INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
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R&D SHOWCASE 2021

VALIDATION OF KRIGING TO UNDERSTAND TEMPERATURE PROFILES IN THE EVENT OF VOLCANIC ERUPTION TO IMPROVE NWP MODEL GRADIENTS

ABSTRACT

Defining spatial distribution of airborne volcanic ash, in the neighborhood of an erupting volcano, is a synoptic scale problem impacting lives. Robust algorithms are needed to model such natural phenomenon from sparse field data without false positives. Spatial analysis is a multidisciplinary field aimed at analyzing diverse geographic data. Spatial interpolation techniques, like Kriging, based on geostatistics generate probabilistic predictions/error surfaces. In this study, ash temperature values sampled using flights during an Icelandic eruption in 2010 were kriged using a stochastic method, known as Empirical Bayesian Kriging to model the dispersion. Distances computed from location data and temperature values were spatially autocorrelated using semivariograms. Block averages were accurate upto 90% when validated against NCEP, a Numerical Weather Prediction model.

DATA & METHOD

Data collected using BOMEM Michelson interferometer on four days (May 14, May16, May 17, May 18) above Europe. Coarse grid sizes used in NWP models, such as NCEP do not accurately represent the state of the atmosphere. Kriging is a weighted average technique that assigns higher weights on nearby observations, based on the distance and direction. It involves, generation of semivariogram which expresses the rate of change of regionalized variable w.r.t. different distance bands. Using Linear Mixed Model framework in a Bayesian context, clusters are modelled using EBK. This method treats structured drift, spatial variations and errors separately. EBK produces surface outputs for prediction by fitting different transitive functions. 1 degree x 1 degree grids to compare estimates predicted by EBK block averages against NCEP. Global mean is around ~243K, which is around 10K lesser than NCEP average. (Fig – i)

VALIDATION

- RMS Standardized was less than 1 (0.938776) and Mean Square was unbiased (0.018348).
- EBK profile reveals a steady decrease in temperature as the distance from the vent gradually increases, as observed in the sampled inputs. (Fig – iv)
- Variations observed in input data against the predicted data where samples of 14th May were located are mapped (Fig –ii)
- For 3 hour forecast of normal weather, the measure of success for prediction of temperatures is defined by UK Met Office to be within ±2º C, 92% of the time it is reported. The smallest size of the grid cell achieved for this study site with kriging is 4x2/2x4 units. The error range for this zone is found to be between 0K-2K. With EBK, the defined success rate is achieved for a spatial resolution as low as 2km x 4km.

RESULTS

To arrive at Go/No-Go Zones, the point prediction map generated using EBK was compared against NCEP values. NCEP has a narrow temperature range of 251.4K-253.9. Regions with same range of observations are highlighted with green (~247K to ~254K). Areas with gradual variations in orange reveal EBK underestimations/overestimations against NCEP (±25K) while regions with red depict significant overestimations in comparison against NCEP (~+40K). Fig –(iii) & (v)

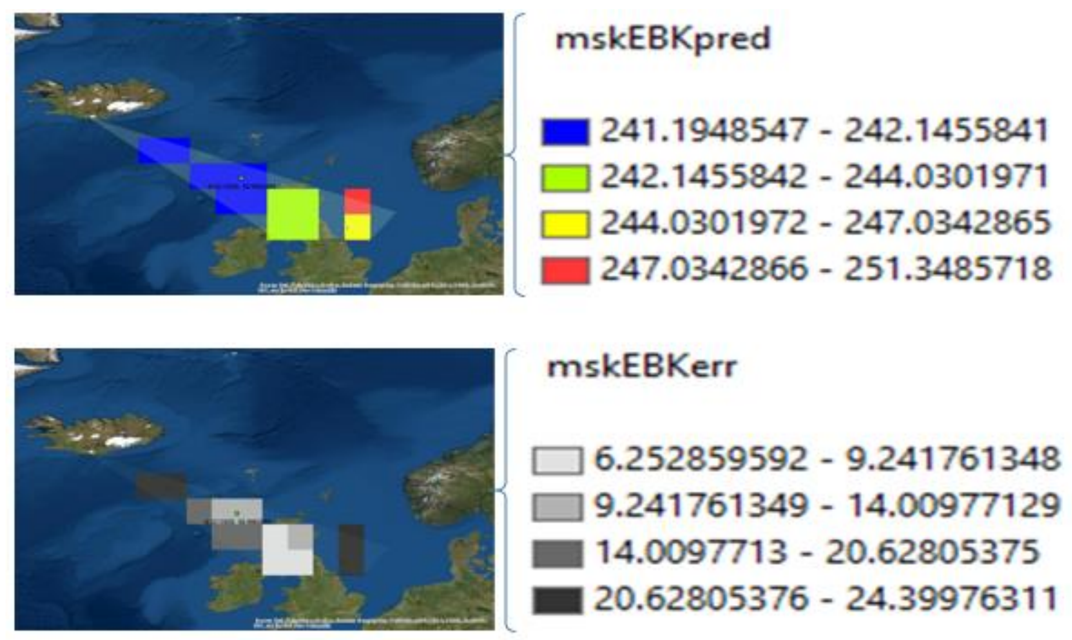

Fig (i)

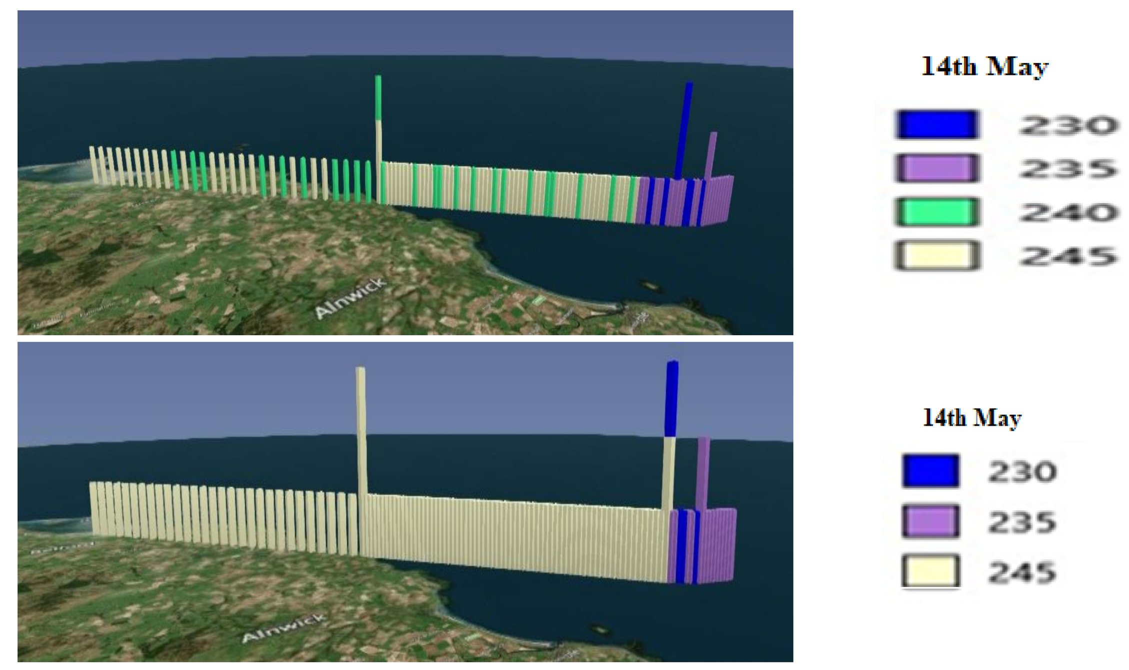

Fig (ii)

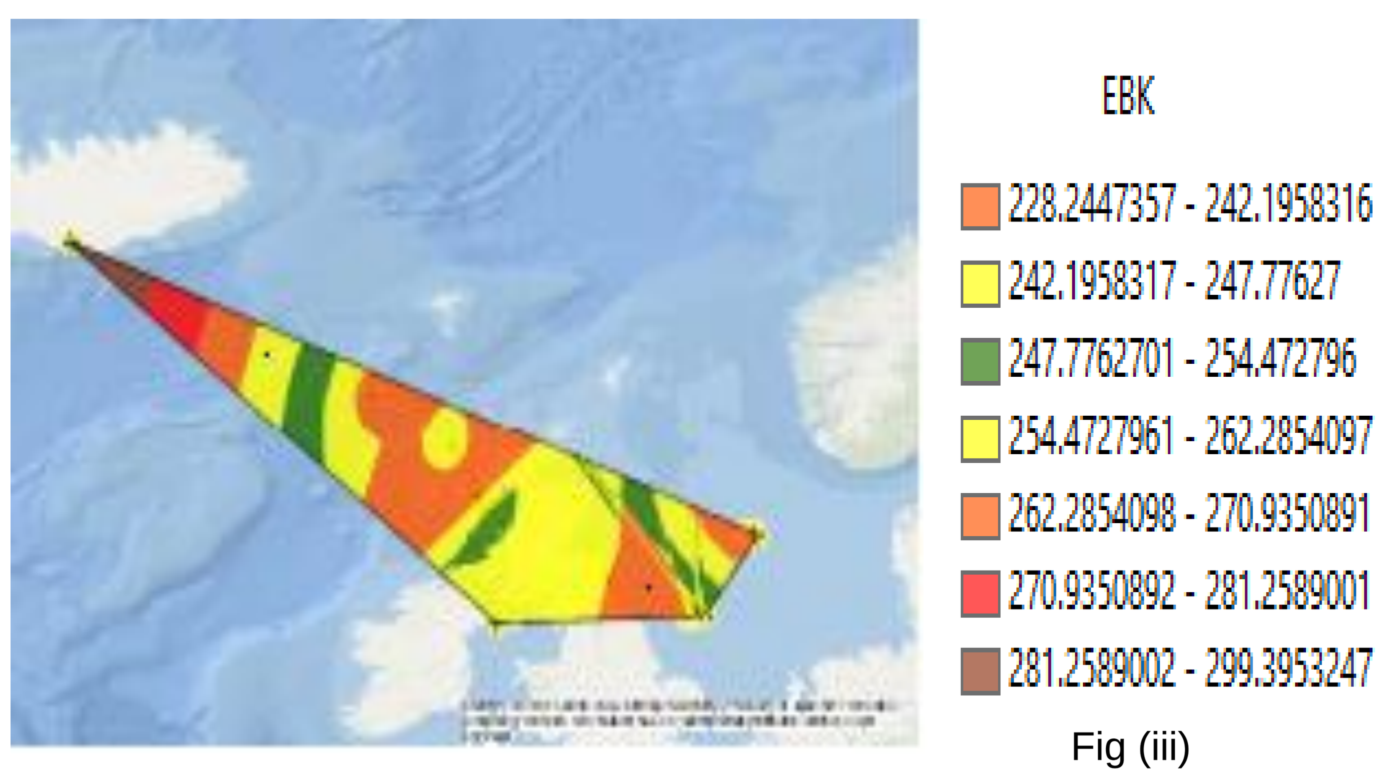

Fig (iii)

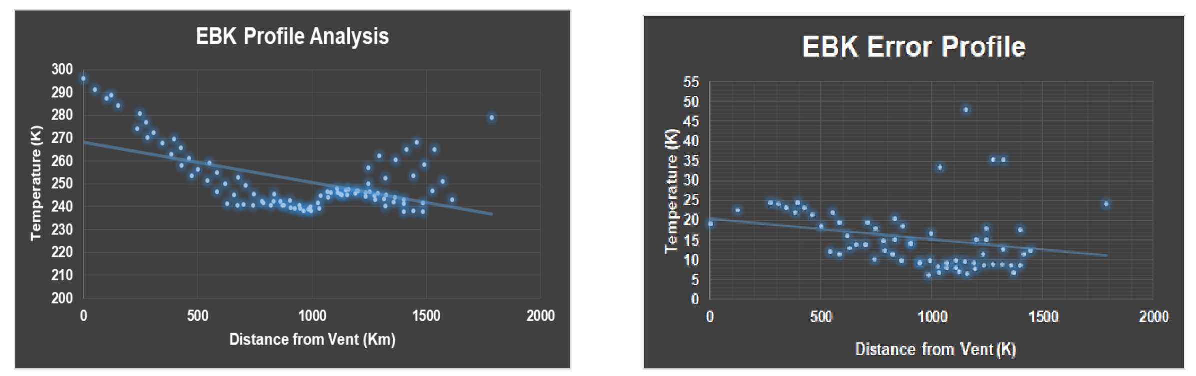

Fig (iv)

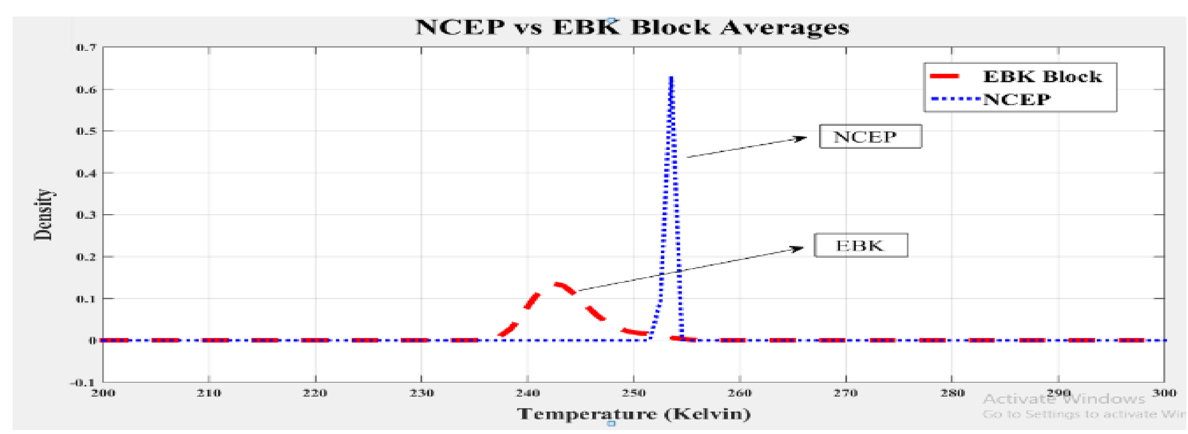

Fig (v)

APPLICATION

In aerospace industry, this can aid in detection of potential ash laden field as early 20 seconds ahead of time by jet aircrafts in cruising altitude with high airspeeds and wind speed conditions. So, this methodology is highly suited to augment on-board severe weather alert system despite its probabilistic origins and simulation scope. The study can also help to define guidelines for sample data collection during future eruptions to assess the safety of an airspace.

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