Characteristics, Values and Innovations of Meteorological Science and Technology Courtyard

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Abstract As a new collaborative platform for university - government - enterprise cooperation, meteorological science and technology courtyard has emerged with distinct features of localized adaptation, collective synergy, and grassroots engagement. It has created significant multidimensional value across economic, social, ecological, and theoretical dimensions. In practice, meteorological science and technology courtyard has achieved two major innovations: technological innovation—precise service technology upgrades; and service innovation—optimized supply - demand matching models. Looking ahead, meteorological science and technology courtyard can achieve high-quality development through three key approaches.

Key words Meteorological science and technology courtyard; Agricultural meteorological services; Service characteristics; Multidimensional values; Innovation practice

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Under the backdrop of global climate change, agricultural meteorological disasters such as droughts, frosts, and rainstorms are occurring more frequently and severely, posing a serious challenge to agricultural production stability and food security. Meanwhile, the deepening advancement of rural revitalization strategy has raised higher demands for the precision, coverage, and industrial integration of meteorological science and technology services. The meteorological science and technology courtyard serves as a collaborative innovation platform that integrates resources from universities, meteorological departments, local governments, and market entities. With its core mission of "rooting in grassroots and serving industries", it brings laboratories to the fields, achieving deep integration of meteorological science and technology with agricultural production and rural development, thereby becoming a crucial solution to the challenges in grassroots meteorological services. In this paper, the innovation logic, core characteristics, and value dimensions of meteorological science and technology courtyard are systematically analyzed, and the theoretical system of grassroots meteorological services and university - government collaborative innovation is improved. It helps deepen the understanding of agricultural meteorological service innovation models, and enrich agricultural science and technology promotion theories. It could provide decision-making references for government departments to formulate relevant policies, meteorological departments to optimize service supply, and universities to improve talent training models, promoting the standardized and large-scale development of meteorological science and technology courtyard models.

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1 Core characteristics of meteorological science and technology courtyard

As an important carrier of innovative agricultural meteorological service models, meteorological science and technology courtyard has formed distinct core characteristics in practice.

1.1 Suiting measures to local conditions: based on local industries The service model of "one size fitting all" cannot adapt to the basic national conditions of China: vast territory, diverse agricultural types, and vastly different climate conditions. However, the science and technology courtyard takes "researching whatever farmers need" as its research guide to solve practical problems in agricultural production practice on the spot.

1.1.1 Industry adaptation. The courtyard is industry oriented, focusing on regional leading industries to provide services, and this characteristic is clearly reflected in the name of the courtyard. Crape Myrtle Courtyard in Cangbu of Hubei is located within the national level rural complex area of *Lagerstroemia indica*. With the rural complex as the core service carrier, it combines meteorological services with local agriculture, culture, and tourism integration practices, offering distinctive services such as flowering period forecasting, meteorological knowledge popularization, and research course development.

1.1.2 Requirements alignment. The courtyard provides precise services to meet the differentiated needs of different entities, and offers easy to understand technical guidance for farmers. The Cherry Meteorological Science and Technology Courtyard in Baqiao of Shaanxi has established an automated cherry observation network, which accurately monitors and reports meteorological information to farms.

1.2 Gathering forces: multi-party linkage and joint construction With the deepening of the construction of science and technology courtyard, the participation force will continue to strengthen, and it is moving towards a new stage of integration of "multi department co-construction, multi-disciplinary collaboration, and multi subject co-governance"[1]. Through multi-party linkage, the meteorological science and technology courtyard comprehensively uses the resources and advantages of various entities, builds a platform to integrate the strengths and resources of various departments[2], and achieves optimized resource allocation and service efficiency improvement. That is, universities provide intellectual resources and research equipment, meteorological departments provide monitoring data and technical support, governments provide policy support and financial guarantees, and enterprises, cooperatives, and farmers provide practical venues and market channels, breaking through the capacity boundaries of a single department and building a comprehensive collaborative network. For example, Fuyang Courtyard of Zhejiang adopts the model of "meteorological department + scientific research unit + farmers (cooperative)".

1.3 Rooted in the grassroots: practicing the "four zero" service Different from other agricultural service organizations, rooted in rural areas is a distinctive feature of science and technology courtyard[3]. Following the "four zero" service model of "zero distance", "zero threshold", "zero time difference", and "zero cost", teachers and students of the courtyard eat, live, and work together with farmers. Through "zero distance", they enter the countryside, enhance interaction with farmers. Through "zero threshold", they break down barriers to technology dissemination. Through "zero time difference", they promote the diffusion and application of technology and knowledge. Through "zero cost", they reduce the burden of technology application[4].

1.3.1 "Zero distance" in spatial layout. The courtyards are all located near the service objects, achieving "zero distance" from the service locations. Cotton Courtyard in Manasi of Xinjiang is located in a small agricultural supply store, making it convenient for farmers to consult at any time.

1.3.2 "Zero threshold" for technology transformation. The courtyard is committed to transforming difficult and professional meteorological techniques and knowledge into "understandable, learnable, and applicable" local knowledge. This down-to-earth and practical form that is easily accepted by grassroots people breaks down the barriers to the dissemination of meteorological knowledge, enabling farmers to conveniently access and use meteorological services. Cotton Courtyard in Manasi of Xinjiang conducted 15 technical training sessions on cotton meteorology serving agriculture and 8 scientific and technological consultation sessions, serving more than 500 technical personnel and cotton growers.

1.3.3 "Zero time difference" in personnel response. The courtyard implements a system of experts stationed and graduate students rooted, achieving round the clock presence of service personnel, ensuring the timeliness of service response, and building a strong social bond. This "human centered" service model is a key factor in winning the trust and support of farmers for the meteorological science and technology courtyard. All typical courtyards have long-term resident experts and graduate students, enabling talents to experience in the big stage of rural revitalization and contribute to rural construction. Zhangzhuang Courtyard in Handan of Hebei has 4 permanent graduate students from China Agricultural University and 10 floating personnel in meteorological operations.

1.3.4 "Zero cost" of meteorological services. The core meteorological information services, and basic technical consultation and training are usually free for farmers. This greatly reduces the cost threshold for small farmers to access advanced meteorological technology services, reflects the inclusiveness of public services, and quickly establishes trust relationships. And its sustainability is achieved through government procurement of services, project support, and indirect returns linked to industrial value-added income.

2 Diverse values of meteorological science and technology courtyards

The meteorological science and technology courtyards have transformed the traditional uncontrollable and non-negotiable public information of "weather" into a key production factor that can be accurately predicted and quantitatively priced in agricultural production, creating significant diversified value in the economic, social, ecological, and theoretical dimensions.

2.1 Economic value: empowering agricultural production to improve quality and efficiency Agriculture is highly dependent on weather phenology. The effective implementation of agricultural meteorological services can enhance the disaster resistance and prevention capabilities of agriculture, reduce or prevent disaster losses, and ensure the yield and quality of agricultural products, and the safety of production operations[5].

2.1.1 Assisting in disaster prevention and mitigation. The courtyard disseminates meteorological information and knowledge through precise warning and technical guidance, helping farmers take preventive measures to cope with disasters[6], and effectively reducing the direct losses caused by meteorological disasters. Fuyang Courtyard of Zhejiang has established a meteorological service business system for facility agriculture. During the rainy season of 2024, professional meteorological services was used to reduce losses of more than 1 million yuan for large agricultural households.

2.1.2 Production capacity increase. Through technological innovation and precise meteorological services, the courtyard has significantly improved the yield and quality of agricultural products[7]. The commodity rate and market competitiveness of agricultural products could also be improved. Through refined meteorological services, Zhangzhuang Courtyard of Hebei has achieved an annual yield of 22.8 t/hm^2 of wheat and corn in barren and mildly saline low-yield fields, turning "low-yield fields" into "ton grain fields" and breaking through the goal of "green 1.5-ton-per-mu grain".

2.1.3 Industrial chain extension. The courtyard has expanded the value space of the agricultural industry through the integration of meteorology and industry. Wuyuan Courtyard in Inner Mongolia utilizes greenhouse light and heat resources to introduce tropical fruits such as *Passiflora edulis*, *Ficus carica*, *Pseudocydonia sinensis*, *etc.*, achieving "northern planting of southern fruits". 1.33 hm^2 of high value-added fruits are added, which promotes the extension of facility agriculture to multiple formats such as high-quality fruits, science popularization research, and standard output.

2.2 Social value: building a solid foundation for rural safety

2.2.1 Enhancing social stability. Meteorological disasters usually pose a great threat to the normal production and life of society, and may even trigger related public safety risks[8], affecting social security and stability. The meteorological science and technology courtyard enhances public literacy by organizing disaster prevention and reduction activities, providing meteorological forecasts, and conducting science popularization activities. Quzhou Courtyard of Hebei held the "Meteorological Science Popularization Tour of Thousand Townships and Ten Thousand Villages" and the activity of meteorological technology going to the countryside, which enhanced the awareness and ability of the whole society to prevent and reduce disasters, and played a positive role in maintaining social stability.

2.2.2 Ensuring food security. Food security is the most important aspect of a country. Extreme weather caused by climate change directly affects agricultural production and has varying degrees of impact on the stability of food and other crop production[9], affecting food security[10]. In response, the meteorological science and technology courtyard has provided grassroots support for national food security by empowering medium and low yield fields to improve quality and strengthening disaster prevention and mitigation capabilities. Zhangzhuang Courtyard of Hebei focuses on the main grain producing areas, achieving an annual yield of 22.8 t/hm^2 of wheat and corn, an average increase of 42% in yield per mu, and a increase of 40% in efficiency, and forming a replicable production capacity improvement model.

2.3 Ecological value: supporting green and low-carbon development of agriculture The widespread application of meteorological services in agricultural production promotes the green and sustainable development of agricultural resources, and avoids resource waste[11]. By combining meteorological data, the use of fertilizers and pesticides could be optimized, environmental pollution could be reduced, and the quality of agricultural products could be improved[12].

2.3.1 Optimizing resource utilization. Through the combination of meteorological services and agricultural production, the courtyard has improved the utilization efficiency of natural resources. The water-saving irrigation technology of Yongning Agricultural Courtyard in Ningxia has significantly improved the efficiency of water resource utilization.

2.3.2 Reducing agricultural pollution. The green prevention and control, precision irrigation and other technologies promoted by the courtyard effectively reduce agricultural non-point source pollution. The precise pest and disease forecasting of Manasi Cotton Courtyard in Xinjiang has reduced the blind use of pesticides and lowered environmental pressure.

2.4 Theoretical value: Improving academic and talent systems

2.4.1 Talent cultivation and output of achievements. The science and technology courtyard is a base for cultivating high-level talents, allowing them to practice and train in the fields, leave their achievements in rural areas, write papers on the land, and organically combine serving rural revitalization with promoting talent revitalization[13]. It effectively solves the problems of solid theoretical knowledge but insufficient practical training and weak professional skills for graduate students in higher agricultural colleges[2]. Crape Myrtle Courtyard of Cangbu of Hubei has successfully cultivated two master's students who are rooted at the grassroots level, forming a stable talent pipeline.

2.4.2 Enriching the theory of meteorological services. As an innovative carrier for university – government – enterprise collaborative services for rural revitalization, the meteorological science and technology courtyard has built a new model of meteorological services that is "precisely adapted to grassroots", improved the academic system of grassroots meteorological services, and provided a new academic paradigm for university – government collaborative innovation. Crape Myrtle Courtyard of Cangbu of Hubei has compiled the popular science manual *Meteorological Flower Language*, published 3 high-quality academic papers, formed 20 weekly reports and 130 work logs, providing theoretical and practical support for agricultural meteorological research and integrated development of agriculture, culture and tourism. At the same time, it has expanded its influence through media dissemination and provided the "crape myrtle experience" for industry development.

3 Practical innovation of meteorological science and technology courtyards

3.1 Technological innovation: precise adaptation of service technology upgrade Science and technology are the primary productive forces, but they must be mastered by practitioners and tailored to local development needs in order to be transformed into real productive forces. Agricultural meteorological business technology is the foundation and prerequisite for carrying out agricultural meteorological services[14], so technological innovation is conducive to improving the service capabilities of meteorological science and technology courtyards.

3.1.1 Monitoring technology innovation. In terms of innovation in monitoring technology, the courtyard is promoting the upgrade of meteorological monitoring from a sparse national station network to an integrated three-dimensional observation of "sky – air – ground" at the scale of farmland and crop. Fuyang Courtyard of Zhejiang focuses on incubation and cultivation of meteorological scientific research, with more than 100 sets of various professional meteorological equipment deployed. It has a leading smart agricultural meteorological mobile observation system in Zhejiang Province, which can achieve full time and space monitoring of meteorological conditions for crop growth and digitally display the meteorological environment during crop growth.

3.1.2 Application technology innovation. The courtyard has developed a series of adaptation technologies to address key meteorological issues related to specific crops. Wuyuan Courtyard of Inner Mongolia has developed a green control technology for high temperature greenhouse at 48 – 50 ℃. Combined with biological control, green control of melon powdery mildew has been achieved, reducing pesticide use by 17 600 kg.

3.2 Service innovation: optimization of service mode for supply and demand matching Service innovation is the core path for meteorological science and technology courtyards to achieve value realization, reflected in the comprehensive optimization of service content, service channels, and service scenarios.

3.2.1 Innovation in service content. The courtyard has expanded from traditional single disaster warning to a full chain service of "meteorology + industry". Throughout the entire production chain, Cherry Courtyard of Baqiao of Shaanxi provides customized meteorological service packages for key production periods of cherry such as flowering stage, hardcore stage, and maturity stage. In terms of scenario applications, Crape Myrtle Courtyard of Cangbu of Hubei combines meteorological services with agricultural, cultural, and tourism industries, developing characteristic services such as flowering period forecasting study courses and meteorological disaster experience activities.

3.2.2 Innovation in service channels. The courtyard has built a "direct and personalized" service network. Cotton Courtyard of Manasi of Xinjiang has set up service points through agricultural material stores to provide one-stop services of "agricultural material purchase + meteorological consultation + technical guidance". Wuyuan Courtyard of Inner Mongolia has established a WeChat group service network, covering 23 facility agriculture enterprises, cooperatives, and 425 large-scale growers, to provide real-time forecasting, warning, and technical guidance.

3.2.3 Innovation in service scenarios. The courtyard has extended from a single agricultural production scenario to a diversified rural development scenario. In addition to traditional agricultural production scenarios, Crape Myrtle Courtyard of Cangbu of Hubei has extended its meteorological services to the integration of agriculture, culture, and tourism. Quzhou Courtyard of Hebei has expanded its services to popular science education scenarios, and Yongning Courtyard of Ningxia has extended its services to brand building scenarios, helping to build the brand of "Golden Climate Belt for Wine Grapes" on the eastern foothills of the Helan Mountain.

In summary, the meteorological science and technology courtyard has achieved precise integration of industrial demand, diverse resources, and grassroots services with the core characteristics of adapting to local conditions, gathering joint forces, and rooting at the grassroots level. This development model of "demand-oriented, resource integration, and rooted in rural areas" is the key to the success of meteorological science and technology courtyard. The meteorological science and technology courtyard has diverse values in terms of economy, society, ecology, and theory. It not only empowers agricultural production to improve quality and efficiency, builds a solid foundation for rural safety, but also contributes to the green and low-carbon development of agriculture, improves academic and talent systems, and provides an effective path for meteorological science and technology to empower rural revitalization. The realization of these values fully demonstrates the scientificity and feasibility of the meteorological science and technology courtyard model. Technological innovation and service innovation are the core driving forces of the meteorological science and technology courtyard. Through the construction of a three-dimensional monitoring network, adaptive technology research and development, and optimization of service models, a precise and efficient meteorological service system has been established. Technological innovation provides capability support for services, while service innovation realizes the value transformation of technology, and the two promote each other and develop synergistically.

In the future, meteorological science and technology courtyards can achieve high-quality development in three aspects. First, it should deepen technological innovation. Using technologies such as big data and artificial intelligence, the accuracy of monitoring and early warning, as well as the level of service intelligence could be improved. Second, it should improve the collaborative mechanism, further strengthen the multi-party linkage among university, government, and enterprise, break down barriers to data sharing, and enhance the efficiency of resource integration. Third, it should expand the radiation range, summarize the mature experience of typical courtyards, form standardized models for promotion to more regions, and promote the large-scale and standardized development of meteorological science and technology courtyards.

References

[1] HE KF, GAN C. Science and technology courtyard: Historical origins, realistic implications, and future trends[J/OL]. Studies in Science of Science, 1-17. [2026-01-05].

[2] YANG JC. Science and technology courtyard enabling Chinese farmers to achieve increased production and efficiency[J]. Scientia Sinica (Vitae), 2016, 46(12): 1451-1452.

[3] ZHANG JW, WANG N. Agricultural science popularization model of science and technology courtyard[J]. Studies on Science Popularization, 2024, 19(2): 54-63, 104.

[4] LI Q, ZHANG FS, JIAO XQ, *et al.* Innovative development of the science and technology backyard: Realistic needs, functional positioning, and operation guarantee mechanism[J]. Research of Agricultural Modernization, 2023, 44(1): 1-9.

[5] WANG YH, SONG JY, PEI SQ, *et al.* On agrometeorological service demands as for different production industries and user[J]. Science & Technology Review, 2023, 41(21): 69-78.

[6] LU HG, CHENG XB, ZHANG JB. Impact of digital meteorological information services on the climate adaptation behavior of rice farmers: Based on TAM and TPB integration frameworks[J]. Journal of China Agricultural University, 2025, 30(2): 189-202.

[7] BAI QY, SHEN QL, ZHANG J, *et al.* "Farming in accordance with climate": Meteorological services and agricultural economic growth[J]. Journal of China Agricultural University, 2025, 30(9): 217-231.

[8] HUANG YF, WANG QY, ZHU YF. Disaster meteorological prediction and emergency management based on public safety thinking: Comment on the *Pre-assessment Theory and Method of the Impact of Catastrophic Meteorological Events*[J]. Journal of Safety and Environment, 2021, 21(1): 457-458.

[9] YU FW. Climate-resilient agriculture: Connotation and characteristics, theoretical explanation and promotion strategies[J]. Studies on Socialism with Chinese Characteristics, 2024(6): 52-62.

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age of total water vapor content was above 105 mm, and that of LWP was above 26 mm. At 16:00, 17:00, 22:00, and 23:00, the rainfall was heavy, and the maximum of total water vapor content and LWP was up to 236.9 and 50 mm, respectively. From 04:00 to 06:00 and from 15:00 to 17:00 on August 21, hourly rainfall intensity was less than 1 mm, and the hourly average of total water vapor content was between 55 and 76 mm, while the hourly average of LWP ranged from 3.5 to 17.5 mm. As the precipitation ended at 18:00, total water vapor content dropped to 51.4 mm, and LWP reduced to 1.61 mm.

6 Conclusions

(1) This precipitation process occurred under the circulation pattern of a high-pressure system in the east and a low-pressure system in the west at 500 hPa. The subtropical high was northward and stable. The low vortex moved eastward and northward along the edge of the subtropical high. The blocking high and the cut-off low vortex system near the Ural Mountains were deep. In the rear of the cut-off low vortex, cold air continuously spread eastward and southward, and a short-wave trough formed in the middle latitudes. Cold air moved eastward to continuously converge with warm and humid air currents from the northwest side of the subtropical high over Fuxin, which was the main circulation pattern for the occurrence of this heavy precipitation event.

(2) The low-level jet stream guided the moisture from the periphery of the subtropical high to be transported to Liaoning. The southerly jet stream provided abundant moisture and energy for the rainstorm, and a water vapor convergence center formed in Fuxin. Fuxin was located in the superimposed area of the strong divergence zone on the right side of the entrance area of the high-altitude westerly jet stream and the strong convergence zone on the left front of the outlet of the low-altitude jet stream, and the upward movement was intense, which was conducive to the occurrence of heavy precipitation.

(3) As the system continued to develop, the low-level water vapor convergence center gradually extended to the upper and middle levels, indicating that the continuous water vapor supply and the strong water vapor convergence provided the necessary water vapor conditions for the rainstorm. The strengthening and maintenance of positive vorticity in the middle and lower levels were the result of the coupling effect between the low vortex and the low-level jet stream. During the period of heavy precipitation, Fuxin was located in the upper-level divergence zone and the lower-level convergence zone, and the updraft movement was strong, which was very conducive to the occurrence and maintenance of heavy precipitation.

(4) During the precipitation process from August 19 to 21, the mesoscale and small-scale convective systems all had the characteristic of backward propagation. In the early stage of the convection, the updraft movement was strong. On the infrared cloud image, TBB decreased significantly, and the cloud top height rose obviously. As the convective system developed, the newly formed convective cells merged with the mature cells, so that rainstorm cloud clusters continuously developed. The strong echo center was low, and the precipitation efficiency was high. Under the effect of the train effect, a continuous rainstorm process occurred in Fuxin.

(5) With the increase of atmospheric water vapor and liquid water content, short-term heavy precipitation appeared. At the same time, the changing trend of water vapor derived by microwave radiometer inversion was relatively consistent with that of precipitation. The continuous transportation of water vapor was a necessary condition for the occurrence of the rainstorm.

References

[1] LIU JY, GUO M, ZHANG HY, *et al.* Analysis of a rainstorm weather process in Ma'erkang City during July 2 – 3, 2023[J]. Journal of Agricultural Catastrophology, 2025, 15(7): 114 – 116.

[2] SUN K, SUN BL, YANG XT, *et al.* Characteristics of agricultural drought and countermeasures of artificial precipitation enhancement in Fuxin[J]. Acta Agriculturae Jiangxi, 2022, 34(6): 113 – 118.

[3] SUN K, SUN BL, LIU J. Research on artificial rain enhancement operation indicators in summer in Fuxin City[J]. Jilin Agriculture, 2017(20): 94 – 95.

[4] FANG YJ, HUA L, HU QH, *et al.* Analysis of characteristics of two heavy rainstorms in Guizhou Province in August 2023[J]. Journal of Agricultural Catastrophology, 2025, 15(6): 89 – 91.

[5] WANG QX, TANG MH, WU YH, *et al.* Analysis of "4 · 29" severe convective weather event in Changsha based on multi-source observation data[J]. Torrential Rain and Disasters, 2025, 44(3): 309 – 321.

[6] LUO J, XU QW, TONG LQ. Diagnosis and analysis of a strong convective weather process in Fujian during April 18 – 19, 2019[J]. Journal of Agricultural Catastrophology, 2025, 15(4): 172 – 174.

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[10] CHEN XT, LI XY, ZHAO C, *et al.* Research progress on the impact of extreme weather on rice yield in China[J/OL]. Chinese Journal of Agrometeorology, 1 – 16. [2026 – 01 – 07].

[11] WANG F, LI HQ, SONG RN, *et al.* Research on promoting green and sustainable development of agricultural resources in Jinpu New Area through meteorological services[C]//Summary of the 2nd National Climate Ecological Product Value Implementation Technology Exchange Conference and National Climate Ecological Value Implementation Typical Case Promotion Conference. 2025.

[12] China Meteorological Administration. White paper on meteorological water resource management and agricultural green development[R]. Beijing: Meteorological Publishing House, 2024.

[13] ZENG HQ. On the value connotation, realistic situation, and action orientation of practice-oriented education in science and technology backyard[J]. Education Research Monthly, 2024(4): 43 – 48.

[14] HOU YY, ZHANG L, WU MX, *et al.* Advances of modern agrometeorological service and technology in China[J]. Journal of Applied Meteorological Science, 2018, 29(6): 641 – 656.