Recent changes to and further plans for the operational production system at the Canadian Meteorological Centre

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June 27th, 2008

- CMC Implementation and Operational Services
- FY 2007-2008 in review
- Ongoing and upcoming work
- Data products
- Conclusion

Implementation & Operational Services

Mission:

- Run, oversee and protect the integrity of operational automated prediction and meteorological data processing
- Manage implementation projects from Development to Operations
- Manage the NWP archive and online data

Implementation & Operational Services

Running, maintaining and developing an automated environmental prediction system that is...

- Robust
- Reliable
- Timely
- Reproducible
- Re-run safe
- Scientifically and informatically validated
- Easy to maintain and upgrade
- Documented
- Supported 24/7

In a real-time, uninterrupted, ISO 9001-compliant production environment.

Implementation & Operational Services

Our main clients:

- Storm Prediction Centres, Aviation Meteorology Centres and meteorologists at military offices, who need input from automated prediction products in 24/7 real-time
- An internal EC client base of meteorologists, emergency responders, researchers, managers and developers (both as users of data products and technological transfer partners)
- EC Service outlets catering to an external client base, including Nav Canada, National Defence, the private sector, academia, and other government levels

Infrastructure and Operational Runs

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Operational Systems

Automated NWP systems:

- Data Acquisition and Assimilation
- Numerical Weather Prediction
  - Deterministic (regional, global)
  - Ensemble (global, NAEFS)
- Downstream models:
  - Atmospheric Chemistry
  - Airborne contaminant trajectory and dispersion
  - Wave forecasting
- Air Quality Health Index
- Product generation (including SCRIBE matrices, GRIB, graphics)
- Operational Verification

Operational Systems (non-NWP)

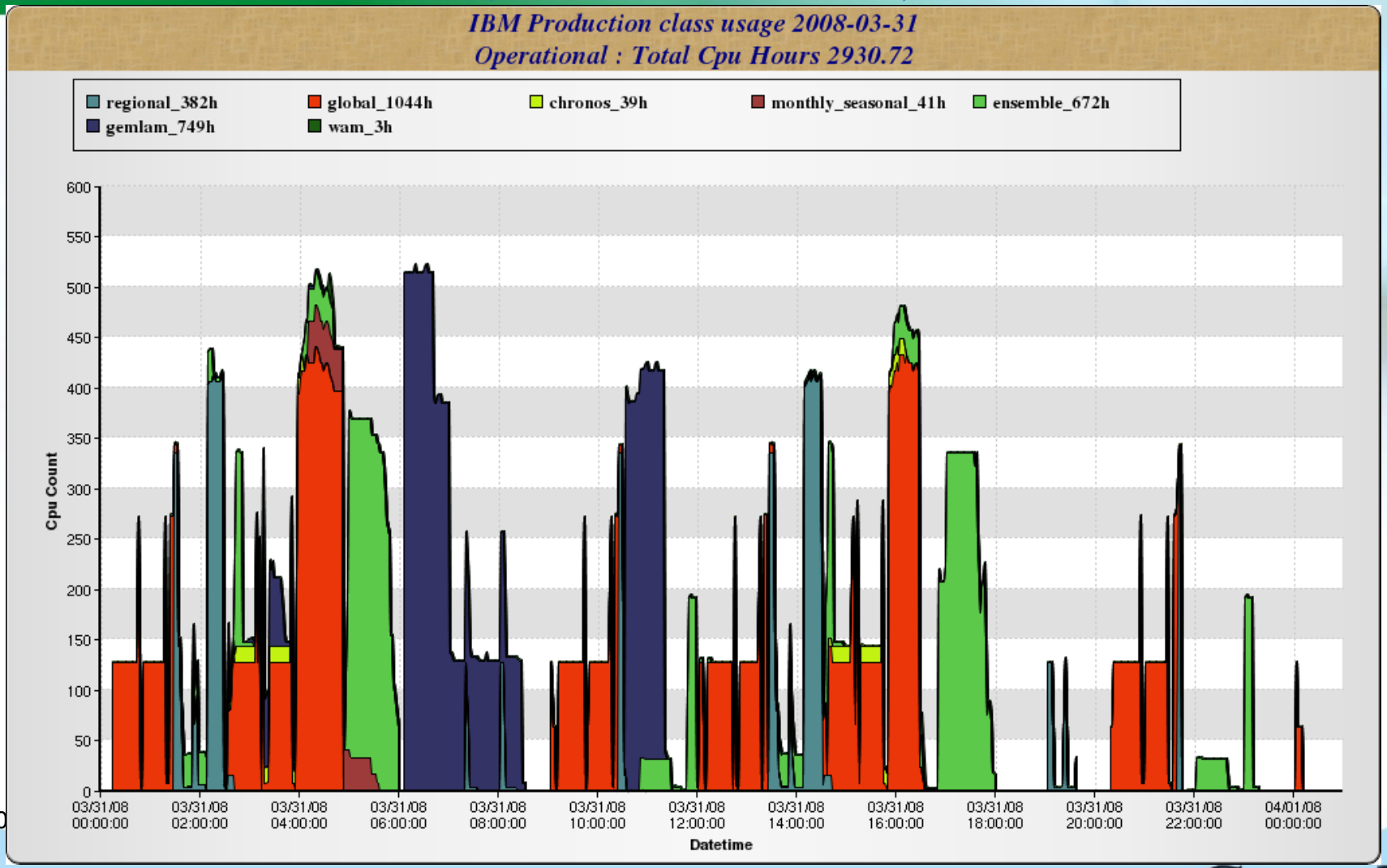
- Archives (NWP data, Observed data, selected products)
- NURP National Unified Radar data Processor
- Satellite imagery processing

Operational Systems (experimental)

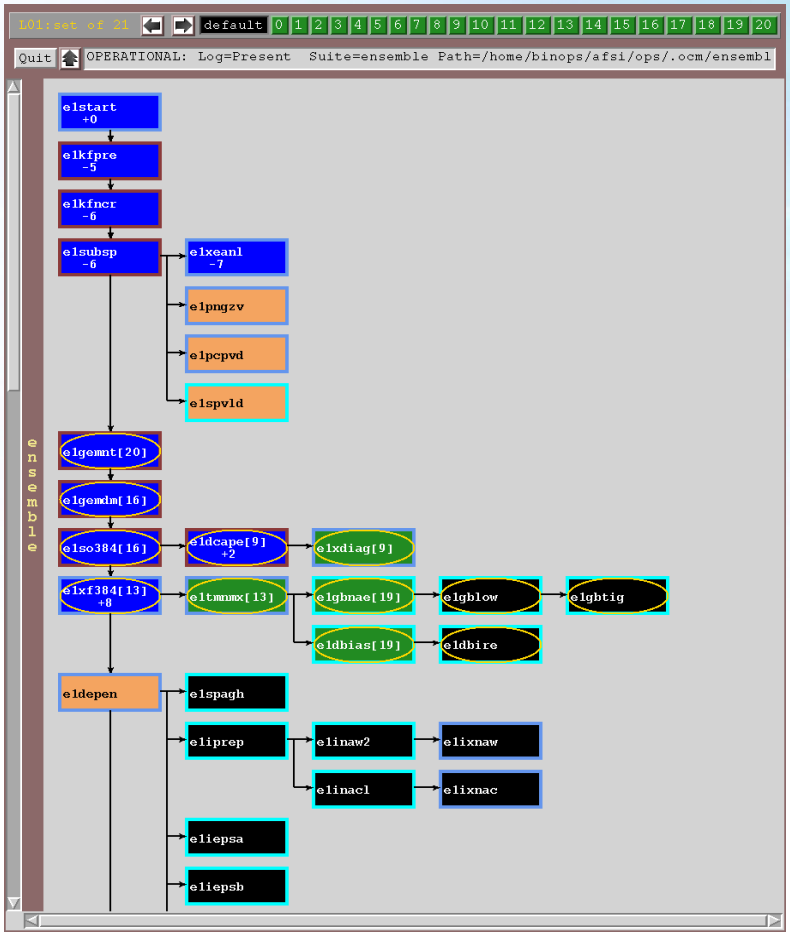
Experimental systems in operational setting:

- LAM 2.5 km: 4 domains
  - Atlantic Canada, Central, Baffin, West
- Coupled Atmosphere/Ocean/Sea ice model over Gulf of St-Lawrence
- UMOS AQ (summer 2008)

Operational runs on Naos supercomputing cluster (March 31st, 2008)



Example: Flowchart for run E112 from the Ensemble suite



- **Suites** (Global, Regional, Ensemble, etc)
  - **Runs** (G100, R206, ...)
    - **Jobs** (R1GEMMD)
- Data processing and post-processing in each run is organized in a tree structure with a logical flow and dependencies

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FY 2007-2008 in review

- Major upgrade to EPS system : 20-member 0.9 degree global GEM, 96-member EnKF data assimilation at appropriate time. Multi-parametrization approach.
- North American Ensemble Forecasting System (NAEFS) became operational
- TIGGE data transfers became operational
- 6-hour Regional GEM data assimilation spin-up (down from 12 hour spin-up), 3D-Var FGAT regional analysis
- AIRS, SSMI, QuickScat data in assimilation system
- UMOS V.9 in Regional System

FY 2007-2008 in review (cont'd)

- New – Experimental Atmospheric/Oceanic/Sea-ice model in operational environment
- New – Air Quality Health Index system (Phases I, II, III)
- Seasonal forecasting system upgraded to 4 models (from 2)
- Improvements to experimental 2.5 km LAM models, 2 new domains, + MAP D-Phase participation in quasi-operational mode
- Migration of graphics post-processing to new Linux cluster

North American Ensemble Forecast System
(« *NAEFS* », *Canada-US-Mexico*)

- Operational exchange of ensemble forecast data between CMC and NCEP
- Production of day 1-15 probabilistic products based on pooled ensemble members
- Forecasts cover all of North America, common products possible. Increasingly seen as operational counterpart of TIGGE.
- Experimental forecasts available for Canada, US, Mexico

http://weatheroffice.ec.gc.ca/ensemble/index_naefs_e.html

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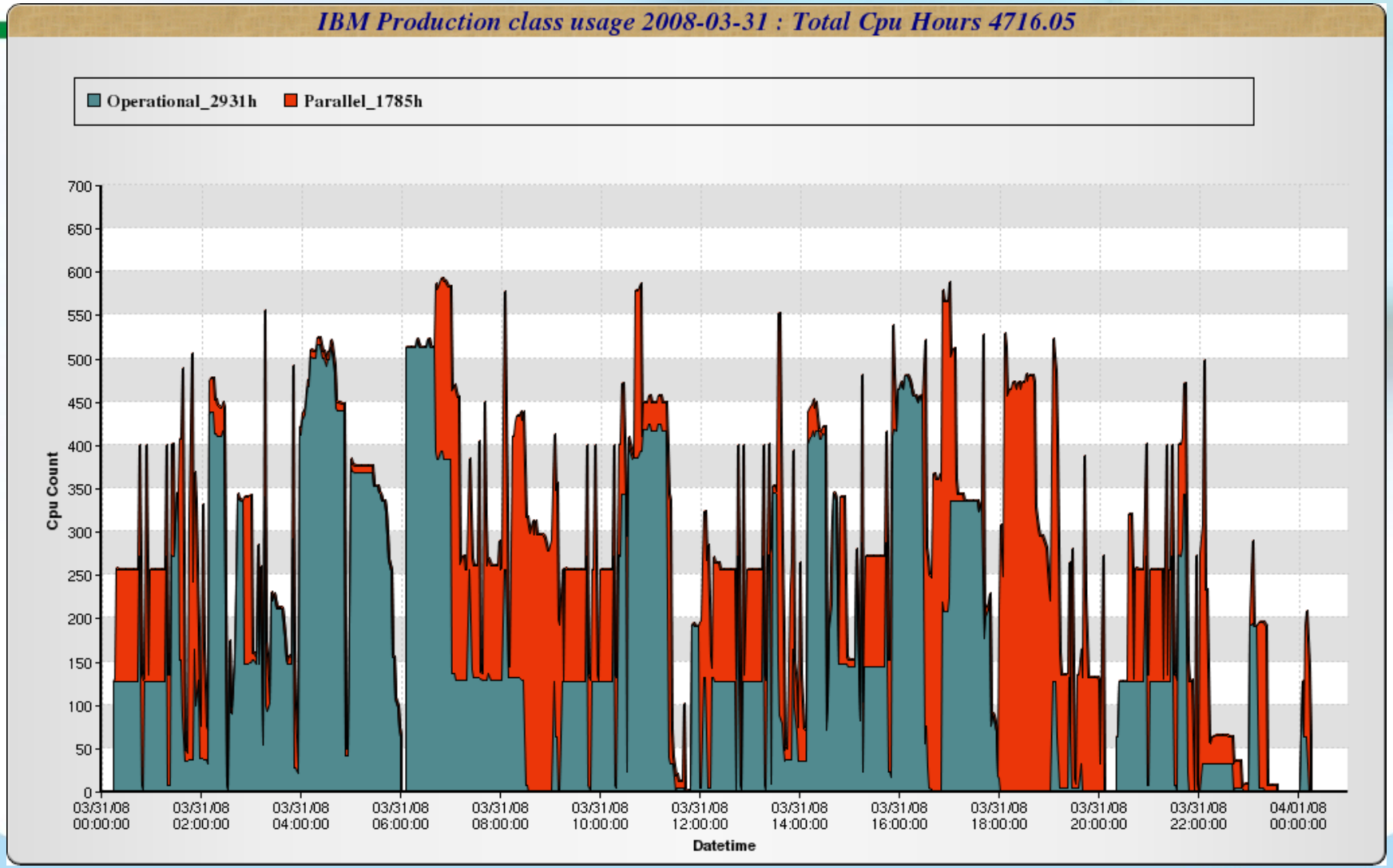
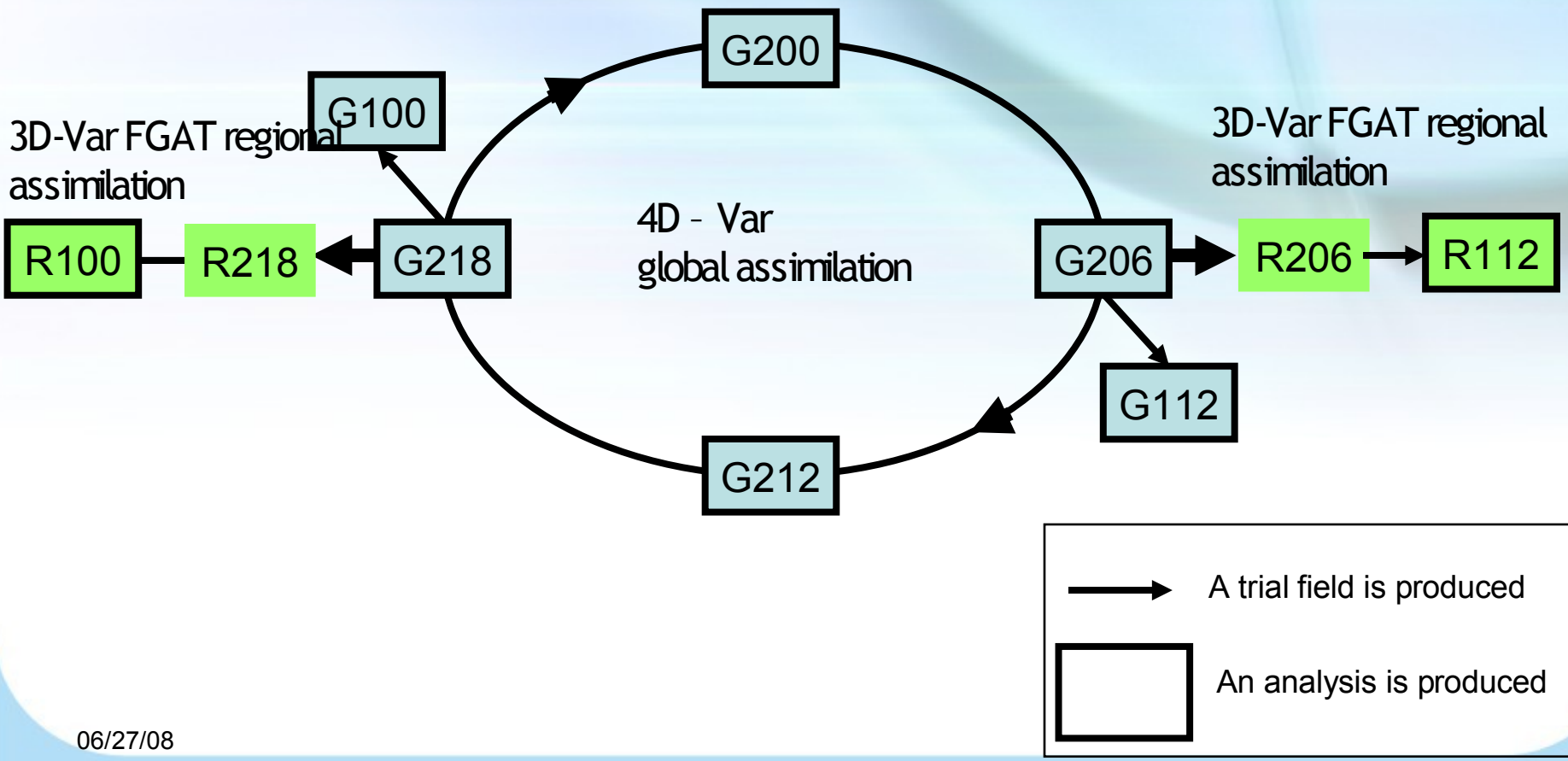
March 31, 2008 on Naos supercomputing cluster



CMC upper air run cycle (deterministic) with 6-hour regional cycle

Since July 4th, 2007



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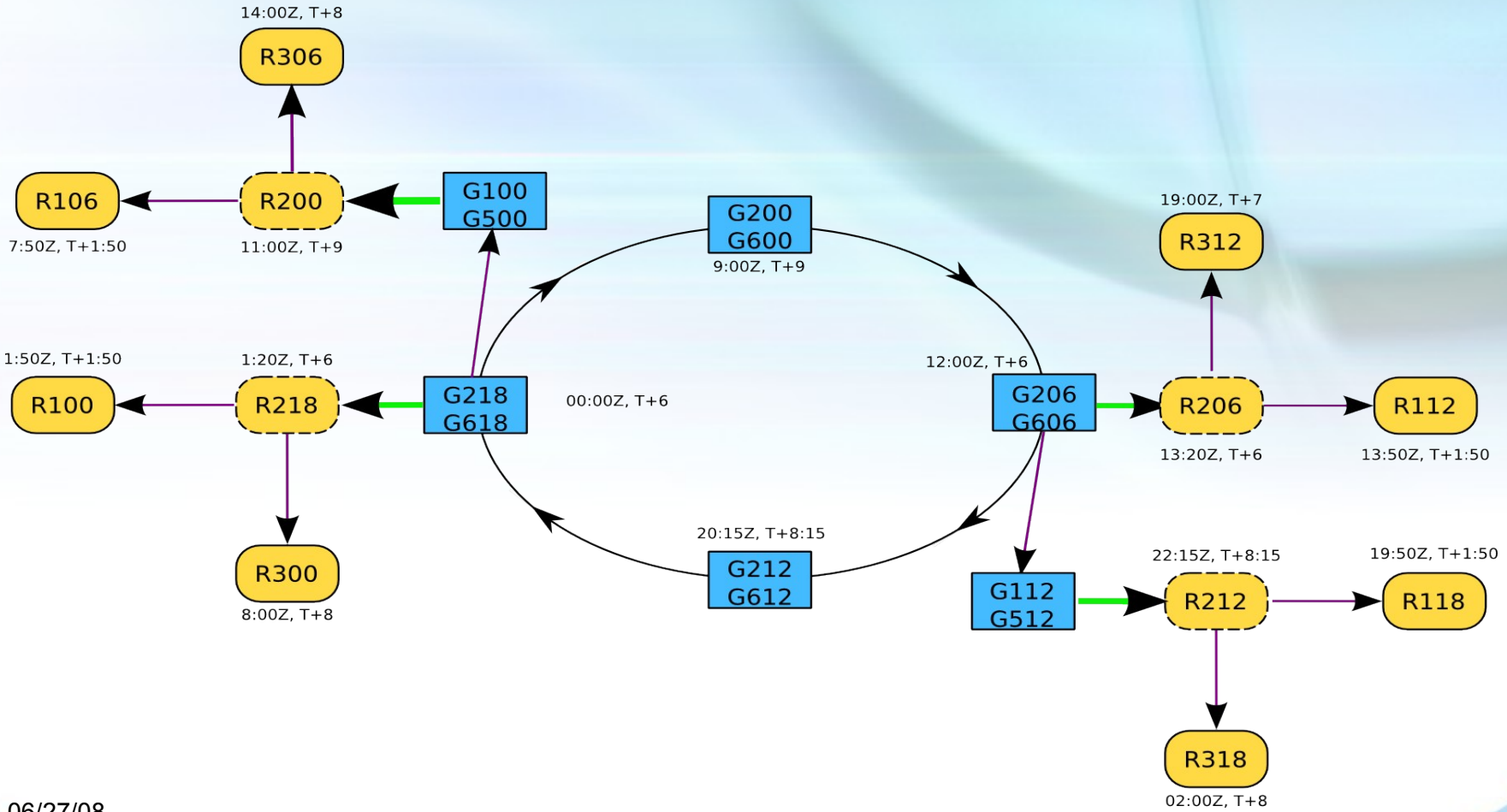
Proposed cycles with 4x per day Regional GEM production



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Ongoing and Upcoming Work

2008 forecast system upgrades

- Regional GEM forecasts and post-processing 4 times a day (2008 through March 2009 to allow migration of post-processsing)
- Regional GEM with new radiation scheme and extended domain
- MACH-GEM atmospheric chemistry model (summer 2008)
- Coupled model Phase II (Atmosphere-Ocean-Sea ice)

Ongoing and Upcoming Work

2008 forecast system upgrades (cont'd)

- Addition of new satellite data sources (GPS, METOP, SSMI/S)
- CAPA precipitation analysis
- UMOS Air Quality
- WAM
- Increase of LAM domain for Atlantic Region

Ongoing and Upcoming Work

2009: Further upgrades

- "Strato" Global GEM model with 0.1 hPa top (early 2009)
- SCRIBE matrices extension to days 6-7
- UMOS 2.5 km
- Global EPS upgrade
- Addition of new satellite data sources (IASI, CSR)
- WAM parallel run
- New - Regional EPS (FY 2009-2010)

Other Ongoing Work

- Data availability and access
- Contributing to process improvements and ISO 9001 compliance
- Contributing to more efficient technological transfer
- Operational verification systems (with CMOS – Nicole Bois)
- Operational systems performance measures
- Work on GRIB and BUFR (WMO codes)

- Implementation and Operational Services
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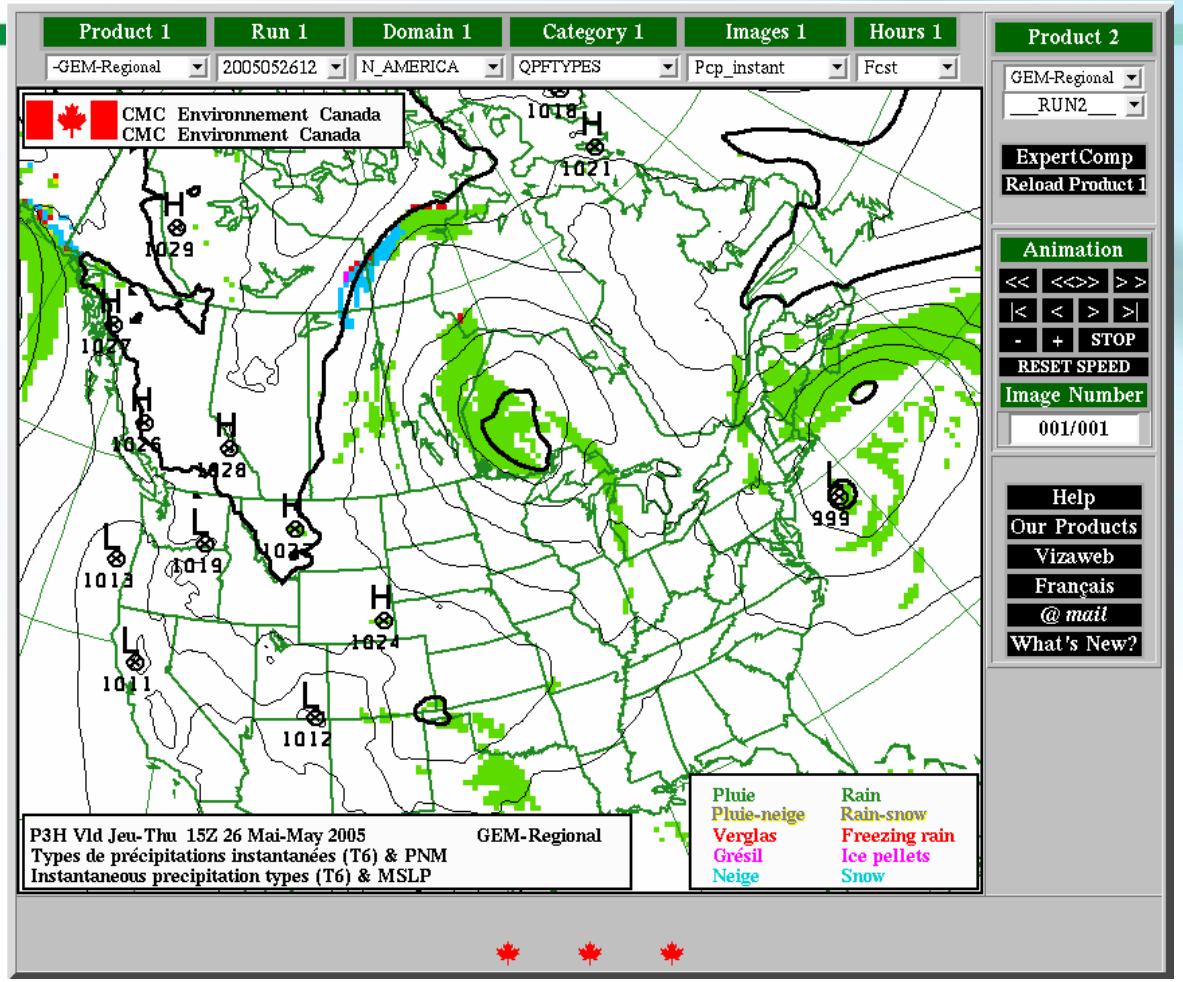
Vizaweb: for quick view & comparison of CMC's NWP ouputs



- Over 65 000 images per day
- Access to 260K images on-line
- High priority images delivered 15 min after model output

http://iweb.cmc.ec.gc.ca/cmc/vizaweb

Other products

- GRIB data access on weatheroffice
  - *Popular, free NWP data service*
  - *Over 150 registered users of the high resolution data*
  - *Wide range of corporate, academic, government users*

- CMC Product Guide: made available on external server
  - collaboration.cmc.ec.gc.ca/cmc/CMOI/product_guide/index_e.html
  - collaboration.cmc.ec.gc.ca/cmc/CMOI/product_guide/index_f.html

Conclusion

- Major forecasting system upgrades implemented in the last year
- Much still awaiting implementation in 2008-2009
- Continuing trend towards implementing environmental prediction applications into the CMC operational runs
- Operational automated applications suite continues to grow

Conclusion

- Ongoing work to improve the technology transfer process as systems become more complex and number of partners increases (MSC National Labs, EC Research, private sector, universities, etc.)
- Ongoing work to improve access to NWP data and documentation
- Ongoing work to review, modernize current operational products or retire legacy products

Implementation & Operational Services

Our services:

- Production management and 24/7 production troubleshooting support
- Technological transfer project management
- Meteorological data management (live and archived)
- Meteorological data standards management (in-house & WMO)
- Technical services and expert consultation

Operational Systems

Automated NWP systems:

- Data Acquisition, Assimilation (4D-Var, EnKF, Surface)
- Numerical Weather Prediction
  - Deterministic
    - Global GEM
    - Regional GEM
  - Ensemble
    - Global Medium Range (20 GEM models + control)
    - North American Ensemble Forecasting System (NAEFS)
    - Global Seasonal (GCM2, GCM3, GEM-CLIM, SEF (time-lagged over 6 days))

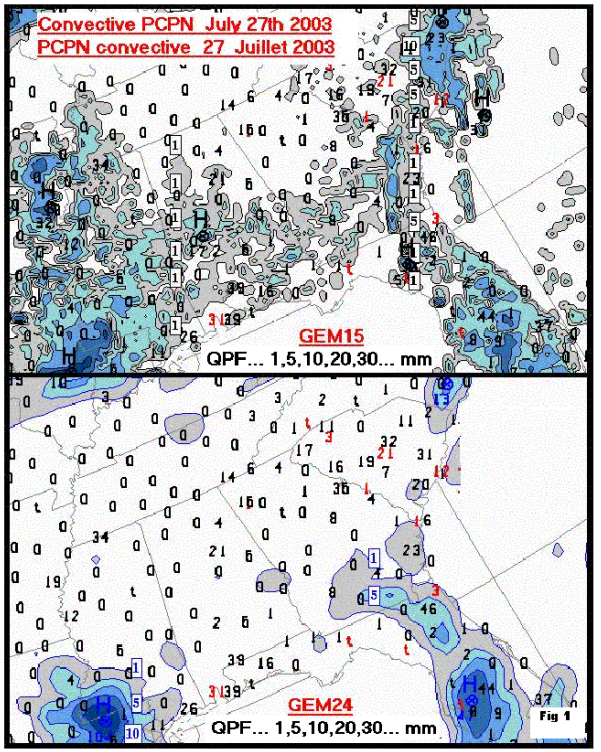
Operational Sytems

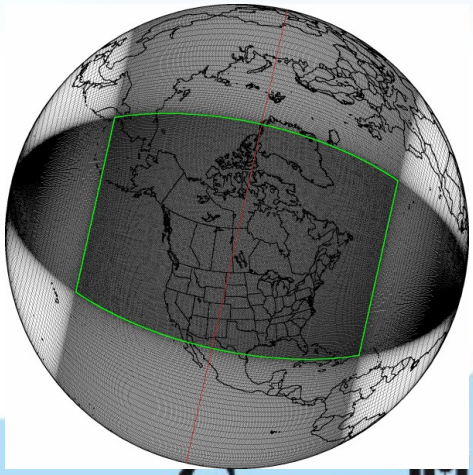
Automated NWP systems (cont'd):

- Downstream models:
  - Atmospheric Chemistry
  - Airborne contaminant trajectory and dispersion
  - Wave forecasting
- Air Quality Health Index
- Post-processing
  - Statistical Weather Elements Prediction
  - SCRIBE Matrices
  - Graphical products
  - Gridded and digital data
- Operational Verification

Regional GEM model

- FGAT 3D-Var, 6-hour spin-up
- Analysis on 58 levels
(model has 58 levels)
- Same library versions as Meso-Global
- Snow analysis added to surface runs

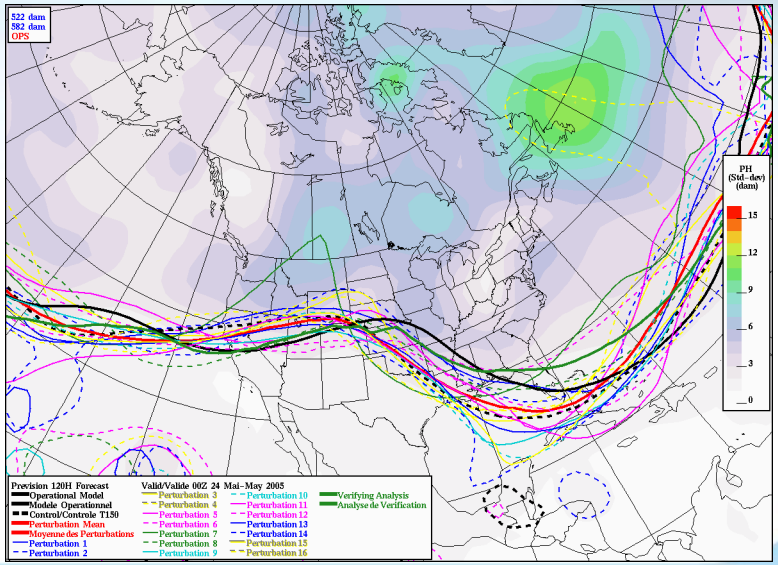




Ensemble Kalman Filter (EnKF)

- EnKF still based on 96 members, multi-parametrization approach
- 0.9 degree resolution (same as new EPS)
- Data assimilation at appropriate time
- Updated member configurations and physical parametrization
- Data flow improvements

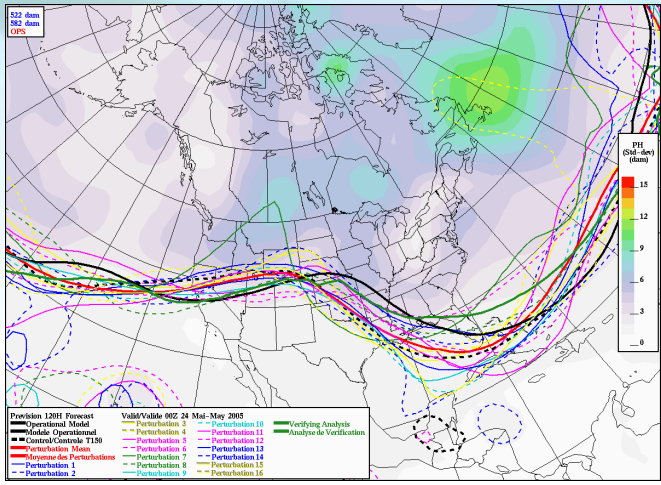
*The ensemble Kalman filter (**EnKF**) is a 4-dimensional data-assimilation method*
*that uses a **Monte-Carlo** ensemble of short-range forecasts to estimate the*
covariances of the forecast error.



Ensemble Prediction System (EPS)

http://weatheroffice.gc.ca/ensemble/index_e.html

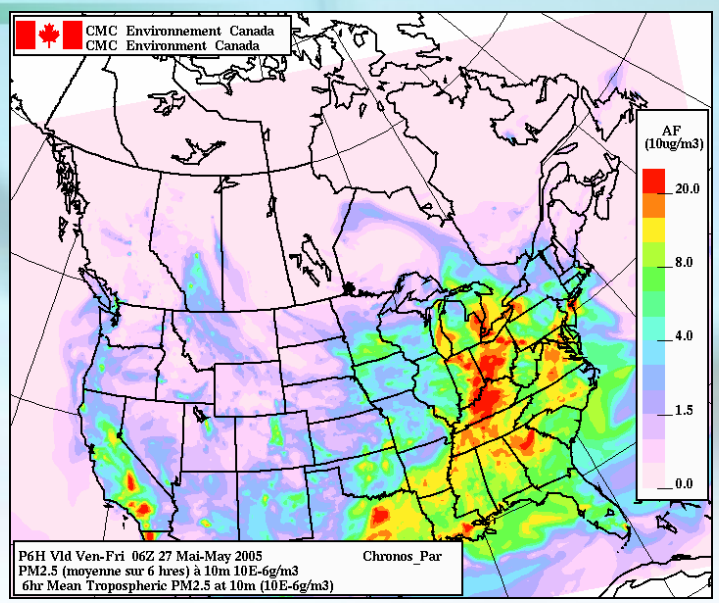
- 20 members (+ control)
- 0.9 degree resolution
- Retired SEF members
- Updated GEM members
- Multi-parametrization approach
- Stochastic physical tendency perturbations
- Stochastic KE backscatter algorithm



CHRONOS model

Atmospheric chemistry and transport model

- 2006 : two runs per day, 00Z and 12Z (Began May 2006)
- 2007 :
  - Updated and corrected emissions
  - Output SO_2
  - Calculation of plume height
  - Updated equilibrium constants for heterogeneous chemistry



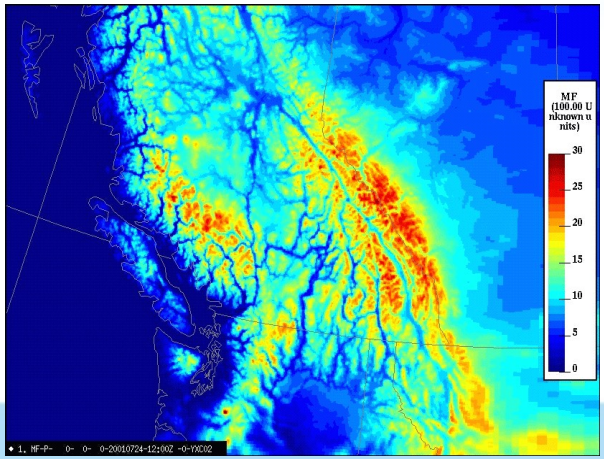
Future:

Eventual replacement of CHRONOS by next-generation model

Meso-scale GEM model

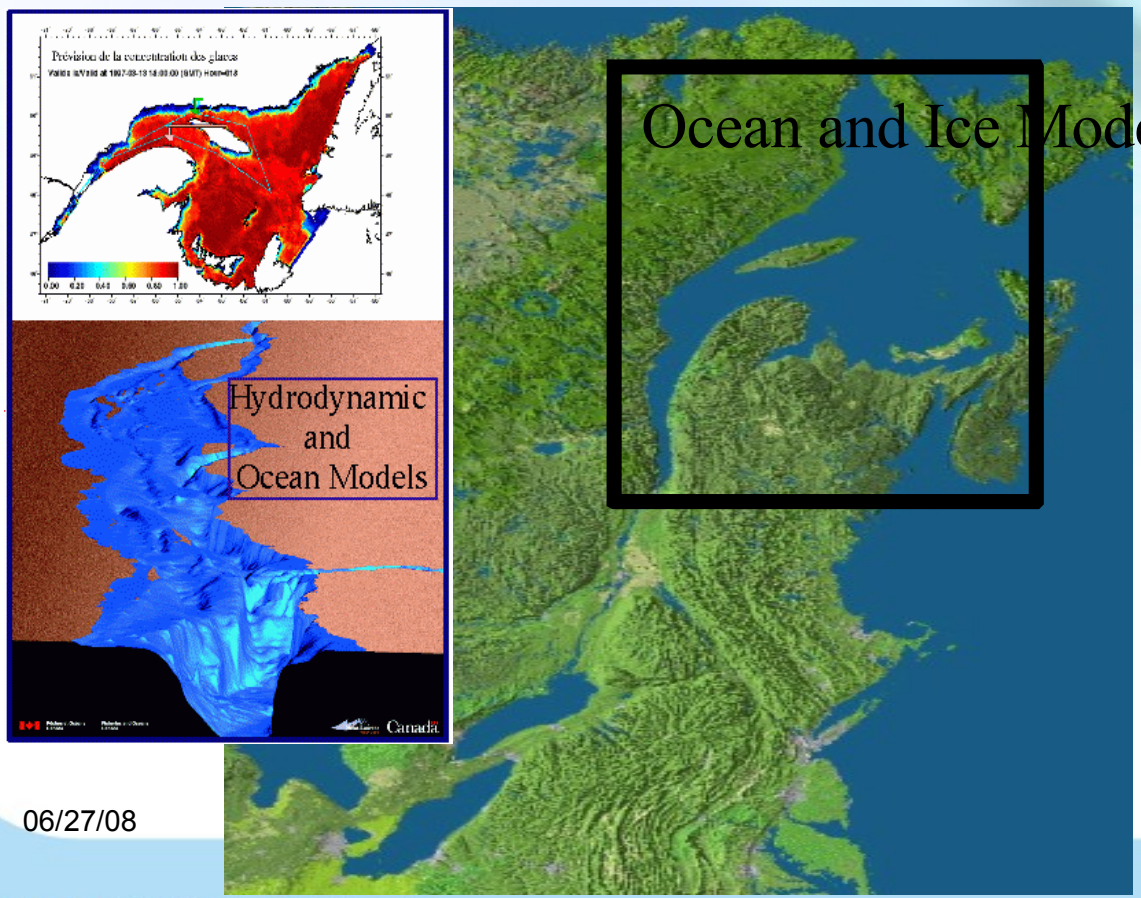
GEM-LAM at 2.5km

- Experimental production run to evaluate operational potential
- Four domains executed at night for 24h forecast based on 12-hour regional GEM forecast:
  - Southern B.C. (West), Baffin (North)
  - Southern Ontario-Québec (East), Atlantic
- Domains being added or enlarged on basis of need and computing capacity
- Images from East, West model output available on CMC's Vizaweb browser



Coupled modeling over the St-Lawrence

Implementing into CMC the science developed at Institut Maurice Lamontagne (IML)



Coupling Ocean – Ice – Atmospheric models

Being transferred to Operations

Plan to implement in experimental run in Fall 2007

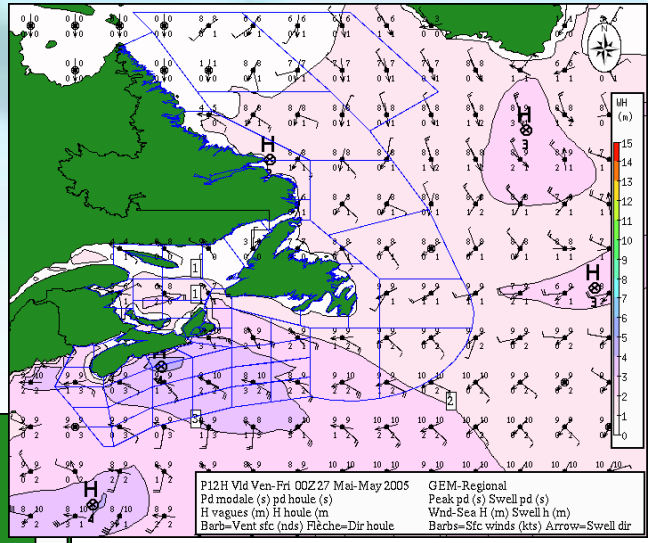
Wave model (WAM)

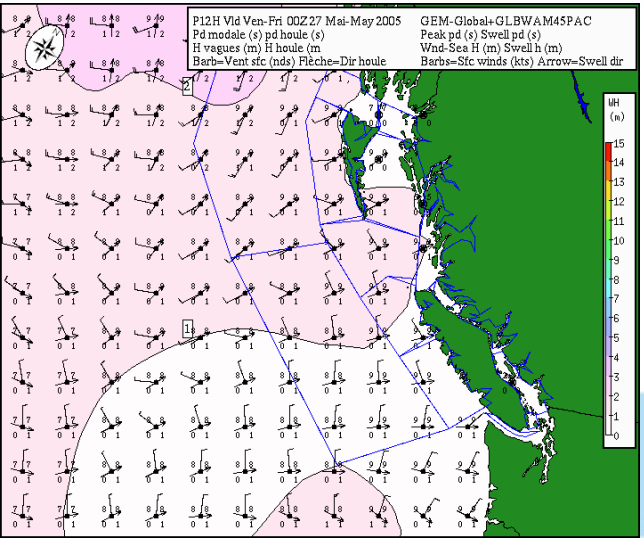
WAM 4.5 running operationally (July 2005)

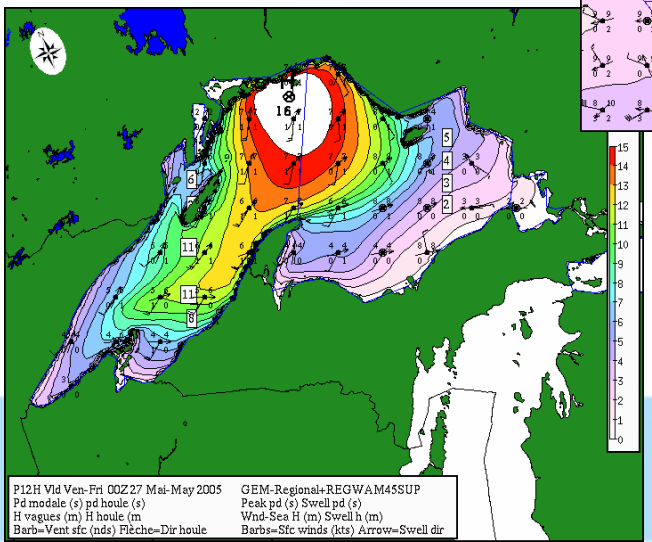
WAM v4.5 at 0.5 degree resolution over Atlantic and Pacific
WAM at 0.05 degree resolution over the Great Lakes

Future:

Review and update WAM products for usefulness, especially over Great Lakes







Canada