Fourth lecture

TROPICAL-EXTRATROPICAL INTERACTIONS

Anomalous tropical SST
    ↓
Anomalous convection
    ↓
Anomalous latent heat source
    ↓
Anomalous ascending motion over the source (divergence) and subsidence (convergence) in local Hadley cell and modified Walker circulation.
    ↓
ROSSBY WAVE SOURCE!
(Fig. 25)

FACTORS AFFECTING THE EXTRATROPICAL RESPONSE:

• Interactions with the mean flow (zonal asymmetries → secondary sources)
• Feedback from transients in storm tracks (Rossby wave patterns → affect storm track → some do it in a way as to produce positive feedback) ⇒
• Preferred modes .
TELECONNECTION PATTERNS

- Patterns that describe simultaneous variations of atmospheric circulation (or other parameters).
- A physical reason for the simultaneous variations is implied.
- Examples and maps (PNA, PSA).

SEASONAL DEPENDENCE

During ENSO, the extratropical response:

- is stronger in the NH winter (stronger westerlies and closer to the equator, and larger SST anomalies)
- is significant in the SH in all seasons, but the impact over SSA is stronger in spring (still strong westerlies in the subtropics and already large SST anomalies).
- shows regional impacts in summer.

REGIONAL IMPACTS ON CLIMATE

PNA: warmer along the west coast of NA
    southward shift of the storm track
    cold breaks across the plains of NA

PSA: more rainfall over Chile
SOURCE REGIONS FOR TELECONNECTION PATTERNS

Motivation:

Dynamical links → better forecast because:
• better statistical models
• better assessment of dynamical models

Influence functions → indicate the regions where the anomalous heating is most effective in producing circulation anomalies at a given point.

Examples - (Figures in Grimm and Silva Dias, 1995)
AIR-SEA INTERACTIONS IN THE EXTRATROPICS

In the tropics → SST changes are cause of large-scale atmospheric anomalies.

In the extratropics → SST changes are primarily response to, rather than causes of atmospheric changes

(Fig. 14 of Trenberth et al. 1998)

Influence of tropical X extratropical SST

Results of models:

• tropical Pacific SST produces stronger atmospheric response than SST in the extratropics
• atmospheric heating effect may not be local in the extratropics
• atmospheric bridge between SST variability in the tropics and extratropics
• SST patterns: oceanic response to atmospheric driving positive feedback from the SST to the atmosphere

(Fig. 12 of Trenberth et al. 1998)
Examples of Air-sea interactions in the extra-tropics

North Pacific

SST in ENSO region:
- positive correlation with SST of the western seabord of North America
- negative correlation with SST in Central North Pacific

Cause: PNA pattern → cyclonic circulation in NP:
→ cold and dry advection to the west of the low → cold SST anomalies in central NP → warm and moist advection to the east.
→ storminess to the south.

South Pacific

Something similar (?)
INTERDECADAL VARIABILITY AND AIR-SEA INTERACTIONS IN THE EXTRATROPICS

a) Pacific Decadal Oscillation (PDO)

- Interaction with ENSO
- Periods above 20 years
- also associated with PNA \(\Rightarrow\) impacts
- What is the dynamics involved in the decadal oscillations?

(Figures in: www.pmel.noaa.gov/~miletta/web/pdo_p1.html and: tao.atmos.washington.edu/PNWimpacts/REPORTS/pdo_clim_pics.html)

b) North Atlantic Oscillation (NAO)

- Interannual and interdecadal variability
- seesaw of anomalous pressure between Iceland Low and Azores High
- Links with SST and oceanic currents
- Links with subtropical SST (dipole?)
- What drives this pattern? Variations in the thermohaline circulation?
- Atmospheric bridge between tropical SST and extratropical circulation (and SST)?

(Figures in: geoid.mit.edu/accp/avehtml.html)
AIR-LAND INTERACTIONS

Air land interactions compared to air-sea interactions:

- The thermal storage is less in the land.
- There is no overturning or circulatory motions to redistribute energy globally;
- Since land is not always moist, the role of latent heat transfer is less extreme than for the oceans.

On the other hand:

- land is more variable and changeable than the oceans for many of the important coupling processes:
- when wet, it can exchange water with the atmosphere more rapidly than the oceans because of greater surface roughness, but when dry it provides no water at all;
- local temperature are much more responsive to net radiation than are the oceans. The annual temperature range over the oceans is much smaller than over land.
- Presence or absence of clouds has a substantial effect;
- the albedo varies with type of surface cover, and this cover is highly variable in space (and even in time).

Different boundary conditions on a mesoscale can alter mesoscale wind and precipitation patterns. Only massive changes would aggregate to significant changes on a continental or larger scale. However, as they may be significant in the regional scale, they must be taken into account. During El Niño or La Niña, for example, changes in land surface hydrology and moisture availability can feedback and influence the total response.

Different boundary conditions over land may also affect, for example, the interannual variability of monsoon. Examples.

(Fig. 22.3 and 22.6, from Dickinson, 1993)