Challenges to Determining High-Latitude Surface Fluxes

1. Surface fluxes transfer heat, fresh water, momentum, and gas across the air-sea interface. As depicted in this cartoon, a broad range of processes influence these fluxes, including radiation, ocean circulation, strong winds, high sea state, grounded ice, and various forms of sea ice. (Adapted from Open University schematic.)

2. High winds drive high sea states and make deployment and maintenance of instruments difficult. Typical wind speeds in the Southern Ocean can exceed 20 m/s, while temperate-latitude winds that were used in the past to develop bulk flux algorithms rarely reach these speeds. (Photo from C-DRAKE field program.)

3. Cold temperatures lead to icing conditions, which further complicate in situ observations. (Photo from SHEBA field program.)

4. Arguably the most thorough flux measurements at high latitudes were collected over multi-year ice during the Surface Heat Budget of the Arctic Ocean Project (SHEBA), which (in spite of challenges depicted here) was able to maintain a year-long ice camp. As a result of warming in the Arctic, the SHEBA region is now open water in summer. Difficult-to-measure seasonal ice regions and marginal ice zones may prove to be critical for understanding climate in the coming century.

5. Available gridded flux products differ markedly at high latitudes, perhaps not surprising given the paucity of in situ observations. Results depicted here show sensible heat fluxes for 03/1992 through 12/2000 for 5 readily available products: NCEP2 (dark blue), JMA (green), ERA40 (purple), FIPREMER (red), and HOAPS (light blue). Each box shows zonally averaged monthly fluxes for either the 5th, 25th, 50th, 75th, or 95th percentile. Even the medians (marked with red box) differ substantially. Long-wave and radiative fluxes show similar inconsistencies.

6. Even in their climatological means, net heat flux estimates differ substantially, often by more than their annual averages. Results shown here show differences between NCEP and NOCS climatological means for the Southern Ocean (courtesy Shenfu Dong). These fields differ by ~50 W m\(^{-2}\), wildly exceeding the net heat flux required to explain observed long-term changes in ocean heat content or even surface water mass transformation.

Present-Day Surface Flux Fields

Moving Forward: Requirements and Recommendations

RECOMMENDATIONS

- Analyze the existing data. New flux-related data collected as part of IPY need to be assembled, shared, and analyzed.
- Expand field observations. Year-round observations of fluxes and of the variables used to compute them from bulk formulations are needed.
- Expand use of ships of opportunity and autonomous instruments. Can we put flux sensors on Antarctic or Arctic cruise ships? We should make more extensive use of automated flux measurement systems.
- Make full use of satellite data, and expand the satellite observing system. Given the adverse conditions and vast size of high-latitude regions, ultimately satellite data will serve as an important tool. Scatterometry, sea surface temperature, and atmospheric sounders can all contribute.
- Improve understanding of the physics underlying all-sea fluxes. Efforts to improve high latitude surface fluxes will require continued efforts to probe the physics governing these fluxes, and to incorporate this physics into the bulk formulae, and this should ultimately lead to improved data assimilation.

To learn more:

- Check the more detailed text in our OceanObs’09 contribution.
- Watch for an expanded assessment (to be submitted to BAMS imminently).
- Supplemental material to be posted to the US CLIVAR web site.

To contribute to the discussion:

- Attend the community workshop to be held March 17-19, 2010, at NCAR Center Green, Boulder, Colorado. Workshop objectives will focus on laying a pathway towards improving surface fluxes for high latitudes. SeeFlux and the US CLIVAR Working Group on High-Latitude Surface Fluxes will organize this.
- Contact us for more information and/or to share your views: Sarah Gille (sgille@ucsd.edu), Mark Bourassa (bourassa@coaps.fsu.edu), or any other working group member/participant.