The MM5-CALPUFF Project

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**On Assignment to EPA OAQPS/AQAD/AQMG

Overview

- Discuss CALMET evaluations and decision of EPA Regions (7 & 10) and Federal Land Managers to seek alternative to CALMET.
- Discuss development of MM5CALPUFF prototype – ***B***ret ***A***nderson ***R***e***F***ormatter (***BARF*** tool) as EPA Region 10 calls it.
- Discuss need for future development for other model platforms such as WRF.

Need for Alternative to CALMET

- Discussed as a potential option for the CALPUFF system at the 8th Conference on Air Quality Modeling – "MCIP style processor for CALPUFF"
- EPA OAQPS evaluation of "VISTAS" CALPUFF version yielded significant concerns about recent MMS sponsored enhancements to CALMET, resulting in "regulatory default" switch in CALMET which disables these enhancements.
- Visual analysis of BART applications shows significant periods when background MM5 field and observations conflict with each other, resulting in destruction of coherent windfields.
- Discussions between Federal Land Managers, EPA OAQPS, EPA Region 7, and EPA Region 10 reached agreement that an alternative to CALMET needed to be implemented due to erratic CALMET performance and Region 10 needs for unique OCS oil exploration projects in Alaska.
- Other organizations and projects could benefit from this approach:
  - USFS BlueSky/RAINS relies exclusively upon NOOBS
  - Many BART applications relied heavily upon NOOBS for screening, and hybrid approach for "refined" analysis. Approach brings level of consistency to review process.

MM5-CALPUFF Prototype

- Developed from the MM5CAMx software developed by Environ and MCIP software maintained by Tanya Otte, EPA ORD.
- Key Features:
  - P-G calculation options: SRDT, Golder, Turner (to be implemented)
  - Mass weighted vertical aggregation of MM5 layers if requested (MM5CAMx).
  - Rediagnosis of PBL or pass through if requested (new – MM5-CALPUFF)

Required Meteorological Parameters for CALPUFF

- CALPUFF requires:
  - U scalar wind component (U-WIND)
  - V scalar wind component (V-WIND)
  - Vertical velocity (W)
  - 3D Temperature (TEMP)
  - Convective Velocity Scale (WSTAR)
  - Surface Friction Velocity (USTAR)
  - Monin – Obukhov Length (EL)
  - Planetary Boundary Layer Height (ZI)
  - Pasquill-Gifford Stability Class (IPGT)
  - Air Density (RHO)
  - Surface Temperature (TEMPK)
  - Shortwave radiation (QSW)
  - Surface Relative Humidity (IRH2D)
  - Precipitation (RMM)
  - Surface parameters: Bowen Ratio, Albedo, Surface Roughness Length, Landuse, Soil Heat Flux, Leaf Area Index, Anthropogenic Heat Flux, Elevations, etc.

Geophysical Data from MM5

- CALMET outputs static fields of elevation, surface roughness, albedo, bowen ratio, leaf area index, and soil heat flux.
- Geophysical data constructed from methodology developed by US Forest Service for use in BlueSky/RAINS modeling system (MM52GEO program).
- Uses MM5 USGS 24-category landuse - assigns seasonally dependent (winter/summer) albedo, surface roughness, and leaf area index.

MM5 – CALMET Grid Structure

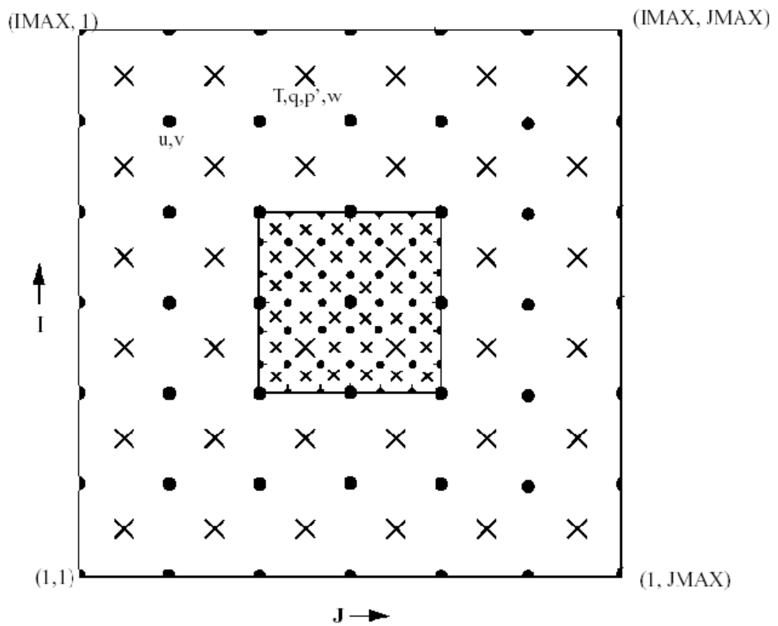
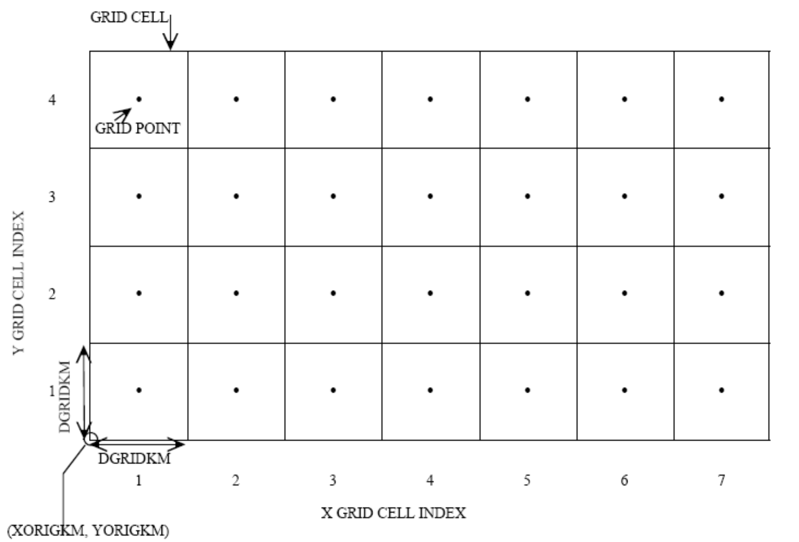


Figure 1.3 Schematic representation showing the horizontal Arakawa B-grid staggering of the dot (l) and cross (x) grid points. The smaller inner box is a representative mesh staggering for a 3:1 coarse-grid distance to fine-grid distance ratio.



PG Stability Class for CALMET

- IWAQM Phase II Guidance (EPA, 1998) recommends use of PG for use in long range transport (LRT) analyses
  - EPA Model Clearinghouse reaffirmed this in Spring 2006 (memo to Region 4 from Clearinghouse)
  - Federal Land Managers typically will not accept turbulence based dispersion for Class I LRT analyses
- Necessary to construct gridded PG fields for output consistent with CALMET output.
- A number algorithms inside of CALPUFF are dependent upon P-G even if turbulence is used.

PG Stability in CALMET

- CALMET calculates PG stability classes based upon Turner method.
  - 2 different methods available in CALMET for calculating PG class

    1. Observation based (ceiling height and cloud cover from NWS surface data)
    2. "NOOBS" method (ceiling height and cloud cover derived from MM5 hydrometeors
  - "NOOBS" method introduced by Robe (Earth Tech, 2001) constructs from MM5 estimated ceiling heights and diagnostic cloud cover.

PG Classes in MM5-CALPUFF

- Two options available for calculation of P-G stability classes.

1. SRDT
   - PG stability class estimate is based upon solar radiation, delta-t (SRDT) method published in Supplement C to the Guideline on Air Quality Models (EPA, 1995).
   - Daytime stability derived from Turner method using incoming solar radiation to estimate insolation class and surface wind speed. Nighttime stability derived from the sign of the temperature difference between 10 meter and 2 meter thermocouples.
   - Code implemented directly from MPRM

2. Golder method (1972) – based upon relationship of Obukhov lengths and surface roughness to P-G class. Code implemented from AERMOD LTOPG subroutine.

PG Classes Using Turner Method

- Insolation estimated from MM5 downward solar radiation (SWDOWN).
- Advantage: Downward solar radiation estimate reflects shortwave radiation attenuated due to optical effects of clouds, etc. No need to derive cloud cover from hydrometeor mixing ratio data, eliminates problem introduced in current "NOOBS" version of CALMET.
- Wind speed derived from MM5 U – V layer 1 values downscaled to 10 meters using similarity theory.
- Nighttime stability (Delta-T method) is activated when insolation equals zero.
- Temperature difference (Delta-T) is derived from difference from near surface temperature and height of first half-sigma level.

PBL Rediagnosis

- Bulk Richardson approach based upon three methods
  - Louis (1979) for calculation of surface friction velocity, Monin-Obukhov Lengths, convective velocity scale, and 2m temperature.
  - Vogelezang, DHP and Holtslag, AAM (1996) for calculating PBL heights using bulk Richardson calculation.
  - Gryning-Batchvarova (2003) variable critical Richardson number for over-water PBL heights. Experiments showed critical Richardson of 0.05 for over-water PBL heights yielded better agreement when using the Vogelezang and Holtslag bulk Richardson method.
- PBL rediagnosis is optional, but is also automatically triggered under the following conditions:
  - When PBL is less than height of first full-sigma level, PBL rediagnosis is automatically triggered.

Additional Features to Be Implemented

- Option for conversion of MM5 native lambert conformal projection to UTM coordinate system for smaller scale applications of CALPUFF.
- Option to window MM5 domain to a smaller grid maintaining original grid resolution of the MM5 simulation.
- Option to interpolate to finer resolution (still being discussed) similar to CAMx "flexinesting" capability.
- Integration with the CALMETSTAT program developed by EPA Region 7 to provide performance evaluation metrics at time of processing.

Next Steps

- Testing of MM5CALPUFF is currently underway as part of CALPUFF evaluation project
- Funding has been committed by OAQPS ($15K), EPA Region 10 ($5K), US Fish and Wildlife Service ($5K), US Forest Service ($5K), and National Park Service ($5K).
  - Region 10 discussed possible contribution from MMS for this project as well.
- Prototype to be passed to contractor for code verification, clean-up, and documentation.
- EPA Met Team to work to develop guidance on the use of prognostic data sets for use in dispersion models, starting with CALPUFF, but ultimately to include AERMOD.
- EPA Region 7 to begin work WRFCALPUFF this summer.
- MM5CALPUFF to be introduced formally at 9th Modeling Conference as a potential alternative to CALMET