Status & Plans of CCMC Activities for the Annex

Status of CCMC Activities

ADAPT

Historic ADAPT maps will be obtained from the Air Force Research Lab. If agreed by SWPC, one potential source is the ADAPT maps in the NOAA folder on the GONG ftp site[1]. CCMC will use whichever ADAPT source is specified by SWPC.

WSA 4.0

A preliminary version of WSA 4.0 was delivered to the CCMC in September 2016, and a newer version, 4.2 delivered in February 2017. These versions are ADAPT capable. These versions were delivered to us before they are approved for official use. They represent a significant rewriting of the model code and re-organization of the model's internal data and file structures compared to the current WSA version 2.2 at CCMC. They were delivered to us early so we could gain hands-on experience with them and rework our supporting software environment so that we would be ready to bring them on-line as soon as Nick was happy with the tuning tests which he needed to complete. Since receiving v4.2 it has been running every 2 hours each day in order to test stability and to build up a database of results for all 12 ADAPT threads. We have developed some preliminary wind speed and imf polarity metrics which allow us to see which of the 12 threads best matches observations at L1 over the previous 7 days.

We are working with Nick and his team to define an approach to analyzing this metric data so that we can optimize selection of threads which should be used when running WSA/Enlil at operational resolution.

Enlil versions 2.8/2.9

Currently, all Enlil versions at the CCMC use WSA 2.2. Full rotation Enlil v2.8b simulations have been available on Runs-on-Request since December 2015. The interface[2] for Enlil v2.8f with time-dependent inner boundary simulations (without ADAPT) has been available for special requests since October 2016 for user testing. Within the last year 100+ user special request simulations have been executed. Enlil v2.8f simulation output pages now provide much more simulation metadata, and new Enlil shock and fieldline output to users. Enlil v2.9b was delivered to CCMC in April 2017 and we plan to make this version (or latest version delivered within the next few months) public on Runs-on-Request. While this version has been tested on a handful of ADAPT-WSA inputs, but it is not the final ADAPT-capable version of the model from Dusan Odstrcil in order to complete the ADAPT-WSA-Enlil runs for the Annex (CCMC R3–R6). CCMC default ambient parameters for Enlil 2.8f/2.9b are a6b1, as recommended by the model developer.

Additionally, the CCMC has recently completed a study of over real-time Enlil v2.6/2.7 simulations of 1800+ CMEs (273 hits) submitted to *Journal of Space Weather and Space Climate* in June 2017 (Wold et al., "Verification of real-time WSA–Enlil+Cone simulations of CME arrival-time

[1] ftp://gong2.nso.edu/adapt/maps/noaa/
[2] https://ccmc.gsfc.nasa.gov/requests/SH/E28/enlil_options.php

at the CCMC/SWRC from 2010–2016"). We fully explored challenges in CME arrival time forecast verification, preparing us for Annex activities.

The International Forum for Space Weather Modeling Capabilities Assessment

The CCMC is leading the newly-established "International Forum for Space Weather Modeling Capabilities Assessment."[3] Its goals are to define metrics to assess the current state of space weather modeling capabilities and to help capture scientific progress in models that feed into operations. The forum is a long-term activity. Six physical domains were identified, with multiple working teams within each domain. To jumpstart the activity, the CCMC organized the "International CCMC-LWS working meeting: Assessing Space Weather Understanding and Applications", held on April 3-7, 2017 in Cape Canaveral. The meeting attracted 120 participants representing all of the elements of the R2O process, including basic research, policy makers, operational modeling and forecasting, and end users. Importantly, there was participation from NOAA/SWPC in the teams and at the workshop (see below).

The Forum is closely related to the Annex tasks, particularly the "CME Arrival Time and Impact" working team[4], led by C. Verbeke (KU Leuven), M. L. Mays, A. Taktakishvili (CCMC). The goal of this working team will evaluate how well different models/techniques can predict CME arrival time and impact for a set of historical events, with open communication with the community. This includes evaluating where we stand with CME arrival time and impact prediction; establishing metrics agreed upon by the community; and providing a benchmark against which future models can be assessed against. The team participants had discussions before the workshop and made much progress during the workshop. Afterwards, the team leads provided a report summarizing the team's status and future plans[5] and a copy of all presentations[6]. Additionally, a survey was sent out to gather more feedback from users[7].

Some report highlights include (all pending community feedback):

- Validate at least 100 CME events (all types) for statistical significance. Overlap some of these events with the "IMF Bz", "3D CME kinematics", "Geomagnetic Indices", and "SEP" working teams.
- The observed CME arrival time will be taken from existing ICME catalogues. For the cases where the CME can be found in multiple catalogues, a random catalogue will be chosen.
- Observed CME plasma parameters will be taken from 1 hour averaged OMNI data.
- Fix the magnetogram, and CME model input parameters for the 100 events—to be obtained from the "3D CME kinematics" working team.
- Arrival time errors: RMSE (Root Mean Square Error), MAE (Mean Absolute Error), and the ME (Mean Error).
- Use different hit definition intervals 3h, 6h, 12h, 18h, 24h and 36h.
- Set up contingency tables. Scores include: Hit rate (POD), False alarm rate, False alarm ratio, Bias, Accuracy, Threat score, Base rate, Proportion correct, HK, HSS.
- Correlation coefficients of CME plasma parameters at arrival.
- How will each model define the modeled CME arrival time? Should all models use the same algorithm?

[3] https://ccmc.gsfc.nasa.gov/assessment/index.php
[4] https://ccmc.gsfc.nasa.gov/assessment/topics/helio-cme-arrival.php
[5] https://ccmc.gsfc.nasa.gov/assessment/topics/CME/CME_summary_working_meeting_20170413.pdf
[6] https://ccmc.gsfc.nasa.gov/assessment/topics/CME/iccmc-lws.php
[7] https://goo.gl/z8EnwK

For the purposes of Annex activities we will work with SWPC to determine appropriate choices for these and other items (which may differ from some of the choices for the working team).

Status of CCMC communications with SWPC related to the Annex

August 2016	Telecons to discuss potential Annex activities and edit the Annex CCMC: Masha Kuznetsova, Antti Pulkinnen, Peter MacNeice, Leila Mays; SWPC: Rodney Viereck, Howard Singer, Vic Pizzo.
November 2016	CCMC established the "International Forum for Space Weather Modeling Capabilities Assessment" and individually invited all SWPC colleagues to participate or lead in working teams.
March 2017	Received feedback during Flare working team telecon from Rob Steenburgh (SWPC).
March 2017	Telecon focused on SWPC needs related for multiple Forum working teams (CME arrival time, SEPs, solar and coronal structure). CCMC: Peter MacNeice, Leila Mays; SWPC: Vic Pizzo, Rob Steenburgh.
3-7 April 2017	Vital SWPC participation at the International CCMC-LWS workshop by Howard Singer, Rob Steenburgh (SWPC), and Curt de Koning. Howard and Rob contributed information on user needs and model validation ideas for nearly all of the working teams. All teams highly benefited from their involvement.
16 June 2017	Telecon to discuss plans to implement Annex activities.
29 June 2017	CCMC visit by Steve Clarke, Brent Gordon, and Terry Onsager.

CCMC infrastructure supporting the Annex

The CCMC is developing a comprehensive IT infrastructure to support all its model validation activities. This infrastructure includes all the database capabilities needed to support the Annex activity. We will need to broaden the meta-data items currently recorded to accommodate the Annex needs, particularly with regard to the provenance of the ADAPT threads.

In addition we have a pre-existing "scientific" model validation system which was developed to provide a semi-automated ongoing record of coronal and solar wind model capabilities, in collaboration with the SHINE community. This system takes result posted by the model developers or model users and automatically generates a set of graphics exposing many elements of the solution. The goal was to allow comparison of results from competing models through the use of identical graphical diagnostics. The initial SHINE effort focused on ambient time-independent model cases. The system will be upgraded to use the database features of the IT infra-structure referenced in the preceding paragraph, and will be extended to process time dependent cases and specifically to include the time of arrival metrics required by SWPC.

Future Plans for Annex Activities

Together, we aim to complete SWPC R1–R3 and CCMC tasks R1–R3. We will have regular communication on SWPC tasks R1–R3 to discuss:

- Event set (SWPC R1)
- Obtaining and databasing SWPC operational model inputs, CME inputs and simulation outputs (SWPC R2)
- Determining predicted/observed arrival times.
- Model ambient settings (CCMC R1, R2)
- Enlil model version (CCMC R1, R2)
- Magnetogram input frequency (CCMC R2)
- Metrics (SWPC R1)
- Grid resolution (SWPC R3)

Three month action plan

- SWPC will provide 40–50 events from Doug Biesecker's list, including CME parameters, input parameters used, and model outputs. A few events will be selected for initial testing. (SWPC R1)
- CCMC will develop a metadata framework to keep track of parameters/settings for all simulations in performed for the Annex study. (SWPC R2)
- CCMC will add the runs received from SWPC to the database. (SWPC R2)
- CCMC will attempt to replicate a few runs using Enlil version 2.6 and 2.9. SWPC sent CCMC a sample run on 23 June 2017.
- SWPC and CCMC will work with Dusan Odstrcil to verify that Enlil v2.9 can replicate v2.6.
- SWPC and CCMC will schedule telecons as needed to discuss other items listed above, such as: replicating runs, grid resolution, outer boundary, metrics, run settings, run versions, magnetogram input frequency, and metrics. (SWPC R2, R3, CCMC R1, R2)
- SWPC and CCMC will talk to Carl Henney and Nick Arge about which version of ADAPT we should use for this study. (CCMC R3)
- CCMC/Peter will continue to collaborate and work with Nick Arge on evaluating polarity and speed predictions at L1 from ADAPT-WSA version 4.2. (CCMC R5)
- CCMC/Peter will provide information on the variance between WSA outputs at L1 for different realizations to Eric/SWPC team. (CCMC R3)

We will also have regular communication to discuss CCMC R1-R3 and any intermediate results. Existing versions of WSA v2.2 and Enlil v2.8f can be used to complete CCMC R1–R2 (single map and time-dependent sequence simulations). CCMC will begin this work as soon as the events, and a few more of the items listed above have been determined. Test runs can be performed to discuss these items.

For CCMC R3 (preliminary time-dependent ADAPT-WSA-Enlil simulation for all 12 realizations for one event) this requires the latest approved final WSA and Enlil. We have contacted both Nick and Dusan to get updates on when the latest version will be approved for our use for this project.