弹性波理论基础实验课

指导教师：王海江

地空学院

Email: wanghj3777@163.com

TEL：13971661006

内容

- 实验目的与要求
- 实验原理
- 实验工具（Fortran、Matlab)
- 实验内容：
  - 点源及结果输出
  - 计算精度分析
  - 多层介质及结果输出
  - 平面波及结果输出
- 实验报告

实验目的与要求

- 理解并掌握用有限差分法来解决二维弹性波传播问题
- 一些关键参数(dx、dt)的选取及对数值模拟精度的影响
- 均匀介质、层状介质
- 用Matlab绘制数值模拟的结果

实验原理

- 运动平衡方程的速度—应力模式

$$\frac{\partial v_x}{\partial t} = \frac{1}{\rho}\left(\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \tau_{xz}}{\partial z}\right)$$

$$\frac{\partial v_z}{\partial t} = \frac{1}{\rho}\left(\frac{\partial \tau_{zx}}{\partial x} + \frac{\partial \sigma_{zz}}{\partial z}\right)$$

$$\frac{\partial \sigma_{xx}}{\partial t} = (\lambda + 2\mu)\frac{\partial v_x}{\partial x} + \lambda \frac{\partial v_z}{\partial z}$$

$$\frac{\partial \sigma_{zz}}{\partial t} = (\lambda + 2\mu)\frac{\partial v_z}{\partial z} + \lambda \frac{\partial v_x}{\partial x}$$

$$\frac{\partial \tau_{zx}}{\partial t} = \frac{\partial \tau_{xz}}{\partial t} = \mu\left(\frac{\partial v_x}{\partial x} + \frac{\partial v_z}{\partial z}\right)$$

实验原理

- 有限差分法之时间外推

$$v_x(t+dt) \approx v_x(t) + \partial_t v_x(t) \cdot dt$$

- 有限差分法之函数空间微分近似

$$\partial_x v_x \approx \frac{v_x(x+dx) - v_x(x-dx)}{2dx}$$

实验原理

- Courant准则

$$c \cdot \frac{dt}{dx} \leq 0.625$$

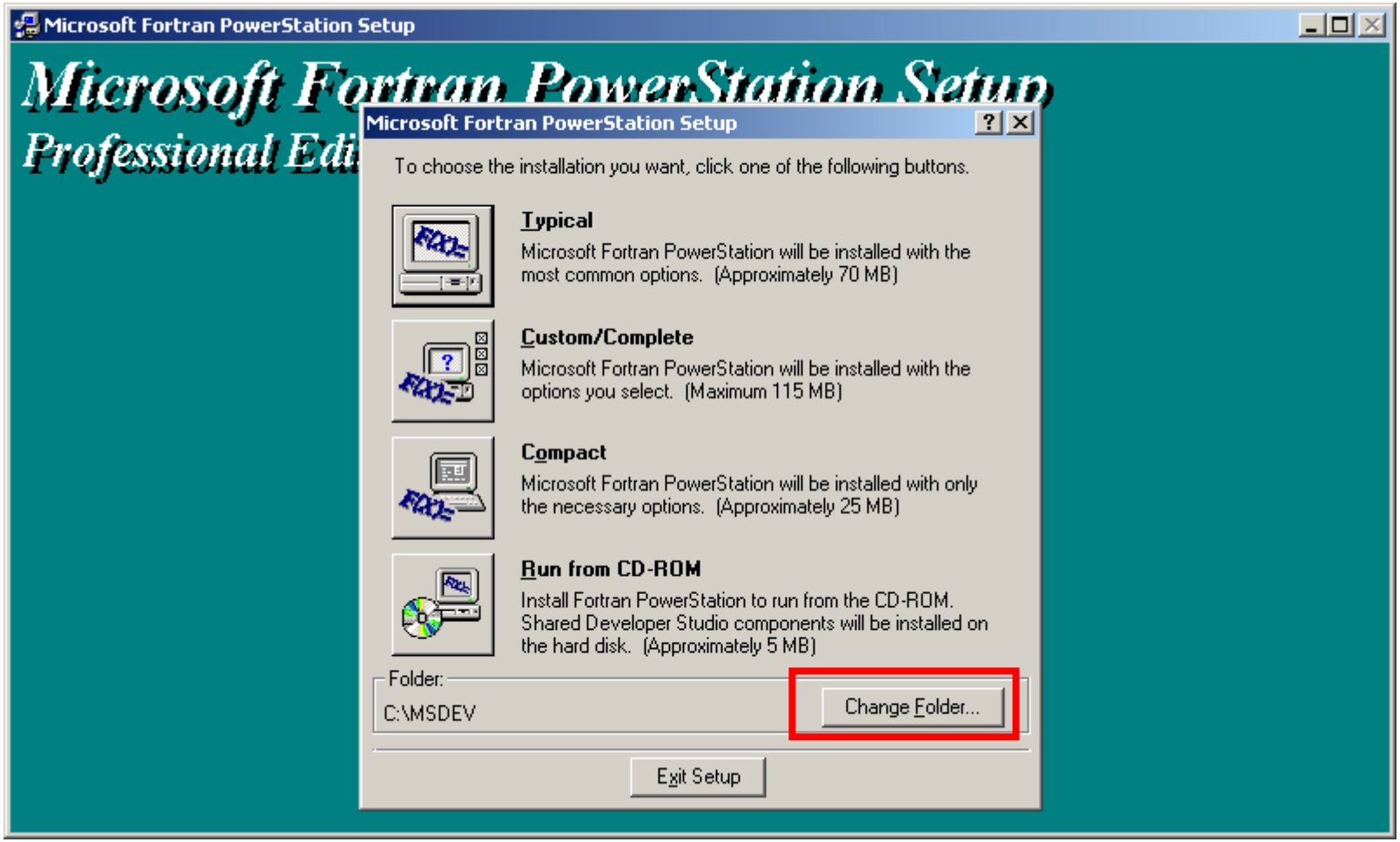
安装Microsoft Fortran PowerStation 4.0

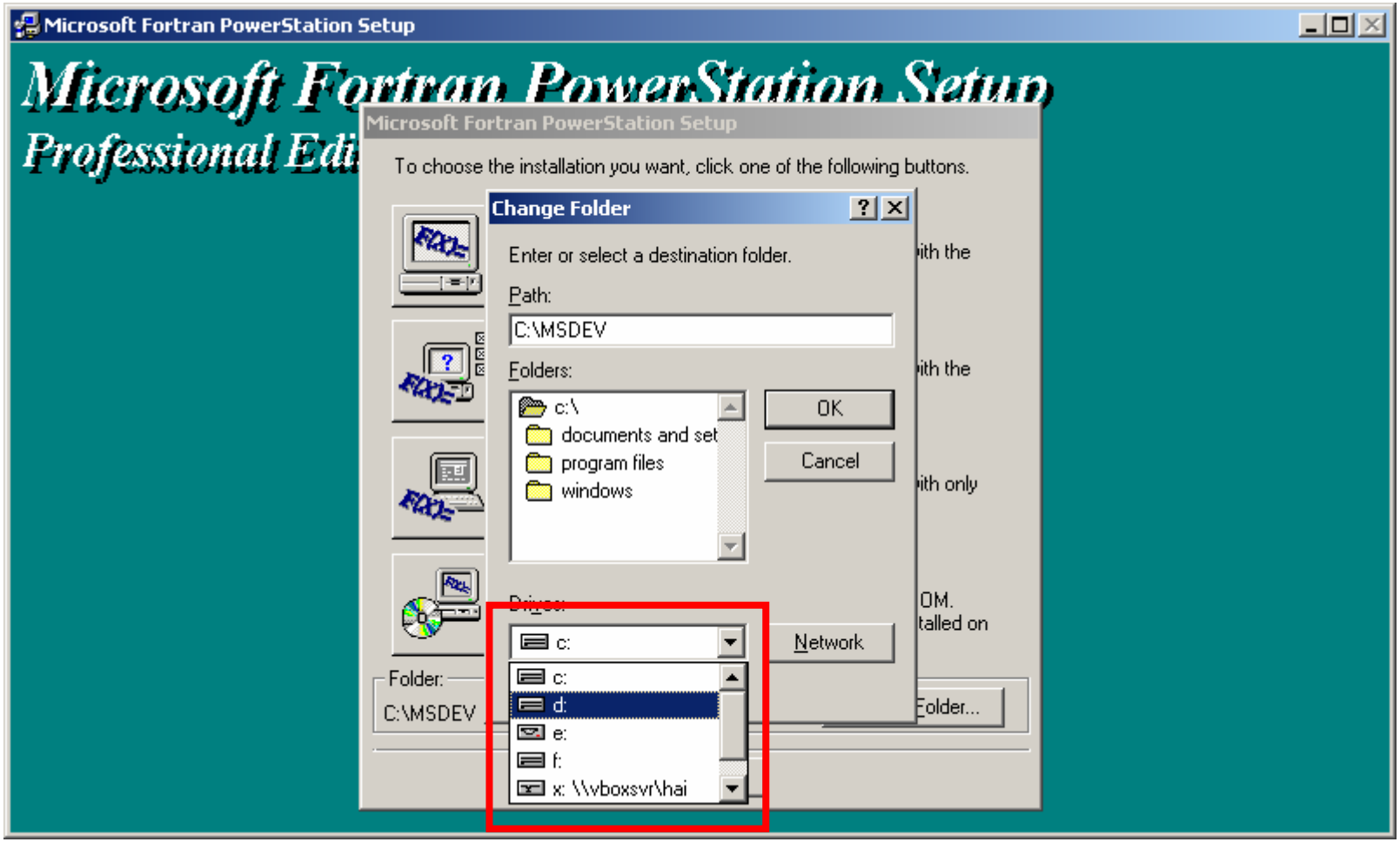
Fortran 90 编译器

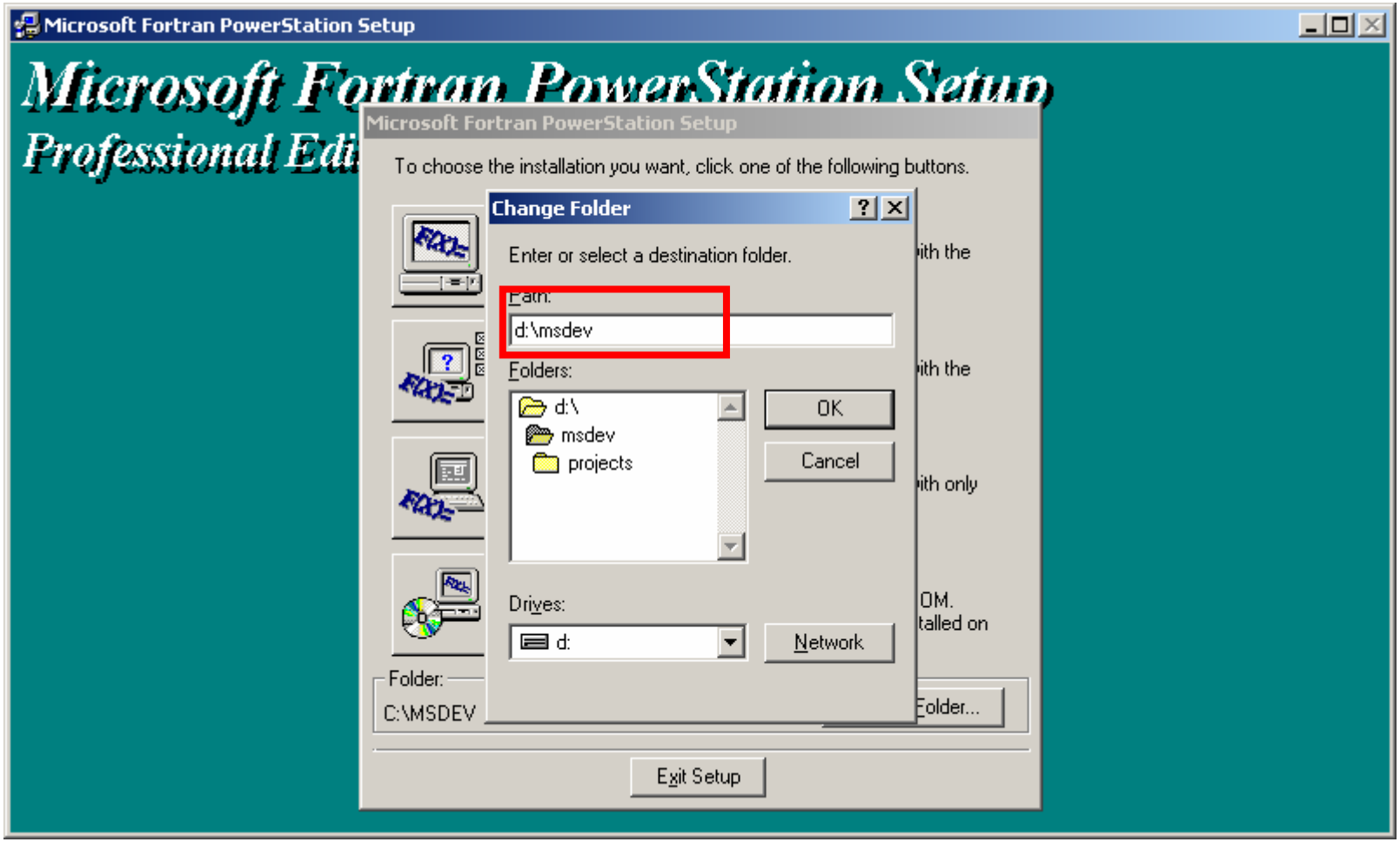
1. 运行Microsoft Fortran PowerStation 4.0.exe
2. 关闭文本编辑器

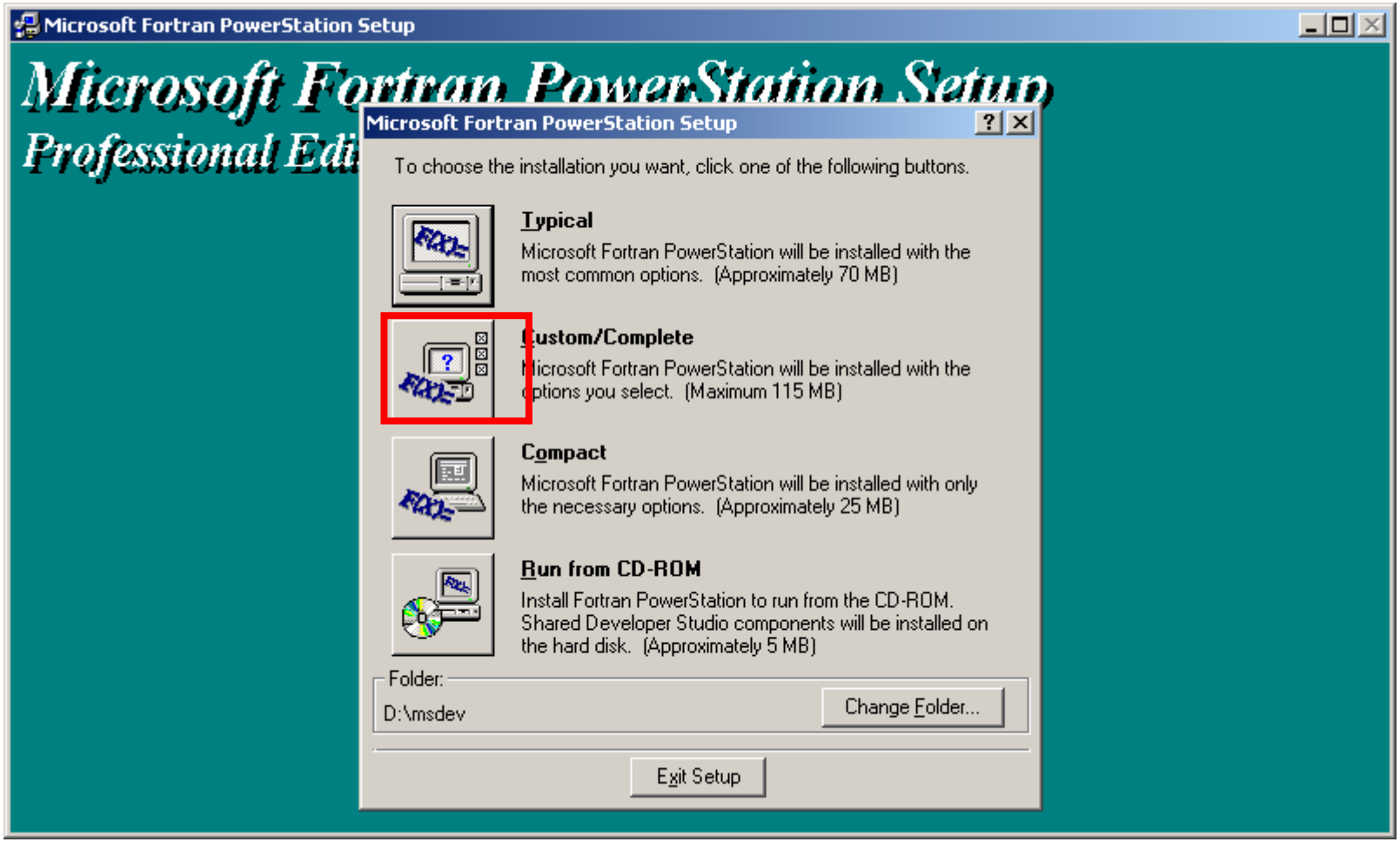

Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional
Microsoft Fortran PowerStation Setup
Welcome to the Microsoft Fortran PowerStation installation program.
Setup cannot install system files or update shared files if the files are in use. Before continuing, close any open applications.
WARNING: This program is protected by copyright law and international treaties.
You may install Microsoft Fortran PowerStation on a single computer. Some Microsoft products are provided with additional rights, which are stated in the End User License Agreement included with your software.
Please take a moment to read the End User License Agreement now. It contains all of the terms and conditions that pertain to this software product. By choosing to continue, you indicate acceptance of these terms.
Continue
Exit Setup

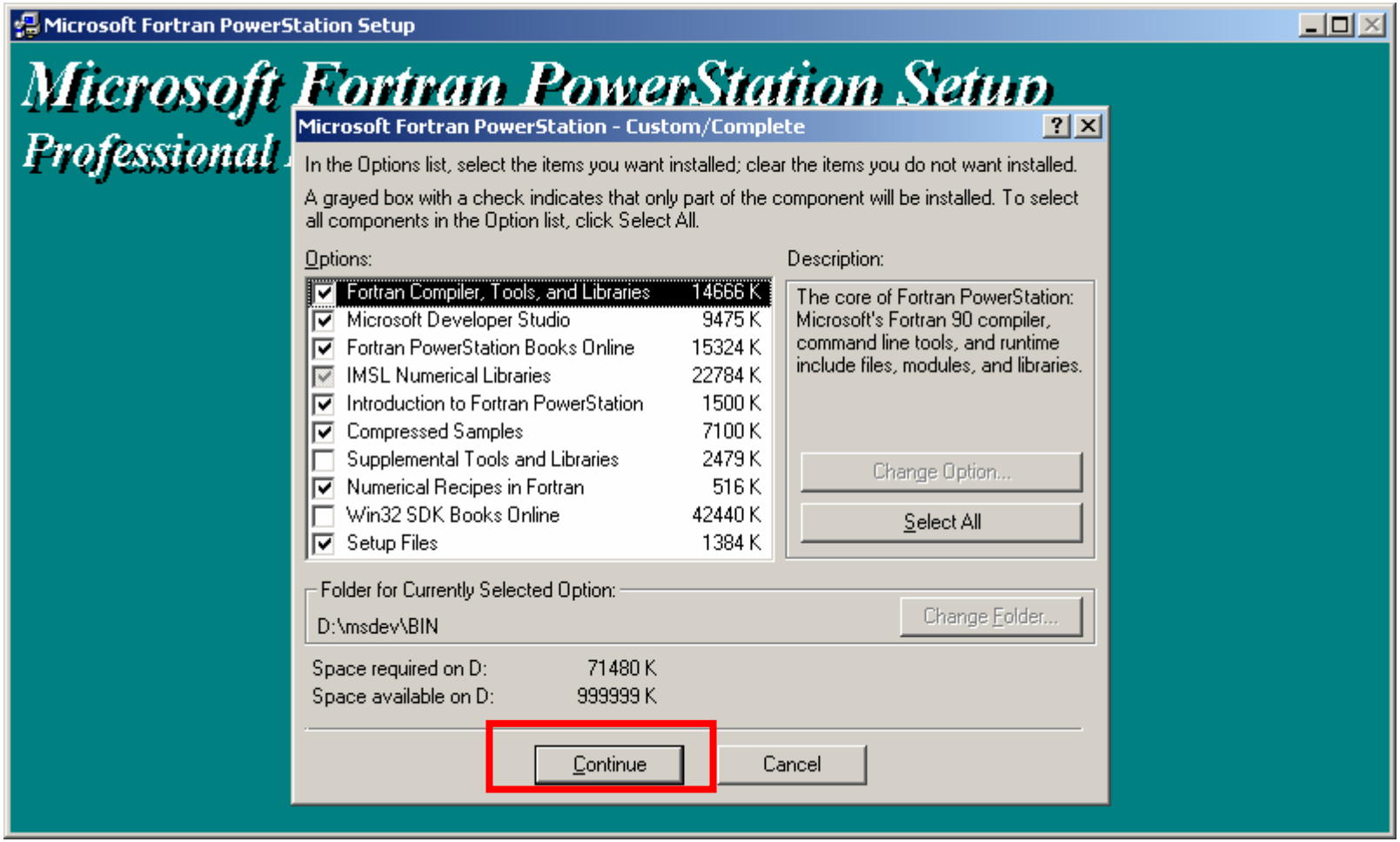
CD KEY=000-0000000

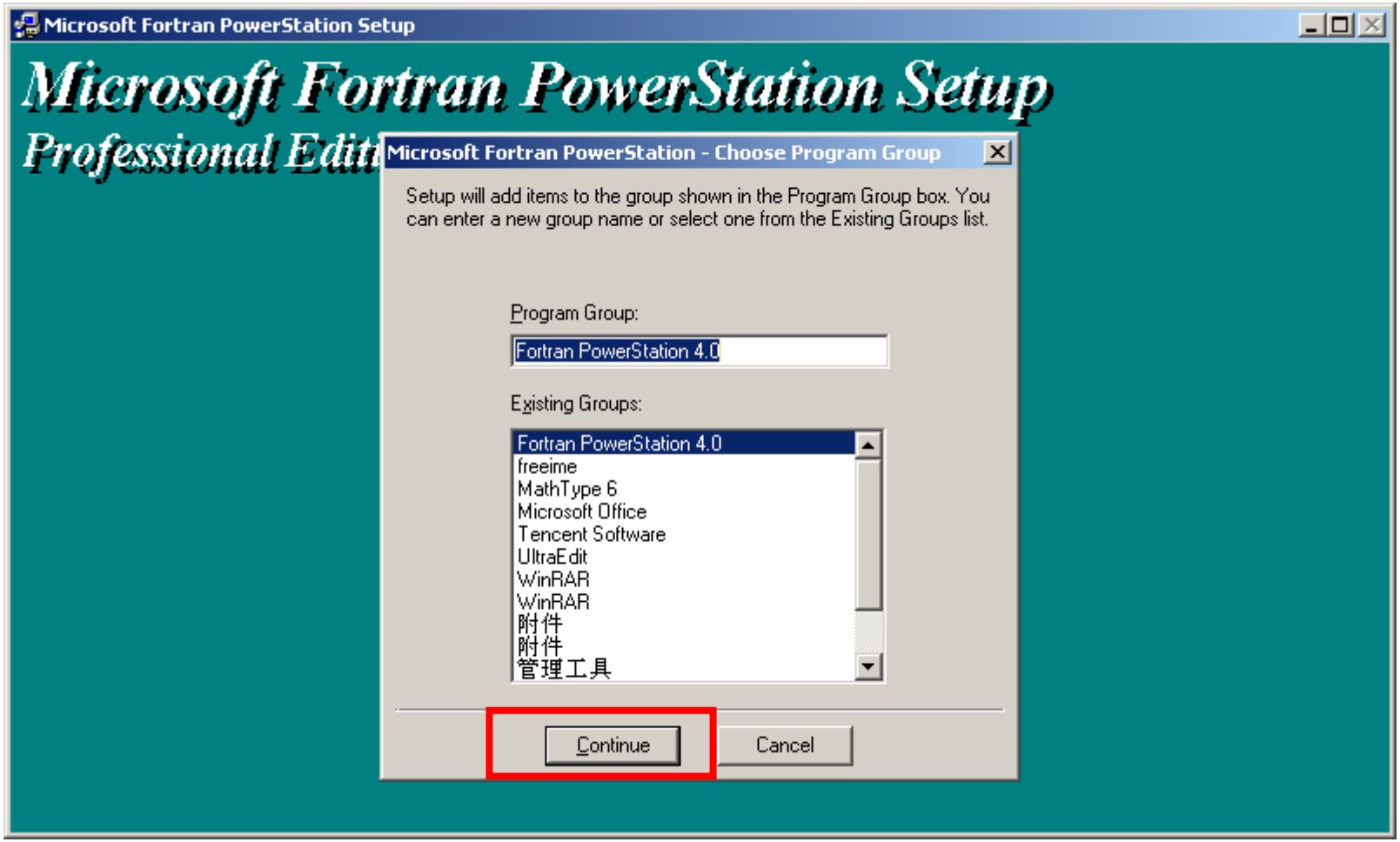

Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional Edi
Microsoft Fortran PowerStation Setup
To choose the installation you want, click one of the following buttons.
Typical
Microsoft Fortran PowerStation will be installed with the most common options. (Approximately 70 MB)
Custom/Complete
Microsoft Fortran PowerStation will be installed with the options you select. (Maximum 115 MB)
Compact
Microsoft Fortran PowerStation will be installed with only the necessary options. (Approximately 25 MB)
Run from CD-ROM
Install Fortran PowerStation to run from the CD-ROM. Shared Developer Studio components will be installed on the hard disk. (Approximately 5 MB)
Folder:
C:\MSDEV
Change Folder...
Exit Setup

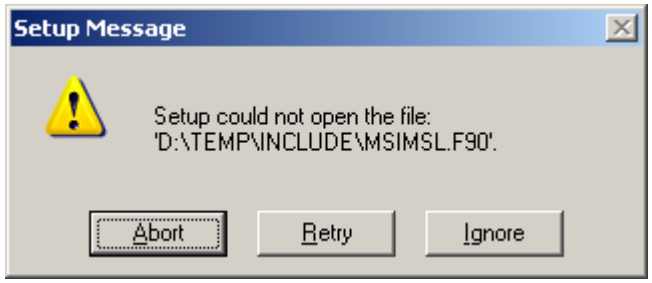

Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional Edi
Microsoft Fortran PowerStation Setup
To choose the installation you want, click one of the following buttons.
Change Folder
Enter or select a destination folder.
Path:
C:\MSDEV
Folders:
c:\
documents and set
program files
windows
OK
Cancel
Drives:
c:
Network
c:
d:
e:
f:
x: \\vboxsvr\hai
Folder:
C:\MSDEV
Folder...

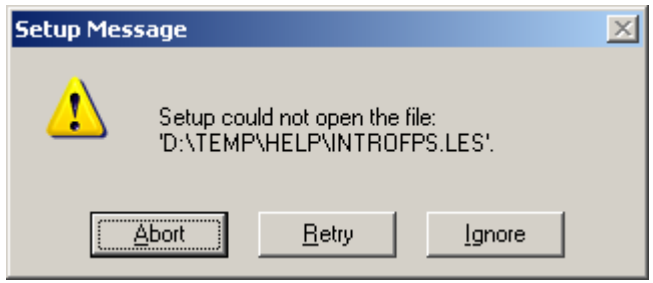

Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional Edi
Microsoft Fortran PowerStation Setup
To choose the installation you want, click one of the following buttons.
Change Folder
Enter or select a destination folder.
Path:
d:\msdev
Folders:
d:\
msdev
projects
OK
Cancel
Drives:
d:
Network
Folder:
C:\MSDEV
Folder...
Exit Setup

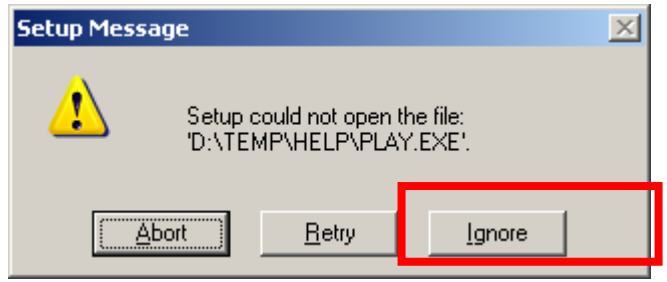

Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional Edi
Microsoft Fortran PowerStation Setup
To choose the installation you want, click one of the following buttons.
Typical
Microsoft Fortran PowerStation will be installed with the most common options. (Approximately 70 MB)
Custom/Complete
Microsoft Fortran PowerStation will be installed with the options you select. (Maximum 115 MB)
Compact
Microsoft Fortran PowerStation will be installed with only the necessary options. (Approximately 25 MB)
Run from CD-ROM
Install Fortran PowerStation to run from the CD-ROM. Shared Developer Studio components will be installed on the hard disk. (Approximately 5 MB)
Folder:
D:\msdev
Change Folder...
Exit Setup

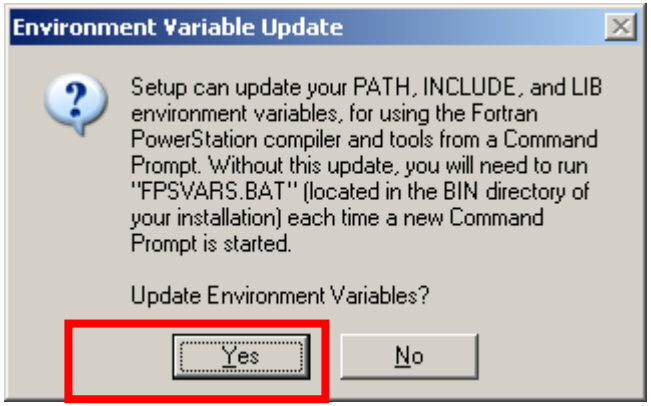

Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional
Microsoft Fortran PowerStation - Custom/Complete
In the Options list, select the items you want installed; clear the items you do not want installed.
A grayed box with a check indicates that only part of the component will be installed. To select all components in the Option list, click Select All.
Options:
Description:
Fortran Compiler, Tools, and Libraries 14666 K
Microsoft Developer Studio 9475 K
Fortran PowerStation Books Online 15324 K
IMSL Numerical Libraries 22784 K
Introduction to Fortran PowerStation 1500 K
Compressed Samples 7100 K
Supplemental Tools and Libraries 2479 K
Numerical Recipes in Fortran 516 K
Win32 SDK Books Online 42440 K
Setup Files 1384 K
The core of Fortran PowerStation: Microsoft's Fortran 90 compiler, command line tools, and runtime include files, modules, and libraries.
Change Option...
Select All
Folder for Currently Selected Option:
D:\msdev\BIN
Change Folder...
Space required on D: 71480 K
Space available on D: 999999 K
Continue
Cancel


Microsoft Fortran PowerStation Setup
Microsoft Fortran PowerStation Setup
Professional Editi
Microsoft Fortran PowerStation - Choose Program Group
Setup will add items to the group shown in the Program Group box. You can enter a new group name or select one from the Existing Groups list.
Program Group:
Fortran PowerStation 4.0
Existing Groups:
Fortran PowerStation 4.0
freeime
MathType 6
Microsoft Office
Tencent Software
UltraEdit
WinRAR
WinRAR
附件
附件
管理工具
Continue
Cancel


Setup Message
Setup could not open the file:
'D:\TEMP\INCLUDE\MSIMSL.F90'.
Abort
Retry
Ignore

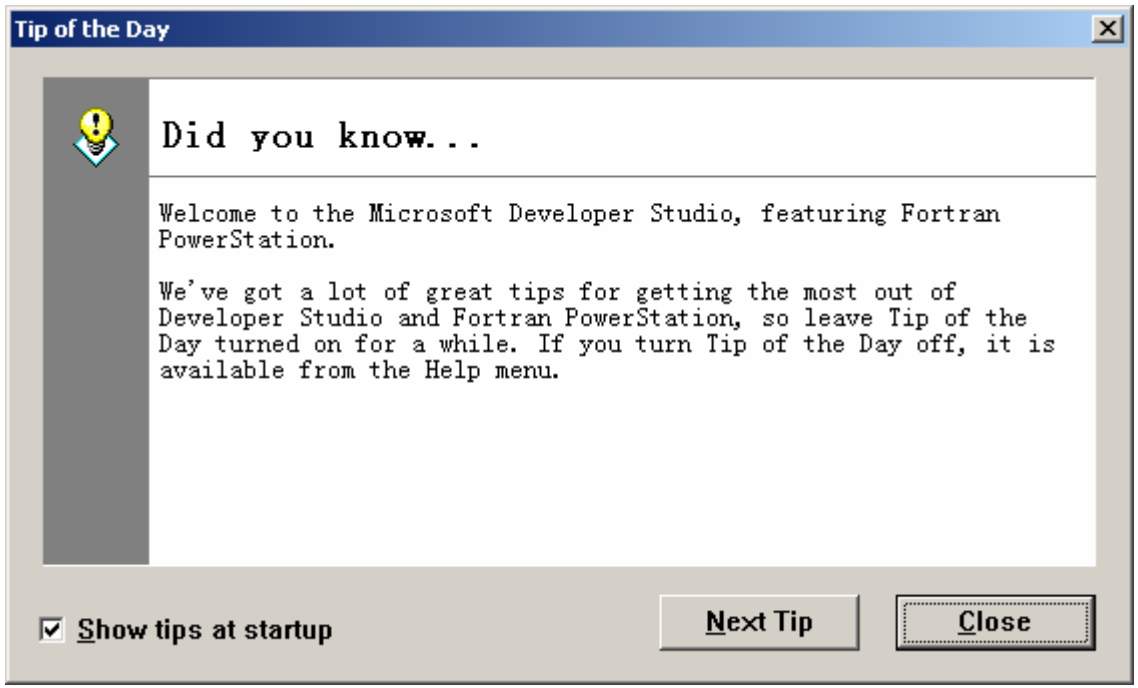

Setup Message
Setup could not open the file:
'D:\TEMP\HELP\INTROFPS.LES'.
Abort
Retry
Ignore


Setup Message
Setup could not open the file:
'D:\TEMP\HELP\PLAY.EXE'.
Abort
Retry
Ignore


Environment Variable Update
Setup can update your PATH, INCLUDE, and LIB environment variables, for using the Fortran PowerStation compiler and tools from a Command Prompt. Without this update, you will need to run "FPSVARS.BAT" (located in the BIN directory of your installation) each time a new Command Prompt is started.
Update Environment Variables?
Yes
No

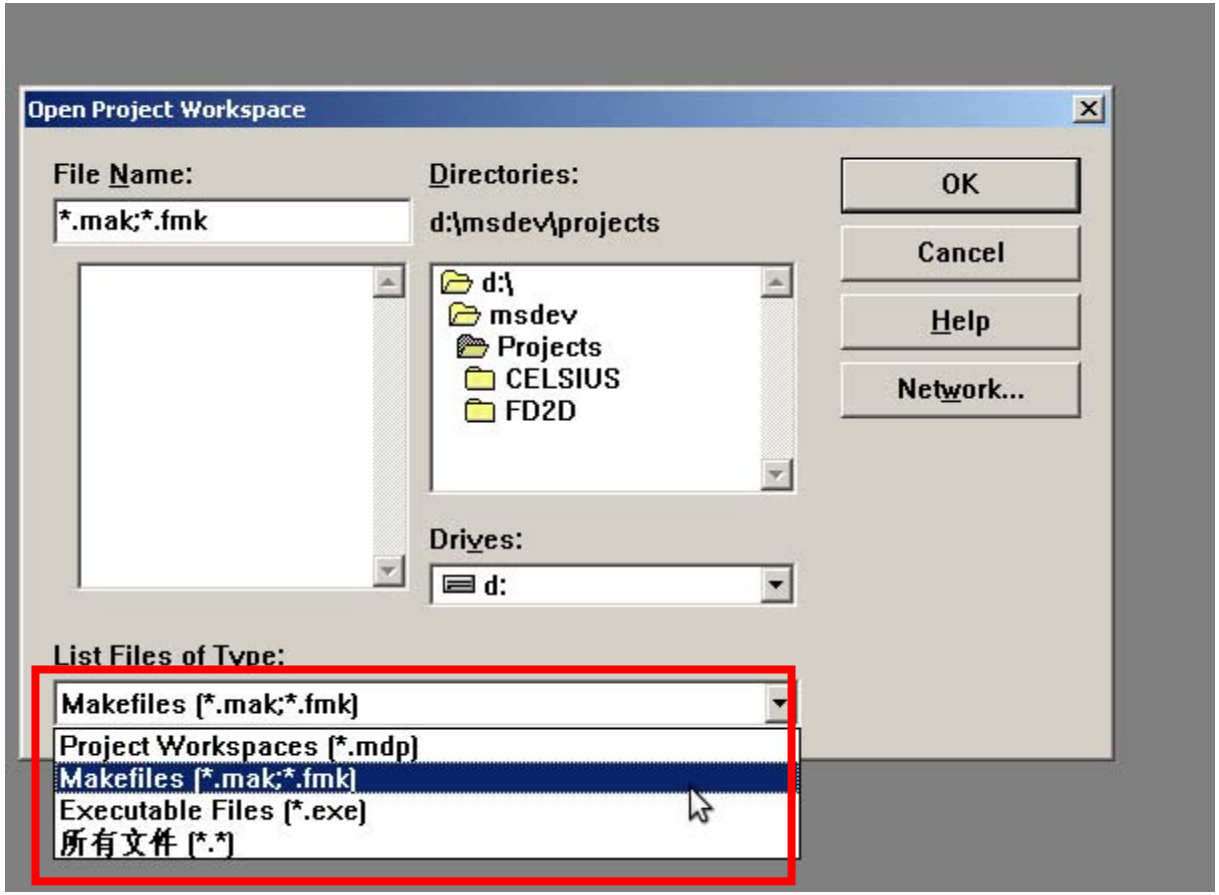
- 软件安装完毕。

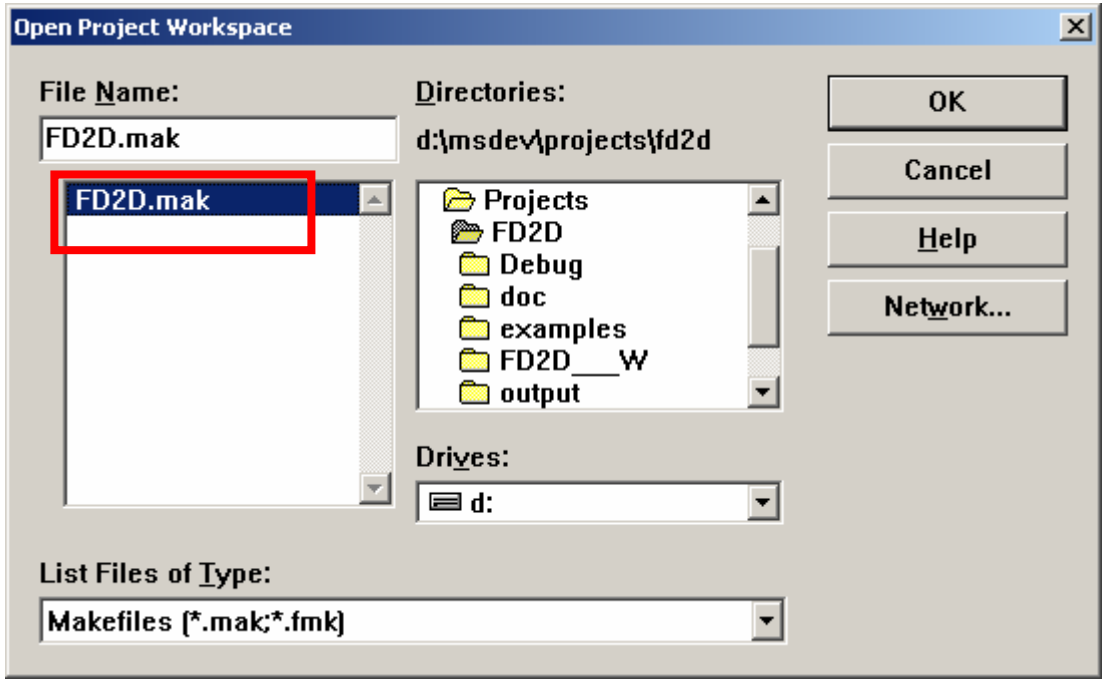
- COPY FD2D.rar到D:\MSDEV\Projects下并解压缩。
- 开始——>运行Microsoft Developer Studio。


Tip of the Day
Did you know...
Welcome to the Microsoft Developer Studio, featuring Fortran PowerStation.
We've got a lot of great tips for getting the most out of Developer Studio and Fortran PowerStation, so leave Tip of the Day turned on for a while. If you turn Tip of the Day off, it is available from the Help menu.
Show tips at startup
Next Tip
Close

开始实验

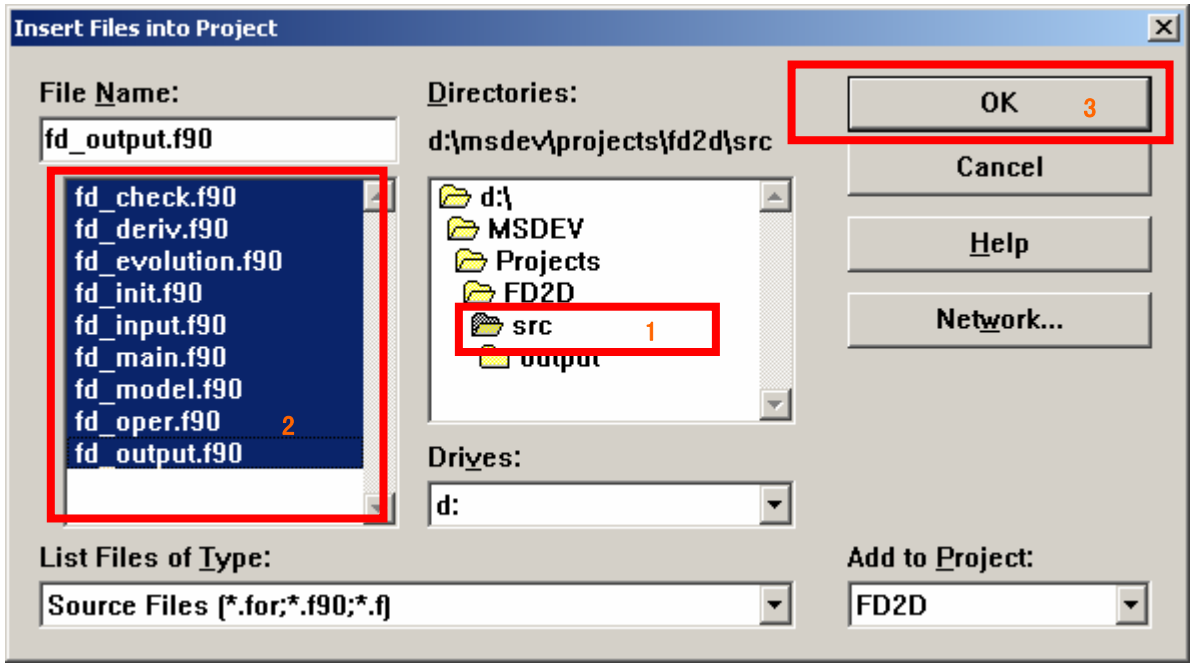
- File ——〉 Open workspace




Open Project Workspace
File Name:
FD2D.mak
FD2D.mak
Directories:
d:\msdev\projects\fd2d
Projects
FD2D
Debug
doc
examples
FD2D___W
output
Drives:
d:
List Files of Type:
Makefiles (*.mak;*.fmk)
OK
Cancel
Help
Network...

如果没有文件则如下操作

- Insert ——> Files into Project



文件描述

- fd_main: main file with time extrapolation loop
- fd_input: reads parameters from standard input (fd2d.exe < Par)
- fd_init: initialization of various things (source)
- fd_model: model initialization
- fd_evolution: numerical solution of wave equation, time exatrpolation, space derivatives, Hookes law
- fd_output: outpuit of snaps and seismograms
- fd_check: paramter check before simulation
- fd_deriv: subroutine to calculate derivatives

文件夹

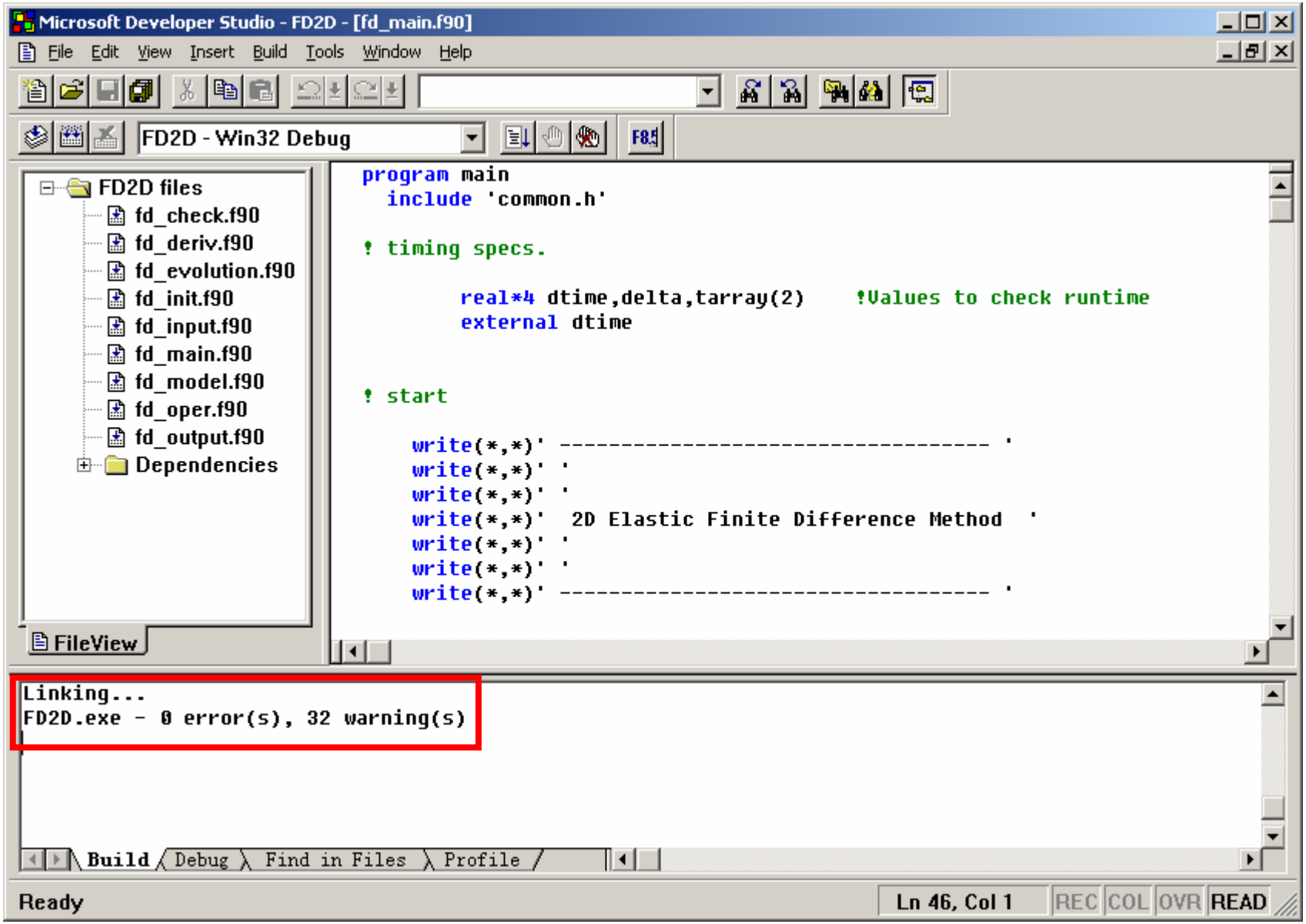
- /src contains source
- /examples contains parameter file
- /tools contains matlab script to visualize snaps and seismograms

参数设定Par文件

parametres ==================	
seisfile =..\output\test	“test” 输出文件名称
modelfile =1	更复杂的模型所在文件名
nt =200	计算时间步
dt (ms) =.5	时间步长
tord =4	时间外推采用步长 (1, 2 or 4)
nop =2	空间差分采用步长 2 or 4
Model ----------	
model_type =1	介质模型类型：1－－均匀介质；2－－层状介质
vs0 =2887.	均匀模型的一些参数
vp0 =5000.	
rho0 =2500.	
Source ----------	
xxs =900.	点源所在位置 x (in m)
zzs =900.	z方向上
source_type =4	源参数选项(1-fx, 2-fz, 3-爆破源, 4-sxz)
srcfreq(Hz) =100.	源时间函数主频率 Hz
alpha =25.	源空间函数Gaussian半宽in m
Receivers----------	
xa =14	x方向上第一个接收器位置
xe =65	x方向上最后一个接收器位置
irec =1	测线上接收器间隔
izrec =0	z方向上接收器位置
isamp =1	输出时程间隔 (in dt‘s, 不用改)
ssamp =10	快照输出间隔 （以步长为单位）
JUNK----------	
ibound =4	边界类型 (1-free surfaces, 2-absorb, 3-freesurf+absorb, 4-circular
icheck =5	模拟检查时间点设置
xmax =1000.	模拟区域[0,xmax] in m
zmax =1000.	z向上模拟区域

开始编译

- Build——>Rebuild All


Microsoft Developer Studio - FD2D - [fd_main.f90]
File Edit View Insert Build Tools Window Help
FD2D - Win32 Debug
FD2D files
fd_check.f90
fd_deriv.f90
fd_evolution.f90
fd_init.f90
fd_input.f90
fd_main.f90
fd_model.f90
fd_oper.f90
fd_output.f90
Dependencies
FileView
program main
include 'common.h'
! timing specs.
real*4 dtime,delta,tarray(2) !Values to check runtime
external dtime
! start
write(*,*)' ---------- '
write(*,*)' '
write(*,*)' '
write(*,*)' 2D Elastic Finite Difference Method '
write(*,*)' '
write(*,*)' '
write(*,*)' ---------- '
Linking...
FD2D.exe - 0 error(s), 32 warning(s)
Build Debug Find in Files Profile
Ready
Ln 46, Col 1
REC COL OVR READ

没有编译错误，则执行

- Build——〉Execute FD2D.exe

实验结果处理

- 进入Tools下
- 用show_snap.m显示movie并输出
- 用show_seism.m显示几个观测点上的时程曲线并输出

实验内容1：

- 点源及结果输出（沿一测线上时程图、整个工作区域内波动传播动画）
- 计算精度分析:
  - nx，nz分别取512、256、128（dt固定为.35），dt分别取为.55、 .45、 .35、 .25、 .15 （nx、nz固定为256），分析距源点距离固定的某一观测点上观测到的震动时程的区别。

  dt修改在Par文件中

  nx,nz修改在params.h文件中

实验内容2：

- 多层介质及结果输出

  修改Par文件中的变量model_type为2

- 平面波及结果输出

  增加若干个点源，其位置在一条线上

实验报告

- 参见：实验报告.doc
- 上交时间：2013.12.20前
- 打印：物探楼413
- 电子：wanghj3777@163.com
- 附件标题格式：班级+学号+姓名