An Update on the AERIoe Retrieval Algorithm

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Presentation at the 2016 Atmospheric System Research (ASR) PI and Atmospheric Radiation Measurement (ARM) Users’ Meeting, Tysons, Virginia, 2-6 May 2016
AERI Thermodynamic Retrieval Background

- AERI observes downwelling infrared radiance at high temporal (30-s) and spectral (1 cm\(^{-1}\)) resolution.

- IR radiance has information on the profile of temperature (T) and humidity (q), as well as cloud properties.

- Current AERI retrieval algorithm (AERIprof) developed in early 2000s, and has limitations:
  - Only able to retrieve T/q in cases with no cloud overhead
  - No uncertainty analysis provided with each retrieval
  - Carbon dioxide concentration fixed to 380 ppm (and unable to change)
  - Fixed fast RT model; unable to change for improved spectroscopy
Sensitivity of Retrieved T Profile to CO₂ Concentration

Impact Using Assumed vs. True CO₂ Profile

Atmospheric CO₂ at Mauna Loa Observatory

Scripps Institution of Oceanography
NOAA Earth System Research Laboratory

March 2015

Night
Day

Night
Day

Solid: CO₂ True vs 377 ppm
Dashed: CO₂ True vs 360 ppm
AERIloe Retrieval Background

- A physical-iterative method (like AERIprof)
- Use the LBLRTM as the forward model
  - Always have latest spectroscopy
  - Can use any trace gas (e.g., CO₂) amounts desired
- Use optimal-estimation framework
  - Propagate uncertainties into retrieved solution
  - Uses prior information (climatology of sonde data) to constrain solution (as retrieval is an ill-posed problem)
- Retrieves cloud properties and thermodynamic profiles simultaneously
  - Developed method to overcome bad first guess
    - Method converges and provides solution over 95% of the time
    - Able to also retrieve trace gas amounts (CO₂, CH₄, N₂O)
- Ultimate goal: To replace AERIprof and MIXCRA
AERIoe Example Profile

- Example from PECAN
  - Ellis, KS on 22 June 2015 at 0600 UTC
- Inputs: AERI radiances, CBH from lidar
AERIoe Example Profile

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• Inputs: AERI radiances, CBH from lidar, middle-and-upper tropospheric T/q from RAP NWP model, surface met
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LES-based OSSE
(Observation System Simulation Experiment)

• Used LES to simulate a convective boundary layer
  – Case is 24 July 2008 (Thijs Heus presentation on Wednesday)

• Simulate AERI observations
  – Compute downwelling IR radiance at 30-s resolution
  – Convolve with AERI instrument function
  – Added random noise

• Apply the PCA-based noise filter
  – Principal components derived from real AERI obs at SGP in July 2015

• Run AERIoe retrieval
  – Use prior dataset derived from SGP radiosondes for July

• Compare retrieved profiles with LES truth profiles
OSSE Results

Ambient Temperature

Potential Temperature ($\theta_v$)

LEO Output

AERlce Retrieval

Altitude [km AGL]

Temperature [C]

Potential Temperature [K]
OSSE Results

Water Vapor Mixing Ratio

Relative Humidity

LES Output

AER|oe Retrieval

Altitude [km AGL]

Altitude [km AGL]

Hour [UTC]

Hour [UTC]

Water Vapor Mixing Ratio [g/kg]

Relative Humidity [%]
AERIoe Results from AWARE

- Computed new prior constraint dataset
- Ran retrieval
AERIoe Results from AWARE

- Uncertainties provided automatically
- Always be careful of retrieved profiles above cloud base
A Challenge at SGP Central Facility

- Oscillations noted in AERI radiance data occasionally
  - Seen in both the v4 AERI and the AERI-01
- Oscillations in radiance result in oscillations in retrieved profiles (esp water vapor)
- Mentor has traced problem to air “leaking” from optical trailer into the AERI front end
- Problem resolved Feb 2016, but need to handle historical data
Possible Approach: Insert a Chimney

SGP’s 60-m tower (with obs at 25-m also)

Chimney

25-m tower as input

$Z=0$

$Z=10$

$Z=21$

$Z=33$

$Z=46$

$Z=61$

$Z=77$

$Z=95$
Summary

• AERIoe algorithm becomes more mature by the day
• One last major modification to make: incorporating MWR brightness temperature observations
  – Improved LWP retrieval over entire dynamic range
  – Excellent constraint on the PWV
• Older version (Release_1_5) was implemented in the ARM Data Management Facility
  – Used to process some examples for LASSO
  – Used to process data from PECAN (in archive)
• New version (Release_2_1) should be provided to ARM by early summer
• Processing is still slow: takes ~2 min per spectrum. However, easily distributed to multiple processors (ARM linux cluster!)