Académie des Sciences de Chine

Symposium franco-chinois de télédétection quantitative en agronomie et environnement

Bilan et perspectives de collaboration

Rapport de mission

(26 au 30 mars 2000)

par

Agnès BEGUE et Gérard DE WISPELAERE

Rapport CIRAD-AMIS N° 00-17 **Avril 2000**

CIRAD-AMIS
Amélioration des méthodes pour
L'innovation scientifique
Programme Agronomie/GEOTROP
CIRAD-EMVT
Elevage et médecine vétérinaire
Programme ECONAP
BP 5035
34032 Montpellier Cedex 1 – FRANCE

AUTEUR(S) : Agnès BEGUE – Gérard DE WISPELAERE

ACCES AU DOCUMENT :
au service Documentation du CIRAD et à la documentation de la Maison de la Télédétection

ORGANISME AUTEUR : CIRAD **ACCES A LA REFERENCE DU DOCUMENT :**

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REFERENCE : CIRAD-AMIS 00-17

AU PROFIT DE : Académie des Sciences de Chine

TITRE : Symposium franco-chinois de télédétection quantitative en agronomie et environnement et perspectives de collaboration

TYPE D'APPROCHE : Rapport de mission

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PAYS OU REGIONS CONCERNES : Chine

MOTS CLES : Chine, Télédétection, Agronomie, Environnement

RESUME : Ce rapport présente les principaux résultats d'un Symposium en Télédétection entre des équipes de chercheurs de l'INRA, du CIRAD, de l'Université de Lille et leurs homologues chinois de l'Institute of Remote Sensing Applications (IRSA) of Chinese Academy of Sciences (CAS), et du National Satellite Meteorological Center (NSMC). Les perspectives d'un programme de collaboration sont présentées avec deux axes majeurs correspondant à deux niveaux d'approche, régional et local en agriculture de précision.

Les résumés des communication sont présentés en annexe II.

Séance inaugurale

1 : Dr . LuBeilei
2 : M. Mynard
3 : Pr. Dong Chaohua
4 : M. Vialle
5 : Pr. Xu Zhilong
6 : M. Hervieu
7 :Pr. Guo Baozhu
8 : (hors image) Pr. Tong
9 : Dr. Xinfa Gu
10 : Pr. Zang Wen-Jian

1. Origine de la mission :

Les collaborations antérieures entre la Chine (l'Académie des Sciences) et la France (INRA Avignon) sont à l'origine de cette mission. En effet, initié par Gérard Guyot de l'INRA d'Avignon, aujourd'hui à la retraite, un PRA (Programme de Recherche Avancé) sur l'étalonnage des satellites avait été élaboré entre les 2 instituts depuis 1992. Ce PRA s'est traduit par des missions croisées d'étalonnage de capteurs satellitaires dans le désert de Gobi et en Crau, et par des échanges d'étudiants en thèse (accueil de 3 thésards Chinois à l'INRA d'Avignon-Bioclimatologie).

Le but de cette délégation française en Chine était double :

- faire le point sur les actions menées depuis 92 dans le cadre du PRA
- proposer des lignes d'orientation et d'actions pour l'avenir.

La présence du Président, du Directeur Général de l'INRA et du vice-président de l'Académie des Sciences (CAS) à la cérémonie d'ouverture du colloque souligne la volonté politique d'un tel rapprochement.

La liste des membres de la délégation française est donnée en annexe I. La présence du CIRAD dans une telle délégation a été explicitement demandée par l'INRA en raison des collaborations de longue date entre le CIRAD et l'INRA d'Avignon Bioclimatologie et en raison de la représentation commune INRA-CIRAD en Chine (M. Zheng Li).

De plus, cette mission faisait suite au récent voyage du Président de l'Académie des Sciences en France (mars 2000) où il a rencontré, entre autre, le Président du CIRAD, M Daniel Nahon, et M. Jean-Luc Renard. M. Li Zhiyi (Directeur de la Division des Programmes avec l'Europe de l'ouest) qui accompagnait cette délégation chinoise en France nous a fait part de la grande satisfaction du Président de CAS engendrée par cette visite.

2. Programme de la mission :

Symposium Franco-Chinois "Télédétection quantitative en agriculture et Environnement"

Session d'ouverture :

Les discours d'introduction du Symposium ont traduit la volonté politique de collaboration entre les organisations scientifiques françaises et chinoises autour des applications de la Télédétection en agronomie et pour l'environnement.

Présentations orales (27-28 et matinée du 29 mars)

Outre les présentations générales d'introduction, 30 communications ont été présentées (programme et résumés en annexes).

Sujets abordés :

Calibration radiométriques des capteurs
Applications de la télédétection hyperspectrale en agriculture et en environnement
Applications de la télédétection radar en agriculture et en environnement
Intégration des données de télédétection, modèles d'analyse quantitative
Agriculture de précision et estimation de prévision de récolte

Les applications couvrent les changements globaux (climatologie, occupation du sol) les évaluations quantitatives de production (riz, pâturages) et l'agriculture de précision.
La délégation française a présenté 7 communications scientifiques, les unités mixtes franco-chinoises, 5 communications et la délégation chinoise 18 communications. La majorité des présentations des équipes chinoises a été faite par de jeunes chercheurs.

Conclusions du colloque
Alors que toutes les présentations avaient été faites en anglais (avec parfois des difficultés de compréhension (de part et d'autre), les conclusions et les discussions sur les collaboration possibles ont été faites dans les langues d'origines et traduites (détails dans le paragraphe suivant).

Visites de laboratoires (30 mars 2000) :

La délégation française a visité deux organismes, **l'Institute of Remote Sensing Application (IRSA), Chinese Academy of Sciences (CAS)** et le **National Satellite Meteorological Centre (NSMC)**.

L'**IRSA** (www.crecs.irsa.ac.cn) et www.digitalearth.net.cn) qui occupe environ 250 personnes est divisé en 4 départements (cf.organigramme). Les matériels sont récents et les logiciels s'apparentent (en chinois) à ceux du marché occidental. Les applications utilisent soit les données des satellites chinois soit celles des satellites occidentaux (NOAA ...). Tous les types de capteurs sont traités (optiques, hyperspectraux, radar) satellitaires aussi bien qu'aériens.

Outre les activités de recherche méthodologiques et instrumentales, les applications en agronomie concerne les estimations de surfaces cultivées en blé, maïs, riz, coton avec des prévisions de production par corrélations empiriques avec les 3 000 stations météorologiques de Chine. Cette application est opérationnelle depuis 1998 et donne lieu à des bulletins synthétiques, destinés au gouvernement, sur les surfaces cultivées et les rendements attendus.

Le **NSMC** (www.nsmc.cma.gov.cn) occupe 600 personnes et ses principales fonction sont :

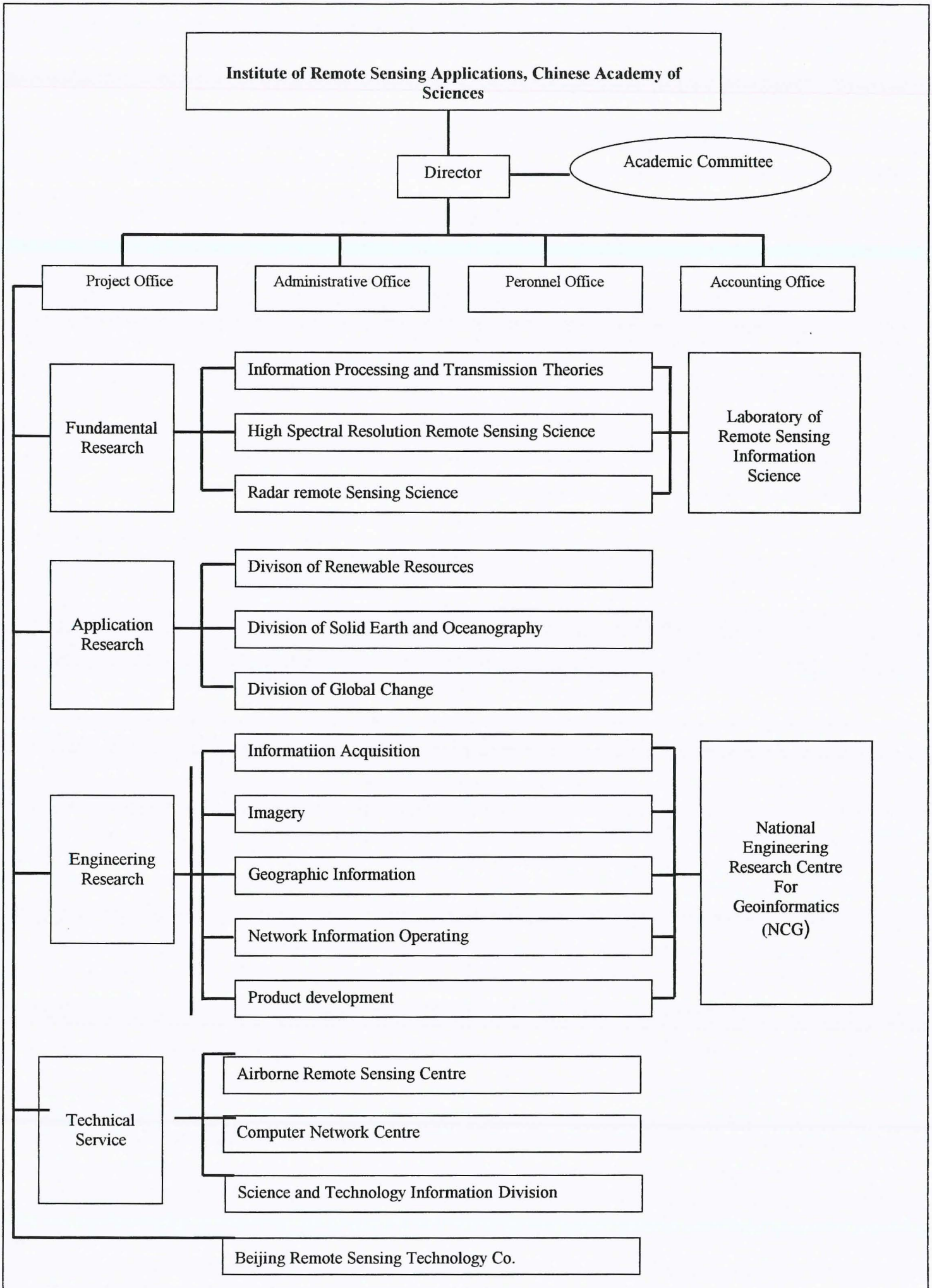
- L'étude et le développement des programmes chinois de météorologie spatiale ;
- La construction des segments sol des stations de réception ;
- Le développement des recherches sur les satellites météorologiques ;
- L'acquisition, le traitement et la distribution des données des satellites météorologiques.

Actuellement le satellite FY-1C (polaire , orbital) est de seconde génération avec 10 canaux pour une résolution au Nadir de 1.1 km (idem AVHRR et SPOT Végétation) tandis qu'un satellite géostationnaire (FY-2) du type de METEOSAT assure les activités opérationnelles de prévisions météorologiques.

Un nouveau satellite d'observation de la terre a été lancé en 1999 dans la cadre de la Coopération sino-brésilienne. Il s'agit de China-Brazil Earth Resources Satellite (CBERS) dont les caractéristiques sont proches de celles de SPOT.

Les moyens informatiques sont importants avec des CRAY récents et pour les applications des stations de travail et des micro-ordinateurs eux aussi très récents.

En routine, les services assurent outre les activités classiques en météorologie (typhons ...), les suivis des inondations, des feux, de l'enneigement etc..


Institute of Remote Sensing Applications, Chinese Academy of Sciences
Director
Academic Committee
Project Office
Administrative Office
Peronnel Office
Accounting Office
Fundamental Research
Information Processing and Transmission Theories
High Spectral Resolution Remote Sensing Science
Radar remote Sensing Science
Laboratory of Remote Sensing Information Science
Application Research
Divison of Renewable Resources
Division of Solid Earth and Oceanography
Division of Global Change
Engineering Research
Informatiion Acquisition
Imagery
Geographic Information
Network Information Operating
Product development
National Engineering Research Centre For Geoinformatics (NCG)
Technical Service
Airborne Remote Sensing Centre
Computer Network Centre
Science and Technology Information Division
Beijing Remote Sensing Technology Co.

3. Relevé de conclusions de la réunion du 29/03/2000 (après-midi) :

Etaient présents : l'ensemble de la délégation française, et Messieurs les Professeurs Tong, Zhang Wen-Jian, ...

Intervention de M. Lévy sur les PRA (Programme de Recherche Avancé). Il apparaît possible de déposer un dossier PRA à la fois par la France et la Chine sur un programme de recherche commun. Le financement des PRA est de l'ordre de 50kF par partie et par an (sur 2 ou 3 ans). Cette somme peut sembler dérisoire au vu des ambitions des différents instituts présents, mais elle peut servir de soutien au démarrage de projets plus conséquents (financement de missions de prise de contacts essentiellement). Clôture de l'appel d'offre au 31 Avril 2000.
M. Lévy nous engage fortement à monter un PRA sur la pollution de l'air à Pékin. A titre d'information, Pékin va être équipé des mêmes enregistreurs de pollution que Paris. Ce domaine d'étude pourrait intéresser l'IRD qui termine un projet européen d'étude de la pollution urbaine par satellite. Information à faire remonter auprès de l'équipe l'IRD de la Maison de la Télédétection.

M. Lévy devrait venir visiter la Maison de la Télédétection en avril/mai 2000.

Suite à l'intervention de M. Lévy, 2 axes de collaboration ont été discutés : au niveau local avec l'Agriculture de précision, et au niveau régional (calibration, aérosols, pâturages).

Projet à l'échelle locale ('Agriculture de précision') :

Les Chinois semblent avoir été impressionnés par les présentations faites au cours du colloque sur l'agriculture de précision AP (pour plus de détails sur l'AP voir paragraphe perspectives). Il est très difficile de connaître leur motivation profonde quant à une collaboration sur le sujet. Le Professeur Tong nous indique que la population en Chine sera de 1.6 milliard d'habitants en 2050 et qu'il faut améliorer la production agricole. Cependant a présenté l'affaire comme étant une réponse à la démographie galopante de la Chine (sic) et au besoin d'accroître la production agricole, alors que d'autres sources chinoises ou étrangères semblent montrer qu'au contraire le pays est excédentaire, et que leur souci majeur est de décroître la production agricole (???) et de reconvertir des millions d'agriculteurs.
D'un point de vue strictement scientifique, il est vrai que, au regard de ce qui nous a été présenté dans la semaine, les chinois ont un retard important en matière de modélisation du transfert radiatif et de l'assimilation des données satellitaires dans les modèles de fonctionnement qui sont un des piliers de l'agriculture de précision. De plus, on soupçonne qu'une collaboration franco-chinoise pourrait donner accès aux chinois à des fonds européens.
Les cultures d'intérêt sont le maïs, le blé, le riz, le coton. Peut-être le CIRAD pourrait-il se positionner sur le coton et le riz ?

Contacts : Prof. Tong Qingxi (ex-Directeur de l'IRSA) et de Martine Guérif de l'INRA Laon (Avignon en Septembre 2000).

Projets à l'échelle globale :

Trois sujets ont été retenus :

a) Validation des paramètres biophysiques
b) Etude des nuages de poussière atmosphérique
c) Evaluation et suivi des parcours (pâturages)

Suite à la mission en Chine de B./ FAYE (Productions animales EMVT), nous savions que les chinois avaient identifié le suivi des pâturages par télédétection dans leurs priorités. Cet axe de recherche méthodologique a été proposé par la délégation française et retenu avec une localisation dans le XINJIANG.

Contacts : Zhang Wen-Jian (DG du Centre Meteo National) et Frédéric Baret (INRA Avignon).

Parmi les prochaines étapes une visite en France de MM les Professeurs Tong et Zhang Wen-Jian au mois d'août est envisagée.

En fin d'après-midi, les plus anciens offrent aux jeunes chercheurs chinois la possibilité d'exprimer leurs souhaits en matière de formation et d'échanges entre les 2 pays. En effet, il existe en Chine un saut de génération entre les chefs (souvent âgés) et les scientifiques de base (jeunes). D'où un fort besoin en encadrement et en formation de ces jeunes scientifiques. En plus des pratiques actuelles (envoi de thésards chinois dans des laboratoires français), les jeunes chinois proposent que la France envoie des thésards français en Chine pour aider les thésards chinois.

Principaux axes de coopération (sur lesquels seront centrés les formations)

Agriculture de précision

Mesures (satellite/sol) : Quel capteur ? Capteur aéroporté chinois (très haute résolution avec plusieurs bandes spectrales), étalonnage, mesures de l'état hydrique et de la teneur en chlorophylle ...
Modélisation du transfert radiatif dans les couverts végétaux + techniques d'inversion. Important manque dans ce domaine du coté chinois.
Modélisation du fonctionnement des couverts végétaux + techniques d'assimilation. Ici aussi, il semble y avoir un grand manque du coté chinois.
Aide à la décision, partie opérationnelle de l'Agriculture de précision.

Suivi global

Etalonnage des capteurs, corrections atmosphérique, mesures de terrain ... Inter-étalonnage des différents capteurs, utilisation du capteur Chinois de FY-1C ...
Modèles de transfert radiatif
Application (suivi et évaluation de la production des pâturages, étude des nuages des poussières)

4. Conclusions et perspectives

Ce symposium semble avoir été un succès. Les principales publications seront éditées dans deux revues, l'une chinois et l'autre française ou internationale.

Des sujets d'intérêt commun ont été identifiés et la volonté de collaborer a été affichée. L'accueil en France de thésards chinois dans des projets de recherches communs ainsi que l'envoi en Chine de thésards français sont souhaités.

Pour les applications il convient de rechercher des financements et si le PRA peut permettre la rédaction de projets, les financements européens semblent incontournables.

A partir des axes de recherches retenus, il convient maintenant d'identifier et de proposer à un bailleur de fonds un projet cohérent avec nos partenaires. Ceci pourrait être développé lors de la venu en France de Messieurs les Professeurs Tong Qingxi et Zhang Wen-Jian en août 2000.

Dans cet esprit la recherche d'un partenaire européen apparaît nécessaire ainsi qu'un autre partenaire asiatique. Concernant l'approche pastorale et compte tenu de la nature de l'écosystème du Xinjiang un rapprochement avec les projets dans le Kazakhstan et l'Ouzbékistan serait peut être à effectuer.

Il convient enfin de noter parmi les conclusions la qualité de l'ambiance qui s'est progressivement installée entre les délégations. Ce climat de confiance semble favorable au développement de projets dans un esprit d'échanges mutuels.

Affaires franco-françaises :

Outre la composante scientifique, la délégation était également composée d'industriels français venus présenter des dossiers technico-commerciaux en Agriculture. SCOT a présenté un projet de suivi de l'agriculture sur 4 zones pilotes (version Chinoise du projet Européen «Monitoring of Agriculture by Remote Sensing». Le financement serait assuré par un prêt du gouvernement français à la Chine.

Dans cette négociation SCOT a comme interlocuteur le Ministère de l'Agriculture (?). Ceci montre la difficulté d'identifier le partenaire (décideur ?) dans des projets de recherche appliquée.

Dossier 'Agriculture de précision' :

Composition du Consortium français 'Agriculture de Précision' ou AP [2000-2006] :

INRA (Avignon Bioclimatologie essentiellement) : modélisation du transfert radiatif dans les couverts végétaux, techniques d'inversion pour retrouver les paramètres biophysiques de surface (LAI, taux de couverture ...), et techniques d'assimilation pour retrouver les paramètres agronomiques (date de semis ...).

SCOT : (Filiale du CNES) cette société intervient dans de nombreux domaines de la télédétection pour les application en agriculture (diagnostics, statistiques agricoles, évaluation des ressources pastorales, foresterie)

AVENTIS : Suivi d'un réseau d'agriculteurs en France et en U.K.:
Suivi avec des images SPOT (1 image par mois de janvier à juillet) :
2 agriculteurs qui pratiquent l'AP
75 agriculteurs en France et UK.
Université de Purdue
Suivi avec des images aériennes (capteur CASI, 10 longueurs d'onde) :
30 agriculteurs en France.

CNES/Matra : Conception d'une mission satellitaire (satellite/capteur) 'Agriculture de précision.

En 2003 est prévu le lancement d'un satellite test 'Agriculture de précision' dans le cadre du consortium. En 2006, si résultats, lancement d'un satellite dédié.

Discussion avec Patrick Rollo d'Aventis sur la possibilité de co-financer un post-doc sur le thème 'Agriculture de précision', appliqué à des cultures tropicales (cas du palmier à huile évoqué). Patrick Rollo s'est montré sensible à cette idée, et estime qu'Aventis serait prêt à co-financer un post-doc sur ce thème. P. Rollo est déjà en contact avec le CIRAD, (Eric Jallas du Programme coton) qu'il doit rencontrer à Montpellier le 3 avril. Affaire à suivre avec le Programme 'palmier à huile' avec lequel des discussions sur le sujet ont commencé. Mais à voir également avec d'autres programmes tels que le programme 'coton' ou le programme 'canne-à-sucre'.

Discussion avec P. Rollo et F. Baret sur la possibilité d'étendre le consortium 'Agriculture de précision' (INRA, Aventis, Scot, CNES, Matra) au CIRAD sur les pays du Sud. Bonne complémentarité avec l'INRA sur les cultures étudiées, et approche commune. Mais manque de personnel CIRAD (mettre sur le dossier demande d'un poste dans le cadre de la Relance Stratégique).

5. Annexes I:

5.1 Principales personnalités rencontrées :

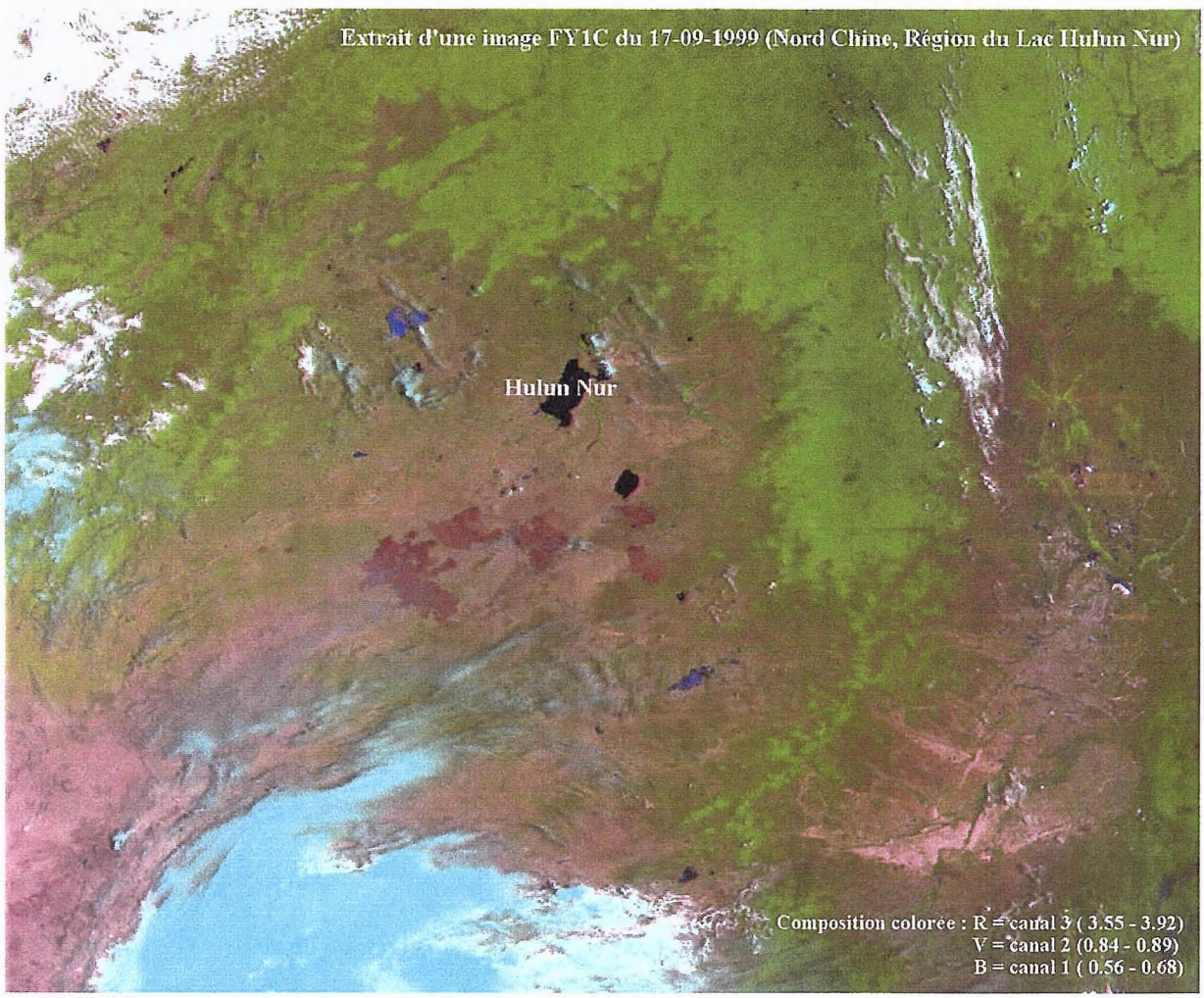
LI ZHIYI	CAS (Bureau de la coopération internationale)	Directeur de la Division des programmes de l'Europe de l'ouest
WU MEI RONG	CRESDA (China center for REsources Satellite Data and Application)	Directeur général
ZHANG WEN-JIAN	NSMC/CMA (National Satellite MeteorologicalCenter/China Meteorological)	Directeur Général adjoint
TONG QUIGXI	Chinese Academy of Sciences (CAS)	Academicien (ancien directeur de l'IRSA)
YANG CHONGJUN	National Engineering Research Center for Geoinformatics of China	Directeur (francophone, formé en France et au Canada)
ZENGYUAN LI	Institute of Forest Resources Informations Techniques	Directeur adjoint
Jean-Claude LEVY	Ministére de l'Equipement, des transports et du Logement	Chargé de mission

5.2 Composition de la délégation française

Name	Sex	Title / Address	Telephone	Fax (33)	Email
Frederic BARET	M	Head of Remote Sensing Team INRA Unite de Bioclimatologie Site Agroparc 84914, Avignon Cedex (France)	(0)4 32 72 23 63	(0)4 32 72 23 62	Baret@avignon.inra.fr
Agnes BEGUE	F	Head of Remote Sensing Team CIRAD-EMVT Maison de la Teledetection 500 rue JF. Breton 34093 Montpellier cedex 5	0)4 67 54 87 39	(0)4 67 54 87 00	begue@cirad.fr
Jean Claude CAZAUX	M	President of SCOT SCOT CONSEIL Parc technologique du Canal 1, rue Hermes 31526 Ramonville ST-Agne Cedex	(0)5 61 39 46 00	(0)5 61 39 46 10	nisso.gargir@scot.cnes.fr
Gerard DE WISPELAERE	M	CIRAD-EMVT Maison de la Teledetection 500 rue JF. Breton 34093 Montpellier cedex 5	0)4 67 54 87 36	0)4 67 54 87 00	gerard.de_wispelaere@cirad.fr
Xingfa GU	M	INRA Unite de Bioclimatologie Site Agroparc 84914, Avignon Cedex (France)	(0)4 32 72 23 86	(0)4 32 72 23 62	gu@avignon.inra.fr
Martine GUERIF	F	INRA Agronomie Rue Fernand Christ 02007 Laon Cedex	(0)3 23 23 64 88	(0)3 23 79 36 15	mog@laon.inra.fr
Michel LEGRAND	M	Laboratoire d'Optique Atmosphérique Université des Science et Technologies de Lille 59655 Villeneuve d'Asq Cedex	(0)3 20 43 66 46	(0)3 20 43 43 42	Michel.Legrand@univ-lille1.fr
Jean-Claude LEVY	M	Coordinator of PRA Environment Conseil Général des Ponts et Chaussées, Ministère de l'Equipement, du Logement et des Tranports	(0)1 69 30 14 89	(0)1 69 30 14 89	: levyjc@club-internet.fr

Zhao-Liang LI	M	GRTR/LSIIT/ENSPS 5 Bld Sebastien Brant 67400 Illkirch-Strasbourg	(0)3 88 65 51 17	3 88 65 51 53	mpstoll@sepia.u-strasbg.fr
Marc Philipe STOLL	M	Head of Remote Sensing Team GRTR/LSIIT/ENSPS 5 Bld Sebastien Brant 67400 Illkirch-Strasbourg	(0)3 88 65 51 26	(0)3 88 65 51 53	Zhao-Liang.Li@mail-grtr.u-strasbg.fr
Patric ROLOT	M	Precision Farming Projetc Manager Rhone Poulenc	(0)4 72 85 48 72 (0)6 08 96 59 64		Patric.rolot@aventis.com
Michel VERBRUGGHE	M	INRA Unite de Bioclimatologie Site Agroparc 84914, Avignon Cedex (France)	(0)4 32 72 23 79	(0)4 32 72 23 62	verbruge@avignon.inra.fr

5.3 Exemple d'image FY1c



5.3. Le NSMC

5.4. Comité d'organisation

China-France
Symposium on Quantitative Remote Sensing in Agriculture and Environment

Sponsors:

- Chinese Academy of Sciences (CAS)
- Institut National de la Recerche Agronomique (INRA) France
- National Natural Science Foundation of China (NSFC)
- China Meteorological Administration (CMS)

Organizers:

- Institute of Remote Sensing Applications (IRSA) (The laboratory of Remote Sensing Information Science)
- National Satellite Meteorological Center (NSMC)
- Bioclimatology Unit, INRA

Co-Organizers:
Anhui Institute of Optics and Fine Mechanics,
CAS China Center for Resources Satellite Data & Application (CRESDA)
Aero-Geophysical & Remote Sensing Center, Ministry of Land & Resources (AGRSC)

Scientific Committee
Co-Chairs:
Tong Qingxi, IRSA CAS
Frédéric Baret, INRA

Members:
Fan Zongyi, NSMC, CMA
Agnès Bégué, CIRAD
Tian Guoliang, IRSA, CAS
Wu Meirong, CRESDA
Qiu Kangmu, NSME, CMA
Xingfa Gu, INRA
Philipe Stoll, GRTR/LSIIT/ENSPS
Qiao Yanli, AIOFM, CAS
Li Zhizhong, AGRSC

Local Organizing Committee:
Chairman:
Zhang Wenjian, NSMC, CMA

Co-Chairman:
Zheng Lanfen, IRSA, CAS

Members:
Liu Geping, IRSA, CAS
Xia Qing, NSMC, CMA
Wangleyi, AIOFM, CAS
Zhang Zhonggui, AGRSC
Min Xiangju, CRESDA
Li Zheng, Representative INRA

Symposium Secretariat:
Zhu Boqin, IRSA, CAS
Zhang Bing, IRSA, CAS
Tian Qingju, IRSA, CAS
Guo Lujun, NSMC, CMA

Service Group:
Ma Lanhua, IRSA, CAS
Xia Mingbao, IRSA, CAS
Liu Jianyong, IRSA, CAS

Schedule of the Opening Ceremony
China-France Symposium on Quantitative Remote Sensing in Agriculture and Environment

(9:30-10:30, 27 March, 2000)

Chaired by
Dr. Xingfa Gu and Dr. Zhang Wenjian

1. Announcement of Symposium Opening
   and Introduction of Symposium Co-Chairs and Guests 9:30-9:38
   Dr. Xingfa Gu, Dr. Zhang Wenjian

2. Opening Remarks 9:38-9:50
Prof. Tong Qingxi ; Dr. F. Baret

3. Adress by Vice-president CAS 9:50-10:00 ; Prof. Xu Zhihong

4. Adress by president INRA 10:00-10:10; Mr. Hervieu

5. Speech of Prof. Guo Huadong 10:10-10:15; Director IRSA

6. Speech of Prof. Dong Chaohua 10:15-10:20-Director NSMC

7. Speechs of Guests 10:20-10:30

8. Closing of Opening Ceremony 10:30

China-France Symposium on Quantitative Remote Sensing in Agriculture and Environment (Program)

Keynote Speech 10:95 am -12:15 noon, Monday, 27 March 2000 Co-Chairs: Zhang Wenjian, National Satellite Meteorological Center, China. Gu Xingfa, I.N.R.A. France.

10: 45 - 11: 05 /NRA - China cooperation: First results in quantitative remotes sensing domain Xingfa GU, I.NR.A., France.

11: 05 -11:25 Satellite Meteorology in China
Zhang Wenjian, National Satellite Meteorological Center, CMA, China.

11: 25 -11:45 Remote Sensing applied to agriculture management: satellite driven precision
Baret F., LN.R.A., France.

11:95 -12: OS Remote Sensing on vegetation
Zlrang Bing, Institute of Remote Sensing Applications, CAS, China.

China-France Symposium on Quantitative Remote Sensing in Agiculture and Environment (Program)

Session I: Calibration and Physical Signature Measurements

14:00-18:00 pm, Monday, 27March 2000

Co-Chairs: Qiu Kangmu, National Satellite Meteorological Center, CMA, China

Marc-Plr. Stop, Universih' Louis Pasteur - Strasbourg Laboratoire des Sciences de

L'Image,France

Time	Presentations	Author
14:00-14:25	Radiometric Calibration of Solar Channels in flight FY-IC Sensor at Dunhuan test site	ZhangYuxiang,
14:25-14:50	Analyzing the Optical,Even and Stable Characteristics of CBERS-1 Radiometric Calibration Field in Dunhuan .	Zhang Zonggui
14:50-15:15	Highly accuracy spectral radiometry standard and standard transfer	Xiaobing Zheng
15:15-15:40	Remote Sensing in the Thermal Infrared domain: Issues of concern in Land applications; issues of interest for cooperative actions	Marc-Ph. Stop
15:40-16:05	Remote Sensing of Mineral Dust over Continents Using the Thermal Infrared Satellite Imagery	Michel Legrand
16:05-16:20 Coffee Break		
16:20-16:45	Observation of natural fluorescence from space: a tool for screening vegetation and diagnose vitality and stress in relation to environmental factors.	Ismael Moya
16:45-17:10	Optical and radiometric characteristic of China Radiation Calibration Site for Remote Sensing Satellite Sensor CRCSRSSS .	Hu Xiuqing
17:10-17:35	Vicarious Calibration of FY-1C Imager in Thermal Infrared	Wang Weihe
17:35-18:00	The vicarious calibration of spin stabilization geostationary meteorological satellites water vapor channel.	Wang Ping

China-France Symposium on Quantitative Remote Sensing in Agiculture and Environment (Program)

Session 2: Agriculture

9:00 am-12:00 noon, Tuesday, 28 March 2000

Co-Chairs: Qiao Yanli, Anhui Institute of Optics and Fine Mechanics, CAS,China

Martine Gueri fl *.NBA . Unite d ' AQronomie de Laon. France*

Time	Presentations	Authors
9:00-9:25	Multitemporal Radar Data for Monitoring Rice	Shao Yun
9:25-9:50	Feasible Analysis of Diagnosing Wheat Water Status Using Spectral Absorption Features	Tian Qingjiu
9:50-10:15	Potential Applications of high spatial resolution and multi - angular thermal camera imagery for accessing crop information at field -scale	Xingfa. GU
10:15-10:40 Coffee Break		
10:40-11:05	Estimation of canopy biophysical VARIABLES from remote sensing observation in the solar domain	F. BARET
11:05-11:30	CIRAD remote sensing activities applied to agronomic and Environmental issues in tropical countries	Agnès Bégué
11:30-11:55	The Result Analysis of Microwave Backscatterometry for Cotton and Its Application on the SAR Data Classification	Zhang Wei .

Session 3: Agriculture

14:00-18:00 pm, Tuesday, 28 March 2000

Co-Chairs: Zheng Lanfen,, Institute of Remote Sensing Applications, CAS, China

Jean Claude CAZAUX, SCOT Conseil,France

Time	Presentations	Authors
14:00-14:25	Mapping of rangeland dynamics in arid and semi-arid lands by remote sensing : Case of South-Tamesna (Niger)	G. De Wispelaere
14:25-14:50	Rice Mapping Using ERS SAR Data in Guangdong Province of China	Li Zengyuan
14:50-15:15	Assimilation of remote sensing data into crop models : a tool for assessing spatial variability. Applications to yield prediction and precision farming.	Martine Guérif
15:15-I 5:40	Scot and French - Chinese cooperation in agriculture	Jean Claude CAZAUX
15:40-16:05	VALERI: Validation of biophysical products derived from large swath sensors for global biosphere monitoring	Baret F.
16: OS-16:20 Coffee Break		
16:20-16:45	FY-1C Meteorological Satellite and Research on Global Vegetation Index	Liu Yujie
16:45-17:10	Study on Relationship between Rice LAI, CH.D and Hyperspectral Data	Liu Weidong
17:10-17:35	Correlation Simulating Analysis Model of the Visible-NIR(400-950nm) Reflectance Spectra of Vegetation in Changzhou and Its Significance	Zhao Yongchao
17:35-18:00	A Thermal Infrared Emission Directionality Model for Continuous Crop Canopies and Component Temperature Inversion	Liu Qinhuo

China-France Symposium on Quantitative Remote Sensing
in Agiculture and Environment
(Program)

Session 4: Environment

9:00 am-12:15 noon, Wednesday, 29 March 2000

Co-Chairs: Li ZhiZhon,, Aero-Geophysical and Remote Sensing center, AGRSC China

Agnès Bégué , CIRAD, France

Time	Presentations	Authors
9:00-9:25	Remote Sensing Applied to Precision Farming	P. Rolot
9:25-9:50	Land Applications using ERS-1/2 Tandem data	Wang Chao
9:50-10:15	Data Fusion for Flood Analysis and Decision Support	Ma Son de
10:15-11:05	Study on the retrieval of emissivity spectra from airborne multispectral thermal infrared data	Zhang Xia
10:15-10:40 Coffee Break		
10:05-11:30	Snow Cover Remote Sensing by Polar Orbiting Satellites	Wang Libo
11:30-11:55	Monitoring Land Cover and Vegetation Growth Stages	Zhang Bing

6. Anexe II : Résumés des communications

Radiometric Calibration of Solar Channels in flight FY-1C Sensor at Dunhuang test site

ZhangYuxiang, ZhangGuangshun, HuangYibin, Qiukangmu, HuXiuqing, WangWeihe, Liuzhiquan, Rongzhiguo, Zhanglijun, ZhuShunbin, WangYongkuan, LiChangbao , XiaQing, Chenxiulian, Fangzongyi

(National Satellite Meteorological Center, CMA, P.R.C)

Abstract FY-1c Meteorological satellite was launched in May 10,1999. Fifty days later, first Radiometric Calibration of solar channels of this satellite sensor on the orbit was performed at China Dunhuang calibration test site , in July 7, 16 and 17,1999. The Radiometric Calibration adopted the reflectance-based method of Slater P. N et al [1987] . First of all making a series of processing of measuring data and the satellite-ground instrument's spectral response match and the satellite spectral response interpolation , then entering these results into a radiative transfer code (6S), apparent reflectance from FY-1c space measured were obtained. By geometric registration of the satellite image pixels with ground measuring region , and a compare of the mean digital counts with the apparent reflectance , calibration coefficient (gain and offset) from FY-1C seven solar channels were determined. An error budget for the reflectance-based calibration method shows a uncertainty as 5% . Comparing the calibration results with the pre-launch, they have better agreement at five solar channels except channels 8 (555nm) and 6 (1610nm).

Analyzing the Optical,Even and Stable Characteristics of CBERS-1 Radiometric Calibration Field in Dunhuang

Zhang Zonggui

(Centre for Aero-Geophysical and Remote Sensing of Land Resources Ministry,Beijing 100083)

Abstract Dunhuang field is one of the chinese remote sensing satellite radiometric calibration fields,located in alluviation fan of dang river,and 22km in south-west of Dunhuang city.The field includes a big field area(called D area:20x20 km2)and a central field area(A area:500x500m2).A area is the radiometric calibration field of China-Brazil Earth Resources Satellite(CBERS-1).The measurement region with the average altitude 1220m,the slope of 0.001,and earth level,mainly consists of the Gobi grit,appears the grey white color,and hasn't got vegetation.

On the basis of the field area test standard of chinese remote sensing satellite calibration field for spectra,by using the spectroradiometer of VF921,GER-IRIS,ASD-FR and so on,the features of the central field earth surface was viewed,including the observation of the weather & atmosphere,bidirectional reflection factor and reflectance in 11x11 grid in Jane 1994,September 1996,and July 1999,and a lot of spectral data(total 13595 curves)were acquried.Meanwhile,in 1994 the reflectance of collected samples was tested by simulation both indoor and outside. Through the pre-processing of original data,the normalization of the solar zenith angle and statistical analysis of reflectance data,the viewing results were analyzed and compared.The viewing results show as follown:

1. The spectral feature of the grit field area is that in the ultraviolet(UV) wavelength between 0.35 and 0.40mm,the reflectance curve rises,and value is from 10% to 12%;in the visible(VIS) from 0.40 to 0.76 mm,the curve goes up continuiously,and value is between 12% and 28%;in the near infrared(NIR) from 0.80 to 1.10mm,the curve varies slight,and value is in the middle from 20% to 34%,besides,in the 1.0mm it has a wide and shallow absorption of Fe2+ ;in the short wave infrared from 1.10 to 1.80mm(SWIR1),the curve continues with ascending,and the value is from 28% to 39%;but from 1.90 to 2.50mm(SWIR2),the curve ascends in the wave,and after 2.10mm it appears falling down in the wave with the value from 22% to 40%,in addition in the near 2.20mm and 2.30mm,the absorption respectively generated by the Al-OH and Mg-OH group appears clearly.Moreover,in the reflectance curves of the indoor samples test,in the 1.40mm and 1.90mm,absorption of the -OH and crystal water is visible.

2. Analysing from the reflectance curve surface distribution of field area,the spectral characteristic distribution is even very well.This even distribution effect is the best in the UV and VIS,the second band is the NIR,and the SWIR is the worst.In the curve surface reflectance difference between the maximum and minimum isn't over 8.5%,the distribution hasn't big waves and be basic even.The reflectance variation in the 10 point of the 7 line and the north-west and south-east corner of field area in 1996 is the biggest,and in 1999 it is in the all points of the 5 line and the 5 point of the 2 line.

3. Viewing from the bidirectional reflection factor curve surface distribution of the field

area,also displays the even reflection property that the distribution appears the symmetry in all bands.When the variation of the solar zenith is small,it's symmetry is very good.At the same time,that indicates the material component distributes very well.

4. The reflectance data variable situation and spectral curves similarity of the three times observation,manifest the field area optical characteristical stability.The difference of the three times viewing reflectance maximum and minimum is only 7.2%,with the hightest and lowest curve in 1996 and 1994 respectively, and in the middle of 1999's reflectance curve.

5. The factor of affecting the data quality of the field area are mainly the performance of spectrometer,such as the ratio of S/N and the steady property,the lambertain feature change of the standard white panel,and the local season rainfall.

* This project is supported by the satellite application project of the National Defence Science & Technology Work Commissiom.

Highly accuracy spectral radiometry standard and standard transfer

Xiaobing Zheng, Haoyu Wu, Junping Zhang, Yucheng Liu, Wei Zhou, Leyi, Wang, and Yanli Qiao

Remote Sensing Department, Anhui Institute of Optics and Fine Mechanics

P.O.Box 1125, Hefei, Anhui 230031

Abstract The goal of radiometric calibration is to quantitatively determine the relationship between light detector's output (current, voltage, etc.) and incident absolute radiation flux. It's realization is based a common primary standard and a transferring chain which consists of a set of transferring standards with different accuracy. User's detector is at the end of transferring chain. Radiometric calibration ensures that: (1) accuracy of user's detectors will meet requirements of applications; (2) output of detectors reflects true change of measurand by radiometric correction of detector's degradation; (3) results obtained by different detectors, at different time and on different platform will be comparable.

There is an urgent demand to improve the accuracy of radiometric calibration in recent years in order to meet requirements from military, environmental monitoring, and especially from Earth Observing Project carried out around the world and recently in China. For example, variation of responsivity of space-borne sensor is required to be less than 1% in several months and even in a few years, which means the uncertainty of standard transferring chain should be far less than 1% when it reaches user's detector.

Two limitations existed which prevent improvement of the accuracy level of current Chinese radiometric calibration. One is the relative low-accuracy primary standard, which is still based on conventional blackbody with typical uncertainty of 0.1-0.3%[1] in visible to near-infrared spectrum. The other is source-based standard transferring chain whose uncertainty will usually be greater than 5% when reaching user's detectors.

A new radiometric primary standard based on cryogenic radiometer has been developed in PTB, BIPM and NIST since early 1990's and correspondingly a detector-based transferring chain was adopted to replace current source-based one. Taking advantage of electrical substitution, liquid nitrogen and helium cooling and superconduction techniques, an unprecedented uncertainty of 0.005-0.01% was achieved by using cryogenic radiometer. Corresponding uncertainty of transfer standard was improved to 0.01-0.03%.

To meet the requirements from fast development of Chinese space remote sensing, we took the lead in China to establish a highly accuracy primary standard based on cryogenic radiometer and transfer standard based on trap detectors at the end of 1999. Our work was supported by "The Project of Chinese remote sensing satellite radiometric validation site". Experiment results obtained at 7 wavelengths of visible spectrum (488-786 nm) showed that uncertainty of cryogenic radiometer were less than 0.023%. Absolute responsivity of trap detectors was calibrated against cryogenic radiometer with an uncertainty of 0.035%. Linearity, spatial uniformity of response, polarization sensitivity and stability of trap detectors were measured.

Remote Sensing in the Thermal Infrared domain: Issues of concern in Land applications; issues of interest for cooperative actions

Marc-Ph. Stoll, Zhao-Liang Li
University Louis Pasteur - Strasbourg
Laboratoire des Sciences de l'Image, de l'Informatique et de la Télédétection
LSIIT- UPRES A 7005 - ULP/CNRS

Abstract Prime objective of Remote Sensing in the Thermal Infrared is concerning retrieval of surface temperature and TIR radiative surface parameters. Since surface temperature is an instantaneous tracer of the system's equilibrium, TIR measurements are necessary in nearly all land applications that address, for instance: i) soil/vegetation/atmosphere processes and interactions; ii) geological issues; iii) urban areas climate issues. The specificity of land surfaces makes access to the surface temperature from space and its scientific usage somewhat problematic. With respect to biosphere/atmosphere interactions recent development emphasize the importance of soil water content and surface temperature for issues such as weather forecast or carbon sequestration estimate. Improvement in model results is searched in two-source models that require soil surface temperature and foliage temperature as well. Efforts have been made toward separate retrieval of both variables from directional TIR measured radiance. Application of simple surface modeling to actual (available ATSR) directional data is encouraging, although extensive studies are necessary to fully assess the potential of the method. A few research issues, linked to possible cooperative actions relevant to the TIR domain are listed.

Remote Sensing of Mineral Dust over Continents Using the Thermal Infrared Satellite Imagery

Michel Legrand
Laboratoire d'Optique Atmosphérique, Université de Lille-1, Villeneuve d'Ascq, France
Tel: (20) 43 66 46 - Fax: (20) 43 43 42 - E-mail: legrand@loa.univ-lille1.fr

Abstract Over oceans and dark surfaces mineral dust is easily detected through solar radiation scattered to space by the particles. The satellite channels suitable to its observation and to the determination of its optical depth stand in the visible and the near infrared. But over high-albedo surfaces such as those found in deserts, the response in reflectance vanishes because the increase of radiation scattered to space by the particles compensates the drop of radiation reflected at the ground surface.

On the other hand, mineral dust is easily detected over arid regions using the thermal infrared satellite channels. The radiance emitted to space by the Earth and its atmosphere is impacted by dust according to a diurnal cycle smoothing alternating daytime decreased maxima and nighttime increased minima.

The daytime radiance decrease is due to the following mechanisms:

1. Dust presence involves a decrease of solar flux incident to the surface. Hence the surface temperature and the subsequent thermal infrared emission, will drop.
2. The size distribution of dust spreads over a wide range comprising radii from submicron (0.1μm) to giant (100μm) particles. The larger particles (r>1μm) involve a significant dust optical depth in the thermal infrared. So, the radiance emitted by the ground surface is attenuated through the colder dust layer.

We processed charts of dust plumes over the African continent using the IR Meteosat images at 12 UTC. For this, an algorithm creates a clear-and-clean image of reference, free of clouds and dust, based on a 15-day time series of raw images geographically coincident and radiometrically corrected. Subtracting a raw image from the reference provides a difference image with clouds and dust, but without the surface structures constituting the reference image. Clouds are identified and masked so as to keep only the dust pattern in the clear areas. This product called Infrared Difference Dust Index (IDDI), is the satellite response to dust in the thermal infrared.

Owing to the underlying physics and to the algorithm, the IDDI is affected by several sources of uncertainties and some shortcomings. So, we carried out controls of the product: (i) comparison between time series of IDDI and photometric measurements (ii) statistics of IDDI with the visibility of the meteorological network (iii) comparison of IDDI dust patterns with areas of reduced visibility (iv) comparison of IDDI images over Africa with their oceanic counterpart in optical depth from Meteosat VIS.

We go through the conclusion that the IDDI is particularly relevant to climatological studies, especially in relation to the process of dust emission from the source areas.

The desert regions being difficult of access and the shortwave remote sensing being ineffective, the IDDI appears to be a valuable technique of study of dust emission and transport over arid regions. So, it is used for making a climatology of Saharan dust (over 1984-1993, extension to 1998 in progress) including the location of the sources and determining their seasonal and year-to-year activity.

The study and the physical modeling of emission was performed by Marticorena and Bergametti (1995). Their model takes into account the properties of the ground surfaces whose threshold of wind friction velocity relating to dust emission is widely depending. The model was applied on a large scale, to the western half of the Sahara by using a dataset for the surfaces of this region and the 10-m windspeed extracted from the analyses of the ECMWF. The mass fluxes derived from the simulated emission of dust were mapped and compared to the IDDI. In addition, the same IDDI data were compared to the simulated dust emission derived from former simple source representations. A large improvement of the agreement between the simulations and the IDDI is observed if the model of Marticorena & Bergametti is used. In this study, the model validation established thanks to the IDDI, is associated to a qualification by the model of the IDDI, proving its ability to detect emission. This fact was exploited further by using IDDI images to a determine directly windspeed threshold of dust emission without help of any simulation or surface information.

Observation of natural fluorescence from space: a tool for screening vegetation and diagnose vitality and stress in relation to environmental factors.

Ismaël Moya [1], Marc-Ph. Stoll [2] and Frederic Baret [3].

[1]CNRS-LURE , Orsay, France
[2]LSIIT - UPRES A 7005 ULP / CNRS, Strasbourg, France
[3]INRA - Bioclimatologie, Avignon, France

Abstract Fluorescence of vegetation is a very specific light signal directly related to photosynthesis and efficiency of light utilization by plant cells. Numerous experimental results, including Laser Induced Fluorescence Imaging, demonstrate that fluorescence is an early stress indicator and early indicator of plant dysfunction. Many factors are known to modulate the efficiency of conversion of light into chemical energy (biomass production), such as atmospheric CO2 concentration, air temperature, PAR availability, air / soil pollution, .., resulting in detectable fluorescence modifications. Hence, remote observation of fluorescence, in addition to usual means, would significantly enhance our capability of identifying stress actions and understanding reaction of vegetation to changing environmental conditions, in a Global Change perspective. Natural, solar induced, fluorescence allows remote sensing from an aircraft or a space-borne sensor, at the expense of observing in the Fraunhofer lines of the solar spectrum, where the otherwise much larger reflectance signal is sufficiently reduced. During the last 15 years, several teams have been actively working, notably in France, toward better understanding of fluorescence process and usage for far range remote sensing. Initiatives for space mission dedicated to fluorescence observation arose recently, in Europe and in the USA, in relation to call for proposals from Space Agencies. Several important issues, regarding instrumentation and signal handling and usage, have been identified and could provide basis and tracks for cooperative actions in this challenging project.

Optical and radiometric characteristic of China Radiation Calibration Site for Remote Sensing Satellite Sensor(CRCSRSSS)

Huxiuqing Zhangyuxiang Liuzhiquan Zhangguangshun Huangyibin Qiukangmu Wangyongkuan Zhanglijun Zhuxunbing Rongzhiguo

(National Satellite Meteorological Center CMA, Beijing, PRC)

Abstract Duhuang site and Qinghai Lake site are selected to be China Radiation calibration site for Remote Sensing Satellite(CRCSRSS)in 1996.We have conducted three field measurement campaigns in 1994,1996 and 1999 and obtained a lot of characteristic data of atmosphere and ground reflectance. Especially in 1999, we used several high accuracy instruments. The ground reflectance measured by ASD FR and other spectroradiometers in Dunhuang site is between 10% and 35% at 350—2500nm spectral range. The results show that the Dunhuang site has a good homogeny with a low standard deviation of the reflectance which is less than 2% at any wavelength in 20×20Km^2. We used three CIMEL sunphotometers and a OL754 integrating sphere spectroradiometer to measure atmospheric optical characterization. Data from 4 areosol bands of CIMEL sunphotometer are used in Lanyley Plot scheme to determine atmospheric spectral optical depths. Average aerosol optical depth (AOD) at 550nm in two sites is 0.125 and 0.18 respectively, which are all small and suitable for in-flight calibration atmosphere condition. Average Junge aerosol parameter ν is 2.7 and 3.0 in Dunhuang and Qinghai Lake respectively. The type of aerosol model in Dunhuang is near to desert model while near to continent model in Qinghai Lake. The columnar water vapor is determined by Modified Langley plot approach in 940nm water-vapor band of sunphotometer .The result of it are compared with radiosonde data and different within 10%. OL754 spetroradiometer is used to measure the diffuse and global downward irradiance of atmosphere. The diffuse-to-global ratio is used to the irradiance-based calibration method to improve more in-flight sensor calibration accuracy .

VICARIOUS CALIBRATION OF FY-1C IMAGER IN THERMAL INFRARED

Weihe Wang, Zhiguo Rong
National Satellite Meteorological Center
China Meteorological Administration

Abstract A vicarious calibration of band 4 (0.3-11.3μm) and band 5(10.5-12.5μm) of FY-1C imager was conducted at Qinghai Lake in July, 1999. The method utilized was based on direct measurement of lake surface radiance. The spectral transmittance and path radiance of the atmosphere over Qinghai Lake was calculated using radiative transfer model MODTRAN. The TOA equivalent radiances of the two bands were derived by combining surface measurements and model simulation. A comparision between the results of vicarious calibration and onboard calibration was made and the methods used in surface measurements and calculation of calibration coefficients were detailed in this report.

The vicarious calibration of spin stabilization geostationary meteorological satellites water vapor channel

Ping Wang, Kang-mu Qiu

National Satellite Meteorological Center

Abstract Because of the rapid development of quantitative remote sensing, especially the development in monitoring and analyzing global climate changes it is imperative to improve the remote sensing precise. Calibration has an important effect in remote sensing precise.

When meteorological satellites had worked for a long time in space there would be some changes in remote sensing sensors. The performance degradation of electronics system and the contamination of optics will impact on in-flight calibration precise. Vicarious calibration is an effective method to improve the calibration precise.

FY-2 and GMS-5 satellites are spin stabilized geostationary meteorological satellite. Limited by their structure, calibration optic path for infrared and water vapor channels of on-board radiometer do not pass the front optics, so the in-flight calibration is only a relative calibration and transforms from relative calibration to absolute calibration is required. It is an important method to take advantage of the vicarious calibration to accomplish absolute calibration.

In this paper we using the radiosonde data, calculated the radiance by the LOWTRAN7 radiative transfer code and fitted the calibration coefficients according to corresponding digital counts. But around equinox eclipse will take place, which is characterized by rapidly temperature variations in satellite and the relationship of radiometer calibration will change correspondingly. Considering the effects in eclipse period we performed water vapor channel vicarious calibration combining with in-flight calibration. Then we did two kinds of validation using radiosonde data and GMS-5 observations respectively.

FY-2 satellite water vapor channels vicarious calibrations have been used operationally and we have obtained identical results to GMS-5 observations with equivalent brightness temperature difference about 2K. It turns out that the method is effective in practice.

Feasible Analysis of Diagnosing Wheat Water Status Using Spectral Absorption Features

Tian Qingjiu

Institute of Remote Sensing Applications, Chinese Academy of Sciences, Beijing 100101, China.

Zhao Chunjiang, Wang Jihua

Beijing Academy of Agricultural and Forestry Sciences, Beijing, 100089, China.

Abstract A total of 110 wheat leaf samples in the field were collected and their spectral reflectances were measured with a FieldSpec-FR spectroradiometer (made in U.S.A) in laboratory. After the spectral analysis using a spectral normalizing technique, the spectral absorption feature parameters: wavelength position, depth and area were extracted from each wheat leaf spectrum. The relative water content (RWC) was measured for each wheat leaf sample. A linear regression analysis was conducted between the spectral absorption feature parameters and corresponding RWCs. The experimental results indicated: (1) the spectral absorption depth and area of wheat leaves at 1450 nm were correlated with their RWCs (R^2>0.84). The relative errors and absolute errors of predicted RWCs were calculated from validation samples by established regression equations. The relative errors and absolute errors of predicted RWCs both were low (<5% for relative errors and <3 for absolute errors). Furthermore, we discuss the possibility of the development of new instrument through the spectroradiometers improvement for non-destructive and instantaneous measurement of the wheat water status in the field. (2) the reflectance spectra of wheat leaves in the 1650-1850 nm region were dominated by water content. With a decrease in wheat leaf RWC, the 1650-1850 nm spectral absorption features gradually become obvious. The relative errors of predicted RWCs and the absolute error of predicted wavelength positions were calculated from 54 validation samples by established regression equations. The relative errors of predicted RWCs and the absolute error of predicted wavelength position (nm) were both low (<6% for RWCs by the depth and area and <12 nm for the wavelength position, respectively). Furthermore, we discuss the potential and limitations of spectroscopic determination of wheat RWC by using remote sensing technology.

Potential Applications of high spatial resolution and multi - angular thermal camera imagery for accessing crop information at field -scale

X. GU, F. Jacob, J.F. Hanocq, Q. LIU, T. YU

INRA - Bioclimatology Unit, 84914 Avignon Cedex (France)
Institute of Remote Sensing Applications (CAS), Beijing (China)

Abstract

Since 10 years, a INFRAMETRICS thermal infrared video camera has been widely used in INRA for field-scale agriculture remote sensing researches. It is equipped with 4 selectable spectral channels from 7 to 13 μm and 3 interchangeable lens of 7°, 20° and 80°FOV. The individual image has 256x250 pixles size and better than 0.1 K radiometric resolution. For quantitative applications, absolute calibration of the camera and atmospheric corrections were deeply investigated., and a special geometric matching software was also developed .

This communication presents the two first results achieved by these thermal infrared data concerning the spatial and directional information applications under European Remote Sensing Project RESEDA. The thermal infrared camera data were acquired with a small airplane at 3000 and 1500 meters flight height over the Alpilles test site. Twenty two days flights were realized with 80° FOV lens allowing directional analysis and giving 20 m pixel size.

High spatial resolution information was applied to evaluate and to improve the "Surface Energy Balance Algorithm for Lands (SEBAL)" model. This model is based on remote sensed albedo, NDVI and temperature images for deriving the net radiation, conductive heat flux and convective heat flux and then the latent heat flux by energy balance. It uses the spatial correlation between the albedo image and temperature image for identifying very dry and high moisture surfaces in order to calculate some key intermediate parameters like wind speed and surface-air temperature difference. The difference between the model derived results and in-situ measurements is comparable to measurement errors.

For directional analysis, multi-axes of sequence images were used, and temporal variation effects of temperature was corrected. The extracted directional effects of different agriculture field have shown some up to 6 °K of large angular temperature variation and evident hot-spot phenomena. Complement experiment over a corn canopy shows that this directional information can be used for separating soil and leaf temperature of canopy and to improve the heat flux estimation accuracy.

Remote sensing applied to agriculture management : satellite driven precision farming

F. Baret, M. Guerif P. Rolet
INRA Bioclimatologie, Avignon & Laon, France

Agriculture management requires to take into account many sources of information to achieve the optimal compromise between production in quantity and quality and environmental issues. Knowledge of the permanent soil characteristics and of the canopy status play a key role in the process of decision making. Moreover, observation of the temporal and spatial variation of these characteristics is required to be able to adjust the cultural practices in space and time. Remote sensing techniques offer therefore an ideal tool to get these information at the proper spatial and temporal resolution.
A brief review of the way to use remote sensing observations for field and farm management is presented. The potential of the spectral domains from visible to micro-wave are listed with regards to specific agriculture operations. Then, examples are provided to illustrate the state of the art in this domain and the actual INRA research activity.

Estimation of canopy biophysical variables from remote sensing observations in the solar domain

F. Baret
INRA Bioclimatologie, Avignon France

The accuracy of canopy characteristics estimation from remote sensing data is driven by the amount of information put in the system. This information comes first from the radiometric signal, which appears however limited : the same radiometric signal may correspond to quite different canopy characteristics. Remote sensing data must therefore be completed by ancillary information. Radiative transfer models can be used to exploit explicitly our knowledge on the physical processes the radiometric signal over a wide range of conditions. However, a priori information on canopy characteristics can be used to reduce the solution space. A comparison of inversion techniques is presented and illustrated over actual observations. This includes neural network, look up table and optimisation techniques. The results are discussed in view of operational applications to precision farming.

CIRAD REMOTE SENSING ACTIVITIES APPLIED TO AGRONOMIC AND ENVIRONMENTAL ISSUES IN TROPICAL COUNTRIES

Agnès Bégué

CIRAD, Department of Advanced Methods for Innovation in Science, Agronomy/GEOTROP Programme.

Abstract The Geographic Information mission of CIRAD is rendered by experimental research and applications, as well as scientific and technical training, on the spatial monitoring and representation of agronomic and environmental data. CIRAD works on integrated actions on different ecosystems (crop lands, rangelands, forests ...) and at different scales (from the tree to the region). These actions range from research, pilot project and technology transfer to consultancy and fully operational applications.

Within this general context, we propose to make a short review of the CIRAD remote sensing activities as follows :

- Use of remote sensing for land use/land cover issues (examples of tools, indicators and methods for crop inventories and characterization of the spatial dynamics of the landscape.)
- Use of realistic 3D vegetation model (AMAP software) to simulate and interpret remote sensing signal of heterogeneous canopies (optical, thermal and radar signal).
- Integration of remote sensing data with GIS for management support system (spatialization of a grassland ecosystem model).

Specific examples on rangeland management should be given in an other presentation (Gérard De Wispelaere).

THE RESULT ANALYSIS OF MICROWAVE BACKSCATEROMETRY FOR COTTON AND ITS APPLICATION ON THE SAR DATA CLASSIFICATION

Zhang Wei* **Yan Tailai*** **Tian Guoliang*** * **Pan Guangdong*** *

(Dept. of Information Management,China Agricultural Univ. Beijing 100094)

Abstract Cotton is one of the main economical crops in China. Especially in the southern part of Hebei province, cotton production is one of very few main income channels for the local people. In the past few years, although the cotton production is no longer belong to the crops which the government encourage the farmers to plant in this district, but there still have many hectares of cottons growth every year. The cotton production must have to face the market: in the past five years the price of cotton is low down to the 1/4, but the areas of cotton is still more than two times than the plan. How to get the real areas of the cotton each year is a very difficult problem the local government has to be deal with. Using the radar remote sensing data, to make the surveying work for the cotton planting is one of the possible methods.

In the past tens years, the big and fast progress has been taken in Radar remote sensing tech. The real-time and all-weather characteristics of SAR could fulfil the need for the agri-crops monitoring. But the radar application is only on the early stage. There still have a lot of problems must be resolved. When we use the ERS data to make the work, the classification results are not satisfied. What should we do in this case? So many parameters of the radar system: the different bands, different resident angles, different polarization, different date and so on. Some limitations make us have to do some fundamental research work.

The microwave backscaterometry of cotton and the other kind of crops could help us to compare the different microwave backscattering characteristics of the different kind of crops, the cotton and the corn, the crops which grows at the same time and periods. We found that the image with the bigger incident angle of the beam is the possible best way to help us to identify the cotton and the corn. When the Radarsat data, 47 degree of the incident angle, to be used, the accuracy of the image classification is far better than before through the near same methods to process the data.

In the microwave backscaterometry, the plant's reaction for the electr-mag signals is to be studied and the crops microwave imaging to be simulated through the models. The theoretical microwave backscatering values were to be given based on the microwave scattering model. Based on the comparison between the measurement values and theoretical values, the model was to be corrected. This kind of work had let us to save a lot of fieldwork and to make the work easier. And also the model could help the radar image process work better. The classification result had shown that this method is satisfied in some aspects. And also we could modify the method and make it more useful.

Mapping of rangeland dynamics in arid and semi-arid lands by remote sensing : Case of South-Tamesna (Niger)

G. DE WISPELAERE[1]

CIRAD-EMVT, Maison de la Télédétection, 500 rue J.F. Breton, 34093 Montpellier Cedex 5, France

email: gerard.de_wispelaere@cirad.fr

Abstract In Africa, at the south limit of Sahara (Sahel), many countries are concerned by rangeland management to struggle against the desertification. The inventories and mapping with satellite image data constitute an interesting complement at the ground investigations. In our work area in Niger, the main ecological characteristics of this area are climate, soils and vegetation. Climate is continental, hot and dry with two main seasons. A rainy season (July to September) and a dry season for the rest of the year. The average annual rainfall is about 300 mm. The average temperature is 26 °C. The soils are principally sandy from Quaternary (fixed dunes) with some ferruginous sandstone outcrops (Tertiary). The vegetation is mainly a annual grassland with less 2 percent of shrub coverage.

Some nomadic people (Touareg and Peuls) live in this région. These pastoralists tend cattle, goats, sheeps and camels which graze only on grassland and shrubland. The animals are fed at pools during the rainy season and at bore holes during the dry season.

In order to get the governmental administration bearings the policy of livestock and help the nomadic people, a french-nigerian team studied the capability of the satellite data from 1985 to 1989 and to 1997. This presentation is an abstract from this study. The data used were Landsat MSS (1985) and SPOT HRV (1986-1988-1989-1997) on an area of over 2 000 000 ha.

The principle is based on the empirical model between Vegetation Index (VI's) or Brightness Index and the herbaceous biomass which has been measured by cutting and drying, on many sampling on the field (36 samples of 1 square meter each, at 28 sites georeferenced of 60 m by 60 m size). The averages of the samples give the herbaceous biomass used to calculate the relationship between VI's and dry biomass. In 1985, Landsat satellite data has been taken at the very end of the rainy season, and the following years, SPOT data has been taken much later, at the beginning of the dry season.

Each year, a biomass map has been carried out in two steps. The first step is to extract, from the images, the units which are unable to product any biomass for livestock (rocky bare soils, pools), thickets and crops. The second one gives the different classes of herbaceous biomass (in dry matter). These two maps are integrated together to give a map of land use and biomass map. This kind of maps should be compared to evaluate the temporal dynamic of the herbaceous biomass.

On a small part of the area studied (Ekrafane ranch), two maps give the different states of the production between 1998 and 1997. An example of a synthetic map (1985, 1986, 1988) show the evolution of the production for all the studied areas after the drought of 1984.

The results and the practicability of this approach are discussed.

Rice Mapping Using ERS SAR Data in Guangdong Province of China

Zengyuan Li[1] Mike Wooding[2]

1 Inst. Of Forest Resources Information, The Chinese Academy of Forestry
Wan Shou Shan Hou, Beijing 100091 China
Tel: +86-10-62889163, Fax: +86-10-62888315
E-mail: lizy@info.forestry.ac.cn
2 Remote Sensing Applications Consultants Mansfield Park, Medstead,
Alton GU34 5PZ UK http://www.rsacl.co.uk

Abstract In China rice is an important food resource and production forecasting is very important for local and central planning. Rice production occurs in a number of large areas in the north east, in central and in southern China. Currently rice production estimates are made from statistics compiled at district and county level. However due the size and distribution of rice growing areas, it is both costly and time consuming to estimate rice areas using traditional ground survey technique. It is therefore useful to map rice areas using remote sensing data.

The capability of the ERS SAR to acquire images independently of cloud coverage or daylight conditions is of major significance in the context of agricultural applications, which are time critical. The accurate identification of rice crops using satellite radar has been shown to be dependent on the availability of images acquired during specific time windows through the growing season. For rice growing areas in the tropics, experience shows that high resolution optical satellite sensors cannot provide the desired information due to constraints related to cloud cover and revisit schedules.

This project has demonstrated the capability for rice classification and area estimation at District level using ERS-2 SAR PRI images. Rice areas could be accurately classified using images acquired in the flooding and heading periods and the difference image. The investigation included ortho-rectification and radiometric correction of SAR images for Zengcheng County, Guangdong Province of China.

ASSIMILATION OF REMOTE SENSING DATA INTO CROP MODELS : A TOOL FOR ASSESSING SPATIAL VARIABILITY. APPLICATIONS TO YIELD PREDICTION AND PRECISION FARMING.

Martine Guérif.
I.N.R.A. Unité d'Agronomie de Laon
02007 Laon cedex – France.

Abstract Crop models can be useful tools for estimating crop growth status and yield. In case of spatially variable situations as their do occur in most of field conditions, the main difficulty is to determine the model parameters and initial conditions values for each point. Remote sensing which deliver precious information on crop status and its spatial distribution offers a way to make the model spatially accurate. By coupling a radiative transfer model with the crop model (through a canopy structure variable like leaf area index), it makes it possible to assimilate, for each point of the spatial domain, remote sensing variables (like reflectance in the visible and near infrared), and to re-estimate some of the parameters and/or initial conditions of the model, providing therefore a better estimation of crop status and yield.

This method is particularly interesting for two main applications : yield prediction on large regions and decision making in precision farming.

It is being applied for sugarbeet yields prediction at the level of a sugar factory area in northern France. The main problem consists in re-estimating crop stand establishment parameters and sowing dates which vary a lot at this regional level. The method has been tested successfully for controlled conditions. It was shown therefore, by the way of stochastic simulation, that using five remotely sensed data during crop establishment allowed a good precision in parameters and sowing date re-estimation as well as in sugar yield prediction. The field validation of the method is ongoing using SPOT data and airborne images on two sugar factory areas.

In case of precision farming, the objective is to develop decision making which is adapted to local variation in crop status, in order to realize a better adequation between crop requirements and inputs application, and doing so, optimize the yield and minimize the risk for the environment. Concerning nitrogen fertilisation, the objective is to develop a method of diagnosis of crop needs based on the use of site specific fitting of a crop model using remote sensing data assimilation. In this case, the required variables for coupling remote sensing and crop model are not only canopy structure, but also nitrogen content of leaves ; they are still obtained from the optical spectral domain, but using hyperspectral data. Such a methodology is under development.

VALERI: Validation of biophysical products derived from large swath sensors for global biosphere monitoring

F. Baret[1], D. Allard[2], A. Begue[3], G. Dewispelaere[3], E. Dufrene[4], J.P. Gastellu[5], D. Guyon[6], A. Kuusk[7], J.P. Lagouarde[6], T. Leonidas[8], M.Leroy[5], P. Lewis[9], D. Lo Seen[3], W. Mauser[10], J. Moreno[11], E. Mougin[5], T. Nilson[7], S. Rambal[12], J.L. Roujean[13], M. Weiss[1]

(1) INRA Bioclimatologie, Domaine Saint-Paul, 84 914 Avignon Cedex 9, France
(2) INRA Biométrie, Domaine Saint Paul, 84 914 Avignon Cedex 9 France
(3) CIRAD, Maison de la télédétection, 34 093 Montpellier cedex 05, France
(4) Laboratoire d'écologie Végétale, Université Paris sud, 91 400, Orsay, France
(5) CESBIO, 18 avenue E.Belin, BP 2801, 31041 Toulouse Cédex 4, France
(6) INRA Bioclimatologie, Domaine de la grande Ferrade, BP 81, 33 883 Villenave-d'Ornon cedex, France
(7) Tartu Observatory, 61 602, Toravere, Estonia
(8) NAGREF, Institute for soil classification and mapping, 1, Theophrastos street, 413 35 Larissa, Greece
(9) University College London, Department of geography, 26 Bedford way, WC1H OAP, London, UK
(10) Institut für Geography, Luisentr. 37, 80 333 Muenchen, Germany
(11) Dept. Termodinamica, Facultad de Fisicas, C/Dr. Moliner 50, 46 100 Burjassot (Valencia), Spain
(12) CEFE, Route de Mende, BP 5051 34 033 Montpellier, cedex 1, France
(13) CNRM, 42, Av. Coriolis, 31 057 Toulouse Cedex, France

Several large swath sensors (VEGETATION, AVHRR, POLDER, SEAWIFS, MSG, MERIS, AATSR, MODIS, GLI) will provide concurrently global monitoring of the Earth's surface. The radiometric data collected by these sensors are then transformed in biophysical products (albedo, LAI, fAPAR, and fCover) used both in ecosystem models and in GCMs to define the surface boundary conditions. However, very little work is dedicated to the evaluation of the actual accuracy of these products as well as to the inter-comparison of products between possible algorithms and sensors that could be exploited to combine their data and get enhanced products (spatial resolution, revisit frequency, accuracy on biophysical products).
The objective of the VALERI project is to develop a network of sites and a methodology designed to evaluate the accuracy of the biophysical products derived from large swath satellites and propose ways to combine them and improve their performances..

The VALERI project is based on a network of 10 to 15 sites covering the Earth's surface and representing a wide range of conditions. Each site is about 100km², a dimension consistent with large swath satellite sensors such as VEGETATION, AVHRR, POLDER, SEAWIFS, MSG, MERIS, AATSR, MODIS, GLI. The biophysical products envisioned are either instantaneous quantities or result from a temporal synthesis spanning over a maximum one month period. A methodology is developed to allow accurate measurements of ground level measurements of the biophysical variables of interest: LAI, fAPAR, fCover, albedo representative both in time and space. It is based on the following steps:
1- Selection of a set of elementary places (around 30 to 50) based on a previous high resolution satellite image (SPOT, TM) thanks to geostatistical methods.
2- Ground measurement of the biophysical quantities using the LAI2000 instrument.
3- Extrapolation of the set of local biophysical quantities measurements to the whole site thanks to a high spatial resolution image acquired during the period of interest and geostatistical methods.
4- Estimation of the biophysical quantities at the resolution of the large swath sensors by agregation, and evaluation of the associated uncertainty.
5- Comparison of the values computed from the large swath sensor data thanks to a given algorithm and the values measured from ground level over the ensemble of sites and the several period of measurements.

The project will therefore provide the basic information to evaluate the absolute accuracy of the proposed sensor/algorithms. It will also provide inter-comparison between products derived from several sensors and thus allow to propose possible ways to combine the data collected concurrently by several large swath sensors.
The VALERI project is complementary to the validation effort conducted in the USA (MODLAND), and exchanges of satellite and ground level data will insure efficient synergy between both projects.

FY-1C Meteorological Satellite and Research on Global Vegetation Index

Liu yujie Yang Zongdong Lu naimeng

National Satellite Meteorological Center (NSMC)

China Meteorological Administration (CMA)

Beijing 100081, P. R. China

ABSTRACT FY-1C meteorological satellite was launched successfully On May 10, 1999. This was the third polar orbiting meteorological satellite after FY-1A and 1B which were launched in 1988 and 1990 separately. FY-1C is a major development in Chinese scientific and technological modernization of meteorology. The main meteorological payload on board of FY-1C is the Multi-channel Visible and Infrared Scan Radiometers(MVISR). It has more ability of remote sensing on vegetation, soil moisture, cloud, snow, sea surface temperature, ocean color, low level moisture and so on. To compare with NOAA satellites, FY-1C provides key observations which is important on research of atmosphere, ocean and land surface, especially the application of remote sensing in the field of agriculture.

The successful launching of FY-1C, we have ability to get the remote sensing data not only cover China but also over the world. The resolution of global data is about 3 km along with each scan line. That is much better than GAC data from NOAA/AVHRR. These data offer the opportunity to monitor, quantify, and investigate large scale changes in vegetation in response to human and climate.

FY-1C satellite has been working very well for ten monthes. It is in operation now. It has been providing regional and global observations to users every day since the first day after launch. Many new images and products are produced from the ground system in National meteorological satellite center. These data and products can be used in services and monitoring of vegetation growing, forest fire, flood, snow cover and drought.

This is the out line of FY-1C satellite and the features of radiometer. It gives the brief introduction of characteristics of global data, the method and processing produre of global vegetation index in different projection. To compare the NDVI derived from FY-1C observations with the NDVI from USGD by using NOAA/AVHRR data. It describes the prospect and problem of global vegetation.

Study on Relationship between Rice LAI, CH.D and Hyperspectral Data

LIU Weidong[1], XIANG Yueqin[2], ZHENG Lanfen[1], TONG Qingxi[1]

1, Institute of Remote Sensing Application, Chinese Academy of Sciences, Beijing 100101

2, Institute of Geography, Chinese Academy of Sciences, Beijing, 100101

Abstract During the past several decades, the tools for agriculture remote sensing have evolved significantly. Utilization of remote sensing information to detect the vigor and condition of agricultural crop has been the dominant content of remote sensing. By using remote sensing technology to monitor the variational process of crop spectra and study LAI (Leaf Area Index) and CH.D (Chlorophyll Density) during the growing period can provide biophysical and biochemical characteristics of crops. It can help us quantificationally analyse the relationship between crop growth and the information of remote sensing. Such as Landsat Thematic Mapper (TM), Le systéme pour l'observation de la terre (SPOT) and high resolution visible (HRV), the information of remote sensing from the current generation of earth-orbiting satellites carrying broad band sensors limited providing accurate estimates of biophysical characteristics of agricultural crops and quantifying other terrestrial ecosystem characteristics. These limitations have motivated the development of the inclusion of hyperspectral sensors onboard the new generation of satellites planned by various governments. Hyperspectral technique is a vital measure to acquire the reflected spectrum with a spectral resolution of few nanometers. The future generation of high spectral resolution space-bone sensors will be much more suitable for quantifying vegetation canopy than previous instruments. And hyperspectral remote sensing have make great improvement of abilities of discriminating of vegetation types or species and quantitatively analyzing of biophysical, biochemical changes and extrapolating the relevant parameters.

The objective of this paper was to determine hysperspectral narrow wavebands that are best suited for estimating rice biophysical characteristics. The paper studied the variational process of leaf area index (LAI), leaf chlorophyll density (CH.D) and hyperspectral data during the period of rice growing season. Correlation between hyperspectral data and LAI, CH.D of rice was analyzed. Spectral derivatives technique was used to suppress the effects of low frequency spectral noises on background. Stepwise regression method was used to create multivariate linear equations for predicting LAI and CH.D of rice with the data of reflectance and the first-order derivatives of reflectance as forecast factors. Results show that: 1) The first order derivatives of reflectance spectrum can enhance the correlation and improve the precision of predicting LAI and CH.D; 2) The first order derivatives of reflectance and CH.D more markedly correlate than LAI at some wavelength, CH.D is more available to express crop canopy spectrum information than leaf area index.

Correlation Simulating Analysis Model of the Visible-NIR(400-950nm) Reflectance Spectra of Vegetation in Changzhou and Its Significance

Zhao Yongchao, Tan Qian, Tong qingxi, Zheng Lanfen, Zhang bing

Institute of Remote Sensing Applications, Beijing 100101, P. R. China

P.O.Box: 9718, Beijing 100101, P. R. China

Abstract A new Correlation Simulating Analysis Model(CSAM) is suggested, discussed and confirmed efficient in this paper to analysis the visible-NIR(400-950) reflectance spectral features of the vegetation in Changzhou, China. It is found according to the vegetation spectrum and is confirmed theoretically that the CSAM is an efficient method to classify vegetation species with a potential to identify. We find that all the correlation curves(CC) on a base spectrum(BS) of certain vegetation in the range of 400-950nm are regular smooth curves or lines. Accordingly, we suggest that such a method can give prominence to the shape difference of spectral curves: if two curves are nearly same, their correlative curve must be a line near y=x while if not, a curve but not line; and different reflectance curves have different correlative curves. Furthermore, it is proved that for the spectra of a same species, the linear infection factors with no relation to wavelength only result in varieties of the slope and interception of line y=x but the correlative curve still is a line. In addition, the multiplying factor only leads to change of slope and the adding factor only leads to interception change and therefore the common linear factors for both samples will be eliminated in their CC. According to the correlation curve features and their regularity, we suggested that CC can be expressed by a correlation simulating function(CSF) and found that it can be simulated as a whole by three steps of first-order trend-line removing, rotation transform, and sinusoid simulating and therefore the CSF expression is generally determined by 6(or no more than 10) correlation eigen-parameters(CEP) as m, b, θ, A, T, ϕ which are gotten from the simulation process. So, the causing factors of shape deference of spectral curves can be expressed by such 6-10 CEPs and as CSF expression can be gotten, the spectral curve of a certain vegetation species can be simulated from another species by CSF. We test such a CSAM by many field measured spectral curves of different vegetation species in Changzhou and find that it is valid and significant. The all efforts by using CSAM to simulate the correlation curves between image spectra and between image spectrum and re-sampled field-measured spectrum also get good results. The inversely built spectrum curves are nearly as same as the measured data both from field and image. Accordingly, we suggest that such a CSAM method has good qualities as eliminating the common infection factors; giving prominence to the factors that result in the difference of different species or different individuals of same species; integrating the highly correlative bands; including the shape information; possible for recognition. It is an effective method to express the shape difference of reflectance spectra and to extract the relative property information for vegetation in band range of 400-950nm. Furthermore, according to the analysis in this paper, we conclude that in order to get good correlative curves to study vegetation: 1.) The certain wavelength range of 670-780 must be divided into more bands while only a few bands needed in ranges of 400-670nm and 780-950nm; 2.) Every band will be narrow; 3.) And therefore hyperspectral is necessary for vegetation or agriculture study; 4.) However, only 3-6 bands needed to get necessary CEP according to CSF expression, so it is possible to select a few certain bands to study the vegetation or agriculture especially for the rice-planted area as Changzhou.

A Thermal Infrared Emission Directionality Model for Continuous Crop Canopies and Component Temperature Inversion

Q. H. Liu[a,b], X. W. Li[b], x. F. Gu[c],
G. L. Tian[a], M. Friedl[b], A. H. Strahler[b]

[a]*Institute of Remote Sensing Application, CAS, Beijing 100101, China*
[b]*Dept. Geography and Center for Remote Sensing, Boston University, Boston, MA02215, USA*
[c]*INRA-Unite De Bioclimatoligie, Avignon, France*

Abstract The directional distributions of thermal infrared emission from crop canopies depend on both the directional emissivity of the surface and the component temperature distribution within the canopy. Li, Strahler and Friedl (1999) suggest a conceptual model (LSF model) for directional emission from non-isothermal surfaces that combines the merits of the DW BRDF model and the KSL GO model. This paper extends the LSF model to deal with continuous crop canopy. Four components are taken into account: shaded soil, sunlit soil, shaded leaves have unique temperatures respectively while sunlit leaves temperatures follow a normal distribution characterized by the average temperature and standard deviation. Accordingly, a four component temperature retrieval methodology is suggested.

Model simulation study and error analyses have been performed using crop canopies possessing different structure parameters and temperature distributions. The results show that the thermal infrared emission directionality is related to the leaf area index, leaf inclination angle distribution, soil structure and solar radiation.

In order to validate the model, a wide-angle thermal video camera (INFRAMETRICS) equipped with an 80 degree FOV lens was mounted on a small aircraft and used to acquire thermal imagery along several different flight traces. Accordingly, directional brightness temperatures were acquired at different view angles for every pixel. The flight experiment was carried out from January 1997 to October 1997 over a 5*5 km2 flat agricultural area, located near Avignon, Southeastern France. The directional brightness temperatures over different crops such as maize, wheat, grass with different LAI and LAD have been extracted from the acquired multi-angular thermal infrared imageries. Results show highly consistent with the model, so the directional thermal emission model would be helpful to improve the crop canopy temperature retrieval accuracy.

Land Applications using ERS-1/2 Tandem data

Wang Chao **Zhang Hong**

Institute of Remote Sensing Applications, Chinese Academy of Sciences, Beijing 100101

Tel:+86 10 6488 9546 Fax:+86 10 6488 9786 Email: cwang@public.bta.net.cn

Abstract Accurate mapping of land-use types is essential to a number of scientific disciplines, in particular environmental monitoring. Recent research shows that interferometric coherence images produced from interferometric image pairs contain information about the target area that is independent of the information in the SAR intensity images. The information available through the interferometric correlation is complementary to the information content of the backscatter coefficient. This extra information channel is useful for example in land-use classification, forest inventory, agricultural studies etc.

The focus of this study was on the land-use classification using SAR interferometric techniques. A classification algorithm based on the interferometric correlation, the backscatter intensity, the backscatter intensity change, and the texture was presented. The algorithm was applied to data over Suzhou area, Jiangsu province. Comparison of the interferometrically derived land-use map with optical data (Landsat TM) confirmed the good potential of the technique.

Interferometric tandem data shows great promise for crop classification and crop height retrieval, the 24 hour temporal baseline seems pretty ideal for C-band SARs. Further studies with better ground truth information that would enable coupling tandem coherence and crop height observations for individual fields are required in order to validate the relationships found between crop height and tandem coherence and to derive these relationships for a vide variety of agricultural crops. If these relationships were known it is conceivable that agricultural crops could be classified and their height retrieved using single tandem image pairs in the future.

Data Fusion for Flood Analysis and Decision Support

(ANFAS)

MA Songde, Olivier MONGA, Veronique PRINET,
WANG Feng, YANG JunQing

Institute of Automation, Chinese Academy of Sciences, PoBox 2728, Beijing 100080
National Research Institute in Computer Sciences and Control (INRIA),
Domaine de Voluceau, Rocquencourt , BP 105, 78153 LeCedex, France
http://lotus.ia.ac.cn/ANFAS *http://www.ercim.org/ANFAS*

Abstract "Data Fusion for Flood Analysis and Decision Support" (ANFAS), is a project of the 5e framework of the European Commission, Information Society Technologies program. This project started in January 2000 and includes 11 partners, among which three in China and three in France. One of the key problem of the project is to build high resolution three-dimensional model of the terrain using fusion from multi-sensor remote sensed images. Two pilot sites are in China ---Three Gorges and Poyang lake---, one in France ---Loire river--- and one in Slovakia ---Vah river.

Study on the retrieval of emissivity spectra from airborne thermal infrared data

Zhang Xia, Zhang Bing, Zheng Lanfen, Tong Qingxi

(Institute of Remote Sensing Applications, CAS, Beijing 100101, China)

Wang Junfa, Shu Rong, Xue Yongqi

(Shanghai Institute of Technical Physics, CAS, Shanghai 200083, China)

Abstract A newly developed method for separating temperature and emissivity (TES) was applied to the airborne multispectral MAIS images. MAIS is an airborne imaging spectrometer made by Shanghai Institute of Technical Physics, CAS. By taking part in the comprehensive experiment of remote sensing in Europe,1997, seven bands of TIR images were acquired over AVIGNON area, France, wavelengths of each channels during this flight were 8.45-8.9μm, 8.9-9.35μm, 9.35-9.8μm, 9.8-10.25μm, 10.25-10.7μm, 10.7-11.15μm, 11.15-11.6μm respectively. The study area was an agricultural area planted mainly maize, sunflower and purple medic. In parallel with the flight, atmospheric profile was obtained synchronously by an airsonde, providing sufficient data for this study. The TES method was developed for the future ASTER in the first place in 1998. In order to extend the TES method to MAIS sensor, some changes were performed. About 132 laboratory reflectance spectra at 8-14μm, therefore emissivity spectra, were collected from the Johns Hopkin University, materials including 6 kinds of vegetation, 40 kinds soils, 9 kinds water and 77 kinds rocks. Based on this set of spectra, a significant exponential correlation for MAIS was built between minimum emissivity and MMD(the difference between maximum and minimum of emissivity ratios). This correlation was used to substitute the MMD model of TES method. Then emissivity was inverted by the revised TES method from the atmospherically corrected images (by LOWTRAN7). Because of the large sampling difference between lab and image emissivity, only the shape of them was compared. It was found that, the image emissivity spectra were quite consistent with those measured in laboratory especially for purple medic and bare soil. The emissivity maximum of vegetation occurs at channel 8, which agreed with Salisbury's conclusion from laboratory measurements. By statistical analysis, the standard error of channel 5 is the minimum of all the seven channels, the value for vegetation of this channel is within 0.9597±0.0066, and bare soil within 0.9574±0.0087. So assuming one value of 0.96 for channel 5, it is possible to retrieve emissivity spectra by using model emissivity method. Channel 2 has the maximum standard error and the widest value range, it's the effective channel for identifying materials. Bare soil has much higher surface brightness temperature than vegetation, and purple medic about 2K higher than maize and sunflower for all channels. As a result, even if only temperature is available, bare soil also can be discriminated easily, purple medic possibly. In the end, classification was tried using the emissivity images combined with one surface brightness temperature image. An stepwise masking scheme was utilized, firstly, discriminating bare soil by assuming one threshold of brightness temperature and creating the mask image of soil, secondly, based on the emissivity images, identifying purple medic by parallel pipe method and creating mask image of purple medic, thirdly, discriminating the remaining maize and sunflower based on emissivity and temperature images, lastly, composing all the resulted mask image from each step into one image, that is, the final classification map. It turned out, the classification precision for each object is 90% for bare soil, 87% for purple medic, 83% for maize and 73% for sunflower.

Snow Cover Remote Sensing by Polar Orbiting Satellites

Wang libo Liu yujie Yuan wanping

National Satellite Meteorological Center

China Meteorological Administration

Beijing, 100081, China

Abstract Snow cover is an important resource of the Earth. It is a potential factor related to climate and global changes. On account of its high reflectance and low heat conductivity, the existence of snow cover can affect surface and air temperature, surface albedo, radiation balance, soil moisture and so on. It may have influence on the radiation, heat and hydrologic budgets of the earth-atmosphere system. In order to study and understand the impact of snow cover on climate and hydrologic budgets, it is necessary to have variation and distribution of snow cover over a long period. Usually the snow cover data can be got regularly by observation of weather station, but these data are limited to point surface measurement and poorly represented in mountainous and sparsely inhabited areas. Remote sensing is a powerful tool for snow cover observations.

In China, snow cover remote sensing plays another important role. 40% of China's land surface is grass covered, and nearly 50% of it is pasture area, mainly distributed in Xizang, Qinghai, Xinjiang and Neimeng areas. In these areas, people mainly live on stock breeding, such as cattles and sheep, from which large amount of meet, milk and fur is produced. But snow disasters are very frequent during winter and spring seasons in these areas, which may bring serious damage to the lives and properties of the local people. Besides, these areas are usually spare populated and with undeveloped communication. Satellite remote sensing is the only way in these areas to provide snow and snowstorm information, such as the areal extent of snow, the location of a snow disaster and the levels of snow disasters. Therefore, snow cover monitoring is especially significant in China.

From the end of 1980s, snow cover remote sensing methods have been developed in NSMC. Satellite snow cover monitoring has performed indispensable functions in every snow season. Since Dec. 1996, an operational system for snow cover monitoring over China using NOAA AVHRR data has been set up. Based on the analysis of the spectral characteristics between snow, cloud and other types of earth surface with AVHRR data, a multi-channel thresholds test method is used to separate snow from cloud. With a spatial resolution of 0.05°×0.05°, pixels covered with snow and the other land surface types have been identified within China and its neighboring areas. By ten days compositing , a cloud free image with the maximum snow cover extent has been obtained in every ten days, and snow cover area in each province has been calculated and analyzed. Percentage of snow cover by 1°×1° is counted for climate applications.

In May 1999, the Multi-channel Visible Infrared Scan Radiometer(MVISR) on board FY1-C satellite was successfully launched. It is a polar orbiting meteorological satellite with 10 spectral bands, covering visible, near-infrared , middle-infrared and thermal-infrared domain. Its spatial resolution is 1.1km for all ten channels at nadir. Based on the fact that snow reflects visible radiation more strongly than it does in the middle-infrared spectral regions, the Normalized Difference Snow Index (NDSI) is calculated from the reflectance of MVISR Band 1 and Band 6. Because the reflectance of clouds remains high in MVISR band 6,and the reflectance of snow drops to near zero values, the NDSI is an effective discriminator for snow and cloud. NDSI for many types of land surface and clouds sampling from MVISR data have been computed and analyzed. Snow cover monitoring algorithm by NDSI threshold method has been developed.

In this paper, the basis of the operational snow cover monitoring system and its applications are briefly introduced. The use of FY1-C MVISR data in snow cover remote sensing based on NDSI threshold method is presented.

Monitoring Land Cover and Vegetation Growth Stages Based on Multitemporal Index Image Cube Analysis

ZHANG Bing*, ZHANG Xia*, RAN Maonong**, XIANG Yueqin***,

ZHENG Lanfen*, TONG Qingxi*

Absrtact Land cover and vegetation growth monitoring are important elements in the resource and environment management, and precision agriculture. Remote sensing technology give us more selections and available spaces in this dynamic change study, which can provide different resolutions in spatial, spectral and temporal areas. Especially, the remote sensing data compatible with high spectral and high temporal resolution, will play a key role in land cover studies at national, regional and global levels. In this paper,Temporal Index Image Cube (TIIC) is provided,which is an effective data structure for the parametrization of multi-dimensions spectral curve. TIIC is very useful to supporting the dynamic analysis on vegetation phenological and physiological characters. Based on multi-temporal meteorological satellite data and multi-temporal ground spectral measurement data, the temporal pedigree characters of different objects and vegetation physiological parameters are extracted, contrasted and analyzed from temporal index image cube.

Dynamic NDVI curves can be extracted from multitemporal index image cube of meterological satellite data, which are in accordance with regular crop periods of duration. There are evident difference between the crops in north and south agriculture area of China. These phenological information will greatly support the crop classification and identification. Hyperspectral data have wide and effective use in the extraction of pigment and biophysical properities of crops. Multitemporal and continuous physiological index curve can be used to investigate the growing situation of crops, which is very important for the precision agriculture. Hyperspectral CCD camera with narrow spectra and limited-number channels play well in acquiring such seasonal or staggered remote sensing data. However, the normalization of these multitemporal data is very important.

Some key tables and figures are shown as follows:

Table 1. Period of Duration of Double-harvest Rice in South Part of China

	Sowing(SO)	Transplant(TR)	Tillering(TI)	Heading(HE)	Harvest(HA)
Early rice	Mar. 10	Apr. 5	May 15	June 11	July 15
Later rice	June 15	July 15	Aug. 11	Sep. 11	Oct. 21

Figure 4. Two-dimension index curve shifted from three-dimension spectral curved surface

Table 3. Summary of the Relation

Content per unit ground area	Index
Chl &Cars	δR_{red}
N	$(R_{707}-R_{589})/(R_{707}+R_{589})$
Leaf senescence (carotenoid/chlorophyll)	$R_{680}-R_{500}$
Biophysical properties	**Index**
LAI	R_{800}/R_{665}
Vegetation coverage (%)	$R_{780\ l}/R_{747}$

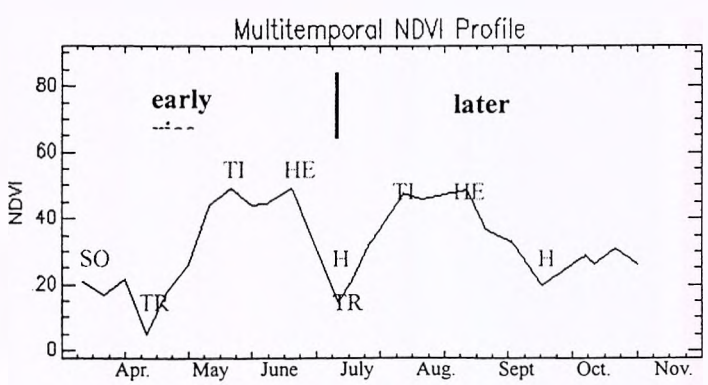


Figure 5a. NDVI profile of double-harvest rice in south part

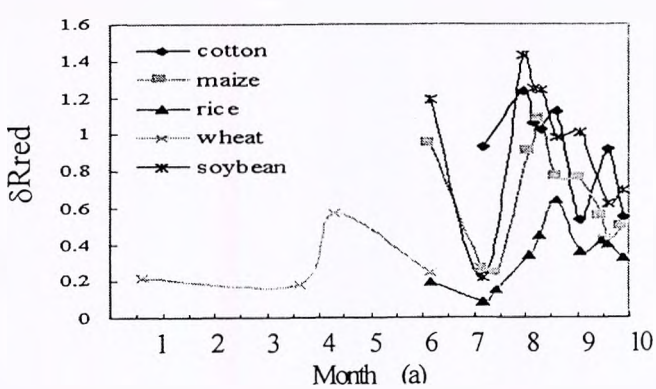


Figure 6. MIIC curves of various kinds of crops

Algorithms for the Estimation of the Concentrations of Chlorophyll A and Carotenoids in Rice Leaves from Airborne Hyperspectral Data

Guan Yangning Tong Qingxi Zheng Lanfen
Zhang Xia Liu Jiangui
(Institute of remote Sensing applications, CAS, Beijing, 100101, China)

Abstract Algorithms based on reflectance band ratios and first derivative have been developed for the estimation of chlorophyll a and carotenoid content of rice leaves by using airborne hyperspectral data acquisited by Pushbroom Hyperspectral Imager (PHI). There was a strong R680/R825 and chlorophyll a relationship with a linear relationship between the ratio of reflectance at 680nm and 825nm. The first derivative at 686 nm and 601 nm correlated best with carotenoid. The relationship between the ratio of R680/R825 and chlorophyll a relationship, the first derivative at 686 nm and carotenoid concentration were used to develop predictive regression equations for the estimation of canopy chlorophyll a and carotenoid concentration respectively. The relationship was applied to the imagery, where a chlorophyll a concentration map was generated in XueBu, which is one of the sites for rice.

The Situation and Application of Remote Sensing Images and Ground Truth Measurement in PCM

Zhu Yonghao **Lu Yihuai**

(Anhui Institute of Optics and Fine Mechanics , CAS P.O. Box 1125 Hefei Anhui 230031)

Abstract Presently, precision crop management(PCM) is the outcome of agriculture and information technology. It requires the crop information to be of high spectral resolution, high spatial resolution and high thermal resolution. The main information source of PCM is agricultural information obtained from remote sensing images of different flatforms.

In this article, section 1 addresses the basic requirements for remote sensing images. On that foundation, it reviews how PCM contents to satellite and airborne remote sensing images and the possible development in the next five or ten years.

Section 2 analyzes the problems and foreground in developing PCM technology and brings forward the technology approaches of PCM application adapting to the current developing level of our country, especially the current condition in the northwest area and crop truth measurement information.

Section 3 analyzes its possibility in PCM application of our country, by using the image statistics of visible band, near-infrared band and thermal-infrared band with the support of agriculture management mode and ground truth measurement.

Section 4 recommends on the newly-exploited instrument used to observe the growth condition of ground crops---double bands radiometer .

A Sub-pixel Abundance Retrieval Method via Feature Space Projection

Liu Jiangui, Tong Qingxi, Zheng Lanfen

(IRSA, CAS, Beijng, P. R. China, 100101)

Abstract Classification is a rudimental procedure in remote sensing image processing. In many conditions, pure pixel is unpractical, therefore it is not reasonable for traditional accurate classification. Estimating the abundance of components at pixels where there are over one kind of materials appear is important not only to improve the classification accuracy but also to detect the minor appearance of endmembers. This paper developed a method to evaluate the relative abundance of each kind of endmembers in a pixel through feature space projection. The intensity of the resultant image reflect the abundance of the endmembers. A simulated and a real hyperspectral data sets were analysed using this method. The result shows that the proportion of the components can be retrieved one by one accurately.

SENSITIVITY ANALYSIS OF SPECTRAL PROPERTIES FOR A DIGITAL MULTISPECTRAL CAMERA SYSTEM

Qian Tan Yongchao Zhao Bing Zhang
Qingxi Tong Lanfen Zhen
(Laboratory of Remote Sensing Information Sciences ,Institute of Remote Sensing Applications CAS , Beijing,100101,China)

Abstract A new spectral feature selection and extraction model(for vegetation only!)---Eigen-position and Eigen-parameter model is presented , which is especially for a digital multispectral camera system . The camera system will operate in the visible light to near infrared light , its bandwidth being narrow or broad , according to the corresponding band center position . The model is acquired by sensitivity analysis of spectral properties of a set of field data at different times and places , which indicates that some chracteristic band positions are insensitive to land covers , environmental influnces , etc ,while their corresponding reflectances are quite different with land covers ,environmental influnces , etc(Furthermore , from the band correlation image , we can prove that .).The Eigen-position refer to 8 positions, which are respectively ,

1) Absorption peak in purple-blue band-M(λM， RM) 2)Absorption edge of blue waveband (blue edge)-B(λB， RB) 3)Reflectance peak of green band(green peak)-G(λG， RG) 4)Absorption edge of yellow waveband(yellow edge)-Y(λY， RY) 5)Absorption peak in red band(red "valley")-R(λR， RR) 6)Red edge-V(λV， RV) 7)Start site of the NIR platform-I1(λI1， RI1) 8)Maximum point of reflectance in NIR of 780-950-I(λI， RI)

The Eigen-parameter refer to 14 parameters(to be developed), which are respectively ,

1)The coordinate of 8 eigen-position M, B, G, Y, R, V, I1, I and two accessorial positions as G' and R': (λP， RP).2) Slope of blue edge-SB 3) Slope of yellow edge-SY 4) Slope of the incline among bands of red-NIR-SV 5) Slope of the continuum-SC 6) Net height of green peak-HG 7) Net depth of red absorption "valley"-HR 8) Net height of infrared platform-HI 9) FWFH of green peak-λwG 10) FWFH of red absorption peak-λwR 11) Averaged reflectance of NIR platform-RIa 12) Area of green peak-AG 13) Pure area of green peak-AG 14) Net area of red absorption peak-AR

At last , we discuss the feasibility of applying the model to classification as well as biochemical parameter estimation .The results are exciting . It suggests that the eigen-parameter group is sensitive to vegetation species and can be used to distinguish vegetation in the same time , as for biochemical parameter estimation , for our total samples in our study conditions, the water content has relatively higher linear correlation with the reflectance in band range of 600-900 and also with the first-order derivative in some band regions of 550-650nm, 700-760nm and 900-950nm, Some intensity eigen-parameters as SV and HR and so on also have high linear correlation to water content . Some fitting functions are as follows:

water%= 0.9248*R(λ =795nm)+42.359

water%= -670.09*R'(λ =906nm)+61.412

water%=74.505*SV+48.501

In these conditions, the other biological parameters have poor correlation with all the spectral parameters. The only possible relationship with higher confidence is for CK ,but it is not so good as water content.

A Neural Network Classification Algorithm Based On Object Decomposition For Hyperspectral Image Data

Xiong Zhen, Tong Qingxi, Zheng Lanfen

(Lab of Remote Sensing Information Science, IRSA, CAS, Beijing, 100101)

Abstract Artificial neural network classification algorithm has many advantages: it can combine other features expediently, it needs not the transcendental knowledge of training samples, it needs not the hypothesis that the training sample presents normal distribution, each training data has equal power, its classification effect is good, etc. So the Artificial neural network classification algorithm is widely used in remote sensing image classification[5-12]. But Artificial neural network classification algorithm has its own disadvantages: its largest shortcoming is that its training speed is slow. In general, the sample training of neural network takes much time, especially when the training sample does not present normal distribution. But the phenomenon that training sample does not present normal distribution is universal[3,4]. This forms a contravention.

On the other hand, the phenomenon that one matter has several spectral features always occur during classification using hyperspectral remote sensing image data. This phenomenon makes classification based on spectral features more difficult

In order to solve the contravention, a neural network classification algorithm based on object decomposition for hyperspectral image data is presented. for hyperspectral image data is presented in this article. For the matter that has several spectral features, this method separates it into several sub-class substances. This sub-class matter has only one spectral feature and presents mono-peak normal distribution. Then these sub-class substances, treated similarly as other substances, are sent into the neural network together with other substances. In the output port of the neural network, a logic operation cell reunites sun-class substances into their own class. So that improves the classification accuracy.

In this article, the structure, the training program, and the processing step of the neural network classification algorithm are introduced detailedly. An experiment using hyperspectral image data is done and a good result is gained. The experiment result proved that this algorithm is effective.

Modeling SAR Backscattering from Rice based on Radiation Transfer and L System

Qiming Zeng* **Hongbin Ma**** **Tao Zhang***

* *Institute of Remote Sensing and Geographical Information System, Peking University*

** *Department of Electric and Electronics Engineering, Tsinghua University*

Abstract Rice is one of main staple food for Asian countries. Because it is often cloudy and rainy in rice growing season, there is no many chances to acquire optical remote sensed image for mapping and monitoring rice growth. The high-resolution space borne Synthetic Aperture Radar (SAR) with imaging ability in all weather condition and any time is an economical and operational means for rice mapping and monitoring. The authors first gave out a backscattering model for rice based on radiation transfer theory, and analyzed backscattering coefficient varying with wavelength, polarization and incidence angle. Then L system was introduced to describe the configuration and space architecture of rice, and a coherent model was derived, using in situ measurement made numerical simulation analysis.

Remote Sensing of Water Environment

Yin Qiu, Kuang Dingbo

(Shanghai Institute of Technical Physics, Chinese Academy of Sciences)

Abstract The paper first briefly introduces the characteristics of water problems along Taihu Area and the limitations of routine water quality measurement and management method. It is shown that (1) the water is rich from the point of view of water amount on one hand, but the water is lack from the point of view of water quality on other hand, and (2) the routine water quality measurement and management method are weak in the macro grasp of water environment, the updating of water quality data in time and the real-time supervise of water pollution accident.

Then, it analyzes the light spectrum responsibilities of water pollutants such as chlorophyll, suspended sand, oil and warmed water etc. to illustrate that it is possible to determine several important water quality parameters by means of remote sensing on theory.

In the following, it introduces the advantages and the limitations of the remote sensing instruments of abroad (such as Landsat, SPOT, NOAA, SeaWiFS and IRS-1C) and that of our country (such as FY-1C, CERBS CMODIS, and OMIS) when they are used for the measurement of water environment. From this we can say that we have possessed some technical conditions to conduct water remote sensing.

On this base, a series of inland and coastal water environment remote sensing field experiments and data inversion experiments are conducted, which include the application of Landsat, FY-1C, CMODIS, OMIS etc on Taihu, Beibu Bay, Pohai Bay Hangzhou bay and Changjiang etc.

At last, suggestions are given about the present works ought to be done for the remote sensing of water environment.

Atmosphere Resistant Vegetation Index Application in Crop Yield Estimation Through FY-1 Meteorological Satellite

Xiao Qianguang ZhengBo XiaoLan ChenWeiying

National Satellite Meteorological Center , China Meteorological Addministrtion

Email:xqg@nsmc.cma.gov.cn

Abstract Normalized different vegetation index approach is generally used in the crop yield estimation work. Because it is influenced greatly by the Atmosphere, the forecast difference will also be great if it is used as the unit area crop yield estimation approach, thus can not fulfil the user's requirement. Atmosphere resistant vegetation index ARVI is constructed by the information of Red light channel CH1(0.58-0.68 μ m) near infrared channel CH2(0.84-0.8 μ m) and blue light channel CH7(0.43-0.48 μ m), which is obtained from FY-1 Meteorological Satellite. ARVI is defined as following:

$$ARVI = \frac{CH_2 - CH_{1,7}}{CH_2 + CH_{1,7}}$$

$$CH_{1,7} = CH_1 - \gamma(CH_1 - CH_7)$$

γ is a constant related to the satellite scan angel , spectrum observation is starting when the satellite is passing by the receive scope. The result can get is: By Comparing the data obtained from satellite Observation and Ground observation, the NDVI difference is 30%, while only 5% difference using ARVI approach. Monitoring the winter wheat growth situation of 2000/3/17, we can know ARVI has obvious advantage than NDVI(Fig.1,2).

Fig.1

FY-1C 河北ARVI 2000年3月17日

Fig.2

FY-1C 河北NDVI 2000年3月17日

The Research of Radiometric Calibration Process of the Optical Remote Sensing

Qiao Yanli Wang Leyi Yi Weining

(Anhui Institute of Optics and Fine Mechanics , CAS P.O. Box 1125 Hefei Anhui 230031)

Abstract Radiometric calibration is a systematical research experiment process. To improve its accuracy, both hardware method and software method should be taken. The former should be used to establish the highly precise radiometric standard, such as the standard based on absolute radiometer, and to improve the accuracy of radiometric calibration system, that is, to improve the accuracy of transfer standard by controlling the source of error in all processes. The latter should be used to determine the configuration of radiometric calibration system according to various kinds of sensors, the content of radiometric calibration experiment and the related calibration program. Since the accuracy of the transfer standard or reference standard on which ground vicarious calibration of satellite sensors relies could be controlled, the improvement of accuracy of the "reflectance based method" depends mostly on the determination of atmosphere pattern parameters.

Highly accuracy radiometric standard and its transferring , radiometric calibration of measuring equipments, and radiometric calibration of satellite sensors are indispensable factors to improve quantitative application of remote sensing information. First of all, the accuracy of radiometric standard on which optical remote sensing detection relies must be improved by such means as the cryogenic absolute radiometer standard system. To determine the relationship between output of remote sensing sensors and the measured, highly precise transfer standards and applied calibration system are required. However, responsibilities of almost all satellite sensors determined in laboratory will inevitably change as result of various factors in the process of satellite launching and in-orbits operation. "The vicarious calibration method", which takes advantage of the calibration to ground reference, is one of the effective ways to re-calibrate these changes.

The accuracy of laboratory radiometric calibration depends on the accuracy of the radiation calibration system and the radiometric calibration method. Standard lamp radiation calibration system is affected by such factors as the standard lamp, power system, geometrical condition and the capacity of the standard panel. So, the great number of its sources of error prevents its accuracy from being improved. To improve the accuracy of the integrating sphere calibration system, the key point is to acquire accuracy data of the integrating sphere radiant point. The pre-calibration system achieved through diode Trap could be an effective way of doing that.

In ground radiometric calibration, no matter which method is adopted, whether it is "reflectance based method", "radiance based method" or "irradiance based method", its errors come mainly from two sources: one is the measuring errors of calibration ground optical parameter and atmosphere optical parameter, the other is the calculating error of atmosphere radiation transfer pattern. The measuring errors could be controlled by such methods as the BRDF calibration of the reference panel and the standardization of measuring process. The calculating accuracy of atmosphere radiation transfer pattern, when this pattern is actually determined, depends mainly on the determination of its input parameter.

Hyper-spectral Data Application on Land use survey

Wang Changyao, Niu Zheng, and zhang Qingyuan

(Institute of Remote Sensing Application, CAS, P. O. Box 9718, Beijing 100101)

Abstract Imaging spectrometer is a now technology for earth observation, which is an important measure for land use survey to acquiring field data. In this paper, Airborn Imaging spectrometer has been used to get the hyper-spectral data in study area. After Optimum collection of hypekspectral data channels, the HYPERSAM method (sppectral Angle Mapper algorithm) has been adopted for hyper-spectral image classification. Comparing with common remote Sensing data, more information of crops, farm Land as well as its environmental conditions can be obtained.

As for the selection of the optimal channels and their combination. Comparing with other remote sensing data, hyper-spectrum data is with following characteristics: narrow channel range, rich spectral information and high power for object recognition. However, it does not mean that the more channels are used in classification, the better the result is.

Two factors are taken into account in channel selection. One is the co-relationship between channels. The other is the spectral response property of object in experimental area. Object types are determined in accordance with the ground data After sampling, curve of average spectral reflectance of each object type can be determined. Based on following model, channel is selected:

$$M_{am}\left\{\left|p_{ki}-p_{li}\right|+a\left|D_{ki}^{(1)}-D_{li}^{(1)}\right|+b\left|D_{ki}^{(2)}-D_{li}^{(2)}\right|\right.$$

$$I=1,\ldots N,1\le L\le k\le p$$

Where N is number of total channels, p is the number of total object types, $D_{ki}^{(1)}$ is first differential, $D_{ki}^{(2)}$ is second differential, a and b are two constants.

With regard to Hypersam method, the logic is briefly that the reflectance information recorded in a spectral curve file is measured in a laboratory under constant viewing conditions. However, the data in a hyper-spectral image contains additional variations that exist because of variations in illumination. For example, solar elevation varies with the time of year and topo-graphic variations lead to variations in aspect relative to the the sun. As a consequence, there can be significant differences between the spectral response patterns as recorded by the sensor system and those measured in the lab. The Spectral Angle Mapper algorithm is based on the assumption that variations in illumination conditions will lead to a set of signatures that fall along a line connected to the origin of the band space.

Estimating China Winter Wheat Yield Using Net Primary Product Model

ChenWeiying XiaoLan XiaoQianguang

National Satellite Meteorological Center , China Meteorological Addministrtion

Email:xqg@nsmc.cma.gov.cn

Abstract The Remote estimation of winter wheat yield is including the estimation of unit area yield, and the calculation of planting area. The calculation of planting area has to use high resolution satellite images which is too expensive to carry out in operation;. And since it is hard to remove the influence of atmosphere, the remote estimation of unit area makes great error. A new approach is introduced in this paper, which calculates the whole yield directly without using former two parameter, that is net primary product approach.
The research shows that the leaf area index has following relationship with vegetation index:
NDVI=1-EXP(-K*LAI)

Where NDVI is the vegetation index, and LAI is the leaf area index. Usually, the leaf area index has following relationship with dry mass weight:
LAI=aDW/(1+bDW)
DW=-ln(1-NDNI)/(aK+bln(1－NDNI))

Dry mass weight is represented for the net primary product, that is the net primary product of total photosynthesis minus the consuming of respiration. That is :NPP=GPP-RSA

Following NPP model is used in this paper:
NPP=A(-ln(1-B*NDVI))

NDVI is the average of the every ten days MVC value of whole winter wheat growth season. Using this formula, we can calculate the whole NPP value of each province(or county), and obtain the percentage of yield to the NPP by using the whole yield of the year, Supposing the percentage remains the same in the next year, we can estimation the next year's whole yield by using next year's NPP value. We estimate the whole yield of primary wheat growth provinces of 1997,1998 in China, and got satisfying result.

Radiometric characterization of Dunhuang satellite calibration test site and in-flight radiometric calibration of SPOT-3 HRV-2 with respect to this test site

Min Xiangjun† Wu Daogang Gu Xingfa
Wang Zhimin Zhu Yonghao
(†China Center for Resources Satellite Data and Application Beijing 100073)

Abstract In China, CRSG and CRESDA have conducted investigations for selecting a test site for in-flight calibration of Chinese Earth observation satellites. This test site is situated near the northwest border of the Gobi desert near the Dunhuang city. The calibration area is 400 × 400 m^2 and situated in the center of an homogeneous and perfectly flat region of 30 × 40 km^2.

In August 1996, a joint Chinese-French team has conducted a field measurement campaign for determining the characteristics of the ground reflectance and atmosphere. The results show that the test site has a very good homogeneity with a variation coefficient of the reflectance in any channel lower than 3%. The ground reflectance increases progressively from 17% at 400 nm to 32% at 1600 nm. BRDF measurements in the solar principal plane from -50° to +50° off-nadir have shown, for a solar zenith angle of 33°, an increasing of the reflectance factor reaching 30% in the backscattering direction and a decreasing limited to 13% in the forwardscattering direction.

Based on the atmospheric measurements performed during the period of August 25 to 30, 1996, we carried out the optical and radiometric characterization of atmospheric aerosols in Dunhuang test site. Atmospheric measurements have indicated that, at 0.5 μm the total atmospheric optical depth (about 0.27) and the aerosol optical depth (about 0.15) are low and the effect of atmospheric water vapor content is relatively small. We retrieved the spectra of aerosol optical depths, the size distribution of aerosol particles, the scattering phase function, the single scattering albedo, and the aerosol scattering asymmetric factor. We also make a comparisons between these retrieved optical parameters of atmospheric aerosols and those given in four typical aerosol model (continental, urban, maritime, and desert). The results indicates that the type of aerosols in Dunhuang test site is very closed to the continental model with a slight influence of desert aerosol. These first results show that the selected test site is well adapted for in-flight satellite radiometric calibration.

Using the measured ground reflectance and atmospheric optical parameters as inputs to 6S code, we calculated the band-weighted radiances at the entrance pupil of SPOT-3 HRV-2. We can get the absolute radiometric calibration coefficient for each band of SPOT-3 HRV-2 after comparing the model-computed radiance to the digital number recorded by SPOT-3 HRV-2 sensor. The calibration coefficients are 1.427, 1.380, and 1.180 DN/($W \cdot m^{-2} sr^{-1} \mu m^{-1}$) for bands XS1, XS2, and XS3 respectively. At the end of this paper, we also present the error estimates for this in-flight calibration of SPOT-3 HRV-2.