Figures annex

1 Simuation sketch

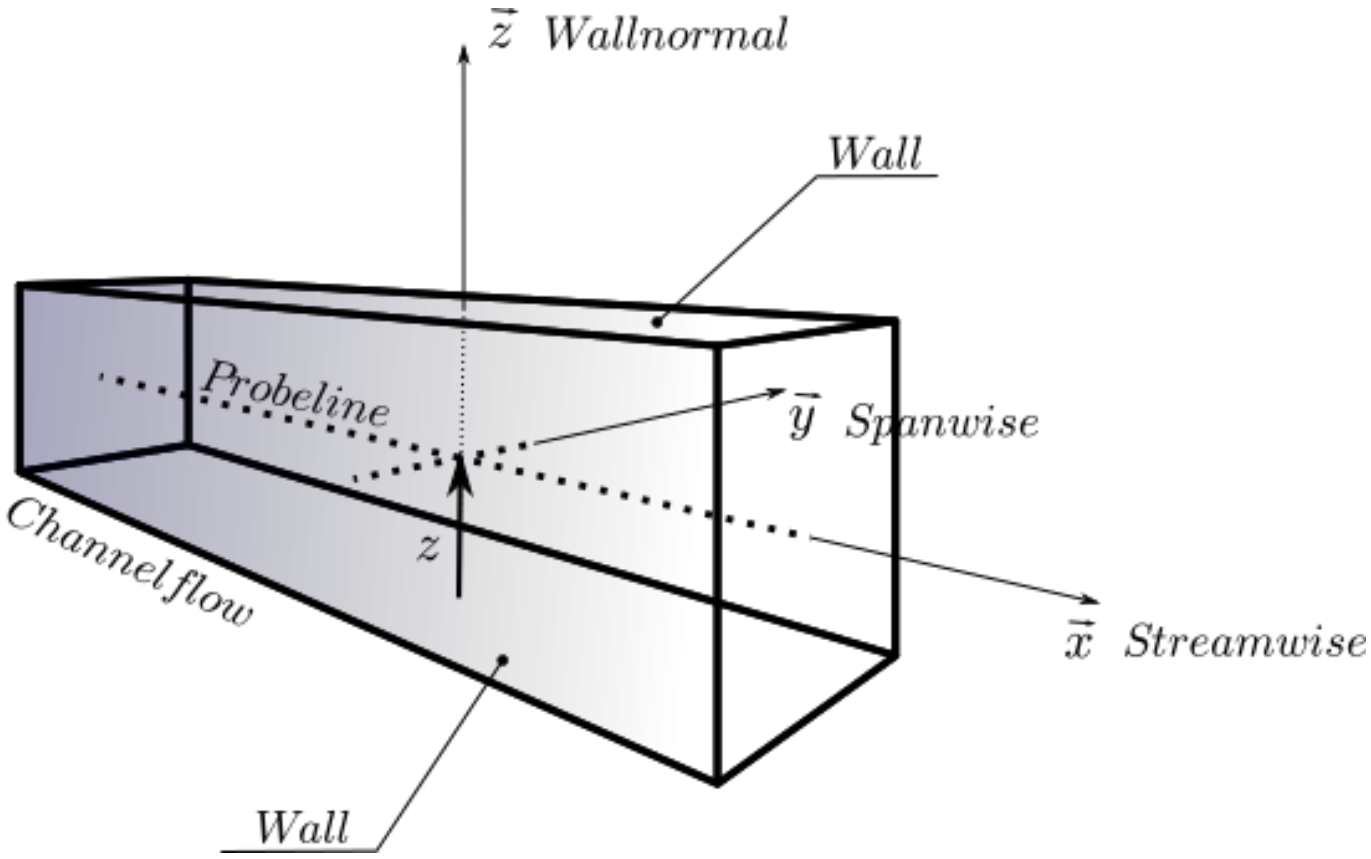


Figure 1: Sketch of the simulation

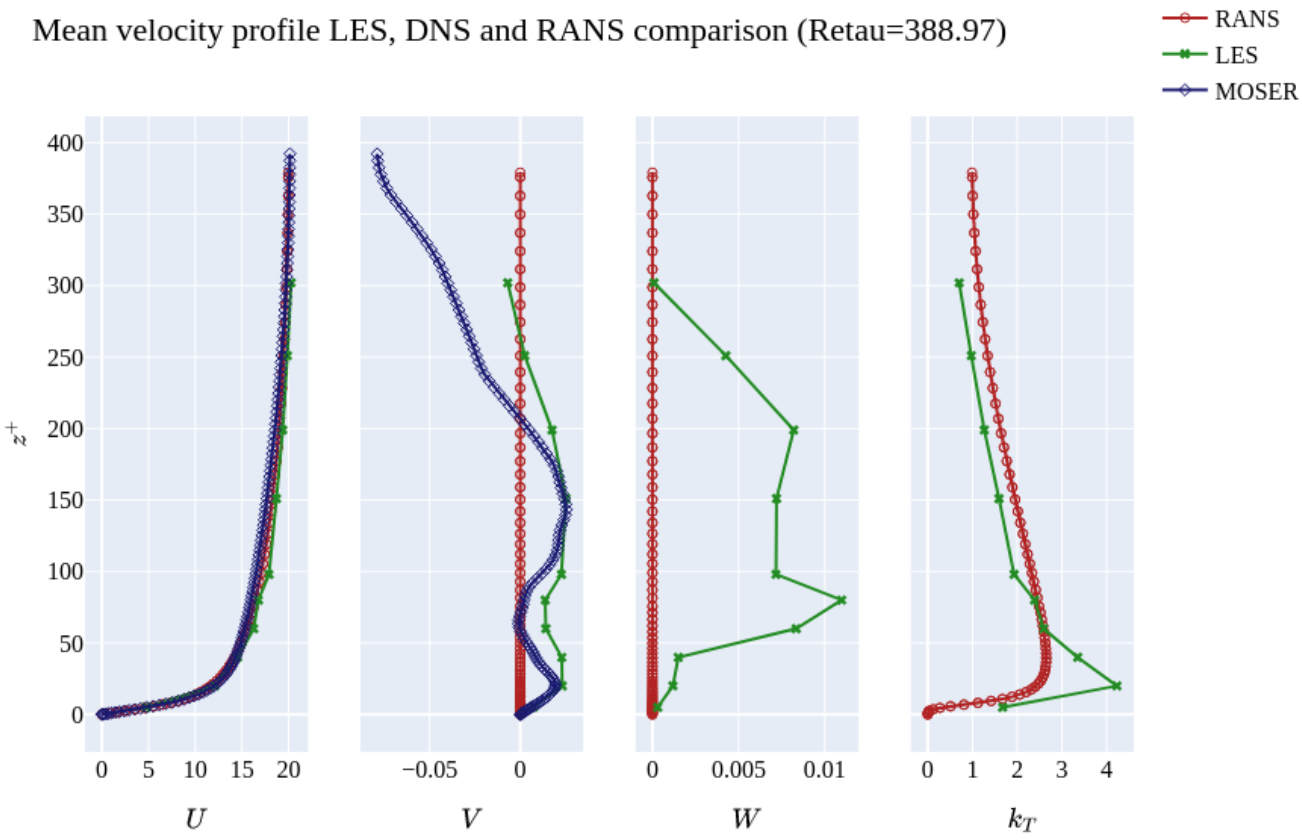


Figure 2: The comparison between RANS and LES data profiles of streamwise velocity (left figure) and kinetic energy (right) in function of z^+

2 RANS and LES comparison

3 Velocity analyses

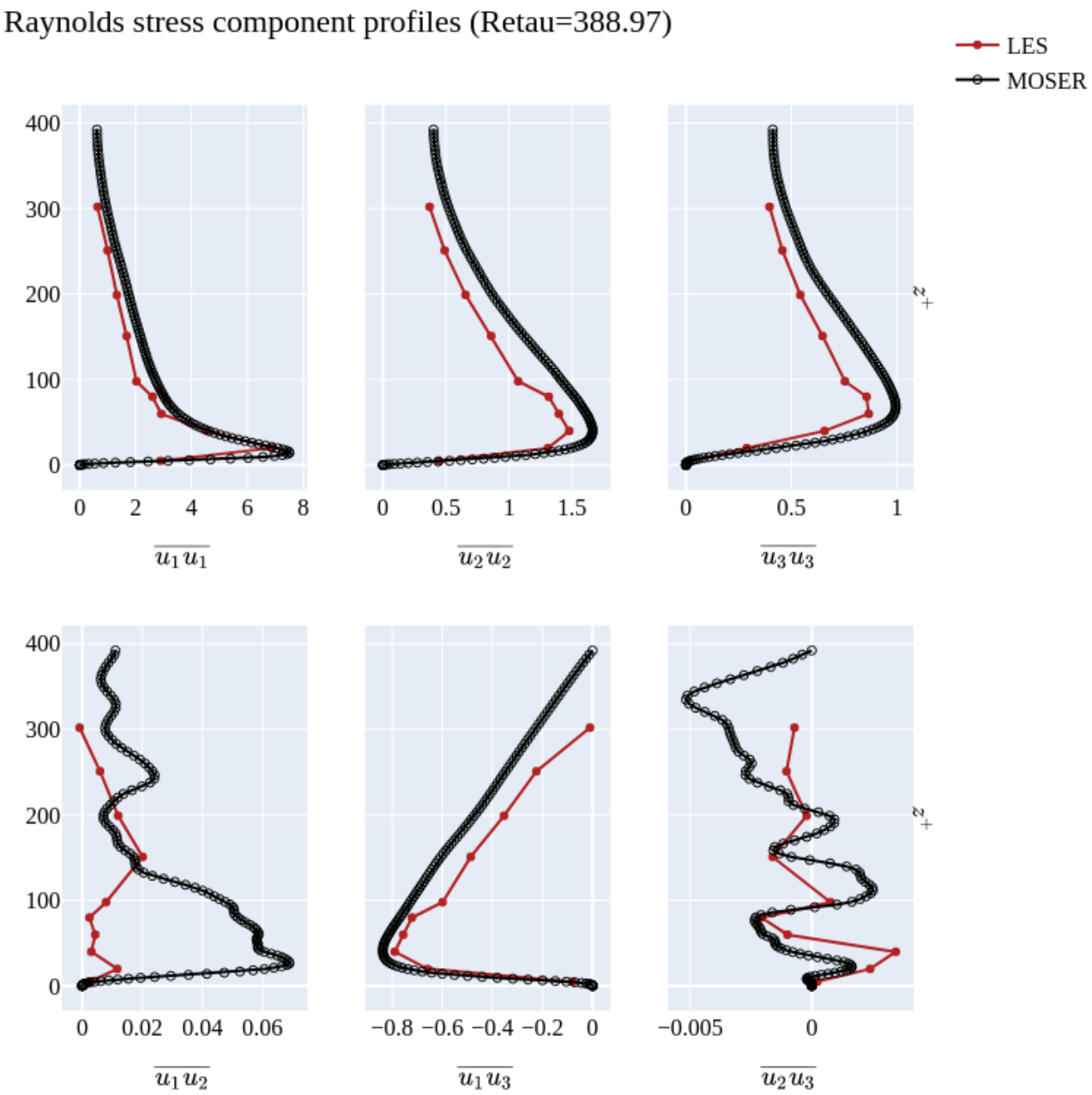


Figure 3: Three variance velocity fluctuation profiles from LES datas extract from 10 streamwise plan.

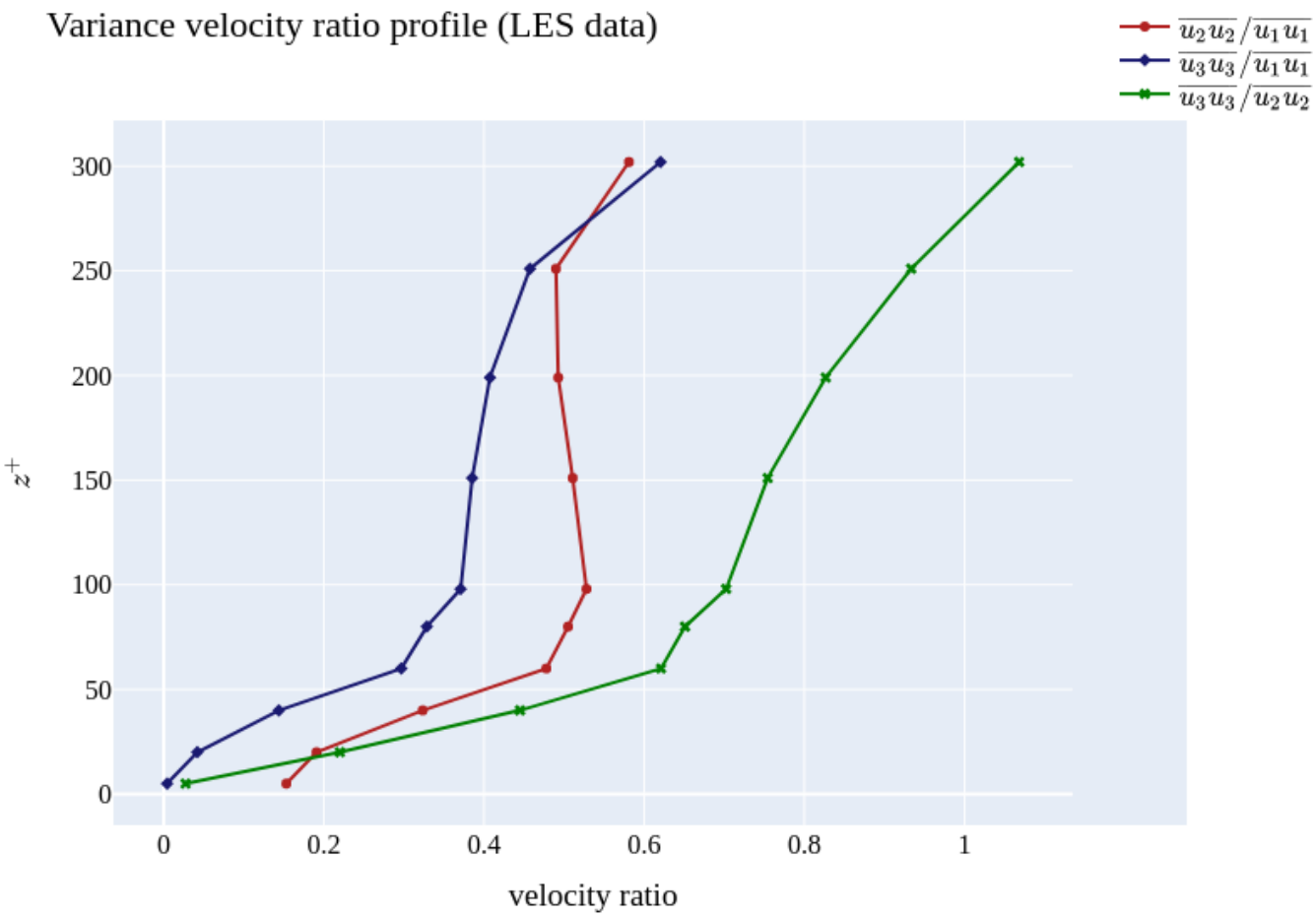
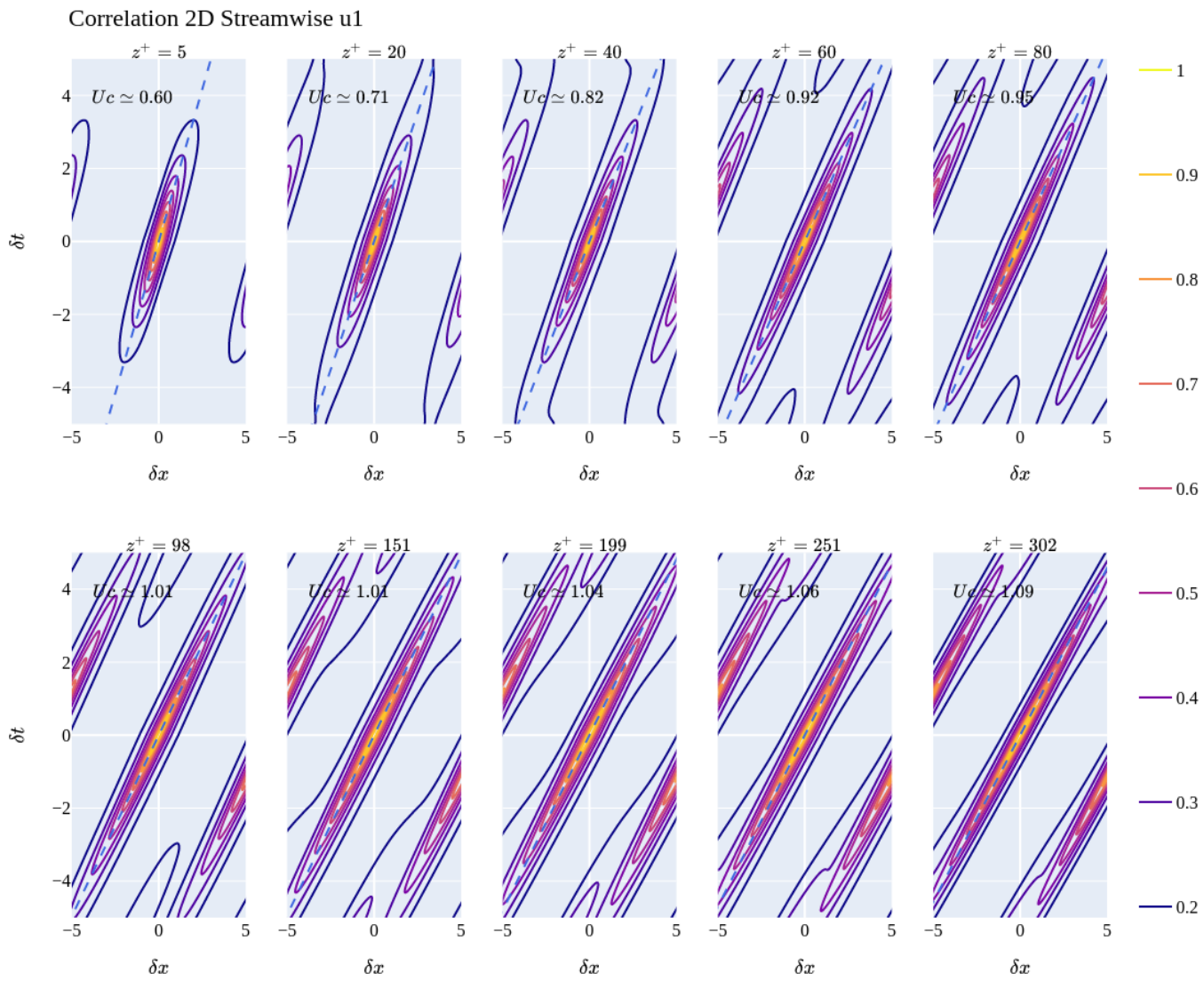


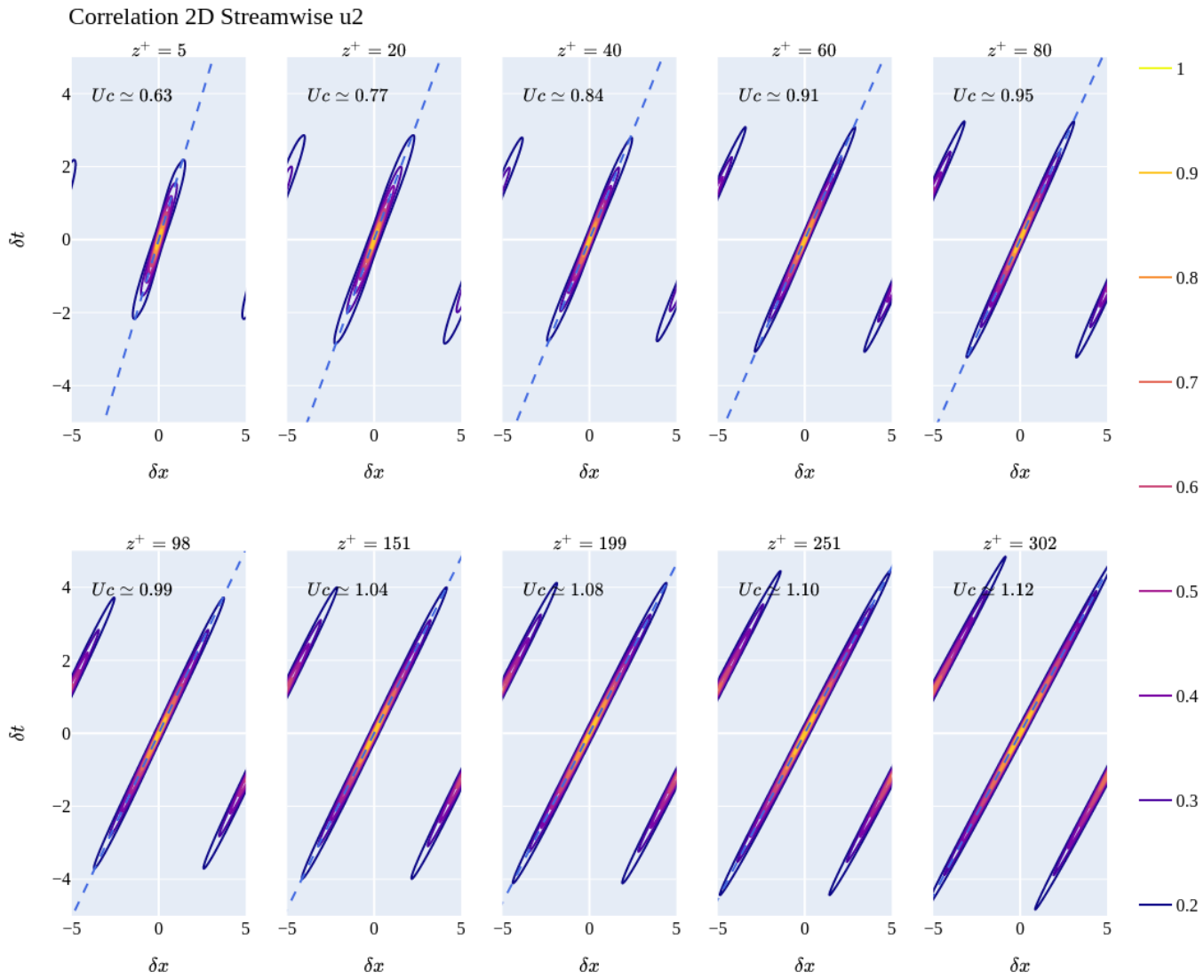
Figure 4: Square ratio of the spanwise on streamwise velocity (red) and the wall-normal on streamwise velocity (blue). They have been calculated taking the 10 streamwise plans. The streamwise velocity appears to be very dominant on both the spanwise and the wall-normal velocity.

4 Frozen turbulence

We want to verify the frozen turbulence hypotethis which state that $\phi_{ij}^{[1]}(k_1, x_2, x_3) = U_c\psi_{ij}(U_ck_1, x_2, x_3)$ with $\omega = U_ck_1$. U_c is the mean streamwise velocity, $\phi_{ij}^{[1]}$ is the spatial spectra in the streamwise direction and ψ_{ij} is the time spectra.

4.1 2D correlation




Correlation 2D Streamwise u2
$z^+ = 5$
$Uc \simeq 0.63$
$z^+ = 20$
$Uc \simeq 0.77$
$z^+ = 40$
$Uc \simeq 0.84$
$z^+ = 60$
$Uc \simeq 0.91$
$z^+ = 80$
$Uc \simeq 0.95$
$z^+ = 98$
$Uc \simeq 0.99$
$z^+ = 151$
$Uc \simeq 1.04$
$z^+ = 199$
$Uc \simeq 1.08$
$z^+ = 251$
$Uc \simeq 1.10$
$z^+ = 302$
$Uc \simeq 1.12$
δt
δx
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2

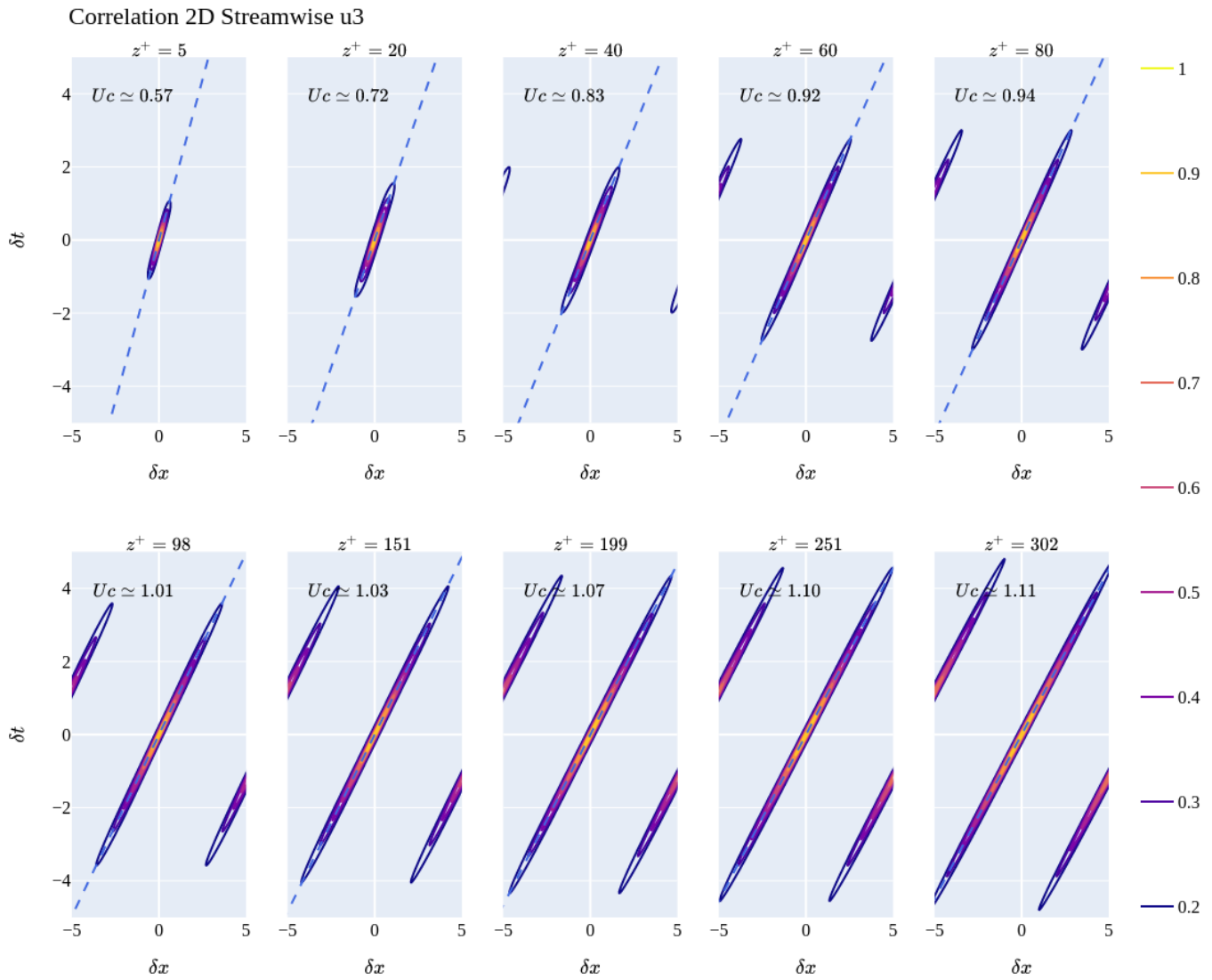


Figure 5: Contour plot of 2D correlation in four streamwise plans. (- - -) slop of the ellipses correponding at $\frac{1}{U_c}$. To determine the slop we take the following values of the correlation function: (0.7, 0.8, 0.85, 0.9, 0.95)

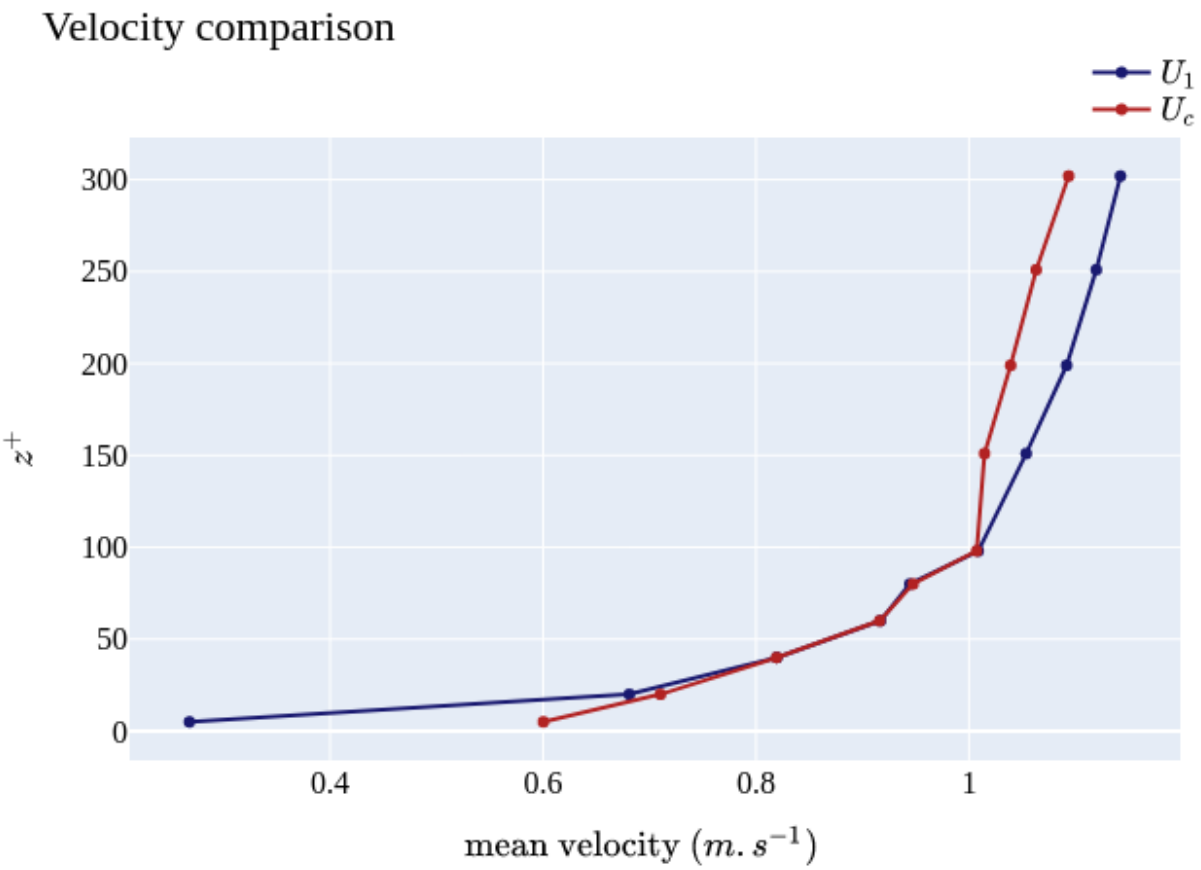


Figure 6: Comparion of slop determined velocity (U_c) and streamwise mean velocity (U_1) in function of z^+

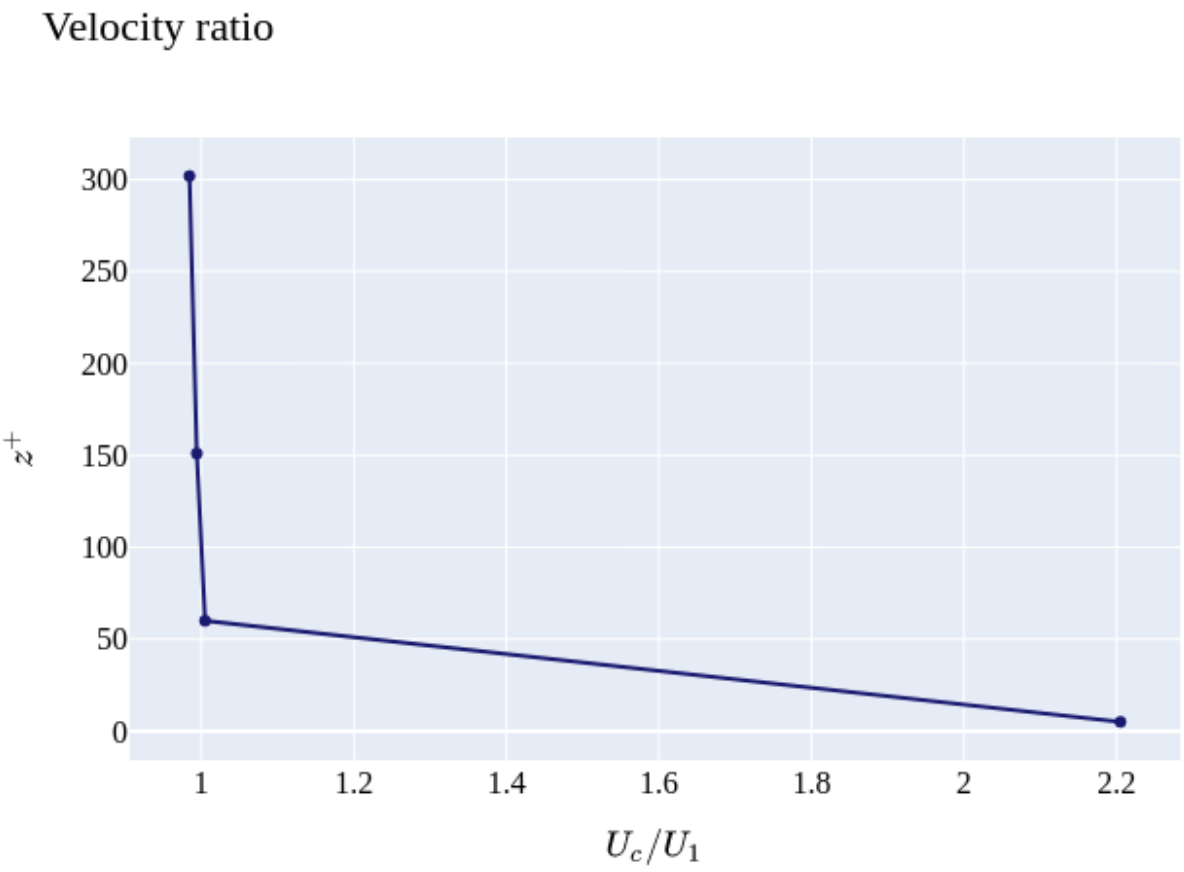
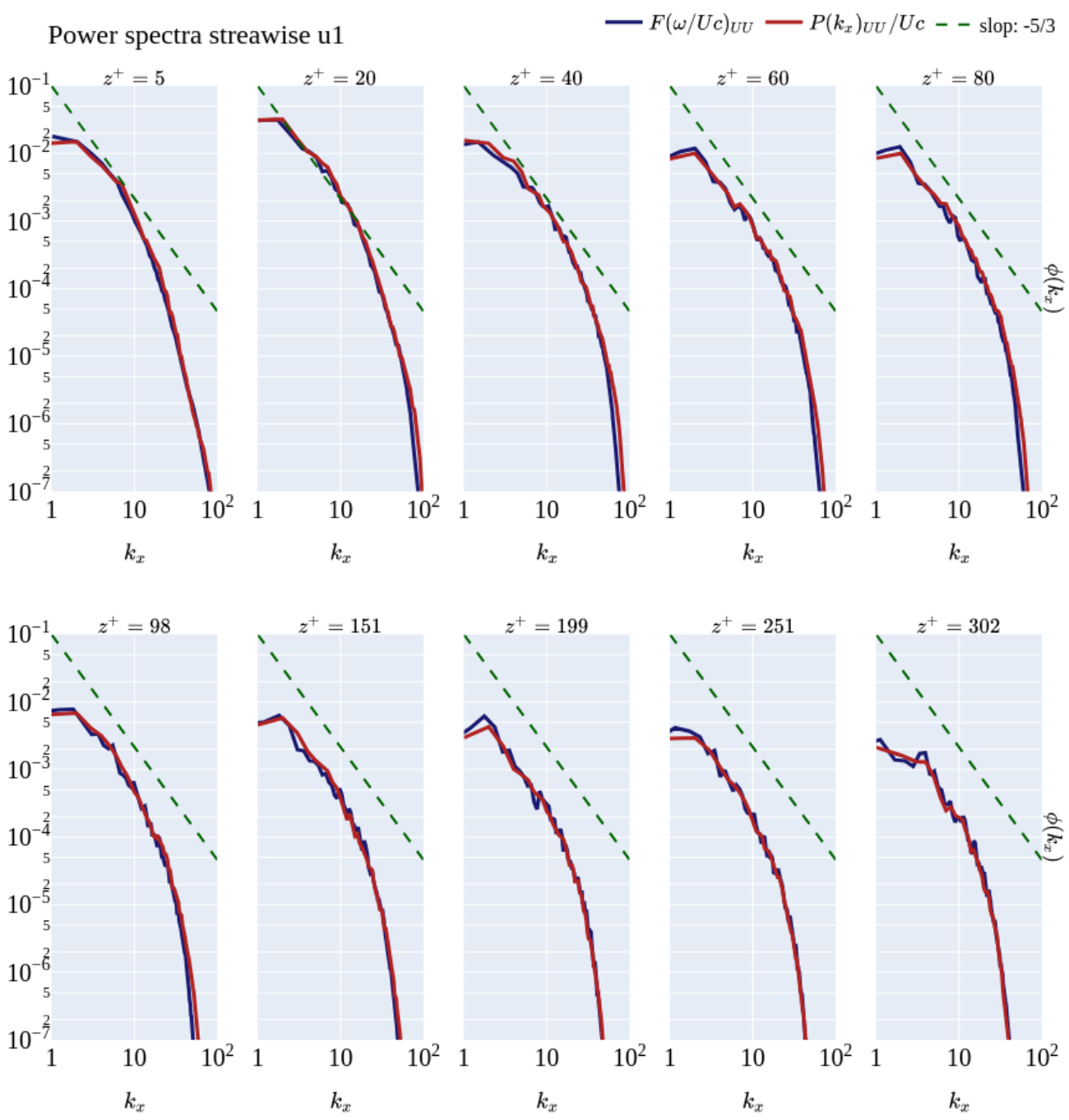
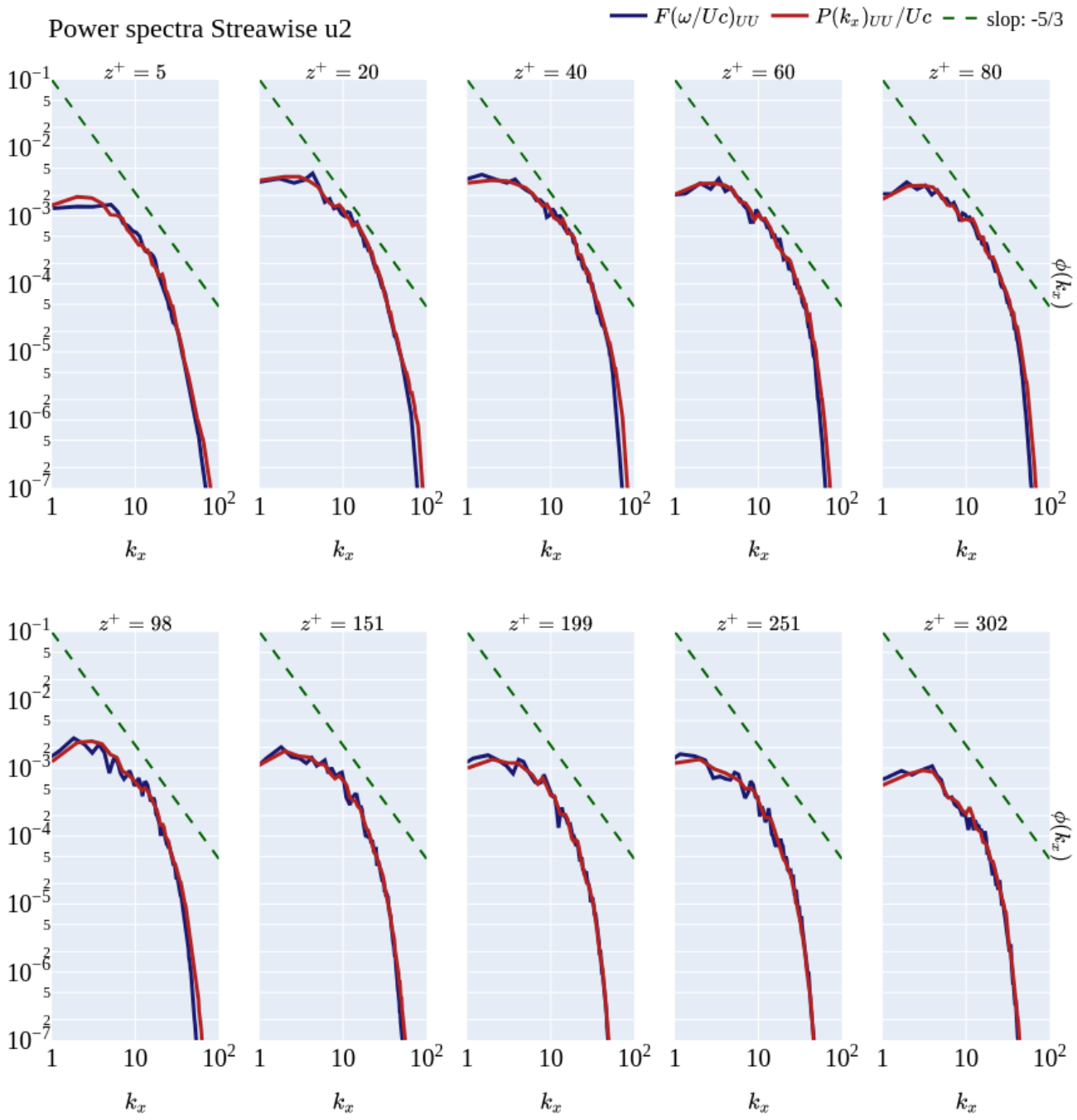


Figure 7: Ratio of slop determined velocity (U_c) and streamwise mean velocity (U_1) in function of z^+

4.2 Power spectras




Power spectra Streawise u2
$F(\omega/Uc)_{UU}$
$P(k_x)_{UU}/Uc$
slop: -5/3
$z^+ = 5$
$z^+ = 20$
$z^+ = 40$
$z^+ = 60$
$z^+ = 80$
$z^+ = 98$
$z^+ = 151$
$z^+ = 199$
$z^+ = 251$
$z^+ = 302$
$\phi(k_x)$
k_x

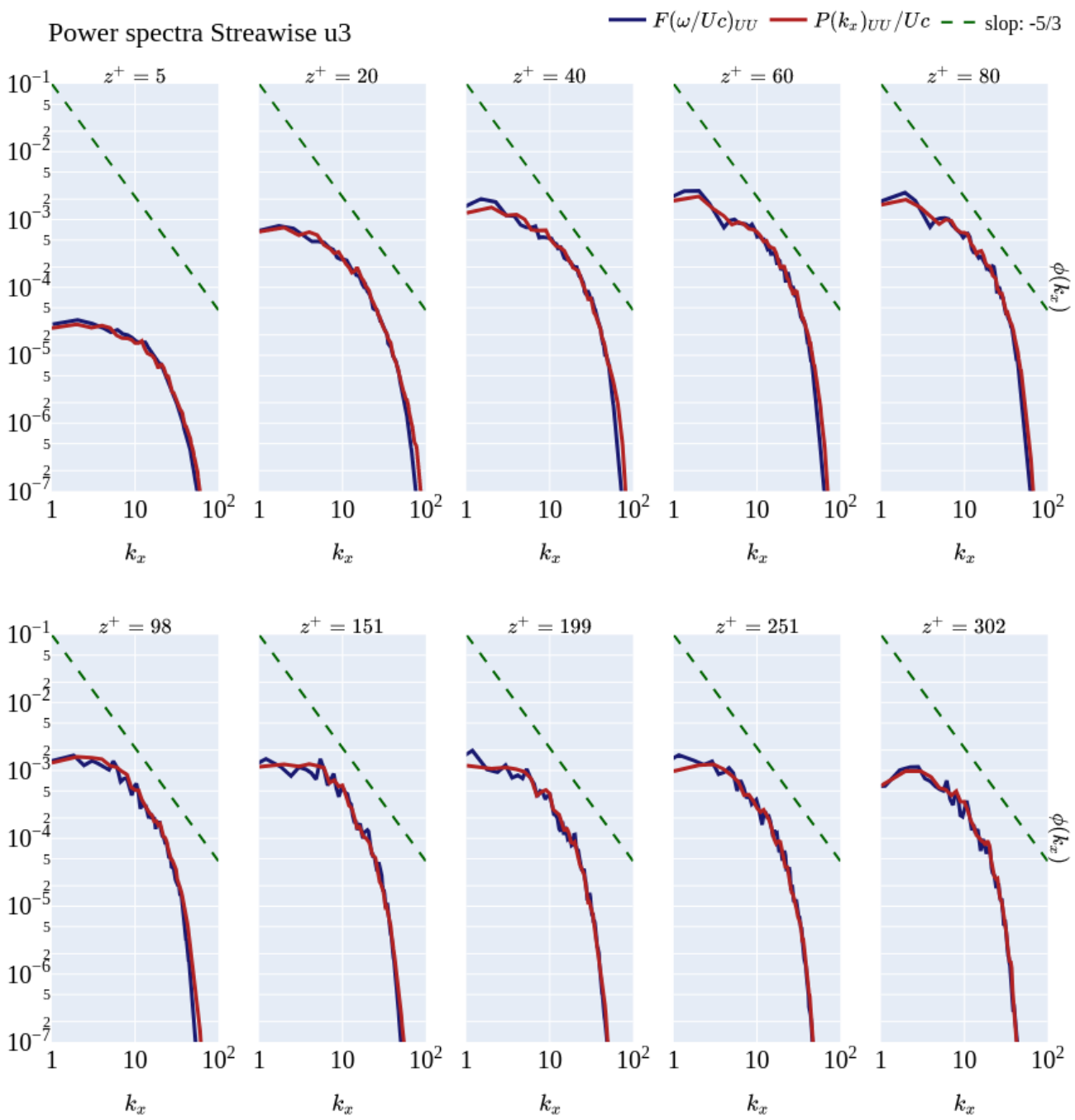


Figure 8: Power spectra in space (red) and time (blue) for the streamwise velocity (top), spanwise velocity (middle) and wall-normal velocity (bottom) at 10 different heights. The Uc took is the mean velocity along the streamwise axis

5 Spatial correlations

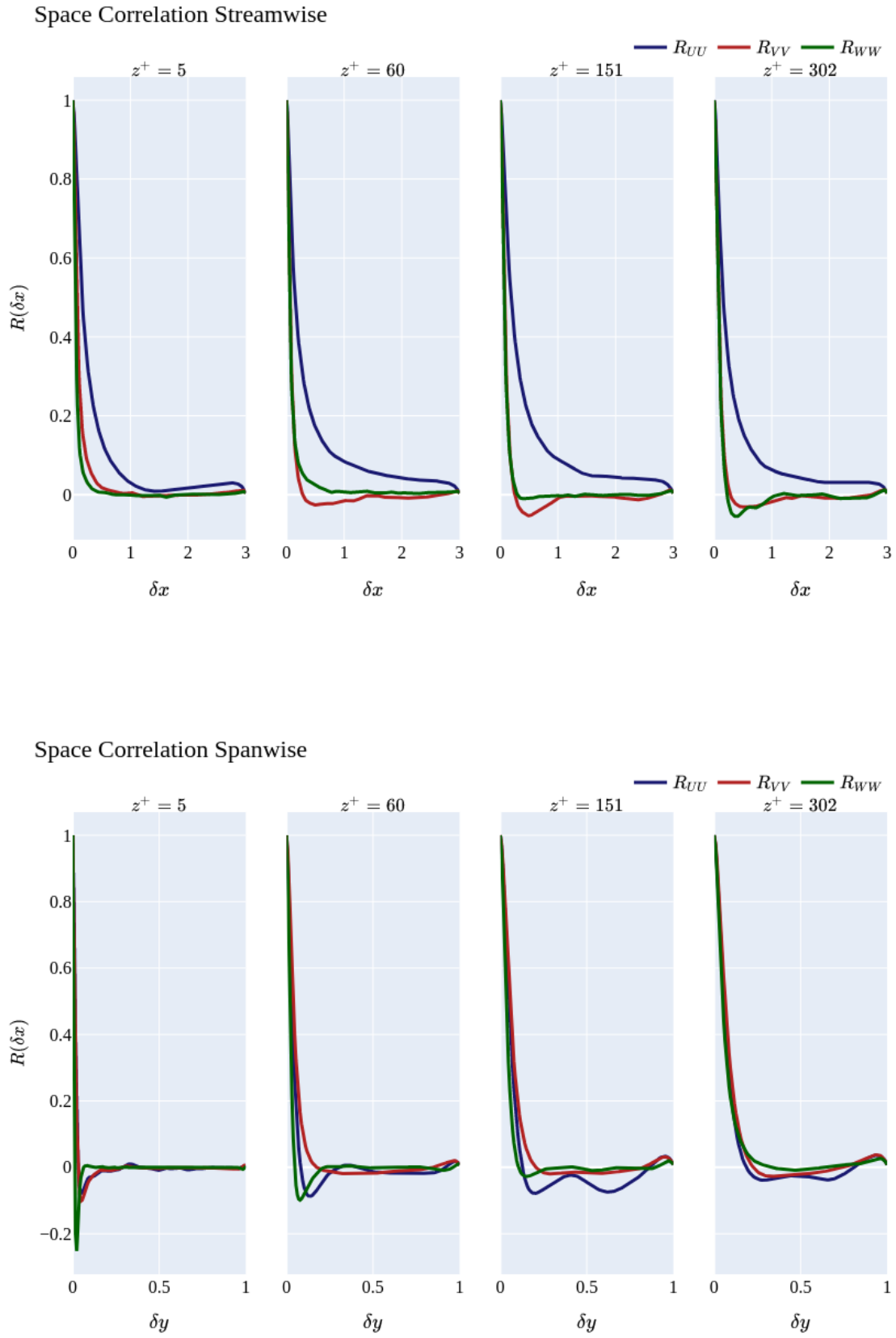
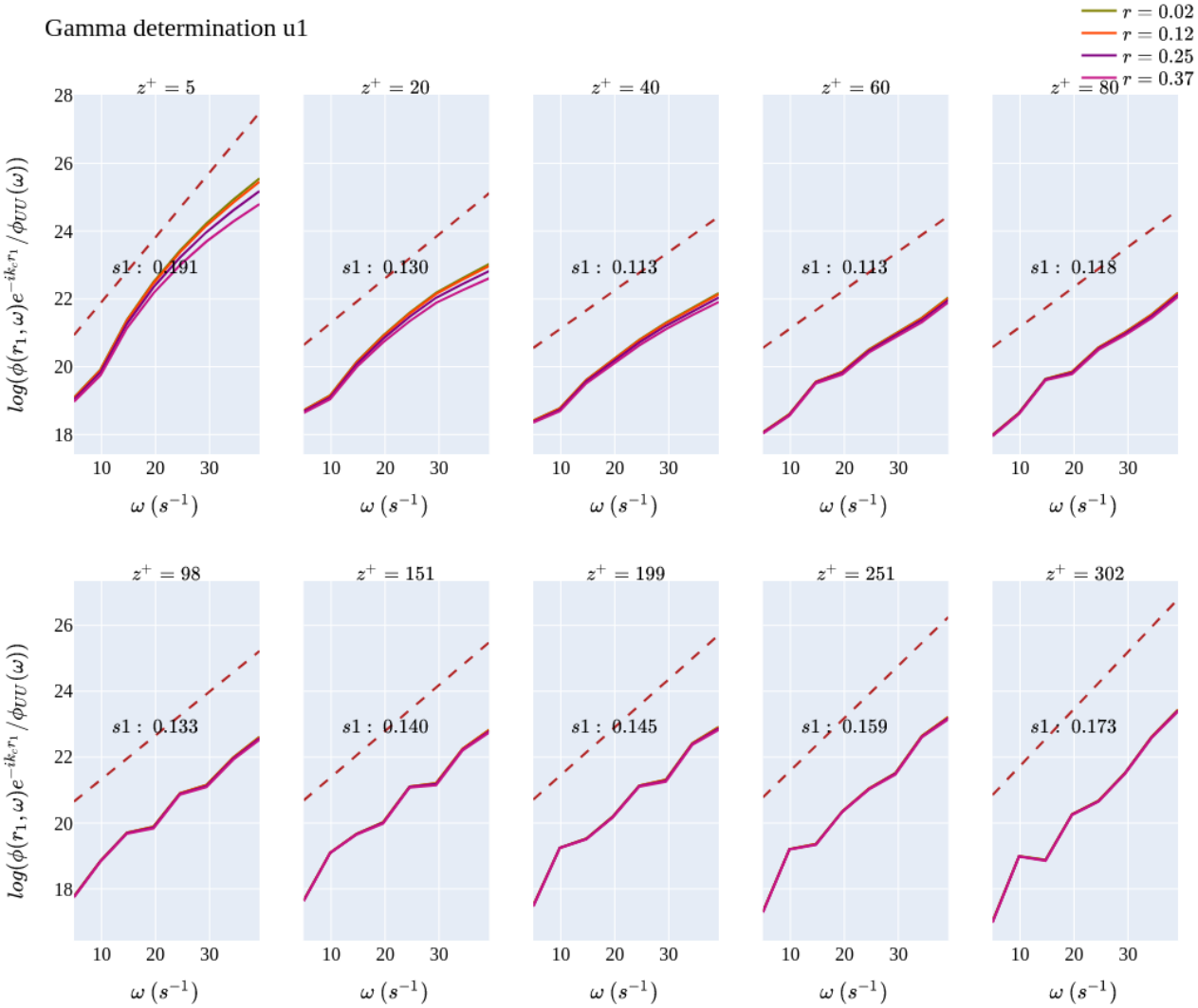
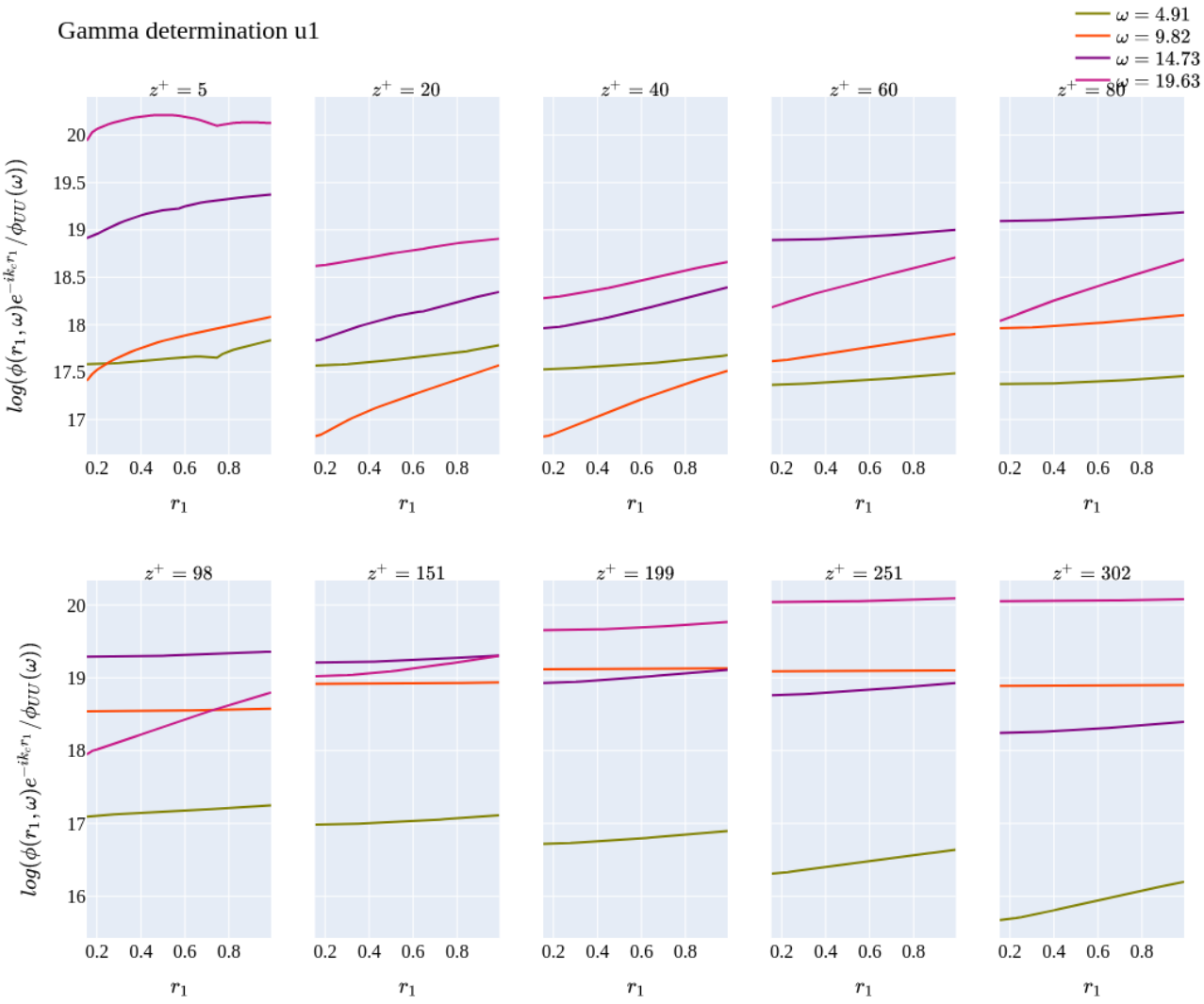
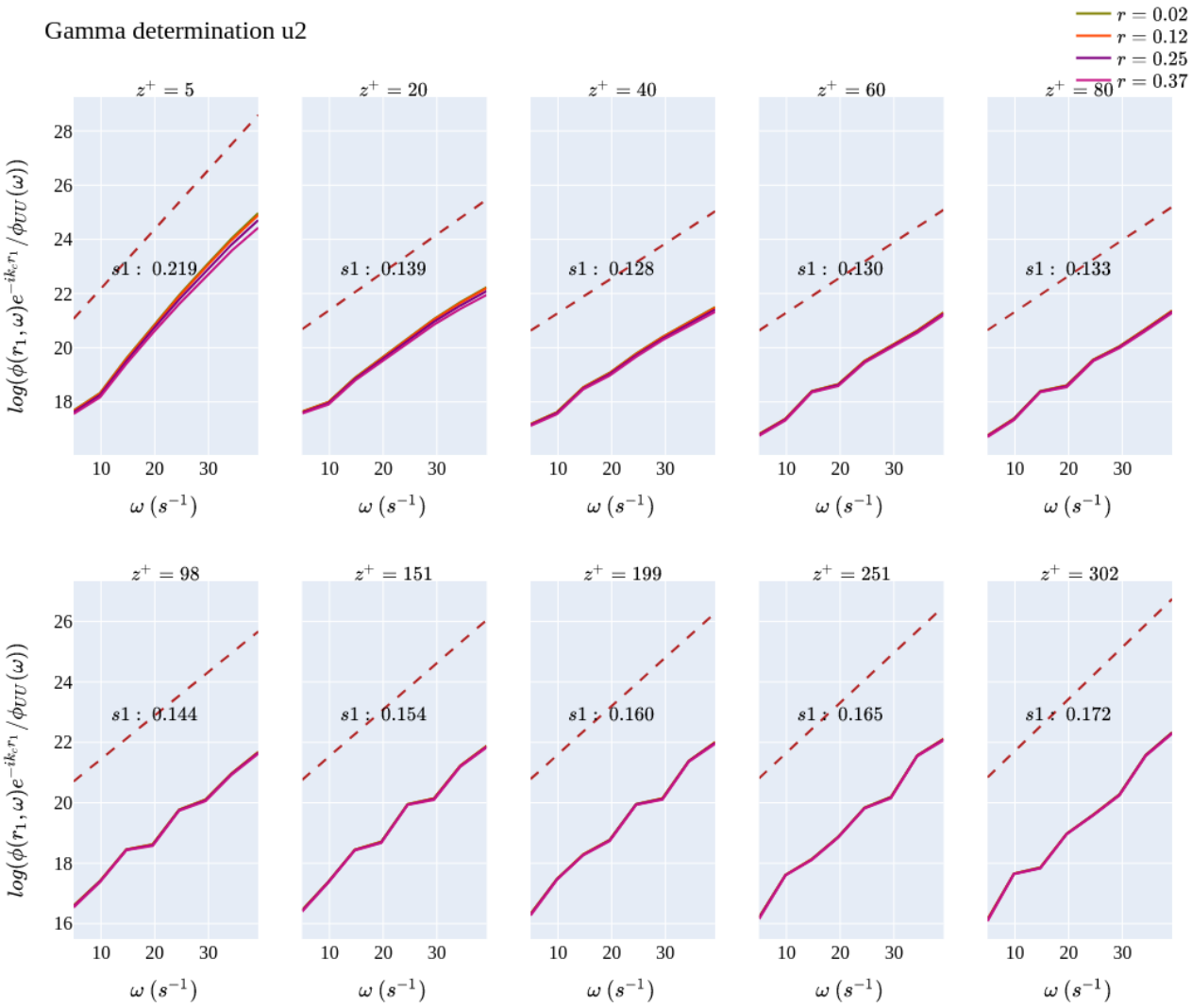


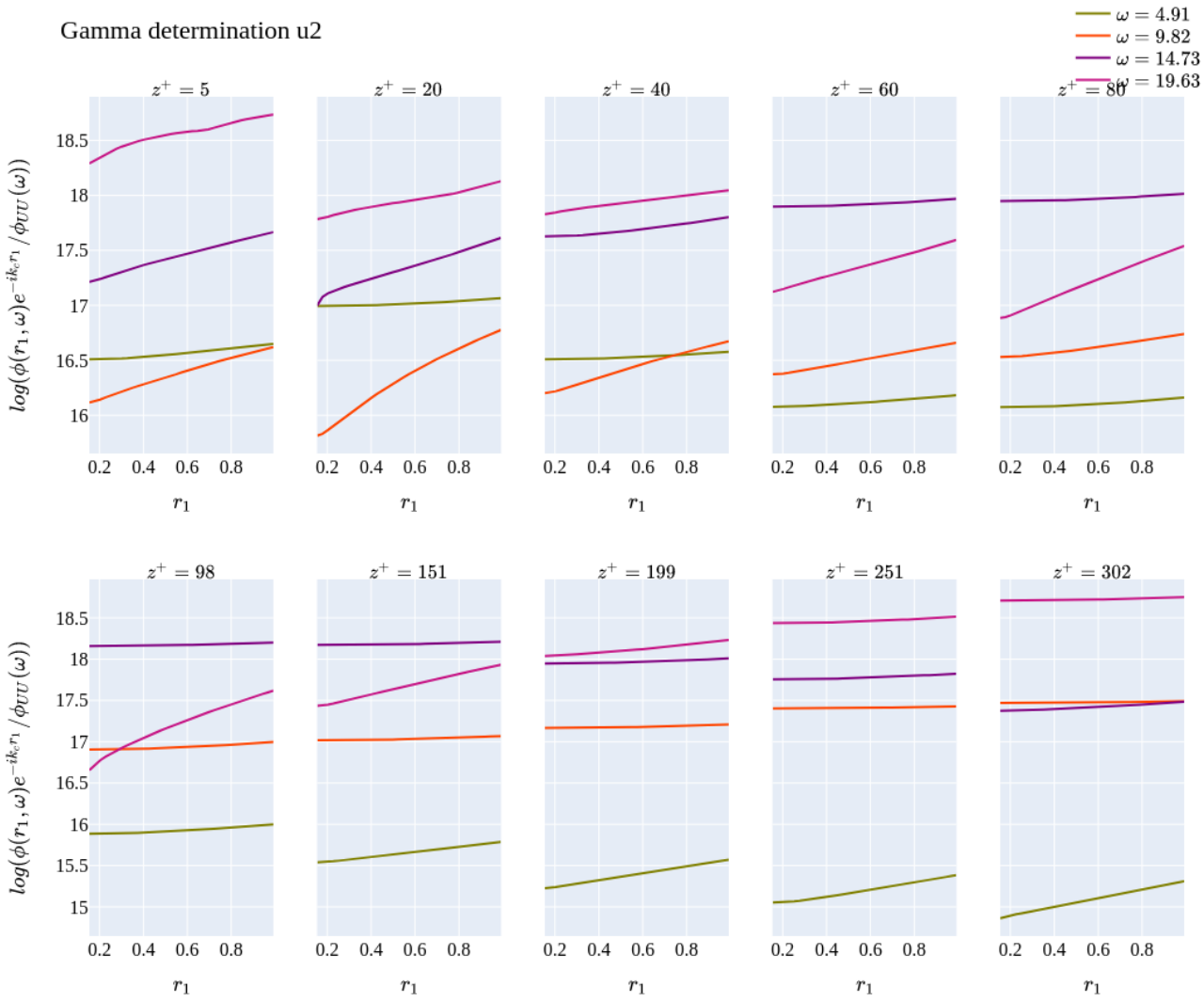
Figure 9: Spatial correllation in a streamwise plan (top figure) and in a spanwise plan (bottom figure). U is the streamwise, V the spanwise and W the wall-normal velocities

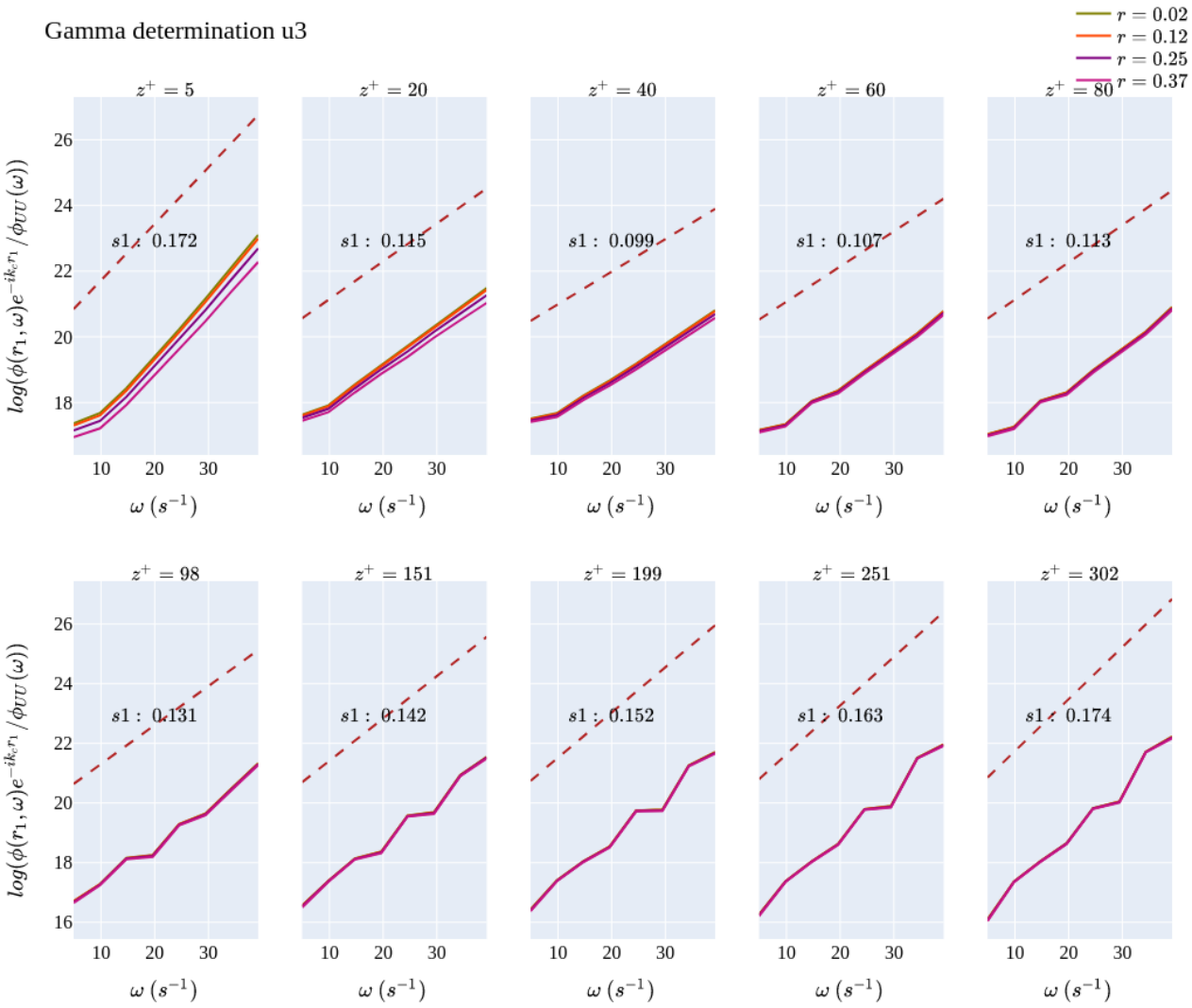
6 Gamma coefficient determination




Gamma determination u1
$\omega = 4.91$
$\omega = 9.82$
$\omega = 14.73$
$\omega = 19.63$
$z^+ = 5$
$z^+ = 20$
$z^+ = 40$
$z^+ = 60$
$z^+ = 80$
$z^+ = 98$
$z^+ = 151$
$z^+ = 199$
$z^+ = 251$
$z^+ = 302$
$log(\phi(r_1,\omega)e^{-ik_c r_1}/\phi_{UU}(\omega))$
r_1


Gamma determination u2
$r = 0.02$
$r = 0.12$
$r = 0.25$
$r = 0.37$
$z^+ = 5$
$z^+ = 20$
$z^+ = 40$
$z^+ = 60$
$z^+ = 80$
$z^+ = 98$
$z^+ = 151$
$z^+ = 199$
$z^+ = 251$
$z^+ = 302$
$s1: 0.219$
$s1: 0.139$
$s1: 0.128$
$s1: 0.130$
$s1: 0.133$
$s1: 0.144$
$s1: 0.154$
$s1: 0.160$
$s1: 0.165$
$s1: 0.172$
$log(\phi(r_1, \omega)e^{-ik_c r_1}/\phi_{UU}(\omega))$
$\omega\ (s^{-1})$


Gamma determination u2
$\omega = 4.91$
$\omega = 9.82$
$\omega = 14.73$
$\omega = 19.63$
$z^+ = 5$
$z^+ = 20$
$z^+ = 40$
$z^+ = 60$
$z^+ = 80$
$z^+ = 98$
$z^+ = 151$
$z^+ = 199$
$z^+ = 251$
$z^+ = 302$
$log(\phi(r_1, \omega)e^{-ik_c r_1} / \phi_{UU}(\omega))$
r_1


Gamma determination u3
$r = 0.02$
$r = 0.12$
$r = 0.25$
$r = 0.37$
$z^+ = 5$
$z^+ = 20$
$z^+ = 40$
$z^+ = 60$
$z^+ = 80$
$z^+ = 98$
$z^+ = 151$
$z^+ = 199$
$z^+ = 251$
$z^+ = 302$
$s1:\ 0.172$
$s1:\ 0.115$
$s1:\ 0.099$
$s1:\ 0.107$
$s1:\ 0.113$
$s1:\ 0.131$
$s1:\ 0.142$
$s1:\ 0.152$
$s1:\ 0.163$
$s1:\ 0.174$
$log(\phi(r_1,\omega)e^{-ik_c r_1}/\phi_{UU}(\omega))$
$\omega\ (s^{-1})$

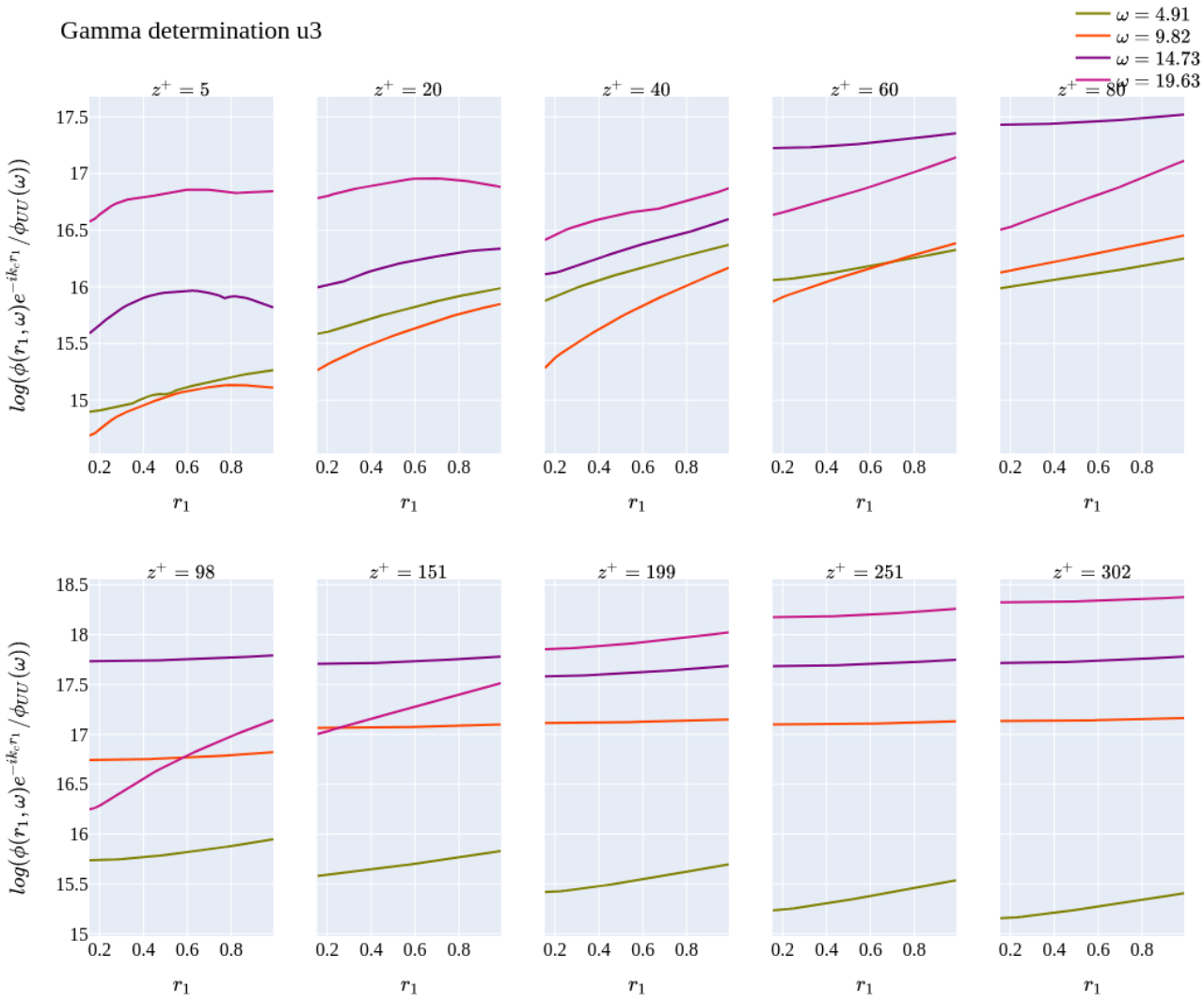


Figure 10: Determination of γ coefficient as $e^{-\gamma k_c r_1} = \frac{\phi(r_1,\omega)}{\phi_{ii}(\omega)} e^{-ik_c r_1}$ ploted in function of ω or r. All these spectra are computed with streamwise plan with streamwise velocity (top figure), spanwise velocity (middle figure) and wall-normal velocity (bottom figure)

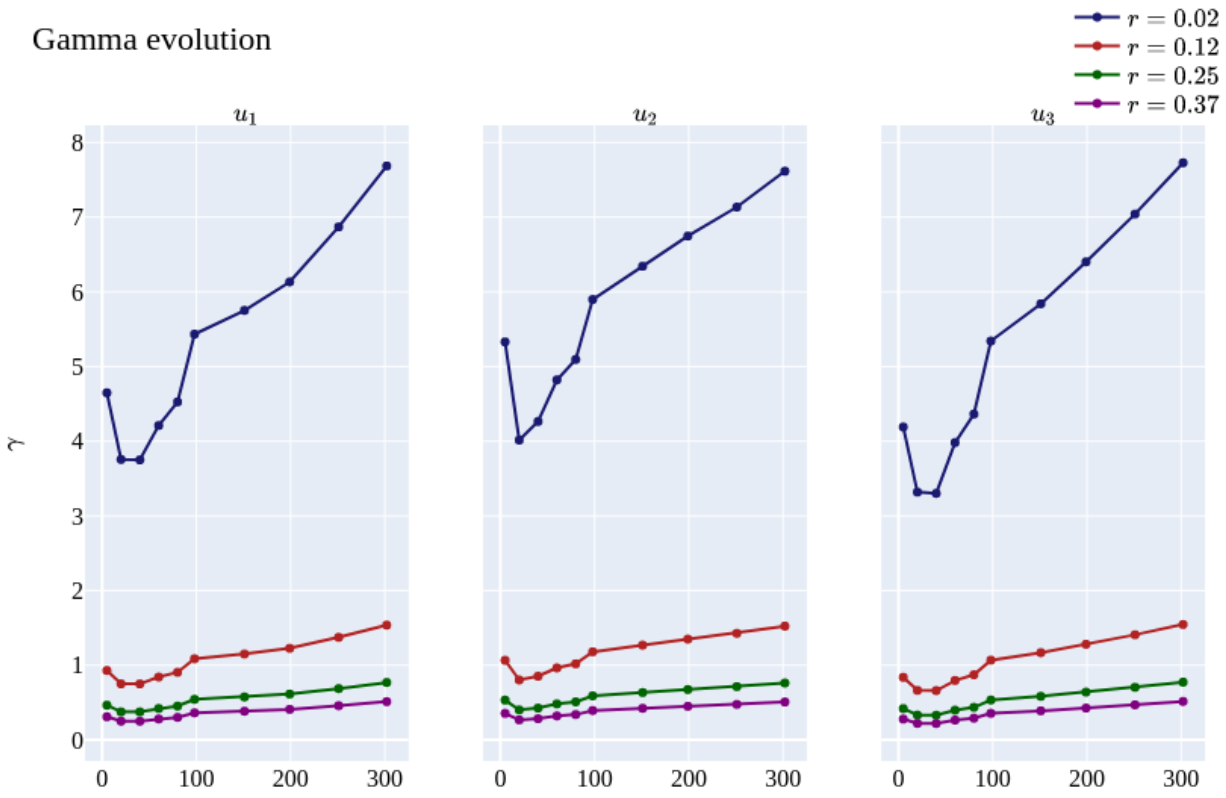


Figure 11: Figure representing the evolution of γ coefficient in function of z^+ for the ω dependency, determined by the precedent figures.

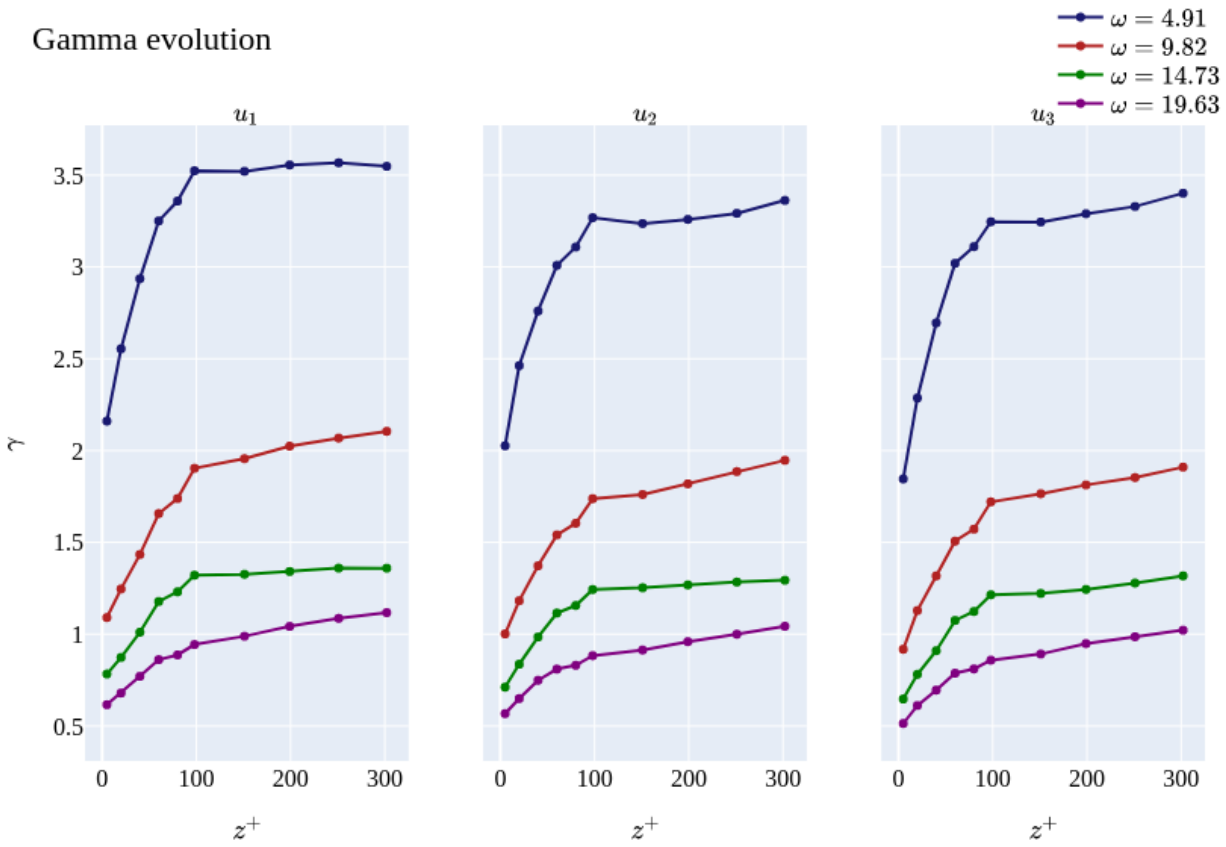


Figure 12: Figure representing the evolution of γ coefficient in function of z^+ for the r dependency determined by the precedent figures.

7 Wall-normal plan study

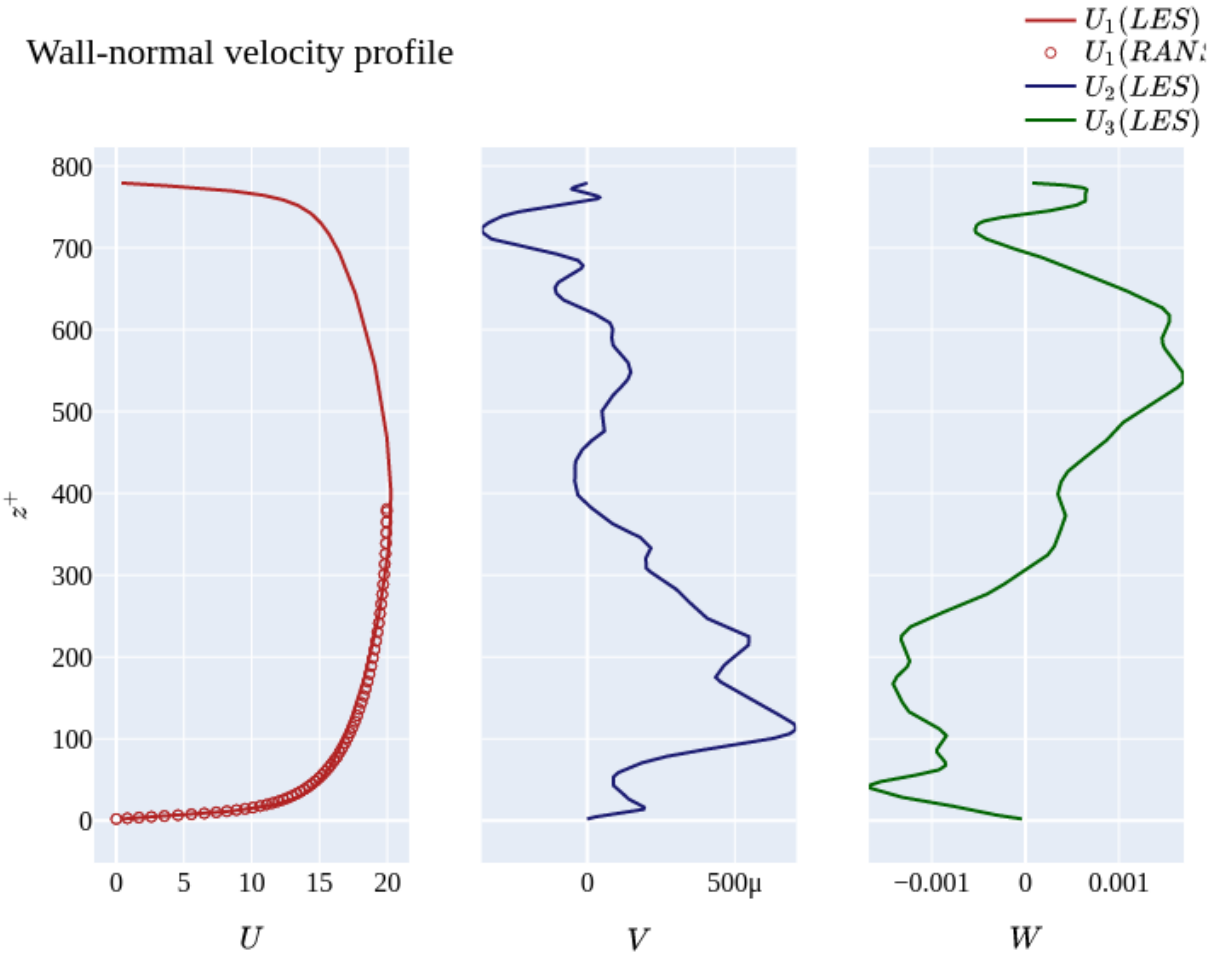


Figure 13: Mean velocity profile for a normal plan taken at the middle of the channel with 10 wall-normal lignes having 1936 points each.

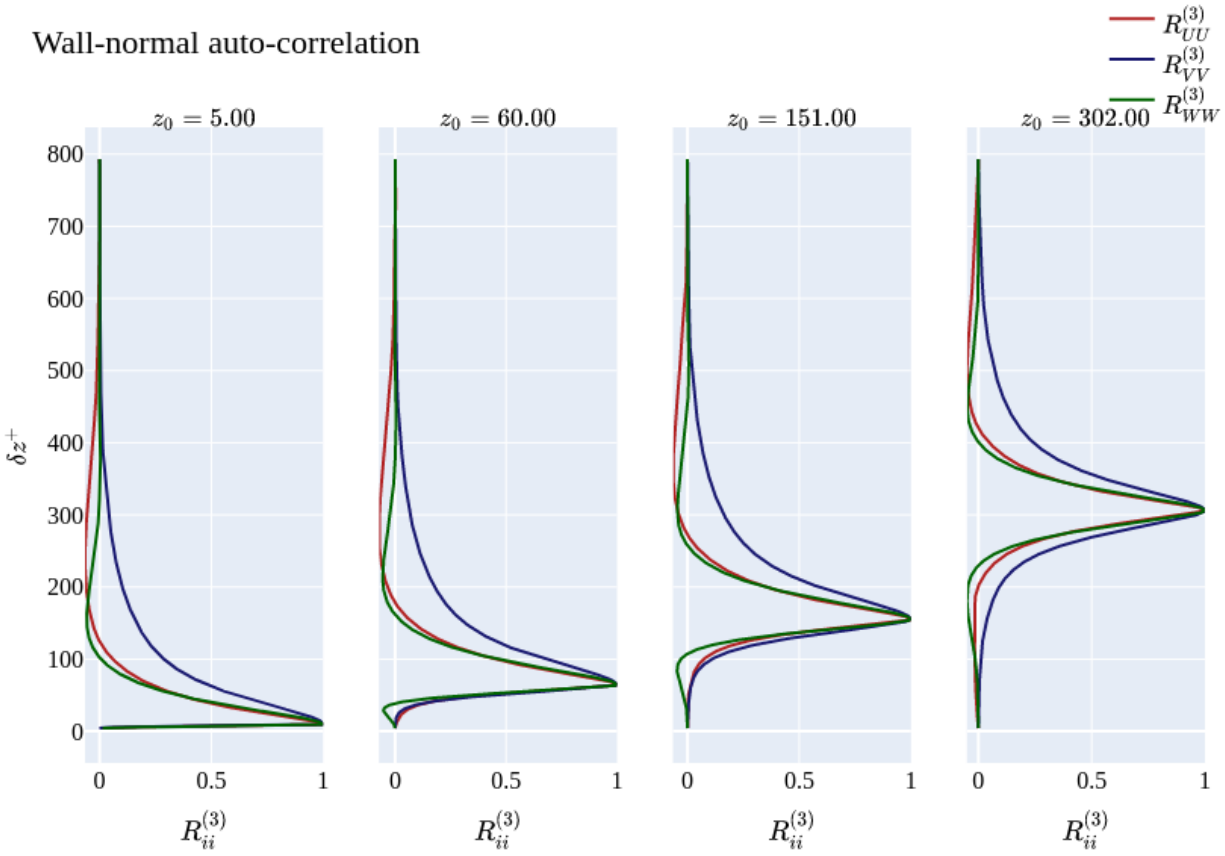
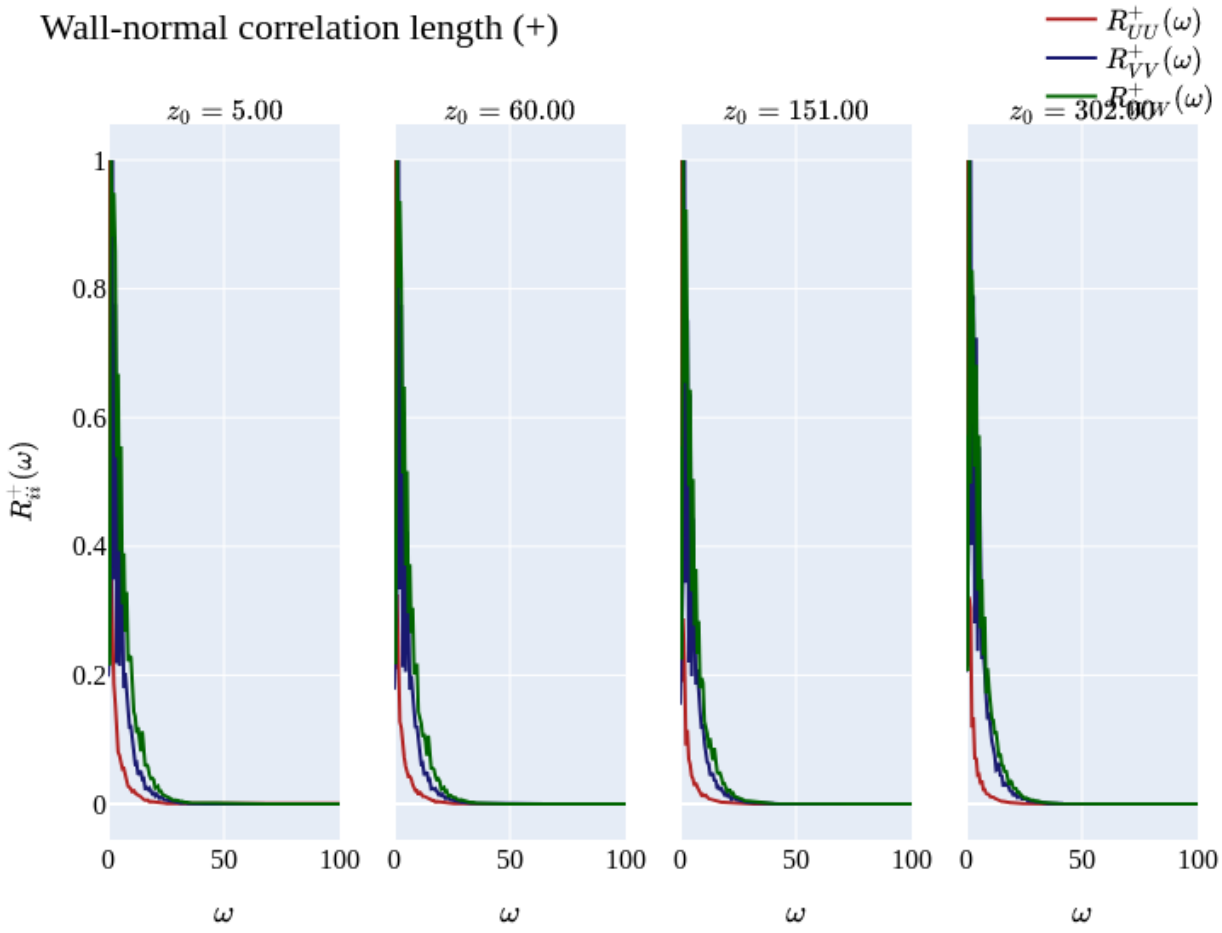


Figure 14: Autocorrelation at different height references (z_0) for the wall-normal plan.


Wall-normal correlation length (+)
$R^+_{UU}(\omega)$
$R^+_{VV}(\omega)$
$R^+_{WW}(\omega)$
$z_0 = 5.00$
$z_0 = 60.00$
$z_0 = 151.00$
$z_0 = 302.00$
$R^+_{ii}(\omega)$
1
0.8
0.6
0.4
0.2
0
0
50
100
ω

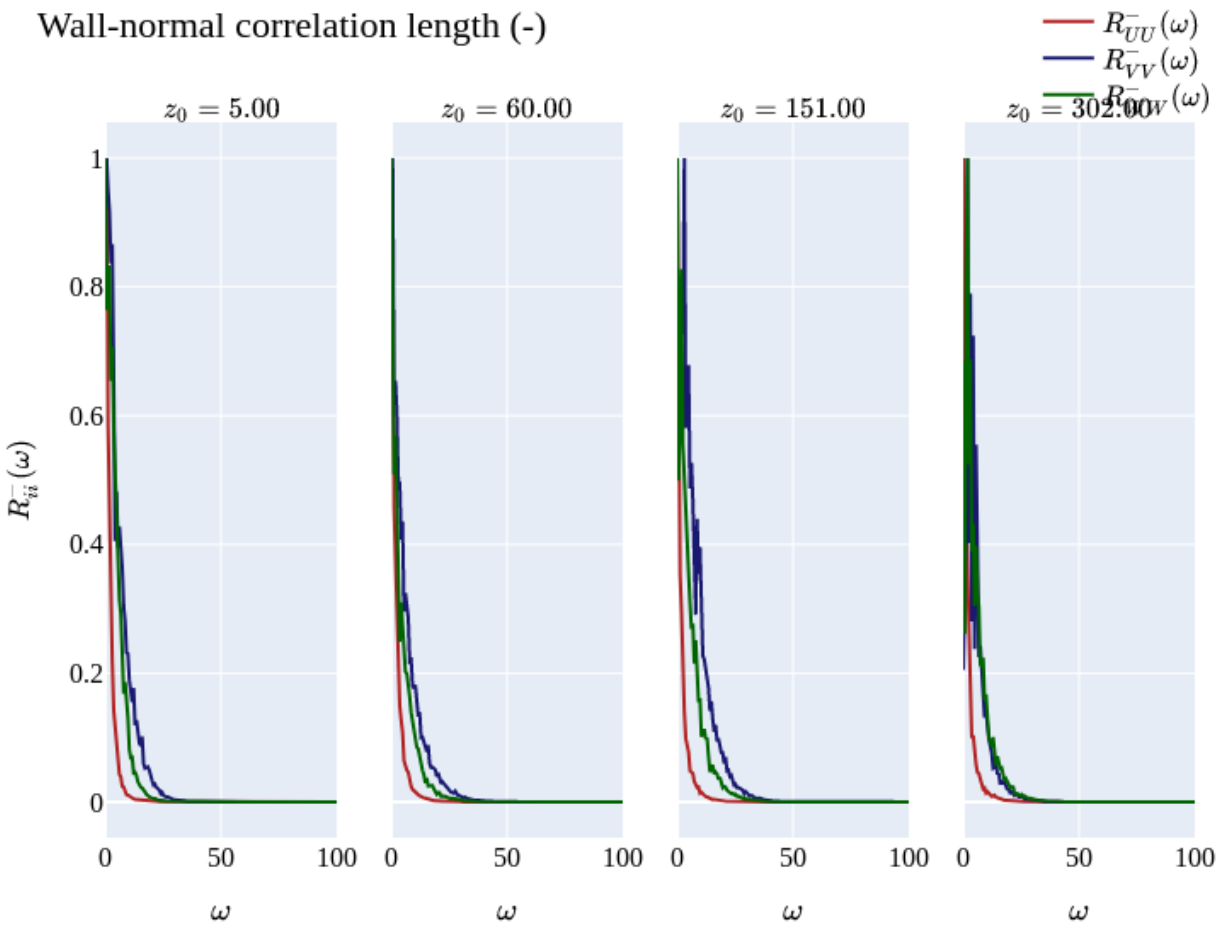


Figure 15: Representing the function $R^{+/-}_{ii}(z,\omega) = \int_{\delta z} < u_i(z,\omega)u_i^*(z+\delta z,\omega) > d\delta z$ summed on z and ploted in function o ω

8 Von Karman

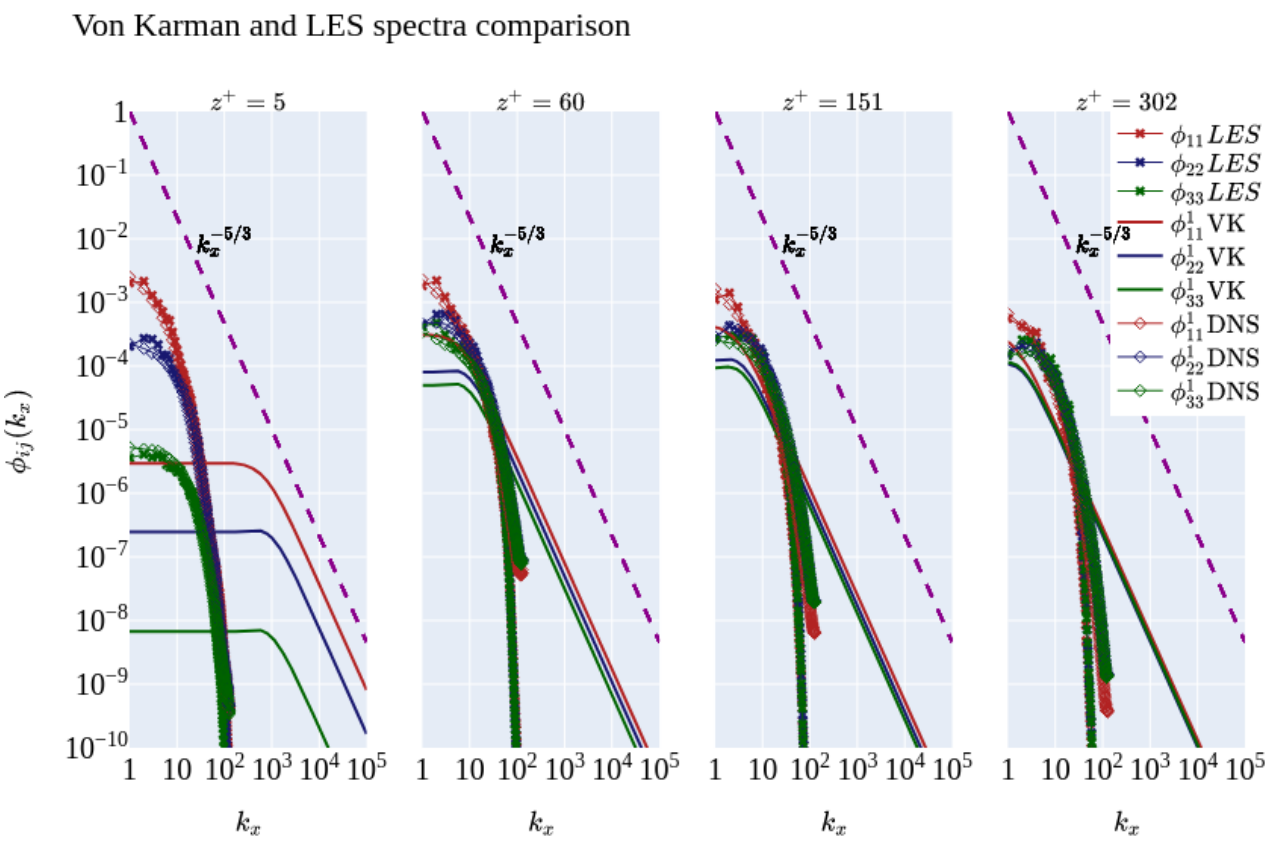


Figure 16: Spectra comparison of LES and DNS datas against von Karman theoretical spectra. The LES spectra have been compute using welch method.

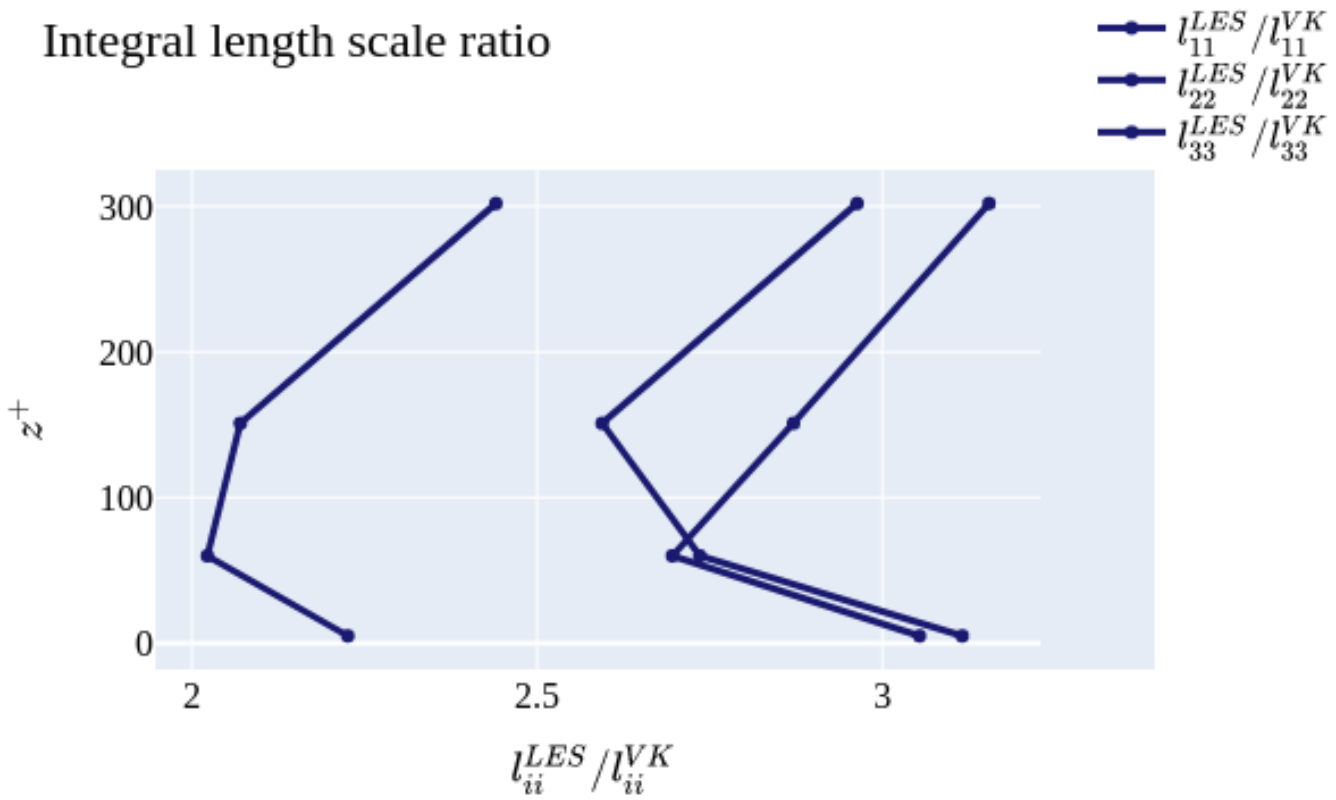


Figure 17: Ratio of integral length scale of spectra for LES datas and von Karman theoretical results. These have been computed by integrating (trapez method) the spectra above.