NCAR
UCAR

Ben Foster <foster@ucar.edu>

dependence of TIEGCM Output on time step

15 messages

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Mar 30, 2015 at 6:29 AM
To: Ben Foster <foster@ucar.edu>, wbwang <wbwang@ucar.edu>
Cc: Stan Solomon <stans@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, maute <maute@ucar.edu>

Hi Ben and Wenbin,

How are you doing? Recently we checked the TIEGCM simulations with different time steps and found the the model outputs depend on the used time step. Here I reported the results I got to you. Please see the attachment (5x5 resolution). We run the TIEGCM 1.94 at three time steps: 120s, 60s, 30s (we did not change other inputs).

Peak electron densities at the F2 layer (NmF2) decrease as a smaller time step is adopted. The EIA is not obvious at 30s time step as compared with the simulation at 120s. The maximum change reached as large as 30% when electron densities at 120s and 30s are compared. The changes of Te, Ti, Tn and neutral densities are also checked. The changes of Te are about 300 K, and the changes in neutral gas are smaller.

We think too much smooth in the oplus.F. In the oplus.F, when the shapiro and filer smooths are prefermed every 120s regardless of the time step we used, in this case the changes in electron densities between different time steps are not so obvious.

We also did simulations by changing the shapiro factor. When shapiro factor is 0.003 (instead of the default value 0.03), and the shapiro and filer smooths are used each time step , the EIA latitudinal structue is more clear compared with the default simulation. The decrease of electron densities at different time steps is much less obvious as compared with the default model simuations.

Please note that we got similar results at different seasons. These simulations were conducted at our local computer. The results are the same when the model is run at yellowstone.

From our test, it seems that the smooth procedure causes the problem. Should we use a smaller shapiro factor, at least in oplus.F as the latitudinal variation in electron density is strong in the F2 layer.

Any suggestion or idea?

Jiuhou

EIA_dangtong_20150330.pptx
1450K

Stan Solomon <stans@ucar.edu> Mon, Mar 30, 2015 at 8:07 AM
To: Jiuhou Lei <leijh@ustc.edu.cn>, Ben Foster <foster@ucar.edu>, wbwang <wbwang@ucar.edu>
Cc: Art Richmond <richmond@hao.ucar.edu>, maute <maute@ucar.edu>

Jiuhou -

Can you upgrade to TIE-GCM v. 1.95, and repeat these tests? I don't think that there were any changes between v. 1.94 and v. 1.95 that would pertain to this problem, but if we are going to look into this, we need to be on the same page. Version 1.94 is almost four years old now.

(Ben, do you have an opinion as to whether they should be using v. 1.95, or should they just be on the trunk?)

Stan

--

Stanley C. Solomon
High Altitude Observatory
National Center for Atmospheric Research
Boulder, Colorado, USA

Stan Solomon <stans@ucar.edu> Mon, Mar 30, 2015 at 8:20 AM
To: Ben Foster <foster@ucar.edu>, wbwang <wbwang@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, maute <maute@ucar.edu>, liuh@ucar.edu, Liying Qian <lqian@ucar.edu>, Alan Burns <aburns@ucar.edu>

Has anybody seen anything like this before?

It's surprising to me that we didn't notice it when we were experimenting with filters and time steps for the high-res version. I do recall that Ben noticed some strange behavior recently when changing time steps on restart, but nothing like this. It seems to mostly pertain to the ionosphere.

If this is right, and is actually an issue in the current version, then Jiuhou makes a persuasive case concerning the frequency (and strength) of the Shapiro filter. However, there may be stability issues during storms - the filter is there for a reason.

Since we are working on Oplus for WACCM-X anyway, it seems that we need to look into this. I keep saying that we need to stop trying to make things better and just get the WACCM-X ionosphere up and running, but if this is an issue for TIE-GCM then we should address it in TIE-GCM, especially because we are approaching a release (at last) of the high-res version, which uses shorter time steps.

The lack of "definition" in the equatorial anomaly has been troubling me lately anyway, because I have been working on airglow maps. It's better at high-res, see http://download.hao.ucar.edu/pub/stans/gold/plot/DecMaxOI.png.

Stan

[Quoted text hidden]

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Mar 30, 2015 at 8:23 AM
To: Stan Solomon <stans@ucar.edu>
Cc: Ben Foster <foster@ucar.edu>, wbwang <wbwang@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, maute <maute@ucar.edu>

Hi Stan,
Thanks for your quick response! I asked my student Haibing who ran the TIE-GCM 1.95 and almost got the same results.

Jiuhou

> -----原始邮件-----
> 发件人: "Stan Solomon" <stans@ucar.edu>
> 发送时间: 2015-03-30 22:07:59 (星期一)
> 收件人: "Jiuhou Lei" <leijh@ustc.edu.cn>, "Ben Foster" <foster@ucar.edu>, wbwang <wbwang@ucar.edu>

> 抄送: "Art Richmond" <richmond@hao.ucar.edu>, maute <maute@ucar.edu>
> 主题: Re: dependence of TIEGCM Output on time step
[Quoted text hidden]

Astrid Maute <maute@ucar.edu> Mon, Mar 30, 2015 at 8:49 AM
To: Jiuhou Lei <leijh@ustc.edu.cn>
Cc: Stan Solomon <stans@ucar.edu>, Ben Foster <foster@ucar.edu>, wbwang <wbwang@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, Astrid Maute <maute@ucar.edu>

Jiuhou,

thanks for quantifying the model dependence on the time step size. I am surprised about the magnitude not only in the ionosphere but neutral winds.

Just a comment about your simulations: did you run it till you get a diurnally reproducible state for each time step size. I do not think that this would explain these large differences but the simulation with smaller time stepping might settle faster.

Apart from the local differences did you look into convergence of e.g. NmF2 n L2 norm to quantify globally the behavior and if this is linear.

Stan, let me know how I could help.

Astrid
[Quoted text hidden]

Ben Foster <foster@ucar.edu> Mon, Mar 30, 2015 at 9:22 AM
To: Stan Solomon <stans@ucar.edu>, Joe McInerney <joemci@ucar.edu>, Wenbin Wang <wbwang@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, Astrid Maute <maute@ucar.edu>, Jiuhou Lei <leijh@ustc.edu.cn>

Stan, Jiuhou:

I can test this on the trunk, but I suspect we will see the same or similar results as 1.94 or 1.95 in terms of different time stepping. I don't think the shapiro smoother has been changed in the last few years. It would be best if we are all running the same code, preferably the trunk.

Joe mentioned that CAM users are encouraged not to change the timestep in a run, i.e., in restart/continuation. In fact, if you try to do this, the model will stop with a warning. This implies that there can be non-zero numerical differences when changing timestep, but certainly not at the magnitudes you are finding. CAM uses different timesteps for different processes ("timestep splitting"), but TIEGCM does not.

Jiuhou, thanks for finding this, and for your time testing and debugging. We are in the process of installing the oplus code in waccm, so its important to resolve the issue..

--Ben

[Quoted text hidden]
--
Ben Foster
National Center for Atmospheric Research (NCAR)
High Altitude Observatory (HAO)

303-497-1595

Wenbin Wang <wbwang@ucar.edu> Mon, Mar 30, 2015 at 9:26 AM
To: Astrid Maute <maute@ucar.edu>
Cc: Jiuhou Lei <leijh@ustc.edu.cn>, Stan Solomon <stans@ucar.edu>, Ben Foster <foster@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>

Hi, all

First of all, Astrid, I asked Jiuhou and they did run to a diurnally reproducible state, i.e. they are the result of 20-day runs.

I just checked my notes, the number of 0.03 was the result of numerical experiments for 5 degree resolution and 5 minutes time step. I did play with the Shapiro factor when I was developing the TING model, and it has impact on the global solutions.

Clearly we do not need to apply the filter each time step when we reduce the time step, which leads to over-filtering and removes both latitudinal and longitudinal structures in real solutions, as in the case of O+ in the EIA region. Another way to do this is to divide the Shapiro factor by the ratio between 5 minutes and the selected time step. For the 30 seconds time step it is 10, or 0.003.

I do not worry the storm-time effect, as this filter is more a long-term effect, I think.

Regards

Wenbin

[Quoted text hidden]

Stan Solomon <stans@ucar.edu> Mon, Mar 30, 2015 at 11:17 AM
To: Ben Foster <foster@ucar.edu>, Joe McInerney <joemci@ucar.edu>, Wenbin Wang <wbwang@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, Astrid Maute <maute@ucar.edu>

I agree that we should discourage people outside the perimeter from changing the timestep. When we initially released TIE-GCM we told people just use 2 minutes. (I remember that the first thing CCMC did was to change it to 2.5 minutes because they wanted output on 15-minute centers.) We need to select a time step (for each resolution) that is relatively crash-proof and go with it. Of course, for our own testing purposes, we want to play around with this. Jiuhou and his students count as inside the perimeter, and I'm really glad they showed us this.

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Mar 30, 2015 at 7:45 PM
To: Wenbin Wang <wbwang@ucar.edu>
Cc: Astrid Maute <maute@ucar.edu>, Stan Solomon <stans@ucar.edu>, Ben Foster <foster@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>

Hi all,
Thanks for your feedback! We will run the code on the trunk, and send you the results soon. Regarding the changes in neutral gas (wind and temperature), one possibility is through the ion-neutral coupling, and the other possibility is associated with the over-filtering for the short time step size. We will check the changes in neutral temperate and winds in the test when Shapiro factor is reduced in the oplus.F. As suggested by Astrid, we will provide the global behavior of the output at different time step size.

Jiuhou

> -----Original Messages-----
> **From:**"Wenbin Wang" <wbwang@ucar.edu>
> **Sent Time:**2015-03-30 23:26:43 (Monday)
> **To:** "Astrid Maute" <maute@ucar.edu>
> **Cc:** "Jiuhou Lei" <leijh@ustc.edu.cn>, "Stan Solomon" <stans@ucar.edu>, "Ben Foster" <foster@ucar.edu>, "Art Richmond" <richmond@hao.ucar.edu>
> **Subject:** Re: Re: dependence of TIEGCM Output on time step
> [Quoted text hidden]

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Apr 6, 2015 at 8:30 PM
To: Ben Foster <foster@ucar.edu>, Wenbin Wang <wbwang@ucar.edu>
Cc: Stan Solomon <stans@ucar.edu>, Joe McInerney <joemci@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, Astrid Maute <maute@ucar.edu>

Hi All,

We did a few more tests on the basis of the TIEGCM 1.95 simulations. Please see the attachment.

When we reduced the shapiro factor from 0.03 to 0.003, the differences between 30s and 120s runs are still obviously seen in neutral and ionospheric fields. However, as this factor is reduced to 0.0003, the outputs for neutral gas at 30s are almost the same as those at 120s; The differences in ionosphere are still there.

Interestingly, the changes in NmF2 from 0.003 to 0.0003 are small for either 30s or 120s run. This suggests that a smaller shapiro factor (<0.0003) is not helpful to fully resolve the problem. We did another test. In this case, we used a smaller factor 0.0003 every time step,but turn on the Fourier filter in every 2mins. In this case, NmF2s are the same for two time step sizes.

Out tests indicated that a much smaller shapiro factor should be used (say around 0.0003).For the default TIEGCM, EIA strucutres are smoothed out and many waves in the thermosphere are filtered at high latitudes.

Besides shapiro factor, at least in oplus.F, there is over-filtering associated with Fourier filter for smaller time step. I do not know how to solve this problem.

Jiuhou

> -----原始邮件-----
> 发件人:"Ben Foster" <foster@ucar.edu>
> 发送时间:2015-03-30 23:22:22 (星期一)
> 收件人: "Stan Solomon" <stans@ucar.edu>, "Joe McInerney" <joemci@ucar.edu>, "Wenbin Wang" <wbwang@ucar.edu>, "Art Richmond" <richmond@hao.ucar.edu>, "Astrid Maute" <maute@ucar.edu>, "Jiuhou Lei" <leijh@ustc.edu.cn>
> 抄送:
> 主题: Re: dependence of TIEGCM Output on time step
>
> [Quoted text hidden]

TIEGCM195test.pptx
3602K

Ben Foster <foster@ucar.edu> Mon, Apr 6, 2015 at 9:00 PM
To: Jiuhou Lei <leijh@ustc.edu.cn>

Jiuhou,

Note that the time smoothing in oplus.F does not use the shapiro constant:

```
|  dtsmooth = 0.95,     ! time smoothing constant
|  dtsmooth_div2 = 0.5*(1.-dtsmooth),
 do i=lon0,lon1
   do k=lev0,lev1-1
     optm1out(k,i,lat) = dtsmooth*op(k,i,lat)+dtsmooth_div2*
|      (optm1(k,i,lat)+opout(k,i,lat))
   enddo ! k=lev0,lev1-1
 enddo ! i=lon0,lon1
```

[Quoted text hidden]

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Apr 6, 2015 at 9:23 PM
To: Ben Foster <foster@ucar.edu>

Hi Ben,

In oplus.F, shapiro is used in latitudinal and longitudinal smooth.

Jiuhou

> -----原始邮件-----
> 发件人:"Ben Foster" <foster@ucar.edu>
> 发送时间:2015-04-07 11:00:22 (星期二)
> 收件人: "Jiuhou Lei" <leijh@ustc.edu.cn>
> 抄送:
> 主题: Re: Re: dependence of TIEGCM Output on time step
> [Quoted text hidden]

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Apr 20, 2015 at 3:11 AM
To: Ben Foster <foster@ucar.edu>, Wenbin Wang <wbwang@ucar.edu>
Cc: Stan Solomon <stans@ucar.edu>, Joe McInerney <joemci@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, Astrid Maute <maute@ucar.edu>

Hi Ben and Wenbin,

We recently did a few more runs to see the dependence of the high resolution TIEGCM output on the time step. When we used a very small shapiro constant (0.0003)in cons.F, the outputs from the 2.5 degree model

runs are not so sensitivity to the time step as the single solution model does. These are consistent with Wenbin's test. But you still see slightly lower NmF2 over the EIA crests as the time step goes smaller.

The results from these double resolution runs are similar to those from the 5 degree model with 2 mins time step. Our test runs told that the double resolution TIEGCM is better to be used if a smaller shapiro constant value is applied. When someone use the single resolution TIEGCM, the time step should be less than 2 mins.

Regards,

Jiuhou

> -----原始邮件-----
> 发件人:"Ben Foster" <foster@ucar.edu>
> 发送时间:2015-03-30 23:22:22 (星期一)
> 收件人: "Stan Solomon" <stans@ucar.edu>, "Joe McInerney" <joemci@ucar.edu>, "Wenbin Wang" <wbwang@ucar.edu>, "Art Richmond" <richmond@hao.ucar.edu>, "Astrid Maute" <maute@ucar.edu>, "Jiuhou Lei" <leijh@ustc.edu.cn>
> 抄送:
> 主题: Re: dependence of TIEGCM Output on time step
>
> [Quoted text hidden]

TIEGCM195_double.pptx
472K

Stan Solomon <stans@ucar.edu> Mon, Apr 20, 2015 at 7:43 AM
To: Wenbin Wang <wbwang@ucar.edu>
Cc: Ben Foster <foster@ucar.edu>

Wenbin -

I think you should attempt to discover why they seem to want to run at a variety of time steps. Are they having stability issues?

We should probably be gravitating toward a "recommended" time step and an "emergency" time step of half that. I'm not sure what the issue is with the low-res model. Ben recommended changing to a default one-minute step, so he must have encountered some crashes. Yet, we did that 17-year run with a two-minute step, and I don't think we had any problems. That was with Heelis, however, perhaps there are more problems with Weimer.

My point is that we can't tune every field at every resolution for every conceivable time step - it's just too much work.

Stan

Jiuhou Lei <leijh@ustc.edu.cn> Mon, Apr 20, 2015 at 9:31 PM
To: Jiuhou Lei <leijh@ustc.edu.cn>
Cc: Ben Foster <foster@ucar.edu>, Wenbin Wang <wbwang@ucar.edu>, Stan Solomon <stans@ucar.edu>, Joe McInerney <joemci@ucar.edu>, Art Richmond <richmond@hao.ucar.edu>, Astrid Maute <maute@ucar.edu>

Sorry, there is a typo. if someone want to use the single resolution TIEGCM, the time step should NOT be less than 2 mins.

Jiuhou

-----Original Messages-----
From:"Jiuhou Lei" <leijh@ustc.edu.cn>
Sent Time:2015-04-20 17:11:16 (Monday)
To: "Ben Foster" <foster@ucar.edu>, "Wenbin Wang" <wbwang@ucar.edu>
Cc: "Stan Solomon" <stans@ucar.edu>, "Joe McInerney" <joemci@ucar.edu>, "Art Richmond" <richmond@hao.ucar.edu>, "Astrid Maute" <maute@ucar.edu>
Subject: Re: Re: dependence of TIEGCM Output on time step
[Quoted text hidden]