Pacific dominance to global air-sea CO_2 flux interannual variability: Atmospheric inversions and ocean models

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Seventh International Carbon Dioxide Conference

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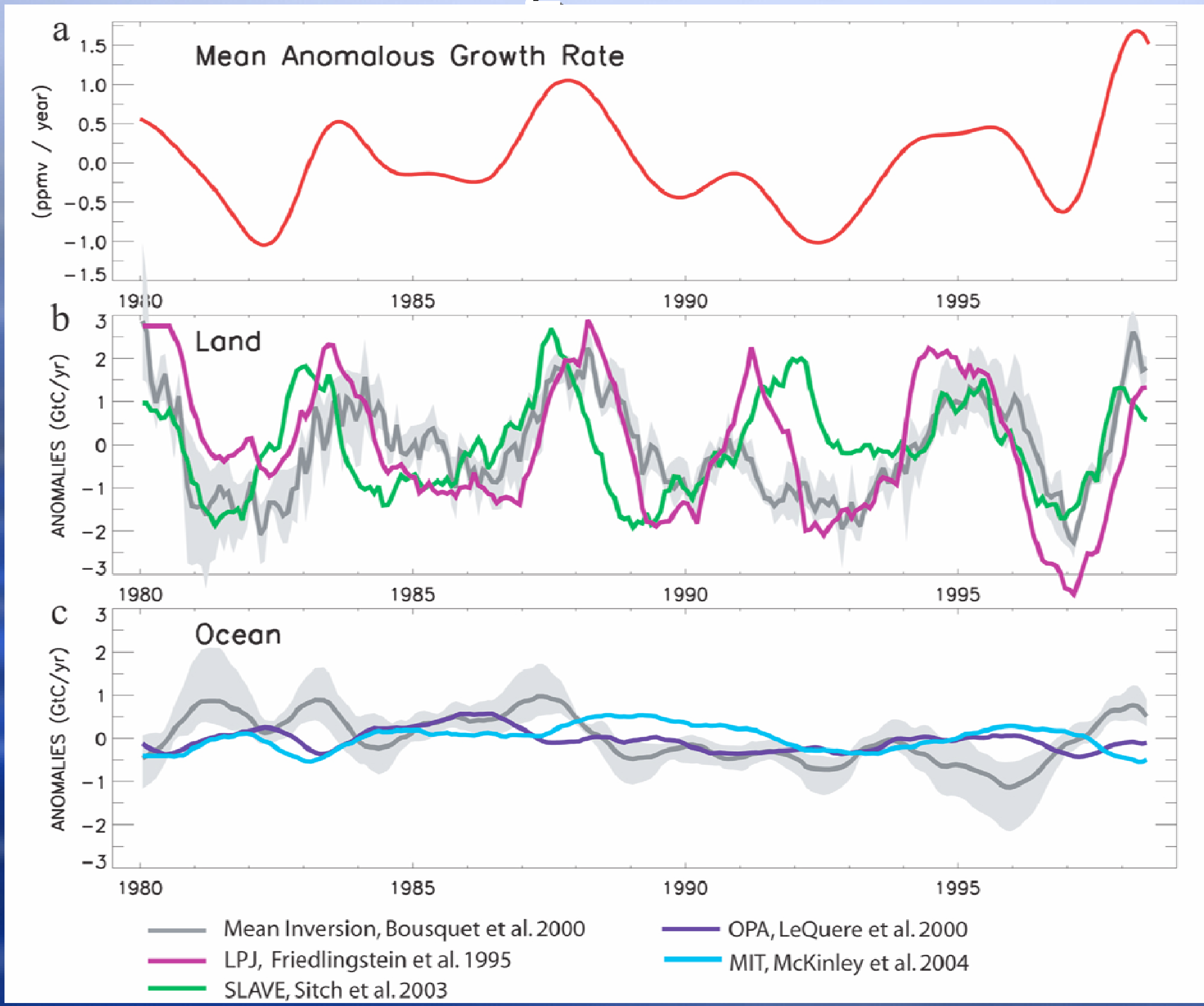
CO_2 sink variability

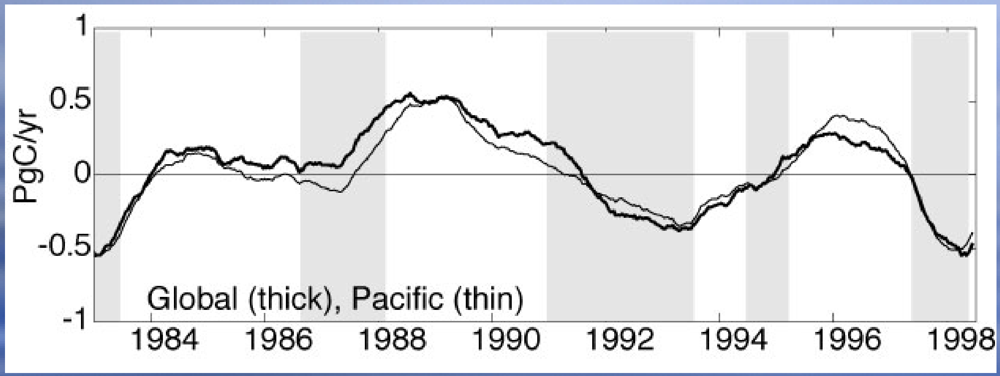


Peylin et al. 2005

±2 PgC/yr in land; ±0.7 PgC/yr in ocean

Regional dominance to air-sea CO_2 flux variability?

- Ocean models: Pacific drives >80%



MIT Model McKinley et al. 2004

  – Highly concentrated in Equatorial Pacific, dominated by ENSO
  – Very similar results in: Winguth et al. 1994; LeQuere et al. 2000, 2003; Obata and Kitamura 2003; Wetzel et al. 2005

- Inversions:
  – Bousquet et al. 2000 - High Latitudes
  – Rödenbeck et al. 2003 - Pacific

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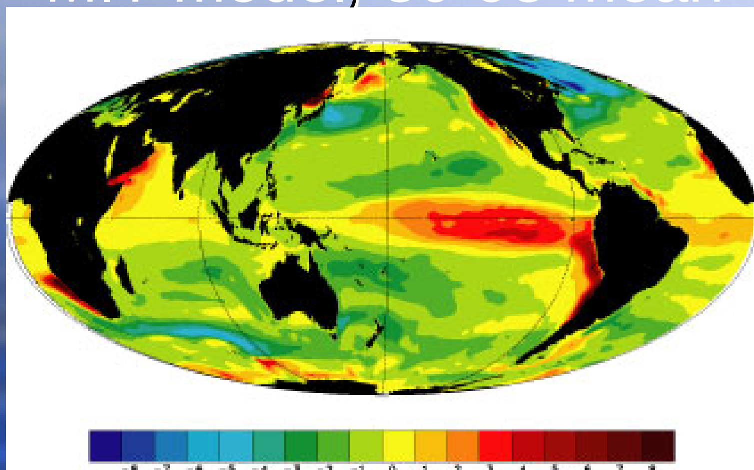
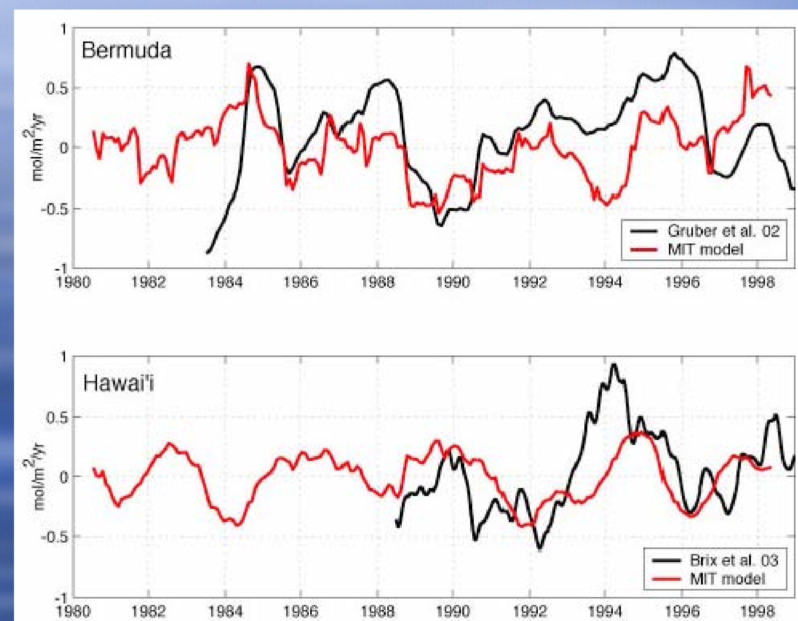
Ocean biogeochemical models

MIT model, 80-98 mean



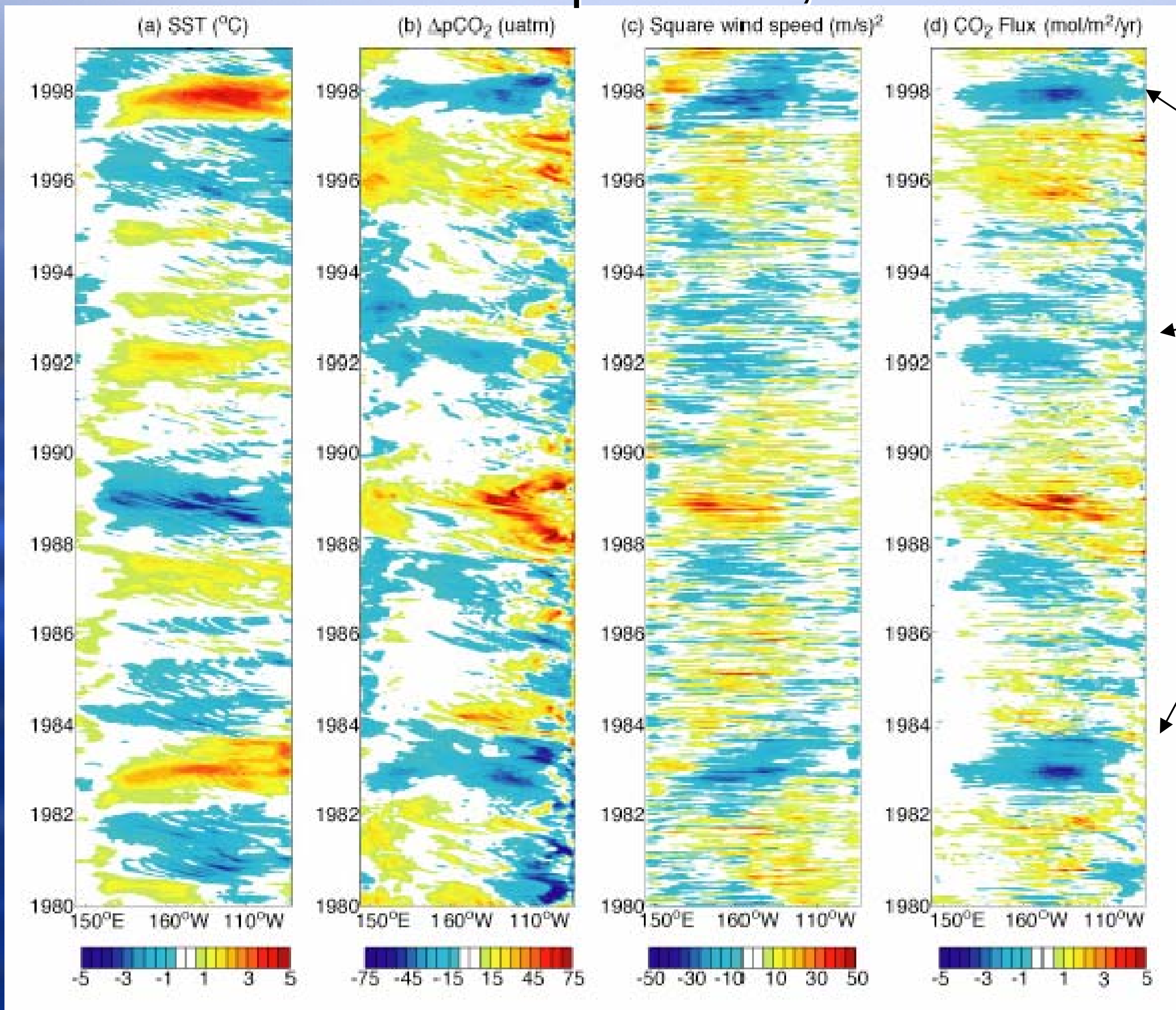
Interannual variability compared to data

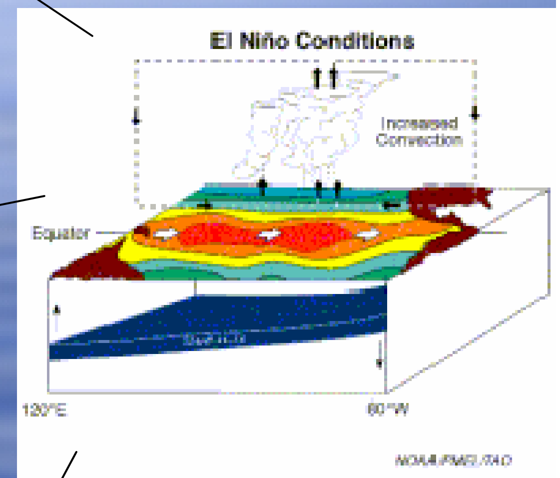


- Strengths
  - Process-based
- Challenges
  - Under-representation of variability
  - Resolution, Parameterizations, Forcing fields

ENSO is flux driver

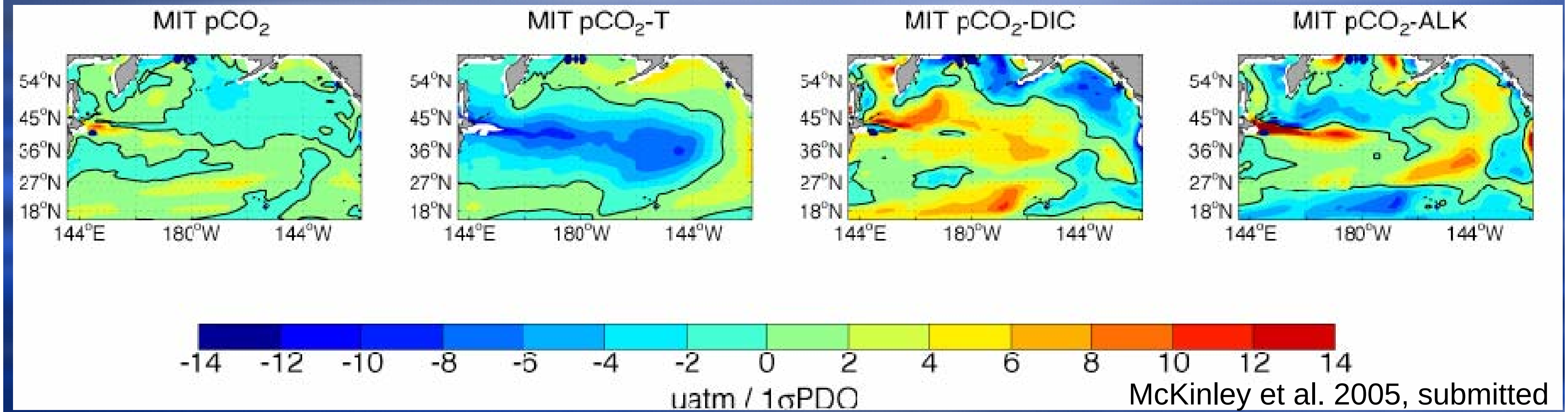
MIT model: Eq. Pacific , 5S-5N





Small high-latitude variability in models:
balancing influences on pCO_2 of temperature, DIC, and Alkalinity signals

North Pacific: Regression of pCO_2 and key components on Pacific Decadal Oscillation

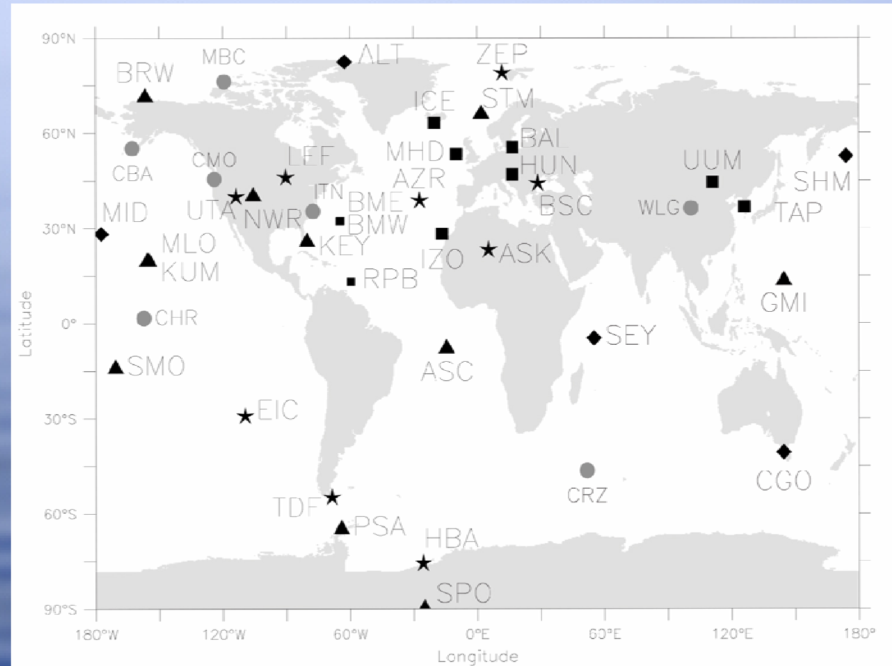


McKinley et al. 2005, submitted

Similar response patterns in 6 other ocean models

Inversions of atmospheric CO_2 data

CO_2 flask data



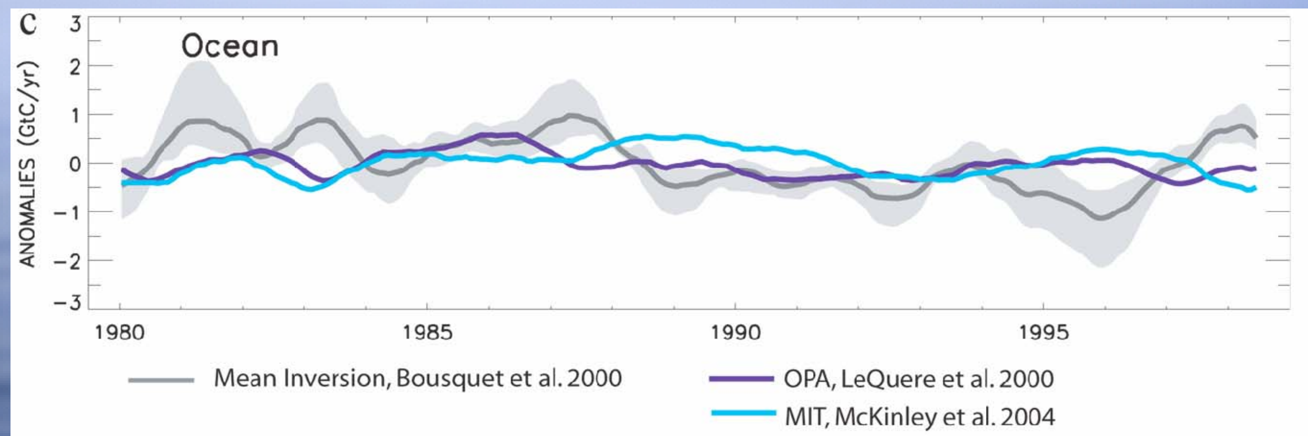
- Concentration = Transport x Flux
  -> Flux = Transport $^{-1}$ x Concentration
- Challenges
  - Ill-constrained -> requires many choices in set-up
  - Solutions very sensitive to these choices

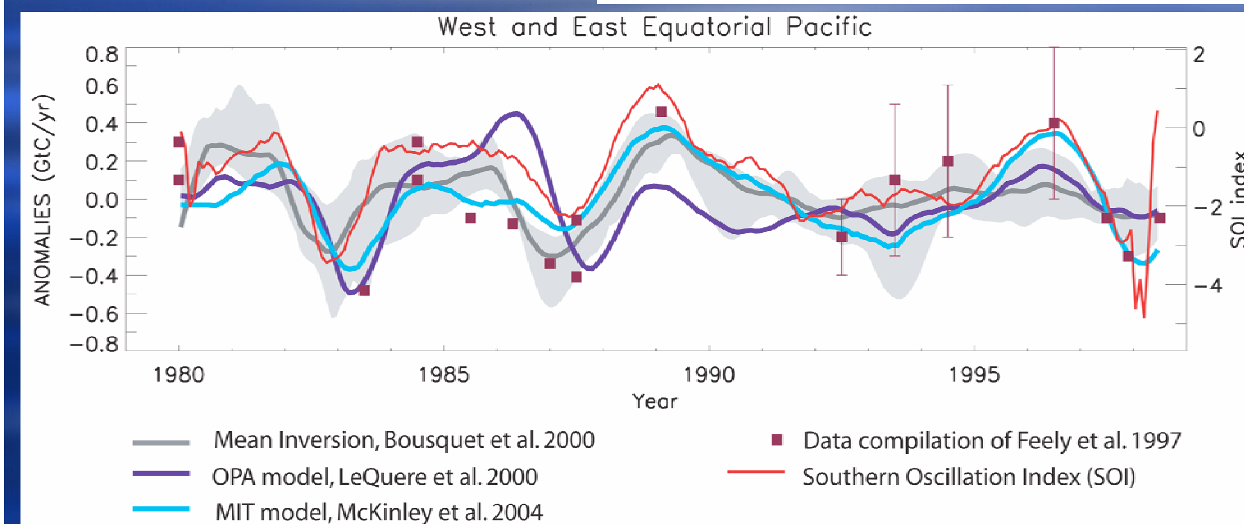
Comparing inversion setups

	Rödenbeck et al. 2003	Traditional (Bousquet et al. 2000)
Resolution	Small regions	Large regions
Regularization	Priors Covariance matrix	Priors
Station set	Constant over inversion period	Increasing
Winds	Interannual	Climatology

Inversion of Bousquet et al. 2000

Globally, inversion and ocean models not in agreement





Yet, very good agreement in Equatorial Pacific

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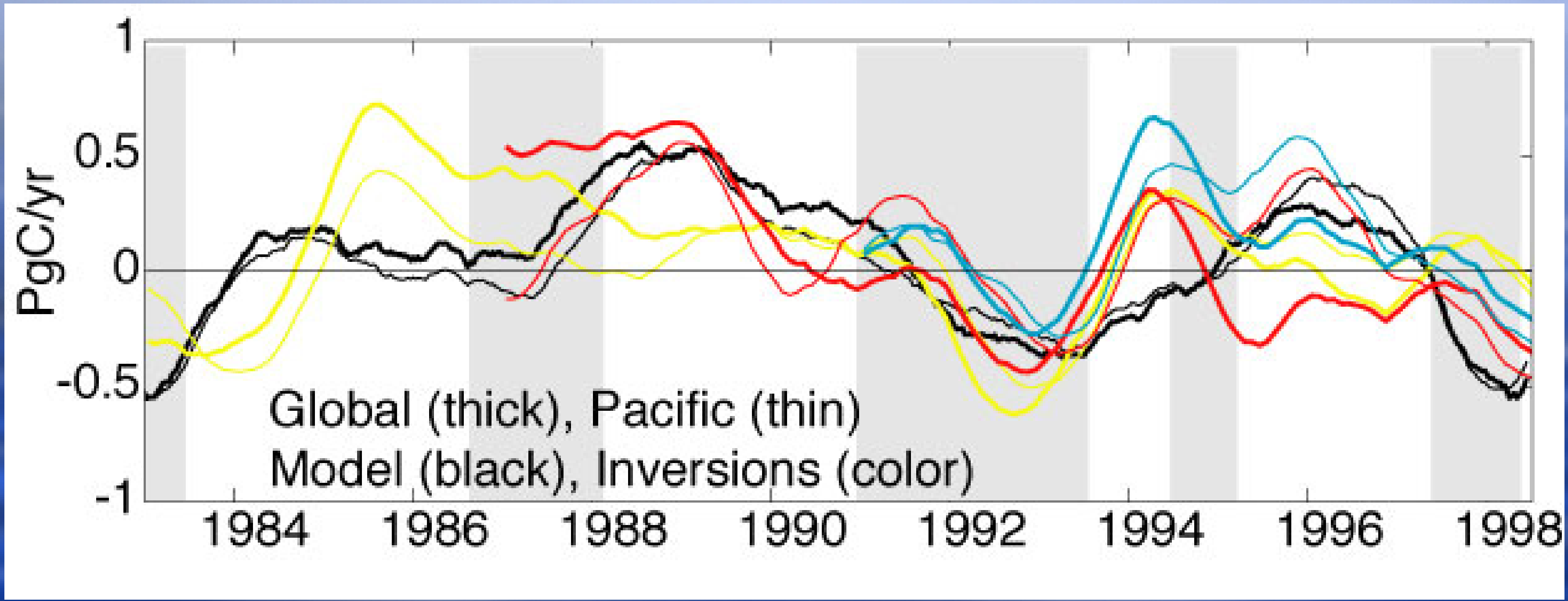
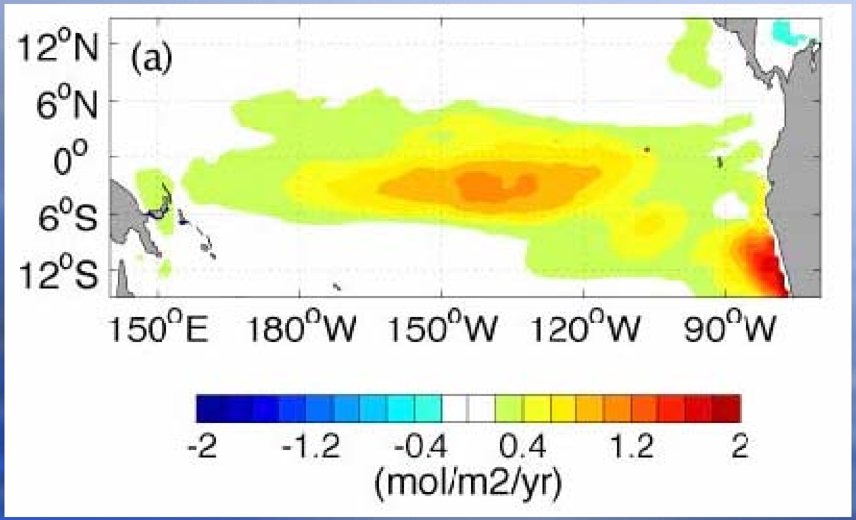
Inversion of Rödenbeck et al. 2003



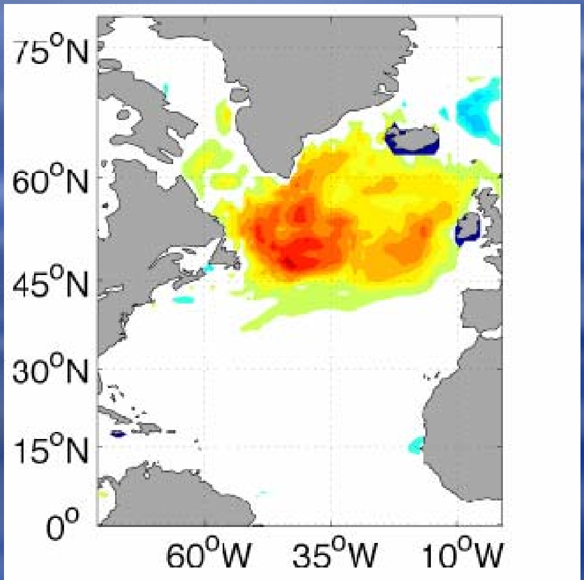
- Inversion: >60% variability in Pacific
- But, Equatorial Pacific not dominant

Difference in correlation lengths



- EOF1 explains 50% of Eq. Pacific variability

- But EOF1 explains only 11% in N. Atlantic



Remaining challenges

- Ocean Models
  - High latitude mechanisms
- Atmospheric Inversions
  - Data density
  - Methodology - ongoing sensitivity studies
- Ultimate goal: Agreement in temporal structure of ocean sink

Questions?

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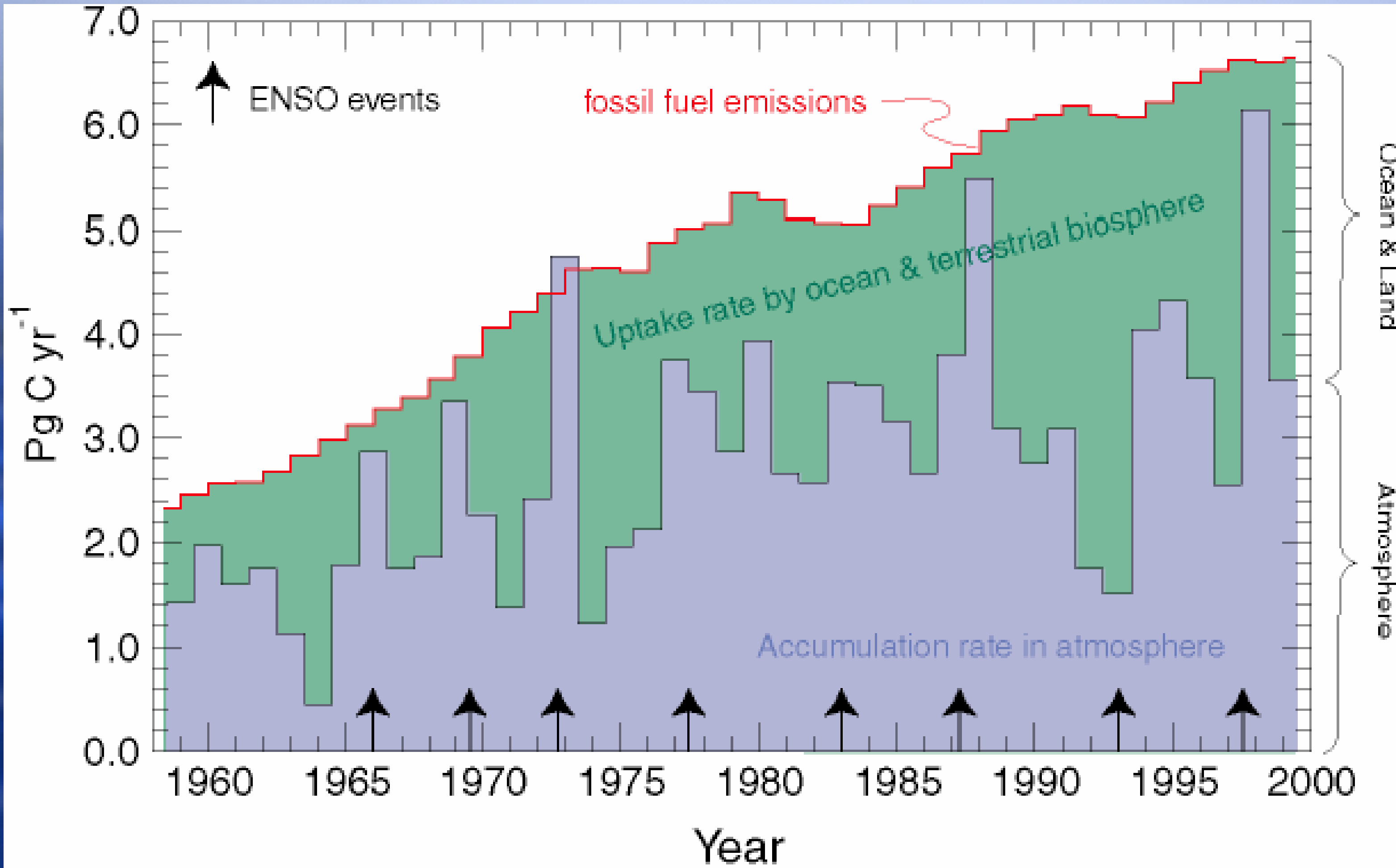
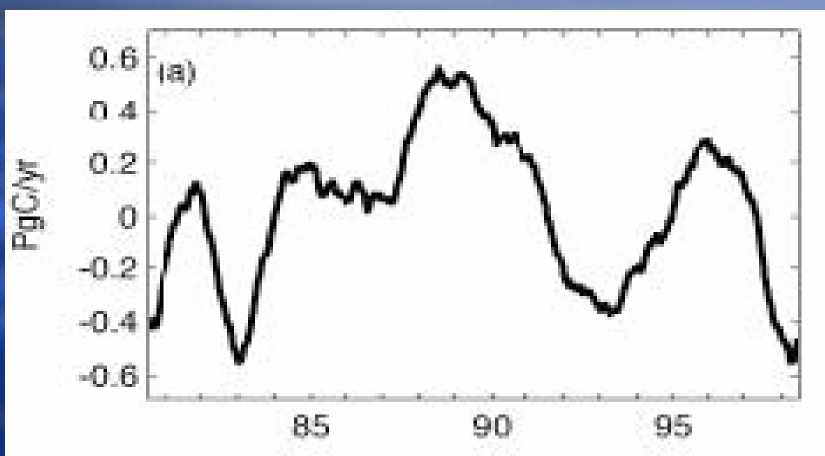
Interannual variability in CO_2 sink



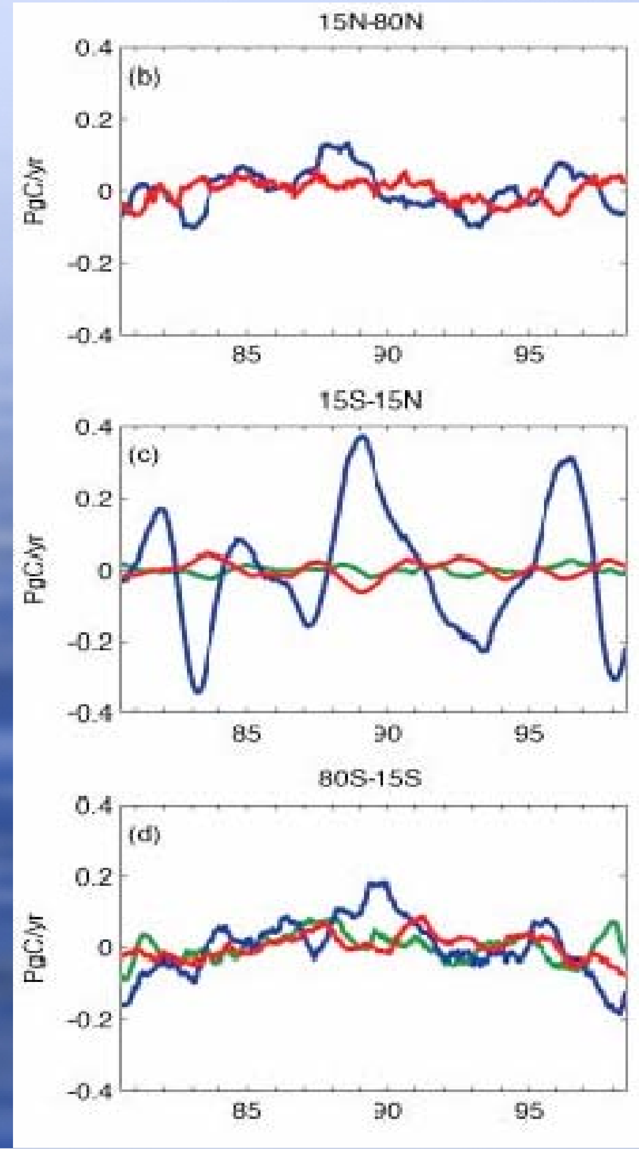
Sarmiento & Gruber 2002

Modeled air-sea CO_2 flux variability (PgC/yr)

Global flux anomaly



Regional breakdown

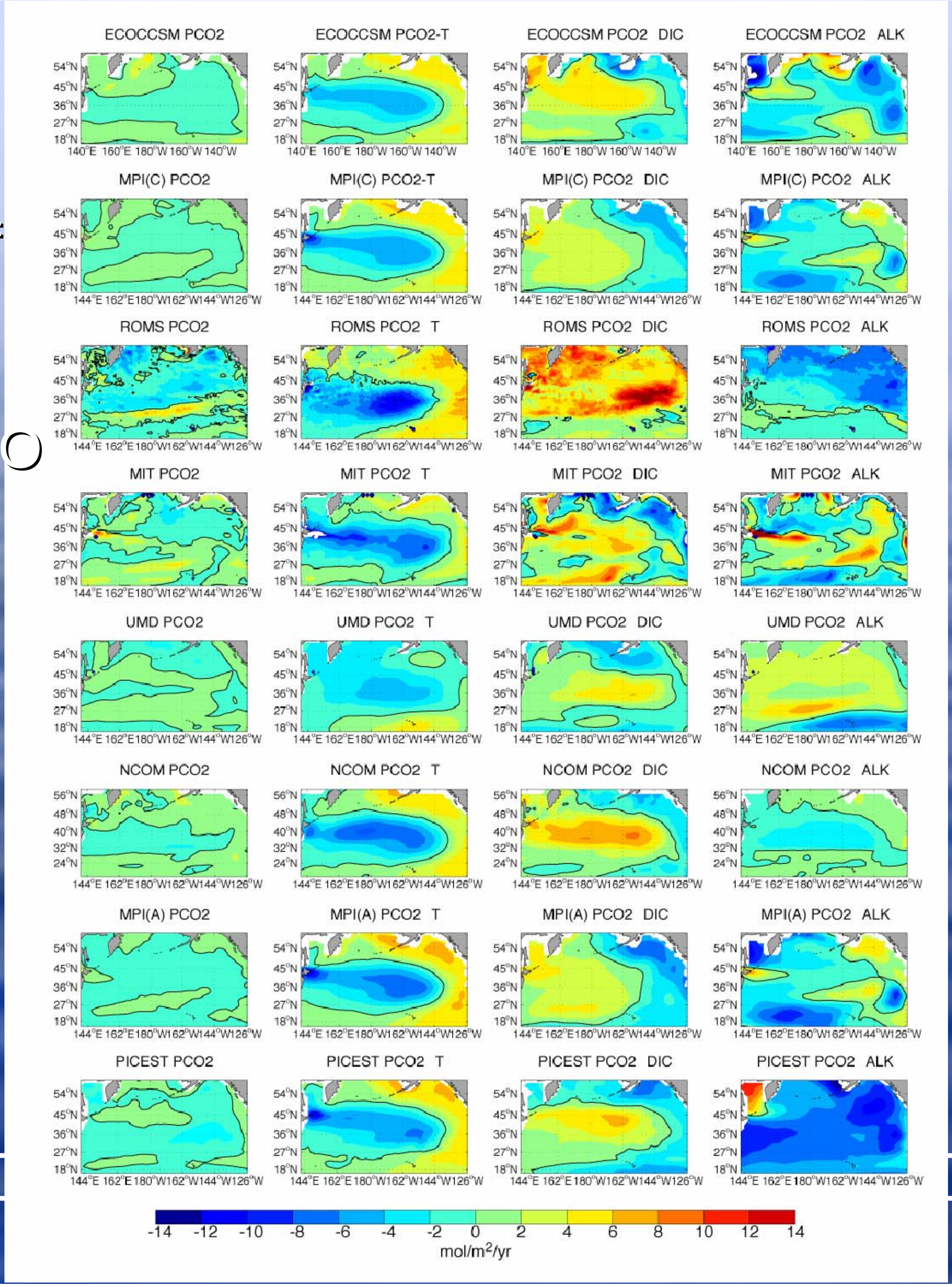


Red = Atlantic

Blue = Pacific

Green = Indian

Wide range of models show similar pCO_2 response to PDO forcing



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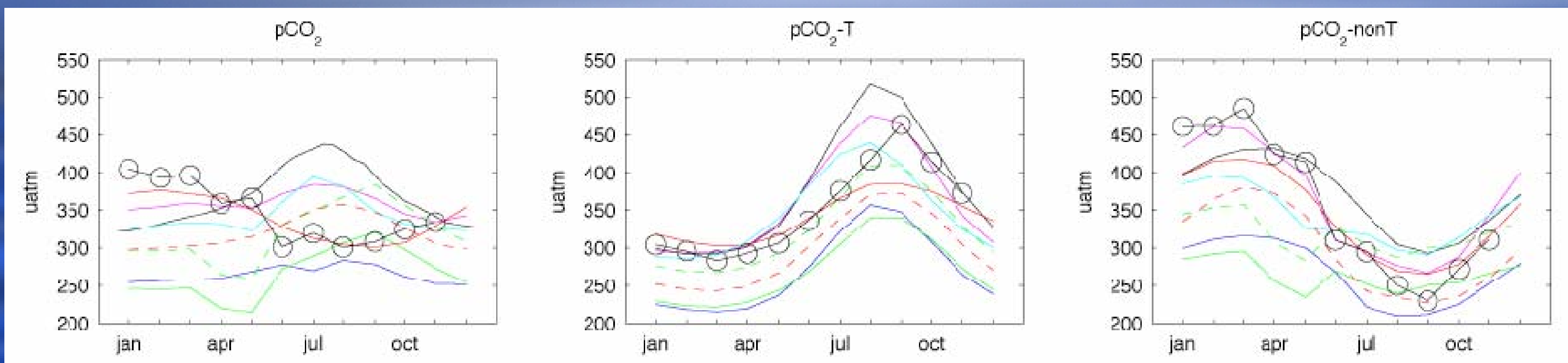
One modeling challenge: High-latitude seasonal cycle

pCO_2 and components, cycles near Kuril islands



o = Data, Takahashi et al. 2005, submitted