Analysis of Integrated Forecasts from Different Combinations of NWP Models

Environment Environnement Canada

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Background

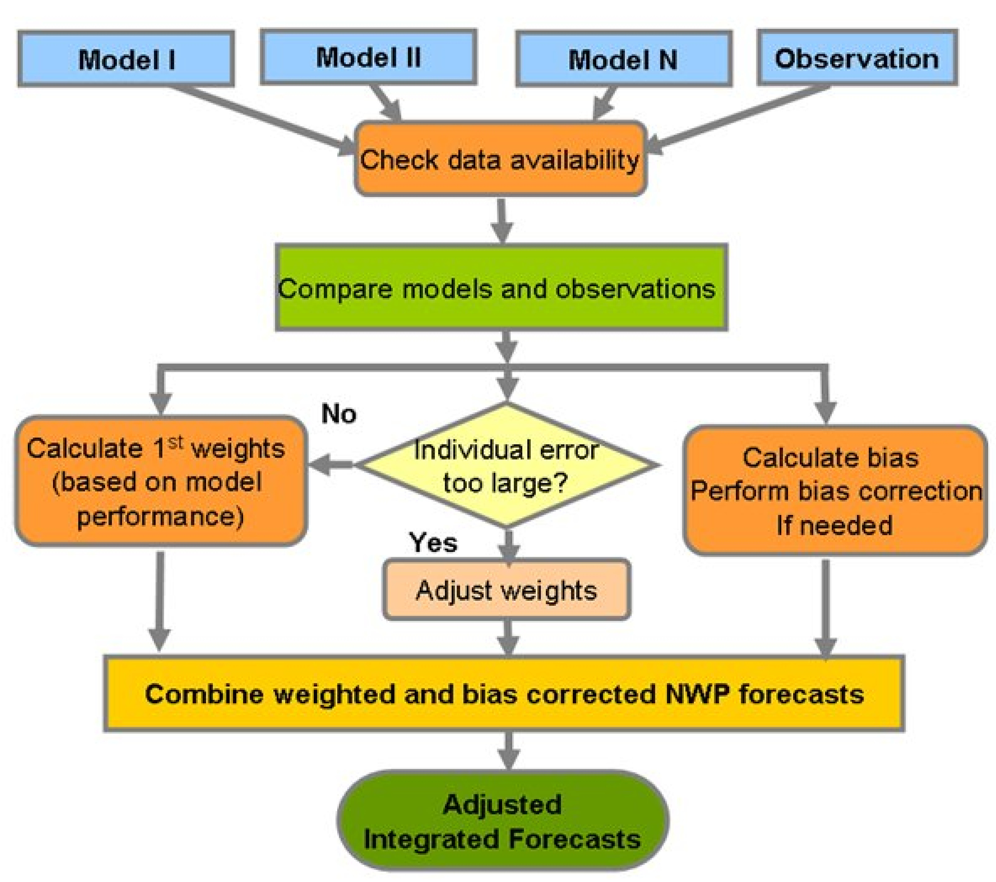
- General lack of numerical models specifically designed and developed to do nowcasting
- Nowcasting is often based on one or several available Numerical Weather Prediction (**NWP**) models regardless of the spatial resolution for a particular location
  - NWP models originally developed for short to medium weather forecasts with lead times greater than 12 hours
  - Major limitations of using NWP models for nowcasting
    - coarse spatial resolution
    - spin-up
    - cannot be updated frequently
- A weighting, evaluation, bias correction and integrated system (**WEBIS**) has been developed at EC to generate integrated weighted forecasts (**INTW**) from several NWP models for nowcasting (up to 6 hrs)

Integrated Model Generation

Major Steps of INTW Generation

- Data pre-checking - defining the available NWP models and observations
- Extracting the available data for specific variable and location
- Calculating statistics from NWP model data, e.g. MAE, RMSE
- Deriving weights from model variables based on model performance
- Defining and performing dynamic and variational bias correction
- Generating Integrated Model forecasts

Flowchart of Integrated Model Generation



Data Sources Used in This Study

Name	Run times	Resolution		Data from
		Spatial	Temporal	
GEM Regional (REG)	0, 6, 12, 18 Z	15 km	7.5 min	CMC of EC
GEM LAM east (LAM)	12 Z	2.5 km	5 min	CMC of EC
GEM LAM west (LAM)	9, 21 Z	2.5 km	1 min	CMC of EC
RUC	every hour	13 km	1 hour	NOAA/NCEP
OBS	1 min	point	1 min	Airports

Verification of NWP Models

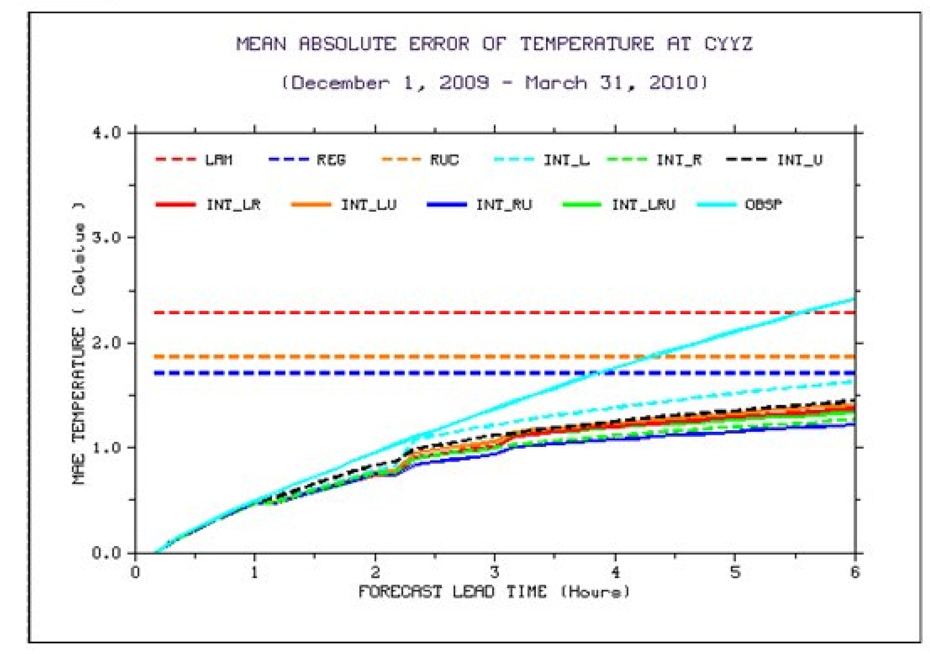
MAE from 3 NWP models for different variables in winter at CYYZ

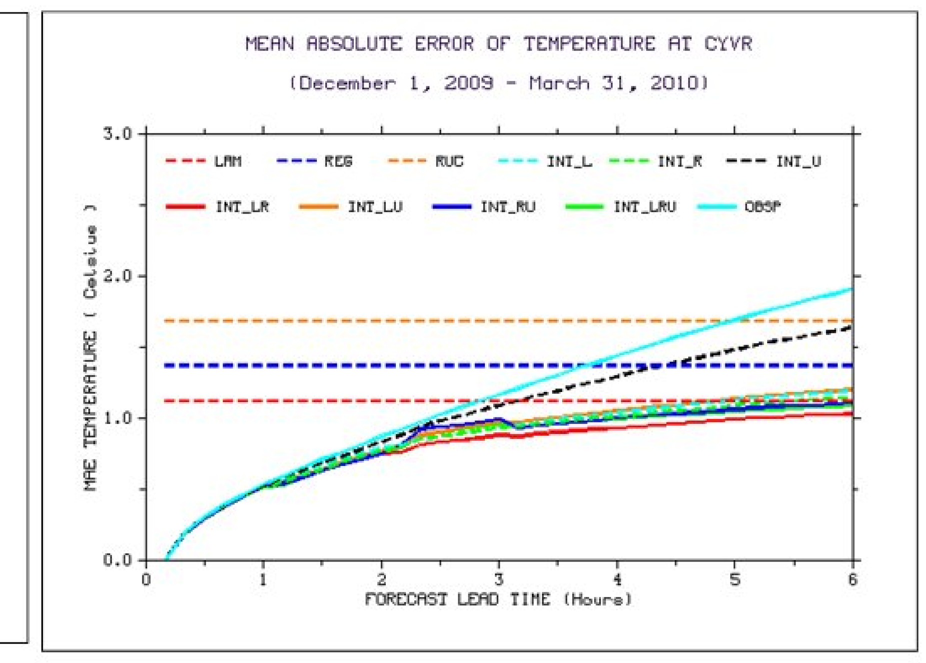
Variables	REG	LAM	RUC	Units
Temperature	1.7	2.3	1.9	deg C
Relative humidity	10.5	9.0	12.1	%
Wind Speed	1.6	1.2	1.4	m/s
Wind Direction	19.3	20.6	23.3	deg
Wind Gust	2.3	2.4	1.7	m/s

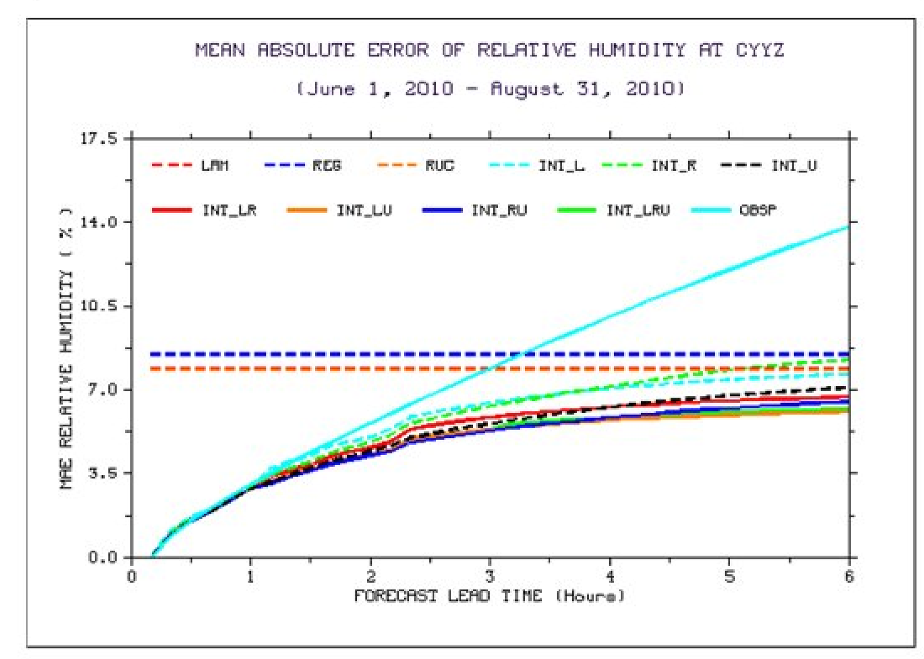
NWP Model with minimum MAE at CYYZ and CVYR
(Winter: 2009.12.01- 2010.03.31, Summer: 2010.06.01- 2010.08.31)

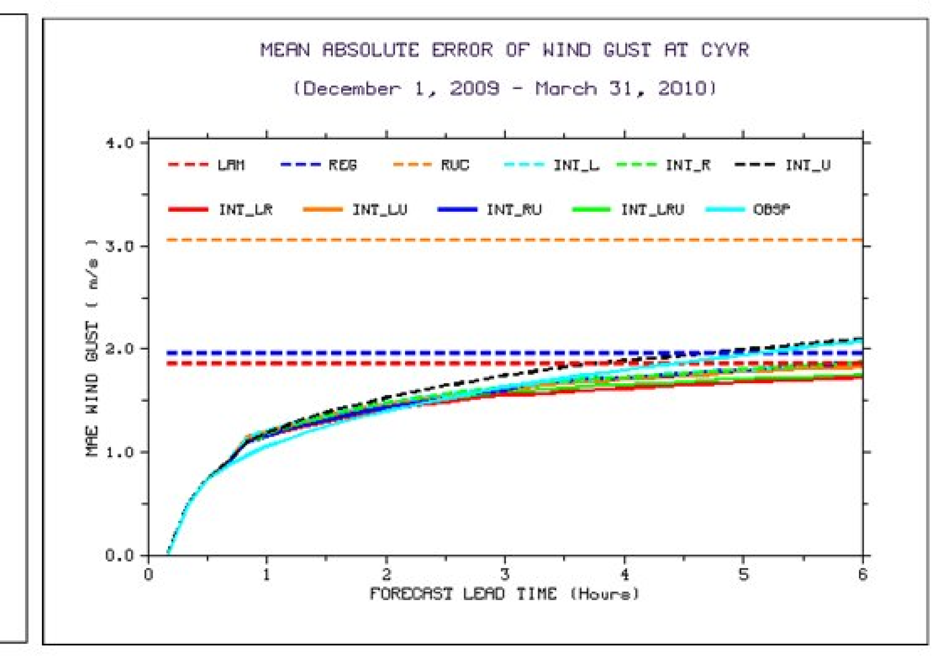
Variables	CYYZ		CYVR	
	Winter	Summer	Winter	Summer
Temperature	REG	RUC	LAM	REG
Relative humidity	LAM	LAM	LAM	LAM
Wind speed	LAM	RUC	LAM	LAM
Wind direction	REG	RUC	REG	REG
Wind gust	RUC	RUC	LAM	REG

Verification of Model Performance at 6 Hour Lead Time









In the graphs:

- INT_L – INTW based on LAM
- INT_U - INTW based on RUC
- INT_LU - INTW based on LAM and RUC
- INT_LRU - INTW based on LAM, REG and RUC
- INT_R - INTW based on REG
- INT_LR - INTW based on LAM and REG
- INT_RU - INTW based on REG and RUC
- OBSP - Observation persistence

Comparison of model performance from all models

Site	Season	Temperature	Relative Humidity	Wind Speed	Wind Direction	Wind Gust
CYYZ	winter	RU / Y*	LR / Y	LU / Y*	RL / N	UR / Y
	summer	RU / Y*	LU / Y*	LR/ Y*	UR / Y*	UR/ Y*
CYVR	winter	LR / Y	LR / Y*	LR / Y*	RL / N	LR / Y*
	summer	LR / Y	LR / Y	LR / Y*	RL / Y*	RU / Y*

In the table:

- **L**, **R** and **U** represent models of **LAM**, **REG** and **RUC** respectively
- The 2 optimal NWP models (with smaller MAE than the 3rd one) are listed and the 1st one has the smallest MAE
- **Y** means integrated model based on the 2 optimal models leading to the smallest MAE among all models, **N** means integrated model (**INT_LRU)** having the smallest MAE
- ***** means integrated model (**INT_LRU**) based on 3 NWP models having the similar MAE with the integrated model using 2 optimal models
- The MAE from **INT_LRU** are very close to the model using 2 optimal NWP models without *

Analysis of Model Performance

- NWP model performance varies by variable, time and location
- All integrated models have smaller MAE than raw NWP models
- The integrated models based on more than one model have smaller MAE than integrated model based on only one NWP model
- The integrated models based on 2 optimal models lead to the smallest MAE for most of cases
- For same variable, there are no big differences of MAE among models based on either two "***optimal***" NWP models (2 with smaller MAE than 3rd one) or three NWP models
- However, it cannot be predetermined which two models will be the optimal ones when making a real time forecast. Thus it is best to use all available models

Summary

- Integrating multiple forecasts can increase nowcasting accuracy
- Dynamic weighting and variational bias correction are the key methods for the improvement
- High frequency observations and NWP models are critical for deriving integrated forecasts
- Integrated model can provide better forecasts than individual NWP models for the first couple of hours regardless of selected variables and locations
- It is better to use as many NWP models as possible to generate integrated forecasts when NWP model performances are unknown

References

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