ANNUAL WWW TECHNICAL PROGRESS REPORT ON THE GDPFS FOR 2005

AUSTRALIA

CENTRE: **NMOC Melbourne**

1. SUMMMARY OF HIGHLIGHTS (2005):

Meteorological, Oceanographic and Computer Systems:

21 January:	NEC SX-6 upgraded to 28 nodes.
8 February:	NTFGS (National Thunderstorm Forecast Guidance System) upgraded, featuring additional products.
8 March:	Daily OCF site forecasts operational.
	Quikscat data used operationally in LAPS_PT375.
1 April:	Commencement of 2-month WMO/CTBTO EER Test.
5 April:	Operational MESO_LAPS_PT050 system extended to include ADELAIDE and PERTH domains.
11 May:	Global WMO/IAEA EER Test.
30 May:	FMD EER Exercise (SA RO)
30 August:	Operational GASP upgraded, featuring: 33-levels, assimilation of scatterometer data, EC land/surface scheme and soil moisture nudging.
4 October:	Hourly OCF operational.
2 November:	FIRE_WEATHER system operational.
8 November:	Operational MESO_LAPS_PT125 enhanced to give 1-hourly model output.
21 November:	Monthly reject list implemented in operational GASP.
1 December:	Resolution of global meteorological input, from GASP, improved for operational HYSPLIT (EER) system .

2. EQUIPMENT IN USE AT CENTRE:

The following table shows the main computer systems used in NMOC Melbourne, with their basic functions:

FUNCTION	COMPUTER	NO. OF CPUS	MEMORY	OPERATING SYSTEM	DISK STORAGE
Supercomputing (Assimilation and Prediction)	Multi-Node NEC SX-6	8 cpu / node 28 Nodes	64 GB / node	SUPER-UX 15.1 SX-6	22 TB (GFS) 133 GB (Local - total of all nodes)
Interface to Supercomputer	NEC TX7/i9510	16 cpu / node 2 Nodes	32 GB / node	NEC Linux R3.4	22 TB (GFS) 140 GB (Local - total of both nodes)
Communications / Message Switching	(i) HP RP7410 (ii) HP RP7410	(i) 4 (ii) 4	(i) 8 GB (ii) 8 GB	(i) HP-UX 11.11 (ii) HP-UX 11.11	200 GB
Scheduling / Data Base / Satellite Post-Processing / Graphics	(i) HP RP8400 (ii) HP RP8400 (iii) HP RP8400	(i) 8 (ii) 8 (iii) 8	(i) 8 GB (ii) 8 GB (iii) 8 GB	(i) HP-UX 11.11 (ii) HP-UX 11.11 (iii) HP-UX 11.11	600 GB 10 TB (SAN)
Horace	(i) HP C3600 (ii) HP C3600 (iii) HP C3600	(i) 1 (ii) 1 (iii) 1	(i) 512 MB (ii) 512 MB (iii) 512 MB	(i) HP-UX 11.11 (ii) HP-UX 11.11 (iii) HP-UX 11.11	(i) 27 GB (ii) 35 GB (iii) 30 GB
RADAR and Visualisation	(i) SGI Octane (ii) SGI-O2	(i) 1 (ii) 1	(i) 512 MB (ii) 128 MB	(i) IRIX 6.5 (ii) IRIX 6.5	(i) 17 GB (ii) 8.5 GB
web / ftp	8 x Dell PowerEdge 2650	8 x 2	6 x 2 GB 2 x 6 GB	Linux RH ES 3.0	8 x 120 GB
MARS	2 x IBM p690	2 x 18 cpus (total) (MARS: 8 cpus)	128 GB (total) (MARS: 24 GB)	AIX 5.2	3 TB
Development	HP RP8400	8	8 GB	HP-UX 11.11	1.8 TB 22 TB (uGFS)

Peripheral Equipment:

Magnetic Cartridge Archive System:

StorageTek Mass Store 9310 ACS (Automatic Cartridge System)
16 drives, for 9840 fibre channel tapes, in silo (4 for SAM-FS, 8 for MARS, 2 for backup and 2 others); tape capacity (uncompressed): 20GB
14 drives for 9940B tapes (6 for SAM-FS and 8 for backup), tape capacity (uncompressed): 200GB

Hardcopy Printers/Plotters:

HP DesignJet 1055cm plus and 650C plotters
HP LaserJet 5 SiMX printers
HP LaserJet 8150DN
HP Color LaserJet 5500dtn
HP Color LaserJet 4500DN

Facsimile Machines:

RICOH FAX 4420NF
RICOH FAX 4500L

Software in use at Centre:

The overall computer environment in the NMOC is mainly Unix. A real-time data base, currently using ORACLE 8.1.7.4.0, is used for storage of observational data and grids from the various NWP systems. The U.S. Navy's Environmental Operational Nowcasting System (NEONS) software is commonly used for accessing the data base. The operational NWP models are written mainly in Fortran, with many of the associated files having the NetCDF structure. Most displays are produced using the NCAR graphics package and IDL. The UK Met. Office's Horace (V4.1) system is used to prepare, in an on-screen mode, manual-computer products for: significant weather prognoses, Australian Region surface analyses and prognoses and Southern Hemisphere surface analyses. Sam-fs is currently being used for magnetic cartridge archives in the NMOC. The Meteorological Archive and Retrieval System (MARS from the ECMWF), established in research, is being gradually integrated into operations, along with METVIEW for the display of products.

Other Systems in use at Centre:

The DIFACS system is used to to disseminate a selection of basic analysis and prognostic charts, and some satellite imagery, to the Bureau's regional offices and some outside users. MCIDAS is used for comprehensive interaction and display of satellite imagery and products, observational and gridded data, and is also a major component of the Australian Integrated Forecast System (AIFS). Products from the NWP systems are written to internal and external (www.bom.gov.au) web servers. Magnetic cartridge archives are kept of various numerical analysis and prognosis products with Australian region analyses available back to 1970 and Southern Hemisphere analyses back to 1972. Hard copy and microfilm archives of charts also exist. An aviation system, which interacts with the WAFS data, is used to view and display the data and prepare the various flight and route forecasts. Regular statistics (including S_1 skill scores, root mean square errors and anomaly correlations), monitoring and comparing the performance of the NMOC's NWP systems (and also some NWP models from overseas centre), are also produced.

3. DATA AND PRODUCTS FROM GTS IN USE:

The following table gives a list of the major observation report types used in the NMOC Melbourne and the approximate numbers received in a 24-hour period (during 2005):

Observational Data Type or Report Type	Approximate number received during 24 hour period (unless otherwise stated)
SYNOP	49344
SHIP	8519
TEMP	1288
PILOT	747
BUOY	26763
AIREP / AMDAR	39512
SATOB	387386
ATOVS (SATEM)	24319
ATOVS (BUFR)	99873
METAR (Australian stations only)	16406
CLIMAT	1935 / month
SATOB_SST	3195
BATHY / TESAC	551
WAVEOB	751
TRACKOB	765
AMV	830314
SAT_ALT	10858
QUIKSCAT	1230798
JASON	63122
RA2_WWV	47342

The following Gridded Products are also received in NMOC Melbourne:

GRIB (ECMWF)
GRIB (EGRR)
GRIB (KWBC)
GRIB (JMA)
[GRID (EGRR,KWBC,EDZW)]

4. DATA INPUT STREAM:

Automated. (Some manual intervention is available for correction of reports.) The observational data, along with NWP gridded data, is stored in a real-time relational data base system (ORACLE/NEONS). An increasing proportion of operationally-produced NWP gridded data is also being stored in MARS.

5. QUALITY CONTROL SYSTEM:

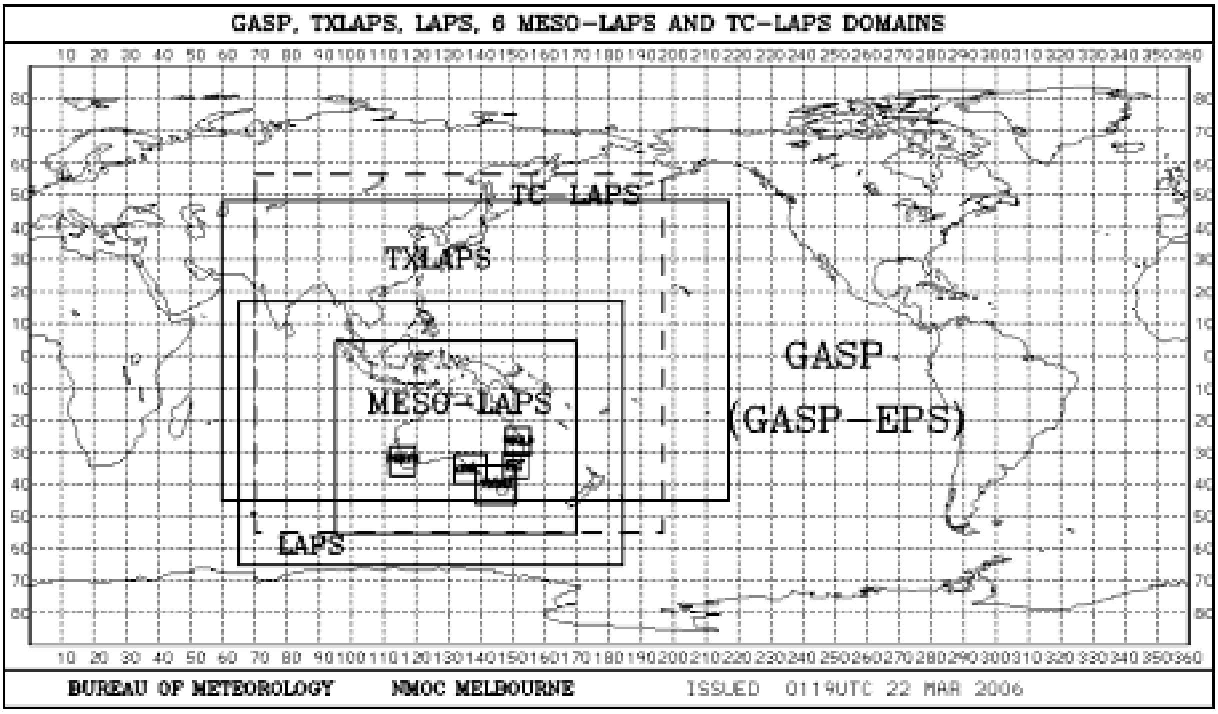
Validity checks are currently confined to within the respective assimilation or analysis schemes. Some gross checking outside these schemes may eventually be installed.

6. MONITORING OF THE OBSERVING SYSTEM:

Monitoring of the observing system is carried out. The quantity of data available is monitored in real-time to ensure that reports are being received reliably and are passed on to the operational systems. For the global system, statistics on the difference between observations and the first guess and analysis fields are routinely generated to identify any problems with either the analysis system or individual data types. Lists and displays of rejected data are also used to identify unreliable reporting from particular observing platforms.

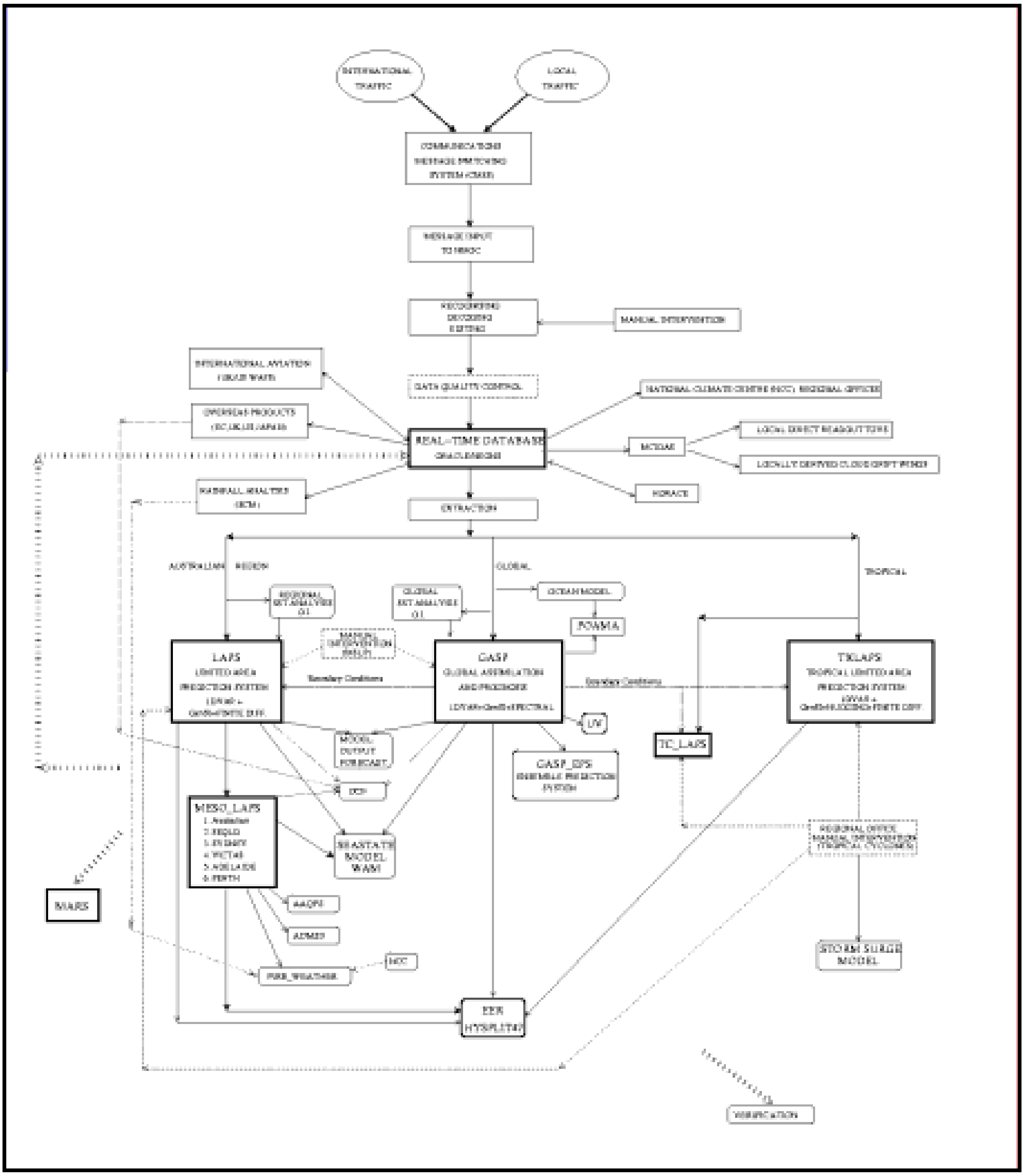
7. FORECASTING SYSTEM:

There are three major operational analysis and forecast systems (viz. the global GASP, regional LAPS and the tropical TXLAPS) in the NMOC Melbourne. A mesoscale version of LAPS, called MESO_LAPS, provides additional high resolution forecast products over 6 smaller domains (viz., Australia, SE Queensland, Sydney, Victoria/Tasmania, Adelaide and Perth). The domains for each of these systems are shown in the figure below. The regional and tropical systems are dependent on the global system for their lateral boundary conditions, whereas the 6 MESO_LAPS systems are all nested in LAPS. An additional system, called TC_LAPS, is run to provide tropical cyclone, and other tropical guidance, for the region. (The possible lateral extent of this guidance is also depicted in the figure below.) Manual intervention is used for mean sea level pressure in the global and regional systems. The resulting hemispheric "pseudo-observations" for mean sea level pressure are disseminated on the GTS. The tropical and Australian region limited area systems both use a tropical cyclone synthetic specification scheme. An additional feature of the tropical system is its dynamical nudging. Output from the global system is also used in the cold start procedure for the Australian region LAPS and tropical TXLAPS. It is noted that the MESO_LAPS systems do not have their own separate analyses but currently use initial (and boundary) conditions derived directly from LAPS (i.e. interpolated laterally from 37.5 km to either 12.5 or 5 km.)



Domains of the operational NWP systems in NMOC Melbourne.

The global, Australian region and mesoscale streams have associated sea-state systems. There are a large number of additional systems including sea surface temperature analysis, environmental emergency response, generation of weather elements from model output (OCF), amendment and dissemination of aviation products, MCIDAS, archives, verification, display and dissemination of products. A schematic representation of the overall system is shown in the following figure.



Schematic representation of the operational analysis and prediction system in NMOC.

7.1 System Run Schedule and Forecast Ranges:

At the present time, the centre produces major analyses at 00 and 12 UTC daily for the globe, Australian region and tropical domains. Global forecasts to 10 days, Australian region and tropical forecasts to 72 hours, mesoscale forecasts to 48 hours for the Australian and 36 hours for the 5 other smaller domains, and special tropical cyclone forecasts to 72 hours are produced from these major analyses. The ECMWF's Supervisor Monitor Scheduler (SMS) is used to manage the major part of the operational system and to initiate and monitor the various tasks in the operational NWP suite. An approximate daily schedule for the main operational, and near-operational, numerical systems is shown in the table below (with the times during the daylight saving months, November to March, shown in brackets).

System Run Schedule and Forecast Ranges

SYSTEM	BASE TIME (UTC)	APPROXIMATE START TIME (UTC)	FORECAST AVAILABILITY (UTC)	FORECAST RANGE FROM BASE DATE/TIME (HRS)
SSTANAL (REGIONAL)	1200	0100	0115	0
LAPS_PT375	0000	0145 (0045)	0215 (0115)	+72
MESO_LAPS_PT125	0000	0215 (0115)	0345 (0245)	+48
MESO_LAPS_PT050(VICTAS)	0000	0215 (0115)	0245 (0145)	+36
MESO_LAPS_PT050(SYDNEY)	0000	0215 (0115)	0235 (0135)	+36
MESO_LAPS_PT050(SEQLD)	0000	0215 (0115)	0250 (0150)	+36
MESO_LAPS_PT050(ADELAIDE)	0000	0215 (0115)	0310 (0210)	+36
MESO_LAPS_PT050 (PERTH)	0000	0215 (0115)	0310 (0210)	+36
EER PREP (LAPS)	0000	0215 (0115)	0220 (0120)	+72
OCF (LAPS)	0000	0215 (0115)	0220 (0120)	+72
WAVES (REGIONAL)	0000	0215 (0115)	0240 (0140)	+48
EER PREP (MESO_LAPS_PT050 5 DOMAINS)	0000	0230 (0130)	0320 (0220)	+36
ADMS3 (MESO_LAPS_PT050 5 DOMAINS)	0000	0230 (0130)	0310 (0210)	+24
OCF (MESO_LAPS_PT050 5 DOMAINS)	0000	0235 (0135)	0315 (0215)	+36
AAQFS (VIC)	0000	0240 (0140)	0320 (0220)	+36
AAQFS (NSW)	0000	0330 (0230)	0400 (0300)	+36
TXLAPS	0000	0330	0430	+72
EER PREP (MESO_LAPS_PT125)	0000	0340 (0240)	0345 (0245)	+48
WAVES (MESO_LAPS_PT125)	0000	0340 (0240)	0445 (0345)	+48
ADMS3 (MESO_LAPS_PT125)	0000	0345 (0245)	0350 (0250)	+24
OCF (MESO_LAPS_PT125)	0000	0345 (0245)	0400 (0300)	+48
FIRE_WEATHER (DROUGHT FACTORS)	0000	0350 (0250)	0440 (0340)	0
TC_LAPS	0000	0400	0420	+72
RAINFALL_ANALYSIS	2300 (2200)	0420	0430	0
EER PREP (TXLAPS)	0000	0420	0430	+72
GASP	0000	0545 (0445)	0730 (0630)	+240

FIRE_WEATHER (DROUGHT FACTORS)	0000	0615	0650	0
GASP_EPS	0000	0620 (0520)	0710 (0610)	+240
WAVES (GLOBAL)	0000	0715 (0615)	0750 (0650)	+96
EER PREP (GASP)	0000	0720 (0620)	0840 (0740)	+240
OCF (GASP)	0000	0720 (0620)	0725 (0625)	+168
LAPS_PT375	0600	1045 (0945)	1145 (1045)	+6
TXLAPS	0600	1045	1145	+6
TC_LAPS	0600	1100	1120	+6
GASP (EARLY)	0600	1200 (1100)	1230 (1130)	+24
LAPS_PT375	1200	1345 (1245)	1415 (1315)	+72
MESO_LAPS_PT125	1200	1415 (1315)	1545 (1445)	+48
MESO_LAPS_PT050(VICTAS)	1200	1415 (1315)	1445 (1345)	+36
MESO_LAPS_PT050(SYDNEY)	1200	1415 (1315)	1435 (1335)	+36
MESO_LAPS_PT050(SEQLD)	1200	1415 (1315)	1450 (1350)	+36
MESO_LAPS_PT050(ADELAIDE)	1200	1415 (1315)	1510 (1410)	+36
MESO_LAPS_PT050(PERTH)	1200	1415 (1315)	1510 (1410)	+36
EER PREP (LAPS)	1200	1415 (1315)	1420 (1320)	+72
OCF (LAPS)	1200	1415 (1315)	1420 (1320)	+72
WAVES (REGIONAL)	1200	1415 (1315)	1440 (1340)	+48
EER PREP (MESO_LAPS_PT050 5 DOMAINS)	1200	1430 (1330)	1520 (1420)	+36
ADMS3 (MESO_LAPS_PT050 5 DOMAINS)	1200	1430 (1330)	1510 (1410)	+24
OCF (MESO_LAPS_PT050 5 DOMAINS)	1200	1435 (1335)	1515 (1415)	+36
AAQFS (VIC)	1200	1440 (1340)	1535 (1435)	+36
AAQFS (NSW)	1200	1530 (1430)	1610 (1510)	+36
TXLAPS	1200	1530	1620	+72
EER PREP (MESO_LAPS_PT125)	1200	1540 (1440)	1545 (1445)	+48
WAVES (MESO_LAPS_PT125)	1200	1540 (1440)	1645 (1545)	+48
ADMS3 (MESO_LAPS_PT125)	1200	1545 (1445)	1550 (1450)	+24
OCF (MESO_LAPS_PT125)	1200	1545 (1445)	1600 (1500)	+48
TC_LAPS	1200	1600	1615	+72
EER PREP (TXLAPS)	1200	1620	1630	+72
GASP	1200	1745 (1645)	1930 (1830)	+240
GASP_EPS	1200	1820 (1720)	1910 (1810)	+240

WAVES (GLOBAL)	1200	1915 (1815)	1950 (1850)	+96
EER PREP (GASP)	1200	1920 (1820)	2040 (1940)	+240
OCF (GASP)	1200	1920 (1820)	1925 (1825)	+168
LAPS_PT375	1800	2245 (2145)	2345 (2245)	+6
TXLAPS	1800	2245	2345	+6
TC_LAPS	1800	2300	2320	+6
GASP (EARLY)	1800	0000 (2300)	0030 (2330)	+24
POAMA	(Daily)	0930	1430	+10 months
SSTANAL (GLOBAL)	(Mid-week)	2300 (Sundays only)	0000 (Mondays only)	0
SST (SUB-SURFACE)	(Monthly)	2200 (Mondays only)	2220 (Mondays only)	0
AD HOC (TOP PRIORITY): EER	ANYTIME	ANYTIME	ANYTIME + 30 mins	+72
ADMS3	ANYTIME	ANYTIME	ANYTIME + 30 mins	+24
TC_LAPS	0000 or 1200	ANYTIME	ANYTIME + 45 mins	+72

7.2 Medium-range Forecasting System (4-10 DAYS):

The acronym **GASP** is given to the **G**lobal **AS**imilation and **P**rognosis system, which produces medium-range forecast products to 10 days. Post-processed products from this system are disseminated on the GTS in GRIB form, externally and internally via the web, "DIFACS" and MCIDAS, and also via Radio-facsimile broadcasts (VMC and VMW).

7.2.1 Data Assimilation, Objective Analysis and Initialization:

Assimilated data: Mean sea level pressure (surface network, ships, drifting buoys, PAOBs), thickness (radiosondes, satellite retrievals), moisture (dew points), wind (rawinsonde, aircraft, geostationary satellites), cloud-clear radiances (from NOAA orbiting satellites).
Assimilation cycle, including cut-off time: 6 hourly cycling. H+6 cut-off.
Method of analysis: Generalised Multivariate statistical interpolation (GenSI) + univariate O.I. for moisture, one-dimensional variational retrievals (1DVAR).
Analysed variables: Geopotential, temperature, wind, moisture, surface pressure.
First guess: 6 hour forecast from previous cycle.
Coverage: Global.
Horizontal resolution: Triangular 239.

Vertical resolution: 33 sigma levels (0.9984, 0.9972, 0.9950, 0.9911, 0.9841, 0.9720, 0.9500, 0.9250, 0.9000, 0.8750, 0.8500, 0.8000, 0.7500, 0.7000, 0.6330, 0.5660, 0.5000, 0.4330, 0.3660, 0.3200, 0.2900, 0.2600, 0.2300, 0.2000, 0.1700, 0.1400, 0.1100, 0.0900, 0.0700, 0.0500, 0.0300, 0.0200, 0.0100)
Initialization: Incremental non-linear normal mode.

7.2.2 Model:

Basic equations: Spectral primitive equations.
Independent variables: latitude,longitude,σ,t
Dependent variables: log p_*,T,q,vorticity,divergence.
Numerical technique:
horizontal: Spectral.
vertical: Finite difference.
time: Semi-implicit semi-Lagrangian.
Integration domain (in horizontal and vertical): Global, surface to 10 hPa (approx.).
Horizontal and vertical resolution, time step: Triangular 239, 33 sigma levels, 600 sec.(approx.).
Orography, gravity wave drag: Both included.
Horizontal diffusion: Included.
Vertical diffusion: Included.
Planetary boundary layer: Included.
Treatment of sea surface, earth surface and soil: Included.
Radiation: Diurnal cycle, diagnostic clouds, interactive optical properties.
Convection (deep and shallow): Included.
Atmospheric moisture: Included.
Boundaries: Stand alone.
Albedo: Climatology.
SST Analysis: Weekly (1^0x1^0).

7.2.3 Numerical Weather Prediction Products:

The following table lists some of the post-processed fields that are available from GASP:

Mean sea level pressure	Pressure at cloud top	Net solar radiation
Surface pressure	Temperature Tendency	Net downward radiation at surface
Temperature	Mixing ratio tendency	Outgoing longwave radiation
Wind	Radiative tendency	Albedo
Mixing ratio	Vorticity surface flux tendency	Surface wind stress
Geopotential height	Divergence surface flux tendency	Evaporation
Vorticity	Solar heating tendency	Roughness length at surface
Divergence	Precipitable water	Sub-surface temperature
Velocity potential	Soil moisture	Sensible heat flux
Precipitation	Snow depth, melt, cover	Latent heat flux

Stream function	Runoff	UV index
Cloud amount	Topography	

7.2.4 Operational Techniques for Application of NWP Products:

GASP output fields are used to drive a number of systems including the global components of the sea-state and EER systems. In addition, GASP fields are used in the generation of OCF and meteogram products.

7.2.5 Ensemble Prediction System:

An Ensemble Prediction System based on the GASP system is currently being run in test mode in real-time in NMOC Melbourne. The 33-member ensemble system is running at the resolution: T119L19 (ie Triangular 119, 19 vertical levels), with a timestep of 1200 sec., and producing forecasts out to 10 days, off 00 and 12 UTC. Singular vectors are used to perturb the initial state derived from GASP. These perturbed states are then used as the initial conditions for each of the ensemble members.

7.3 Short-range Forecasting System (0-72 HRS):

The Australian region **L**imited **A**rea **P**rediction **S**ystem (**LAPS**), the **T**ropical e**X**tended domain **L**imited **A**rea **P**rediction **S**ystem (**TXLAPS**) and the **MESO**scale **L**imited **A**rea **P**rediction **S**ystem **(MESO_LAPS)** provide short-range forecasting guidance and products that are disseminated externally and internally via the web, "DIFACS" and MCIDAS, and also via Radio-facsimile broadcasts (VMC, VMW). TXLAPS and TC_LAPS, for specific tropical cyclone guidance, are run on behalf of RSMC Darwin. Again it is noted that the 6 MESO_LAPS systems do not have their own assimilation, or analysis, but use an initial starting condition derived directly from LAPS. It is also noted that TC_LAPS runs in 2 steps. The first preparatory step produces analyses and prognoses over a large domain, or what is called the Large Scale Environment (LSE), and the second step then generates analyses and forecasts at a higher resolution on a relocatable domain centred on the tropical cyclone (and nested within the LSE part).

7.3.1 Data Assimilation, Objective Analysis and Initialization:

Assimilated data: Surface synop, ship, drifting buoy, radiosonde, rawinsonde, GTS TOVS, GTS cloud drift winds, aircraft single level winds, bogus MSLP ("pseudo-observations"), tropical cyclone synthetic data, cloud-clear radiances (from NOAA orbiting satellites).

Assimilation cycle, including cut-off time: 6 hourly cycling; cut-off: LAPS: H+2 hr, TXLAPS: H+4 hr.

Method of analysis: Generalised Multivariate statistical interpolation (GenSI) + univariate statistical interpolation for moisture, one-dimensional variational retrievals (1DVAR). LAPS and TXLAPS are initiated from GASP 12 hours prior to target analysis, with two successive 6-hour assimilation steps.

Analysed variables: Geopotential, temperature, wind, moisture, surface pressure.

First guess: 6 hour forecast from previous cycle.

Coverage: LAPS: 17.125^0N-65.0^0S, 65.0^0E-184.625^0E

TXLAPS: 48.375^{0}N-45.0^{0}S, 60.0^{0}E-217.125^{0}E

TC_LAPS: 56.75^{0}N-55.0^{0}S, 70.0^{0}E-163.25^{0}W (LSE), 27.0^{0}x27.0^0 (Relocatable)

Horizontal resolution: LAPS and TXLAPS: 0.375^0

TC_LAPS: 0.75^0 (LSE) and 0.15^0 (Relocatable)

Vertical resolution: LAPS, TXLAPS, TC_LAPS: 29 sigma levels (0.9988, 0.9974, 0.9943, 0.9875, 0.9750, 0.9625, 0.9500, 0.9250, 0.9000, 0.8750, 0.8500, 0.8000, 0.7500, 0.7000, 0.6000, 0.5000, 0.4500, 0.4000, 0.3500, 0.3000, 0.2750, 0.2500, 0.2250, 0.2000, 0.1750, 0.1500, 0.1000, 0.0700, 0.0500)

Initialization: LAPS and MESO_LAPS: Digital filtering technique.

TXLAPS and TC_LAPS: diabatic dynamical nudging scheme incorporating GMS IR imagery.

(For Tropical Cyclones: Synthetic vortex specification.)

7.3.2 Model:

Basic equations: Grid primitive equations.
Independent variables: x,y,z,t
Dependent variables: P_*,T,q,u,v.
Numerical technique:
horizontal: Finite difference.
vertical: Finite difference.
time: Explicit.
Integration domain (in horizontal and vertical):
LAPS: 17.125^{0}N-65.0^{0}S, 65.0^{0}E-184.625^{0}E, surface to 50 hPa (approx.)
TXLAPS: 48.375^{0}N-45.0^{0}S, 60.0^{0}E-217.125^{0}E, surface to 50 hPa (approx.)
MESO_LAPS:
Australian: 4.875^{0}S-55.0^{0}S, 95.0^{0}E-169.875^{0}E, surface to 50 hPa (approx.)
SYDNEY: 30.05^{0}S-38.00^{0}S, 147.00^{0}E-154.95^{0}E, surface to 50 hPa (approx.)
VICTAS: 34.05^{0}S-46.00^{0}S, 139.00^{0}E-150.95^{0}E, surface to 50 hPa (approx.)
SEQLD: 22.05^{0}S-31.00^{0}S, 148.00^{0}E-155.95^{0}E, surface to 50 hPa (approx.)
ADELAIDE: 30.55^{0}S-39.50^{0}S, 132.00^{0}E-141.95^{0}E, surface to 50 hPa (approx.)
PERTH: 28.05^{0}S-37.00^{0}S, 112.00^{0}E-119.95^{0}E, surface to 50 hPa (approx.)
TC_LAPS:
LSE: 56.75^{0}N-55.0^{0}S, 70.0^{0}E-163.25^{0}W, surface to 50 hPa (approx.)
Relocatable: 27.0^{0}x27.0^0 , surface to 50 hPa (approx.).
Horizontal and vertical resolution, time step:
LAPS: 0.375^0 , 29 sigma levels, 40 sec
TXLAPS: 0.375^0 , 29 sigma levels, 40 sec
MESO_LAPS:
Australian: 0.125^0, 29 sigma levels, 10 sec
SYDNEY: 0.05^0, 29 sigma levels, 5 sec
VICTAS: 0.05^0, 29 sigma levels, 5 sec
SEQLD: 0.05^0, 29 sigma levels, 5 sec
ADELAIDE 0.05^0, 29 sigma levels, 5 sec
PERTH: 0.05^0, 29 sigma levels, 5 sec
TC_LAPS:
LSE: 0.75^0 , 29 sigma levels, 40 sec
Relocatable: 0.15^0 , 29 sigma levels, 15 sec.

Orography, gravity wave drag: Included.
Horizontal diffusion: Included.
Vertical diffusion: Included.
Planetary boundary layer: Included.
Treatment of sea surface, earth surface and soil: Included.
Soil moisture analysis: Included in LAPS, TXLAPS, TC_LAPS and MESO_LAPS.
Radiation: Diurnal cycle, diagnostic clouds, interactive optical properties.
Convection (deep and shallow): Included.
Atmospheric moisture: Included.
Boundaries: LAPS, TXLAPS and TC_LAPS (LSE): Lateral boundaries from GASP.
MESO_LAPS (6 domains): Lateral boundaries from LAPS.
TC_LAPS (Relocatable): Lateral boundaries from LSE TC_LAPS.
Albedo: Climatology.
SST Analysis: Weekly (1^0x1^0) - in LAPS, MESO_LAPS (Australian), TXLAPS and TC_LAPS.
Daily (0.25^0x0.25^0) - in MESO_LAPS (SYDNEY, VICTAS, SEQLD, ADELAIDE, PERTH).

7.3.3 Numerical Weather Prediction Products:

The following table lists some of the post-processed fields that are available from the Limited Area Prediction Systems:

Mean sea level pressure	Stream function	Saturation deficit
Surface pressure	Wind shear	Cloud amount
Temperature	Boundary layer convective energy flux	Surface wetness
Wind	Shearing deformation	Atmospheric boundary layer height
Mixing ratio	Stretching deformation	Surface sensible heat flux
Geopotential height	Temperature gradient	Surface latent heat flux
Dew point temperature	Temperature advection	Surface wind stress
Dew point depression	Q vector	Surface total heat flux
Ageostrophic wind	Moisture convergence	Boundary layer convective energy flux
Potential temperature	Moisture advection	Skin temperature of boundary layer
Equivalent potential temperature	Wet bulb potential temperature	Pressure at cloud top
Wet bulb potential temperature	Total precipitation	Frontogenesis function
Layer thickness	Convective precipitation	Total totals index
Vorticity	Non-convective precipitation	Lifting index
Divergence	Lifting condensation level	Forest fire danger index
Vorticity advection	Topography	Grassland fire danger index
Relative humidity	Precipitable water	

7.3.4 Operational Techniques for Application of NWP Products:

LAPS and MESO_LAPS output fields are used to drive the sea-state system for the Australian and a smaller domain. In addition they, along with TXLAPS, are used to drive the respective components of the EER system, and are also used in the generation of OCF and meteogram products. Fields from the Australian domain version of MESO_LAPS are used in the NTFGS decision tree system.

7.4 Specialized Numerical Analysis and Prediction:

7.4.1 Sea Wave Models:

The following table summarises the characteristics of the sea-state system in the NMOC:

Domain	**Global**	**Australian Region**	**Australian MESO_LAPS Region**
Numerical Scheme	Deep water 3rd generation (WAM)	Deep water 3rd generation (WAM)	Shallow water 3rd generation (WAM)
Wind data source	GASP (10m)	LAPS_PT375 (10m)	MESO_LAPS_PT125 (10m)
Grid	Latitude/ longitude	Latitude/ longitude	Latitude/ longitude
Resolution	1^0	0.5^0	0.125^0
Nesting	Stand alone	Within Global	Within Regional
Start time of forecast	00,12 UTC	00, 12 UTC	00, 12 UTC
Forecast Period	+96 hrs	+48 hrs	+48 hrs
Initial state	12 hr hindcasting and assimilation of satellite altimeter data		No assimilation
Model output	Wind and swell significant wave height, period and direction. Significant wave spectra and probabilities.		
Verification	With respect to rigs and buoys		

Specialized sea-state forecasts are provided for the North West Cape and Bass Strait gas and oil fields.

7.4.2 Storm Surge System:

A system capable of forecasting storm surges caused by tropical cyclones is currently driven by wind and pressure field distributions defined according to the central pressure and maximum wind radius bogussed for tropical cyclones by Darwin RFC.

7.4.3 Atmospheric Transport Model - EER System:

An air dispersion, or transport, system is available for running on demand and can produce forecast trajectories, concentrations (or exposures) and depositions for nuclear accident, volcanic ash, smoke, air-borne virus and other episodes. Currently, the operational Environmental Emergency Response (EER) system consists of the Hybrid Single_Particle Lagrangian Integrated Trajectories (HY-SPLIT using Version 4.7) system, developed at the NOAA Air Resources Laboratory, with meteorological input from the operational NWP systems in NMOC (viz., GASP, LAPS, TXLAPS, and MESO_LAPS). Analysed backward trajectories, and retro-plumes, are also available from GASP, LAPS and TXLAPS in operations.

7.4.4 Solar Ultraviolet (UV) Radiation Forecast System:

Forecasts out to 36 hour forecasts of a UV index (defined as the product of the UV irradiance and a human skin response function) are produced operationally. The system analyses ozone concentrations, available from the global TOMS (being replaced by OMI) and 120 km GTS ATOVS data, using 2-dimensional univariate statistical interpolation. Forecasts of the ozone distribution are then computed using isentropic fields derived from GASP output. From vertical profiles of temperature and ozone, the UV index is calculated. Currently, forecasts of the UV index (defined according to the WMO standard categories) and UV alerts are produced, once per day, after completion of the 1200 UTC run of GASP.

7.4.5 Rainfall Analysis:

A daily rainfall analysis is run for both an Australian (10.00^{0}S-44.50^{0}S, 112.00^0 E-156.25^{0}E) and a South East Australian (32.50^{0}S-44.00^{0}S, 134.50^0 E-152.40^{0}E) domain. The analysis uses a Barnes' successive correction method applied to observational data derived from SYNOP, telegraphic and AWS reports. The analysis is performed on a latitude/longitude grid at a horizontal resolution of 0.25^0 for the Australian and 0.10^0 for the South East Australian domains.

7.4.6 National Thunderstorm Forecast Guidance System (NTFGS):

The NTFGS is a decision tree system that uses diagnostic fields derived from MESO_LAPS (Australian domain) together with defined thresholds to provide forecast guidance on likely storm or severe weather areas over Australia. Storm types considered include thunderstorms, supercells and tropical squall lines. Severe weather classifications include events associated with large hail and heavy rain, tornadoes and severe convective gusts. The system is updated twice a day, after the runs of MESO_LAPS.

7.4.7 Operational Consensus Forecasts (OCF):

The OCF system generates forecasts of weather elements using a consensus of direct model output and model output statistics. A bias correction (with a 30-day adaptation period) is applied to the component forecasts and then a composite forecast (based on the mean absolute error, using a weighted average algorithm) is generated. The system currently uses model output from GASP, LAPS, MESO_LAPS (all 6 domains), and a number of overseas models (UK, US and Japan). OCF is run in a daily and an hourly mode. For the daily mode, forecast elements include temperature (maximum, minimum, ground minimum), rainfall (amount and probability), sunshine hours and evaporation. In this mode, forecasts are produced for over 600 sites throughout Australia, where the available forecast period can be up to 7 days, depending on the weather elements. For the hourly mode, the forecast weather elements produced include: screen-level air and dew point temperatures, relative humidity, QNH, wind speed and direction, and precipitation - with forecasts up to 42 hours for approximately 280 stations.

7.4.8 Fire Weather system:

The Fire Weather system, in the NMOC operational context, uses the daily rainfall and maximum temperature (from the National Climate Centre) analyses to generate a set of gridded soil moisture deficit (eg Keetch-Byram Drought Index and Mount’s Soil Dryness Index) and associated drought factor fields, and other derivatives. These products are used to support fire weather services throughout the regions. By combining some of these products with output from MESO_LAPS, a number of additional products (eg forest and grassland fire danger indices) are also made available.

7.4.9 Microscale Dispersion Modelling System:

A microscale dispersion system: ADMS3 (Atmospheric Dispersion Model Version 3), from CERC (UK), is in a near-operational state. This system is a skewed Gaussian plume model, which has the capacity of allowing the definition of a variety of sources in terms of shape and pollution types. Currently, MESO_LAPS (all 6 domains) provides the meteorological input for driving the system.

7.4.10 Australian Air Quality Forecast System (AAQFS):

The AAQFS, currently in a near-operational state, provides a facility for generating air quality forecasts for regions including and surrounding the Australian capital cities. The system features a Chemical Transport Model (using the Generalised Reaction Scheme), an emissions data base or inventory and, eventually, an evaluation module. The system is an Eulerian numerical forecasting system. Currently, the system is run over 4 airsheds: Sydney, NSW, Melbourne and Victoria. The SYDNEY and VICTAS runs of MESO_LAPS provide the meteorological input to the system. Products include forecasts (up to 36 hours) of: Air Quality Index and Air Particle Index, and concentrations of: O_3, SO_2, CO, NO, PM2.5 and PM10.

7.5 Extended-range Forecasts (10 - 30 DAYS): Not applicable yet.

7.6 Long-range Forecasts (30 DAYS - 2 YEARS):

A three-month rainfall seasonal climate outlook is prepared. Each month, a risk-assessment for three-month total rainfall across Australia is issued mid-month for the three-month period starting the following month. Probabilities are calculated for the three-month total rainfall being in the lowest one-third of historical falls (tercile 1), the middle one-third (tercile 2), and the upper one-third (tercile 3). The technique used is discriminant analysis, with the inputs being derived from recent Sea Surface Temperature (SST) patterns. Subsidiary techniques involved in the forecast model include principal component analysis of SSTs for the Pacific Ocean, Indian Ocean and Southern Ocean, and principal component analysis of rainfall patterns across Australia. SST EOF (Empirical Orthogonal Function) loadings, at one and three months lag, for the Pacific Ocean ENSO pattern and the Indian Ocean pattern are the current predictor inputs. The tercile probabilities, computed across Australia on a 1^0x1^0 grid are published in the form of contoured maps, tabulated averages for the 107 Australian rainfall districts, and tabulated interpolations for cities and towns around Australia. Similar outlooks are also provided for above/below median seasonal rainfall and additionally for both maximum and minimum (three-month average) temperatures (tercile and median probabilities).

Additional guidance at the rainfall district level is presented in the form of stratified rainfall climatologies based on recent values of the SOI (Southern Oscillation Index). Rainfall outcomes for eastern Australia, obtained from SOI analogues, are also described.

An ocean model for climate monitoring and seasonal prediction is run daily with forcing provided by GASP. Assimilation of ocean (sub-surface) observations is performed every three days.

7.6.1 Ocean-Atmosphere Coupled Model:

The same ocean model, referred to above, is also used to provide the ocean initial conditions and ocean component of a seasonal to interannual coupled ocean/atmosphere general circulation model known as POAMA (Predictive Ocean Atmosphere Model for Australia). Atmospheric initial conditions are obtained from the operational runs of GASP. The atmospheric component of the coupled system is essentially the same model as the operational GASP but run at the reduced resolution: T47L17 (ie Triangular 47, 17 vertical levels). Ten month forecasts are produced daily from this system and used as monthly, or last 30 day, ensemble forecasts for the seasonal outlooks.

8. VERIFICATIONS OF PROGNOSTIC PRODUCTS:

An annual summary of verification statistics for 2005, for the Australian regional and global schemes, is given in the following tables.

The following abbreviations have been used in the tables:

S1 - 30 day mean Teweles skill score over Australian verification area
r - anomaly correlation coefficient between forecast heights and climatology over Australian verification area
PERSIS - 24, 36 or 48 hour persistence prediction
REGN - Australian Regional LAPS (Limited Area Prediction System)
GASP - Global Assimilation and Prognosis model
RMSE - Root Mean Square Error

Note:

The LAPS and GASP results are with respect to their own analyses, but on a common grid.

8.1 Skill Scores and Anomaly Correlation Coefficients:

24 HR VERIFICATION STATISTICS - AUSTRALIAN REGION 2005

BASE TIME: 0000UTC - VALID TIME: 0000UTC

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	54	61	54	59	49	53	52	54	63	64	61	58
	S1	REGN	19	22	20	17	19	20	18	19	20	19	20	19
	r	REGN	.97	.97	.98	.98	.98	.98	.97	.97	.97	.98	.97	.98
500hpa height	S1	PERSIS	46	51	49	50	44	44	46	50	47	48	53	43
	S1	REGN	13	13	15	13	14	13	13	14	11	11	14	12
	r	REGN	.98	.98	.98	.98	.98	.98	.98	.98	.98	.99	.98	.98
250hpa height	S1	PERSIS	42	47	43	46	40	35	39	40	41	41	49	42
	S1	REGN	12	12	13	12	13	10	10	11	9	10	13	11
	r	REGN	.98	.98	.98	.97	.98	.98	.98	.98	.98	.98	.97	.98

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	54	61	55	59	50	54	53	56	63	64	61	58
	S1	GASP	18	21	20	16	17	19	17	17	17	17	17	18
	r	GASP	.97	.97	.98	.98	.98	.98	.98	.98	.98	.98	.98	.98
500hpa height	S1	PERSIS	46	51	49	51	45	45	48	51	48	49	53	44
	S1	GASP	12	12	14	12	13	12	12	12	11	10	12	10
	r	GASP	.99	.99	.99	.98	.99	.99	.98	.98	.99	.99	.98	.99
250hpa height	S1	PERSIS	43	48	45	47	41	36	40	41	42	42	49	43
	S1	GASP	10	11	12	11	11	10	10	10	9	9	11	9
	r	GASP	.99	.98	.98	.98	.99	.99	.98	.98	.98	.99	.98	.99

36 HR VERIFICATION STATISTICS - AUSTRALIAN REGION 2005

BASE TIME: 1200UTC - VALID TIME: 0000UTC

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC

MSLP	**S1**	**PERSIS**	62	70	63	66	57	64	60	64	72	72	69	66
	S1	**REGN**	24	26	27	21	24	25	24	25	26	25	25	24
	r	**R**EGN	.95	.94	.95	.96	.96	.96	.94	.94	.94	.95	.95	.96
500hpa height	**S1**	**PERSIS**	54	61	57	54	51	53	55	57	53	56	60	50
	S1	**REGN**	17	18	21	17	19	18	18	18	15	16	18	15
	r	**REGN**	.96	.96	.96	.96	.97	.96	.95	.95	.97	.97	.96	.97
250hpa height	**S1**	**PERSIS**	49	57	50	49	46	42	46	47	45	48	55	49
	S1	**REGN**	15	16	19	16	17	13	13	14	12	13	17	14
	r	**REGN**	.96	.95	.96	.95	.97	.96	.95	.96	.97	.97	.95	.97

			JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
MSLP	**S1**	**PERSIS**	63	70	63	67	59	66	62	65	72	73	70	66
	S1	**GASP**	24	26	26	20	22	25	22	23	22	23	23	23
	r	**GASP**	.95	.95	.96	.97	.97	.96	.96	.95	.96	.97	.96	.97
500hpa height	**S1**	**PERSIS**	55	61	58	54	52	54	56	58	54	57	60	51
	S1	**GASP**	17	16	19	16	18	17	16	17	14	14	17	14
	r	**GASP**	.97	.97	.97	.97	.97	.97	.96	.97	.97	.98	.97	.98
250hpa height	**S1**	**PERSIS**	50	58	52	50	47	43	47	48	47	49	56	50
	S1	**GASP**	15	15	17	15	15	13	13	13	12	12	16	13
	r	**GASP**	.97	.96	.97	.96	.97	.97	.96	.97	.97	.97	.96	.98

48 HR VERIFICATION STATISTICS - AUSTRALIAN REGION 2005

BASE TIME: 0000UTC - VALID TIME: 0000UTC

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	69	73	65	67	61	70	67	69	74	74	76	71
	S1	REGN	29	32	32	27	30	31	30	31	32	31	31	29
	r	REGN	.93	.90	.92	.93	.92	.93	.89	.88	.90	.92	.92	.93
500hpa height	S1	PERSIS	57	64	61	54	56	57	60	61	53	57	62	54
	S1	REGN	22	23	26	22	24	23	22	23	20	20	23	18
	r	REGN	.93	.92	.93	.92	.94	.93	.92	.92	.94	.95	.93	.95
250hpa height	S1	PERSIS	52	60	54	50	50	46	50	50	45	48	58	52
	S1	REGN	19	21	23	20	21	17	16	17	15	16	20	18
	r	REGN	.93	.91	.93	.91	.94	.93	.93	.93	.95	.95	.92	.95

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	70	74	66	68	62	71	68	70	74	75	77	71
	S1	GASP	28	30	32	23	27	30	27	28	28	28	28	27
	r	GASP	.94	.92	.94	.95	.94	.94	.93	.92	.93	.94	.94	.95
500hpa height	S1	PERSIS	58	64	61	54	56	59	61	63	54	58	62	54
	S1	GASP	20	19	24	19	21	21	20	21	18	18	21	17
	r	GASP	.95	.95	.95	.95	.96	.95	.94	.94	.96	.96	.95	.96
250hpa height	S1	PERSIS	53	61	54	50	51	47	51	51	46	49	59	52
	S1	GASP	17	18	22	17	18	15	15	16	14	15	19	16
	r	GASP	.95	.94	.94	.94	.96	.96	.94	.95	.96	.96	.94	.96

8.2 Root Mean Square Errors (Annual 2005):

(a) Verification against GASP analyses:

AREA	FIELD	RMSE or RMSVE UNIT	+24HR		+72HR		+120HR	
			00UTC	12UTC	00UTC	12UTC	00UTC	12UTC
Northern Hemisphere	500 hPa Height	m	15.5	15.4	40.7	40.8	68.0	67.9
	250 hPa Wind	m/s	5.6	5.6	11.6	11.5	16.6	16.6
Southern Hemisphere	500 hPa Height	m	19.1	19.0	51.7	51.4	81.5	81.9
	250 hPa Wind	m/s	5.9	5.9	12.8	12.8	18.1	18.2
Tropics	850 hPa Wind	m/s	3.0	3.0	4.6	4.6	5.3	5.2
	250 hPa Wind	m/s	5.1	5.1	8.1	8.2	9.8	9.9

(b) Verification against radiosondes:

AREA	FIELD	RMSE or RMSVE UNIT	+24HR		+72HR		+120HR	
			00UTC	12UTC	00UTC	12UTC	00UTC	12UTC
North America	500 hPa Height	m	17.1	17.5	42.4	43.6	70.2	71.2
	250 hPa Wind	m/s	10.9	10.7	15.4	15.3	19.5	19.5
Europe	500 hPa Height	m	22.7	20.5	47.5	45.8	83.6	80.2
	250 hPa Wind	m/s	9.1	9.1	13.6	13.4	19.4	18.9
Asia	500 hPa Height	m	21.8	21.5	41.3	40.0	61.1	60.8
	250 hPa Wind	m/s	11.2	11.5	14.7	14.8	17.3	17.6
Australia/NZ	500 hPa Height	m	17.4	17.8	32.3	40.0	53.0	65.7
	250 hPa Wind	m/s	10.3	10.4	13.7	14.0	17.9	18.3
Tropics	850 hPa Wind	m/s	4.6	4.5	5.4	5.2	5.8	5.5
	250 hPa Wind	m/s	7.1	7.3	8.2	8.6	9.3	9.7
Northern Hemisphere	500 hPa Height	m	21.1	20.7	45.8	45.8	75.4	75.0
	250 hPa Wind	m/s	10.2	10.1	14.3	14.3	18.4	18.4

Southern Hemisphere	**500 hPa Height**	**m**	22.1	22.5	41.5	45.3	63.9	70.8
	250 hPa Wind	**m/s**	10.8	11.2	14.6	15.2	18.8	19.5

9. PLANS FOR THE FUTURE:

9.1 Development of the GDPFS

Plans for operational systems in the NMOC Melbourne include:

. ongoing improvements to LAPS including: more vertical levels (51 initially, followed by 60), multi-node MPI version, improvements to cloud and radiation parameterisations, a non-hydrostatic formulation, improved horizontal resolution to 10km;

. the introduction of a Severe Weather relocatable version of LAPS;

. the introduction of a LAPS ensemble prediction system (using 2 physics schemes, with 16 members per scheme);

. an increase in the number of vertical levels to 51 for all the MESO_LAPS configurations and the setting up of MESO_LAPS (Australian) to run off the additional base times 06 and 18UTC;

. the introduction of a new MESO_LAPS_PT050 domain (for Darwin);

. the introduction of a mesoscale assimilation system;

. the operational implementation of a high resolution surface analysis;

. enhancements to GASP incorporating: increased vertical resolution to 60 levels (up to 0.1 hPa), multi-node MPI version, locally derived cloud drift winds;

. the operational implementation of the GASP Ensemble Prediction System, along with an appropriate verification scheme;

. an upgrade of the rainfall analysis to use the Kriging method;

. the implementation of a rainfall verification scheme;

. the introduction of a National Rainfall Forecasting System;

. the introduction of a Poor Man's Ensemble (PME) system for rainfall forecasts;

. the introduction of a gridded version of OCF, and an extension OCF to provide sea-state forecast guidance;

. the introduction of the Graphical Forecast Editor (GFE) into NMOC and Regional Offices;

. a move to drive the storm surge model using meteorological input from TC_LAPS;

. an upgrade to the coupled ocean-atmospheric model (POAMA) for seasonal analysis and prediction, along with further development of products;

. the introduction and development of a tsunami operational modelling capability using scenario selection initially (with input bathymetry) followed by an assimilation and forecast system (incorporating tidal gauge observations);

. an ongoing improvement to the operational Environmental Emergency Response System featuring: a unified wind input system, a full radionuclide database, inclusion of a number of chemical transformations, time-dependent sources, ATM ensembles, automatic initiation of forecast plumes (when remotely sensed) and analysed retro-plumes (when CTBTO initiated);

. the full implementation of a gaussian-type plume model (ADMS3) for the microscale;

. the introduction of the HPAC (Hazard Prediction and Assessment Capability) system;
. the full operational implementation of the urban Australian Air Quality Forecasting System (AAQFS);
. the further development of the air-borne virus facility within the EER system and extensions to the microscale dispersion and air quality systems;
. the rationalisation and upgrade of verification systems;
. an ongoing improvement and generalization of data processing and graphical display (including the full integration of MARS and METVIEW and, eventually, a GIS, and the development of high-resolution background products);
. improvement in data monitoring systems;
. improvement in product dissemination methods.

9.2 Research Activities in NWP

Global Assimilation and Prediction:
The operational Global Assimilation and Prediction (GASP) system, in NMOC, was upgraded on 30 August 2005. New features include:
. An increase in the number of model vertical levels from 29 to 33, with additional levels included in the planetary boundary layer.
. Assimilation of QuikSCAT scatterometer data.
. The use of a (ECMWF, Viterbo and Beljaars, 1995) land surface scheme to replace the old "bucket" scheme.
. Soil moisture nudging, using METAR observations.
. Changes to vertical diffusion.
. Activation of mid-level convection.
. Reorganisation of file names, data and model file contents and segment types.
. A new set of scripts that supports both operational,test and research versions.
. Extensive Diagnostics have been developed for observation monitoring; a comprehensive reject list of dubious observations is now incorporated in the GASP operational assimilation.

LAPS Assimilation and Prediction:
The assimilation of QuikSCAT scatterometer has been validated for LAPS and is now operational. The current LAPS system nested within the upgraded GASP system has been demonstrably improved through use of improved boundary conditions from the global system.

The assimilation and impact of scatterometer data on GASP, and also LAPS, are discussed in more detail by Kepert et al.(2005).

The current operational LAPS has been evaluated with an extension to 51 levels for both the LAPS assimilation and prediction systems. The data usage is equivalent to current LAPS. The 51 sigma level values are:
0.99880, 0.99740, 0.99500, 0.99110, 0.98410, 0.97200, 0.95000, 0.92500, 0.90000, 0.87500, 0.85000, 0.82500, 0.80000, 0.77500, 0.75000, 0.72500, 0.70000, 0.67500, 0.65000, 0.62500, 0.60000, 0.57500, 0.55000, 0.52500, 0.50000, 0.47500, 0.45000, 0.42500, 0.40000, 0.37500, 0.35000, 0.32500, 0.30000, 0.27500, 0.25000, 0.22500, 0.20000, 0.17600, 0.15350, 0.13300, 0.11500, 0.09900, 0.08450, 0.07150, 0.05940,

0.04800, 0.03750, 0.02840, 0.02070, 0.01452, 0.00980

The implementation of a Tropical Cyclone genesis forecast system is planned.

Satellite Data Assimilation:
Extensive evaluation of the use of ATOVS radiances produced from the EUMETSAT AAPP package have been undertaken from both the GASP and LAPS system. Currently global AAPP generated radiances are obtained from UKMO via a dedicated link in 1D format. Additionally the processing of local read-out of ATOVS data stream is now using the same AAPP package. In using the AAPP radiances, the research versions of the GASP and LAPS assimilation and prediction systems have been extended to 60 levels with the uppermost level at 0.1 hPa; the assimilation of the radiances is using an extension of the current operational 1D VAR strategy.

Initial experiments in both GASP and LAPS have shown positive impact from both the increase in vertical resolution and also in the use of AAPP radiances in comparison to the NOAA/NESDIS based 1D radiances. The 60 level GASP experiments have been reported by Harris et al (2005).

It is planned that these 60 level systems will be implemented in operations in 3Q/2006; an earlier upgrade of LAPS to 51 levels is expected in 1Q/2006.

Meso-Scale Assimilation:
A meso-scale assimilation system for the south-eastern Australia domain (SA, NSW/Vic/Tas) is being evaluated using horizontal resolution of 10 km with 60 levels in the vertical.

Evaluation of the use of AMVs:
Assimilation of AMVs with refined use of QI accompanying the BUFR disseminated winds has provided positive impact of AMV data in Bureau of Meteorology Global Assimilation and Prediction system. BMRC is generating routine QI monitoring statistics and also is monitoring Speed Bias, RMS deviation from model first guess for each of the AMV producers.

Ensemble Kalman Filter Assimilation:
A prototype Ensemble Kalman Filter (EnKF) assimilation system is being evaluated in comparison to the current GenSI assimilation for the GASP system. Assessments of ENKF algorithms are also being conducted within a shallow water modeling framework. Some of this work is described in Kepert (2005).

10. REFERENCES:

Alves, O., Wang, G., Zhong, A., Smith, N., Tzeitkin, F., Warren, G., Schiller, A., Godfrey, S. and Meyers, G.: “POAMA: Bureau of Meteorology operational coupled model seasonal forecast system.” Proceedings of the National Drought Forum 2003: Science for Drought, 49-56, 2003.

Bourke, W., Hart, T., Steinle, P., Seaman, R., Embery, G., Naughton, M. and Rikus, L.: "Evolution of the Bureau of Meteorology's Global Data Assimilation and Prediction System. Part 2: Resolution Enhancements and Case Studies." Australian Meteorological Magazine, 44, 19-40, 1995.

Bourke, W., Buizza, R. and Naughton, M.: "Performance of the ECMWF and the BoM Ensemble Prediction Systems in the Southern Hemisphere." Monthly Weather Review, 132, 2338-2357, 2004.

Davidson, N.E. and Puri, K. : "Tropical prediction using dynamical nudging, satellite defined convective heat source and a cyclone bogus." Monthly Weather Review, 120, 2501-2522, 1992.

Davidson, N.E. and Weber, H.C.: "The BMRC high resolution tropical cyclone prediction system TC-LAPS." Monthly Weather Review, 128, 1245-1265, 2000.

Draxler, R.R. and Hess, G.D. : "An overview of the HYSPLIT_4 modelling system for trajectories, dispersion and deposition." Australian Meteorological Magazine, 47, 295-308, 1998.

Finkele, K., Mills, G.A., Beard, G. and Jones, D.A.: “National daily gridded soil moisture deficit and drought factors for use in prediction of Forest Fire Danger Index in Australia.” BMRC Research Report, No. 119, Bureau of Meteorology, Australia, 2006.

Greenslade, D.J.M.: “The assimilation of ERS-2 significant wave height data in the Australian Region.” Journal of Marine Systems, 28, 141-160, 2001.

Hanstrum, B.N.: “A national NWP-based thunderstorm and severe thunderstorm forecasting guidance system.” BMRC Research Report, 93, 7-12, Bureau of Meteorology, Australia, 2003.

Harris, B.A. and Kelly, G.: “A satellite radiance bias correction scheme for data assimilation.” Quarterly Journal of the Royal Meteorological Society, 127, 1453-1468, 2001.

Harris, B., Tingwell, C., Steinle, P., Bourke, W., Naughton, M., Roff, G. and Paevere, J.: “Use of Level-1d ATOVS Radiances in GASP.” ITSC XIV Proceedings, Beijing, China, 25-31 May 2005 (See http://cimss.ssec.wisc.edu/itwg/itsc/itsc14/proceedings/), 2005.

Kepert, J.: “Localisation, Balance and Choice of Analysis Variable in an Ensemble Kalman Filter.” Fourth WMO International Symposium on Assimilation of Observations in Meteorology and Oceanography, April 2005 Prague, Czech Republic, 2005.

Kepert, J.K., Tingwell, C., Tory, K., Steinle, P. and Paevere, J.: “Scatterometer Assimilation in the Bureau of Meteorology Numerical Weather Prediction Systems.” Submitted to BMRC Research Letters, 2005.

Lee, J.: "Quarterly numerical weather prediction model performance summary: April 2004 to June 2005." Australian Meteorological Magazine, 54, 253-261, 2005.

Lee, J.: "Numerical weather prediction model performance summary: July to September 2005." Australian Meteorological Magazine, 54, 361-363, 2005.

Lemus-Deschamps, L., Rikus, L. and Gies, P.: “The operational Australian ultraviolet index forecast 1997.” Meteorological Applications, 6, 241-251, 1999.

Lemus-Deschamps, L., Rikus, L., Grainger, S., Gies, P., Sisson, J. and Li, Z.: “UV index and daily total UV dose distributions for Australia (1997-2001).” Australian Meteorological Magazine, 53, 239-250, 2004.

Mills, G.A. and Colquhoun, J.R.:” Objective Prediction of Severe Thunderstorm Environments: Preliminary Results Linking a Decision Tree with an Operational Regional NWP Model.” Weather and Forecasting, 13, 1078-1092 1998.

Puri, K., Dietachmayer, G.S., Mills, G.A., Davidson, N.E., Bowen, R.A. and Logan, L.W.: "The new BMRC Limited Area Prediction System, LAPS." Australian Meteorological Magazine, 47, 203-223, 1998.

Seaman, R., Bourke, W., Steinle, P., Hart, T., Embery, G., Naughton, M. and Rikus, L. : "Evolution of the Bureau of Meteorology's Global Data Assimilation and Prediction System. Part 1: Analysis and Initialisation." Australian Meteorological Magazine, 44, 1-18, 1995.

Steinle, P.J., Bermous, I., Bourke, W., Glowacki, T., Harris, B., Kepert, J., Le, T., Paevere, J., Seaman, R., Sun, X. and Yi, X.: “Generalized statistical interpolation: A new assimilation system for the Australian Bureau of Meteorology's numerical weather prediction systems.” Australian Meteorological Magazine, *in preparation,* 2005.

Stewart, P.K.: "RSMC Melbourne - Procedures, Standards, Results of Exercises and Ongoing Products." WMO Expert Team on Environmental Emergency Response. Beijing, China, 20-24 September 1999.

Viterbo, P. and Beljaars, A. C. M.: “An improved land surface parametrization scheme in the ECMWF model and its validation.” Technical Report 75, Research Department, ECMWF, 1995.

Woodcock, F. and Engel, C.: "Operational Consensus Forecasts." Weather and Forecasting, 20, 101-111, 2005.

Web References:
POAMA: http://www.bom.gov.au/bmrc/ocean/JAFOOS/POAMA/index.htm
http://www.bom.gov.au/climate/coupled_model/poama.shtml