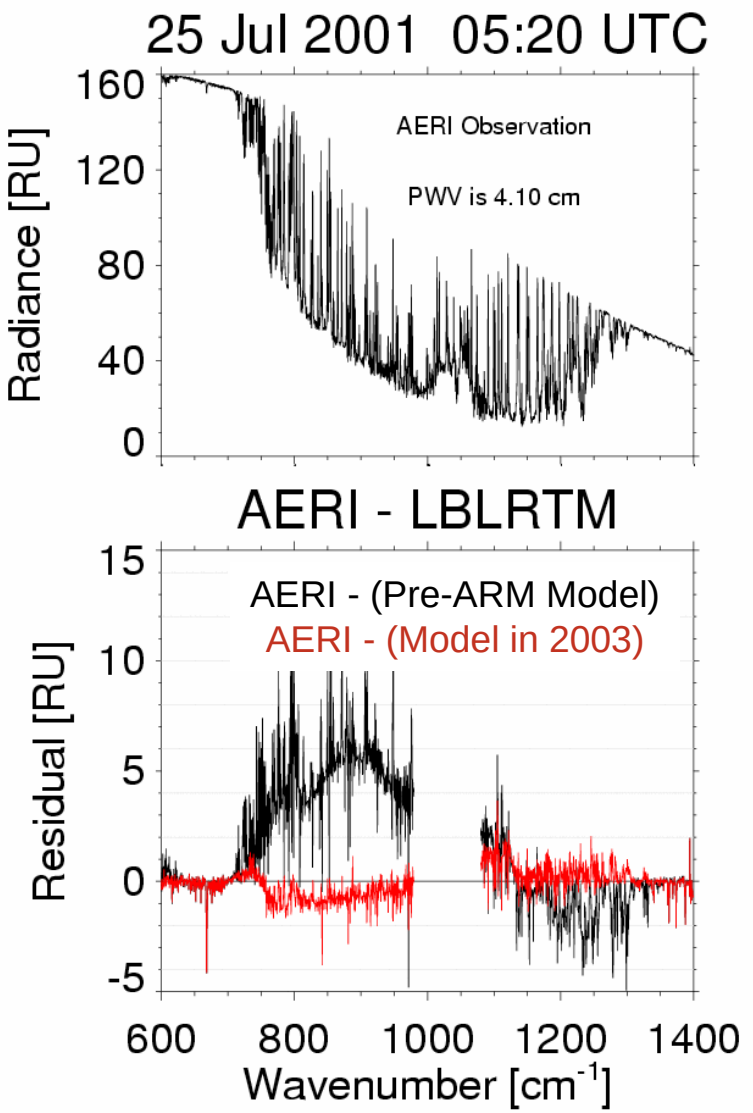
DOE ARM Program

Accomplishments of the Instantaneous Radiative Flux (IRF) Working Group

August 2006

AERI Observations at Southern Great Plains Improve Infrared Radiative Transfer Models

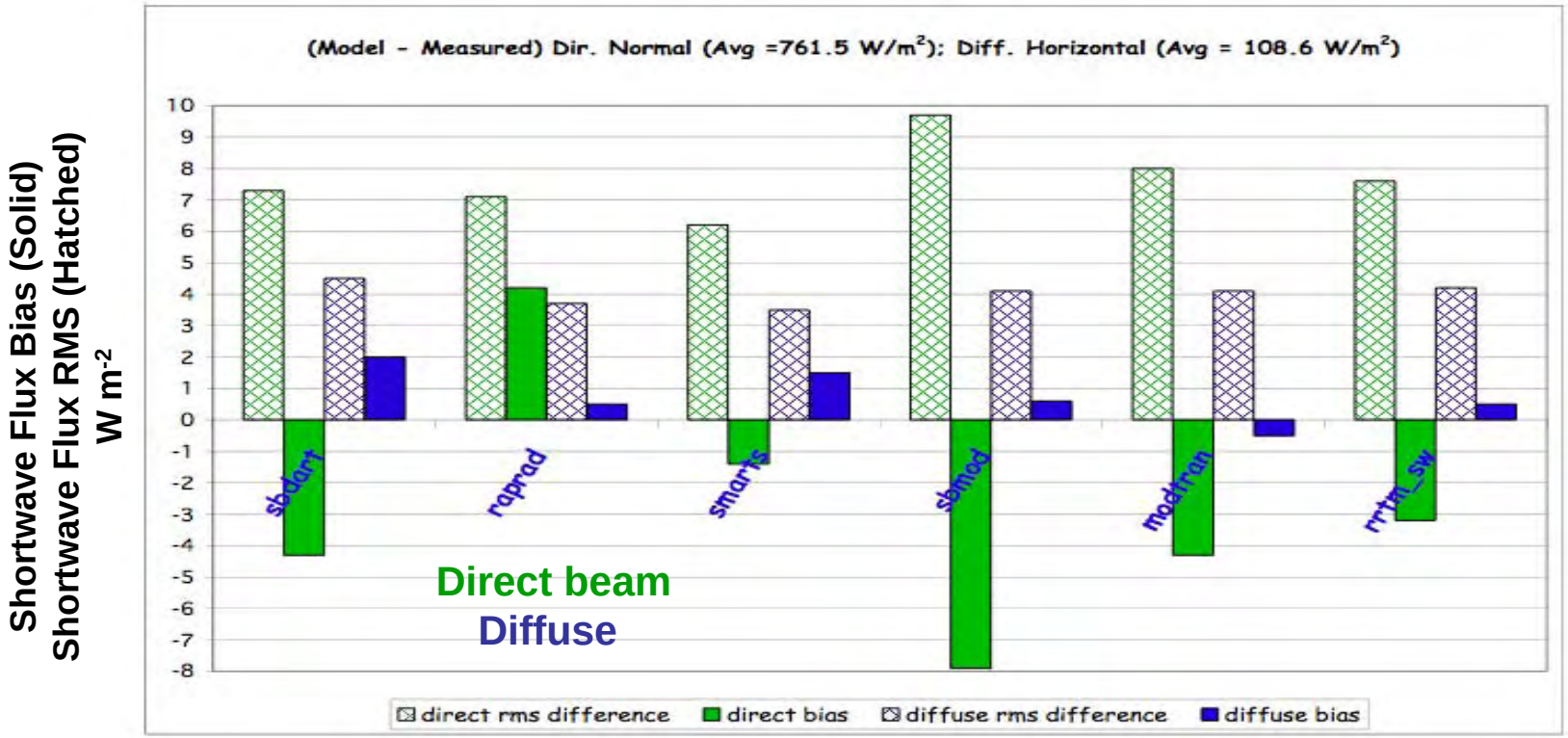


1 RU = 1 mW / (m^2 sr cm^{-1})

- AERI observations used to evaluate clear sky IR radiative transfer models
- Long-term comparisons have improved
  - Spectral line database parameters
  - Water vapor continuum absorption models
- Reduced errors in computation of downwelling radiative IR flux by approx 4; current uncertainty is on the order of 1.5 W/m^2

Turner et al., JAS, 2004

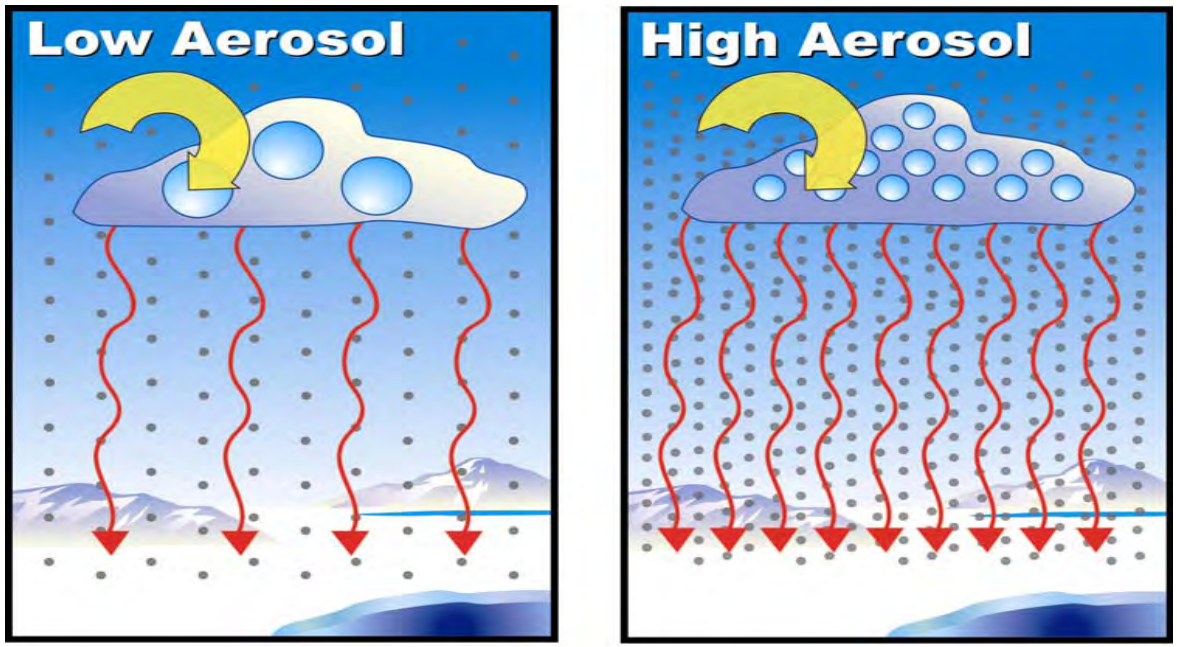
Excellent Agreement in Clear Sky Shortwave Radiative Transfer Between Obs and Calcs



- Comparison of shortwave radiative flux at the surface during 2003 aerosol IOP with 6 different models
- Better specification of input parameters (esp. aerosol) yield excellent agreement, with the bias < 1% in direct beam, bias < 2% in diffuse

Michalsky et al., JGR, 2006

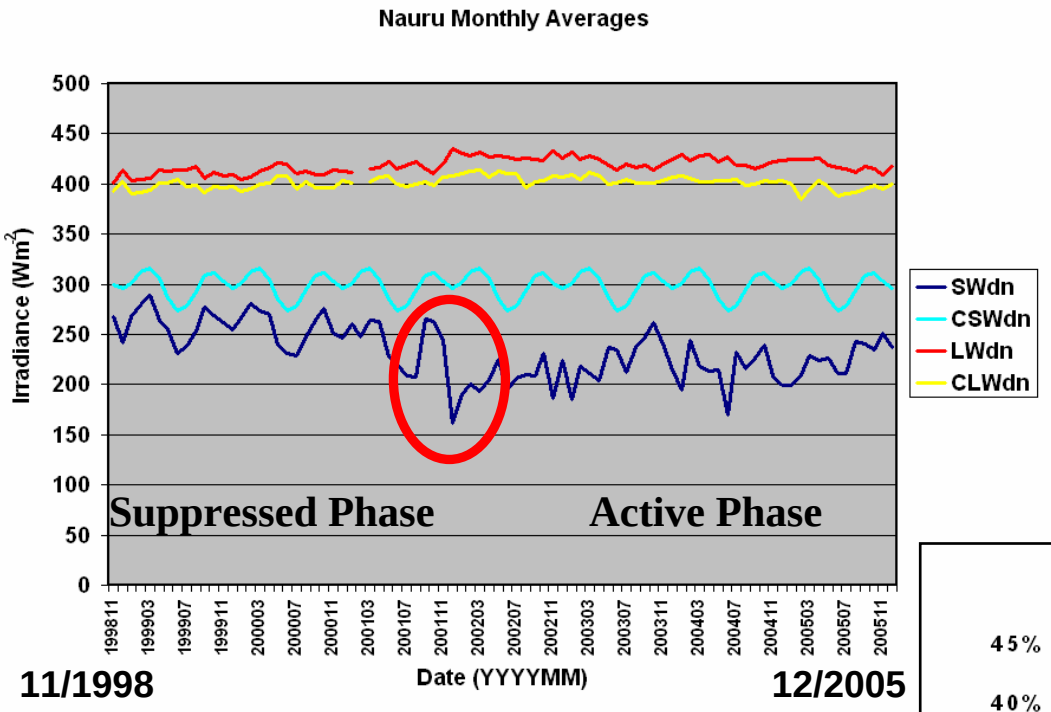
Indirect Effect of Arctic Aerosols in the Infrared



- In a process known as the first aerosol indirect effect, enhanced aerosol concentrations cause the droplets in a cloud to be smaller and more numerous within a cloud of fixed water amount.
- 6-yr analysis at NSA found that this process can make clouds more opaque and emit more thermal energy to the surface.
- Significant for the Arctic energy balance

Lubin and Vogelmann, Nature, 2006

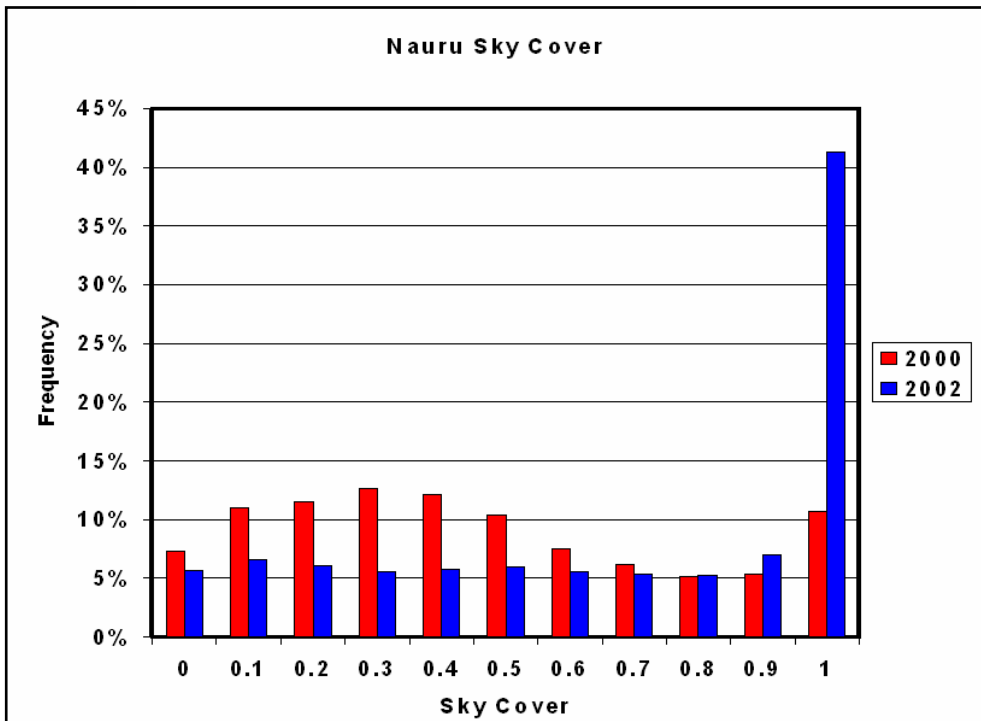
Shortwave Flux Analysis



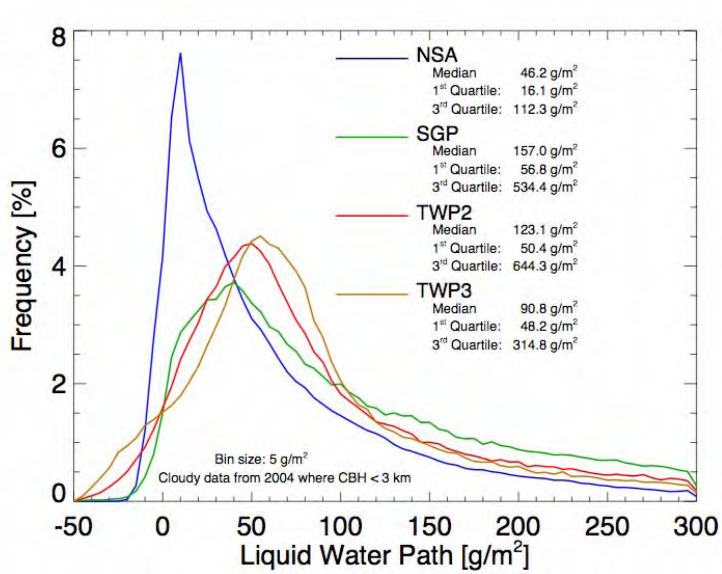
ARM Value Added Product (VAP) -Produces continuous estimates of daylight clear-sky downwelling total, direct and diffuse SW, plus fractional sky cover. These quantities allow assessment of radiative impact of clouds at the surface.

Analyses show a decrease in all-sky downwelling SW (above) is associated with a transition from less to more convectively active phase at Nauru in December of 2001 and a distinct shift in sky cover frequency distribution (right).

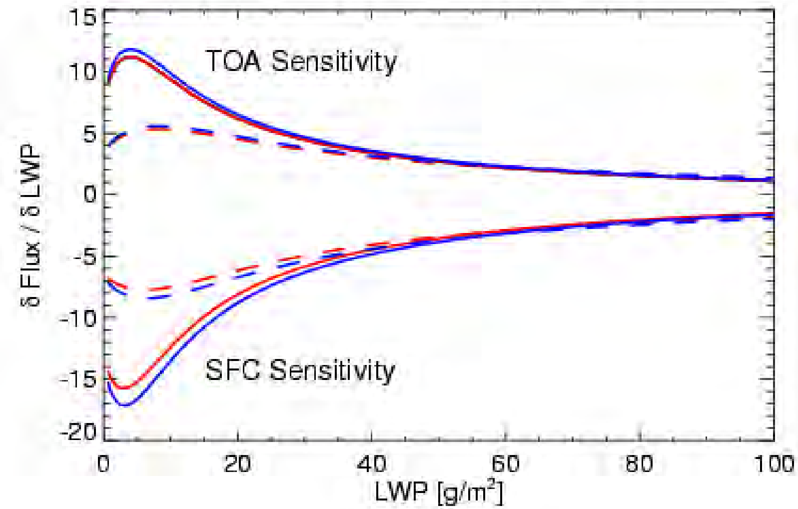
Long et al., JGR, 2006



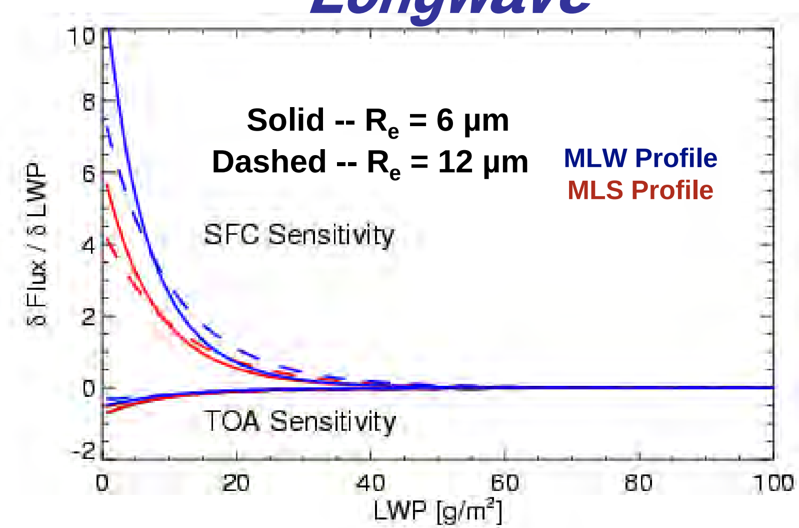
Radiative Importance of “Thin” Liquid Water Clouds



Shortwave



Longwave

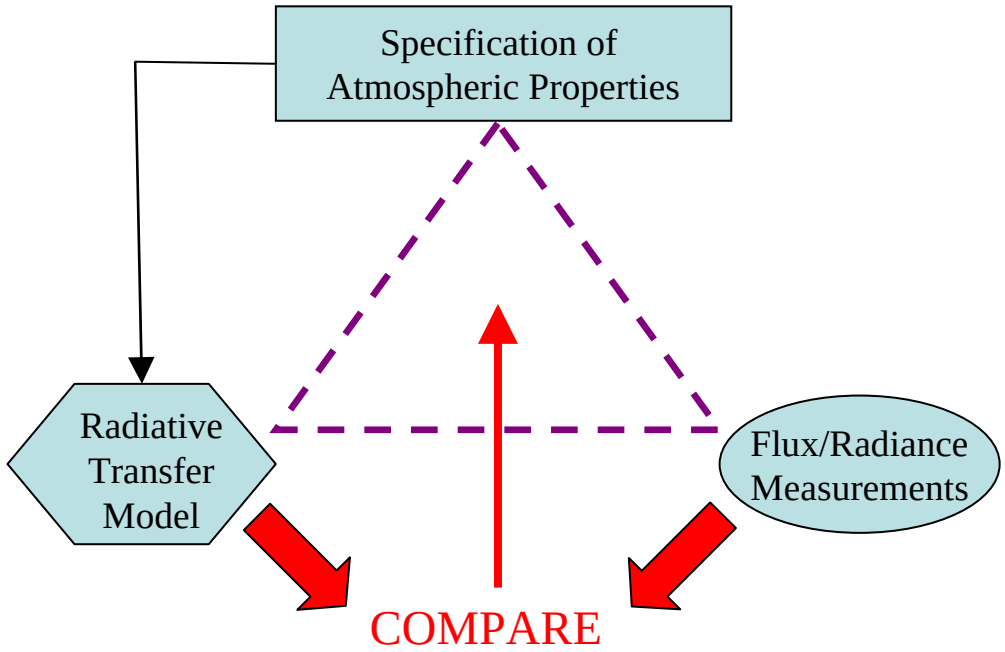


- Thin clouds occur very frequently in Arctic, mid-latitudes, and tropics
- Radiative fluxes are very sensitive to small changes in liquid water path (LWP) when LWP <100 g/m^2

Turner et al., BAMS, 2006 (accepted), Sengupta et al., J Climate, 2003

Major Expansion of ARM Radiative Closure Studies: **Broadband Heating Rate Profile Project (BBHRP)**

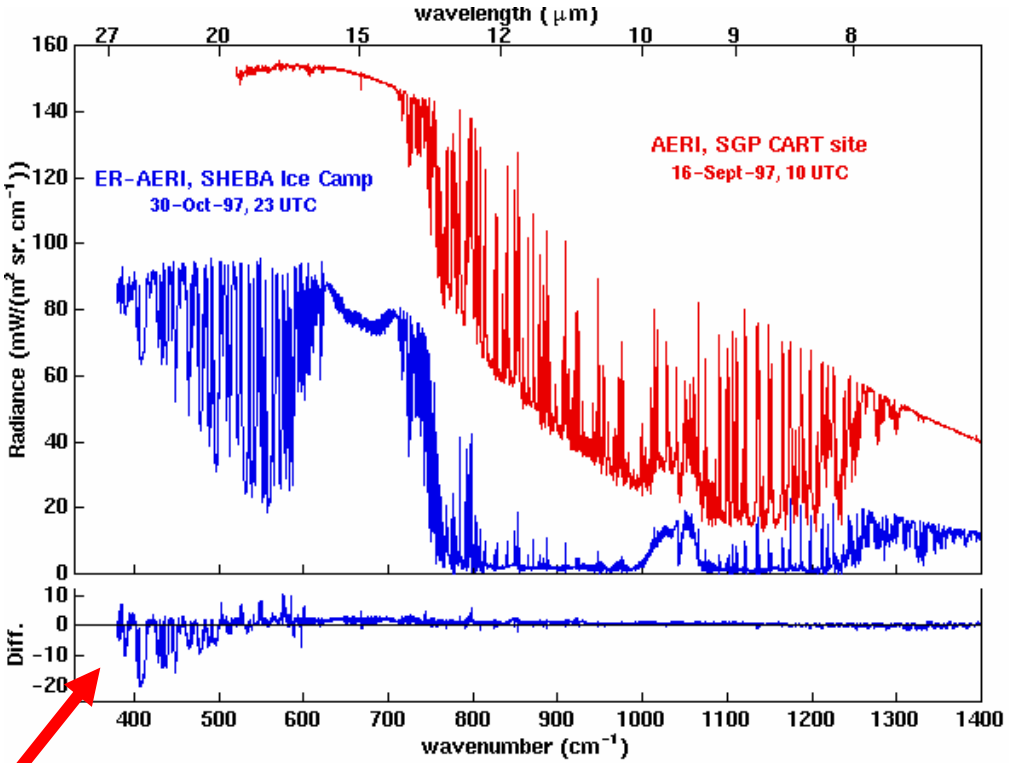
Since the beginning of ARM, *radiative closure studies* have been instrumental in the evaluation and improvement of radiation codes and ARM measurements.

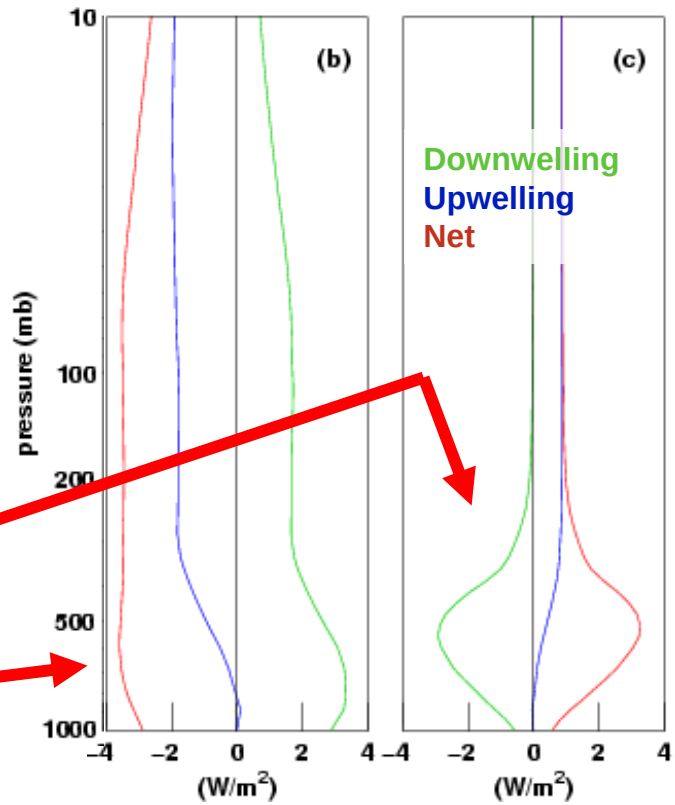


Main objective of BBHRP - Generation of long-term dataset of radiative heating rate profiles at all ARM Climate Research Facilities:

- accomplished for SGP and NSA
- in progress for TWP and ARM mobile facility deployments

AERI Observations During SHEBA Improve Far-Infrared Radiative Transfer Models





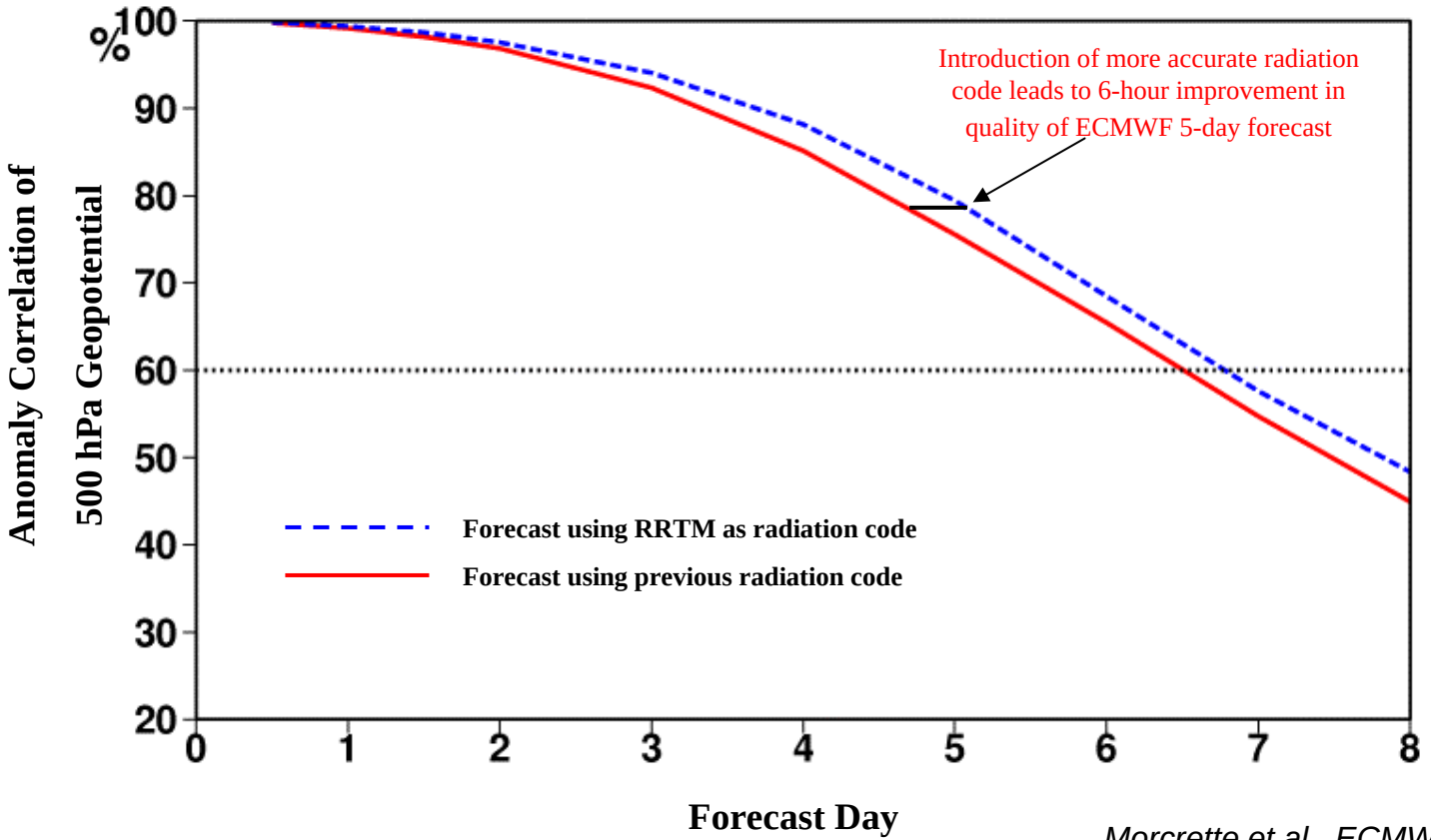
300% error in water vapor continuum absorption model in far infrared (18-25 μm)

Impact on radiative flux profile (c) is the same magnitude as CO_2 doubling (b)

Tobin et al., JGR, 1999

ARM-Developed Radiation Code Improves Weather and Climate Prediction

- Radiation code 'RRTM' developed at AER, Inc., *with ARM funding and using ARM data*, has been implemented in a number of forecast models, including:
  - NCEP Global Forecast System (GFS)
  - ECMWF Forecast Model
  - PSU/NCAR Mesoscale Model (MM5)

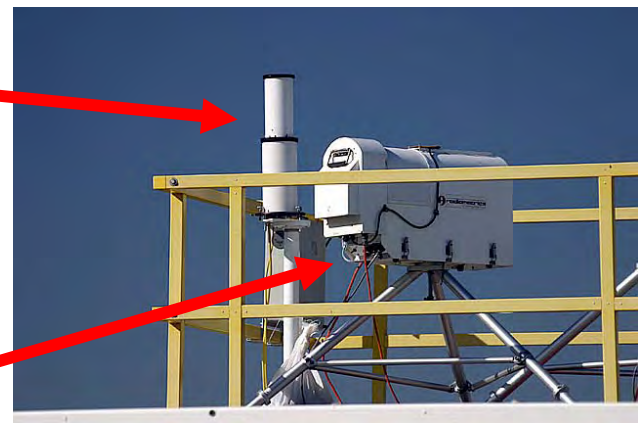


Morcrette et al., ECMWF Memo, 1998

Remote Sensing of Cloud Properties Using Measurements of Zenith Radiance

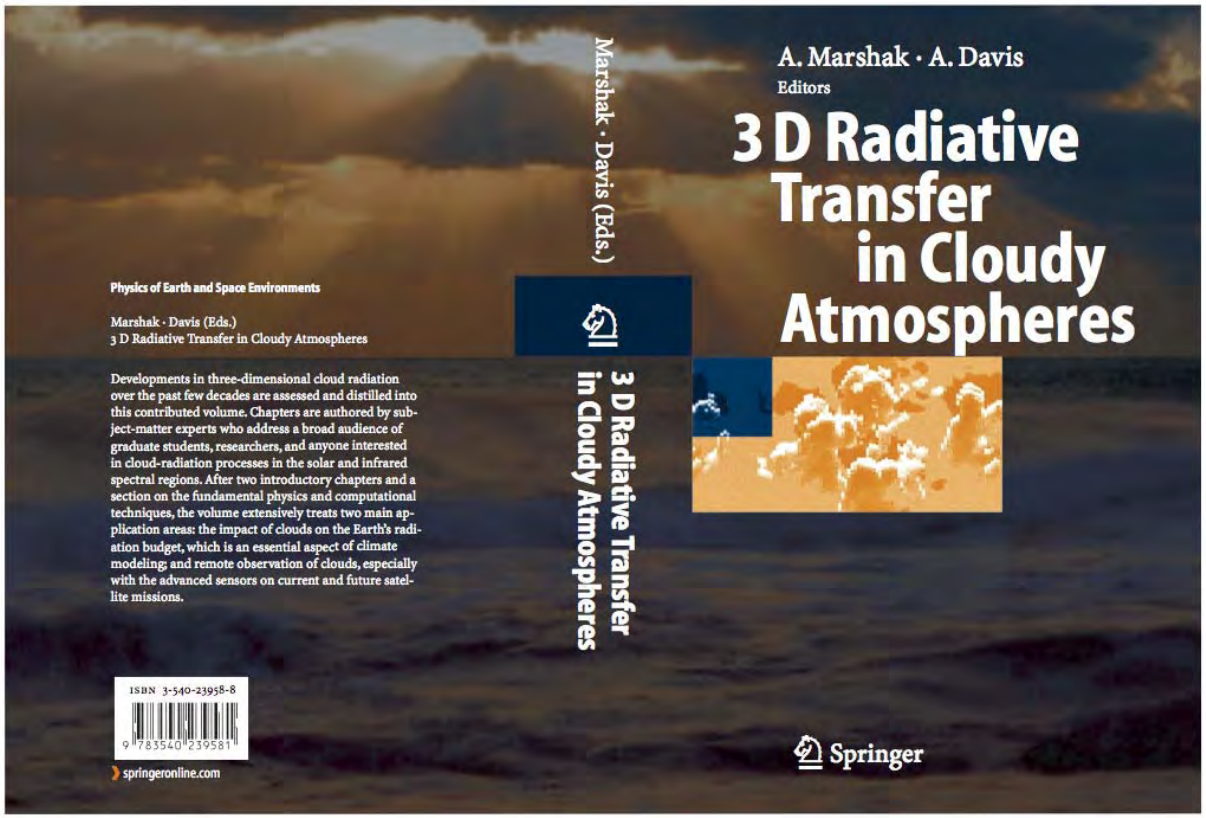
Cloud optical thickness is the most fundamental optical variable in any cloud-resolving model, including the ones used in super-parameterization. If we cannot confidently and unambiguously measure it, we will never be able to validate such models.

ARM accomplishment:
We have recently pioneered in the development of a new cloud optical thickness retrieval algorithm that accounts for a fully 3D cloud structure including broken clouds. This method uses the new ARM ground-based passive two-channel narrow-field-of-view (2NFOV) measurements. In addition to cloud optical thickness, an *effective* cloud fraction is also provided.



Marshak et al., JAS, 2004
Chiu et al., JGR, in press 2006

New book has been published by Springer



3D cloud radiative community has matured enough to prepare a volume on 3D radiative transfer in cloudy atmosphere. More than half of the authors of the book chapters are from ARM science team

The objective of the book was to capture and preserve much of the best ARM 3D cloud radiation work, and bring it to better maturity as authors took special care to explain their discoveries and advances to a larger audience. The book starts with the basic 3D radiative transfer problem, describes its solutions and models, discusses the effects of cloud inhomogeneity for remote sensing, addresses climate problems in realistic atmosphere and studies cloud-vegetation interactions.