EXEMPLARY QUESTIONS – Environmental Transport Phenomena

LECTURE 7 (FPA):

- Definitions of basic concepts in turbulence: e.g., basic properties of turbulence, Reynolds number, Integral scale, Kolmogorov scale, dissipation rate, and relationship between them. Exemplary estimation for common environmental turbulent flows of interest (e.g., rivers, ABL).

- Definition and description of the calculation of different turbulence statistics (e.g., mean, r.m.s., turbulent fluxes, turbulence kinetic energy, autocorrelation function, integral scale) from time series. Application to example cases.

- Turbulent diffusion vs. Molecular diffusion. Estimation of time and length scales associated with molecular and turbulent diffusion in laminar and turbulent flows.

- The turbulent advection-diffusion equation: Derivation. Definition of turbulent flux. The closure problem.

- The eddy-diffusion model. Differences between molecular and turbulent diffusion coefficients.

- Diffusion coefficients in rivers. Basic formulations, anisotropy and relative magnitudes (horizontal, transversal and vertical).

LECTURE 8 (FPA):

- Define DNS, RANS, URANS and LES.

- Explain basic differences between DNS, RANS and/or LES (e.g., equation used, level of modelling, etc.).

- The filtered advection-diffusion equation used in LES: Derivation. Definition of the subgrid-scale flux and closure problem in LES.

LECTURE 9 (FPA):

- The atmospheric boundary layer (ABL): Structure and main characteristics.

- The log-layer: What is it? Derivation of the logarithmic law (velocity profile) based on the eddy-viscosity model for the Reynolds stress.

- Aerodynamic roughness: Definition, typical values. Exemplary application of log law.

- Atmospheric stability. What is it? What is potential temperature? What factors (atmospheric variables) affect atmospheric stability? What is the Pasquill stability classification? Give examples (qualitative) of different stability categories (e.g., very stable, neutral, very unstable).

- Using the profiles of mean temperature, demonstrate what is the sign of the vertical turbulent heat flux $\overline{w'T'}$ under different stability conditions.

- Using the profile of mean velocity U, demonstrate what is the sign of the vertical momentum flux $\overline{w'u'}$ in a turbulent boundary layer.

- Turbulent mixing in 3 dimensions: turbulent diffusion of a pollutant released: the Gaussian plume. Exemplary application of the Gaussian plume solution to a particular smoke stack emission.

LECTURE 10 (FPA):

- Turbulent dispersion in rivers: What is it? How is it different from turbulent diffusion? Exemplary application of the turbulent advection-dispersion equation.

- Exemplary estimation of longitudinal dispersion coefficient in rivers from dye study field measurements.