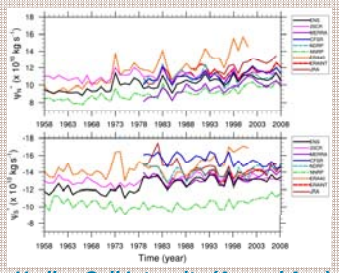
Tropical and Subtropical Cloud Regimes in Reanalysis Data using an ISCCP Simulator

Justin P. Stachnik, and Courtney Schumacher

Department of Atmospheric Sciences—Texas A&M University, College Station, TX

Introduction and Motivation



Hadley Cell Intensity (Annual Avg)

Considerable debate remains whether reanalyses can be used to identify long-term dynamical and physical climate trends, particularly for those regions constrained by fewer observations (e.g., the tropical Hadley cell). Whereas radiative feedbacks explain much of the sensitivity in GCMs, no studies exist that document the variability of simulated clouds types and frequency using reanalyses. The ability of reanalysis to predict the full range of observed tropical and subtropical cloud types is evaluated, with comparisons made to previous simulations using GCM data and relevant climate trends regarding the tropical circulation.

Data and Methods

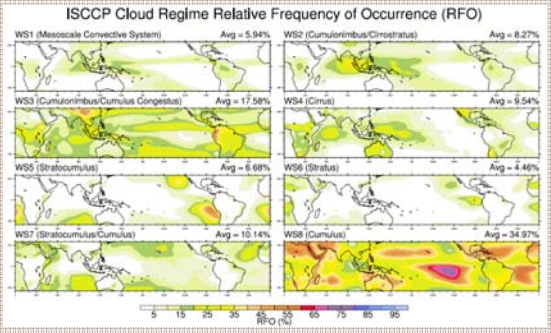
Reanalysis Dataset

- The NASA Modern-Era Restrospective Analysis for Research and Applications (MERRA) (Rienecker et al. 2011)
- All data re-gridded to a common 2.5° x 2.5° fixed grid (35°S-35°N)
- 30 pressure levels from 1000-10 hPa
- 6-hourly data, 7/1983 – 6/2008 (25 years)
- Offline calculations for LWP/IWP consistent with ISCCP D-series

ISCCP Simulator/COSP (Bodas-Salcedo et al. 2011)

- Produces joint histograms of emissivity-adjusted cloud-top pressure and visible optical depth
- Gridbox mean quantities divided into 200 sub-columns using a maximum/random or purely random overlap parameterization
- Cloud results restricted to daytime only

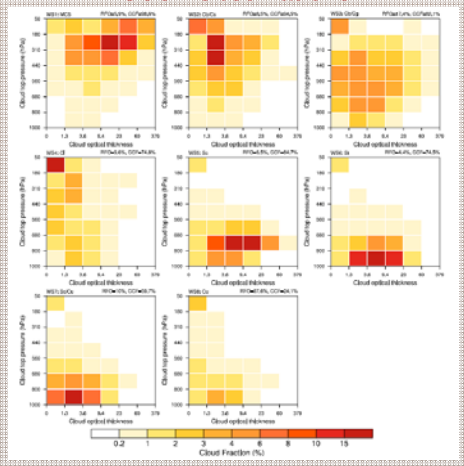
Cloud Regime Climatology



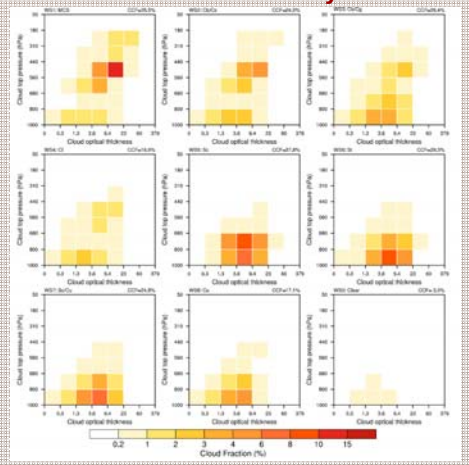
- Eight unique "weather states" identified from clustering
- No long-term trends in regime frequency of occurrence

Comparison of Observed and Simulated Cloud Regimes

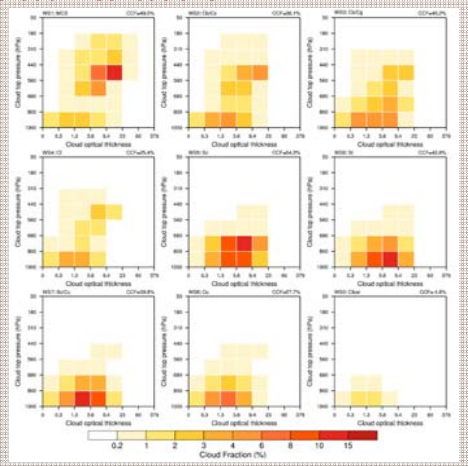
ISCCP Observations



Reanalysis-Derived Cloud Distributions

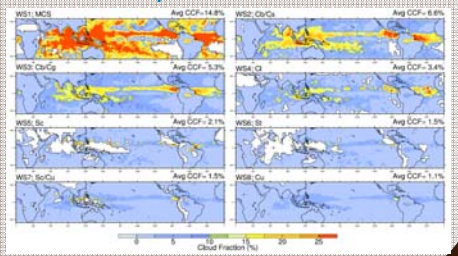


Maximum/Random Overlap



Random Overlap

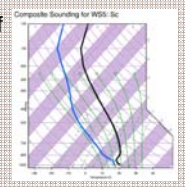
- Cloud fraction increases significantly with random overlap, with smaller decreases in optical depth
- Both overlap assumptions produce significantly less cloud cover than observed by ISCCP
- The reanalysis is unable to reproduce optically thick and high cloud tops associated with deep convection and the cirrus regime
- Simulated cloud fractions above 440 hPa are lower than observed at all longitudes
- MERRA is generally able to correctly identify cloud type in those regions identified by ISCCP



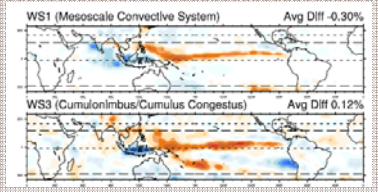
MERRA Cloud Fraction: p = 560–440 hPa

Discussion and Future Work

- Reanalysis-derived cloud fractions are significantly lower than ISCCP (consistent with many GCMs), though MERRA overestimates tropical rainfall
- Composite soundings generated for individual regimes suggest MERRA does well at predicting the thermodynamic environment and successfully diagnoses cloud type
- Preliminary trends suggest a lowering of cloud-top pressure for the subtropical stratocumulus regime, consistent with observations of increasing subtropical OLR and/or Hadley cell intensification in MERRA (Stachnik and Schumacher, in press)



- Future work will evaluate more reanalyses and identify any potential regional differences perhaps influencing the Hadley cell mean-state or associated trends
- Additional coupling of reanalysis and observational datasets may lead towards a mesoscale decomposition of the global Hadley cell



Acknowledgments

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