

**MODELING ATMOSPHERIC VORTICES FOR PUBLIC SAFETY:
A BELARUSIAN CASE STUDY**

**Моделирование атмосферных вихрей в интересах общественной безопасности:
кейс Беларуси**

The purpose of this research is to develop laboratory models of atmospheric vortices and investigate practical methods for enhancing public safety through an improved understanding of tornado formation and destruction mechanisms, with specific application to Belarusian meteorological conditions. This work aims to bridge the gap between theoretical atmospheric physics and applied disaster resilience, providing a scientific basis for practical countermeasures. The study's urgency is underscored by the increasing frequency and intensity of tornado events in Belarus, notably the devastating July 2023 Zaslavskoye Reservoir tornado that caused fatalities and significant damage. With over a dozen recorded tornado incidents since independence, developing effective prediction and protection strategies is a critical and timely public safety priority.

Our theoretical analysis examined the complex physical processes underlying tornado formation, focusing on how large temperature differences between colliding atmospheric fronts create powerfully unstable systems that transform potential energy into destructive rotational motion. We investigated how uneven surface heating, particularly over varied terrain, generates concentrated thermal currents that initiate and sustain vortex formation, progressing through distinct developmental stages from initial funnel appearance to mature vortex and eventual dissipation.

The experimental methodology employed a sophisticated laboratory setup with precision-controlled DC motors and rotating disks immersed in liquid media within transparent containers of different geometries. This versatile apparatus allowed systematic variation of rotation parameters while maintaining consistent thermal and hydrodynamic conditions, effectively simulating various environmental influences on vortex development and stability.

Comprehensive results revealed significant quantitative relationships between operational parameters and vortex characteristics. As rotation frequency increased from 19 to 51 relative units, funnel depth grew linearly from 1 to 3 centimeters, while vortex diameter expanded from 1.5 to 2.5 centimeters. Container geometry proved crucial for vortex stability, with cylindrical vessels producing more stable and symmetrical vortices than rectangular configurations due to the absence of disruptive corner interactions. Water level analysis demonstrated a clear inverse relationship with vortex intensity, showing

a pronounced decrease in funnel depth from 3 to 1.5 centimeters as levels rose from 3 to 9 centimeters, suggesting that atmospheric depth may similarly influence real tornado behavior and intensity.

Flow visualization using dye markers and particle tracking revealed complex internal dynamics with characteristic spiral motion patterns, descending peripheral flows, and ascending central currents. The central vortex column exhibited noticeable stochastic oscillations around its rotational axis, closely mirroring the unpredictable wandering motion observed in natural tornado events. A key finding involved developing practical vortex disruption methodologies; strategic placement of optimized grid structures at container bases effectively fragmented coherent vortices into multiple chaotic flow patterns, efficiently dissipating the concentrated kinetic energy of the central vortex and suggesting potential applications for targeted atmospheric vortex mitigation.

The research provides valuable, empirically grounded insights for developing enhanced early warning systems and science-based infrastructure protection measures. The validated laboratory models offer cost-effective and reproducible tools for continued fundamental research, engineering testing, and advanced education in atmospheric physics. This work demonstrates that controlled, systematic experimentation can yield practical conceptual solutions for complex natural disasters, contributing to proactive disaster prevention strategies in Belarus and other mid-latitude regions facing similar emerging meteorological threats in a changing climate. The promising disruption techniques warrant further investigation at larger scales to assess their practical feasibility for protecting critical infrastructure and populated areas.

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PROSPECTS FOR ECONOMIC INTEGRATION IN THE POST-SOVIET SPACE

Перспективы экономической интеграции на постсоветском пространстве

Economic integration is part of the globalization of the world economy and progresses through five stages: free trade area, customs union, common market, economic union, and finally, economic and monetary union. Its development is stimulated by the removal of trade barriers, trade liberalization, expanded cooperation, a deeper division of labor, common interests and goals, as well as historical and cultural proximity and geographical neighborhood [1, p. 77]. The purpose of the study is to analyze the potential for economic integration within the CIS and identification of the key advantages of this process for the participating countries.