High vertically resolved atmospheric state and surface/cloud parameters retrieved with Infrared Atmospheric Sounding Interferometer (IASI)

Daniel K. Zhou[1], Xu Liu[1], Allen M. Larar[1], William L. Smith[2,3] Jonathan P. Taylor[4], Peter Schlüssel[5], L. Larrabee Strow[6], and Stephen A. Mango[7]

[1]NASA Langley Research Center, Hampton, VA, USA; [2]Hampton University, Hampton, VA, USA; [3]University of Wisconsin-Madison, Madison, WI, USA; [4]Met Office, Exeter, Devon, UK; [5]EUMETSAT, Darmstadt, Germany, [6]University of Maryland Baltimore County, Baltimore, MD, USA; [7]NPOESS Integrated Program Office, Silver Spring, MD, USA

Introduction

The Joint Airborne IASI Validation Experiment (JAIVEx) was conducted during April 2007 mainly for validation of the IASI on the MetOp satellite. IASI possesses an ultra-spectral resolution of 0.25 cm-1 and a spectral coverage from 645 to 2760 cm-1. Ultra-spectral resolution infrared spectral radiance obtained from near nadir observations provide atmospheric, surface, and cloud property information. An advanced retrieval algorithm with a fast radiative transfer model, including cloud effects, is used for atmospheric profile and cloud parameter retrieval. This physical inversion scheme has been developed, dealing with cloudy as well as cloud-free radiance observed with ultraspectral infrared sounders, to simultaneously retrieve surface, atmospheric thermodynamic, and cloud microphysical parameters. A fast radiative transfer model, which applies to the cloud-free and/or clouded atmosphere, is used for atmospheric profile and cloud parameter retrieval. A one-dimensional (1-d) variational multi-variable inversion solution is used to improve an iterative background state defined by an eigenvector-regression-retrieval. The solution is iterated in order to account for non-linearity in the 1-d variational solution. It is shown that relatively accurate temperature and moisture retrievals are achieved below optically thin clouds. For optically thick clouds, accurate temperature and moisture profiles down to cloud top level are obtained. For both optically thin and thick cloud situations, the cloud top height can be retrieved with relatively high accuracy (i.e., error < 1 km). Preliminary retrievals of atmospheric soundings, surface properties, and cloud optical/microphysical properties with the IASI observations are obtained and presented. These retrievals will be further inter-compared with those obtained from airborne FTS system, such as the NPOESS Airborne Sounder Testbed – Interferometer (NAST-I), dedicated dropsondes, radiosondes, and ground based Raman Lidar. The capabilities of satellite ultra-spectral sounder such as the IASI are investigated indicating a high vertical structure of atmosphere is retrieved.

Retrieval Methodology (Single FOV under all-sky conditions)

PART A: REGRESSION RETRIEVAL (Zhou et al., 2005)

Using a global training database to diagnose 0-2 cloud layers from radiosonde relative humidity profile:

A single cloud layer is inserted into the input radiosonde profile. Approximate lower level cloud using opaque cloud representation.

Use parameterization of balloon and aircraft cloud microphysical data base to specify cloud effective particle diameter and cloud optical depth:

Different cloud microphysical properties are simulated for same radiosonde using random number generator to specify visible cloud optical depth within a reasonable range. Different habitats can be specified (Hexagonal columns assumed here).

Use LBLRTM/DISORT "lookup table" to specify cloud radiative properties:

Spectral transmittance and reflectance for ice and liquid clouds interpolated from multi-dimensional look-up table based on DISORT multiple scattering calculations.

Compute EOFs and Regressions from cloudy radiance data base:

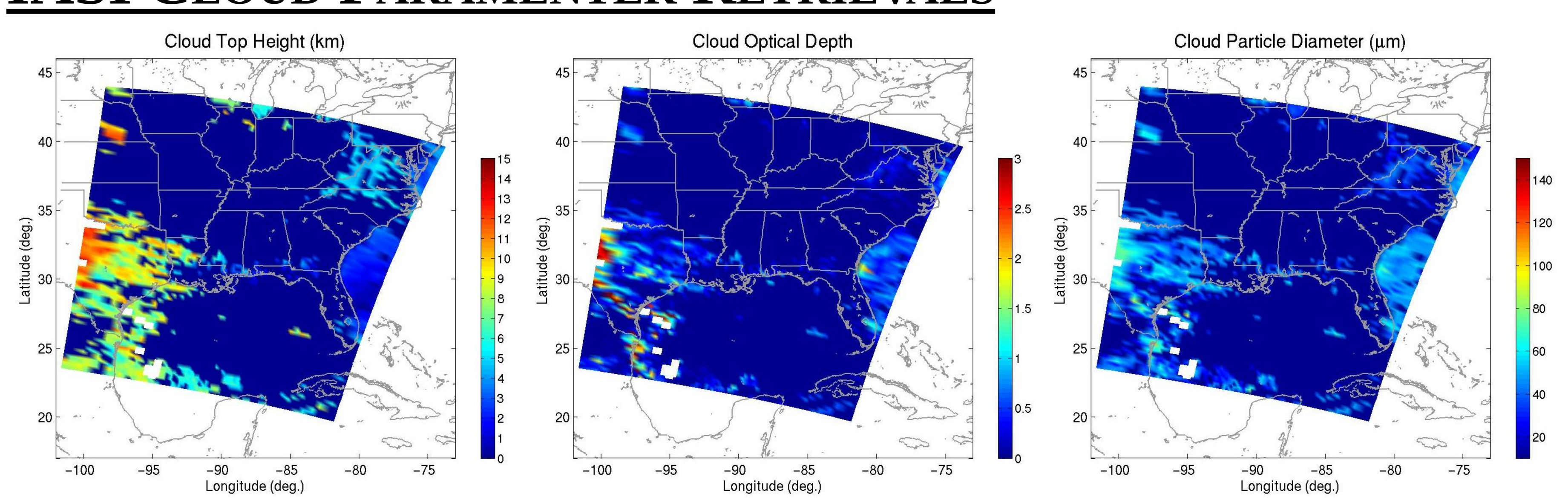
Regress cloud properties, surface & atmospheric profile parameters against radiance EOFs.

PART B: 1-D VAR PHYSICAL RETRIEVAL (Zhou et al., 2007)

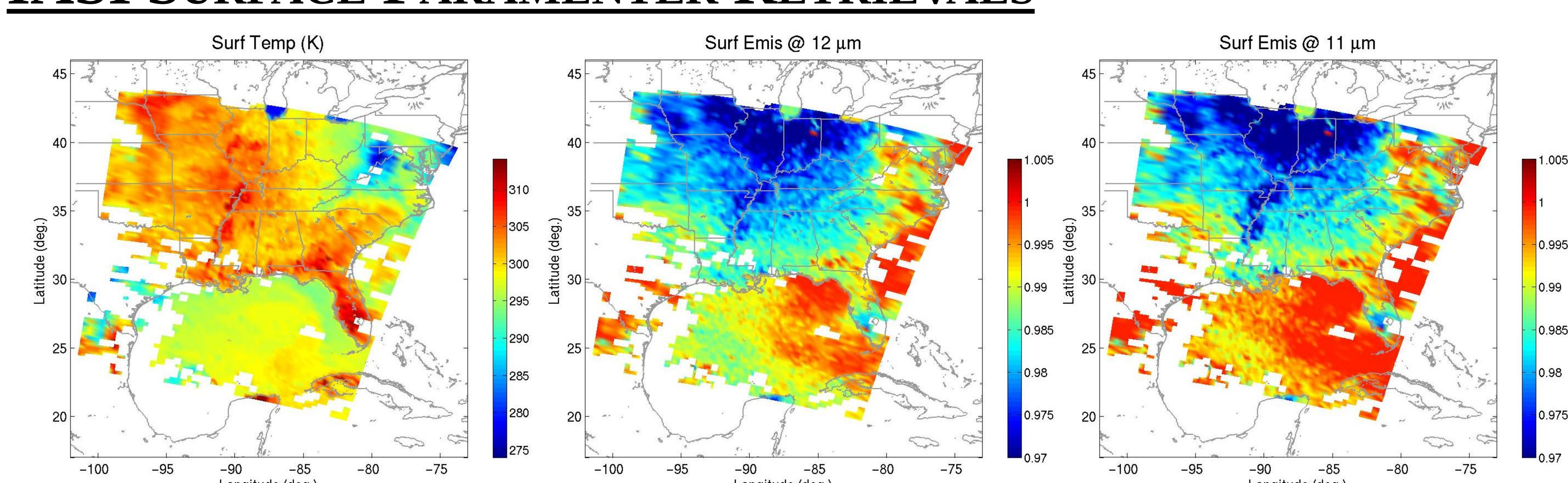
A one dimensional (1-d) variational solution with the regularization algorithm or the minimum information method, is chosen for physical retrieval methodology which uses the regression solution as the initial guess.

Cloud microphysical parameters, namely effective particle diameter and visible optical thickness, are further refined with the radiances observed within the 10.4 μm to 12.5 μm window region.

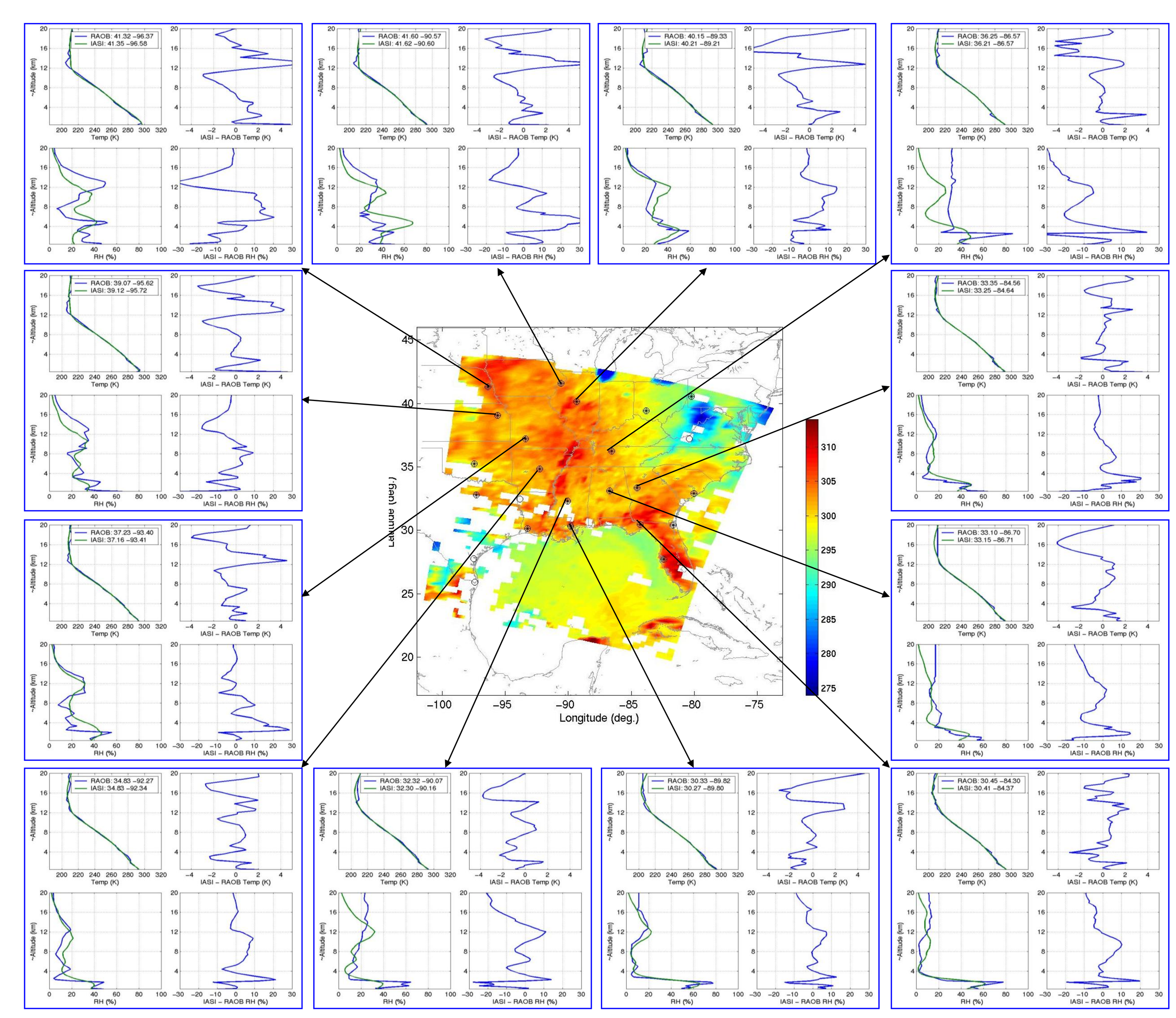
IASI Cloud Paramenter Retrievals



IASI Surface Paramenter Retrievals

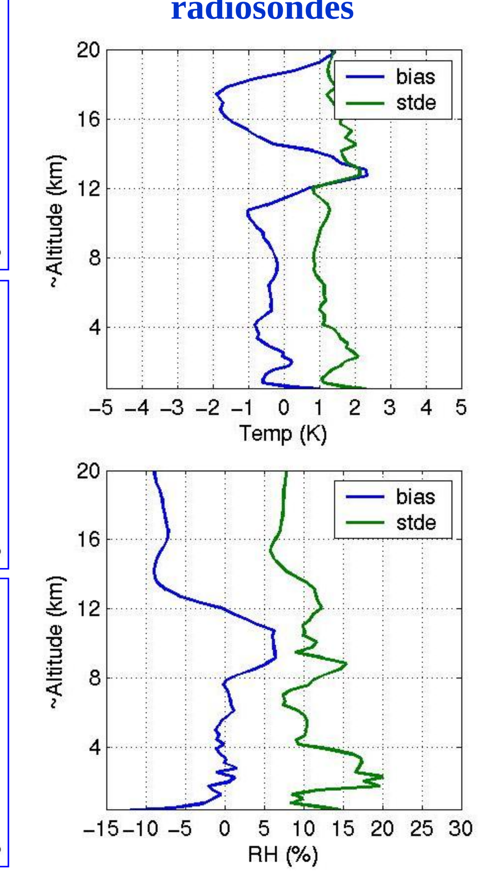


IASI Retrieval vs. Radiosonde



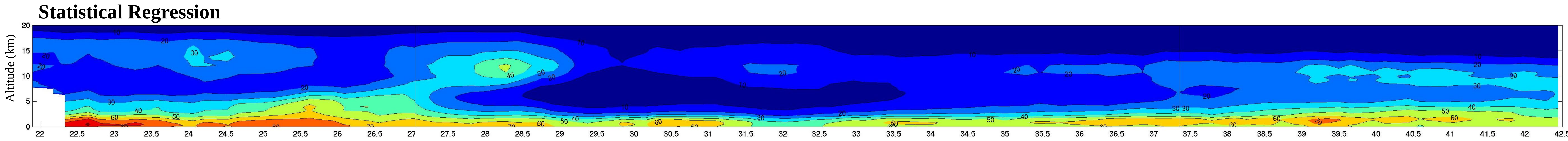
Note:
1200 UTC = 0700 Local
1545 UTC = 1045 Local

Radiosonde and IASI retrieval comparison and statistical profiles over 20 radiosondes

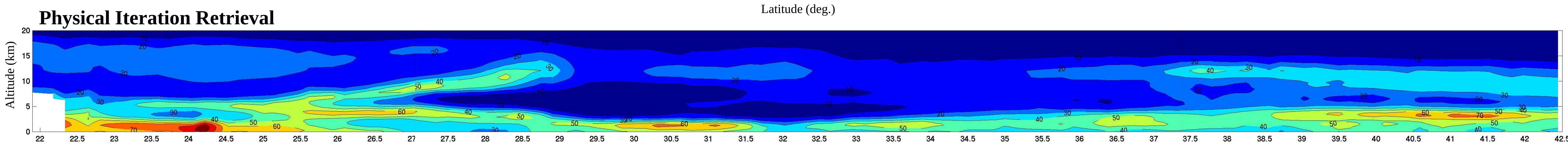


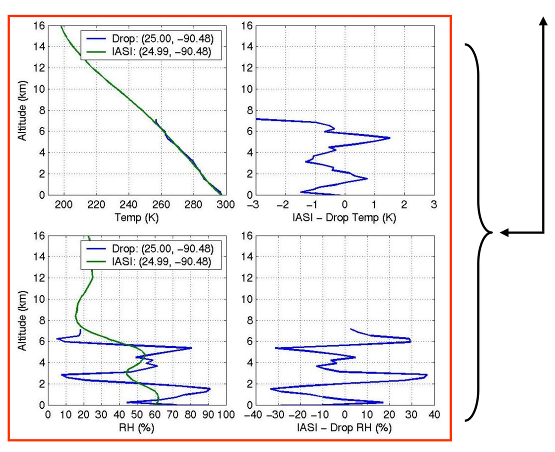
High Vertically resolved Relative Humidity

Statistical Regression

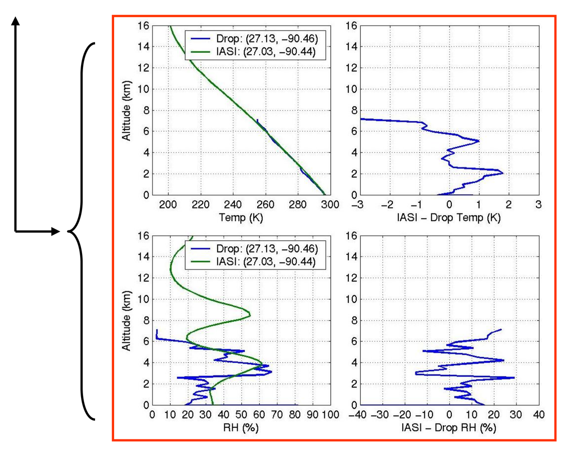


Physical Iteration Retrieval

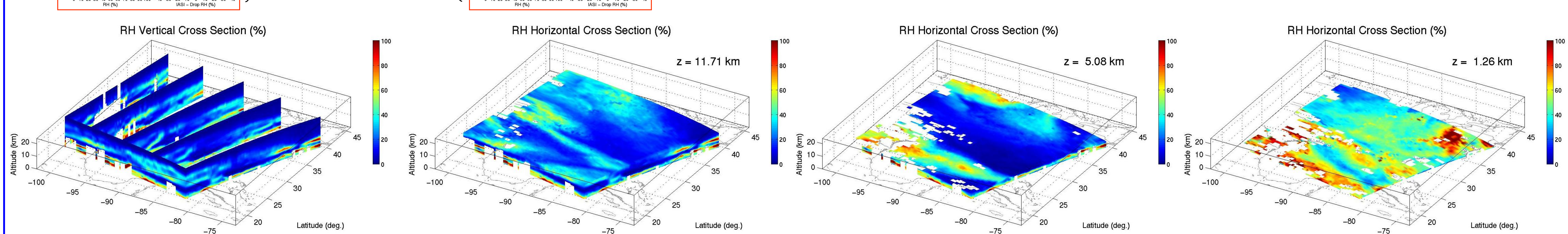




Validation with coincident dropsondes from location-to-location.



The retrieval improvement based on the EOF statistical regression through physical iteration is only contributed by IASI measurements as the minimum information methodology is used. A high resolution atmospheric structure is very well captured by IASI measurements (retrievals); not only in the troposphere but also in the boundary layer.



Summary and Future Work

A State-of-the-art retrieval algorithm dealing with all-weather conditions has been applied to satellite instruments retrieving cloud/surface and atmospheric parameters with a "higher" spatial resolution (single field-of-view). First of many case studies of IASI (29 April 2007) indicate that atmospheric conditions were captured coherently; and IASI retrieval comparison with radiosondes is very encouraging. Excellent agreement between IASI retrieval and dropsondes is obtained showing that atmospheric spatial variation is well captured by IASI measurements. This work has laid a foundation for some critical studies such as retrieval algorithm refinery, satellite remote instrument validation and inter-comparison, and risk reduction study for future instrument development.