Effects of natural variability on biogeochemical processes in climate models

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What do we (can we) expect of climate models?

- Climate models increasingly reproduce the natural modes of internal variability of the climate system (ENSO, PDO, SAM), but not as well as we would like.
- Whether the total magnitude of internal variability is adequate is difficult to verify because data records are short and much of the variability is low-frequency.
- Biogeochemical fields are particularly poorly observed.
AR5 models now online!

Models:
- CanESM v.2
- HadGEM v.2

Data:
- IGOSS SST (Reynolds and Smith 1990)

1960-2005
1982-2007
The **Canadian Earth System Model (CanESM)**

**Anthropogenic CO₂ emissions**
- Prescribed fluxes of CH₄, N₂O, etc

**AGCM4**
- Simple atmospheric chemistry
- **CLASS**
  - Photosynthesis

**Land**
- Leaves
- Stem
- Litter
- Soil Carbon
- Roots

**CO₂ release**
- CO₂ uptake

**Atmosphere**
- CO₂

**Ocean**
- POC + Calcite
- Primary Production
- Respiration
- DIC
- Surface Ocean
- Nutrients
- DOC
- Sinking Particles

**Transformations**
- Biotic Pumping
- Mixing + Advection
- Burial

**Simple atmospheric chemistry**
CanESM ocean ecosystem model

NPZD with simple parameterizations of $N_2$ fixation and calcification
Increased vertical resolution particularly in upper 200 m
Correlation of surface CO$_2$ flux with climate indices

Christian et al 2010 JGR
SST EOF 1
Tropical Pacific

**OBS**

**CanESM**

**HadGEM**
SST EOF 1
North Pacific
Power spectra: SST principal components

PDO

ENSO
NINO3 SST anomaly

![Graph showing NINO3 SST anomaly with lines for CanESM, HadGEM, and OBS over the years 1960 to 2005.](image)
• climate models such as CanESM and HadGEM are getting better at simulating ‘modes’ of natural variability in the Pacific

• HadGEM does a better job of tropical SST anomaly pattern; amplitude and overall variability are similar

• global patterns of correlation of biogeochemical processes with climate indices are similar; difficult to test vs observations but SOCAT should help

• coherence of biogeochemical processes with ENSO and PDO modes is stronger in CanESM, particularly in the extratropics