Ensemble Predictions at CMC

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Overview

- **Current Status**

- **Upcoming changes**

- **Applications**

- **International collaboration**

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HISTORY OF THE ENSEMBLE FORECASTING SYSTEM

- **8 SEF models semi-operational March 1996**
- **OI-SEF officially in February 1998**
- **8 GEM models added in August 1999**
- **External Web page in October 1999**
- **Increased resolution in June 2001**
- **Improved GEM model in March 2002**
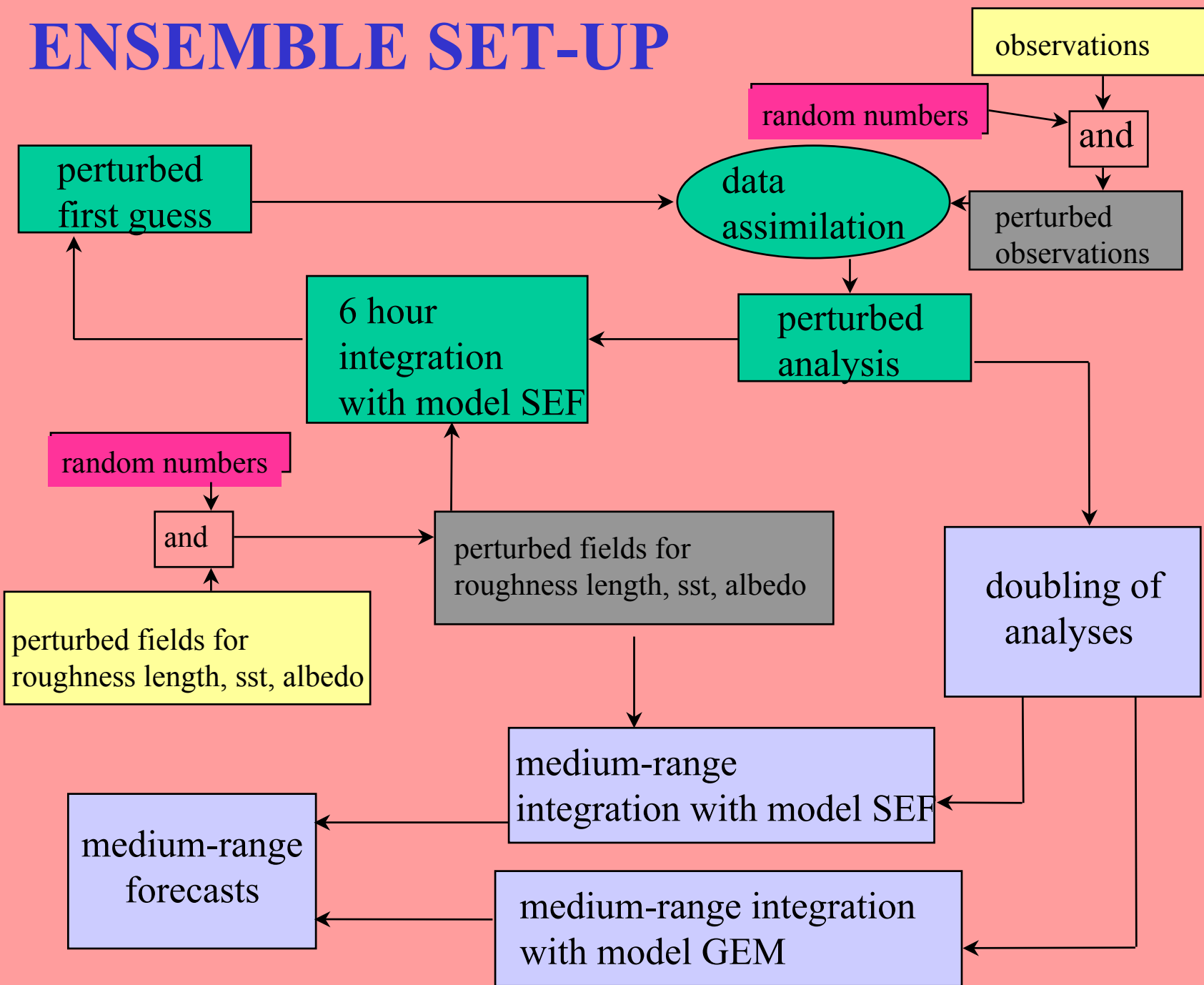- **Thinned SATWINDS in March 2002**

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Current System

- **Runs to 10 days, at 00Z**
- **16 members:**
  - **8 GEM 1.2º**
  - **8 SEF T149**
- **Perturbed analyses**
  - **Perturbed observations**
  - **Perturbed OI assimilation cycles**
- **Varying physical parameterizations**

ENSEMBLE SET-UP

observations

random numbers

and

perturbed observations

perturbed first guess

data assimilation

6 hour integration with model SEF

perturbed analysis

random numbers

and

perturbed fields for roughness length, sst, albedo

perturbed fields for roughness length, sst, albedo

doubling of analyses

medium-range integration with model SEF

medium-range forecasts

medium-range integration with model GEM

Introduction of new gravity wave drag parameterization in GEM

RMS error 500 mb global area
gwd01 vs gwd86 (8 mems)
January 2002 (20 cases)
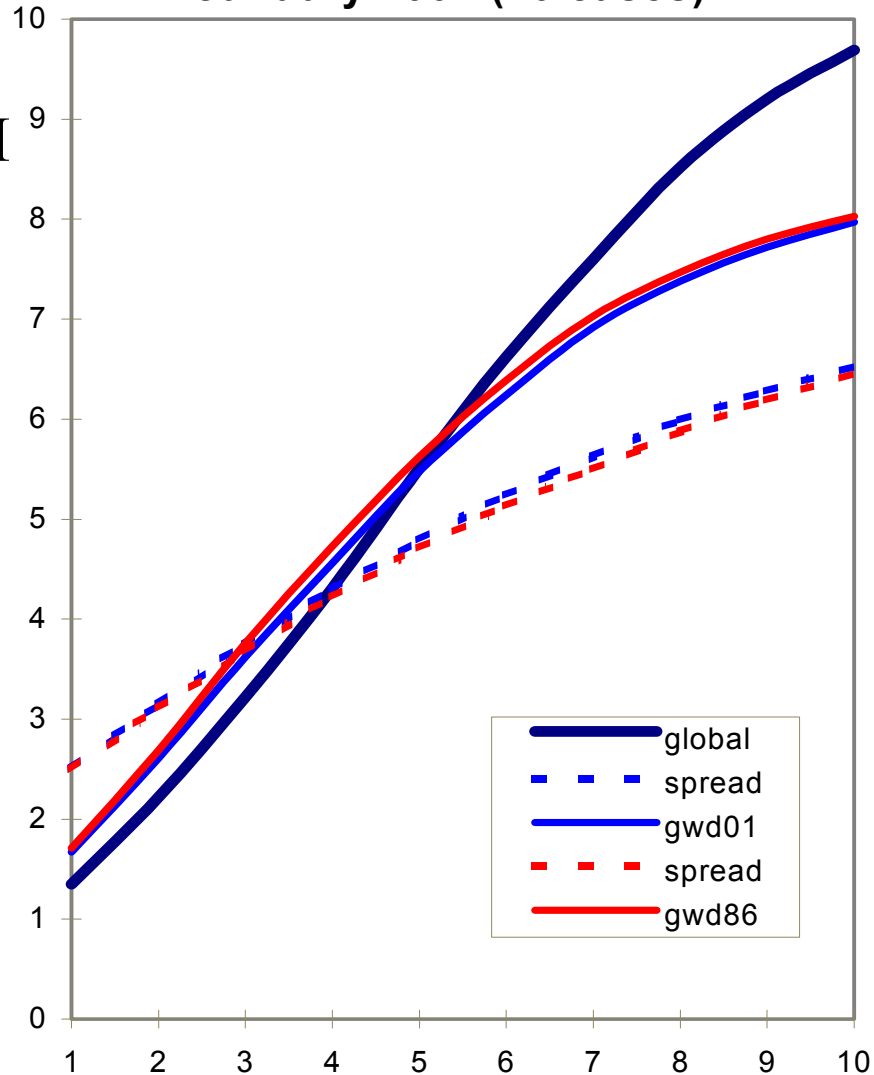
INCLUSION OF SATWINDS IN THE ENSEMBLE FORECASTING SYSTEM

- application of thinner 1.5º x 1.5º
- observation closest to analysis time
- quality control including blacklisting
- GOES-8&10, METEOSAT5&7, GMS-5
- mostly improves high troposphere
- Implemented March 2002
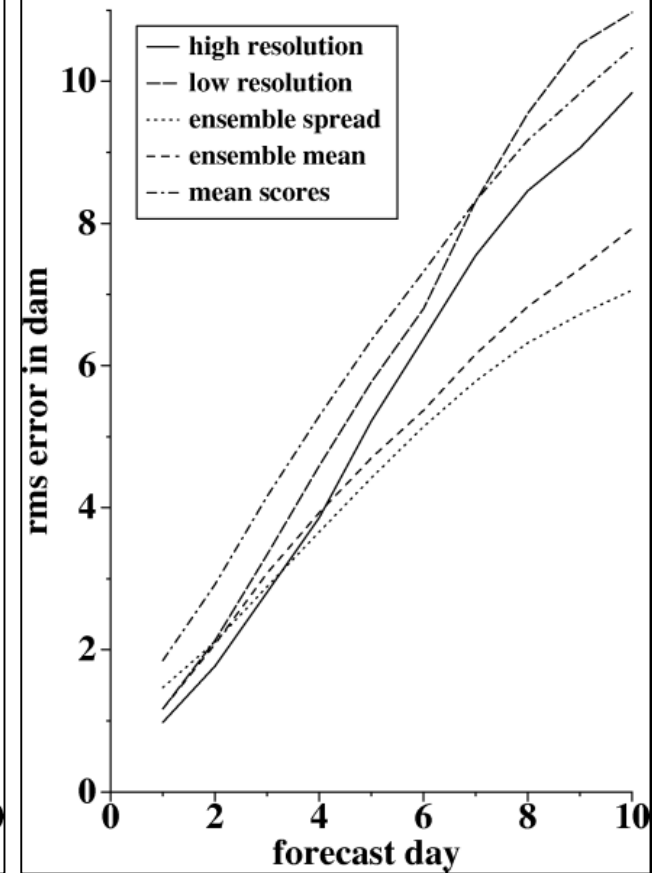
Satwinds coverage after thinning in operations at CMC
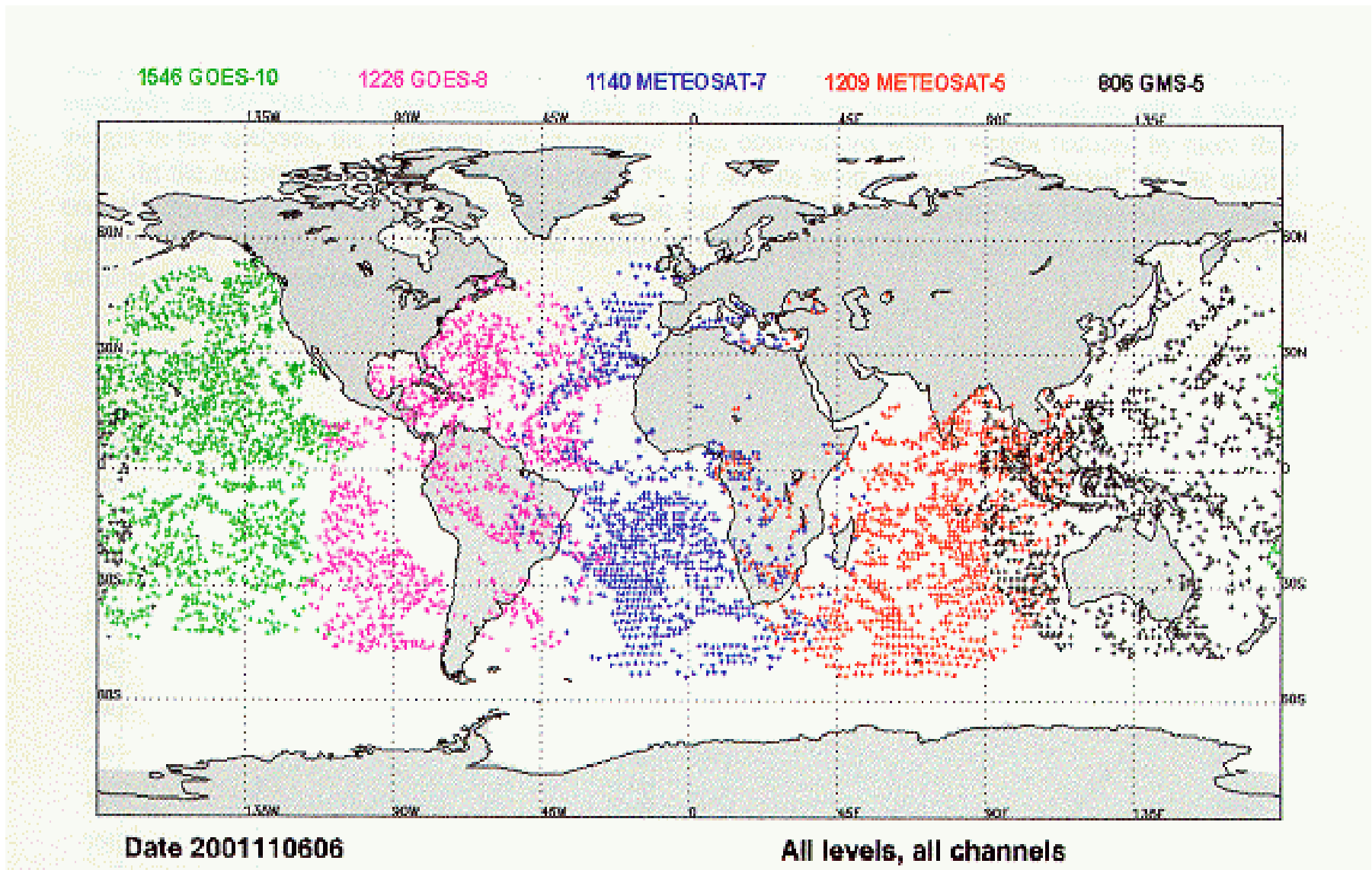
Verification
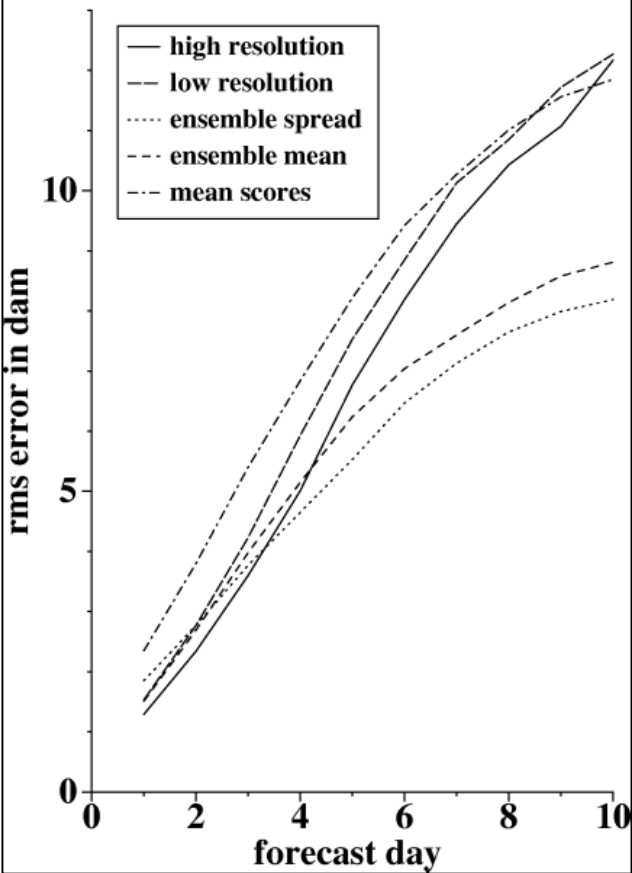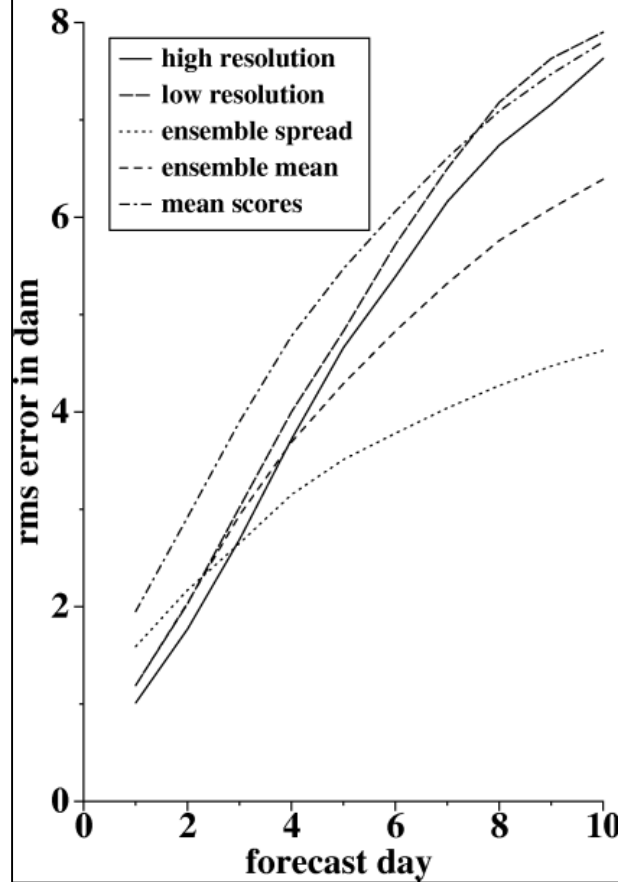
The area under the relative operating characteristic curve (ROCA) measures the hability of a system to discriminate between hits and false alarms.
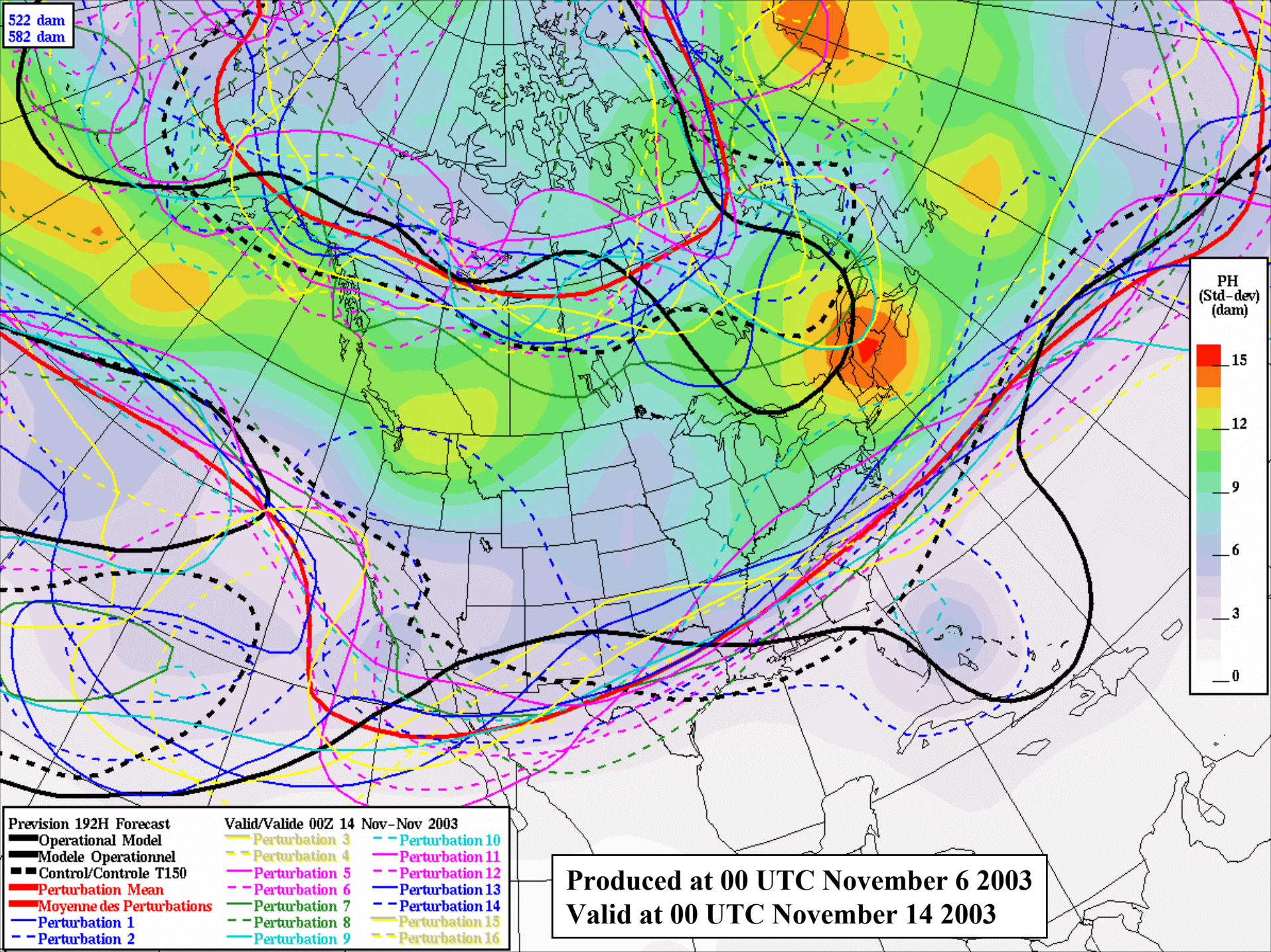
The ROCA skill score (ROCASS) is defined as:
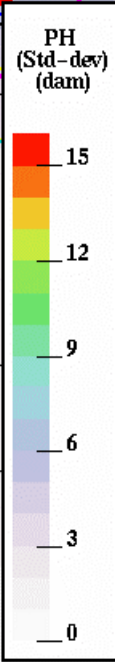
ROCASS = 2*ROCA – 1

(ROCASS tends to 1 for a skilful system

Northern Hemisphere 500 mb Height
Average For 20020501 – 20020731

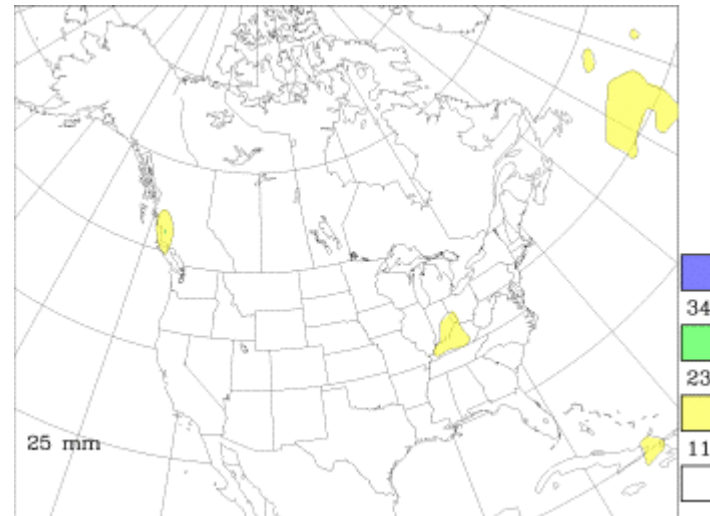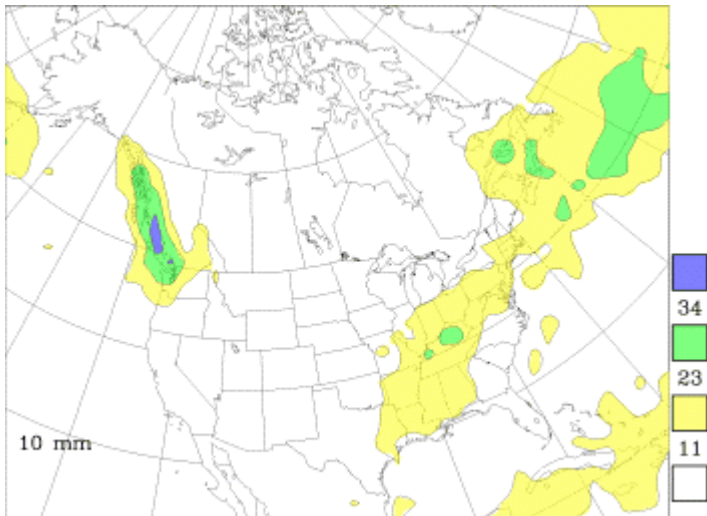Produced at 00 UTC November 6 2003
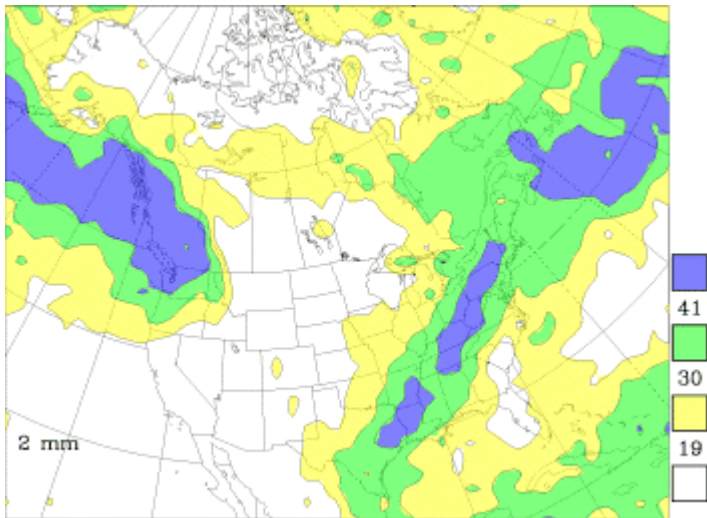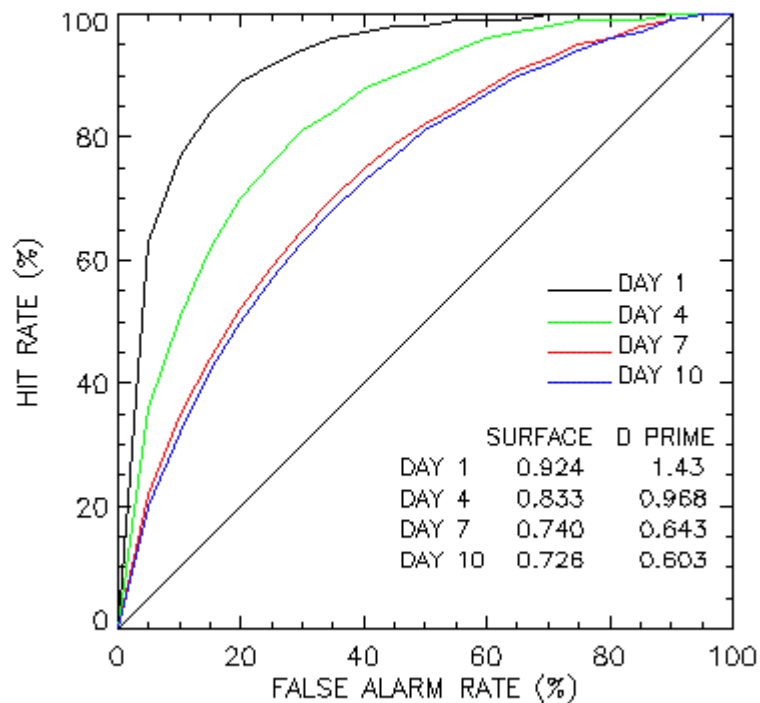Valid at 00 UTC November 14 2003

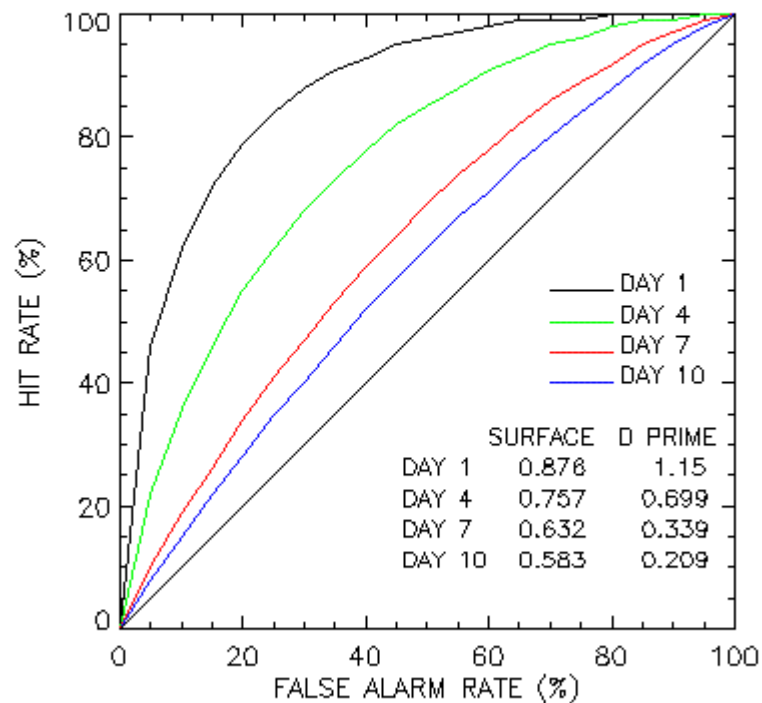# Calibrated probability of precipitation
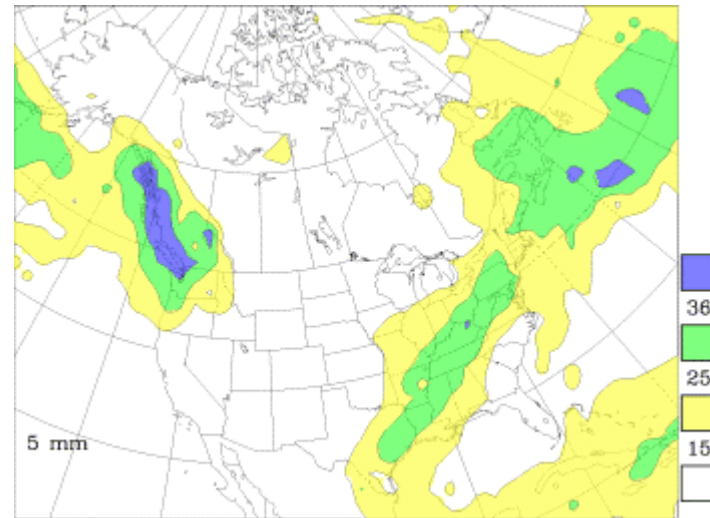
Produced at 00 UTC November 6 2003
Valid at 00 UTC November 14 2003

5 MM PRECIPITATION (DECEMBER 2002–FEBRUARY 2003)
STATISTICS (HIT RATE vs FAR)
ALL_STNS

5 MM PRECIPITATION (JUNE–AUGUST 2003)
STATISTICS (HIT RATE vs FAR)
ALL_STNS

	SURFACE	D PRIME
DAY 1	0.924	1.43
DAY 4	0.833	0.968
DAY 7	0.740	0.643
DAY 10	0.726	0.603

	SURFACE	D PRIME
DAY 1	0.876	1.15
DAY 4	0.757	0.699
DAY 7	0.632	0.339
DAY 10	0.583	0.209

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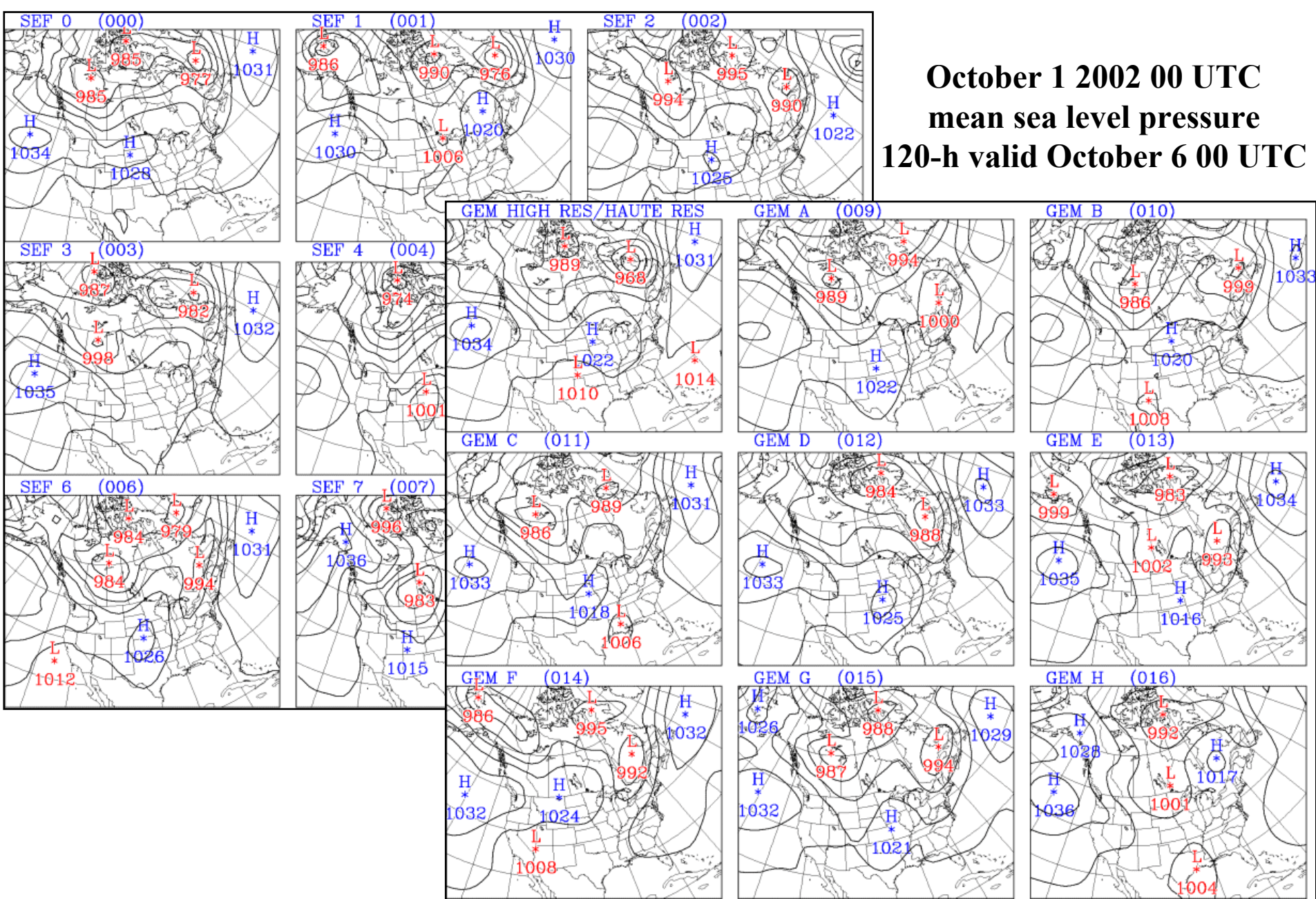Canada

10 DAY MEAN - MOYENNE SUR 10 JOURS
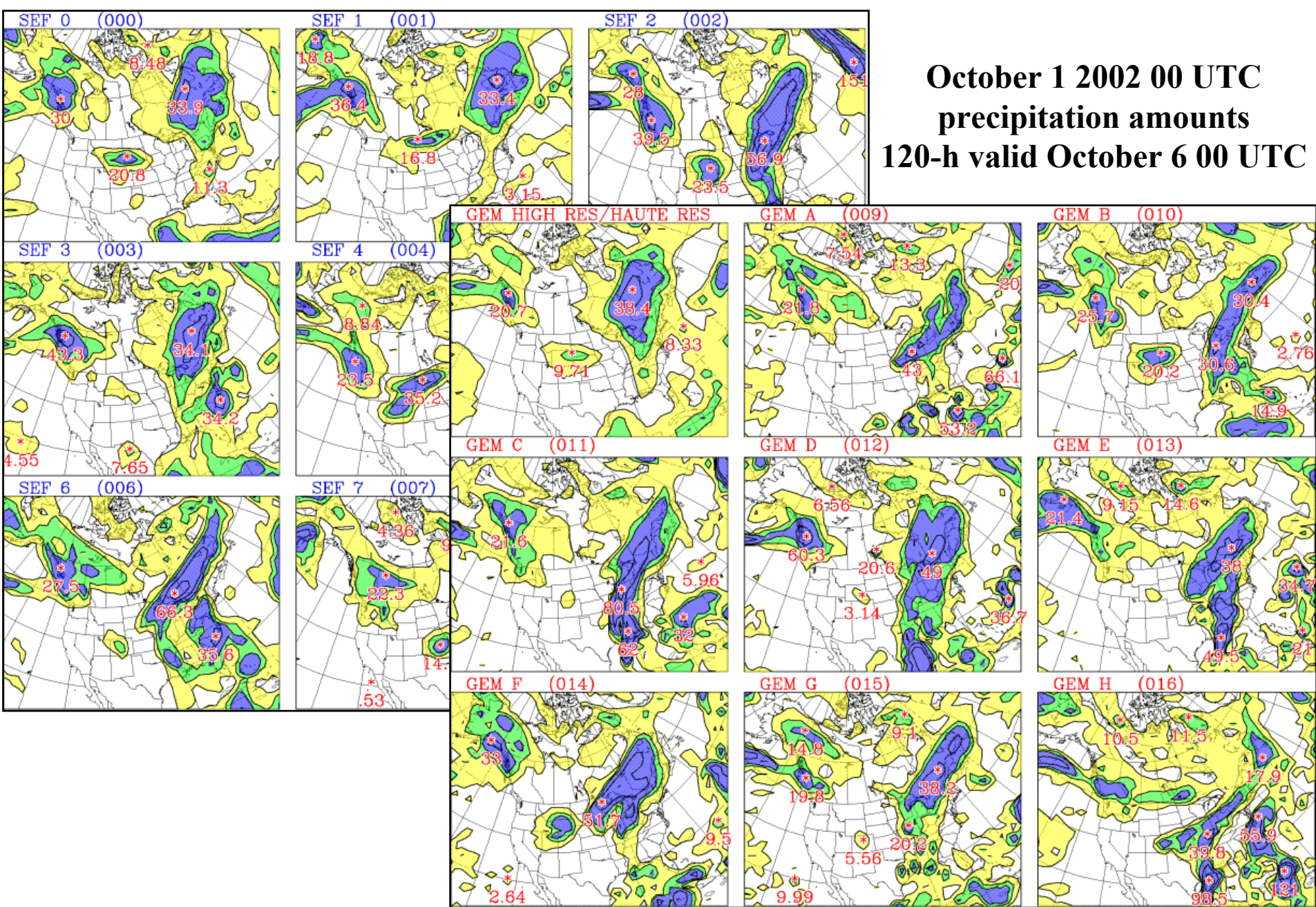NORMALISED TEMPERATURE ANOMALY
ANOMALIE DE TEMPERATURE NORMALISEE

ENSEMBLE
8 SEF 8 GEM
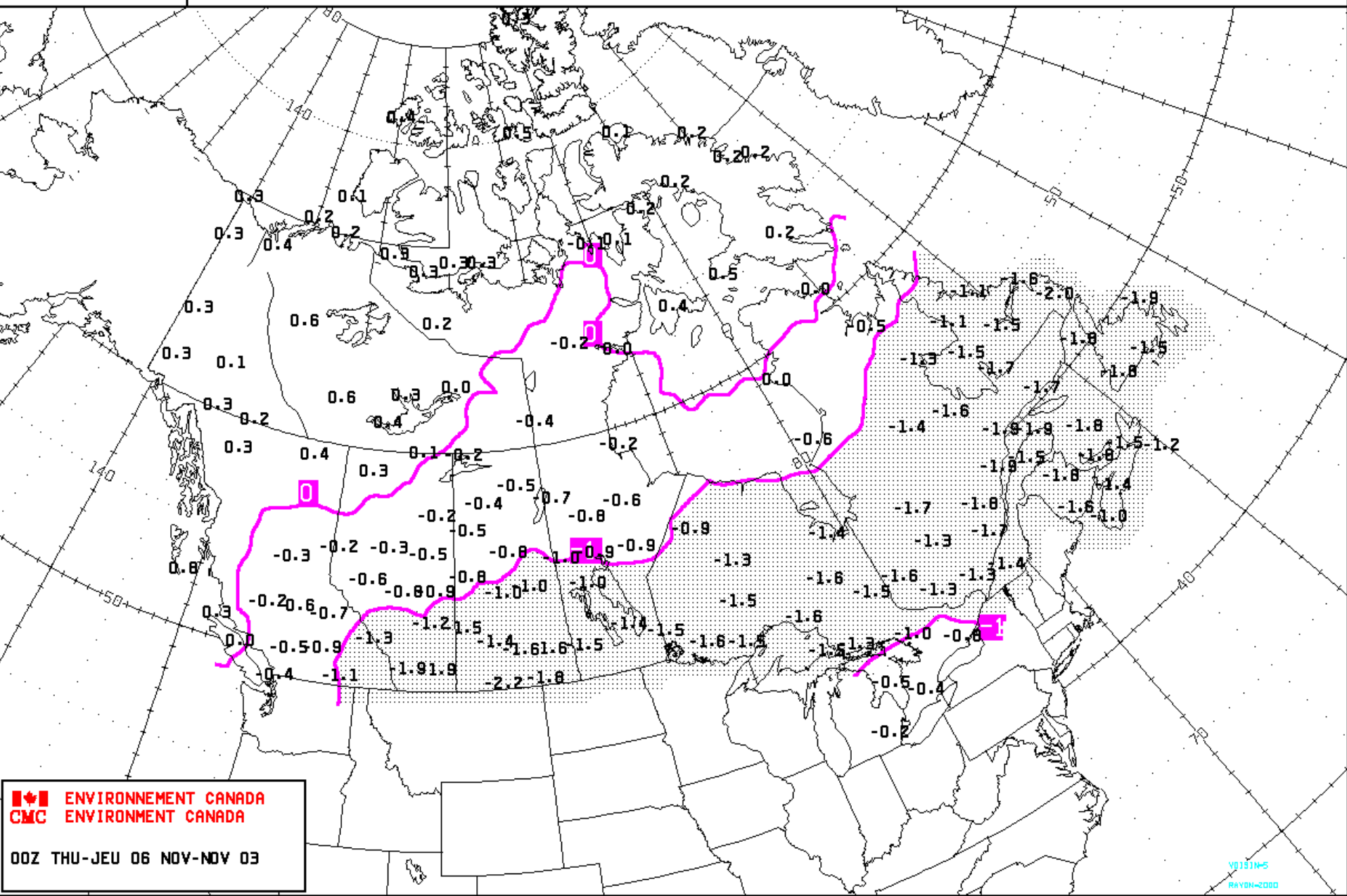
ENVIRONNEMENT CANADA
ENVIRONMENT CANADA

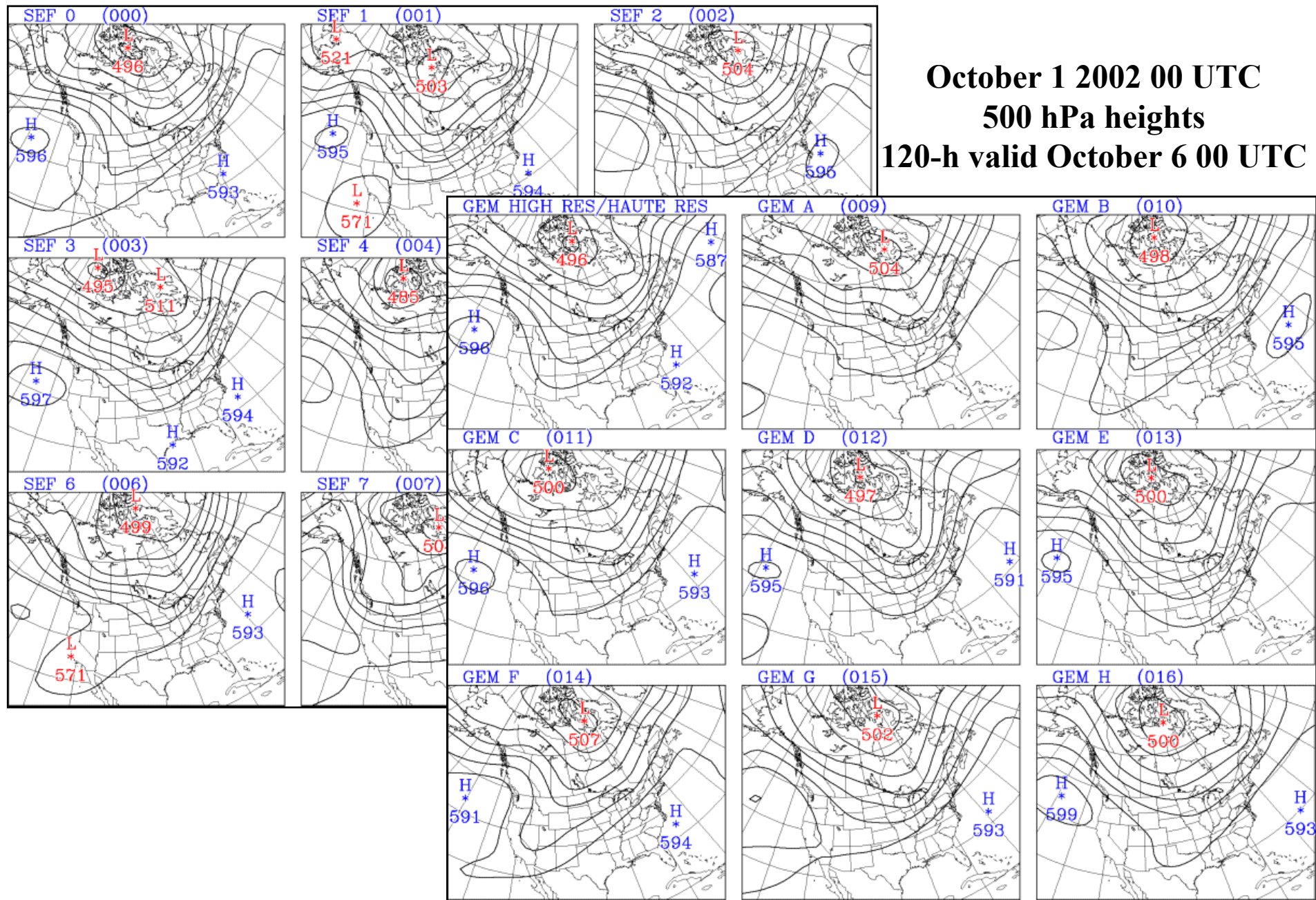00Z THU-JEU 06 NOV-NOV 03

**October 1 2002 00 UTC
mean sea level pressure
120-h valid October 6 00 UTC**

October 1 2002 00 UTC precipitation amounts 120-h valid October 6 00 UTC

statistics

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October 1 2002 00 UTC
500 hPa heights
120-h valid October 6 00 UTC

Upcoming changes

- **March 2003: Ministerial Announcement**

- **Major restructuring of MSC**

- **A few areas with new funding**

- **Ensembles is one of these**

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Announcement on Ensembles

- **Development of 7 day forecasts**
- **Development of week 2 forecasts**
- **Probabilistic forecasts for specialized users**
- **High impact weather forecasts**

- **400K US$ per year**

Upcoming changes

- **Runs as 00Z and 12Z**

- **Up to 15 days**

- **More members, higher resolution**

- **New data assimilation scheme:**
  - **Ensemble Kalman Filter (EnKF)**

- **Single model with stochastic physics?**

0-P6hr

Comparison between EnKF & OI

OI is in blue.
EnKF is in red.

For winds, temperature and humidity, the EnKF shows remarkable improvement over OI.

The geopotential height biases are worse because of surface pressure bias present in the new driving model.

These large improvements are due to a combination of factors: a more balanced scheme but also a better treatment of observations.

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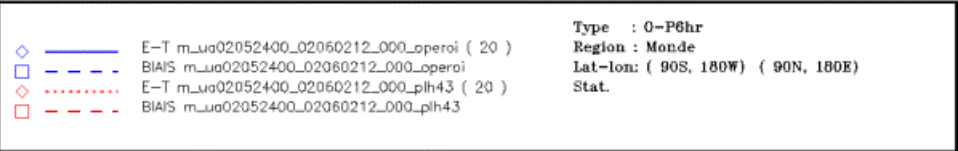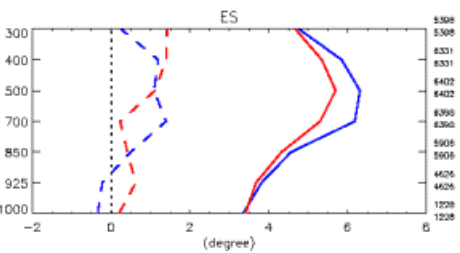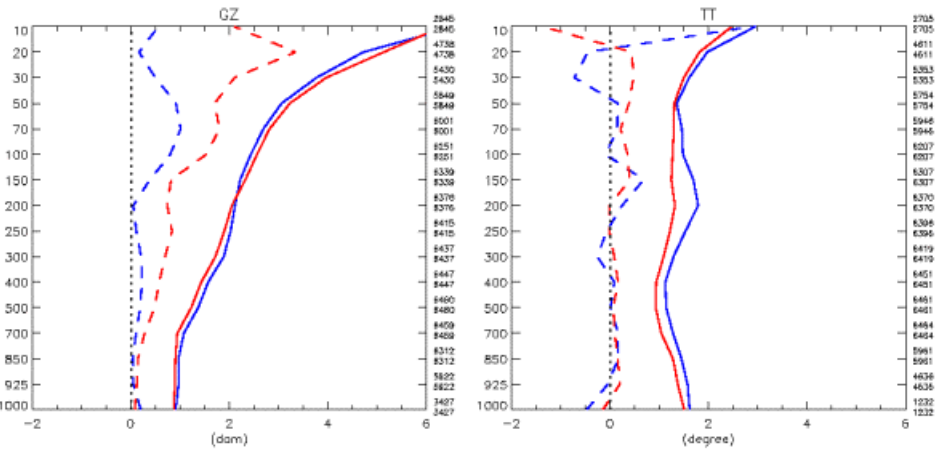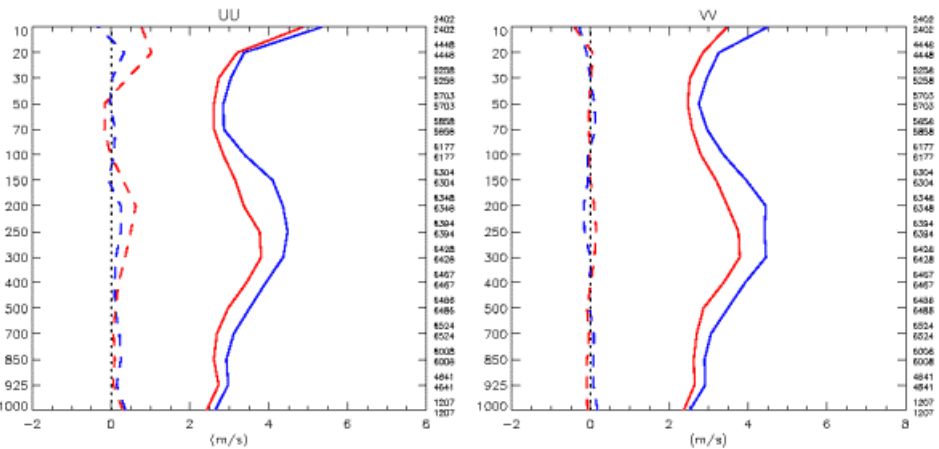
Comparison of 3D-VAR and EnKF

A comparison of 3D-VAR and EnKF has been performed (manuscript by Houtekamer et al. submitted to MWR).

The 3D-VAR and the EnKF have been used with exactly the same forecast model (resolution, physical parameterizations, etc) and with exactly the same observational network. The same data are assimilated. The same error statistics are used for the observations. The same quality control procedure (background check and variational quality control) is used.

Data assimilation cycles were started on 00 UTC May 19 2002. The innovation statistics are compared for the period 00 UTC May 24 – 12 UTC June 2 2002 (a 10 day period). Innovation statistics were computed with respect to an extremely reliable subset of the radiosonde network.
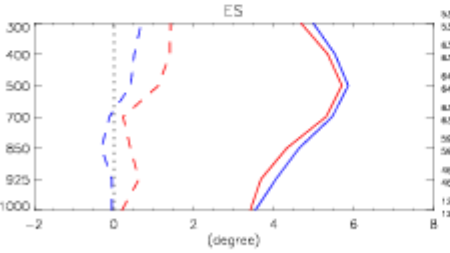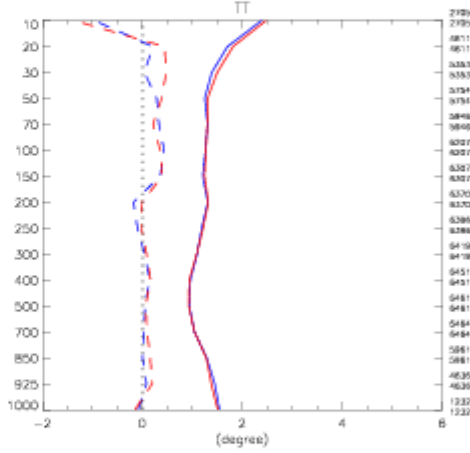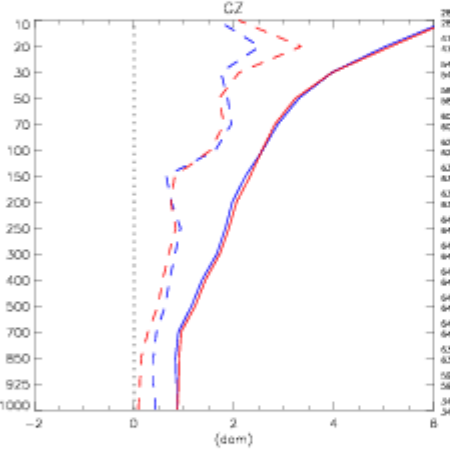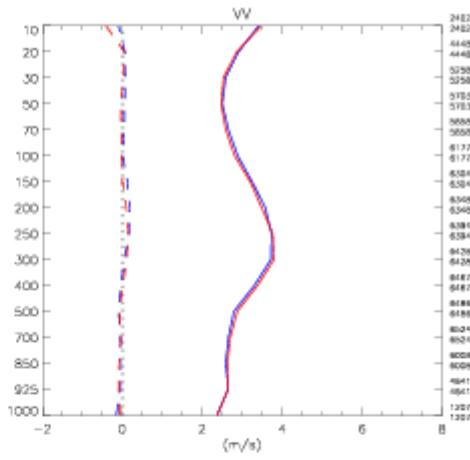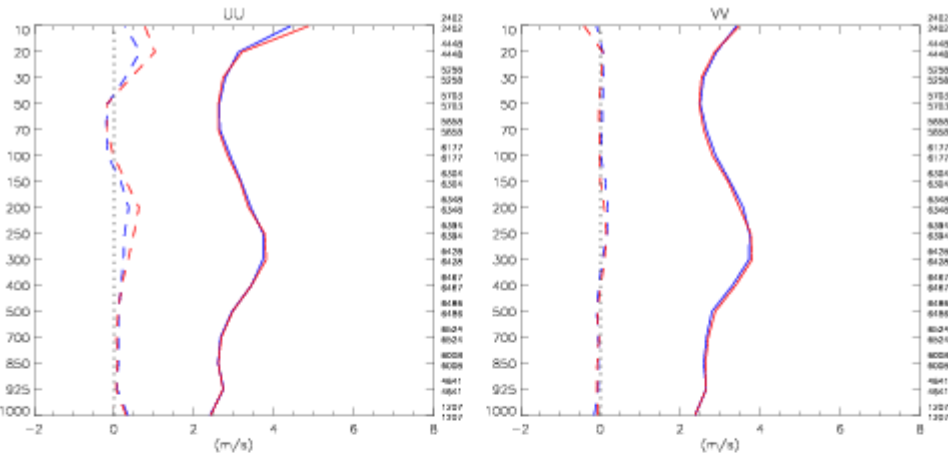
Agreement between the EnKF and the 3D-VAR

3D-VAR is in blue.
EnKF is in red.

For winds and temperature the EnKF and the 3D-VAR have remarkably similar innovation statistics.

For humidity the EnKF has a bigger bias but a smaller rms error.

Generally the scores are very similar. It would appear that the impact of the 4D aspect is small.

Applications

- **Goal: use of probabilistic and scenario based forecasts in decision making**

- **Automated products, up to 2 weeks**

- **Targeting major economic sectors:**
  - **energy, transport, forestry, energy, agriculture, water resources…**
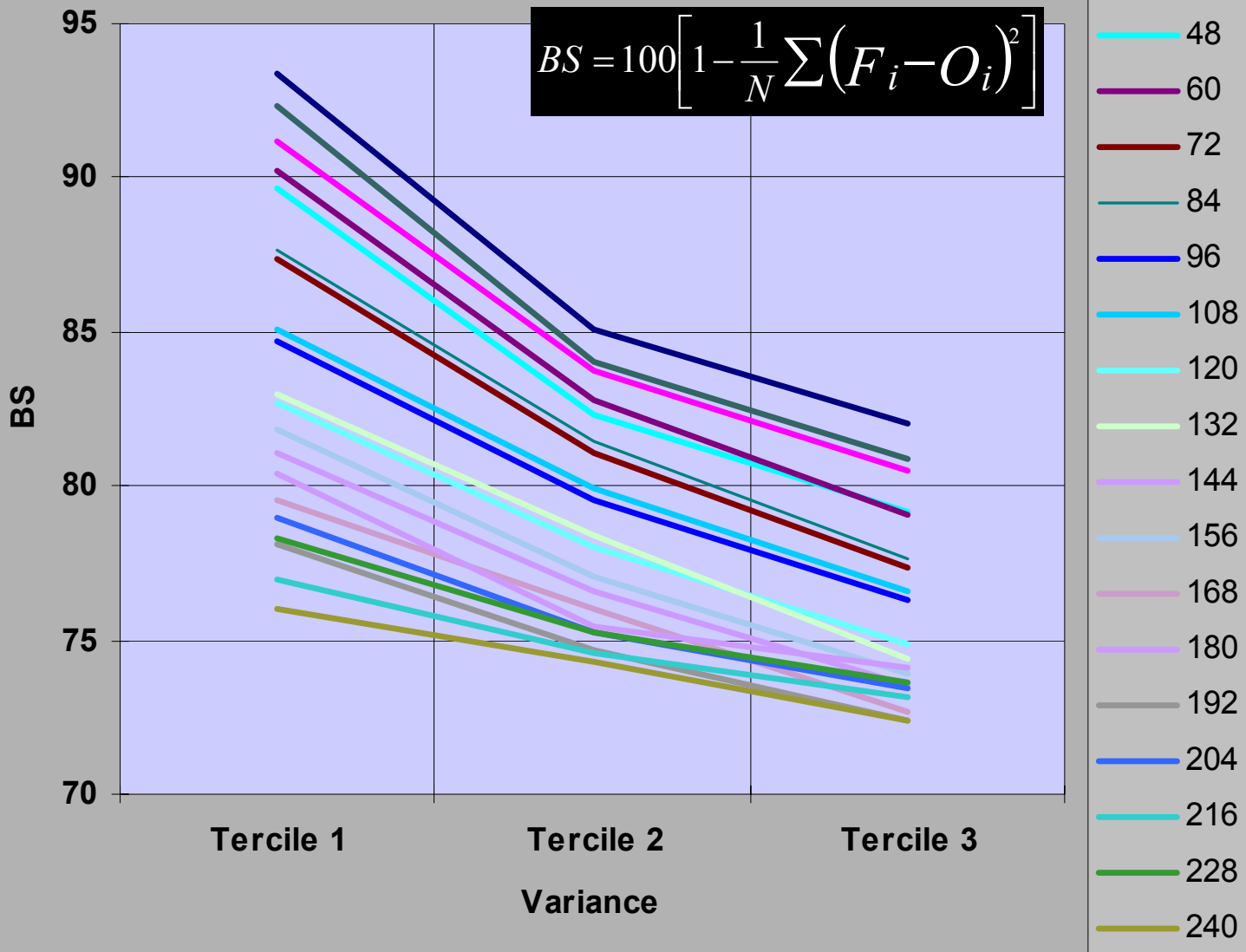
- **Targeting high impact weather events**

Extending forecasts up to 7 days

- **Mean of ensemble already better than deterministic model**

- **Use of spread-skill relationship to provide information on skill within the forecast**

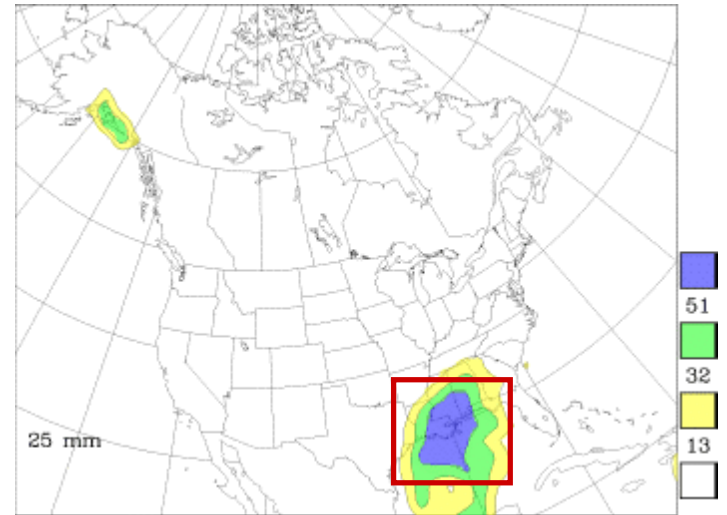- **Automated plain language forecasts**

Brier score as function of variance terciles
June 1 2000 - December 31 2000 all stations
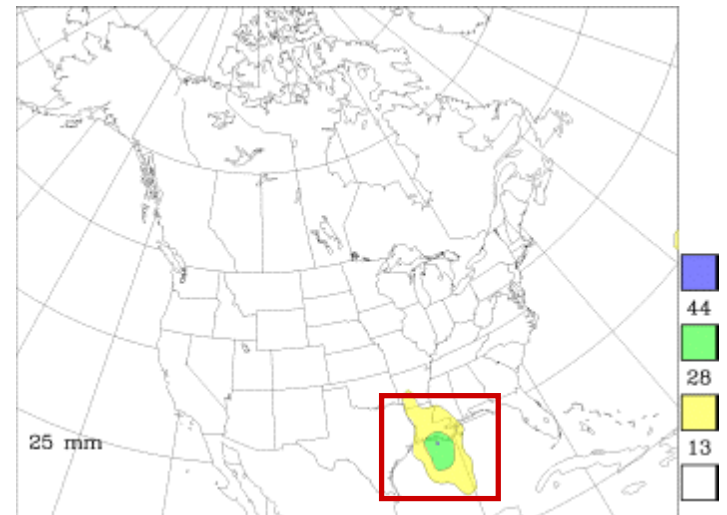
$$BS = 100\left[1 - \frac{1}{N}\sum\left(F_i - O_i\right)^2\right]$$

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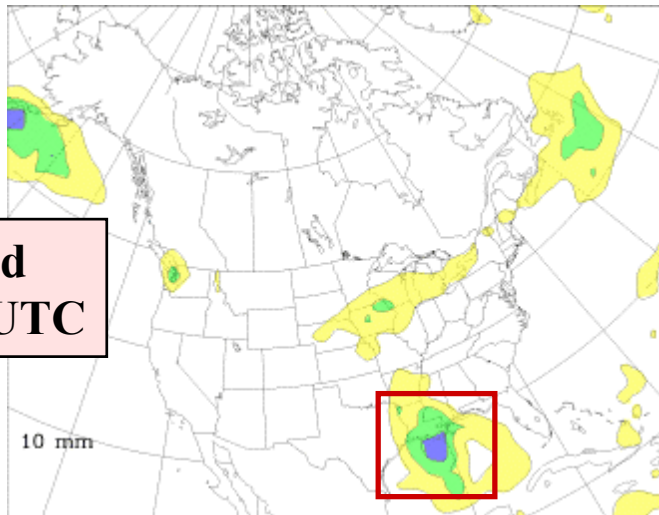Service météorologique du Canada
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**48-h forecast valid
September 26 2002 00 UTC**

Hurricane Isidore
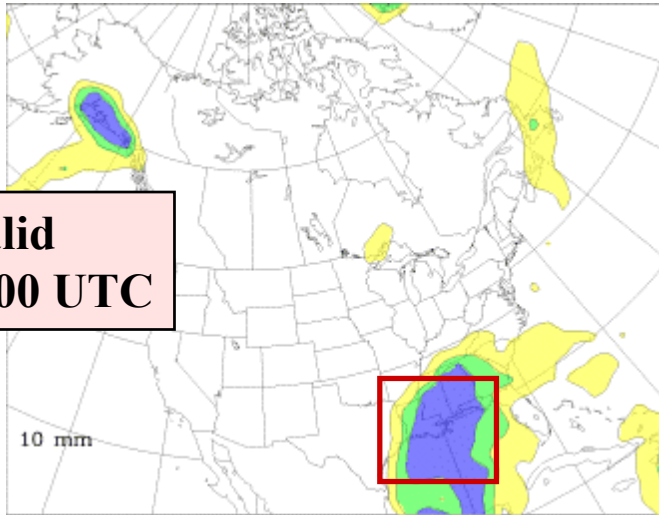
**72-h forecast valid
October 4 2002 00 UTC**

Hurricane Lili

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International collaboration

Agreement with NCEP to develop joint approach

- Data exchange: standardized outputs

- Debiasing of each model-joint methodology

- Moving to similar looking products

- Products based on combined ensembles

- Eventually, joint products

International collaboration

Hoping that experience between Canada and US can eventually be extended to other ensemble producers

Hoping that more ensemble products can be made widely accessible to all countries, possibly as part of EOS strategy

Conclusion

- **CMC is strengthening its ensemble forecasting system**
- **Emphasis on high impact events and major economic sectors**
- **Applications will diversify rapidly**
- **Key challenge: REPRESENTATIVENESS**
- **International collaboration essential**