Aerosols, Dust and High Spectral Resolution Remote Sensing

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Goals and challenges

<u>MAIN GOALS</u>:

- **establish a framework for the development of a new physically-based treatment of mineral dust for IR hyperspectral remote sensing**

- **based on this framework, analyze NAST-I aircraft spectra acquired over the East China Sea region during Spring of 2001 to identify the spectral radiative signature of Asian dust**

<u>MAIN CHALLENGES</u>:

a common "look-up table" approach used for aerosol retrievals from narrow-band sensors (e.g., MODIS) will not work for high spectral resolution observations in the IR

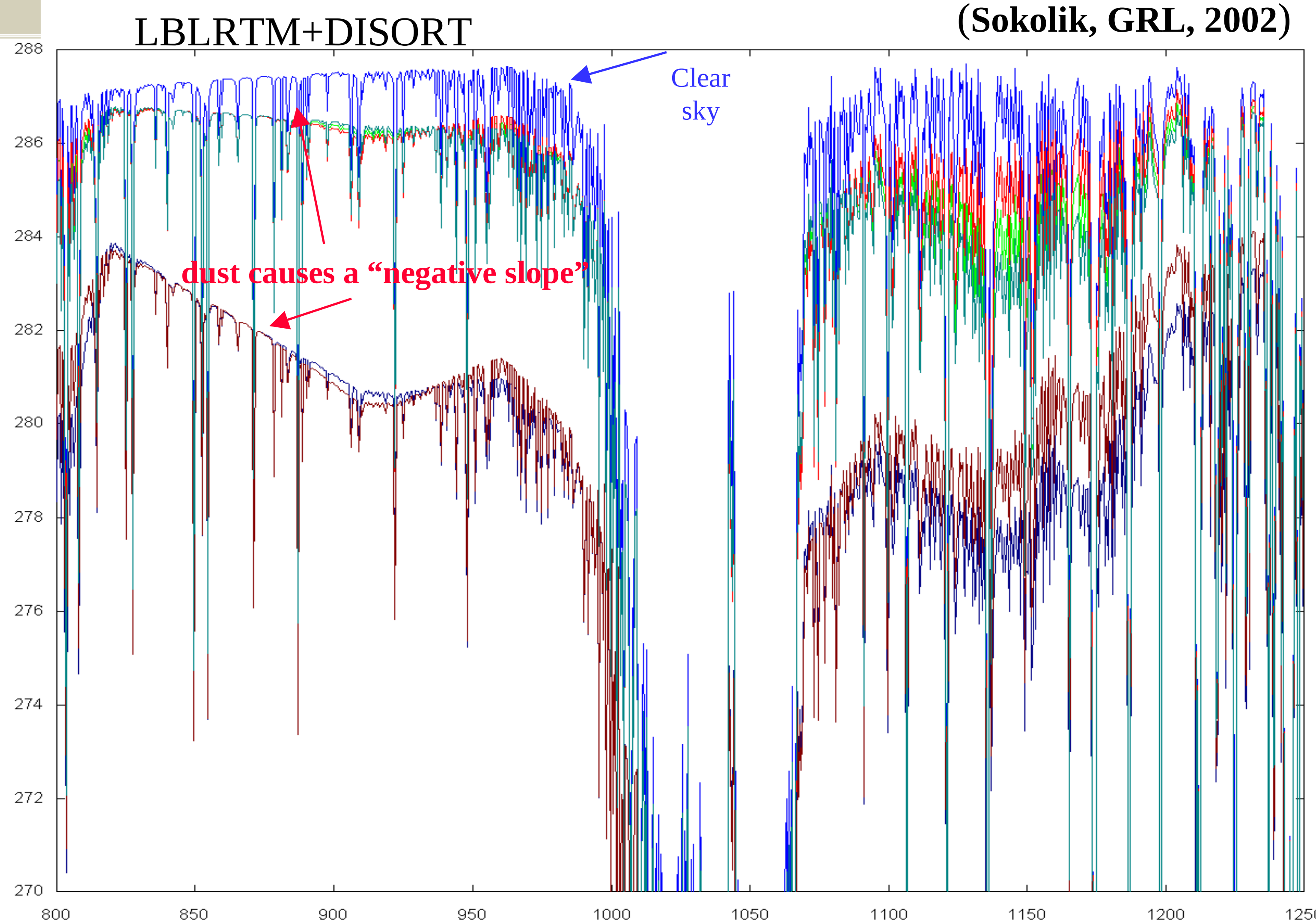
⇩

A need for new conceptual approaches

Effect of the dust mixture and loading on brightness temperature

(US 1976 Standard Atmosphere, observation at 100 km, averaging $\Delta\nu = 0.5\ cm^{-1}$, dust in the lowest 2.5 km)

(Sokolik, GRL, 2002)



YEAR 1 ACTIVITIES

***Development of new aerosol models*:**

Developed and tested new high resolution optical models of Asian dust and several individual aerosol species. The models were incorporated into a new database called HROMAA (High Resolution Optical Models of Atmospheric Aerosols) available online to the MURI Team: http://irina.colorado.edu/HROMAA/

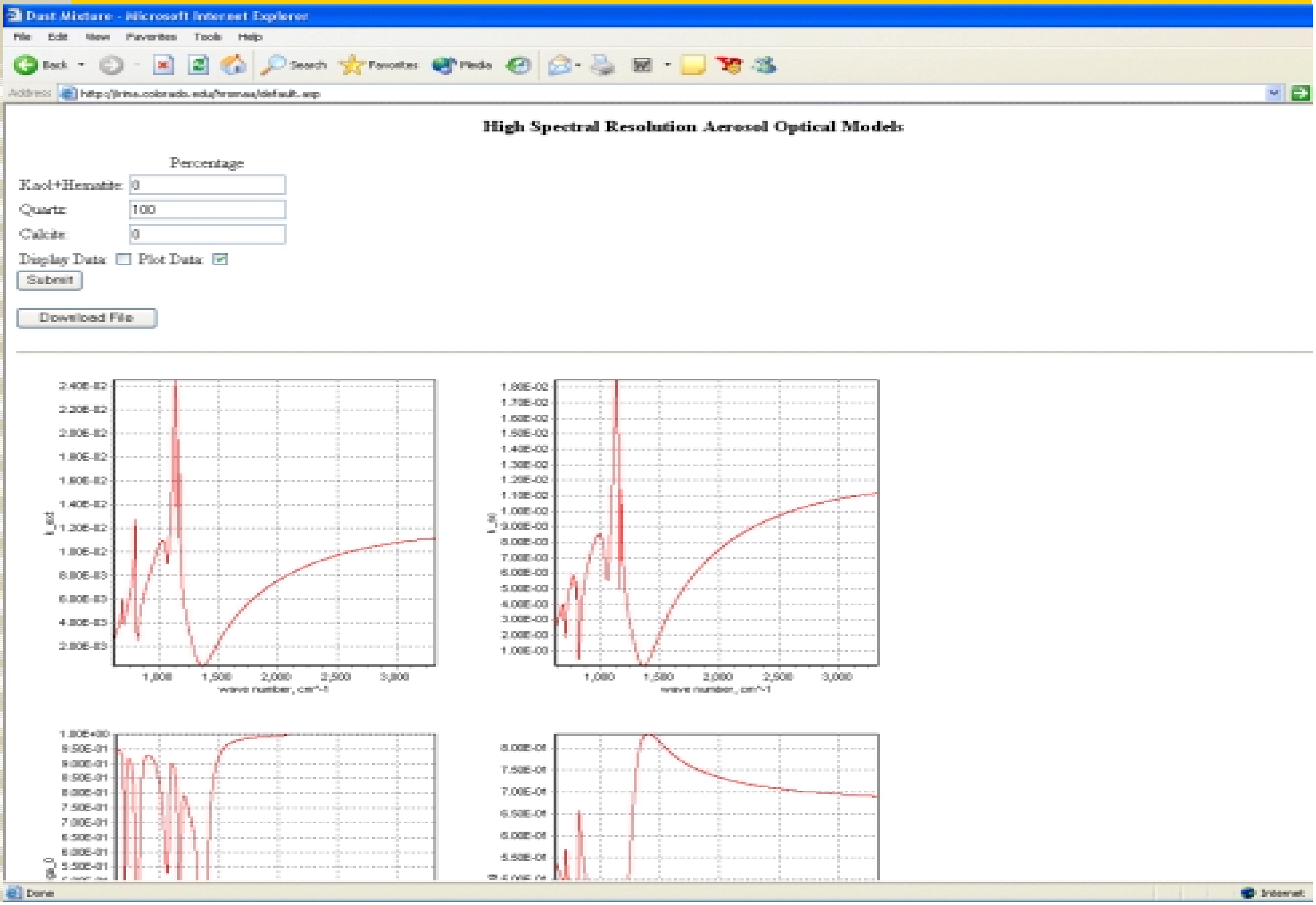
Forward modeling&sensitivity studies:

Linked kCARTA and DISORT that was modified to handle the new aerosol models. The code was used to perform forward modeling to determine the sensitivity of IR high-resolution spectral radiances to various dust characteristics (such as dust composition, vertical distribution, particle sizes, etc.). The main goal was to test robustness of a 'negative slope' approach for the detection of dust from high spectral resolution sensing.

***NAST-I data analysis*:**

Received NAST-I raw data from the Smith group and started to work on the analysis of spectra acquired over the Yellow Sea in spring of 2001. Collected and analyzed various data (meteorological, satellite, lidar network, etc.) available for this time period over East Asia to support the analysis of NAST-I data. Examination of Asian dust outbreaks based on observational data and MM5 simulations has been started.

High Resolution Optical Models of Atmospheric Aerosols (HROMAA)



High Resolution Optical Models of Atmospheric Aerosols (HROMAA)

Optical properties of individual aerosol species:

Normalized extinction coefficient K_{ext} (per unit number concentration; need N(Z) to get the profile of aerosol optical depth);

Single scattering albedo ω_0

Asymmetry parameter g

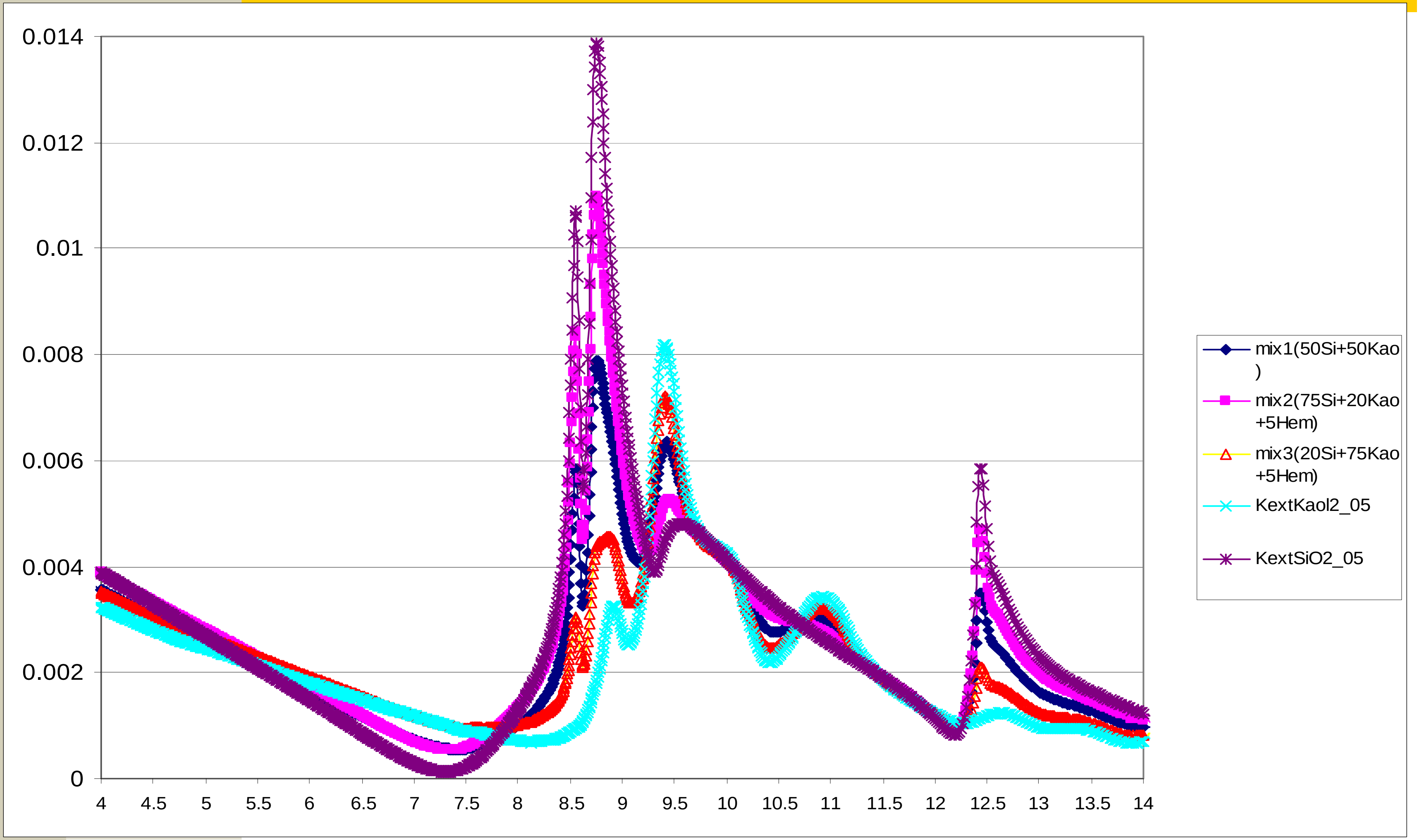
Optical properties of the external mixture of several aerosol species:

$$K_{ext}^{mixture} = \sum_i N_i K_{ext,i}$$

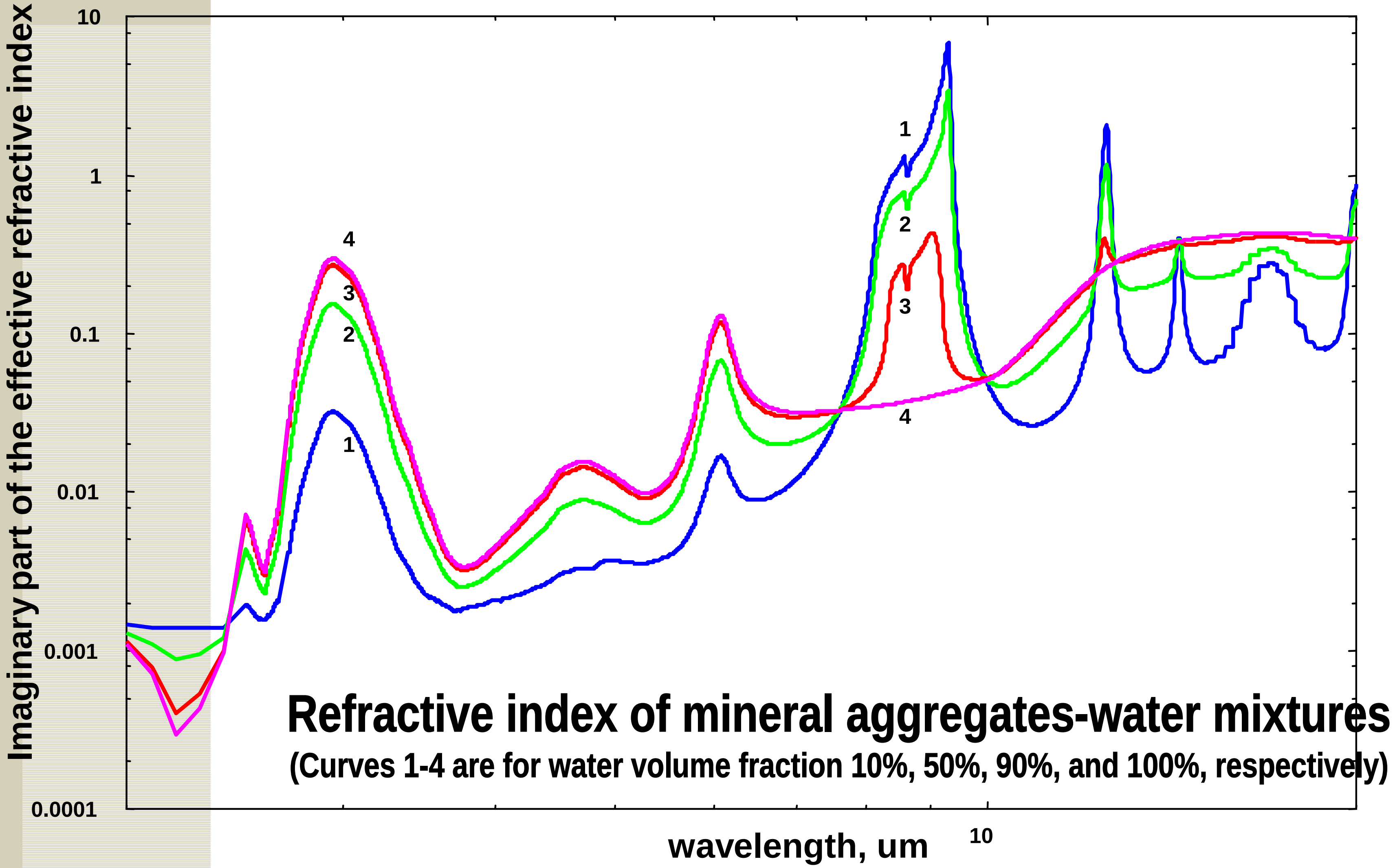
$$\omega_0 = \frac{\sum_i \omega_{0,i} N_i K_{ext,i}}{\sum_i N_i K_{ext,i}}$$

$$g = \frac{\sum_i g_i N_i K_{sc,i}}{\sum_i N_i K_{sc,i}}$$

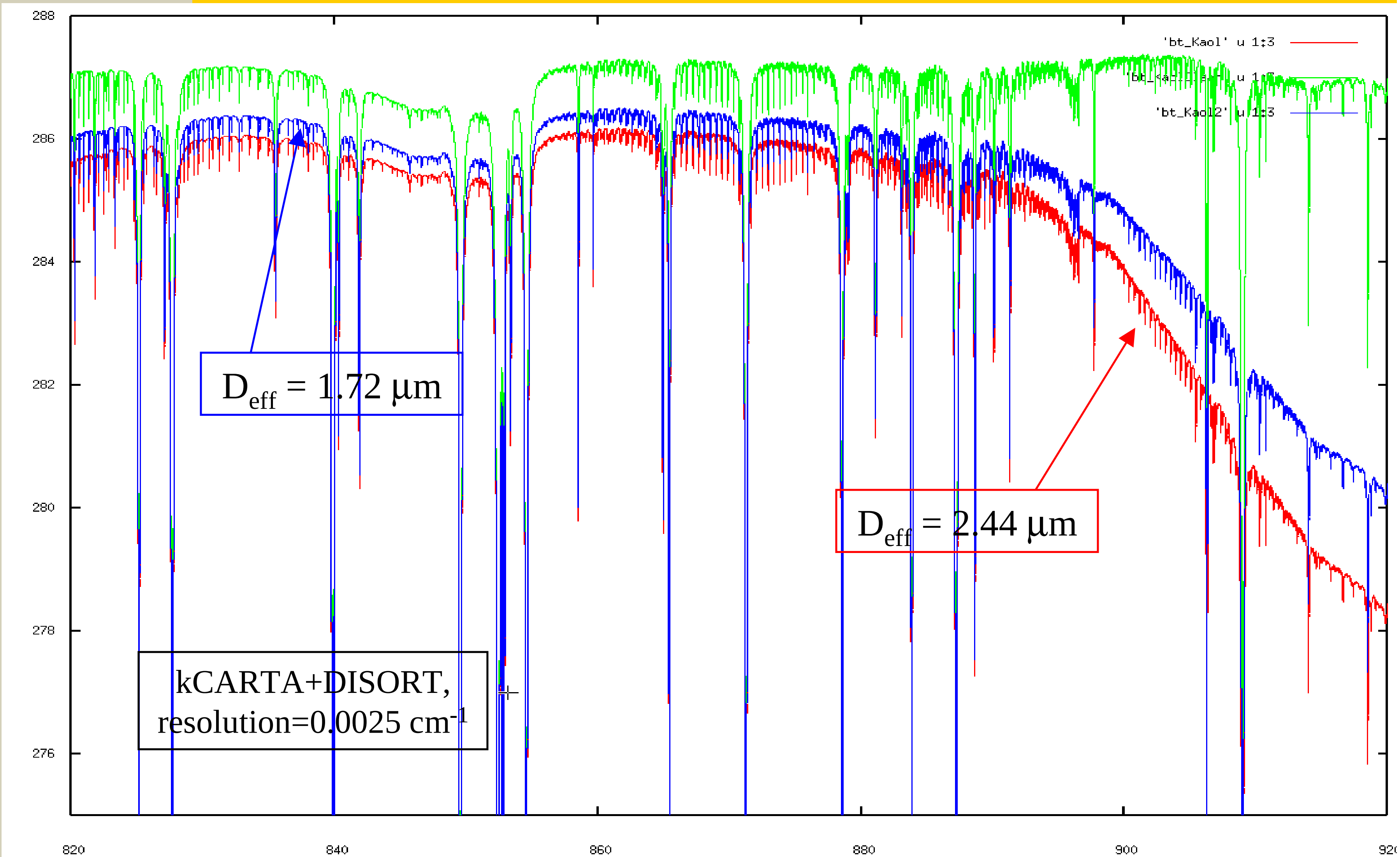
Normalized extinction coefficient



Effect of dust coating



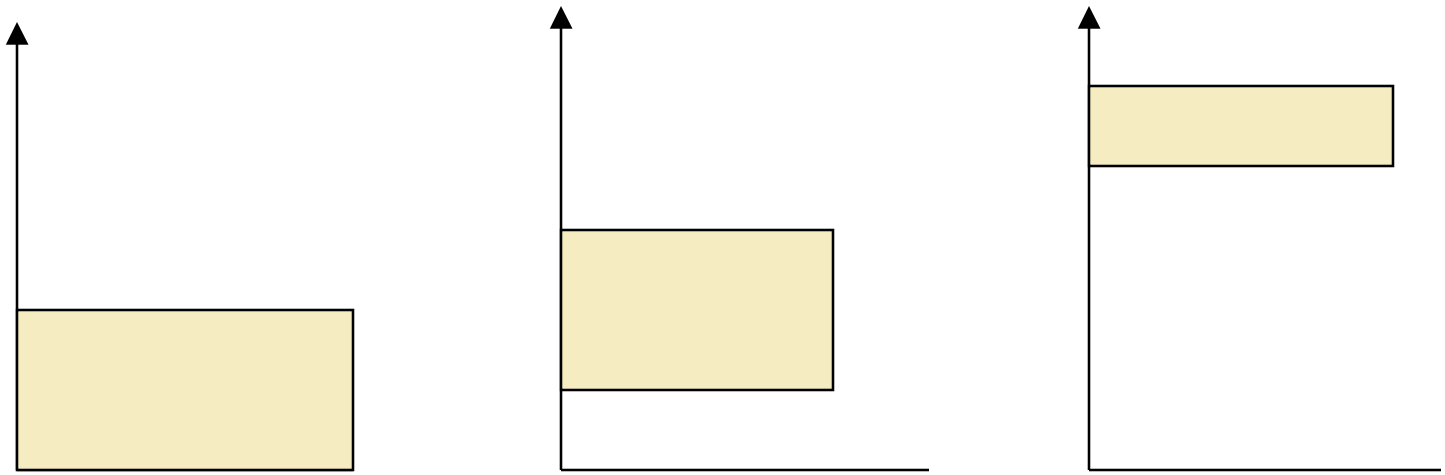
Effect of dust particle sizes



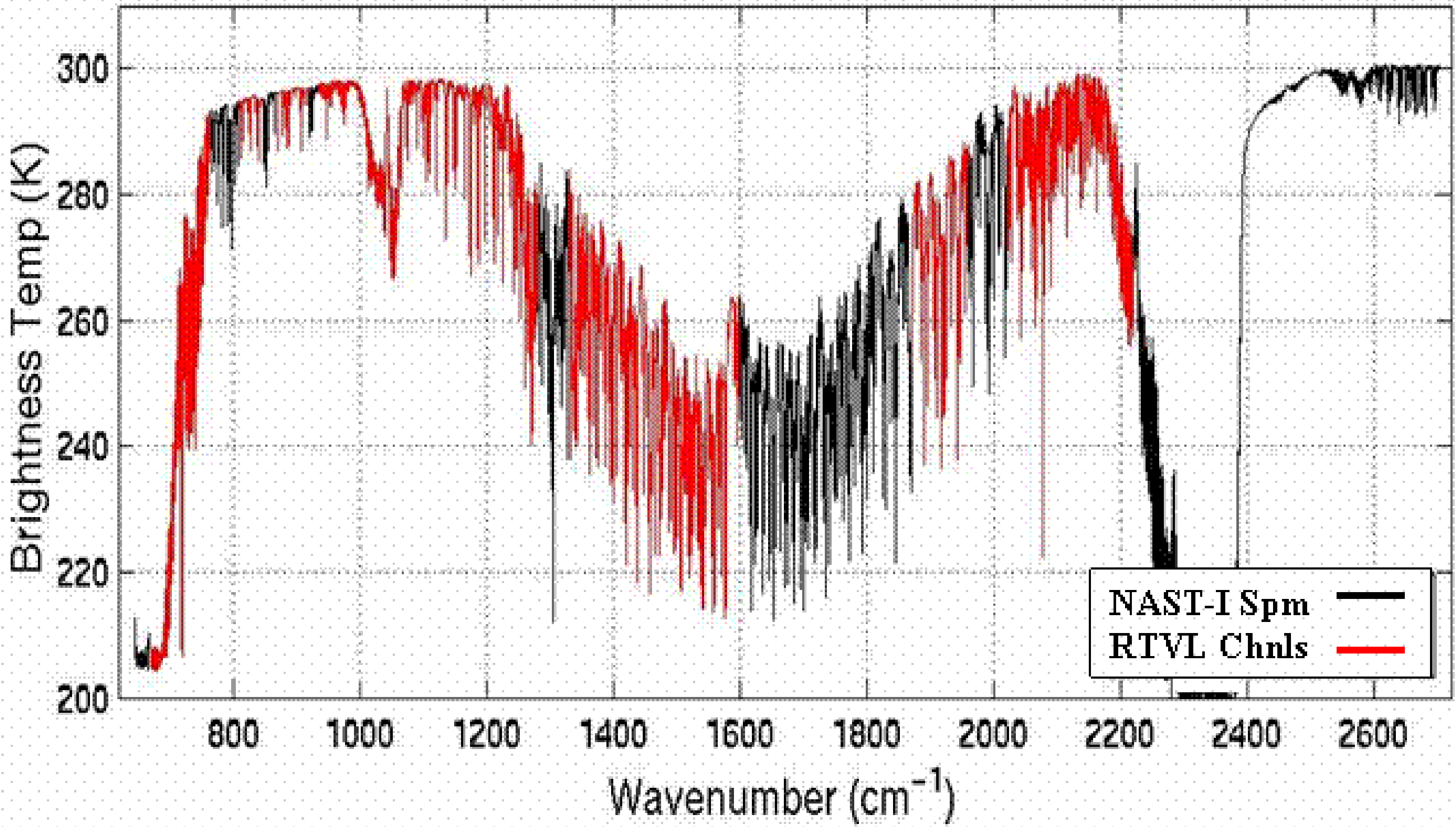
Effect of the vertical profile of dust on brightness temperature

We performed a series of modeling experiments for several vertical profiles of dust

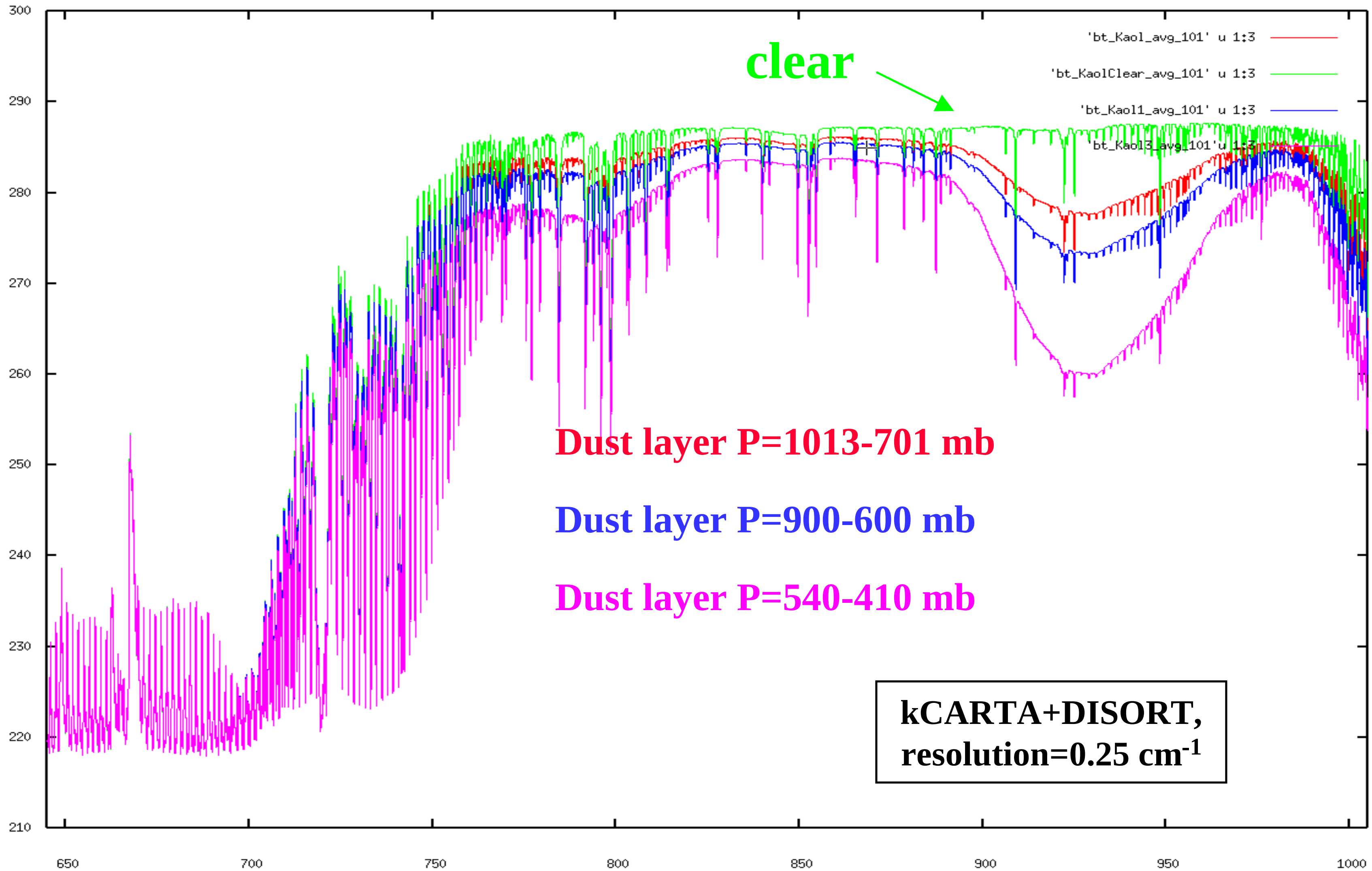
- The vertical profiles were reconstructed based on aircraft and lidar observations
- In each experiment, dust properties remains the same but the position of a dust layer varies



NAST-I Spectrum and Retrieval Channels



Effect of the vertical profile of dust on brightness temperature



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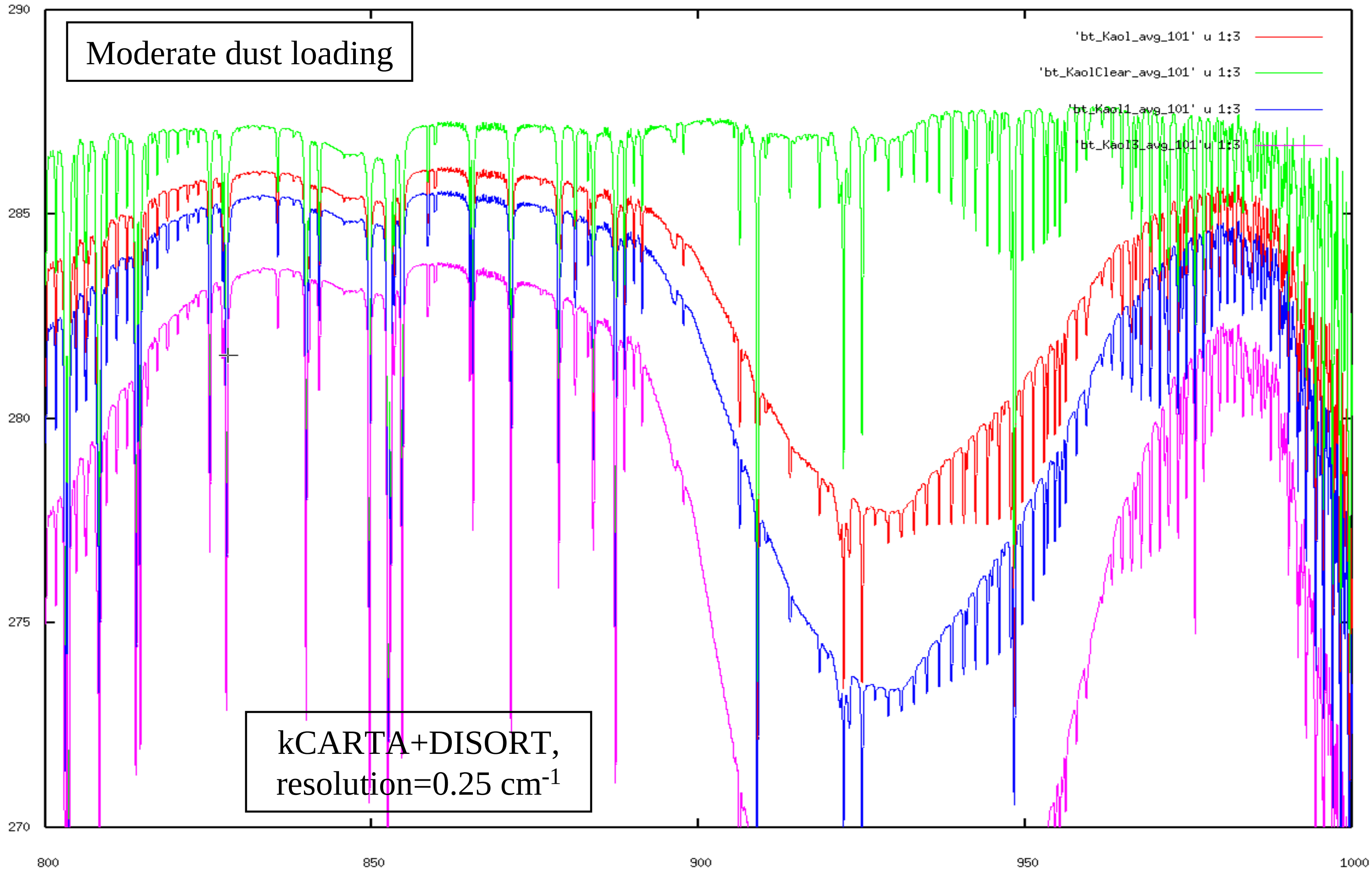
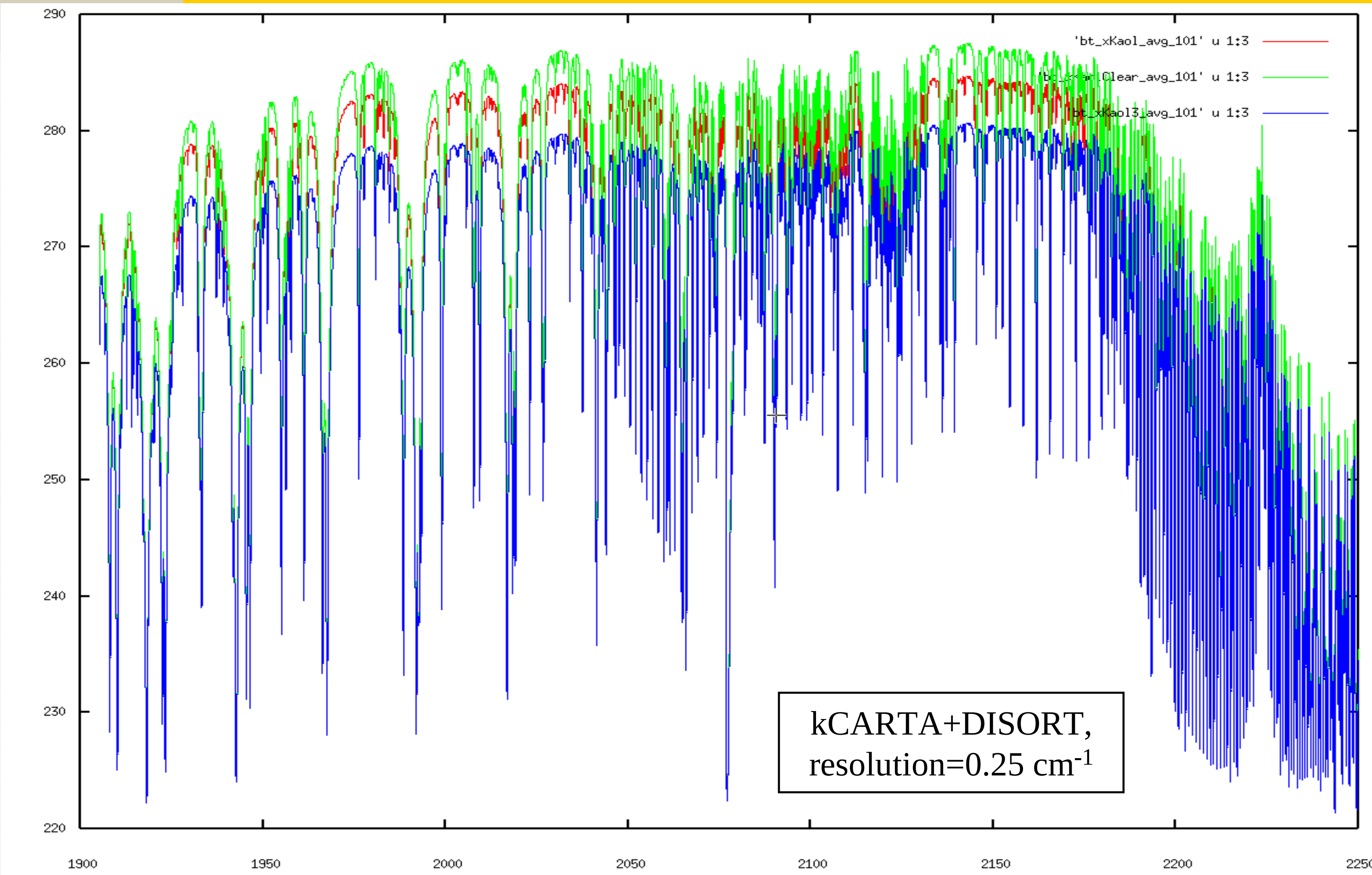
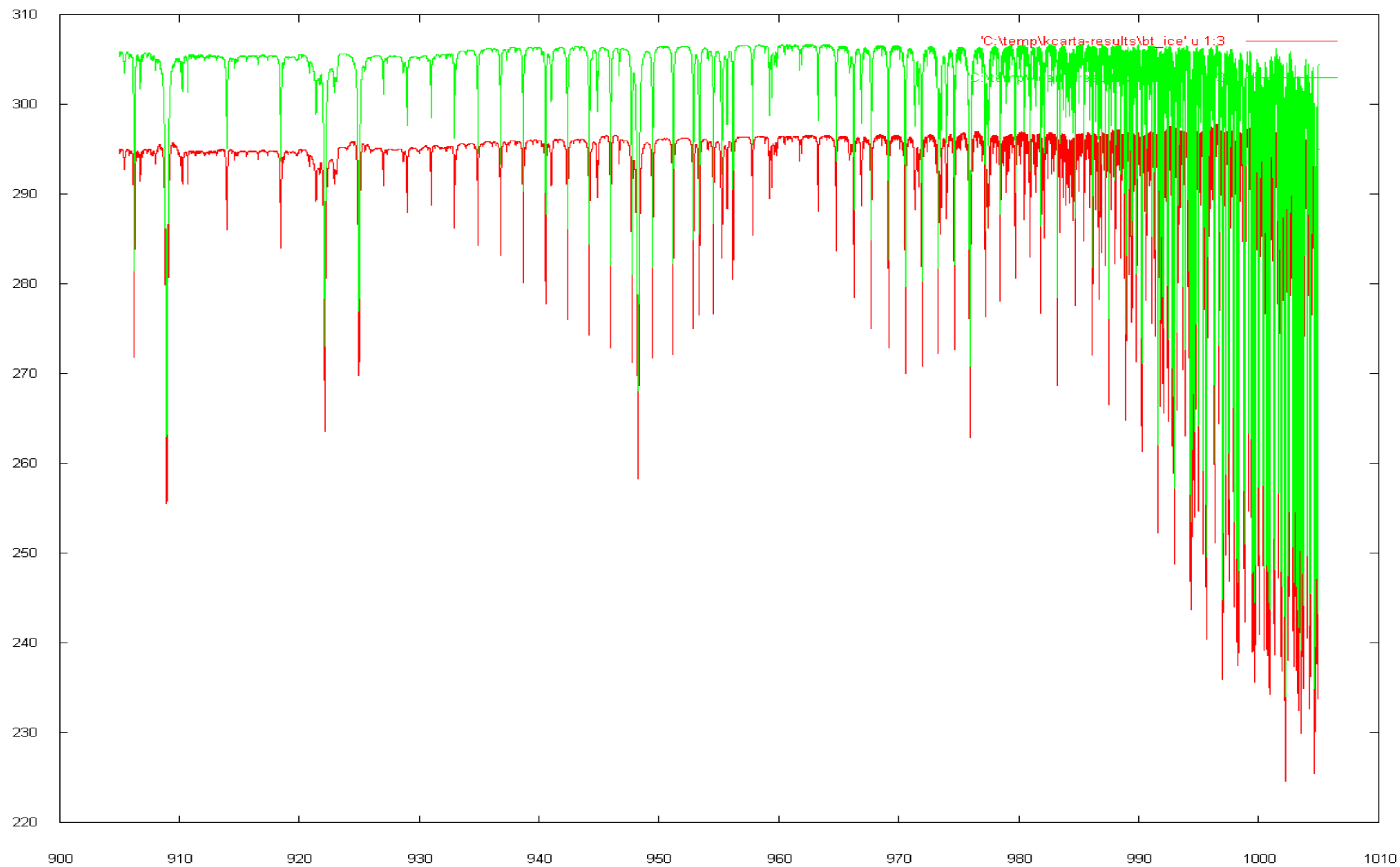


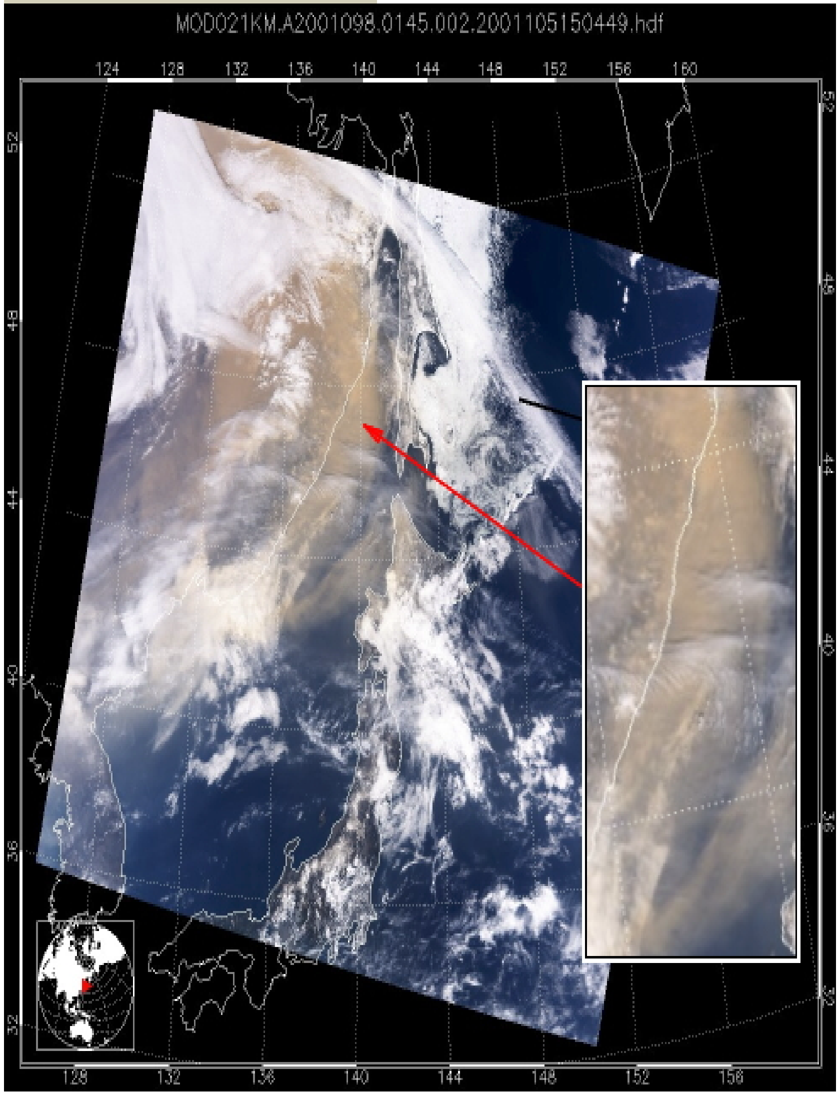
Effect of the vertical profile of dust on brightness temperature



Sub-visible cirrus spectral signature

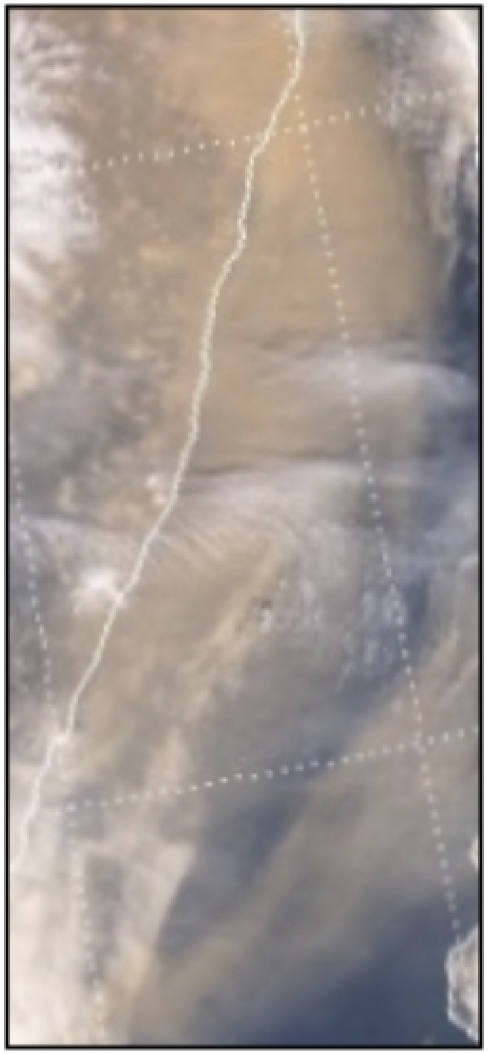


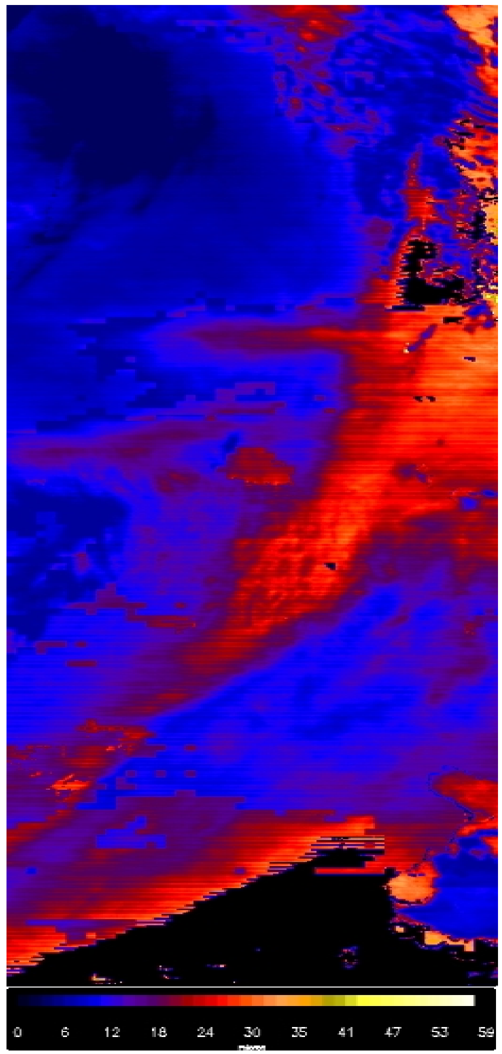
Discrimination of dust from clouds: problems in MODIS cloud mask



Black-cloud, white – clear

Effective "cloud particle" sizes





- **Red color denotes larger particles (30 µm) ; Blue color denotes small particles (< 10 µm).**
- **MODIS algorithm does not discriminate between cloud and dust particles – it treats a dust layer as a cloud with smaller particle sizes**

Summary and work for Year 2

Continue forward modeling studies:

* How to handle dust scattering:

  Heney-Greenstein vs. actual scattering phase functions

* Multi-layered vertical distribution
* Variations in the vertical profiles of T and atmospheric gases (H_2O)

Dust retrievals:

* Test retrieval algorithms using NAST-I data

Strategy: use forward modeling as *a prior* to constrain the retrievals

Some issues

- **Dust causes additional heating/cooling of a layer => affects T and H_2O profiles**

- **Potential problems: a radiosonde "climatology" of T and H_2O profiles in the dust laden conditions is limited**

2th International Workshop on Mineral Dust

10-12 September, 2003

Paris, France

http://www.lisa.univ-paris12.fr/DUST2003