# Data assimilation system applied to Short-range Forecast System.

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# Abstract

The research's objetive is to compare the 3DVAR and 3DEnVAR's methods skill over fog forecasting applied to the Short-range Forecast System (SisPI). Prepbufr and radiances data joint to observations from the KBYX and KBMA radars data are assimilated in a combined way for a first time in Cuba. On the other hand, five differents hydrometeors species with the vertical velocity was included as control variables into a traditional covariance matrix CV7 used for these experiments. The evaluation is performed considering the phenomenon as a binary event. Dichotomous analysis uses the present weather code data with the visibility predicted by the model, which is obtained by an empirical algorithm. The results suggest that the hybrid scheme allows a more realistic representation of the environment where the phenomenon develop and leads to more accurate forecasts.

**keywords**:SisPI; WRFDA; short-range, assimilation

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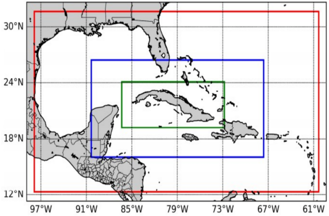
- SisPI (Short-range Forecast System, acronyms in Spanish), fundamental core is the WRF-ARW
- The main objetive of SisPI is the short and very short-range numerical forecast, for that the specialists make bigs efforts for to include operationally the data assimilation, taking in account the technological limitations.

# Experiments desing




(a)

| Parametrizations | Domain 27 km Domain 9 km | Domain 3 km |
|---|---|---|
| Microphysics | WSM5 (WRF-single moment 5) | Morrison 2-moment |
| Cumulus | GF (Grell-freitas) | not used |
| Boundary layer | MYNN 2.5 (Mellor-Yamada Nakanishi and Niino 2.5) | |
| Short wave radiation | Dudhia | Goddard |
| Long wave radiation | RRTM (Rapid Radiative Transfer Model) | |
| Surface border | Monin-Obukhov | |
| Surface | Unified Noah land-surface model | |
| Vertical levels | 28 | |

(b)

**Data for assimilation**:Prepbufr format, AMSU-A(NOAA-15/16/18/19), MHS (NOAA-18/19), SSMIS(DMSP-16), ATMS (Suomi-NPP).

**3 Outers loops** 3DVAR, **weight ensemble/CV7:** 75/25

Modifying the multiplicative weight of 3DVAR background error (CV7 matrix)

# Experiment desing

**3DVAR**: Three-Dimensional Variational

$$J(x) = \frac{1}{2}(x - x_b)^T B^{-1}(x - x_b) + \frac{1}{2}(y - H(x))^T R^{-1}(y - H(x)) \quad (1)$$

**3DEnVAR**: Three-Dimensional Ensemble-Variational. (Hybrid)

$$J(x_1, \alpha) = B_s \frac{1}{2}(x_1 - x_b)^T B^{-1}(x_1 - x_b) + B_e \frac{1}{2} \sum_{i-1}^{n} (\alpha_i^T C^{-1} \alpha_i) + \frac{1}{2}\left[y - H(x_1 - x_e)\right]^T R^{-1}\left[y - H(x_1 - x_e)\right] \quad (2)$$

$\alpha_i$ is the weight attributed to ensemble, where $C$ is the correlation matrix for the effective location of ensemble perturbations.

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3. For all experiments, a statistical background error domain-dependent was used, using the forecasts generated up to 15 days prior to initialization at interest day. The construction of background error was carried out using the gen_be_wrapper.ksh program, available in the WRFDA.

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4. The assimilation was executed only on the domain with the highest horizontal resolution (3 km).

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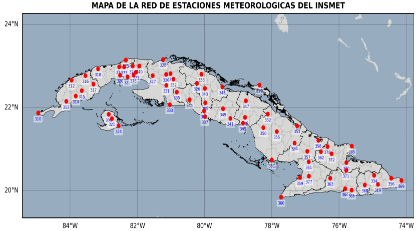
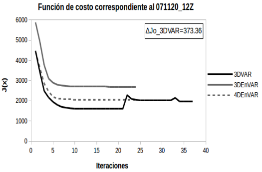



- For the evaluation of the experiments, the satellite precipitation estimation data of the GPM product were used, as well as the data from the surface meteorological stations of Meteorology Institute.

# Results

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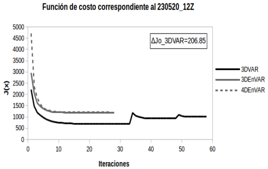


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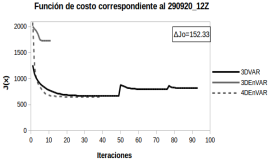


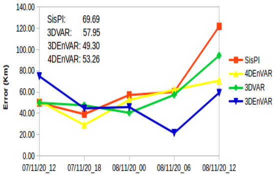

(c)

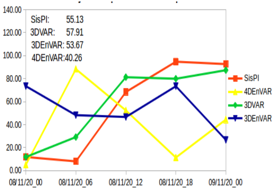
- The use of multiple OLs leads to an increase in the computational cost and does not always guarantee variational control.
- Hybrid methods lead to the minimization of the cost function in a similar number of iterations, 4DEnVAR achieves a more effective minimization than 3DEnVAR.

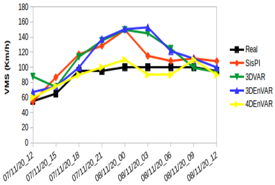
# Results

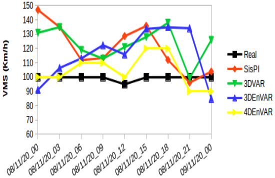
## Tropical Storm ETA

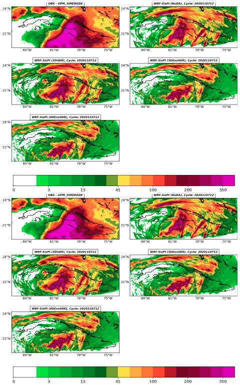
SisPI and 3DVAR's solutions are closer, 4DEnVAR represents better the track and intensity.



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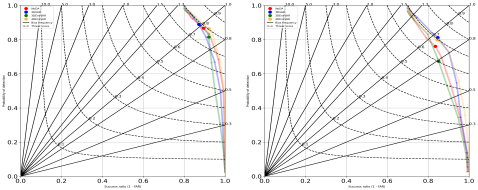
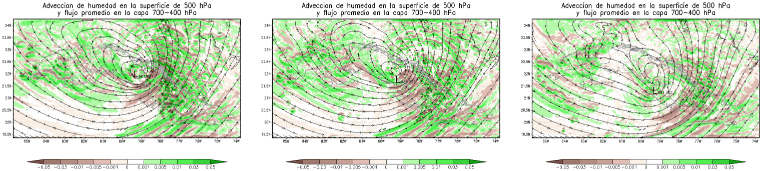


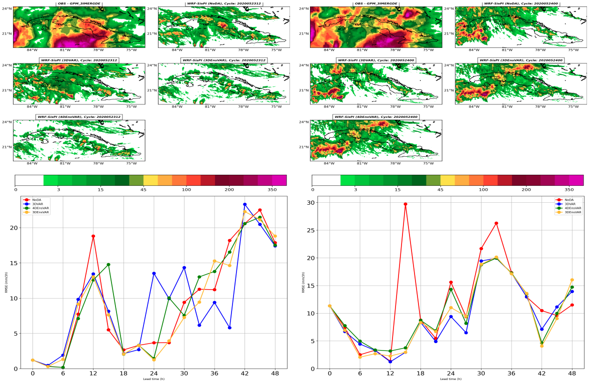

The model tends to underestimate the total amount of precipitation in 24 hours.

The intrusion of dry air at mid-levels, may have been the determining factor in the forecast of the distribution of the storm's rainfall areas.

# Results

## Mesoscale Convective System

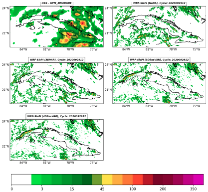
In this case the hybrid schemes lead to very similar forecasts with errors in the spatial coverage of the precipitation areas higher than those exhibited by 3DVAR or SisPI

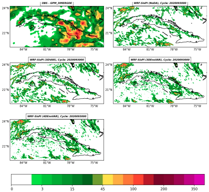


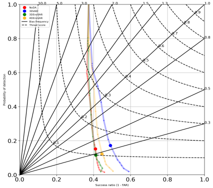
# Results

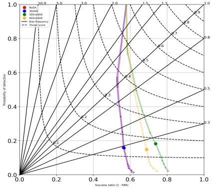
## Thunderstorm case

SisPI and 3DVAR solutions were closer, hybrid methods increased the prediction error towards the eastern part, significantly reducing the precipitation areas.









However the hybrid schemes corresponding to the initialization of 0000 UTC turned out to be much superior to the forecasts emanating from SisPI and 3DVAR, improving the spatial coverage and the intensity of the precipitation in numerous points of the domain.

## Conclusions

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4. 4DEnVAR method allows assimilating a significantly larger volume of conventional data, however it does not exhibit the same superiority in relation to radiances.
5. 4DEnVAR scheme it is the only one that always superior to the run without assimilation.

Thanks!