56420 THE LAND SURFACE HYDROLOGY COMPARISONS BETWEEN THE VITERBO AND BELJAARS LAND SURFACE SCHEME AND OBSERVATIONS

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1. INTRODUCTION

Soil moisture, that is the amount of water in a volume of soil, has been recognized to play an important role in the exchange of water and energy between the land surface and the atmospheric boundary layer. For example, the initiation of moist convection can be heavily influenced by the distribution of soil moisture in the region (Pielke Sr., 2001; Weaver and Avissar, 2001). Numerical experiments have shown that the soil moisture pattern over Victoria can alter the movement of wind shift lines significantly (Mills, 1995), which, in an Australian context, is particularly relevant for the prediction of fire behaviour some hours ahead. Fog and low cloud prediction, as another threshold process, is also very sensitive to the surface fluxes controlled by soil moisture (Bergot and Guedalia, 1994).

About three years ago the Australian Bureau of Meteorology Research Centre (BMRC) adopted the Viterbo and Beljaars (1995) (hereafter VB95) land surface scheme in order to replace the previously used bucket scheme. Plans are now under way to introduce VB95 into all numerical weather prediction (NWP) and climate models in use at the Australian Bureau of Meteorology (BOM). Although VB95 has been tested extensively in various climatic regimes, its performance under Australian climate, soil and vegetation conditions is unknown. With significant efforts in progress for obtaining Australian soil moisture and soil temperature time series, we are now in a position to carry out the required verification efforts. This article first provides a brief description of the operational NWP model suite at the BOM, followed by a description of VB95. The focus of this study is the preliminary comparison of the VB95 model soil moisture with a first set of observed values obtained in a particularly wet catchment in New Zealand. Finally, we outline planned validation experiments with Australian soil datasets.

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2. THE BOM NWP MODEL SUITE AND VB95

VB95 is likely to become the land surface scheme of the entire suite of operational NWP models in Australia. Figure 1 shows the spatial domains of three of these operational models, the

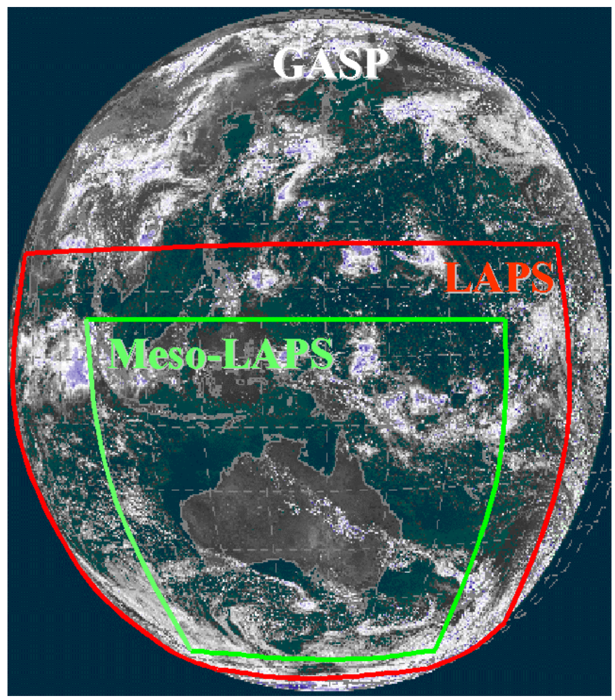

Fig.1: Domains of the GASP, LAPS and Meso-LAPS models with spatial resolutions of ~75 km, ~37.5 km and ~12.5 km, respectively. GASP runs atmospheric predictions out to 7 days, LAPS out to 60 h, Meso-LAPS out to 36 h.

Global Assimilation and Prognosis (GASP) global model, the Limited Area Prediction System (LAPS) and its mesoscale companion model Meso-LAPS (Seaman et al., 1995; Puri et al., 1998).

The subsequent discussion will focus on the Meso-LAPS model, the domain of which covers Australia, Indonesia and New Zealand (Fig. 1). Fields in the Meso-LAPS model are defined on 29 sigma-levels (a terrain-following coordinate) between the ground and ~20 km (10 m–2 km resolution), and at a horizontal resolution of 0.125 degrees (~12.5 km resolution). The dynamic timestep is 40 seconds, while physics packages (including the land surface scheme) are called every 6 minutes. The initialization of the soil moisture field in the Meso-LAPS model is currently a 12-hour nudging process, which uses observed screen-level specific humidity to correct the root-zone layer soil moisture (Mahfouf, 1991; Viterbo, 1996).

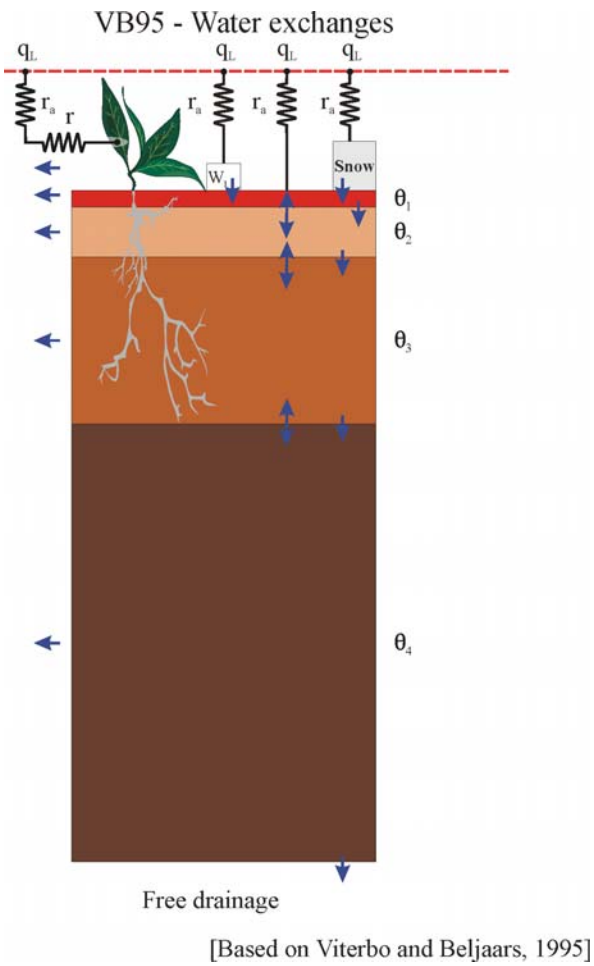

Fig.2: Water fluxes in the VB95 land surface scheme. The four soil layers have depths of 7 cm, 21 cm, 72 cm and 189 cm.

VB95 is forced by the following Meso-LAPS fields: large-scale rainfall, convective rainfall, shortwave radiation (down), thermal radiation (down), specific humidity, temperature, wind speed and wind direction (the last four fields all taken at the lowest model level). Primarily, VB95 is a prognostic scheme for soil moisture and soil temperature in four soil levels, along with a skin temperature.

3. VB95 DETAILS

Figure 2 details how water flows through VB95. Apart from solving the Richard's equation for the vertical water exchanges between soil layers, plants are able to access water in the top three soil layers (the top metre of soil). Rainfall first fills up an interception reservoir (W_l) before infiltration into the topmost soil layer begins. Evapotranspiration can occur from the interception reservoir, the bare soil and through the dry vegetation (we omit discussing all snow-related fluxes for Australia).

Some strong uniformity assumptions are made in VB95. The model uses a globally uniform, medium-texture soil type, a globally uniform soil depth of 289 cm, a globally uniform leaf area index (LAI=4) and seasonally fixed fractional vegetation coverage. We believe that the relaxation of these uniformity assumptions will lead to a significant improvement in the model behaviour for the Australian region. It is also likely that a more realistic representation of the flowpaths will improve the model behaviour further.

4. COMPARISON WITH OBSERVATIONS

The first verification soil moisture and soil temperature dataset we present was collected in the Mahurangi catchment on the North Island of New Zealand between 1 January 1998 and 31 December 1999. The Mahurangi catchment measures about 50 km^2, typical annual rainfalls are around 1600 mm, soils are predominantly fine-textured, and the terrain is undulating to hilly rising from near sea level to about 250m (Woods et al. 2001).

The volumetric soil moisture comparisons in Fig.3 suggest that the uniform soil type present in VB95 is not a good representation of the nearly saturated fine-textured soils encountered in the Mahurangi catchment. It is also apparent that the model soil moisture is too responsive to precipitation events. These preliminary findings strengthen the case for sensitivity tests to be carried out with the soil type being varied.

In Australia, the model-predicted soil moisture and soil temperature values will soon be compared against observations taken in the Murrumbidgee catchment in southern NSW (southeast Australia). Figure 4 shows the 18 monitoring sites where soil data (moisture, temperature and suction at 4 depths – 0-7 cm, 0-30 cm, 30-60 cm and 60-90 cm) have been recorded by the scientists from the University of

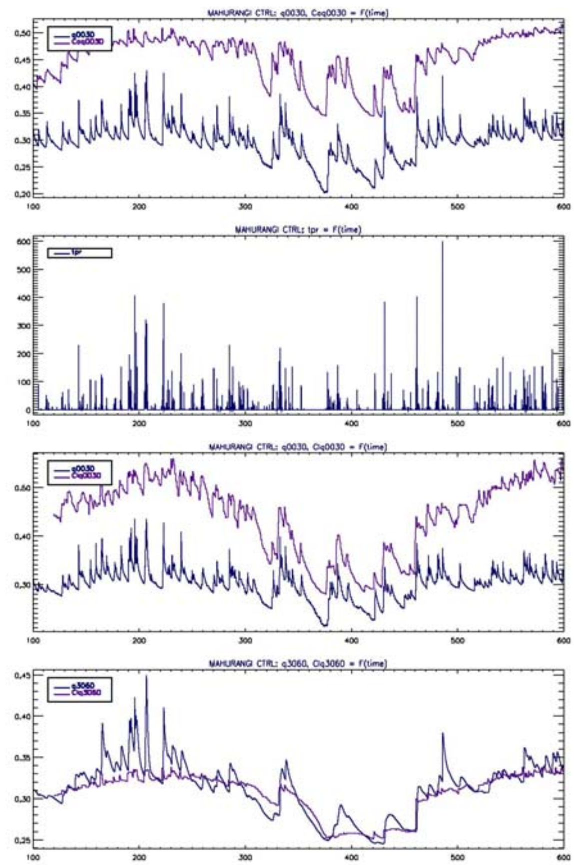

Fig.3: Comparison of soil moisture observations with VB95 model soil moisture for the Mahurangi catchment in New Zealand. (a) Observed volumetric soil moisture (purple) and VB95 soil moisture (blue) in the 0-30 cm soil layer at the "Carrans" site; (b) observed precipitation (kg m^{-2} d^{-1}); (c) as in (a), but for the Claydons site; (d) observed (purple) and modelled (blue) 30-60 cm soil moisture.

Melbourne and the Cooperative Research Centre for Catchment Hydrology (CRCCH). Monitoring began in September 2001, and is expected to continue until 2005. The first forcing datasets and soil moisture datasets for the Murrumbidgee sites will be available by the end of 2002, and preliminary findings will be probably be presented at the conference.

Rainfall across this large (~100,000 km^2) catchment varies from about 330 mm per year in the western part to about 1900 mm per year in the mountaineous eastern part. Elevations ranges from 50 m to 1900 m, also from West to East. More details regarding the soil moisture and soil temperature monitoring can be found in Western et al. (2002).

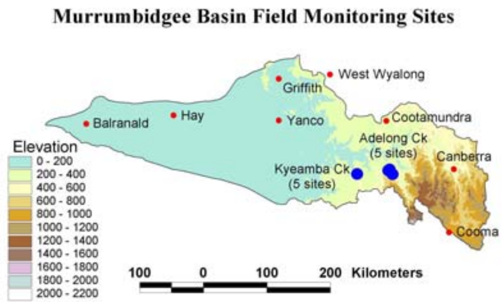

Fig. 4: 18 sites where measurements of soil moisture, soil temperature and soil suction are being recorded over the coming years (September 2001 onwards). The blue dots mark clusters of 5 individual sites each.

5. CONCLUSIONS

This study presents preliminary comparisons of VB95 soil moisture output to observations in the Mahurangi catchment in New Zealand. For the clay soils encountered in the observations, VB95 strongly underpredicts soil moisture. It is also too responsive to rainfall events. This comparison highlights a need to investigate the model response when spatially variable soil types are used. Similar comparisons using observations collected in southeast Australia are about to begin, along with efforts to include spatially and temporally variable soil and vegetation data.

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