GIFTS-IOMI Clear Sky Forward Model

- Status
  - Line-by-line Model
  - Fast Model
- Future Plans
  - Line-by-line Model
  - Fast Model

Definition of terms:

Input parameters : $X = p, T, w, o$

Forward (Radiance) model : $R = f(p, T, w, A), \quad A = g(p, w, o)$

Tangent Linear (TL) model : $dR = \frac{\partial f}{\partial p} dp + \frac{\partial f}{\partial T} dT + \frac{\partial f}{\partial w} dw + \frac{\partial f}{\partial A} dA$

Adjoints (transpose of TL model) : $d^* p = \frac{\partial f}{\partial p} d^* R, \quad d^* T = \frac{\partial f}{\partial T} d^* R$ etc ...

Jacobian : $\frac{\partial R_n}{\partial X_i}$

Monochromatic absorption and radiative transfer algorithms:

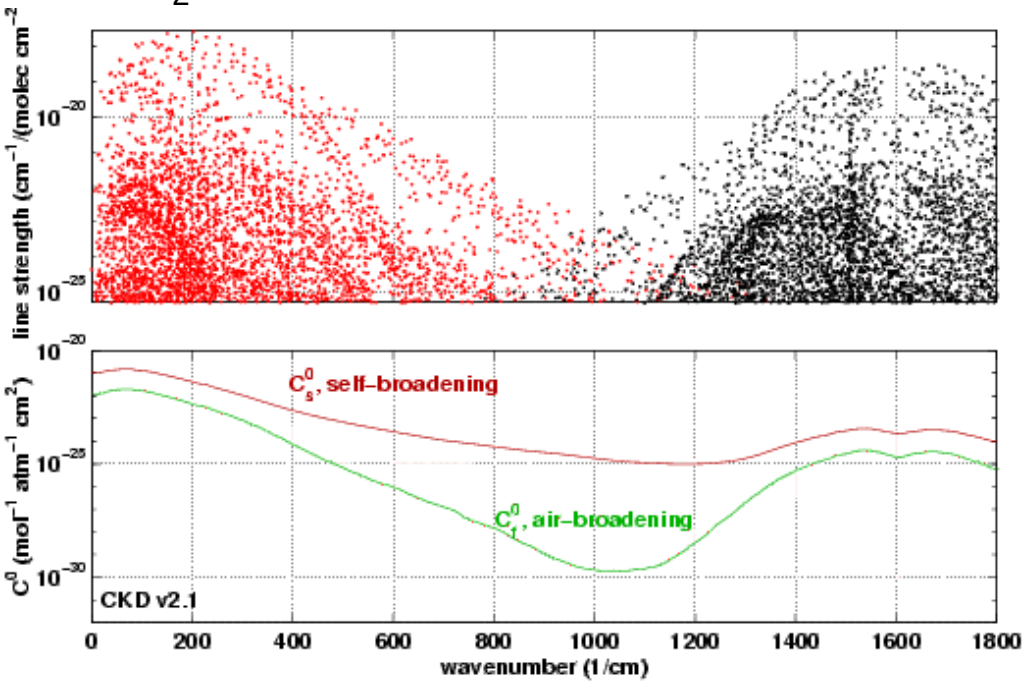
- LBLRTM: Line-by-line Radiative Transfer Model
- kCARTA: k Compressed Atmospheric Radiative Transfer Algorithm

Fast Model Approaches:

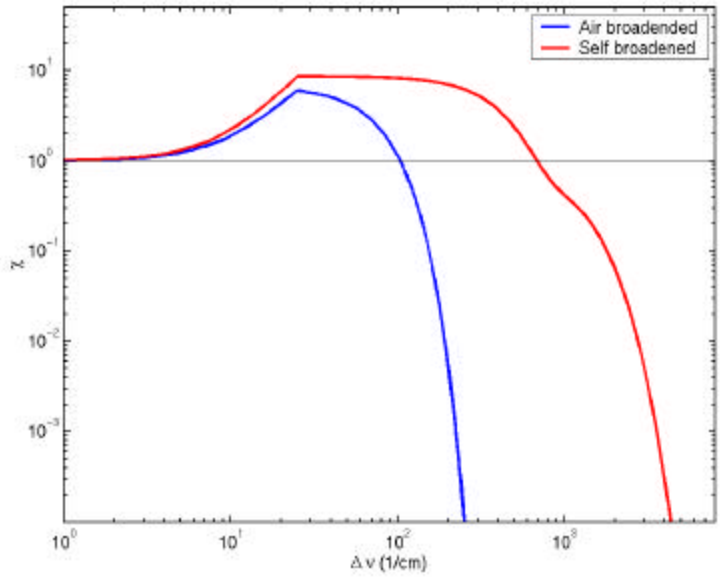
- PLOD: Pressure Layer Optical Depth
- OPTRAN: Optical Path Transmittance algorithm
- OSS: Optimal Spectral Sampling

Water vapor absorption modeling

H_2O lines and continuum coefficients



CKDv0 χ-functions



$$k(\nu) \propto \sum_{\text{all lines},i} k_{\text{local}}(\nu_i, \nu) + \underbrace{\rho_{H_2O}\{\rho_{H_2O} C_s^0(\nu, T) + \rho_{air} C_f^0(\nu)\}}_{\text{continuum}}$$

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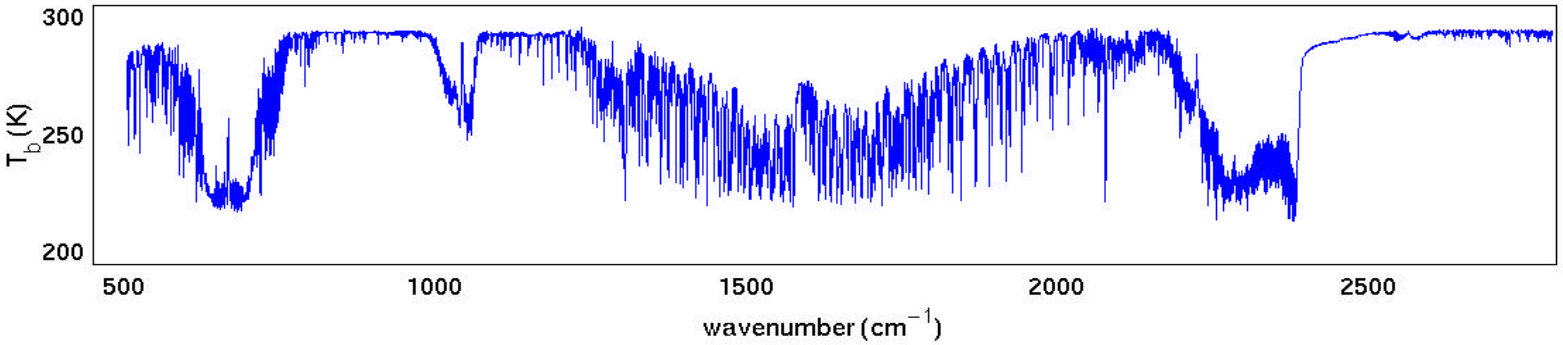
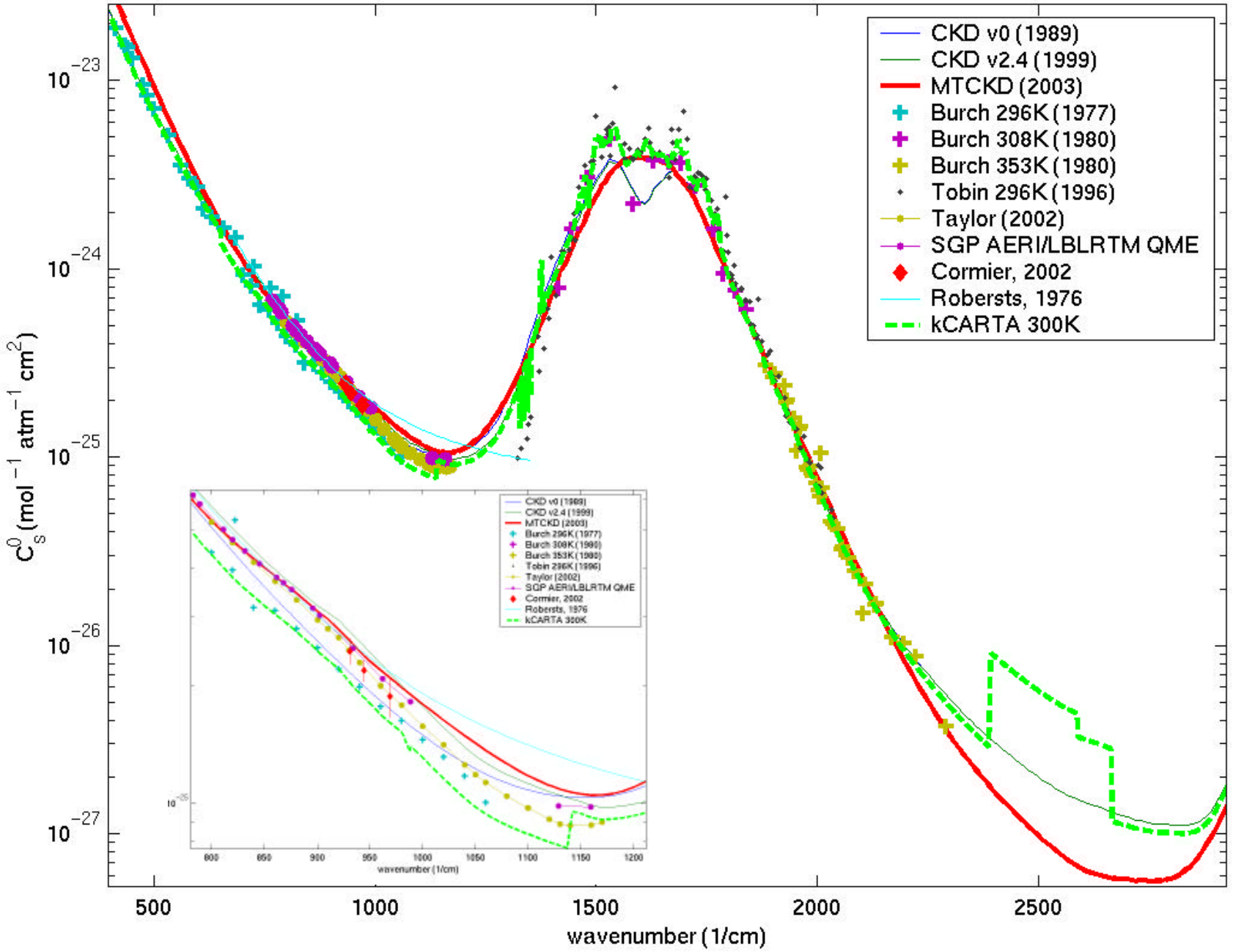
recent line-by-line development efforts. LBLRTM and kCARTA



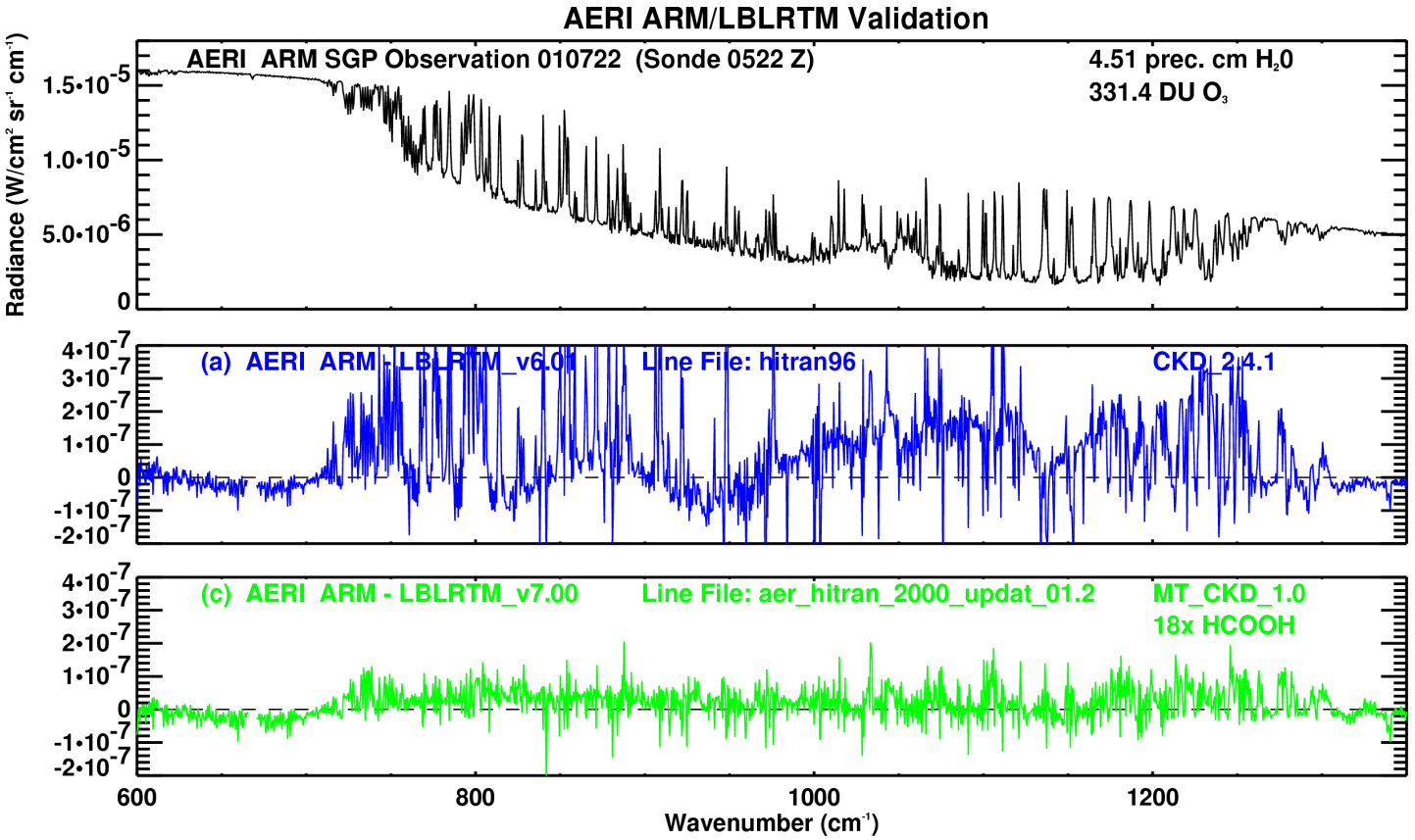
- ARM Site Atmospheric State Best Estimate products
- The AERI / LBLRTM QME
    - longwave window water vapor continuum
- MTCKD v1.0 continuum module
    - H_2O
    - 15µm CO_2
- AIRS obs-calcs
    - non-Local Thermodynamic Equilibrium
    - CO2 line-mixing at 4.3µm
    - upper level water channels and the water vapor continuum
    - 710-720 1/cm

Self Broadened Water Vapor Continuum



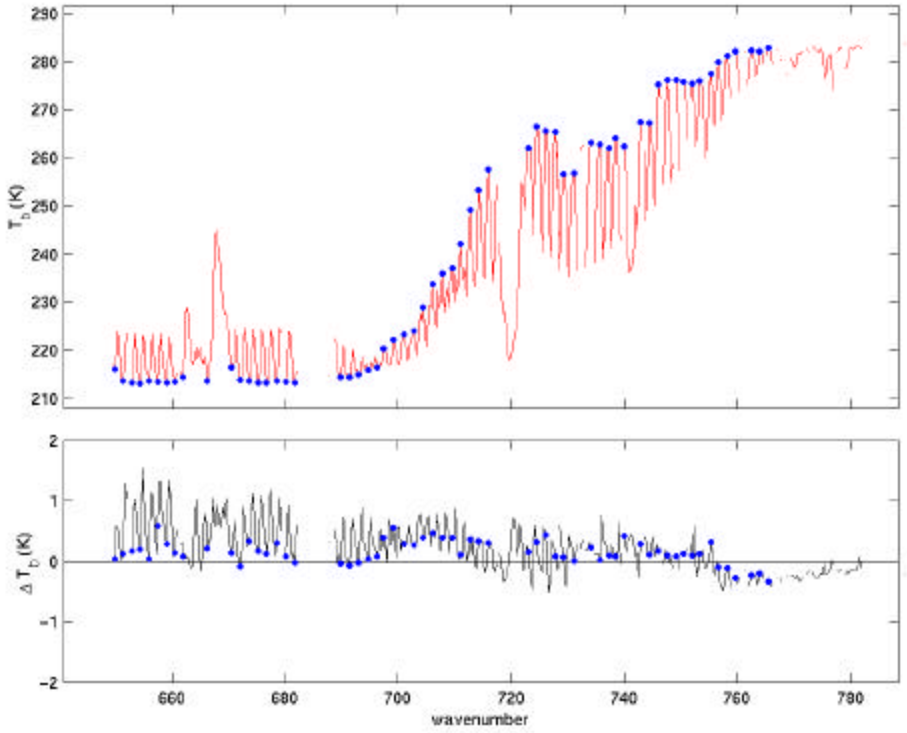
AERI (downwelling at surface) obs-calc

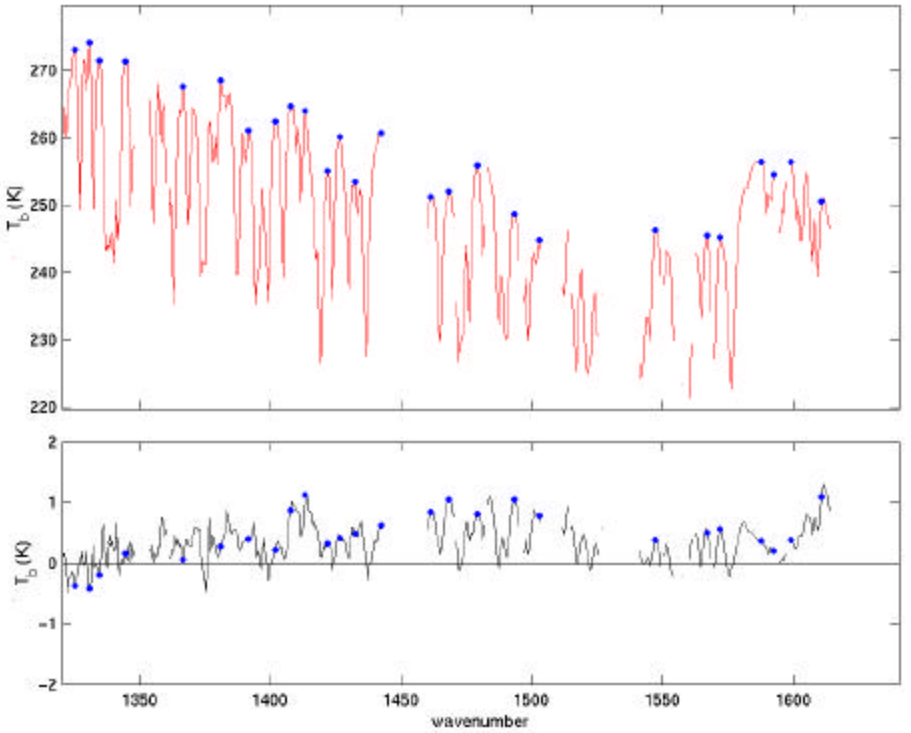
SGP ARM site, 22 July 2001, clear sky, LBLRTM



AIRS (upwelling at TOA) obs-calcs

SGP ARM site, Sep ‘02 to Feb ‘03, night, ~clear sky, kCARTA (Dec ‘02 Delivery)





PLOD

- current UW effort
- Polychromatic regression based model with fixed pressure levels following UMBC approach, but currently with LBLRTM physics
- Status:
  - "task0" is finished
  - Model is characterized, but performance is sub-par. Why ?
  - Regressions using SVDs and optical depth weighting
  - Incorporating kCARTA
  - Incorporating Adjoint and Tangent Linear modules

OPTRAN

- NOAA effort
- Polychromatic regression based model with fixed optical depth levels, currently with LBLRTM physics. Includes adjoint and tangent linear modules.
- Status:
  - GIFTS spectral parameters provided to NOAA
  - model built for GIFTS will be available in a few months

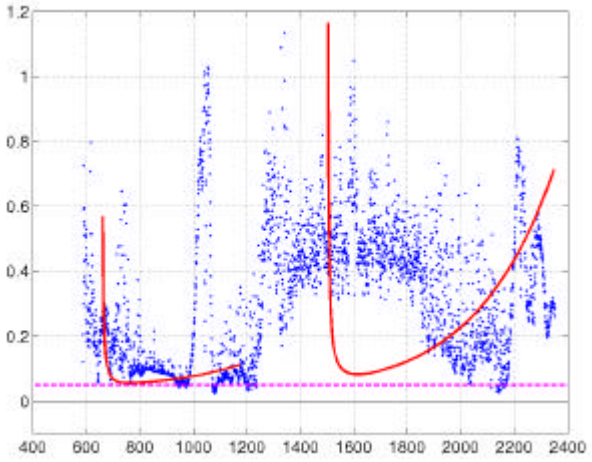
OSS

- AER, Inc. effort
- New approach using linear combination of selected monochromatic frequencies to represent channel radiances. LBLRTM based.
- A portion of the algorithm is patented.
- Has advantages due to the use of real (monochromatic) transmittances.
- Status:
  - gaining experience with a NASTI model
  - considering obtaining a model for GIFTS

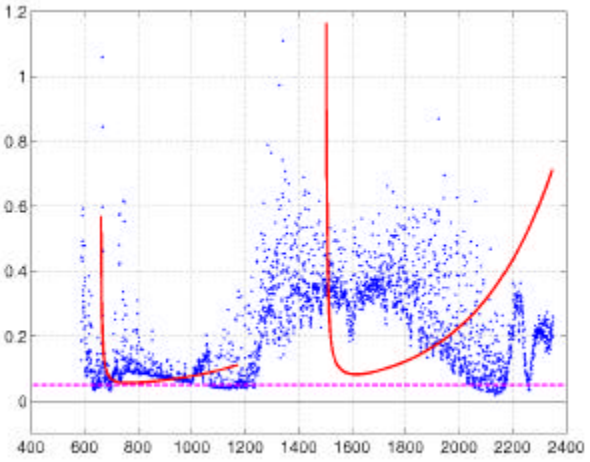
Dependent Set Statistics: RMS(LBL-FM)

------- GIFTS NeDT@296K
------- OSS RMS upper limit*

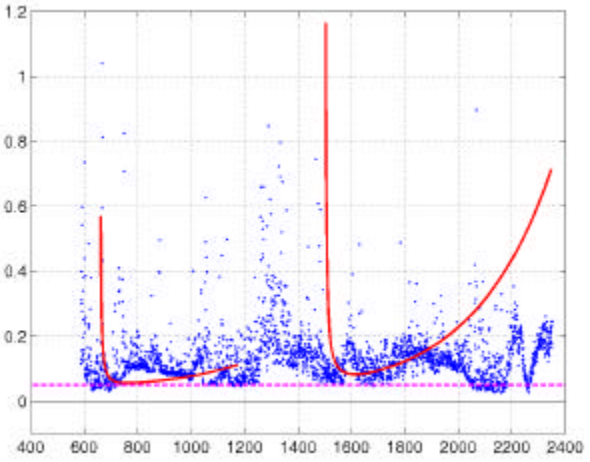
heritage model



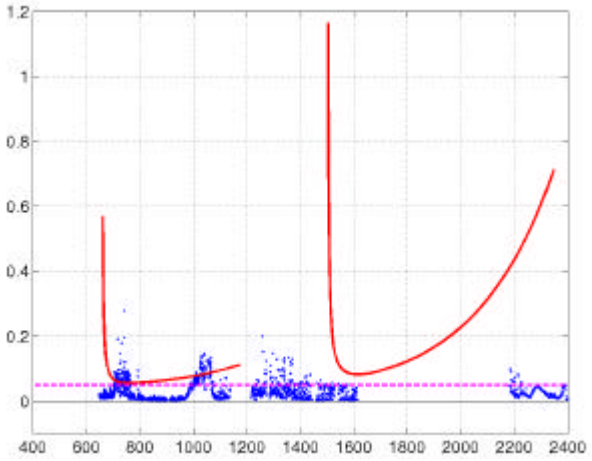
MURI version



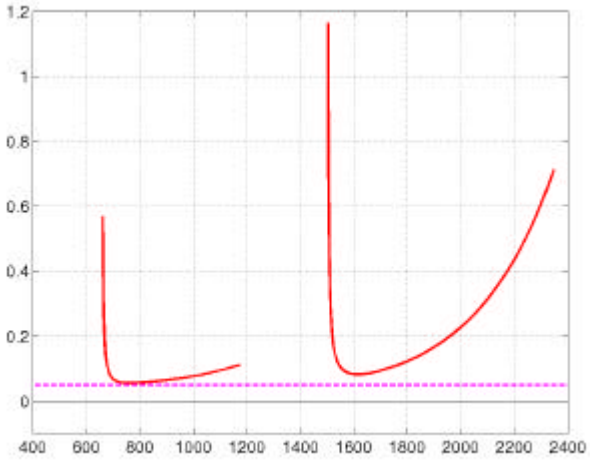
MURI model w/ OD weighted SVD



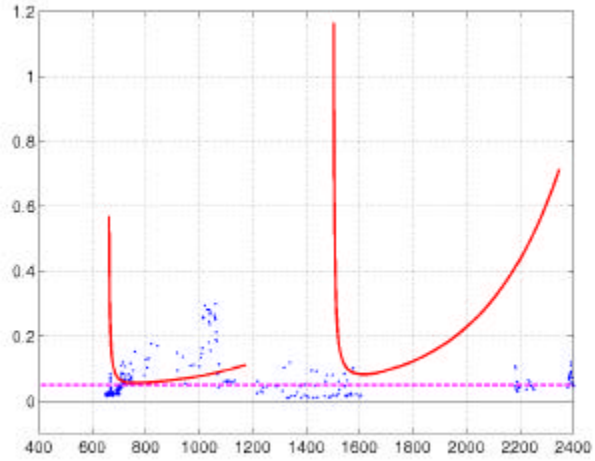
AIRS model c/o L. Strow, UMBC



OSS model c/o Xu Liu, AER, Inc.



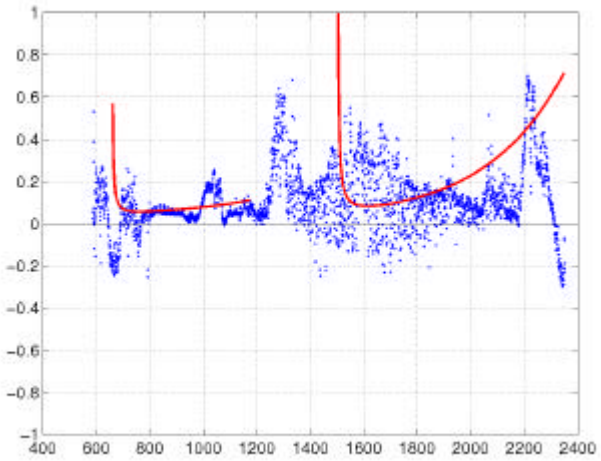
OPTRAN, AIRS 281 channel set c/o PVD



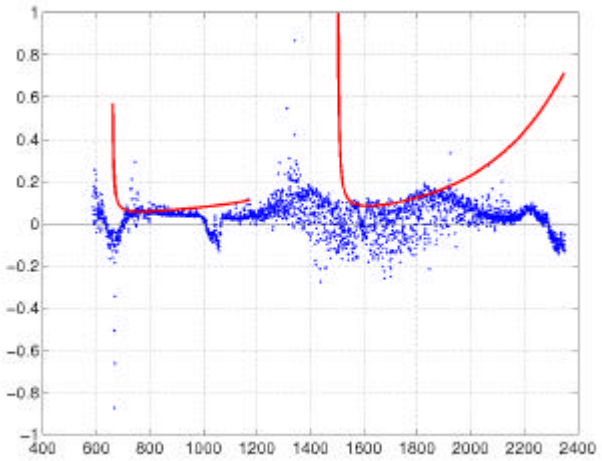
Dependent Set Statistics: Mean(LBL-FM)

------- GIFTS NeDT@296K

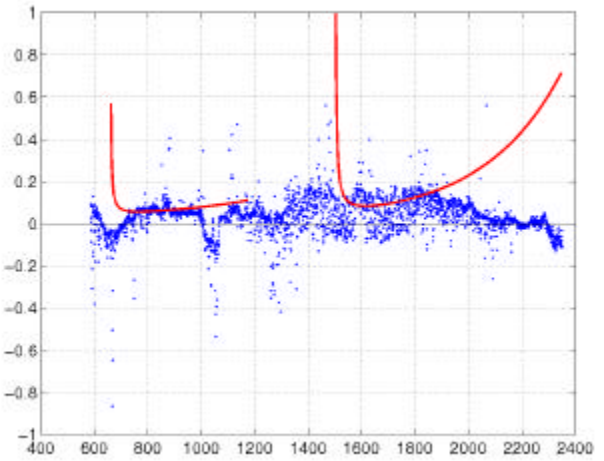
heritage model



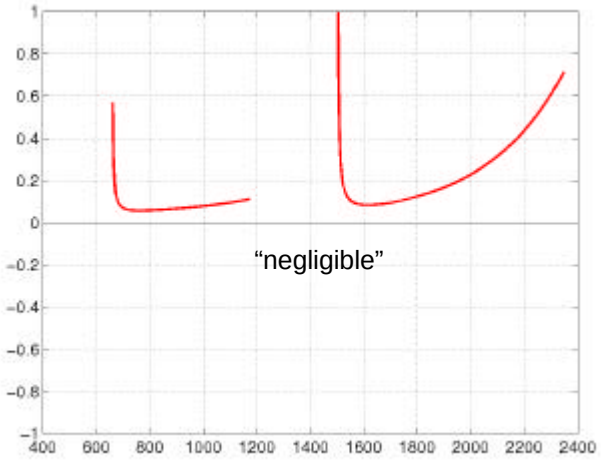
MURI version



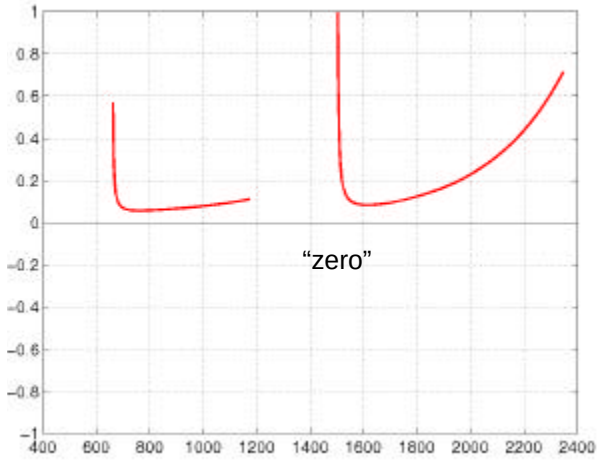
MURI model w/ OD weighted SVD



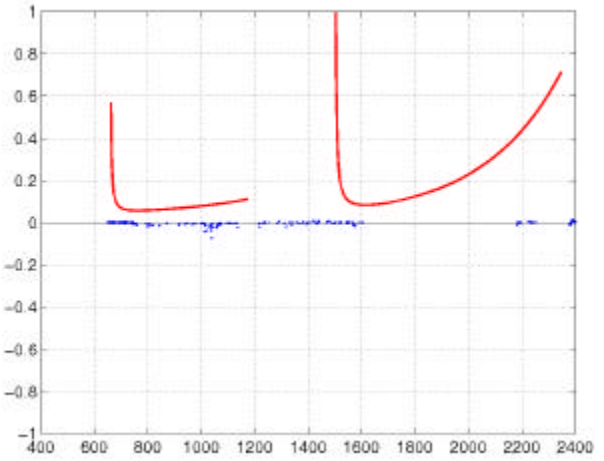
AIRS model c/o L. Strow, UMBC



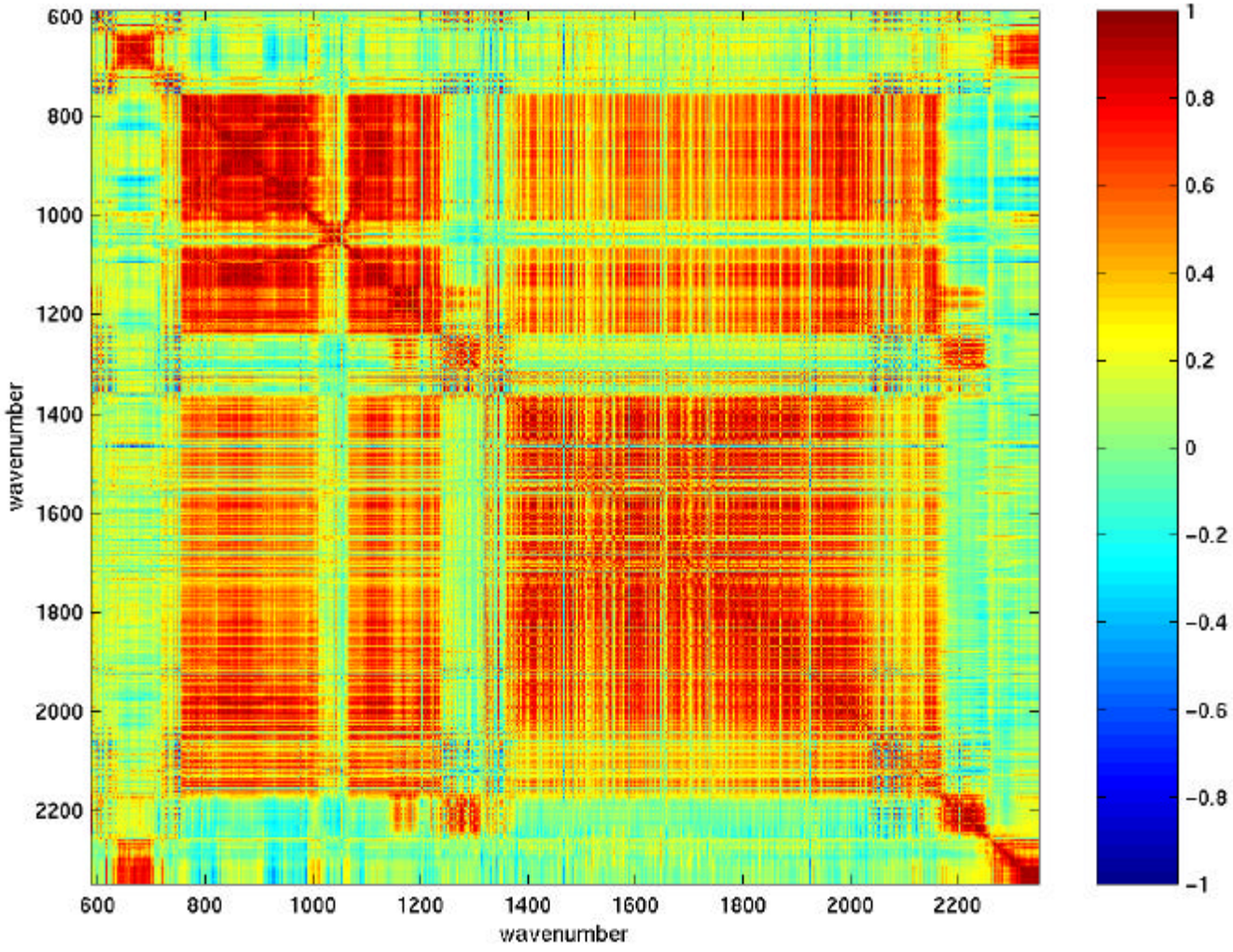
OSS model c/o Xu Liu, AER, Inc.



OPTRAN, AIRS 281 channel set c/o PVD



Spectral correlation (LBL-FM), GIFTS Model, SVD w/ OD weighting



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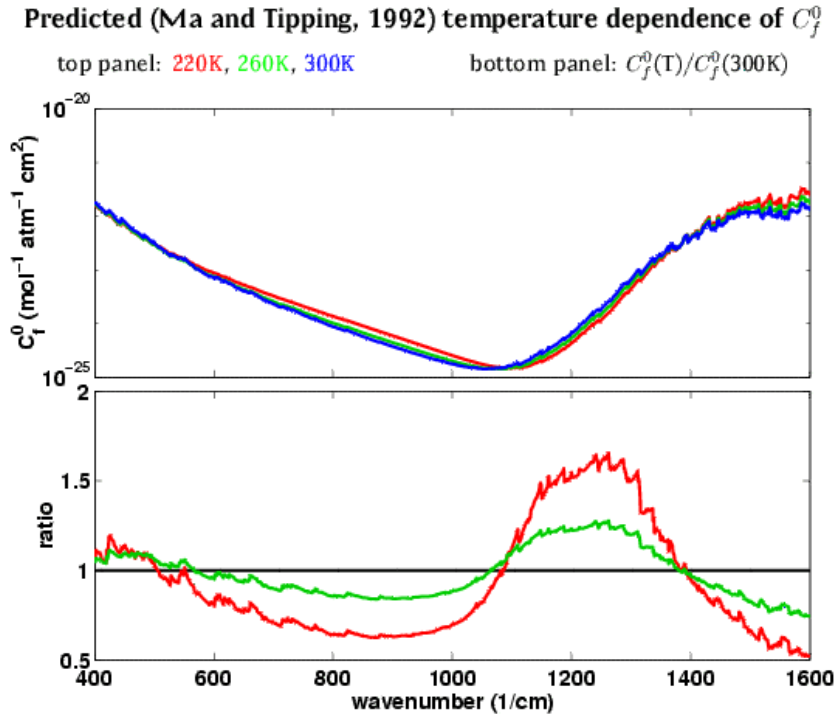
Line-by-Line Model. Future Plans

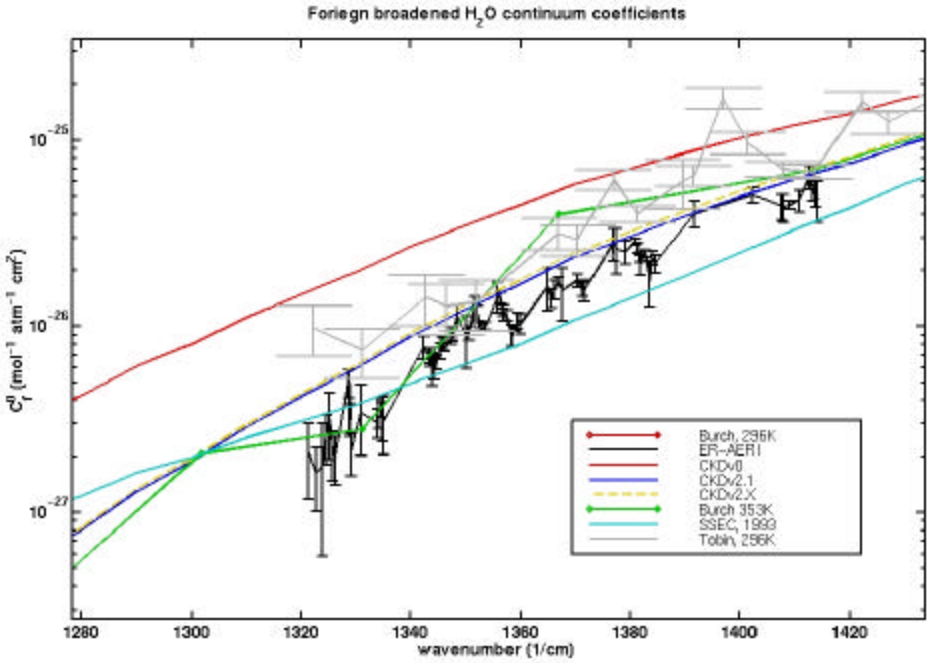
With the exception of a few spectral regions/issues, the line-by-line models kCARTA and LBLRTM are "converging" in general. Based on analysis of the highest quality validation cases, most spectral regions show absolute accuracy at or below the ~0.5 K level.

Remaining issues/efforts:

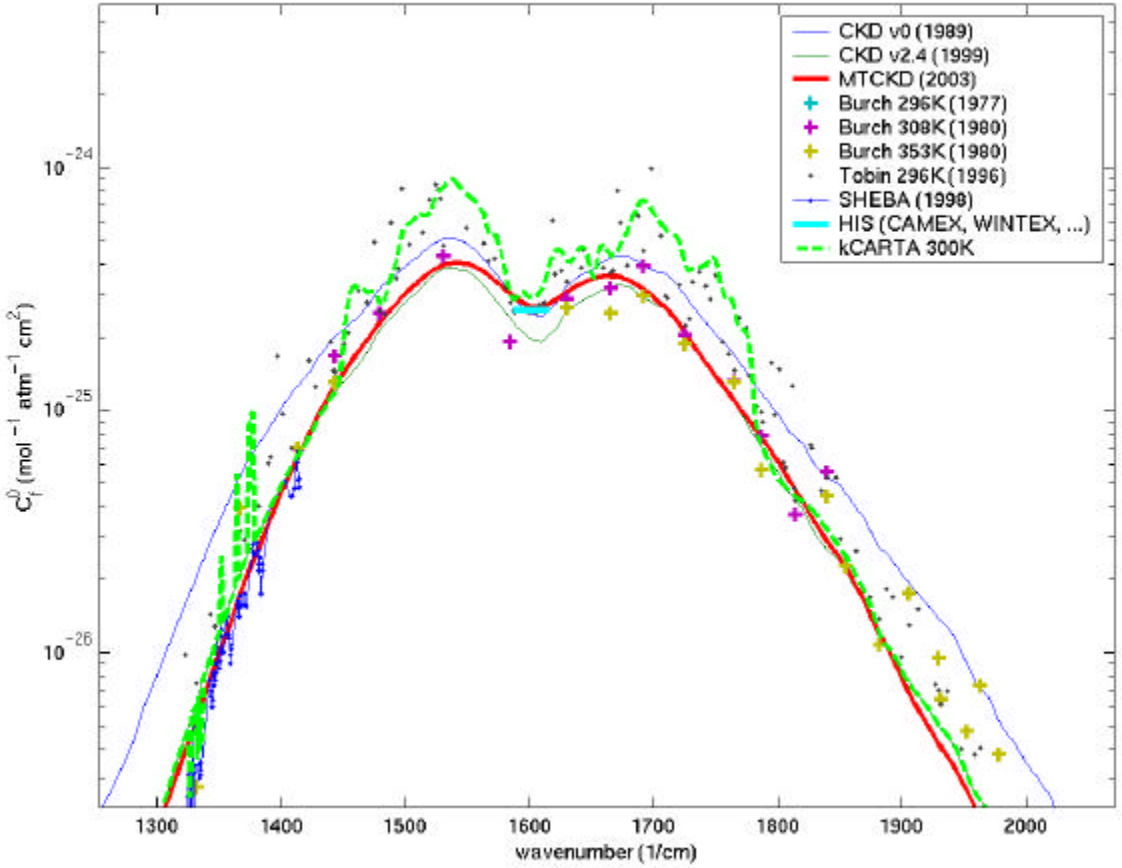
- Produce a "ground-up" estimate of line-by-line model errors
- Investigate temperature dependence of foreign broadened water vapor continuum
- Evaluate uncertainty of upper level water vapor "truth", and the nature of the 1400-1800 1/cm water vapor continuum and near wing lineshape
- Intercompare LBLRTM and kCARTA approaches to CO2 15μm lineshape
- Further validation of LBLRTM with upwelling TOA data (e.g. AIRS) and further validation of kCARTA with downwelling surface (e.g. AERI) data.
- Evaluate need for non-LTE in GIFTS model
- Investigate 710-720 1/cm obs-calcs

Temperature Dependence of C_f^0





Biggest uncertainty wrt upper level water vapor forward model is knowledge and parameterization of the foreign broadened water vapor continuum component of the absorption (C_f^0). For upper level water channels, the forward model is most certain at ~ 1587 1/cm, where a convergence of measurements and models of C_f^0 exists. (CKDv2.4 is/was known to be in error in this region and has since been fixed.) "On-line" channels, which sense highest in the atmosphere, also have higher certainty because contribution from C_f^0 is small for these channels.



Fast Model. Future Plans

- UW PLOD model
  - Solve our accuracy problem
  - Finish Adjoint, TL, and jacobian modules
  - Re-make model with kCARTA and new dependent set profiles (UMBC 48 or UKMET 52)
  - Allow non-unit emissivity and add surface reflectance terms
  - Break-out other trace gases. CO, CH_4, CO_2, …
- Obtain and gain experience with OPTRAN model from NOAA
- Obtain OSS model from AER (?)
- Evaluate PLOD vs. OPTRAN vs. OSS


The End
Thank You