Providing an increasing range of CMC Numerical Environmental & Weather Prediction to expert users

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World Weather Open Science Conference
Palais des Congrès, Montréal, August 17th 2014
Summary

- Introduction
- Link to MSC’s Service Strategy
- Canadian Meteorological Center NWP production
- How to provide access to expert users
- Future Trends & Challenges
Providing NWP guidance to a wide range of users

Numerical Weather Prediction (NWP)

- Raw model output
- Post-processed model output

Meteorological Service of Canada Forecast Offices

Analysis
- Added-value
- Production of official forecast

Warnings
- Public, Marine, Aviation, Air Quality, Etc.

Broad range of Users

Additional added-value
- Impact based assessment
- Warning Preparedness
- Meteorologists (WPM)

Emergency Measures Organizations (EMO)
- Provincial and Municipal agencies
- Etc.

General users

Expert users
- Also, specialized access

Under cost recovery
Meteorological Service of Canada’s Services Strategy: 4 client-focused goals...

Goal 1 – Authoritative Alerting of Canadians to High Impact Weather & Water Events:
  ▪ Canadians and public authorities involved in public health and safety are provided with authoritative and timely alerting of high impact weather and water conditions and how these might affect them, on time scales of minutes to seasons.

Goal 2 – Quality Services in Support of the Decision-making of Public Authorities:
  ▪ Public authorities and institutions are provided with weather, water and climate information to support operational program decisions and policy development using cost-effective business approaches and innovative collaborative arrangements.

Goal 3 – Advanced Access for all Canadians to MSC Information
  ▪ Canadians are provided with timely and relevant weather, water and climate information for personal decision making.

Goal 4 – Targeted Services to Economic Sectors
  ▪ Weather sensitive industries and the private-sector meteorological industry are provided with weather, water and climate information to support business decisions and value-added services using cost-effective business approaches.
Canadian Meteorological Centre (CMC), Dorval

Meteorological Research Division (S&T): Data Assimilation, Modeling, Cloud Physics

National Prediction Development: Data Assimilation, Numerical Weather Prediction, Weather Elements, Scientific Applications

IT Infrastructure (SSC): Supercomputer, National Telecommunications, Network, User support

CMC Operations Analysis & Prognosis, Environmental Emergency Response, Air Quality Modeling Application, Implementation and Operational Services
Efficient technological transfer from Research and Development into Operations is critical to improve Weather and Environment Prediction.
• Remote sensing, monitoring
• Weather trends, Hurricane Forecasting

- Severe Weather Forecasting today and tomorrow
- St-Lawrence hydrodynamic modeling
- Severe Weather forecasts for today,
- Air Quality

- NAEFS, Probabilistic forecasting
- Emergency response, national and international

CanSIPS - Canadian Seasonal-Interannual Prediction System
Climate trends: La Nina, El Ninjo

Main NWP components
Global Deterministic Prediction system (GDPS)

- 10-day forecasts; 2 runs per day
- Horizontal resolution: 25 km
- 4D-Var Assimilation

To come:

2014:
- EnVar replace 4DVAR
- IAU: fix cloud & precip spinup
- still more satellite data
- 4D treatment of raobs

2016:
- Yin-Yang grid
- Resolution: 15 ou 10 km
- Surface assimilation: CalDAS

8 Millions observations are actually assimilated from the 800 Million received
Global Ensemble Prediction System
(GEPS)

- 20 members + control
- 16-day forecast twice per day
- Horizontal resolution: 66 km
- Assimilation: EnKF 192 members

To come:
2014:
- From 66 km to 50 km
- EnKF: from 192 to 256 members
- more satellite data
- 4D treatment of raobs
Regional Deterministic and Ensemble Prediction Systems (RDPS & REPS)

**RDPS: 10 km**
- 2014: EnVar replace 4DVar

**REPS: 15 km**
- 20 members + control
- 3-day forecast twice per day
- No assimilation yet. Initial conditions from Global EPS

**To come:**
- From 15 to 10 km
- From 3 to 5 days
- From 2 to 4 times/day

- EnVar or REnKF assimilation
- Surface assimilation: CalDAS ens
- Coupling with ocean-ice model
High resolution deterministic prediction system (HRDPS)

- 4 domains
- Resolution: 2.5 km
- Frequency: 1 run /day but western domain (2 runs /day)

To come in 2014:
- Pan-Canadian domain; 4 runs /day, 0-48 h
- Reduced cloud and precipitation spin-up
- Surface assimilation (CalDAS 2.5 km)
Expansion into integrated ocean-ice-atmosphere NWP systems

Regional Ice Prediction System (RIPS)

- 5km N.American grid
- 3DVar Ice analysis
  - SSMI, AMSR-E, CIS daily charts
- CICE4.1 Ice model
  - Forced by regional RDPS
- 48hr forecasts at 0, 6, 18, 24Z
- Experimental implementation: March 2013

Global Ice-Ocean Prediction System (GIOPS)

- Mercator Ocean Assimilation System (SAM2-SEEK):
  - Sea surface temperature
  - Temperature and salinity profiles
  - Sea level anomaly from satellite altimeters
- 3DVar Ice analysis
- Daily blended ice-ocean analysis and 10day forecast
- Model configuration:
  - ORCA025 (~1/4°), <15km in Arctic
  - NEMOv3.1, LIM2-EVP
- Experimental implementation
Application example… «FireWork»: Smoke emissions from Forest Fires using GEM-MACH air quality model

- Assessing air quality impact (PM2.5) from forest fires
- Uses the same set-up as the operational AQ forecast, with the addition of forest fire emissions over N-A
- Emissions based on remote-sensing (MODIS, AVHRR), near real-time, Inclusion of “old smoke” from the previous run, Run twice a day

Forest fire locations (NRCan), 13 July 2014

Surface PM2.5 from forest fires, 24 hour forecast valid 00Z 15July 2014
Managing increasing NWP data volumes: NWP production each day

Current operational production: 5 000 GB (5TB) of data per day

Data management of operational system requires 1 000 TB (1PB) of disk space.

Plus significant additional disk space for archive needs.
Managing increasing NWP data volumes: Graphical map production each day

Based on that 5TB of NWP input (including additional post-processing) operational production of:

476,000 graphical maps per day

Probabilistic Guidance (i.e. NAEFS)  
Deterministic Guidance
Accessing NWP: MSC Datamart

• Free and Open access for specialized users
• Authoritative weather data (real-time observations, warnings, public forecasts and NWP) on an http server
• Anonymous, free data download service. Formats: GRIB, XML, PNG, CSV
• 24/7 infrastructure, business hours user support

• Each day, on average, 805 GB of data, in 14 million files, are downloaded from 500,000 unique IP addresses.
• Beta-testing an ‘AMQP Notification Service’ (Advanced Message Queing protocol : optimizing data “push”)
• License: Datamart Open Data License. Credit to EC should be mentionned.

• http://dd.weather.ec.gc.ca/
Who are the “expert” users?

• Public sector
  • Provincial agencies and departments, including Emergency Response Organizations
  • State-owned companies
  • Municipalities
  • Academia

• Private sector
  • Weather companies
  • Specialized agencies
  • Mobile applications developers
  • Agriculture, transports, energy, insurance, etc.

• Hundreds of thousands of ordinary people (through third-party mobile or web applications)
Managing increasing NWP data volumes: NWP datasets provided on MSC Datamart each day

Based on the **5TB** of operational NWP input (*including additional post-processing*) we make available on MSC Datamart:

- **90 GB of data per day**
  - (1.8% of total daily NWP production)
  - **Global Forecast System**
  - **Regional Forecast System**
  - **High Resolution 2.5km windows Forecast System**
  - **Global Ensemble Forecast System**
  - **12 GB per day**
  - **9 GB per day**
  - **9 GB per day**
Managing increasing NWP data volumes: Trends in daily NWP production

- 2010: 5,000 GB per day (5 TB)
- 2014: 25,000 GB per day (25 TB)
- 2017: Estimated increase

Graph showing the increase in daily NWP data production from 2010 to 2017.
Web services, a paradigm shift

- Accessing and visualizing data products and raw data
- No file download involved for visualization
- Layers are served on-the-fly, there’s no pre-generated images
- Data is sent only for a client-specified geographic extent and scale, it is lightweight bandwidth-wise
- Data is always the latest available
- Enable users to integrate the layers directly into their tools
- **Important to distinguish geospatial web services (dissemination and access) and web maps (visualization), serving data via geospatial web services is required to display it on web maps**
MSC GeoMet

- Publicly available geospatial web services
- Standards supported: Web Map Service (WMS) and KML
- The latest available data served on-the-fly for client-specified geographic extent via web services (no file download)
- Suited for interactive web maps, graphs and direct integration in client-side tools: web, mobile and desktop
- Data currently served by MSC GeoMet:
  - North-American weather radar mosaic
  - NWP forecast model layers and data: GDPS, RDPS, HRDPS, RAQDPS, RDPA
- Officially launched in July 2013, now about 100,000 map layers served on week days
Public GeoMet usage examples

nXstream

UberWeather

ArcGIS Online
NWP… main future trends ….

• Further increases in data assimilated and increases in model resolutions with emphasis in ensemble forecasting approaches (probabilistic forecasts, threshold probabilities, risk assessment, forecast confidence, etc)

• Expansion of model applications in environmental prediction that rely directly on the outputs of the « core » NWP systems (regionally and globally)

• Increase in ocean modeling and coupled atmosphere-ocean modeling for integrated system approach…

• Focus on improvement forecast capabilities in urban meteorology and in the Canadian Arctic

• Cover the entire spectrum from minutes to seasons and run integrated systems as much as possible

  • Continued increase in the quality, accuracy and the amount of data!
  • Increase in scope of applications and in integrated modeling systems
  • Increase in probabilistic type products
How our dissemination approaches should evolve to meet these trends in NWP?

• Continue to expand and facilitate access using cost-effective data access approaches (i.e. MSC Datamart)
• Further develop web services dissemination approaches (i.e. WMS format offering such as through GEOMET)
• Improve and develop web access for specialized graphical products (which might not be suitable for the generic public weather web site)
• Emphasis on expanding access to probabilistic based products form ensemble prediction systems (NAEFS, etc.)
User needs, decision making, probabilistic guidance...

• Important to have a better understanding of our users decision making process, how they can benefit from the current and future NWP guidance products, including the ingestion of these directly into their decision support systems.

• Provide products that let the user determine the critical thresholds that impacts its processes…

• Important to invest in outreach and education to inform users of what products are available and how these could support their decision making process

• Users are becoming more knowledgeable on how to use uncertainties and probabilistic information but we need to increase that knowledge and use, improve linkages with users to develop relevant probabilistic products and increase their use.
Providing access to increasing NWP data volumes: Some *additional* considerations…

- Costs to maintain IT infrastructure (disk space, bandwidth, overall support): need to ensure cost-effective and flexible access methods.
- Security of IT systems / Standards
- Data access policies (basic service VS specialized) / Open Data framework
- Data mining / Metadata / Information on available content
- Archives… accessing the archive « gold mine »…
- Meeting the needs for highly specialized access (R&D, extracting full 3D boundary conditions to run local models, etc.)
Conclusion

• Increase in accuracy and of a widening range of NWP datasets, including in terms of probabilistic guidance

• Challenges to engage with the user community to maximize their use of the NWP guidance information…Training and communication - Dialogue !

• Challenges to maintain and increase cost-effective dissemination approaches (web, datamarts, web services, apps, etc.) to provide access to the NWP data

• Opportunity to share with other agencies in particular NWP centers that provide data to users on best practices and on « Big Data » management issues !