



Evaluation of Lower Stratosphere Temperatures in Reanalyses in the Southern High Latitudes

Craig S. Long

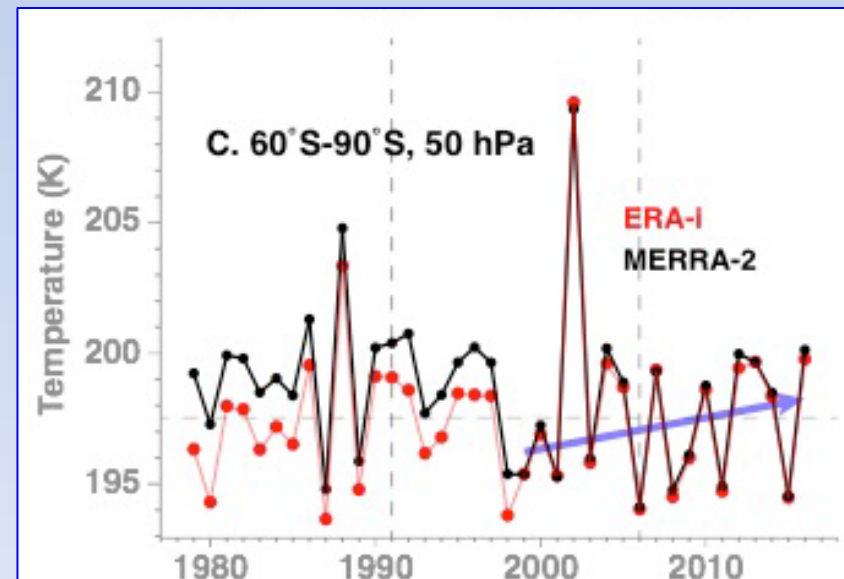
NOAA/NWS/NCEP – Climate Prediction Center

With consultation from

A. Simmons – ECMWF and K. Wargan & L. Coy – NASA/GMAO

What initiated this investigation?

- In the SOC Ozone Hole section there is a plot showing the SH polar latitude 50 hPa temperatures during September from 1980-2015.
- My concern is not so much what has been happening after 1999, but the 2°C difference between MERRA-2 and ERA-I prior to this.
- This difference will impact any pre-1999 period used for trends.
- The question is: Which is correct?
- MERRA-2 or ERA-I?
- What about CFSR or JRA55?
- What about other levels & months?



Evaluation Plan

- Intercompare the four more recent reanalyses in the SH high latitudes:
 - MERRA-2, ERA-I, JRA55, and CFSR
- Compare against each other but also against ‘truth’ (radiosonde observations).
 - Use Integrated Global Radiosonde Archive (IGRA)
- IGRA monthly mean radiosonde temperatures at stations in Antarctica with long, uninterrupted, year-long observation records.
 - Casey, Davis, Swoya, Novolazarevskaya, Dumont d’Urville, Mirny
- And temperatures from ozonesoundings:
 - at Amundsen-Scott (South Pole)
- Unsure how many Antarctica radiosonde observations are assimilated.
 - And what adjustments were made to them.

September 50 hPa Temps

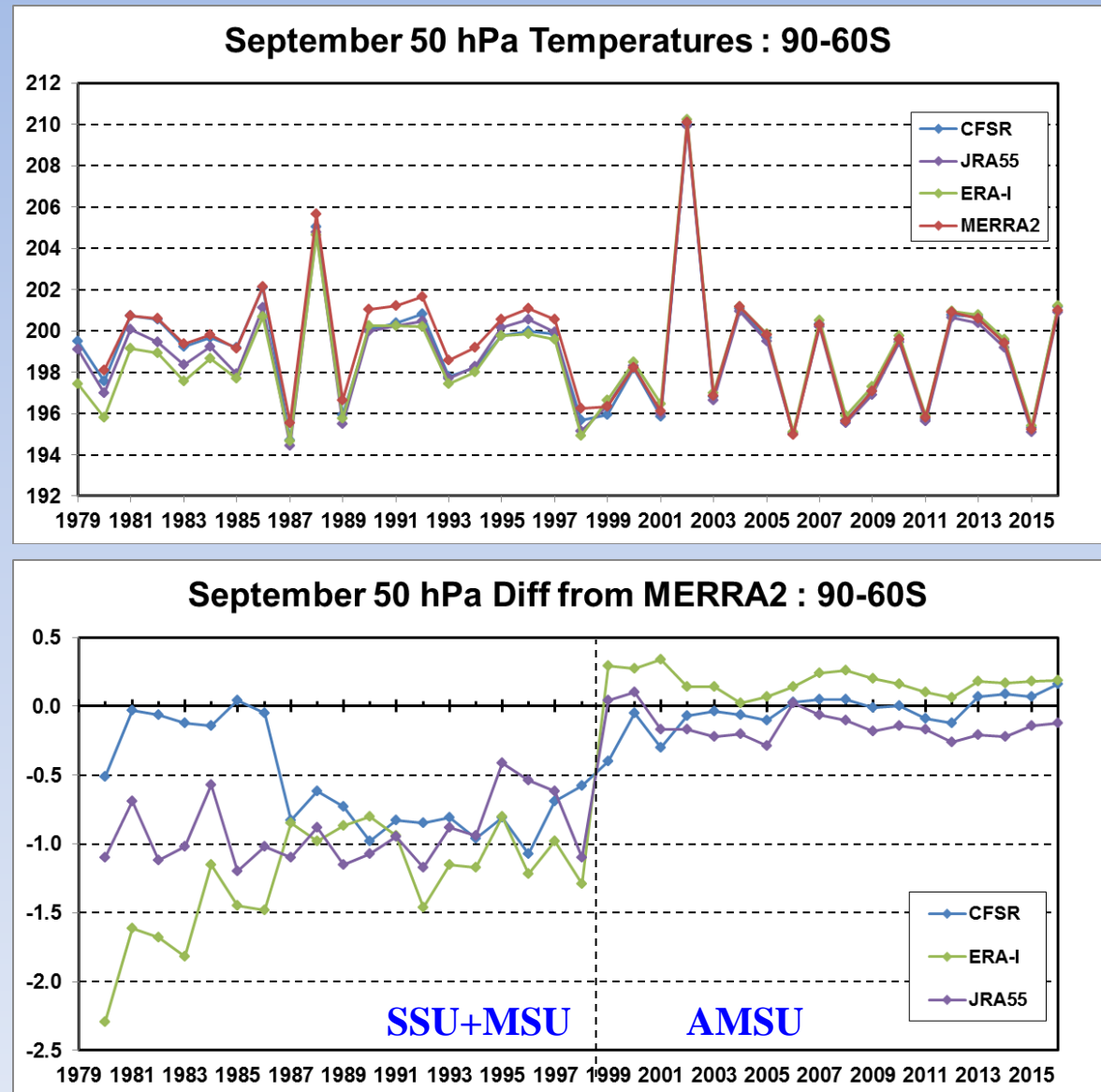
Same as shown a few slides ago. Added CFSR and JRA55.

MERRA-2 is warmer than the other 3 reanalyses pre 1999.

-Differencing the three reanalyses from MERRA-2 confirms that something happened between 1998 and 1999.

-CFSR and ERA-I differences vary with time.

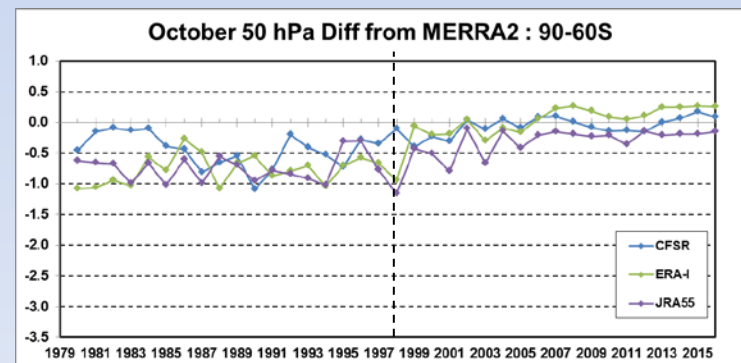
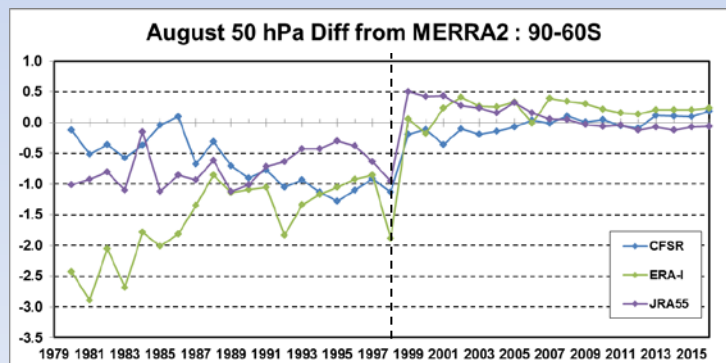
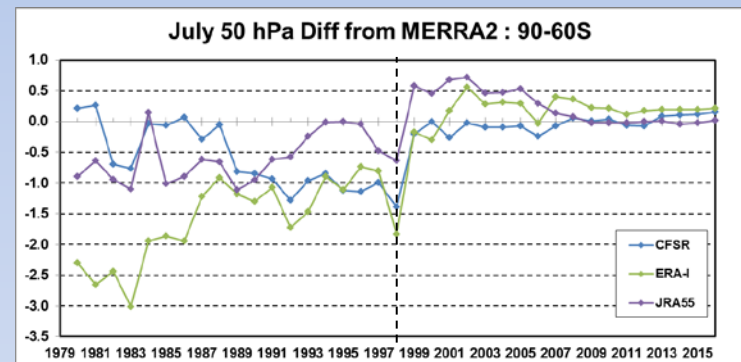
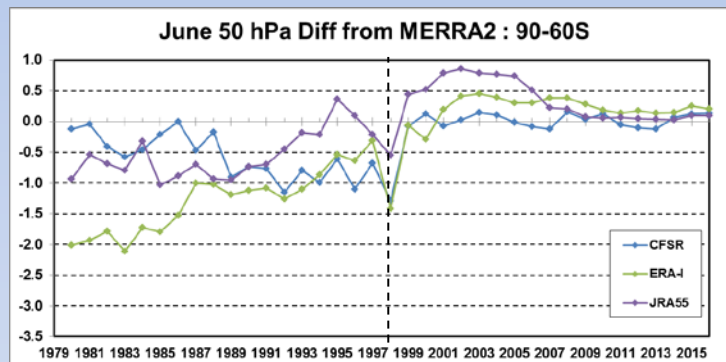
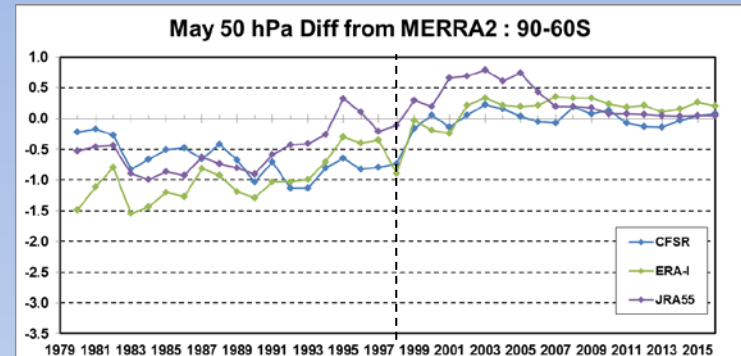
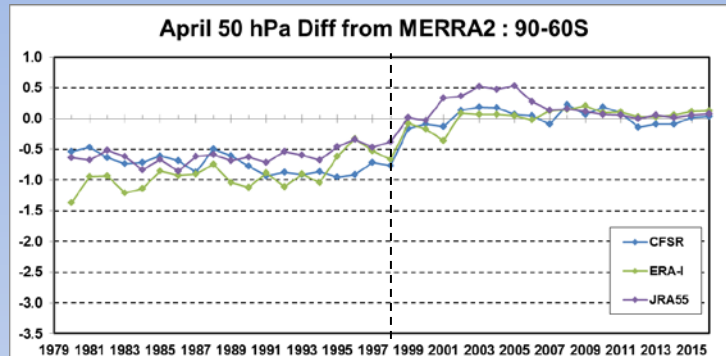
-After 1999 they all agree within a couple tenths of a degree.



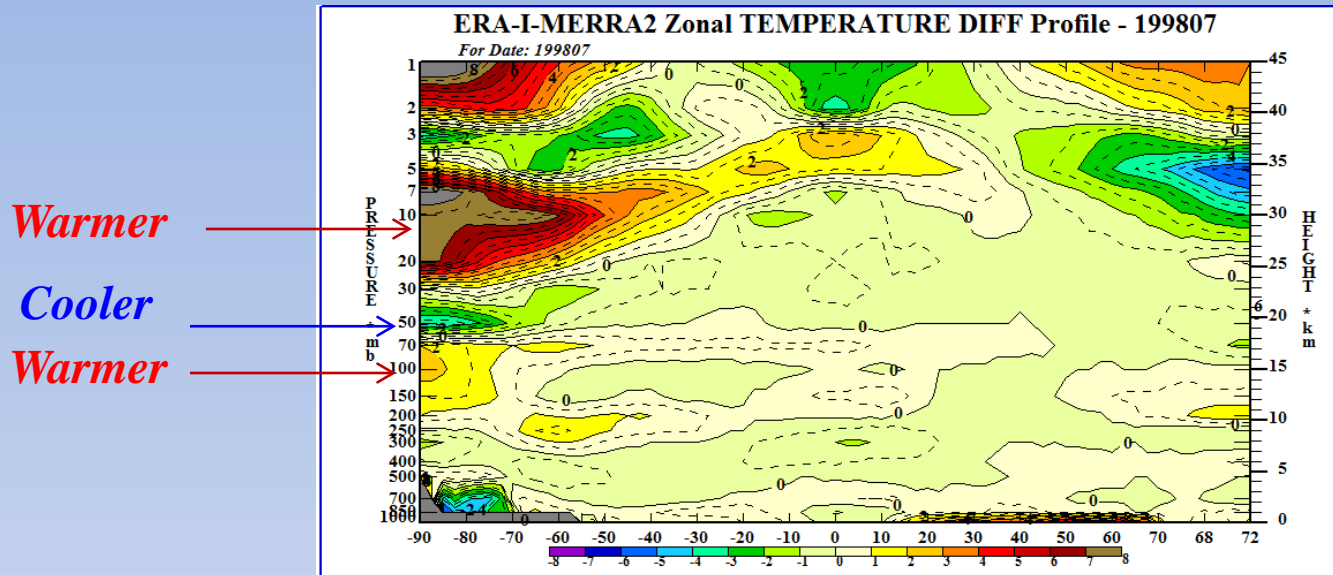
Other Months 50 hPa Temp Diff from MERRA-2

Other month's differences from MERRA-2 show equally distinct change or gradual change.

ERA-I differences in 1980's are larger than the other reanalyses.

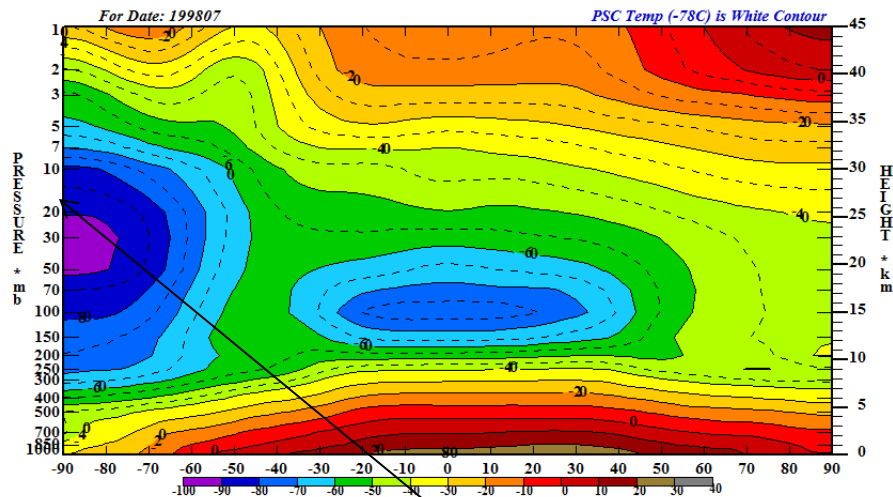


ERA-I – MERRA2 Temperature : SH July 1998



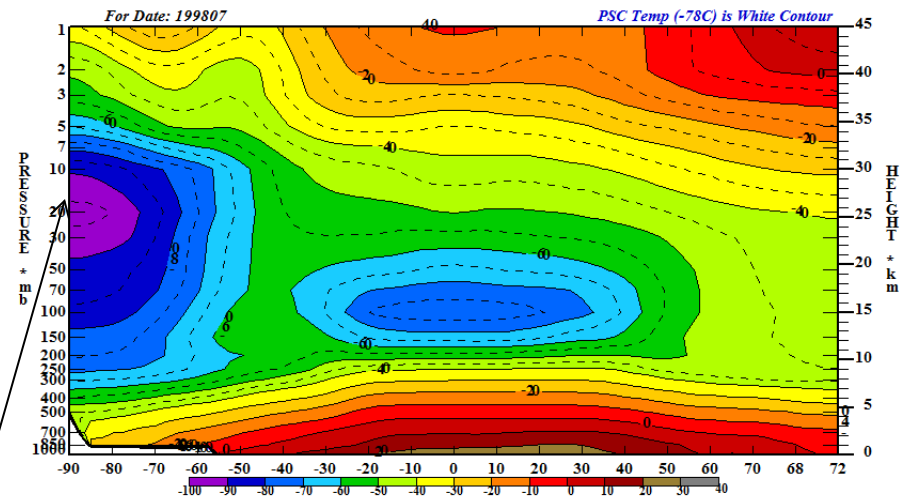
ERA-I : July 1998

ERA-I Zonal TEMPERATURE Profile - 199807



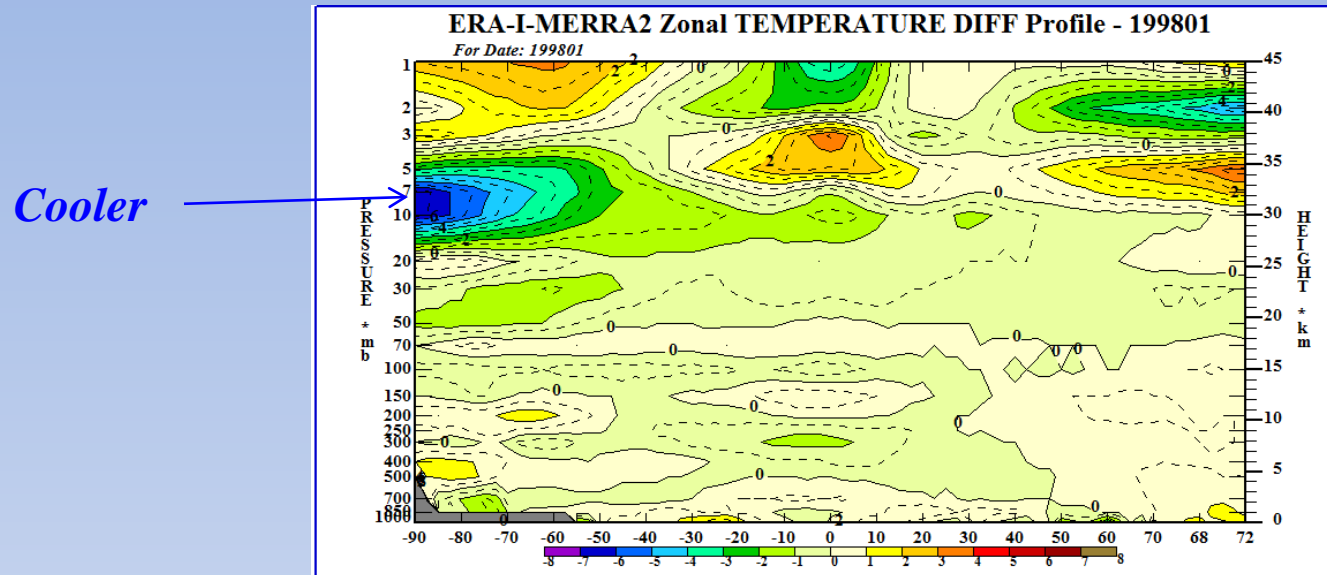
MERRA2 : July 1998

MERRA2 Zonal TEMPERATURE Profile - 199807

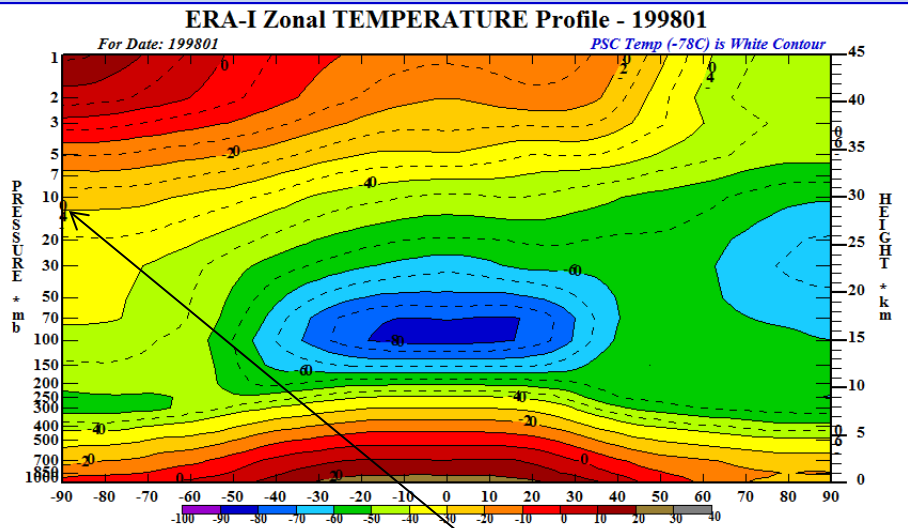


ERA-I is warmer than MERRA2 between 20 and 10 hPa but colder at 50 hPa

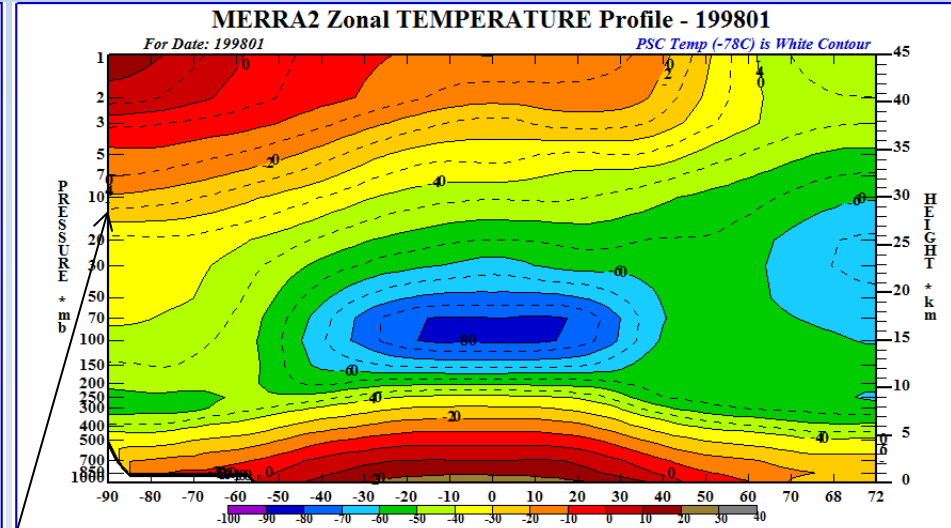
ERA-I – MERRA2 Temperature : SH January 1998



ERA-I : January 1998



MERRA2 : January 1998

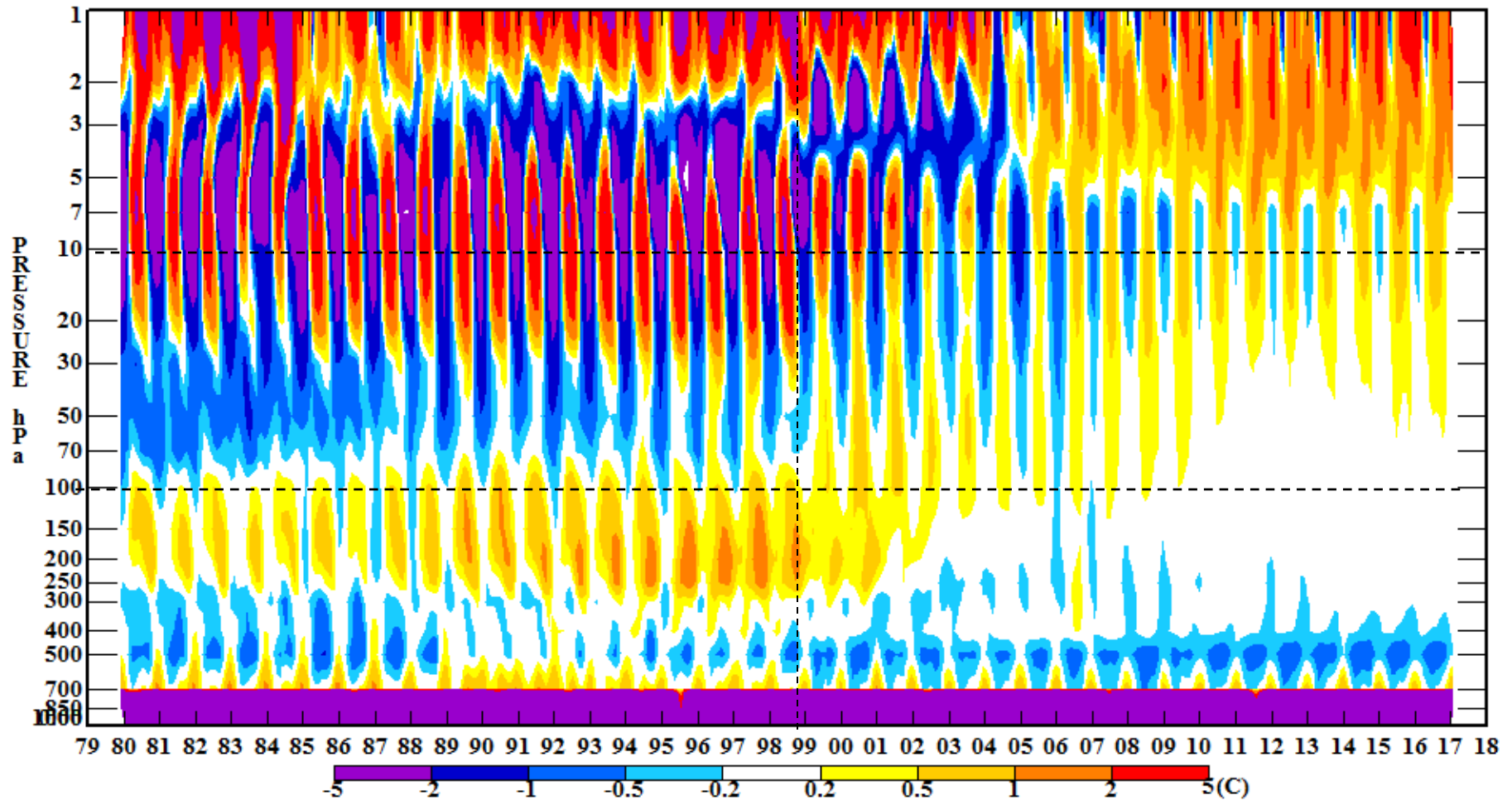


ERA-I is cooler than MERRA2 between 20 and 5 hPa .

Time/height variability of ERA-I and MERRA2 differences

ERA-I - MERRA2 Monthly Temperature Differences

-90 to -60



*Ringling pattern in vertical is seasonal. Has largest amplitude between 20 and 3 hPa
Greatly diminishes in upper trop and lower strat during AMSU + GPSRO period*

AMS Middle Atmosphere Meeting ~ June 26-29, 2017 ~ Portland, OR

It is obvious that MERRA-2 and ERA-I have seasonal differences in the vertical over Antarctica.

So which is correct?

What are the differences wrt radiosondes?
Why do they differ so much?

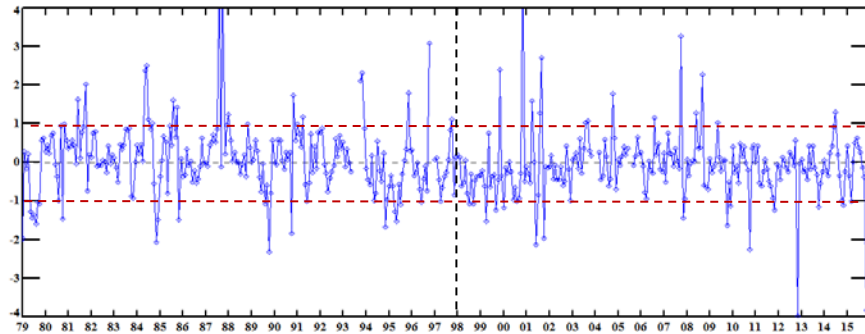
Location of Radiosonde Sites and those used in this study



50 hPa Monthly Temp Differences from Swoya

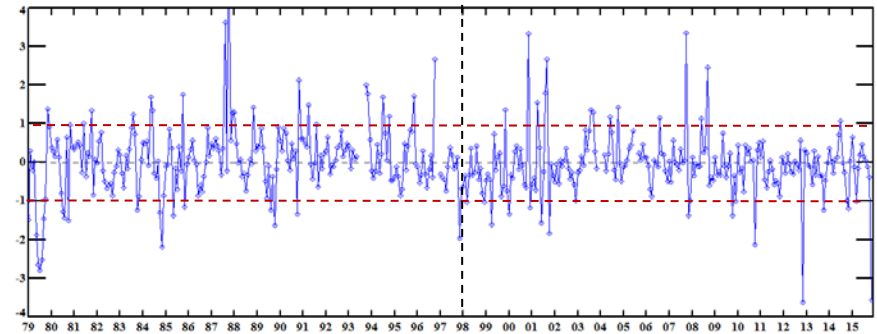
CFSR

CFSR IGRA Anomaly Differences SWOYA 50hPa



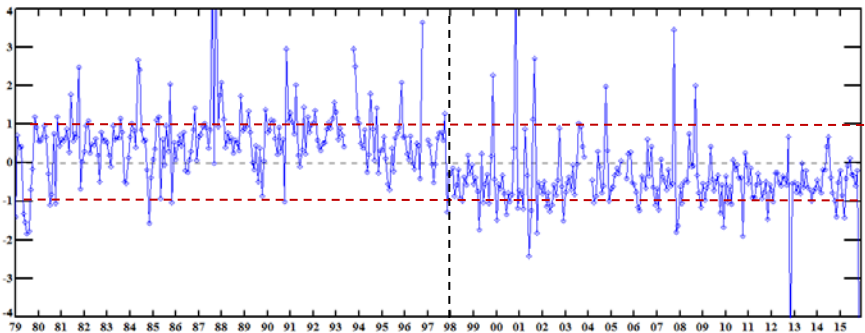
JRA55

JRA55 IGRA Anomaly Differences SWOYA 50hPa



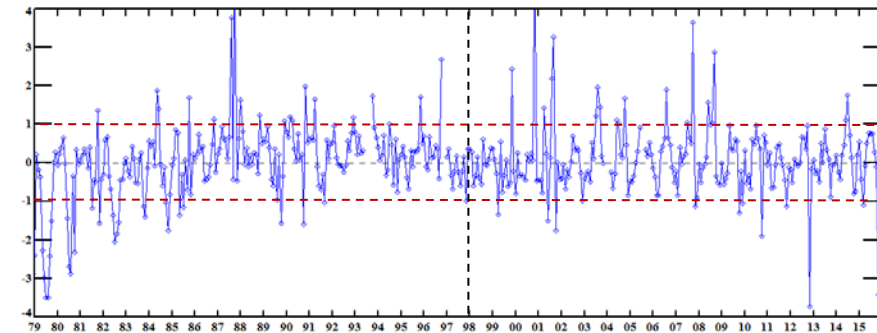
MERRA-2

MERRA2 IGRA Anomaly Differences SWOYA 50hPa



ERA-I

ERA-I IGRA Anomaly Differences SWOYA 50hPa

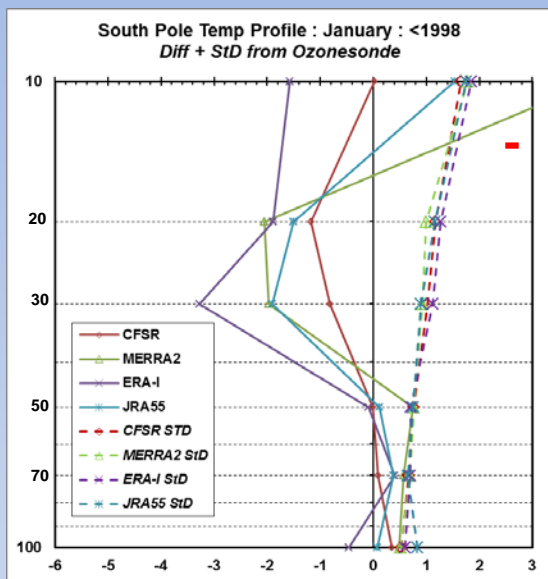


- *Most temperature differences are within $\pm 1^\circ \text{C}$.*
- *All have same outliers wrt Swoya obs.*
- *MERRA-2 has warm bias pre-1999 and cool bias afterward.*
- *ERA-I has is noisy and warming trend the first five years.*

Profiles of Differences from South Pole

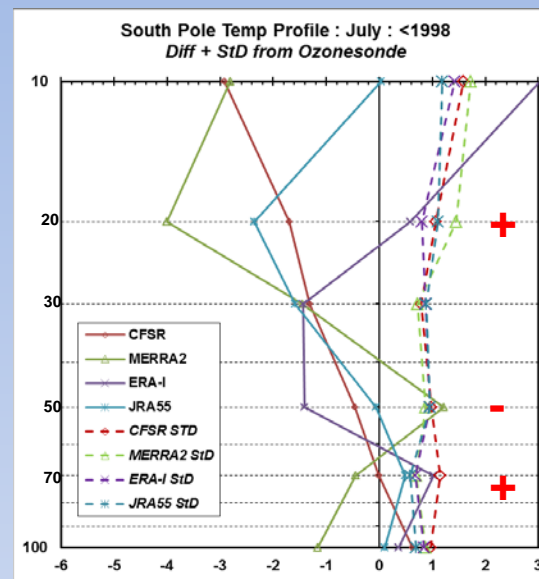
January

*Large diff
from sonde
pre-1998*

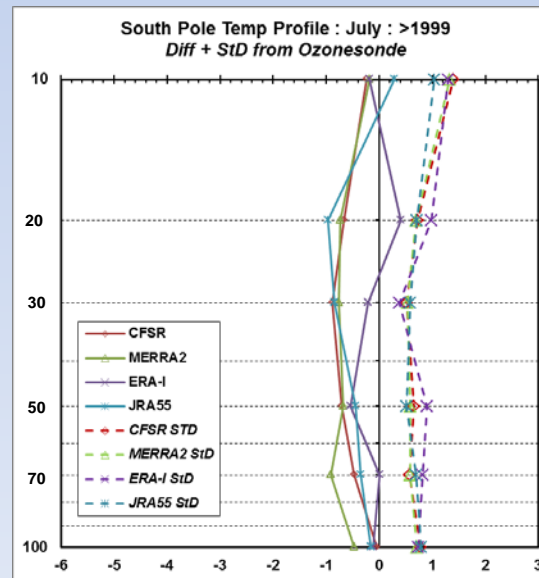
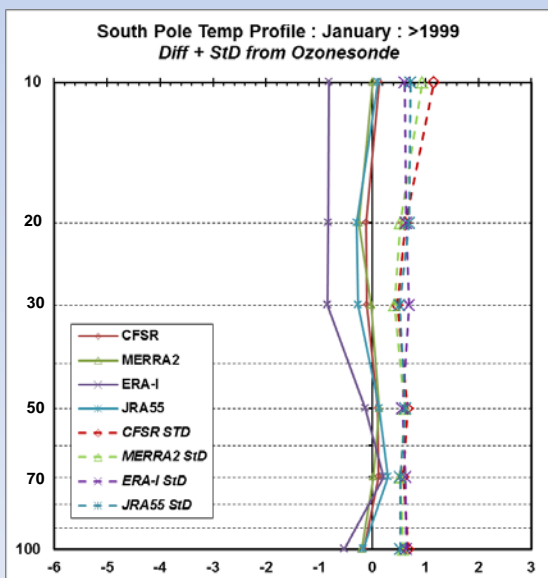


July

*Ring of
diff between
ERA-I and
MERRA2*

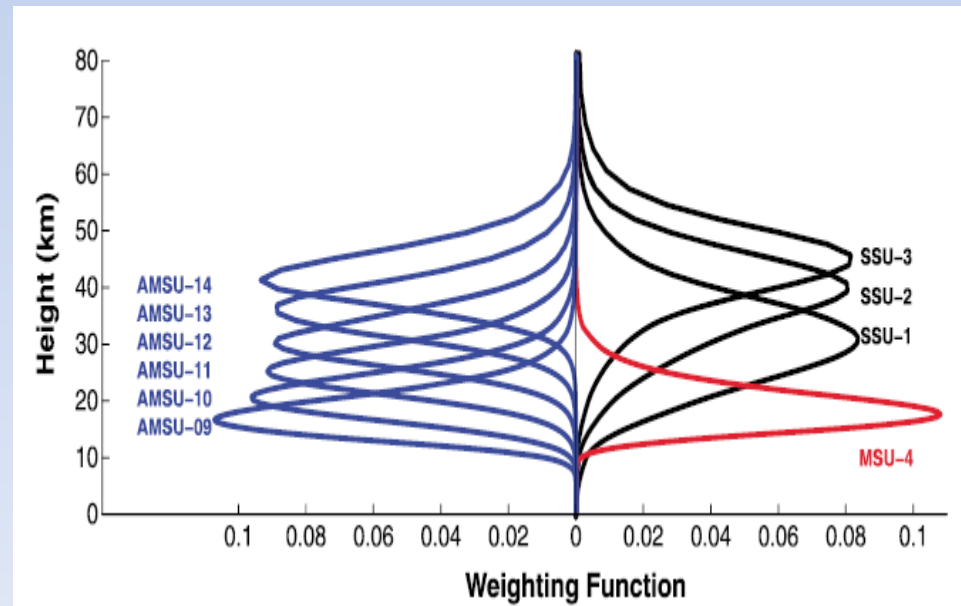


*Smaller mean
diffs from
sonde temps
after 1999*



Likely Culprits

- Model issues assimilating the broad SSU (and MSU 4) channels.
- Bias correction issues
- Gravity wave drag issues
- Propagation or errors vertically



What has been learned?

- There is much greater agreement between the various reanalyses after 1998 between themselves and with Antarctic radiosonde obs.
 - AMSU, AIRS, GPSRO
- Prior to 1998, during the winter months, ERA-I and MERRA-2 have ringing in their difference that varies with altitude and season.
 - SSU, MSU
 - Antarctic radiosonde obs.
- CFSR and JRA55 variability of differences from radiosonde in the vertical is smaller than ERA-I and MERRA-2.
- MERRA-2 temps have a noteworthy modification after the change to ATOVS radiances over Antarctica .
 - Most noticeable in winter months.
 - Lower and middle stratosphere
 - Not seen in the other reanalyses
- ERA-I has larger differences in early 1980's
- Caution is warranted when using reanalysis temperatures in lower and middle stratosphere prior to 1999.
- Interacting with GMAO and ECMWF as to pre-1998 features