OBSERVATION ERROR COVARIANCES

INTRODUCTORY SLIDES FOR SCIENCE MEETING #2

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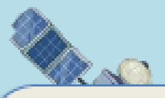
CONTRIBUTION TO OBS ERROR (NIELS BORMANN)

Contributions to observation error

Measurement error

E.g., instrument noise for satellite radiances

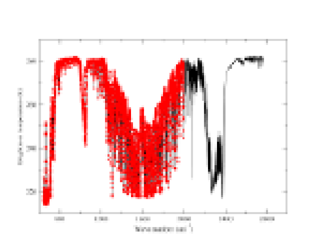


Representation error

(e.g., Janjić et al 2017)

Forward model (observation operator) error

E.g., radiative transfer error

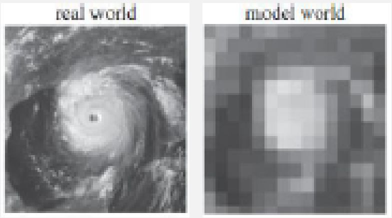


Observation errors can be:

- situation-dependent
- correlated between observations (spatially, temporally, between channels)

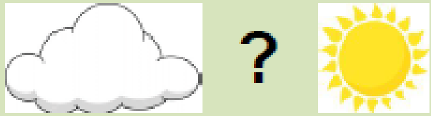
Representativeness error

E.g., point measurement vs model representation



Quality control/pre-processing error

E.g., error due to the cloud detection scheme missing some clouds in clear-sky radiance assimilation

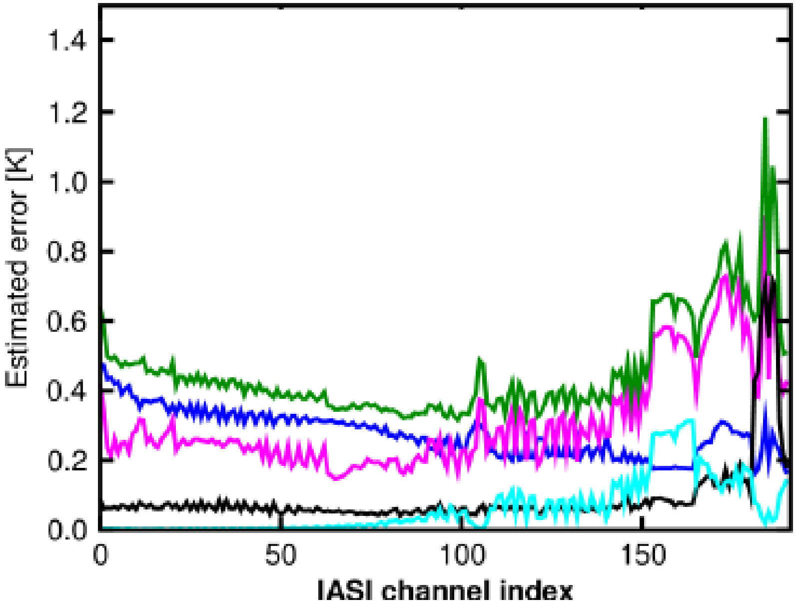


ESTIMATION OF CONTRIBUTIONS (NIELS BORMANN)

Error inventory

(e.g., Chun et al 2015)

- Idea: Estimate the observation error from ***estimates of <u>all</u> uncertainty*** contributions.
- Example: error inventory for IASI

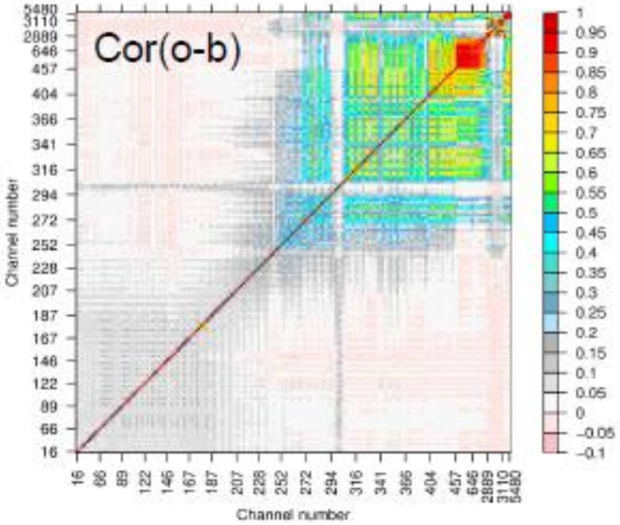


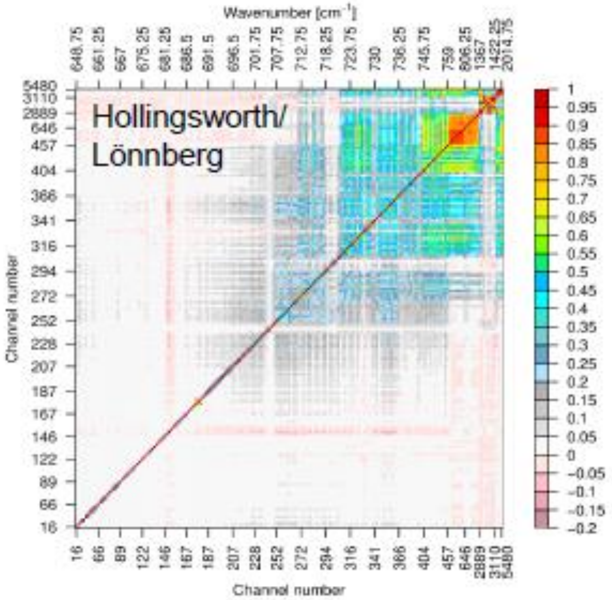
- Instrument noise (information from data providers)
- Radiative transfer error (estimated through reference obs)
- Spatial representativeness error (e.g, through high vs low-resolution simulations)
- Cloud detection error (e.g., using simulations of cloudy radiances)
- Combined observation error

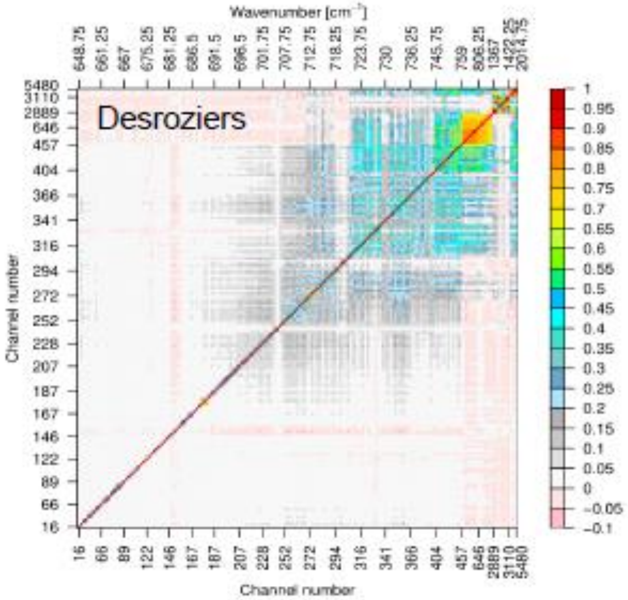
DIAGNOSTIC METHODS (NIELS BORMANN)

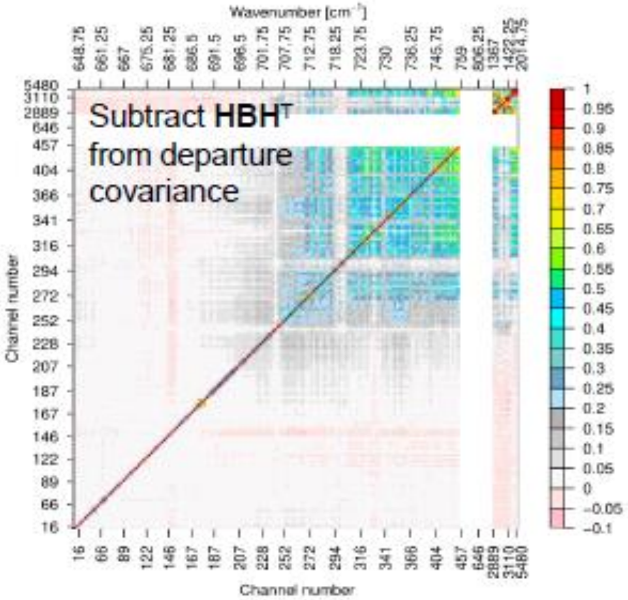
Estimating inter-channel error correlations for hyperspectral IR: Different diagnostics, similar results

(Bormann et al 2010)







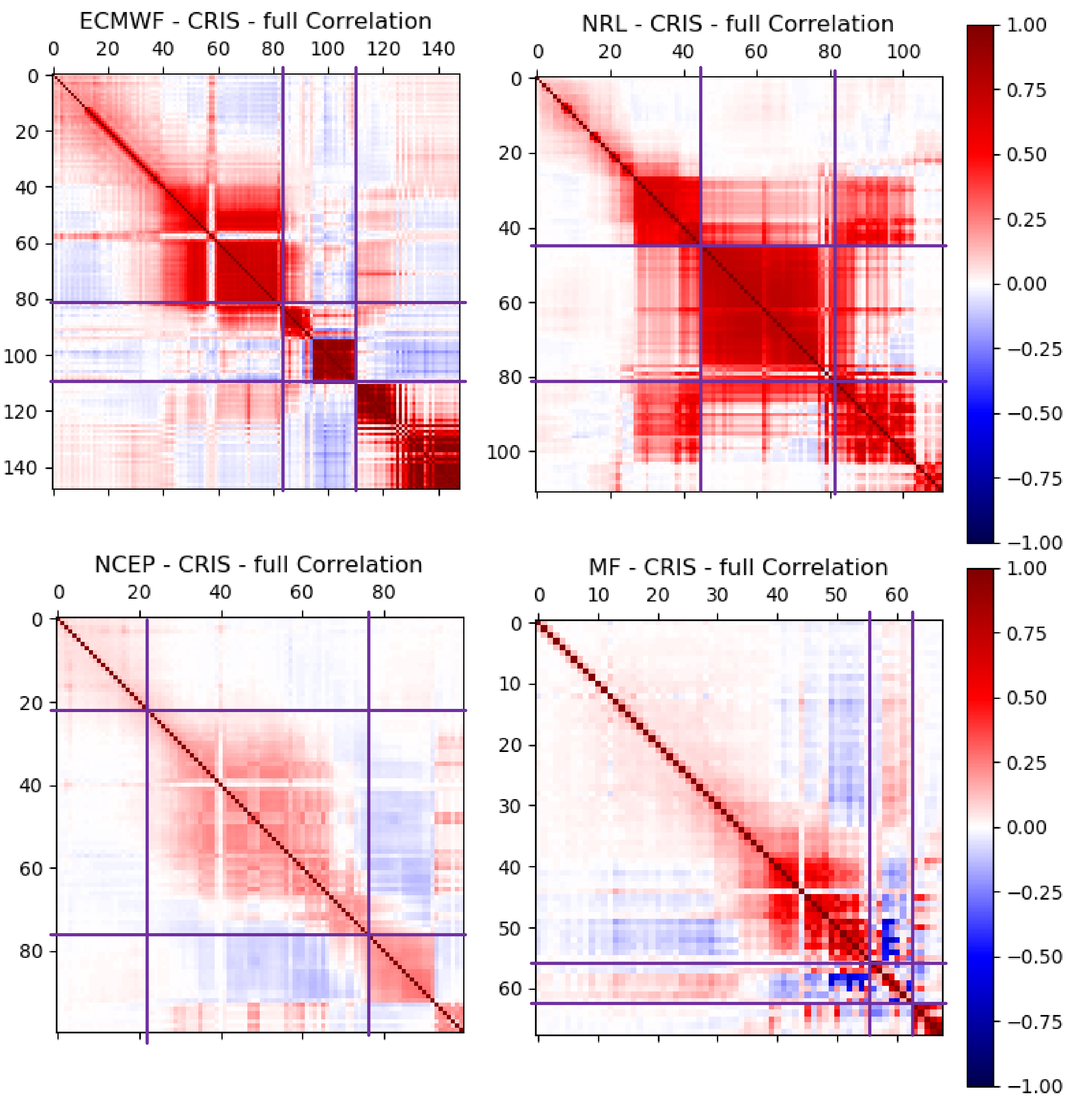


Australian Government
Bureau of Meteorology

OPERATIONAL OBS ERROR MANIPULATIONS (FIONA SMITH)

Centre	Shrinkage Method	Inflation over Desroziers	Condition number
Met Office + UM Partners	Add constant to all eigenvalues	Effectively: IASI T ~1.5, W.V. ~1.1	IASI 67
NRL	Add constant to all eigenvalues	IASI: T 1.65, WV 1.9	IASI 169
ECMWF	Increase small eigenvalues	IASI: 1.75 CrIS: 2.75	IASI 131 CrIS 4075
Meteo-France		IASI: 2.0	
NCEP	Increase small eigenvalues to condition number IASI: 200 CrIS: 125	T 1.6, WV 1.3, Window 1.8*	IASI 93 CrIS 53
DWD	Increase small eigenvalues	IASI: 1.75	
JMA		1.7**	
ECCC	Ensure positive definite	1.6	

- NCEP find that stricter cloud detection is necessary to get good results with correlated error covariances
- ** JMA justify their inflation with a corresponding deflation of background error by the equivalent factor (1/1.7)



CRIS ERROR CORRELATIONS FOR DIFFERENT CENTRES (FIONA SMITH)

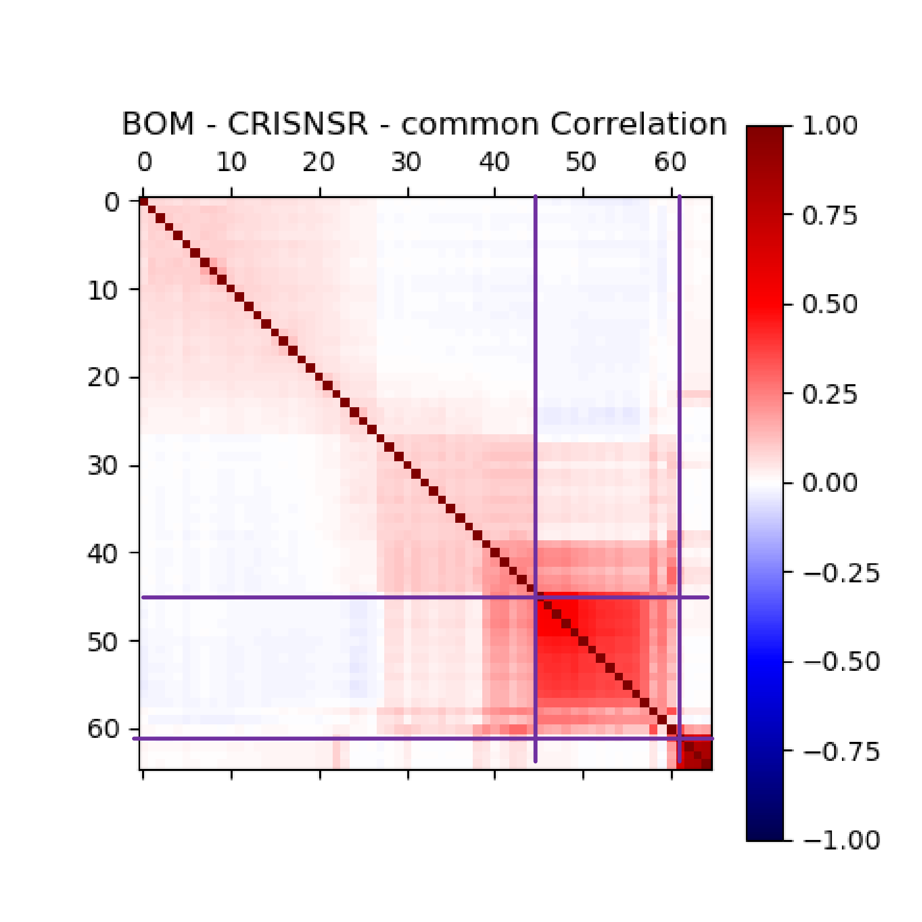
Comparison of CrIS FSR Correlation matrices. These appear quite different.

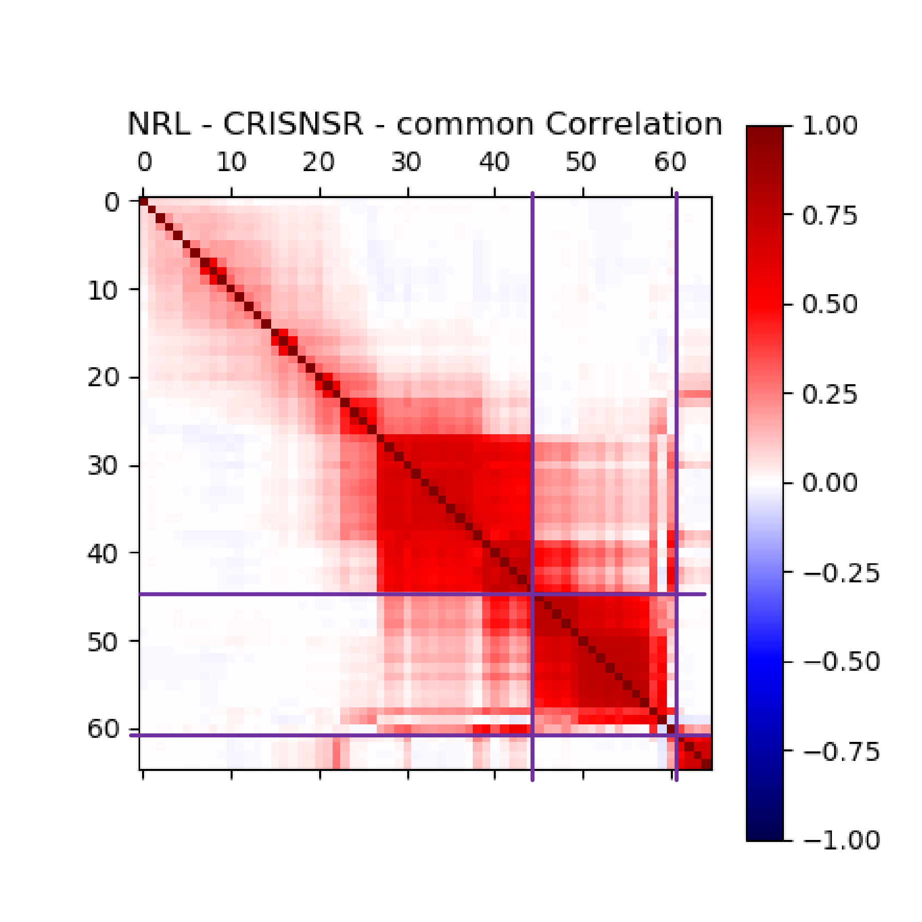
For some centres off-diagonal elements are much more prominent than for IASI.

Difficult to draw any conclusions…

Comparison of CrIS NSR Correlation matrices. Common channels between centres. (FIONA SMITH)

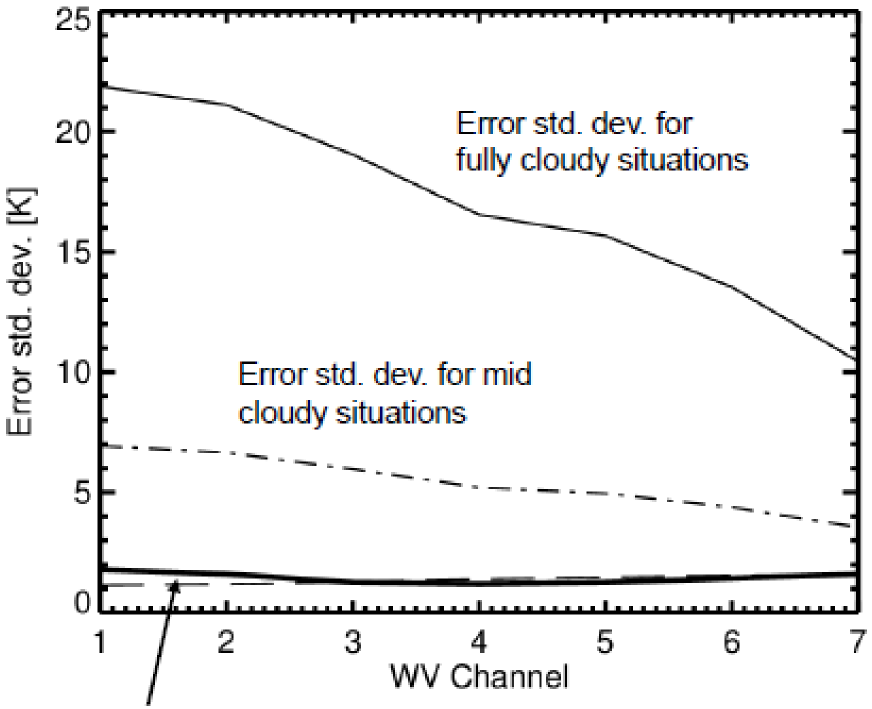
Still rather different – what does this mean for our diagnostic processes?



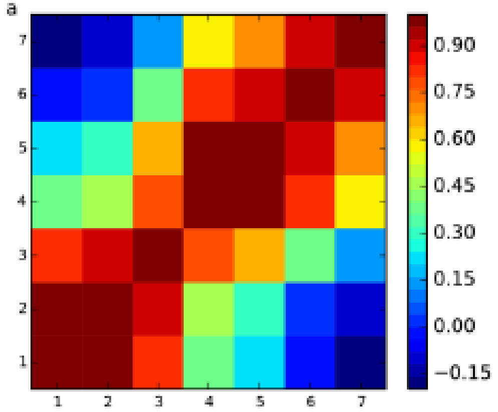


IASI SITUATION DEPENDENT ERRORS (ALAN GEER)

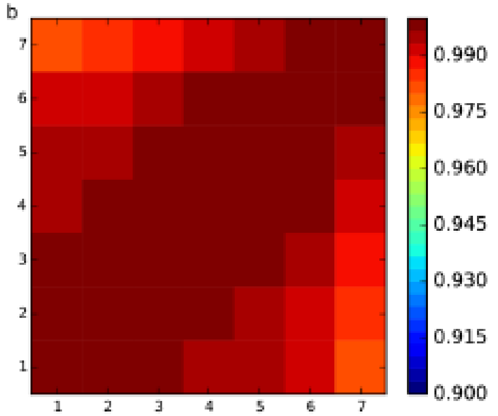
All-sky IR error model: one error covariance matrix with **eigenvalue scaling** as function of symmetric cloud amount -> adaptive covariance matrix



Similar error std. dev. in clear-sky situations from new model and existing clear-sky error model



Correlation matrix for clear-sky situations



Correlation matrix for fully cloudy situations

SMALL EIGENVALUES (ALAN GEER)

Using observation error covariance matrices is not just about conditioning

- Small trailing eigenvalues in the observation error covariance matrix amplify sensitivity to high-order combinations of channels
- Issues
  1. Trailing eigenvalues amplify some odd bias patterns seen in the eigendepartures
  2. Eigenjacobians of trailing eigenvectors map onto high-order vertical T oscillations: gravity waves
  3. Unexpected sensitivities: Trailing eigenjacobian (j=7) over very high clouds has 60% of its temperature sensitivity in the stratosphere

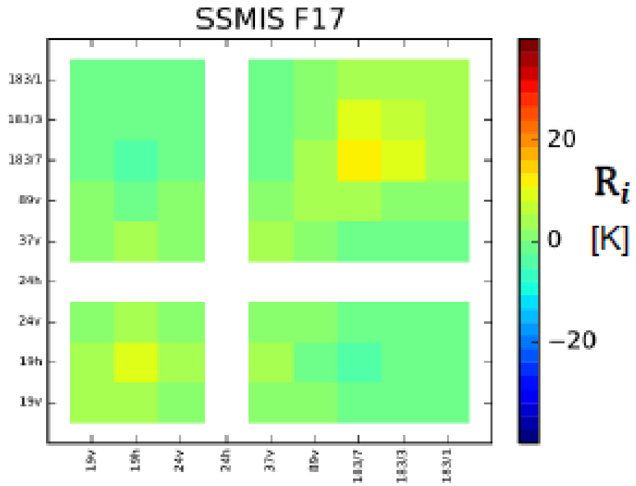
- By increasing the trailing eigenvalues
  - are we protecting the analysis?
  - are we losing real information?
- Are the trailing eigenstructures reliable? (sampling errors?)

ALL-SKY MICROWAVE INTERCHANNEL ERRORS (ALAN GEER)

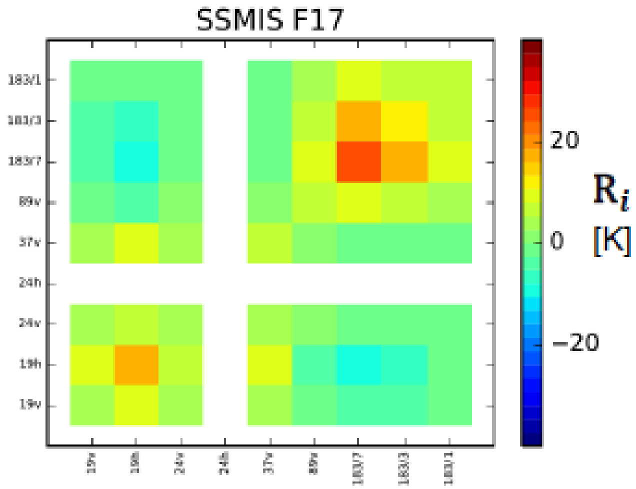
New error model for all-sky microwave – one fully specified interchannel covariance matrix per symmetric cloud & TWCV bin (-> 164 error covariance matrices)

C37 bin: -1.00 to 0.02

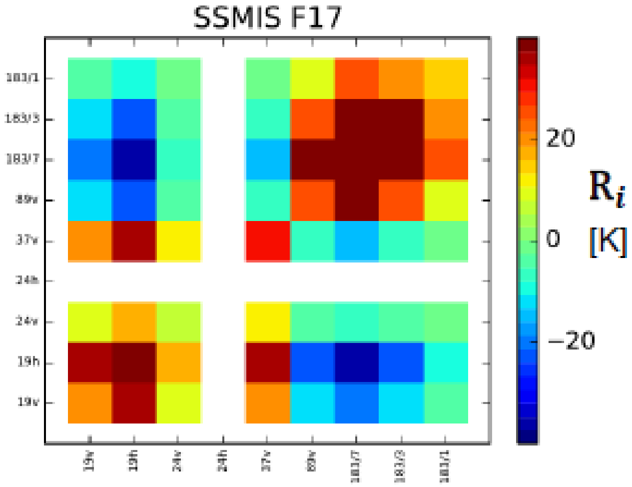
Increasing amount of cloud at observation location



C37 bin: 0.04 to 0.05



C37 bin: 0.12 to 0.13



RECOMMENDATIONS FROM ECMWF WORKSHOP

1. There is a need **to better understand the diagnostic uncertainty estimation tools and the estimates that they produce**, including understanding the influence of background and model error on diagnosed observation errors. Cross-comparison of results from different tools is recommended, as well as comparison to metrological/physical estimates.
2. The groups recommend **developing further** the treatment of situation-dependence of observation errors, including **the treatment of situation-dependent error correlations** where appropriate. Results from departure-based diagnostics may have to be treated with extra care in this case, due to increased sampling error when splitting the error estimates into different situations.
3. The groups recommend **increased efforts targeted at overcoming the technical challenges that currently limit the use of horizontal error correlations**. This is seen as a particular priority for convective-scale systems to better assimilate small-scale features.
4. More work is required regarding **automated or online estimation of observation errors**. This is considered particularly important when dealing with many new satellite instruments simultaneously, such as future constellations of small satellites.
5. More work regarding **metrological/physical understanding of random observation-related errors**, as it is seen as fundamental in informing their treatment in data assimilation

TOPICS FOR DISCUSSION

- How do we make sure of our diagnostics?
  - Is Desroziers the answer?
  - Why doesn't anyone use Hollingsworth-Lönnberg?
  - How to regularize the matrix?
    - The magic factor?
    - Eigenvalues?
- Scene dependence – who is working on that and what problems need solving
- Physically-based models – how do we proceed with such studies?