**User Waves Based on Frequency Components**

A new wave model (*WaveMod* = 7) will be introduced to allow the user to define the incident waves using frequency components.

**User Wave-Component Input File and Changes to the SeaState Input Format**

When *WaveMod* = *7*, an input file containing the wave frequency components will be read. This input file can be formatted in two different ways. First, the standard OpenFAST convention is given in Table 1. With this convention, the input file should contain the four data columns listed in Table 1 **separated by whitespaces**. All header lines (lines not starting with a number) will be ignored.

**Table 1.**Columns of the wave-component input file – OpenFAST format.

|  |  |  |  |
| --- | --- | --- | --- |
| **Column Number** | **Quantity** | **Symbol** | **Unit** |
| 1 | Angular Frequency |  | rad/s |
| 2 | Wave Height |  | m |
| 3 | Direction (from the +-direction) |  | deg |
| 4 | Phase |  | deg |

Second, the format of the .SEA files is also made compatible, so that existing .SEA files can be used directly. To signal to OpenFAST that the wave-component file is prepared following the SEA convection, the first line of the file must start exactly with “source: SEAFileGenerator.exe” with a whitespace after the semicolon. As before, four data columns are required, which are listed in Table 2; however, the data columns should be **separated with commas** instead of white spaces. Finally, if the wave-direction convention (dconv) in the header lines is naut(ical) in the SEA file, OpenFAST will error out; only cart(esian) convention is supported currently. The differences between the OpenFAST and SEA formats are highlighted in red in Table 1 and Table 2.

**Table 2.** Columns of the wave-component input file – SEA format.

|  |  |  |  |
| --- | --- | --- | --- |
| **Column Number** | **Quantity** | **Symbol** | **Unit** |
| 1 | Frequency |  | Hz |
| 2 | Wave Amplitude |  | m |
| 3 | Direction (from the +-direction) |  | rad |
| 4 | Phase |  | rad |

The SeaState input file is updated to accommodate the new wave-model option. With *WaveMod* set to 7:

1. In the WAVES section of the HydroDyn input file, only the following inputs are used: *WaveMod*, *WaveStMod*, *WaveTMax*, *WvKinFile*, *NWaveElev*, *WaveElevxi*, *WaveElevyi*. The rest of the inputs are ignored.
2. The *WaveTMax* entry defines the maximum length of the nonrepeating wave signal, but it also determines the angular-frequency step used in the inverse fast Fourier transform (IFFT), which is given by *WaveTMax*. needs to be consistent with the wave-component input file (see restrictions on the input frequencies below). The *WaveTMax* entry is only used when the OpenFAST input file format is used. If the SEA input file format is used, the “duration” specified in the file header lines supersedes *WaveTMax* in the SeaState input file.
3. The *WaveDT* entry in the SeaState input file is not used because the time step for the wave time series is implicitly given by , where is the number of frequency components. This time step for the wave time series does not need to match the time step of the glue code. Furthermore, SeaState might adjust internally by appending additional frequency components of zero amplitude on the high-frequency end to enable efficient IFFTs, reducing at the same time. However, it is guaranteed that will be higher than the highest angular frequency in the wave-component input file.
4. The *WvKinFile* entry should be used to provide the name of the wave-component input file. The filename extension must be included.

To ensure that the input frequency components are compatible with the requirements of IFFT. Several restrictions are placed on the list of frequencies in the wave-component input file:

1. All frequency entries must be integer multiples of the frequency step, *WaveTMax* (*WaveTMax* is specified in the input file for SeaState). If this requirement is not met within a predefined tolerance, e.g., (or with the SEA format) deviates by more than from the nearest integer, SeaState will abort and provide a suitable error message. It is therefore critical that enough significant digits are retained for the frequencies in the input file.
2. The lowest possible angular frequency is .
3. If a frequency component has zero amplitude, it can be omitted in the input file. Internally, SeaState will assume zero amplitude for any omitted frequency components in the list . This added flexibility is required to accommodate existing .SEA files.
4. The frequencies in the input file need not be in any particular order.
5. For each frequency, there can be only one entry. It is not allowed, for example, to have two wave components with different directions but the same frequency.

**Implementation in OpenFAST**

The list of input frequency components can be directly used to generate the relevant time series in SeaState following the usual IFFT convention. The time-domain wave signal at a given location is computed using IFFT as:

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where the vector wave number of the th frequency component is given by and is the scalar wave number from the linear dispersion relation. The angular frequency, , is equal to . The total number of frequency components, , is . Note that with OpenFAST, the DC and Nyquist components ( and ) are always set to zero. The complex Fourier coefficient, , is defined as

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

The negative-frequency Fourier coefficients are the complex conjugates of the positive-frequency coefficients with . Eq. (1) can be simplified to

|  |  |  |
| --- | --- | --- |
|  |  | (3) |