An Object-Based Approach for Identifying and Evaluating Convective Initiation

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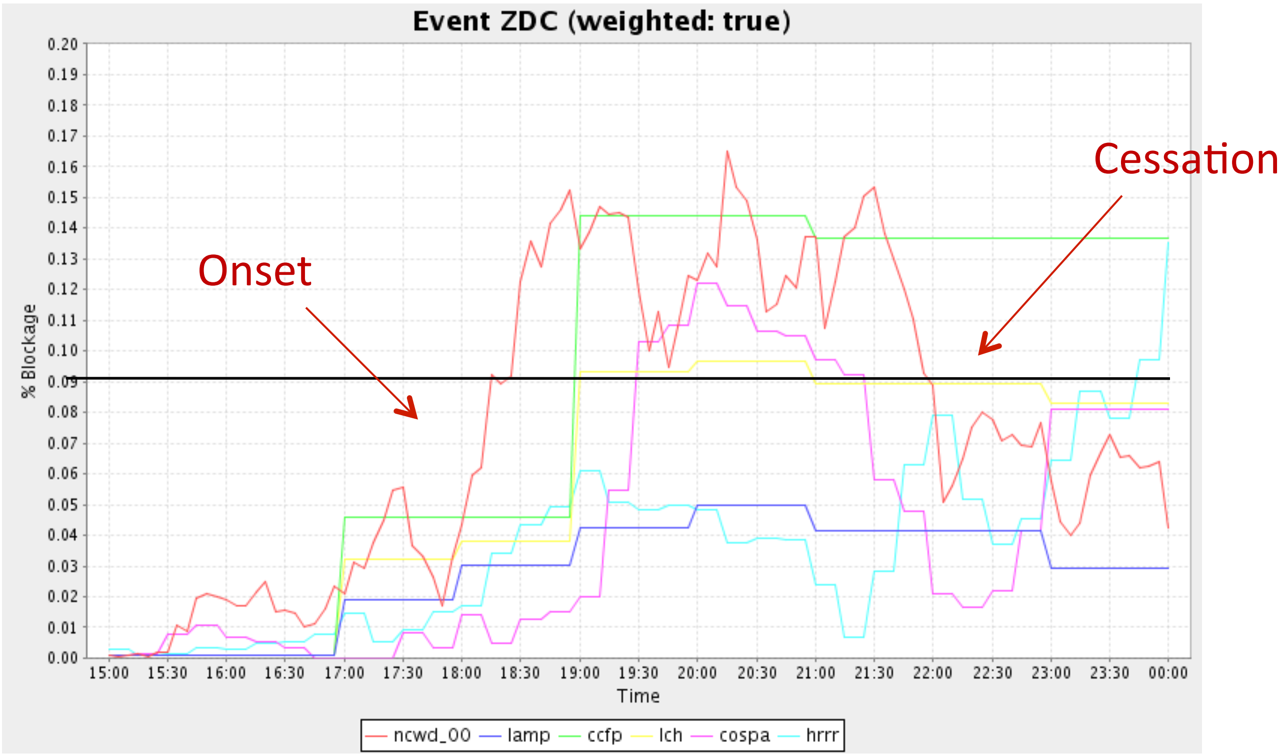
Outline

- Motivation
  - Definition of Convective Initiation (CI)
- Object-Oriented Verification
- Convective Initiation Identification
  - Threshold methodology
  - FFT methodology
- CI Verification
  - ANC Example
- Conclusions

Convective Initiation Problem

- Modelers are continually trying to improve the initiation of convective activity in their solutions
- How do you quantify that the model is improving convective initiation?
  - Qualitative assessments are often misleading
  - Improvement of performance measures at typical initiation times misleading
- Isolating CI in observations and forecasts to validate improvement is not widely applied
- A solution: use an object-oriented verification approach to assist in the automated identification of CI in the observation and the forecast

Initiation Confusion



The above plot (Layne and Lack, 2010) shows a measure of impact to an ARTCC over time. It is important to note that initiation is not the same as onset. Onset could have been caused by advection into a particular domain. Likewise, cessation of an event is not the same as decay or dissipation.

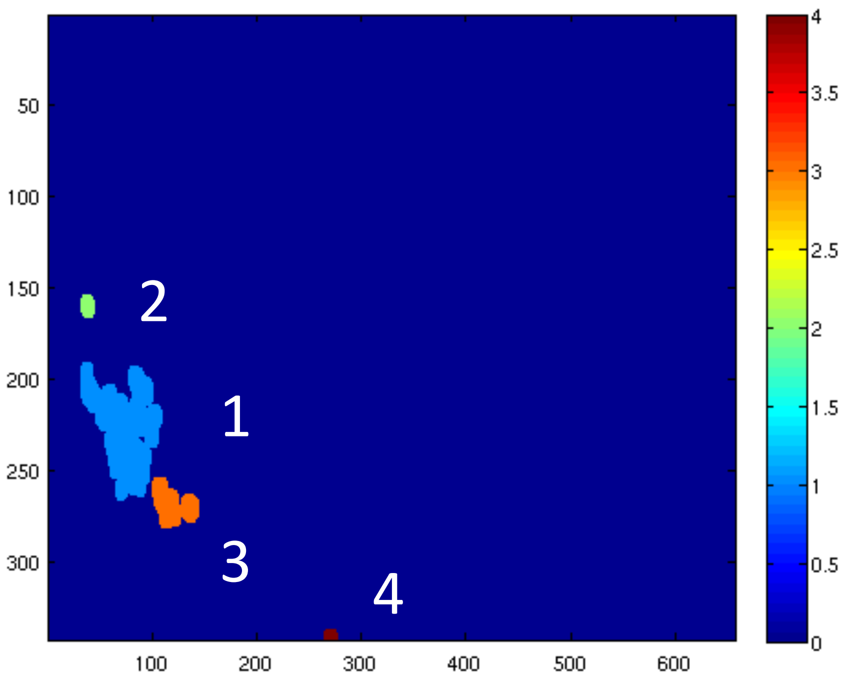
Procrustes Verification Approach

- Procrustes verification approach (Lack et al. 2010 WAF) identifies objects by using threshold/minimum size of object criteria or FFT transform for signal strength object detection
- Object matches are based on minimizing a user-defined weighted cost function
- Observed objects are matched to all forecast objects and vice versa to be tagged hits, misses, and false alarms
- Error statistics are broken down into components
  - displacement magnitude and direction, intensity, rotation, and shape

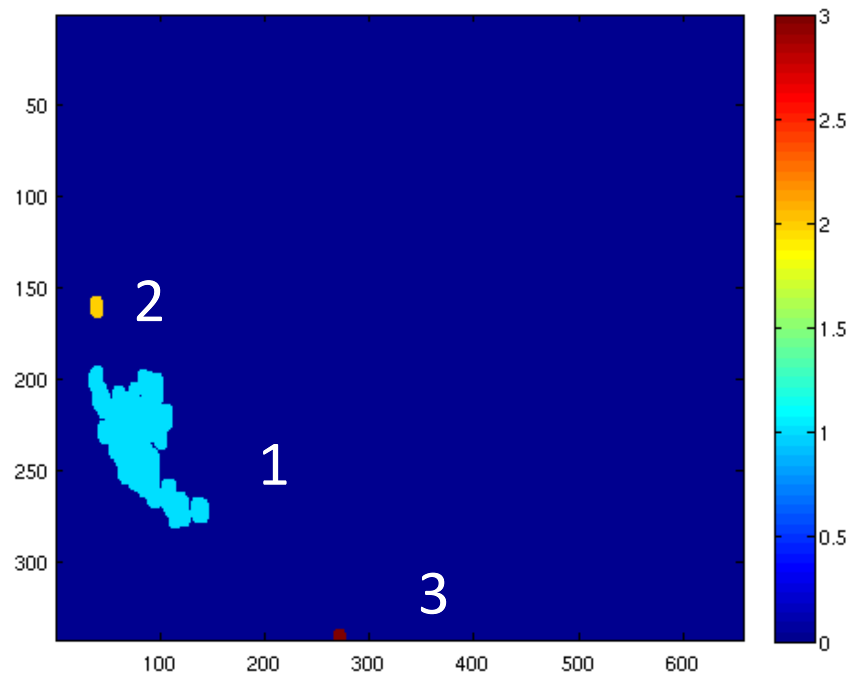
Procrustes Scheme for Initiation

- A weakness of object-oriented approaches is from counter-intuitive matching that may occur during matching forecast and observation objects (esp. large time steps)
  - This is minimized when using small time steps and examining consecutive observation fields or forecast fields (High spatio-temporal correlation for convection)
- Hits, miss, false alarm detection in Procrustes scheme helps identify new initiation from growth, decay, and advection
  - Misses from t=0 to t-5 generally are initiation cells
- Decay of larger storms into smaller ones to avoid initiation on cluster breakdown is also implemented

No Initiation Example (threshold method)



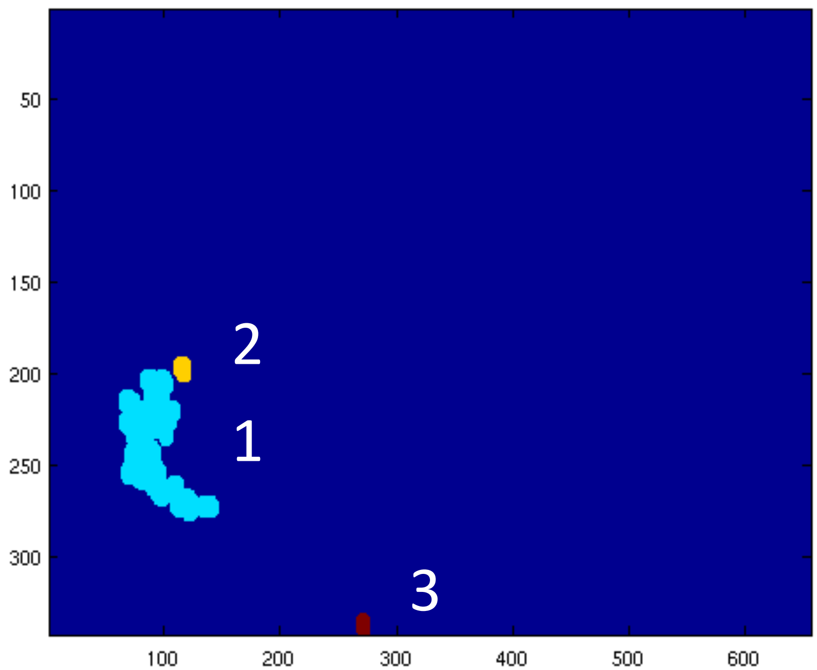
T-5=2105Z



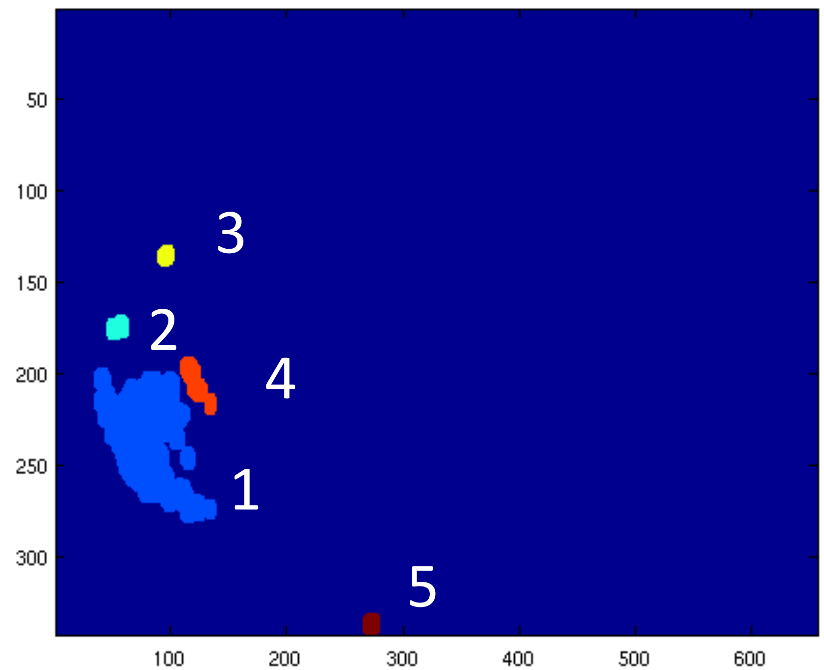
T0=2110Z

Procrustes matching is from T=0 to T-5, so 1 matches to 1, 2 matches to 2, and 3 is matched to 4. 3 in the T-5 is tagged as a false alarm and there is no initiation just growth.

Initiation Example (threshold method)



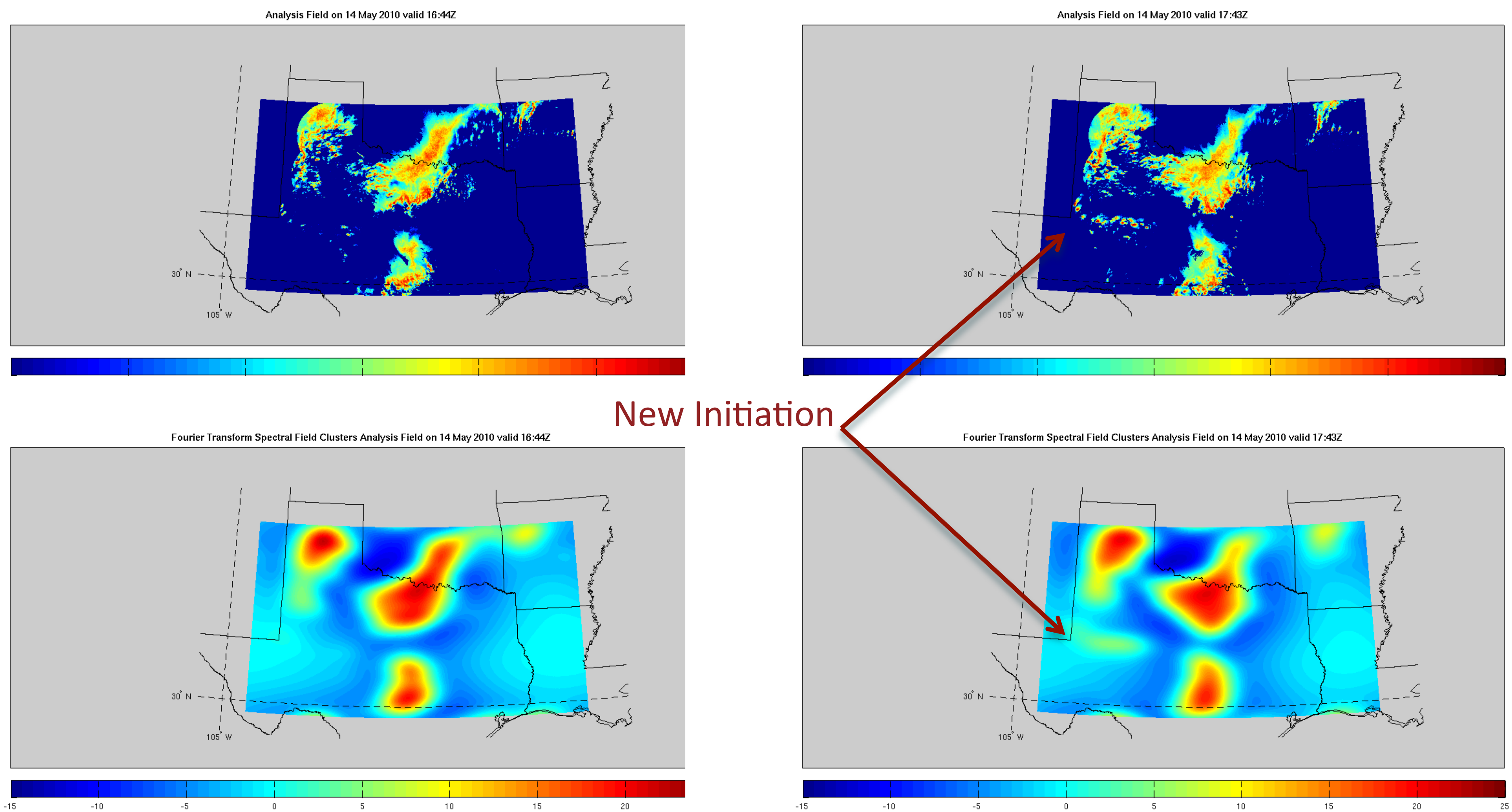
T-5=2105Z



T0=2110Z

In this case there are 2 new areas of initiation: Cells 2 and 3 at T=0 on the right (tagged as misses in the scheme). Cells 1 ,4 and 5 at T=0 on the right are growing cells from 1,2, and 3, respectively.

Initiation at 1-h intervals (FFT method)

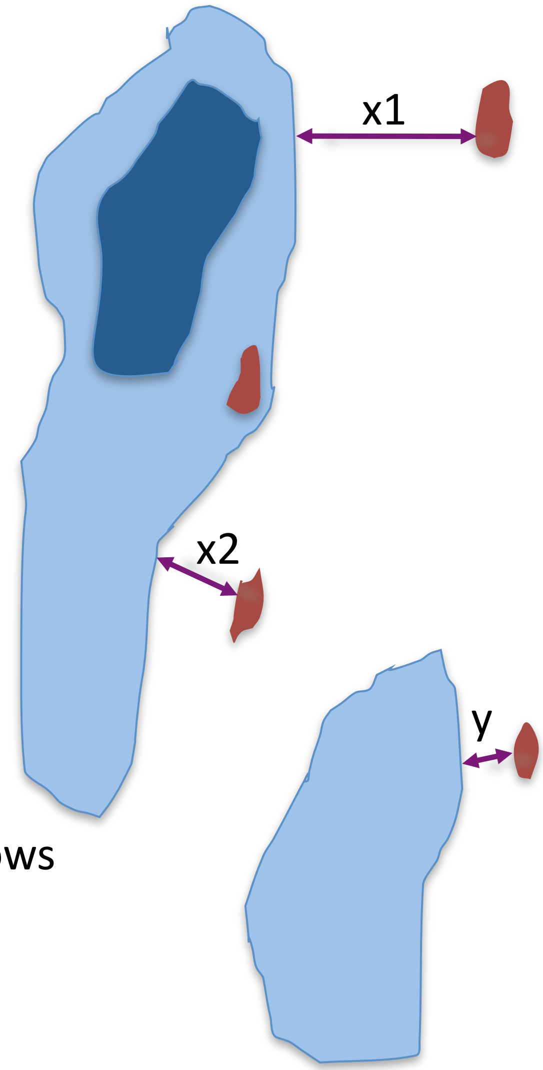


Initiation Detection Challenges

- Sensitivity in what defines an initiation cell (object)
  - No standard definition for evaluation
- Radar outages or coverage gaps
  - Large cells may appear during outage and tagged as initiation
- Inconsistent radar time steps…(e.g. Δt=5,6, 10-min) especially on merged radar products
  - Growth may appear inconsistent
- Radar QC (different modes, clutter)
  - When switching to different modes, initiation objects may spike at those time steps
- Some mitigation is applied to the initiation
  - Ex: Minimum size restrictions for radar outages and gaps

Verification Methodology

ANC-like example



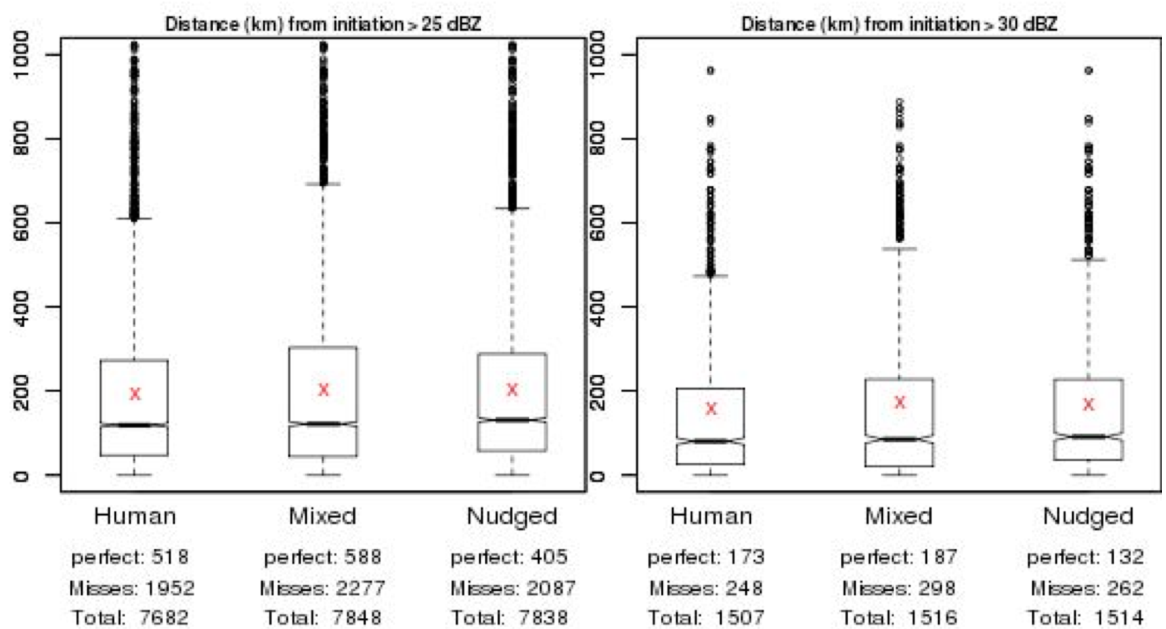
Initiation area 1 (top blue object) has a nest of initiation 2 and has 3 cells nearby. It has 1 intersection (distance 0) and 2 cells distance x1 and distance x2 away within +/- z minutes from forecast valid time.

Initiation area 2 (bottom blue object) has 1 cell distance y away from it within +/- z minutes from forecast valid time.

If no forecast initiation zone is present and initiation cells are present, the forecast tagged as a total miss.

Procrustes error decomposition allows for distributions of distances, etc.

Example Results



- ANC HITL Pilot Evaluation for ZFW
- HITL (regime selection and boundary input) altered initiation potential regions (intensity and some location)
- May adjust time window for initiation and define alternate initiation thresholds

Future Directions

- Aforementioned study focused on comparing convective forecasts using radar data as the observation
  - Using radar has its challenges but may have value as a verification methodolgy for CI
- Expand approach to include other parameters or fields
  - Use of satellite data, especially for oceanic applications
  - Total lightning for a "truer" convective initiation measure, although model comparisons become more challenging
    - GOES-R

Conclusions

- To improve the accuracy of high-resolution models and nowcasters for CI forecasting, there is a need to directly assess the accuracy of CI.
- Correlating an increased skill score during typical times of convective initiation may be misleading
- Convective initiation should be detected in an observation field and a forecast field and then scored appropriately in isolation
- Object-oriented verification approaches may aid in providing useful feedback to the improvement of CI in forecasts

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