The Australian Community Climate and Earth System Simulator

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The Australian Community Climate and Earth System Simulator is a fully coupled system to be developed as a joint initiative of the Bureau of Meteorology and CSIRO, with university sector involvement

**Objectives**

- Develop a *national* approach to climate and weather prediction model development
- Focus on the needs of a wide range of stakeholders:
  - Providing the best possible services
  - Analysing climate impacts and adaptation
  - Linkages with relevant University research
  - Meeting policy needs in natural resource management
‘Blueprint for ACCESS’, K. Puri, June 2005
‘Project Plan for ACCESS’, K. Puri, September 2005

1. ACCESS should import the MetOffice atmospheric model HadGAM1 to provide the initial atmospheric model for ACCESS
2. The MetOffice 4DVAR scheme should be imported to form the atmospheric data assimilation module in ACCESS
The atmospheric models used at the Met Office for operational NWP and climate modelling (including Regional Climate Modelling) are all derived from the Unified Model (UM) System.
Data Assimilation

- Atmospheric data assimilation is performed using a variational scheme (3DVAR and 4DVAR) designed to be used by both global and limited area models.
- The 4DVAR system includes perturbation forecast and adjoint models to provide explicit representation of the time dimension with a 6-hour data window.
1. Observations coverage and accuracy

To make accurate forecasts it is important to know the current weather:

- ~155 million observations (99% from satellites) covering the whole globe are continuously downloaded and fed into the system;
- At ECMWF, ~9 million observations (96% from satellites) are used every 12 hours by complex assimilation procedures to optimally define the initial state of the system.

Unfortunately, there are still regions (e.g. the polar caps and the oceans) with either very few or less accurate observations.
What we are trying to develop

Consistent with the strategy of *seamless prediction*
“Seamless Prediction”
ACCESS NWP Configuration

NWP component of ACCESS has been fully implemented

This represents a significant milestone
MSLP verifications over Australian region

GASP ACCESS-G

Global
01 Jul to 31 Dec 2008

Skill scores

Regional
14 Jul to 31 Dec 2008

LAPS ACCESS-R
ACCESS-R
37.5°×37.5°×50L
Prediction for TC Hamish
ACCESS Global and Regional Ensemble Prediction System, AGREPS

- Ensemble prediction has become an essential component in NWP, seasonal prediction and climate/climate change studies
- AGREPS is an Australian implementation of the MetOffice Global and Regional Ensemble Prediction System (MOGREPS)
- Test global and regions runs have been executed successfully
Probability that NARGIS will pass within 120km radius during the next 120 hours:
tracks: black - OPER, green - CTRL, blue - EPS numbers, observed positions at 12 UTC
Coupling

- Atmosphere
- UKCA (Chemistry)
- CABLE
- Coupler
- AusCOM Ocean (MOM4p1 code)
- AusCOM Sea ice (CICE4 code)
ACCESS
Current status

- CABLE has been successfully coupled to the UM
- Good progress has been made in Coupling AusCOM/CICE to the UM
  - Full coupled model system has been assembled
  - First successful completion of a 2-month trial simulation without technical difficulty
  - Remaining technical matters (e.g., specification of runoff and river outflow; removal of inconsistencies in some of the boundary flux calculations) need to be treated
- UKCA has been coupled to the UM and a number of runs have been completed
- The Regional Climate Model version of ACCESS, HadREM, has been developed and testing has commenced

Expect to have technically fully coupled system available soon
Global Model inline in UK UM atmospheric model framework for advection, diffusion, convection, deposition, etc

- **Tropospheric Chemistry**: gas-phase, with 24 Species including NOx and speciated VOCs, Ozone, Methane, Sulfur Cycle, NH3

- **Stratospheric Chemistry**: gas-phase and heterogeneous, with 15 Species including NOx and N2O, Ozone, Methane, Sulfur Cycle, CLOx, BrOx, CFC’s
The model is expected to support various research activities including:

- Ensemble downscaling of multiple GCM datasets
  - Improve estimates of uncertainties in regional climate projections
- Extreme events
  - Cyclones, storm surges, etc
- Regional air quality climate studies
- University RCM research
Linkages to Hydrology
Brisbane storms, 16 November 2008

AIFS 12-36 fcst for 20081116

Daily gauge analysis for 20081116

Validation statistics for 20081116 n=50777 Verif. grid=0.110°

<table>
<thead>
<tr>
<th></th>
<th>Forecast</th>
<th>Observed</th>
<th>Analysed Forecast</th>
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<tbody>
<tr>
<td></td>
<td>&lt;1</td>
<td>≥1</td>
<td></td>
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<tr>
<td># gridpoints raining</td>
<td>27761</td>
<td>4107</td>
<td>18909 17768</td>
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<tr>
<td>Average rainrate (mm/d)</td>
<td>9.84</td>
<td>12.66</td>
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<tr>
<td>Rain volume (km³)</td>
<td>24.64</td>
<td>29.77</td>
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<tr>
<td>Maximum rain (mm/d)</td>
<td>70.40</td>
<td>153.15</td>
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<tr>
<td>Max 0.25° rain (mm/d)</td>
<td>71.55</td>
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Mean abs error = 3.70 mm/d
RMS error = 8.47 mm/d
Correlation coeff = 0.552
Bias score = 0.940
Probability of detection = 0.722
False alarm ratio = 0.231
Hanssen & Kuipers score = 0.594
Equitable threat score = 0.430
Nudging Scheme for initialising soil moisture in ACCESS

- Using screen-level temperature and humidity observations model background errors are calculated → ΔT and Δq
- Soil moisture analysis increments in 4 soil layers are calculated based on ΔT and Δq
Requirements for Hydrological Prediction

- Initial analysis of soil moisture (and temperature). This involves access to and assimilation of:
  - in-situ data
  - data from SMOS (tentatively scheduled for launch in September 2009)
  - data from HYDROS (passive and active L-Band) and other remote sensing products including the C-band, passive (AMSR) or active (SCAT and ASCAT)
  - data from GRACE (twin set of satellites for gravity)
- Detailed verification of CABLE for hydrological applications, including water budgets
Requirements for Hydrological Prediction

- Development of methods to convert/downscale outputs from ACCESS models (NWP or coupled) to a form that can be used as input to hydrological models
- Development of ensemble techniques for hydrological applications including customisation of AGREPS
- High resolution Australian region reanalysis to develop water budget climatology
Following the disastrous floods in Elbe and Danube river basins in August 2002 the European Commission announced the development of a European Flood Alert System (EFAS) to provide:

- Medium range flood risk across Europe with a lead-time of 3-10 days
- Increased preparedness in an upcoming flood event

**Basic features of EFAS:**
- A range of medium-range early flood alerts based on several medium-range weather forecasts
- Consistent and comparable discharge simulations
- Probabilistic flood risk estimation based on full sets of Ensemble Prediction Systems
ACCESS could deliver the forecasting component provided resources are available for:

- Development of module to generate initial analysis of soil moisture (and temperature) – assimilation of satellite data
- Detailed verification of system for hydrological applications, including water budgets
- Development of methods to convert/downscale outputs from ACCESS models (including ensembles) to a form that can be used as input to hydrological models
**Potential ACCESS deliverable**

- A high resolution Australian region reanalysis (~25 years) with the ACCESS data assimilation system would provide invaluable information for model evaluation and other studies such as water budgets.

- An added benefit of performing such a reanalysis is that it will require the construction of a centralised, consolidated data base prior to the reanalysis - **this data base would be a major national research asset**.

- The implementation within ACCESS of a state-of-the-art assimilation scheme (namely four-dimensional data assimilation) makes a reanalysis possible provided **adequate additional resources are available**.
Concluding comments

ACCESS has made significant progress

However a number of challenges and uncertainties remain:

- Insufficient resources to fully exploit and further develop the system
- Limitations in Bureau system to receive and process large quantities from future sounders, radars ….
- Serious limitations in supercomputing
  - Impose restrictions on model resolutions
  - Inability to run adequate ensemble systems
  - Inability to conduct detailed testing of further development of the system