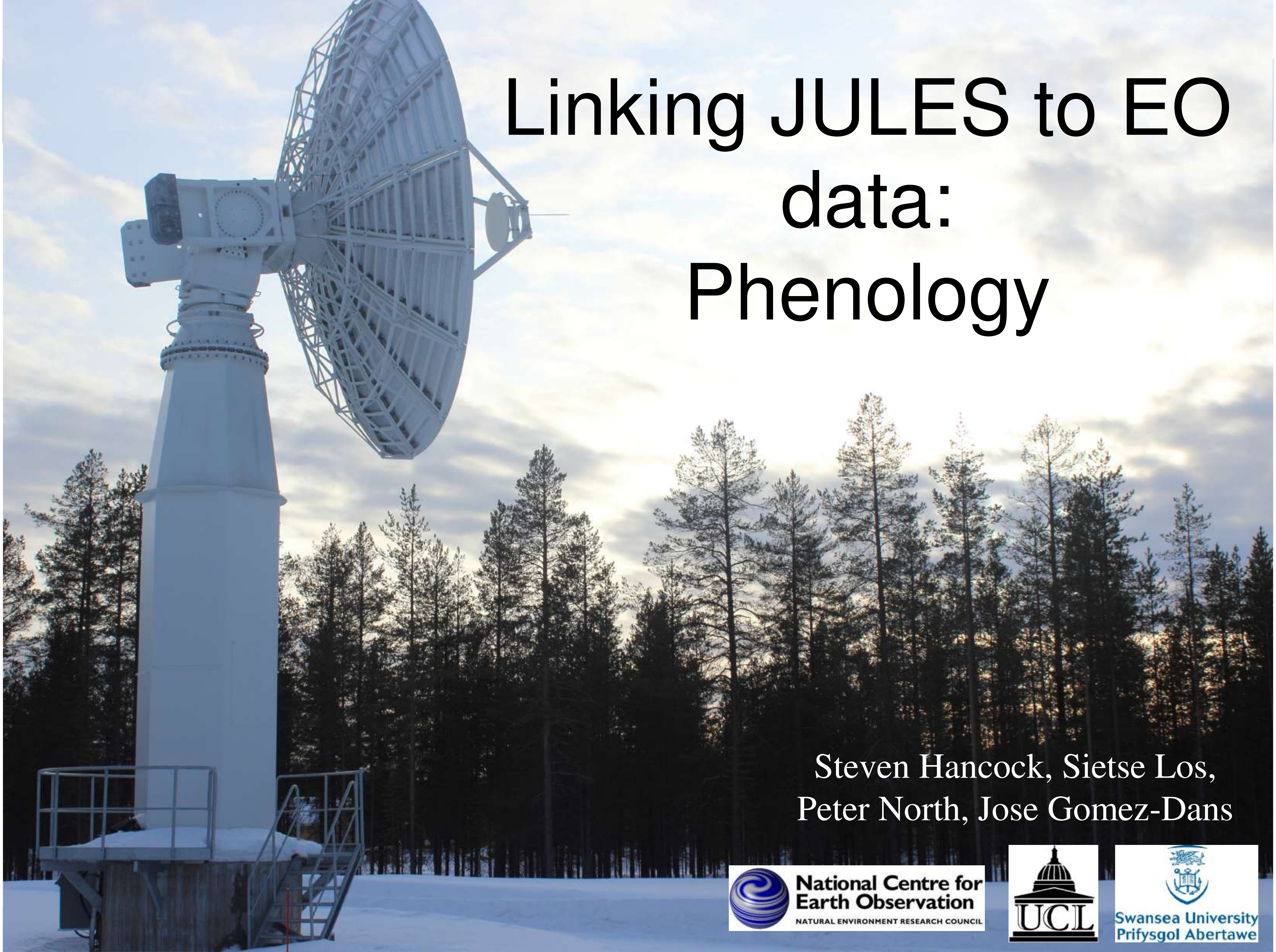

Linking JULES to EO data: Phenology

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NATURAL ENVIRONMENT RESEARCH COUNCIL
UCL
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Prifysgol Abertawe

JULES and EO

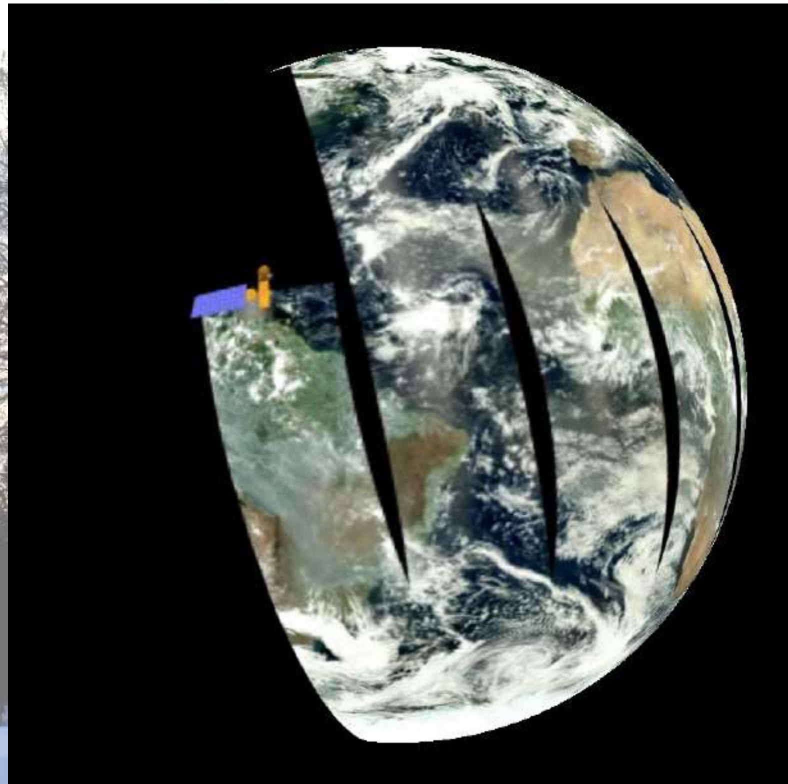
- We have an increasing range of Earth Observation data

- Lots of high level products
  - SWE, LAI, soil moisture
  - Errors are often poorly quantified
  - Can include biases

- Using dates alone can hide issues.

- Lots of low level products
  - Radiance

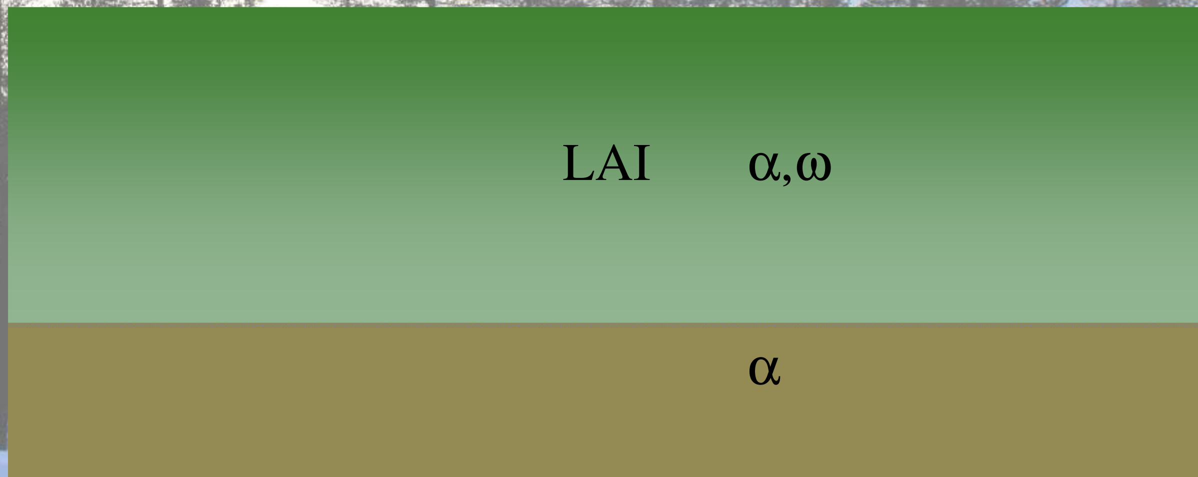
- Passive optical sensors are the most common
  - Measure surface radiance



JULES reflectance

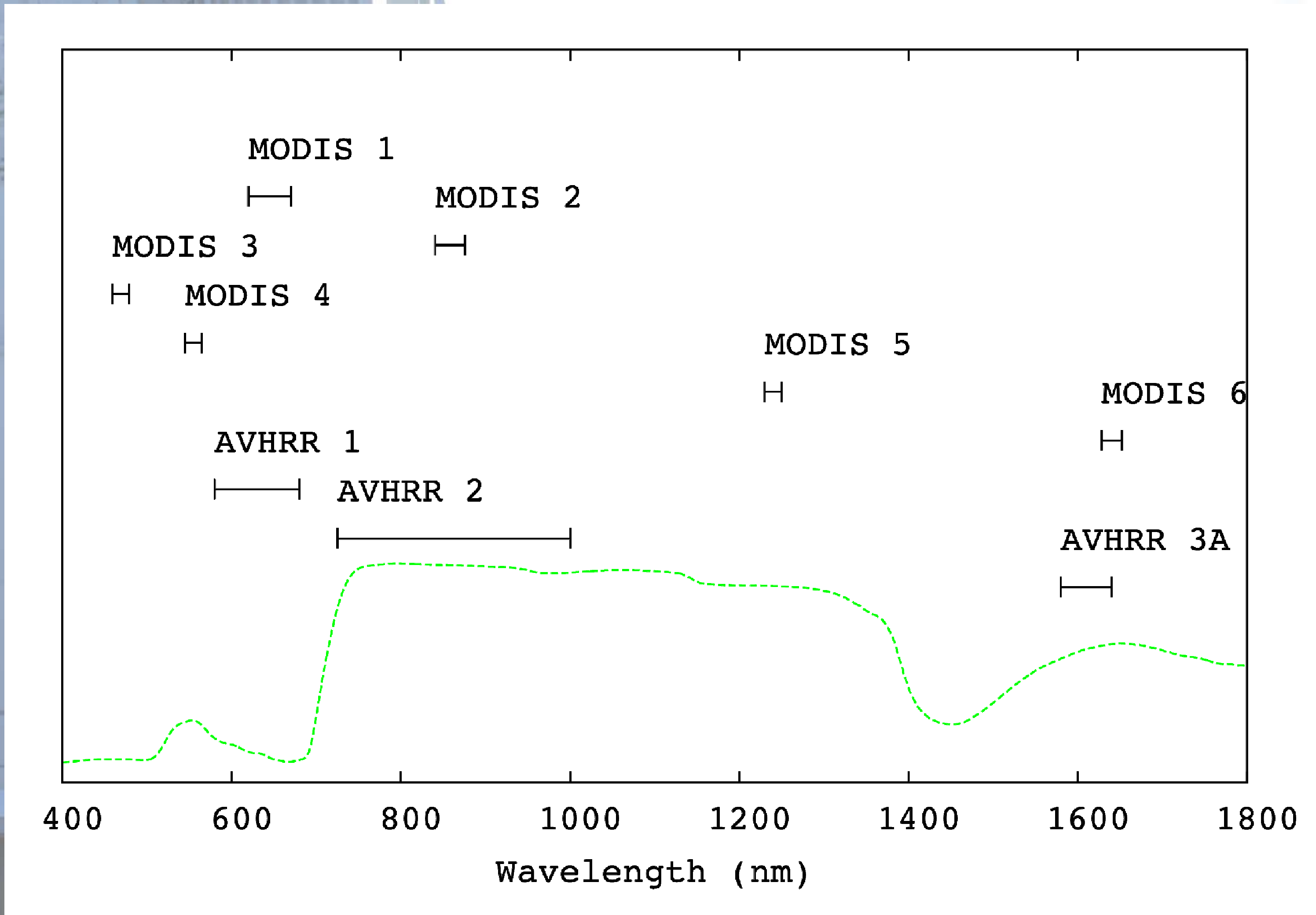
- Surface reflectance is controlled by snow and vegetation
    - Snow melt is a big area so leave out for now

    - LAI controlled by phenology and TRIFFID.
    - "Sellers" scales from leaf and soil to canopy reflectance



Reflectance wavebands

- Different instruments measure different band widths
  - JULES has broadband visible and NIR



Reflectance wavebands

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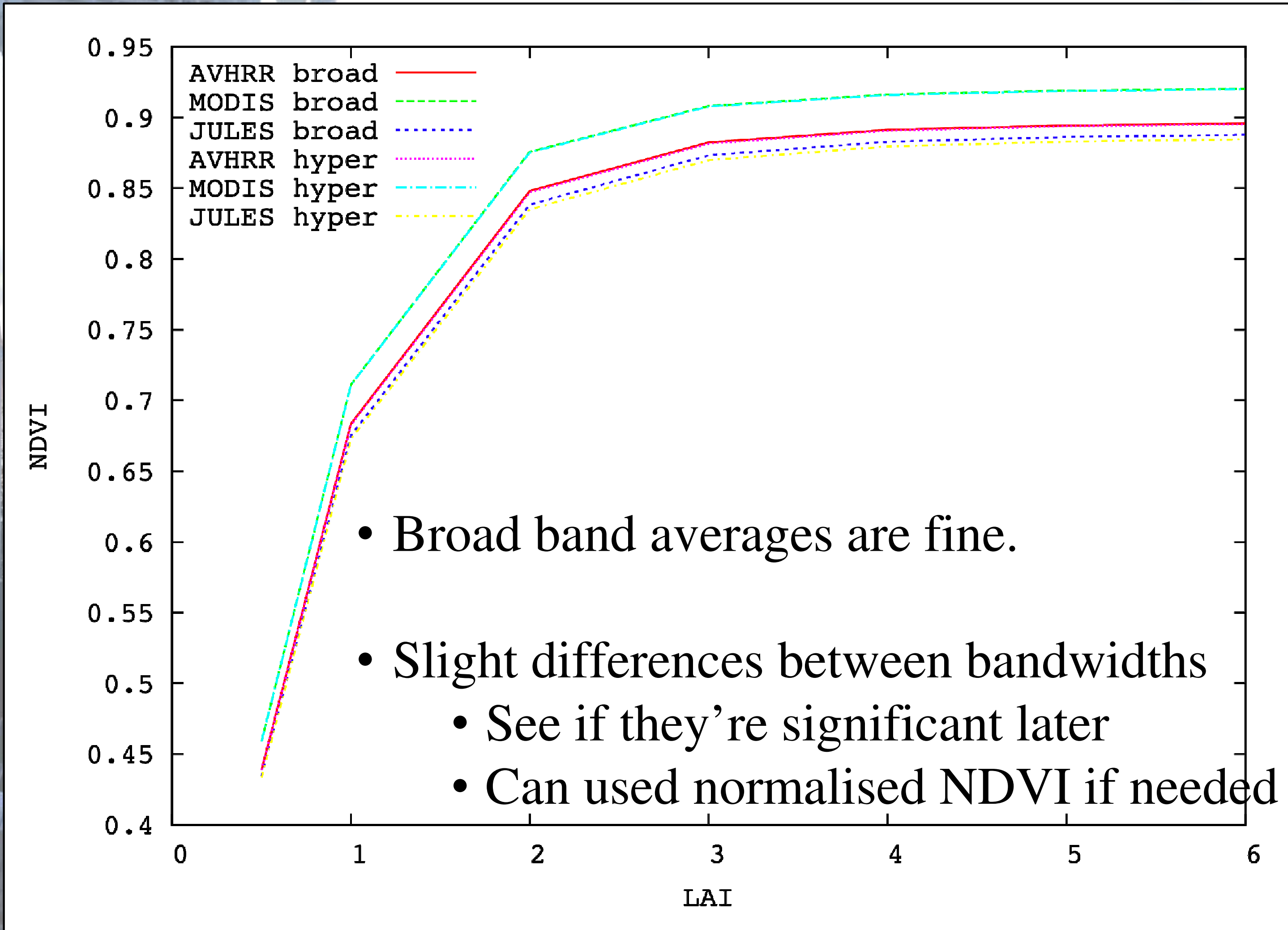
- Canopy reflectance is non-linear. Different bands will have different average reflectances.
  - Can we use a band average or do we need to run the RT model multiple times per band?

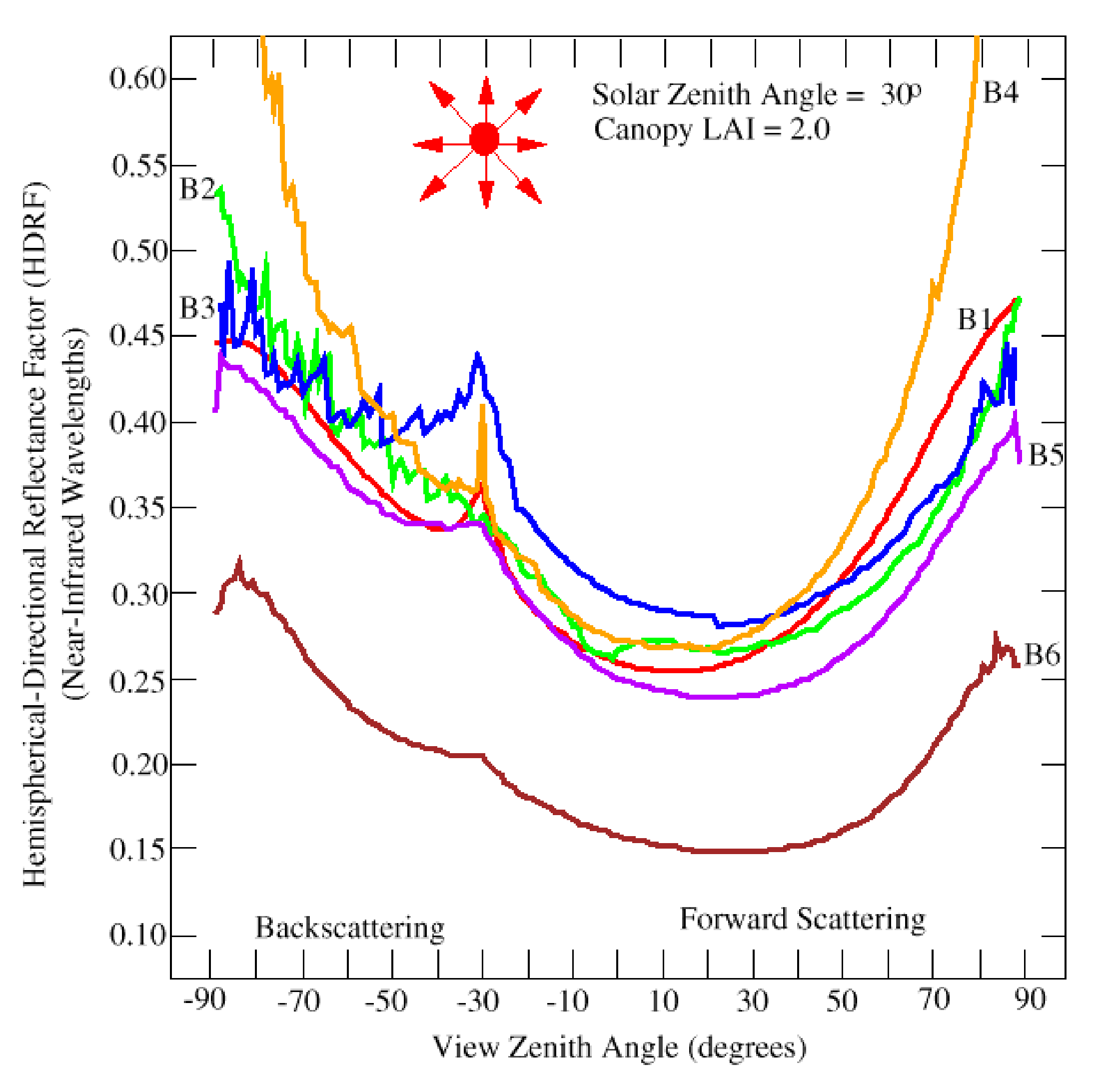


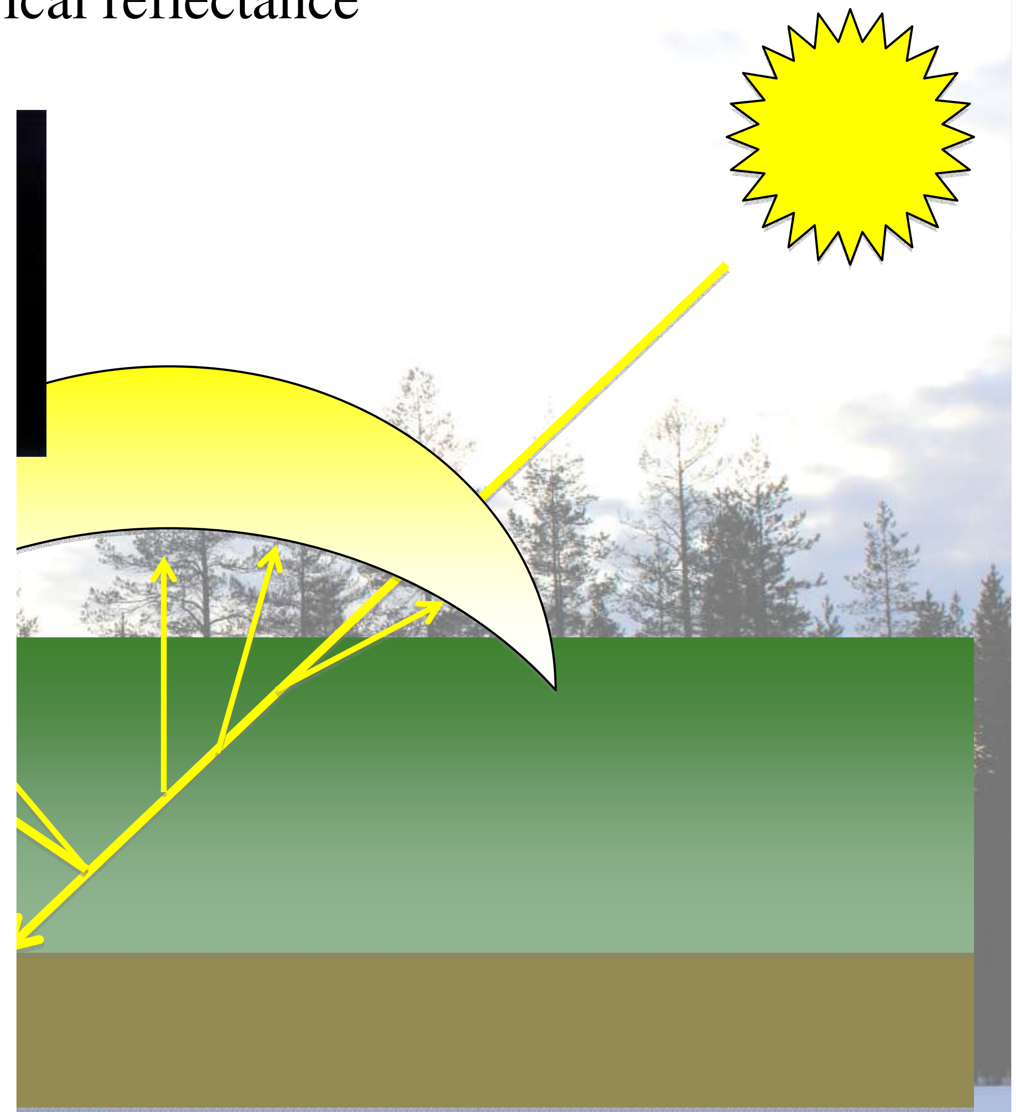
- Broad band averages are fine.

- Slight differences between bandwidths
  - See if they're significant later
  - Can used normalised NDVI if needed

Reflectance structure

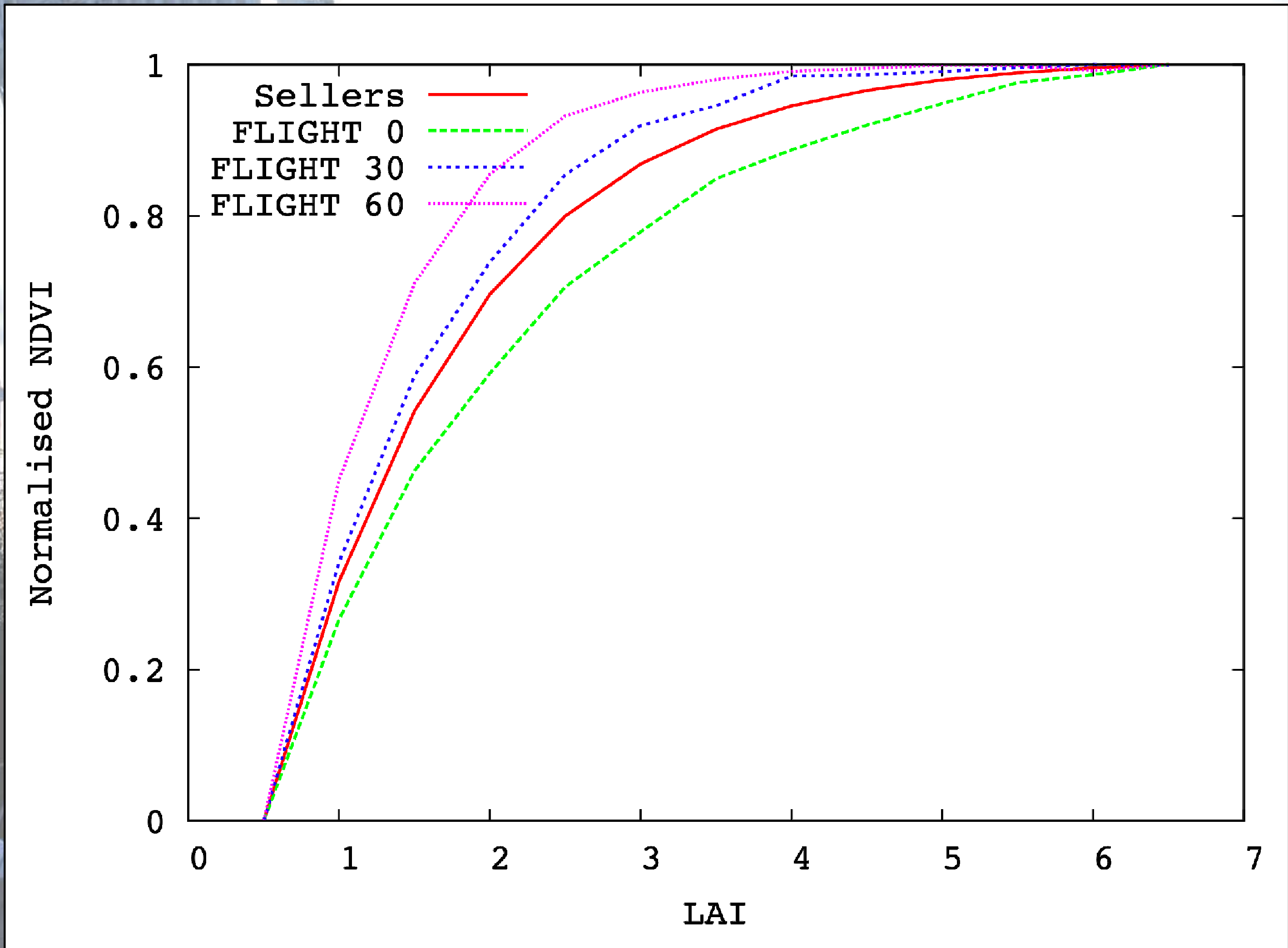
- Sellers is a 1D model
- Variable illumination direction, hemispherical reflectance





Reflectance structure

- Sellers is a 1D model
- Variable illumination direction, hemispherical reflectance



Reflectance structure

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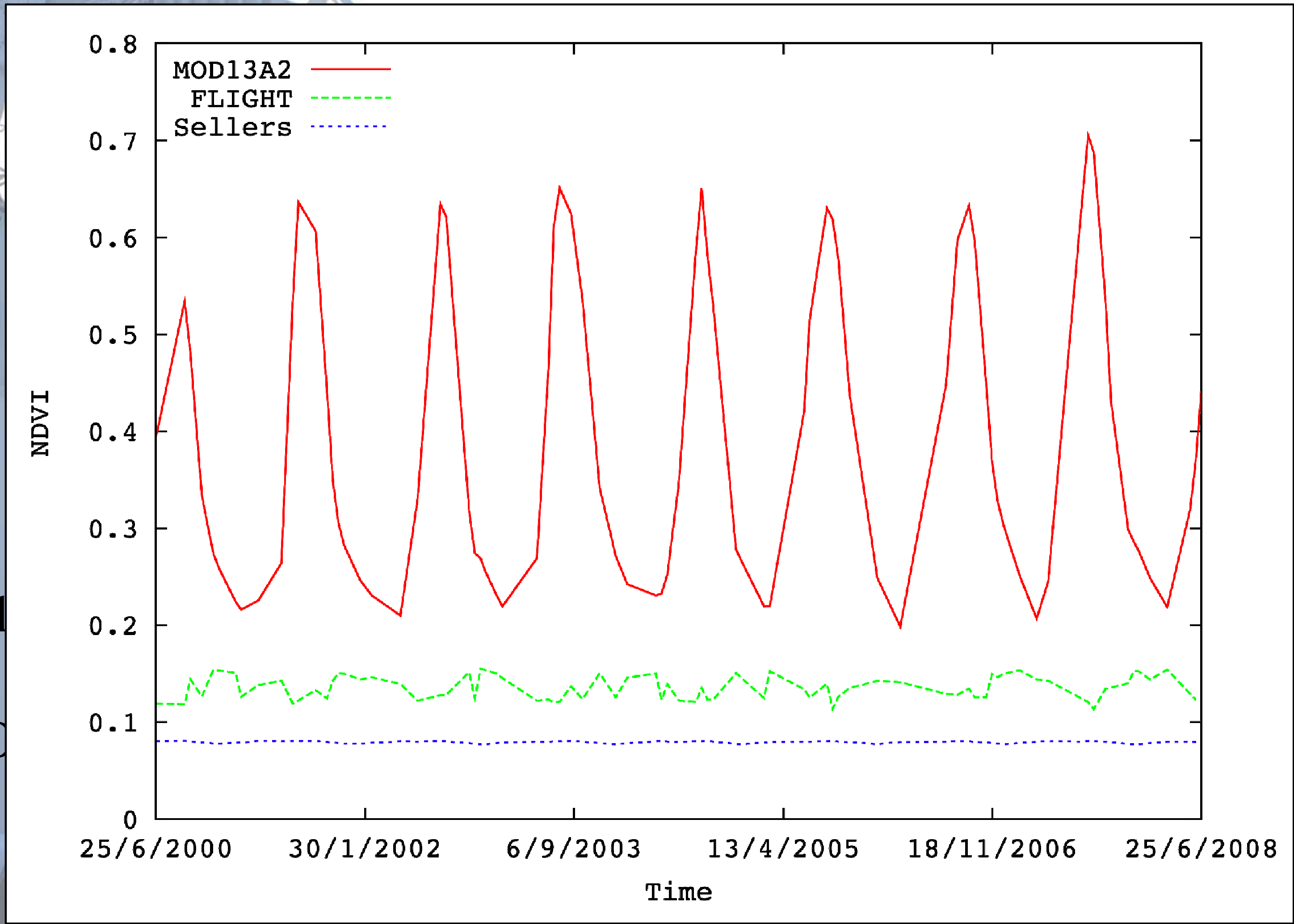
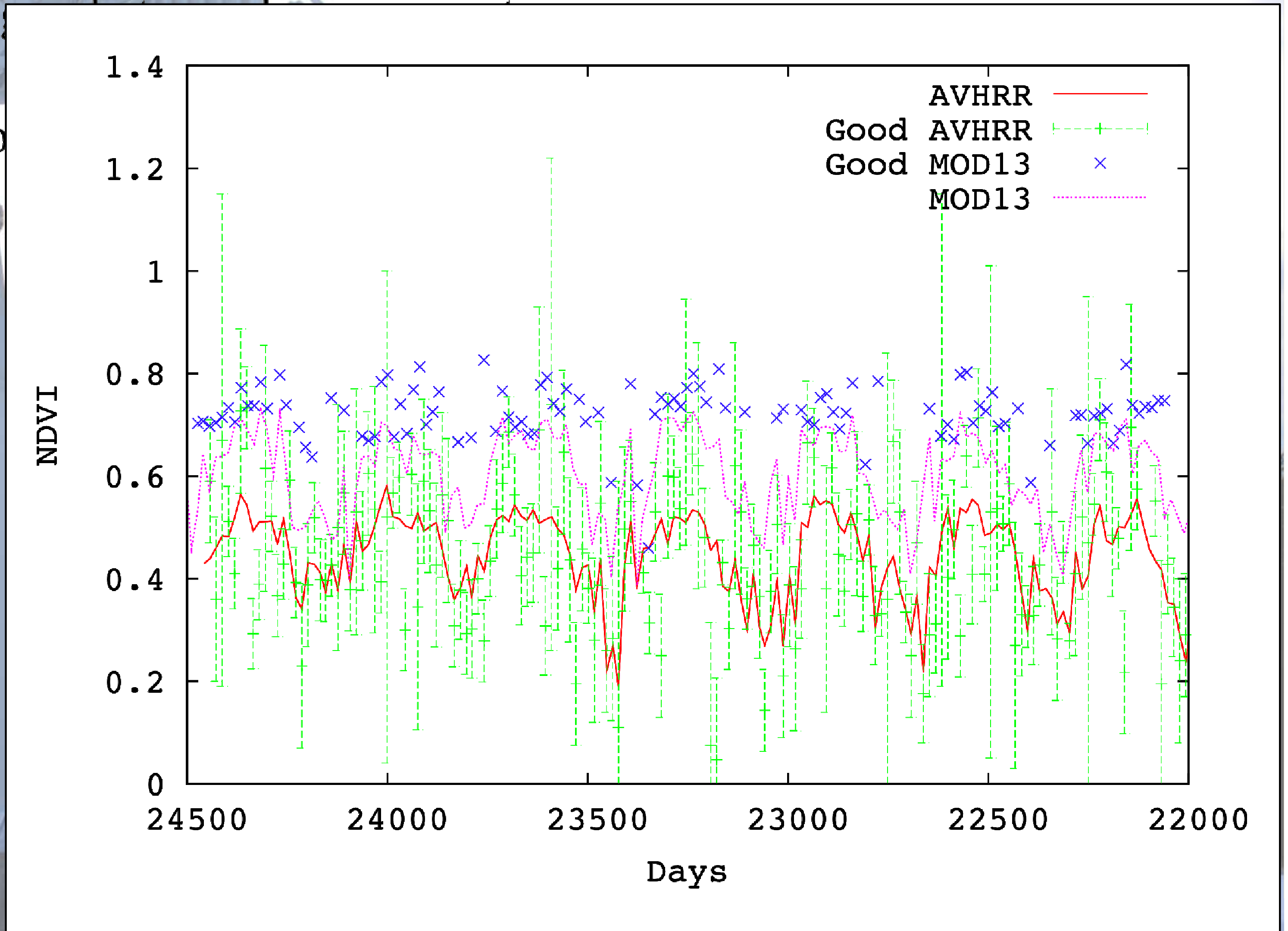
- Angular effects are significant.
- Satellite geometry changes considerably during the year.



- Either need a ful
corrected product
  - Such as MC

Eo data

- Two readily available global datasets;
  - MODIS, 1999-now, 250m-1km, at least daily
    - Bands allow g
  - AVHRR, 1980-no
    - Atmospheric



JULES LAI

- Controlled by phenology with some inter-annual variation from TRIFFID

$$ft = \begin{cases} 1 & \text{for } T_c > T_{off} \\ (1 + d_T(T_{off} - T_c)) & \text{for } T_c \leq T_{off} \end{cases}$$

$$fm = \begin{cases} 1 & \text{for } \beta > M_{off} \\ (1 + d_M(M_{off} - \beta)) & \text{for } \beta \leq M_{off} \end{cases}$$

$$\gamma_{lm} = ft.fm.\gamma_0$$

$$\frac{dp}{dt} = \begin{cases} MAX(-\gamma_p, 0.01 - p) & \text{for } \gamma_{lm} > 2\gamma_0 \\ MIN(\gamma_p(1-p), 1-p) & \text{for } \gamma_{lm} \leq 2\gamma_0 \end{cases}$$

$$p = p + \frac{dp}{dt}dt$$

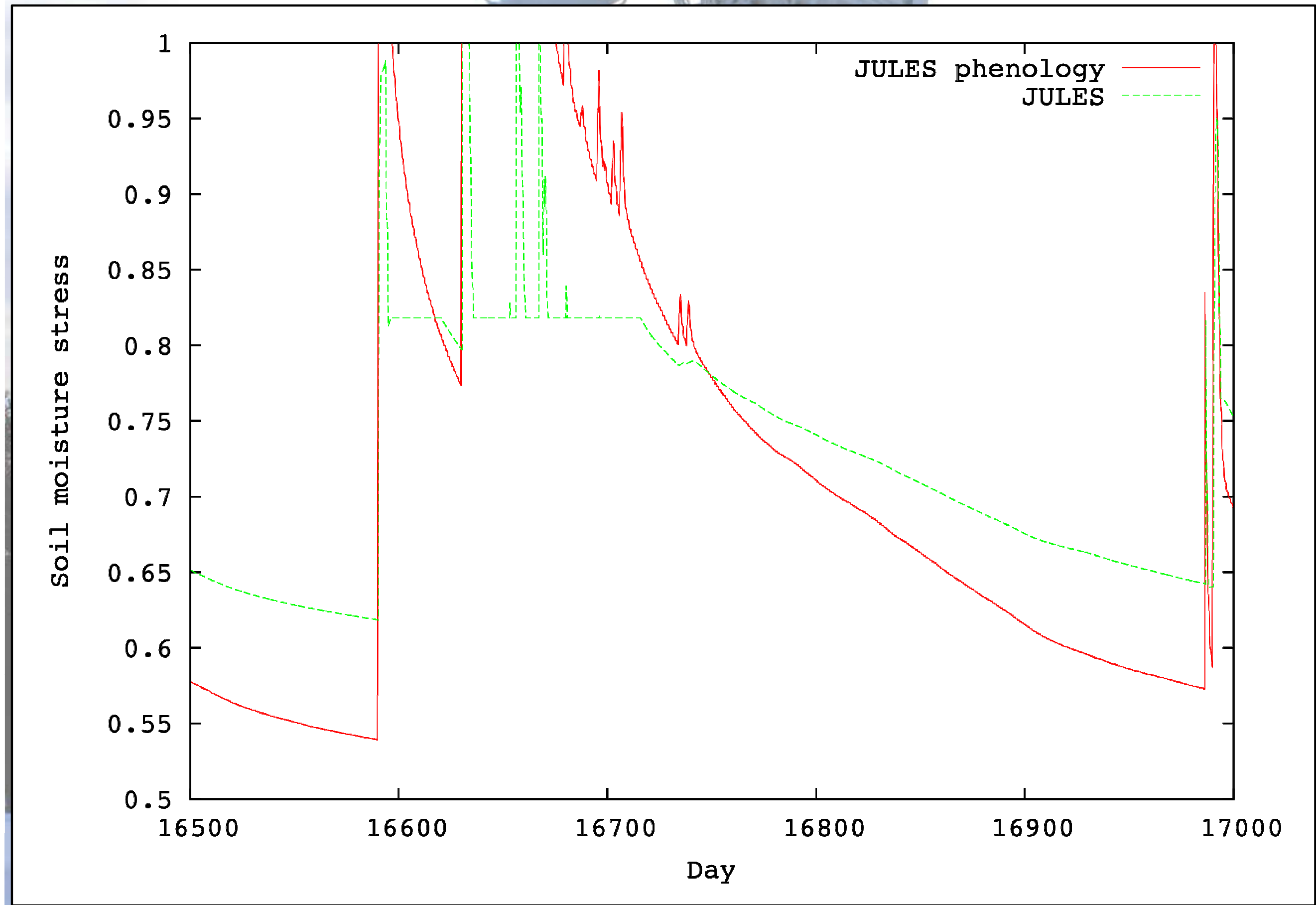
$$L = L_b.p$$

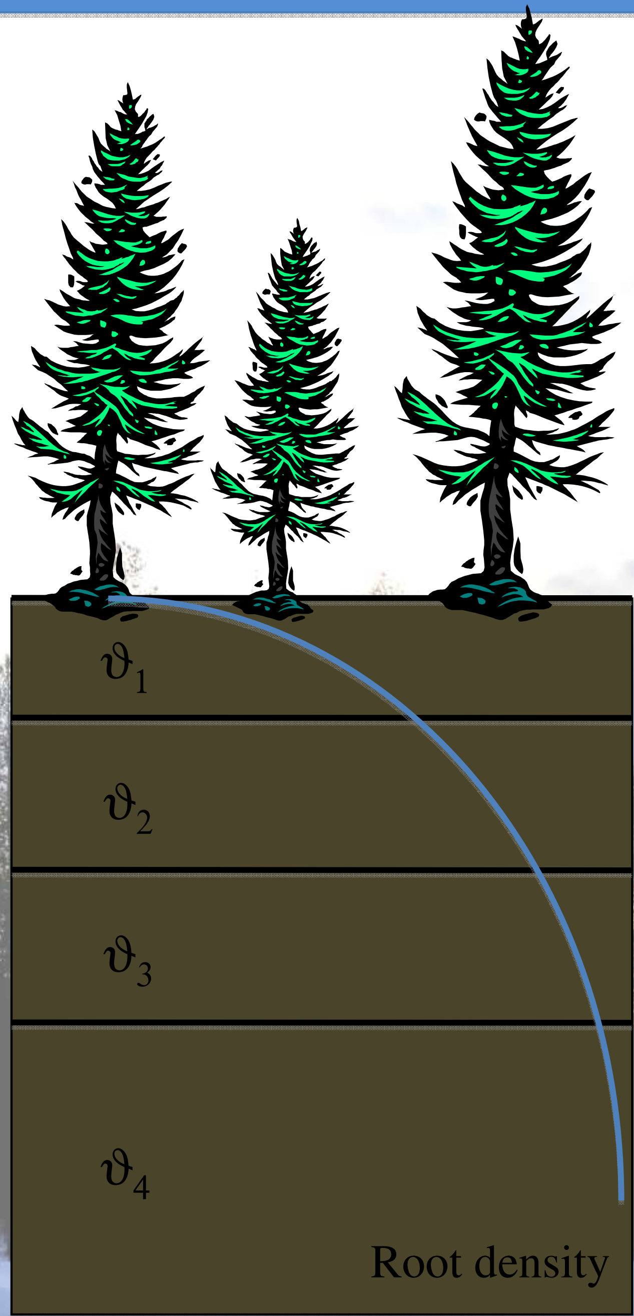
- Use just the phenology equations driven by soil moisture (either observed or from full JULES runs and met data.

JULES moisture stress

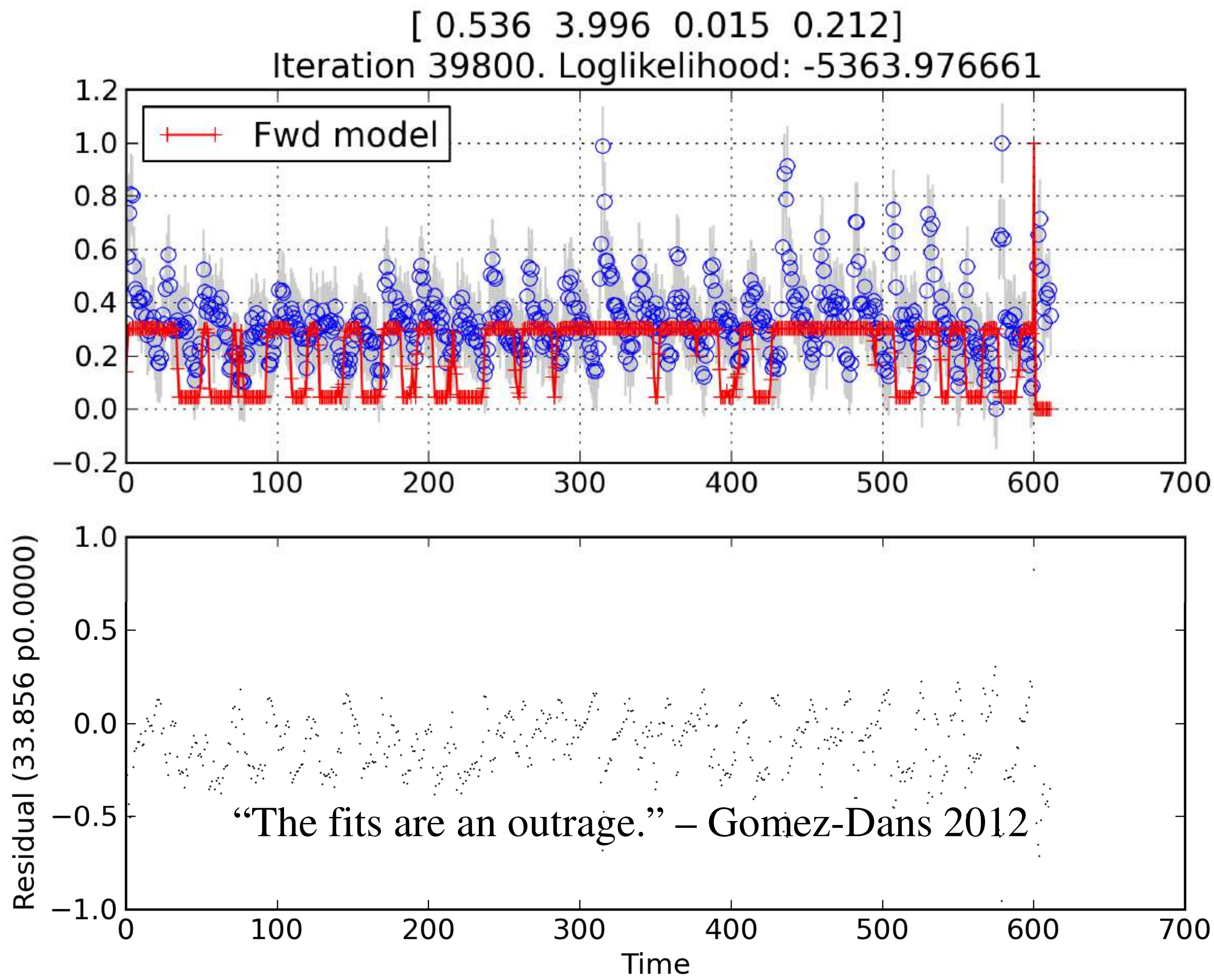
- JULES has layered soil
  - Moisture stress is a weighted average

$$\beta = \begin{cases} 1 & \text{for } \theta \geq \theta_c \\ \frac{\theta - \theta_w}{\theta_c - \theta_w} & \text{for } \theta_w < \theta < \theta_c \\ 0 & \text{for } \theta \leq \theta_w \end{cases}$$





Comparison



“The fits are an outrage.” – Gomez-Dans 2012

Alternative schemes

- We'd like something prognostic.
- BETHY – Knorr et al (2010).

$$\Lambda(t+\Delta t) = \Lambda_{lim} - (\Lambda_{lim} - \Lambda(t))e^{-r\Delta t}$$

$$\Lambda_{lim} = \frac{\xi \Lambda_{max} f}{r}$$

$$r = \xi f + \frac{(1-f)}{\tau_l}$$

$$f = \quad \Phi\left(\frac{T - T_\phi}{T_r}\right)\Phi\left(\frac{t_d - t_c}{t_r}\right)$$

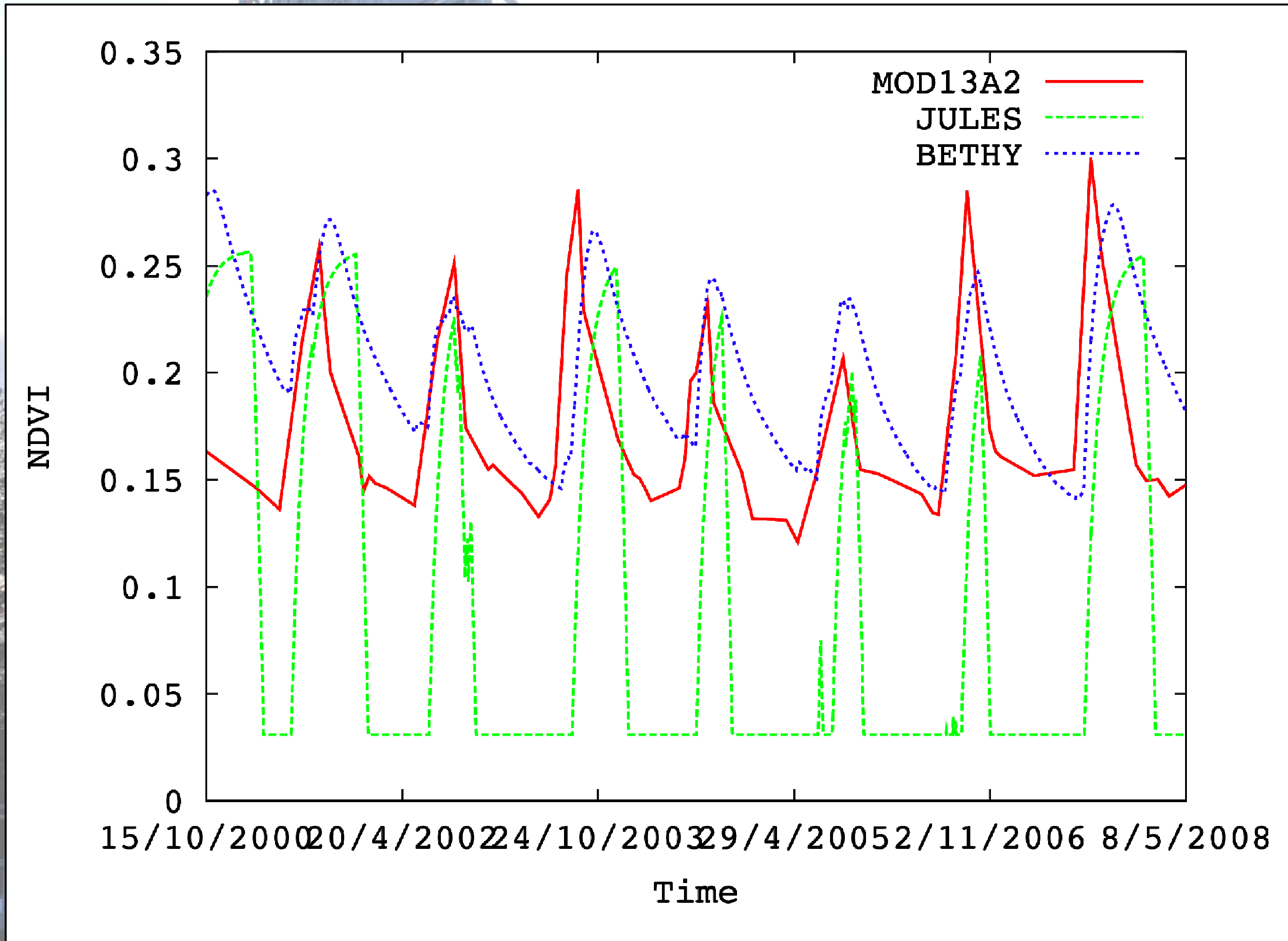
$$T(t+\Delta t) = e^{\frac{-\Delta t}{\tau_m}} T(t) + T_{2m}(t)(1 - e^{\frac{-\Delta t}{\tau_m}})$$

$$\Lambda_{max}(t+\Delta t) = e^{\frac{-\Delta t}{\tau_s}} \Lambda_{max}(t) + \tilde{\Lambda}_{max}(t)(1 - e^{\frac{-\Delta t}{\tau_s}})$$

$$\Lambda_w = \frac{W\tilde{\Lambda}}{\tilde{E}\tau_w}$$

$$\Lambda_{max} = \nu(\tilde{\Lambda}, \Lambda_w)$$

BETHY



MOD13A2
JULES
BETHY
NDVI
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
15/10/2000
20/4/2002
24/10/2003
29/4/2005
2/11/2006
8/5/2008
Time

BETHY

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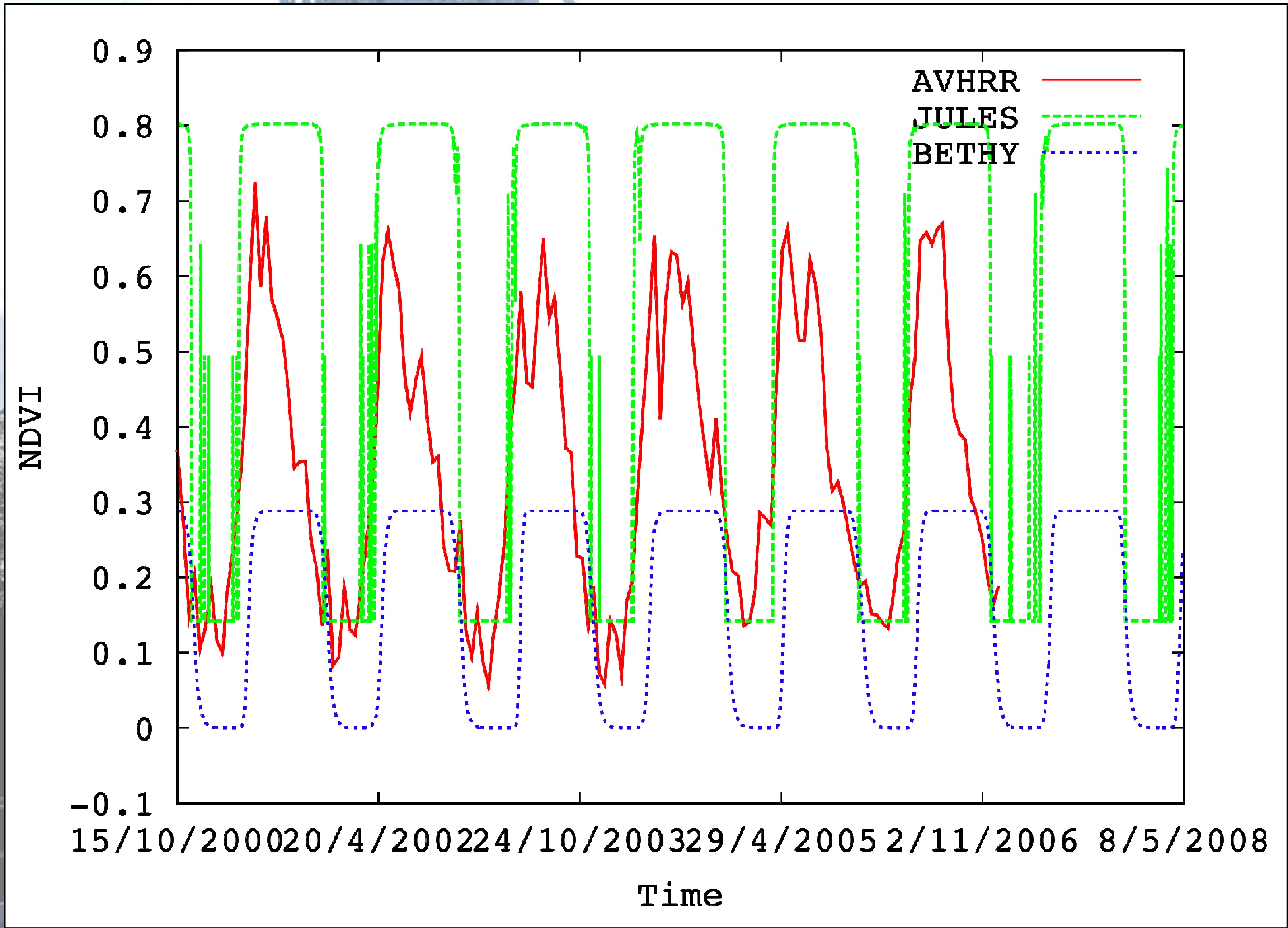
- Look at the two over Europe and Africa



47.5°N, 38.5°E

Conclusions

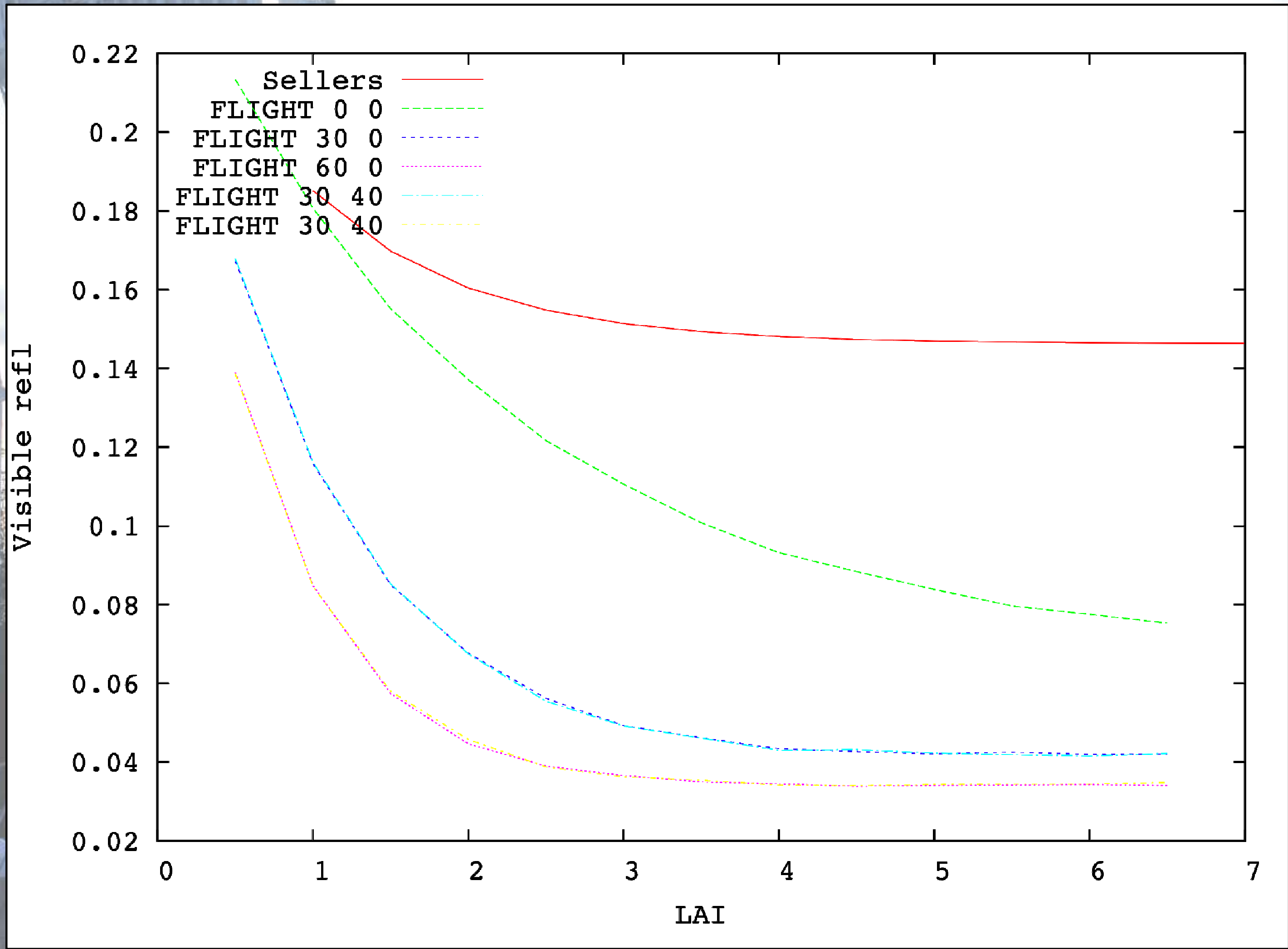
- Radiative transfer
  - Broadband averages will do fine
  - Need to correct for angles, either with a corrected or normalised EO product or a full BRDF model in JULES.
  - NDVI will do for now

- Phenology – controls reflectance away from snow.
  - JULES water phenology is inadequate
  - BETHY seems a bit better

- To do;
  - Optimise BETHY phenology in mini-JULES, Europe and Africa
  - Assess impact on growing season and fluxes

Reflectance structure

- Sellers is a 1D model
- Variable illumination direction, hemispherical reflectance



Model fitting