Government of Canada Program for International Polar Year (IPY)
2008/09 PROGRESS REPORT

Project Title:
TAWEPI - Thorpex Arctic Weather and Environmental Prediction Initiative

Government of Canada Project Number: 2006-SR1-CC-088	**IPY International Project Number(s):** 638

Project Website (if available):
http://collaboration.cmc.ec.gc.ca/science/rpn/tawepi/en/index.html

Principal Investigator

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Project Team
Please complete this information for each member of your project team. This may include co-applicants, collaborators and other key contributors such as Elders and students. Please indicate northern team members with a *. Add additional rows as necessary.

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1. Plain Language Summary

Provide a plain language summary of the project, including essential background information, purpose of the project, a description of the progress to date, key activities and early results. This summary will be made available to the public and should be written at a level appropriate for a popular magazine or newspaper. (500 words maximum)

Weather and Environmental Prediction (WEP) constitutes one of the most important technological and societal successes of the last century. The positive impact of WEP on health, safety and economic competitiveness is recognized worldwide. The benefit of WEP applications in polar regions has been somewhat delayed due the higher priority of forecasting in the more densely populated southern regions. Concerns about an amplification of anthropogenic climate change at higher latitudes combined with an increasing interest of the federal Government in exerting Canadian sovereignty throughout the Arctic requires a better understanding of weather and climate processes in this region so as to improve our ability to make reliable, quantitative predictions. The International Polar Year provides the important international context for a Canadian-led initiative to improve WEP capabilities for the Arctic.

The primary objective of TAWEPI is to develop and validate a regional Numerical Weather Prediction (NWP) model over the Arctic during the IPY observational period. The proposed experimental model, called Polar-GEM, is a twin of the Environment Canada (EC) operational regional GEM (Global Environmental Multiscale) model, used for one- to two-day weather forecasts. This initiative includes modelling research and data assimilation studies that will help enhance our weather and environmental forecasting capabilities in Polar Regions and improve our understanding of the Arctic and its influence on world weather. These research activities and studies are taking place in various research divisions of EC, in collaboration with the Canadian Meteorological Centre (CMC), the Canadian Ice Service (CIS), the Department of Fisheries and Oceans (DFO), various Canadian universities and other IPY projects.

TAWEPI's research activities started in April 2007 and large progress has been made in the development of Polar-GEM since then. A research version of the model, covering the Arctic basin and surrounding regions is being used to study the representation of radiative and cloud processes in weather forecasts. A multi-layer snow model coupled to sea-ice and blowing-snow parametrizations, describing processes over the various types of surfaces of the Arctic environment, such as sea-ice, tundra, glaciers and ice caps, was tested and evaluated. Using a stratospheric extension of the GEM model, analyses of the stratosphere were generated for the IPY period of 2007/2008, including estimates of the ozone field. A methodology to validate model forecasts of cloud and radiation using satellite hyperspectral radiances was developed. Climatology of the sensitivity of the Arctic weather to disturbances originated elsewhere was generated and archived for the IPY period of 2007/2008. A state-of-the-science sea-ice model is being adjusted to improve the sea-ice representation in the Arctic.

2. Key Messages

Please provide plain language key messages in bullet form, which would indicate progress and/or results thus far. (Maximum of 3 to 5 key messages)

- The development of TAWEPI's Polar-GEM model is taking place in collaboration with the Canadian Meteorological Centre (CMC). A new version of the CMC regional NWP model is expected to become operational in the spring of 2009. The new model, which will include a northward extension of its high-resolution domain covering most of the Arctic, shares many features with Polar-GEM and represents the ideal platform for a future technology transfer from TAWEPI to the CMC.

- Global atmospheric analyses of meteorological and physical variables as well as stratospheric chemical fields have been produced for Feb. 1, 2007 – Feb. 29, 2008 and uploaded to SPARC IPY public data base.

- Daily sets of singular vectors for the IPY period of 2007/2008 were generated, to study the sensitivity of the Arctic weather to disturbances originated elsewhere. Climatology and other statistical and physical properties of these sensitive regions were generated and archived.

- A methodology to validate model forecasts of cloud and radiation using AIRS hyperspectral radiances was developed for global applications.

- Various combinations of microphysical and radiative-transfer schemes were tested and compared in Polar-GEM simulations; their behaviour and benefit on the mean radiative and cloud properties were analysed.

3. Introduction

This introduction to the project should briefly cover the rationale, overall project purpose and objectives, as well as linkages to other projects in Canada and internationally.

In a significantly changing Arctic climate it will be more and more difficult to rely on traditional and climatological knowledge to predict day-to-day to seasonal environmental variability. Indeed, experienced elders and hunters who have been able to predict the weather for most of their lives are finding that recently their prediction skills no longer work and the weather changes they are witnessing are unprecedented. It will be essential to rely on science based forecasting technologies to reduce the impact of weather and related hazards on health, safety and the economy.

The primary objective of TAWEPI is to develop and validate a regional Numerical Weather Prediction (NWP) model over the Arctic during the IPY observational period. The proposed experimental model, called Polar-GEM, is a twin of the Environment Canada operational regional GEM (Global Environmental Multiscale) model, used for one- to two-day weather forecasts. This initiative includes modelling research and data assimilation studies that will help enhance our weather and environmental forecasting capabilities in Polar Regions and improve our understanding of the Arctic and its influence on world weather.

TAWEPI is a component the International IPY-THORPEX initiative. THORPEX is an international research and development program, created in response to weather related challenges of the 21st century, and aiming to accelerate improvements in the accuracy of 1-day to 2-week high-impact weather forecasts, for the benefit of society, the economy and the environment. THORPEX research topics include: global-to-regional influences on the evolution and predictability of weather systems; global observing system design and demonstration; targeting and assimilation of observations; societal, economic and environmental benefits of improved forecasts.

The development of the Polar-GEM model is taking place in collaboration with the Canadian Meteorological Centre (CMC). The development and coupling of the sea-ice model is being done through cooperation among EC, CIS and DFO. Various TAWEPI investigators are members or collaborators of other national and international IPY projects and programs, such as THORPEX-IPY, ArcticNet, the “Circumpolar Flaw Lead” (CFL) project, SPARC-IPY, and the project “Variability and Change in the Canadian Cryosphere”.

4. Activities and Progress in 2008

Please identify the regions in which the activities described below took place:

☐ Yukon ☐ Nunavik
☐ Northwest Territories ☐ Nunatsiavut

☐ Nunavut ☒ Other: Quebec, Ontario, British Columbia

a) Please provide details about the project's progress towards meeting its goals, and include information about where and when activities took place.

TAWEPI's research activities were planned as five PDF and one RA projects, taking place in three EC centres (in Dorval, Downsview and Victoria) dedicated to numerical weather prediction, data assimilation and climate modelling/diagnostics.

As described in the previous report, the research activities in some of TAWEPI's subprojects began later than the planned starting date (April 2007) – mostly due to delays in the approval of funds, in the selection process, and in visa related issues. Therefore, some of the 2-year subprojects, which were supposed to end in March 2009, will continue for a few more months – carry-forward funds will be managed internally (i.e. within EC). Details about the progress made so far are provided below, each subproject being discussed separately.

In the fall of 2008, the CMC began preparations to implement a new version of its operational regional NWP model (an initiative partly funded by LIEP-IPY). Among other changes, the new model will include a northward extension of its high-resolution domain thus covering most of the Arctic. This new regional model is expected to become operational in the spring of 2009. It shares many features with TAWEPI's research model (Polar-GEM) and represents the ideal platform for a future technology transfer from TAWEPI to the CMC.

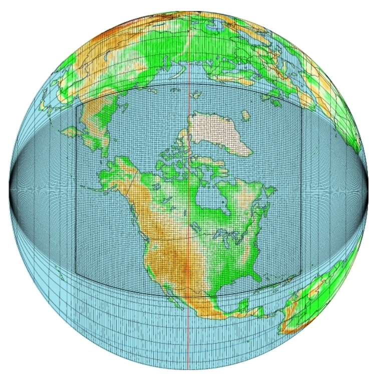


***Figure 1**: Horizontal grid of the extended regional NWP model of the CMC, expected to become operational in the spring of 2009.*

S1.1 - Snow processes in Polar-GEM

The NEW-RPN model, a coupled system including a multi-layer snow model (SNTHERM) and the sea-ice model currently used in MSC's operational forecasting system, was evaluated in a one-dimensional mode using meteorological observations from SHEBA's Pittsburgh site in the Arctic Ocean collected during 1997–98. Blowing snow frequently occurs in the Arctic Ocean and Antarctica, transporting snow by saltation and suspension and yielding sublimation of snow particles. To evaluate the effect of blowing snow, PIEKTUK model was incorporated into the snow/sea-ice coupled system. This coupled system was modified in order to account for wind erosion for low-level wind speed greater than 9 m/s.

S1.2 – Arctic clouds

This subproject is dedicated to the development of cloud and radiative transfer schemes and their interactions within the Polar-GEM modelling system. Various microphysical schemes (a classical Sundqvist-like single moment, and the Milbrandt and Yau (M&Y) microphysical scheme, which can be used in its single, double or triple moment version) were tested in Polar-GEM. Two radiative transfer schemes – the scheme NEWRAD used operationally at CMC, and CCCMARAD based on a k-correlation method – were considered. Several Polar-GEM 48-h forecasts of transition cases (spring and fall) over the Arctic basin were generated, focussing on the budget of radiative and cloud properties over the Arctic. NEWRAD, CCCMARAD, Sundqvist, M&Y single and double moment were compared, and their respective behaviour and benefit on the mean radiative and cloud properties were analysed. The role of the sub-grid cloud fraction parameterization used in Sundqvist like schemes was studied. The representation of precipitation processes within various different microphysical schemes was investigated. A more coherent link between radiative transfer code and the different cloud schemes was developed for Polar-GEM.

S2.1 - Sensitivity studies for weather forecast in the Arctic
The configuration of the singular vector algorithm (model configuration, optimization time, initial and final time norms), developed and tested during the first year of this subproject, was used to compute daily sets of singular vectors for the IPY period of 2007/2008, to study the sensitivity of the Arctic weather to disturbances originated elsewhere. The climatology, and other statistical and physical properties of these sensitive regions for the duration of IPY, were generated and archived.

S2.2 – Validation and assimilation of satellite data from polar orbiting satellites
A methodology to validate model forecasts of cloud and radiation using AIRS hyperspectral radiances was developed for global applications. Statistics were compiled over the month of July 2008 for 6-h and 12-h forecasts. Results provide the means and distributions of radiance spectra, cloud height and amount. These monthly results are themselves compared to those for the same cloud parameters from independent sources: Modis and AIRS JPL team.

S2.3 - Stratospheric analysis during IPY
Global atmospheric analyses of meteorological and physical variables as well as stratospheric chemical fields have been produced for Feb. 1, 2007 – Feb. 29, 2008 and uploaded to SPARC IPY public data base. Analyses for Mar. 1, 2008 – Feb. 28, 2009 are being generated.

S3 - Sea-ice model development
The latest version of the Los Alamos sea ice model, CICE 4.0, was downloaded and installed on the local Linux servers at CCCma. This installation included revisions to the compiler options, and to the code to allow the model to run under the CCCma computing environment and to use the CCCma global climate model grid.

b) Describe how the IPY Northern Coordination Offices have assisted in the planning, coordination and/or delivery of any aspect of the project.

Not needed so far.

5. Issues and Challenges

Discuss any problems encountered, how they have been addressed and any resulting deviations from the original approved application.

A discussion per subproject follows:

S1.1 - Snow processes in Polar-GEM
No problems encountered.

S1.2 – Arctic clouds
The main problem has been the lack of published information on the parameterization of optical properties of specific shapes of snow particles.

S2.1 - Sensitivity studies for weather forecast in the Arctic
No problems encountered.

S2.2 – Validation and assimilation of satellite data from polar orbiting satellites

No major problem, but results need to be recompiled after corrections to the cloud parameter extraction algorithm. Fortunately, a full month of data can be processed rapidly (in about one week).

S2.3 - Stratospheric analysis during IPY
Due to the considerable time required for development and validation of the assimilation scheme, analyses could not be produced in real time. However, the scheme is expected to catch up to real time by March 2009.

S3 - Sea-ice model development
Owing to the short-term nature of the funding (2 years), we were unable to attract a full-time research associate, so initial work was done under contract, and subsequent work was done by a term RES whose salary was supported indirectly by TAWEPI funds.

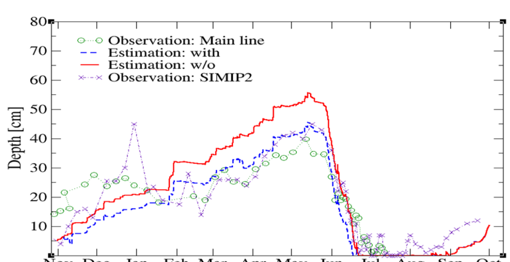
6. Results and Discussion

a) Describe any results to date and their significance/impact with respect to the science for climate change impacts and adaptation and/or the health and well being of northern communities. Please include figures and tables as appropriate.

Results from each subproject are presented separately. They summarize the main modelling and data assimilation contributions from TAWEPI to the development of the Polar-GEM system and to Arctic-related research at the Meteorological Research Division of EC.

S1.1 - Snow processes
Results show that NEW-RPN – a coupled system including a multi-layer snow model (SNTHERM) and the sea-ice model currently used at MSC – exhibits better agreement in the timing of snow depletion, ice thickness and the temperature transition at the snow/ice interface in spring. The profiles of snow thermal conductivity in NEW-RPN show considerable variability across the layers but the mean value (0.39 W m^{-1} K^{-1}) is within the range of reported observations for SHEBA and larger than the value of 0.31 W m^{-1} K^{-1} commonly used in single-layer snow models. Besides, the strong stratification of temperature in the snowpack estimated by NEW-RPN indicates that a multi-layer snow model is needed in the SHEBA scenario. A sensitivity analysis indicates that snow compaction is also a crucial process for a realistic representation of the snowpack with the snow/sea-ice system. Based on observations, the overestimation of snow depth by NEW-RPN may be related to other processes not included in the study, such as small-scale variability of snow depth and snow erosion due to wind blowing snow.

The blowing-snow model PIEKTUK was incorporated into the snow/sea-ice coupled system. Total erosion due to blowing snow was found to be as large as 56 mm of snow water equivalent and was shown to strongly influence snowpack redistribution for the particular case under study. A sensitivity analysis of ice thickness revealed that ice depth depends on surface albedo, new snow density and thermal conductive fluxes at the ice/snow interface; results that are similar to those from a sensitivity analysis of snow depth. Results show that including blowing snow significantly improves the simulation of snow depth and of temperature at the snow/ice interface, but slightly degrades the simulated sea ice thickness. It also leads to other changes such as a decrease of snow temperature by an average of 0.87K and a decrease of snow depth by 4.93 cm on average. An overall effect is to shorten the duration of the snowpack and increase the underlying ice thickness.



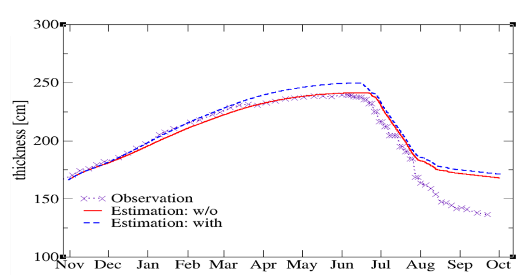


***Figure 2**: Snow depth (left) and sea-ice thickness (right) simulated with (blue dashed lines) and without (red solid lines) wind erosion, compared with SHEBA observations for the period of Nov 1997 to Oct 2008.*

S1.2 – Arctic clouds

The Milbrandt and Yau (M&Y) microphysical scheme, which can be used in its single, double or triple moment version, provides much more detailed description of microphysical and precipitation processes than the classical Sundqvist-like single moment microphysical scheme, using six hydrometeor classes and explicit representation of their number concentration, improving the realism of cloud processes. The radiative transfer scheme NEWRAD was rejected (due to systematic biases near model top and lack of accuracy in radiative computation); instead, the scheme CCCMARD was chosen for Polar-GEM. A sub-grid cloud fraction parameterization is used in Sundqvist like schemes. This simple parameterization offers the possibility to start condensation under sub-saturated conditions, producing partly cloudy grid cell. Such a parameterization is not yet present in the more recent M&Y microphysical scheme and represents a good opportunity to study its impact on cloud processes. It has been found that this impact is not straightforward and can have counter-intuitive effects via non-linear interactions between radiative and cloud-processes.

Many kinds of condensate are actually taken into account by the radiative transfer scheme, including rain, snow (large ice particles and aggregates) and other precipitations. Its treatment as generic cloud condensates can lead to serious biases in radiative transfer computation, notably through detection of cloudy and clear air. Is has been shown that graupel, hail, and in a lesser extent rain have negligible effect on radiative transfer and cloud amount, whereas snow content is a major component of cloud-radiation interaction. It has been found that the parameterization of water vapour diffusion on ice particles, based on the "capacity" approach has a major impact on snow production and high cloud amount. The Sundqvist microphysical scheme was shown to be 2 to 4 times more efficient in producing precipitation than the more accurate M&Y schemes.

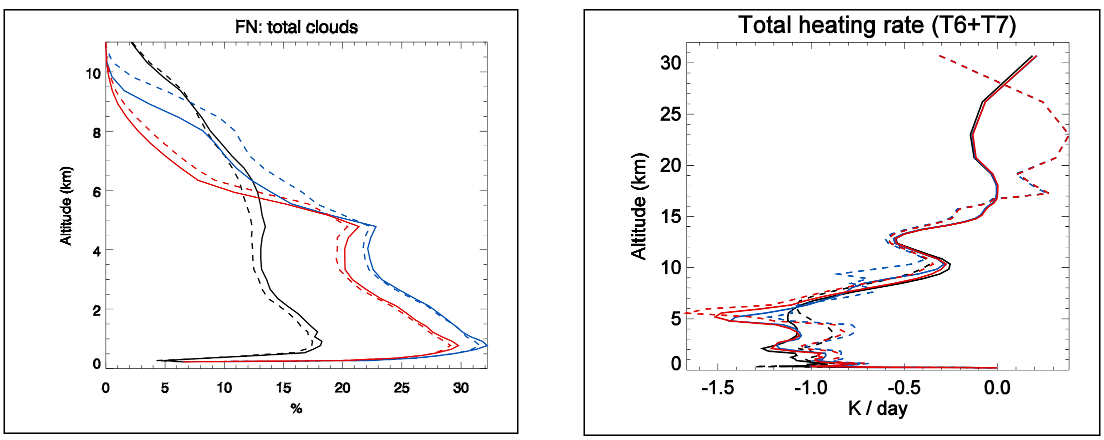


***Figure 3**: Results from Polar-GEM simulations: vertical profile of cloud fraction (left) and radiative heating rate (right) averaged over time and over Arctic domain, using three microphysics schemes (Sundqvist in black; M&Y single moment in blue; M&Y double moment in red) combined with two radiative transfer schemes (CCCMARD solid; NEWRAD dashed).*

S2.1 - Sensitivity studies for weather forecast in the Arctic

Results based on singular vector calculations provide daily, intra-seasonal and seasonal patterns of sensitive regions, where the quality of observations and initial conditions are most likely to impact short-term (up to 48-h) forecasts over the Arctic. This picture of the most sensitive regions may help optimize the design of Arctic regional NWP models (the Polar-GEM itself and the smaller, higher-resolution sub-domains) and indicate regions where observations and data assimilation should be enhanced. Examples of seasonal averages of sensitive maps for Arctic regions are shown below.

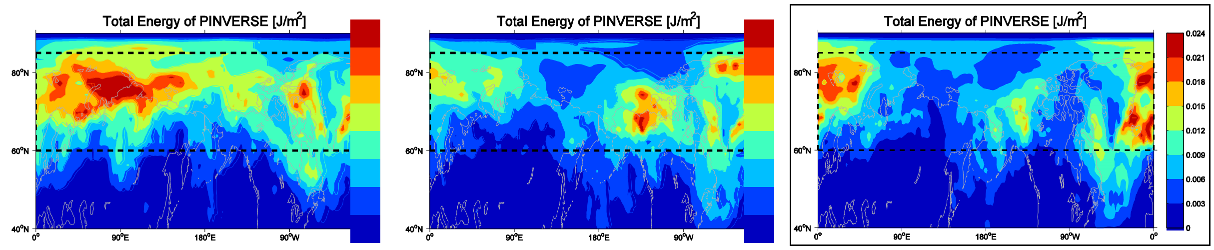


***Figure 4**: Total energy (J/m²) of the pseudo-inverse (linear combination of initial-time SVs, using coefficients defined by the projection of the final-time SVs on forecast error) vertically integrated and averaged over three seasons: summer 2007 (left), autumn 2007 (top centre) and winter 2007/2008 (winter). This average distribution shows sensitive regions, where unstable perturbations to initial conditions were likely to impact on the 48-h forecast over the Arctic during that period.*

S2.2 – Validation and assimilation of satellite data from polar orbiting satellites

Results suggest a deficit of mid-level model clouds. The use of simulated radiances from model output also allows us to improve the retrieval technique to extract cloud parameters. A first paper will be submitted by April 2009. The work lends itself to several specific studies worthy of publication: retrieval methodology, identification of model deficiencies (notably over the Arctic), and impact of improved radiance quality control in assimilation.

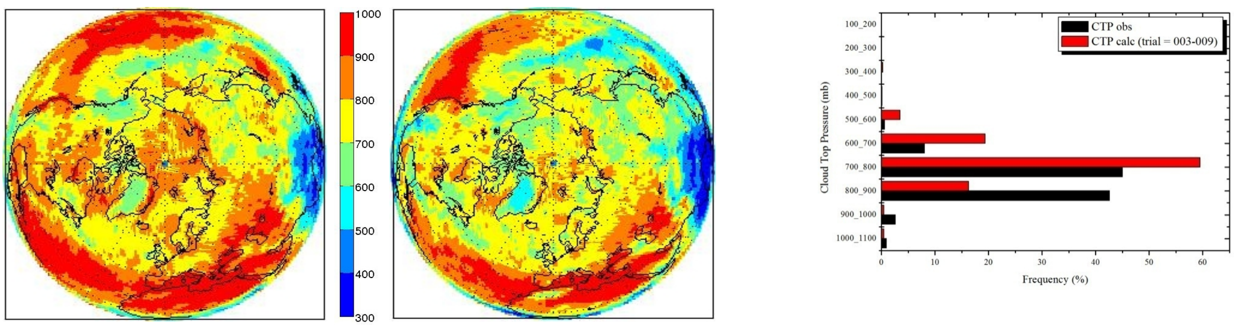


***Figure 5**: Horizontal mean distribution from 15-July-2008 to 15-Aug-2008 of cloud top pressure derived from observed satellite AIRS data (left) and calculated from the GEM model's 6-h forecasts (centre). Also, frequency distribution of cloud top pressure (right) derived from observations (black) and calculated from the model (red) for the same period, suggesting that the model has a deficit in mid altitude clouds.*

S2.3 - Stratospheric analysis during IPY

Global atmospheric analyses of meteorological and physical variables as well as stratospheric chemical fields have been produced for Feb. 1, 2007 – Feb. 29. A comparison study involving ground-based trace gas measurements demonstrated the high quality of the analysed chemistry distributions and variability (collaboration with University of Toronto). Other investigations of dynamical/chemical processes are in progress.

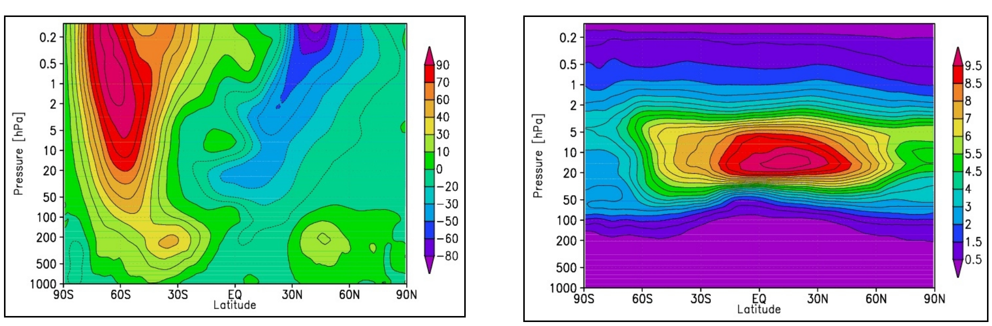


***Figure 6**: Snapshot of zonally averaged zonal wind (left, in m/s) and ozone (right, in ppmv) obtained from a global stratospheric GEM-IPY analysis for 01-Aug-2007.*

S3 - Sea-ice model development

Most of the work necessary to update from the Los Alamos sea-ice model CICE3.x (a previous development version) to CICE 4.0 has now been done and testing will commence shortly. In parallel, data sets (CCCma climate model output) have been assembled to allow the CICE4.0 code to be run in a configuration that closely mimics how it will eventually be run in the fully coupled climate model. This will allow evaluation of the sea-ice model when driven by climate model forcing.

b) Are you aware of ways in which the results of this research are going to be used by others? If so, please explain.

All modelling projects and data assimilation studies of TAWEPI are expected to contribute to the development of the Polar-GEM system. It is also expected that results obtained from this experimental system will eventually be transferred to the CMC, which will represent the main legacy of TAWEPI.

Results and data generated by TAWEPI will be archived (see description in section 7) and will be used by collaborators and students, during and beyond the IPY period.

c) Please list publications and posters/presentations given at conferences that are directly related to this project.

General

- Zadra, A. (2008): TAWEPI – First year of modelling and data assimilation results. Meteorological and Oceanographical Society (CMOS) Congress, Kelowna, BC. Oral presentation by A. Zadra.
- Zadra, A. (2008): TAWEPI – status of modelling and data assimilation activities. IPY-Cryosphere Project Meeting, Toronto, ON. Oral presentation by A. Zadra.
- WCRPNews (2008): Climate-and-cryosphere challenges in Canada (http://www.wmo.ch/pages/prog/wcrp/documents/WCRPnews_CanadaRes20080415.pdf)
- EnviroZine (2008): Taking on Arctic Weather Prediction with TAWEPI (http://www.ec.gc.ca/EnviroZine/default.asp?lang=Eng&n=2588861F-1)

S1.1 - Snow processes

- Chung, Y.-C., Bélair, S. and Mailhot, J. (2009) Wind Effect on Snow Over Arctic Sea-ice: Evaluation of a Sea-ice / Snow / Blowing Snow Model. Journal of Hydrometeorology. In preparation.
- Chung, Y.-C., Bélair, S. and Mailhot, J. (2008) Simulation of Snow-Covered Sea Ice in the Arctic Ocean Using A Coupled Snow/Ice Model. Journal of Hydrometeorology. In revision.
- Chung, Y.-C., Bélair, S. and Mailhot, J. (2008) Wind Effect on Snow Over Arctic Sea-ice: Evaluation of a Sea-ice / Snow / Blowing Snow Model. Proceedings of the International Snow Science Workshop (ISSW), Whistler, BC, Canada. 950-957.
- Chung, Y.-C., Bélair, S. and Mailhot, J. (2008) Evaluation of a coupled sea ice system including blowing snow processes over arctic. Arctic Change, Quebec City, QC, Canada. Oral presentation by Y.-C. Chung.
- Chung, Y.-C., Bélair, S. and Mailhot, J. (2008) Improved snow modeling over sea-ice. Thorpex Arctic Weather and Environmental Prediction Initiative (TAWEPI) Workshop, Montreal, QC, CANADA. Oral presentation by Y.-C. Chung.
- Chung, Y.-C., Bélair, S. and Mailhot, J., Zadra, A. and Barszcz, A. (2008). Evaluation of a coupled snowpack / sea ice model using SHEBA observations. Canadian Meteorological and Oceanographical Society (CMOS) Congress, Kelowna, BC, CANADA. Poster presentation by A. Zadra.

S1.2 – Arctic clouds

- Chosson, F., Vaillancourt, P., Milbrandt, J., Zadra, A. and Mailhot, J. (2008): Mixed-Phase Arctic Clouds and Radiation Interactions within the Polar-Gem Modelling System. Canadian Meteorological and Oceanographical Society (CMOS) Congress, Kelowna, BC, CANADA. Poster presentation by F. Chosson.
- Chosson, F., Milbrandt, J. and Vaillancourt, P. (2008): Simulation of precipitation over the Arctic basin: a sensitivity study with Polar-Gem modelling system. Arctic Change 2008, Quebec City, QC. Oral presentation by F. Chosson.

S2.1 - Sensitivity studies for weather forecast in the Arctic

- Mahidjiba, A., M. Buehner and A. Zadra (2008): Sensitivity of weather forecasts over the Arctic due to analysis errors in the extra-tropics and vice-versa. CMOS Congress, Kelowna, British Columbia. Poster presentation by A. Mahidjiba.

S2.2 – Validation and assimilation of satellite data from polar orbiting satellites

- Pancrati, O., Garand, L. and Heilliette, S. (2009): Hyperspectral model validation in cloudy radiance space from AIRS. 16th Conference on Satellite Meteorology and Oceanography, 89th American Meteorological Society Annual Meeting, Phoenix, USA. Poster presentation by O. Pancrati.

S3 - Sea-ice model development

- Dupont, F., Lu, Y., Wang, Z. and Wright, D.G. (2009): Effects of thermal and wind forcing in a model study of Arctic sea-ice changes. Submitted to Geophysical Research Letters.

7. Data Management

a) Briefly describe/list the data set(s) collected and or used during the current funding year.

Please note that for TAWEPI's activities, the term "data management" refers mostly to the generation and archiving of data generated by numerical models (e.g. weather forecasts, atmospheric analyses, climate simulations).

No observational data is collected in Arctic sites by activities funded by TAWEPI. According to clarifications provided by experts at the IPY Researchers Workshop (October 2007, Gatineau), the delicate data management / data policy issues discussed during the workshop do not apply to the type of data produced by the research activities in TAWEPI (i.e. numerical data generated or processed by our numerical models).

b) Which data centre(s) has and/or will this project's data been sent to?

Most data and metadata generated by TAWEPI modelling activities will be archived at the CMC, as described in the original proposal.

Regarding subproject S2.3 (Stratospheric analysis during IPY): A copy of the stratospheric analyses will continue to be provided to the SPARC-IPY database.

Regarding subproject S3 (Sea-ice model development): The CCCma has a robust data storage system both locally (in Victoria) and at the EC supercomputing facility in Dorval. Some of the funds from this project have been used to upgrade the local data storage system in Victoria to allow a greater volume of model output to be held locally for analysis and for distribution to users via the CCCma web server. This data is held on a reliable RAID system, with tape back-ups locally and in Dorval.

c) Identify the project team member(s) responsible for managing the data for this project.

Jocelyn Mailhot (RPN/EC) is responsible for the development of the Polar-GEM model.

Louis Garand (ARMA/EC) is responsible for the data assimilation projects in TAWEPI.

Greg Flato, Manager of CCCma, is responsible for data management of the sea-ice project.

d) Describe the process used or to be used in making these data available to other IPY researchers and/or the public.

As shown in section 6c above, TAWEPI's objectives, plans and results have been regularly presented in congresses and workshops related to IPY, as well as in articles and interviews for the general public.

Publications and reports will be submitted to the Canadian IPY Publications Database.

f) If applicable, please list any requests for data or information that have been received. If possible, note who the request was from, their affiliation and the type of data requested.

No requests so far.

8. Training and Capacity-Building

a) Describe the education and training opportunities, both formal and informal, provided through this project, including the extent to which Northerners and Aboriginal people have benefited from these opportunities. Please indicate how many individuals were involved in each activity and the type of training provided.

Not applicable so far. This is expected to change as the model and the data begin to be used by students and collaborators.

Thanks to the training opportunity provided by TAWEPI, two of our six post-doc, namely Dr. Ahmed Mahidjiba and Dr. Mateusz Reszka, have recently been selected by the CMC to occupy PC positions at the implementation and data assimilation divisions, respectively.

b) Students and New Researchers
Please provide information about the students and new researchers[1] who have participated in this project to date using the table below.
Note: Students and new researchers listed below may also be listed as project team members on page 1 of this report.
This information will be used by the IPY Federal Program Office to determine the level of involvement of students and new researchers in IPY projects and, at the completion of IPY, to assess whether these students continue in Northern research or other science fields beyond IPY. The data collected in this table will only be used by the IPY Federal Program Office and the Science Review Boards. No information that identifies an individual or which could be used to deduce the identity of an individual will be released to the public. Any statistical data derived from this information will only be released to the public in aggregate form. Provision of information marked with an asterisk (*) is voluntary. Under the *Privacy Act*, the individual to whom the information pertains has rights of access to, and protection of, the personal information provided.
Add additional rows as necessary.

[1] New researchers are individuals who are younger than 30 **OR** who have less than 10 years northern research experience.

Name*	Affiliation and contact information*	Current Education Level (e.g., High School, College, Undergraduate, Masters, PhD, PDF or N/A)	Northern student[2]	New Researcher	Nature of Involvement (Indicate the type of activity each individual undertook)	Time (indicate duration i.e. number of days, months)
Yi-Ching Chung	MRD / EC yi-ching.chung@ec.gc.ca	PDF		X	full-time investigator; implementation and testing of multi-layer snow model	since Aug 2007
Frederick Chosson	MRD / EC chosson@cerfacs.fr	PDF		X	full-time investigator	since Apr 2008
Ahmed Mahidjiba	MRD / EC ahmed.mahidjiba@ec.gc.ca	PDF		X	full-time investigator	Apr 2007 to Dec 2008
Ovidiu Pancrati	MRD / EC ovidiu.pancrati@ec.gc.ca	PDF		X	full-time investigator	since Jan 2008
Mateusz Reszka	MRD / EC mateusz.reszka@ec.gc.ca	PDF		X	full-time investigator	Apr 2007 to Dec 2008
Nadja Steiner	contractor CRD / EC nadja.steiner@ec.gc.ca	PhD		X	full-time investigator; sea-ice model implementation and testing	since Oct 2007

9. Northern Community Engagement

a) Describe how this project has engaged Northerners, northern communities and Aboriginal organizations (e.g., consultation, partnerships, membership on project team, outreach activities, etc.). In addition, please fill out the table below.

Not applicable so far.

This information will be used by the IPY Federal Program Office to determine the level of involvement of Northerners in IPY research projects. The data collected in this table will only be used by the IPY Federal Program Office and the Science Review Boards. No information that identifies an individual or which could be used to deduce the identity of an individual will be released to the public. Any statistical data derived from this information will only be released to the public in aggregate form. Provision of information marked with an asterisk (*) is voluntary. Under the *Privacy Act*, the individual to whom the information pertains has rights of access to, and protection of, the personal information provided.
Add additional rows as necessary.

Name* (if applicable)	Community, Institution or Affiliation	Nature of Involvement (indicate the type of activity each individual undertook)	Time (indicate duration i.e. days, months)

[2] Northern students are individuals who originate from the North or whose permanent residence is in the North and who are enrolled in a formal education or training program. For the purposes of the IPY Program, the North is defined as the three Territories as well as the northern parts of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec and Newfoundland and Labrador.

b) How is this project integrating Traditional Knowledge and western science?

Not applicable so far.

10. Communication and Outreach

Describe any communication and outreach activities and products developed to date, for example community consultations, presentations, websites, posters etc. Please provide copies of any communications materials developed.

Not applicable so far.

11. Upcoming Activities

Describe the work that will be carried out in the next fiscal year (April 1, 2008 to March 31, 2009) and any expected changes that will be made to the project as compared to the originally approved project proposal and any financial implications of these changes. Please complete Budget Table 1 using the template provided to you.

Due to the late arrival of some PDFs, some projects are slightly behind schedule. Otherwise, there are no major deviations from the original plans.

12. Revenue and Expenditures

a) Please complete the *2008/09 Statement of Revenue and Expenditures* using the template and worksheets that have been provided to you. The template and worksheets cover actual expenditures from April 1, 2008 to December 31, 2008 and projected expenditures from January 1, 2009 to March 31, 2009. (Note: A fiscal year-end Financial Report confirming total expenditures will be required by May 31, 2009)

Please see attached worksheets.

b) Explain any deviations from the previously approved budget and how you propose to address them.

In the approved budget of TAWEPI, the IPY funds received for the second year (April 2008 to March 2009), that is $342,000 correspond to the salary and travel expenses of six PDFs ($55,000 for salary and $2,000 for travel, per PDF).

For fiscal year 2008/2009, the approved IPY funds ($342,000) were received by EC, according to a provisional allocation among three co-applicants: Ayrton Zadra, Pierre Gauthier and Greg Flato. Also,

$15,000 corresponding to carry-forward funds was divided equally among the 6 sub-projects. Please notice that Pierre Gauthier was replaced by Louis Garand, as stated in the previous annual report. Following recommendations given at the IPY Workshop in Gatineau in Oct 2007, the received funds have been re-profiled and managed internally (i.e. within EC) when needed, as described by the details below (values are approximate). The estimated total balance of approximately $13,000 will be carried forward into the next fiscal year.

In Budget Table for recipient Ayrton Zadra:

1a) Estimated expenses in salaries are slightly above those in the original budget, due to adjustments in PDF salary. Amount of $5,000 included as cash contributions, corresponding to carry-forward funds from the previous fiscal year, managed internally (i.e. within EC).

2a) Computer upgrades were postponed.

4b) Expenses related to participation in conferences are slightly above original budget.

5b) Expenses with publications are below the original budget, due to the late arrival of some PDFs; publications are expected in the next fiscal year.

In Budget Table for recipient Louis Garand (previously, Pierre Gauthier):

1a) In spite of salary adjustments, the estimated expenses in salaries are slightly below those in the original budget, due to the fact that 2 PDFs have been hired by the CMC and will finish their projects earlier than planned. Amount of $7,500 included as cash contributions, corresponding to carry-forward funds from the previous fiscal year, managed internally (i.e. within EC).

2a) Computer upgrades were postponed.

4b) Expenses related to participation in conferences are slightly above original budget.

5b) Expenses with publications are below the original budget, due to the late arrival of one PDFs; publications are expected in the next fiscal year.

In Budget Table for recipient Greg Flato:

The total amount of $57,000 received by the recipient – plus $2,500 from carry-forward funds – was partly re-profiled ($32,000 from O&M into salary), with the approval of EC finances, and has been used to pay part of the salary of Dr. Nadja Steiner (currently hired as a Research Scientist to work in the same project). The remaining $27,3000 will be used as O&M.

c) Describe all additional cash contributions in support of this project, their sources and amounts.

Some cash contributions are different from those in the original proposal, to accommodate carry-forward funds ($15,000) from the previous fiscal year.

Please note: The overhead / administrative amounts listed in the original budget are contributions from MRD/EC, and correspond to the standard administrative costs associated with PDFs at EC. No IPY funds are used for this.

d) Describe any in-kind contributions made in support of the project, their sources and estimated values.

In-kind contributions are those described in the original proposal, there were no additional contributions.

e) Please estimate the project expenditures spent in each of the following regions, if applicable:

Yukon: $____________ Nunavik: $____________
Northwest Territories: $____________ Nunatsiavut: $____________
Nunavut: $____________ Other (Quebec, Ontario, B. Columbia) $356,000