

How to use the NRL time and location dependent atmospheric model

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1 NRL atmospheric model

The model is formally called NRLMSISE-00. From the wikipedia:

NRL stands for the US Naval Research Laboratory. MSIS stands for Mass Spectrometer and Incoherent Scatter Radar respectively, the two primary data sources for development of earlier versions of the model. E indicates that the model extends from the ground through exosphere and 00 is the year of release.

NRLMSISE-00 is an empirical, global model of the Earth's atmosphere from ground to space. It models the temperatures and densities of the atmosphere's components. A primary use of this model is to aid predictions of satellite orbital decay due to atmospheric drag.

See for more detail the following web sites:

<http://www.nrl.navy.mil/ssd/branches/7630/modeling-upper-atmosphere>
<http://www.nrl.navy.mil/research/nrl-review/2003/atmospheric-science/picone/>

2 How to use

Since it is rather difficult to make the NRL atmosphere data format compatible with one used by the current multi-segmented atmosphere (\approx ISA=Internatinal Standard Atmosphere), the current resolution is to fix a model before making library. This means once the model is fixed, we cannot switch to another model by specifying the model in the parameter file; we must recompile the library to switch back to the previously used model. **This inconvenience should be improved ? module function will help this? not sure**

To fix the model, the basic procedure is to define

ATMOSPHERE in **\$COSMOSTOP/cosmos/Zcondc.h**. Namely,

```
#define ATMOSPHERE 2
(defualt) is to use the current standard atmosphere model and
#define ATMOSPHERE 3
is to use the NRL model. Then, the user must make library by putting
make clean;make
in $COSMOSTOP.
```

However, a command **atmosModel.sh** is prepared which may be invoked at any place provided that **\$COSMOSTOP/Scrt** is in the user's **\$PATH**. The command may be used
1) to know which atmospheric modele is usable currently,
2) to switch the models or
3) to see a brief usage of models.

2.1 Standard model

If `#define ATMOSPHERE 2` (default) is used at library making time, the parameter `AtmosFile` in the "param" file may be kept blank (default), although the user may specify `$COSMOSTOP/Data/Atmos/stdatmos1.d` in "AtmosFile"; the file content is the same as the data kept in the program so that the effect is the same as the case for "blank". The user may make similar data file for a specific purpose. The parameter "NRL_period" which is for controlling the NRL atmosphere may exist but is neglected.

2.2 NRL model

If `#define ATMOSPHERE 3` is used at library making time, the user can control the model either by giving a data to `AtmosFile` or to `NRL_period`. If "AtmosFile" is not blank, the latter is neglected. In this case, the file content must be for the NRL model. The location is specified by `LatitOfSite` and `LongitOfSite` which are in degree to show latitude and longitude of the observation site.

If "AtmosFile" is blank, `NRL_period` is referred. It specifies a period over which the average feature of the atmosphere is calculated. It must be given in the "param" file, otherwise, error stop will be made. The format is:

`NRL_period=day1, day2, hour1, hour2`

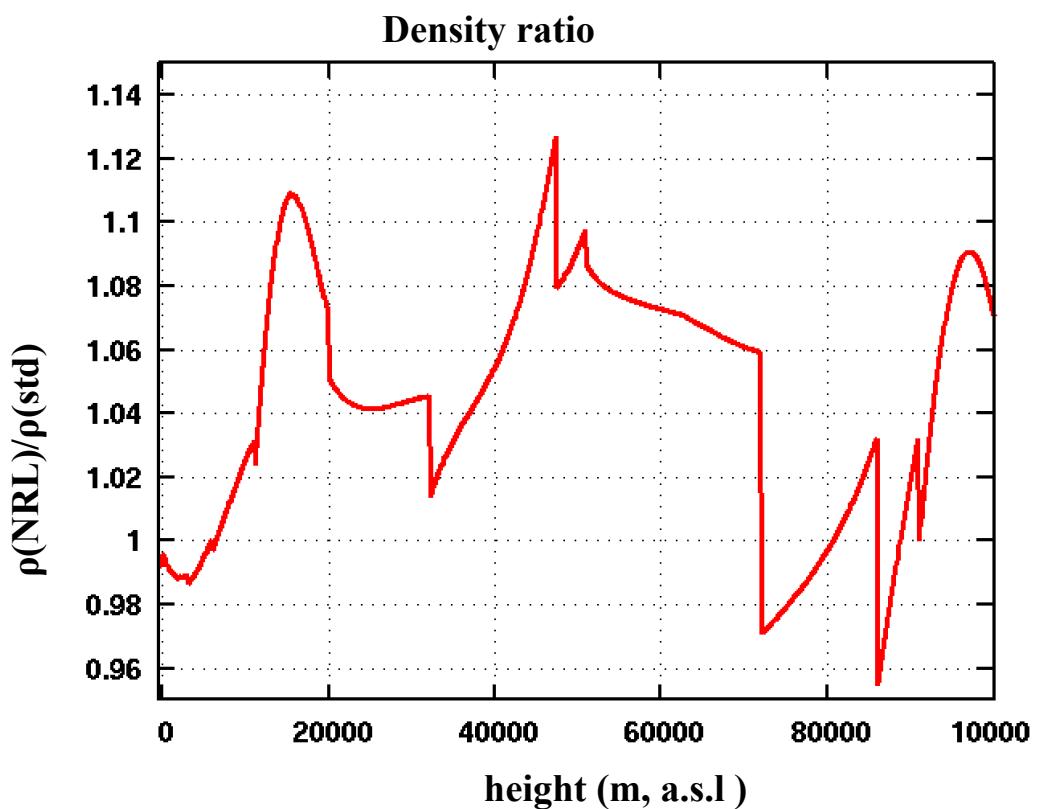
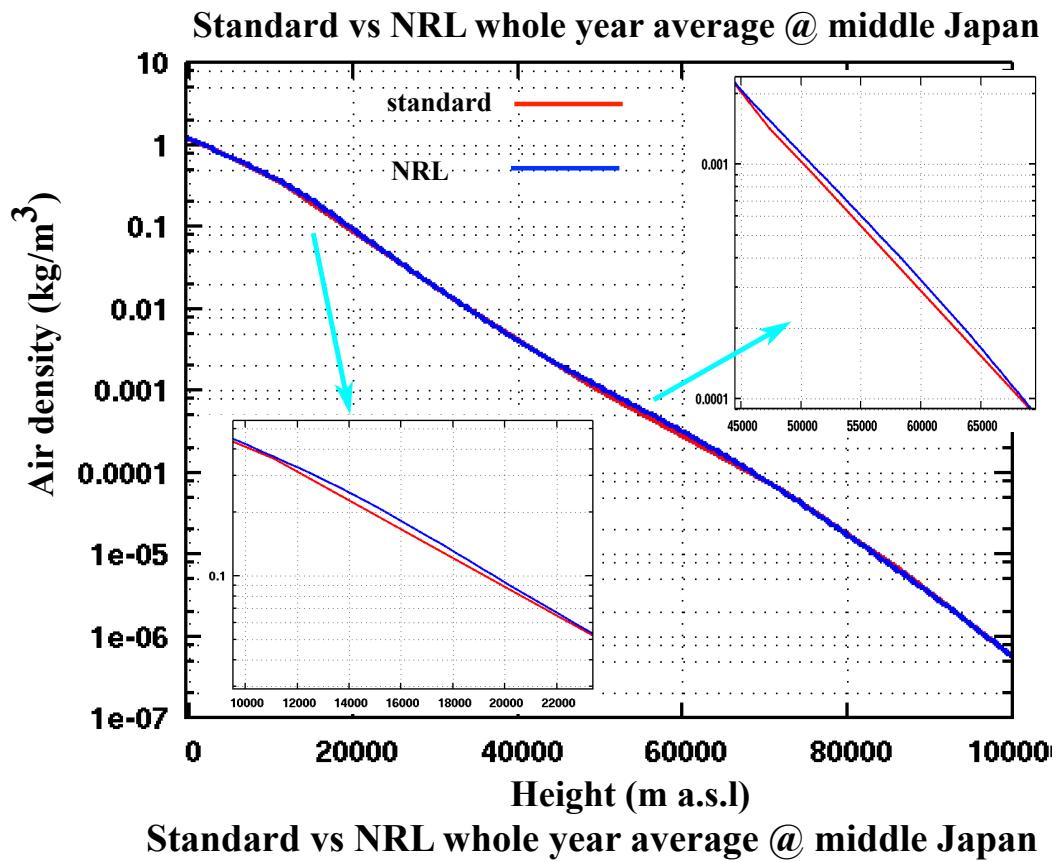
where day1 and day2 are integers (1~365). 1 means Jan. 1 and 365 Dec.31 (no leap year consideration). The period from day1 to day2 is the target period. If `day1 > day2`, it is assumed that the period straddles Dec.31 to Jan.1.

The next hour1 and hour2 are also integers ranging 0 to 23 and specify the hours in each day in the period. If `hour1 > hour2`, midnight (0) is included. For example, `NRL_period = 335 60 21 3` means roughly night time in Dec. to Feb.

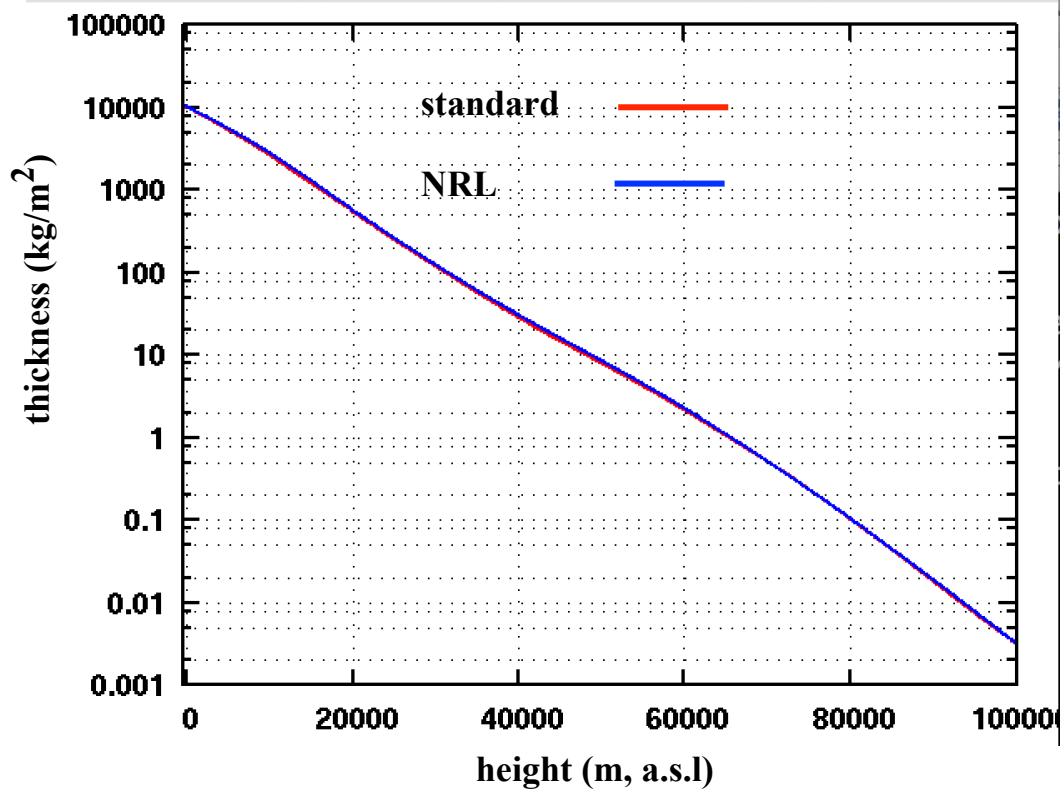
The average is computed by sampling days and hours in the period: For days, 7-day step sampling is made, but the day1 and day2 are always included. (So the last step may not be 7 but greater than 3). For hours, 4-hour step sampling is made but hour1 and hour2 are always included (the last step may not be 4 but greater than 2). For `NRL_period=1 360 0 23`, we need a computation time of few to several seconds.

These sampling steps cannot be changed by input parameters. If the user need to do so, the variables, `daystep`, `nearday`, `hourstep`, `nearhour`, in `$COSMOSTOP/Tracking/Atmosphere/cNRLAtmos.f` must be modified.

Comparisons are shown between the standard and NRL model. For the latter, average is taken over the whole year in the middle Japan. The last two figures are for the ratios, ρ_{p1}/ρ_{p2} and $Depth_{p1}/Depth_{p2}$ (in some graphs, term "thickness" is used), as a function of vertical height, where $p1$ and $p2$ mean the period; $p1$ for the first one is winter night time and $p2$ summer day time at latitude 45 degree and longitude 0. In the second one, $p1$ is winter and $p2$ summer (whole days) at the south pole.



Standard vs NRL whole year average @ middle Japan



Standard vs NRL whole year average @ middle Japan

