ANNUAL WWW TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING SYSTEM 2003

COUNTRY: **Australia** CENTRE: **NMOC Melbourne** **January 2004**

1. SUMMMARY OF HIGHLIGHTS (2003):

Meteorological, Oceanographic and Computer Systems:

20 January:	NOAA-17 (ATOVS) data used in GASP.
13 February:	METAR processing, over high topography, improved in LAPS.
24 February:	Global CTBTO-WMO EER Test.
2 April:	Bulk Explicit Microphysics (BEM) rainfall scheme introduced into LAPS.
15 April:	CO_2 concentration parameter increased from 330 ppm to 375 ppm in all NMOC's operational NWP systems.
1 May:	Solar constant changed from 1360 to 1366 W/m^2 in all NMOC's operational NWP systems.
7 May:	TC_LAPS upgraded (including an increase in vertical resolution to 29 levels).
22 May:	Replacement of GMS-5 by GOES-9.
4 June:	NOAA-17 (ATOVS) used in 1DVAR bias correction procedure in LAPS.
18 June:	MESO_LAPS_PT125 upgraded (featuring BEM physics and an extension of forecast period to +48 hours).
26 June:	Further low level modification, over high topography, introduced into LAPS.
2 July:	Total ozone data from TOMS used in the the initialization of the operational ozone analysis and forecast system.
12 August:	GOES-9 locally-derived cloud drift winds used in LAPS.
1 September:	Surface wind extrapolation procedure improved in LAPS.
28 October:	Severe problem with availability of NOAA-17 (ATOVS) data.
28 October:	Trial version of the National Thunderstorm Forecast Guidance system, based on MESO_LAPS_PT125, introduced.

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)	Dual-Node NEC SX-5	Node 1: 16 Node 2: 16	Node 1: 128 GB Node 2: 96 GB	SUPER-UX 10.2 SX-5	2.3 TB
Communications / Message Switching	(i) HP RP5470 (ii) HP RP5470	(i) 4 (ii) 4	(i) 4 GB (ii) 4 GB	(i) HP-UX 11.11 (ii) HP-UX 11.11	200 GB
Scheduling / Data Base / Satellite Post-Processing	(i) HP N4000-55 (ii) HP N4000-55	(i) 6 (ii) 6	(i) 6 GB (ii) 6 GB	(i) HP-UX 11.11 (ii) HP-UX 11.11	(1) 450 GB (ii) 300 GB
Post-Processing / Graphics Processing	(i) HP D390 (ii) HP D390	(i) 2 (ii) 2	(i) 1.5 GB (ii) 1.5 GB	(i) HP-UX 10.20 (ii) HP-UX 10.20	(i) 8 GB (ii) 8 GB
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 10.20 (ii) HP-UX 10.20 (iii)HP-UX 10.20	(i) 27 GB (ii) 35 GB (iii) 30 GB
RADAR	(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) 17 GB
web / ftp	4-Node HP lp2000r Cluster	2 / Node	2 GB / Node	Linux RedHat 7.3	120 GB / Node
MARS	4-Node IBM RS/6000 SP	High Node 1: 4 High Node 2: 4 Wide Node 1: 2 Wide Node 2: 2	1 GB / cpu	AIX 4.3	1.5 TB
Development	HP RP8400	8	8 GB	HP-UX 11.11	1.8 TB

Peripheral Equipment:

Magnetic Cartridge Archive System:

StorageTek Mass Store 9310 ACS (Automatic Cartridge System)
1 StorageTek 9710 Library Storage Module (with a 37 TB capacity)
6 DLT (Digital Linear Tape) Units
24 drives, for 9840 fibre channel tapes, in silo (8 for SAM-FS, 8 for MARS and 6 for backup)
3 drives for 9940B tapes (for SAM-FS)

Hardcopy Printers/Plotters:

HP DesignJet 1055cm plus and 650C plotters
HP LaserJet 5 SiMX printers
HP LaserJet 8150DN
HP Color LaserJet 5500dtn
HP DeskJet 1600CM

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 (V3.8) 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) is being gradually integrated into both research and operations.

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 NWP 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 2003):

Observational Data Type or Report Type	Approximate number received during 24 hour period (unless otherwise stated)
SYNOP	46400
SHIP	6500
TEMP	1200
PILOT	800
BUOY	12400
AIREP / AMDAR	21600
SATOB	263000
SATEM	27500
ATOVS (120KM)	123000

METAR	14800
CLIMAT	1700 / month
SATOB_SST	3800
BATHY	200
WAVEOB	870
TRACKOB	440
AMV	809000
TOVS1C	814000
SAT_ALT	29000
QUIKSCAT	1115000

The following Gridded Products are also received in NMOC Melbourne:

GRIB (ECMWF)
GRIB (EGRR)
GRIB (KWBC)
GRIB (JMA)
GRID (ECMWF)

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.

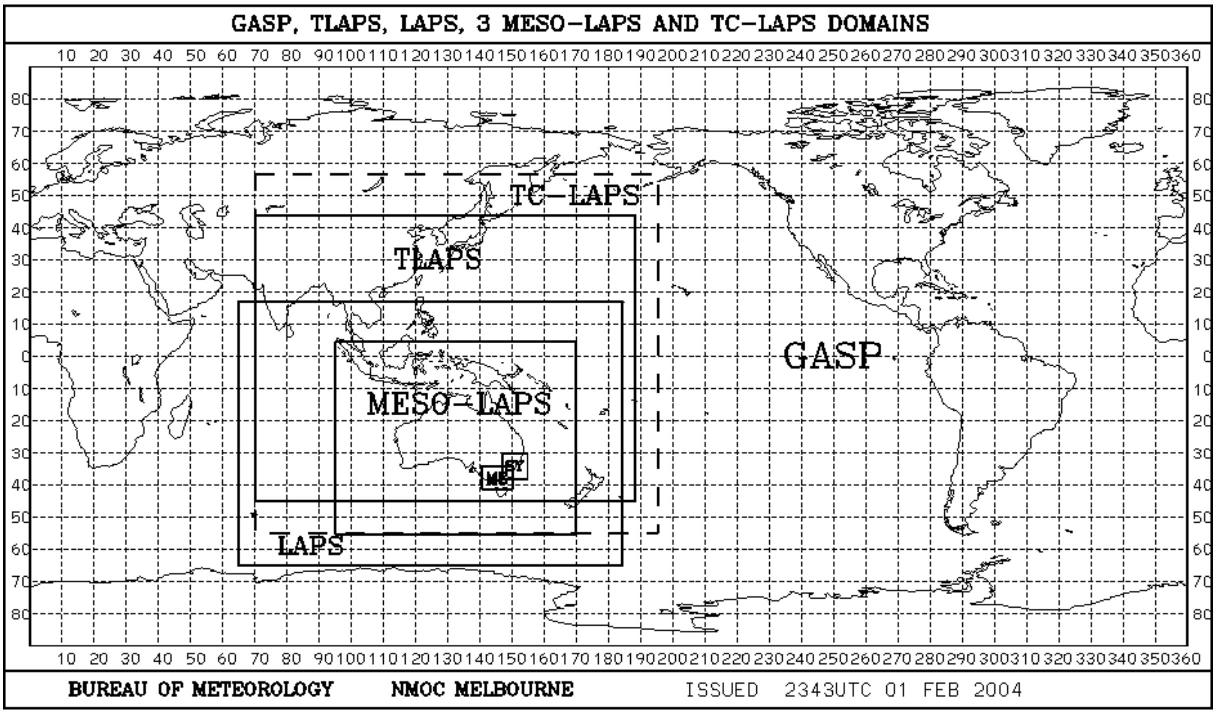
6. MONITORING OF THE OBSERVING SYSTEM:

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 prepared 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:

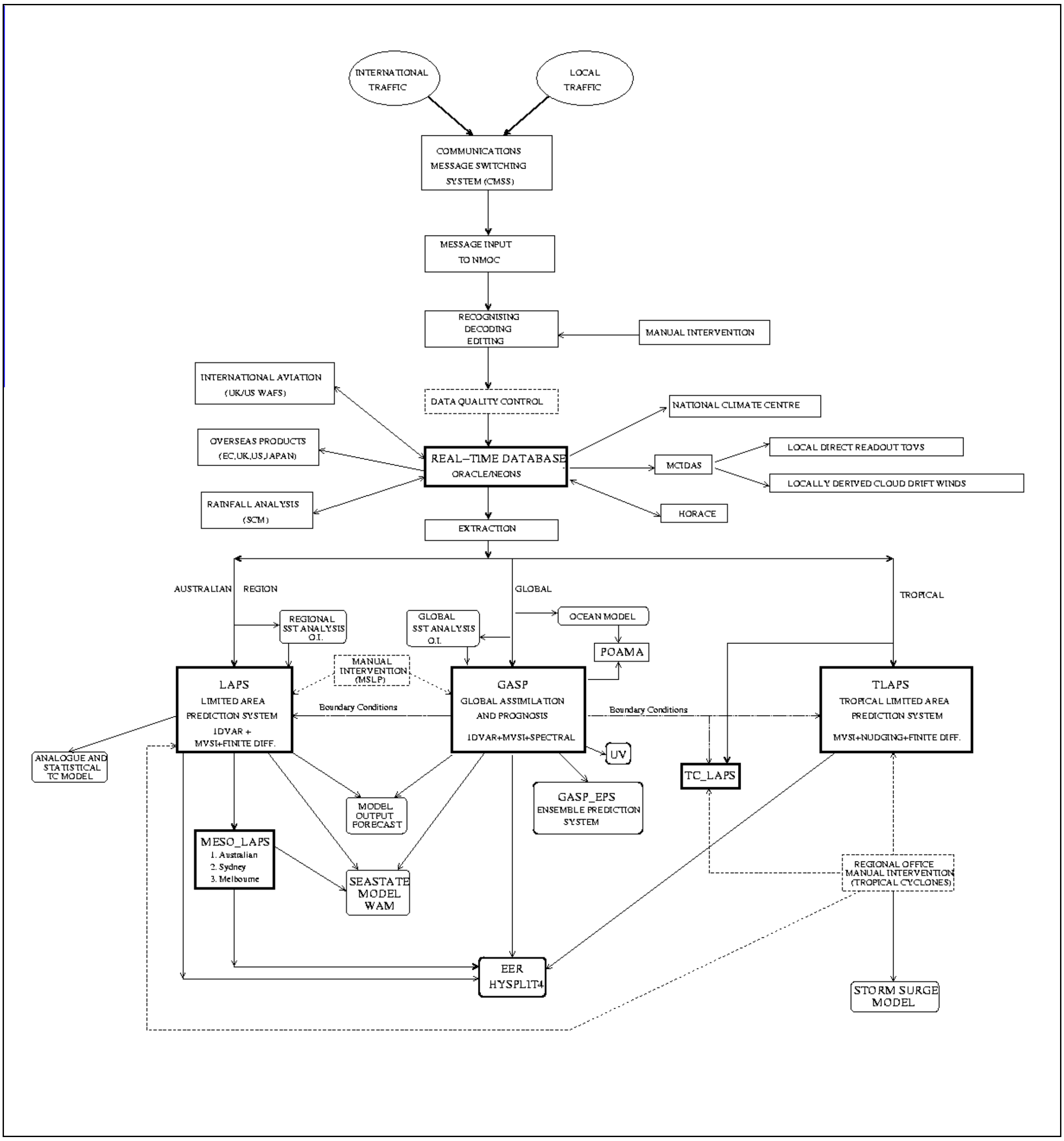
There are three major operational analysis and forecast systems (viz. the global GASP, regional

LAPS and the tropical TLAPS) in the NMOC Melbourne. A mesoscale version of LAPS, called MESO_LAPS, provides additional high resolution forecast products over 3 smaller domains (viz., Australia, Sydney and Melbourne). 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 3 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 both 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 and tropical systems. 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.



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 other parts to the basic scheme. These include systems for sea surface temperature analysis, environmental emergency response, generation of weather elements from model output (MOF), 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 out to 10 days, Australian region and tropical forecasts out to 72 hours, mesoscale forecasts out to 48 hours, and special tropical cyclone forecasts out to 72 hours are produced off these major analyses. The ECMWF's Supervisor Monitor Scheduler is used to integrate 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 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	0115	0130	0
LAPS_PT375	0000	0145 (0045)	0215 (0115)	+72
MESO_LAPS_PT125	0000	0215 (0115)	0335 (0235)	+48
MESO_LAPS_PT050(ME)	0000	0215 (0115)	0245 (0145)	+36
MESO_LAPS_PT050(SY)	0000	0245 (0145)	0330 (0230)	+36
EER PREP (MESO_LAPS_PT050 ME)	0000	0245 (0145)	0300 (0200)	+36
EER PREP (LAPS)	0000	0315 (0215)	0330 (0230)	+48
WAVES (REGIONAL)	0000	0315 (0215)	0325 (0225)	+48
EER PREP (MESO_LAPS_PT050 SY)	0000	0330 (0230)	0345 (0245)	+36
EER PREP (MESO_LAPS_PT125)	0000	0335 (0235)	0350 (0250)	+36
TLAPS375	0000	0345	0420	+72
WAVES (MESO_LAPS_PT125)	0000	0400 (0300)	0430 (0330)	+36
TC_LAPS	0000	0400	0410	+72
EER PREP (TLAPS375)	0000	0500	0520	+48
GASP	0000	0630 (0530)	0800 (0700)	+240
GASP_EPS	0000	0710 (0610)	0900 (0800)	+240
EER PREP (GASP)	0000	0730 (0630)	0830 (0730)	+240
WAVES (GLOBAL)	0000	0730 (0630)	0750 (0650)	+96
TLAPS375	0600	1045	1130	+6
TC_LAPS	0600	1100	1140	+6
LAPS_PT375	0600	1130 (1030)	1230 (1130)	+6

GASP (EARLY)	0600	1200 (1100)	1220 (1120)	+24
LAPS_PT375	1200	1345 (1245)	1415 (1315)	+72
MESO_LAPS_PT125	1200	1415 (1315)	1535 (1435)	+48
MESO_LAPS_PT050(ME)	1200	1415 (1315)	1445 (1345)	+36
MESO_LAPS_PT050(SY)	1200	1445 (1345)	1530 (1430)	+36
EER PREP (MESO_LAPS_PT050 ME)	1200	1445 (1345)	1500 (1400)	+36
EER PREP (LAPS)	1200	1445 (1345)	1500 (1400)	+48
WAVES (REGIONAL)	1200	1515 (1415)	1525 (1425)	+48
EER PREP (MESO_LAPS_PT050 SY)	1200	1530 (1430)	1545 (1445)	+36
EER PREP (MESO_LAPS_PT125)	1200	1535 (1435)	1550 (1450)	+36
TLAPS375	1200	1545	1620	+72
WAVES (MESO_LAPS_PT125)	1200	1545 (1445)	1615 (1515)	+36
TC_LAPS	1200	1600	1610	+72
EER PREP (TLAPS375)	1200	1700	1720	+48
GASP	1200	1830 (1730)	2000 (1900)	+240
GASP_EPS	1200	1910 (1810)	2100 (2000)	+240
EER PREP (GASP)	1200	1930 (1830)	2030 (1930)	+240
WAVES (GLOBAL)	1200	1930 (1830)	1950 (1850)	+96
TLAPS375	1800	2245	2330	+6
TC_LAPS	1800	2300	2340	+6
LAPS_PT375	1800	2330 (2230)	0030 (2330)	+6
GASP (EARLY)	1800	0000 (2300)	0020 (2320)	+24
OCEAN	(Daily)	1000	1005	0
POAMA	(Daily)	2000	0200	+8 months
SSTANAL (GLOBAL)	(Mid-week)	2315 (Mondays only)	2345 (Mondays only)	0
SST (SUB-SURFACE)	(Monthly)	2215 (Tuesdays only)	2245 (Tuesdays only)	0
AD HOC (TOP PRIORITY): EER	ANYTIME	ANYTIME	ANYTIME + 30 mins	+72
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 out to 10 days. Post-processed products from this system are disseminated on the GTS in GRIB form, nationally through "DIFACS" and MCIDAS, and also via Radio-facsimile broadcasts (VMW, VMC and VLM).

7.2.1 Data Assimilation, Objective Analysis and Initialization:

Assimilated data: Mean sea level pressure (surface network, ships, drifting buoys), thickness (radiosondes, satellite retrievals), moisture (dew points, satellite precipitable water), wind (rawinsonde, aircraft, geostationary satellites, constant level balloons), cloud-clear radiances (from NOAA orbiting satellites).
Assimilation cycle, including cut-off time: 6 hourly cycling. H+6 cut-off.
Method of analysis: Multivariate statistical interpolation + univariate O.I. for moisture, one-dimensional variational retrievals (1DVAR).
Analysed variables: Geopotential, wind, moisture.
First guess: 6 hour forecast from previous cycle.
Coverage: Global.
Horizontal resolution: Triangular 239.
Vertical resolution: 29 sigma levels (0.991, 0.975, 0.950, 0.925, 0.900, 0.875, 0.850, 0.800, 0.750, 0.700, 0.633, 0.566, 0.500, 0.433, 0.366, 0.320, 0.290, 0.260, 0.230, 0.200, 0.170, 0.140, 0.110, 0.090, 0.070, 0.050, 0.030, 0.020, 0.010)
Initialization: Incremental non-linear normal mode.

7.2.2 Model:

Basic equations: Spectral primitive equations.
Independent variables: latitude,longitude,s ,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, 29 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	Surface pressure	Evaporation (over ocean)
Surface temperature	Geopotential height	Snow
Temperature	Mixing ratio	Sub-surface temperature
Topography	Zonal velocity	High level cloud
Meridional velocity	Vorticity	Middle level cloud
Divergence	Stream function	Low level cloud
Velocity potential	Vertical velocity	Outgoing longwave radiation
Radiative tendency	Temperature Tendency	Albedo
Mixing ratio tendency	Vorticity surface flux tendency	Net downward radiation at surface
Divergence surface flux tendency	Zonal stress	Roughness length at surface
Meridional stress	Sensible heat flux	Earth albedo
Latent heat flux	Solar heating tendency	Net solar radiation
Precipitation	Soil moisture (over land)	

7.2.4 Operational Techniques for Applications of NWP Products:

The 10 m wind field from GASP is used to drive a global sea-state model.

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 **L**imited **A**rea **P**rediction **S**ystem (**TLAPS**) and the **MESO**scale **L**imited **A**rea **P**rediction **S**ystem **(MESO_LAPS)** provide short-range forecasting guidance and products that are disseminated nationally through "DIFACS" and MCIDAS, and also via Radio-facsimile broadcasts (VMC, VMW and VLM). TLAPS and TC_LAPS, for specific tropical cyclone guidance, are run on behalf of RSMC Darwin. Again it is noted that, at present, the 3 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 basic parts. The first preparatory part produces analyses and prognoses over a large domain, or what is called the Large Scale Environment (LSE), and the second part 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, locally processed TOVS, GTS and locally derived GMS 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,
TLAPS: H+4 hr.

Method of analysis: Multivariate statistical interpolation + univariate statistical interpolation for moisture, one-dimensional variational retrievals (1DVAR).

Analysed variables: Geopotential, wind, moisture.

First guess: 6 hour forecast from previous cycle.

Coverage: LAPS: 17.125^{0}N-65.0^{0}S, 65.0^{0}E-184.625^{0}E
TLAPS: 44.25^{0}N-45.0^{0}S, 70.0^{0}E-188.25^{0}E
TC_LAPS: 56.75^{0}N-55.0^{0}S, 70.0^{0}E-164.75^{0}W (LSE), 27.0^{0}x27.0^0 (Relocatable)

Horizontal resolution: LAPS and TLAPS: 0.375^0
TC_LAPS: 0.75^0 (LSE) and 0.15^0 (Relocatable)

Vertical resolution: LAPS, TLAPS, 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.
TLAPS 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: Semi-implicit.

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.)
TLAPS: 44.25^{0}N-45.0^{0}S, 70.0^{0}E-188.25^{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.)

Melbourne: 34.05^{0}S-41.00^{0}S, 141.00^{0}E-150.45^{0}E, surface to 50 hPa (approx.)

TC_LAPS:

LSE: 56.75^{0}N-55.0^{0}S, 70.0^{0}E-164.75^{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

TLAPS: 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

Melbourne: 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, TLAPS, TC_LAPS and MESO_LAPS.

Radiation: Diurnal cycle, diagnostic clouds, interactive optical properties.

Convection (deep and shallow): Included.

Atmospheric moisture: Included.

Boundaries: LAPS, TLAPS and TC_LAPS (LSE): Lateral boundaries from GASP.
MESO_LAPS (3 domains): Lateral boundaries from LAPS.
TC_LAPS (Relocatable): Lateral boundaries from LSE TC_LAPS.

Albedo: Climatology.

SST Analysis: Weekly (1^{0}x1^0) - in LAPS, MESO_LAPS (Australian), TLAPS and TC_LAPS.
Daily (0.25^{0}x0.25^0) - in MESO_LAPS (Melbourne and Sydney).

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	Dew point depression	V-component of wind
Surface temperature	Equivalent potential temperature	Potential temperature
Convective precipitation	Ucomponent ageostrophic wind	Divergence
Thickness (1000-500 hPa)	Shearing deformation	Relative humidity
Temperature gradient at 950 hPa	Ucomponent of deformation	Temperature advection
Lifting condensation level	Q vector in x-direction	Stretching deformation
Grassland fire danger index	U-component stream function	Pressure of cloud top

Surface mixing ratio	Moisture advection	Vertical velocity
Boundary layer convective energy flux	Surface pressure	Wet bulb potential temperature
Sensible heat	Non-convective precipitation	Frontogenesis function
U-component of wind	Total precipitation	Vcomponent ageostrophic wind
Temperature	Total totals index	1000-500 hPa shear
Geopotential height	Topography	Vcomponent of deformation
Dew point temperature	Lifting index	Q vector in y-direction
Wind speed	Forest fire danger index	V-component stream function
Vorticity	Mixing ratio	Moisture convergence
Cloud cover	Stream function	
Vorticity advection	Latent heat	

7.3.4 Operational Techniques for Applications of NWP Products:

The 10 m wind field from LAPS and MESO_LAPS are used to drive sea-state models for the Australian region and smaller domains. The Model Output Forecast (MOF) system, which is driven by LAPS and GASP, is used to produce numerous weather elements including temperatures (minimum, maximum, dry bulb, dew point, wet bulb and ground minimum), wind (speed and direction), precipitation, cloud amount, evaporation, sunshine and visibility. Meteograms, giving time series of meteorological variables, are also available. In addition, forecast guidance for thunderstorms (based on a decision tree approach) and cold-season tornadoes ("COLDIES"), with input from (the Australian domain) MESO_LAPS, is available.

7.4 Specialized Forecasts:

An analogue/regression tropical cyclone model ("TOPEND") is also available for providing guidance to the Australian Tropical Cyclone Warning Centres, but is rarely used. Specialized sea-state forecasts are provided for the North West Cape and Bass Strait gas and oil fields.

7.4.1 Sea Wave Models:

The following table summarises the characteristics of the seastate 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	+36 hrs
Initial state	12 hr hindcasting and assimilation of satellite (ERS) 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, buoys and satellite (ERS) altimeter data		

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 Air Dispersion Model:

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 system consists of the Hybrid Single_Particle Lagrangian Integrated Trajectories (HY-SPLIT using Versions 4.0 to 4.6) system, developed at the NOAA Air Resources Laboratory, with meteorological input from the operational NWP systems in NMOC (viz., GASP, LAPS, TLAPS, and MESO_LAPS). Analysed backward trajectories, and retro-plumes, are also available from GASP, LAPS and TLAPS 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 and 120 km GTS TOVS 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) are produced, once per day, after completion of the 1200 UTC run of GASP.

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). Eight 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 2003, 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.

8.1 Skill Scores and Anomaly Correlation Coefficients:

<u>24 HR VERIFICATION STATISTICS - AUSTRALIAN REGION 2003</u>
BASE TIME: 0000UTC - VALID TIME: 0000UTC

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	55	50	52	55	55	50	57	63	59	61	52	58
	S1	REGN	19	21	22	20	19	18	19	20	19	20	18	21
	r	REGN	.97	.96	.97	.98	.97	.98	.97	.97	.98	.98	.97	.97
500hpa height	S1	PERSIS	49	46	49	47	47	44	48	49	43	47	47	47
	S1	REGN	13	16	17	15	14	12	13	13	11	13	14	13
	r	REGN	.98	.97	.97	.98	.98	.98	.98	.98	.98	.98	.98	.98
250hpa height	S1	PERSIS	45	42	42	42	41	36	38	38	34	40	43	44
	S1	REGN	11	13	14	13	11	10	10	10	9	11	12	12
	r	REGN	.98	.97	.98	.98	.98	.98	.98	.98	.99	.98	.98	.97

<u>36 HR VERIFICATION STATISTICS - AUSTRALIAN REGION 2003</u>
BASE TIME: 1200UTC - VALID TIME: 0000UTC

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	66	58	63	66	66	61	67	76	65	70	63	68
	S1	GASP	24	25	27	25	24	21	22	25	24	24	23	27
	r	GASP	.95	.95	.95	.97	.96	.97	.96	.96	.97	.97	.95	.95
500hpa height	S1	PERSIS	61	55	58	56	55	51	56	57	48	55	57	53
	S1	GASP	17	19	21	19	18	15	16	16	15	17	18	16
	r	GASP	.97	.96	.96	.97	.97	.98	.96	.97	.97	.97	.97	.96
250hpa height	S1	PERSIS	55	50	51	50	48	43	44	45	39	48	53	48
	S1	GASP	14	16	17	16	14	12	12	12	11	14	16	15
	r	GASP	.97	.96	.97	.97	.96	.97	.96	.96	.97	.97	.97	.96

48 HR VERIFICATION STATISTICS - AUSTRALIAN REGION 2003

BASE TIME: 0000UTC - VALID TIME: 0000UTC

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MSLP	S1	PERSIS	73	61	70	73	72	68	72	84	69	76	70	74
	S1	GASP	29	29	33	31	29	25	27	30	29	29	28	31
	r	GASP	.91	.92	.93	.94	.93	.96	.93	.93	.95	.95	.92	.92
500hpa height	S1	PERSIS	64	57	62	62	60	56	60	62	51	59	62	57
	S1	GASP	20	22	25	24	21	18	19	20	18	21	23	20
	r	GASP	.95	.94	.93	.95	.94	.97	.94	.94	.96	.95	.94	.94
250hpa height	S1	PERSIS	58	52	54	55	52	47	48	48	42	52	57	51
	S1	GASP	17	19	22	20	18	15	14	15	14	17	20	18
	r	GASP	.95	.94	.93	.95	.93	.96	.94	.94	.96	.94	.94	.93

8.2 Root Mean Square Errors (Annual 2003):

(a) Verification against analyses:

AREA	FIELD	RMSE or RMSVE UNIT	+24HR		+72HR		+120HR	
			00UTC	12UTC	00UTC	12UTC	00UTC	12UTC
Northern Hemisphere	500 hPa Height	m	15.3	15.3	40.6	40.8	67.3	67.7
	250 hPa Wind	m/s	5.6	5.6	11.5	11.5	16.5	16.5
Southern Hemisphere	500 hPa Height	m	19.5	19.4	50.7	50.5	80.3	80.1
	250 hPa Wind	m/s	6.1	6.1	12.9	12.9	18.5	18.4
Tropics	850 hPa Wind	m/s	2.9	2.9	4.6	4.6	5.4	5.3
	250 hPa Wind	m/s	5.3	5.3	8.5	8.5	10.2	10.2

(b) Verification against radiosondes:

AREA	FIELD	RMSE or RMSVE UNIT	+24HR		+72HR		+120HR	
			00UTC	12UTC	00UTC	12UTC	00UTC	12UTC
North	500 hPa							

America	**Height**	**m**	17.1	17.4	41.7	42.1	67.5	68.4
	250 hPa Wind	**m/s**	8.3	8.1	14.2	14.0	19.4	19.1
Europe	**500 hPa Height**	**m**	19.9	18.7	44.1	44.3	78.3	78.0
	250 hPa Wind	**m/s**	7.3	7.1	13.4	13.2	20.1	20.1
Asia	**500 hPa Height**	**m**	19.7	19.9	40.5	40.2	59.1	58.9
	250 hPa Wind	**m/s**	7.8	8.2	13.3	13.6	16.7	16.9
Australia/NZ	**500 hPa Height**	**m**	15.9	16.1	31.7	33.4	49.0	52.5
	250 hPa Wind	**m/s**	7.5	7.6	12.1	12.3	16.8	16.8
Tropics	**850 hPa Wind**	**m/s**	4.5	4.5	5.7	5.6	6.3	6.1
	250 hPa Wind	**m/s**	6.6	6.8	8.5	8.8	9.8	10.1
Northern Hemisphere	**500 hPa Height**	**m**	19.9	19.8	44.6	45.0	73.1	73.6
	250 hPa Wind	**m/s**	7.7	7.7	13.4	13.4	18.5	18.5
Southern Hemisphere	**500 hPa Height**	**m**	21.5	22.6	41.1	43.7	62.8	66.0
	250 hPa Wind	**m/s**	8.2	8.5	13.2	13.5	18.4	18.4

9. PLANS FOR THE FUTURE:

Plans for future operational systems in the NMOC Melbourne include:

. the move and conversion of systems across to a new Central Computing Facility (which includes a NEC SX-6 system) located in a new building (along with all HO staff) in 2004;

. an ongoing improvement and generalization of data processing and graphical display (including the further use of MARS and METVIEW and, eventually, a GIS);

. improvement in data monitoring systems;

. ongoing improvements to LAPS including: full warm running, improvements to cloud and radiation parameterisations, more vertical levels, and a non-hydrostatic formulation;

. the introduction of 2 new MESO_LAPS_PT050 domains (for South-East Queensland and Victoria-Tasmania);

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

. the implementation of an extended domain for TLAPS and an associated integration of TC_LAPS;
. the introduction of a mesoscale assimilation system;
. enhancements to GASP incorporating: locally derived cloud drift winds and scatterometer winds, increased vertical resolution (50 levels up to 0.1 hPa), GenSI;
. the introduction of a rainfall verification scheme;
. a move to drive the storm surge model using meteorological input from TC_LAPS;
. an ongoing improvement to the operational Environmental Emergency Response System including the use of a unified wind input system and an extension to include a number of chemical transformations;
. the full implementation of a gaussian-type plume model (ADMS3) for the microscale;
. the operational implementation of an urban Australian Air Quality Forecasting System (AAQFS);
. the further development of the air-borne virus facility within the EER system and, eventually, its incorporation within the microscale dispersion and air quality systems;
. the implementation of the OCF (Operational Consenus Forecasts) system which combines direct model output with model output statistics;
. an upgrade to the coupled ocean-atmospheric model (POAMA) for seasonal analysis and prediction, along with further development of products.

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