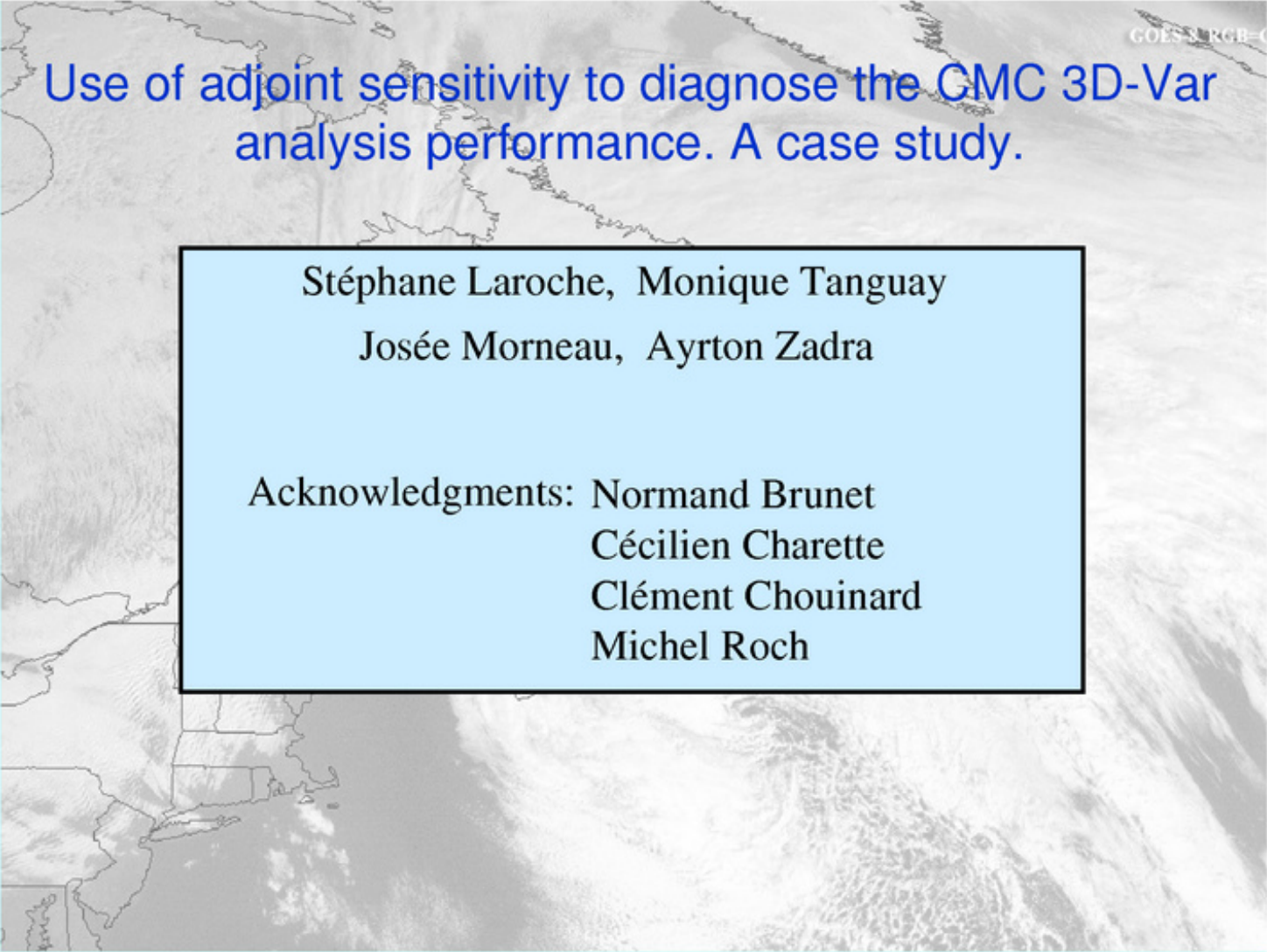


Présentation de Stéphane Laroche

The presentation is structured as follows:

- Slide 1:** Introduction and speaker information (Stéphane Laroche, Meteorologist, etc.).
- Slide 2:** Outline of the talk, including the 7-day forecast performance and the 3D key analysis system.
- Slide 3:** Motivation for developing a 3D key analysis system based on the 3D key analysis model.
- Slide 4:** Summary facts about the winter storm that hit eastern Canada on 10 February 2001.
- Slide 5:** Synoptic overview of the storm on 10 February 2001.
- Slides 6-10:** A series of maps comparing QZ (quasi-geostrophic) and MSL (mass streamlines) analyses for the storm on 10 February, showing differences in the key analysis.
- Slide 11:** A 3D key analysis map for 10 February.
- Slide 12:** A 3D key analysis map for 11 February.
- Slide 13:** A 3D key analysis map for 12 February.
- Slide 14:** A 3D key analysis map for 13 February.
- Slide 15:** A 3D key analysis map for 14 February.
- Slide 16:** A 3D key analysis map for 15 February.
- Slide 17:** A 3D key analysis map for 16 February.
- Slide 18:** A 3D key analysis map for 17 February.
- Slide 19:** A 3D key analysis map for 18 February.
- Slide 20:** A 3D key analysis map for 19 February.
- Slide 21:** A 3D key analysis map for 20 February.
- Slide 22:** A 3D key analysis map for 21 February.
- Slide 23:** A 3D key analysis map for 22 February.
- Slide 24:** A 3D key analysis map for 23 February.
- Slide 25:** A 3D key analysis map for 24 February.
- Slide 26:** A 3D key analysis map for 25 February.
- Slide 27:** A 3D key analysis map for 26 February.
- Slide 28:** A 3D key analysis map for 27 February.
- Slide 29:** A 3D key analysis map for 28 February.
- Slide 30:** A 3D key analysis map for 29 February.
- Slide 31:** A 3D key analysis map for 30 February.
- Slide 32:** A 3D key analysis map for 1 March.
- Slide 33:** A 3D key analysis map for 2 March.
- Slide 34:** A 3D key analysis map for 3 March.
- Slide 35:** A 3D key analysis map for 4 March.
- Slide 36:** A 3D key analysis map for 5 March.
- Slide 37:** A 3D key analysis map for 6 March.
- Slide 38:** A 3D key analysis map for 7 March.
- Slide 39:** A 3D key analysis map for 8 March.
- Slide 40:** A 3D key analysis map for 9 March.
- Slide 41:** A 3D key analysis map for 10 March.
- Slide 42:** A 3D key analysis map for 11 March.
- Slide 43:** A 3D key analysis map for 12 March.
- Slide 44:** A 3D key analysis map for 13 March.
- Slide 45:** A 3D key analysis map for 14 March.
- Slide 46:** A 3D key analysis map for 15 March.
- Slide 47:** A 3D key analysis map for 16 March.
- Slide 48:** Conclusions, summarizing the key analysis system and its performance.



GOES-1 RGB-C

Use of adjoint sensitivity to diagnose the GMC 3D-Var analysis performance. A case study.

Stéphane Laroche, Monique Tanguay
Josée Morneau, Ayrton Zadra

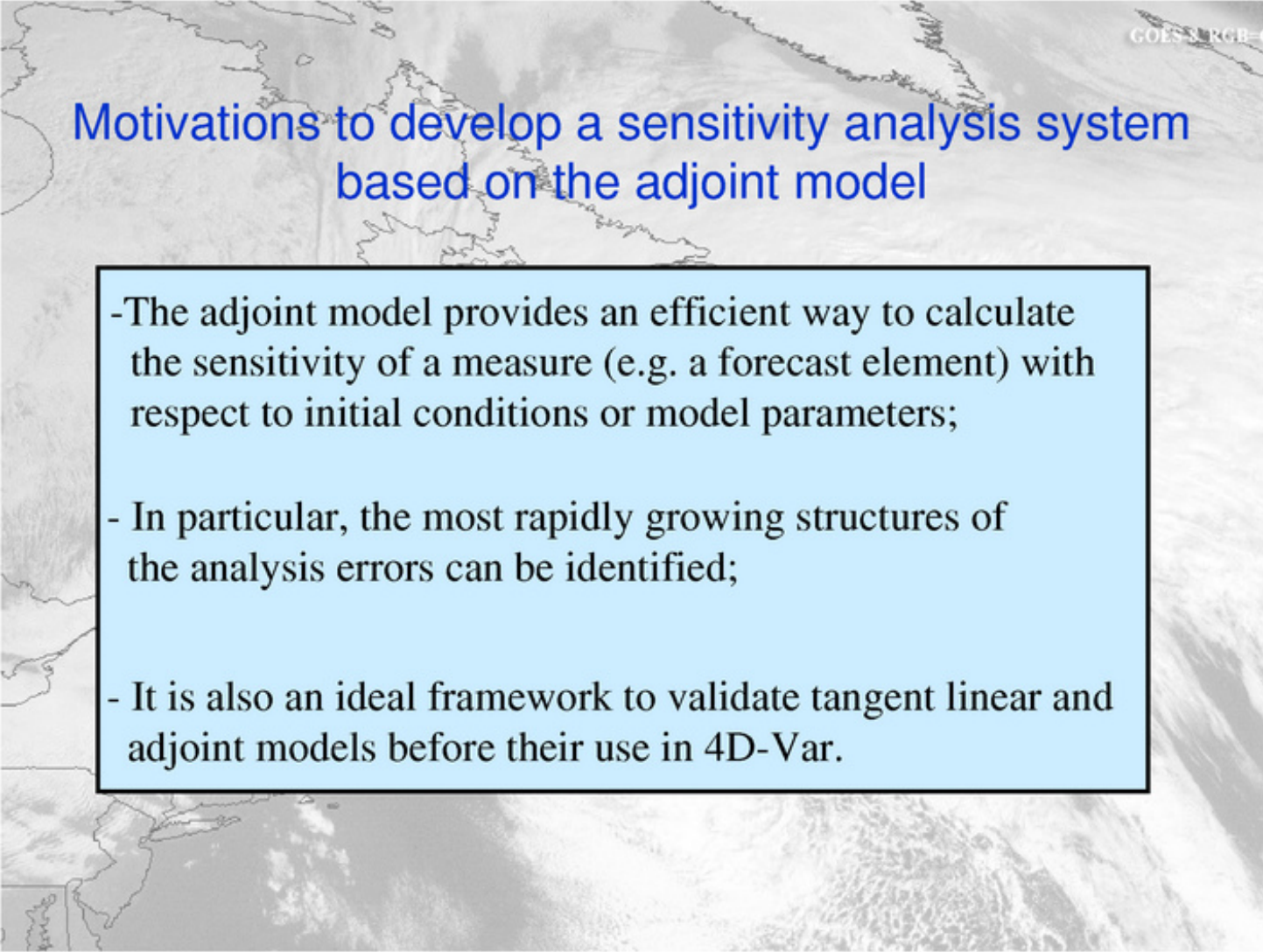
Acknowledgments: Normand Brunet
Cécilien Charette
Clément Chouinard
Michel Roch

A satellite image of the North Atlantic region, showing the eastern coast of North America and the western coast of Europe. The text "GOES 3 RGB-C" is visible in the top right corner. A blue box with a black border is overlaid on the image, containing the title "Outline of talk" and a list of topics.

GOES 3 RGB-C

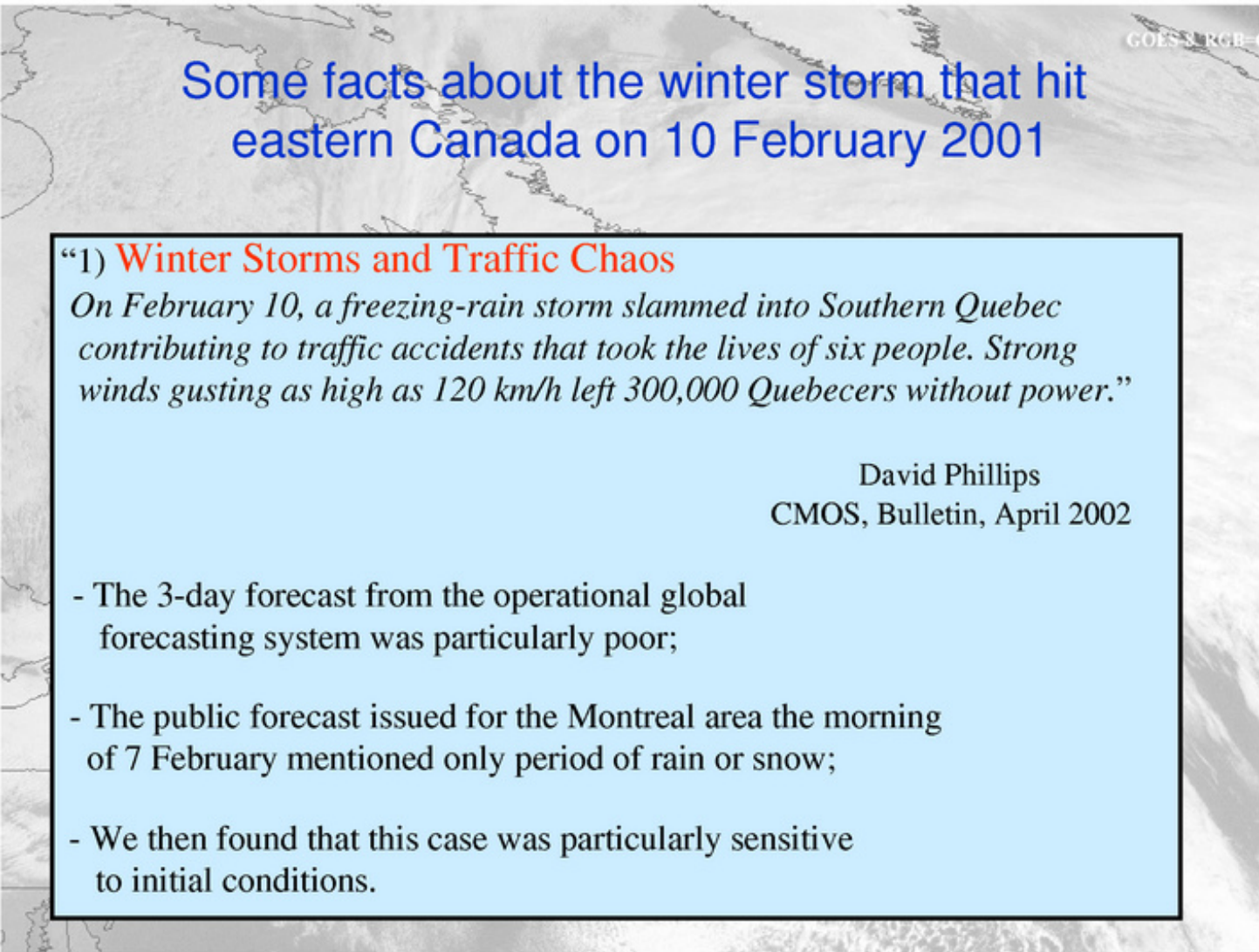
Outline of talk

- Motivations;
- Synoptic overview 7-10 February 2001;
- 3-day operational forecast performance;
- Sensitivity analysis (the key analysis error algorithm);
- Improvements from the new 3D-Var;
- Comparison between analysis differences and key analysis errors;
- Conclusions.

A satellite image of Earth showing cloud patterns over the Americas. A semi-transparent light blue box with a black border is overlaid on the image, containing text. The text is in a dark blue font for the title and black font for the list items. The text reads: "Motivations to develop a sensitivity analysis system based on the adjoint model". Below this is a list of three bullet points: "-The adjoint model provides an efficient way to calculate the sensitivity of a measure (e.g. a forecast element) with respect to initial conditions or model parameters;", "- In particular, the most rapidly growing structures of the analysis errors can be identified;", and "- It is also an ideal framework to validate tangent linear and adjoint models before their use in 4D-Var." The text "GOES 3 RGB-C" is visible in the top right corner of the satellite image.

Motivations to develop a sensitivity analysis system based on the adjoint model

- The adjoint model provides an efficient way to calculate the sensitivity of a measure (e.g. a forecast element) with respect to initial conditions or model parameters;
- In particular, the most rapidly growing structures of the analysis errors can be identified;
- It is also an ideal framework to validate tangent linear and adjoint models before their use in 4D-Var.



GOES 3 RGB-C

Some facts about the winter storm that hit eastern Canada on 10 February 2001

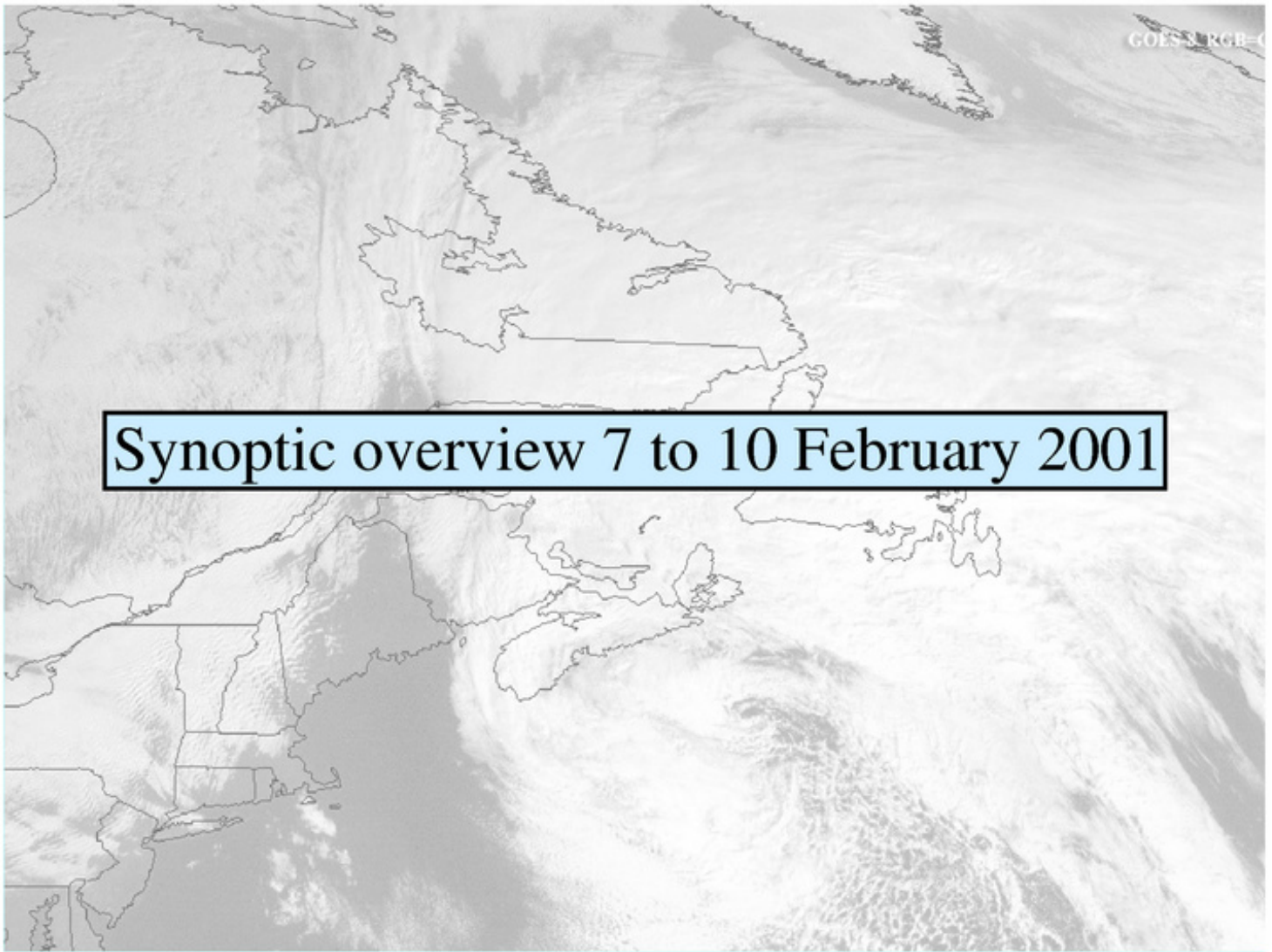
“1) **Winter Storms and Traffic Chaos**

On February 10, a freezing-rain storm slammed into Southern Quebec contributing to traffic accidents that took the lives of six people. Strong winds gusting as high as 120 km/h left 300,000 Quebecers without power.”

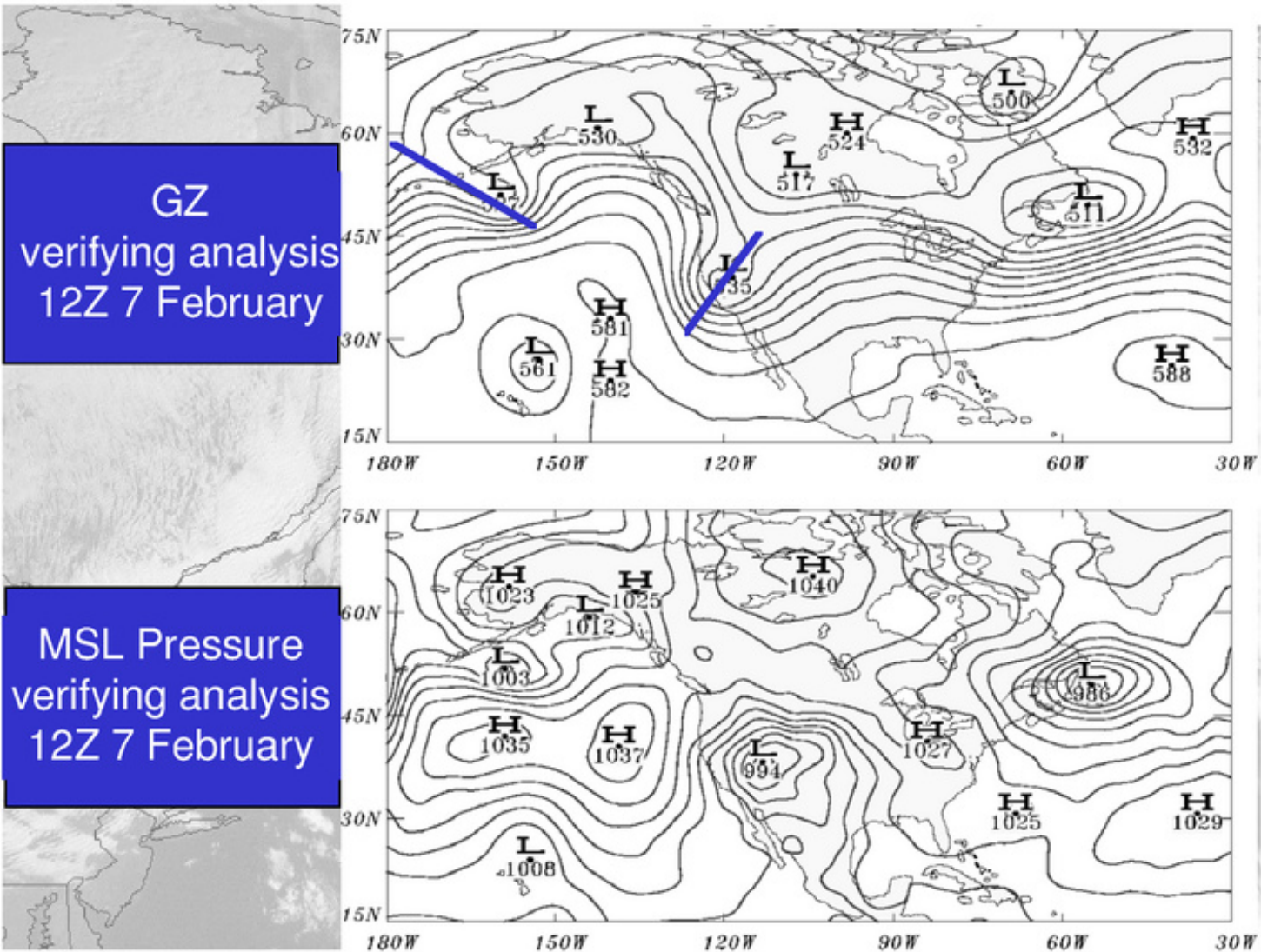
David Phillips
CMOS, Bulletin, April 2002

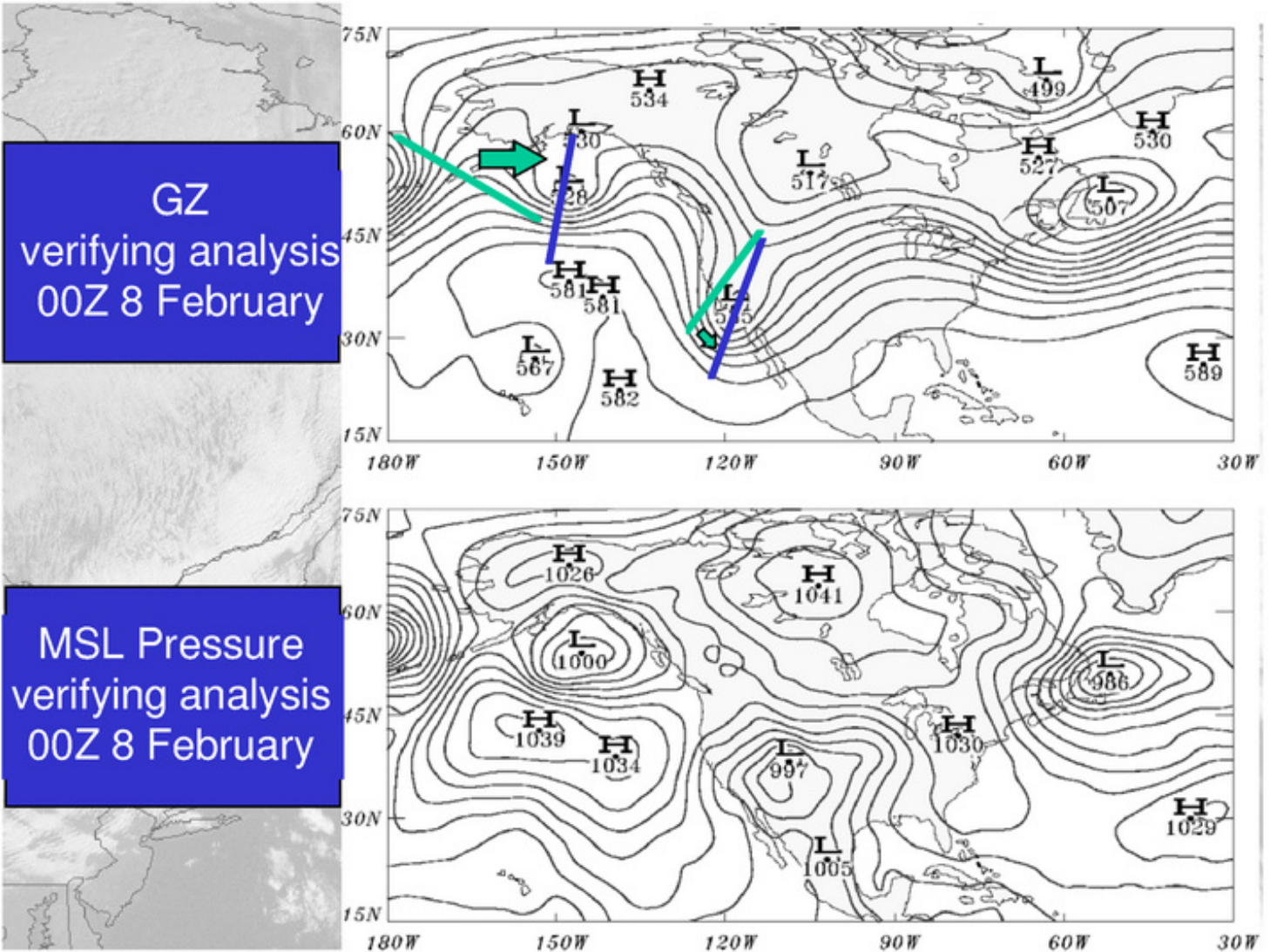
- The 3-day forecast from the operational global forecasting system was particularly poor;
- The public forecast issued for the Montreal area the morning of 7 February mentioned only period of rain or snow;
- We then found that this case was particularly sensitive to initial conditions.

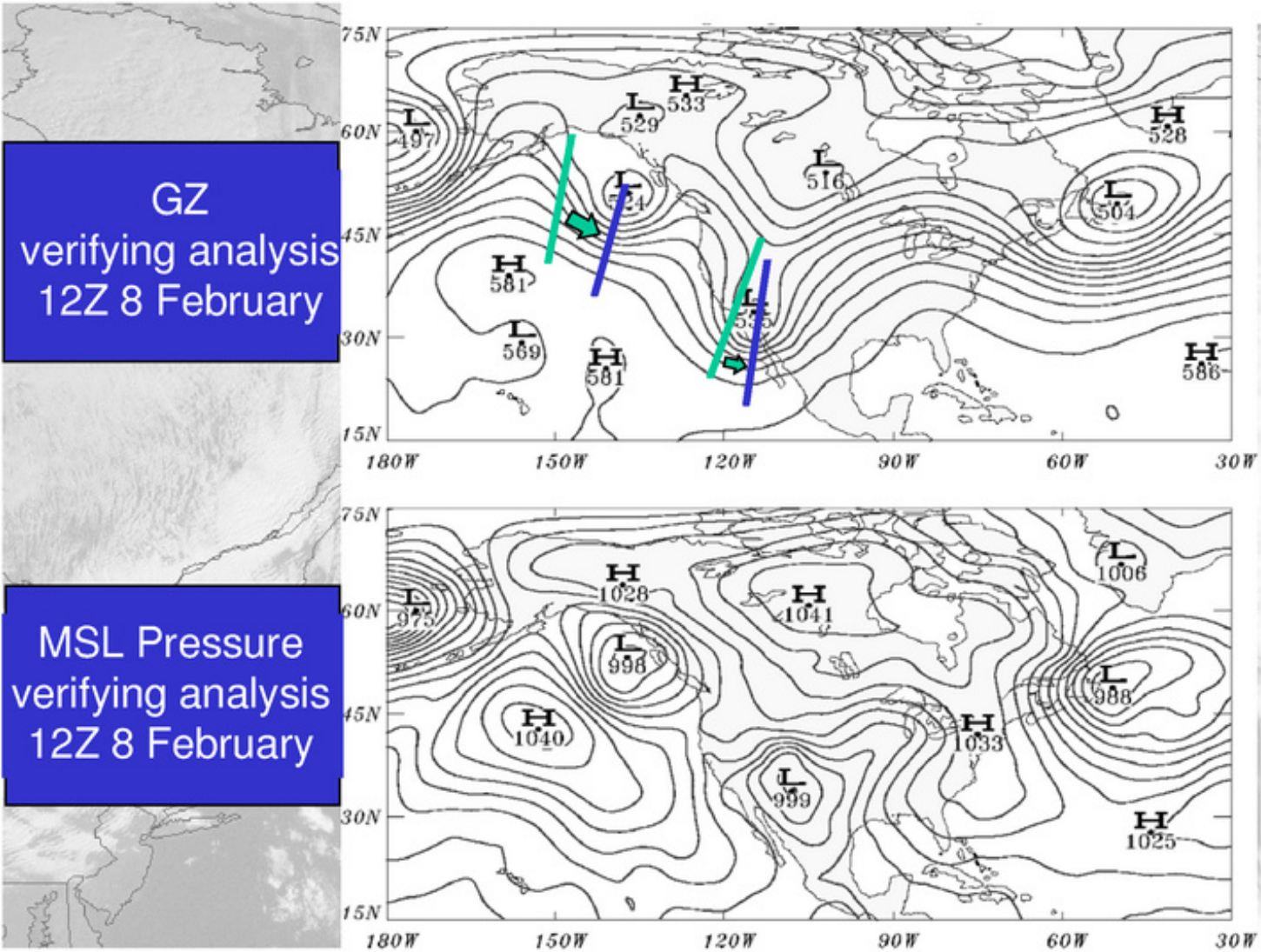
[<< Prev](#) | [Index](#) | [Next >>](#)

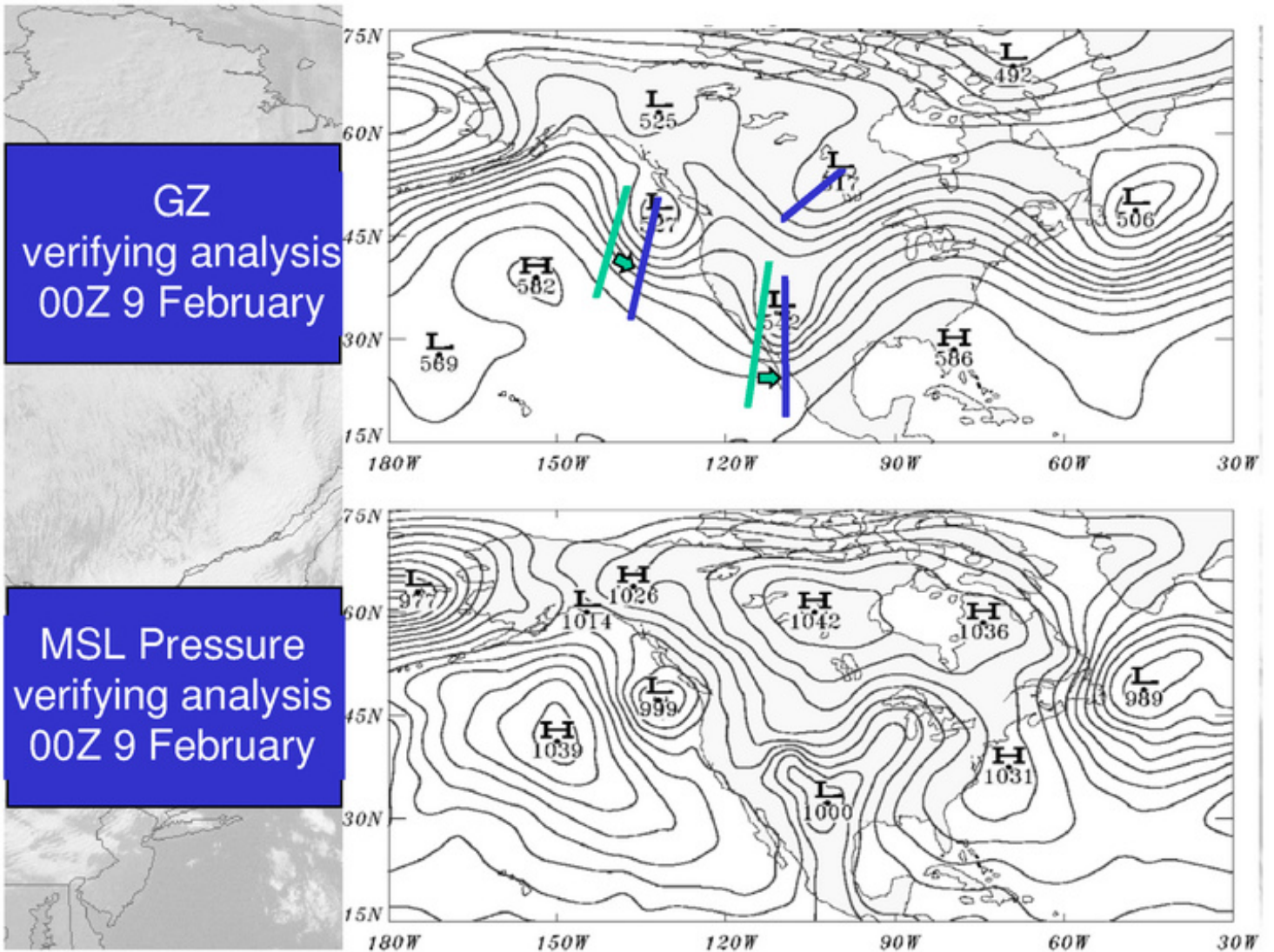


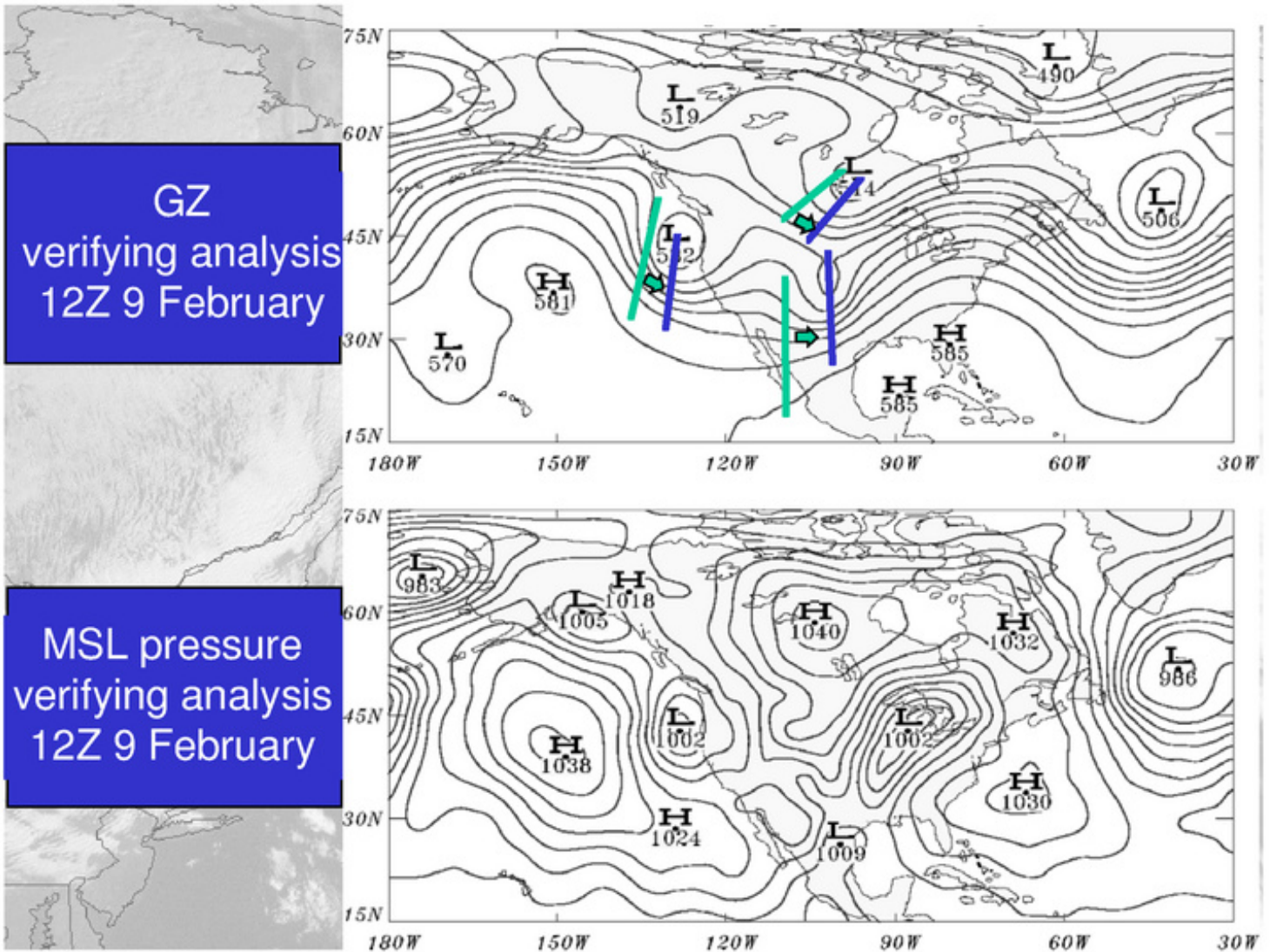
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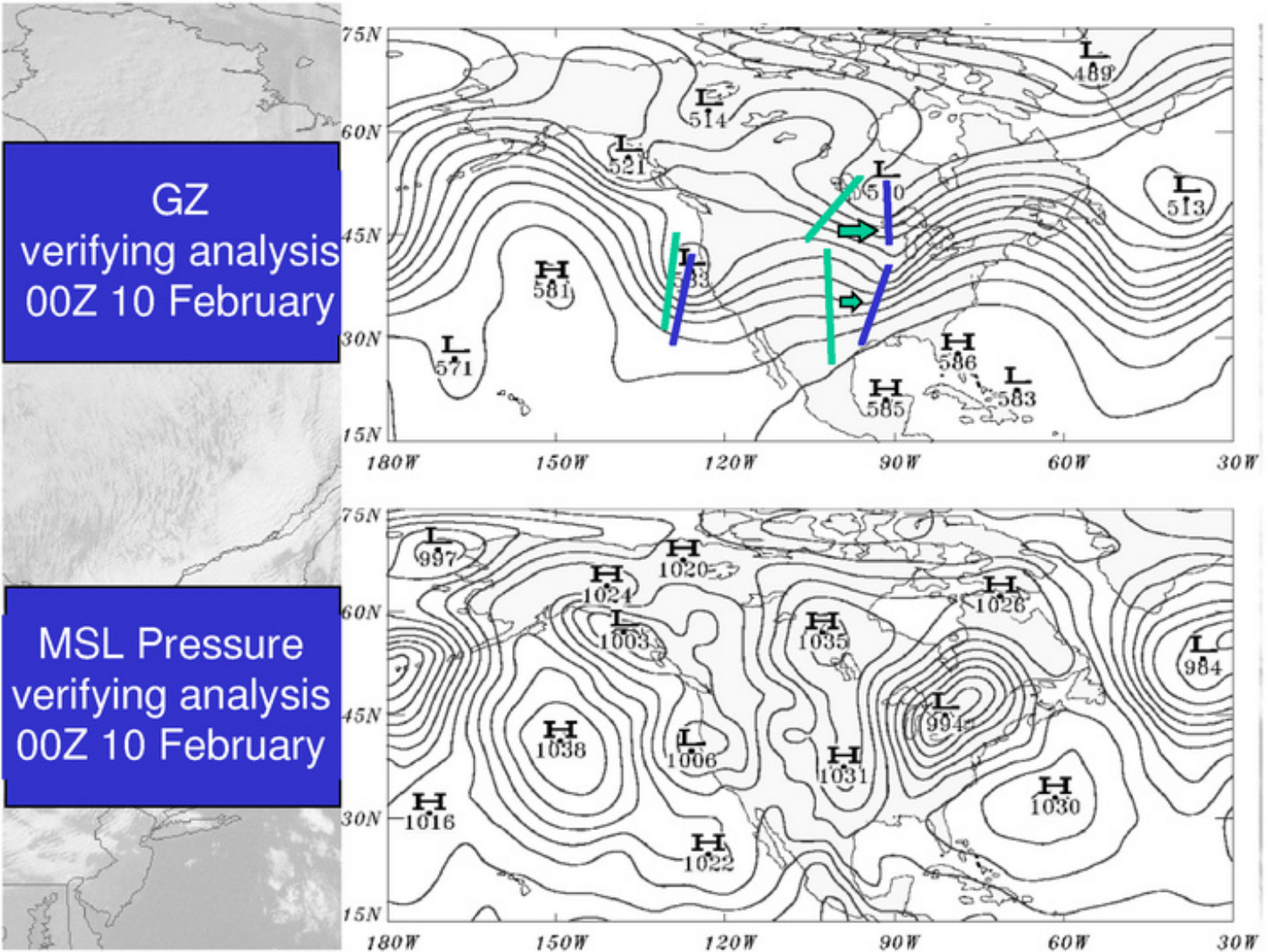


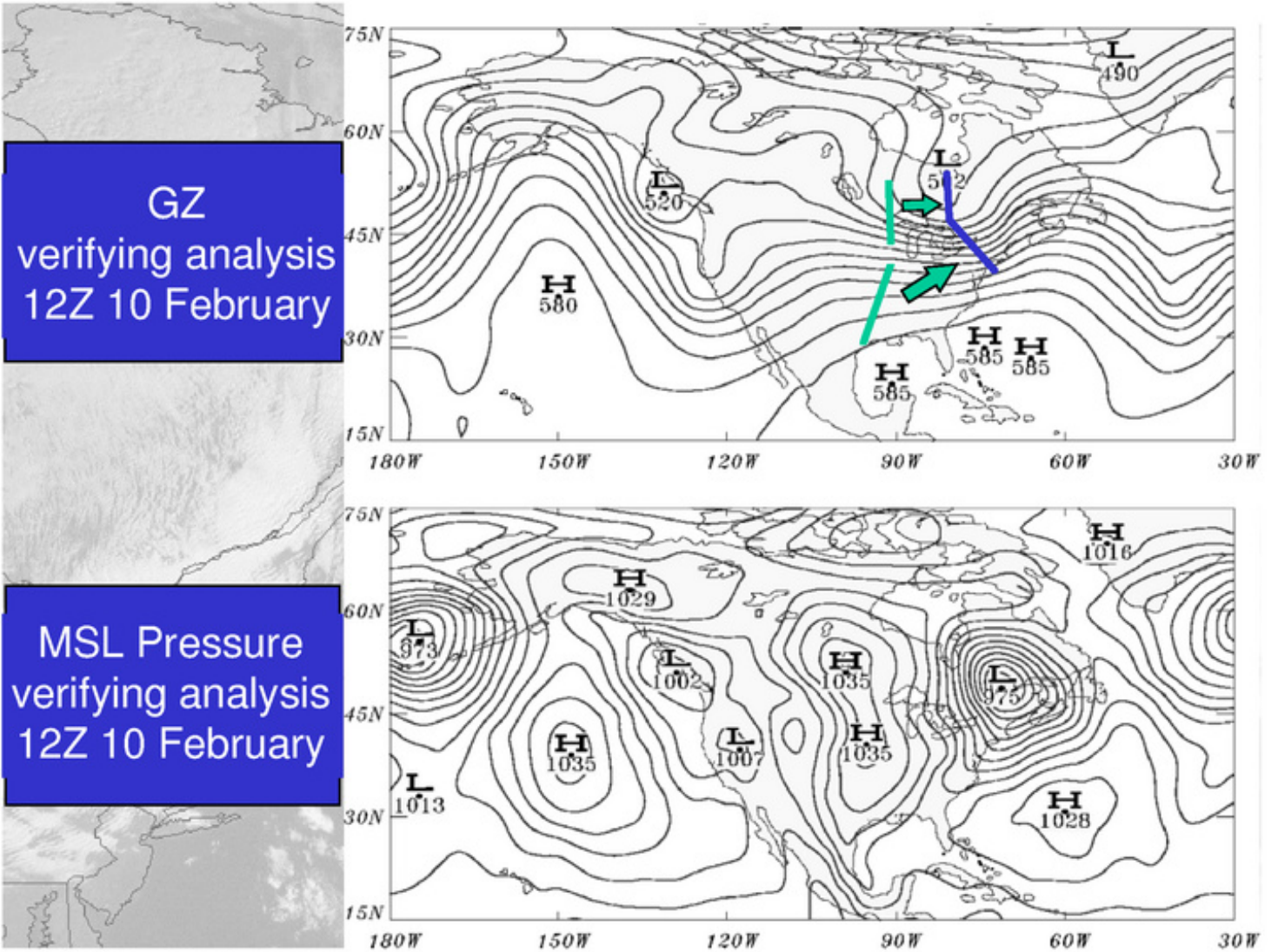


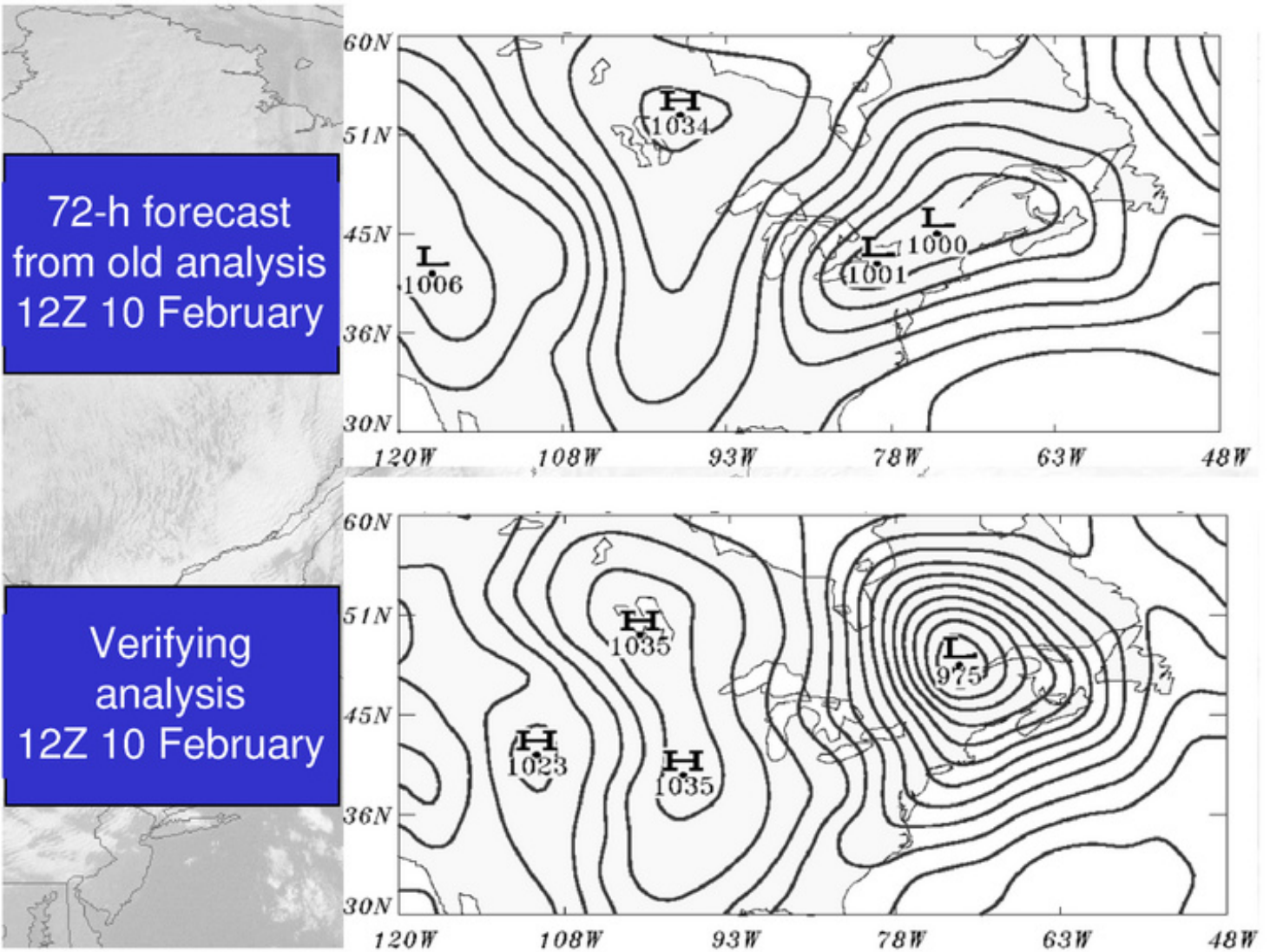


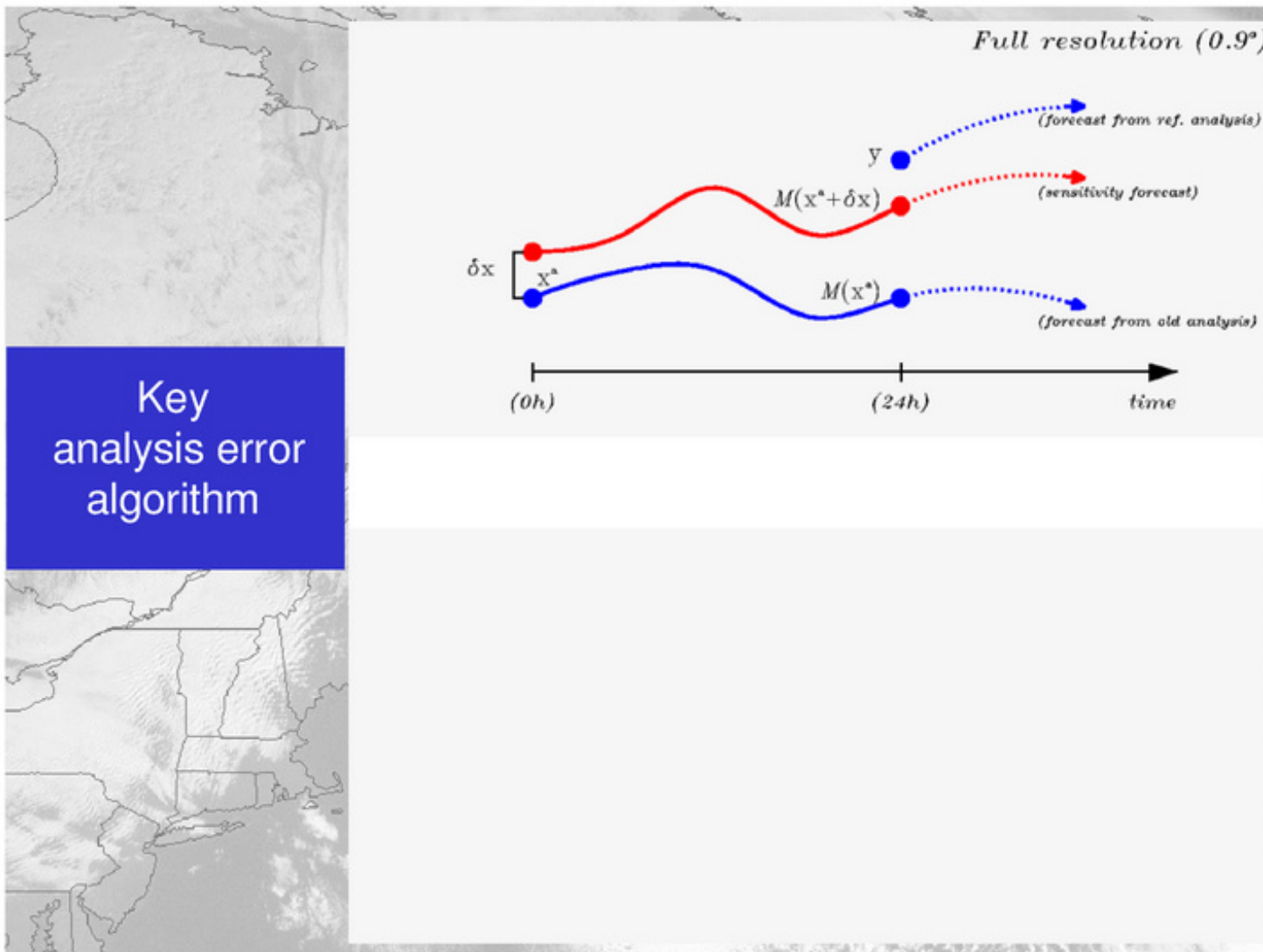


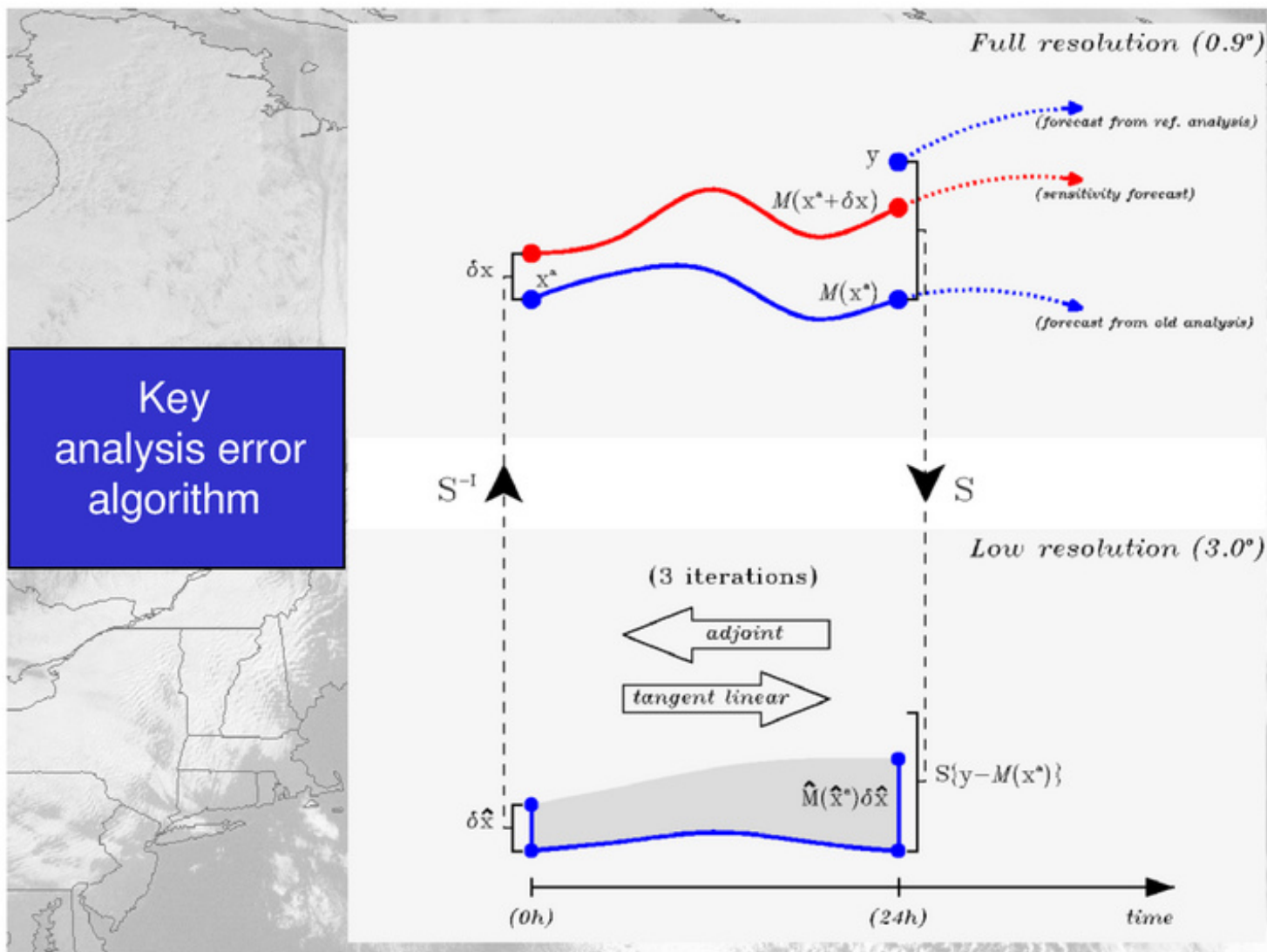


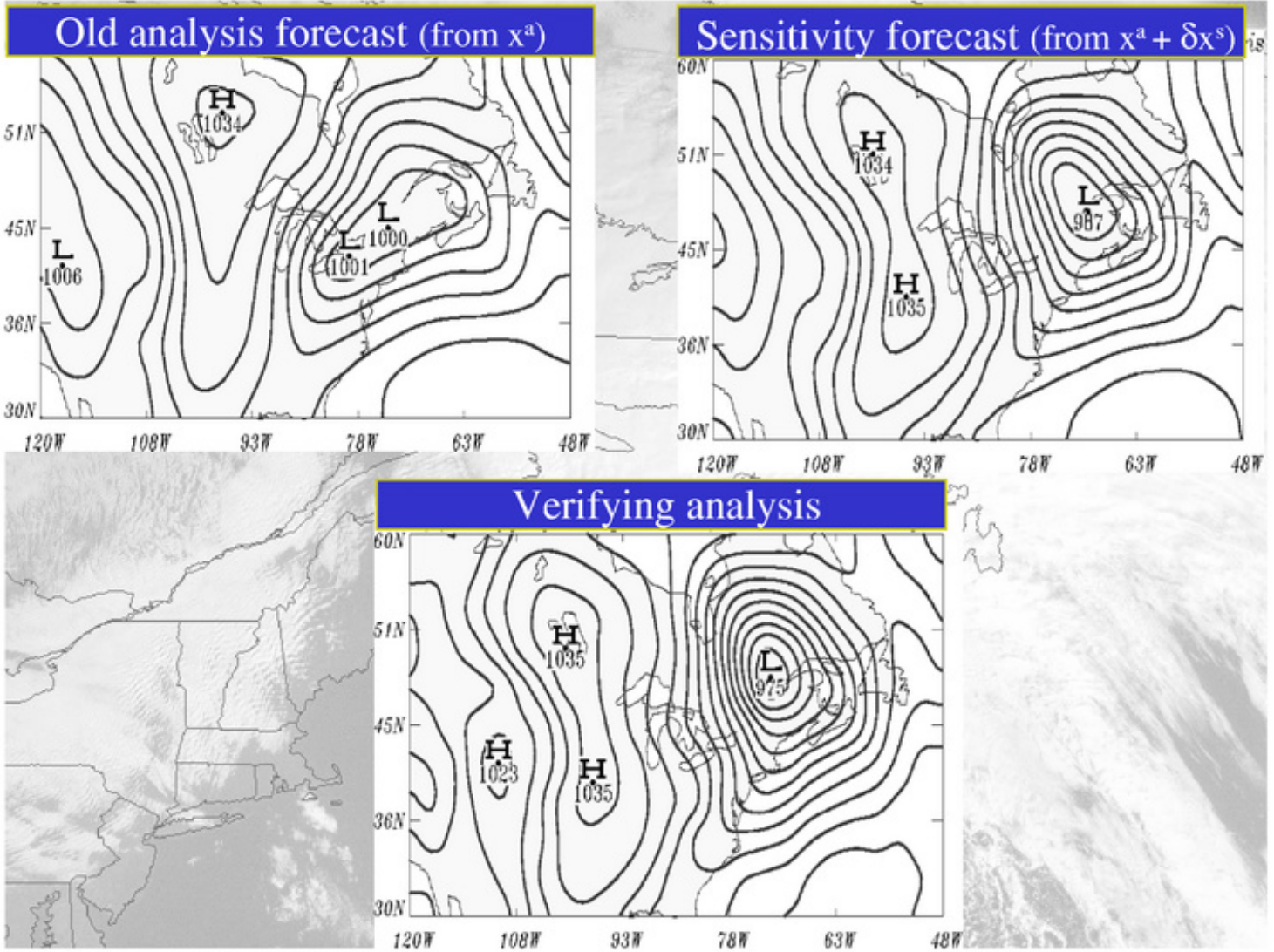


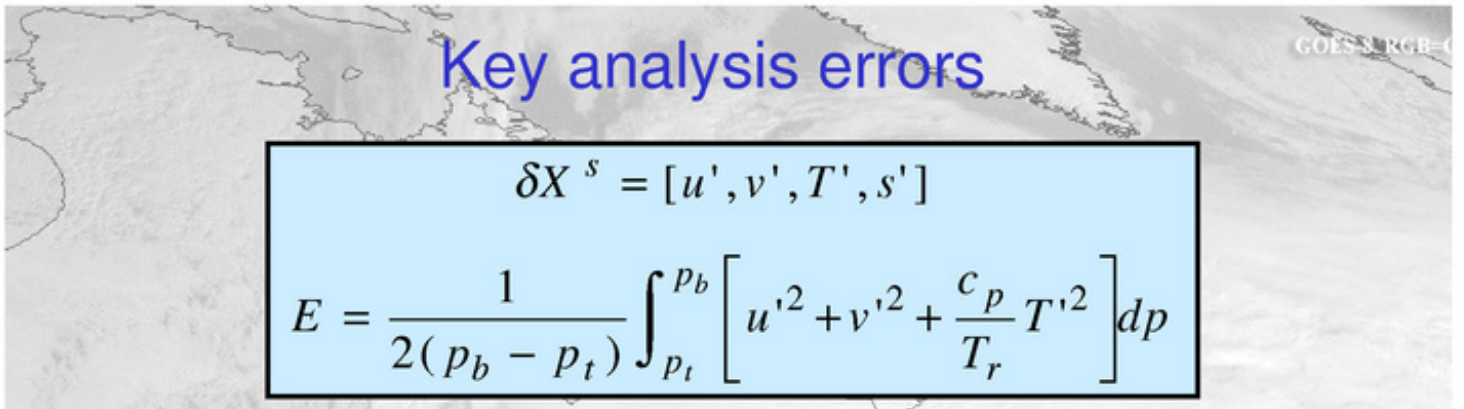






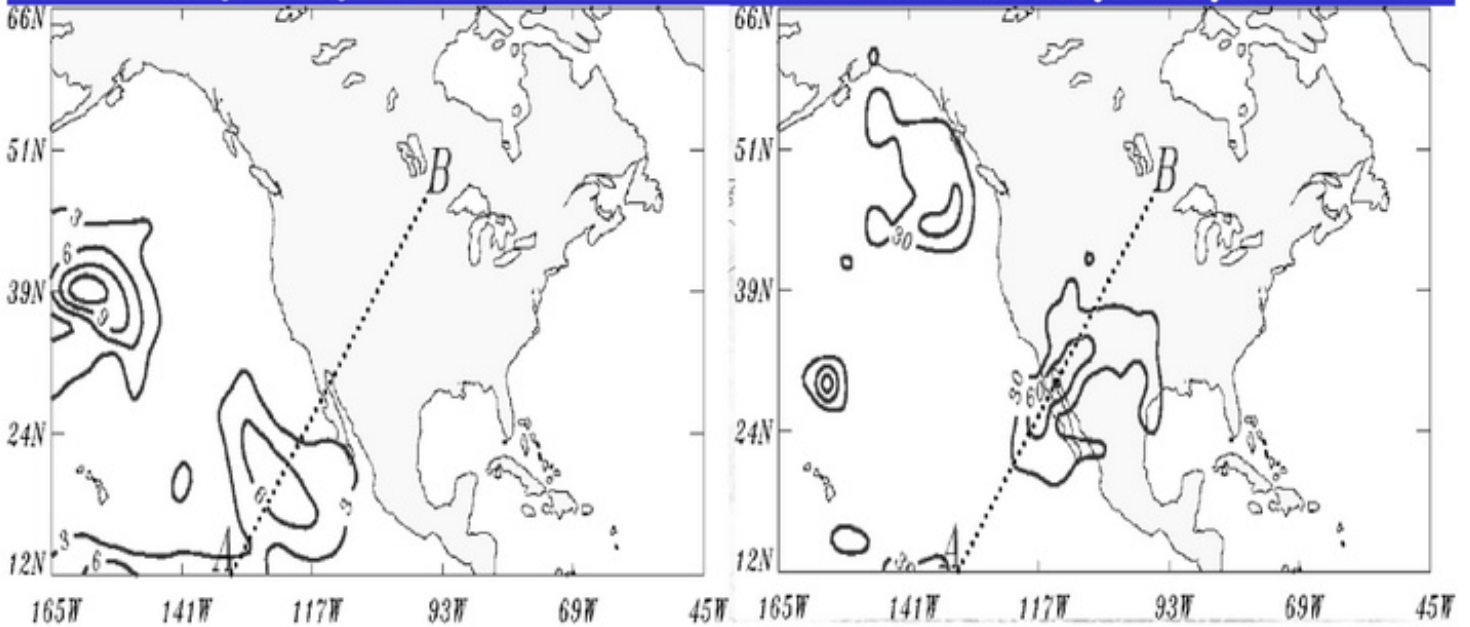


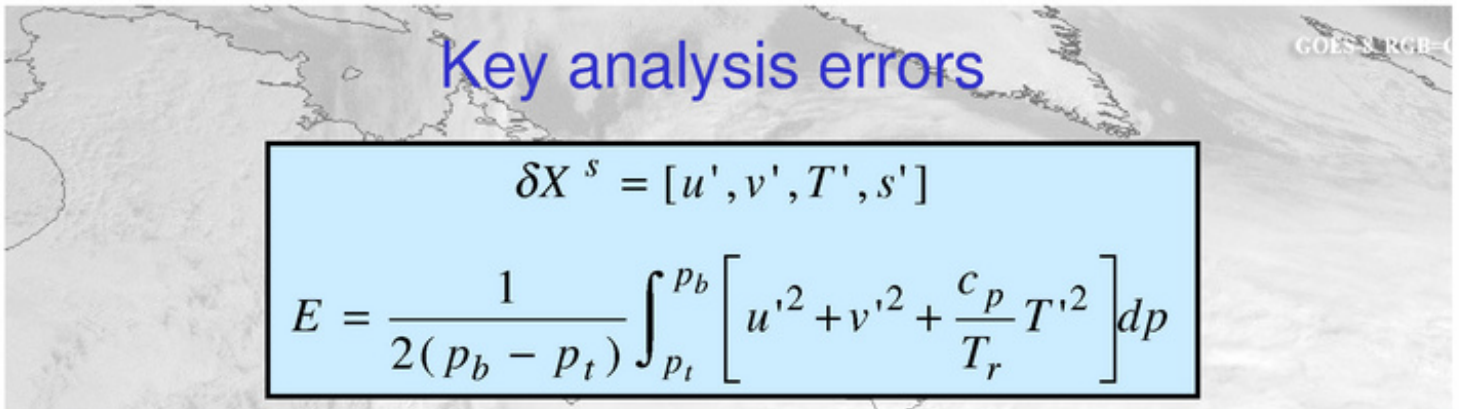




Key analysis errors

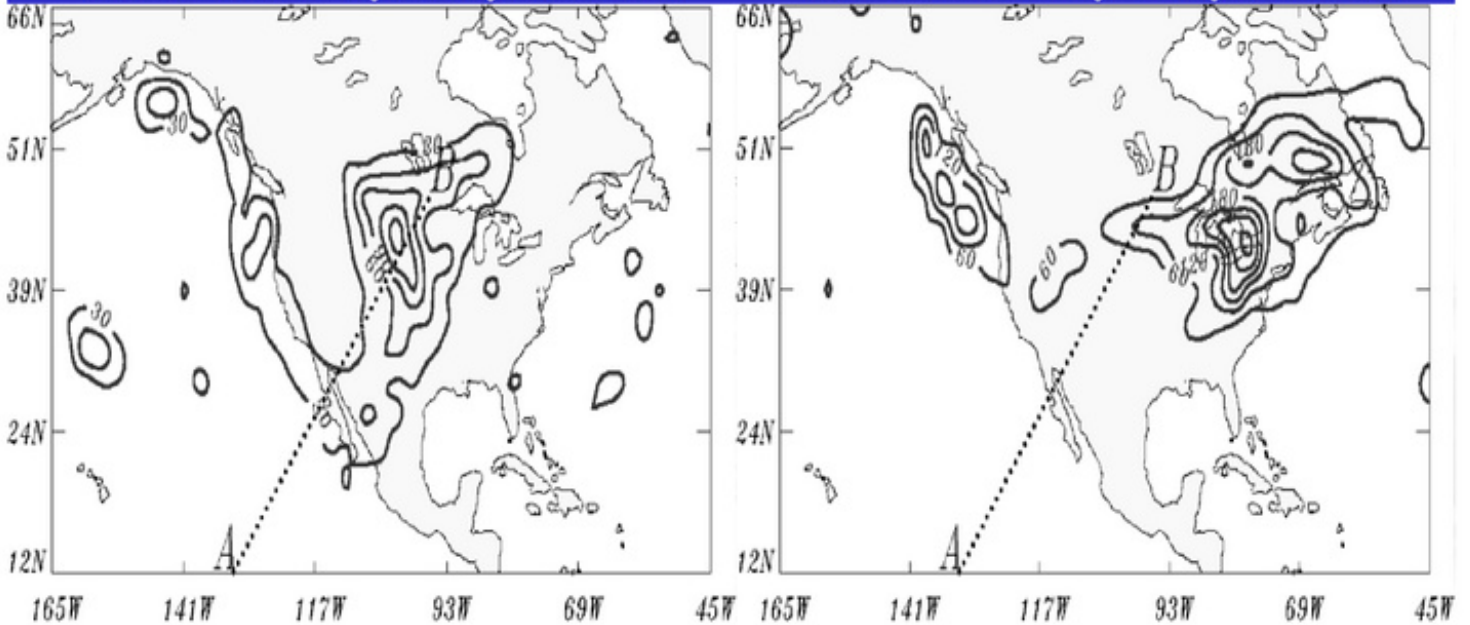
24h evolved key analysis errors

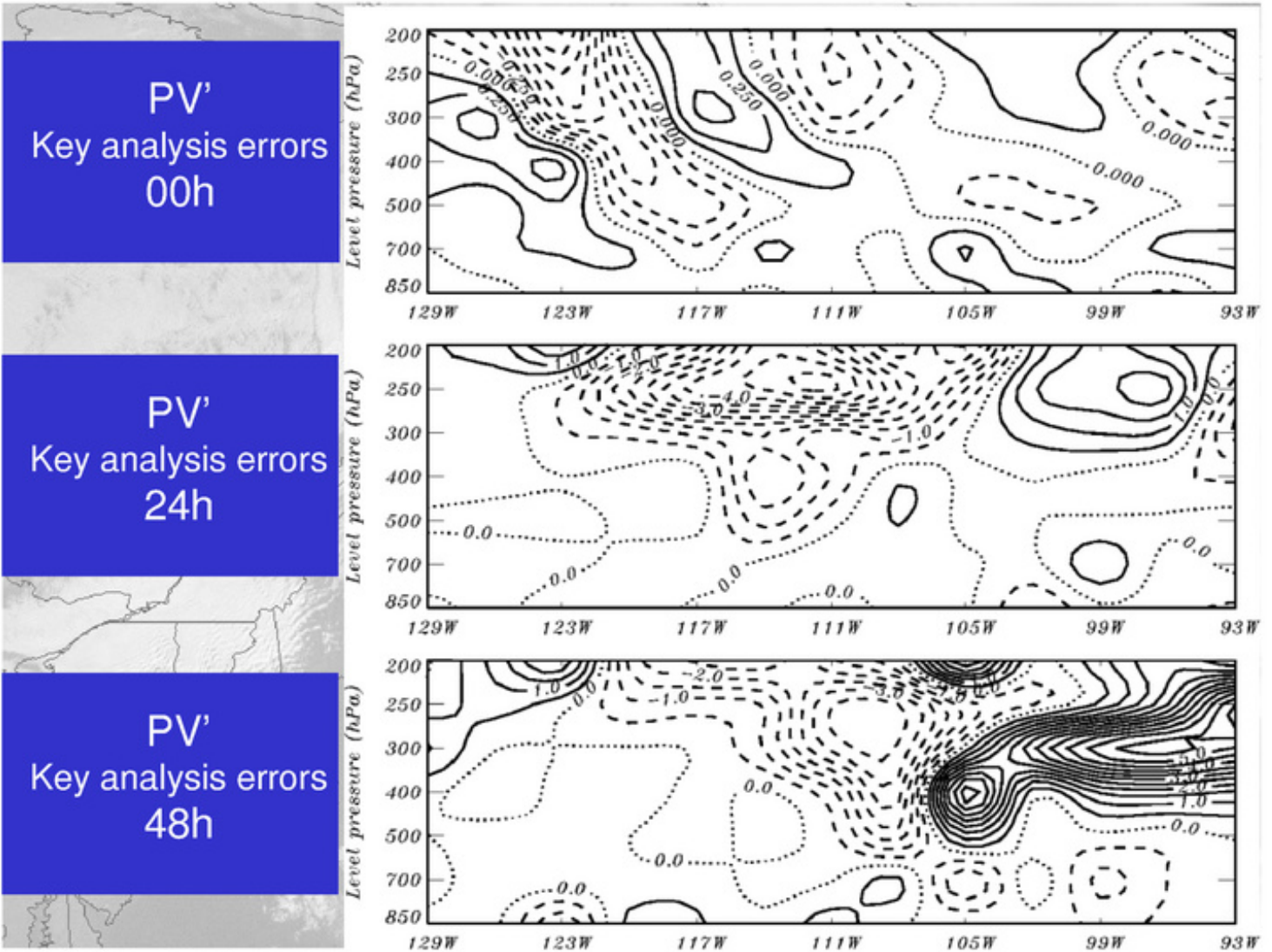




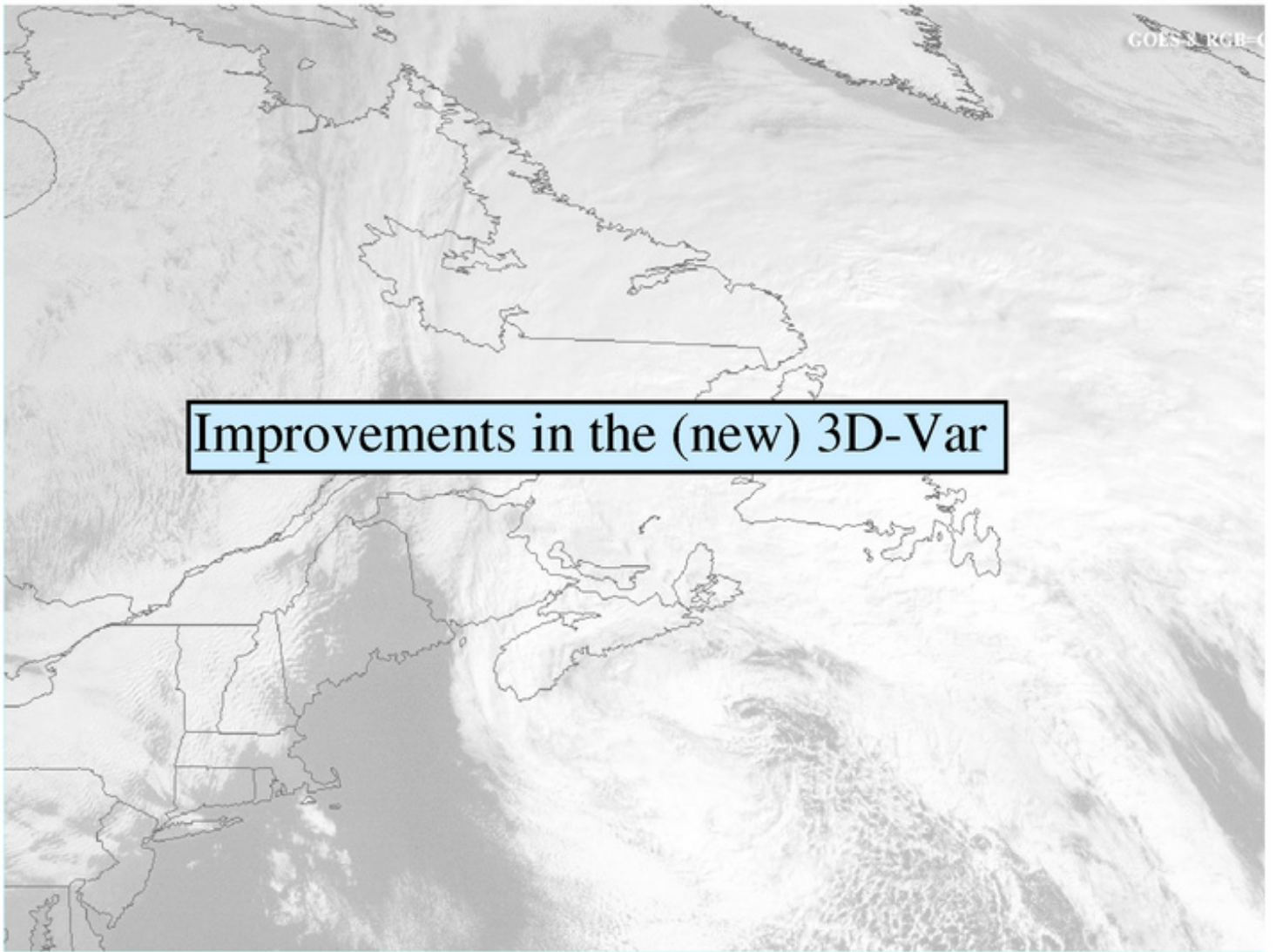
48h evolved key analysis errors

72h evolved key analysis errors

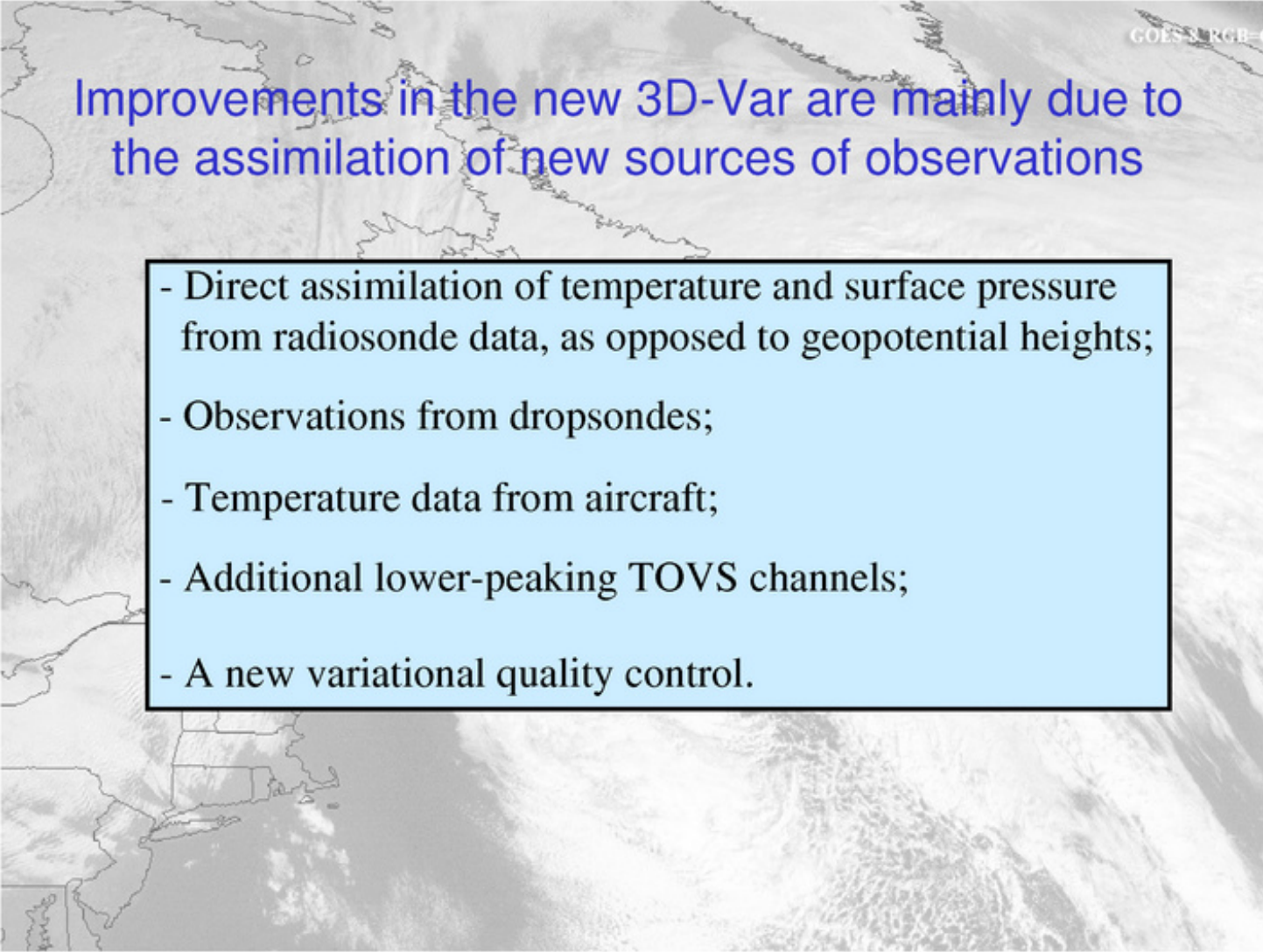




[<< Prev](#) | [Index](#) | [Next >>](#)

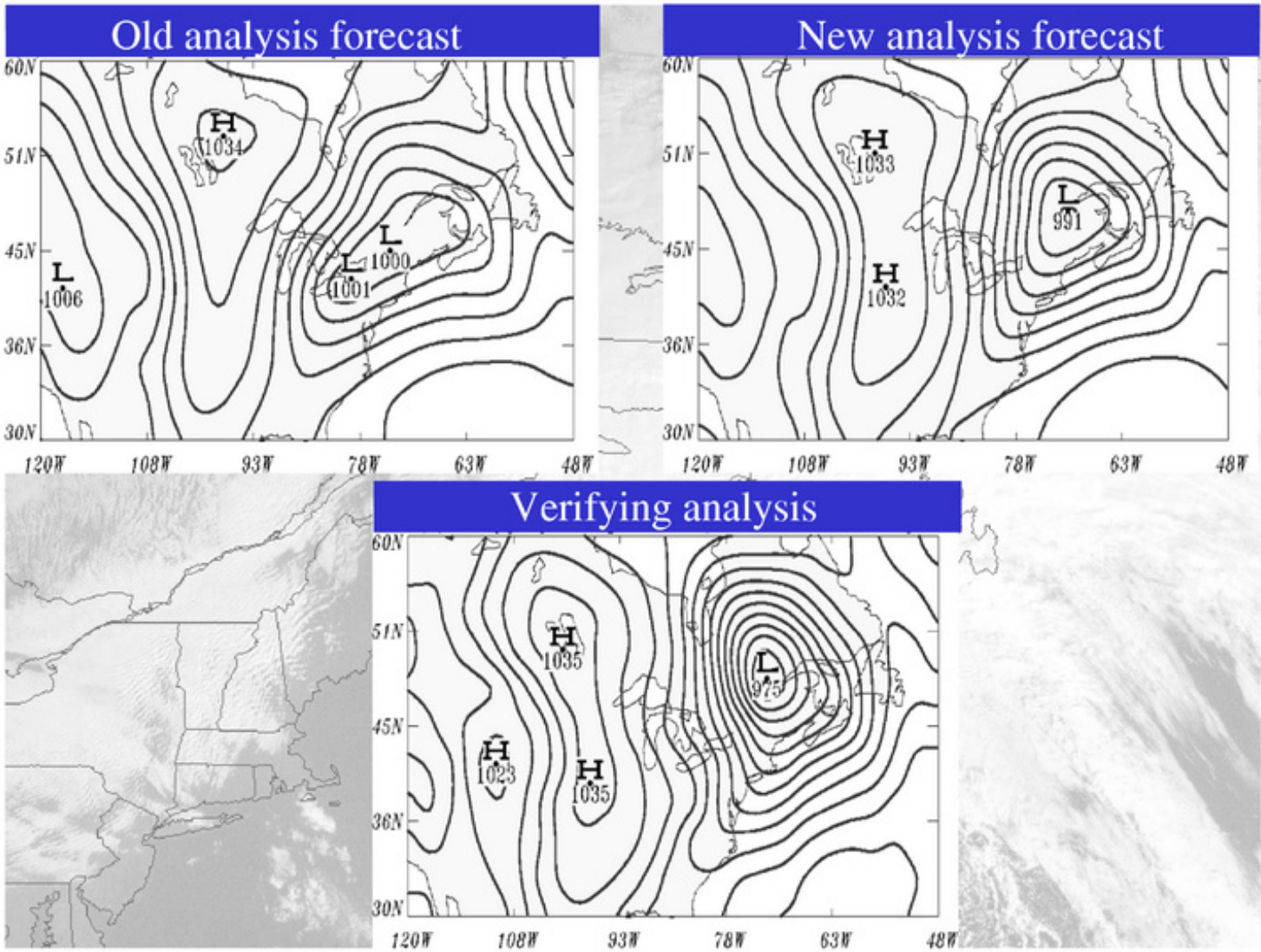


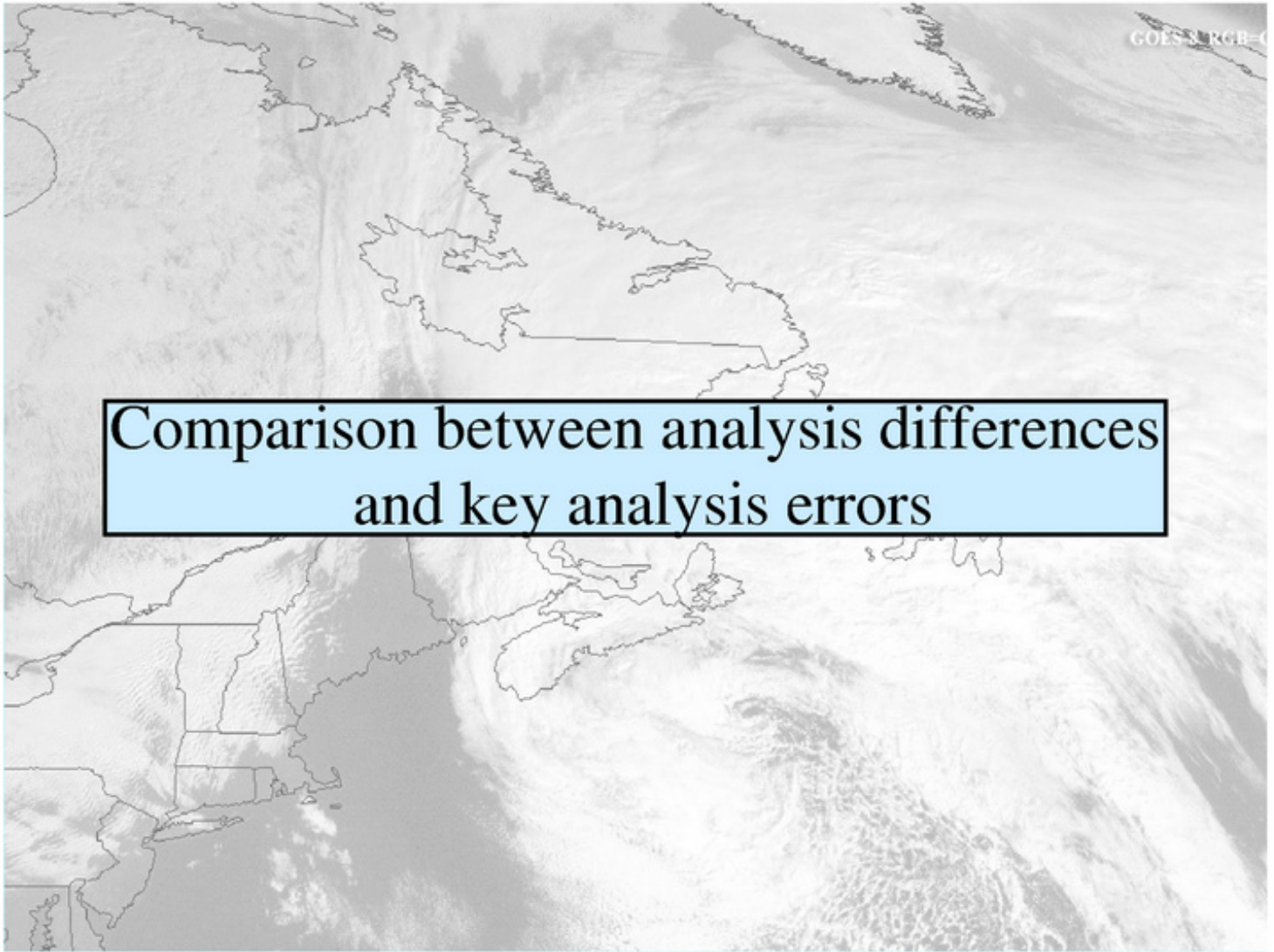
[<< Prev](#) | [Index](#) | [Next >>](#)

A satellite image of Earth showing cloud patterns over the Americas. A semi-transparent light blue box with a black border is centered on the image, containing a list of improvements. The text 'GOES 3 RGB-C' is visible in the top right corner of the image.

Improvements in the new 3D-Var are mainly due to the assimilation of new sources of observations

- Direct assimilation of temperature and surface pressure from radiosonde data, as opposed to geopotential heights;
- Observations from dropsondes;
- Temperature data from aircraft;
- Additional lower-peaking TOVS channels;
- A new variational quality control.



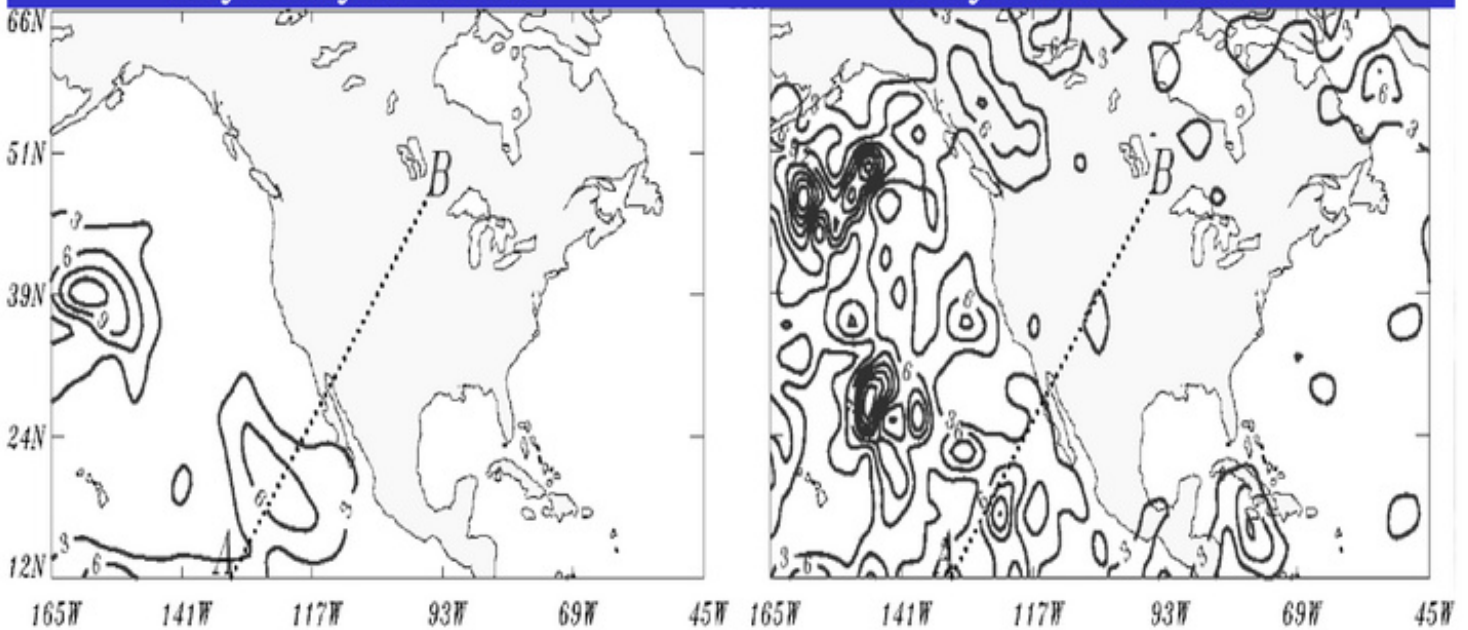


Comparison key analysis errors vs analysis differences

$$E = \frac{1}{2(p_b - p_t)} \int_{p_t}^{p_b} \left[u'^2 + v'^2 + \frac{c_p}{T_r} T'^2 \right] dp$$

Key analysis errors

analysis differences

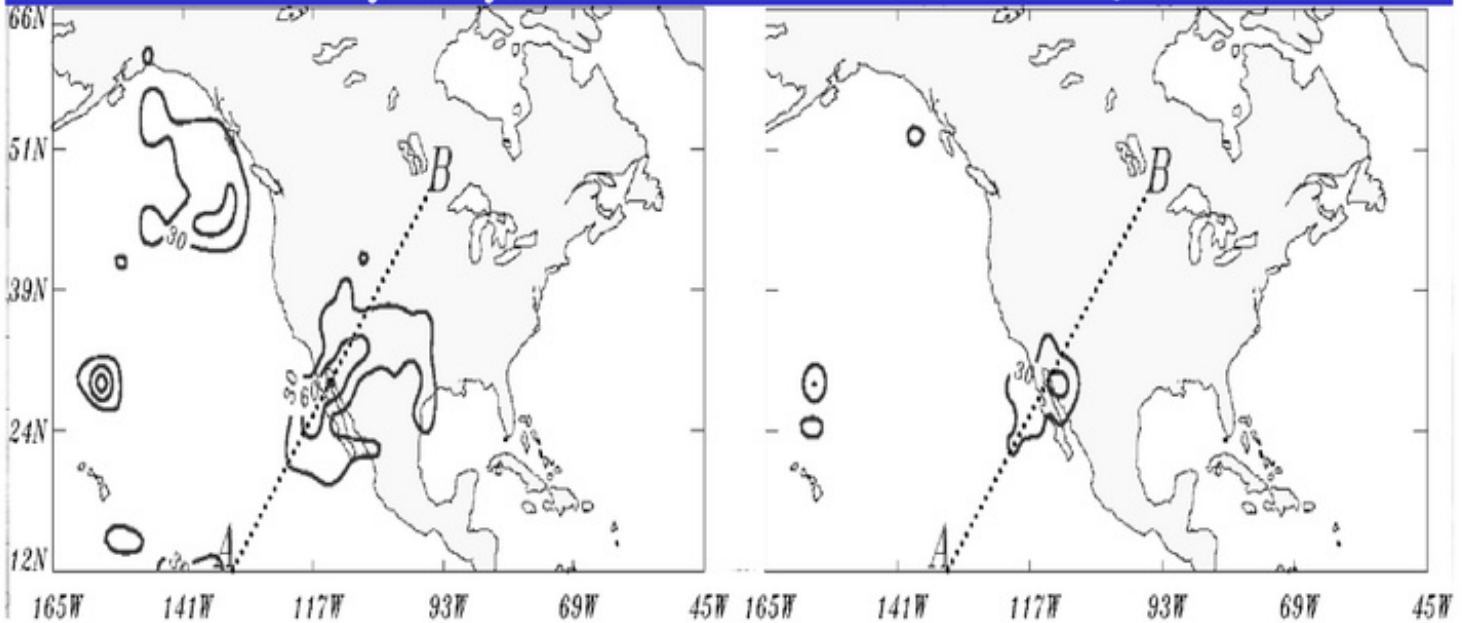


Comparison key analysis errors vs analysis differences

$$E = \frac{1}{2(p_b - p_t)} \int_{p_t}^{p_b} \left[u'^2 + v'^2 + \frac{c_p}{T_r} T'^2 \right] dp$$

24h evolved key analysis errors

24h evolved analysis differences

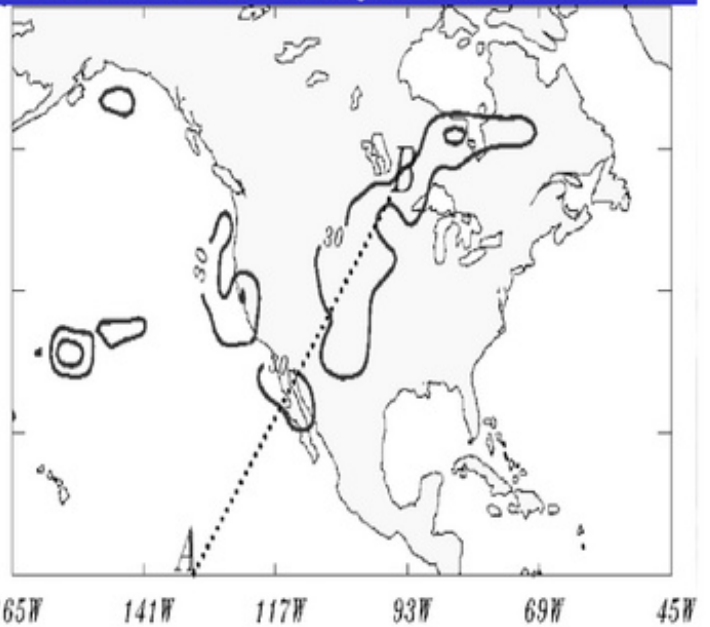
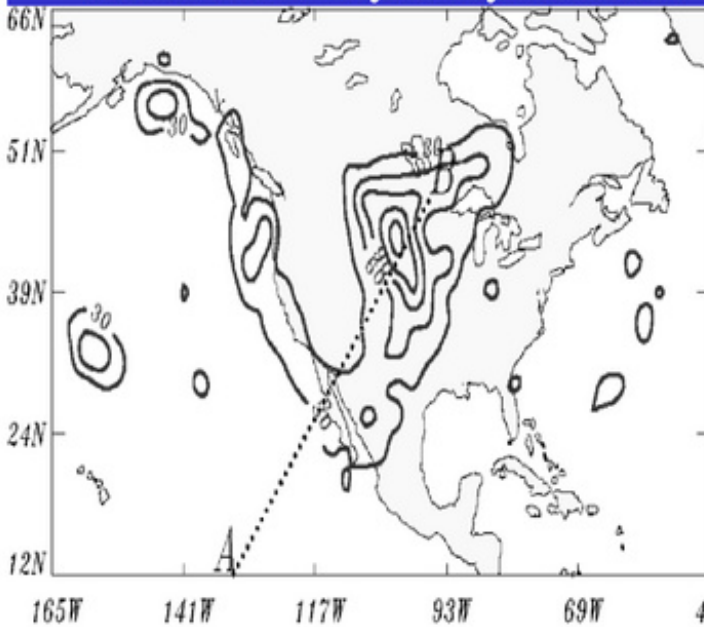


Comparison key analysis errors vs analysis differences

$$E = \frac{1}{2(p_b - p_t)} \int_{p_t}^{p_b} \left[u'^2 + v'^2 + \frac{c_p}{T_r} T'^2 \right] dp$$

48h evolved key analysis errors

48h evolved analysis differences

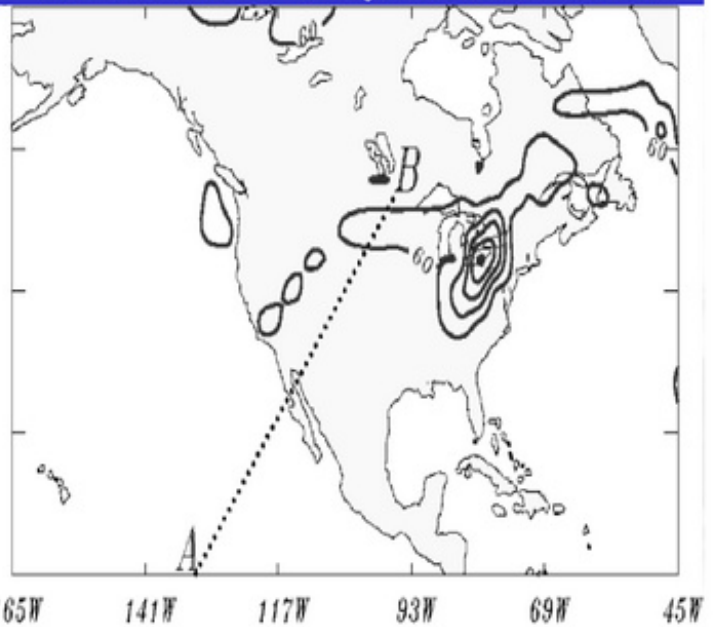
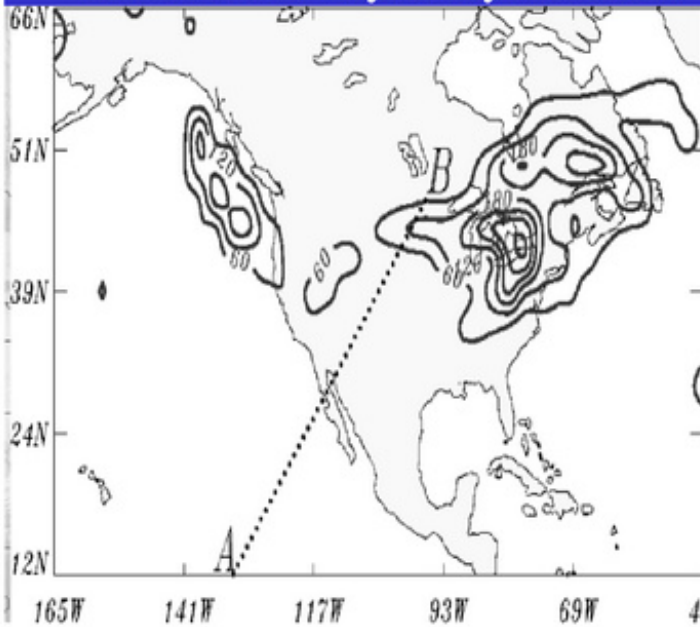


Comparison key analysis errors vs analysis differences

$$E = \frac{1}{2(p_b - p_t)} \int_{p_t}^{p_b} \left[u'^2 + v'^2 + \frac{c_p}{T_r} T'^2 \right] dp$$

72h evolved key analysis errors

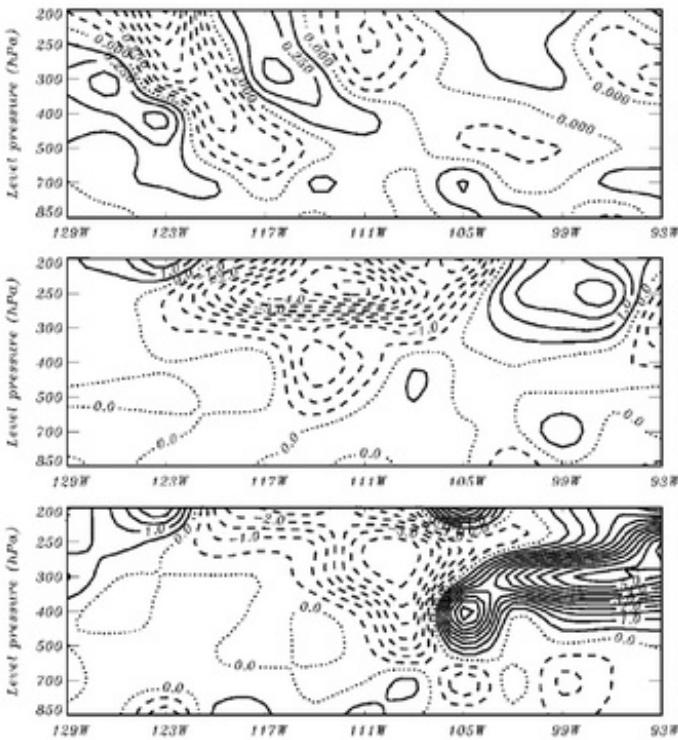
72h evolved analysis differences



Comparison key analysis errors vs analysis differences

PV'
Key analysis errors

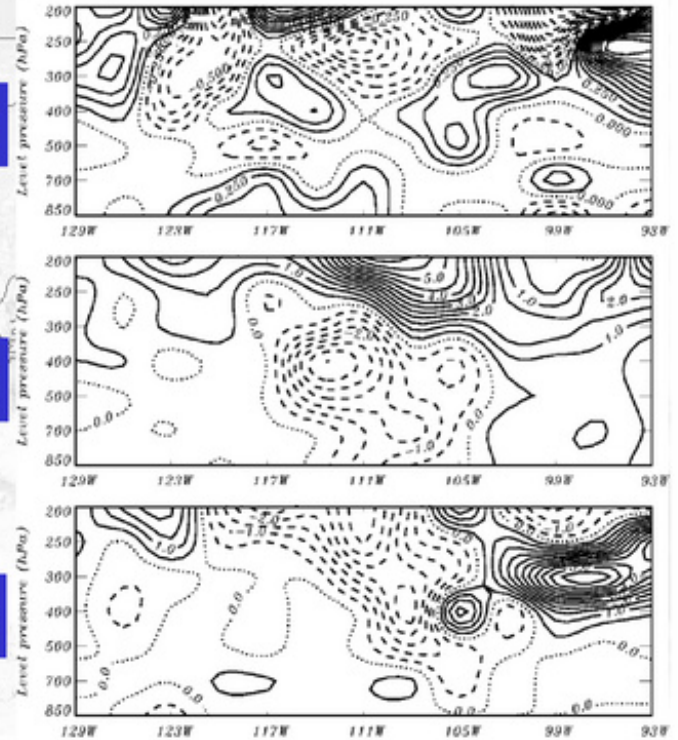
PV'
analysis differences

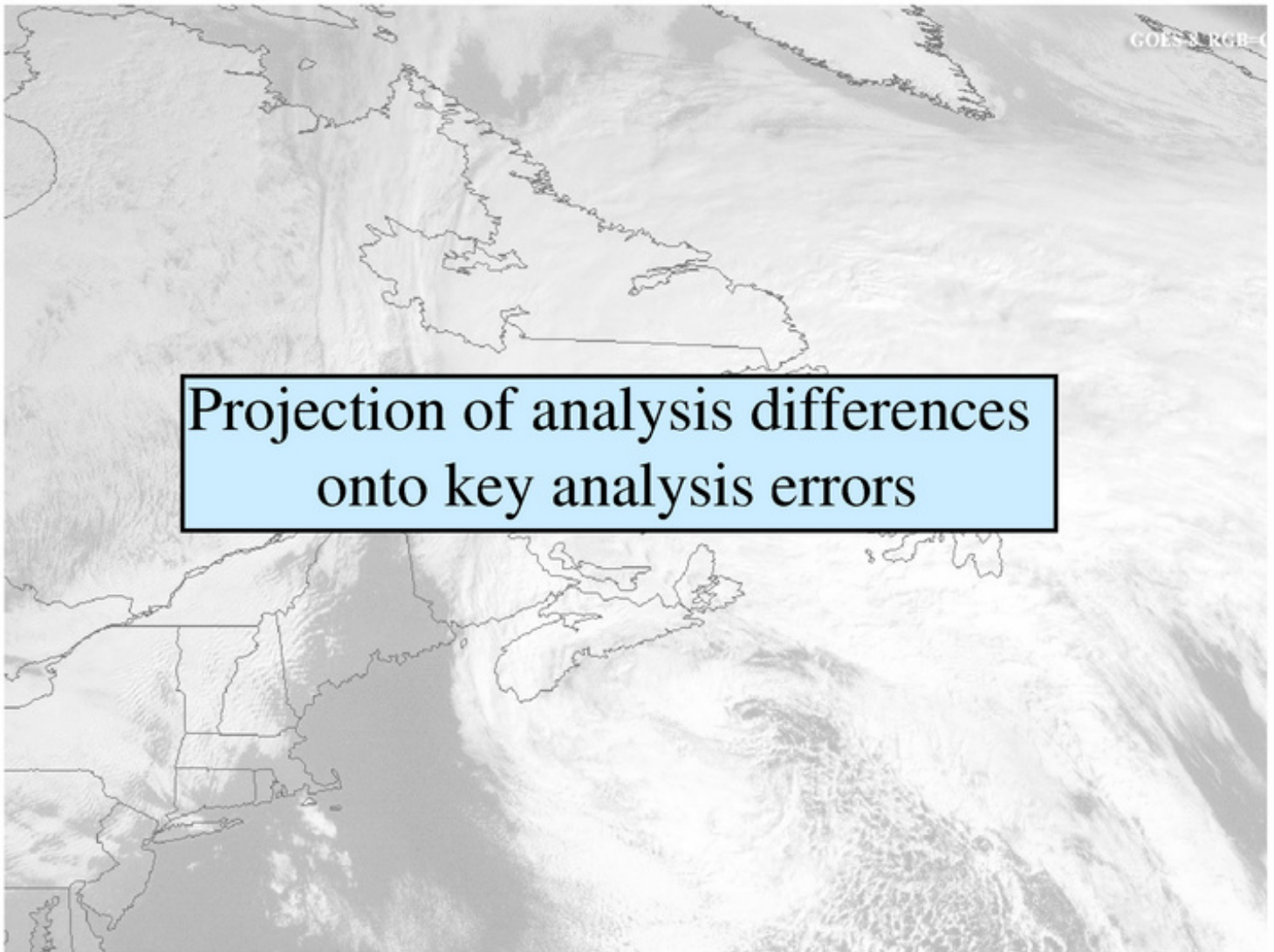


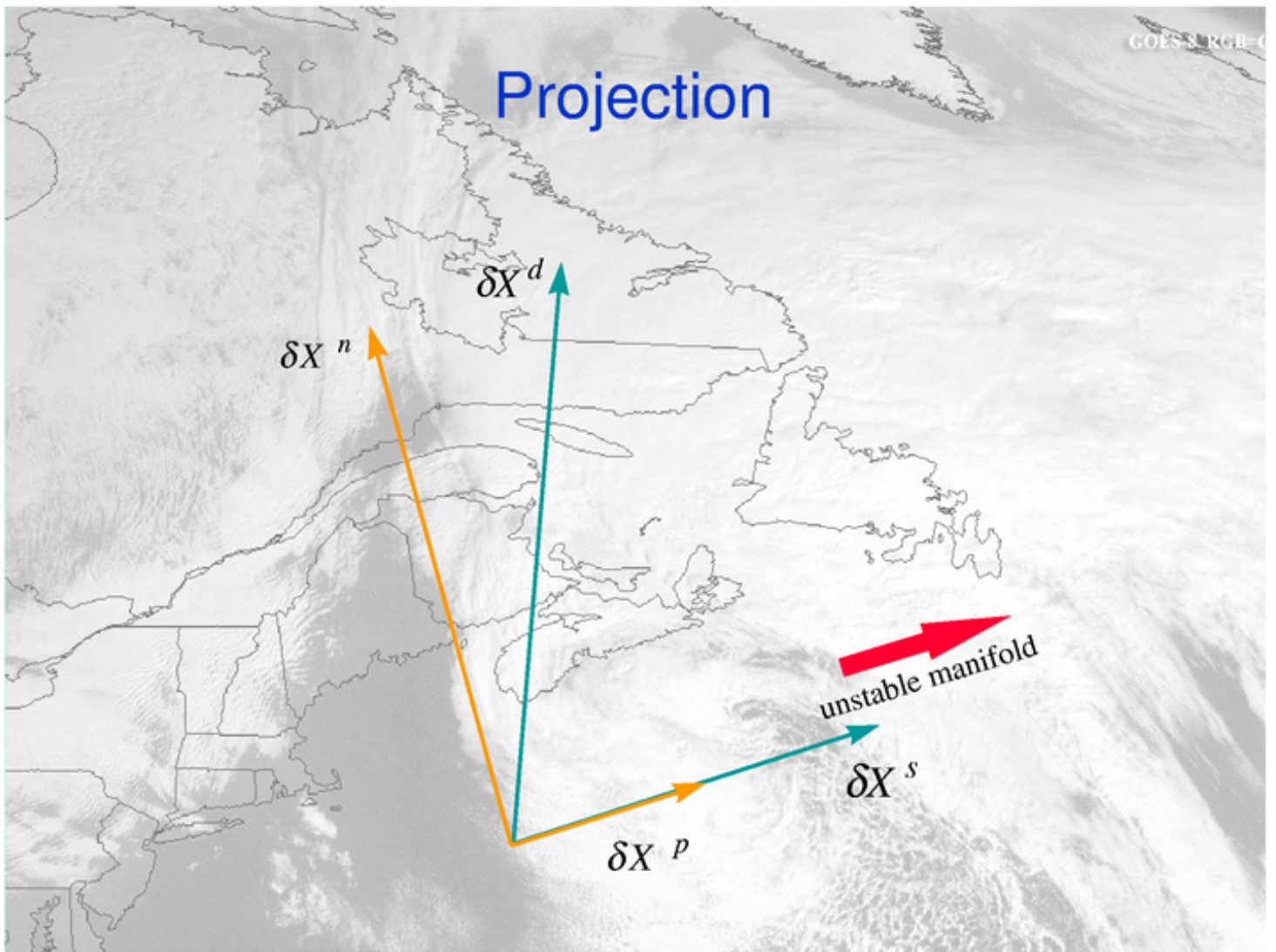
00h

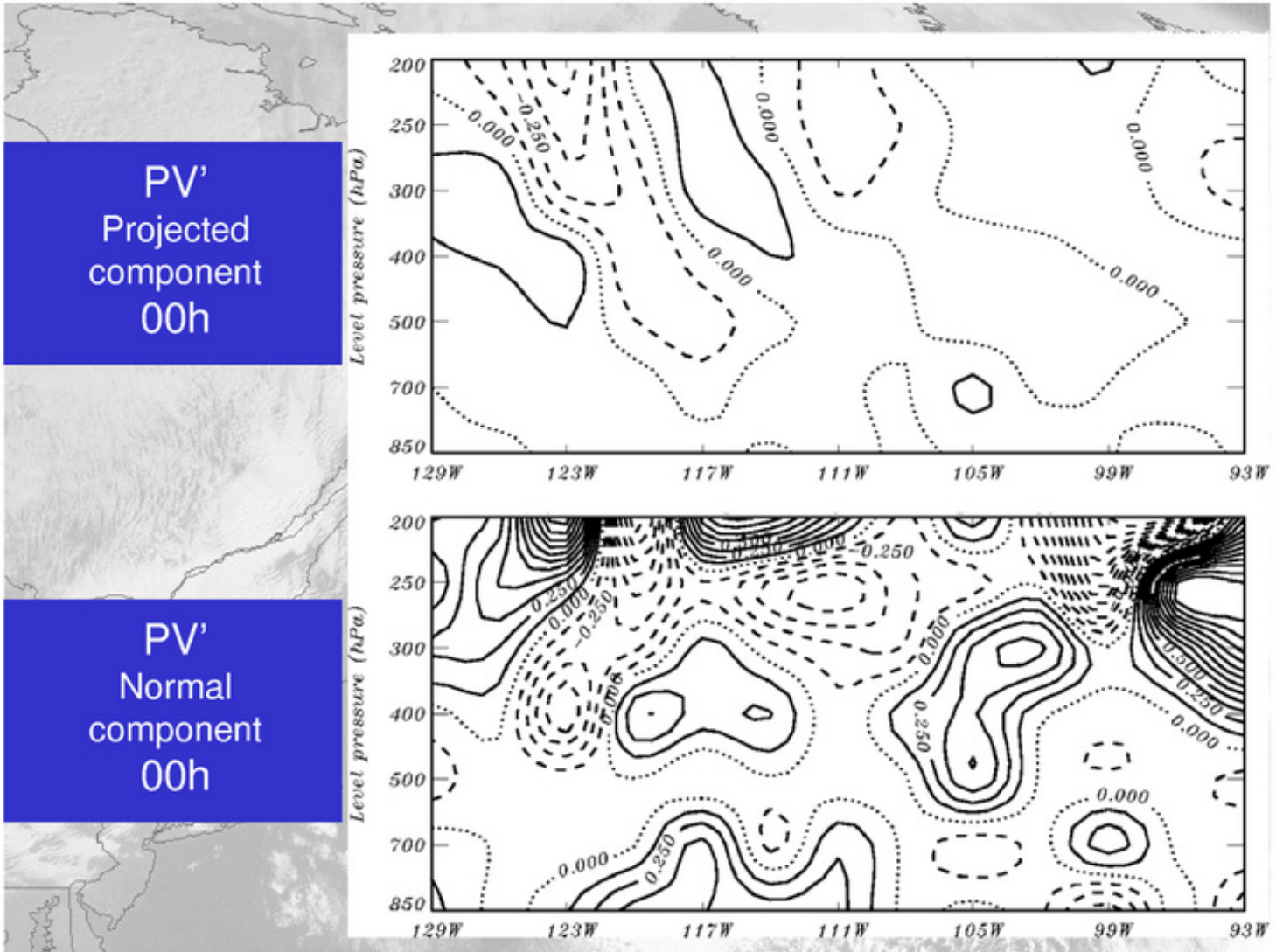
24h

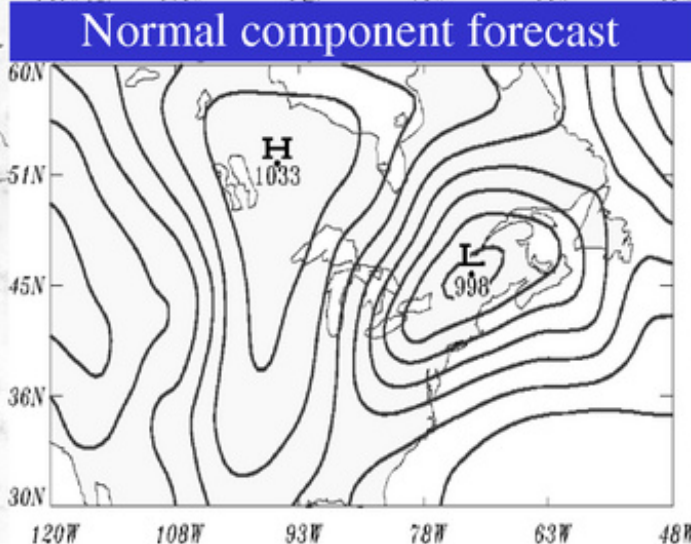
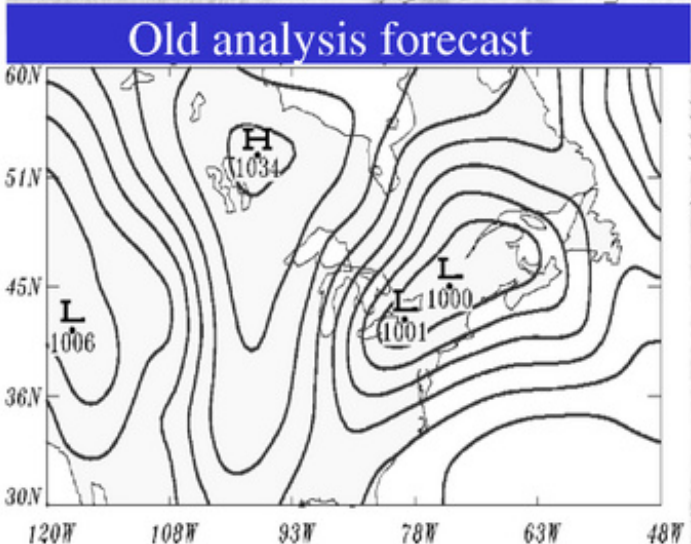
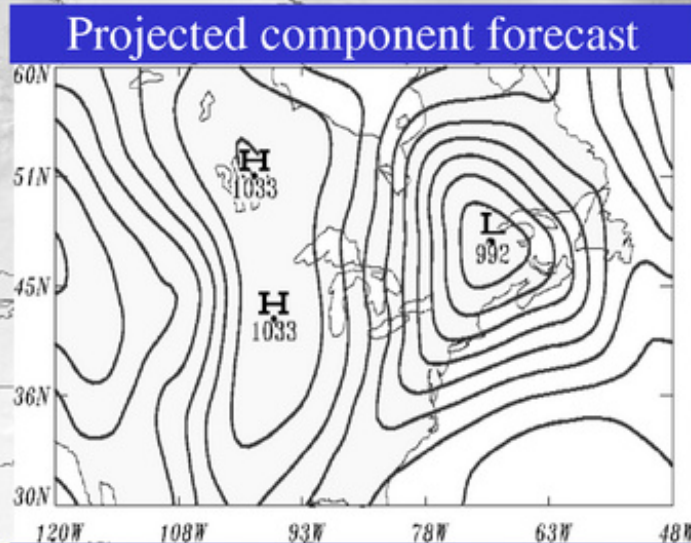
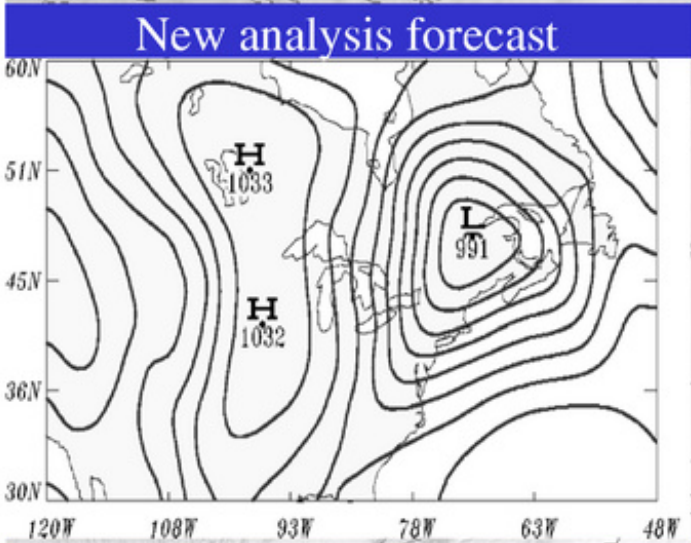
48h













Conclusions

- The key analysis error algorithm was able to locate the main area of analysis errors responsible for the forecast failure;
- The algorithm was able to extract the component in the new 3D-Var responsible for the forecast improvements;
- Although δX^d is three times more energetic than δX^s , only 13% of δX^d projects onto δX^s . We showed that this small component of δX^d is however responsible for most of the improvements.