Twelve Plus One Lectures:
A Climate System View of Clouds & Convection

Bjorn Stevens (MPI-M)

1. Cloud climatologies (Maps, Regimes, ISCCP Histograms, Conceptualizations)
2. Precipitation climatologies (Maps, Relationships)
3. The energy budget (Radiative convective equilibrium the role of Clouds)
4. Cloud radiative effects and climate susceptibility
5. Energy balance models: climate forcing, feedback, and adjustment
6. Clouds in large-scale models (an overview)
7. Clouds feedbacks and adjustments
8. Cloud aerosol interaction
9. Changes in the hydrological cycle
10. Cloud land-surface interactions
11. Remote effects of tropical convection
12. Clouds and polar climate (change)
13. …
Radiation

Reflectance (Vis)

Cloud Top Pressure (IR)

\[ S_0(1-\alpha) - 4\varepsilon\sigma T^4 = J \]

Images courtesy of R. Preusker & J. Fischer (Institut für Weltraumwissenschaften, FU Berlin)
Large-scale Order (i)

Data from CERES Instruments

Donnerstag, 24. November 11
Fig. 20. Radiative convective equilibrium temperature at the earth’s surface as a function of cloudiness (cirrus, altostratus, low cloud). FB and HB refer to full black and half black, respectively.
Its rationalization

Fig. 3. Numerically computed trajectories corresponding to the schematic curves in Fig. 2, for the change of spherical albedo with increasing pollution for thin, moderate and thick clouds.
**Clouds and Climate**

GFDL AM2

- clouds act to enhance the warming (positive effect)
- clouds act to mitigate the warming (negative effect)

**positive** cloud effect, larger climate sensitivity

NCAR CAM3

- **negative** cloud effect, smaller climate sensitivity

Following Stephens, following Soden (unpublished), Arakawa 1975
cloud regimes
Cloud regimes (the cartoon)

TRMM JJA Rain

mm/day

Cloud Clusters
Hadley/Walker Circulation
Land/Sea Circulation

warm, western tropical oceans
tradewinds
stratocumulus
cold, eastern subtropical ocean

Lower figure from Stevens  (Annual Reviews Earth and Planetary Science, 2005)
Precipitation

Image from Benjamin Möbis
Large-scale Order (ii)

Stevens (2005), following Arakawa 1975, also Augstein and Malkus
Stratocumulus
Trade Cumulus

Donnerstag, 24. November 11
Cumulonimbus
ISCCP Histograms

- Cirrus
- Cirrostratus
- Cumulonimbus
- Altocumulus
- Altostratus
- Nimbostratus
- Cumulus
- Stratocumulus
- Stratus

$\ln(\tau)$ (optical thickness)

Cloud-top pressure [hPa]
Slide Title