1DVAR Preprocessor Applications for Satellite Data Assimilation

Kevin Garrett, Eric Maddy and Krishna Kumar
Riverside Technology, Inc., JCSDA

Yingtao Ma
AER, Inc, JCSDA

Sid Boukabara
NOAA/NESDIS/STAR, JCSDA

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Benefits

- Consistent Quality Control
- Characterization of surface state
- Characterization of atmospheric state
- Linearization of state vector elements / background adjustment

Inversion Process

- Inversion/algorithm consistent across all sensors
- All parameters included in state vector
- Uses CRTM for forward and Jacobian operators
- Valid over all surfaces/all-sky conditions
- Use forecast, fast regression or climatology as first guess/background

Motivation: Increase the number and types of satellite radiometric observations assimilated in NWP

**MIIDAPS extended to the hyperspectral Infrared for IR only or IR+MW 1DVAR analysis**
Quick overview of MIIDAPS 1DVAR

Development status

Preliminary analysis and forecast impacts

Future work
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1DVAR Retrieval/Assimilation Process

Iterative Processes

\[
J(X) = \frac{1}{2}(X - X_0)^T \times B^{-1} \times (X - X_0) + \frac{1}{2}(Y^m - Y(X))^T \times E^{-1} \times (Y^m - Y(X))
\]
MIIDAPS Outputs

1DVAR Analysis Fields and Derived Parameters

1DVAR Outputs
- Temp. Profile
- Humidity Profile
- Cloud Amount Prof
- Ice Amount Prof
- Rain Amount Prof
- Emissivity Spectrum
- Skin Temperature

State Vector [X]

Vertical Integration

Post Processing (Algorithms)

TPW
RWP
IWP
CLW

-VIPP

-Sea Ice Concentration
-Snow Water Equivalent
-Snow Pack Properties
-Land Moisture/Wetness
-Rain Rate
-Snow Fall Rate
-Wind Speed/Vector
-Cloud Top
-Cloud Thickness
-Cloud Phase
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MIIDAPS IR Expansion

Extended state vector with hyperspectral IR covers trace gases / surface emissivity

1DVAR Analysis Fields and Derived Parameters

1DVAR Outputs

- Temp. Profile
- Humidity Profile
- Cloud Amount Prof
- Ice Amount Prof
- Rain Amount Prof
- Emissivity Spectrum
- Skin Temperature
- State Vector [X]

Extended to IR

IR expansion

1DVAR Analysis Fields and Derived Parameters

- CO
- CO2
- O3
- CH4
- N2O

Outputs

- TPW
- RWP
- IWP
- CLW

Derived Parameters

- Sea Ice Concentration
- Snow Water Equivalent
- Snow Pack Properties
- Land Moisture/Wetness
- Rain Rate
- Snow Fall Rate
- Wind Speed/Vector
- Cloud Top
- Cloud Thickness
- Cloud Phase

VIPP
• MIIDAPS atmospheric state vector extended to trace gas profiles
• MIIDAPS emissivity state vector expanded to IR channels (AIRS, CrIS, IASI)
• ATMS/CrIS brightness temperatures simulated using ECMWF analysis (T, Q, CLW), trace gas climatologies, and various IR/MW emissivity models
• MIIDAPS applied to simulated data to retrieve state vector elements for MW only, IR only and combined IR+MW
MIIDAPS MW+IR Compared to ECMWF

MW Only 94.5% Conv.

MW+IR 94% Conv.
MIIDAPS Technical Status

MIIDAPS Standalone Mode
- Data preprocessing
- Optional NWP collocation/guess
- CRTM Initialization
  - Call MIIDAPS
- Post processing

DA Interface (GSI)
- CRTM initialization
- Collocate guess to obs
  - Call MIIDAPS
- Call CRTM for background calc
- Call quality control subroutines
- Bias correction
- Gross error check
- Diagnostic file output

MIIDAPS Package
- MIIDAPS Library
  - Ingest
  - FM
  - Guess
  - MIIDAPS Driver
  - Post process
- Ancillary Data
  - Covariance Matrix [B]
  - Obs Error [E]
  - Bias Coefficients

Primary arguments are Tb, guess fields, geometry, qc/geophysical output

MIIDAPS package is freely available!
**Experiment Setup**

- **GSI r46725, T670/254 (GFS/GDAS)**
  - PRCN: GDAS/GFS Operational configuration
  - PR1D: PRCN + MIIDAPS applied to ATMS only

- **Summer season**
  - August 1, 2014-September 10, 2014

- **MIIDAPS Applied to ATMS only**
  - ATMS QC based on MIIDAPS output
  - SSMI/S QC still being tuned
  - Use of 1DVAR Geophysical outputs still being explored
MIIDAPS-based QC Schemes:

- O-B (all observations) for LEFT: SNPP ATMS Channel 5 (52 GHz) and RIGHT: Channel 7 (54 GHz)

### Points Passing MIIDAPS QC but Failing Operational QC

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ATMS 54.5 GHz

GSI O-B – atms_npp Ch 7

ATMS 54.5 GHz

GSI O-B – atms_npp Ch 7

MIIDAPS-based GSI QC Flags for LEFT: SNPP ATMS Channel 5 (52 GHz) and RIGHT: Channel 7 (54 GHz)

With 1DVAR QC

With Heritage QC
Summary of Impacts

• MIIDAPS applied to just ATMS has neutral impact on traditionally important metrics

• Exploitation of MIIDAPS on all MW, or all MW+IR, will show true utility for QC application

• Further impact expected from utilizing MIIDAPS for hydrometeor and surface characterization, background adjustment
MIIDAPS Forecast Impact
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Preliminary analysis and forecast impacts

Future work
Future Work

- Finalize QC implementation for current sensors and extend to new sensors – ATMS, SSMI/S, AMSU/MHS, GMI, AMSR2, SAPHIR, IR sensors
- Use of 1DVAR geophysical fields – Surface emissivity, hydrometeors
- Explore use of 1DVAR analysis as background and all-sky radiance assimilation
  - Resolve displacement errors
  - Linearization

**Figure.** MIIDAPS retrieved liquid water path and GFS 6hr forecast valid 12Z Jul 3, 2014, for Hurricane Arthur event off the U. S. Southeast coast. a) Displacement of MIIDAPS 1DVAR analysis and GFS forecast; b) 1DVAR liquid water path; c) GFS 6hr liquid water path; and d) MIIDAPS-GFS liquid water path. GFS forecast is collocated in space/time to GPM GMI observation points.