

Advanced air quality forecasting through coupled data assimilation of hyperspectral PACE aerosol retrievals and all-sky radiances from multiple satellite-based sensors

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PACE-SAT3 Team Overview

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NASA ROSES Award for coupled data assimilation of PACE AOD



- Project Goals
 - 1) Build a new community air quality analysis and forecasting system called MPAS-GOCART-JEDI, the Model for Prediction Across Scales online-coupled with the Goddard Chemistry Aerosol Radiation and Transport – 2nd Generation (GOCART-2G) and interfaced with the Joint Effort for Data Assimilation Integration (JEDI).
 - 2) Assess the value of PACE AOD retrievals in operational air quality forecasting (through coupled data assimilation).

- Project team: Rajesh Kumar, Forrest Lacey (RAL), Gabi Pfister (ACOM), Mary Barth (ACOM/MMM), Laura Fowler, Michael Duda, Jun Park, Chris Snyder (MMM), Cheng Dang, Benjamin Johnson (JCDSA/CRTM), Jerome Barré, Shih-Wei Wei, and Cheng-Hsuan Lu (JCSDA/Compo), Sachine Ghude (IITM, India)

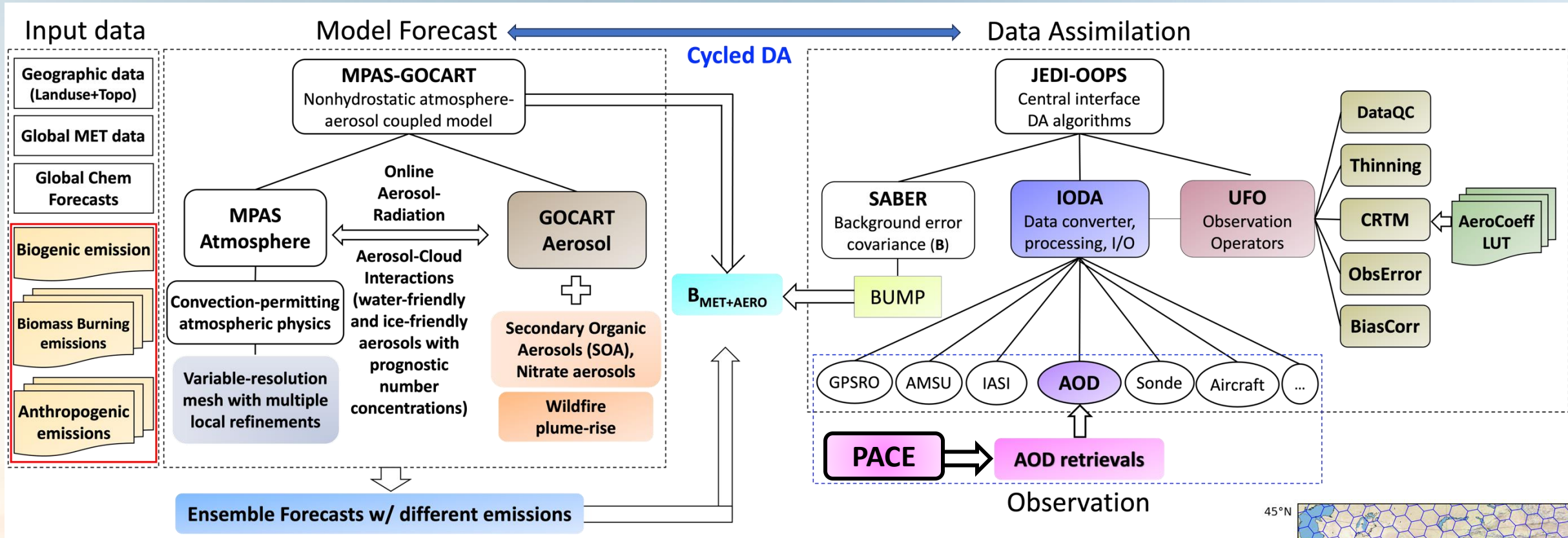
Choice of observation operator (H(x)) for satellite AOD DA

- The Community Radiative Transfer Model (CRTM) provides the critical link between satellite radiances and physical properties of the atmosphere.
- CRTM can provide one of the most sophisticated ways to assimilate satellite Aerosol Optical Depth (AOD) retrievals.

Satellite Data Assimilation -> Analysis, Forecasting
 Calibration / Validation
 Satellite Simulations
 Reanalysis
 Real-time Weather Analysis / Support
 Satellite Sensor Health Monitoring

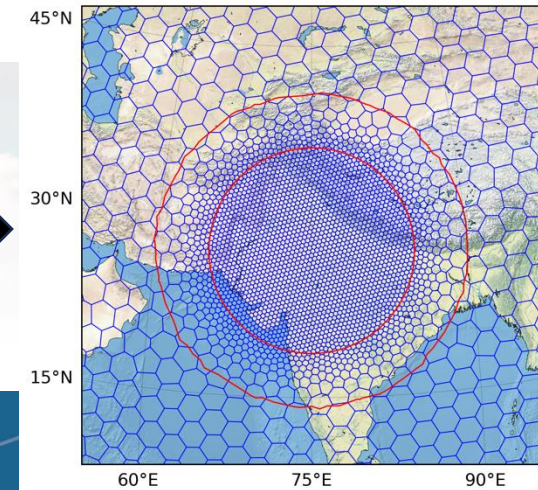
Johnson et al. (2023)

- Support for Polarized UV, VIS/near-IR, IR, sub-MM, MW – future: far IR.** Instrument specific (center frequency, bandwidth, side bands, viewing geometry, polarization basis, spectral response)
- Clouds:** multi-species / habits supporting clouds / precipitation from VIS -> MW, microphysics-model specific LUTs (Thompson, GFDL, WSM-6)
- Aerosols** (salt, dust, smoke, black carbon, volcanic ash, etc.)
- Gaseous species** available in CRTM: H₂O, CO₂, O₃, N₂O, CO, CH₄, O₂, NO, SO₂, NO₂, HNO₃, N₂, OCS, and CFCs – *many others available from LBLRTM, not yet used in CRTM.*
- Surface properties:** land (soil moisture, vegetated), ocean (wind, foam, sea-ice, snow cover (land, sea-ice, depth) --- primarily tested in IR/MW.
- Active sensor** development: space-based radar / lidar (backscat, extinct.)
- Non-LTE** (daytime) and Zeeman effects; Aircraft-based simulation



All the colored boxes – New developments for this project.

Variable-resolution (240-40 km) mesh over India



Key aspects

- NSF NCAR develops a next-generation **online-coupled** atmosphere-chemistry analysis and forecast system to assimilate PACE AOD.
- A unified system with **variable-resolution** analysis and forecasting for both regional and global settings
- PACE AOD retrievals are assimilated to improve air quality and weather prediction (“**chemical weather forecasting**”) in the operational environment.
- Data assimilation through a **full radiative transfer model** – Community Radiative Transfer Model (CRTM) - within JEDI
- **Multi-sensor, multi-channel** AOD products can be incorporated simultaneously – MODIS, VIIRS, GEMS as well as PACE => Consistent intercomparison
- **Coupled DA** with numerous meteorological observations including **all-sky radiances** from microwave to IR channels