NCAR

Evaluating parameterized variables in the Community Atmospheric Model along the GCSS Pacific cross-section

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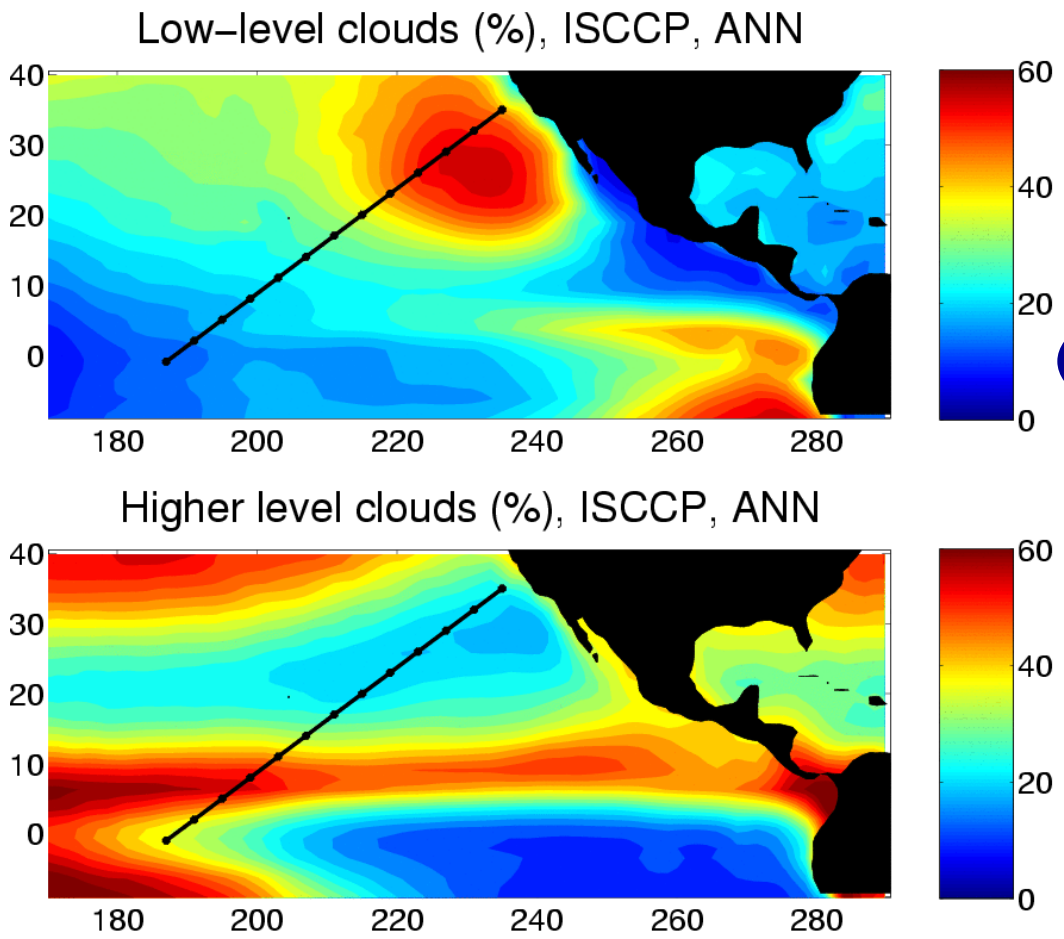
The GCCS Pacific Cross-section

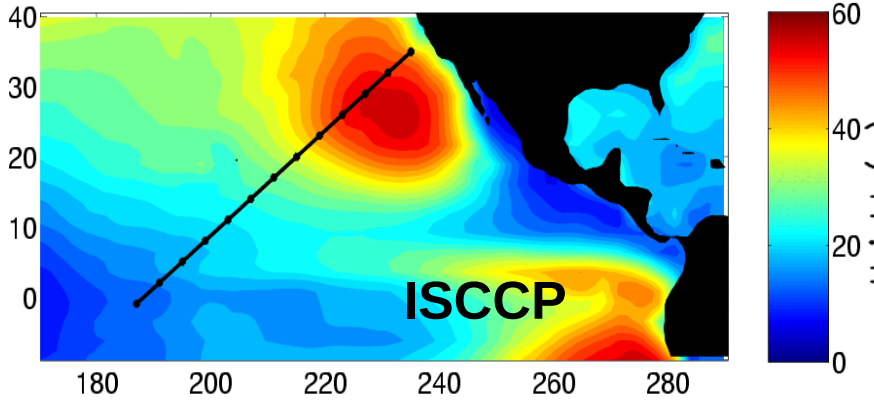
Several cloud regimes: stratocumulus, transition, deep convection



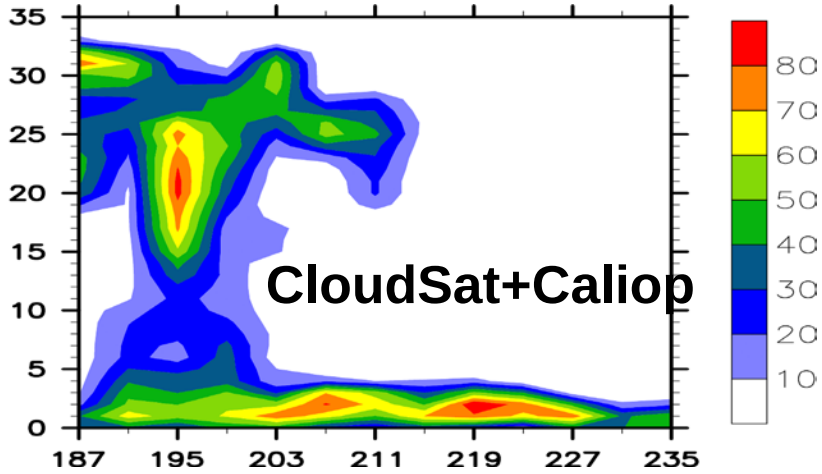
- **EUROCS project**
  - **JJA 1998**
- **GCSS intercomparison**
  - **JJA 1998/2003**
- **This study**
  - **YOTC: JJA 2008**
- **Observations**
  - **ISCCP data**
  - **SSM/I product**
  - **CloudSat + Calipso**
  - **GPCP and TRMM precip**
  - **Flash Flux data**
- **Reanalyses**
  - **ERA-Interim, Merra**

Observations along the cross-section

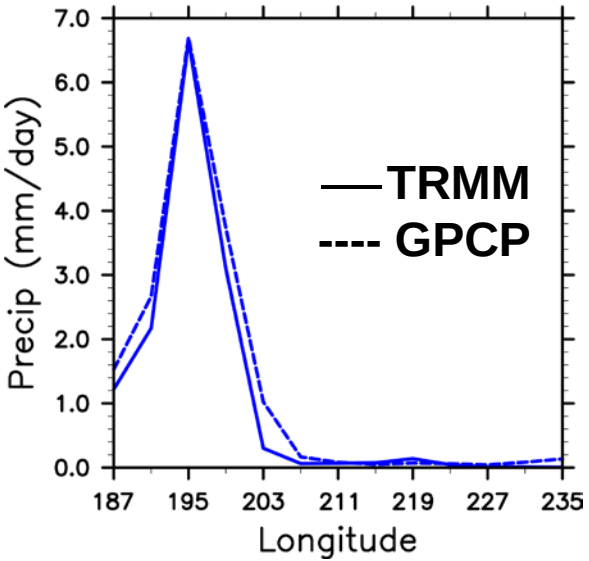
Low-level cloud



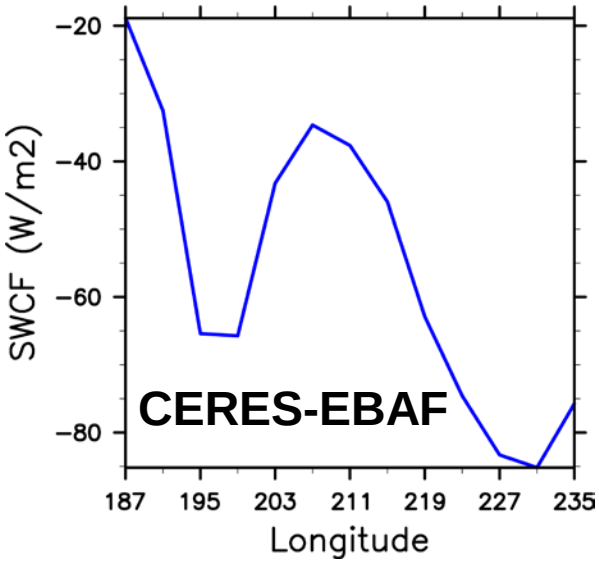
Cloud fraction



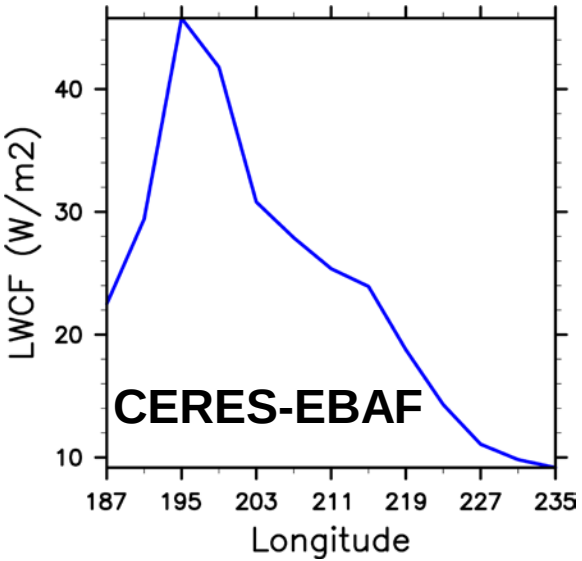
Precipitation



SWCF

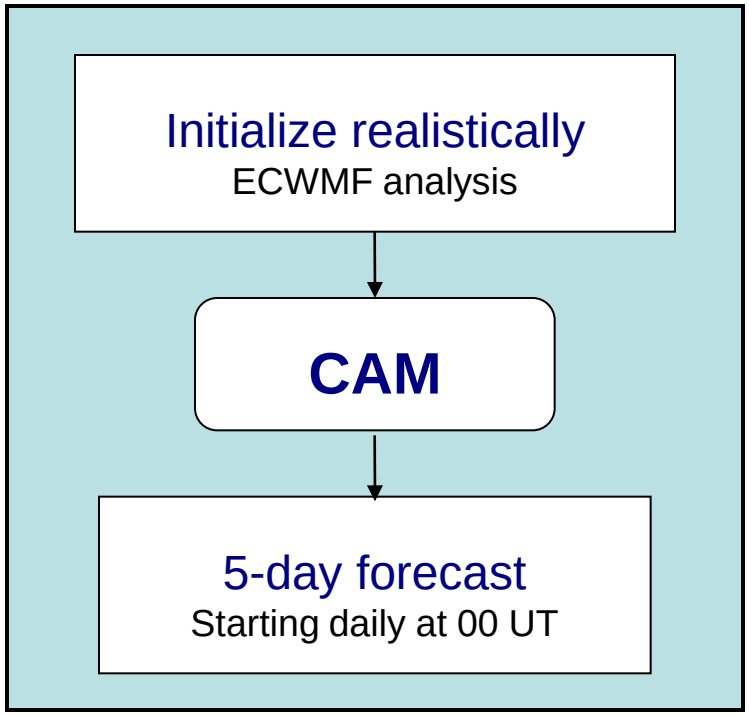


LWCF



Methodology for the forecasts

Forecast



Evaluation

AIRS, ISCCP, TRMM, GPCP, SSMI, CloudSat, Flash-Flux, ECWMF analyzes

• Strategy

If the atmosphere is initialized realistically, the error comes from the parameterizations deficiencies.

• Advantages

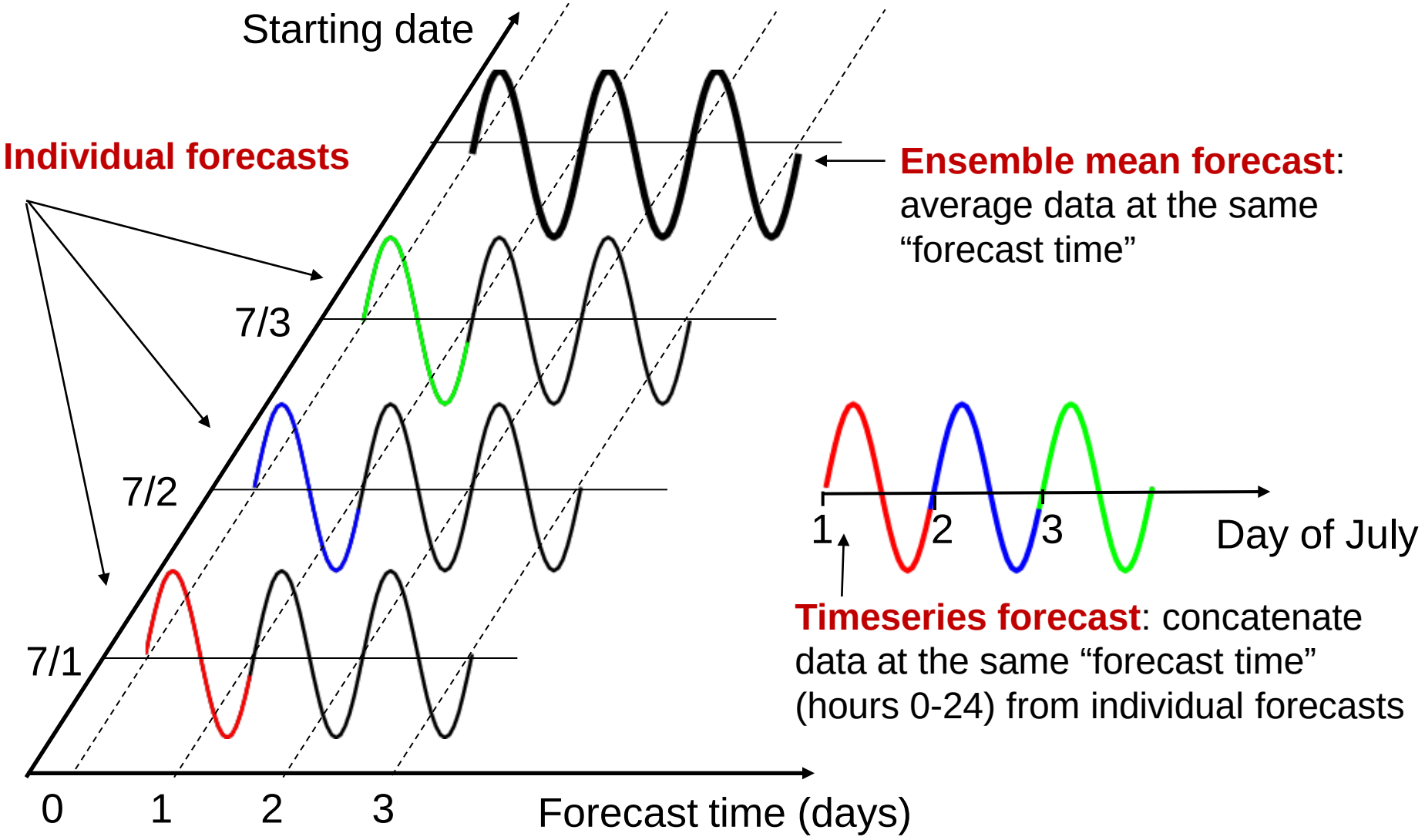
- Evaluate the forecast against observations on a particular day and location

- Evaluate the nature of moist processes parameterization errors before longer-time scale feedbacks develop.

• Limitations

Accuracy of the atmospheric state ?

Ensemble mean forecast and timeseries forecast



Model versions

3 versions of CAM

CAM3	**Release 2004**
CAM4 **“track1”**	**Release April 2010** **New physics:** - Deep convection (Neale and Richter, 2008)
CAM5 **“track5”**	**Release June 2010** **New Physics:** - Cloud microphysics (Morrison, Gettelman) - Radiative Transfer (Iacono, Collins, Conley) - PBL and Shallow convection (Bretherton and Park) - Macrophysics (Park, Bretherton, Rasch) - Aerosol formulation (Ghan, Liu, Easter) - Ice clouds (Gettelman, Liu, Park, Mitchell)

Highlights of the results

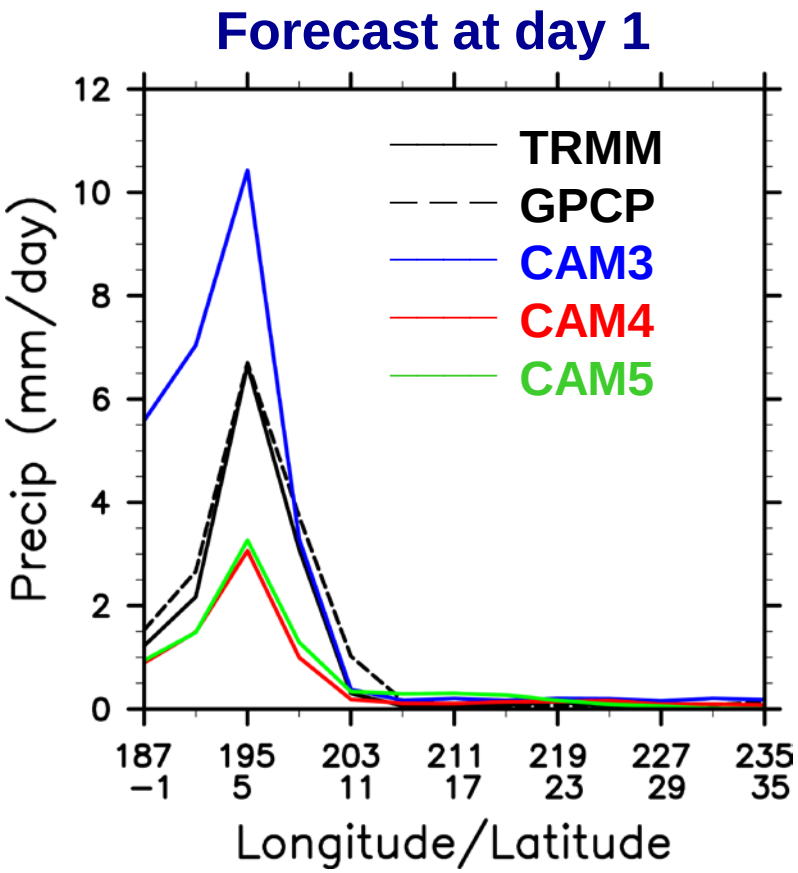
- **Climate bias appears very quickly**
  - **where deep convection is active, error is set within 1 day**
  - **5-day errors are comparable to the mean climate errors**

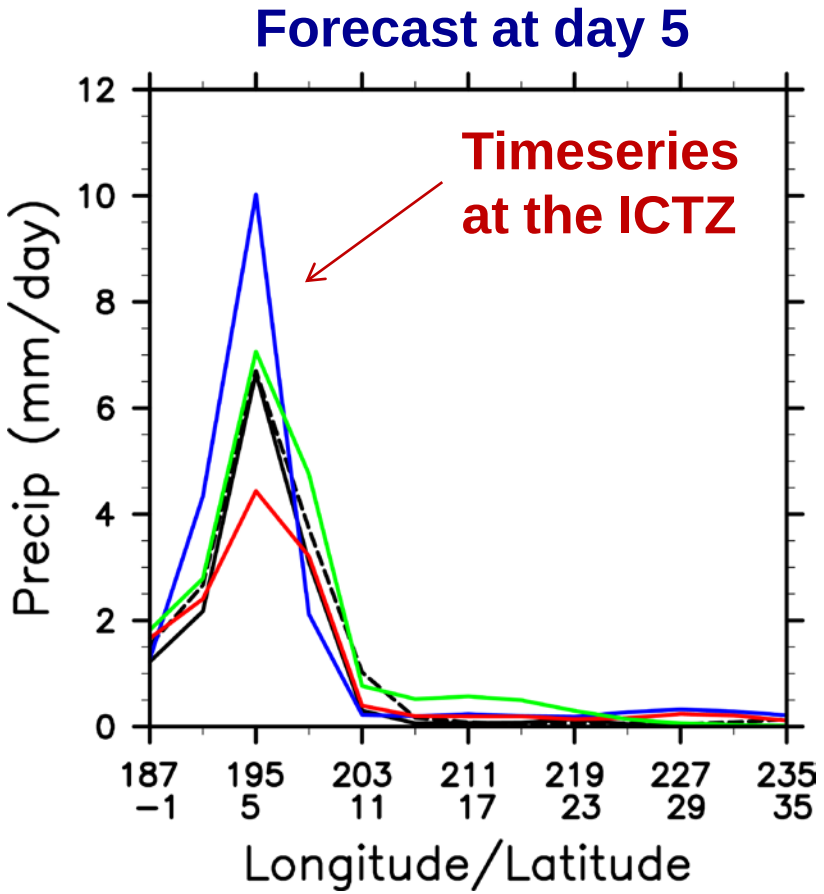
- **CAM3**
  - **ITCZ: warm/wet bias of the upper troposphere**
    too much precipitation and high level cloud
  - **StCu: cloud too close to the coast and PBL too shallow**

- **CAM4/Track 1**
  - **ITCZ: CAM4 reduces warm/wet bias of the upper troposphere**
    dramatic improvement of precipitation
    … but too little high-level cloud compared to observations

- **CAM5/Track 5**
  - **ITCZ: same improvements as with CAM4**
  - **StCu: better PBL height and low-level cloud fraction**
    … but underestimates high-level cloud and LWP

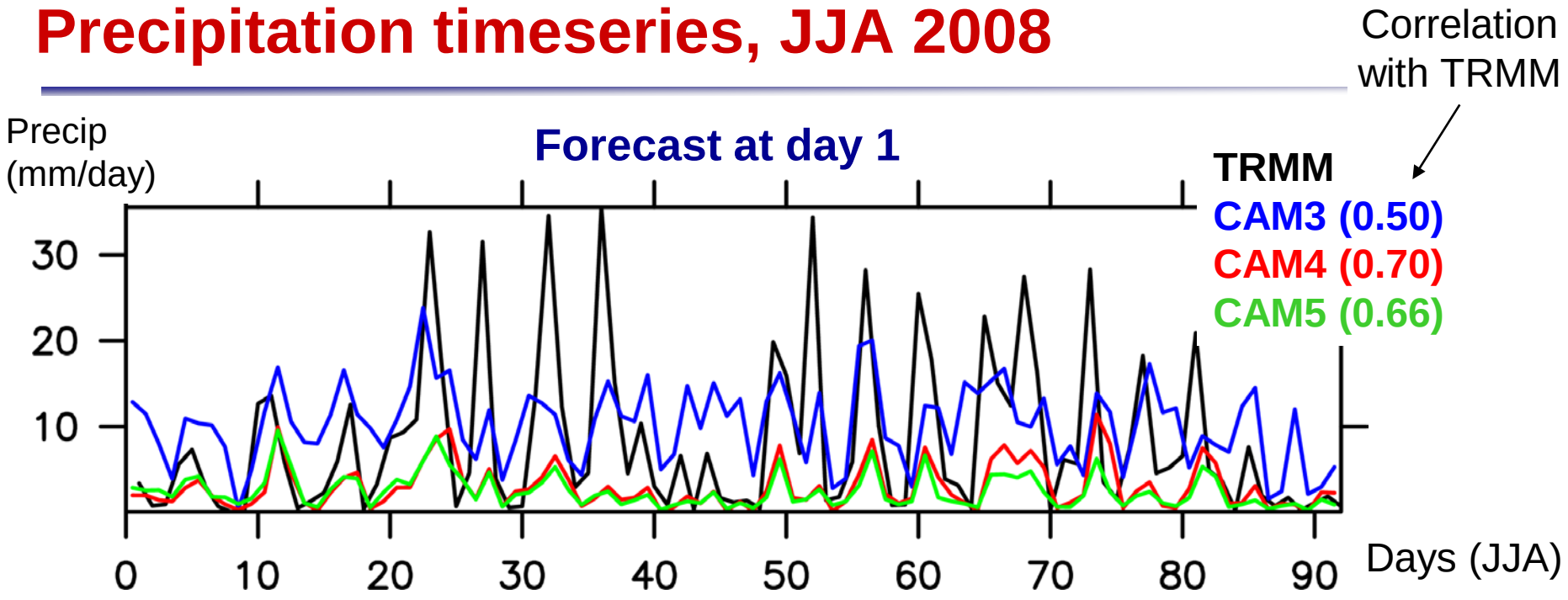
Precipitation: Monthly means, June 2008





- **CAM3:** **overestimates** the precipitation in the ITCZ
- **CAM4/5:** **reduction** in the ITCZ precipitation at day 1
  precipitation intensity **increases later** in the forecast

Precipitation timeseries, JJA 2008



At the ITCZ:

Mixing parcel⇔ env

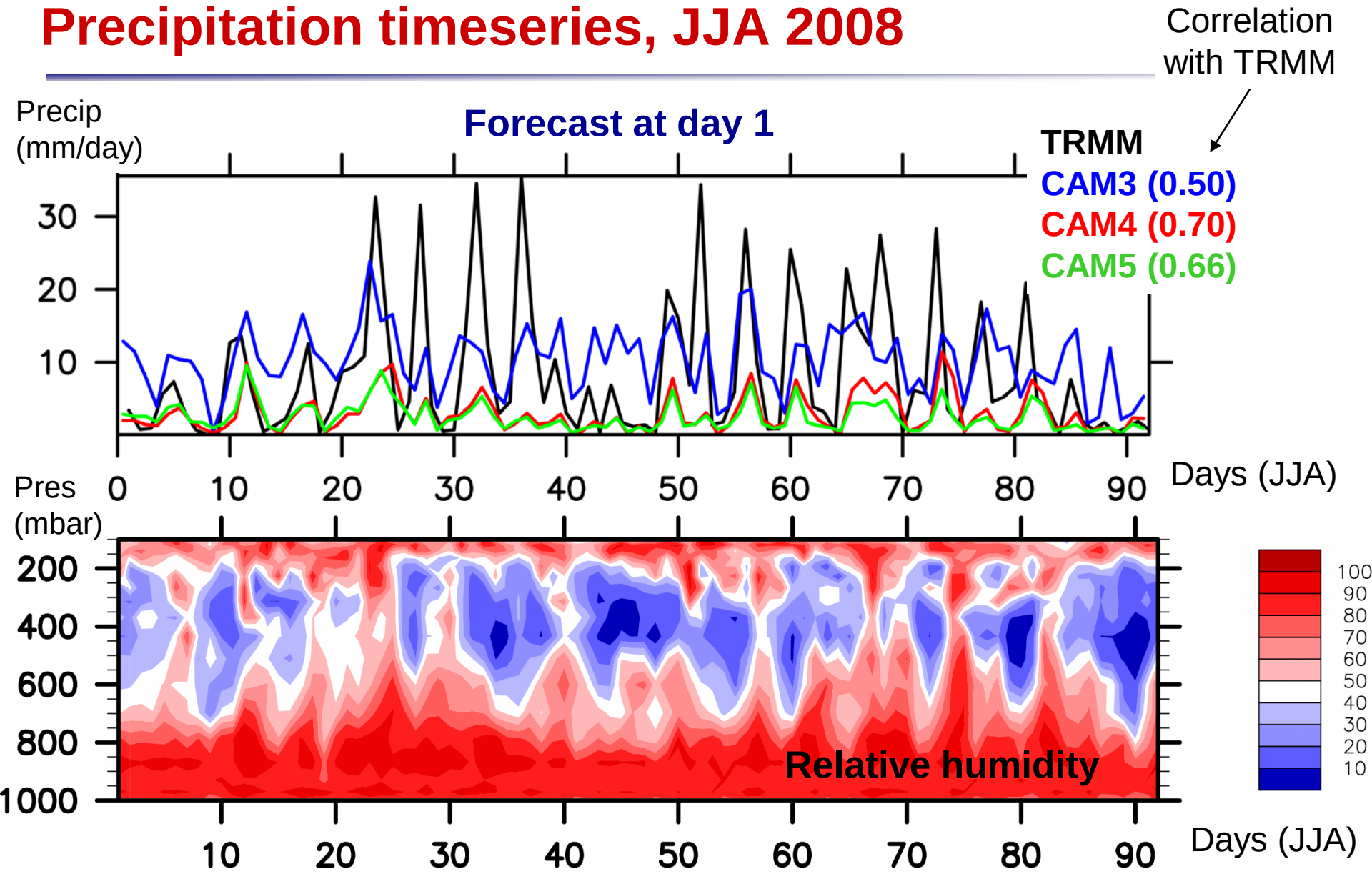
- **CAM3:** **overestimates the precipitation in the ITCZ**
  rains all the time

No mixing

- **CAM4/5:** **reduction in the ITCZ precipitation**
  better correlation with observed precipitation
  underestimates strong events

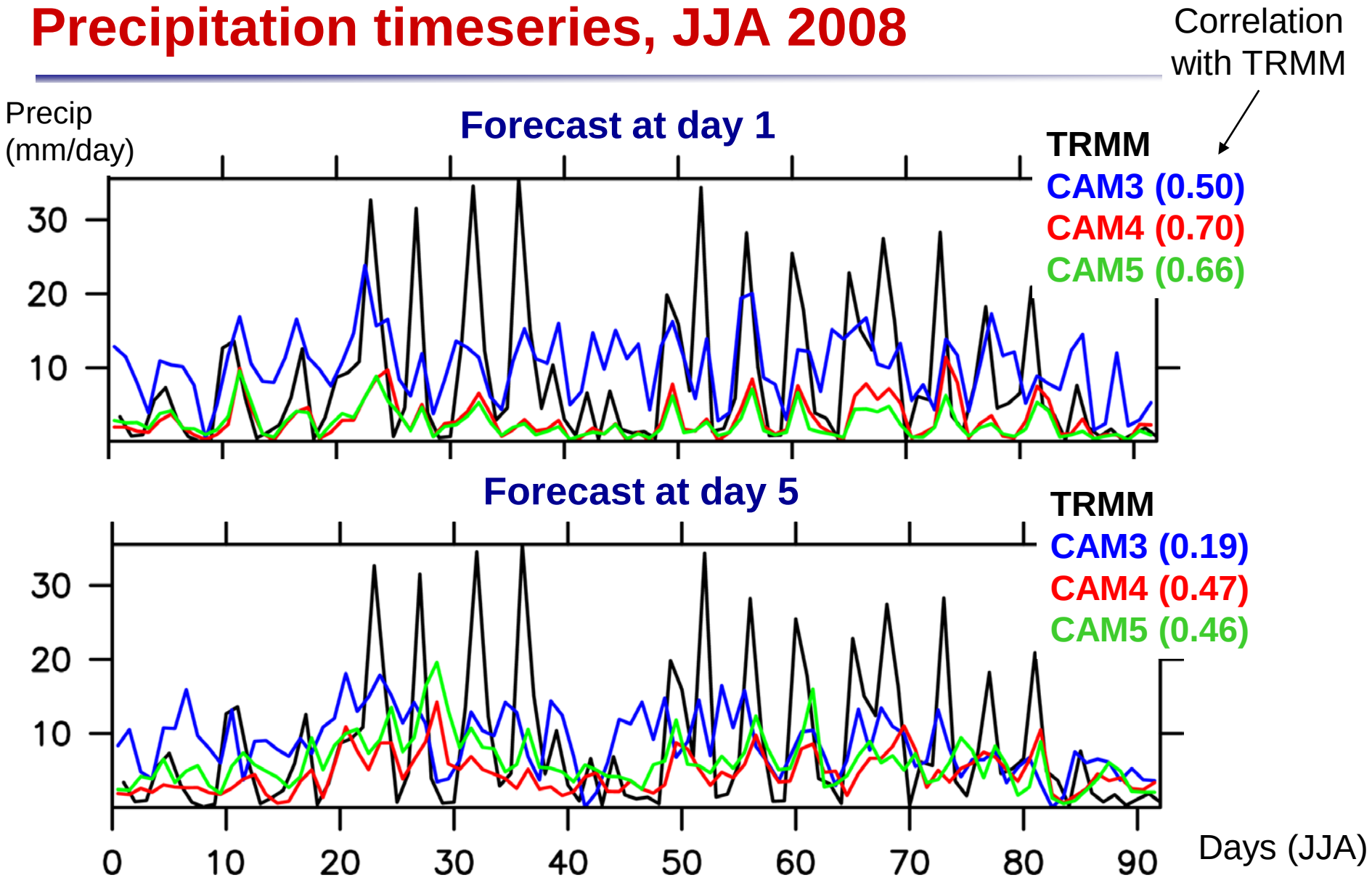
Allows mixing

Precipitation timeseries, JJA 2008



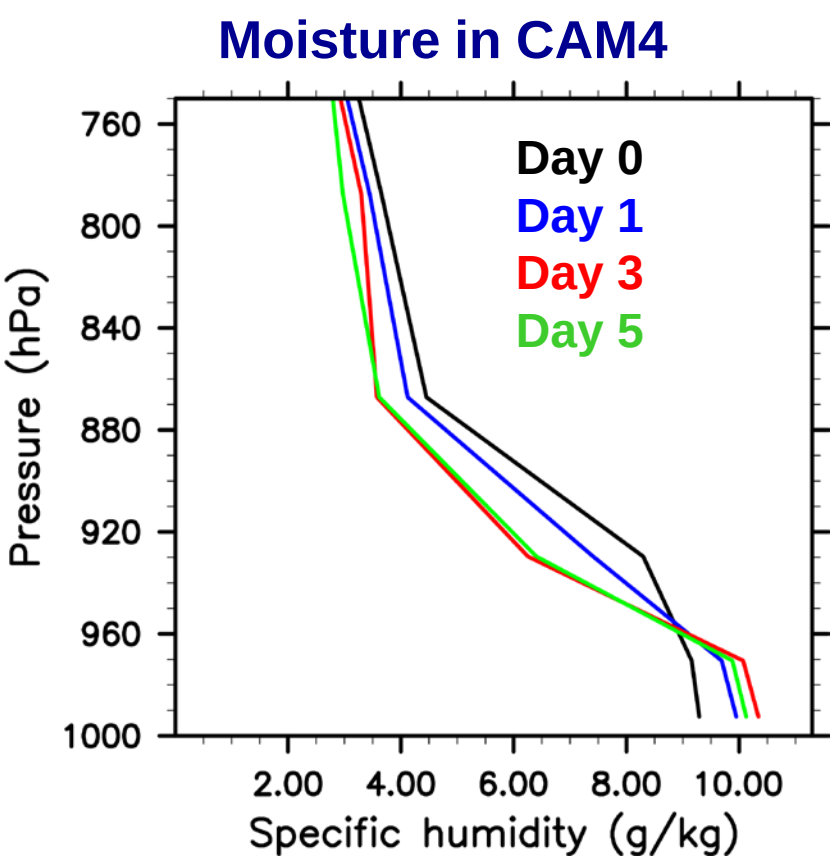
CAM4/5: precipitation better connected to mid-troposphere

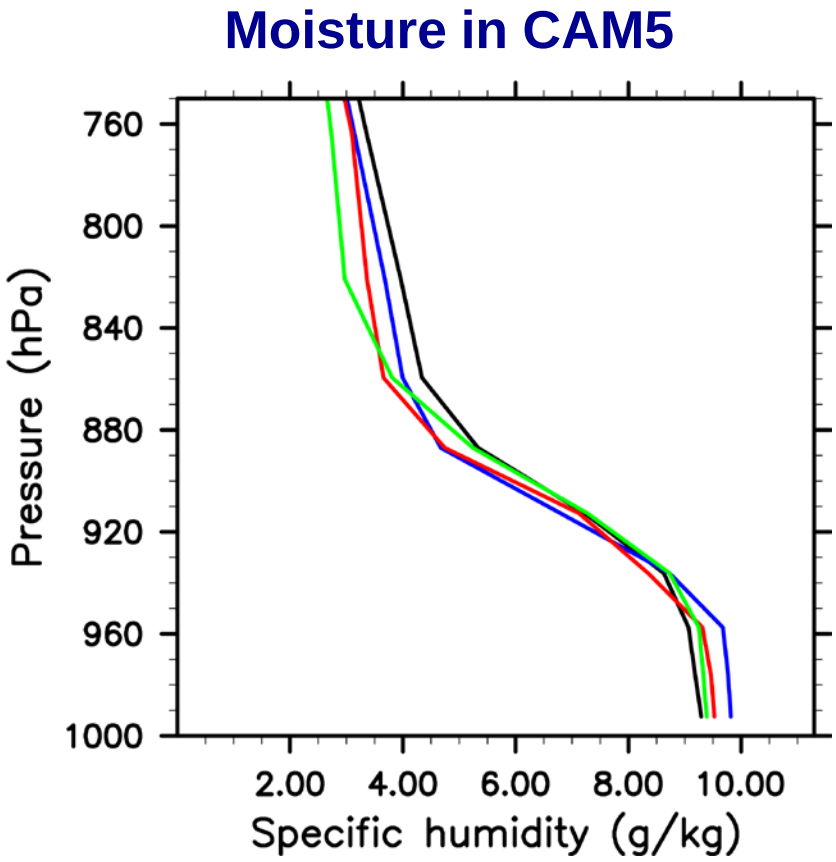
Precipitation timeseries, JJA 2008



CAM4/5: correlation w/obs decreases in 5-day forecast

Moisture profile in the stratocumulus regime





CAM4: PBL collapses

Dry and surface-driven PBL scheme

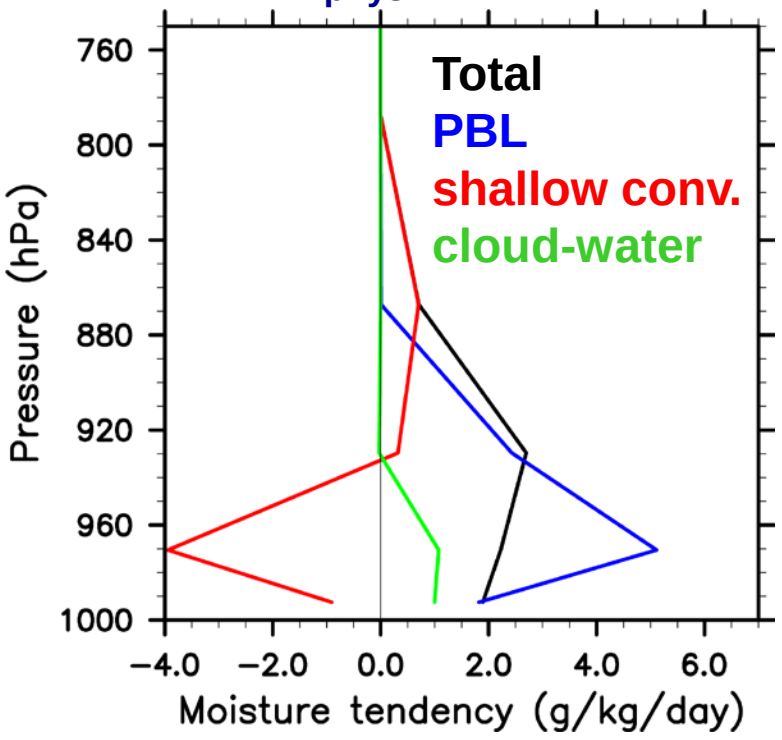
CAM5: PBL height is maintained

scheme based on prognostic TKE w/ explicit entrainment at top of PBL

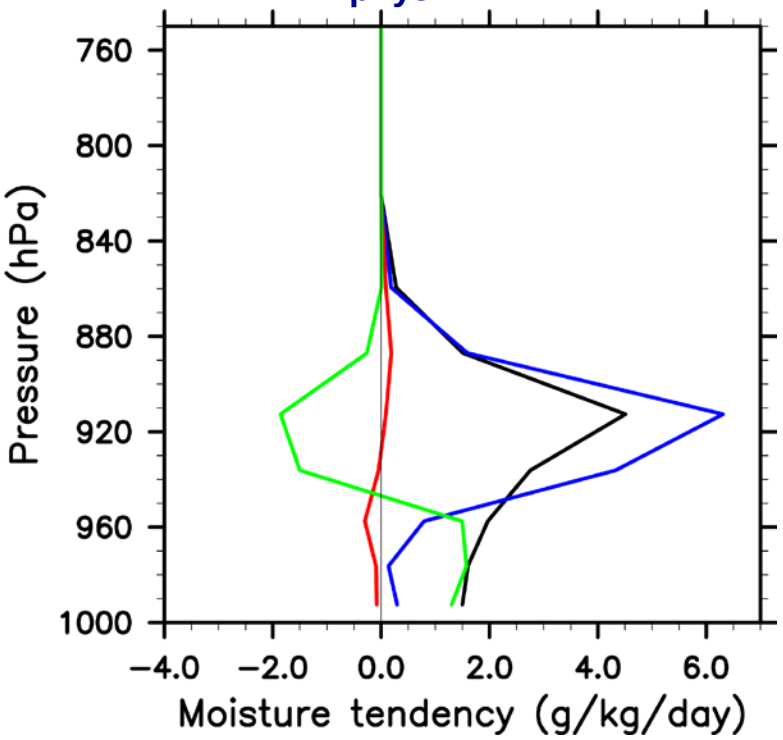
Water vapor budget in the stratocumulus regime

$$\frac{\partial q}{\partial t} = \underbrace{-V \bullet \nabla q - \omega \frac{\partial q}{\partial p}}_{\text{Advective tendencies}} + \underbrace{Q_{PBL} + Q_{shallow} + Q_{cloud-water}}_{\text{Total physics tendency: } Q_{phys}}$$

Q_{phys} in CAM4



Q_{phys} in CAM5



Conclusion

• **CAM forecasts allows for diagnosing parameterization errors in different cloud regimes**

• **CAM3**
- too much precipitation near ITCZ (deep convection scheme: no mixing between the parcel and its environment)
- PBL too shallow in StCu (dry and surface-driven PBL scheme)

• **CAM4**
- dramatic improvement of precipitation in the early forecast with the new convection scheme (entrainment of environment)

• **CAM5**
- new PBL scheme produces deeper and better mixed PBLs (PBL scheme: prognostic TKE with explicit entrainment at top of PBL)