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An Analysis of the Behavior of Westerly Jets in global reanalyses

Lawrie Rikus, CAWCR





Acknowledgements:
Tracey Elliott
Gary Dietachmayer
Ben Hu

6th CLIVAR C20C Workshop
Melbourne, 7th November 2013

Introduction

- Initial intention: model evaluation of GCM's
- Inspired by methods of the past
  - In the beginning
    - …Subjective comparisons of zonal mean fields
    - (particularly zonal mean wind fields)
- The hunt for robust data for model metrics
  - Reanalyses
    - Arguably realistic representation of the ‘real world’
  - Zonal mean zonal wind
    - 'class A' (at least in mid-latitudes)
  - Look at as many data sources as possible
    - Allows uncertainty to be quantified
- This work is a by-product!
  - I got sidetracked by the data



Why zonal mean zonal wind?

- Zonal wind is a type A variable in Kistler et al terminology
  - Type A variables “including .. rotational wind” “are generally strongly influenced by the available observations and are therefore the most reliable product of the reanalysis”
  - Zonally averaged U is “primarily non-divergent except in the tropics where model influence is larger and makes it a B variable.”
- Provides the basis for one definition of large scale jets
  - Jets are good diagnostic of large scale dynamics
  - Jets have intrinsic meteorological value

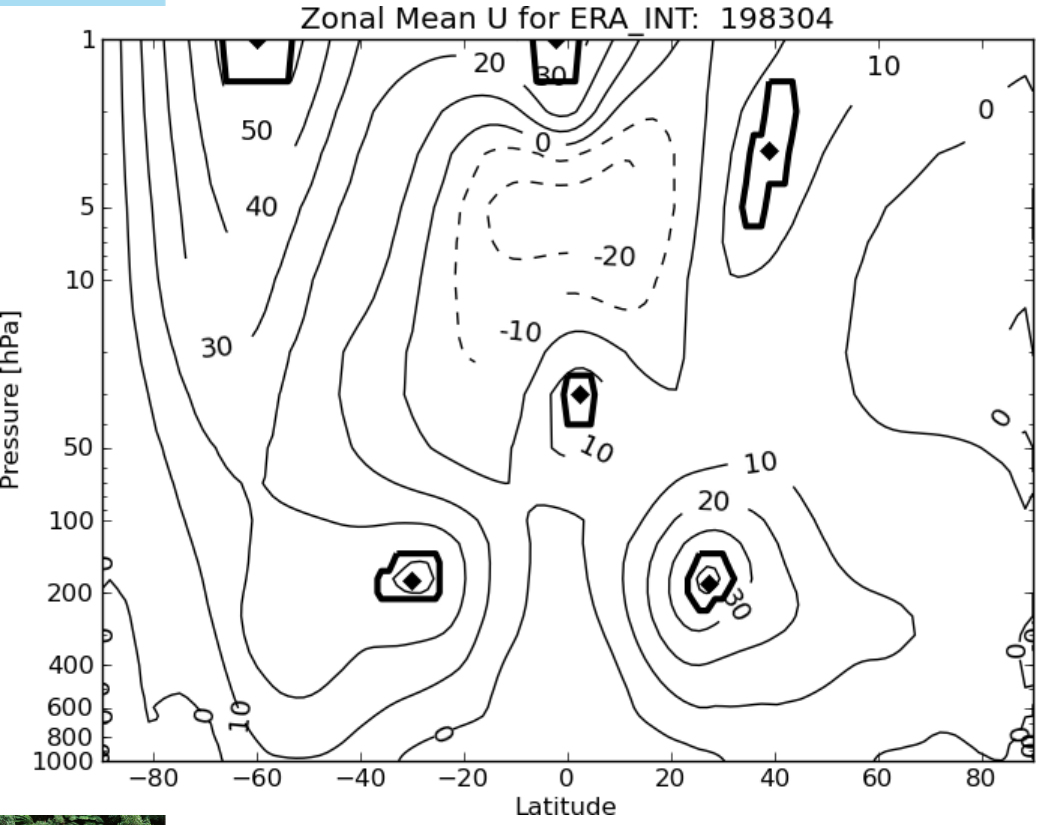
Global reanalyses

Name	Assimilation type	Period	Latitude resolution	No of standard pressure levels	No of levels in 100-400hPa
ERA_INT	4D-VAR	1979 -	1.5°	37	10
ERA-40	3D-VAR	1957 - 2002	2.5°	23	6
JRA-25/JCDAS	3D-VAR	1979 -	1.25°	23	6
MERRA	3D-VAR+IU	1979 -	0.5°	42	7
CFSR	3D-VAR	1979 -	0.5°	36	10
NCEP/DOE	3D-VAR	1979 -	2.5°	17	6
NCEP/NCAR	3D-VAR	1948 -	2.5°	17	6
20CR	EnKF	1871 - 2010	2°	24	7

NB: These details are for the pressure level data. Using this data avoids extra processing from model levels but restricts the number of levels (and horizontal resolution).

Satellite era started in 1979'
Also 5 reanalyses start in 1979
Hence for common period consider only 1979-2009

An objective assessment – the blob analysis



The algorithm

- Find local maxima
- Order in reverse order (largest first)
- Delinerate area within 10% of maximum
- Delete lower valued overlapping blobs
- Increase percentage until blob extends over at least 2 levels/latitudes or is deleted.
- Save the properties of surviving blobs

Parameters

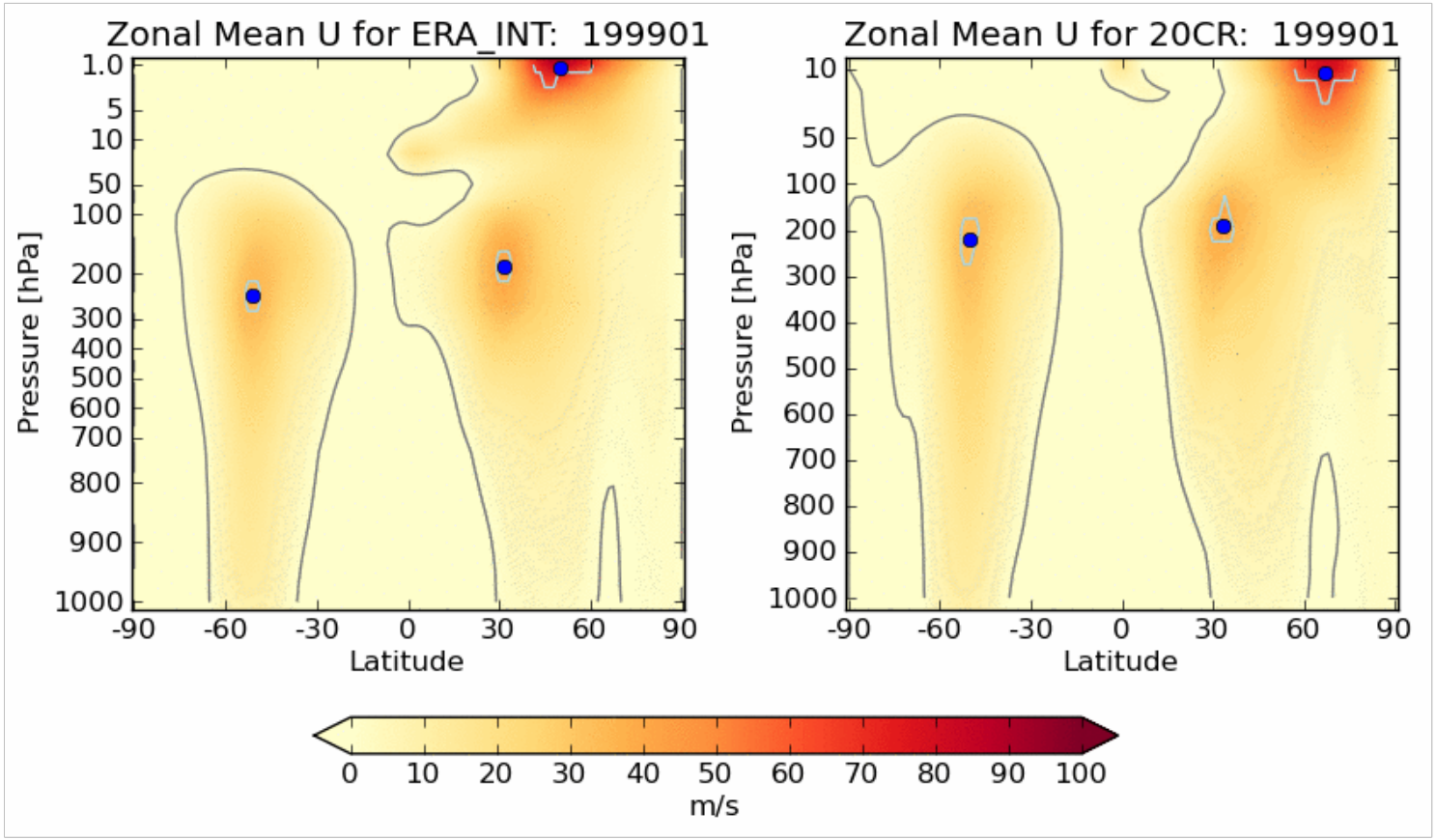
- Relief for local maximum
- Percentage defining boundary

- Implemented as very fast and efficient python scripts
- Converts multi-year monthly mean netcdf files into simple text!

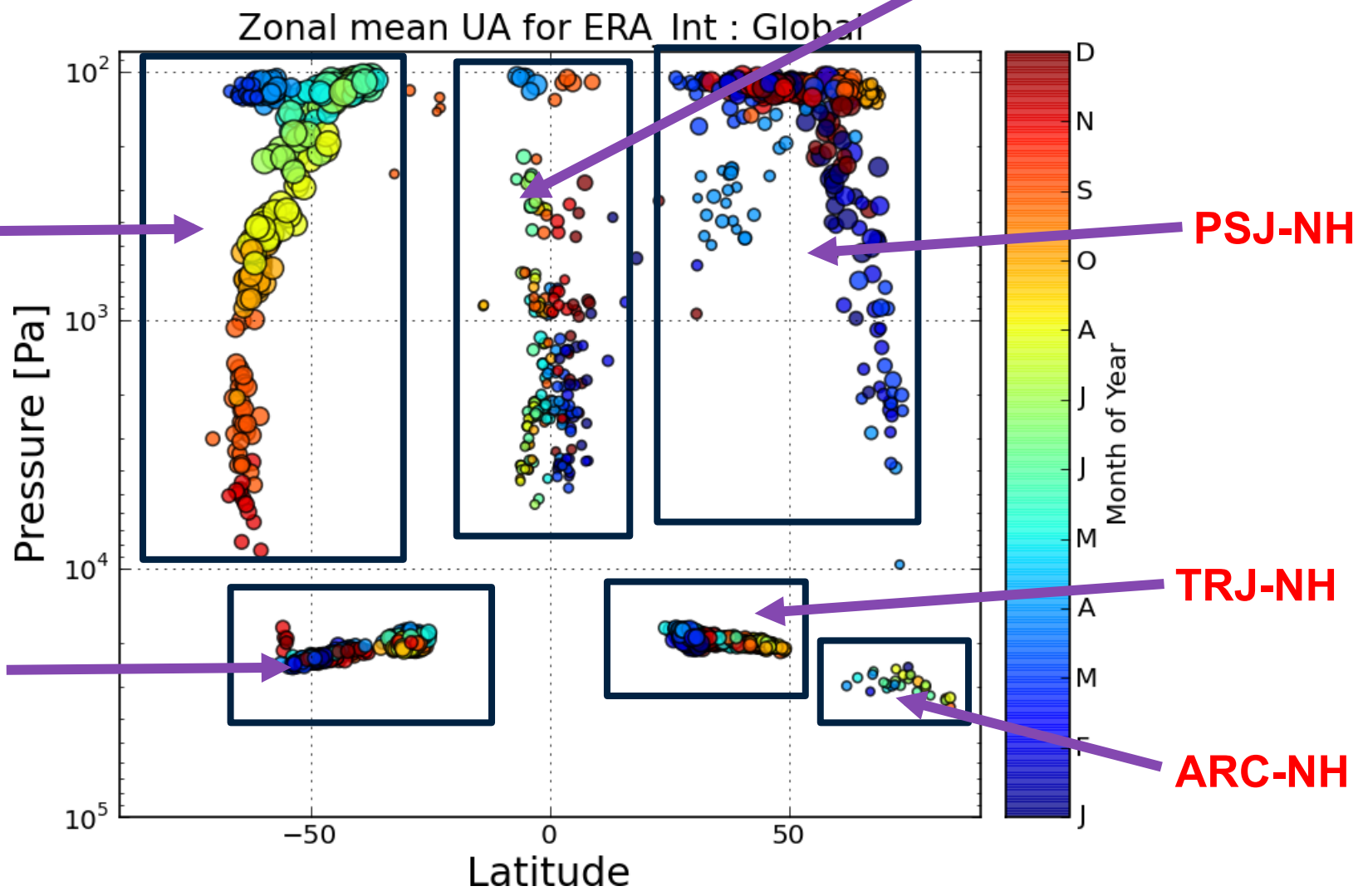
January 1999 to December 2009

ERA-Interim

20CR

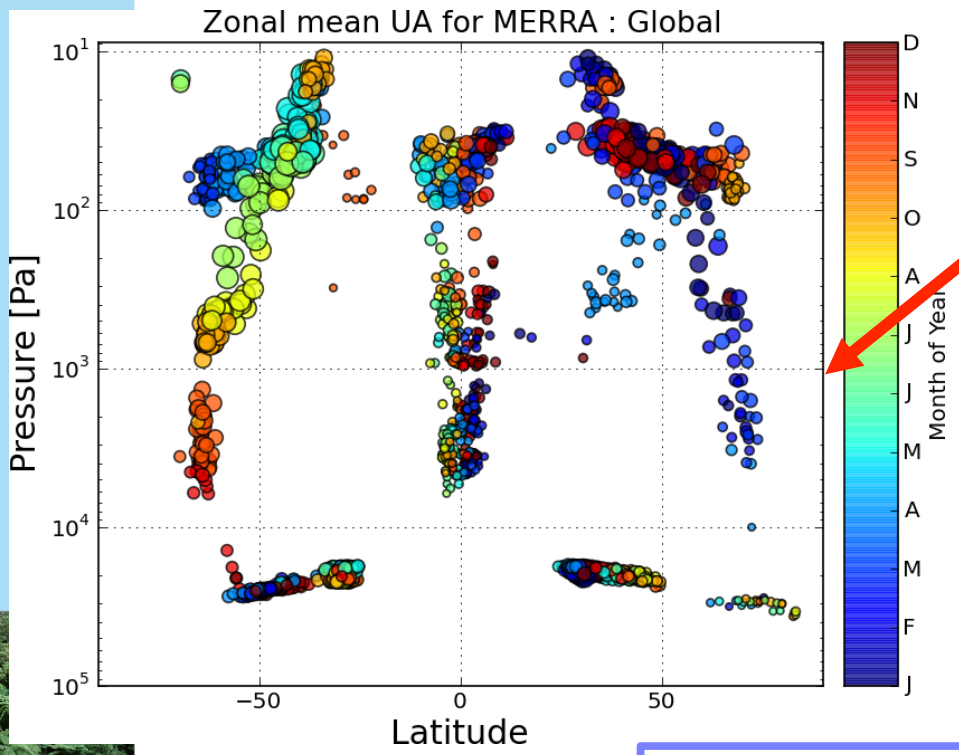


Scatter plot for 1979-2009 ERA-Interim

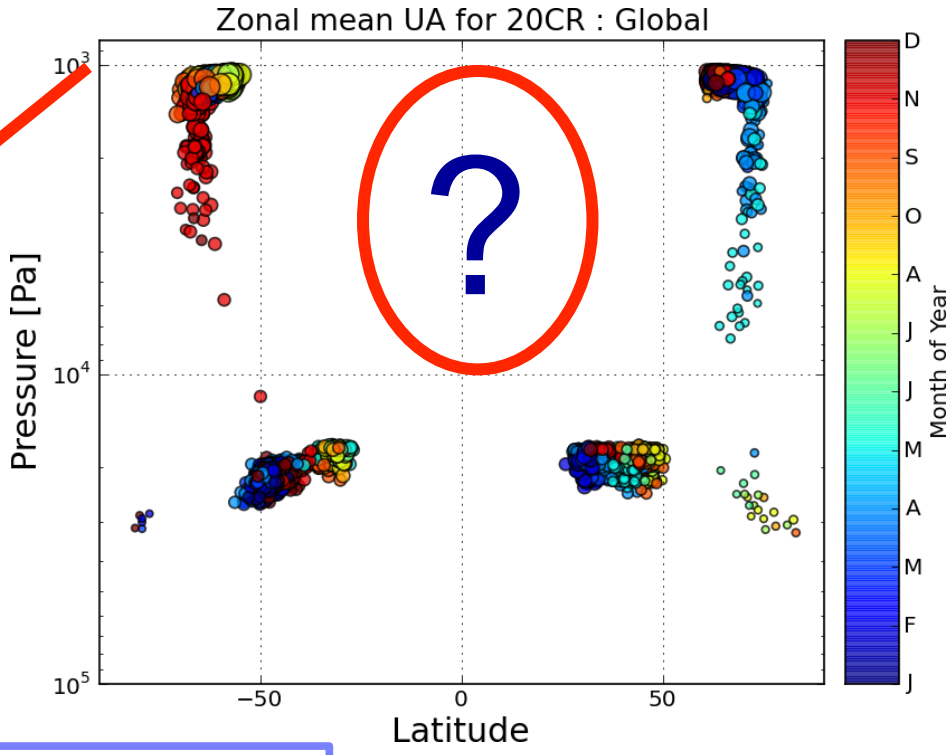


The range of scatter

Merra



20CR



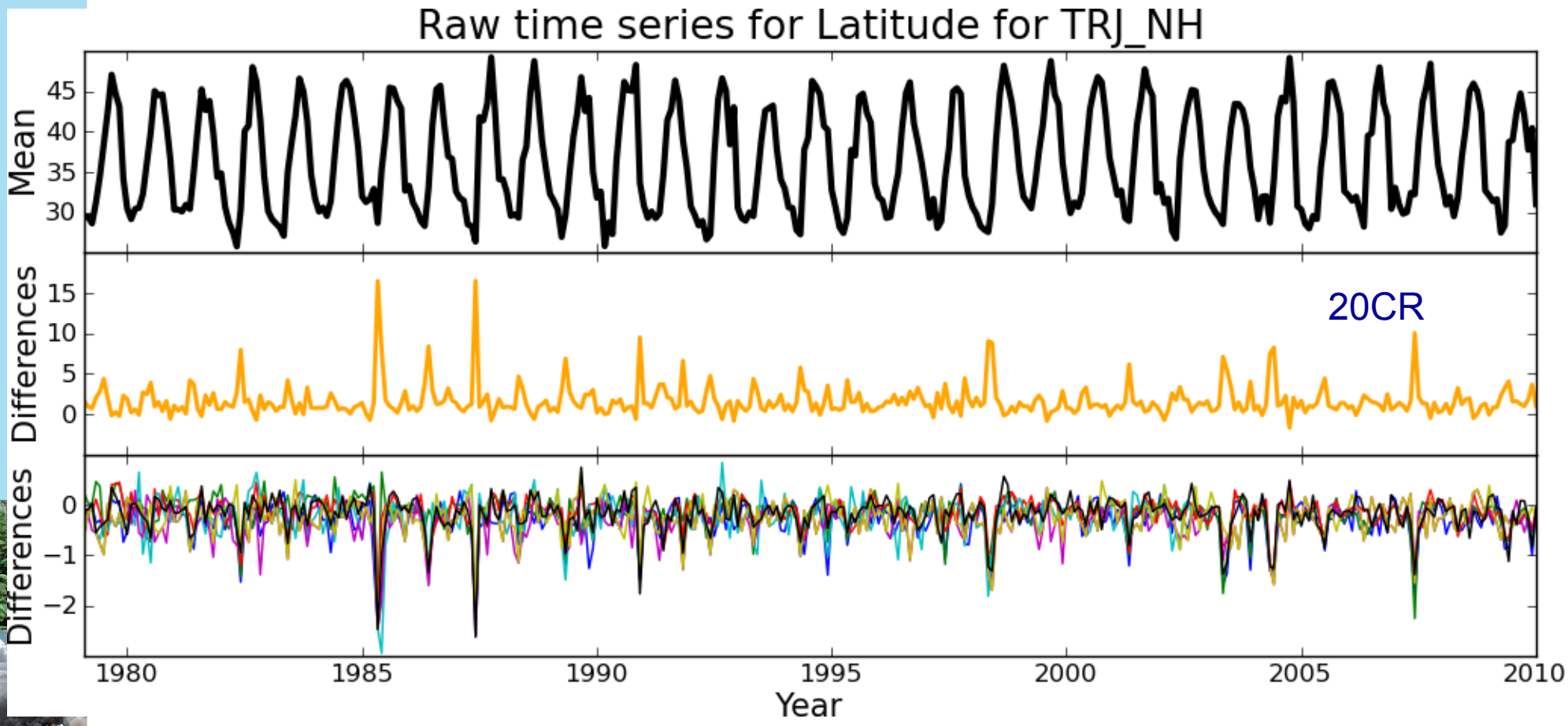
Differences in:

- height of lid
- No of levels
- Input information
- DA methods and data
- Horizontal resolution

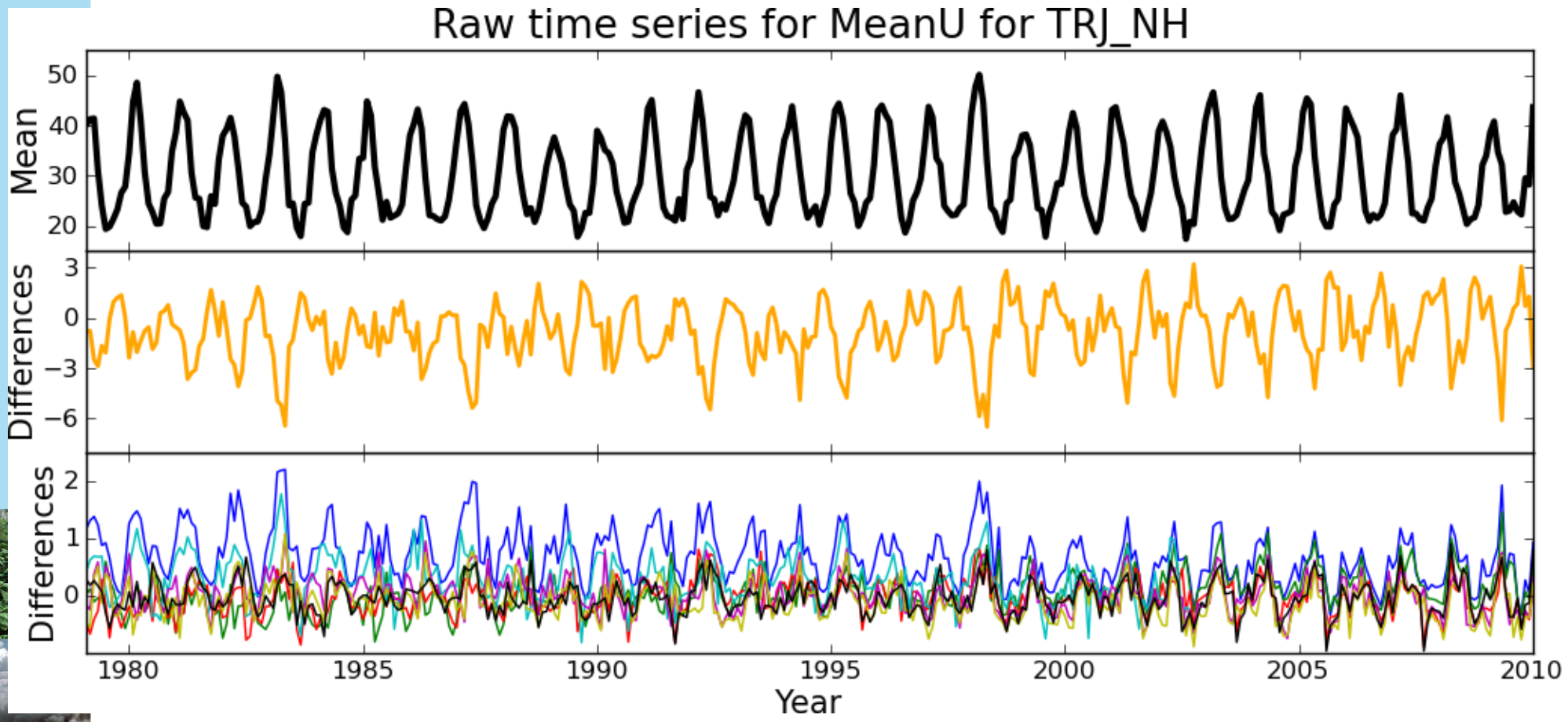
Northern hemisphere tropospheric jet

TRJ_NH

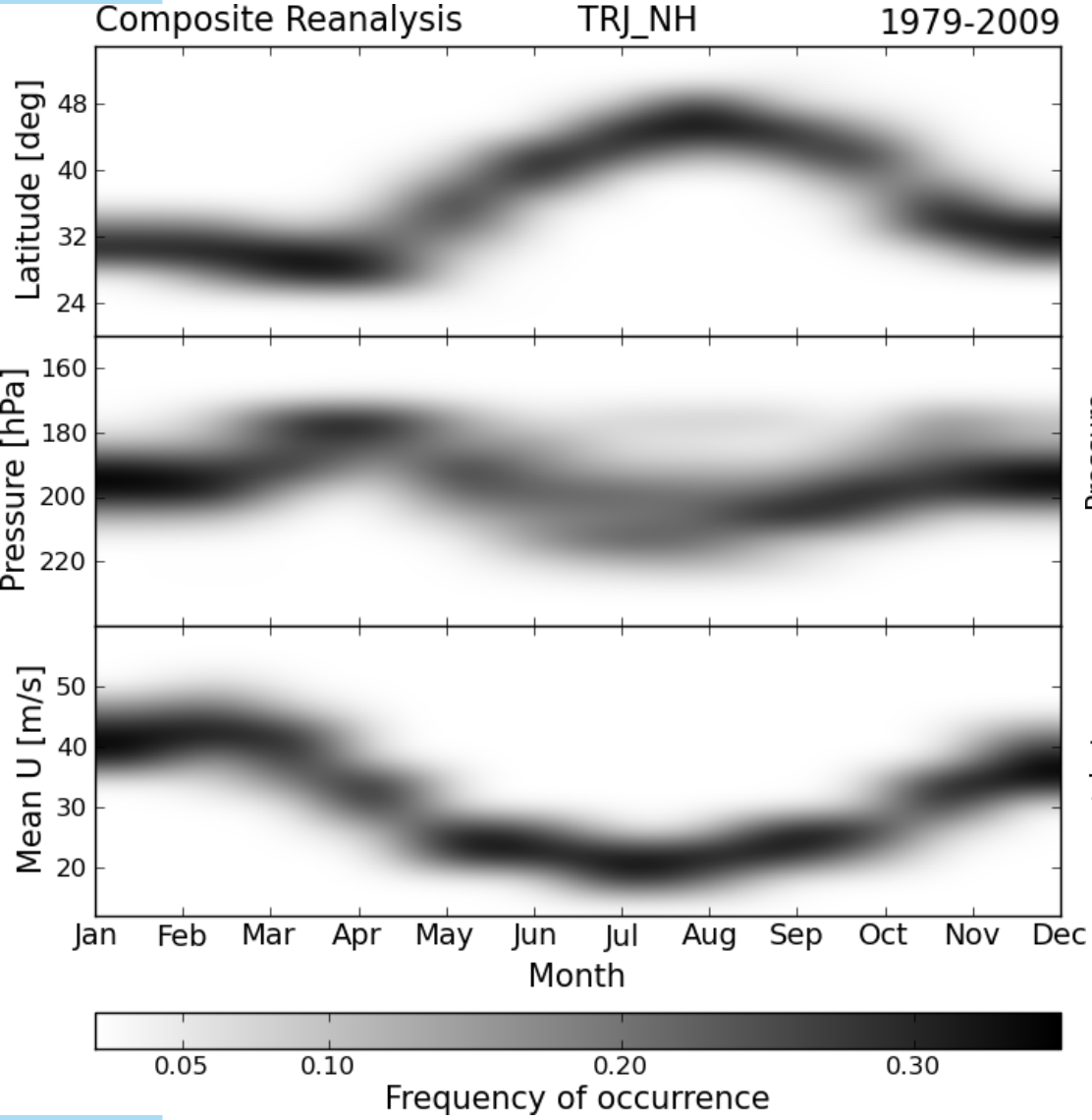
TRJ-NH: Mean Latitude time series



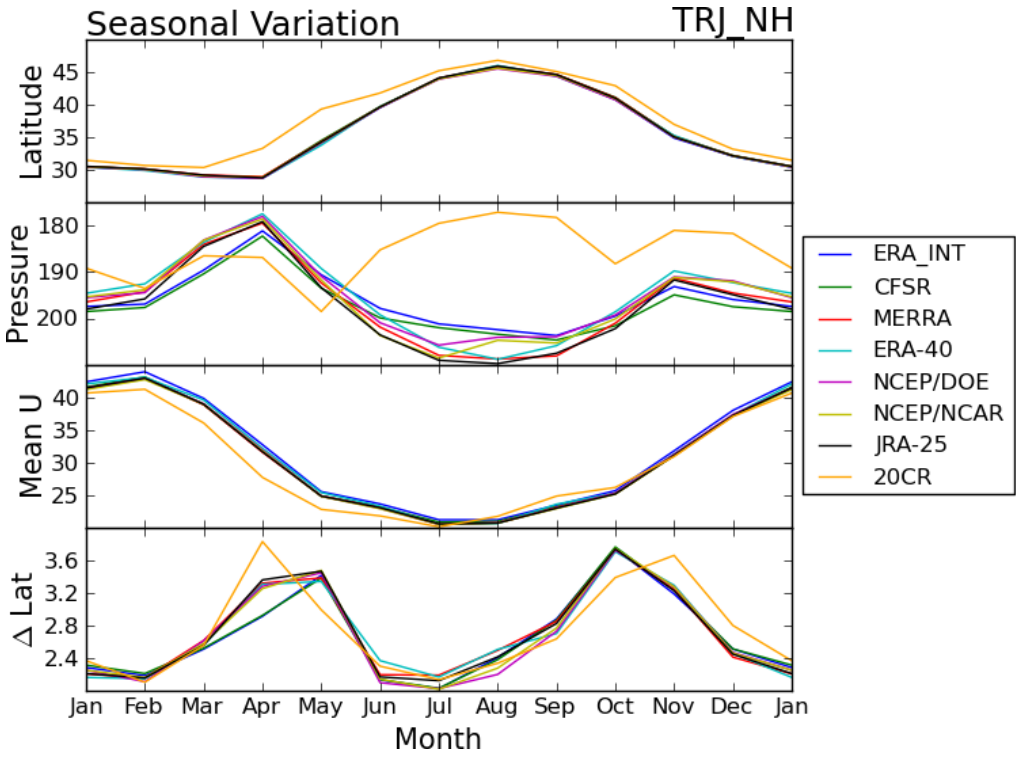
TRJ-NH: Mean U time series



TRJ-NH seasonal frequencies



Folding monthly means



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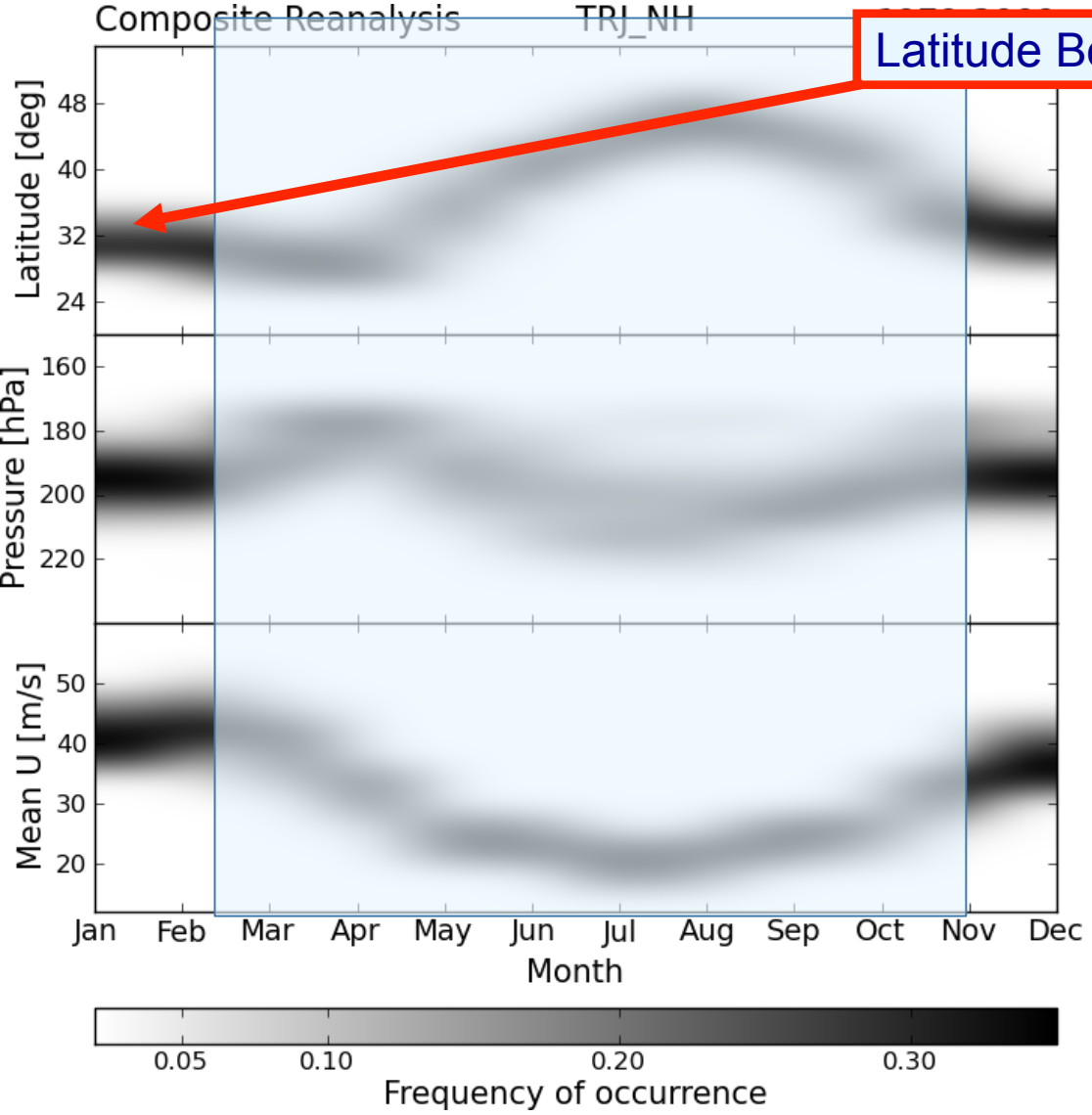
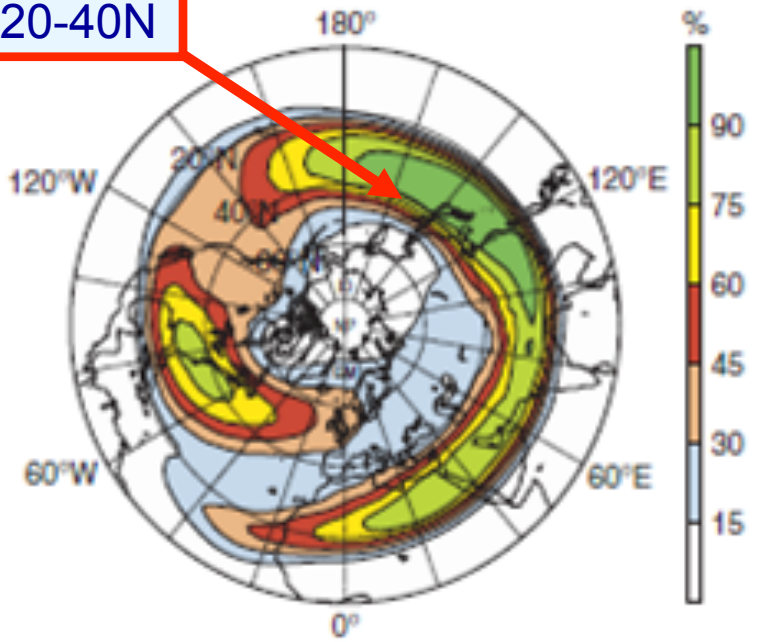
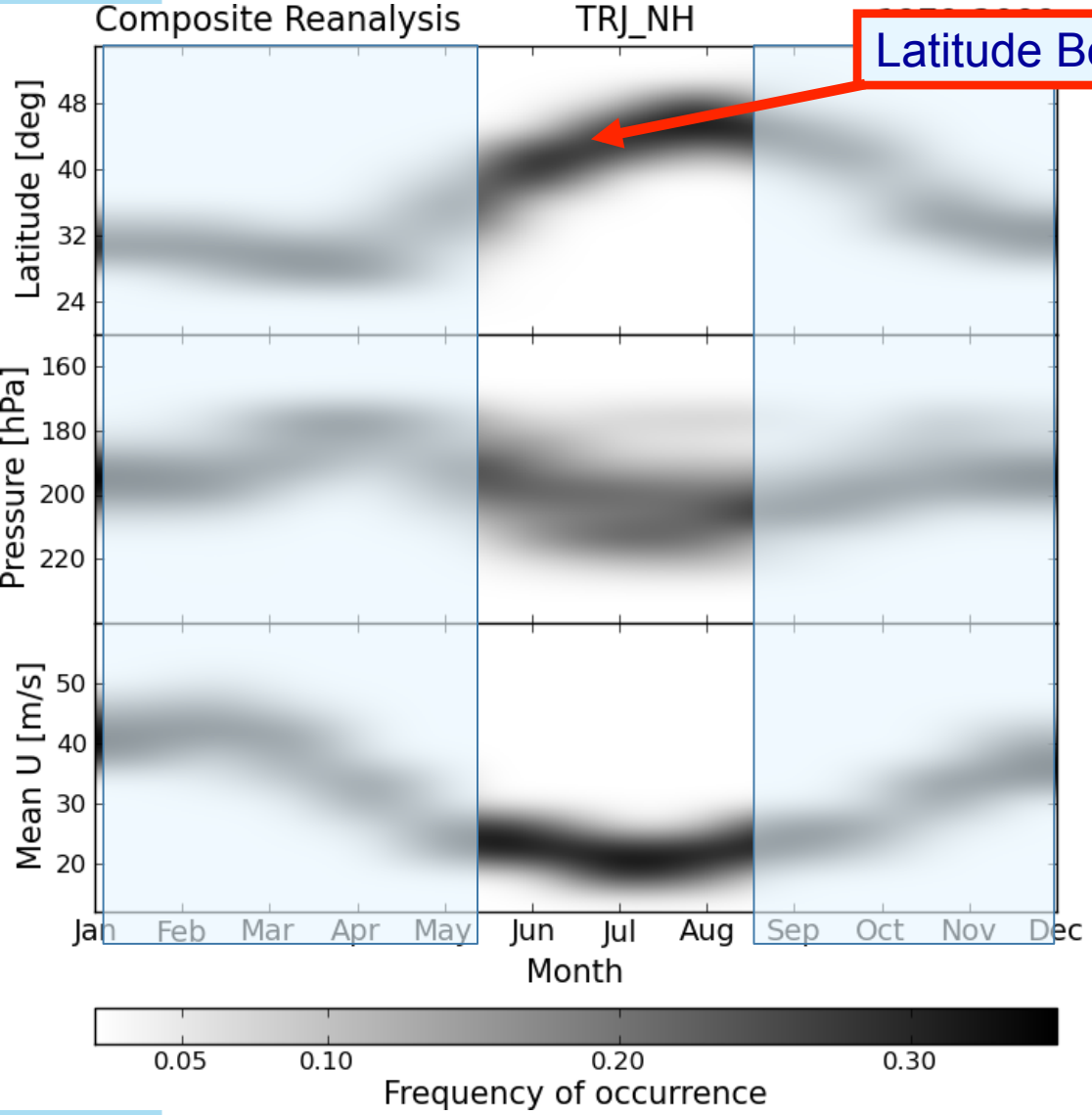
TRJ-NH DJF frequencies



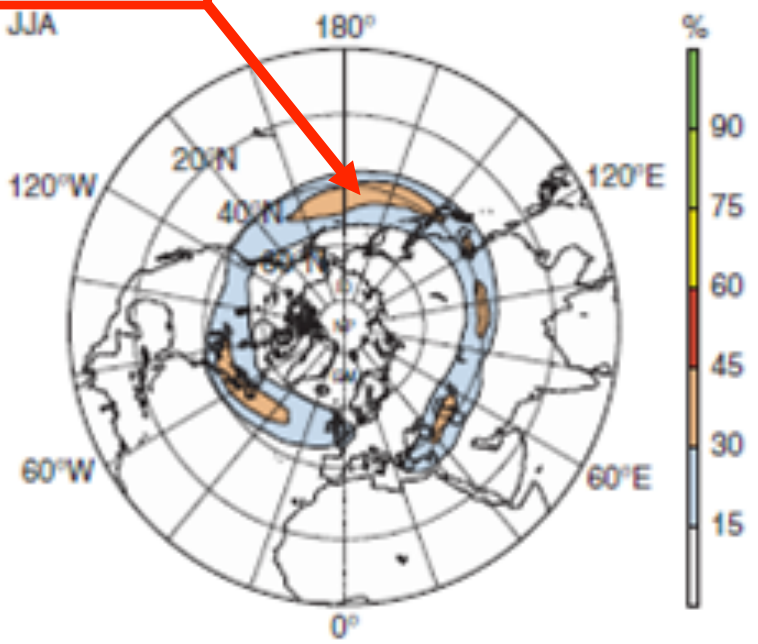


P. KOCH, H. WERNLI AND H. C. DAVIES (2006)

TRJ-NH JJA frequencies

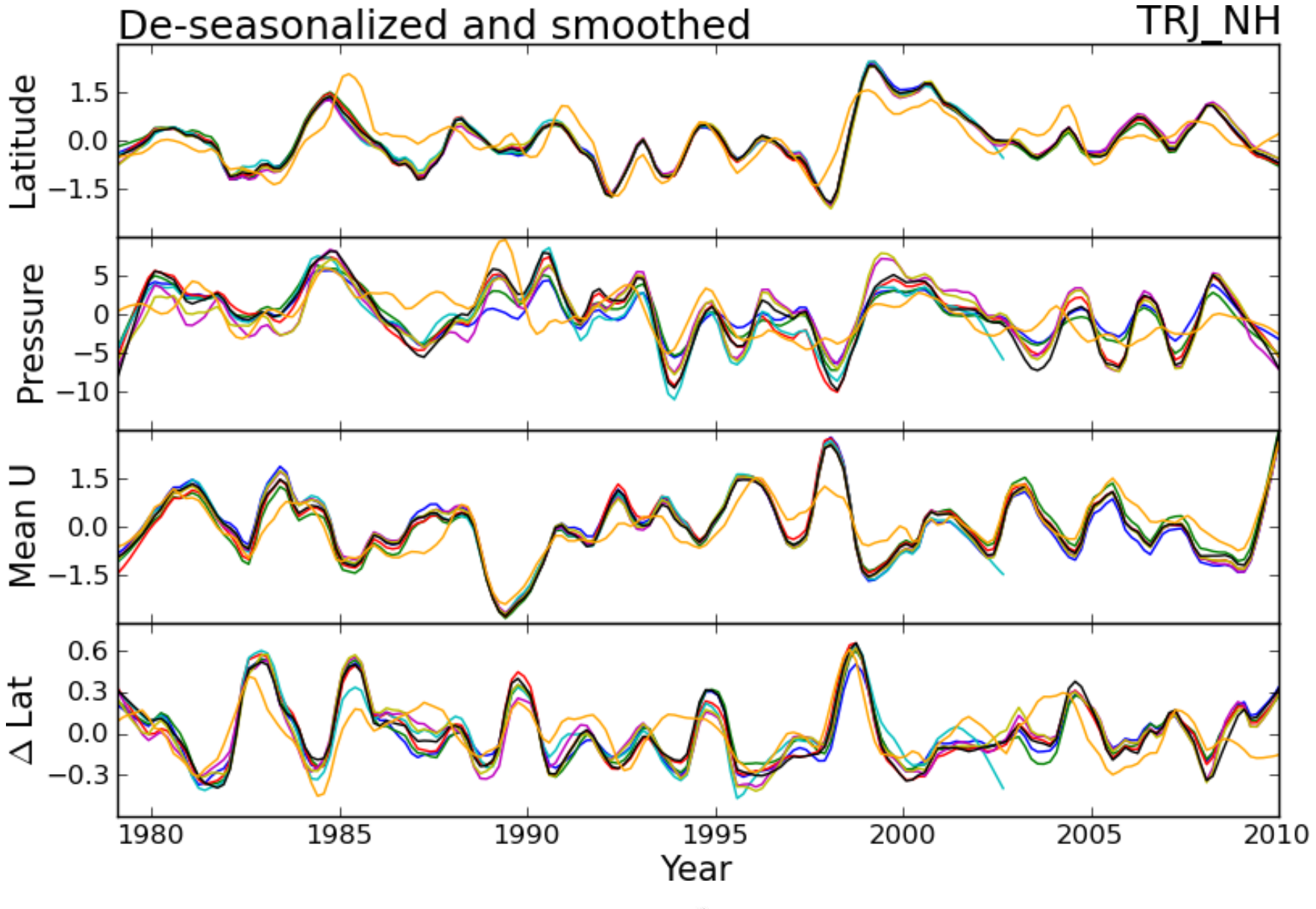


Latitude Between 40-50N



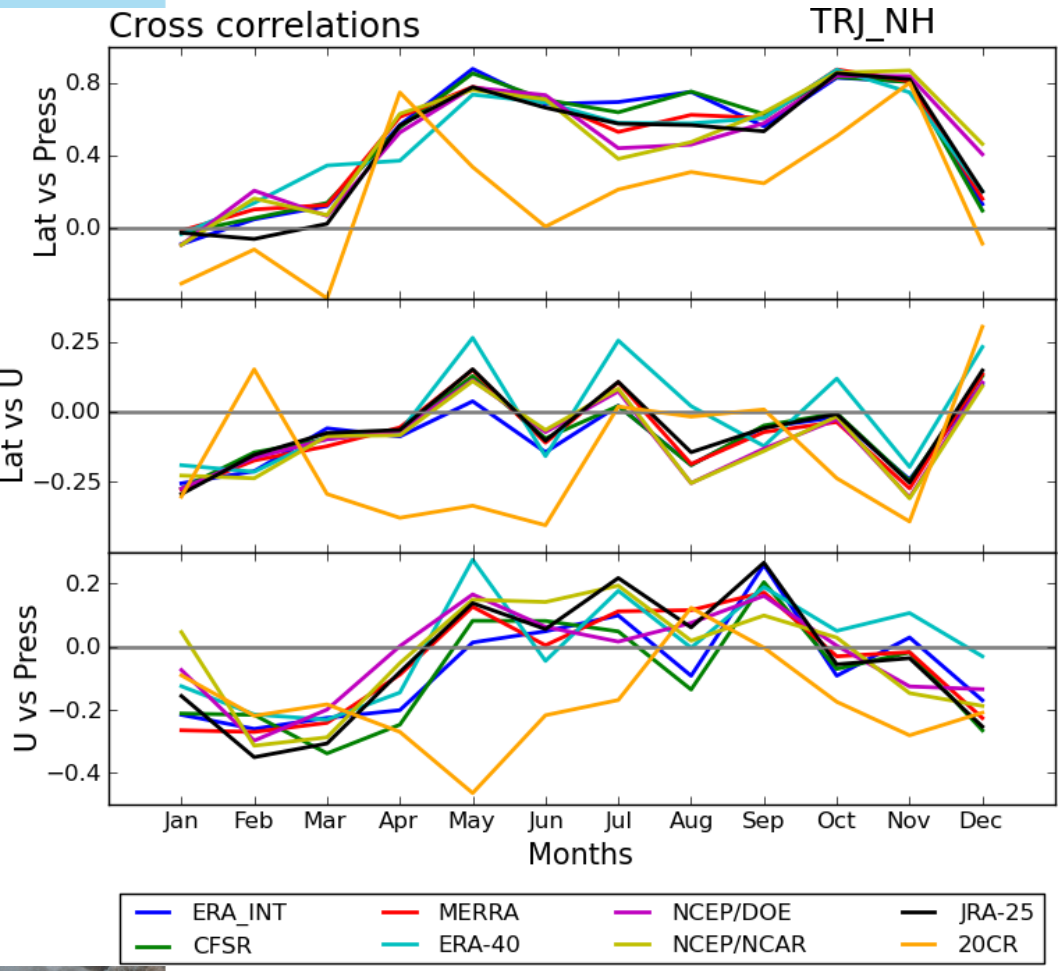
P. KOCH, H. WERNLI AND H. C. DAVIES (2006)

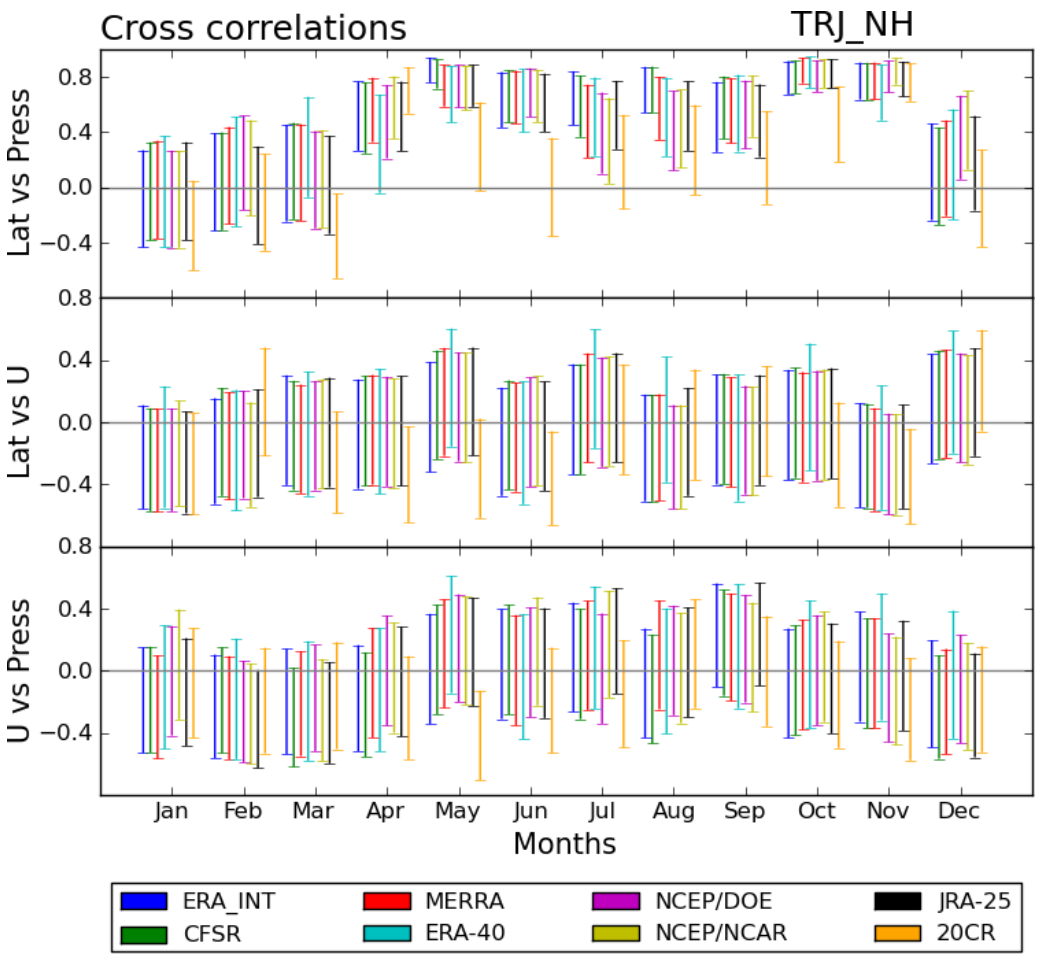
TRJ-NH smoothed series



Created using R-stl (seasonal mean plus Loess fit)

Variable cross correlations - TRJ_NH





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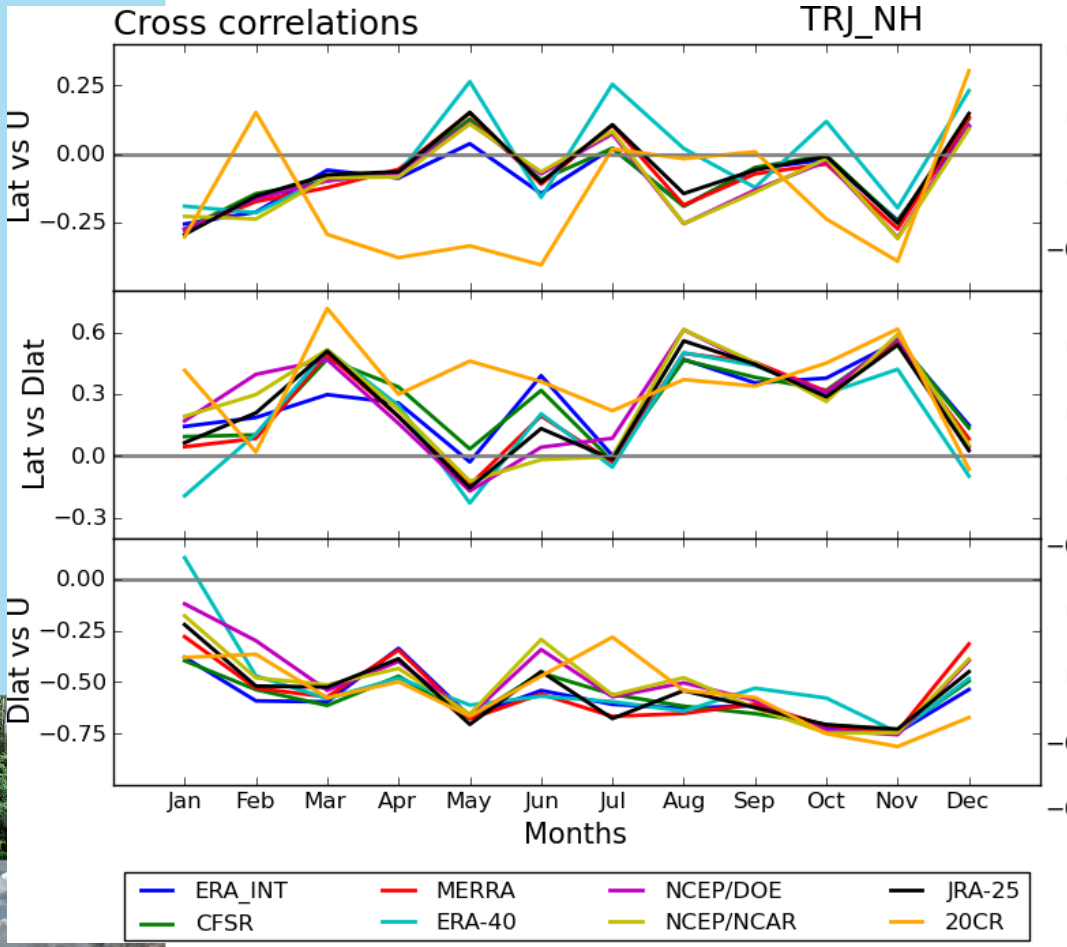
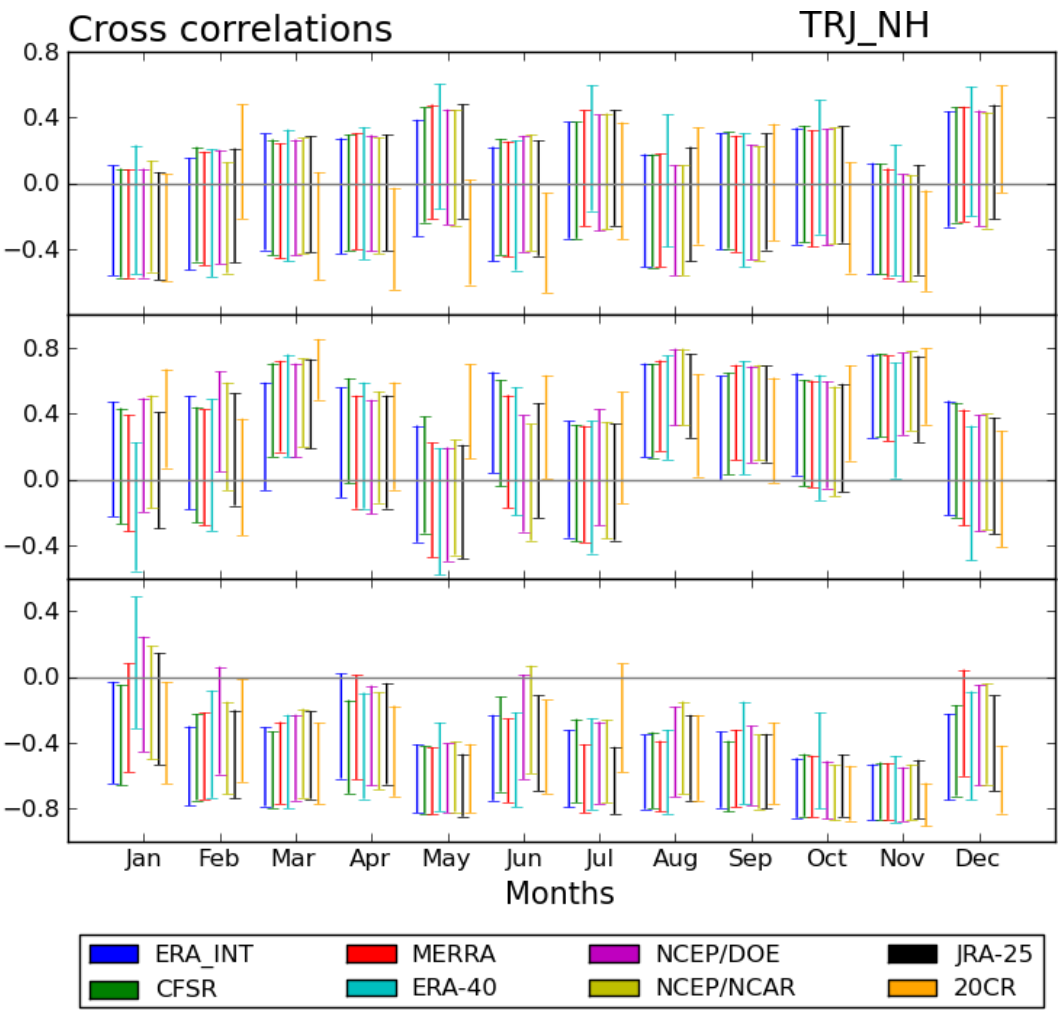
Variable cross correlations – TRJ_NH (2)





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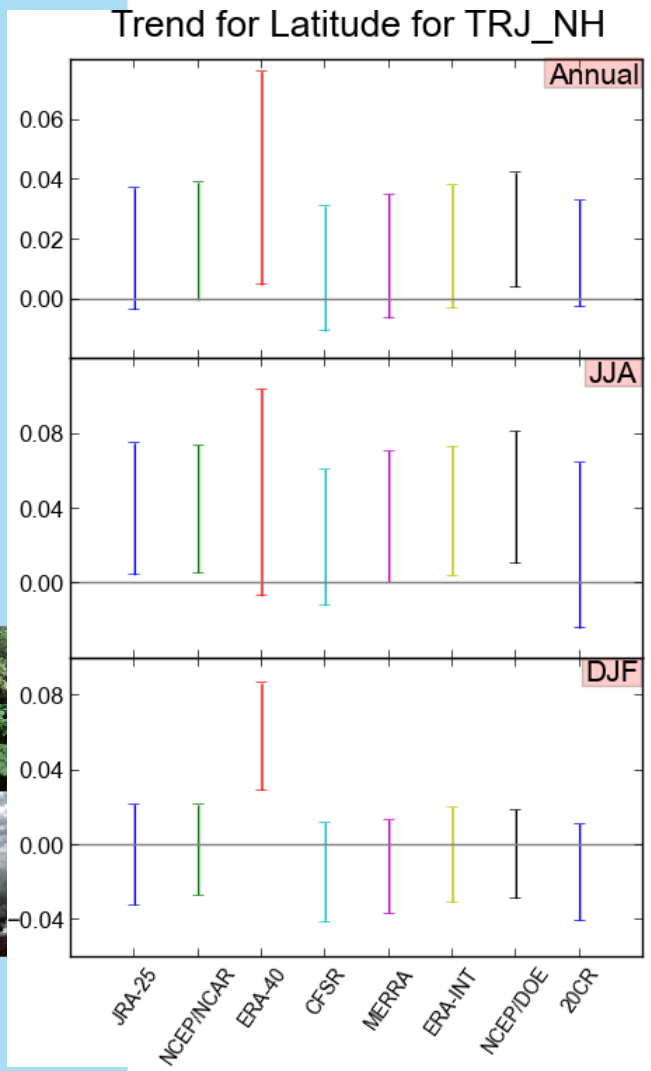
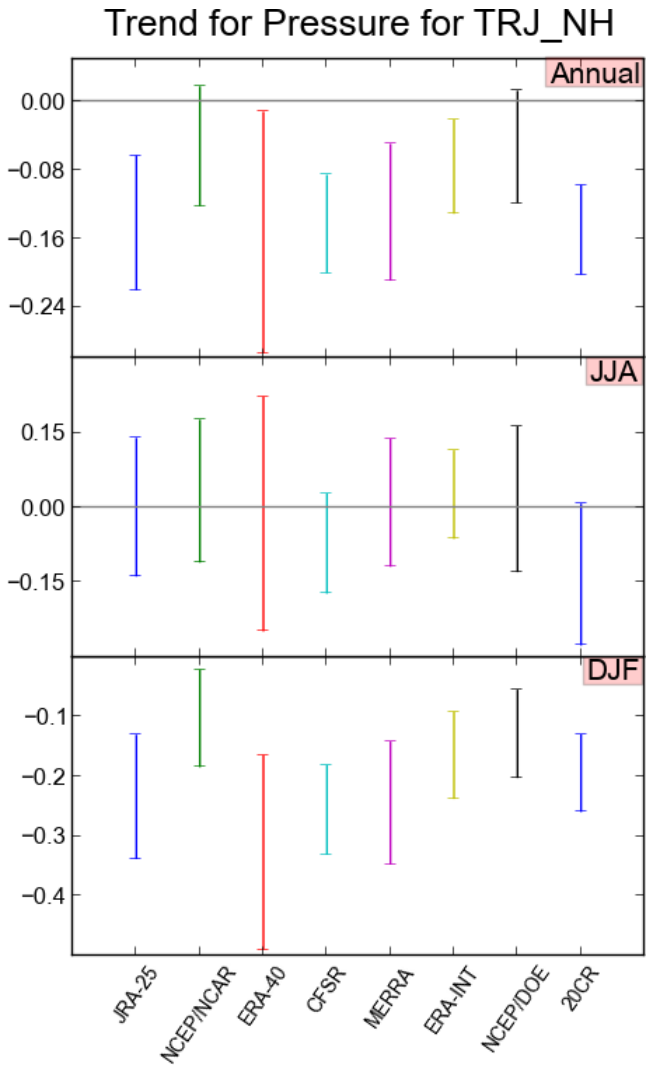
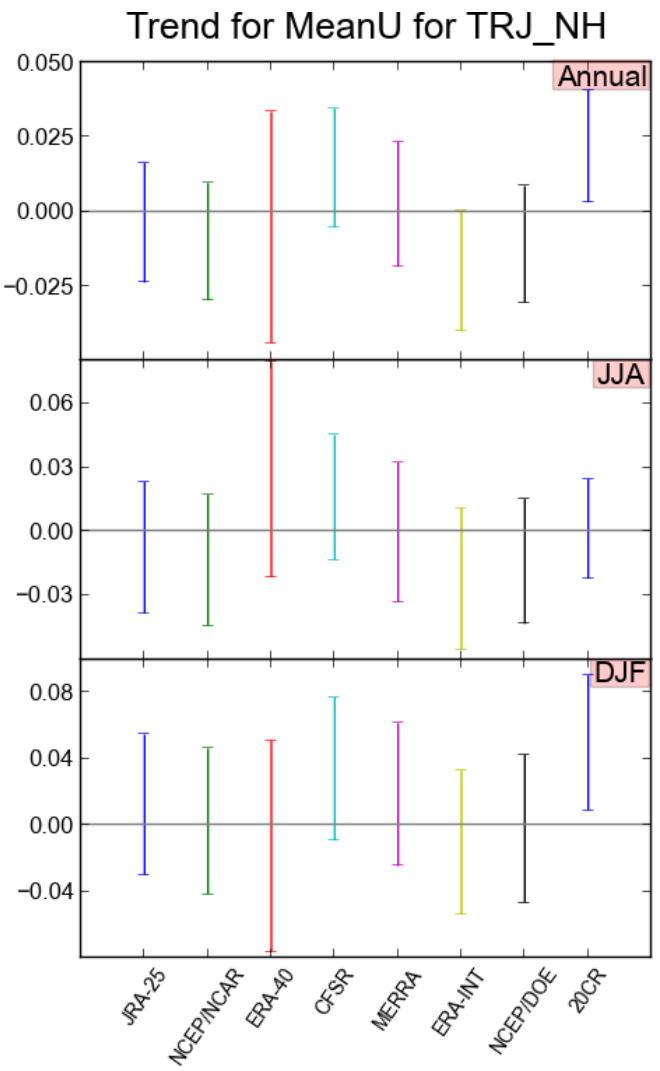
TRJ-NH - Trends

Jan 1979 - Dec 2009 (except ERA-40)







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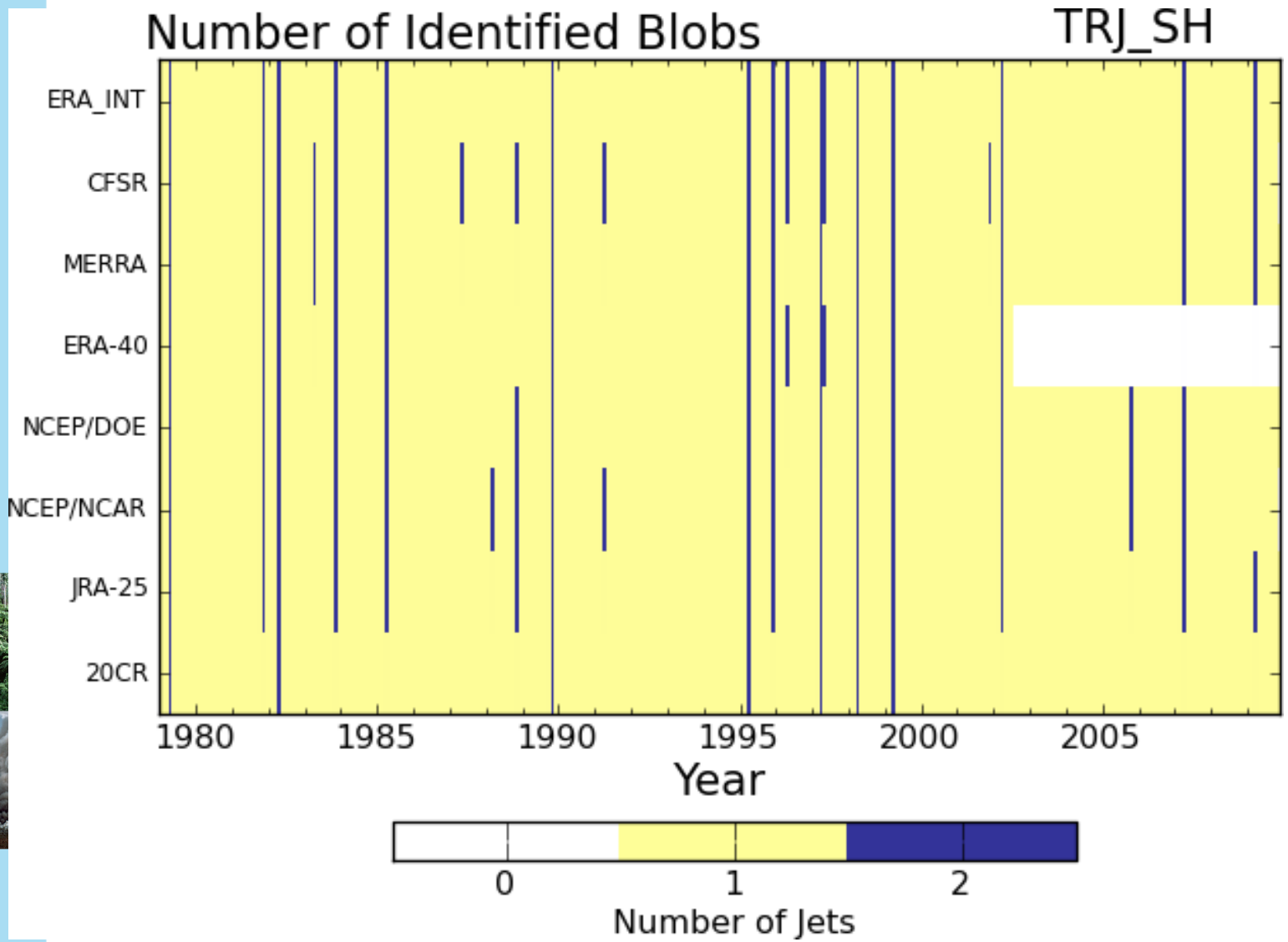
Southern hemisphere tropospheric jet

TRJ_SH

TRJ-SH Monthly numbers



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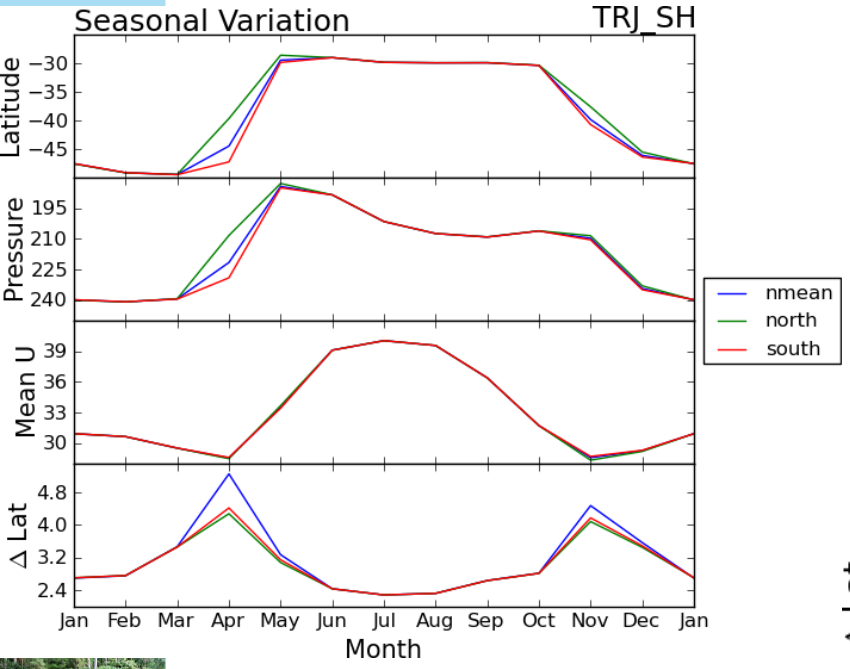
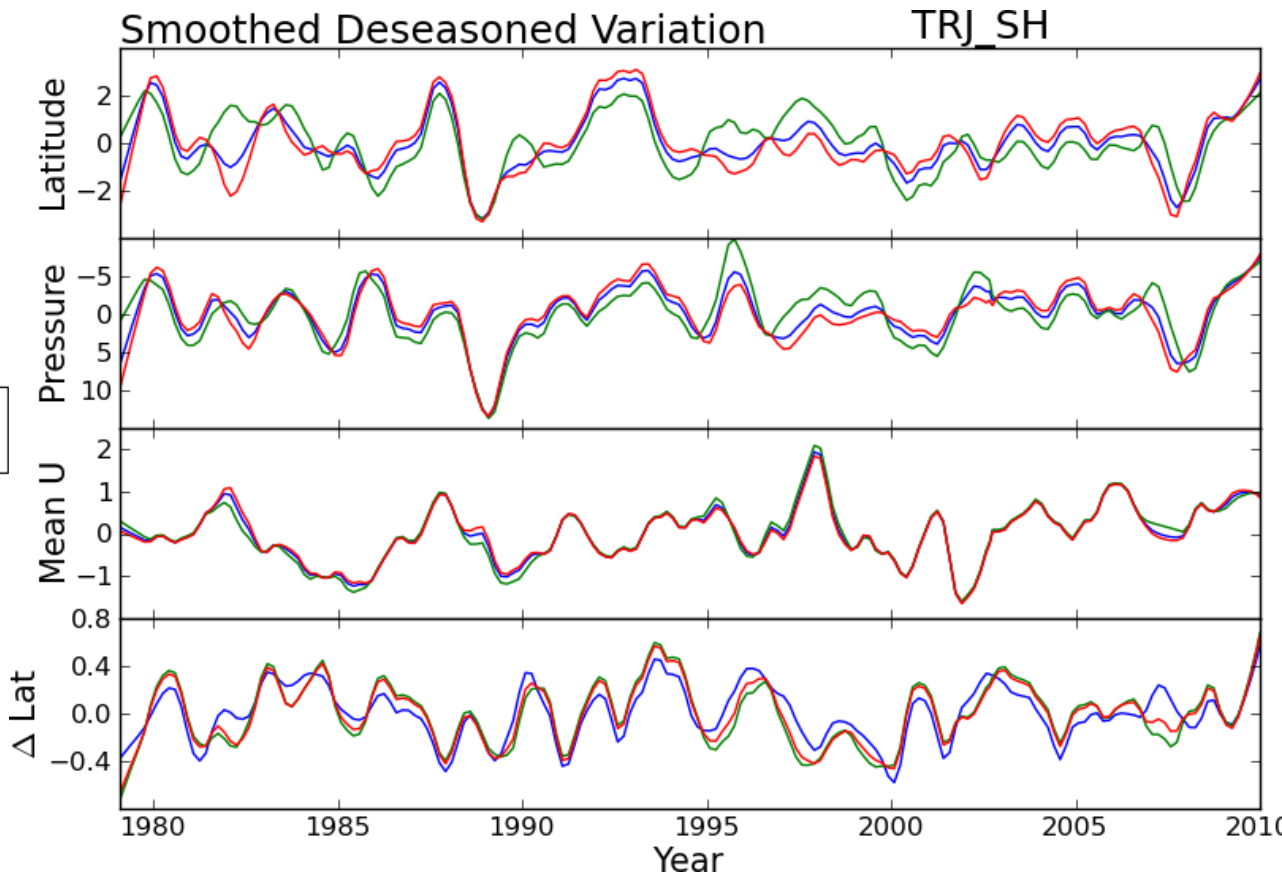
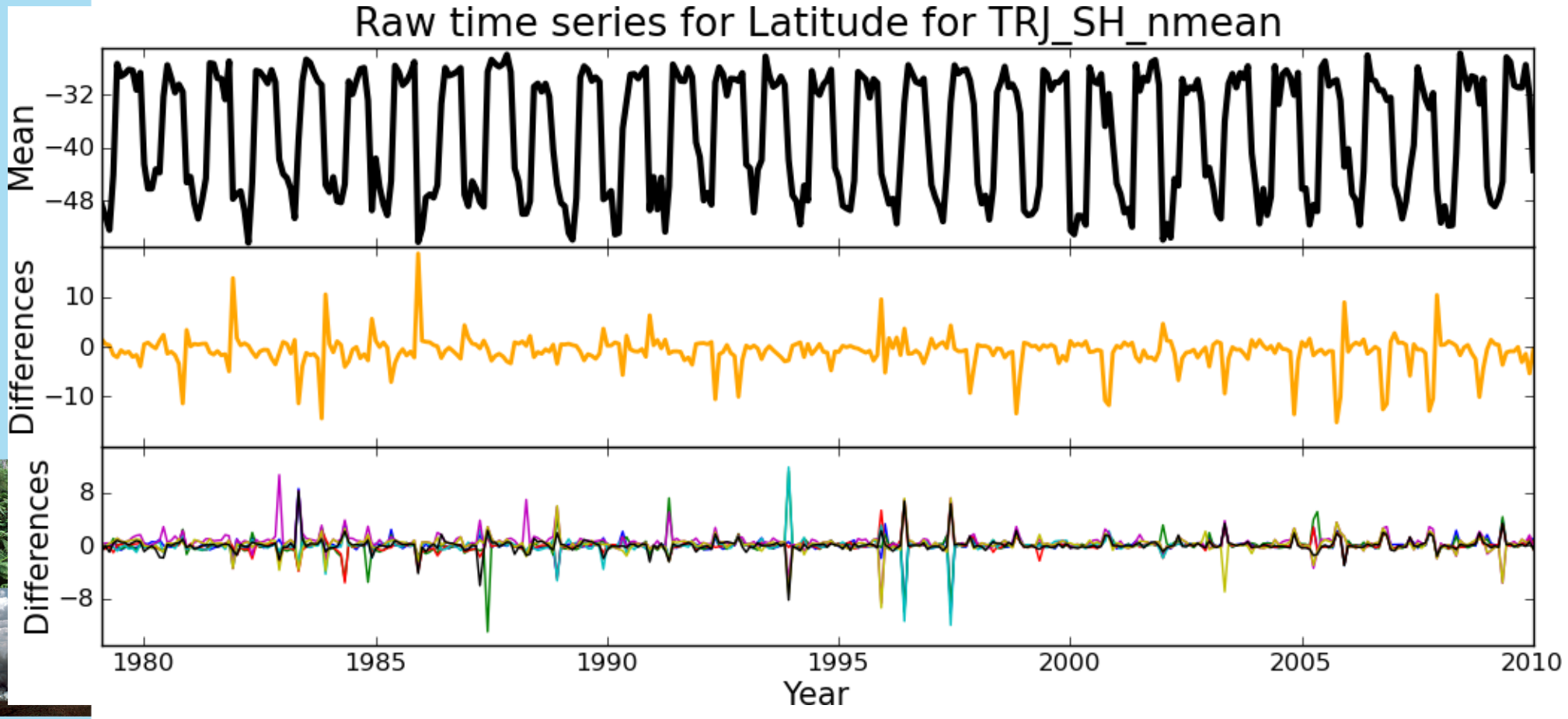
Strategies for double blobs





1. Size weighted mean
2. Northern-most
3. Southern-most

TRJ-SH – Mean latitude time series



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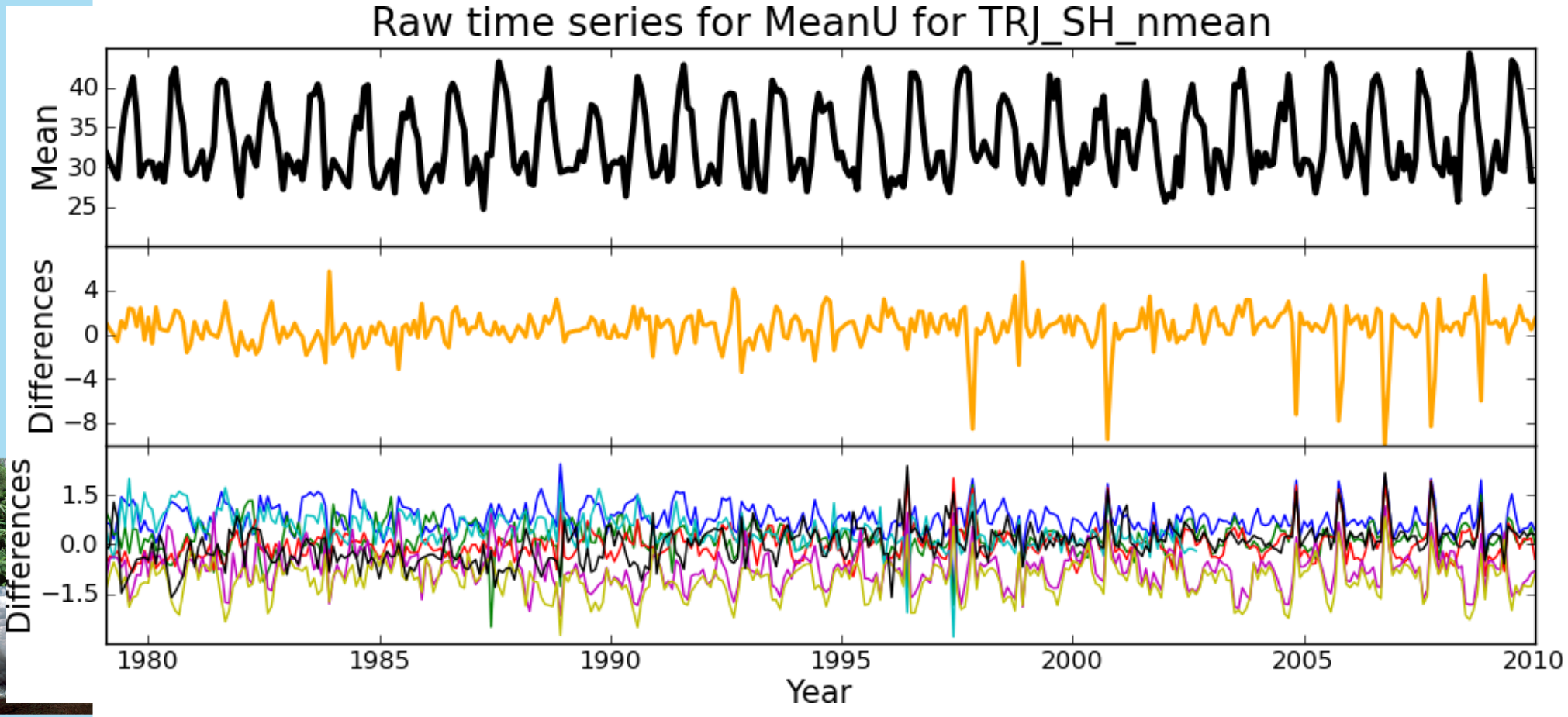
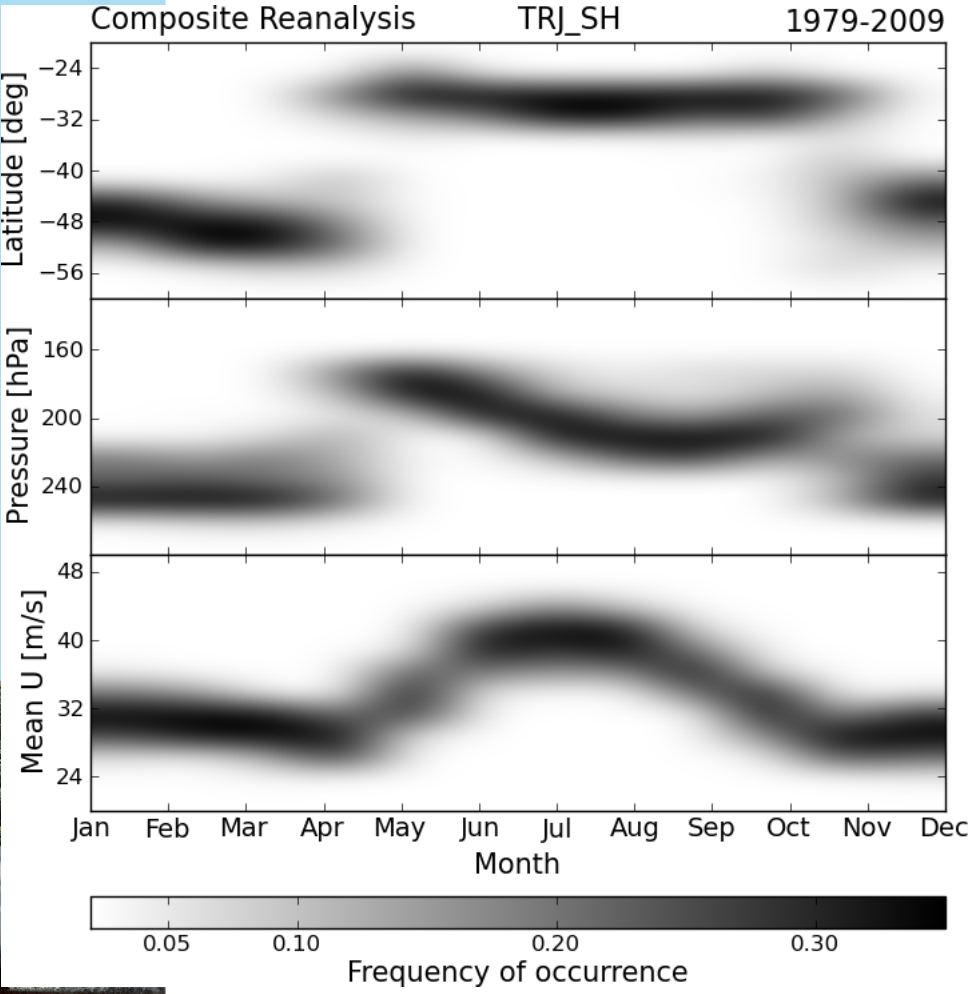
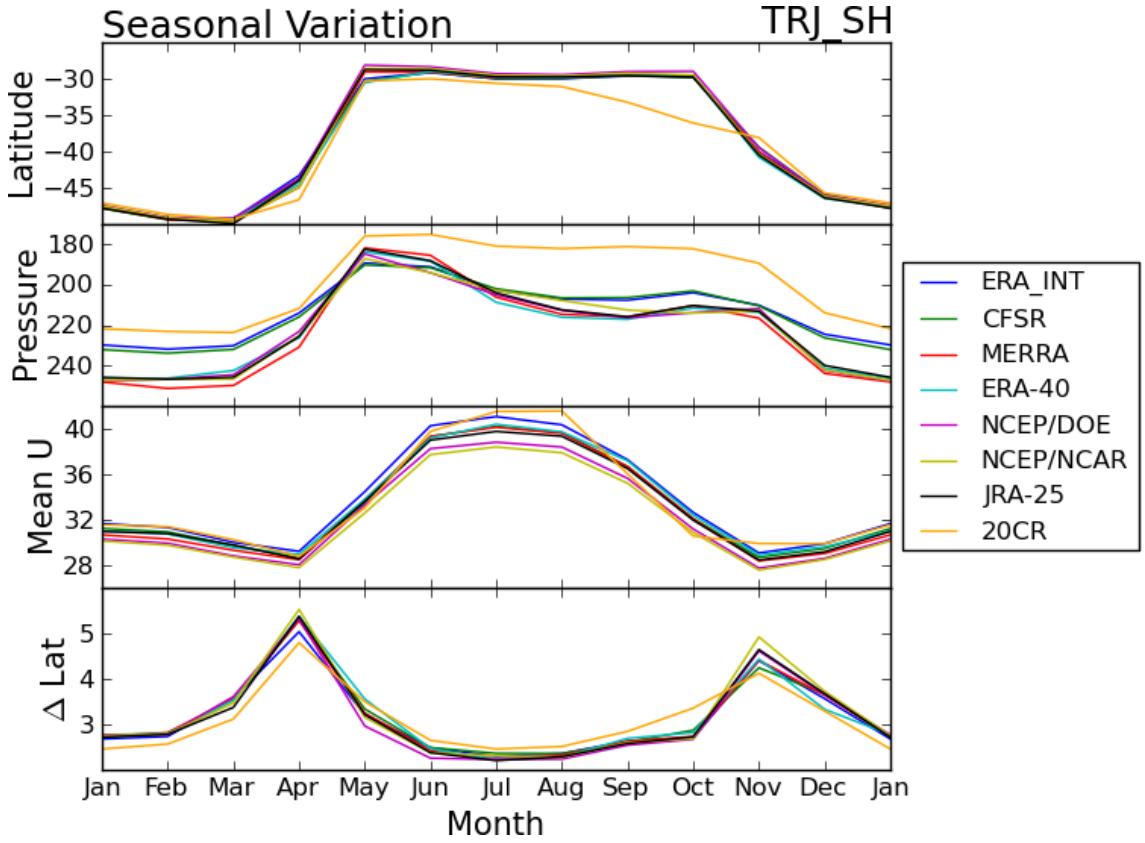
TRJ-SH – Mean U time series



TRJ_SH folding monthly mean





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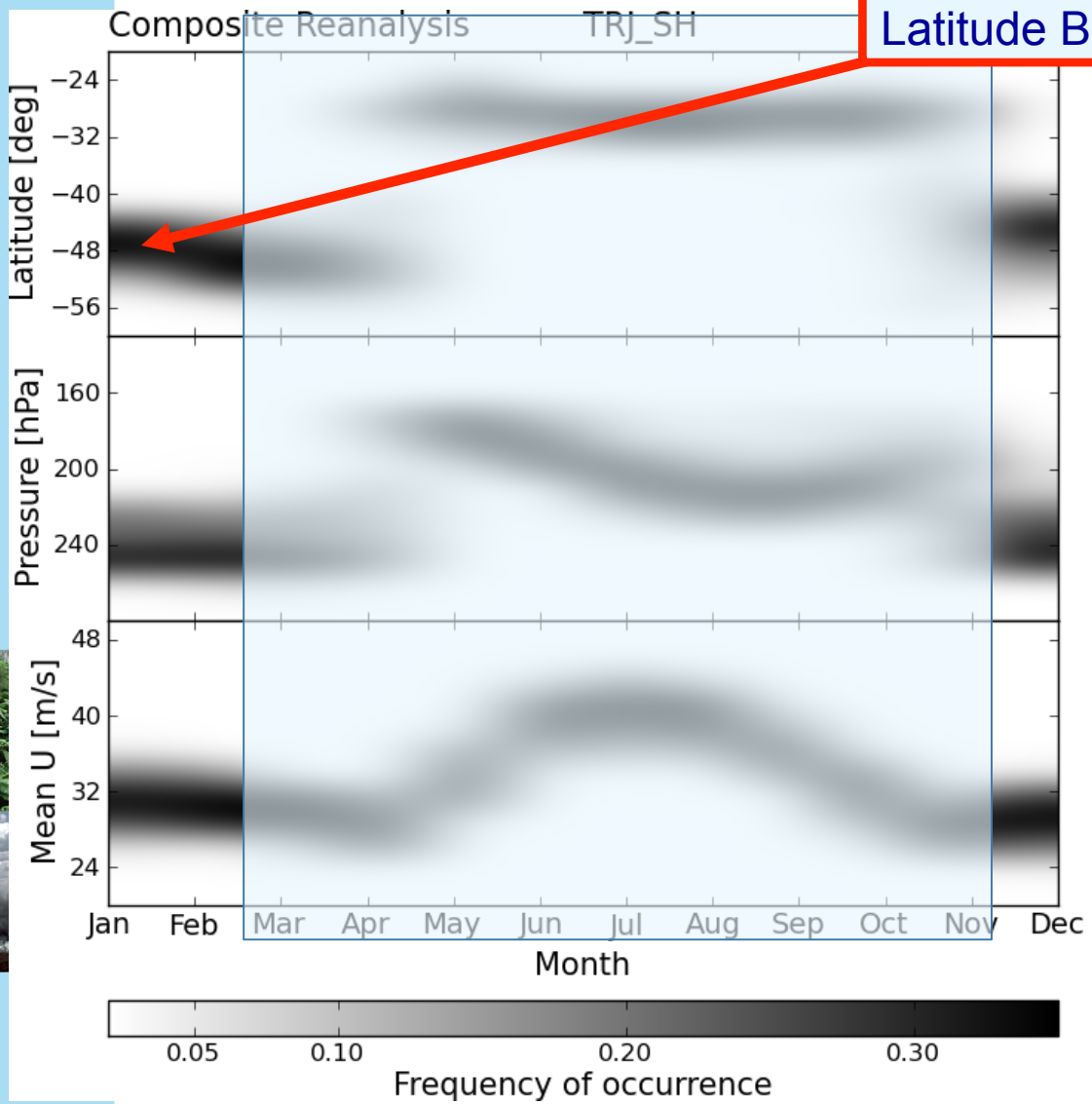
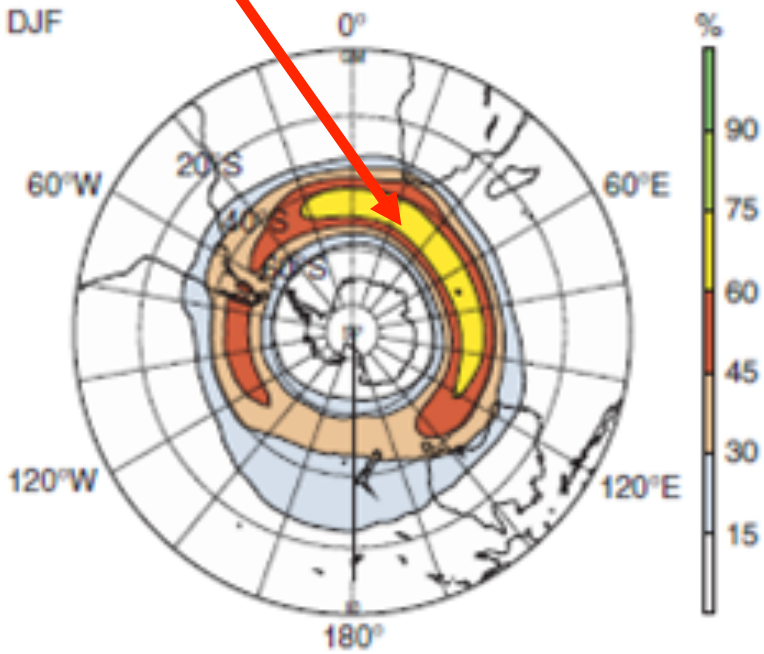
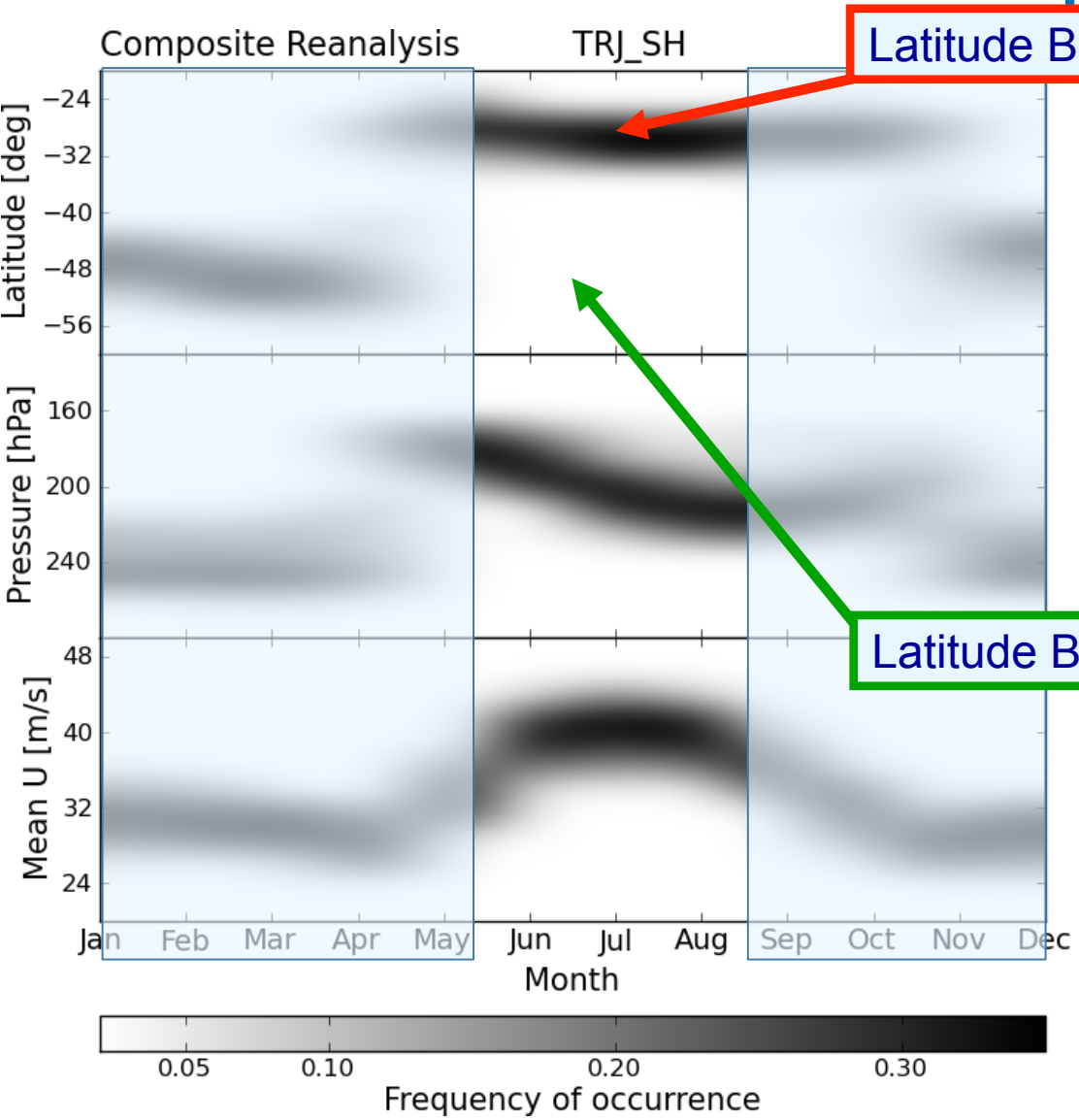
TRJ-SH DJF frequencies



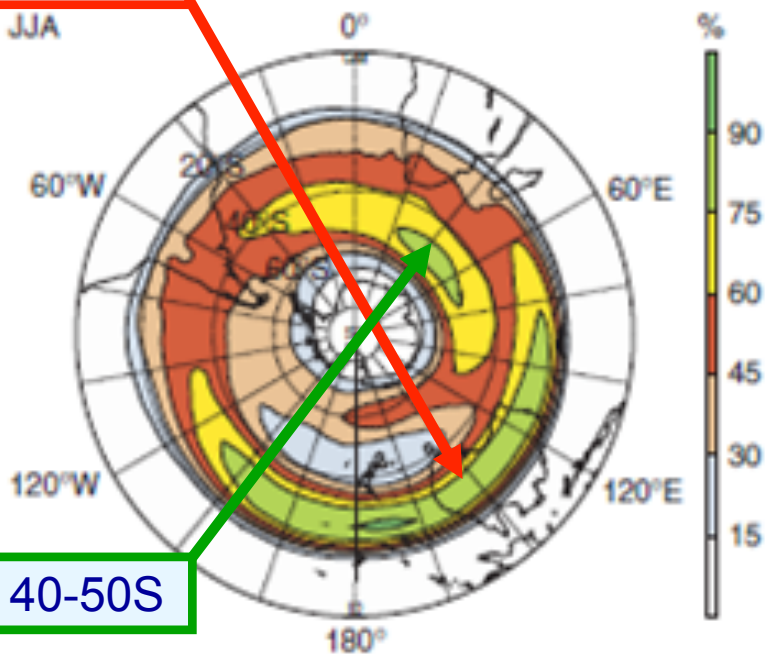


TRJ-SH DJF frequencies



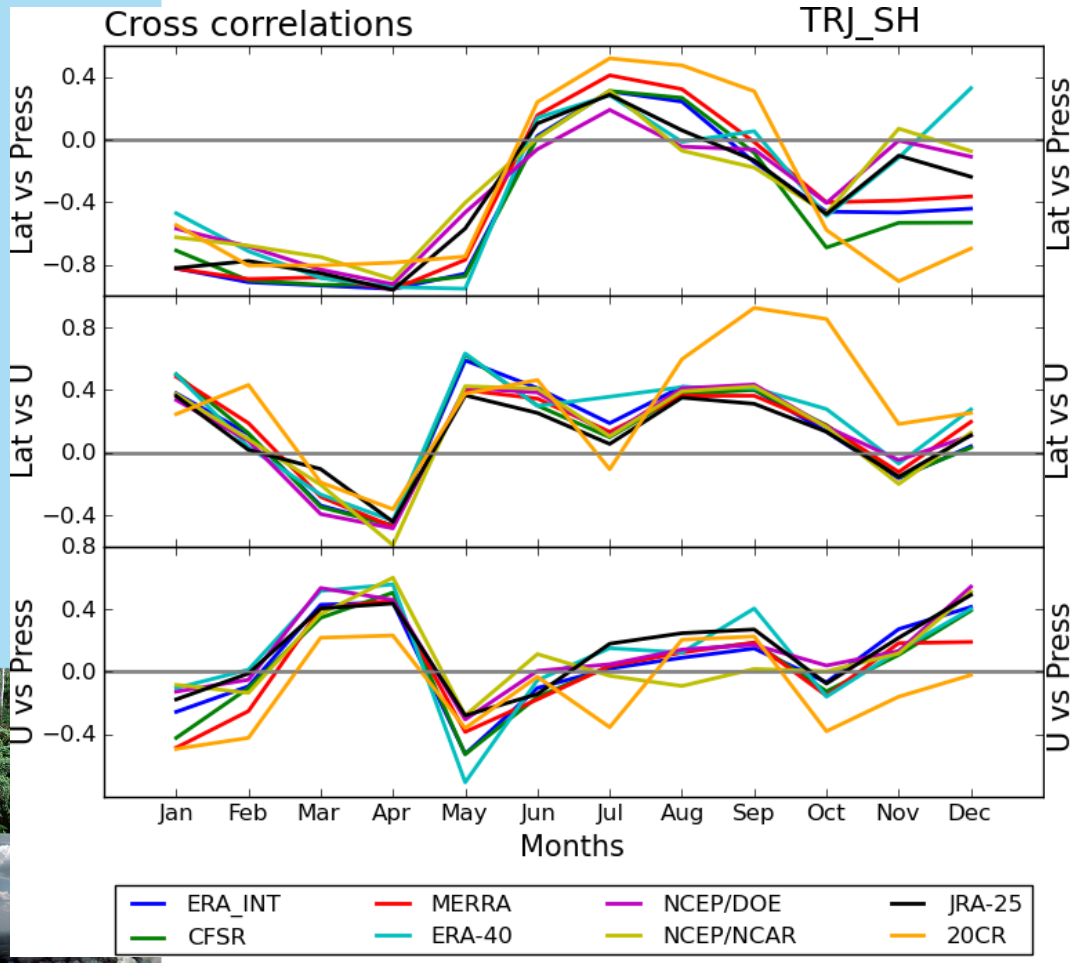
Latitude Between 20-30S

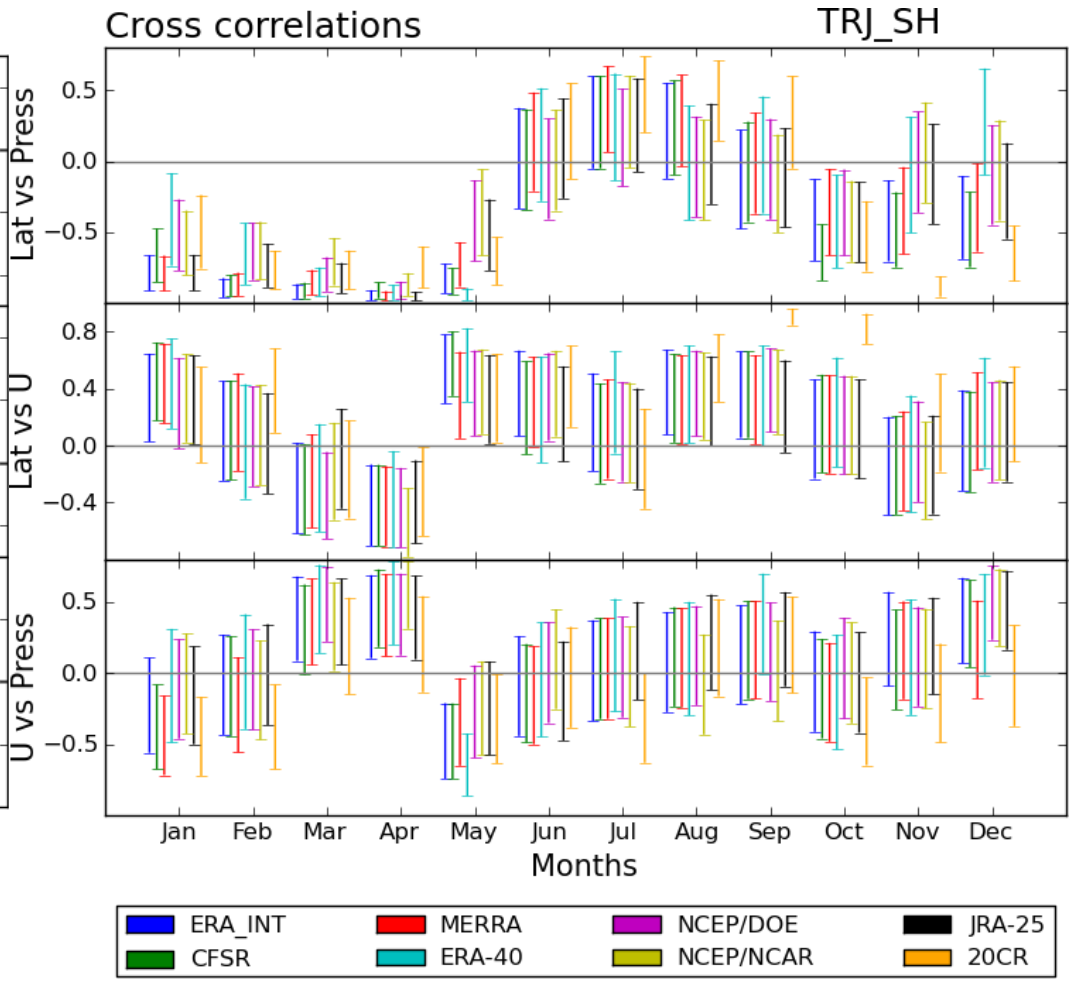
Latitude Between 40-50S



P. KOCH, H. WERNLI AND H. C. DAVIES (2006)

Cross variable correlations





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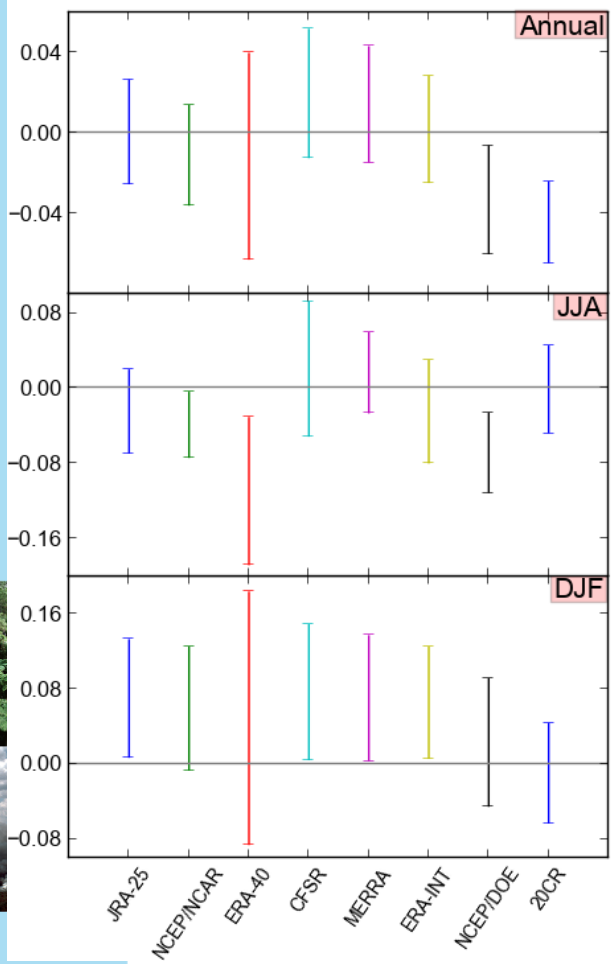
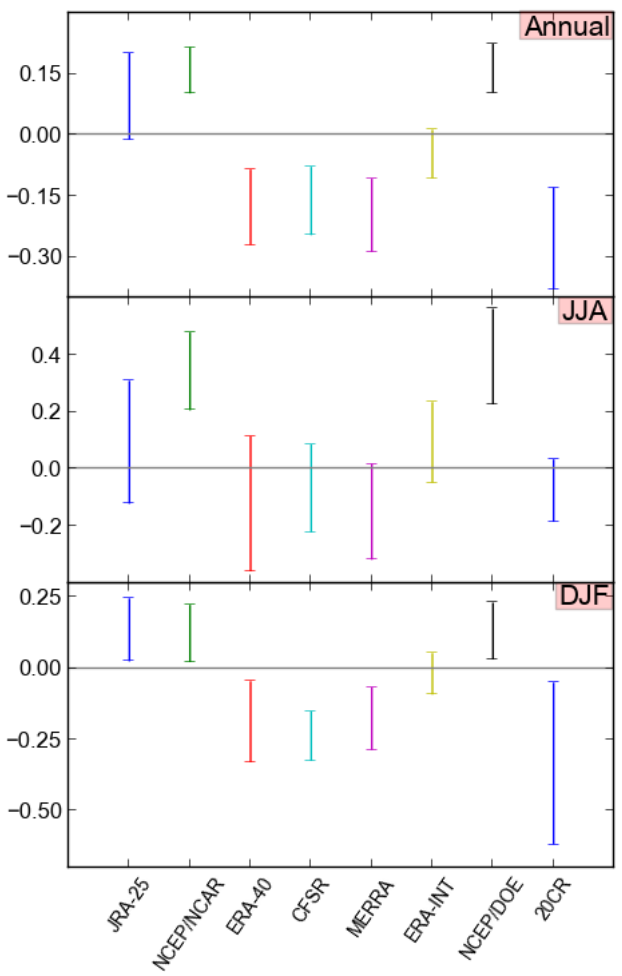
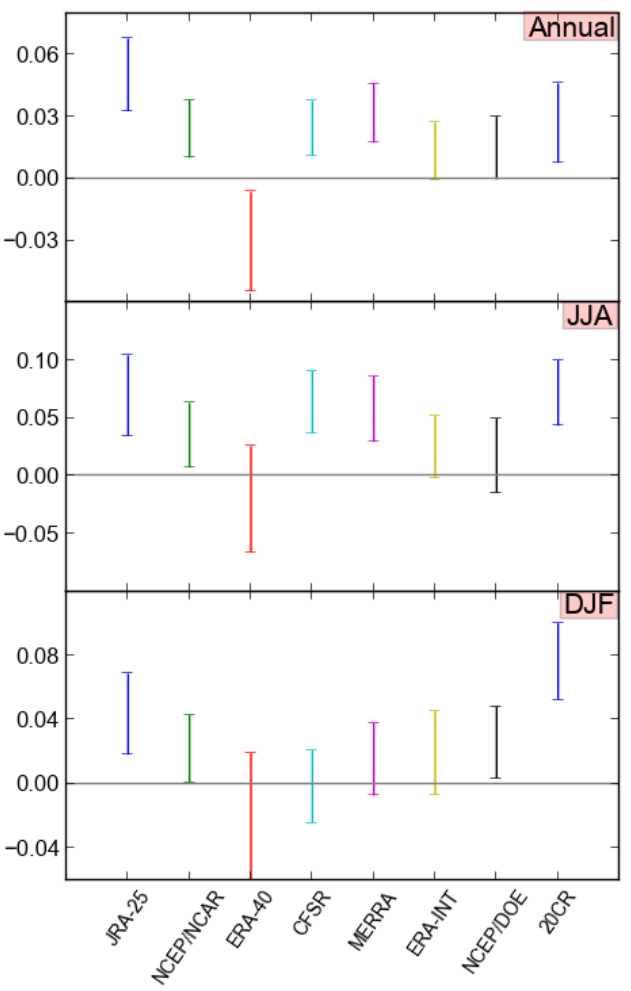
TRJ-SH (nMean) - Trends

Jan 1979 - Dec 2009 (except ERA-40)







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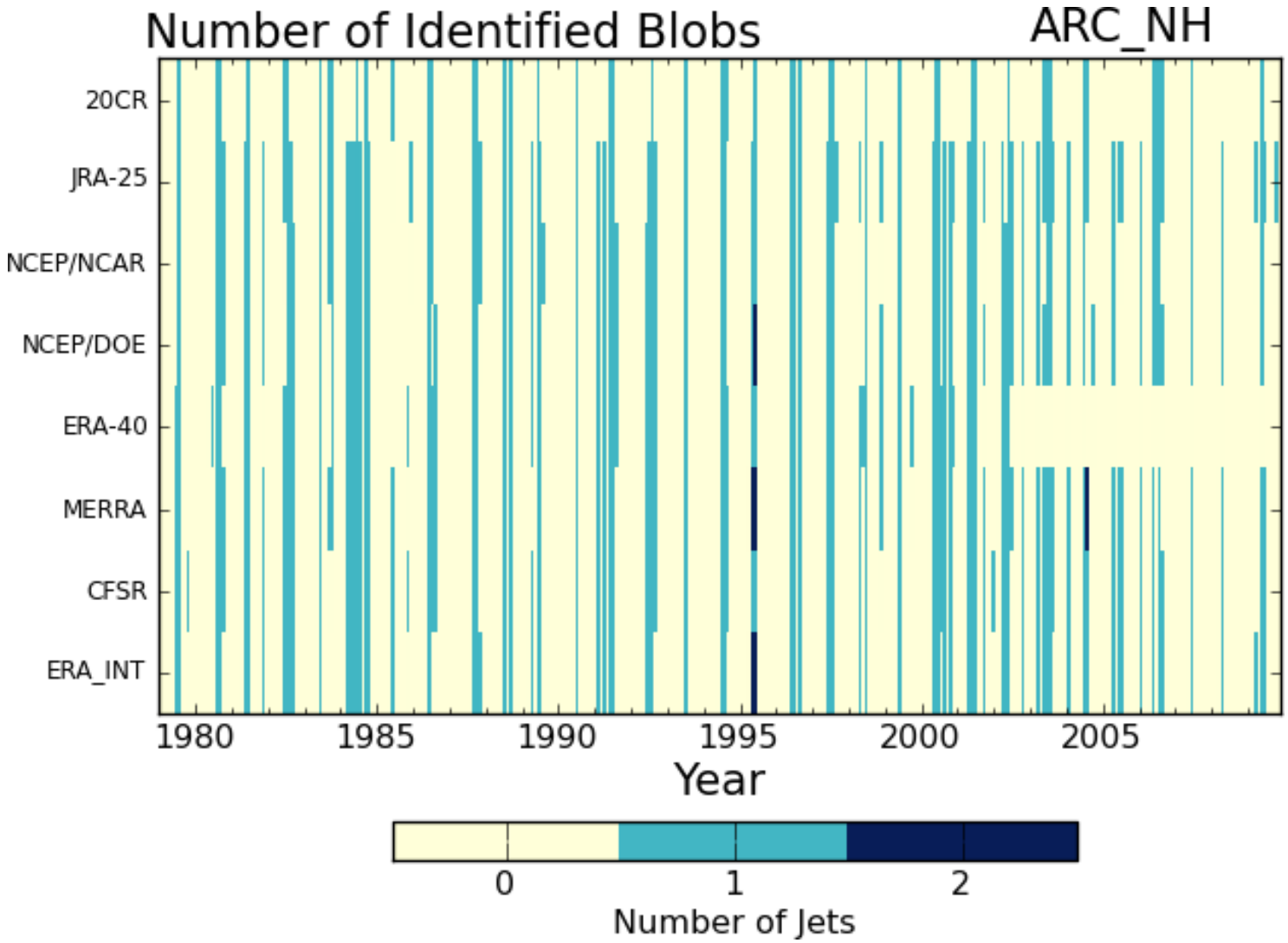
Arctic jet
ARC_SH



ARC-NH blob numbers



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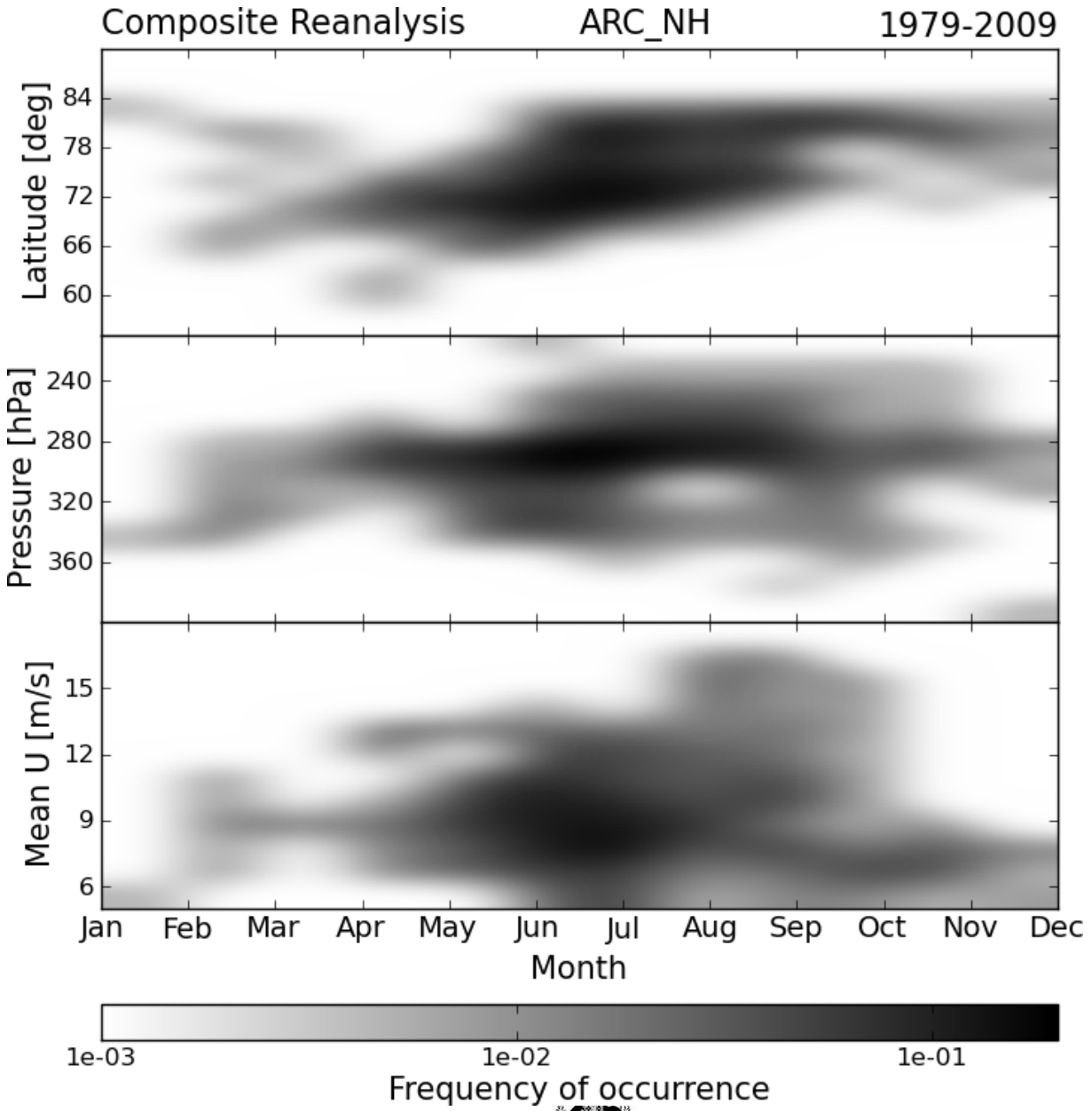
Arctic Jet frequencies



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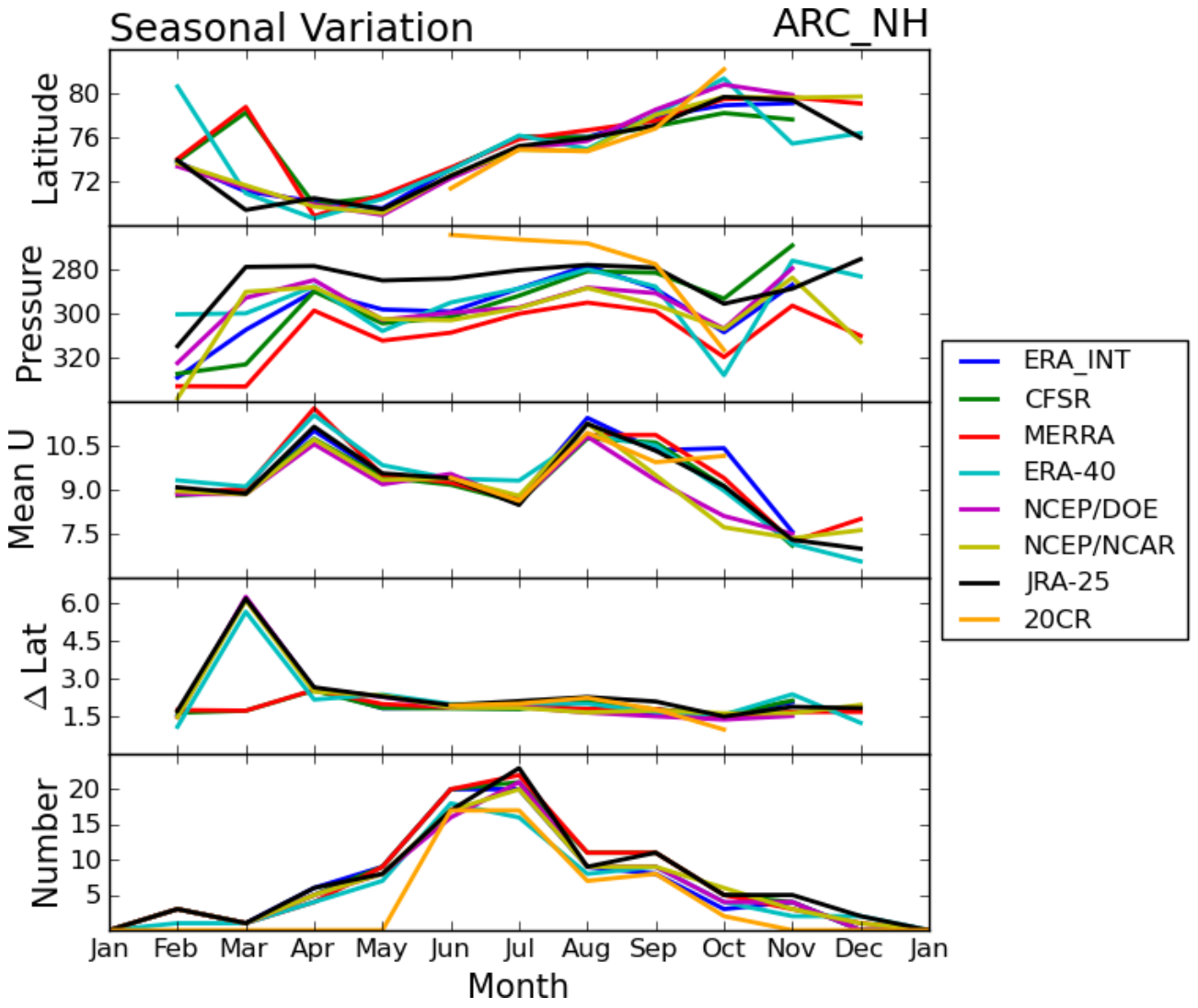
ARC_NH Seasonal Means



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May-October Means

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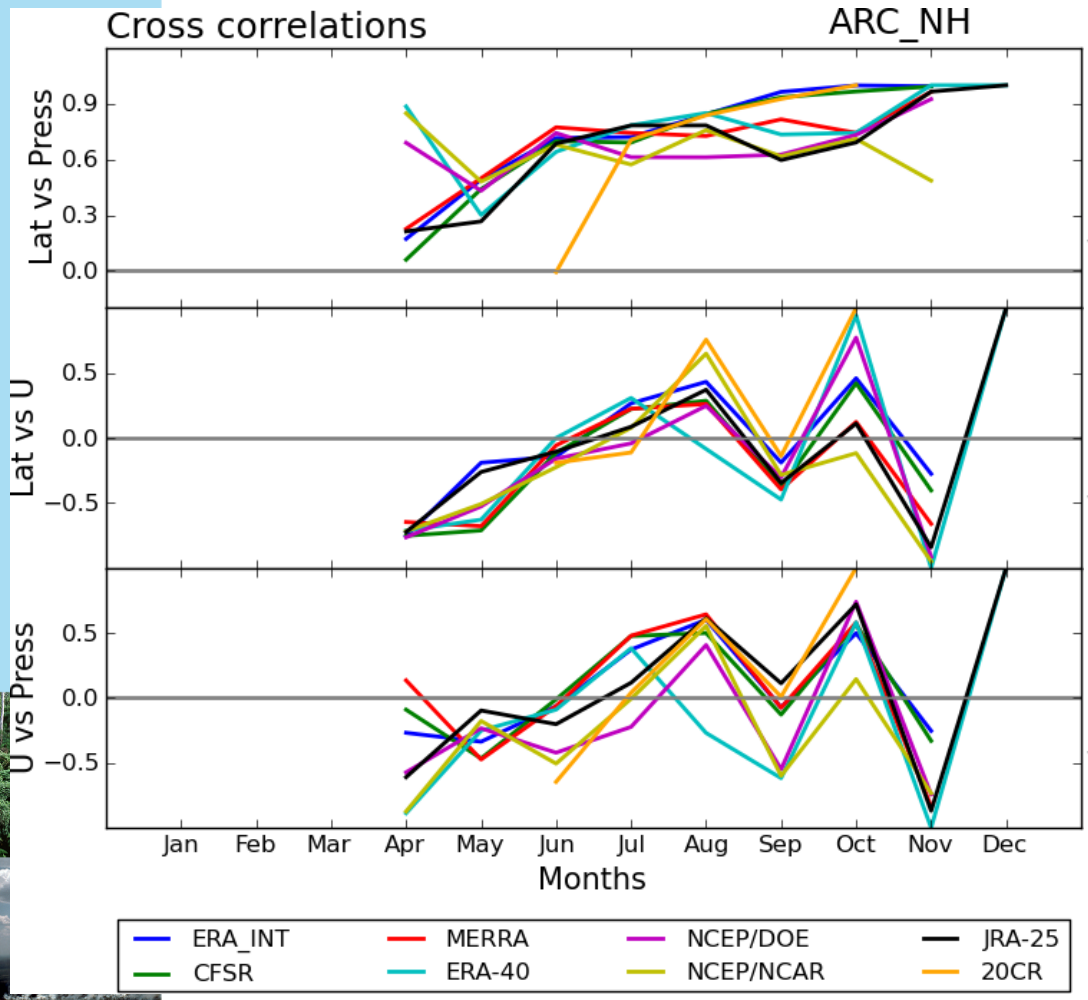
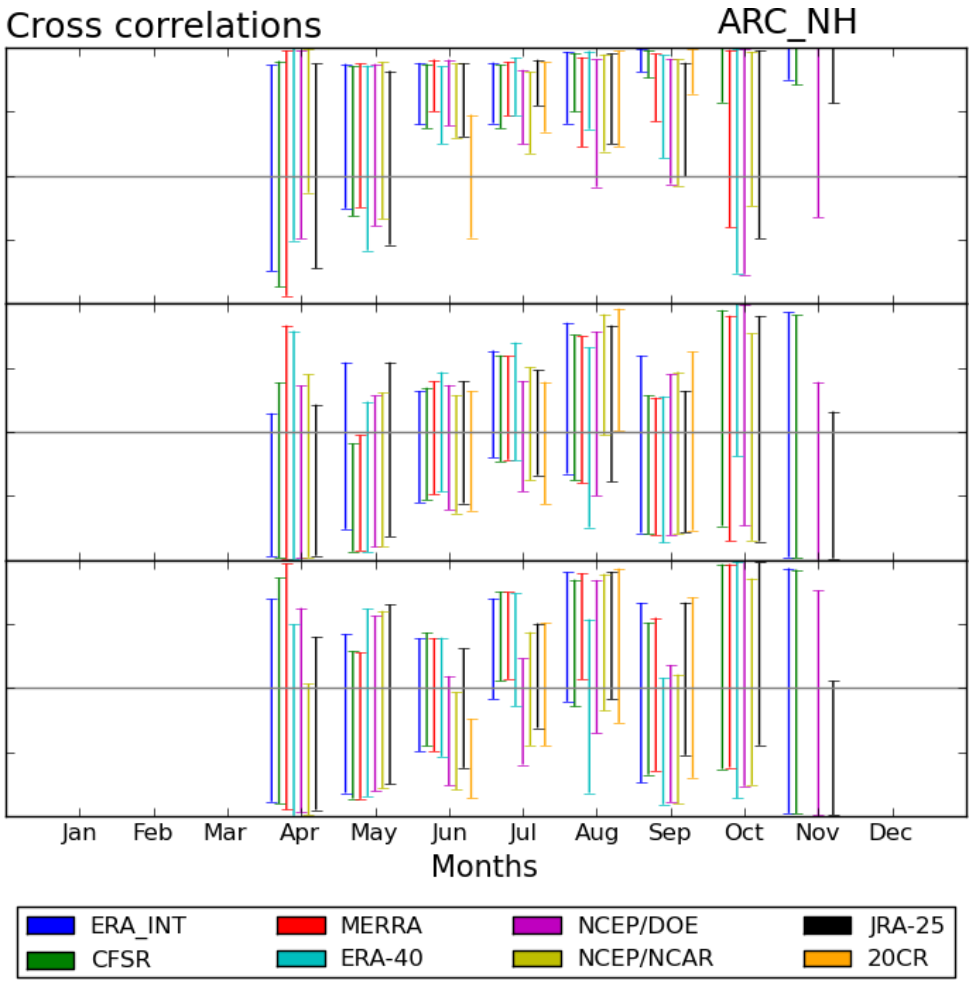
Cross variable correlations





Stratospheric jets

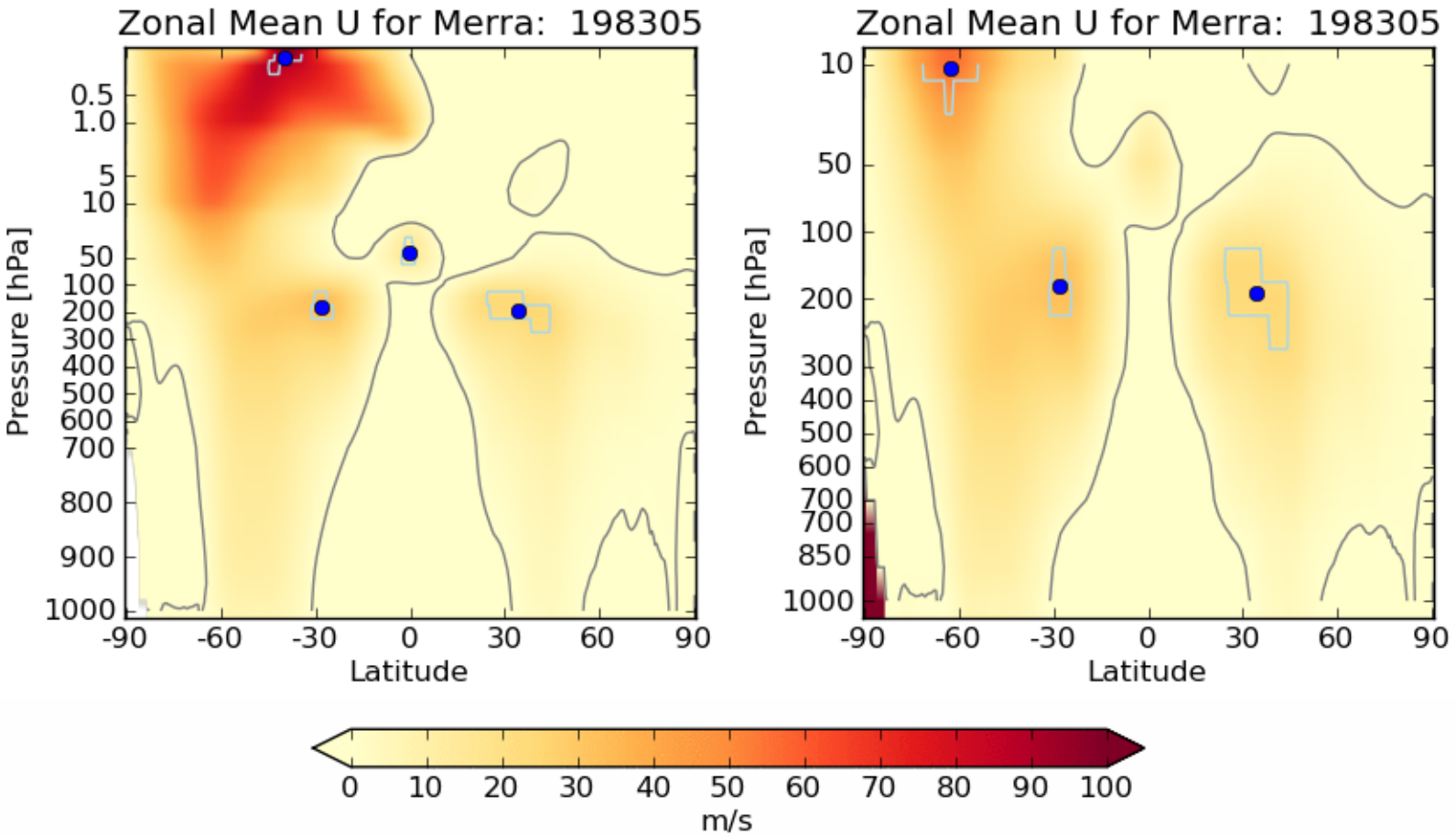
Pressure levels

Available versus common values

Name	List of available pressure levels [hPa]
ERA_INT	1,2,3,5,7,10,20,30,50,70,100,125,150,175,200,225,250,300,350,400,450,500,550, 600,650,700,750,775,800,825,850,875,900,925,950,975,1000
ERA-40	1,2,3,5,7,10,20,30,50,70,100,150,200,250,300,400,500,600,700,775,850,925,1000
JRA-25	0.4,1,2,3,5,7,10,20,30,50,70,100,150,200,250,300,400,500,600,700,850,925,1000
MERRA	0.1,0.3,0.4,0.5,0.7,1,2,3,4,5,7,10,20,30,40,50,70,100,150,200,250,300,350,400,450, 500,550,600,650,700,725,750,775,800,825,850,875,900,925,950,975,1000
CFSR	1,2,3,5,7,10,20,30,50,70,100,125,150,175,200,225,250,300,350,400,450,500,550, 600,650,700,750,775,800,825,850,875,900,925,950,1000
NCEP/DOE	10,20,30,50,70,100,150,200,250,300,400,500,600,700,850,925,1000
NCEP/NCAR	10,20,30,50,70,100,150,200,250,300,400,500,600,700,850,925,1000
20CR	10,20,30,50,70,100,150,200,250,300,350,400,450,500,550,600,650,700,750,800,850,900,950,1000
Common standardised	10,20,30,50,70,100,150,200,250,300,400,500,600,700,850,925,1000



High vs low lid - May



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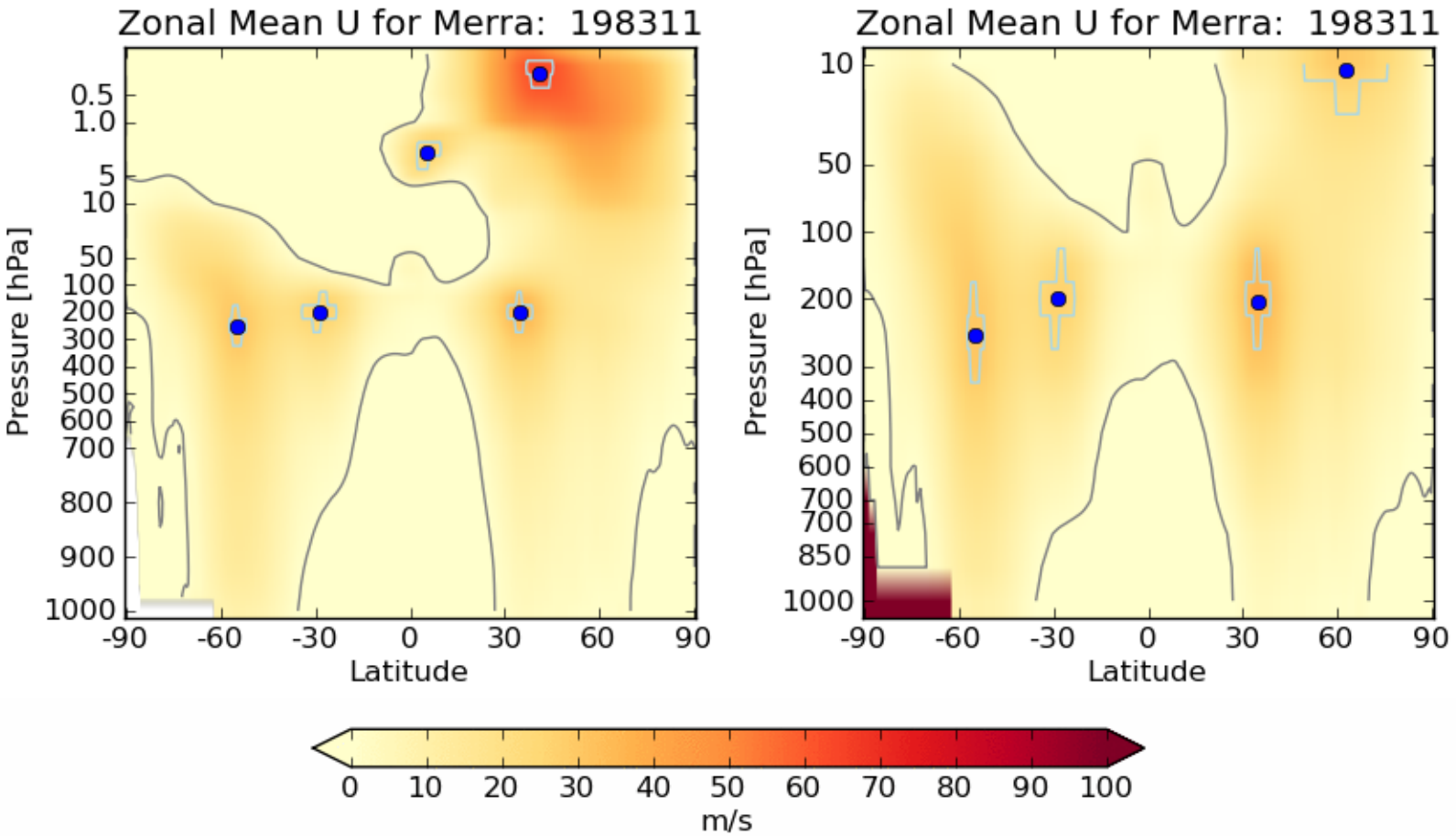
High vs low lid - November



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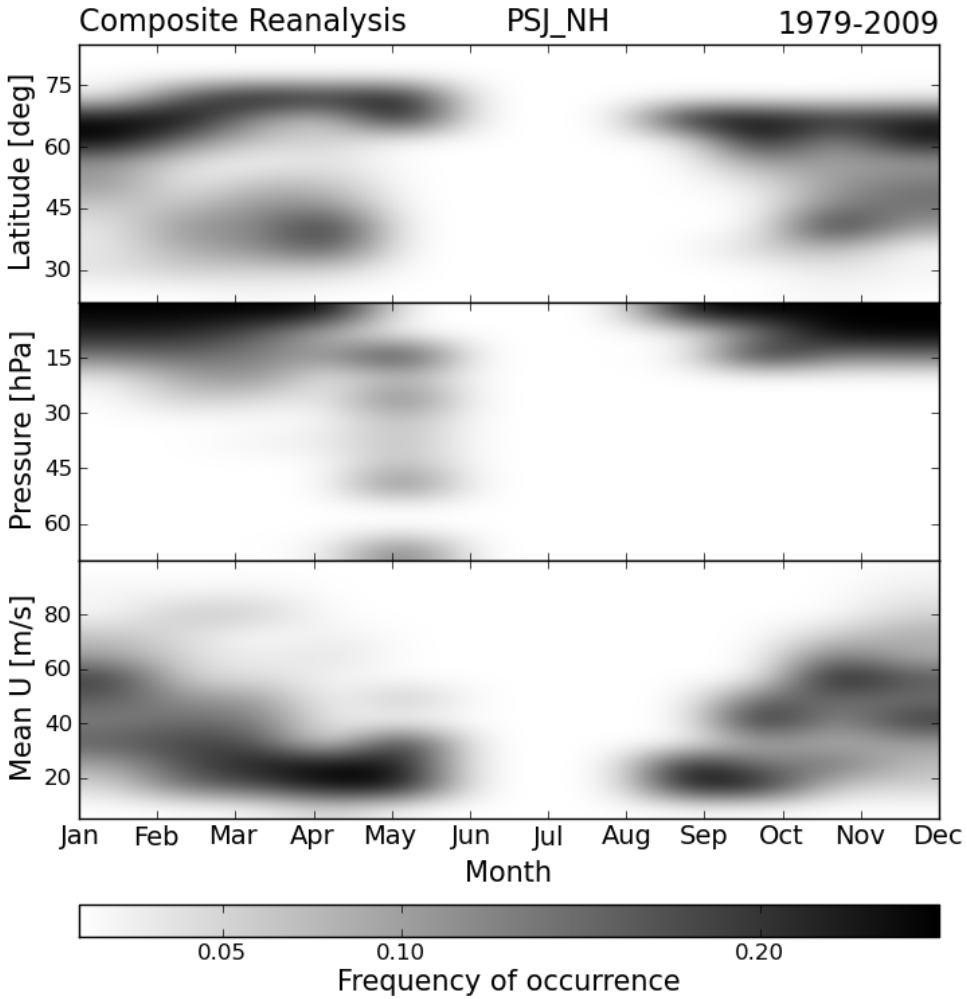
Northern hemisphere stratospheric jet

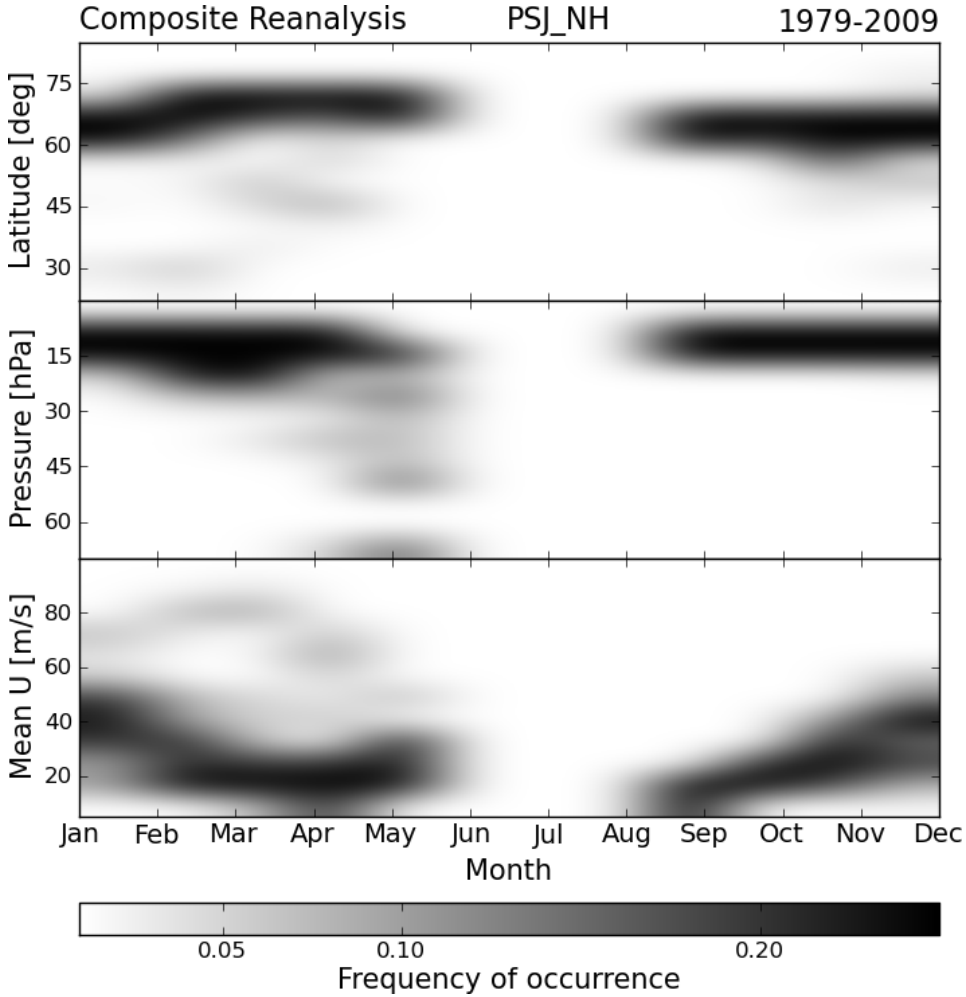
PSJ_NH

PSJ-NH Frequencies

Native levels

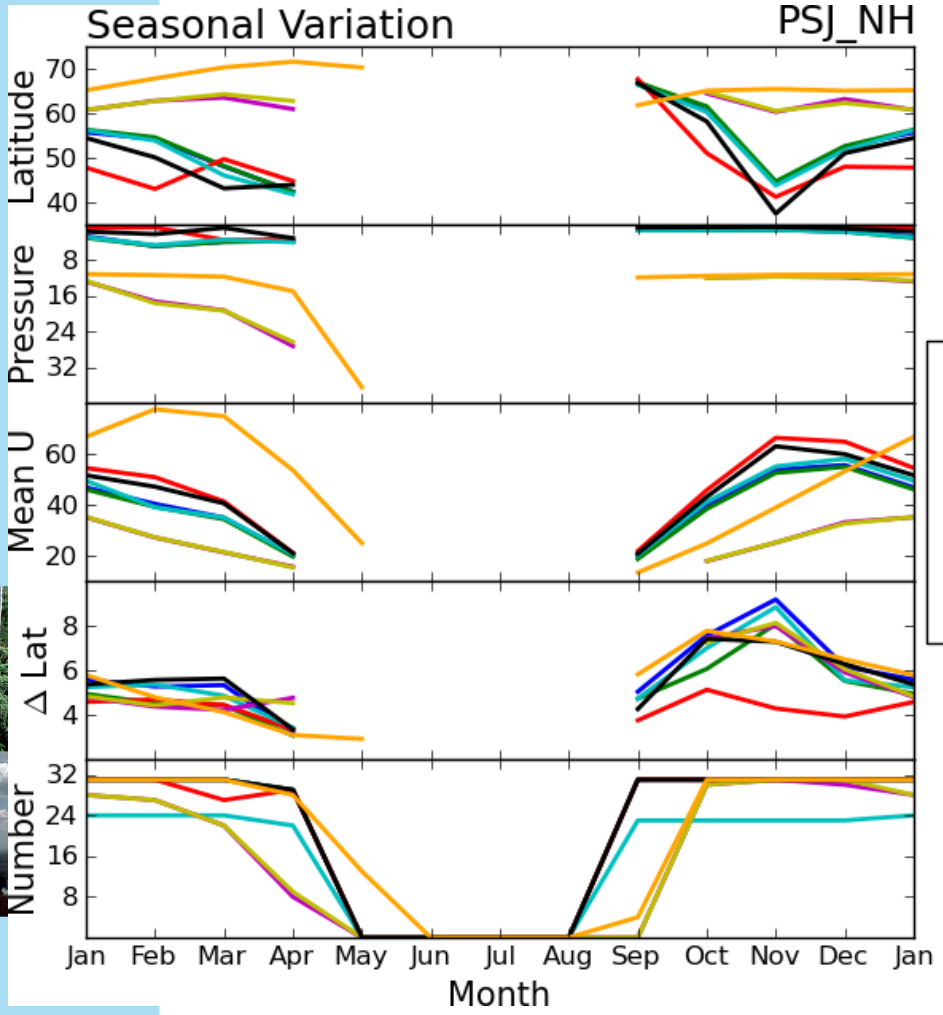


Standard levels

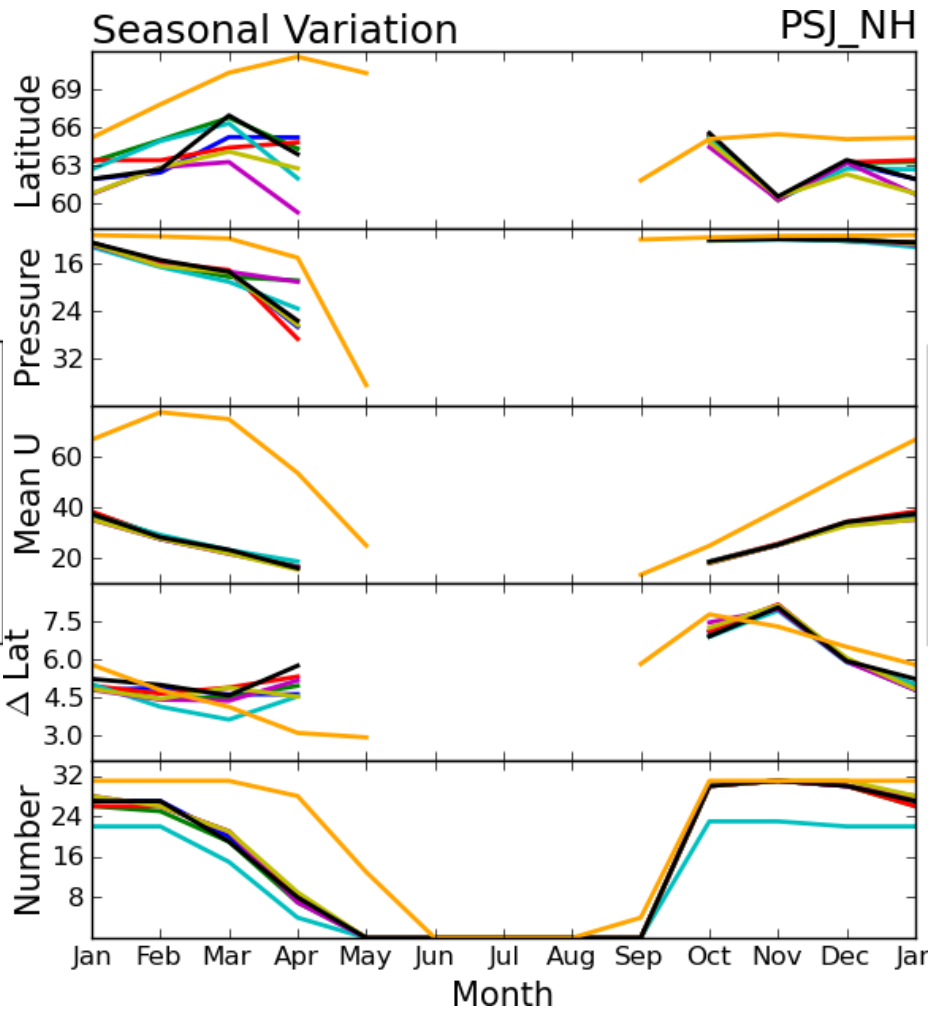


PSJ-NH seasonal mean

Native levels



Standard levels

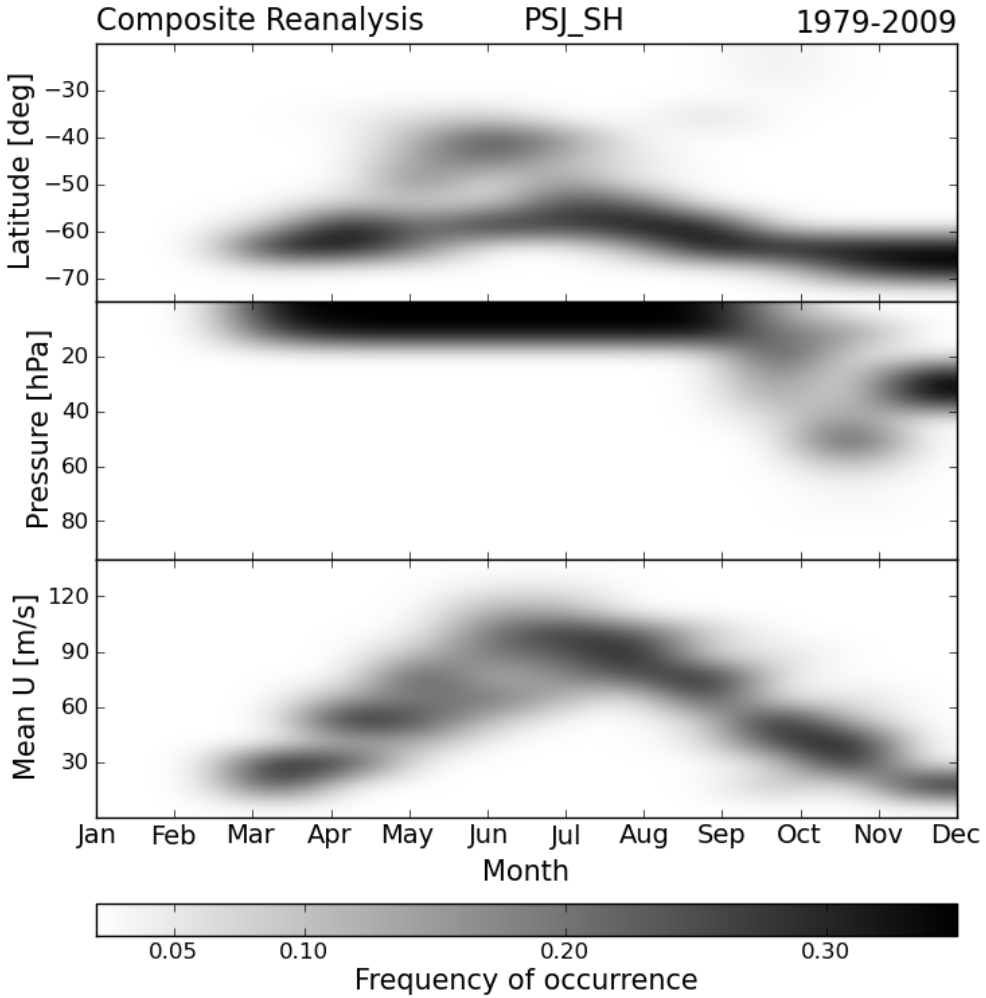


Southern hemisphere stratospheric jet

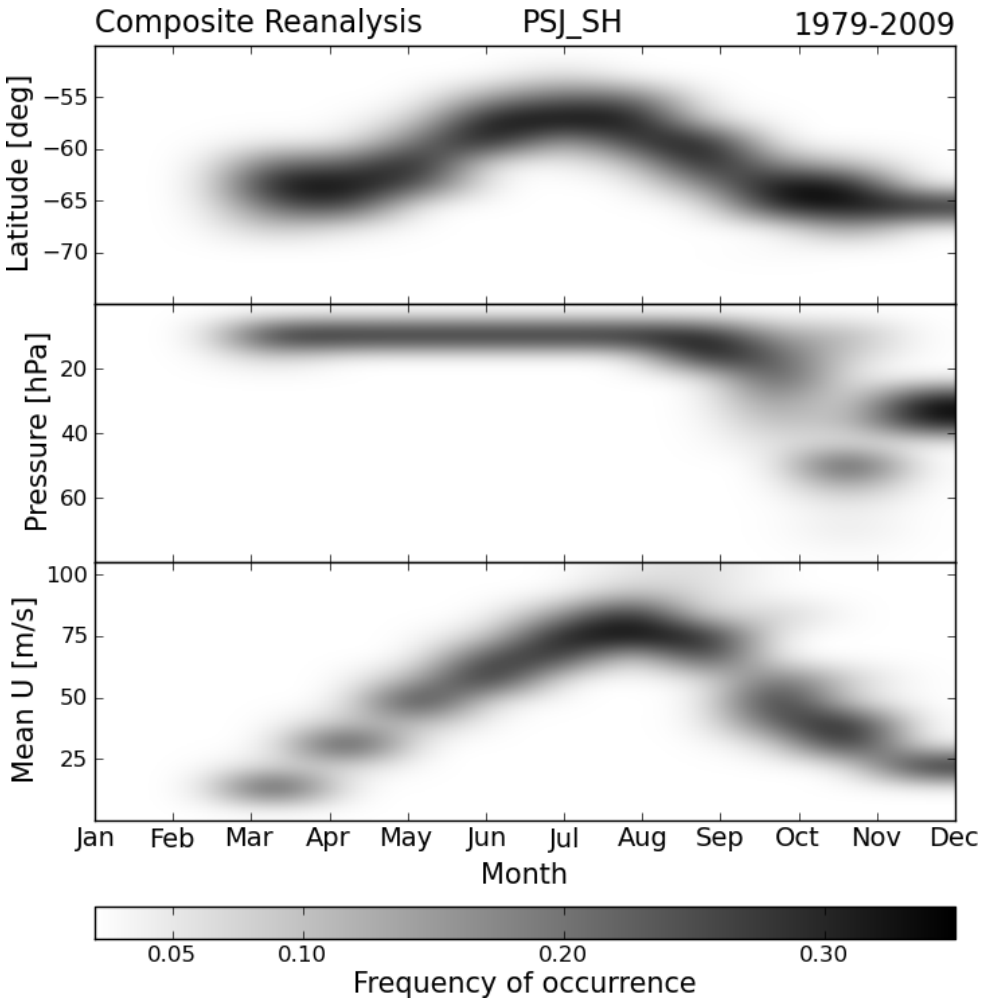
PSJ_SH

PSJ-SH frequencies

Native levels

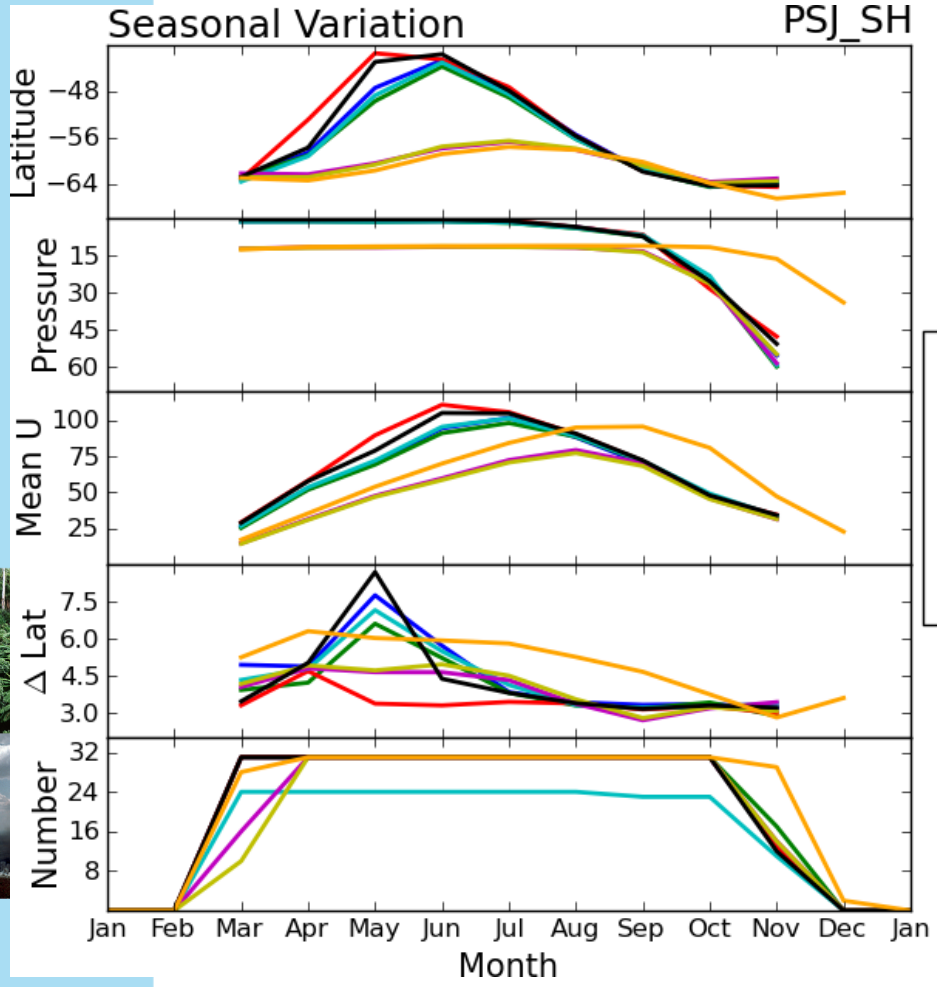


Standard levels

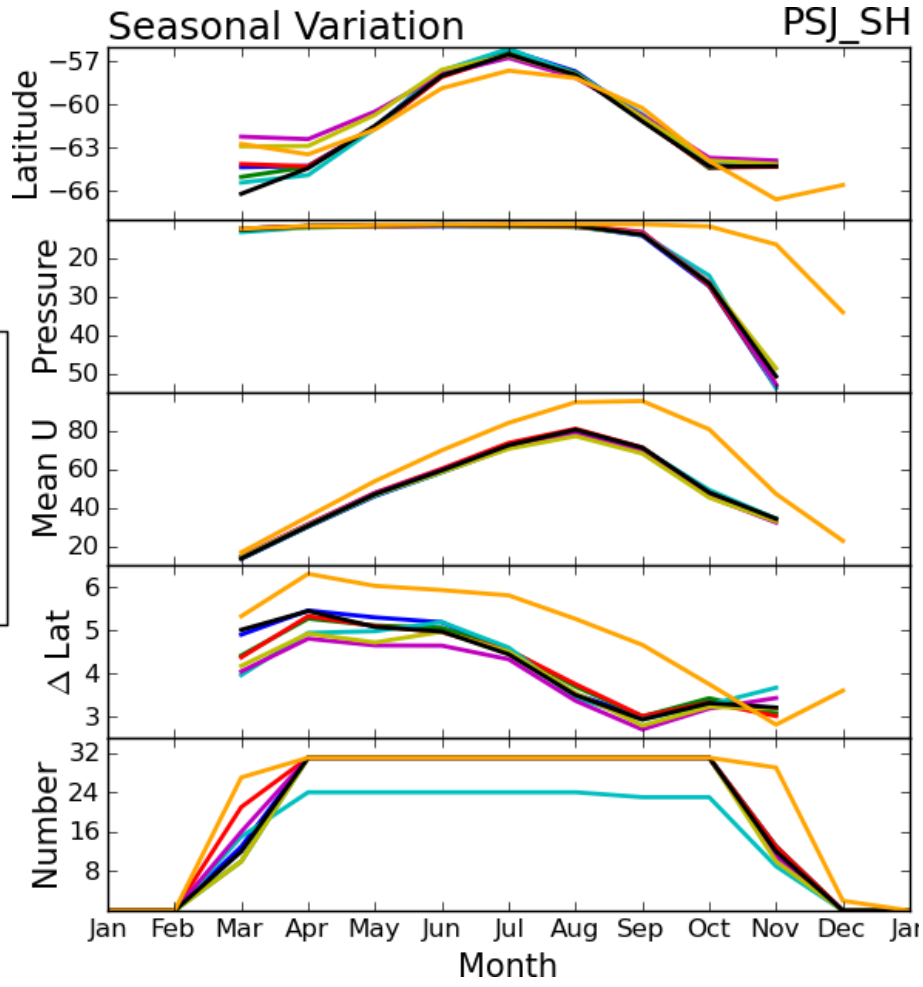


PSJ-SH seasonal mean

Native levels



Standard levels

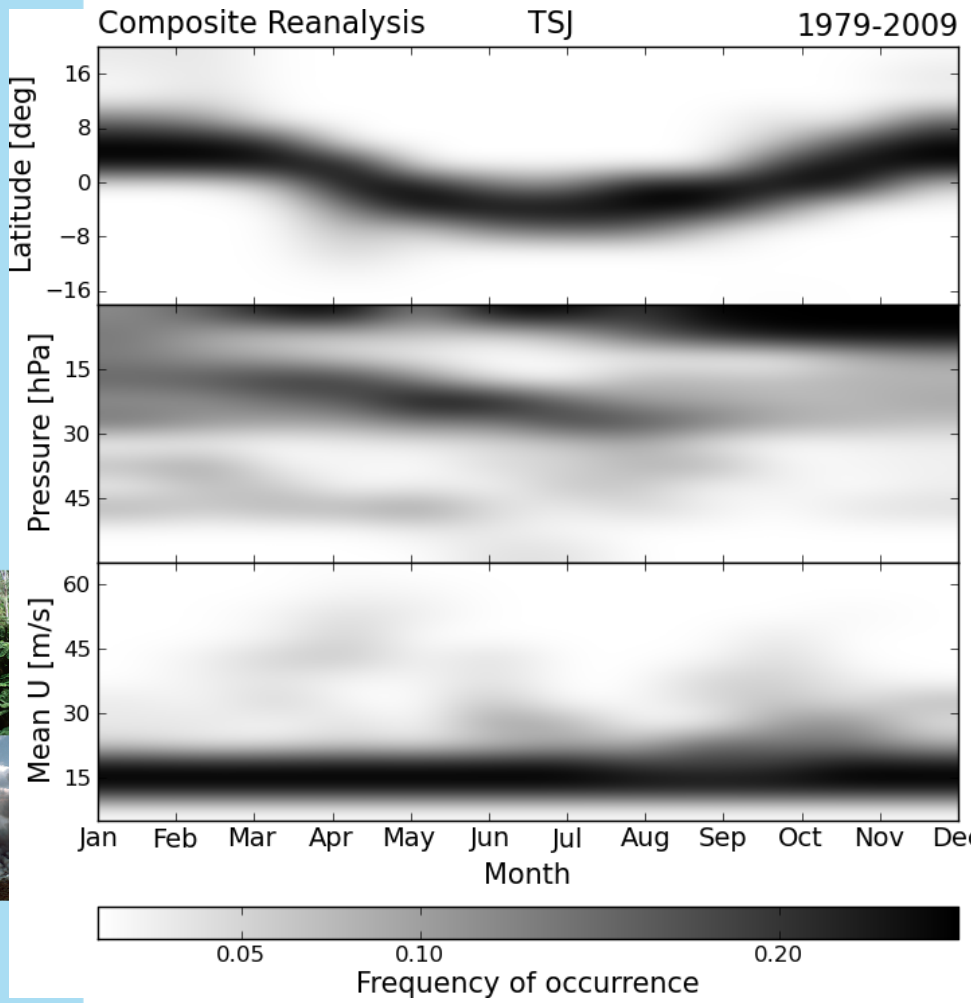


Tropical stratospheric jet

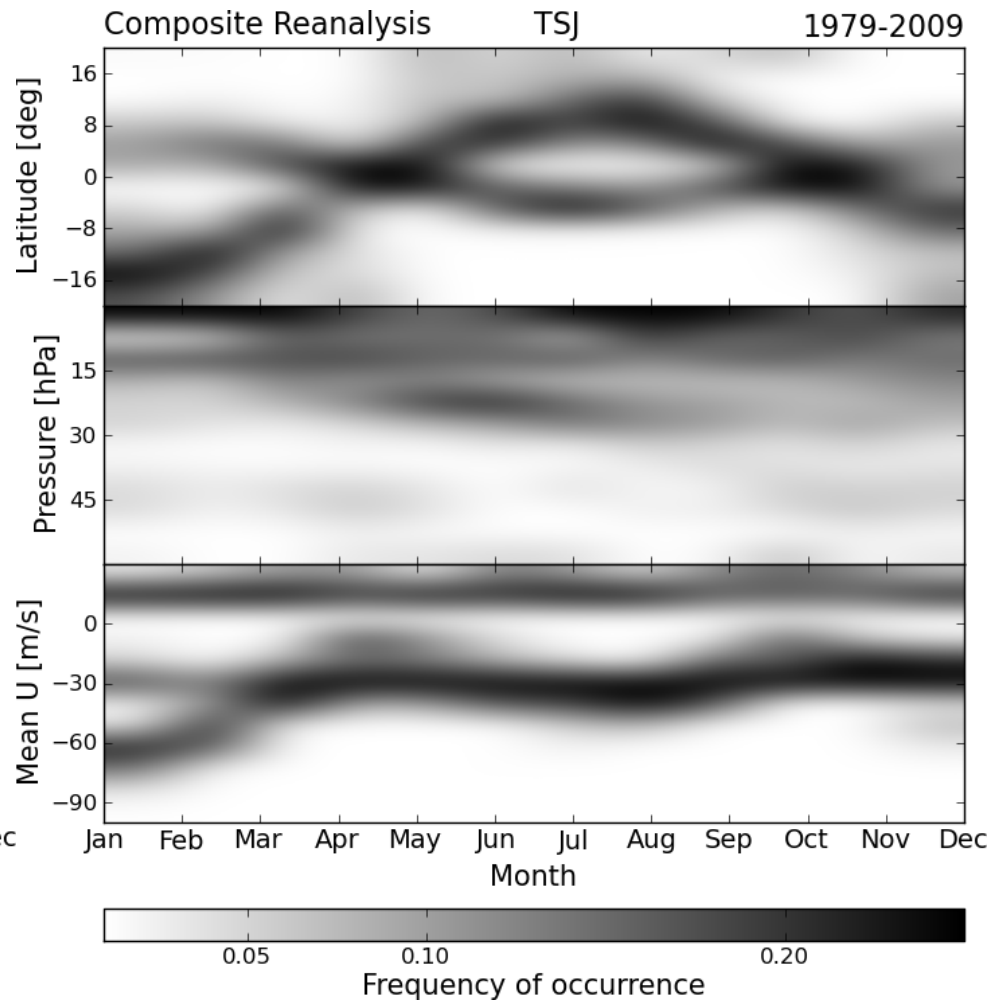
TSJ

Tropical Stratospheric Jet frequencies

Westerly



Westerly and Easterly



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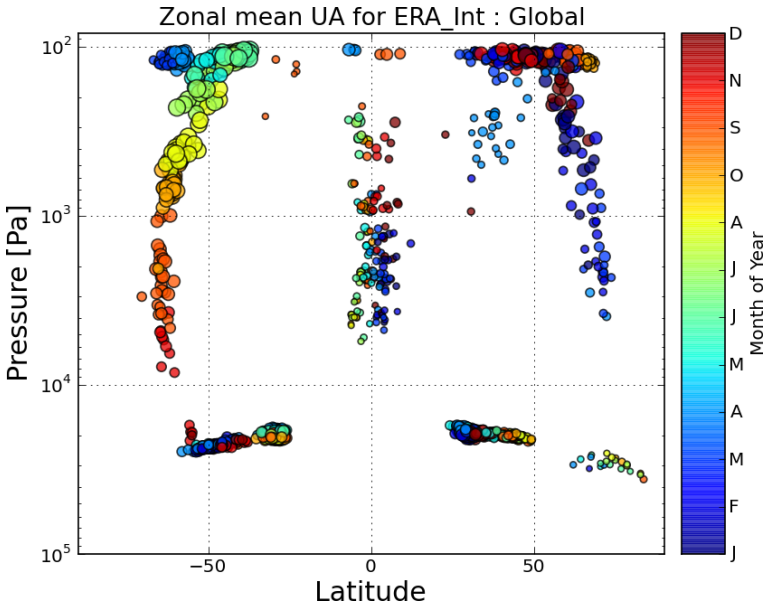
Other applications

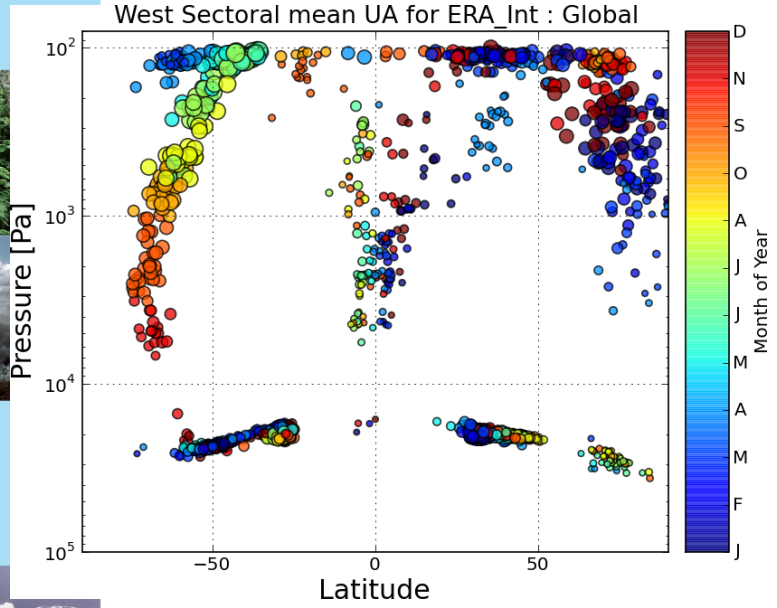
Application to longitude sectors can illustrate 4D behavior

Size – mean blob U
Colour – Month of year

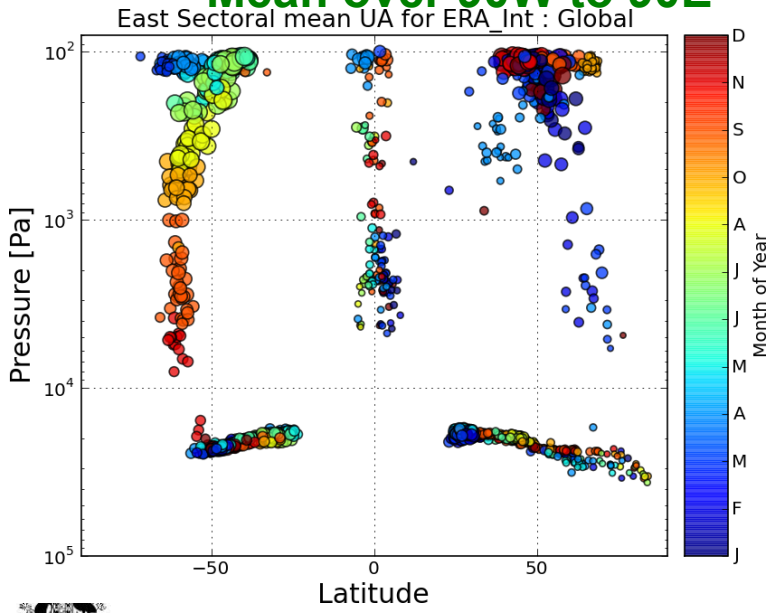
Full zonal mean



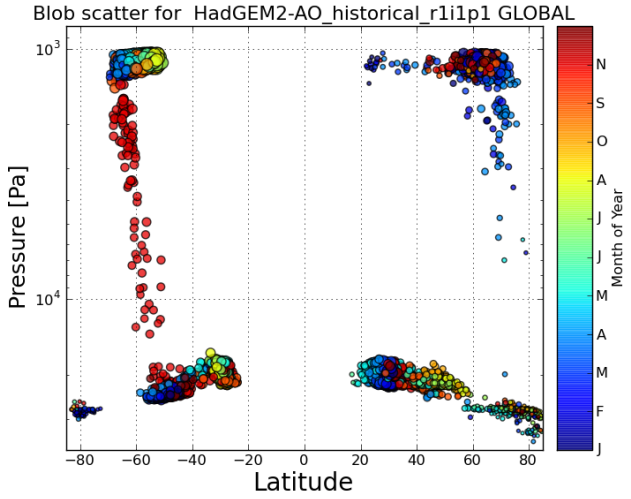
Mean over 90E-270E

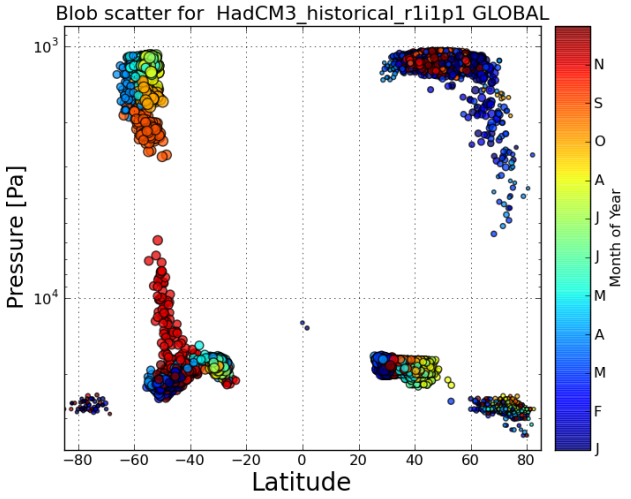


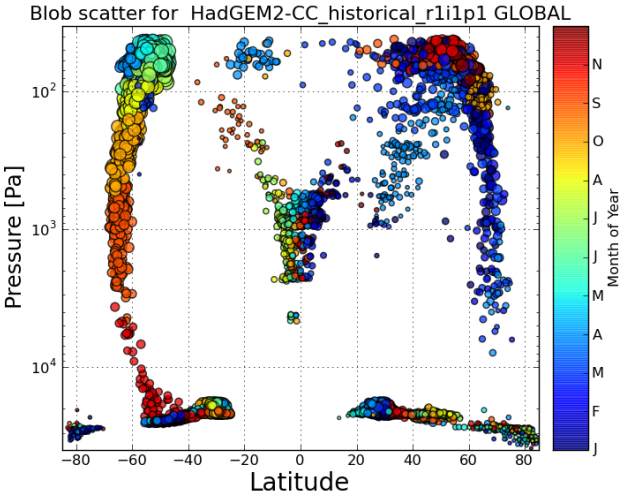
Mean over 90W to 90E

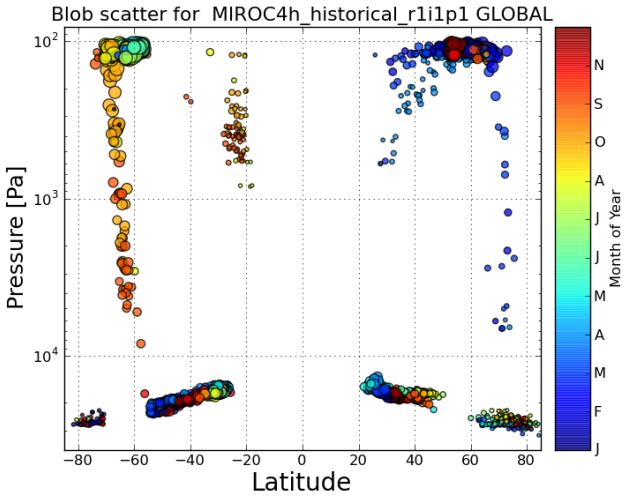


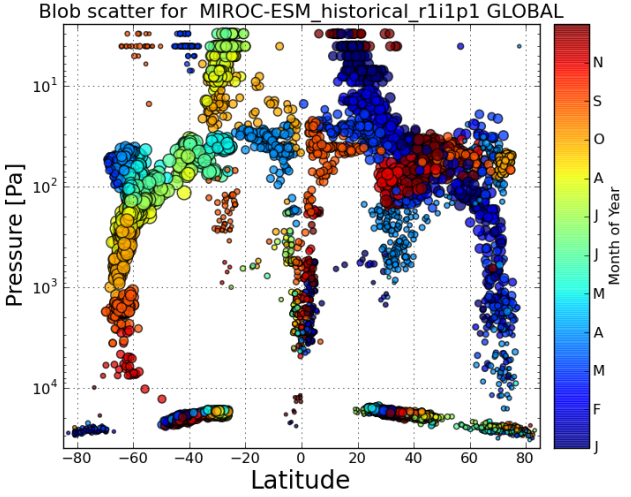
CMIP5 models

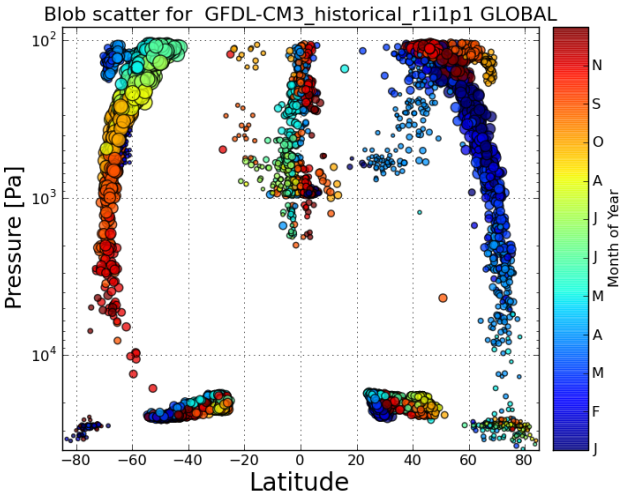












- ~80% do not have TSJ
- Ensemble members more similar than different models

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Conclusions

- Simple easy-to-apply objective method to extract time series of blob properties from a time series of a 2D field.
- Six jets identified with robust properties between re-analysis data sets.
- Strong agreement between reanalyses for latitude and U
  - 20CR is an outlier, particularly in the stratosphere
  - Evidence for convergence?.
- Best agreement is for TRJ_NH followed by TRJ+SH
- Time series analysis provides a rich field of opportunity to get lost in



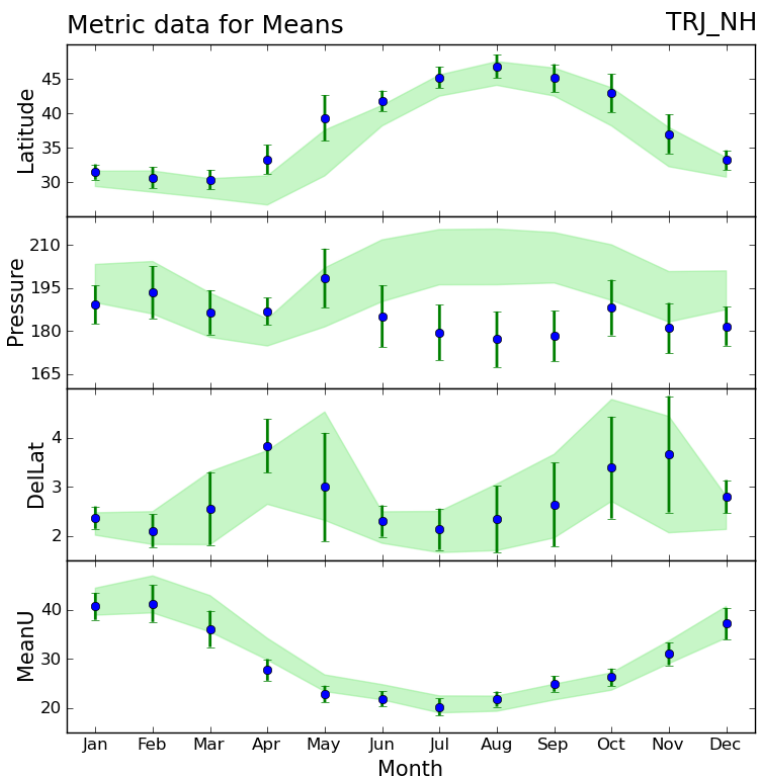
Future and ongoing work

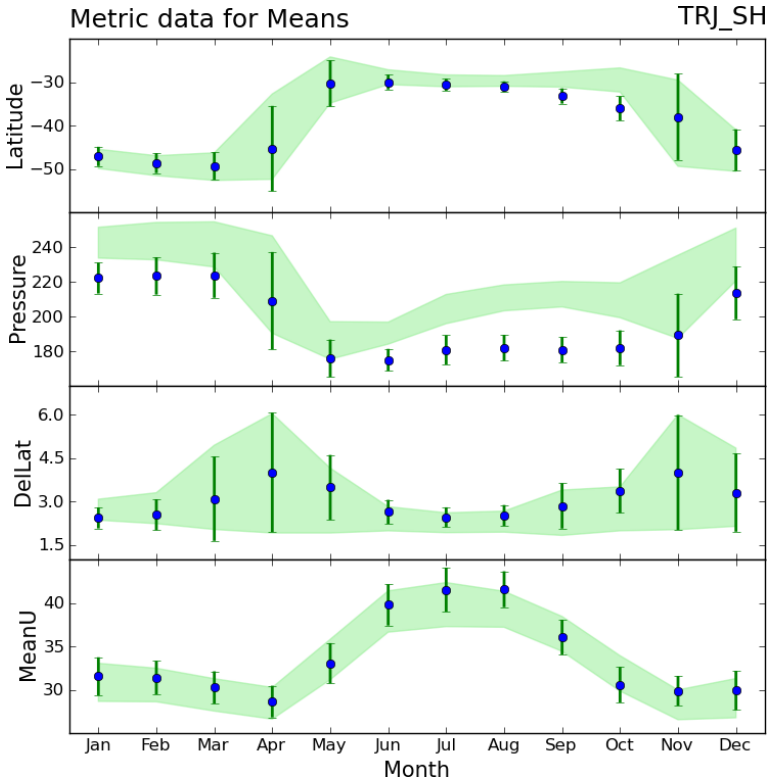
- Continue tropospheric jet analysis including wavelet analysis
- In-depth look at stratospheric jets
- Analyse data on already on disk
  - Jets in CMIP5
  - Zonal mean T, RH, ZMPSI
- Apply blob analysis to other fields and models
- More detailed look at reanalysis differences
  - Can timing be related to changes in data sources etc?



Questions

- Do we believe the 20CR for upper tropospheric and stratospheric jetstream winds?
  - Is satellite data causing the other reanalyses to get it wrong?
    - What satellite data?
      - Temperature soundings
      - Cloud drift winds





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More questions

- How robust are these results with respect to different realizations?
  - Does relative invariance over time imply stability over realization?
  - Can we use ensembles to tease this out?
- How do we check the validity of reanalysis data?
  - In principle process involves ongoing error monitoring
- Can we link the differences to changes in data sources and dates of implementation?