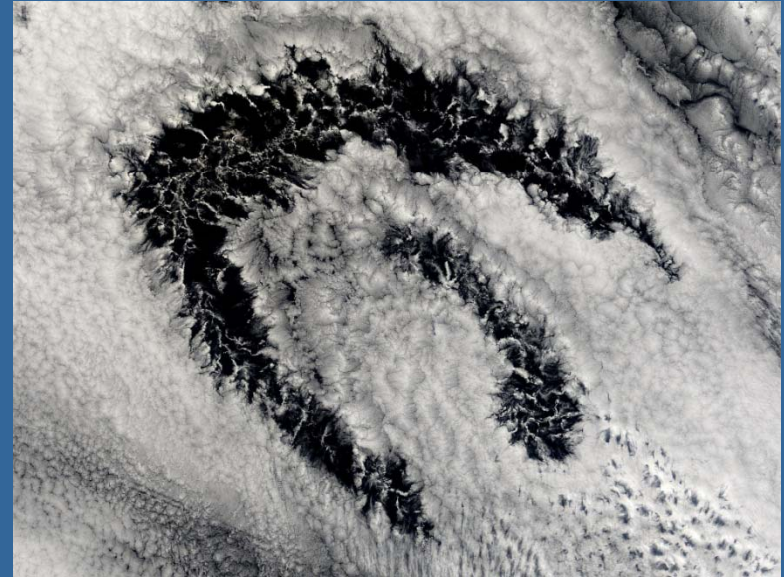
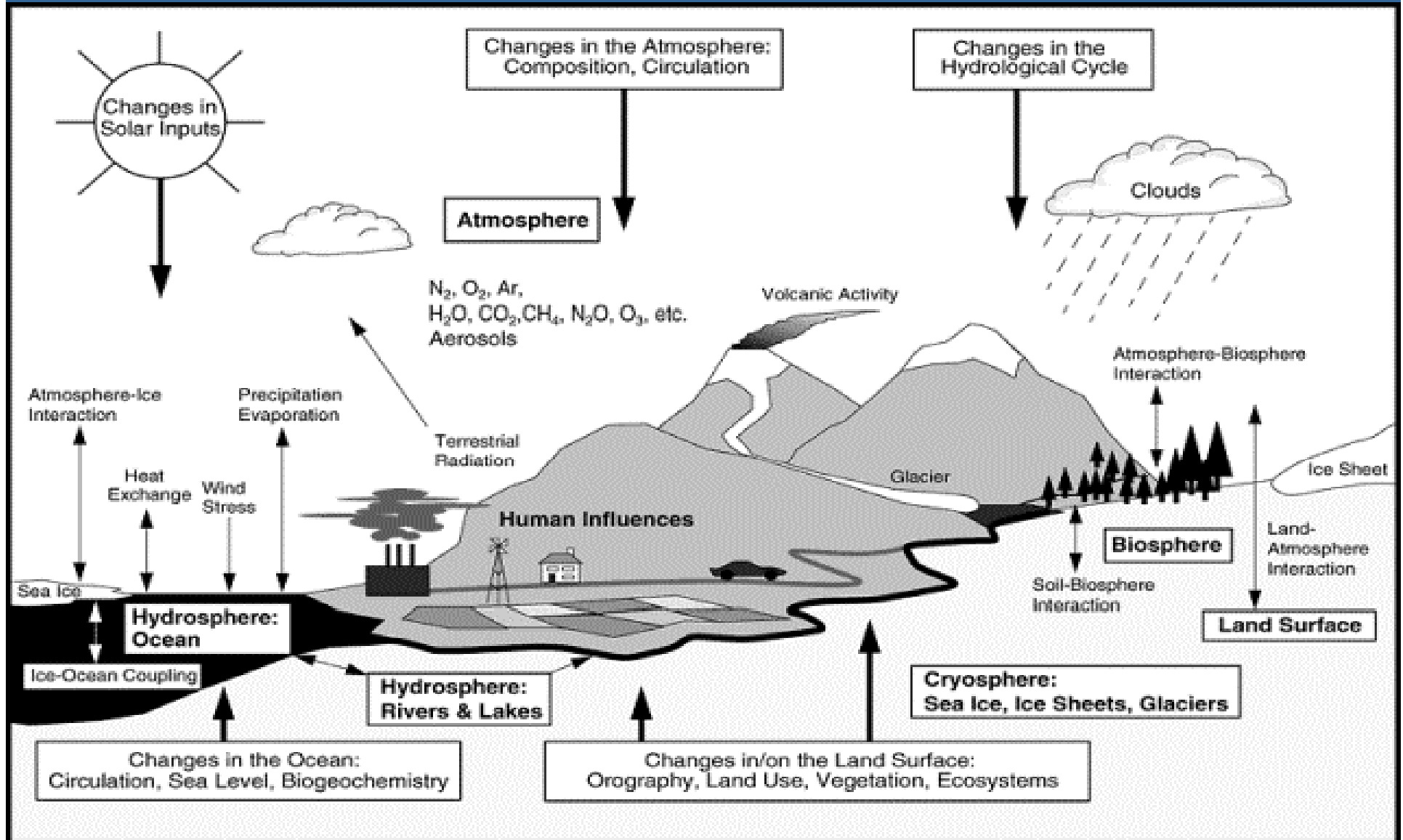


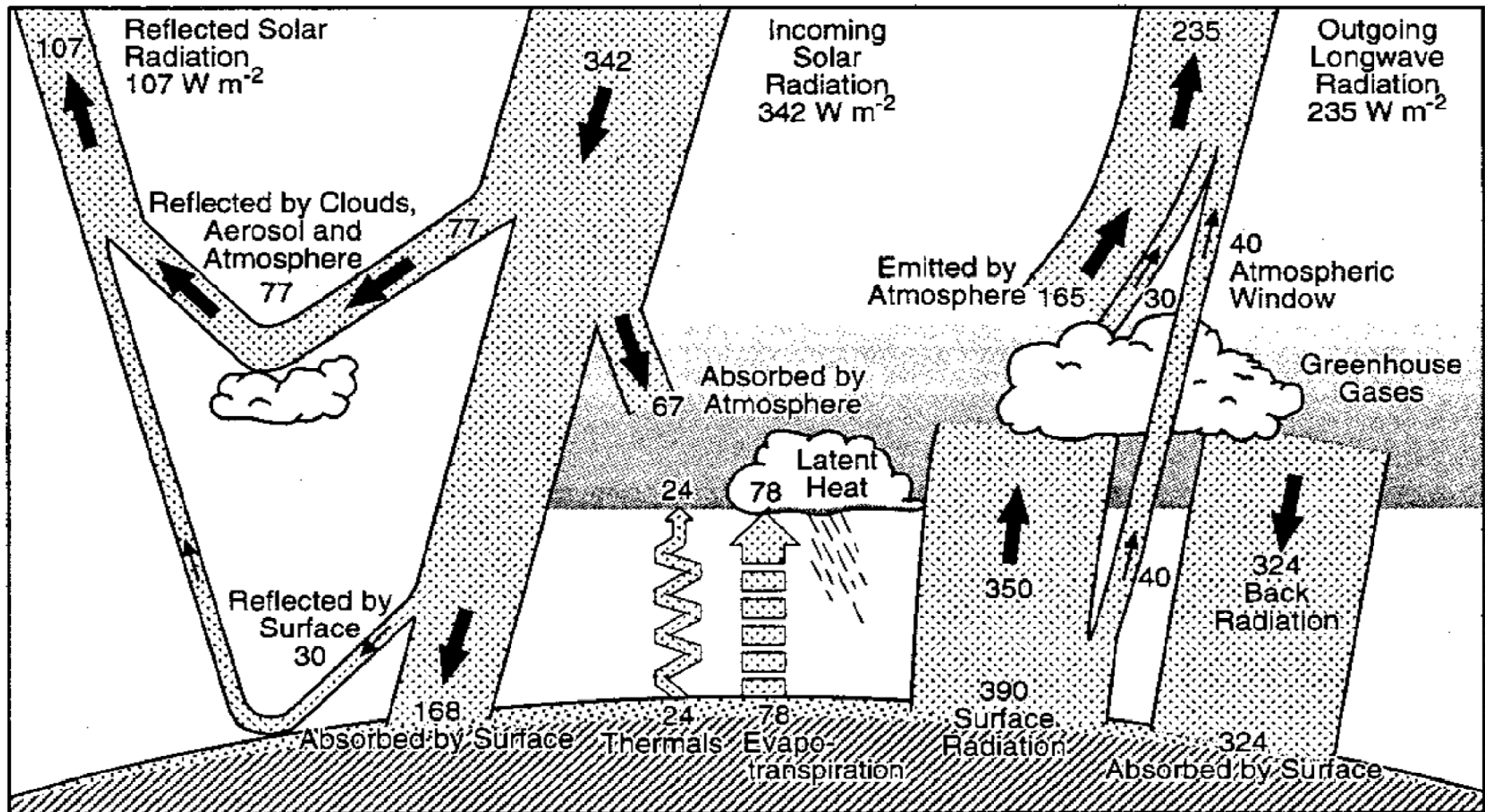
The importance of clouds

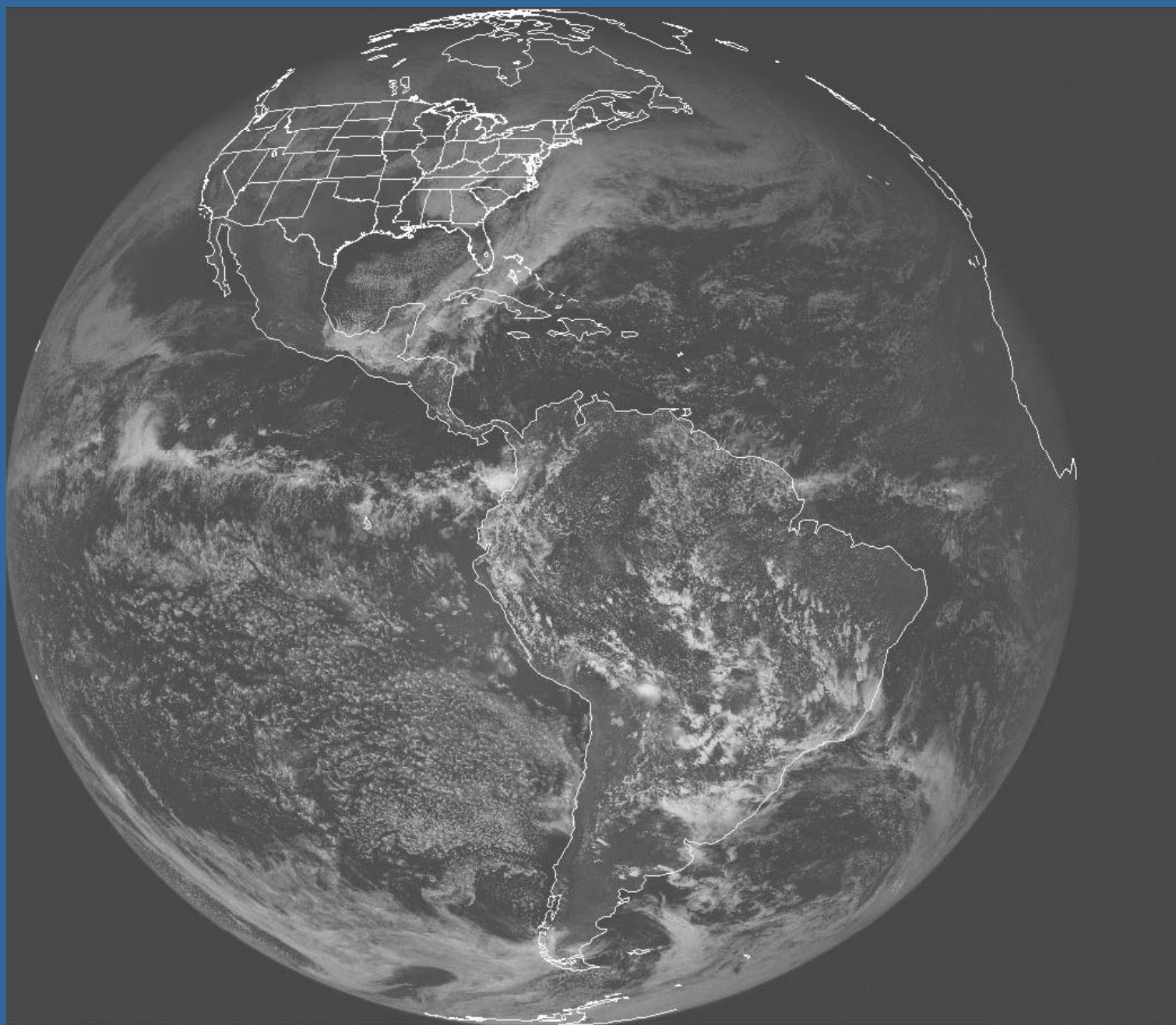


The Global Climate System



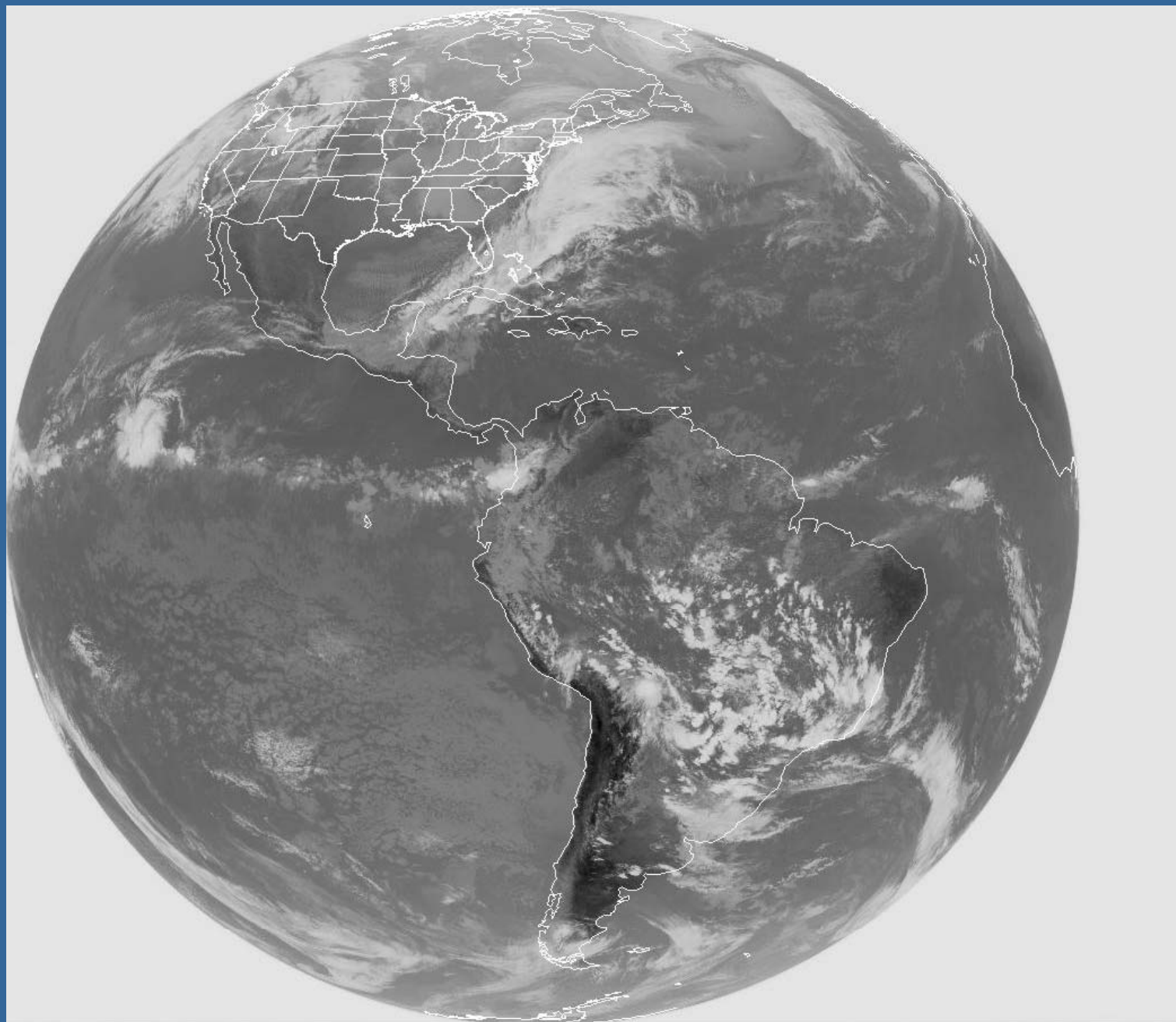
Radiation in the climate system





03 Jan 2003 17:45:14Z 0.65 um GOES-8

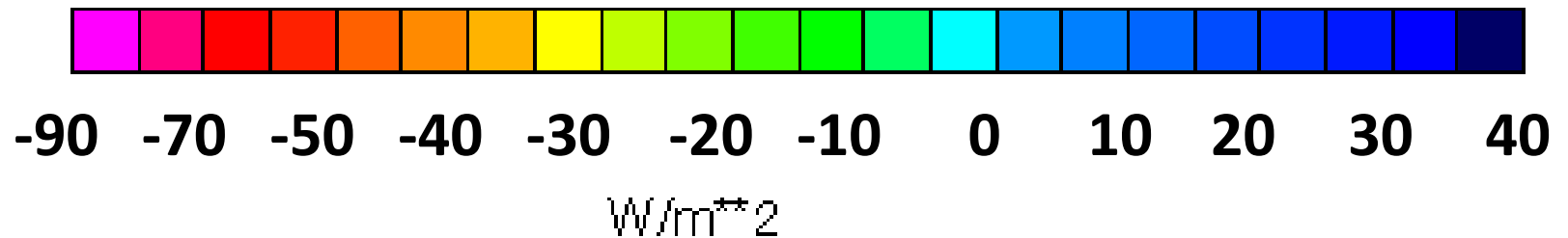
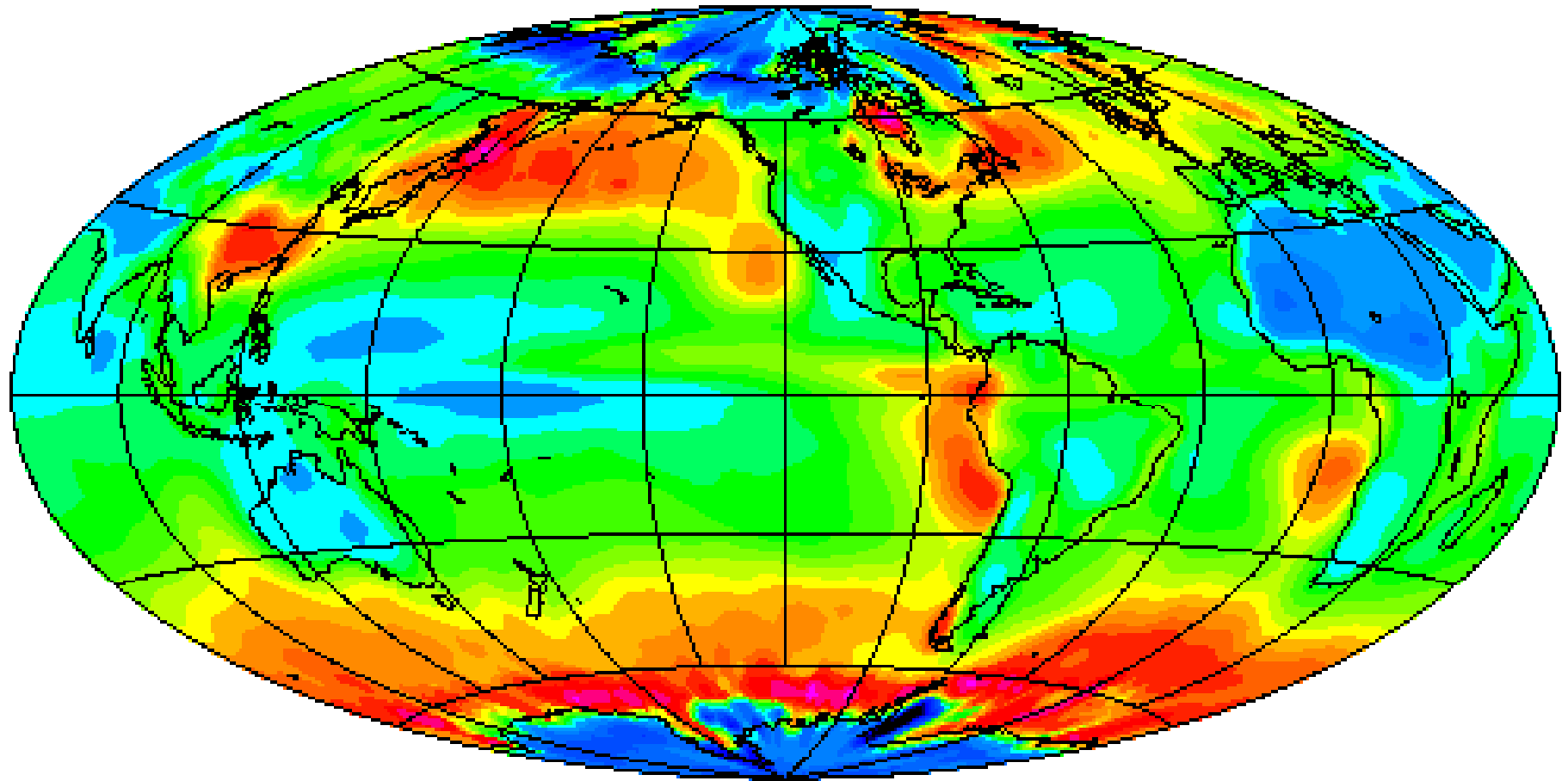
CIRA/NOAA-CSU



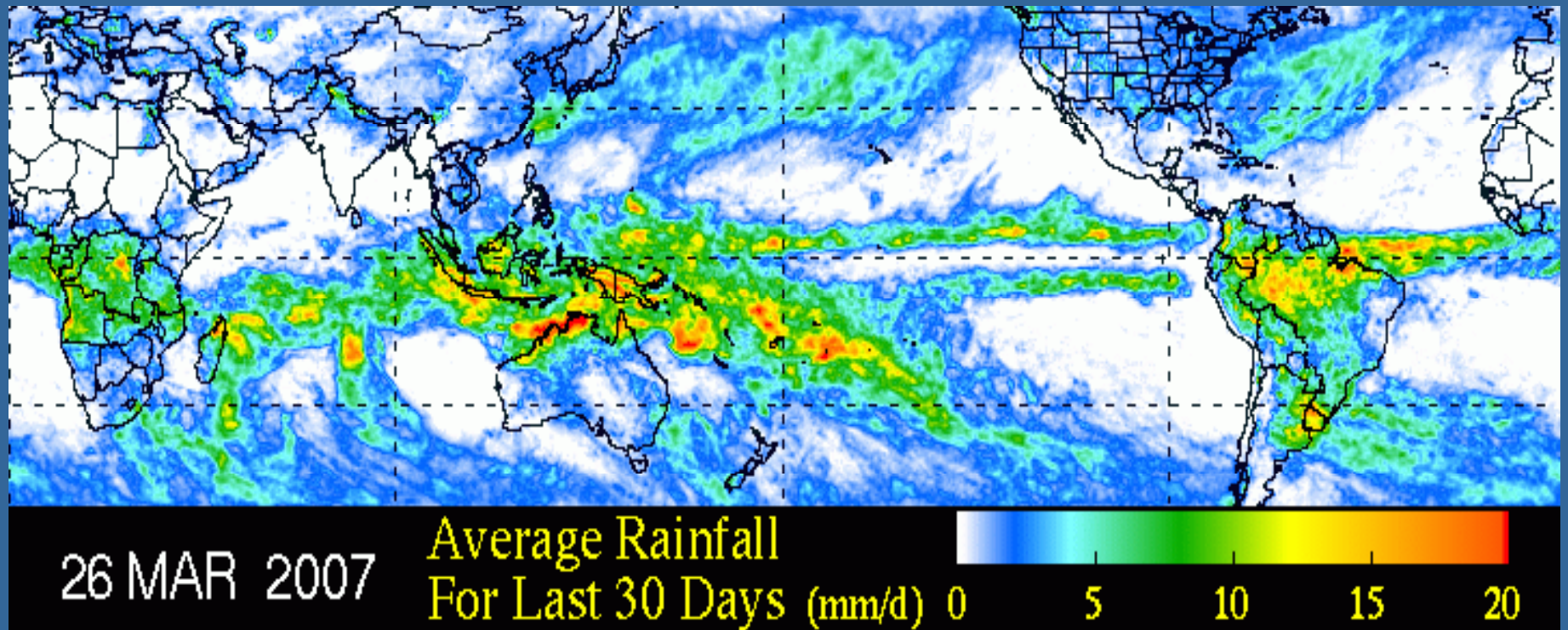
03 Jan 2003 17:45:14Z 10.70 um GOES-8

CIRA/NOAA-CSU

Net cloud radiative effect from ERBE



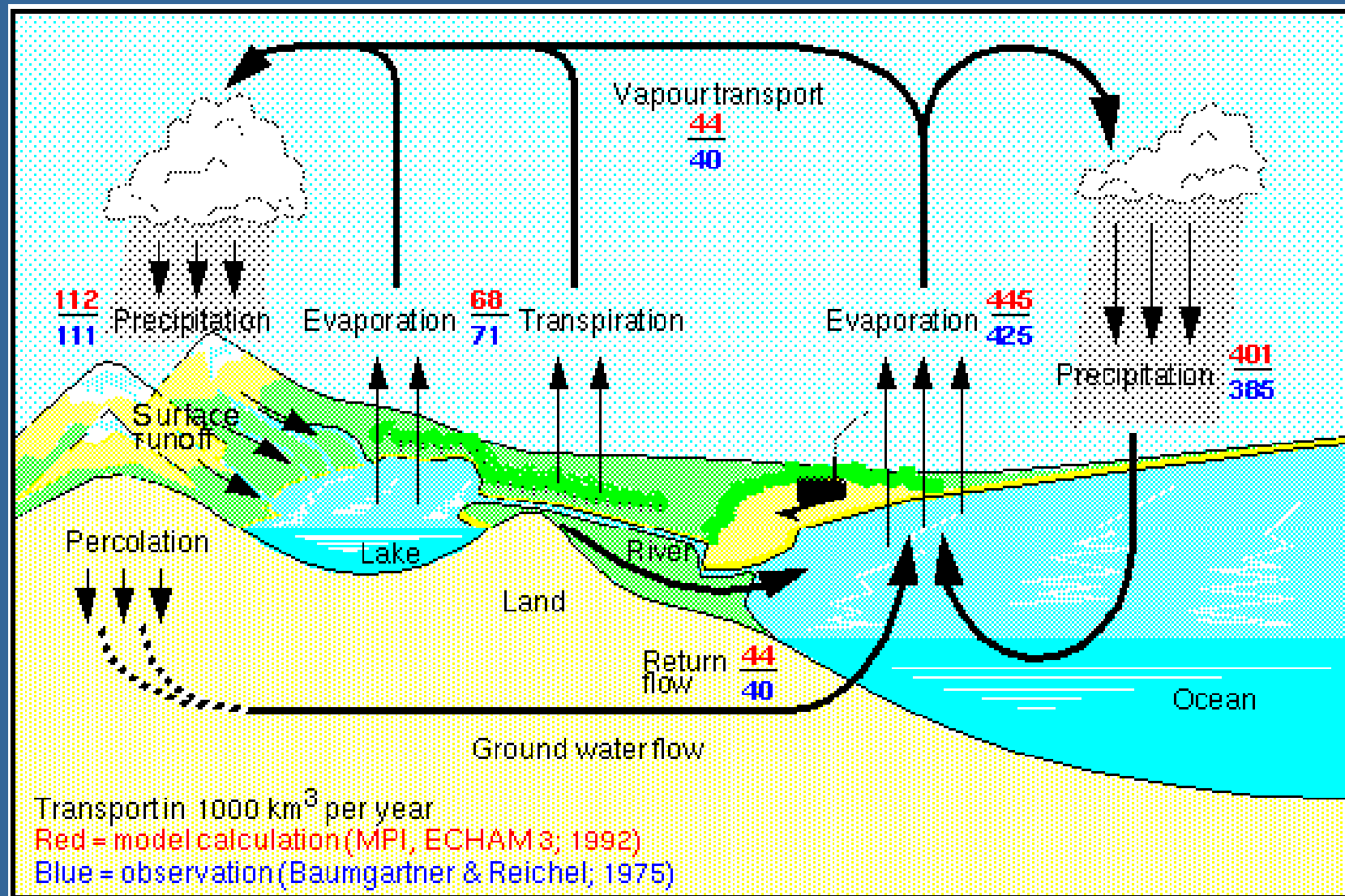
Latent Heating



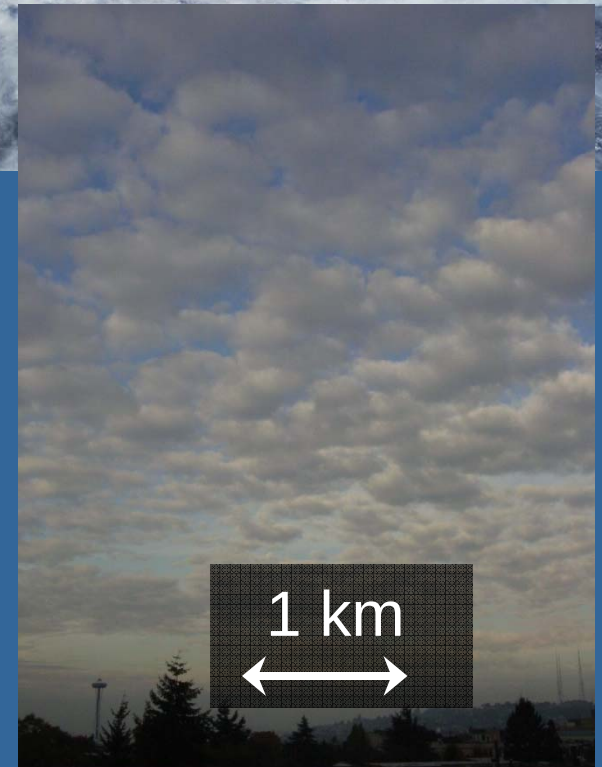
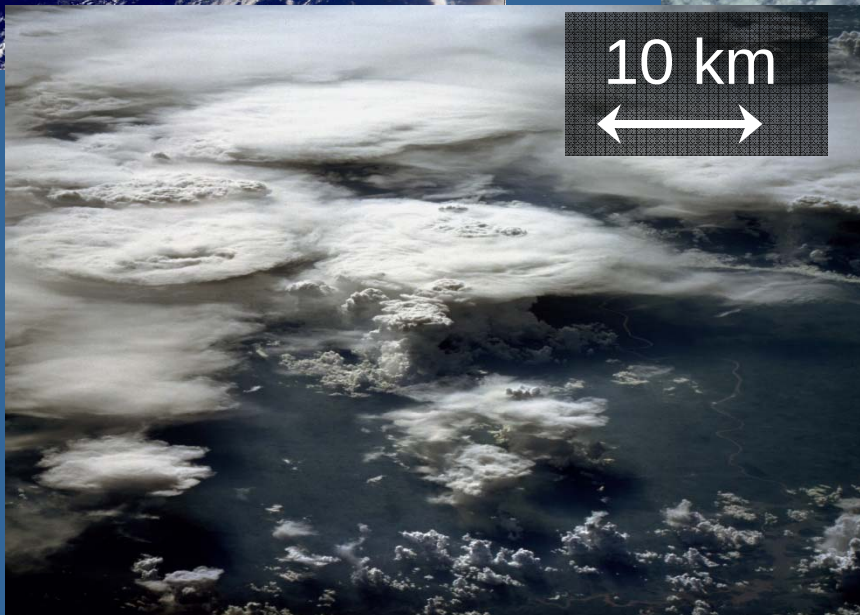
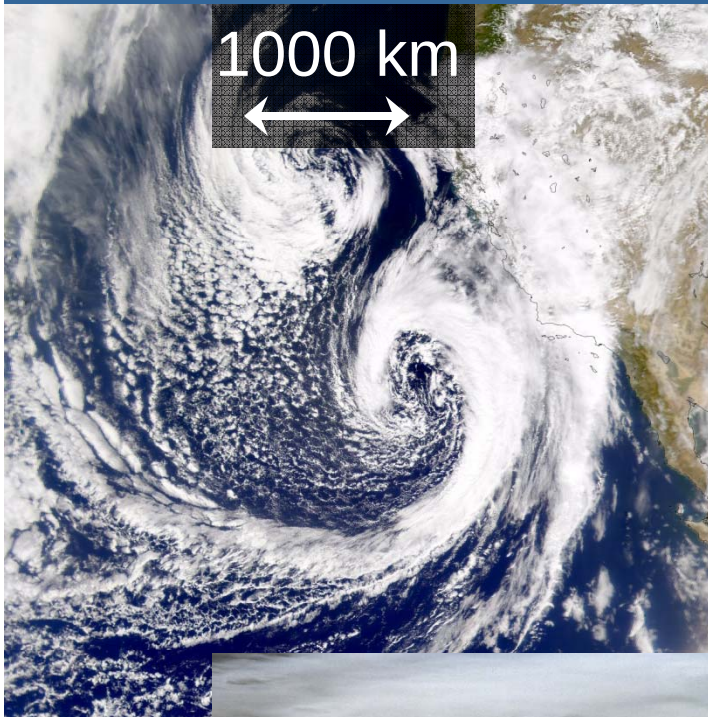
Combined satellite rainfall measurements

Reflects locations of major precipitating cloud systems
spatiotemporal variability

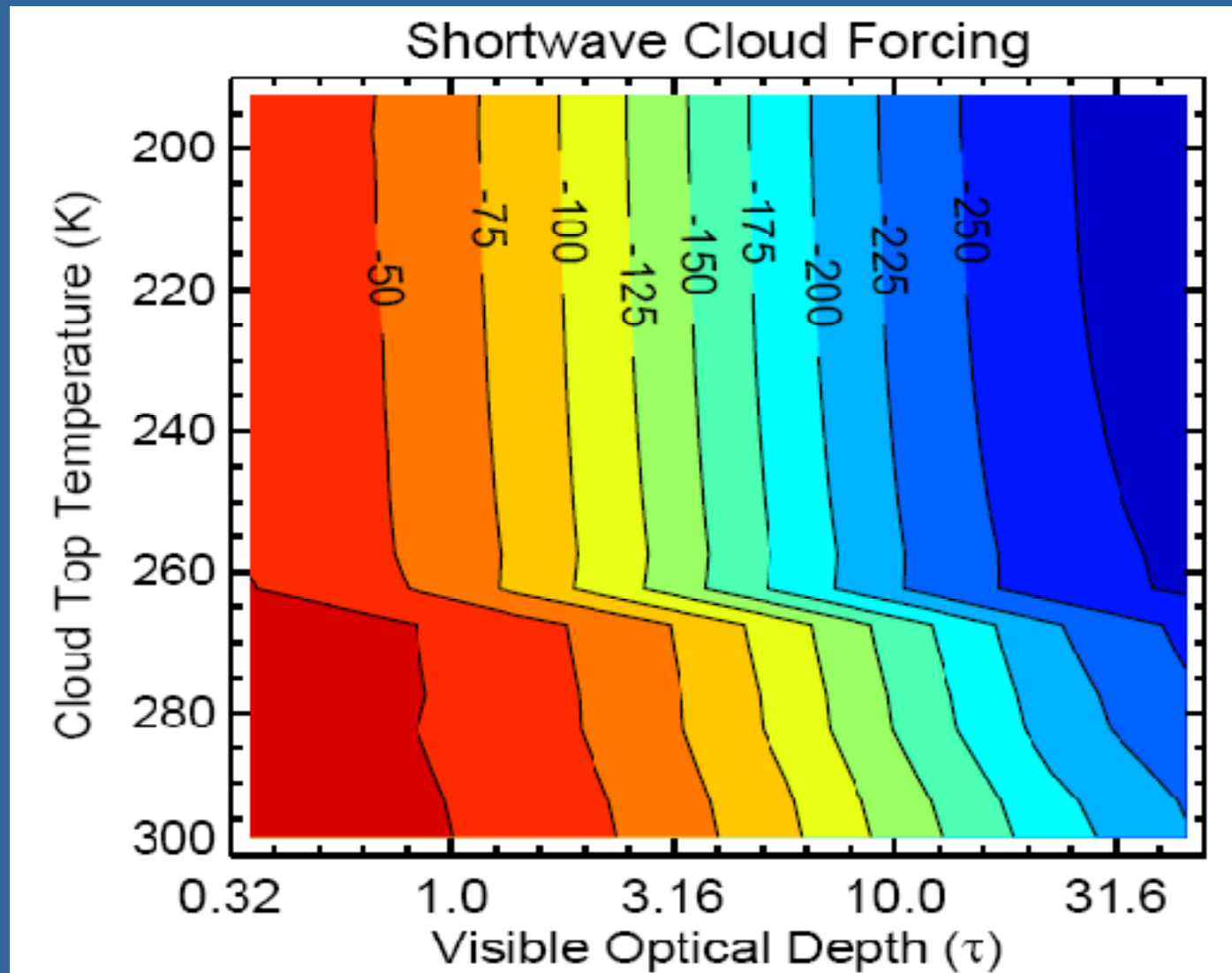
The Global Hydrological Cycle



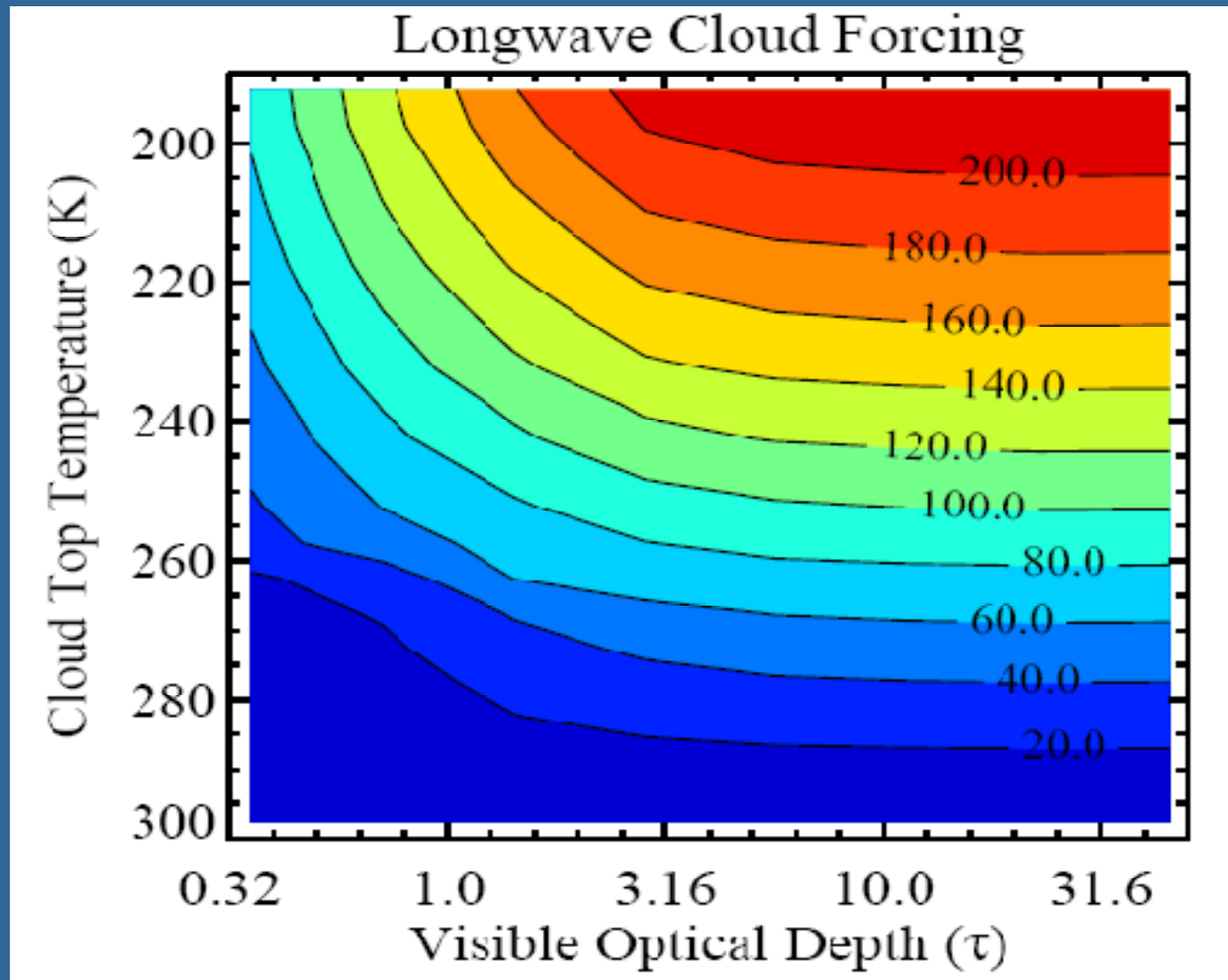
From global to local – range of scales



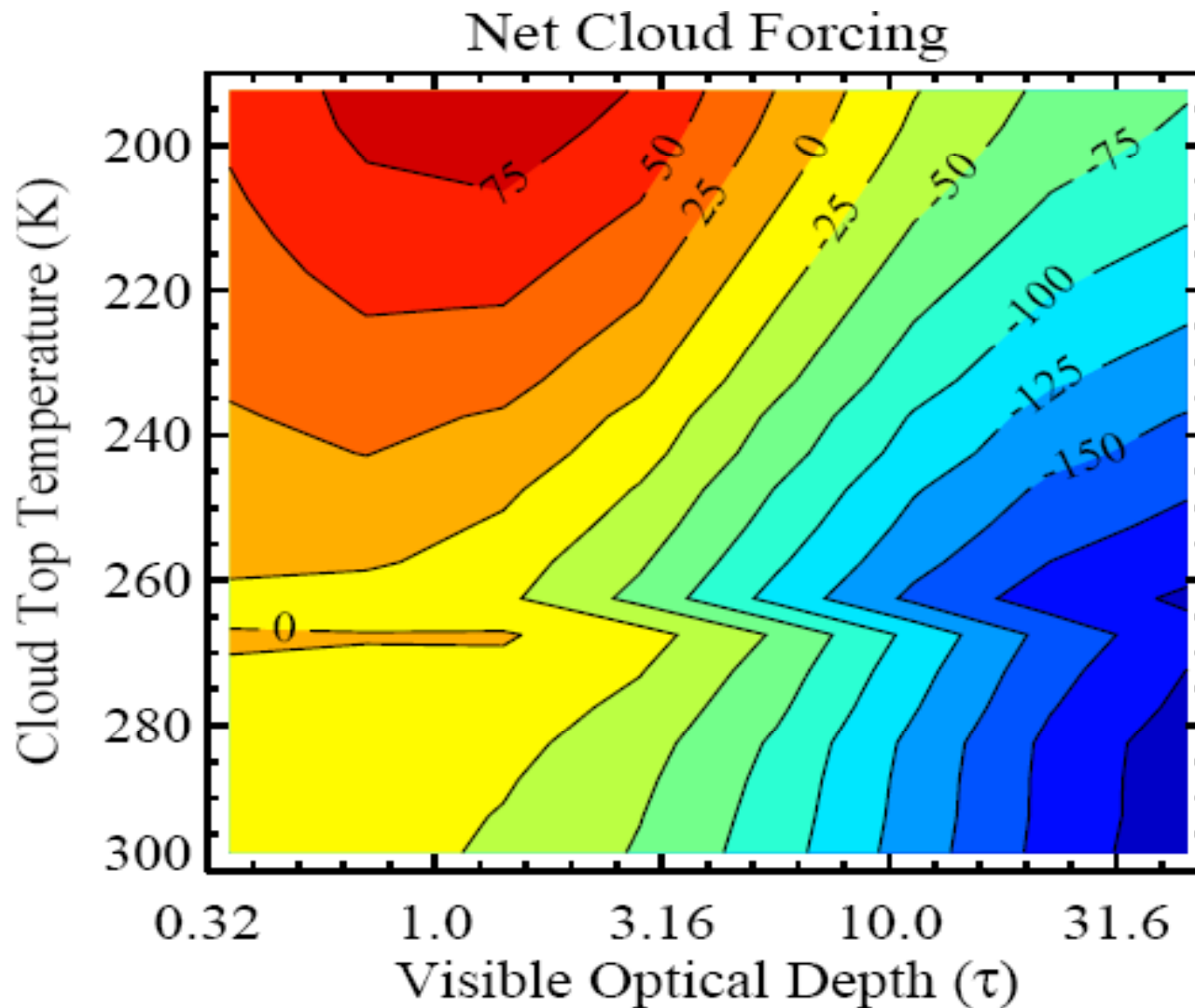
Impact of cloud type upon radiation



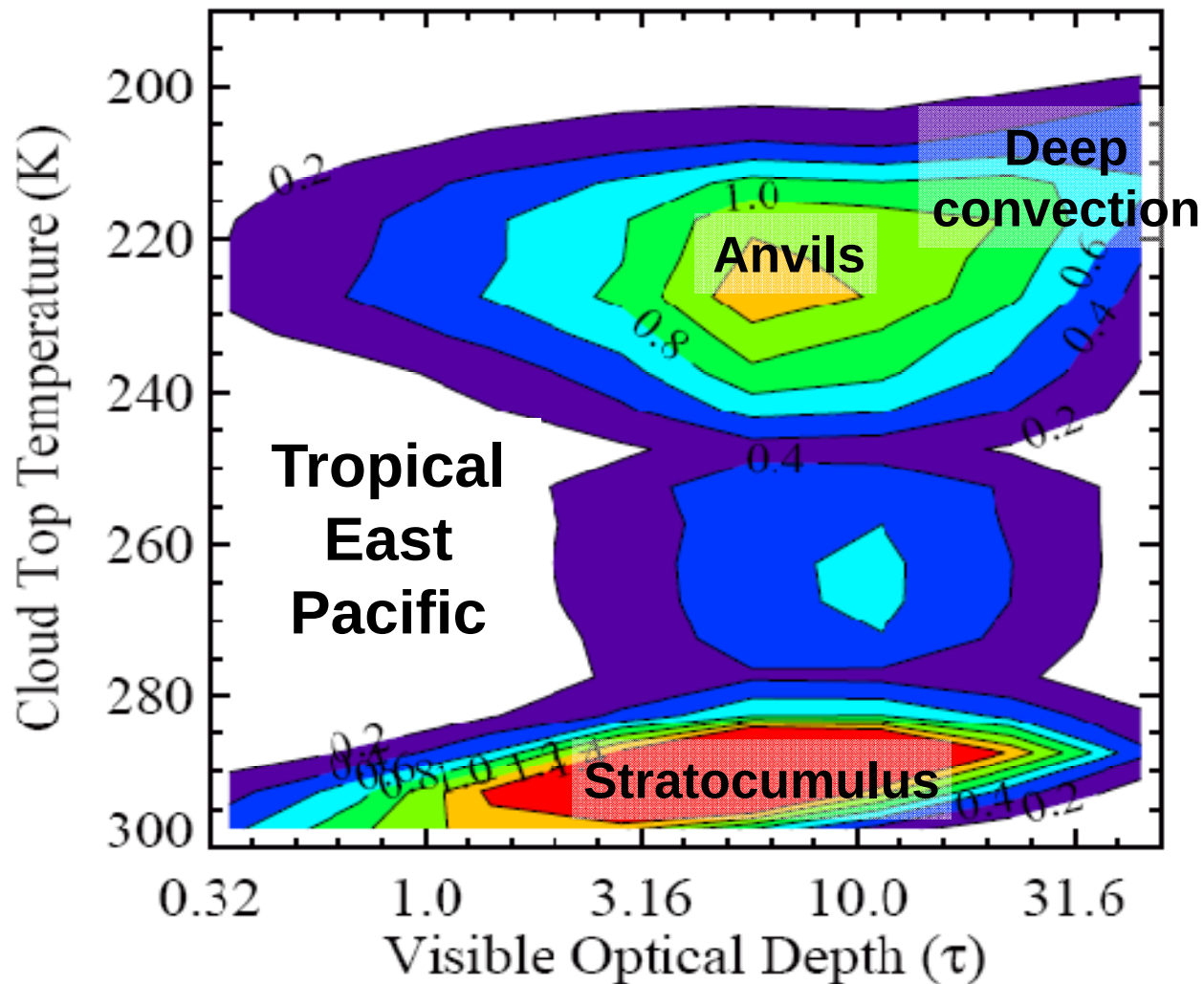
Impact of cloud type upon radiation



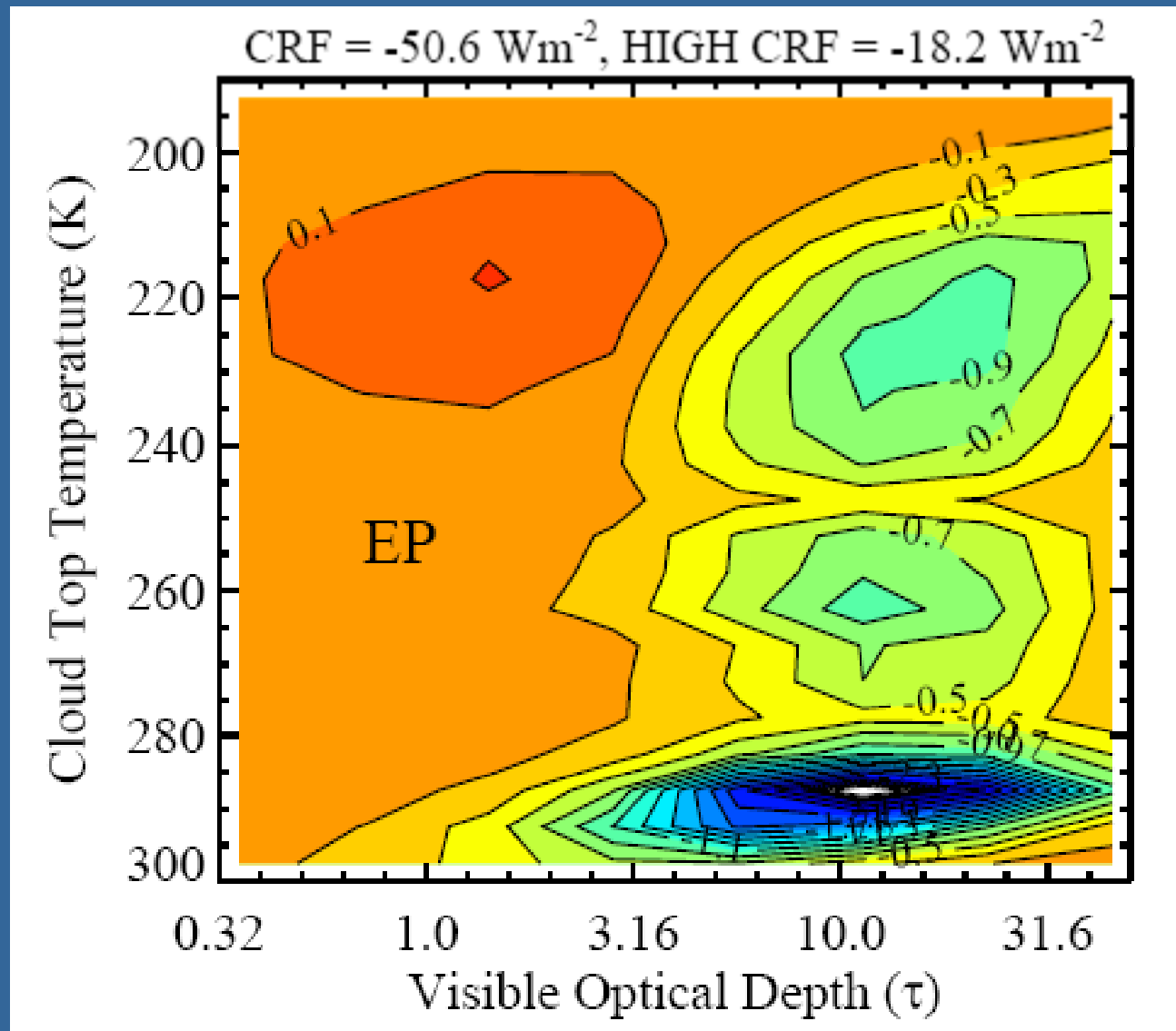
Impact of cloud type upon radiation



Distribution of cloud types



Radiative effect of cloud types



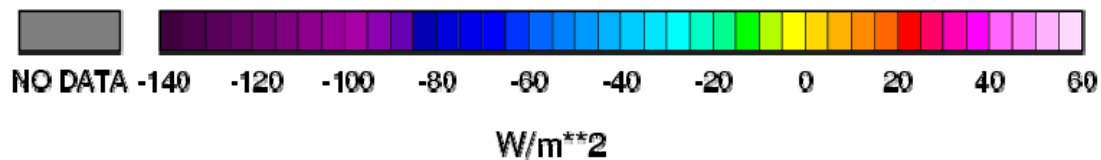
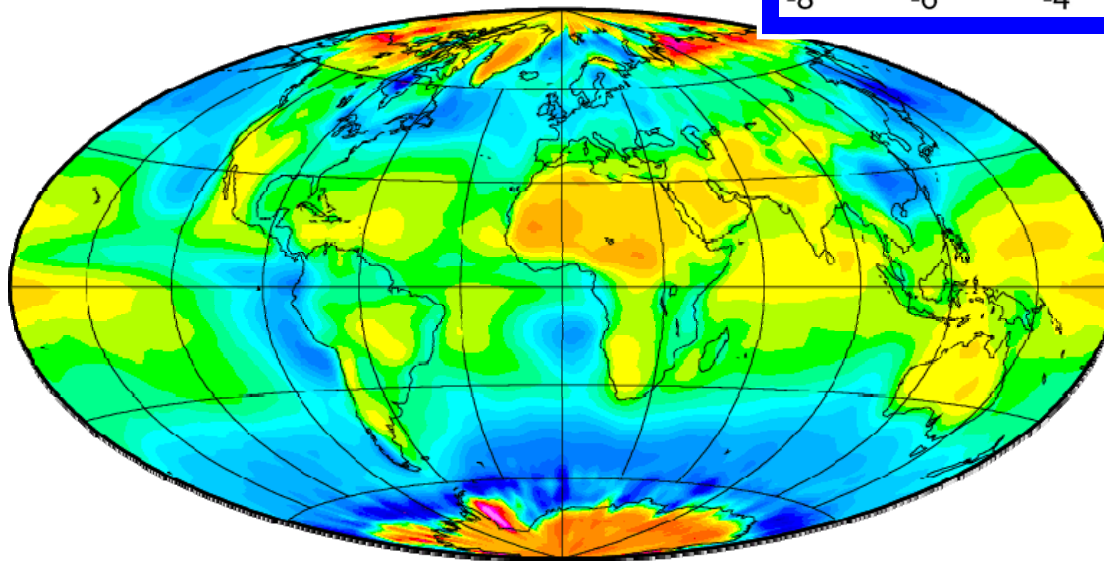
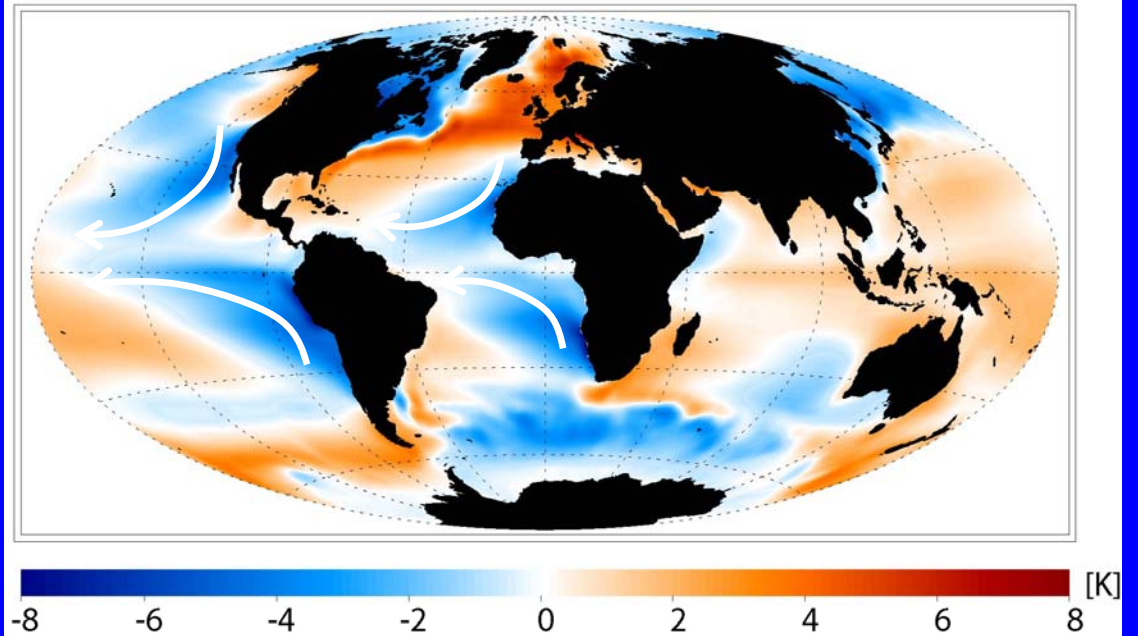
High

Mid-level

Low

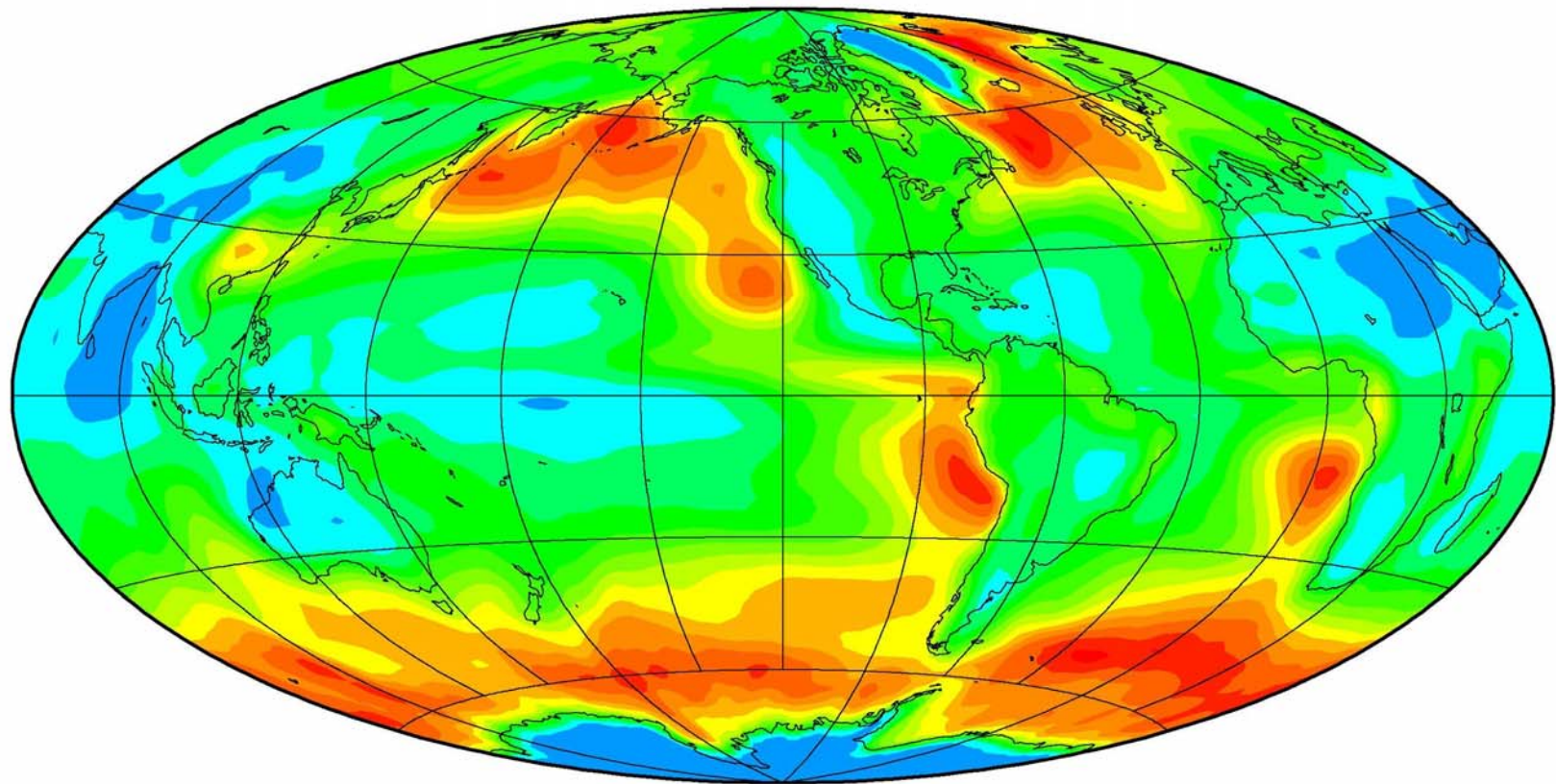
Factors influencing cloud types

SST anomaly from zonal mean

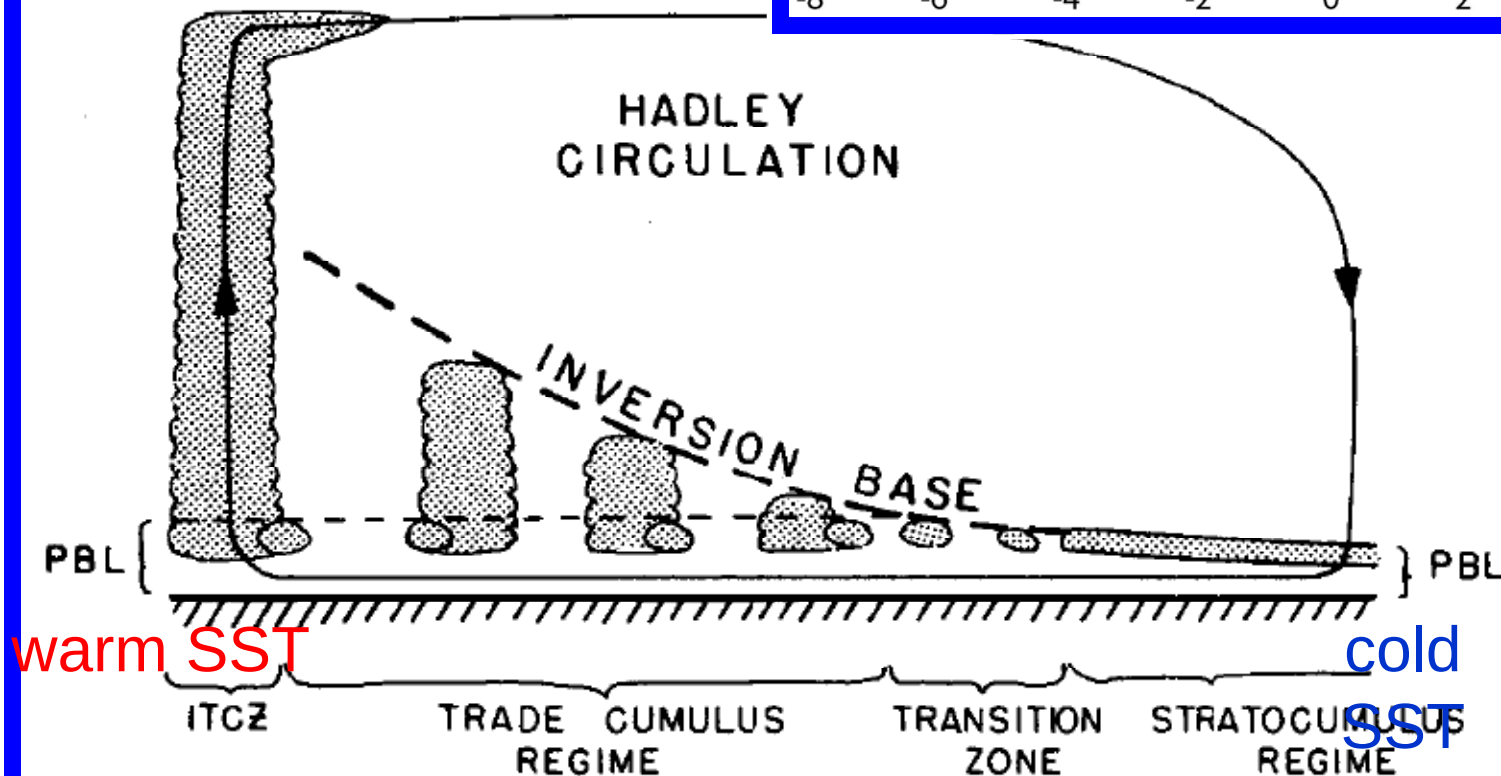
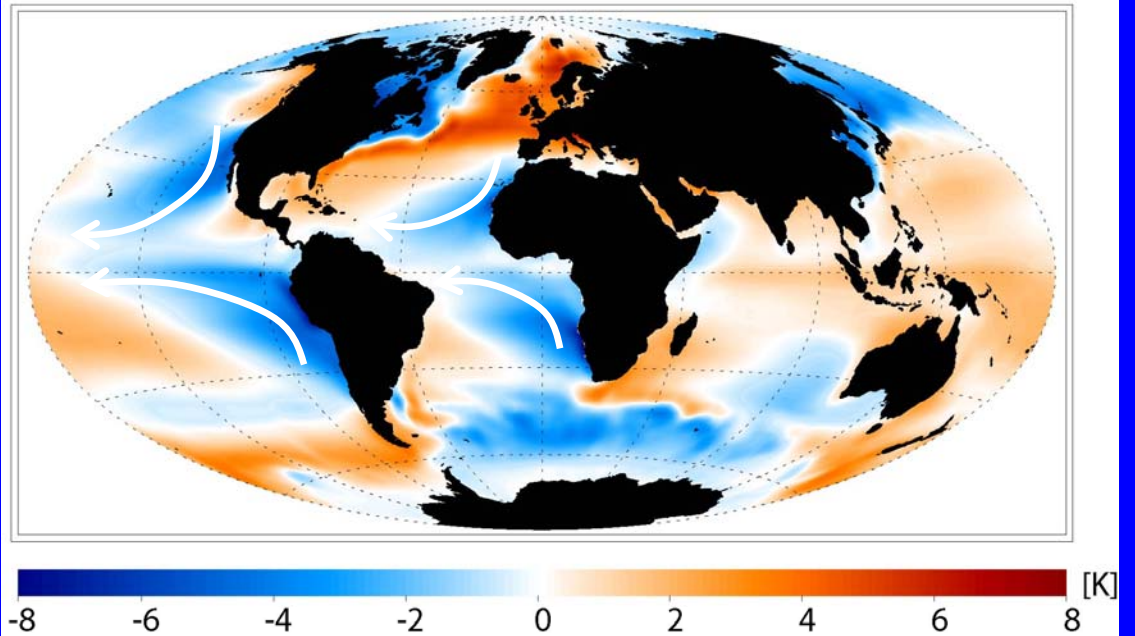


ERBE net
cloud
forcing

ISCCP inferred St/Sc amount

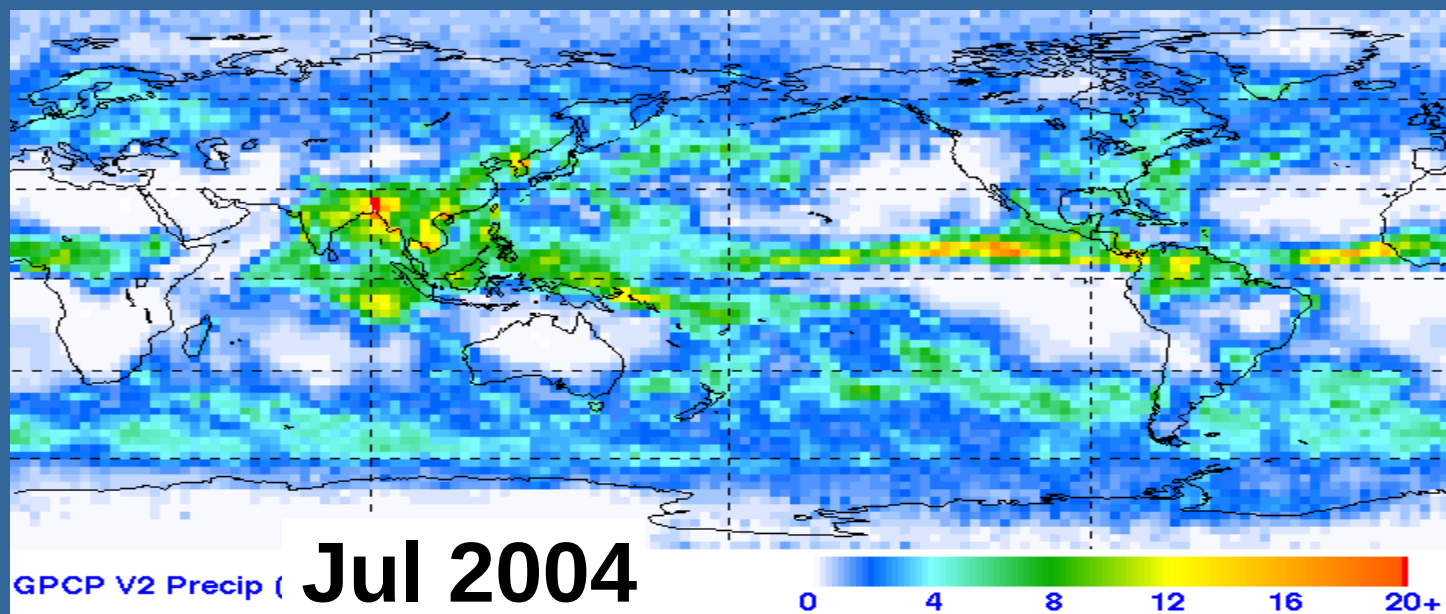
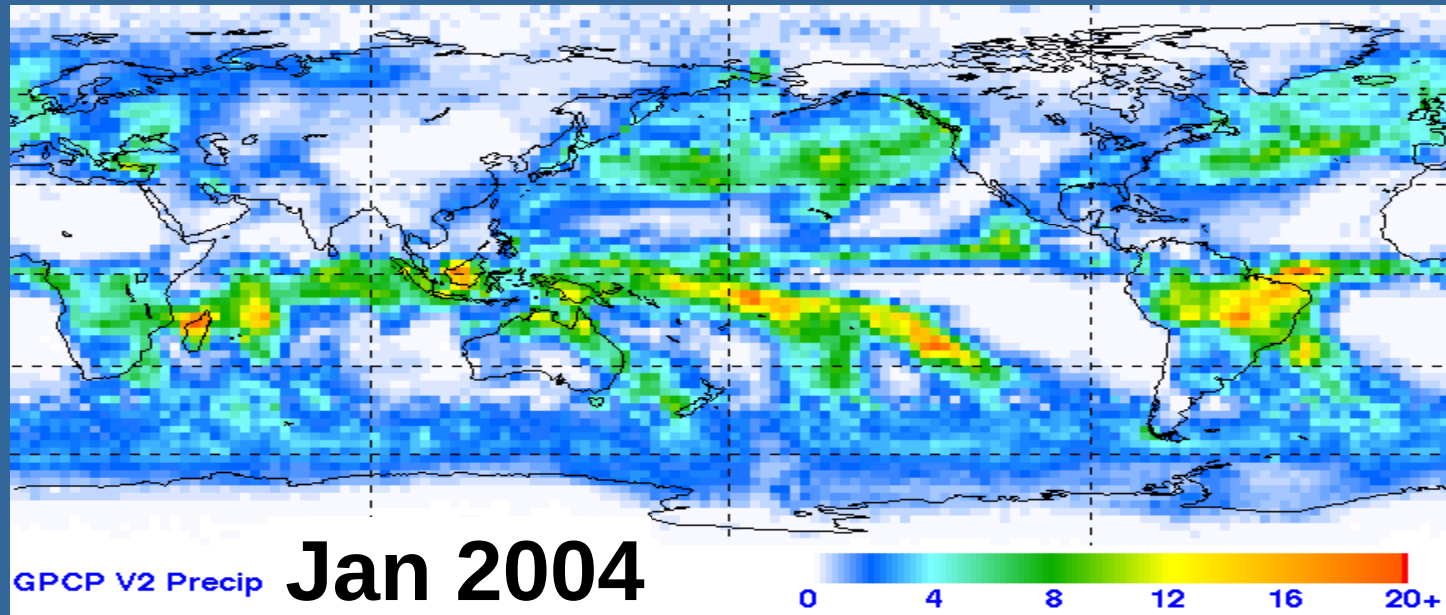


Tropical-subtropical general circulation

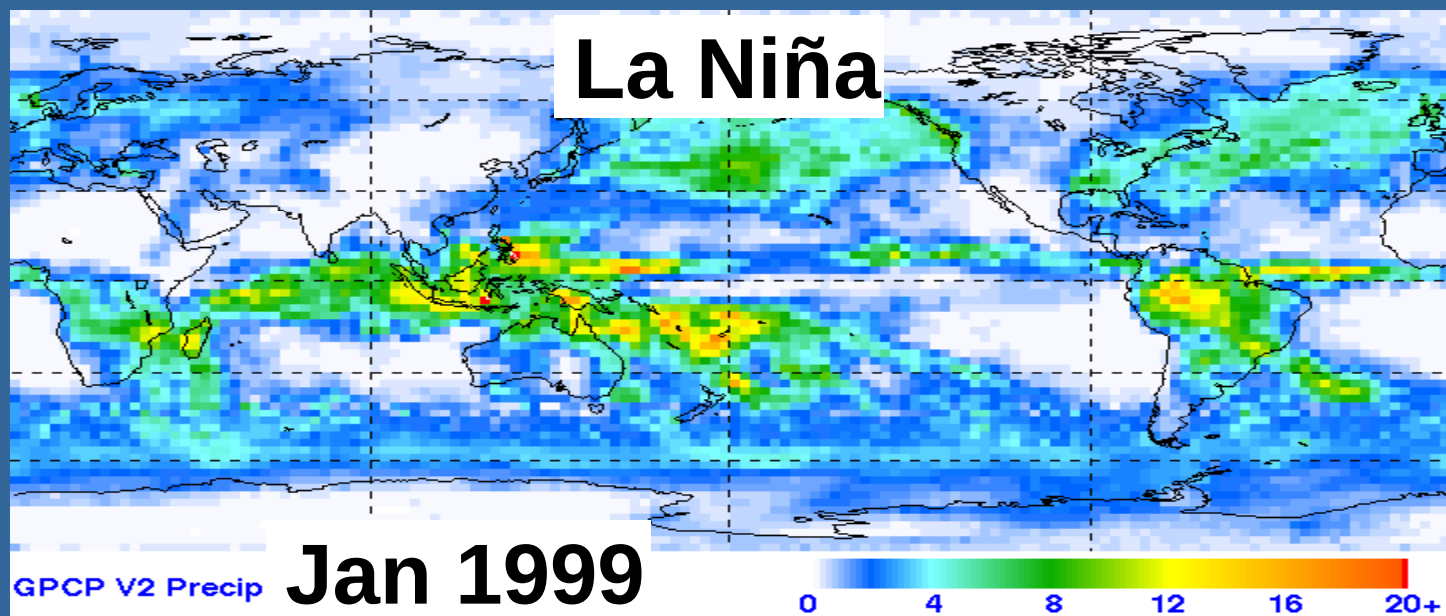
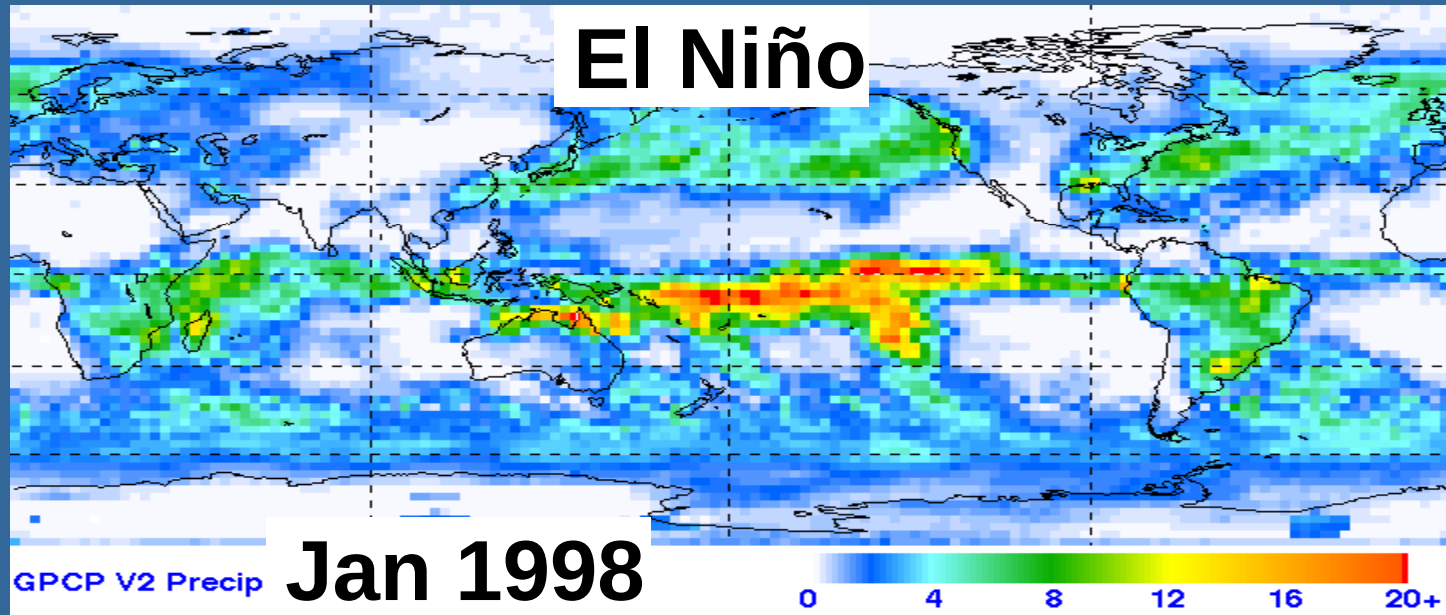


from
Randall et al.,
J. Atmos. Sci.,
37, 125-130,
1980

Seasonal cycle of precipitation

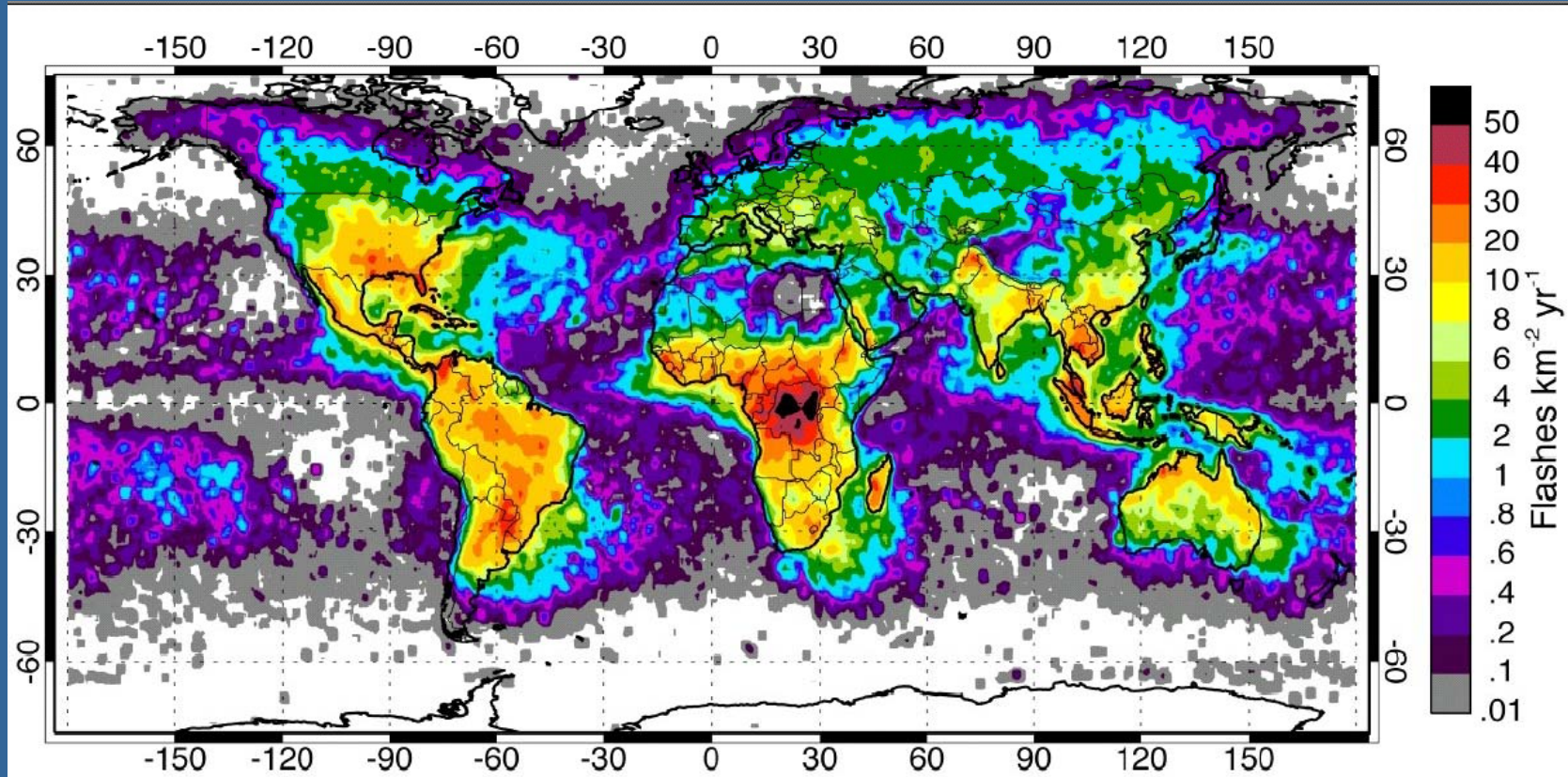


Interannual variability of precipitation

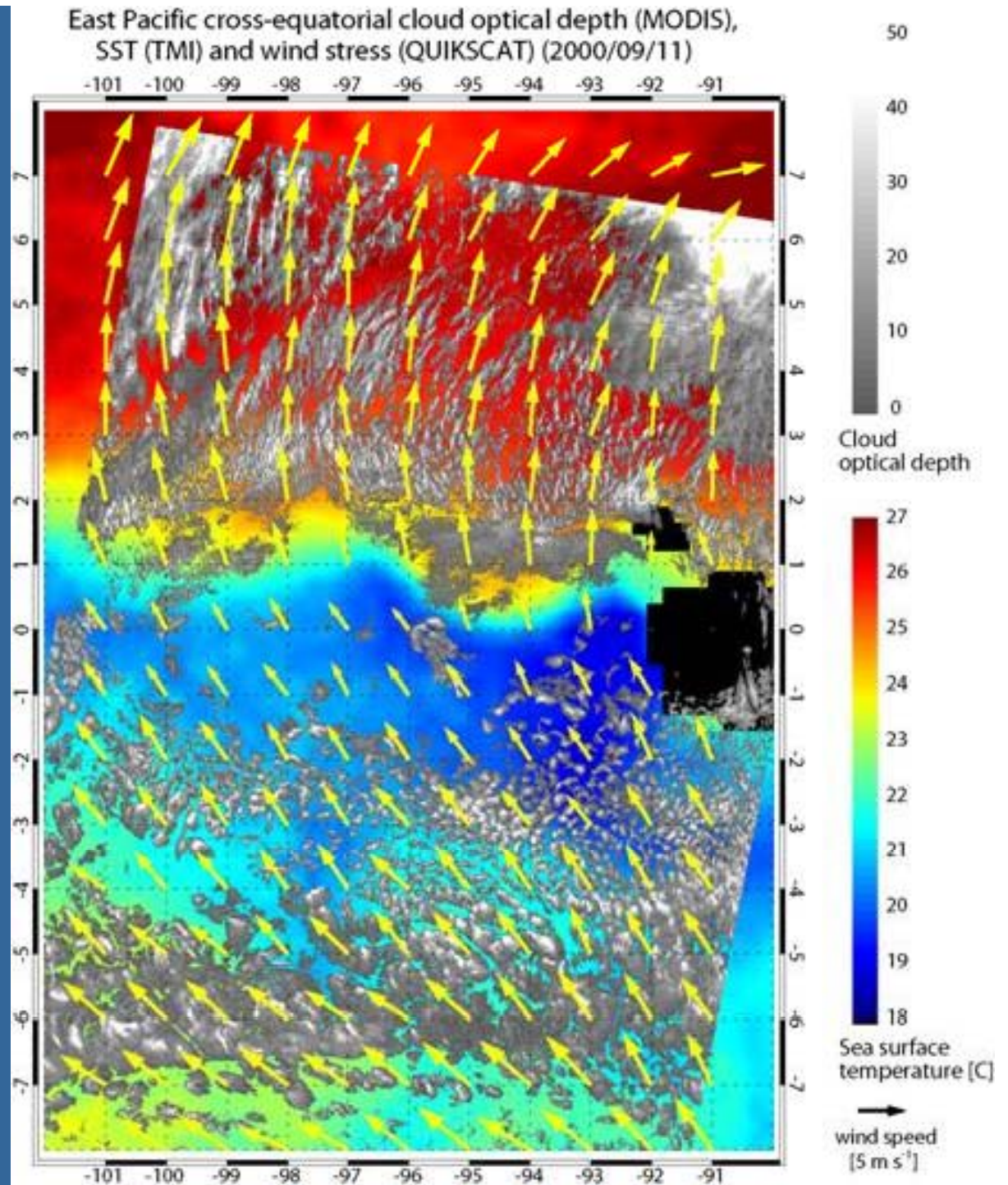


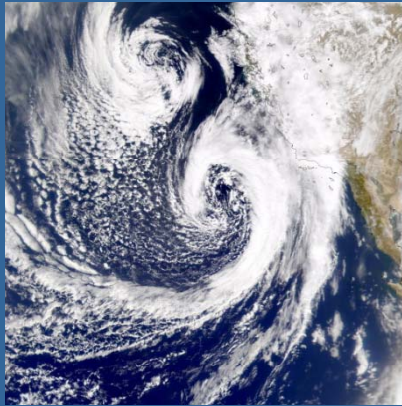
Global frequency and distribution of lightning as observed from space

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

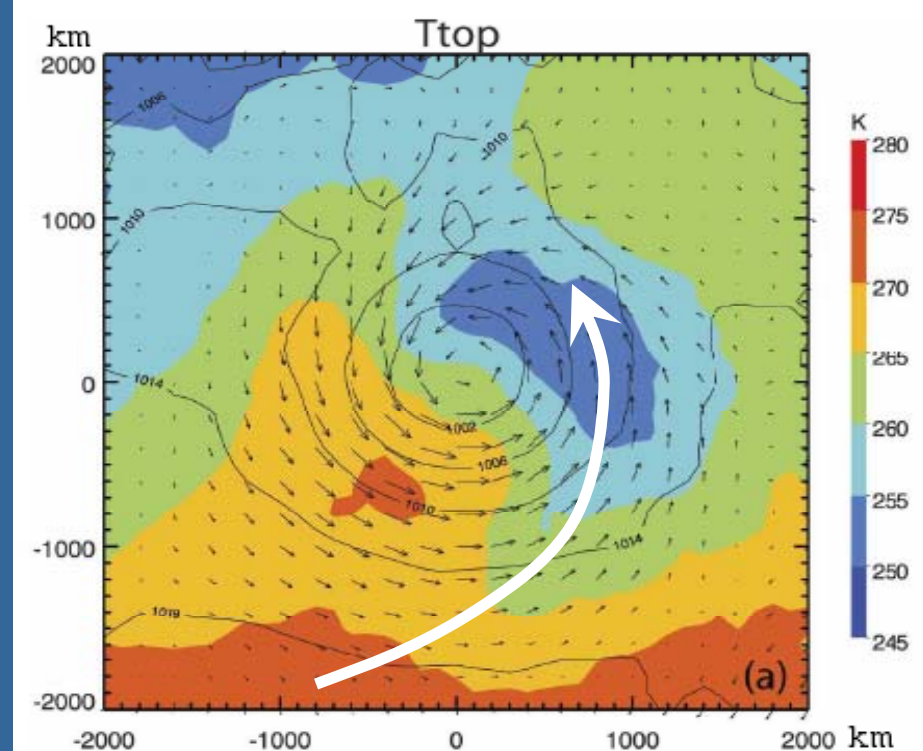
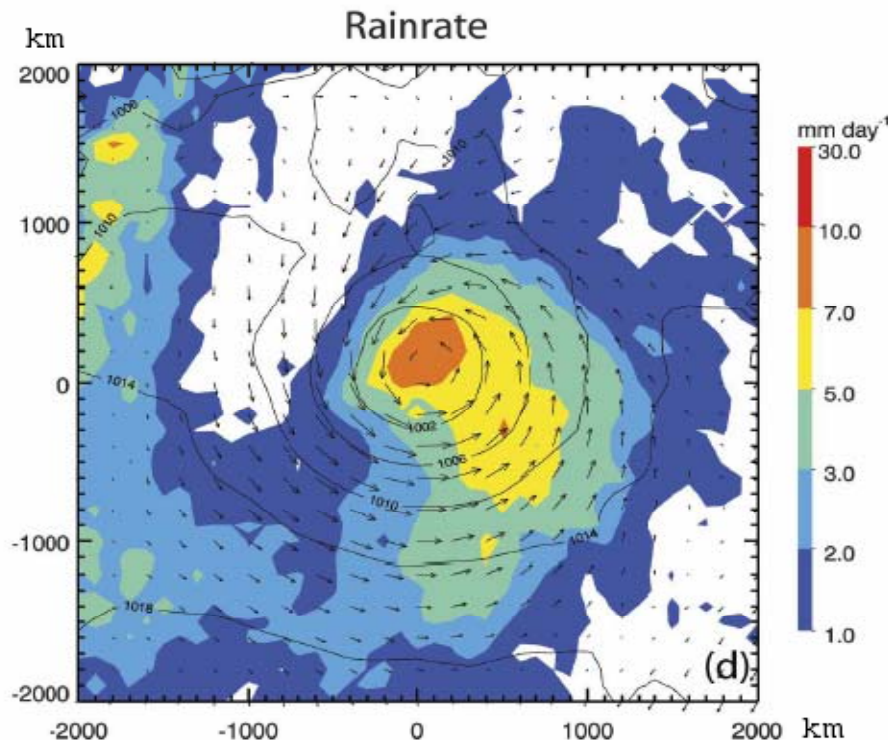


Tight couplings between SST, winds, and clouds



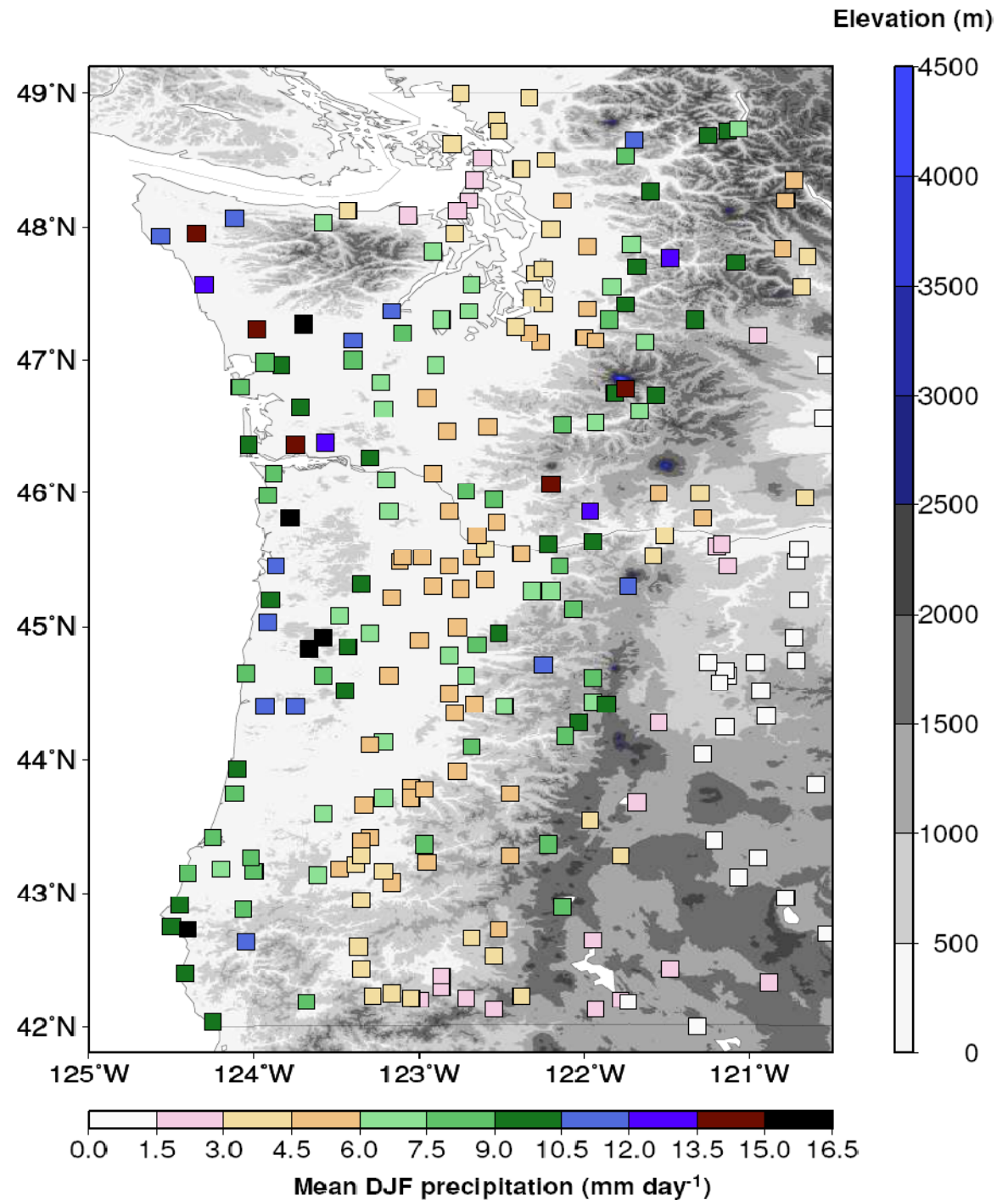


Clouds and precipitation associated with midlatitude cyclones



warm conveyor

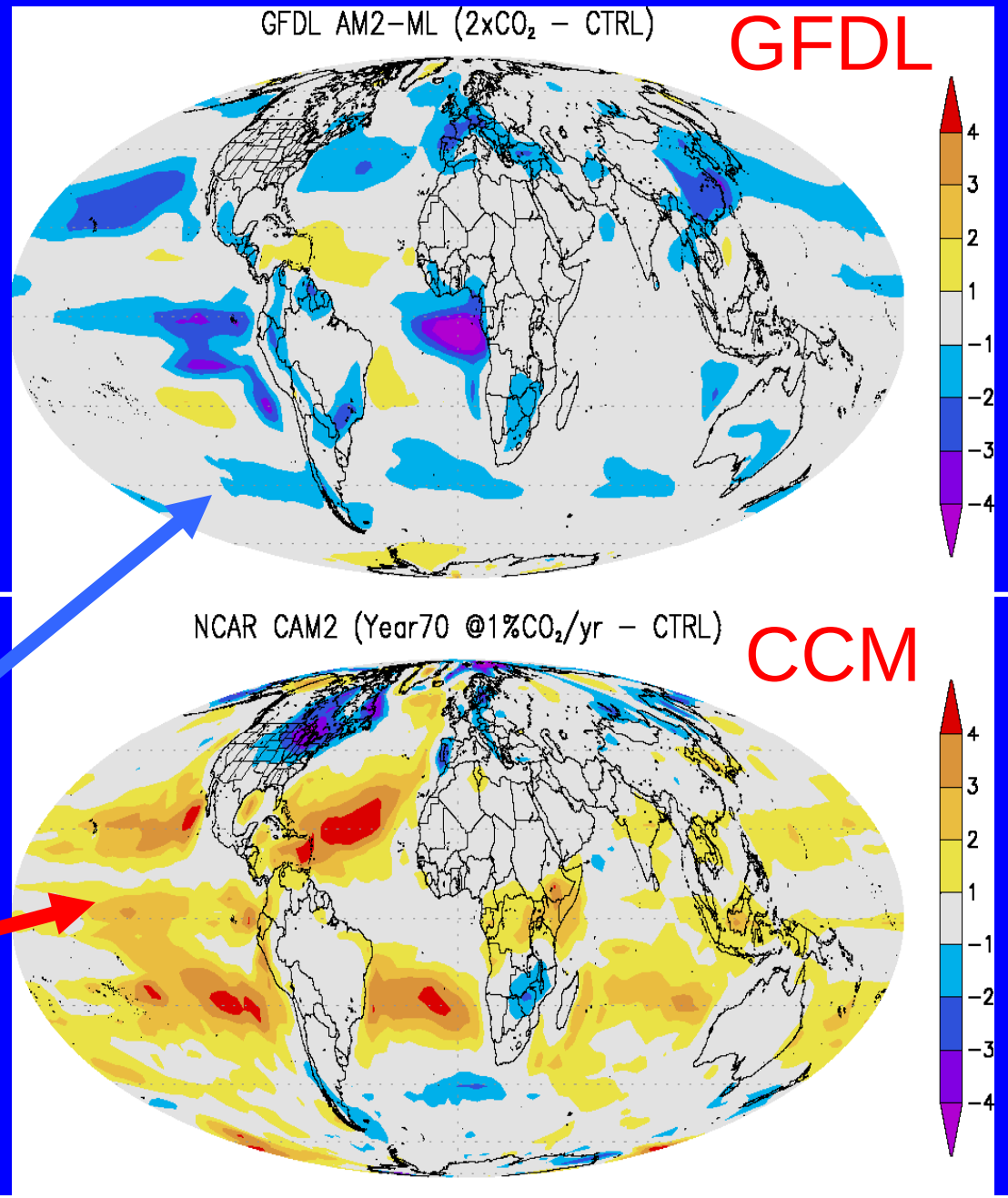
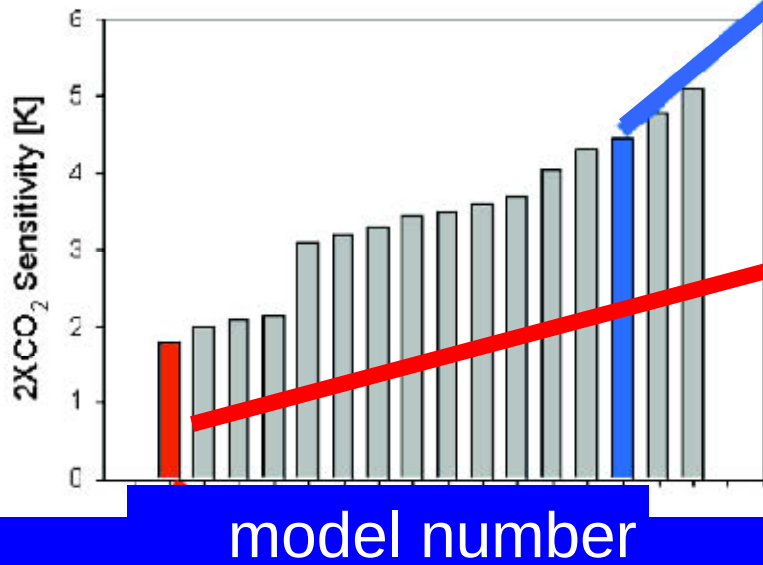
Orographic precipitation enhancement



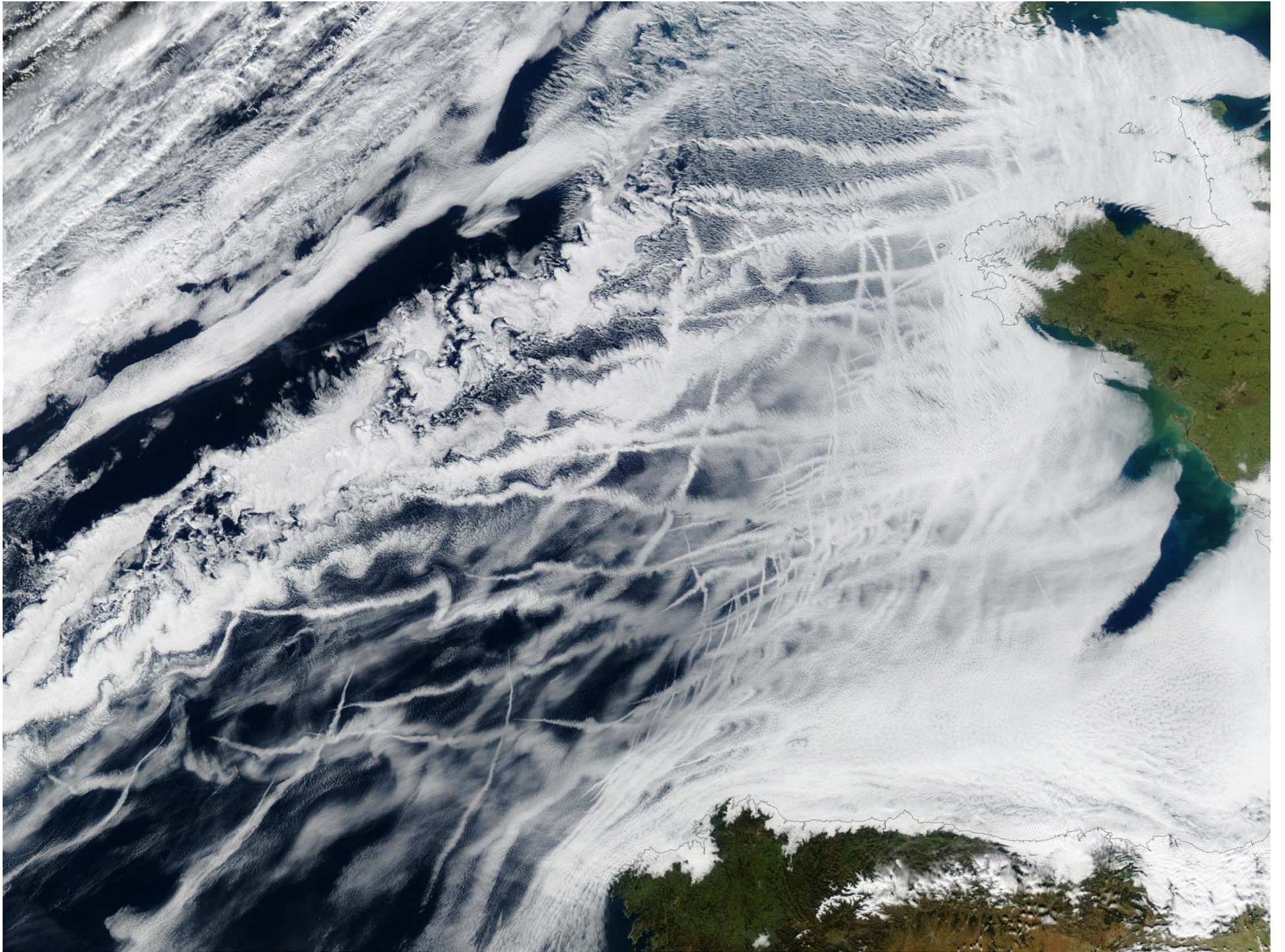
Clouds and climate change

Clouds in climate models

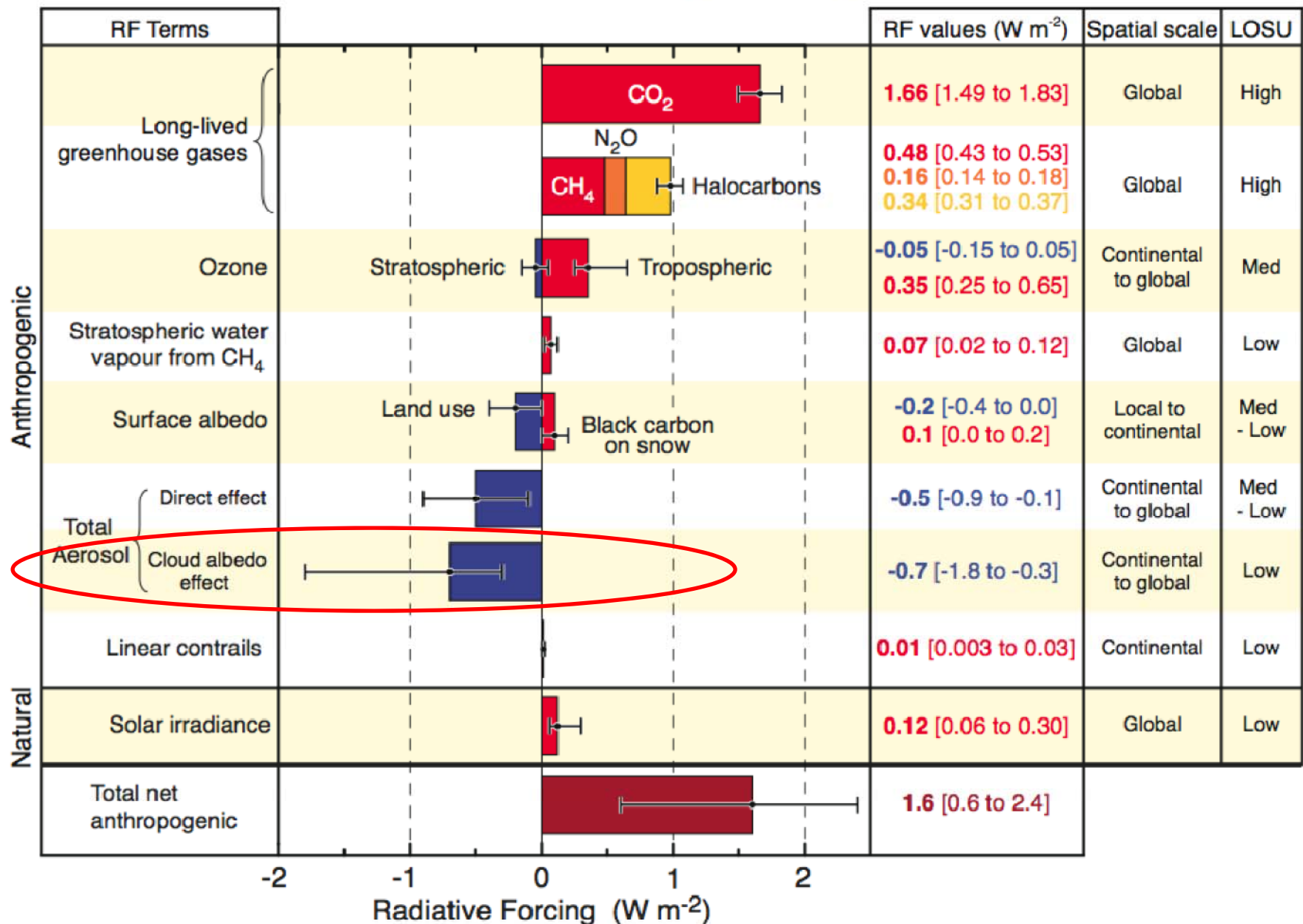
- change in low cloud amount for $2\times\text{CO}_2$



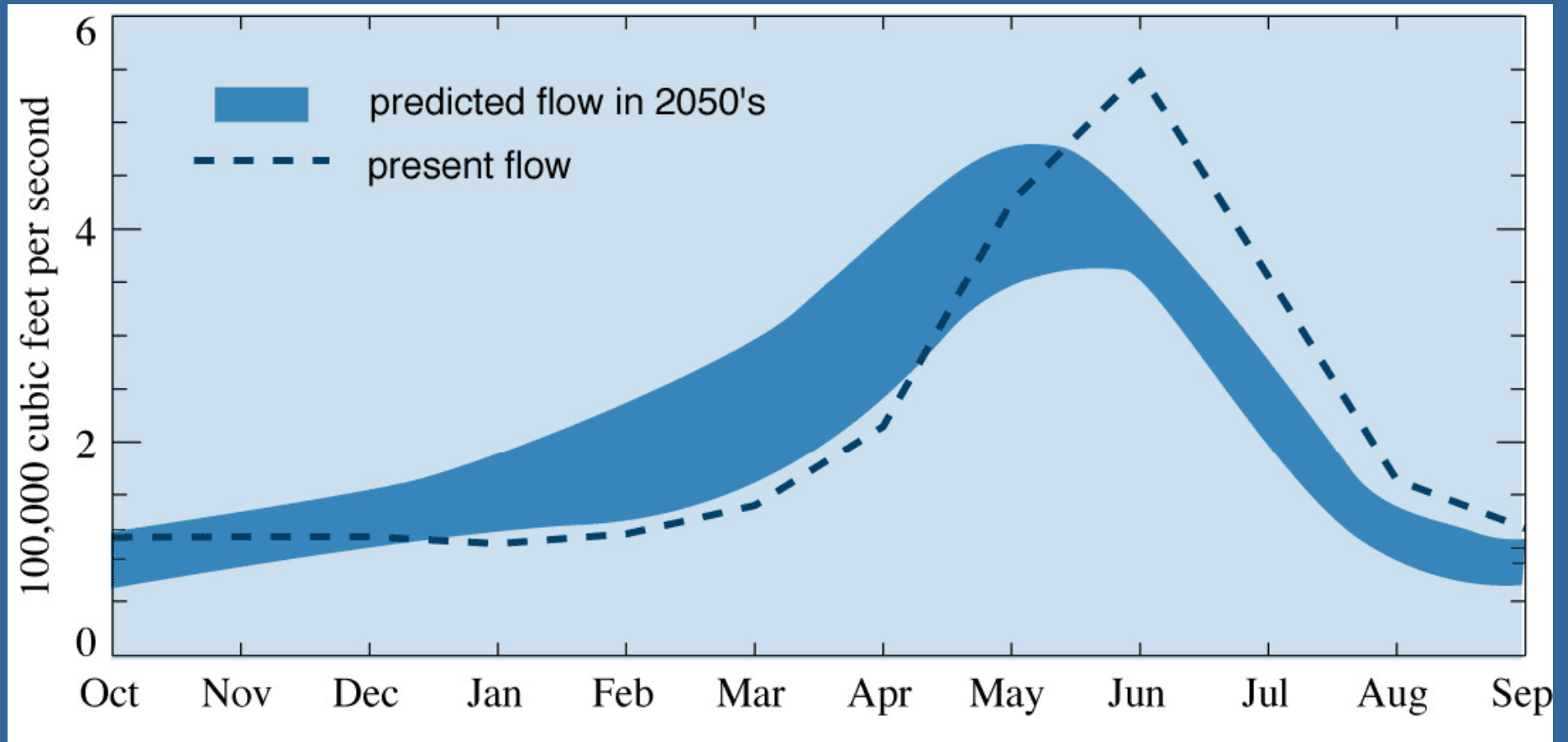
from Stephens (2005)



Radiative Forcing Components



Pacific Northwest Projected River Flow



Cloud effects on atmospheric chemistry

- Acidity of rain
- Gas-particle conversion
- Biogeochemical feedbacks to tropical cloud pattern

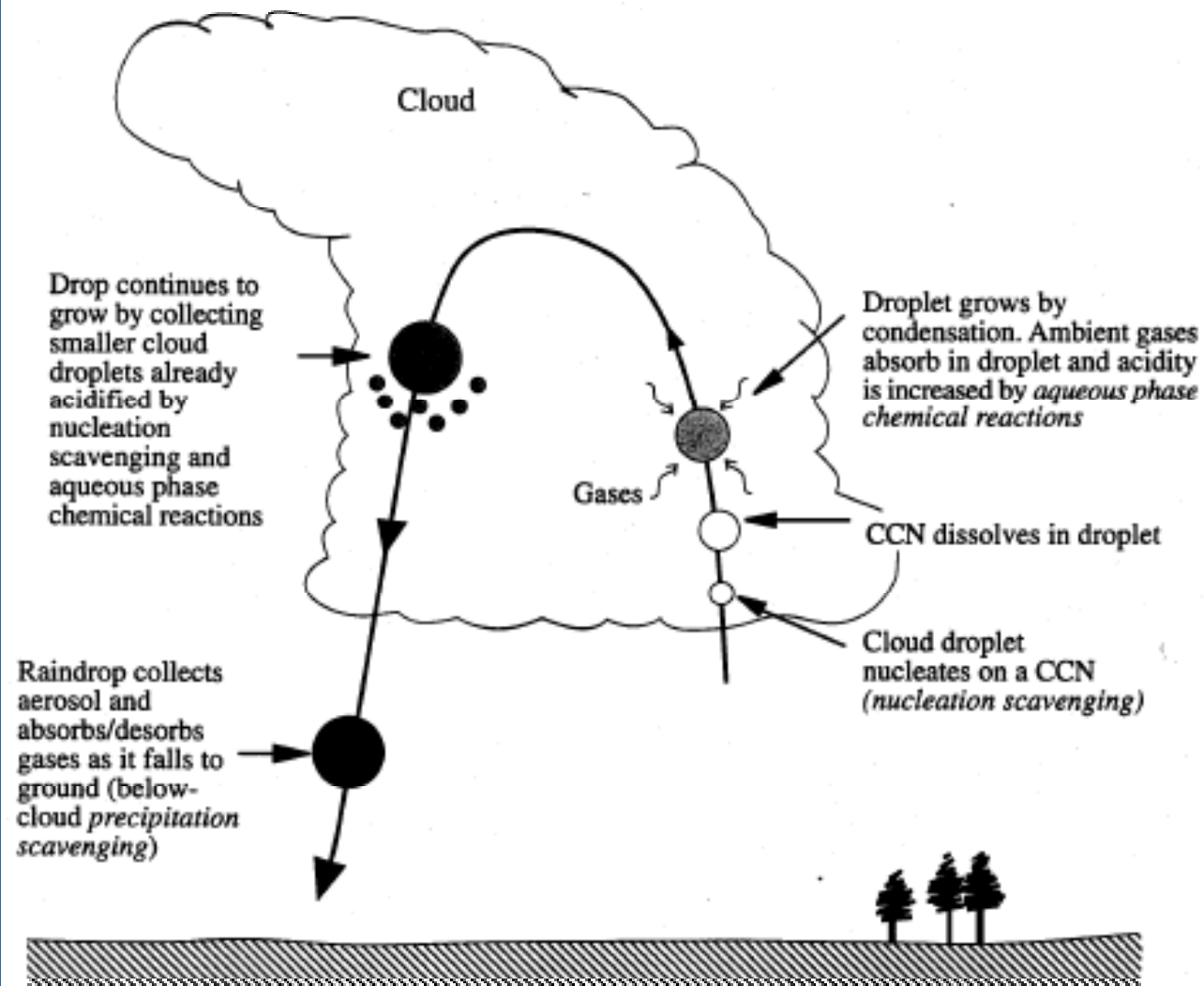


Figure 7.1. Schematic diagram of the processes affecting the chemical compositions of cloud droplets and rain. Not drawn to scale.

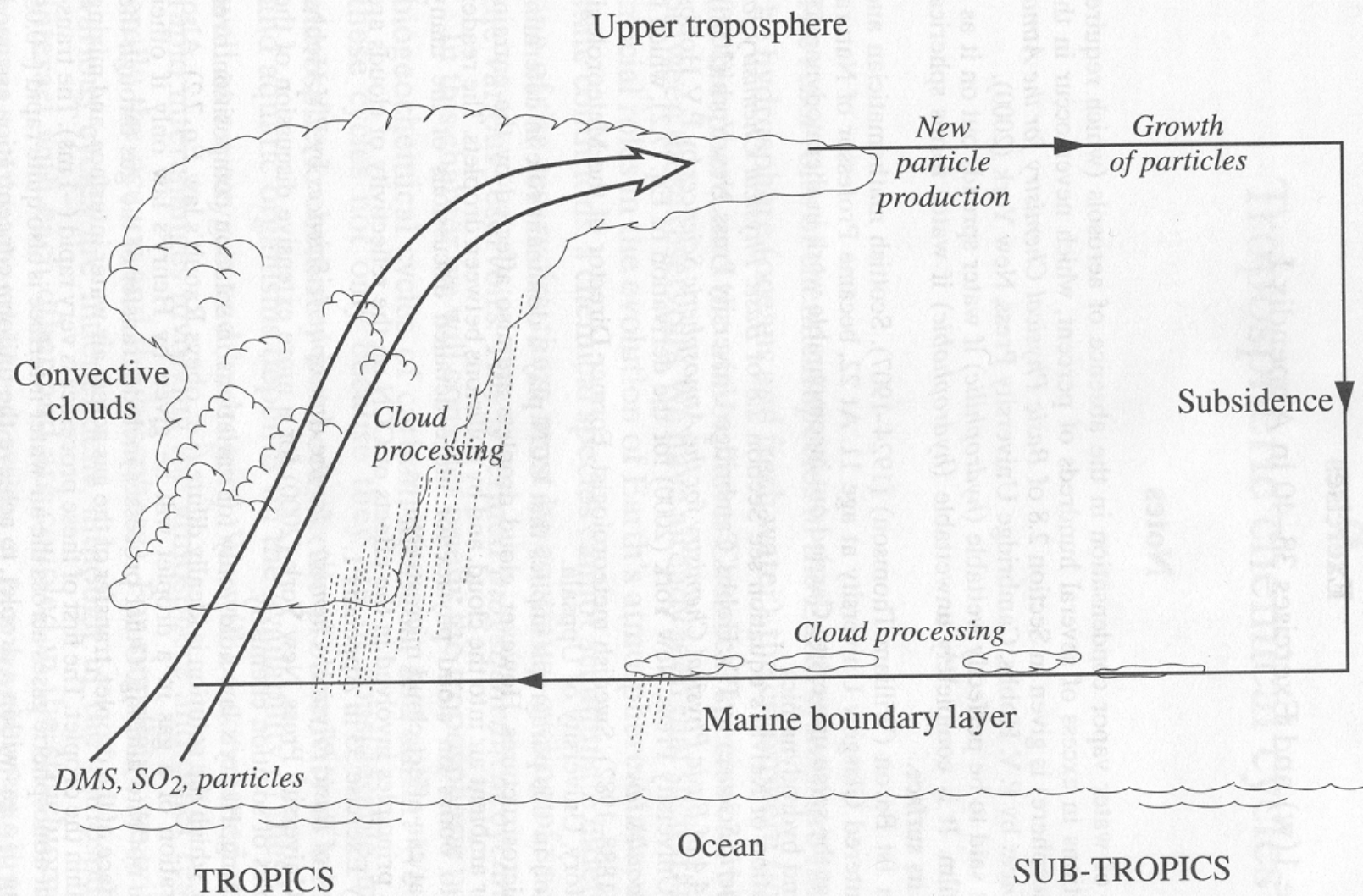
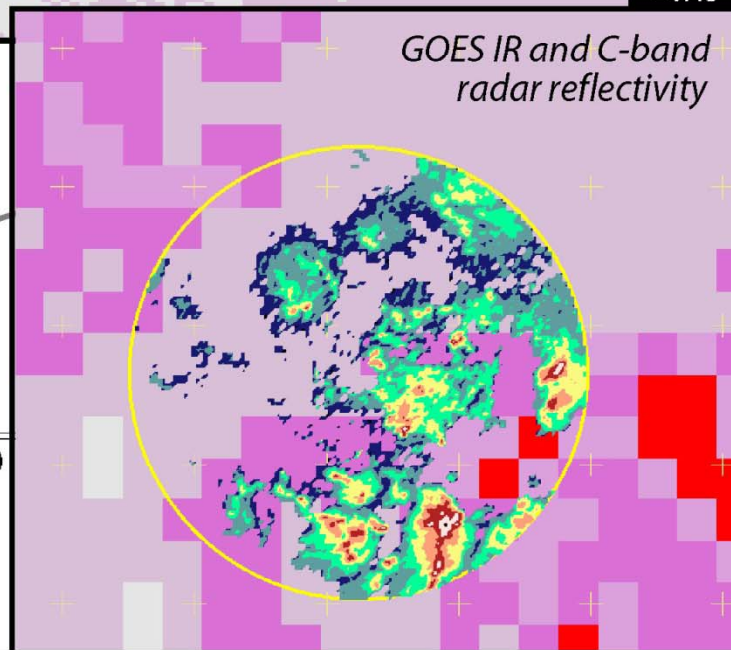
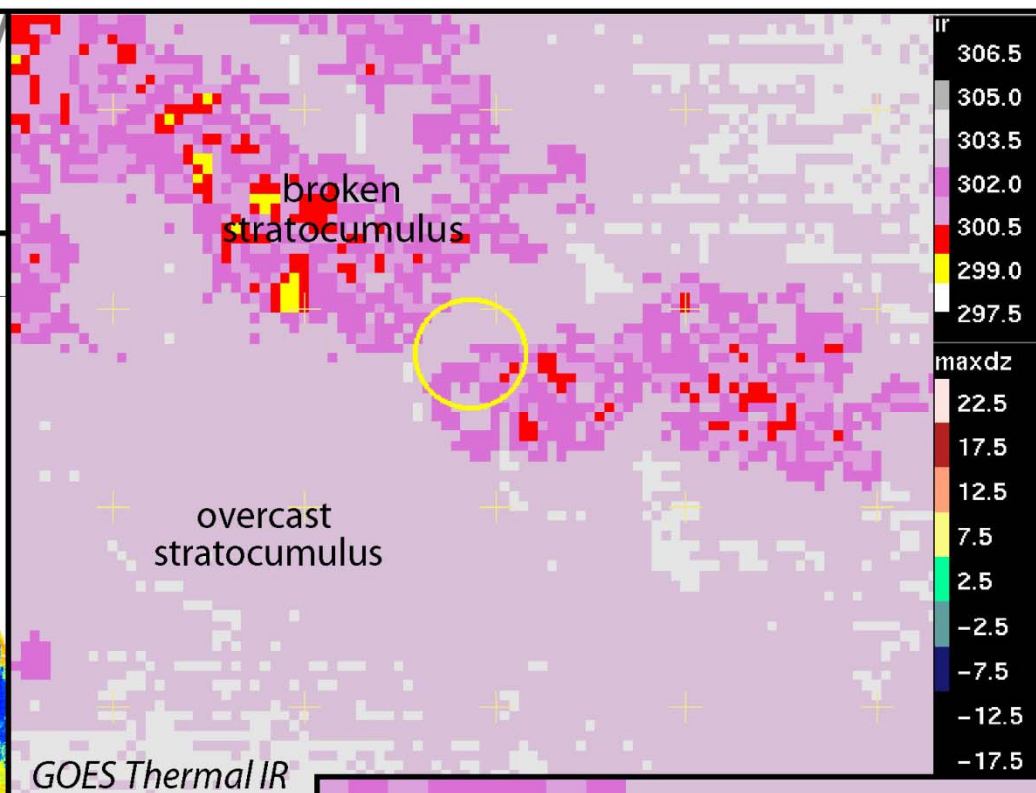
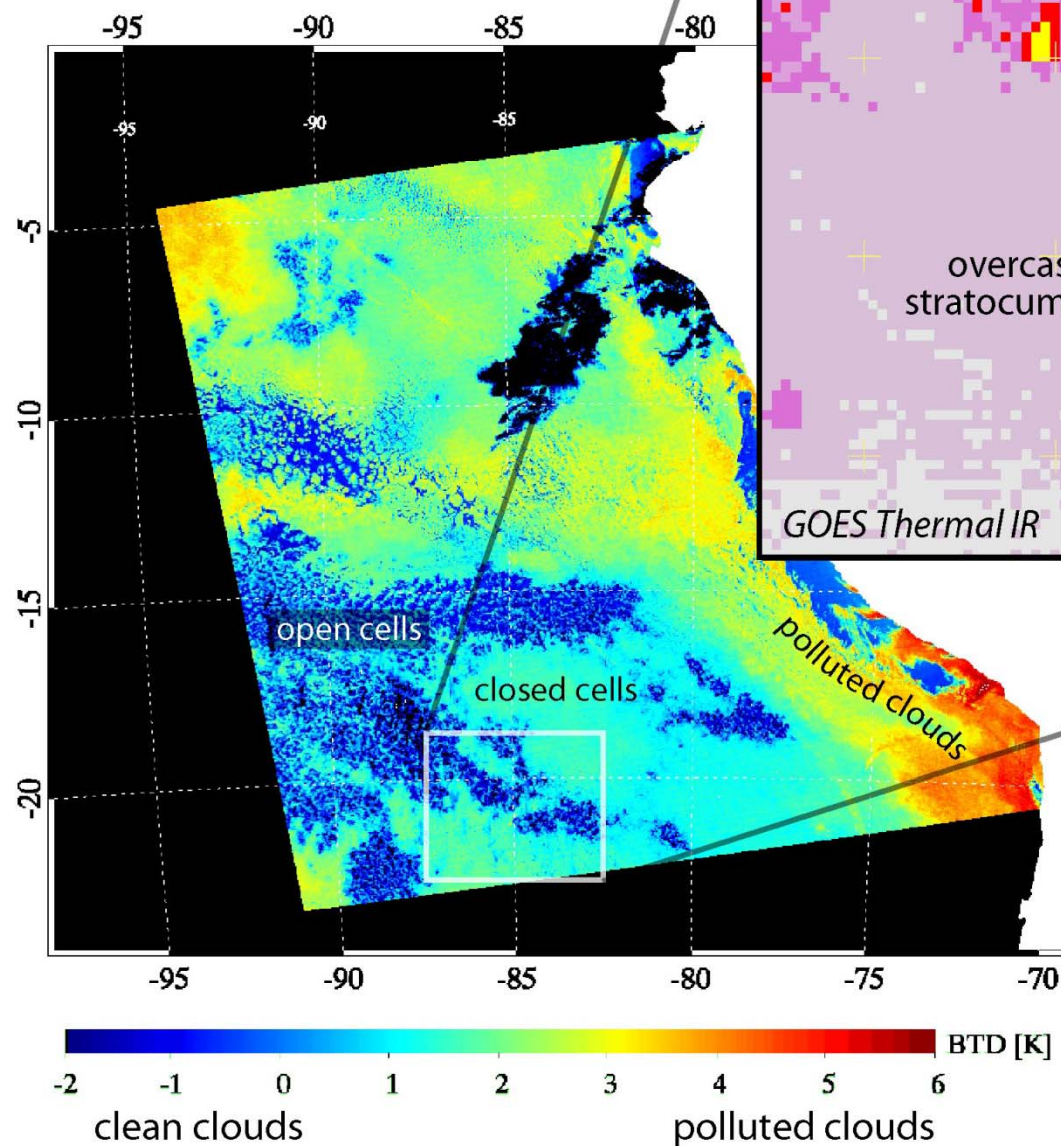


Figure 7.12. The Hadley cell scenario for transporting aerosols between the tropics and sub-tropics. [Adapted from F. Raes et al., in *Dimethylsulphide: Oceans, Atmosphere and Climate*, Ed. G. Restelli and G. Angeletti, Kluwer Academic Publishers (1993), with permission from Kluwer Academic Publishers.]

Hobbs 2000

October 19 2001 - 11:45pm local

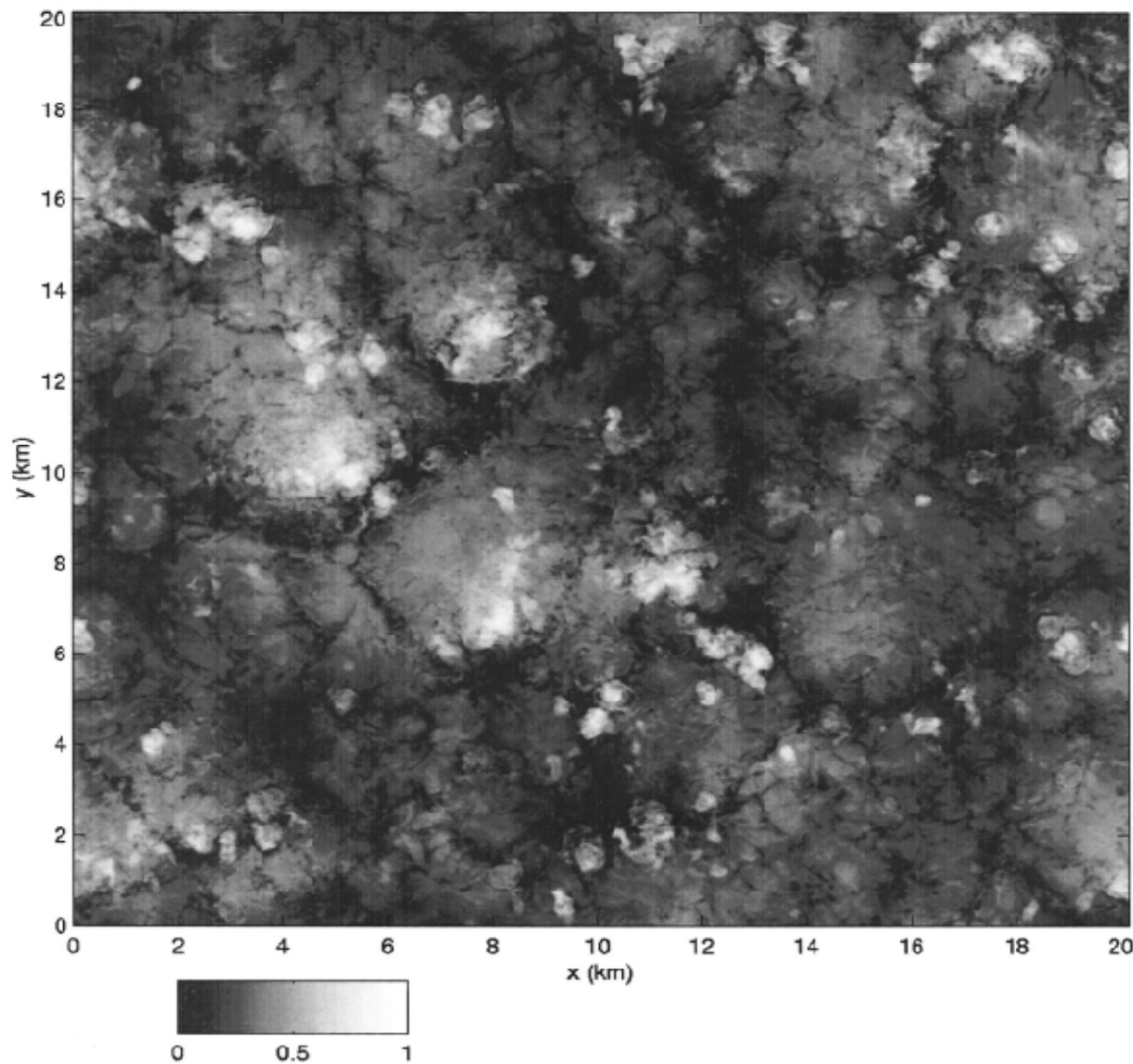
MODIS Ch20-Ch31
Brightness Temperature Difference



Modeling clouds and precipitation

- **Forecasting of precipitation**
 - **Climate impacts**

From the sublime....

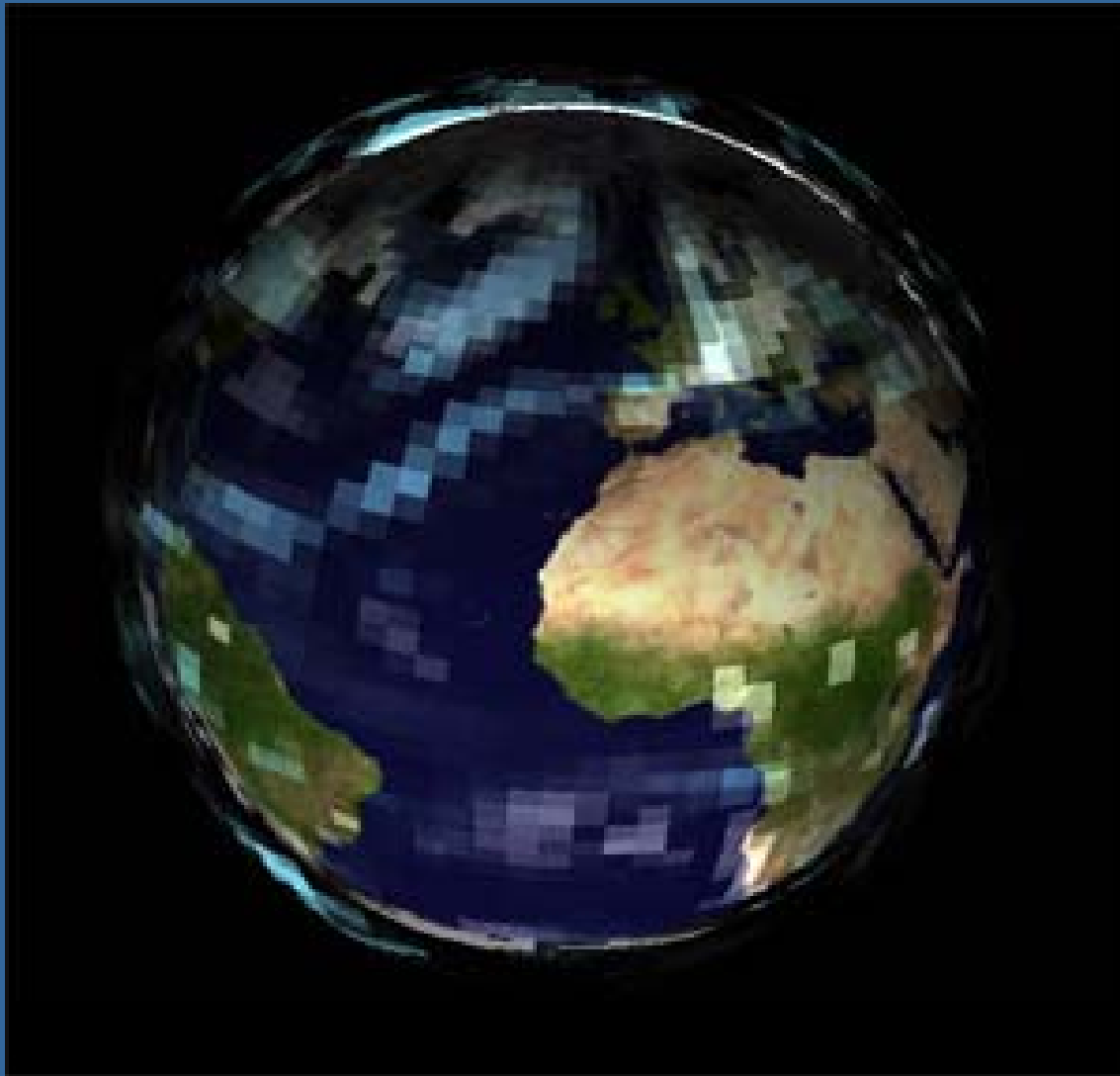


**10x10x5 m
resolution**

**20x20x3 km
domain**

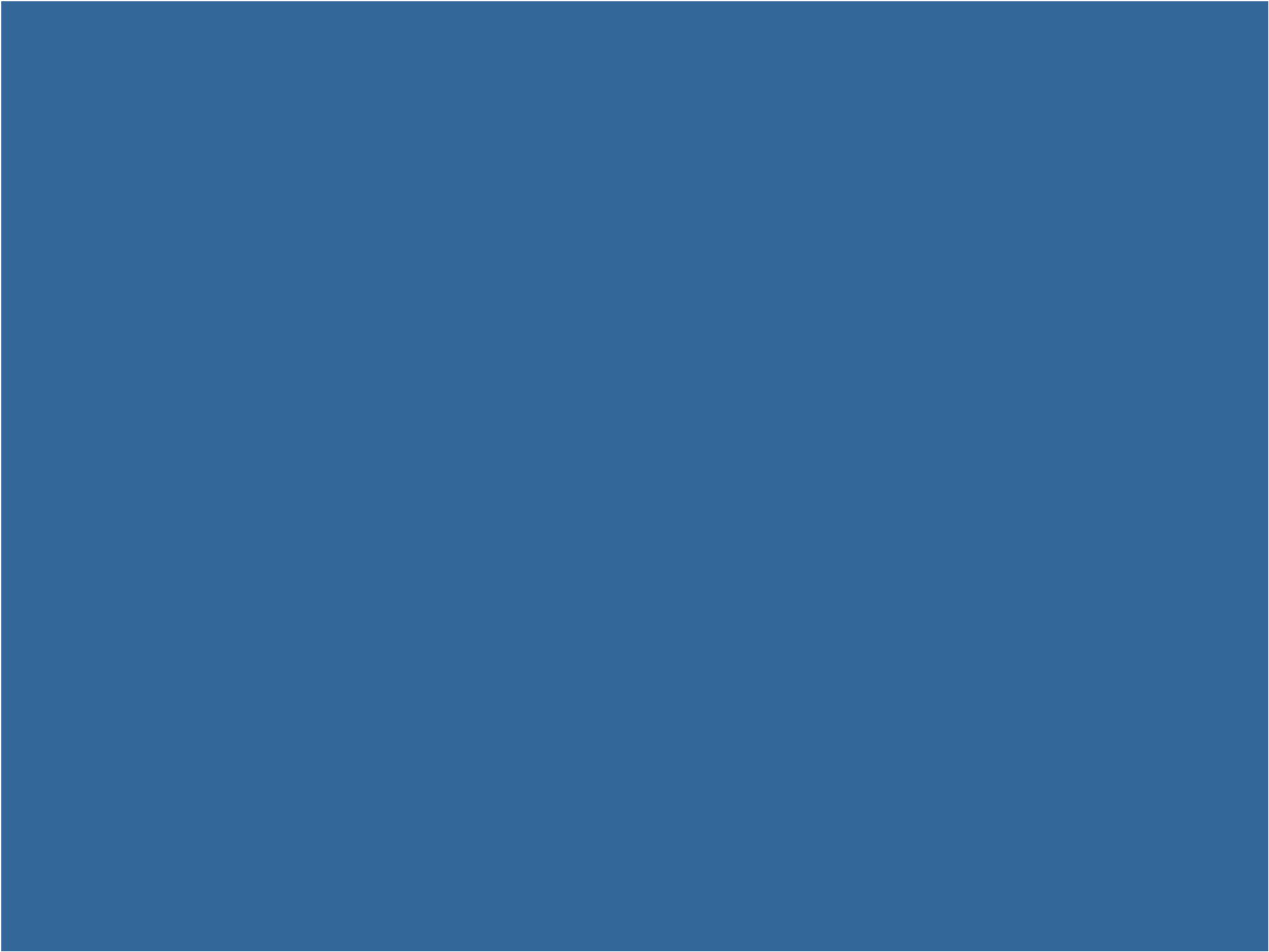
Stevens et al. (2002)

....to the ridiculous, but necessary



**3x3° resolution
global domain**

climateprediction.net



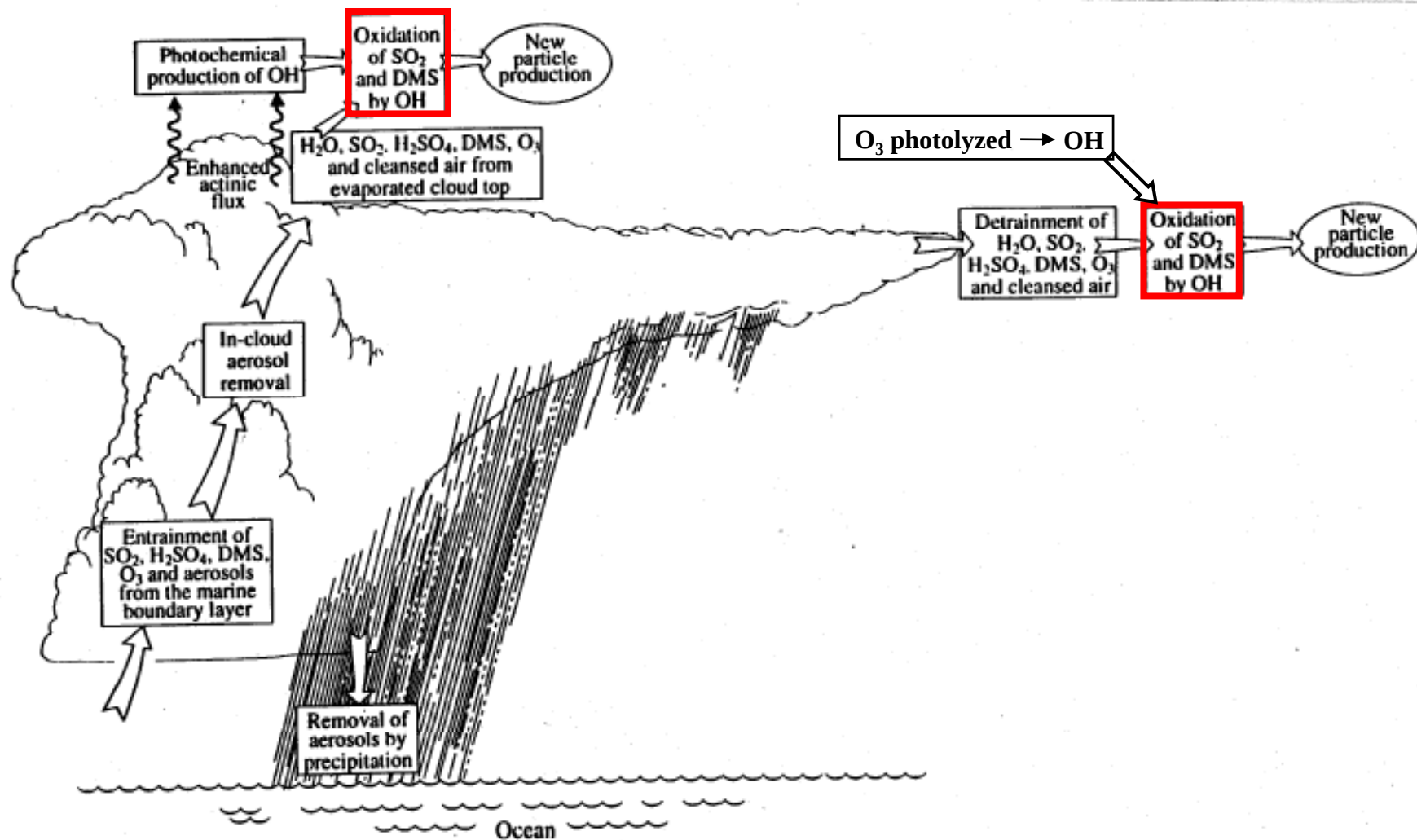


Figure 7.11. Schematic diagram illustrating a conceptual model for new particle production near marine convective clouds. [From K. Perry and P. V. Hobbs, *J. Geophys. Res.*, **99**, 22813 (1994). Copyright © by the American Geophysical Union.]