Preliminary Results of the CPTEC's Regional Modeling System with Rapid Update Cycle in Support to the Olympic Games in Rio de Janeiro

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OVERVIEW

The Center for Weather Forecast and Climate Studies (CPTEC) from the Brazilian National Institute for Space Research (INPE) has started on July, 2015 its rapid update cycle (RUC) in experimental mode over South America. This system is intended to be used as both operational regional tool for high impact weather as well as in support to the Olympic Games that will take place in the city of Rio de Janeiro during August and September of 2016. The modeling suite, named Regional Modeling System (RMS), comprises nested domains with resolution of 9 km, 3 km and 1 km over South America, southeastern Brazil and Rio the Janeiro regions, respectively. A 3DVar data assimilation scheme based on the Gridpoint Statistical Interpolation (GSI) system has been implemented in the larger (9 km) domain using full observation system, including conventional, satellite radiances and GPS data. Furthermore, radar data assimilation has been implemented in the 1 km domain in order to capture the convective scale atmospheric features using the Weather Research and Forecasting Data Assimilation system (WRFDA). The 1 km domain is covered by 3 radars that provide reflectivity and radial velocity data to be assimilated. This work aims to assess the preliminary results from this CPTEC RMS/RUC and the value of radar information over the Rio de Janeiro in preparation to the Olympic Games. Additionally, the impact of conventional and satellite data over the South America is also investigated.

MODEL AND DATA ASSIMILATION METHOD

Forecast Model: **W**eather **R**esearch and **F**orecasting model (WRF) for all domains.

Data Assimilation: **G**ridpoint **S**tatistical **I**nterpolation (GSI) for regional domain (9km) and **W**RF **D**ata **A**ssimilation (WRFDA) for local domain (1km), both using 3D-Var

CYCLE SETUP

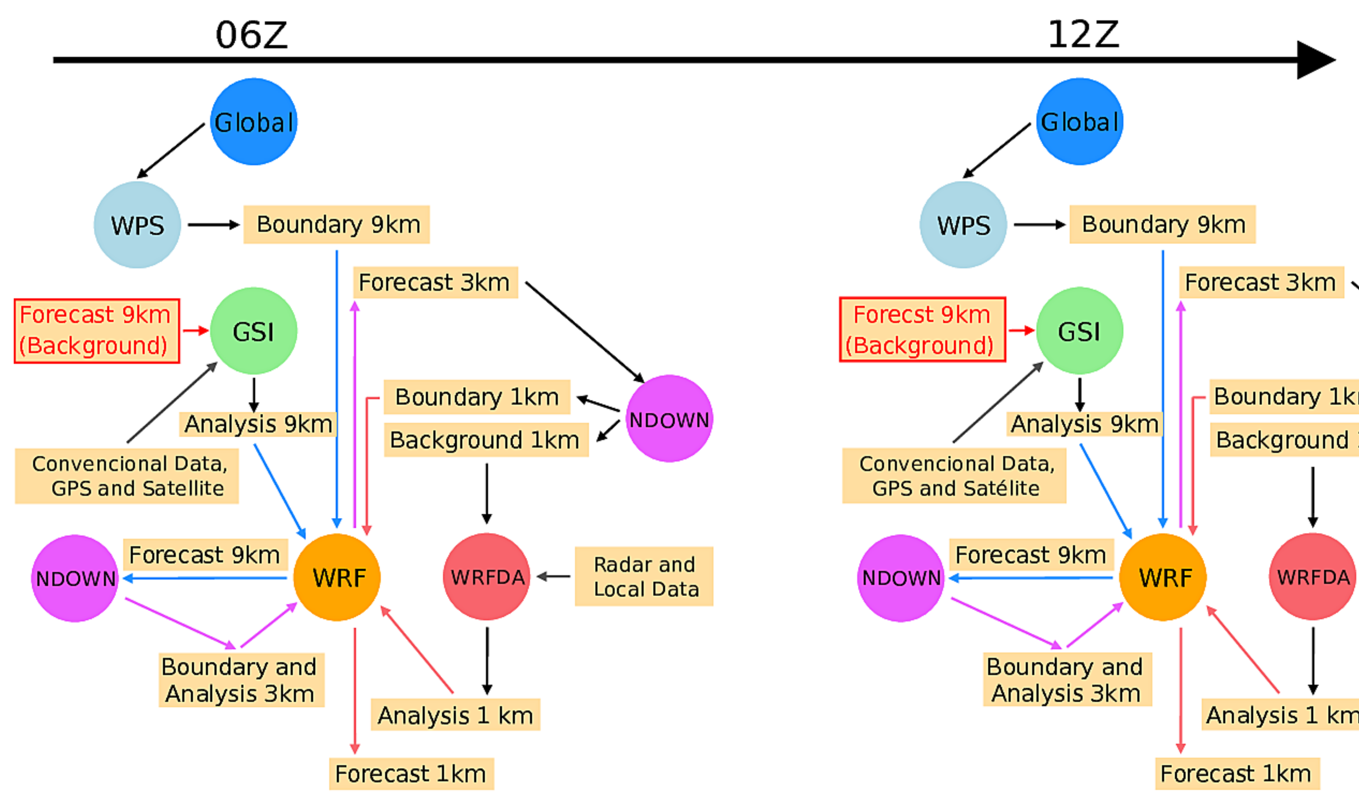

Figure 1: Schematic representation of CPTEC's Regional Modeling System (RMS) Cycle.

The RMS domains and available observations are show below. Figure 2 gives an overview of the 3 domains plus the location of the 3 radars available within the domain 3. Figure 3 shows local observations close to where the Olympic Games will take place, including buoys, automated weather stations, weather radars and a sodar (highlighted in red).

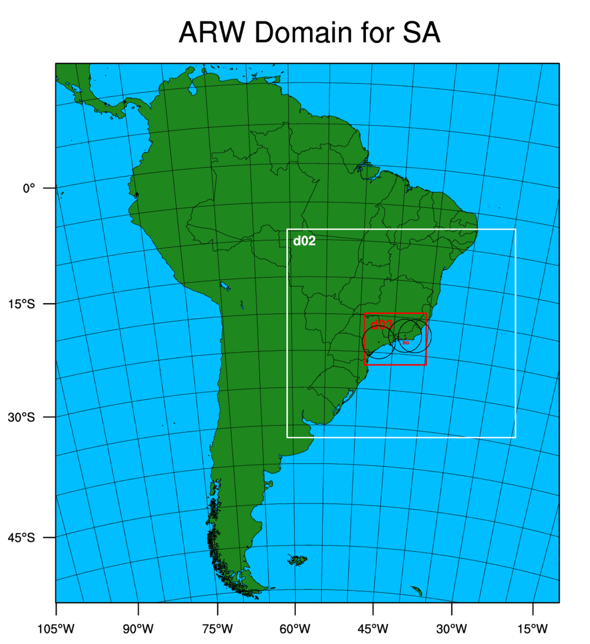

Figure 2: RMS domains and the location of 3 weather Doppler radars within the domain 3.

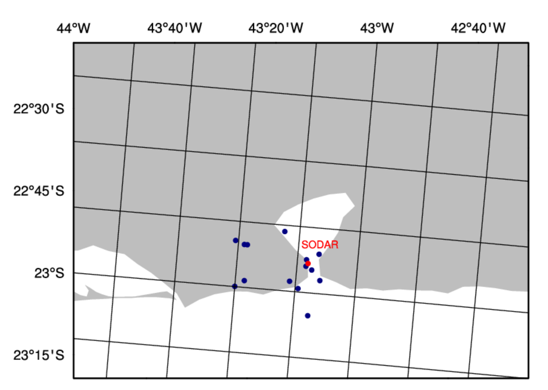

Figure 3: Local observations close to the Olympic Games area.

Local observations and/or specific for the Olympic Games

- Buoys
- Weather stations
- SODAR – wind profile
- 3 Doppler Radars
  - Reflectivity and Radial Velocity

Satellite radiance/brightness temperature available observations (instrument/satellite ID)

- SBUV: n17, n18, n19
- HIRS: metop-a, metop-b, n17, n19
- GOES_IMG: g11, g12
- AIRS: aqua
- AMSU-A: metop-a, metop-b, n15, n18, n19, aqua
- AMSU-B: metop-b, n17

Conventional available observations: (including satellite retrievals)

- Radiosondes
- Pibal winds
- Synthetic tropical cyclone winds
- Wind profilers: US, JMA
- Conventional aircraft reports
- ASDAR aircraft reports
- MDCARS aircraft reports
- Dropsondes
- MODIS IR and water vapor winds
- GMS, JMA, and METEOSAT cloud drift IR and visible winds
- EUMETSAT and GOES water vapor cloud top winds
- GEOS hourly IR and coud top wind
- Surface land observations
- Surface ship and buoy observation
- SSM/I wind speeds
- QuikScat, ASCAT and OSCAT wind speed and direction
- SSM/I and TRMM TMI precipitation estimates
- Doppler radial velocities
- VAD (NEXRAD) winds
- GPS precipitable water estimates
- GPS Radio occultation (RO) refractivity and bending angle profiles
- SBUV ozone profiles, MLS (including NRT) ozone, and OMI total ozone
- SST
- Tropical storm VITAL (TCVital)
- PM2.5
- MODIS AOD (when using GSI-chem package)
- Doppler wind Lidar data
- Radar radial wind and reflectivity Mosaic
- METAR cloud observations
- Tail Dopppler Radar (TDR) radial velocity and super-observation
- Flight level and Stepped Frequency Miscrowave Radiometer (SFMR) High Density
- Observation (HDOB) from reconnaissance aircaraft
- Tall tower wind

RESULTS

Figure 4 shows the average over January 2015 of the O-B and O-A Root Mean Square Error for wind, temperature and specific humidity from the GSI 3D-Var data assimilation at the domain 1 (9km). It clearly shows the reduction of the errors due to the assimilation process, mainly for the wind.

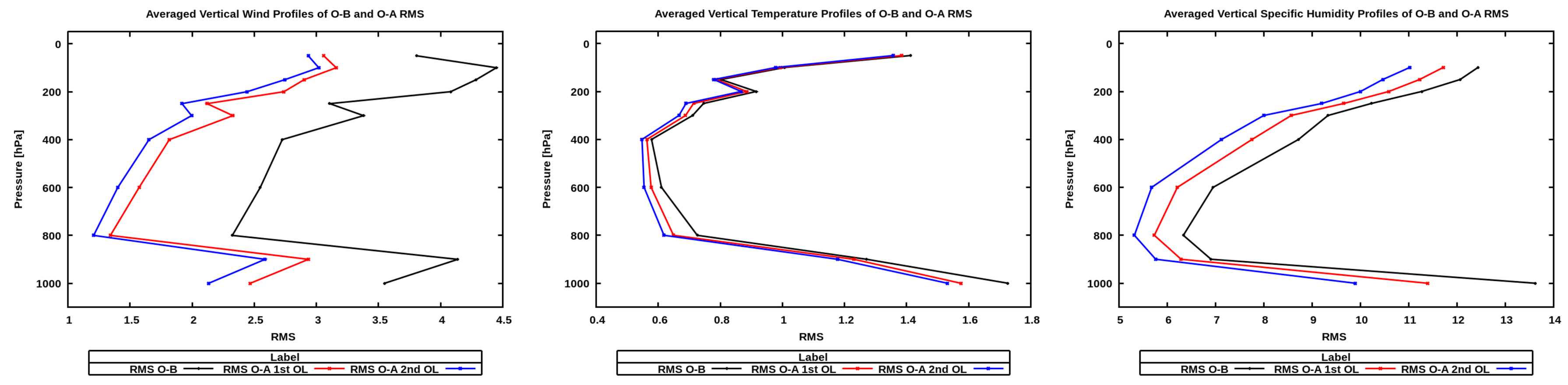

Figure 4: Averaged O-B and O-A RMS error. The average was taken over the month of January 2015 using information from GSI output each 6 hours. The black line stands for O-B, the red line stands for O-A first outer loop and the blue line stands for O-A second outer loop.

Besides the evaluation of the assimilation through the O-B/O-A statistics, it was also evaluated the 24-h forecast applying the Fractional Skill Score (FSS) on the forecasted precipitation against the one estimated from the Global Precipitation Measurements (GPM) project, Figure 5. It is possible to observe improvement on the precipitation field over all 24 hours on the average.

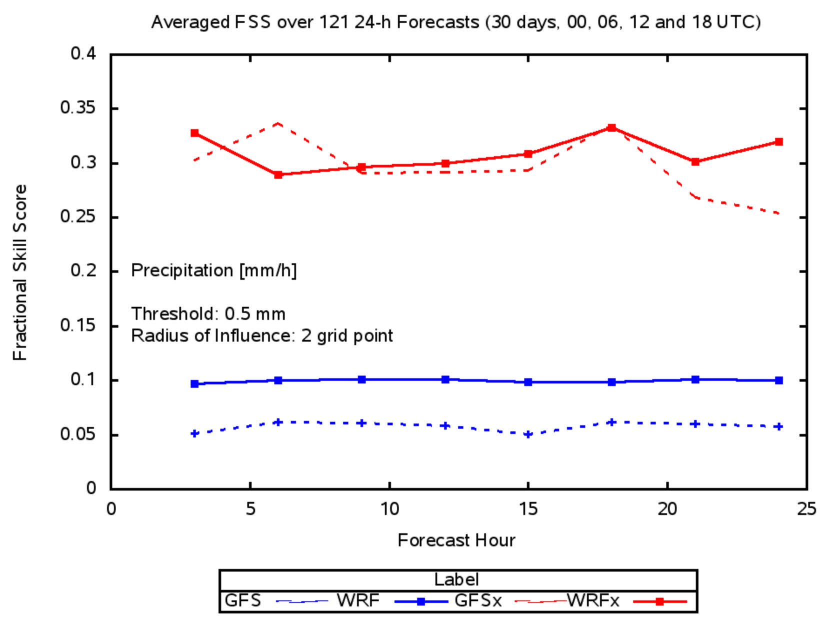

Figure 5: Fractional Skill Score of forecasted precipitation from GFS and WRF (domain 1 – 9km) against GPM observation. The blue lines stand for the average over a month and the red ones stands for the maximum value along the month. The dashed lines refers to GFS and the solid ones refers to WRF.

Figure 6 shows wind profiles from domain 3. It is just examples of improvements on the wind, mainly at low levels) when assimilating radar data for a specific observation station close to the Olympic Village.

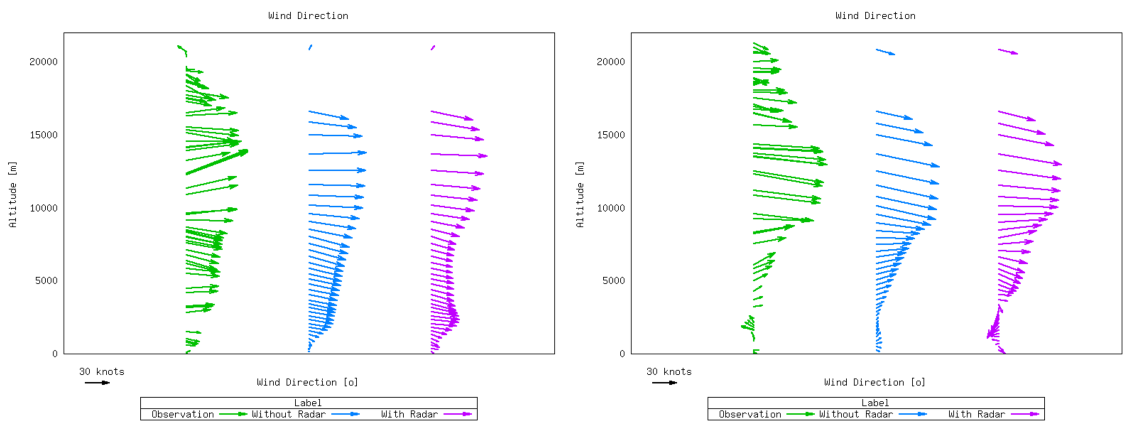

Figure 6: Wind profiles at SGBL Galeao station: sounding (green), WRF without radar data assimilation (blue) and WRF assimilating reflectivity and radial velocity (purple).

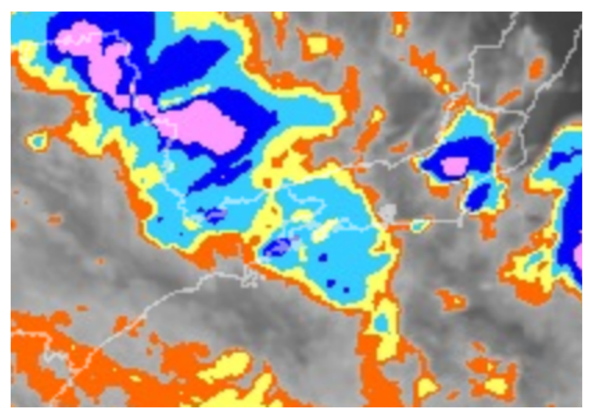

Figure 7: GOES-13 brightness temperature on 7th June 2016, 03 UTC.

Figure 9a shows the integrated rainwater from the entire column at the analysis time after assimilating radar data. It's possible to note that Figure 9a it is well correlated to Figure 8, that shows radar reflectivity at the same time as Figure 9a. This result exemplifies the improvement on microphysics when assimilating radar observations. After 3 hours forecast the radar data assimilation still shows improvements, refers to Figures 9b, 9c and 7 (brightness temperature).

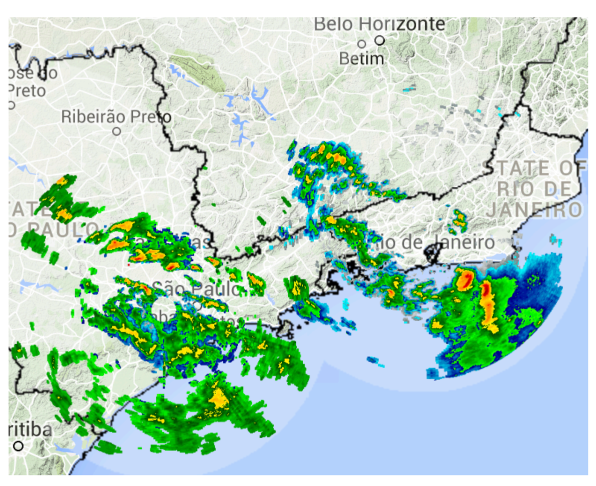

Figure 8: Radar reflectivity (CAPPI) on 7th June 2016, 00 UTC.

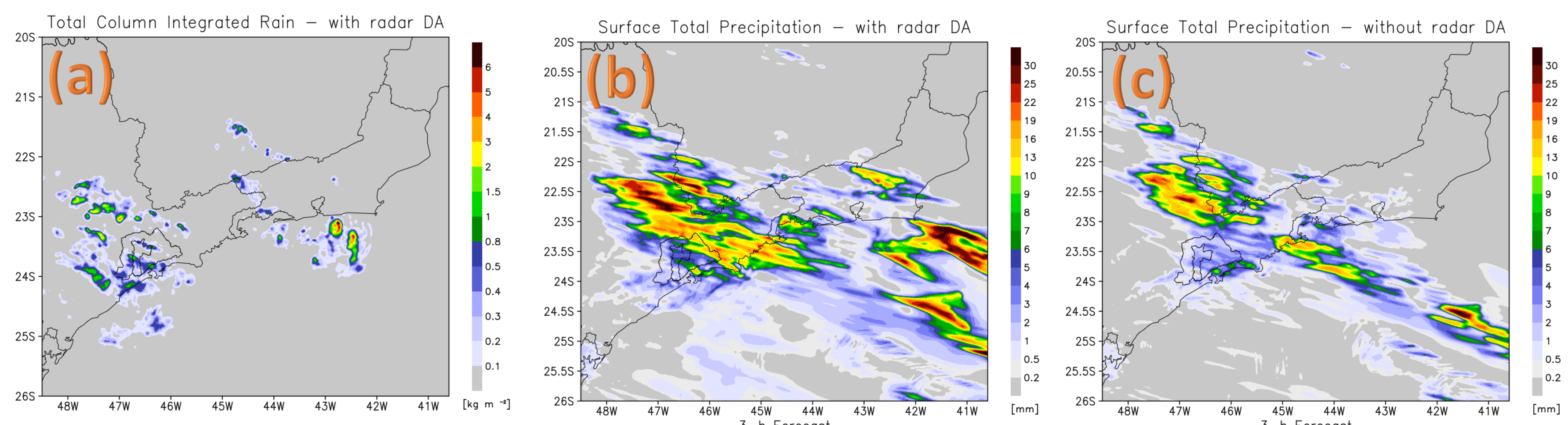

Figure 9: (a) Total column integrated rain after assimilating radar data; b) 3-h forecast from domain 3 without assimilating radar data and c) 3-h forecast from domain 3 assimilating radar data. a) 7th June 2016, 00UTC; b) and c) 7th June 2016 03 UTC.

SUMMARY

Regional Modeling System (RMS) comprising regional and local data assimilation, including radar observations, has been successfully implemented at CPTEC/INPE. The impact of data assimilation has proven to be positive, reducing the errors of the main meteorological variables, i. e., wind speed, temperature and humidity throughout the troposphere. The radar data assimilation has shown improvements on the wind and microphysics. Special attention must be given to radar quality control because small error can lead to a negative impact on the analysis and therefore on the forecast. It is not addressed this issue here, but the positive results presented has been achieve only after performing a strict quality control on the radar data. Further tuning on the RMS must be done, nevertheless preliminary results seem to be promising.

GDAD – Group on Data Assimilation Development

ACKNOWLEDGEMENTS

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