

WRFDA 2020 Update

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DA algorithms available in WRFDA

- Deterministic analysis
 - 3DVAR
 - 3 options for non-cloud analysis variables and static background error covariance models (cv_options = 5, 6, 7)
 - 3 options for cloud analysis variables needed for radar reflectivity and cloudy radiance DA (cloud_cv_options=1, 2, 3)
 - 4DVAR
 - Need WRFPlus: tangent linear and adjoint of WRF model
 - Can calculate adjoint-based forecast sensitivity to obs (FSO)
 - Hybrid-3D/4DEnVar
 - Can run in dual-resolution mode
- Ensemble analysis
 - ETKF (Ensemble Transform Kalman Filter) w/o localization
 - Ensemble of hybrid-EnVar with perturbed observations

- **In-Situ:**
 - **SYNOP**
 - **METAR**
 - **SHIP**
 - **BUOY**
 - **TEMP**
 - **PIBAL**
 - **AIREP, AIREP humidity**
 - **TAMDAR**
- **Remotely sensed retrievals:**
 - **Atmospheric Motion Vectors (geo/polar)**
 - **SATEM thickness**
 - **Ground-based GPS **TPW or ZTD****
 - **SSM/I oceanic surface wind speed and TPW**
 - **Scatterometer oceanic surface winds**
 - **Wind Profiler**
 - **Radar data (reflectivity/retrieved rainwater, and radial-wind)**
 - **V3.9: No-rain echo radar DA (from KNU)**
 - **Satellite temperature/humidity/thickness profiles**
 - **GPS refractivity (e.g. COSMIC)**
 - **Stage IV precipitation/rain rate data (4D-Var only)**
- **Bogus:**
 - **TC bogus**
 - **Global bogus**
- **Radiances (VarBC, RTTOV & CRTM, All-sky radiance):**
 - **HIRS** **NOAA-16, NOAA-17, NOAA-18, NOAA-19, METOP-A**
 - **AMSU-A** **NOAA-15/16/18/19, EOS-Aqua, METOP-A, METOP-B**
 - **AMSU-B** **NOAA-15, NOAA-16, NOAA-17**
 - **MHS** **NOAA-18, NOAA-19, METOP-A, METOP-B**
 - **AIRS** **EOS-Aqua**
 - **SSMIS** **DMSP-16, DMSP-17, DMSP-18**
 - **IASI** **METOP-A, METOP-B**
 - **ATMS** **Suomi-NPP**
 - **MWTS/MWHS** **FY-3 A/B; **MWHS2 from FY-3 C/D (new in 4.1)****
 - **SEVIRI** **METEOSAT**
 - **AMSR2** **GCOM-W1 (all-sky microwave radiance DA)**
 - **GOES-Imager, Himawari-AHI (new in 4.1)**

New Features in release-v4.2

<http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-4.2.html>

- **New capability for directly assimilating radar reflectivity using a new observation operator and its TL/AD considering snow and graupel.**
 - Wang, S. and Z. Liu, 2019: A radar reflectivity operator with ice-phase hydrometeors for variational data assimilation (version 1.0) and its evaluation with real radar data, Geosci. Model Dev., 12, 4031–4051.
- **Now WRFDA has 3 options for radar reflectivity DA**

Namelist parameter	Direct assimilation of reflectivity	Direct assimilation of reflectivity	Assimilation of retrieved hydrometeors
use_radar_rf =	True	True	False
radar_rf_opt =	1	2	No effect
use_radar_rhv =	False	False	True
use_radar_rqv =	False	False	True or False
cloud_cv_options =	1	2 or 3	2 or 3

New Features in release-v4.2

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- **New capability for variational bias correction of TAMDAR aircraft T observations.**
 - Gao, F., Z. Liu, J. Ma, A. N. Jacobs, P. P. Childs, and H. Wang, 2019: Variational Bias Correction of TAMDAR Temperature Observations in the WRF Data Assimilation System. Monthly Weather Review. 147. 10.1175/MWR-D-18-0025.1.
- **The bias correction is applied based upon aircraft's IDs and phases (descent/ascent/cruise). To turn on this function, set "use_varbc_tamdar = true" in \wrfvar4.**

Note: Bias correction algorithm is not implemented for other aircraft types under 'airep'.

New Features in release-v4.2

<http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-4.2.html>

- A new channel-based (i.e., can keep channels not affected by clouds) cloud detection scheme for hyperspectral Infrared sensors based on the **Particle Filter. Default** option
 - Xu D., T. Auligné, G. Descombes, and C. Snyder, 2016: A method for retrieving clouds with satellite infrared radiances using the particle filter. Geosci. Model Dev., 9, 3919–3932.
 - **WRFDA includes two other schemes: Minimum Residual and ECMWF's ranking, which need the third-party software to make them work.**
- New **gen_be_v3**, developed by Jamie Bresch (NCAR/MMM)
 - This program generates ensemble perturbations (for hybrid-EnVar input) and background error statistic file
 - Now only works for cv_options=7 and cloud_cv_options=2 applications.
 - gen_be_v3 is much more efficient than the standard gen_be package.

Updated Features in release-v4.2

<http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-4.2.html>

- Improved analysis_type="**RANDOMCV**". Now multiple perturbed output can be obtained with one WRFDA run, set new namelist "**n_randomcv**" to the desired number of ensemble. (Contributed by Jamie Bresch)
- For EnVar DA applications, old logical "**alpha_vertloc**" namelist switch is replaced by new integer option "**alpha_vertloc_opt**". (contributed by Jamie Bresch)
 - =0, no vertical localization.
 - =1, the behavior is the same as before. Need a file named "be.vertloc.data" generated by an offline program
 - **=2, default, recommended**, let WRFDA internally calculate logP-based vertical localization. be.vertloc.dat will be written out.

Updated Features in release-v4.2

<http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-4.2.html>

- New “**ep_format**” option to read in ensemble perturbation (ep) generated by existing **gen_be_ep2** and new **gen_be_v3** utilities. (by Jamie Bresch)
 - **=1**: (default) original format, double precision, each ep file is for one variable and one member, as the output from the current **gen_be_ep2**.
 - **=11**: same as **ep_format=1** except data are in single precision
 - **=2**: single precision, each ep file is for one variable and all members
 - **=3**: single precision, each ep file is for one variable and all members but on **decomposed patch domain**. This is recommended for large size of grid points.

Bug fixes in release-v4.2

<http://www2.mmm.ucar.edu/wrf/users/wrfda/updates-4.2.html>

- Fix dual-resolution hybrid-EnVar significant different results with different number of processors.
(By Jamie Bresch)
- A fix for retrieving a snow profile with radar reflectivity retrieval DA. (by Tao Sun, NUIST)
 - In the snow profile retrieval with radar DA, when the temperature is above 0°C, dry snow should be replaced by wet snow. This bug resulted in the overestimation of snow.

New features in **develop** branch

- Pixel-based cloud detection scheme for clear-sky Himawari AHI radiance DA
 - <https://github.com/wrf-model/WRF/pull/1139>
- Super-obbing capability for Himawari AHI radiances
 - <https://github.com/wrf-model/WRF/pull/1173>

Plan for v4.3 release

- Aerosol/Chemical DA capability for WRF-Chem
 - Assimilate surface PM2.5, PM10, O3, CO, SO2, NO2
- Multi-Resolution Incremental 4DVar (MRI-4DVar)
 - Speed up 4DVar