



The CCCma strategic plan and building a collaborative CanESM

Neil Swart on behalf of CCCma
ARRCU workshop on Analysis, Applications and
Collaborative Development of CanESM
12 March 2021

Outline

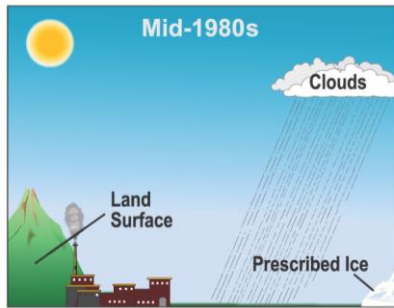
1. History and future of CanESM
2. The CCCma strategic plan
3. Progress and challenges in developing a collaborative version of CanESM

The History and Future of CanESM

History of CCCma modelling & science

Models

AGCM1
Boer and McFarlane
(1979)

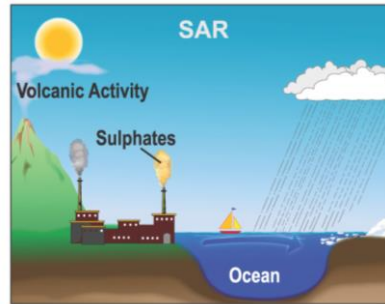


Atmosphere only

AGCM2
McFarlane et al. (1992)

CGCM2

CGCM1
Flato et al. (2000)

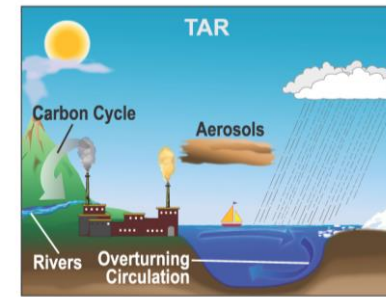


Coupled to ocean

CanESM1
Christian et al. 2010

CGCM3
McFarlane et al. (2005)
Scinocca et al. (2008)

CanESM2 / CGCM4



Carbon cycle

CanESM5
Swart et al. 2019

1970

1980

1990

2000

2010

2020

Assessments & MIPs

WCRP MIPs:

CMIP1

CMIP2

CMIP3

CMIP5

CMIP6

IPCC assessments:

AR1
1990

AR2
1995

TAR
2001

AR4
2007

AR5
2013

SR15 2018
SROCC 2019

**AR6
2021**

Canadian climate assessments:

CCC 2014

CCCR 2019

**WMO Scientific Assessment of Ozone
Depletion:**

2006

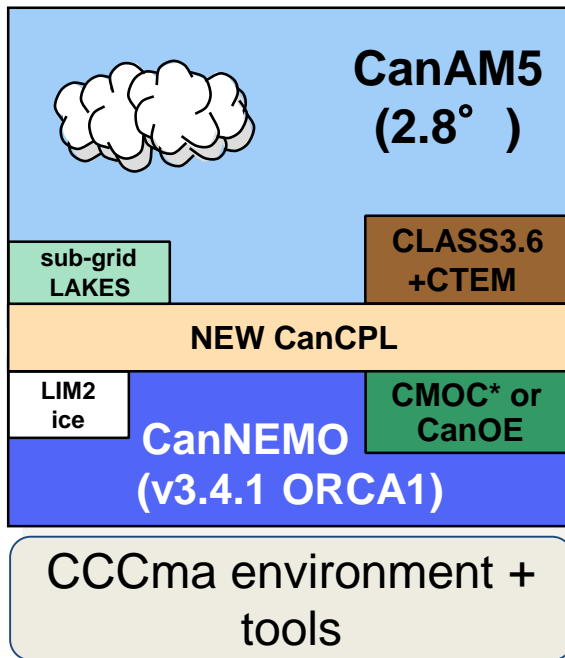
2010

2014

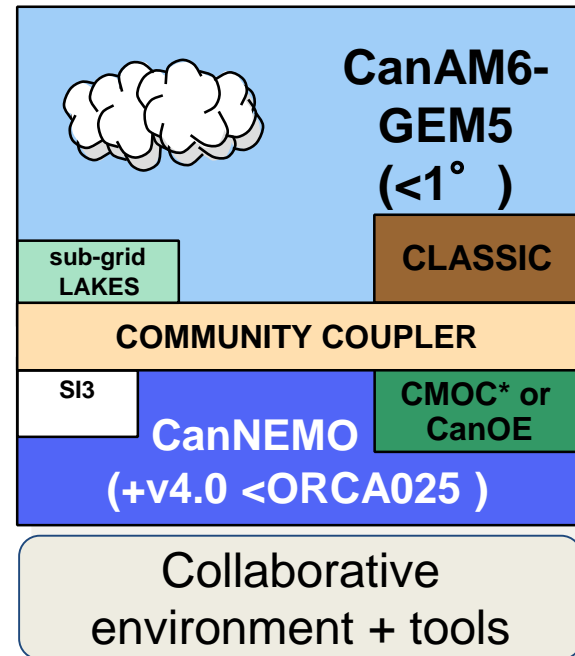
2018

The future of CanESM

CanESM5.0 (CMIP6)



CanESM6.0 (CMIP7)



The CCCma strategic plan

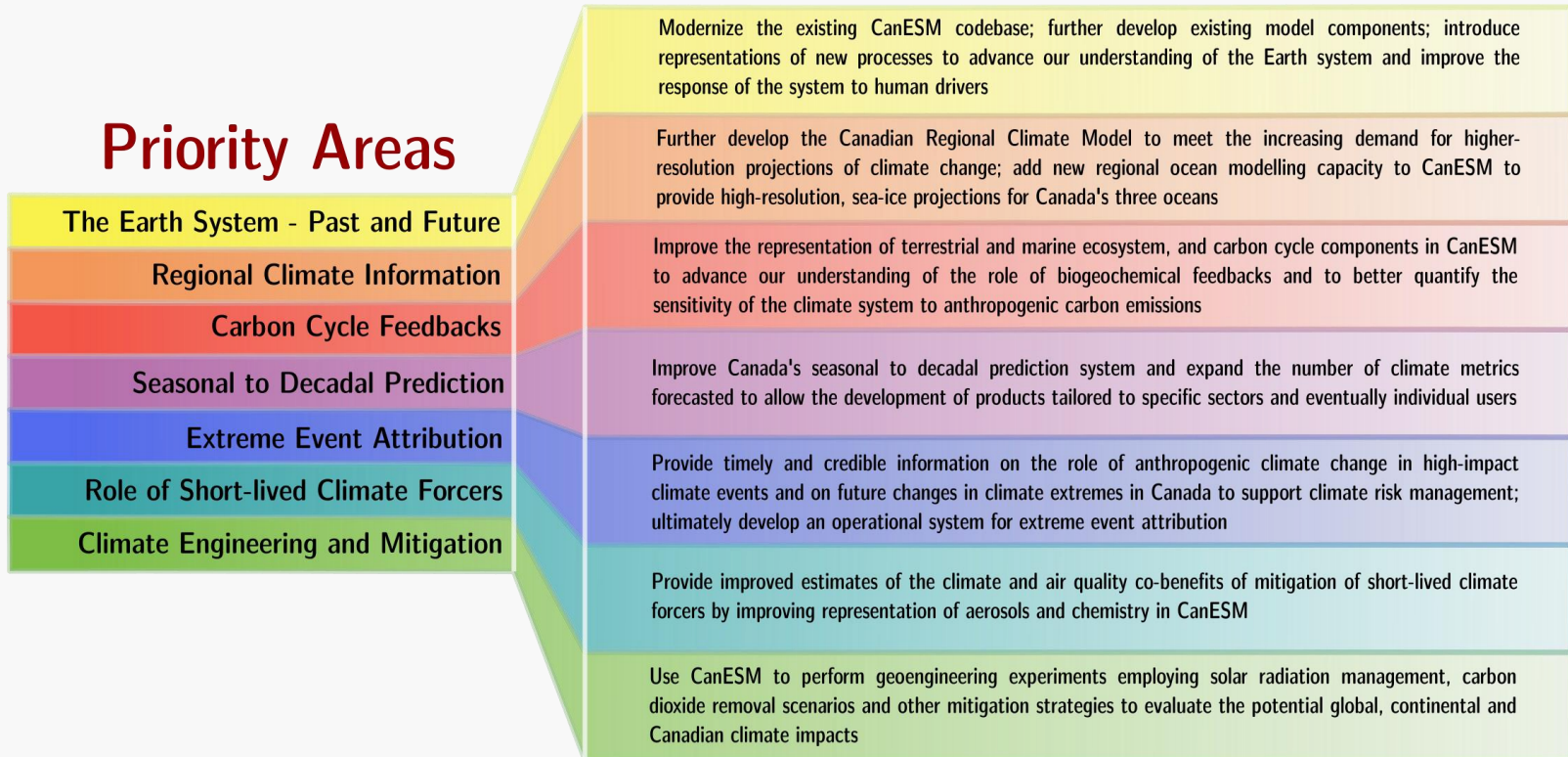


Priorities Areas and Action Plan

CanESM and its modelling systems will deliver global-, continental- and regional-scale climate change projections, analyses, and scientific information for Canadians and others striving to mitigate and adapt to climate change over the next decade.

Action Plan

Priority Areas

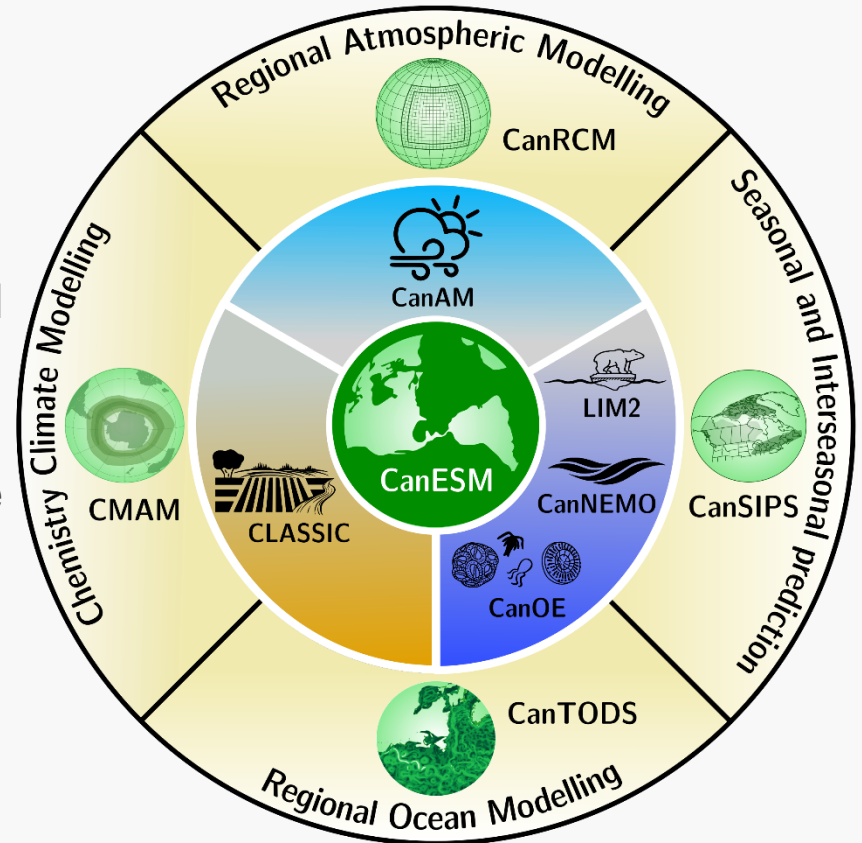




CanESM Modelling Systems

CCCma also develops application-specific climate modelling systems. **CanESM** is the foundation for 4 primary modelling systems.

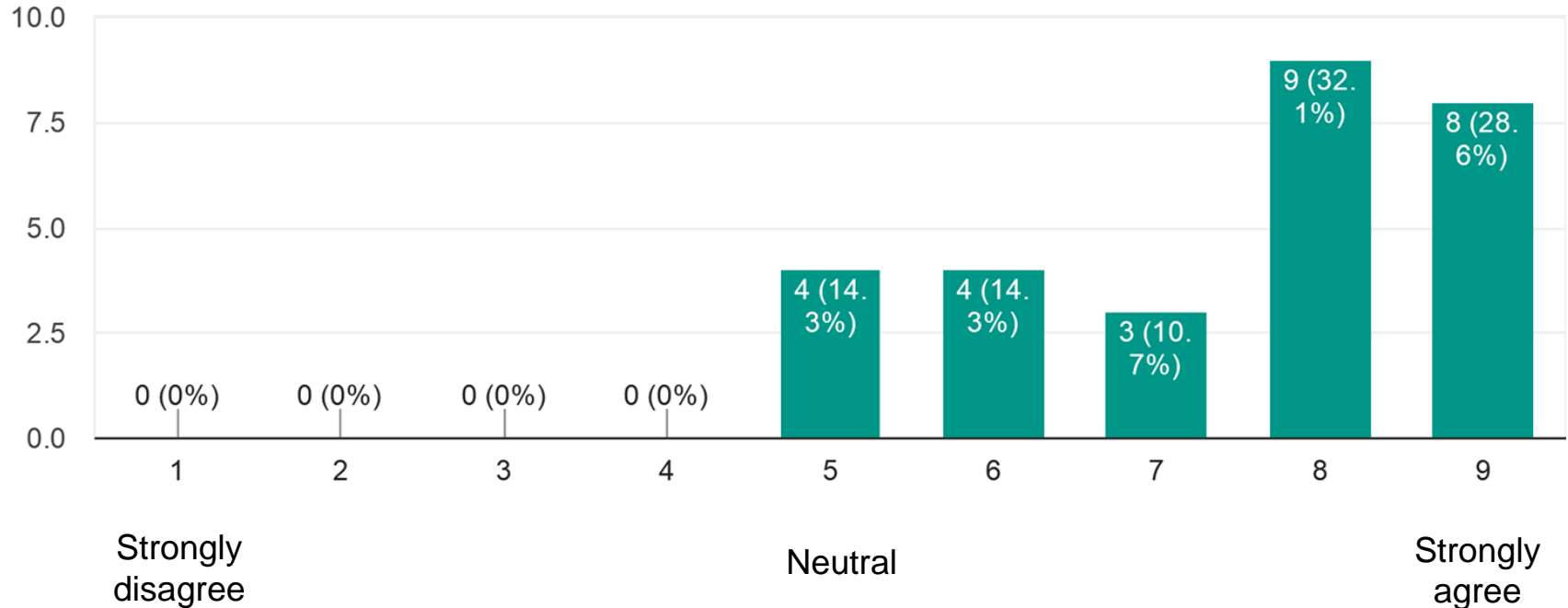
- CanRCM** Atmospheric Regional Climate Modelling downscaling system
- CanSIPS** Seasonal and Interannual Prediction System
- CMAM** Stratosphere/troposphere chemistry climate system
- CanTODS** Canada's Three-Ocean Downscaling System
- Proposed** Event attribution system



CCCma Nov 2019 survey results

More collaboration outside of ECCC/ Government would be an effective way to develop our models (e.g. with universities, other international modelling centres).

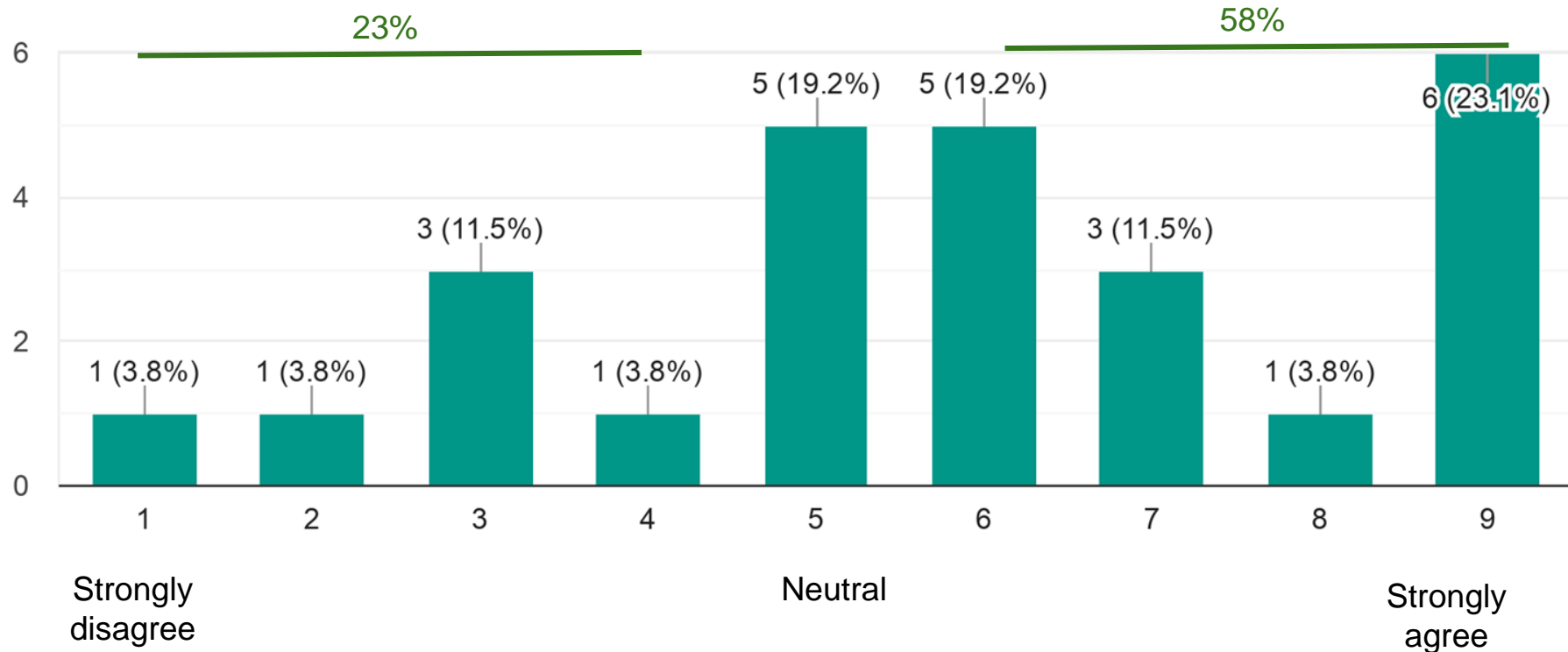
28 responses



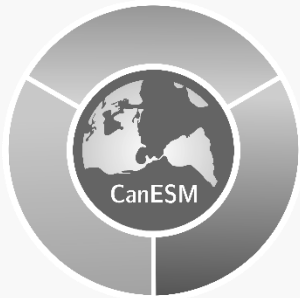
CCCma Nov 2019 survey results

CCCma should consider moving more towards a “Canadian community model”, to encourage collaboration, and to leverage the expertise of the broader Canadian science community.

26 responses



Concerns raised by staff and management focus on the resources required. More on this later.

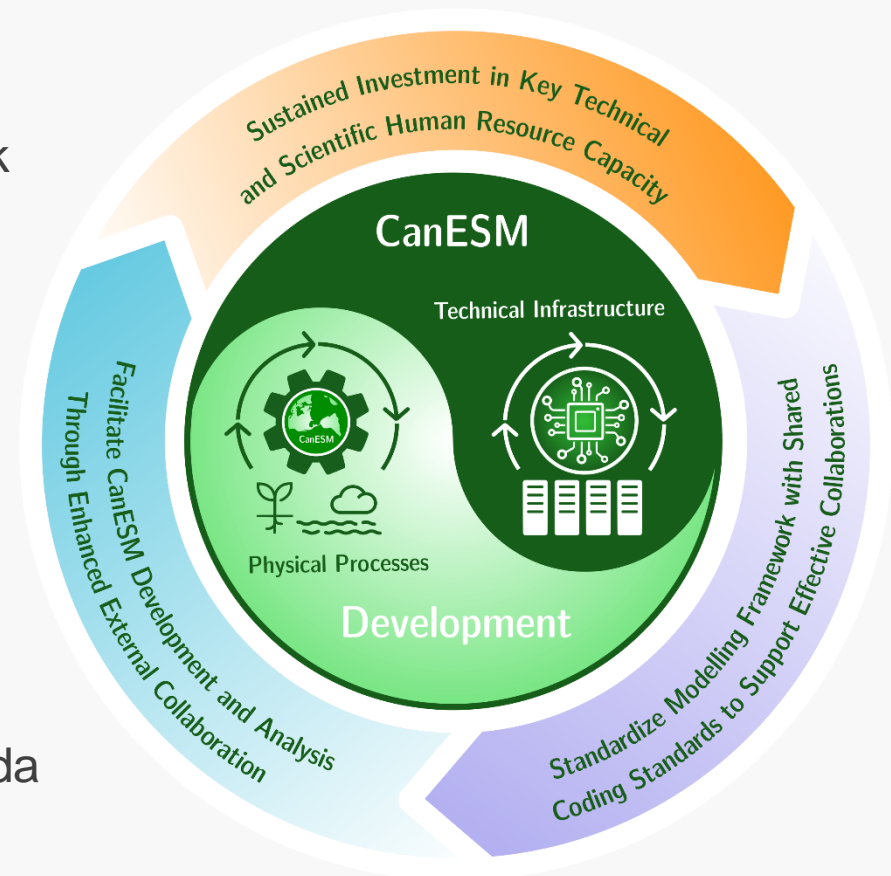


CanESM Community Engagement

Adopting open source and portability policies, **CanESM** development and analysis now can more easily facilitate collaboration with Canadian universities and external partners.

A two-way benefit:

- Standardized modelling framework and community tools enable wider collaborations
- Technical user guides and training materials support external users
- Collaborative analysis and development of **CanESM** expand model expertise and resources
- More collaborations train and engage more users, and enhance climate science expertise in Canada



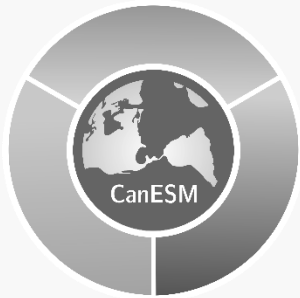


CCCma strategic plan

Long term commitment to a collaborative modelling system

The plan

1. Recognizes the historical contribution of the academic community to CanESM+.
 2. Identifies enhancing future collaborations as key to remaining world-class and providing high quality climate information.
 3. Commits to developing a long term, stable modelling system focused on open standards and interoperability to enable enhanced collaborative application and development by external partners.
-



CCCma strategic plan

Long term commitment to a collaborative modelling system

Snippets from the plan

- The current version of CanESM represents the culmination of several decades of active research involving collaborators within the Climate Research Division, the Atmospheric Science and Technology Directorate, other government departments (notably Fisheries and Oceans Canada), and the academic community.
- Increased collaboration between CCCma and partner organizations is vital to maintaining the globally recognized, state-of-the-science Earth system modelling capacity required
- CanESM is well positioned to be the foundation of a comprehensive integrated modelling infrastructure within the Canadian community
- By striving towards an open standards-based collaborative modelling framework, CCCma can leverage the expertise of the broader Canadian climate science community, thus, helping to maintain a world-leading standard of scientific quality and technical efficiency. This system will provide the best possible scientific basis for informing decisions in Canada.
- ..focus on creating a modelling foundation that is robust, efficient, and designed to support interoperability and collaborative development. Embracing open community standards and leveraging community tools will allow both the technology and skills of code developers to be more transferable, and will support the Open Government science objective
- **Requirements to realize goals of the plan**
 - *Enhanced external collaborations to further the development and analysis of CanESM*
 - developing the model in a manner that lowers the technical barriers to using the model for partner organizations and the academic community; followed by developing a clear governance framework to support an expansion in the scope of collaboration
 - *The establishment of a standard modelling framework and shared coding standards to support effective collaborations with partner organizations.*
- **Ambition for the next decade**
 - This plan envisions continued collaborative development of CanESM as the foundation of a comprehensive integrated modelling system

Building a Collaborative CanESM

How is a “collaborative CanESM” different to existing/previous collaborations?

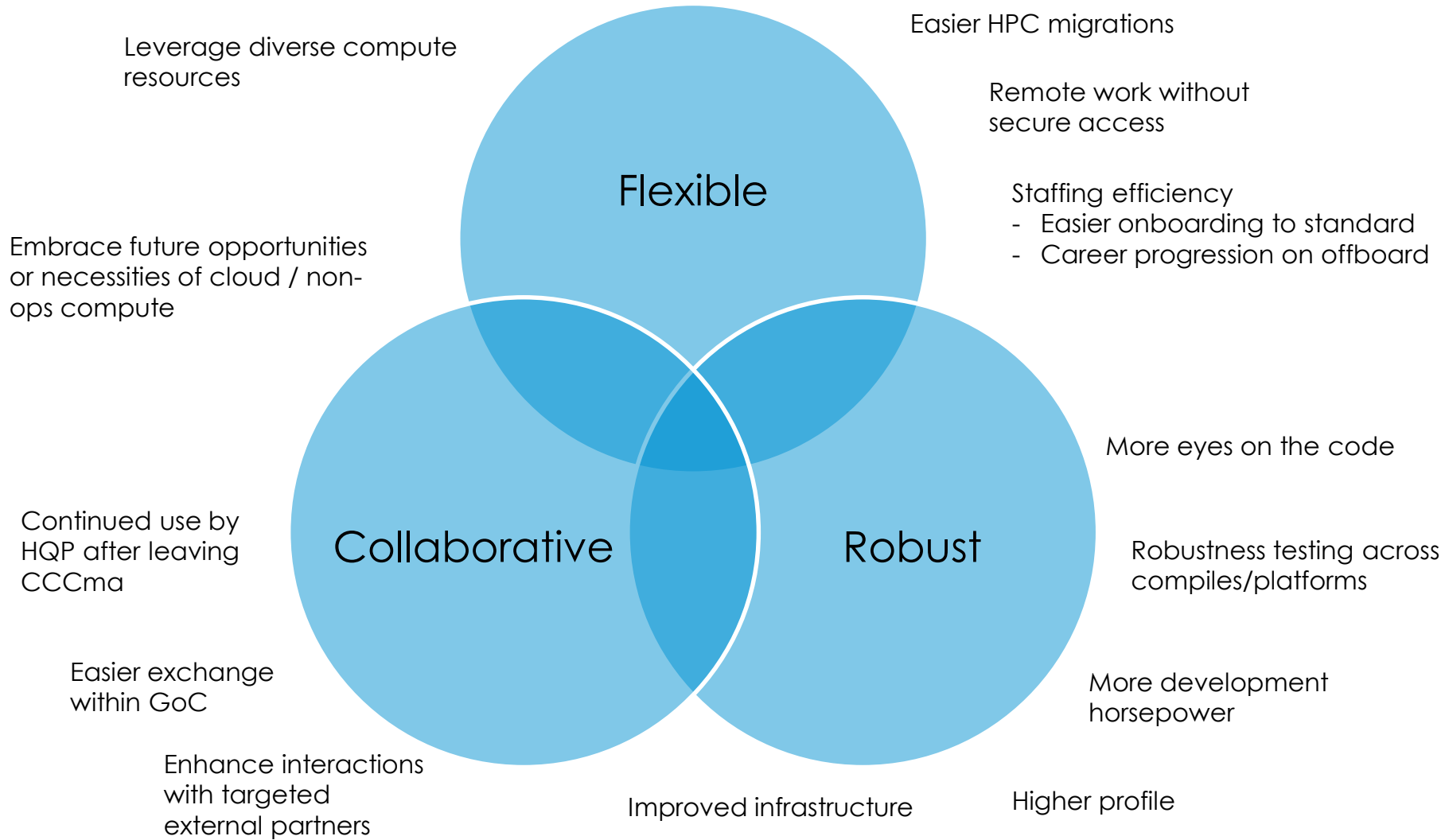
- Fundamentally, we anticipate collaborations will remain on a scientist-to-scientist, mutually beneficial basis, as before.
- There are great opportunities to improve by:
 - Co-design of simulations and model products for end-users
 - Promoting findability and ease of use of data
 - Enabling external application and development of the CanESM.

10 Elements of a collaborative CanESM

1. A new philosophy
2. Open code base
3. A reproducible environment (container)
4. Portable, standards compliant code
5. Experiment configuration & forcing
6. Usable in/out files and diagnostic capability
7. Portable compilation & sequencing utilities
8. Current documentation and user/dev guides
9. Robust testing and Quality Assurance
10. Collaboration philosophy & support

1. Rationale for a collaborative model

Recognize that work needed to enable external use is not an add on expense, but rather what is required for internal operations and developing improved climate change information for Canadians via a CanESM that is...



Collaborative CanESM = Mutual internal/external benefits

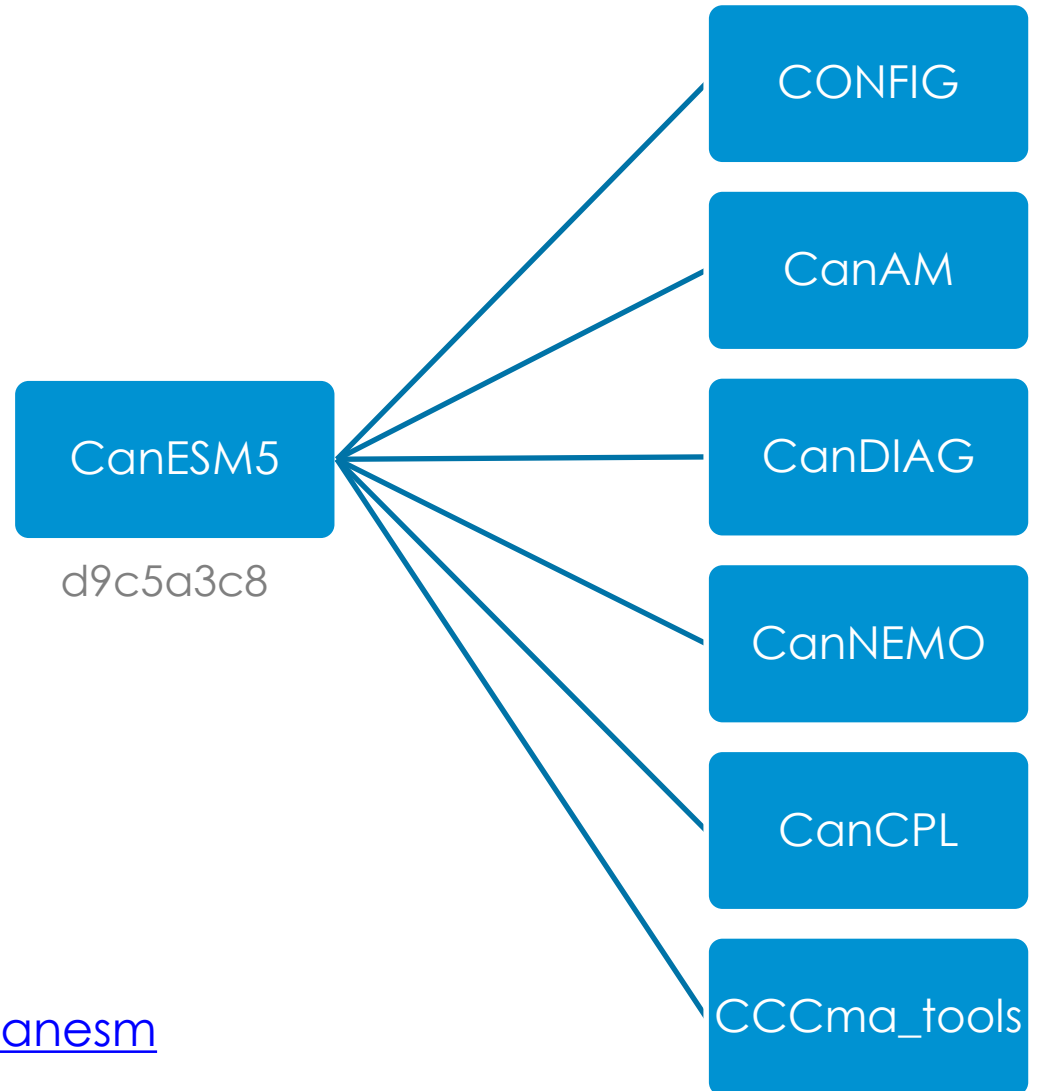
2. A complete, open and controlled code base

One hash to rule them all

Every single piece of >3m SLOC defined by an 8 character CanESM5 hash and open on:

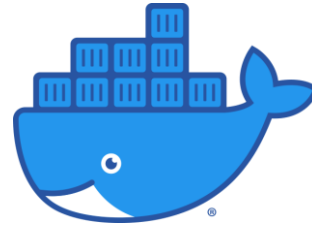


<https://gitlab.com/cccmma/canesm>



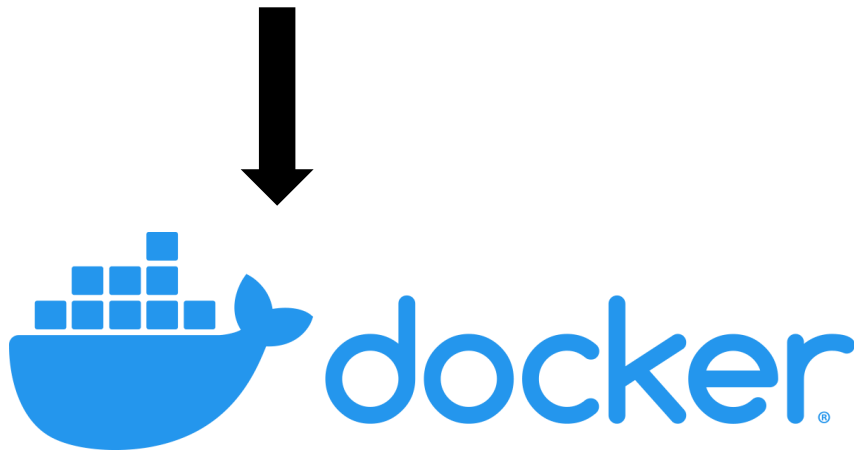
3. CanESM container

Proof of concept



A reproducible runtime environment allowing the same code to operate on a diversity of host platforms / OSs.

Dockerfile container definitions live on gitlab



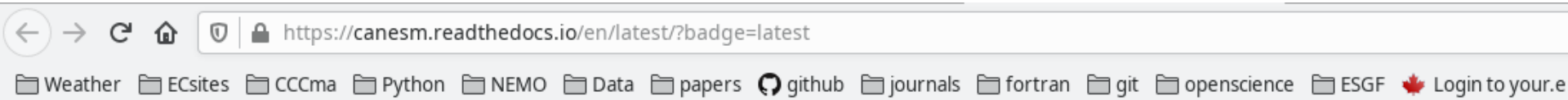
Built container image lives on dockerhub



Docker to Singularity conversion in 1 line (for HPC systems).

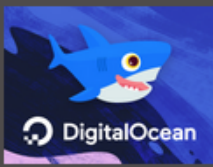
<https://hub.docker.com/repository/docker/swartn/canesm-docker>

8. Documentation and user guides



CanESM user guide
latest

- CONTENTS:**
- Quickstart guides
 - Overview of CanESM
 - CanESM code structure
 - Contributing to CanESM (Developers guide)
 - Advanced topics



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» CanESM user guide [Edit on GitLab](#)

CanESM user guide

The Canadian Earth System Model is comprehensive representation of the climate system used to simulate past climate change, to make projections of future climate change, and to make initialized seasonal and decadal predictions.

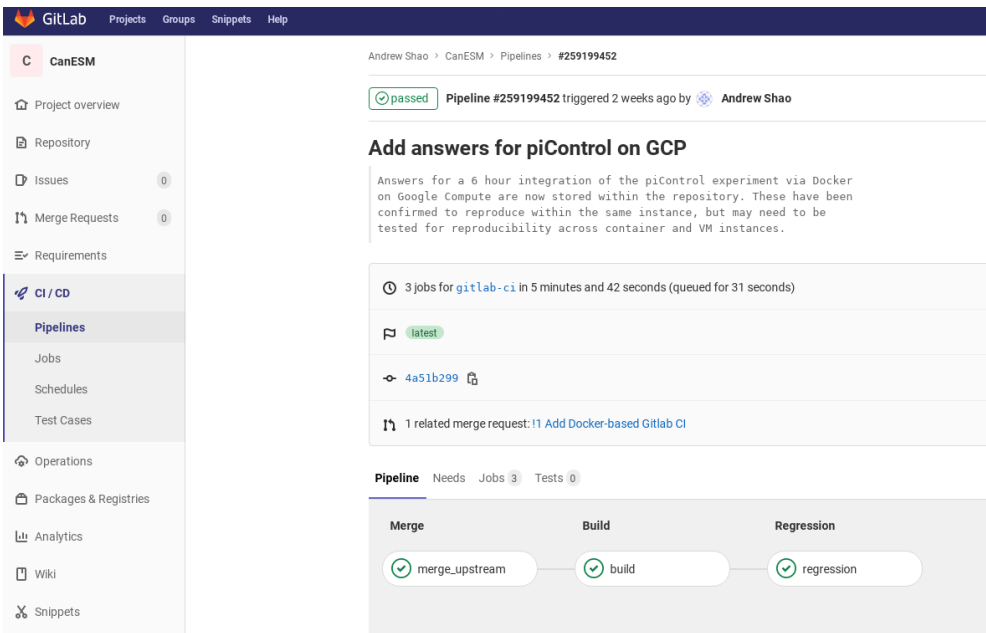
CanESM is developed at the [Canadian Centre for Climate Modelling and Analysis](#), Climate Research Division, Environment and Climate Change Canada.

This guide provides an overview of the modelling system and practical usage guidance on configuring and running climate simulations. The scientific documentation of the model is provided separately, and referenced in the overview section.

Contents:

- [Quickstart guides](#)
- [Overview of CanESM](#)
- [CanESM code structure](#)
- [Contributing to CanESM \(Developers guide\)](#)
- [Advanced topics](#)

9. Robust testing & QA



9a Automated continuous integration limited tests of compilation, bit-identity

9b Manual ensemble tests extensive tests of climate in CMIP6 DECK

9c Analysis for Development (A4D) Comprehensive evaluation diagnostics

9d Quality Assurance CanESM working group

10 Elements of a collaborative CanESM

1. ~~A new philosophy~~
2. ~~Open code base~~
3. ~~A reproducible environment (container)~~
4. Portable, standards compliant code
 - CanAM and CanDIAG are particular challenges
5. Experiment configuration & forcing (WIP)
6. Usable in/out files and diagnostic capability
 - CanAM CCCma format / CanDIAG & CMIP netcdf pipeline
7. Portable compilation & sequencing utilities (WIP)
8. Current documentation and user/dev guides (WIP)
9. Robust testing and QA (WIP)
10. Collaboration philosophy & support
 - ECCC commitment to open platform and collaboration, but no mandate or resources for direct user/platform support. Requires community ingenuity. Philosophy TBD.

Computing platforms tested

Initial testing on laptop and GCP. Any other cloud vendor should work too.



Google Cloud Platform

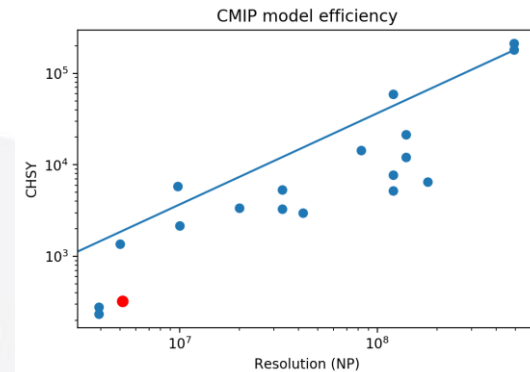
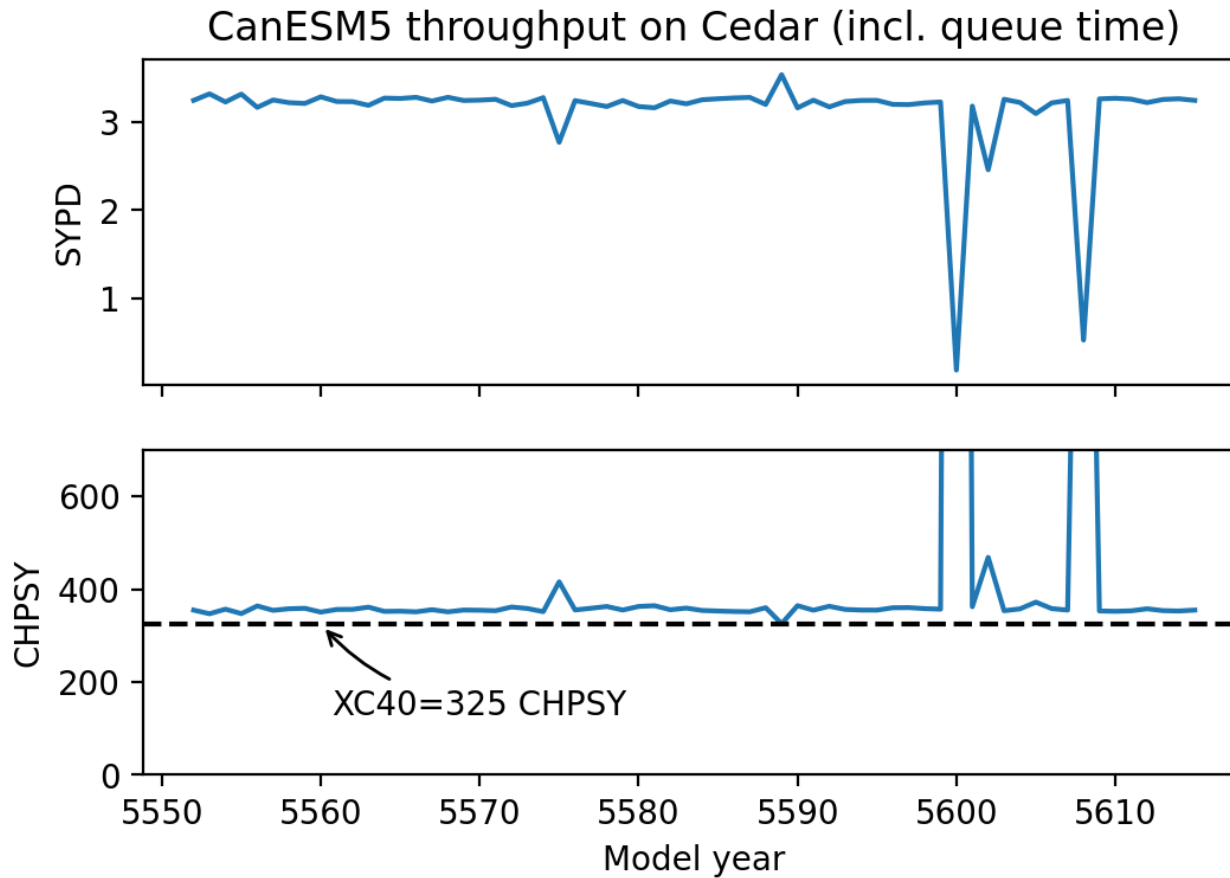


compute | **calcul**
canada | canada

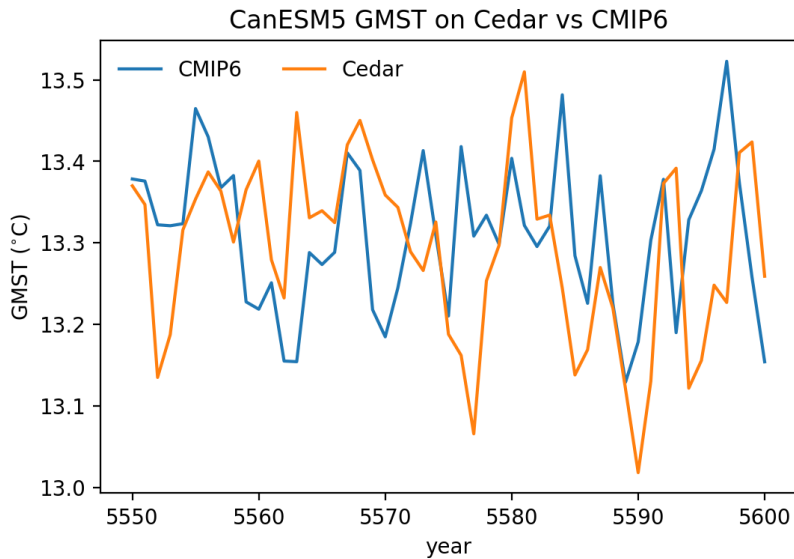
More comprehensive testing on Compute Canada's *Cedar* system.

SLURM is a challenge. Much improvement still to be made.

Throughput and efficiency



Surface air temperature

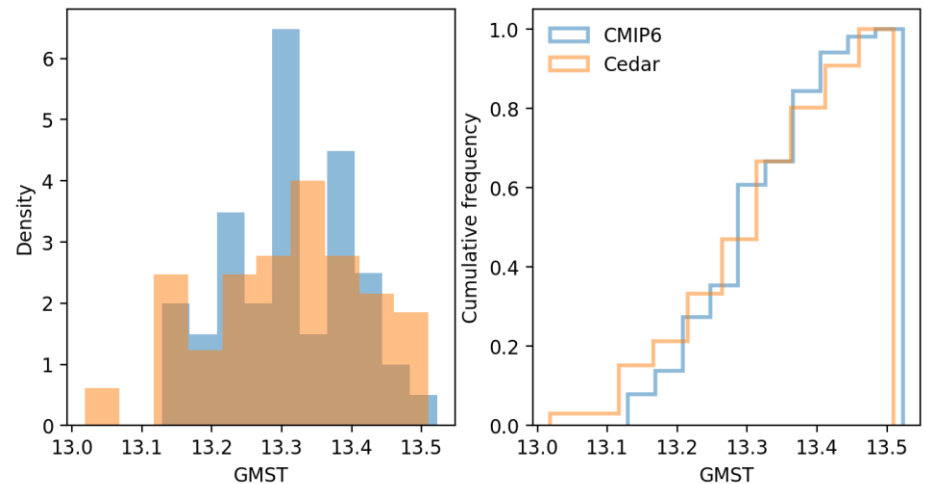


T-test (means) : $p=0.86$

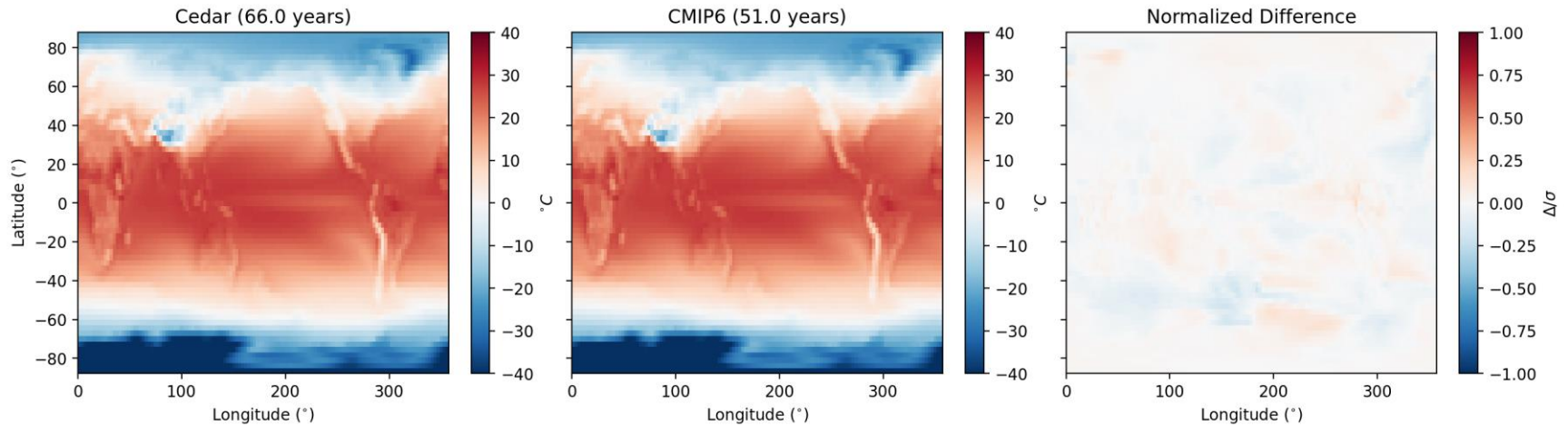
F-test (variance) : $p=0.95$

KS test (distribution) : $p=0.76$

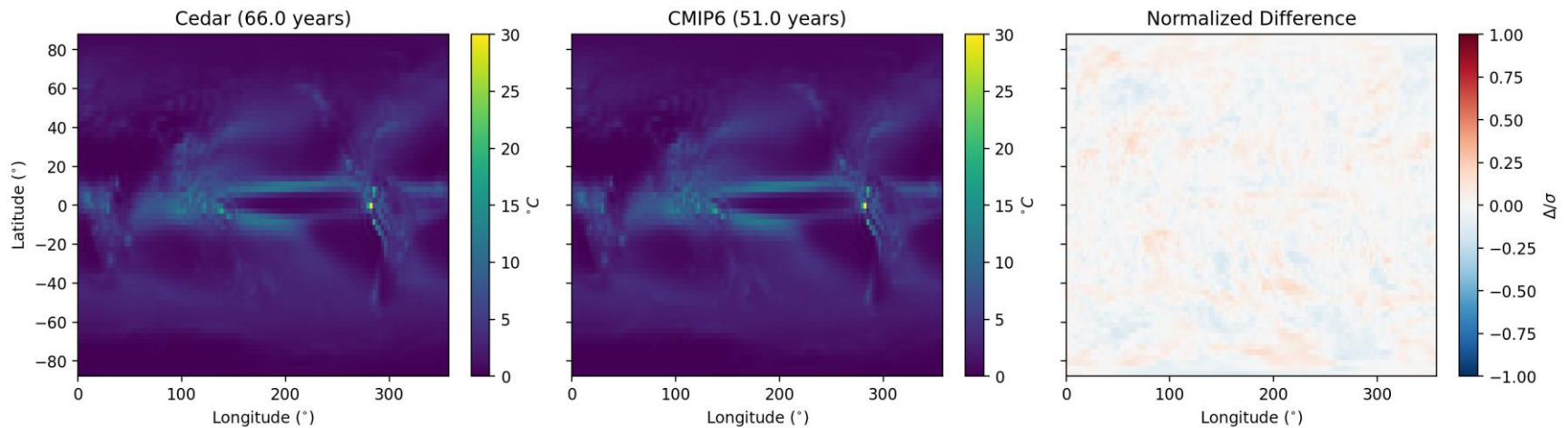
i.e. results are indistinguishable



Surface air temperature



Precipitation



Moving forward

- Identify and engage with targeted pilot projects for external application / development.
- CCCma will continue to improve the systems as a part of our ongoing work and within our resources and mandate.
- Further development required for the contribution and governance policies, as well as support structures.
- We need to explore the ideas of identity and ownership related to newly enabled external usage.

Summary

- ECCCC has a long-term commitment to developing and maintaining an open, collaborative modelling system (see CCCma strategic plan).
- A portable, containerized and nominally documented version of CanESM already exists. It is functional, but has rough edges and incomplete functionality.
- Collaborations will continue on a scientist to scientist basis, enhanced by the new flexibility of a portable CanESM.
- Users and platform support teams (not ECCCC) are responsible for machine specific details.
- A mechanism is required for community information exchange, to help answer model questions.
- An exciting opportunity to build a community and improve climate projections in Canada via new functionality.