



Monte Carlo Uncertainty Analysis Program v1.0

Lam Tzeng Yih, Kyeong-hak Lee*, and Raehyun Kim
Center for Forest & Climate Change
Korea Forest Research Institute



“Uncertainty estimates are an **essential** element of a **complete** inventory greenhouse gas emission and removals.”

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories

- An analysis software is needed to:
 - Assist in the uncertainty calculation,
 - Automate the calculation process,
 - Standardize/harmonize the estimation process,
 - Making the calculation process transparent.



Monte Carlo Uncertainty Analysis Program v1.0

Introduction

The Package

The Structure

An Example

- Available popular analysis softwares are:
 - @RISK: Palisade Cooperation (US\$2,000),
 - Crystal Ball: Oracle (US\$1,000).
- The hefty price tag discourages:
 - Uncertainty analysis in developing countries with a lack of resources,
 - Technology and knowledge transfer to developing countries.
- The motivation is:
 - Developing an **open source analysis software** that is freely available to developing countries to **assist uncertainty analysis** in their greenhouse gas report to IPCC and to **assist knowledge transfer**.



Monte Carlo Uncertainty Analysis Program v1.0

Introduction

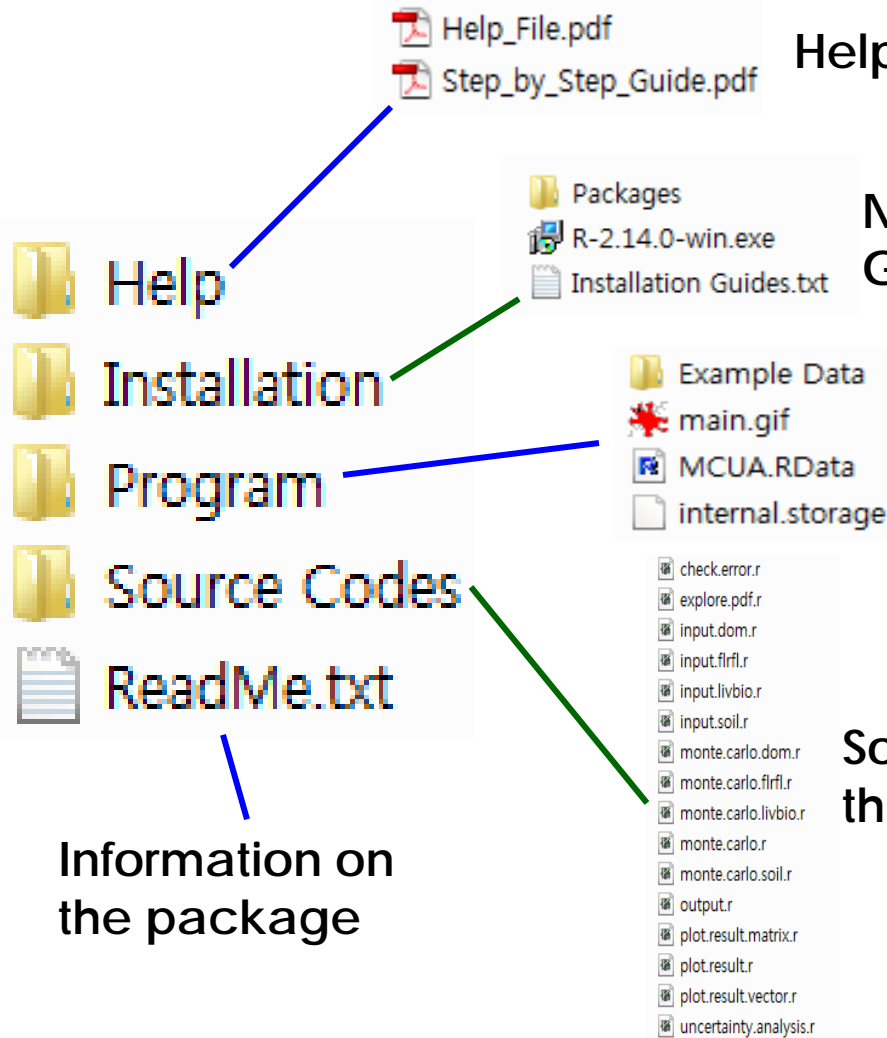
The Package

The Structure

An Example

As a result of this effort

Monte Carlo Uncertainty Analysis Program v1.0




Help Documents

Necessary Installation Softwares and Guides

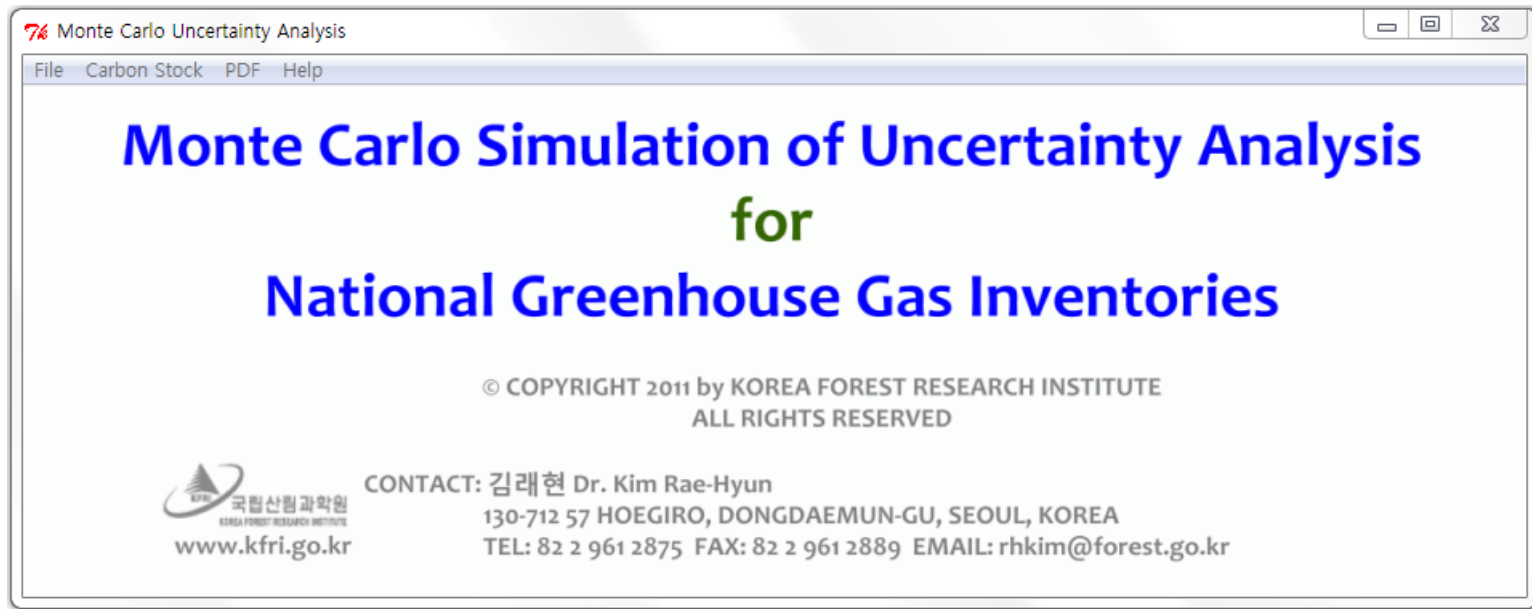
Main program and example datasets

Source codes of the subroutines of the program

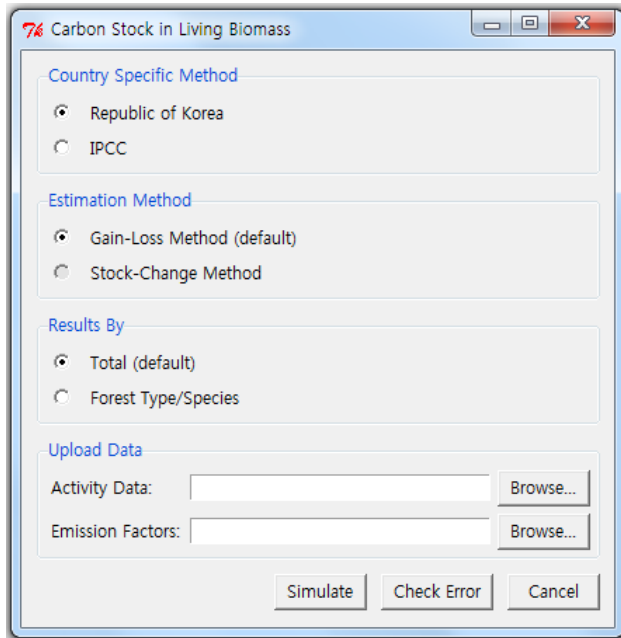
Information on the package

- The program is built in the  statistical software:
 - The software is distributed under General Public License (GPL),
 - It is freely available to any individual and any place,
 - It is a powerful statistical analysis software that could do all kinds of analysis.
- The structure of the program is separated into two parts:
 - Front-end (Graphic User Interface – GUI)
 - Back-end (analysis framework)
- The program relies heavily on available R packages, which are functions that perform analysis or routines.

- The GUI of the program:
 - Is built from `tk`, `panel` and `tkrplot` packages,
 - They provide a convenient way to operate the program,
 - 80% of the codes in the program.



Above- and belowground biomass



Carbon Stock in Living Biomass

Country Specific Method

- Republic of Korea
- IPCC

Estimation Method

- Gain-Loss Method (default)
- Stock-Change Method

Results By

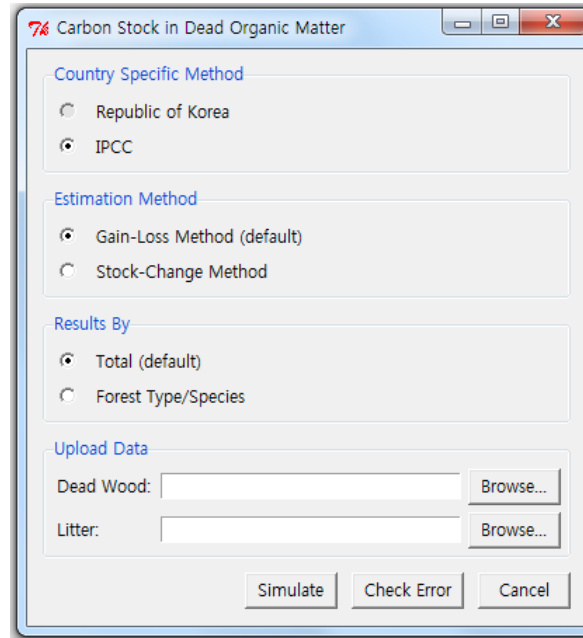
- Total (default)
- Forest Type/Species

Upload Data

Activity Data:

Emission Factors:

Dead Organic Matter



Carbon Stock in Dead Organic Matter

Country Specific Method

- Republic of Korea
- IPCC

Estimation Method

- Gain-Loss Method (default)
- Stock-Change Method

Results By

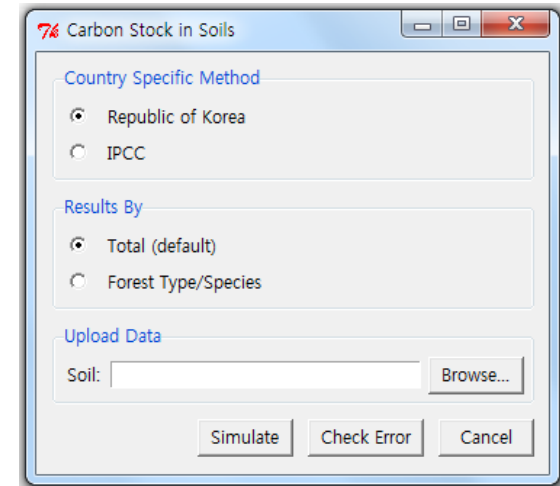
- Total (default)
- Forest Type/Species

Upload Data

Dead Wood:

Litter:

Soils



Carbon Stock in Soils

Country Specific Method

- Republic of Korea
- IPCC

Results By

- Total (default)
- Forest Type/Species

Upload Data

Soil:

Forest Land Remaining Forest Land (FLRFL)

Methods/equations specific to a country (Korea or IPCC)

Estimation methods (Gain-Loss, Stock-Change)

Upload data files

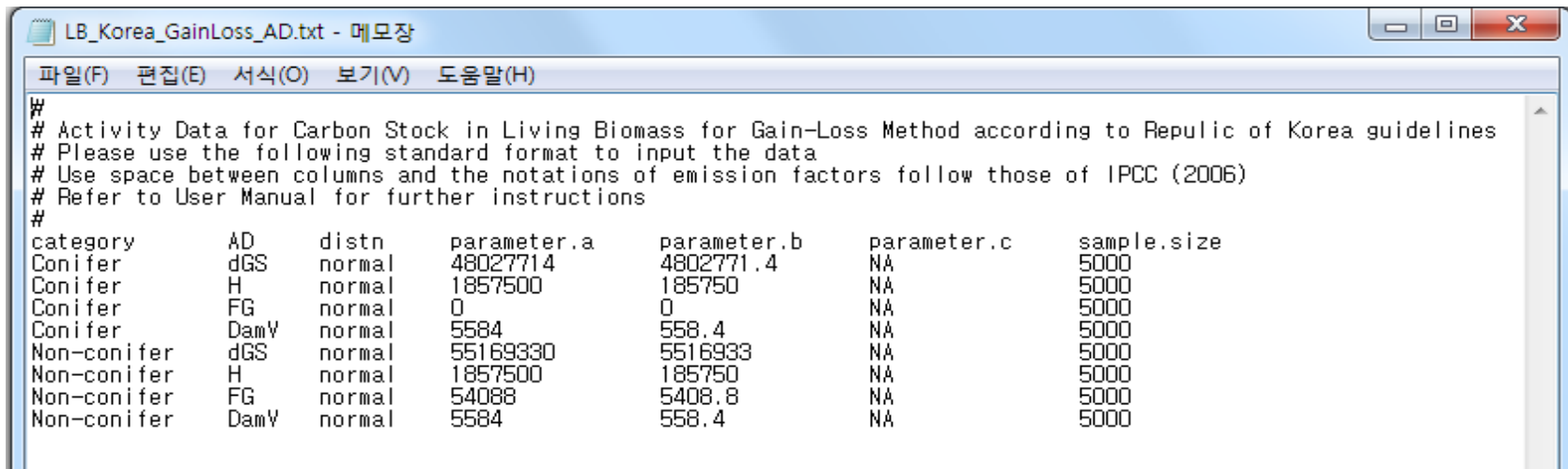
Output results by total or by categories

Start the simulation

Check for common error in data files

Exit the GUI

- Preparing input data files:
 - The preparation maybe tricky and complex because the data files have to follow specific formats depending on biomass component, country specific method and estimation method,
 - The specific preparation is explained in the Help File,
 - At present, only text file (.txt) is accepted and spaces are used to separate columns (spacebar).



```

LB_Korea_GainLoss_AD.txt - 메모장
파일(F) 편집(E) 서식(O) 보기(V) 도움말(H)
#
# Activity Data for Carbon Stock in Living Biomass for Gain-Loss Method according to Republic of Korea guidelines
# Please use the following standard format to input the data
# Use space between columns and the notations of emission factors follow those of IPCC (2006)
# Refer to User Manual for further instructions
#
category      AD      distn      parameter.a      parameter.b      parameter.c      sample.size
Conifer       dGS     normal     48027714         4802771.4        NA               5000
Conifer       H       normal     1857500          185750           NA               5000
Conifer       FG      normal     0                0                NA               5000
Conifer       DamV   normal     5584             558.4            NA               5000
Non-conifer   dGS     normal     55169330         5516933          NA               5000
Non-conifer   H       normal     1857500          185750           NA               5000
Non-conifer   FG      normal     54088            5408.8           NA               5000
Non-conifer   DamV   normal     5584             558.4            NA               5000
  
```



Monte Carlo Uncertainty Analysis Program v1.0

Introduction
The Package

The Structure
An Example

- The analysis framework (back-end) of the program:
 - Is built from `MASS` and `triangle` packages,
 - They provide functions to randomly draw values from a specified probability distribution function (pdf),
 - The pdfs available for this program to generate random numbers are:
 - Normal pdf (`rnorm`),
 - Log-normal pdf (`rlnorm`),
 - Exponential pdf (`rexp`),
 - Gamma pdf (`rgamma`),
 - Weibull pdf (`rweibull`),
 - Triangle pdf (`rtriangle`)

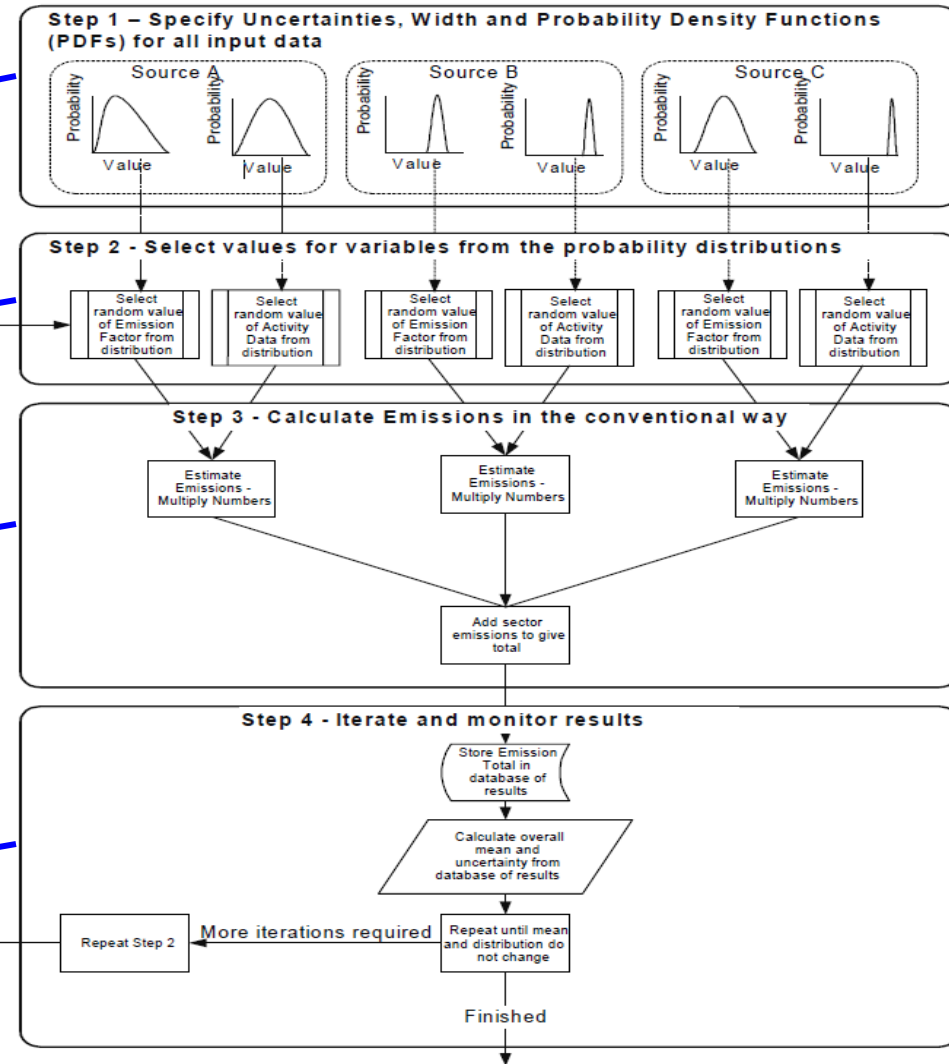
The concept of Monte Carlo Uncertainty Analysis is

Step 1: specify pdfs for all variables in the equations representing their uncertainties.

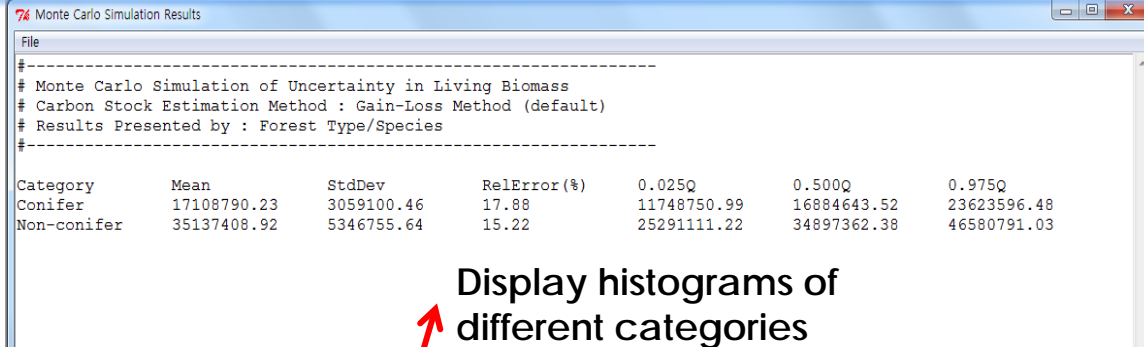
Step 2: select one random value from the specified pdf for each variable.

Step 3: Pretend the randomly selected values are collected from a sample, estimate emission using the selected values.

Step 4: Go back to Step 2 until the number of iteration is over



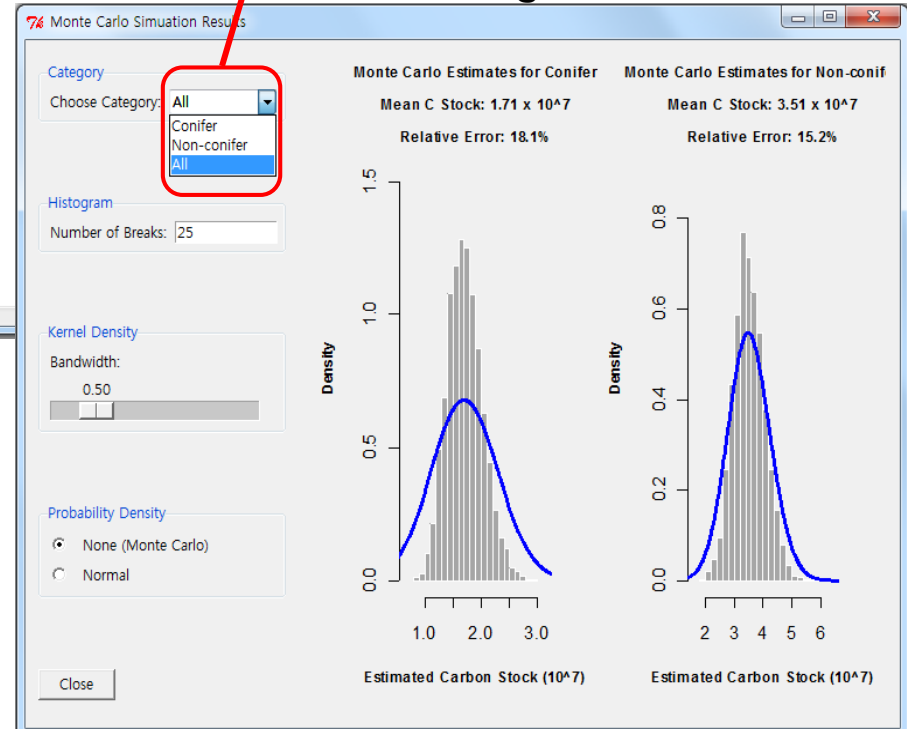
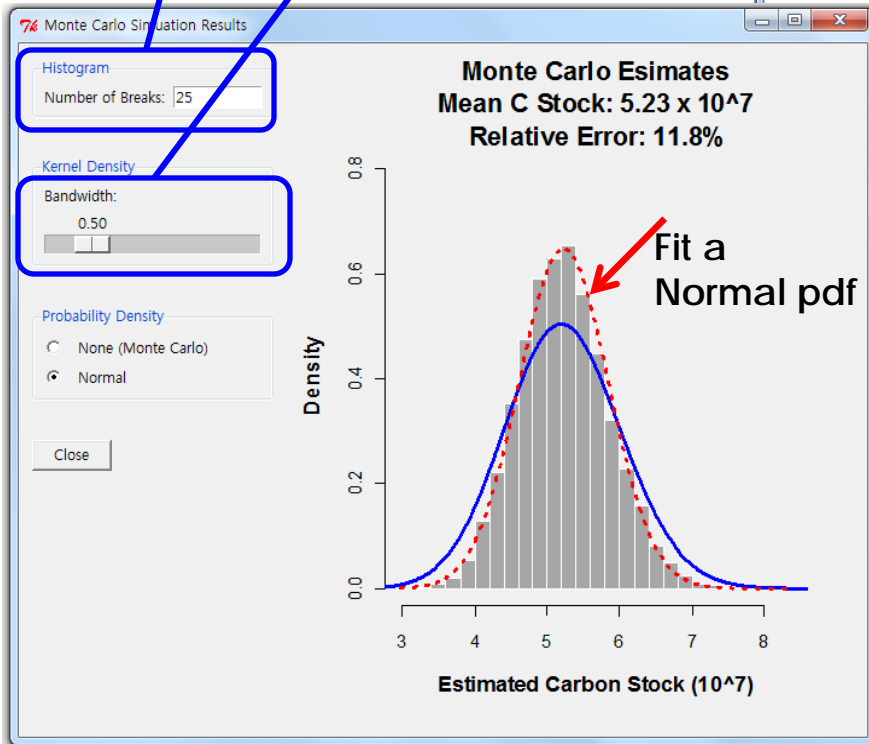
Outputs



Change number of breaks in histogram

Change smoothness of blue curve

Display histograms of different categories





Monte Carlo Uncertainty Analysis Program v1.0

Introduction
The Package

The Structure
An Example

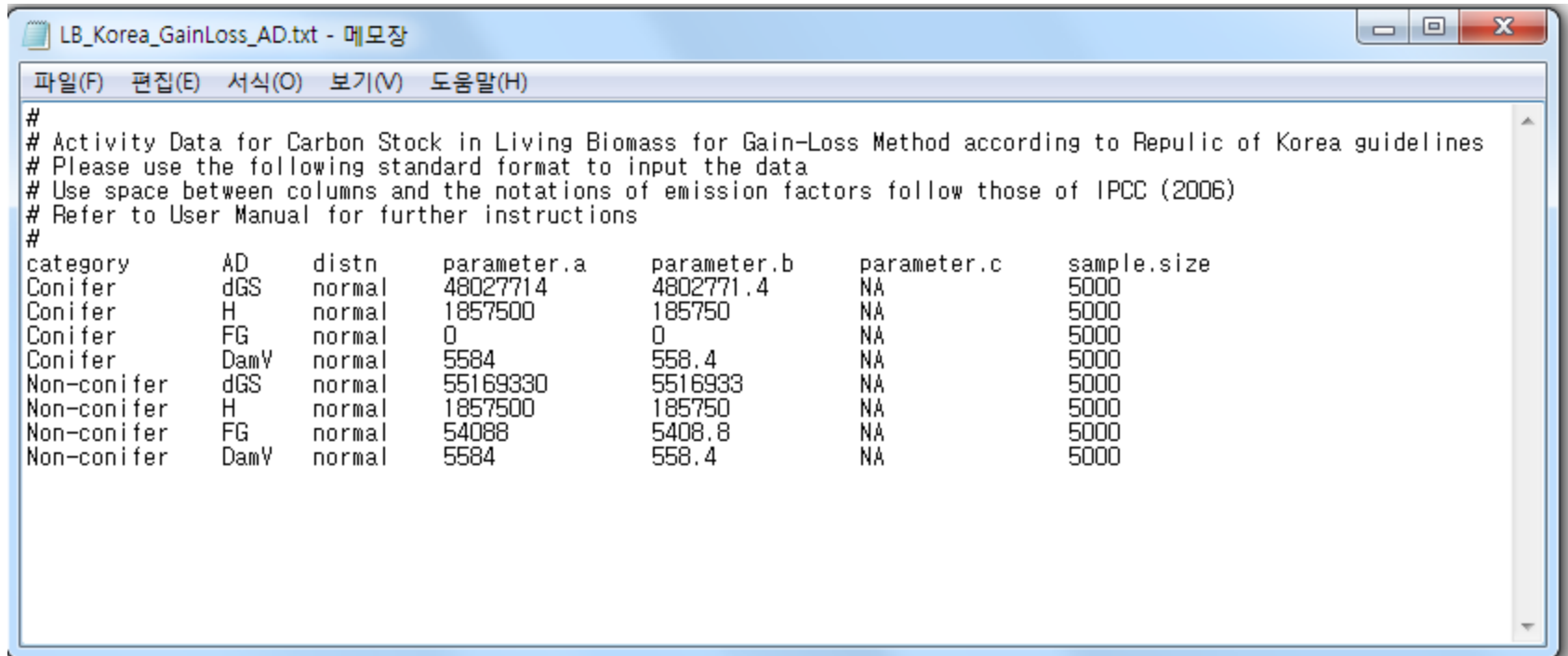
- The advantages:
 - Freely available and portable,
 - Expandable to include other countries specific methods or other biomass component,
 - Expandable to include other more complex estimation method (correlation between variables),
 - A bit of learning curve to operate the software but the GUI helps.
- The disadvantages:
 - Limited functionalities in version 1.0: current assumption is that all variables are independent,
 - Non-fancy GUI and basic output options,
 - “A/S” After-sales support (website, feedback forum) needs to be set up,
 - Need manpower to continuously improve on the program.



**Estimating uncertainty for
2010 emission level of
Above- and belowground biomass in
Republic of Korea using
Gain-Loss Method for
Conifer and Non-conifer forests**

Step 1: Prepare Data Files

Activity Data



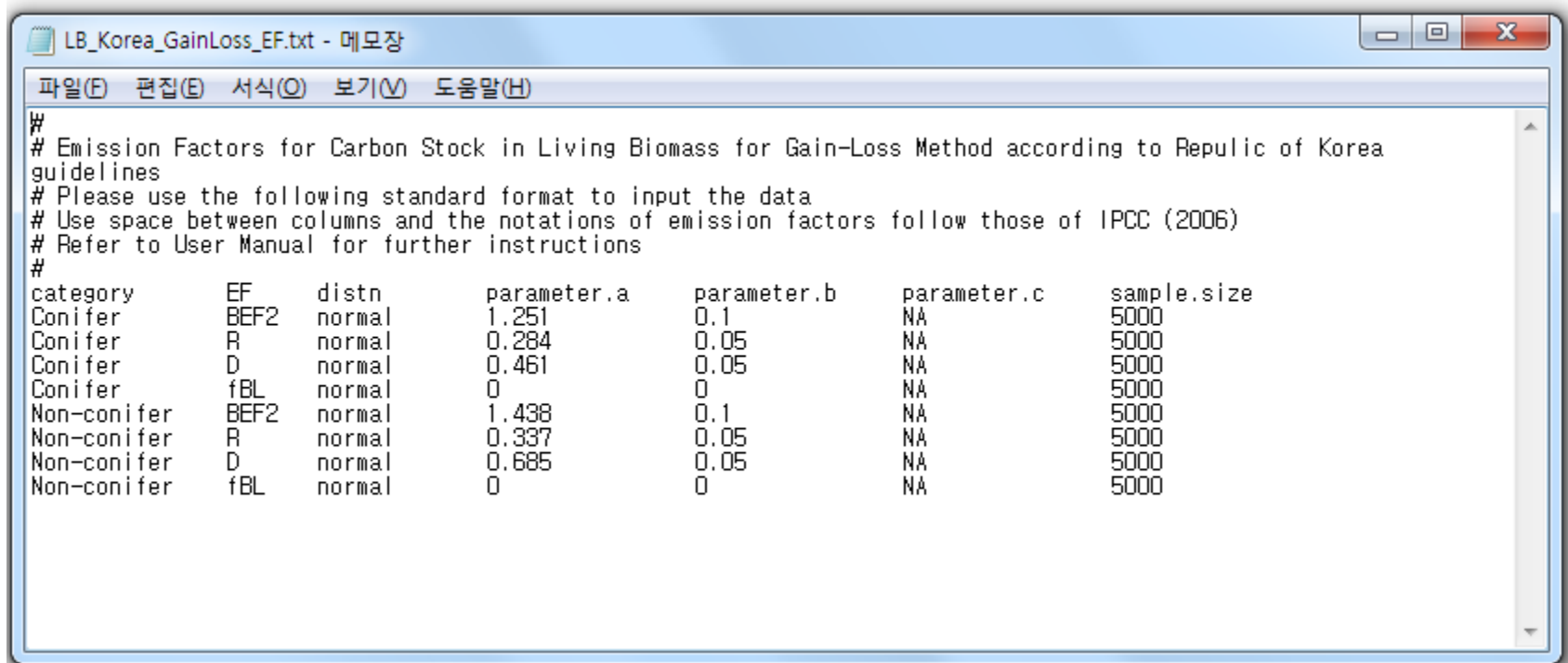
LB_Korea_GainLoss_AD.txt - 메모장

파일(F) 편집(E) 서식(O) 보기(V) 도움말(H)

```
#
# Activity Data for Carbon Stock in Living Biomass for Gain-Loss Method according to Republic of Korea guidelines
# Please use the following standard format to input the data
# Use space between columns and the notations of emission factors follow those of IPCC (2006)
# Refer to User Manual for further instructions
#
category      AD      distn      parameter.a      parameter.b      parameter.c      sample.size
Conifer       dGS     normal     48027714         4802771.4        NA               5000
Conifer       H       normal     1857500          185750           NA               5000
Conifer       FG      normal     0                0                NA               5000
Conifer       DamV   normal     5584             558.4            NA               5000
Non-conifer   dGS     normal     55169330         5516933          NA               5000
Non-conifer   H       normal     1857500          185750           NA               5000
Non-conifer   FG      normal     54088            5408.8           NA               5000
Non-conifer   DamV   normal     5584             558.4            NA               5000
```


Step 1: Prepare Data Files

Emission Factors



```
LB_Korea_GainLoss_EF.txt - 메모장
파일(E) 편집(E) 서식(O) 보기(V) 도움말(H)
#
# Emission Factors for Carbon Stock in Living Biomass for Gain-Loss Method according to Republic of Korea
# guidelines
# Please use the following standard format to input the data
# Use space between columns and the notations of emission factors follow those of IPCC (2006)
# Refer to User Manual for further instructions
#
category      EF      distn      parameter.a  parameter.b  parameter.c  sample.size
Conifer       BEF2    normal     1.251        0.1           NA           5000
Conifer       R       normal     0.284        0.05          NA           5000
Conifer       D       normal     0.461        0.05          NA           5000
Conifer       fBL     normal     0            0             NA           5000
Non-conifer   BEF2    normal     1.438        0.1           NA           5000
Non-conifer   R       normal     0.337        0.05          NA           5000
Non-conifer   D       normal     0.685        0.05          NA           5000
Non-conifer   fBL     normal     0            0             NA           5000
```



Step 2: Start the Program

```
R Console
파일 편집 기타 패키지 윈도우즈 도움말

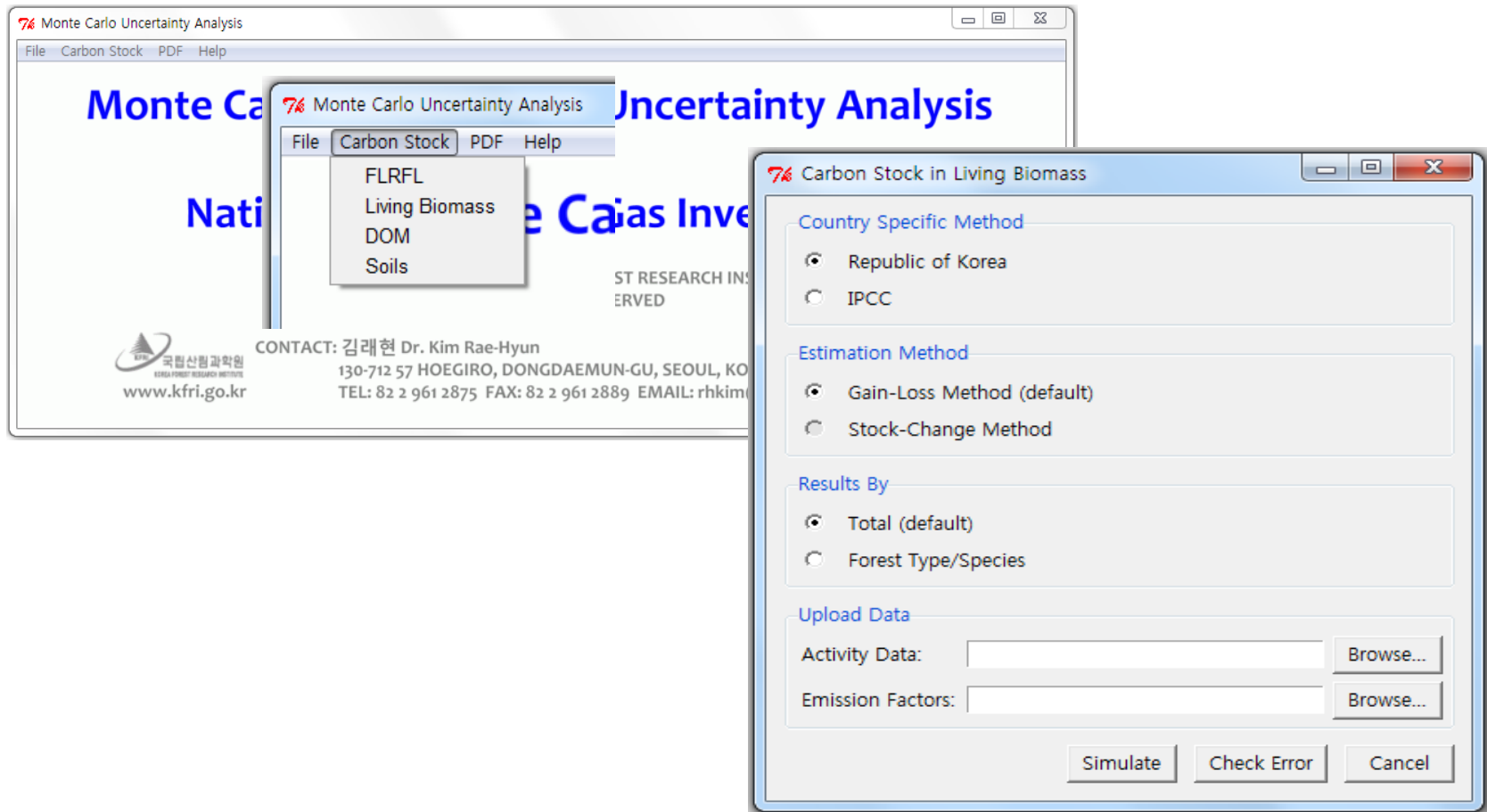
R version 2.12.2 (2011-02-25)
Copyright (C) 2011 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: i386-pc-mingw32/i386 (32-bit)

R은 free 소프트웨어이고, [완전하게 무료]입니다.
일정한 조건에 따르면, 자유롭게 이것을 재배포할수가 있습니다.
배포 조건의 상세한것에 대해서는 'license()' 또는 'licence()' 라고 입력해주시오

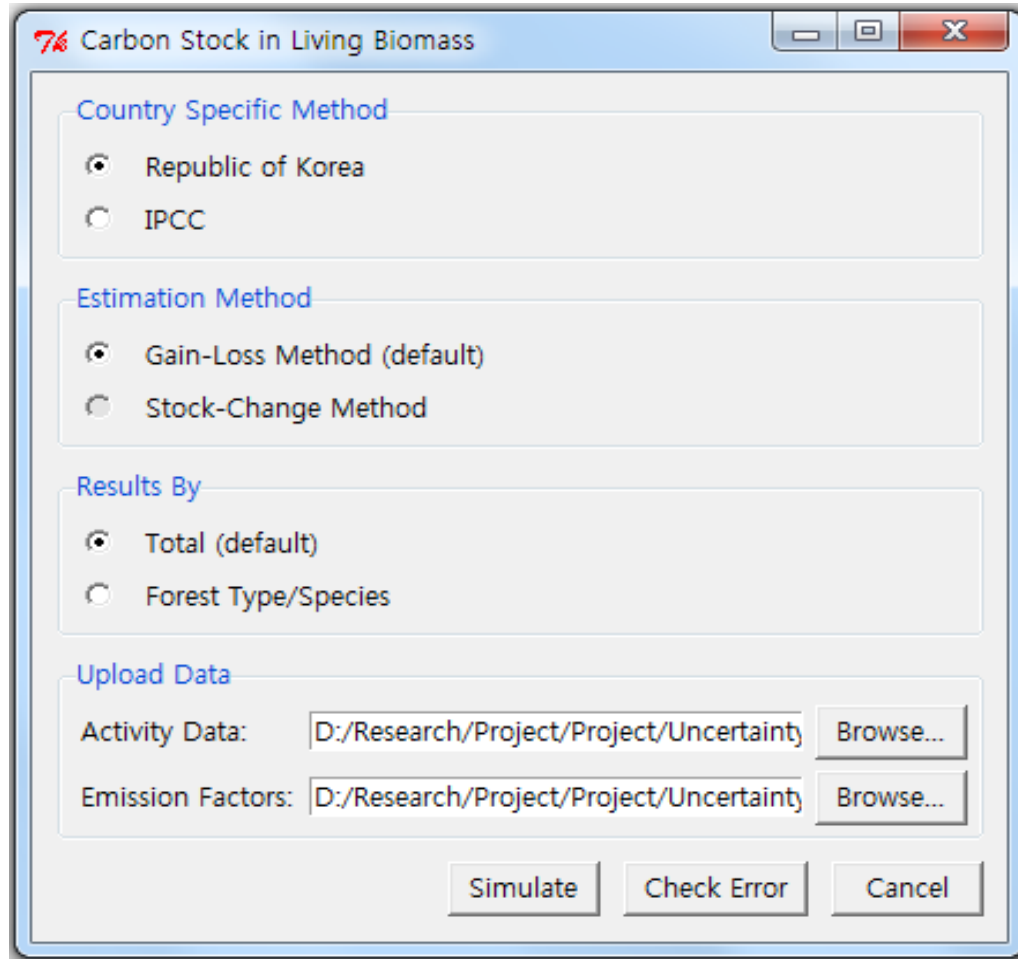
R는 많은 공헌자에의한 공동 프로젝트입니다
더 자세한것에 대해서는 'contributors()'라고 입력해 주십시오.
또는, R나 R의 패키지들 출판물로 인용할때의 형식에 대해서는
'citation()'라고 입력해주시오
'demo()'라고 입력하면, demos를 볼수가 있습니다.
'help()'라고 한다면, on-line help가 나옵니다.
'help.start()'로 HTML 브라우저에 의한 help가 보여집니다
'q()'라고 입력하면 R를 종료합니다
[이전에 저장된 workspace를 복귀합니다]

> uncertainty.analysis(|
```

Step 3: Open the Living Biomass Window



Step 4: Enter the Necessary Information

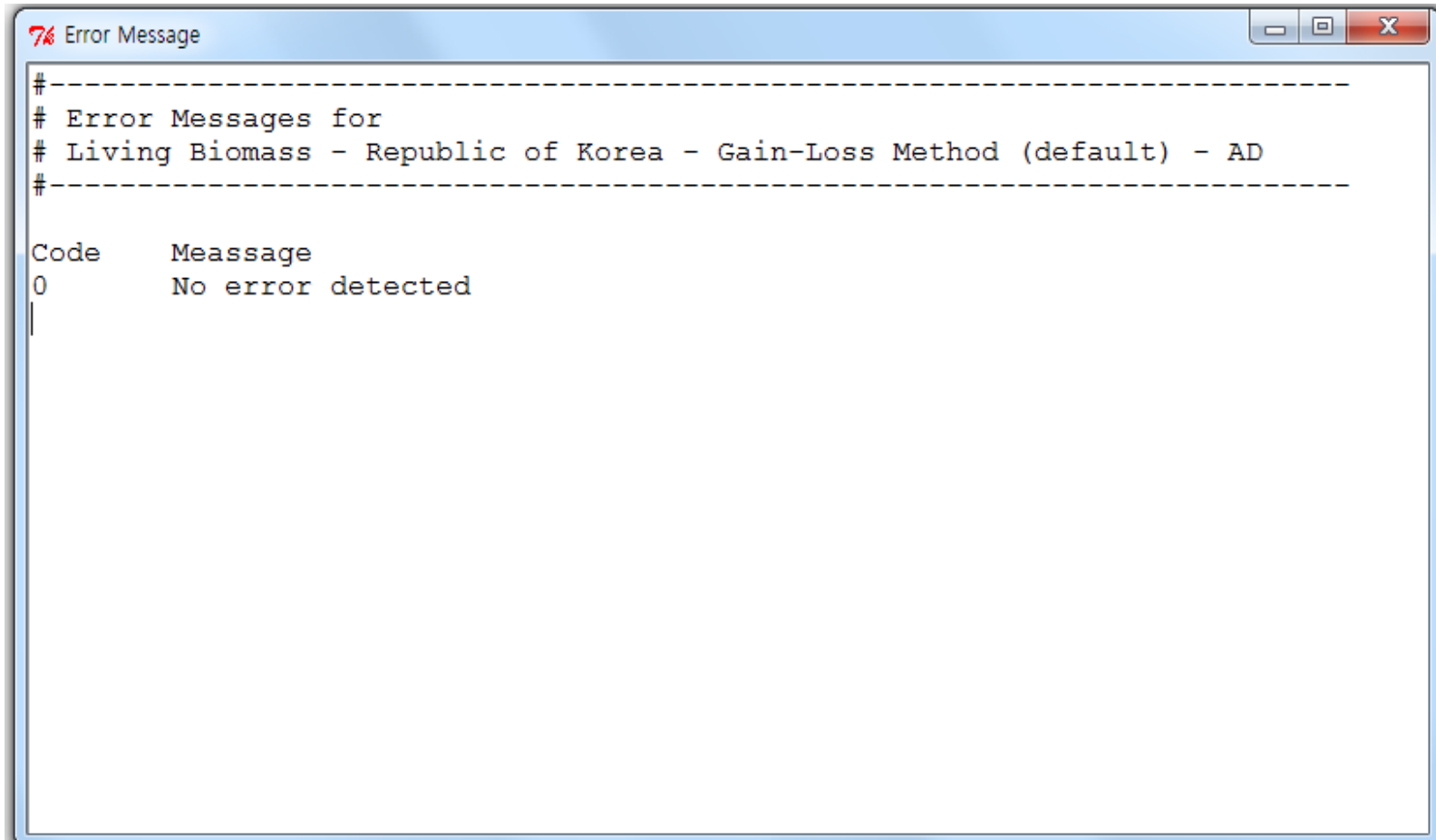


The screenshot shows a dialog box titled "Carbon Stock in Living Biomass" with a red "76" icon in the top-left corner. The dialog contains four sections with radio button options:

- Country Specific Method:**
 - Republic of Korea
 - IPCC
- Estimation Method:**
 - Gain-Loss Method (default)
 - Stock-Change Method
- Results By:**
 - Total (default)
 - Forest Type/Species
- Upload Data:**
 - Activity Data: - Emission Factors:

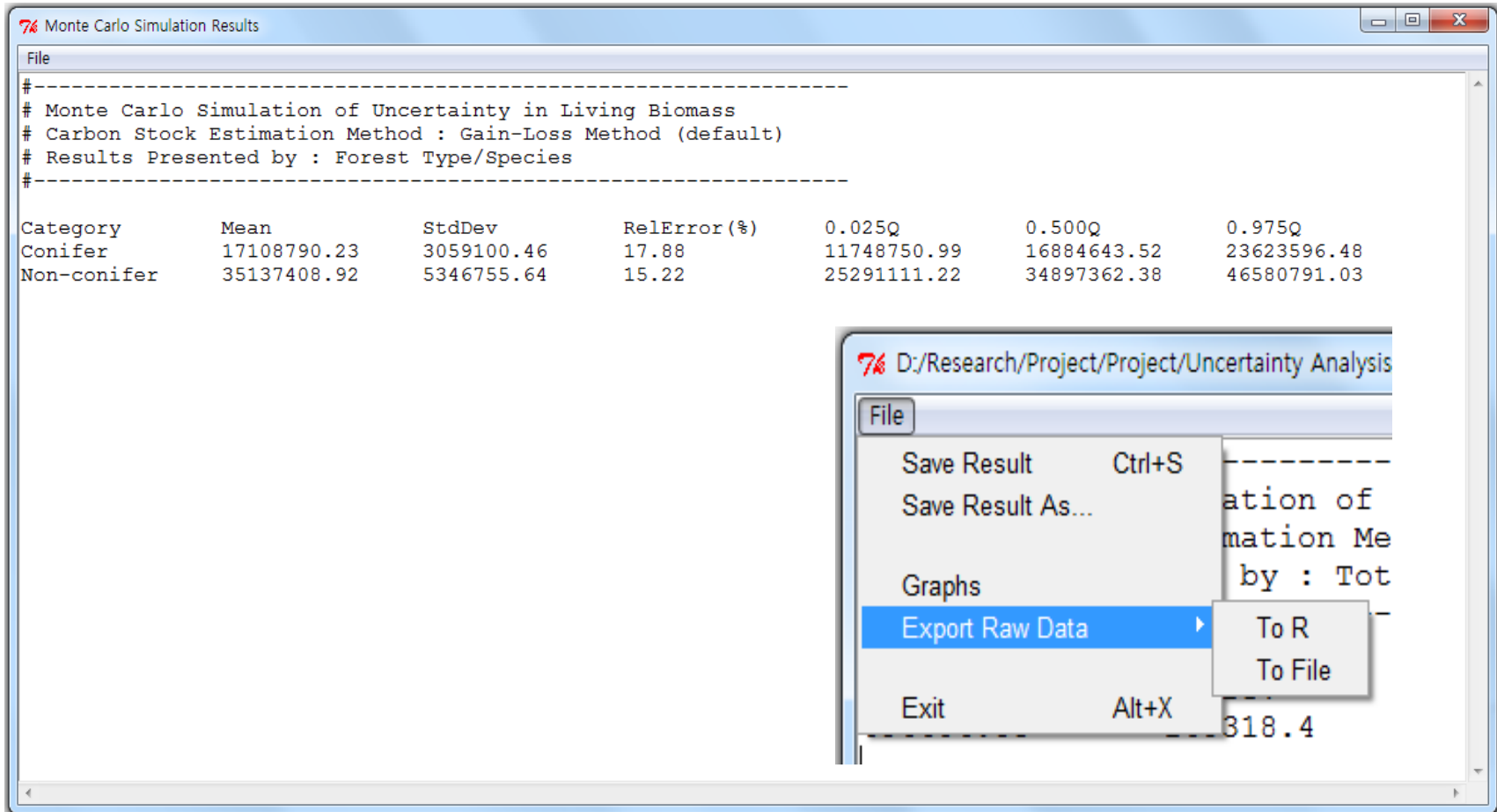
At the bottom of the dialog are three buttons: "Simulate", "Check Error", and "Cancel".

Step 5: Check for Data Error



```
7% Error Message
#-----
# Error Messages for
# Living Biomass - Republic of Korea - Gain-Loss Method (default) - AD
#-----
Code      Meassage
0         No error detected
|
```

Step 6: Run the Simulation and get Outputs



7% Monte Carlo Simulation Results

File

```
#-----
# Monte Carlo Simulation of Uncertainty in Living Biomass
# Carbon Stock Estimation Method : Gain-Loss Method (default)
# Results Presented by : Forest Type/Species
#-----
```

Category	Mean	StdDev	RelError(%)	0.025Q	0.500Q	0.975Q
Conifer	17108790.23	3059100.46	17.88	11748750.99	16884643.52	23623596.48
Non-conifer	35137408.92	5346755.64	15.22	25291111.22	34897362.38	46580791.03

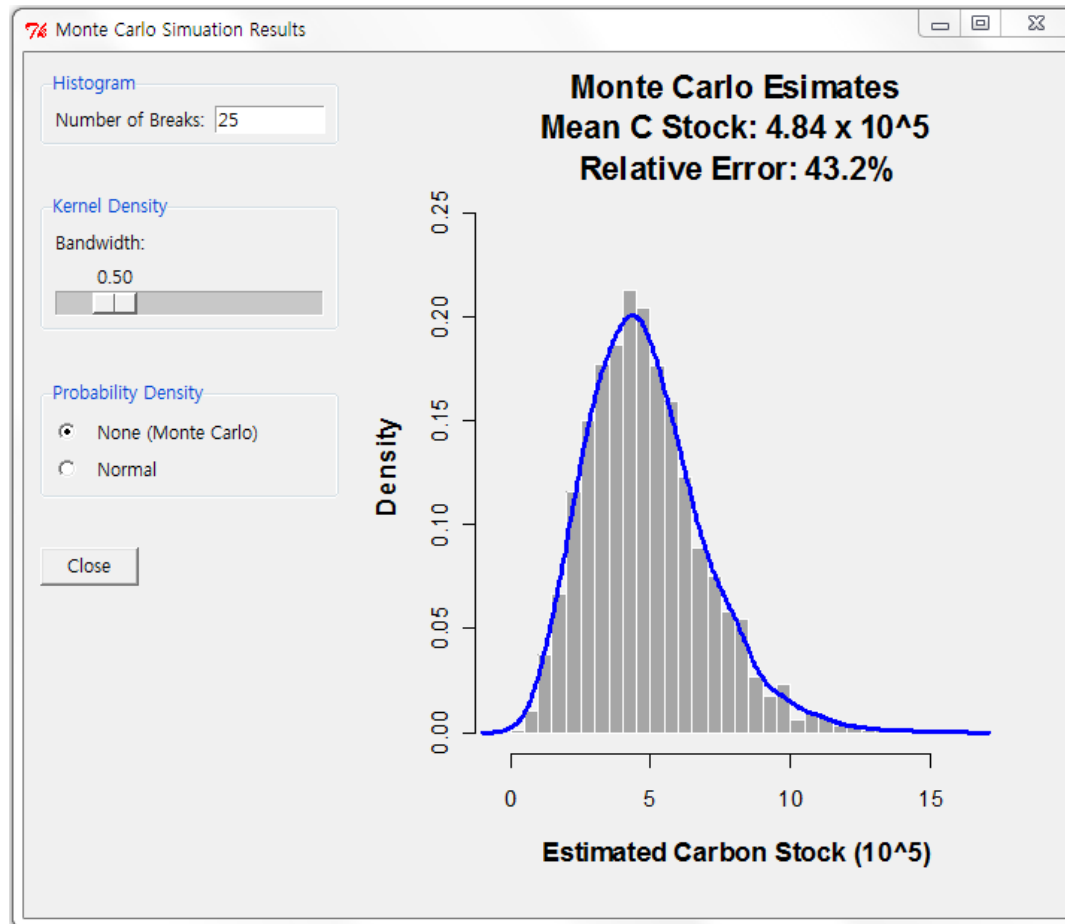
7% D:/Research/Project/Project/Uncertainty Analysis

File

- Save Result Ctrl+S
- Save Result As...
- Graphs
- Export Raw Data**
 - To R
 - To File
- Exit Alt+X

ation of
mation Me
by : Tot
318.4

Step 7: Display the Outputs





**Estimating uncertainty for
1990 - 2010 emission level of
Above- and belowground biomass in
Republic of Korea using
Gain-Loss Method**



Monte Carlo Uncertainty Analysis Program v1.0

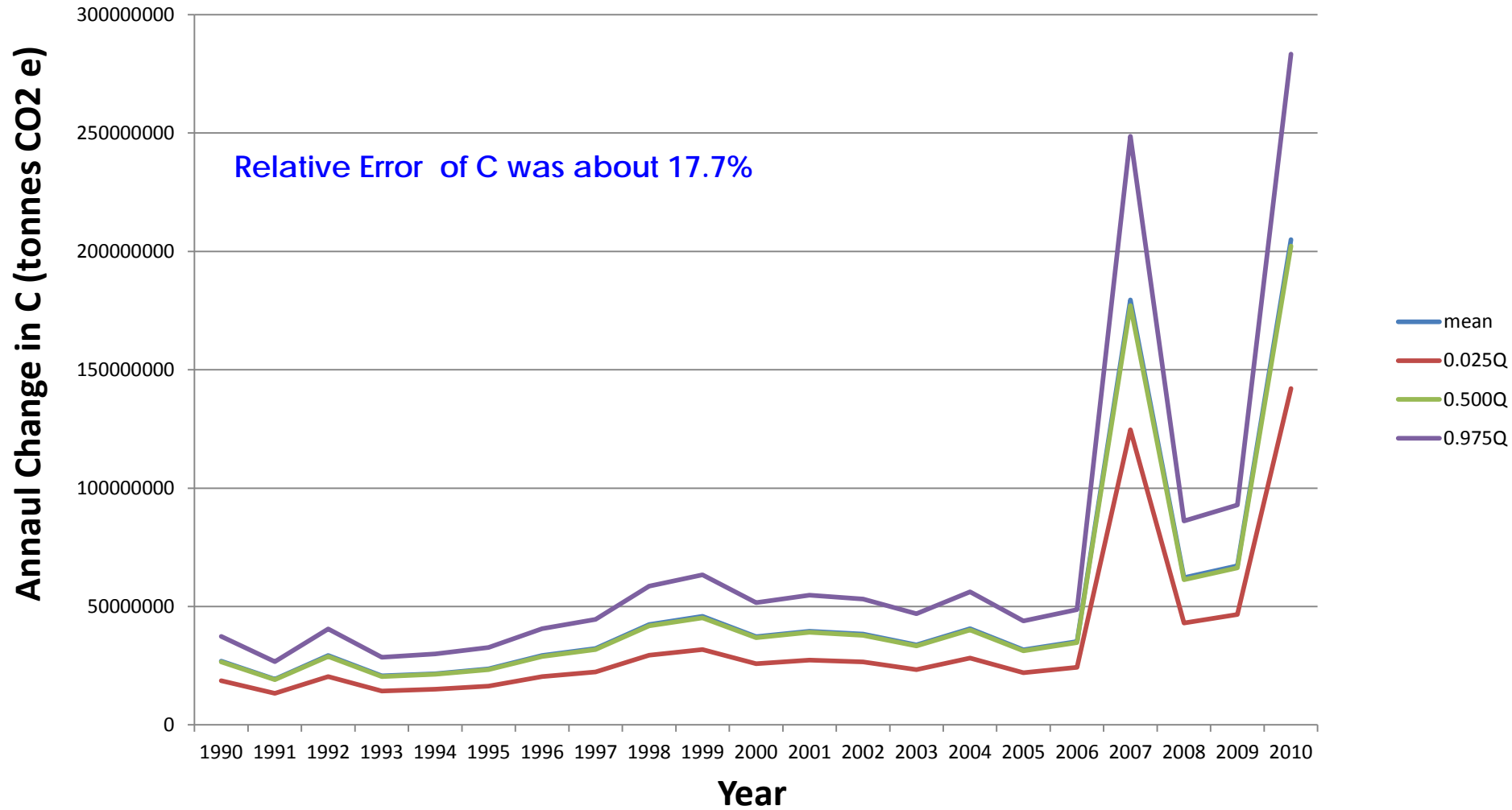
Introduction
The Package

The Structure
An Example

- **Data:**
 - Statistical Yearbook of Forestry published by Korea Forest Service

- **Assumptions:**
 1. 10% variation for all activity data and emission factors,
 2. Activity data are all assumed normally distributed,
 3. Emission factors are all assumed lognormally distributed,
 4. Half of harvest volume comes from conifer forests and half of harvest volume comes from non-conifer forests,
 5. Half of fire damage volume comes from conifer forests and another half from non-conifer forests,
 6. All fuelwood gathering come from non-conifer forests,
 7. 50,000 iterations.

Annual Change in C from 1990 - 2010 for Republic of Korea





Monte Carlo Uncertainty Analysis Program v1.0

**Thank You for Your Attention!
Questions?**