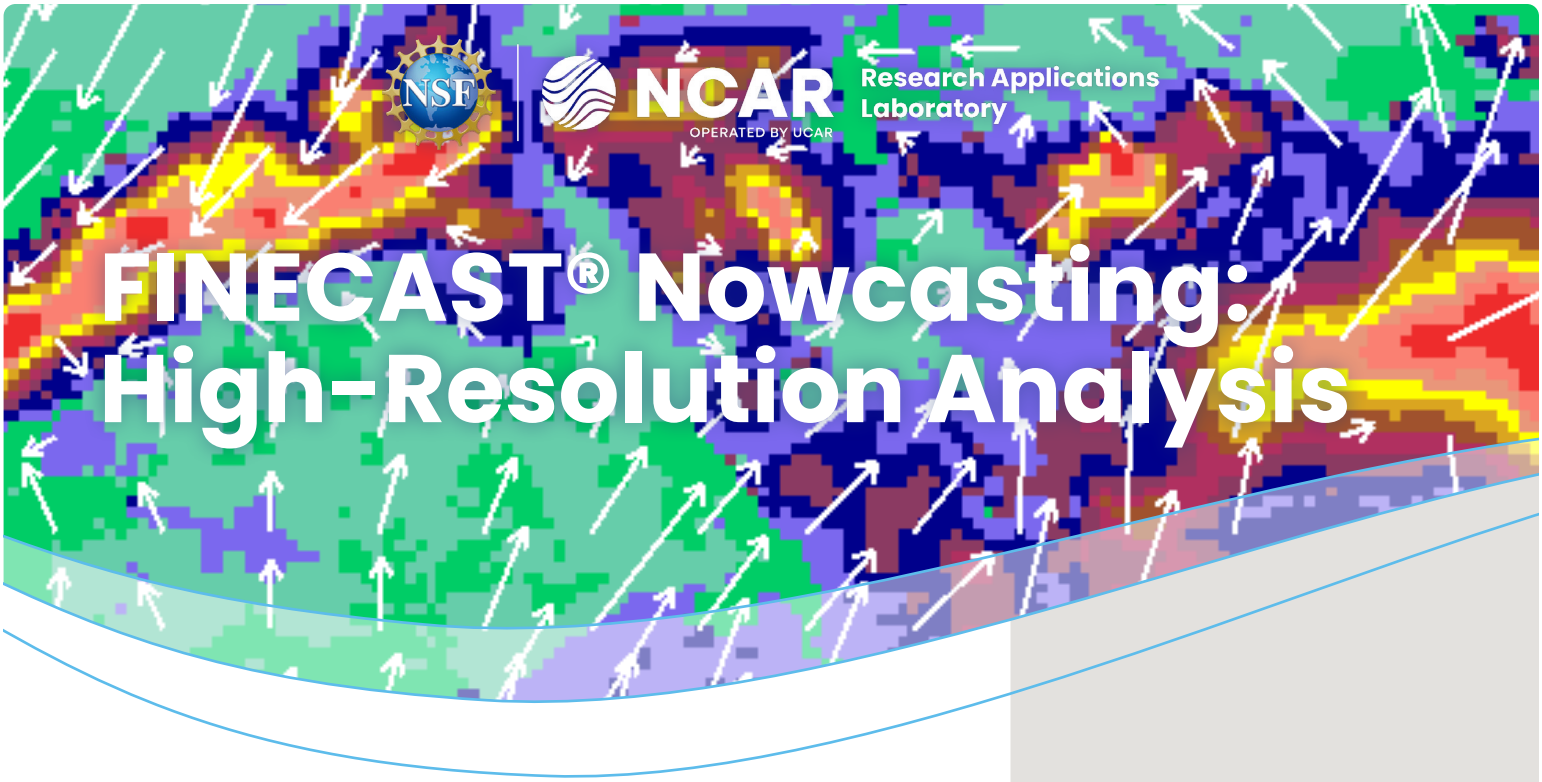

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FINECAST® Nowcasting: High-Resolution Analysis

Improving Nowcasting via Data Assimilation

Fine-Scale Analysis and Nowcast System (FINECAST) is used by the research community to study convective-weather initiation mechanisms, as well as by the operational community to improve nowcasting.

Since 1998, FINECAST has been implemented in real time for severe-weather nowcasting, wind-energy prediction, hazardous-chemical detection, and model initialization. The code is fully parallelized to handle the computation demand of the advanced data assimilation scheme (4DVar) so that each analysis can be produced in a few minutes with an update frequency of 10 minutes to meet the nowcasting requirement.

High-Density and Frequent Observations

Scientists and engineers developed the fine-resolution analysis and nowcasting system, named FINECAST® (previously known as Variational Doppler Radar Analysis System), based on high-density and frequency observations, such as those from Doppler radars and surface networks. The core technology of FINECAST is a 4-dimensional variational (4DVar) data-assimilation system within a convection-permitting model. By making use of the observations from multiple times, the model trajectory of a specified time window is fitted to the observations to produce the optimal evolution and meteorological analyses of observed and unobserved variables. These analyses could not otherwise be obtained from operational

Benefits & Impacts

- Severe-weather nowcasting
- Wind-energy prediction
- Hazardous-chemical detection
- Analyses produced in a few minutes
- Real-time applications

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NWP models because they are primarily based on large-scale observations or are too slow to provide near real-time updates.

High-Resolution Analysis

Rapidly updated high-resolution meteorological analysis is a key requirement for accurately forecasting hazardous weather events. Operational Doppler radar networks provide temporally and spatially high-resolution observations, but they are limited to observable variables, such as radial wind and reflectivity. Variables of 3-dimensional wind, temperature, and cloud states that provide the whole picture must be retrieved from these limited observations.

3D Picture of Convective Storms

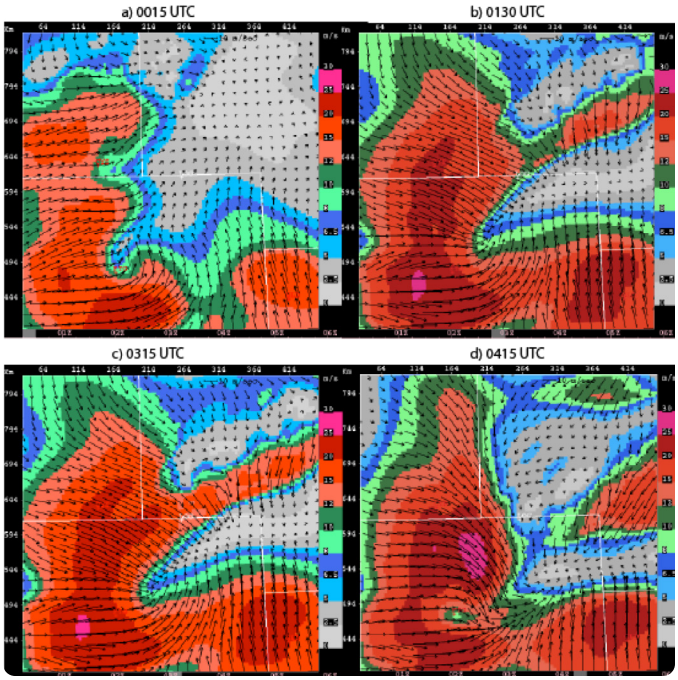
A critical step toward improved nowcasting capability for convective storms is understanding their initiation and evolution mechanisms. FINECAST helps researchers and forecasters identify thunderstorm predictors and develop conceptual models for convective-weather nowcasting. By fitting model trajectories to observations using the 4DVar technique, dynamically consistent meteorological fields are retrieved.

> From observations to actionable nowcasts in minutes.

From these retrieved fields, dynamical and thermodynamical diagnostic fields, such as divergence, updraft/downdraft, Convective Available Potential Energy (CAPE), Convective Inhibition (CIN), vertical wind shear, perturbation temperature (cold pool), helicity, etc., can be derived, which are essential for characterizing and predicting convective storms. These diagnostic fields provide depictions of the mesoscale environment, the triggering mechanism, and the structure of convective storms. Some of these fields are being used in the AutoNowcaster to identify regions of convective initiation.

Nowcasting Wind & Precipitation

The analysis fields produced by FINECAST are also used to initialize Numerical Weather Prediction (NWP) models to improve precipitation and wind nowcasts. FINECAST analyses are initial conditions for the cloud model used in FINECAST that constrain the 4DVar analyses, from which nowcasts can



Thrity minute nowcasts of wind speed at a wind farm.

be launched by directly integrating the cloud model. FINECAST analyses have also been used to initialize other non-hydrostatic models, such as WRF (Weather Research and Forecasting).

FINECAST is being studied for its ability to address the challenges of nowcasting wind-ramp events in hopes of improving wind-power prediction. Research is also being conducted to evaluate FINECAST's skill in nowcasting convective precipitation. Our goal is to expand FINECAST into a new generation of nowcasting system that is model-based and initialized by assimilating multiple platforms of high-resolution observations producing rapidly updated nowcasts every 10 minutes or less.

Ongoing & Future Developments

The capability of FINECAST has expanded to include terrain effects. Recent studies demonstrate that the IBM terrain scheme is capable of simulating the updraft/downdraft and associated precipitations caused by complex terrain. Assimilating polarimetric radar observations is another research activity with the potential to improve the accuracy of FINECAST analyses and nowcasts. Integration of machine learning models with FINECAST is being explored to further improve forecast skill.

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