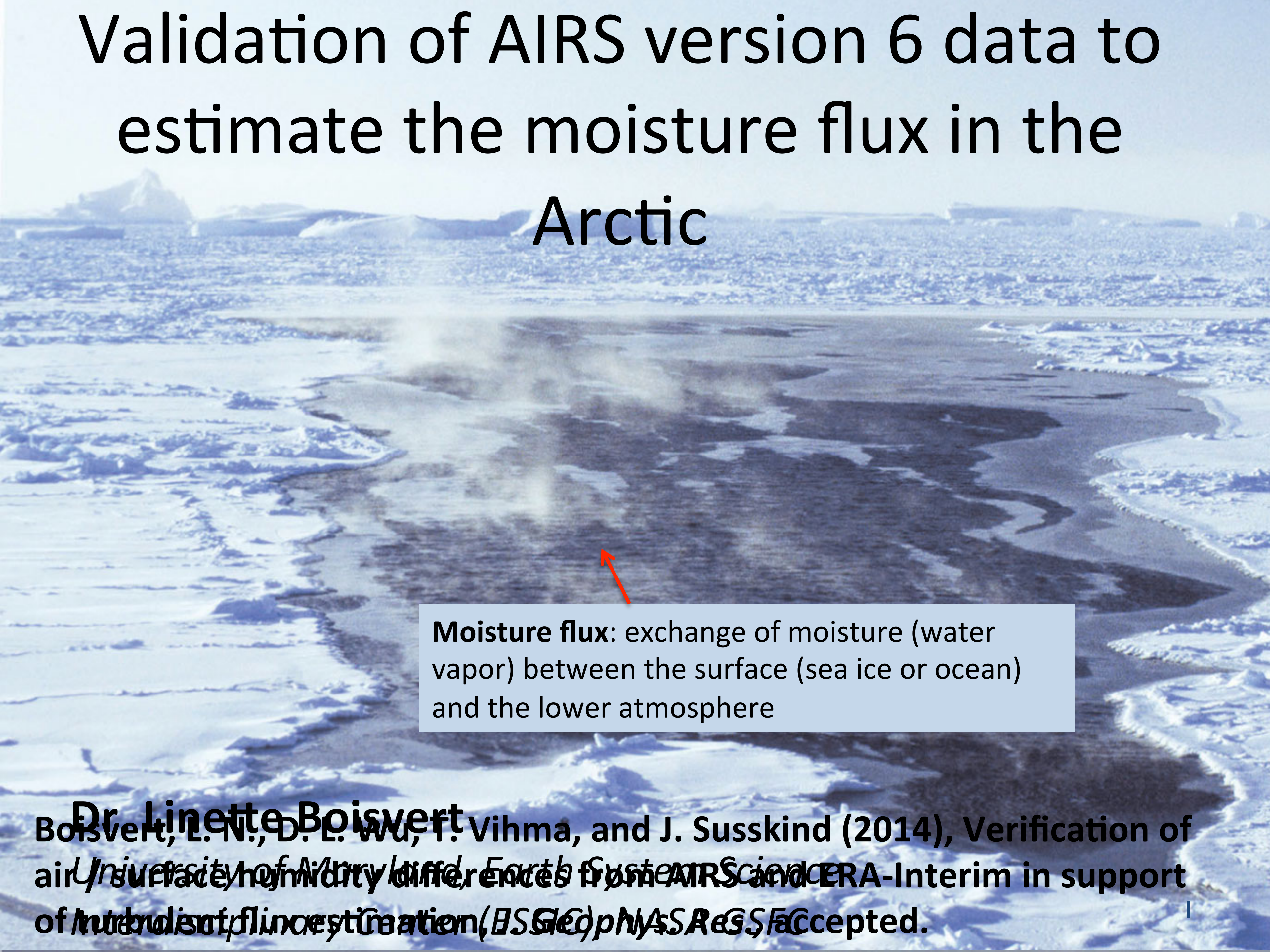
Validation of AIRS version 6 data to estimate the moisture flux in the Arctic



Moisture flux: exchange of moisture (water vapor) between the surface (sea ice or ocean) and the lower atmosphere

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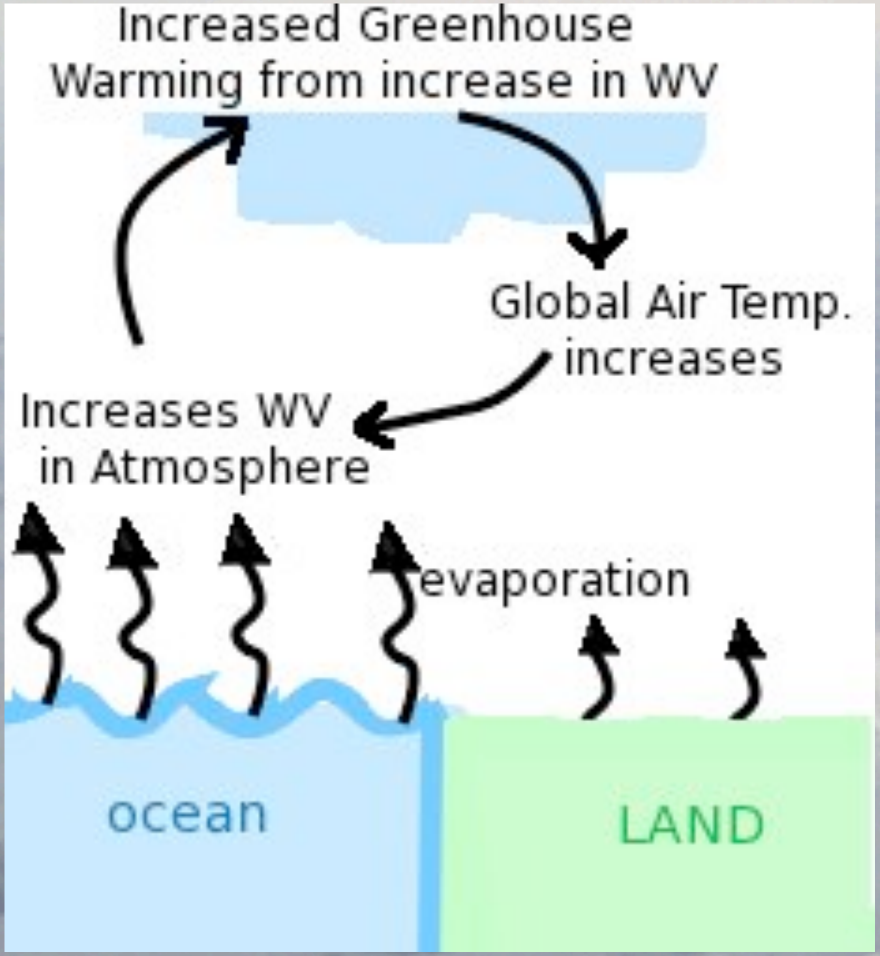
Boisvert, L. N., D. L. Wu, T. Vihma, and J. Susskind (2014), Verification of air / surface humidity differences from AIRS and ERA-Interim in support of turbulent flux estimation, J. Geophys. Res., accepted.

Water Vapor

- Most abundant and radiatively important greenhouse gas in the atmosphere [*Rinke et al.*, 2009]
  - Transports large amounts of latent heat into atm.
  - Affect amount of clouds
    - Warm the Arctic by trapping outgoing longwave radiation
  - **Arctic Amplification**: warming faster than anywhere else on the globe



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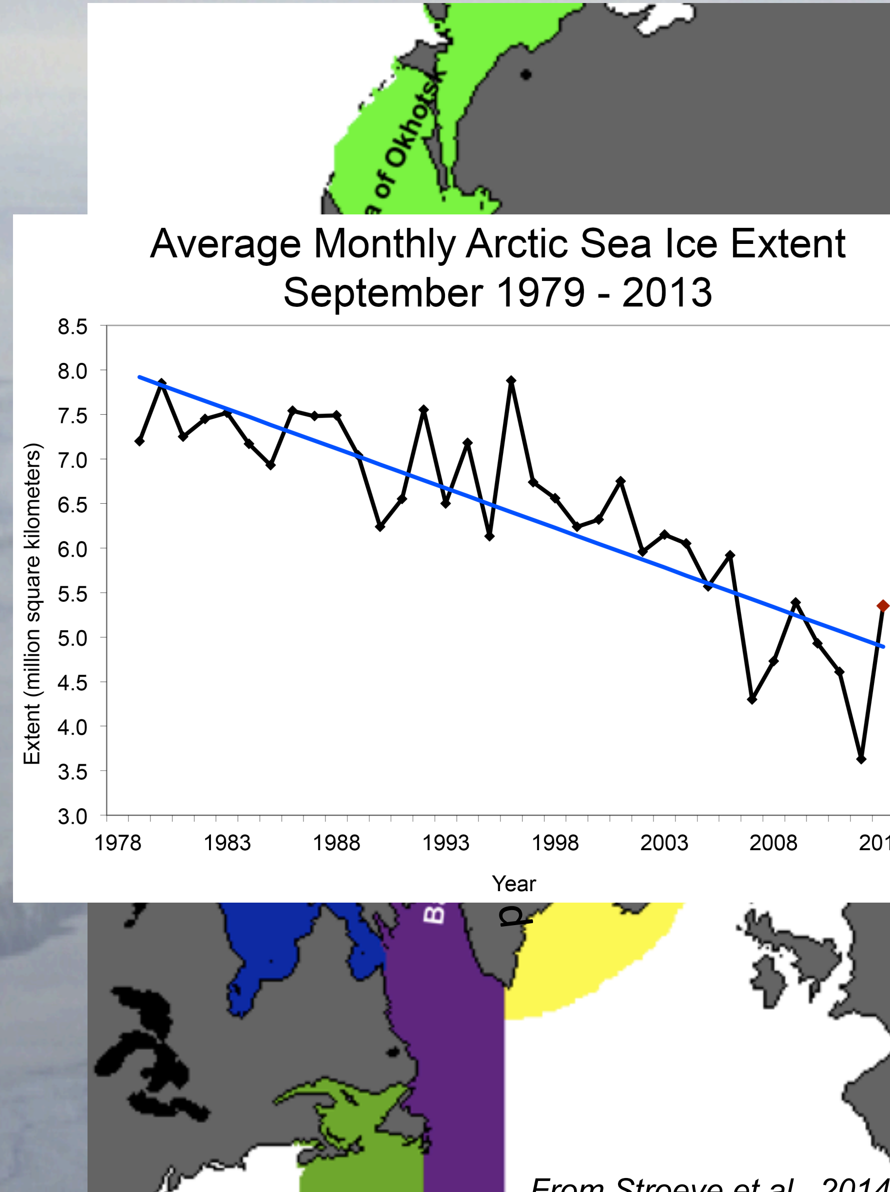
Impacts of the changing sea ice

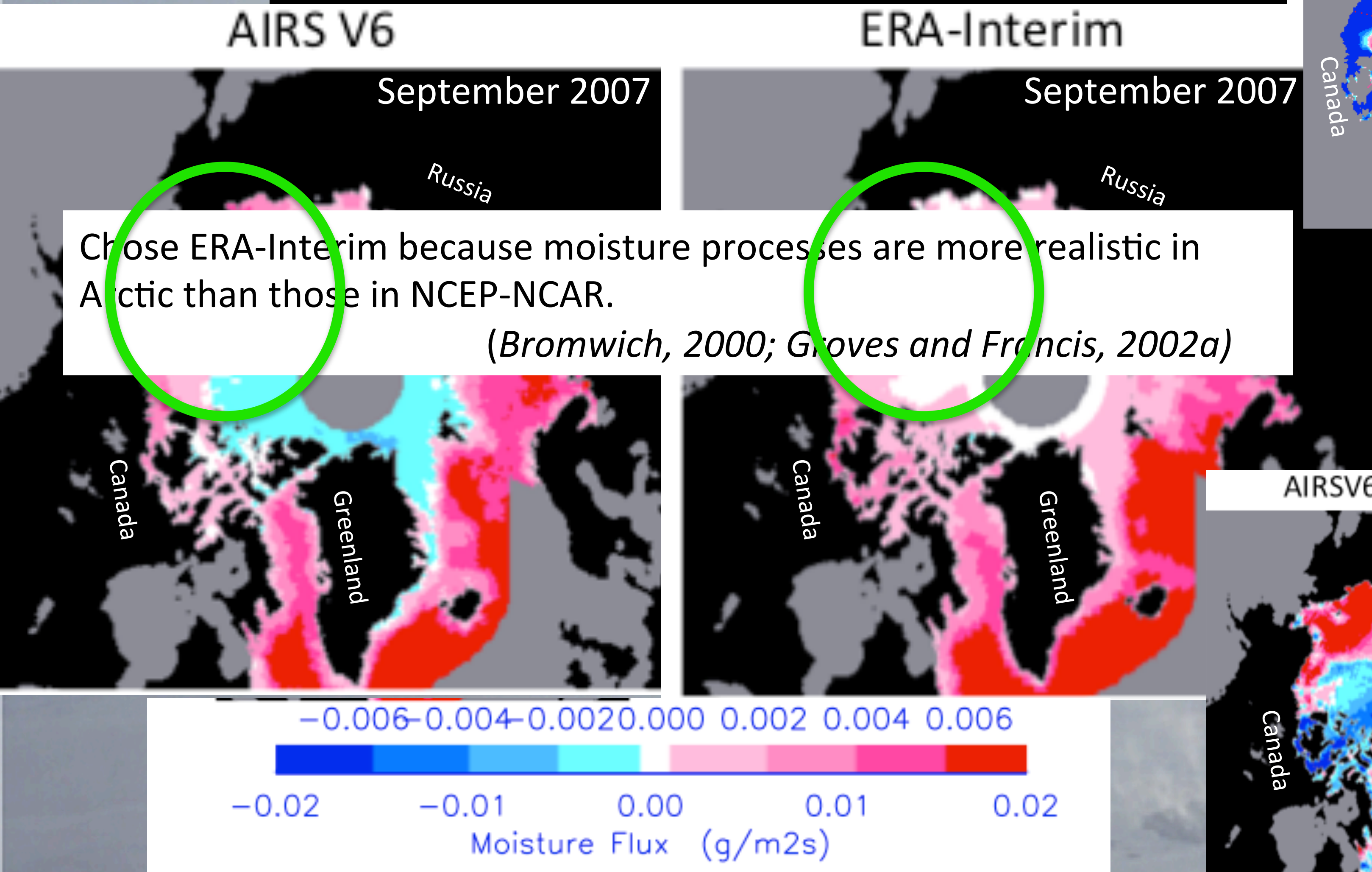
- The compact Arctic sea ice is a very efficient insulator:
  - Prevents large exchanges **of heat and moisture** between the ocean and atm. (*Dare and Atkinson,* 1999)
- Rapid loss of sea ice cover could cause an increased release of water vapor into the atmosphere



Problems with estimating the moisture flux

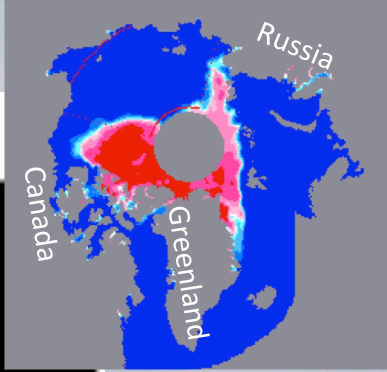
- Calculating the moisture flux continues to be a difficult quantity to estimate [*Dong et al.,* 2007], especially over the high latitude oceans [*Bourassa et al.,* 2013].
  - Cannot be measured directly
  - Quality of input data into models
    - In situ observations of input variables are sparse & little validation
  - Models do not contain parameterizations that are suited for the Arctic.
  - Other issues: turbulent transfer coefficient & surface roughness lengths not well known

Comparing Moisture Flux Products

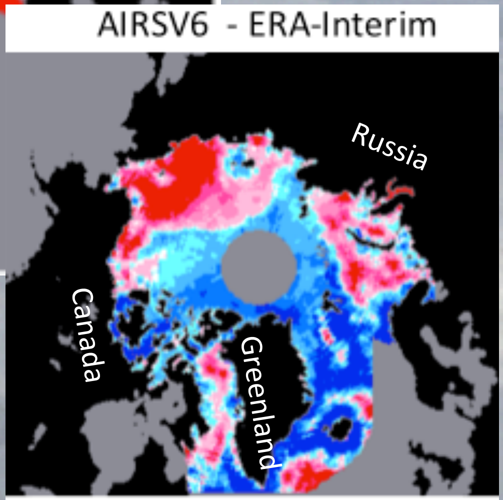


Chose ERA-Interim because moisture processes are more realistic in Arctic than those in NCEP-NCAR.

(Bromwich, 2000; Groves and Francis, 2002a)



Sea Ice extent 2nd minimum on record.



- Differences of moisture fluxes in the open water BESS region in September 2007 were up to 2.2×10^{-2} g $m^{-2}s^{-1}$ (equivalent to 55 W m^{-2} in latent heat) larger using our MF scheme.
- Affect atmospheric water vapor estimates & ocean-atmosphere energy exchange.

Figures from Boisvert et al., 2014

Data

Input Parameters	Symbol	Source	Level
Surface Skin Temperature (C)	Ts	AIRS Version 6, level 3	Surface
Air Temperature (C)	Ta	AIRS Version 6, level 3	1000 hPa
Relative Humidity (%)	RH	AIRS Version 6, level 3	1000 hPa
Geopotential Height (m)	GH	AIRS Version 6, level 3	1000 hPa
Ice Concentration (%)	IC	SSM/I	Surface
Wind Speed (m/s)	V	ECMWF ERA-Interim	10 m

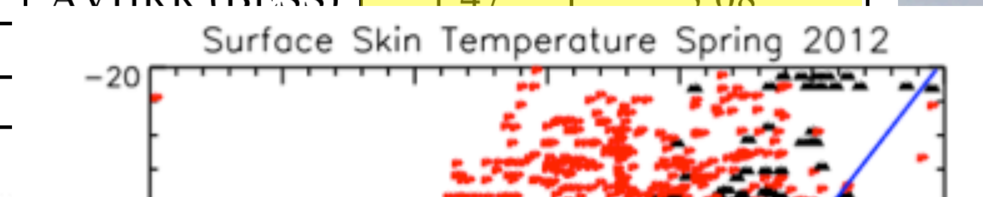
$$E = \rho S_r \left[C_{ez,I} I_C (q_{s,I} - q_z) + C_{ez,w} (1 - I_C) (q_{s,w} - q_z) \right]$$

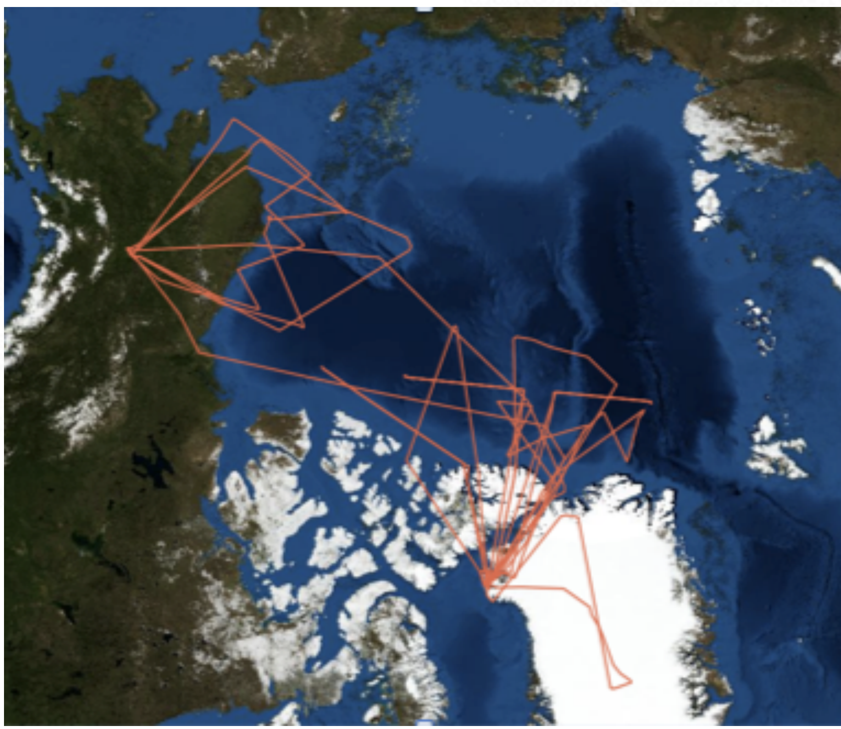
- **Moisture flux** (E): Calculated daily between 2003-2013 via Monin-Obukhov Similarity Theory, *Launiainen & Vihma* [1990], changes to parameterizations [*Grachev et al., 2007; Andreas et al., 2010*] to better suit Arctic conditions.

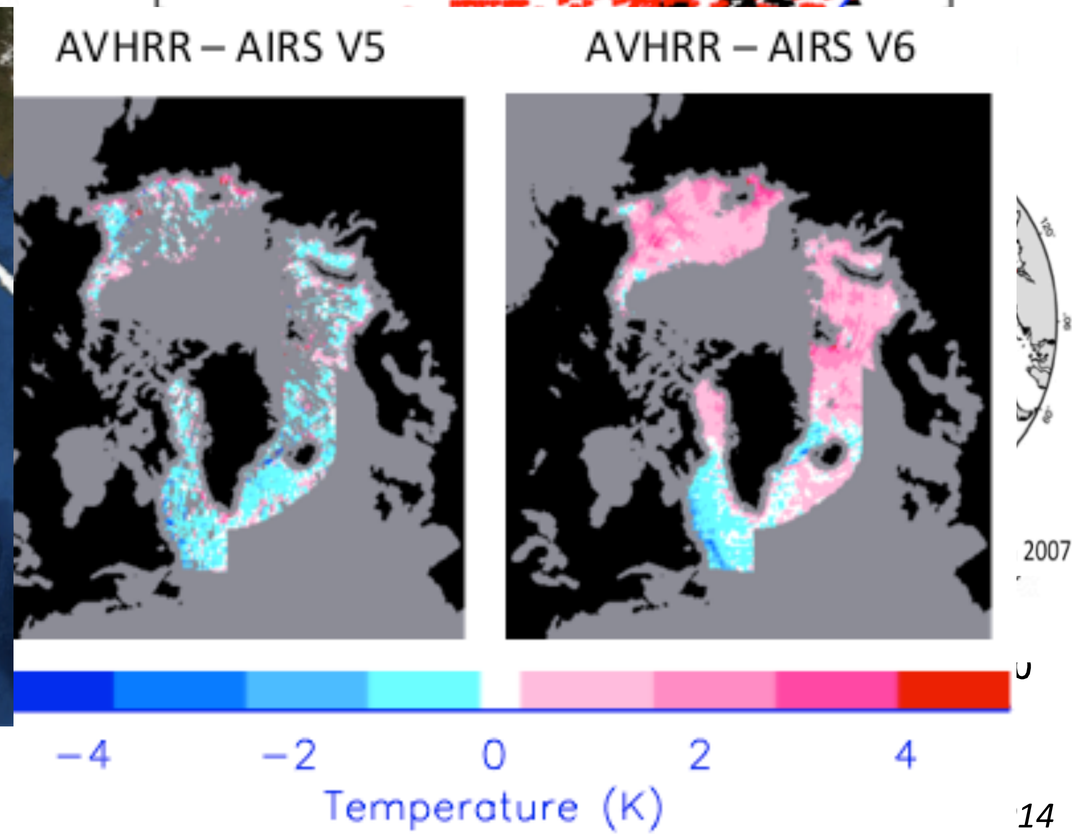
Data Comparisons

RMSE

	Platform	AIRS V6	ERA-Interim
Skin Temperature (K): Sea Ice	Tara	2.34	4.86
	IceBridge	3.34	8.87
Skin Temperature (K): Open Water	AVHRR (All)	1.22	1.67
	AVHRR (BESS)	1.47	3.08
Specific Humidity kg kg^{-1}: Sea Ice			
Specific Humidity kg kg^{-1}: Open Water			







Quality of the input data

- Differences in the data can cause moisture flux estimates to differ by as much as 1.6 x10^{-2} g$m^{-2}s^{-1}$ (equivalent to 40 W m^{-2} latent heat) in the BESS region

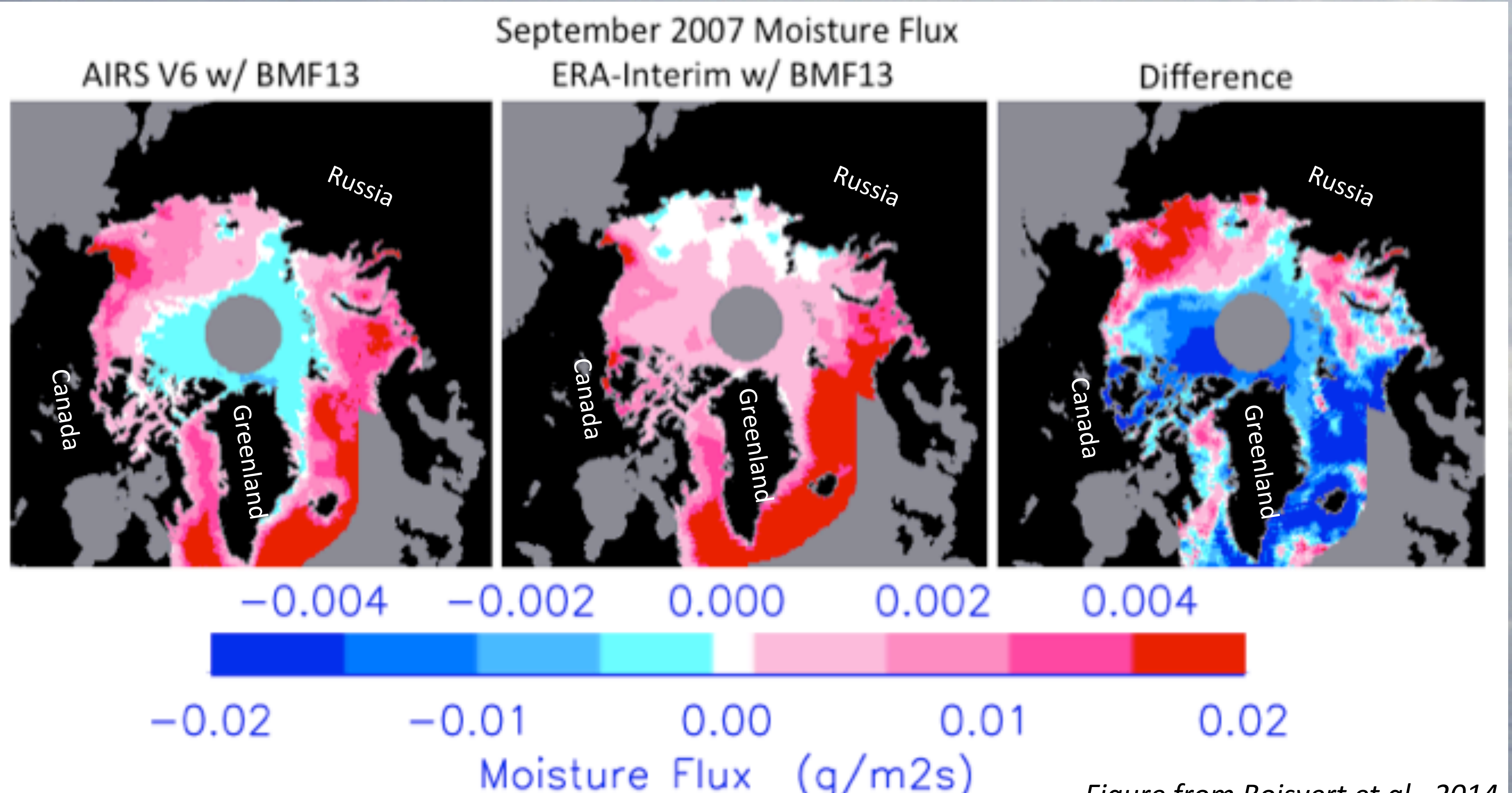
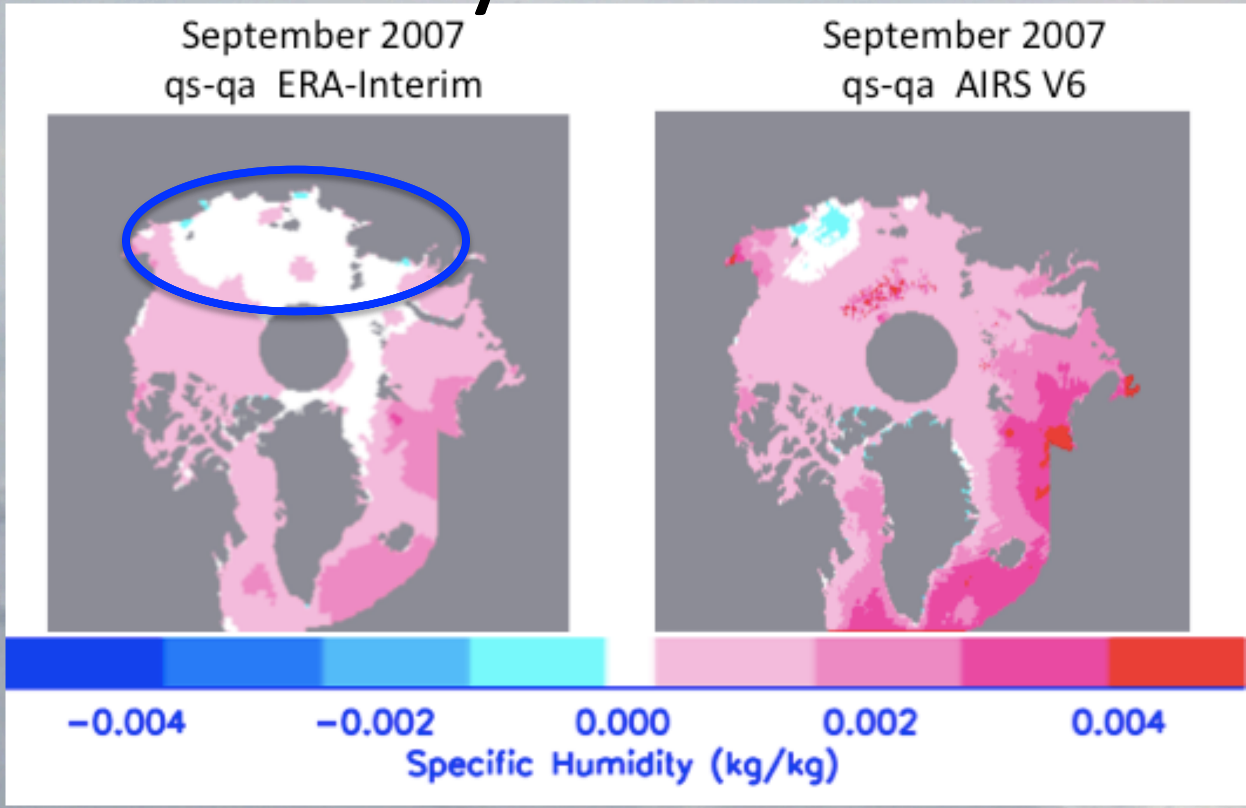


Figure from Boisvert et al., 2014

Summary

Large cold bias in SST -> lower qs

Slight positive bias in qa -> smaller magnitude of qs-qa -> decreased moisture flux



AIRS V6 overestimates the qs-qa difference slightly

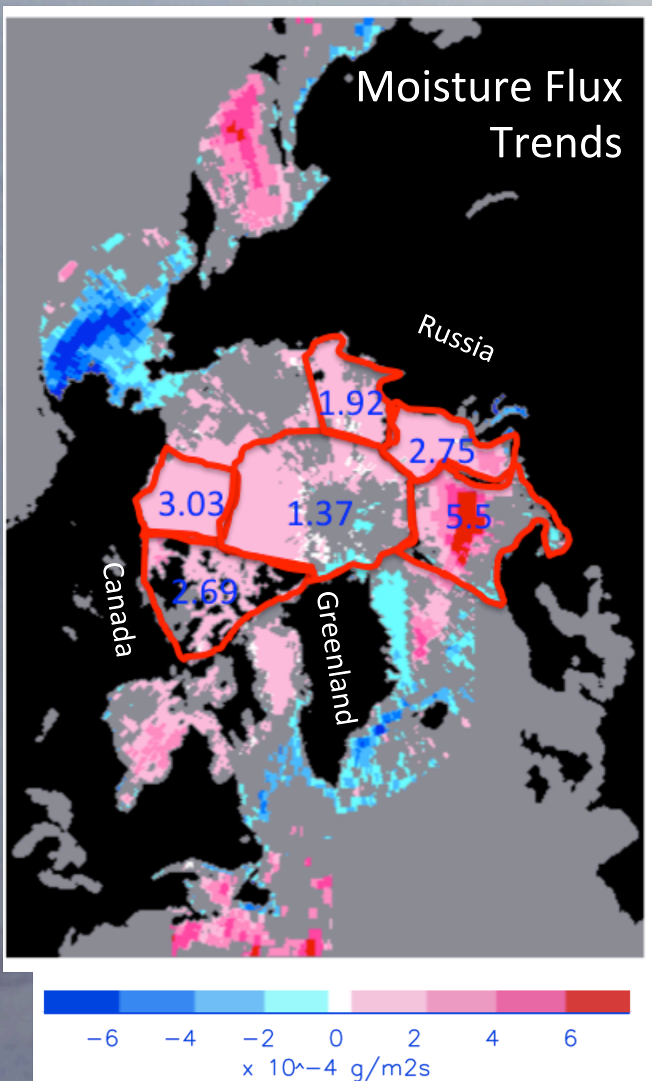
- AIRS has some limitations, however it is still a fairly reliable data source & we trust our moisture flux products
  - 18% error when compared to the average moisture flux *(Boisvert et al., 2014)*
  - Air specific humidity product accuracy needs to be improved
- Quality of the input data is very important
- Would like to see more in situ measurements made in the Arctic

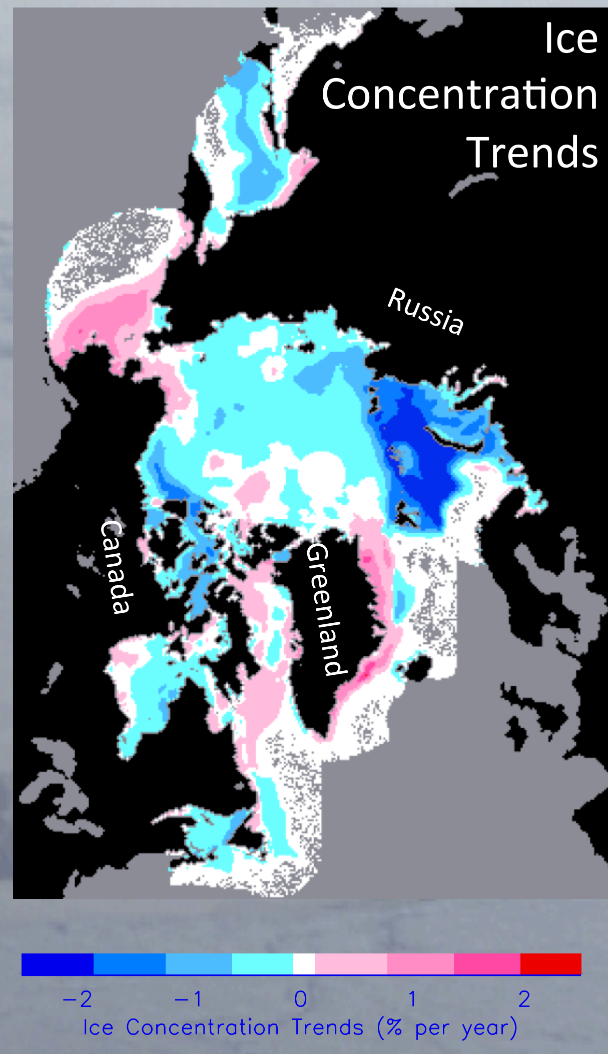
Moisture flux trends seen in the Arctic 2003-2013

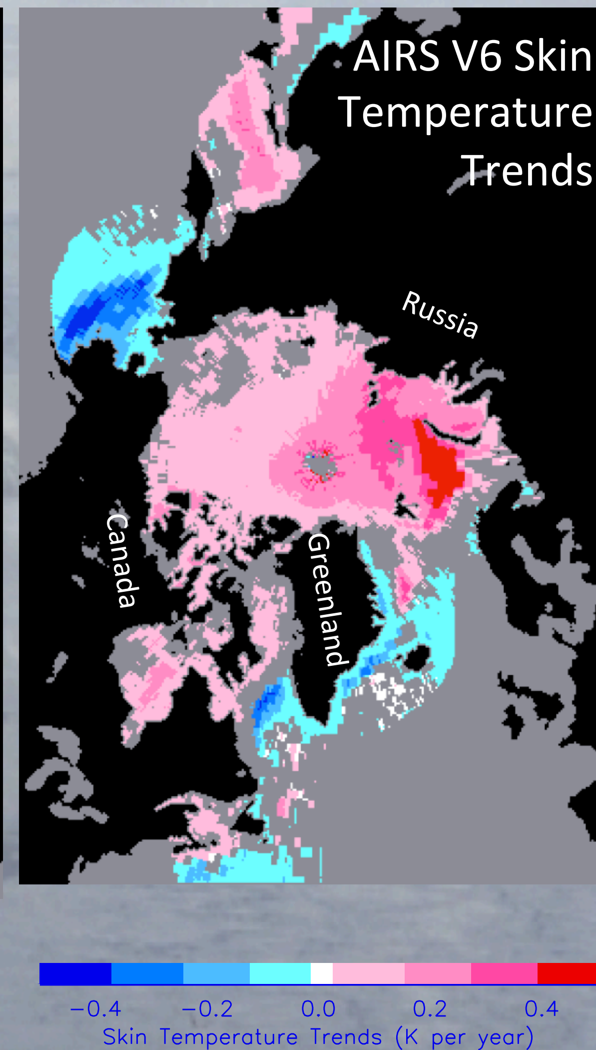
Using AIRS V6 data

Increases in MF due to loss of sea ice cover and warming SSTs

~ 17 ±3 W/m² additional latent heat energy added to atmosphere since 2003

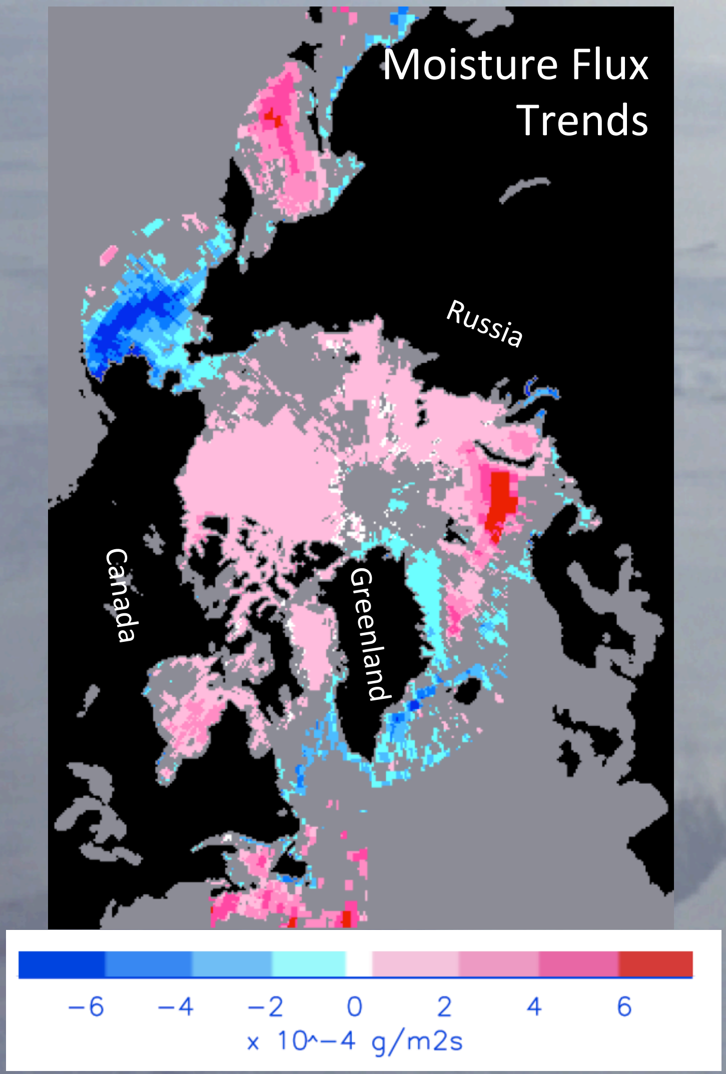


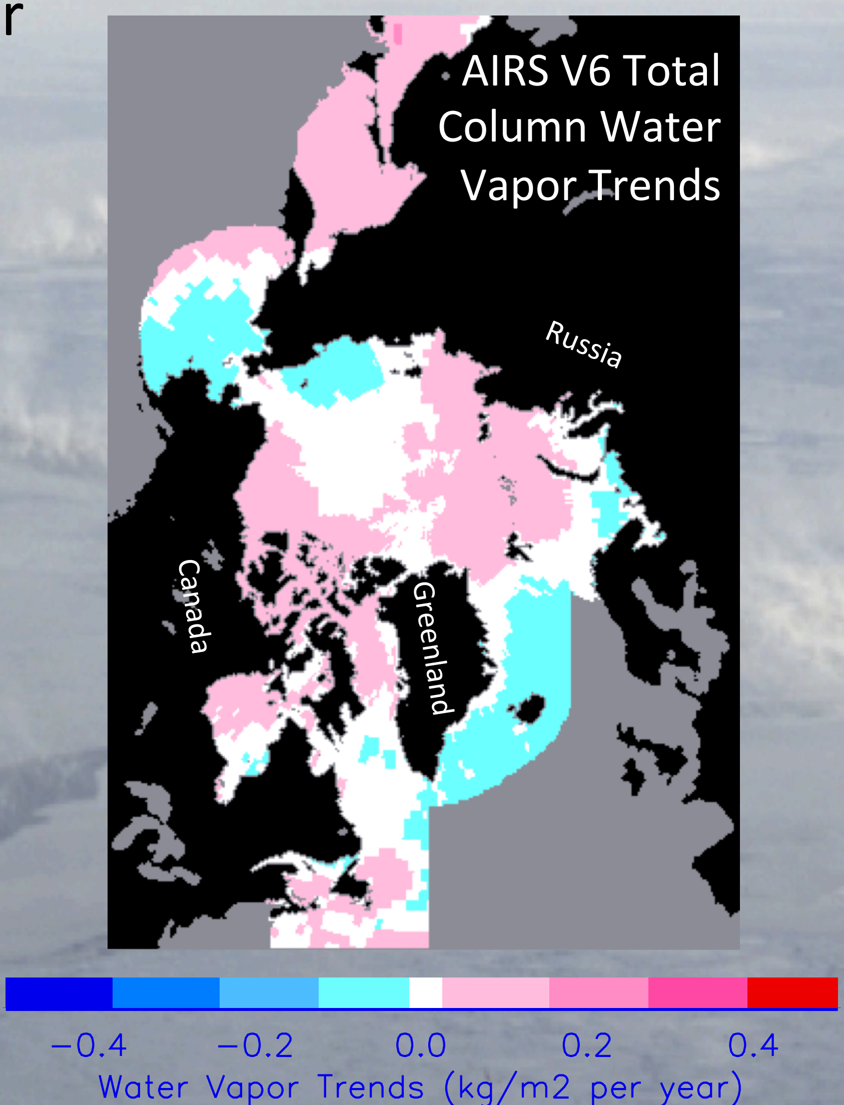




Increases in MF correspond to increases in total column water vapor

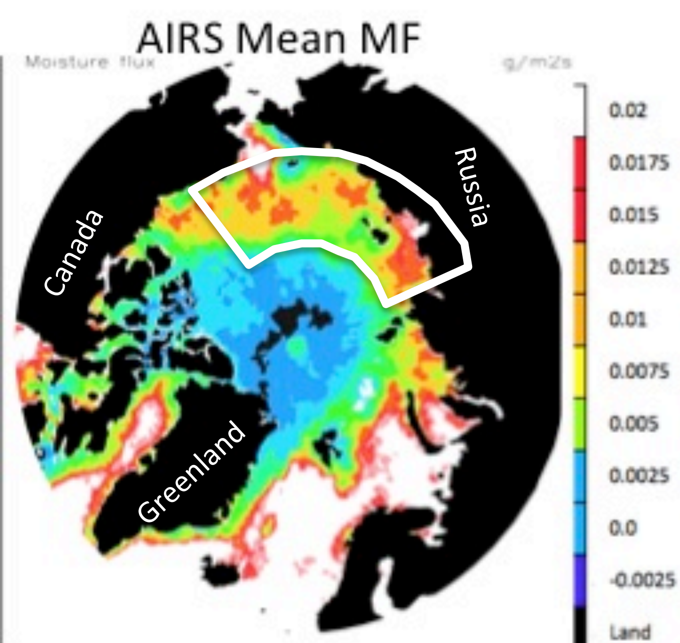
Evaporation from surface accounts for ~ 10% of total column water vapor

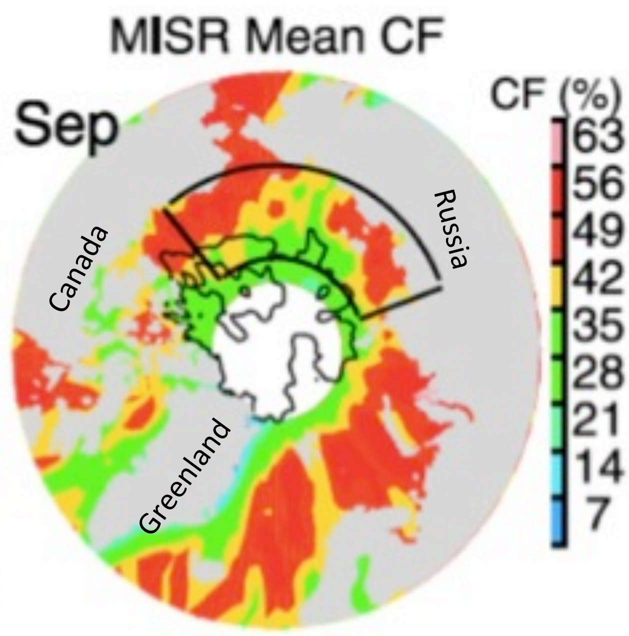


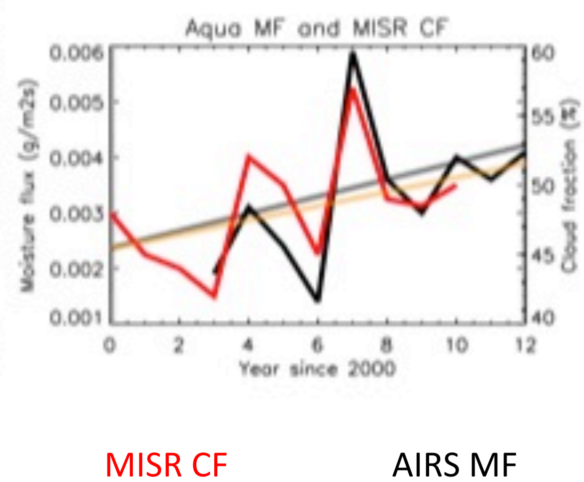


Moisture fluxes and clouds

- Arctic boundary layer and clouds are coupled over open water, but seems to happen only during certain months.
- In September, the moisture flux into the lower atmosphere and low-level clouds are coupled.
  - Years with larger moisture flux have larger cloud fraction & vice versa







2003-2012

2000-2010