

CCPP Training

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## CCPP Scientific Documentation

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Developmental Testbed Center

# Outline of Talk

- Big Picture
- Where is it
  - Directory Structure
- What should be documented
  - Edit Configuration File
  - Document a Physics Suite
- Wrap Up

Common Community Physics Package (CCPP) Scientific Documentation Version 2.0

Common Community Physics Package

- Introduction
- Overview of the Code
- GFS RRTMG Shortwave/Longwave Ra
- GFS Surface Layer Scheme
- GFS Near-Surface Sea Temperature
- GFS Noah Land Surface Model
- GFS Sea Ice Scheme
- GFS Hybrid Eddy-Diffusivity Mass-F
- GFS Orographic Gravity Wave Drag S
- GFS Ozone Photochemistry Scheme
- GFS Stratospheric H2O Scheme
- GFS Rayleigh Damping Calculation
- GFS Scale-Aware Mass-Flux Deep C
- GFS Convective Gravity Wave Drag S
- GFS Scale-Aware Mass-Flux Shallow
- GFS Zhao-Carr Microphysics Scheme
- GFDL Cloud Microphysics Scheme
- GFS Precipitation Type Diagnosis Sc
- Bibliography
- Modules
- Modules
- Data Types List

**Introduction**

Welcome to the GMTB Common Community Physics Package (CCPP) v2.0 scientific documentation. This release of the CCPP contains two parts: CCPP-Physics (a collection of physical parameterizations) and CCPP-Framework (the infrastructure that connects the CCPP-Physics to host models).

The CCPP-Physics is envisioned to contain parameterizations used by NOAA operational models for weather through seasonal prediction timescales, as well as developmental schemes under consideration for upcoming operational implementations. This version contains the parameterizations of the default physics suite of FV3GFS as of August 2018, along with the microphysics scheme that is used in the operational GFS implemented in July of 2017. In this website you will find documentation on various aspects of each parameterization, including a high-level overview of its function, the input/output argument list, and a description of the algorithm.

The most significant change with respect to CCPP-Physics v1.0 has been the inclusion of the **GFDL Cloud Microphysics Scheme**, which is undergoing tests for possibly replacing the operational **GFS Zhao-Carr Microphysics Scheme** in the operational NCEP global model in early 2019. With the GFDL microphysics, six prognostics cloud species have been introduced to enable a more physically-based representation of water vapor, mixed-phase (liquid/ice) clouds and precipitating rain/snow/graupel hydrometeors. When used with the FV3 dynamic solver, the GFDL microphysics uses a unique condensation adjustment when variables are mapped from Lagrangian to Eulerian surfaces.

The public release of CCPP v2 is supported for use with the GMTB Single Column Model. The CCPP v2 is currently being integrated with FV3GFS and is available for use by those working closely with NOAA in the development of the Unified Forecast System (UFS). Future direction for the CCPP includes broad support for use with FV3 and addition of new parameterizations for potential transition to operations.

You can find more information about GMTB Common Community Physics Package (CCPP) on the DTC website.

Generated by doxygen 1.8.11

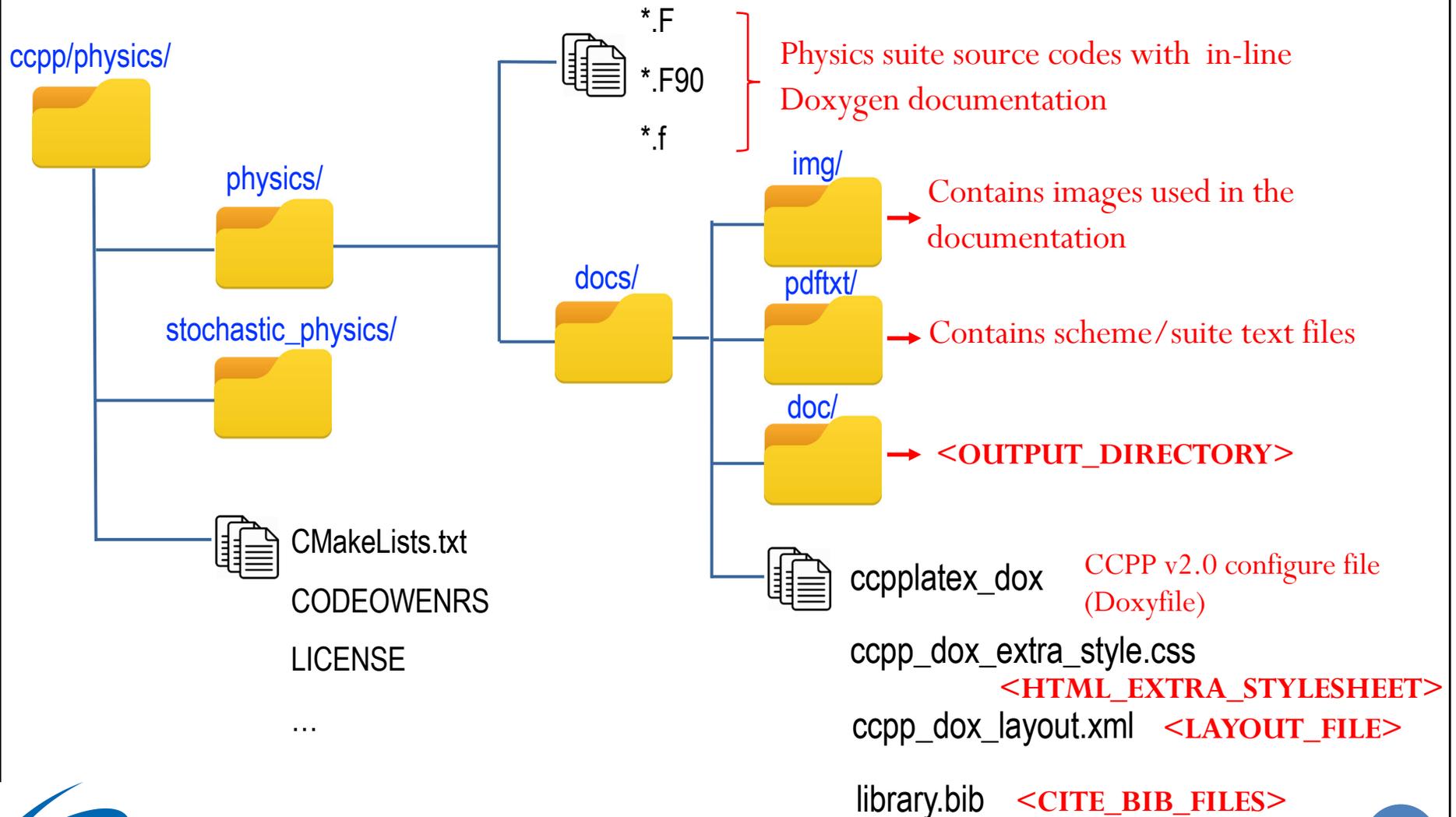
CCPP V2.0 scientific documentation includes  
FV3GFS physics suite

# Big Picture

## Doxygen + GitHub :

- Provides history tracking and branching that no Wiki can provide
- Provides the same development workflow for your documentation as well as for your source code
- Makes information easily accessible, facilitates stakeholder communication and helps cut support costs

# Directory Structure of CCpp-Physics



# Edit the Configuration File

Insert the scheme text files and source codes into **<INPUT>**

```

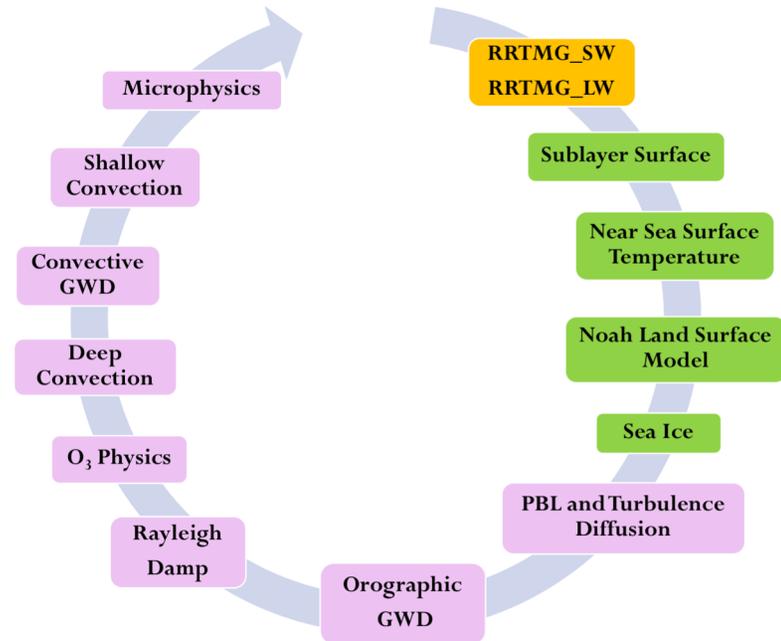
OPTIMIZE_FOR_FORTRAN = YES → set up Doxygen for Fortran project
...
INPUT
  = pdftxt/mainpage.txt \
  pdftxt/code_overview.txt \
  pdftxt/GFS_RRTMG.txt \
  pdftxt/GFS_SFCLYR.txt \
  pdftxt/GFS_NSST.txt \
  pdftxt/GFS_NOAH.txt \
  pdftxt/GFS_SFCSICE.txt \
  pdftxt/GFS_HEDMF.txt \
  pdftxt/GFS_GWDPS.txt \
  pdftxt/GFS_OZPHYS.txt \
  pdftxt/GFS_H2OPHYS.txt \
  pdftxt/GFS_RAYLEIGH.txt \
  pdftxt/GFS_SAMFdeep.txt \
  pdftxt/GFS_GWDC.txt \
  pdftxt/GFS_SAMFshal.txt \
  pdftxt/GFS_ZHAOC.txt \
  pdftxt/GFDL_cloud.txt \
  pdftxt/GFS_CALPRECIPTYPE.txt \

### Radiation
  ../radlw_main.f \
  ../radsw_main.f \
  ../radiation_aerosols.f \
  ../radiation_astronomy.f \
  ../radiation_clouds.f \
  ../radiation_gases.f \
  ../radiation_surface.f \
  ../radlw_param.f \
  ../radlw_datatb.f \
  ../radsw_param.f \
  ../radsw_datatb.f \
  ...
  
```

main page and  
scheme intro  
pages

RRTMG  
source codes

Process ordering  
of the operational FV3GFS suite



The order in which schemes are listed determines the order in the html output.

Currently schemes are listed in order of the operational FV3GFS suite

# Edit the Configuration File

```
GENERATE_HTML           = YES
HTML_OUTPUT             = html
HTML_FILE_EXTENSION     = .html
HTML_HEADER             =
HTML_FOOTER             =
HTML_STYLESHEET         =
HTML_EXTRA_STYLESHEET  = ccpp_dox_extra_style.css
HTML_EXTRA_FILES        =
HTML_COLORSTYLE_HUE     = 220
HTML_COLORSTYLE_SAT     = 100
HTML_COLORSTYLE_GAMMA   = 80
```

} Define HTML as output format

} Color customization of the output

<HTML\_EXTRA\_STYLESHEET> contains CSS formatting over and above the standard Doxygen CSS

# Running Doxygen

Doxygen is prebuilt on Theia. Add the following line into `.cshrc` file under your home directory:

```
alias doxygen /scratch4/BMC/gmtb/doxygen-1.8.10/bin/doxygen
```

Source your `.cshrc` file. Then under `./docs/`, type:

```
$doxygen ccpplatex_dox
```

The generated HTML documentation can be viewed by pointing a HTML browser to the `index.html` file in the `./docs/doc/html/` directory

# Documenting a Physics Suite

A broad array of information should be included in order to serve both software engineering and scientific purposes.

The documentation style could be divided into three categories:

- **Doxygen Pages:** external text files that generate scheme/suite pages with a high-level scientific overview
- **In-line Documentation:** describing scheme arguments and algorithm
- **A Bibliography File:** in BibTex format

# Creating the Suite/Scheme Pages

Doxygen pages (`.\pdftxt\*.txt`) are used for documentation that is not directly attached to the Fortran codes:

- **Physics suite main page (“\mainpage”)**: the place to describe the project, background, and any history that might be useful for a reader to be aware of. You can refer to any source code entity from within the page if required.
- **Physics scheme page (“\page”)** will often describe the following:
  - Description
    - Scientific origin and scheme history (“\cite”)
    - Key features and differentiating points
    - A picture is sometimes worth a thousand words (“\image”)
  - Intrapysics Communication
    - Insert a link to in-line [SCHEME]\_run Argument Table (“\ref”)
  - General Algorithm
    - Insert a link to in-line [SCHEME]\_run General Algorithm (“\ref”)

# Doxygen Pages: GFS Zhao-Carr MP Scheme

```
1  /**
2  \page GFS_ZHAOC GFS Zhao-Carr Microphysics Scheme } “\page” - indicate this is a free floating page
3
4  \section des_zhao Description
5  This is the GFS scheme for grid-scale condensation and precipitation which is
6  based on Zhao and Carr (1997) \cite zhao_and_carr_1997 and
7  Sundqvist et al. (1989) \cite sundqvist_et_al_1989 . “\image” - insert an image file located
8  .....
9  Figure 1 shows a schematic illustration of this scheme. under <IMAGE_PATH> in config file
10 .....
11 \image html GFS_zhaocarr_schematic.png "Figure 1: Schematic illustration of the
12 precipitation scheme" width=10cm
13 .....
14 \section intra_zhao Intraphysics Communication } “\section” – divide a Doxygen page into sections
15 + For grid-scale condensation and evaporation of cloud process
16 (\ref arg_table_zhaocarr_gscond_run)
17 + For precipitation (snow or rain) production (\ref arg_table_zhaocarr_precpd_run)
18
19 \section Gen_zhao General Algorithm
20 + \ref general_gscond } “\ref” – insert a link to the specified
21 + \ref general_precpd } page in this section
22
23
24 */
```

The symbols “/\*\*” and “\*/” need to be the first and last entries of the page

# In-line Documentation Style

In the first line of each Fortran file, brief one sentence overview of the file purpose following “\file”:

```
!> \file gwdps.f
!! This file is the parameterization of orographic gravity wave
!! drag and mountain blocking.
```

The Doxygen code block begins with “!>”, and subsequent lines begin with “!!”.

The parameter definition begin with “!<”

```
integer, parameter, public :: NF_VGAS = 10    !< number of gas species
integer, parameter         :: IMXCO2  = 24    !< input CO2 data longitude points
integer, parameter         :: JMXCO2  = 12    !< input CO2 data latitude points
integer, parameter         :: MINYEAR = 1957 !< earliest year 2D CO2 data available
```

# Doxygen Modules

CCPP v2.0 has structured documentation based on modules, and tag each child subroutine or function with the parent module name. A module implements a particular parameterization functionality.

In each subroutine that is a CCPP entry point to the scheme, a module is defined using “**\defgroup**”, e.g., to define a parent module “**GFS radsw Main**”:

```
!> \defgroup module_radsw_main GFS radsw Main
!! This module includes NCEP's modifications of the RRTMG-SW radiation
!! code from AER.
!! ...
!!\author Eli J. Mlawer, emlawer@aer.com
!!\author Jennifer S. Delamere, jdelamer@aer.com
!!\author Michael J. Iacono, miacono@aer.com
!!\author Shepard A. Clough
!!\version NCEP SW v5.1 Nov 2012 -RRTMG-SW v3.8
!!
```

if applicable, “**\author**” and “**\version**” should be listed

Later in the source code or a separated code, you can associate a subroutine or function with this module by using “**\ingroup**”:

```
!>\ingroup module_radsw_main
!! The subroutine computes the optical depth in band 16: 2600-3250
!! cm-1 (low - h2o,ch4; high - ch4)
!-----
      subroutine taumol16
!.....
```



# In-line Documentation Style

For each subroutine that is an entry point to the scheme, further documentation will include:

- An argument table section

**CCPP functional significance:** see Grant’s CCPP-compliant parameterizations slides)

**Argument Table**

local_name	standard_name	long_name	units	rank	type	kind	Intent	optional
lsidea	flag_idealized_physics	flag for idealized physics	flag	0	logical		in	F
im	horizontal_loop_extent	horizontal loop extent	count	0	integer		in	F
ix	horizontal_dimension	horizontal dimension	count	0	integer		in	F
km	vertical_dimension	number of vertical layers	count	0	integer		in	F

- The scheme general algorithm section “\section”
  - list in-line calculation step by using “-#” markers
- The In-line detail algorithm section usually includes:
  - convert existing Fortran comments to Doxygen comments
  - using Latex formulas in the Doxygen comment is recommended “\f” and “\f”

## GFS precpd Scheme General Algorithm

The following two equations can be used to calculate the precipitation rates of rain and snow at each model level:

$$P_r(\eta) = \frac{p_s - p_t}{g\eta s} \int_{\eta}^{\infty} (P_{raut} + P_{racw} + P_{sacw} + P_{sm1} + P_{sm2} - Err) d\eta$$

# In-line Documentation Style

For each subroutine that is *not* the entry point to the scheme:

- Using “**\ingroup**” to associate it with the parent module
- A brief one-sentence description “**\brief**”
- Using “**\param**” to define each parameter with local name, a short description and unit

```
!> \ingroup HEDMF
!! \brief This subroutine is used for calculating the mass flux and updraft properties.
!! ...
!! \param[in] im      number of used points
!! \param[in] ix      horizontal dimension
!! \param[in] km      vertical layer dimension
!! \param[in] ntrac   number of tracers
!!
!! \section general_mfpbl mfpbl General Algorithm
!! -# Determine ...
!! -# Calculate ...
!! -# ...
!! \section detailed_mfpbl mfpbl Detailed Algorithm
!! @{
!!     subroutine mfpbl(im,ix,km,ntrac,delt,cnvflg,           &
!!         &  z1,zm,thvx,q1,t1,u1,v1,hpbl,kpbl,             &
!!         &  sflx,ustar,wstar,xmf,tcko,qcko,ucko,vcko)
!!
!!     ...your code goes here
!!
!!     end subroutine mfpbl
!! @}

```

# Bibliography/Citation

Doxygen can handle in-line paper citations and link to an automatically created [bibliography page](#)

- A *library.bib* (i.e., `<cite_bib_files>` in `doxyfile`) for FV3GFS physics in BibTeX format is provided in the repository.

```
@article{han et al 2017,  
  Author = {J. Han and W. Wang and Y. C. Kwon and S.-Y. Hong and V. Tallapragada and F. Yang},  
  Date-Added = {2018-01-24 18:48:52 +0000},  
  Date-Modified = {2018-01-24 18:53:21 +0000},  
  Journal = {Weather and Forecasting},  
  Pages = {2005-2017},  
  Title = {Updates in the NCEP GFS cumulus convective schemes with scale and aerosol awareness},  
  Volume = {32},  
  Year = {2017}}
```

*Note: A red arrow points from the text "bibtex\_key\_to\_paper" to the underlined key "han et al 2017" in the BibTeX entry above.*

- To use citations within the comment text, use Doxygen command:

```
\cite bibtex_key_to_paper
```

# Wrap Up

- Reviewing CCPPv2 scientific documentation provide a good start point for advanced CCPP physics suites documentation.
- The procedure outlined herein is not unique, but following it will provide a level of continuity with previously documented schemes.
- For precise instruction on creating the scientific documentation:
  - <http://www.doxygen.nl/manual/>
  - contact the GMTB helpdesk: [gmtb-help@ucar.edu](mailto:gmtb-help@ucar.edu)