

Vertical Spectral Phases

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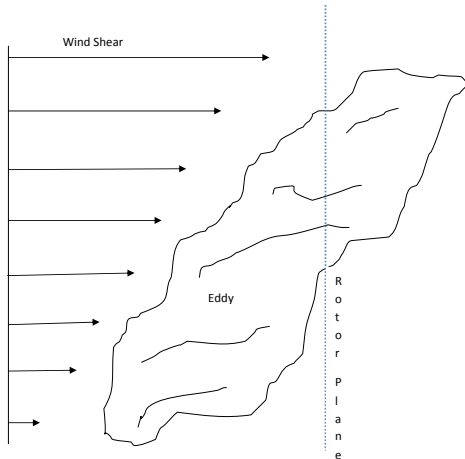
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Outline

- Motivation
- Definitions
- Model
- Observations

Motivation

Eddy stretching due to Shear



Turbulence Structure in Rotor Plane

u.....v w

Definitions

Cross-spectra :

$$\chi_{ij}(f) = \langle \hat{u}_i(f) \hat{u}_j^*(f) \rangle \quad (1)$$

Phase :

$$\varphi_{ij}(f) = \arg(\chi_{ij}(f)) \quad (2)$$

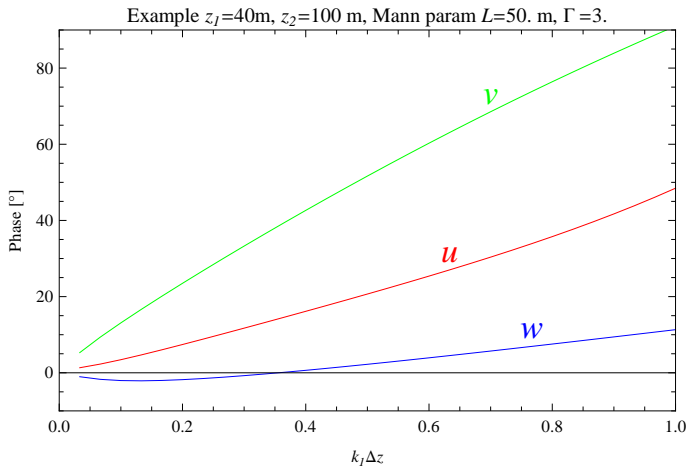
Coherence :

$$Coh_{ij}(f) = \frac{|\chi_{ij}(f)|^2}{F_i(f)F_j(f)} \quad (3)$$

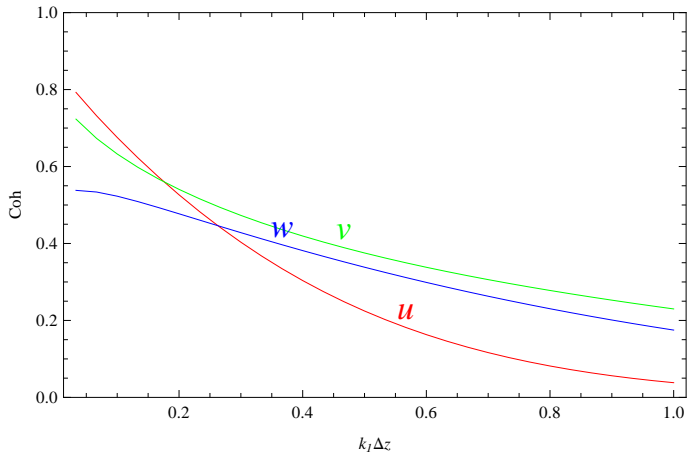
where

$$\hat{u}_i(f) = \int u_i(t) \exp(-i2\pi ft) dt \quad (4)$$

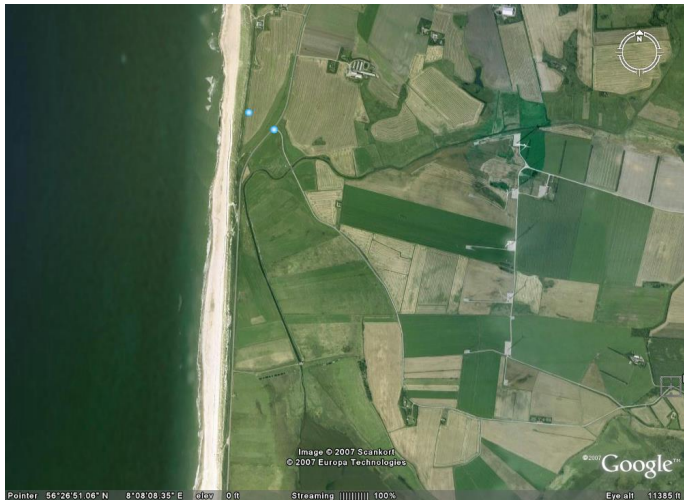
What model shows



Example $z_1=40\text{m}$, $z_2=100\text{ m}$, Mann param $L=50\text{ m}$, $\Gamma=3$



Observations from Høvsøre testing site

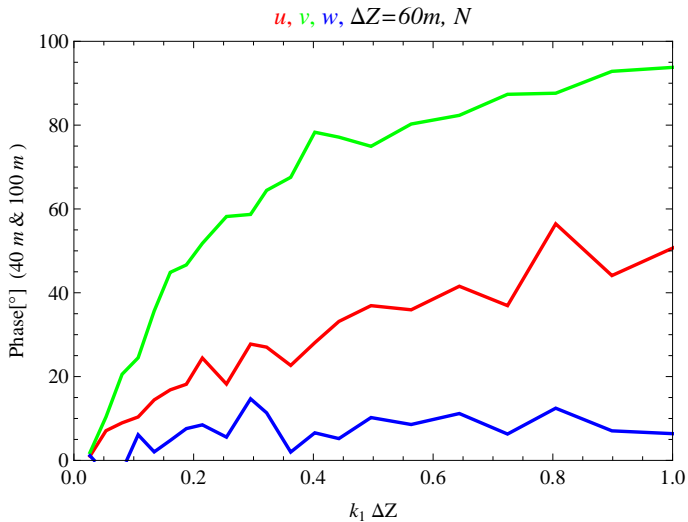


Høvsøre Sonic Data (2004 -2010)

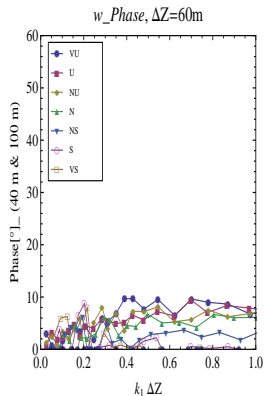
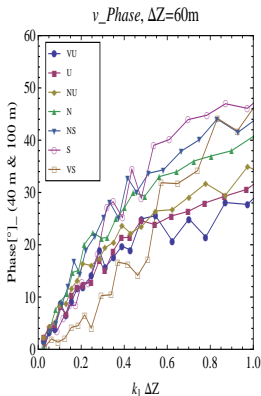
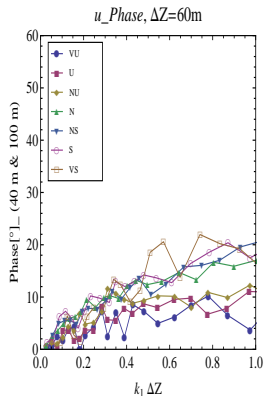
Wind Speed between 8m/s and 9m/s at 80m height
Direction between 60° and 120° at 60m height

Obukhov Length (m)	Atmospheric Stability	No of 30 min. time series
$-100 < L < -50$	Very Unstable (VU)	244
$-200 < L < -100$	Unstable (U)	595
$-500 < L < -200$	Near Unstable (NU)	595
$ L \geq 500$	Neutral (N)	3290
$200 < L < 500$	Near Stable (NS)	1709
$50 < L < 200$	Stable (S)	2075
$10 < L < 50$	Very Stable (VS)	1693

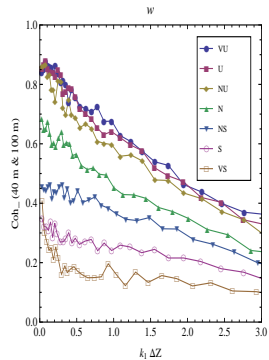
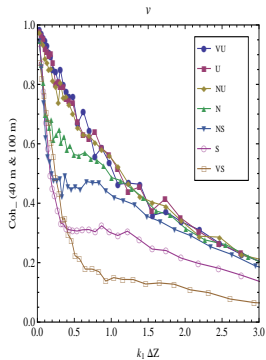
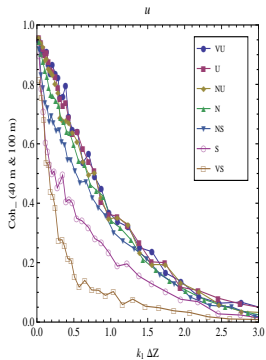
Phase : Neutral Case



Phase : All Stability Cases

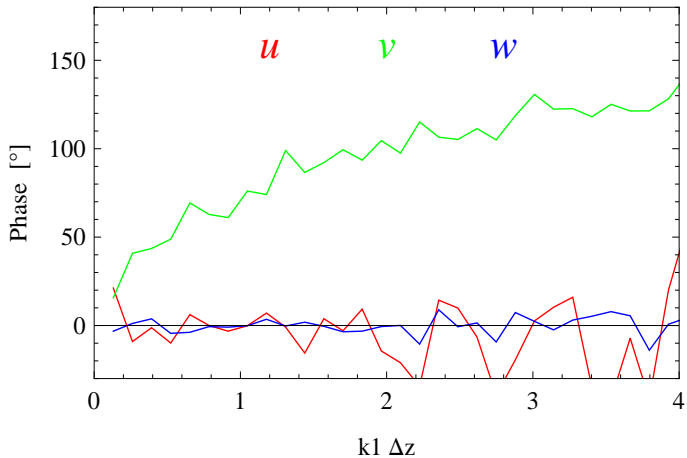


Coherence : All Stability Cases



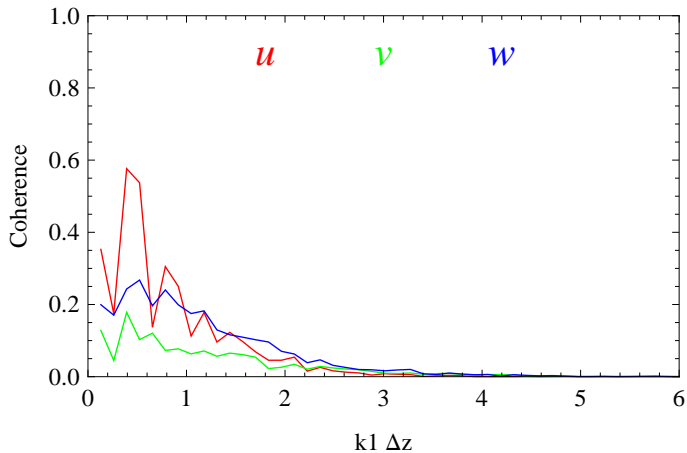
Phase : LES-Neutral

$$z_1 = 50m - z_2 = 100m$$



Coherence : LES-Neutral

$$z_1 = 50m - z_2 = 100m$$



Summary

- The phase angles between the two observation heights are analysed for all (7) atmospheric stabilities
- We see that $\varphi_v > \varphi_u > \varphi_w$
- This is also seen theoretically (as in Mann 1994)
- The u, v and w coherence decreases from very unstable to very stable case

Thank you