Description of Météo-France Numerical Weather Prediction models used for cyclone forecast

ARPEGE Global Model

a) Data Assimilation

The assimilation runs with a 6-hour cycle, with the following cut-off : 8h05 at 00 UTC, 6h55 at 06UTC, 8h05 at 12UTC and 7h30 at 18 UTC.

Assimilated data:	TEMP/TEMP-SHIP/TEMP-DROP/TEMP-MOBIL, PILOT/PILOT-SHIP/PILOT-MOBIL/PROFILER,SYNOP/SHIP, BUOY/BATHY/THESAC , GPS, ACAR/AIREP/AMDAR, SATOB, ATOVS, SSMI, AIRS, ASCAT, QuikScat
Assimilation cycle:	6 hour cycle
Analysis method:	Four dimensional variational analysis for upper air fields
Analysed variables:	temperature (at sea surface, 2m and upper-air), wind (10m, satellites and upper-air), relative humidity (2m and upper-air), radiances, surface pressure.
First guess:	A 6-hour ARPEGE forecast (TL538C2.4L60)
Cover:	Global cover
Horizontal resolution:	The objective TL538C2.4L60 analysis is obtained with an incremental scheme (TL107C1L60, TL224C1L60)
Vertical resolution:	60 levels (hybrid vertical co-ordinate) from screen (lowest model level around 17m) up to 0.1 hPa.
Initialisation:	external and internal digital filtering

The surface analysis is performed with the Optimal interpolation algorithm and for the following fields : soil moistures, soil temperatures, sea-ice and sea surface temperature from conventional observations. The NESDIS SST analysis is used as a climatological constraint with a sea-ice location deduced from SSM/I.

b) Initialisation of TC's

None

c) Forecast Model

ARPEGE-IFS is a common development between Météo-France and ECMWF. ARPEGE (Action de Recherche Petite Echelle Grande Echelle) is the French name while IFS (Integrated Forecast System) is the name used by ECMWF.

ARPEGE uses Schmidt's transformation leading to variable mesh configurations, having a pole of maximum resolution and a resolution varying continuously from that

pole to the antipode. T being the nominal truncation and C the "stretching factor", the local resolution of the model is T x C over the pole, and T / C at the antipode.

Basis equations:	Primitive equation system.
Independent variables:	Both components of the horizontal wind, temperature, specific humidity and surface pressure.
Dependent variables:	Vertical velocity and density
Numerical technique:	Spectral model. 2 time-level semi-lagrangian semi-implicit scheme.
Integration domain:	Global.
Resolution, time step:	Triangular truncation T538 with a stretching factor of C2.4. The resolution varies from T1291 (15km) over France to T224 (90km) over New-Zealand. 60 vertical levels from screen level up to 0.1hPa, using the hybrid co-ordinate from Simmons and Burridge (1981). The time step is 900 seconds.

d) Physical Parameterisations

Orography:	The orography of this model is computed on the Gaussian grid from GTOPO30 data using a variational technique that strongly reduces the noise associated to Gibbs waves (see Bouteloup, 1993).
Gravity wave drag:	The gravity wave drag is adapted from Boer et al. (1984) for the linear 'gravity wave drag' part (with full use of the Lindzen (1981) saturation criterion) and from Lott and Miller (1997) for the 'form drag' low level part. A parameterisation of the sub-grid scale so-called 'lift' effect exists, following Lott (1999). The gravity wave drag takes into account some anisotropy and resonance effects.
Horizontal diffusion:	Implicit in spectral space.
Vertical diffusion:	1st order "K" vertical diffusion scheme (Louis *et al.,* 1981) with adaptative mixing length and combined with the shallow convection incorporated according to Geleyn (1987). « Anti-fibrillation » scheme of Bénard et al. (2000)
Planetary boundary layer:	Included in the vertical diffusion scheme
Earth surface:	Fixed analysed sea surface temperature and amount of sea -ice; ISBA land surface scheme (Giard and Bazile 2000) for the parameterization of soil processes.
Radiation:	Solar radiation scheme by Fouquart and Bonnel (1980) improved by Morcrette (1991) with 2 spectral bands and the thermal radiations scheme RRTM (16 spectral bands)
Microphysics:	Clouds and stratiform precipitations scheme with 4

	prognostic variables for condensed cloud and precipitating water (Lopez, 2002).
Convection:	Mass flux scheme (Bougeault, 1985) with Kuo-type closure. Include vertical transport of horizontal momentum, vertically varying detrainment and entrainment rates, downdrafts, simple diagnostic microphysics.
Humidity:	5 prognostic variables representing water specific humidity (water vapour, water liquid cloud, water solid cloud, rain, snow)

e) Operational Schedule

00 UTC data : 2h15 cut-off, ARPEGE analysis and forecast up to 102 hours.
06 UTC : 3h cut-off, ARPEGE analysis and forecast up to 72 hours.
12 UTC : 1h50 cut-off, ARPEGE analysis and forecast up to 84 hours.
18 UTC : 3h cut-off, ARPEGE analysis and forecast up to 60 hours.

ALADIN-Réunion Limited Area Model

a) Data Assimilation

The assimilation runs with a 6-hour cycle and with the following cut-off : 10h35 at 00UTC, 9h35 at 6UTC, 11h20 at 12UTC and 10h05 at 18UTC.

assimilated data	As ARPEGE
Assimilation cycle:	6 hour cycle
Analysis method:	3DVAR with linear beta-plane, non linear and omega balances for upper-air observations including 2M temperature and humidity. The surface analysis is inherited and interpolated from ARPEGE one.
Analysed variables:	As ARPEGE
First guess:	A 6-hour ALADIN-Réunion forecast.
Cover:	[0°-32S] [31.5E – 88.5E]
Horizontal resolution:	10km horizontal mesh size : 400 (lat) x 648 (lon) points.
Vertical resolution:	60 levels (hybrid vertical co-ordinate) from screen (lowest model level around 17m) up to 0.1 hPa.
Initialisation:	Incremental digital filtering

b) Initialisation of TC's

Bogussing of synthetic wind observations from the surface to 500 hPa deduced from the Holland analytical model, plus the mean sea level pressure at the center.

c) Forecast Model

Basis equations:	As ARPEGE
Independent variables:	As ARPEGE
Dependent variables:	As ARPEGE
Numerical technique:	As ARPEGE
Integration domain:	[0°-32S] [31.5E – 88.5E]
Resolution, time step:	10km horizontal mesh size. 400 (lat) x 648 (lon) points. Elliptical truncation E149x149. 60 vertical levels from screen level up to 0.1hPa, using the hybrid co-ordinate. Time step : 415s

d) Physical Parameterisations

As ARPEGE

e) Operational Schedule

00 UTC data: 4h40 cut-off, ALADIN-Réunion analysis and forecast up to 84 hours.
12 UTC data: 4h25 cut-off, ALADIN-Réunion analysis and forecast up to 84 hours.