Uncertainties in Water vapor: Budgets in two versions of CAM (Track 1 and Track 5)

Cécile Hannay, Dave Williamson, Jerry Olson,
Rich Neale, Sungsu Park, Phil Rasch*,
Andrew Gettelman and Hugh Morrisson.

National Center for Atmospheric Research, Boulder
*Pacific Northwest National Laboratory, Richland

What are Track 1 and Track 5 ?

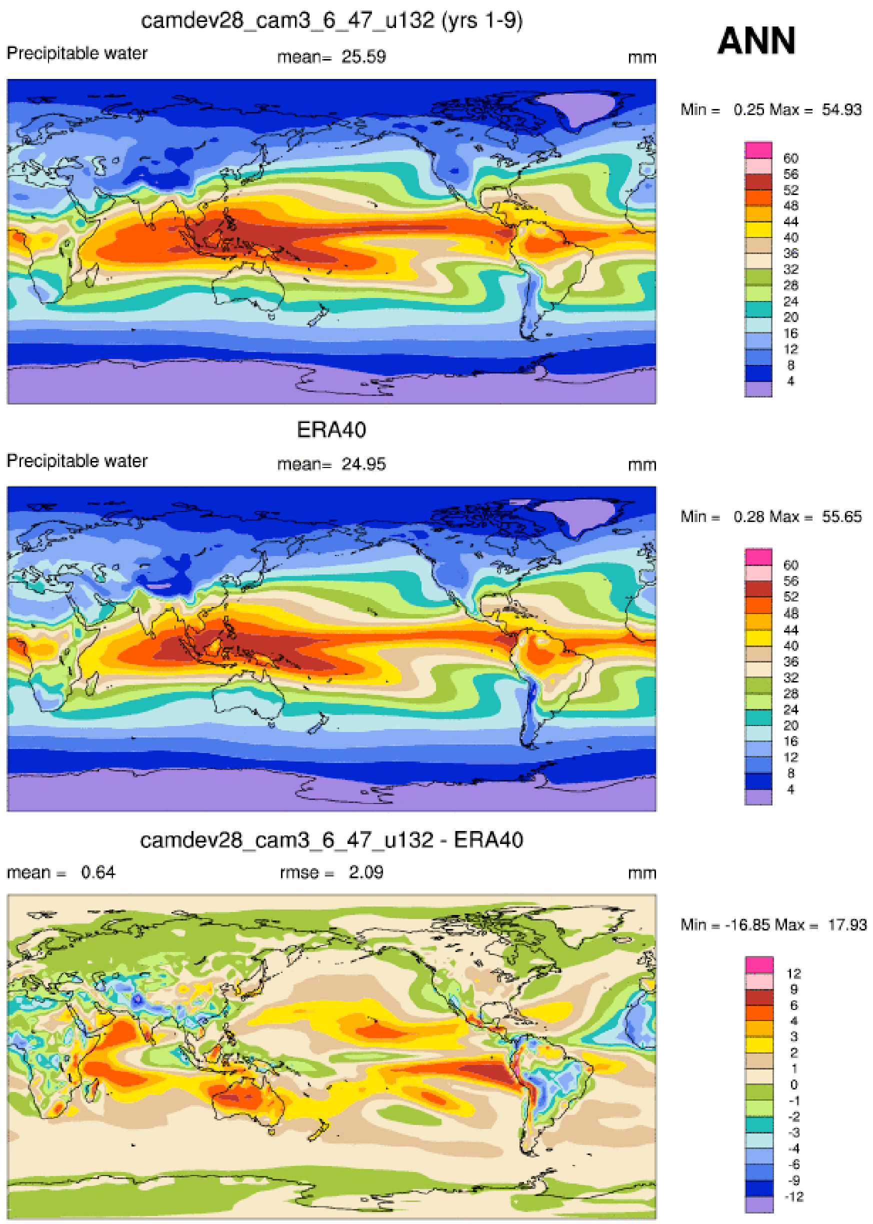
- Track 1 = cam3.5.1

  - Deep convection: Neale-Richter (2008)
  - Microphysics: Rasch-Kristjansson (1998)
  - Boundary layer: Holtslag-Boville (1993)
  - Shallow convection: Hack (1993)
  - Bulk Aerosol Model (BAM, Barth, Rasch, Mahowald … 2000-2009)
  - Radiation: CAMRT (Ramanathan, Kiehl, Collins,…1970s-2006)

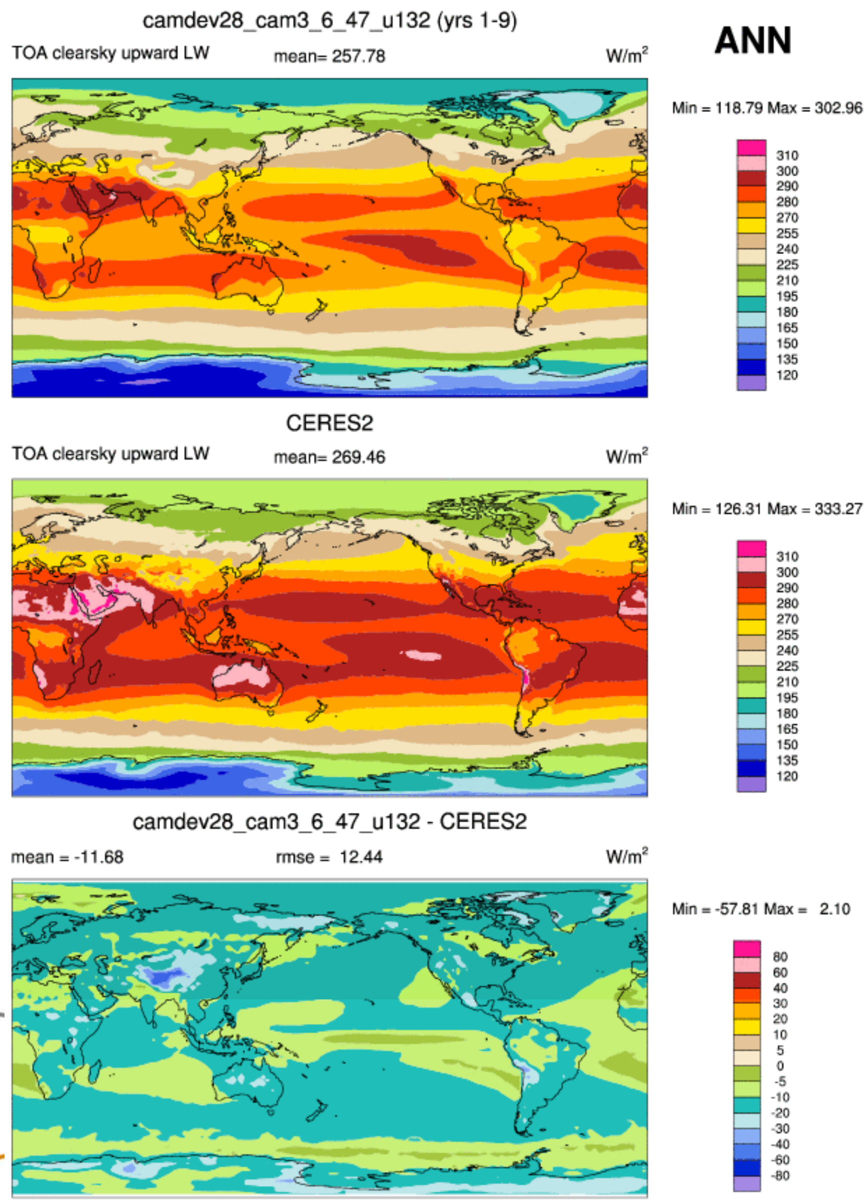
- Track 5 = cam4

  - Deep convection: Neale-Ritcher (2008)
  - Microphysics: Morrison and Gettelman (2008)
  - Boundary layer: Bretherton and Park (2009)
  - Shallow convection: Park and Bretherton (2009)
  -Macrophysics: Park, Rasch, Bretherton (2009)
  - Modal Aerosol Model (MAM): Ghan and Liu
  - Radiation: RRTMG: Iacono et al (2008)

Water vapor biases



Clear Sky OLR



- Model values too low
- Partly explained by
  - Emissions above top of model
  - Differences in Sampling methodology btw models and CERES
  - Too much water vapor

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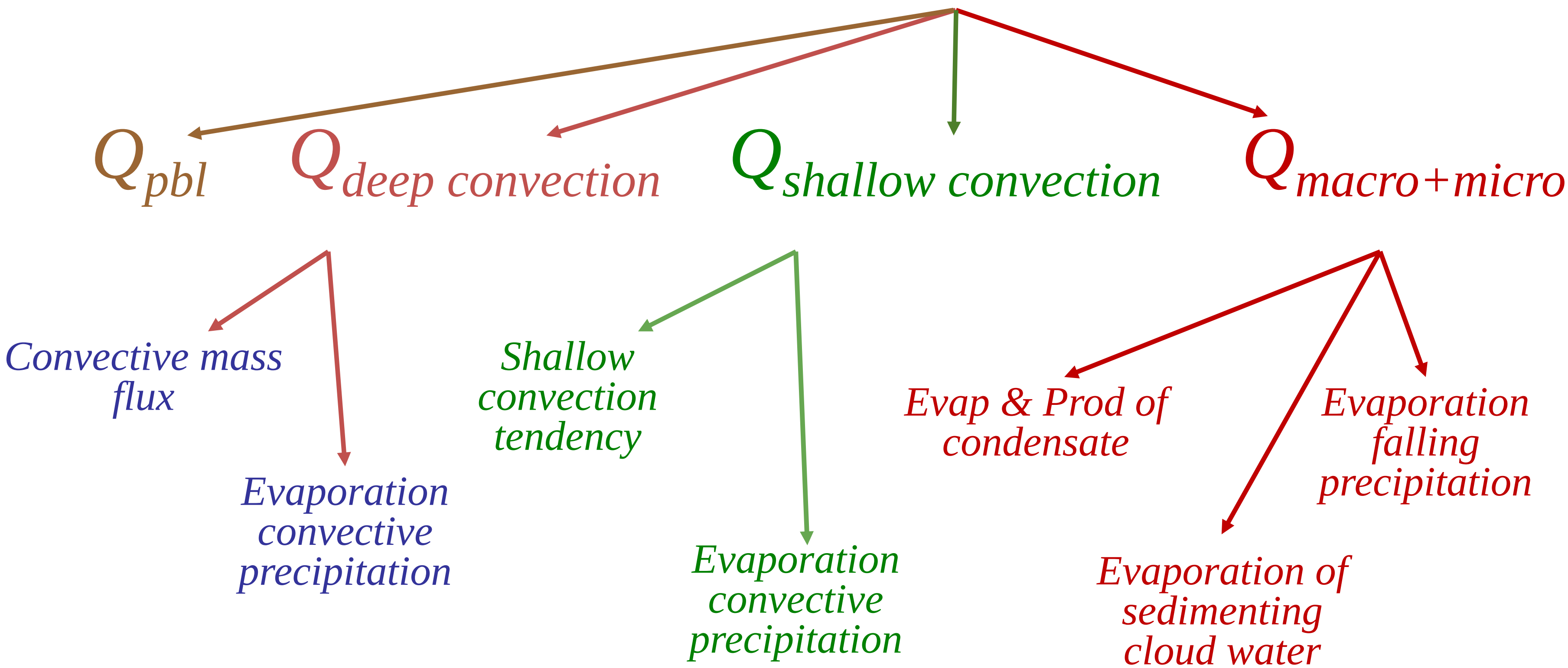
Motivation

- Analysis of the budget for temperature, moisture and condensate
- Climate runs:
  understand the balance that controls the climate
- Forecast runs:
  - understand how we attain this balance

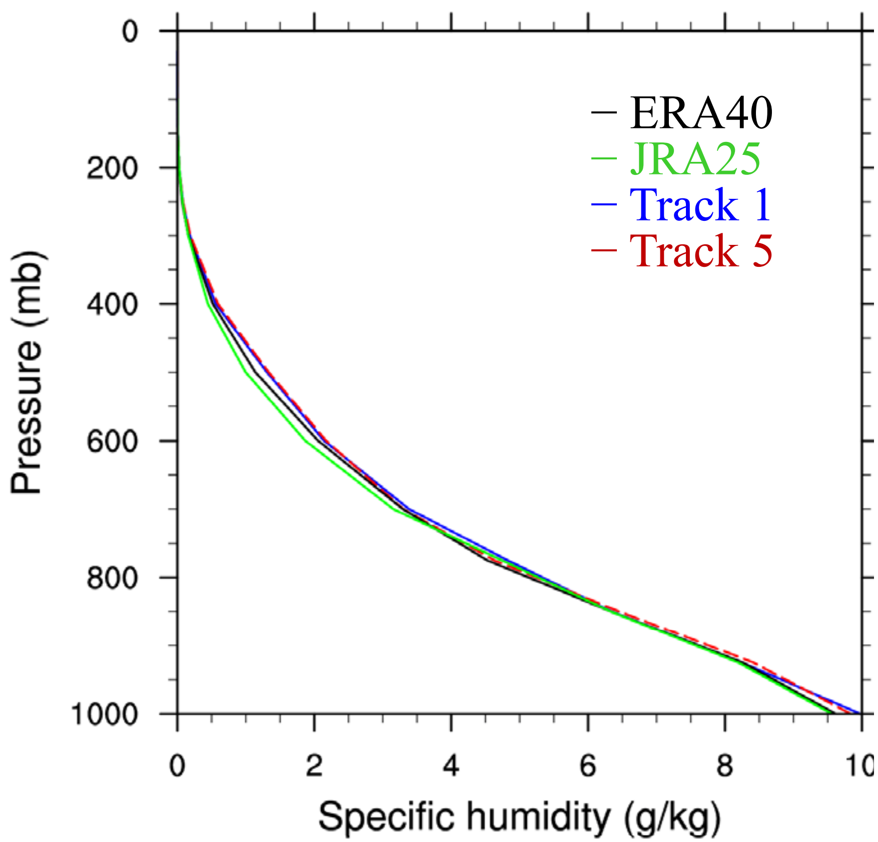
Water vapor budget

$$\frac{\partial q}{\partial t} = \underbrace{-V \bullet \nabla q - \omega \frac{\partial q}{\partial p}}_{\text{Advective tendencies}} + \underbrace{Q_{physics}}_{\text{Physics tendencies}}$$

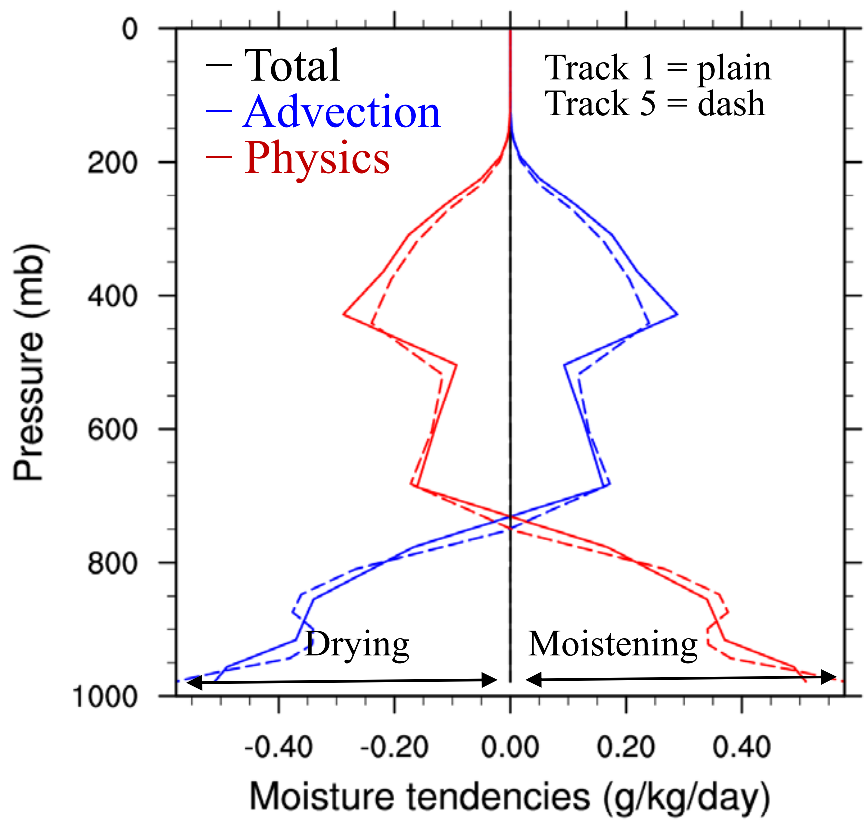


Global annual means: q profiles and tendencies

Moisture profile



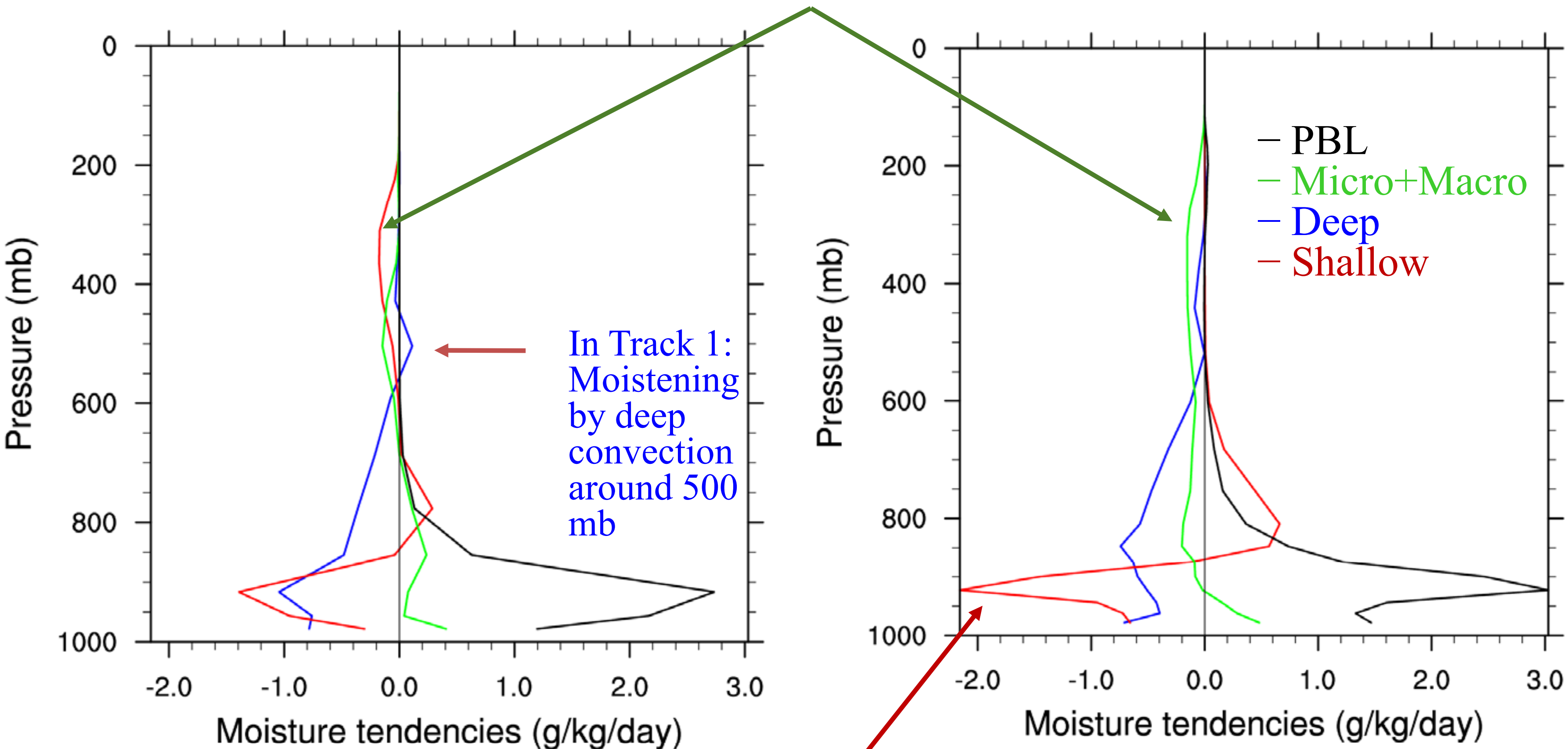
Moisture tendencies



Global annual mean: physics tendencies break-up

Drying of upper troposphere
- by Hack in Track 1
- by microphysics in Track 5

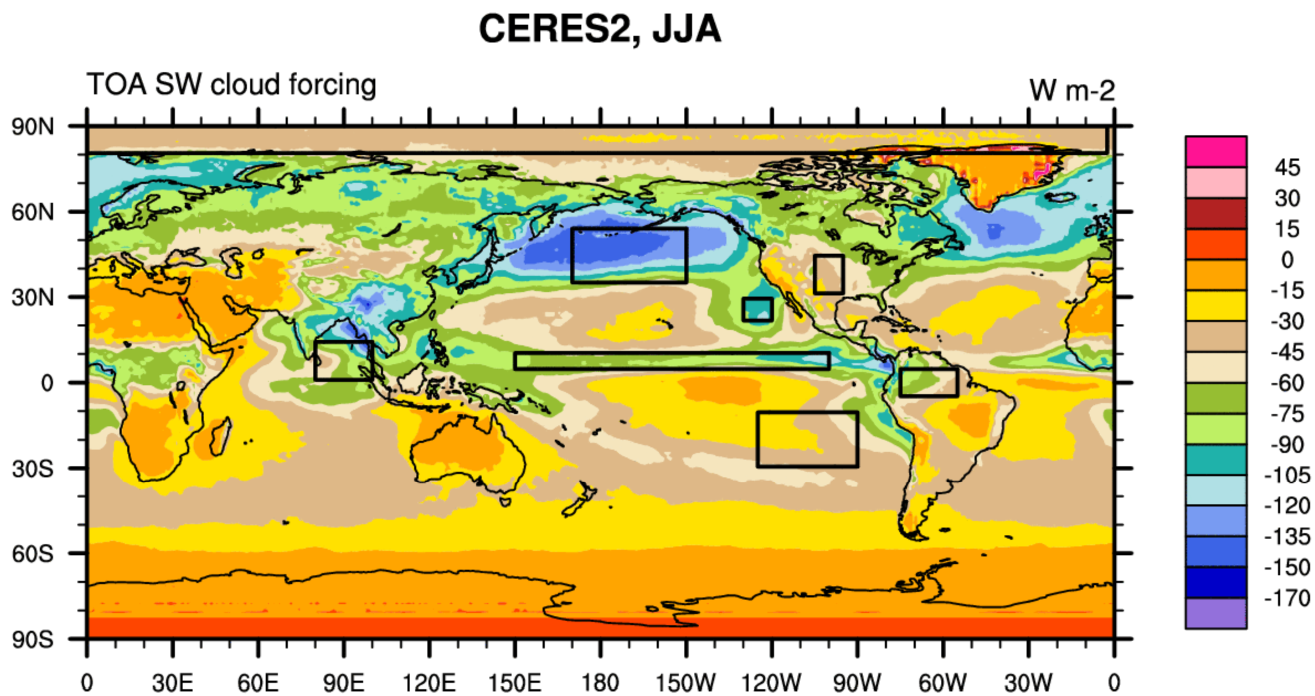
Track 1 **Track 5**



Shallow convection
is stronger in Track 5

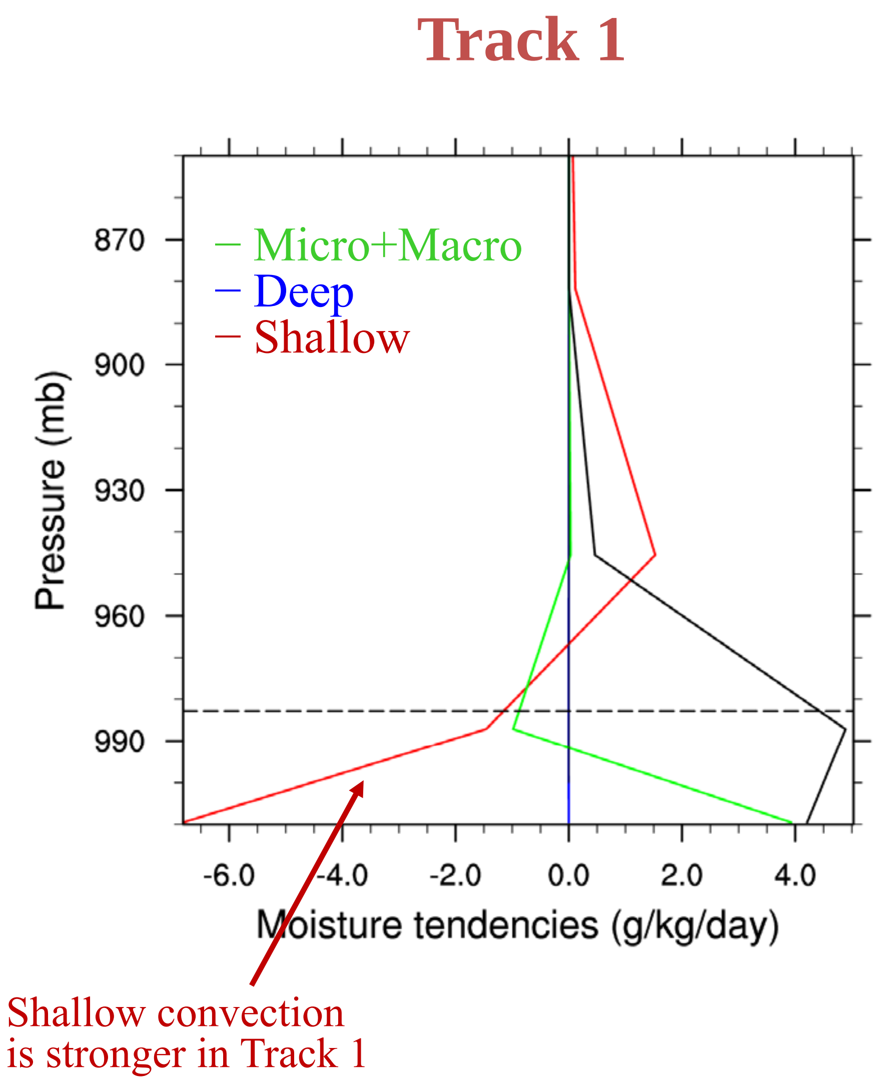
Budget terms in various regimes

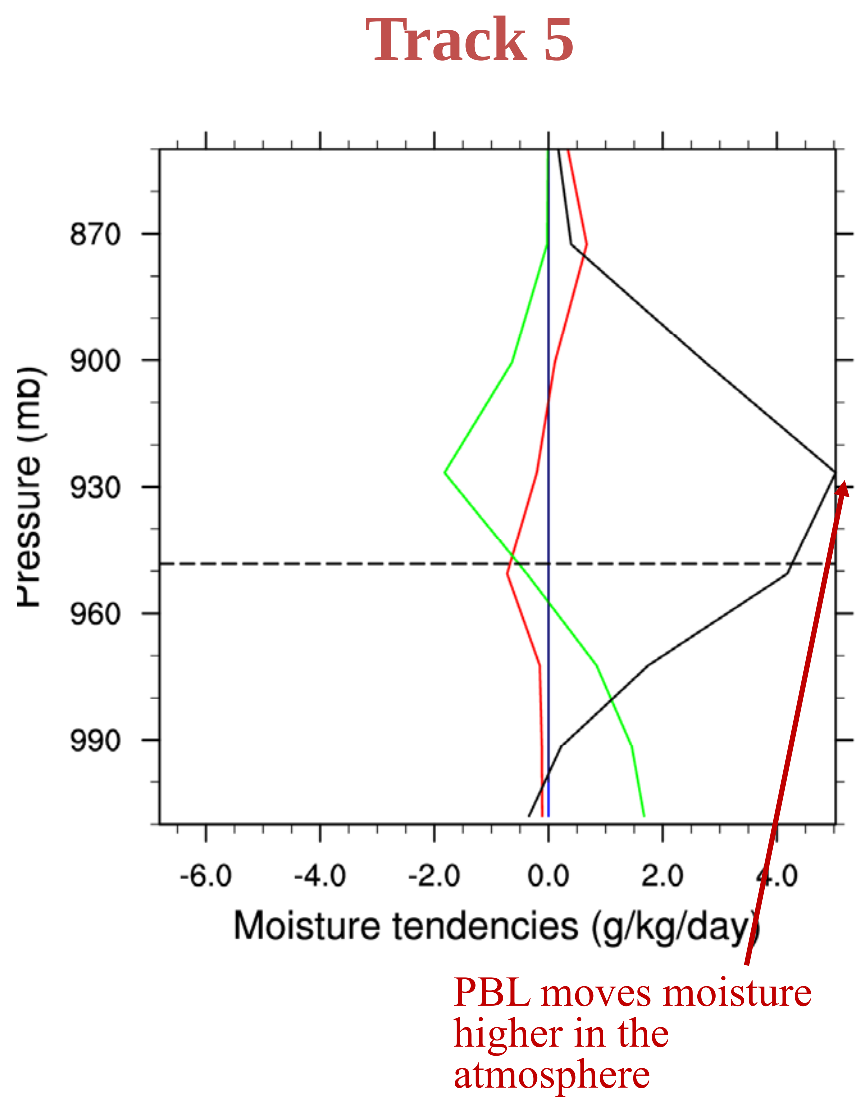
- Stratocumulus
- Transition
- ITCZ
- Bay of Bengal
- Storm Tracks
- Arctic
- Continental US
- Tropical land



http://www.cgd.ucar.edu/cms/hannay/internal/cam4_dev/budgets/t1_t5/Budget_t1_t5.html

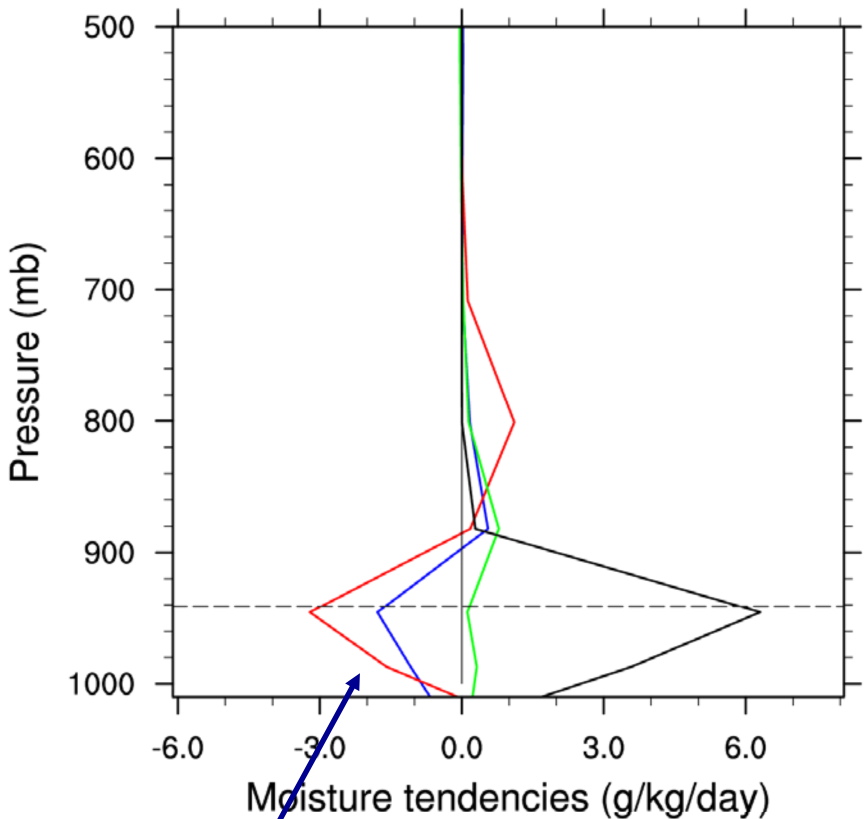
Stratocumulus



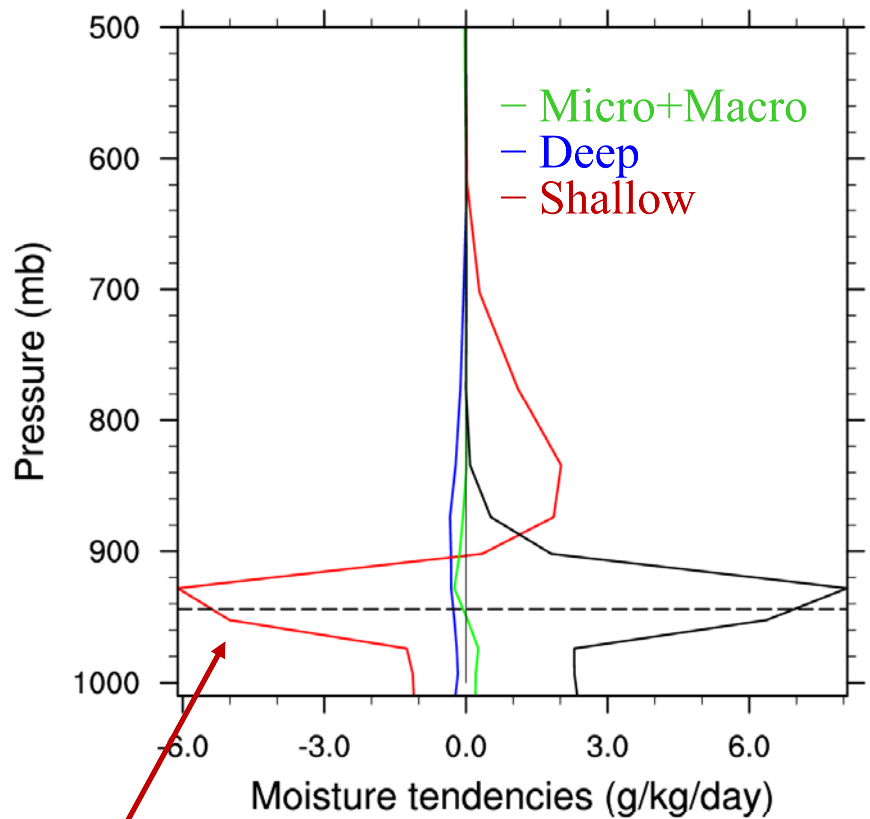


Transition region

Track 1



Track 5



Deep convection is stronger in Track 1

Shallow convection is stronger in Track 5

Conclusion and future work

- Budgets help to understand the balance that controls the climate

- Water vapor tendencies are very different in Track 1 and 5, even when the states in the two tracks are similar.

  A major difference is in the shallow convective tendencies, which are globally stronger in Track 5 than Track 1

  The drying of the upper troposphere is driven by different processes:
  - Track1: Hack convection scheme (unrealistic)
  - Track5: macro+micro (reflects new ice microphysics)

  In the stratocumulus regions, there is an unrealistically large contribution from the shallow convection scheme in Track 1

Future work

Next , we will look at :

- the temperature, liquid and ice budgets
- forecast runs (CAPT framework):
  - understand how we attain this balance
  - allows direct comparison of the parameterized variables (e.g. clouds) with observations from field campaigns
- How do we use observations to help us understand the balances in the real world for these regimes, and achieve similar balance in models?