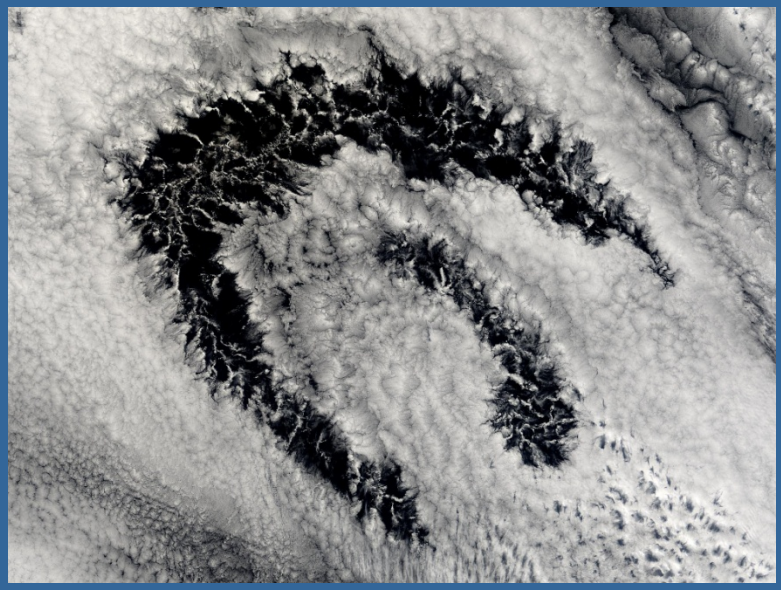
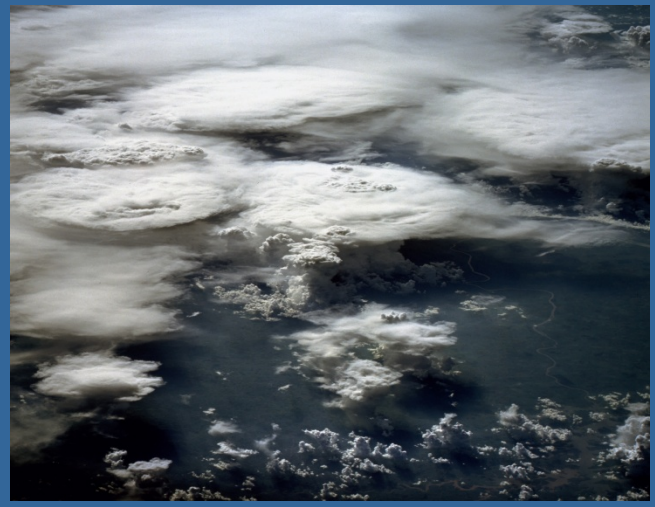
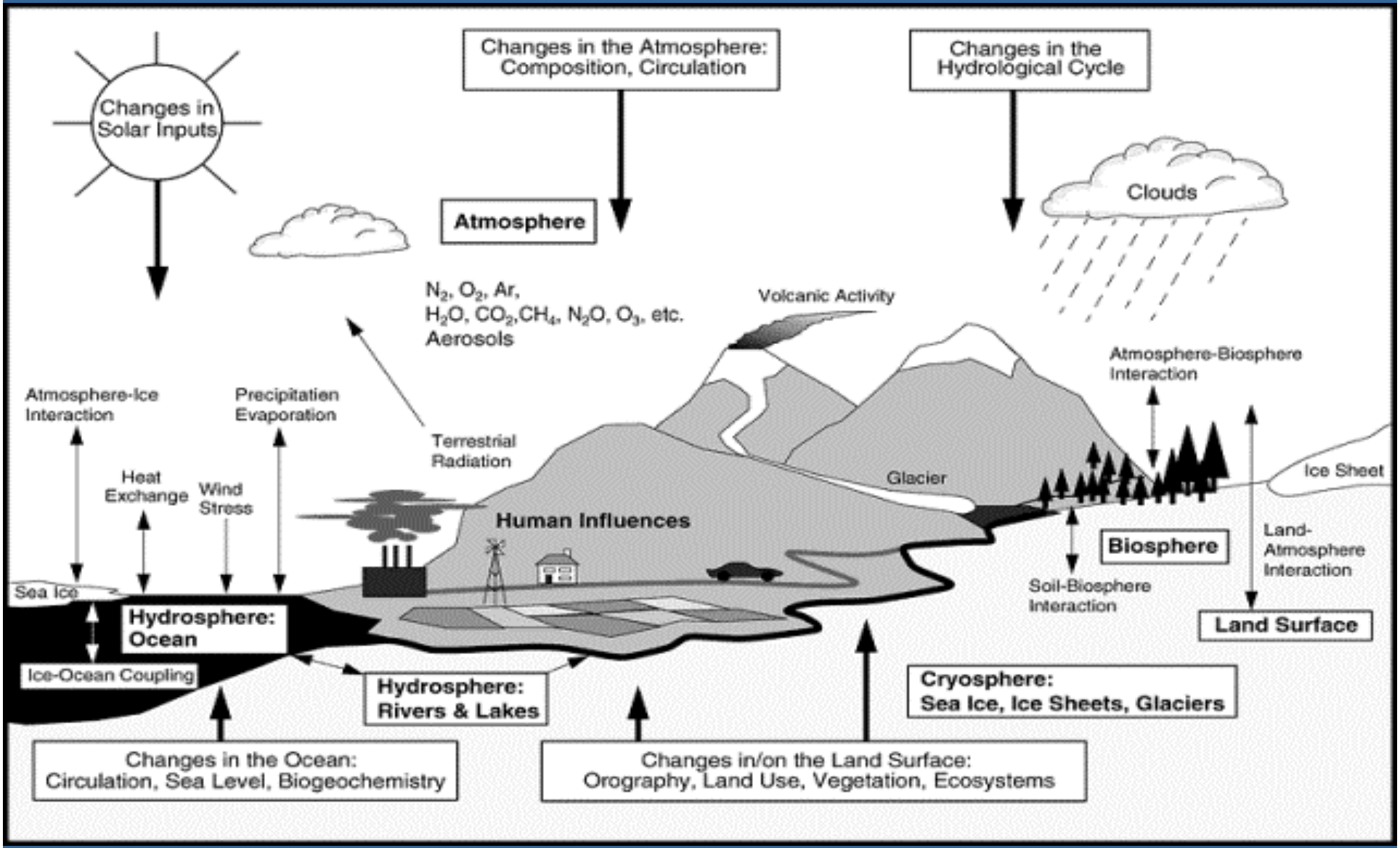
The importance of clouds



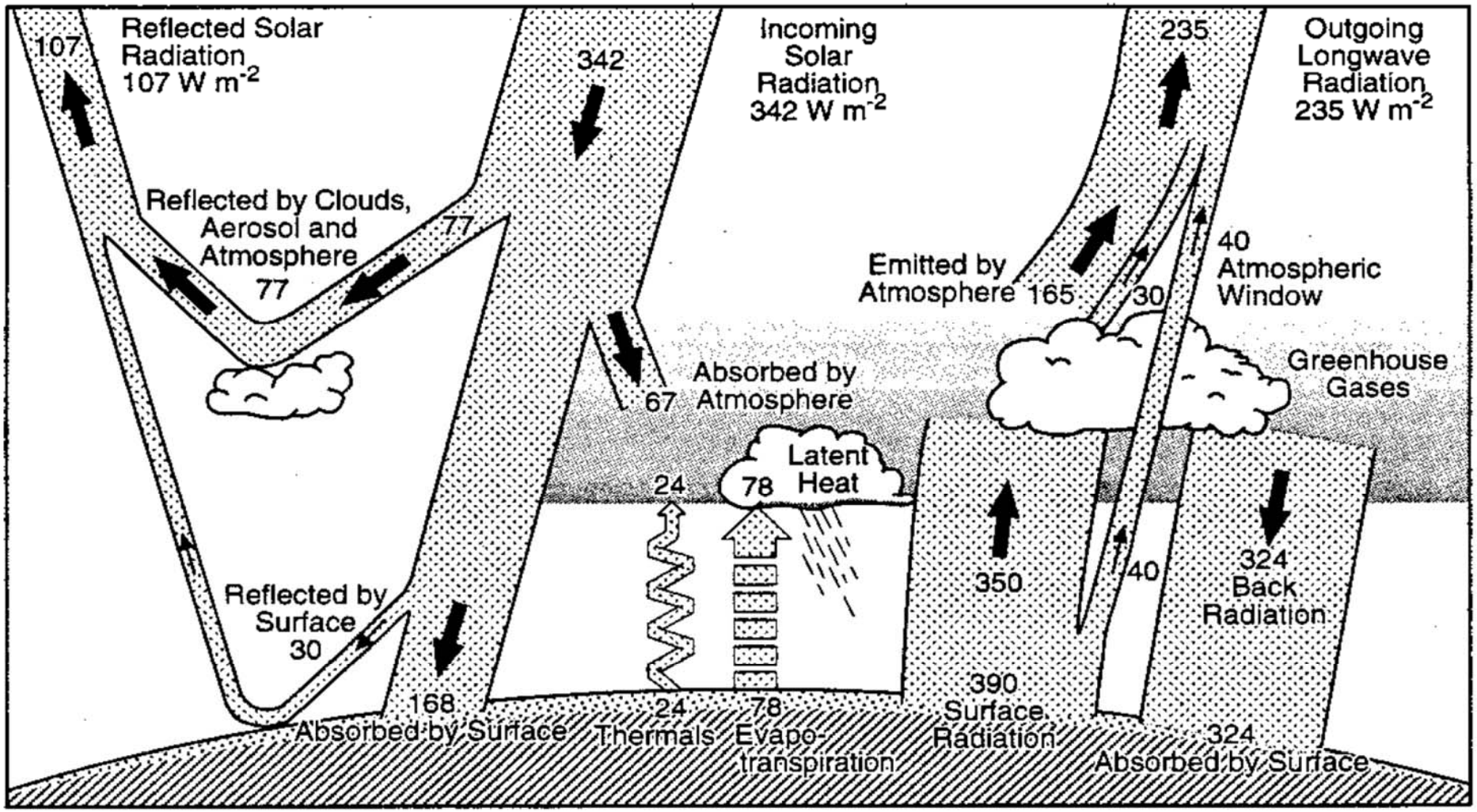


The Global Climate System

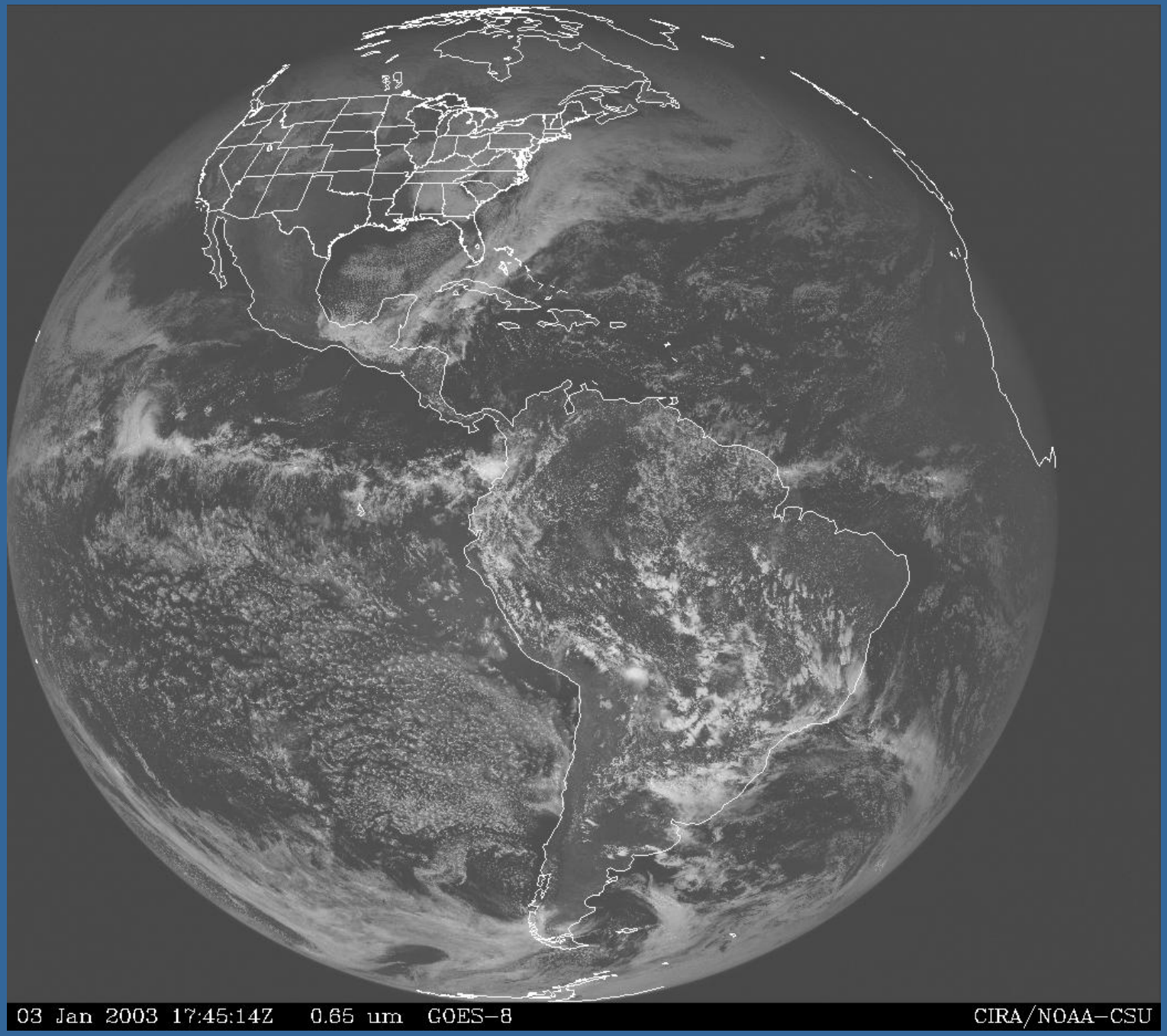


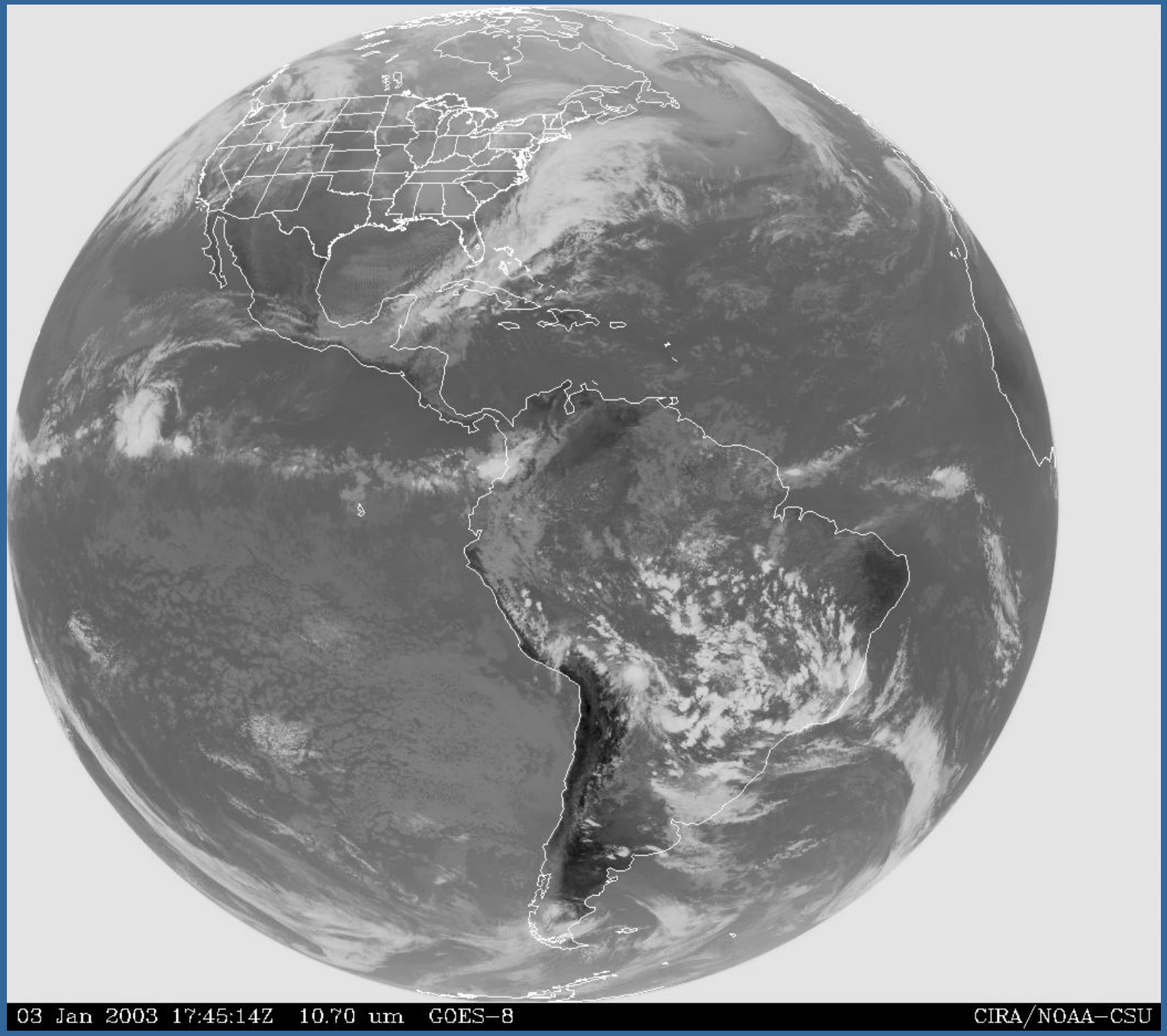
http://www.lwr.kth.se/Grundutbildning/1B1292/Compendium_online/ch05s01s02.html

Radiation in the climate system

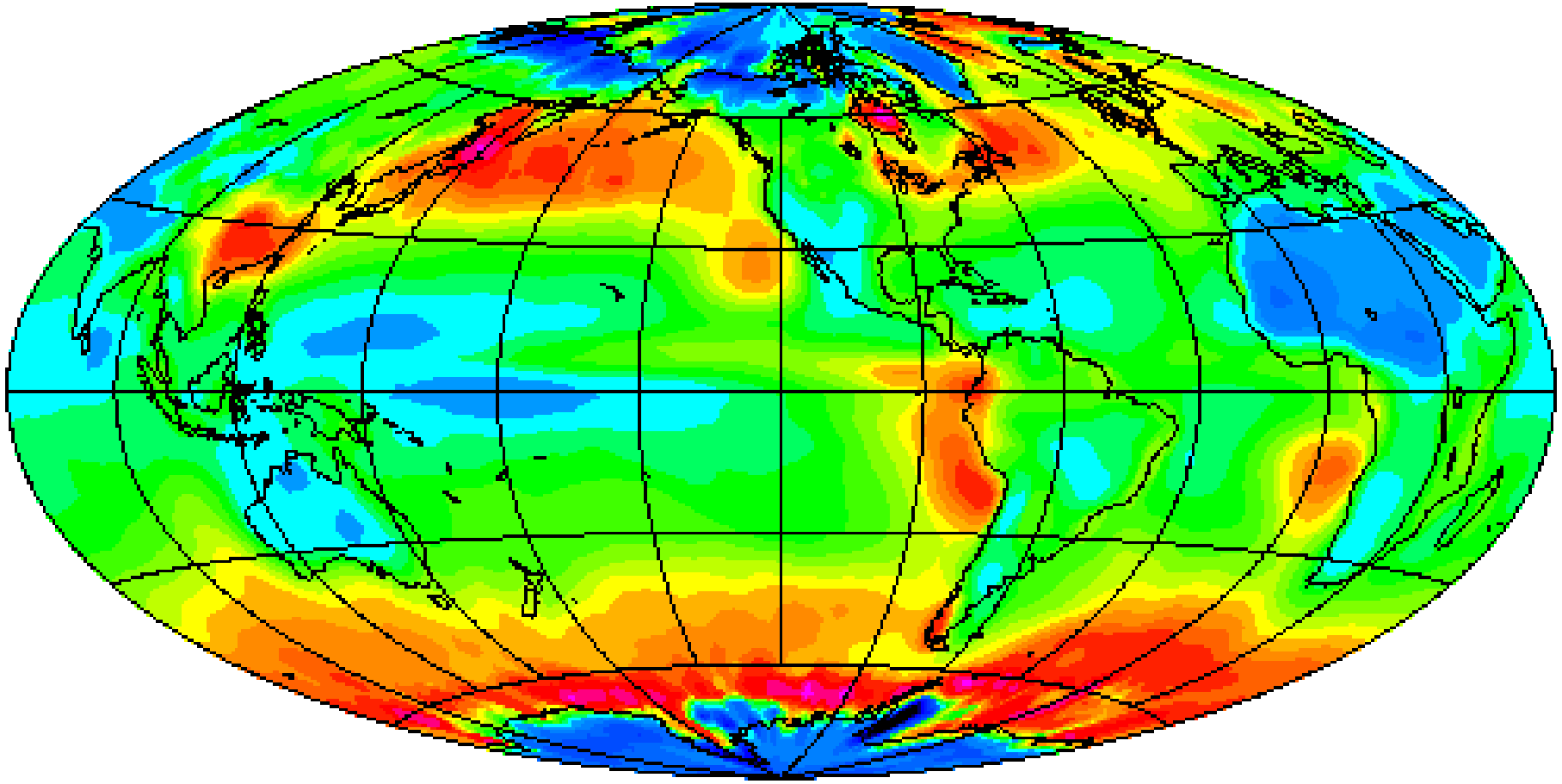


Kiehl and Trenberth, *BAMS*, 1997

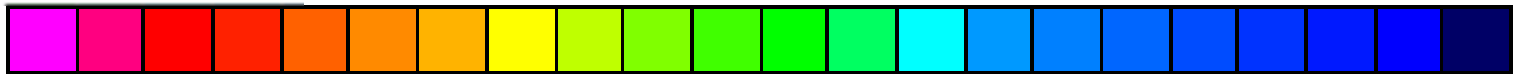

03 Jan 2003 17:45:14Z 0.65 um GOES-8
CIRA/NOAA-CSU


03 Jan 2003 17:45:14Z 10.70 um GOES-8
CIRA/NOAA-CSU

Net cloud radiative effect from ERBE



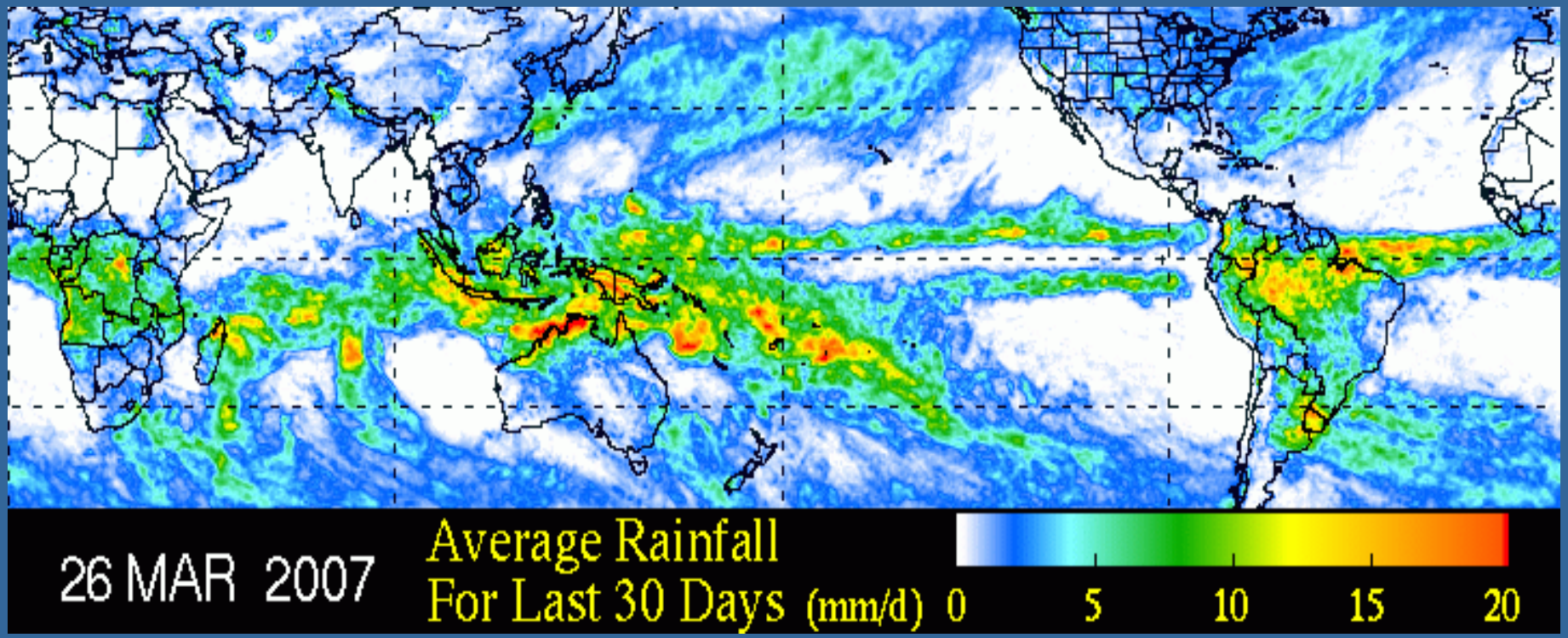
Hartmann et al. (1992)



-90 -70 -50 -40 -30 -20 -10 0 10 20 30 40

W/m**2

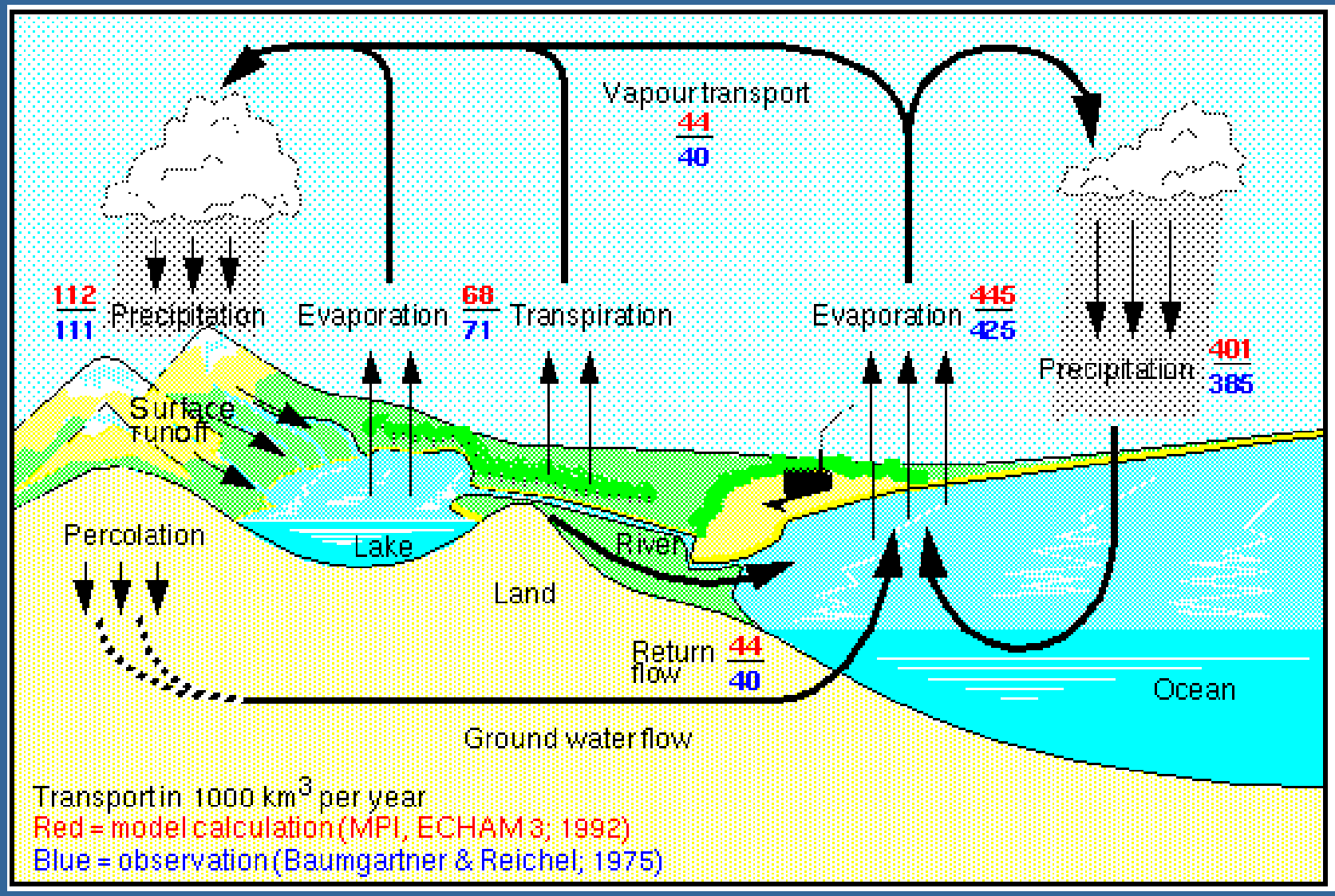
Latent Heating



Combined satellite rainfall measurements

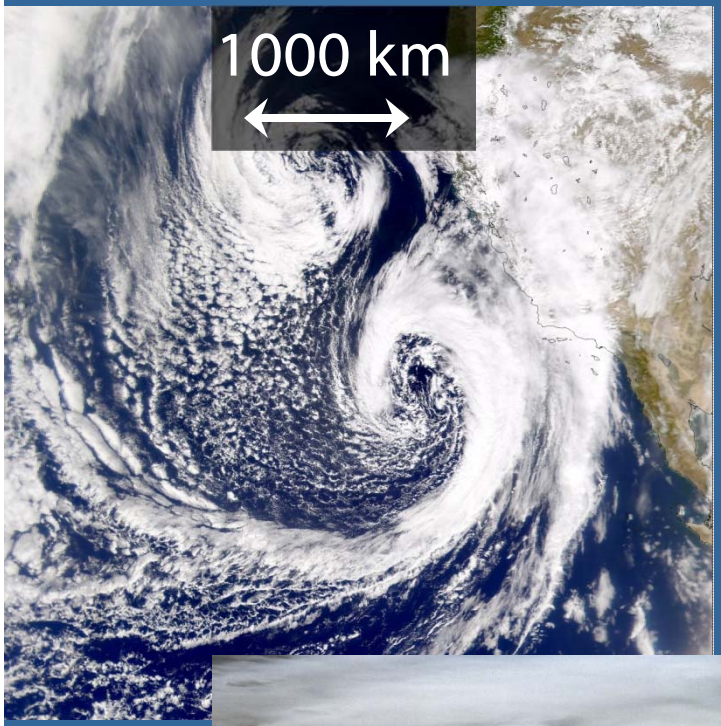
Reflects locations of major precipitating cloud systems spatiotemporal variability

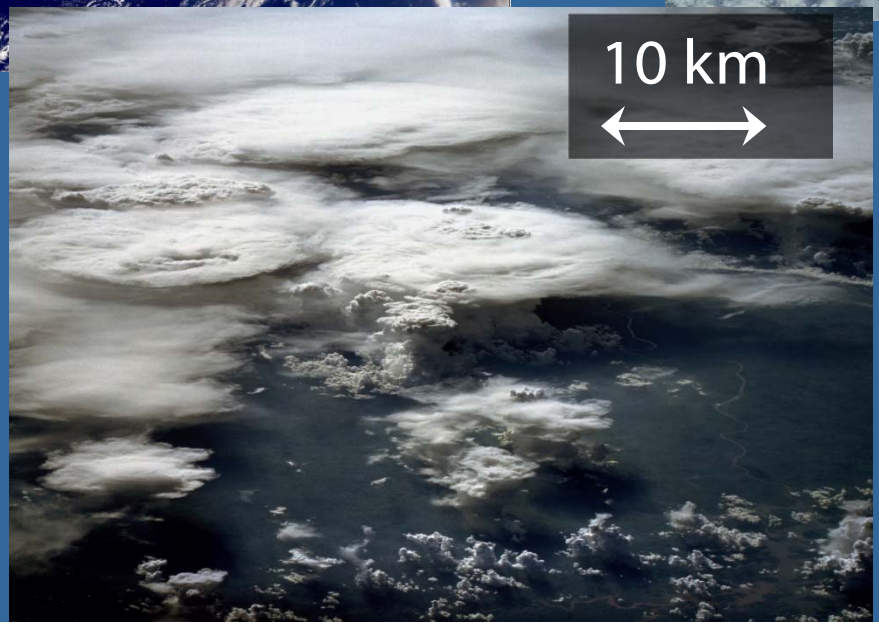
The Global Hydrological Cycle

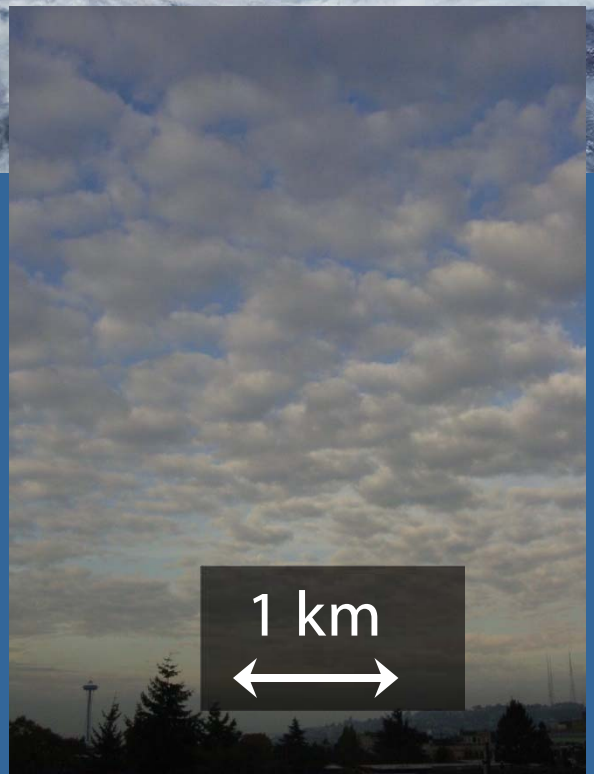


http://www.dkrz.de/dkrz/broschuere-eng/research/water.html

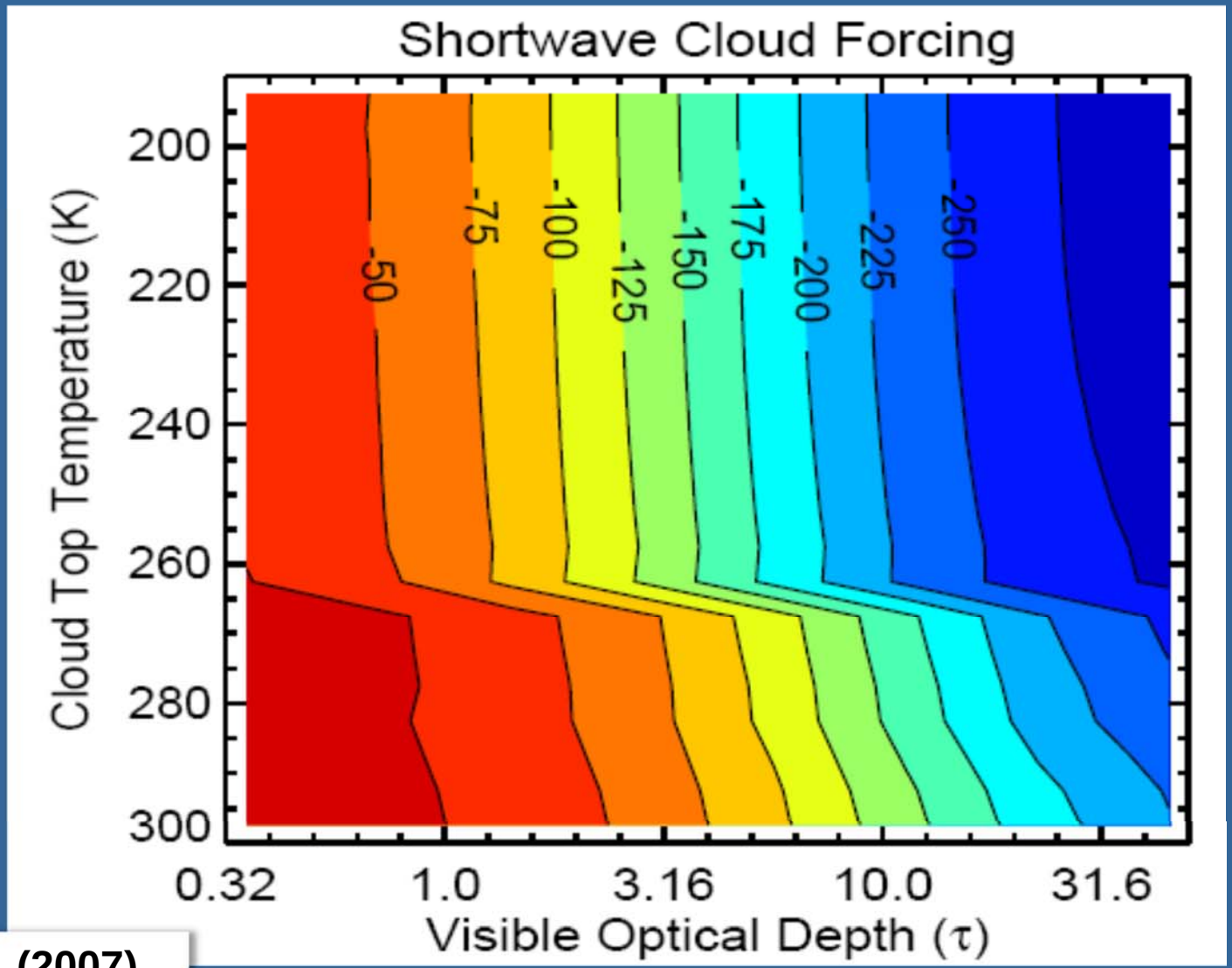
From global to local – range of scales





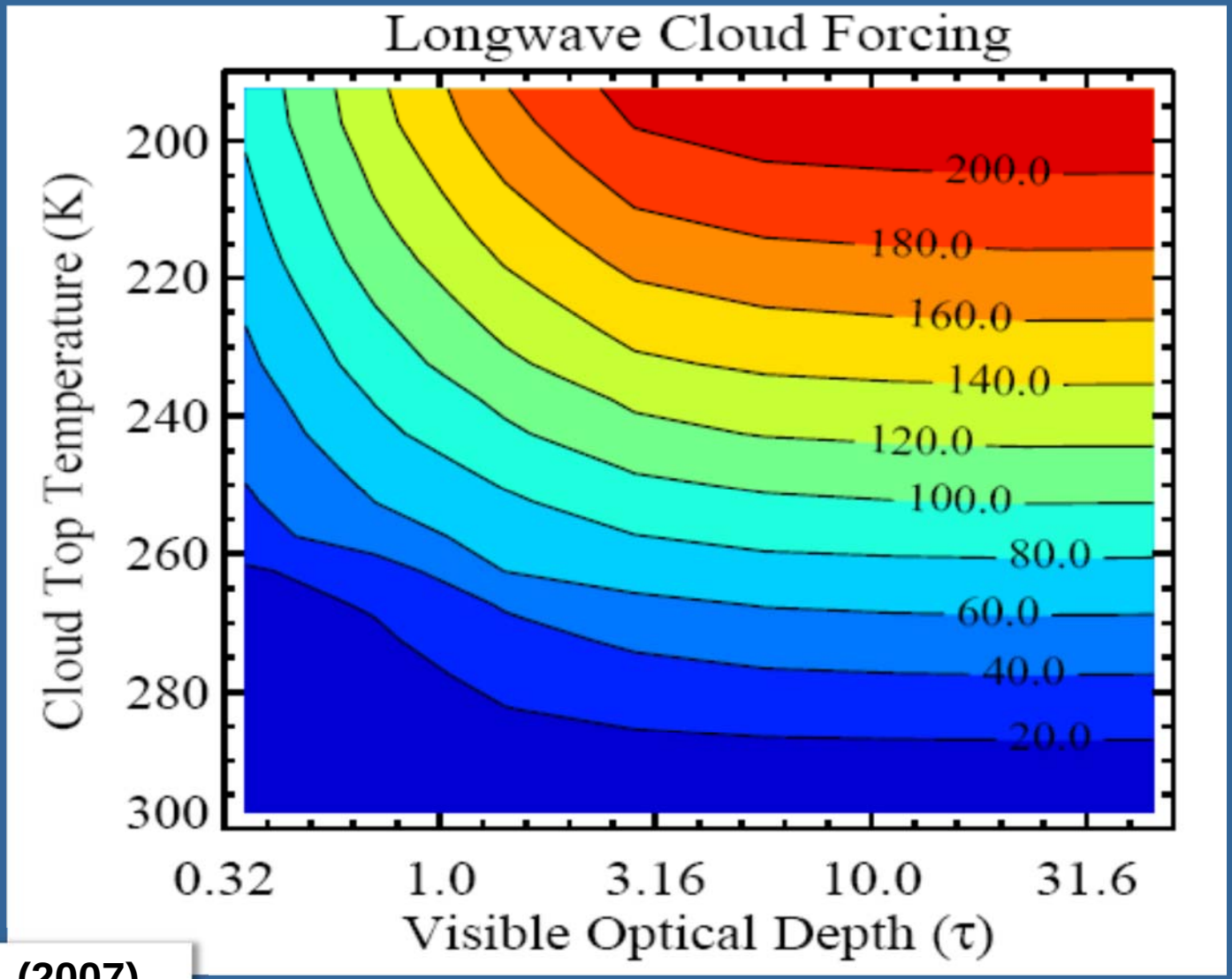


Impact of cloud type upon radiation



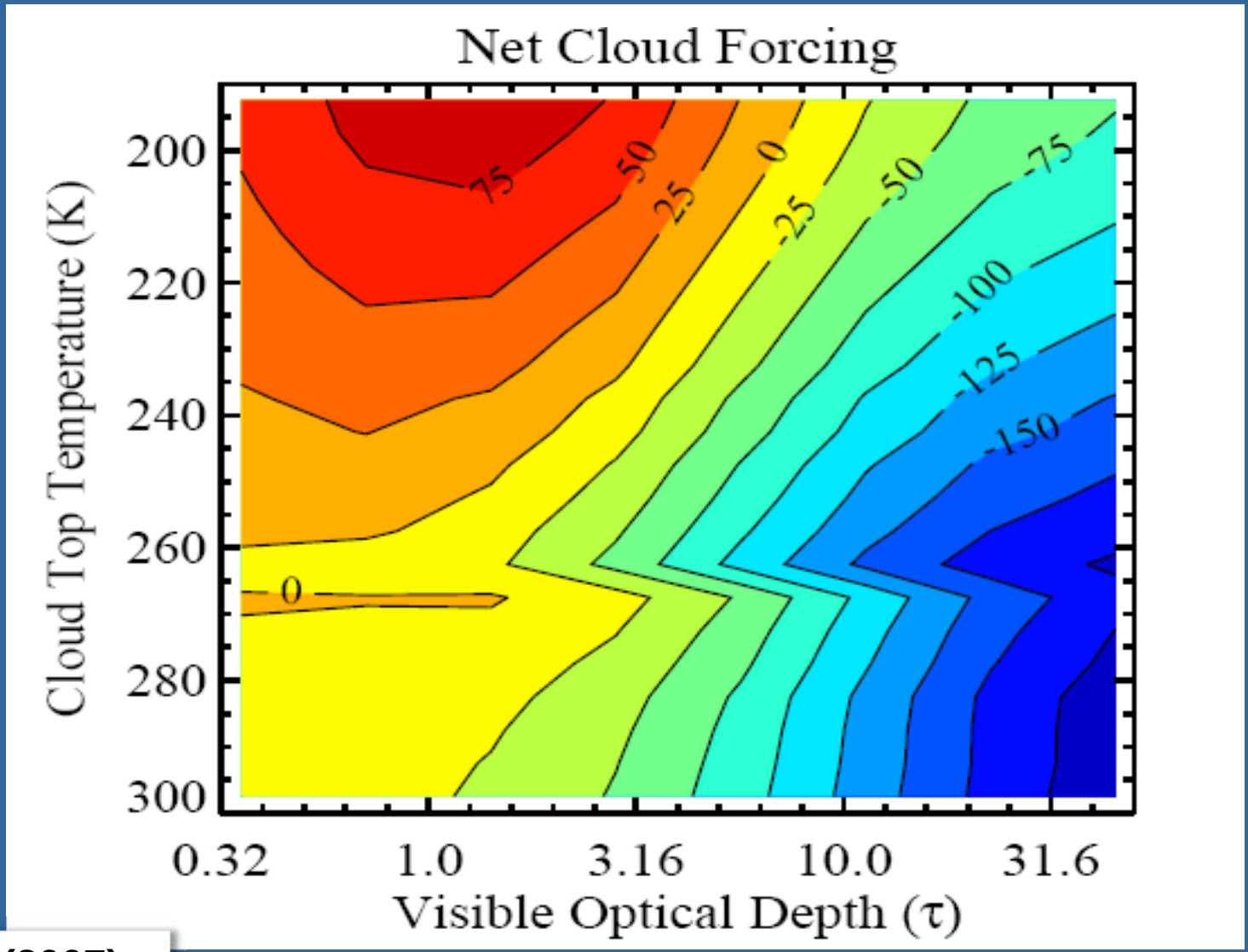
Kubar et al. (2007)

Impact of cloud type upon radiation



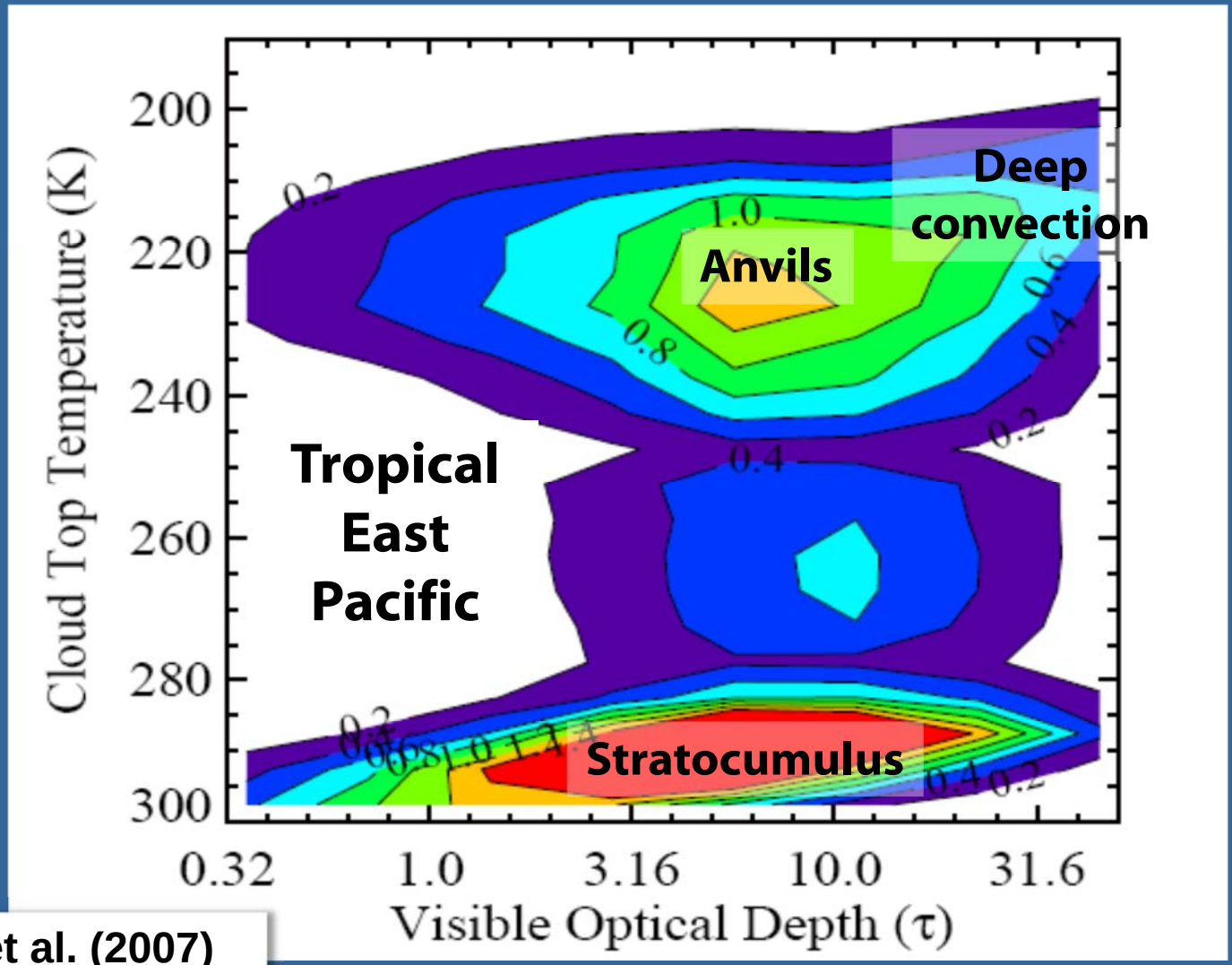
Kubar et al. (2007)

Impact of cloud type upon radiation



Kubar et al. (2007)

Distribution of cloud types



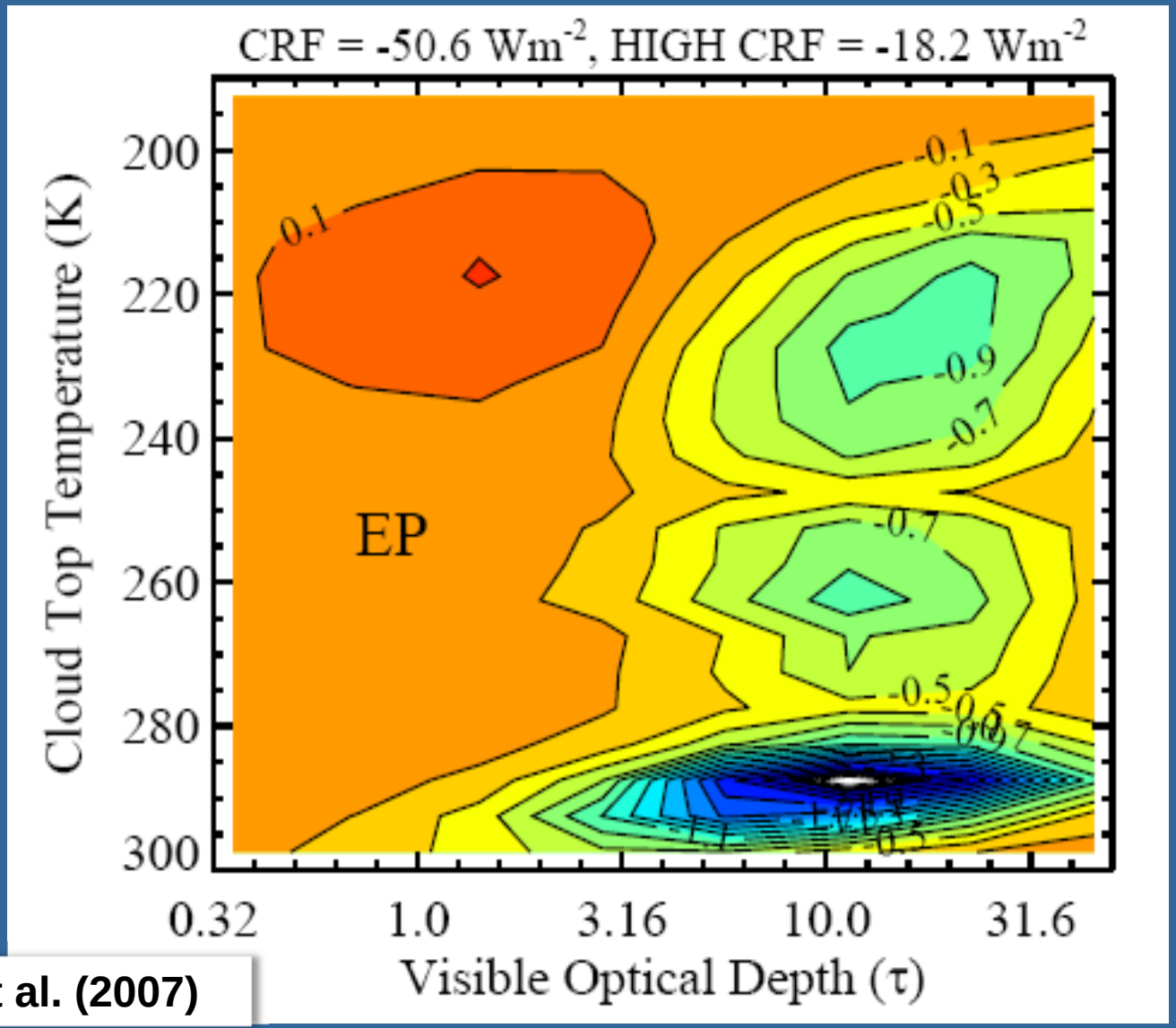
High

Mid-level

Low

Kubar et al. (2007)

Radiative effect of cloud types



High

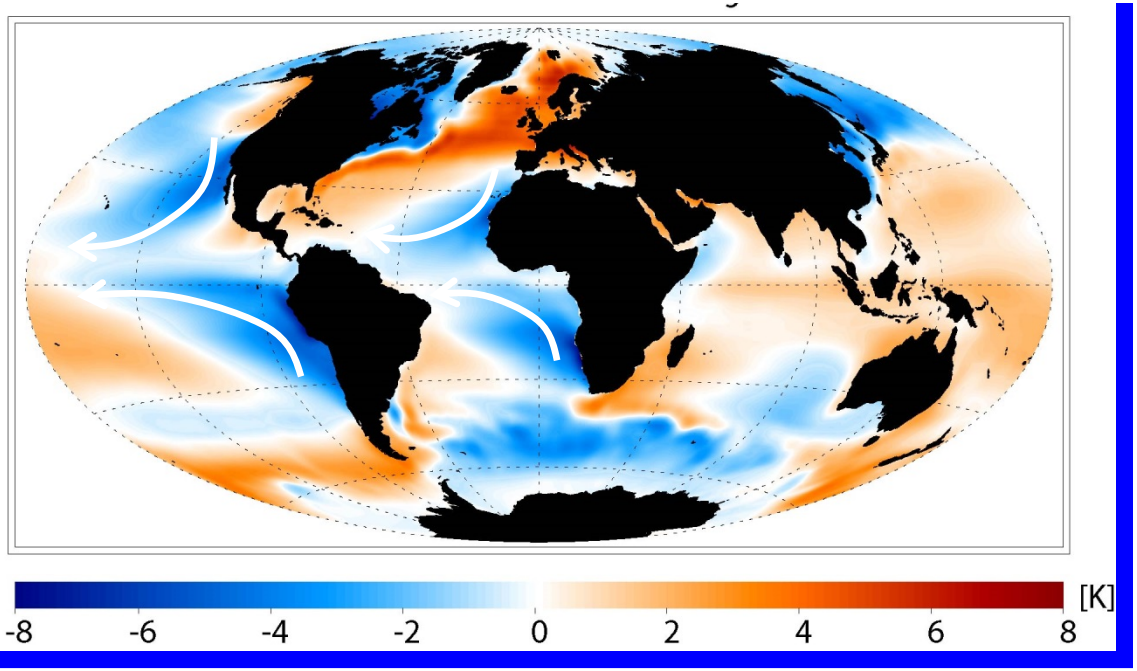
Mid-level

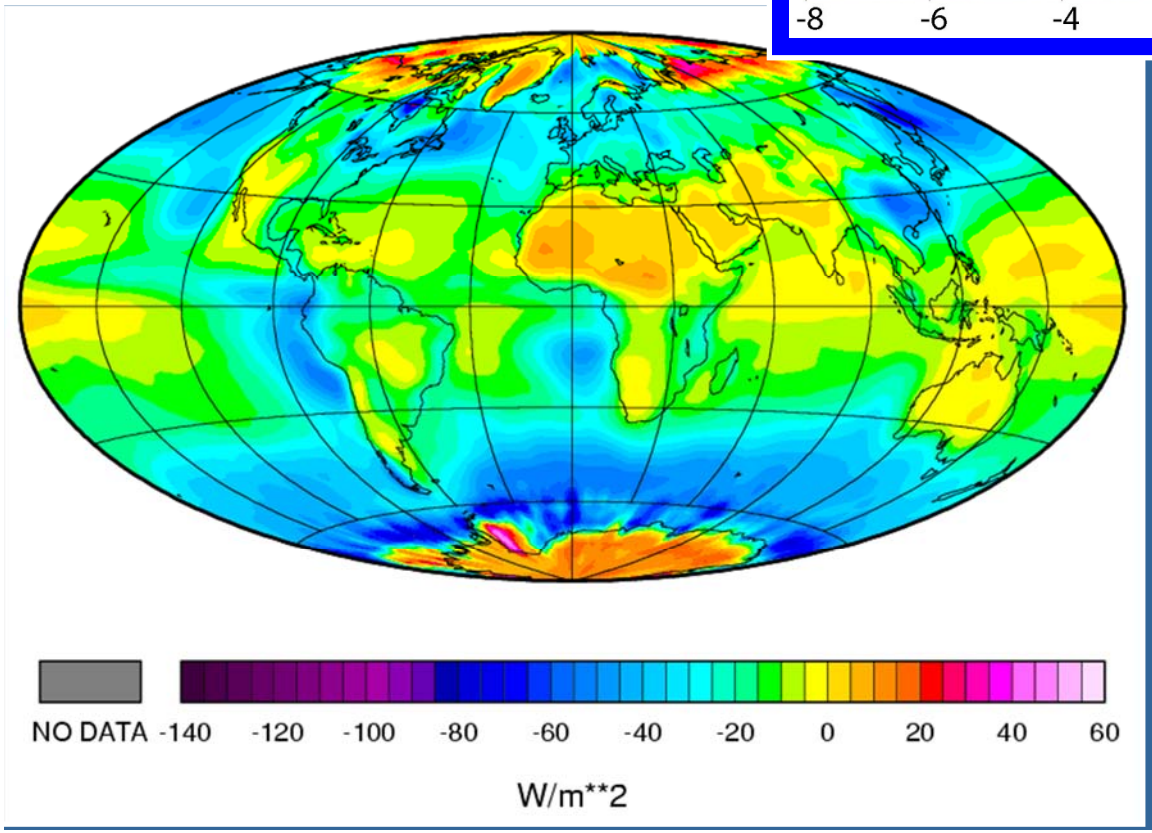
Low

Kubar et al. (2007)

Factors influencing cloud types

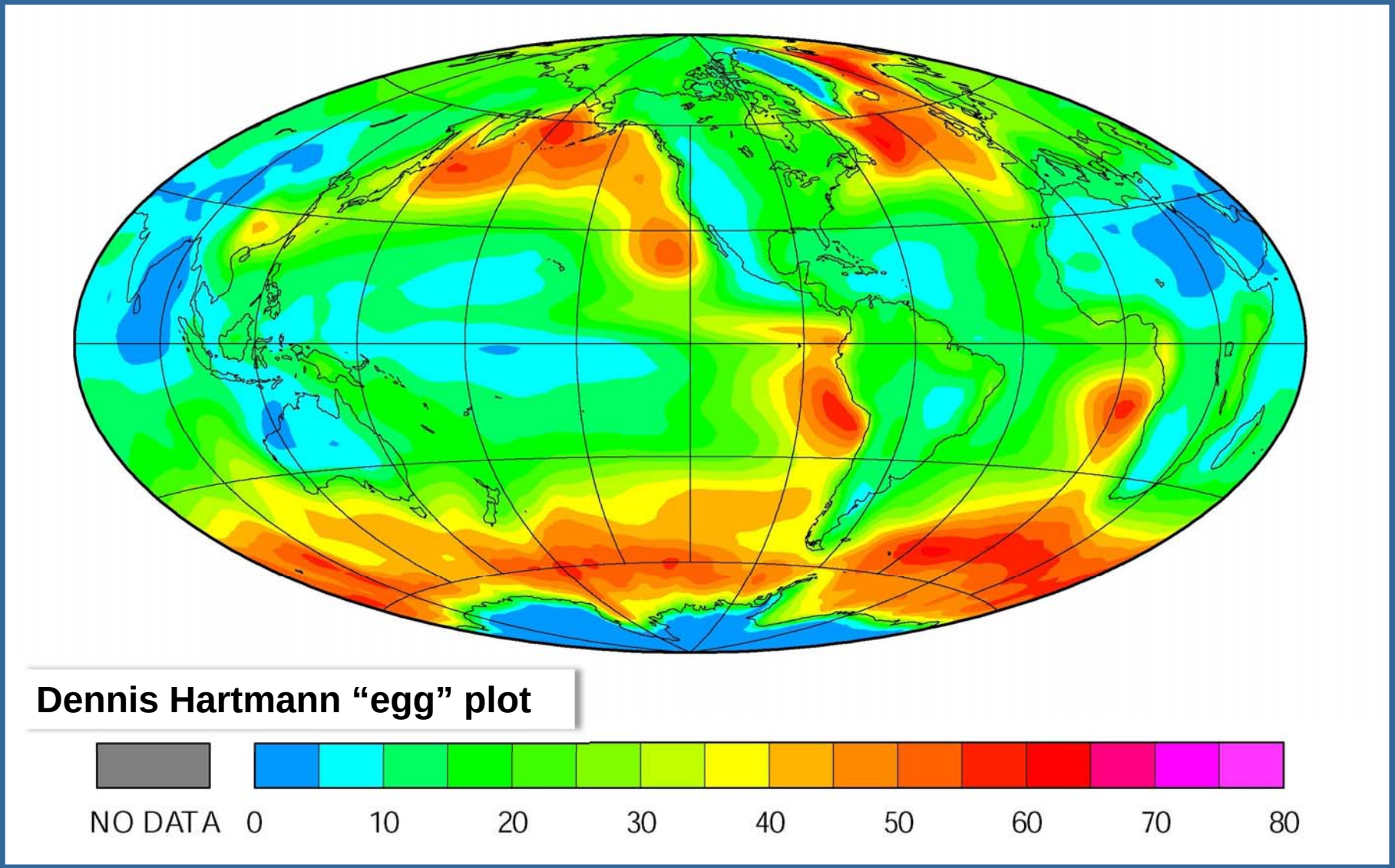
SST anomaly from zonal mean



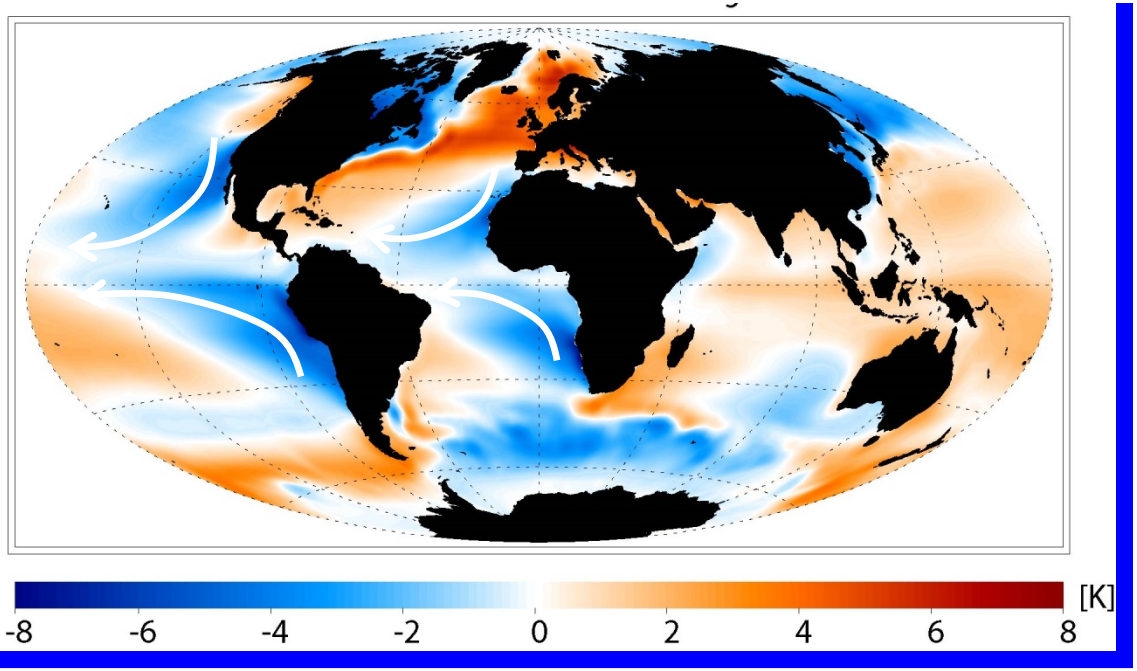


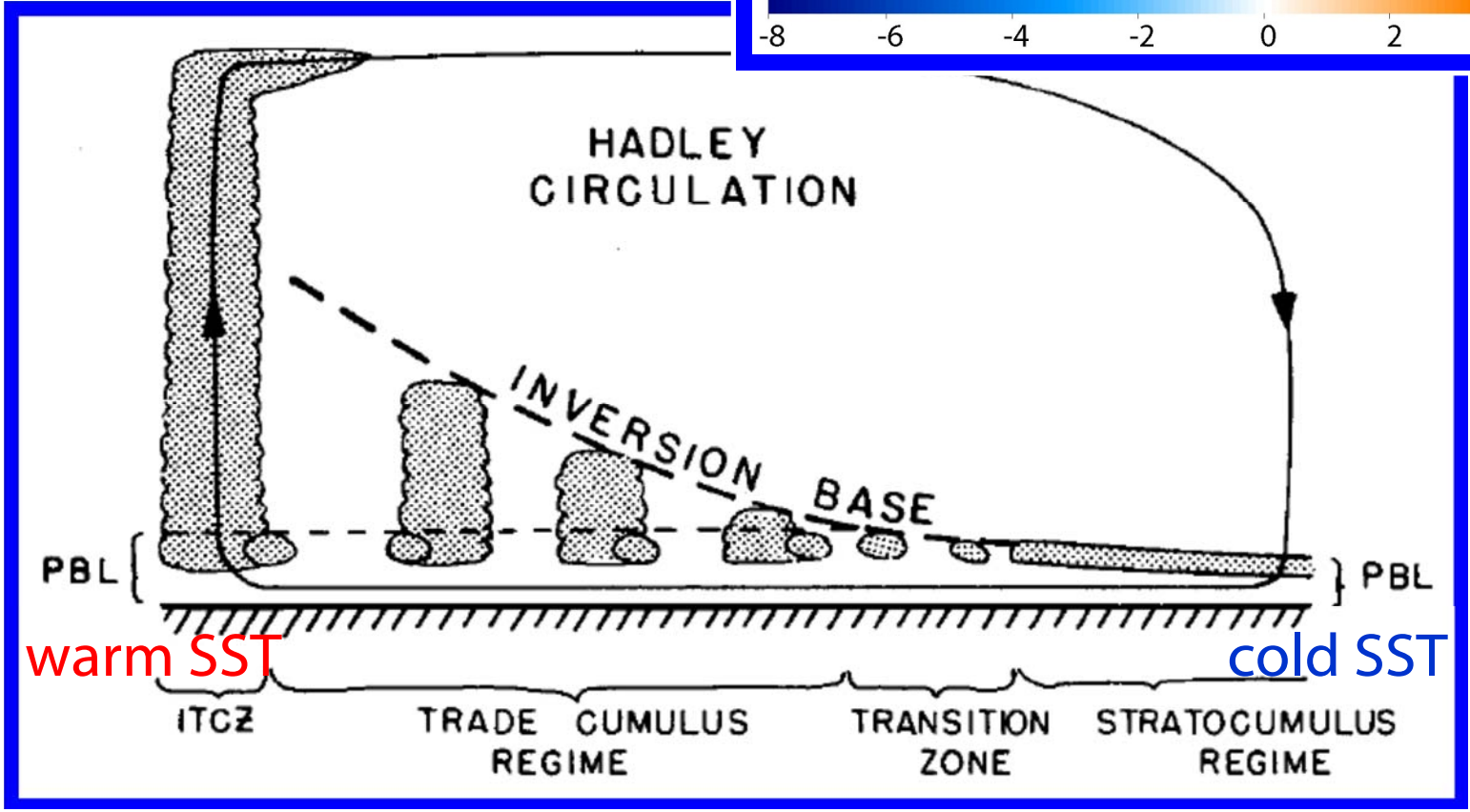
ERBE net cloud forcing

ISCCP inferred St/Sc amount



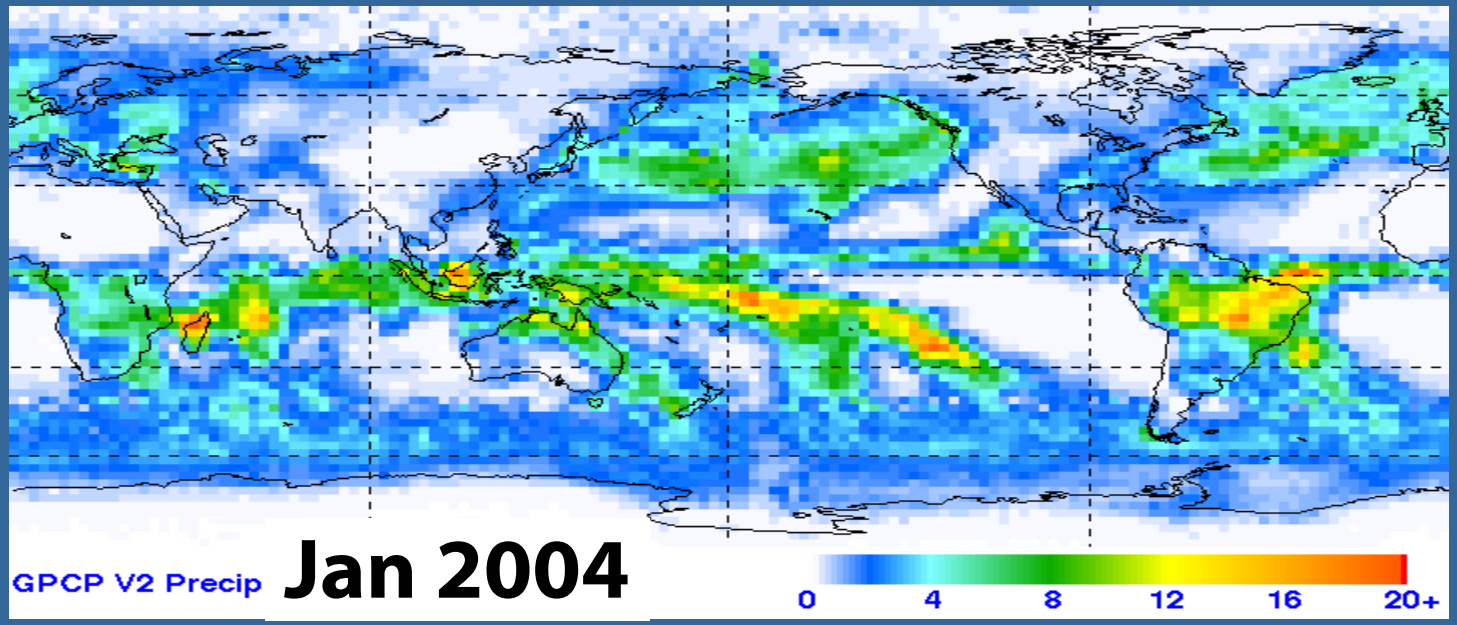
Tropical-subtropical general circulation

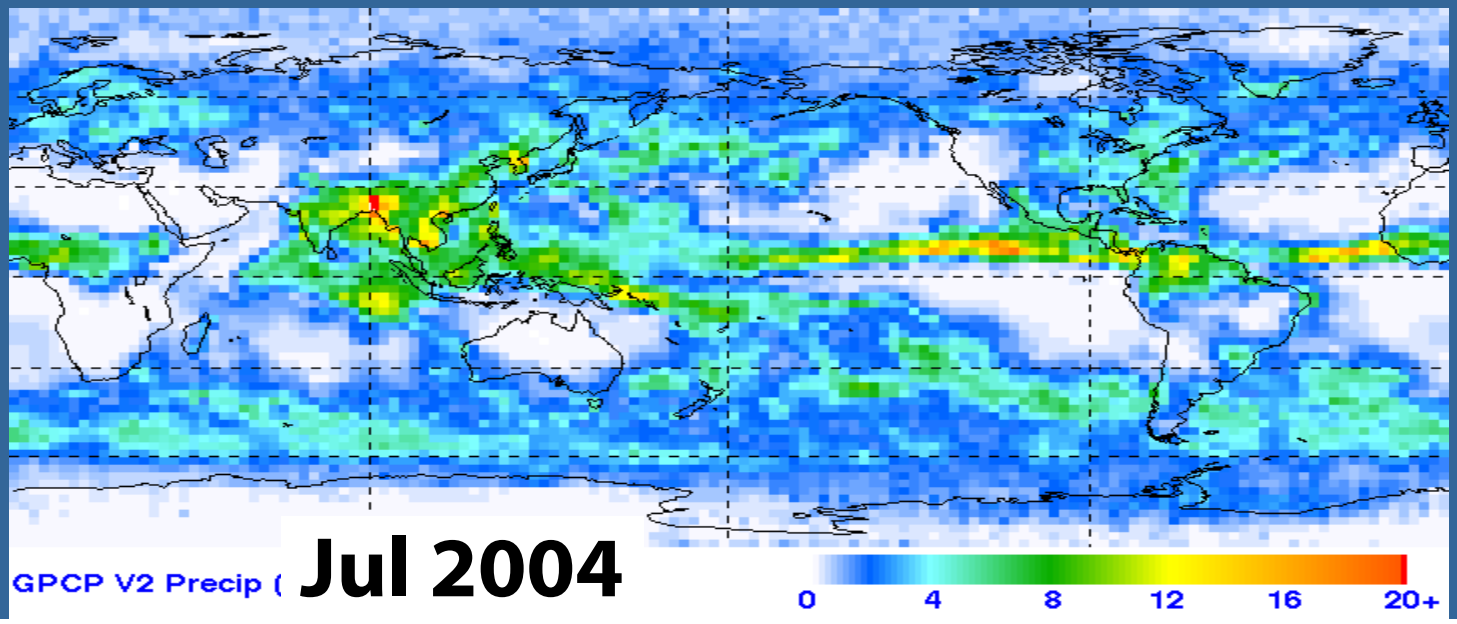




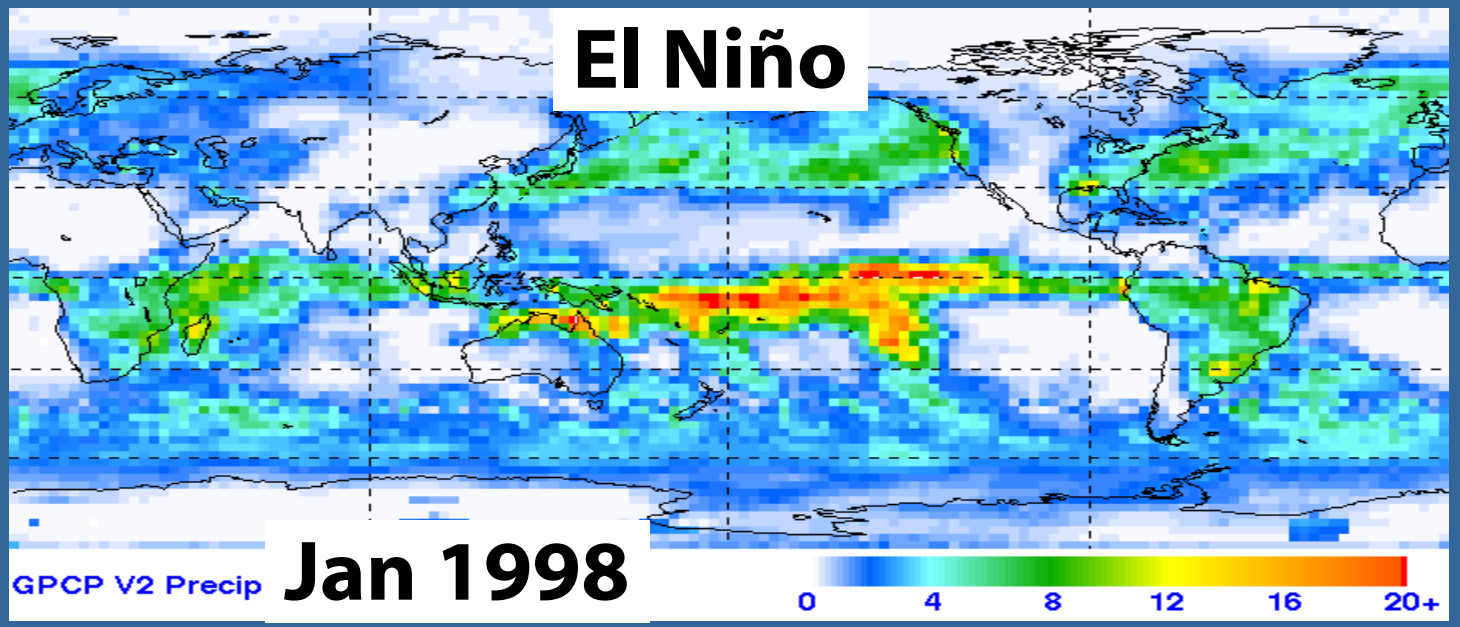
from
Randall et al.,
J. Atmos. Sci.,
37, 125-130, 1980

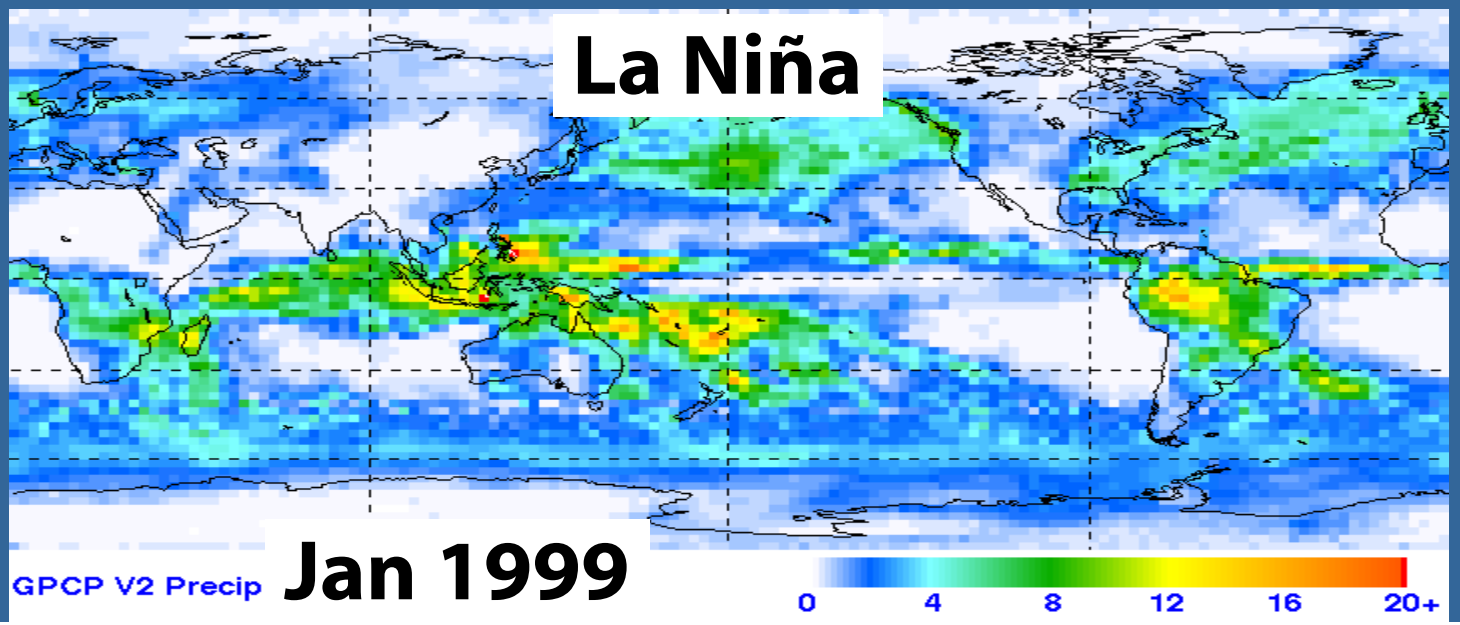
Seasonal cycle of precipitation





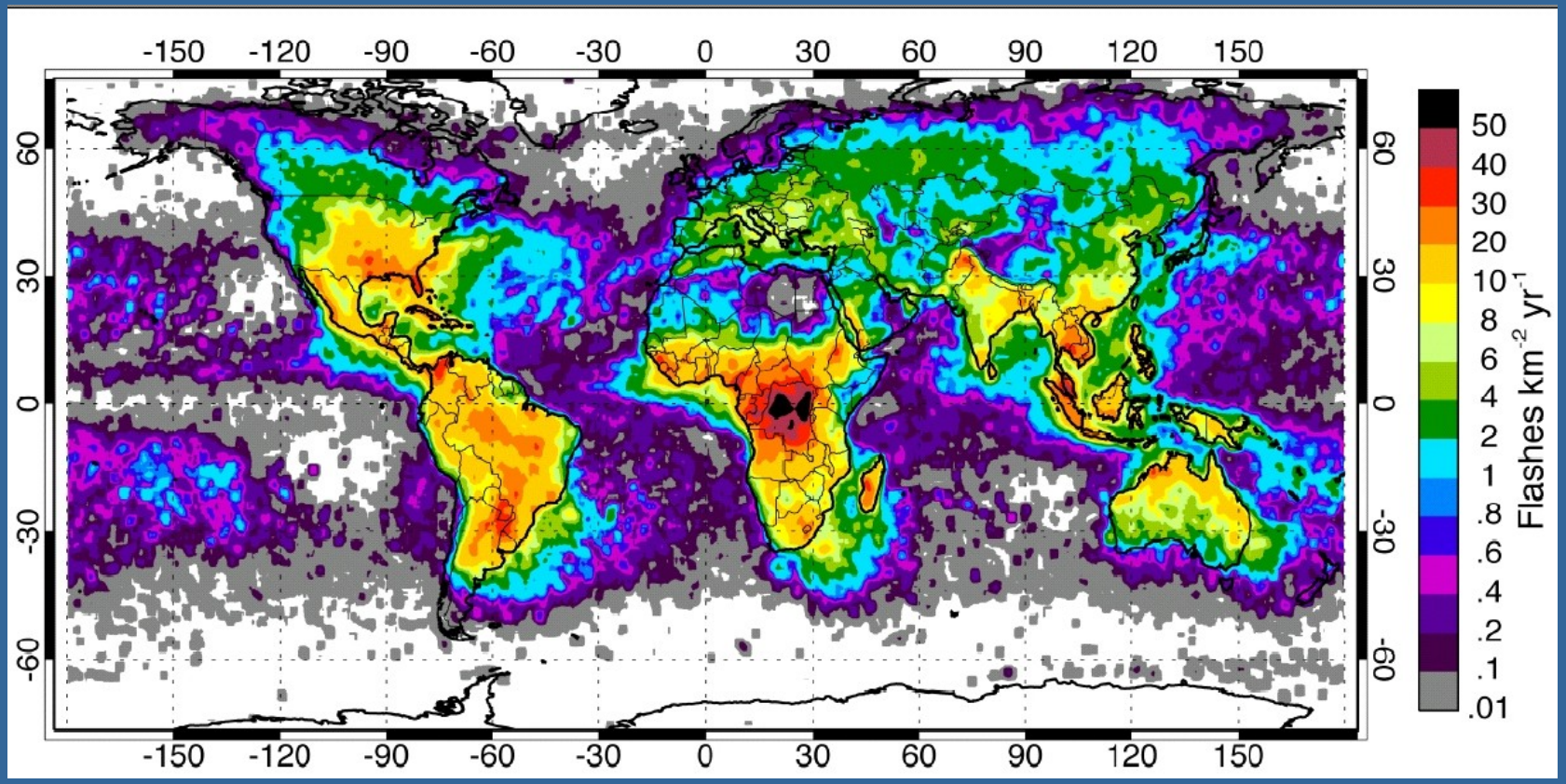
Interannual variability of precipitation



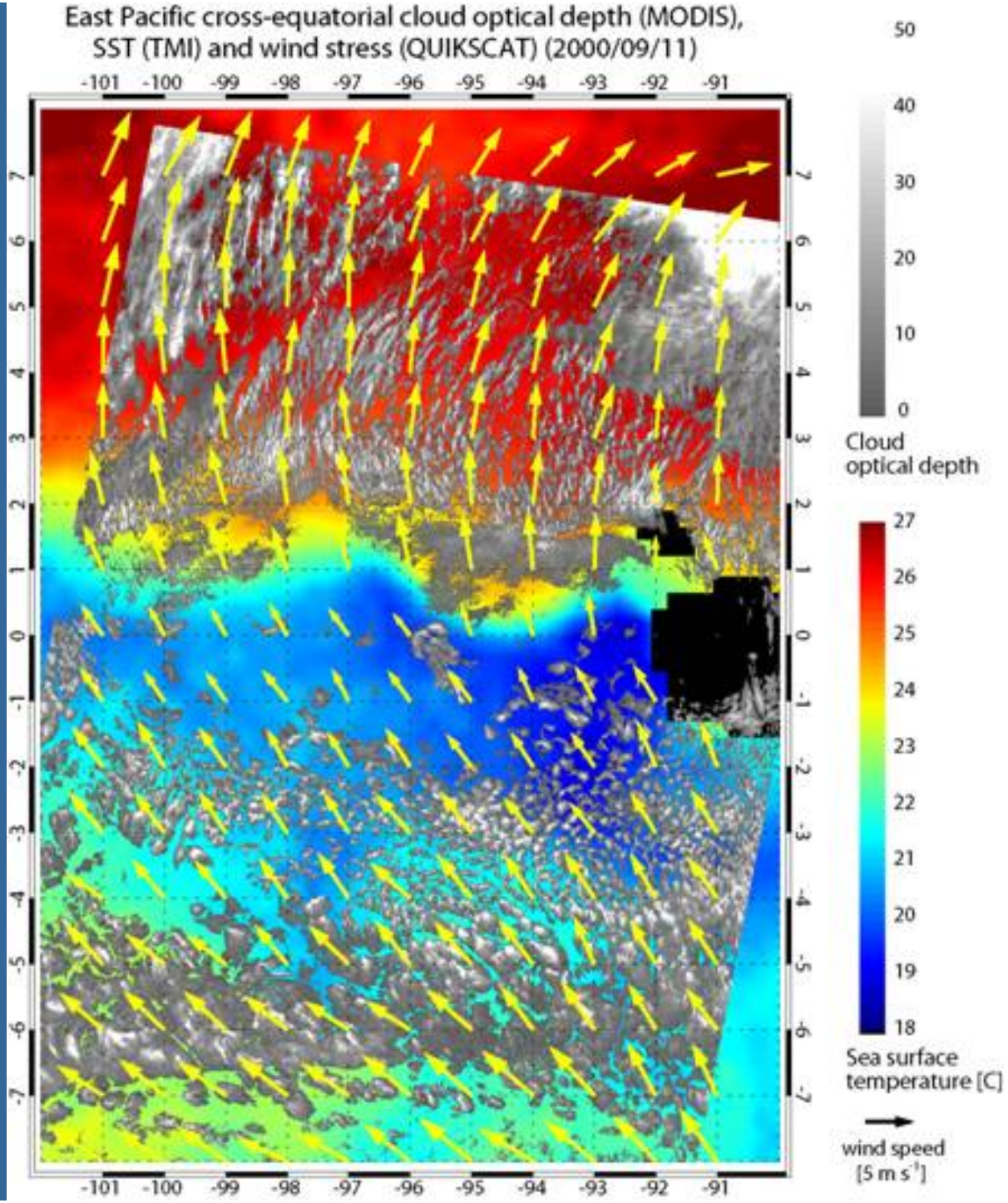


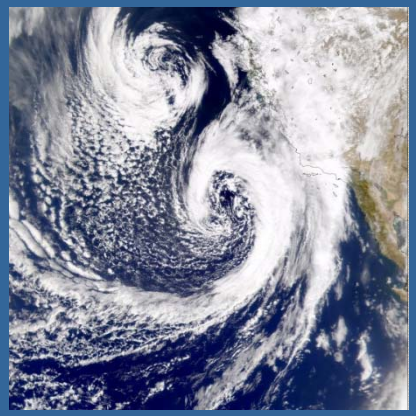
Global frequency and distribution of lightning as observed from space

Christian et al., J. Geophys. Res., 2003.

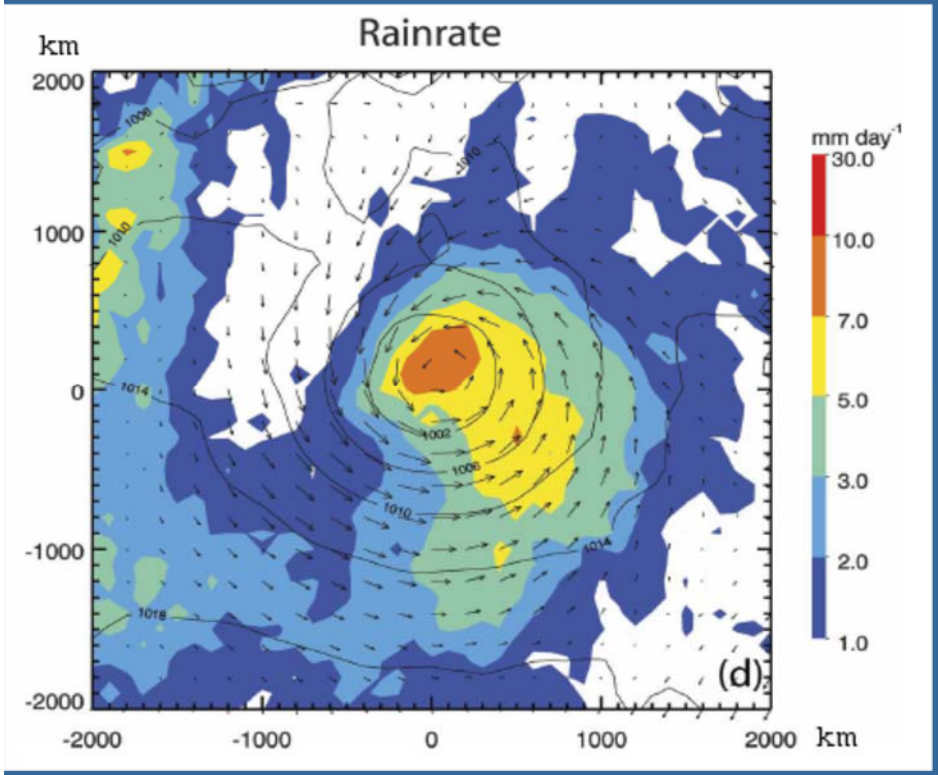


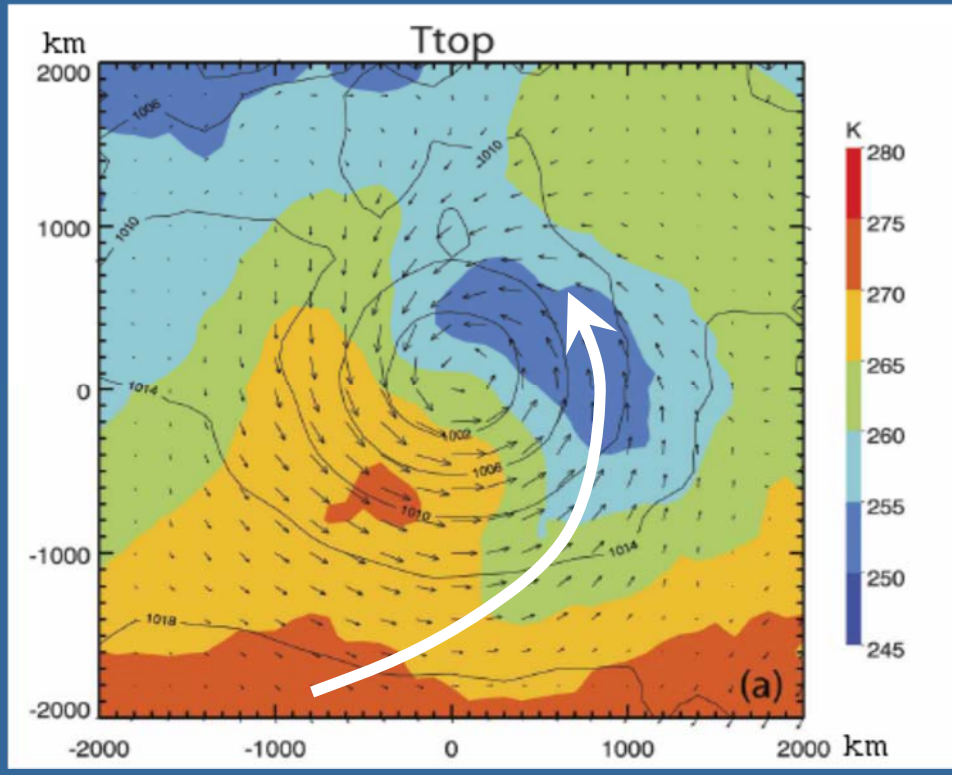
Tight couplings between SST, winds, and clouds





Clouds and precipitation associated with midlatitude cyclones

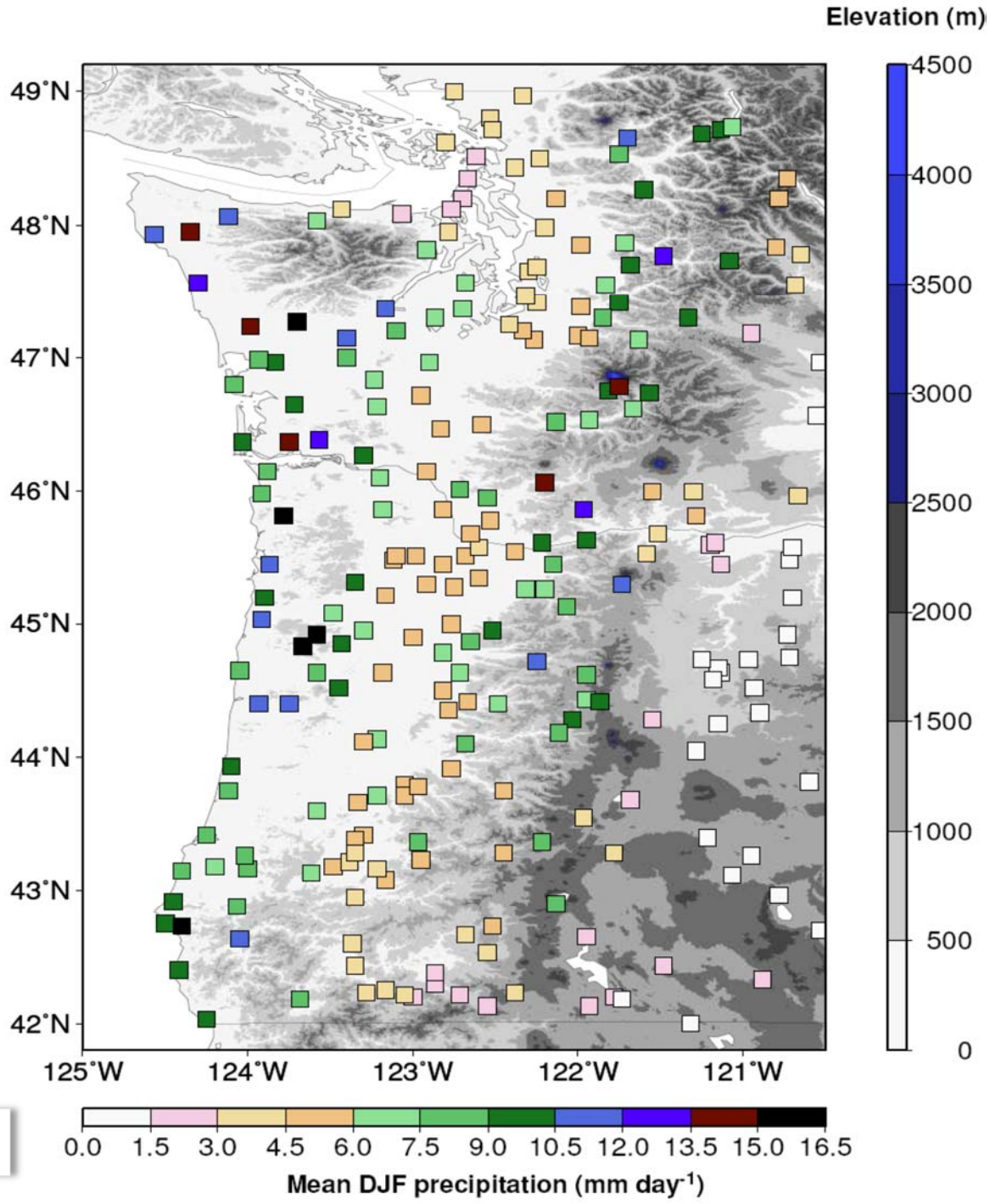




Field and Wood (2007)

warm conveyor

Orographic precipitation enhancement

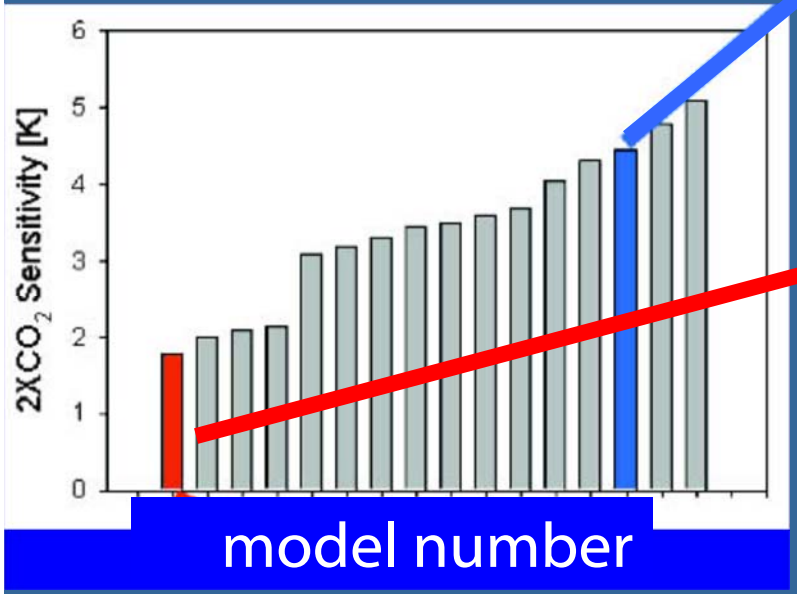


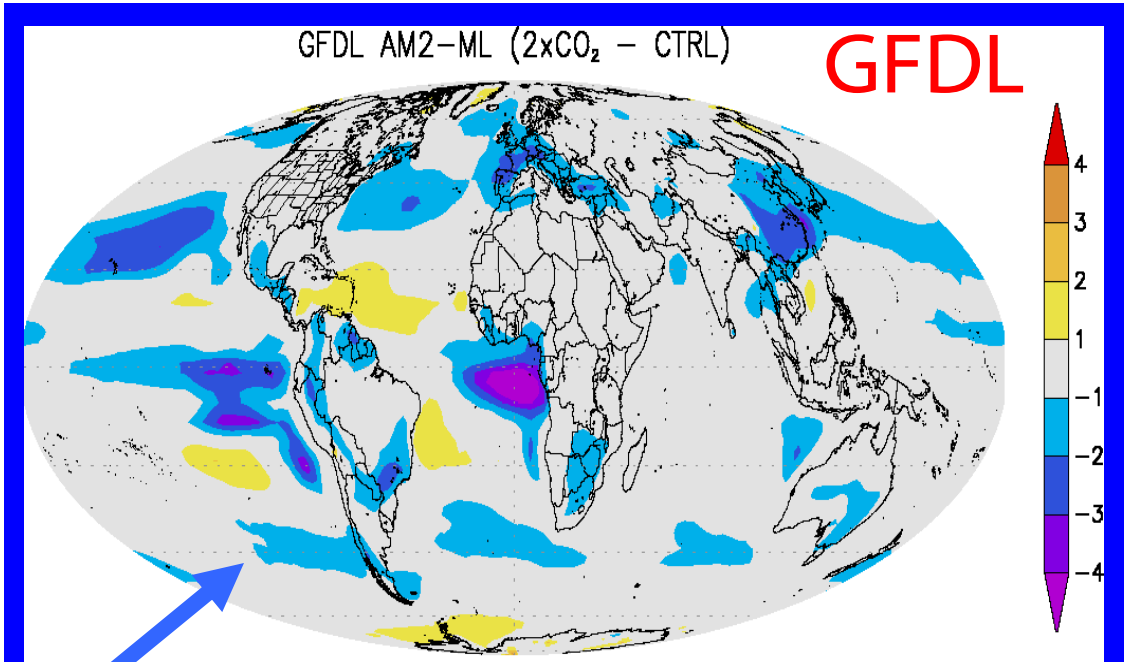
Matt Garvert (PhD thesis, UW)

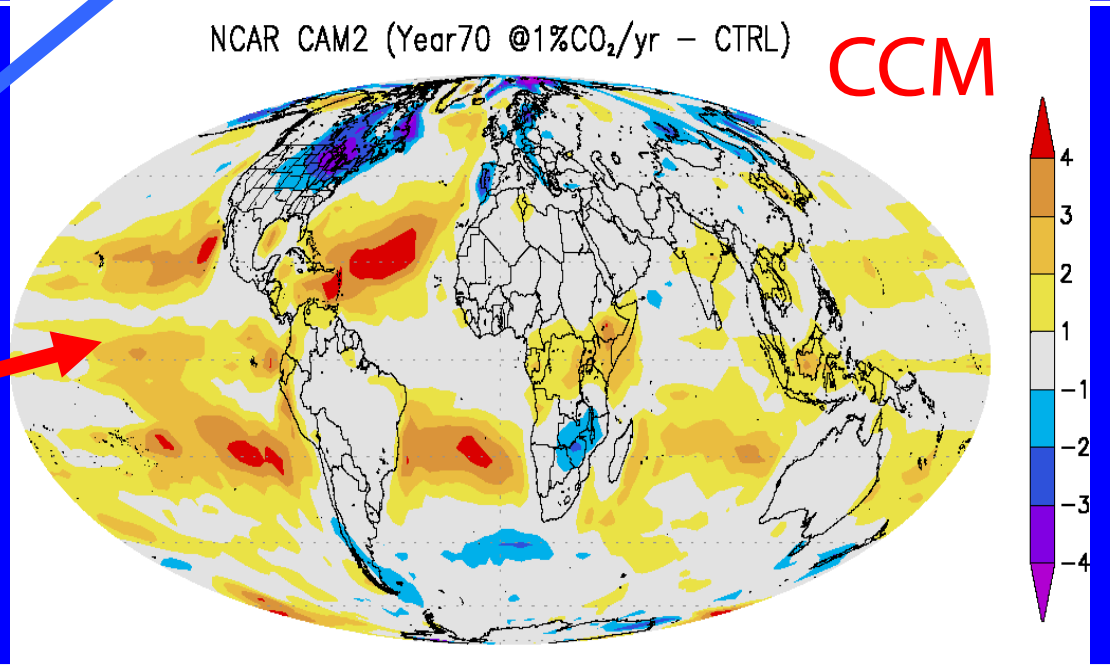
Clouds and climate change

Clouds in climate models

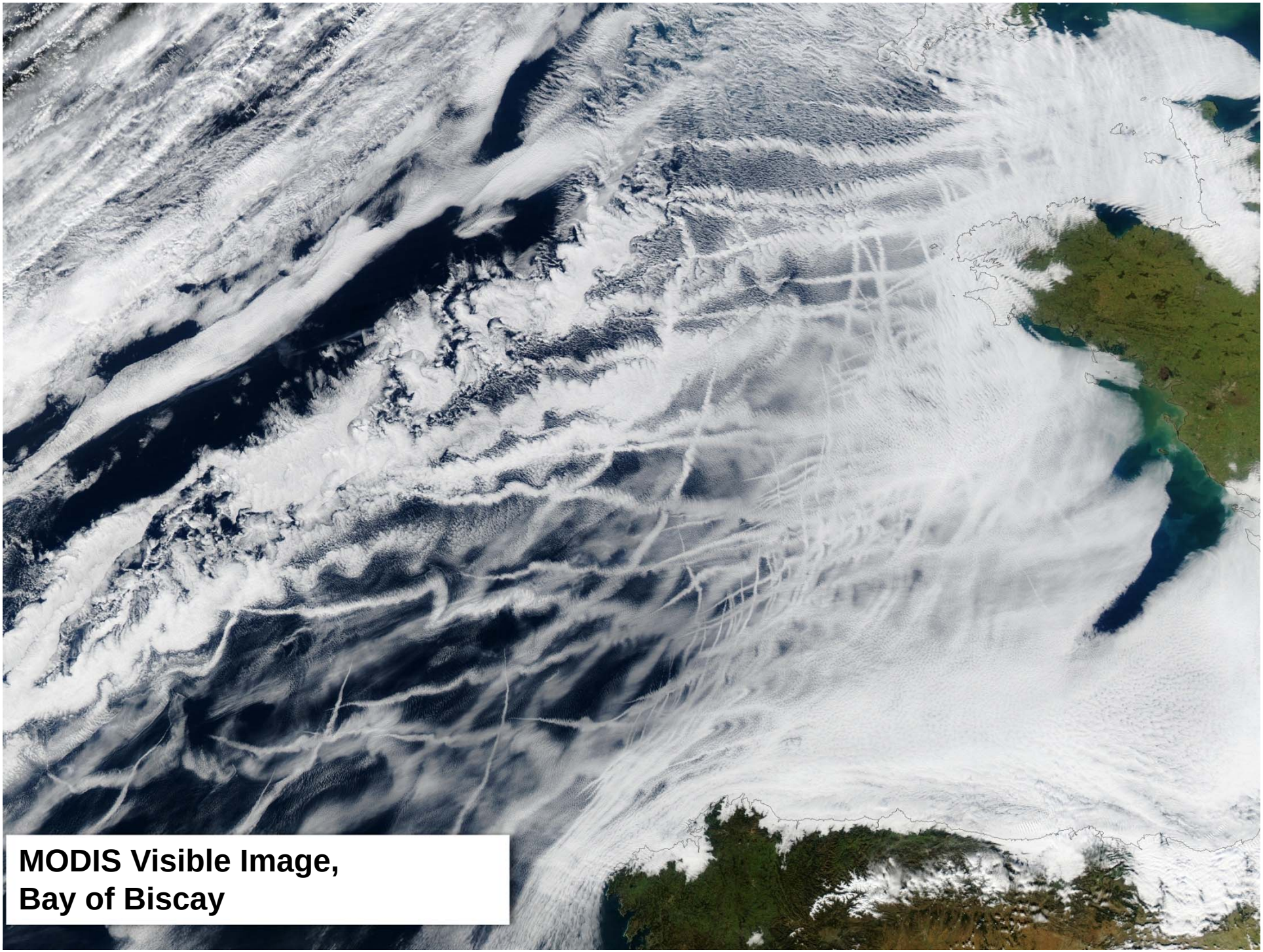
- change in low cloud amount for $2\times CO_2$



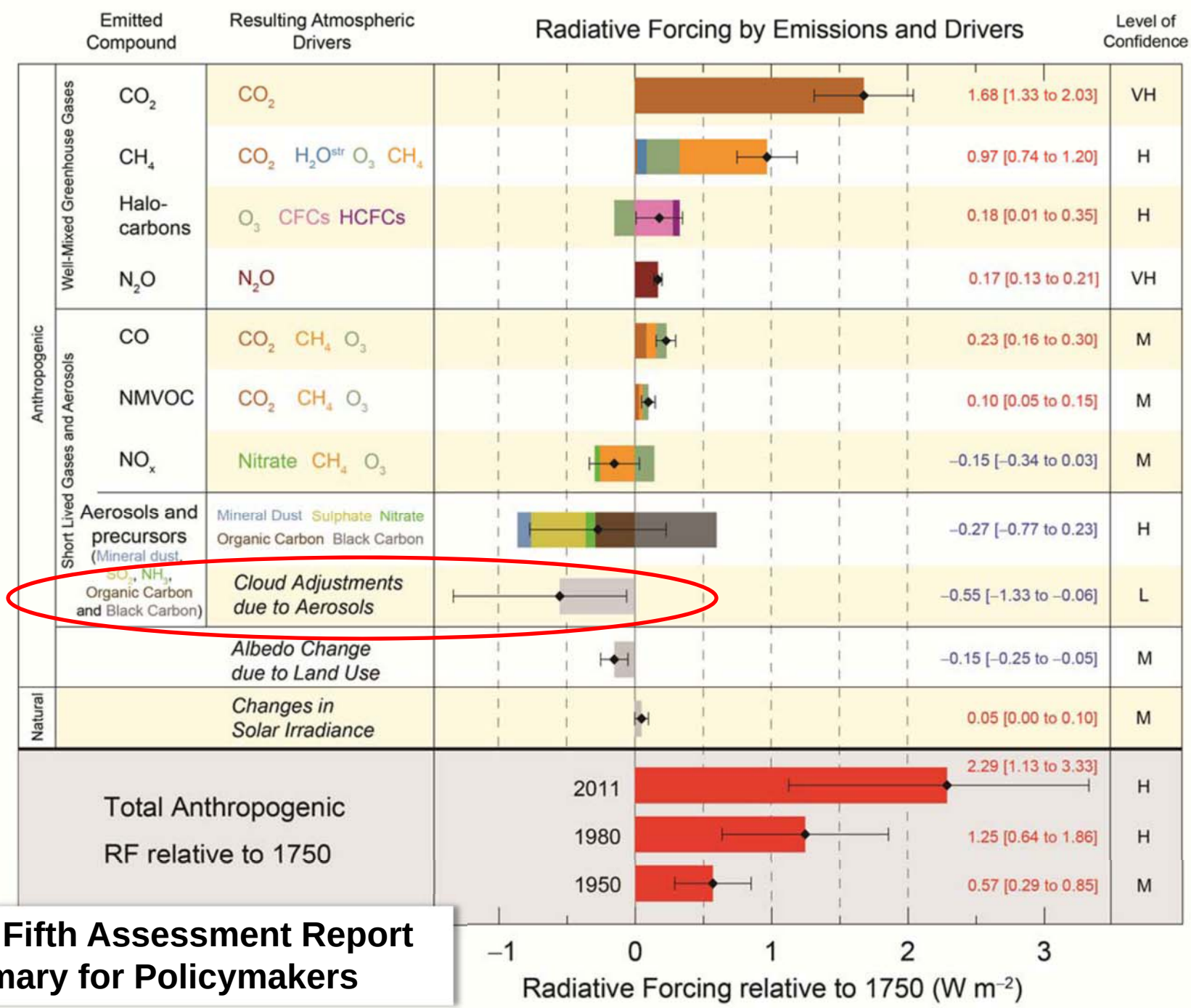




from Stephens (2005)

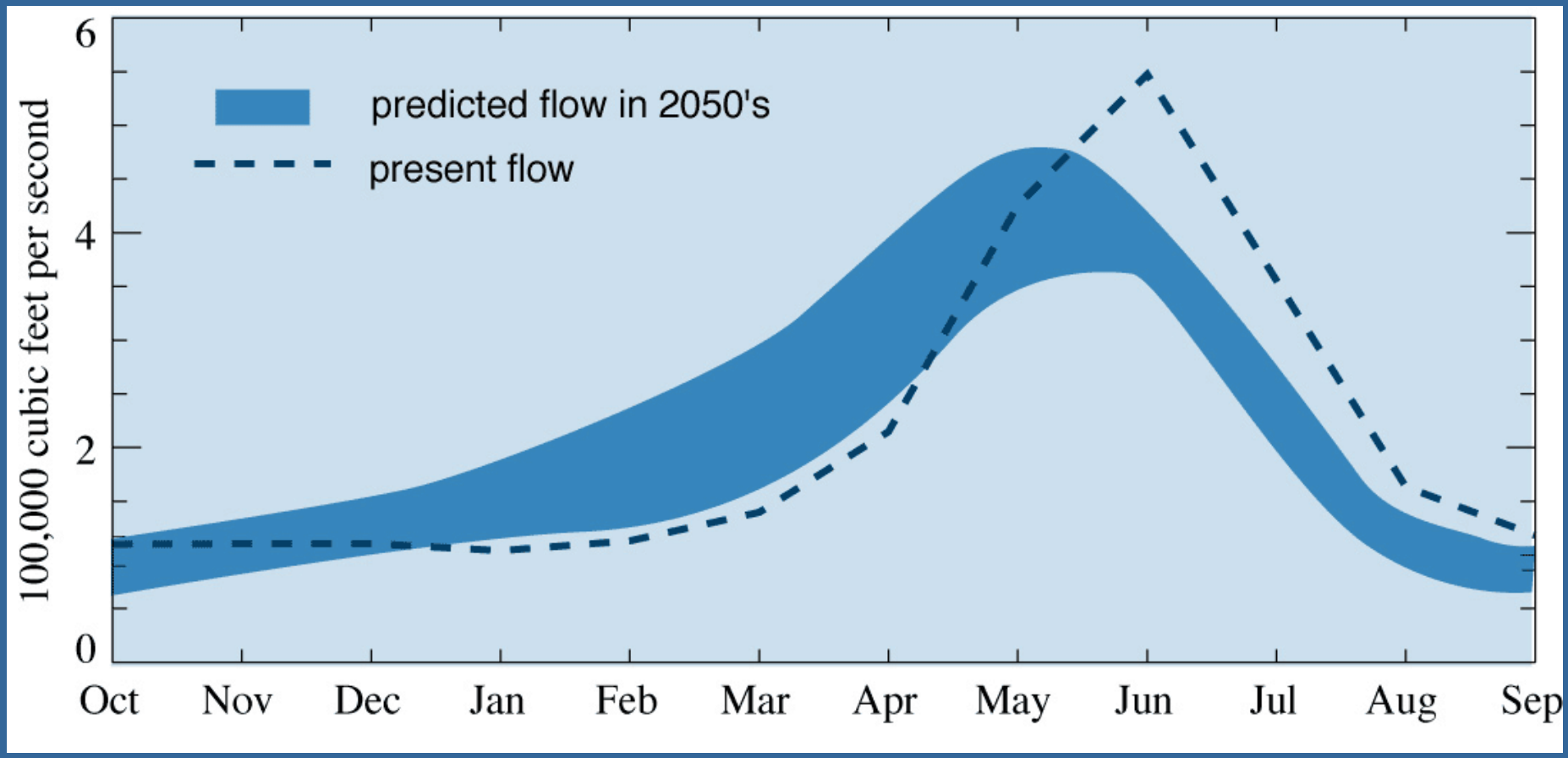


MODIS Visible Image,
Bay of Biscay



IPCC Fifth Assessment Report Summary for Policymakers

Pacific Northwest Projected River Flow



Cloud effects on atmospheric chemistry

- Acidity of rain
- Gas-particle conversion
- The aerosol "general circulation"

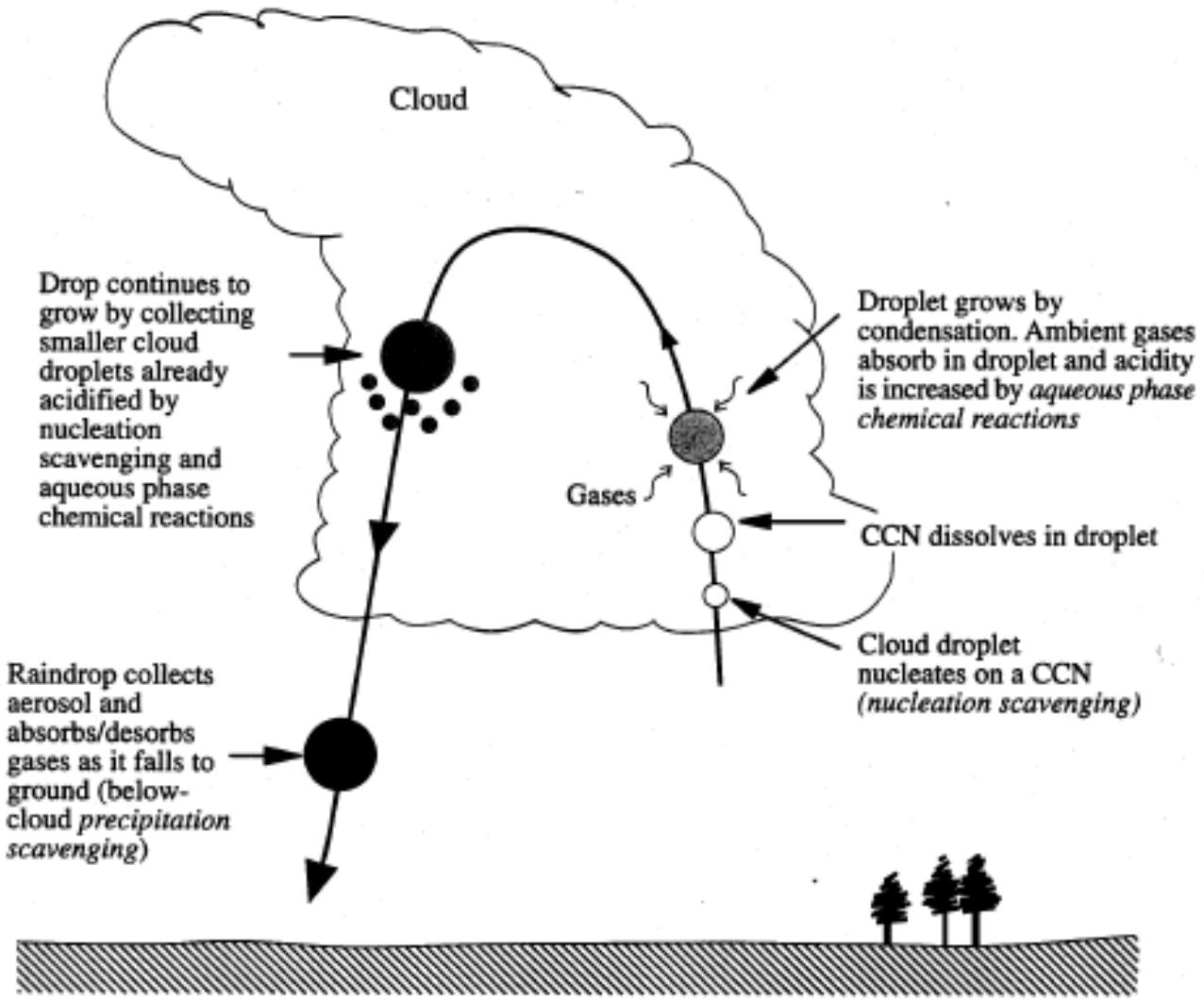


Figure 7.1. Schematic diagram of the processes affecting the chemical compositions of cloud droplets and rain. Not drawn to scale.

Hobbs 2000

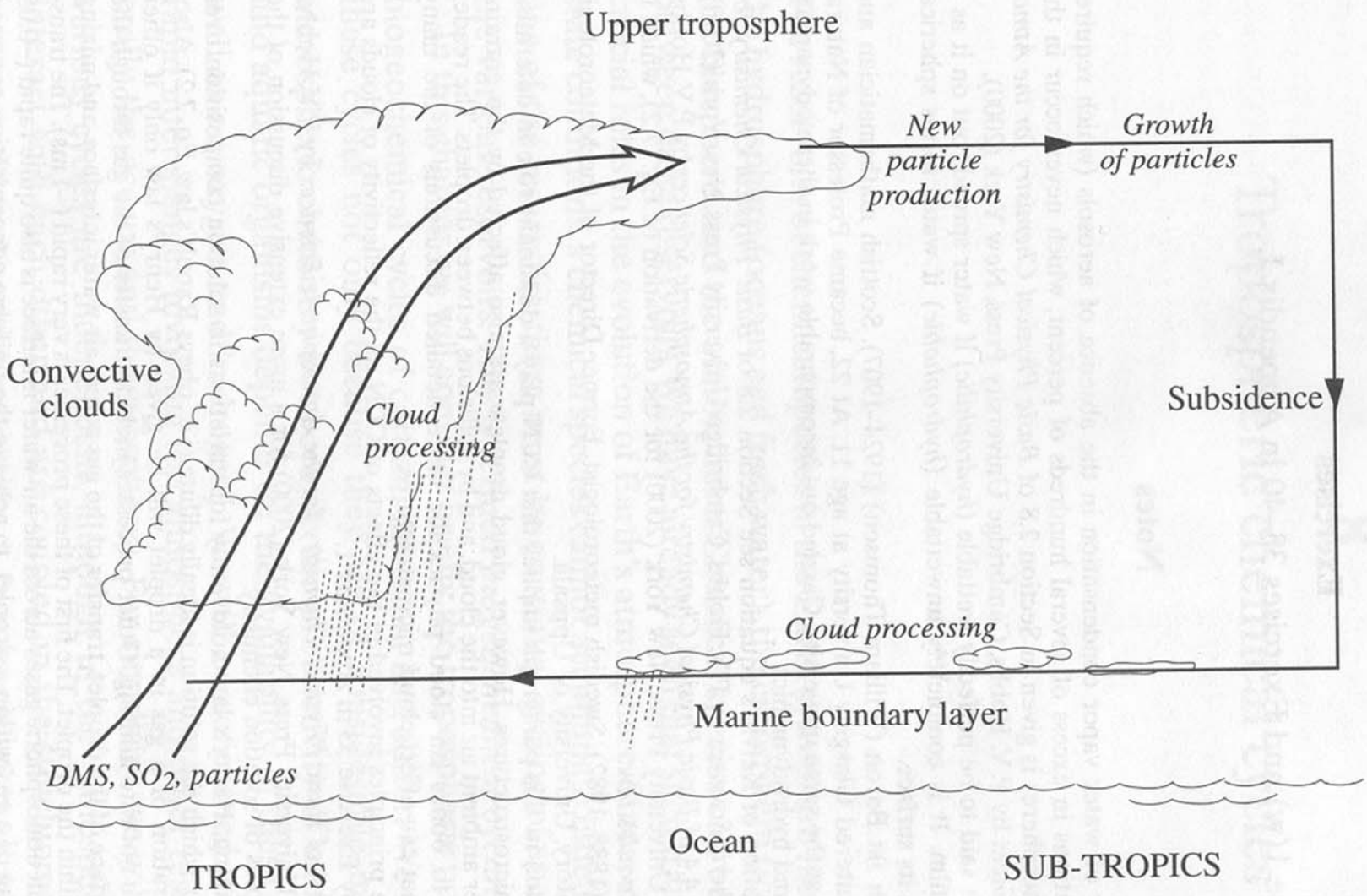


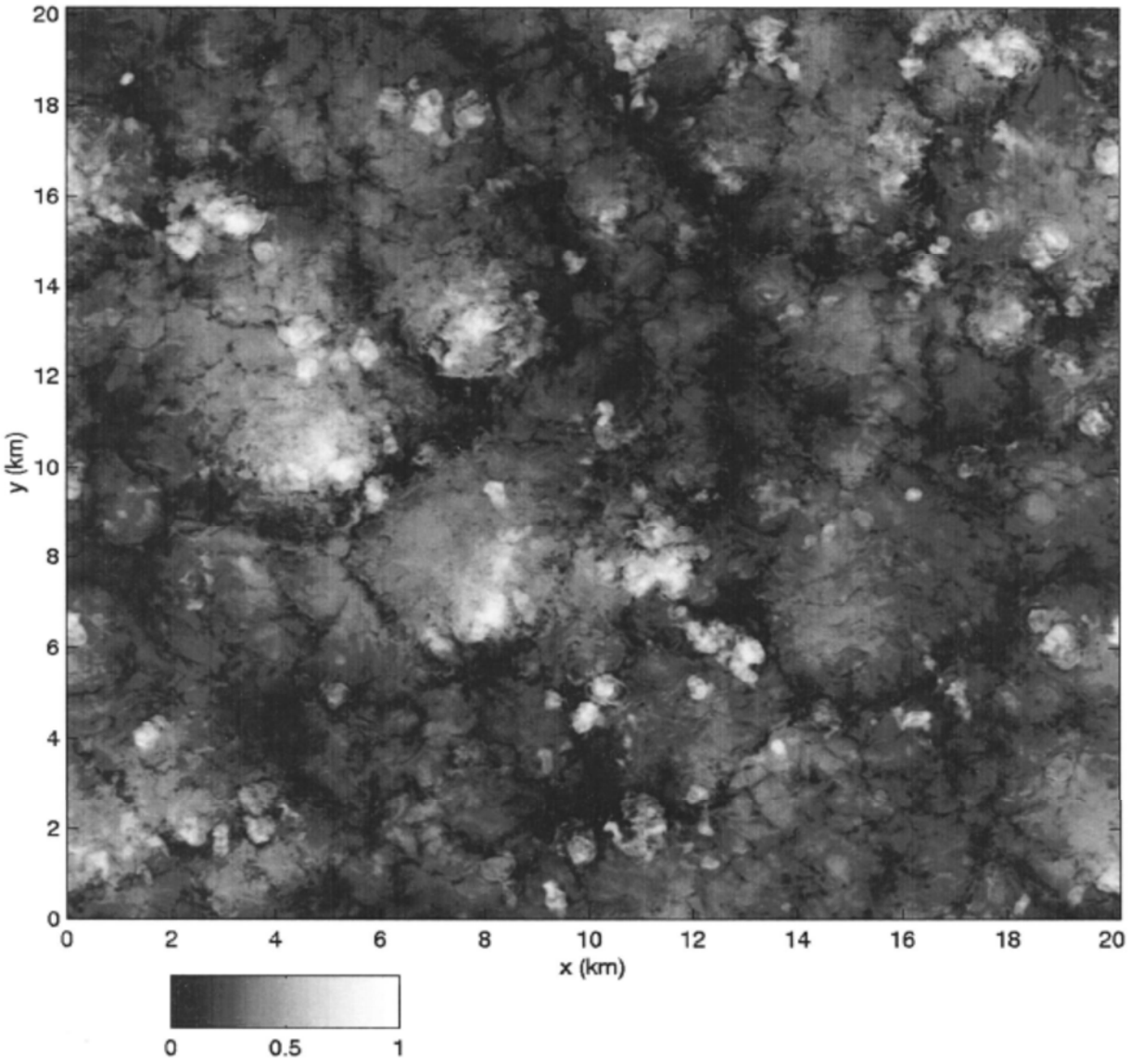
Figure 7.12. The Hadley cell scenario for transporting aerosols between the tropics and sub-tropics. [Adapted from F. Raes et al., in *Dimethylsulphide: Oceans, Atmosphere and Climate*, Ed. G. Restelli and G. Angeletti, Kluwer Academic Publishers (1993), with permission from Kluwer Academic Publishers.]

Hobbs 2000

Modeling clouds and precipitation

- Forecasting of precipitation
- Climate impacts

From the sublime….

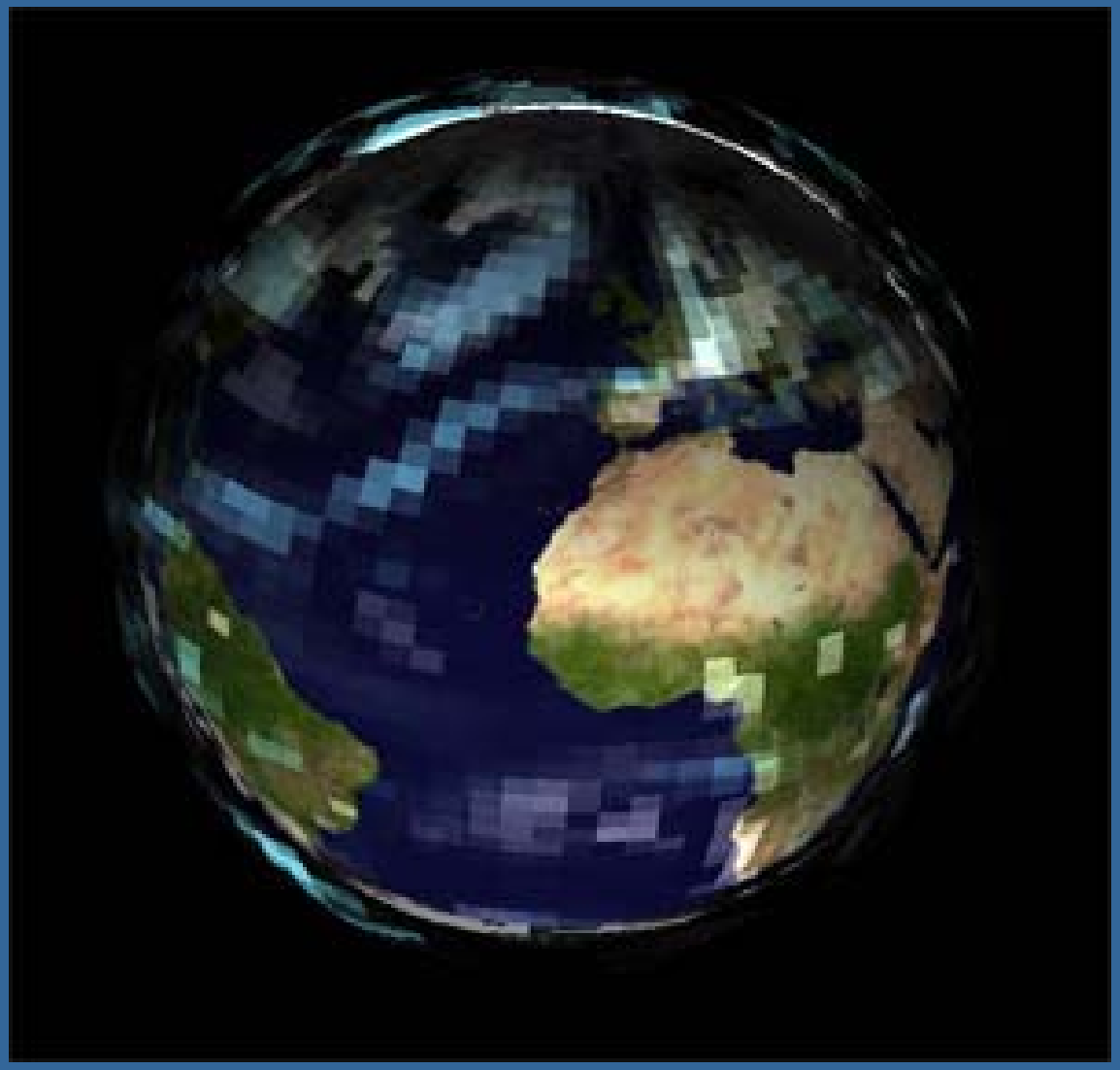


10x10x5 m resolution

20x20x3 km domain

Stevens et al. (2002)

….to the ridiculous, but necessary



3x3º resolution
global domain

climateprediction.net

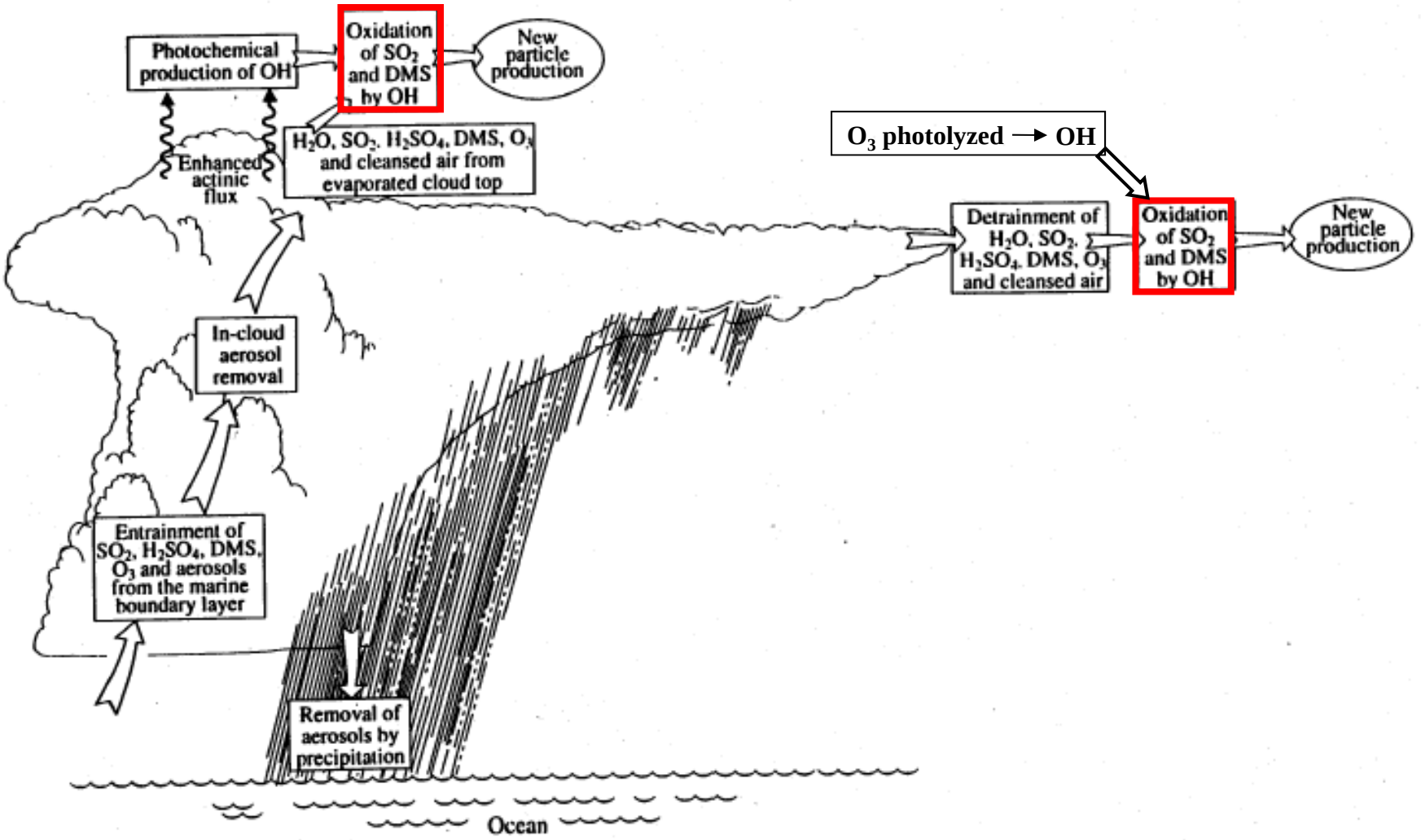


Figure 7.11. Schematic diagram illustrating a conceptual model for new particle production near marine convective clouds. [From K. Perry and P. V. Hobbs, *J. Geophys. Res.*, **99**, 22813 (1994). Copyright © by the American Geophysical Union.]

Hobbs 2000

Radiative Forcing Components