



New Satellite Observations of Recent Change in the Arctic Climate

Jennifer Francis
Institute of Marine and Coastal Sciences, Rutgers University

with lots of help from

Eli Hunter, IMCS, Rutgers
Jaci Secora, IMCS, Rutgers
Cheng-Zhi Zou, NOAA/NESDIS

David Groves, RAND
Axel Schweiger, PSC, UW
Mark Ortmeyer, PSC, UW

- **The Big Picture**
- **New and Updated Products**
- **Low-Hanging Fruit**

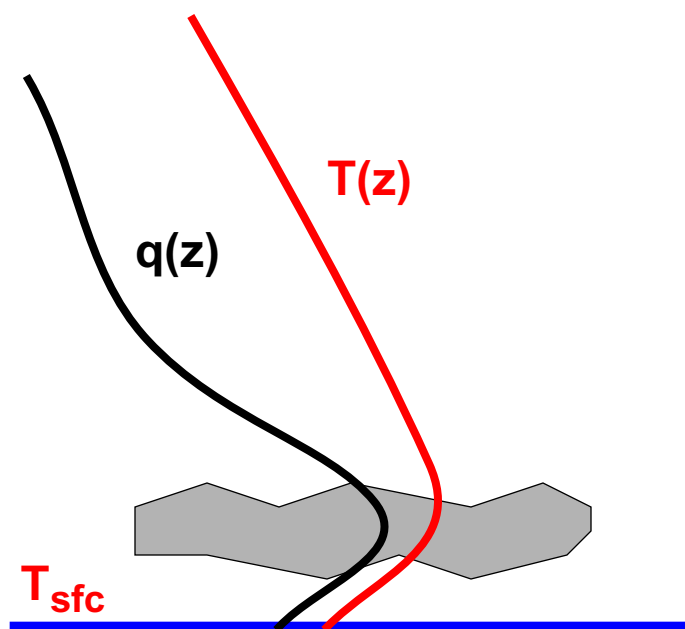
photo: S. Dery

The Big Picture



22.5 years of TOVS retrievals

=> $T(z)$, $q(z)$, skin temperature, cloud fraction and height, PBL parameters...

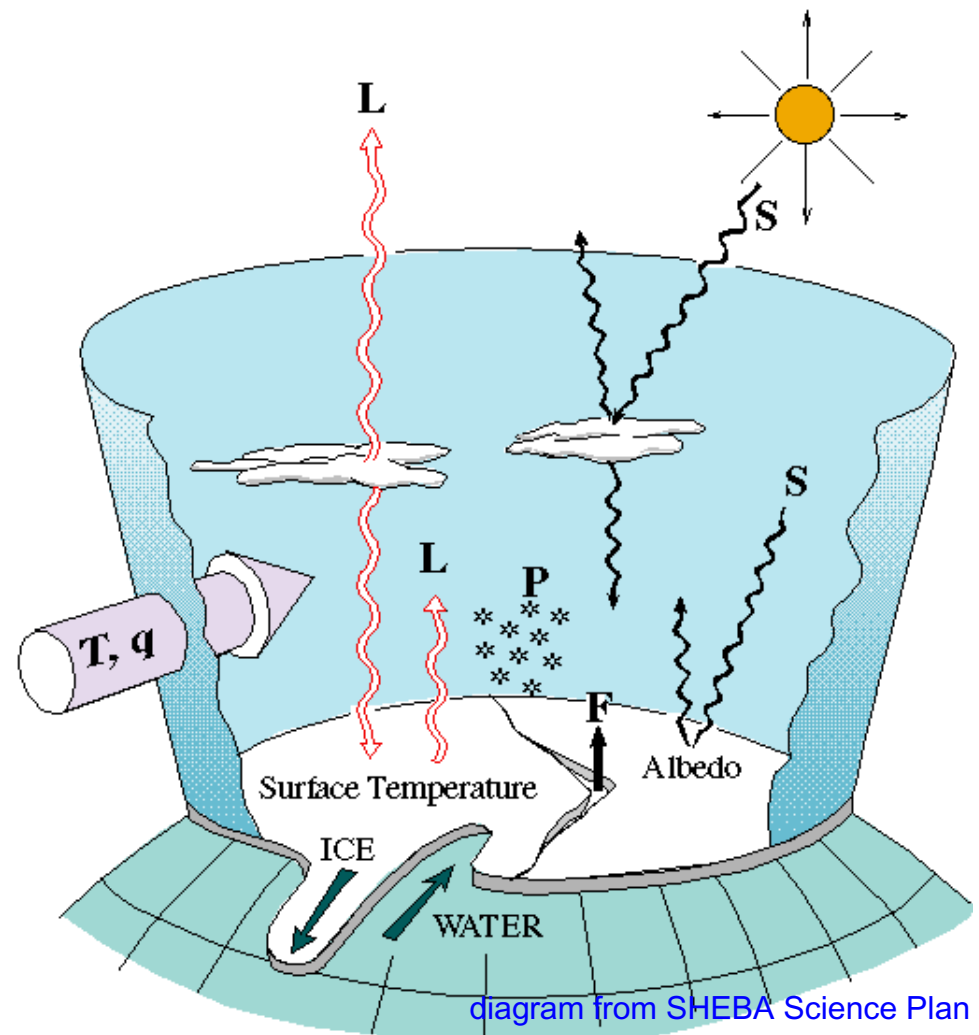


TIROS Operational Vertical Sounder

- 1979 to 2001
- $(100 \text{ km})^2$ resolution
- 39 vertical layers for $T(z)$
- 5 layers for $q(z)$
- Gridded daily/monthly Path-P data set available from NSIDC

The Big Picture

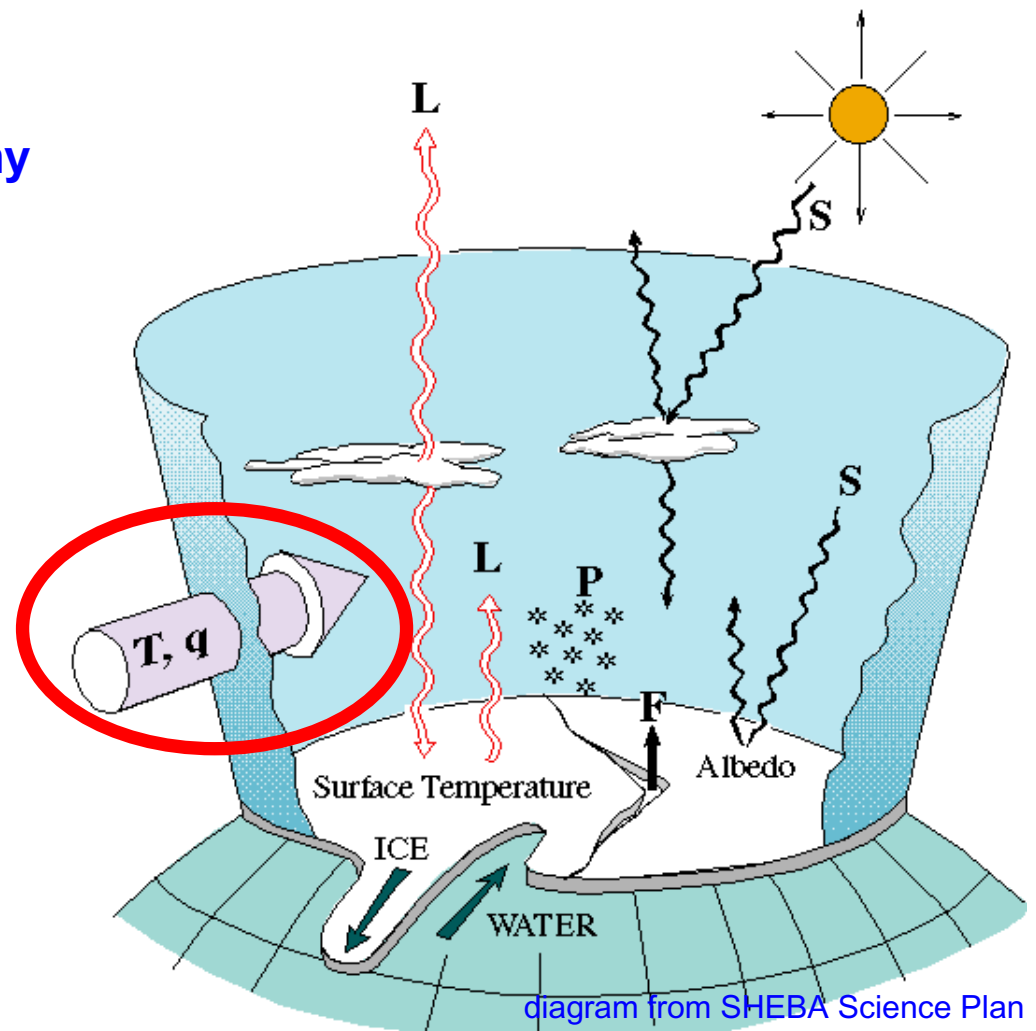
- Use TOVS retrievals to diagnose and analyze as many components of the Arctic energy budget as possible:



The Big Picture

- Use TOVS retrievals to diagnose and analyze as many components of the Arctic energy budget as possible:

⇒ Advection of T and q

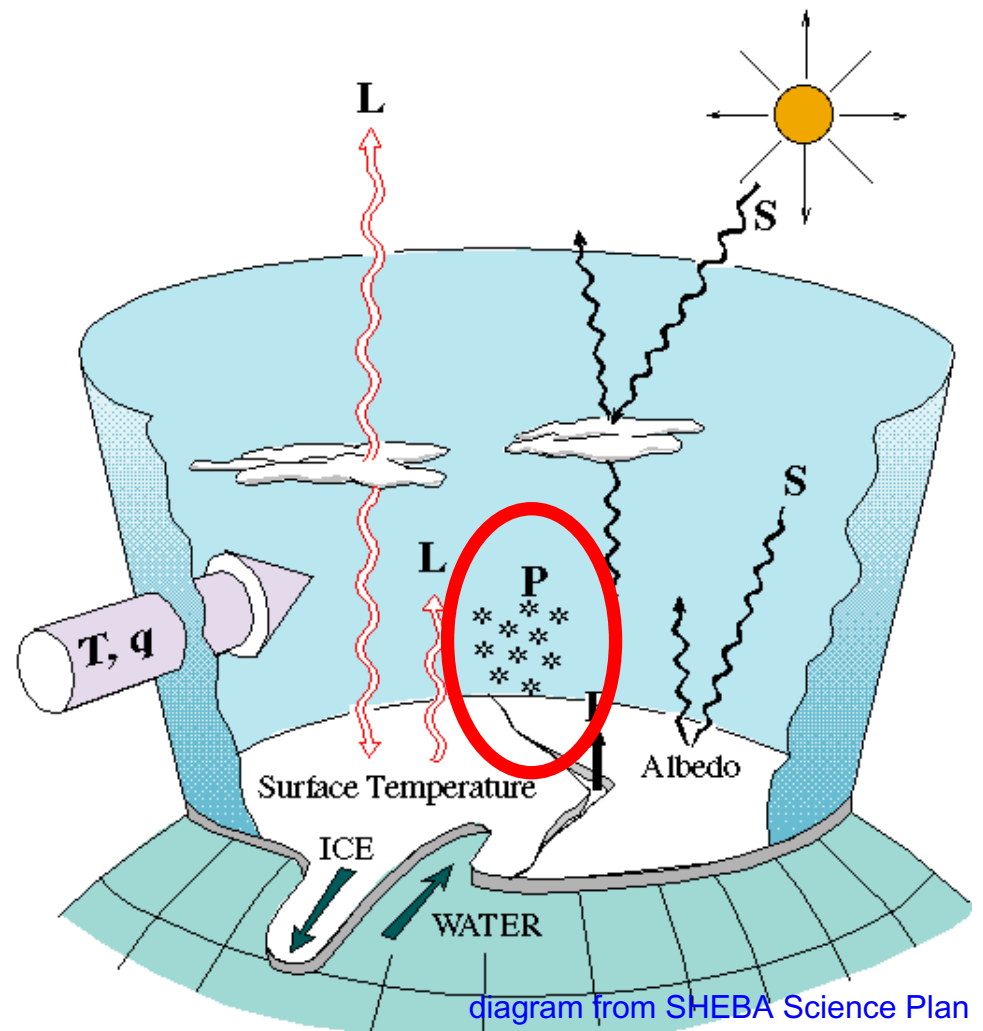


The Big Picture

- Use TOVS retrievals to diagnose and analyze as many components of the Arctic energy budget as possible:

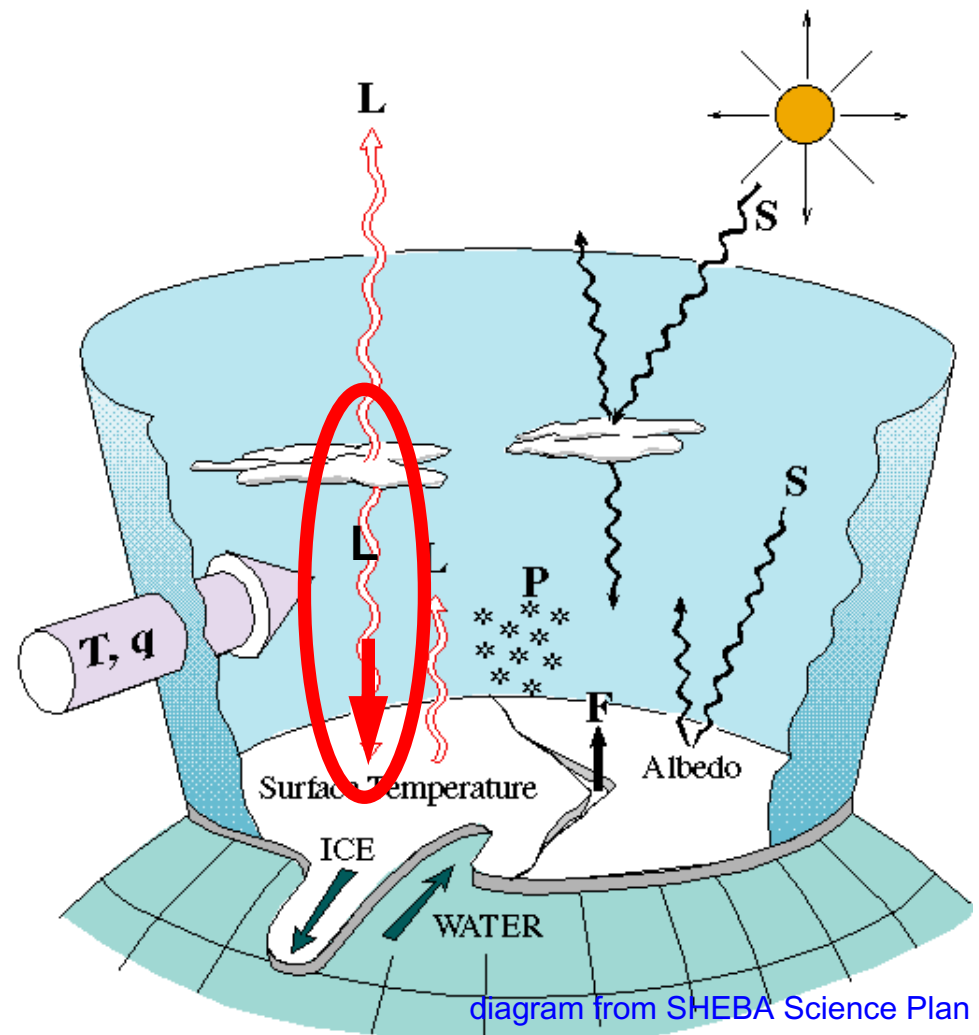
=> Advection of T and q

=> $P - E$



The Big Picture

- Use TOVS retrievals to diagnose and analyze as many components of the Arctic energy budget as possible:
 - => Advection of T and q
 - => $P - E$
 - => **Downwelling longwave flux**



The Big Picture

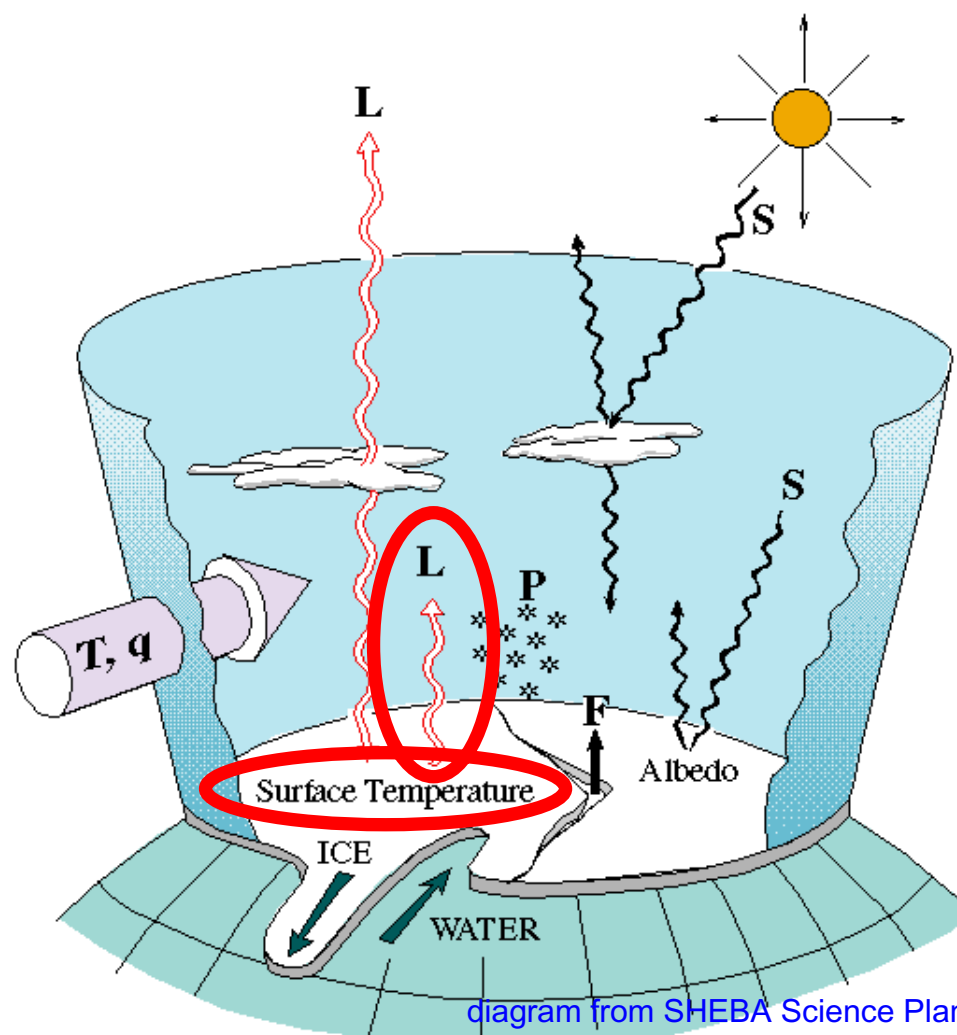
- Use TOVS retrievals to diagnose and analyze as many components of the Arctic energy budget as possible:

=> Advection of T and q

=> P - E

=> Downwelling longwave flux

=> **Surface Temperature**
(=> upwelling LW flux)



The Big Picture

- Use TOVS retrievals to diagnose and analyze as many components of the Arctic energy budget as possible:

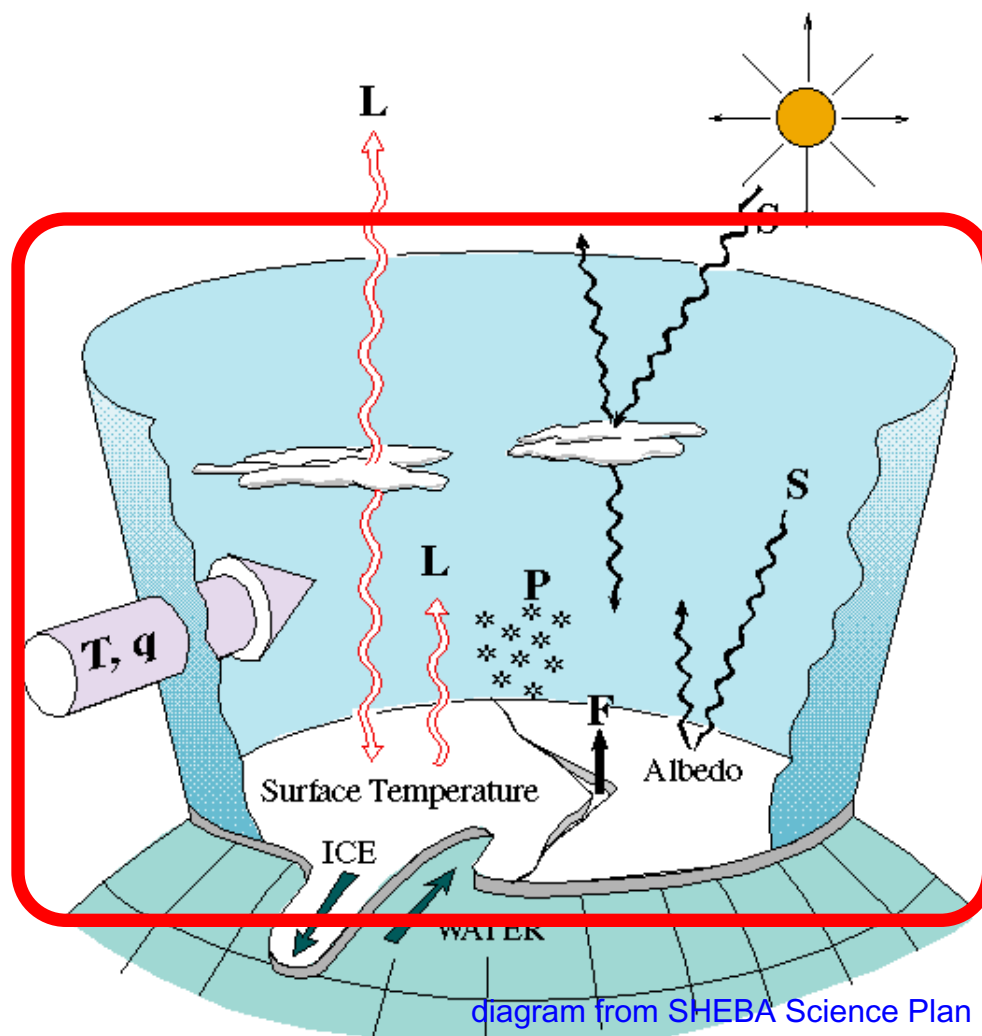
⇒ Advection of T and q

⇒ $P - E$

⇒ Downwelling longwave flux

⇒ Surface Temperature
(⇒ upwelling LW flux)

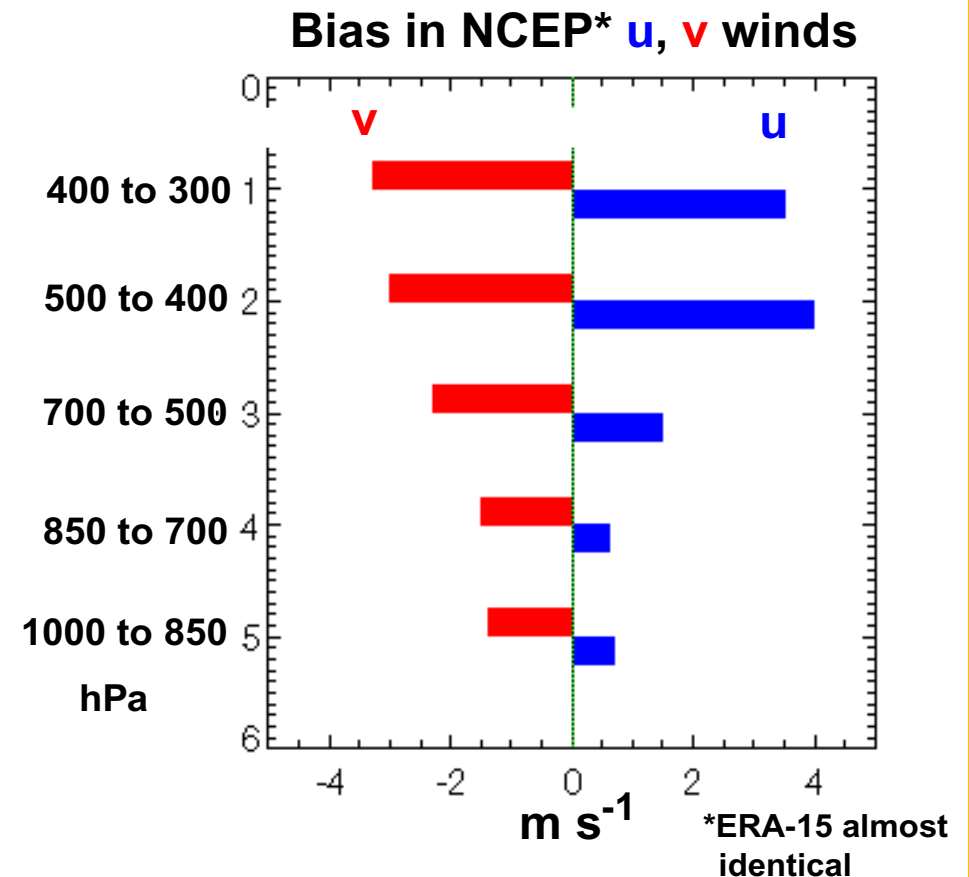
⇒ **CONNECTIONS...**



New and Updated Products

WINDS

- Winds essential ingredients in
 - => T and q advection
 - => $P - E$
 - => changes in circulation
- Errors in reanalysis upper-level winds [Francis, 2002]
 - => need new wind product



New and Updated Products



WINDS

- **New Arctic 3-D wind product generated from satellite-retrieved (TOVS) temperature profiles and NCEP/NCAR 10-meter wind fields with the Zou and Van Woert (2002) mass conservation constraint.**
- **22.5 years, daily grids, 9 levels, (100-km)² resolution.**
- **Details in Francis *et al*, submitted to *Journal of Climate*.**

New and Updated Products



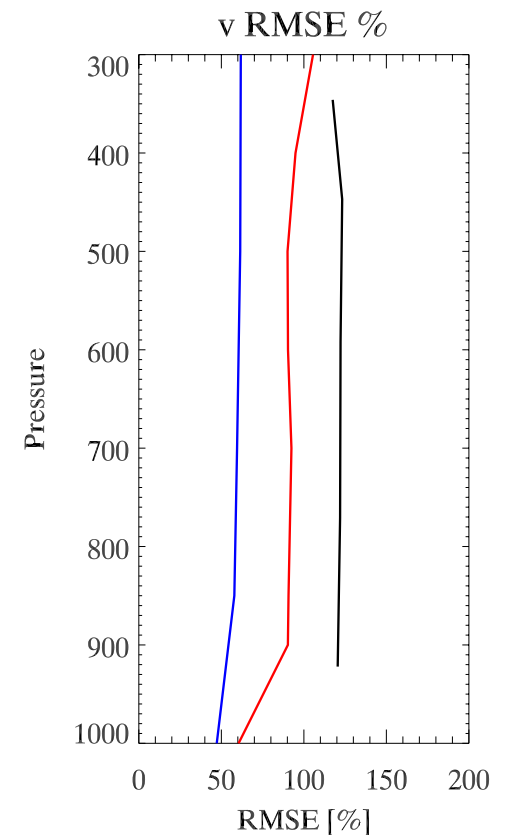
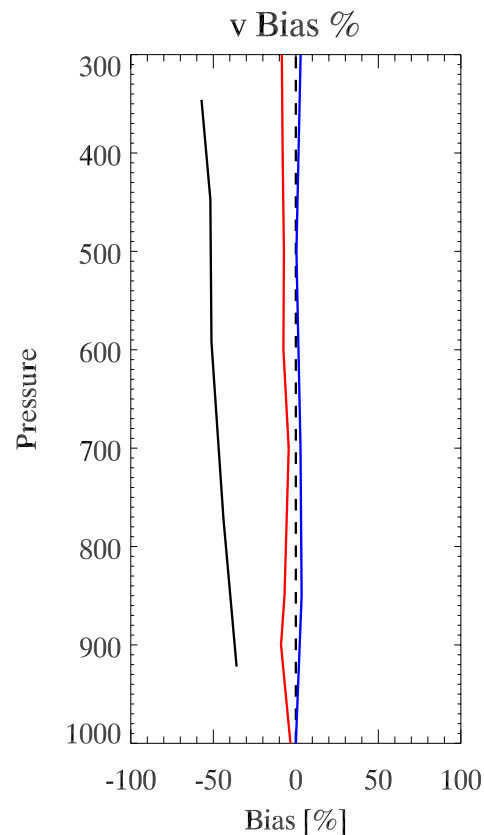
WINDS: Validation of meridional (v) component

***Bias and RMSE
weighted by mean $|v|$***

**Black = NCEP/NCAR
Reanalysis vs.
CEAREX/LeadEx**

**Red = Arctic TOVS vs.
SHEBA**

**Blue = Southern Ocean
TOVS vs. Macquarie Is.**



New and Updated Products



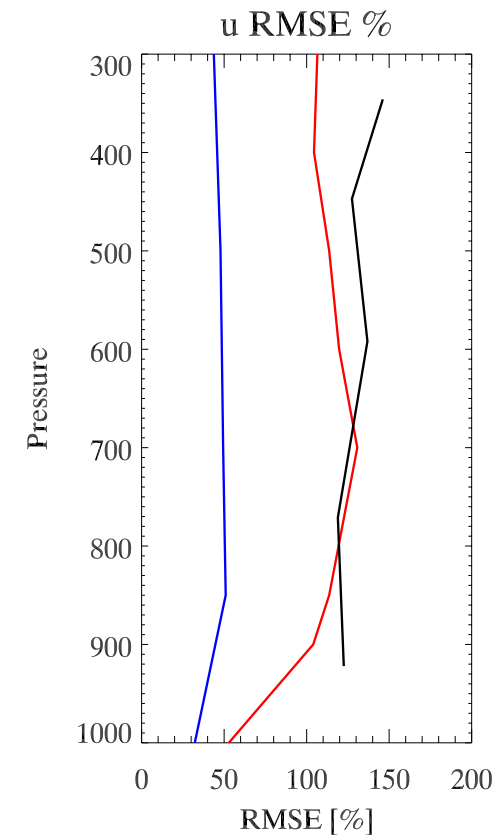
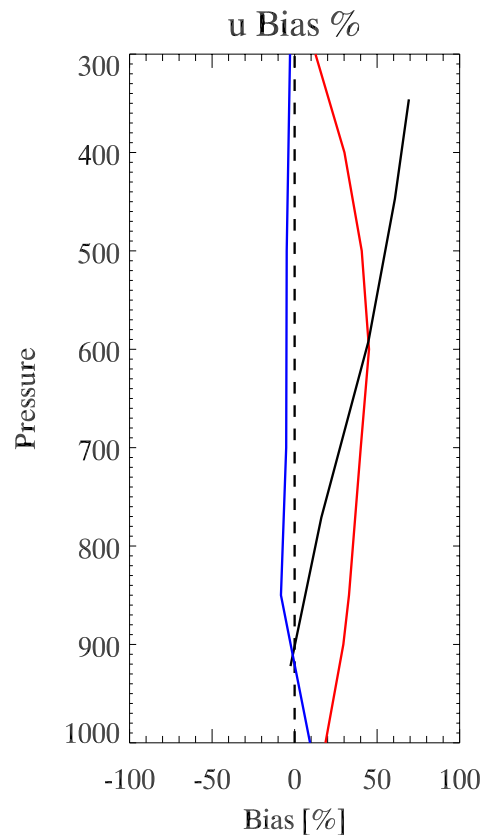
WINDS: Validation of zonal (u) component

**Bias and RMSE
weighted by mean |u|**

**Black = NCEP/NCAR
Reanalysis vs.
CEAREX/LeadEx**

**Red = Arctic TOVS vs.
SHEBA**

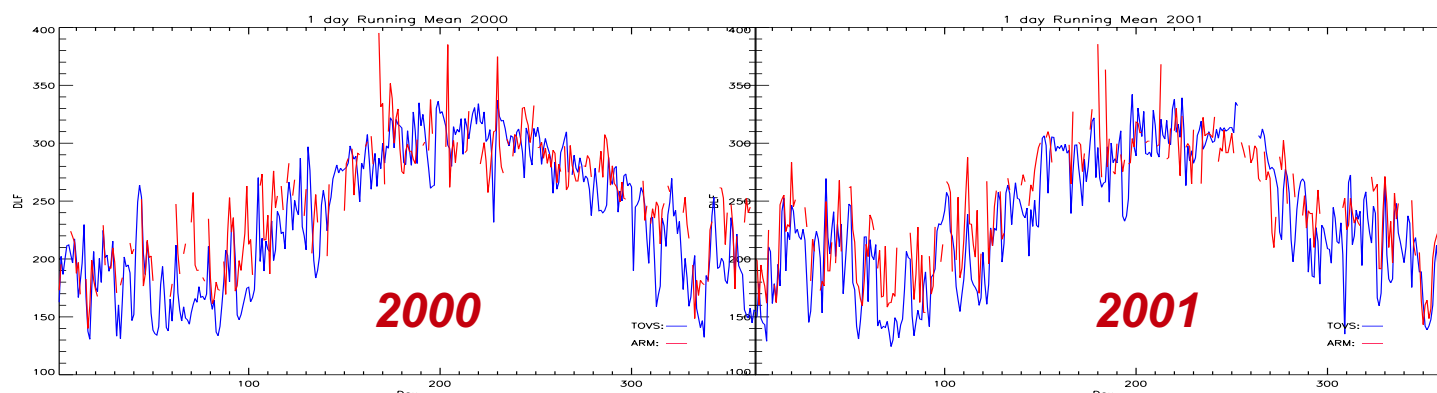
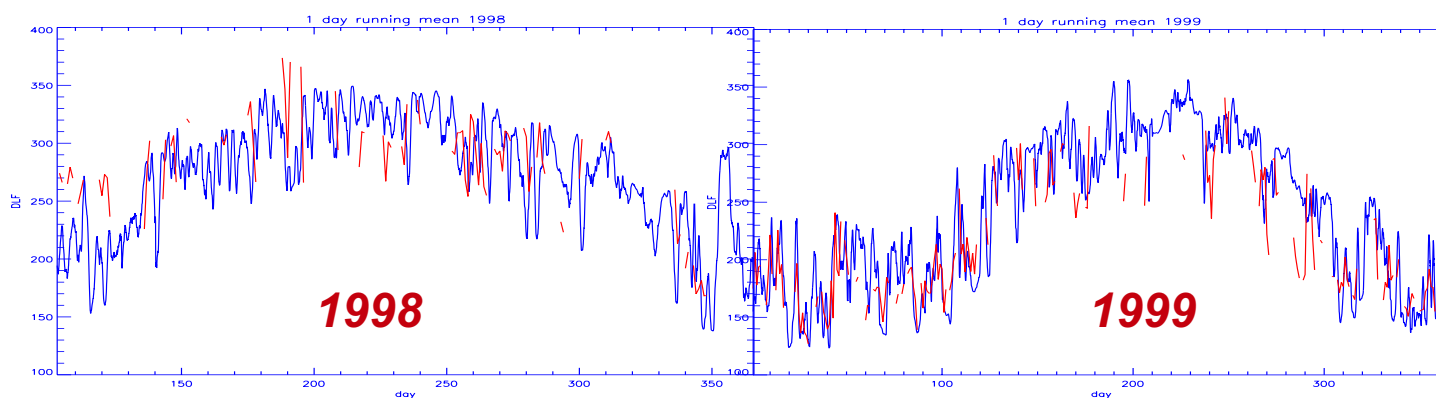
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New and Updated Products



DOWNWARD LONGWAVE RADIATION



bias $\sim 12 \text{ W m}^{-2}$

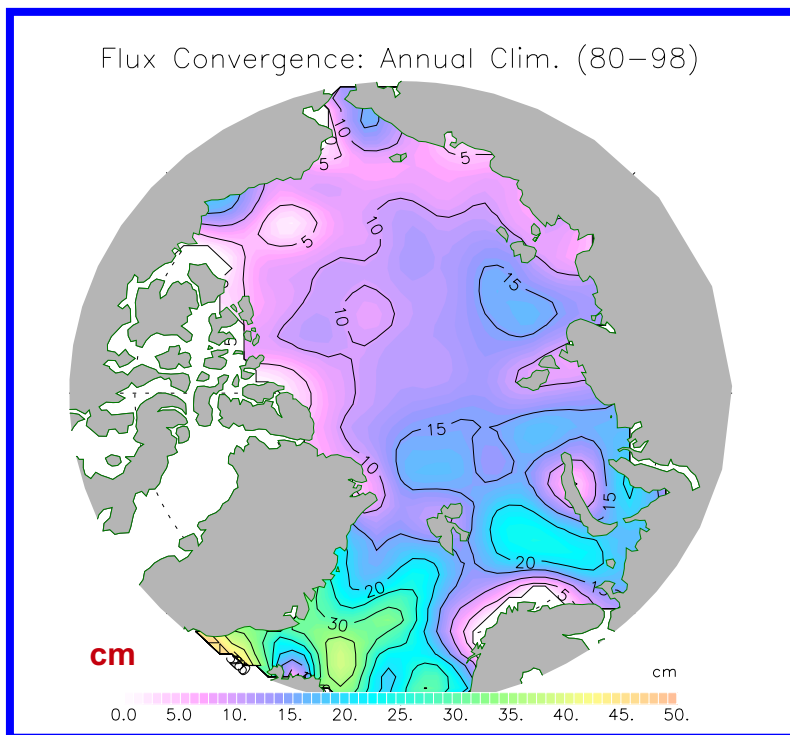
TOVS ARM

New and Updated Products



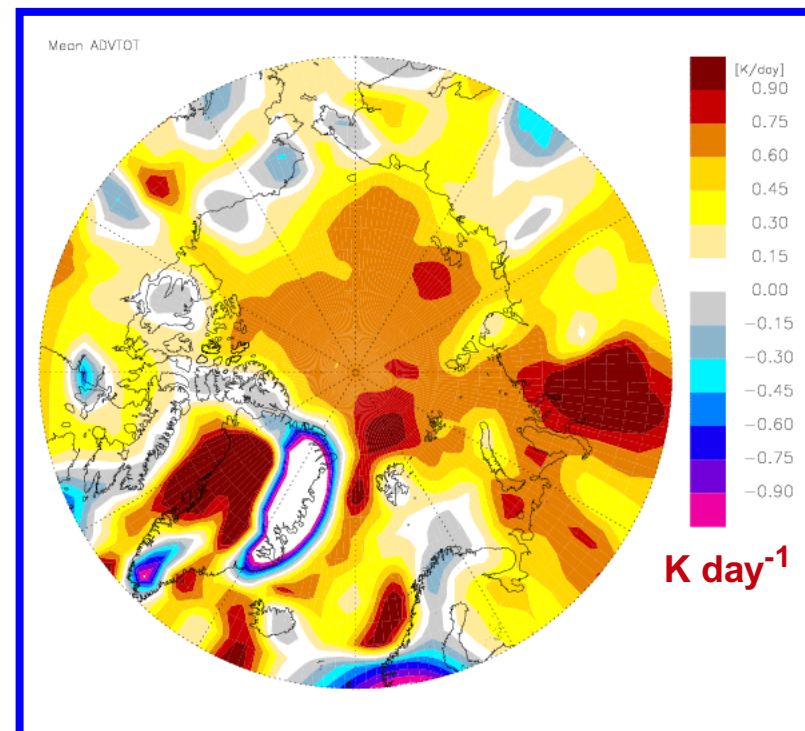
COMING ATTRACTIONS

Net Precipitation (P-E)



Groves and Francis, JGR, 2002a,b

Sensible Heat Advection



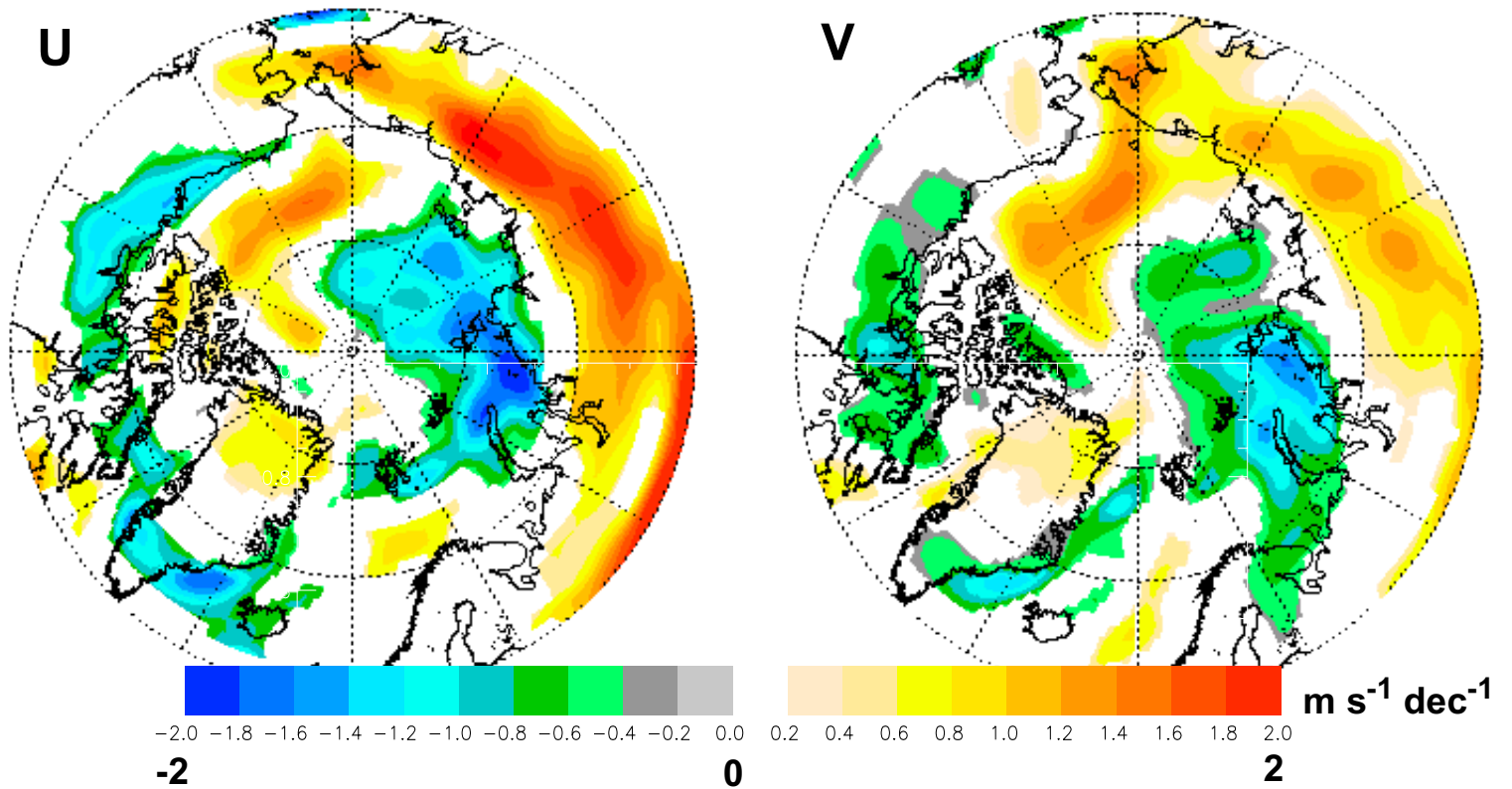
20-yr annual mean 1000 to 300 hPa

Low Hanging Fruit



WIND S: 23-Year Trends

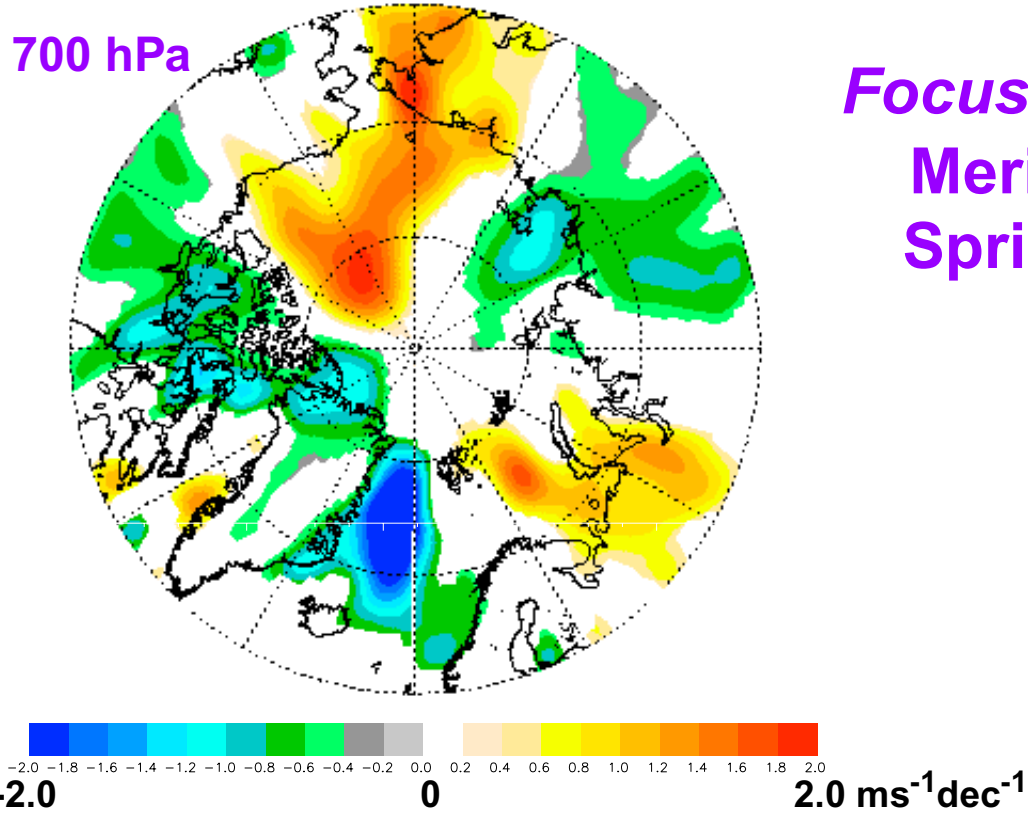
Total column (surface to 300 hPa)



Low Hanging Fruit



WINDS: 23-Year Trends

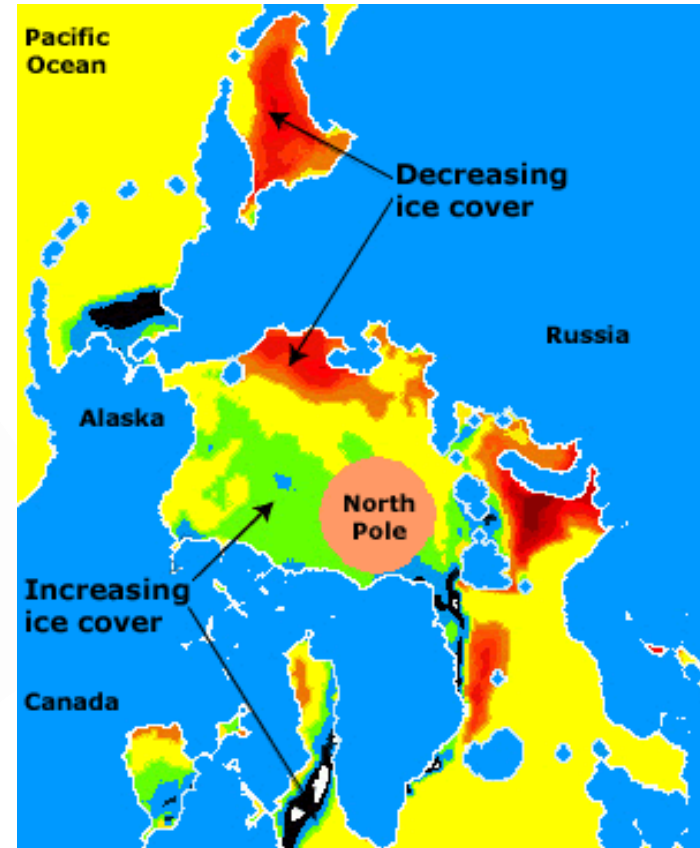
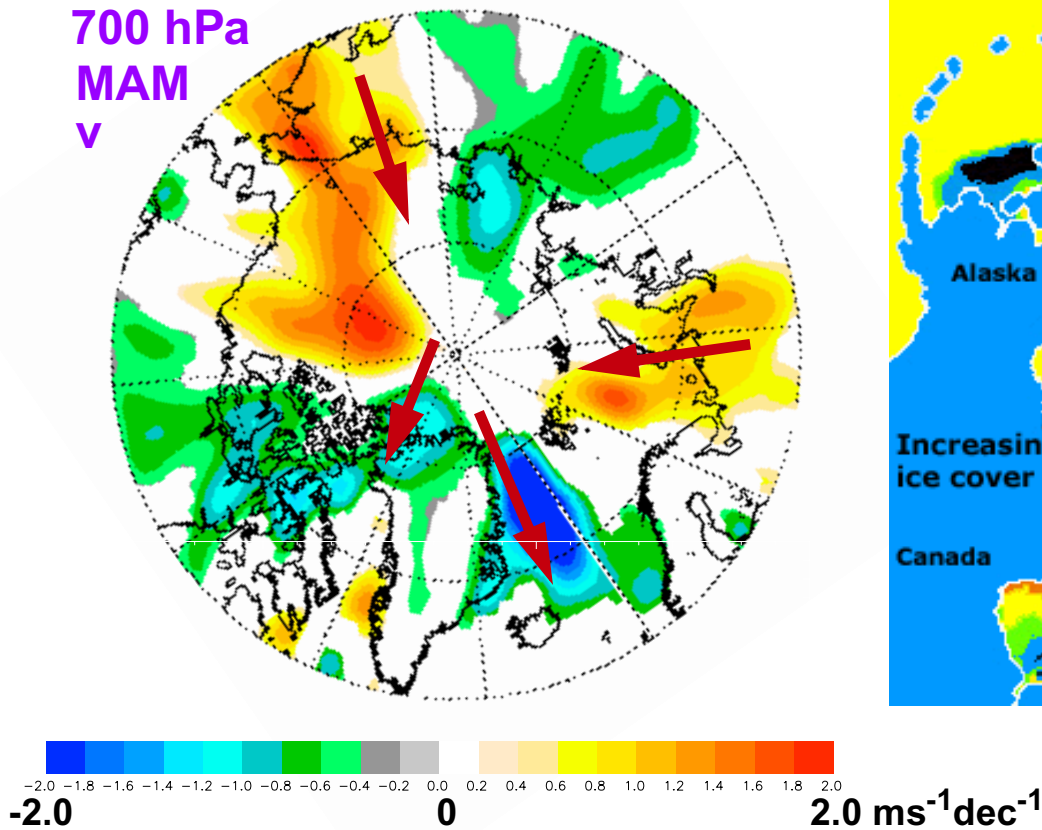


Focus:
Meridional component
Spring (MAM)

Low Hanging Fruit



WIND S: 23-Year Trends

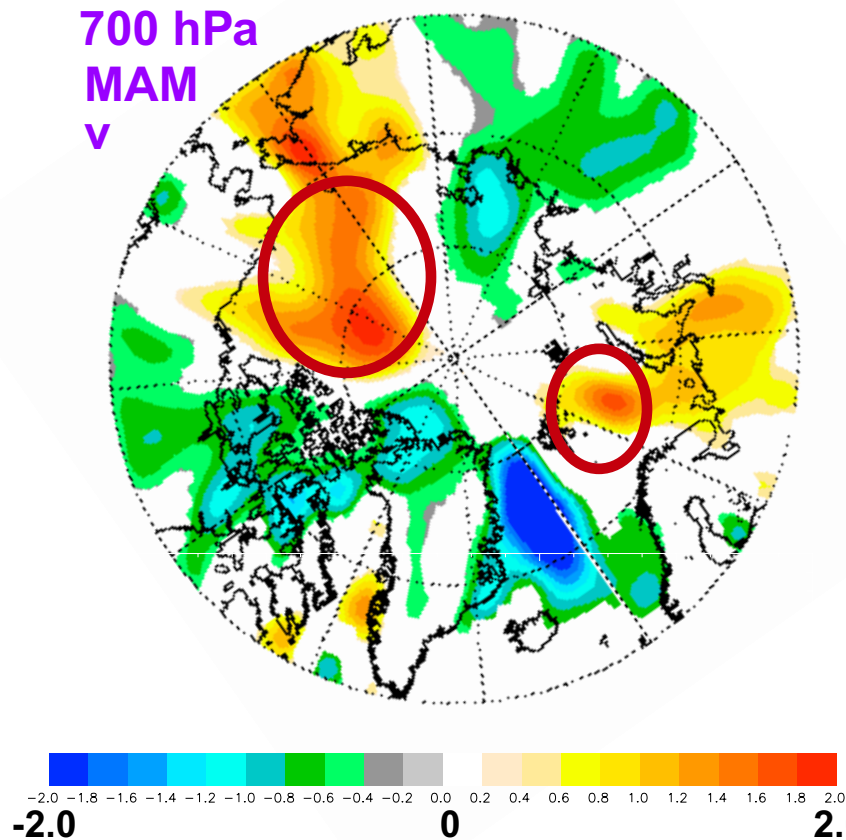


J. Maslanik, NSIDC

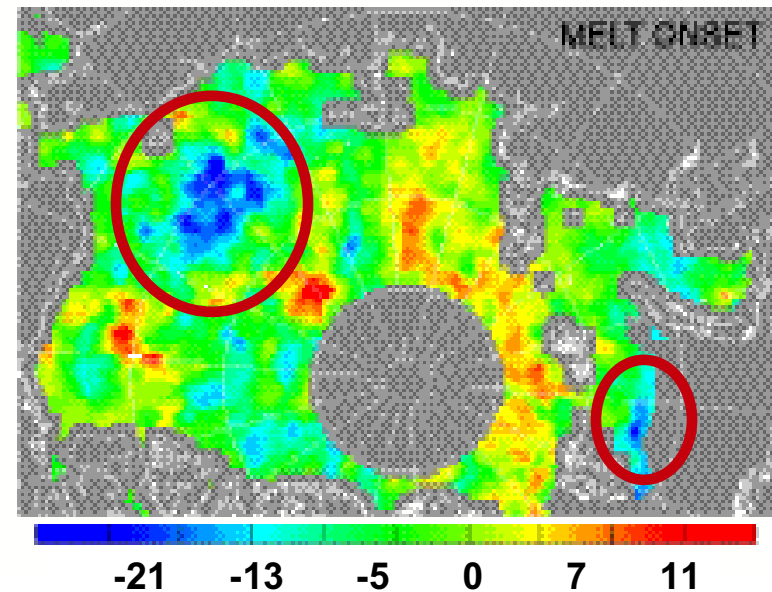
Low Hanging Fruit



WIND S: 23-Year Trends



Change in Melt Onset Date
(1989-2001) minus (1979-1988)



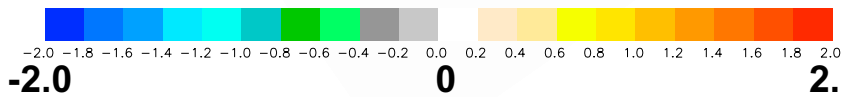
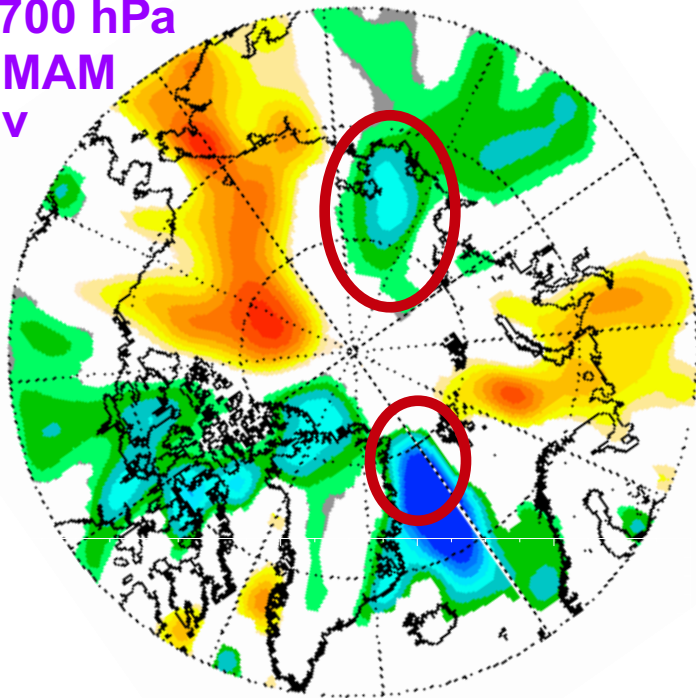
Belchansky *et al*, J. Clim, 2003

Low Hanging Fruit

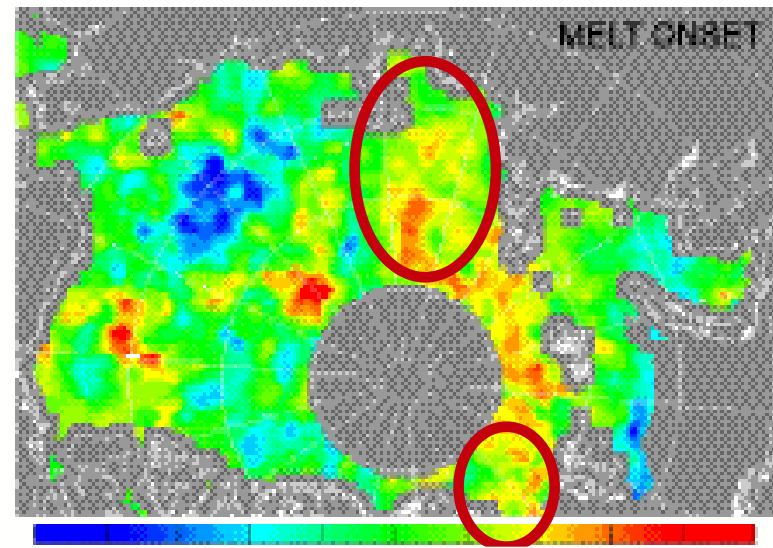


WIND S: 23-Year Trends

700 hPa
MAM
v



Change in Melt Onset Date
(1989-2001) minus (1979-1988)

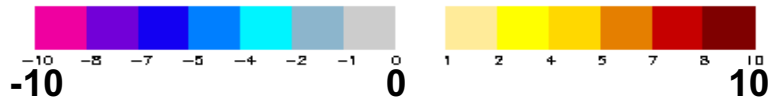
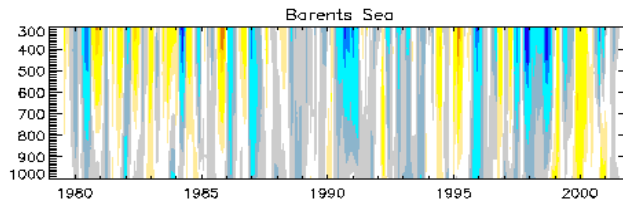
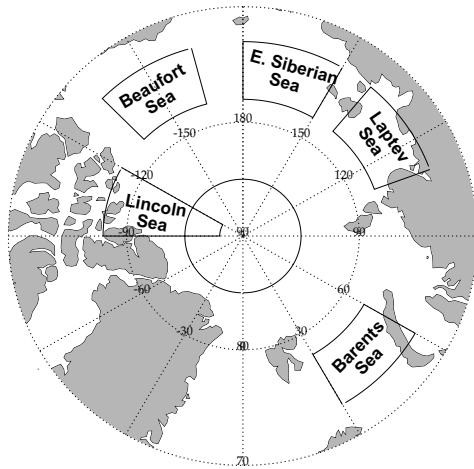
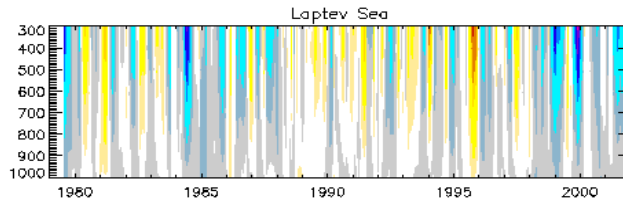
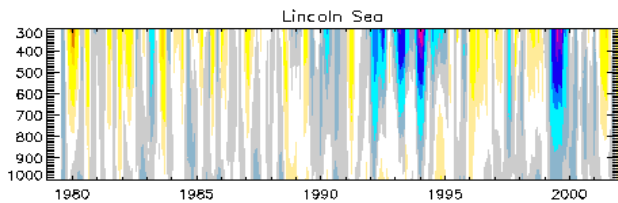
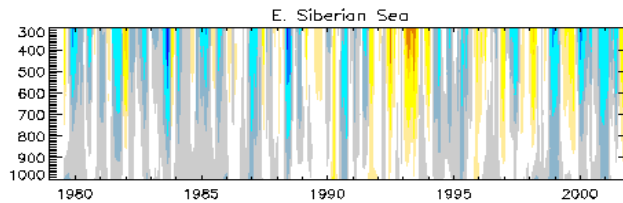
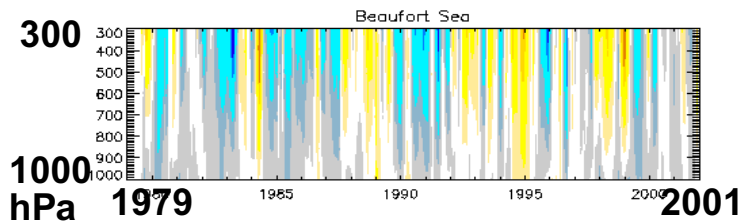


Belchansky et al, J. Clim, 2003

Low Hanging Fruit



WIND S: 23-Year Meridional Anomalies



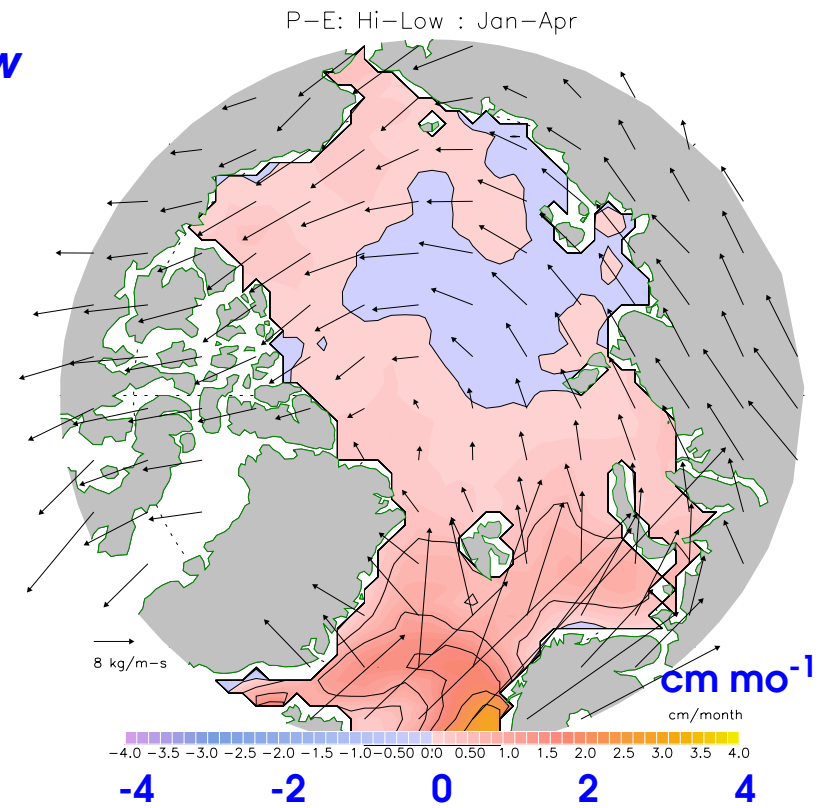
Low Hanging Fruit



NET PRECIPITATION: *Pos.* – *Neg.* AO

- Trends and patterns in P-E are intriguing -- *recalculation with new wind fields underway*

PW Flux Vectors and P-E

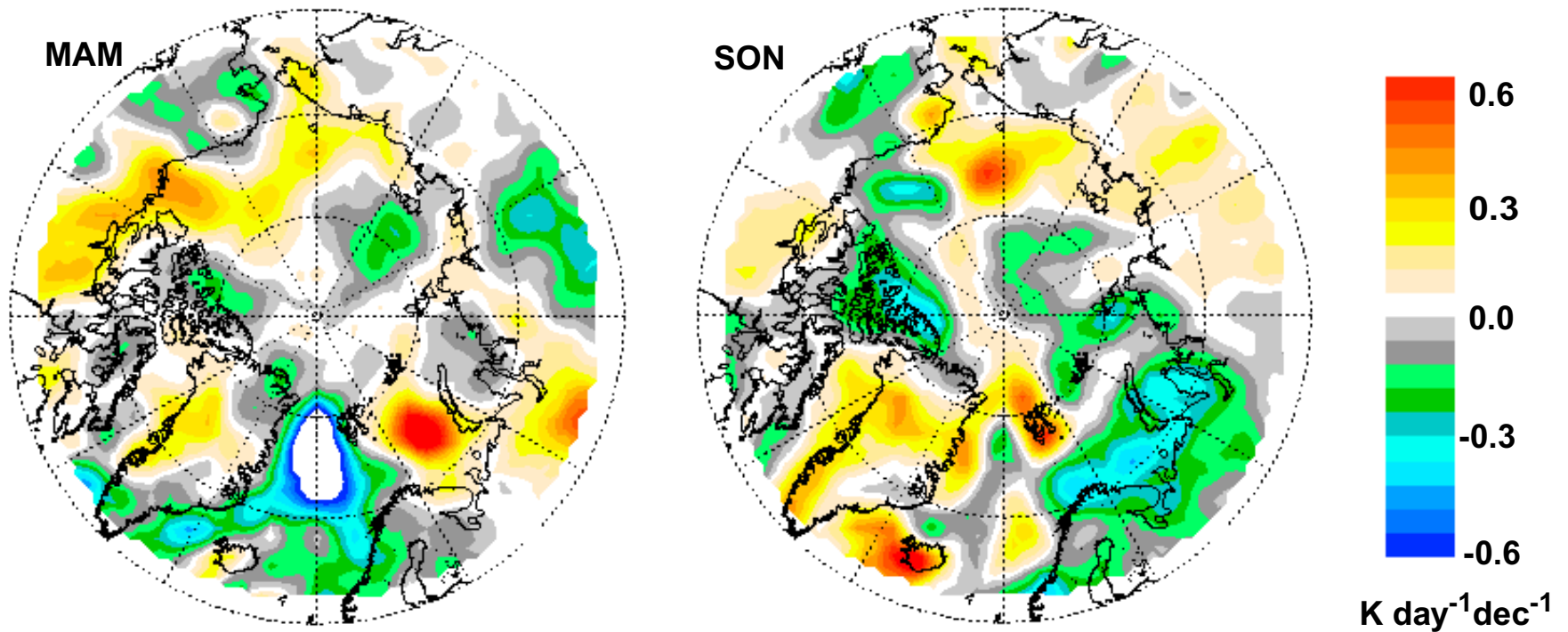


Low Hanging Fruit



SENSIBLE HEAT ADVECTION: *23-Year Trends*

Poleward Component in 1000 to 700 hPa Layer

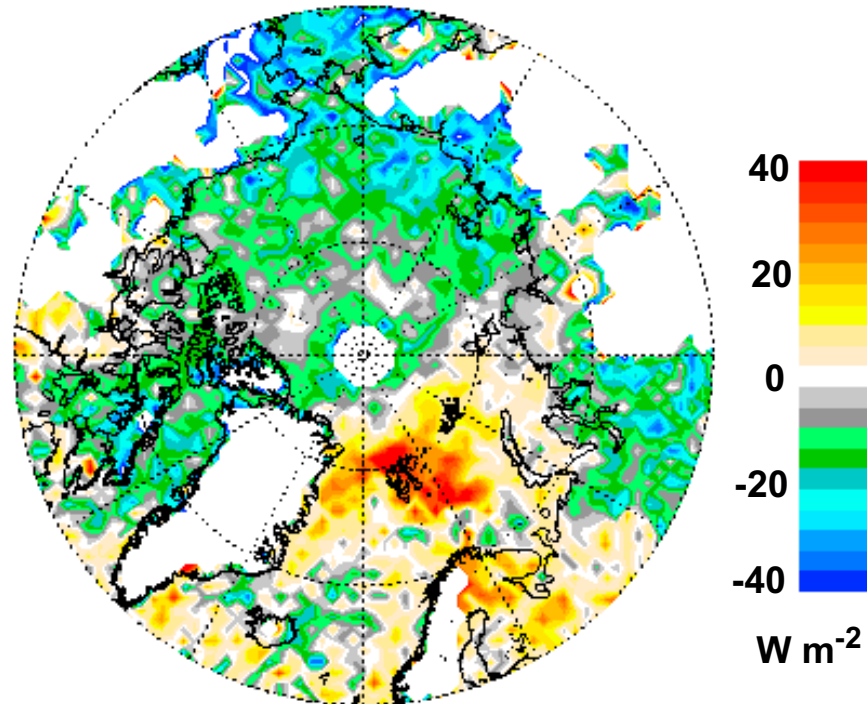


Low Hanging Fruit



DOWNWELLING LONGWAVE RADIATION: (*an appetizer**)

MAM (1998 to 2001) – (1980 to 1983)



*** Stay tuned!**

Wrap-Up



Satellites have arrived as a climate tool.

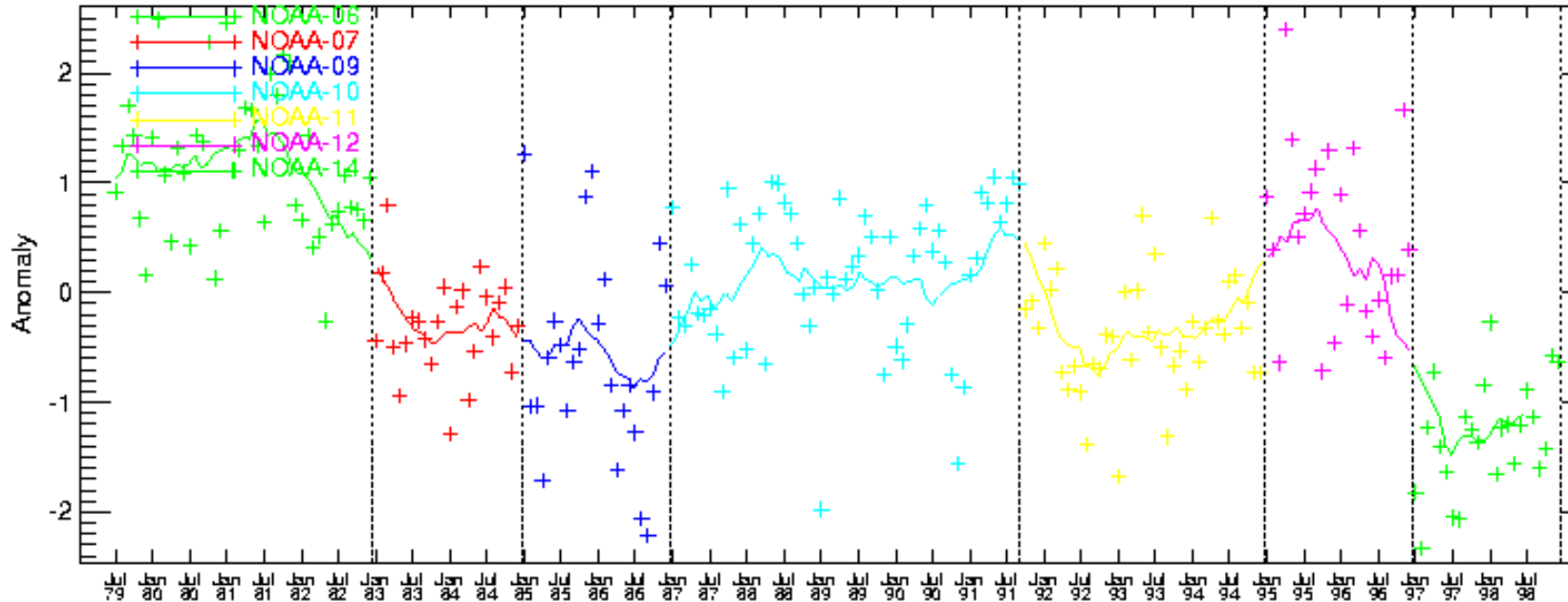
- => 23 years and counting: passive microwave, profilers, imagers**
- => Recent decades characterized by dramatic Arctic change**
- => Suite of retrieved products fills gaps in conventional observations**
- => Great potential for understanding relationships, feedbacks, connections to global climate system**

Still Plenty on the “To-Do” List...



Inter- and Intra-Satellite Radiance Corrections*

500 hPa Monthly Temperature Anomalies



*a Rutgers, U. of WA, NOAA project



Thanks!

NASA

NSF

NOAA/ U. of AK

DOE/ARM

for support

francis@imcs.rutgers.edu

image from MODIS