CERES Overview

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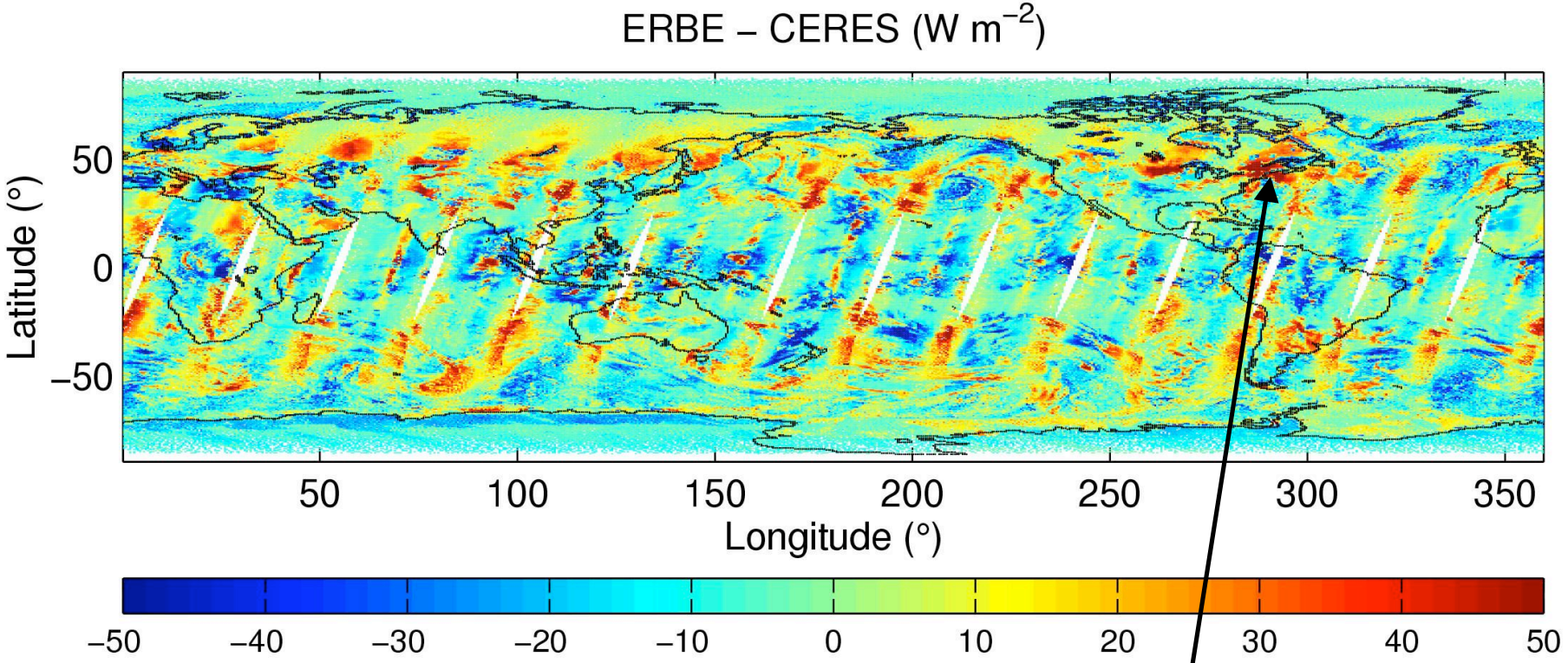
New CERES ADMs greatly improve instantaneous fluxes

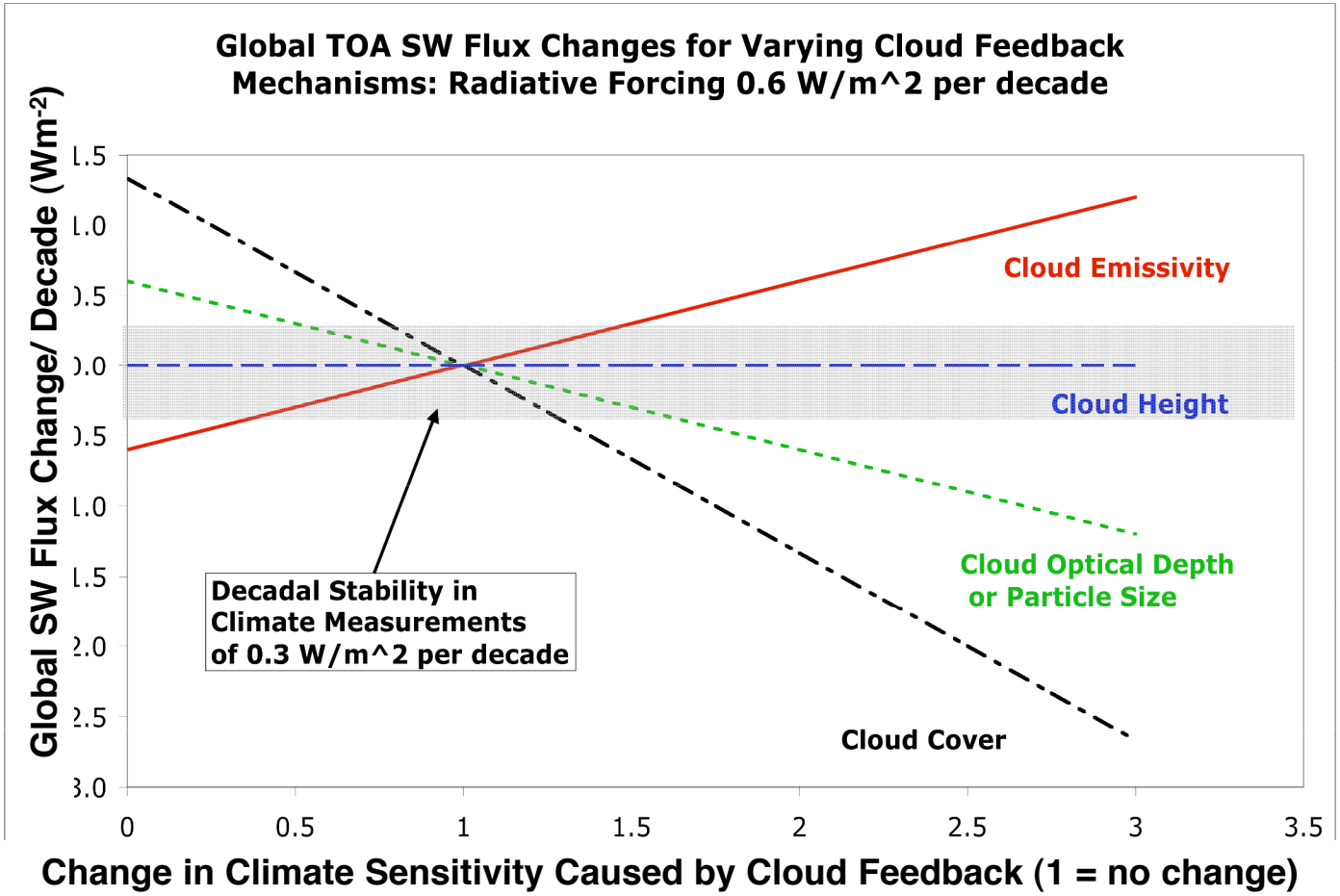
Key to constraining more accurate surface fluxes
Key to accurate cloud fluxes by cloud type
Key to accurate matched satellite/surface fluxes for aerosol absorption



CERES TOA instantaneous shortwave fluxes differ from ERBE by +/- 50 Wm^{-2} with a strong dependence on scene type & viewing angle

How do we take advantage of the greatly improved accuracy & integration of the CERES data?

How accurate must measurements be to constrain equilibrium global cloud feedback?



- Regional changes will be larger: but no regional "constraint" and global mean still must be accurately known for global feedback.
- UKMO ensemble climate noise for annual tropical mean SW and LW fluxes ~ 0.3 Wm^{-2}: this might be a reasonable lower limit on accuracy.

New approaches to cloud modeling

- In addition to traditional monthly mean grid box climate model comparisons:
  - Cloud Objects (Xu et al.): large ensembles of matched met state, cloud properties, aerosol, radiative fluxes
  - Improve cause/effect and lower noise/variability
  - Pc/Tau classification as in Jacob and Rossow
  - Vertical velocity as in Bony: only monthly mean? daily?
  - CERES fov data: 20 km scale, instantaneous
  - CERES 1 deg gridded data: instantaneous, 3-hourly, daily, monthly
  - Use LES, CRMs, NWP, and Climate models in weather prediction mode and test against cloud types/regimes: large number of case studies (100s to 1000s)
  - A-train lidar/radar add vertical cloud/aerosol profiles in a vertical 2-D sheet along the satellite ground-track. Proposed special CERES CRS A-train to merge CERES radiative assimilation with lidar and radar aerosol/cloud profiles

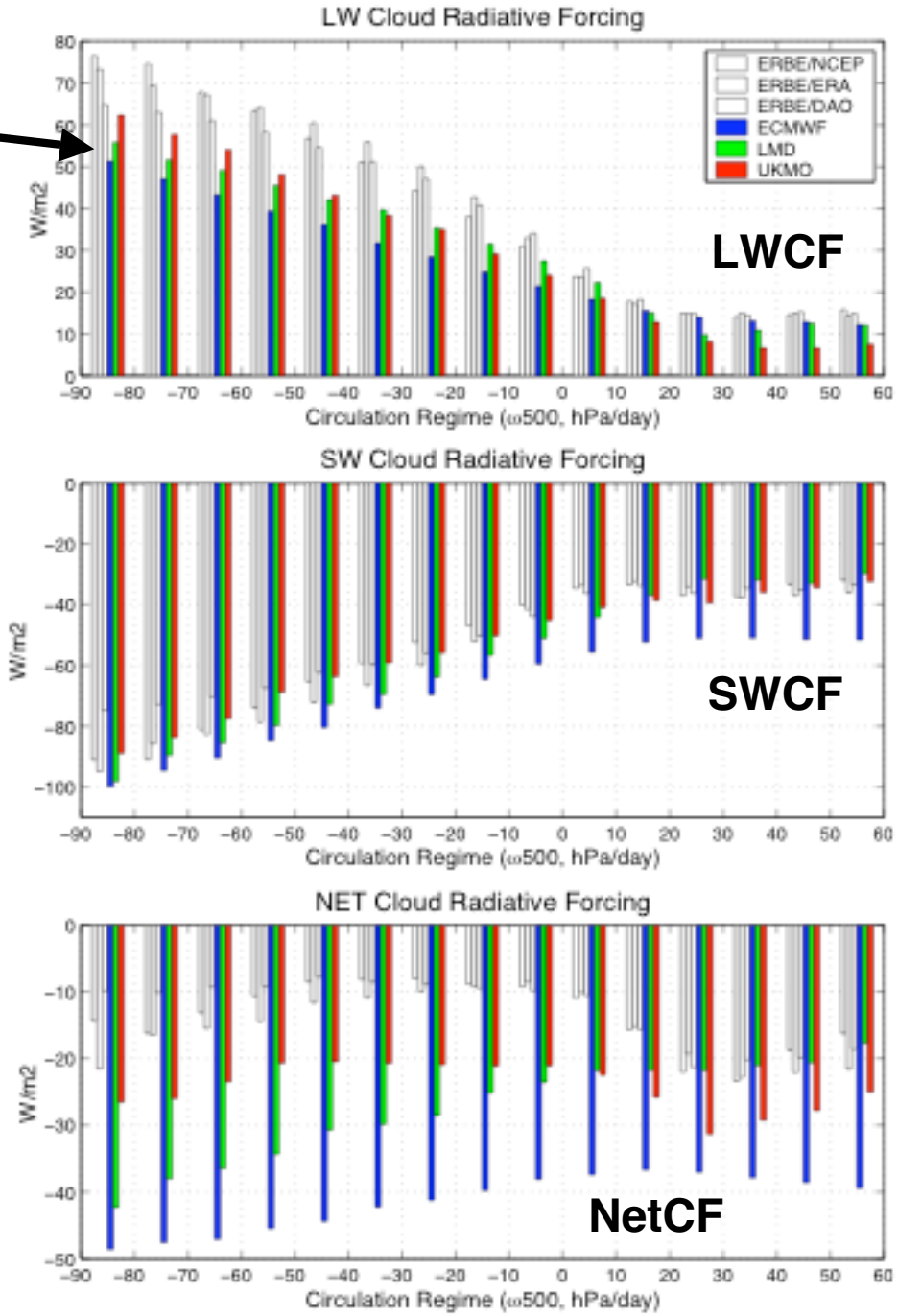
white: ERBE/NCEP, ERA, DAO
blue: ECMWF
green: LMD
red: UKMO

Model vs Data Intercomparisons by Dynamic Regime:

Vertical Velocity

(Bony et al., 2003)

Need to redo with CERES fluxes since ERBE much less accurate by dynamic state

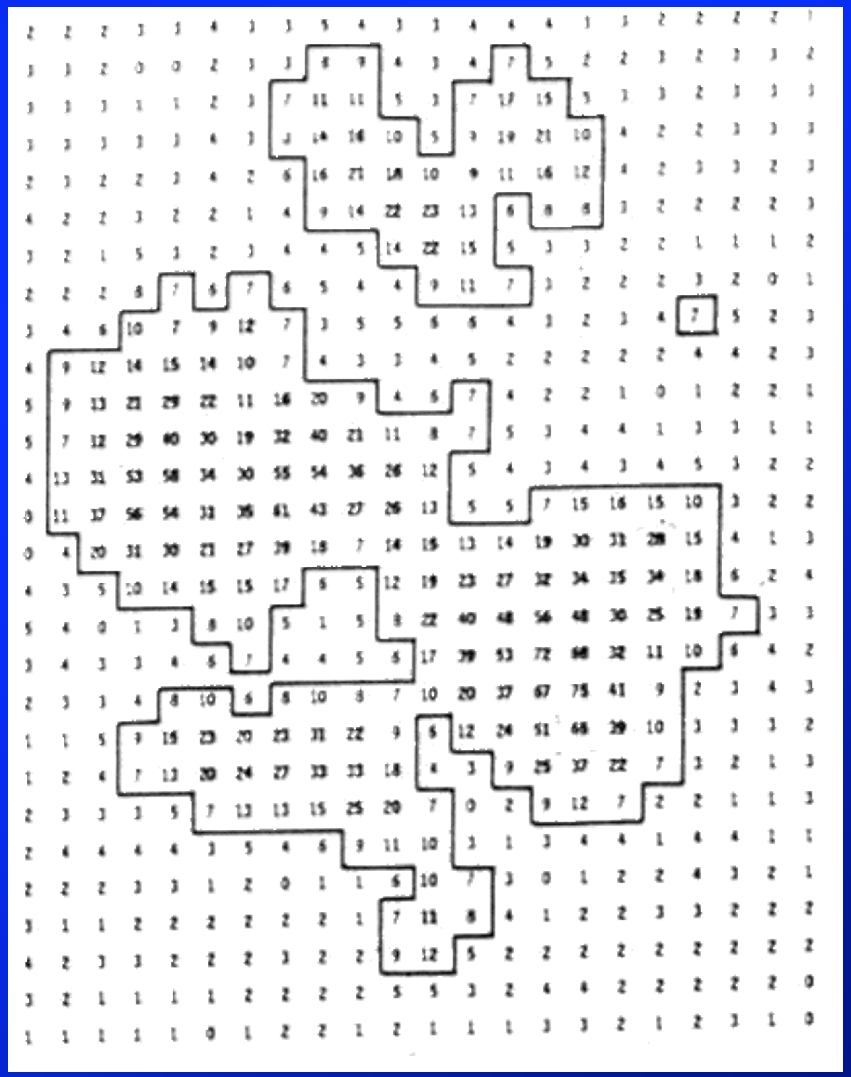


How do we study clouds at the short time/space scales of cloud physics, yet at climate accuracy?

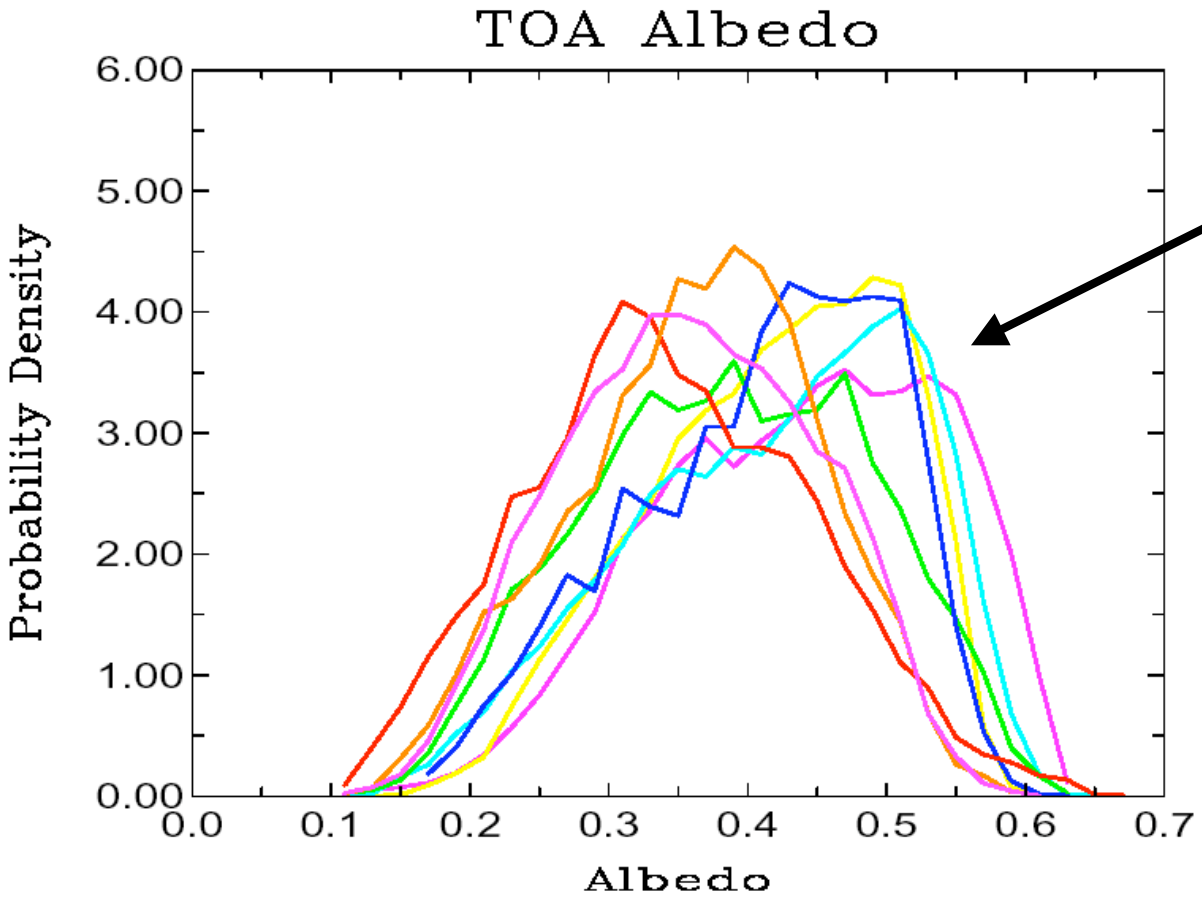
Objectively Define Cloud Systems

- Define a cloud system as a contiguous region of the Earth with a single dominant cloud type (e.g. stratocumulus, stratus, and deep convection)

- Determine the shapes and sizes of the cloud systems by the satellite data and by the cloud property selection criteria (Wielicki and Welch 1986)

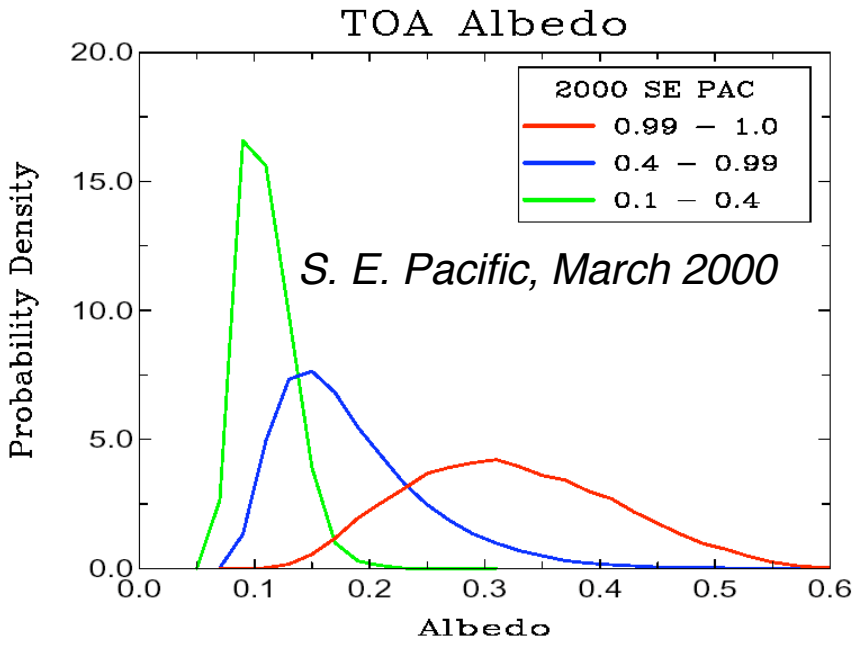


Overcast Boundary Layer: Observed CERES Cloud Object Pdfs for March, 1998

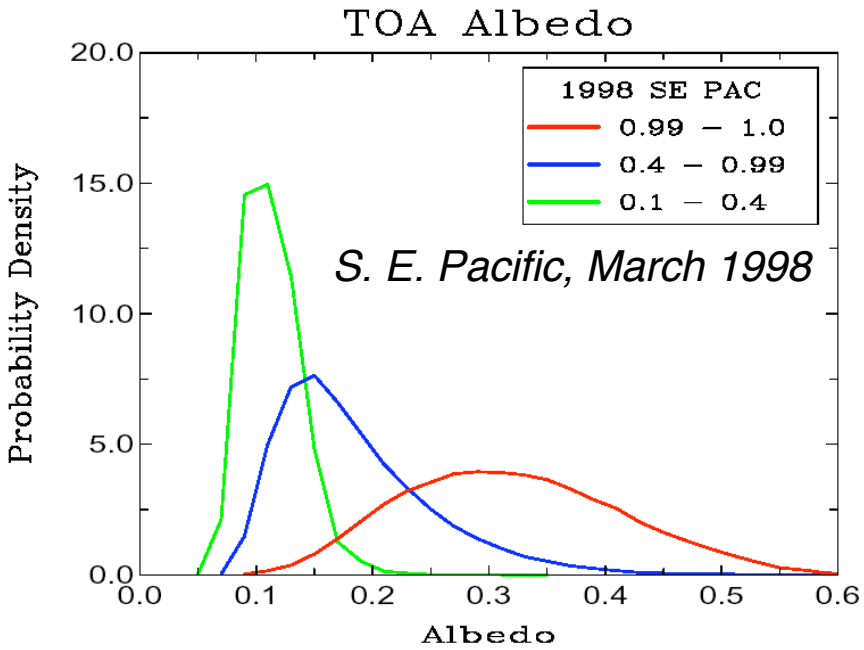


Sample individual pdfs for just 8 of the stratus cloud systems (CERES SSF TOA albedo)

Boundary Layer: Observed CERES TOA Albedo Pdfs for March, 2000 vs March, 1998

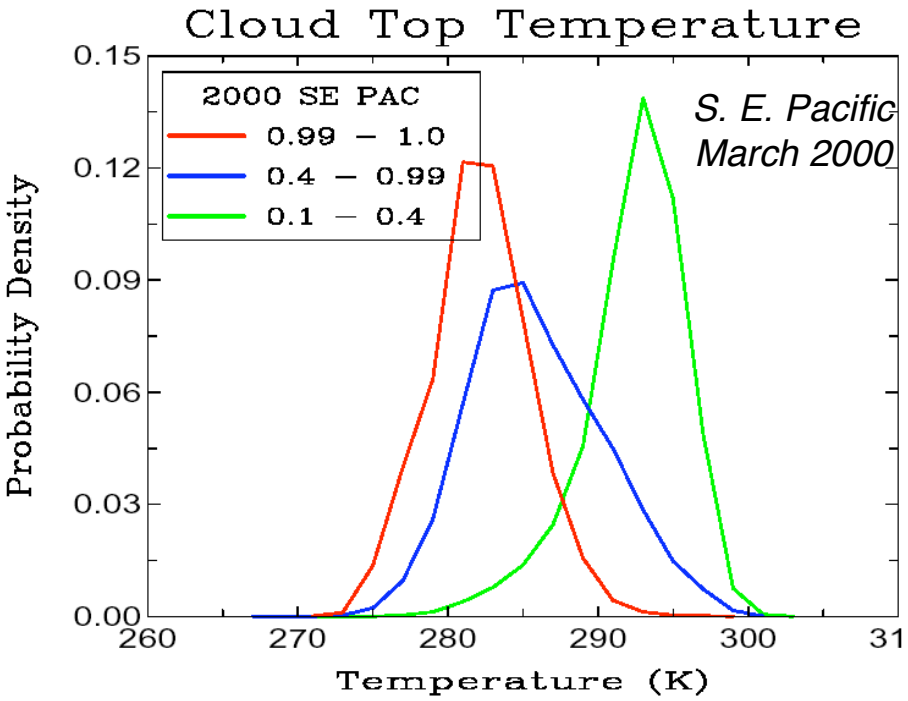


No apparent difference in the S.E. Pacific, even though the Walker Cell strength reduced, Hadley cell strengthened...

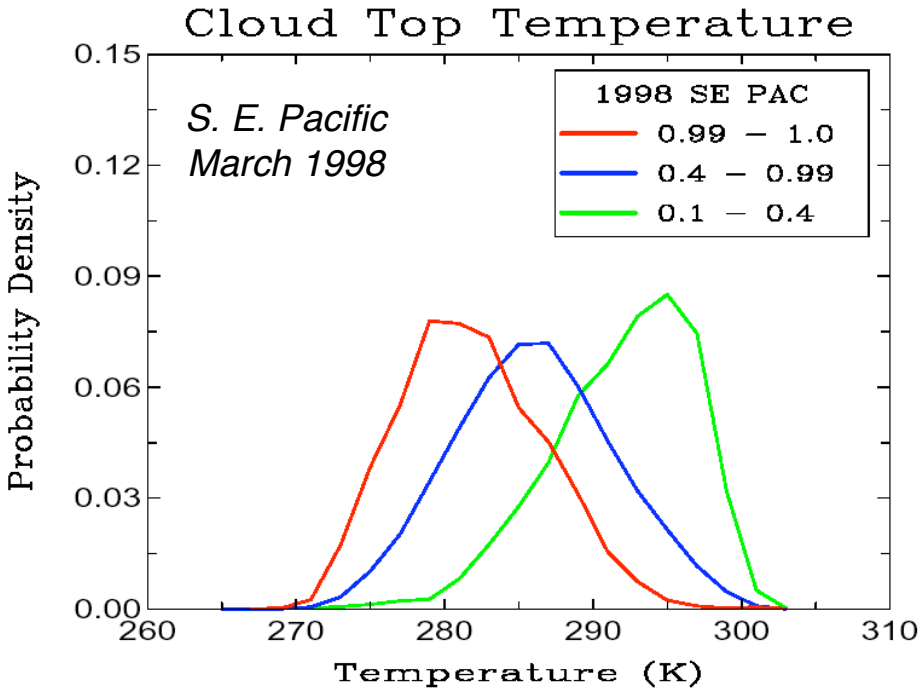


Suggests stable properties by cloud type: next step to quantify how stable....

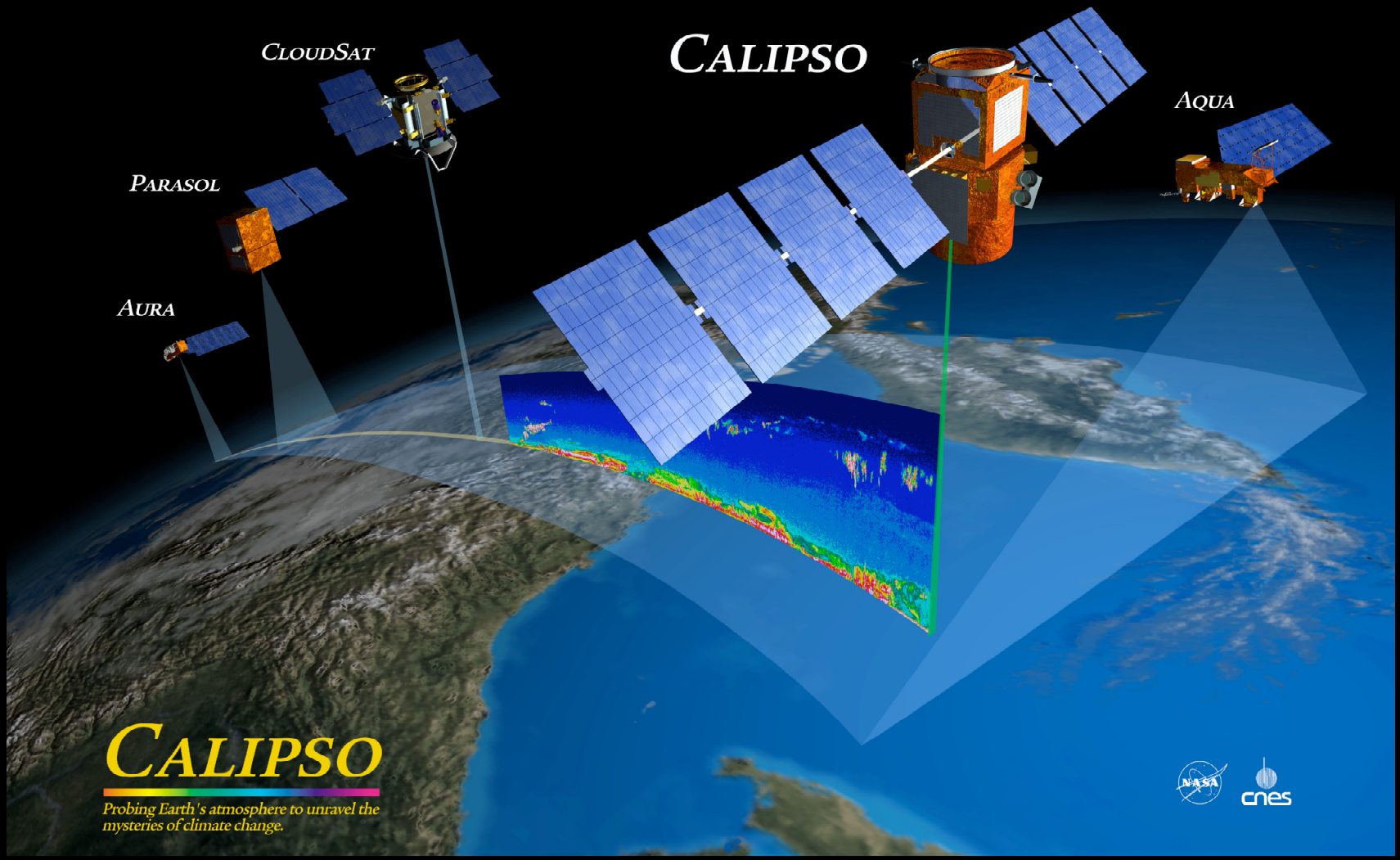
Boundary Layer: Observed CERES Cloud Top Temperature Pdfs for March, 2000 vs March, 1998



March 2000: Colder SST (La Nina) & Colder Cloud Top Temperature, but Narrower Frequency Distribution



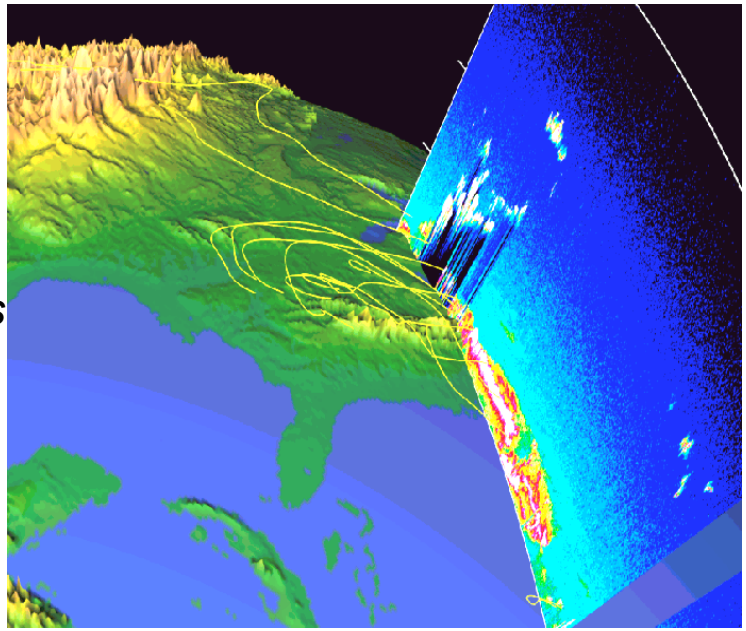
"A-Train" Formation for Aerosol and Cloud Vertical Profiles
Atmospheric State => Aerosol/Cloud => Radiative Heating

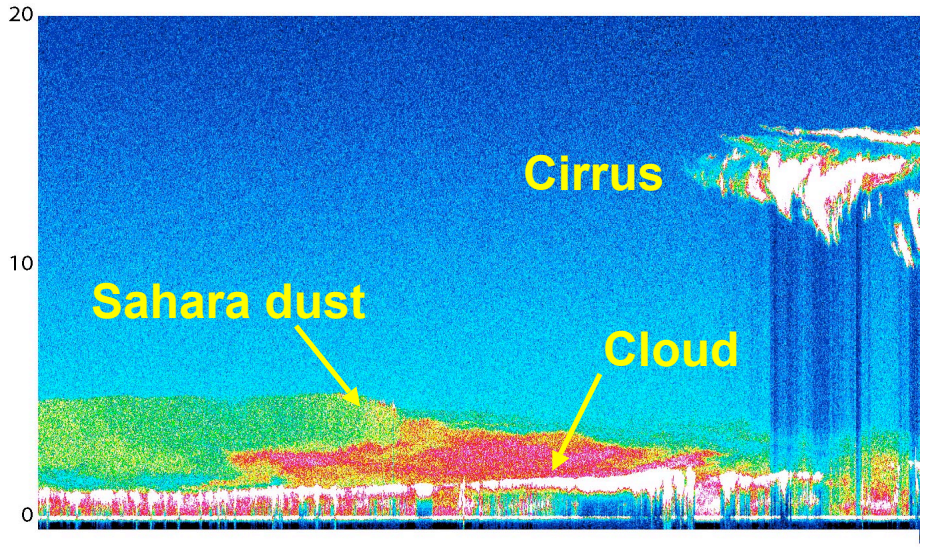


The Vertical: CALIPSO Aerosol

Aerosol Direct Radiative Forcing

- CALIPSO aerosol profiles
  - *enable back-trajectories to aerosol sources*
- 4-D assimilation of aerosol profiles
  - *constrains uncertainties in source/transport models*
  - *partitioning of natural, anthropogenic forcings*
- A-train: CALIPSO + MODIS + CERES
  - *improved surface SW fluxes*



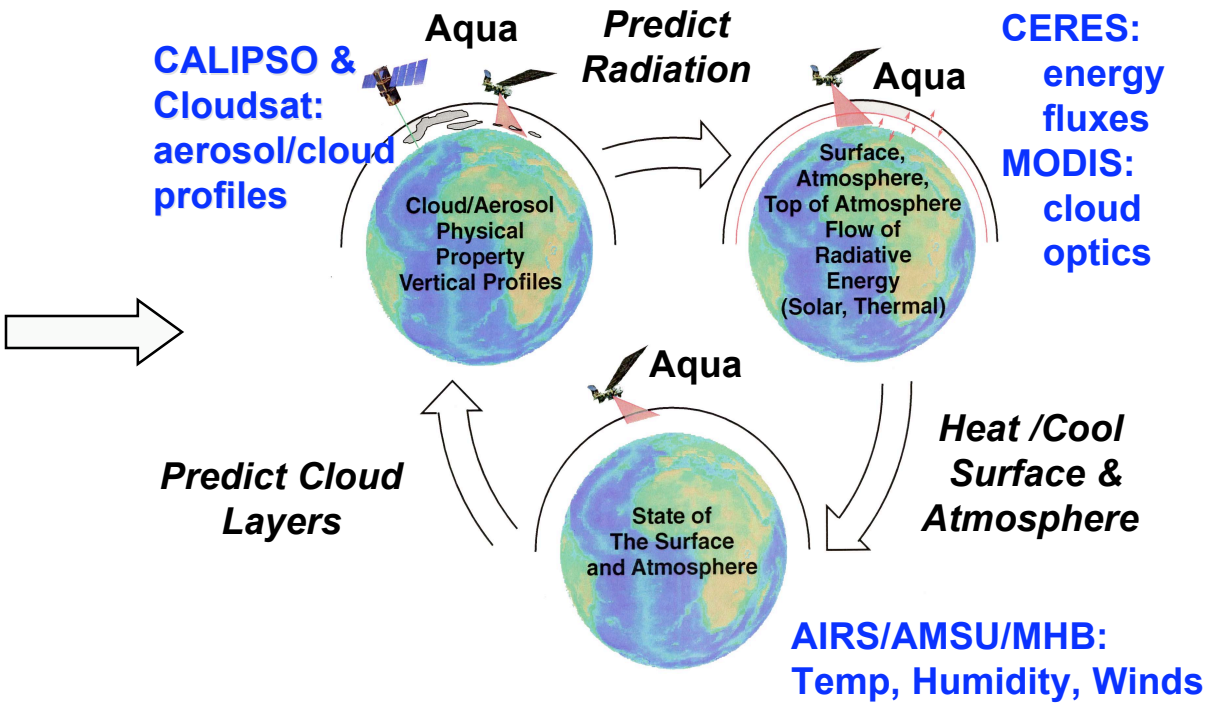


Aerosol Indirect Radiative Forcing

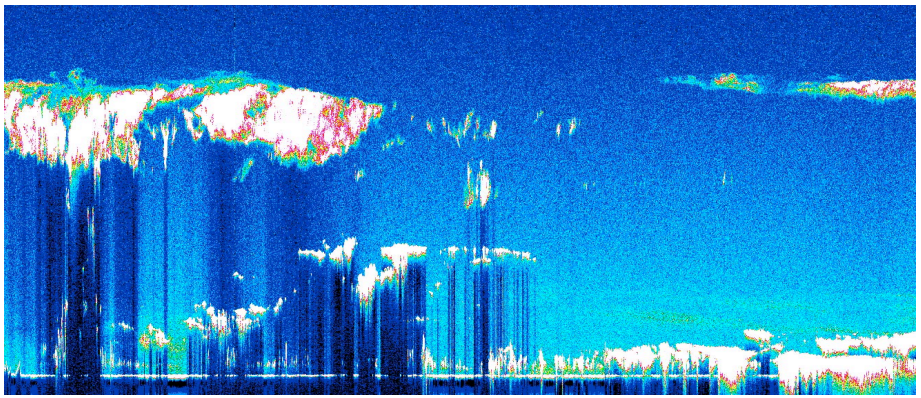
- CALIPSO cloud and aerosol profiles
  - unique ability to determine if cloud and aerosol are in the same layer.
- A-train: add MODIS + CERES
  - cloud microphysics, optics, radiation
- A-train: add AMSR, Cloudsat radar
  - adds rain, LWP plus drizzle.

A-train: New Cloud and Climate Observations

Cloud/Radiation Feedback



Cloud Monitoring



- Lidar Cloud Fraction/Height
- Self calibrating 532nm backscatter
- Nadir only sampling noise: 0.3 Wm^{-2} LW zonal annual average
- UKMO zonal climate noise: 0.3 Wm^{-2}
- Greenhouse forcing: 0.6 Wm^{-2}/decade

Aerosol Forcing and Cloud Feedback Approaches

- **Cloud Feedback**
- **Atmosphere => Cloud => Radiation => Atmosphere**
- **Aerosol Direct Radiative Forcing**
- **Aerosol Source => Advection => Sinks => Radiation => Atmosphere**
- **Aerosol Indirect Radiative Forcing**
- **Aerosol Source => Advection => Sinks => Atmosphere => Cloud => Radiation => Atmosphere**
- ***Aerosol Chemistry must be tracked by source region***
- ***Aerosol indirect effect must be sorted by atmosphere dynamic state which dominates cloud properties***

New Approaches to Cloud Modeling

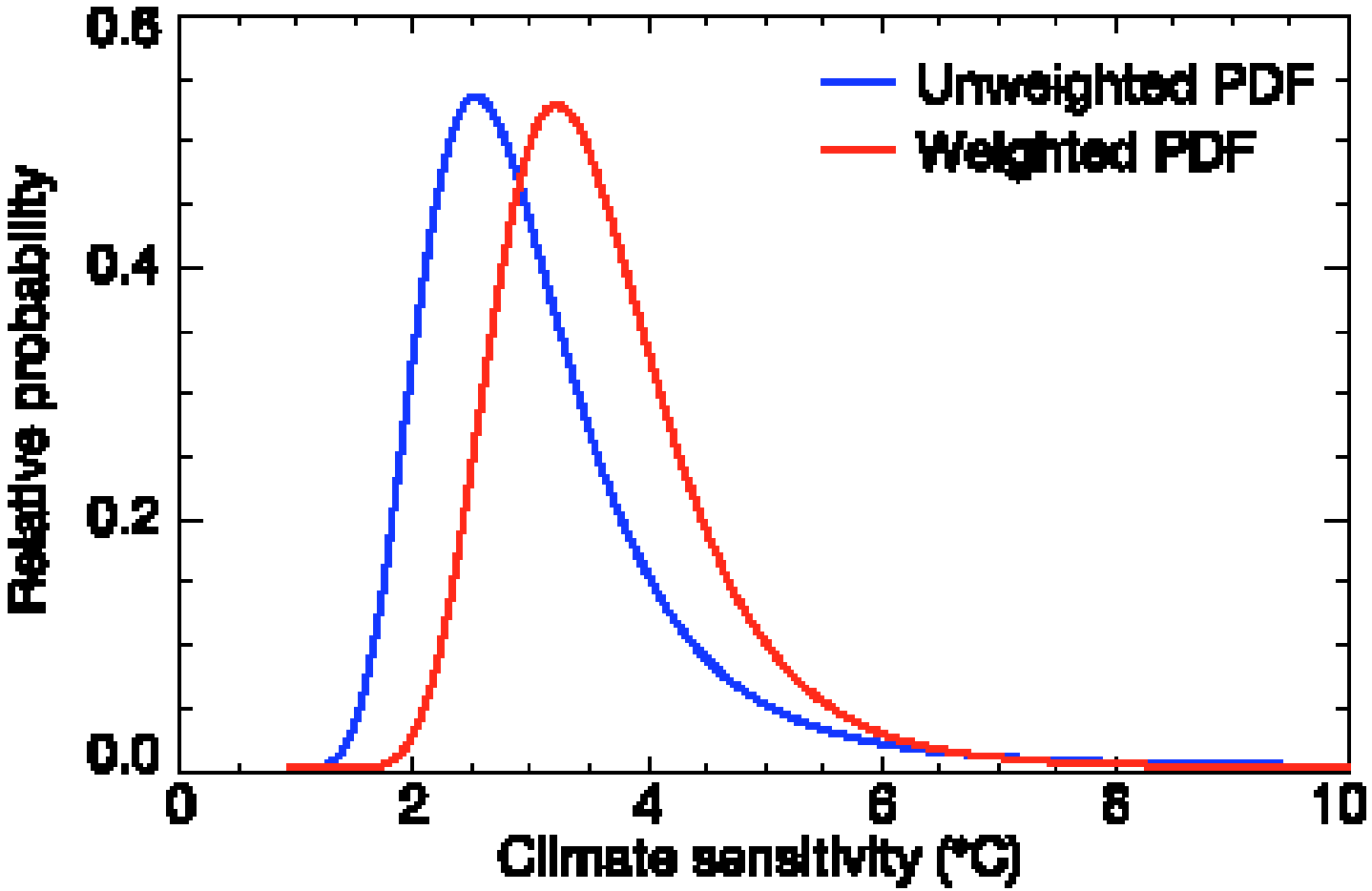
- Perturbed Physics Ensemble (PPE) climate model simulations: 1000s of physically different systems
  - Use to develop mapping function for climate model errors (vs obs) to uncertainty in climate model sensitivity and climate prediction
  - Key idea is to consider 2 physically different earth-like climate models as: model A = true earth. model B = model of earth
  - 1000s of climate model runs become a surrogate for 1000s of days of weather prediction: study prediction error.
  - May provide first rigorous climate observation requirements by variable and space/time scale
  - Nature paper in early August (Murphy et al.)

Perturbed Physics Ensembles: PPEs

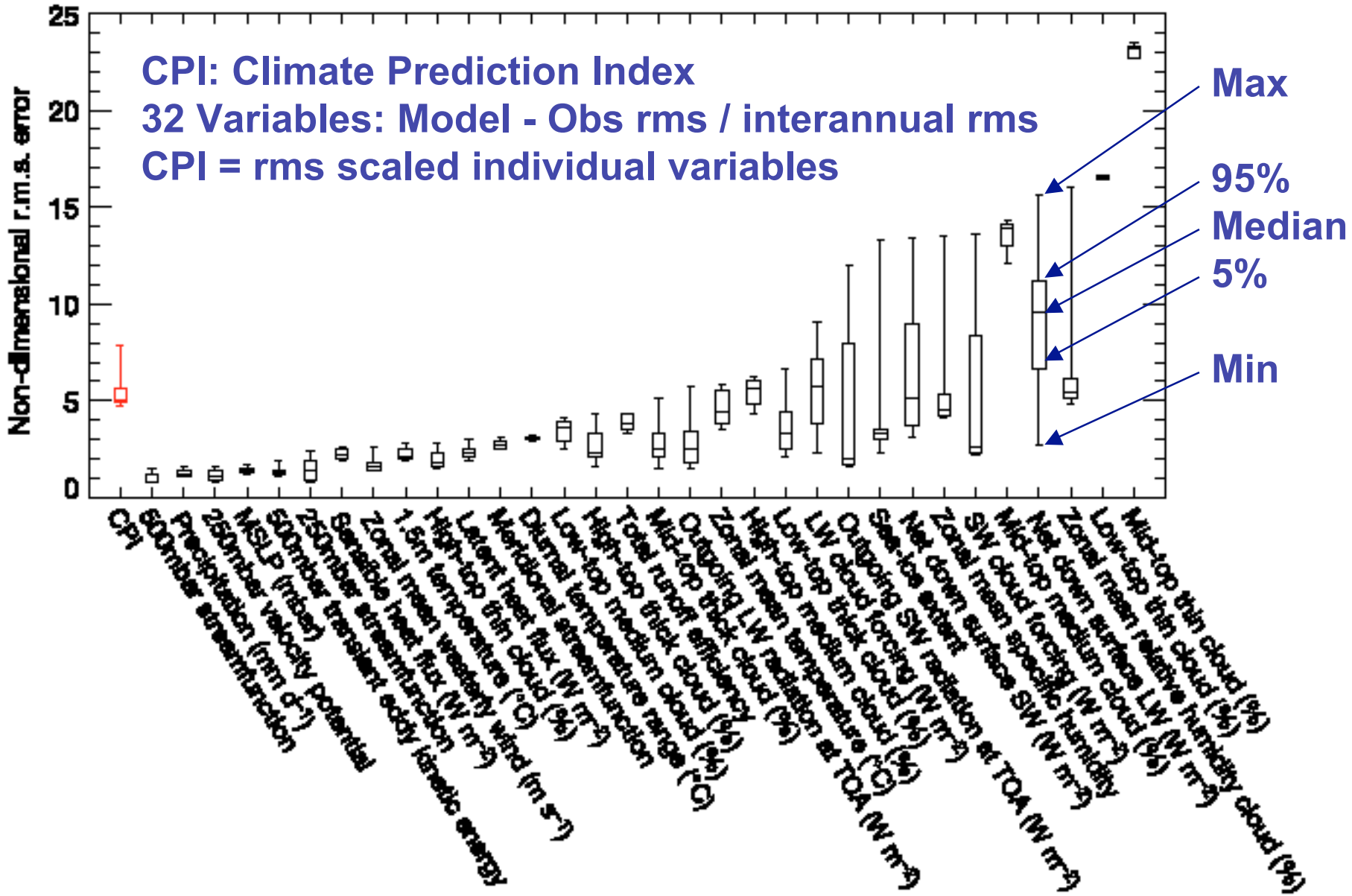
53 runs of physically different Earth-like planets

Vary 29 HadAM3 sub-grid parameterizations within reasonable range

Each planet run in mixed layer mode for normal and doubled CO_2 cases



Murphy et al., Nature, Aug 7, 2004



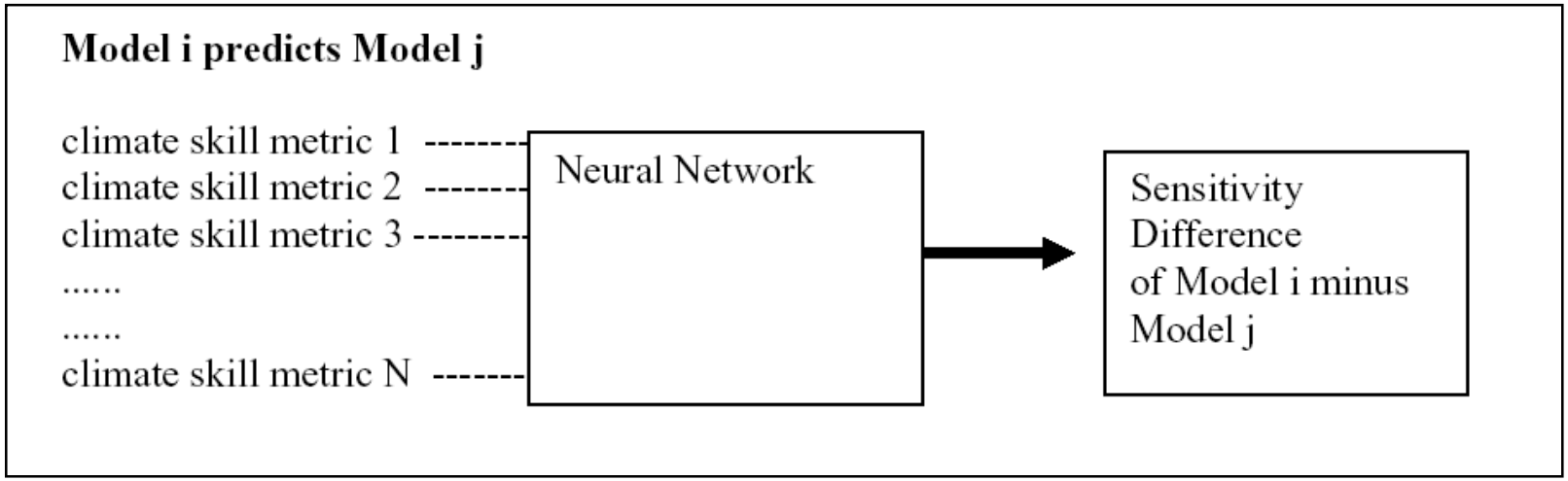
How can we more rigorously weight variables and time/space scales to predict uncertainty in climate prediction?

Murphy et al., Nature, Aug 7, 2004

Climateprediction.net: 1000s of Perturbed Physics Ensembles using UKMO model with mixed layer ocean.

Climate@home: similar using GISS coupled ocean/atmosphere

- From these 1000s of runs, 1000s of different earth-like planets
- For any two model runs, let model i be "Earth" and model "j" be the model
- Climate metrics for "i minus j" = observed minus modeled Earth (no obs error)
- Sensitivity for "i minus j" = climate sensitivity difference and is KNOWN
- Sensitivity not only for global surface temperature: regional summer precip, etc.



Over 1000s of model pairs in the PPE: let the varying model physics show how to optimize the selected climate metrics, and predict uncertainty.
Test robustness comparing other climate models (NCAR, LMD...) and other climate forcings (solar, volcanic, aerosol ...) Test observing system reqmts...