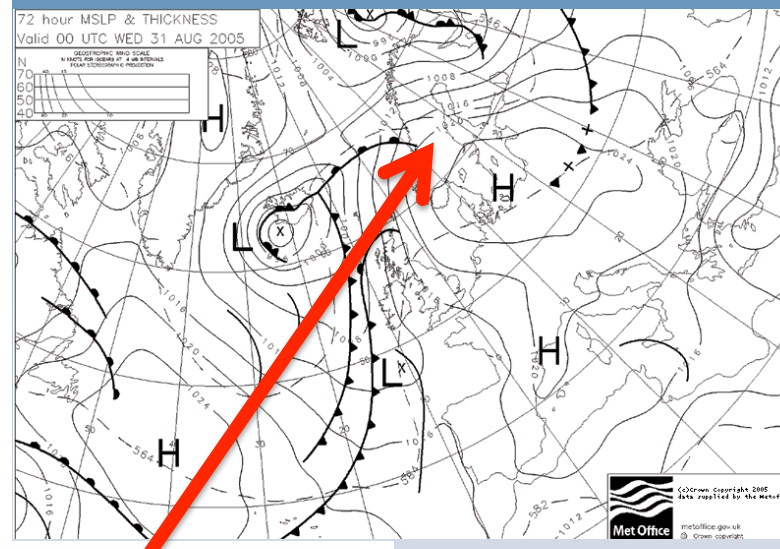
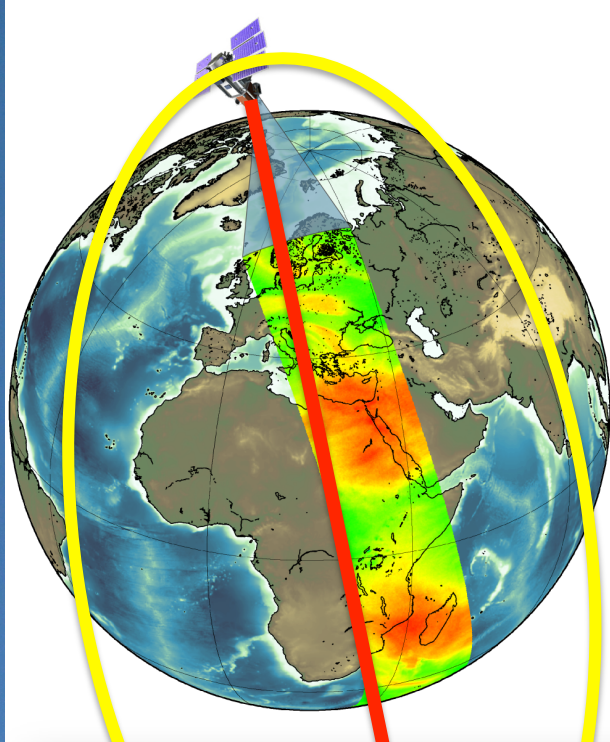


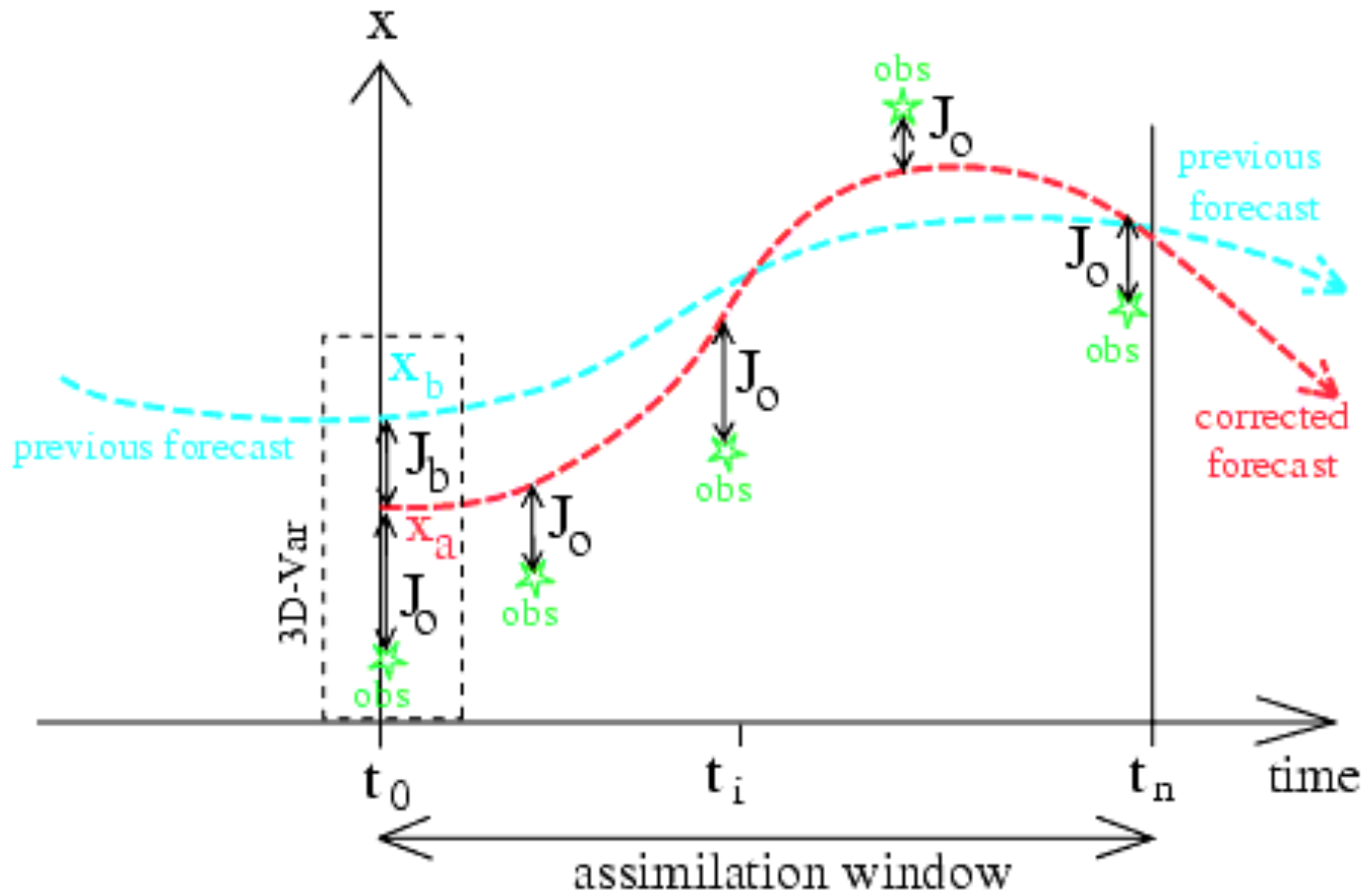
Use of Spectral Information in the Microwave Region for Numerical Weather Prediction Data Assimilation

Mathias Milz

Department of Computer science, Electrical and
Space engineering







Why do we look for new sounding channels for MW and sub-mm instruments?

Why do we look for new sounding channels for MW and sub-mm instruments?

- Advances in mm-/sub-mm remote sensing technology
 - Extended instruments' spectral range (1 THz)
 - Increased channel numbers (hyperspectral)
- Hyperspectral approach in mm/sub-mm range
 - Clear sky (T-, H₂O-, O₃- profiles)
 - Cloud properties
- NWP improvement by assimilation of additional spectral data

Method

- To assess the information content for suitable channels one needs
 - Background error covariance matrix \mathbf{B}
 - Observation error covariance matrix \mathbf{R}
 - Jacobian Matrix \mathbf{H}
- Providing the covariance of the analysis error $\mathbf{A}=(\mathbf{B}^{-1}+\mathbf{H}^T\mathbf{R}^{-1}\mathbf{H})^{-1}$
- Degree of Freedom for Signal DFS= $\text{Tr}(\mathbf{I}-\mathbf{A}\mathbf{B}^{-1})$
- Information gain:
 - Entropy reduction: $\text{ER}=0.5(\log_2(\mathbf{B})-\log_2(\mathbf{A}))$

The Atmospheric Radiative Transfer Simulator (ARTS)

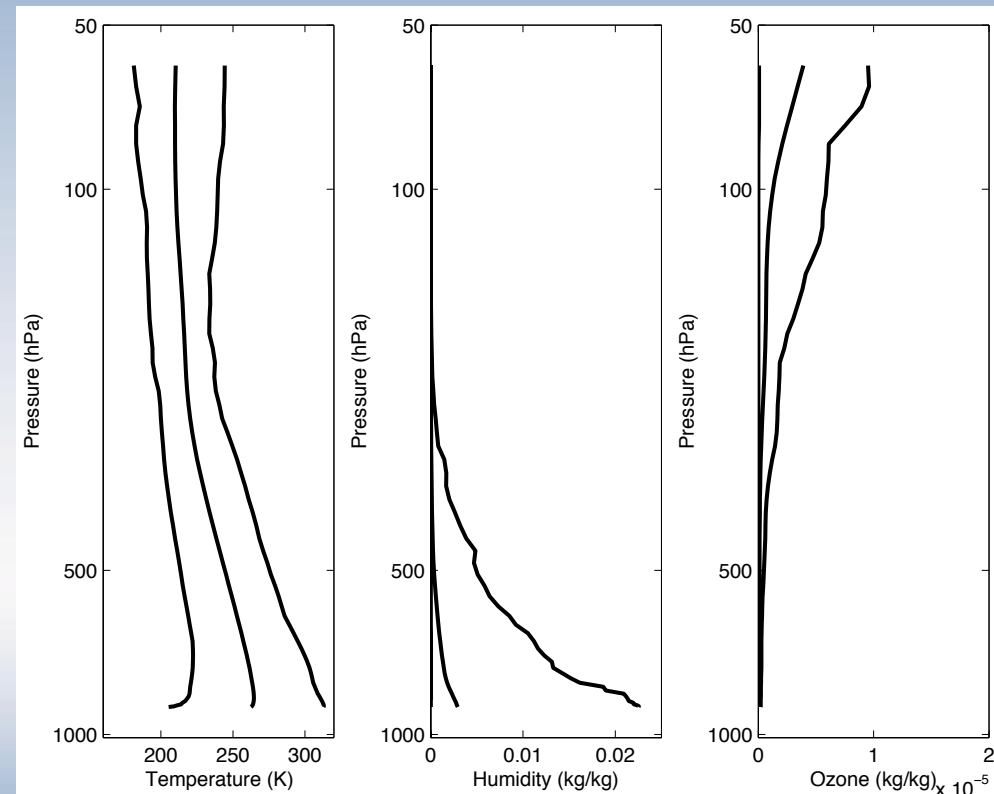
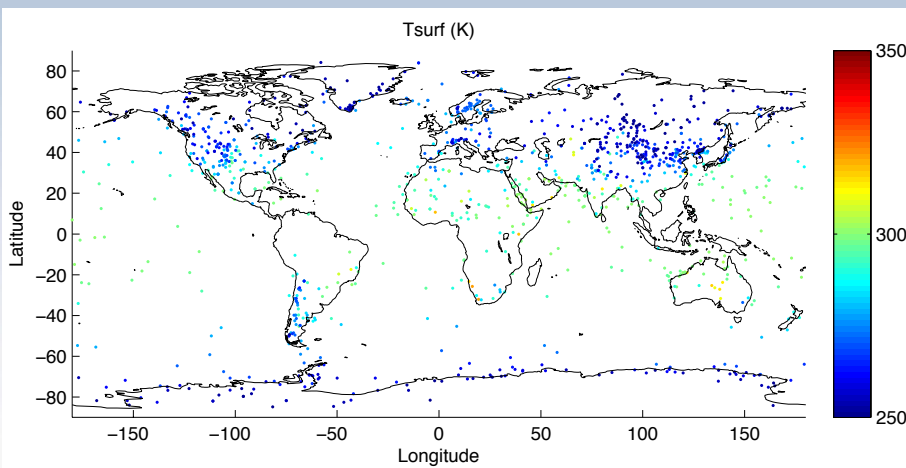
- Clearsky: line-by-line; Jacobians: analytical
- Scattering:
 - Discrete Ordinate Iterative approach (DOIT)
 - Jacobians : perturbative
 - Time consuming
 - N-level calculations
 - Optimisation required
 - Simulated annealing.
 - Optimised treatment of scattering.

- 2525 (276) preselected channels
- Simulations over land/ocean, Nadir/53°, clear sky
- Including Jacobians

Spectral band	Type	Nb chan. (res. 4)	Res. 4 (MHz)	Res. 3 (MHz)	Res. 2 (MHz)	Res. 1 (MHz)
Around 60GHz	O_2 - Temperature	94	100	50	20	10
Around 118GHz	O_2 - Temperature	51	200	100	40	20
Around 183GHz	H_2O - Water vapour	51	400	200	80	40
Around 325GHz	H_2O - Water vapour	21	1000	500	200	100
Around 425GHz	O_2 - Temperature	17	1000	500	200	100
Around 448GHz	H_2O - Water vapour	17	1000	500	200	100
From 6.9GHz to 874GHz	Window channels	25				

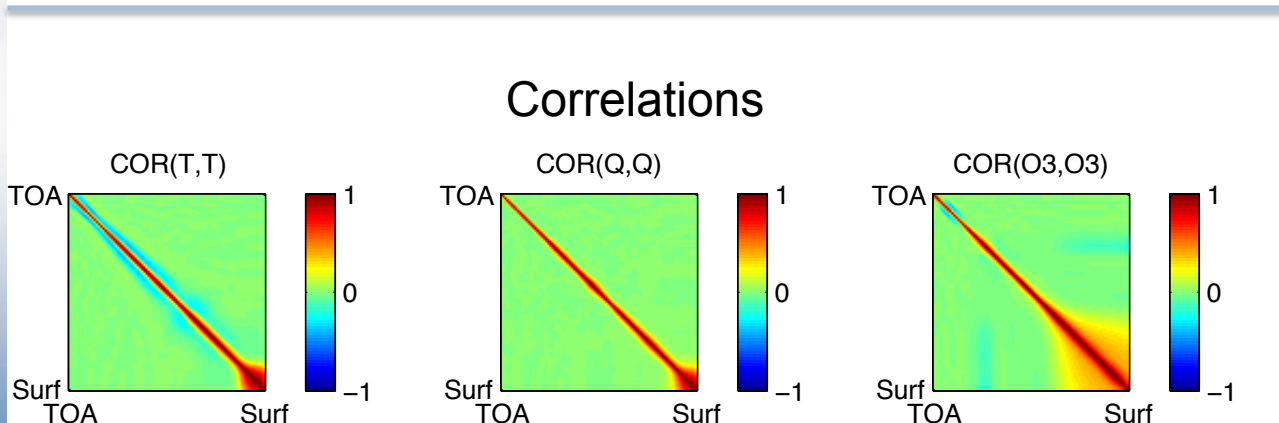
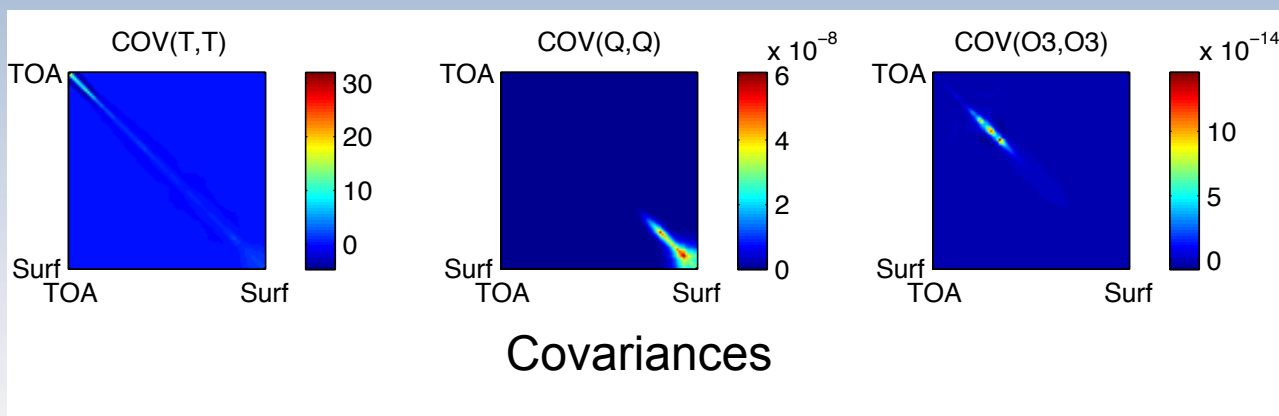
Atmospheric database

- 1989 atmospheric situations from ECMWF
- Constraint on B-matrix availability



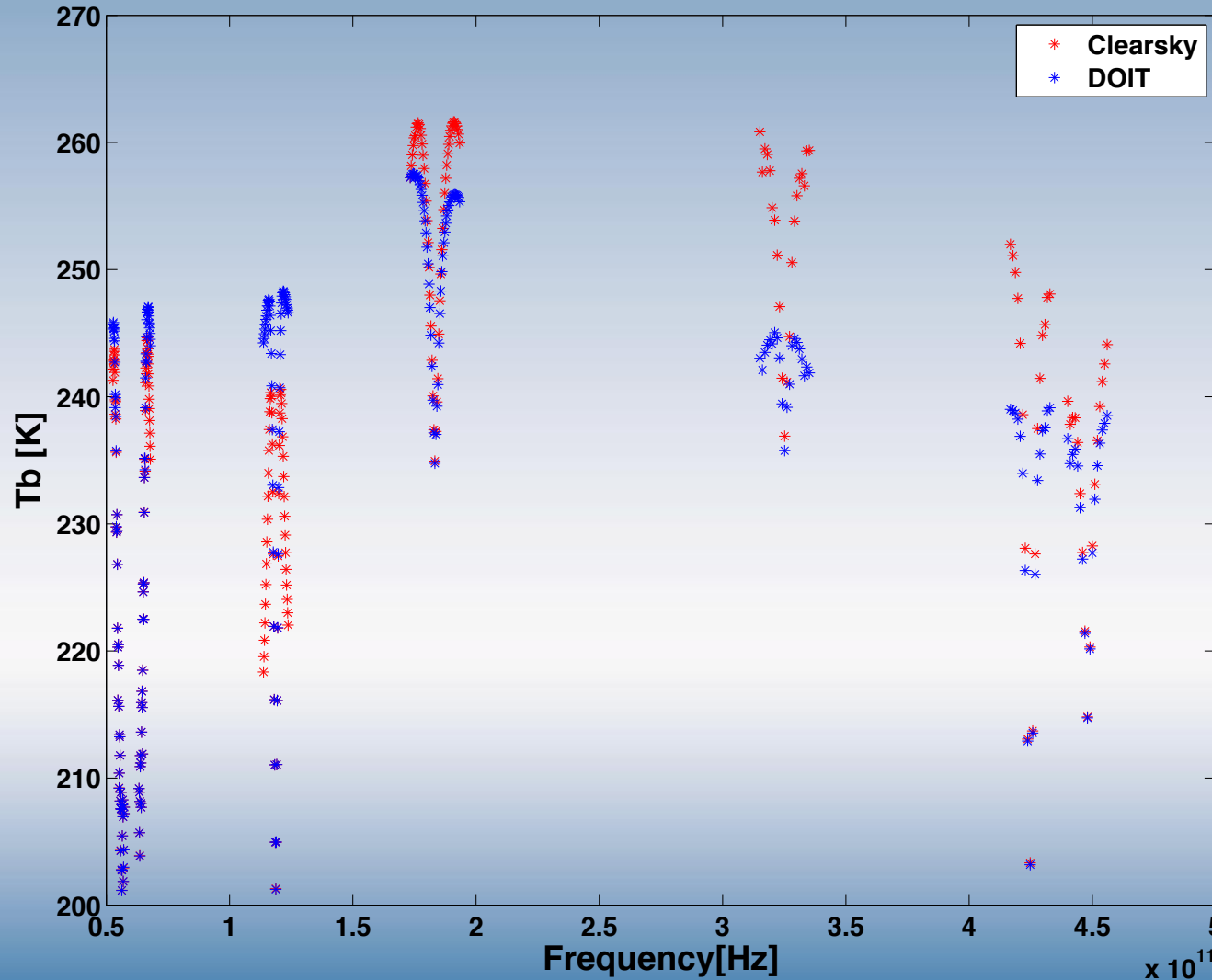
Background information from ECMWF

- From Holm and Kral 2012
- Clear sky only, for temperature, humidity and ozone



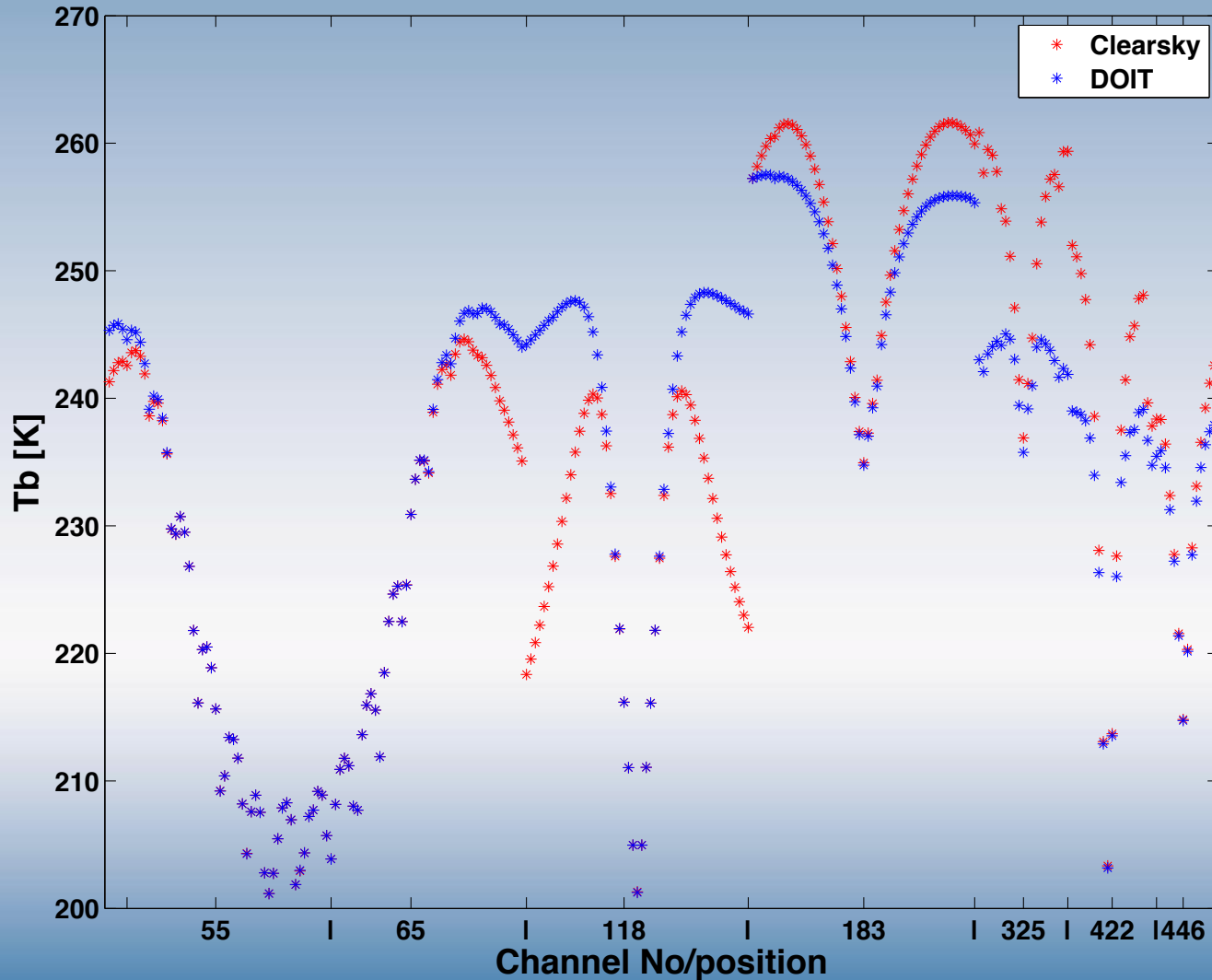
Sounding Channels

Channel radiances, CHAN LINES, 15



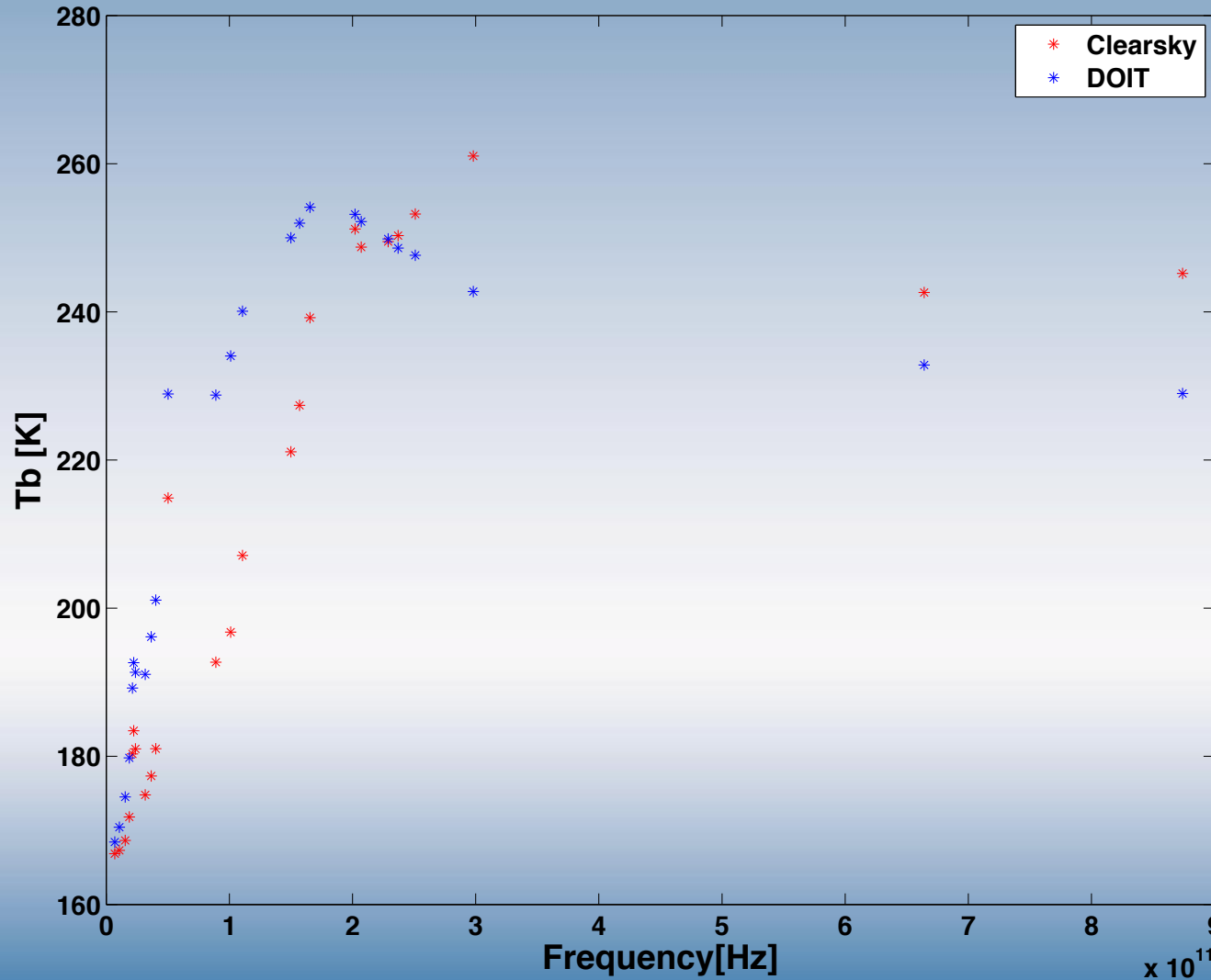
Sounding Channels

Channel radiances, CHAN LINES, 15



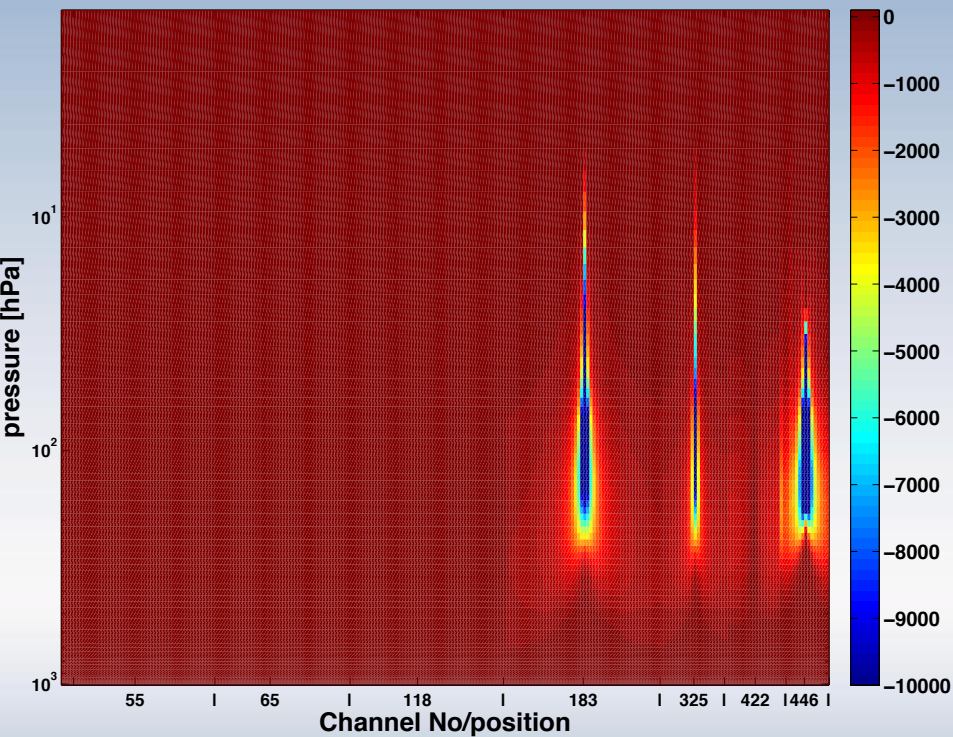
Window Channels

Channel radiances, CHAN WINDOWS, 15

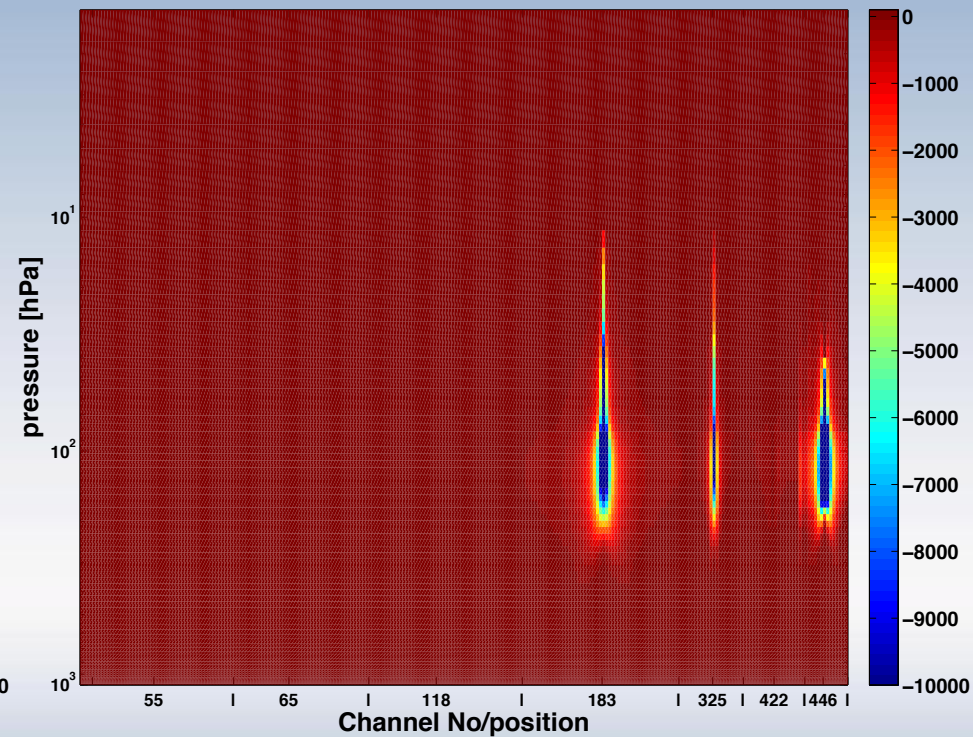


Jacobians H2O (Sounding channels)

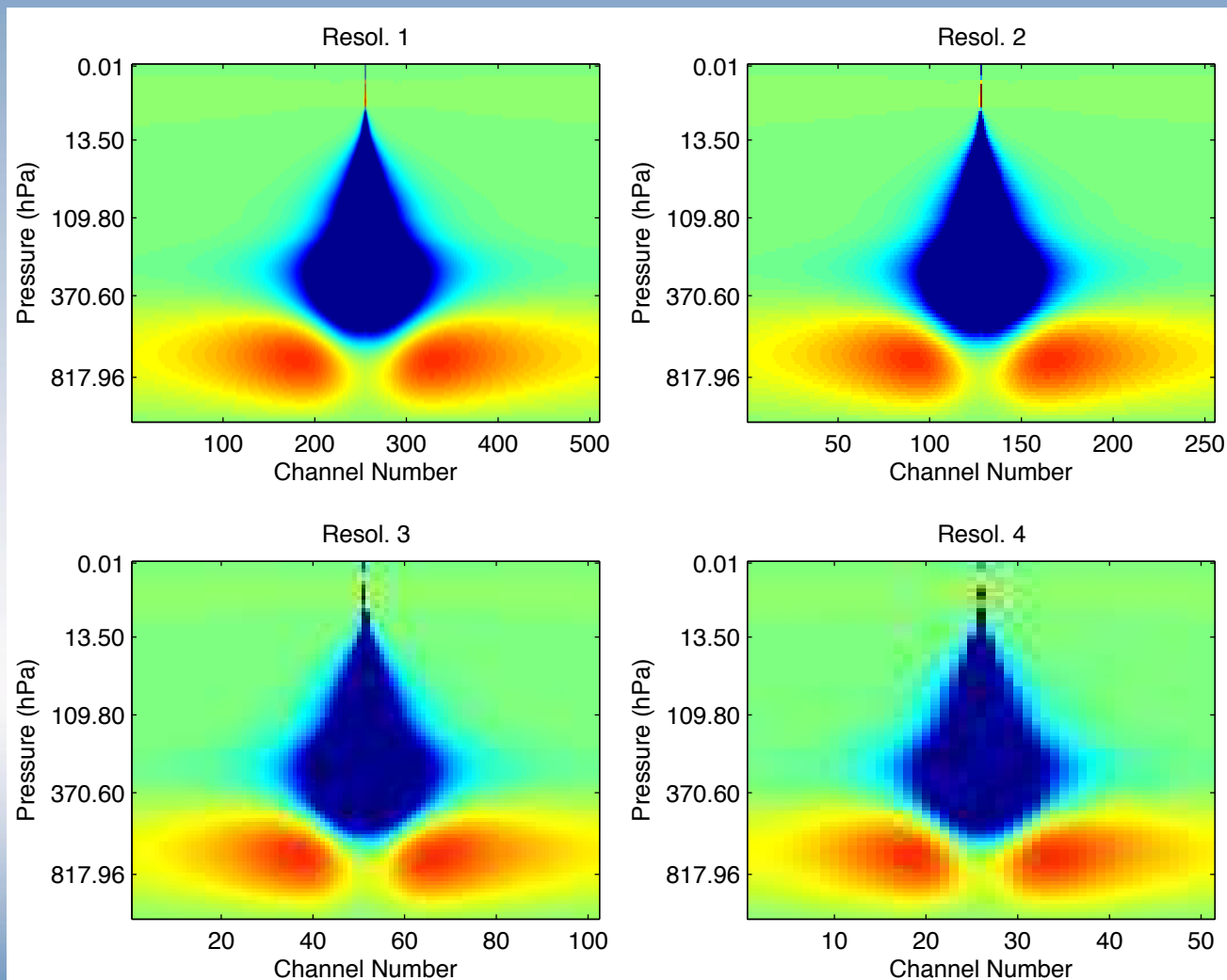
Jacobians,CHAN LINES, clearsky, H2O



Jacobians,CHAN LINES, DOIT, H2O

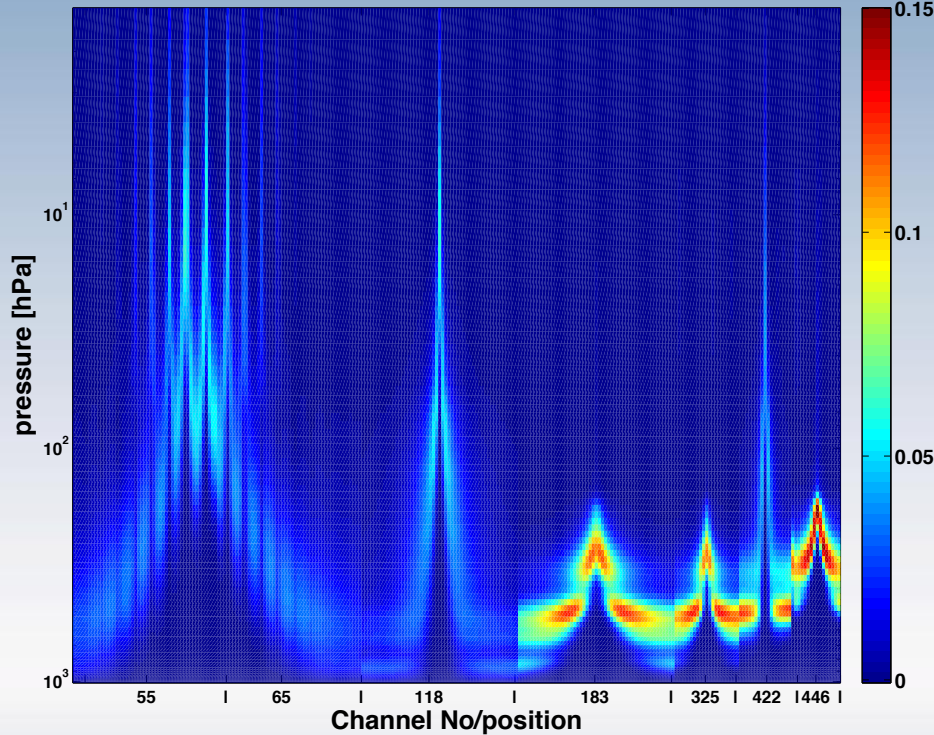


Jacobians H2O (K/(kg/kg), 183.3 GHz)

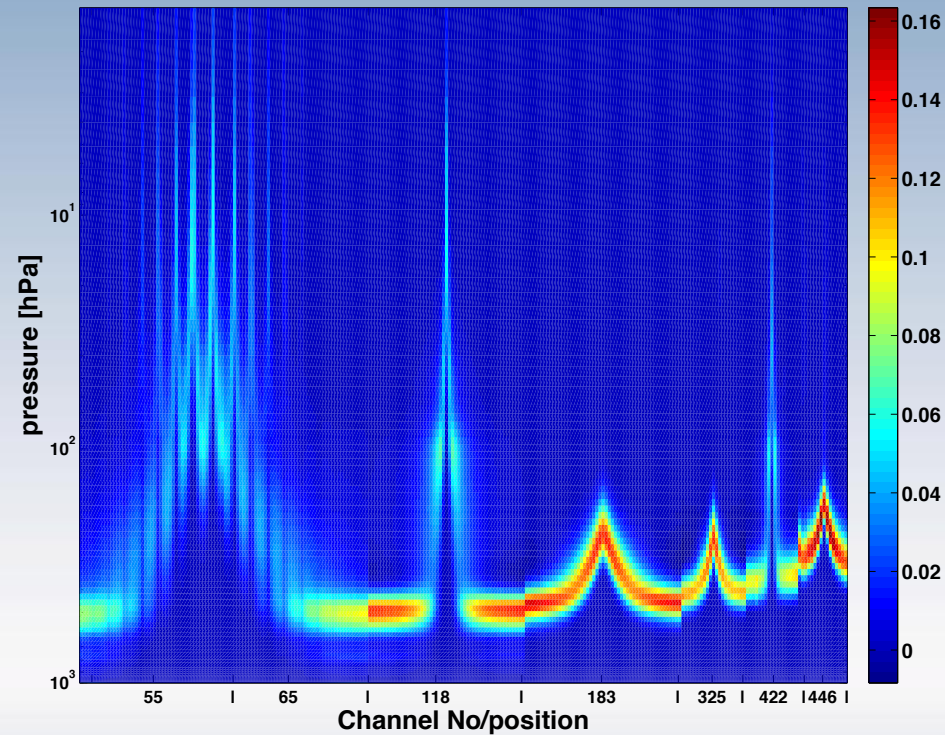


Jacobians T (Sounding channels)

Jacobians,CHAN LINES, clearsky, T

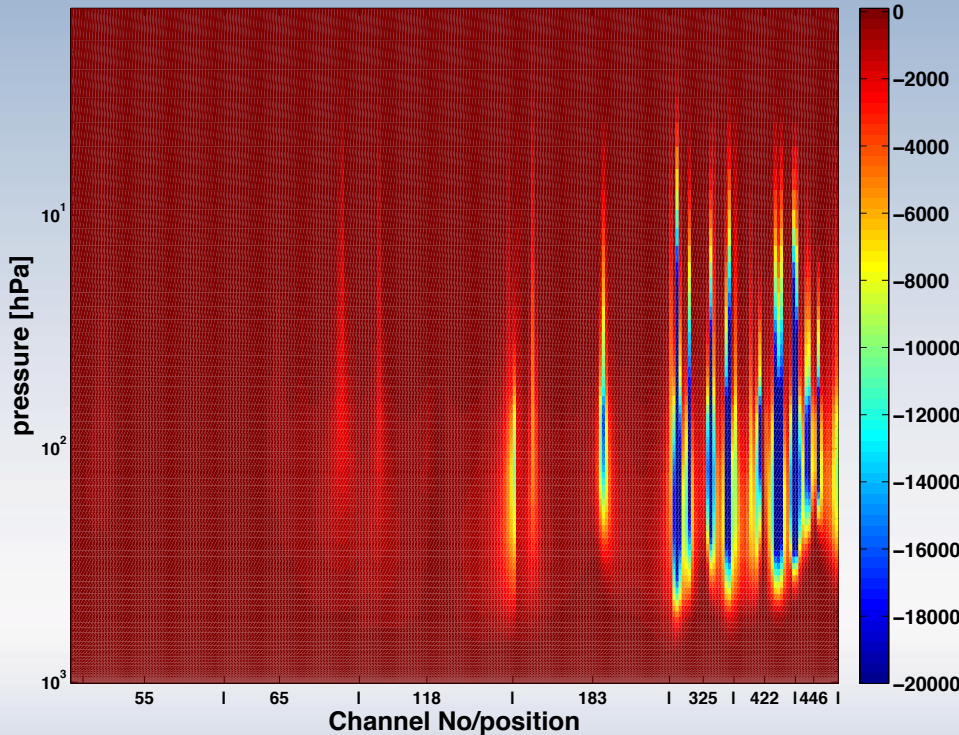


Jacobians,CHAN LINES, DOIT, T

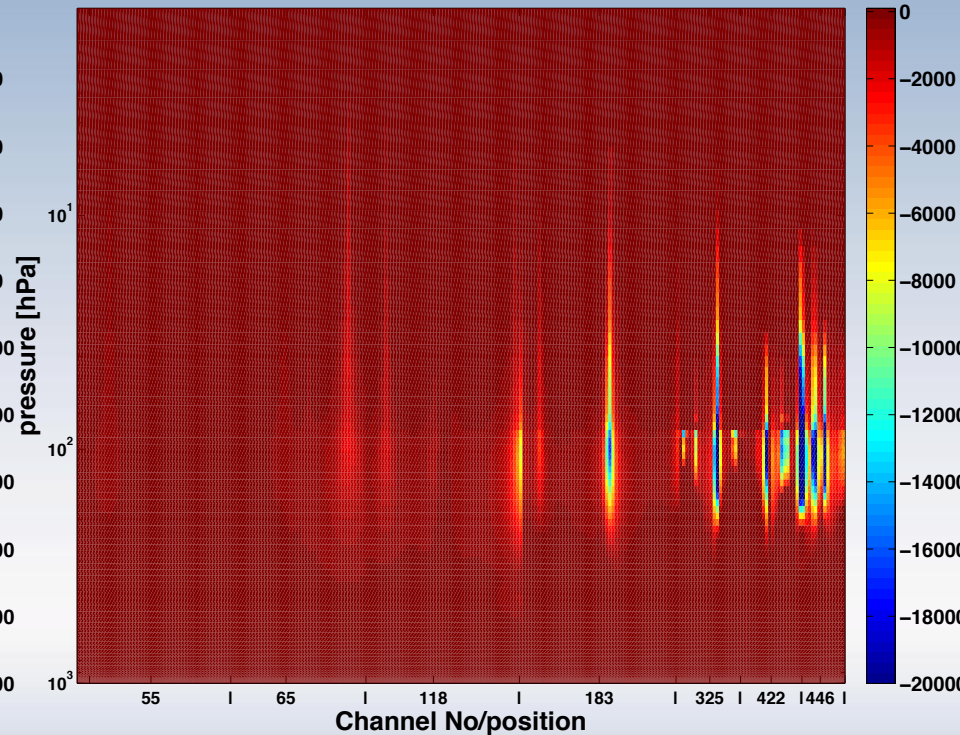


Jacobians O3 (Sounding channels)

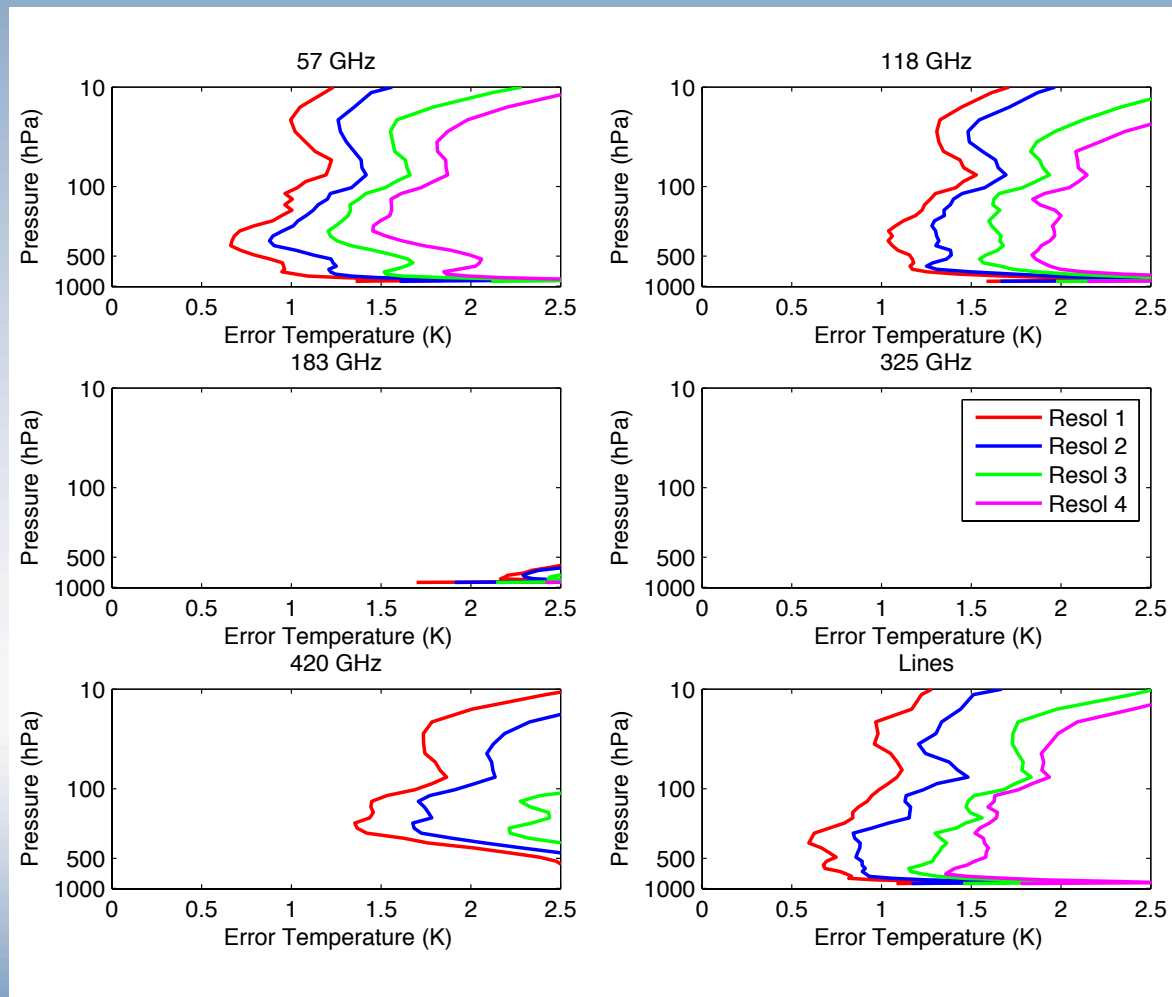
Jacobians,CHAN LINES, clearsky, O3



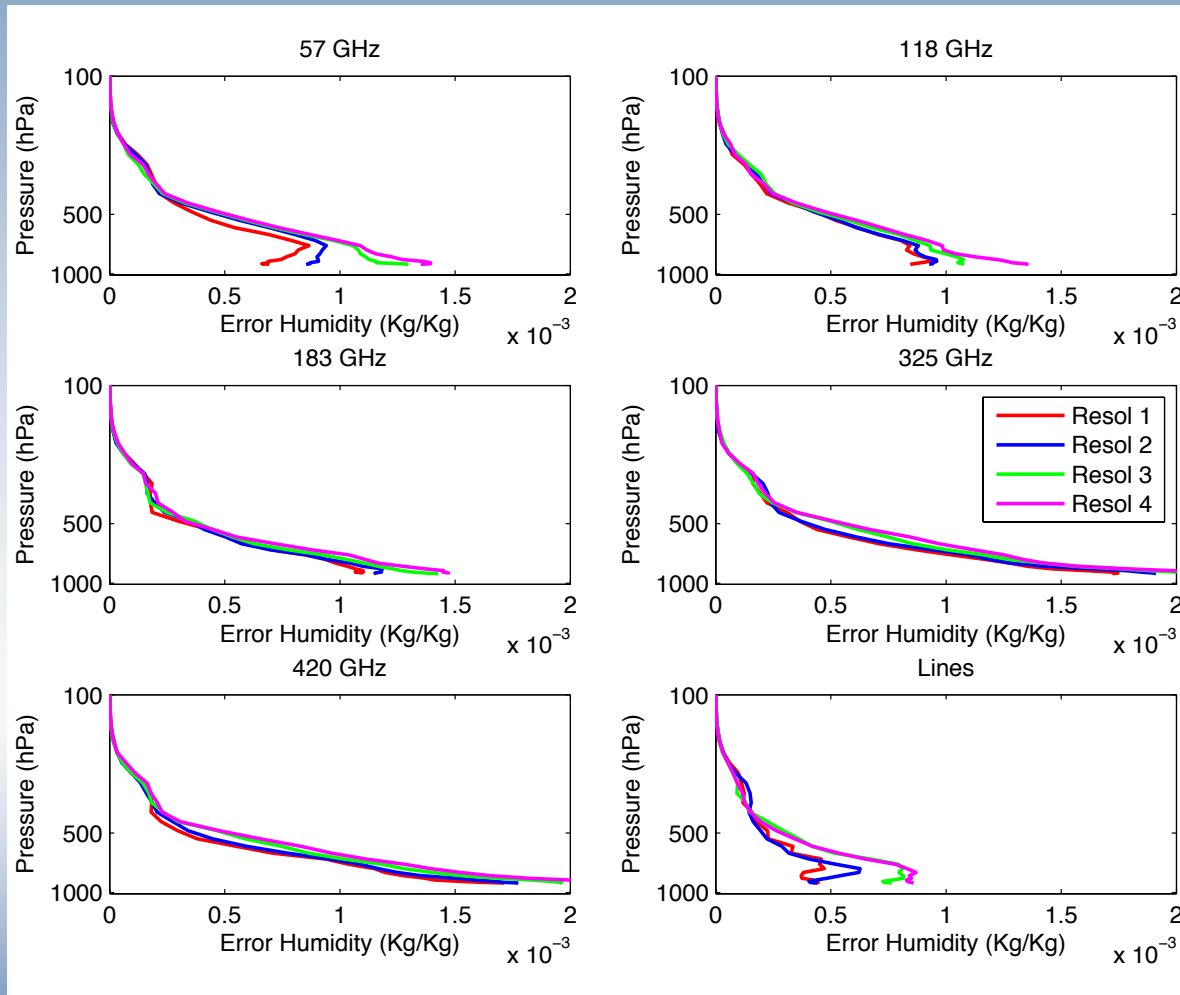
Jacobians,CHAN LINES, DOIT, O3



Retrieval errors, Temperature

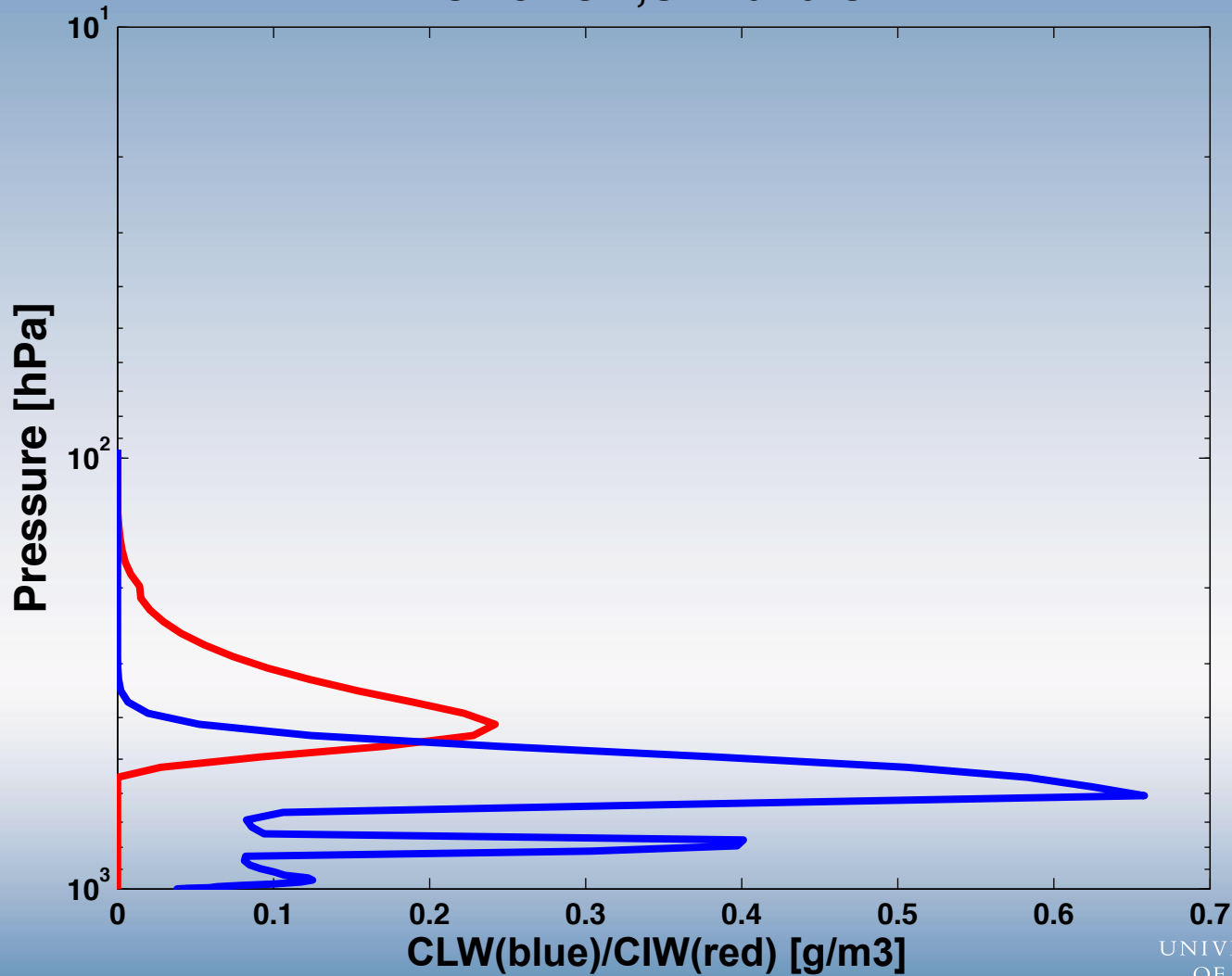


Retrieval errors, q

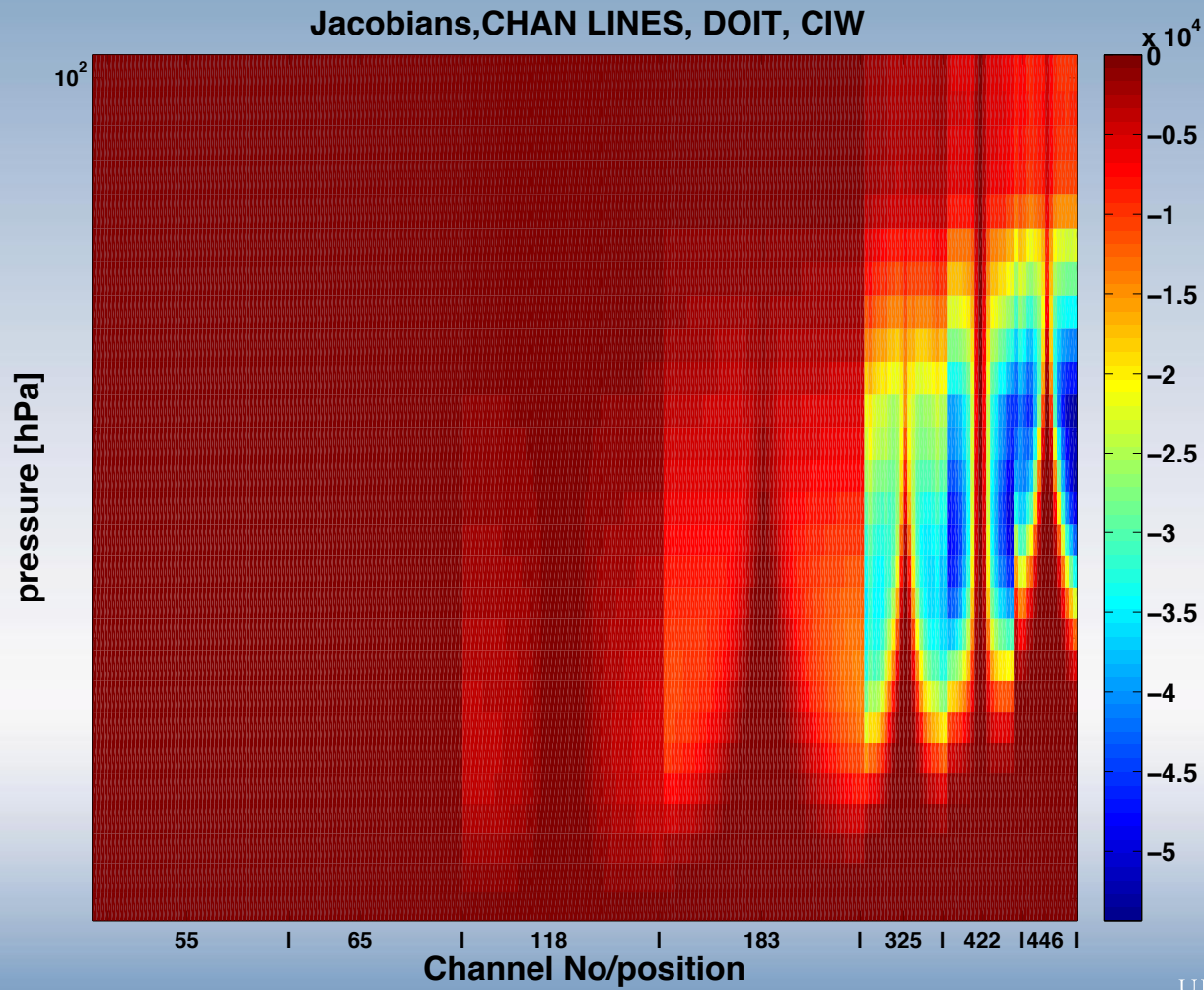


Cloudy - conditions

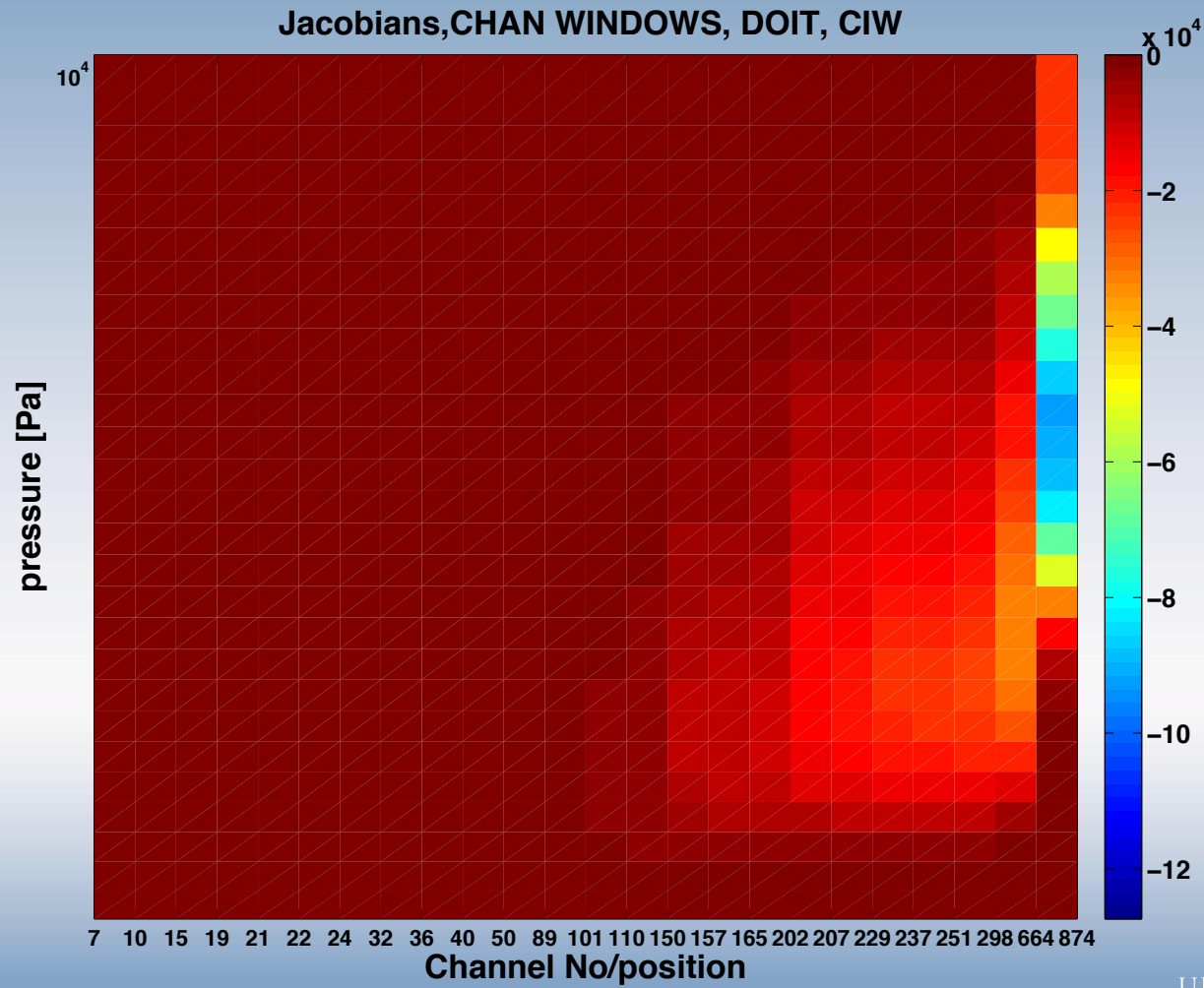
Profile no 7, CIW and CLW



Jacobians CIW

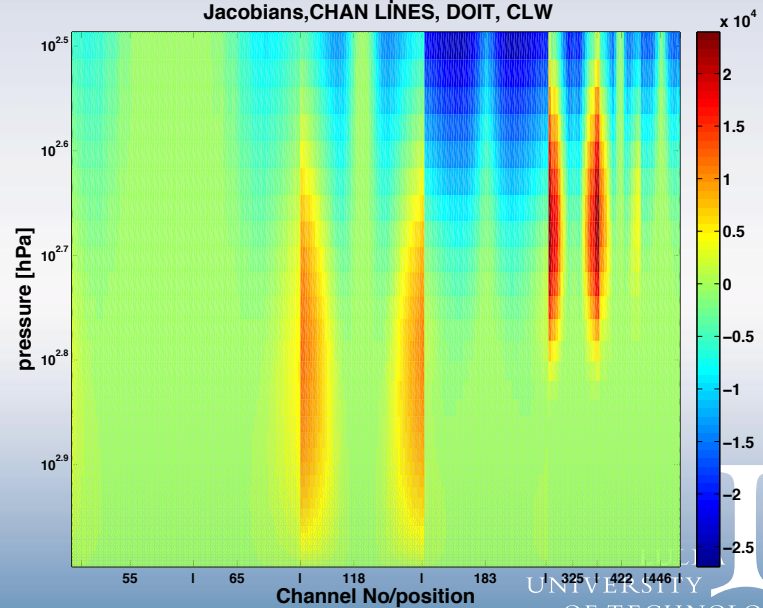
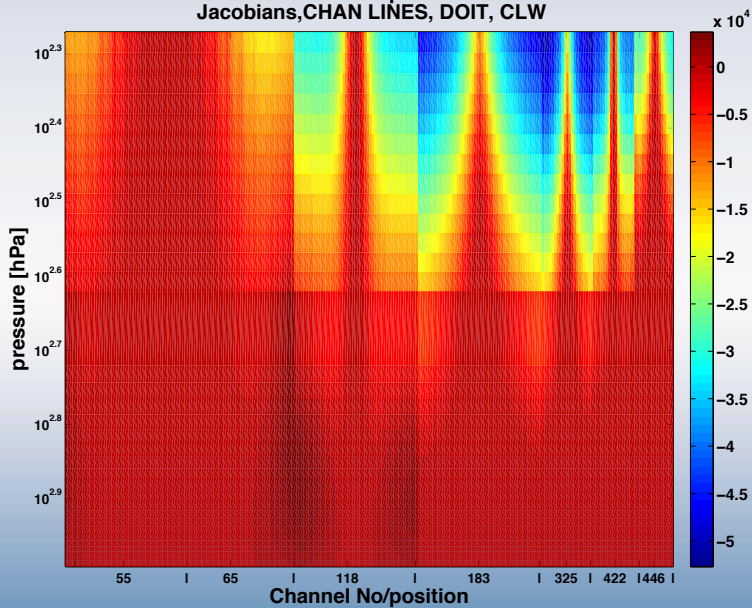
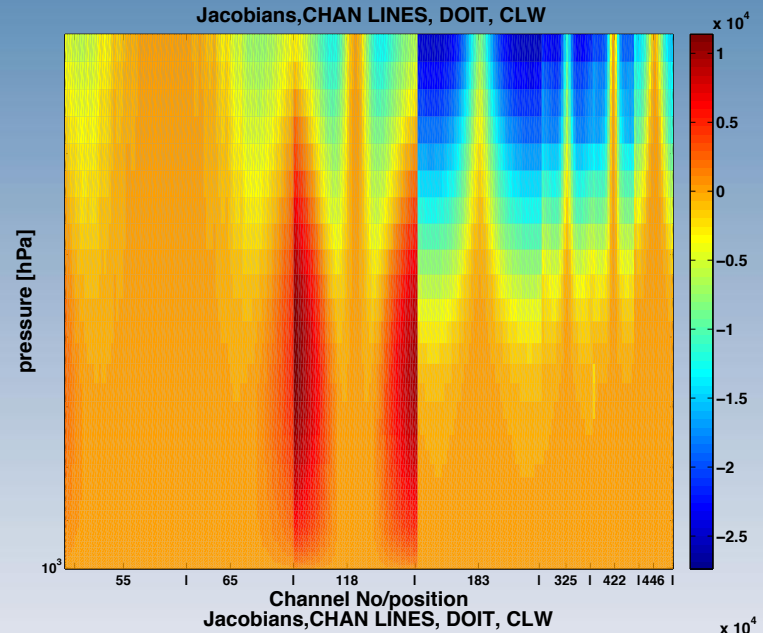
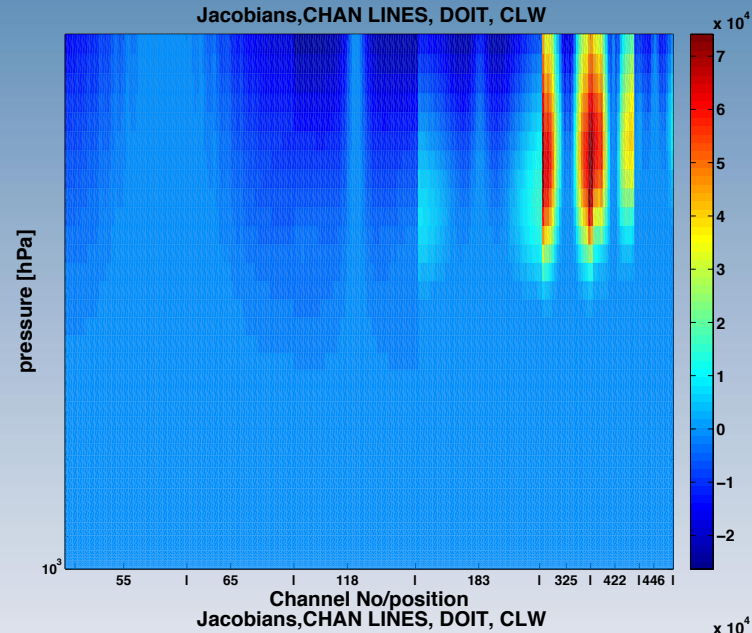


Jacobians CIW

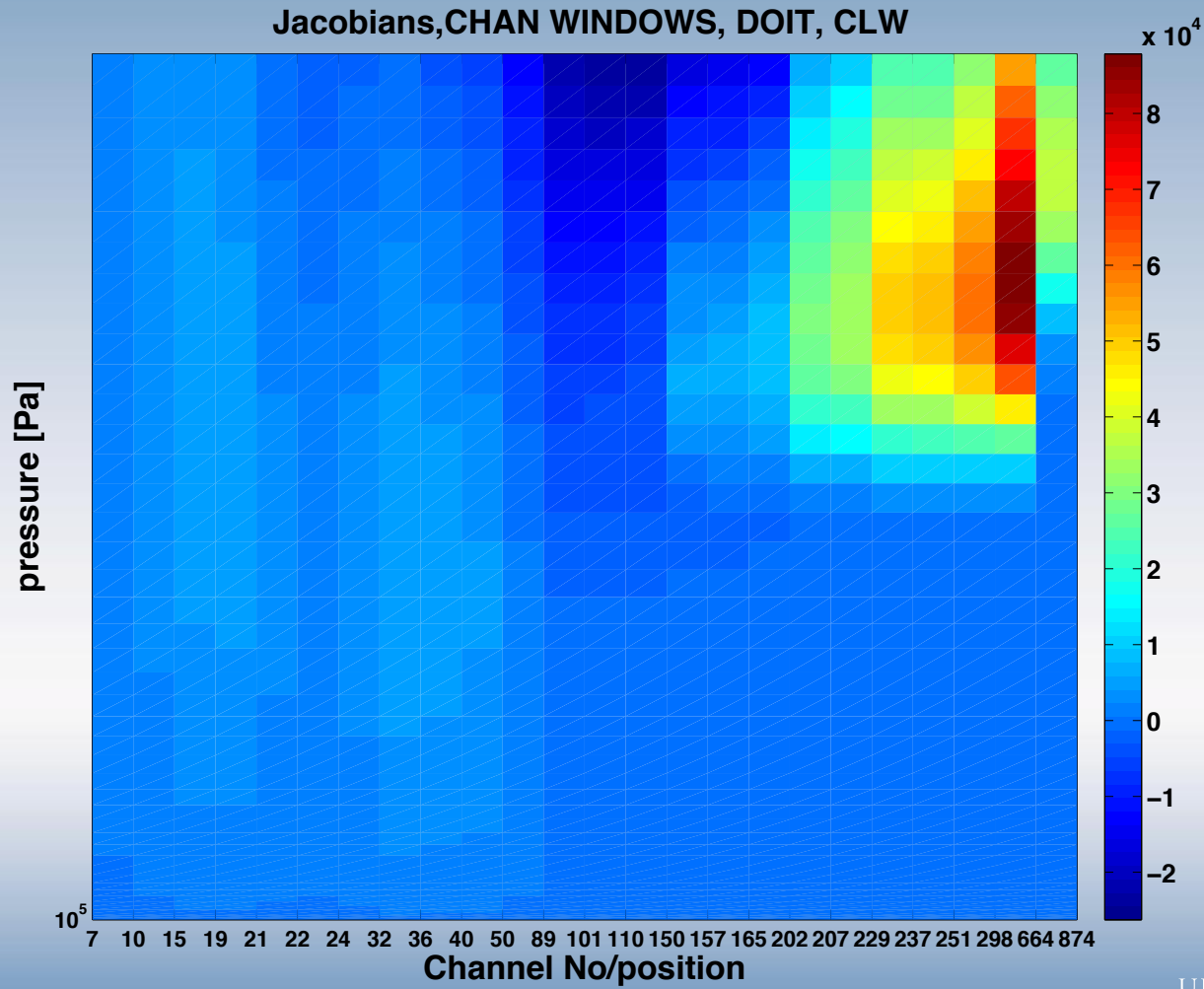




Jacobians CLW



Jacobians CLW



Summary/Conclusions

- Tools for the determination of sounding channels in the sub-mm/mm range suitable for NWP-use
- Jacobians for clear sky and cloudy conditions
- High resolution matters!

Summary/Conclusions

- Optimisation of Setup (not only) for cloudy conditions recommended
- Jacobians for Cloud Ice Water similar for different cloud sizes
- Jacobians w.r.t. Cloud Liquid Content strongly depend on boundary conditions
 - Cloud thickness, cloud height
 - Neighboring ice clouds
 - Surface

Coworkers

- M. Milz (LTU)
- F. Aires (Estellus, Paris)
- S. A. Buehler (LTU/Univ. Hamburg)
- S. Crewell (University of Cologne)
- P. Eriksson (Chalmers University, Gothenburg)
- A. Maestrini (Observatoire de Paris, LERMA)
- J.-F. Mahfouf (Meteo France)
- E. Orlandi (University of Cologne)
- C. Prigent (Observatoire de Paris)
- W. Bell (UK MetOffice)
- S. English (ECMWF)
- O. Lemke (LTU/Univ. Hamburg)
- Manfred Brath (ZMAW)

Thank You

