# Towards global convection-permitting NWP using MPAS and MPAS-JEDI

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## Joint Effort for Data assimilation Integration (JEDI)

led by Joint Center for Satellite Data Assimilation (JCSDA)



JCSDA and all groups from its partner agencies contribute to JEDI's development



## https://www.jcsda.org/jedi-mpas

<b>Version</b> 1.0.0	<b>Download</b> Code	Quick Start - Tutorials Build and Test JEDI-MPAS	Support Documentation	<b>Date</b> 2021-09-24
Release Notes		Simulating Observations with a JEDI-MPAS Application	Forums MPAS started from	<b>5-JEDI</b> n early 2018
		Running the JEDI-MPAS Variational		
Model-agnostic https://github.com https://github.com https://github.com https://github.com	components: /JCSDA/oops /JCSDA/saber /JCSDA/ufo /JCSDA/ioda	MPAS model and model-specific https://github.com/JCSDA-internal/M https://github.com/JCSDA/mpas-jedi Build mechanism based on cmak https://github.com/JCSDA/mpas-bund	interfaces: <u>PAS-Model</u> ke/ecbuild: <u>dle</u>	

Liu Z et al., 2022: Data Assimilation for the Model for Prediction Across Scales - Atmosphere with the Joint Effort for Data assimilation Integration (JEDI-MPAS 1.0.0): EnVar implementation and evaluation, Geosci. Model Dev., *15*, 7859–7878.



## **Main Features in MPAS-JEDI**

- Deterministic analysis: **3DVar**, **3D/4DEnVar**, **and hybrid-3D/4DEnVar**
- Ensemble analysis : Ensemble of EnVar (EDA), with perturbed observations or LETKF
- Analysis directly done on MPAS unstructured grid for uniform or variable-resolution mesh, global or regional mesh.
- Multivariate B model follows GSI/WRFDA, e.g., use variable transform from stream function and velocity potential to u/v wind components



## All-sky radiance DA capability in MPAS-JEDI

- UFO includes interface to both CRTM and RTTOV, and allows great flexibility of configurations for using either of two or even combination of two RTMs
- Mixing ratios of 5 hydrometeors (cloud water, cloud ice, rain, snow, graupel) as part of analysis variables
  - Currently two microphysics schemes (WSM6 and Thompson) available in MPAS
- So far evaluated all-sky DA impact for AMSU-A, MHS, ABI/AHI, using CRTM-v2.3

A fully open-source model and DA system, a convenient R&D testbed for DA or model evaluation for new satellite missions like EarthCare



### AMSU-A window channel all-sky DA impact @ 30km mesh

- Two 6-hourly cycling experiments of 30km-60km dual-resolution hybrid-3DEnVar
  - clrama+clrmhs : non-radiance obs + 6 clear-sky AMSU-A (ch 5-9) + 4 clear-sky MHS (ch 3-5)
  - cldama+clrmhs: above + 5 all-sky window channel (ch 1-4, 15) AMSU-A over water
- One-month period from 15 April to 14 May, 2018.
- Configuration:
  - 75% weight in ensemble B and 25% weight in static B for non-cloud analysis variables
  - 100% weight on ensemble B for 5 cloud analysis variables
  - 1200km/6km localization scale in horizontal/vertical
  - 80-member ensemble input from MPAS-JEDI's own EDA cycling at 60km mesh
  - Variational Bias Correction, CRTM-v2.3, situation-dependent obs error model



## situation-dependent all-sky obs error model

89GHz,  $\bar{c}_{clr}$ =0.03,  $\bar{c}_{cld}$ =0.24,  $\sigma_{clr}$ =6.33,  $\sigma_{cld}$ =19.24

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#### % RMSE change by adding AMSU-A window channels: verify against NCEP-GFS analyses







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Impact of AMSU-A window channels on clouds in terms of ABI/AHI ch13 radiances

Day-1 forecast

% STD reduction

Improvement concentrated in tropical cloudy regions, with a similar magnitude (10%) of improvement like for Q and U

#### **ABI observations vs. Day-1 forecast**



ABI channel 13 (10.3  $\mu$ m) Brightness Temperatures (degree C) valid at 00 UTC 9 May 2018



#### **Anomaly Correlation Coefficient for geopotential height**

#### hybrid-3DEnVar: 15km-60km vs. 30km-60km



Overall beneficial when increasing resolution from 30km to 15km



## High-resolution experiments @15km & 7.5km

- 3 pure 3DEnVar (i.e., 100% weight on ensemble B) experiments:
  - 6-hourly cycling for May 2019
  - **15km**-30km (full-month), **7.5km**-30km (13 days), **7.5km**-15km (13 days)
  - 11 7-day forecasts from 00 UTC analyses
  - 7.5km mesh has > 10M cells!
- 80-member ensemble input at 30km or 15km, produced using MPAS-DART
- Assimilated non-Radiance obs + (5 AMSU-A's clear-sky T-channels + all-sky window channels) (from NOAA-15/18/19 and METOP-A/B)



#### Time Series of RMS (omb/oma): NOAA19-AMSU-A







#### Percentage change of 0-7-day forecast RMSE (vs. 15km-30km exp)



## Verified against NOAA19-AMSU-A temperature sounding channels









#### Percentage change of 0-7-day forecast RMSE (vs. 15km-30km)





#### Gilbert Skill Scores for 24-h accumulated precipitation forecast: day-1 to day-7

#### Verified against IMERG data





#### A single day-1 forecast of 24-h accumulated precipitation



## **Two physics suites in MPAS**

# 'mesoscale\_reference' suite used in all cycling DA experiments

#### 'convection\_permitting' suite

Parameterization	Scheme	Parameterization	Scheme
Convection	New Tiedtke	Convection	Grell-Freitas
Microphysics	WSM6	Microphysics	Thompson (non-aerosol aware)
Land surface	Noah	Land surface	Noah
Boundary layer	YSU	Boundary layer	MYNN
Surface layer	Monin-Obukhov	Surface layer	MYNN
Radiation, LW	RRTMG	Radiation, LW	RRTMG
Radiation, SW	RRTMG	Radiation, SW	RRTMG
Cloud fraction for radiation	Xu-Randall	Cloud fraction for radiation	Xu-Randall
Gravity wave drag by orography	YSU	Gravity wave drag by orography	YSU

New Tiedtke convection scheme is NOT scale-aware

Grell-Freitas convection scheme is scale-aware



Init: 2019-05-01 00z from GFS analysis 24-h forecast: valid 2019-05-02 00z



Observed brightness temperatures From GOES16-ABI channel 13

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Init: 2019-05-04 00z 24-hour forecast: valid 2019-05-05 00z ABI Ch13









#### A single day-1 cold-start forecast of 24-h accumulated precipitation



#### A single day-1 cold-start forecast of 24-h accumulated precipitation





## **Concluding Remarks**

- MPAS-JEDI is MMM's new-generation community DA system with advanced features using satellite observations for DA or model evaluation, computationally successful for a global 7.5km DA setting
  - Release 2.0 this Spring/Summer and the 1<sup>st</sup> tutorial this Fall
- Using a proper physics package is important to gain from 7.5km setting
- Will likely be able to run MPAS-JEDI at 3-4km resolution with NCAR's new HPC Derecho's arrival later this year.

