



SCIENCE APPLICATIONS FROM NAST-I MEASUREMENTS: PBL THERMODYNAMIC CHARACTERIZATION AND VARIATION

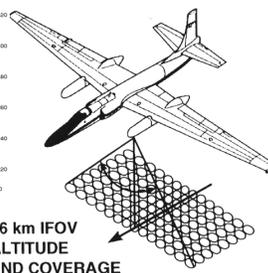
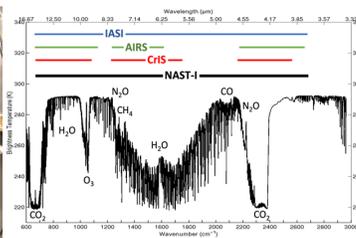
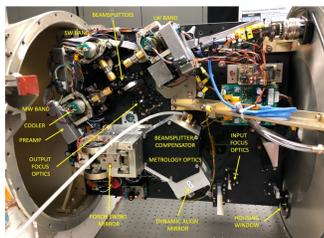


Daniel K. Zhou¹, Hyun-sung Jang², Xu Liu¹, Allen M. Larar¹, Anna M. Noe¹, Rachael Kroodma³, and Antonia Gambacorta³

¹NASA Langley Research Center, Hampton, VA 23681, USA
²Analytical Mechanics Associates, Hampton, VA 23666, USA
³NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

INTRODUCTION & NAST-I INSTRUMENT

The National Airborne Sounder Testbed-Interferometer (NAST-I) suborbital system serves as a spaceborne instrument simulator and pathfinder for future satellite capabilities and airborne science experiments. The NAST-I measurements are made to advance understanding of science critical for weather, climate, chemistry, and radiation applications. NAST-I provides high-spatial linear resolution equal to 13% of the aircraft altitude at nadir, and high-spectral resolution (0.25 cm^{-1}) measurements within the spectral region of $645\text{--}2700 \text{ cm}^{-1}$. NAST-I measurements and corresponding geophysical retrievals and their potential benefits toward improved atmospheric state and composition characterizations needed for air quality, wildfire, and other science applications have been published in many Peer-reviewed papers. NAST-I capabilities could be of particular importance toward enhancing characterization and understanding of the Planetary Boundary Layer (PBL). Initial results of PBL thermodynamic characterization and variation with its time evolution from NAST-I measurements will also be presented.



NADIR 2.6 km IFOV
20 km ALTITUDE
± 23 km GROUND COVERAGE

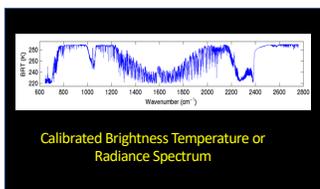
NAST-I Field Campaigns:

- Before AIRS launch (<2002): 9 missions collecting geophysical field state characterization for satellite remote sensing system risk mitigation (sensors and algorithms).
- After AIRS launch (>2002): 13 missions for advanced satellite remote sensor Cal/Val (e.g., Aqua AIRS, MetOp IASI, & SNPP/JPSS CrIS), and airborne science.
- The recent field campaign: FIREX-AQ (August 2019).
- The upcoming field campaign: WH²YMSIE (Oct-Nov 2024).

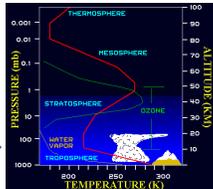
Aircraft Accommodation:

- ER-2 wing super pod & nose cone
- PROTEUS underbelly pod
- WB-57 underbelly pallet.

NAST-I LEVEL 2 DATA PROCESSING



NUMERICAL INVERSION



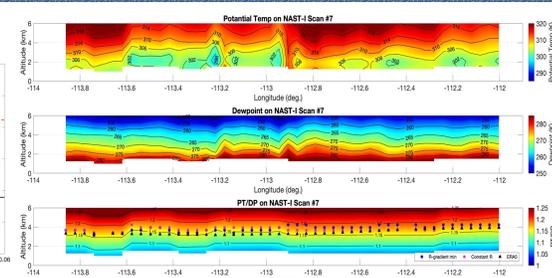
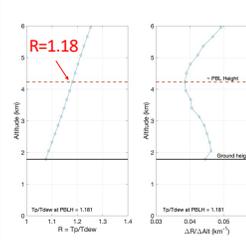
Retrievals under cloudy conditions:

- Atmospheric profile through optically thin cirrus clouds and above optically thick clouds.
- Effective cloud parameters.

Retrievals under clear conditions:

- Surface skin temperature and emissivity.
- Atmospheric temperature and moisture profiles; and atmospheric CO and O₃ profiles.

PBL TOP ESTIMATION

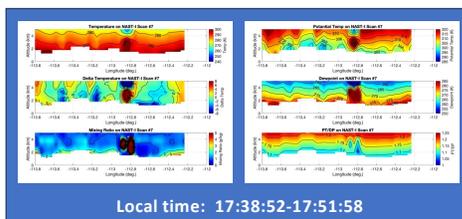
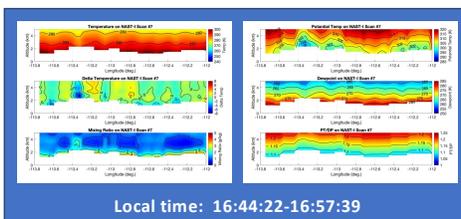
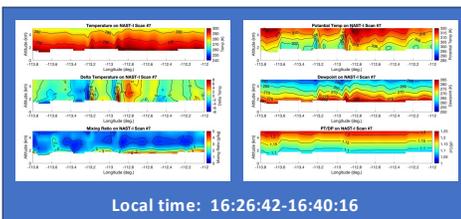


PBL Height at minimum gradient of Tp/Td and a constant of Tp/Td

- The minimum gradient of (Tp/Td) falls around a constant of (Tp/Td) where is at the PBL top.
- PBL top estimated agrees with that from ERA5.
- Note: NAST-I (2.6 km) and ERA5 (~25 km) are at different spatial resolutions.

PBL INFERENCE UNDER EVALUATION WITH FIREX-AQ NAST-I DATA (AUGUST 21, 2019)

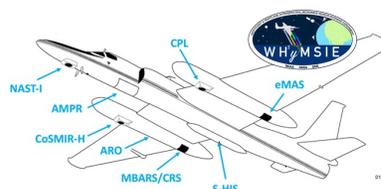
Time evolution of surface skin temperature & PBL temperature and mixing ratio distributions (over Sheridan wildfire location near 34.80° latitude & -112.85° longitude). The PBL thermodynamic parameters are retrieved from NAST-I measurements, and PBL top is estimated. PBLH is affected by the wildfire (near -112.85° long.)



NAST-I TO PARTICIPATE WH²YMSIE FIELD CAMPAIGN THIS FALL

WH²YMSIE (West-coast & Heartland Hyperspectral Microwave Sensor Intensive Experiment) is the very first step forward towards an integrated, intelligent, and affordable PBL observing system of systems.

- To bring together multiple observing nodes – i.e., space, suborbital, and ground – from passive and active sensors to enable a comprehensive and coherent picture of essential PBL thermodynamic variables such as temperature, water vapor, height, and hydrometeors to provide new understanding of the PBL.
- To mature PBL technology, retrieval algorithms, and modeling capabilities.
- NAST-I status: NAST-I performed well in the ER-2 nose cone for the first time in July 2024 (test flights) and is on schedule to be ready for the WH²YMSIE science campaign in Oct/Nov 2024. Below is RH retrieval samples from one of the test flights.



WH²YMSIE ER-2 payload will provide a first-of-its-kind PBL sensor architecture prototype, acting as a testbed for technology and retrieval concepts.

WH²YMSIE ER-2 payload:

1. Conical Scanning Millimeter-wave Imaging Radiometer – Hyperspectral (CoSMIR-H)
2. Microwave Barometric Radar and Sounder (MBARS)
3. Cloud Physics Lidar (CPL)
4. Cloud Radar System (CRS)
5. National Airborne Sounder Testbed – Interferometer (NAST-I)
6. Scanning-High-resolution Interferometer Sounder (S-HIS)
7. Advanced Microwave precipitation Radiometer (AMPR)
8. Enhanced MODIS Airborne Simulator (eMAS)
9. Cloud Radar System (CRS)
10. GPS-RO instrument (ARO)

