1DVAR Preprocessor Applications for Satellite Data Assimilation

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1DVAR Preprocessor

Multi-Instrument Inversion and Data Assimilation Preprocessing System (MIIDAPS)

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

****CrIS****

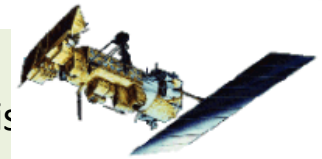
S-NPP ATMS

Megha-Tropiques SAPHIR

****IASI****

MetOp-A AMSU/MHS

MetOp-B AMSU/MHS



NOAA-18 AMSU/MHS

NOAA-19 AMSU/MHS

- Consis rol
- Characterization of surface state
- Characterization of atmospheric state
- Linearization of state vector elements / background adjustment

TRMM TMI

MIIDAPS

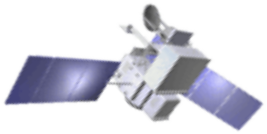
Inversion Process

- 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

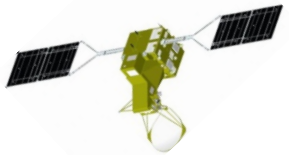
DMSP F16 SSMI/S

DMSP F17 SSMI/S

DMSP F18 SSMI/S



GPM GMI



GCOM-W1 AMSR2

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

Outline

- Quick overview of MIIDAPS 1DVAR
- Development status
- Preliminary analysis and forecast impacts
- Future work

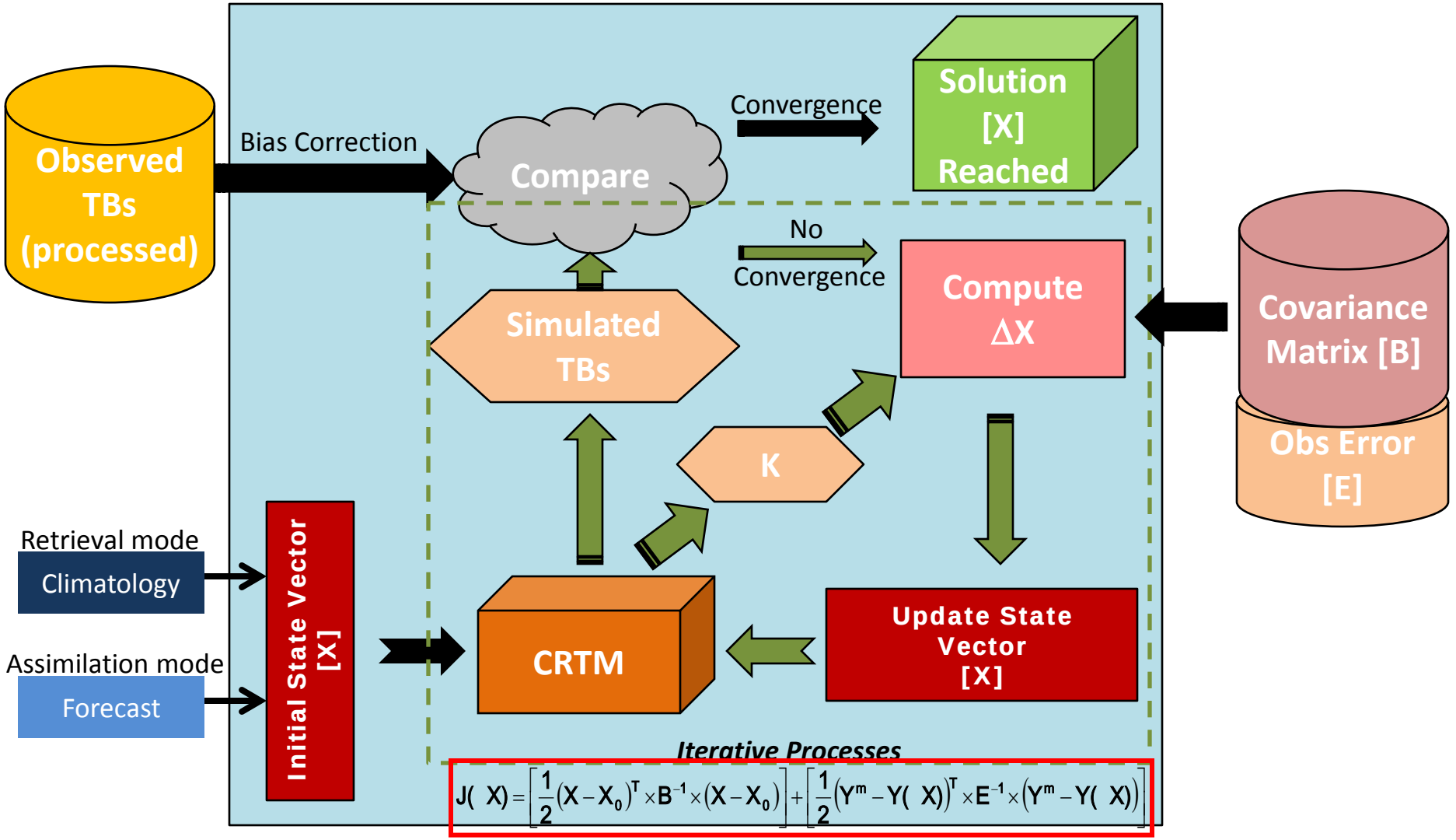
Quick overview of MIIDAPS 1DVAR

Development status

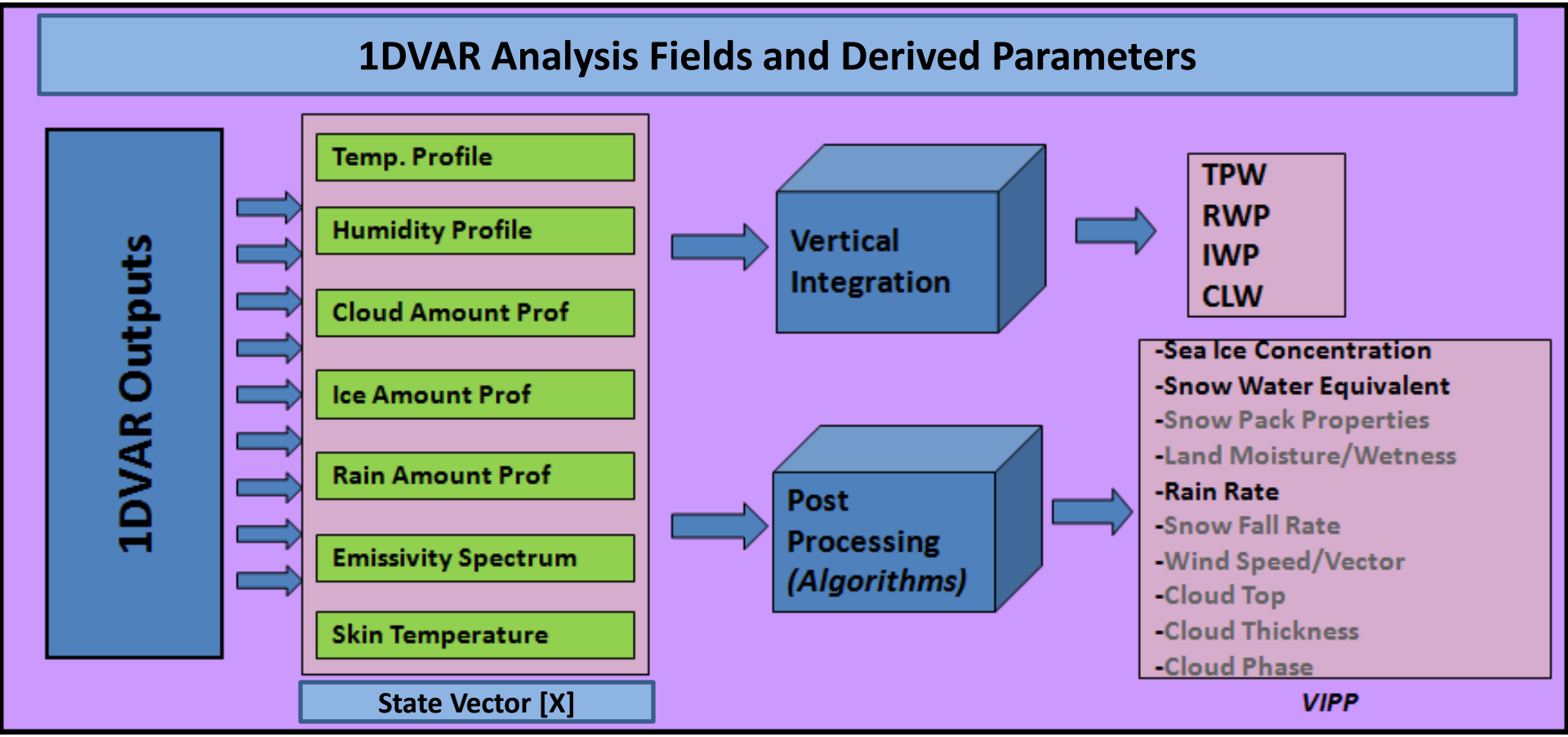
Preliminary analysis and forecast impacts

Future work

1DVAR Retrieval/Assimilation Process



MIIDAPS Outputs



- Quick overview of MIIDAPS 1DVAR
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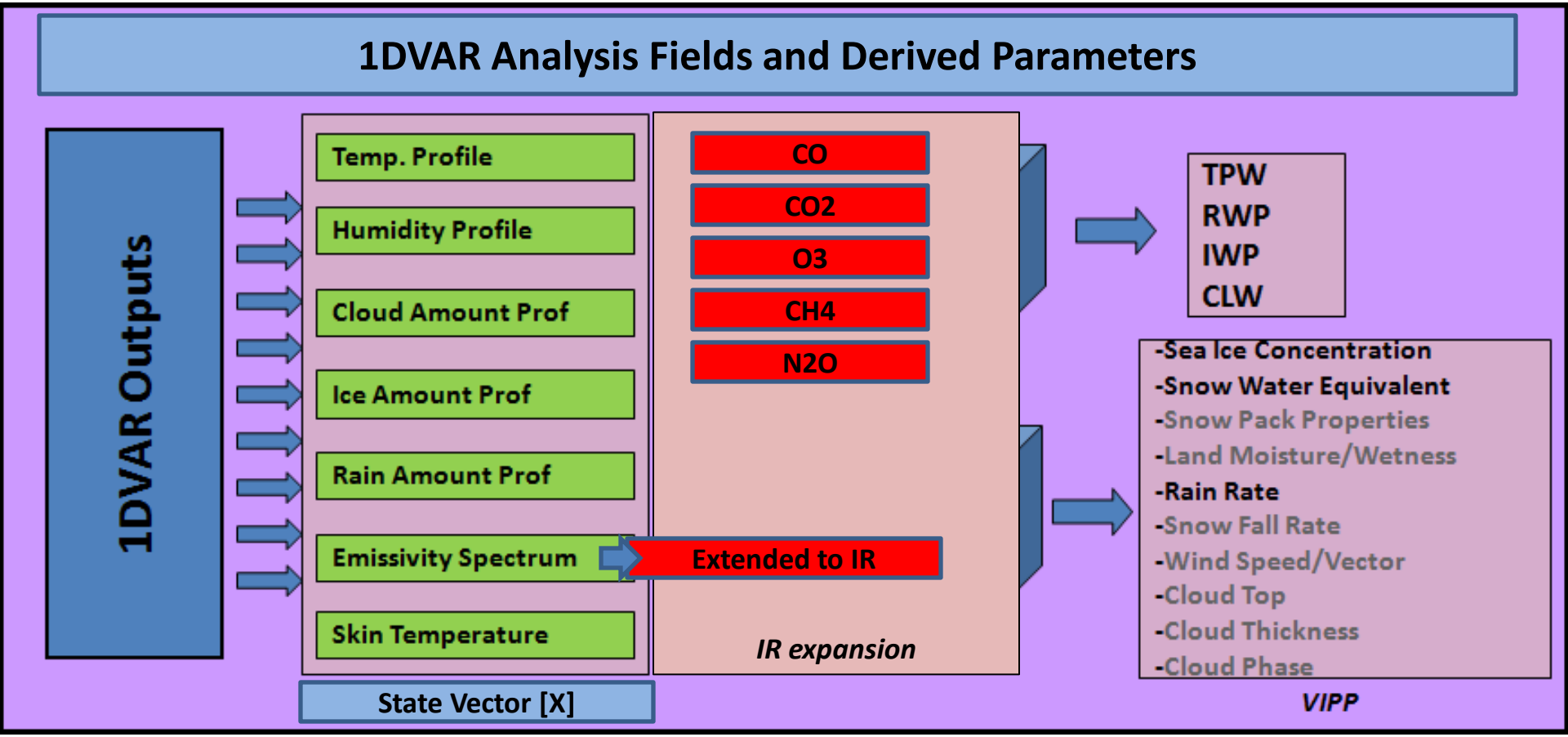
MIIDAPS IR Expansion

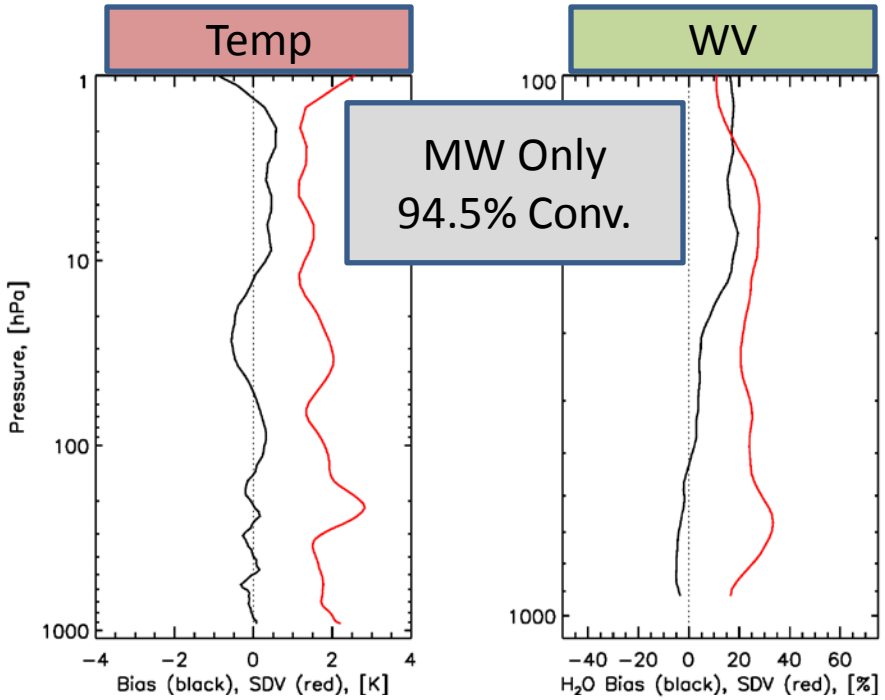
Extended state vector with hyperspectral IR covers trace gases / surface emissivity

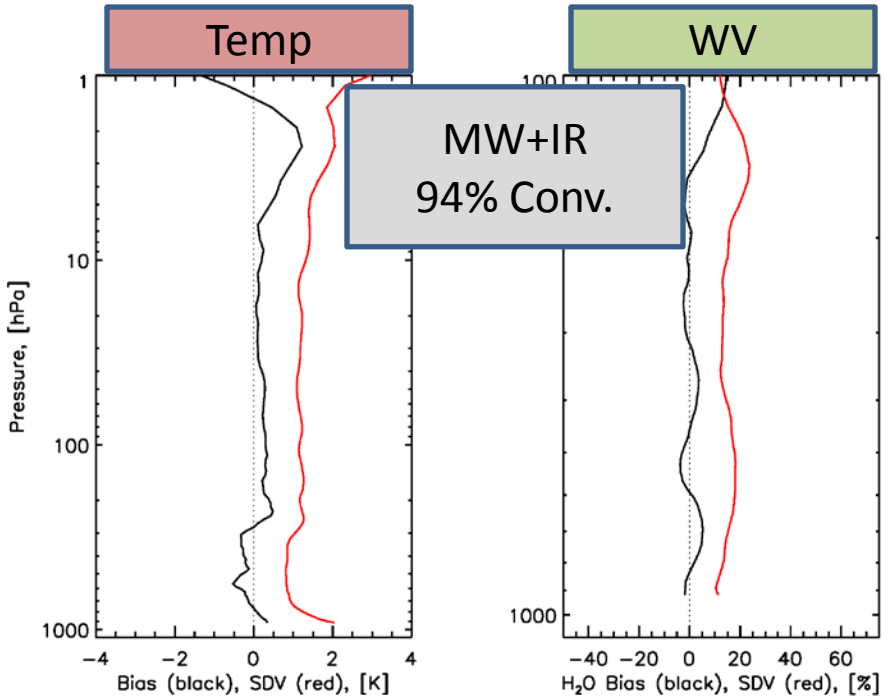


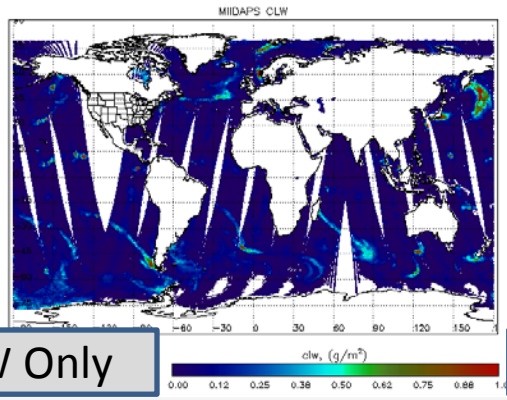
MIIDAPS IR Expansion

- 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

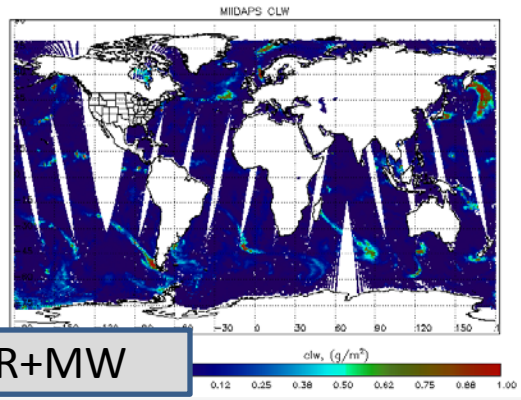
MIIDAPS MW+IR Compared to ECMWF



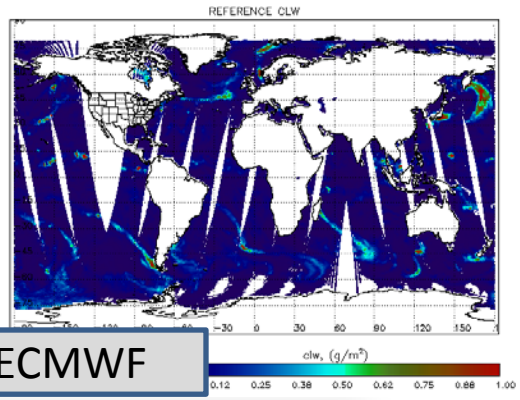




MW Only



IR+MW



ECMWF

MIIDAPS Technical Status

MIIDAPS package is freely available!

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 outp

Use the same MIIDAPS interface

MIIDAPS Package

Ingest
FM
Guess
MIIDAPS Driver
Post process

MIIDAPS Library

readers
FM/ averaging
Colloc/ regress
1DVAR
gridding
figures

Ancillary Data

Covariance Matrix [B]
Obs Error [E]
Bias Coefficients

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

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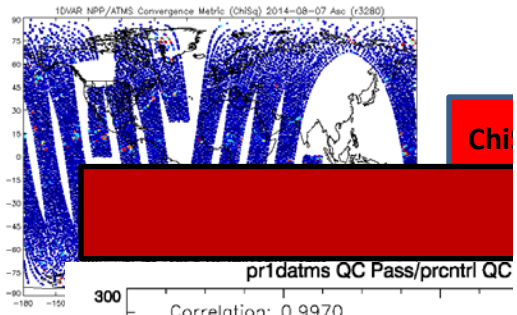
Experiment Setup

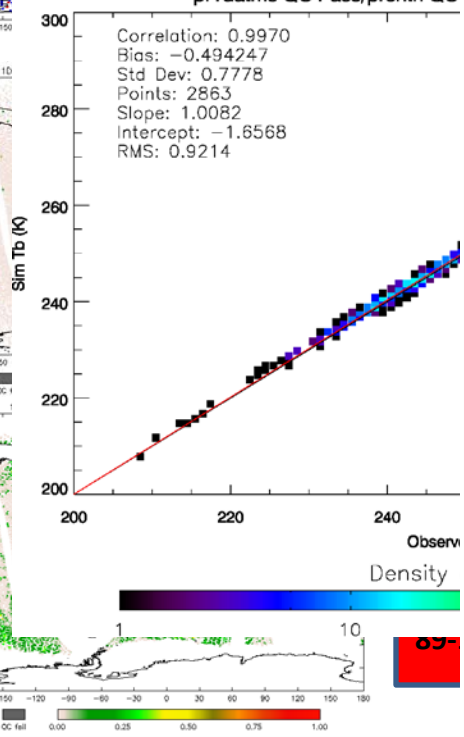
- GSI r46725, T670/254 (GFS/GDAS)
  - PRCN: GDAS/GFS Operational configuration
  - PR1D: PRCN + MIIDAPS applied to ATMS only
- Summer season
  - August 1, 2014-September 10, 2014
- MIIDAPS Applied to ATMS only
  - ATMS QC based on MIIDAPS output
  - SSMI/S QC still being tuned
  - Use of 1DVAR Geophysical outputs still being explored

MIIDAPS Analysis Impact

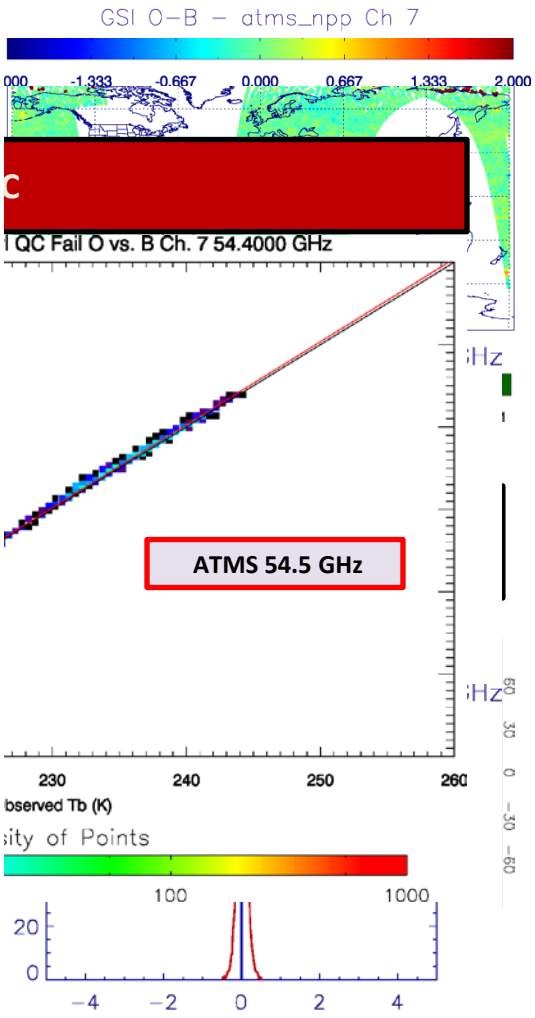
MIIDAPS-based QC Scheme:

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



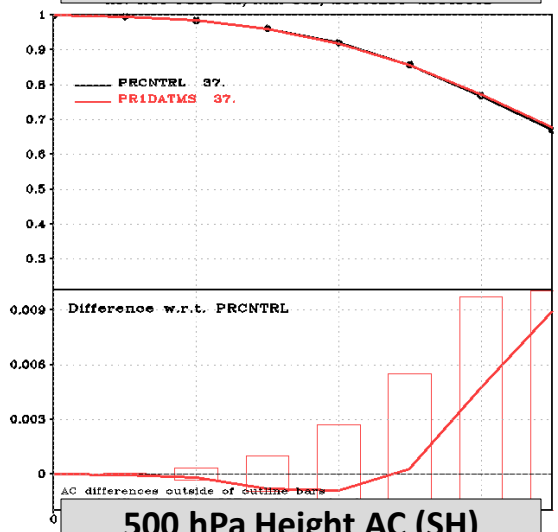


Freq	Prcntrl			Pr1datms		
	O-B	O-A	NObs	O-B	O-A	NObs
23	1.66	1.39	5695	1.92	1.69	7328
31	1.04	0.97	5715	1.55	1.43	7197
50.2	0.94	0.85	5705	1.22	1.10	7489
51.7	0.57	0.50	5715	0.98	0.89	8283
52.8	0.27	0.22	5715	0.36	0.31	8553
53	0.16	0.14	5715	0.26	0.22	9703
54.4	0.13	0.12	8736	0.15	0.13	10165
54.9	0.13	0.12	10299	0.12	0.11	10174
55.5	0.13	0.11	10261	0.13	0.11	10174
57.2	0.17	0.15	10299	0.17	0.15	10174
57.2	0.20	0.19	10299	0.20	0.18	10174
57.2	0.22	0.21	10299	0.22	0.21	10174
57.2	0.32	0.29	10279	0.32	0.28	10149
57.2	0.52	0.41	10292	0.52	0.41	10166
57.2	1.20	0.89	10287	1.14	0.90	10163
88.2	1.88	1.69	5599	2.16	1.98	7311
165	0.87	0.81	4994	0.93	0.85	7109
183	0.85	0.71	5280	0.91	0.76	8142
183	0.91	0.74	5256	0.94	0.78	8288
183	0.95	0.79	5201	0.97	0.82	8347
183	0.99	0.82	5109	0.98	0.84	8337
183	1.01	0.88	4959	1.02	0.89	8063

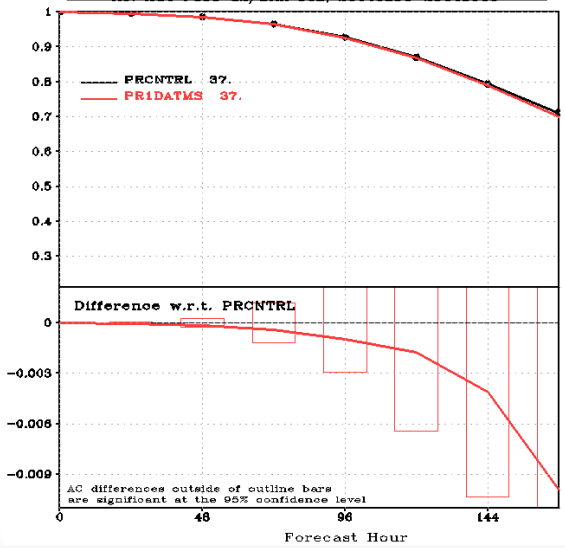


MIIDAPS Forecast Impact

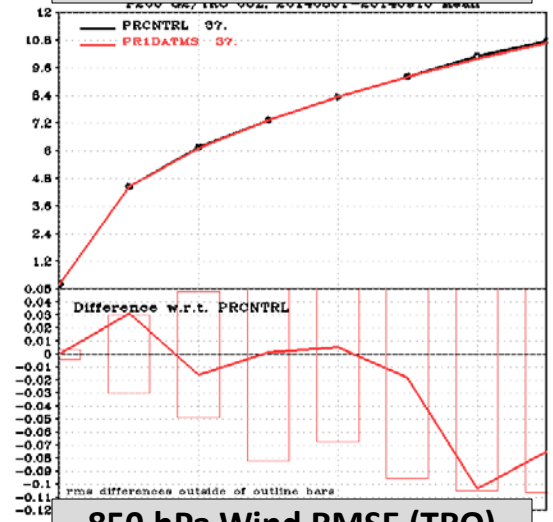
500 hPa Height AC (NH)



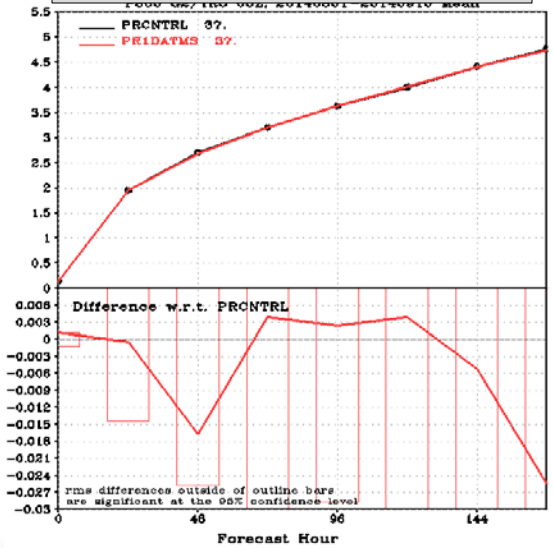
500 hPa Height AC (SH)



200 hPa Wind RMSE (TRO)



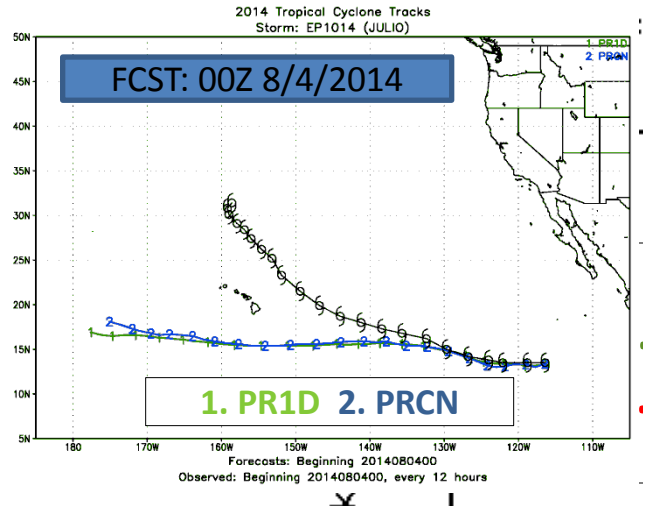
850 hPa Wind RMSE (TRO)

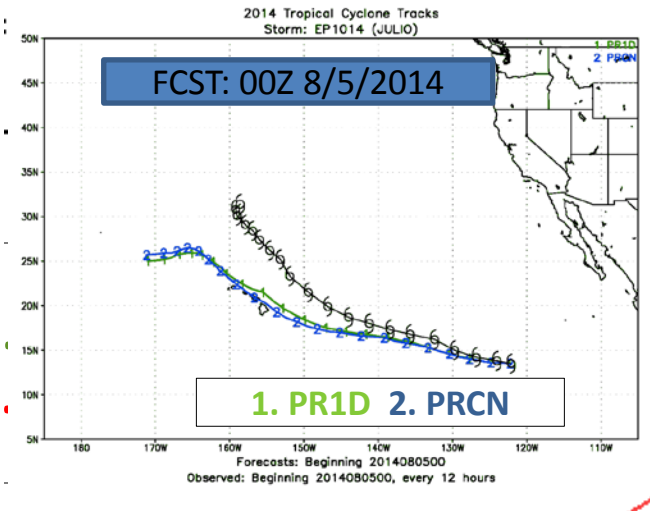


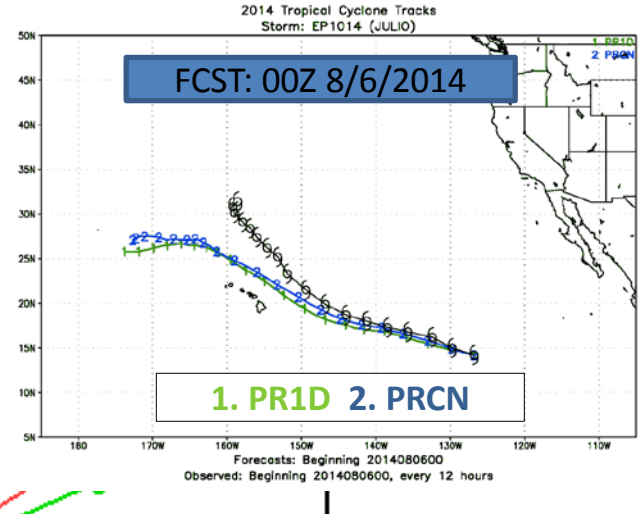
Summary of Impacts

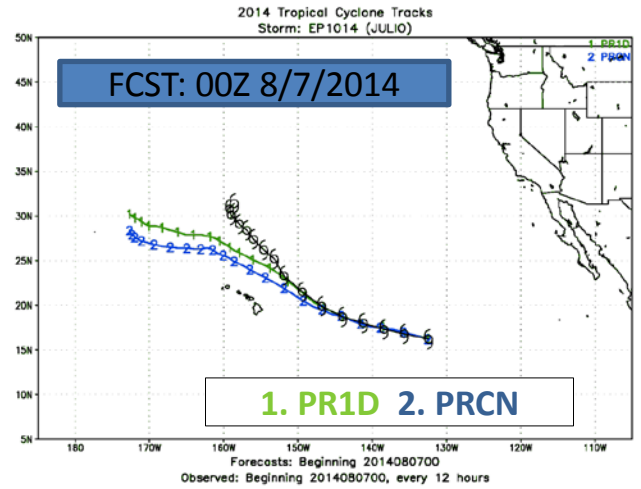
- MIIDAPS applied to just ATMS has neutral impact on traditionally important metrics
- Exploitation of MIIDAPS on all MW, or all MW+IR, will show true utility for QC application
- Further impact expected from utilizing MIIDAPS for hydrometeor and surface characterization, background adjustment

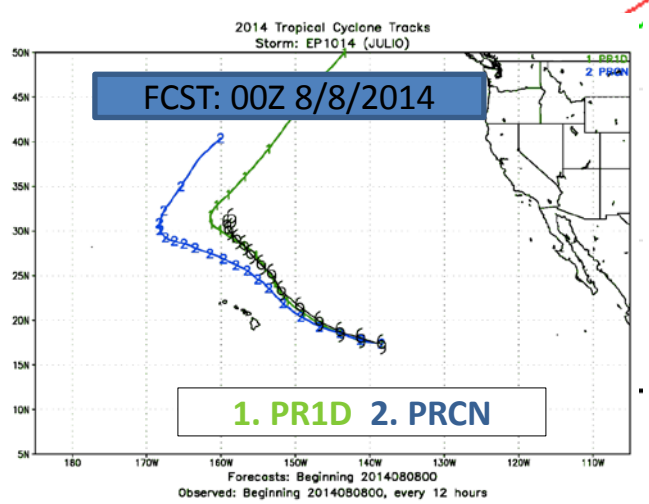
MIIDAPS Forecast Impact

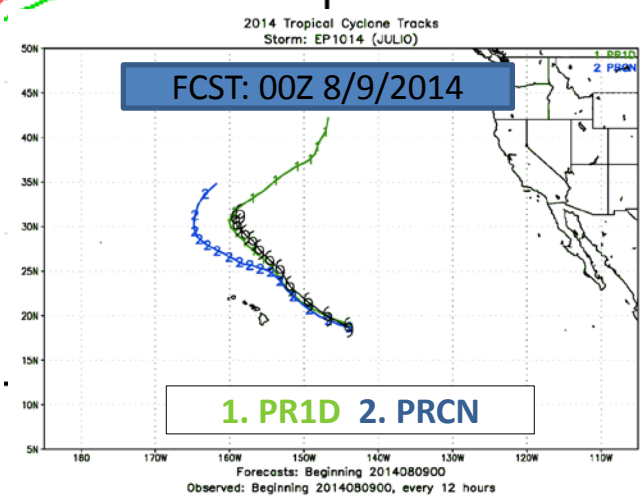












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Future Work

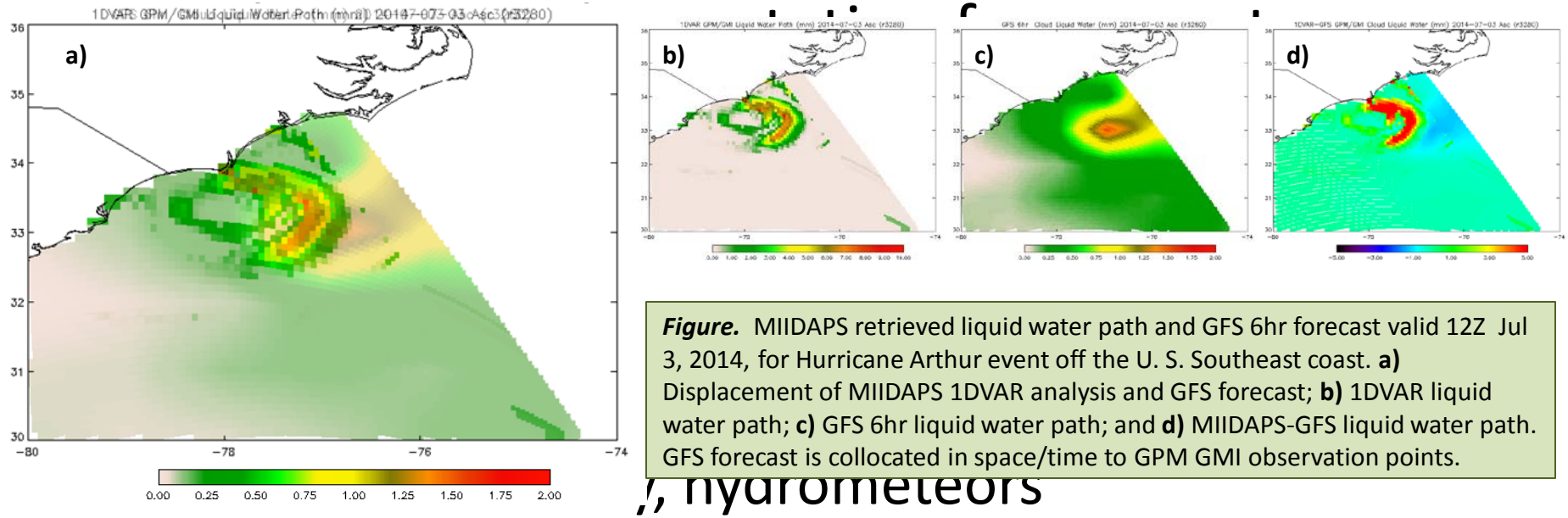

Figure. MIIDAPS retrieved liquid water path and GFS 6hr forecast valid 12Z Jul 3, 2014, for Hurricane Arthur event off the U. S. Southeast coast. **a)** Displacement of MIIDAPS 1DVAR analysis and GFS forecast; **b)** 1DVAR liquid water path; **c)** GFS 6hr liquid water path; and **d)** MIIDAPS-GFS liquid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

,, hydrometeors

- Explore use of 1DVAR analysis as background and all-sky radiance assimilation
  - Resolve displacement errors
  - Linearization