

Optimization of the Analog Ensemble Method

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Research Data

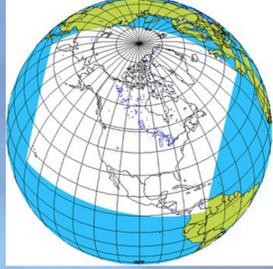
Ground Truth

- 550 hourly METAR surface observations
- 1 May 2010 – 31 July 2011 (457 days)



Regional Global Environmental Multi-scale Model (GEM15)

- Environment Canada, operational, deterministic forecast model
- 0.14°x0.14° (~15km), 58 vertical levels
- 48-h forecast, initialized 12Z, 3-h increments

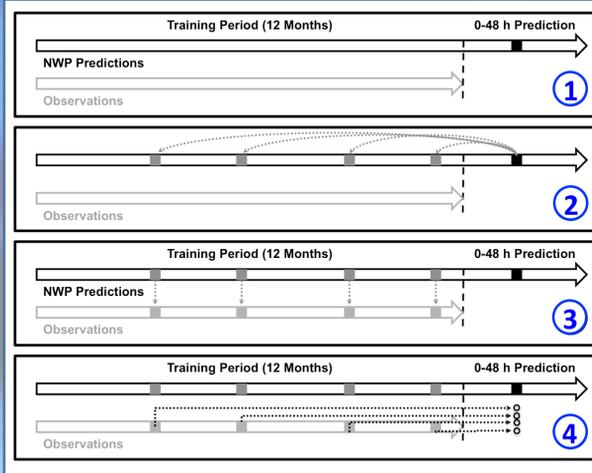


Regional Ensemble Prediction System (REPS)

- Environment Canada, 21-member, operational EPS
- Regional GEM 4.2.0, 0.3°x0.3° (~33km), 28 levels
- 72-h forecast, initialized 12Z, 3-h increments
- Cold-start initial conditions and boundary updates from GEPS
- Stochastic Physics

Analog Ensemble (AnEn)

- Run a single, NWP model for the forecast cycle
- Find* n similar predictions (i.e., analogs) from historical predictions by same model
- Obtain the verifying observation for each analog
- Each selected, past observation is an ensemble member for the current forecast



*Analogues are found separately for each forecast lead time, and each forecast location

Metric to Define Analog Quality

$$\|F_t, A_t\| = \sum_{i=1}^{N_v} \frac{w_i}{\sigma_{f_i}} \sqrt{\sum_{j=-\tilde{t}}^{\tilde{t}} (F_{i,t+j} - A_{i,t'+j})^2}$$

(see Delle Monache et al., MWR, 2011)

F_t -- Current deterministic forecast for time t at a point location

A_t -- Forecast analog, same location and lead-time, but valid in the past

N_v -- Number of predictor variables used in the analog search

w_i -- Weight given to each predictor

σ_{f_i} -- Predictor's standard deviation over analog training period, at a location

\tilde{t} -- Integer # of valid times, as half width of metric's time window

Hybrid Ensemble (HyEn)

Ensemble of $M \times N$ total members constructed by finding N analogs for each of M members of an NWP ensemble

- In this study, $M=5$ members of REPS, and N varies
 - HyEn5x4 means 5 REPS members with 4 analogs each

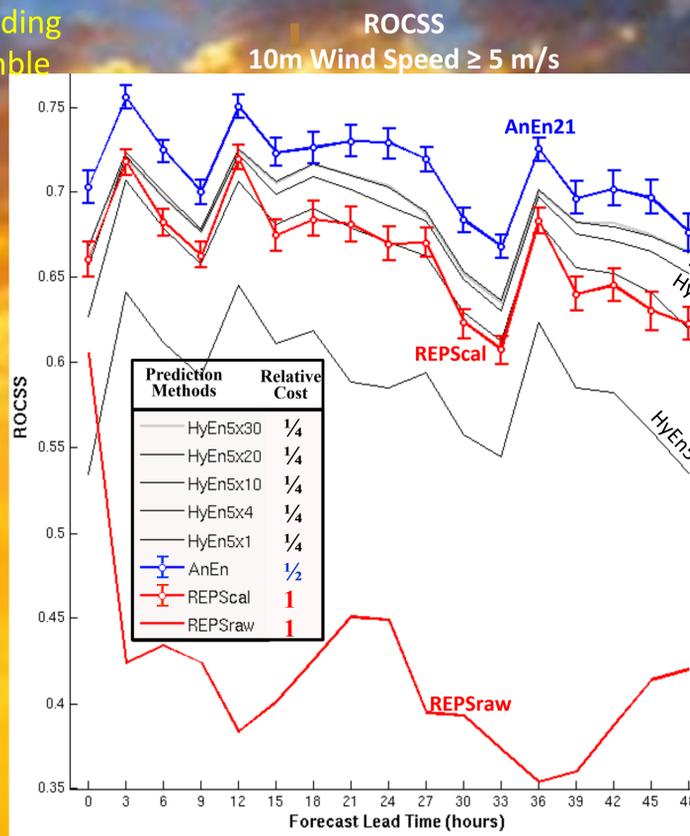
Other ensembles compared:

- REPSraw – Original REPS output
- REPScal – REPS calibrated by Shift-and-Stretch using same historical data as AnEn (Eckel et al. WAF, 2012)
- AnEn21 – 21 members, based on GEM15 forecasts
 - Predictors: 10m wind speed and direction, surface pressure, 2m temperature

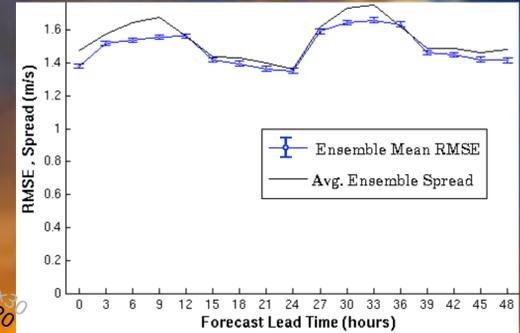
- 100-Day Verification Period: 23 April 2011 – 31 July 2011

Training Data (for AnEn21 and REPScal):

- 1 May 2010 – 21 Apr 2011 (356 days) for forecast #1
- 1 May 2010 – 29 Jul 2011 (455 days) for forecast #100



HyEn5x20 displays good statistical consistency (and good reliability) but is slightly overspread.



Preliminary Conclusions

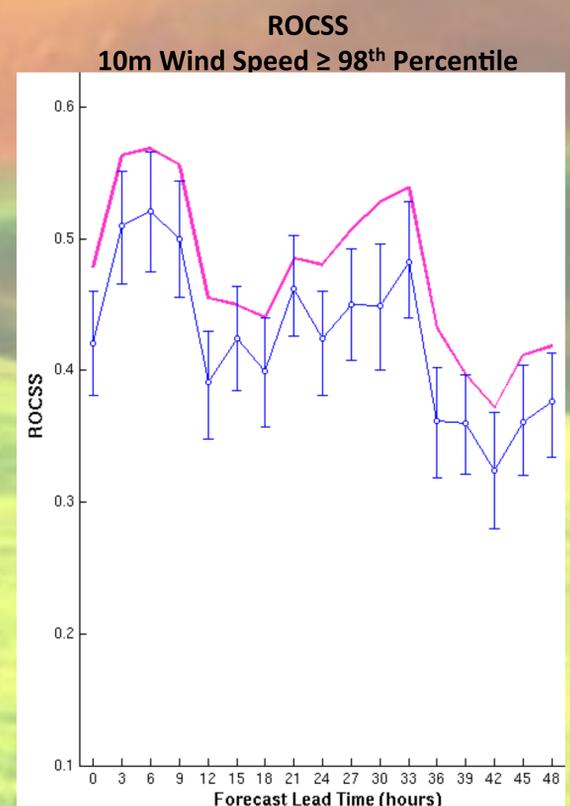
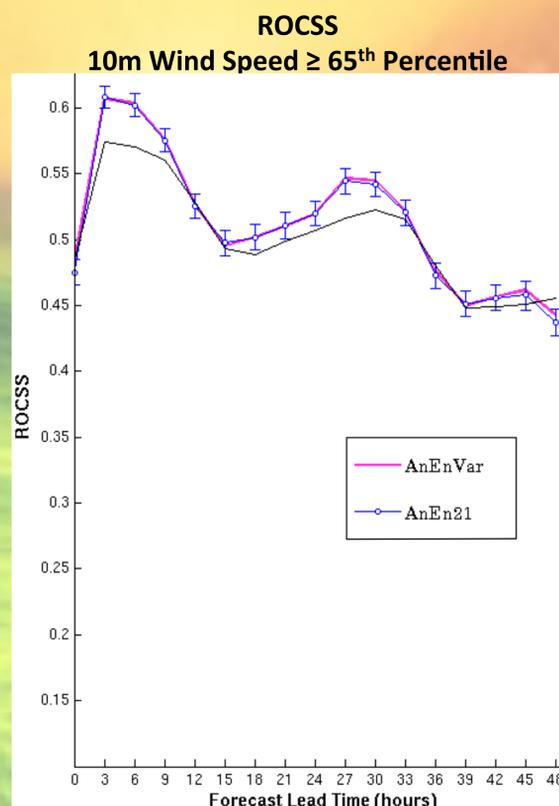
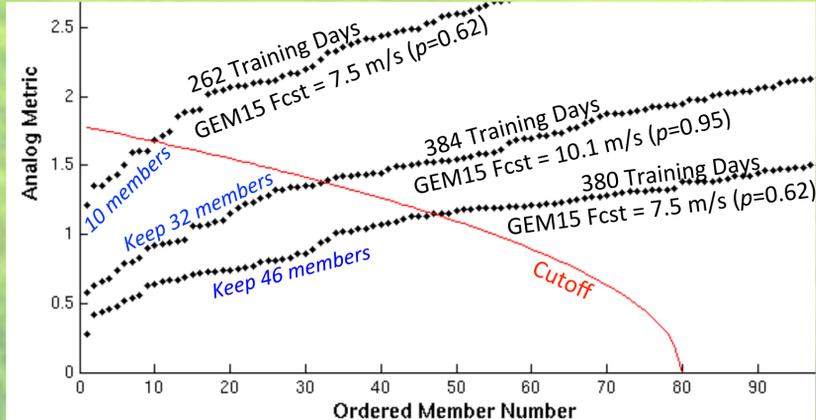
- Hybrid ensemble skill saturates as analog quality drops and become repetitive between REPS members.
- Hybrid ensemble can outperform a well-calibrated NWP ensemble, and at a lower cost.
- Analog ensemble, using a single, higher resolution NWP model, provides best performance

Variable # of Members

AnEnVar uses a highly variable number of members based on members' expected skill

- Define members' expected skill with the analog metric
 - Highly dependent on predictors' distribution within the training data
 - Weaker analogs are associated with fewer available trainings days and/or more rare forecasts
- Include enough members for good sampling, but avoid expanding the forecast PDF towards climatology
- Empirically find a cutoff for selecting # or members to keep (for any given forecast)

Member Selection for 3 Separate 12-h Forecasts at Kingsville, TX



Preliminary Conclusions

- An Hybrid NWP/analog ensemble can be competitive
- Using a variable number of members may improve skill