Environment Canada Environnement Canada

Canada

Post-Processing at the Meteorological Service of Canada

Statistical Post-Processing Workshop,

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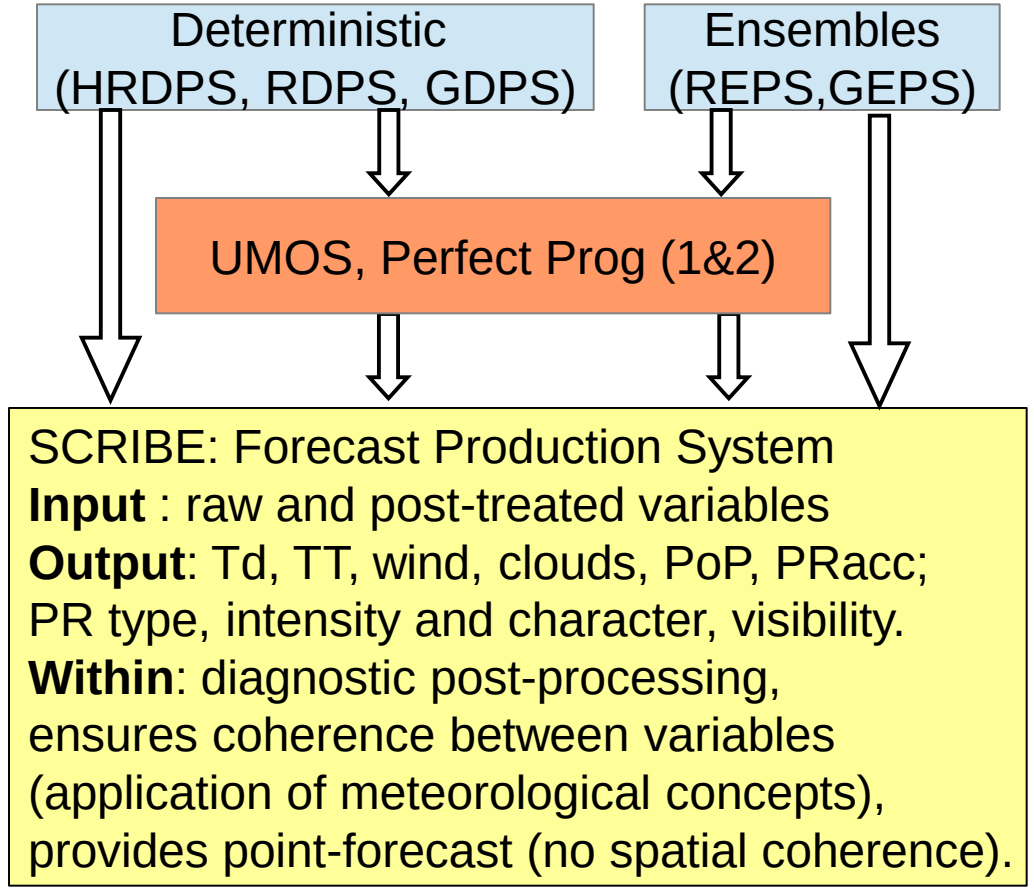
Thanks: A.Methot, J.Monpetit, G.Croteau, S.Beauregard, B.Denis, N.Gagnon, L.Wilson.

Talk outline: forecast production chain

1. NWP products
2. Post-Processing
3. Operational Public Forecast
4. Future directions



NWP products

Deterministic:
HRDPS = High Res. Deterministic Prediction System (2.5 km, Canada)
RDPS = Regional Deterministic Prediction System (10 km, North America)
GDPS = Global Deterministic Prediction System (25 km, Global, Yin-Yang)

Ensembles:
REPS = Regional Ensemble Prediction System (15 km, North America)
GEPS = Global Ensemble Prediction System (50 km, Global, lat-lon)

All based on the GEM model (Cote et al, 1998, MWR 126).
GEM = Global Environmental Multi-scale.

Note 1: HRDPS can be run in a cascade up to 250m resolution (up to 48h).
Note 2: GDPS (GEPS) runs up to 10 days (16 days -32 days once a week).
Note 3: GEPS is contributed daily to the NAEFS (North America Ensemble Forecasting System): 2 weeks lead-time, 50 km resolution.

Operational NWP products

Day 1-2:

RDPS + UMOS → Td ,TT, wind, PoP, clouds
raw model output for PRacc

⇨ SCRIBE

Day 3-4-5:

GDPS + UMOS → TT
GDPS + PP1 → PoP, clouds
raw model output for PRacc, wind
Td is obtained from UMOS(TT)-model(ES)

⇨ SCRIBE

Day 6-7:

GEPS mean + PP1 → PoP, clouds
GEPS mean + PP2 → TT
raw model output for PRacc, wind
Td is obtained from PP2(TT)-model(ES)

⇨ SCRIBE

Deterministic: HRDPS (2.5 km), RDPS (10 km), GDPS (25 km)
Ensembles: REPS (15 km), GEPS (50 km), NAEFS (50 km).

Operational NWP products (extended)

Montlhy:
(week 1-4)

GEPS + Reforecast → TT ,PR
Prob for above, near normal, below category

→ Image production

Seasonal:
(month1-12)

CanSIPS + Hindcast → TT, PR
Prob for above, near normal, below category
with statistical calibration

→ Image production

GEPS runs 32 days once per week.
GEPS Reforecast: 20 year reforecast (1995-2014) using 4 members from the GEPS, running "on-the-fly" in operations.

Canadian **S**easonal to **I**nter-annual **P**rediction **S**ystem: 20 member ensemble (2 model, 10 members each) runs 12 month once per month
CanSIPS Hindcast: 30 year hindcast (1981-2010) with the full 20 members

Off-line NWP products

HRDPS is run in experimental mode.
Post-processing is applied to HRDPS outputs:

HRDPS+UMOS → Td, TT, wind, PoP, clouds

raw model outputs Td, TT, wind, clouds
PoP produced by spatial sampling (neighborhood)
PR types explicitly resolved by the HRDPS physics

⇒ SCRIBE

HRDPS+SCRIBE is available to forecasters only.

REPS: there is no operational public product based on REPS!!!
(REPS is however available to the forecasters).
Post-processing of the REPS should be a priority!!!

GDPS and GEPS model output are available to forecasters for longer lead times (10 and 30 days), as well as the NAEFS products (2 weeks lead time).

Operational Post-Processing: UMOS (1/2)

Up-dateable MOS (Wilson and Vallee, 2002, W&F 17)

Predictands:

- Temperature, wind, Probability of Precipitation (PoP).
- In a second development stage cloud cover was added.
- Observations : ~ 800 stations across Canada.

Predictors:

- Model output is interpolated to the station location.
- 18 (for TT), 35 (for wind), 33 (for PoP) predictors have been prescreened from 177 initially considered model variables.
    - Screened by using a forward stepwise procedure, validated by a one-step backward elimination.
    - Predictors also include obs persistence and sun elevation.

Operational Post-Processing: UMOS (2/2)

Relation:

- Multiple Linear Regression → SSCP matrices
  - for cloud cover: Multiple Discriminant Analysis.
- A different relation is developed for each station, initialization-time, lead-time, NWP system.
- SSCP matrices are produced for two seasons, summer and winter
  - transition is performed by a weighted blending.

Training: 300 cases needed for stable equations (~ 2 years).

Up-dateable:

- SSCP matrices are updated weekly, and regression coefficients are re-calculated.
- At the implementation of a new model version, old and new model SSCPs are merged with a weighting system (min needed = 30 days).

Operational Perfect Prog (1/2)

PP1 (Verret, 1987; Brunet 1987 – CMC Tech Doc).

Predictands: temperature, wind, PoP. Later cloud cover.
Predictors:

- Upper-air analysis fields (381 km), obs persistence.
- 22 years (1963-1984) of data, stratified every 2 months for temperature, and every three months for PoP; 8 years of data , stratified on 4-2-4-2 months for winds.

Relation: Multiple Linear Regression → SSCP matrices
(for cloud cover, Multiple Discriminant Analysis).

Predictors are interpolated to the station location.
Note the large discrepancies between the resolutions of the predictors in the development stage, versus the (more modern) NWP systems daily used in the application of the PP1.

Operational Perfect Prog (2/2)

PP2 (B.Denis, S. Edouard).

Predictands: temperature (precip in development).
Predictors: NCEP2 (T62 ~ 300 km) upper-air variables (~100).
20-40 years of data, one equation for each month (3-month data centered on the month considered).

Relation: Multiple Linear Regression → SSCP matrices

Predictors are interpolated to the station location. Modern NWP outputs are up-scaled prior interpolation, to match the NCEP2 coarser resolution.

UMOS versus Perfect Prog

Wilson and Vallee (2003)

UMOS is more reliable, but less sharp.
For longer lead times UMOS converges to climatology.
UMOS involves a large amount of equations, and needs constant monitoring/maintenance (e.g. changes in stations).

Perfect Prog retains the sharpness for the entire range of the forecast, however it is less reliable. Perfect Prog involves fewer equations than UMOS, and it is virtually maintenance free ...

... maybe too much maintenance free?
(... PP1 dates 1987, R. Verret retired few years ago ...)

GEPS Reforecast post-processing

The GEPS Reforecast climate is computed for these variables:

At surface and 5 pressure levels:

- geopotential, temperature, winds, surface pressure, dew point depression

Also computed for precipitation

Only precipitation and temperature are currently used for monthly (week 1-4) forecasts.

The runs for 5 weeks are combined (total 400 runs), centered on the forecast date

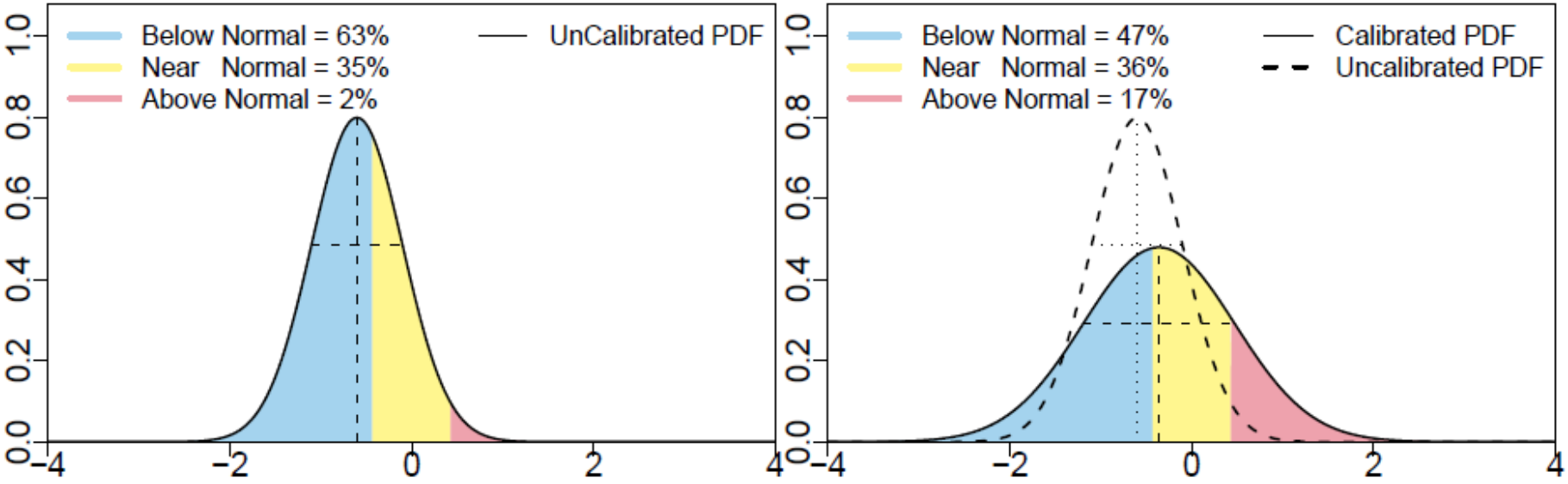
The following statistics are computed:

- Mean
- Standard deviation
- Min and max values
- Percentiles for 15 different ranks:
  2.5;5;10;20;25;33.3;40;50(median);60;66.6;75;80;90;95;97.5

CanSIPS seasonal forecast calibration

Seasonal probability forecast are calibrated according using Kharin and Zwiers (2003) method:

- Parametric probability estimator used by fitting a normal distribution to the forecast ensemble
- Rescaling coefficients optimize the brier score on the hindcast, and are then smoothed seasonally and spatially



Future directions (1/2)

The post-processing procedures of the Meteorological Service of Canada need to be **renovated** (and possibly **simplified**).

Needs:

- Ought to perform also for **extremes**, not only for the mean.
- Ought to be resistant to the frequent **model updates**.

Desiderata:

- One **single flexible** post-processing platform which can be applied to all different NWP products. Is it possible?
- We aim for a **spatial post-processed product** (no more point-forecasts, pseudo stations). How to achieve this?
  - Kriging on post-processed point forecasts
  - Use gridded observations / analyses
  - Apply spatially post-processing relation obtained from station obs

Future directions (2/2)

- Post-processing ought to preserve spatial coherence and inter-variable coherence: is **Ensemble Copula Coupling** (ECC, Schefzik et al 2013) suitable / efficient in a (high-dimensional) operational environment?

- Current system switches between NWP products based on fixed lead times. **Bayesian Model Averaging** (BMA; Raftery et al 2005; Wilson et al 2007) to **simultaneously blend and post-process different NWP products** (ongoing work by S. Beauregard: excellent results)!

- Other considered approaches: Non-homogeneous Gaussian Regression; Extended Logistic Regression. Kalman Filter. Analogues and Re-forecasts.

THANK YOU

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