Orientation of Mann Wind Boxes in FAST/FAST.Farm, HAWC2, and the Aeroelastic Codes

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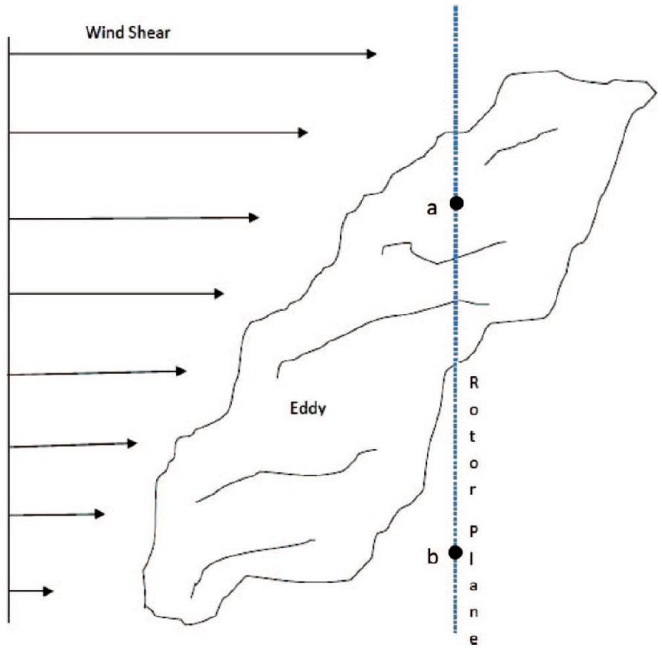
Linear Shear and Velocity Fluctuations

- Eddy stretching due to linear shear in the Mann model results in turbulence at point **a** leading in phase with respect to the turbulence at point **b**
  - Greatest for v, but also somewhat for u
- This matches observations and LES (see next slide)
- From Chougule and Mann et. al. (2012)



Chougule and Mann et. al. (2012)

Linear Shear and Velocity Fluctuations contd.

Mann model and Høvsøre phases

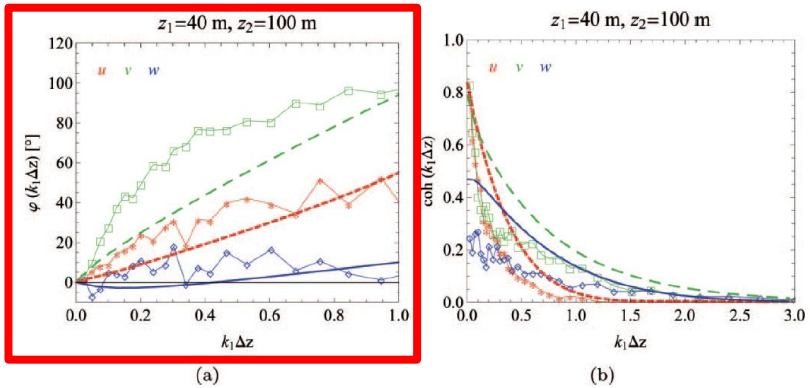


Figure 3. The phases (a) and the coherences (b) between 40 m and 100 m at Høvsøre for a neutral ABL with the predictions from the Mann model [2]. Phase angles from the measurements: φ_u; –∗–, φ_v; –□–, φ_w; –◇–. Model phases: φ_u; - - -, φ_v; – – –, φ_w; ——. Similar notations are followed for the coherences.

Mann model and LES phases

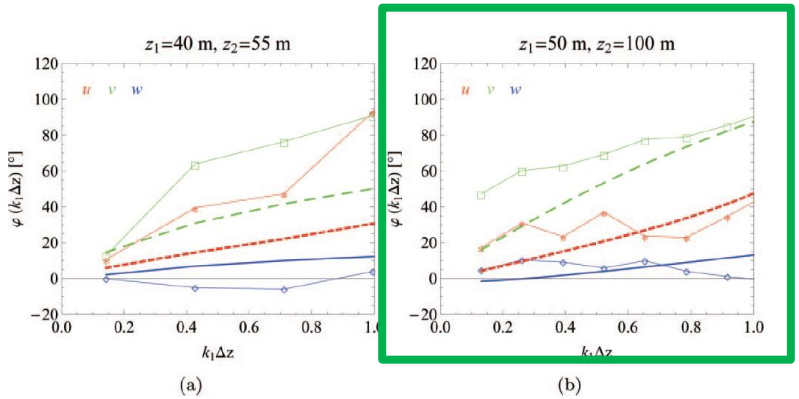
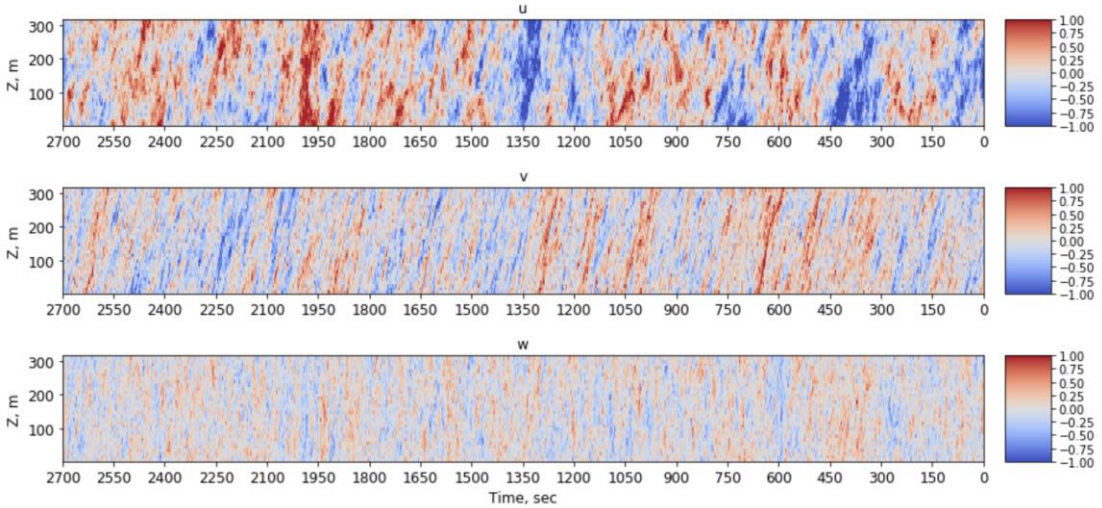


Figure 4. A comparison of phases from (a) CASES-99 and (b) LES for a neutral ABL with the phases from the Mann uniform shear model. Mann model: φ_u; - - -, φ_v; – – –, φ_w; ——. CASES-99 and LES: φ_u; –∗–, φ_v; –□–, φ_w; –◇–.

Chougule and Mann et. al. (2012)

Raw Mann Wind Boxes

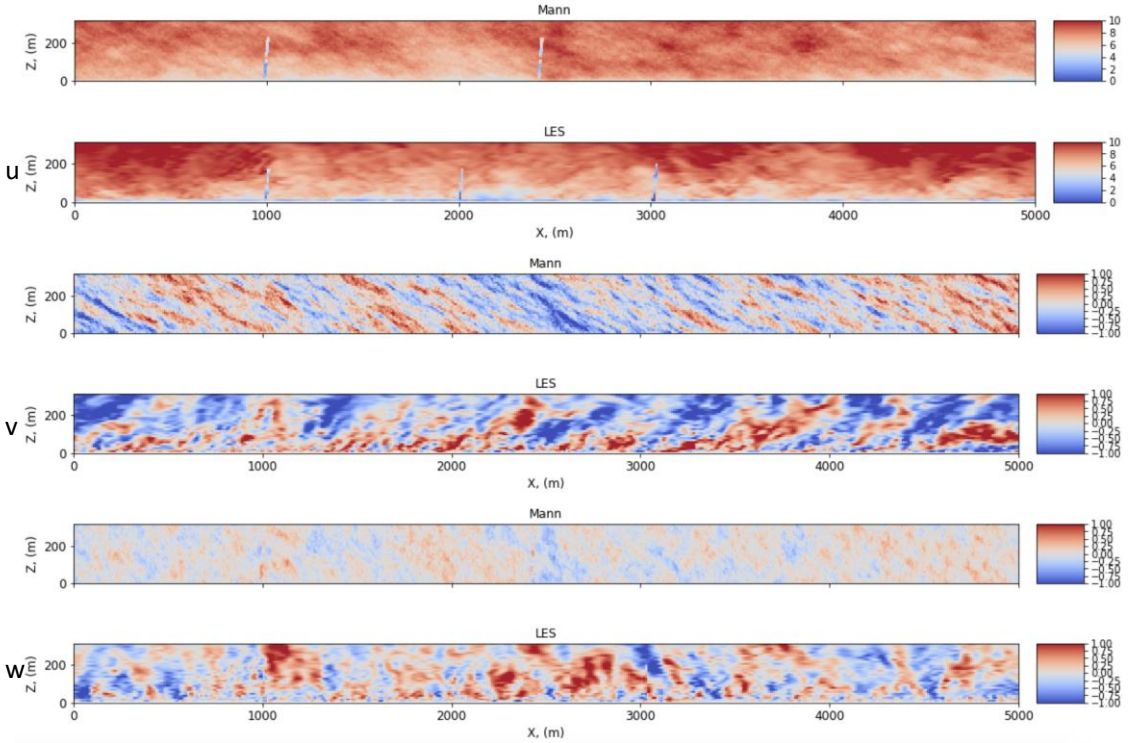
- Vertical slice at horizontal mid-point of wind box
- Wind propagation direction from left to right (to be consistent w/ slide 2)
  - time t=0 is at the right of the domain
- No post-processing (e.g. no scaling)
- Velocity fluctuations look similar to those described in Chougule and Mann et. al. (2012)



Raw Mann wind velocity components assuming that the wind box is written in decreasing t (increasing x). Wind box generated using the Mann 64bit turbulence generator v2.0 available here.

Wind Boxes in FAST.Farm

- Vertical slice of wind speed at horizontal mid-point of wind box (same wind box as previous slide, just post-processed and truncated)
- Wind propagation direction from left to right
  - X and Z scales have been equalized (e.g. 10m in X has the same number of pixels as 10m in Z)
- Mann wind and LES have the same mean wind speed (8 m/s) and TI (10%)
  - Mann box has been scaled to match shear exponent (0.2) and TI
  - Neutral atmospheric stability
- Velocity fluctuations for Mann look opposite as expected
  - Most clear for v when comparing to LES
  - Also look opposite of raw wind boxes

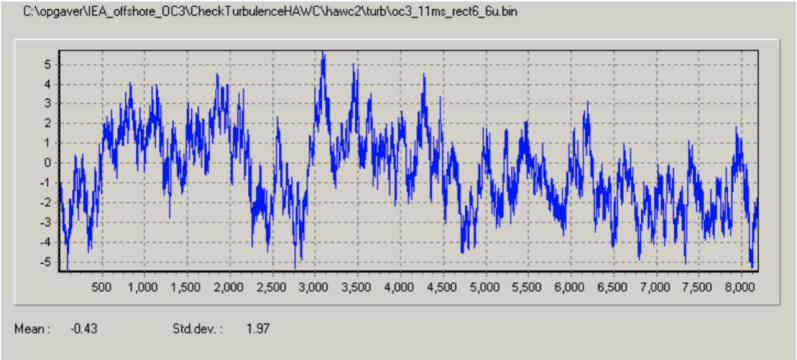


LES generated by an ABLSolver precursor and provided by NREL. FAST.Farm version is the March 2018 pre-release

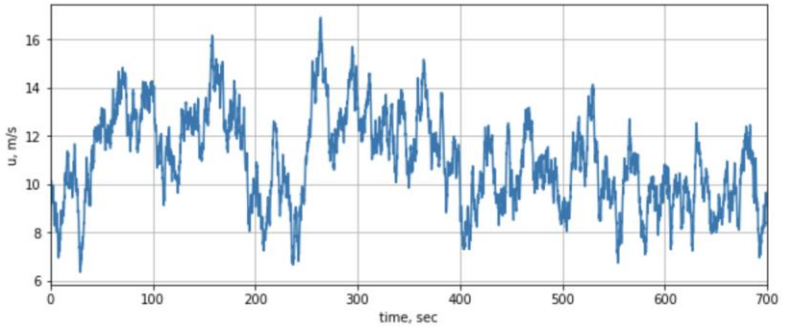
Comparison of OpenFAST v0.1.0 and OC3 Documentation

- Time series at the center point of the grid matches with original OC3 documentation

- FAST post-processing includes mean wind speed (11.4 m/s) and shear

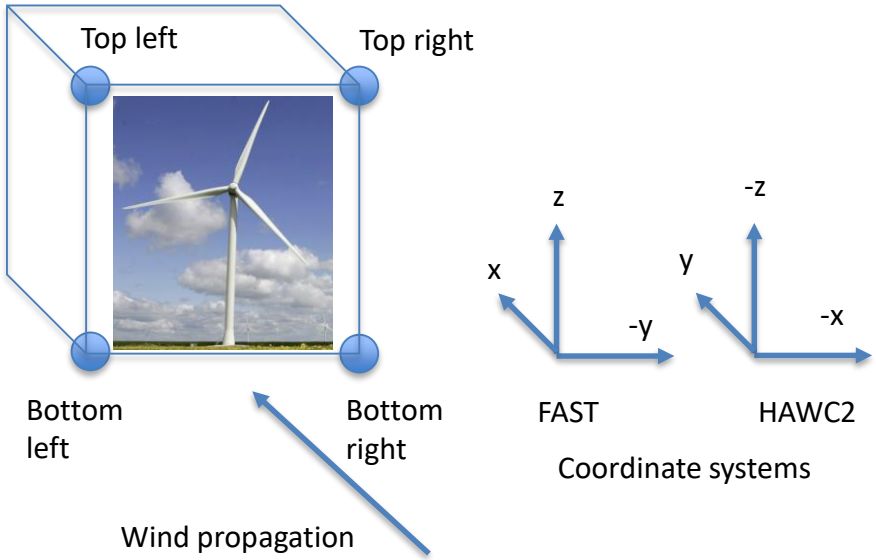


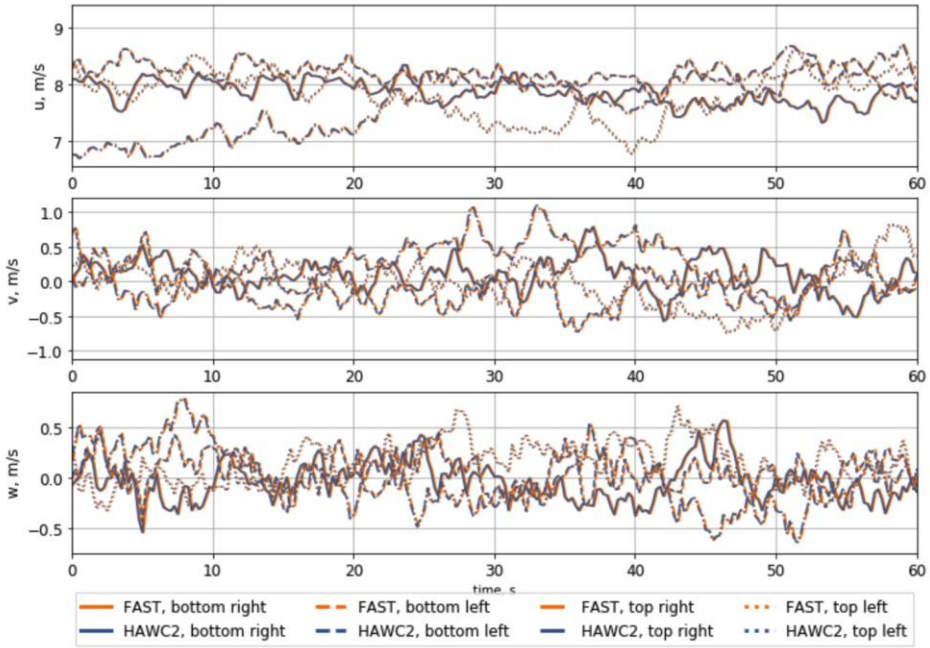
OC3 time series



OpenFAST v0.1.0 time series

Recent Comparison of OpenFAST v0.1.0 and HAWC2 version 12.2





- Time series at the four corners of the grid are the same (they are on top of each other for the figure above), confirming that FAST and HAWC2 read Mann boxes identically

Souce Code for Reading Mann files in FAST

```
DO IC = 1,NC

   CALL OpenBInpFile ( UnWind, DataFiles(IC), ErrStat )

   DO IX = NX,1,-1                  ! Time is the opposite of X ....
      DO IY = NY,1,-1
         DO IZ = 1,NZ

            READ( UnWind, IOSTAT=ErrStat ) DumReal

            WindData( IZ, IY, IX, IC ) = SF(IC)*DumReal    ! possible type conversion here

            IF (ErrStat /= 0) THEN
               CALL WrScr( ' Error reading binary data from "'//TRIM(DataFiles(IC))//'".' )
               CALL WrScr( ' I/O error '//TRIM(Num2LStr(ErrStat))//' occurred at IZ='//TRIM(Num2LStr(IZ))//&
                                          ', IY='//TRIM(Num2LStr(IY))//', IX='//TRIM(Num2LStr(IX))//'.' )
               CLOSE ( UnWind )
               RETURN
            END IF

         END DO
      END DO
   END DO

   CLOSE ( UnWind )

END DO
```