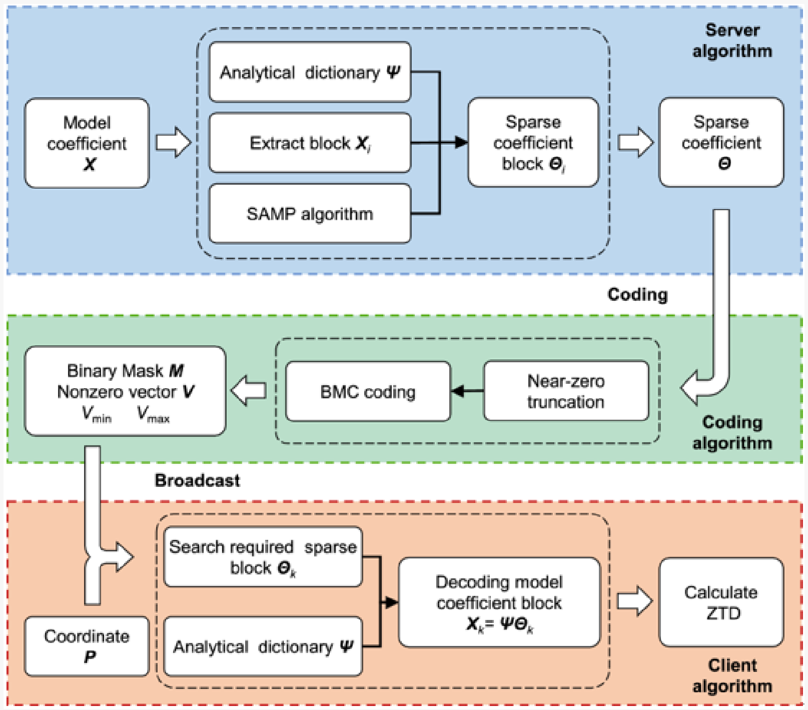
Sparse coding cuts the data burden for high-precision GNSS

FAYETTEVILLE, GA, UNITED STATES, August 18, 2026 /EINPresswire.com/ -- A new compression framework could make high-precision Global Navigation Satellite System (GNSS) atmospheric corrections easier to store, transmit, and use where ground networks are unavailable. The study introduces a training-free sparse representation method that reduces the data burden of global tropospheric grid models while preserving the accuracy needed to estimate zenith tropospheric delay (ZTD), a major source of positioning error. By combining block-wise compression with compact coding and location-based reconstruction, the framework shrinks both static and dynamicallyupdated atmospheric products. The approach points toward lighter satellite delivery of precision corrections over oceans, deserts, and other remote areas, where communication bandwidth and terminal computing resources are limited.



The algorithmic workflow for the sparse representation and application of tropospheric grid models.

Modern high-precision positioning depends on increasingly detailed models of the lower atmosphere, because radio signals from navigation satellites slow as they pass through the troposphere. More accurate models generally require more grid parameters, increasing storage, computation, and transmission costs. This becomes especially difficult for global services that must update atmospheric products frequently or broadcast them by satellite to users beyond terrestrial networks. Earlier machine-learning and learned-dictionary compression methods can reduce data volume, but they may require costly training, separate dictionaries, or complex decoding. Given these challenges, further research is needed into compression strategies that preserve atmospheric-model accuracy while remaining simple enough for global, low-bandwidth deployment.

Published (DOI: 10.1186/s43020-026-00210-2) on August 4, 2026, in Satellite Navigation, the study was led by researchers from the State Key Laboratory of Precision Geodesy, Innovation Academy for Precision Measurement Science and Technology, Chinese Academy of Sciences, with collaborators from the University of Chinese Academy of Sciences and Xi’an University of Posts and Telecommunications. The team developed and tested an end-to-end framework for compressing, encoding, broadcasting, and reconstructing tropospheric grid products, focusing on both a static empirical model and a dynamically updated global model.

The researchers replaced training-intensive learned dictionaries with the analytical Discrete Cosine Transform (DCT), then divided model coefficients into spatial blocks so users could reconstruct only the data needed near their location. Sparse coefficients were estimated with the Sparsity Adaptive Matching Pursuit (SAMP) algorithm, while Binary Mask Coding (BMC) packed their positions for storage and transmission. Tests used the Institute of Geodesy and Geophysics Troposphere Semi-annual (IGGtropS) model and Vienna Mapping Functions 1 (VMF1) products. The static model was checked against high-precision ZTD products from 252 International GNSS Service (IGS) stations from 2019 to 2022, and client calculations were benchmarked on a Raspberry Pi 5. For IGGtropS, memory use fell by 63.49%, with reconstructed ZTD root mean square error (RMSE) of about 1.7 mm; the location-based scheme completed the 252-station calculation in 0.62 s, versus 266.78 s when the full model was repeatedly restored. For VMF1, memory use fell by 81.19% and ZTD RMSE was about 2.1 mm, with performance remaining stable through 2025. In broadcast simulations, 12-bit quantization kept maximum absolute error at or below 0.37 cm. At 2 kbit/s, sparse VMF1 transmission took 253 s versus 565 s for original data; a roughly 30-s broadcast required about 15 kbit/s instead of 31 kbit/s.

The authors said the key advance is not compression alone, but the way the method links compression to practical delivery and terminal use. By avoiding dictionary training and allowing users to recover only nearby blocks, they said the framework reduces the work required at both the server and receiver while keeping reconstruction errors small. They added that the broadcast results show a realistic path toward sending global atmospheric corrections through bandwidth-limited satellite links, although the simulated latency values should be treated as engineering estimates rather than fixed operational thresholds.

The approach could support future high-precision navigation services in places where continuous ground-network access is difficult, including open oceans and remote deserts. Lower storage requirements may also make sophisticated atmospheric correction products easier to deploy on resource-constrained receivers, while reduced broadcast demand could help satellite augmentation systems update global grids more efficiently. Because the method is based on an analytical transform rather than a trained model, it may also be easier to adapt across products and operating environments. The authors suggest that the same compression-and-broadcast framework could eventually be extended to ionospheric grid products, providing another route toward lightweight global correction services for precise positioning.

References
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