

- Session 1 - Why single-trial EEG analyses?
- Session 2 - Pre-processing, introduction to ICA
 - Example session I: Setting-up your data and running a single-trial regression analysis with the *STA-TB*
- Session 3 - ICA as a tool to increase SNR in EEG data
 - Example session II: COMPASS to select ICs
 - Example session III: EEG regression with independent component activity
- Session 4 - Within-subject to across-subject analyses
 - Example session IV: Combine data across participants
- Session 5 - Time-frequency decomposition and single-trial analyses
 - **Example session V: Run a TF decomposition and GLM analysis**
- End and Discussion

Frequency Resolved Regression

- we can use the exact same set-up, data, and regression scripts

`open RunRegressionTF.m`

- we load the same participant as in the time-domain analyses (VP0005)
- we will run a TF decomposed regression in electrode space using the same model
- and run a regression in IC space without back projection
- (and run a final analysis in IC space restricted to theta power, that allows to test frequency specific hypotheses as quickly as analyzing time-domain data can be)
- first: load the data...

5. TF settings

```

TF.frequencies    = [4 20];           %frequency range (4 to 20 Hz)
TF.stepnumber     = 12;               %steps in between frequencies
TF.space          = 'lin';           %spacing of frequency steps ('lin' or 'log')
TF.cyclenumber    = 4.5;             %number of cycles for morlets
TF.transform      = 'log';           %what happens with the data after TF transformation?
                                     'none'          - do absolutely nothing (or leave empty)
                                     'normalize'       - normalize power within each frequency
                                     'log'            - take the log of the frequency power

TF.basetype       = 'none';          %baseline correction. ,none' = default
                                     'subtract'       - subtracts each individual trials' baseline
                                                         within each frequency
                                     'percent'        - subtracts each individual trials' baseline
                                                         and divides by the mean baseline over all
                                                         trials (determined prior to subtraction)

TF.basetime       = [-500 -300];     %the time for baseline correction
TF.padding        = 0;               %added zero-padding around epochs
TF.bandfreq       = {};              %define bands for frequencies over which to average before
                                     regression (instead of full spectrum). Example: {[4 8]; [8 12]}
TF.bands          = {};              %names for these frequency bands. Example: {'theta' 'alpha'}

```

```

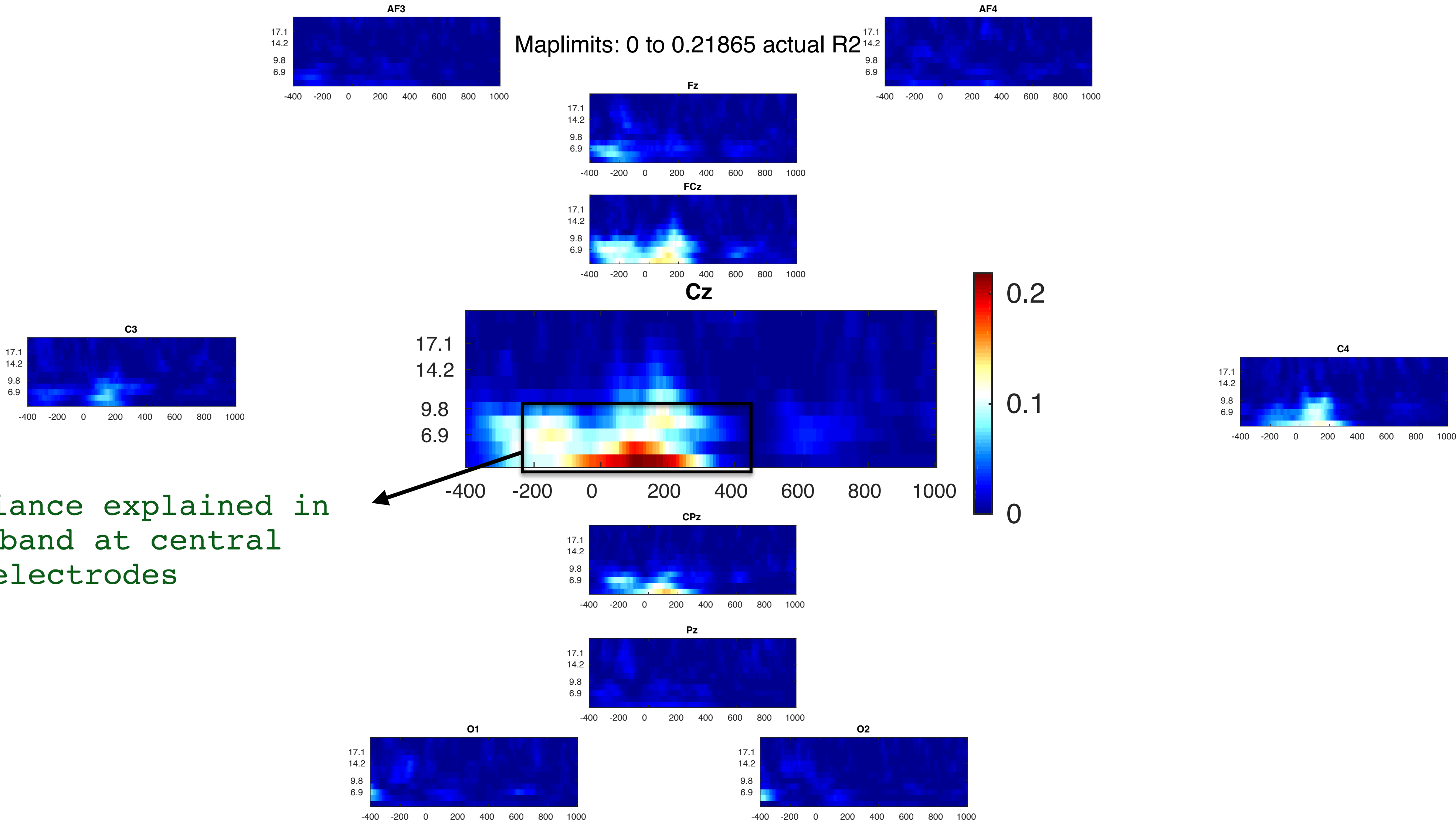
[ReggyD, Info] = STA_Fast_Regress(RESP, TFElectrodes, TimeWin, 'model 1', {{select_trials} Predictors {'EEG'} {'TF1'}},...
    'PredNames', Reg2Name, 'PredLabels', RegLables, 'TF', TF, 'bin_size', 4, 'stepsize', 1,
    'binEEG', 3, 'RetAll', 3, 'NormaliseOn', 0, 'Downsample', 5, 'ERPimage', 0);

```

pass on TF settings

5.1 TF Regression Result

R2 values for the whole model including 3 regressors

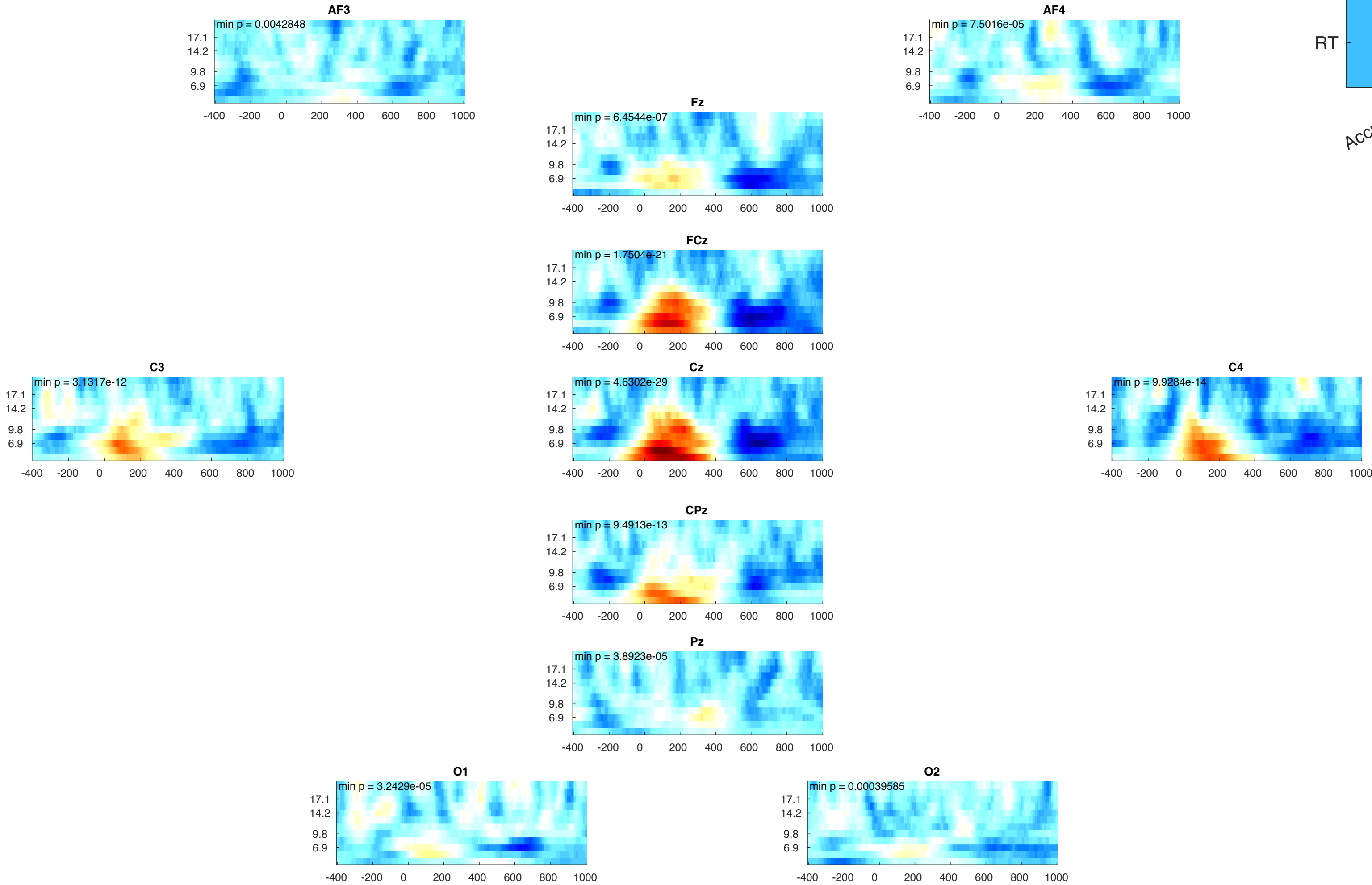
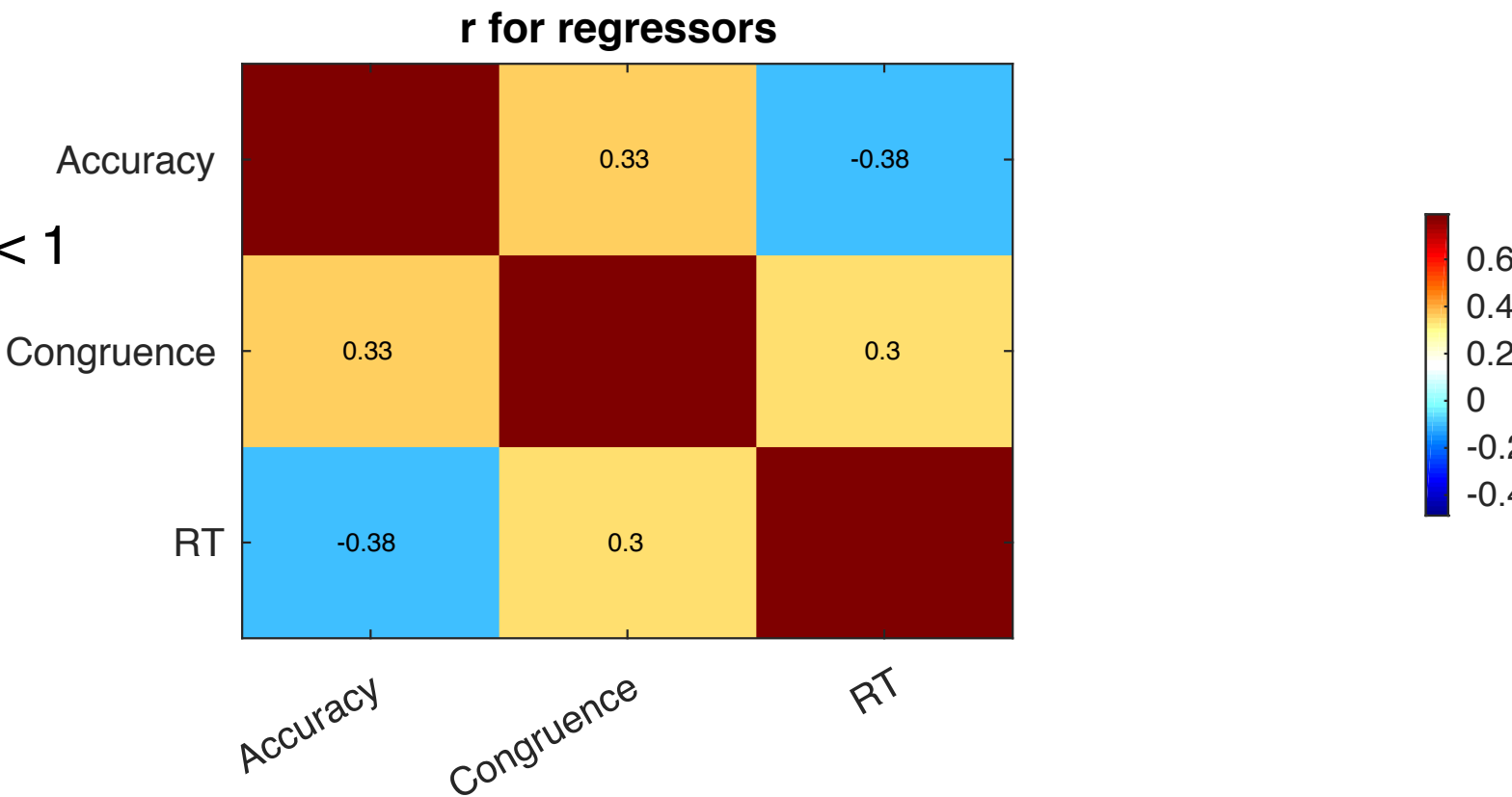


5.1 TF Regression Result

Simple Error Model TF
Reg: Accuracy - cor(-1) & err(1)
Reg: Congruence - con(-1) & inc(1)
Reg: RT - low(5.6082) & high(5.8902)

TF Regressor: Accuracy - values: cor(-1) and err(1)

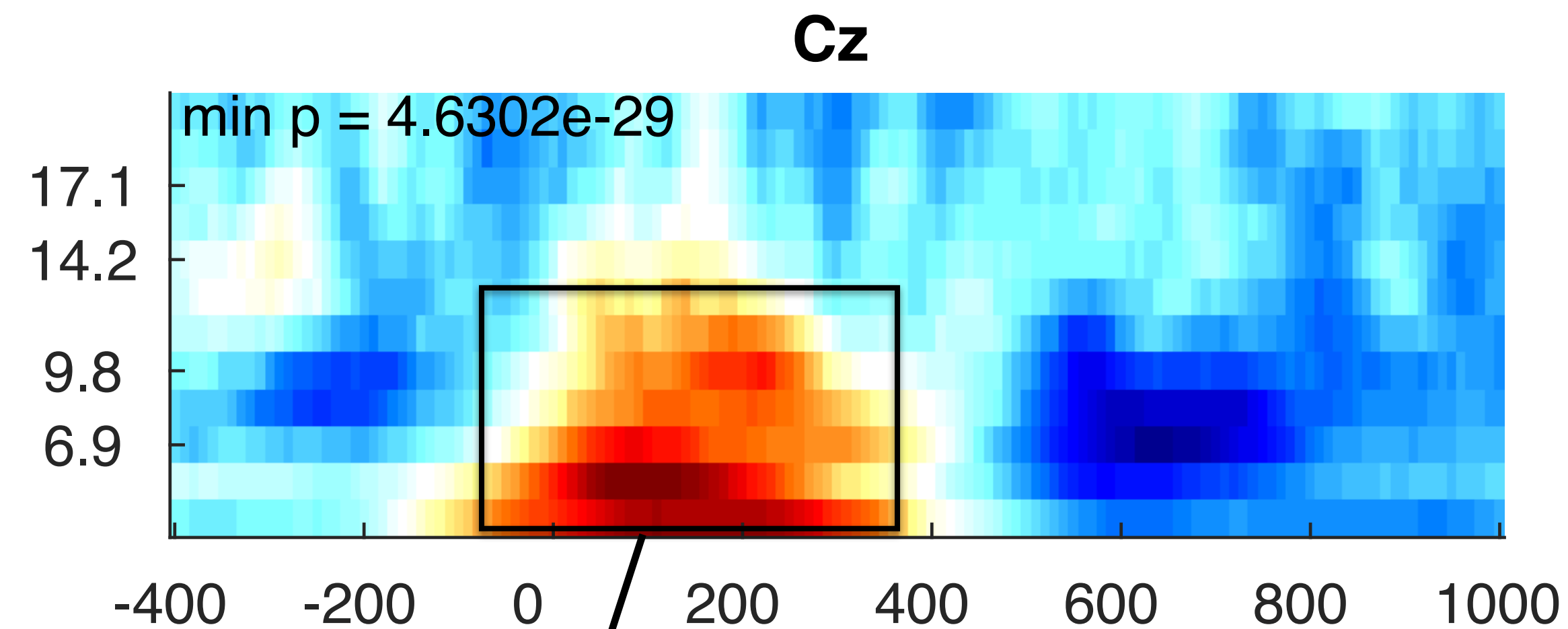
Maplimits: -0.48692 to 0.79069 (average first level b values) & masked with $p < 1$



5.1 TF Regression Result

TF Regressor: Accuracy - values: $\text{cor}(-1)$ and $\text{err}(1)$

Maplimits: -0.48692 to 0.79069 (average first level b values) & masked with $p < 1$



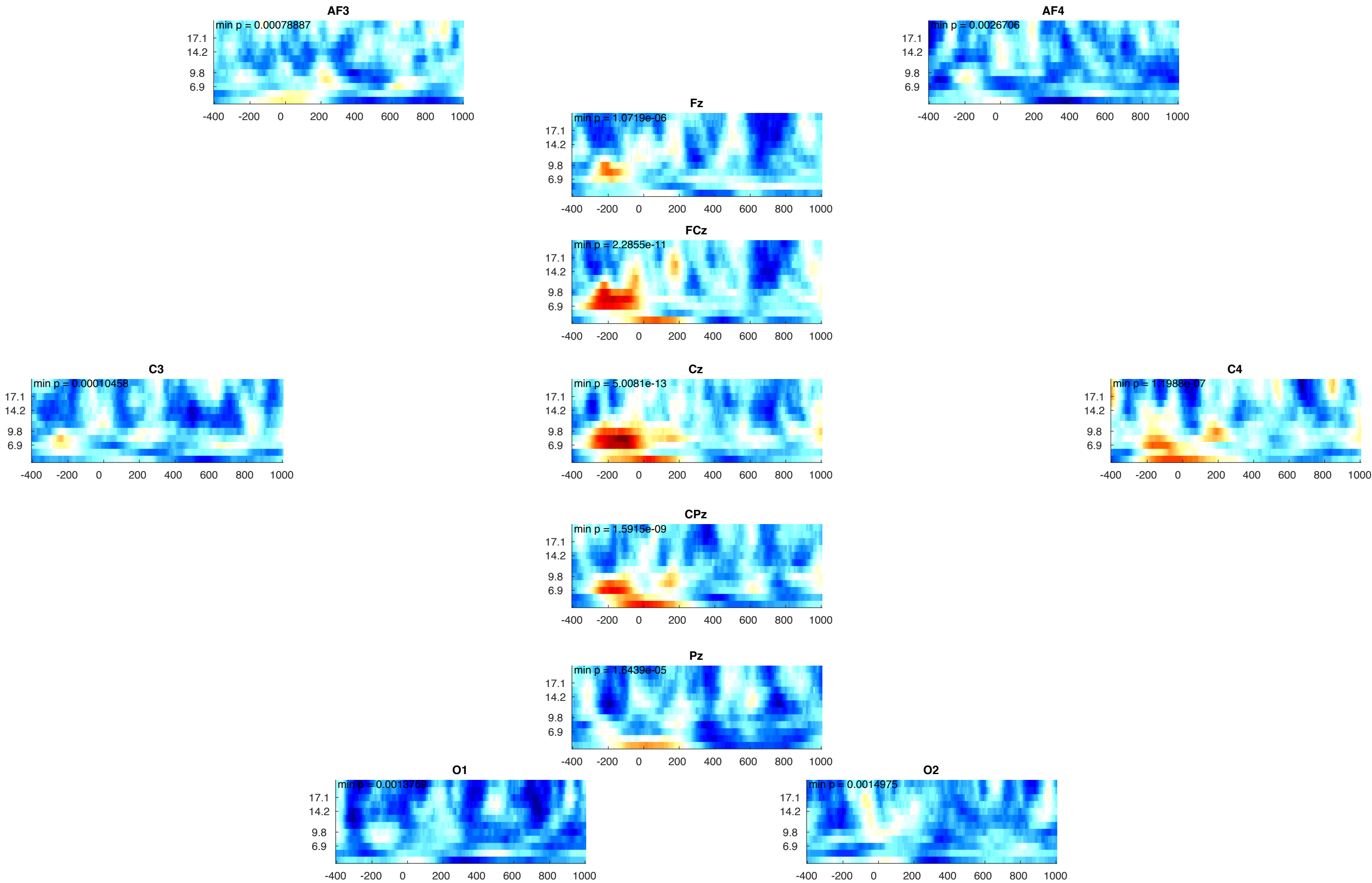
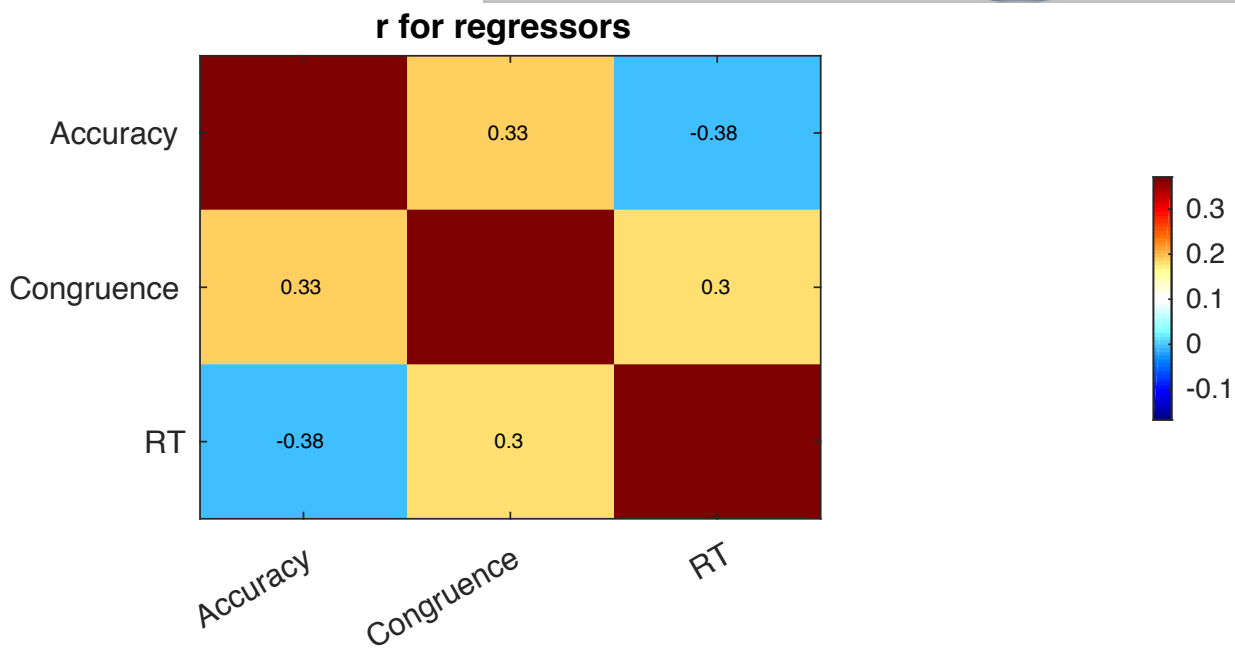
errors induce strong theta to
alpha (4 - 12 Hz) power
increases with a central
topography
independent of congruence and
RT

5.1 TF Regression Result

Simple Error Model TF
Reg: Accuracy - cor(-1) & err(1)
Reg: Congruence - con(-1) & inc(1)
Reg: RT - low(5.6082) & high(5.8902)

TF Regressor: Congruence - values: con(-1) and inc(1)

Maplimits: -0.16758 to 0.37077 (average first level b values) & masked with $p < 1$

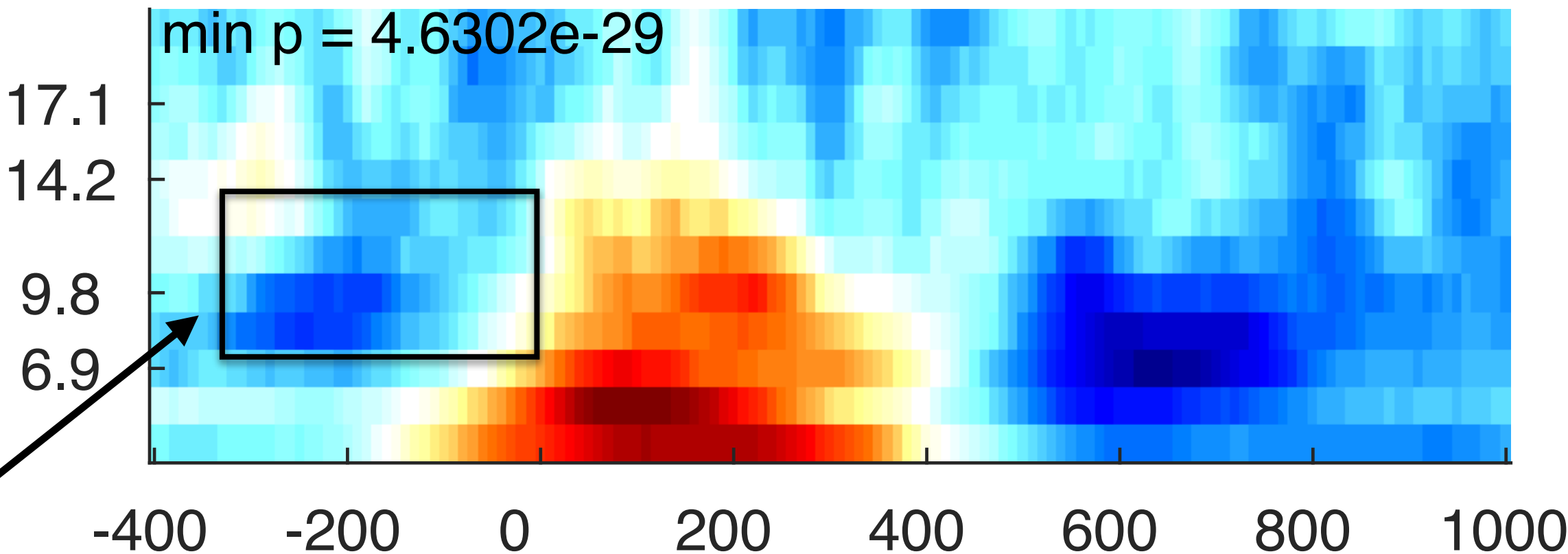


5.1 TF Regression Result

TF Regressor: Accuracy - values: cor(-1) and err(1)

Maplimits: -0.48692 to 0.79069 (average first level b values) & masked with $p < 1$

Cz

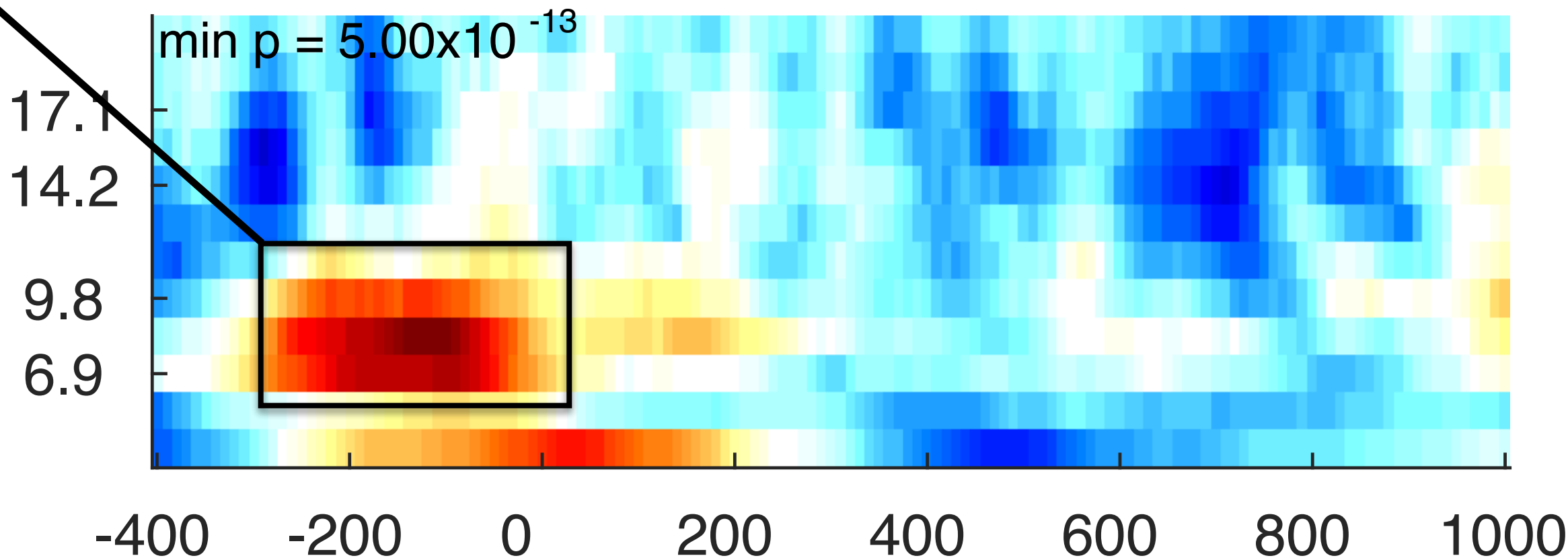


earlier high theta to alpha
effect for congruence
compared to errors

TF Regressor: Congruence - values: con(-1) and inc(1)

Maplimits: -0.16758 to 0.37077 (average first level b values) & masked with $p < 1$

Cz



- Dimensionality in TF spectral space is very high
 - example 60 electrodes, 4 regressors, 20 frequencies in 1s 500 Hz data
 - ➔ 2.4 million comparisons(!) **and** 2.4 million regressions need to be computed (per participant, in whole dataset > **2 billion!**)
 - ➔ $p < 2.1 \times 10^{-8}$ required for FDR or Bonferroni correction
- It is highly desirable to reduce this dimensionality as far as possible
 - Use IC instead of electrode data
 - to stay in *component space* avoids selection of electrodes at all
- Call:

```
load(['../ST Workshop/COMPASS/ERN/Subject-' num2str(i) '-Components_Final.mat']);
```

```
[ReggyD, Info] = STA_Fast_Regress(RESP, TFElectrodes, TimeWin, 'model 1', {{select_trials} Predictors {'EEG'} {'TF1'}},...  
'PredNames', Reg2Name, 'PredLabels', RegLables, 'TF', TF, 'bin_size', 4, 'stepsize', 1,...  
'binEEG', 3, 'RetAll', 3, 'NormaliseOn', 0, 'Downsample', 5, 'ERPimage', 0,...  
'UseIca', {components'}, 'icaname', {'ErrC1'}, 'IcaCSpace', 1, 'IcaElectrode', 'Cz');
```

pass on
components

give the selection
a name

remain in
IC space!
(no backprojection)

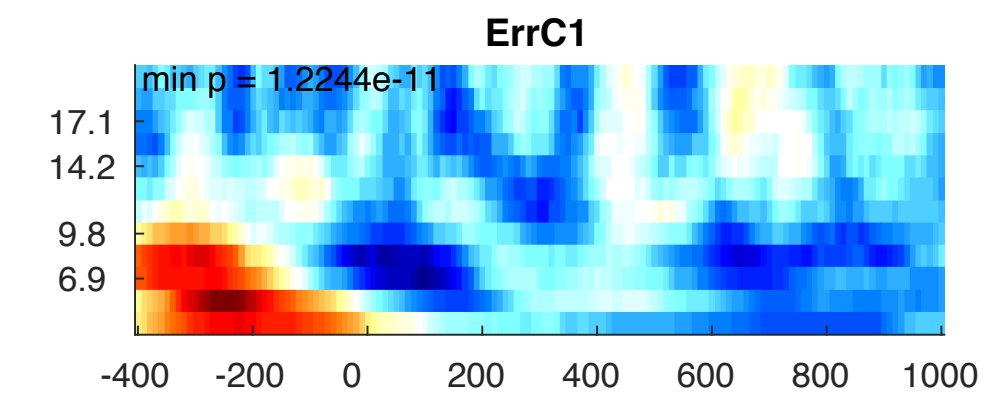
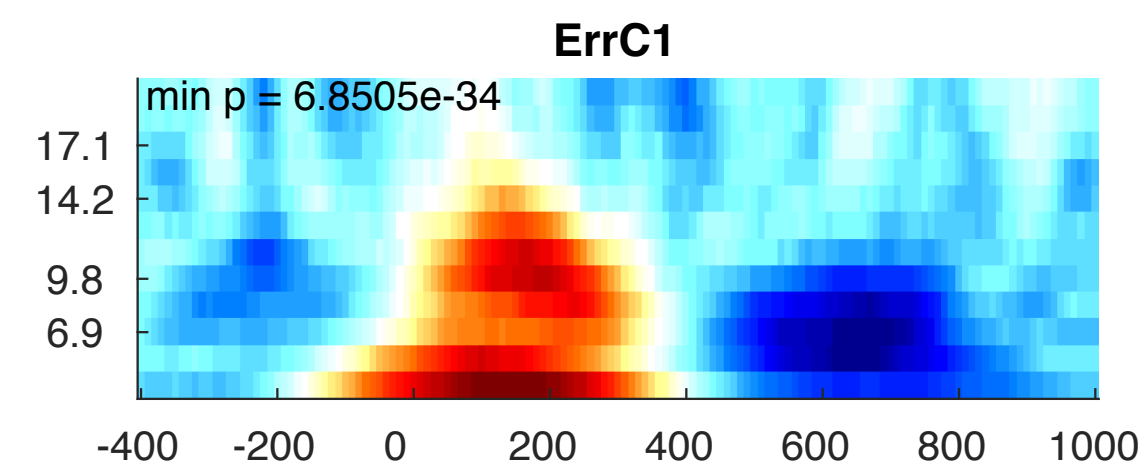
why still an electrode?
To determine polarity of the
component. Correlates EEG and
IC time course and flips (x
-1) IC activity if $\sim \text{sign}(r)$

TF Regressor: Accuracy - values: cor(-1) and err(1)

TF Regressor: RT - values: low(5.6082) and high(5.8902)

Maplimits: -0.57873 to 0.85729 (average first level b values) & masked with $p < 1$

Maplimits: -0.81687 to 1.5014 (average first level b values) & masked with $p < 1$

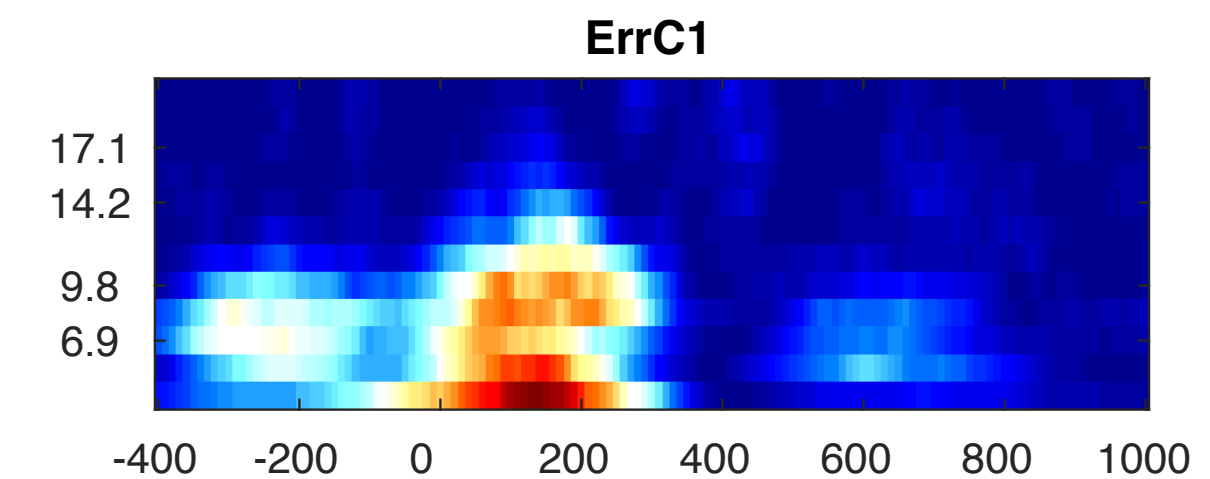
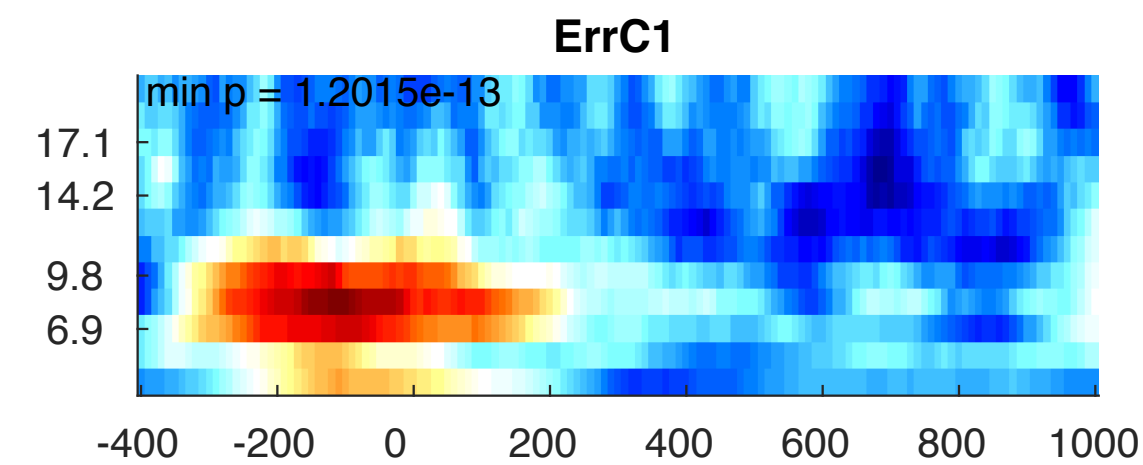


TF Regressor: Congruence - values: con(-1) and inc(1)

R2 values for the whole model including 3 regressors

Maplimits: -0.12923 to 0.38304 (average first level b values) & masked with $p < 1$

Maplimits: 0 to 0.22396 actual R2



```
s1.MaskPval      = 'fdr';  
s1.fdr_q         = 0.05 / 3;  
s1.UseValues     = 'b';  
s1.AddString     = ' fdr';
```

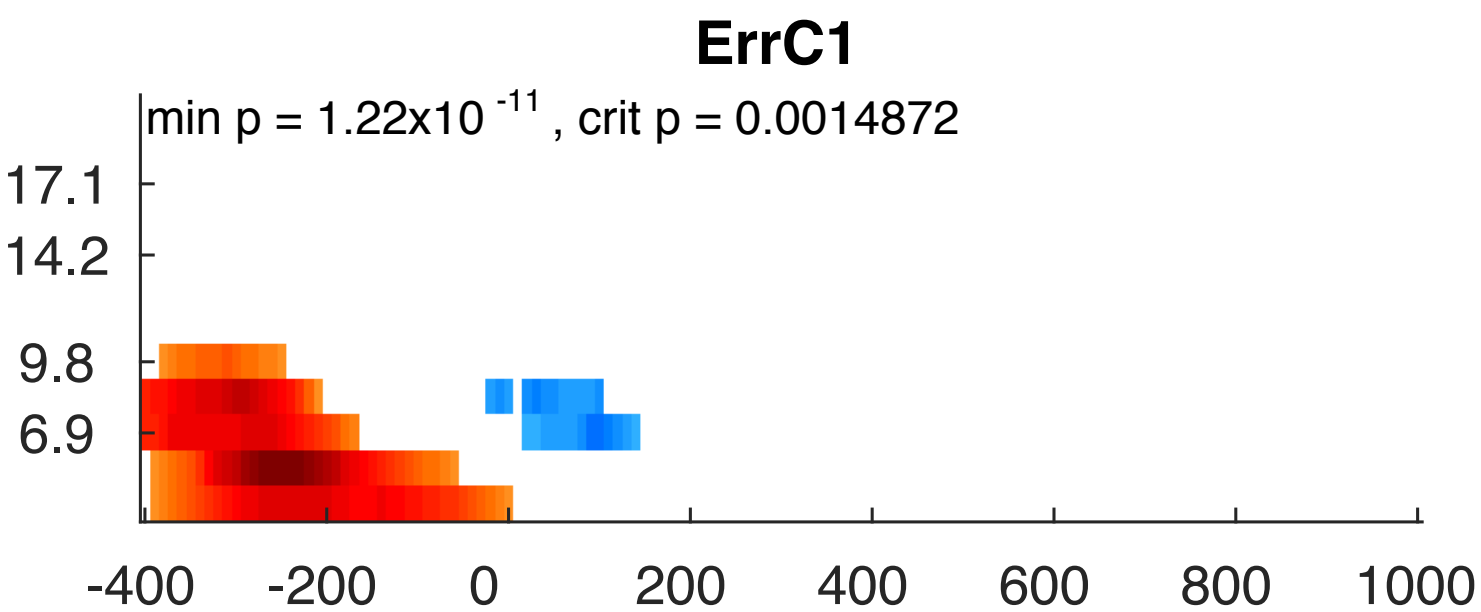
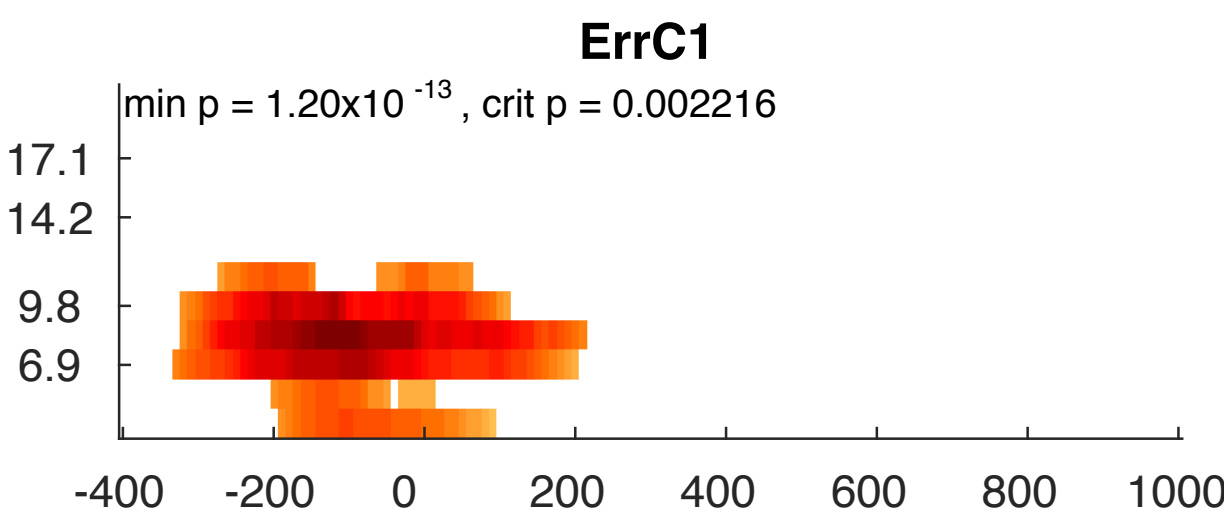
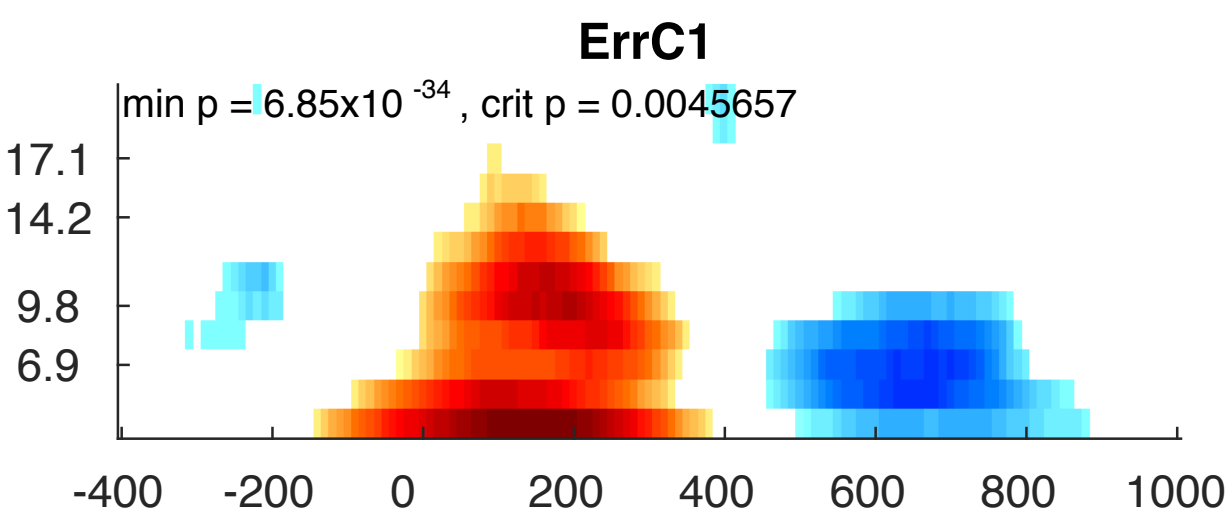
```
STA_Plot_Regression( [pathOut ModelName '/' ], [pathPic ModelName], s1 )
```

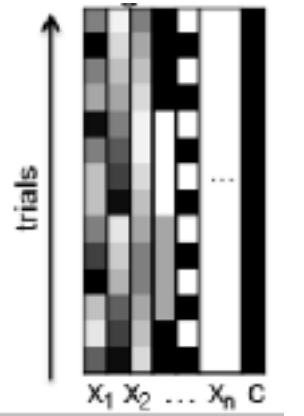
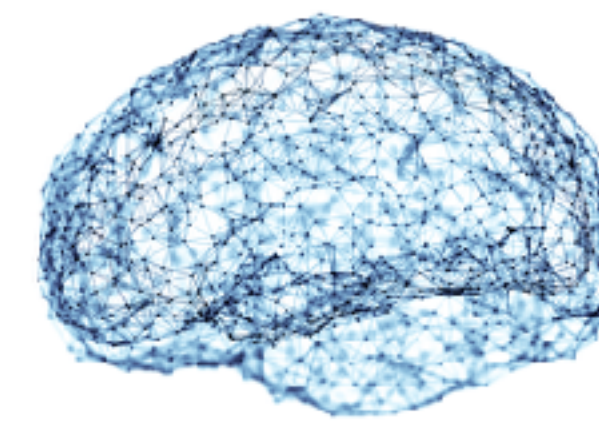
TF Regressor: Accuracy - values: cor(-1) and err(1)

TF Regressor: Congruence - values: con(-1) and inc(1)

Extremes: -0.579 to 0.857 (average first level b values) & masked with fdr

Extremes: -0.129 to 0.383 (average first level b values) & masked with fdr





- I hope we could motivate you to try single-trial analysis approaches, because this
 - ▶ allows to get a more in-depth understanding of your neural data and brain behavior interactions
 - ▶ you can get much more specific results (by controlling confounds within- and across-participants)
 - ▶ you can get better results (by more efficiently explaining uncorrelated noise)
 - ▶ can well be combined with ICA and extended into frequency power analyses, and combines methodology across different techniques
 - ▶ is relatively easy done and does not require much more time than an ERP analysis, for example when making use of the scripts provided in this workshop

