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Submission Information

SMOS-CalVal


SMOS-CalVal Project

ID	3219
Password	42armpit
Title	DISAGGREGATION OF SMOS DATA AT THE CATCHMENT SCALE AND ASSIMILATION INTO DISTRIBUTED HYDROLOGICAL MODELS
Type	AO for SMOS CalVal
Class	CAL/VAL - Quality
Cost	Free of Charge
Primary Application Domain	Calibration/Validation
Secondary Application Domain	Hydrology
Location	Various

Principal Investigator

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Co-Investigators

Co-Investigators	Dr Gilles Boulet, CESBIO, Gilles.Boulet@cesbio.cnes.fr Dr Jeffrey Walker, The University of Melbourne, j.walker@unimelb.edu.au
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Team Composition, Experience, Innovation and Contribution

Team	<p>Team is composed of two collaborating groups, one in Australia (at Newcastle and Melbourne Universities, resp.) and one in France (at CESBIO); both groups have a long history of collaboration. The Team members are:</p> <p>In Australia:</p> <ul style="list-style-type: none"> - Jetse Kalma, Professor, University of Newcastle, hydrologist, scale issues expert - Jeff Walker, Senior Lecturer, University of Melbourne, hydrologist, remote sensing specialist, data assimilation expert - Greg Handcock, Senior Lecturer, University of Newcastle, geomorphologist, expert in land distributed hydrology modelling - Jorg Hacker, Assoc. Professor, Flinders University, Chief Scientist, Airborne Research Australia (ARA), expert in airborne environmental monitoring and boundary layer meteorology - Manju Hemakumara, PhD student, University of Newcastle, PhD title "Scaling of Soil Moisture Estimates" - Christopher Ruediger, PhD student, University of Melbourne, PhD title: "Streamflow Data Assimilation" <p>In France:</p> <ul style="list-style-type: none"> - Gilles Boulet, CR IRD, CESBIO, hydrologist, data-assimilation expert
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	<ul style="list-style-type: none"> - Yann Kerr, IR CNES, CESBIO, SMOS Leader Investigator, remote sensing expert - Philippe Maisongrande, IR CNES, expert in stochastic disaggregation of remote sensing data - Ghani Chehbouni, DR IRD, CESBIO, hydrologist, scale issues expert - Patricia de Rosnay, CR CNRS, CESBIO, hydrologist, remote-sensing expert - Valérie Estupina-Borrell, Postdoc, CESBIO, hydrologist - Maria-José Escorihuela, PhD student, CESBIO, PhD title "Preparation of the SMOS mission: Extraction of soil moisture from radiometric measurements" - Olivier Merlin, PhD student, CESBIO, PhD title: "Disaggregation of the SMOS soil moisture and assimilation of the disaggregated soil moisture into a SVAT type model for hydrological applications"
Experience	<p>The team has considerable research expertise in the areas of scale issues in hydrology, remote sensing applications in hydrology and data assimilation techniques. CESBIO has a particular expertise in the area of radiative transfer modelling as it relates to remote sensing, whereas the Australian partners have significant expertise in scaling, data assimilation and remote sensing applications in hydrology.</p> <p>A selection of papers is listed below: Boulet, G., Kerr, Y. H., Chehbouni, A. and J. D. Kalma (2002). "Deriving catchmentscale water and energy balance parameters using data assimilation based on extended Kalman filtering." Hydrol.Sci. J. 47 (3):449-467. Pellenq, J., Kalma, J.D., Boulet, G., Saulnier, G.-M., Wooldridge, S., Kerr, Y. and A. Chehbouni (2003). "A disaggregation scheme for soil moisture based on topography and soil depth" J. Hydrol. 276, 112-127. Walker, J. P., Willgoose, G. R., and Kalma, J. D. (2002). Three-dimensional soil moisture profile retrieval by assimilation of near-surface measurements: Simplified Kalman filter covariance forecasting and field application. Water Resour. Res. 38(12), 1301, 37, 1-18. Walker, J. P., Willgoose, G. R. and Kalma, J. D. (2001). One dimensional soil moisture profile retrieval by assimilation of near-surface measurements: a simplified soil moisture model and field application. J. Hydrometeorol. 2(4), 356-373. Pellenq, J. and Boulet, G. (2004) A methodology to test the pertinence of remote-sensing data assimilation into vegetation models for water and energy exchange at the land surface, Agron. 24, 197-204. Walker, J.P., Houser, P.R. and Willgoose, G.R. (2004). Soil Moisture Measurement Using ERS-2: A Field Evaluation. Hydrol. Proc. 18, 1975-1997 Walker, J.P. and Houser, P.R. (2004). Requirements of a global near surface soil moisture satellite mission: Accuracy, repeat time and spatial resolution. Adv. in Water Res. 27, 785-801</p>
Innovation	<p>Knowledge of the spatial and temporal variation in both near-surface and rootzone soil moisture at various resolutions is critical for achieving efficient and sustainable water use and for improvements in climate change prediction. Such data are essential for efficient irrigation scheduling and cropping practices and for accurate initialisation of climate prediction models. The fundamental limitation is that spatial and temporal variation in soil moisture is not well known or easy to measure, particularly at high resolution over large areas. This project has two main objectives. Firstly, it aims to develop and test several disaggregation and data assimilation techniques. These techniques are based on existing radiative transfer models and distributed hydrological models. Secondly, the project will provide calibrations and validations of the surface soil moisture retrieval algorithms using data obtained in intensive field campaigns involving high resolution airborne remote sensing as well as intensive groundbased soil moisture measurements. The outcomes of this project will provide insight in the accuracy of remotely sensed soil moisture data and will give an evaluation of the disaggregation and assimilation methodologies for generating soil moisture maps across regions from coarse-resolution space-borne radio-brightness data (SMOS). Such spatial and temporal soil moisture data will assist in weather and climate prediction, early warning systems (for example in flood forecasting), climate sensitive socio-economic activities (for example in agriculture and water management) and in policy planning (for example in bush fire hazard mapping, drought relief and global warming). An ability to map (in real time) the magnitude as well as the temporal and spatial variation in soil moisture content at the scale of the irrigation district will provide critical information to irrigators and irrigation managers.</p>
Contribution	<p>This proposal will contribute towards the test of the SMOS Soil Moisture retrieval algorithms at local and SMOS pixel scales. To our knowledge, there are few datasets that will produce at the scale of one SMOS pixel a map of airborne remote sensing data in the three major wavelength (microwave, visible and near-infra-red, thermal-infra-red) as well as distributed simultaneous measurements of surface soil moisture, root-zone soil moisture and streamflow. The proposed project will provide a unique data-set that includes such features. This data-set will be used to test (1) the inversion of surface soil moisture through high resolution airborne L-band brightness temperature and NDVI, compared to distributed soil moisture measurements (test of the radiative transfer scheme inversion at local scale); this task is similar to and will benefit from the experience of other SMOS cal/val related activities (SMOS-REX, COSMOS...) and (2) the inversion of local-scale soil moisture by disaggregation of the coarse scale brightness temperature using auxiliary data (NDVI and surface temperatures) observed at local scale; this task will ensure that the coarse resolution SMOS data can be used to derive local-scale soil moisture estimates, using simultaneous measurements of soil moisture and brightness temperatures at local scale. Details on the airborne campaigns in Australia can be found on the web (http://www.civenv.unimelb.edu.au/~jwalker/data/nafe) as well as on the uploaded document.</p> <p>In summary, this proposal falls within two themes of the AO:</p> <ul style="list-style-type: none"> - "comparison of soil moisture products with field measurements, considering scale issues" (for the use of airborne (for the comparison between inversed soil moisture from L-band at several nested scales and the in-situ network of soil moisture measurement) - "impact of auxiliary information used in the processing (land surface temperature, leaf area index, etc.)" (for the disaggregation part using surface temperature/NDVI data)

Executive Summary and Schedule

Executive Summary	<p>Objectives: The aim of this proposal is to use a combination of gridded airborne L-band brightness temperature, NDVI and surface temperature data and distributed in-situ soil moisture data acquired at the scale of several SMOS pixels during two field experiments in SE Australia (NAFE) to test (1) the soil-moisture retrieval algorithms (inversion of local soil moisture from airborne brightness temperature data) and (2) the disaggregation algorithms (inversion of local soil moisture from coarse brightness temperature and auxiliary data).</p> <p>Methods: 1. SOIL MOISTURE RETRIEVAL ALGORITHMS: the inversion of the tau-omega radiative transfer scheme for each airborne acquisition point will be tested by comparing measured and inverted surface soil moisture. 2. DISAGGREGATION USING LOCAL SCALE AUXILLARY DATA: two different disaggregation approaches, one based on a deterministic approach, the other on geostatistical techniques, will be employed, using the coarse-scale L-band brightness temperature estimate (obtained from the local airborne measurements) and local-scale measurements of NDVI and surface temperature. 3. DATA ASSIMILATION: the distributed surface soil moisture estimate obtained by the disaggregation algorithm will be assimilated to retrieve local-scale root-zone soil moisture.</p> <p>Deliverables: The project team members will produce research reports on: 1- Expected accuracy of soil moisture retrieval for a range of land-cover types present in the Australian catchments, 2- The efficiency of disaggregation schemes for downscaling coarse-scale soil moisture estimates and 3- Root-zone soil moisture retrieval accuracy with Data Assimilation methods using coarse-scale (SMOS) L-Band brightness temperature.</p> <p>Funding Source (for NAFE): - ARC 2002-2005 Discovery Project DP0209724 Scaling and Assimilation of Soil Moisture and Streamflow (SASMAS)(Kalma, Willgoose and Walker; AUS\$235K). The SASMAS project will provide the instrumentation infrastructure in the Goulburn catchment for the present project as well as the long-term soil moisture, climate and streamflow monitoring data obtained during 2002-2005 - ARC 2005-2008 Discovery Project DP 0557543 High Resolution Mapping of Surface and Root Zone Soil Moisture project (Walker, Kalma and Kim; AUS\$676K) will fund the airborne monitoring and groundbased experiments during NAFE05 and NAFE06 - ARC 2004 LIEF Project LE0453434 has provided funding for Polarimetric L-band Multibeam Radiometer (PLMR) and Thermal Imager. This new facility will allow measurement of near-surface soil moisture content under low to moderate vegetation conditions at 50 m resolution for a flying height of 150 m, together with surface temperature and Normalised Difference Vegetation Index (NDVI) at 1 m resolution. T -ARC 2005 LIEF Project LE0560930 will fund a new airborne laser scanner and associated GPS/inertial navigation/attitude reference system. The main use of the new laser equipment will be to obtain high precision, high resolution terrain elevation data.</p>
Schedule	<p>TIME TABLE</p> <p>2005</p> <ul style="list-style-type: none"> - implementation of all methods - calibration of the hydrological model with ancillary 2003-2005 Goulburn River catchment data - participation in the NAFE05 field campaign in the Goulburn River catchment (November 2005) <p>2006</p> <ul style="list-style-type: none"> - 1st NAFE workshop (April/May 2006) - inversion of airborne brightness temperature observations (NAFE05) - implementation and test of the disaggregation strategies (NAFE05) - implementation and test of the data assimilation strategies (NAFE05) - participation in the NAFE06 field campaign in the Murrumbidgee River catchment (November 2006) <p>2007</p> <ul style="list-style-type: none"> - 2nd NAFE workshop (April/May 2007) - inversion of airborne brightness temperature observations (NAFE06) - implementation and test of the disaggregation strategies (NAFE06) - implementation and test of the data assimilation strategies (NAFE06) - publication and reporting <p>2008</p> <ul style="list-style-type: none"> - implementation of the methods for the SMOS data (inversion +disaggregation + assimilation for level 1C, disaggregation + assimilation for level 2) - evaluation with data obtained in the on-going soil moisture and distributed streamflow measuring program in both catchments

Detailed Description

Detailed Description	<p>Knowledge of the spatial and temporal variation in both near-surface and rootzone soil moisture is critical for achieving efficient and sustainable water use and for improvements in climate change prediction. Soil moisture information may be obtained in three different ways. First, there are direct ground-based measurements which need to be made at many individual points if regional data are required. Second, surface hydrology models may be used to predict the spatial and temporal variation of near-surface and rootzone soil moisture but those estimates suffer from inadequate model physics, parameter estimates and atmospheric forcing data. Third, remote sensing provides spatially distributed soil moisture data at a regional scale, but the data acquired (in the visible or the thermal infra-red wavelengths) are only indirectly related to soil moisture.</p> <p>In recent years there has been an increasing interest in using passive microwave remote sensing for large scale measurements of soil moisture in the top few centimetres, because the data acquired is directly related to surface soil moisture. Clearly, these different approaches are complementary and so one approach has been to utilise all three sources of data.</p> <p>In 2007, the Soil Moisture and Ocean Salinity (SMOS) sensor will be launched. SMOS will offer a temporal resolution of the order of 3 days, compatible with the time-scale of the soil moisture evolution as driven by hydrological processes. Its spatial resolution will be on the order of a 50 by 50 km pixel, which is not well-matched with the observed scale of variability of soil moisture due to the average space-scale of hydrological processes (less than a km) and hence not particularly useful for small scale applications. Moreover, the depth of integration of the soil moisture measurements does not exceed a few centimetres, whereas for most hydrological applications an evaluation of the root-zone soil moisture is required. The future use of SMOS data for operational prediction of catchment scale soil moisture status will thus require three types of studies: (1) calibration and validation of SMOS surface soil moisture retrieval algorithms; (2) development of disaggregation techniques for downscaling the coarse scale SMOS surface soil moisture values to local-scale estimates and (3) development of data assimilation techniques for deriving estimates of root-zone soil moisture from surface soil moisture values.</p> <p>The project has two main objectives. Firstly, it aims to test disaggregation and data assimilation techniques based on existing radiative transfer models and distributed hydrological models. Secondly, the project will provide calibrations and validations of the SMOS surface soil moisture retrieval algorithms using data obtained in intensive field campaigns involving high resolution airborne remote sensing as well as intensive ground-based soil moisture measurements.</p> <p>The proposed project is motivated by the existence of unique long-term data sets acquired in the Goulburn and Murrumbidgee catchments in SE Australia (which are of the size of several SMOS pixels), the availability of experimental data obtained at the long-term SMOSREX monitoring site in SW France, and two National Airborne Field Experiments to be held in the Goulburn (NAFE05) and the Murrumbidgee (NAFE06) catchments in November 2005 and 2006. These two experiments will provide high resolution maps of L band brightness temperature, Thermal Infra Red temperature and NDVI for both catchments as well as a wide range of groundbased observations.</p> <p>The following approaches will be taken in this project:</p> <ol style="list-style-type: none"> 1. SOIL MOISTURE RETRIEVAL ALGORITHMS (INVERSION) <ol style="list-style-type: none"> 1.1. The SMOS-REX data set will be used to test the surface soil moisture retrieval capabilities of current radiative transfer models. These models are used in direct mode to simulate brightness temperatures from estimates of the surface soil moisture, and therefore an inversion procedure must be developed to obtain surface soil moisture from the remotely sensed brightness temperature. Comparison between measured in-situ and inversed soil moisture at the time of the aircraft overpass will be carried out for a range of land cover types for the Goulburn catchment. This catchment is a mixture of open woodland, grassland and agricultural zones in a dry sub-humid climate. it is therefore a good candidate to test the combined role of soil and vegetation on the producing the radiobrightness signal. 2. DISAGGREGATION <ol style="list-style-type: none"> 2.1. First the high-resolution L-band brightness temperature maps acquired by the aircraft in the microwave domain during NAFE05 will be aggregated to produce a coarse-resolution brightness temperature corresponding to the size of one SMOS pixel. 2.2. Next, small-scale (high-resolution) landsurface data and the coarse-scale SMOS brightness temperature will be combined into two different disaggregation approaches, one based on a deterministic approach, the other on geostatistical techniques. <ol style="list-style-type: none"> 2.2.1. The high-resolution thermal infrared surface temperature data acquired by the aircraft will be used in a deterministic disaggregation approach together with the SMOS generated brightness temperature to produce high-resolution surface soil moisture maps. 2.2.2. Simulated surface soil-moisture by a distributed hydrological model will be used together with a geostatistical procedure to produce high-resolution surface soil moisture maps. 2.3. The surface soil moisture maps produced by both disaggregation techniques will be compared to soil moisture fields obtained by inversion of the L-band brightness temperature maps acquired by the aircraft as well as ground-based soil moisture measurements. 3. DATA ASSIMILATION <ol style="list-style-type: none"> 3.1. The Inversion and Disaggregation procedures will be used to generate maps of surface soil moisture each time the aircraft flies. In order to produce continuous time-series of spatially distributed root-zone soil moisture, these maps need to be assimilated into a distributed hydrological model. To achieve this, methods based on optimal estimation and optimal control will be developed to assimilate surface soil moisture fields and estimate distributed root-zone soil moisture 3.2. The hydrological model will first be calibrated against streamflow and in-situ soil moisture data obtained for a network of continuous sampling sites 3.3. Next, the performance of the data assimilation methods will be assessed by comparing predictions and measurements of streamflow and soil moisture content during NAFE05.
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Non ESA Comment

Non ESA Data

File Upload

Upload file comment	National Airborne Field Experiments (NAFE) general description and field plan; Cvs of key personal: PI Jetse kalma, CI Jeff Walker and Gilles Boulet, ref. Yann Kerr
Upload Filename	NAFE_description_and_PCI_CVs.pdf View

Product of ENVISAT / AATSR

Product	Total	New	Archived
Level 2 Gridded (ATS_NR__2P)	60	10	50

Product of ENVISAT / MERIS

Product	Total	New	Archived
Level 2 Full Resolution (650 Km) (MER_FR__2P)	360	30	330
Level 2 Reduced Resolution Vegetation indices (MER_RRV__2P)	360	30	330

Product of SMOS / MIRAS

Product
Level 1C
Level 2 (Soil Moisture)

Data Requirements

ERS/ENVISAT: Details about archived data	It is impossible to provide exact orbit data for the requested archived data, because the later depend on the ground experimental campaigning in 2008, which are not defined yet. Details about archived data request will be determined 6 months before campaign. Geographic name is: Murray-Darling Basin / Australia
ERS/ENVISAT: Details about new acquisitions	It is impossible to provide exact orbit data for new acquisition, because the later depend on the ground experimental campaigning in 2008, which are not defined yet. Details about new acquisition will be determined 6 months before campaign. Geographic name is: Murray-Darling Basin / Australia
Specific polarisation schemes required for ASAR	no
Specific swaths required for ASAR	no
Alternative bands set required for MERIS	no
Simultaneous acquisition of different sensors required	no
NRT Data requirements	no

