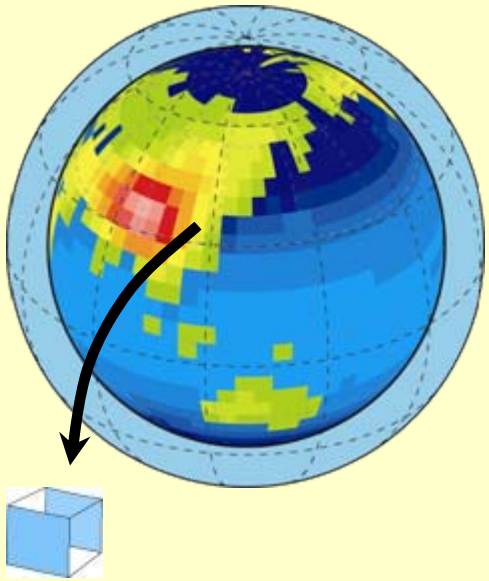
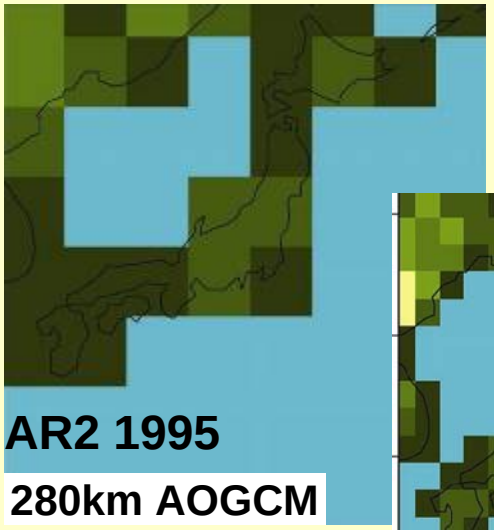
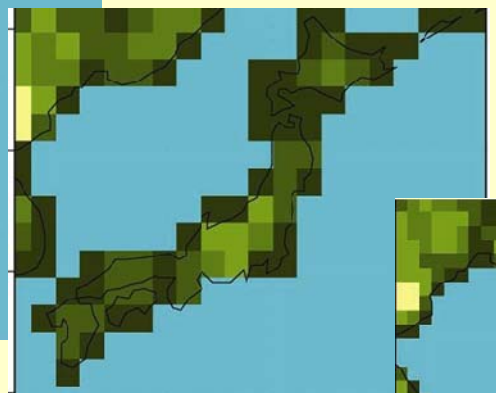
課題2：解像度





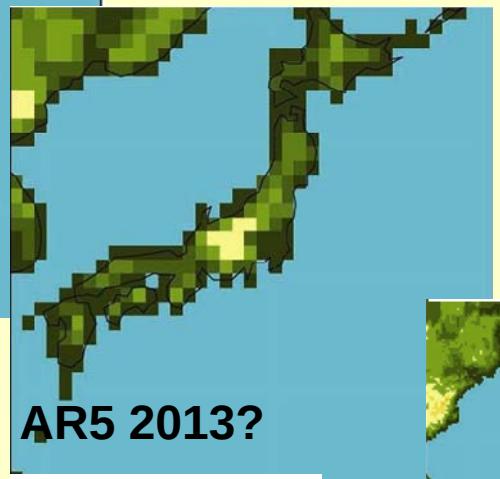
AR2 1995

280km AOGCM



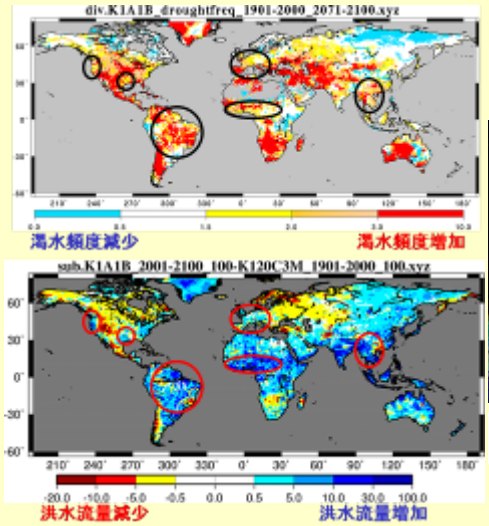
AR4 2007

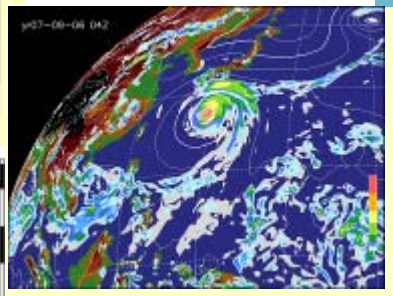
110km AOGCM



AR5 2013?

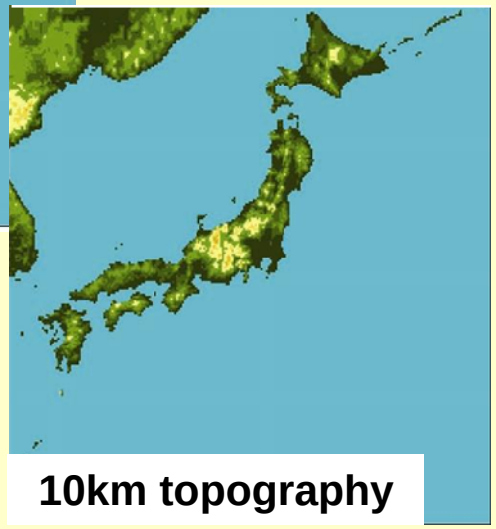
60km AOGCM





20km AGCM

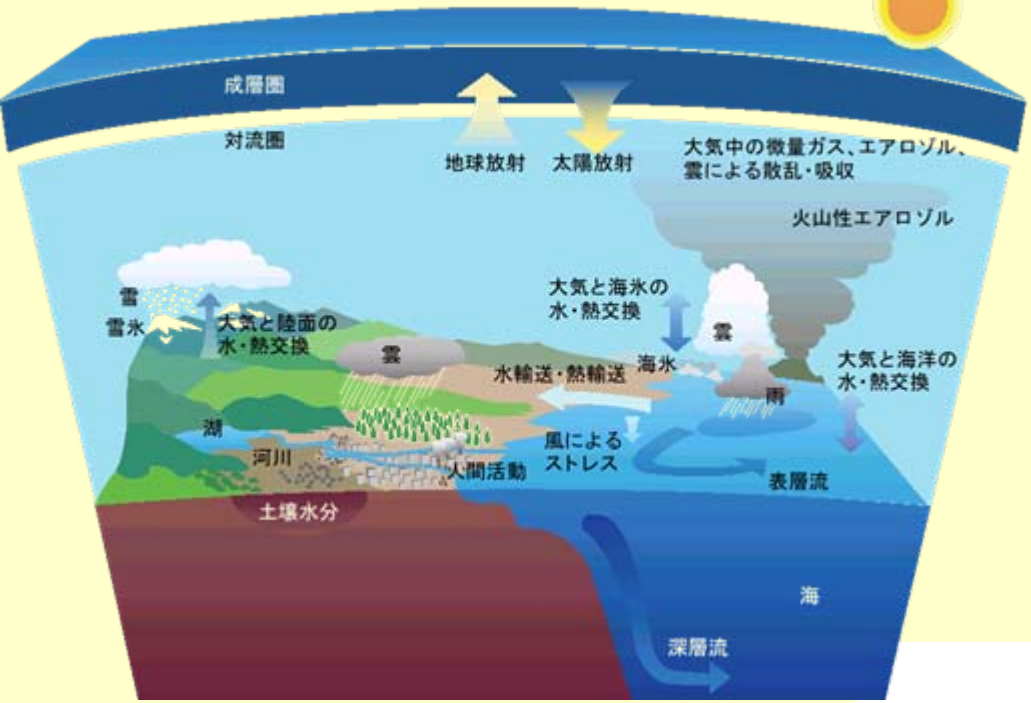
雲解像～数km以下

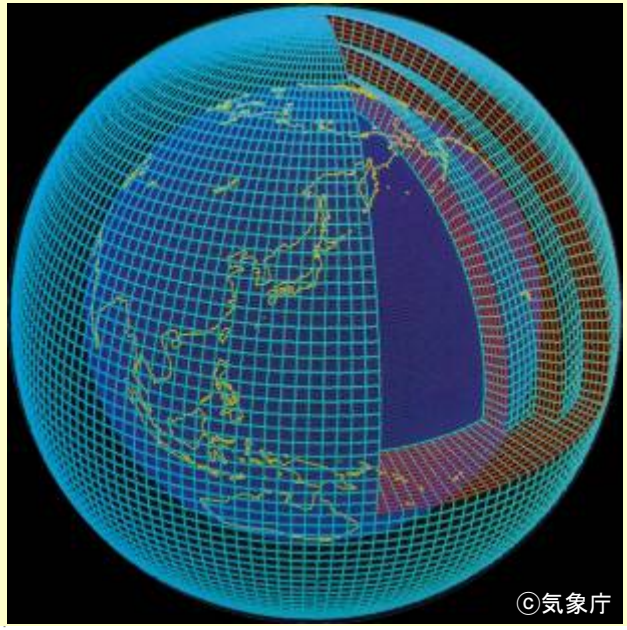


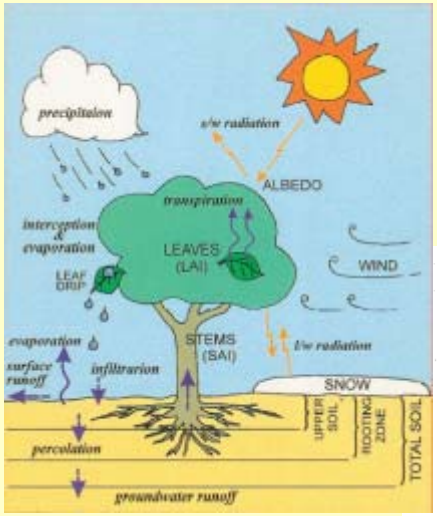
10km topography

台風など極端現象の変化、その地理分布に大きな不確定

気候モデル—コンピュータの中の地球







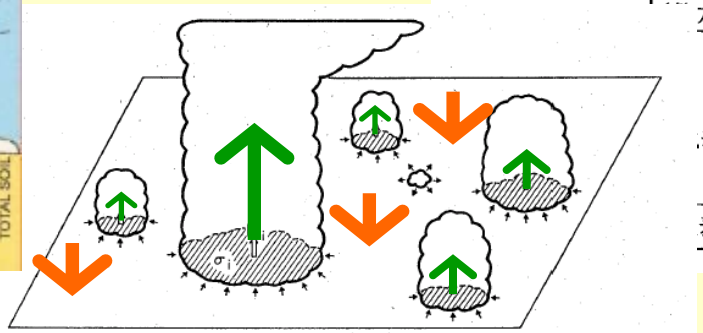
$$\frac{d\rho}{dt}+\rho\left(\frac{1}{a\cos\varphi}\frac{\partial u}{\partial\lambda}+\frac{1}{a\cos\varphi}\frac{\partial v\cos\varphi}{\partial\varphi}+\frac{\partial w}{\partial z}\right)=0$$

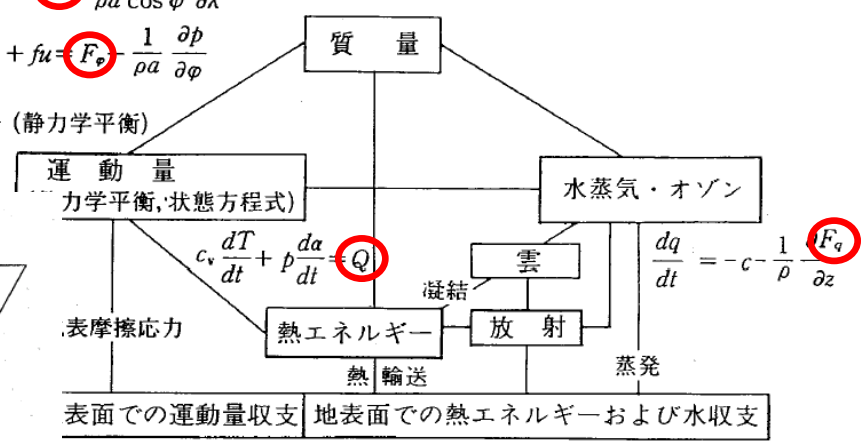
$$\frac{du}{dt}-\frac{\tan\varphi}{a}uv-fv=F_\lambda-\frac{1}{\rho a\cos\varphi}\frac{\partial p}{\partial\lambda}$$

$$\frac{dv}{dt}+\frac{\tan\varphi}{a}u^2+fu=F_\varphi-\frac{1}{\rho a}\frac{\partial p}{\partial\varphi}$$

$$0=-g-\frac{1}{\rho}\frac{\partial p}{\partial z}\quad\text{(静力学平衡)}$$

$$p=\rho RT$$

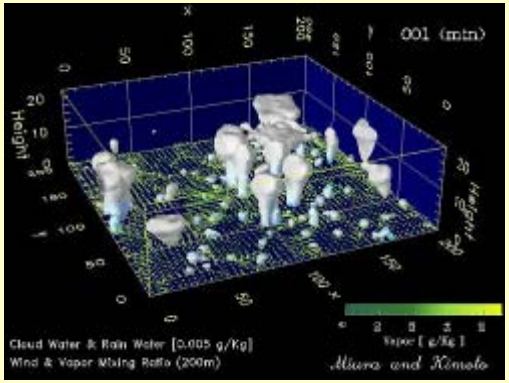




物理過程のパラメタリゼーション*

*格子平均量で格子点以下のスケール（サブグリッドスケール）の現象の(集団)効果を表現すること

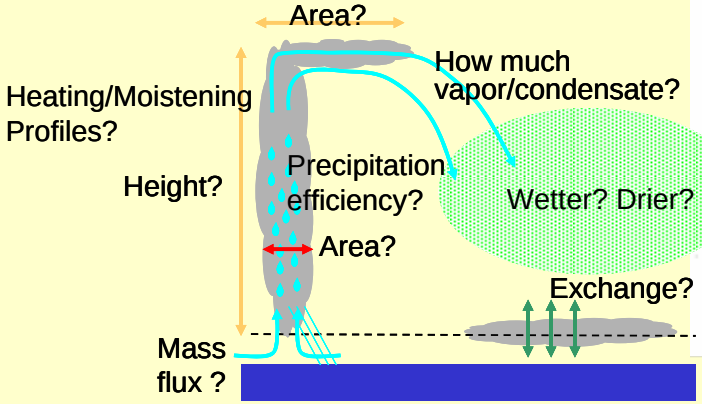
- 放射
- 雲（層状）
- 積雲対流
- 降水
- 乱流
- 境界層
- 地表面過程
- 重力波抵抗
- …

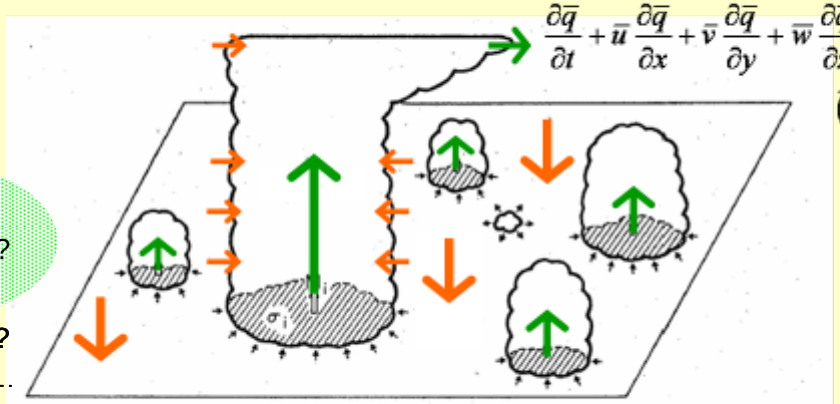


$$\frac{\partial \overline{T}}{\partial t} + \overline{u}\frac{\partial \overline{T}}{\partial x} + \overline{v}\frac{\partial \overline{T}}{\partial y} + \overline{w}\frac{\partial \overline{T}}{\partial z} = -\frac{\partial \overline{w'T'}}{\partial z} \Leftarrow F(\overline{T}, \overline{q}, \overline{u}, \overline{v}, \overline{w})$$

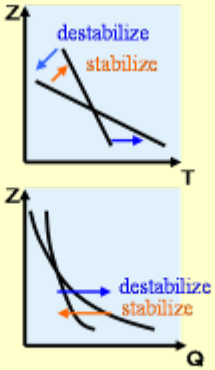
$$\frac{\partial \overline{q}}{\partial t} + \overline{u}\frac{\partial \overline{q}}{\partial x} + \overline{v}\frac{\partial \overline{q}}{\partial y} + \overline{w}\frac{\partial \overline{q}}{\partial z} = -\frac{\partial \overline{w'q'}}{\partial z} \Leftarrow G(\overline{T}, \overline{q}, \overline{u}, \overline{v}, \overline{w})$$

$\overline{(\ )}$: grid average, $(\ )'$: deviation

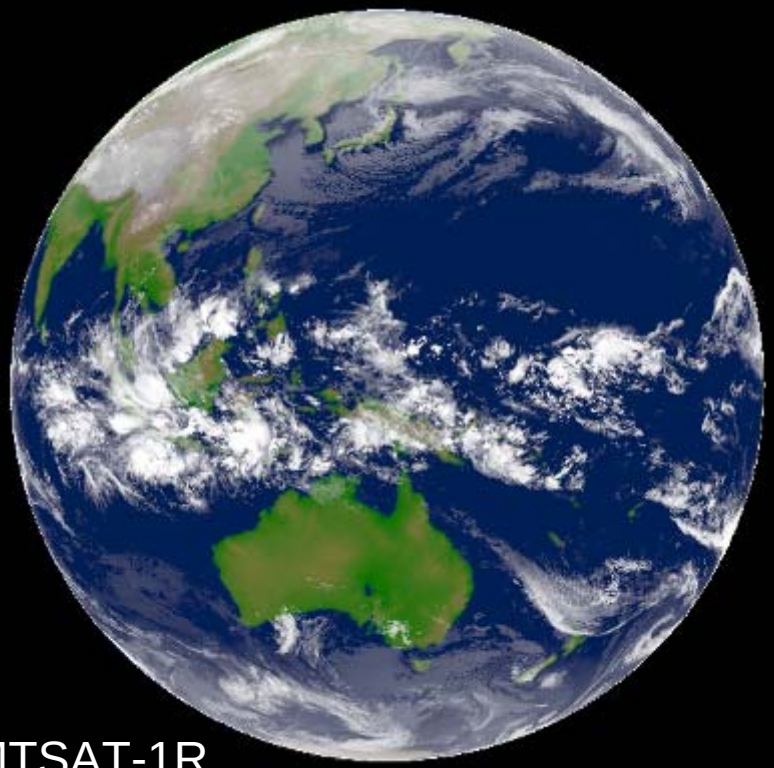




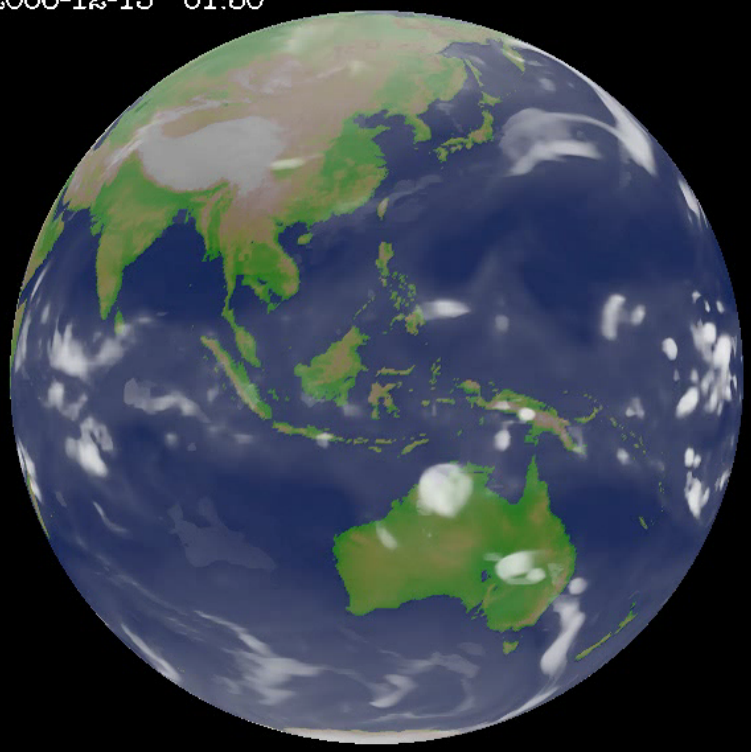
AGCM grid interval~O(100km)



Global Cloud System Resolving Model



MTSAT-1R



M. Satoh and NICAM group

A case study
- MJO event in the boreal winter, 2006

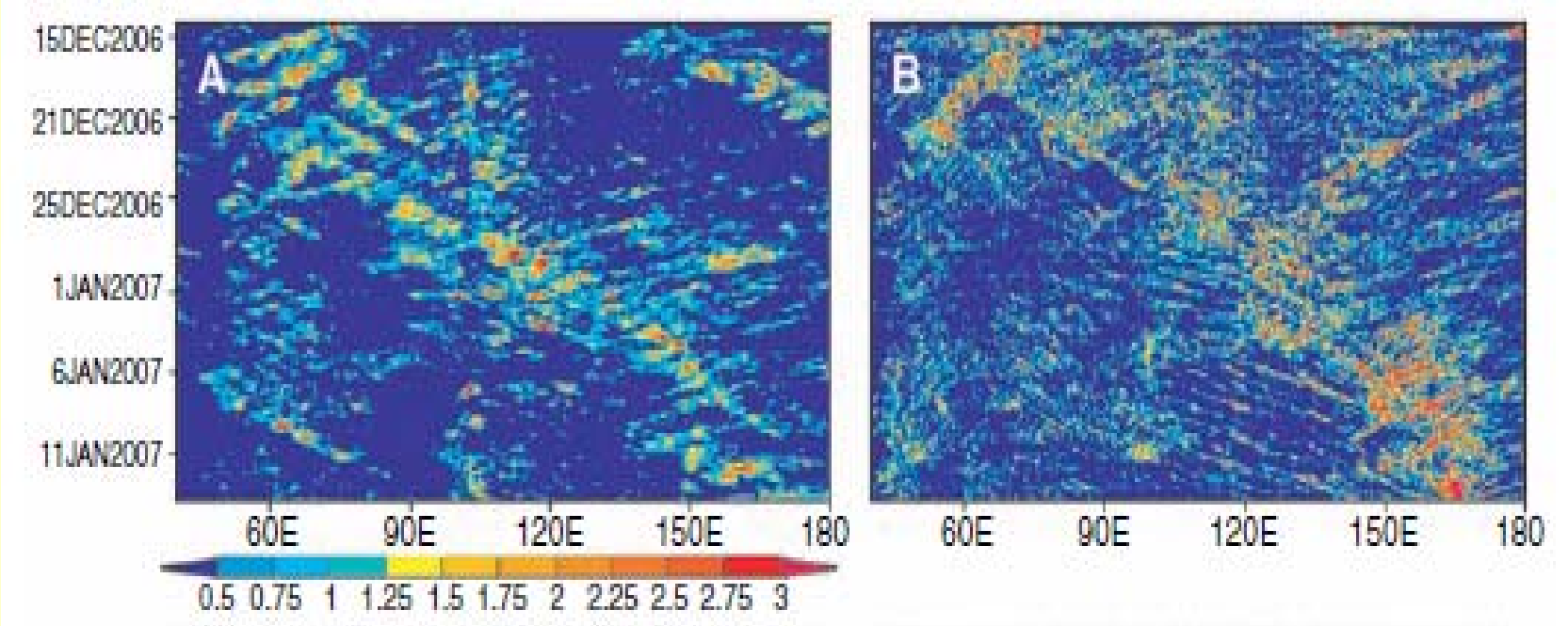


Fig. 3. Time/longitude (Hovmöller) sections. Surface precipitation (in millimeters per hour) averaged between 10°S and 5°N from (**A**) the TRMM 3B42 data and (**B**) the 7-km grid run. The vorticity (10^{-5} per second) at the 850-hPa level averaged between 10°S and 5°S from (**C**) the NCEP analyses and (**D**) the 7-km grid run.

Miura et al., *Science* 318, 1763 -1765 (2007)