The NWP System at NCMRWF and the Use of Satellite Data

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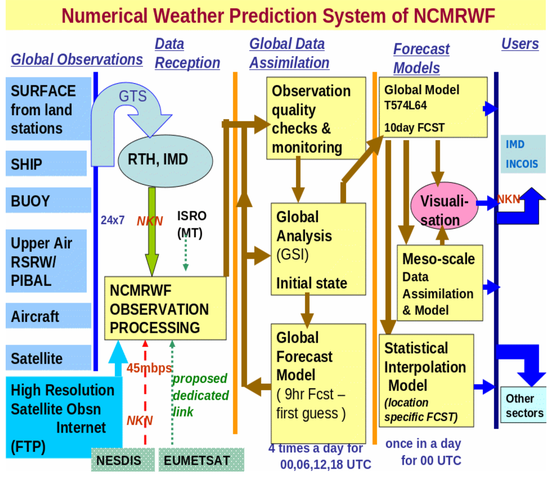
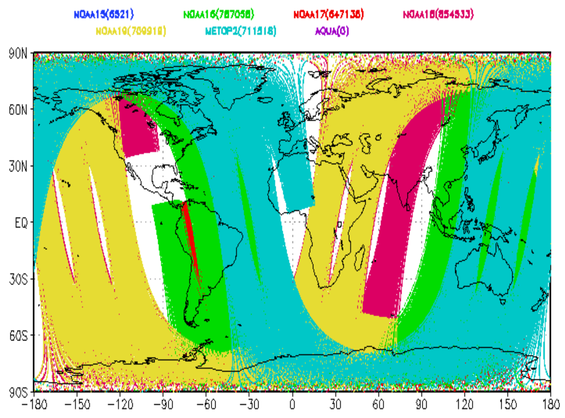
Numerical Weather Prediction System of NCMRWF



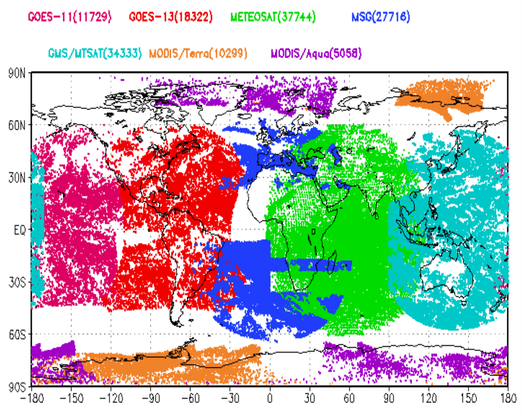
Types of observations Assimilated

Observation category	Name of Observation.
Surface	Land surface, Mobile, Ship, Buoy (SYNOPs)
Upper air	TEMP (land and marine), PILOT (land and marine), Dropsonde, Wind profiler
Aircraft	AIREP, AMDAR, TAMDAR, ACARS
Atmospheric Motion Vectors from Geo-Stationary Satellites	AMV from Meteosat-7, Meteosat-9, GOES-11, GOES-13, MTSAT-1R, MODIS (TERRA and AQUA),
Scatterometer winds	ASCAT winds from METOP-A satellite,
NESDIS / POES ATOVS Sounding radiance data	1bamua, 1bamub, 1bmhs,1bhirs3, 1bhirs4
Satellite derived Ozone data	NESDIS/POES, METOP-2 and AURA orbital ozone data
Precipitation Rates	NASA/TRMM (Tropical Rainfall Measuring Mission) and SSM/I precip. rates
Bending angles from GPSRO	Atmospheric profiles from radio occultation data using GPS satellites
NASA/AQUA AIRS & METOP/ IASI brightness temperature data	IASI,AIRS,AMSR-E brightness temperatures

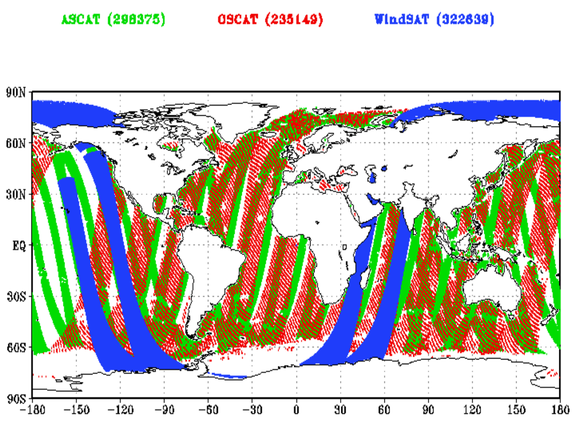
Satellite Radiance



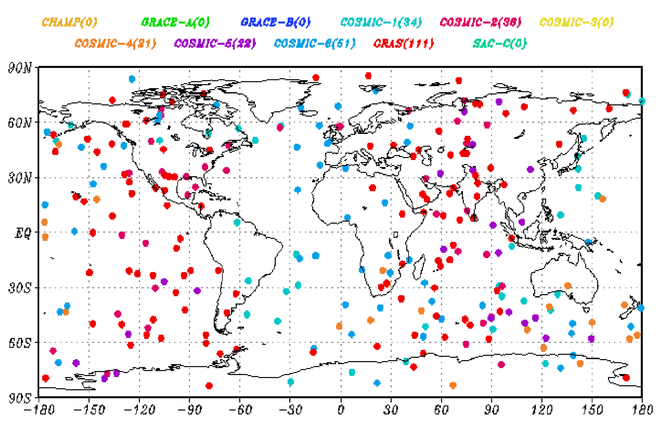
Atmospheric Motion Vectors



Scatterometer Winds



GPSRO DATA



NCMRWF Global Data Assimilation System (GDAS)

✓ GDAS operational at NCMRWF is a six hourly intermittent three dimensional scheme

✓Meteorological data sets received at NCMRWF through GTS are assimilated four times a day at 0000, 0006, 0012 and 0018 UTC to the global analysis system.

✓Meteorological observations assimilated in T574L64 (~23km horizontal resolution) are SYNOP, BUOY, METAR, TEMP, PILOT, AIREP, AMDAR, ACARS, AMVs, Scatterometer winds, GPSRO, and radiance data from different platforms

✓A six hour prediction from model with previous initial condition valid for current analysis time is used as the background field (FG) for the subsequent analysis

✓The global analysis scheme used is the Grid point Statistical Interpolation (GSI)

Up-gradation of NCMRWF GFS from T382L64 to T574L64

•The T574L64 GFS was first implemented in November 2010.

•Its performance was evaluated during November-December 2010 and found better than the T382 GFS.

•The latest version of the NCEP T574L64 GFS was implemented in May 2011

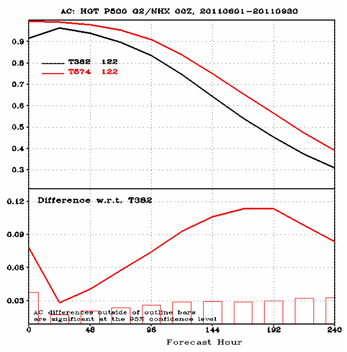
Physical Parameterization schemes in T382L64 and T574L64

Physics	T382L64	T574L64
Surface Fluxes	Monin-Obukhov similarity	Monin-Obukhov similarity
Turbulent Diffusion	Non-local Closure scheme (Hong and Pan (1996)	Non-local Closure scheme (Lock et al., 2000)
SW Radiation	Based on Hou et al. 2002 –no aerosols – invoked hourly	Rapid Radiative Transfer Model (RRTM2) (Mlawer et al. 1997; Mlawer and Clough, 1998)- aerosols included– invoked hourly
LW Radiation	Rapid Radiative Transfer Model (RRTM) (Mlawer et al. 1997). –no aerosols- invoked 3 hourly	Rapid Radiative Transfer Model (RRTM1) (Mlawer and Clough 1997;1998). –aerosols included-invoked hourly
Deep Convection	SAS convection (Pan and Wu (1994)	SAS convection (Han and Pan, 2006)
Shallow Convection	Shallow convection Following Tiedtke (1983)	Mass flux scheme (Han and Pan, 2010)
Large Scale Condensation	Large Scale Precipitation (Zhao and Carr ,1997; Sundqvist et al., 1989)	Large Scale Precipitation (Zhao and Carr ,1997; Sundqvist et al., 1989)
Cloud Generation	Based on Xu and Randall (1996)	Based on Xu and Randall (1996)
Rainfall Evaporation	Kessler (1969)	Kessler (1969)
Land Surface Processes	NOAH LSM with 4 soil levels for temperature & moisture (Ek et al., 2003)	NOAH LSM with 4 soil levels for temperature & moisture (Ek et al., 2003)
Air-Sea Interaction	Roughness length by Charnock (1955)Observed SST,Thermal roughness over the ocean is based on Zeng et al., (1998).3-layer Thermodynamic Sea-ice model (Winton, 2000)	Roughness length by Charnock (1955), Observed SST, Thermal roughness over the ocean is based on Zeng et al., (1998). 3-layer Thermodynamic Sea-ice model (Winton, 2000)
Gravity Wave Drag & mountain blocking	Based on Alpert et al. (1988)	Lott and Miller (1997), Kim and Arakawa (1995), Alpert et al., (1996)
Vertical Advection	Explicit	Flux-Limited Positive-Definite Scheme (Yang et al., 2009)

Differences in the T574L64 GSI Data Assimilation system compared to T382L64

New observations assimilated	Improvements in Data Assimilation system
Inclusion of METOP IASI (Infrared Atmospheric Sounding Interferometer) data	Use of variational qc
Reduction of number of AIRS (Atmospheric Infrared Sounder) water vapor channels used	Addition of background error covariance input file
Assimilating tropical storm pseudo sea-level pressure observations,	Flow dependent reweighting of background error variances
NOAA-19 HIRS/4 (High Resolution Infrared Radiation Sounder) and AMSU-a (Advanced Microwave Sounding Unit) brightness temperature,	Use of new version and coefficients for community radiative transfer model (CRTM -2.02)
NOAA-18 SBUV/2, (Solar Backscatter Ultraviolet Spectral Radiometer) Ozone , EUMETSAT-9 atmospheric motion vectors.	Change in land/snow/ice skin temperature variance
Using uniform thinning mesh for brightness temperature data.	
Improving assimilation of GPS radial occultation data. RE-tuned observation errors.	
ASCAT (Advanced Scatterometer) winds included	
Korean AMDAR data and more number of Aircraft Reports	
European Wind profiler data	

Anomaly correlation of 10 day forecasts of 500 hPa Geopotential Height T382L64 (Black) and T574L64 (Red)

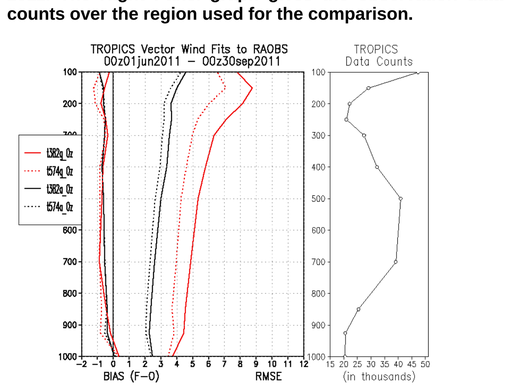


•The anomaly correlation values are comparatively higher in the T574 GFS with a gain of 1 day in the skill of the forecasts.

•In the lower panel the line plot depicts the difference of the forecasts of Geopotential Height of the T574 GFS from the T382 GFS.

•The difference values outside the histograms are statistically significant at 95% level of confidence.

Vertical Profile of T574L64 (Dotted Line) and T382L64 (Bold Line) Analyses (Black) and First Guess (Red) Vector Wind Fits (Bias and RMSE) to RAOBS over Tropics for JJAS, 2011. The Right Panel graph gives the observation data counts over the region used for the comparison.



Validation of Atmospheric Motion Vectors

RMSVD against Radiosonde winds over Tropics (2011)

RMSVD (m/s) w.r.t. RS/RW winds		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High Level CMV	Kalpana	10.19	11.0	6.56	6.56	5.38	6.68	7.80	7.63	7.84	5.56	6.01	6.46
	Meteosat-7	5.60	4.94	4.88	4.47	3.85	5.01	5.60	5.04	5.36	4.05	4.05	4.85
High Level WVW	Kalpana	11.04	11.79	6.27	6.20	5.55	7.07	7.55	8.34	7.71	5.93	5.54	6.21
	Meteosat-7	5.82	5.62	4.79	4.83	4.32	6.12	6.83	5.86	6.09	4.44	4.47	5.27

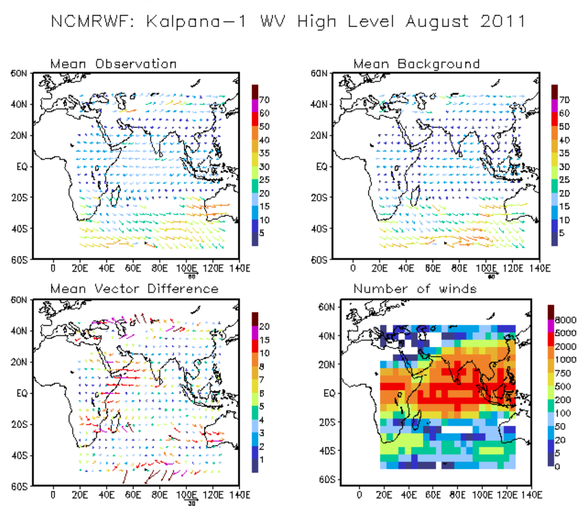
Kalpana-1 AMVs w.r.to RS/RW winds improved in terms of

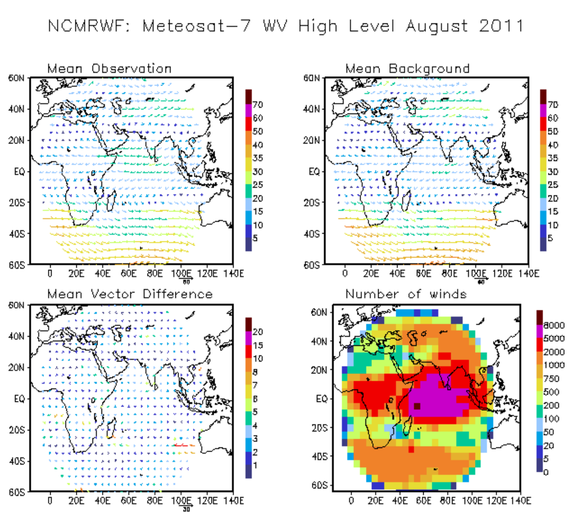
✓speed bias (12m/s to 5m/s), and

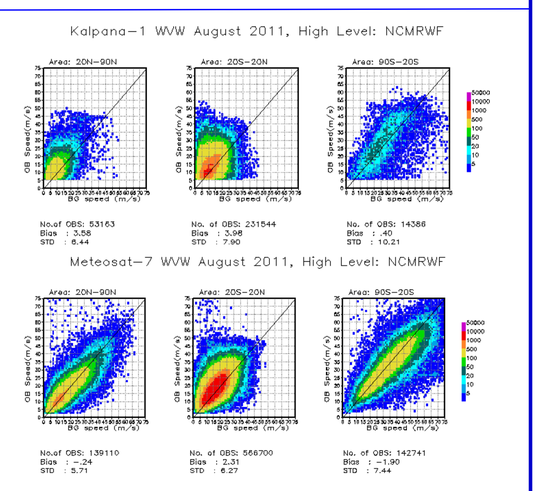
✓RMSVD (14 m/s to 6.5 m/s) since March 2011.

✓In general, RMSVD for other geostationary satellites are also in the same range (5-7 m/s).

Validation against NCMRWF T574L64 First Guess



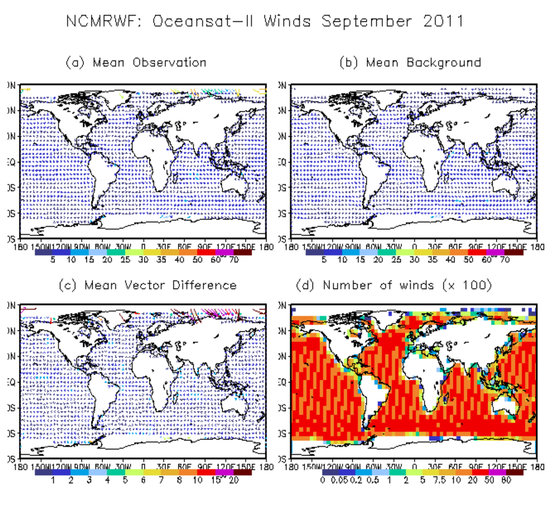


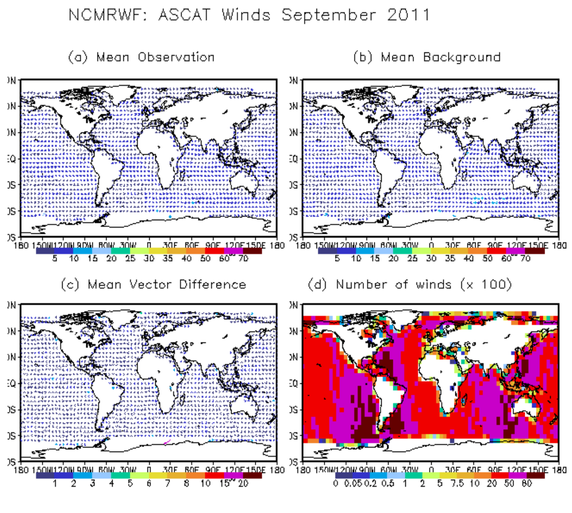


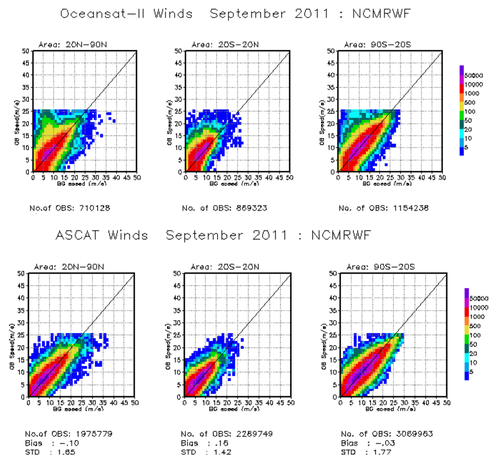
Empirical Genetic Algorithm used for the height assignment of Kalpana-1 winds does not use model first guess as background and hence the AMVs are erroneous compared to Meteosat-7 AMVs.

Validation of Scatterometer Winds

Against NCMRWF T574L64 First Guess







Both OSCAT and ASCAT Scatterometer winds show lesser standard deviation over Tropics.

Remarks

NCMRWF GDAS assimilates different types of conventional and remote sensing observations all over the globe.

Satellite data assimilated to NCMRWF GDAS includes

- **NESDIS / POES ATOVS Sounding radiance data**
- **NESDIS/POES, METOP-2 and AURA orbital ozone data**
- **NASA/TRMM and SSM/I precipitation rates**
- **Bending angle from radio occultation data using GPS satellites**
- **NASA/AQUA AIRS & METOP/ IASI brightness temperature data**
- **Atmospheric Motion Vectors from Geo-Stationary and Polar Satellites (Meteosat-7, Meteosat-9, GOES-11, GOES-13, MTSAT-1R, MODIS (TERRA and AQUA))**
- **Scatterometer winds (ASCAT winds from METOP-A)**

Regular monitoring of all types of observations are being done during each assimilation cycle and daily monitoring reports are being generated operationally.

Validation of Kalpana-1 and Oceansat-2 winds with respect to insitu observations and first guess is also being done regularly