MM5: CURRENT STATUS AND PLANS

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1. INTRODUCTION

Last December we released Version 3.5 of MM5, the latest in a series of releases since Version 3.0 came out in June 1999. The current frequency of releases is about one per year, so we expect to release 3.6 later in 2002.

Here we will outline the main changes in last year's 3.5 release, and describe some ideas we have for 3.6 and future releases. Much of this year's section 2 was in last year's section 3 (Planned Changes).

2. CHANGES

Version 3.5

Additional surface diagnostic fields are being output for the Blackadar and Eta (Mellor-Yamada) PBL options. Version 3.4 only had these for the MRF PBL. This makes it possible to compare 2m temperature and specific humidity, and 10m winds, with observations at those levels. The diagnostics are computed consistently with the version of similarity theory in the PBL option being used.

In the current surface scheme used in both the Blackadar and MRF PBL's, there is a viscous sub-layer for moisture fluxes, but for heat fluxes the roughness length is that used for momentum. For this release we are adding a new switch that selects some different formulations of thermal roughness length. *IZ0TOPT=0* gives the original Carlson-Boland formulation applied to moisture flux (Zhang and Anthes 1982) that has been used in MM5 for many years. *IZ0TOPT=1* gives the Garratt (1992) option, recommended by Pagowski and Moore (2001). This has equal thermal roughness lengths for heat and moisture fluxes that are less than the momentum roughness length, and also has different formulations for land and water surfaces. *IZ0TOPT=2* gives the Zilitinkevich formulation, similar to what is used in the Eta model. Here the thermal roughness length over land is reduced and used for heat and moisture fluxes, but for water where the roughness length is small, there is no modification. The effect of using reduced roughness lengths is to restrict fluxes. These modifications produce quite large differences in fluxes (30-40 %), particularly for water, where options 1 and 2 produce respectively smaller and larger latent heat fluxes than option 0. When using the OSU land-surface model we already use the Carlson-Boland viscous sublayer formulation for both heat and moisture. With this change, the land-surface model can also use the new z_{0T} formulations.

The Oregon State University / Eta Land Surface Model is documented by Chen and Dudhia 2001. We have now added this to option to the Eta PBL scheme in 3.5. Four-dimensional data assimilation is also now possible with the Eta PBL scheme since it computes the relevant PBL height information.

In regional climate applications that use the LSM, there is a need for a time-varying green vegetation fraction. Previously this value remained at its initial value which was determined climatologically from global monthly fields. We extended this to have a climatologically varying value using this same data, but updating it daily while the model runs. It is hoped that the same can be done if a climatological sea-surface temperature is desired, using global monthly climatological SSTs, and this may be done in a future release. However, time-varying SSTs from analyses can be used in Version 3.

A simple change allows the vertical mixing to follow moist adiabats not just within the cloud, as was formerly the case, but also at the top cloud boundary. This change mimics shallow convection by entraining drier air into the cloud, reducing its lifetime. It is a modification to the moist vertical diffusion scheme that is used in the MRF and Blackadar PBL options. The change helps reduce widespread low-level cloudiness and light rain, particularly over oceans.

The *ISSTVAR* switch previously did not allow a specified snow-cover change, and the new release allows this to also be updated when the lower boundary file (LOWBDY) is read periodically while using the *IFSNOW=1* option.

Release 3.5 has a simple snow-cover variation scheme (*IFSNOW=2*) that has so far been used in the global MM5 runs. This scheme has an additional capability in the *slab.F* routine to predict water-equivalent accumulated snow depth, and is therefore applicable to all the PBL schemes that call *slab.F*. The snow-cover prediction requires water-equivalent accumulated snow depth as an input field, and uses a heat and moisture budget to update the snow amount based on precipitation, melting and sublimation. It assumes melted snow runs off and is a single-layer model regardless of snow depth, but does allow the albedo and moisture availability to change with snow cover, and still includes the 5-layer soil model beneath the snow, so it should be considered a first-order approximation. It can be applied with the simple ice and other microphysical schemes. Note that in the initial 3.5 release this option was not fully functional and did not have the snow melting and sublimation processes, only accumulation. This is being corrected in the tar file this summer.

As part of the effort to make MM5 suitable for polar regions, John Cassano (Byrd Polar Research Center, now at University of Colorado), implemented a change to the CCM2 radiation that allowed it to interact directly with model clouds instead of just with the cloud fraction diagnosed from relative humidity. This makes it more like the other cloud-radiation options. It is now in the standard CCM2 code when using *ICLOUD=1*. Setting *ICLOUD=2* for the CCM2 radiation option will revert to the old relative humidity/ cloud fraction scheme.

A new version of the Kain-Fritsch convective scheme has been developed for the Eta model, and is now included in release 3.5 as option *ICUPA=8*. There are many differences from the original KF scheme, including a shallow convection treatment.

Another change follows from a recent paper by Xu et al. (2001), where there was a recommendation to allow user control over the background horizontal diffusion coefficient. They suggest that it can be expressed as $K_{H0} = \alpha\Delta x$ instead of being fixed as $K_{H0} = 0.003\Delta x^2/\Delta t$ m^{2}s^{-1}, where α is a set from a new namelist parameter, called *CKH* and *CKH*=1.0 ms^{-1} would give the same background diffusion when the standard "$3\Delta x$" rule is used for the timestep. This removes an inherent time-step dependence in the background diffusion, making the results more similar for different choices of time-step for a given grid size.

The Reisner graupel microphysics option also underwent more changes and improvements for release 3.5, and results will differ from previous releases. These changes are documented at the top of routine *EXMOISG*. Thanks to Greg Thompson, Roy Rasmussen and Bill Hall for their work on this scheme.

Scott Braun provided changes that have now been implemented in the Goddard microphysics option. These include sedimentation of ice and a choice between hail and graupel for the third ice category. Other June 2001 changes are detailed at the top of the scheme's subroutines.

Other changes and bug fixes can be found in the *CHANGES* file.

3. PLANNED CHANGES

Version 3.6 and beyond

Additional changes are currently being implemented in MM5 for polar applications. These come from John Cassano and David Bromwich at the Byrd Polar Research Center at Ohio State University. Primary among these is a fractional sea-ice treatment, that takes into account the effect of open water and finite-depth ice in the same grid cell. The thermal conductivity effects of snow and permanent ice are also modified to better represent polar surface properties. Other modifications include latent heat and saturation effects at ice surfaces in the PBL scheme. Initially these changes are being incorporated in the Eta PBL scheme and the multi-layer soil model, and later other PBL schemes will become modified similarly.

A new version of the land-surface model is being developed that is closely related to MM5's current OSU LSM, but has been unified with the versions used at NCEP and AFWA in preparation for implementation in WRF. This work by Fei Chen will first provide MM5 with the unified LSM. It includes frozen-soil physics among other new features.

It is hoped that the OSU LSM will be coupled to other PBL options, specifically Gayno-Seaman and Blackadar, in the near future. Possibly also by the next release the PLACE LSM from Peter Wetzel (NASA Goddard) will be added to MM5 thanks to work by Dave Stauffer, Ricardo Munoz (Penn State), and Barry Lynn (HUJ, Israel). This is initially coupled to the Gayno-Seaman PBL, but may also be coupled to some other schemes in the release.

We have also received code from Gunther Zaengl (University of Munich) for improved diffusion in topographically complex regions (Zaengl, 2002), and for using terrain slope in solar radiation calculations, that we would like to implement by the next release.

There is a new shortwave scheme by the developers of the RRTM longwave scheme that we are also interested in implementing, resources permitting. This is newer than and has a similar level of complexity to the CCM2 shortwave scheme.

The global version for MM5 is also being considered for release as this is a capability that WRF is not going to have in the near term. The global version of MM5 is designed for medium-range studies and forecasting (Dudhia and Bresch, 2000, 2002) and has been running reliably since 1999 providing real-time forecasts out to five days.

MM5 support is continuing for a few more years, and releases will be made as necessary. Beyond 3.6, it is unclear how many further MM5 releases will need to be made as WRF capabilities increase to those of MM5. Users are encouraged to migrate their work to WRF as soon as it becomes feasible. By 2003, WRF will have nesting capabilities making it a more competitive choice as a forecast model. It is already a better scientific tool than MM5 for single-domain idealized studies, and is achieving good forecast scores with its available physics packages.

4. REFERENCES

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