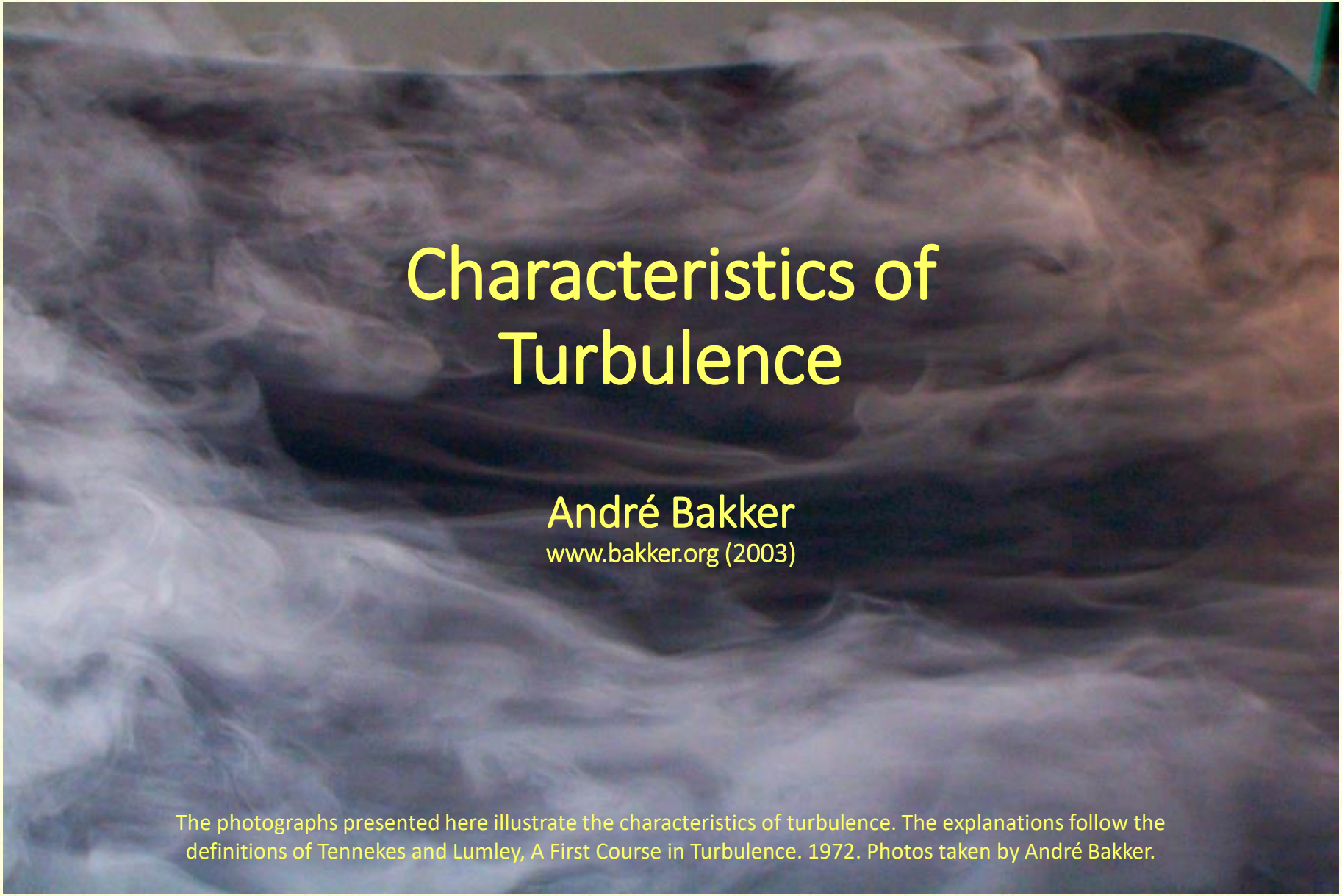


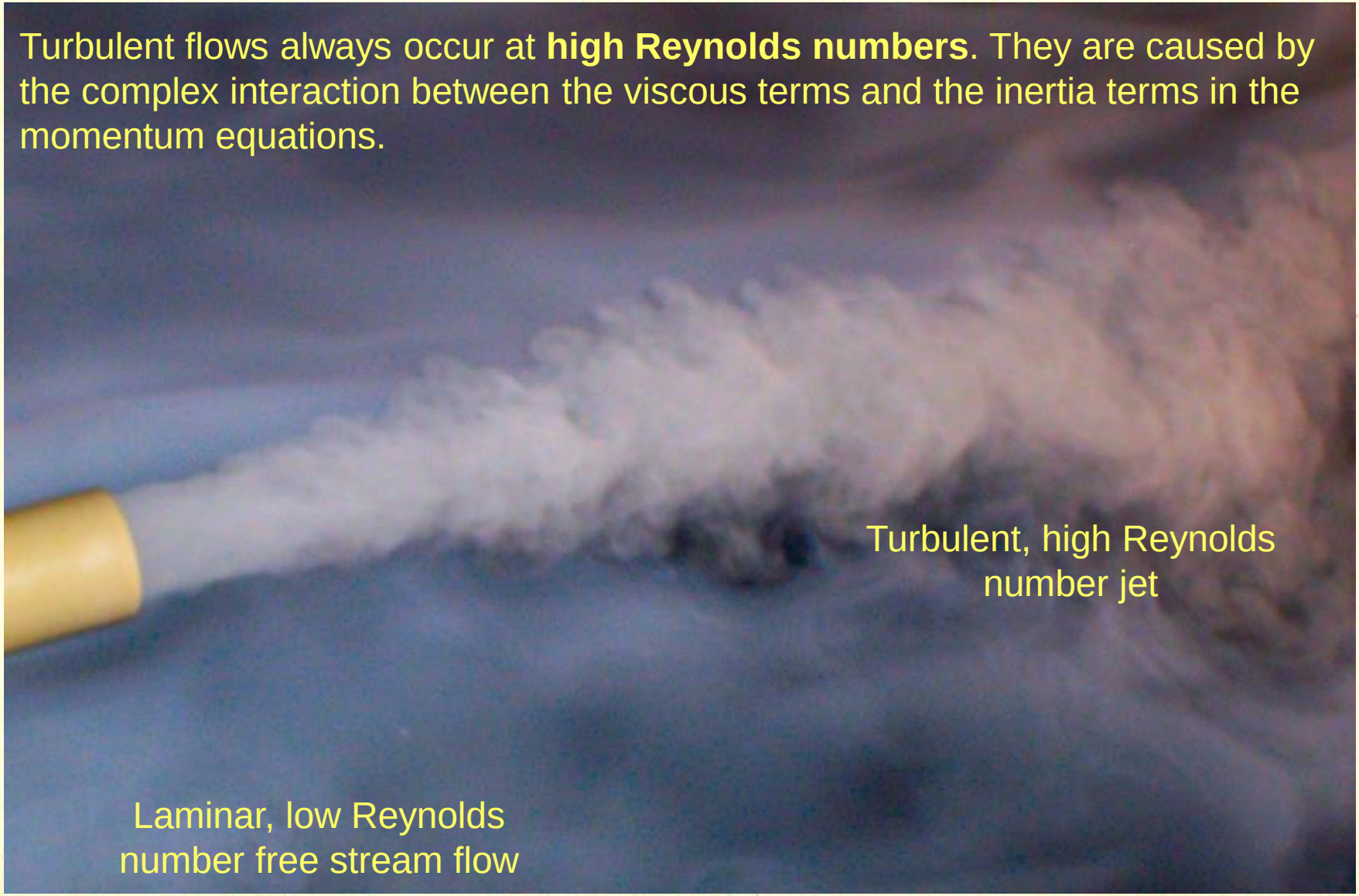
Characteristics of Turbulence

André Bakker
www.bakker.org (2003)

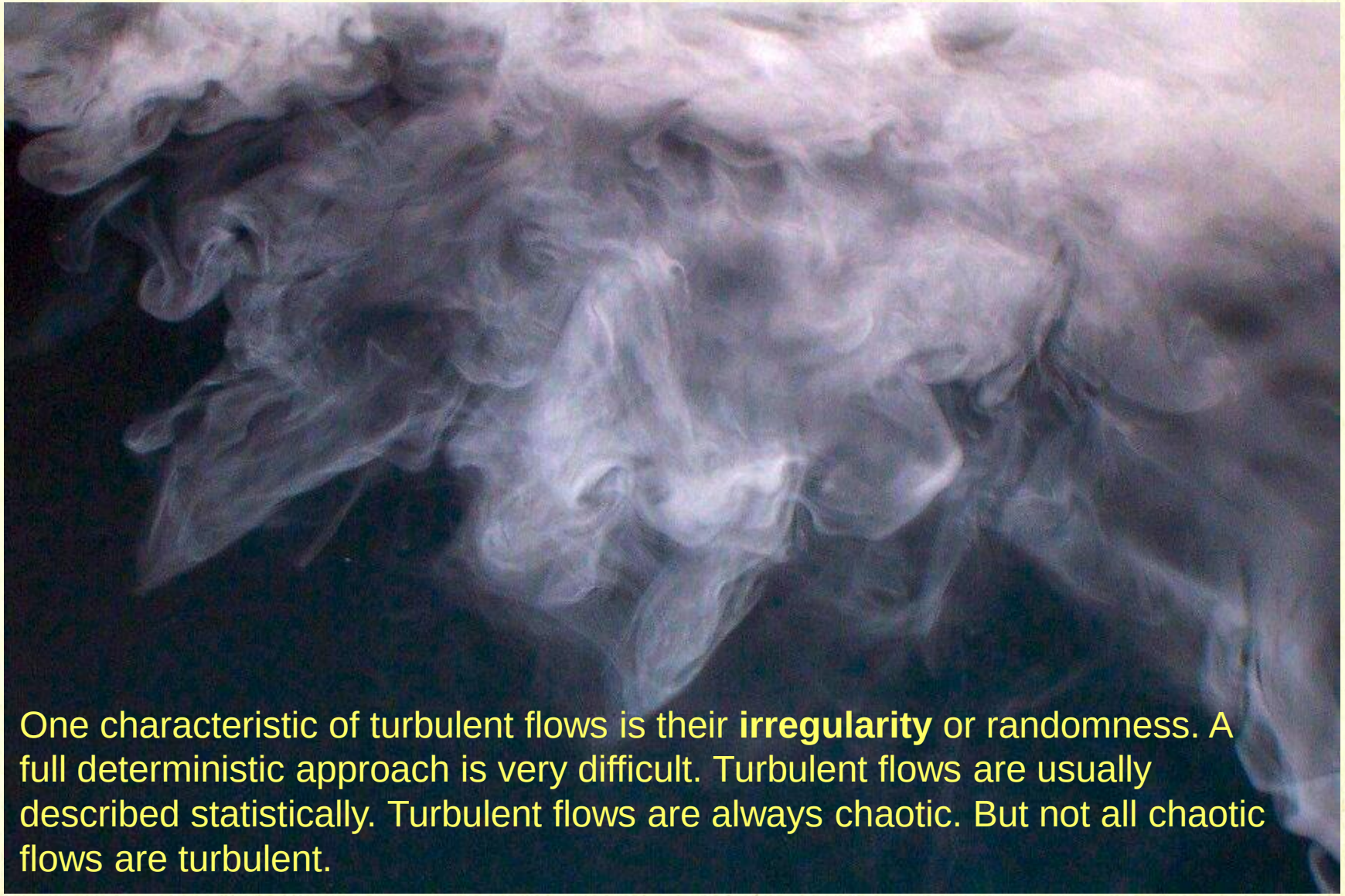
The photographs presented here illustrate the characteristics of turbulence. The explanations follow the definitions of Tennekes and Lumley, A First Course in Turbulence. 1972. Photos taken by André Bakker.

Turbulence: high Reynolds numbers

Turbulent flows always occur at **high Reynolds numbers**. They are caused by the complex interaction between the viscous terms and the inertia terms in the momentum equations.



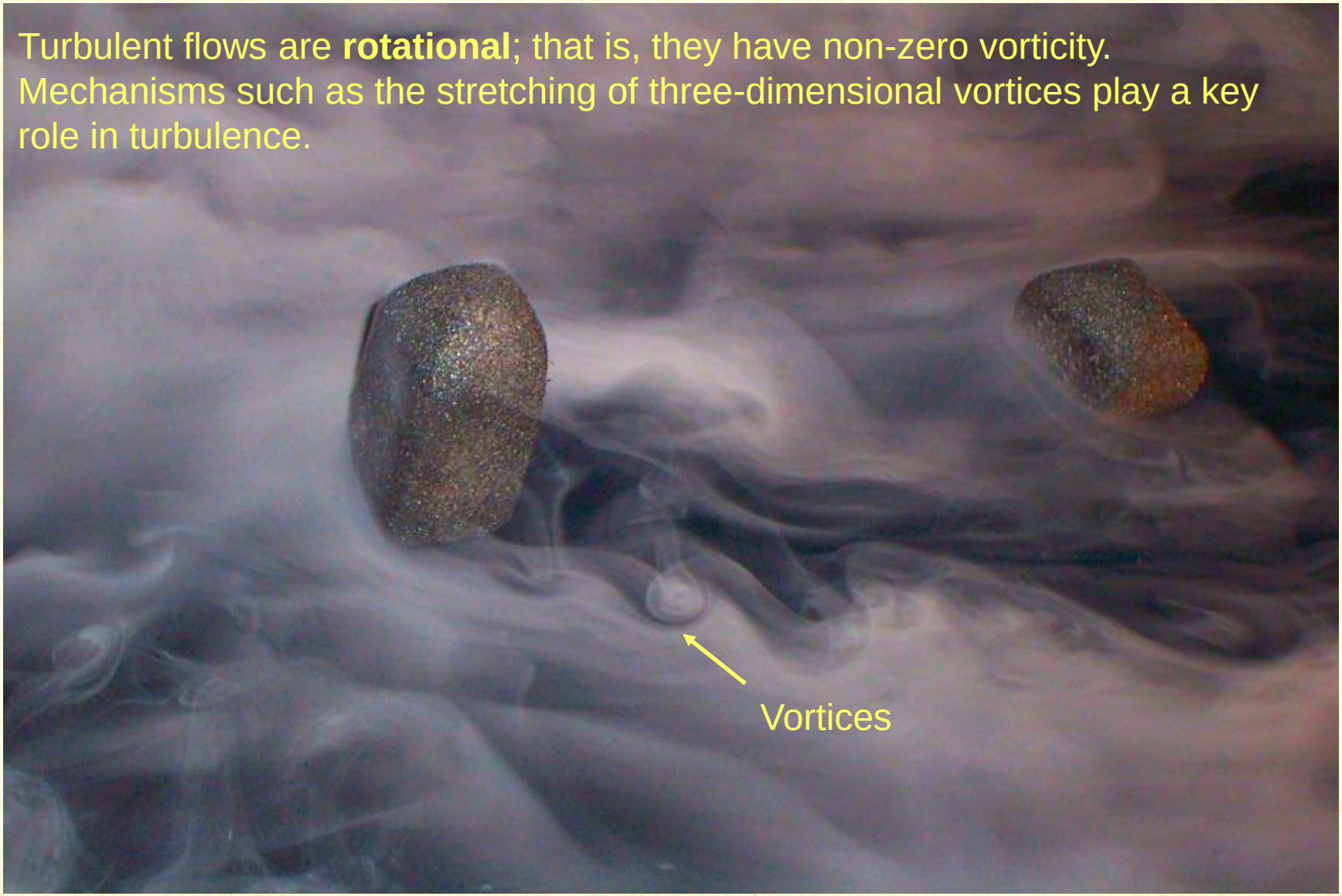
Turbulent flows are chaotic



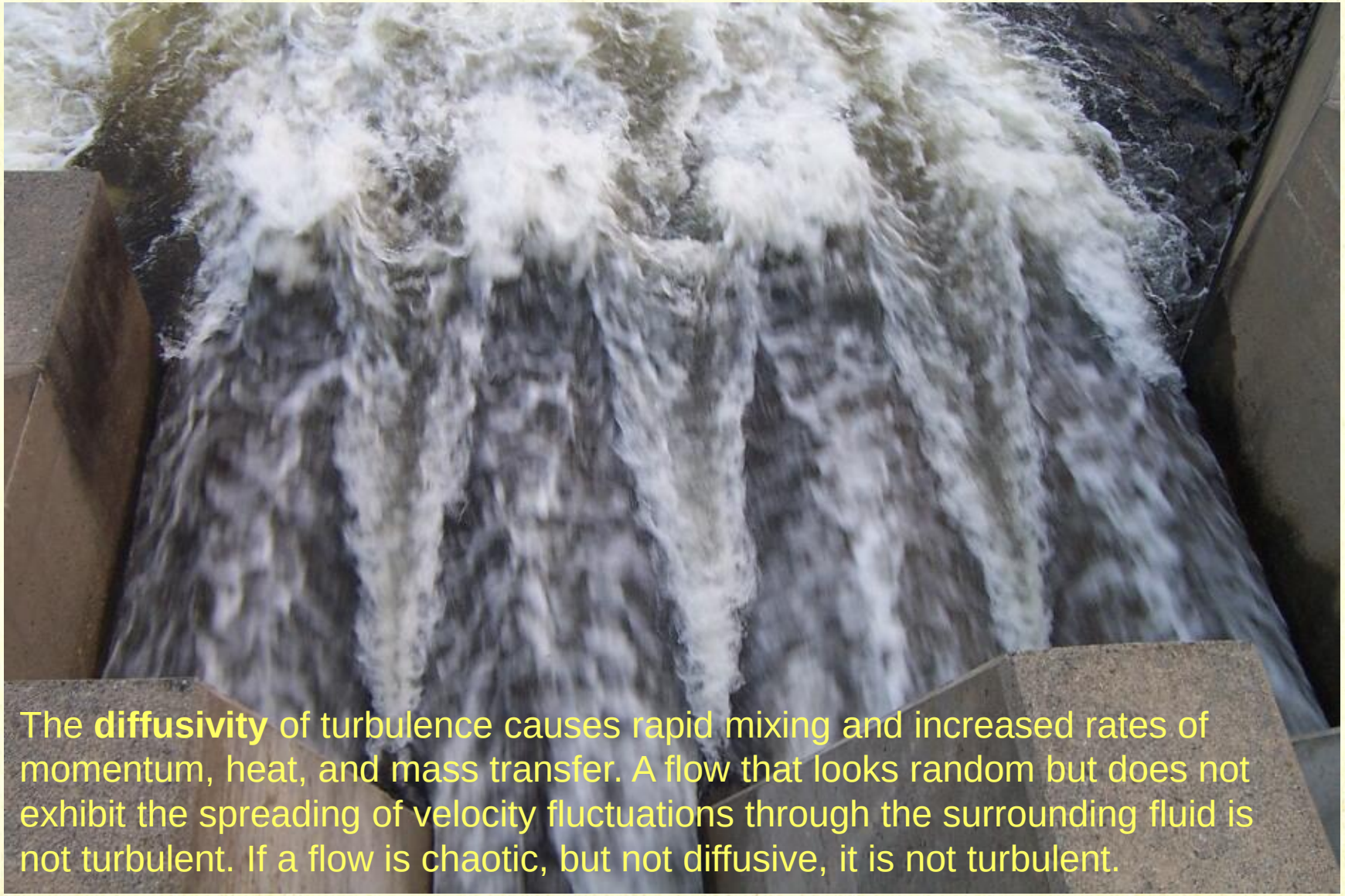
One characteristic of turbulent flows is their **irregularity** or randomness. A full deterministic approach is very difficult. Turbulent flows are usually described statistically. Turbulent flows are always chaotic. But not all chaotic flows are turbulent.

Turbulence: rotation and vorticity

Turbulent flows are **rotational**; that is, they have non-zero vorticity. Mechanisms such as the stretching of three-dimensional vortices play a key role in turbulence.

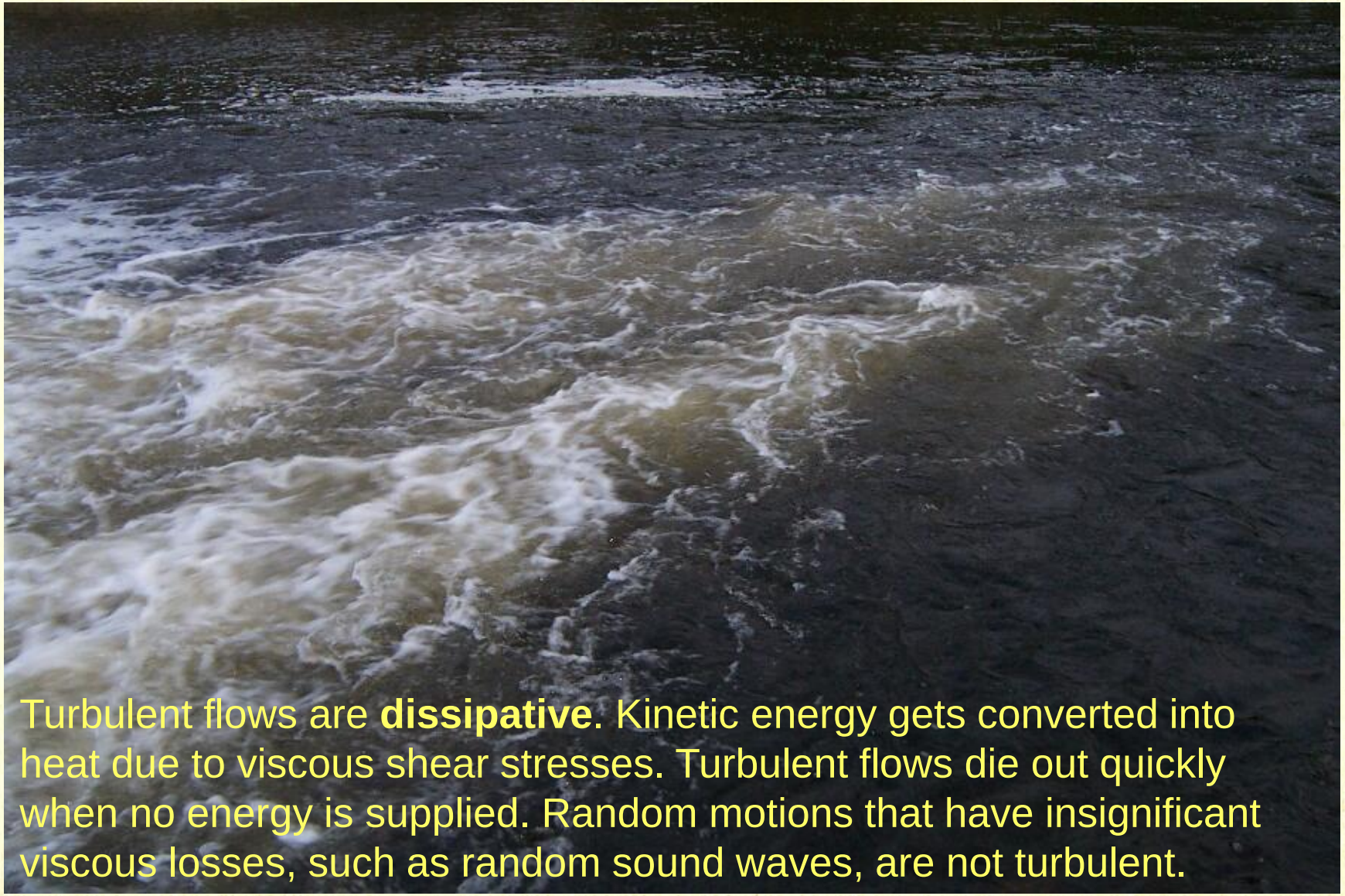


Turbulent flows are diffusive



The **diffusivity** of turbulence causes rapid mixing and increased rates of momentum, heat, and mass transfer. A flow that looks random but does not exhibit the spreading of velocity fluctuations through the surrounding fluid is not turbulent. If a flow is chaotic, but not diffusive, it is not turbulent.

Turbulent flows are dissipative



Turbulent flows are **dissipative**. Kinetic energy gets converted into heat due to viscous shear stresses. Turbulent flows die out quickly when no energy is supplied. Random motions that have insignificant viscous losses, such as random sound waves, are not turbulent.

Turbulent free jet

Fog flow around an object

Fog wave front moving from left to right

Flow separation

END