Compilation of WAVEWATCH III code

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Covered in this lecture:

- How to install the model
- How does compiling of WAVEWATCH III work?
  - Why not direct FORTRAN code?
  - How does the pre-processor work?

Background material

- Background information can be found on the website below; particularly recommended are:
  - The WAVEWATCH III manual.
  - The best-practices guide for WAVEWATCH III programming.

http://polar.ncep.noaa.gov/waves/wavewatch/wavewatch.shtml

- Applications can be found on the NCEP operational wave model website below. Recommended information on this site are:
  - Two COMET training web sites.
  - Training material from this and previous courses.

http://polar.ncep.noaa.gov/waves

WAVEWATCH III basics

WAVEWATCH III is a third-generation wave model descended from WAM, but with many differences:

- Governing equations (wave action vs. wave energy).
- Grid system (wavenumber on variable grid vs. relative frequency).
- Numerics (dynamic time stepping, higher-order propagation schemes, Garden Sprinkler Effect alleviation techniques).
- Physics (framework with multiple options).

WAVEWATCH I and II were developed at TU Delft (Netherlands) and NASA/Goddard Space Flight Center based on different governing equations.

WAVEWATCH III is similar to SWAN, but there are some major differences:

- Basic numerical solution techniques:
  - WAVEWATCH III: explicit hyperbolic equations, marching in time.
  - SWAN: implicit elliptical equations (stationary and nonstationary), solved by iterative sweeping.
  - *However*, both models now offer implicit propagation schemes on unstructured grids (coastal application)
- Program structure:
  - WAVEWATCH III: separate subprograms, compile-level user options
  - SWAN: single program, runtime user options

WAVEWATCH III v3.14 is trademarked and licensed, as close to open source as the US government allows.

WAVEWATCH III sub-programs

- Preprocessors:
  - Grid, numerics, physics: ***ww3_grid***
  - Initial conditions, stationary BCs: ***ww3_strt***
  - External boundary data: ***ww3_bound***
  - Input fields: ***ww3_prep***
- Core wave models: ***ww3_shel*, *ww3_multi***
- Output post-processors:
  - ASCII/Binary (point, field, track): ***ww3_outp*, *ww3_outf*, *ww3_trck***
  - GRIB/GRIB2 (field): ***ww3_grib***
  - NetCDF (point, field) ***ww3_ounp, ww3_ounf***
  - GrADS (point, field): ***gx_outf*, *gx_outp***
  - Wave system tracking (field): ***ww3_systrk***
- Regridding processors: ***ww3_gint***

Distribution methods

- Most WAVEWATCH III users will get the code from the NCEP website (after agreeing to the license).
  - Tar files + install script:
  - Manual chapter 5.
- Beta testers get newer versions.
- Those who work as co-developers have access to our Subversion (svn) server to get the latest developmental versions of the code.
  - svn server + install script.
- We will focus on the first distribution method; transitioning to second is trivial.
- NOTE: WAVEWATCH III is Linux/UNIX only. Installation on windows will require preparations using Linux/UNIX.

WAVEWATCH III distribution files (old)

install_wwatch3 (install_ww3_svn)	Installation script.
wwatch3.aux.tar	Auxiliary programs and scripts, including GrADS scripts.
wwatch3.ftn.tar	Source code files.
wwatch3.inp.tar	Example input files, identical to those printed in the manual.
wwatch3.tst.tar	A large variety of test cases.

WAVEWATCH III distribution files (current)

install_ww3_v4_svntar (install_ww3_svn)	Installation script.
wwatch3.guide.tar	A guide for general coding practices
wwatch3.manual.tar	WAVEWATCH III manual
wwatch3.model.tar	The model with source codes, input files, auxiliary programs etc.
wwatch3.regtests.tar	A regression testing package that replaces the old set of tests

Installation procedure

- Copy five files to WAVEWATCH III designated directory, for instance **~/wwatch3**
- Ensure that **install_wwatch3** has execute permission.
- Execute the install script and answer all questions.
  - Will practice this in afternoon session.
  - Will require a basic FORTRAN 77 compiler to be assessable, typically gfortran (gnu) will do. This compiler will be used for aux programs only, not for actual WAVEWATCH III code.
- Add directories to search path in shell profile (e.g. **.cshrc**, **.bashrc**) as directed by script. In particular at paths for **wwatch3/bin/** and **wwatch3/exe/**.

Installation procedure (2)

- NOTE: installation will generate file **.wwatch3.env** in the home directory.
- This file is used by all WAVEWATCH III management scripts, and points to directories used for code etc.

- HINT: If multiple versions of WAVEWATCH III are maintained simultaneously, then:
  - Point to proper directory by modifying **.wwatch3.env** by hand or by re-running **install_wwatch3**, or
  - Place a generic name like **wwatch3/** in **.wwatch3.env** and use this as a symbolic link to the actual wave model directory (recommended).

Setting compiler options

- WAVEWATCH III is not distributed as ready-to-compile FORTRAN 90 code, but has a set of scripts to build the model according to user specifications:
- Critical files needed to compile:

switch	List of model options selected by user (manual section 5.4). Preset with default model options.
comp	Compile script (section 5.3). Requires user interventions once.
link	Link script (section 5.3). Requires user interventions once
w3_make	Compiles wave model code-by-code

Setting compiler options (2)

- The **compile** and **link** scripts need to be modified to address error capturing for the given hardware and compiler (see ‘comp=’ and ‘opt=’ lines).
- Setup procedure described in manual section 5.3.
- Various **comp** and **link** scripts are provided with the model distribution for well-known compilers (e.g. gfortran, ifort, pgf90).
- Please provide us with yours for further distribution with the code

- NOTE: the compiler used here can be different from the compiler set in *.wwatch3.env*, compile optimization is set in these scripts.

Setting compiler options (3)

- Installation on parallel systems (SMP or MPP) gets a little more complicated. Generally only the main programs **ww3_shel** or **ww3_multi** will be run as a parallel code, whereas all other codes remain serial. Proper compilation requires one of the following options:
  - First compile all auxiliary programs with the proper **compile** and **link** options (switches) of serial codes. Then reset **compile** and **link** options, and then compile **ww3_shel** and/or **ww3_multi** alone.
  - Generate individual and complete source codes for all programs and create the proper corresponding compile protocols.

See Day 4 presentation

Windows installation

- WAVEWATCH III is not set up for installation under MS Windows®.

- For installation under MS Windows, the following procedure can be used:
  - Find a Linux/UNIX box and perform the basic installation.
  - Set required model options in the **switch** file.
  - Run the script **w3_source** to extract the clean FORTRAN codes and corresponding **makefile** in tar files.
    - Set compiler options for MS Windows compiler in **w3_source**, or
    - manually edit makefiles as needed.

Subversion installation:

- Similar to installation from tar files, but …
  - Svn directory under main directory holds all versioned copies of model elements.
  - “Conventional” elements all are links to versioned copies.
  - Separate install script updates svn files, and all links.
  - Commit changes from svn directory, make sure new elements are added, old elements removed from here.

Coding philosophy

- WAVEWATCH III is intended as both:
  - A general modeling framework, and
  - An efficient operational wave model.

- This implies that…
  - It should be possible to include many options in the modeling framework, but
  - That the final compiled code should include only essential components.

To achieve this, the WAVEWATCH III source code is not plain FORTRAN 90, but needs to go through a preprocessor to obtain the FORTRAN 90 code.

Manual chapter 5

Filename convention

- WAVEWATCH III follows the FORTRAN 90 standard, and all files are build as complete modules to enable and enforce interface checking and use association.
- A typical WAVEWATCH III file is named ID*name*md.ext

ID	Type identifier	w3	Basic wave model routine
		wm	Multi-grid extension routine
		ww3_	Main program
		gx_	GrADS postprocessor.
name	Code name, typically 4 characters, e.g. “srce”		
md	Identifier that this is a module.		
ext	File extension	ftn	Code requiring preprocessing
		f90	Plain FORTRAN 90 code.

Filename convention (2)

- For instance,
  - w3srcemd.ftn contains the module of the basic wave model that processes source terms, and that will need to be preprocessed before it can be compiled.
  - wmwavemd.ftn contains the multi-grid wave model module, requiring preprocessing.
  - ww3_grid.ftn contains the main program ***ww3_grid*** and requires preprocessing.
  - mod_xnl4v5.f90 does not follow the convention, except that the file extension indicates that the file does not need to be preprocessed.
    - This is part of Gerbrant van Vledder's quadruplet interaction package that is distributed with the wave model.

Using switches

- Below is part of **w3srcemd.ftn**, where input source terms are computed.
- The lines starting with !/XXX are optional pieces of code, activated by their "switches" XXX, in this case for
  - linear input, or
  - exponential input.

```
!
! 2.  Calculate source terms ----------------------------------------- *
!
! 2.a Input.
!
!/LN1        CALL W3SLN1 (       WN1, FHIGH, USTAR, U10DIR , VSLN       )
!/LNX        CALL W3SLNX
!
!/ST1        CALL W3SIN1 ( SPEC, WN2, USTAR, U10DIR ,        VSIN, VDIN )
!/ST2        CALL W3SIN2 ( SPEC, CG1, WN2, U10ABS, U10DIR, CD, Z0,         &
!/ST2                                                  FPI, VSIN, VDIN )
!/ST3        CALL W3SIN3 ( SPEC, CG1, WN2, U10ABS, USTAR, DAIR/DWAT, AS,   &
!/ST3                 U10DIR, Z0, CD, TAUWX, TAUWY, VSIN, VDIN, LLWS )
!/STX        CALL W3SINX
!
```

Using switches (2)

- Switches to be using in the compilation are stored in the **switch** file:
  - This file is stored as **./bin/switch** in the WAVEWATCH III directory. The installation script makes links to the original file in most work directories.
  - If the switches **NL1** and **ST2** are present in the **switch** file, the corresponding part of the preprocessed code **w3srcemd.f90** will become:

```
!
! 2.  Calculate source terms ------------------------------------- *
!
! 2.a Input.
!
        CALL W3SLN1 (       WN1, FHIGH, USTAR, U10DIR , VSLN       )
!
        CALL W3SIN2 ( SPEC, CG1, WN2, U10ABS, U10DIR, CD, Z0,        &
                                                   FPI, VSIN, VDIN )
```

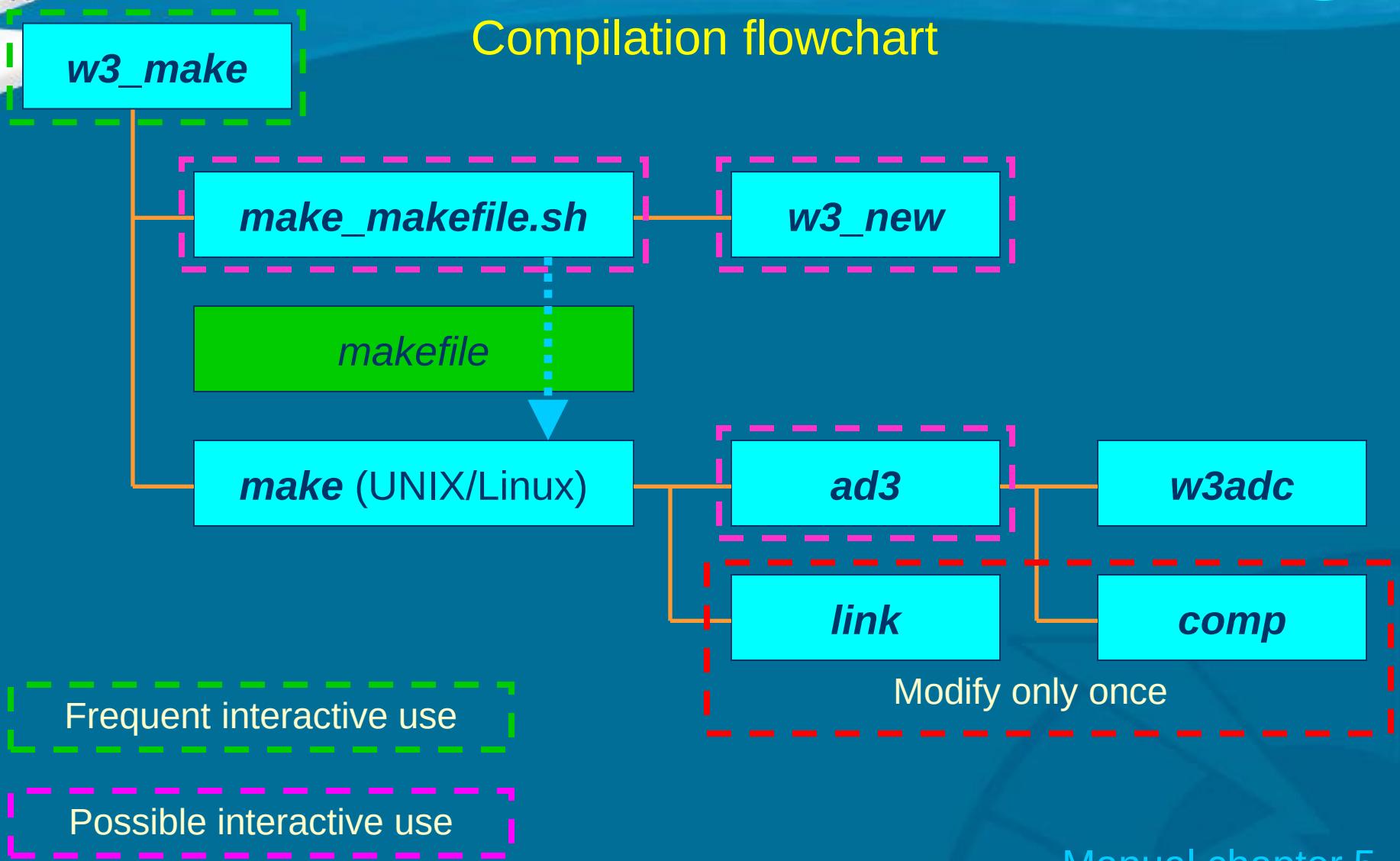
Manual Section 5.4

How does this work?

- A FORTRAN 77 program **w3adc.f** is compiled during installation of the model to produce the program ***w3adc***.
- ***w3adc*** is managed by the script ***ad3***, also put in place during model installation.
- ***ad3*** also uses the ***comp*** script, in which compiler options are set.
- ***ad3*** and the ***link*** script are called in the **makefile**, which is used by the standard UNIX/Linux ***make*** facility
- The **makefile** is updated by the script ***make_makefile.sh***, every time the **switch** file is modified.
- ***make_makefile.sh*** calls ***w3_new*** to touch the appropriate files to be recompiled by ***make***.
- And all this is managed by the ***w3_make*** script

Compiling the code

Compilation flowchart



Manual chapter 5

In summary

- Only ***w3_make*** is normally used:
  - ***w3_make*** by itself compiles all recognized WAVEWATCH III programs.
  - ***w3_make ww3_grid*** compiles this program only.
- ***ad3*** can be run interactively, particularly if test output needs to be switched on in selected routines.
- ***make_makefile.sh*** and ***w3_new*** can be run interactively as indicated in the manual.
- The rest of the system you will never see after the model is installed, but…

- It is essential that ***comp*** and ***link*** are set up with compiler error capturing if codes are to be edited.

Manual chapter 5

Do's and don'ts

- Even if the system may look a little complicated, do use it by properly modifying the ***.ftn*** files.
  - This is the only way of modifying this inside WAVEWATCH III in such a way that it can be ported to the distribution version of the model.
  - It is therefore more or less required by the license.

- ***w3_source*** will give you the clean FORTRAN files and the corresponding **makefile**:
  - Use this for operational implementations of the model.
  - Don't use this for upgrading source code.
  - Use it for MS Windows applications …

Compiling the code

Upon successful compilation, the following executables will reside in ./wwatch3/exe/ (slide 6):

- Preprocessors:
  - Grid, numerics, physics: ***ww3_grid***
  - Initial conditions, stationary BCs: ***ww3_strt***
  - External boundary data: ***ww3_bound***
  - Input fields: ***ww3_prep***
- Core wave models: ***ww3_shel*, *ww3_multi***
- Output post-processors:
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  - GRIB/GRIB2 (field): ***ww3_grib***
  - NetCDF (point, field) ***ww3_ounp, ww3_ounf***
  - GrADS (point, field): ***gx_outf*, *gx_outp***
  - Wave system tracking (field): ***ww3_systrk***
- Regridding processors: ***ww3_gint***

The end

End of lecture