a '.RTS'(Receiver Time Series) file which can be plotted using PLOTTS

'D' for Depth stack (vertical array).

The resulting time series can also be plotted using PLOTTS.

<table>
<tr><td rowspan="6">OPT(5:5)</td><td colspan="2">计　算　类　型</td></tr>
<tr><td rowspan="2">S</td><td>计算快照。</td></tr>
<tr><td>随后必须运行 FIELDS，将'.GRN'文件转换为包含声压场的'.SHD'文件。然后可以用 PLOTSHD 对渲染文件进行绘图。</td></tr>
<tr><td rowspan="2">R</td><td>计算距离堆栈（水平阵）。</td></tr>
<tr><td>时间序列写入'.RTS'（接收器时间序列））文件，该文件可用 PLOTTS 绘成图形。</td></tr>
<tr><td>D</td><td>计算深度堆栈（垂直阵）。</td></tr>
<tr><td colspan="3">由此生成的时间序列可用 PLOTTS 进行绘图。</td></tr>
</table>

Additional lines:

附加行：

(1) - SOURCE PULSE INFORMATION:

Syntax: PULSE
FMIN FMAX

Description:

PULSE(1:1): Type of interpolation to be used for the SSP

'P' Pseudo-Gaussian
'R' Ricker wavelet
'A' Approximate Ricker wavelet
'S' Single sine
'H' Hanning weighted four sine
'N' N-wave
'G' Gaussian

'F' From a '.STS' (Source Time Series) file.
'B' From a '.STS' file Backwards

PULSE(2:2): Hilbert transforming.
'H' perform a Hilbert transform of the source
'N' don't
Hilbert transforming is used to eliminate the left travelling wave.

PULSE(3:3): Source sign flipping.
'+' don't flip it (recommended)
'-' flip it

PULSE(4:4): Source filtering.
'L' low cut filter
'H' high cut filter
'B' both high and low cut filter
'N' no cut

FMIN: Low cut frequency (Hz)

FMAX: High cut frequency (Hz).
This should be no higher than necessary since the runtime is proportional to the bandwidth.

（1）声源脉冲信息			
语　　法		说　　明	
PULSE	PULSE(1:1)	SSP 插值类型	
		P	伪高斯
		R	Ricker 小波
		A	近似 Ricker 小波
		S	单正弦
		H	Hanning 加权正弦
		N	N 波
		G	高斯
		F	来自'.STS'(声源时间序列)文件
		B	来自'.STS'文件（后向）
	PULSE(2:2)	Hilbert 变换。	
		H	对声源执行 Hilbert 变换。
		N	不执行。
		希尔伯特变换用于消除左行波。	
	PULSE(3:3)	声源符号翻转。	
		+	不翻转(推荐)
		-	翻转
	PULSE(4:4)	声源滤波。	
		L	下端截止滤波
		H	上端截止滤波
		B	下端、下端都截止的滤波
		N	不截止
FMIN　FMAX	FMIN	下端截止频率	

	FMAX	上端截止频率
	由于运行时与带宽成正比，所以不宜高于所需的值。	

(2) - RECEIVER RANGES

Syntax: NRR
RR(1:NRR)

Description:
NRR: Number of receiver ranges
RR(): Receiver ranges (km)

This line is ignored unless option 'R' has been selected for a range-stack.

（2） *接收器距离*		
语法	NRR RR(1:NRR)	
说明	NRR	接收器距离的数目
	RR()	接收器距离（km）
		除非为计算距离堆栈选择了'R'选项，否则将忽略此行。

(3) - OUTPUT TIMES

Syntax: NTOUT
TOUT(1:NTOUT)

Description:
NTOUT: Number of output times
TOUT(): Output times (s)

（3） *输出时间*		
语 法	NTOUT TOUT(1:NTOUT)	
说 明	NTOUT	输出时间数值
	TOUT()	输出时间

(4) - TIME INTEGRATION PARAMETERS

Syntax: TSTART TMULT ALPHA BETA V

Description:
TSTART: Starting time for the march.
This should always be earlier than the time at which the source begins to rise.
TMULT: Time step multiplier.
Specifying TMULT = 1.0 means that the maximum stable time step is used.
ALPHA: Lumping parameter

BETA: Explicitness parameter

V: Convection velocity

<table>
<tr><td>语法</td><td colspan="2">TSTART TMULT ALPHA BETA V</td></tr>
<tr><td rowspan="5">说明</td><td>TSTART</td><td>演进开始时刻。这应该总是早于声源开始激发的时间。</td></tr>
<tr><td>TMULT</td><td>时间步距乘法器。设定 TMULT=1.0 意味着使用最大稳定时间步距。</td></tr>
<tr><td>ALPHA</td><td>集总参数</td></tr>
<tr><td>BETA</td><td>显性参数</td></tr>
<tr><td>V</td><td>对流速度</td></tr>
</table>

A good check of convergence can be done by running an isovelocity problem with a gaussian pulse. The pulse should, of course, be undistorted at the receivers. Remember that Hilbert transforming the source causes it to rise early so TSTART has to be adjusted accordingly.

通过用高斯脉冲运行等声速问题，可以很好地检验收敛性。当然，接收器处的脉冲应该不失真。由于对声源进行 Hilbert 变换造成声源激发较早，所以 TSTART 必须做出相应的调整。

It's a good habit to plot the source function using PLOTTS before running SPARC. This is done by providing the same source information to PLOTTS that is used to drive SPARC. Thus, if you are using a pseudo-gaussian pulse in SPARC you specify a pseudo-gaussian in PLOTTS and look at the time series.

在运行 SPARC 之前，应用 PLOTTS 绘制声源函数是一个很好的习惯。这将驱动 SPARC 的同一声源信息提供给 PLOTTS 即可完成。因此，如果您在 SPARC 中使用伪高斯脉冲，就用 PLOTTS 也绘制这个伪高斯脉冲，并查验其时间序列。

9 SCOOTER

SCOOTER is a finite element code for computing acoustic fields in range-independent environments. The method is based on direct computation of the spectral integral (reflectivity or FFP method). Pressure is approximated by piecewise-linear elements as are the material properties. (One exception is the density which is approximated by piecewise constant elements).

SCOOTER 是一套有限元程序，用来计算与距离无关的环境中的声场。其方法以直接计算谱积分（反射率法或 FFP 法）为基础。声压通过分段线性微元来近似计算，材料属性也是如此。（密度例外，它近似为分段常数微元）。

The SCOOTER package includes two modules:

SCOOTER 程序包包括两个模块：

SCOOTER the main program

SCOOTER 主程序

FIELDS Produces shade files

FIELDS 生成渲染文件

The input (.ENV) file is identical to that used by KRAKEN or KRAKENC. The output is a Green's function file (in place of the mode file produced by KRAKEN).

输入(.ENV)文件与 KRAKEN 或 KRAKENC 的输入文件相同。输出 Green 函数文件(代替 KRAKEN 生成的模式文件)。

Note that SCOOTER includes the effect of density gradients within media (KRAKEN and KRAKENC do not). Also, interfacial scatter is not treated in SCOOTER.

注意，SCOOTER 包含介质内部密度梯度的影响（KRAKEN 和 KRAKENC 不包含）。此外，在 SCOOTER 中不处理界面散射。

Files:

	Name	Unit	Description
Input			
	*.ENV	1	ENVironmental data
	*.BRC	10	Bottom Refl. Coef. (optl)
	*.TRC	11	Top Refl. Coef. (optl)
	*.IRC	12	Internal Refl. Coef. (optl)

Output

*.PRT 6 PRinT file

*.GRN 20 GReen's function

文 件	名 称	单位	说 明
输 入	*.ENV	1	环境数据（ENVironmental data）
	*.BRC	10	底端反射系数（可选）（Bottom Refl. Coef. (optl)）
	*.TRC	11	顶端反射系数（可选）（Top Refl. Coef. (optl)）
	*.IRC	12	内部反射系数（可选）（Internal Refl. Coef. (optl)）
输 出	*.PRT	6	打印（回显）文件（PRinT file）
	*.GRN	20	Green 函数（GReen's function）

EXAMPLE AND DESCRIPTION OF ENV FILE

ENV 文件的示例和说明

```
'Pekeris problem'
10.0
1
'NVF'
500   0.0   5000.0
      0.0   1500.0 /
  5000.0   1500.0 /
'A'   0.0
5000.0   2000.0   0.0   2.0 /
1400.0   2000.0
500.0              ! RMAX (km)
1                  ! NSD
500.0 /            ! SD(1:NSD) (m)
1                  ! NRD
2500.0 /           ! RD(1:NRD) (m)
```

RMAX is the maximum range for a receiver. Its real purpose is to set the number of k-space points that will be used in the spectral integral (deltak = pi / Rmax). You can get increased accuracy by making Rmax larger than the largest receiver range; however, run time will increase in direct proportion.

RMAX 是接收器的最大距离。它的真正目的是设置 k 空间的点的数目，以便于在谱积分中使用($\delta k = \pi / R_{max}$)。通过让 Rmax 大于最远的接收器距离，可以获得更高的精度；当然，运行时间也按比例递增。

Note that both source and receiver must lie within the finite element domain. That is, the capability for placing source or receiver in the homogeneous half-space has not been implemented.

请注意，声源和接收器都必须位于有限元区域中。也就是说，在均匀半空间中放置声源或接收器的能力尚未实现。

CPU time is roughly independent of the number of receivers but increases linearly with the number of sources. (However, the first source requires about 3 times as much CPU time as subsequent sources, since an LU decomposition is required only for the first source.)

CPU 时间与接收器数目基本无关，但会随声源数目增加而线性增加。(而且，第一个声源所需 CPU 时间大约是后续声源的 3 倍，因为只需要对第一个声源进行 LU 分解。)

Shade files or plots of transmission loss versus range are obtained by running FIELDS which uses the '.GRN' file as input.

运行 FIELDS，用'.GRN'文件作为输入，就可得到渲染文件或者随距离变化的传播损失图。

10 FIELDS

The FIELDS program uses the Green's functions calculated by SCOOTER or SPARC and produces a shade file that contains a sequence of snapshots of the acoustic field as a function of range and depth.

FIELDS 程序应用 SCOOTER 或 SPARC 算出的 Green 函数，生成一个渲染文件，文件中包含一系列快照，将声场表达为距离和深度的函数。

Files:

	Name	Unit	Description
Input			
	*.FLP	1	FieLd Parameters
	*.GRN	20	GReen's function
Output			
	*.PRT	6	PRinT file
	*.SHD	25	SHaDe file

相关文件	名　称	单　位	说　　明
输　入	*.FLP	5	声场参数（FieLd Parameters）
	*.GRN	20	Green 函数（GReen's function）
输　出	*.PRT	6	打印文件（PRinT file）
	*.SHD	25	阴影文件（SHaDe file）

EXAMPLE AND DESCRIPTION OF FLP FILE

FLP 文件示例与说明

```
'RDB'                 ! 'R/X (coord), Lin/DB, Pos/Neg/Both'
200.0  220.0  501     ! RMIN, RMAX, NR
```

(1) - OPTIONS

Syntax:
OPT
Description:
OPT(1:1): Coordinates
'R' Cylindrical (R-Z) coordinates.
'X' Cartesian (X-Z) coordinates.
OPT(2:2): Spectrum
'P' Positive (recommended)

'N' Negative

'B' Both positive and negative

The spectral integral should formally be done from all along the real k-axis, however the negative portion contributes significantly only in the near-field. Run-time is less if it is neglected.

谱积分应该沿着实数 k 轴进行。不过，负数谱仅对近场贡献显著。如果忽略负数谱，运行时间会更少。

OPT(3:3): Interpolation type

'O' POlynomial (for broadband runs) (default)

'A' PAde (can produce better results for CW runs but is less reliable)

The Pade option (OPT(3:3)) is less robust. Use polynomial interpolation if an underflow/overflow occurs ...

Pade 选项（OPT(3:3)）不太稳健。如果发生下溢/上溢，则采用多项式插值。

OPT(4:4): Selects a source beam pattern

'*' Read in a source beam pattern file.

'O' Omnidirectional (default).

“选项”条目	设置	说　　明
OPT(1:1)	坐标系	
	R	圆柱(R-Z)坐标系
	X	笛卡尔(X-Z)坐标系
OPT(2:2)	频　谱	
	P	正（推荐）
	N	负
	B	正和负
OPT(3:3)	插值类型	
	O	多项式插值(用于宽带运行)(默认)（POlynomial）
	A	PAde 插值(能为 CW 运行带来更好结果,但不太可靠)
OPT(4:4)	声源波束模式	
	*	从声源波束模式文件中读取
	O	全向(默认)。（Omnidirectional）

(2) - RECEIVER RANGES

Syntax:

RMIN RMAX NR

Description:

RMIN: First receiver range (km)
RD: Last receiver range (km)
NR: Minimum number of receiver ranges

The actual number of ranges used is increased slightly to satisfy FFT sampling requirements.

语法	RMIN RMAX NR	
说明	RMIN	第一个接收器的距离（km）
	RMAX	最后一个接收器的距离（km）
	NR	接收器距离点的最小数目
		为满足 FFT 的采样要求，实际使用的距离点数目略有增加。

11 BOUNCE

11 反弹

BOUNCE computes the reflection coefficient for a stack of acoustic media optionally overlying elastic media. The reflection coefficient is written to both a '.IRC' file (internal reflection coefficient) and to a '.BRC' file (bottom reflection coefficient). These files can be used by KRAKEN, SCOOTER, and BELLHOP to provide a boundary condition, or plotted using PLOTRTH.

BOUNCE 用于计算声学介质覆盖在弹性介质之上时的反射系数。反射系数写入'.IRC'文件（内反射系数）和'.BRC'文件（底端反射系数）。这些文件可给 KRAKEN、SCOOTER 和 BELLHOP 使用，以提供边界条件，也可用 PLOTRTH 绘成图案。

The input structure is identical to that used by KRAKENC although the input lines for source and receiver depth are not read and can be omitted. Furthermore, the surface boundary condition is ignored and, in effect, replaced by a homogeneous halfspace where the incident wave propagates.

其输入结构与 KRAKENC 使用的文件结构相同。因为不会读取声源和接收器的深度输入行，可以将其省略。此外，忽略入射波传播的表面边界条件，从实效上采用均匀半空间来代替。

If you are interested in getting a reflection coefficient for a bottom which is being used in a KRAKENC, SCOOTER, or BELLHOP run, you will need to delete the layers corresponding to the water column. Otherwise you will get a reflection coefficient corresponding to a wave incident from above the ocean surface.

在 KRAKENC、SCOOTER 或 BELLHOP 的运行中，如果您对获得底端反射系数感兴趣，则需要删除与水体对应的层。否则，你会得到对应于声波从海面上方入射的反射系数。

The angles used for calculating the reflection coefficient are calculated based on the phase-velocity interval [CMIN, CMAX]. For a full 90 degree calculation set CMIN to the lowest speed in the problem (say 1400.0) CMAX to 1.0E9. The actual number of tabulated points is then determined by RMAX.

用于计算反射系数的角度是基于相速度区间[CMIN，CMAX]算得的。对于完整的 90 度计算，需将 CMIN 设置为问题中的最低速度（比如说 1400.0），CMAX 设置为 1.0E9。列表点的实际数目随后由 RMAX 确定。

If you are using the reflection coefficient for a coherent TL calculation then RMAX should be the maximum range to which you are propagating. The further you go, the finer the sampling that is needed in the reflection coefficient. Run time is usually not an issue; however, if you pick an RMax that is insanely large then it could be.

如果您采用反射系数计算相干 TL，RMAX 就该是传播的最远距离。传播越远，反射系数需要的采样就越精细。运行时间通常不是问题；当然，如果您把 RMAX 设定得非常大，那它就可能是问题了。

Note that a reflection coefficient depends on the impedance contrast between the halfspace from which the field is incident and the reflecting medium. Therefore BOUNCE must know the sound speed and other properties of the upper halfspace. If you're using the reflection coefficient to replace the sub-bottom in the ocean then you must set the speed of that upper halfspace to match the sound speed at the bottom of the ocean.

请注意，反射系数取决于声场入射半空间与反射介质之间的阻抗对比。因此，BOUNCE 必须知道上半空间的声速和其他属性。如果您使用反射系数来代替海洋中的次层海底，则必须设置上半空间的速度来匹配海底的声速。

If you set the number of finite-difference grid points (NPTS) to zero, then BOUNCE automatically calculates a value to have 20 points per wavelength. If there is shear in a certain layer, then the shear wave will have a shorter wavelength than the P-wave speed. Then the smaller shear wavelength will be used to calculate the default. In some cases, 20 points per wavelength does not provide sufficient accuracy and you may need to increase that to as much as 100 points per wavelength.

如果将有限差分网格点的数目（NPTS）设置为零，BOUNCE 则会自动算出一个值，使每个波长有 20 个点。如果某层存在剪切效应，剪切波的波长会短于 P 波。就用较短的剪切波长来计算缺省值。在某些情形下，每波长 20 个点还无法提供足够的精度，您可能需要增加点数，多到每个波长 100 个点。

Files:

	Name	Unit	Description
Input			
	*.ENV	1	ENVironmental data
	*.BRC	10	Bottom Refl. Coef. (optl)
Output			
	*.PRT	6	PRinT file
	*.BRC	10	Bottom Refl. Coef.
	*.IRC	12	Internal Refl. Coef.

文 件	名 称	单位	说 明
输 入	*.ENV	1	环境数据（ENVironmental data）
	*.BRC	10	底端反射系数（可选）（Bottom Refl. Coef. (optl)）

输 出	*.PRT	6	打印（反馈）文件（PRinT file）
	*.BRC	10	底端反射系数（Bottom Refl. Coef.）
	*.IRC	12	内部反射系数（Internal Refl. Coef.）

EXAMPLE OF ENV FILE

ENV 文件示例

```
'Refl. coef. test problem'
50.0
1
'NAW'
0.0   1500.0   0.0   1.0 0.0 0.0/         ! Z(m) CP CS (m/s) RHO (g/cm3) AP AS
100 0.0 20.0
    0.0 1600.0 400.0 1.8 0.2 0.5
   20.0 /
'A' 0.0
   20.0 1800.0 600.0 2.0 0.1 0.2
1400.0 19000.0
10.0                    ! RMAX (km)
1                       ! NSD
50.0 /                  ! SD(1:NSD)
501                     ! NRD
0.0 150.0 /             ! RD(1:NRD)
```

The above example (taken from the SAFARI reference manual) involves two elastic layers.

上面的例子(取自 Safari 参考手册)涉及两层弹性层。

12 Range-Dependent SSP File

12 距离相关的 SSP 文件

If you select option 'Q' (quadrilateral elements) for the SSP interpolation, BELLHOP will read a range-dependent SSP from an SSPFIL. The format of the SSPFIL is as follows:

如果您将 SSP 插值选项设置为'Q'（四边形微元），BELLHOP 会从 SSPFIL 中读取与距离相关的 SSP。SSPFIL 的格式如下：

Syntax:

NPROFILES
RPROF(1)   RPROF(2) ...   RPROF(NPROFILES)
C(1, 1)   C(1, 2)   ...   C(1, NPROFILES)
C(2, 1)   C(2, 2)   ...   C(2, NPROFILES)
.
.
.
C(NZ, 1)   C(NZ, 2)   ...   C(NZ, NPROFILES)

Description:

NPROFILES: Number of profiles.
NZ: Number of depth points where SSP is sampled
RPROF(): Range of each profile in km.
C(): Sound speed. c(iz, iprof) is the sound speed at the depth point, iz, in profile, iprof.

<table>
<tr><th colspan="3">距离相关的 SSP</th></tr>
<tr><td>语 法</td><td colspan="2">NPROFILES
RPROF(1)   RPROF(2) ...   RPROF(NPROFILES)
C(1, 1)   C(1, 2)   ...   C(1, NPROFILES)
C(2, 1)   C(2, 2)   ...   C(2, NPROFILES)
.
.
.
C(NZ, 1)   C(NZ, 2)   ...   C(NZ, NPROFILES)</td></tr>
<tr><td rowspan="4">说 明</td><td>NPROFILES</td><td>剖面数目</td></tr>
<tr><td>NZ</td><td>SSP 采样处的深度点数目</td></tr>
<tr><td>RPROF()</td><td>各个剖面采样所在的距离（km）</td></tr>
<tr><td>C()</td><td>第 iprof 剖面中第 iz 深度点处的声速 c(iz，iprof)</td></tr>
</table>

Example:

范例：

8

0.0	12.5	25.0	37.5	50.0	75.0	100.0	125.0
1536	1536	1536	1536	1536	1536	1536	1536
1506	1508.75	1511.5	1514.25	1517	1520	1524	1528
1503	1503	1503	1502.75	1502.5	1502	1502	1502
1508	1507	1506	1505	1504	1503	1501.5	1500
1508	1506.6	1505	1503.75	1502.5	1500.5	1499	1497
1497	1497	1497	1497	1497	1497	1497	1497
1500	1500	1500	1500	1500	1500	1500	1500
1512	1512	1512	1512	1512	1512	1512	1512
1528	1528	1528	1528	1528	1528	1528	1528
1545	1545	1545	1545	1545	1545	1545	1545

Note: The main BELLHOP envfil must contain a dummy SSP with NZ depth points. Those depths points are used to interpret the depths in the above SSP matrix.

注意：BELLHOP 的主环境文件（envfil）中必须包含 NZ 个深度点和对应的虚设的 SSP。这些深度点用来描述以上 SSP 矩阵中的深度。

The vector of profile ranges must increase strictly monotonically.

剖面距离向量必须严格单调地递增。

See the example in at/tests/Gulf.

参看 at/tests/Gulf.中的范例。

13 Altimetry or Bathymetry File

13 测高和测深文件

The format is the same for top altimetry or bottom bathymetry. Only BELLHOP uses these files.

顶端测高和底端测深的文件格式相同。这些文件只用于 BELLHOP。

Syntax:

TYPE
NPOINTS
R(1) Z(1)
R(2) Z(2)
.
.
.
R(NPOINTS) Z(NPOINTS)

Description:

TYPE(1:1)
'L' for piecewise linear
'C' for curvilinear
TYPE(2:2)
'S' Short format (bathymetry only) (default)
'L' Long format (bathymetry and geoacoustic parameters)
NPOINTS: Number of r-z points to follow.
R(): Range (km)
Z(): Depth (m).

Example (bathymetry only):

示例（仅为测深）：

```
'L'
5
  0   3000
 10   3000
 20    500
 30    3000
100    3000
```

Example (bathymetry and geoacoustics):

示例（测深和地声学）：

```
'LL'
3
  0 100 1700 0.5 1.2 0 0
2.5 100 1550 0.5 1.2 0 0
5.0 100 1550 0.5 1.2 0 0
```

<table>
<tr><td>语法</td><td colspan="3">TYPE
NPOINTS
R(1) Z(1)
R(2) Z(2)
.
.
.
R(NPOINTS) Z(NPOINTS)</td></tr>
<tr><td rowspan="9">说明</td><td rowspan="6">TYPE</td><td colspan="2">TYPE(1:1)</td></tr>
<tr><td>L</td><td>分段线性插值。</td></tr>
<tr><td>C</td><td>曲线拟合。</td></tr>
<tr><td colspan="2">TYPE(2:2)</td></tr>
<tr><td>S</td><td>短格式（仅限测深）（默认）。</td></tr>
<tr><td>L</td><td>长格式（测深和地声参数）。</td></tr>
<tr><td>NPOINTS</td><td colspan="2">以下的（r,z）点数目。</td></tr>
<tr><td>R()</td><td colspan="2">距离（km）。</td></tr>
<tr><td>Z()</td><td colspan="2">深度（m）。</td></tr>
</table>

Generally the piecewise linear option should be selected. However, if the boundaries are sampled on a very fine scale (a few wavelengths) then the curvilinear option produces a smoother fit. That in turn improves the results obtained with geometric ray tracing. The curvilinear option was implemented to treat fine scale scattering effects.

一般情况下，应该选择分段线性插值选项。但是，如果边界采样尺度非常精细（为几个波长），那么“曲线拟合”选项就拟合得更加平滑。相应地就可以改进几何声线追踪的结果。“曲线拟合”选项用于处理精细尺度散射效应。

Note that depths, z, are positive downward, following a convention used throughout the models. This is a bit counter-intuitive for altimetry; however, a different convention for that would also have been counter-intuitive for others.

请注意，遵循全体模型使用的约定，深度 z 正值朝下。对于测高，这有点违背直觉；但是若对深度 z 作相反的约定，对于其他参量来说，也会违背直觉。

The vector of range values must increase strictly monotonically.

距离向量必须严格单调增加。

The second letter of the TYPE string is used to select a range-dependent bottom type. If you set it 'L' additional entries will be read with that geoacoustic information given in the same format as used for halfspaces in the environmental file (compressional wave speed, compressional wave attenuation, density, shear wave speed, shear wave attenuation).

TYPE 字符串的第二个字母用于选择距离相关的海底类型。如果设置为'L'，将从附加条目中读取地声信息，其格式与环境文件中半空间的格式相同（纵波速度、纵波衰减、密度、横波速度、横波衰减）。

14 Reflection Coefficient File

14 反射系数文件

The format is the same for top or bottom reflection coefficients.

顶端和底端反射系数的格式相同。

Syntax:

NTHETA
THETA(1)   RMAG(1)   RPHASE(1)
THETA(2)   RMAG(2)   RPHASE(2)
.
.
.
THETA(NTHETA) RMAG(NTHETA) RPHASE(NTHETA)

Description:

NTHETA: Number of angles.
THETA(): Angle.
RMAG():   Magnitude of reflection coefficient.
RPHASE(): Phase of reflection coefficient (degrees).

<table>
<tr><td>语　法</td><td>NTHETA
THETA(1)   RMAG(1)   RPHASE(1)
THETA(2)   RMAG(2)   RPHASE(2)
.
.
.
THETA(NTHETA)   RMAG(NTHETA)
RPHASE(NTHETA)</td></tr>
<tr><td>说　明</td><td><table><tr><td>NTHETA</td><td>角度数</td></tr><tr><td>THETA( )</td><td>角度</td></tr><tr><td>RMAG( )</td><td>反射系数幅度</td></tr><tr><td>RPHASE( )</td><td>反射系数相位（度(°)）</td></tr></table></td></tr>
</table>

Example:

范例：

3
0.0   1.00 180.0

45.0	0.95	175.0
90.0	0.90	170.0

15 BARTLETT ESTIMATOR

15 BARTLETT 估计器

BART uses the Bartlett estimator to produce an ambiguity surface. Required input is a covariance matrix and a set of replica vectors. The replica vectors are provided in the form of a 'SHD' file and the ambiguity surface is written in that same format.

BART 利用 Bartlett 估计器生成模糊度面。所需的输入是一个协方差矩阵和一组拷贝向量。拷贝向量以'SHD'文件的形式提供，模糊度面也以相同的格式记录。

\begin{verbatim}

Files:

```
      Name        Unit       Description
Input
      *.SHD        20      SHaDe      file
      *.COV        21      COVariance file

Output
      *B.SHD       25      SHaDe file for ambiguity surface
```

\end{verbatim}

文件	名 称	单位	说　　明
输入	*.SHD	20	渲染文件（SHaDe file）
	*.COV	21	协方差文件（COVariance file）
输出	*B.SHD	25	模糊度面的渲染文件（SHaDe file for ambiguity surface）

16 Acoustics Toolbox

16 声学工具箱

GUI Wrapper:

GUI 程序包

ACT: Matlab front-end for the Acoustic Toolbox written by Alec Duncan from the Centre for Marine Science and Technology at Curtin University.

ACT: 由 Curtin 大学海洋科学与技术中心的 Alec Duncan 编写的声学工具箱的 MATLAB 前端。.

Which version should I download?

我应该下载哪个版本？

There is only one version of the source code; however, you may see options for different pre-compiled binaries. If you're using another machine or operating systems you'll need to recompile it which requires a Fortran95 compiler. The free GFortran compiler works well. We have also used the free g95 compiler in the past; however, the current version of AT uses get_command_parameter, which is a feature of Fortran 2003 not in g95 as of this writing.

只有一个版本的源代码；但是，您可能会看到预编译成不同二进制文件的选项。如果您使用另一台计算机或操作系统，则需要用 Fortran95 编译器来重新编译它。免费的 GFortran 编译器运行较好。我们过去也使用过免费的 g95 编译器；但是，AT 的当前版本使用 get_command_parameter，这种写法是 Fortran 2003 的一个特点，而不是 g95 的特点。

atWinPII_f95. Version for a Windows, Pentium II machine. The Makefiles are in a sort of Unix style. If you download cygwin (publicly available on the web) you get a sort of pseudo-Unix window in which you can just type 'make all' and 'make install' to recompile and install.

atWinPII_f95. 奔腾 II 机器 Windows 的版本。Makefile 是 Unix 风格。如果您下载 cygwin(在 web 上可公开获取)，您会得到一种伪 Unix 窗口，在该窗口中，您可以键入'make all'和'make install'以重新编译和安装。

atLinuxPII_f95. Same as above but with binaries compiled under Linux.

atLinuxPII_f95. 与上述相同，但在 Linux 平台编译成二进制文件。

atOSXintel. For the Mac. Compiled with gfortran.

atOSXintel. 用于 Mac 平台，用 gfortran 编译。

To use the binaries, you will like need gfortran installed (which is very easy) since the binaries use dynamic libraries that need to be pre-installed.

要使用二进制文件，您需要安装 gfortran(这非常容易)，因为二进制文件要使用需预先安装的动态库。

Overview

概述

The Acoustic ToolBox includes four acoustic models:

声学工具箱包括四个声学模型：

BELLHOP: A beam/ray trace code

BELLHOP: 波束/射线追踪代码

KRAKEN: A normal mode code

KRAKEN: 简正波代码

SCOOTER: A finite element FFP code

SCOOTER: 有限元 FFP 代码

SPARC: A time domain FFP code

SPARC: 时域 FFP 代码

In addition, AT contains BOUNCE, which computes the reflection coefficient for a layered medium and may be used to provide input to BELLHOP. A common input structure has been used throughout so that only minor modifications are needed to switch from one program to another.

此外，AT 包含反射，它计算分层介质的反射系数，并为 BELLHOP 提供输入。整个 AT 都使用通用的输入结构，因此，只需进行一些小修改，就可从一个程序切换到另一个程序。

All the models produce `shade' files that can be processed using a common set of plotting routines to plot transmission loss vs. range or vs. range and depth.

所有模型都生成“阴影”文件，该文件可以使用一组共同的绘图程序来绘制随距离变化的传播损失，或者随距离和深度变化的传播损失。

Porting the code

移植代码

Depending on your platform, you may be able to execute the pre-compiled binaries. Currently we use GFORTRAN to compile those. However, our version requires access to gcc dynamic libraries. Therefore, you will need to have a compatible version of gcc and gfortran installed on your system to run the pre-compiled binaries.

根据您的平台，您可能能够执行预编译的二进制文件。当前，我们使用 GFORTRAN 来编译。但是，我们的版本需要访问 GCC 动态库。因此，您需要在系统上安装兼容的 gcc 和 gfortran 版本，才能运行预编译的二进制文件。

The package adheres strictly to the Fortran 2003 standard. A few of the Fortran 2003 extensions from Fortran 90 are used.

该软件包严格遵守 Fortran 2003 标准。使用了一些 Fortran 90 的 Fortran 2003 扩展。

Record length

记录长度

Fortran compilers differ in whether record lengths should be declared as bytes or words. To ensure the programs run, I declare lengths in bytes. If your compiler uses words as the default, look for a compiler switch to override that so that your files are not unnecessarily large.

Fortran 编译器在记录长度应声明为字节还是单词方面存在差异。为了确保程序运行，我声明长度单位为字节。如果您的编译器使用单词作为默认值，请查找编译器切换到覆盖，以便您的文件不是不必要的大。

Some of the programs in this package use direct access I/O and need to know a record length. Many systems do not maintain this information as part of the file info so the code writes that information directly into the file. Then the file is opened twice. First it is opened with a dummy record length to read the actual record length from the file. Then it is re-opened with the correct record length. On machines that *do* know the correct record length, that first open may generate an error message and will have to be removed. The RECL specifier should then also be removed from the second open.

该程序包中的一些程序使用直接访问 I/O，需要知道记录长度。许多系统并不将此信息作为文件信息的一部分来维护，因此编写代码时会将该信息直接写入文件。然后两次打开文件。首先使用虚拟记录长度打开它，从文件中读取实际的记录长度。然后再用正确的记录长度重新打开它。在知道正确的记录长度的机器上，第一次打开可能会产生错误消息，必须移除。然后，RECL 说明符也应该在第二次打开时移除。

Ice Scatter module

海冰散射模块

The Twersky-scatter option is problematic because it calls mathieu.f and slbessel.f which don't adhere to a rigorous Fortran standard. To avoid this problem, the current distribution has this option disabled.

Twersky 散射选项有问题，因为它调用的 mathieu.f 和 slbessel.f 没遵守严格的 Fortran 标准。为避免此问题，当前的发行版本废弃了这个选项。

If you want to put it back in, you will need to link to twersk.f instead of twerskfuse.f. These routines call mathieu.f which needs to be compiled with a switch to initialize all variables to zero. Most compilers have some such switch.

如果你想把它放回去，你需要链接到 twersk.f，而不是 twerskfuse.f。这些程序调用 mathieu.f，需要用开关来进行编译，以便将所有变量初始化为零。大多数编译器都有这样的开关。

Plotting

绘图

Plot packages come and go. However, the output formats of the various models are all fairly simple to work with. The distribution includes Matlab scripts which I currently use for plotting. If you don’t have Matlab, then these will at least provide an example of how to read the file formats.

绘图包版本变化多次。不过，各种模型的输出格式都非常简单。该发行版包括我目前用来绘图的 Matlab 脚本。如果你没有 Matlab，那么将至少提供一个如何读取这种文件格式的例子。

Installation Notes

安装提醒

To run the Acoustics Toolbox, the executables need to be in your path. The process for setting your path depends on your operating system. I can't stay current with the options but here are some things that have worked in the past:

要运行 AcousticsToolbox，可执行文件必须在您的路径中。路径设置过程取决于您的操作系统。我不能一直坚持这些选择，但以下是在过去行之有效的一些事情：

DOS: add the following to your autoexec.bat to make the scripts executables in your default path:

DOS: 将以下内容添加到 autoexec.bat，以便让可执行脚本在默认路径中：

SET PATH=%PATH%;C:\AT\SCRIPTS;C:\AT\BIN

Windows 2000 (and perhaps NT): right click on the “My Computer” icon and select “Properties”, “advanced”.

Windows 2000 (或 NT): 右键单击“我的计算机”图标并选择“属性”、“高级”。

Windows XP: go to control panel/Performance and Maintenance/System/Advanced and look for the pushbutton labled “Environment Variables”. There you can edit the system variable “Path”.

Windows XP: 转到控制面板/性能和维护/系统/高级，并查找标有“环境变量”的按钮。在那里，您可以编辑系统变量“路径”。

Obviously these lines should be updated to reflect whichever directory you installed things in. You may need to reboot to make sure this takes effect. Note that the DOS and Unix scripts are not maintained. We currently execute the binaries via Matlab.

显然，这些行应该更新以反映您安装的目录。您可能需要重新启动，以确保此操作生效。请注意，DOS 和 Unix 脚本并不持续保持。我们目前通过 Matlab 执行二进制文件。

If you're having problems, verify your path includes these by typing "path" from a DOS window. Typically you run KRAKEN by typing something like "kraken pekeris". at the DOS command line, or kraken('pekeris') at the Matlab command line.

如果您碰到问题，可从 DOS 窗口键入"path"并包括这些路径，来验证您的路径。通常，通过在 DOS 命令行键入类似于"kraken pekeris"，或在 Matlab 命令行键入 kraken('pekeris')等内容，就可已运行 KRAKEN。

On Unix/Linux/MacOSX systems you can ensure that path info is set in Matlab at start up by editing .../bin/matlab to add something like: source ~/.profile

在 Unix/Linux/MacOSX 系统上，您可以通过编辑.../bin/matlab 来添加类似于：source~/.profile 之类的内容，以确保在 Matlab 启动时设置路径信息。

where .profile is the shell start up script that initializes your path.

其中.profile 是初始化路径的 shell 启动脚本。

Finally, if you use Matlab then you just need to use the "Set Path" option under the "File" menu. If you include all of the Acoustics Toolbox in your Matlab path, then the Matlab scripts find the location of the binaries using the Matlab "which" command.

最后，如果您使用 Matlab，那么您只需要使用"文件"菜单下的"设置路径"选项。如果在 Matlab 路径中包含了所有的声学工具箱，那么使用 Matlab 命令"which"，Matlab 脚本就会二进制文件的位置。

Once you have the basic code working, you might want to run some of the test batteries in at/tests to completely verify your installation. The m-file, runtests.m runs the complete suite of tests using the Fortran binaries. The m-file runtestsM.m does the same thing, using the Matlab versions of BELLHOP, SCOOTER, BOUNCE, and SPARC.

一旦基本代码正常工作，您可能需要运行一些 at/test 中的测试算例，来完全验证您的安装。M-文件 runtests.m 应用 Fortran 二进制文件运行完整的测试算例集。

M-文件 runtestsM.m 使用 BELLHOP，SCOOTER，BOUNCE 和 SPARC 的 Matlab 版本，也完成相同的工作。

Updates

更新历程

(Check also the individual subdirectories for updates on individual components of the Acoustics Toolbox.)

(还请检查各个子目录，以获得有关 AcousticsToolbox 各个组件的更新。)

December（12 月） 1997

Minor changes have been made to the package for improved f77 to f90 portability. Fortran 90 seems to treat parameters differently in terms of precision so some of those changes are important for the most accurate results.

为了改善从 f77 到 f90 的可移植性，对软件包做了一些小的修改。Fortran 90 在精度方面似乎对参数有不同的处理方式，因此其中一些变化对于获得最准确的结果非常重要。

July（7 月） 1999

The whole package has been converted to f90/95 standard with free-format lines and taking advantage of dynamic allocation. The code is more concise and portable. Dynamic allocation means that you will not have to worry about dimensional limits--- the size of the problem you can solve is limited only by RAM on your system.

整个软件包已转换为 F90/95 标准，有自由格式的行，并利用动态分配。代码更加简洁并便于移植。动态分配意味着您不需担心维度限制-能解决的问题的大小只受你系统上 RAM 限制。

The change to dynamic allocation has forced a small change in the input structure. Previously an input format was often used with a number of items in a vector followed by the actual vector. For instance, the vector of receiver depths is read this way.

动态分配变化迫使输入结构发生些小小的变化。以前，输入格式通常与向量中的若干项一起使用，后面跟着实际的向量。例如，接收深度向量就是这样读取的。

In the new version the number of items in the vector must appear on a separate line so that the code can read it, allocate the space, and then read the vector contents.

在新版本中，向量内部的项目数必须出现在单独一行之中，以便代码能够读取它，分配空间，然后再读取向量内容。

May（5 月） 2009

The Matlab version of BELLHOP has been replaced by a new version that traces one beam at a time. The ealier version traced all the beams in parallel for efficiency; however, the logic is too complicated to maintain.

BELLHOP 的 Matlab 版本已经换为一个新版本，新版本一次追踪一束波束。较早的版本以并行方式追踪所有波束，以提高效率；但是，其逻辑太复杂了，不易于维护。

December（12 月） 2009

Converted most "char foo*5' references, which are deprecated in the new Fortran, in favor of "char (len=5) :: foo".

转换了大多数"char foo*5"引用，这些引用在新的 Fortran 中已废弃，取而代之的是"char (len=5) :: foo"。

January（1 月） 2010

Updated the volume attenuation from the 1967 Thorp formula to the more recent one in JKPS. Converted all the Fortran models so that they would determine the file names from the command line arguments. This eliminates the need for DOS, Unix, or Matlab scripts to move files around.

将体积衰减从 1967 年的 Thorp 公式更新到最近的 JKPS。转换了所有 Fortran 模型，以便从命令行参数就确定文件名。这样就不需要 DOS、Unix 或 Matlab 脚本来移动文件了。

July（7 月） 2010

Made all type conversions, e.g. complex to real or double to single, explicit. Expanded use of EXPLICIT NONE to ensure all variable types are called out. Further expansion of the lengths of variable names to take advantage of Fortran 2003. Expanded use of structure-variables. Additional changes as described in the read.me files for the various models. This is a fairly significant revision in terms of the evoloution from Fortran 77 to Fortran 2003. However, there are virtually no changes to the input and output files.

进行了所有类型转换，例如，从复数到实数或双精度到单精度。扩展'EXPLICIT NONE'的使用，以确保调用所有变量类型。进一步扩展变量名的长度以利用 Fortran 2003。扩展结构变量的使用。各种模型的 read.me 文件中描述了其他更改。从 Fortran 77 版本演变到 Fortran 2003 版本而言，这是一次相当重要的修订。但是，输入和输出文件实际上没有任何更改。

April（4 月） 2011

Greatly expanded use of INTENT(IN, OUT, etc.) to clarify the source code. Continued changes in variable and subroutine names to make them more readable as the Fortran 2003 standard permits. Use of explicit dimension sizes in variable declarations to make it easier for the compiler to detect incompatibilities. Change to SHDFile format for the pressure field to allow multiple x-y coordinates for the source.

极大地扩展了 INTENT(IN, OUT, 等)使用，以使声源代码更加清晰。以 Fortran 2003 允许的标准继续更改变量和子程序名称，使它们更易读。在变量声明中使用显式维度大小，使编译器更容易检测不兼容。更改声压场的 SHDFile 格式，对声源允许使用多组 x-y 坐标。

October（8 月） 2011

Added an option for a source beam pattern in KRAKEN and SCOOTER. The pattern is read from a file, following the same procedure as in

BELLHOP. The beam pattern is actually introduced after the KRAKEN or SCOOTER run by processing the mode file (FIELD and FIELD3D) or the Green's function file (FIELDS). Currently the beam pattern is implemented by shading the wavenumber spectrum. As a result the beam pattern must be symmetric with respect to the horizontal (only the part of the pattern with positive angles is used). This capability has also been implemented in the Matlab versions of FIELD and FIELDS; however, in FIELD it current only works for the range-independent case.

在 KRAKEN 和 SCOOTER 中增加了一个声源波束模式的选项。该模式从文件读取，遵循与 BELLHOP 相同的过程。波束模式实际上是在 KRAKEN 或 SCOOTER 运行后通过处理模式文件（FIELD 和 FIELD3D）或 Green 函数文件（FIELDS）引入的。目前，波束模式是通过对波数谱进行渲染来实现的。因此，波束模式必须相对于水平方向是对称的（只使用模式的正角度部分）。这一功能也已在 FIELD 和 FIELDS 的 Matlab 版本中实现；不过，在 FIELD 中，目前只适用于与距离无关的情况。

March（3 月） 2012

The new Matlab changed how it did shell escapes (to run things at the command line level) so that piping of stdin and stdout no longer worked. To get around this FIELD and FIELDS have been modified so that they read from a user specified file instead. The field parameter information is now read from 'root.flp' instead of field.flp, where 'root' is the root of a filename passed to the code. This change has been made in both the Fortran and Matlab versions. In addition, to make the Matlab more compatible with the Fortran version, the various output files (SHDFIL.mat, GRNFIL.mat, etc.) now use individually named files (root.shd.mat and root.grn.mat, etc.).

新的 Matlab 改变了 shell 转义的方式（在命令行级别运行），使 stdin 和 stdout 管道不再工作。为了绕过这事，FIELD 和 FIELDS 作出了修改，代以从用户指定的文件中读数。声场参数信息现在从'root.flp'而不是 field.flp 读取，其中'root'是传递给代码的文件名的根。这种改变在 Fortran 和 Matlab 版本中都有。此外，为了使 Matlab 与 Fortran 版本、各种输出文件（SHDFIL.mat、GRNFIL.mat 等）更加兼容，现在使用单独命名的文件（root.shd.mat 和 root.grn.mat 等）。

February（2 月） 2013

A bug was fixed in detecting the end of the SSP for a given layer. Instead of testing for exact equality of the SSP depth to the bottom-depth of the layer, I had previously checked for agreement to within a tolerance. The tolerance was scaled based on the bottom depth of the layer so for a bottom depth of zero (in an aeroacoustic problem) the tolerance was 0 and the bottom was not detected.

在检测某给定层的 SSP 末尾时，修复了一个 bug。为替代检测 SSP 深度与层底深度确切相等，我以前曾检查过在某容限内的一致性。容限是根据层的底部深度进行缩放的，因此对于深度为零的底部（在空气声学问题中），容限为 0，就不能检测到底部。

February（2 月） 2014

Checks have been added to ensure certain vectors are monotonically increasing where that assumption is critical to the codes.

增加了确保某些向量单调递增的检查，在此处，该检查对程序至关重要。

November（11 月） 2014

The Matlab routines that read altimetry and bathymetry files were not clearing old data on subsequent calls. This occured only when the flat boundary was selected and the routines were supposed to return dummy boundary information. Also, the ranges were not being converted to meters from kilometers. It effected SimplePE runs and probably the Matlab version of BELLHOP as well. These routines are not used by any of the Fortran implementations and the error often had no effect on the Matlab codes.

读取测高和测深文件的 Matlab 程序没有清除后续调用中的旧数据。只有当选择水平边界，并假定子程序返回虚拟边界信息时，才会发生这种情况。此外，距离单位也没有从公里转换成米。这影响 SimplePE 的运行，也可能影响 Matlab 版本的 BELLHOP 运行。任何 Fortran 实现都不使用这些子程序，此错误对 Matlab 代码没有影响。

June（6 月） 2014

Sometime around January of 2010 the Thorpe formula for volume attenuation was modified at the request of a user. The modified formula was slightly more accurate. The change was verified in BELLHOP; however, there an incorrect variable name was used in the crci routine used by KRAKEN and SCOOTER. That error mean the added Thorpe attenuation was never added. This is corrected in the new code. The volume attenuation was typically most important for higher frequency sources, which in turn were more often treated in BELLHOP. However, the error can be important for low frequency sources at very long range.

2010 年 1 月前后的某个时候，根据用户的要求，对 Thorpe 体积衰减公式进行了修正。修改后的公式略微更准确一些。在 BELLHOP 中验证了这项变化；但是，KRAKEN 和 SCOOTER 使用了在 crci 子程序中使用的一个不正确的变量名。这一错误意味着增加的 Thorpe 衰减从来没有增加过。这在新代码中得到了纠正。对于高频声源来说，体积衰减是最重要的，反过来，在 BELLHOP 中也常常得以处理。不过，对于低频声源而言，这种误差在很远的距离处也很重要。

July（7 月） 2017

The package has been modified to allow broadband runs for most of the models. Thus, for example, you can give a vector of frequencies to KRAKEN or SCOOTER and produce a single pressure file containing results for each of the frequencies. In addition, all the Matlab codes have been modified to allow the '/' convention used in the Fortran versions. This option allows a user to either specify a full vector or just specify the upper and lower limits terminated by '/'. It then uses those limits to create a vector of equally spaced points.

对软件包作出修改，以使大多数模型允许宽带运行。例如，您可以向 KRAKEN 或 SCOOTER 提供频率向量，并生成一个声压文件，其中包含每个频率的结果。此外，所有 Matlab 代码也都作了修改，以允许采纳在 Fortran 版本中使用的 '/' 约定。该选项允许用户指定一个完整的向量，或者只指定上限与下限并以 '/' 结尾。然后利用这两个界限来创建等间距的向量。

November（11 月） 2017

Updates and fixes to the noise routines in at/Matlab/noise. A routine has been added to construct the noise covariance matrix directly from the shdfil. The shdfil contains the complex pressure field vs. range and depth and the noise routine can use such files produced by KRAKEN, KRAKENC, SCOOTER, and BELLHOP.

更新和修复 at/matlab/noise 中的噪声程序。添加了一个直接从 shdfil 构造噪声协方差矩阵的程序。shdfil 包含与距离和深度对应的复声压场，噪声程序可以使用由 KRAKEN、KRAKENC、SCOOTER 和 BELLHOP 生成的这种文件。

March（3 月）*2018*

SimplePE was not updating the marching matrices in the case where there was a range-dependent SSP but a flat bottom. Fixed ...

在 SSP 与距离相关且海底平坦的场景下，SimplePE 没有更新步进矩阵，修复好了…

November （11 月）*2018*

A Piecewise-Cubic Hermite Interpolating Polynomial (PCHIP) option has been added for interpolating the SSP in the various models. This is really motivated by BELLHOP. The beam tracing algorithm can be sensitive to the profile interpolation. Ideally the interpolation should produce a smooth profile and the c-linear and n2-linear options are only piecewise linear so they have discontinuities in their first derivatives. The spline option is smooth (up to second derivatives) but in some cases produces contorted interpolants to achieve that smoothness. The PCHIP option sacrifices some smoothness for better behavior. This has been implemented in all the Fortran codes. The Matlab versions are not current. i.e. do not have this implemented; however, it is an easy modification.

在各种模型中，增加了分段-三次 Hermite 插值多项式（PCHIP）选项，用来对 SSP 进行插值。这其实是由 BELLHOP 激发的。波束追踪算法对剖面插值比较敏感。理想情况下，插值应该产生平滑的剖面，c-线性和 n2-线性选项只是分段线性的，因此它们的一阶导数并不连续。样条曲线选项是平滑的（直到第二阶导数），但在某些情况下会生成扭曲的插值来实现这种平滑。PCHIP 选项为更好的行为牺牲了一些平滑度。这在所有 Fortran 代码中都已实现。Matlab 版本不是最新版本。也就是说，还没有实现这一点；不过，这个修改比较简单。

There are many varieties of PCHIP; the earlier spline option is one of them. A popular PCHIP is based on work by Fritsch and Carlson and produces a monotonic curve between data points--- so does not introduce new extrema. The key in that implementation is to replace nodal derivatives with zero if there is a sign change in the derivative between adjacent segments. There are also variations in how the endpoints are treated. The monotonic pchip did not have the effect I wanted. I've gone with a simpler piecewise cubic that simply averages the derivatives between adjacent segments. That average is not O(h^2) if the grid is varying. However, there are physical arguments that motivate the simpler average and I didn't see a benefit in spending more time on that.

PCHIP 有很多种，早期的样条选项就是其中之一。流行的 PCHIP 是以 Fritsch 和 Carlson 的工作为基础的，它在数据点之间产生单调的曲线--因此不会引入新的极值。实现的关键是，如果相邻段之间的导数有符号变化，则将节点的导数替换为零。对端点的处理方式也有很多种。我用一个更简单的分段立方来计算相邻分段之间导数的平均值。如果网格是变化的，平均值就不是 O(h^2)。不过，有一些物理上的论据可以激发更简单的平均，我还没看到花更多的时间在这上面有什么好处。

Frequently Asked Questions

常见问答

Why do I get an end-of-file in reading the very last line of the envfil?

为什么我在阅读 Envfile 的最后一行时得到了文件的结尾？

You left off a carriage return/line feed after the last line, or other appropriate end-of-line marker for your system.

你在最后一行之后没用回车/行反馈，或者您的系统提供的其他合适的行尾标记。

Why do I get a segmentation violation?

为什么我会有分割违规？

You ran a case that required an outrageous amount of storage. The code is supposed to catch all such cases by detecting an error in the allocation of dynamic variables (or limits for the few arrays with fixed dimensions). However, we see cases where the compiler simply does not handle huge arrays properly.

你运行了一个需要大量内存的算例。代码假定是通过检测动态变量分配中的错误（或少数固定维度数组的限制）来捕获所有此类算例)。不过，我们看到的是编译器不能正确处理大型数组的情况。