The EOLDAS prototype

Earth Observation Land Data Assimilation System

eo-ldas

support to science element

Lewis P[1], Quaife T[2], Settle J[3], Kaminski T[4], Gobron N[5] and Styles J[6]

1.UCL, UK: plewis@geog.ucl.ac.uk
2.University of Exeter, UK: t.l.quaife@ex.ac.uk
3.University of Reading, UK.
4.FastOpt, Germany.
5.Joint Research Centre, Ispra, Italy.
6.Assimila Ltd, Reading, UK

Introduction:

The EOLDAS is the Earth Observation Land Data Assimilation (DA) System and is a research project funded by the European Space Agency. The project developed a prototype DA scheme to demonstrate the assimilation of satellite reflectance observations into a canopy Radiative Transfer (RT) model. This poster shows some preliminary results of the EOLDAS prototype from synthetic experiments using modelled reflectance data from prescribed parameter trajectories.

The ultimate aim of the EOLDAS system is to build a DA system that will assimilate top of atmosphere radiance data into a coupled land-atmosphere RT scheme. The individual components of the system will be interchangeable.

Experiment:

For this demonstration of the prototype a configuration was selected with 1 point in space and 100 points in time. The matrix A (see Data Assimilation box) was specified to constrain the first difference of the model parameters to be zero. Synthetic parameter profiles were generated for 100 time steps. Fig 1a shows the LAI trajectory. For the results presented here all other parameters were static in time. From these profiles the RT model was used to forward predict daily reflectance data at MODIS wavelengths. Normally distributed noise was then added into these data with a standard deviation of 0.004 (reflectance units). Model fits without noise give perfect fits.

The DA scheme was used to assimilate the noisy data to reconstruct the temporal evolution of the parameters. The retrieved parameters were also used to forward model MODIS reflectance data. Results are shown in Fig 1.

The ability of the system to predict the reflectance data of one sensor from another was also tested. The synthetic and retrieved parameter sets were used to model reflectance observations at MERIS wavelengths. Results are shown in Fig 2.

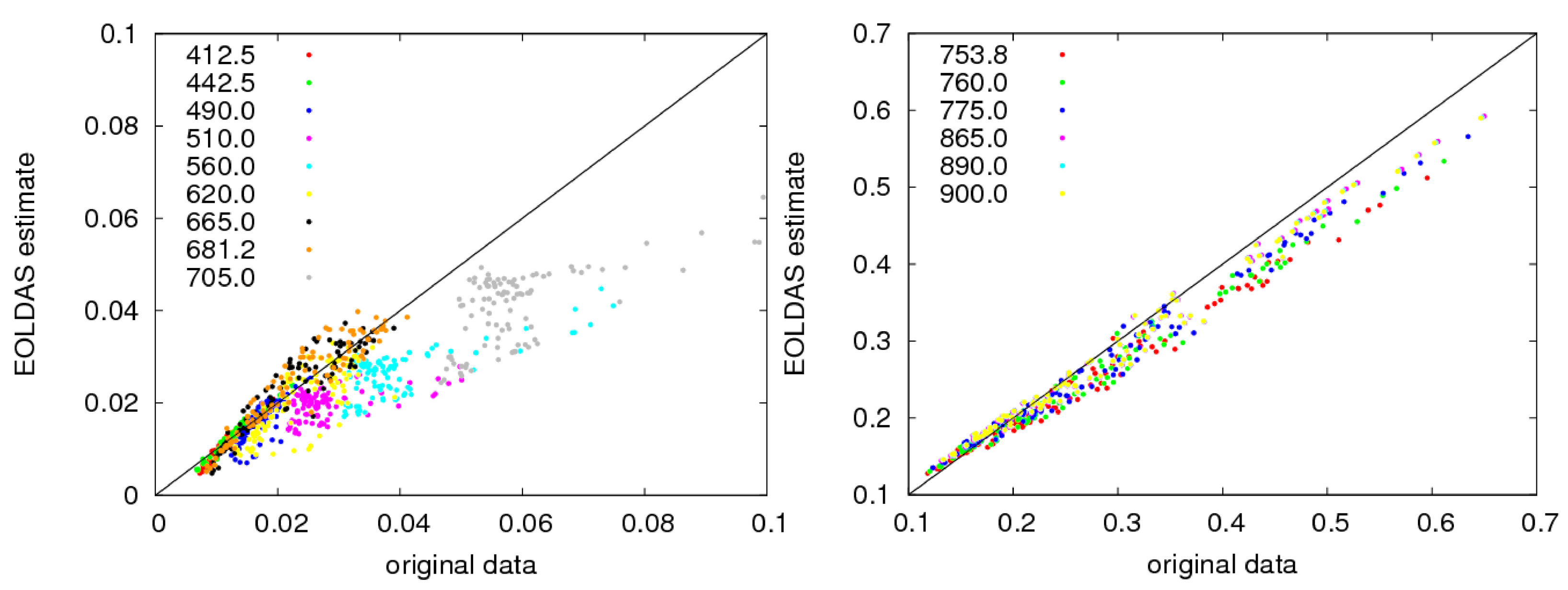

Figure 2. Predictions of MERIS reflectance data using parameters retrieved from the EOLDAS prototype using MODIS data. Results have been separated into two separate panels to increase the dynamic range.

Validation:

Field data has been collected at a test site in Germany in collaboration with the University of Jena, for an entire agricultural growing cycle. The EOLDAS prototype will be used to assimilate DMC satellite observations (Fig 3) for this area and the retrieved parameters compared against field observations.

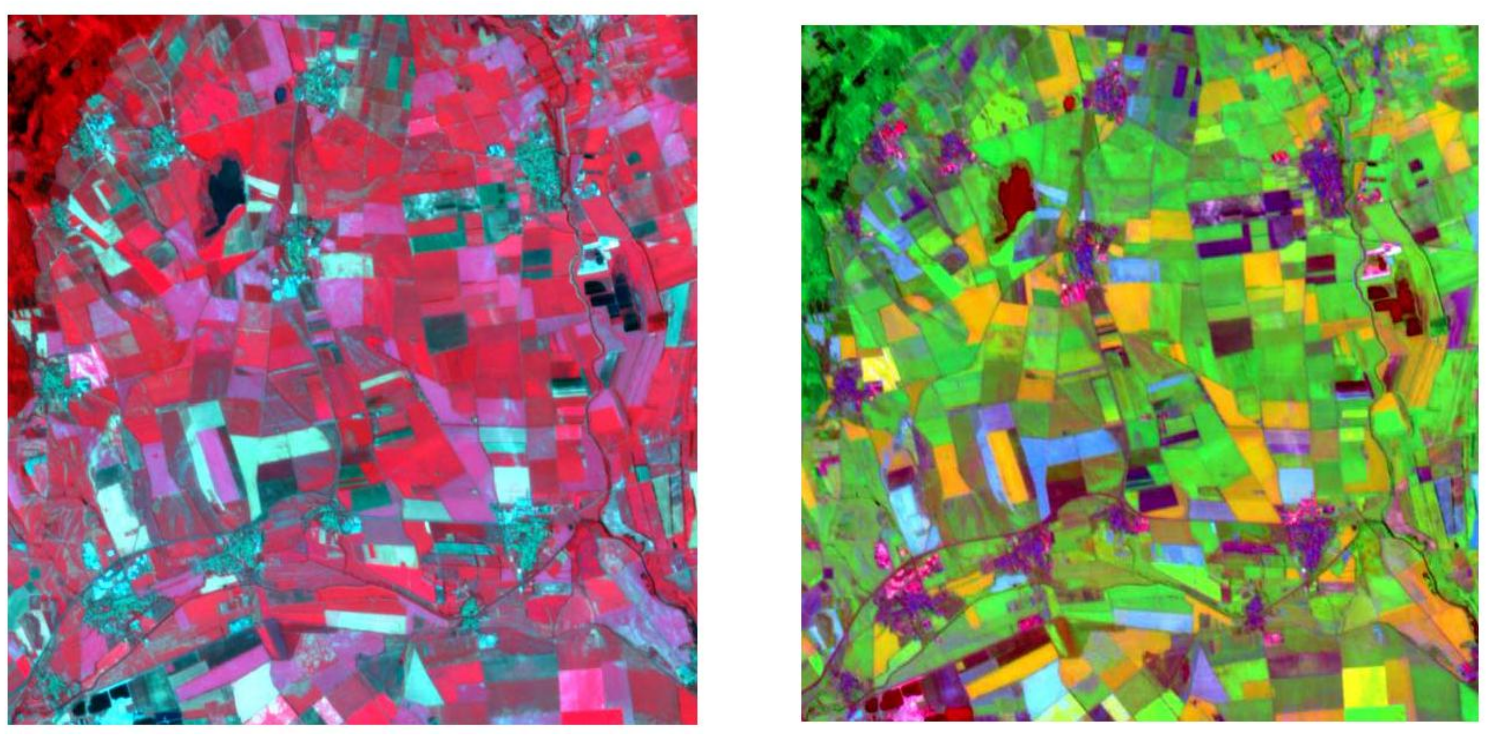

Figure 3. DMC images of German test site. Standard false colour composite (left) and with decorrelation stretch applied (right).

RT Model:

The prototype system uses the semi-desctrete model of Gobron et al. (1997) to describe canopy level radiation transport. Leaf optical properties are prescribed using an emulation of the PROSPECT model (Féret et al., 2008) and soil albedo is defined using the empirical orthogonal components described by Price (1990). In total there are 13 parameters per point in space and time.

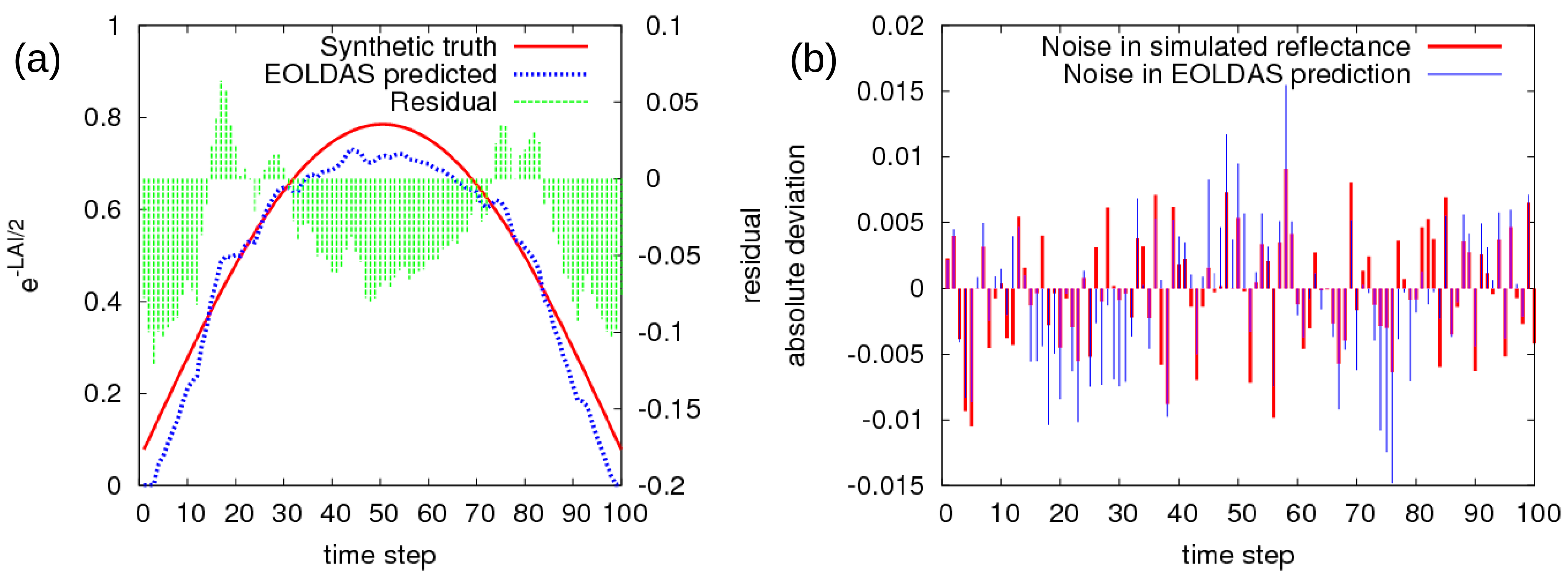

Figure 1. Residuals in reconstructed LAI profile (a) and associated predictions of reflectance at 660nm. Red lines show the synthetic truth and blue lines the EOLDAS predictions. Residuals in the synthetic truth (b) illustrate noise added into the modelled data.

Data Assimilation strategy:

A variational system is used to define the data assimilation problem with the following cost function, J(x), where x is the model state vector:

$$J(x) = J_{pr}(x) + J_{obs}(x) + J_{mod}(x)$$

The first term

$$J_{pr}(x) = 0.5\,(x-x')^T C_{x'}^{-1} (x-x')$$

quantifies deviation of x from prior information described by the mean, x′, and covariance $C_{x'}^{-1}$. The second term

$$J_{obs}(x) = 0.5\,(M_R(x)-d)^T C_d^{-1} (M_R(x)-d)$$

quantifies the fit to the observed satellite reflectance data, d, with covariance C_d^{-1} to the predicted reflectances from the radiative transfer model, $M_R(x)$, described in the model section. The final term

$$J_{mod}(x) = 0.5\,(M_V(x)-x)^T C_V^{-1} (M_V(x)-x)$$

describes the deviation of the vector of states at any point in space and time from the constraint inposed by the model $M_V(x)$. C_V characterises uncertainty in the temporal model. For the prototype a simple linear model for $M_V(x)$ has been selected:

$$M_V(x) = Ax + b$$

The user is free to specify the matrix A and vector b as required. J(x) is minimised by a gradient descent method. Efficient gradient code is generated by the automatic differentiation toll TAF (Giering and Kaminski, 1998).

Conclusions:

- 1300 parameter values retrieved from 100 days of 7 waveband data
- Parameters retrieved to high degree of confidence (Fig1 a)
- Good prediction of MERIS data from MODIS wavebands

References:

Féret JB, C François, GP Asner, AA Gitelson, RE Martin, LPR Bidel, SL Ustin G le Marie and S Jacquemoud (2008) PROSPECT-4 and 5: Advances in the leaf optical properties model separating photosynthetic pigments. *Remote Sensing of Environment*. 112(6) 3030-3043.

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