COASTCOLOUR
Consensus protocol for case 2 algorithms

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From the statement of Works: [UR-18] Consensus Case 2 Regional Protocols

Best practice protocols for defining regional algorithms for a specific area.

The protocols should address the following specific topics.

- An overview of the individual steps required to defining a regional ocean colour algorithm and documenting existing software and tools that can be used to undertake such a task.
- Specific documents going in more depth on the following:
  - Minimum requirements for *in-situ* data for defining a regional algorithm.
  - Methods for the definition and parameterisation of a reflectance model (forward model) for a specific regional of interest, including techniques for atmospheric correction and modelling marine optics.
  - Approaches to solving the inverse problem, including a comparison of different methods.

Task 9: Development of Consensus Case 2 Regional Protocols

This task shall occur during Phase 2. It builds on the experience gained from the Case 2 algorithm prototyping as well as the results of the multi-sensor Case 2 regional round robin exercise. Initial draft protocols shall be presented and discussed at UCM-2.

Input:

- Prototype Regional Products Report (DEL-20)
- Regional Round Robin Report - Draft version (DEL-22)

Task description

- Under the guidance of the Science Team, draft a series of synthesized protocols (5-10 pages each), which document agreed approaches for defining regional empirical and semi-analytical Case 2 algorithms (see [UR-18]), including:
  - description of existing regional and class-based approaches and their related uncertainties;
  - methods of atmospheric correction;
  - water constituent, IOP and AOP product types;
  - approaches for deriving new regional algorithms;
  - characterisation of regional bio-optical water types;
  - EO and in-situ data requirements and available tools;
  - relevant bibliography.
- Include a simple users' guide to allow non-specialist ocean colour users to quickly assess regional characteristics and likely uncertainty value classes.
- Publish the Consensus Case 2 Regional Protocols on the CoastColour web portal

Output:

- DEL-26 KO + 24 Consensus Case 2 Regional Algorithm Protocols [UR-18]

Different Approaches possible

- Are you in
  - Case 1 type of water with 1 dominant component
  - complex water with many and varying components
- Is it necessary
  - to develop your own AC or adapt existing one
  - Or can you rely on water reflectances with standard L2 products
- Is the reflection by the sea bottom an issue or even the task?
  - Determine optical properties of sea bottom
  - Algorithm for correction
- Most critical: bio-optical model
- Select type of algorithm (depending on complexity of water) and application
- Determine scope of algoirthm
- Consider test procedures and data
- Validation plan (short and long term)

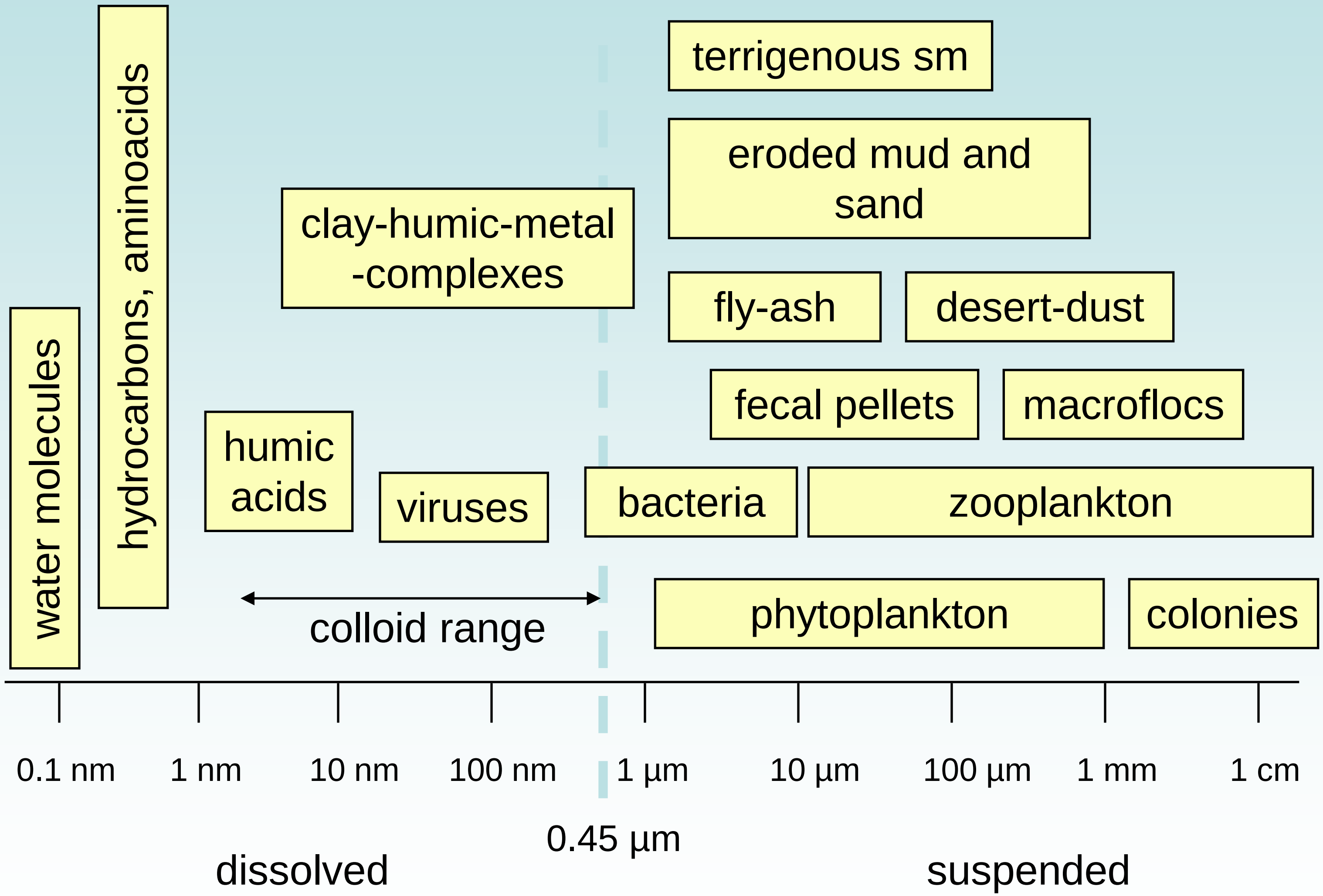
Checklist to characterise the area

- Dominant water constituents
- Concentration ranges
- Concentration matrix -> any dominant components
- Co-variances
- Occurence of exceptional events (blooms), floating material
- Water depth
- Specific atmospheric properties:
  - Desert dust
  - Biomass burning
  - Volcanoe smoke

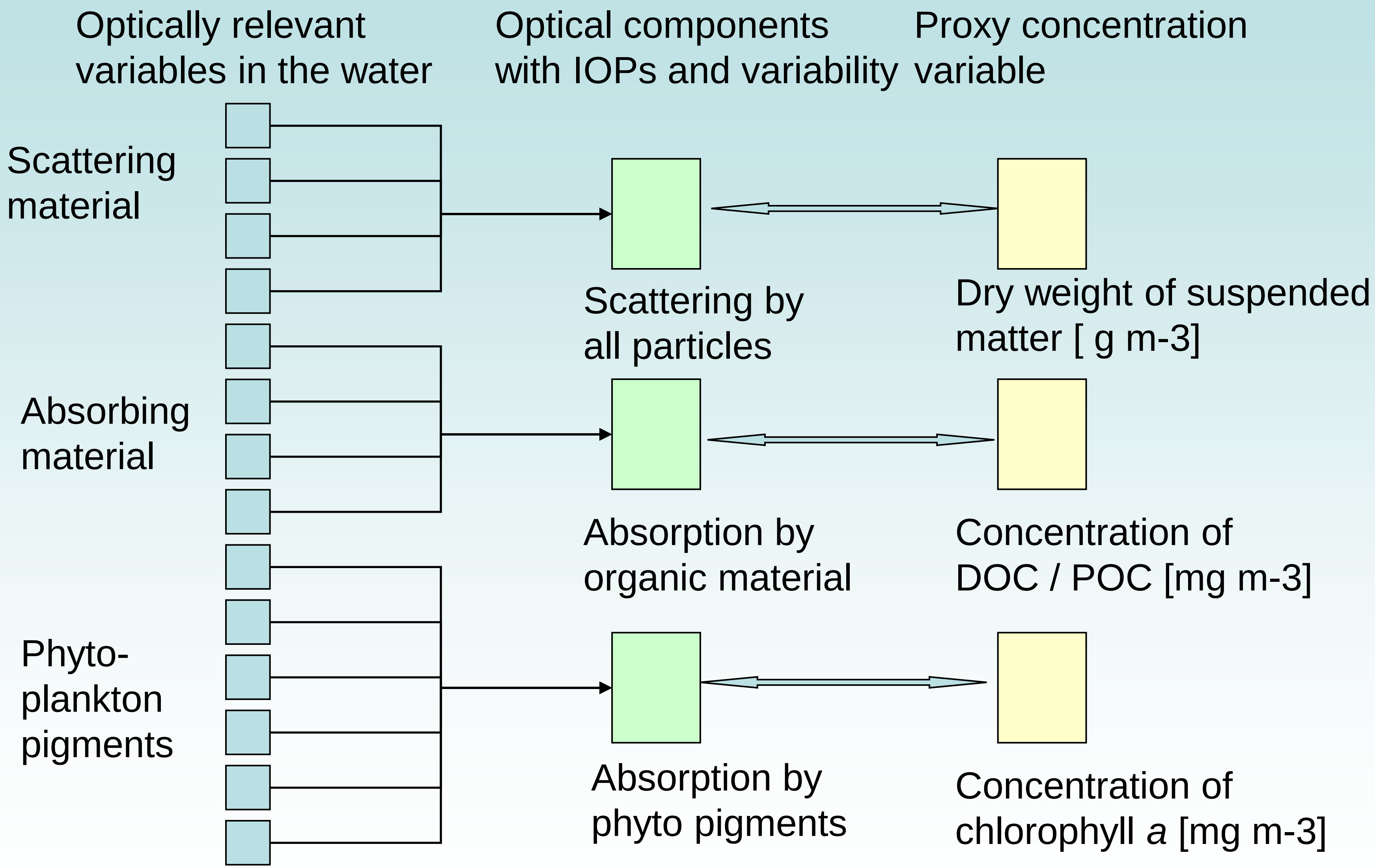
Steps to define a regional algorithm

- Do you need your own atmospheric correction?
- Determine the bio-optical components
- Determine the concentration ranges for each component
- Analyse any co-variances between components
- Determine IOPs (a,b) of each component and ist variability
- Test sensitivity for different mixtures of these components with simple reflectance model of type R~ bb/a
- If SPM is dominant component
  - Try simple band ratio (red, green bands, NIR, red bands)
- If phytoplankton is the dominant component:
  - Try blue gree band ratio, FLH, MCI
- If a multicomponent system is required:
  - Select a decomposition or inversion algorithm
  - s. also IOCCG reports 2 and 5
- Test algorithm with sufficient independent data from your region
  - Determine uncertainties
  - Define scope of your algorithms
- Validation of results is a permanent effort

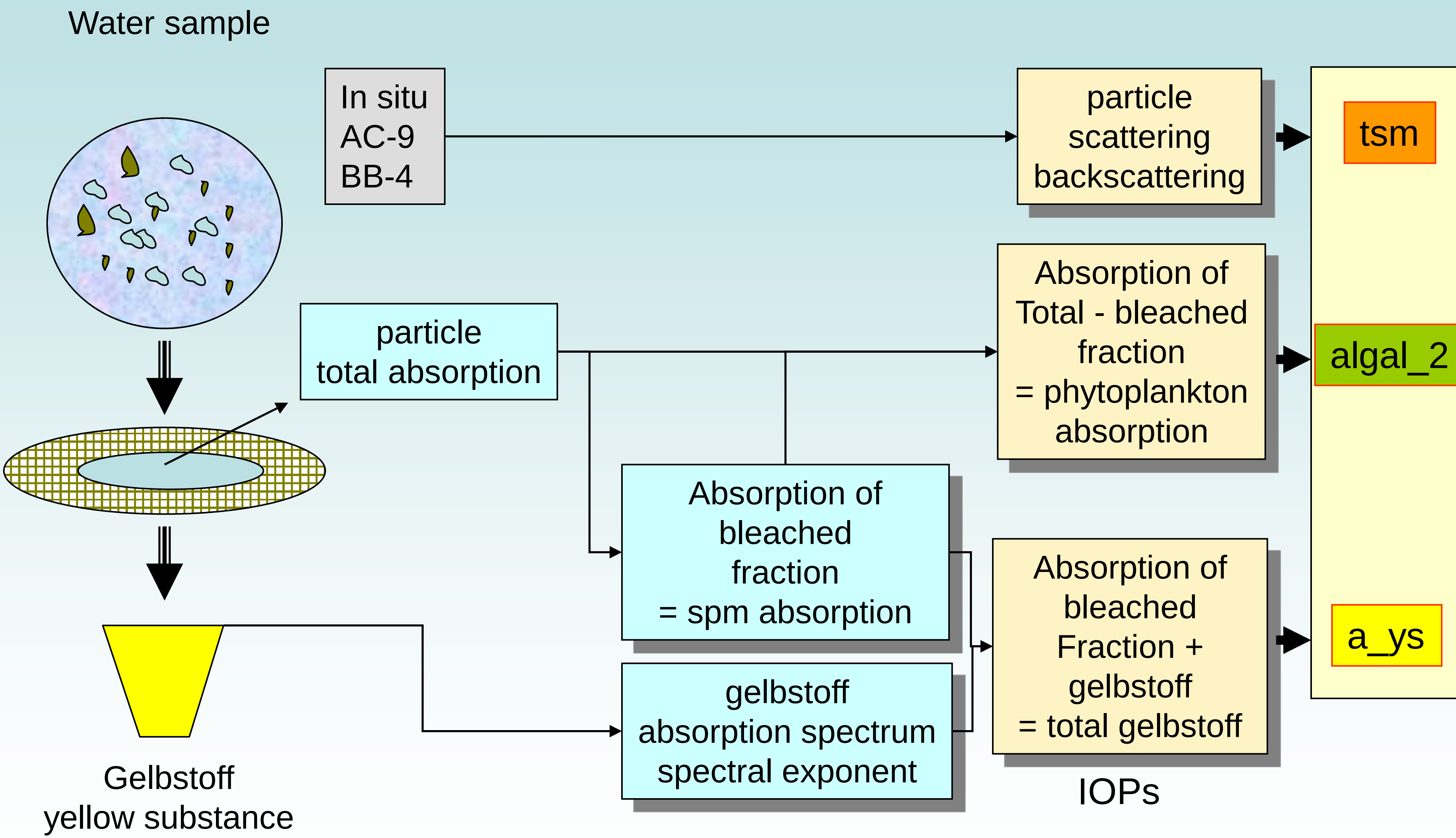
Dissolved and suspended matter in coastal water



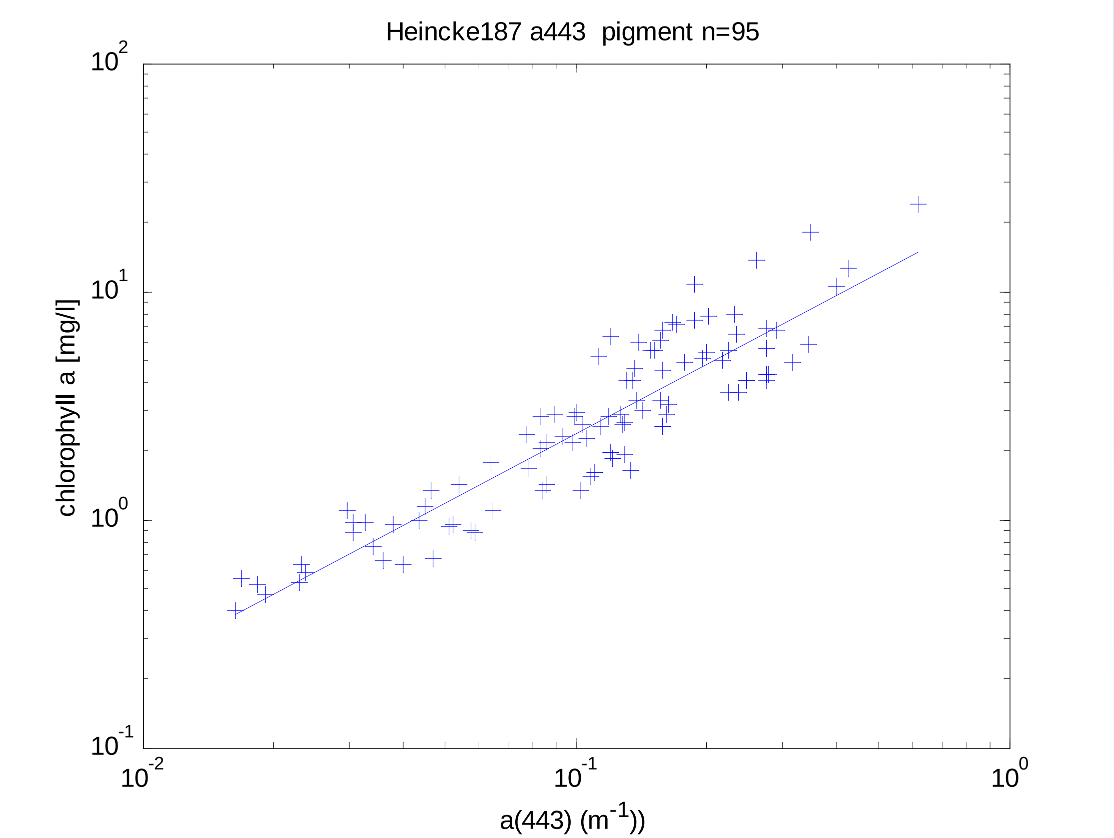
Define the bio-optical model



Realisation of a bio-optical model by measurements:
Scheme of a bio-optical model: optical components for MERIS



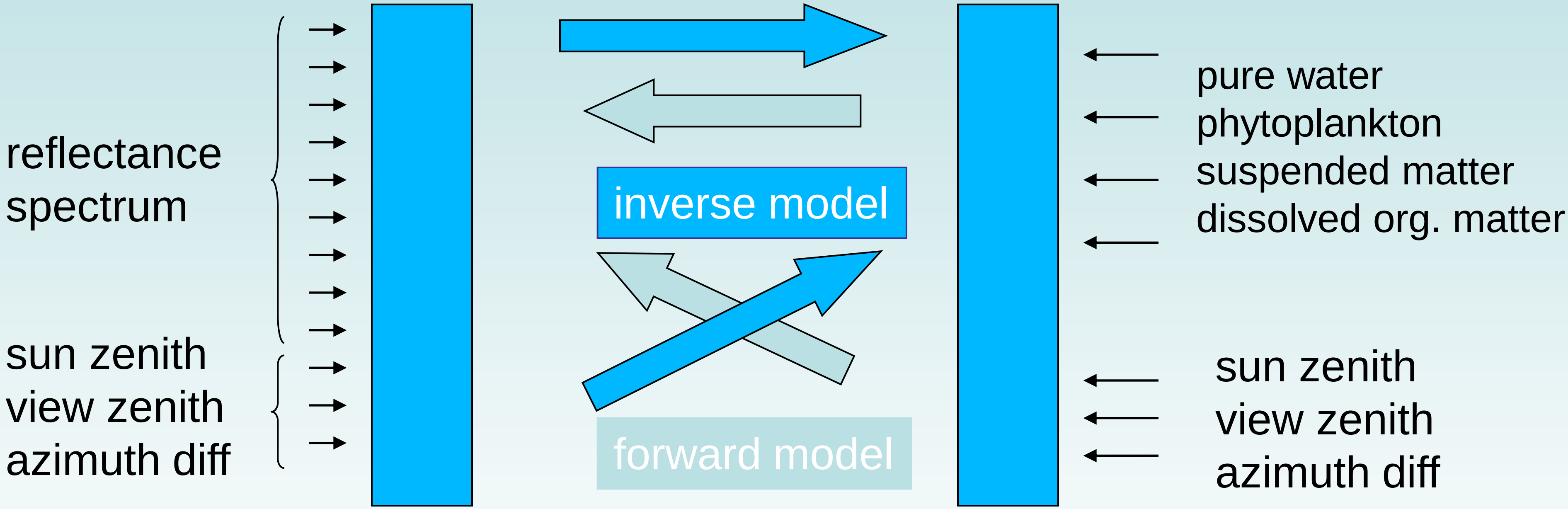
Pigment absorption – Chl. a, H187



Conversions:

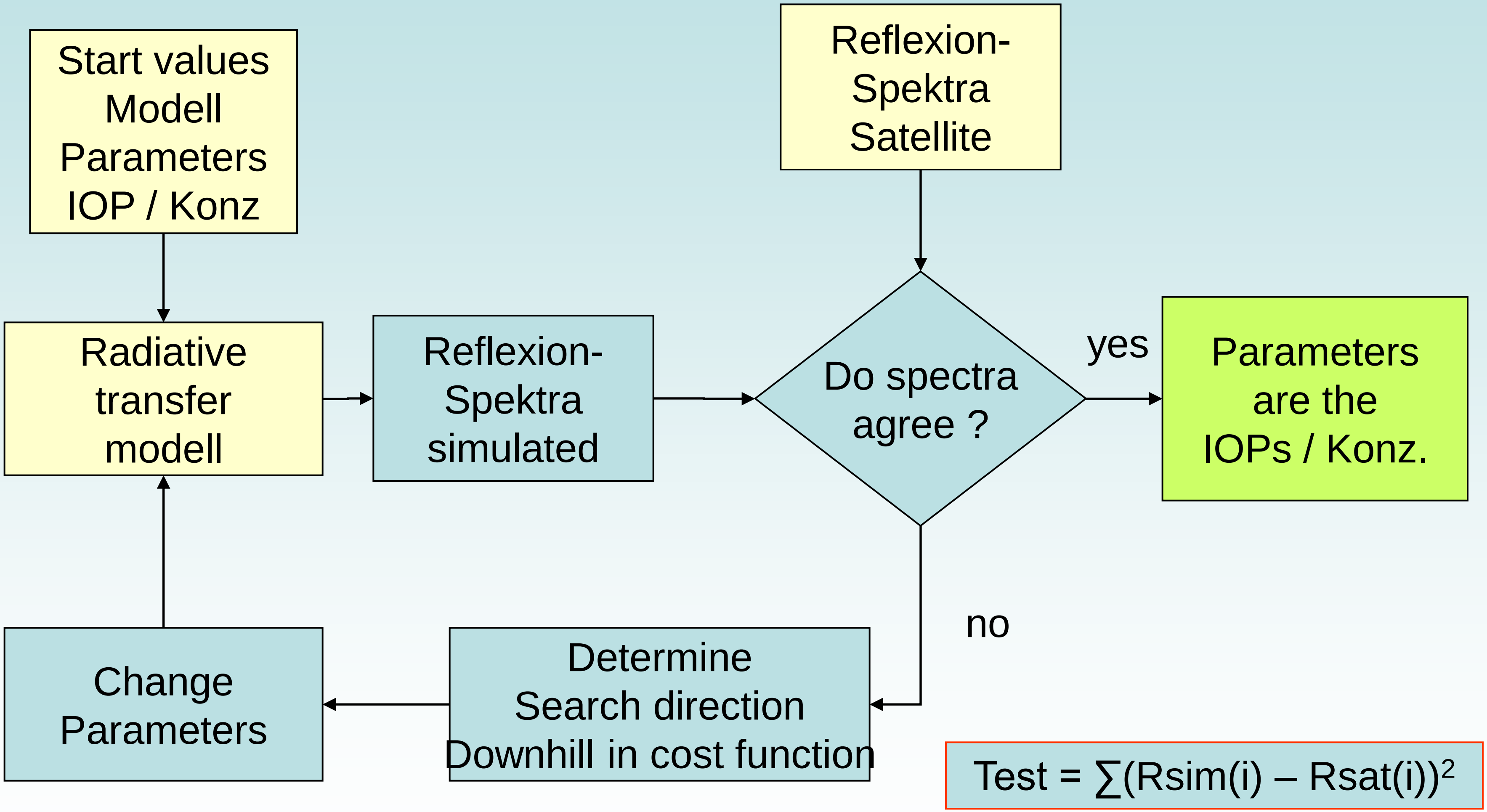
Chl. a [mg m-3] = 21 * a_pig_442 ^1.04

Multivariate Relationship

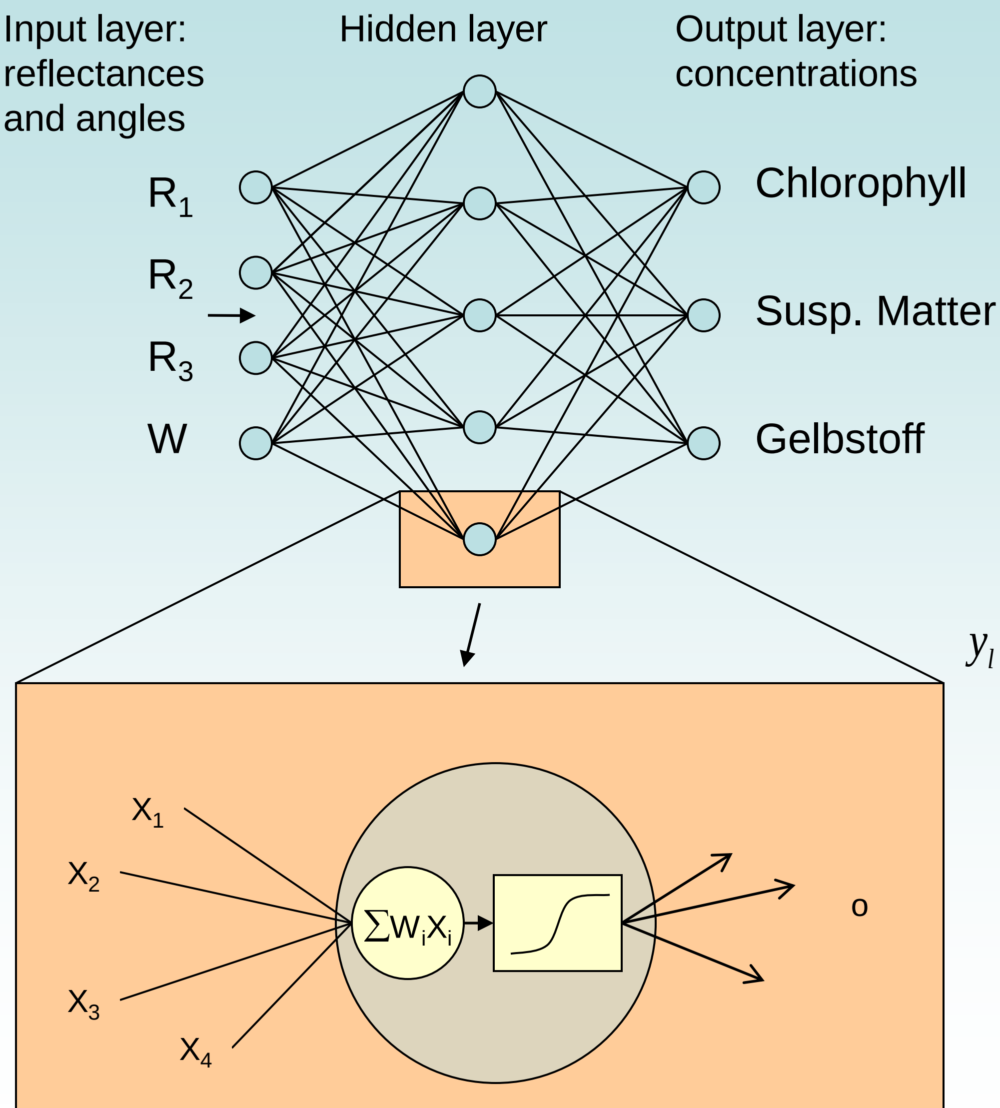


- Inverse modelling by iteration using optimization procedure
- Table look up
- Linear matrix inversion
- Non-linear multiple regression (Neural Network)

Inverse Modellierung using Optimization Procedures



Simplified scheme of NN Algorithm



$$y_l = s(-d_l + \sum_{k=1}^{3} w_{kl} \cdot s(-c_k + \sum_{j=1}^{5} v_{jk} \cdot s(-b_j + \sum_{i=1}^{4} u_{ij} x_i)))$$

Existing algorithms

- Empirical algorithms
  - Based on statistical relationships (regression) between reflectances and water properties (IOPs, concentrations, water depths, secchi disc depth)
  - band ratio algorithms,
  - FLH, MCI,
  - neural networks when trained directly with observations
  - After reduction by principal component analyis
- Semi-analytical decomposition algorithm (QAA)
  - Based on a simple model, which describes relationship between IOPs and reflectance, determine coefficients from observational data, decompose a_toal and b_total into a_pig, a_g etc.
- Inversion of a forward model
  - Matrix inversion
  - optimization techniques
  - Substitute forward model by neural network
- Inversion by using a NN proxy of the model

Atmospheric Correction

- **Atmospheric correction complex and most critical task**
- Check if water reflectances supplied with L2 data are sufficient
- Check for cloud flagging, extend threshold if necessary
- Check sun glint, foam (wind), cloud shadows
- Check TOA RGB image if doubtful pixels /artefacts are detected
- Check for negative reflectances of strange reflectance spectra

- Determine which type of AC is required, depending on type of water
  - Turbid water
  - Water with high concentations of absorbing material
- Check for AERONET data

Define scope of an algorithm

- Ranges of concentrations or IOPs
- Conditions of atmosphere and water:
  - Solar angle
  - Haze (optical thickness)
  - Wind (foam, glint)
  - Floating material
- Respect existing flags
- Re-define existing or create new flags
- Water reflectance spectrum different from spectra of water type classes
- Reproduce spectrum with forwarded model and compare
  - Chi-square > threshold (tbd)

Determine uncertainties

Approaches

- Based on analysis of relationship between algorithm output and in situ reference data
  - Based on sensitivity and uncertainty analysis using in situ data, for concentration intervals
  - Based on classification of water and uncertainty analysis for each type using in situ observations
  - Transfer this information pixel by pixel using look-up table

- Computation pixel by pixel
  - From second partial derivatives using a forward model
  - Error propagation method (QAA algorithm)
  - Ensemble method, compring results from different algorithms and / or sensors

s. also OC-CCI document

Testing

- Create test data set
- Test under different conditions of atmosphere and water, sun and observation angles
- Test time series
  - Different sun and observation angles
  - Changes in water constituents
- Diagnostic site or transect

Validation

- Validation permanent effort
- Minimum are the variables of interest, dependeing on applications
- Look for other programs, which can be utilized (ferrybox, monitoring by environmental agencies, other research projects, standard data bases)
- Check against general knowledge of your area
- Look into TOA RGB image if doubtful pixels, stange structures, which might be artefactds
- If data are available. Check separation of atmosphere and water reflectance
- Consider flags
- Own measurements:
  - Check how products are defined (chl a HPLC vs. Fluorometric, with or without degradation products)
  - Respect existing protocols for sampling and analyis of match up data
  - Select critical diagnostic sites or transects
  - Sample all seasons of interest

Next steps for this document

- Outcome of round robin
- Review of literature
- Draft first version
- Distribute within team, science team and champion users (via web)
- Collect comments
- Revise document