Air-sea Fluxes:
OCEAN-model needs from Re-analyses

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Ocean analyses
  • Sensitivity to surface forcing estimates

Air-sea Flux Products
  • Some new products
  • Comparison with re-analyses
  • Buoy data

Atmosphere & Ocean Re-analyses
  • Workshop recommendations
    Ongoing Analysis of the Climate System (August 2003)
    Coupled Data Assimilation Workshop (April 2003)
• Surface Fluxes have a significant impact on ocean estimates, even in assimilation mode
• Important for ocean reanalysis - paucity of the historical ocean obs

**Assimilation Sensitivity Tests**

Poseidon V4 quasi-isopycnal ocean model, 1/3° x 5/8° x 27 layers

"quasi-global": (no Arctic Ocean)

Assimilation scheme: OI
Sensitivity: forcing + treatment of salinity
Period: 1993-2003

**Surface Forcing**

**ODASI** forcing:
- NCEP CDAS forcing, wind stress climatology replaced by Atlas/SSMI analyses -
  relaxation to Reynolds weekly SST and Levitus salinity.

**GMAO** forcing:
- Atlas/SSMI time varying wind stress
- GPCP monthly mean precipitation
- NCEP CDAS SW (for penetrating radiation) & LH (for evaporation)
- relaxation to Reynolds SST
Surface Flux Product Comparisons

- NCEP1
- GFDL - NCEP2/CDAS
- CORE (NCAR - Large & Yeager)
  Common Ocean-ice Reference Experiments for CLIVAR/WGOMD
  http://data1.gfdl.noaa.gov/nomads/forms/mom4/CORE.html
- WHOI (OAFlux - Yu & Weller)
  Objectively Analyzed air-sea FLUXes
  http://oaflux.whoi.edu/data.html
- ERA-40
Large & Yeager (2004)

- Use Bulk formulae -- use Ocean Model SST (vs observed SST)
- Correct fields so that long-term mean fluxes are in balance

- Turbulent fluxes - shift temperature and humidity to height of wind - shift coefficients to this height and atmospheric stability

- Radiative fluxes - use consistent products for both components (cloud compensation)

- Precipitation data - highly uncertain - need breakdown in terms of rain and snow

- Runoff (distributes net P-E over land into runoff)

- Relaxation to observed SST - negative feedback helps contain the accumulation of flux errors
  - Precipitation does not depend on salinity - no feedback to contain the flux errors

- Ice-ocean fluxes - use a sea-ice model

NCEP; ISCCP
- Precipitation - blend of GPCP (tropics) and Xie-Arkin (GPCP/Serreze data in polar regions)
- SST and SSS data sets for relaxation

Flux corrections:
- SW (ISCCP c.f. other products)
- Qscat $\rightarrow$ corrections in wind speed
- LH $\rightarrow$ corrections in specific humidity $\rightarrow$ changes to P
- Global imbalances reduced to 1 Wm$^{-2}$ and -0.1mg/s/m$^2$
Qnet
Seasonal Means

WHOI
Dec/Jan/Feb
Min, Max: -455, 248.

NCEP1
Dec/Jan/Feb
Min, Max: -442, 210.

GFDL
Dec/Jan/Feb
Min, Max: -502, 249.

CORE
Dec/Jan/Feb
Min, Max: -446, 245.

Jun/Jul/Aug
Min, Max: -243, 219.

Jun/Jul/Aug
Min, Max: -239, 223.

Jun/Jul/Aug
Min, Max: -258, 246.

Jun/Jul/Aug
Min, Max: -306, 237.

Wm\(^2\)
Latent Heat Flux Differences
Seasonal Mean

GFDL - CORE
Min, Max: -110, 235

GFDL - NCEP1
Min, Max: -50.7, 56.82

GFDL - WHOI
Min, Max: -137, 129.1

No Data
Changes in Qlh+Qsh (W/m²) During 1997–1998 (Average over 5S to 5N)
Why is it difficult to get the flux correct? Data? Algorithm?
Problems in model humidity

Year-to-year variations of zonally averaged latent heat flux from TAO buoys and ERA40

Positive (negative) flux anomalies indicate more (less) latent heat loss from the ocean.
Surface Flux Panel

Background:

- Fluxes between the atmosphere and the ocean, land surface, sea-ice are important for understanding climate variability.
- Surface forcing is a major source of error and uncertainty for ocean and land surface products.
- Need better products and information on error statistics as input to ocean and land surface data assimilation.

Findings:

- Current Reanalysis surface flux products are not adequate for climate analyses (not accurate, budgets don’t close) or to force ocean and land surface models (not accurate).
- Of particular note: significant biases in precipitation and radiation.
- We need accurate surface fields more than accurate fluxes so that we can calculate our own surface fluxes. We replace reanalysis fields with corrected fields or other observational analyses (such as satellite-based surface radiation) when needed. Corrections for humidity are problematic.
Recommendations (1):

- Atmosphere, Ocean, Land Surface, Sea-ice analyses and the fluxes for each should be “synchronized” - coordinated programmatically
- Atmospheric analyses for climate purposes (such as CDAS) should be kept current
- Analysis should be best estimate of the state - that’s what we measure
- Surface analyses should encompass:
  - realistic variability in the modern era down to 1 degree resolution globally, resolving diurnal cycle

Recommendations (3):

- R&D priorities:
  - Improve cloud & PBL (atmosphere and ocean) representations so that analyses can produce realistic fluxes.
  - Develop assimilation for coupled systems
  - Improve assimilation methods so as to use surface observations more effectively
How should the problem be approached from theoretical and practical aspects? What are the first steps that could/should be taken?

• A loosely coupled system is the proper first step (NCEP, FNMOC)
• An incremental approach (e.g., atmosphere coupled to mixed layer; hybrid coupled models)

Summary

• Need better products and information on error statistics as input to ocean data assimilation
• Need long time-series and for analyses to be kept current
• Need consistent analyses of atmosphere and ocean - Coupled?
• Requirements (SCOR, Taylor, 2000): high quality flux products, 3hrly, 50km, errors of a few Wm$^{-2}$, consistency and continuity