Methods used at CGAM

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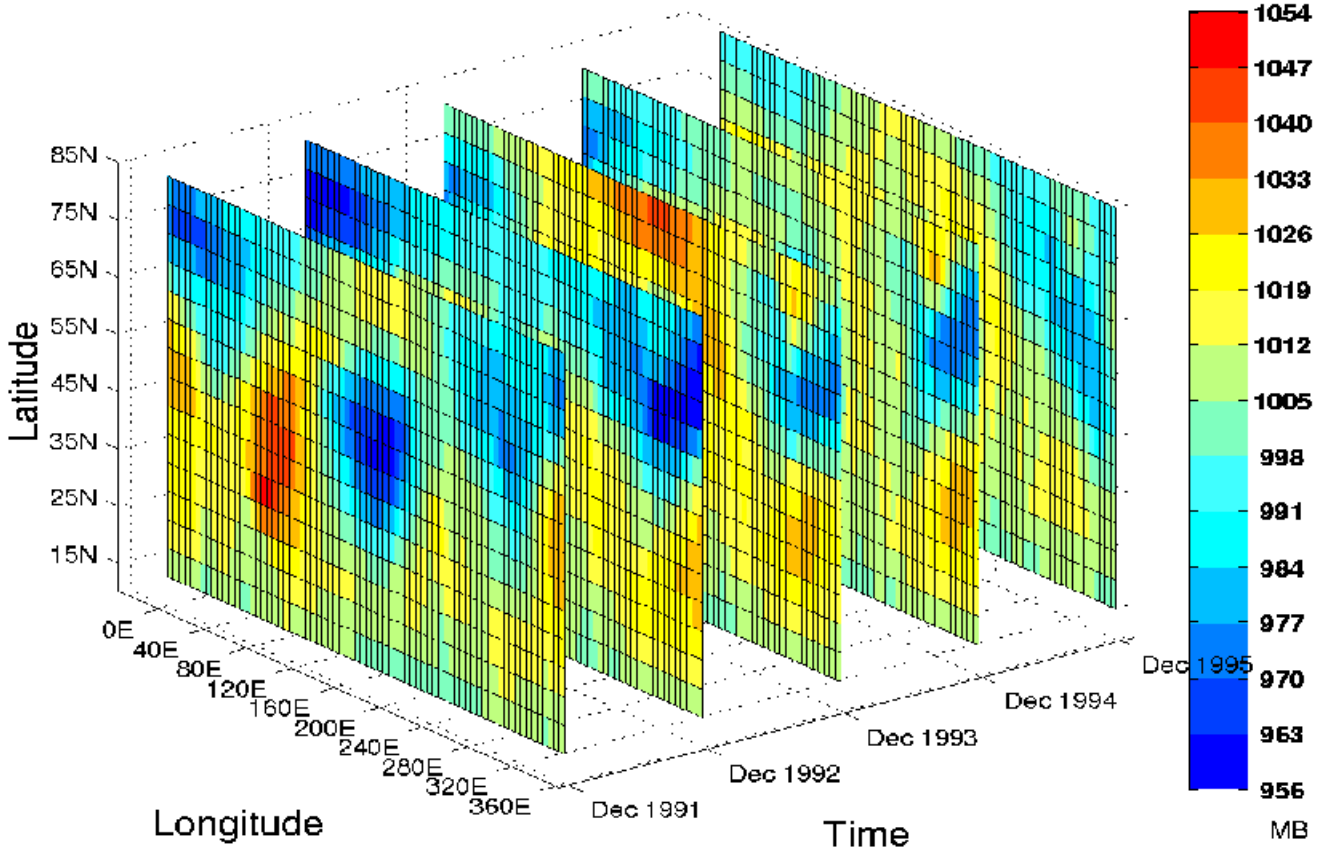
1. Structure of gridded climate data
2. Techniques
3. Software
4. Conclusion

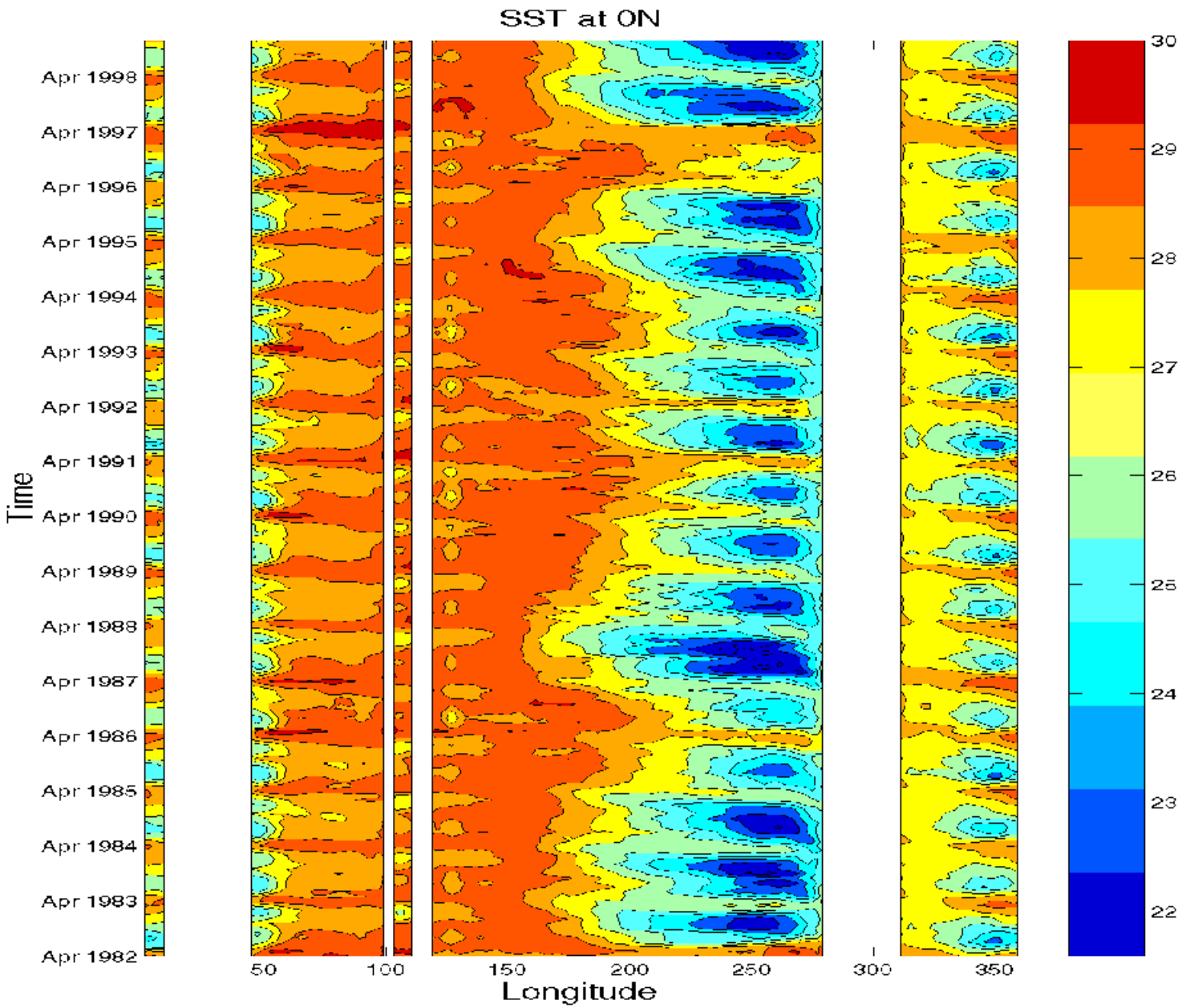
Gridded data sets

Gridded data are weather data interpolated onto a regular space-time grid $X(\lambda_i, \phi_j, t_n)$

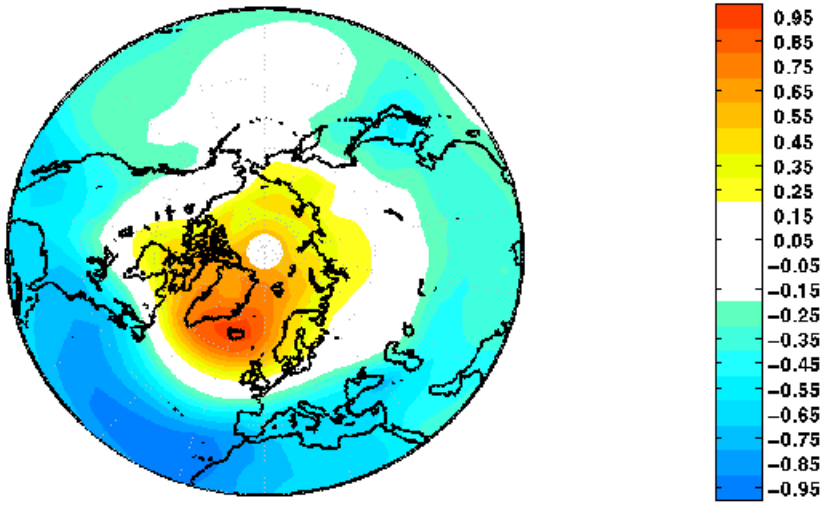


Various plotting techniques

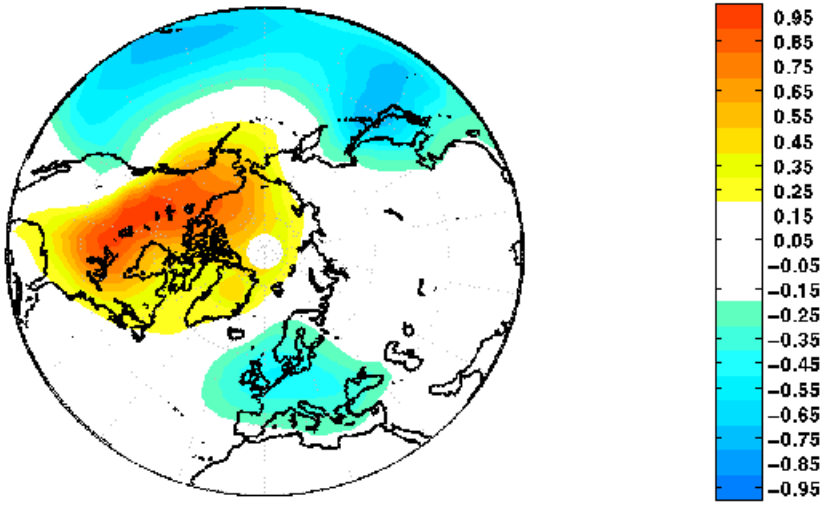
- Time slices
- Hovmoller diagrams
- Animation
- Point correlation


SST at 0N
Time
Apr 1998
Apr 1997
Apr 1996
Apr 1995
Apr 1994
Apr 1993
Apr 1992
Apr 1991
Apr 1990
Apr 1989
Apr 1988
Apr 1987
Apr 1986
Apr 1985
Apr 1984
Apr 1983
Apr 1982
50
100
150
200
250
300
350
Longitude
30
29
28
27
26
25
24
23
22

Point correlation: MSLP



(65N,20W)



(50N,100W)

Various eigen techniques

- Empirical orthogonal function (EOF) analysis

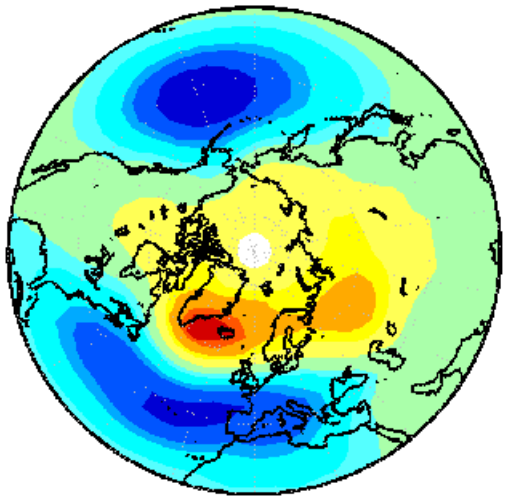
$$X(t,s) = \sum_{k=1}^{\text{rank}} e_k(s)\tilde{X}_k(t)$$

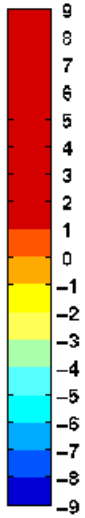
EOFs

PCs

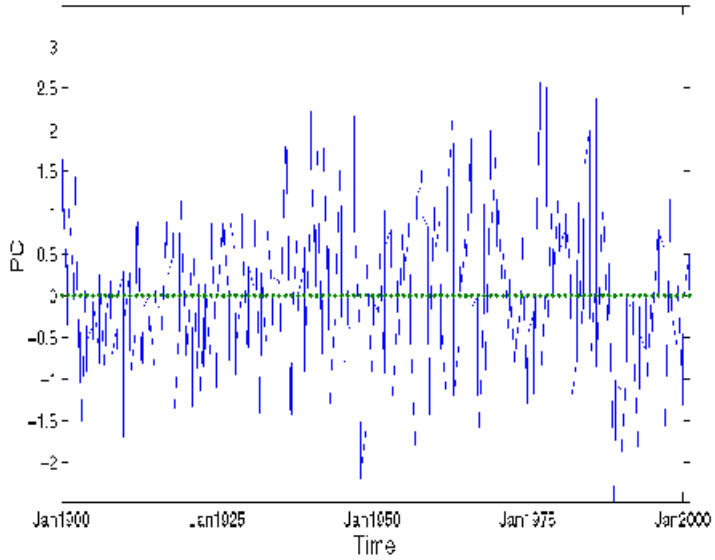
- Rotated EOFs: based on minimising some criteria
- Complex EOFs
- Canonical Correlation analysis (CCA): looks for maximum covariance between 2 fields X and Y.

MSLP: EOF1 (19%)

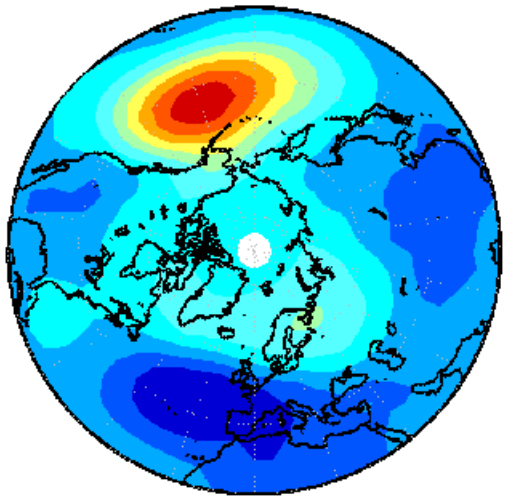


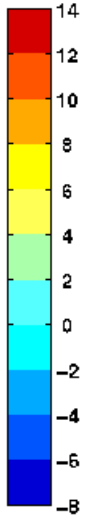


MSLP: PC1

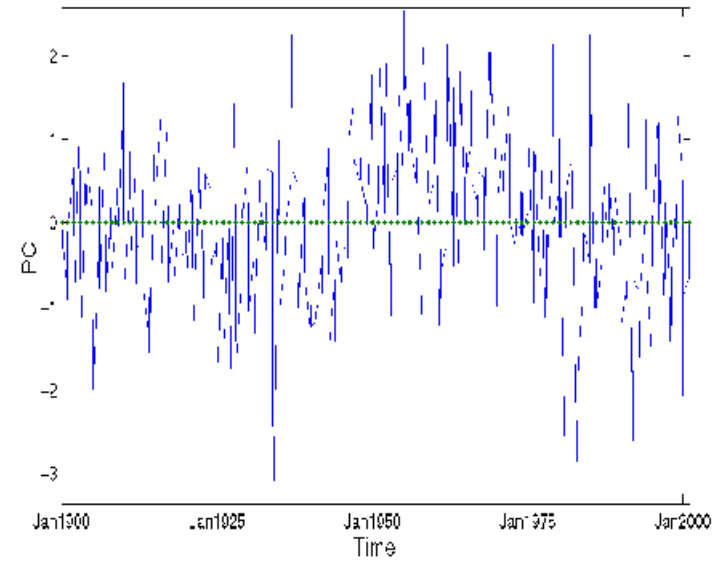


MSLP: EOF2 (14%)

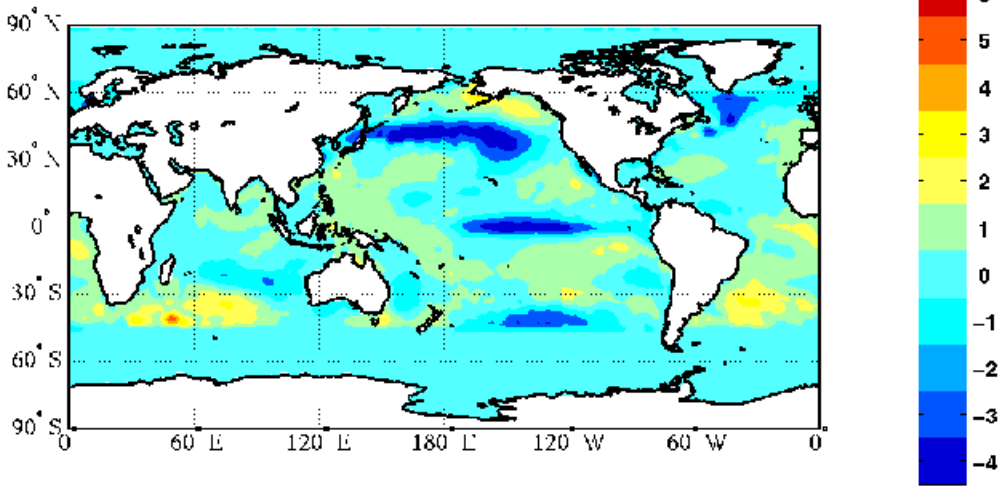




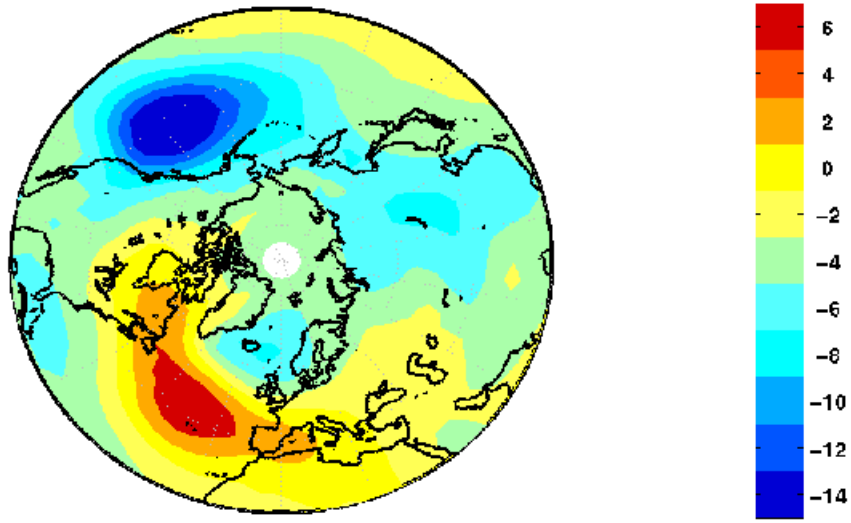
MSLP: PC2



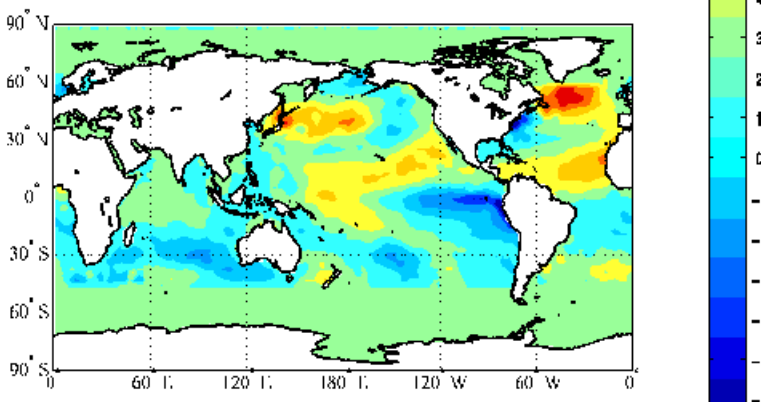
CCA: SST Pattern 1

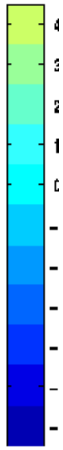


CCA: SLP Pattern 1

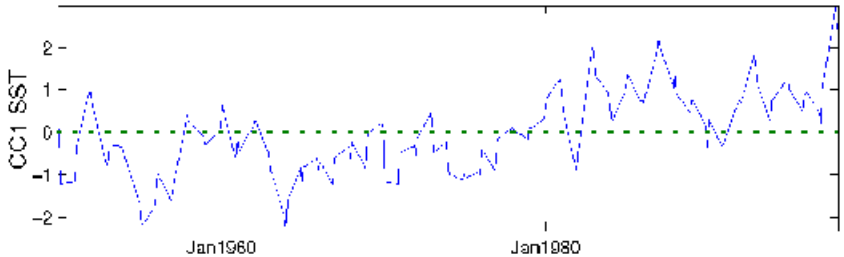


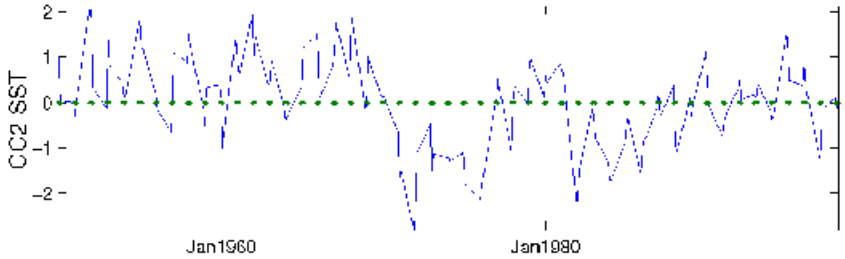
CCA: SST Pattern 2



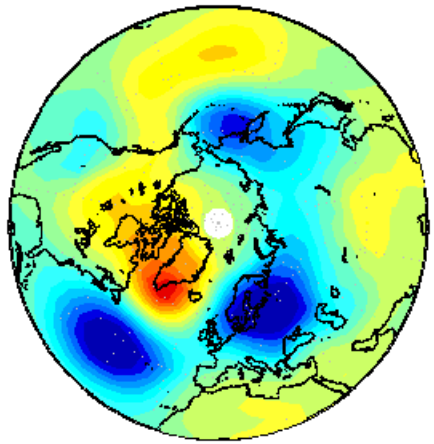


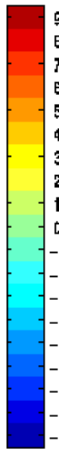
CC TIME SERIES

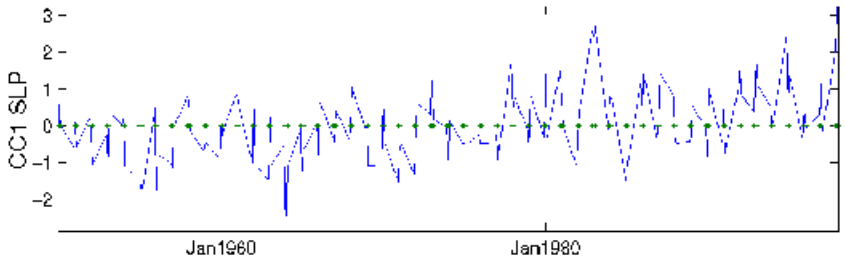


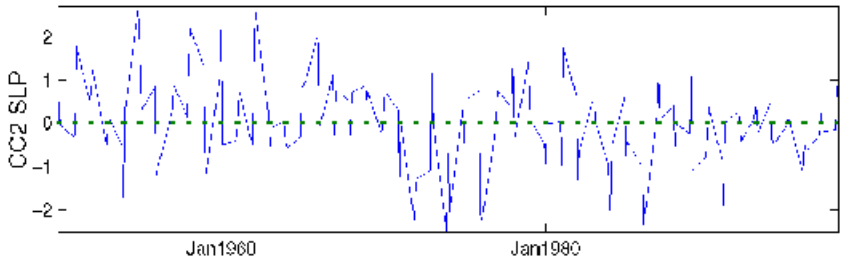


CCA: SLP Pattern 2



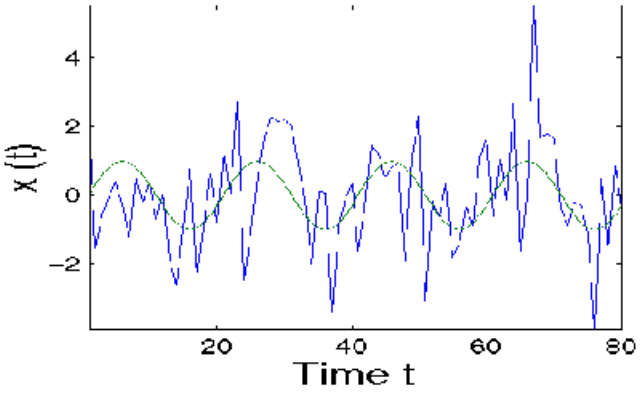


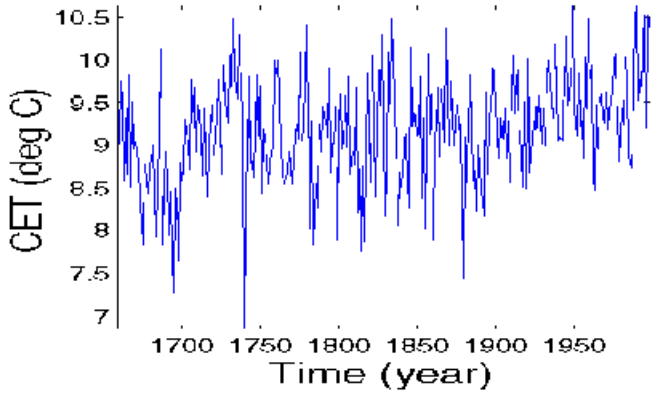


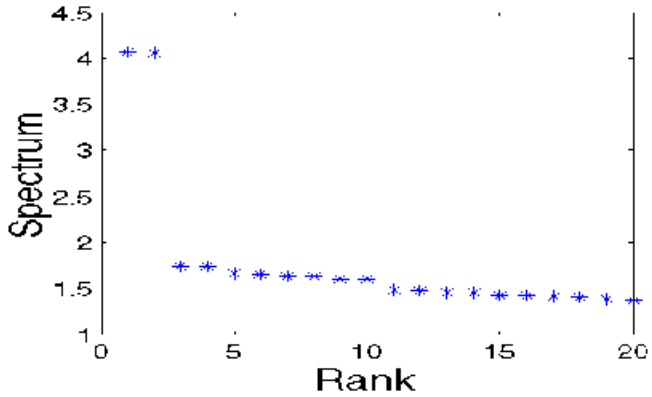


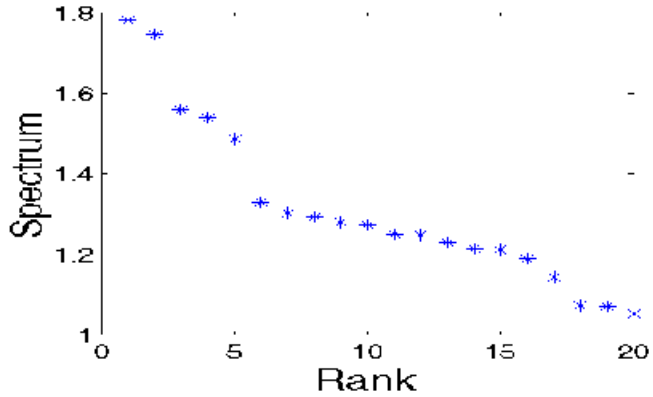
Spectral and other techniques

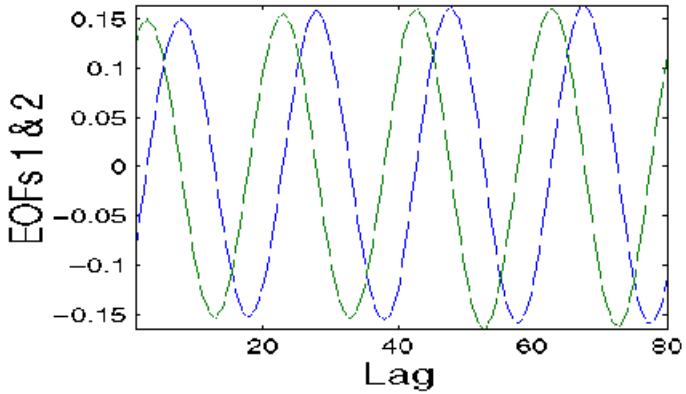
- Singular system analysis (SSA): looks for (intermittent) periodic signals and uses (time) delay coordinates.
- Other time filtering analyses: moving average, Lanczos filters.
- Spectral techniques: Fourier spectra, space-time spectra, wavelets.

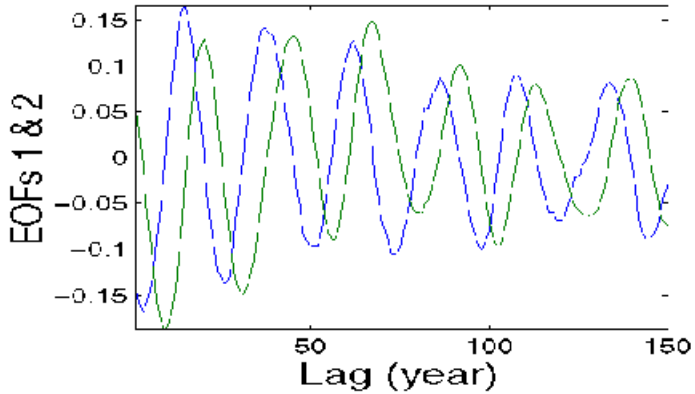

x (t)
Time t

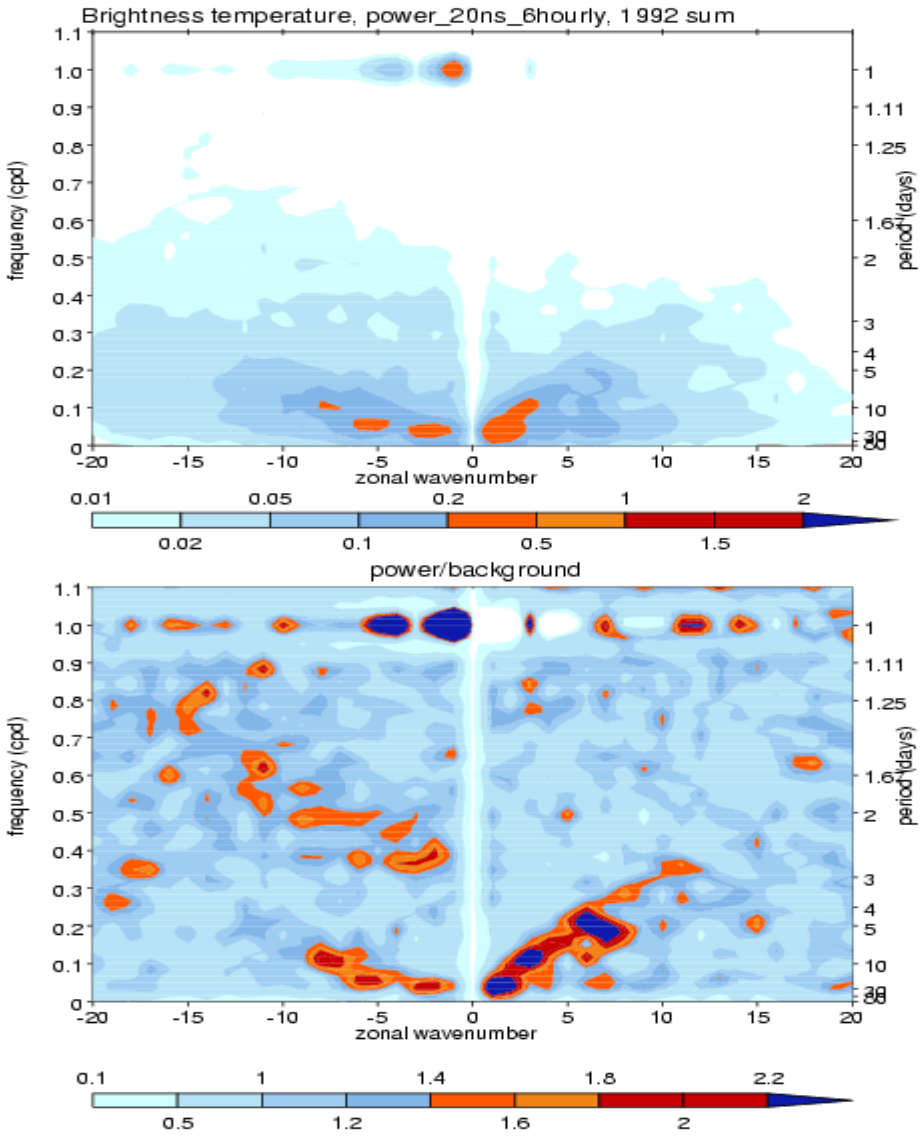

CET (deg C)
Time (year)


Spectrum
Rank


Spectrum
Rank


EOFs 1 & 2
Lag


EOFs 1 & 2
Lag (year)


Brightness temperature, power_20ns_6hourly, 1992 sum
frequency (cpd)
period (days)
zonal wavenumber
0.01
0.05
0.2
1
2
0.02
0.1
0.5
1.5
power/background
frequency (cpd)
period (days)
zonal wavenumber
0.1
1
1.4
1.8
2.2
0.5
1.2
1.6
2

Techniques used at CGAM

Format 4D data

- **GRIB (WMO)**
- **NETCDF**

In house (Fortran) tailored to models : ugamp.nerc.ac.uk

- **UM mean routine**
- **UMAP (for Um outputs, ERA40)**
- **SUMO**

Commercial

- **MATLAB**
- **METVIEW (ECMWF)**
- **IDL (statistics)**
- **S+**

Free

- **GRADS**
- **FERRET**

Conclusions

Challenges: Data mining (4D, non-linear, multivariate) + DA +
+ Satellites + coupled climate system + Monte-Carlo .

Tools: Available! Time series, EOF, Optimal detection, SSA

Issues: - Technical (Petabytes).
- Marketing (Knowledge management).

Vision for the future

GRID + WEB SERVICES = MORE EFFECTIVE WORK

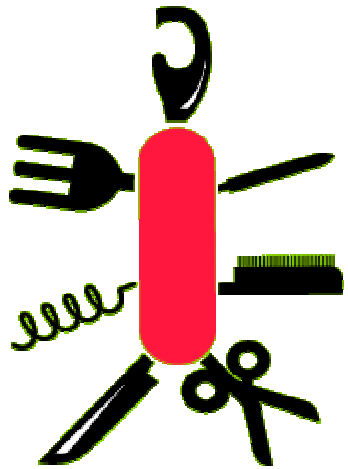
- **Web:** Harness computer time + data base + Remote use.

- **Browser**: User-friendly + Doc + Multi-platform + KM.

- **Applets:** Standard + Less bug (open source) + Transparent.

- **Live Access Data server**: XML + embedded visualisation.

- **Reality?** www.noa.cdc.gov (composite, correlation, ….)
  climate explorer knmi, CDC (google)



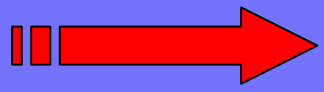
I-1. What is “climate analysis”?

Climate

the long-term statistical properties

of the state of the atmosphere

“The climate is what we expect, but the weather is what we get” (Ed Lorenz, 1970.)

Data  **Knowledge**

Analysis

Structure of climate data

Characteristic: large dimensions

$$\mathbf{x} = \begin{bmatrix} x\,(t=1, s=1) & \cdots & x(t=1, s=D) \\ & \cdots & \\ x(t=n, s=1) & \cdots & x\,(t=n, s=D) \end{bmatrix}$$

I-3. Space-time data brick