ARM/NSA validation of Arctic clouds and radiative impacts in reanalyses

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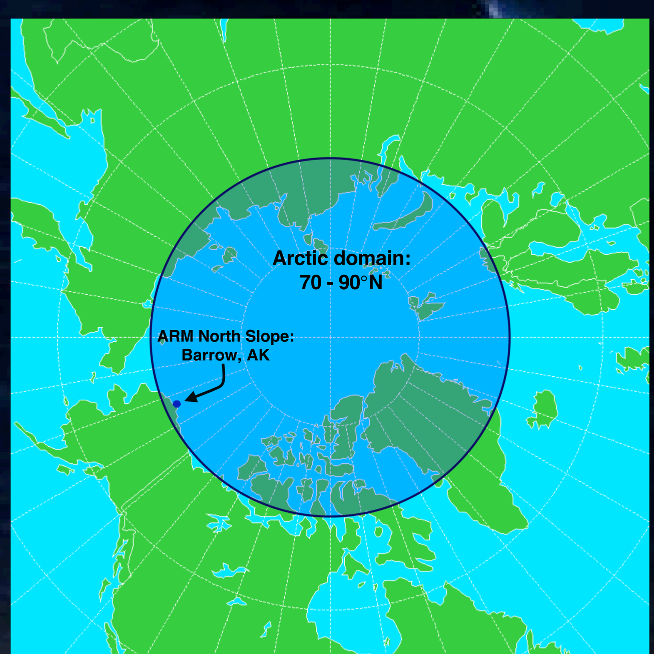
Objectives:

-- use ARM/NSA measurements to assess reanalysis-derived surface radiation fluxes and clouds at the Barrow site

-- evaluate cloud/radiative forcing in the reanalyses

-- compare cloud/radiative parameterizations in each model

Arctic domain



Four reanalyses

Reanalysis	years	Center
NCEP	1948-2006	National Center for Env. Prediction / National Center for Atmos. Research (USA)

The NCEP reanalysis uses a frozen version (1995) of the NCEP global operational model with added improvements, such as the cloud diagnostic scheme after Campana et al. 1994. This scheme replaced the quadratic cloud-RH relationship with the USAF Real Time Nephanalyses. The convective cloud is obtained from the model precipitation rate (after Slingo, 1987).

Reanalysis	years	Center
ERA40	1958-2002	European Centre for Medium-range Weather Forecasts

The ERA40 reanalysis builds on the original ECMWF reanalysis (ERA-15) with increased availability of assimilable data and improvements in the operational model since the mid-1990s (Uppala et al. 2005). The ERA40 uses a prognostic cloud scheme of Teidtke (1993) which traces the time evolution of cloud cover and its water/ice content by advective processes and the sources and sinks due to diabatic processes. The model includes improvements to the parametrizations of deep convection, radiation, clouds and orography, introduced operationally since ERA-15 (Gregory et al. 2000; Jakob and Klein 2000; Jakob et al. 2000; Morcrette et al. 2001).

Reanalysis	years	Center
JRA25	1979-2006	Japan Meteorological Agency (JAPAN)

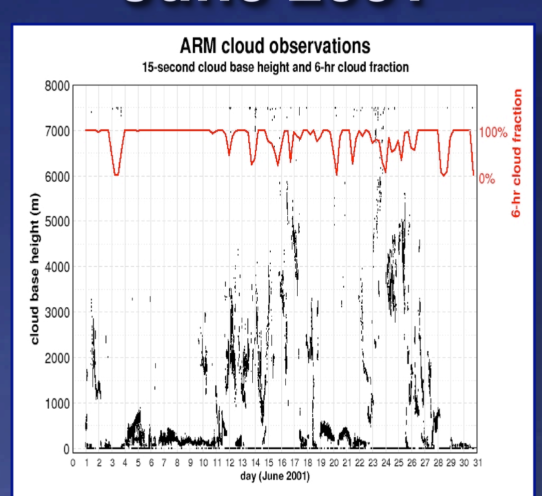
The global model used in JRA-25 is a low-resolution version of the JMA operational model reported in JMA (2002), where clouds are diagnosed from relative humidity with maximum overlap assumed. The cloud model of this parameterization is a mass flux scheme based on an entrainment-detrainment plume model. Both the fractional entrainment rate and the detrainment rate are constant and they are equivalent for simplicity.

Reanalysis	years	Center
NARR	1979-2006	National Center for Env. Prediction (USA)

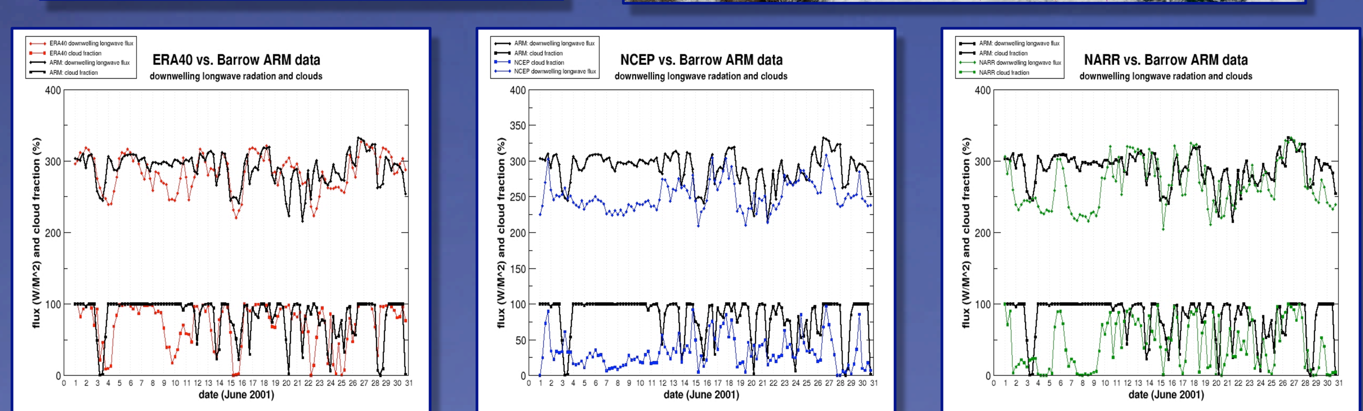
The NARR reanalysis uses a frozen version (2003) of the NCEP meso-Eta with some differences; e.g. the cloud microphysics after Zhao et al. (1997) (Mesinger et al. 2004). According to Chuang and Manikin (2001), both stratiform and convective clouds are parameterized. Key variables in the parameterization are relative humidity and convective precipitation rate. Clouds fall into three categories: low (approximately 640 to 990mb), middle (350 to 640 mb), and high (above 350 mb). Fractional cloud coverage for stratiform clouds is computed using a quadratic relation in relative humidity (Slingo, 1980). The NCEP version of the GFDL radiation scheme with interactive random overlap clouds is used.

ARM/NSA vs. reanalysis clouds and radiation

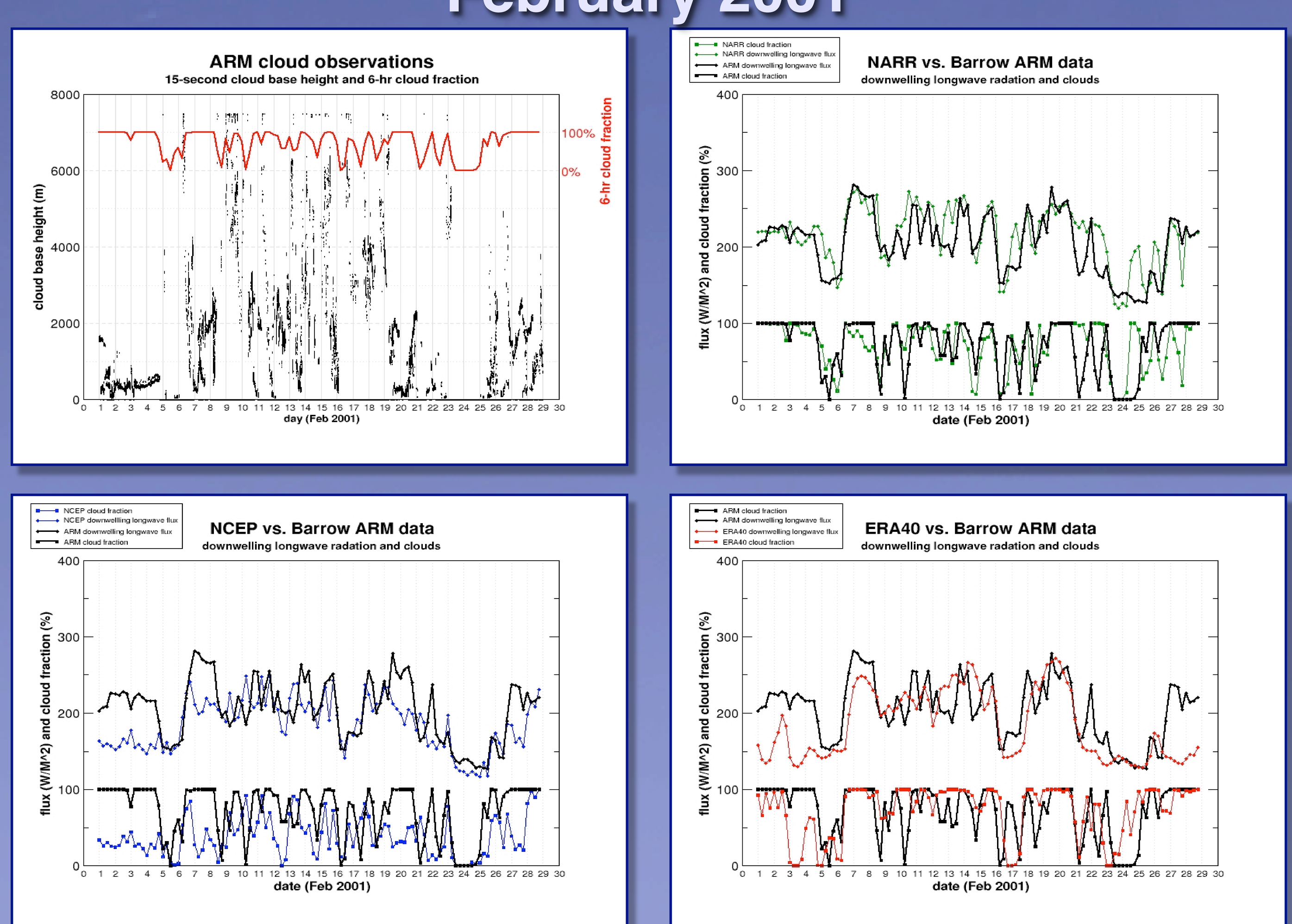
June 2001



MODIS: June 8, 2001

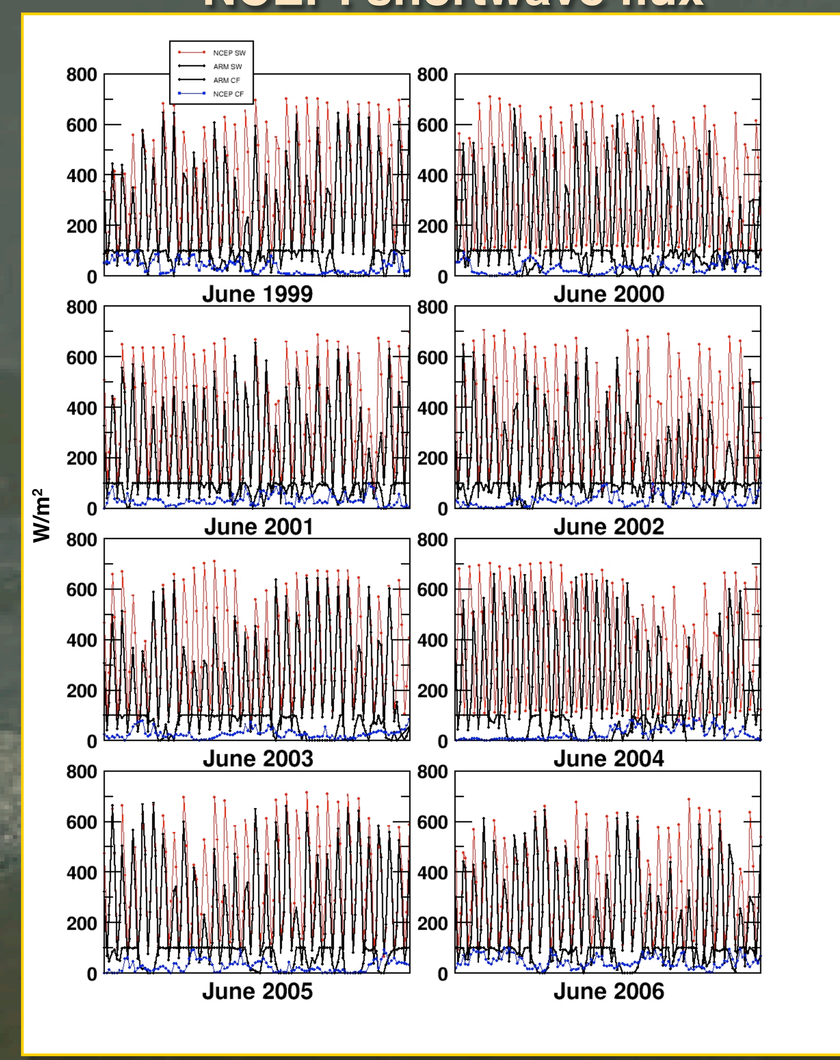


February 2001

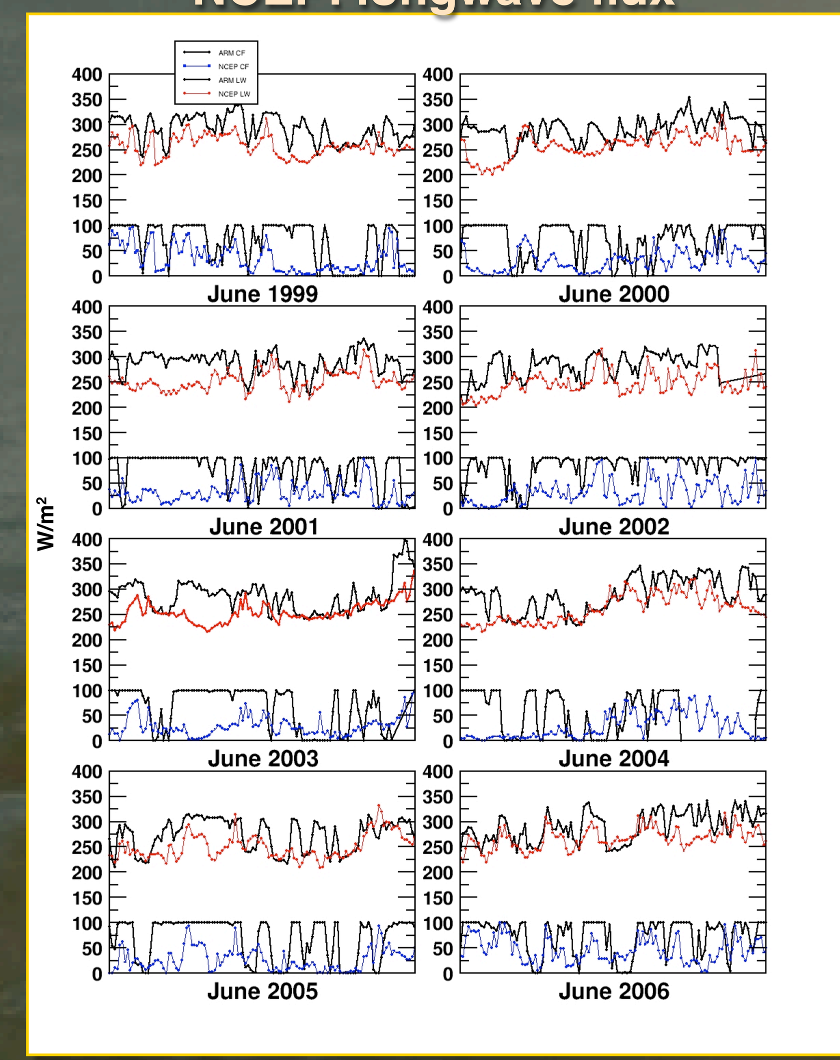


ARM/NSA vs. reanalysis summmaries

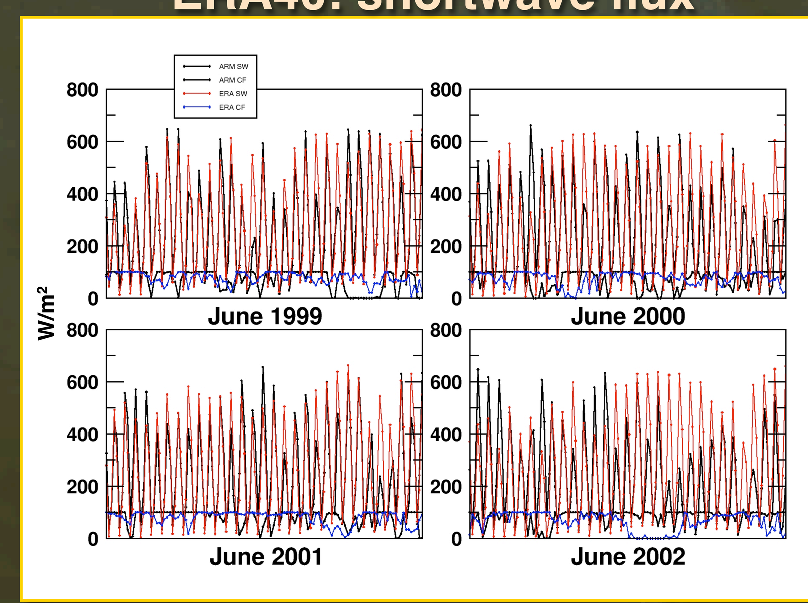
NCEP: shortwave flux



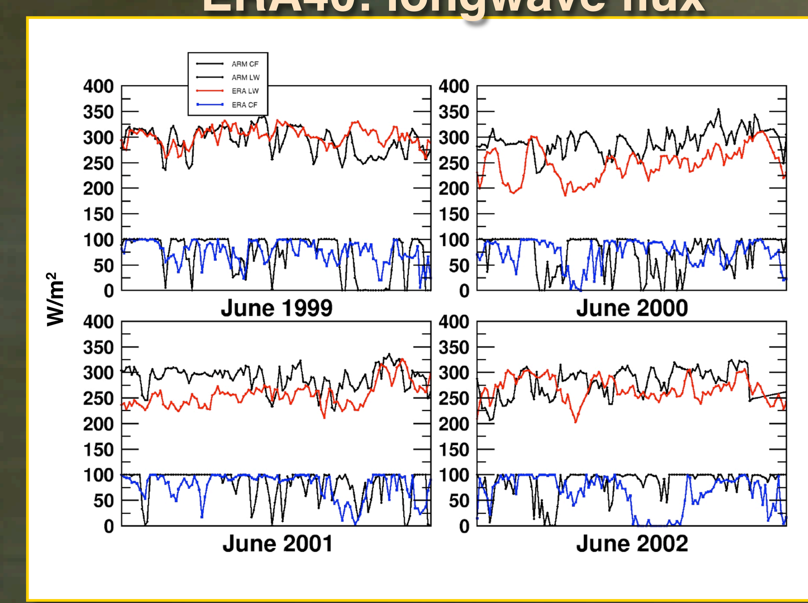
NCEP: longwave flux



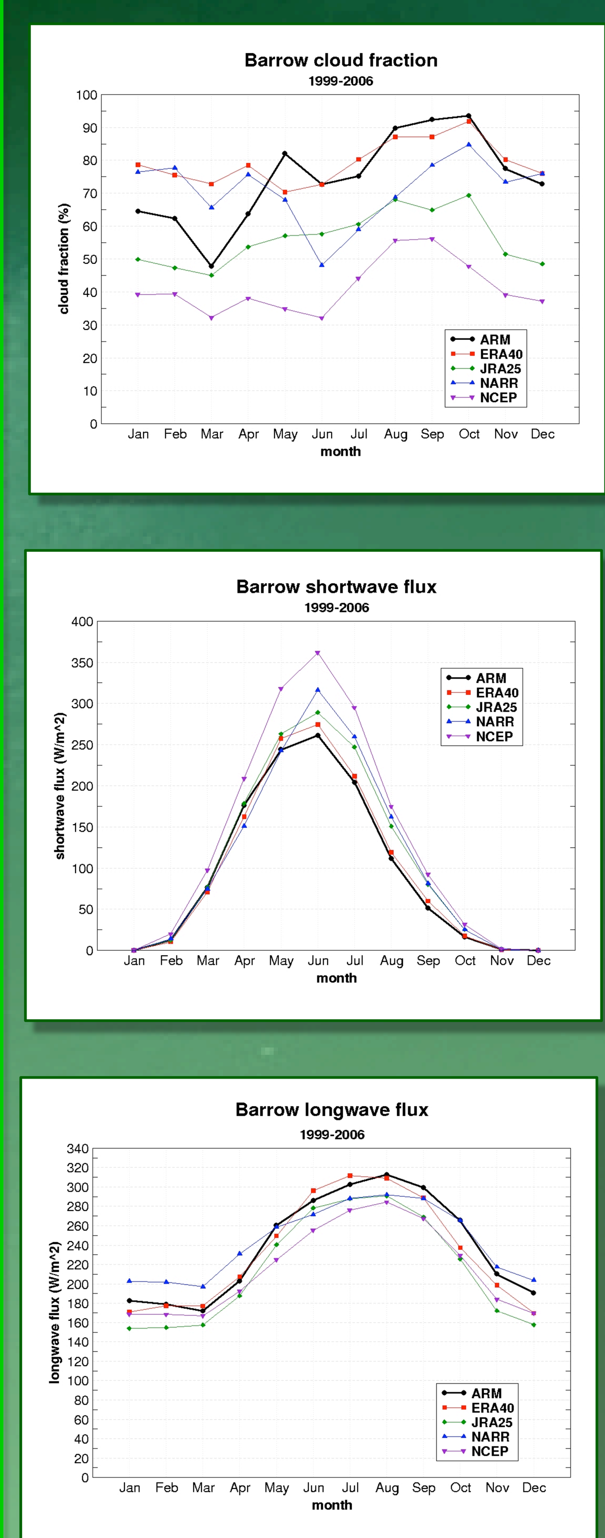
ERA40: shortwave flux



ERA40: longwave flux

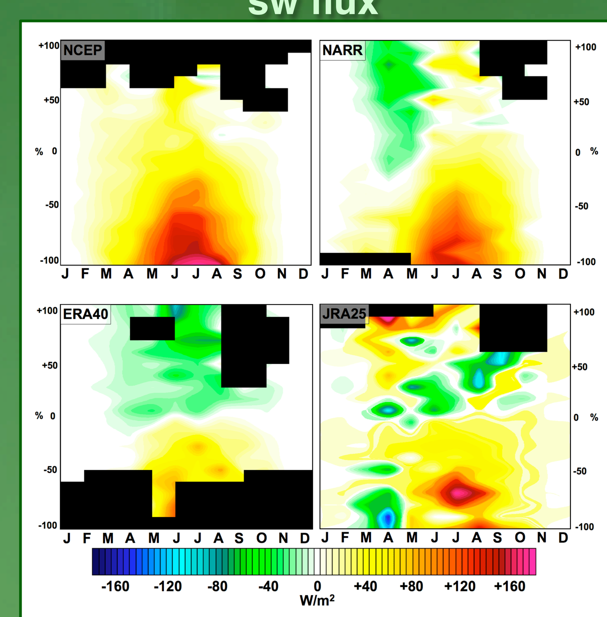


Reanalysis biases

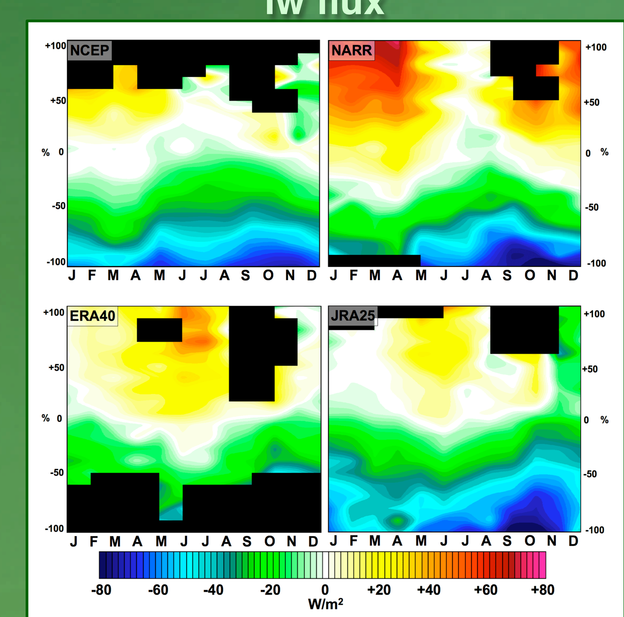


Surface flux errors as a function of cloud fraction error:

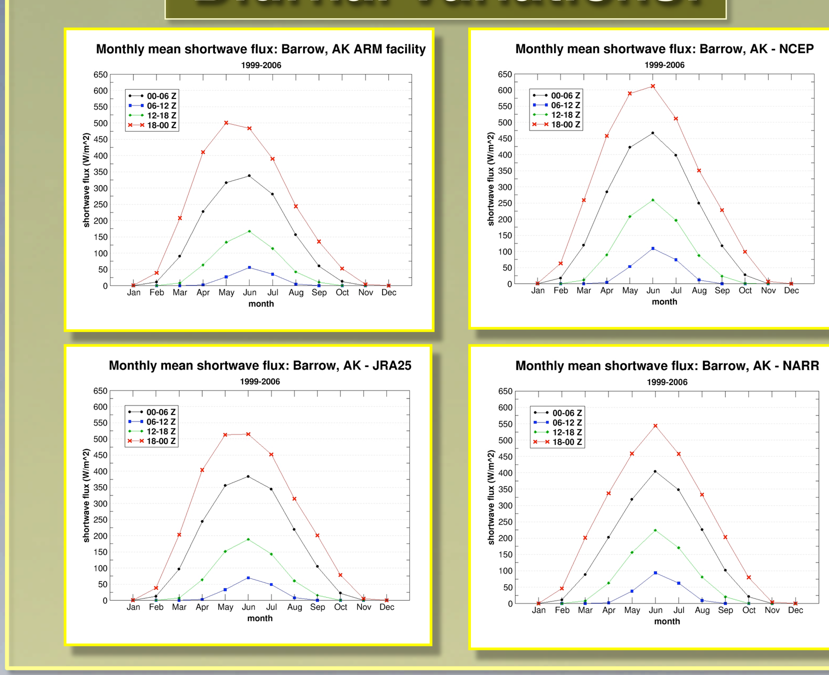
sw flux



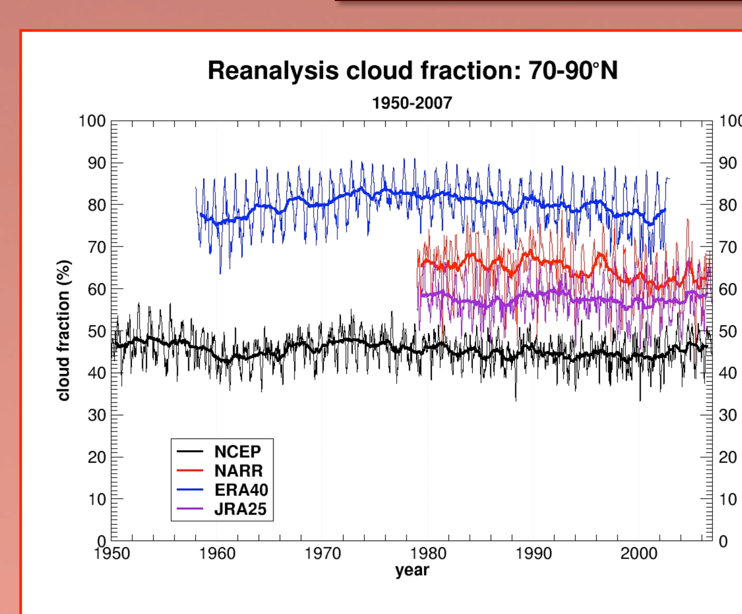
lw flux

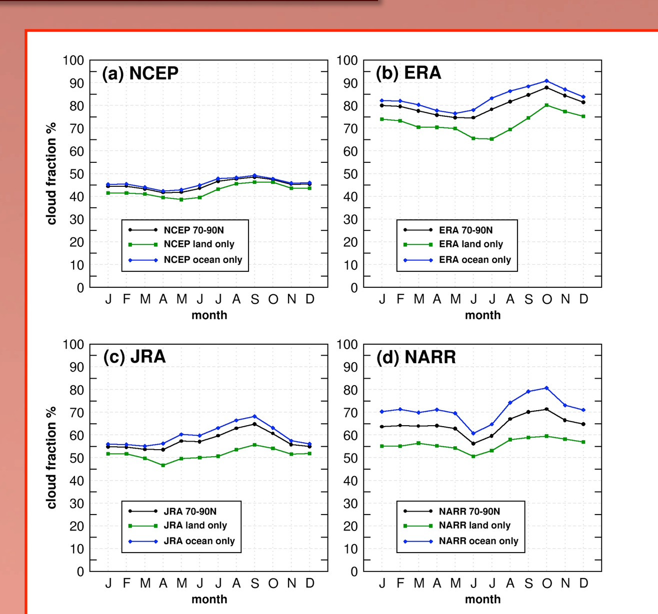


Diurnal variations:



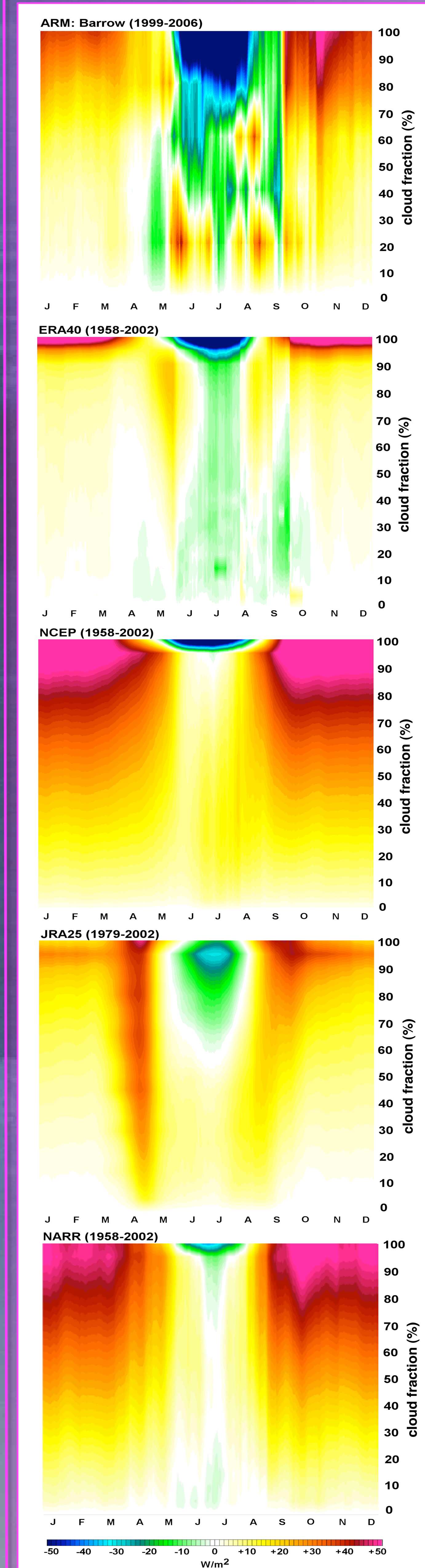
Arctic-wide: 70-90°N





Cloud radiative forcing:

surface net radiation:
cloudy sky - clear sky



Conclusions

When compared with ARM observations:

- reanalysis downwelling shortwave and longwave fluxes are simulated well under both clear and cloudy conditions, but biases in cloud cover simulations result in large mean radiative flux errors.
- cloud fractions are undersimulated by NCEP, JRA25, and NARR in all seasons; oversimulated by ERA40 in winter.
- shape of seasonal cycle of cloudiness is well-simulated, but amplitude is muted in reanalyses.
- seasonal variations in cloud cover result in maximum downwelling solar flux in May for ARM observations, JRA25 and ERA40, not NCEP and NARR.
- seasonal pattern of cloudy-sky surface radiative forcing is well-simulated by the models, but the magnitudes can have significant biases.
- cloud radiative forcing at surface under partly cloudy conditions is especially problematic for the models.