Relationship of regional radiation anomalies with environmental conditions

[1]Bing Lin and [2]Tai-Fang (Alice) Fan

[1]NASA Langley Research Center, [2]SSAI

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Introduction

➢ Short-Term Variations and Feedbacks

- climate states vary & drive radiation changes
- variations in radiation fields: lead climate state changes
- simulations & observations focus on radiation & clouds
- difficulties: no clear signals <<<< non-linear, chaotic
- climate variations in different time scales

➢ Clouds and Radiation

- clouds are the direct factor affecting radiation fields
- predictions of clouds >>>>>>> radiation

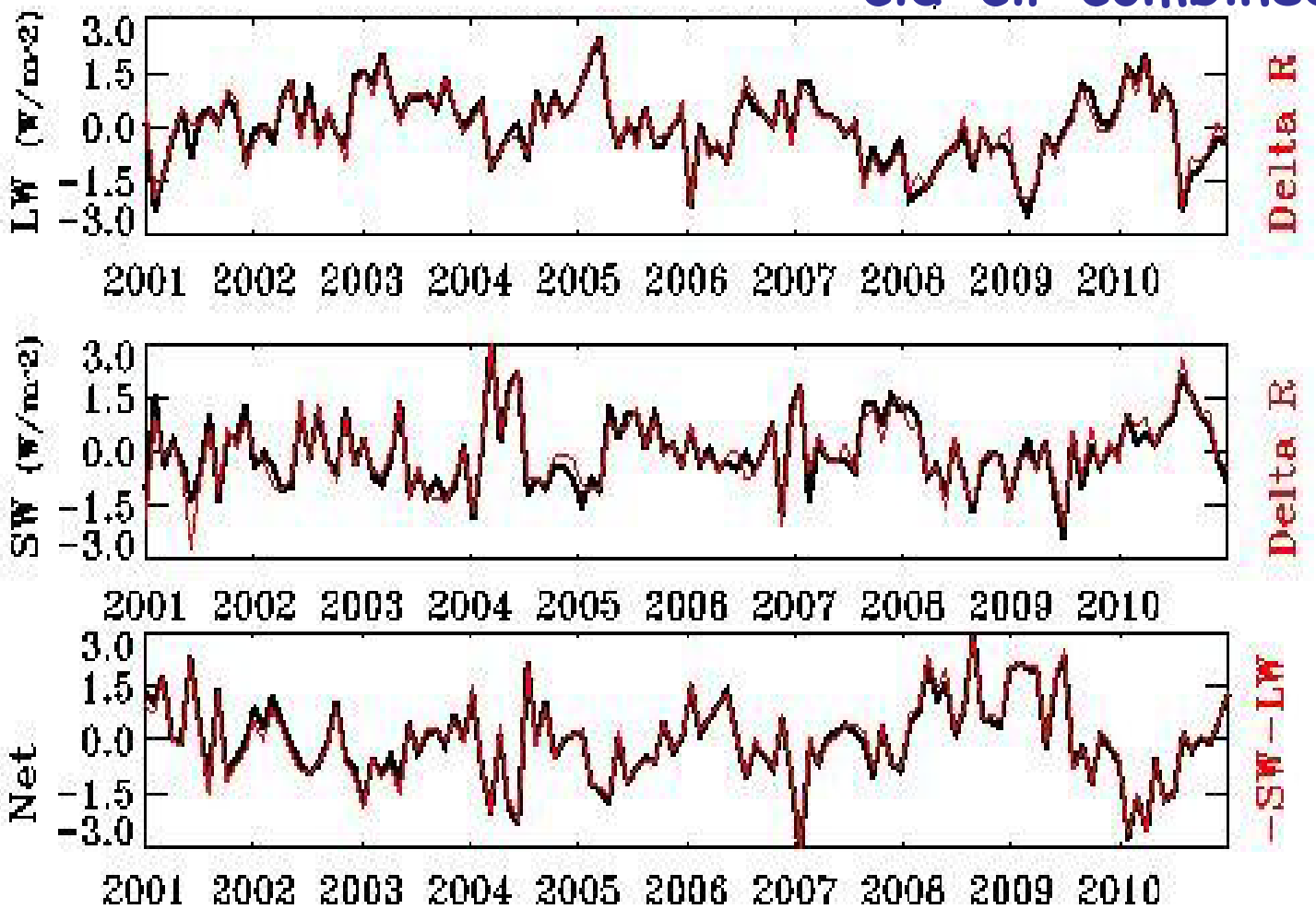
$$\Delta R = -\Delta c\, R_{clr} + (1-c)\Delta R_{clr} + \Delta c R_{cld} + c\, \Delta R_{cld} + \ldots\ldots$$

- clouds: also hard to resolve

Do not use clouds as one of
the predictors or analysis variables

radiation anomaly

cld+clr combined



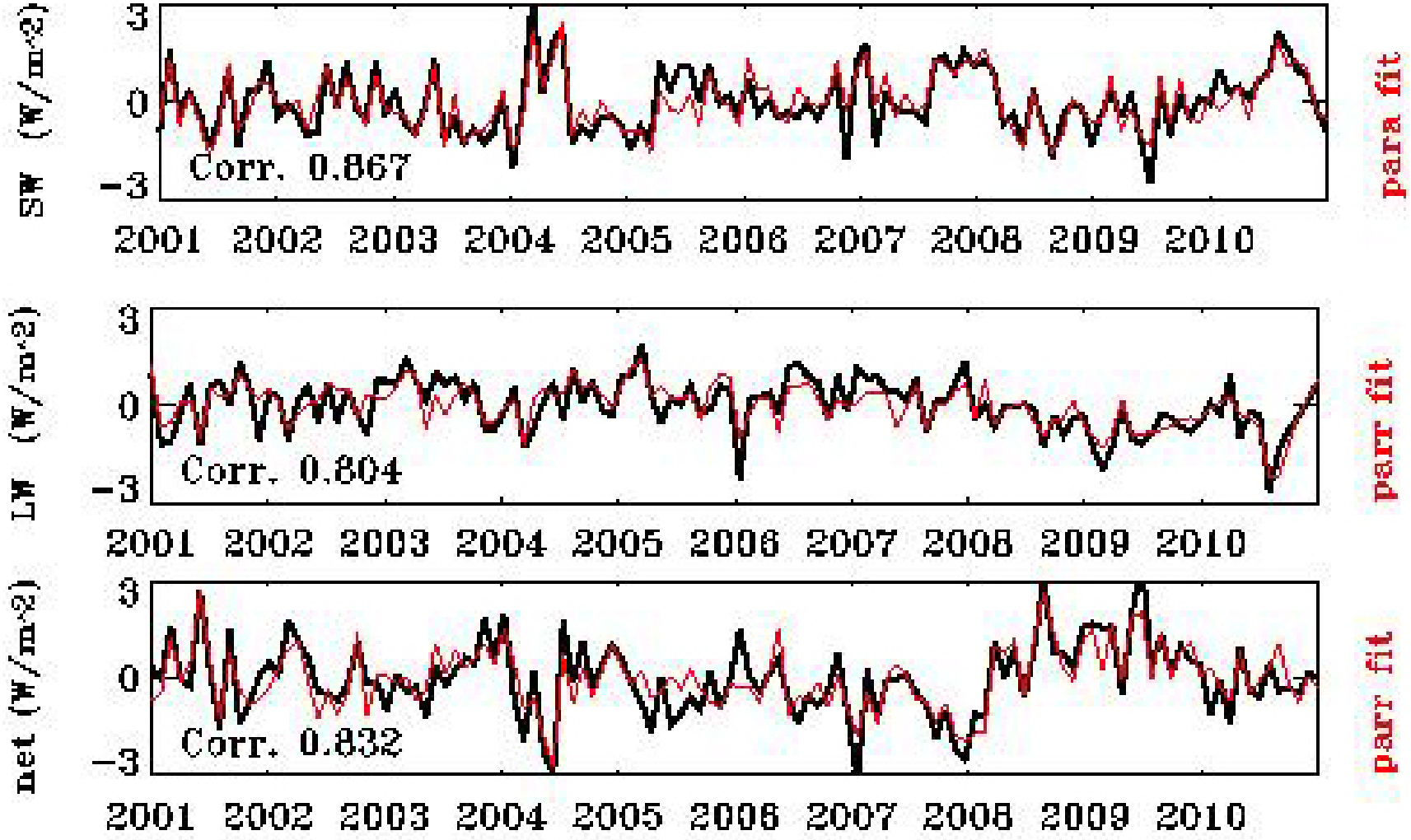
$$\Delta R \approx -\Delta c\, R_{clr} + (1-c)\Delta R_{clr} + \Delta c R_{cld} + c\, \Delta R_{cld}$$

Introduction (conti.)

- **Observed radiation variations**
  - climate tendency: maintain its base state, especially LW
  - processes: radiation, dynamics, & thermodynamics
  - previous studies for global and tropical means
    very good results

Tropical Mean Analysis

Observed anomalies Estimates: meteorological variables



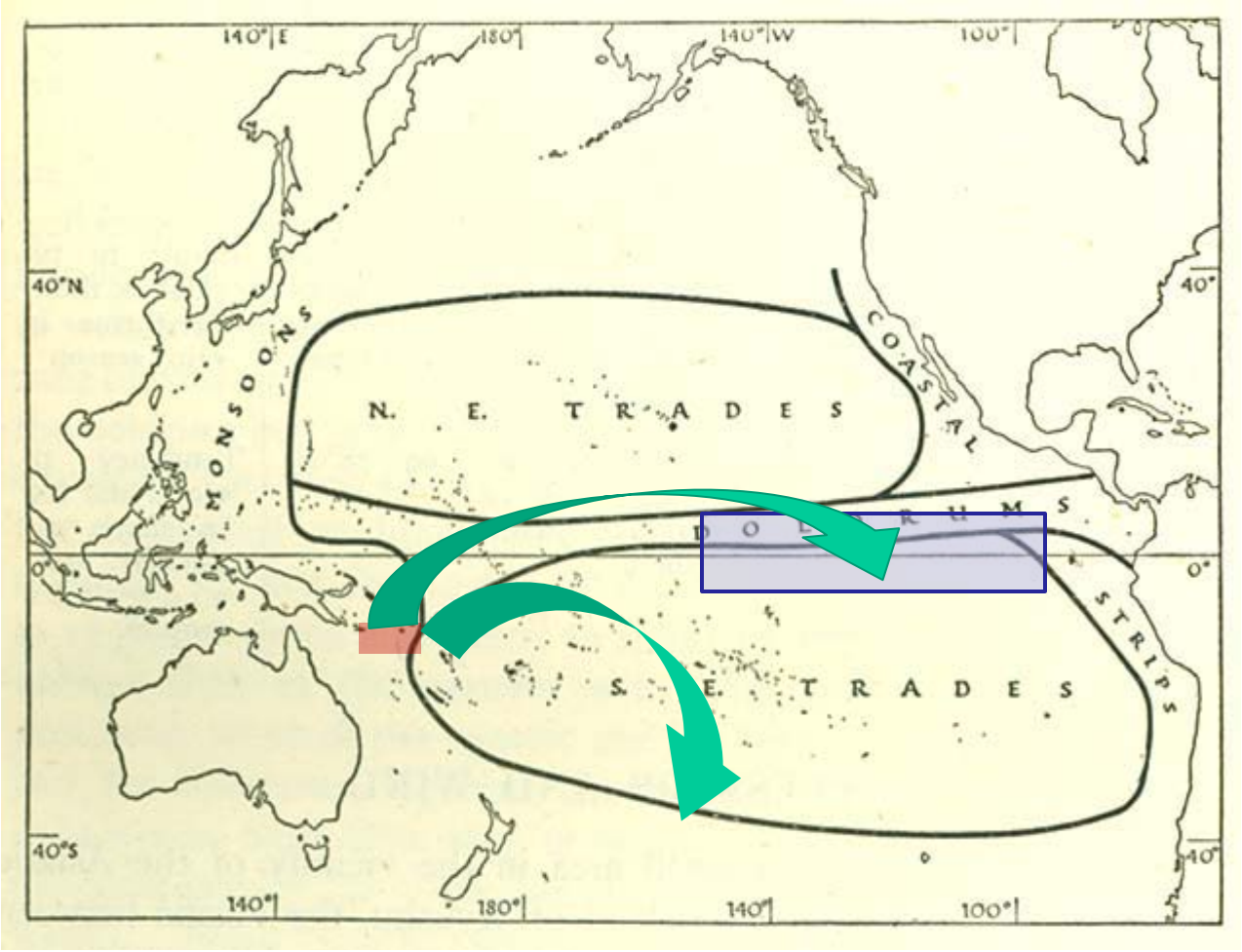
time (yr)

Introduction (conti.)

- Current work on regional scales: tropics (±23°N)

What kinds of variables ?

subtropical 23 ° ~ 40° latitudes



Tropical Eastern Pacific

5° N ~ 5° S
90 ° ~ 150° W

Introduction (conti.)

➢ Observed radiation variations

- climate tendency: maintain its base state, especially LW
- processes: radiation, dynamics, & thermodynamics
- previous studies for global and tropical means
  very good results
- extended to regional analysis for the tropics
- anomalies of key parameters and variables for radiation:
  T, CWV, $\underline{W}$, $\nabla \bullet \underline{W}$, ΔT_{LAT}, ΔT_{LON}, O_3
  higher-order terms: e.g. CWV*W, $T\nabla \bullet \underline{W}$, $\Delta T_{LON} O_3$
  total 35 variables/parameters compound terms

  and, Blackbody emission due to T:
  ΔLW_{BB} about -3.3W/K globally
  remove this term from CERES LW & Net first

Approaches

- 10-years CERES data: 2001 ~ 2010
  - TOA radiation fields & changes
  - variations in T and other variables
  - 10 years 'climatologies'

- Data Processing
  - tropical 23°S to 23°N zonal band
  - deseasonalized anomalies >>> perturbation/linearization
  - SSF1DEG monthly 1° × 1° grid boxes

Approaches (conti.)

- Radiation Change

$$R = (1-c)R_{clr} + cR_{cld}$$

$$\Delta R = -\Delta c\, R_{clr} + (1-c)\Delta R_{clr} + \Delta c R_{cld} + c\, \Delta R_{cld} + \ldots\ldots$$

$$= \Sigma_i\, (\partial R/\partial v_i)\Delta v_i + \Sigma_{ij}\, \partial^2 R/(\partial v_i\, \partial v_j)\Delta v_i\, \Delta v_j + \text{other terms}$$

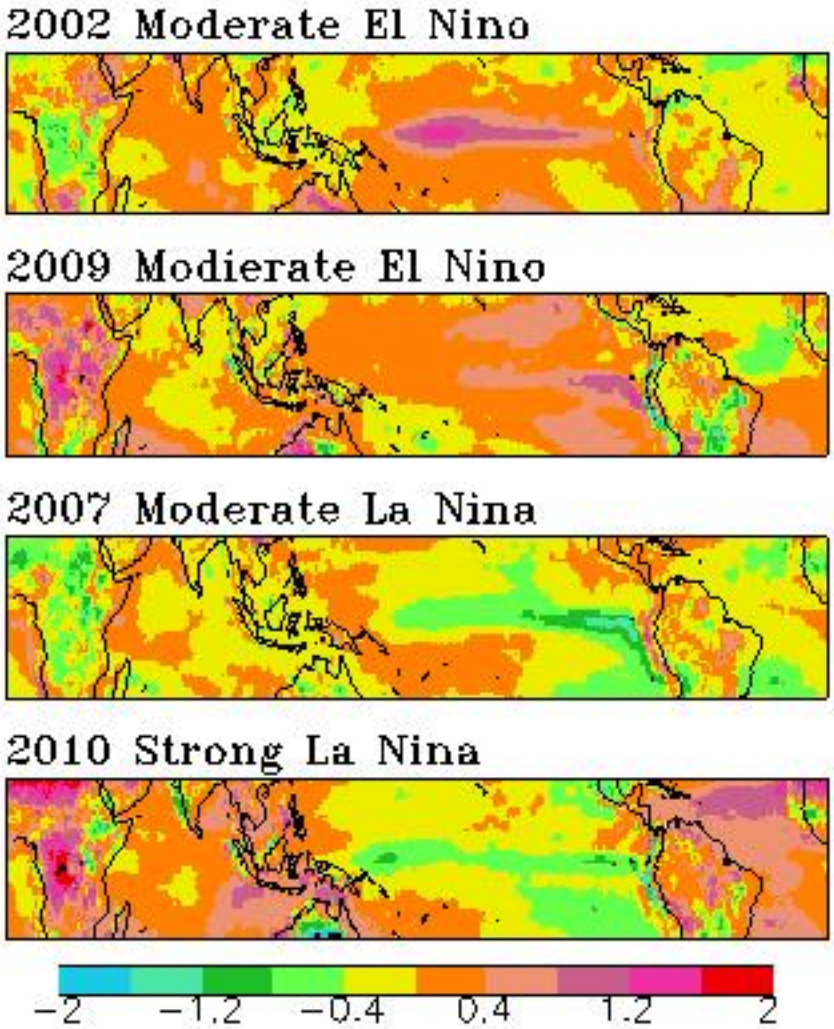
after removing the ΔLW_{BB} term in LW and Net

- multivariable linear regression
  eliminating statistically insignificant terms,
  until all terms are statistically meaningful
  empirically explain the anomalies in radiation fields

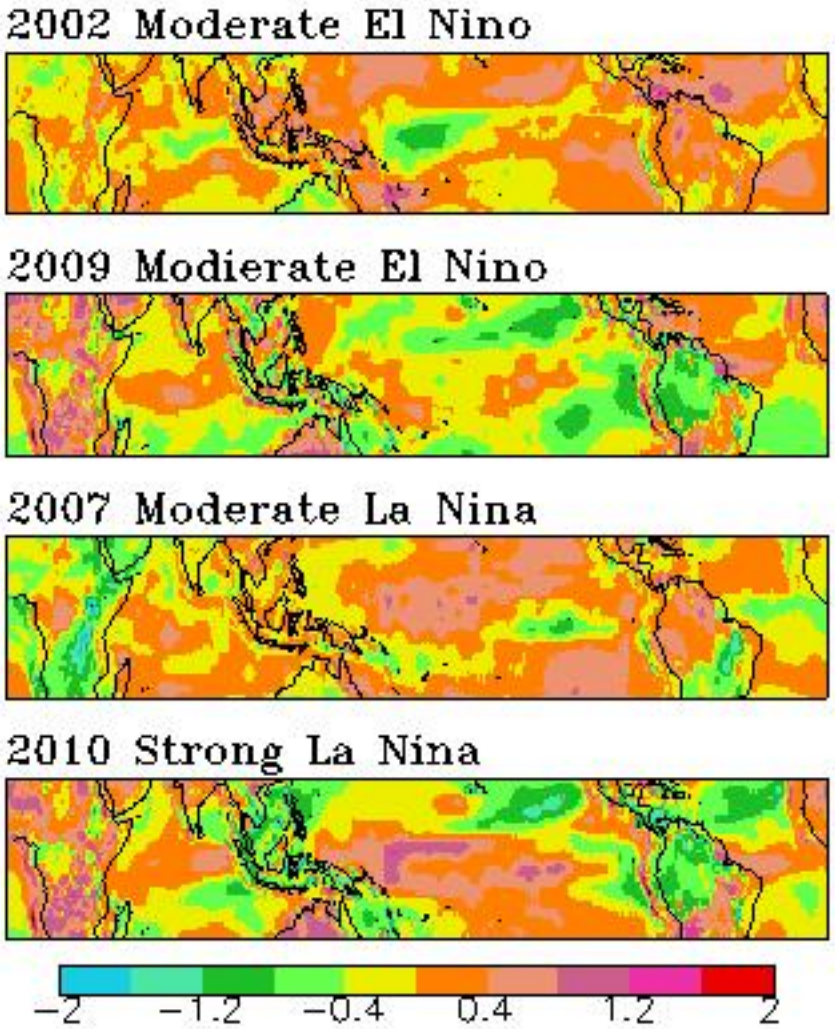
Thus, this analysis emphasizes on individual variable's influences on radiation

Results: environmtl anomalies

skin temperature

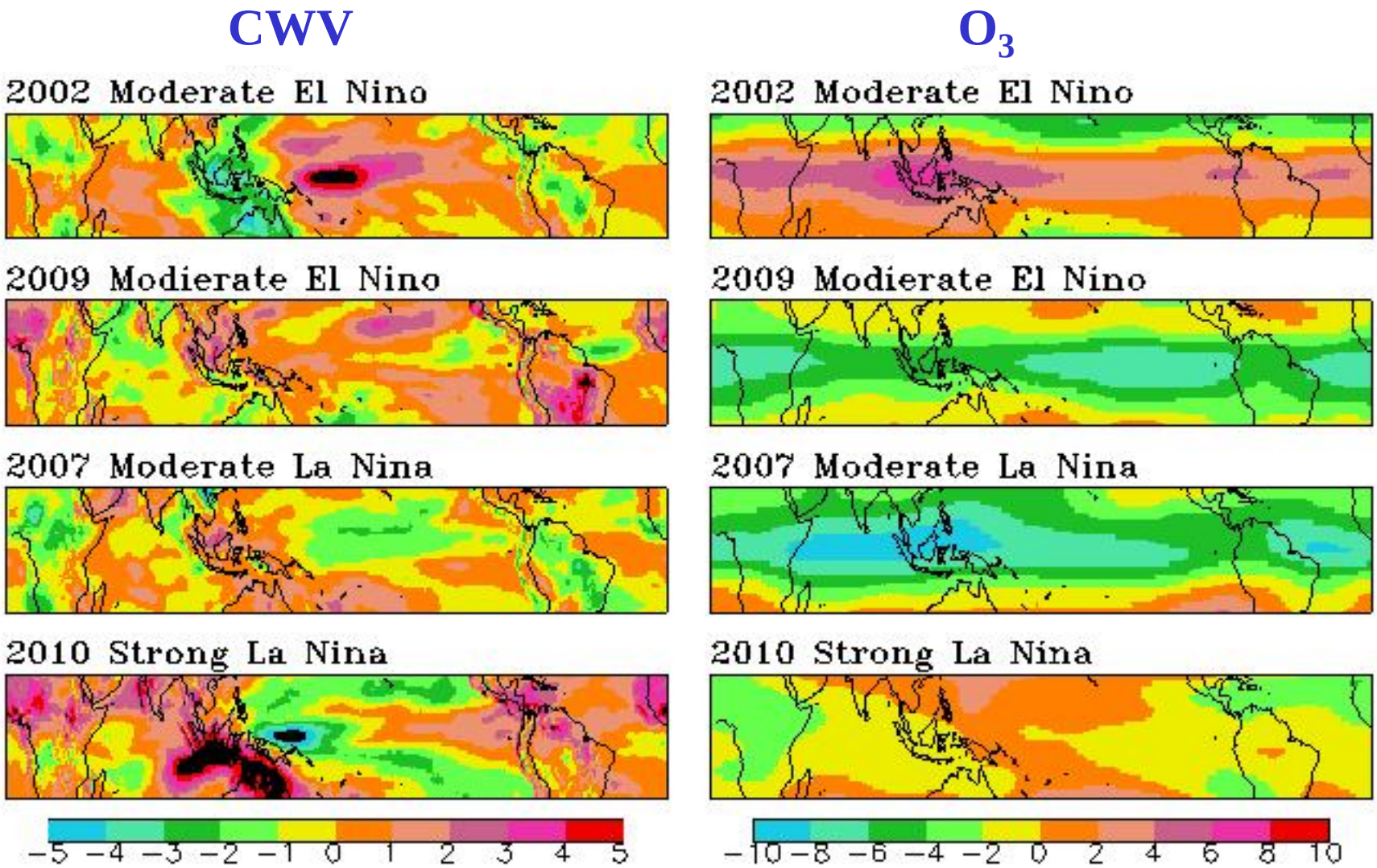


wind speed



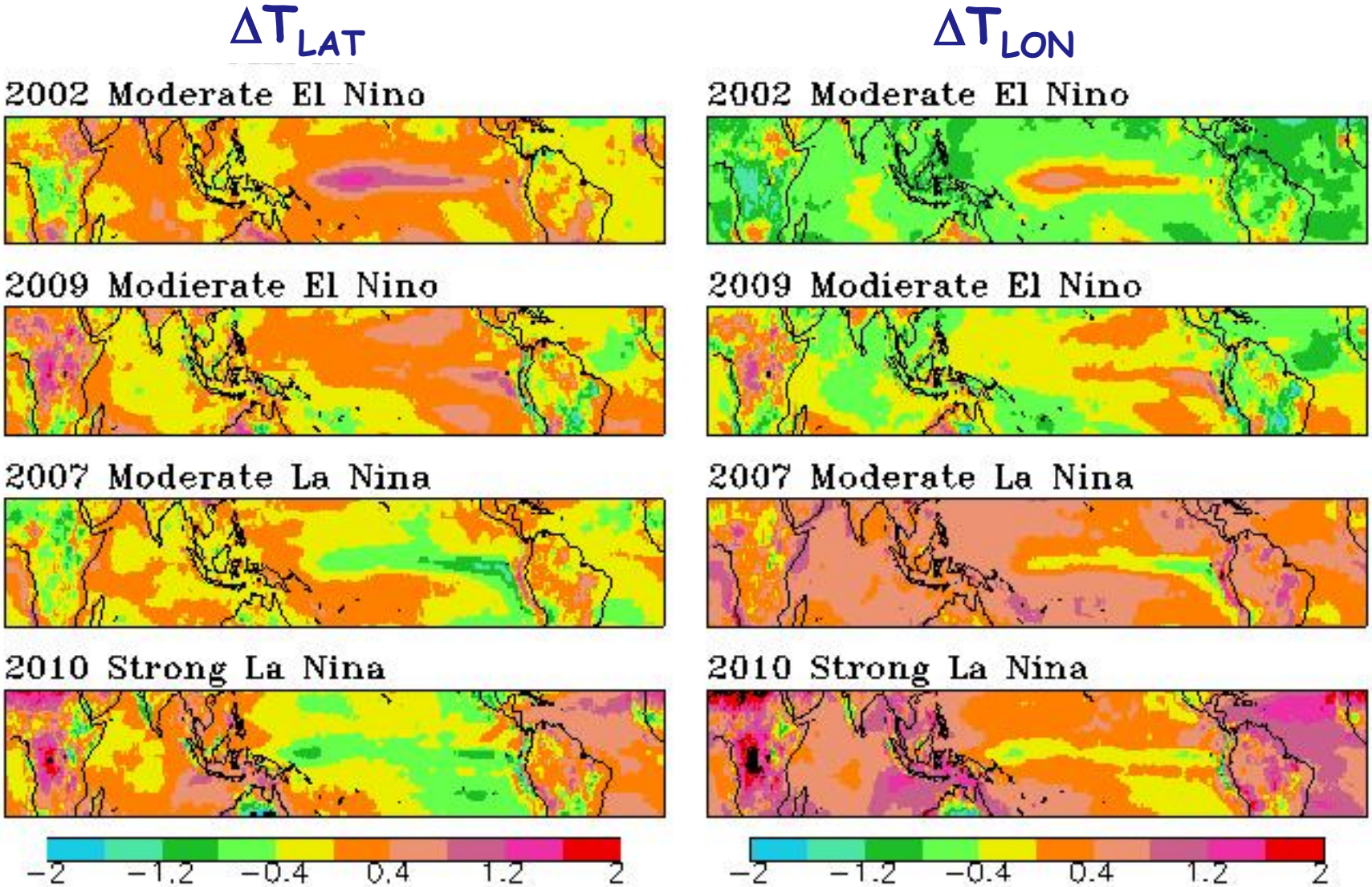
Anomaly for El Nino and La Nina years

Results: environmtl anomalies



Anomaly for El Nino and La Nina years

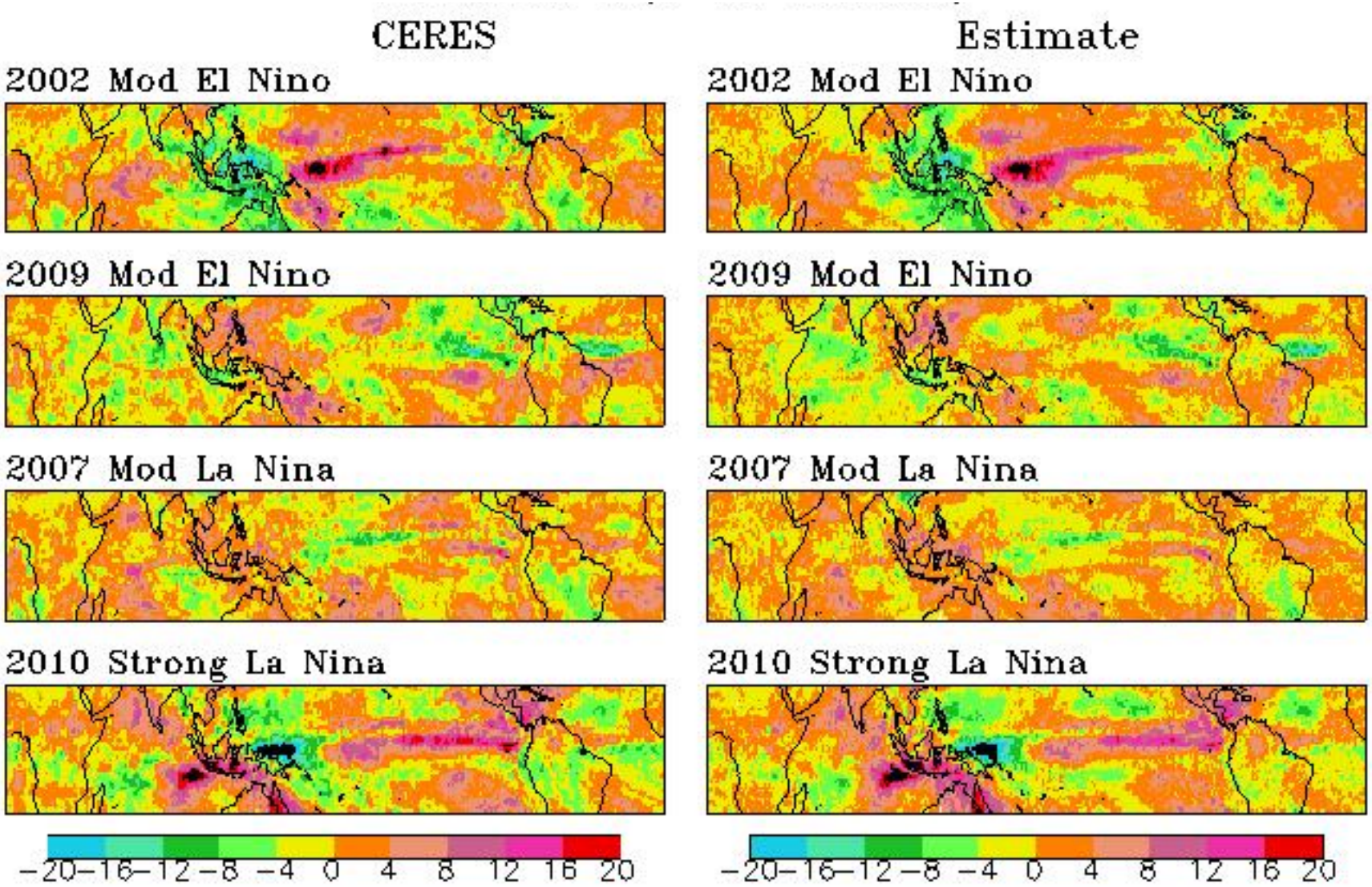
Results: environmtl anomalies



Anomaly for El Nino and La Nina years

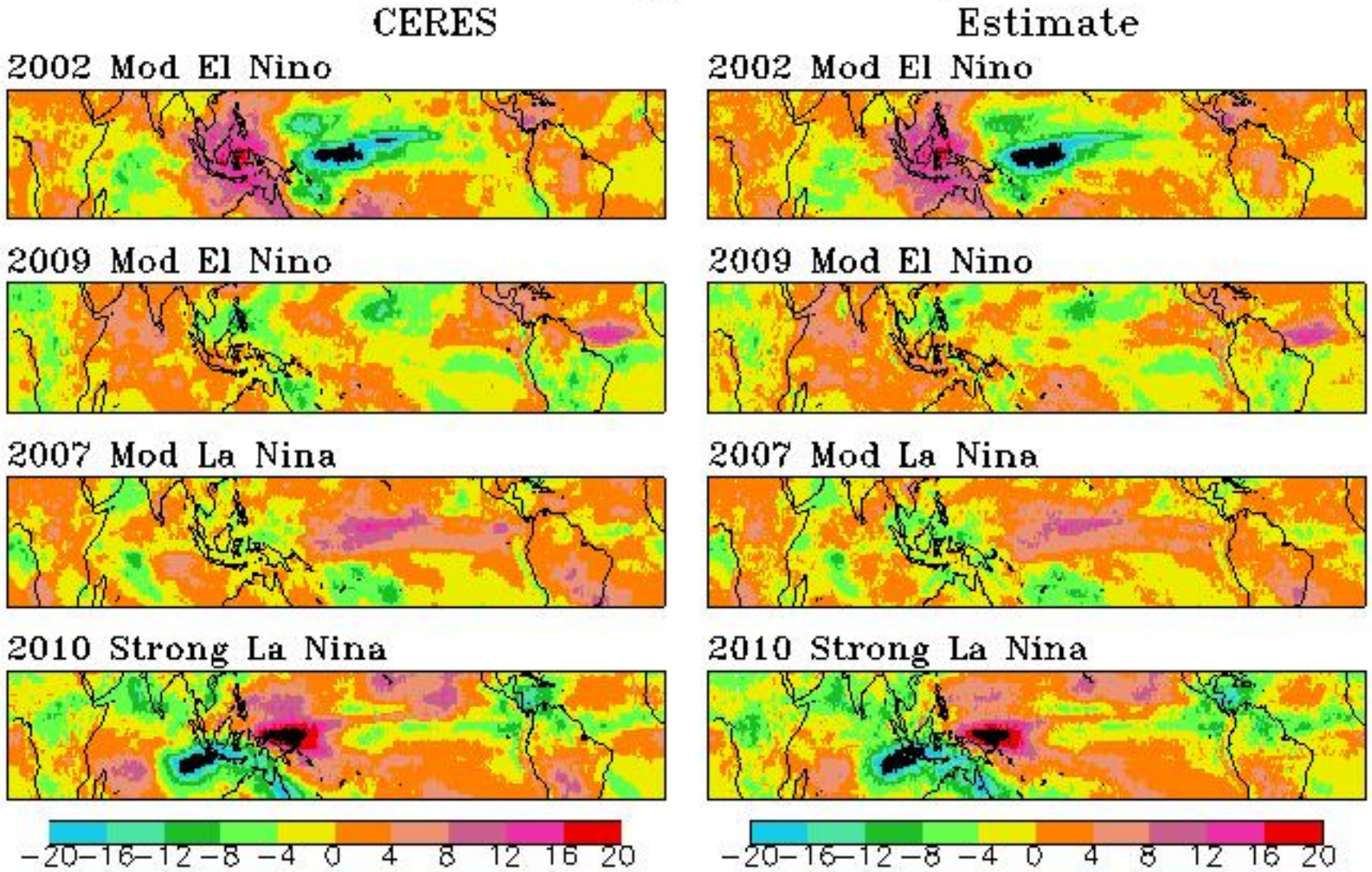
Estimations

SW comparison



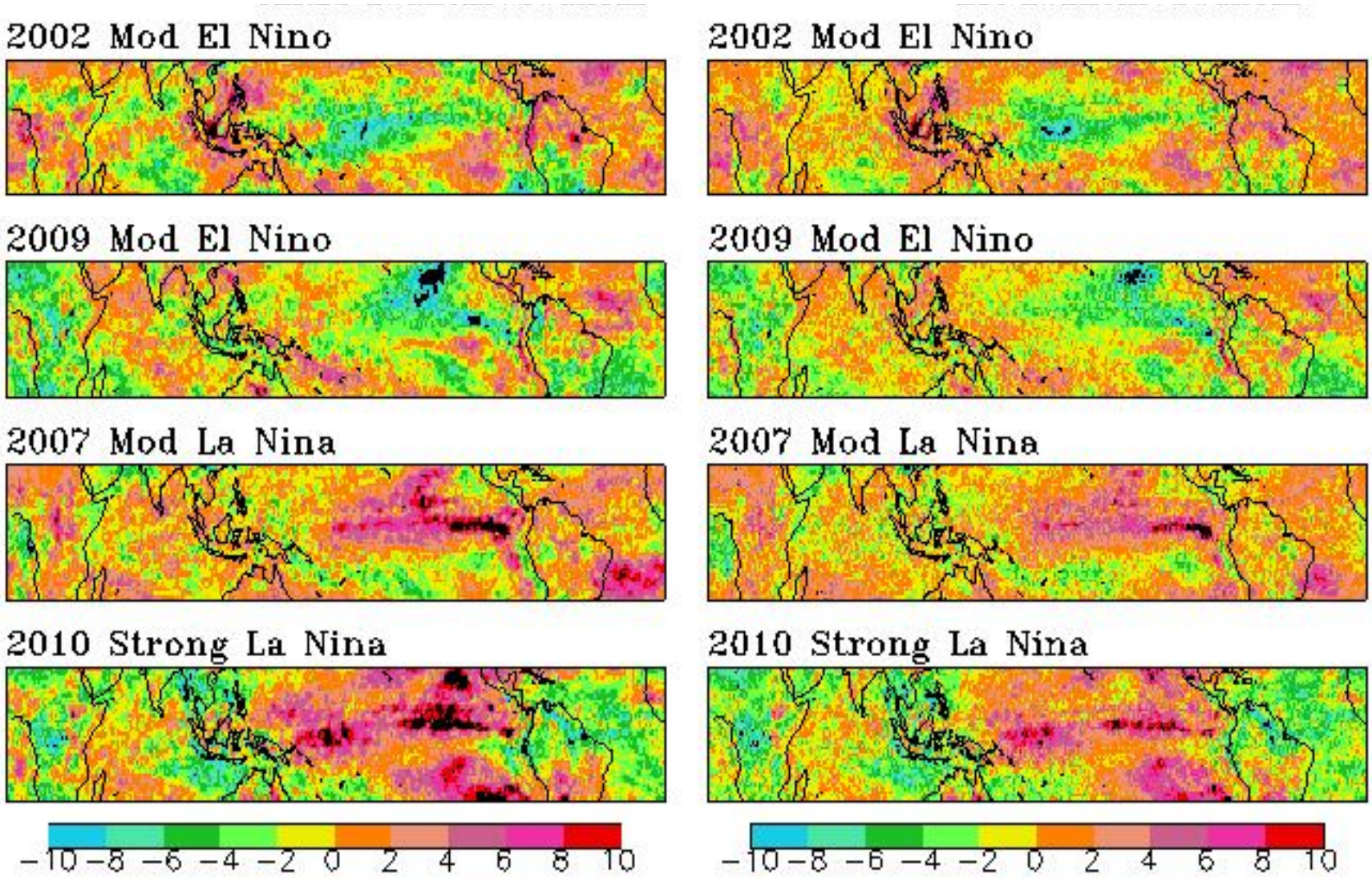
Estimations

LW comparison



Estimations

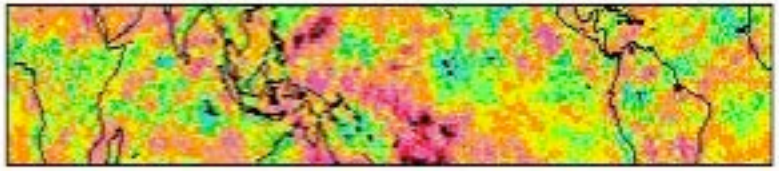
CERES **Net radiation comparison** Estimate



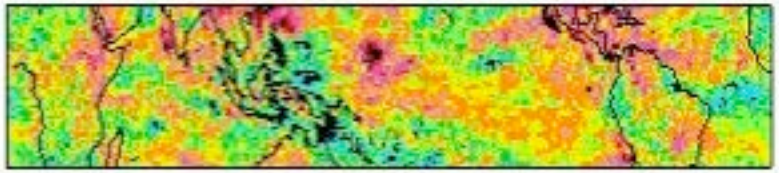
CERES - Estimate

LW

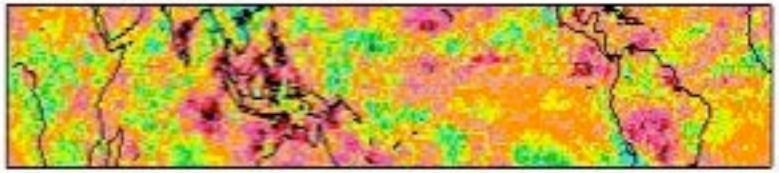
2002 Mod El Nino



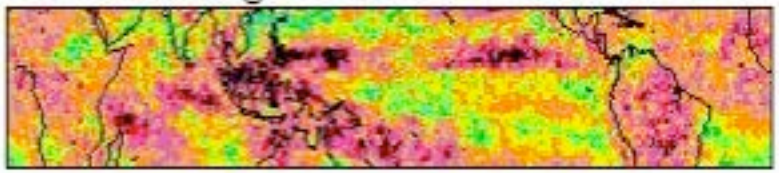
2009 Mod El Nino



2007 Mod La Nina

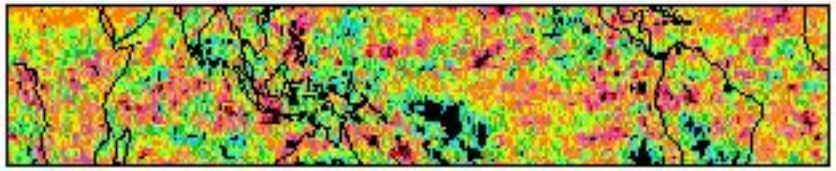


2010 Strong La Nina



SW

2002 Mod El Nino



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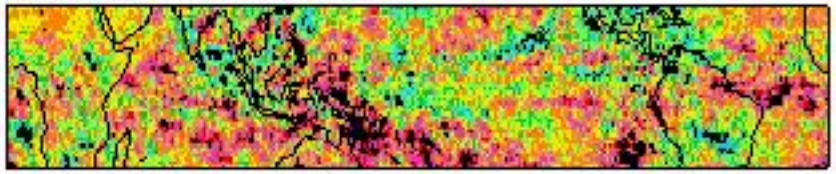

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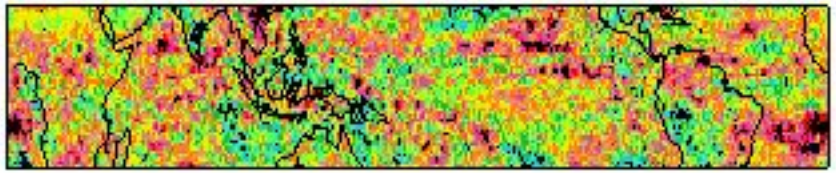
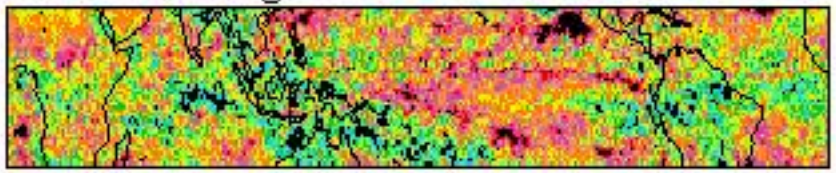
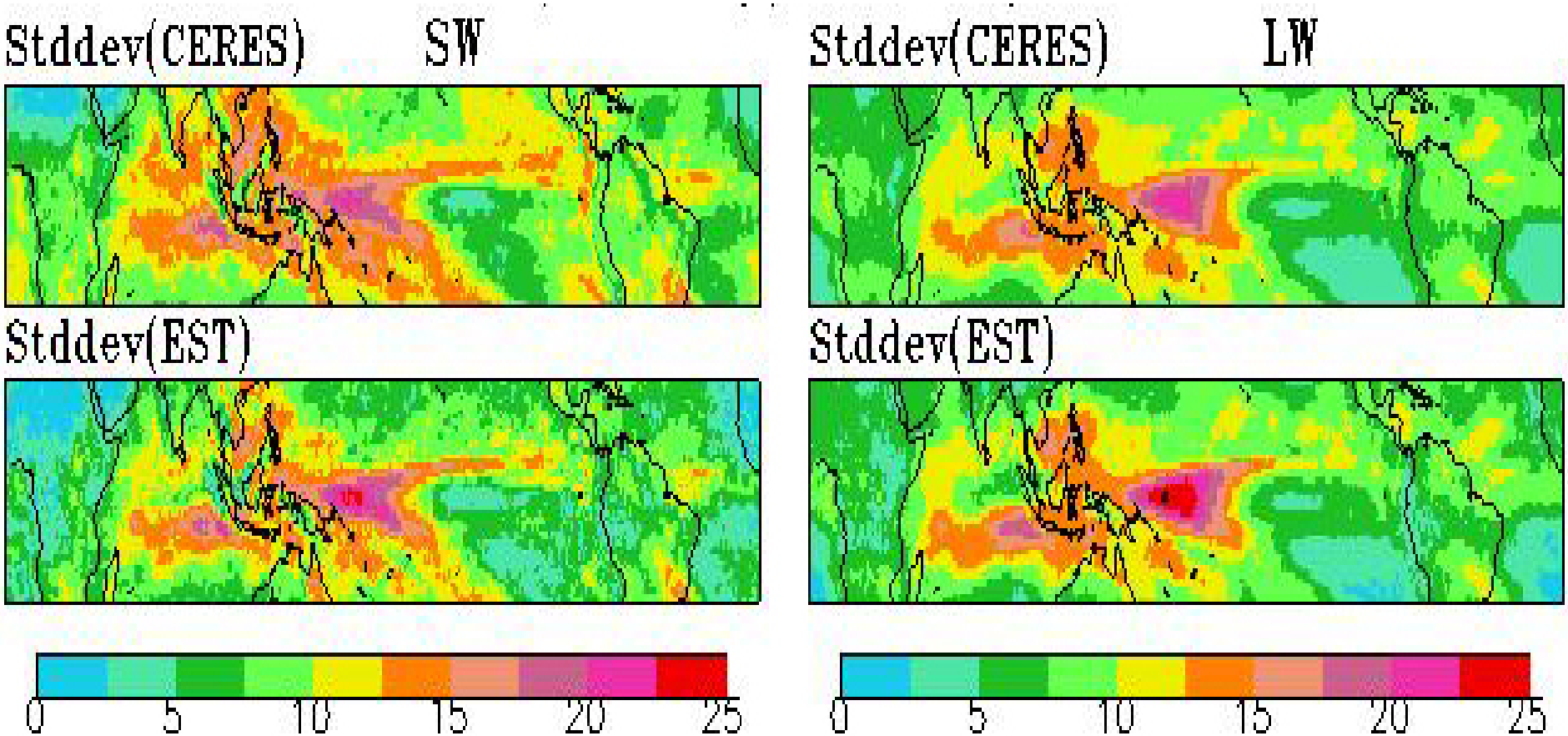


2010 Strong La Nina



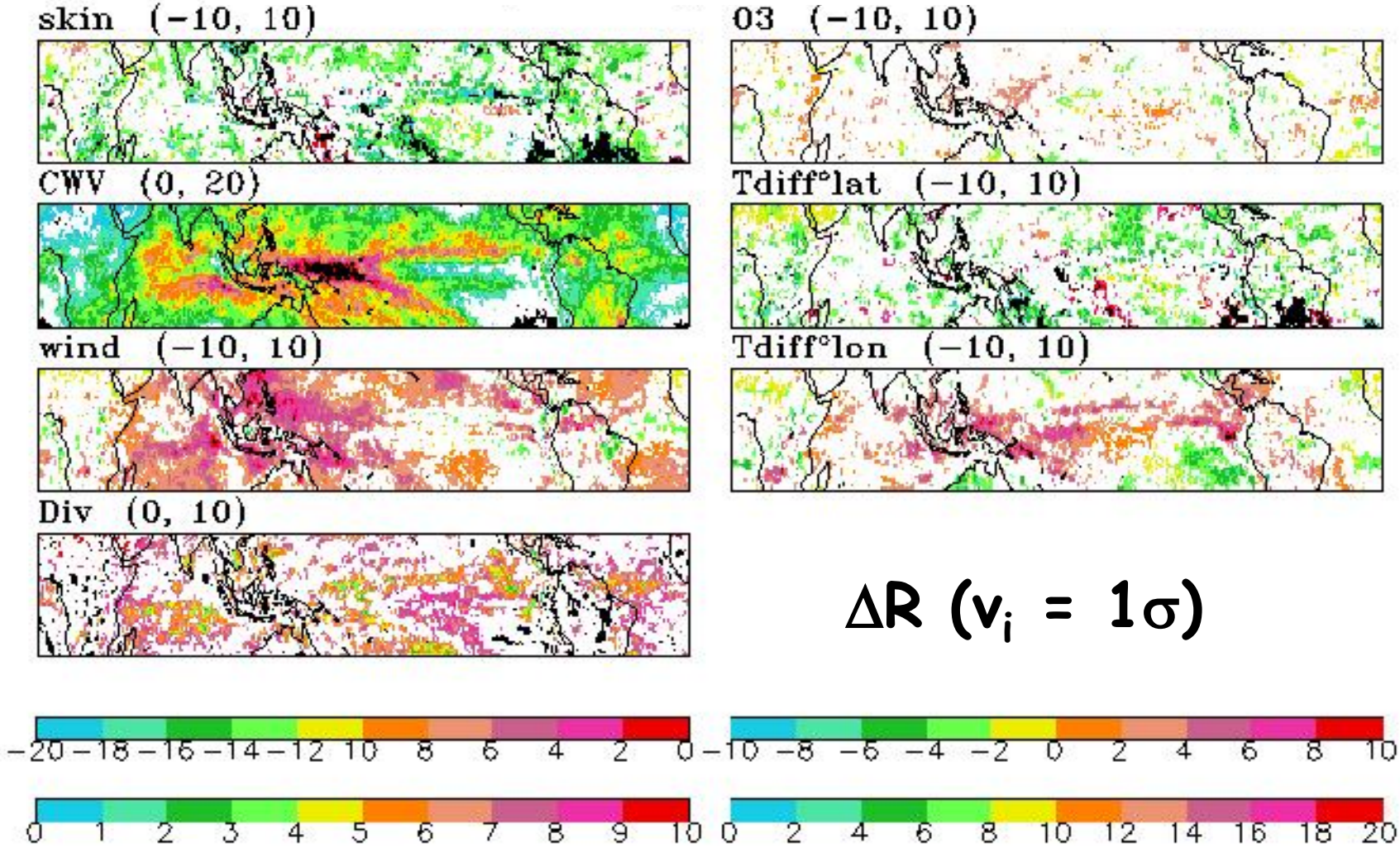
Variability



- Very similar patterns for both SW and LW
- Large variability over convergent zones
- Minimal in tropical southeastern Pacific

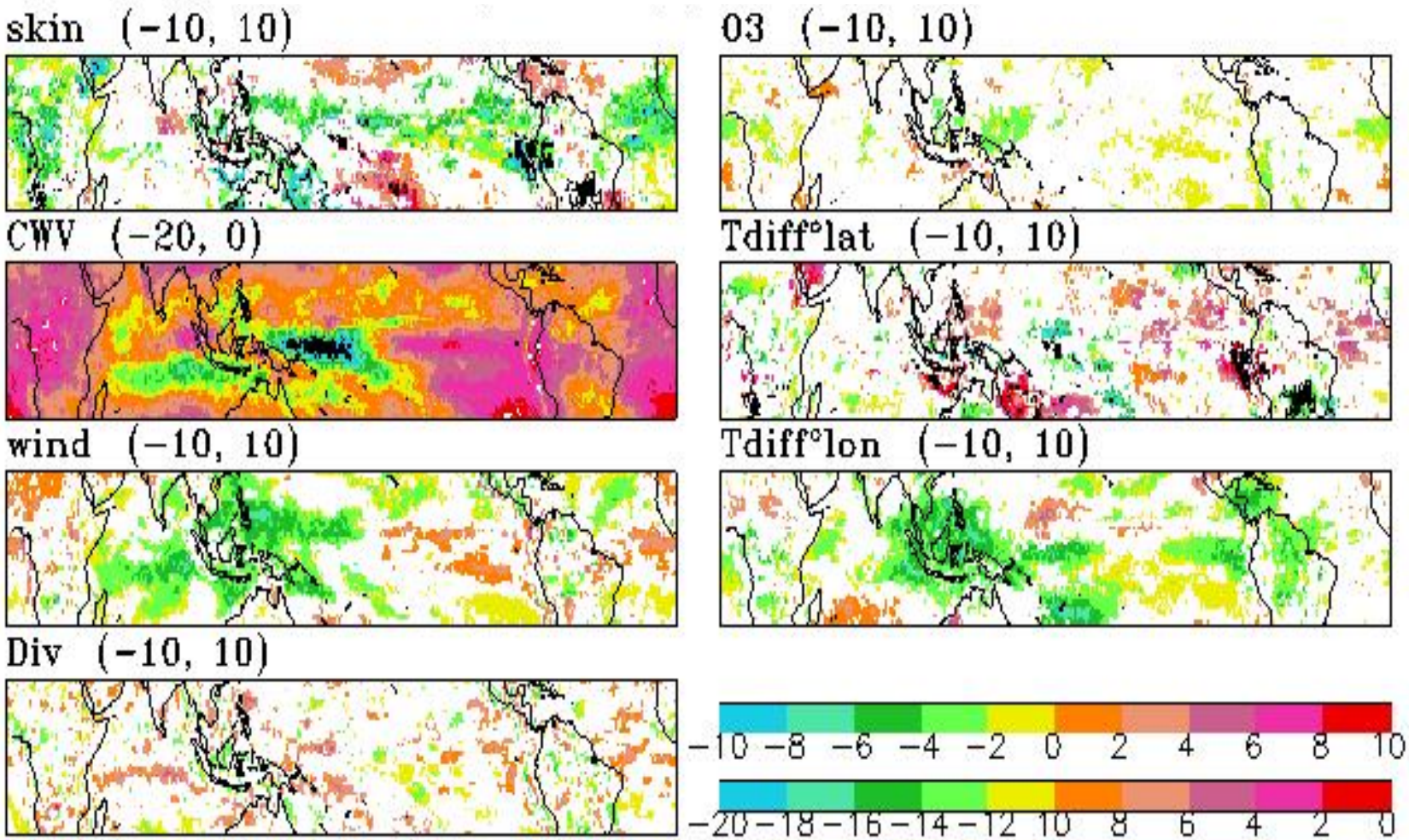
} clouds

Radiation from Individual Variables: SW



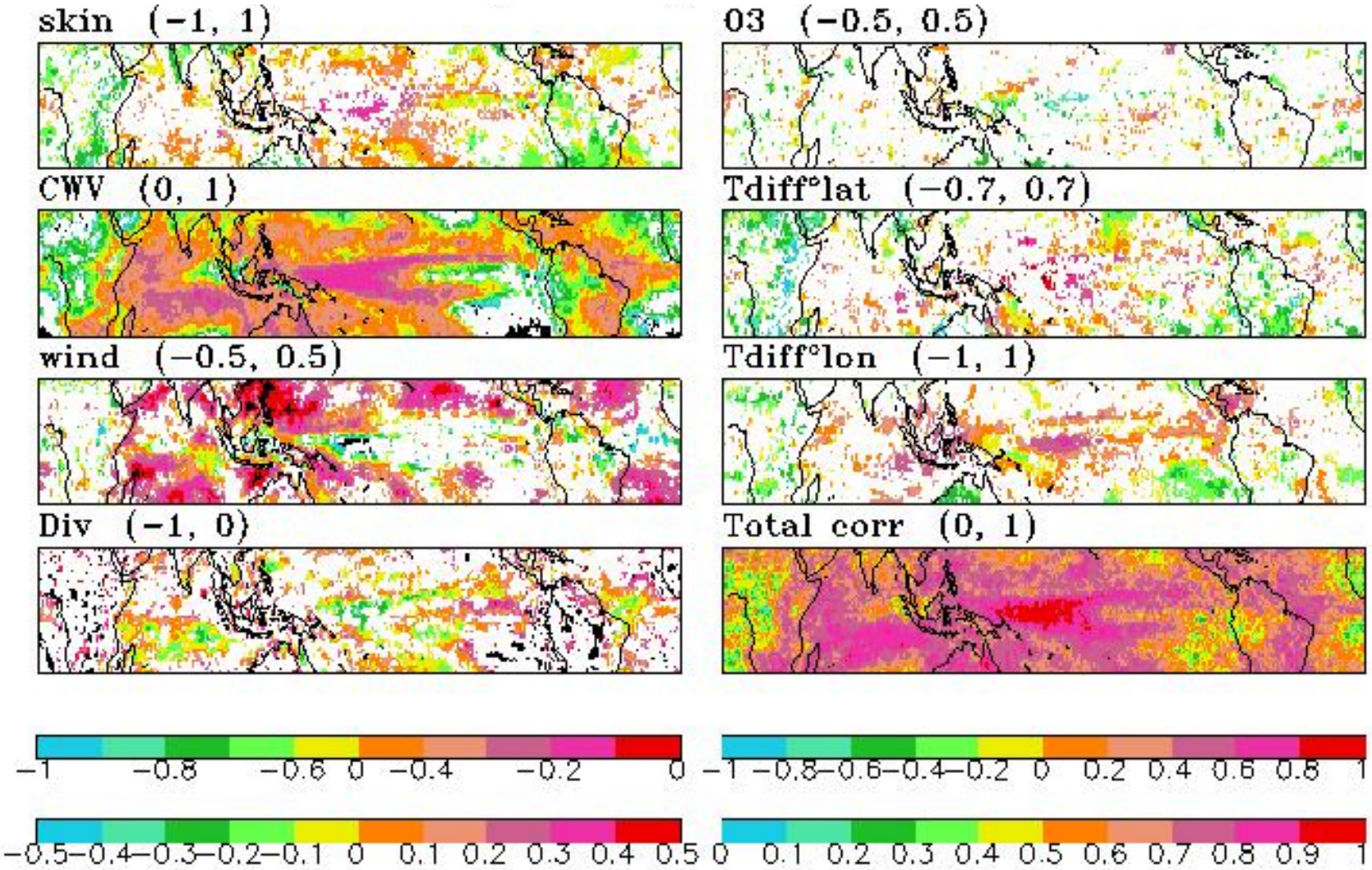
$\Delta R\ (v_i = 1\sigma)$

Radiation from Individual Variables: LW



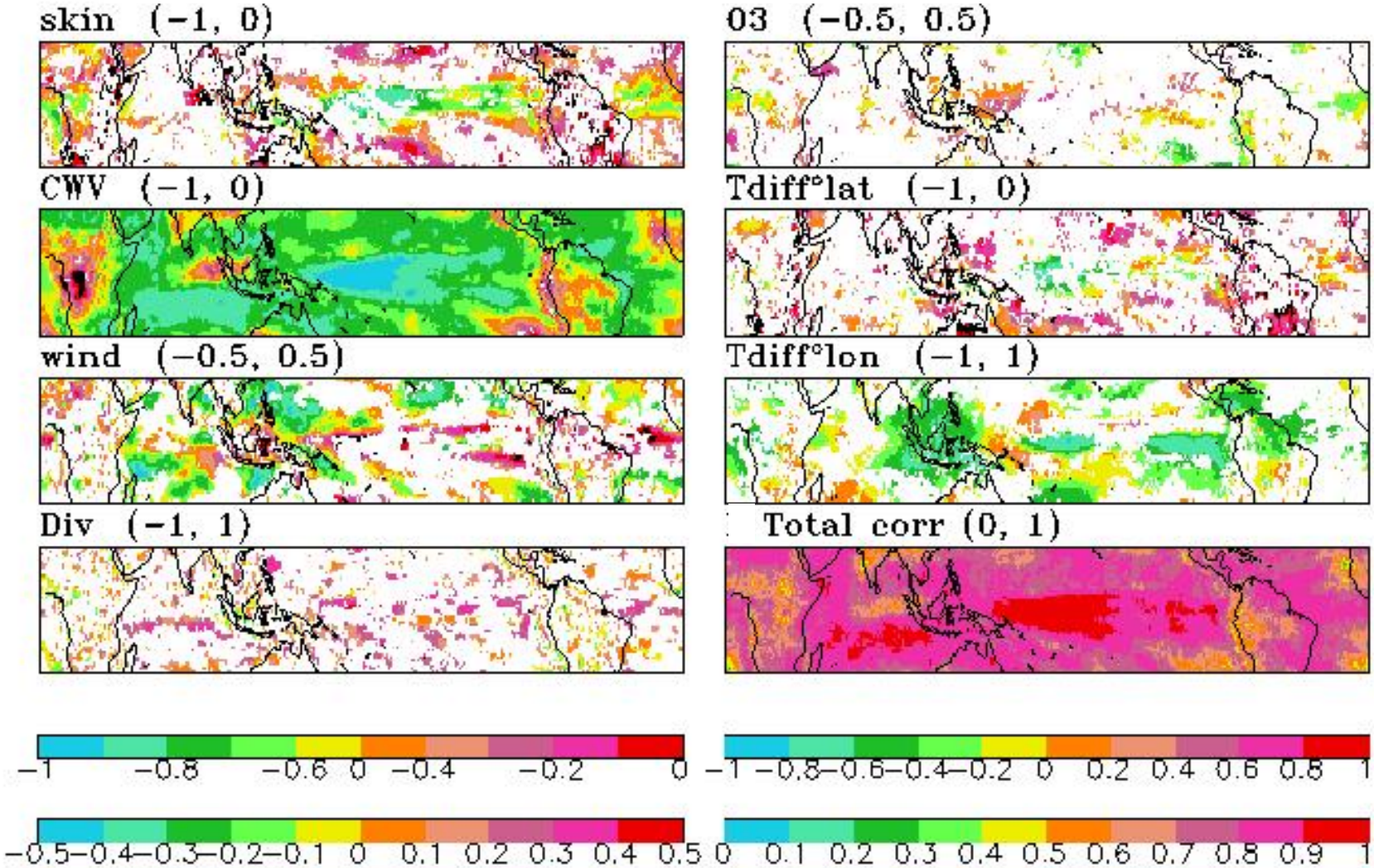
Relation to Environments

Relationship with individual variables: SW Corr



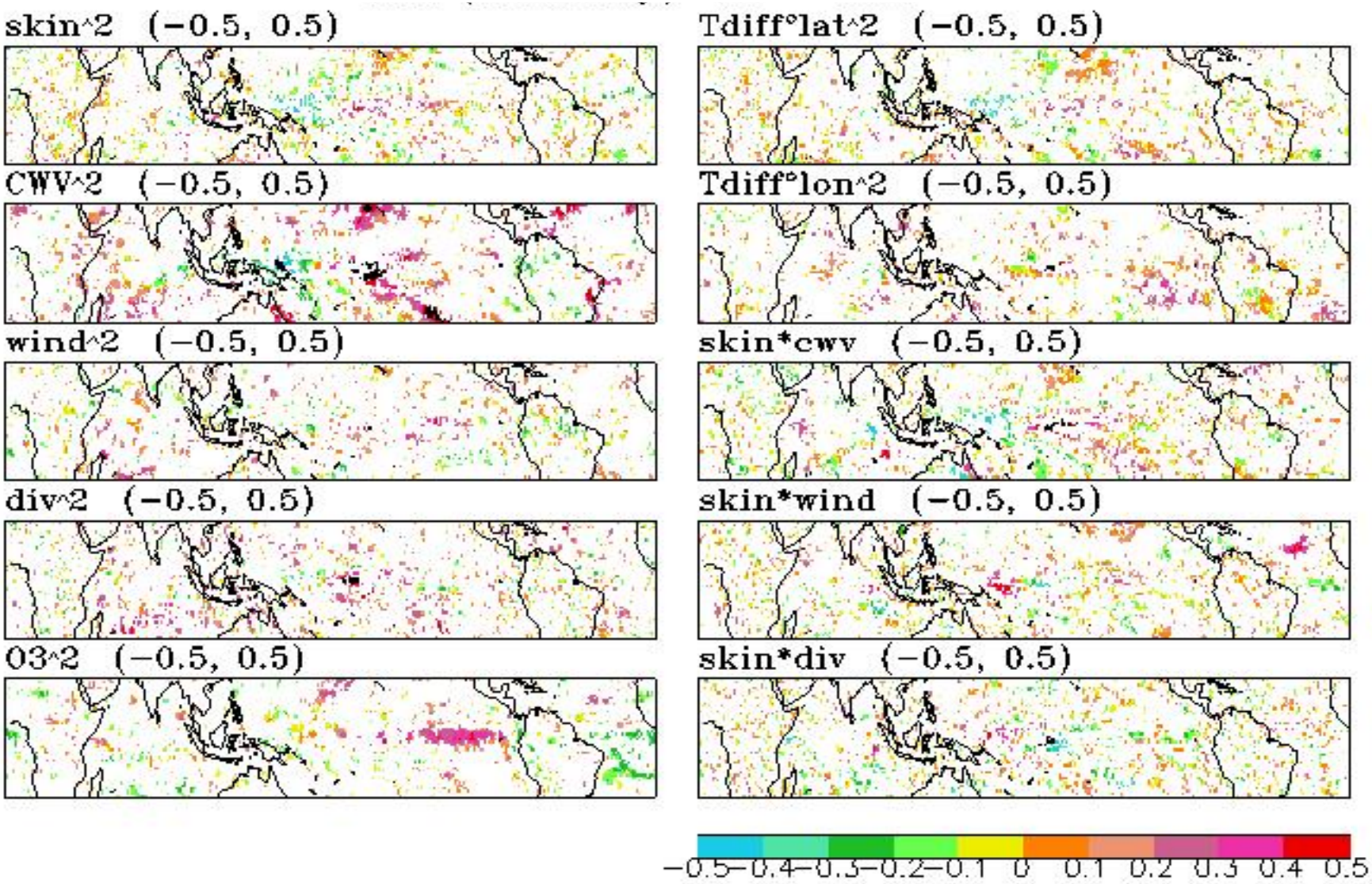
Relation to Environments

Relationship with individual variables: LW Corr



Relation to Environments

Relationship with individual variables: SW Corr



Summary

- Climate system has different characteristics in different time scale. This study analyzes radiative variations in short-time scales (within few years).
- TOA radiation variations are strongly related to basic meteorological state variables such as column water vapor, wind speed, divergence, O_3, and temperature gradient.
- The strongest contribution of surface temperature is from the blackbody emission.
- Wind and column water vapor dominant radiation variations, representing dynamic/thermodynamic impacts.

Summary (conti.)

- Surface temperature gradients along east-west directions clearly show certain general patterns, but not for those along meridional directions, which may indicate concentrated areas for Walker cells and wide spread Hadley circulation.
- These environmental variables could explain changes of regional radiation fields very well. (~70% variability explained)
- The use of the radiative relationships here as climate feedbacks should be with caution due to its short-term response nature as indicated by many dynamic and thermodynamic terms.
- Additional variables such as aerosols on radiation anomalies still need to be investigated.

Acknowledgement

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