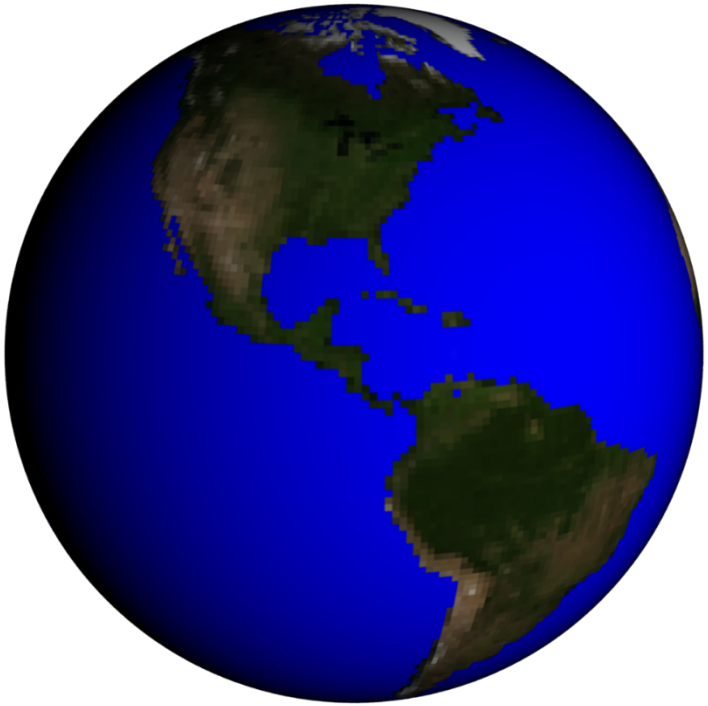
How FIFE and BOREAS changed the World

Then



Now

Flashback !

You have all been time-warped back to

July 20 1994, 0000 UTC

You are waiting for the nightly BOREAS Ops meeting to begin…..

BOREAS Aircraft/Satellite Schedule

(1)

Thursday

Date: 07-21-94 **Mission Manager:** SELLERS **Hot Site:** SSA **NSA SAM:** NEWCOMER **SSA SAM:** MITCHELL

GMT	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	100	200	300	400
NSA	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SSA	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200

N-12 4,56 ▽ N-9 34,47 ▽ S-3 30,36 ▽ N-11 24,52 ▽

N-12 24,58 △ N-9 49,48 △ N-9 49,37 △ S-3 5,34 △ N-11 47,48 △ N-11 50,63 △

ER-2 RE-MS 60000'

DC-8 RD-MN RT MS 26000 YXE

NUQ

CV-580 RV-MN RV-RT MS

C-130 RC-MS,TS 25000 20000' MS, OA, OBS, OJP, YJP, Fen, KLake

Chieftain RP-TS Cal at YPA., OA, WL, OBS, YJP, Fen

Helo RH-TS RH-TS RH-BS

Electra FE-RT 2100'

Kingair FK-GS 2200'

Twotter FT-GS FT-TS,CS 2000'

Long EZ FL-CS FL-CS FL-CS

RH-BS { OA, OBS

RH-TS { B9B7A, OA, YA, OBS, Fen, F1NOM, YJP, G6K8S, G9LQP, I2I8P

BOREAS Daily Team Participation Form

(2)

Thursday

DATE: 07-21-94 | Mission Manager: Sellers | Hot Site: SSA | NSA SAM: NEWCOMER | SSA SAM: MITCHELL

Team	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
AFM	W YPA *	W YPA *	W YKE *	W YPA *	7 W 7	* W OJP	* W *	W OPS *															
TF	W OA *	W OA *	* W DBS	W YJP *	W OJP *	W YA *	W OBS *	* W OJP	W OBS *	* W YJP FEN	W FEN *												
TE	PW OBS OJP *	W OA OJP *		W MIX YJP *	* OJP OBS *	W AUX MIX *	W OA MIX OBS *	W YA PWD *	* AWABCD	W OA *	P MIX OJP *	W YA YJP *	* AT 391 W AUX *		W WL *					W 913 120 *		W OBS AUX *	W Aux OBS *
TGB	* W BP Lab OJP		* FEN OBS OJP GIL	* W BP OJP	* W GFS			W OJP *	W OBS *	W OA OJP *													
HYD	* OJP YJP OJP YJP							* W JL	Piez 391 $20 HR LT														
RSS	W OA *	W YPA *	W YPA *				W FEN *			W *		W SBC *	W YPA *		W YJP *	W ALL TF *	W YJP *	W CAL *	W YPA 120+ WSL *	W RC *			
STAFF	W AUX PWD *																						

JL - Joey Lake
BP - Beaver Pond
GIL - Gilliam Rd.
CAL - Calibration Site
WL - Waskesui Lake

GFS - Gillum Fire Site
SBC - Sandy Bay Campground
120 - Hwy 120
HR - Harding Rd.

AT - Arrived Today
WSL - White Swan Lake
LT - Lake Temperature

Te 9 a - Lab OBS
b - repairs
c - 89 burn
d - OJP

(7)

MM/SAM Issues 07/21/94

1. Science meetings: 10 minutes/group.
   NSA - 1900, Friday night
   SSA - 1830, Saturday night : Snax , please bring beer.

2. Tower climbing course in SSA , monday 07/25/94, 1000LT.
   Last Chance for SSA people.

3. Modelers Workshop and tours
   Modelers will be at the SSA Science mtg + BOG
   Monday am tours of SSA TF sites.
   Monday pm tours of the aircraft.
   Tuesday tours of TF sites.
   (Wanna see TGB, TE, HYD stuff as well as TF).

4. Possible immense BBQ/beer bash at Waskesiu 7/28/94

5. Forms for Group reps: these are designed to help - try 'em out.

6. NSA-OA Site characterisation; TE-9D requested help; TE-22 wants to discuss after the BOG mtg.

7. Camera crew touring SSA tomorrow :
   am - YPA, Ops,
   pm - OJP, OA, PWD Labs

8. NSA low-level aircraft AM radio link up for tuesday.

9. SSA-OBS old TE tower site: request from TF-9 to take core samples from 28 trees around the old site. OK?

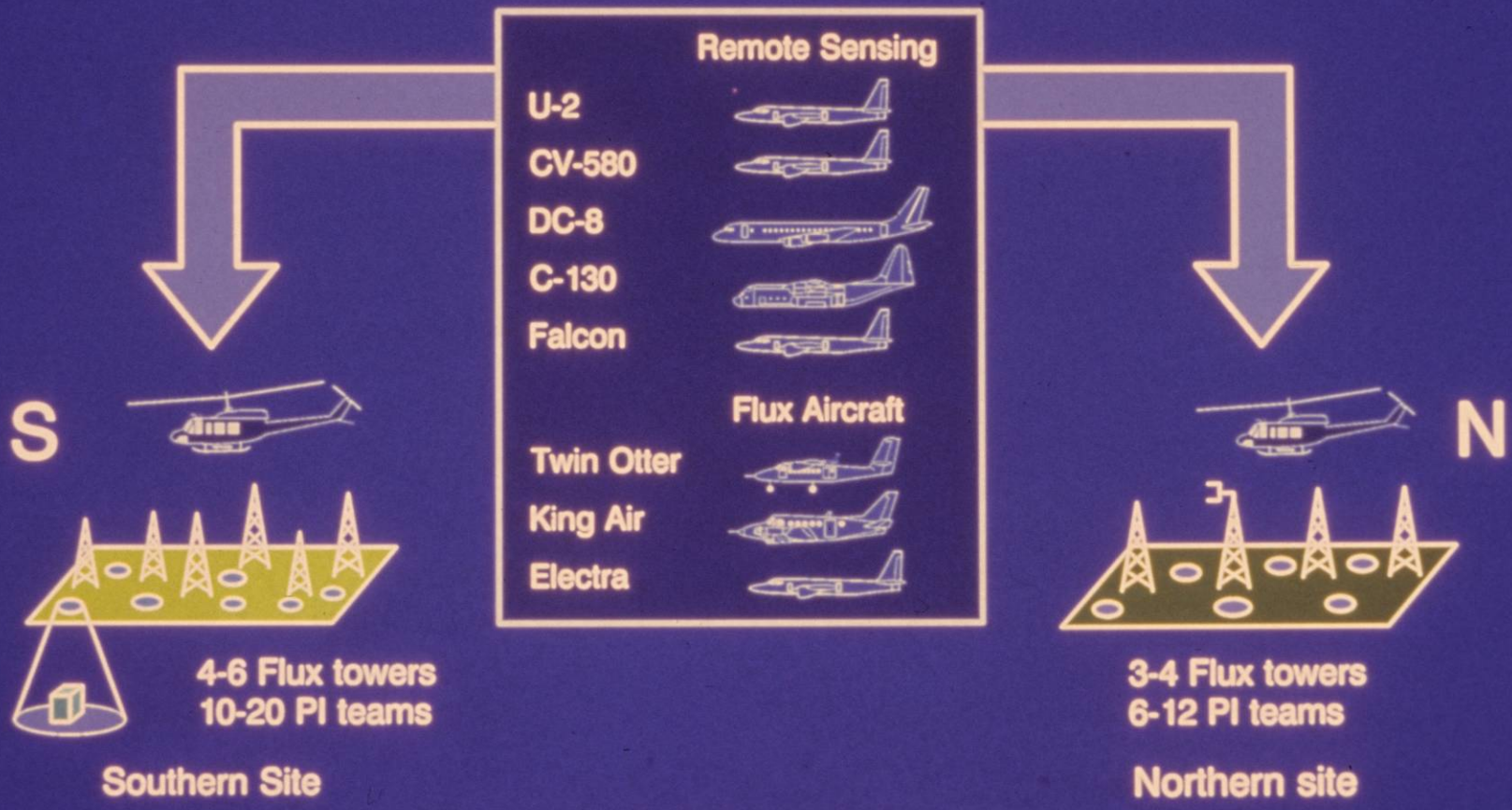
10. No alteration of TE towers without talking with TE captain or Ops

11. Want to go to SSA-OA? Arrange access the day before; double up vehicles. (Traffic jam at the gravel pit).
    VERY LIMITED ACCESS TO SSA-OA TOMORROW: ROAD REPAIRS

PLEASE DRIVE CAREFULLY

12. RSS-20 (Vern Vanderbilt) Need manual on GPS. Model Garmin GPS 100
Any info on Garmin (Phone #?) Extra manuals?

IFC OPERATIONS: FLEXIBLE RESPONSE



- Surface teams committed to each site
- Some specialized teams (radiometry) and aircraft committed to either site depending on conditions.

D223.027

(1)

SATURDAY

BOREAS Aircraft/Satellite Schedule

Date: 07-23-94

Mission Manager: SELLERS

Hot Site: SSA

NSA SAM: NEWCOMER

SSA SAM: ROSENBAUM

GMT	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	100	200	300	400
NSA	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300
SSA	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200

N-12 ▽ 46,62 | N-9 ▽ 53,26 | N-12 ▽ 49,49 | N-9 ▽ 41,40 | S-3 ▽ 10,37 | S-2 ▽ 28,36 | N-11 ▽ 44,49 | N-11 ▽ 50,63

N-11 △ 49,70 | N-12 △ 40,50 | N-9 △ 29,40 | S-2 △ 8,35 | N-11 △ 29,59

1200 RD-BS 0400

RD-BS 21600

30 RV-BS 0330

RV-BS 22000

RC-TS 19500

YA

RP-TS

RH-TS

RH-BS

RH-BS

FW-CS

FT-TS

OA, CS, OBS, OJP, LL

FL-CS

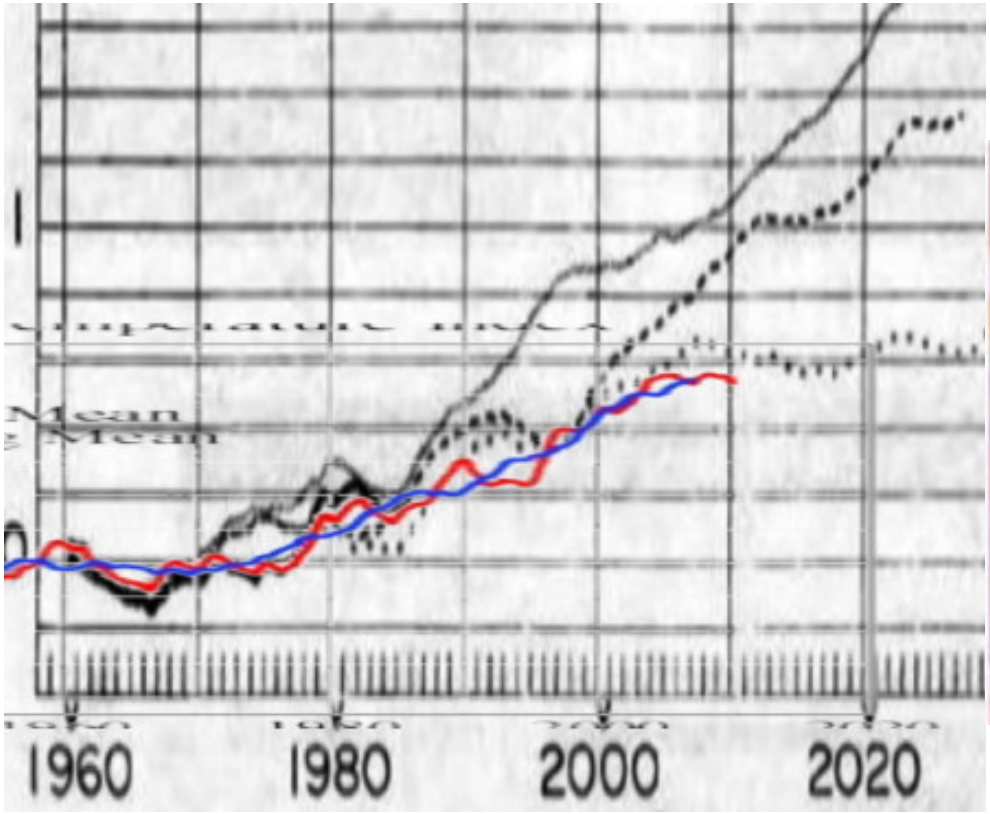
FL-TS OJP

FE WX SCRUB

RH-TS: DOH65, YA, FSI6P
F1JOP, OBS

Jim Hansen and Congress (1988)

but the papers were written in 1975, 1979..



FIFE and BOREAS

Its been 29 years since FIFE-87.

How did it all start? ..or what did we know and when did we know it?

1981: NASA Workshop on Land Surface Parameterizations (LSPs) as used in atmospheric General Circulation Models (GCMs).

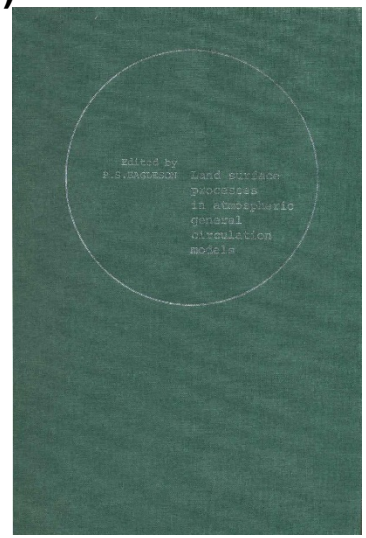
Hydrologists, Meteorologists, Satellite-ists

The Book (Ed. Peter Eagleson; 1983) concluded that:

- **LSPs were unrealistic and primitive**
- **Fixed fields of albedo and surface roughness ("made up")**
- **One-dimensional soil block model**
- **Beta-function used for Evapotranspiration**
- **No accounting for vegetation**

Question: " ***Is it worth improving LSPs in GCMs ? "***

Note: 4 acronyms on the first chart…



THE BUCKET MODEL

ALBEDO

Prescribed from measurements, biased to visible wavelengths

Too dark; forests were 7%, not 13%

ROUGHNESS

Uniform roughness
Tuned to optimize drag or energy balance
Usually too rough

EVAPORATION

The bucket model
Full bucket: Evaporates like a lake
Empty bucket: Dry

$$\text{e.g., } \frac{dW}{dt} = P - W.E_{wet}$$

M737.003

First Generation LSP

Fixed Albedo

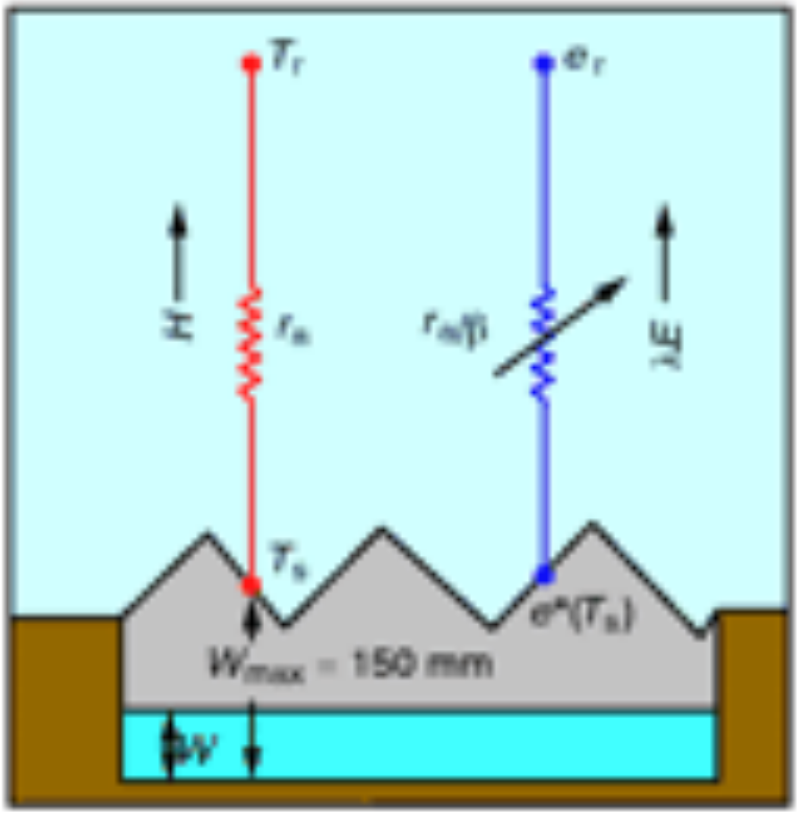
Fixed Roughness

Simple ET

"Manabe bucket model".

150 mm capacity

B = W/Wmax

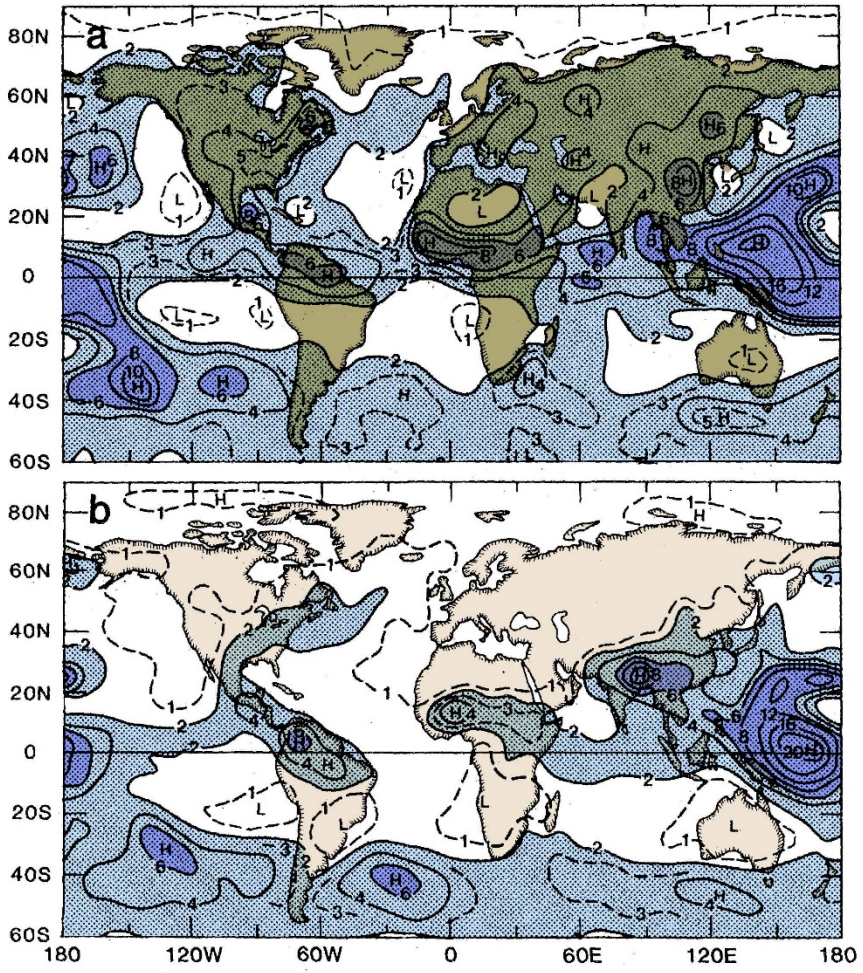


Model Simulated July Precipitation mm/day

Wet Soil Case (β = 1)

Dry Soil Case (β = 0)

Shukla and Mintz, Science 1982

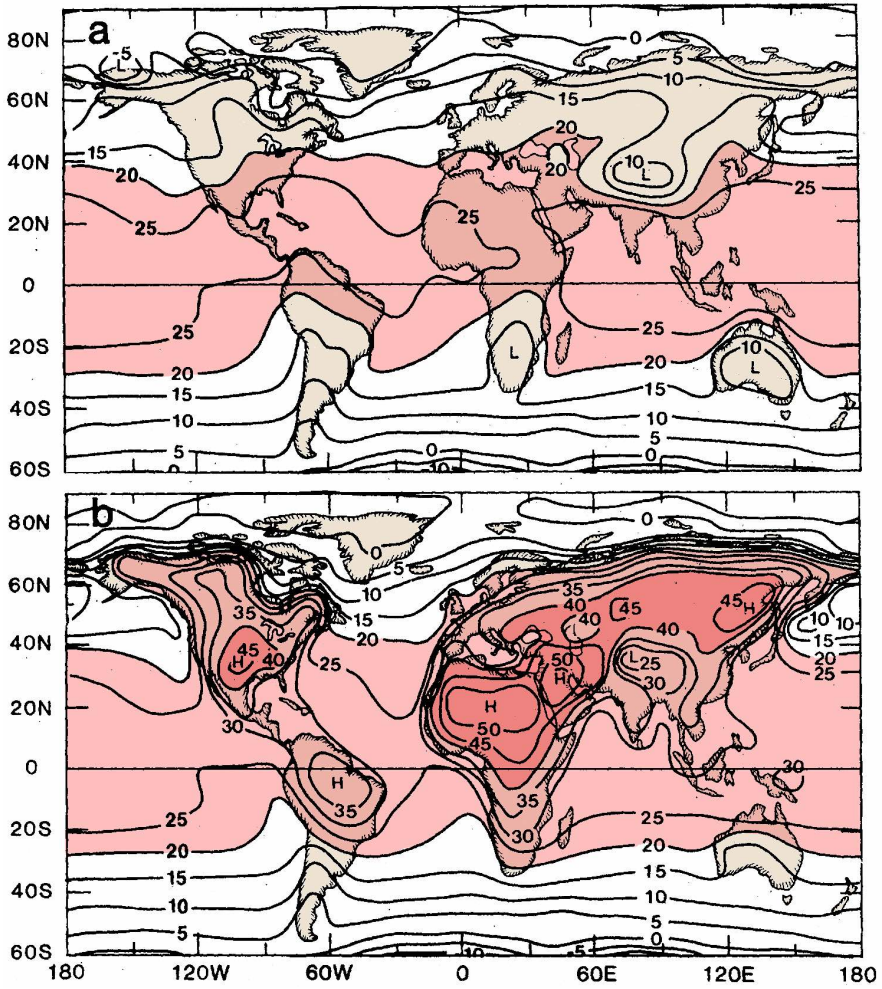


Model Simulated July Surface Temperature ℃

Wet Soil Case (β = 1)

Dry Soil Case (β = 0)

Shukla and Mintz, Science 1982



And so ISLSCP was born..

1984: First meetings of ISLSCP, and the first report.
A series of field experiments was called for to:

(i) Collect the data required to develop and improve LSPs, and
(ii)Develop satellite-based methods to initialize and validate these parameterizations on regional and global scales.

1985-1986: NASA 923 (Biospheric Sciences) steps up to the plate.
….the search for funds, PI selection, thinking, planning…

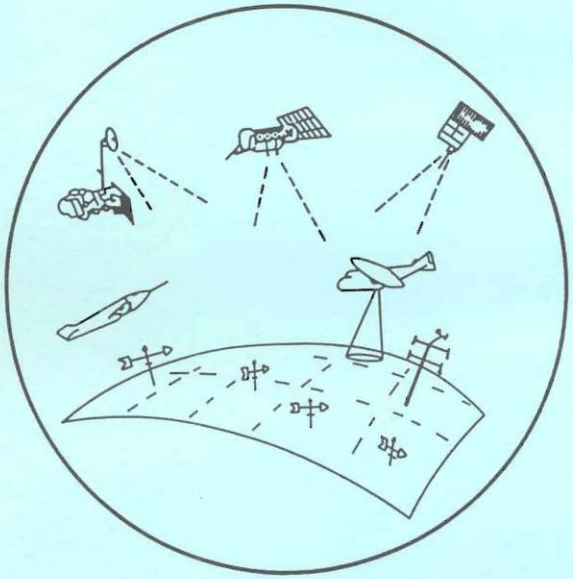
1986: The HAPEX-Mobilhy experiment in France

1987: FIFE-87 hits the field near Manhattan, Kansas
15 km by 15 km prairie site, near KSU
….too late to back out now..


FIFE

FIFE SCIENCE PLAN

ISLSCP INTERNATIONAL SATELLITE LAND SURFACE CLIMATOLOGY PROJECT



FIFE

First ISLSCP Field Experiment

Final Version : May 1986

EXPERIMENT PLAN

International Satellite Land Surface Climatology Project

May 1987

ABL	Atmospheric Boundary Layer	6
SF	Surface Fluxes	7
CC	Correction/Calibration	4
SRB	Surface Radiances/Biology	7
SM	Soil Moisture	7
IS	Integrative Science	4
		35

Staff science (GSFC, KSU)
FIFE Information System (GSFC)
Soviet teams in 1989

FIFE-87..baptism by fire, chiggers, and sleep deprivation

MetNet, soil moisture monitoring all year

4 Intensive Field Campaigns (IFCs), each ~2 weeks

- **Green-up**
- **Peak Greeness**
- **Drydown** (didn't happen in FIFE-87 ..Kansas stayed green)
- **Senescence** (peak deadness)

Coordinated measurement plans with on-the-fly improvizations

5 satellites; 10 aircraft; ~150 people.

Satellite overpass schedule, weather, equipment failures, personnel disasters….

Coordinated operations management through nightly meetings and real-time radio communications (eventually)

Long-suffering hardworking Staff from NASA/GSFC Code 923, and Kansas State University

The FIFE Information System

Revolutionary idea, and managed by a revolutionary (a great contribution by Don Strebel)

Consistent formatting and documentation for all data sets

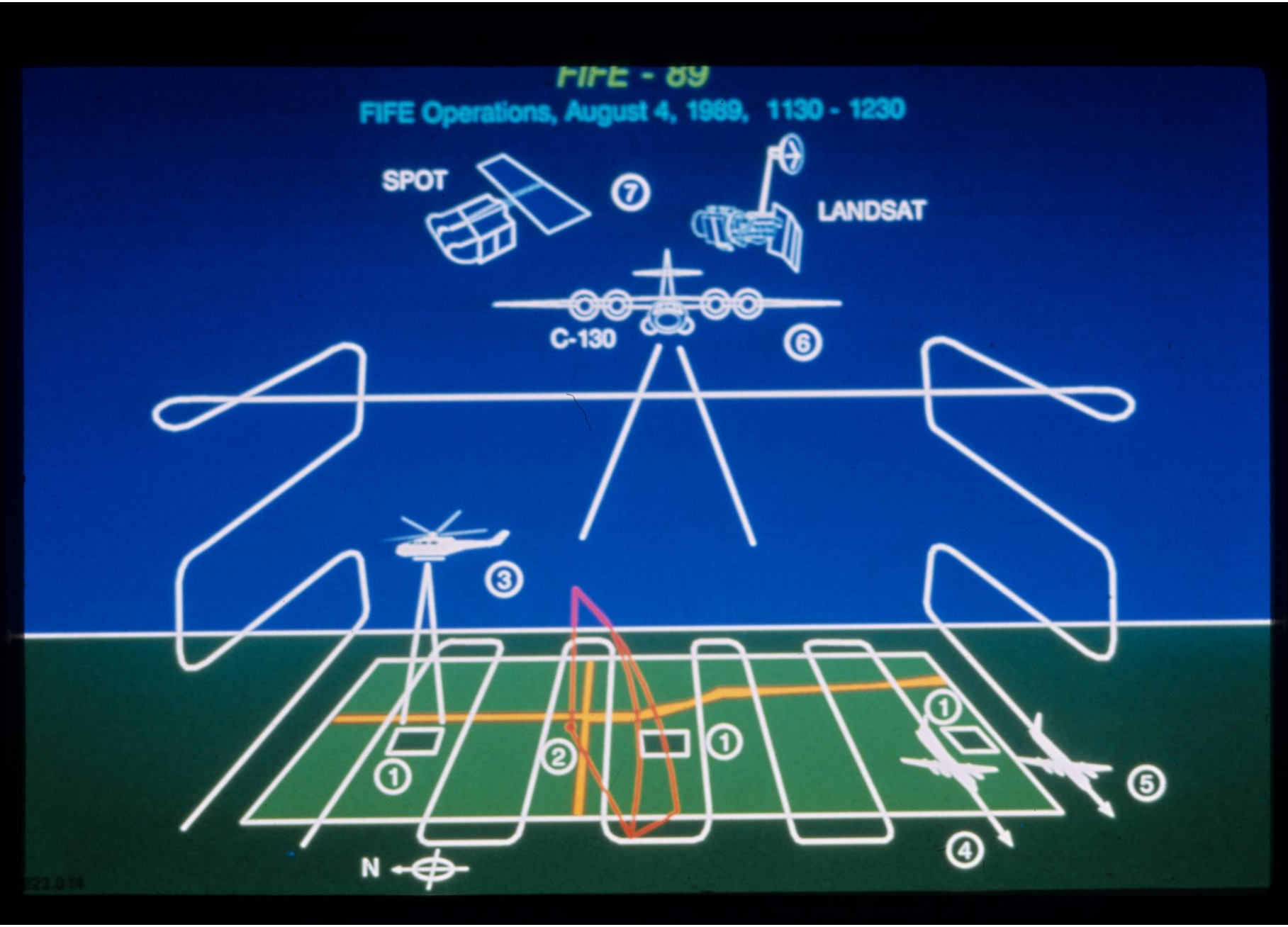
Data sharing agreements – the key to successful interdisciplinary science

Immediate results of FIFE-87

Very successful collection of almost all the required data sets: simo observations from subsoil to orbit.

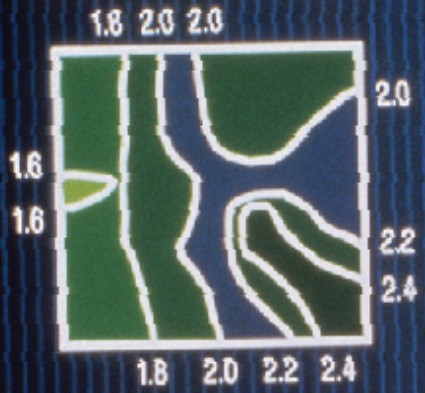
No drydown observed > so FIFE-89 was designed and executed


C-FYDE

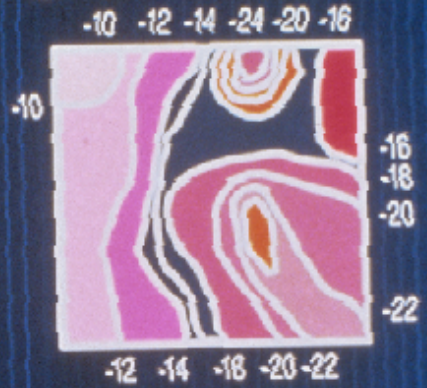

FIFE - 89
FIFE Operations, August 4, 1989, 1130 - 1230
SPOT
7
LANDSAT
C-130
6
3
1
2
1
1
5
4
N

JULY 28, 1989

Greenness Index

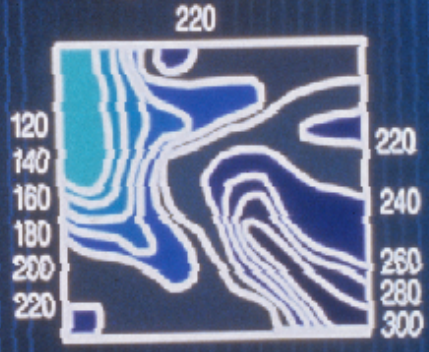


CO_2 Flux ($kg\ ha^{-1}\ h^{-1}$)

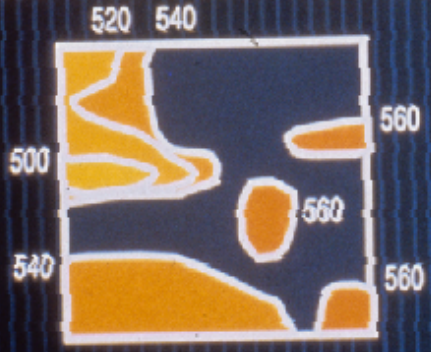


Ts – Ta (°C)

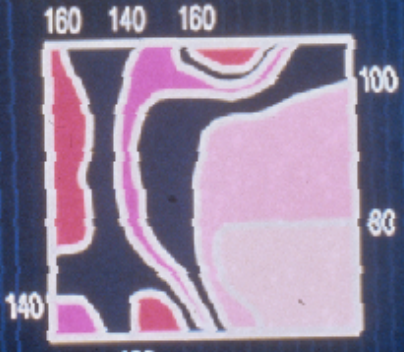
H_2O (Wm^{-2})



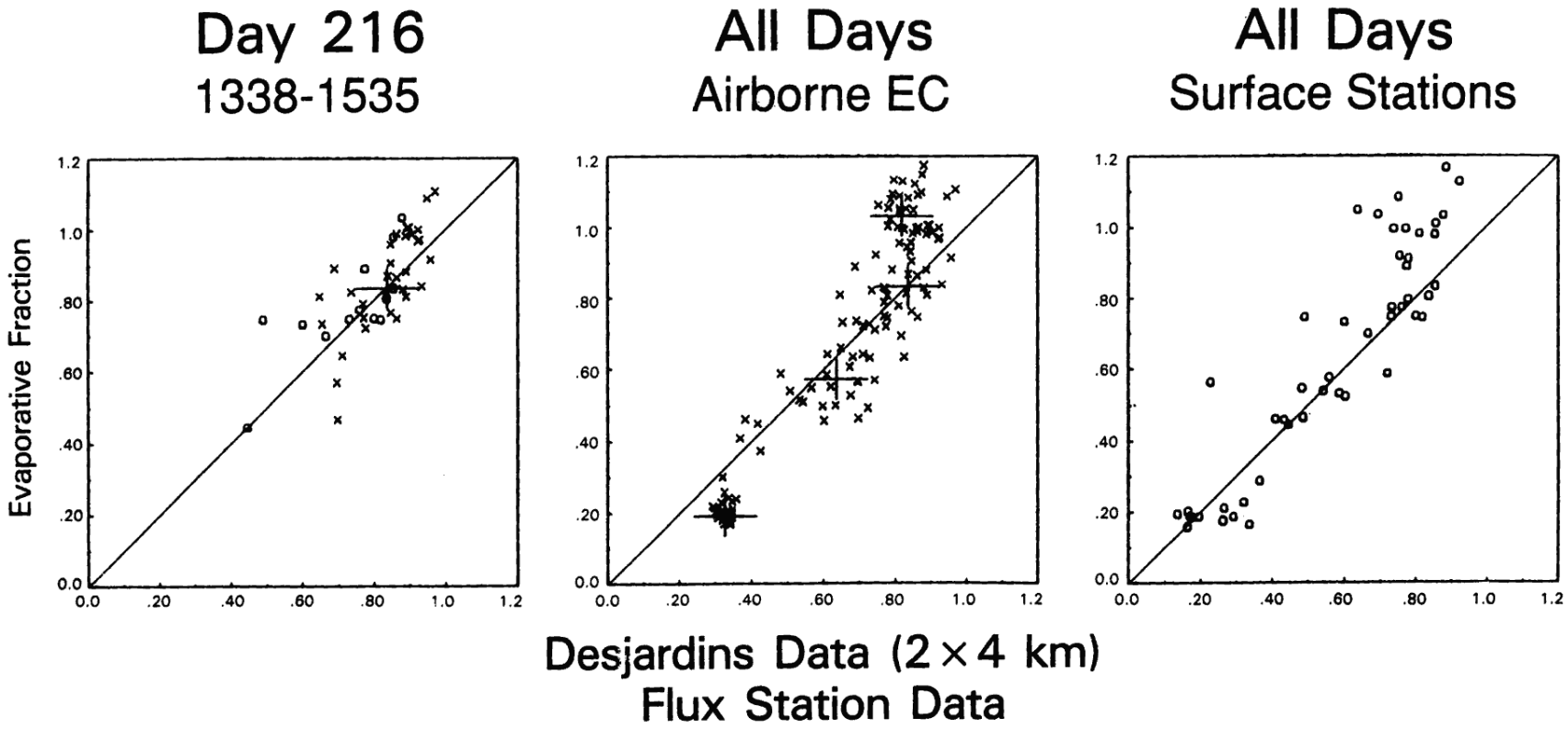
Net Radiation (Wm^{-2})



Heat Flux (Wm^{-2})



Simple Biosphere Model (SiB)
Calculations

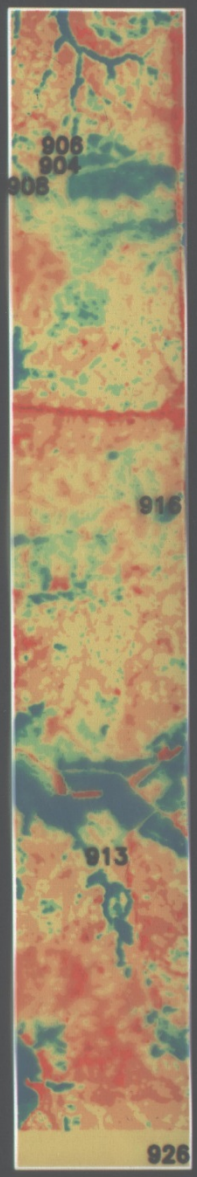


DEM

320 340 360 380 400 420 440 460

GrADS: COLA/IGES

SPOT Simple Ratio



2 2.5 3 3.5 4 4.5 5 5.5 6

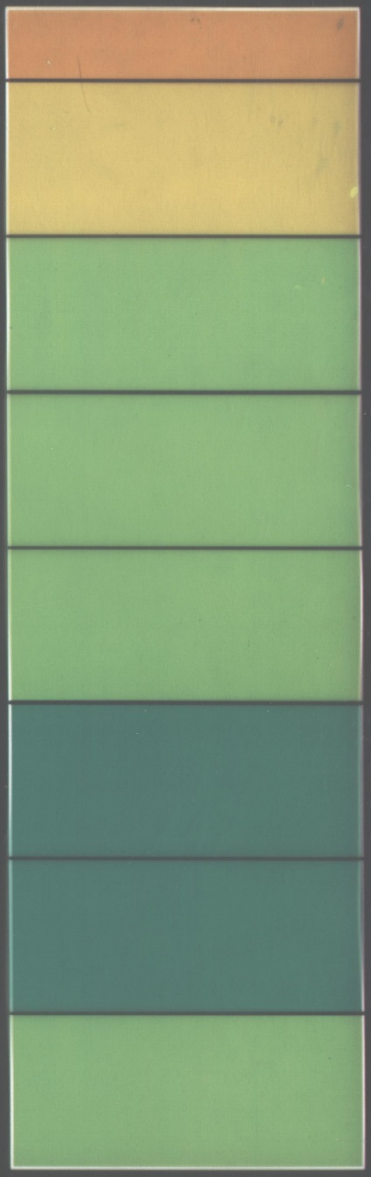
GrADS: COLA/IGES

W1(PBMR)

0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

GrADS: COLA/IGES

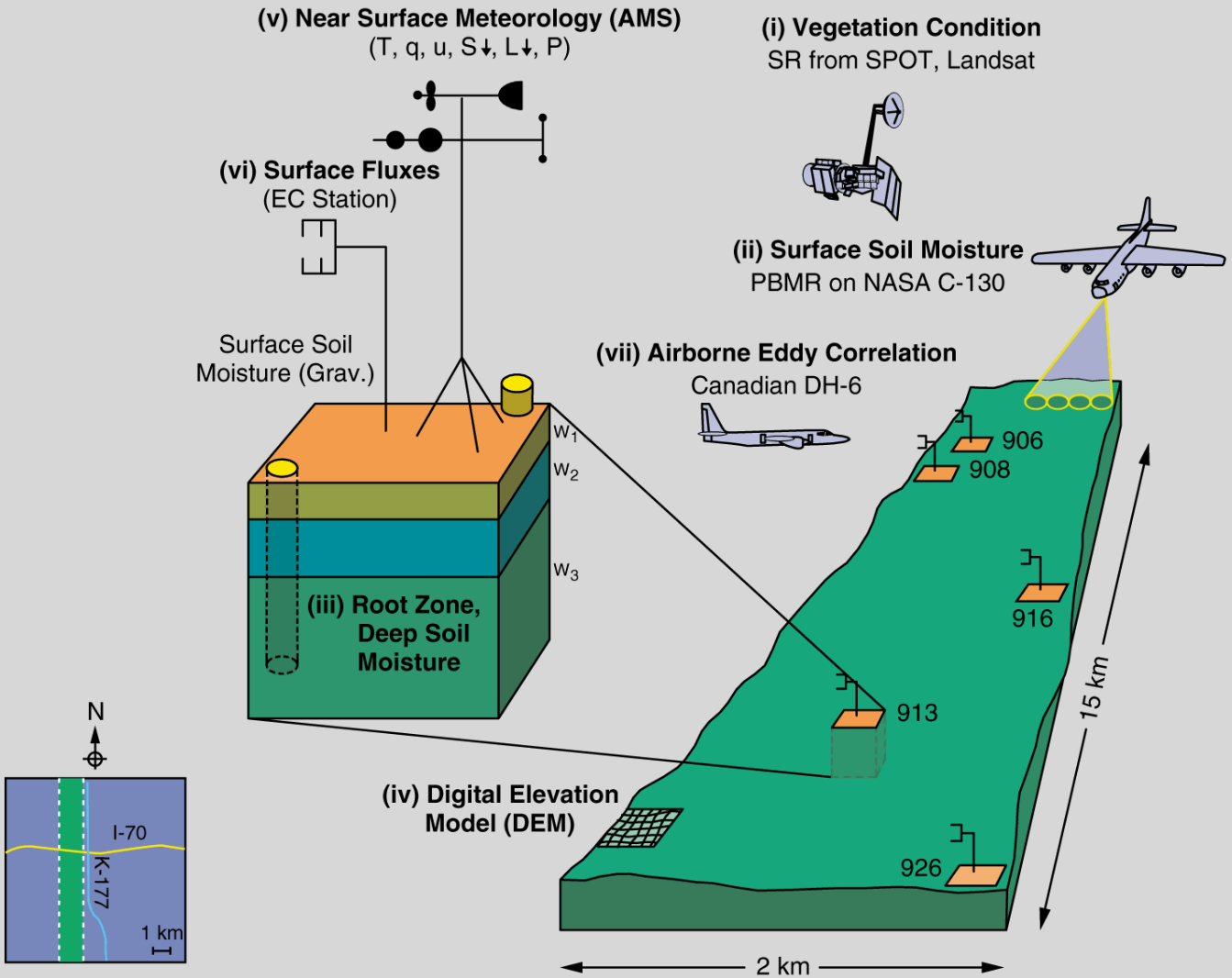
Airborne Flux EF



0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95

GrADS: COLA/IGES

FIFE-89 Testbed Area
Verification of g_c* vs. Vegetation Index Relationship



A1350.006 Sellers

REMOTE SENSING SCIENCE

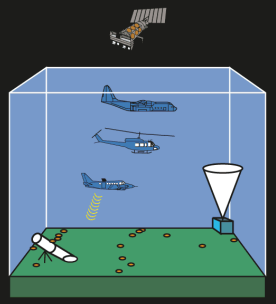
Satellite
(TIR, Optical)

Airborne
(TIR, Optical,
Microwave, Radar,
Gamma-ray)

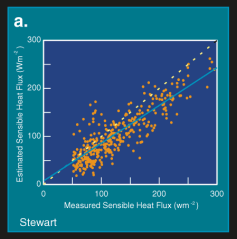
Lidar, photometry

Surface radiometry
(various)

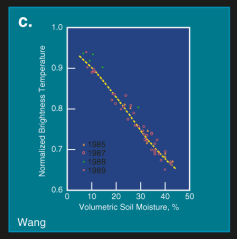
In situ validation techniques



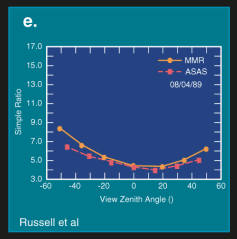
Thermal | **Microwave** | **Optical**



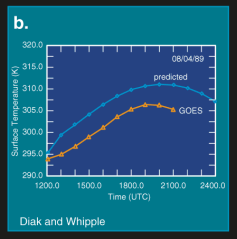
Stewart



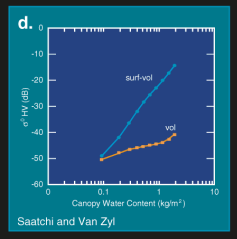
Wang



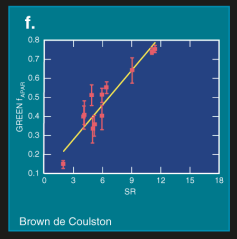
Russell et al



Diak and Whipple



Saatchi and Van Zyl



Brown de Coulston

A1020.003 OD6

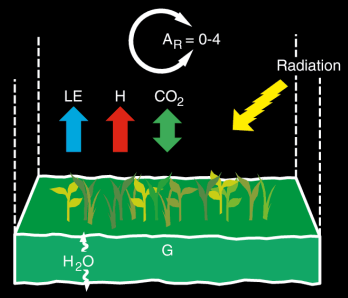
PROCESS MODELS

ABL processes

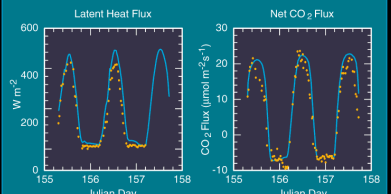
Mixed layer models

Coupled SVAT Models
(Energy-Water-Carbon)

Soil Physics
(Heat and Water)



a. SVAT Model Improvement



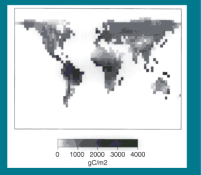
Berry (pers. comm.)

b. Improved NWP Model Performance


Viterbo and Beljaars (1995)
Beljaars et al (1995)

c. Global Energy-Water-Carbon Models

Annual Gross
Primary Production



Sellers et al (in press; a, b)
Randall et al (in press)

A1020.002 OD6

MEASUREMENTS AND FIELD EXPERIMENT DESIGN

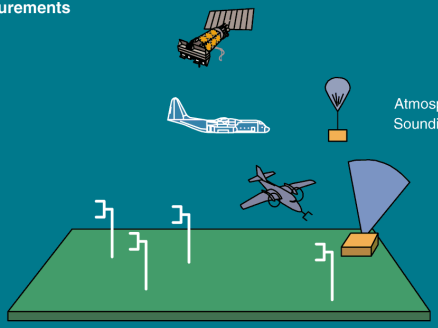
a. Improved Measurements

Satellite and Airborne Remote Sensing

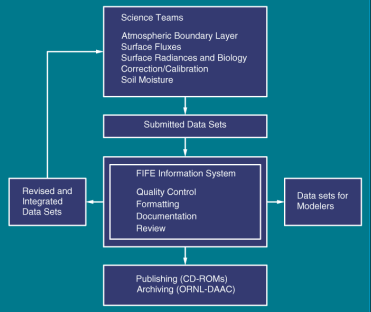
Atmospheric Sounding

Airborne and Surface Fluxes

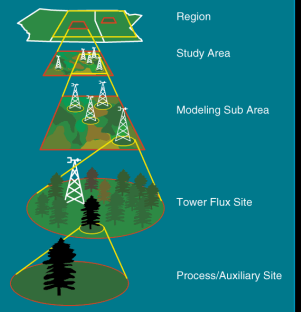
In situ Measurements



b. Integrated Data System



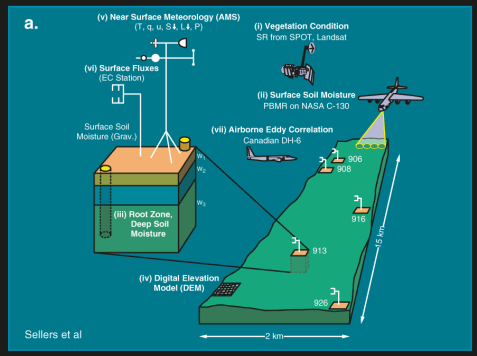
c. Nested Scale Design



A1020.04 OD6

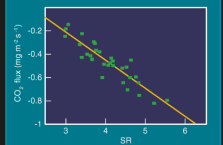
SCALE INTEGRATION

a.



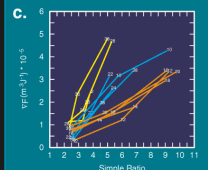
Sellers et al

b.



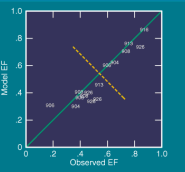
Desjardins et al

c.



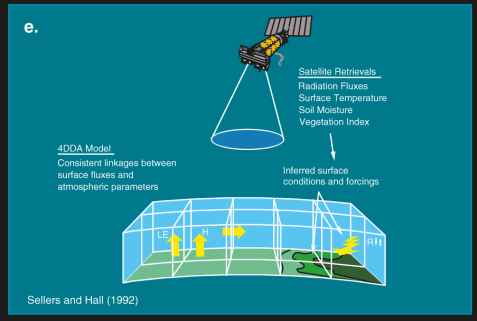
Sellers et al (1992)

d.



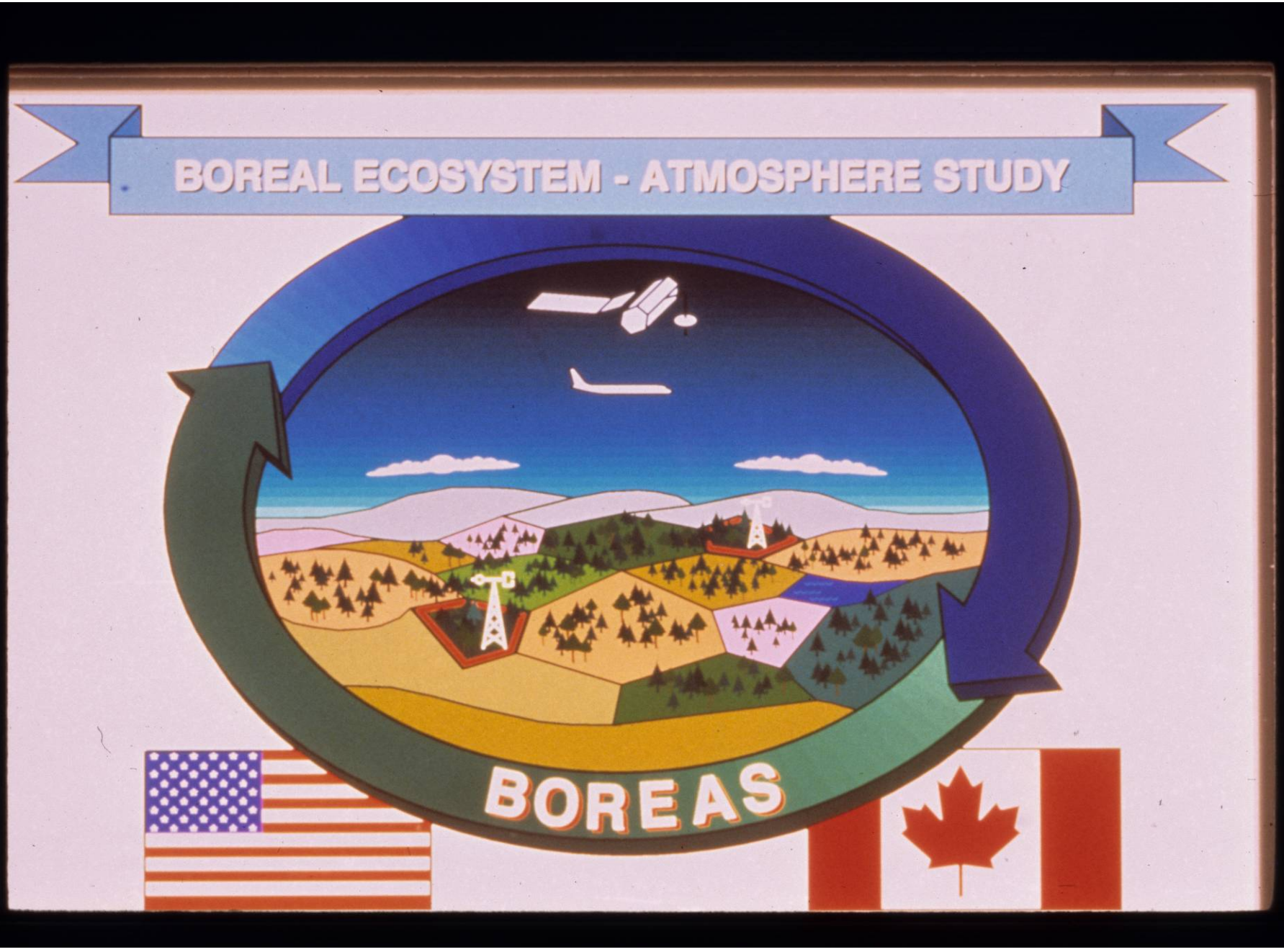
Sellers et al

e.



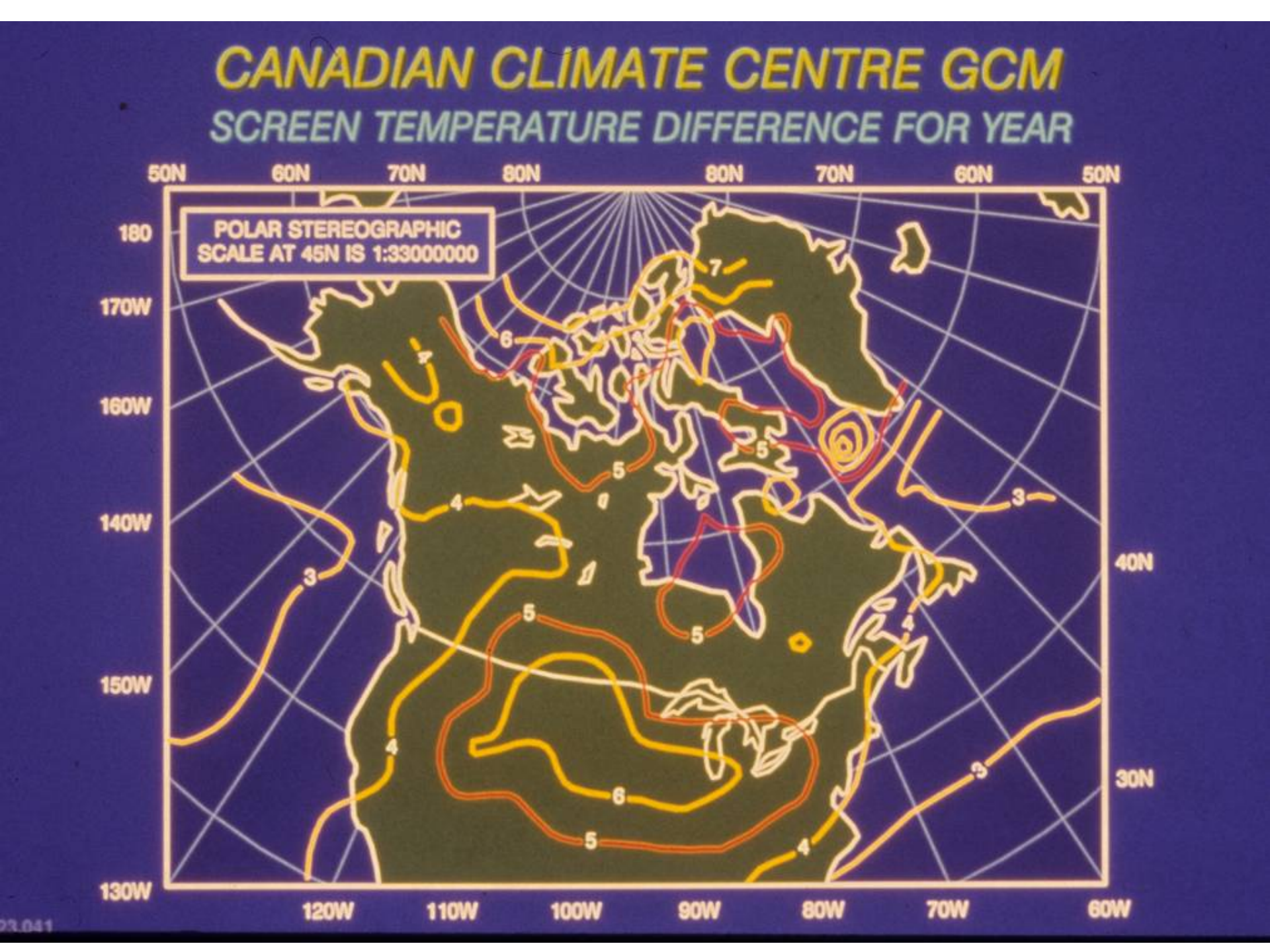
Sellers and Hall (1992)

A1020.005 OD6

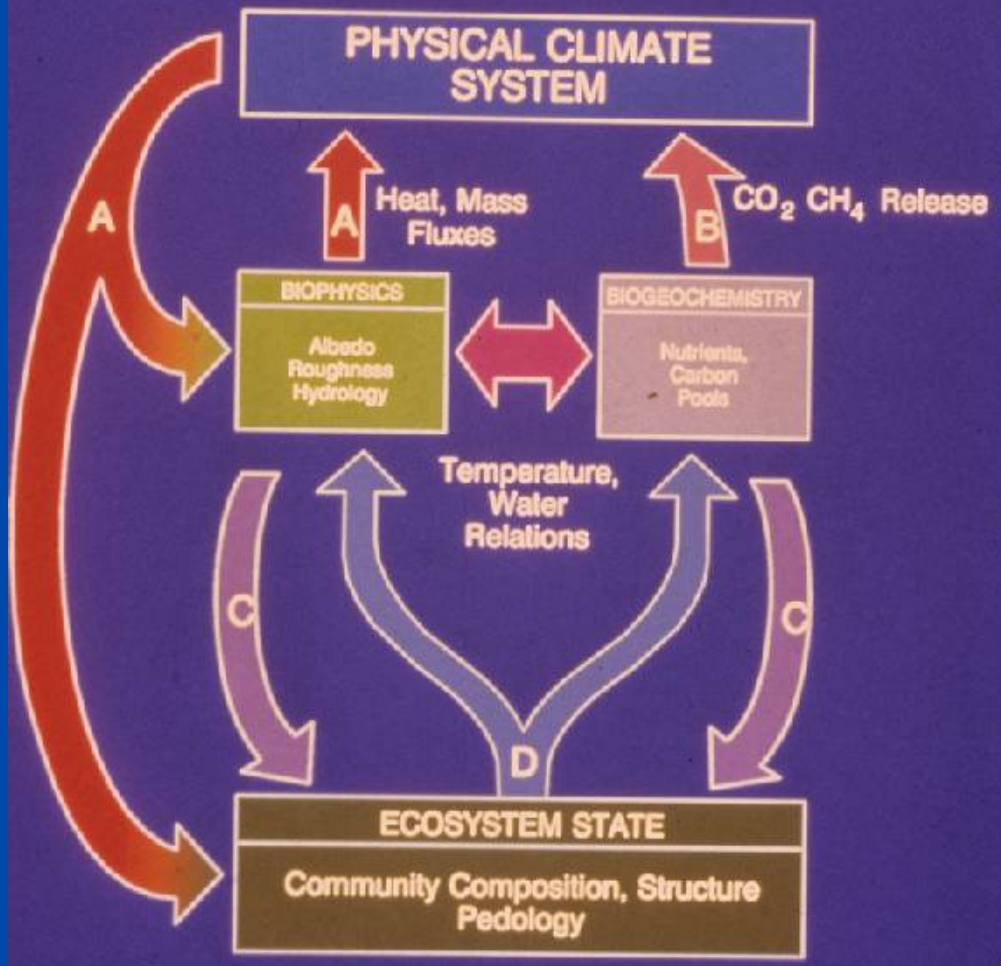

BOREAL ECOSYSTEM - ATMOSPHERE STUDY
BOREAS

CANADIAN CLIMATE CENTRE GCM

SCREEN TEMPERATURE DIFFERENCE FOR YEAR



THE CLIMATE SYSTEM AND THE BOREAL FOREST
FORCINGS AND FEEDBACKS



BOREAS was tougher, but so were we…

US and Canadian Project, with international participation.

Southern and Northern Study Areas selected in 1990-91.
Each study area ~ 100 km; separated by 600 km

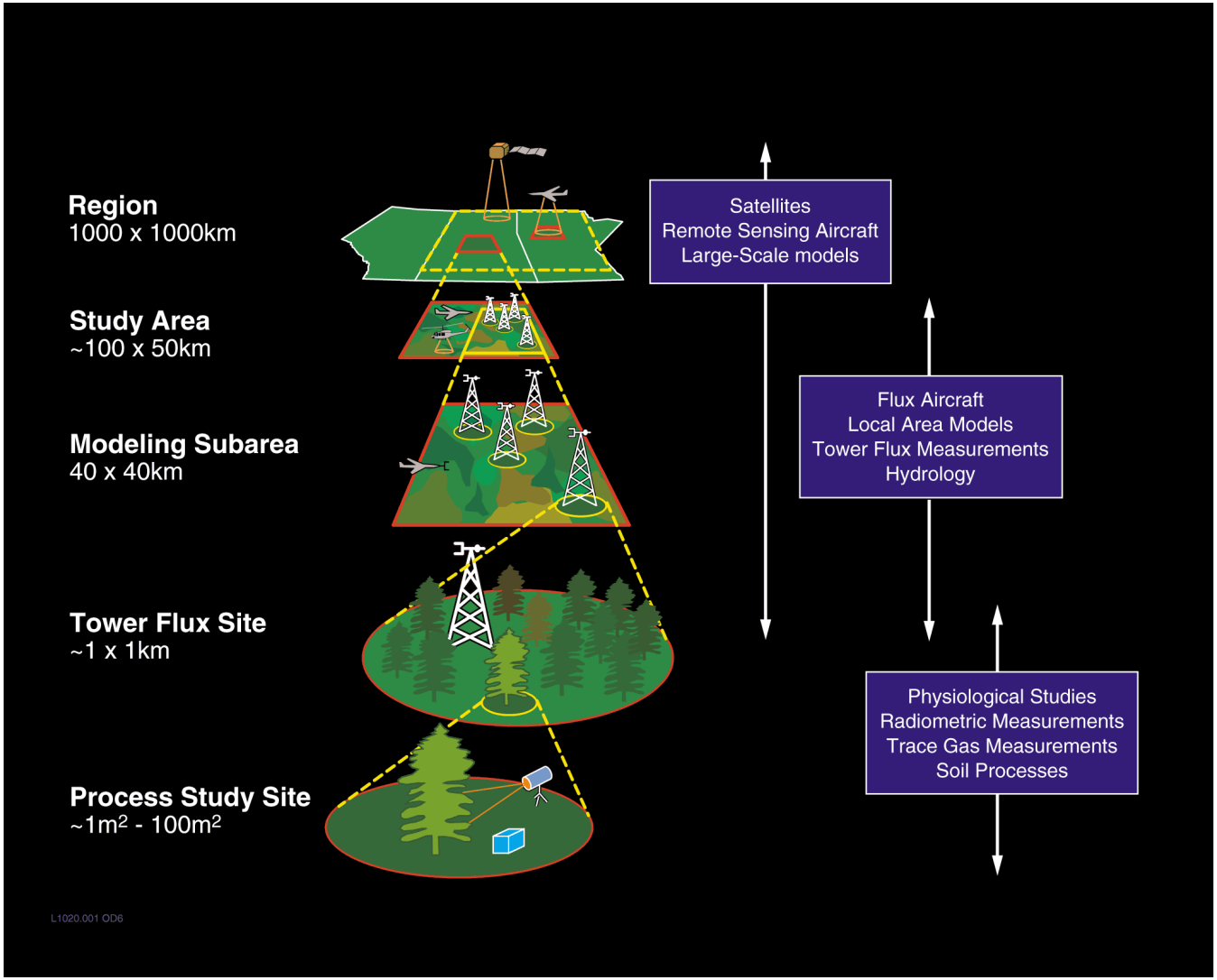
Field Campaigns in 1993, 1994, 1996:
*12 aircraft; 1000*1000 km area; 12 towers; 300 people.*
Complex logistics; communications; operations.

Operating in the wilderness, harsh climate, vile bugs.

Infrastructure taken over by Canada.

AFM	Aircraft fluxes, meteorology	14
TF	Tower flux	10
TE	Terrestrial Ecosystems	21
HYD	Snow and Hydrology	10
TGB	Trace gas and biogeochemistry	10
RSS	Remote Sensing Science	21

0737.001

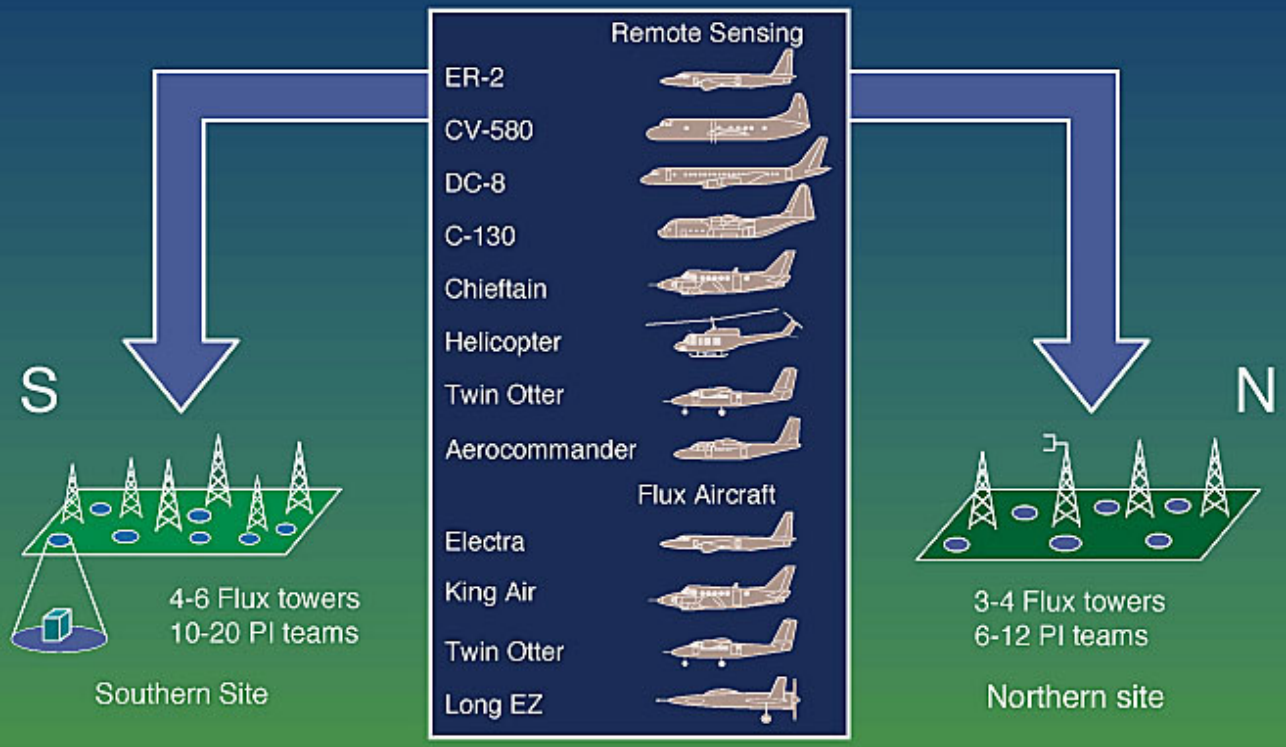

Region
1000 x 1000km
Study Area
~100 x 50km
Modeling Subarea
40 x 40km
Tower Flux Site
~1 x 1km
Process Study Site
~1m² - 100m²
Satellites
Remote Sensing Aircraft
Large-Scale models
Flux Aircraft
Local Area Models
Tower Flux Measurements
Hydrology
Physiological Studies
Radiometric Measurements
Trace Gas Measurements
Soil Processes
L1020.001 OD6


N415NA


BB
17 13 10

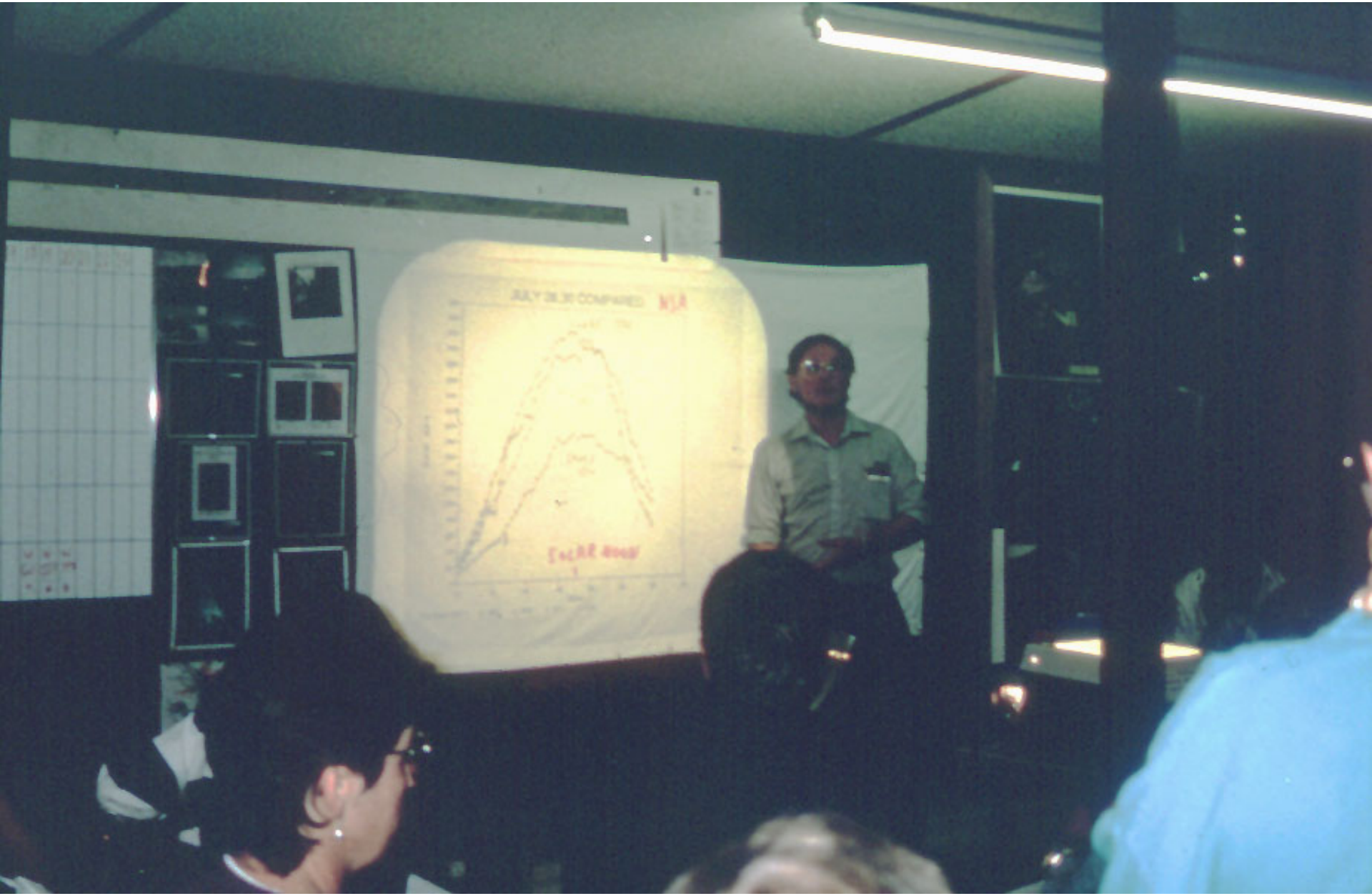

N2UW

IFC OPERATIONS: FLEXIBLE RESPONSE



- Surface teams committed to each site
- Some specialized teams (radiometry) and aircraft committed to either site depending on conditions.

D223.027




MM
SAM

Results from FIFE and Boreas

Collection of large integrated data sets.

Data sets that can be used by everyone.

(thanks to FIS, BORIS, ORNL-DAAC).

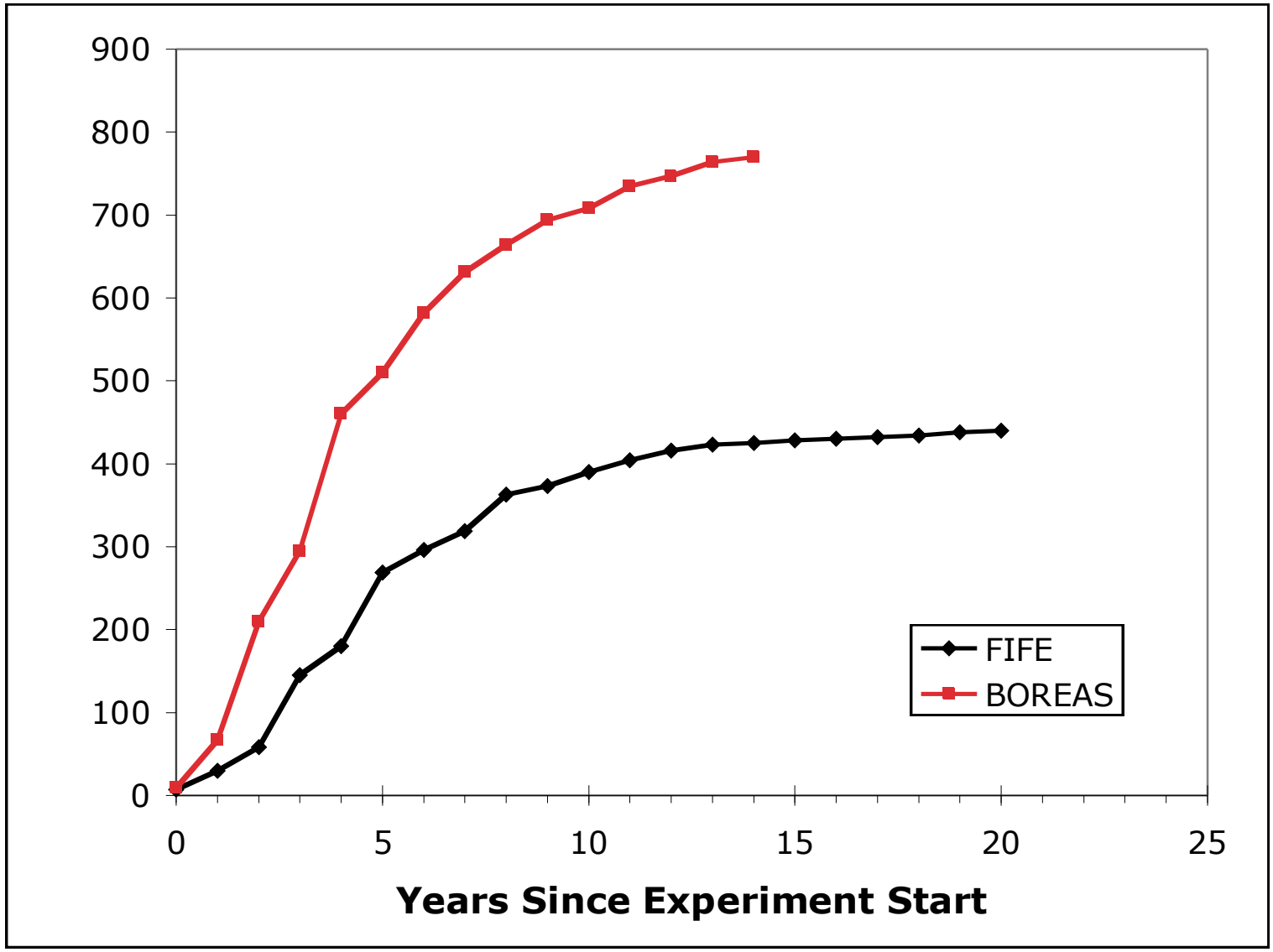
Tsunamis of publications.

First – single discipline work, as PIs sorted out their data.

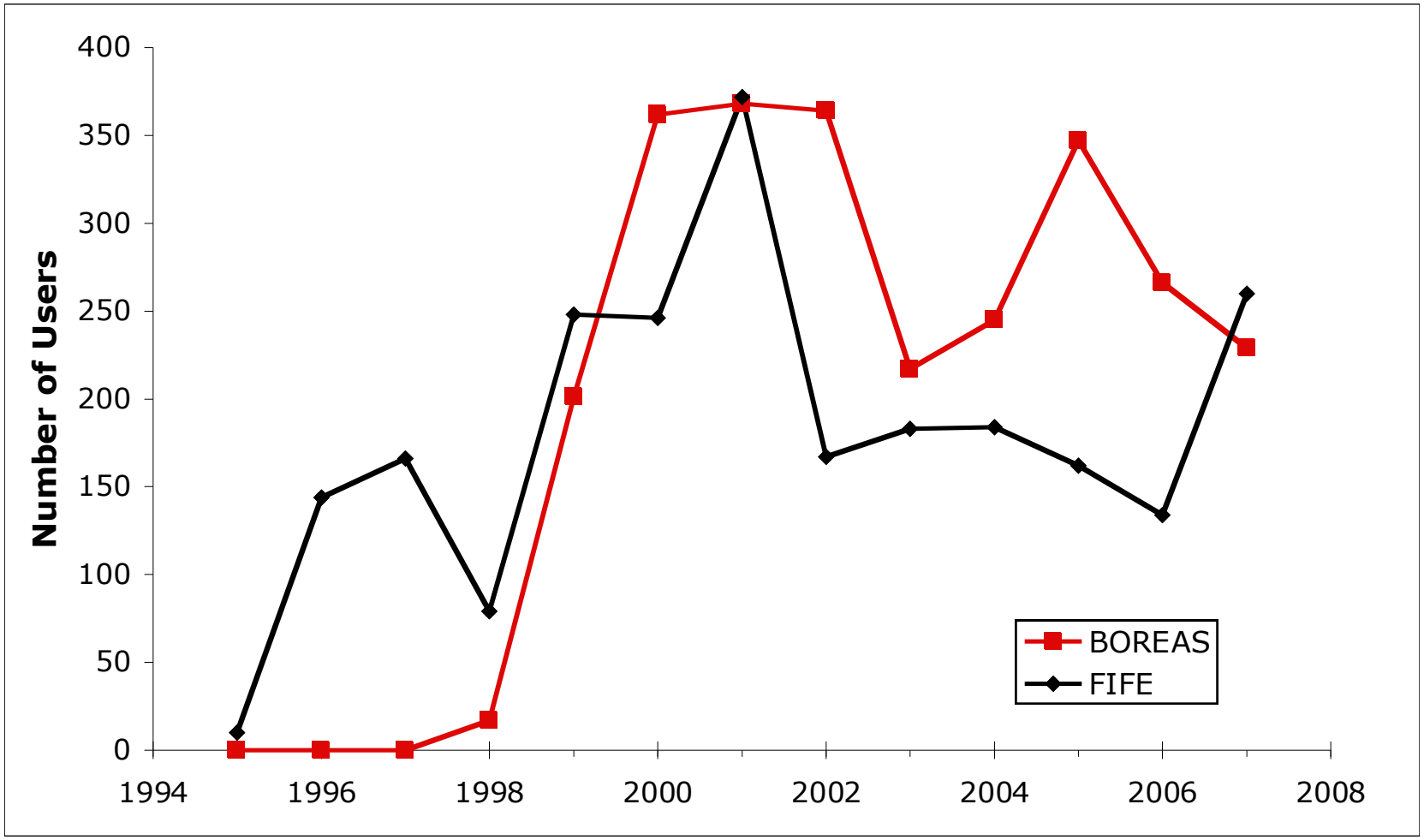
Later – interdisciplinary modeling and analysis.

Several special issues

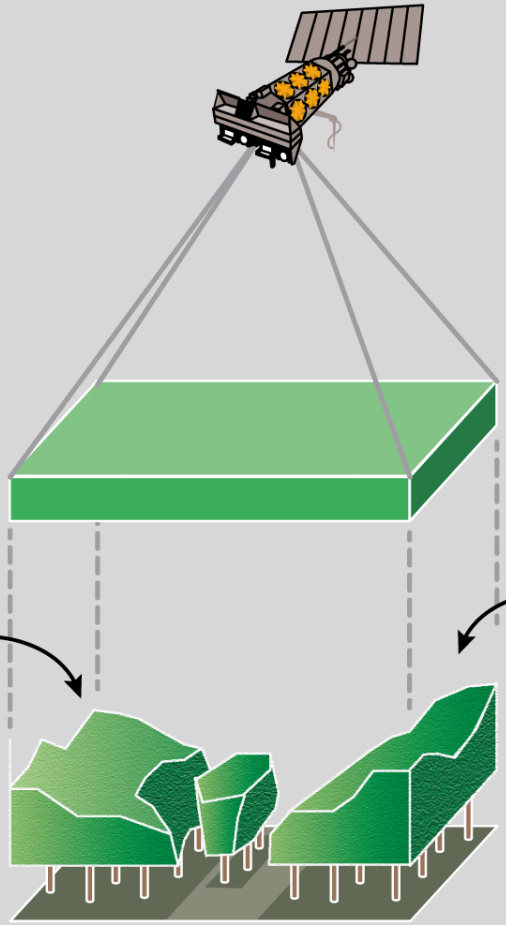
Data use continues actively to this day..


900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
Years Since Experiment Start
FIFE
BOREAS

Number of Users Accessing Data from ORNL DAAC



Area-integrated Photosynthesis, Conductance are retrievable from orbit



"Uniform" pixel of Greeness, **VI**

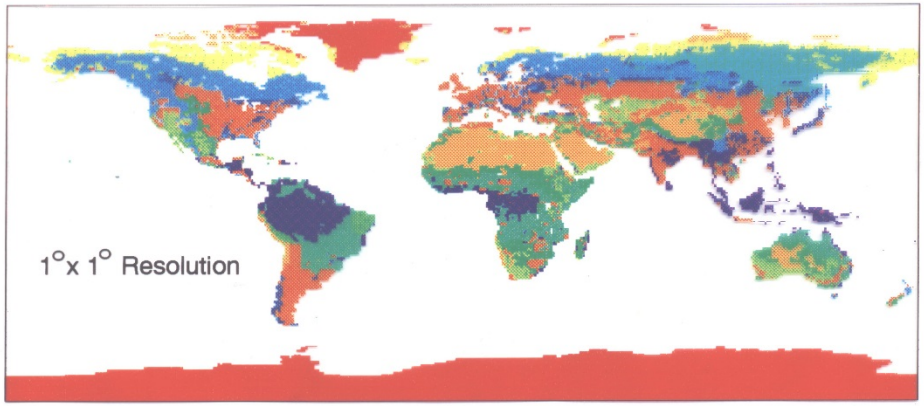
V_{max_0}

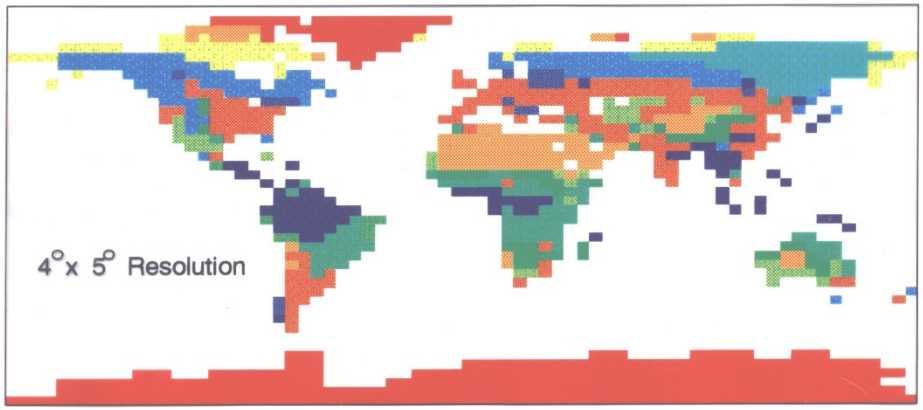
A_s, g_s

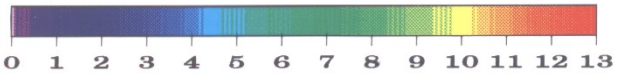
Optimally distributed "cloud" of cloroplasts

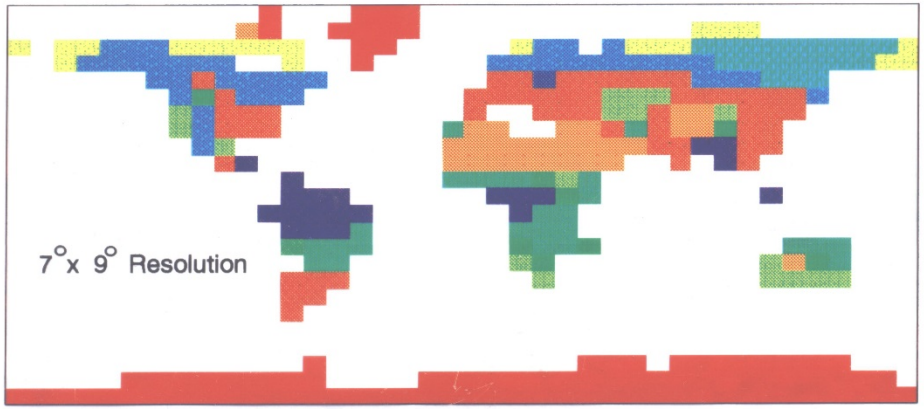
$$\langle A_C, g_C \rangle \propto \textit{Spectral vegetation index}$$

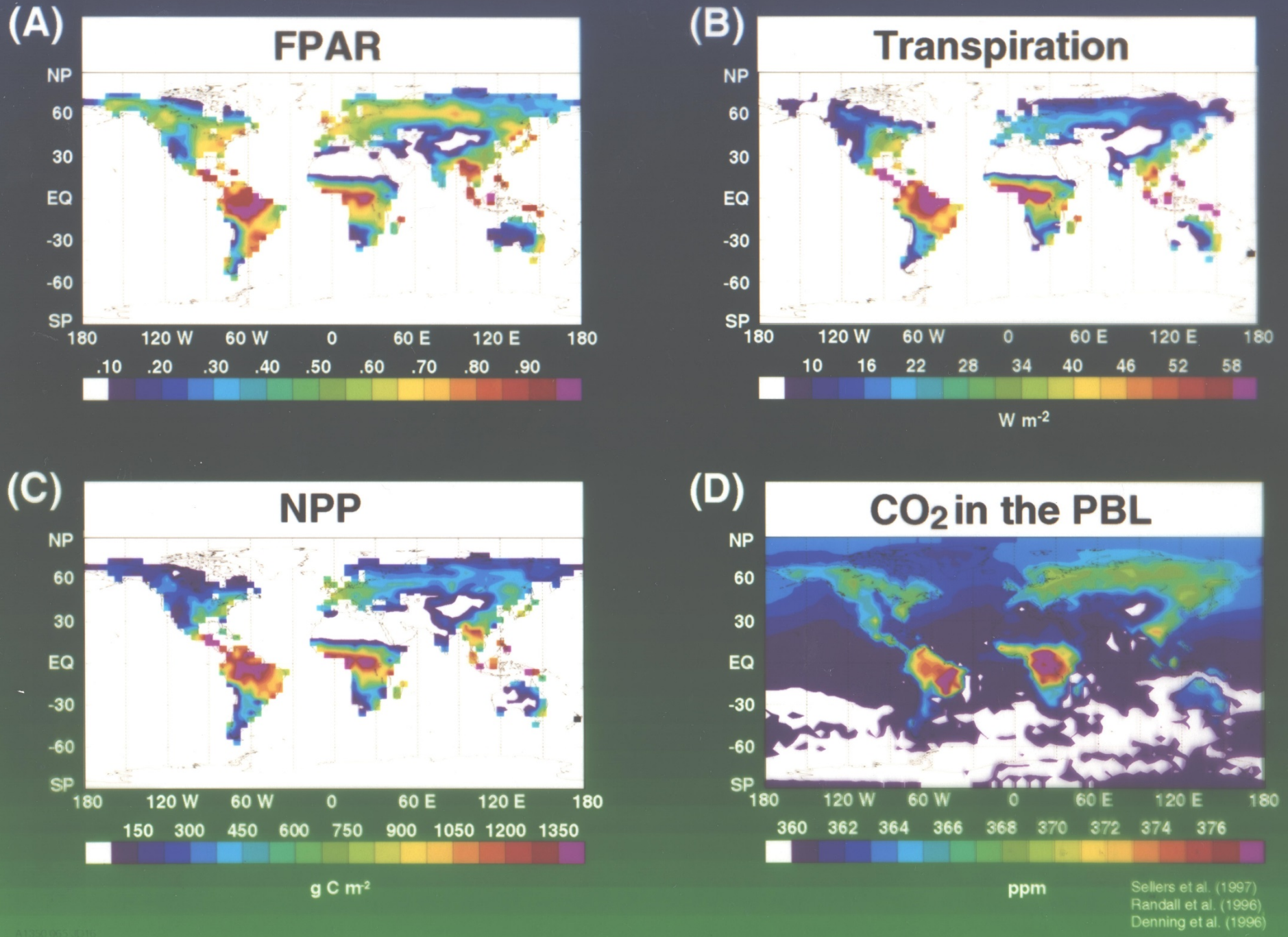
SiB2 Vegetation Maps










(A)
FPAR
NP
60
30
EQ
-30
-60
SP
180
120 W
60 W
0
60 E
120 E
180
.10 .20 .30 .40 .50 .60 .70 .80 .90
(B)
Transpiration
10 16 22 28 34 40 46 52 58
W m-2
(C)
NPP
150 300 450 600 750 900 1050 1200 1350
g C m-2
(D)
CO2 in the PBL
360 362 364 366 368 370 372 374 376
ppm
Sellers et al. (1997)
Randall et al. (1996)
Denning et al. (1996)

…The field experiments arrived just in time for Earth System Science..

Accelerated collaboration between previously separated scientific communities.

Interdisciplinary science (as real work, instead of a cliché).

Incredibly fast development of new models and techniques.

Pathfinder for much EOS work.

A new generation of experienced, motivated students.

Friends, shared adventures, war stories….

So..what was achieved?

- *Input for Eos, in the nick of time.*
- *Complete integrated data sets – from subsoil to orbit.*
- *Development and testing of realistic physiological LSPs; integration of physiology and carbon exchange.*
- *Integration and testing of remotely-sensed data into surface process models and GCMs.*
- *Scaling up to the globe: production of global data sets from satellite data.*
- ***More credible (3rd-generation) LSP-GCMs for global change prediction**.*

..it was worth the effort..