Application of AIRS Radiances to Evaluating General Circulation Model Upper Tropospheric Water Vapor

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Models and Databases Supported at AER

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Clough et al., JQSRT, (2005)

www.rtweb.aer.com

ARM Atmospheric Radiation Measurement Program

LBLRTM	General line-by-line model
CHARTS	Multiple Scattering (Plane Parallel)
MonoRTM	LBL for limited spectral ranges (e.g. microwave)
RRTM_LW • Standard Version • GCM Version (RRTMG_LW)	LW Flux and Cooling Rate (broadband)
RRTM_SW • Standard Version: DISORT • GCM Version: Two-Stream (RRTMG_SW)	SW Flux and Cooling Rate (broadband)
OSS • LW Region	Optimal Spectral Sampling
Databases	
• Continuum	MT_CKD_1.1
• Line Parameters	HITRAN+
• Solar Source Function	Kurucz, Monochromatic & 1 cm^{-1}

OSS Description

Optimal Spectral Sampling (OSS) Model Features:

- Efficient method for modeling **narrow band radiances**
- Includes absorption from all major gases and many trace gases
- **Approximates radiance** in a channel as a weighted sum of monochromatic radiances calculated **at selected wavenumbers** in the spectral interval
- Can include instrument functions (OSS can model AIRS)
- OSS attains **accuracy close to LBLRTM**
- OSS about **100 times faster** than LBLRTM
- Currently being modified to include scattering calculations
- More information available at www.rtweb.aer.com

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Project Overview

AIRS Atmospheric Infrared Sounder

Objective:

- To utilize AIRS spectral radiances for GCM evaluation by comparing modeled and observed radiances, with emphasis on upper tropospheric water vapor.

Observations:

- AIRS Level 3 cloud-cleared radiances
- Focus on spectral elements or intervals relevant to water vapor
- Earlier experiments utilized HIRS cloud-cleared radiances (*Bates et al.*)

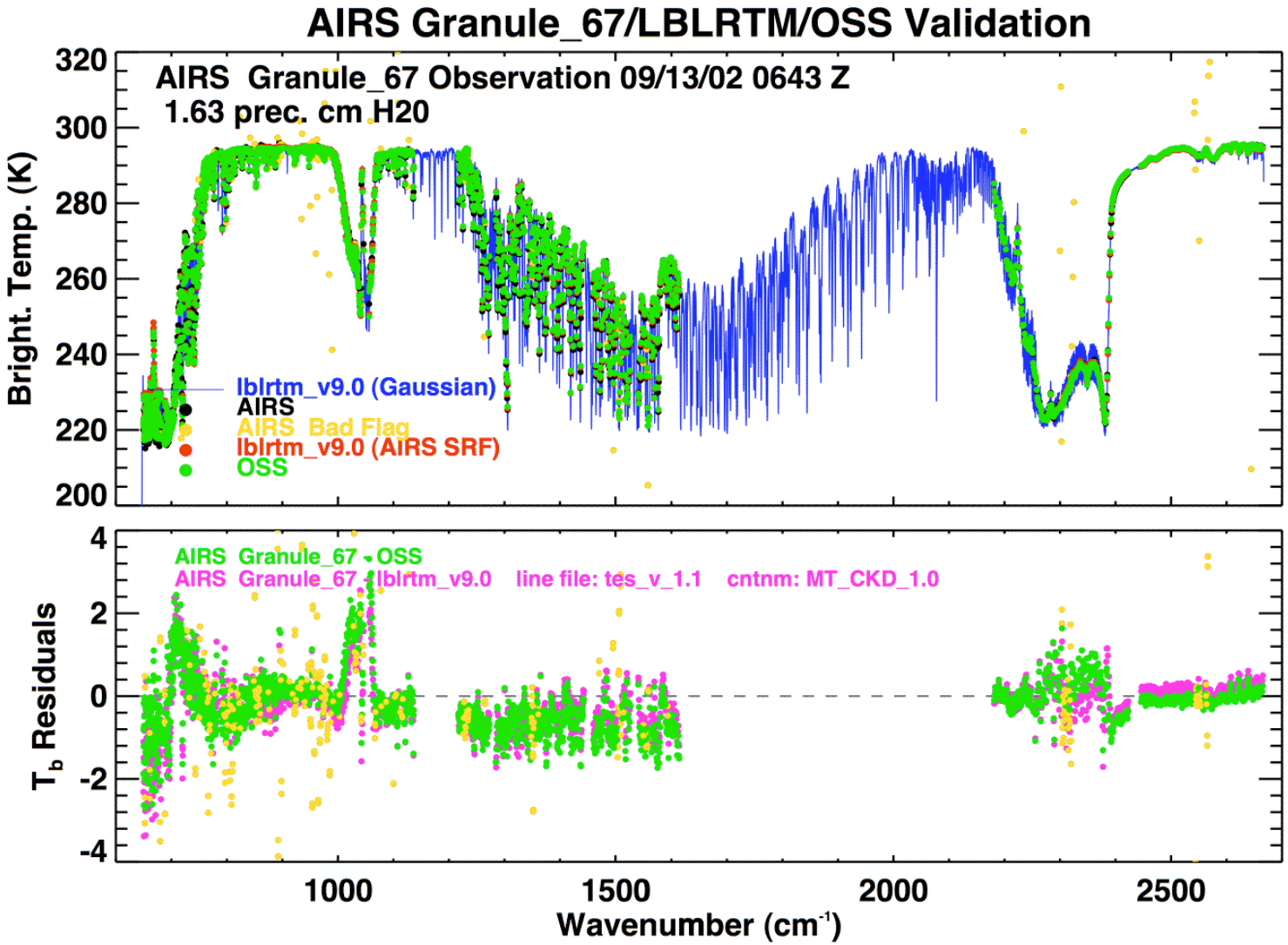
General Circulation Model:

- NCAR Community Atmosphere Model, CAM3; 2002-04 ensemble simulations
- Separate proposed project will analyze NASA GISS ModelE

Radiative Transfer:

- RRTMG_LW and RRTMG_SW have been installed in CAM3
- OSS will be implemented in CAM3 to calculate spectral radiance
- Evaluate accuracy of OSS and adapt it for application to GCMs

Comparison of OSS and LBLRTM to AIRS Radiance Spectrum



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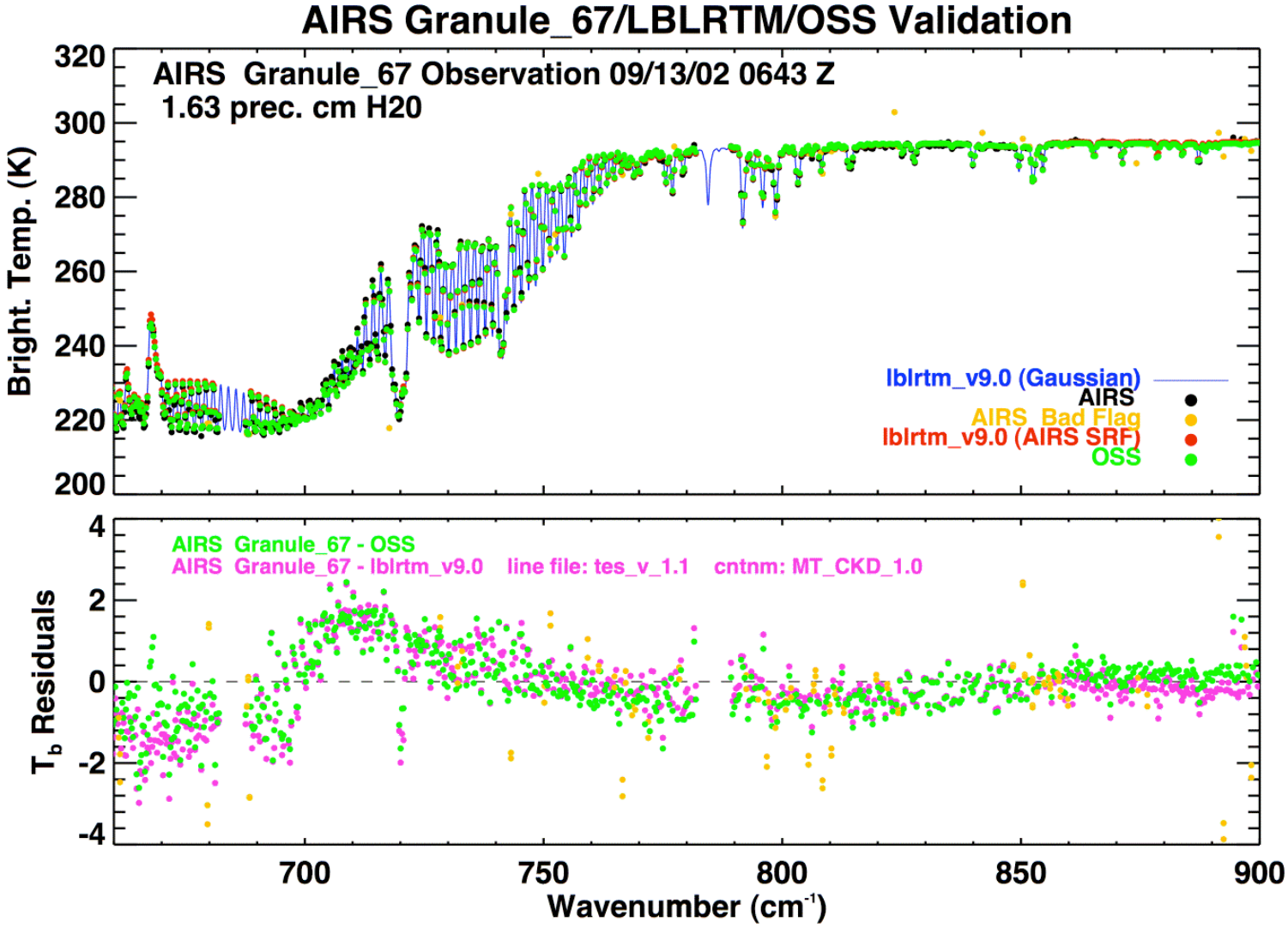

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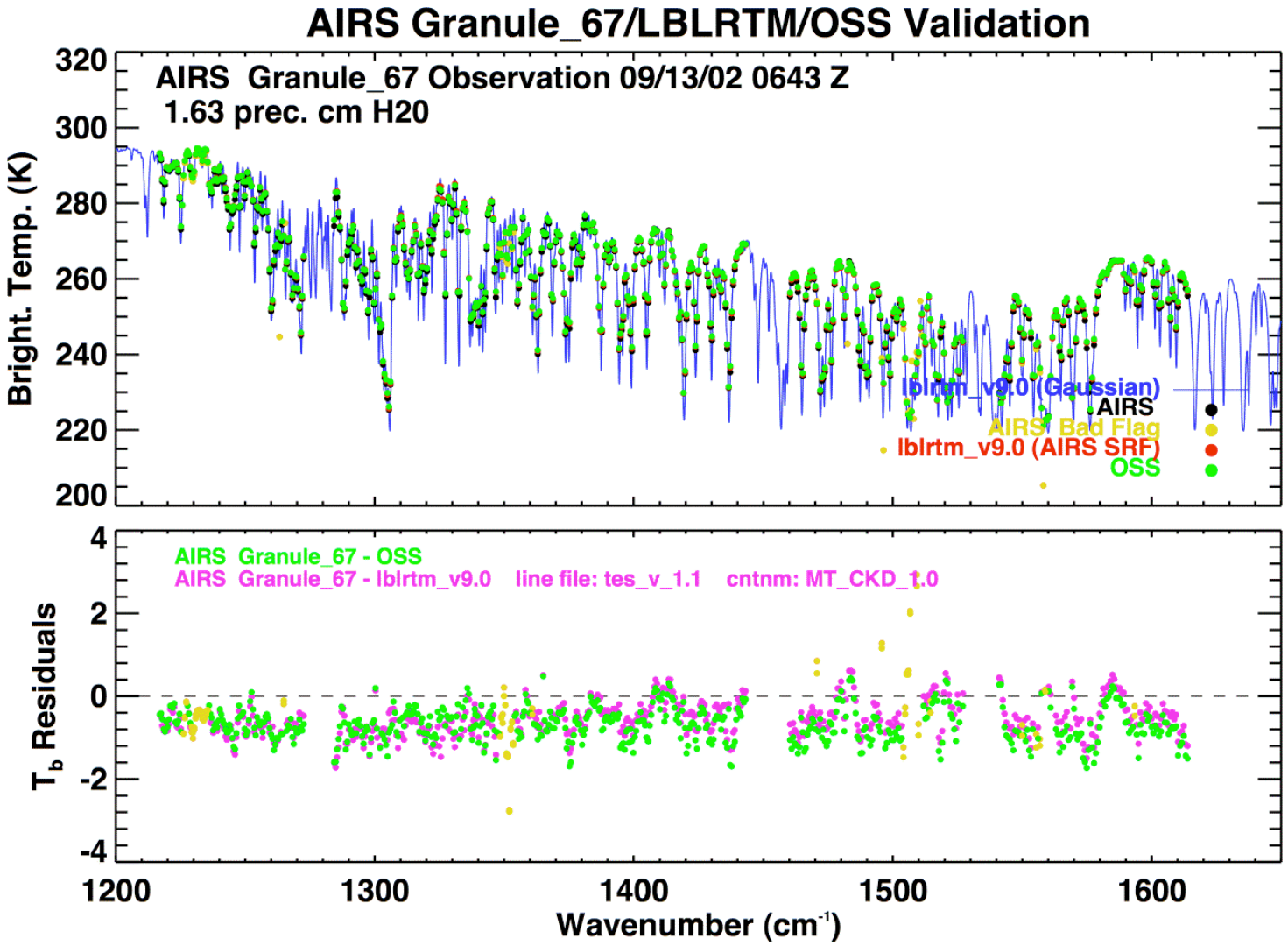
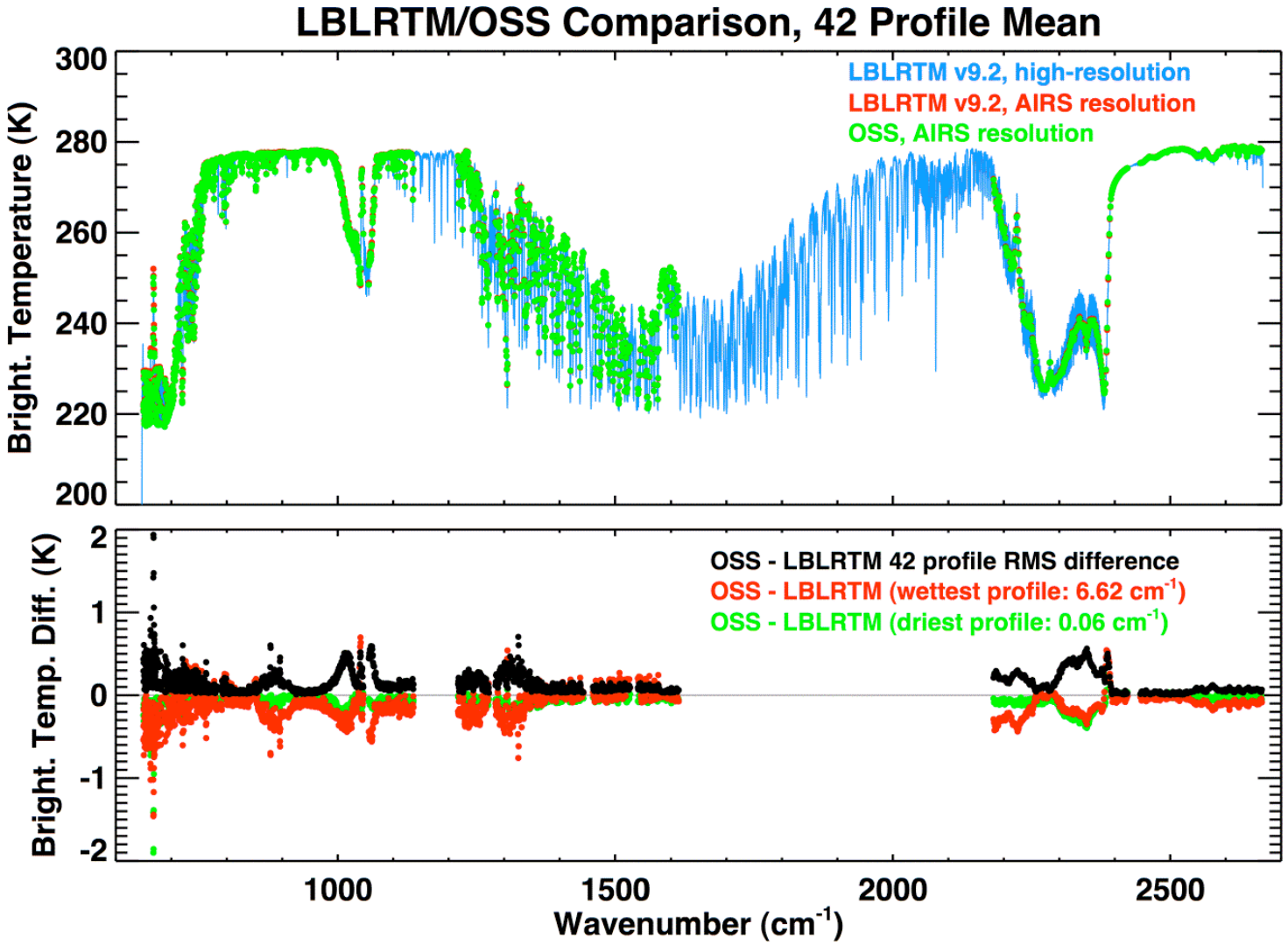


Comparison of OSS and LBLRTM for Set of 42 Diverse Profiles



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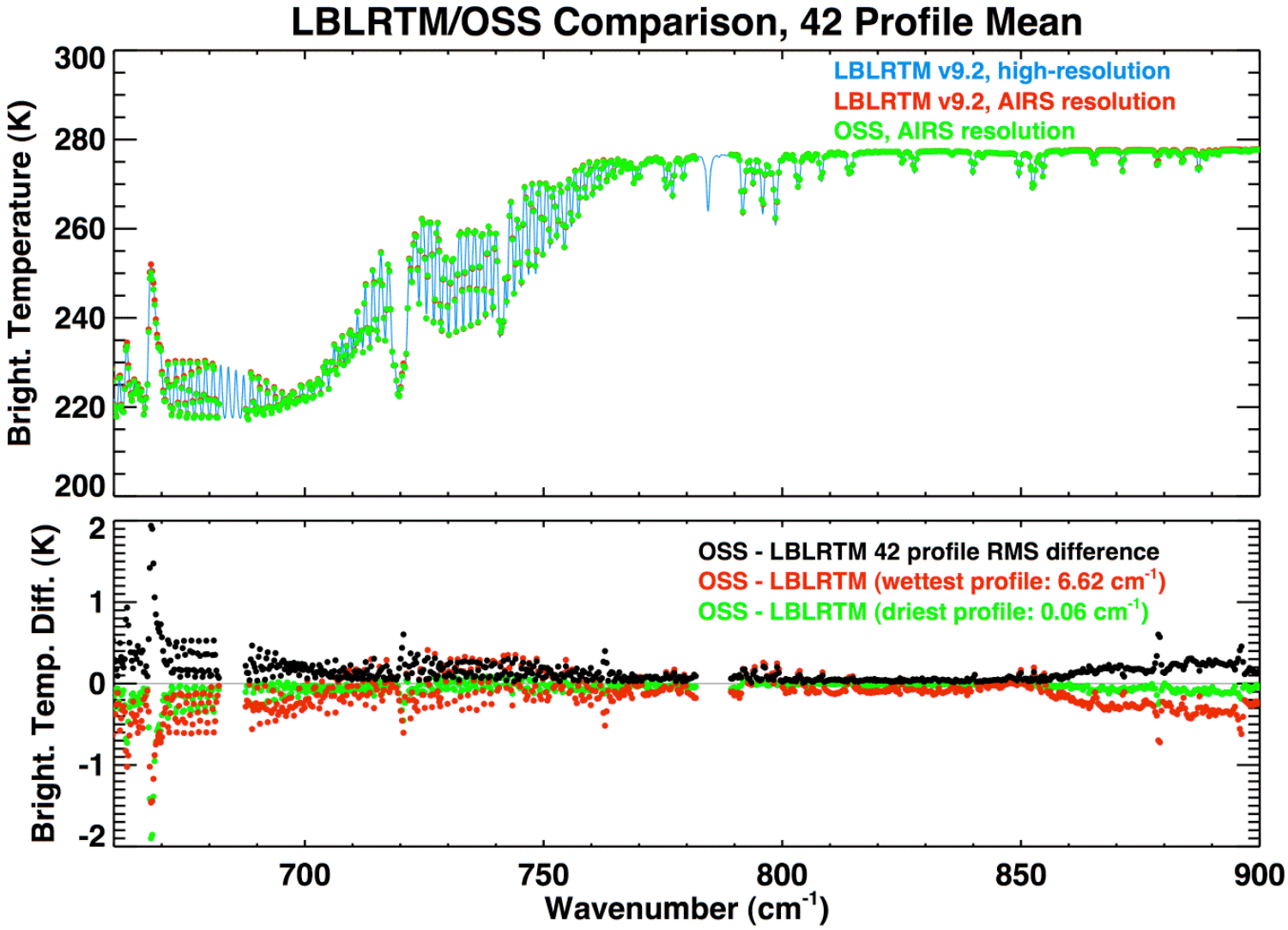

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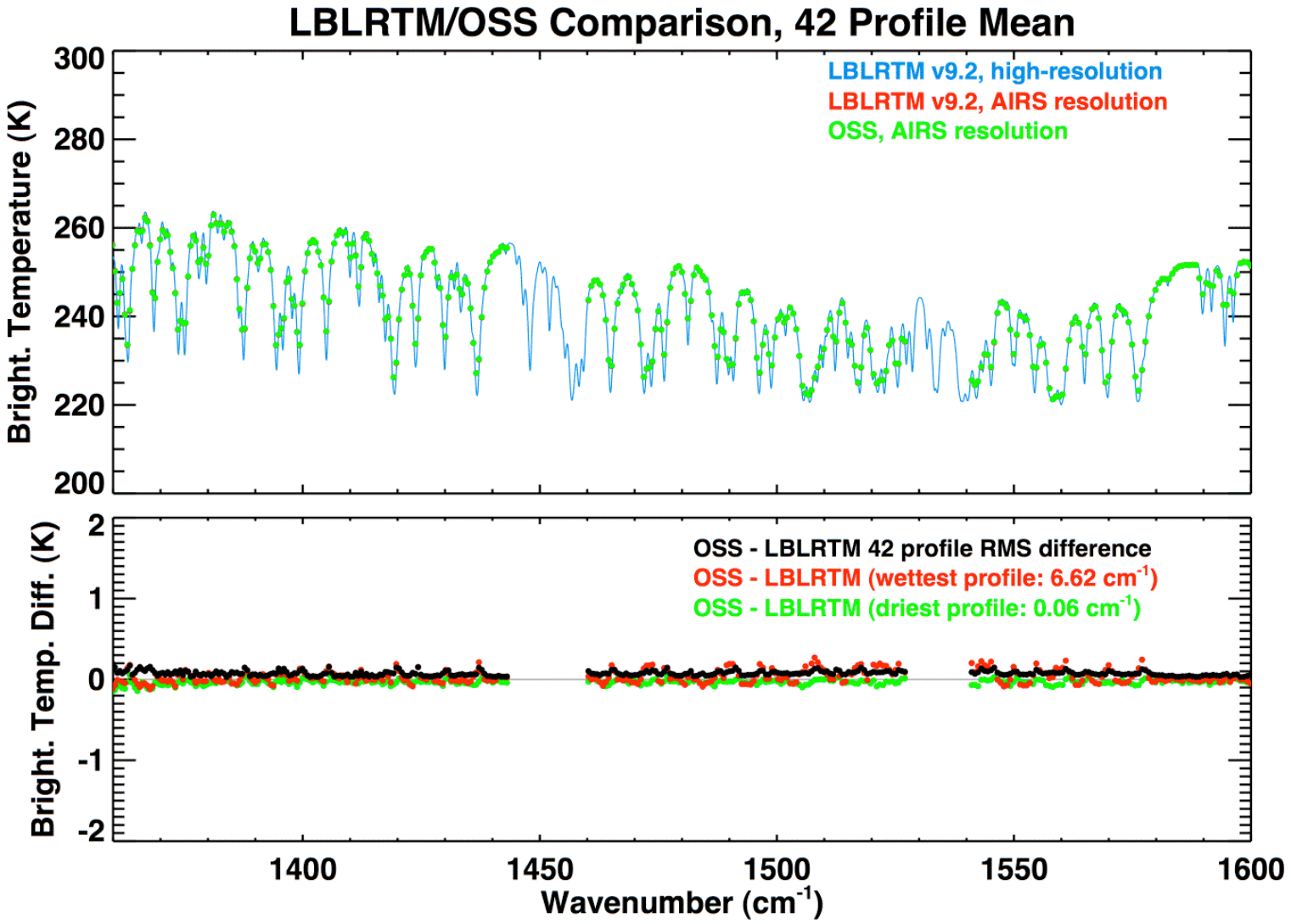

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GCM Evaluation With HIRS 6.7 μm Water Vapor Channel

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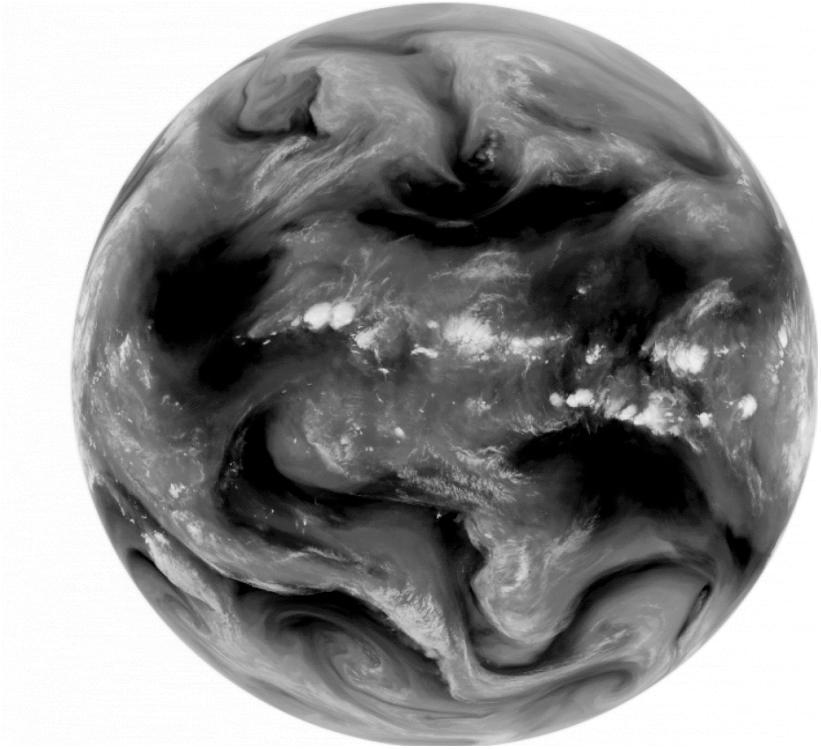
GCM Experiment Description:

- Analysis of **NCAR CAM3** climate model **upper tropospheric water vapor**
- Prescribed, monthly varying SSTs
- **Five-member ensemble** simulation of 1980-1983; ensemble needed to determine level of GCM internal noise
- Compare modeled and HIRS-observed CH04 to establish temperature accuracy and effectiveness of cloud-clearing in data
- Examine CH12 to evaluate GCM water vapor

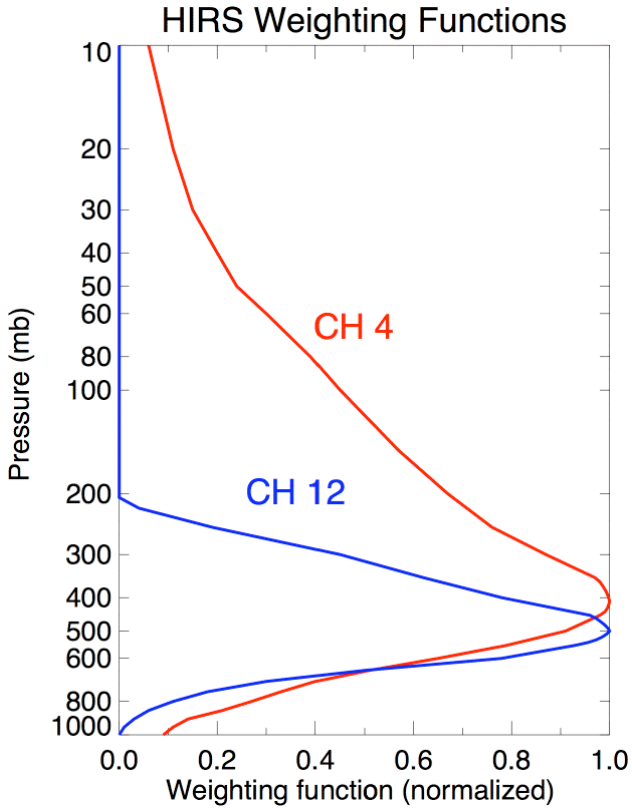
GCM Radiative Transfer:

- CAM3 modified to run with RRTMG_LW and RRTMG_SW
- NOAA-7 HIRS radiances calculated with RRTM-like module
- GCM **evaluation more efficient** with accurate radiative transfer

HIRS 6.7 μm Water Vapor Channel



GOES-10 6.7 μm water vapor (**CH12**) image from 1200 UTC 5 April 2002 centered over the equatorial eastern Pacific Ocean at 135° W (NASA-GSFC image, data from NOAA GOES).



CH 4: 675-732 cm^{-1} (Temperature)

CH12: 1382-1572 cm^{-1} (Water Vapor)

Observed and Calculated HIRS CH04 Clear Sky Brightness Temperature

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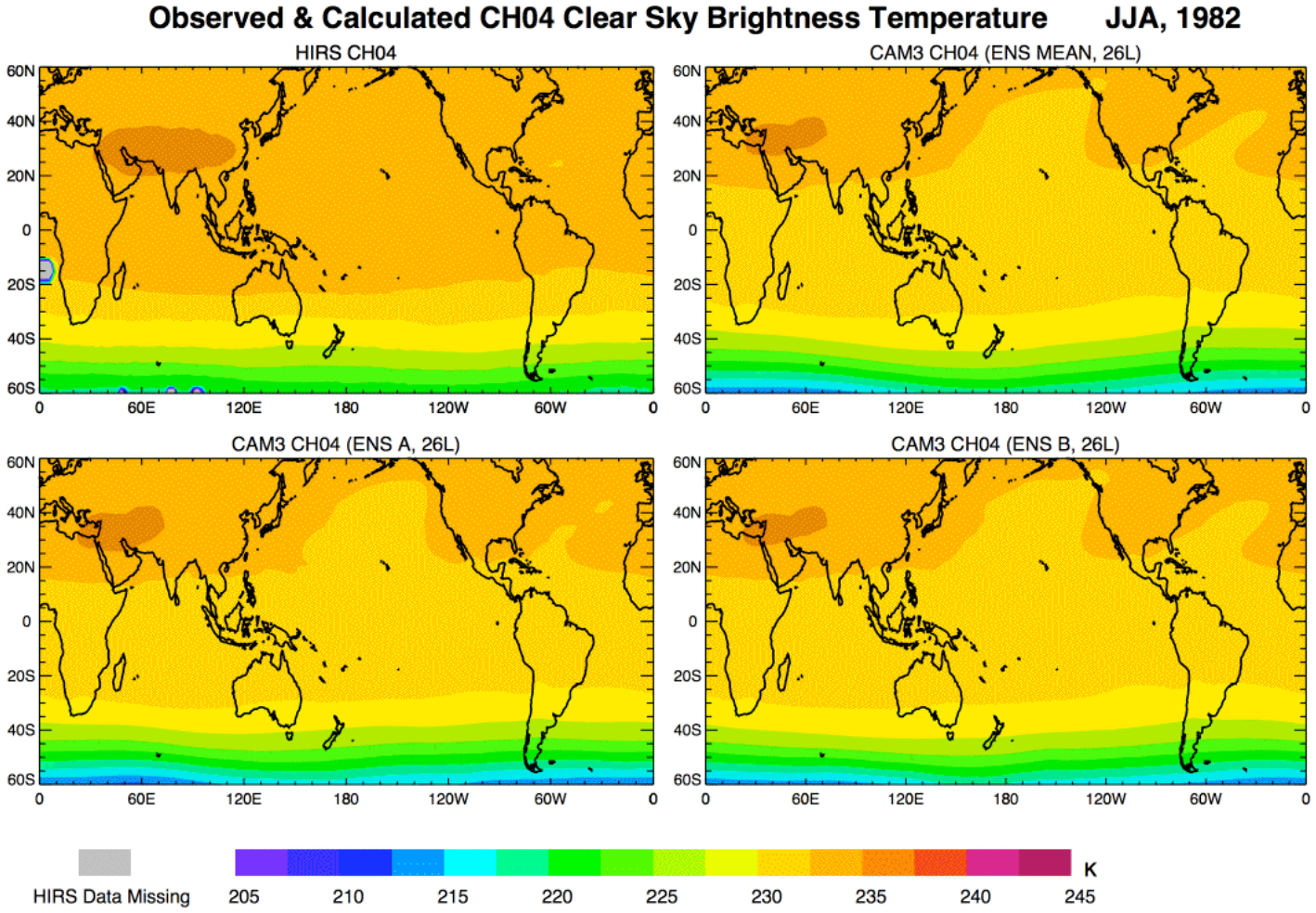
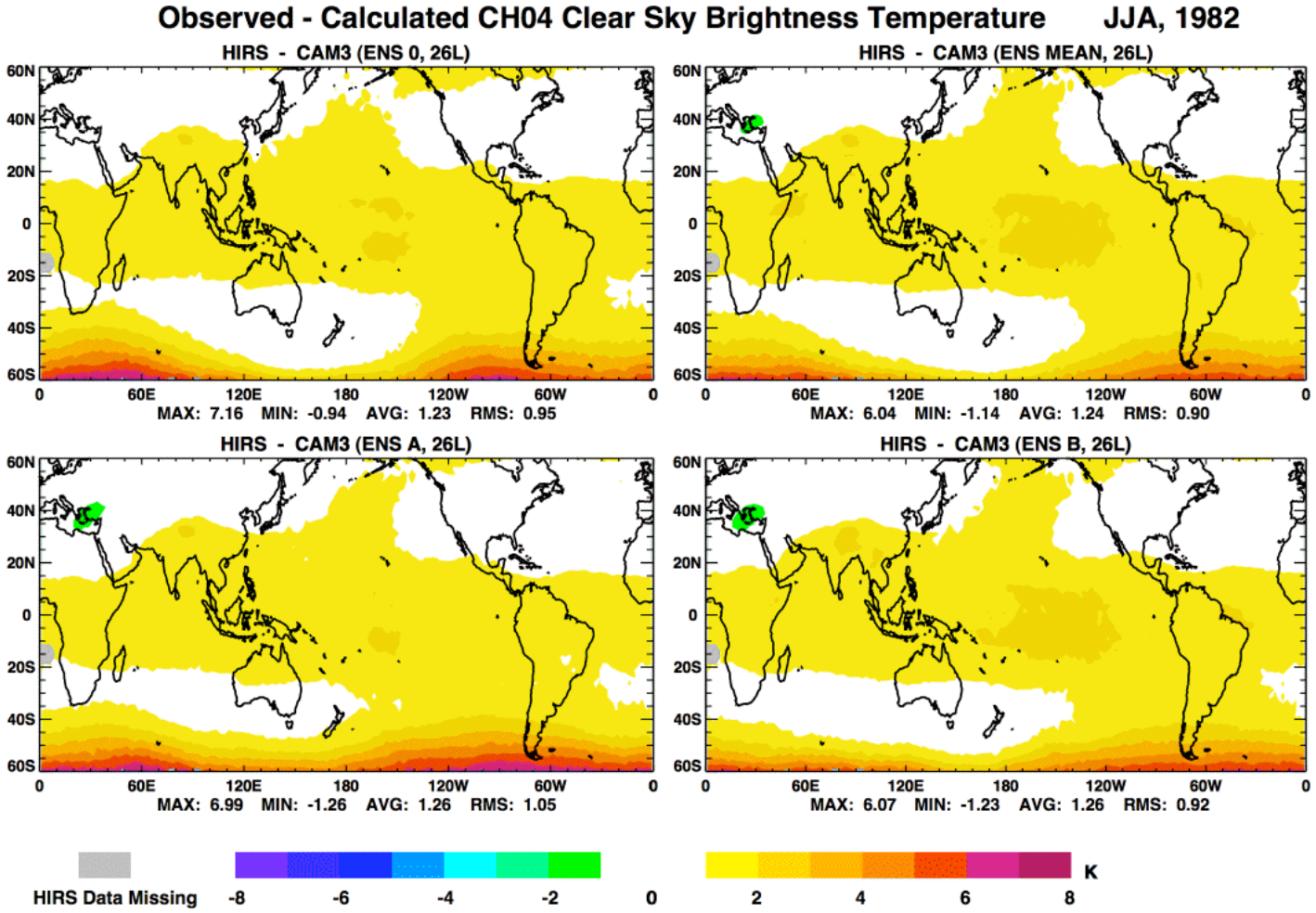
AIRS Atmospheric Infrared Sounder



Observed - Calculated HIRS CH04 Clear Sky Brightness Temperature



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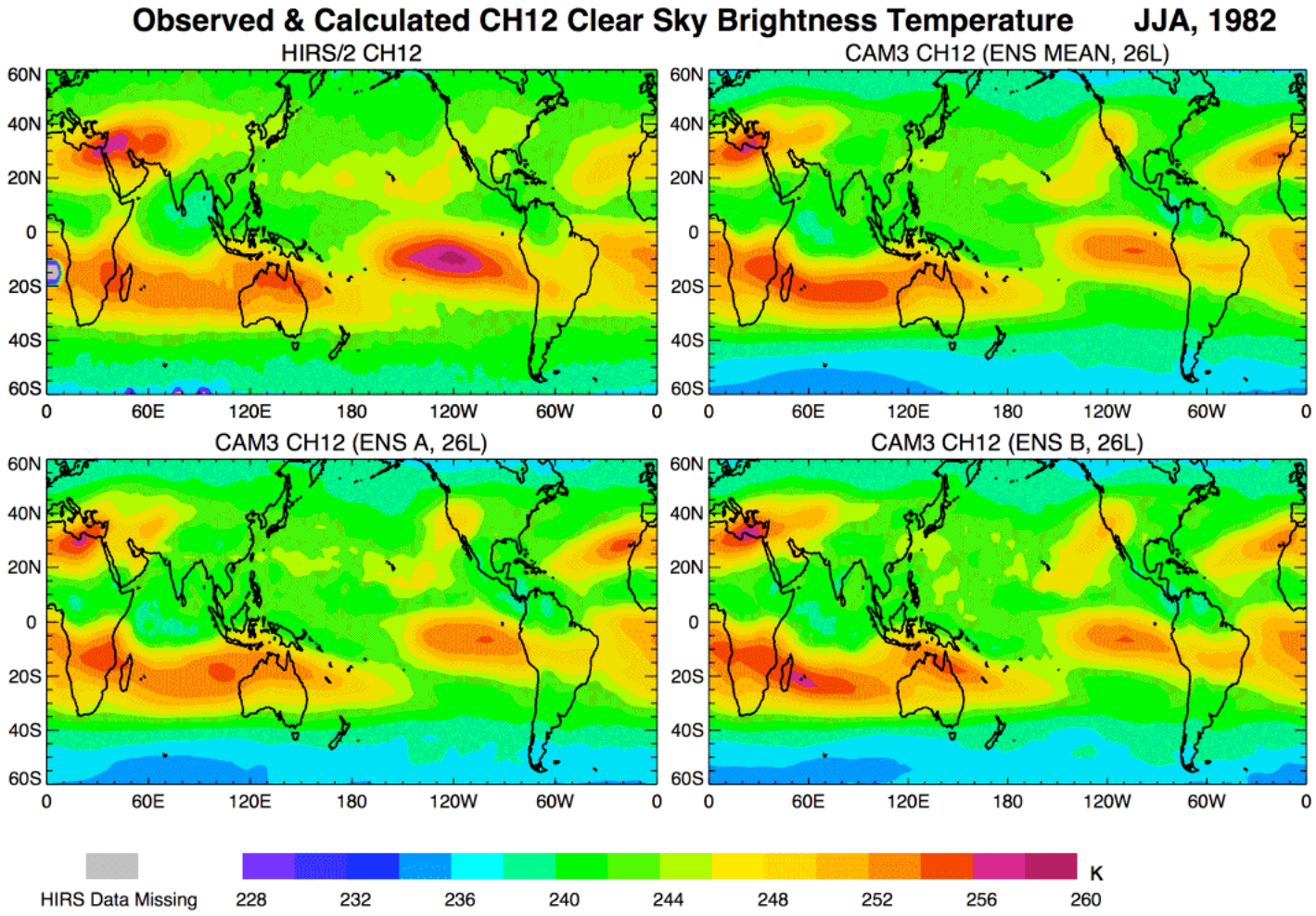
Observed and Calculated HIRS CH12 Clear Sky Brightness Temperature

AIRS Atmospheric Infrared Sounder



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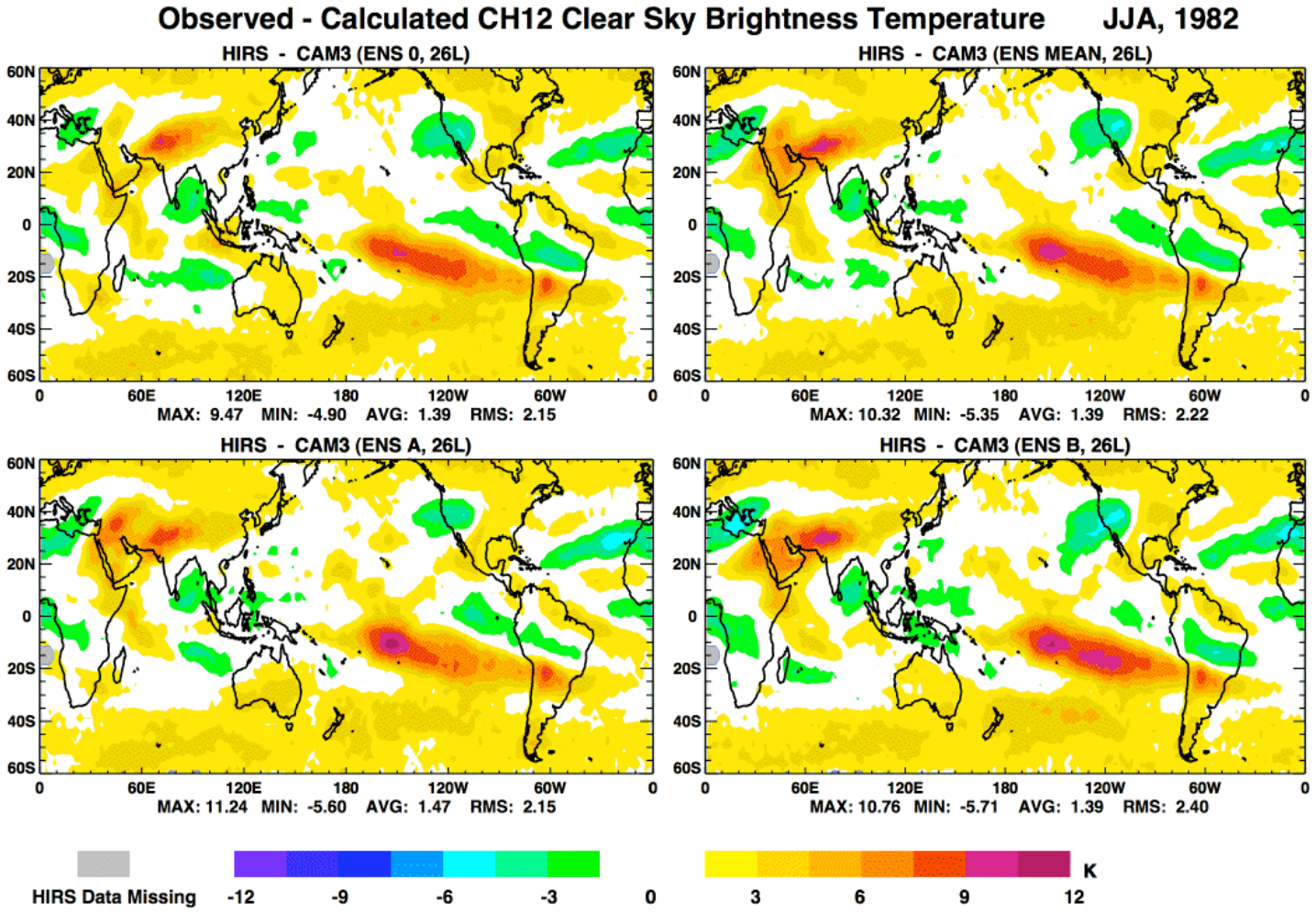
Observed - Calculated HIRS CH12 Clear Sky Brightness Temperature

AIRS Atmospheric Infrared Sounder



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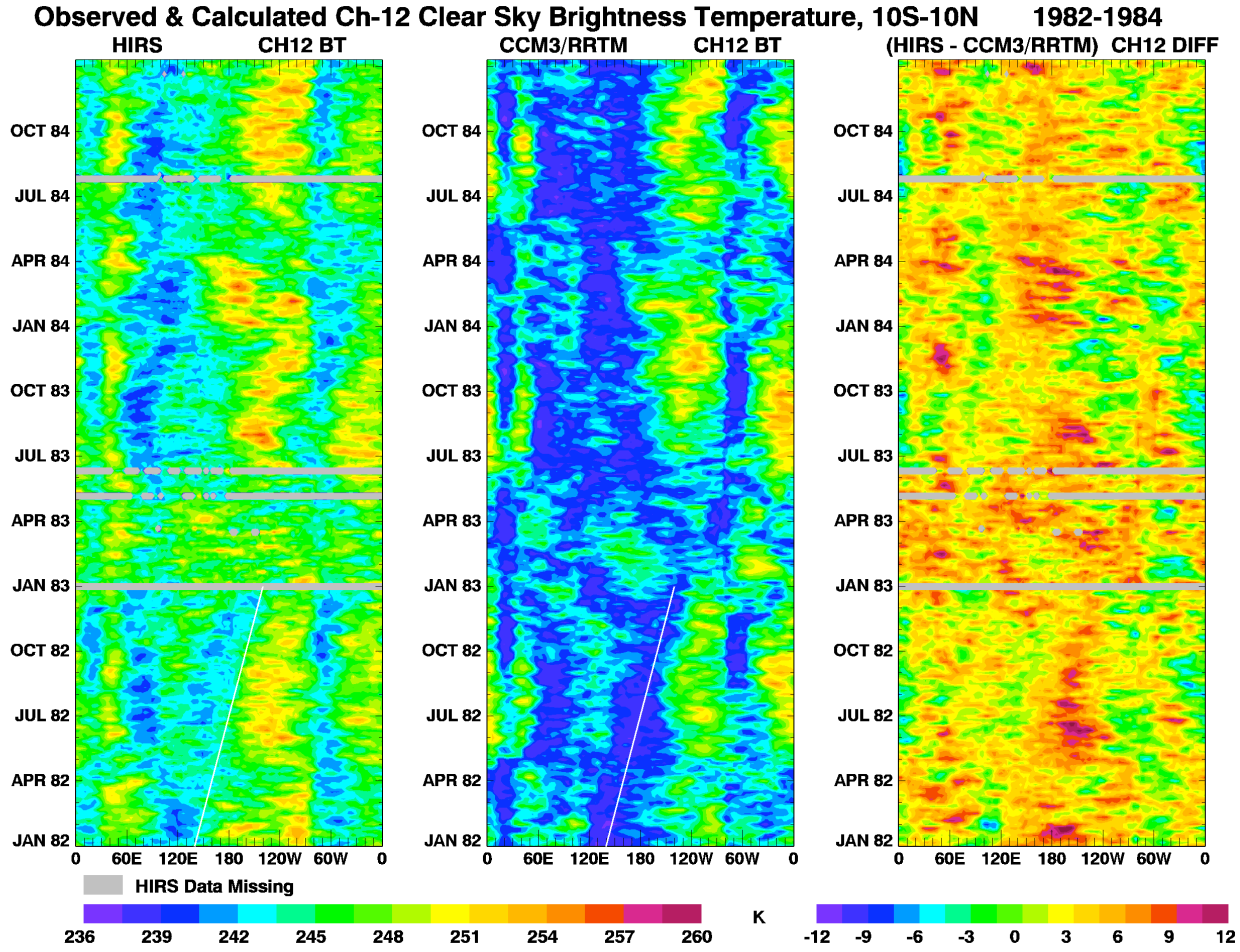
Observed and Calculated HIRS CH12 Clear Sky Brightness Temp., 1982-1984

AIRS Atmospheric Infrared Sounder



Summary

- Objective: Examine spectral component of GCM radiative transfer; **focus on evaluating GCM water vapor** by comparing modeled and AIRS radiances.
- **OSS** method provides **accurate and efficient spectral radiances** relative to LBLRTM; will be adapted for use in GCMs
- HIRS CH12 brightness temperatures have been used to show **GCM deficiencies** in NCAR CAM3 upper tropospheric water vapor
- Comparison to satellite radiance is an **important diagnostic** for GCMs to provide closure

Future Work

- Experiments will require AIRS Level 3 cloud-cleared radiances for spectral regions or elements to be decided
- Proposed project will use this approach to examine NASA GISS ModelE