A New Advanced DIscrete Model (NADIM) of radiation transfer to simulate GLI measurements

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Outline of the presentation

- Introduction to the issues
- Model philosophy and fundamental equations
- Model set-up
- Model evaluation
- Applications

Introduction to the issues (1)

- A radiation transfer model is necessary to simulate the radiances
  - emerging from land surfaces through the atmosphere
  - entering the GLI sensor
  - as a function of surface and atmospheric properties
- A panoply of such models exist, for a variety of purposes and with differing performances, requirements and costs
- In the solar domain, models account for the (scalar) radiation intensity only, not the (vector) Stokes parameters
- Such models
  - represent the geophysical system as a "turbid medium" composed of a low density gas of small particles (d << λ)
  - assume the "far field approximation" or independence of scatterers
- These models, originally developed by astrophysicists, have been used extensively by atmospheric scientists

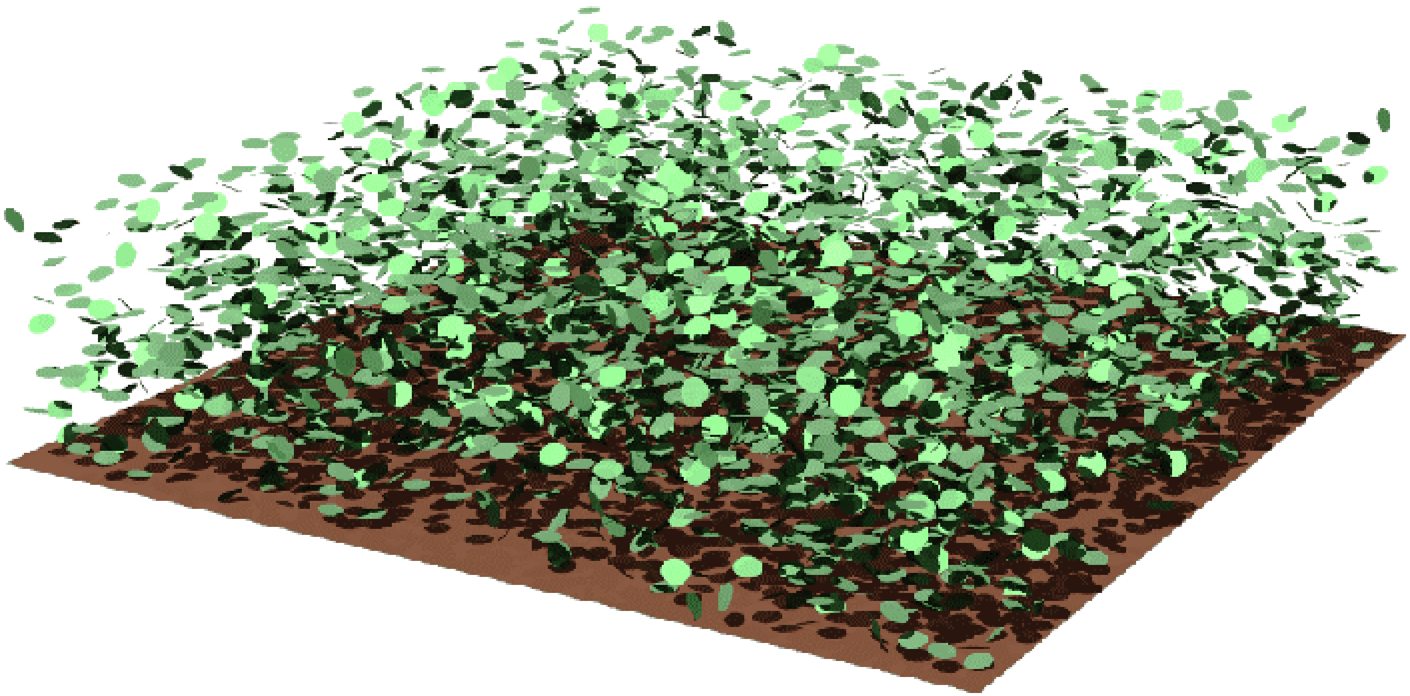
Introduction to the issues (2)

- **Vegetation canopies are significantly and specifically different from turbid media:**
  - **leaf size >> λ**
  - **medium is dense and compact, far field approximation is not verified**
  - **discrete number of finite size scatterers: spatial gradients undefined**
- **External boundary conditions are poorly known**
  - **direct + diffuse downward radiation from sky**
  - **upward reflectance from soil below the canopy**
- **For the purpose of the GLI simulator, this model must**
  - **adequately represent the spectral and directional properties of the solar radiation field reflected by typical terrestrial environments**
  - **be computationally economical**

Model philosophy and characteristics

- The NADIM model was specifically designed to represent
  - any homogeneous terrestrial environment as a function of the structural and spectral properties of the vegetation and soil
  - for relevant geometrical conditions of illumination and observation
  - as a 1-dimensional model for fast computations
- This model features
  - an explicit representation of canopy architecture for the first two orders of scattering, including the hot spot
  - the Discrete Ordinate Method (DOM) to represent higher-order multiple scattering effects

3-D representation of a homogeneous scene



Input models parameters

- **Vegetation architecture is specified through any three of the following 4 parameters:**
  - **Canopy height**
  - **Equivalent leaf diameter**
  - **Number of leaves per unit volume**
  - **Leaf Area Index**
- **Characteristics of plant leaves:**
  - **reflectance and transmittance of leaves**
  - **leaf angle distribution**
- **Optical properties of the underlying ground:**
  - **Albedo (if Lambertian), or**
  - **Single scattering albedo, asymmetry factor, and hot spot parameter (if non-Lambertian)**

Input data sources

- **Leaf optical properties:**
  - LOPEX (1995) database available at JRC
  - Simulations with the PROSPECT model of Jacquemoud et al.
- **Leaf orientation distributions:**
  - See the RAMI pages on http://www.enamors.org/
- **Soil optical properties:**
  - Price (1995) database
  - Bowker (1985) database
- **Incoming (downward) radiation field:**
  - Use models such as 6S or field measurements
- **Linearized spatial heterogeneity representation:**
  - $R = f_1 \times R_1 + (1 - f_1) \times R_2$

Model output and validation procedure

- Primary output is the spectral bidirectional reflectance factor, derived output includes albedo and fraction of absorbed radiation

- Comparison with RAYTRAN

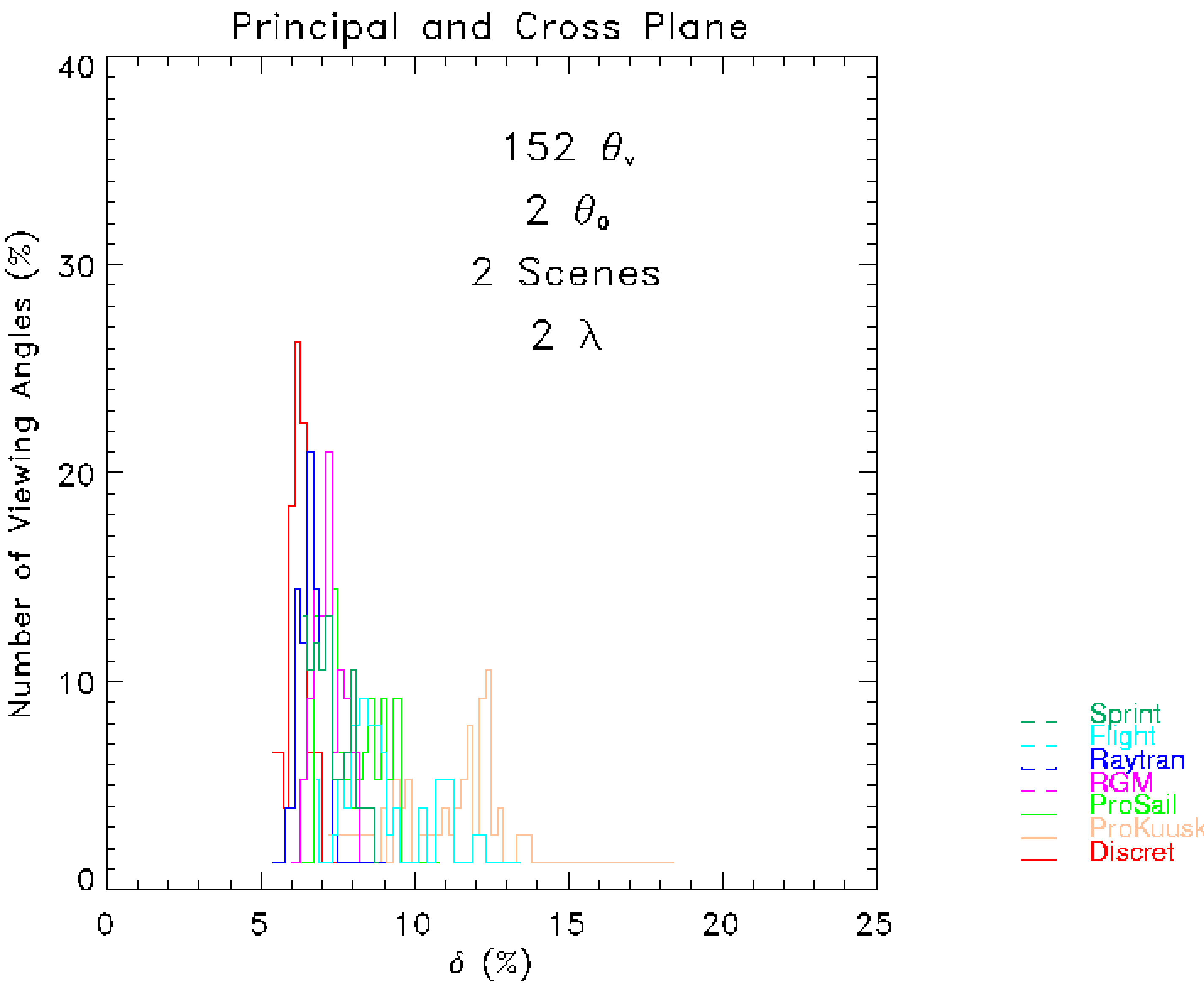
- Validation in inverse mode

- Evaluation within the RAMI Phase 1 exercise (See the web page)

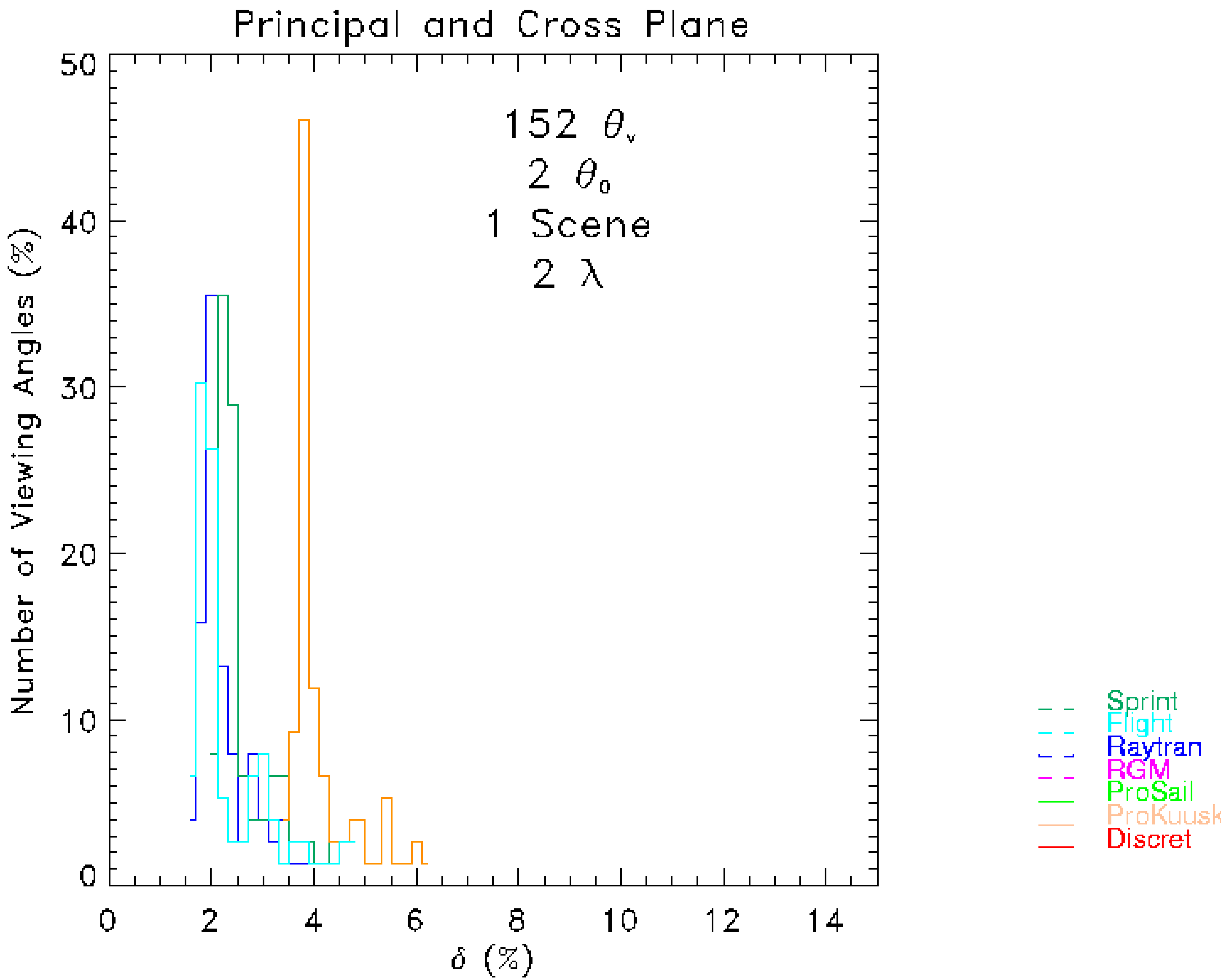
RAdiation transfer Model Intercomparison (RAMI)

- **The aim was not to validate BRF models but to assess the degree of coherence between them**
  - **Criterion: construct a measure of distance between BRF fields generated under identical geophysical and geometrical conditions**
- **The metrics were computed as sums of relative differences between pairs of reflectances, where the sum is taken over some or all models, wavelengths, scenes, and illumination zenith angles**
- **Both 1-D and 3-D models participated**
- **Reference: Pinty, B. et al. (2000) 'The RAdiation transfer Model Intercomparison (RAMI) Exercise', *Journal of Geophysical Research*, in print.**

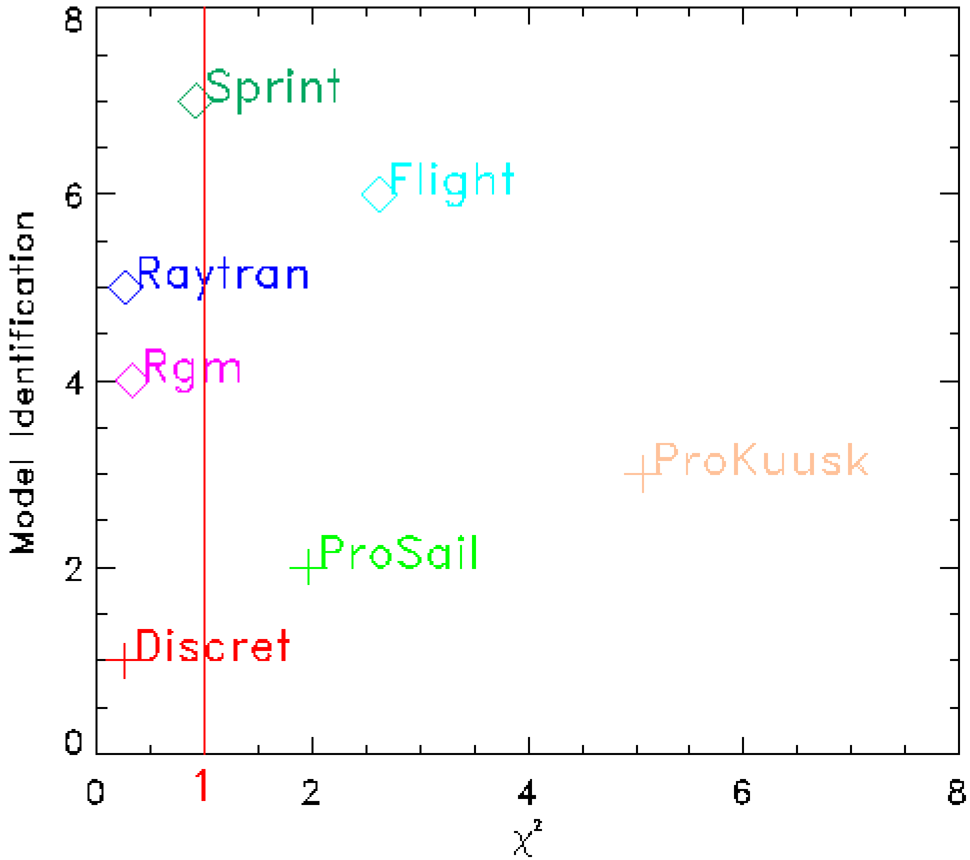
Local model deviations (homogeneous)



Local model deviations (heterogeneous)



Overall model comparison and discernability



Conclusions

- The New Advanced DIscrete Model (NADIM) is an efficient and accurate model to describe the spectral bidirectional reflectance of horizontally homogeneous areas

- NADIM has been extensively evaluated and delivers reflectances essentially indiscernible from 3-D ray tracing models for homogeneous scenes

- The FORTRAN software code for NADIM is publicly available from the ENAMORS Web site at http://www.enamors.org/

- NADIM has been used in a variety of contexts, including to simulate GLI data and to prepare the GLI VI