WORLD METEOROLOGICAL ORGANIZATION

ANNUAL JOINT WIVIO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM (GDPFS) INCLUDING NUMERICAL WEATHER PREDICTION (NWP) RESEARCH ACTIVITIES

TABLE OF CONTENTS

1. Summary of highlights

New Zealand has two organisations which perform Global Data Processing and Forecasting. These are the National Institute of Water and Atmosphere (NIWA) and the Meteorological Service of New Zealand (MSNZ). Some items in this report are only relevant to one organisation and such items will be indicated by either [NIWA] or [MSNZ].

- [MSNZ] Implementation of WRF 4km and 8km mesoscale models.
- [NIWA]
  - Introduction of AIRS, IASI and GPS-RO data into to the 12 km resolution New Zealand Limited Area Model (NZLAM);
  - Implementation of 4DVAR in NZLAM;
  - Implementation of NZCONV (New Zealand CONVective scale model) variable grid, 1.5 km resolution convection resolving model;
  - Implementation of a high resolution (25 km) global wave model;
  - Implementation of a data assimilating distributed hydrological model;
  - Implementation of MOS post processing on Global Model output.

2. Equipment in use

- [NIWA] Supercomputing Platform - IBM p575/POWER6 system, with 58 nodes (1856 cores, 5.3 TB memory), AIX operating System, GPFS file system, Dual cabinet DCS9900 storage (Total capacity 663 TB), Dual TS3500 Tape Libraries (each holding 5 PB), Hierarchical Storage Management via TSM-SM.

- [NIWA] Other processing is performed on IBM RHEL X86, individual servers and clusters

- [MSNZ] Other processing is performed on IBM RHEL X86, individual servers and clusters

3. Data and Products in use

- [NIWA] – Data assimilated by NZLAM via 3 and 4DVAR
  - SYNOP pressure, wind, temperature, RH
  - SHIP pressure and wind
  - BUOY pressure
  - TEMP temperature, RH, wind
  - PILOT wind
  - AIREPS, AMDAR temperature and wind
  - ATOVS, AIRS, IASI, SSMI/S – direct radiance assimilation
  - AMV MTSAT and GOES-W high resolution IR, VIS and WV winds

- ERS, ASCAT via 1DVAR wind-speed retrieval
- GPS-RO

4. Forecasting system

4.1. System run schedule and forecast ranges

- [MSNZ]
  - 4km WRF run with GFS initial and boundary conditions. Model starts 4h 30m from data time four times daily out to 60 hours.
  - 8km WRF run with GFS initial and boundary conditions. Model starts 4h 30m from data time four times daily out to 48 hours.
  - 8km WRF run with UKMO initial and boundary conditions. Model starts 5h 30m from data time two times daily out to 48 hours.
  - 8km WRF run with ECMWF initial and boundary conditions. Model starts 7h 00m from data time two times daily out to 48 hours.
  - 12km WRF run with GFS initial and boundary conditions. Model starts 4h 30m from data time four times daily out to 84 hours.
  - 12km WRF run with UKMO initial and boundary conditions. Model starts 5h 30m from data time two times daily out to 84 hours
  - 12km WRF run with ECMWF initial and boundary conditions. Model starts 7h 00m from data time two times daily out to 84 hours
- [NIWA]
  - The NZLAM data assimilating (FGAT7) mesoscale model is run at 12 km resolution on a 324 × 324 × 70 level domain four times daily from data time + 3h 15m to data time + 48h. NZLAM is an implementation of the Unified Model System (UM 7.4, PS 23 science, OPS 26.1 and VAR 26.1).

4.2. Medium range forecasting system (4-10 days). NOT APPROPRIATE

4.2.1. Data assimilation, objective analysis and initialization

4.2.1.1. In operation

4.2.1.2. Research performed in this field

4.2.2. Model

4.2.2.1. In operation

4.2.2.2. Research performed in this field

4.2.3. Operationally available Numerical Weather Prediction (NWP) Products

4.2.4. Operational techniques for application of NWP products (MOS, PPM, KF, Expert Systems, etc.)

4.2.4.1. In operation

4.2.4.2. Research performed in this field

4.2.5. Ensemble Prediction System (EPS) (Number of members, initial state, perturbation method, model(s) and number of models used, number of levels, main physics used, perturbation of physics, post-processing: calculation of indices, clustering)

4.2.5.1. In operation

4.2.5.2. Research performed in this field

4.2.5.3. Operationally available EPS Products

4.3. Short-range forecasting system (0-72 hrs)

- [NIWA] The NZLAM data assimilating (FGAT7) mesoscale model is run at 12 km resolution on a 324 × 324 × 70 level domain four times daily from data time + 3h 15m to data time + 48h. It is an implementation of the Unified Model System (UM 7.4, PS 23 science, OPS 26.1 and VAR 26.1).

- [NIWA] NZCONV, is a variable grid 1.5 km resolution model on a 1222 × 1370 × 70 level domain is run once daily from the NZLAM 06 UTC analysis. It is an implementation of the Unified Model System (UM 7.4, PS 23 science).

- [MSNZ] WRF mesoscale models are run as per section 4.1

4.3.1. Data assimilation, objective analysis and initialization

4.3.2.1 In operation

- [NIWA] FGAT7 (i.e. 3.5DVAR) is used to assimilate surface, upper air, aircraft and satellite data as described above. Lateral boundary conditions, updated hourly, are derived from UM Global (25 km resolution) model.

- [MSNZ] The 4km WRF uses FDDA (observation nudging) with surface and upper air observations as well as MTSAT Atmospheric Motion Vectors.

4.3.2.2 Research performed in this field

- Land Surface Model – soil moisture.
- Data monitoring and quality control;
- [NIWA]
  - Optimising the information in satellite radiances;
  - Improving data density without violating fundamental assumptions relating to correlated errors;
  - 4DVAR intercomparisons with FGAT7 (i.e. 3.5DVAR)
  - Very high resolution data assimilation (i.e. for NZCONV)

4.3.2. Model

4.3.2.1. In operation

- [NIWA] NZLAM is an implementation of the Met Office (UK) Unified Model 7.4 (i.e. non-hydrostatic), PS 23 science, OPS 26.1 and VAR 26.1
  - Domain size: 324 × 324 at 0.11° on a rotated latitude longitude grid (approximately 12 km resolution)
  - Number of levels: 70 to 80 km altitude
  - Forecast range 48 h

- [MSNZ] Operationally the WRF-ARW runs at 12, 8, and 4km are driven by different global models as stated in the schedule above.

4.3.2.2. Research performed in this field

- Land Surface Model processes;
- Alternative Boundary layer and surface layer schemes
- Land use data and associated parameters;
- Forecast verification.
- [NIWA]

- Convective scale modelling at resolutions from 100 m to 1.5 km via the Unified Model;
- CFD self-refining grid models to forecast winds and turbulence a very high resolution (i.e. order of 10m horizontal resolution);
- Improved specification of boundary conditions;

4.3.3. Operationally available NWP products

- Public good forecasts are provided to forecasters at the Meteorological Service of New Zealand in the form of maps, vertical profiles and time-series at spots.
- Multi-Hazard environmental forecasts are provided directly to end users via EcoConnect.
- Some time-series data is presented directly to the public on the Meteorological Service of New Zealand web site.

4.3.4. Operational techniques for application of NWP products (MOS, PPM, KF, Expert Systems. etc.)

4.3.4.1. In operation

- [NIWA] Forecasts from the NZLAM and NZCONV models are downscaled to observation sites using both statistical and dynamical methods.
- [NIWA] MOS is applied to MSLP, Temperature, RH, Wind speed, u and v components, using multiple predictors (for each predictand) chosen from a large pool of forecast fields via stepwise regression using a 16 week training period prior to analysis time.
- [NIWA] Dynamical downscaling of winds is available on demand via an embedded CFD model.
- Probabilistic spot forecasts are generated using MOS from all available models.
- Automated spot text forecasts are generated from model output.

4.3.4.2. Research performed In this field

- [NIWA] Research on (MOS) predictor selection and statistical methods.
- [NIWA] Improving the information in the predictors through the use of model data that contains more information on surface and near surface processes, primarily through increasing NWP model resolution (to as high as 100 m)

4.3.5. Ensemble Prediction System (Number of members. initial state. perturbation method, model(s) and number of models used. perturbation of physics. post-processing: calculation of indices, clustering). NOT APPROPRIATE

4.3.5.1. In operation

4.3.5.2. Research performed in this field

4.3.5.3. Operationally available EPS products

4.4. Nowcasting and Very Short-range Forecasting Systems (0-6 hrs). NOT APPROPRIATE

N/A – incorporated within the data assimilating NWP (NZCONV and NZLAM) models.

4.4.1. Nowcasting system

4.4.1.1. In operation

4.4.1.2. Research performed in this field

4.4.2. Models for Very Short-range Forecasting Systems

4.4.2.1. In operation

4.4.2.2. Research performed in this field

4.5. Specialized numerical predictions (on sea waves. storm BI-W94. sea ice, Marine pollution transport and weathering. tropical cyclones. air pollution transport and dispersion. solar ultraviolet (UV) radiation. air quality forecasting, smoke, sand and dust, etc.)

- [NIWA]
  - A global (WW3) wave model to 6 days at 120 km resolution in operations (and 25 km in research),
  - A regional (WW3) wave model to 48 h at 12 km resolution driven by NZLAM over the NZLAM domain
  - A Sea level forecasting model (RiCOM) incorporating tide and storm surge covering effects for the NZ EEZ domain.
  - A data assimilating distributed hydrological catchment model (TopNet) providing river flow forecasts on each stream reach to 48 hours.

4.5.1. Assimilation of specific data, analysis and initialization (where applicable)

4.5.1.1. In operation

- [NIWA] Stream flow data are assimilated hourly into TopNet via a Retrospective Ensemble Kalman Filter (REnKF), with rainfall forcing from NZLAM (now), and in the future NZCONV

4.5.1.2. Research performed in this field

- [NIWA]
  - Improving the resolution of both global and regional wave model forecasts, including into the surf zone;
  - Development of variable grid wave models;
  - Improving sea level forecasts by properly accounting for the combined effects of tide, storm surge, and wave stress;

4.5.2. Specific models (as appropriate related to 4.5)

4.5.2.1. In operation

- [NIWA]
  - Wave Watch 3 (WW3)
  - Rivers and Coastal Ocean Model (RiCOM)
  - TopNet
- [MSNZ] PUFF for volcanic ash – driven by GFS

4.5.2.2. Research performed in this field

- [NIWA]
  - Sea State Forecasting: Development of a variable grid implementation of WW3 to enable higher spatial resolution forecasts in areas of rapidly changing bathymetry.
  - Sea level Forecasting: Parallelisation of RiCOM to reduce run time, enable incorporation of more processes, larger domains, and higher resolution 3D (triangular) grids
  - Hydrological Forecasting:
    - Extending the range and type of catchments that can be modelled by TopNet
    - Retrospective Ensemble Kalman Filter data assimilation

4.5.3. Specific products operationally available

- [NIWA]
  - Sea State:

        - Spatial and Site specific forecasts of wave properties (e.g. Significant wave height, mean wave period, peak wave height direction and period, wave spread etc.) at hourly resolution.
    - Sea Level:
        - Spatial and Site specific forecasts of tide and storm surge height and depth averaged currents (both tide and storm surge) – at hourly resolution;
    - Flood Forecasting
        - Site specific hydrographs on all river reaches within a catchment - at hourly resolution;
- [MSNZ] PUFF volcanic ash imagery

4.5.4. Operational techniques for application of specialized numerical prediction products (MOS, PPM, KF, Expert Systems, etc.) (as appropriate related to 4.5)

4.5.4.1. In operation

4.5.4.2. Research performed in this field

- [NIWA] Methods are being developed to correct sea level forecasts, which are calculated with respect to mean sea level, for Chart Datum offsets and for time varying MLoS (Mean Loss of the Sea) effects.

4.5.5. Probabilistic predictions (where applicable)

4.5.5.1. In operation

4.5.5.2. Research performed in this field

4.5.5.3. Operationally available probabilistic prediction products

4.6. Extended range forecasts (10 days to 30 days) (Models, Ensemble. Methodology]. NOT APPROPRIATE

4.6.1. In operation

4.6.2. Research performed in this field

4.6.3. Operationally available EPS products

4.7. Long range forecasts (30 days up to two years) (Models, Ensemble, Methodology). NOT APPROPRIATE

4.7.1. In operation

4.7.2. Research performed in this field

4.7.3. Operationally available products

5. Verification of prognostic products

- [MSNZ]
    - All WRF models are routinely verified against surface observations using the Model Evaluation Toolkit (http://www.dtcenter.org/met/users/).
    - All spot forecasts are routinely verified by an internal verification system.
- [NIWA]

- All NZLAM and NZCONV model forecasts are routinely verified against all assimilated data (surface, aircraft and satellite etc.) via vectr
- All post processed site specific forecasts (including precipitation) are routinely verified via vectr
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5.1. Annual verification summary

5.2. Research performed in this field

6. Plans for the future (next 4 years)

6.1. Development of the GDPFS

6.1.1. [MSNZ] Major changes in the operational DPFS which are expected in the next year

- Cloud based data processing and modelling.
- Routine objective rainfall verification using spatial verification methods.
- All spot temperature forecasts fully automated without human intervention.

6.1.2. Major changes in the operational DPFS which are envisaged within the next 4 years

- [MSNZ] WRF models
  - Assimilate ASCAT in highest resolution model.
  - Assimilate radar reflectivity via latent heat nudging.
  - Improved surface layer / boundary layer parameterization
  - Assimilate GPS derived precipitable water vapour
  - Assimilate radar radial winds
  - Probabilistic Quantitative Precipitation Forecasts
  - High resolution ensemble over New Zealand
  - Improved treatment of soil moisture in land surface model.
- [NIWA]
  - Increasing NWP model resolution (focused on ~1 km resolution, large domain
  - Data assimilation (4DVAR) to improve the use of satellite observations
  - High resolution re-forecasting to define climatological variables over New Zealand and surrounding marine areas.

6.2. Planned Research Activities in NWP, Nowcasting, Long-range Forecasting and Specialized Numerical Predictions

6.2.1. Planned Research Activities in NWP-

- [MSNZ] Assimilate ASCAT in highest resolution model into WRF.
- Assimilate radar reflectivity via latent heat nudging.

- Improved surface layer / boundary layer parameterization
- Assimilate GPS derived precipitable water vapour
- Assimilate radar radial winds
- Probabilistic Quantitative Precipitation Forecasts
- High resolution ensemble over New Zealand
- Improved treatment of soil moisture in land surface model.

6.2.2. Planned Research Activities in Nowcasting

6.2.3. Planned Research Activities in Long-range Forecasting

6.2.4. Planned Research Activities in Specialized Numerical Predictions

7. Consortium (if appropriate). NOT APPROPRIATE

7.1. System and/or Model

7.1.1. In operation

7.1.2. Research performed in this field

7.2. System run schedule and forecast ranges

7.3. List of countries participating in the Consortium

7.4. Data assimilation, objective analysis and initialization

7.4.1. In operation

7.4.2. Research performed in this field

7.5. Operationally available Numerical Weather Prediction (NWP) Products

7.6. Verification of prognostic products

7.7. Plans for the future (next 4 years)

7.7.1. Major changes In operations

7.7.2. Planned Research Activities

8. References

Meteorological Service of New Zealand web site: http://metservice.com/national/index

National Institute of Water & Atmospheric Research (NIWA) http://www.niwa.co.nz