



Surface Fluxes: Challenges for High Latitudes  
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# Evaluation of Arctic Energy and Moisture Budgets in MERRA

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# Modern Era Retrospective-analysis for Research and Applications (MERRA)

- Provide a climate context for the NASA satellite observing system.
- Improve the representation of the water cycle in reanalyses.
- $2/3^\circ\text{lon} \times 1/2^\circ\text{lat} \times 72$  hybrid-sigma coordinate vertical levels.
- Incremental Analysis Update (IAU):
  - No temporal mismatch between analysis fields and surface fluxes.
  - Balance terms for budget variables are maintained.
- Hourly, 1979 to the present.

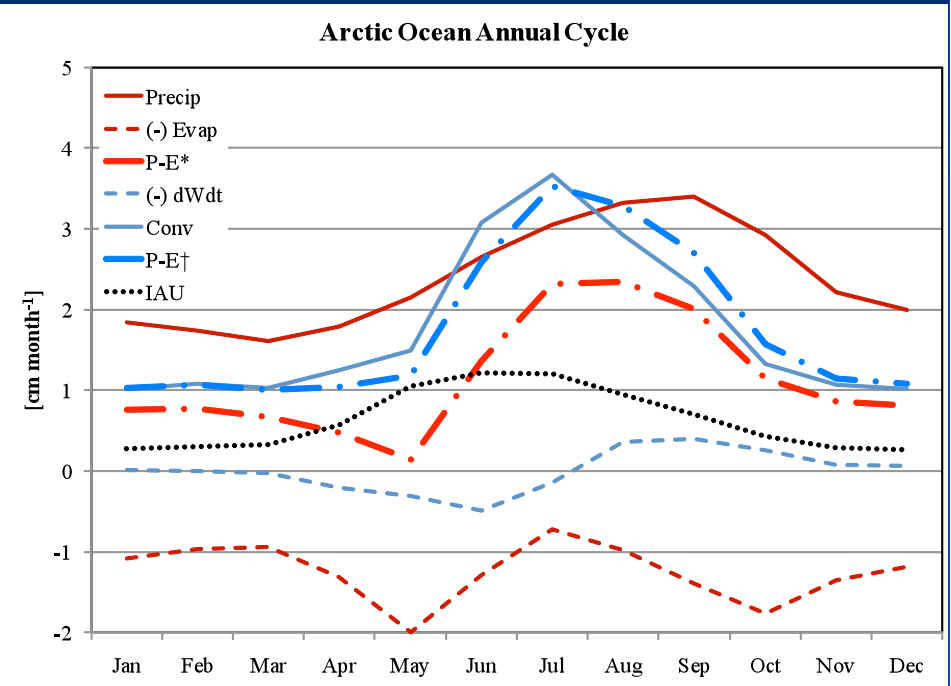
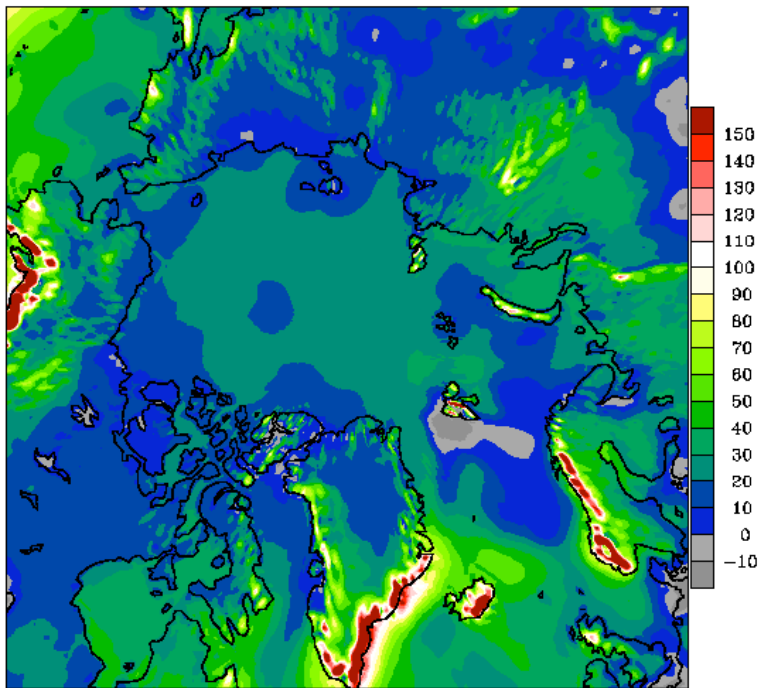
# Initial Evaluation

- Focus on atmospheric energy and moisture budgets.
- 3 defined regions for comparison to previous study.
- Comparison to observation at point locations.



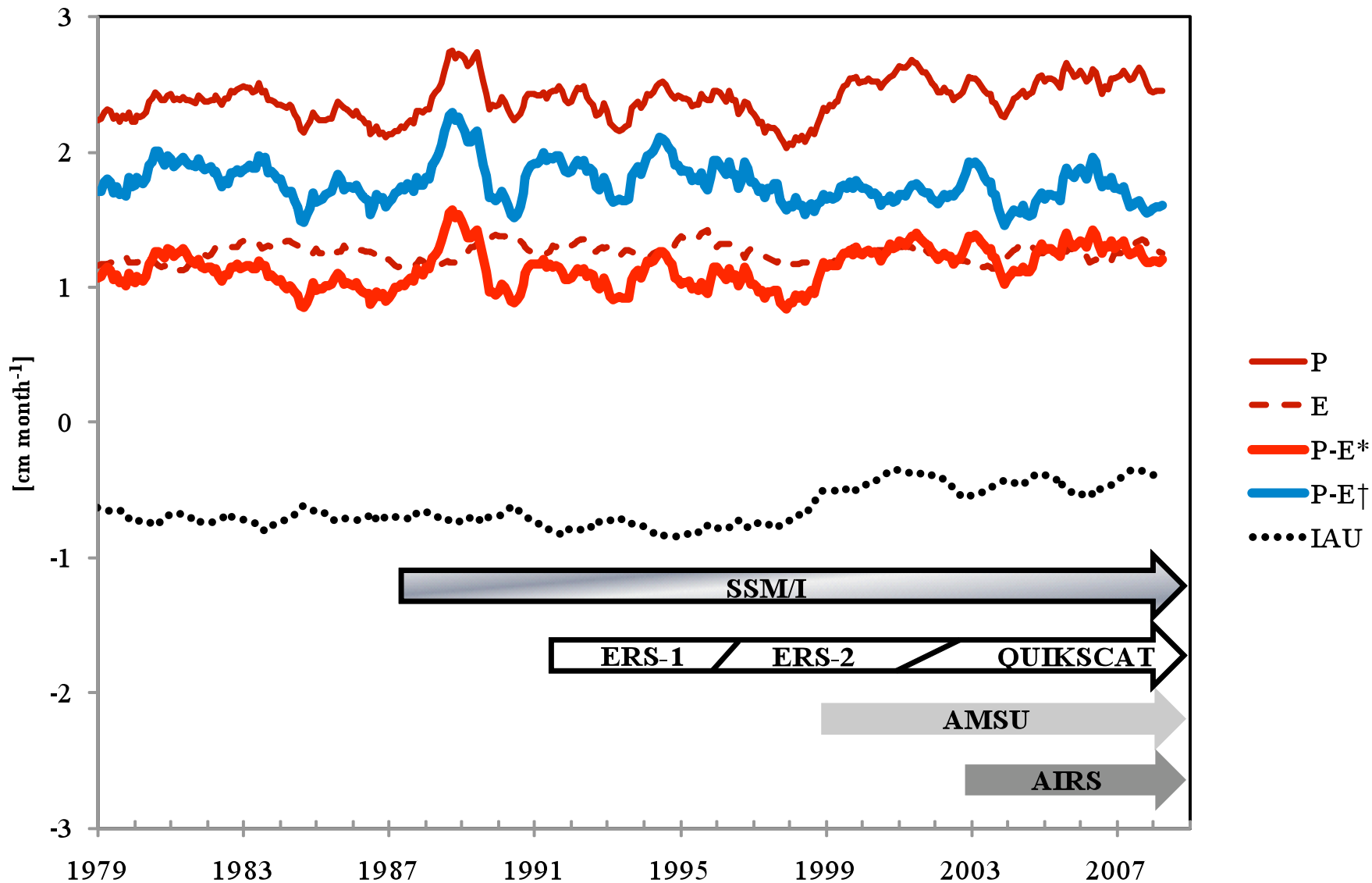
- 70°N – 90°N
- Arctic Ocean
- Greenland Ice Sheet

# Atmospheric Moisture Flux Convergence [mm yr<sup>-1</sup>]



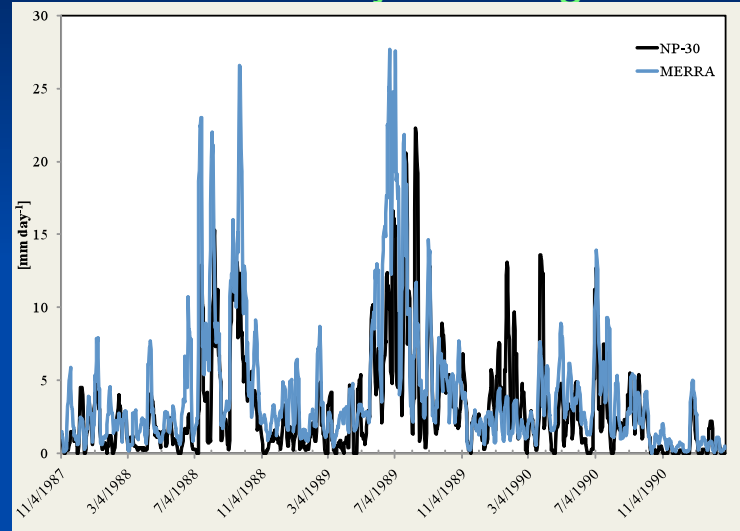
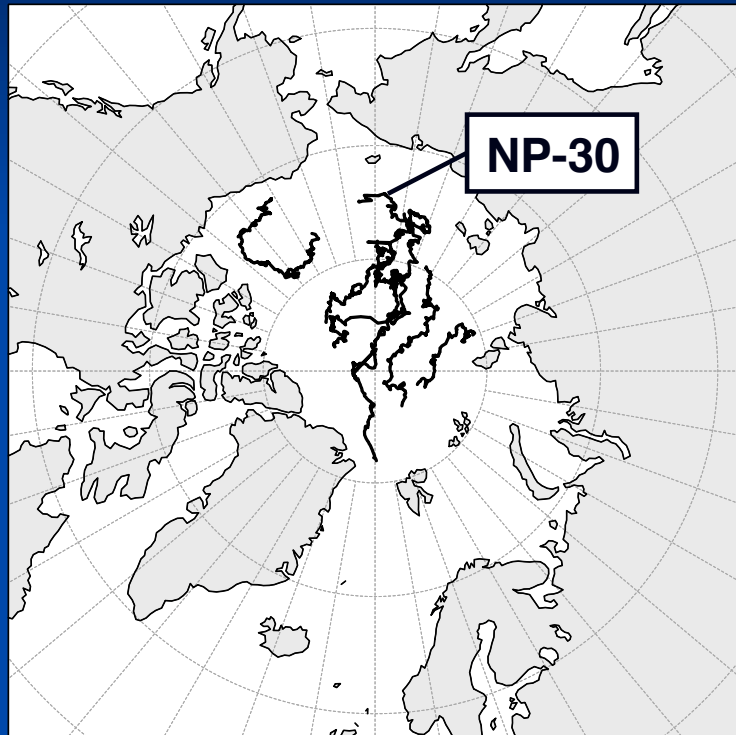


## Arctic Ocean Moisture Budget 12 Month Running Mean

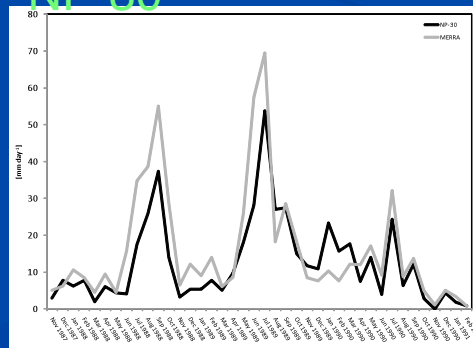


# Former Soviet Ice Drifting Station Gauge Comparison

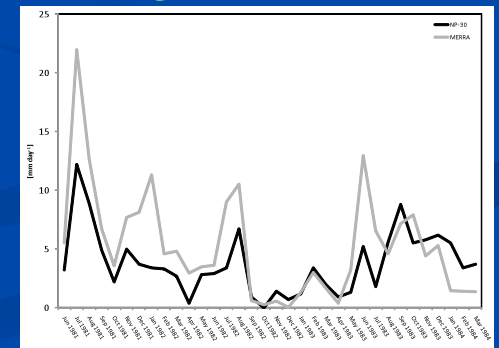
## NP-30 Seven Day Running Mean



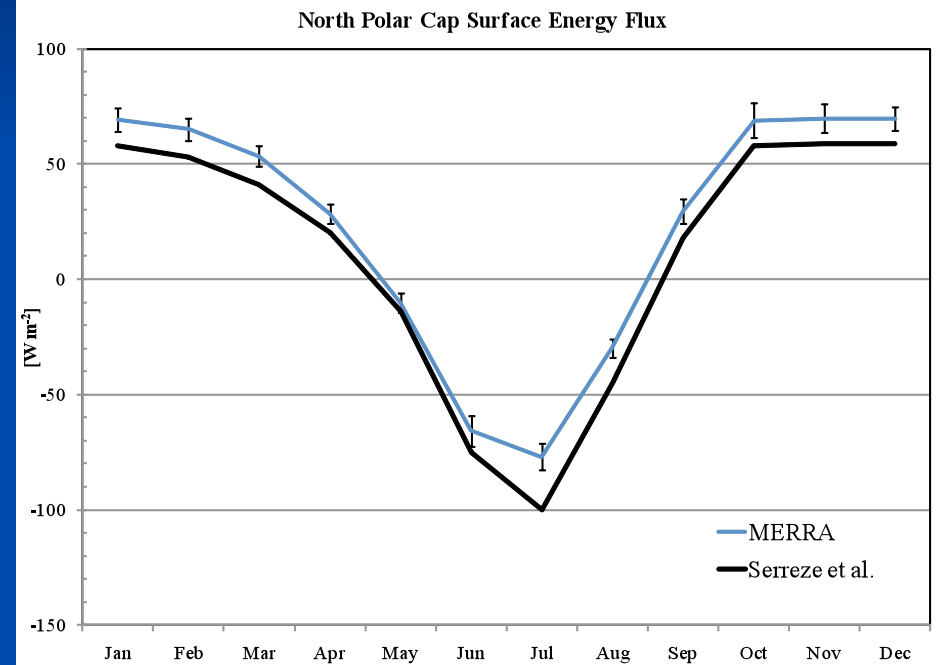
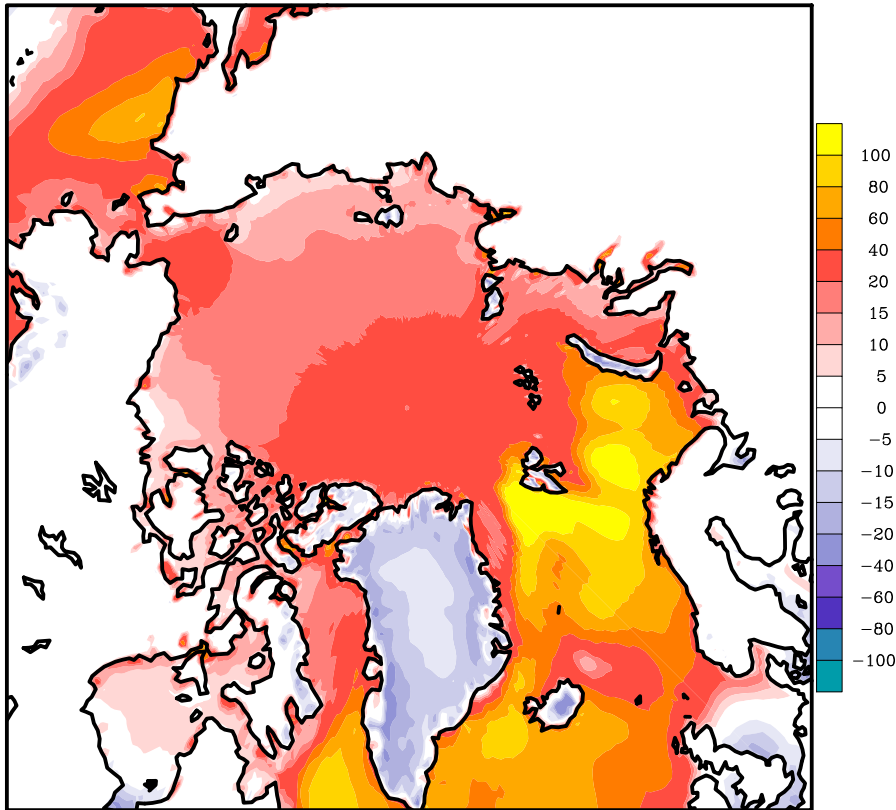
## Monthly Means NP-30



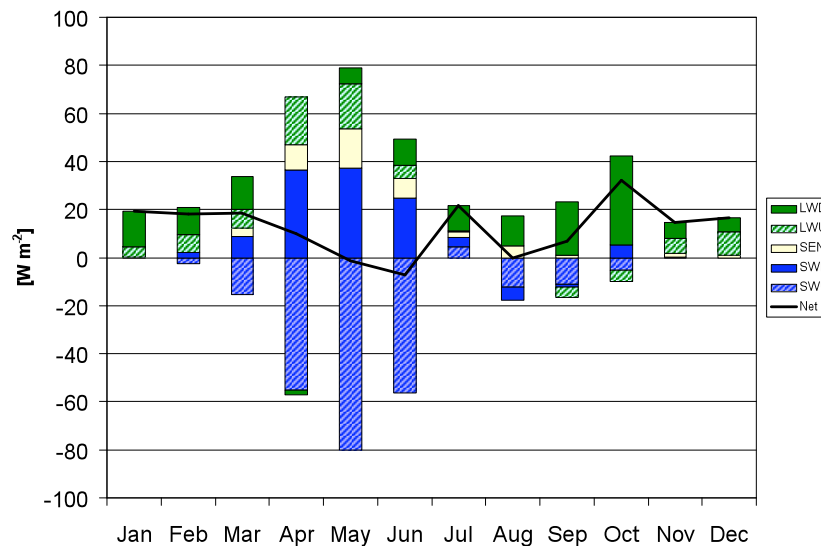
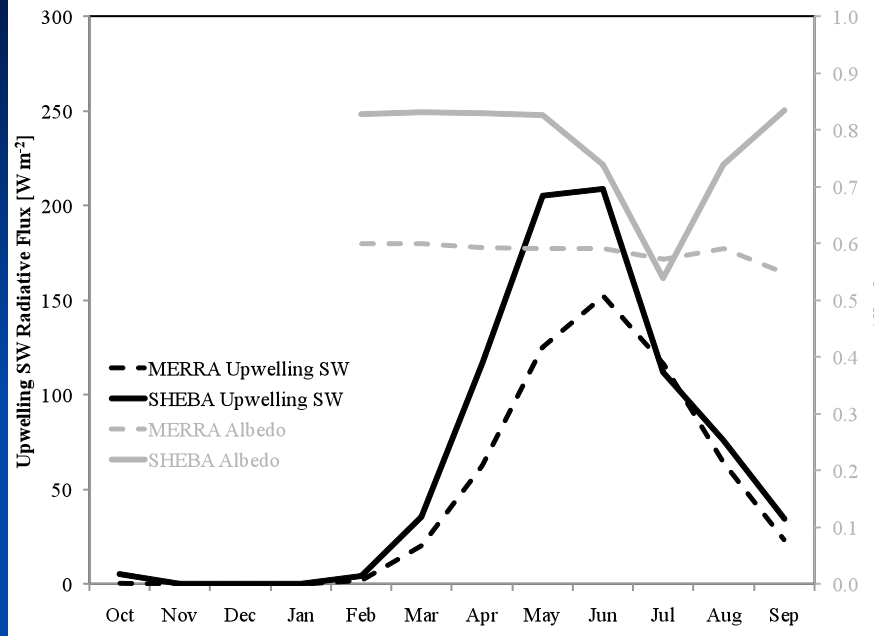
## NP-25



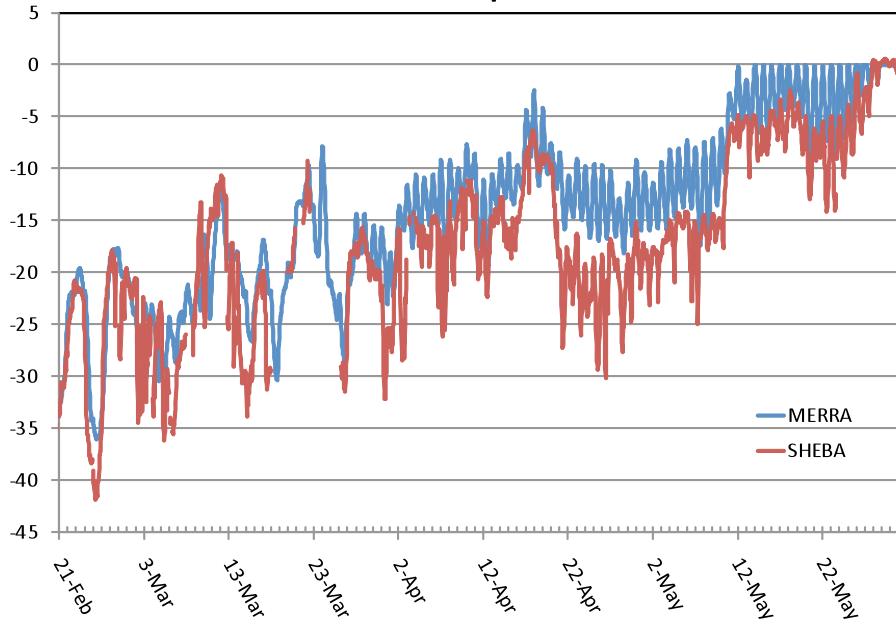
# Surface Energy Flux



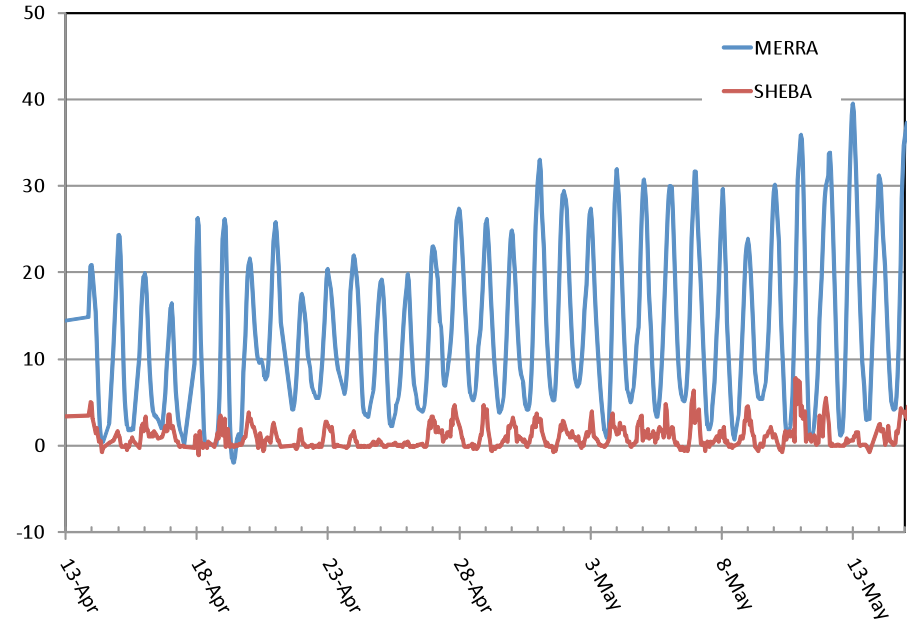
# Comparison to SHEBA



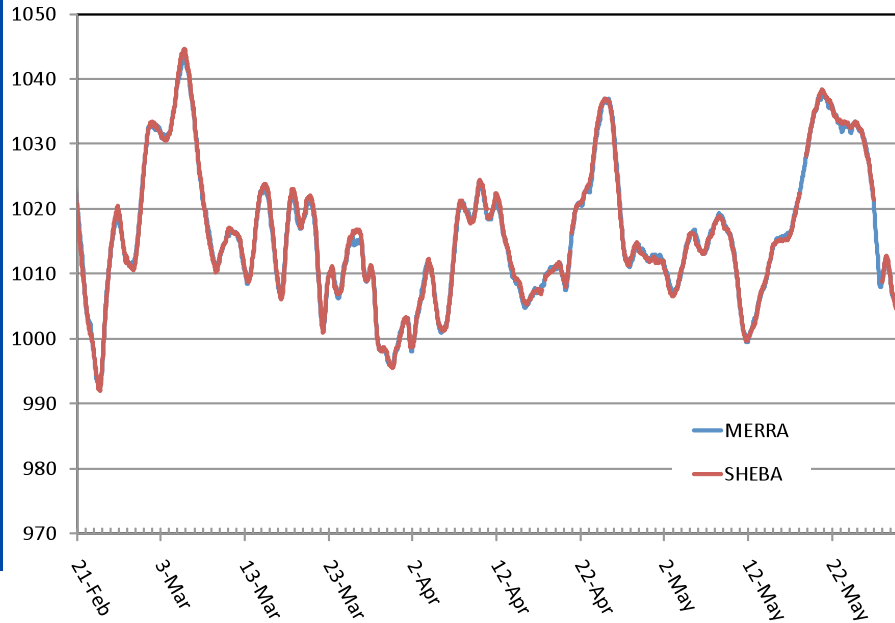
### 2m Air Temperature



### Sensible Heat Flux



### Sea Level Pressure

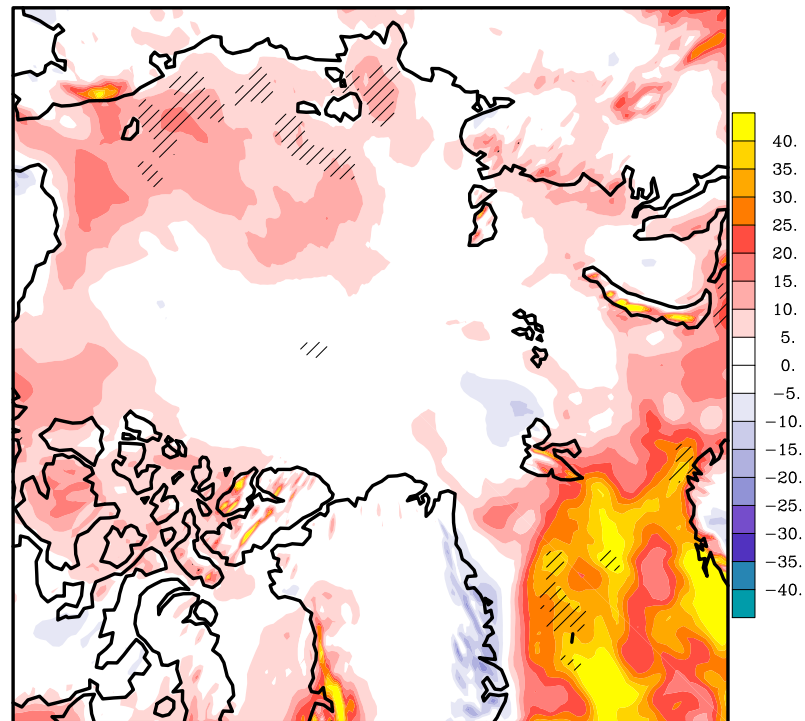
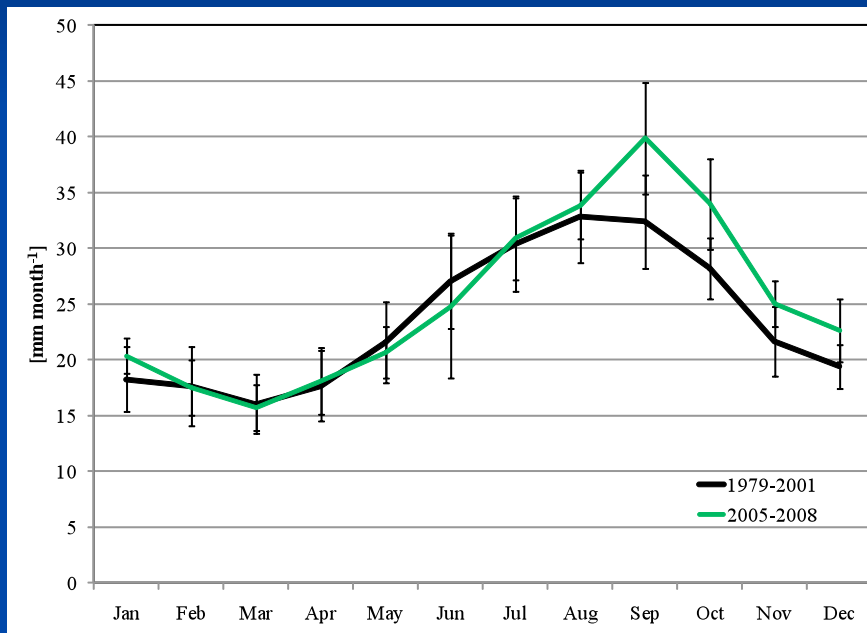


# Analysis of the Arctic in a Changing Climate

September sea ice reduction during  
2005-2009 period: 5 years of at least  
12% below the 1979-2001 climatology

# Precipitation [ $\text{mm month}^{-1}$ ]

## October Anomaly [ $\text{mm month}^{-1}$ ]





# Summary

- MERRA offers a valuable alternative to other reanalyses.
- Significant problems in polar regions
  - Simplistic representation of sea ice.
  - Sensitivity to changes in the observing system (more so for the Southern Hemisphere).
- Preliminary evaluation of the period 2005-present indicates significant changes to energy, moisture fluxes in the Arctic.

- Further evaluation of MERRA.
- Improve representation of the polar atmosphere in the GMAO forecast model.
- Draw attention to the treatment of changes in the observing system.
- Use of budget balance terms as *one* implement in the evaluation of flux uncertainty.

MERRA Page:

<http://gmao.gsfc.nasa.gov/research/merra/>

NASA Goddard Earth Sciences

Data and Information Services Center (DISC):

<http://disc.sci.gsfc.nasa.gov/mdisc/>

