Theme

Retrieval of Cloud Geometrical Parameters and Water Vapor for GLI

Makoto Kuji (Nara Women's University),
Akihiro Uchiyama (Meteorological Research Institute) and
Teruyuki Nakajima (University of Tokyo)

Topics

1. Retrieval of Cloud Geometrical Parameters;
   - This talk;

2. Retrieval of Water Vapor Amount;
   - Using GLI NIR Channels;
   - Tomorrow’s Poster Session;

Theme

Retrieval of Cloud Geometrical Parameters Using Remote Sensing Data

Makoto Kuji (Nara Women's University)
and
Teruyuki Nakajima (University of Tokyo)

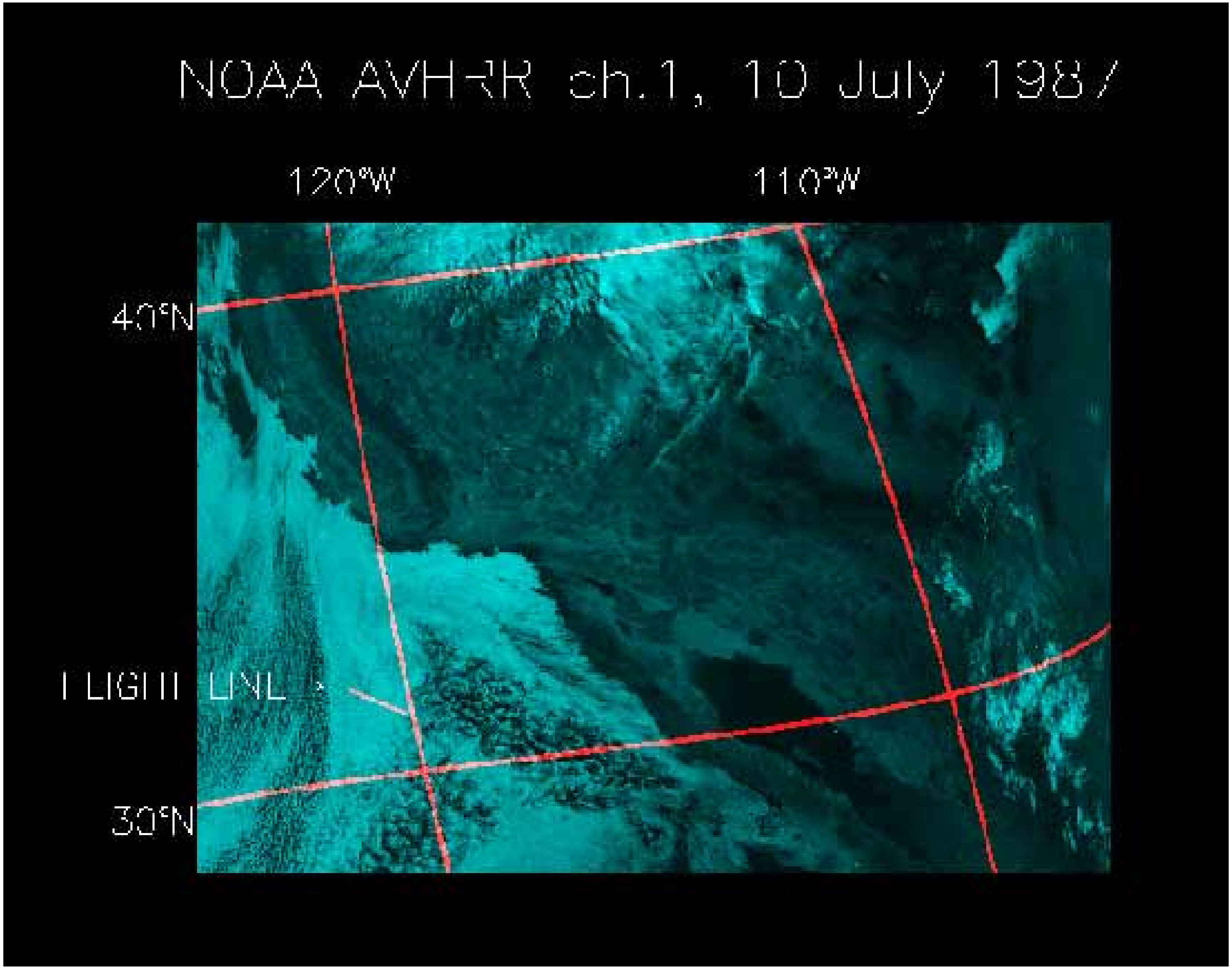
Outline

- 4-channel Method:

  Visible, Oxygen A-band, NIR, and TIR;
- Retrieval of Cloud Geometrical

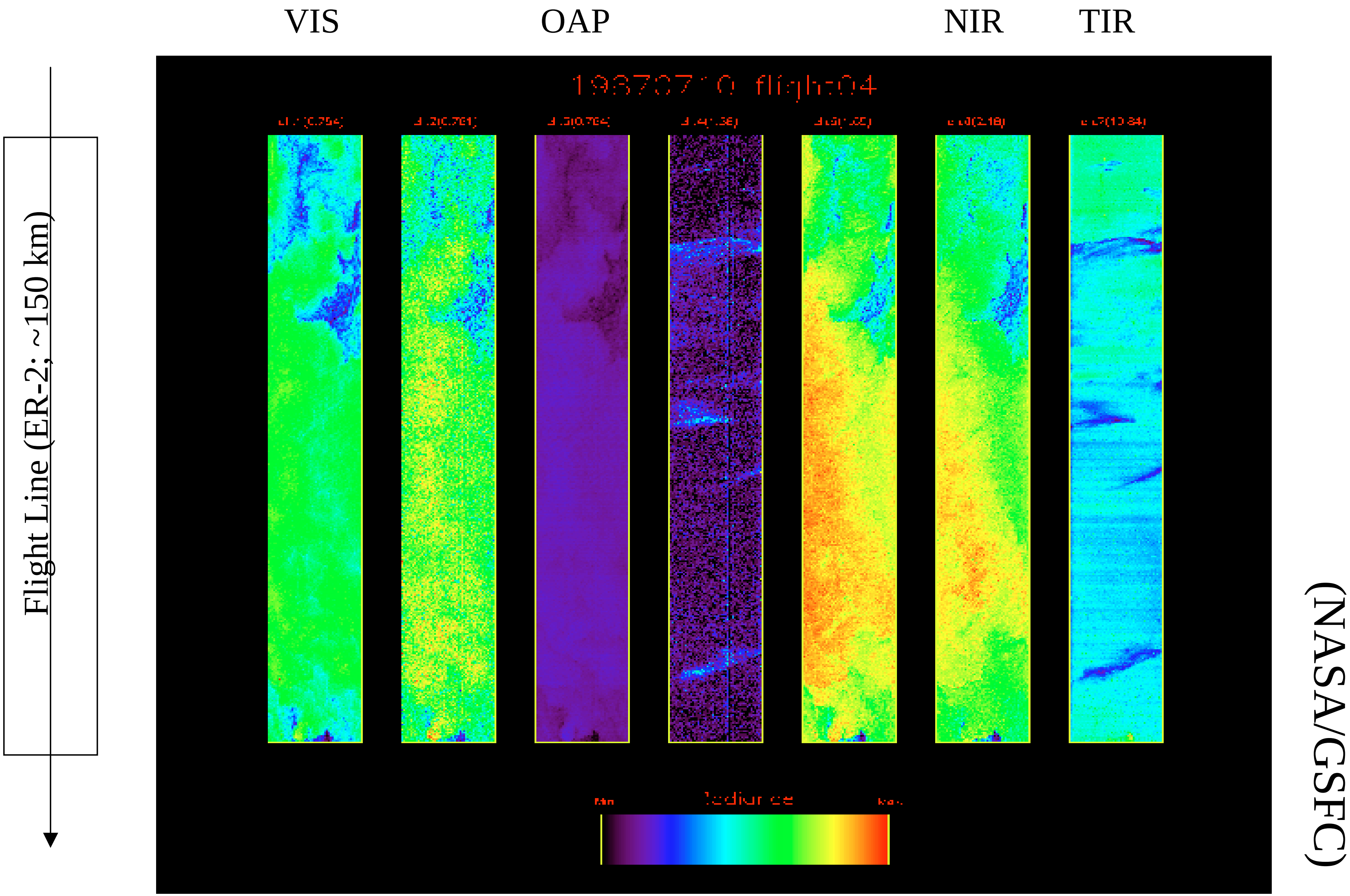
  Parameters (τ_c, r_e, z_t, and Δz);
- Low-Level Marine Clouds (Summer St.);
- MCR / ER-2 (Airborne; FIRE);
- Algorithm Development and Validation;

AVHRR image (FIRE)

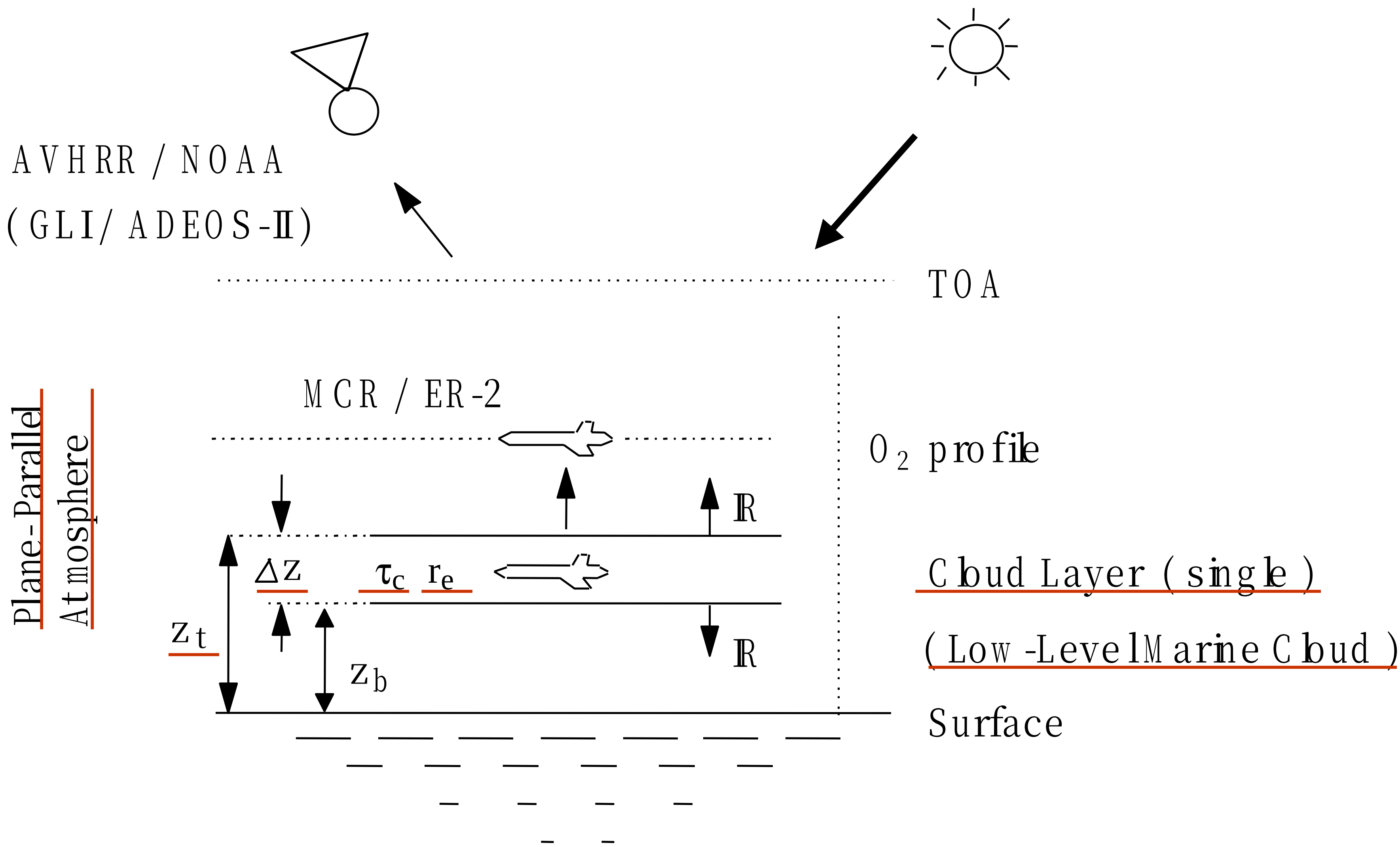


(NOAA-10, NASA/GSFC)

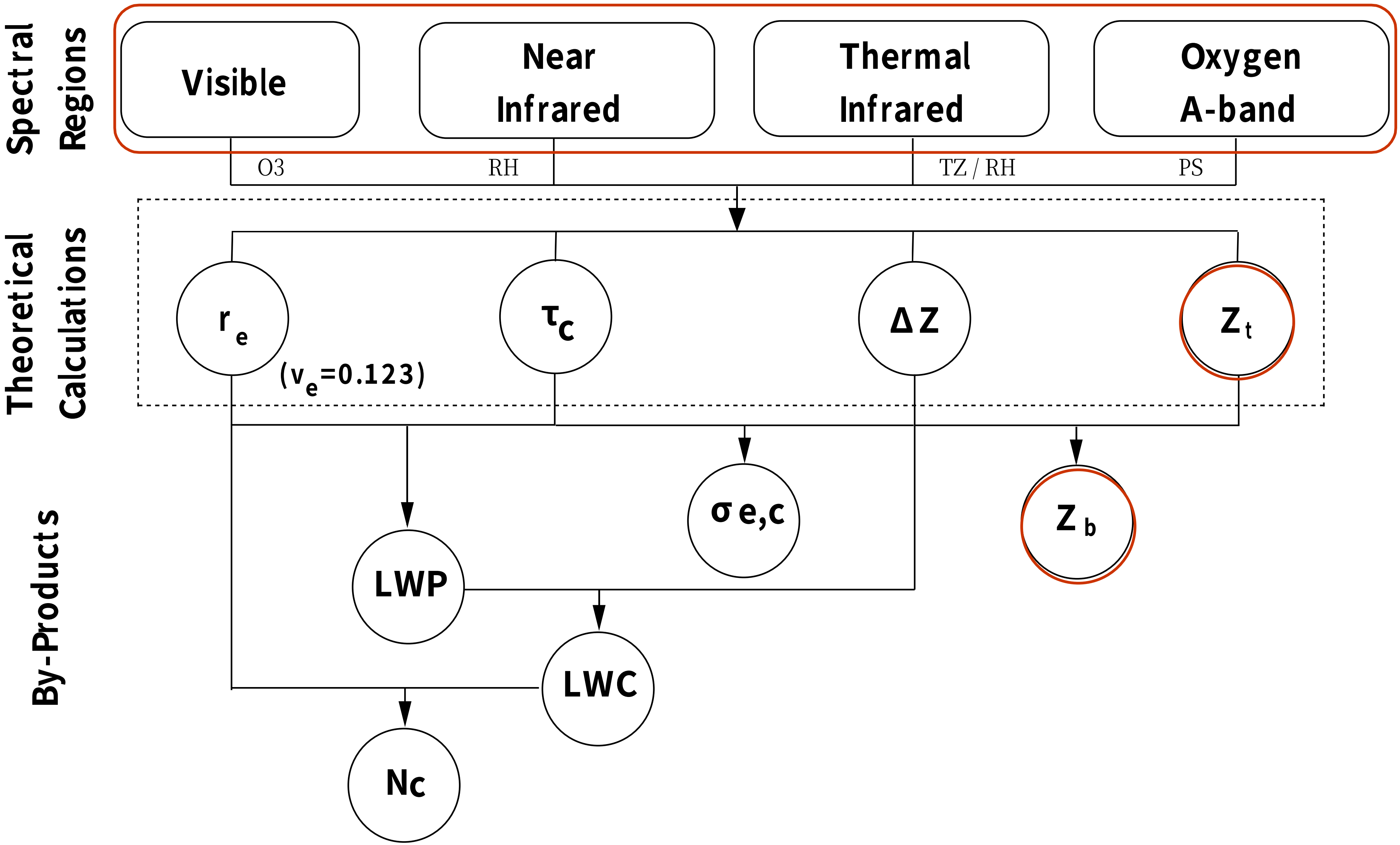
MCR image (FIRE)



Overview (Model Atmosphere)

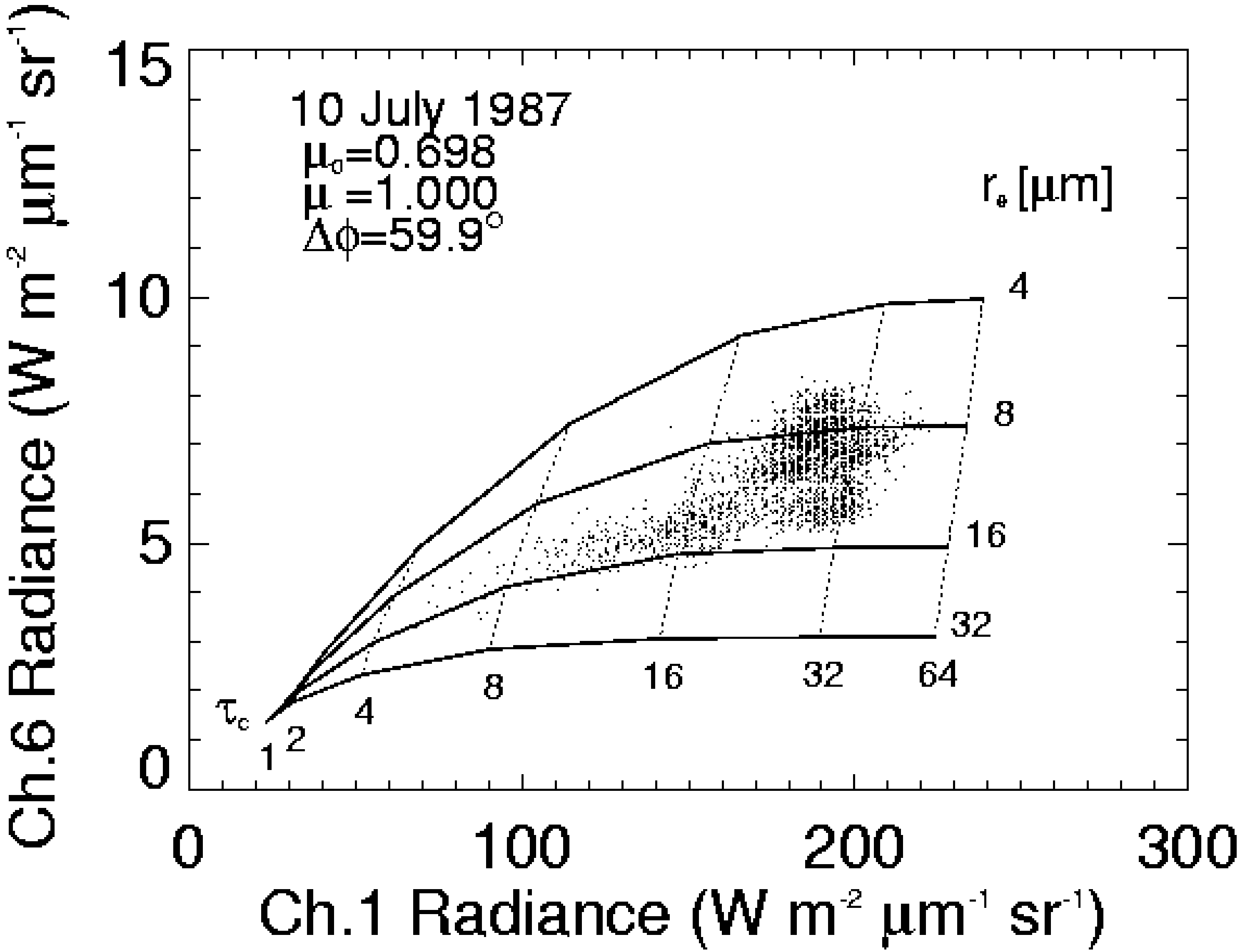


Algorithm

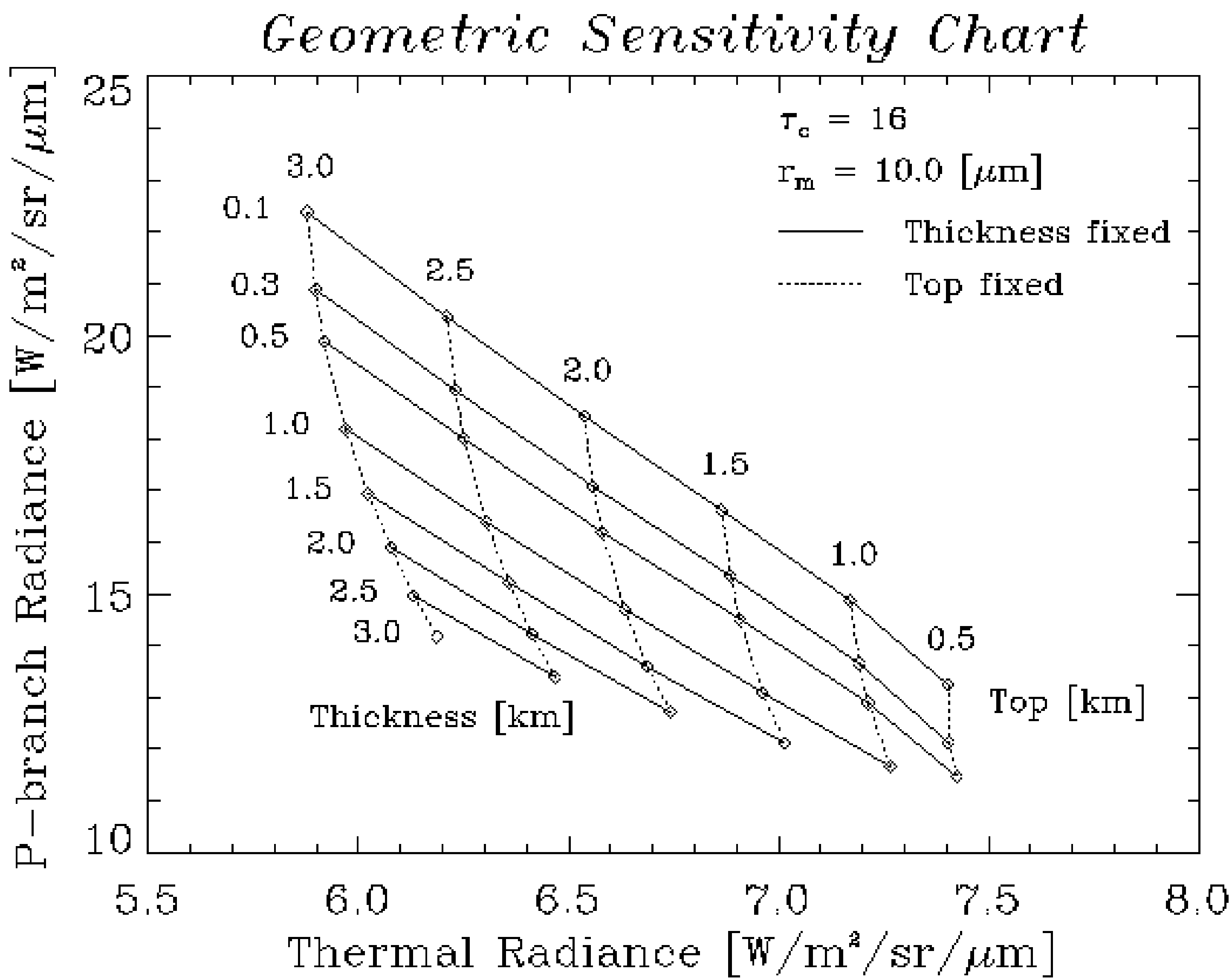


Spectral Regions
Visible
Near Infrared
Thermal Infrared
Oxygen A-band
O3
RH
TZ / RH
PS
Theoretical Calculations
r_e
$(v_e=0.123)$
τ_c
ΔZ
Z_t
By-Products
$\sigma_{e,c}$
Z_b
LWP
LWC
Nc

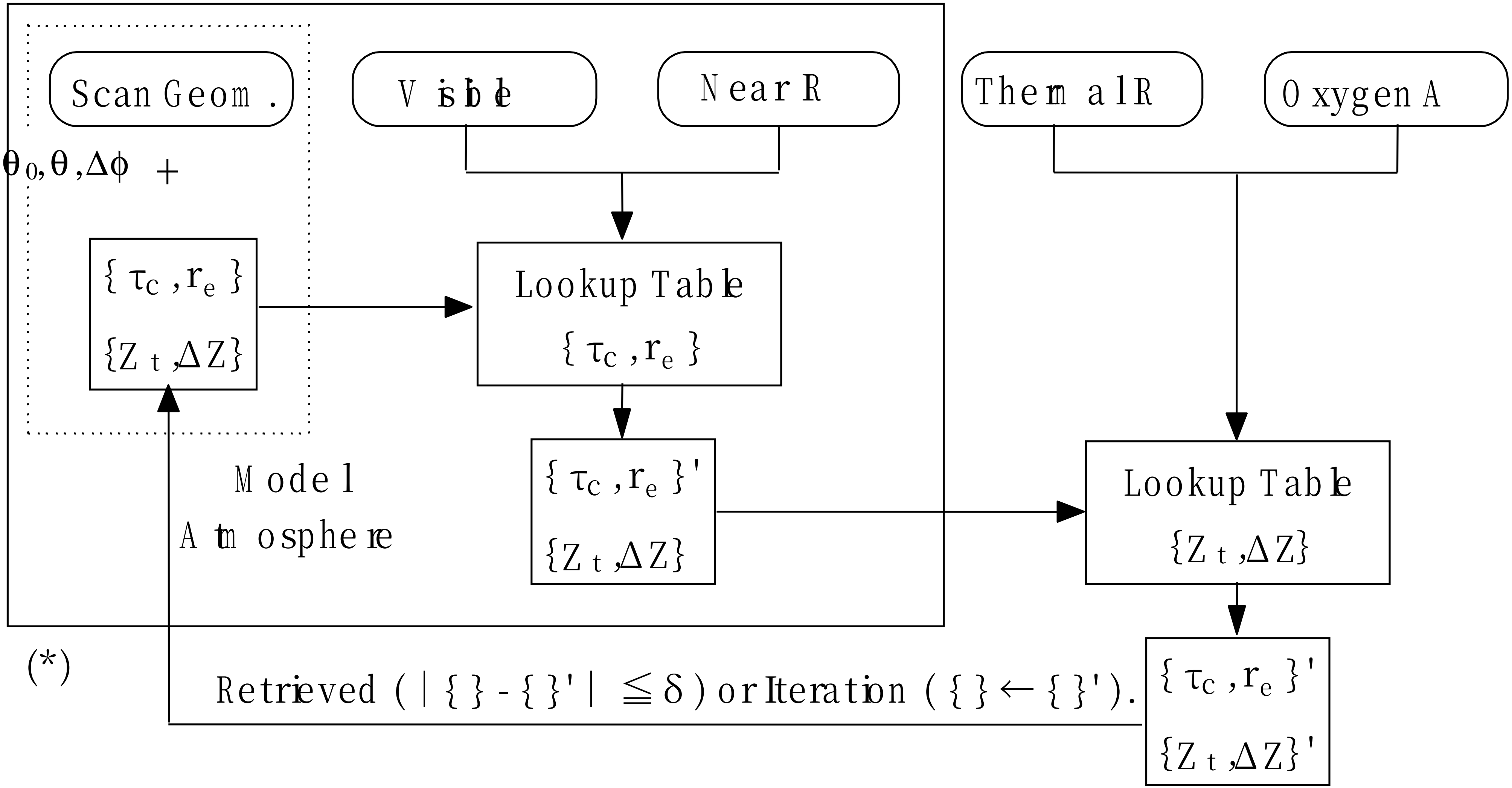
Lookup Table (1): Retrieval (τ_c and r_e)



Lookup Table (2): Geometric Sensitivity Chart (Z_t and ΔZ)

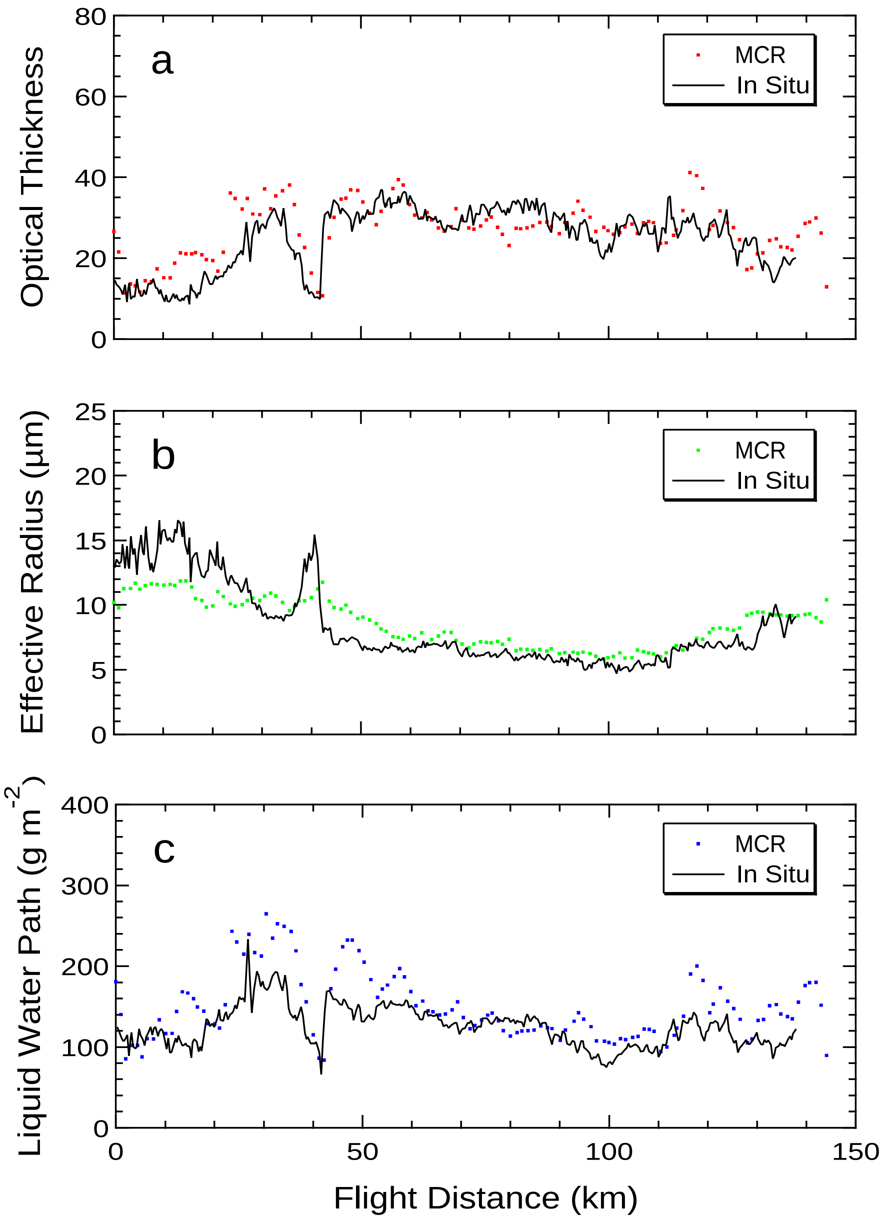


Retrieval Flow

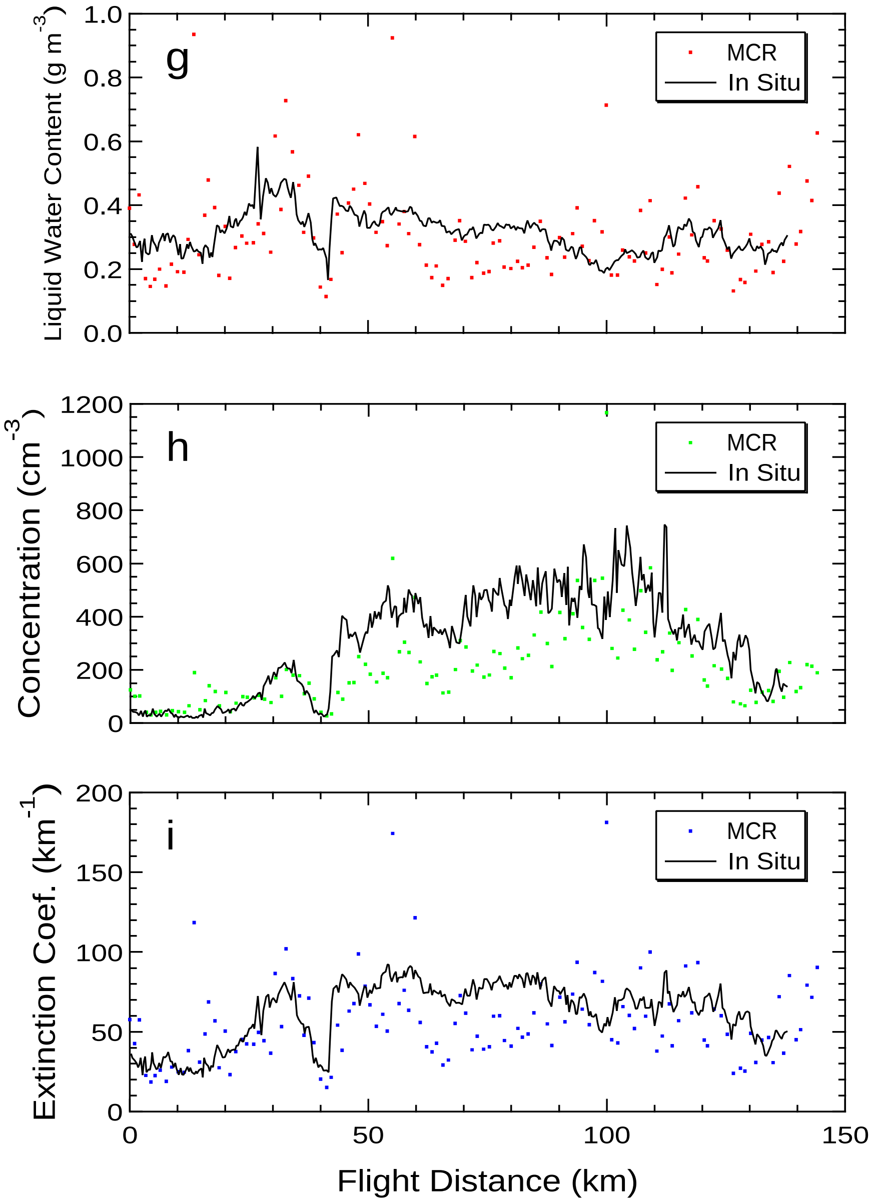


(*) Nakajima and King (1990)

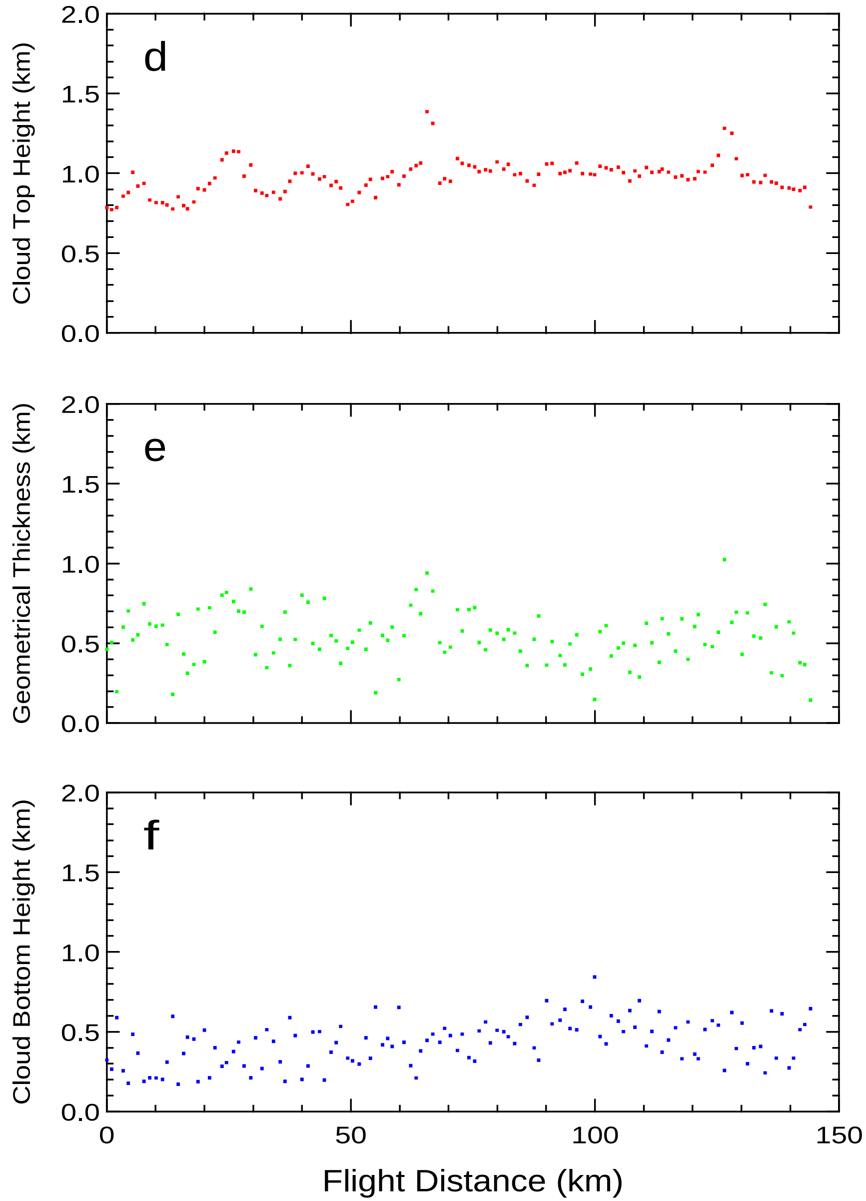
Retrieved Results (τ_c, r_e and LWP)



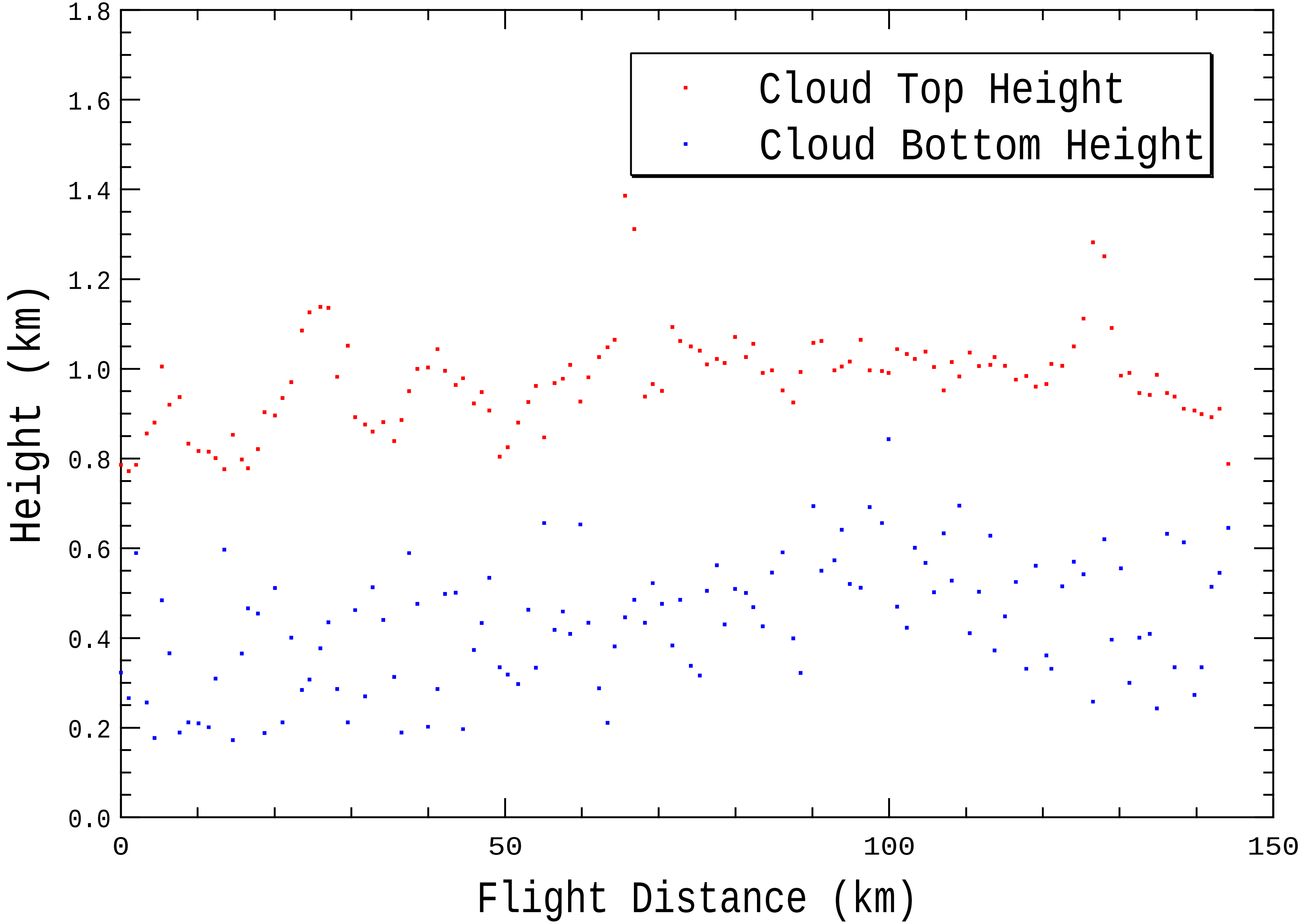
Retrieved Results (LWC, N_c and σ_e)



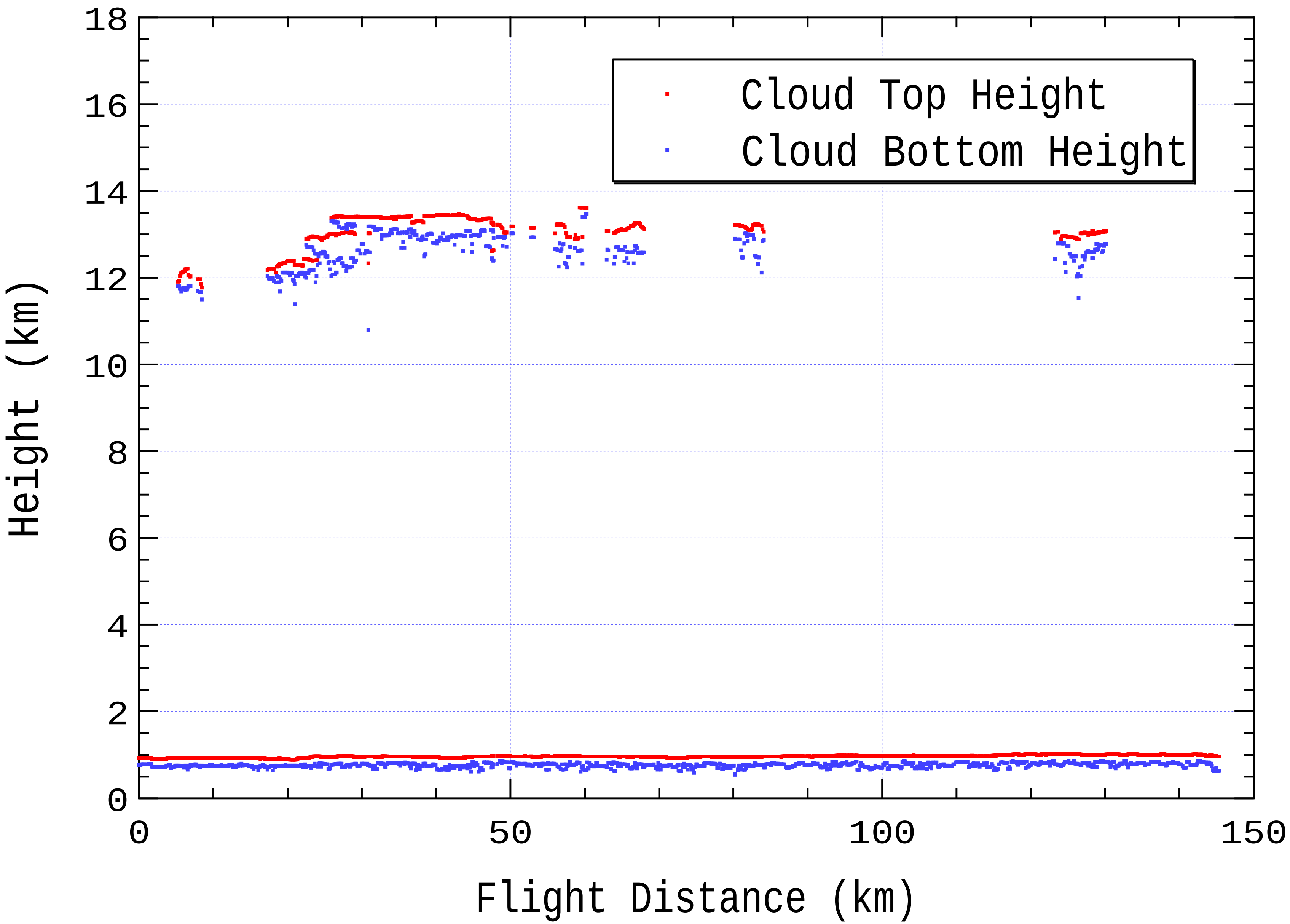
Retrieved Results (Z_t, ΔZ and Z_b)



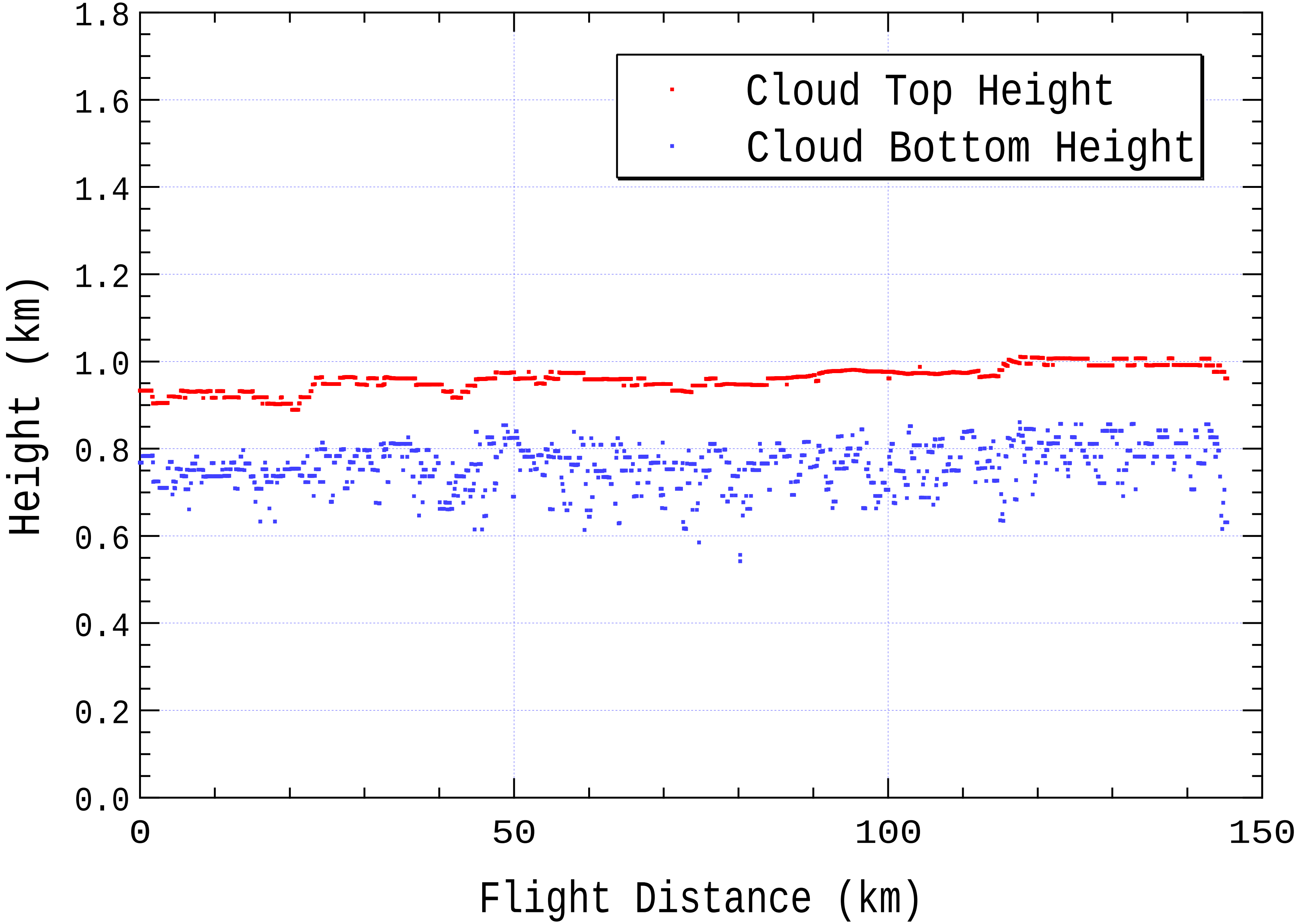
Retrieved Results (Z_t and Z_b)



LIDAR Observation (for Validation of Z_t and Z_b)

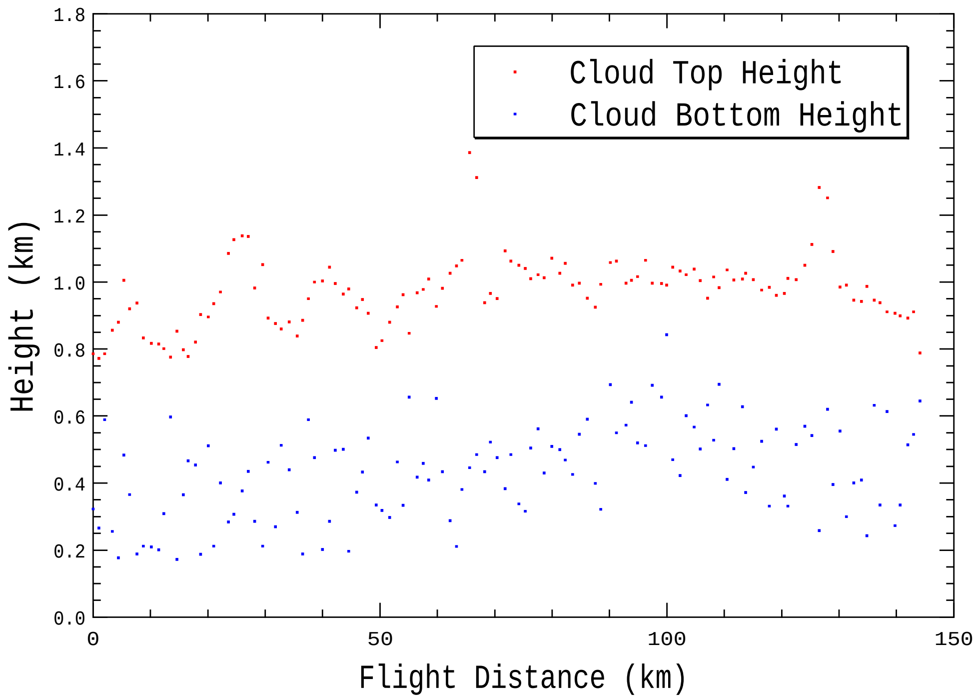


LIDAR Observation (Z_t and Z_b; Lower Layer)

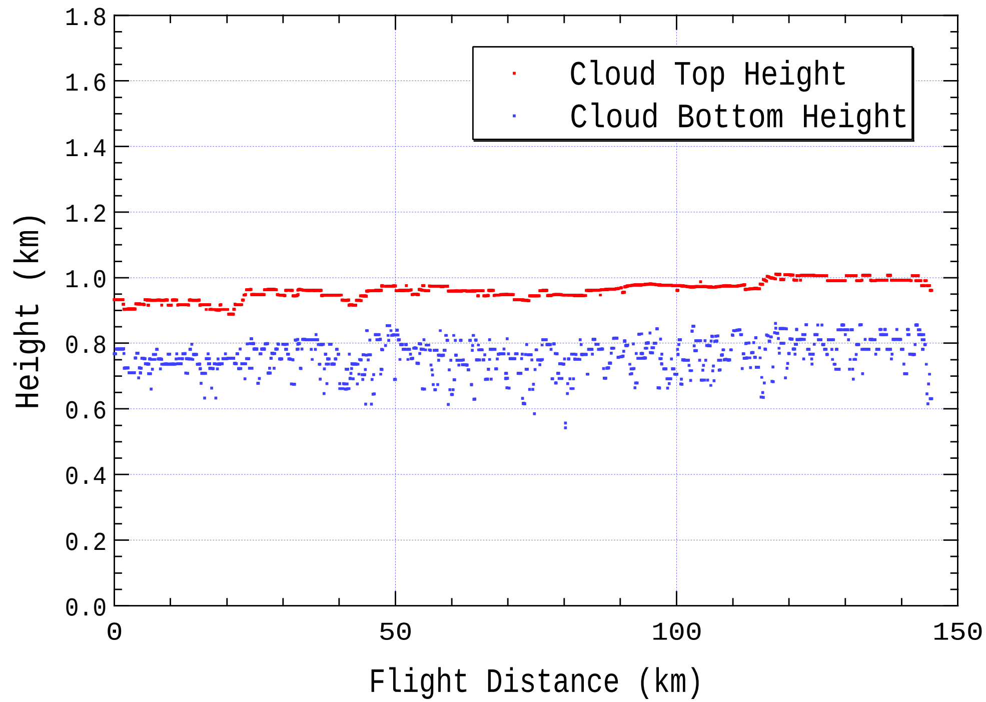


Validation (Z_t and Z_b)

MCR / ER-2 (Four-channel method)

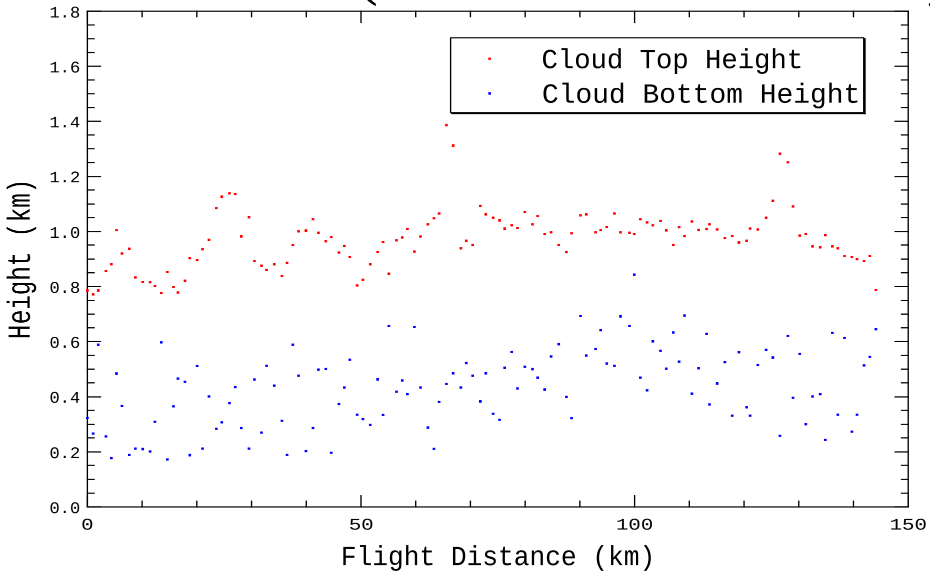


LIDAR / ER-2

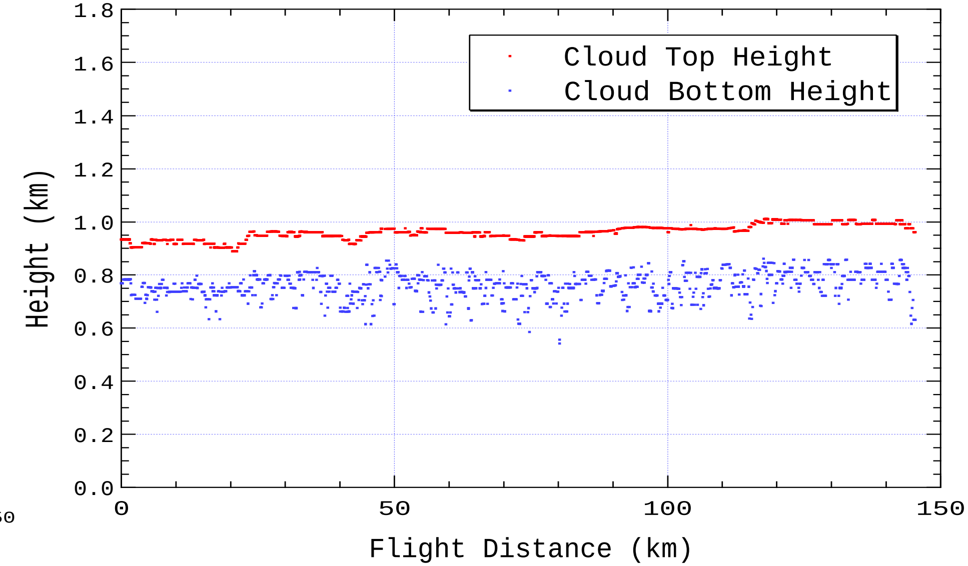


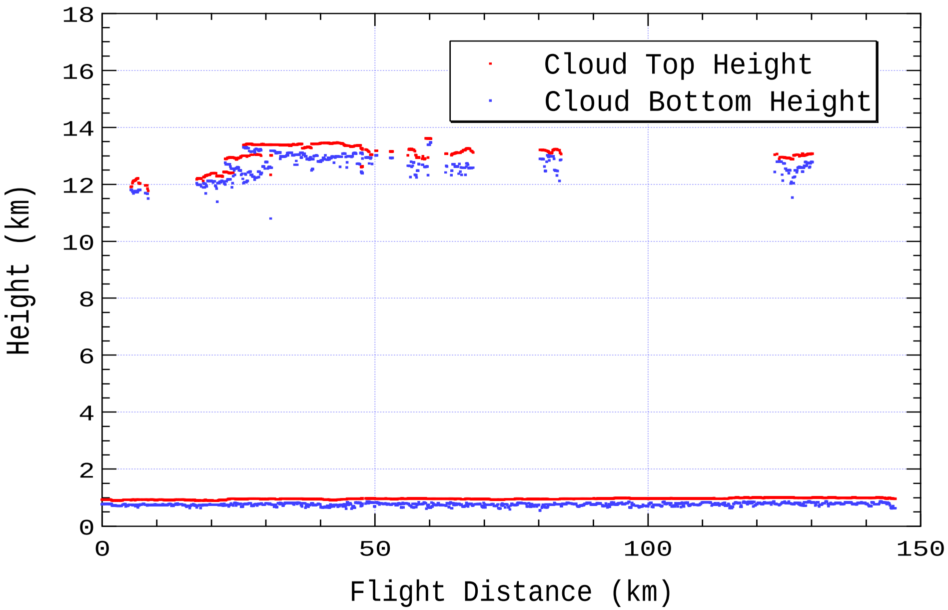
Validation (Z_t and Z_b)

MCR / ER-2 (Four-channel method)



LIDAR / ER-2 (Lower Layer)





LIDAR / ER-2

Summary

- Four-channel method was applied
  to the airborne remote sensing data (MCR):

  - Good consistent with in situ observation;

- Validation with the airborne LIDAR
  for both top and bottom heights:

  - Dispersion and deviation are rather large
    for both top and bottom heights;
  - Multilayer system affects the results;

Future Works

- Refinement of the algorithm
  - Surface (Boundary) Conditions, such as reflectance, pressure, and temperature;
  - Consideration of photon escape effect;
- Multilayer issue
  - Cirrus detection (1.38 μm or 10.8 μm);
  - Multiple stratification of cloud layer, or an incorporated (gross) approach,
  - Using TOVS, MODIS, or GLI;

Logic of Algorithm

- Visible= f (τ_c, r_e (, z_t, Δz));
- NIR= f (τ_c, r_e (, z_t, Δz));

1st step

- TIR = f (τ_c, r_e, z_t, and Δz);
- Oxygen A-band = f (τ_c, r_e, z_t, and Δz);

2nd step

Theme

Retrieval of Precipitable Water in a Global Scale using Near Infrared Data

Makoto Kuji (Nara Women's University)
Akihiro Uchiyama (Meteorological Research Institute)

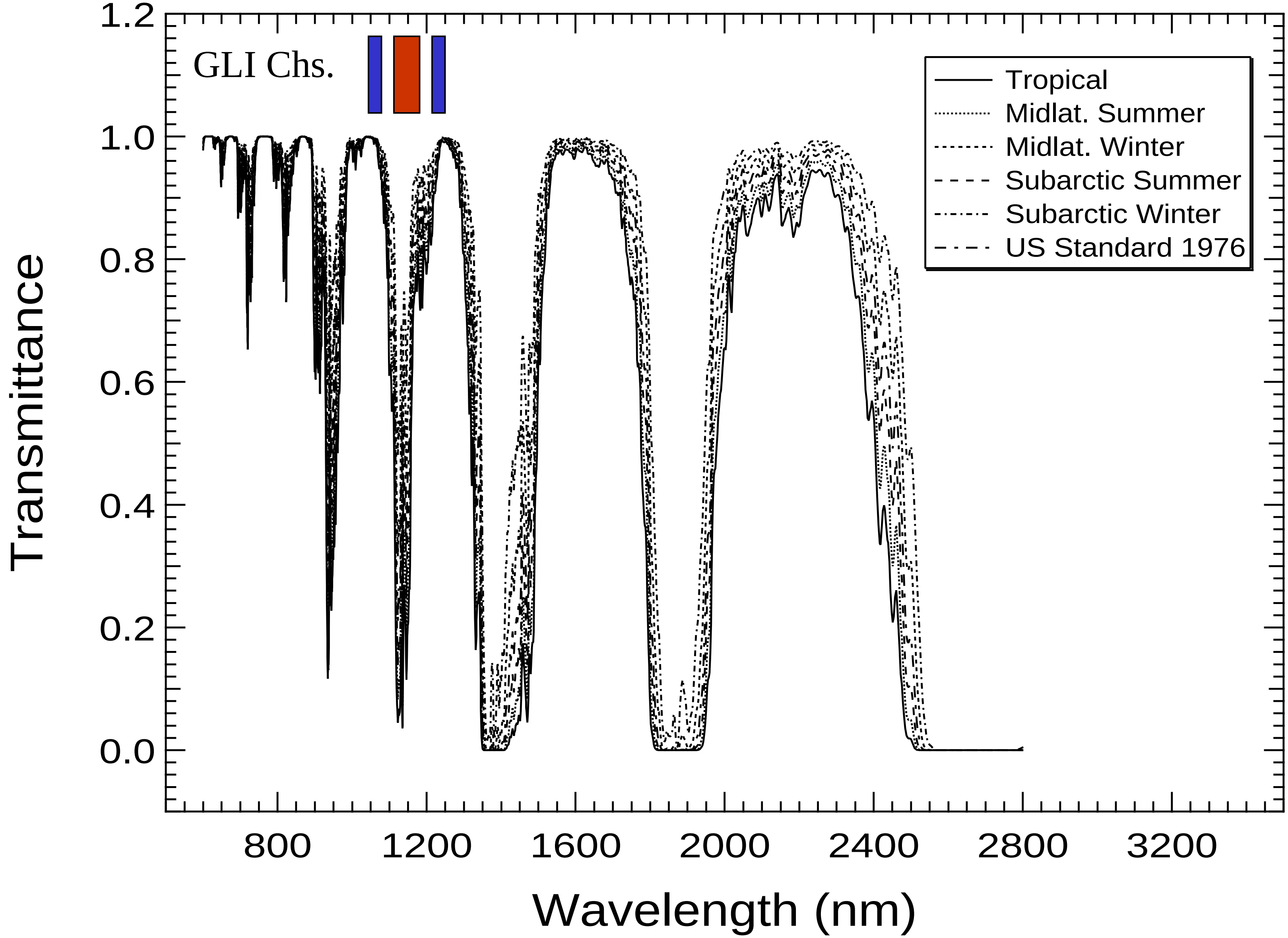
Objectives

- Applications to ADEOS-II / GLI (Nov., 2002);
- Water Vapor: Column (Precipitable Water);
- Utility: Atmospheric Correction or Product;
- Advantage: Fully Synchronized Data Set;
- Scale: Pixel-by-Pixel (about 1 km^2);
- Status: Algorithm Refinement (from MODIS);

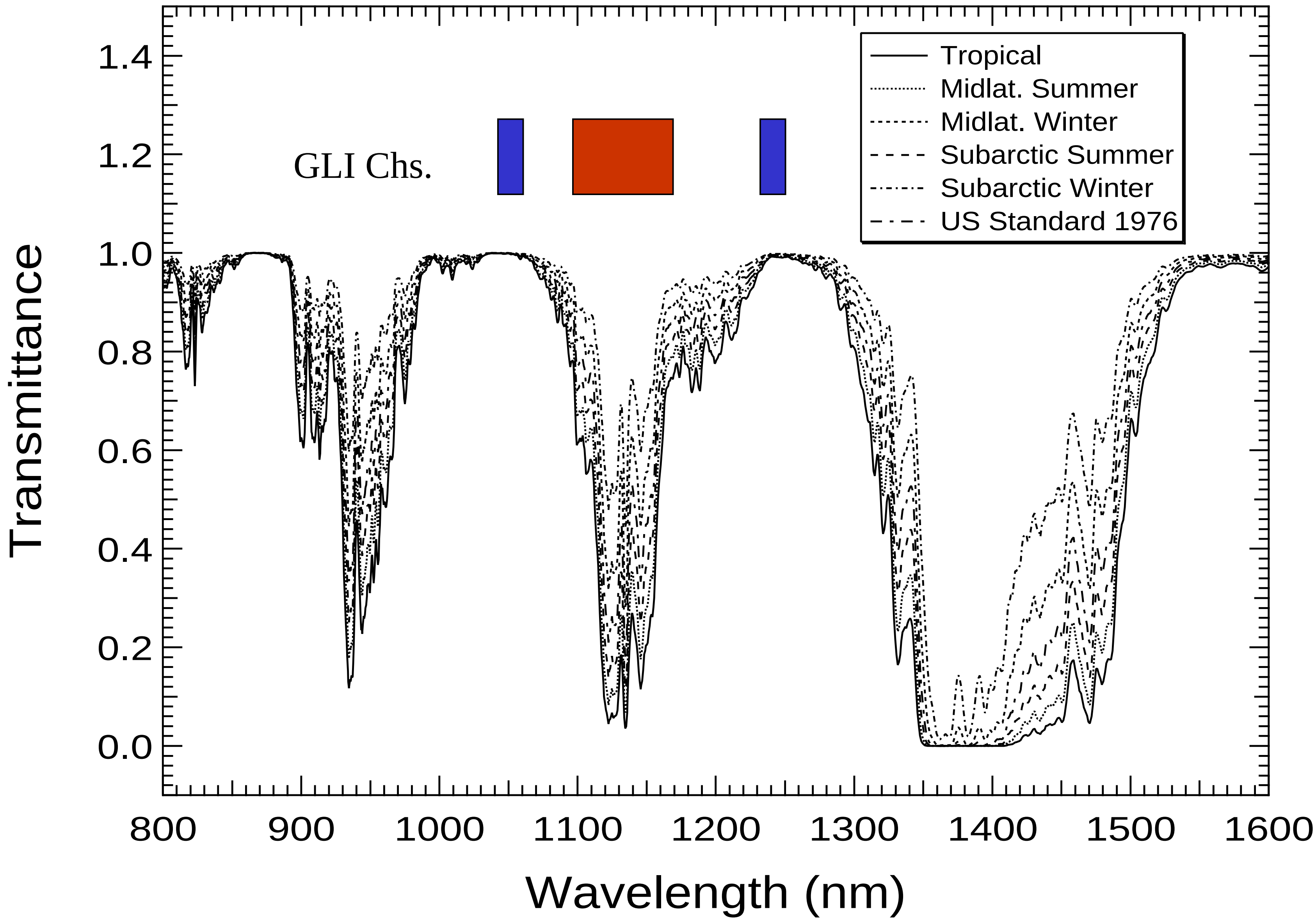
Approach

- Radiance Ratio between:
  - Water Vapor Absorbing Band and;
  - Non-Absorbing Band over NIR;
  - Related to Precipitable Water;
- GLI Application:
  - R_{1135}/R_{1240} or R_{1135}/R_{1050} ;
  - Nonlinear Regression Curve Fitting;
  - Calibration Curve to Retrieve Precipitable Water;

Transmittance (Water Vapor)



Transmittance (Water Vapor)



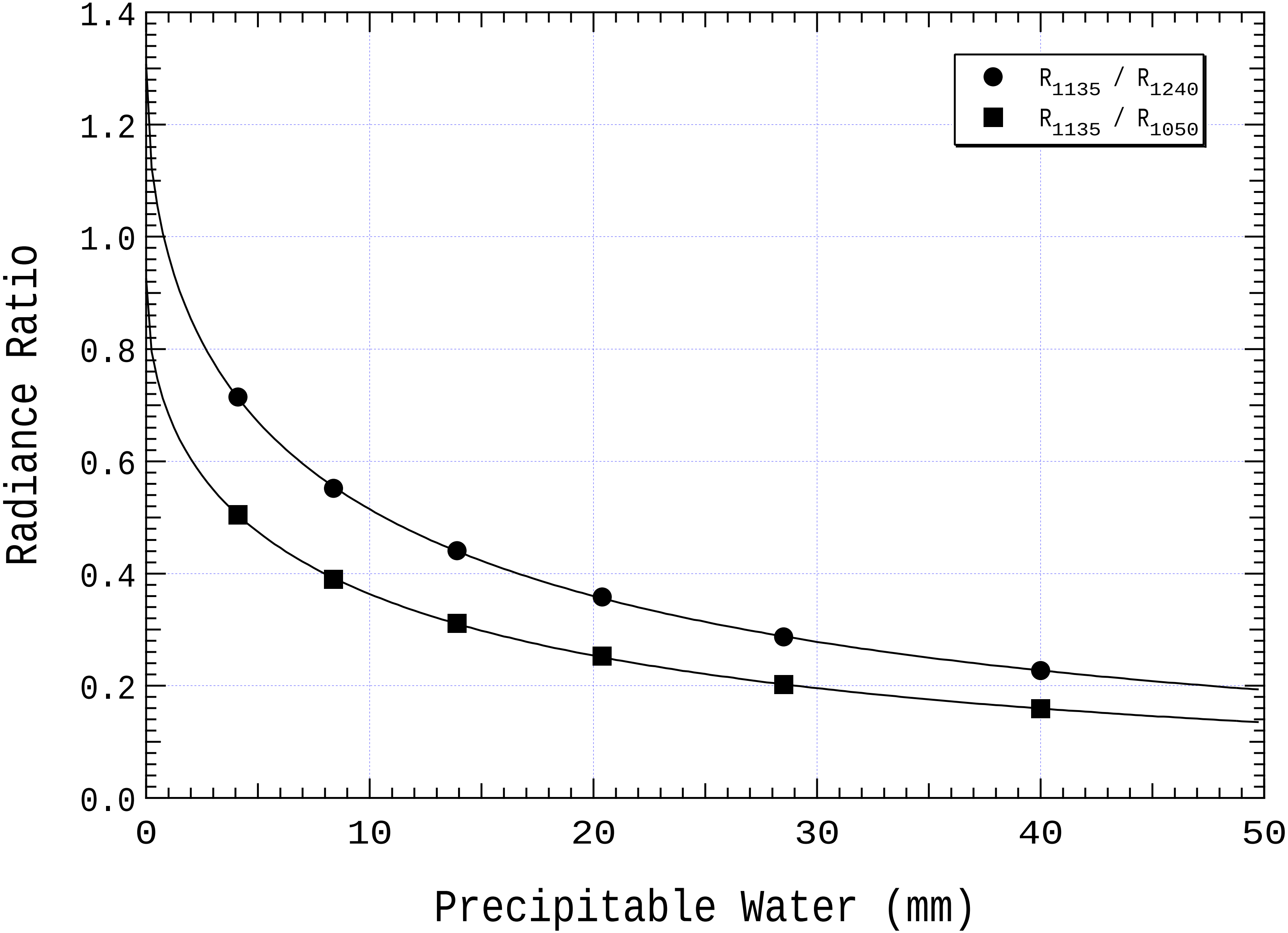
Simulation for Feasibility (1/2)

- Radiance Ratio:
  - R_{1135}/R_{1240} and R_{1135}/R_{1050} using GSS;
- Target (Background):
  - Bright (50%) and Dark (a few %) Reflectivity:
    - Land: Lambertian (for simplicity);
    - Ocean: Non-Lambertian ($u_{10} = 5\ \mathrm{m\ s^{-1}}$);
- Aerosol Loading:
  - $\tau_{a,500}$: 0.0, 0.1 and 1.0 (Rural and Oceanic Models);

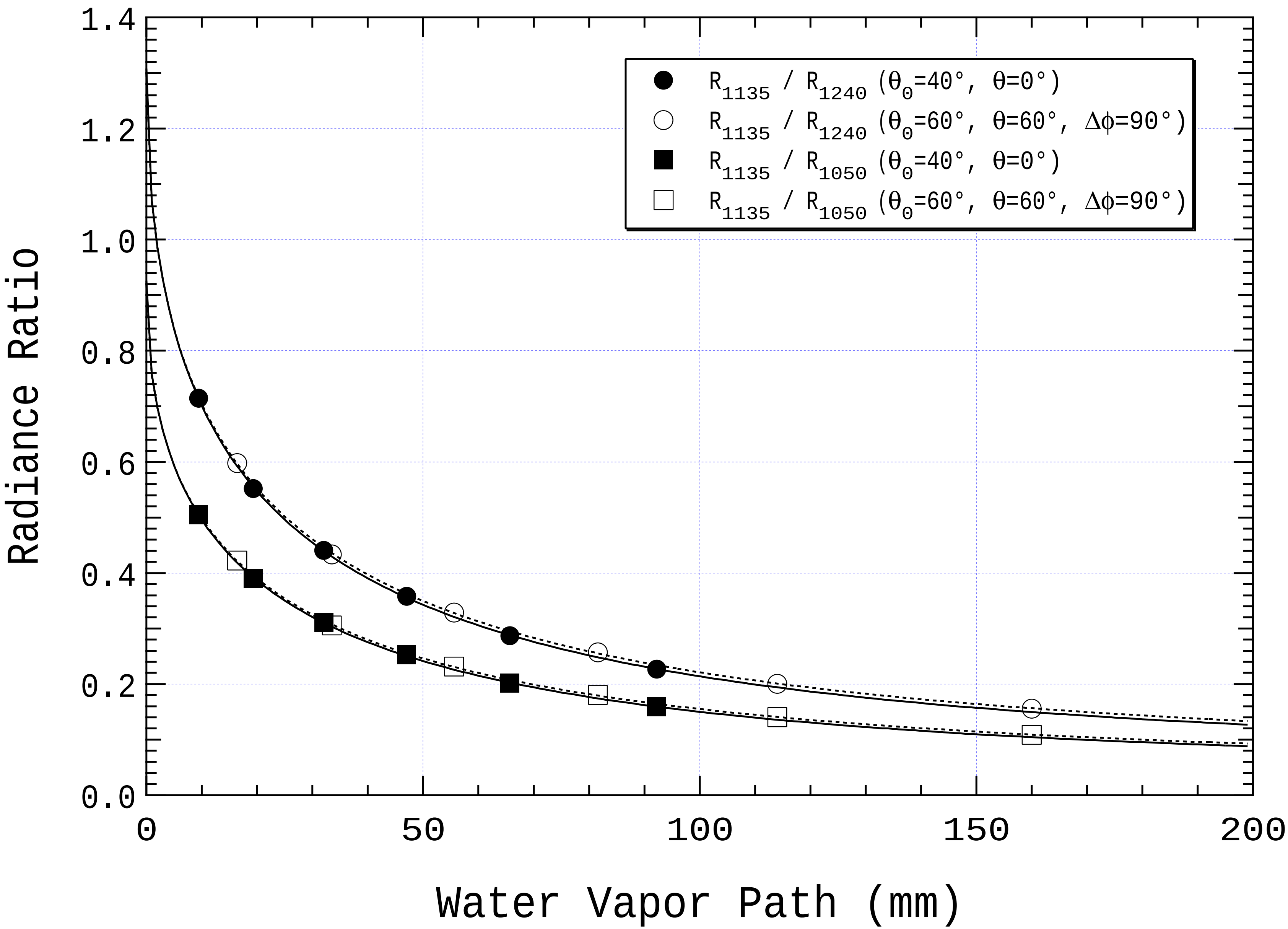
Simulation for Feasibility (2/2)

- Scan Geometry:
  - Nadir: $\theta_0=40^\circ$ and $\theta=0^\circ$;
  - Off-Nadir: $\theta_0=60^\circ$, $\theta=60^\circ$ and $\Delta\phi=90^\circ$;
- Calibration Curve:
  - $\frac{R_{wv}}{R_{nwv}} = a + b\exp\left(-c\sqrt{W}\right)$ or $= a^* + b^*\exp\left(-c^*\sqrt{W^*}\right)$;
- Scaled Water Vapor Path (W*):
  - $W^* = W\left(\frac{1}{\cos\theta} + \frac{1}{\cos\theta_0}\right)$;

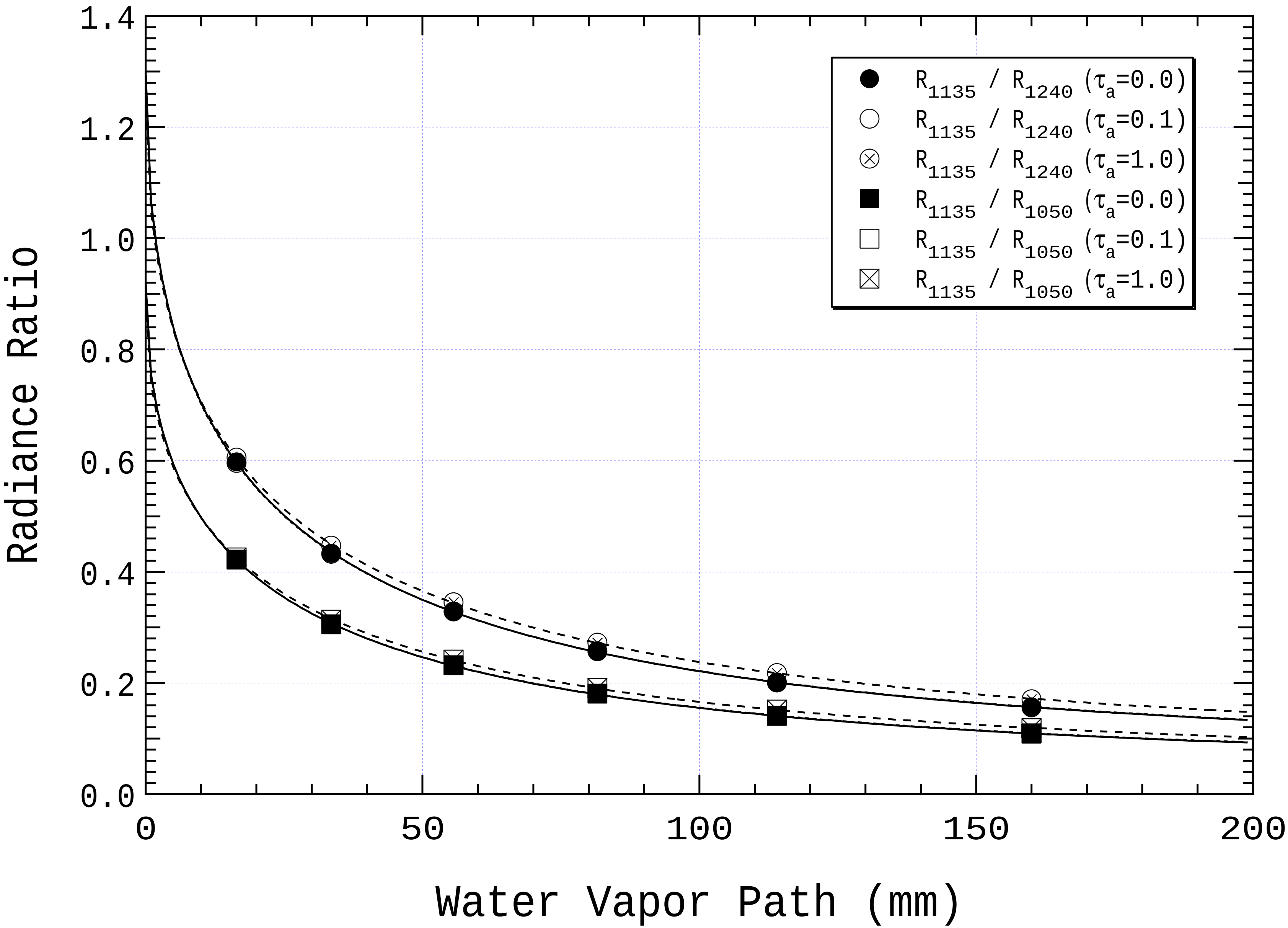
Calibration (Bright Target; Lambertian)



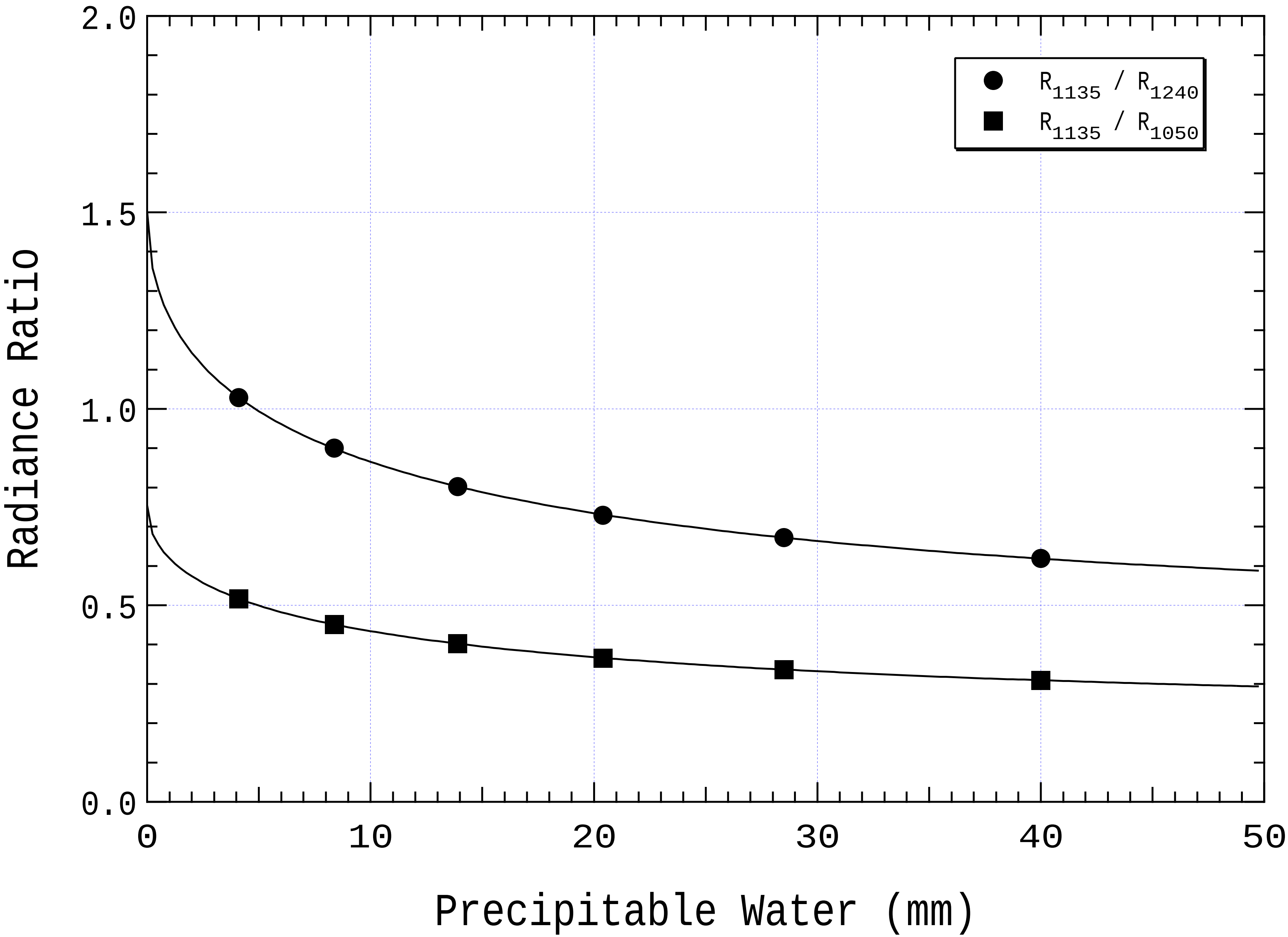
Calibration (Bright Target; Water Vapor Path)



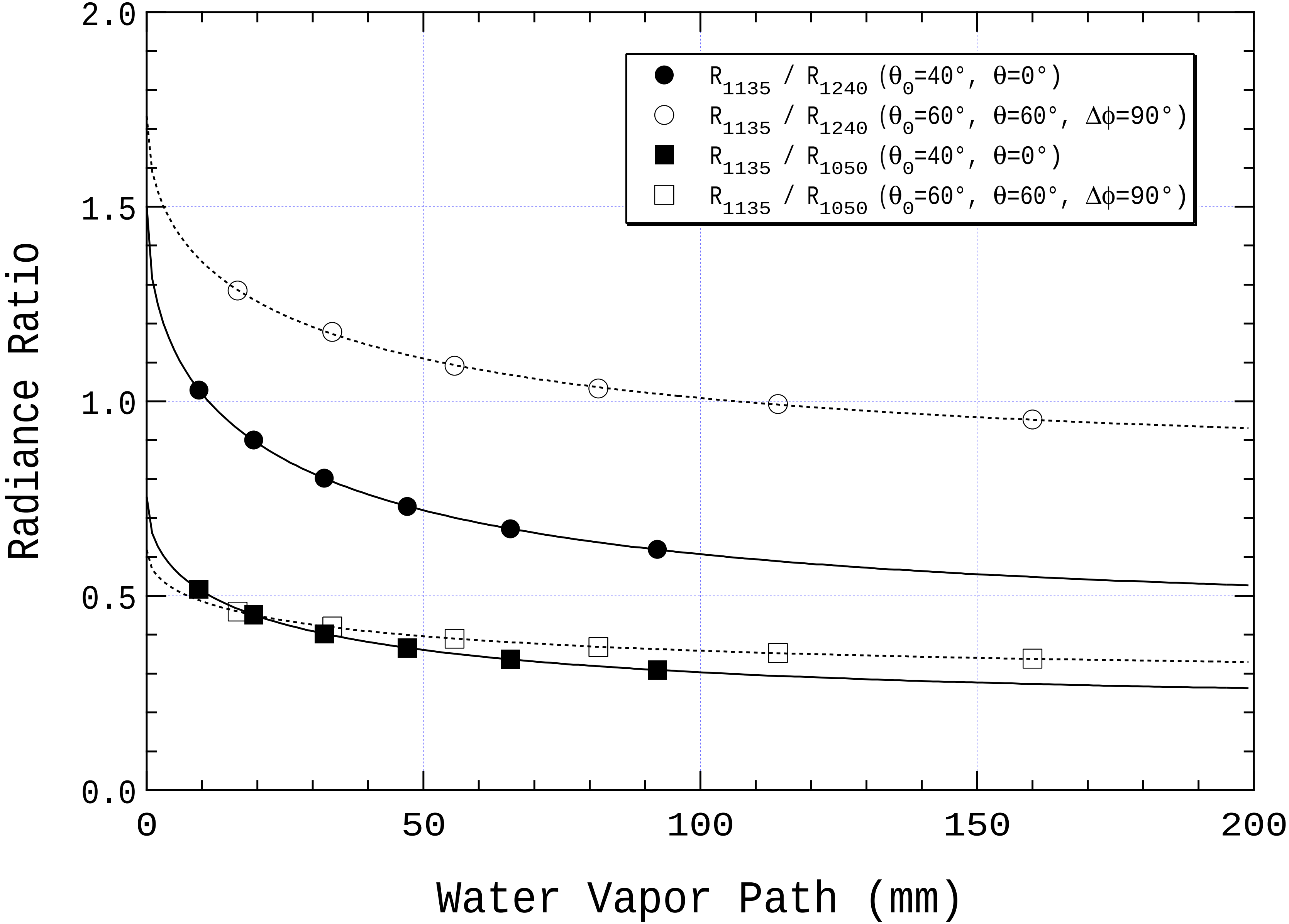
Calibration (Bright Target; Aerosol Loading)



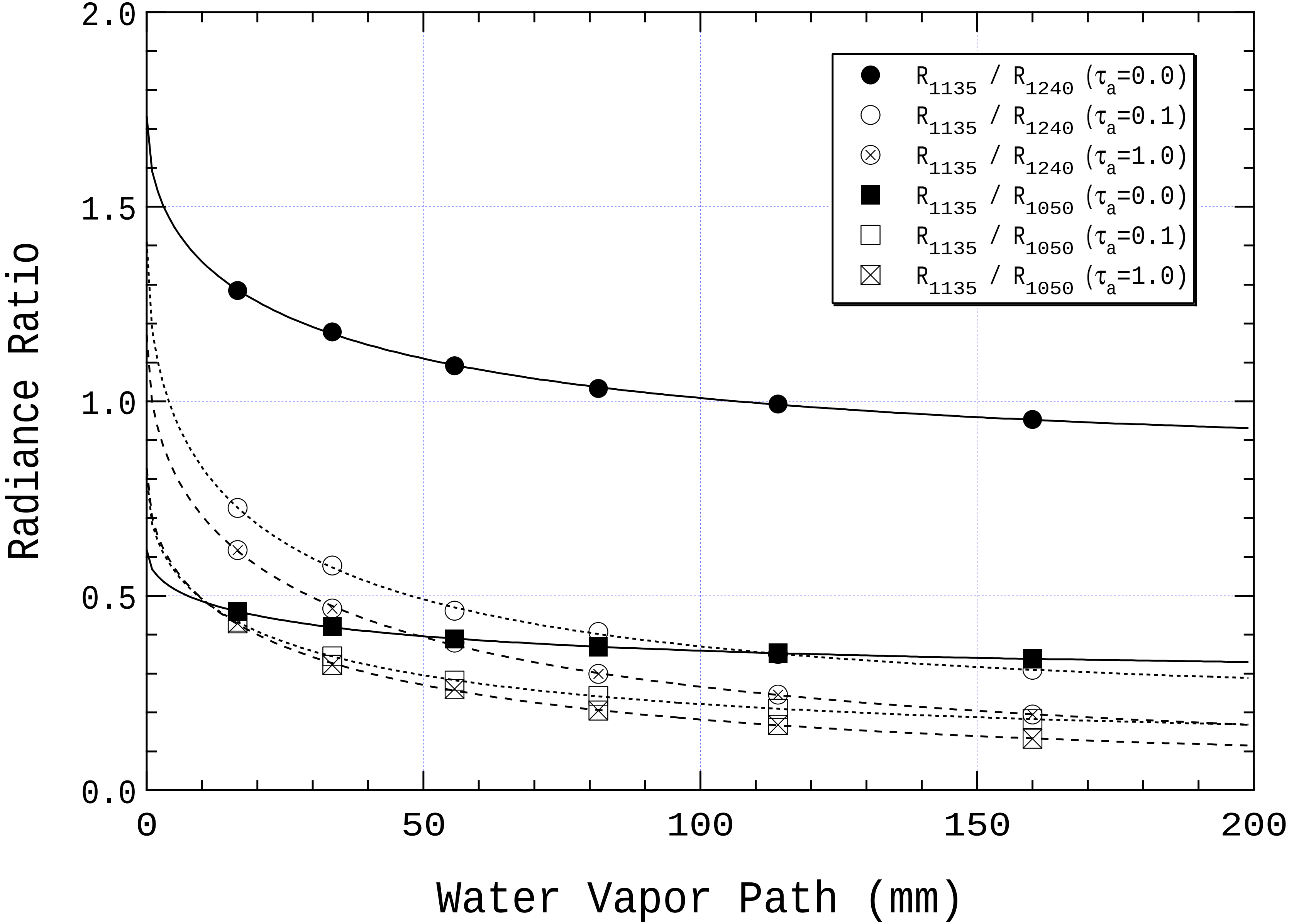
Calibration (Dark Target; non-Lambertian)



Calibration (Dark Target; Water Vapor Path)



Calibration (Dark Target; Aerosol Loading)



Summary

- Precipitable Water Retrieval using NIR Channels;
- Radiance Ratio Approach was Examined;
- Feasibility Study using GSS:
  - Both R_{1135}/R_{1240} and R_{1135}/R_{1050} are available;
  - Bright and Dark Target: up to 10 mm in PW;
  - Bright Target (Rural Aerosol): up to 6 mm;
  - Dark Target (Oceanic Aerosol): up to 8 mm;

Future Works

- Application (Lookup Table)
  - Land and Cryosphere:
    Surface Condition (BRDF from L. or C. Gs.);
- Combined Method (similar to MODIS)
  - $2*R_{1135}/(R_{1240} + R_{1050})$;
  - Take Surface Variability Properly;

Objectives

- Applications to ADEOS-II / GLI (Feb., 2002);
- Water Vapor: Column (Precipitable Water);
- Utility: Atmospheric Correction or Product;
- Advantage: Fully Synchronized Data Set;
- Status: Algorithm Refinement (from MODIS);
  - NIR Channels (GLI: 1135 and 1240 or 1050 nm);
  - Scale: Pixel-by-pixel (about 1 km^2);
  - Radiance Ratio between WV and Window;

Objectives

- ADEOS-II / GLI;
- Water vapor: Column or Profile;
- Utility: Atmospheric Correction or Product;
- Scale: Segment or Pixel-by-pixel;
- Advantage: Fully Synchronized Data Set;
- Possibility:
  - NIR (1135 nm) over Bright Targets;
  - WV (6.7, 7.3, 7.5, and 8.6 μm) for Vertical Structure;

Summary (Water Vapor)

W1. Precipitable Water Retrieval

- 1135 / 1050 nm channel: available (Pixel-by-pixel);
  - Land: Promising (0-10 g cm^{-2} in WVP);
  - Ocean: Promising (0-5 g cm^{-2} in WVP);
- Analysis and Validation;
  - AMSS does not have 1135 nm channel...;

W2. Correction for Ocean Color Algorithm

- Split-Window Channels (VISSR);
  - Barton and Prata (1999) also suggested the inconsistency;

Future Works (Water Vapor)

W1. Precipitable Water Retrieval

- Lookup Table;
  - Land: Scan Geometry (BRDF from Land G.);
  - Ocean: Aerosol Loading (over Dark Target);

W2. Correction for Ocean Color Algorithm

- Split-Window (AMSS, VISSR and AVHRR);
  - Comparison between Ratio and Difference (ΔT) Methods;
- WV Channels (AMSS, VISSR and TOVS);
  - Utility of 6.7, 7.3, and 8.3 μm channels;

Single Scattering Approximation