Redundancy analyses of the coupled atmosphere-ocean system using state space model representations

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Presentation Outline

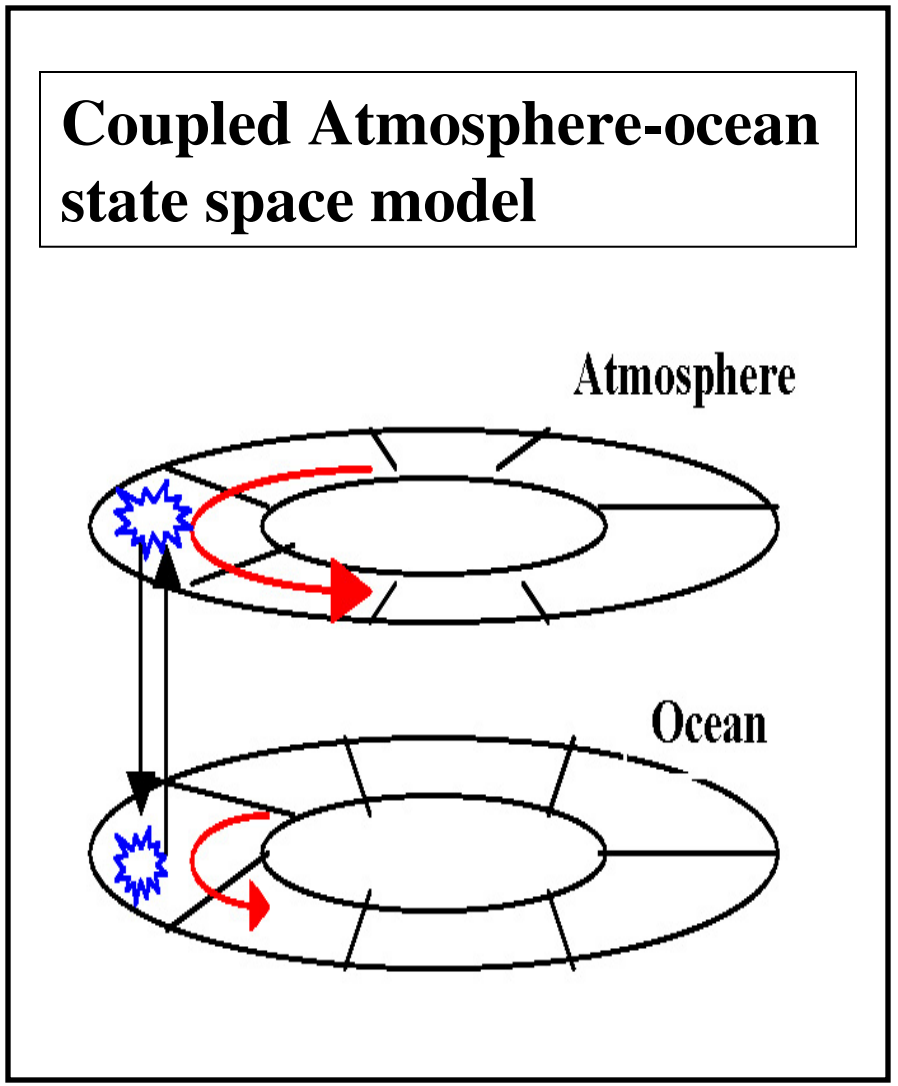
- Introduce **simplified State Space Model**
- Carry out **an idealized case study** for a single standing mode
- **Analyze State Space Model results:**
  - compare and contrast coupled PCA to Redundancy Analysis
  - discuss **advantages** and **disadvantages** of each statistical approach
- **Present a summary of Findings**

Motivation for Redundancy Analysis

- **Coupled PCA analyses:**
  - Identify patterns that maximize variance in coupled SST and SLP fields … no directionality implied
- **Redundancy analysis**
  - Set up a regression equation
  - Find pattern in one variable that best explains variance in other variable
  - carry out time-lagged analyses
- **Identify "signal-response" patterns**

The "Annular" State Space Model

- **Simplified representation** of coupled atmosphere-ocean system
- **Model Parameters:**
  - **Diffusion** (both media)
  - **Advection** (both media)
  - **Coupling** between overlying ocean / atmosphere cells
- **Eigenvector Analyses** of state model output

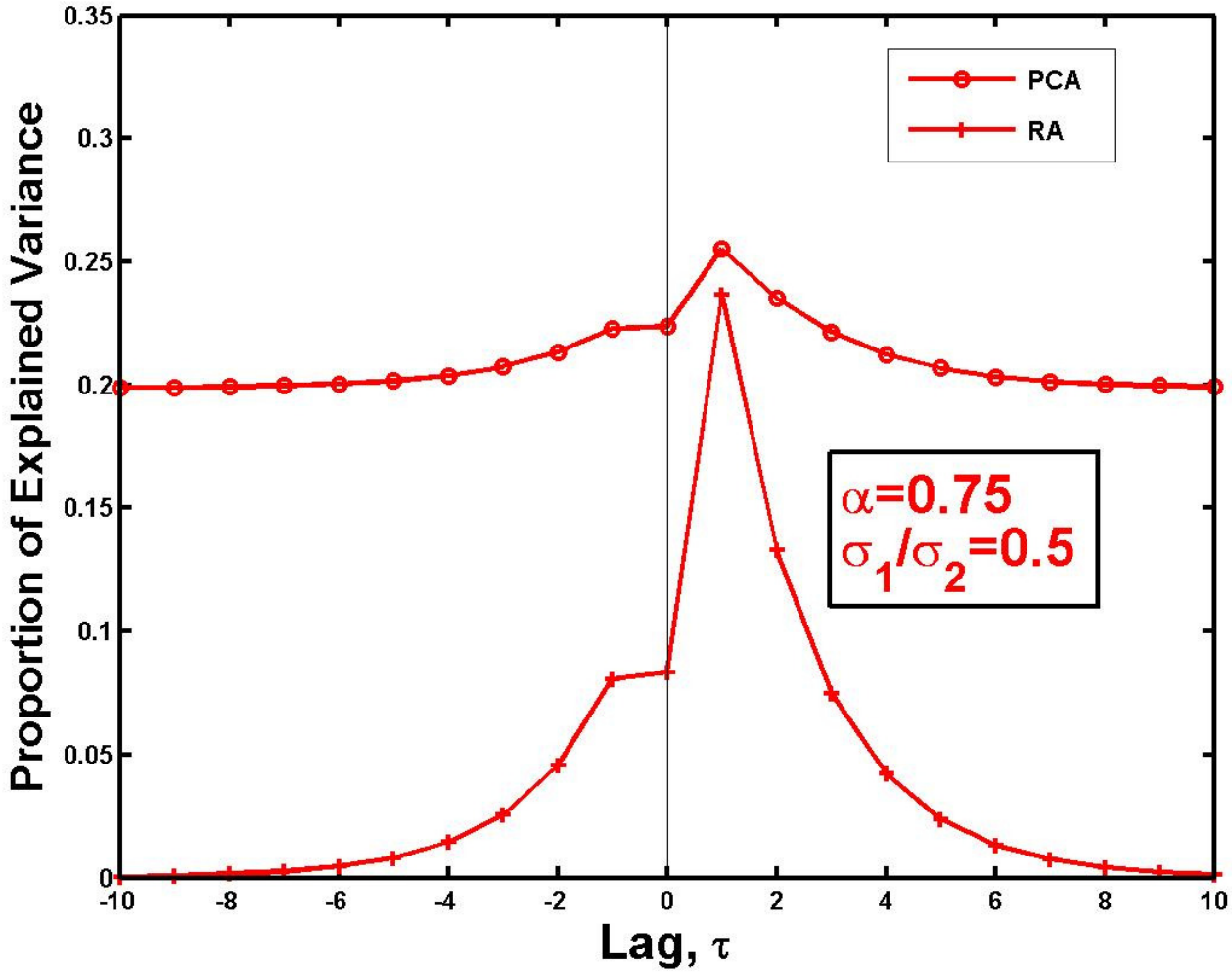


An "Idealized" case study

- Assume a single standing mode pattern in the ocean and atmosphere
- The RA and PCA eigenvectors/eigenvalues are a function of 3 parameters:
  - γ, the memory of system
  - σ_1 and σ_2, the standard deviation of atmospheric and oceanic forcing, respectively
  - ϕ, the structure of the standing mode
- Analytical solutions

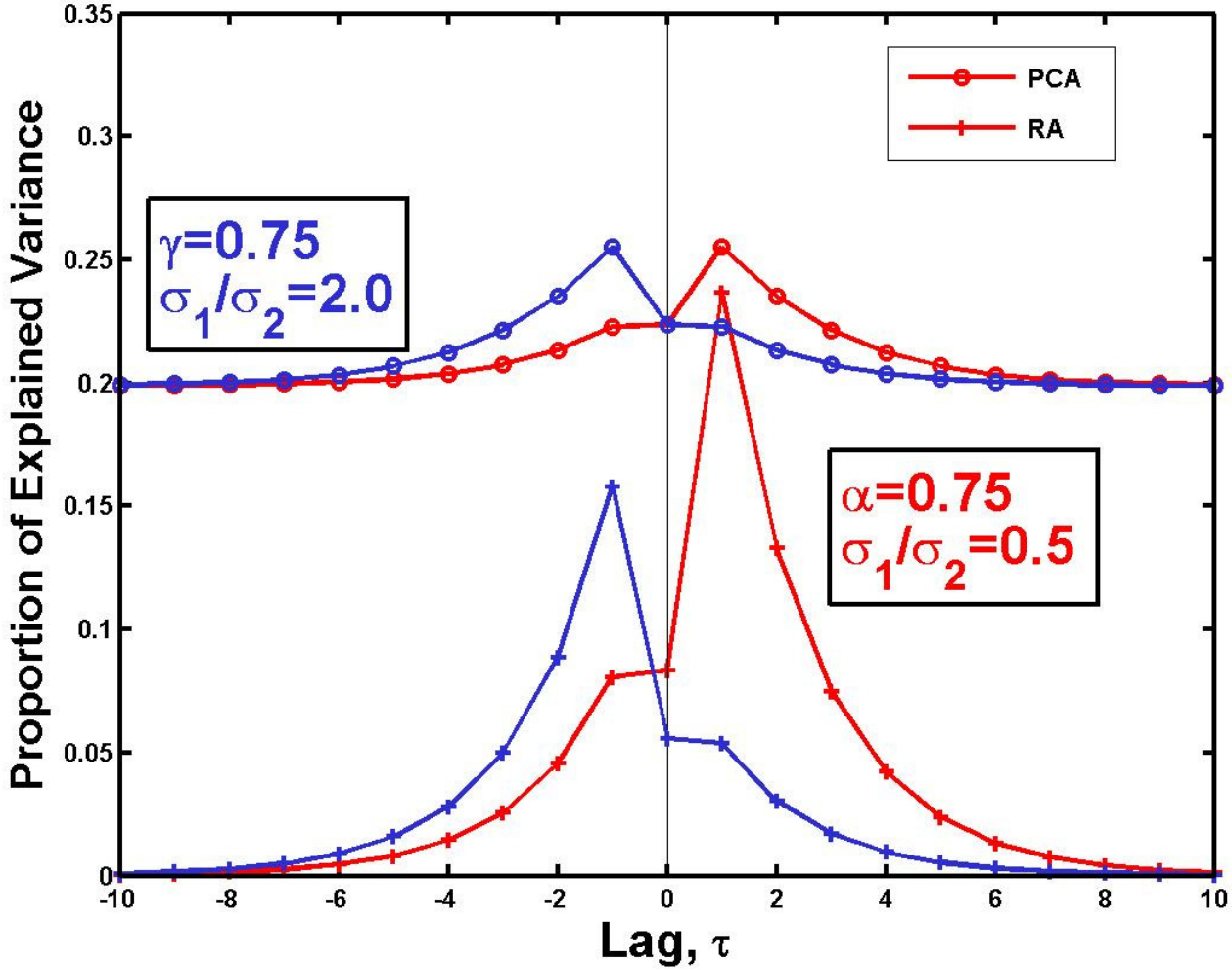
Atmosphere forcing Ocean

Ocean response - positive lags

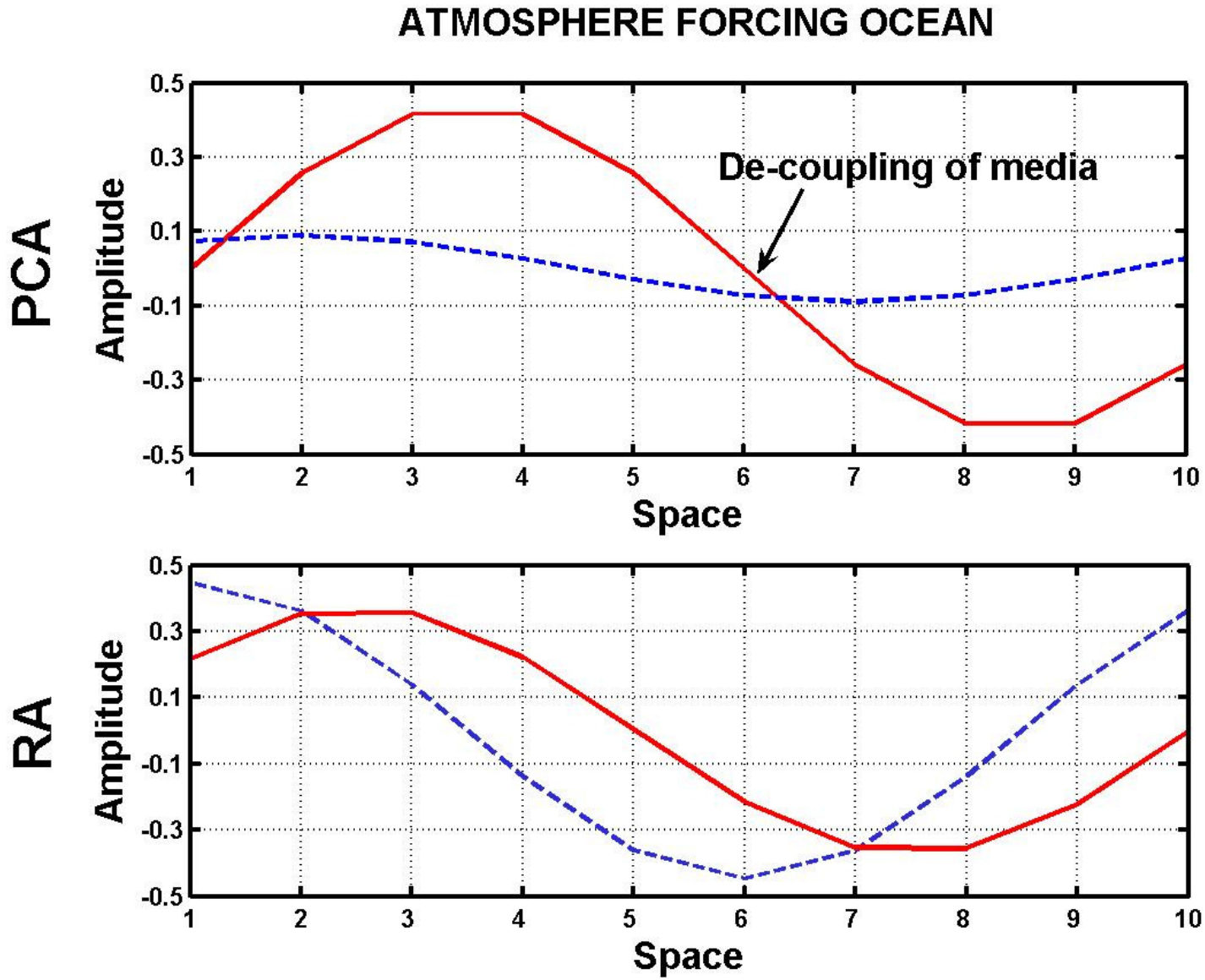


Reality: Ocean forcing Atmosphere

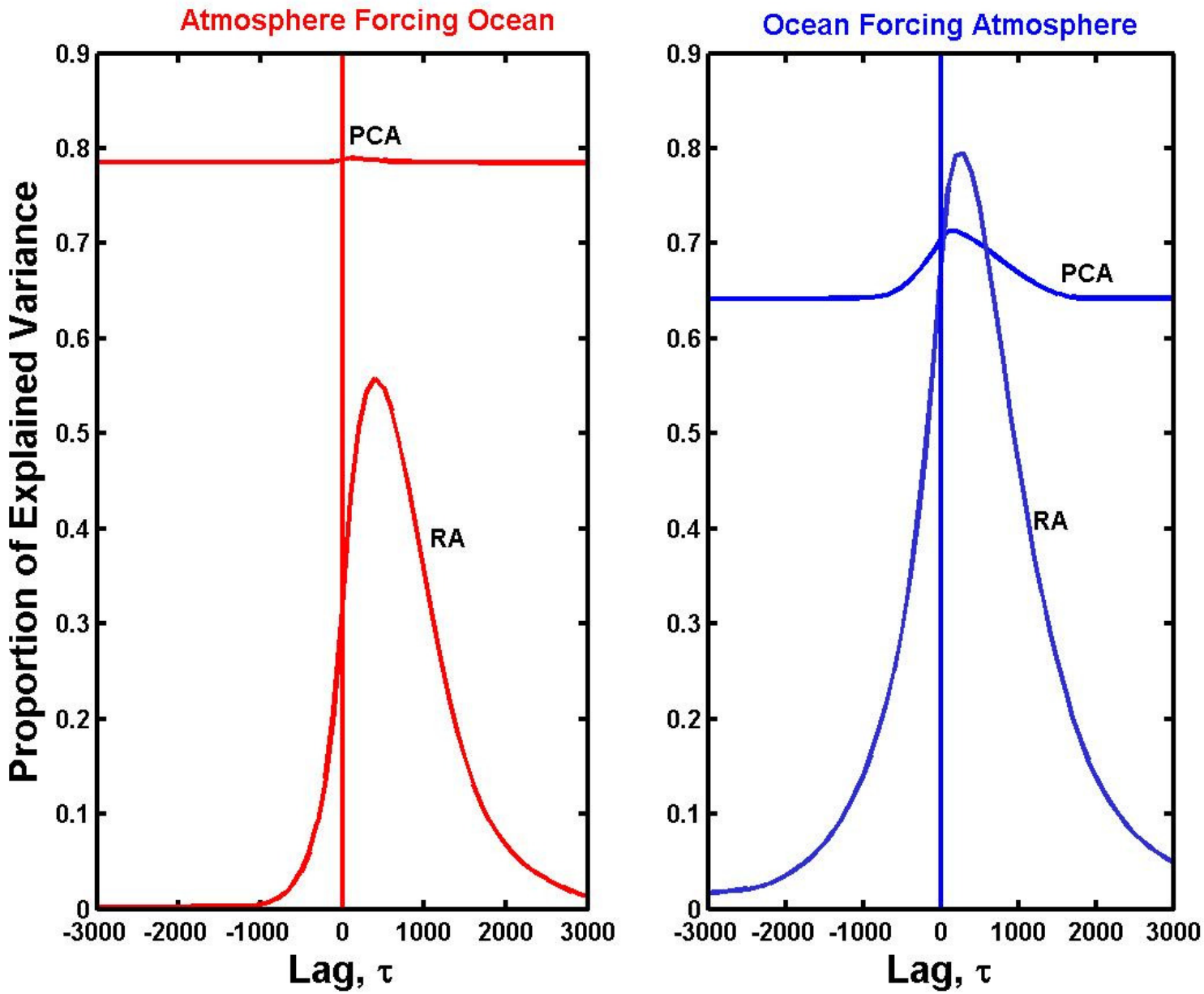
Ocean response - negative lags



Coupled diffusion-advection model



Time-Lagged Analysis



Summary of Results

- **Time-lagged RA** curves exhibit **pronounced peaks** whereas those of **PCA are relatively flat**
- As time lags increase, **PCA modes** are dominated by noise from stochastic forcings
- **Time-lagged redundancy index** is a powerful tool for determining directionality
- **RA** generally **provides a lower-order representation** of the variability than coupled PCA

State Space Model Results for weakly coupled systems

- **PCA eigenvector amplitudes** approach zero for non-stochastically forced medium
  - de-coupling of the two media
  - over-representation of one medium

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