Statistical Analysis for High Resolution Data Assimilation: Falklands Campaign 2000/2001

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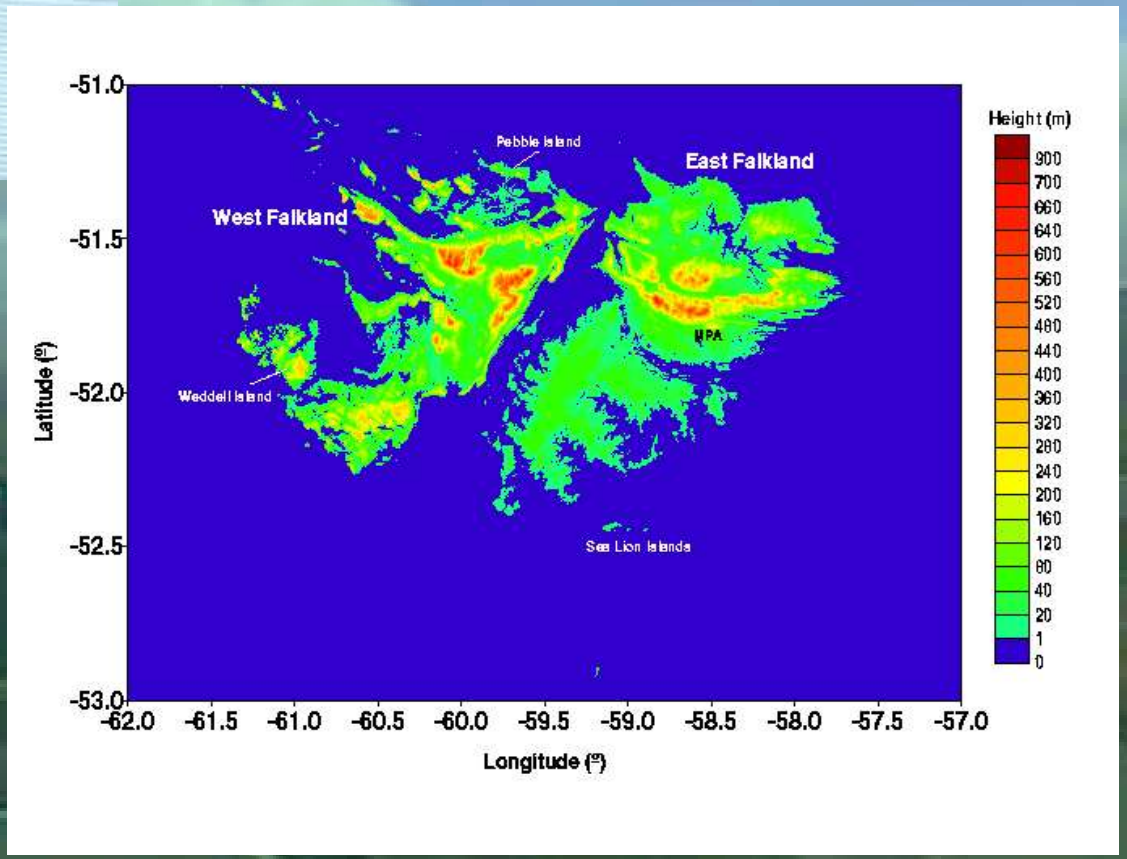
Mount Pleasant Airport – East Falkland Island

- 3d VOM model developed by Simon Vosper of Met Office/University of Leeds
- Accuracy limited by lack of sophistication in boundary layer processes
- Better understanding of these together with development of data assimilation scheme offers scope for performance enhancement
- No currently operational scheme viable for application to this model

Falklands Campaign - 2000/2001

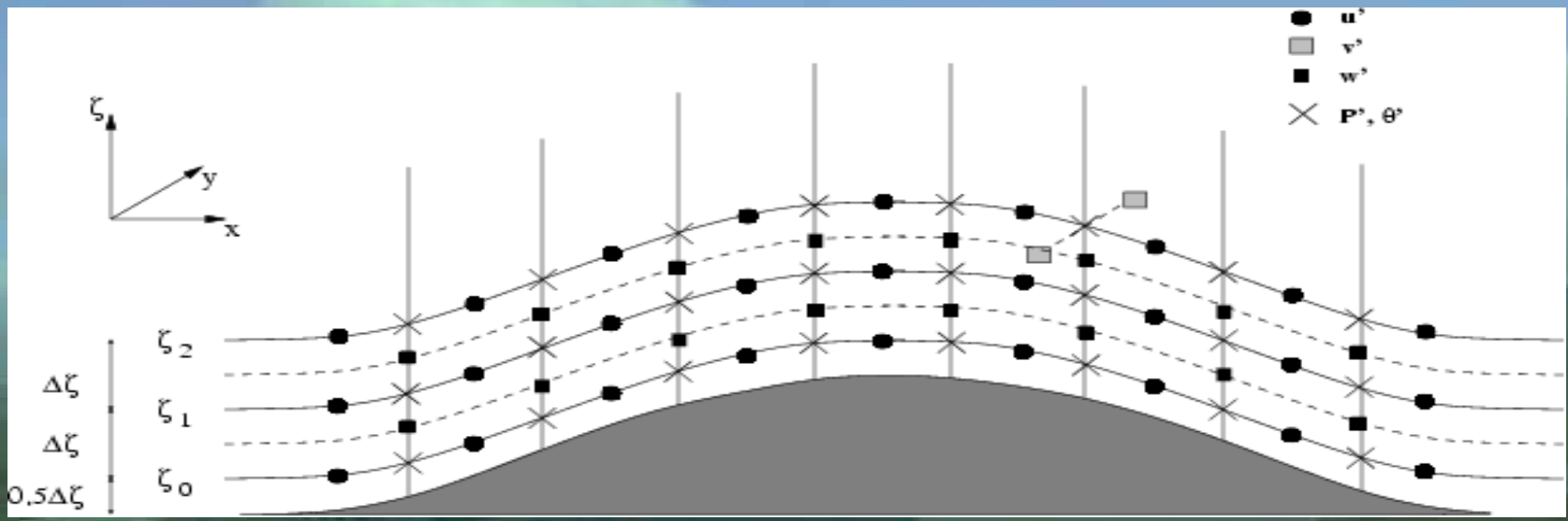
- 20 Automatic weather stations
- Majority clustered around airport
- Remainder in rough north-south transect of island
- Logged data at 30 sec averaged intervals
- Experiment ran for a full year



- Introduce observationally derived nudging constraints to model
- Reasonably straightforward as 3D Vom is a linear model ∴ no requirement for calculation of adjoint matrix
- Nudging terms in model equation present in each iteration of model run – not simply a case of adjusting initialisation step
- Model will run to alternative steady state

3d VOM Schematic

- Terrain following
- Linear model for flow over hills
- Initialised with upwind radiosonde data
- Real orography data set
- 100m resolution in *x* and *y*



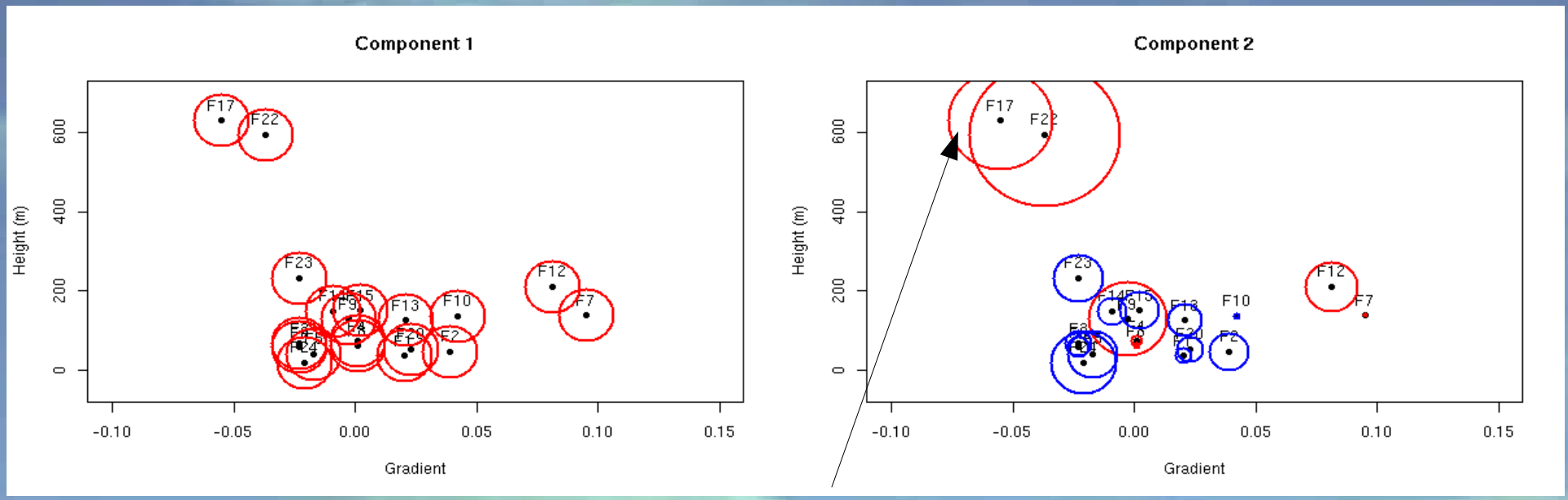
Schematic diagram illustrating the computational grid and the location of the variables on the staggered mesh. Lowest grid level occurs at one half of a grid length above the hill surface.

- To facilitate assimilation step, must understand spatio-temporal behaviour of near surface data
- High-density temporal data yields strong station-wise autocorrelation (AR*(p)* processes)
- Spatially sparse data, experimental design and turbulent system means no obvious spatial correlation between observation sites
- Standard interpolation/Kriging techniques not feasible
- PCA (aka EOF) technique applied to observational data to help determine underlying spatial/temporal patterns

Principal Component Analysis

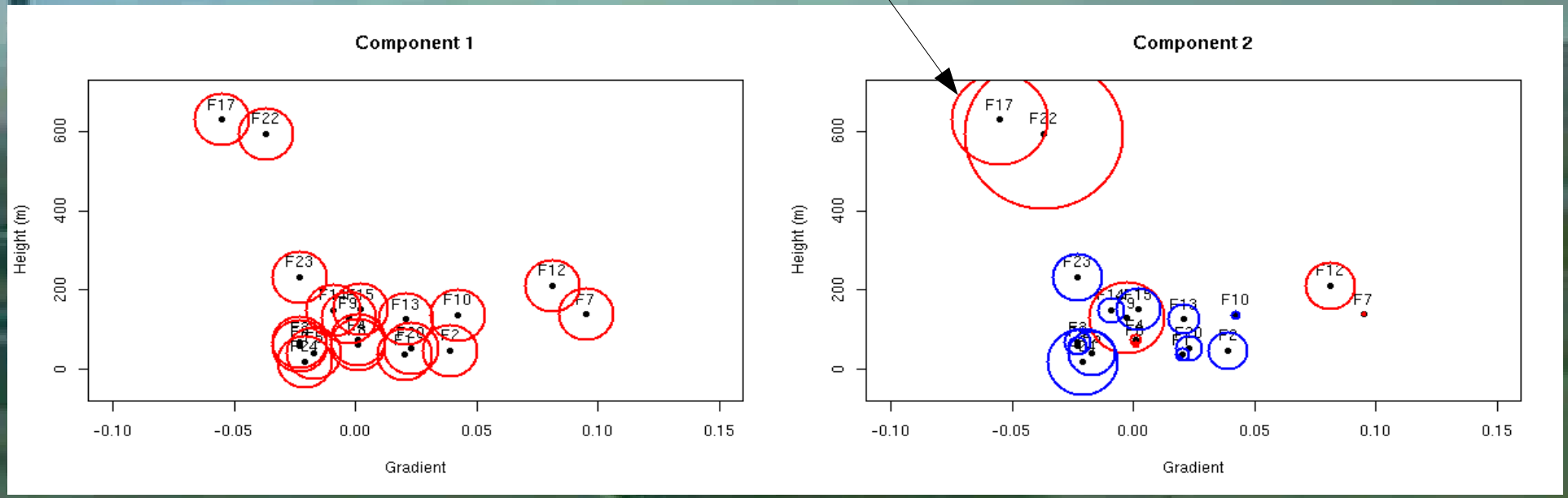
- Objective method for determining underlying trends in data
- May be used as data reduction technique whilst retaining most of variability in data set
- Examines variance associated with principal orthogonal components of a time series in both spatial and temporal formats
- Components representing small proportion of cumulative variance can still provide great insight
- Provides an alternative to the fast Fourier Transform

Raw Data – 10 minute averaged

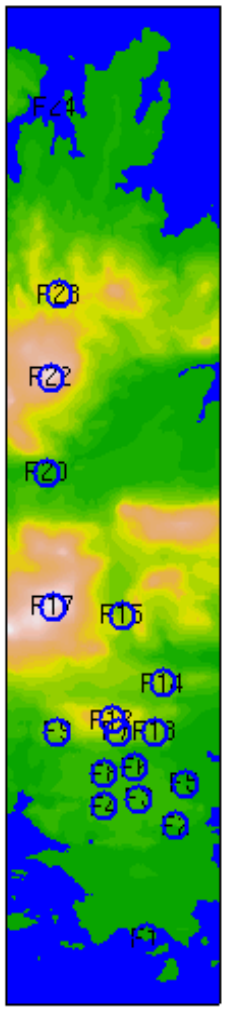


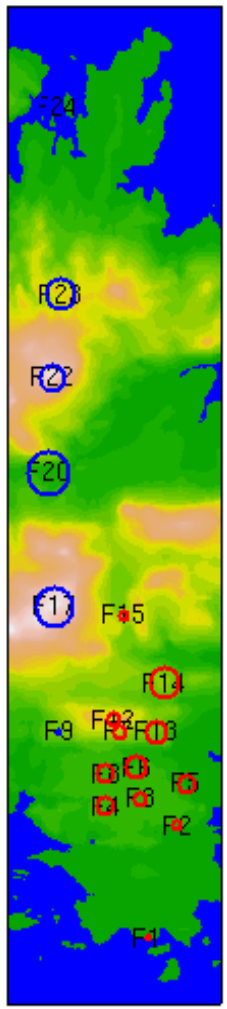
tiny variations just about visible

Hydrostatically Corrected Data – 10 minute averaged



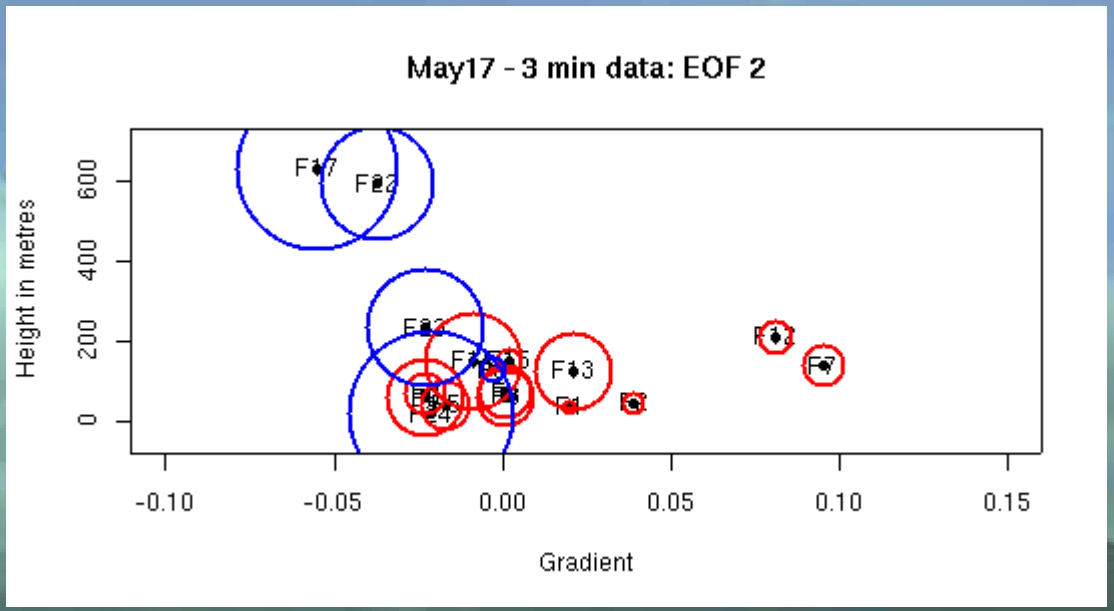
Case Study: May 17 – no rotor activity





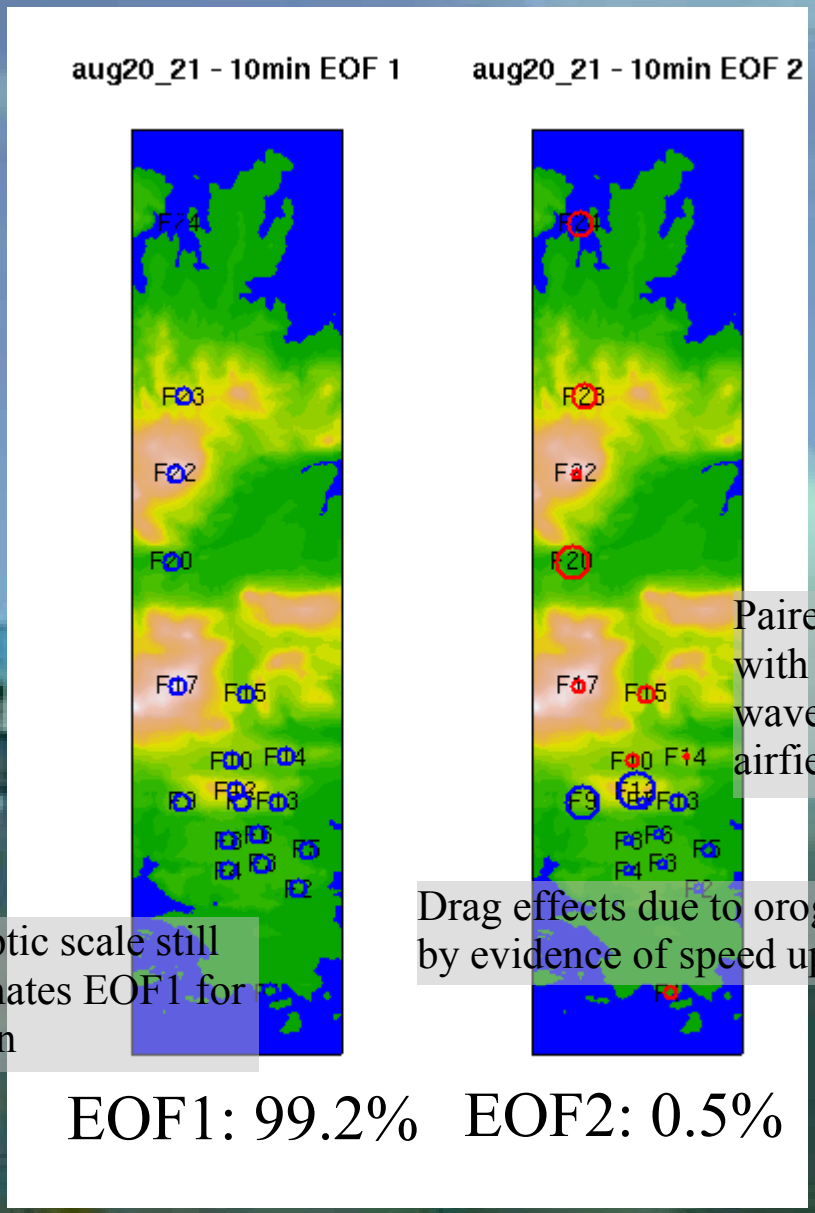
10 min vs 3min almost identical

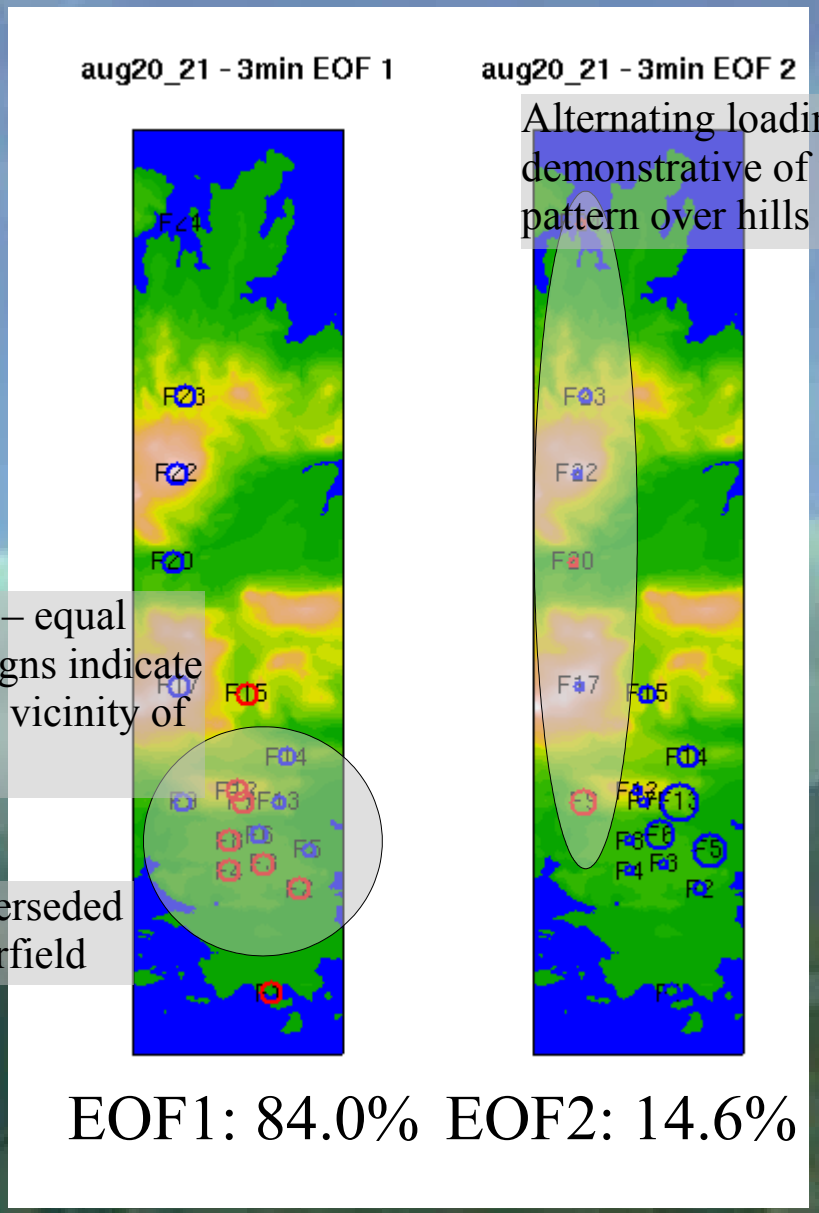
EOF 1: 98.5% of variance
Constant throughout field – indicative of steady synoptic scale flow



EOF 2: 1.0% of variance
On first inspection appears driven by east/west split. Mapping onto alternative axes reveals driven by gradient. Represents the drag acting on the system.

Case Study: Aug 21 – downslope windstorms





Alternating loadings demonstrative of wave pattern over hills

Paired loadings – equal with opposite signs indicate wave activity in vicinity of airfield

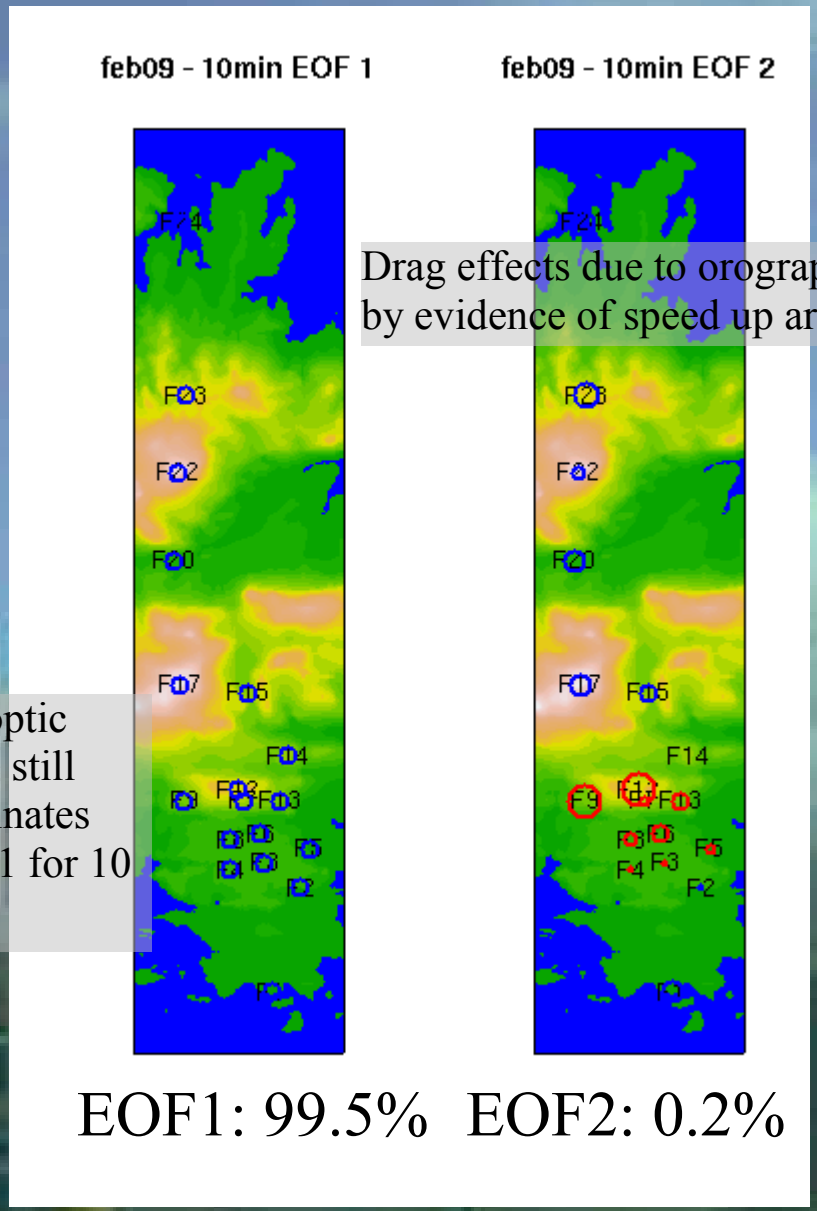
Drag effects due to orography superseded by evidence of speed up around airfield

Synoptic scale still dominates EOF1 for 10 min

EOF1: 99.2% EOF2: 0.5%

EOF1: 84.0% EOF2: 14.6%

Case Study: Feb 09 – rotors, downslope windstorms

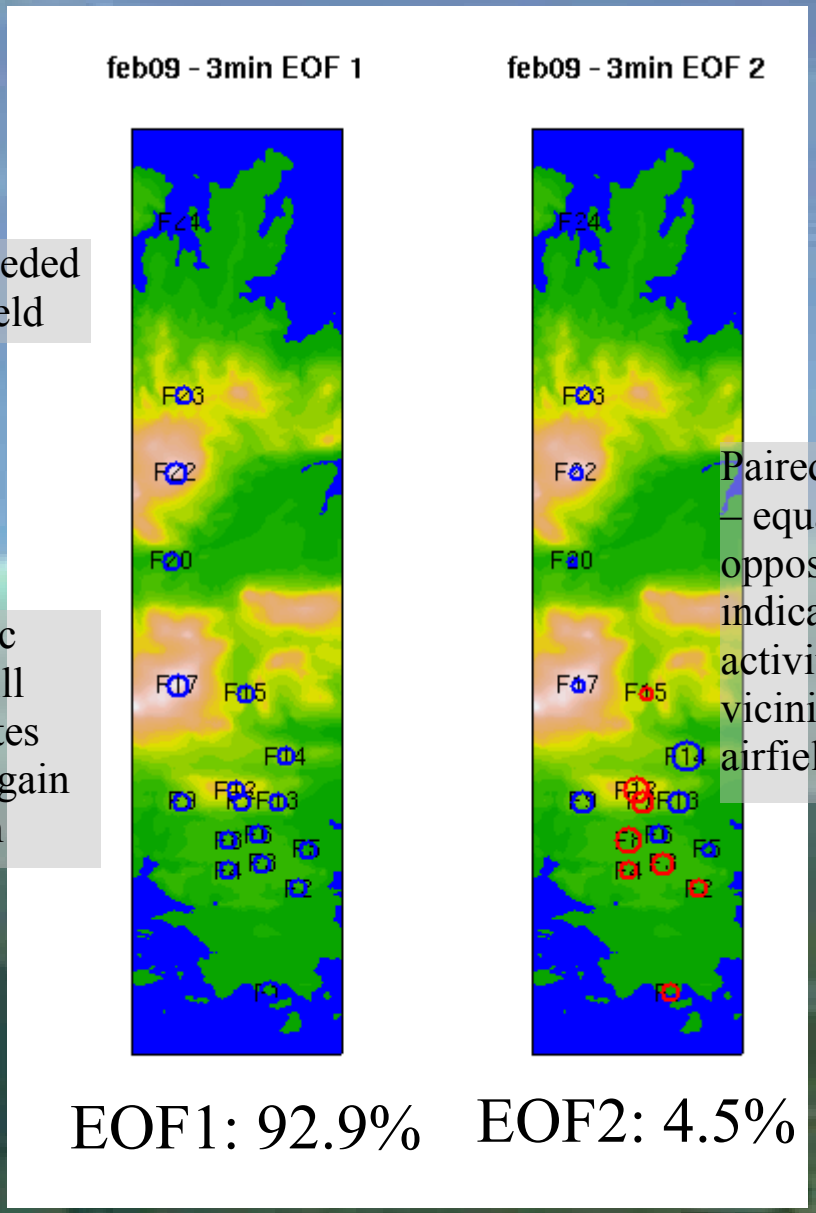


Drag effects due to orography superseded by evidence of speed up around airfield

Synoptic scale still dominates EOF1 for 10 min

EOF1: 99.5%

EOF2: 0.2%



Synoptic scale still dominates EOF1 again at 3 min

Paired loadings – equal with opposite signs indicate wave activity in vicinity of airfield

EOF1: 92.9%

EOF2: 4.5%

- Similar analysis performed on 3d VOM model output (*see poster D13*)
- Cross comparison key in providing information regarding position of wave structures – correcting phase shift would dramatically improve model performance
- Assimilation will occur via perturbation of lower boundary conditions
- Model mesh points in close proximity to observation sites will be forced toward observations
- Perturbation relaxed to zero away from region of influence

Summary

- PCA saves pre-processing of data (negates need for hydrostatic correction)
- Used as diagnostic tool – threshold values for EOF1 (~95%) used to identify turbulent events
- Even when representing a small proportion of cumulative variance, can still be extremely significant
- EOF2 in non-turbulent conditions represents drag on system – opportunity for spatial modelling
- EOF2 gives strong indication of speed up and wave propagation - “fingerprint” for rotor events
- PCA of different time averaged data sets gives insight into temporal variation of events
- Combine observational PCA with model output PCA to facilitate assimilation step


Thank you!