CCPP Training

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CCPP Scientific Documentation

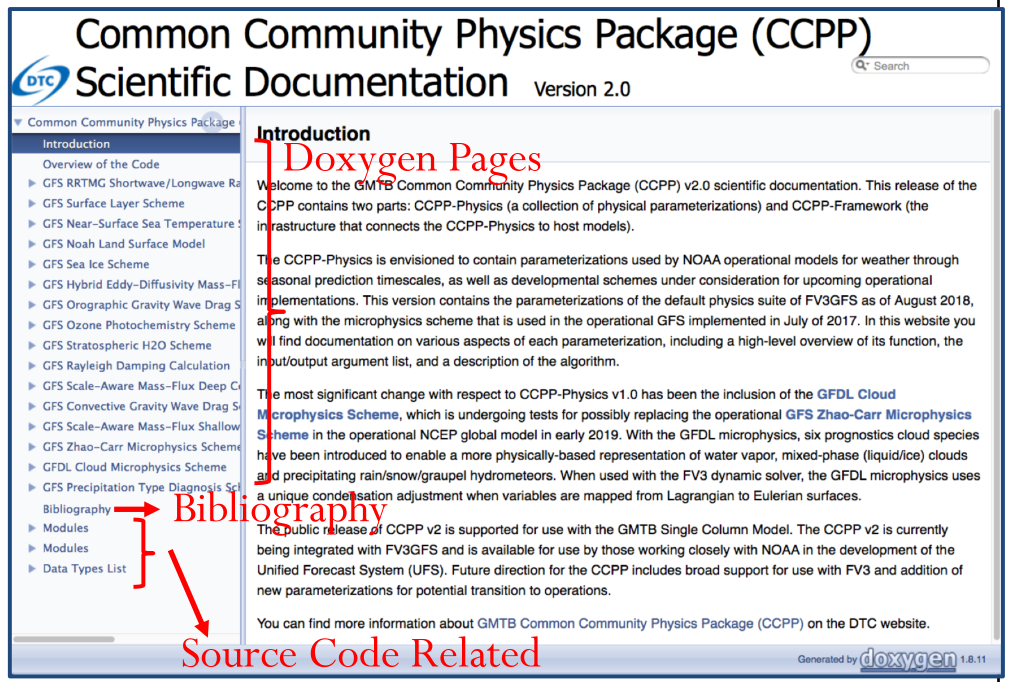
Man Zhang and Grant Firl

Global Model Test Bed

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**



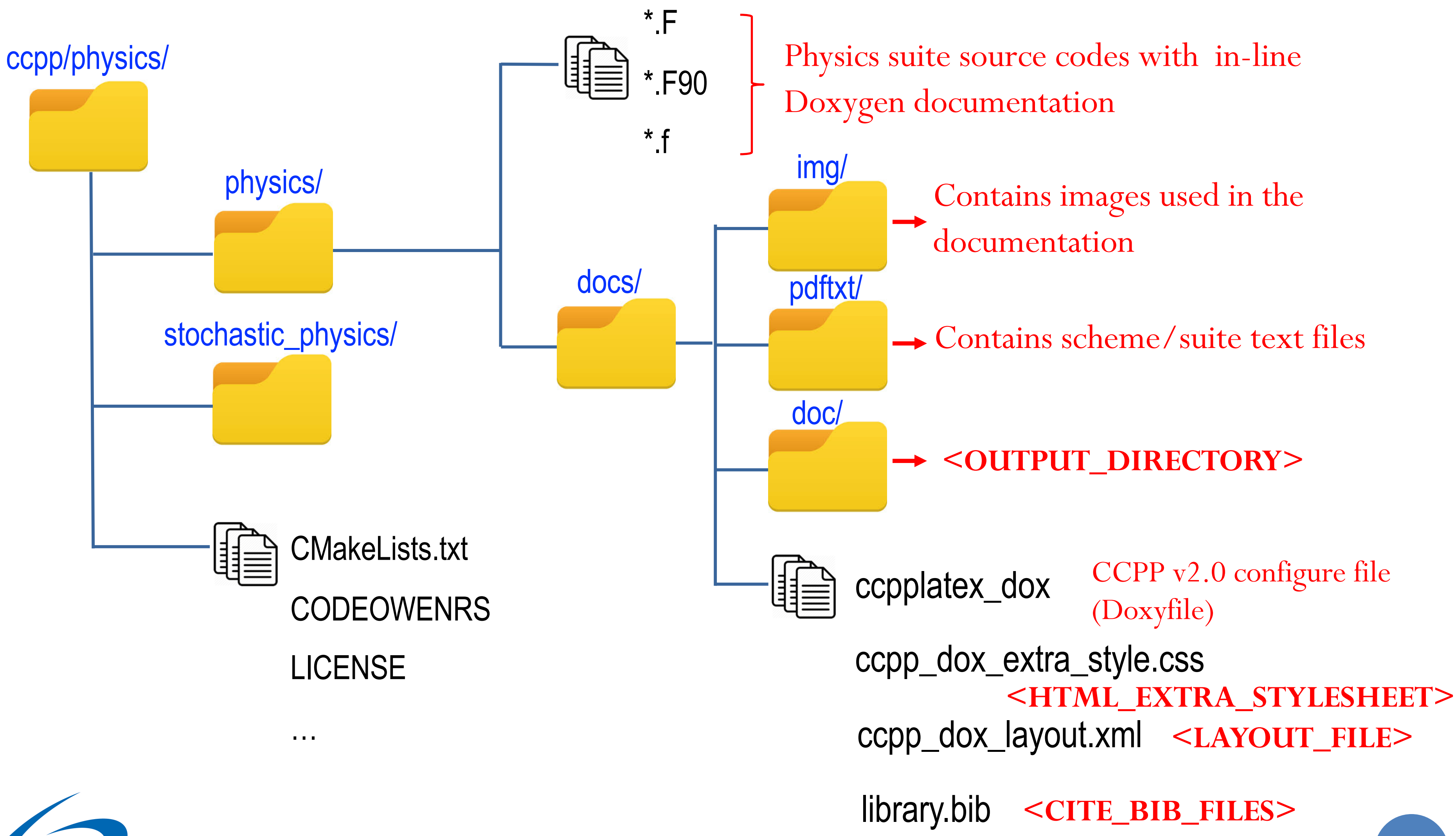
[CCPP V2.0 scientific documentation](#) includes FV3GFS physics suite

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



*** ALL <KEYWORD> are defined in Doxyfile**

Edit the Configuration File

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

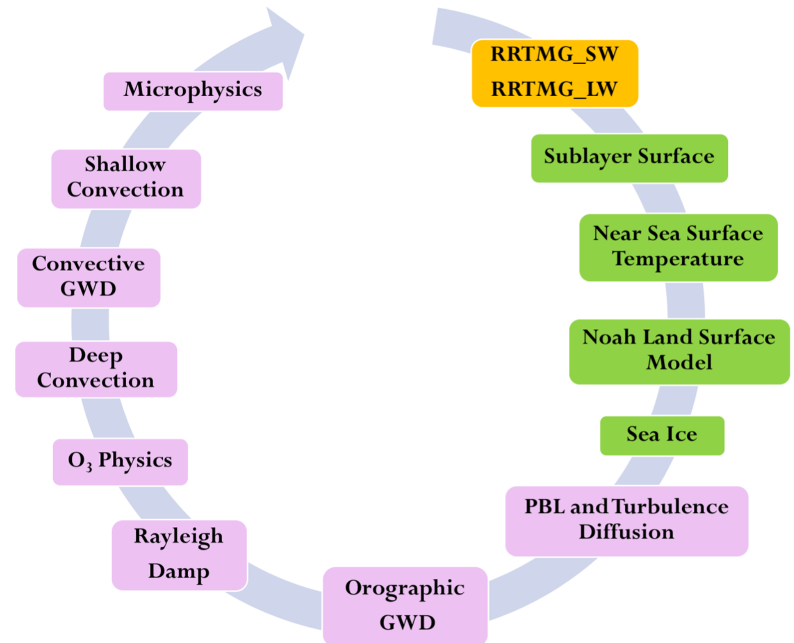
```
OPTIMIZE_FOR_FORTRAN    = YES
...
INPUT                   =  pdftxt/mainpage.txt       \
                           pdftxt/code_overview.txt \
                           pdftxt/GFS_RRTMG.txt      \
                           pdftxt/GFS_SFCLYR.txt     \
                           pdftxt/GFS_NSST.txt       \
                           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           \
...
```

→ set up Doxygen for Fortran project

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")**
  - Intraphysics 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")**

All commands start with a backslash("\") or an at-sign("@")

Doxygen Pages: GFS Zhao-Carr MP Scheme

```
/**
\page GFS_ZHAOC GFS Zhao-Carr Microphysics Scheme

\section des_zhao Description
 This is the GFS scheme for grid-scale condensation and precipitation which is
 based on Zhao and Carr (1997) \cite zhao_and_carr_1997 and
 Sundqvist et al. (1989) \cite sundqvist_et_al_1989 .
 ......
 Figure 1 shows a  schematic illustration of this scheme.
 ......
 \image  html  GFS_zhaocarr_schematic.png "Figure 1: Schematic illustration of the
  precipitation scheme" width=10cm
 ......
\section intra_zhao Intraphysics Communication
 + For grid-scale condensation and evaporation of cloud process
 (\ref arg_table_zhaocarr_gscond_run)
 + For precipitation (snow or rain) production (\ref arg_table_zhaocarr_precpd_run)

\section Gen_zhao  General Algorithm
 + \ref general_gscond
 + \ref general_precpd


*/
```

"**\page**" - indicate this is a free floating page

"**\image**" - insert an image file located under **<IMAGE_PATH>** in config file

"**\section**" – divide a Doxygen page into sections

"**\ref**"– insert a link to the specified page in this section

The symbols "/**" and "*/" need to be the first and last entries of the page

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Link to the HTML Result

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 !< earlist 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
!..................................
```

Link to the HTML Result

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:

$$P_r(\eta) = \frac{p_s - p_t}{g\eta_s} \int_{\eta}^{\eta_t} (P_{raut} + P_{racw} + P_{sacw} + P_{sm1} + P_{sm2} - E_{rr}) d\eta$$

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,                      &
     &   zl,zm,thvx,q1,t1,u1,v1,hpbl,kpbl,                              &
     &   sflx,ustar,wstar,xmf,tcko,qcko,ucko,vcko)

    ...your code goes here

    end subroutine mfpbl
!! @}
```

[Link to the HTML Result](#)

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.

bibtex_key_to_paper

```
@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}}
```

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

`\cite bibtex_key_to_paper`

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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