Microscale Model Development Project

Rationale

1. No generally available meteorological model meets UWERN's modelling objectives on small scales (e.g. steep orography, buildings).
2. UWERN has a strong numerical modelling programme but no coordinated model development.
3. The UK currently has no community mesoscale or boundary-layer model but makes extensive use of the UM the LEM and BLASIUS. These are not aimed principally at meeting UWERN's research objectives.
4. The UM has no LES capability, is primarily designed for mesoscale and larger scales. It will need to be reformulated to cope with steep orography and buildings
5. The LEM has no orographic capability.
6. Large Eddy Modelling will not be possible on regional scales ($>$ several km) for the foreseeable future. Hence need for LES models to assimilate data from larger scale models.
7. The science objectives of UWERN will best be met by close coordination between these objectives and ongoing model development.
8. UWERN benefits from strong collaborations with the Me Office, greatly enhancing its access to numerical modelling expertise and thereby improving the viability of a coordinated numerical modelling strategy.
9. It is envisaged that as a UWERN member and collaborator on this project, the Met Office will have access to any developments and improvements which may benefit their models.

Microscale Model Development Project

Objectives

1. To carry out a thorough review of current capability to model atmospheric flows and processes down to the building scale, including the modelling of building-scale flows themselves.
2. To adapt or build from scratch a core dry dynamics and thermodynamics code capable of addressing the research objectives of UWERN within the orographic flow and boundary layer areas (including urban flows). This will inevitably involve addressing the problem of very steep orography (i.e. cliffs).
3. In due course, to add to (2) physical and chemical models for a wide range of relevant processes. Early priorities will be the incorporation of moist processes (water vapour, clouds, precipitation), tracer transport and surface exchange processes, the ordering of which will be governed by the science priorities.
4. Provide support to UWERN for the modelling system. Documentation. Research-orientated design.
5. Run workshops on the development and usage of the system.

Microscale Model Development Project

Issues to Address

1. The equation set. Compressible? Anelastic?
2. Coordinates. It is likely that spatial variables (x, y, z) will be used as coordinates. Closely linked to question of the lower boundary conditions and the representation of orography.
3. Initialisation and/or data assimilation. A requirement will be the facility to assimilate data (either initial data or boundary data) from existing larger scale models.
4. Variable horizontal resolution? A range of science objectives, including cloud-resolving modelling, orographic flows and urban modelling will require resolution down to fine scales (e.g. tens of metres) in an “inner” region whilst simultaneously modelling a much larger domain. Whether to adapt or to nest.
5. Vertical coordinate and representation of orography. Vertical stretching for boundary-layer resolution will inevitably be required. A challenging question for the representation of orography concerns the choice between a traditional boundary fitting (of which there are many variations, see e.g. Mesinger 1997) and a non-transformed vertical mesh arrangement which intersects the orography.

Microscale Model Development Project

Issues to Address

6. Discretisation of equations.
7. Numerical schemes, particularly for advection and time stepping. Conservation and stability properties.
8. Turbulence models and LES schemes.
9. The scope of physical parametrizations.
   i. passive tracer transport
   ii. clouds (water & ice)
   iii. precipitation (water & ice)
   iv. surface (and later) cloud radiation
   v. transport and reaction of chemical species.
10. Code design, allowing for efficient parallelisation from the start.
11. Programming language (probably FORTRAN 90), programming standards (ensuring maximum portability), code management (e.g. Makefile, RCS).
12. Tests and test cases. Standard set of tests will need to be developed (accuracy, conservation, symmetry, etc) and applied to all future changes. Many exist.
13. Diagnostics and graphics. Output standards.

Microscale Model Development Project

Timetable

1. 12 months. Review of requirements and current practice. Initial tests of likely schemes.

1a. Issue of model design proposal for consideration by the UWERN Management Committee.

2. 24 months. Working dry dynamics model, with orography and limited variable resolution.
3. 30 months. Tracer transport. Multiple levels of nesting or equivalent.
4. 36 months. Inclusion of arbitrary orography (special facilities for steep slopes).

4a. 36 months. Availability of version 1.0 as community UWERN model.

5. 42 months. Moist physics (including warm clouds) & surface energy balance.
6. 48 months. LES capability. Ice microphysics.
7. 54 months. Higher order turbulence closure. Simple chemistry.
8. Open ended. Maintenance, user support and continued development.