New Course

Proposal Reference Number : 11846
PRN Alias : 16-17#484
Version No : 2
Submitted By : Dr Timothy Merlis
Edited By : Dr Timothy Merlis

Program Affected? Y
Program Change Form Submitted? Y
Subject/Course/Term ATOC 404
• one term
Credit Weight or CEU's 3 credits

Course Activities

<table>
<thead>
<tr>
<th>Schedule Type</th>
<th>Hours per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Lecture</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours per Week : 3
Total Number of Weeks : 13

Course Title

<table>
<thead>
<tr>
<th>Official Course Title :</th>
<th>Climate Physics</th>
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<tr>
<td>Course Title in Calendar :</td>
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Rationale

ATOC has long been considering a course on 1D climate to fill a gap between their 200-level sequence and the more math/physics intensive 500-level courses that primarily serve M.Sc. students. It would also serve to increase the visibility of ATOC in the university at large, which resonates with McGill’s new emphasis on sustainability and could very well be an optional course for students in the Earth System Science program. At the recent McGill Space Institute board meeting, Dean Lennox stated that the Faculty wants to see more interdisciplinary courses, including courses co-listed in two departments. In the context of MSI, the course would consummate the relationship between ATOC and PHYS via planetary climate, much like EPSC/PHYS-186 Astrobiology does for those departments. As the Halley Professor of Physics at Oxford, Fred Taylor, has written, “Understanding the Earth’s climate and predicting its future behavior is, first and foremost, a problem of Physics.” Yet McGill physics students have very little opportunity to study climate. This lack of opportunity has become clear given the emergence of exoplanet research designed to find habitable planets. This course would introduce physics undergrads to climate and atmospheric science, which would serve as valuable background to
those interested in pursuing planetary science or exoplanet graduate degrees after completing their undergraduate Physics degree. Alternatively, some may decide to pursue graduate education in atmospheric and climate science. For example, two thirds of ATOC grad students have bachelors in physics, math, or engineering. We expect enrollment of 20-30. Mean enrollment in ATOC 300-level courses is 12 (they currently do not have any 400 level courses). We expect a dozen physics students because climate change and planetary habitability are hot topics. We also expect interest from EPS and Earth System Science majors. The course will be required for the ATOC Climate Science stream of the undergraduate Major and Honours programs. The are three pros well-positioned to teach this course: Yi Huang and Tim Merlis in ATOC, and Nick Cowan in PHYS. The plan would be to alternate teaching between the two departments: for example Cowan (2017), Huang (2018), Cowan (2019), Merlis (2020). This fits with Cowan’s teaching schedule since he is currently teaching PHYS-641 Observational Astrophysics, which is only taught every two years. This course was approved in departmental votes in ATOC and PHYS in Nov 2016.

Responsible Instructor
Timothy Merlis

Course Description
This course covers the essentials of climate physics through the lens of one-dimensional, vertical atmospheric models. This includes shortwave and longwave radiative transfer, convection, phase changes, clouds, greenhouse gases, and atmospheric escape. This is an adequate level of detail for understanding Earth’s climate, paleoclimate, anthropogenic climate change, or pursuing studies of Solar System planets and extrasolar planets.

Teaching Dept. 0291 : Atmospheric & Oceanic Sciences

Administering Faculty/Unit SC : Faculty of Science

Prerequisites PHYS 230 or PHYS 251, PHYS 232 or PHYS 253, MATH 222, MATH 315 or MATH 325
Web Registration Blocked? : Y
Minimum Grade or Test Scores : C
Prereq course or test taken at the same time? : Y

Corequisites
Restrictions Not open to students who have taken PHYS 404.

Supplementary Calendar Info

Additional Course Charges
Campus Downtown
Projected Enrollment 25
<table>
<thead>
<tr>
<th>Requires Resources Not Currently Available</th>
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<tbody>
<tr>
<td>Explanation for Required Resources</td>
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<tr>
<td>Required Text/Resources Sent To Library?</td>
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<tr>
<td>Library Consulted About Availability of Resources?</td>
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<tr>
<td>Consultation Reports Attached?</td>
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<tr>
<td>Effective Term of Implementation</td>
<td>201709</td>
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**File Attachments**
- ATOC_PHYS-404_proposal_revision.pdf

**To be completed by the Faculty**

**For Continuing Studies Use**

**Approvals Summary**

<table>
<thead>
<tr>
<th>Version No.</th>
<th>Departmental Curriculum Committee</th>
<th>Departmental Meeting</th>
<th>Departmental Chair</th>
<th>Other Faculty</th>
<th>Curric/Academic Committee</th>
<th>Faculty</th>
<th>SCTP</th>
<th>Version Status</th>
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<td>Submitted to Curriculum/Academic Committee for approval Edited by: Timothy Merlis on: Nov 15 2016</td>
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<td></td>
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</table>
ATOC/PHYS-404
Climate Physics

Context
ATOC has long been considering a course on 1D climate to fill a gap between their 200-level sequence and the more math/physics intensive 500-level courses that primarily serve M.Sc. students. It would also serve to increase the visibility of ATOC in the university at large, which resonates with McGill’s new emphasis on sustainability and could very well be an optional course for students in the Earth System Science program. At the recent McGill Space Institute board meeting, Dean Lennox stated that the Faculty wants to see more interdisciplinary courses, including courses co-listed in two departments. In the context of MSI, the course would consummate the relationship between ATOC and PHYS via planetary climate, much like EPSC/PHYS-186 Astrobiology does for those departments.

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This course was approved in departmental votes in ATOC and PHYS in Nov 2016.

Course Description
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convection, phase changes, clouds, greenhouse gases, and atmospheric escape. This is an adequate level of detail for understanding Earth’s climate, paleoclimate, anthropogenic climate change, or pursuing studies of Solar System planets and extrasolar planets.

We will follow the textbook *Elementary Climate Physics*, by F.W. Taylor, at a pace of one chapter per week. At a slim 212 pages, this gives a good survey of climate physics, but leaves enough time for deeper looks at a few select topics, depending on the instructor.

Additional material can be taken from Taylor’s follow-up book, *Planetary Atmospheres* (applying the physical concepts of the first book to other Solar System worlds), Andy Ingersoll’s *Planetary Climate* (similar scope in a more condensed form), Geoff Vallis’ *Climate and the Oceans* (covers the basic fluid dynamics of atmospheres and oceans), or Ray Pierrehumbert’s *Principles of Planetary Climate* (a graduate-level treatment of 1D climate). Pierrehumbert maintains a website with Python code for reproducing every plot in his book, including radiative-convective models. Some of these would make great coding projects and would allow students to use real cutting-edge models.

**Pre-requisites**
PHYS 230 or PHYS 251, PHYS 232 or PHYS 253, MATH 222, MATH 315 or MATH 325

**Course Content**
1. The climate system
2. Solar radiation and the energy budget of the earth
3. Atmosphere and climate
4. Clouds and aerosols
5. Ocean and climate
6. Radiative transfer
7. Earth’s energy budget: the Greenhouse effect
8. The ozone layer or atmospheric escape
9. Climate observations by remote sensing
10. Climate sensitivity and change
11. Climate models and predictions
12. Climate on other planets: exoplanet climates

**Class Structure**
There will be two lectures per week and regular quantitative homeworks from the textbook. Two exams and one written research project. Students will provide peer review on an early version of their term project. The final version will be graded by the faculty member who is the course instructor. Homeworks will be graded by the TA. Midterm and final will be graded by the TA and Prof.

**Assessment**
25% Homeworks
25% Term Project
25% Midterm
25% Final
### 1.0 Degree Title
Specify the two degrees for concurrent degree programs

| B.Sc. |

### 1.1 Major (Legacy = Subject) (30-char. max.)

| Atmospheric Science |

### 1.2 Concentration (Legacy = Concentration/Option)
If applicable (30 char. max.)

### 1.3 Minor (with Concentration, if applicable)
(30 char. max.)

### 1.4 Category

- [ ] Faculty Program (FP)
- [X] Major
- [ ] Joint Major
- [ ] Major Concentration (CON)
- [ ] Minor
- [ ] Minor Concentration (CON)
- [ ] Honours (HON)
- [ ] Joint Honours Component (HC)
- [ ] Internship/Co-op
- [ ] Thesis (T)
- [ ] Non-Thesis (N)
- [ ] Other
- Please specify

### 1.5 Complete Program Title

| B.Sc.; Major Atmospheric Science |

### 2.0 Administering Faculty/Unit

| Science |

### Offering Faculty/Department

| Science/Atmospheric and Oceanic Sciences |

### 3.0 Effective Term of revision or retirement
Please give reasons in 5.0 "Rationale" in the case of retirement

| Term: 201709 |

### 4.0 Existing Credit Weight

| 62 credits |

### Proposed Credit Weight

| 62 credits |

### 5.0 Rationale for revised program

The revision to the Major (i) adds a new proposed course (ii) adds to the list of complementary courses. The new proposed course is ATOC/PHYS 404 Climate Physics will be added to the complementary course list for three of the Streams of the Major and will be added as a required course for the Climate Science Stream, where it replaces MATH 203. In the proposed Major, MATH 203 is a complementary course across all streams. In addition, two ESYS courses (ESYS 300 and ESYS 301) have been added to the complementary course lists for three streams (Weather Analysis and Forecasting, Climate Science, and General), as these are appropriate for the Atmospheric Science major and distinct from other complementary courses.

### 6.0 Revised Program Description (Maximum 150 words)

(None)
7.0 List of existing program and proposed program

Existing program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)

<table>
<thead>
<tr>
<th>Required Courses (24 credits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOC 214 Introduction: Physics of the Atmosphere, (3 credits)</td>
</tr>
<tr>
<td>ATOC 312 Rotating Fluid Dynamics (3 credits)</td>
</tr>
<tr>
<td>ATOC 315 Thermodynamics and Convection (3 credits)</td>
</tr>
<tr>
<td>COMP 208 Computers in Engineering (3 credits)</td>
</tr>
<tr>
<td>MATH 222 Calculus 3 (3 credits)</td>
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<tr>
<td>MATH 223 Linear Algebra (3 credits)</td>
</tr>
<tr>
<td>MATH 314 Advanced Calculus (3 credits)</td>
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<td>MATH 315 Ordinary Differential Equations (3 credits)</td>
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<table>
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<tr>
<th>Complementary Courses (38 credits)</th>
</tr>
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<tbody>
<tr>
<td>36-38 credits</td>
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</tbody>
</table>

Note: Students are required to fulfill the core complementary requirements along with one of the four streams listed below. In cases of overlap, each course can only be used once toward the satisfaction of the core complementary courses or the chosen stream.

<table>
<thead>
<tr>
<th>Core (21 credits)</th>
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<tbody>
<tr>
<td>3-6 credits from:</td>
</tr>
<tr>
<td>ATOC 215 Oceans, Weather and Climate (3 credits)</td>
</tr>
<tr>
<td>ATOC 219 Introduction to Atmospheric Chemistry (3 credits)*</td>
</tr>
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<td>CHEM 219 Introduction to Atmospheric Chemistry (3 credits)*</td>
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<td>* Note: students may select ATOC 219 or CHEM 219 but not both.</td>
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<tr>
<td>ATOC 357 Atmospheric and Oceanic Science Laboratory (3 credits)</td>
</tr>
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<td>PHYS 257 Experimental Methods 1 (3 credits)</td>
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<td>CHEM 223 Introductory Physical Chemistry 1 (2 credits)</td>
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<td>CHEM 243 Introductory Physical Chemistry 2 (2 credits)</td>
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<tr>
<td>CHEM 253 Introductory Physical Chemistry 1 Laboratory (1 credit)</td>
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<tr>
<td>CHEM 263 Introductory Physical Chemistry 2 Laboratory (1 credit)</td>
</tr>
<tr>
<td>CHEM 367 Instrumental Analysis 1 (3 credits)</td>
</tr>
<tr>
<td>CHEM 575 Chemical Kinetics (3 credits)</td>
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<tr>
<td>MATH 203 Principles of Statistics 1 (3 credits) *</td>
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<td>MATH 317 Numerical Analysis (3 credits)</td>
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<td>MATH 323 Probability (3 credits)</td>
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<td>Statistics</td>
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<td>PHYS 333</td>
<td>Thermal and Statistical Physics</td>
<td>3 credits</td>
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<tr>
<td>PHYS 340</td>
<td>Majors Electricity and Magnetism</td>
<td>3 credits</td>
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<tr>
<td>PHYS 342</td>
<td>Majors Electromagnetic Waves</td>
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</tr>
<tr>
<td>PHYS 350</td>
<td>Honours Electricity and Magnetism</td>
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<tr>
<td>PHYS 352</td>
<td>Honours Electromagnetic Waves</td>
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* Students cannot receive credit for both MATH 203 and MATH 324.
** Students cannot receive credit for both PHYS 340 and PHYS 350.
*** Students cannot receive credit for both PHYS 342 and PHYS 352.

**Weather Analysis and Forecasting Stream (17 credits)**

13 credits from:
- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- ATOC 540 Synoptic Meteorology 1 (3 credits)
- ATOC 541 Synoptic Meteorology 2 (3 credits)
- ATOC 546 Current Weather Discussion (1 credit)

3-4 credits selected from:
- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 513 Waves and Stability (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 530 Paleoclimate Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- GEOG 322 Environmental Hydrology (3 credits)
- GEOG 372 Running Water Environments (3 credits)
- MATH 555 Fluid Dynamics (4 credits)
- PHYS 432 Physics of Fluids (3 credits)

**Climate Science Stream (15 credits)**

6 credits from:
- ATOC 531 Dynamics of Current Climates (3 credits)
- MATH 203 Principles of Statistics 1 (3 credits)

9 credits (at least 6 of which must be ATOC) selected from:
- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 513 Waves and Stability (3 credits)
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)

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- ATOC 513 Waves and Stability (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 530 Paleoclimate Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- GEOG 322 Environmental Hydrology (3 credits)
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- MATH 555 Fluid Dynamics (4 credits)
- PHYS 432 Physics of Fluids (3 credits)

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- MATH 203 Principles of Statistics 1 (3 credits)

9 credits (at least 6 of which must be ATOC) selected from:
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- ATOC 513 Waves and Stability (3 credits)
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 404 Climate Physics (3 credits)
- PHYS 404 Climate Physics (3 credits)

* Students cannot receive credit for both PHYS 432 or MATH 555.
** Students cannot receive credit for both PHYS 432 or MATH 555.
++ Students cannot receive credit for both ATOC 404 and PHYS 404.

9 credits (at least 6 of which must be ATOC) selected from:
### 7.0 List of existing program and proposed program

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<tbody>
<tr>
<td>ATOC 530</td>
<td>Paleoclimate Dynamics</td>
<td>3</td>
</tr>
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<td>ATOC 540</td>
<td>Synoptic Meteorology 1</td>
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<td>ATOC 558</td>
<td>Numerical Methods and Laboratory</td>
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<td>ATOC 568</td>
<td>Ocean Physics</td>
<td>3</td>
</tr>
<tr>
<td>EPSC 513</td>
<td>Climate and the Carbon Cycle</td>
<td>3</td>
</tr>
<tr>
<td>EPSC 542</td>
<td>Chemical Oceanography</td>
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</tr>
<tr>
<td>GEOG 322</td>
<td>Environmental Hydrology</td>
<td>3</td>
</tr>
<tr>
<td>GEOG 372</td>
<td>Running Water Environments</td>
<td>3</td>
</tr>
<tr>
<td>MATH 323</td>
<td>Probability</td>
<td>3</td>
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</tbody>
</table>

**Atmospheric Chemistry and Physics Stream (15 credits)**

15 credits from:

- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- CHEM 223 Introductory Physical Chemistry 1 (2 credits)
- CHEM 243 Introductory Physical Chemistry 2 (2 credits)
- CHEM 253 Introductory Physical Chemistry 1 Laboratory (1 credit)
- CHEM 263 Introductory Physical Chemistry 2 Laboratory (1 credit)

**General Stream (17 credits)**

15-17 credits (at least 12 of which must be ATOC) selected from:

- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 513 Waves and Stability (3 credits)
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 530 Paleoclimate Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- ATOC 540 Synoptic Meteorology 1 (3 credits)
- ATOC 541 Synoptic Meteorology 2 (3 credits)
- ATOC 546 Current Weather Discussion (1 credit)
- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- CHEM 367 Instrumental Analysis 1 (3 credits)
- CHEM 375 Chemical Kinetics (3 credits)
- EPSC 513 Climate and the Carbon Cycle (3 credits)
- EPSC 542 Chemical Oceanography (3 credits)
- GEOG 322 Environmental Hydrology (3 credits)
- GEOG 372 Running Water Environments (3 credits)
- MATH 555 Fluid Dynamics (4 credits) +
- PHYS 432 Physics of Fluids (3 credits) +
- MATH 555 Fluid Dynamics (4 credits) +

**Proposed program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)**

<table>
<thead>
<tr>
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<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>ATOC 512</td>
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<td>ATOC 513</td>
<td>Waves and Stability</td>
<td>3</td>
</tr>
<tr>
<td>ATOC 519</td>
<td>Advances in Chemistry of Atmosphere</td>
<td>3</td>
</tr>
<tr>
<td>ATOC 521</td>
<td>Cloud Physics</td>
<td>3</td>
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<tr>
<td>ATOC 525</td>
<td>Atmospheric Radiation</td>
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<tr>
<td>ATOC 530</td>
<td>Paleoclimate Dynamics</td>
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</tr>
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<td>ATOC 540</td>
<td>Synoptic Meteorology 1</td>
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</tr>
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<td>ATOC 558</td>
<td>Numerical Methods and Laboratory</td>
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</tr>
<tr>
<td>ATOC 568</td>
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<td>3</td>
</tr>
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<td>EPSC 513</td>
<td>Climate and the Carbon Cycle</td>
<td>3</td>
</tr>
<tr>
<td>EPSC 542</td>
<td>Chemical Oceanography</td>
<td>3</td>
</tr>
<tr>
<td>ESYS 300</td>
<td>Investigating the Earth System</td>
<td>3</td>
</tr>
<tr>
<td>ESYS 301</td>
<td>Earth System Modelling</td>
<td>3</td>
</tr>
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<td>GEOG 322</td>
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<td>3</td>
</tr>
<tr>
<td>MATH 323</td>
<td>Probability</td>
<td>3</td>
</tr>
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**Atmospheric Chemistry and Physics Stream (15 credits)**

15 credits from:

- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 404 Climate Physics (3 credits) +
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- CHEM 223 Introductory Physical Chemistry 1 (2 credits)
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**General Stream (17 credits)**

15-17 credits (at least 12 of which must be ATOC) selected from:

- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 404 Climate Physics (3 credits) +
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- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- CHEM 367 Instrumental Analysis 1 (3 credits)
- CHEM 575 Chemical Kinetics (3 credits)

+ Students cannot receive credit for both ATOC 404 and PHYS 404.
### Existing program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)

<table>
<thead>
<tr>
<th>Subj Code/Crse Num</th>
<th>Title</th>
<th>Credit weight</th>
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</thead>
<tbody>
<tr>
<td>EPSC 513</td>
<td>Climate and the Carbon Cycle</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>EPSC 542</td>
<td>Chemical Oceanography</td>
<td>(3 credits)</td>
</tr>
<tr>
<td>ESYS 300</td>
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<td>(3 credits)</td>
</tr>
<tr>
<td>MATH 555</td>
<td>Fluid Dynamics</td>
<td>(4 credits)++</td>
</tr>
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<td>Climate Physics</td>
<td>(3 credits)++</td>
</tr>
<tr>
<td>PHYS 432</td>
<td>Physics of Fluids</td>
<td>(3 credits)++</td>
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+ Students cannot receive credit for both ATOC 404 and PHYS 404.
++ Students cannot receive credit for both PHYS 432 and MATH 555.

### Proposed program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)

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+ Students cannot receive credit for both ATOC 404 and PHYS 404.
++ Students cannot receive credit for both PHYS 432 and MATH 555.
8.0 Consultation with Related Units

- [ ] Yes
- [ ] No

Attach list of consultations

9. Approvals

<table>
<thead>
<tr>
<th>Routing Sequence</th>
<th>Name</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department</td>
<td>John Gyakum</td>
<td>[Signature]</td>
<td>November 11, 2016</td>
</tr>
<tr>
<td>Curric/Acad Committee</td>
<td></td>
<td></td>
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<tr>
<td>Faculty 1</td>
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</table>

Submitted by

- Name: Timothy Merlis
- Phone: (514) 398-3140
- Email: Timothy.merlis@mcgill.ca
- Submission Date: November 11, 2016

To be completed by ARR:

- CIP Code

10. FQRSC (Research) Indicator (for GPS): Yes  No
1.0 Degree Title
Specify the two degrees for concurrent degree programs

| B.Sc. |

1.1 Major (Legacy = Subject) (30-char. max.)

| Atmospheric Science |

1.2 Concentration (Legacy = Concentration/Option)
If applicable (30 char. max.)

|  |

1.3 Minor (with Concentration, if applicable)
(30 char. max.)

|  |

1.4 Category

- Faculty Program (FP)
- Major
- Joint Major
- Major Concentration (CON)
- Minor
- Minor Concentration (CON)

- Honours (HON)
- Joint Honours Component (HC)
- Internship/Co-op
- Thesis (T)
- Non-Thesis (N)
- Other

Please specify

1.5 Complete Program Title

| B.Sc.; Honours in Atmospheric Science |

2.0 Administering Faculty/Unit

| Science |

2.1 Offering Faculty/Department

| Science/Atmospheric and Oceanic Sciences |

3.0 Effective Term of revision or retirement
Please give reasons in 5.0"Rationale" in the case of retirement
(Ex. Sept. 2004 = 200409)

| 201709 |

4.0 Existing Credit Weight

| 72-73 credits |

5.0 Proposed Credit Weight

| 72-74 credits |

5.1 Rationale for revised program

The revision to the Honours program (i) adds a new proposed course (ii) adds to the list of complementary courses. The new proposed course is ATOC/PHYS 404 Climate Physics will be added to the complementary course list for three of the Streams of the Major and will be added as a required course for the Climate Science Stream. In addition, two ESYS courses (ESYS 300 and ESYS 301) have been added to the complementary course lists for three streams, as these are appropriate for the Atmospheric Science major and distinct from other complementary courses.

6.0 Revised Program Description (Maximum 150 words)

|  |

7.0 Revised Program Description (Maximum 150 words)

| (None) |
### Existing program

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATOC 214</td>
<td>Introduction: Physics of the Atmosphere</td>
<td>(3     )</td>
</tr>
<tr>
<td>ATOC 312</td>
<td>Rotating Fluid Dynamics</td>
<td>(3     )</td>
</tr>
<tr>
<td>ATOC 315</td>
<td>Thermodynamics and Convection</td>
<td>(3     )</td>
</tr>
<tr>
<td>ATOC 480</td>
<td>Honours Research Project</td>
<td>(3     )</td>
</tr>
<tr>
<td>COMP 208</td>
<td>Computers in Engineering</td>
<td>(3     )</td>
</tr>
<tr>
<td>MATH 222</td>
<td>Calculus 3</td>
<td>(3     )</td>
</tr>
<tr>
<td>MATH 223</td>
<td>Linear Algebra</td>
<td>(3     )</td>
</tr>
<tr>
<td>MATH 314</td>
<td>Advanced Calculus</td>
<td>(3     )</td>
</tr>
<tr>
<td>MATH 315</td>
<td>Ordinary Differential Equations</td>
<td>(3     )</td>
</tr>
</tbody>
</table>

### Proposed program

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</tr>
<tr>
<td>MATH 315</td>
<td>Ordinary Differential Equations</td>
<td>(3     )</td>
</tr>
</tbody>
</table>

### Complementary Courses (45-47 credits)

Note: Students are required to fulfill the core complementary requirements along with one of the four streams listed below. In cases of overlap, each course can only be used once toward the satisfaction of the core complementary courses or the chosen stream.

### Core (24 credits)

- 3-6 credits from:
  - ATOC 215 Oceans, Weather and Climate (3 credits)
  - ATOC 219 Introduction to Atmospheric Chemistry (3 credits)*
  - CHEM 219 Introduction to Atmospheric Chemistry (3 credits)*
  - * Note: students may select ATOC 219 or CHEM 219 but not both.

- 3 credits selected from:
  - ATOC 357 Atmospheric and Oceanic Science Laboratory (3 credits)
  - PHYS 257 Experimental Methods 1 (3 credits)

- 3 credits selected from:
  - PHYS 230 Dynamics of Simple Systems (3 credits)
  - PHYS 251 Honours Classical Mechanics (3 credits)

- 3 credits selected from:
  - PHYS 232 Heat and Waves (3 credits)
  - PHYS 253 Thermal Physics (3 credits)

- 3 credits selected from:
  - CHEM 223 Introductory Physical Chemistry 1 (2 credits)
  - CHEM 253 Introductory Physical Chemistry 1 Laboratory (1 credit)
  - MATH 319 Introduction to Partial Differential Equations (3 credits)

- 6-9 credits selected from:
  - CHEM 223 Introductory Physical Chemistry 1 (2 credits)
  - CHEM 243 Introductory Physical Chemistry 2 (2 credits)
  - CHEM 253 Introductory Physical Chemistry 1 Laboratory (1 credit)
  - CHEM 263 Introductory Physical Chemistry 2 Laboratory (1 credit)
  - CHEM 367 Instrumental Analysis 1 (3 credits)
7.0 List of existing program and proposed program

Existing program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)

<table>
<thead>
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<th>Credit Weight</th>
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<td>CHEM 367</td>
<td>Instrumental Analysis 1</td>
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<td>CHEM 575</td>
<td>Chemical Kinetics</td>
<td>3 credits</td>
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<td>MATH 203</td>
<td>Principles of Statistics 1</td>
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<tr>
<td>MATH 317</td>
<td>Numerical Analysis</td>
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<td>MATH 319</td>
<td>Introduction to Partial Differential Equations</td>
<td>3 credits</td>
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<td>MATH 323</td>
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<td>MATH 324</td>
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<tr>
<td>PHYS 333</td>
<td>Thermal and Statistical Physics</td>
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<td>PHYS 340</td>
<td>Majors Electricity and Magnetism</td>
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<td>PHYS 342</td>
<td>Majors Electromagnetic Waves</td>
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<td>PHYS 350</td>
<td>Honours Electricity and Magnetism</td>
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<tr>
<td>PHYS 352</td>
<td>Honours Electromagnetic Waves</td>
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*Students cannot receive credit for both MATH 203 and MATH 324.**Students cannot receive credit for both PHYS 340 and PHYS 350.***Students cannot receive credit for both PHYS 342 and PHYS 352.

Weather Analysis and Forecasting Stream (22-23 credits)

16 credits from:

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<tr>
<td>ATOC 309</td>
<td>Weather Radars and Satellites</td>
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<tr>
<td>ATOC 512</td>
<td>Atmospheric and Oceanic Dynamics</td>
<td>3 credits</td>
</tr>
<tr>
<td>ATOC 521</td>
<td>Cloud Physics</td>
<td>3 credits</td>
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<tr>
<td>ATOC 540</td>
<td>Synoptic Meteorology 1</td>
<td>3 credits</td>
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<td>ATOC 541</td>
<td>Synoptic Meteorology 2</td>
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<tr>
<td>ATOC 546</td>
<td>Current Weather Discussion</td>
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6-7 credits selected from:

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<th>Course Title</th>
<th>Credit Weight</th>
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<tr>
<td>ATOC 513</td>
<td>Waves and Stability</td>
<td>3 credits</td>
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<tr>
<td>ATOC 525</td>
<td>Atmospheric Radiation</td>
<td>3 credits</td>
</tr>
<tr>
<td>ATOC 530</td>
<td>Paleoclimate Dynamics</td>
<td>3 credits</td>
</tr>
<tr>
<td>ATOC 531</td>
<td>Dynamics of Current Climates</td>
<td>3 credits</td>
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<tr>
<td>ATOC 558</td>
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<tr>
<td>PHYS 432</td>
<td>Physics of Fluids</td>
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*Students cannot receive credit for both PHYS 432 or MATH 555.

Climate Science Stream (22 credits)

12 credits from:

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<td>ATOC 404</td>
<td>Climate Physics</td>
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<tr>
<td>ATOC 513</td>
<td>Waves and Stability</td>
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<tr>
<td>ATOC 525</td>
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<td>ATOC 530</td>
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<td>3 credits</td>
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<tr>
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<td>PHYS 432</td>
<td>Physics of Fluids</td>
<td>3 credits</td>
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*Students cannot receive credit for both ATOC 404 and PHYS 404.++Students cannot receive credit for both PHYS 432 and MATH 555.

Climate Science Stream (21-22 credits)

15 credits from:

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<tr>
<td>GEOG 322</td>
<td>Environmental Hydrology</td>
<td>3 credits</td>
</tr>
<tr>
<td>GEOG 372</td>
<td>Running Water Environments</td>
<td>3 credits</td>
</tr>
<tr>
<td>MATH 555</td>
<td>Fluid Dynamics</td>
<td>4 credits</td>
</tr>
<tr>
<td>PHYS 404</td>
<td>Climate Physics</td>
<td>3 credits</td>
</tr>
<tr>
<td>PHYS 432</td>
<td>Physics of Fluids</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

*Students cannot receive credit for both ATOC 404 and PHYS 404.++Students cannot receive credit for both PHYS 432 and MATH 555.
7.0 List of existing program and proposed program

**Existing program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)**

- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- MATH 323 Probability 1 (3 credits)
- MATH 324 Statistics I (3 credits)

Students cannot receive credit for both MATH 203 and MATH 324.

**Proposed program (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)**

- ATOC 404 Climate Physics (3 credits) *
- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- MATH 323 Probability 1 (3 credits)
- MATH 324 Statistics I (3 credits)
- PHYS 404 Climate Physics (3 credits) *

* Students cannot receive credit for both ATOC 404 and PHYS 404.

**6-7 credits (3 of which must be ATOC) selected from:**

- ATOC 513 Waves and Stability (3 credits)
- ATOC 515 Turbulence in Atmosphere and Oceans (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 530 Paleoclimate Dynamics (3 credits)
- ATOC 540 Synoptic Meteorology 1 (3 credits)
- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- EPSC 513 Climate and the Carbon Cycle (3 credits)
- EPSC 542 Chemical Oceanography (3 credits)
- MATH 423 Regression and Analysis of Variance (3 credits)
- MATH 555 Fluid Dynamics (4 credits) *
- PHYS 432 Physics of Fluids (3 credits) *

* Students cannot receive credit for both PHYS 432 or MATH 555.

**Atmospheric Chemistry and Physics Stream (21 credits)**

- 15 credits from:
  - ATOC 309 Weather Radars and Satellites (3 credits)
  - ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
  - ATOC 521 Cloud Physics (3 credits)
  - CHEM 223 Introductory Physical Chemistry 1 (2 credits)
  - CHEM 243 Introductory Physical Chemistry 2 (2 credits)
  - CHEM 253 Introductory Physical Chemistry 1 Laboratory (1 credit)
  - CHEM 263 Introductory Physical Chemistry 2 Laboratory (1 credit)

- 6 credits selected from:
  - ATOC 512 Atmospheric and Ocean Dynamics (3 credits)
  - ATOC 513 Waves and Stability (3 credits)
  - ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
  - ATOC 525 Atmospheric Radiation (3 credits)
  - ATOC 530 Paleoclimate Dynamics (3 credits)
  - ATOC 540 Synoptic Meteorology 1 (3 credits)
  - ATOC 558 Numerical Methods and Laboratory (3 credits)
### 7.0 List of existing program and proposed program

**Existing program** (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 367</td>
<td>Instrumental Analysis 1</td>
<td>3 credits</td>
</tr>
<tr>
<td>CHEM 575</td>
<td>Chemical Kinetics</td>
<td>3 credits</td>
</tr>
<tr>
<td>EPSC 513</td>
<td>Climate and the Carbon Cycle</td>
<td>3 credits</td>
</tr>
<tr>
<td>EPSC 542</td>
<td>Chemical Oceanography</td>
<td>3 credits</td>
</tr>
<tr>
<td>MATH 423</td>
<td>Regression and Analysis of Variance</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

**General Stream** (22 credits)
21-22 credits (at least 15 of which must be ATOC) selected from:

- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 513 Waves and Stability (3 credits)
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 530 Paleoclimate Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- ATOC 540 Synoptic Meteorology 1 (3 credits)
- ATOC 541 Synoptic Meteorology 2 (3 credits)
- ATOC 546 Current Weather Discussion (1 credit)
- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- CHEM 367 Instrumental Analysis 1 (3 credits)
- CHEM 575 Chemical Kinetics (3 credits)
- EPSC 513 Climate and the Carbon Cycle (3 credits)
- EPSC 542 Chemical Oceanography (3 credits)
- MATH 555 Fluid Dynamics (4 credits)
- PHYS 432 Physics of Fluids (3 credits)

+ Students cannot receive credit for both PHYS 432 or MATH 555.

**Proposed program** (list courses as follows: Subj Code/Crse Num, Title, Credit weight, under the headings of: Required Courses, Complementary Courses, Elective Courses)

<table>
<thead>
<tr>
<th>Course Code</th>
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<tr>
<td>EPSC 542</td>
<td>Chemical Oceanography</td>
<td>3 credits</td>
</tr>
<tr>
<td>MATH 423</td>
<td>Regression and Analysis of Variance</td>
<td>3 credits</td>
</tr>
<tr>
<td>PHYS 404</td>
<td>Climate Physics</td>
<td>3 credits</td>
</tr>
</tbody>
</table>

+ Students cannot receive credit for both ATOC 404 and PHYS 404.

**General Stream** (21-22 credits)
21-22 credits (at least 15 of which must be ATOC) selected from:

- ATOC 309 Weather Radars and Satellites (3 credits)
- ATOC 404 Climate Physics (3 credits)
- ATOC 512 Atmospheric and Oceanic Dynamics (3 credits)
- ATOC 513 Waves and Stability (3 credits)
- ATOC 519 Advances in Chemistry of Atmosphere (3 credits)
- ATOC 521 Cloud Physics (3 credits)
- ATOC 525 Atmospheric Radiation (3 credits)
- ATOC 530 Paleoclimate Dynamics (3 credits)
- ATOC 531 Dynamics of Current Climates (3 credits)
- ATOC 540 Synoptic Meteorology 1 (3 credits)
- ATOC 541 Synoptic Meteorology 2 (3 credits)
- ATOC 546 Current Weather Discussion (1 credit)
- ATOC 558 Numerical Methods and Laboratory (3 credits)
- ATOC 568 Ocean Physics (3 credits)
- CHEM 367 Instrumental Analysis 1 (3 credits)
- CHEM 575 Chemical Kinetics (3 credits)
- EPSC 513 Climate and the Carbon Cycle (3 credits)
- EPSC 542 Chemical Oceanography (3 credits)
- ESYS 300 Investigating the Earth System (3 credits)
- ESYS 301 Earth System Modelling (3 credits)
- MATH 423 Regression and Analysis of Variance (3 credits)
- MATH 555 Fluid Dynamics (4 credits)
- PHYS 404 Climate Physics (3 credits)
- PHYS 432 Physics of Fluids (3 credits)

+ Students cannot receive credit for both ATOC 404 and PHYS 404.
++ Students cannot receive credit for both PHYS 432 or MATH 555.
10. FQRSC (Research) Indicator (for GPS): Yes  No
<table>
<thead>
<tr>
<th>1.0 Degree Title</th>
<th>2.0 Administering Faculty/Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specify the two degrees for concurrent degree programs</td>
<td>Science</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.1 Major (Legacy= Subject) (30-char. max.)</th>
<th>2.0 Offering Faculty/Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science/Atmospheric and Oceanic Sciences</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.2 Concentration (Legacy = Concentration/Option)</th>
<th>3.0 Effective Term of revision or retirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>If applicable (30 char. max.)</td>
<td>Please give reasons in 5.0&quot;Rationale“ in the case of retirement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.3 Minor (with Concentration, if applicable) (30 char. max.)</th>
<th>4.0 Existing Credit Weight</th>
<th>Proposed Credit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric Science</td>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.4 Category</th>
<th>5.0 Rationale for revised program</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Faculty Program (FP)</td>
<td>The current Atmospheric Science Minor has limited flexibility with only one complementary course. The proposed revision is intended to increase the flexibility of the Minor, so that students have a broader range of options that reflects the full range of course offerings by the Atmospheric &amp; Oceanic Science department. This revision will bring the course requirements of the Minor in line with the course requirements of the Major program, which were revised in September 2014. The current Minor has certain required courses that are now Complementary for the Major; this has been amended in the proposed Minor.</td>
</tr>
<tr>
<td>☐ Major</td>
<td>☐ Honours (HON)</td>
</tr>
<tr>
<td>☐ Joint Major</td>
<td>☐ Joint Honours Component (HC)</td>
</tr>
<tr>
<td>☐ Major Concentration (CON)</td>
<td>☐ Internship/Co-op</td>
</tr>
<tr>
<td>✗ Minor</td>
<td>☐ Thesis (T)</td>
</tr>
<tr>
<td>☐ Minor Concentration (CON)</td>
<td>☐ Non-Thesis (N)</td>
</tr>
<tr>
<td>☐ Other</td>
<td>Please specify</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.5 Complete Program Title</th>
<th>6.0 Revised Program Description (Maximum 150 words)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.Sc.; Minor Atmospheric Science</td>
<td>(None)</td>
</tr>
</tbody>
</table>
### Existing Program

<table>
<thead>
<tr>
<th>Subj Code/Crse Title</th>
<th>Credit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Courses (2 credits):</strong></td>
<td></td>
</tr>
<tr>
<td>ATOC 214 Introduction: Physics of the Atmosphere</td>
<td>3</td>
</tr>
<tr>
<td>ATOC 215 Oceans, Weather and Climate</td>
<td>3</td>
</tr>
<tr>
<td>ATOC 309 Weather Radars and Satellites</td>
<td>3</td>
</tr>
<tr>
<td>ATOC 315 Thermodynamics and Convection</td>
<td>3</td>
</tr>
</tbody>
</table>

**Complementary Courses (15 credits):**
- 3-6 credits selected from:
  - ATOC 219 Introduction to Atmospheric Chemistry | 3 |
  - CHEM 219 Introduction to Atmospheric Chemistry | 3 |

*Note: students may select ATOC 219 or CHEM 219 but not both.*

**Elective Courses (9-12 credits):**
- 9-12 credits selected from:
  - ATOC 309 Weather Radars and Satellites | 3 |
  - ATOC 315 Thermodynamics and Convection | 3 |
  - Either of the following courses:
    - ATOC 219 Introduction to Atmospheric Chemistry | 3 |
    - CHEM 219 Introduction to Atmospheric Chemistry | 3 |
  - Additional courses for electives |

### Proposed Program

<table>
<thead>
<tr>
<th>Subj Code/Crse Title</th>
<th>Credit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required Courses (3 credits):</strong></td>
<td></td>
</tr>
<tr>
<td>ATOC 214 Introduction: Physics of the Atmosphere</td>
<td>3</td>
</tr>
</tbody>
</table>

**Complementary Courses (15 credits):**
- 3-6 credits selected from:
  - ATOC 215 Oceans, Weather and Climate | 3 |
  - ATOC 219 Introduction to Atmospheric Chemistry* | 3 |
  - CHEM 219 Introduction to Atmospheric Chemistry* | 3 |
*Note: students may select ATOC 219 or CHEM 219 but not both.*

**Elective Courses (9-12 credits):**
- 9-12 credits selected from:
  - ATOC 309 Weather Radars and Satellites | 3 |
  - ATOC 312 Rotating Fluid Dynamics | 3 |
  - ATOC 315 Thermodynamics and Convection | 3 |
  - ATOC 357 Atmospheric and Oceanic Science Laboratory | 3 |
  - ATOC 512 Atmospheric and Oceanic Dynamics | 3 |
  - ATOC 513 Waves and Stability | 3 |
  - ATOC 515 Turbulence in Atmosphere and Oceans | 3 |
  - ATOC 519 Advances in Chemistry of Atmosphere | 3 |
  - ATOC 521 Cloud Physics | 3 |
  - ATOC 525 Atmospheric Radiation | 3 |
  - ATOC 531 Dynamics of Current Climates | 3 |
  - ATOC 540 Synoptic Meteorology I | 3 |
  - ATOC 558 Numerical Methods and Laboratory | 3 |
  - ATOC 568 Ocean Physics | 3 |
8.0 Consultation with Related Units

☐ Yes  ☐ No

Financial Consult

☐ Yes  ☐ No

Attach list of consultations

9. Approvals

Routing Sequence

Department
Curric/Acad Committee
Faculty 1
Faculty 2
Faculty 3
CGPS
SCTP
APC
Senate

Name
John Gyakum

Signature

Date
November 11, 2016

Submitted by

Name
Timothy Merlis

Phone
(514) 398-3140

Email
Timothy.merlis@mcgill.ca

Submission Date
November 11, 2016

To be completed by ARR:

CIP Code

10. FQRSC (Research) Indicator (for GPS): Yes  No