Ocean carbon states

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Years past...
Or, how to not do clouds and still get away with it…

- Oceans and climate
- Air-sea fluxes and climate; radiation, heat, momentum, tracers
- The ocean carbon cycle
- Only Bill knows…
Decorrelation Scales of High-Resolution Turbulent Fluxes at the Ocean Surface and a Method to Fill in Gaps in Satellite Data Products

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ABSTRACT
In the first part of the paper, a high space–time resolution (1-h) turbulent fluxes at the ocean surface is used to estimate and study the decorrelation scales of the latent and sensible heat fluxes, the temporal and spatial patterns that dominate the flux fields (with dominant variability in the air-sea interaction. Regional and hour-related variables such as the wind stress, the humidity of mechanism responsible for the variability in each flux field.

In the second part of the paper, the decorrelation scales are

20th century changes in surface solar irradiance in simulations and observations

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[1] The amount of solar irradiance reaching the surface is a function of the earth's rotation using the following equation:

\[ \text{I} = \frac{1}{\text{cos} \theta} \]

where \( \theta \) is the angle between the sun and the plane of the earth's equator. In general, this equation can be applied to any point on the earth's surface.

[2] A negative shortwave anomaly at the ground does not automatically imply atmospheric cooling since the air layers above the ground can absorb the shortwave heating and reduce the surface temperature. Therefore, the observed longwave flux incident to the surface is expected to increase due to enhanced anthropogenic greenhouse gas emissions, such as carbon dioxide, which is known to absorb longwave radiation.

[3] This longwave anomaly is also related to the so-called “greenhouse effect” which refers to the process by which the earth's atmosphere and surface temperature is raised by the absorption of infrared radiation from the earth's surface.

Decadal variations of global energy and ocean heat budget and meridional energy transports inferred from recent global data sets

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[1] We use the most recent global, decades-long data sets, consisting of two satellite-derived top-of-atmosphere (TOA) and surface radiative flux data sets from the International Satellite Cloud Climatology Project Flux product (ISCCP-FD) and the Global Energy and Water Cycle Experiment Surface Radiation Budget project (GEWEX-SRB), three ocean surface turbulent flux data sets from Goddard Satellite-Based Surface Turbulent Fluxes (GSSTF), and a global ocean heat storage data set from the National Oceanic and Atmospheric Administration (NOAA).

[2] These data sets are then analyzed to determine the energy budget and meridional energy transports over the period from 1984 to 2005.
Carbon sources & sinks

http://earthobservatory.nasa.gov/Features/CarbonCycle/

Air-sea gas exchange flux

\[ F = \kappa \alpha (pCO_2^{atm} - pCO_2^{ocean}) \]

- CO\(_2\) Flux
- Solubility pump (wind speed, SST, SSS)
- Biological Pump
Flux of CO2 into the Ocean

Carbon Dioxide Flux (CarbonTracker 2015 Mean)
- Flux of CO2 from the Takahashi 2012 climatology
- Surface T,S,nutrients from World Ocean Atlas 2009
- Mixed layer depth from Ifremer – DeBoyer
- Wind speeds from scatterometer
- GISS modelEv2.1 historical emissions run (20th Century)
Clusters for Observations and Model
Temporal Attribution of the Regimes

Model seasons

Monthly Attribution

Distance from Point to Cluster Centroid

- Winter Cluster
- Summer Cluster
- Transition Cluster

N. Atlantic Takahashi Data, k = 3
\[
\Delta pCO_2 = \frac{\partial pCO_2}{\partial T} \Delta T + \frac{\partial pCO_2}{\partial S} \Delta S + \frac{\partial pCO_2}{\partial H} \Delta H + \frac{\partial pCO_2}{\partial w} \Delta w + \frac{\partial pCO_2}{\partial N} \Delta N + \frac{\partial pCO_2}{\partial Si} \Delta Si
\]

- Surface temperature
- Surface salinity
- Mixed layer depth
- Surface wind speed
- Surface nitrate
- Surface silicate
Regional error attribution: subpolar North Atlantic

PCO2 0-300 || SST -3-10

Regional error attribution: subtropical North Atlantic
Regional error attribution: the tropical North Atlantic
Usefulness of data mining/data reduction/big data science for climate

- Identify modes of variability; either in space or time, or both
- Use those to extract meaningful states of the ocean-climate system
- Use them to assess model skill