Modification of the general circulation of the atmosphere due to climate change

„Global change monitoring“

Martin König

Klima
Umweltbundesamt

umweltbundesamt
www.umweltbundesamt.at

Basics for the general circulation

- Parameters for the atmospheric circulation are:

1. Temperature and
2. Moisture content of airmasses

- These result in regionally diversified (thermal/hydro) air pressure fields compensation movements which are:

on the local level – wind

on the regional level – cyclons and pressure fields

on the global level – general circulation of the atmosphere

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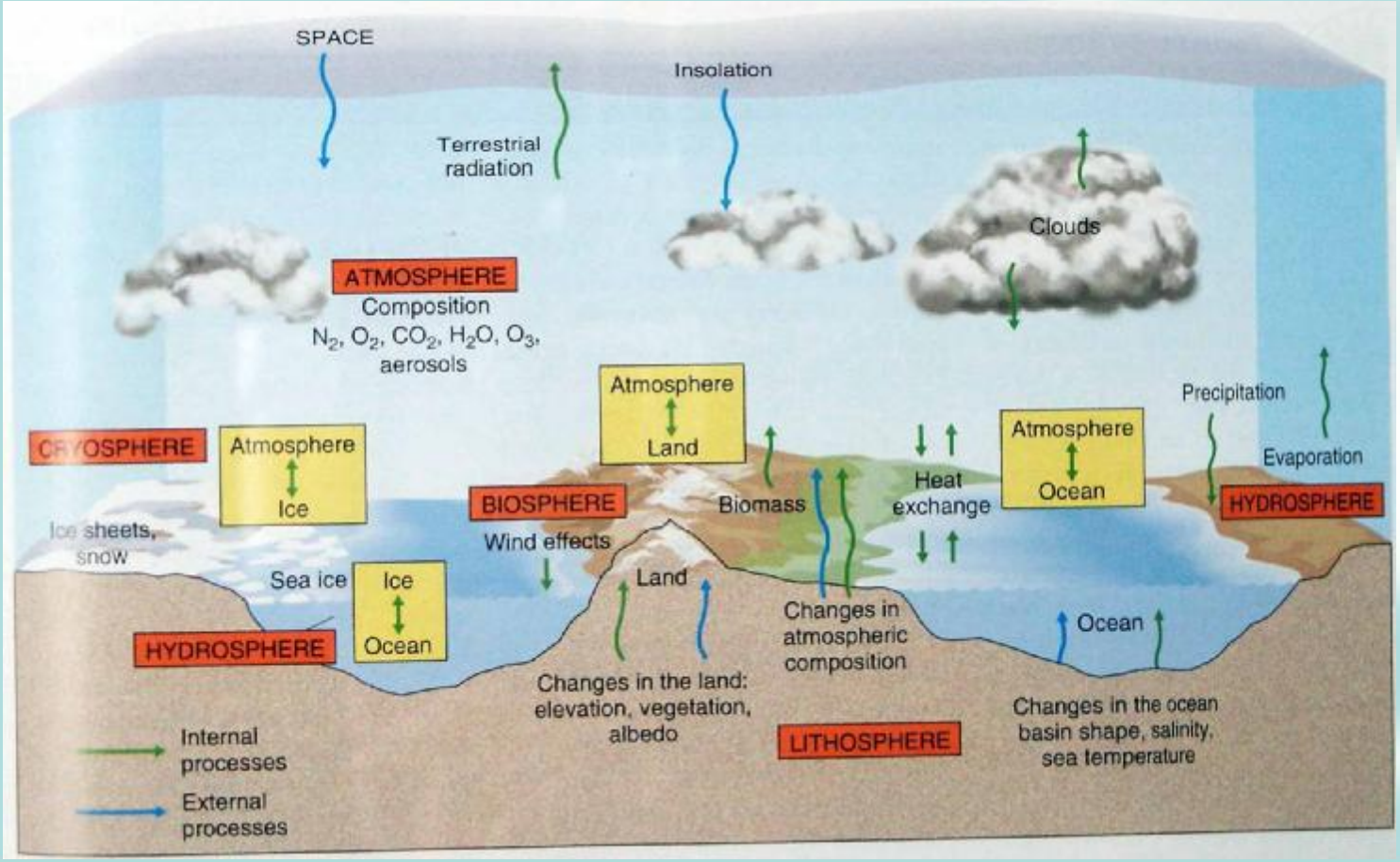
Basics for the general circulation

- **Variable factors are:**

1. **Surface temperatures of oceans (SST) and continents**
2. **The oceanic circulation**
3. **Sea ice (albedo and interrupted heat transport)**
4. **Snow coverage (albedo)**
5. **Soil(moisture)**
6. **Vegetation**
7. **Land-use (sealing, acres, pasture, urban spaces,...)**
8. **Sun activity, gravitation field and other extraterrestrial influences**

Basics for the general circulation

- **4 interactions**



Christopherson 2000

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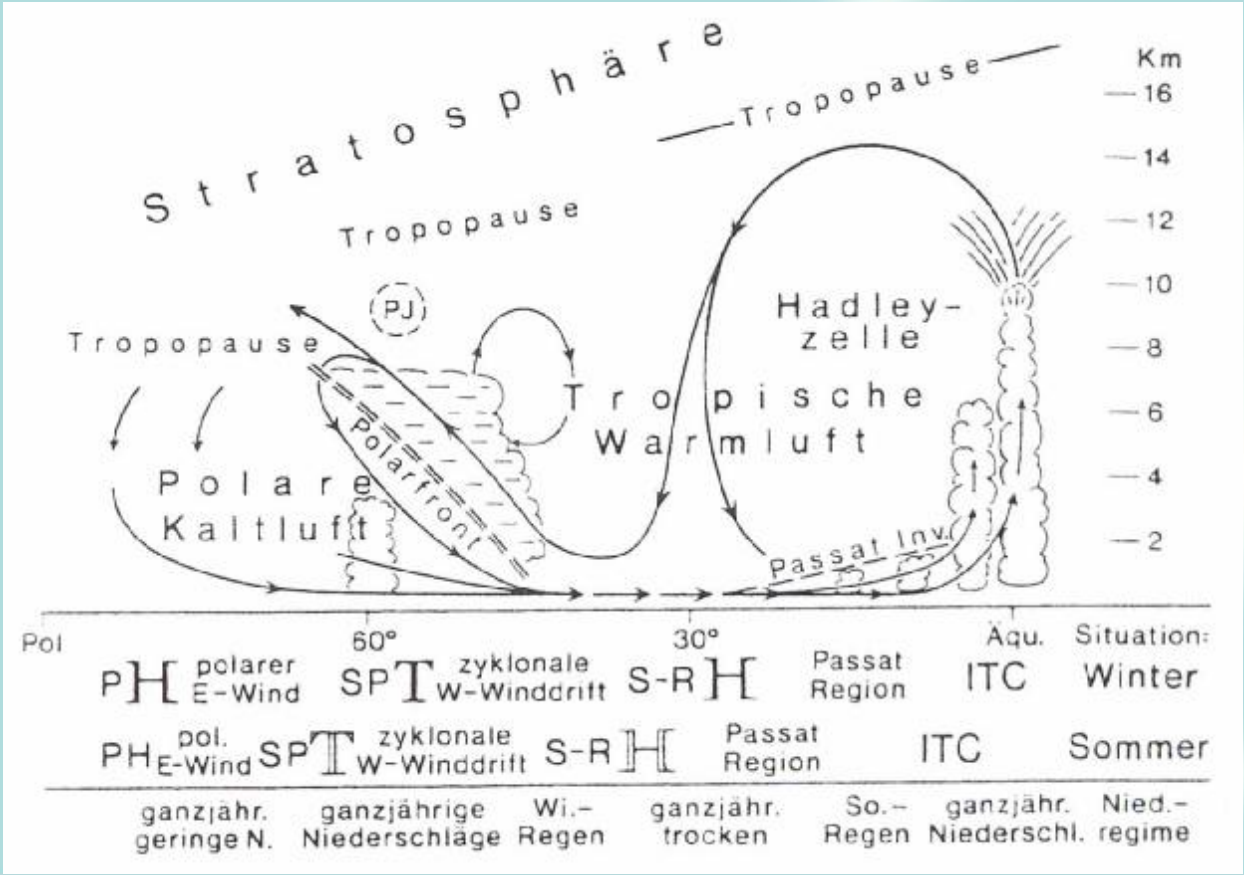
Basics for the general circulation

- **stabilisation criteria:**
- **There is a lower stability of air films where there is:**

1. **High temperature on the ground (heating from the surface)**
2. **Wet airmasses which accelerate convection (the higher the humidity of airmasses, the stronger is the convection = ascending of airmasses)**

Resulting circulation patterns

4 **Hadley circulation and inner-tropical convergence (ITC):**



Weischet 1991

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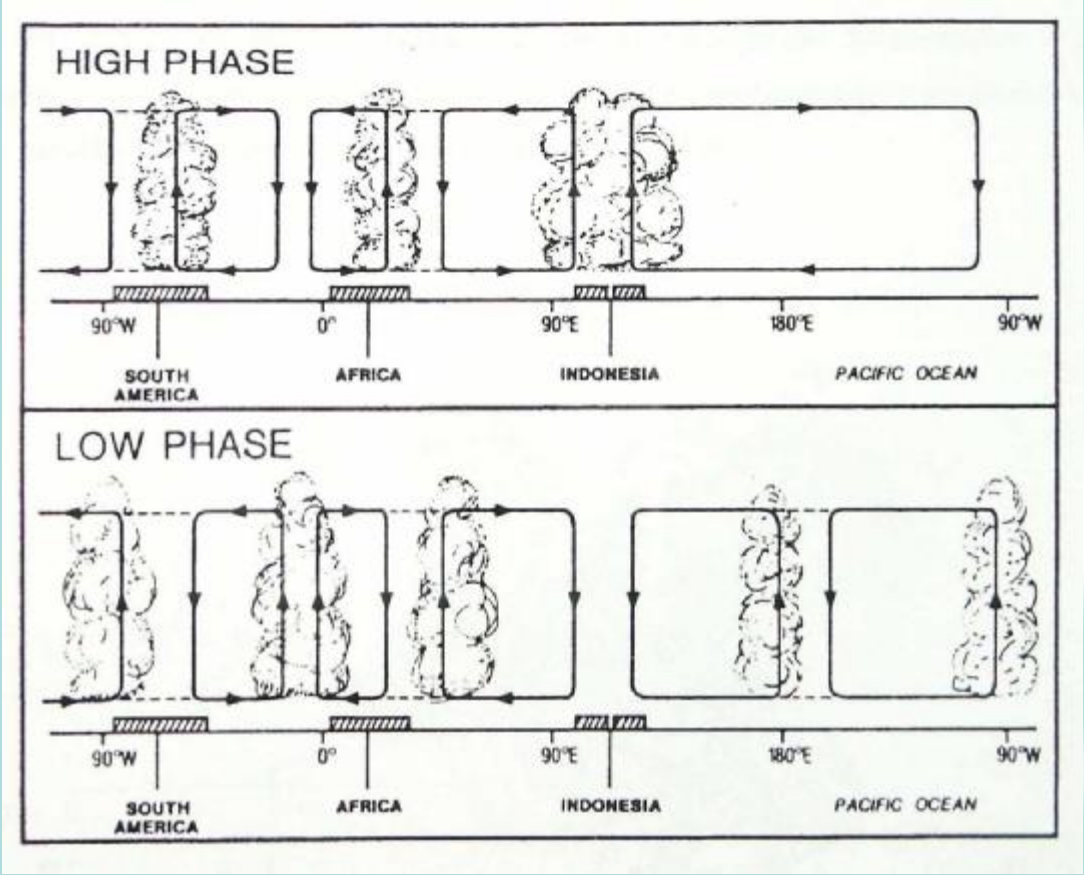
Resulting circulation patterns

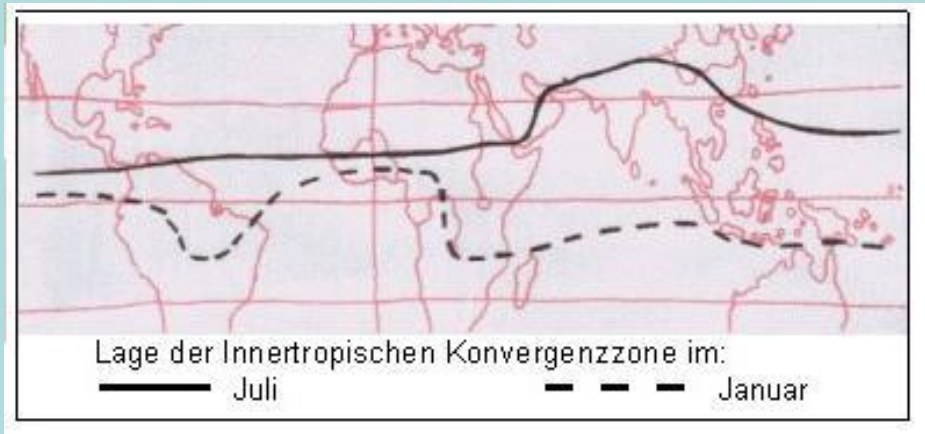
- **Walker circulation:**



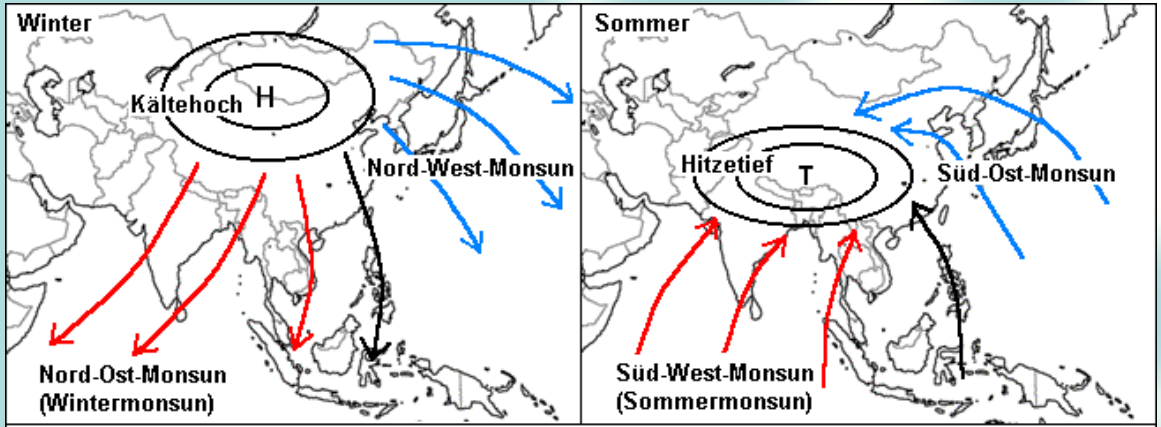
Lindesay/Tyson 1986

Resulting circulation patterns

4 Monsoon circulation:



http://muf.forkel.bei.t-online.de/klima/zirk_passat.html



Die tropische und außertropische Monsunzirkulation

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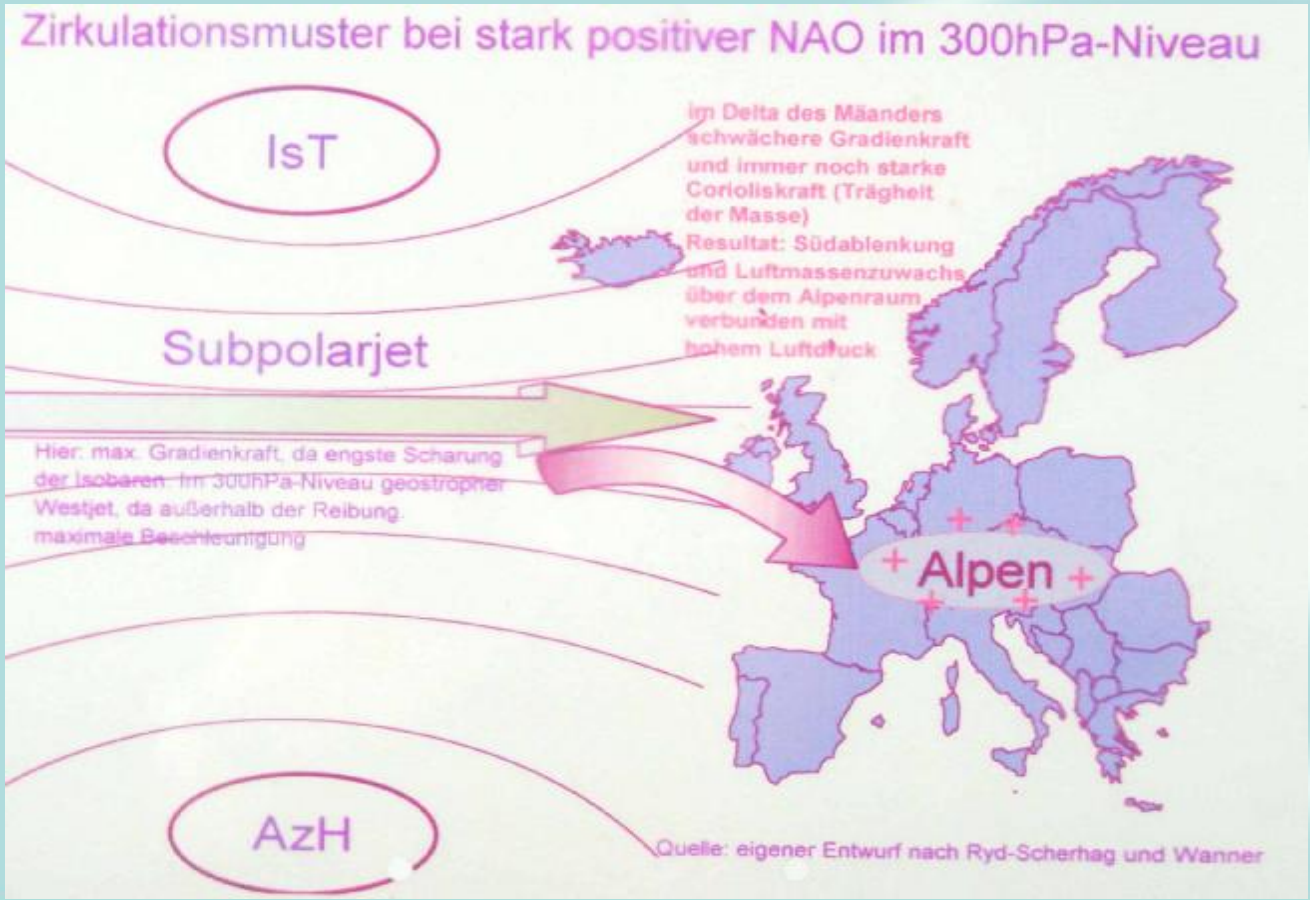
Resulting circulation patterns

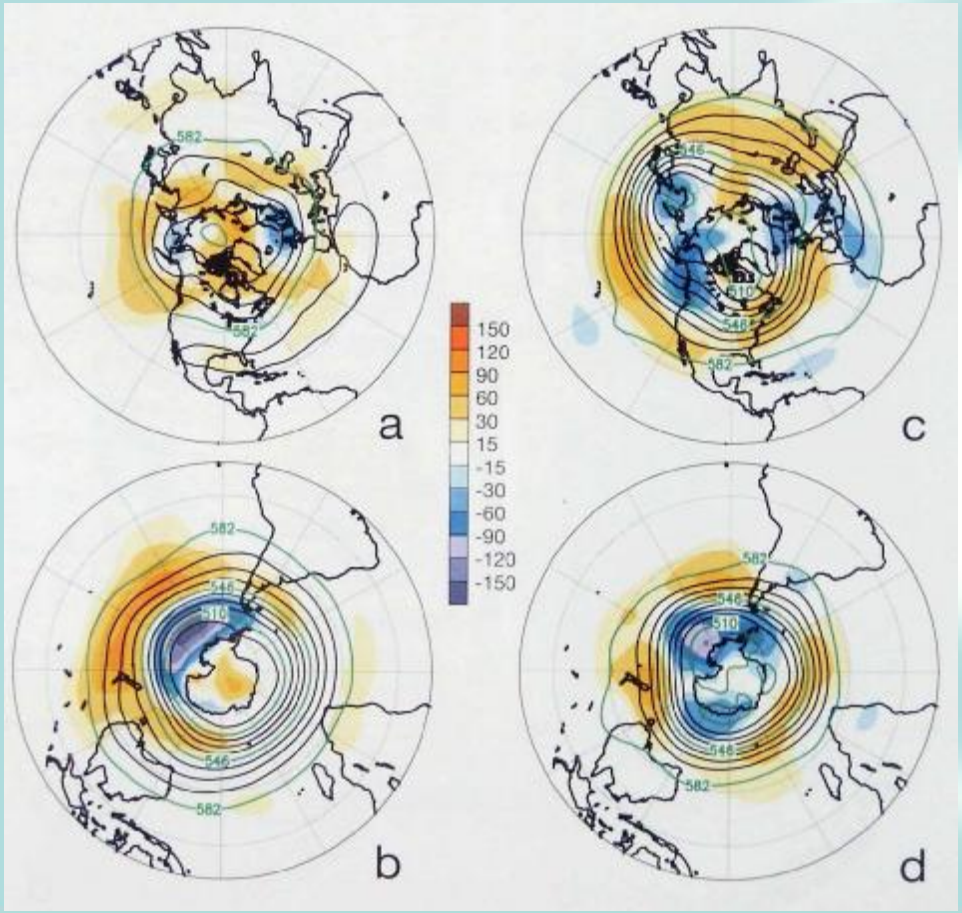
- **North Atlantic Oscillation (NAO) and dynamic air pressure fields:**



König 1996

Resulting circulation patterns

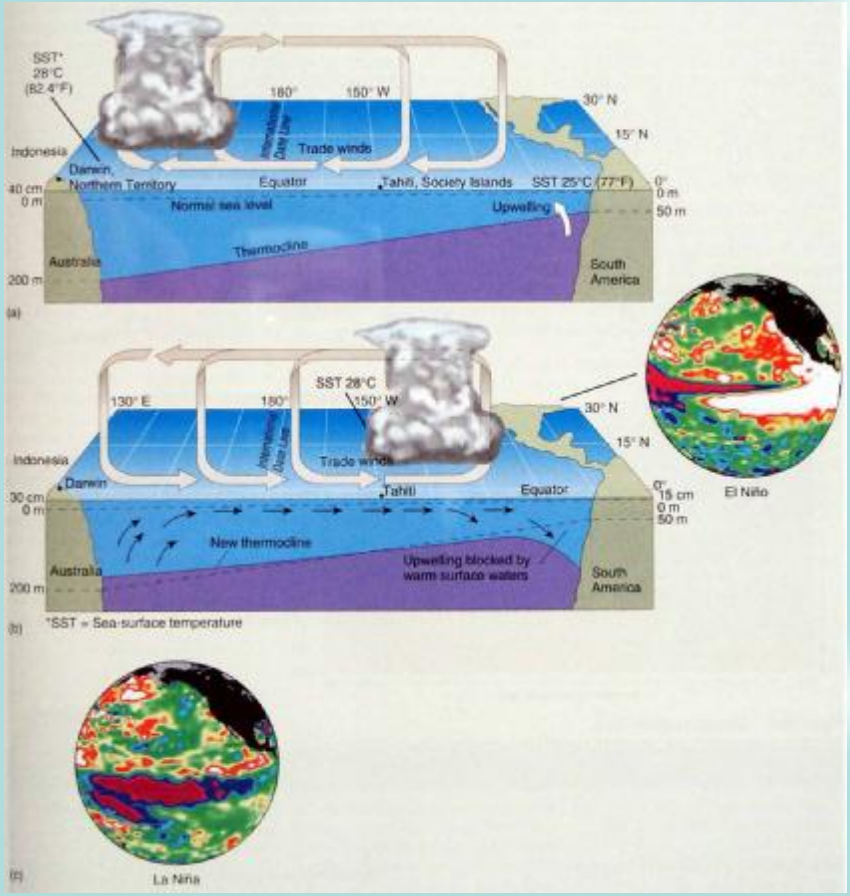
4 **Southern hemisphere circulation versus northern hemisphere circulation:**



WMO 2003

Resulting circulation patterns

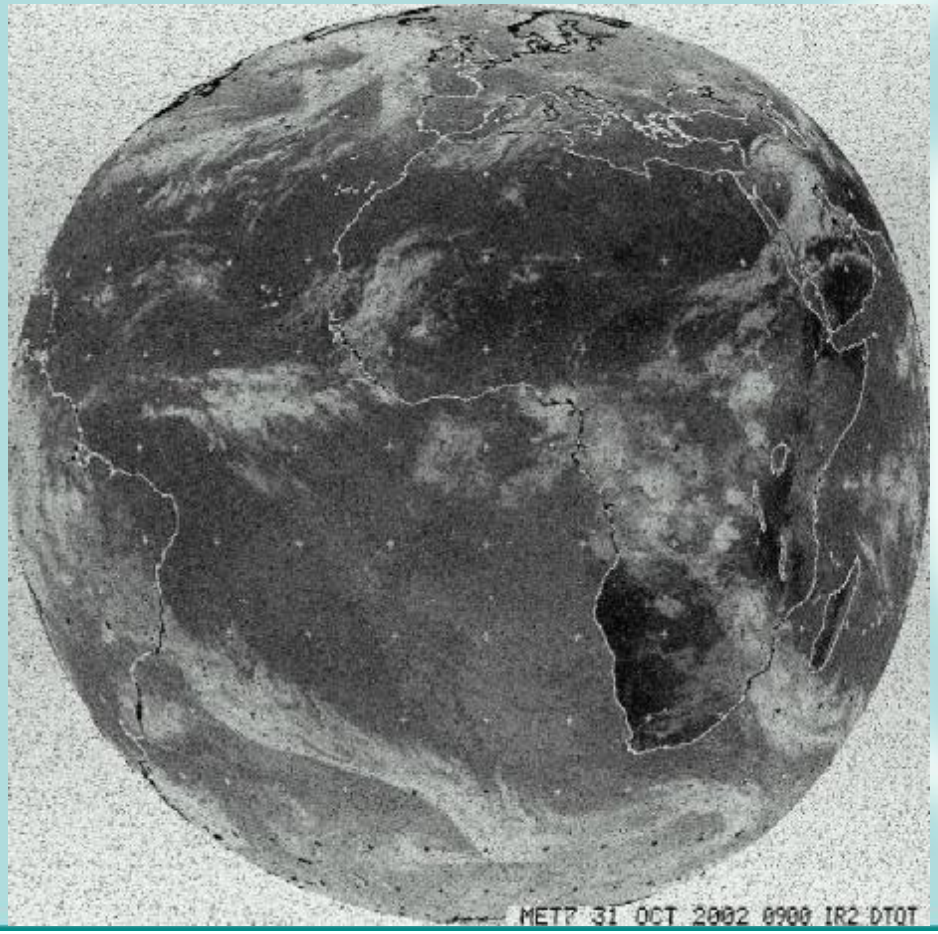
4 **El Nino Southern Oscillation (ENSO):**



WMO 2003

Resulting circulation patterns

- **METEOSAT, 31rd October 2002:**



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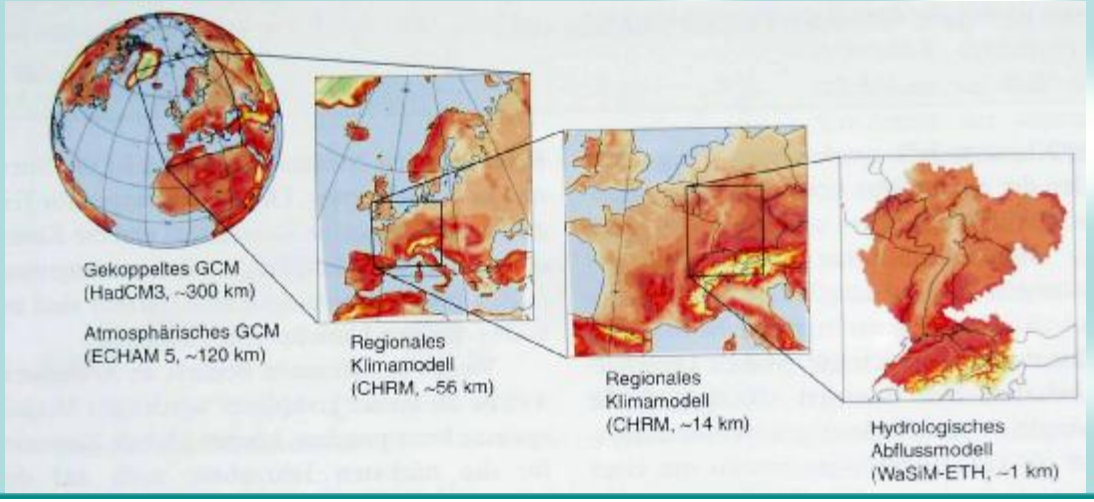
Excursus: climate models

- Energy balance models (EBM) – history
- Radiative convective models – history
- Global circulation models (GCM)
  - Only atmosphere – history
  - Atmosphere coupled with ocean – state of the art

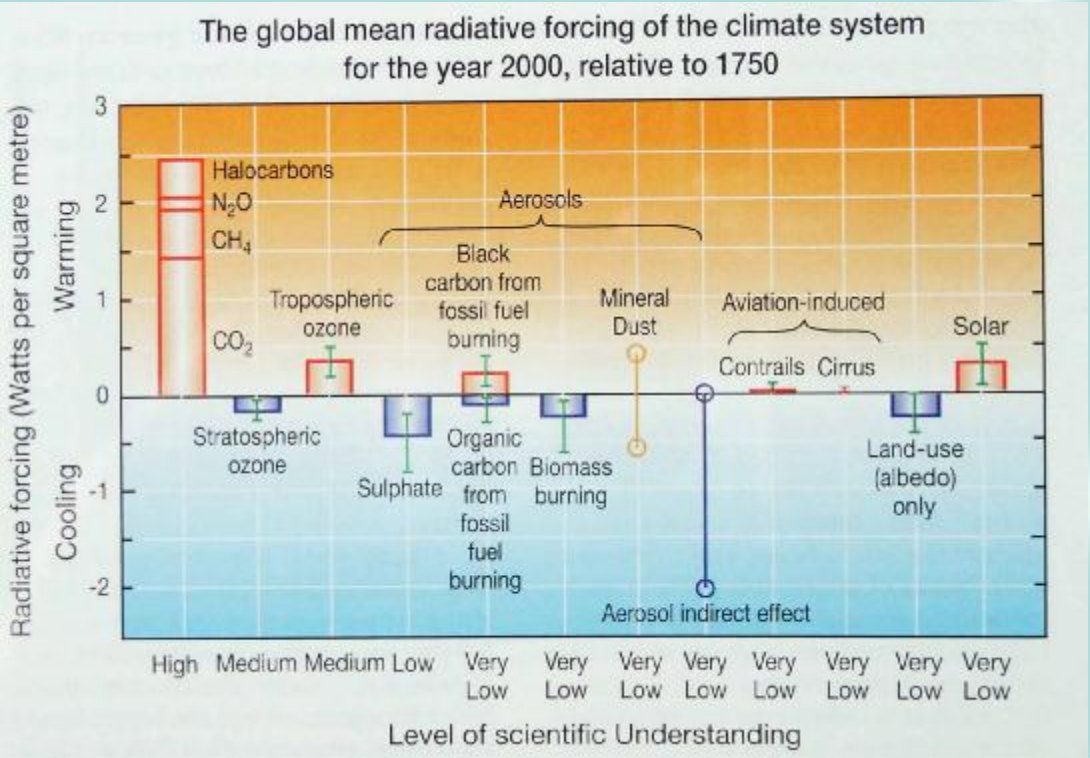
- Resolution of global versus regional circulation models:

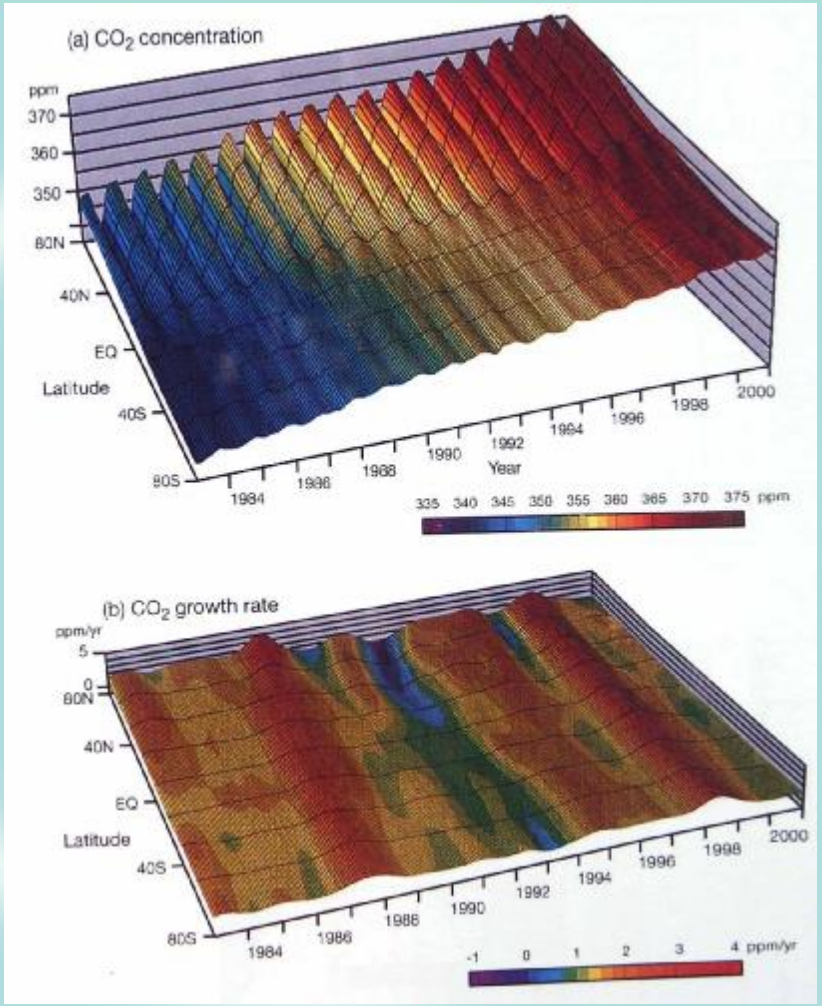


OcCC 2003

Greenhouse gas concentration and impact

- **CO2-concentration**
- **Radiative forcing**





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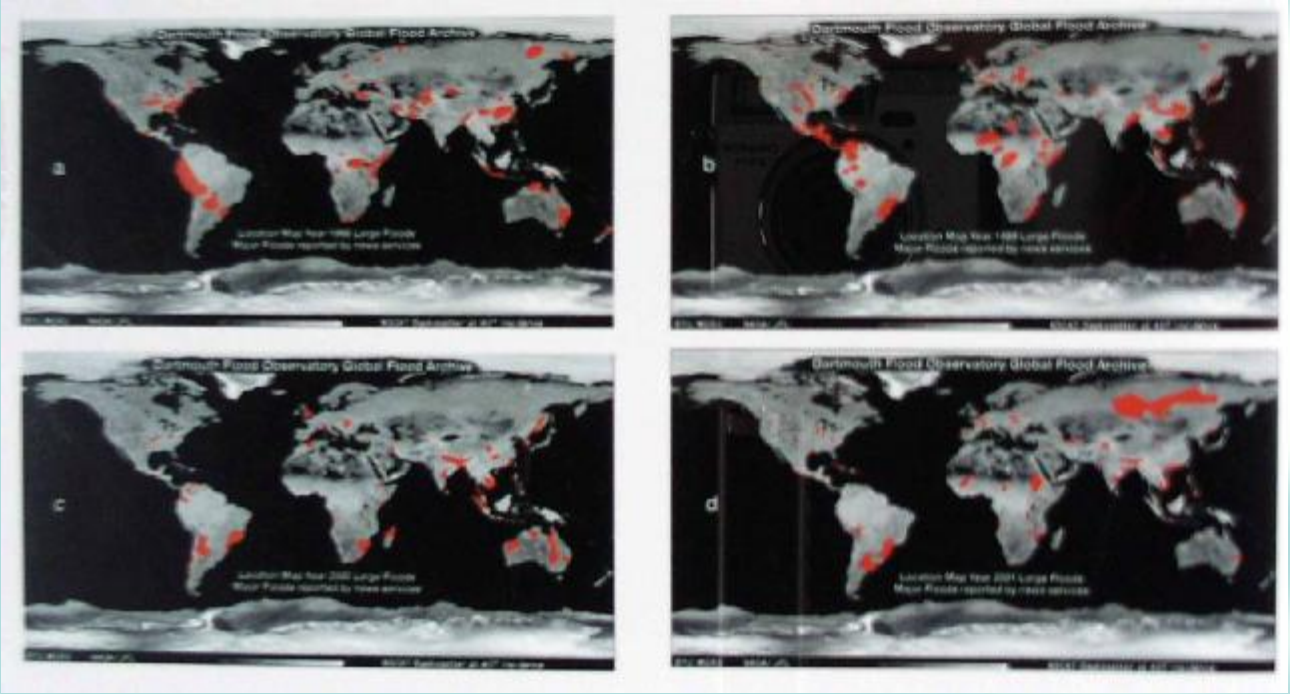
Possible changes of circulation patterns

- More extreme events (?) e.g. floodings, droughts, heat waves, storms/hurricanes, mudflows, avalanches,...



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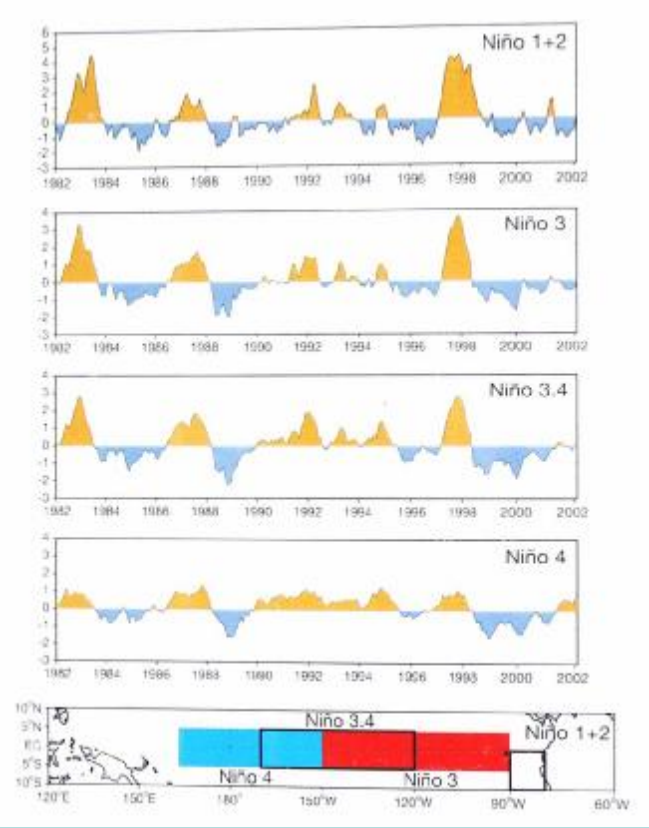
Possible changes of circulation patterns

- **Long-term changes in ENSO (?)**



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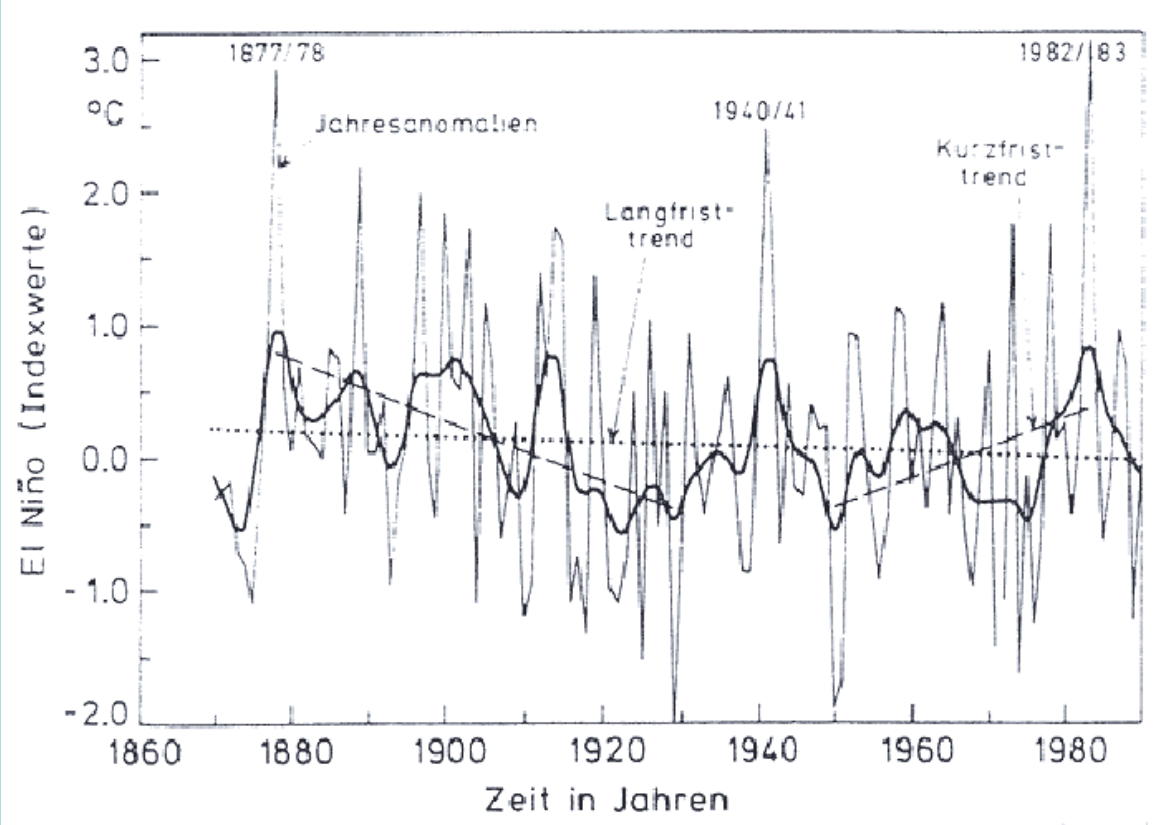

Schönwiese 1995

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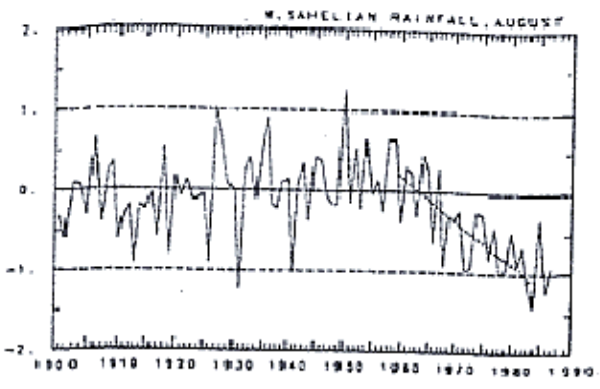
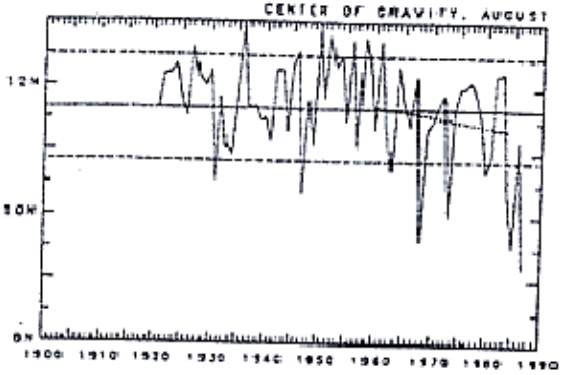
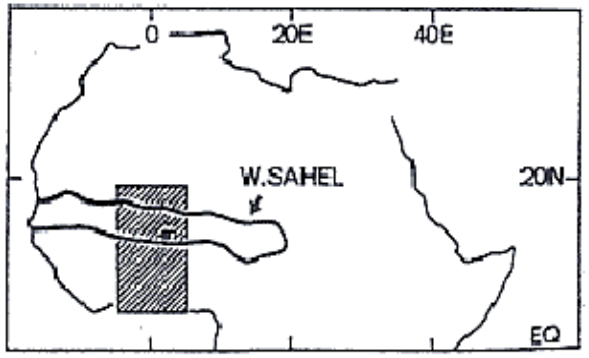
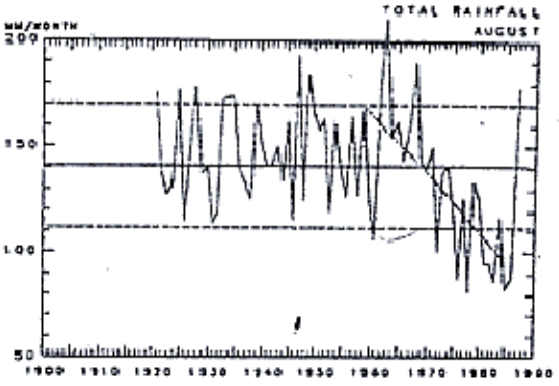
Possible changes of circulation patterns

4 Long-term changes in the ITC (?)

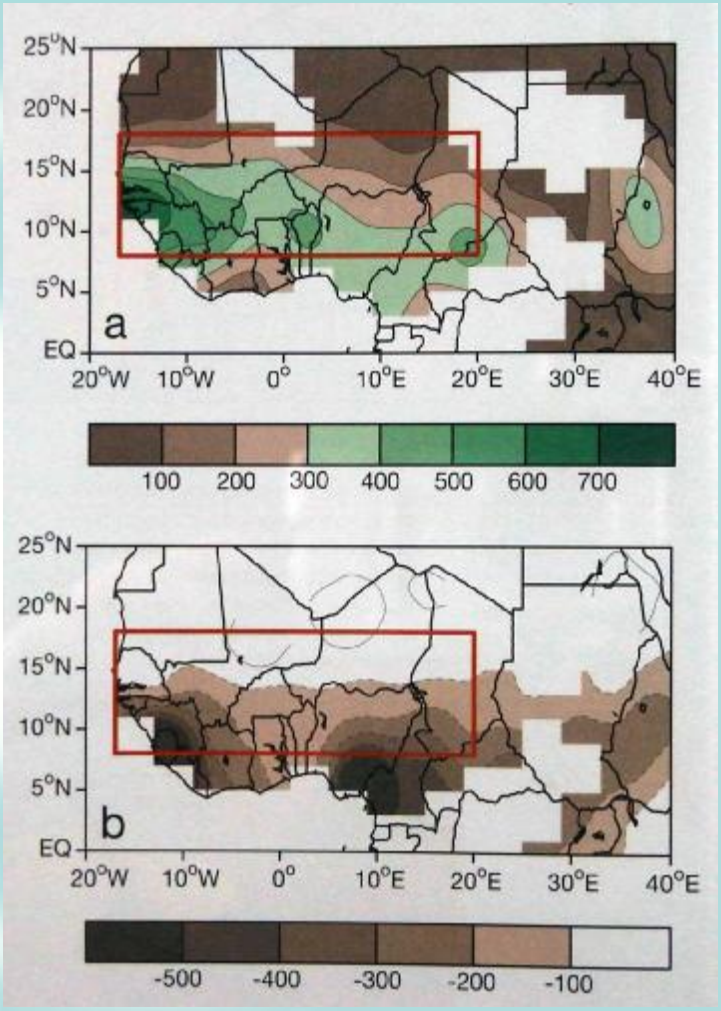








Shinoda/Kawamura 1994



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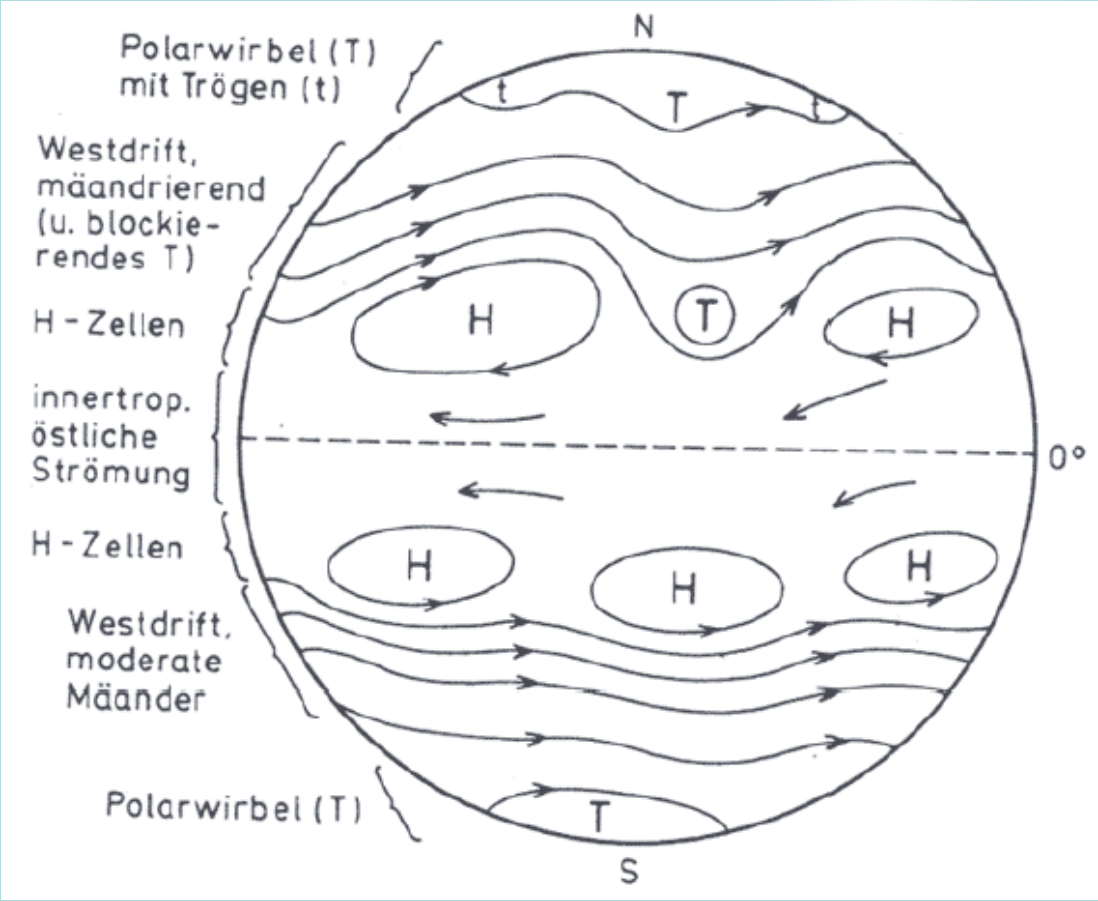
Possible changes of circulation patterns

4 **Shift in air pressure belts due to stronger Hadley circulation**



Flohn 1975

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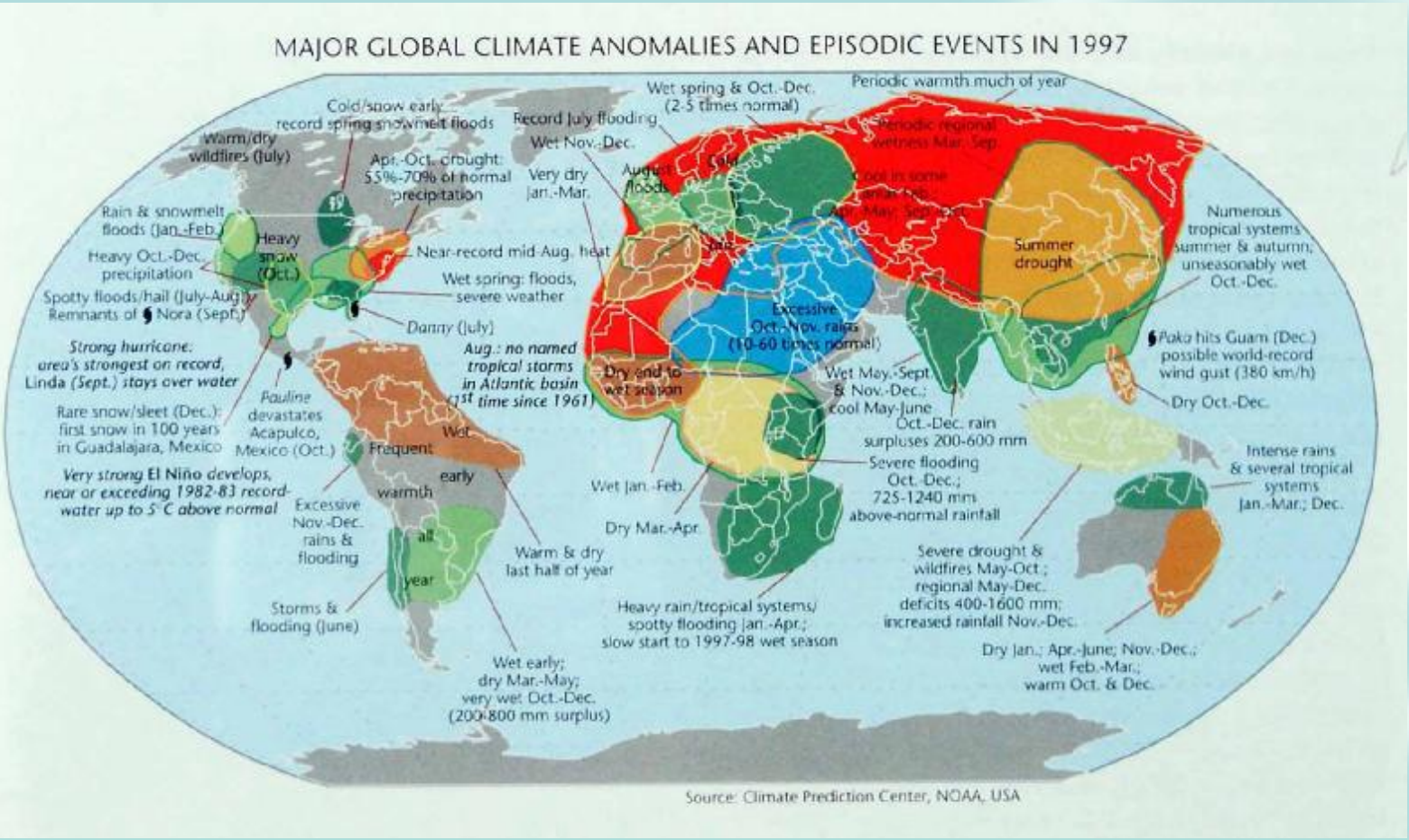
Anomalies of recent years

4 Anomalies 1997



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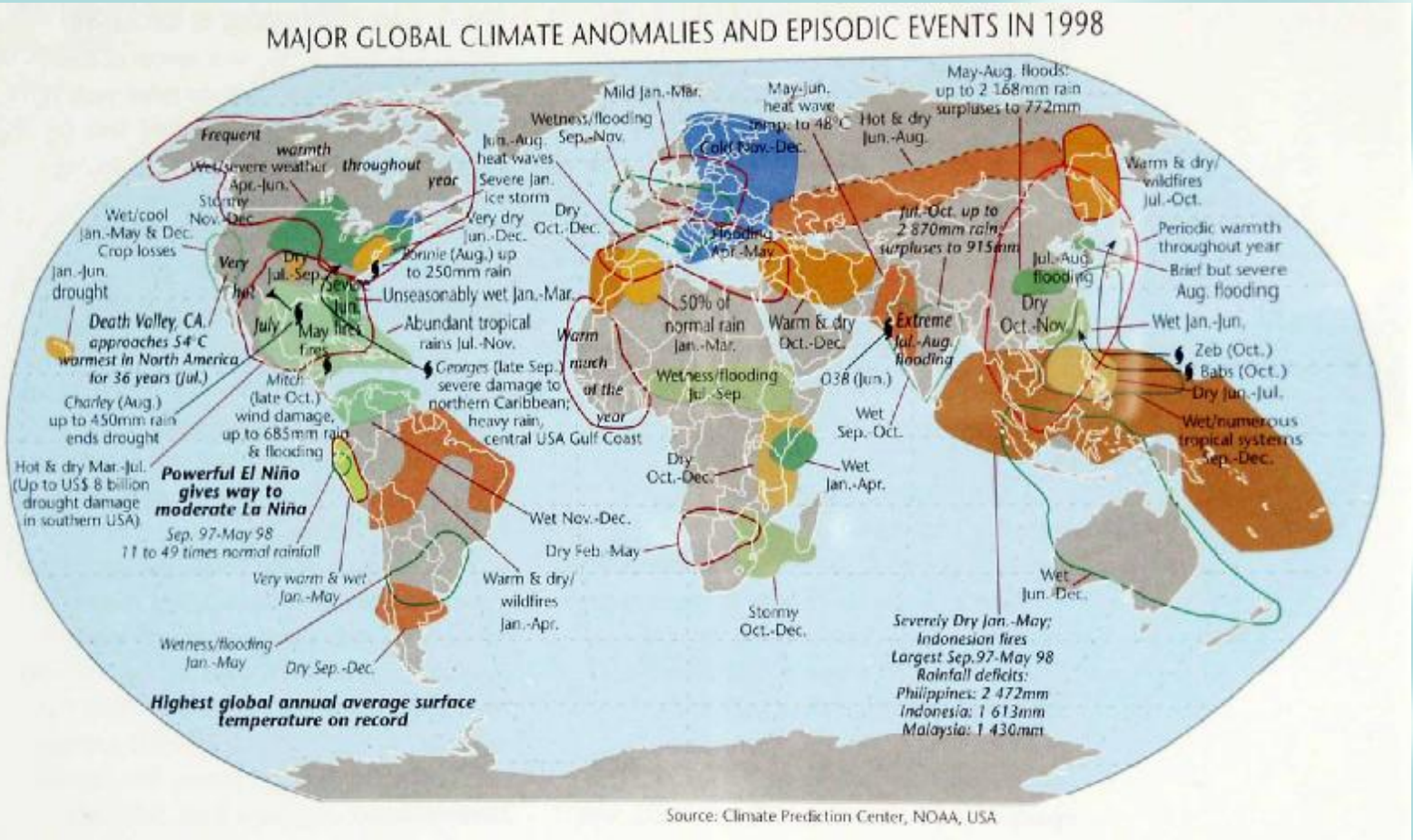
Anomalies of recent years

4 Anomalies 1998



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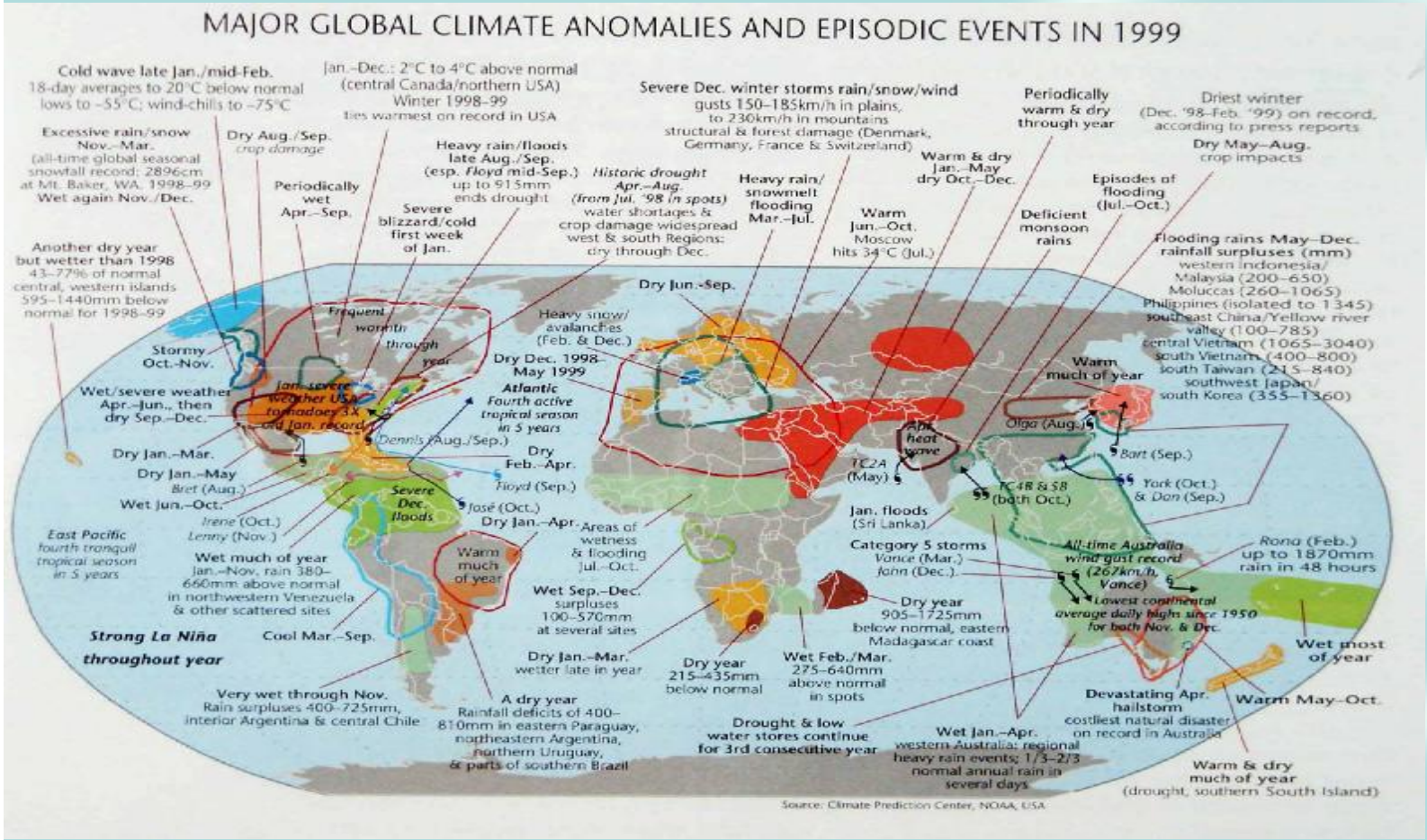
Anomalies of recent years

4 Anomalies 1999



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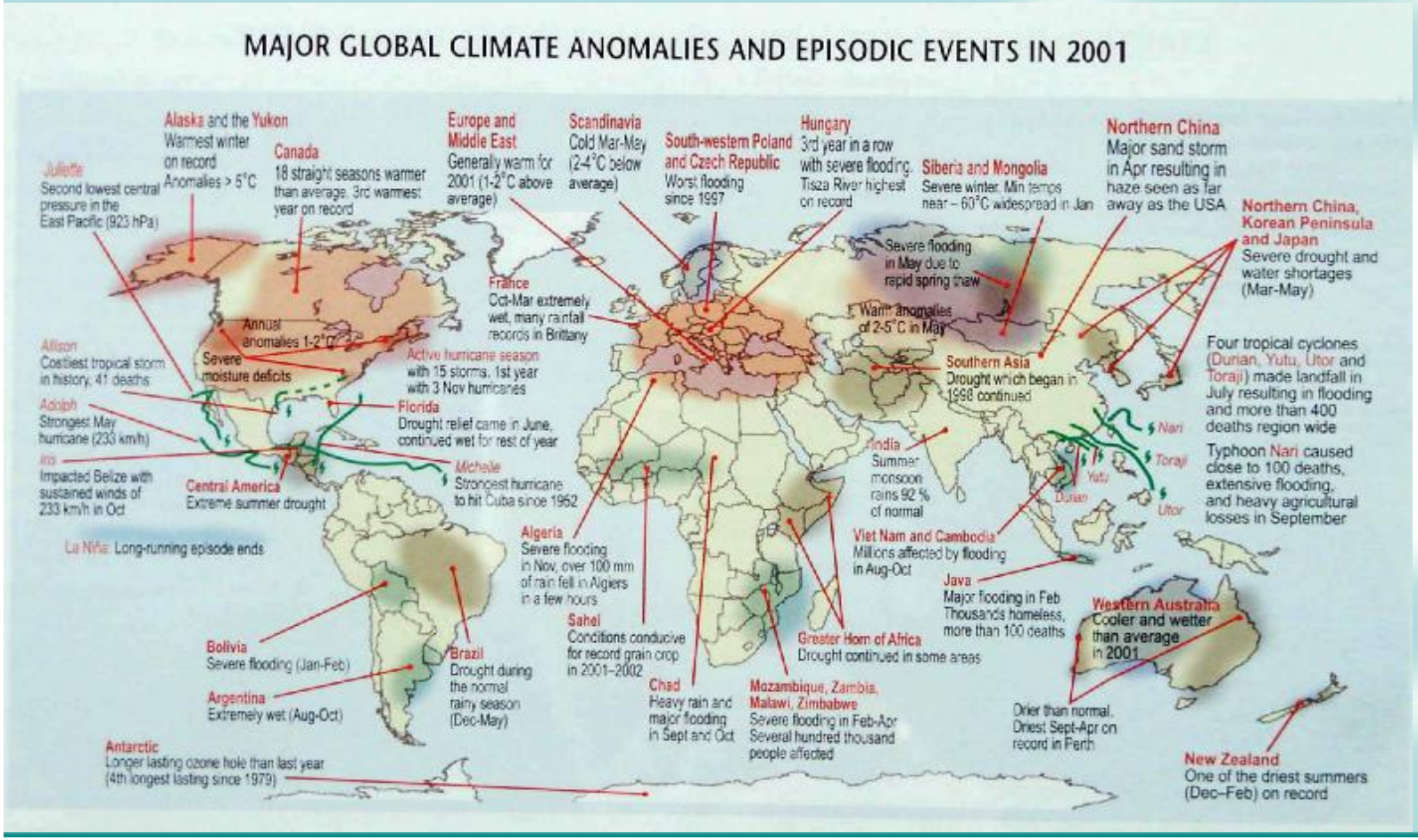
Anomalies of recent years

4 Anomalies 2001



WMO 2003

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Literature to read on

Recommended actual literature:

- **IPCC (2001): Climate Change 2001 (TAR)**
- **OcCC (2003): Extremereignisse und Klimawandel**
- **WMO (2003): The Global Climate System Review**

Recommended basic literature:

- **Christopherson (2000): Geosystems**
- **Lauer (1993): Klimatologie**
- **Schönwiese (1995): Klimatologie**
- **Schultz (1995): Die Ökozonen der Erde**
- **Weischet (1991): Einführung in die allg. Klimatologie**