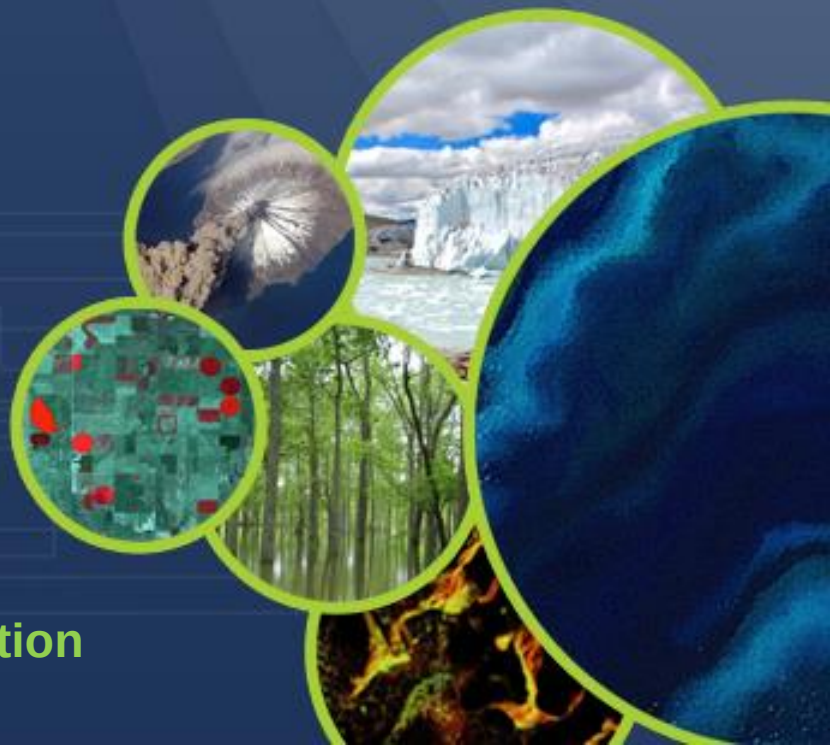
RadCalNet (CEOS- CV9)

Marc Bouvet

ESA

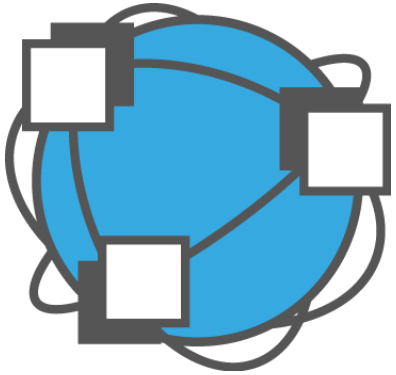
WGCV Plenary # 40



Working Group on Calibration and Validation

RadCalNet

Status



M. Bouvet on behalf of the RadCalNet WG

Why RadCalNet?

Why a new network of instrumented sites dedicated to the radiometric calibration of EO optical sensors?

- **To support the establishment of the Global Earth Observation System of Systems by providing measurements to verify the radiometric consistency between EO space sensors**
- **To collect surface and atmospheric data necessary for the simulation of observations by EO high spatial resolution optical sensors and thus verify their radiometric calibration**
- **To increase the number of matchups between in-situ measurements and space sensor observations and reduce the overall uncertainties (and reduce the efforts of individual agencies)**
- **To ensure traceability of the space sensor radiometry to the "Système International" (SI)**
- **To provide space organisations with an opportunity to calibrate their sensors in orbit when they do not have the resources to perform their own vicarious calibration activities**
- **To provide guidance on ensuring SI-traceability and developing instrumented ground sites for use in vicarious calibration**

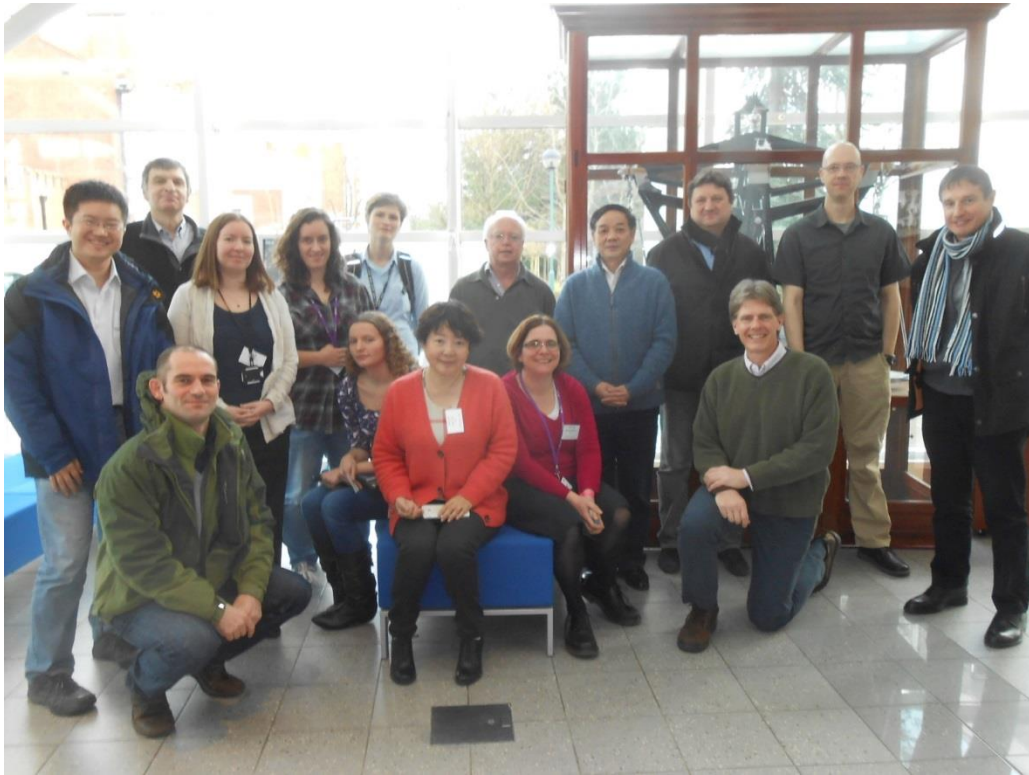
Who is involved in establishing RadCalNet?

RadCalNet WG objectives:

- Define the detailed architecture of RadCalNet
- Demonstrate RadCalNet operational concept with the currently available infrastructure and resources
- Provide recommendations to CEOS/WGCV/IVOS and CEOS/WGCV for evolution of RadCalNet towards an operational network

RadCalNet WG members at 3rd meeting (NPL, UK):

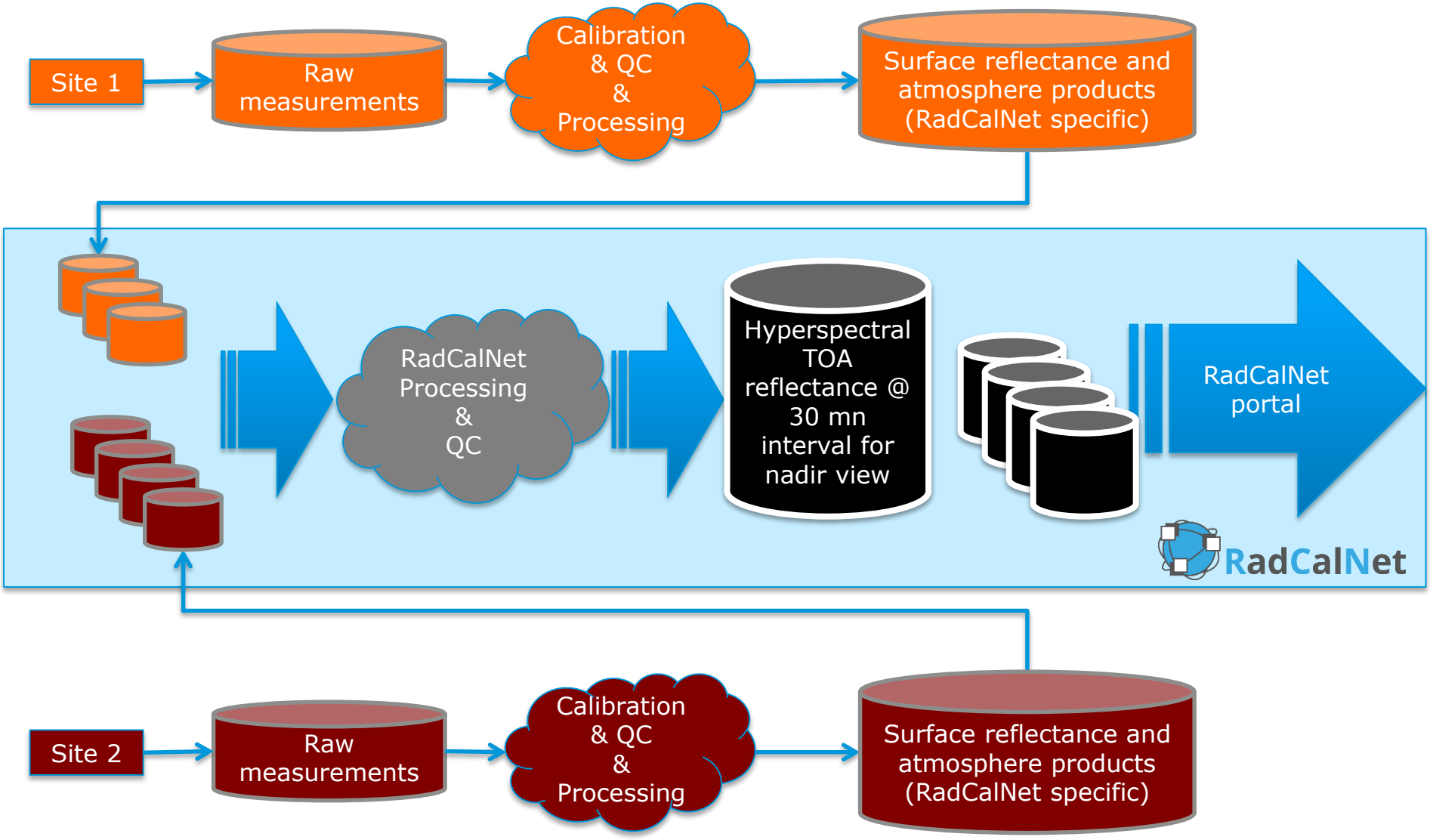
- AOE (China) (C. Li, L. Ma, L. Tang, N. Wang)
- CNES (P. Henry, A. Meygret)
- ESA (M. Bouvet, P. Goryl) supported by Magellium (B. Berthelot)
- NASA (K. Thome, B. Wenny) and University of Arizona (J. Czapla-Myers)
- NPL (N. Fox, E. Woolliams)



The initial contributions to RadCalNet

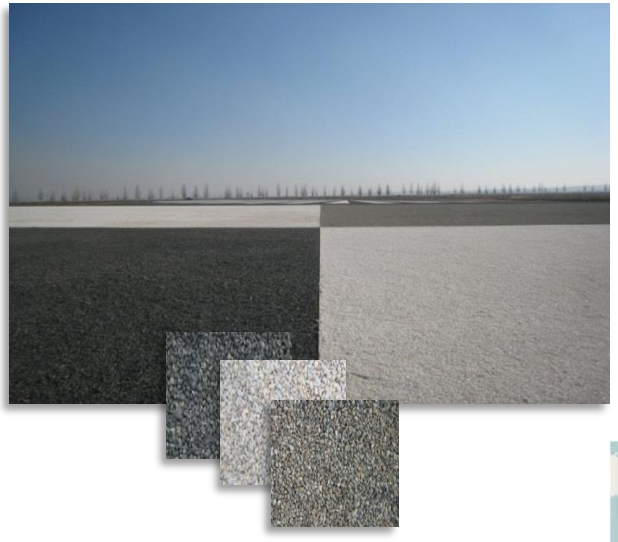
- NASA, CNES and AOE offered each a site
- CNES and Magellium made study to define a methodology for the identification at global scale of the best locations for RadCalNet-like sites
- ESA initiated the ACTION study (run by NPL and Magellium) to:
  - ✓ Identify, characterise and equip a 4th site jointly operated by ESA and CNES.
  - ✓ Support the emergence of a prototype RadCalNet: data circulation, portal, support to the RadCalNet WG
- NASA offered to host the processing of the in-situ surface and atmosphere data into TOA reflectance
- NPL offered support across the RadCalNet sites owner writh respect to harmonization, traceability of the measurement protocol, instrument calibration and QA4EO => uncertainty budgets

The shared vision of RadCalNet



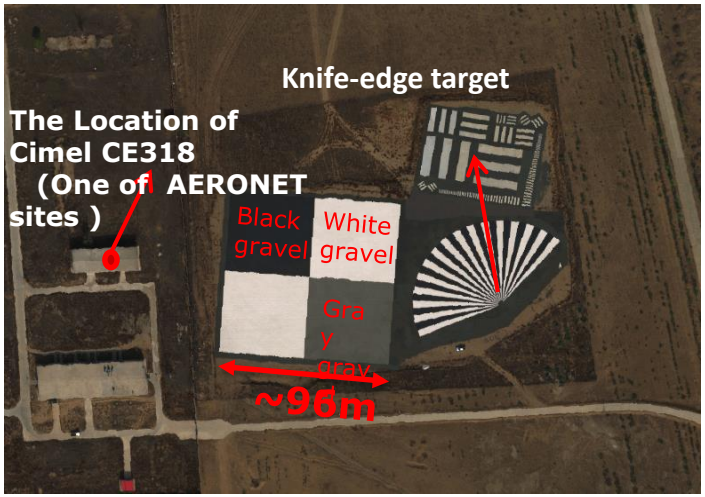
The sites

- Currently 3 instrumented are providing data to RadCalNet:
  - ✓ Baotou (China)
  - ✓ La Crau (France)
  - ✓ Railroad Valley Playa (US)



Baotou

- Three automated reflectance spectrum measurement systems have been installed + sun photometer
- Artificial target (3 colours)
- All the data from these three systems is being transferred directly to Beijing since OCT 25, 2015.
- Uncertainty analysis ongoing.



Aerial image acquired in Baotou site October 17, 2015

Stationary system in black and white targets

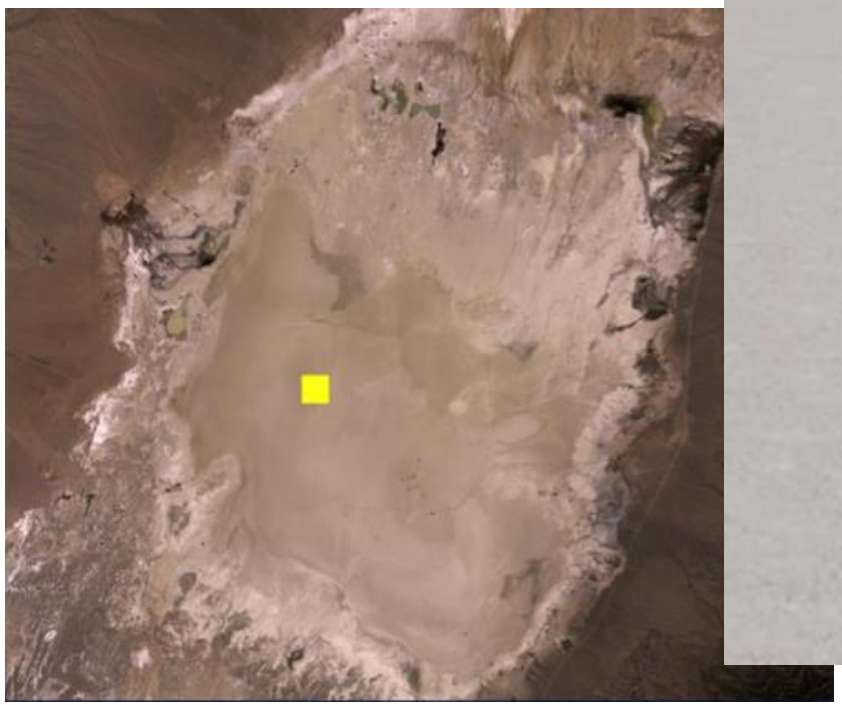
Rotatory system in gray target

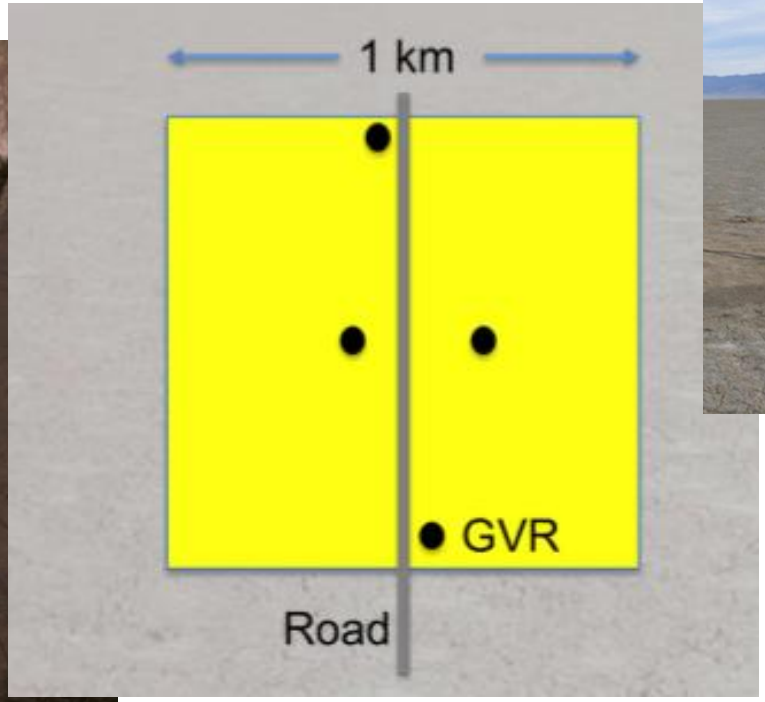
La Crau

- Instrument: CIMEL photometer (12 bands)
- Surface type: pebbles and low vegetation
- Site used since 1987 for calibration and instrumented since 1997.
- Running operationally

Railroad Valley Playa

- 4 radiometers (GVRs) + sun photometer + met station
- Surface type: dry lakebed
- UoA has 20+ years working experience on the site
- Site operational with data set via sat link





The sites

- Since the beginning of the WG activities, significant efforts dedicated to:
  - ✓ Operationally running the sites
  - ✓ Defining measurement uncertainties: NPL supports the RadCalNet sites in terms of harmonization, traceability of the measurement protocol, instrument calibration and QA4EO



The sites: a fourth site to test mechanisms for joining

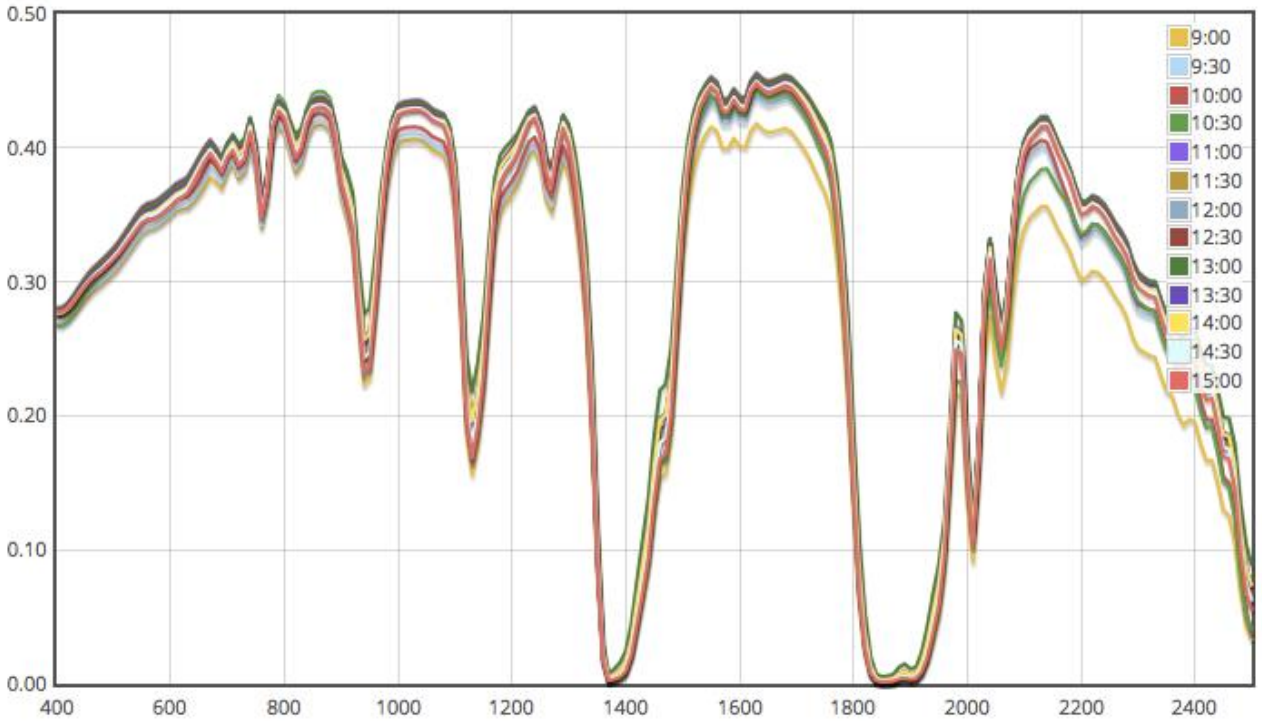
- A European contribution to RadCalNet: ESA/CNES will contribute this site supported by NPL.

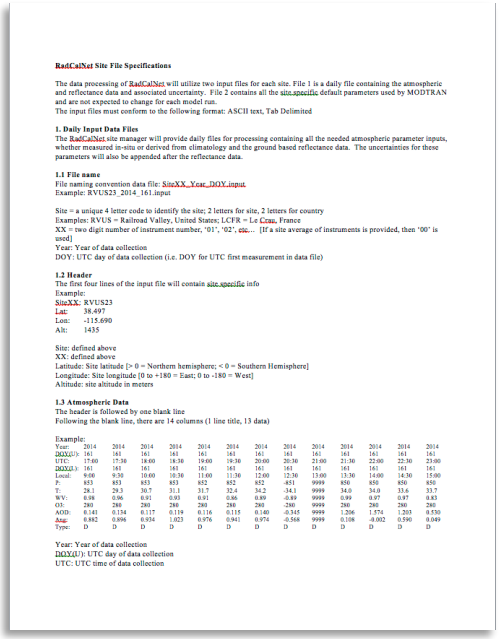
- Site identification was based on a methodology developed through a CNES contract with MAGELLIUM (France) (Final report: Test site identification for radiometric calibration, B. Berthelot, E. Hillairet, 2013) a set of global criteria were defined to identify a fourth ESA/CNES site:
  - ✓ At least 30 % of clear sky days (based on ECMWF data)
  - ✓ Terrain slope < 2 % within 10 km x 10 km (SRTM DEM)
  - ✓ Spatial homogeneity within 10 km x 10 km < ~ 3 % (based on MODIS White sky albedo data in NIR)
  - ✓ Additionally, other parameters were collected: aerosol load, altitude
- Regionally then, spatial homogeneity within 1 km x 1 km < ~ 3 % (based on 1 year of OLI data)

RadCalNet output data

RadCalNet output is the TOA reflectance:

- 30 minute intervals
- 9 am to 3 pm local standard time
- Nadir view only
- 10-nm intervals at least between 400 nm and 1000 nm and possibly can beyond (up to 2500 nm)





RadCalNet Site File Specifications

The data processing of RadCalNet will utilize two input files for each site. File 1 is a daily file containing the atmospheric and reflectance data and associated uncertainty. File 2 contains all the site specific default parameters used by MODTRAN and are not expected to change for each model run.
The input files must conform to the following format: ASCII text, Tab Delimited

1. Daily Input Data Files
The RadCalNet site manager will provide daily files for processing containing all the needed atmospheric parameter inputs, whether measured in-situ or derived from climatology and the ground based reflectance data. The uncertainties for these parameters will also be appended after the reflectance data.

1.1 File name
File naming convention data file: SiteXX_Year_DOY.input
Example: RVUS23_2014_161.input

Site = a unique 4 letter code to identify the site; 2 letters for site, 2 letters for country
Examples: RVUS = Railroad Valley, United States; LCFR = Le Creu, France
XX = two digit number of instrument number, '01', '02', etc... [If a site average of instruments is provided, then '00' is used]
Year: Year of data collection
DOY: UTC day of data collection (i.e. DOY for UTC first measurement in data file)

1.2 Header
The first four lines of the input file will contain site specific info
Example:
SiteXX: RVUS23
Lat: 38.497
Lon: -115.690
Alt: 1435

Site: defined above
XX: defined above
Latitude: Site latitude [> 0 = Northern hemisphere; < 0 = Southern Hemisphere]
Longitude: Site longitude [0 to +180 = East; 0 to -180 = West]
Altitude: site altitude in meters

1.3 Atmospheric Data
The header is followed by one blank line
Following the blank line, there are 14 columns (1 line title, 13 data)

Example:

Year:	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014	2014
DOY(J):	161	161	161	161	161	161	161	161	161	161	161	161	161
UTC:	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00
DOY(J):	161	161	161	161	161	161	161	161	161	161	161	161	161
Local:	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00
P:	853	853	853	852	852	852	852	851	9999	850	850	850	850
T:	28.1	29.3	30.7	31.1	31.7	32.4	34.2	-34.1	9999	34.0	34.0	33.6	33.7
WV:	0.98	0.96	0.91	0.93	0.91	0.86	0.89	-0.49	9999	0.99	0.97	0.87	0.83
O3:	280	280	280	280	280	280	280	-240	9999	280	280	280	280
AOD:	0.141	0.134	0.117	0.119	0.116	0.115	0.140	-0.345	9999	1.206	1.074	1.203	0.530
Asy:	0.882	0.886	0.934	1.023	0.976	0.941	0.974	-0.568	9999	0.108	-0.002	0.590	0.049
Type:	D	D	D	D	D	D	D	D	D	D	D	D	D

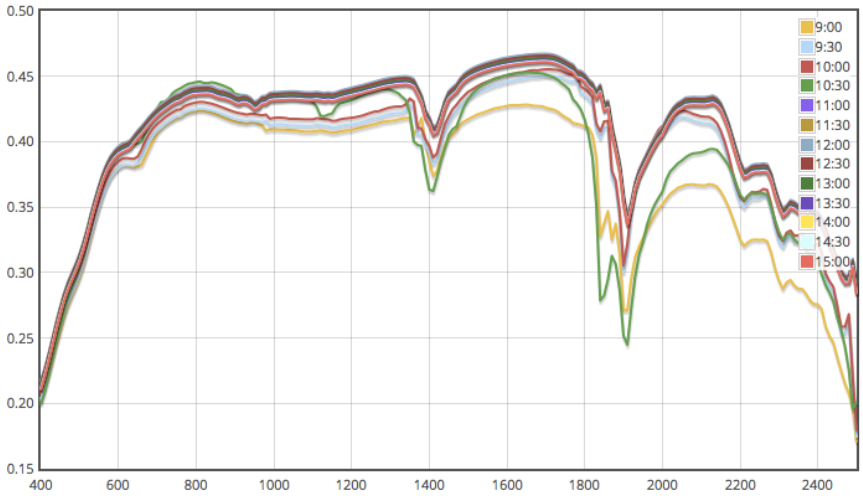
Year: Year of data collection
DOY(J): UTC day of data collection
UTC: UTC time of data collection

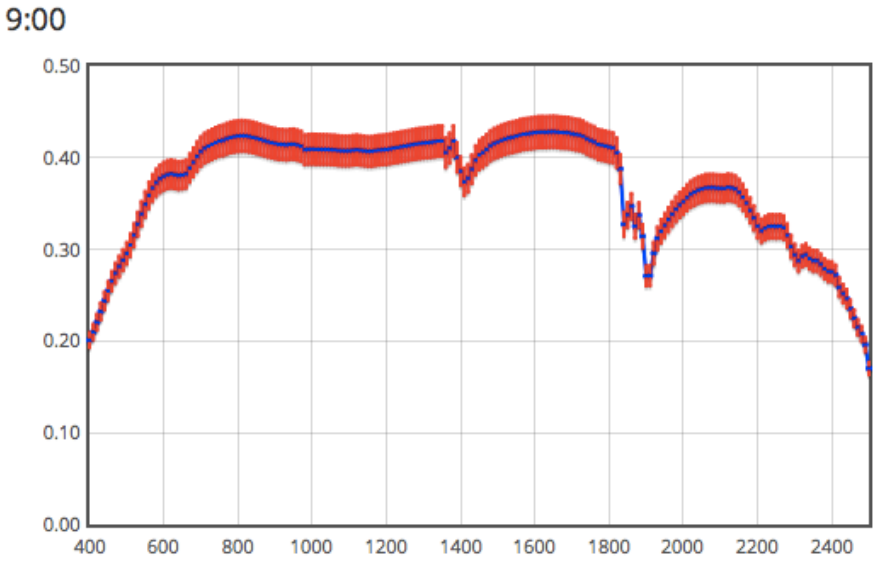
RadCalNet input data

RadCalNet inputs are:

1. The surface reflectance:

- 30 minute intervals
- 9 am to 3 pm local standard time
- Nadir view only
- 10 nm intervals from 400 nm to 2500 nm (=goal) or at least between 400 nm and 1000 nm + uncertainty

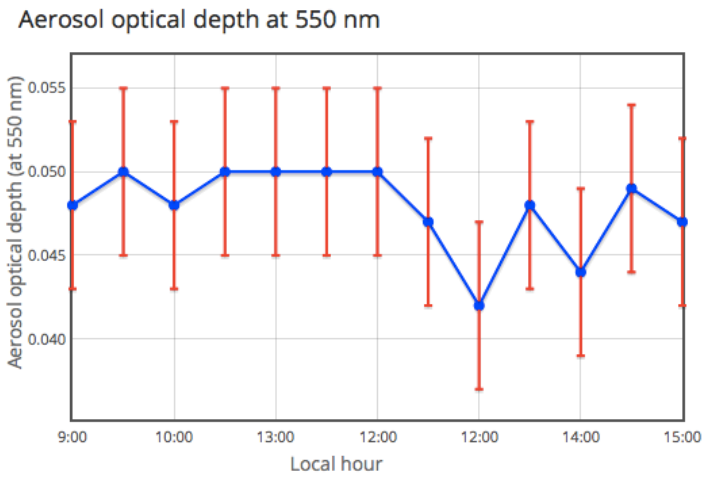


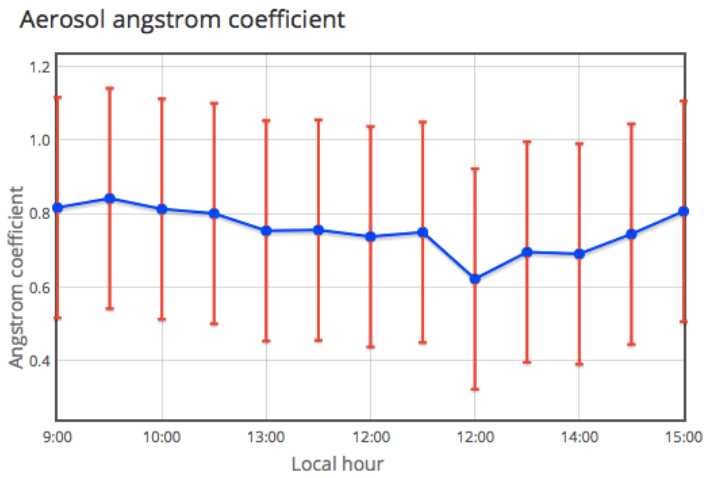


RadCalNet input data

2. Concomitant atmosphere data for the TOA propagation:

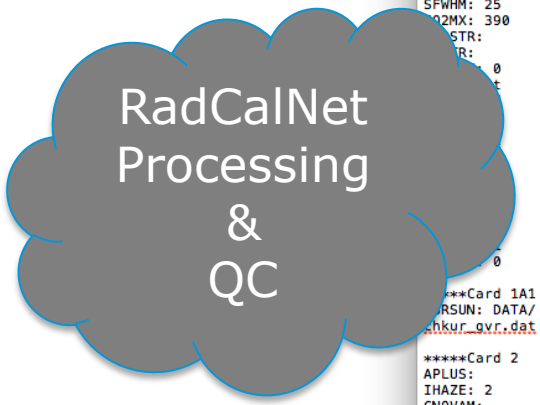
- Pressure + uncertainty
- Temperature + uncertainty
- Total column water vapour + uncertainty
- Total column ozone + uncertainty
- Aerosol optical thickness + uncertainty
- Aerosol Angstrom exponent + uncertainty
- Aerosol Type (following MODTRAN options)

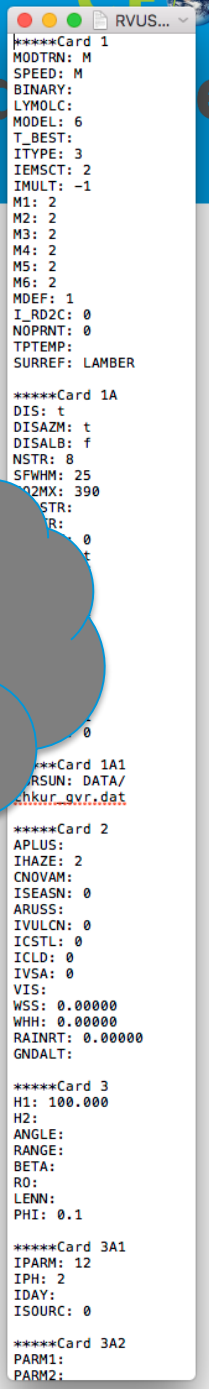




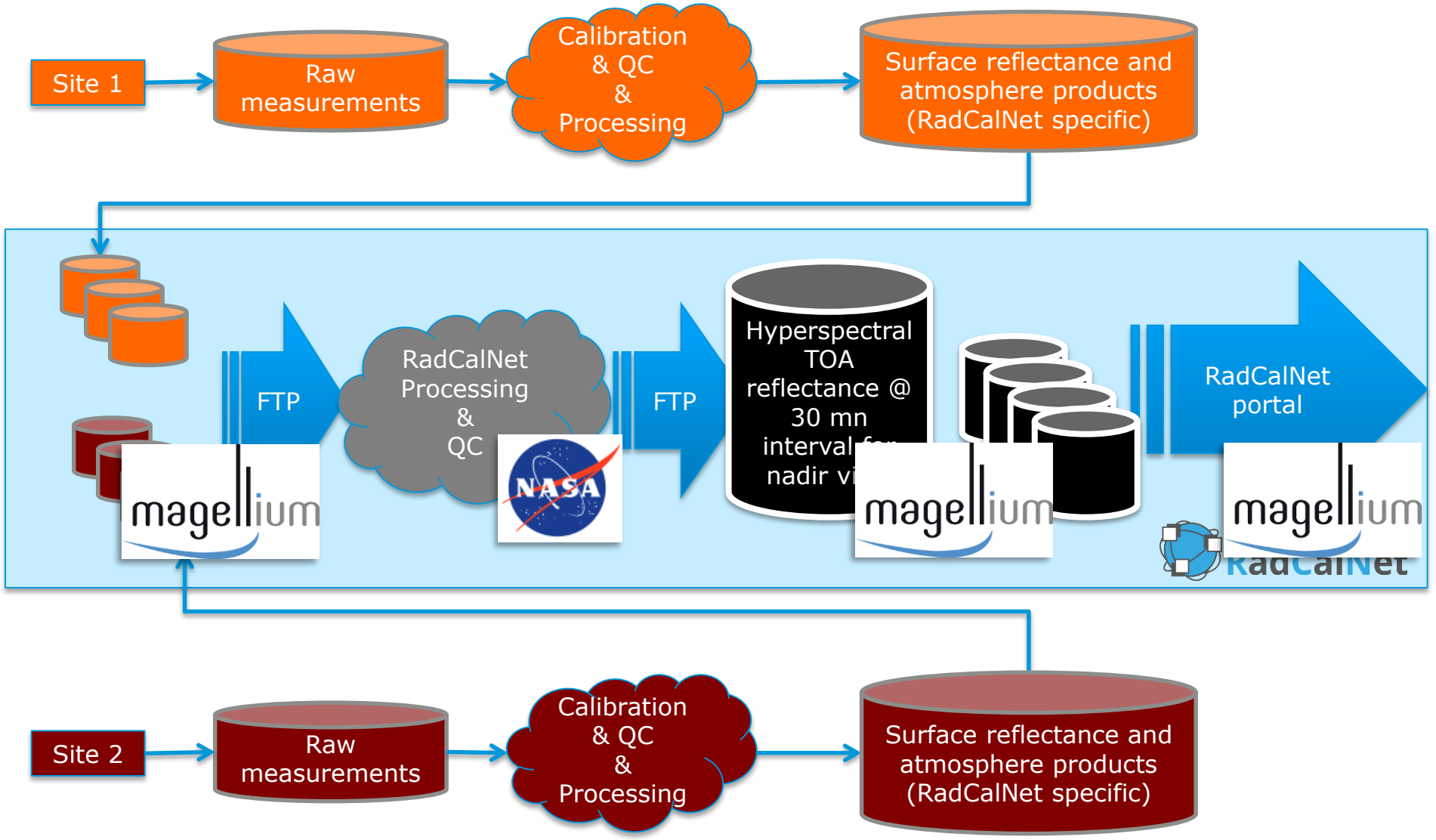
The RadCalNet processing

- Hosted by NASA/GSFC and based on Modtran 5
- Parameterisation of the code will be fully documented
- Key assumptions of the RadCalNet processing:
    - Lambertian surface
    - Aerosol optical properties based on pre-defined types
    - Pre-defined atmospheric profiles
- On-going work on how to propagate the surface / atmosphere uncertainties to TOA uncertainties
- QC mostly inherited from site .input files



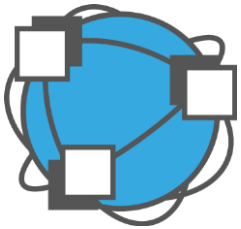


The data circulation… today in practice



The portal

Not open to public yet!



Plan to open for Beta testing from ~June 2016

Call to CEOS WGCV for candidates

Criteria for Beta Testers

- Full Member of CEOS WGCV (operate a sensor)
- Sensors should be compatible with site characteristics <~50 m
  - Specifics for each site
- Must register with RadCalNet project team (Marc Bouvet as lead)
- Must make available sensor response characteristics to RadCalNet team
-
- Provide feedback to RadCalNet on: ease of use, fitness for purpose etc
- Not publish during beta phase without agreement of RadCalNet team

Data policy

- Publically available
- Free
- Acknowledgment of RadCalNet and site owners

Criteria for new sites to join

RadCalNet is intended to be an operational network able to deliver a post-launch radiometric calibration service to in-flight sensors in the solar reflective band. It is operated for the community under the auspices of CEOS through its Working Group on Calibration and Validation (WGCV). Test Sites within RadCalNet are owned and maintained by site owners but output data are delivered from a central coordinating hub. Membership of RadCalNet is open to any site owner; however, to ensure harmonisation and coherence of the products delivered by RadCalNet and to minimise cost of administration and centralised coordination functions, all prospective site members must adhere on a continuing basis to the following criteria, which have been agreed by CEOS WGCV and are subject to annual review and update by agreement of RadCalNet members and CEOS WGCV. Conformance with these criteria and thus acceptance and continuance of membership will be subject to approval by CEOS WGCV and administered through the RadCalNet working group which will consist of the site owners and the chair of the WGCV IVOS sub-group. On acceptance new members will receive an acceptance letter and be listed on the RadCalNet portal.

- Sites should be larger than 45 × 45 m².
- The sites should be equipped, as a minimum, with instrumentation to enable representative hyper-spectral surface reflectance at 10 nm intervals at nadir to be assigned to the site on a 30 minute cycle (±3 hrs of local noon) over at least the spectral range 400 nm to 1000 nm and delivered operationally to the RadCalNet FTP site (see below). A spectral range coverage of 400 nm to 2500 nm is preferred.
- Sites should be equipped with instrumentation to obtain the necessary metadata to allow propagation to top of atmosphere: e.g. aerosol optical thickness and Angstrom exponent, air temperature, pressure, total column water vapour and total column ozone (full list in the data format specification).
- Surface and atmospheric measurements should have been carried out operationally for at least six months of the previous year prior to acceptance of membership.
- The site should deliver at least 90 days' worth of data per year of suitable quality to be used by RadCalNet.
- Site providers should adhere to the data format specified by RadCalNet (available on the portal).
- Site providers should provide documented description of their site characteristics, following examples on the RadCalNet website. This should include: methods used, instrument description, calibration (SI traceability), strategy and detailed uncertainty budgets for the delivered data. This documentation will be posted on the RadCalNet website.
- Site providers should be prepared to have site documents subjected to peer-review and should also be prepared to participate in RadCalNet comparisons involving travelling reference standards (e.g. reflectance panels and/or reference sensors) to ensure consistency with other RadCalNet sites.
- Sites should be offered to RadCalNet for a minimum of 5 yrs.
- Site providers should adhere to the data policy of RadCalNet.

The intercomparison of RadCalNet sites using SPOT-5 and Landsat-8

- An intercomparison is being done between:
  - ✓ Remote sensing TOA data: Landsat-8 /SPOT-5 (Take-5) / Sentinel-2
  - ✓ TOA simulations from the sites (from RadCalNet and from site owners own TOA simulation tools)

- Objective:
  - ✓ Demonstrate the RadCalNet concept
  - ✓ Identify site-to-site differences using the space sensors as transfer radiometers

Next steps

- Consolidate RadCalNet building blocks (4th site, processing, data circulation, portal)
- Consolidated the documentation: site documentation, processing description, data format, data policy, membership criteria, a reference RadCalNet paper
- Intercomparison of the RadCalNet sites using Landsat-8/SPOT-5/Sentinel-2
- Open the portal to beta users (Q3 2016)
- Go operational (Q1 2017)
- Open the network to new sites