Current challenges for the assimilation of high resolution data

J.A. Waller and all colleagues and collaborators

Motivation

To forecast at the convective scale we need to assimilate observations at the appropriate spatial and temporal resolution.

There are a wide range of observations that are not fully exploited in convective scale data assimilation:

- Only 5% of available observations are currently assimilated due to large or unknown observation uncertainties

- Potential useful information at very high resolution may be extracted from unconventional sources.
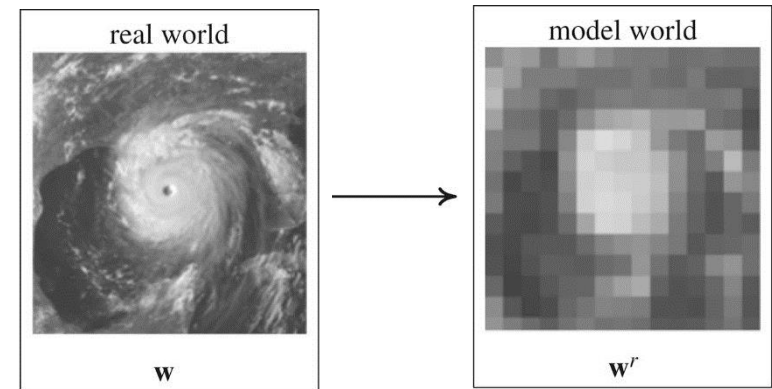
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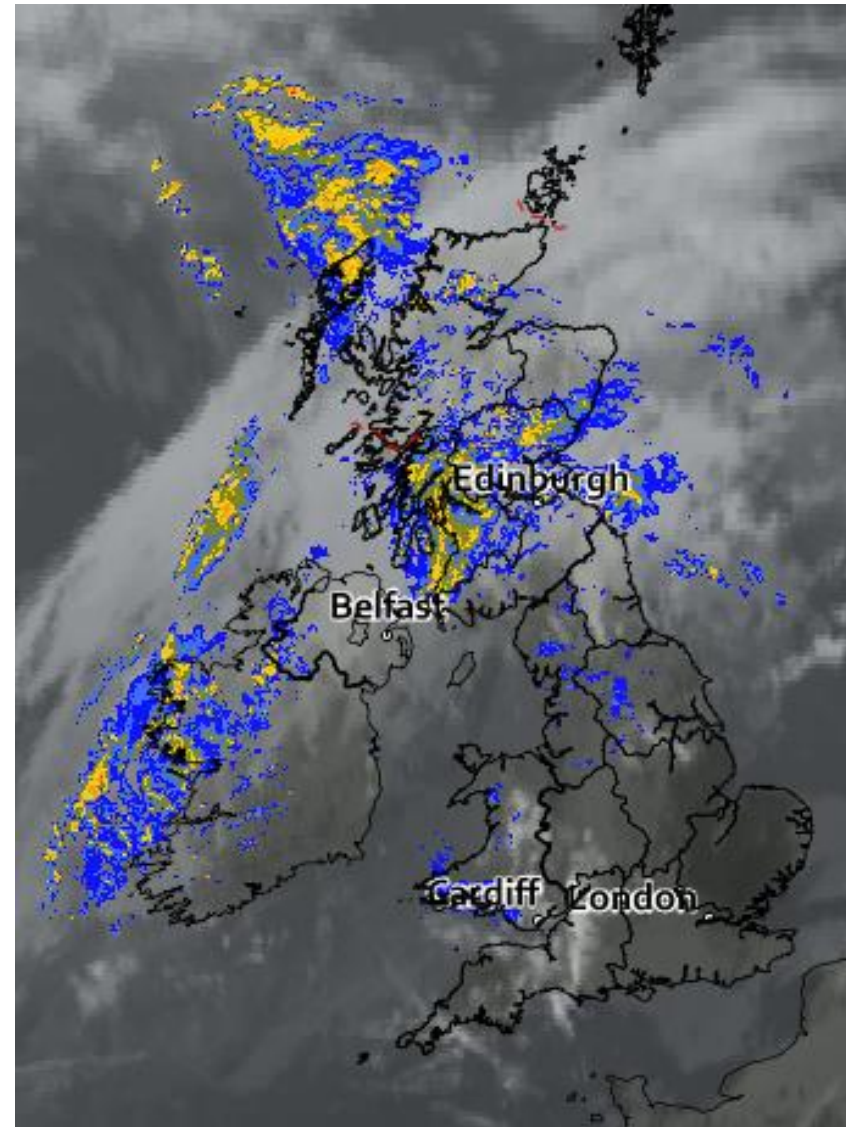
Observation errors

Observation errors arise from four main sources:

Instrument error
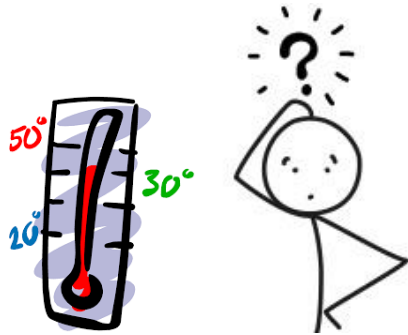
Representativity error

real world

w

model world

w^r

Observation pre-processing

Observation operator error

Beam Top Height

Beam Center
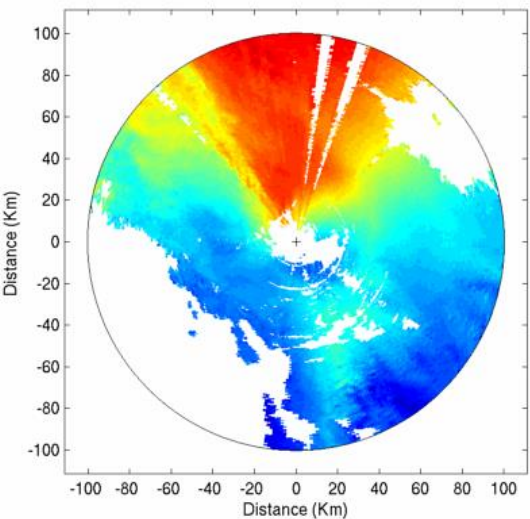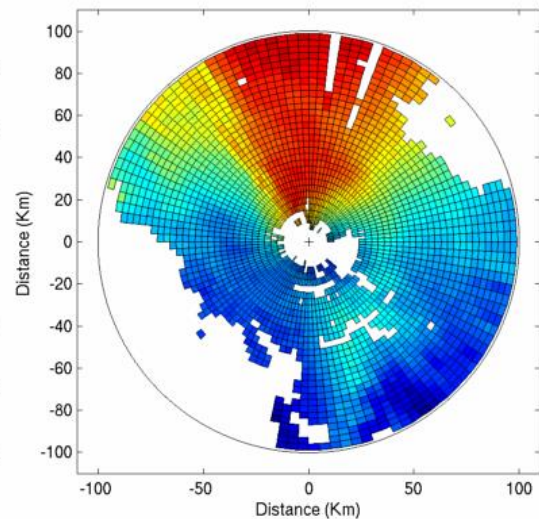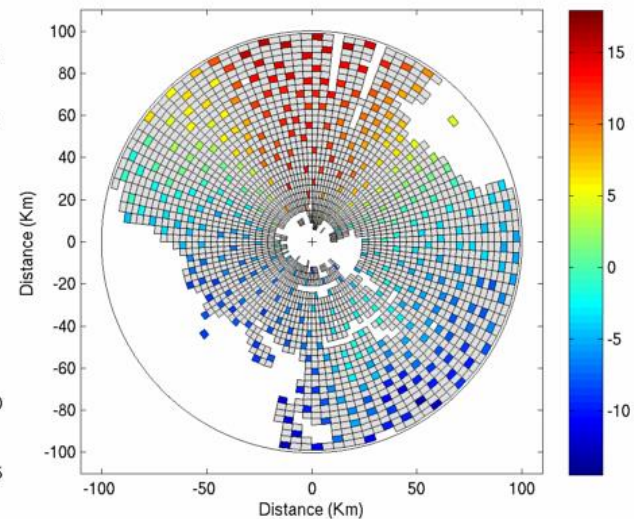
Beam Bottom

1°
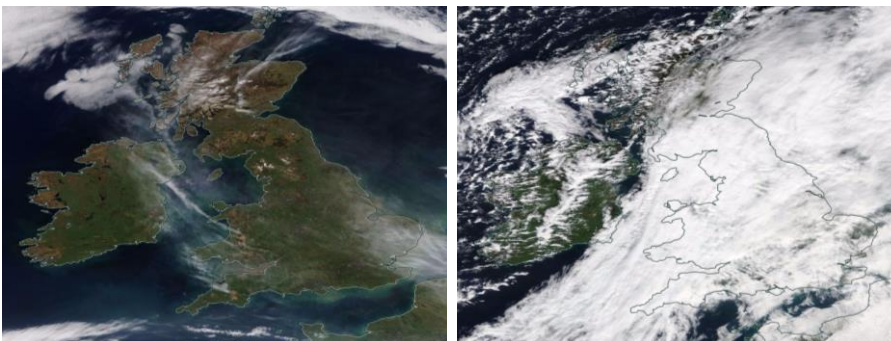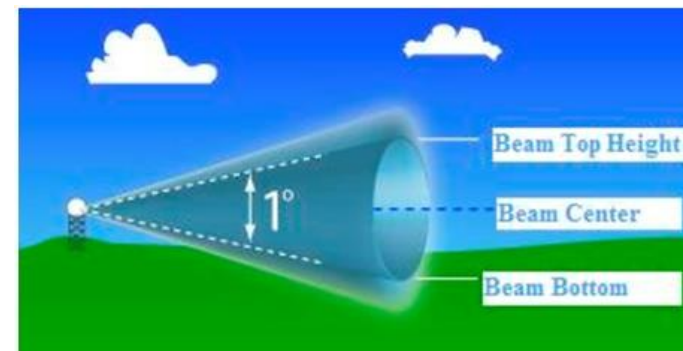
Optimal assimilation

The inability to account for spatially correlated observation errors often results in superobbing and spatial thing of the observations.

Processed raw observations

Super-observations

Thinned super-observations

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Optimal assimilation

Many observation types have correlated errors, e.g.:
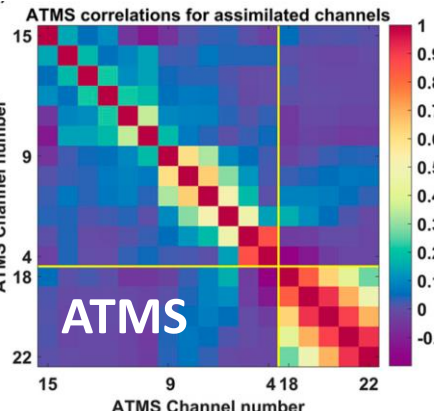
Figure from Campbell et al. 2017

Figure from Bormann et al. 2016

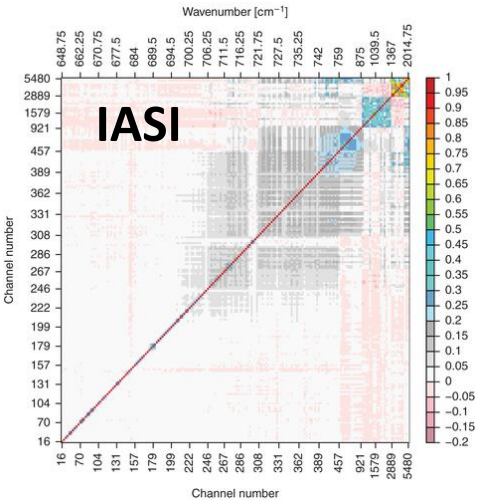Figure from Cordoba et al. 2017
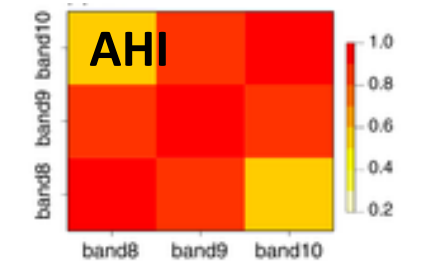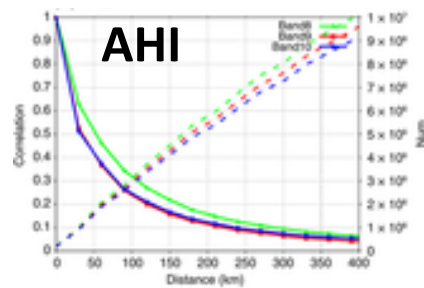
Figure from Okamoto et al. 2019

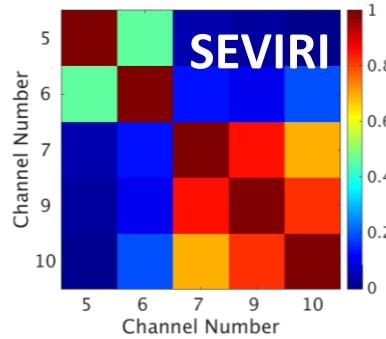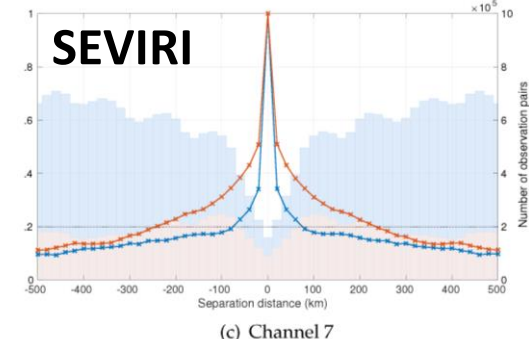

Figure from Waller et al. 2016a

(c) Channel 7
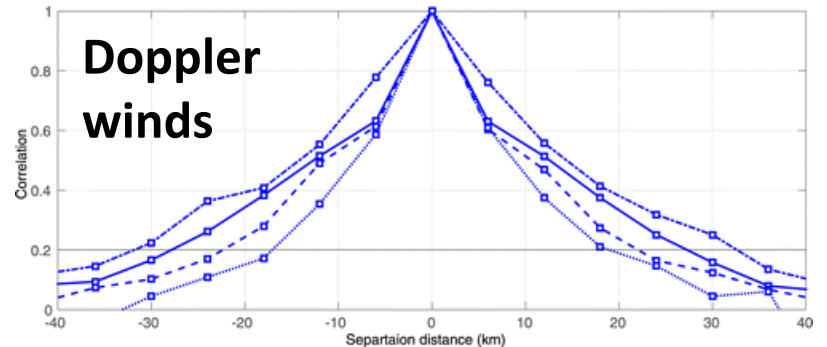
Figure from Waller et al. 2016b

To use more of the available data we must understand the observation error statistics and correctly account for them in data assimilation.

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Optimal assimilation

Observations also not assimilated due to:

- Inability to account for temporal resolution

- Large errors due to highly approximate observation operators

- Non-Gaussianity of observation errors and observation departures

One area where progress has been made if the assimilation of all-sky satellite radiances (Geer et al. 2017). But still only a small percentage of observations are used.
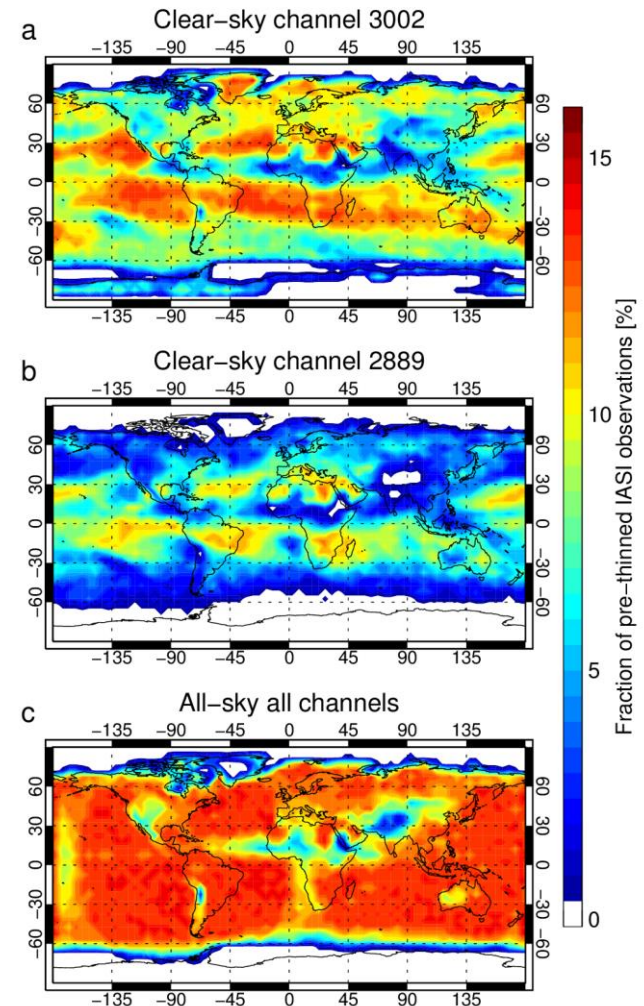
Figure from Geer et al. 2019

Efficient assimilation

Using correlated inter-channel errors :

- Leads to an increase in the analysis accuracy.

- Leads to an increase in the NWP skill score.

- Makes more use of the available data.

Figure from Weston et al. 2014

Bad

Good
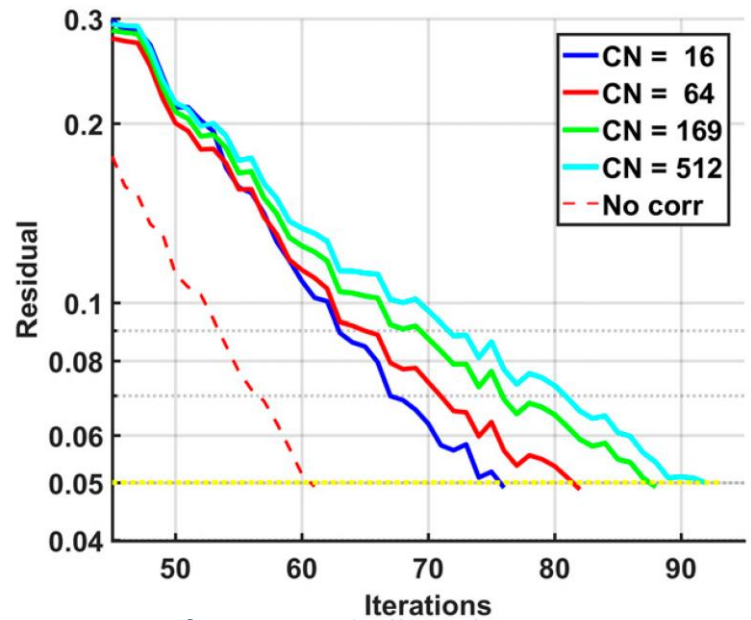
Figure from Campbell et al. 2017
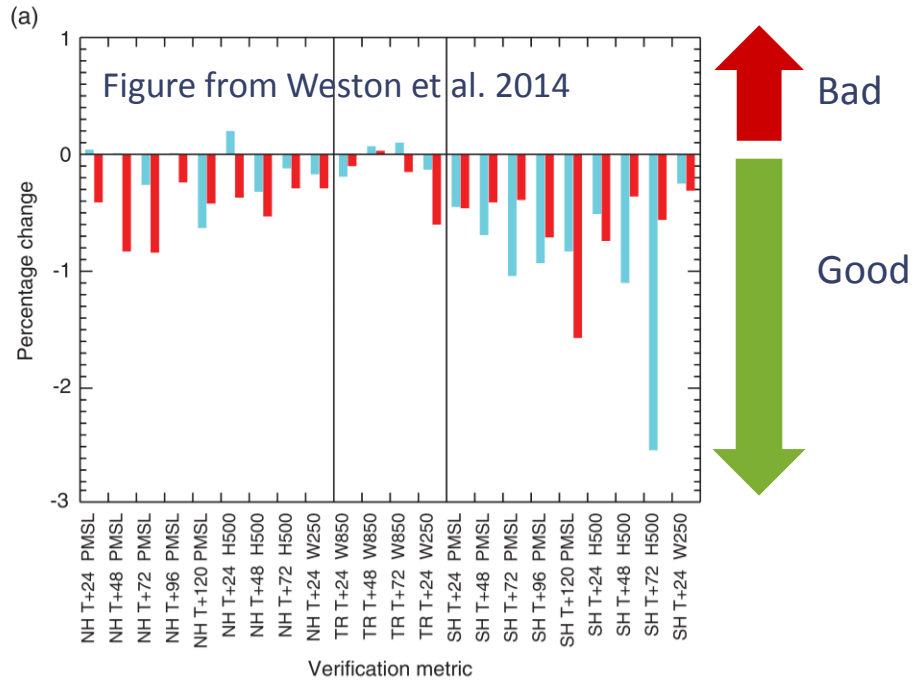
- However, it can lead to problems with convergence of the data assimilation system

- Shown for different instruments and data assimilation systems e.g. Weston et al. 2014, Bormann et al 2016, Campbell et al 2017.

Novel observations

Novel observations have potential to provide data at very high temporal and spatial resolutions not currently captured by standard meteorological observations.

Lowest observed altitude

MODE S EHS - Six million observations per day in UK

above 5000ft (5100334 obs.)
between 3000ft and 5000ft (167987 obs.)
between 1500ft and 3000ft (112931 obs.)
between 500ft and 1500ft (46800 obs.)
below 500ft (7284 obs.)

Figure from EUMETNET Aircraft derived data feasibility study
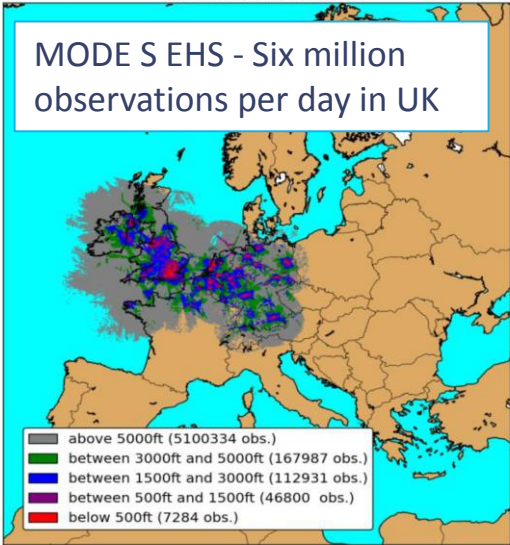
Mode S EHS successful example, but novel observations have many potential issues:

- Quality assessment required,
- Lack of metadata
- Privacy issues,
- Data ownership,
- Data streaming and storage,
- And many more …

Challenges

How can we accurately assimilate more of the currently available observations?

Alan Geer: All-sky assimilation for initial conditions and model improvements

David Simonin: A pragmatic strategy for implementing spatially correlated observation errors in an operational system: an application to Doppler radial winds

How can we efficiently assimilate high resolution observations?

Jemima Tabeart: Using reconditioning methods to reduce the cost of using correlated observation error information: theory and practice

Can novel observations provide benefit in convective scale data assimilation?

Kasper Stener Hintz: Screening, correction and assimilation of smartphone pressure observations in the HARMONIE NWP system using 3D-Var.

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