

EMPIRE DA

0.1

Generated by Doxygen 1.8.6

Wed Oct 1 2014 11:42:06



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# Chapter 1

## EMPIRE Data Assimilation Documentation

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### Date

Time-stamp: <2014-09-26 18:02:48 pbrowne>

## 1.1 Downloading

These codes are hosted on [www.bitbucket.org](http://www.bitbucket.org) and can be attained with the following commands:

```
git clone https://www.bitbucket.org/pbrowne/empire-data-assimilation.git
```

### Copyright

These codes are distributed under the GNU GPL v3 License. See LICENSE.txt.

## 1.2 Compiling

### 1.2.1 Compilation of the source code

The Makefile must be edited for the specific compiler setup. In the main directory you will find the file `Makefile`.

Edit the variables as follows:

- `FC` The fortran compiler

This has been tested with gfortran 4.8.2

- `FCOPTS` The options for the fortran compiler
- `LIB_LIST` The libraries to be called. Note this must include BLAS and LAPACK

To compile the source code, simply then type the command

```
make
```

If successful, the following executables are created in the `bin/` folder:

- [empire](#)
- [alltests](#)
- [test\\_h](#)
- [test\\_hqhtr](#)
- [test\\_q](#)
- [test\\_r](#)

To remove the object and executable files if compilation fails for some reason, run the following:

```
make clean
```

### 1.2.2 Compilation of the documentation

Documentation of the code is automatically generated using Doxygen, dot and pdflatex.

All of these packages must be installed for the following to work.

```
make docs
```

This will make an html webpage for the code, the mainpage for which is located in doc/html/index.html.

A latex version of the documentation will be built to the file doc/latex/refman.pdf.

To simply make the html version of the documentation (if pdflatex is not available) then use the command

```
make doc_html
```

## 1.3 Customising for specific models

*This is where the science and all the effort should happen!!*

The file [model\\_specific.f90](#) should be edited for the specific model which you wish to use. This contains a number of subroutines which need to be adapted for the model and the observation network. We list these subsequently.

- [configure\\_model](#) This is called early in the code and can be used to read in any data from files before subsequently using them in the below operations.
- [h](#) This is the observation operator
- [ht](#) This is the transpose of the observation operator
- [r](#) This is the observation error covariance matrix  $R$
- [rhalf](#) This is the square root of the observation error covariance matrix  $R^{\frac{1}{2}}$
- [solve\\_r](#) This is a linear solve with the observation error covariance matrix, i.e. given  $b$ , find  $x$  such that  $Rx = b$  or indeed,  $x = R^{-1}b$
- [solve\\_rhalf](#) This is a linear solve with the square root of the observation error covariance matrix, i.e. given  $b$ , find  $x$  such that  $R^{\frac{1}{2}}x = b$  or indeed,  $x = R^{-\frac{1}{2}}b$
- [q](#) This is the model error covariance matrix  $Q$
- [qhalf](#) This is the square root model error covariance matrix  $Q^{\frac{1}{2}}$
- [solve\\_hqht\\_plus\\_r](#) This is a linear solve with the matrix  $(HQH^T + R)$

Not all of these subroutines will be required for each filtering method you wish to use, so it may be advantageous to only implement the necessary ones.

## 1.4 Testing

You can test your user supplied routines by running the test codes found in the folder bin/.

These are by no means full-proof ways of ensuring that you have implemented things correctly, but should at least check what you have done for logical consistency.

For example, they will test if  $HH^T x = x$ , and if  $Q^{\frac{1}{2}} Q^{\frac{1}{2}} x = Qx$  for various different vectors  $x$ .

## 1.5 Linking to your model using EMPIRE

Full instructions on how to put the EMPIRE MPI commands into a new model can be found at [www.met.rdg.ac.uk/~darc/empire](http://www.met.rdg.ac.uk/~darc/empire).

## 1.6 Running

For example, to run **N\_MDL** copies of the model with **N\_DA** copies of empire, then the following are possible:

```
mpirun -np N_MDL model_executable : -np N_DA empire
```

```
aprun -n N_MDL -N N_MDL model_executable : -n N_DA -N N_DA empire
```

The empire executable is controlled by the namelist data file [pf\\_parameters.dat](#). As such, this file should be put in the directory where empire is executed.

## 1.7 Bug Reports and Functionality Requests

While the code is not too large, you may email me the issue or request [here](#).

However there is a webpage set up for this:

<https://bitbucket.org/pbrowne/empire-data-assimilation/issues>



## Chapter 2

# Data Type Index

### 2.1 Data Types List

Here are the data types with brief descriptions:

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<a href="#">hqht_plus_r</a>	. . . . .	12
<a href="#">pf_control</a>	Module <a href="#">pf_control</a> holds all the information to control the the main program . . . . .	13
<a href="#">pf_control::pf_control_type</a>	. . . . .	18
<a href="#">qdata</a>	Module as a place to store user specified data for $Q$ . . . . .	22
<a href="#">random</a>	A module for random number generation from the following distributions: . . . . .	24
<a href="#">rdata</a>	Module to hold user supplied data for $R$ observation error covariance matrix . . . . .	34
<a href="#">sizes</a>	Module that stores the dimension of observation and state spaces . . . . .	35





## Chapter 3

# File Index

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## Chapter 4

# Data Type Documentation

### 4.1 comms Module Reference

Module containing EMPIRE coupling data.

#### Public Member Functions

- subroutine [allocate\\_data](#)
- subroutine [deallocate\\_data](#)
- subroutine [initialise\\_mpi](#)

*subroutine to make EMPIRE connections and saves details into [pf\\_control](#) module*

#### Public Attributes

- integer [cpl\\_mpi\\_comm](#)
- integer [mype\\_id](#)
- integer [myrank](#)
- integer [nproc](#)
- integer [pf\\_mpi\\_comm](#)
- integer [pfrank](#)
- integer [npfs](#)
- integer, dimension(:), allocatable [gblcount](#)
- integer, dimension(:), allocatable [gbldisp](#)

#### 4.1.1 Detailed Description

Module containing EMPIRE coupling data.

Definition at line 30 of file comms.f90.

#### 4.1.2 Member Function/Subroutine Documentation

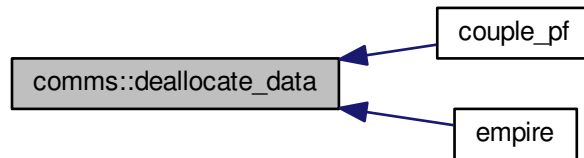
##### 4.1.2.1 subroutine `comms::allocate_data ( )`

Definition at line 37 of file comms.f90.

#### 4.1.2.2 subroutine comms::deallocate\_data ( )

Definition at line 43 of file comms.f90.

Here is the caller graph for this function:

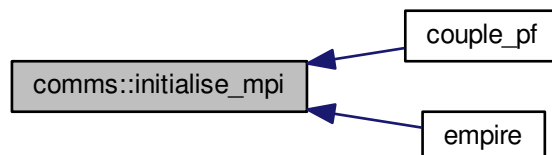


#### 4.1.2.3 subroutine comms::initialise\_mpi ( )

subroutine to make EMPIRE connections and saves details into [pf\\_control](#) module

Definition at line 50 of file comms.f90.

Here is the caller graph for this function:



### 4.1.3 Member Data Documentation

#### 4.1.3.1 integer comms::cpl\_mpi\_comm

Definition at line 31 of file comms.f90.

#### 4.1.3.2 integer, dimension(:), allocatable comms::gblcount

Definition at line 34 of file comms.f90.

#### 4.1.3.3 integer, dimension(:), allocatable comms::gbldisp

Definition at line 34 of file comms.f90.

#### 4.1.3.4 integer comms::mype\_id

Definition at line 31 of file comms.f90.

#### 4.1.3.5 integer comms::myrank

Definition at line 31 of file comms.f90.

#### 4.1.3.6 integer comms::npfs

Definition at line 33 of file comms.f90.

#### 4.1.3.7 integer comms::nproc

Definition at line 31 of file comms.f90.

#### 4.1.3.8 integer comms::pf\_mpi\_comm

Definition at line 32 of file comms.f90.

#### 4.1.3.9 integer comms::pfrank

Definition at line 32 of file comms.f90.

The documentation for this module was generated from the following file:

- [src/utils/comms.f90](#)

## 4.2 histogram\_data Module Reference

Module to control what variables are used to generate rank histograms.

### Public Member Functions

- subroutine [load\\_histogram\\_data](#)  
*subroutine to read from variables\_hist.dat which variables to be used to make the rank histograms*
- subroutine [kill\\_histogram\\_data](#)  
*subroutine to clean up arrays used in rank histograms*

### Public Attributes

- integer, dimension(:), allocatable [rank\\_hist\\_list](#)
- integer, dimension(:), allocatable [rank\\_hist\\_nums](#)
- integer [rhl\\_n](#)
- integer [rhn\\_n](#)

#### 4.2.1 Detailed Description

Module to control what variables are used to generate rank histograms.

Definition at line 29 of file histogram.f90.

## 4.2.2 Member Function/Subroutine Documentation

### 4.2.2.1 subroutine histogram\_data::kill\_histogram\_data ( )

subroutine to clean up arrays used in rank histograms

Definition at line 57 of file histogram.f90.

### 4.2.2.2 subroutine histogram\_data::load\_histogram\_data ( )

subroutine to read from variables\_hist.dat which variables to be used to make the rank histograms

Definition at line 37 of file histogram.f90.

## 4.2.3 Member Data Documentation

### 4.2.3.1 integer, dimension(:), allocatable histogram\_data::rank\_hist\_list

Definition at line 30 of file histogram.f90.

### 4.2.3.2 integer, dimension(:), allocatable histogram\_data::rank\_hist\_nums

Definition at line 31 of file histogram.f90.

### 4.2.3.3 integer histogram\_data::rhl\_n

Definition at line 32 of file histogram.f90.

### 4.2.3.4 integer histogram\_data::rhn\_n

Definition at line 32 of file histogram.f90.

The documentation for this module was generated from the following file:

- [src/utls/histogram.f90](#)

## 4.3 hqht\_plus\_r Module Reference

### Public Member Functions

- subroutine [load\\_hqhtr](#)
- subroutine [hqhtr\\_factor](#)
- subroutine [kill\\_hqhtr](#)

### 4.3.1 Detailed Description

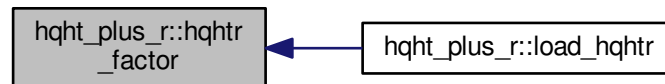
Definition at line 59 of file Rdata.f90.

### 4.3.2 Member Function/Subroutine Documentation

#### 4.3.2.1 subroutine hqht\_plus\_r::hqhtr\_factor ( )

Definition at line 69 of file Rdata.f90.

Here is the caller graph for this function:



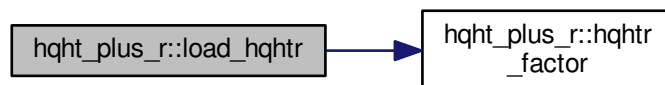
#### 4.3.2.2 subroutine hqht\_plus\_r::kill\_hqhtr ( )

Definition at line 74 of file Rdata.f90.

#### 4.3.2.3 subroutine hqht\_plus\_r::load\_hqhtr ( )

Definition at line 65 of file Rdata.f90.

Here is the call graph for this function:



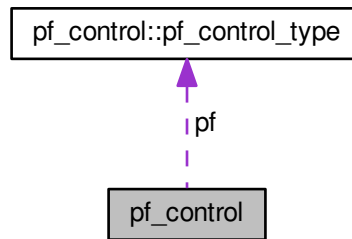
The documentation for this module was generated from the following file:

- [src/data/Rdata.f90](#)

## 4.4 pf\_control Module Reference

module [pf\\_control](#) holds all the information to control the the main program

Collaboration diagram for pf\_control:



## Data Types

- type [pf\\_control\\_type](#)

## Public Member Functions

- subroutine [set\\_pf\\_controls](#)  
*subroutine to ensure [pf\\_control](#) data is ok*
- subroutine [parse\\_pf\\_parameters](#)  
*subroutine to read the namelist file and save it to pf datatype Here we read [pf\\_parameters.dat](#)*
- subroutine [allocate\\_pf](#)  
*subroutine to allocate space for the filtering code*
- subroutine [deallocate\\_pf](#)  
*subroutine to deallocate space for the filtering code*

## Public Attributes

- [type\(pf\\_control\\_type\) pf](#)  
*the derived data type holding all controlling data*

### 4.4.1 Detailed Description

module [pf\\_control](#) holds all the information to control the the main program  
Definition at line 29 of file pf\_control.f90.

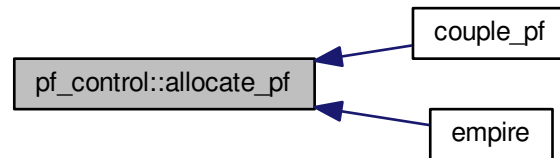
### 4.4.2 Member Function/Subroutine Documentation

#### 4.4.2.1 subroutine pf\_control::allocate\_pf ( )

subroutine to allocate space for the filtering code  
Definition at line 310 of file pf\_control.f90.



Here is the caller graph for this function:



#### 4.4.2.2 subroutine pf\_control::deallocate\_pf ( )

subroutine to deallocate space for the filtering code

Definition at line 332 of file `pf_control.f90`.

#### 4.4.2.3 subroutine pf\_control::parse\_pf\_parameters ( )

subroutine to read the namelist file and save it to pf datatype Here we read [pf\\_parameters.dat](#)

[pf\\_parameters.dat](#) is a fortran namelist file. As such, within it there must be a line beginning

&pf\_params

To make it (probably) work, ensure there is a forward slash on the penultimate line and a blank line to end the file

This is just the fortran standard for namelists though.

On to the content...in any order, the [pf\\_parameters.dat](#) may contain the following things:

Integers:

- [time\\_obs](#)
- [time\\_bwn\\_obs](#)

Reals, double precision:

- [nudgefac](#)
- [nfac](#)
- [ufac](#)
- [Qscale](#)
- [keep](#)
- [rho](#)
- [len](#)

2 Characters:

- [type](#)

1 Character:

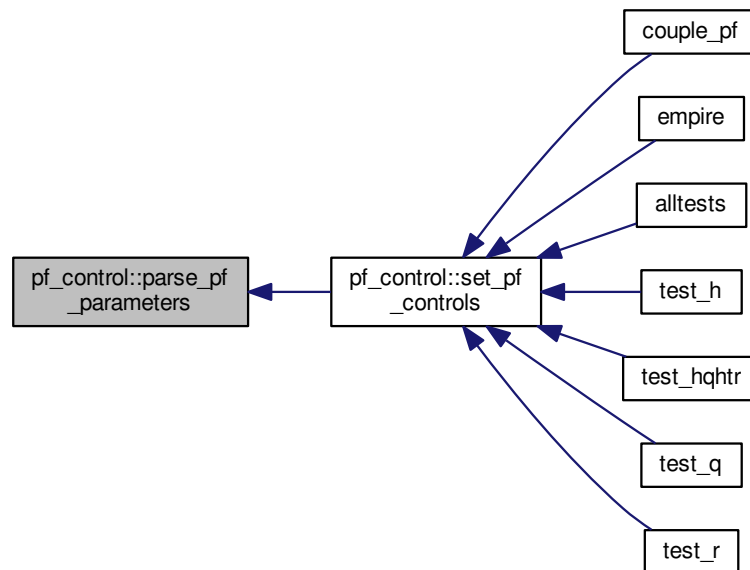
- [init](#)

Logicals:

- [gen\\_Q](#)
- [gen\\_data](#)
- [use\\_talagrand](#)
- [use\\_weak](#)
- [use\\_var](#)
- [use\\_traj](#)
- [use\\_rmse](#)
- [human\\_readable](#)

Definition at line 141 of file pf\_control.f90.

Here is the caller graph for this function:



#### 4.4.2.4 subroutine `pf_control::set_pf_controls` ( )

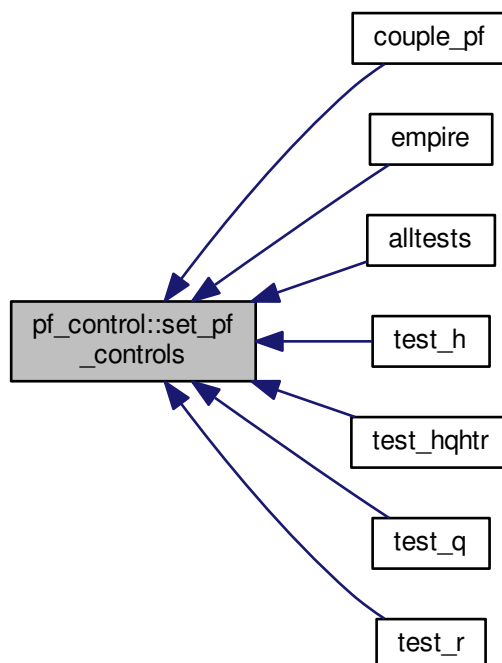
subroutine to ensure [pf\\_control](#) data is ok

Definition at line 74 of file pf\_control.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



### 4.4.3 Member Data Documentation

#### 4.4.3.1 `type(pf_control_type) pf_control::pf`

the derived data type holding all controlling data

Definition at line 69 of file `pf_control.f90`.

The documentation for this module was generated from the following file:

- `src/controllers/pf_control.f90`

## 4.5 pf\_control::pf\_control\_type Type Reference

### Public Attributes

- integer `nens`  
*the total number of ensemble members*
- real(kind=kind(1.0d0)), dimension(:), allocatable `weight`  
*the negative log of the weights of the particles*
- integer `time_obs`  
*the number of observations we will assimilate*
- integer `time_bwn_obs`  
*the number of model timesteps between observations*
- real(kind=kind(1.0d0)) `nudgefac`  
*the nudging factor*
- logical `gen_data`  
*true generates synthetic obs for a twin experiment*
- logical `gen_q`  
*true attempts to build up  $Q$  from long model run*
- logical `human_readable`  
*unused*
- integer `timestep` = 0  
*the current timestep as the model progresses*
- real(kind=kind(1.0d0)), dimension(:, :), allocatable `psi`  
*state vector of ensemble members on this mpi process*
- real(kind=kind(1.0d0)), dimension(:), allocatable `mean`  
*mean state vector*
- real(kind=kind(1.0d0)) `nfac`  
*standard deviation of normal distribution in mixture density*
- real(kind=kind(1.0d0)) `ufac`  
*half width of the uniform distribution in mixture density*
- real(kind=kind(1.0d0)) `efac`
- real(kind=kind(1.0d0)) `keep`  
*proportion of particles to keep in EWPF EW step*
- real(kind=kind(1.0d0)) `time`  
*dunno*
- real(kind=kind(1.0d0)) `qscale`  
*scalar to multiply  $Q$  by*
- real(kind=kind(1.0d0)) `rho`  
*enkf inflation factor so that  $P_f = (1 + \rho)P_f$*
- real(kind=kind(1.0d0)) `len`  
 *$R$  localisation length scale.*
- integer `couple_root`  
*empire master processor*
- logical `use_talagrand`  
*switch if true outputs rank histograms*
- logical `use_weak`  
*switch unused*
- logical `use_mean`  
*switch if true outputs ensemble mean*
- logical `use_var`  
*switch if true outputs ensemble variance*

- logical `use_traj`  
*switch if true outputs trajectories*
- logical `use_rmse`  
*switch if true outputs Root Mean Square Errors*
- integer, dimension(:,:), allocatable `talagrand`  
*storage for rank histograms*
- integer `count`  
*number of ensemble members associated with this MPI process*
- integer, dimension(:), allocatable `particles`  
*particles associates with this MPI process*
- character(2) `type`  
*which filter to use*
- character(1) `init`  
*which method to initialise ensemble*

#### 4.5.1 Detailed Description

Definition at line 31 of file pf\_control.f90.

#### 4.5.2 Member Data Documentation

##### 4.5.2.1 integer pf\_control::pf\_control\_type::count

number of ensemble members associated with this MPI process

Definition at line 64 of file pf\_control.f90.

##### 4.5.2.2 integer pf\_control::pf\_control\_type::couple\_root

empire master processor

Definition at line 56 of file pf\_control.f90.

##### 4.5.2.3 real(kind=kind(1.0d0)) pf\_control::pf\_control\_type::efac

Definition at line 46 of file pf\_control.f90.

##### 4.5.2.4 logical pf\_control::pf\_control\_type::gen\_data

true generates synthetic obs for a twin experiment

Definition at line 37 of file pf\_control.f90.

##### 4.5.2.5 logical pf\_control::pf\_control\_type::gen\_q

true attempts to build up  $Q$  from long model run

Definition at line 38 of file pf\_control.f90.

#### 4.5.2.6 `logical pf_control::pf_control_type::human_readable`

unused

Definition at line 40 of file `pf_control.f90`.

#### 4.5.2.7 `character(1) pf_control::pf_control_type::init`

which method to initialise ensemble

Definition at line 67 of file `pf_control.f90`.

#### 4.5.2.8 `real(kind=kind(1.0d0)) pf_control::pf_control_type::keep`

proportion of particles to keep in EWPF EW step

Definition at line 47 of file `pf_control.f90`.

#### 4.5.2.9 `real(kind=kind(1.0d0)) pf_control::pf_control_type::len`

R localisation length scale.

Definition at line 54 of file `pf_control.f90`.

#### 4.5.2.10 `real(kind=kind(1.0d0)), dimension(:), allocatable pf_control::pf_control_type::mean`

mean state vector

Definition at line 43 of file `pf_control.f90`.

#### 4.5.2.11 `integer pf_control::pf_control_type::nens`

the total number of ensemble members

Definition at line 32 of file `pf_control.f90`.

#### 4.5.2.12 `real(kind=kind(1.0d0)) pf_control::pf_control_type::nfac`

standard deviation of normal distribution in mixture density

Definition at line 44 of file `pf_control.f90`.

#### 4.5.2.13 `real(kind=kind(1.0d0)) pf_control::pf_control_type::nudgefac`

the nudging factor

Definition at line 36 of file `pf_control.f90`.

#### 4.5.2.14 `integer, dimension(:), allocatable pf_control::pf_control_type::particles`

particles associates with this MPI process

Definition at line 65 of file `pf_control.f90`.

**4.5.2.15** `real(kind=kind(1.0d0)), dimension(:,), allocatable pf_control::pf_control_type::psi`

state vector of ensemble members on this mpi process

Definition at line 42 of file pf\_control.f90.

**4.5.2.16** `real(kind=kind(1.0d0)) pf_control::pf_control_type::qscale`

scalar to multiply Q by

Definition at line 49 of file pf\_control.f90.

**4.5.2.17** `real(kind=kind(1.0d0)) pf_control::pf_control_type::rho`

enkf inflation factor so that  $P_f = (1 + \rho)P_f$

Definition at line 51 of file pf\_control.f90.

**4.5.2.18** `integer, dimension(:,), allocatable pf_control::pf_control_type::talagrand`

storage for rank histograms

Definition at line 63 of file pf\_control.f90.

**4.5.2.19** `real(kind=kind(1.0d0)) pf_control::pf_control_type::time`

dunno

Definition at line 48 of file pf\_control.f90.

**4.5.2.20** `integer pf_control::pf_control_type::time_bwn_obs`

the number of model timesteps between observations

Definition at line 35 of file pf\_control.f90.

**4.5.2.21** `integer pf_control::pf_control_type::time_obs`

the number of observations we will assimilate

Definition at line 34 of file pf\_control.f90.

**4.5.2.22** `integer pf_control::pf_control_type::timestep = 0`

the current timestep as the model progresses

Definition at line 41 of file pf\_control.f90.

**4.5.2.23** `character(2) pf_control::pf_control_type::type`

which filter to use

Definition at line 66 of file pf\_control.f90.

**4.5.2.24** `real(kind=kind(1.0d0)) pf_control::pf_control_type::ufac`

half width of the uniform distribution in mixture density

Definition at line 45 of file `pf_control.f90`.

**4.5.2.25** `logical pf_control::pf_control_type::use_mean`

switch if true outputs ensemble mean

Definition at line 59 of file `pf_control.f90`.

**4.5.2.26** `logical pf_control::pf_control_type::use_rmse`

switch if true outputs Root Mean Square Errors

Definition at line 62 of file `pf_control.f90`.

**4.5.2.27** `logical pf_control::pf_control_type::use_talagrand`

switch if true outputs rank histograms

Definition at line 57 of file `pf_control.f90`.

**4.5.2.28** `logical pf_control::pf_control_type::use_traj`

switch if true outputs trajectories

Definition at line 61 of file `pf_control.f90`.

**4.5.2.29** `logical pf_control::pf_control_type::use_var`

switch if true outputs ensemble variance

Definition at line 60 of file `pf_control.f90`.

**4.5.2.30** `logical pf_control::pf_control_type::use_weak`

switch unused

Definition at line 58 of file `pf_control.f90`.

**4.5.2.31** `real(kind=kind(1.0d0)), dimension(:), allocatable pf_control::pf_control_type::weight`

the negative log of the weights of the particles

Definition at line 33 of file `pf_control.f90`.

The documentation for this type was generated from the following file:

- [src/controllers/pf\\_control.f90](#)

## 4.6 qdata Module Reference

Module as a place to store user specified data for *Q*.



## Public Member Functions

- subroutine [loadq](#)  
*Subroutine to load in user data for Q.*
- subroutine [killq](#)

## Public Attributes

- integer [qn](#)
- integer [qne](#)
- integer, dimension(:), allocatable [qrow](#)
- integer, dimension(:), allocatable [qcol](#)
- real(kind=kind(1.0d0)), dimension(:), allocatable [qval](#)
- real(kind=kind(1.0d0)), dimension(:), allocatable [qdiag](#)
- real(kind=kind(1.0d0)) [qscale](#)

### 4.6.1 Detailed Description

Module as a place to store user specified data for  $Q$ .

- the model error covariance matrix

Definition at line 30 of file Qdata.f90.

### 4.6.2 Member Function/Subroutine Documentation

#### 4.6.2.1 subroutine qdata::killq ( )

Subroutine to deallocate user data for Q

Definition at line 44 of file Qdata.f90.

#### 4.6.2.2 subroutine qdata::loadq ( )

Subroutine to load in user data for Q.

Definition at line 38 of file Qdata.f90.

### 4.6.3 Member Data Documentation

#### 4.6.3.1 integer, dimension(:), allocatable qdata::qcol

Definition at line 33 of file Qdata.f90.

#### 4.6.3.2 real(kind=kind(1.0d0)), dimension(:), allocatable qdata::qdiag

Definition at line 34 of file Qdata.f90.

#### 4.6.3.3 integer qdata::qn

Definition at line 32 of file Qdata.f90.

#### 4.6.3.4 integer qdata::qne

Definition at line 32 of file Qdata.f90.

#### 4.6.3.5 integer, dimension(:), allocatable qdata::qrow

Definition at line 33 of file Qdata.f90.

#### 4.6.3.6 real(kind=kind(1.0d0)) qdata::qscale

Definition at line 35 of file Qdata.f90.

#### 4.6.3.7 real(kind=kind(1.0d0)), dimension(:), allocatable qdata::qval

Definition at line 34 of file Qdata.f90.

The documentation for this module was generated from the following file:

- [src/data/Qdata.f90](#)

## 4.7 random Module Reference

A module for random number generation from the following distributions:

### Public Member Functions

- real(kind=kind(1.0d+0)) function [random\\_normal](#) ()  
*function to get random normal with zero mean and stdev 1*
- real(kind=kind(1.0d+0)) function [random\\_gamma](#) (s, first)
- real(kind=kind(1.0d+0)) function [random\\_gamma1](#) (s, first)
- real(kind=kind(1.0d+0)) function [random\\_gamma2](#) (s, first)
- real(kind=kind(1.0d+0)) function [random\\_chisq](#) (ndf, first)
- real(kind=kind(1.0d+0)) function [random\\_exponential](#) ()
- real(kind=kind(1.0d+0)) function [random\\_weibull](#) (a)
- real(kind=kind(1.0d+0)) function [random\\_beta](#) (aa, bb, first)
- real(kind=kind(1.0d+0)) function [random\\_t](#) (m)
- subroutine [random\\_mvnorm](#) (n, h, d, f, first, x, ier)
- real(kind=kind(1.0d+0)) function [random\\_inv\\_gauss](#) (h, b, first)
- integer function [random\\_poisson](#) (mu, first)
- integer function [random\\_binomial1](#) (n, p, first)
- real(kind=kind(1.0d+0)) function [bin\\_prob](#) (n, p, r)
- real(dp) function [lngamma](#) (x)
- integer function [random\\_binomial2](#) (n, pp, first)
- integer function [random\\_neg\\_binomial](#) (sk, p)
- real(kind=kind(1.0d+0)) function [random\\_von\\_mises](#) (k, first)
- real(kind=kind(1.0d+0)) function [random\\_cauchy](#) ()
- subroutine [random\\_order](#) (order, n)
- subroutine [seed\\_random\\_number](#) (iounit)

### Public Attributes

- integer, parameter [dp](#) = SELECTED\_REAL\_KIND(12, 60)

### 4.7.1 Detailed Description

A module for random number generation from the following distributions:

Distribution Function/subroutine name

Normal (Gaussian) random\_normal Gamma random\_gamma Chi-squared random\_chisq Exponential random\_exponential Weibull random\_Weibull Beta random\_beta t random\_t Multivariate normal random\_mvnorm Generalized inverse Gaussian random\_inv\_gauss Poisson random\_Poisson Binomial random\_binomial1 \* random\_binomial2 \* Negative binomial random\_neg\_binomial von Mises random\_von\_Mises Cauchy random\_Cauchy

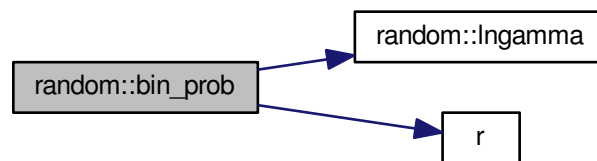
Definition at line 22 of file random\_d.f90.

### 4.7.2 Member Function/Subroutine Documentation

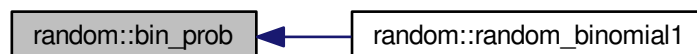
4.7.2.1 `real(kind=kind(1.0d+0)) function random::bin_prob ( integer, intent(in) n, real(kind=kind(1.0d+0)), intent(in) p, integer, intent(in) r )`

Definition at line 1000 of file random\_d.f90.

Here is the call graph for this function:



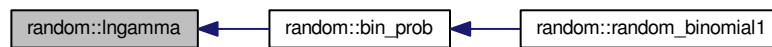
Here is the caller graph for this function:



4.7.2.2 `real (dp) function random::lngamma ( real (dp), intent(in) x )`

Definition at line 1018 of file random\_d.f90.

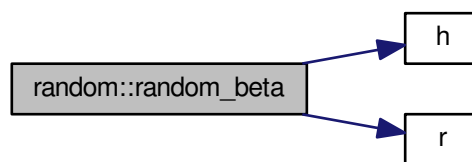
Here is the caller graph for this function:



4.7.2.3 `real(kind=kind(1.0d+0)) function random::random_beta ( real(kind=kind(1.0d+0)), intent(in) aa, real(kind=kind(1.0d+0)), intent(in) bb, logical, intent(in) first )`

Definition at line 371 of file random\_d.f90.

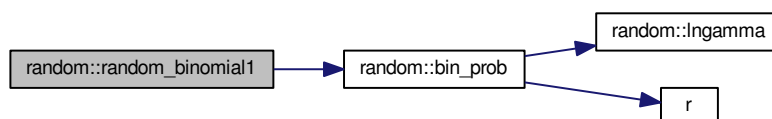
Here is the call graph for this function:



4.7.2.4 `integer function random::random_binomial1 ( integer, intent(in) n, real(kind=kind(1.0d+0)), intent(in) p, logical, intent(in) first )`

Definition at line 923 of file random\_d.f90.

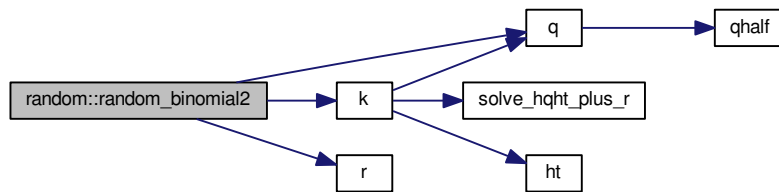
Here is the call graph for this function:



4.7.2.5 `integer function random::random_binomial2 ( integer, intent(in) n, real(kind=kind(1.0d+0)), intent(in) pp, logical, intent(in) first )`

Definition at line 1082 of file random\_d.f90.

Here is the call graph for this function:



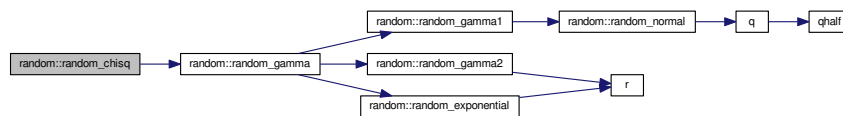
#### 4.7.2.6 `real(kind=kind(1.0d+0))` function `random::random_cauchy ( )`

Definition at line 1517 of file `random_d.f90`.

#### 4.7.2.7 `real(kind=kind(1.0d+0))` function `random::random_chisq ( integer, intent(in) ndf, logical, intent(in) first )`

Definition at line 308 of file `random_d.f90`.

Here is the call graph for this function:



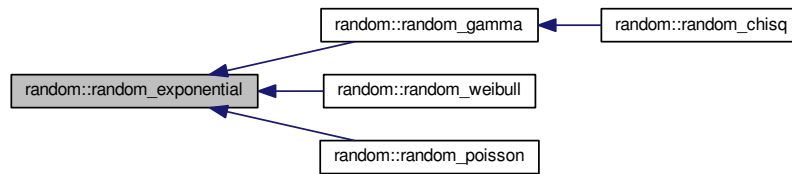
#### 4.7.2.8 `real(kind=kind(1.0d+0))` function `random::random_exponential ( )`

Definition at line 324 of file `random_d.f90`.

Here is the call graph for this function:



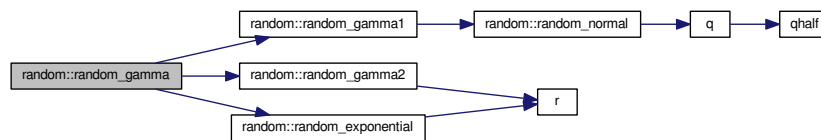
Here is the caller graph for this function:



4.7.2.9 `real(kind=kind(1.0d+0))` function `random::random_gamma ( real(kind=kind(1.0d+0)), intent(in) s, logical, intent(in) first )`

Definition at line 154 of file `random_d.f90`.

Here is the call graph for this function:



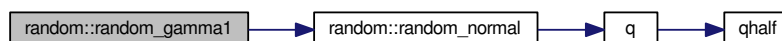
Here is the caller graph for this function:



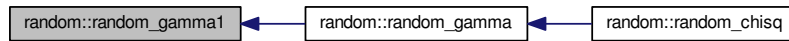
4.7.2.10 `real(kind=kind(1.0d+0))` function `random::random_gamma1 ( real(kind=kind(1.0d+0)), intent(in) s, logical, intent(in) first )`

Definition at line 189 of file `random_d.f90`.

Here is the call graph for this function:



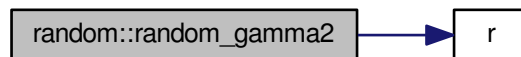
Here is the caller graph for this function:



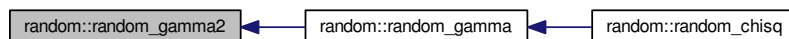
4.7.2.11 `real(kind=kind(1.0d+0)) function random::random_gamma2 ( real(kind=kind(1.0d+0)), intent(in) s, logical, intent(in) first )`

Definition at line 238 of file random\_d.f90.

Here is the call graph for this function:



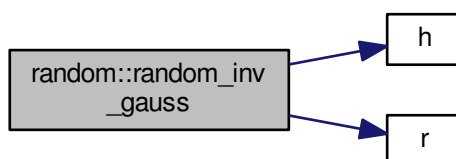
Here is the caller graph for this function:



4.7.2.12 `real(kind=kind(1.0d+0)) function random::random_inv_gauss ( real(kind=kind(1.0d+0)), intent(in) h, real(kind=kind(1.0d+0)), intent(in) b, logical, intent(in) first )`

Definition at line 610 of file random\_d.f90.

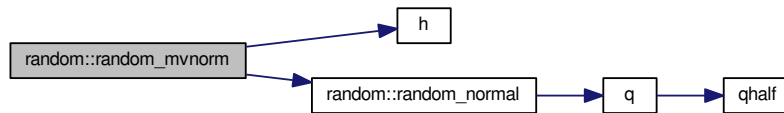
Here is the call graph for this function:



4.7.2.13 subroutine `random::random_mvnorm` ( integer, intent(in) *n*, real(kind=kind(1.0d+0)), dimension(:), intent(in) *h*, real(kind=kind(1.0d+0)), dimension(:), intent(in) *d*, real(kind=kind(1.0d+0)), dimension(:), intent(inout) *f*, logical, intent(in) *first*, real(kind=kind(1.0d+0)), dimension(:), intent(out) *x*, integer, intent(out) *ier* )

Definition at line 509 of file `random_d.f90`.

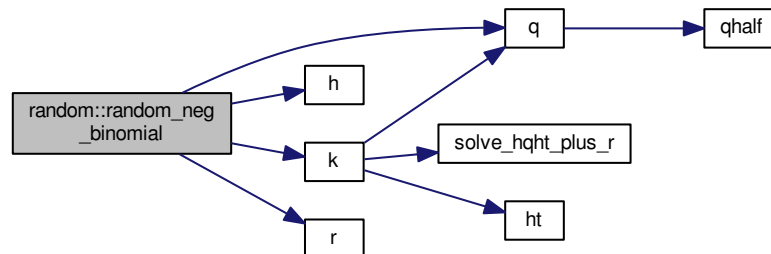
Here is the call graph for this function:



4.7.2.14 integer function `random::random_neg_binomial` ( real(kind=kind(1.0d+0)), intent(in) *sk*, real(kind=kind(1.0d+0)), intent(in) *p* )

Definition at line 1314 of file `random_d.f90`.

Here is the call graph for this function:



4.7.2.15 real(kind=kind(1.0d+0)) function `random::random_normal` ( )

function to get random normal with zero mean and stdev 1



## Returns

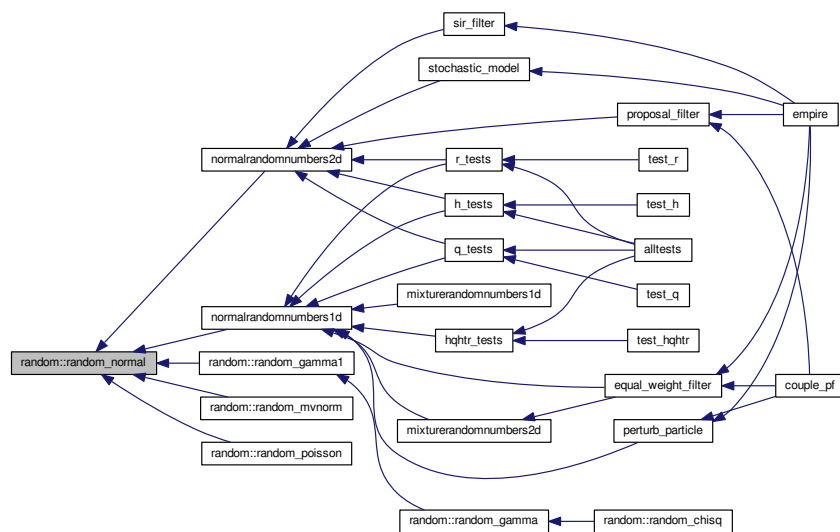
fn\_val

Definition at line 108 of file random\_d.f90.

Here is the call graph for this function:



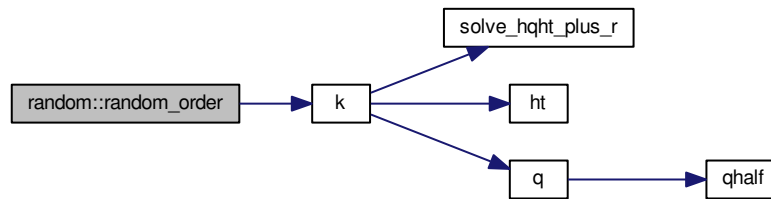
Here is the caller graph for this function:



#### 4.7.2.16 subroutine random::random\_order ( integer, dimension(n), intent(out) order, integer, intent(in) n )

Definition at line 1539 of file random\_d.f90.

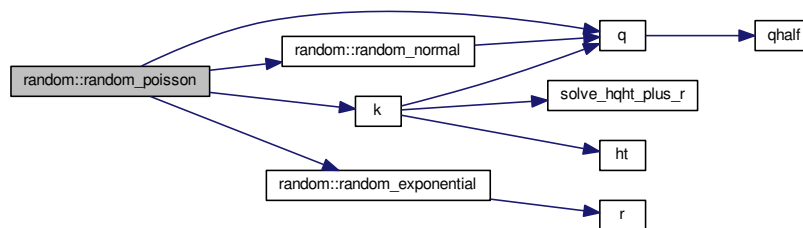
Here is the call graph for this function:



#### 4.7.2.17 integer function `random::random_poisson ( real(kind=kind(1.0d+0)), intent(in) mu, logical, intent(in) first )`

Definition at line 681 of file `random_d.f90`.

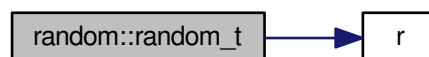
Here is the call graph for this function:



#### 4.7.2.18 `real(kind=kind(1.0d+0))` function `random::random_t ( integer, intent(in) m )`

Definition at line 448 of file `random_d.f90`.

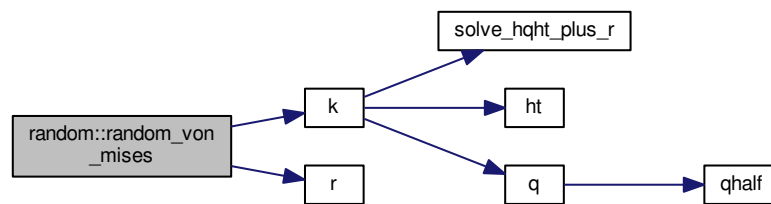
Here is the call graph for this function:



#### 4.7.2.19 `real(kind=kind(1.0d+0))` function `random::random_von_mises ( real(kind=kind(1.0d+0)), intent(in) k, logical, intent(in) first )`

Definition at line 1389 of file `random_d.f90`.

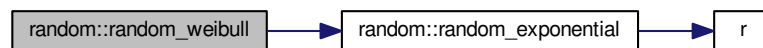
Here is the call graph for this function:



#### 4.7.2.20 `real(kind=kind(1.0d+0))` function `random::random_weibull ( real(kind=kind(1.0d+0)), intent(in) a )`

Definition at line 351 of file `random_d.f90`.

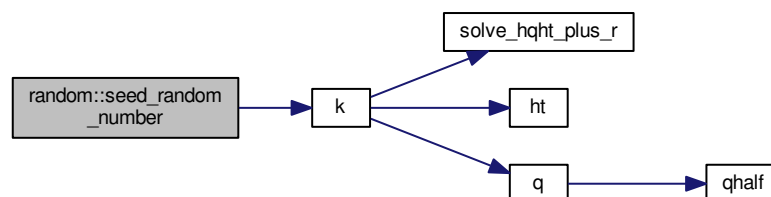
Here is the call graph for this function:



#### 4.7.2.21 subroutine `random::seed_random_number ( integer, intent(in) iounit )`

Definition at line 1573 of file `random_d.f90`.

Here is the call graph for this function:



### 4.7.3 Member Data Documentation

#### 4.7.3.1 `integer`, parameter `random::dp = SELECTED_REAL_KIND(12, 60)`

Definition at line 101 of file `random_d.f90`.

The documentation for this module was generated from the following file:

- [src/utils/random\\_d.f90](#)

## 4.8 rdata Module Reference

Module to hold user supplied data for  $R$  observation error covariance matrix.

### Public Member Functions

- subroutine [loadr](#)  
*Subroutine to load data for R.*
- subroutine [killr](#)

### Public Attributes

- integer [rn](#)
- integer [rne](#)
- integer, dimension(:), allocatable [row](#)
- integer, dimension(:), allocatable [rcol](#)
- real(kind=kind(1.0d0)), dimension(:), allocatable [rval](#)
- real(kind=kind(1.0d0)), dimension(:), allocatable [rdiag](#)

#### 4.8.1 Detailed Description

Module to hold user supplied data for  $R$  observation error covariance matrix.

Definition at line 29 of file Rdata.f90.

#### 4.8.2 Member Function/Subroutine Documentation

##### 4.8.2.1 subroutine [rdata::killr](#) ( )

Subroutine to deallocate R data

Definition at line 49 of file Rdata.f90.

##### 4.8.2.2 subroutine [rdata::loadr](#) ( )

Subroutine to load data for R.

Definition at line 36 of file Rdata.f90.

#### 4.8.3 Member Data Documentation

##### 4.8.3.1 integer, dimension(:), allocatable [rdata::rcol](#)

Definition at line 32 of file Rdata.f90.

##### 4.8.3.2 real(kind=kind(1.0d0)), dimension(:), allocatable [rdata::rdiag](#)

Definition at line 33 of file Rdata.f90.

#### 4.8.3.3 integer rdata::rn

Definition at line 31 of file Rdata.f90.

#### 4.8.3.4 integer rdata::rne

Definition at line 31 of file Rdata.f90.

#### 4.8.3.5 integer, dimension(:), allocatable rdata::rrow

Definition at line 32 of file Rdata.f90.

#### 4.8.3.6 real(kind=kind(1.0d0)), dimension(:), allocatable rdata::rval

Definition at line 33 of file Rdata.f90.

The documentation for this module was generated from the following file:

- [src/data/Rdata.f90](#)

## 4.9 sizes Module Reference

Module that stores the dimension of observation and state spaces.

### Public Attributes

- integer [obs\\_dim](#)  
*size of the observation space*
- integer [state\\_dim](#)  
*dimension of the model*

### 4.9.1 Detailed Description

Module that stores the dimension of observation and state spaces.

Definition at line 29 of file sizes.f90.

### 4.9.2 Member Data Documentation

#### 4.9.2.1 integer sizes::obs\_dim

size of the observation space

Definition at line 31 of file sizes.f90.

#### 4.9.2.2 integer sizes::state\_dim

dimension of the model

Definition at line 32 of file sizes.f90.

The documentation for this module was generated from the following file:

- [src/controlers/sizes.f90](#)

## Chapter 5

# File Documentation

### 5.1 model\_specific.f90 File Reference

#### Functions/Subroutines

- subroutine `configure_model`  
*subroutine called initially to set up details and data for model specific functions*
- subroutine `solve_r` (obsDim, nrhs, y, v, t)  
*subroutine to take an observation vector y and return v in observation space.*
- subroutine `solve_rhalf` (obsdim, nrhs, y, v, t)  
*subroutine to take an observation vector y and return v in observation space.*
- subroutine `solve_hqht_plus_r` (obsdim, y, v, t)  
*subroutine to take an observation vector y and return v in observation space.*
- subroutine `q` (nrhs, x, Qx)  
*subroutine to take a full state vector x and return Qx in state space.*
- subroutine `qhalf` (nrhs, x, Qx)  
*subroutine to take a full state vector x and return  $Q^{1/2}x$  in state space.*
- subroutine `r` (obsDim, nrhs, y, Ry, t)  
*subroutine to take an observation vector x and return Rx in observation space.*
- subroutine `rhalf` (obsDim, nrhs, y, Ry, t)  
*subroutine to take an observation vector x and return Rx in observation space.*
- subroutine `h` (obsDim, nrhs, x, hx, t)  
*subroutine to take a full state vector x and return H(x) in observation space.*
- subroutine `ht` (obsDim, nrhs, y, x, t)  
*subroutine to take an observation vector y and return  $x = H^T(y)$  in full state space.*
- subroutine `dist_st_ob` (xp, yp, dis, t)  
*subroutine to compute the distance between the variable in the state vector and the variable in the observations*

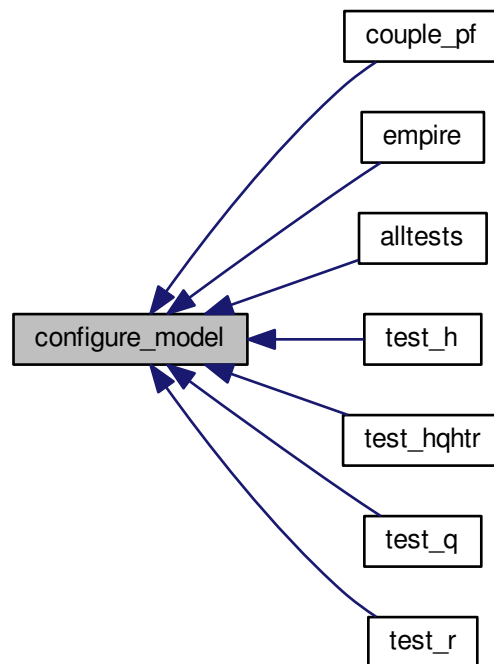
#### 5.1.1 Function/Subroutine Documentation

##### 5.1.1.1 subroutine `configure_model` ( )

subroutine called initially to set up details and data for model specific functions

Definition at line 30 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.2 subroutine `dist_st_ob` ( integer, intent(in) *xp*, integer, intent(in) *yp*, real(kind=kind(1.0d0)), intent(out) *dis*, integer, intent(in) *t* )

subroutine to compute the distance between the variable in the state vector and the variable in the observations

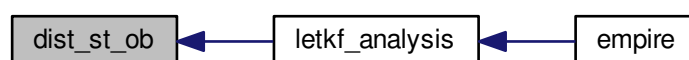
Compute  $\text{dist}(x(xp), y(yp))$

#### Parameters

in	<i>xp</i>	the index in the state vector
in	<i>yp</i>	the index in the observation vector
out	<i>dis</i>	the distance between $x(xp)$ and $y(yp)$
in	<i>t</i>	the current time index for observations

Definition at line 281 of file `model_specific.f90`.

Here is the caller graph for this function:





5.1.1.3 subroutine h ( integer, intent(in) *obsDim*, integer, intent(in) *nrhs*, real(kind=rk), dimension(state\_dim,nrhs), intent(in) *x*, real(kind=rk), dimension(obsdim,nrhs), intent(out) *hx*, integer, intent(in) *t* )

subroutine to take a full state vector *x* and return  $H(x)$  in observation space.

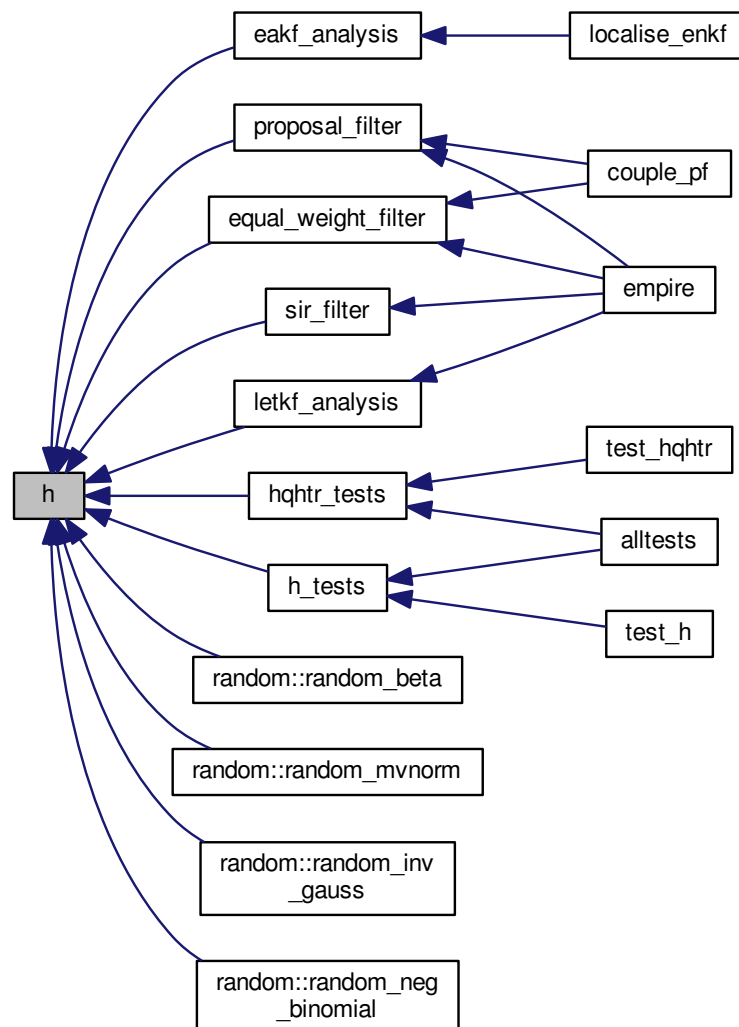
Given *x* compute  $Hx$

#### Parameters

in	<i>obsdim</i>	the dimension of the observations
in	<i>nrhs</i>	the number of right hand sides
in	<i>x</i>	the input vectors in state space
out	<i>hx</i>	the resulting vector in observation space where $hx = Hx$
in	<i>t</i>	the timestep

Definition at line 232 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.4 subroutine ht ( integer, intent(in) *obsDim*, integer, intent(in) *nrhs*, real(kind=rk), dimension(obsdim,nrhs), intent(in) *y*,  
real(kind=rk), dimension(state\_dim,nrhs), intent(out) *x*, integer, intent(in) *t* )

subroutine to take an observation vector  $y$  and return  $x = H^T(y)$  in full state space.

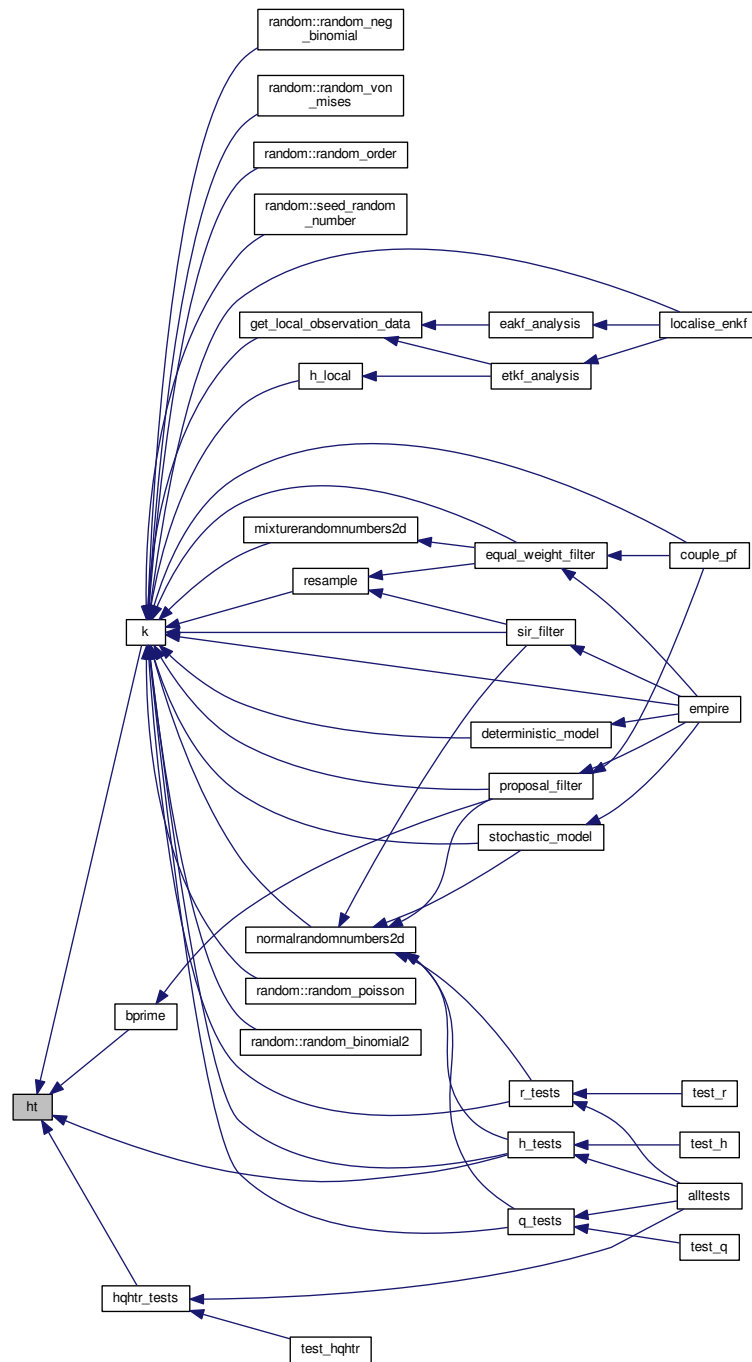
Given  $y$  compute  $x = H^T(y)$

#### Parameters

in	<i>obsdim</i>	the dimension of the observations
in	<i>nrhs</i>	the number of right hand sides
in	<i>y</i>	the input vectors in observation space
out	<i>x</i>	the resulting vector in state space where $x = H^T y$
in	<i>t</i>	the timestep

Definition at line 257 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.5 subroutine `q` ( integer, intent(in) *nrhs*, real(kind=rk), dimension(state\_dim,nrhs), intent(in) *x*, real(kind=rk), dimension(state\_dim,nrhs), intent(out) *Qx* )

subroutine to take a full state vector *x* and return *Qx* in state space.

Given *x* compute  $Qx$

**Parameters**

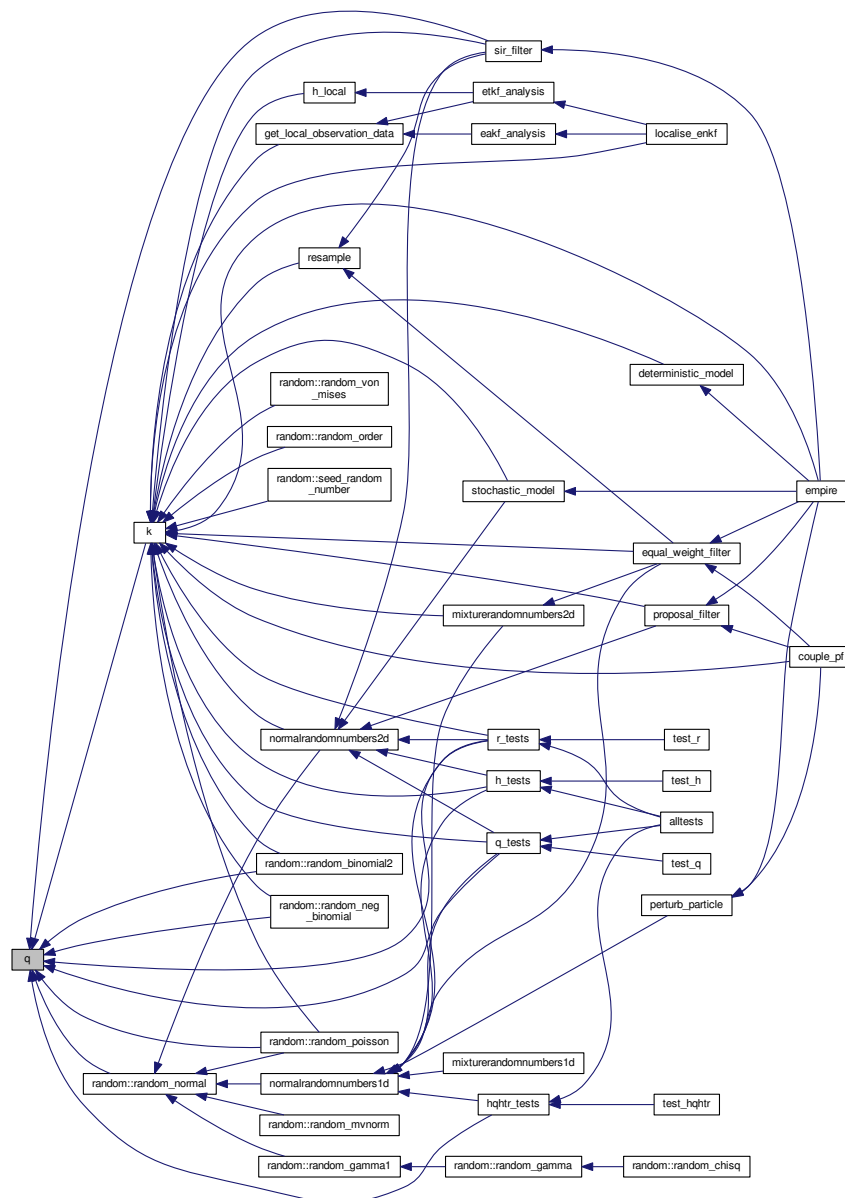
in	<i>nrhs</i>	the number of right hand sides
in	<i>x</i>	the input vector
out	<i>qx</i>	the resulting vector where $Qx = Qx$

Definition at line 140 of file model\_specific.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



5.1.1.6 subroutine qhalf ( integer, intent(in) nrhs, real(kind=rk), dimension(state\_dim,nrhs), intent(in) x, real(kind=rk), dimension(state\_dim,nrhs), intent(out) Qx )

subroutine to take a full state vector x and return  $Q^{1/2}x$  in state space.

Given x compute  $Q^{\frac{1}{2}}x$

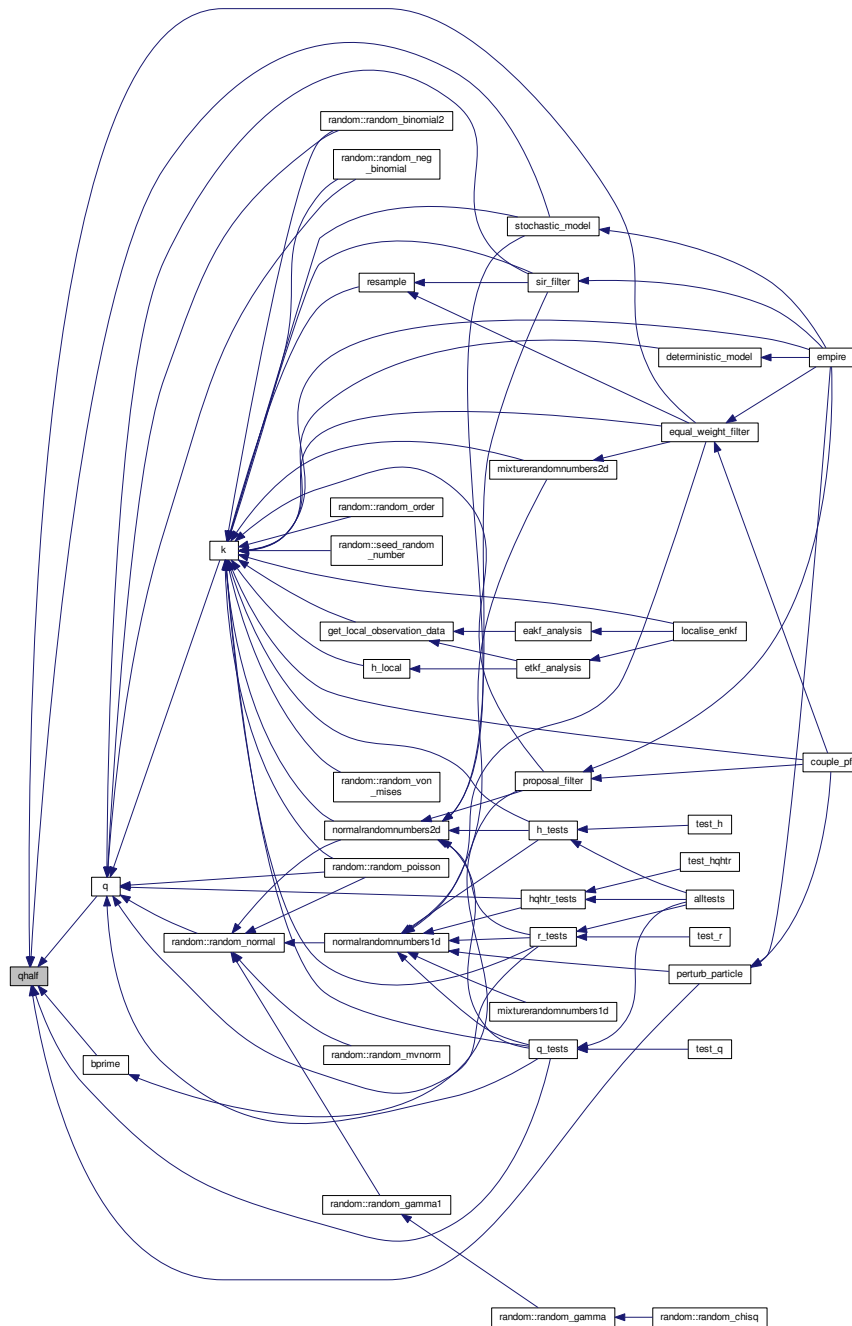
Parameters

in	nrhs	the number of right hand sides
----	------	--------------------------------

in	x	the input vector
out	qx	the resulting vector where $Qx = Q^{\frac{1}{2}}x$

Definition at line 165 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.7 subroutine `r` ( integer, intent(in) *obsDim*, integer, intent(in) *nrhs*, real(kind=rk), dimension(*obsdim*,*nrhs*), intent(in) *y*, real(kind=rk), dimension(*obsdim*,*nrhs*), intent(out) *Ry*, integer, intent(in) *t* )

subroutine to take an observation vector *x* and return *Rx* in observation space.

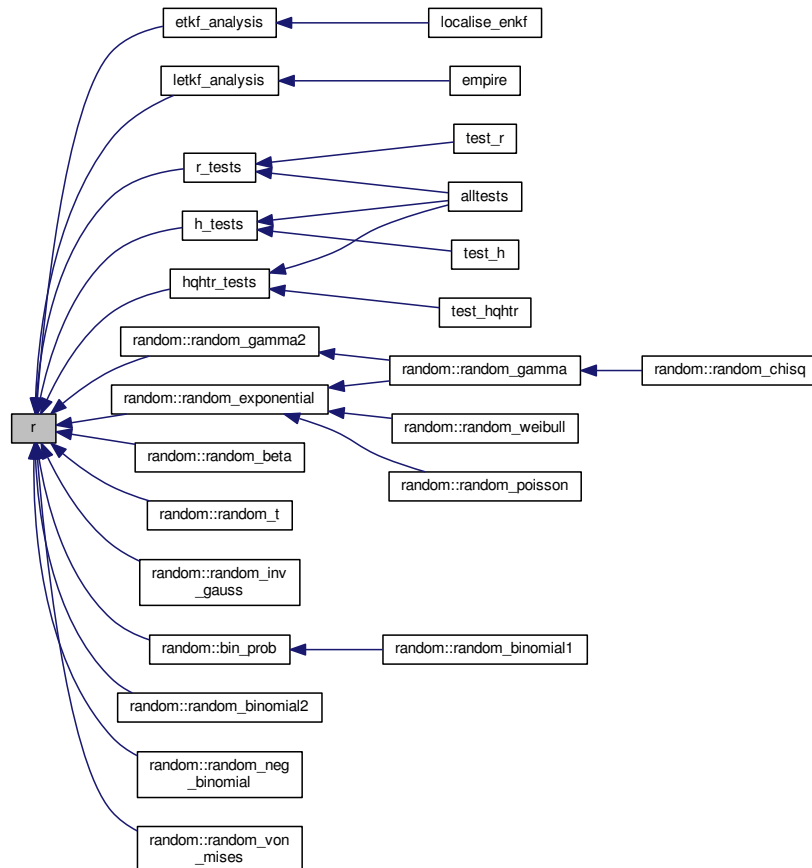
Given  $y$  compute  $Ry$

## Parameters

in	<i>obsdim</i>	the dimension of the observations
in	<i>nrhs</i>	the number of right hand sides
in	<i>y</i>	the input vector
out	<i>ry</i>	the resulting vectors where $Ry = Ry$
in	<i>t</i>	the timestep

Definition at line 186 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.8 subroutine rhalf ( integer,intent(in) *obsDim*, integer,intent(in) *nrhs*, real(kind=rk), dimension(*obsdim*,*nrhs*), intent(in) *y*, real(kind=rk), dimension(*obsdim*,*nrhs*), intent(out) *Ry*, integer, intent(in) *t* )

subroutine to take an observation vector *x* and return *Rx* in observation space.

Given *y* compute  $R^{\frac{1}{2}}y$

## Parameters

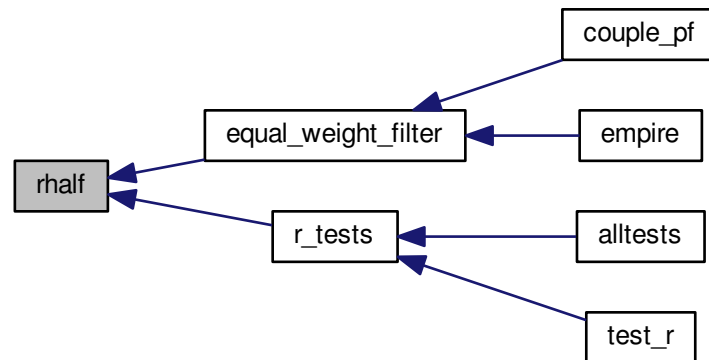
in	<i>obsdim</i>	the dimension of the observations
----	---------------	-----------------------------------



in	<i>nrhs</i>	the number of right hand sides
in	<i>y</i>	the input vector
out	<i>ry</i>	the resulting vector where $Ry = R^{\frac{1}{2}}y$
in	<i>t</i>	the timestep

Definition at line 208 of file model\_specific.f90.

Here is the caller graph for this function:



**5.1.1.9** subroutine solve\_hqht\_plus\_r ( integer, intent(in) *obsdim*, real(kind=rk), dimension(obsdim), intent(in) *y*, real(kind=rk), dimension(obsdim), intent(out) *v*, integer, intent(in) *t* )

subroutine to take an observation vector *y* and return *v* in observation space.

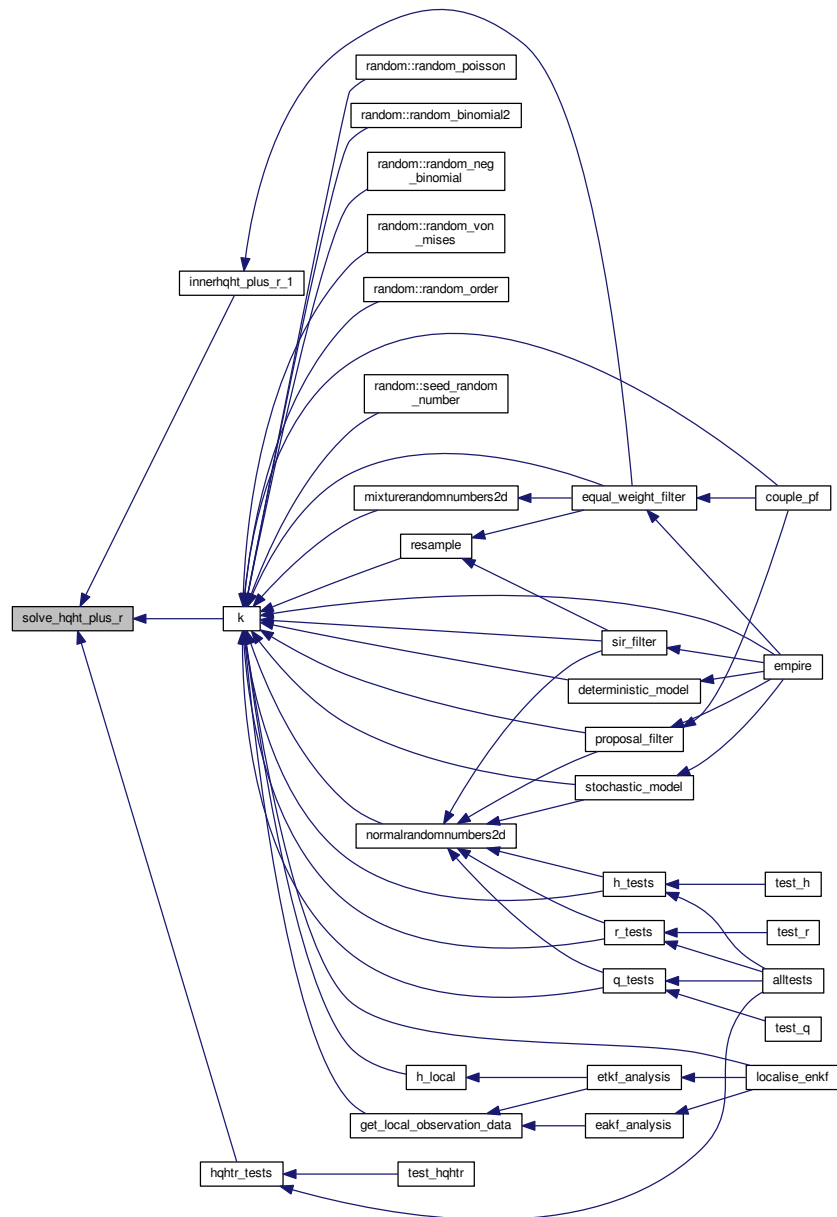
Given *y* find *v* such that  $(HQH^T + R)v = y$

#### Parameters

in	<i>obsdim</i>	the dimension of the observations
in	<i>y</i>	the input vector
out	<i>v</i>	the result where $v = (HQH^T + R)^{-1}y$
in	<i>t</i>	the timestep

Definition at line 120 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.10 subroutine solve\_r ( integer, intent(in) *obsDim*, integer, intent(in) *nrhs*, real(kind=rk), dimension(obsdim,nrhs), intent(in) *y*, real(kind=rk), dimension(obsdim,nrhs), intent(out) *v*, integer, intent(in) *t* )

subroutine to take an observation vector *y* and return *v* in observation space.

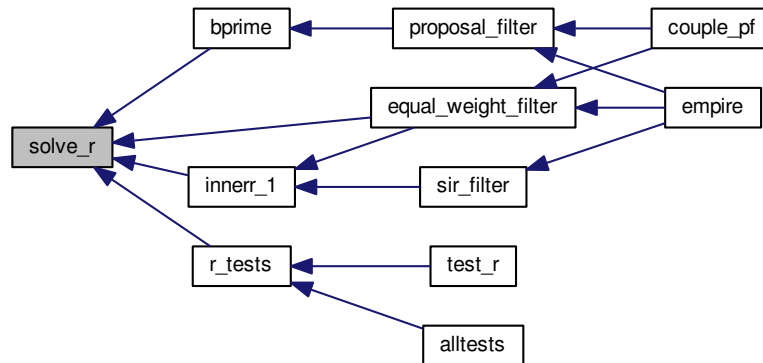
Given *y* find *v* such that  $Rv = y$

**Parameters**

in	<i>obsdim</i>	the dimension of the observations
in	<i>nrhs</i>	the number of right hand sides
in	<i>y</i>	input vector
out	<i>v</i>	result vector where $v = R^{-1}y$
in	<i>t</i>	the timestep

Definition at line 76 of file model\_specific.f90.

Here is the caller graph for this function:



5.1.1.11 subroutine solve\_half ( integer, intent(in) *obsdim*, integer, intent(in) *nrhs*, real(kind=rk), dimension(obsdim,nrhs), intent(in) *y*, real(kind=rk), dimension(obsdim,nrhs), intent(out) *v*, integer, intent(in) *t* )

subroutine to take an observation vector *y* and return *v* in observation space.

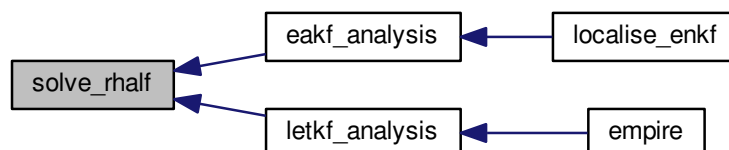
Given *y* find *v* such that  $R^{\frac{1}{2}}v = y$

#### Parameters

in	<i>obsdim</i>	the dimension of the observations
in	<i>nrhs</i>	the number of right hand sides
in	<i>y</i>	input vector
out	<i>v</i>	result vector where $v = R^{-\frac{1}{2}}y$
in	<i>t</i>	the timestep

Definition at line 97 of file model\_specific.f90.

Here is the caller graph for this function:



## 5.2 src/controllers/old\_pf\_couple.f90 File Reference

### Functions/Subroutines

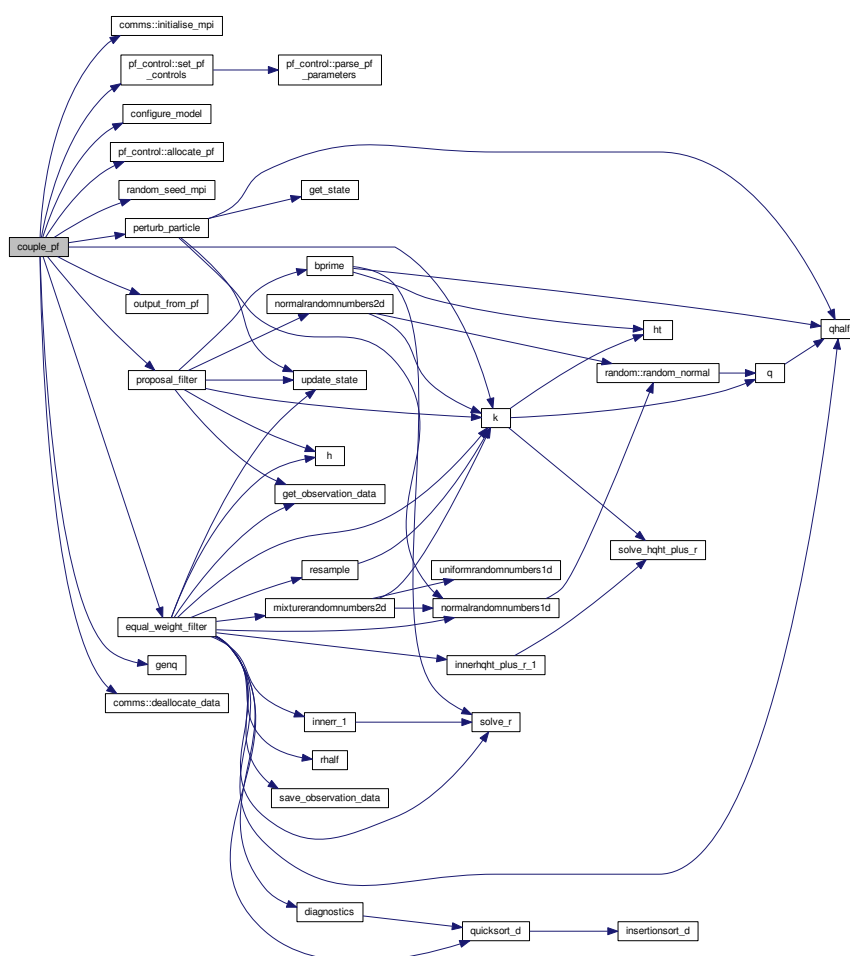
- program [couple\\_pf](#)

#### 5.2.1 Function/Subroutine Documentation

##### 5.2.1.1 program couple\_pf ( )

Definition at line 27 of file old\_pf\_couple.f90.

Here is the call graph for this function:



## 5.3 src/controllers/pf\_control.f90 File Reference

### Data Types

- module [pf\\_control](#)  
*module [pf\\_control](#) holds all the information to control the the main program*
- type [pf\\_control::pf\\_control\\_type](#)

## 5.4 src/controllers/pf\_couple.f90 File Reference

### Functions/Subroutines

- program [empire](#)

*the main program*

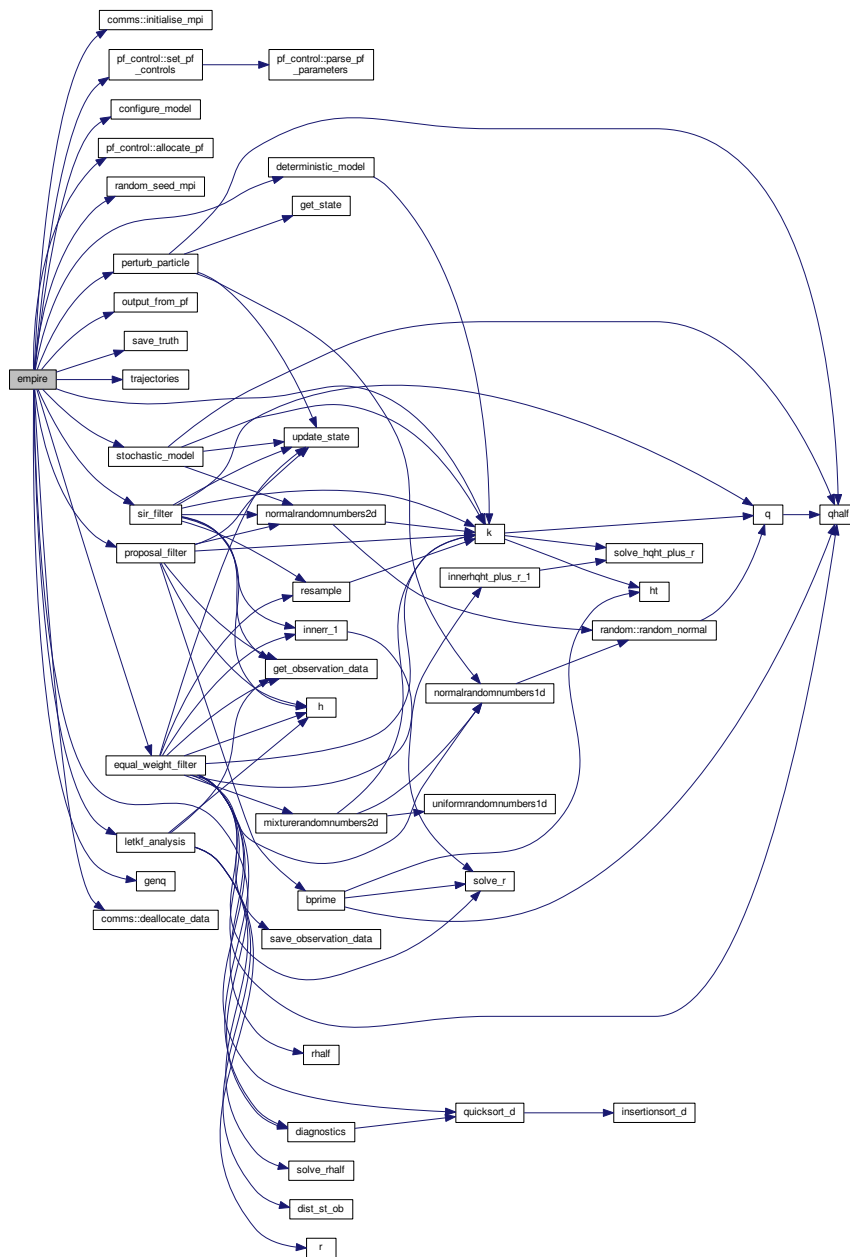
### 5.4.1 Function/Subroutine Documentation

#### 5.4.1.1 program [empire](#) ( )

the main program

Definition at line 37 of file pf\_couple.f90.

Here is the call graph for this function:



## 5.5 src/controllers/pf\_parameters.dat File Reference

### Variables

- &pf\_params [time\\_obs](#) =10
- &pf\_params [time\\_bwn\\_obs](#) =72
- &pf\_params [nudgefac](#) =0.5D3
- &pf\_params [gen\\_data](#) =.false.
- &pf\_params [nfac](#) =1.0D-5
- &pf\_params [ufac](#) =1.0D-5
- &pf\_params [keep](#) =0.95D0

- &pf\_params `Qscale` =1.0D3
- &pf\_params `human_readable` =1.0D3
- &pf\_params `use_talagrand` =.true.
- &pf\_params `use_weak` =.false.
- &pf\_params `use_mean` =.false.
- &pf\_params `use_var` =.false.
- &pf\_params `use_rmse` =.true.
- &pf\_params `gen_Q` =.false.
- &pf\_params `use_traj` =.true.
- &pf\_params `type` ='EW'

### 5.5.1 Variable Documentation

#### 5.5.1.1 & pf\_params gen\_data =.false.

Definition at line 5 of file pf\_parameters.dat.

#### 5.5.1.2 & pf\_params gen\_Q =.false.

Definition at line 16 of file pf\_parameters.dat.

#### 5.5.1.3 & pf\_params human\_readable =1.0D3

Definition at line 10 of file pf\_parameters.dat.

#### 5.5.1.4 & pf\_params keep =0.95D0

Definition at line 8 of file pf\_parameters.dat.

#### 5.5.1.5 & pf\_params nfac =1.0D-5

Definition at line 6 of file pf\_parameters.dat.

#### 5.5.1.6 & pf\_params nudgefacs =0.5D3

Definition at line 4 of file pf\_parameters.dat.

#### 5.5.1.7 & pf\_params Qscale =1.0D3

Definition at line 9 of file pf\_parameters.dat.

#### 5.5.1.8 & pf\_params time\_bwn\_obs =72

Definition at line 3 of file pf\_parameters.dat.

#### 5.5.1.9 & pf\_params time\_obs =10

Definition at line 2 of file pf\_parameters.dat.

#### 5.5.1.10 & pf\_params type ='EW'

Definition at line 18 of file pf\_parameters.dat.

#### 5.5.1.11 & pf\_params ufac =1.0D-5

Definition at line 7 of file pf\_parameters.dat.

#### 5.5.1.12 & pf\_params use\_mean =.false.

Definition at line 13 of file pf\_parameters.dat.

#### 5.5.1.13 & pf\_params use\_rmse =.true.

Definition at line 15 of file pf\_parameters.dat.

#### 5.5.1.14 & pf\_params use\_talagrand =.true.

Definition at line 11 of file pf\_parameters.dat.

#### 5.5.1.15 & pf\_params use\_traj =.true.

Definition at line 17 of file pf\_parameters.dat.

#### 5.5.1.16 & pf\_params use\_var =.false.

Definition at line 14 of file pf\_parameters.dat.

#### 5.5.1.17 & pf\_params use\_weak =.false.

Definition at line 12 of file pf\_parameters.dat.

## 5.6 src/controllers/sizes.f90 File Reference

### Data Types

- module [sizes](#)

*Module that stores the dimension of observation and state spaces.*

## 5.7 src/data/Qdata.f90 File Reference

### Data Types

- module [qdata](#)

*Module as a place to store user specified data for Q.*



## 5.8 src/data/Rdata.f90 File Reference

### Data Types

- module [rdata](#)  
*Module to hold user supplied data for R observation error covariance matrix.*
- module [hqht\\_plus\\_r](#)

## 5.9 src/DOC\_README.txt File Reference

## 5.10 src/filters/deterministic\_model.f90 File Reference

### Functions/Subroutines

- subroutine [deterministic\\_model](#)  
*subroutine to simply move the model forward in time one timestep PAB 21-05-2013*

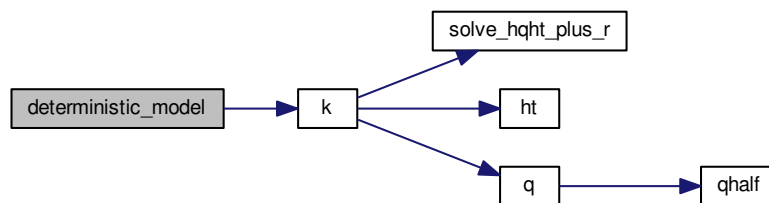
### 5.10.1 Function/Subroutine Documentation

#### 5.10.1.1 subroutine `deterministic_model ( )`

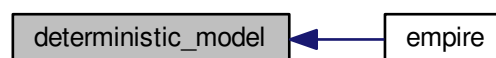
subroutine to simply move the model forward in time one timestep PAB 21-05-2013

Definition at line 32 of file `deterministic_model.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.11 src/filters/eakf\_analysis.f90 File Reference

### Functions/Subroutines

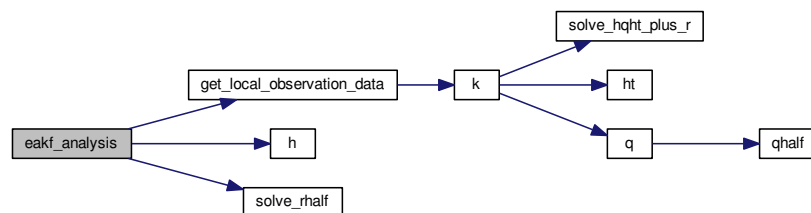
- subroutine [eakf\\_analysis](#) (num\_hor, num\_ver, this\_hor, this\_ver, boundary, x, N, stateDim, obsDim, rho)

### 5.11.1 Function/Subroutine Documentation

5.11.1.1 subroutine `eakf_analysis` ( integer, intent(in) *num\_hor*, integer, intent(in) *num\_ver*, integer, intent(in) *this\_hor*, integer, intent(in) *this\_ver*, integer, intent(in) *boundary*, real(kind=rk), dimension(statedim,n), intent(inout) *x*, integer, intent(in) *N*, integer, intent(in) *stateDim*, integer, intent(in) *obsDim*, real(kind=rk), intent(in) *rho* )

Definition at line 27 of file `eakf_analysis.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.12 src/filters/enkf\_specific.f90 File Reference

### Functions/Subroutines

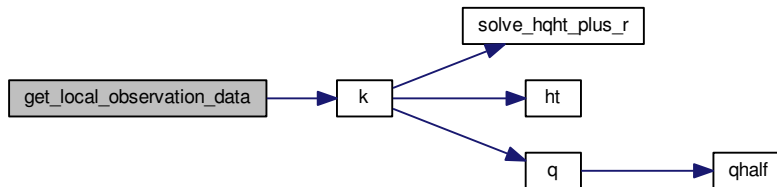
- subroutine [h\\_local](#) (num\_hor, num\_ver, this\_hor, this\_ver, boundary, nrhs, stateDim, x, obsDim, y)
- subroutine [solve\\_rhalf\\_local](#) (num\_hor, num\_ver, this\_hor, this\_ver, boundary, nrhs, obsDim, y, v)
- subroutine [get\\_local\\_observation\\_data](#) (num\_hor, num\_ver, this\_hor, this\_ver, boundary, obsDim, y)
- subroutine [localise\\_enkf](#) (enkf\_analysis)

### 5.12.1 Function/Subroutine Documentation

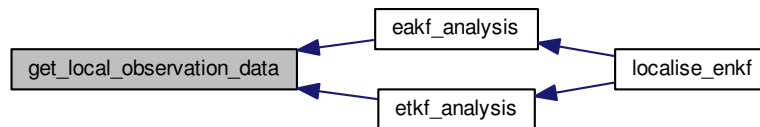
5.12.1.1 subroutine `get_local_observation_data` ( integer, intent(in) *num\_hor*, integer, intent(in) *num\_ver*, integer, intent(in) *this\_hor*, integer, intent(in) *this\_ver*, integer, intent(in) *boundary*, integer, intent(in) *obsDim*, real(kind=rk), dimension(*obsdim*), intent(out) *y* )

Definition at line 83 of file `enkf_specific.f90`.

Here is the call graph for this function:



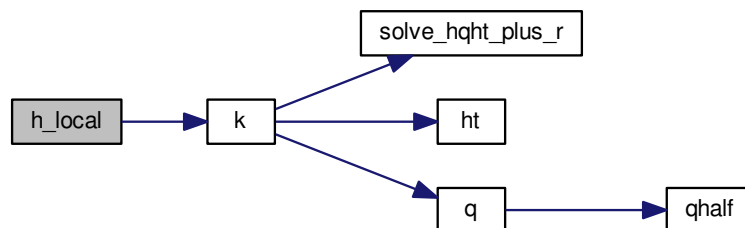
Here is the caller graph for this function:



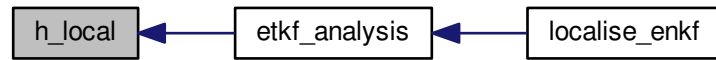
5.12.1.2 subroutine `h_local` ( integer, intent(in) *num\_hor*, integer, intent(in) *num\_ver*, integer, intent(in) *this\_hor*, integer, intent(in) *this\_ver*, integer, intent(in) *boundary*, integer, intent(in) *nrhs*, integer, intent(in) *stateDim*, real(kind=rk), dimension(*statedim*,*nrhs*), intent(in) *x*, integer, intent(in) *obsDim*, real(kind=rk), dimension(*obsdim*,*nrhs*), intent(out) *y* )

Definition at line 27 of file `enkf_specific.f90`.

Here is the call graph for this function:



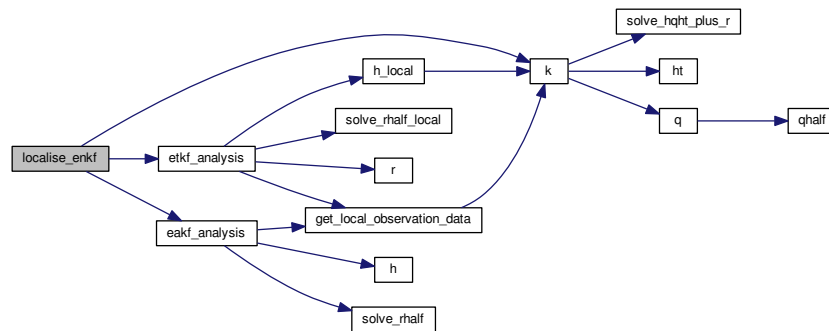
Here is the caller graph for this function:



#### 5.12.1.3 subroutine localise\_enkf ( integer, intent(in) *enkf\_analysis* )

Definition at line 142 of file *enkf\_specific.f90*.

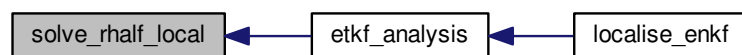
Here is the call graph for this function:



#### 5.12.1.4 subroutine solve\_half\_local ( integer, intent(in) *num\_hor*, integer, intent(in) *num\_ver*, integer, intent(in) *this\_hor*, integer, intent(in) *this\_ver*, integer, intent(in) *boundary*, integer, intent(in) *nrhs*, integer, intent(in) *obsDim*, real(kind=rk), dimension(obsdim,nrhs), intent(in) *y*, real(kind=rk), dimension(obsdim,nrhs), intent(out) *v* )

Definition at line 69 of file *enkf\_specific.f90*.

Here is the caller graph for this function:



## 5.13 src/filters/equivalent\_weights\_step.f90 File Reference

## Functions/Subroutines

- subroutine [equal\\_weight\\_filter](#)

*subroutine to do the equivalent weights step*

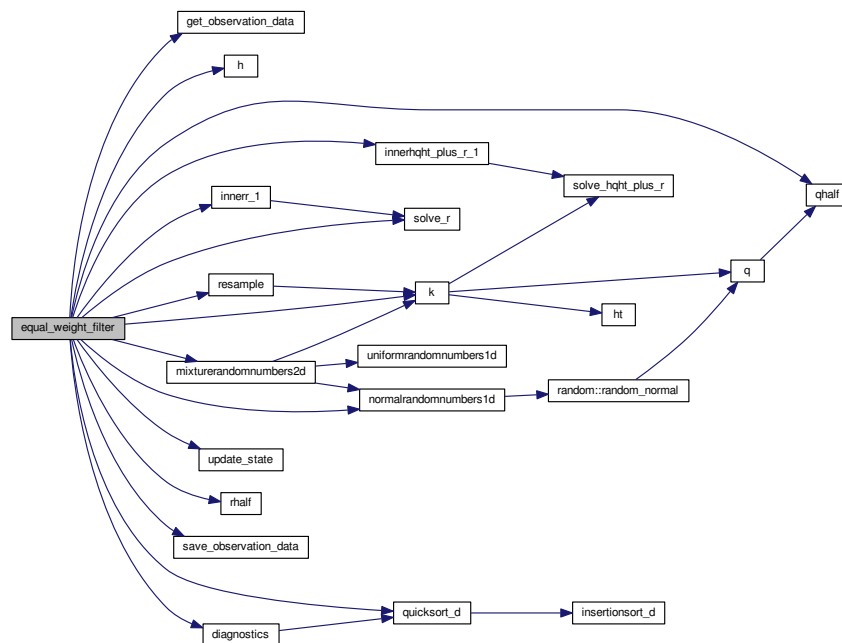
### 5.13.1 Function/Subroutine Documentation

#### 5.13.1.1 subroutine `equal_weight_filter` ( )

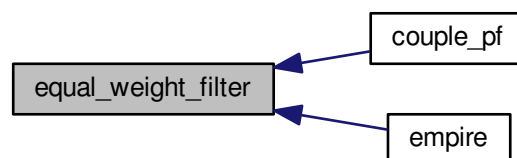
subroutine to do the equivalent weights step

Definition at line 29 of file `equivalent_weights_step.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.14 src/filters/etkf\_analysis.f90 File Reference

### Functions/Subroutines

- subroutine [etkf\\_analysis](#) (num\_hor, num\_ver, this\_hor, this\_ver, boundary, x, N, stateDim, obsDim, rho)  
*subroutine to perform the ensemble transform Kalman filter*

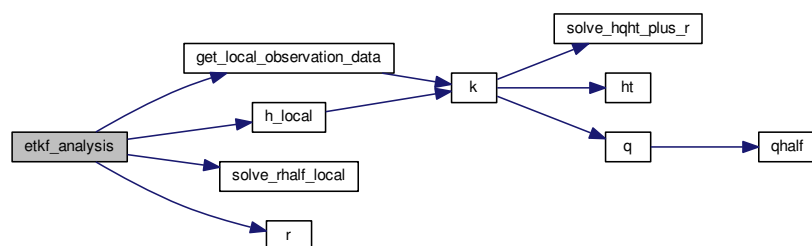
#### 5.14.1 Function/Subroutine Documentation

- 5.14.1.1 subroutine `etkf_analysis` ( integer, intent(in) *num\_hor*, integer, intent(in) *num\_ver*, integer, intent(in) *this\_hor*, integer, intent(in) *this\_ver*, integer, intent(in) *boundary*, real(kind=rk), dimension(statedim,n), intent(inout) *x*, integer, intent(in) *N*, integer, intent(in) *stateDim*, integer, intent(in) *obsDim*, real(kind=rk), intent(in) *rho* )

subroutine to perform the ensemble transform Kalman filter

Definition at line 34 of file `etkf_analysis.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.15 src/filters/letkf\_analysis.f90 File Reference

### Functions/Subroutines

- subroutine [letkf\\_analysis](#)  
*subroutine to perform the ensemble transform Kalman filter as part of L-ETKF*

#### 5.15.1 Function/Subroutine Documentation

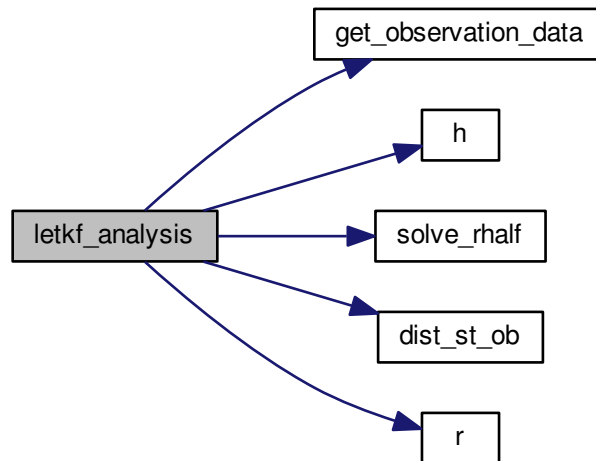
## 5.15.1.1 subroutine letkf\_analysis ( )

subroutine to perform the ensemble transform Kalman filter as part of L-ETKF

The observation

Definition at line 35 of file letkf\_analysis.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.16 src/filters/proposal\_filter.f90 File Reference

## Functions/Subroutines

- subroutine [proposal\\_filter](#)

*Subroutine to perform nudging in the proposal step of EWPF.*

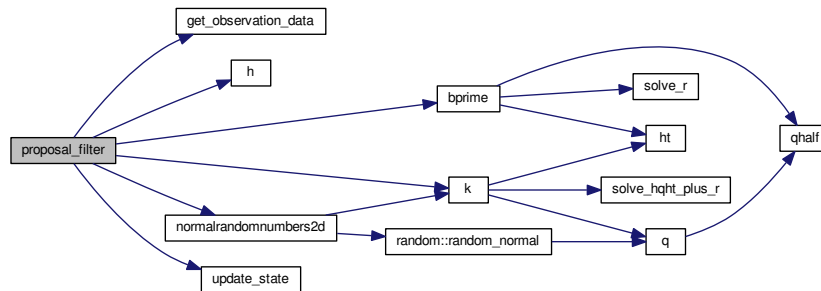
## 5.16.1 Function/Subroutine Documentation

### 5.16.1.1 subroutine proposal\_filter ( )

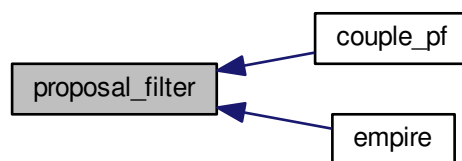
Subroutine to perform nudging in the proposal step of EWPF.

Definition at line 33 of file proposal\_filter.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.17 src/filters/sir\_filter.f90 File Reference

### Functions/Subroutines

- subroutine [sir\\_filter](#)

*Subroutine to perform SIR filter (Sequential Importance Resampling)*

### 5.17.1 Function/Subroutine Documentation

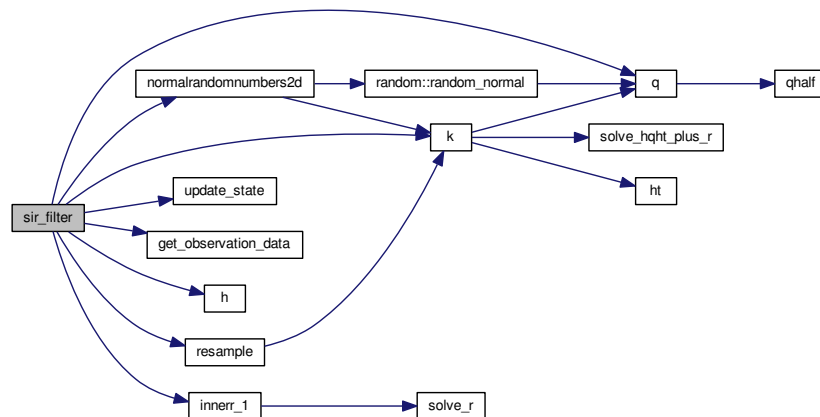
#### 5.17.1.1 subroutine sir\_filter ( )

Subroutine to perform SIR filter (Sequential Importance Resampling)

Definition at line 28 of file sir\_filter.f90.



Here is the call graph for this function:



Here is the caller graph for this function:



## 5.18 src/filters/stochastic\_model.f90 File Reference

### Functions/Subroutines

- subroutine [stochastic\\_model](#)  
*subroutine to simply move the model forward in time one timestep PAB 21-05-2013*
- subroutine [check\\_scaling](#) (x, fx, b, scales)

### 5.18.1 Function/Subroutine Documentation

**5.18.1.1** subroutine `check_scaling` ( real(kind=rk), dimension(state\_dim), intent(in) x, real(kind=rk), dimension(state\_dim), intent(in) fx, real(kind=rk), dimension(state\_dim), intent(in) b, real(kind=rk), dimension(9), intent(inout) scales )

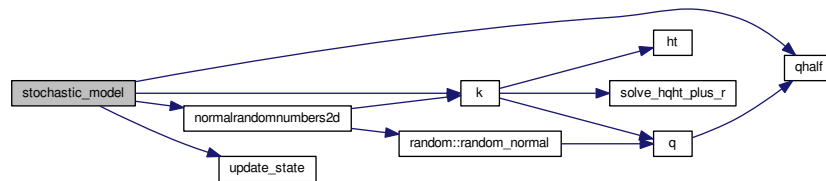
Definition at line 80 of file stochastic\_model.f90.

**5.18.1.2** subroutine `stochastic_model` ( )

subroutine to simply move the model forward in time one timestep PAB 21-05-2013

Definition at line 32 of file stochastic\_model.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.19 src/operations/gen\_rand.f90 File Reference

### Functions/Subroutines

- subroutine [uniformrandomnumbers1d](#) (minv, maxv, n, phi)  
*generate one dimension of uniform random numbers*
- subroutine [normalrandomnumbers1d](#) (mean, stdev, n, phi)  
*generate one dimension of Normal random numbers*
- subroutine [normalrandomnumbers2d](#) (mean, stdev, n, k, phi)  
*generate two dimensional Normal random numbers*
- subroutine [mixturerandomnumbers1d](#) (mean, stdev, ufac, epsi, n, phi, uniform)  
*generate one dimensional vector drawn from mixture density*
- subroutine [mixturerandomnumbers2d](#) (mean, stdev, ufac, epsi, n, k, phi, uniform)  
*generate two dimensional vector, each drawn from mixture density*
- subroutine [random\\_seed\\_mpi](#) (pfid)  
*Subroutine to set the random seed across MPI threads.*

### 5.19.1 Function/Subroutine Documentation

- 5.19.1.1 subroutine [mixturerandomnumbers1d](#) ( real(kind=kind(1.0d0)), intent(in) *mean*, real(kind=kind(1.0d0)), intent(in) *stdev*, real(kind=kind(1.0d0)), intent(in) *ufac*, real(kind=kind(1.0d0)), intent(in) *epsi*, integer, intent(in) *n*, real(kind=kind(1.0d0)), dimension(n), intent(out) *phi*, logical, intent(out) *uniform* )

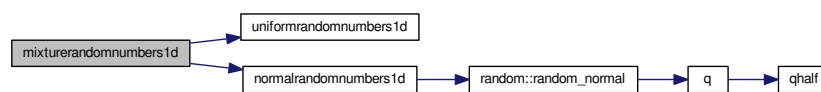
generate one dimensional vector drawn from mixture density

## Parameters

in	<i>mean</i>	Mean of normal distribution
in	<i>stdev</i>	Standard deviation of normal distribution
in	<i>ufac</i>	half-width of uniform distribution that is centered on the mean
in	<i>epsi</i>	Proportion controlling mixture draw. if random_number > epsi then draw from uniform, else normal
in	<i>n</i>	size of output vector
out	<i>phi</i>	n dimensional mixture random numbers
out	<i>uniform</i>	True if mixture drawn from uniform. False if drawn from normal

Definition at line 90 of file gen\_rand.f90.

Here is the call graph for this function:



**5.19.1.2** subroutine mixturerandomnumbers2d ( real(kind=kind(1.0d0)), intent(in) *mean*, real(kind=kind(1.0d0)), intent(in) *stdev*, real(kind=kind(1.0d0)), intent(in) *ufac*, real(kind=kind(1.0d0)), intent(in) *epsi*, integer, intent(in) *n*, integer, intent(in) *k*, real(kind=kind(1.0d0)), dimension(n,k), intent(out) *phi*, logical, dimension(k), intent(out) *uniform* )

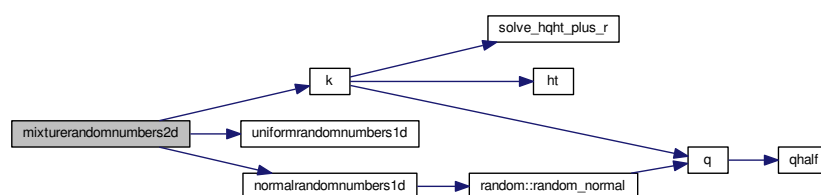
generate two dimensional vector, each drawn from mixture density

## Parameters

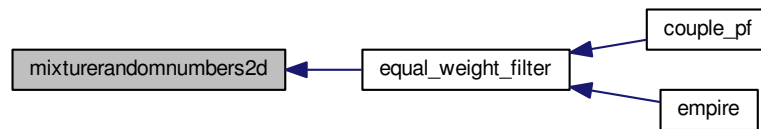
in	<i>mean</i>	Mean of normal distribution
in	<i>stdev</i>	Standard deviation of normal distribution
in	<i>ufac</i>	half-width of uniform distribution that is centered on the mean
in	<i>epsi</i>	Proportion controlling mixture draw. if random_number > epsi then draw from uniform, else normal
in	<i>n</i>	first dimension of output vector
in	<i>k</i>	second dimension of output vector
out	<i>phi</i>	n,k dimensional mixture random numbers
out	<i>uniform</i>	k dimensional logical with uniform(i) True if phi(:,i) drawn from uniform. False if drawn from normal

Definition at line 125 of file gen\_rand.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



5.19.1.3 subroutine `normalrandomnumbers1d` ( `real(kind=rk), intent(in) mean`, `real(kind=rk), intent(in) stdev`, `integer, intent(in) n`, `real(kind=rk), dimension(n), intent(out) phi` )

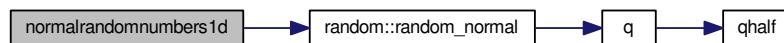
generate one dimension of Normal random numbers

#### Parameters

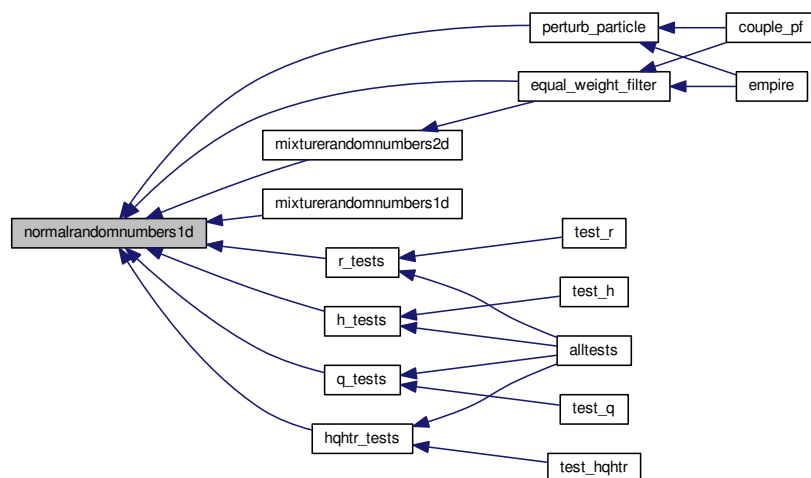
in	<i>n</i>	size of output vector
in	<i>mean</i>	mean of normal distribution
in	<i>stdev</i>	Standard Deviation of normal distribution
out	<i>phi</i>	n dimensional normal random numbers

Definition at line 43 of file `gen_rand.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



5.19.1.4 subroutine `normalrandomnumbers2d` ( `real(kind=rk)`, intent(in) *mean*, `real(kind=rk)`, intent(in) *stdev*, integer, intent(in) *n*, integer, intent(in) *k*, `real(kind=rk)`, dimension(*n*,*k*), intent(out) *phi* )

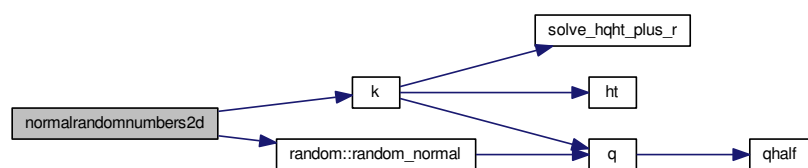
generate two dimensional Normal random numbers

#### Parameters

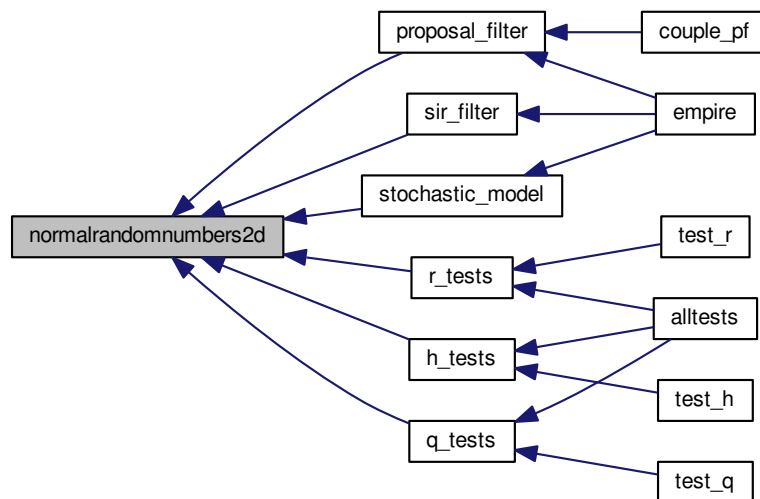
in	<i>n</i>	first dimension of output vector
in	<i>k</i>	second dimension of output vector
in	<i>mean</i>	mean of normal distribution
in	<i>stdev</i>	Standard Deviation of normal distribution
out	<i>phi</i>	n,k dimensional normal random numbers

Definition at line 60 of file `gen_rand.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



5.19.1.5 subroutine `random_seed_mpi` ( integer, intent(in) *pfid* )

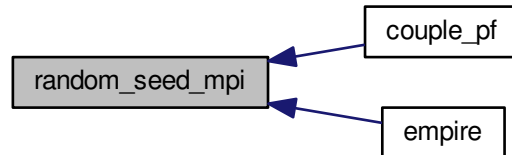
Subroutine to set the random seed across MPI threads.

## Parameters

in	<i>pfid</i>	The process identifier of the MPI process
----	-------------	---

Definition at line 151 of file gen\_rand.f90.

Here is the caller graph for this function:



5.19.1.6 subroutine uniformrandomnumbers1d ( real(kind=rk), intent(in) *minv*, real(kind=rk), intent(in) *maxv*, integer, intent(in) *n*, real(kind=rk), dimension(n), intent(out) *phi* )

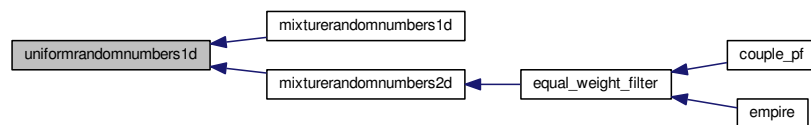
generate one dimension of uniform random numbers

## Parameters

in	<i>n</i>	size of output vector
in	<i>minv</i>	minimum value of uniform distribution
in	<i>maxv</i>	maximum value of uniform distribution
out	<i>phi</i>	n dimensional uniform random numbers

Definition at line 28 of file gen\_rand.f90.

Here is the caller graph for this function:



## 5.20 src/operations/operator\_wrappers.f90 File Reference

### Functions/Subroutines

- subroutine [k](#) (*y*, *x*)  
Subroutine to apply  $K$  to a vector  $y$  in observation space where  $K := QH^T(QH^T + R)^{-1}$ .
- subroutine [innerr\\_1](#) (*y*, *w*)  
subroutine to compute the inner product with  $R^{-1}$
- subroutine [innerhqht\\_plus\\_r\\_1](#) (*y*, *w*)  
subroutine to compute the inner product with  $(HQH^T + R)^{-1}$

- subroutine `bprime` (`y`, `x`, `QHtR_1y`, `normaln`, `betan`)  
*subroutine to calculate nudging term and correlated random errors efficiently*

### 5.20.1 Function/Subroutine Documentation

5.20.1.1 subroutine `bprime` ( `real(kind=rk)`, `dimension(obs_dim,pf%count)`, `intent(in) y`, `real(kind=rk)`, `dimension(state_dim,pf%count)`, `intent(out) x`, `real(kind=rk)`, `dimension(state_dim,pf%count)`, `intent(out) QHtR_1y`, `real(kind=rk)`, `dimension(state_dim,pf%count)`, `intent(in) normaln`, `real(kind=rk)`, `dimension(state_dim,pf%count)`, `intent(out) betan` )

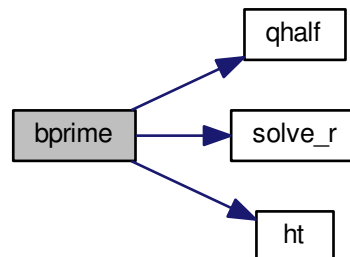
subroutine to calculate nudging term and correlated random errors efficiently

#### Parameters

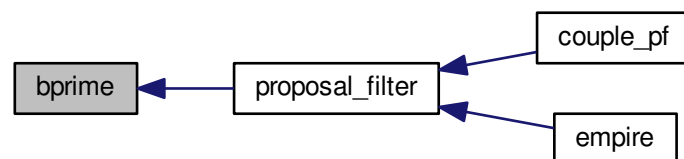
in	<code>y</code>	( <code>obs_dim,pf%count</code> ) vectors of innovations $y - H(x^{n-1})$
out	<code>x</code>	( <code>state_dim,pf%count</code> ) vectors of $\rho H^T R^{-1} [y - H(x^{n-1})]$
out	<code>QHtR_1y</code>	( <code>state_dim,pf%count</code> ) vectors of $\rho QH^T R^{-1} [y - H(x^{n-1})]$
in	<code>normaln</code>	( <code>state_dim,pf%count</code> ) uncorrelated random vectors such that $\text{normaln}(:,i) \sim \mathcal{N}(0, I)$
out	<code>betan</code>	( <code>state_dim,pf%count</code> ) correlated random vectors such that $\text{betan}(:,i) \sim \mathcal{N}(0, Q)$

Definition at line 155 of file `operator_wrappers.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



### 5.20.1.2 subroutine innerhqht\_plus\_r\_1 ( real(kind=rk), dimension(obs\_dim), intent(in) y, real(kind=rk), intent(out) w )

subroutine to compute the inner product with  $(HQH^T + R)^{-1}$

#### Parameters

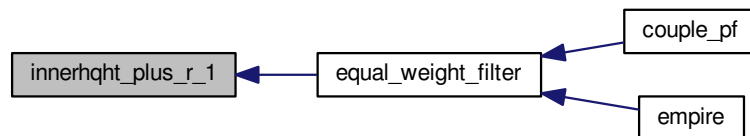
in	y	vector in observation space
out	w	scalar with value $y^T R^{-1} y$

Definition at line 91 of file operator\_wrappers.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



### 5.20.1.3 subroutine innerr\_1 ( real(kind=rk), dimension(obs\_dim,pf%count), intent(in) y, real(kind=rk), dimension(pf%count), intent(out) w )

subroutine to compute the inner product with  $R^{-1}$

#### Parameters

in	y	multiple vectors in observation space (pf%count of them)
out	w	multiple scalars (pf%count) where w(i) has the value $y(:,i)^T R^{-1} y(:,i)$

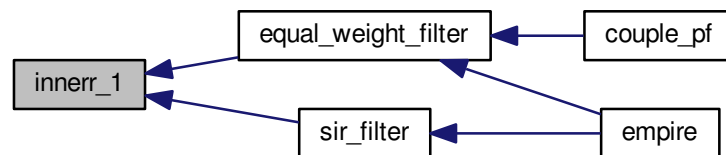
Definition at line 65 of file operator\_wrappers.f90.



Here is the call graph for this function:



Here is the caller graph for this function:



5.20.1.4 subroutine k ( real(kind=rk), dimension(obs\_dim,pf%count), intent(in) y, real(kind=rk), dimension(state\_dim,pf%count), intent(out) x )

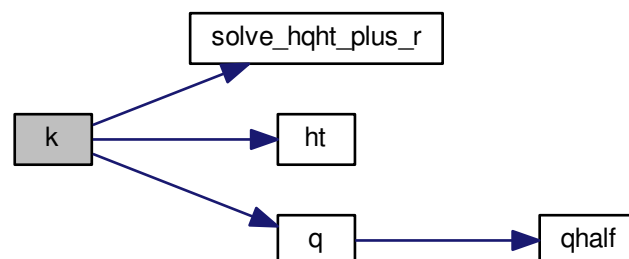
Subroutine to apply  $K$  to a vector  $y$  in observation space where  $K := QH^T(HQH^T + R)^{-1}$ .

Parameters

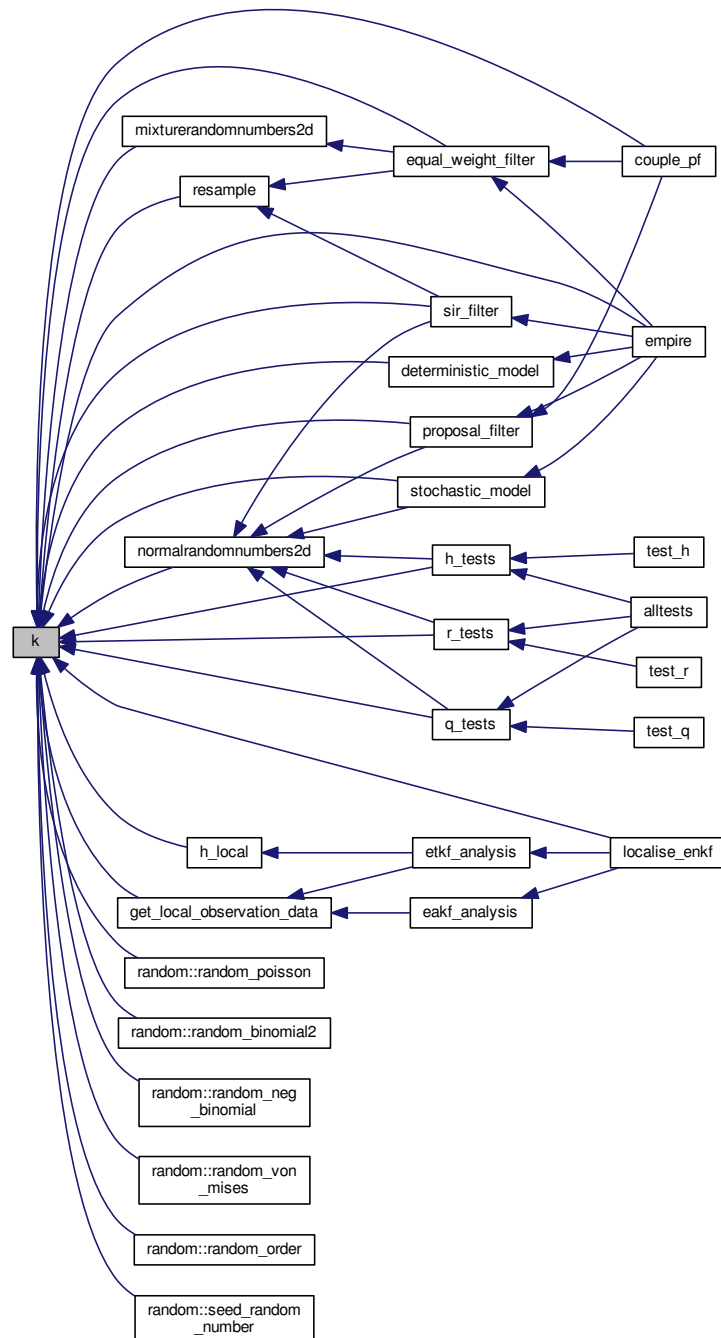
in	y	vector in observation space
out	x	vector in state space

Definition at line 32 of file operator\_wrappers.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.21 src/operations/perturb\_particle.f90 File Reference

### Functions/Subroutines

- subroutine [perturb\\_particle](#) (x)

Subroutine to perturb state vector with normal random vector drawn from  $\mathcal{N}(0, Q)$ .

- subroutine `update_state` (state, fps, kgain, betan)

*Subroutine to update the state.*

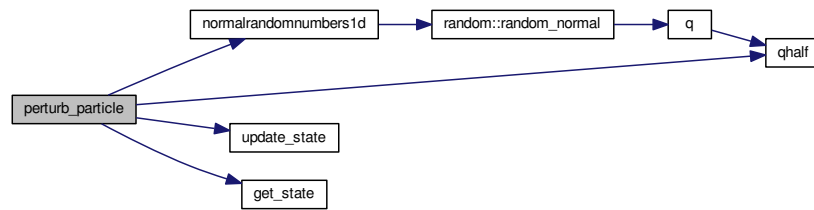
### 5.21.1 Function/Subroutine Documentation

#### 5.21.1.1 subroutine perturb\_particle ( real(kind=rk), dimension(state\_dim), intent(inout) x )

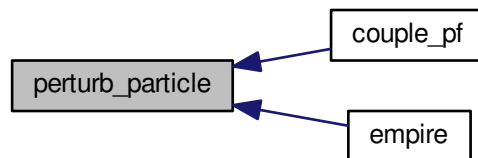
Subroutine to perturb state vector with normal random vector drawn from  $\mathcal{N}(0, Q)$ .

Definition at line 30 of file perturb\_particle.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



#### 5.21.1.2 subroutine update\_state ( real(kind=rk), dimension(state\_dim), intent(out) state, real(kind=rk), dimension(state\_dim), intent(in) fps, real(kind=rk), dimension(state\_dim), intent(in) kgain, real(kind=rk), dimension(state\_dim), intent(inout) betan )

Subroutine to update the state.

This can be changed for the specific model if it needs to be

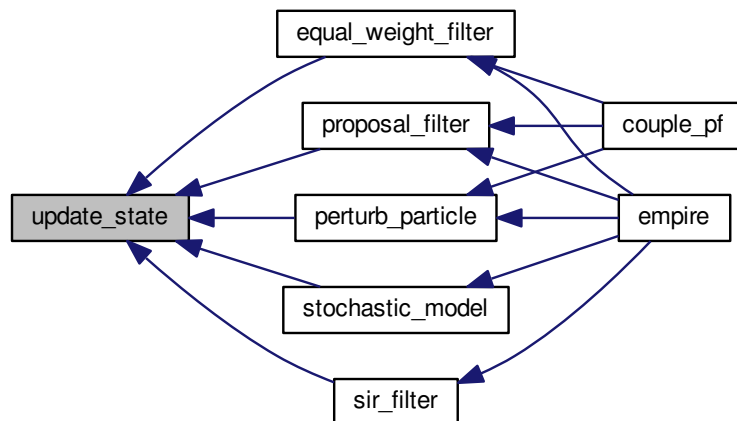
##### Parameters

in	<i>fps</i>	deterministic model update $f(x^{n-1})$
in	<i>kgain</i>	nudging term

in, out	<i>betan</i>	Stochastic term
out	<i>state</i>	The updated state vector

Definition at line 95 of file perturb\_particle.f90.

Here is the caller graph for this function:



## 5.22 src/operations/resample.f90 File Reference

### Functions/Subroutines

- subroutine [resample](#)

*Subroutine to perform Universal Importance Resampling.*

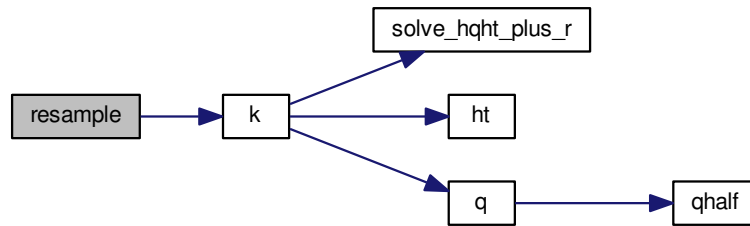
### 5.22.1 Function/Subroutine Documentation

#### 5.22.1.1 subroutine `resample` ( )

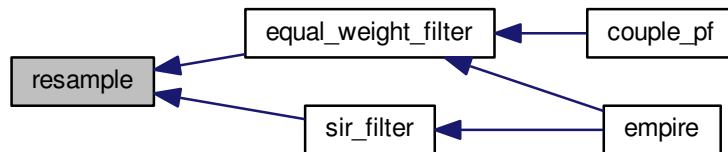
Subroutine to perform Universal Importance Resampling.

Definition at line 28 of file `resample.f90`.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.23 src/tests/alltests.f90 File Reference

### Functions/Subroutines

- program [alltests](#)

*program to run all tests of user specific functions*

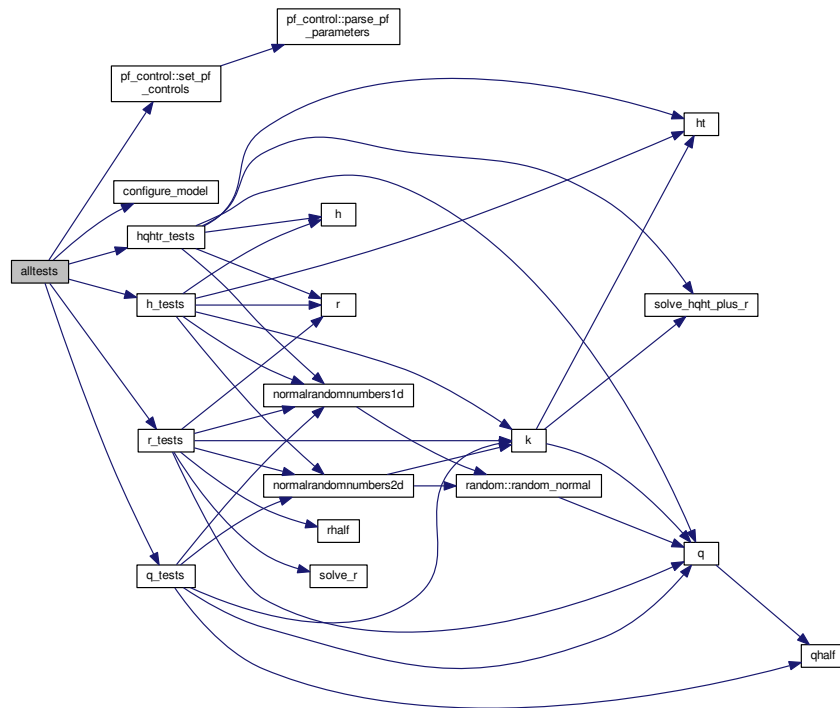
#### 5.23.1 Function/Subroutine Documentation

##### 5.23.1.1 program alltests ( )

program to run all tests of user specific functions

Definition at line 31 of file alltests.f90.

Here is the call graph for this function:



## 5.24 src/tests/test\_h.f90 File Reference

### Functions/Subroutines

- program [test\\_h](#)

*program to run tests of user supplied observation operator*

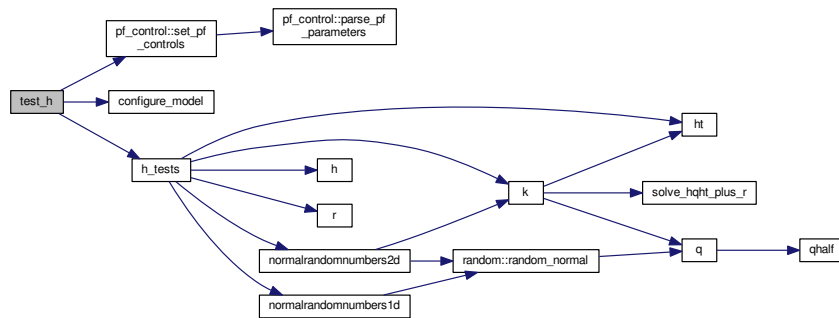
#### 5.24.1 Function/Subroutine Documentation

##### 5.24.1.1 program test\_h ( )

program to run tests of user supplied observation operator

Definition at line 31 of file test\_h.f90.

Here is the call graph for this function:



## 5.25 src/tests/test\_hqhtr.f90 File Reference

### Functions/Subroutines

- program [test\\_hqhtr](#)  
*program to run tests of user supplied linear solve*

#### 5.25.1 Function/Subroutine Documentation

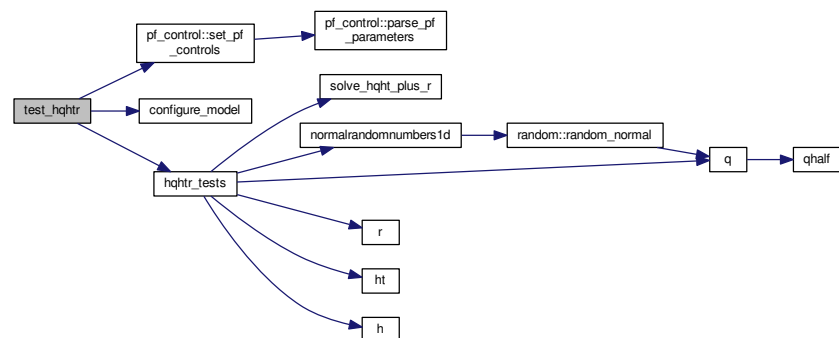
##### 5.25.1.1 program test\_hqhtr ( )

program to run tests of user supplied linear solve

$$(HQH^T + R)^{-1}$$

Definition at line 33 of file test\_hqhtr.f90.

Here is the call graph for this function:



## 5.26 src/tests/test\_q.f90 File Reference

## Functions/Subroutines

- program [test\\_q](#)

*program to run tests of user supplied model error covariance matrix*

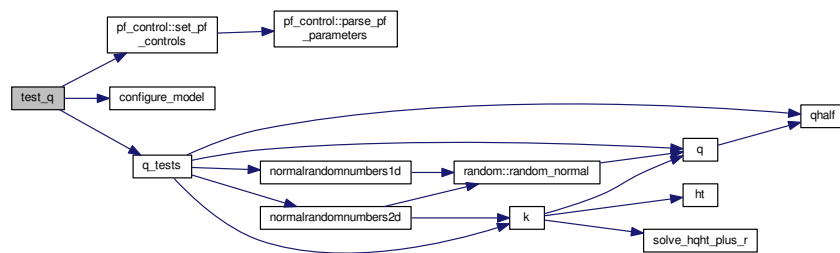
### 5.26.1 Function/Subroutine Documentation

#### 5.26.1.1 program test\_q ( )

program to run tests of user supplied model error covariance matrix

Definition at line 31 of file test\_q.f90.

Here is the call graph for this function:



## 5.27 src/tests/test\_r.f90 File Reference

### Functions/Subroutines

- program [test\\_r](#)

*program to run all tests of user supplied observation error covariance matrix/*

### 5.27.1 Function/Subroutine Documentation

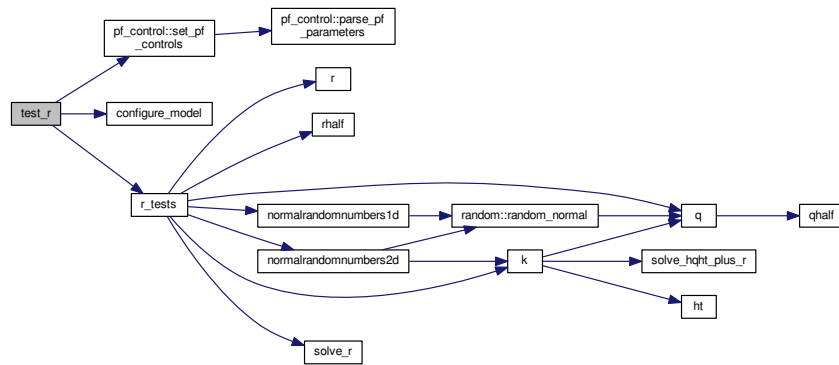
#### 5.27.1.1 program test\_r ( )

program to run all tests of user supplied observation error covariance matrix/

Definition at line 31 of file test\_r.f90.



Here is the call graph for this function:



## 5.28 src/tests/tests.f90 File Reference

### Functions/Subroutines

- subroutine [h\\_tests](#) ()
- subroutine [r\\_tests](#) ()
- subroutine [q\\_tests](#) ()
- subroutine [hqhtr\\_tests](#) ()

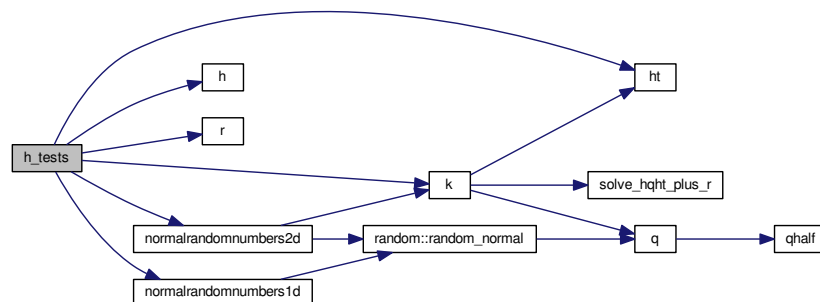
### 5.28.1 Function/Subroutine Documentation

#### 5.28.1.1 subroutine `h_tests` ( )

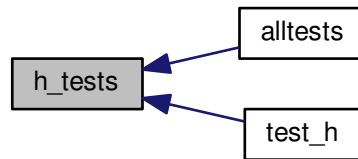
These are some tests to check that the observation operator is implemented correctly

Definition at line 27 of file tests.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



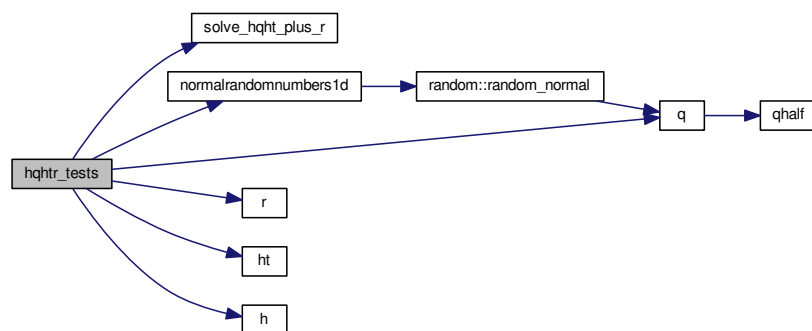
#### 5.28.1.2 subroutine hqhtr\_tests ( )

These are some tests to check that the linear solve operator is implemented correctly

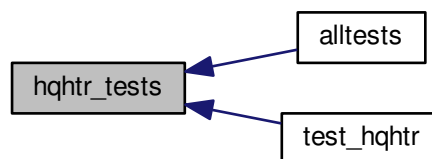
This should check the operation  $(HQH^T + R)^{-1}$  is working

Definition at line 757 of file tests.f90.

Here is the call graph for this function:



Here is the caller graph for this function:

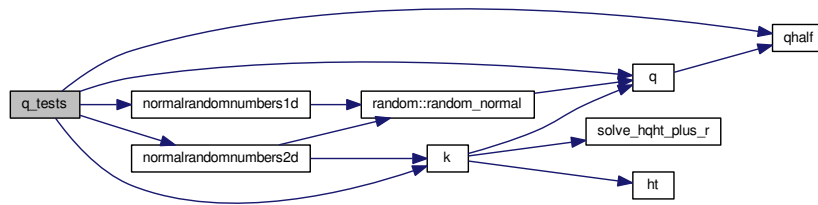


## 5.28.1.3 subroutine q\_tests ( )

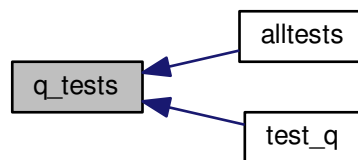
These are some tests to check that the model error covariance matrix is implemented correctly

Definition at line 560 of file tests.f90.

Here is the call graph for this function:



Here is the caller graph for this function:

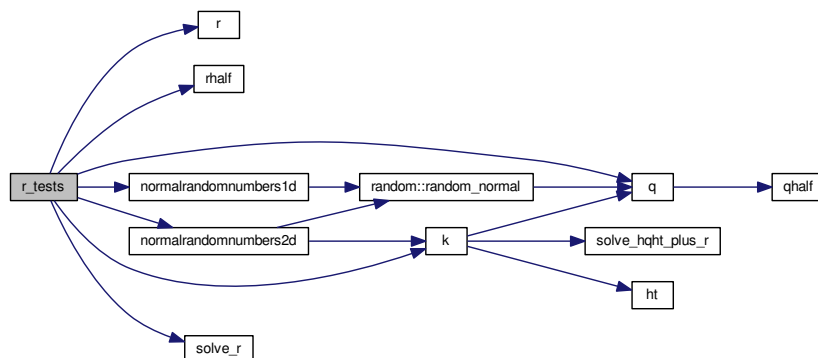


## 5.28.1.4 subroutine r\_tests ( )

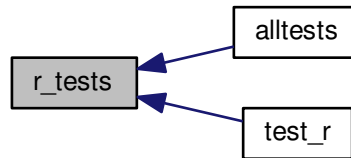
These are some tests to check that the observation error covariance matrix is implemented correctly

Definition at line 254 of file tests.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.29 src/utils/comms.f90 File Reference

### Data Types

- module [comms](#)  
*Module containing EMPIRE coupling data.*

## 5.30 src/utils/data\_io.f90 File Reference

### Functions/Subroutines

- subroutine [get\\_observation\\_data](#) (y)  
*Subroutine to read observation from a file  
Uses pftimestep to determine which observation to read.*
- subroutine [save\\_observation\\_data](#) (y)  
*Subroutine to save observation to a file  
Uses pftimestep to determine which observation to save.*
- subroutine [save\\_truth](#) (x)  
*Subroutine to save truth to a file*
- subroutine [output\\_from\\_pf](#)  
*subroutine to ouput data from the filter*
- subroutine [save\\_state](#) (state, filename)  
*subroutine to save the state vector to a named file as an unformatted fortran file*
- subroutine [get\\_state](#) (state, filename)  
*subroutine to write the state vector to a named file as an unformatted fortran file*

### 5.30.1 Function/Subroutine Documentation

#### 5.30.1.1 subroutine [get\\_observation\\_data](#) ( real(kind=rk), dimension(obs\_dim), intent(out) y )

Subroutine to read observation from a file

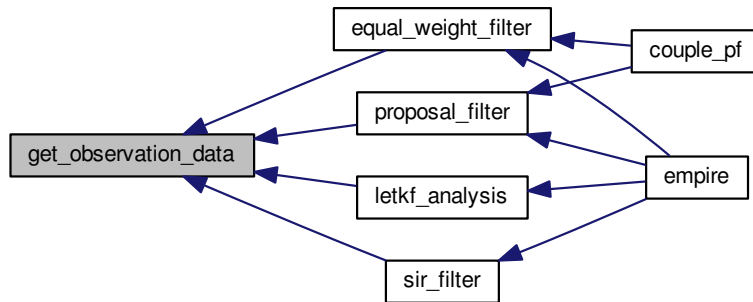
Uses pftimestep to determine which observation to read.

## Parameters

out	y	The observation
-----	---	-----------------

Definition at line 32 of file data\_io.f90.

Here is the caller graph for this function:



#### 5.30.1.2 subroutine `get_state` ( `real(kind=rk)`, `dimension(state_dim)`, `intent(out) state`, `character(14)`, `intent(in) filename` )

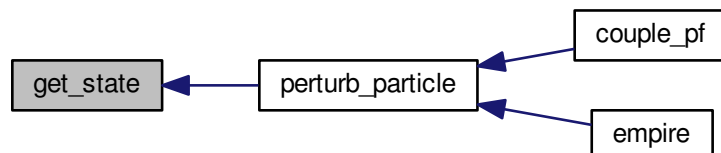
subroutine to write the state vector to a named file as an unformatted fortran file

## Parameters

out	<i>state</i>	the state vector
in	<i>filename</i>	the name of the file to write the state vector in

Definition at line 283 of file data\_io.f90.

Here is the caller graph for this function:

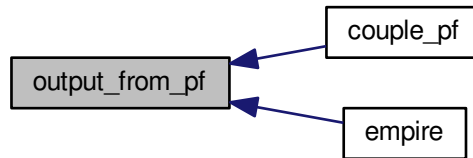


#### 5.30.1.3 subroutine `output_from_pf` ( )

subroutine to output data from the filter

Definition at line 124 of file data\_io.f90.

Here is the caller graph for this function:



#### 5.30.1.4 subroutine save\_observation\_data ( real(kind=rk), dimension(obs\_dim), intent(in) y )

Subroutine to save observation to a file

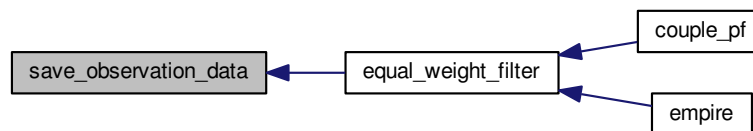
Uses pftimestep to determine which observation to save.

##### Parameters

in	y	The observation
----	---	-----------------

Definition at line 60 of file data\_io.f90.

Here is the caller graph for this function:



#### 5.30.1.5 subroutine save\_state ( real(kind=rk), dimension(state\_dim), intent(in) state, character(14), intent(in) filename )

subroutine to save the state vector to a named file as an unformatted fortran file

##### Parameters

in	state	the state vector
in	filename	the name of the file to save the state vector in

Definition at line 257 of file data\_io.f90.

#### 5.30.1.6 subroutine save\_truth ( real(kind=rk), dimension(state\_dim), intent(in) x )

Subroutine to save truth to a file

.

## Parameters

in	x	The state vector
----	---	------------------

Definition at line 98 of file data\_io.f90.

Here is the caller graph for this function:



## 5.31 src/utls/diagnostics.f90 File Reference

### Functions/Subroutines

- subroutine [diagnostics](#)

*Subroutine to give output diagnostics such as rank histograms and trajectories.*

- subroutine [trajectories](#)

*subroutine to output trajectories*

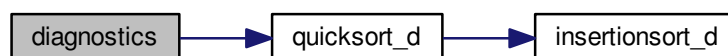
### 5.31.1 Function/Subroutine Documentation

#### 5.31.1.1 subroutine diagnostics ( )

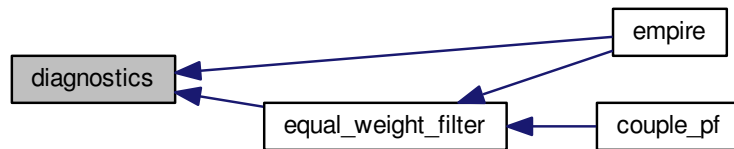
Subroutine to give output diagnostics such as rank histograms and trajectories.

Definition at line 31 of file diagnostics.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



#### 5.31.1.2 subroutine trajectories ( )

subroutine to output trajectories

Definition at line 203 of file diagnostics.f90.

Here is the caller graph for this function:



## 5.32 src/utls/genQ.f90 File Reference

### Functions/Subroutines

- subroutine [genq](#)

*Subroutine to estimate Q from a long model run.*

#### 5.32.1 Function/Subroutine Documentation

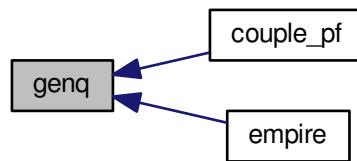
##### 5.32.1.1 subroutine genq ( )

Subroutine to estimate Q from a long model run.

Definition at line 28 of file genQ.f90.



Here is the caller graph for this function:



## 5.33 src/utls/histogram.f90 File Reference

### Data Types

- module [histogram\\_data](#)  
*Module to control what variables are used to generate rank histograms.*

## 5.34 src/utls/quicksort.f90 File Reference

### Functions/Subroutines

- recursive subroutine [quicksort\\_d](#) (a, na)  
*subroutine to sort using the quicksort algorithm*
- subroutine [insertionsort\\_d](#) (A, nA)  
*subroutine to sort using the insertionsort algorithm*

### 5.34.1 Function/Subroutine Documentation

5.34.1.1 subroutine [insertionsort\\_d](#) ( *real(kind=kind(1.0d0))*, dimension(na), intent(inout) *A*, integer, intent(in) *nA* )

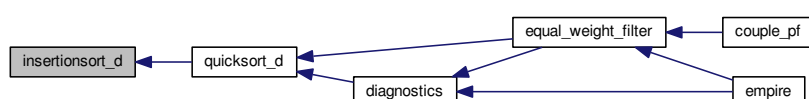
subroutine to sort using the insertionsort algorithm

#### Parameters

<i>in, out</i>	<i>a</i>	array of doubles to be sorted
<i>in</i>	<i>na</i>	dimension of array a

Definition at line 86 of file quicksort.f90.

Here is the caller graph for this function:



5.34.1.2 recursive subroutine quicksort\_d ( real(kind=kind(1.0d0)), dimension(na), intent(inout) a, integer, intent(in) na )

subroutine to sort using the quicksort algorithm

#### Parameters

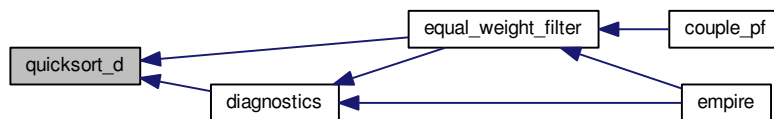
in, out	a	array of doubles to be sorted
in	na	dimension of array a

Definition at line 9 of file quicksort.f90.

Here is the call graph for this function:



Here is the caller graph for this function:



## 5.35 src/utils/random\_d.f90 File Reference

### Data Types

- module [random](#)

*A module for random number generation from the following distributions:*

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