A physical scheme to retrieve simultaneously surface temperature and emissivities using IASI

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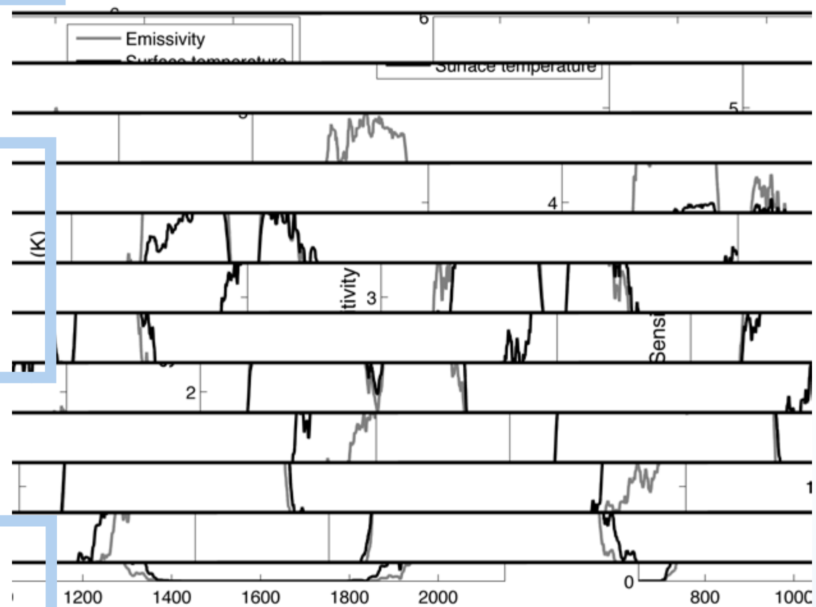
COLLÈGE DES INGÉNIEURS

Objective

- First guess in Ts and emissivity
- Satellite observations

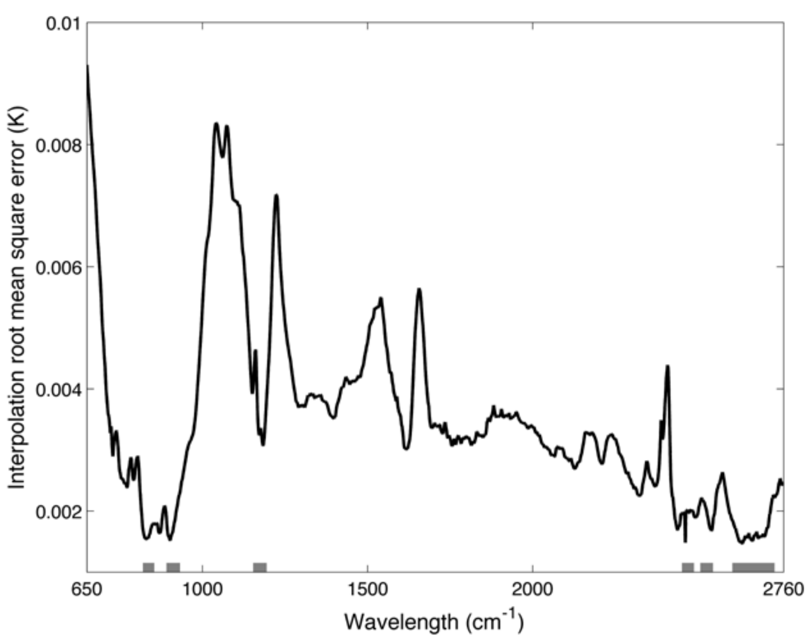
- Retrieved Ts
- High spectral emissivity

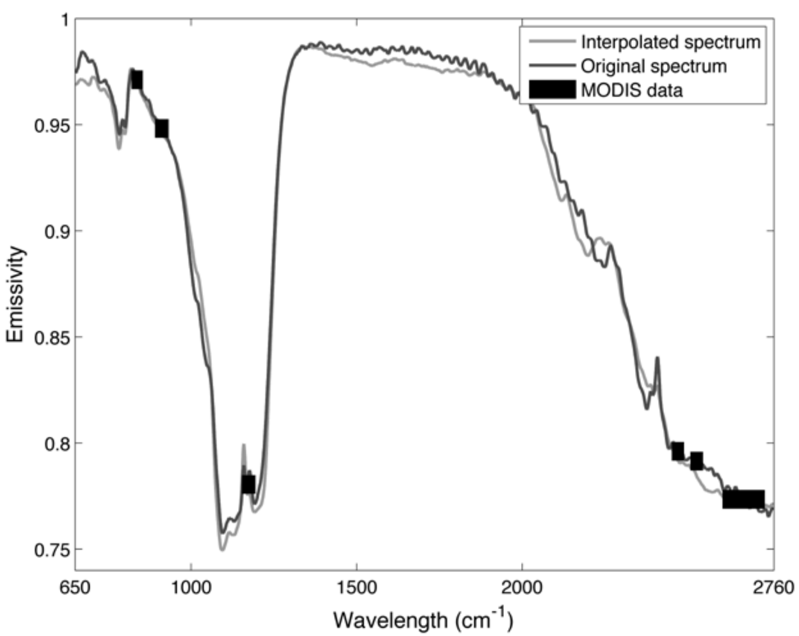
- Used as a first guess for atmospheric profile retrieval



Principle

- First guess: MODIS emissivity interpolator
  - Learning dataset: laboratory measurements + IGBP surface classification
  - Neural network interpolation





Principle

- Retrieval: local Taylor expansion of the radiative transfer equation

$$I(\lambda) = \tau(\lambda) \cdot \epsilon(\lambda) \cdot B(T_s)(\lambda) + atm\uparrow(\lambda) + \tau(\lambda) \cdot (1 - \epsilon(\lambda)) \cdot atm\downarrow(\lambda))$$

$$(I_{obs} - I_{calc})(\lambda) = \tau(\lambda) \cdot (\epsilon_{true}(\lambda) \cdot B(T_{s_{true}})(\lambda) - \epsilon_{fg}(\lambda) \cdot B(T_{s_{fg}})(\lambda))$$

$$\begin{pmatrix} c_1 & \cdots & c_P & \Delta T \end{pmatrix} \cdot \begin{pmatrix} ev_{1,1} & \cdots & ev_{1,N} \\ \vdots & \ddots & \vdots \\ ev_{P,1} & \cdots & ev_{P,N} \\ F'_1(T_{s_{fg}}) & \cdots & F'_N(T_{s_{fg}}) \end{pmatrix} = -\bar{\epsilon} - F(T_{s_{fg}})$$

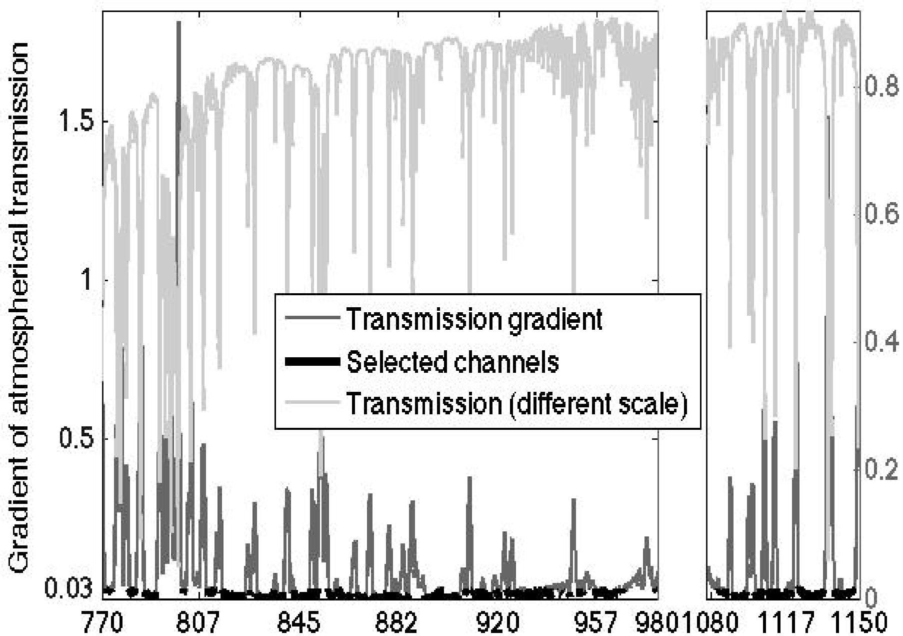
PCA components of emissivity ($c_1 \cdots c_P$)

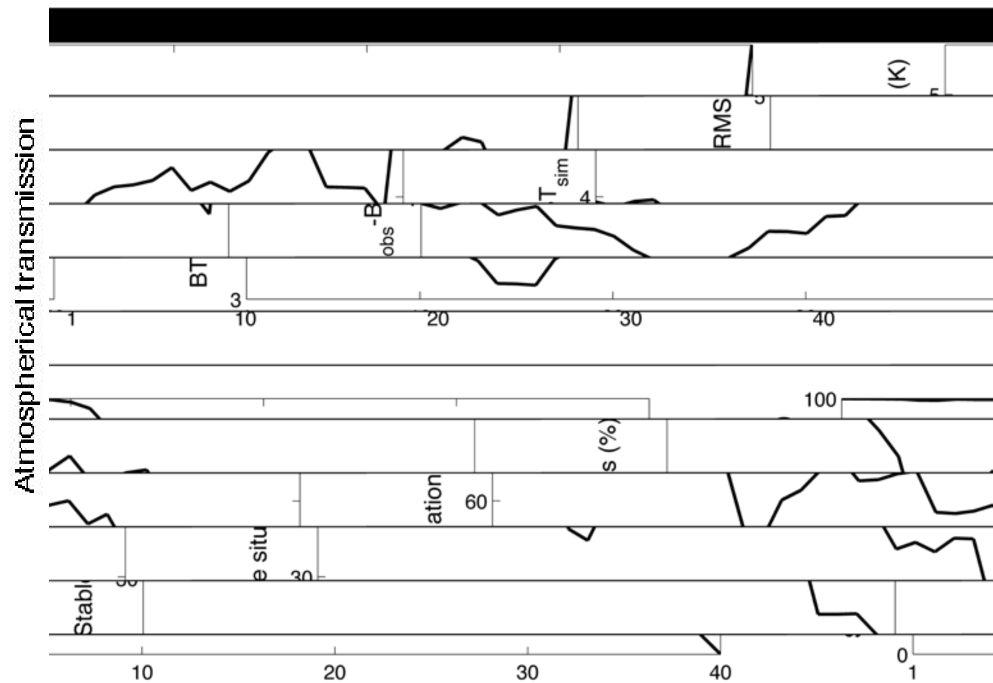
Surface temperature (ΔT)

Taylor expansion ($F'_1(T_{s_{fg}})$)

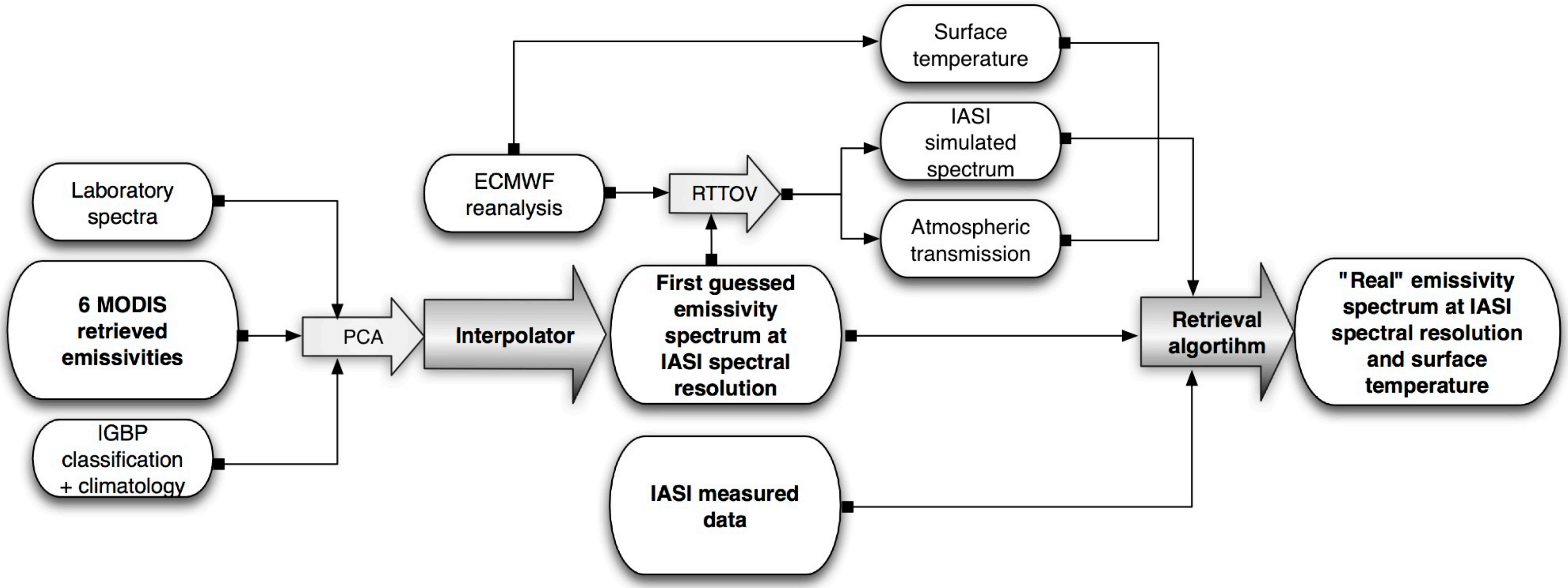
Principle

- Selection of the "window channels" and the number of emissivity PCA components:



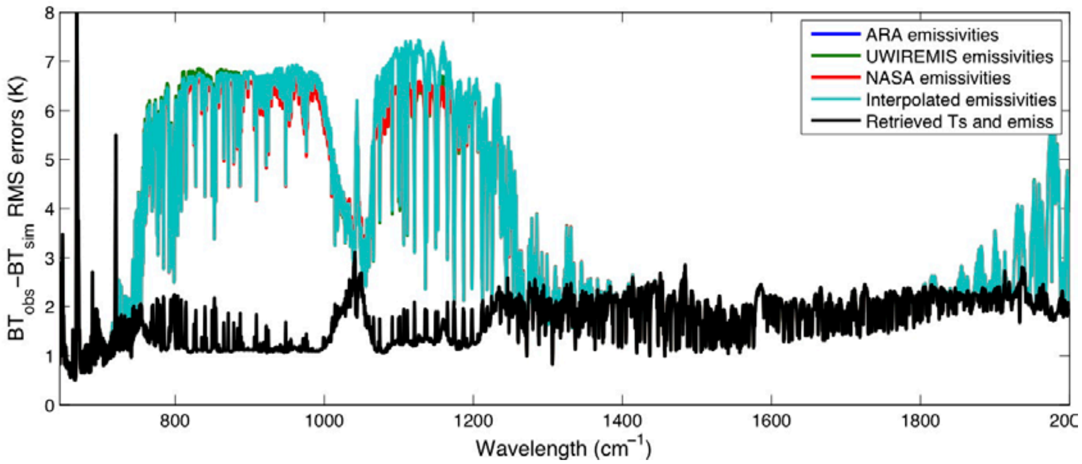


Summary

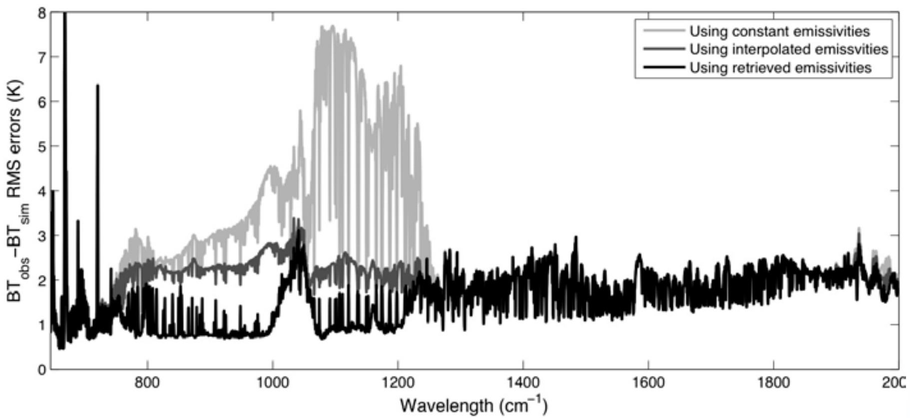

Surface temperature
IASI simulated spectrum
Atmospheric transmission
ECMWF reanalysis
RTTOV
Laboratory spectra
6 MODIS retrieved emissivities
IGBP classification + climatology
PCA
Interpolator
First guessed emissivity spectrum at IASI spectral resolution
Retrieval algortihm
"Real" emissivity spectrum at IASI spectral resolution and surface temperature
IASI measured data

Results

- BT_{obs}-BT_{sim}

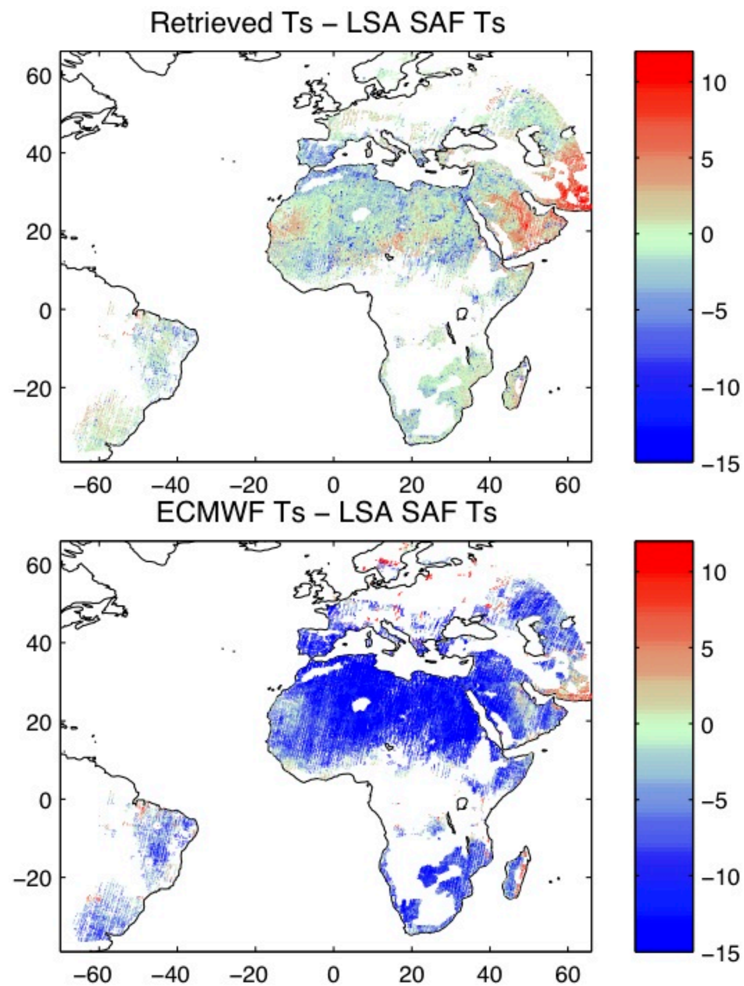


•Péquignot É. et al (2008), Infrared continental surface emissivity spectra retrieved from AIRS hyperspectral sensor., J. Appl. Meteorol. Climat.
•Seemann, S. et al (2008), Development of a global infrared surface emissivity database for application to clear sky retrievals from multispectral satellite radiance measurements, J. Appl. Meteorol. Climat.
•Zhou, D. et al (2011), Global land surface emissivity retrieved from satellite ultraspectral IR measurements, Geoscience and Remote Sensing, IEEE Transactions on



Results

- Ts intercomparison:
  - LSA SAF SEVIRI retrieval
  - ECMWF reanalysis



Results

- Triple collocation: uncorrelated errors

$$X = Ts + \epsilon_X$$
$$Y = Ts + \epsilon_Y$$
$$Z = Ts + \epsilon_Z$$

$$\overline{(X-Y)\cdot(X-Z)} = \overline{\epsilon_X^2}$$
$$\overline{(Y-X)\cdot(Y-Z)} = \overline{\epsilon_Y^2}$$
$$\overline{(Z-Y)\cdot(Z-Y)} = \overline{\epsilon_Z^2}$$

- Results:
  - ECMWF: 5.46 K
  - LSA SAF: 2.99 K
  - Retrieval: 2.08 K

Correlation matrix:

ECMWF	1	0.78	0.83
LSASAF	0.78	1	0.94
Retrieval	0.83	0.94	1

Current work

- Algorithm runs operationally over multiple years of IASI observations
- IASI L2 products used as a priori atmospheric state and surface temperature first guesses for better coherency
- Construction of a monthly mean database with error correlation matrix at high spectral resolution and comparison with existing datasets

Conclusion

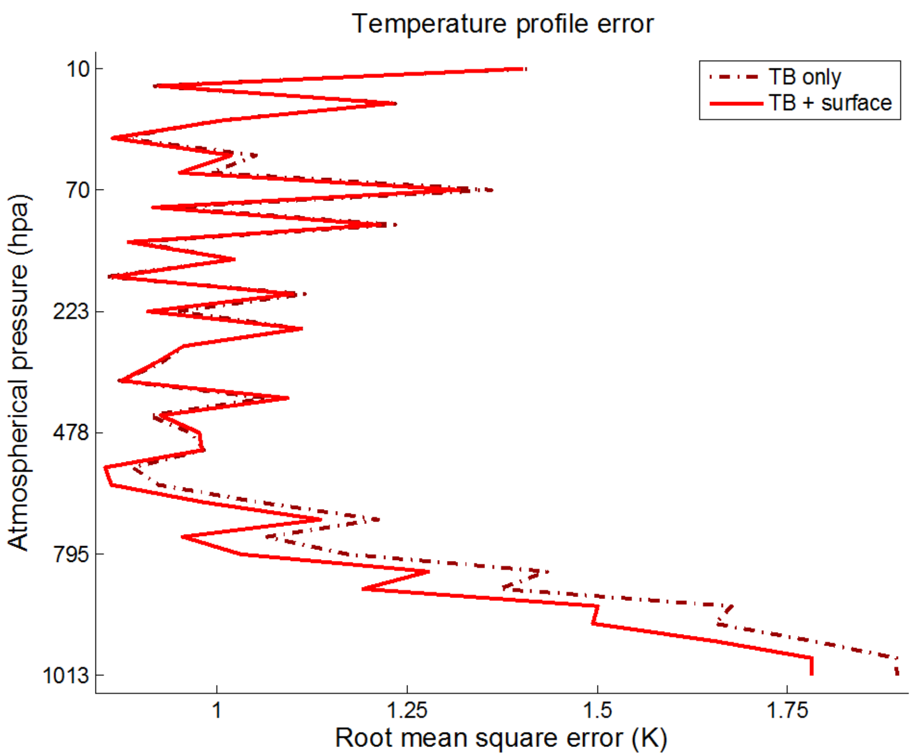
- Non linear spectral emissivity interpolator
- Analytical (surface temperature + emissivity) retrieval scheme
- Results close to other independent Ts retrievals (LandSAF)

Paul, Aires and Prigent (under review), An innovative physical scheme to retrieve simultaneously surface temperature and emissivities using spectral infrared observations from IASI, Journal of Geophysical Research

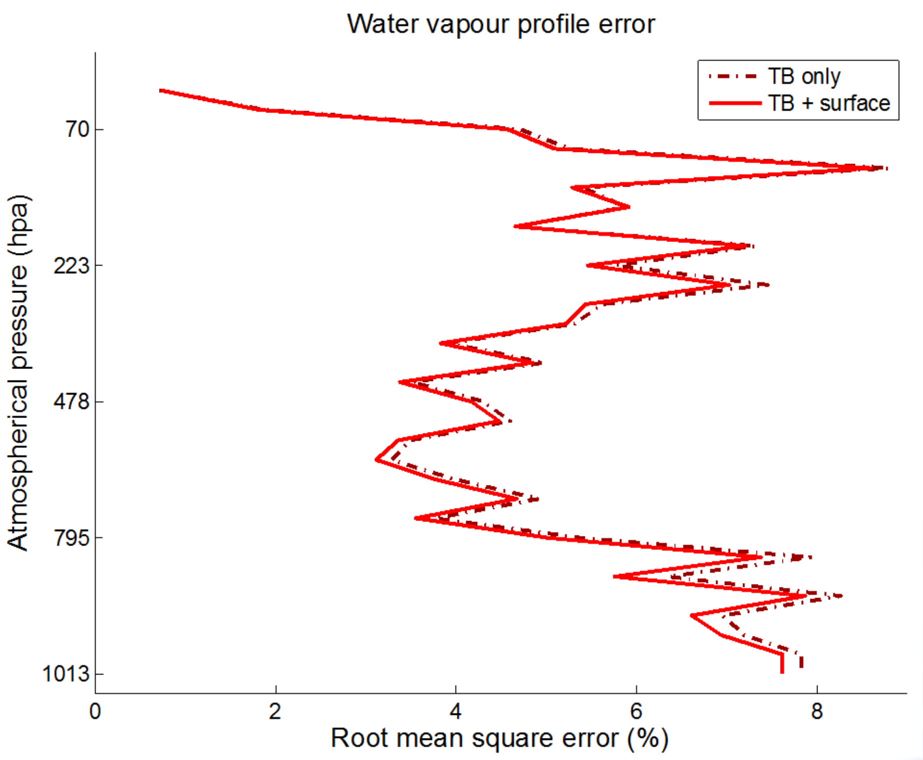
Atmospheric retrievals

PLAN

I. The interpolator
II. Retrieval of surface characteristics
III. **Atmospheric retrievals**



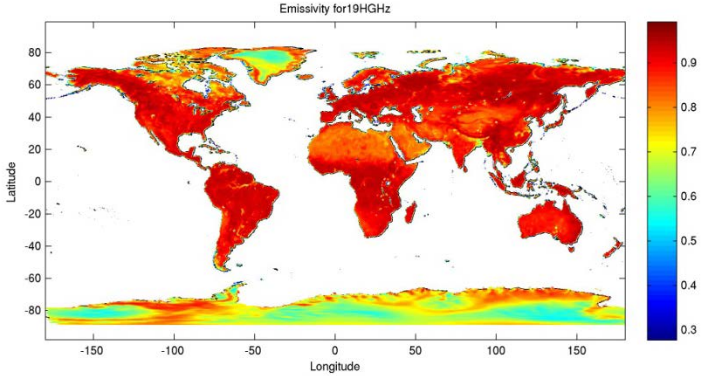
Improvement of up to 13%



Improvement of up to 9%

Future work

- Comparison with microwave emissivity



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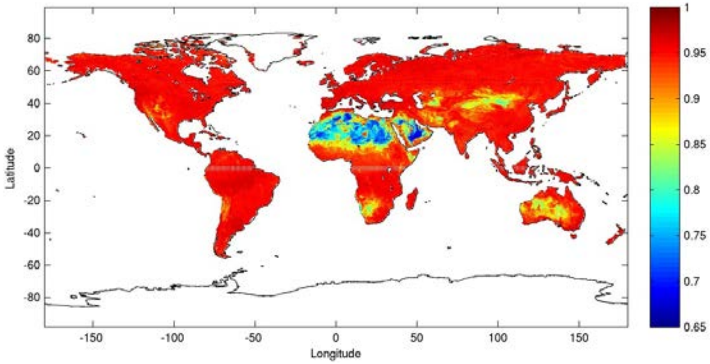

- Use in atmospheric retrieval scheme combined with microwave information using:

$$Cov\left(\varepsilon_{\mathrm{IR}}, \varepsilon_{\mathrm{MW}}\right) = \begin{pmatrix} Cov\left(\varepsilon_{\mathrm{IR}}\right) & Cov\left(\varepsilon_{\mathrm{MW}}, \varepsilon_{\mathrm{IR}}\right) \\ Cov\left(\varepsilon_{\mathrm{IR}}, \varepsilon_{\mathrm{MW}}\right) & \left(\varepsilon_{\mathrm{MW}}\right) \end{pmatrix}$$

- Assimilation tests at NOAA