

# Belz Lecture 2017: A Bird's-Eye View of Statistics for Remote Sensing Data

5 December 2017

The 2017 Belz Lecture was given by Distinguished Professor Noel Cressie on October 31 at University of Melbourne.

Remote-sensing data offer unprecedented opportunities to address Earth-system-science challenges, such as understanding the relationship between the atmosphere and Earth's surface using physics, chemistry, biology, mathematics, and computing. Statistical methods have often been seen by geophysicists as a hybrid of the latter two, so that a lot of attention has been given to computing estimates but far less to quantifying the uncertainty of the estimates. In my "bird's-eye view," I shall give a way to look at these problems using conditional probability models and three states of knowledge. Examples will be given of analyzing remotely sensed data of a leading greenhouse gas, carbon dioxide.

Noel Cressie is Director of the Centre for Environmental Informatics in the National Institute for Applied Statistics Research Australia (NIASRA), Professor of Statistics, and Distinguished Professor at the University of Wollongong, Australia. He is also Adjunct Professor at the University of Missouri. Cressie received his BSc (Hons) from the University of Western Australia and an MA and PhD from Princeton University, USA. His past appointments have been at The Flinders University of South Australia, Iowa State University, and The Ohio State University. He has published in the areas of goodness-of-fit, statistical modelling, empirical-Bayesian and Bayesian methods, remote sensing, and spatial and spatio-temporal statistics. Cressie is the recipient of the Committee of Presidents of Statistical Societies' 2009 R.A. Fisher Award, of the Statistical Society of Australia's 2014 Pitman Medal, of the Royal Statistical Society's 2016 Barnett Award, and of the Institute for Mathematical Geosciences 2017 Matheron Award and Lectureship. He is a Fellow of the American Statistical Association, the Institute of Mathematical Statistics, and the Spatial Econometrics Association; and he is an Elected Member of the International Statistical Institute.

About the Belz Lecture

The Maurice H. Belz Lecture is an annual lecture established by the Statistical Society to honour the work of Professor Belz in establishing and advancing the science of statistics in Australia. Maurice Belz was the Foundation Professor of Statistics at the University of Melbourne (1955 to 1963).

[Link to the video](#)

from a single footprint's observed radiances  $\mathbf{Y}$

- Data model (called "the forward model" by OCO-2)
 
$$\mathbf{Y} = \mathbf{F}(\mathbf{X}; \boldsymbol{\theta}) + \boldsymbol{\epsilon}$$
 where  $\mathbf{X}$  is the atmospheric state, which includes  $\text{CO}_2$  values at a range of geopotential heights, and  $\boldsymbol{\epsilon} \sim \text{Gau}(\mathbf{0}; \mathbf{S}_\epsilon)$
- Process model (called "the prior" by OCO-2)
 
$$\mathbf{X} \sim \text{Gau}(\mathbf{X}_0; \mathbf{S}_x)$$
- Parameter model (largely absent from OCO-2)
 
$$\boldsymbol{\theta} \text{ is fixed (based on calibration)}$$
 ( $\boldsymbol{\theta}$  includes, e.g., forward-model parameter errors. It should also include uncertainties in  $\mathbf{F}$  and process-model uncertainties.)
- Inference is usually on the state  $\mathbf{X}$ . The predicted state  $\hat{\mathbf{X}}$  is called a retrieval. (Statistical inference on  $\boldsymbol{\theta}$  is de-emphasized.)

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