

An Automated Forecast Verification System for Mesoscale Ensembles

Verification Workshop
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Outline

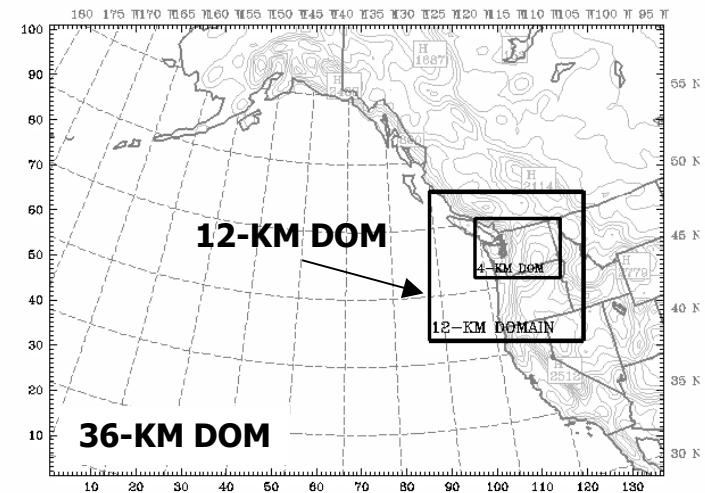
- A Forecaster's Perspective on Verification
- The UW Mesoscale Ensemble
- Verification Methodology
- Issues and Future Research

Verification Issues

- Verification is forecast dependent. Is the parameter, timing, duration, amplitude or areal coverage most important? We should verify to the forecast purpose.
 - Agriculture – Precip amount, minimum temp., precip intensity, duration of cloudiness, evaporation, presence of hail...
 - Navy operation – rain rate, temperature at precise time, cloudiness at precise location, height of cloud, peak wind speed, ...
 - Utilities – degree days, cloud duration, peak wind speed, icing amount, river basin total rainfall, ...
- Mesoscale verification against observations is misleading
 - Smoothed forecast (ensemble mean) has a numeric advantage
 - Synoptic observations are not representative of mesoscale features
- Sophisticated mesoscale models require rapid, automated, verification to detect subtle differences in parameterizations – you can't meaningfully help forecasters or developers with case studies
- Multi-model mesoscale ensembles magnify mesoscale verification issues
- There is too much emphasis on precip in mesoscale verification
 - Errors in parameterizations, initialization of moisture, topography, land use, etc., tend to mask more fundamental model and data issues

UW Ensemble Approach

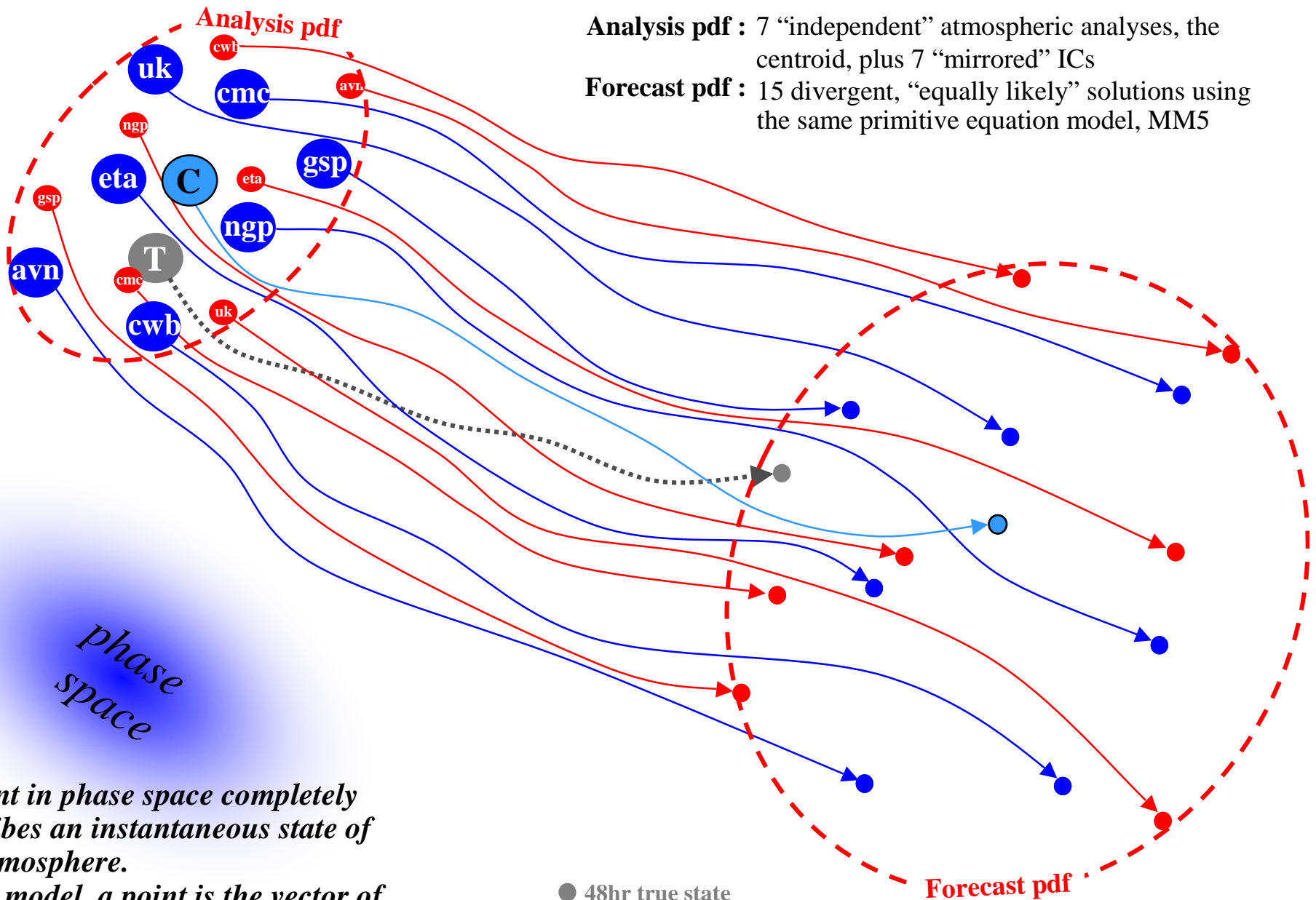
- Single modeling system (MM5)
- 2-day (48-hr) forecasts at 36-km & 12-km grid spacing in real-time.
- Initial Condition Selection: Multi-analysis (MA)
[From different operational centers (NCEP, CMC, FNMOC, BoM, UKMO, CWB)]
Lateral Boundary Conditions (LBCs): Drawn from the corresponding, synoptic-scale forecasts
- Additional members generated from “mirroring” of ICs about centroid of original members



UW SREF Methodology Overview

Analysis pdf : 7 “independent” atmospheric analyses, the centroid, plus 7 “mirrored” ICs

Forecast pdf : 15 divergent, “equally likely” solutions using the same primitive equation model, MM5

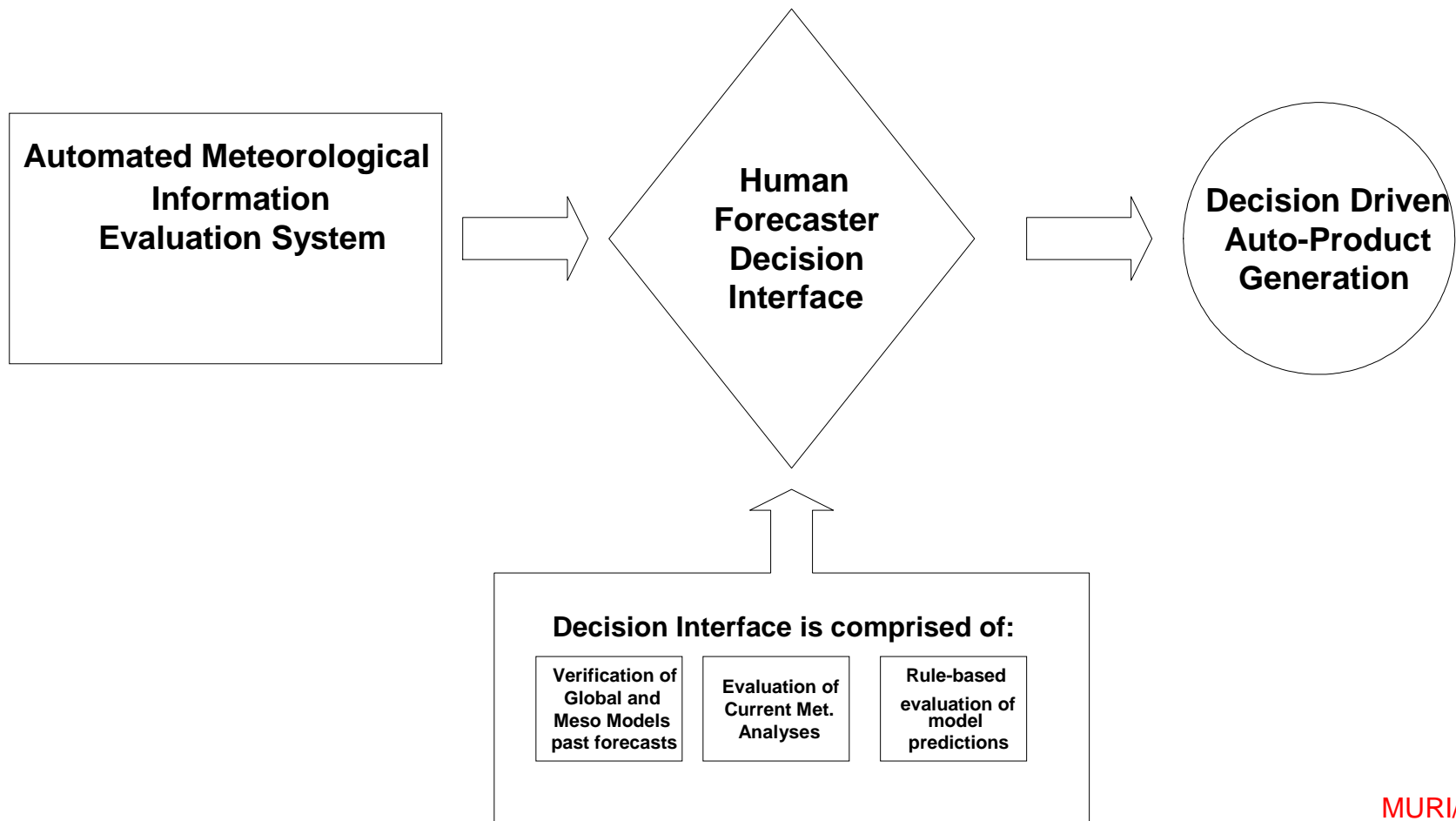


A point in phase space completely describes an instantaneous state of the atmosphere.

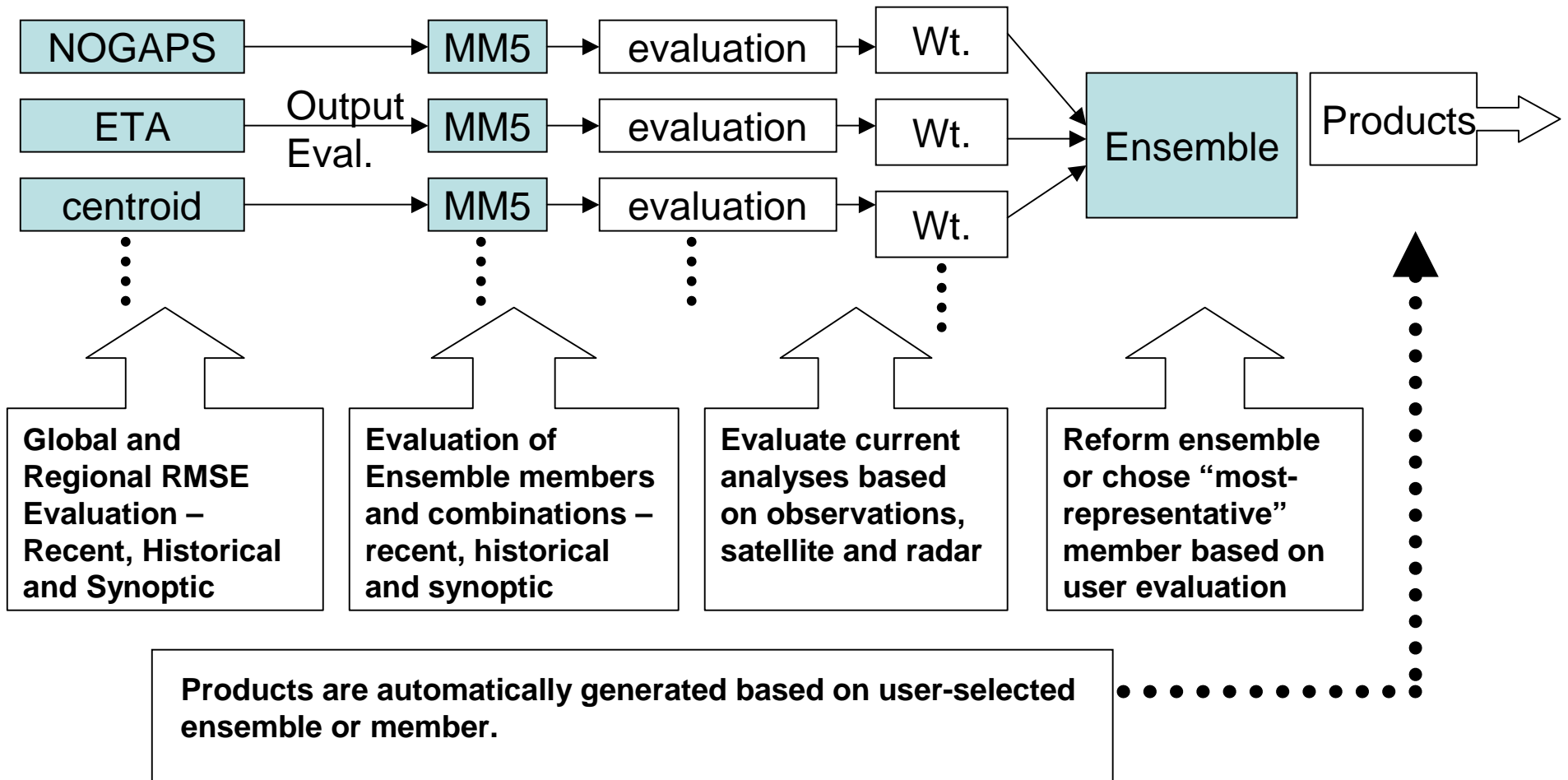
For a model, a point is the vector of values for all parameters (pres, temp, etc.) at all grid points at one time.

- 48hr true state
- 48hr forecast state (core)
- 48hr forecast state (perturbation)

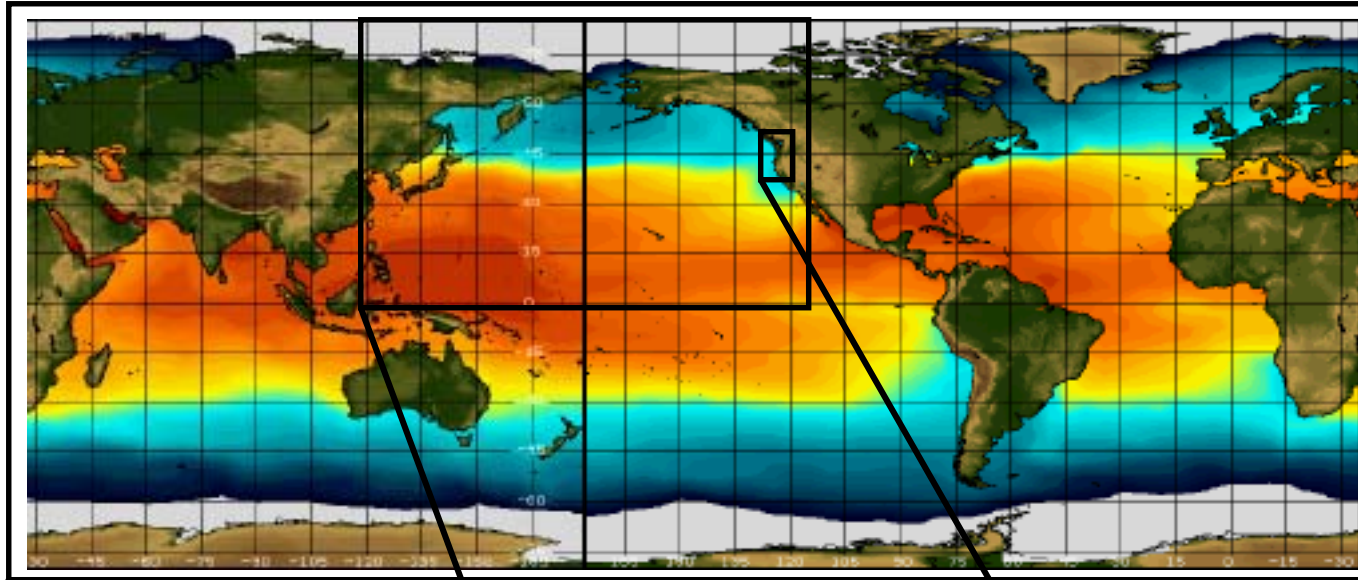
A New Paradigm for Weather Forecasting



Verification and Evaluation



Global (IC/BC) Verification Strategy



Global RMSE - Total Model Performance

- Historical - one to three years
- Seasonal - +/- two weeks for previous years
- Recent - Past one to three weeks

Regional RMSE - 48h to 72h Upstream

- Historical - one to three years
- Seasonal - +/- two weeks for previous years
- Recent - Past one to three weeks

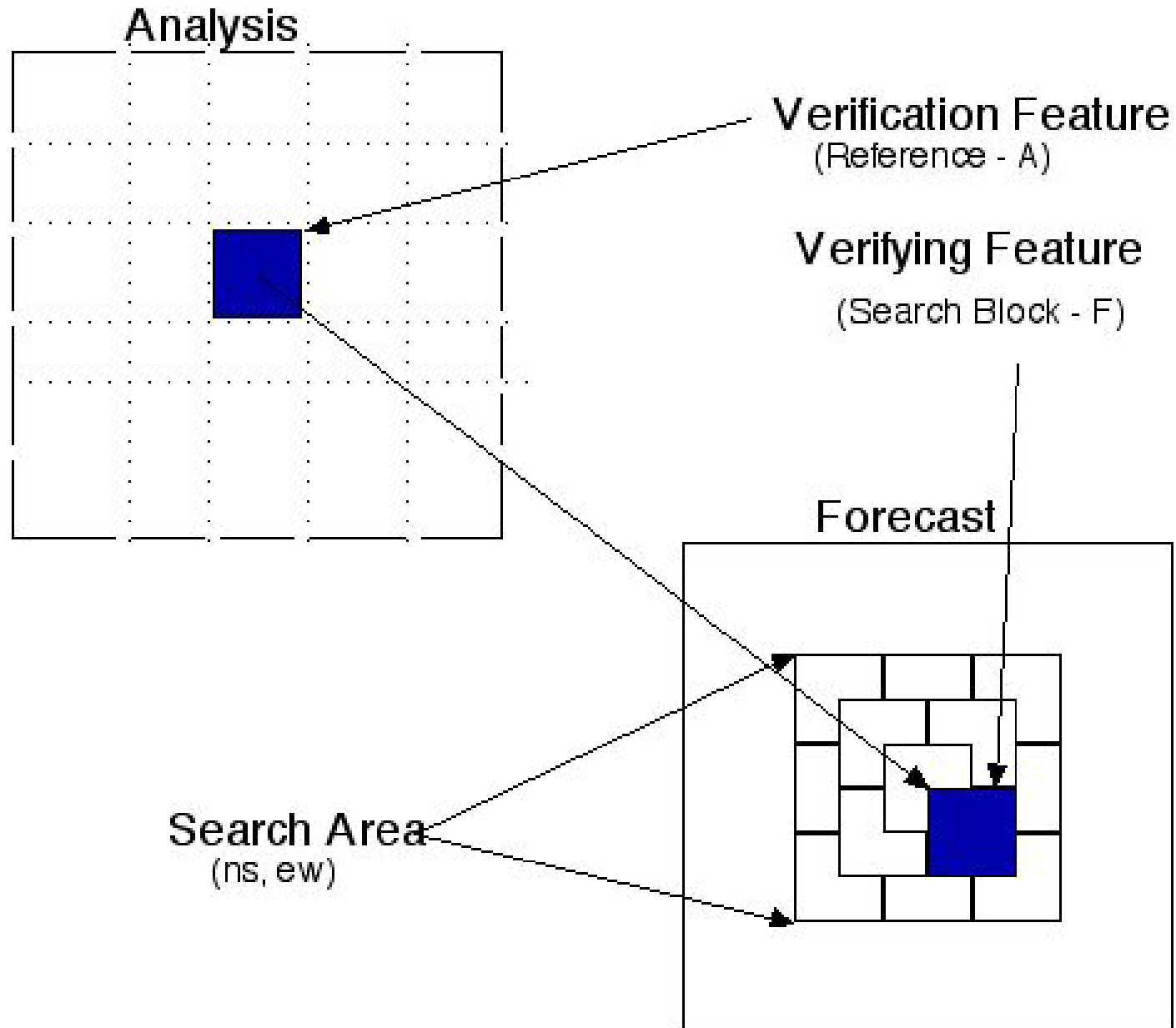
Local RMSE - Forecast Locale

- Historical - one to three years
- Seasonal - +/- two weeks for previous years
- Recent - Past one to three weeks

Mesoscale Verification Attributes

- Automated, comprehensive
- Addresses today's forecast issue
 - Flexible or user-specified
- Timing/Phase Errors
- Amplitude Errors
- Distortion Error (areal, rotation)

Mesoscale Verification



Rapid Search Algorithms

					3	4			
				3	4	3	4		
			2		2	4	3		
		1		1		3			
			0		2				
		1		1		3			
			2		2				

The Motion Picture Industry has stimulated significant research in the area of very efficient block matching and motion detection algorithms. These pattern search routines can be utilized to accelerate pattern-based verification routines.

Mesoscale Verification

- Total Error = Displacement Error + Amplitude Error
Distortion or Pattern Error + Residual Error
 - MSE and CCF give equivalent results
 - Hoffman, et. al., 1995, for satellite data assimilation.
- $MSE(tot) = MSE(displ) + MSE(volume) + MSE(pattern)$
 - Where volume = amplitude of rainfall, pattern = residual
 - Elbert and McBride, 2000, for precipitation pattern verif.
 - Du and Mullen, 200, for ensemble precip verification
- Method
 - Calculate $MSE(tot) = (Forecast - Analysis)^2$
 - Shift forecast field to minimize total MSE and calculate $MSE(displ) = MSE(tot) - MSE(shift)$
 - Adjust amplitude to minimize $MSE(shift)$. $MSE(amp) = MSE(shift) - MSE(shift-min)$
 - $MSE(residual) = MSE(tot) - MSE(displ) - MSE(amp)$
 - Adjust rotation/stretching to minimize $MSE(residual)$

Ensemble Member Skill

Ensemble Member	Total MSE*	Phase Error	Amplitude Error	Distortion Error	Residual
AVN-MM5	832*	357	278	140	57
CMCG-MM5	763	247	321	130	65
ETA-MM5	797	411	140	231	47
GASP-MM5	750	246	257	214	33
NGPS-MM5	718	297	189	185	26
TCWB-MM5	724	264	211	197	52
UKMO-MM5	665	259	198	165	43
CENTROID	729	302	214	165	48

* Values are for illustration only, not derived.

Future Research Issues

- Need to test on “real” data.
- Many computational solutions:
 - Correlation Coef., Mean absolute difference, etc.
 - Rapid ‘image motion’ search techniques
- Map verification or “feature” verification:
 - Phase and amplitude suitable for both
 - Distortion may require a “feature” and more complex search
 - Need to examine usefulness
- Evaluation of “goodness”
 - Relative weight of phase vs amplitude vs distortion error
 - Value of “table” display



Questions and Comments?

References

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