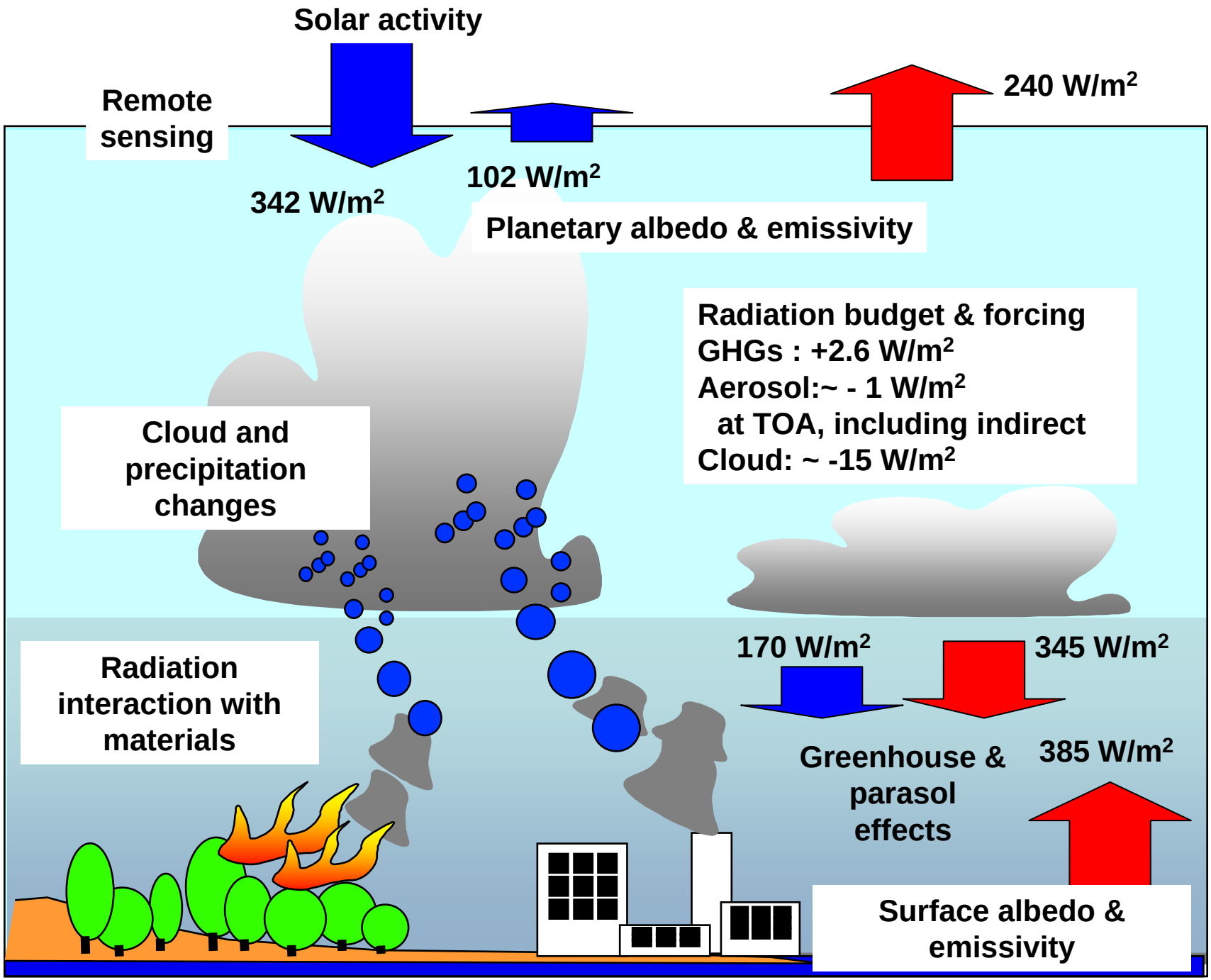
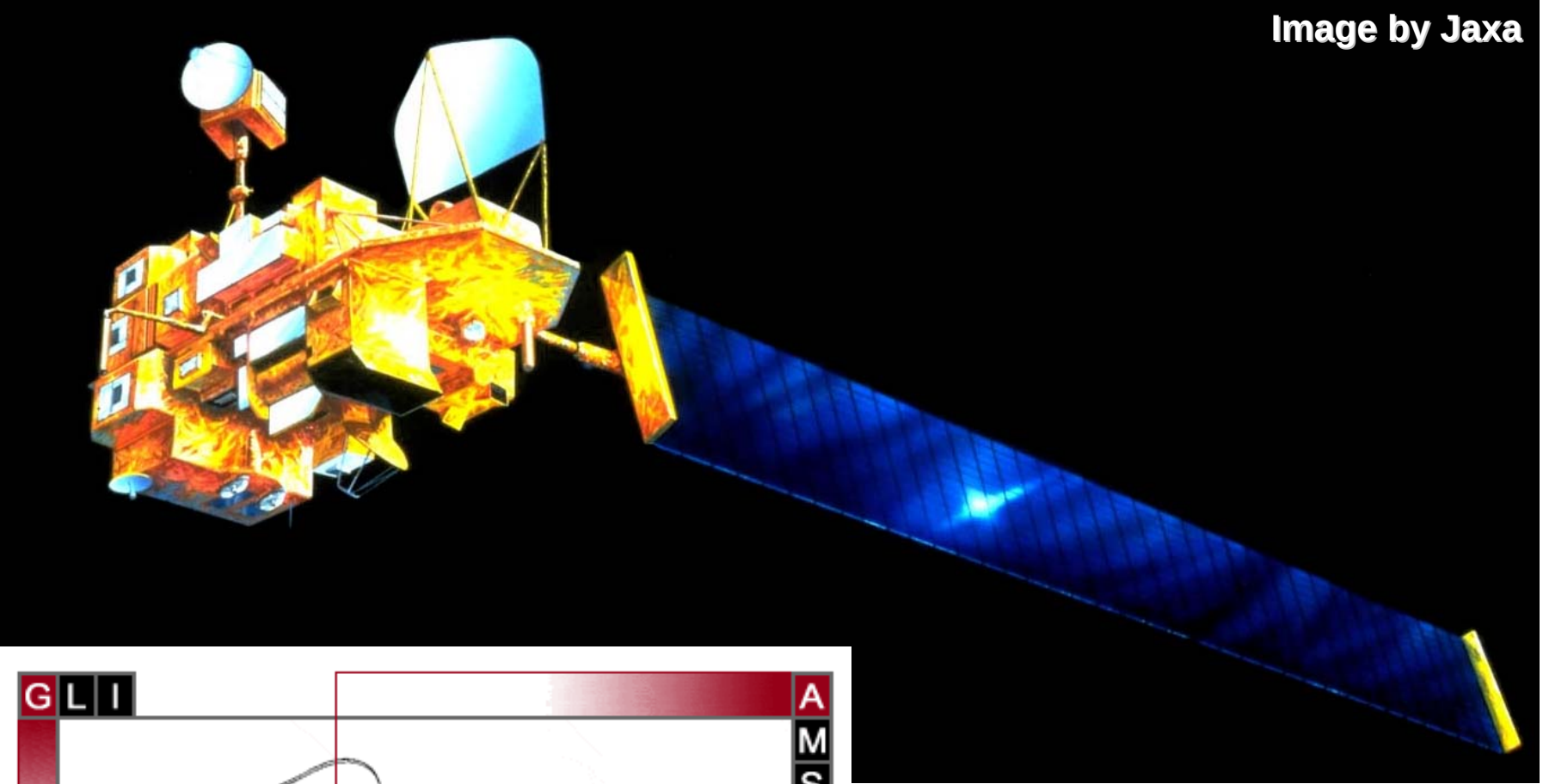
2006年1月23日　東京

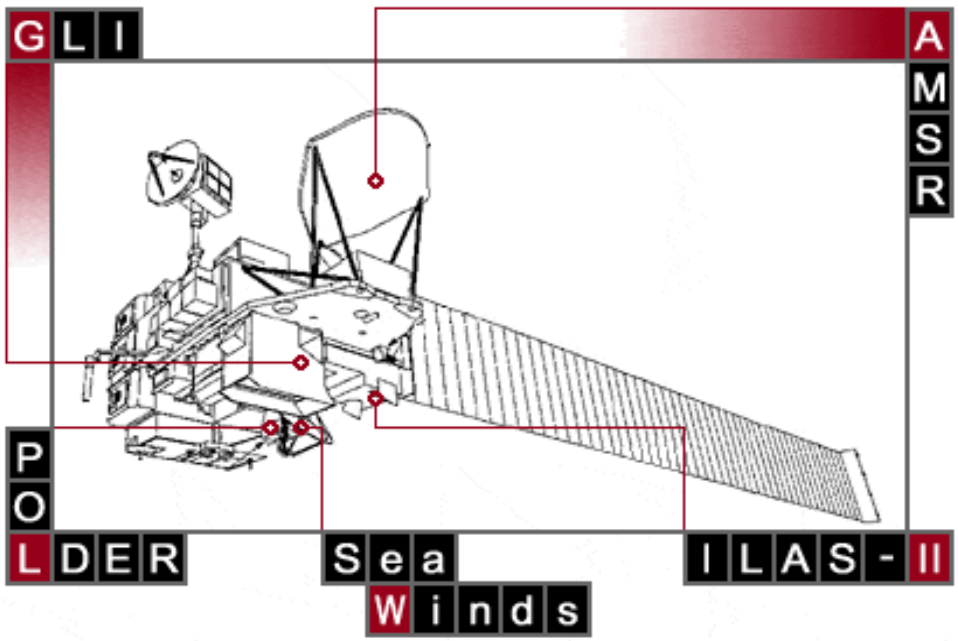
衛星イメジャーによる大気観測と気候問題

中島映至
東京大学気候システム研究センター
(teruyuki@ccsr.u-tokyo.ac.jp)

Asian Aerosols and Fair Weather Cumuli in the East China Sea

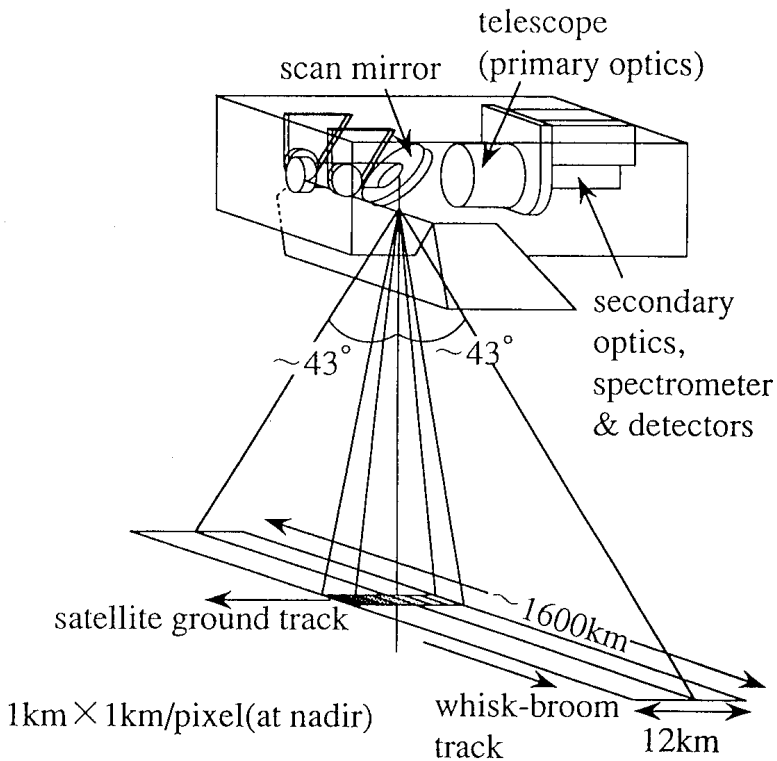

Solar activity
Remote sensing
342 W/m2
102 W/m2
240 W/m2
Planetary albedo & emissivity
Radiation budget & forcing
GHGs : +2.6 W/m2
Aerosol:~ - 1 W/m2
at TOA, including indirect
Cloud: ~ -15 W/m2
Cloud and precipitation changes
Radiation interaction with materials
170 W/m2
345 W/m2
Greenhouse & parasol effects
385 W/m2
Surface albedo & emissivity





Dimension	Approx. 6x4x4m)
Solar Paddle	Approx. 3x24m
Total Mass	3.68t
Power	5,350W (EOL)
Orbit	Sun-synchronous sub-recurrent orbit
Altitude	802.92km
Inclination	98.62 deg
Period	101 minutes
Recurrent Period	4 days
Local Sun Time	AM10:30±15
Launch Vehicle	H-IIA Rocket
Launch Period	2002

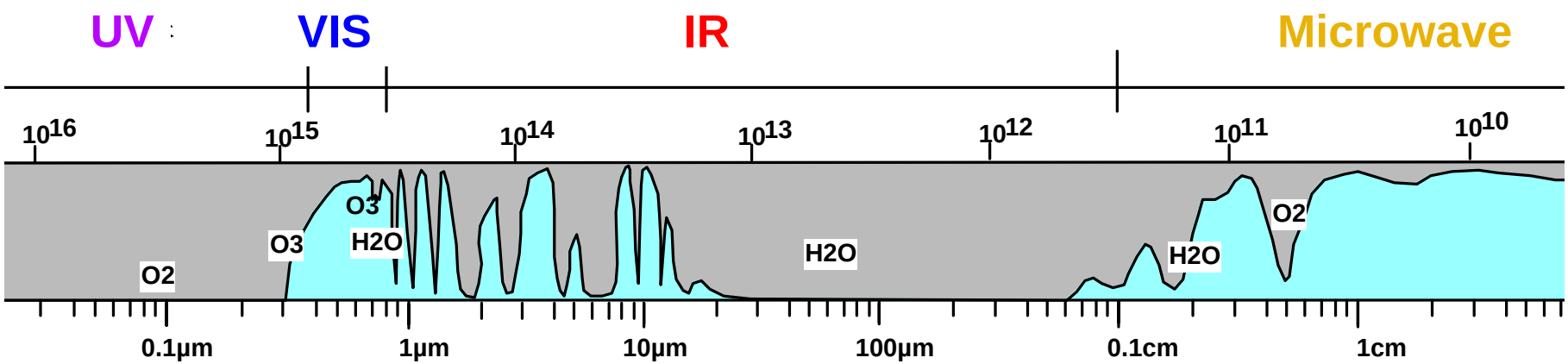
- **MODIS and GLI: General purpose medium resolution imagers**
- **36 channels: Different allocations between MODIS and GLI**
- **GLI with six 250m channels and tilting mechanism**

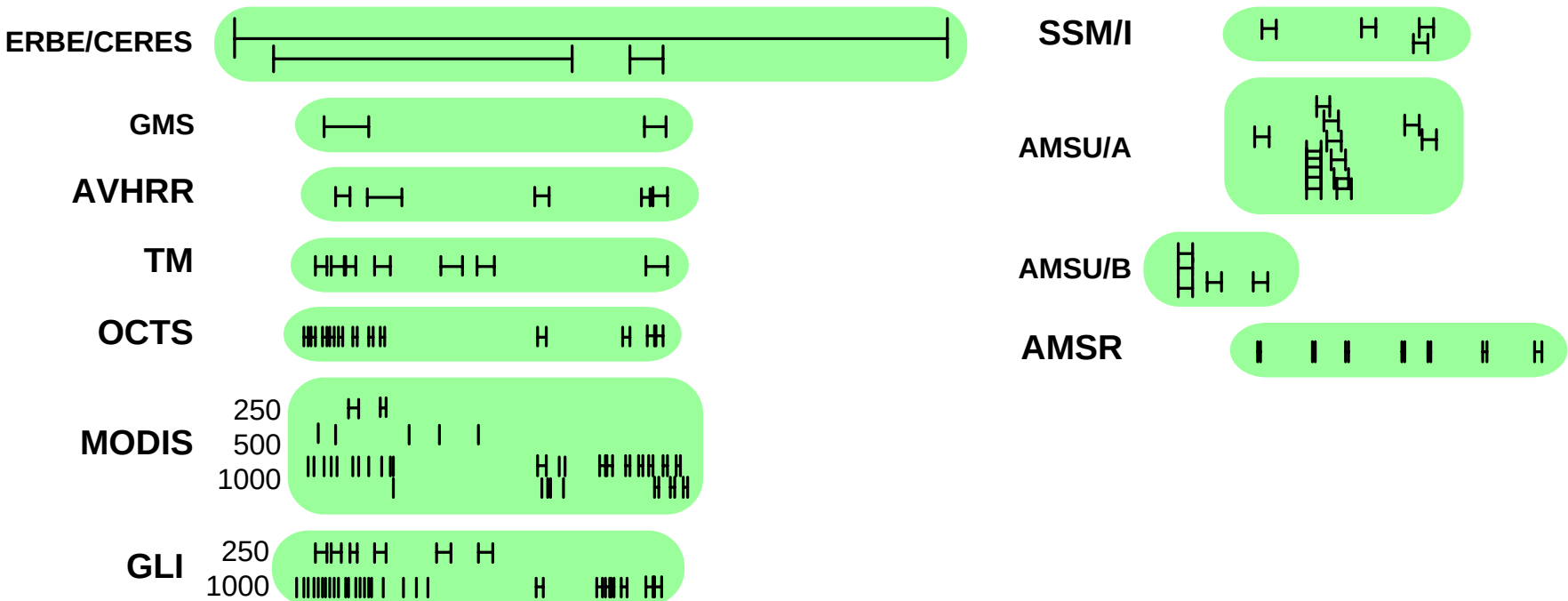


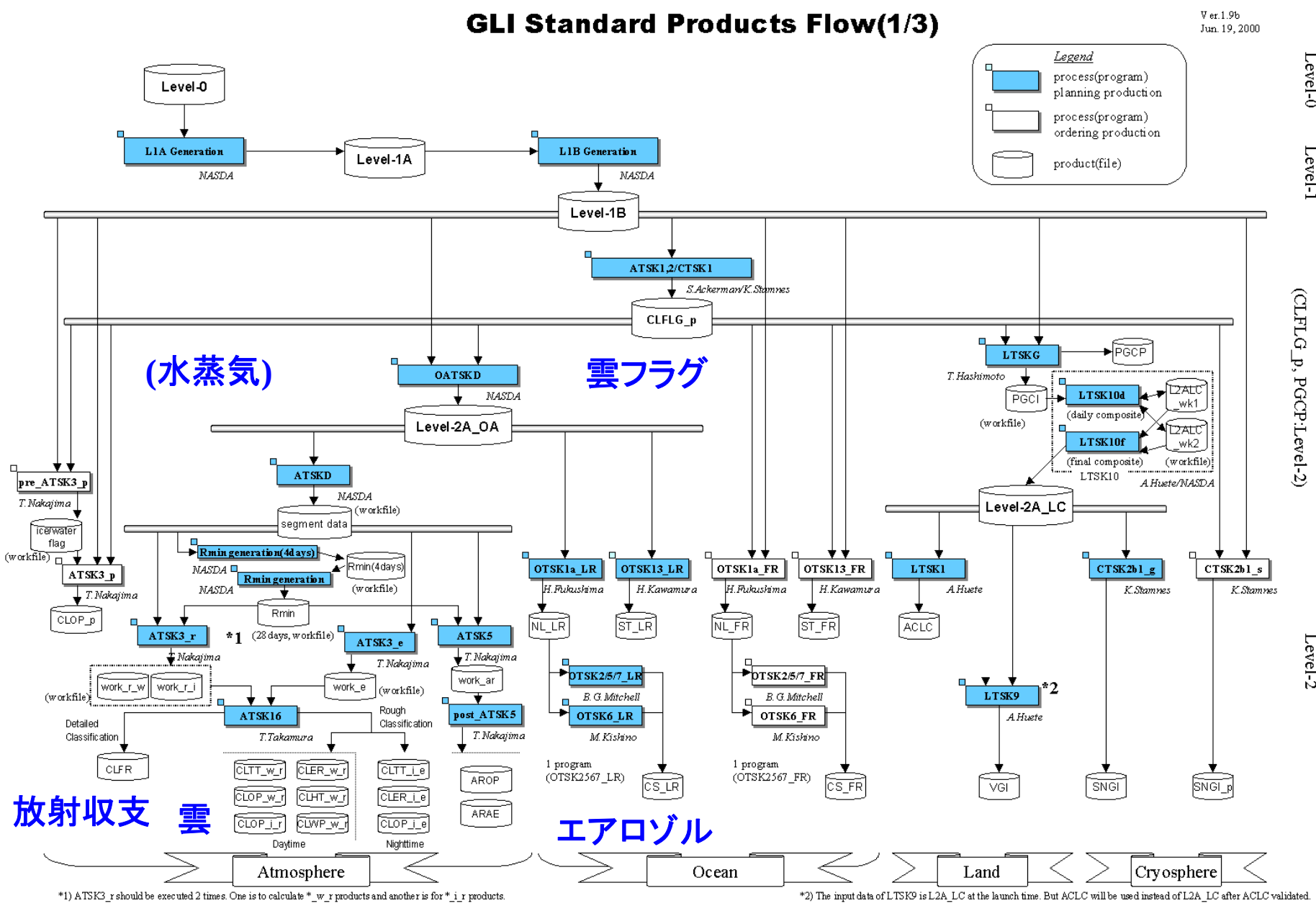
QuickTimeý Ç²
YUV420 ÉRÅ[ÉfÉbÉN êLí£ÉvÉçÉOÉâÉÄ
Ç™Ç±ÇÃÉsÉNÉ`ÉÉÇ¾å©ÇÈÇžÇ½Ç…ÇÕïKóvÇ-Ç⃞ÅB

NASA TERRA/MODIS Operation provided by M.D. King

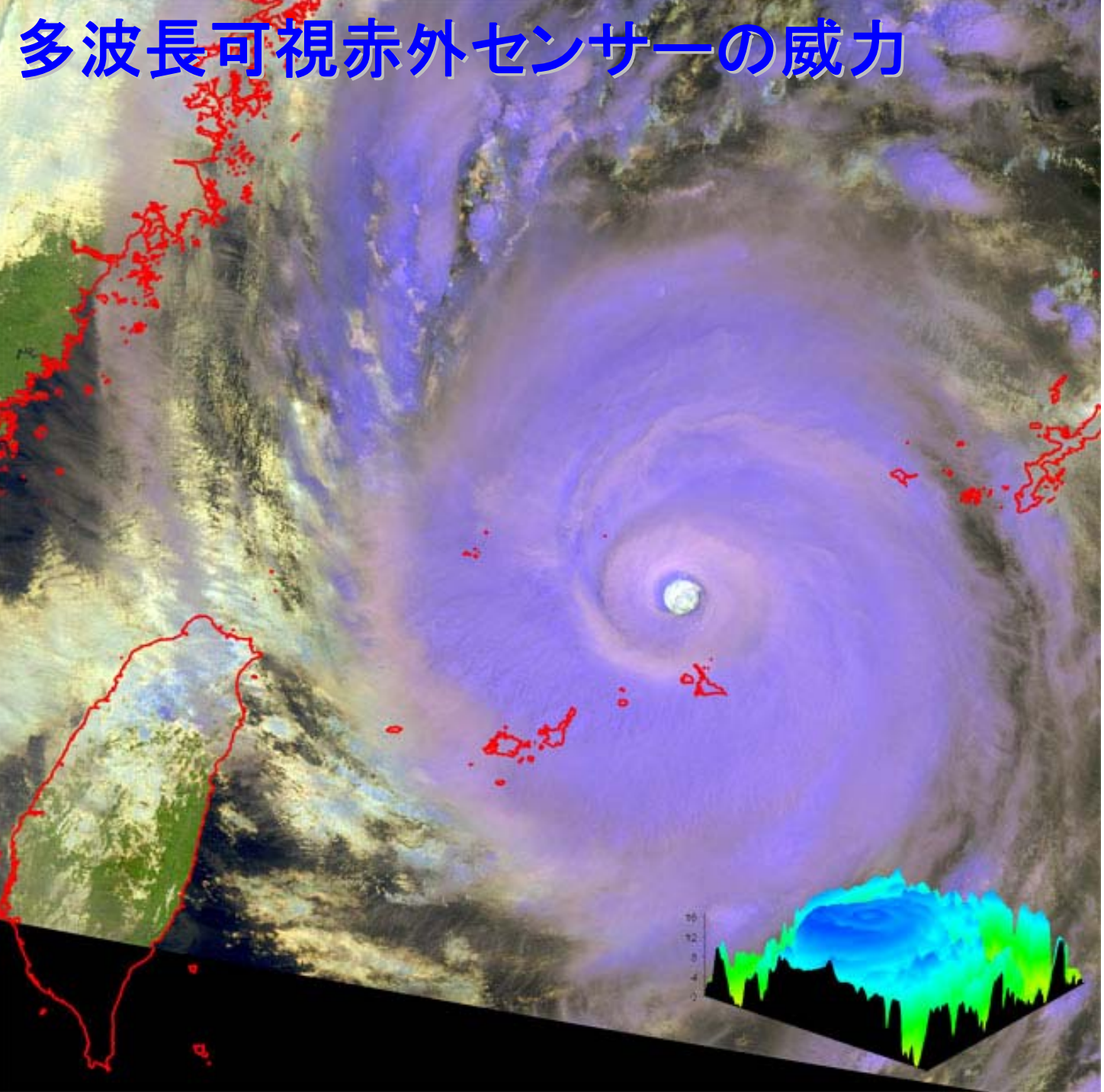
Satellite sensor-channels






GLI Standard Products Flow(1/3)
Ver.1.9b
Jun. 19, 2000
Legend
process(program) planning production
process(program) ordering production
product(file)
Level-0
Level-1
Level-2A (CLFLG_p, PGCP:Level-2)
Level-2
Level-0
L1A Generation
NASDA
Level-1A
L1B Generation
NASDA
Level-1B
ATSK1,2/CTSK1
S.Ackerman/K.Stamnes
CLFLG_p
(水蒸気)
雲フラグ
OATSKD
NASDA
Level-2A_OA
LTSKG
T.Hashimoto
PGCP
PGCI
(workfile)
LTSK10d
(daily composite)
L2ALC_wk1
LTSK10f
(final composite)
L2ALC_wk2
(workfile)
LTSK10
A.Huete/NASDA
ATSKD
NASDA
segment data
(workfile)
pre_ATSK3_p
T.Nakajima
ice/water flag
(workfile)
ATSK3_p
T.Nakajima
CLOP_p
Rmin generation(4days)
NASDA
Rmin(4days)
(workfile)
Rmin generation
NASDA
Rmin
(28 days, workfile)
Level-2A_LC
OTSK1a_LR
H.Fukushima
OTSK13_LR
H.Kawamura
OTSK1a_FR
H.Fukushima
OTSK13_FR
H.Kawamura
LTSK1
A.Huete
CTSK2b1_g
K.Stamnes
CTSK2b1_s
K.Stamnes
NL_LR
ST_LR
NL_FR
ST_FR
ACLC
ATSK3_r
*1
T.Nakajima
ATSK3_e
T.Nakajima
ATSK5
T.Nakajima
work_r_w
work_r_i
(workfile)
work_e
(workfile)
work_ar
OTSK2/5/7_LR
B.G.Mitchell
OTSK6_LR
M.Kishino
OTSK2/5/7_FR
B.G.Mitchell
OTSK6_FR
M.Kishino
LTSK9
*2
A.Huete
ATSK16
T.Takamura
Detailed Classification
Rough Classification
post_ATSK5
T.Nakajima
CLFR
CLTT_w_r
CLER_w_r
CLOP_w_r
CLHT_w_r
CLOP_i_r
CLWP_w_r
Daytime
CLTT_i_e
CLER_i_e
CLOP_i_e
Nighttime
AROP
ARAE
1 program (OTSK2567_LR)
CS_LR
1 program (OTSK2567_FR)
CS_FR
VGI
SNGI
SNGI_p
放射収支
雲
エアロゾル
Atmosphere
Ocean
Land
Cryosphere
*1) ATSK3_r should be executed 2 times. One is to calculate *_w_r products and another is for *_i_r products.
*2) The input data of LTSK9 is L2A_LC at the launch time. But ACLC will be used instead of L2A_LC after ACLC validated.

多波長可視赤外センサーの威力



Sep. 11, 2003

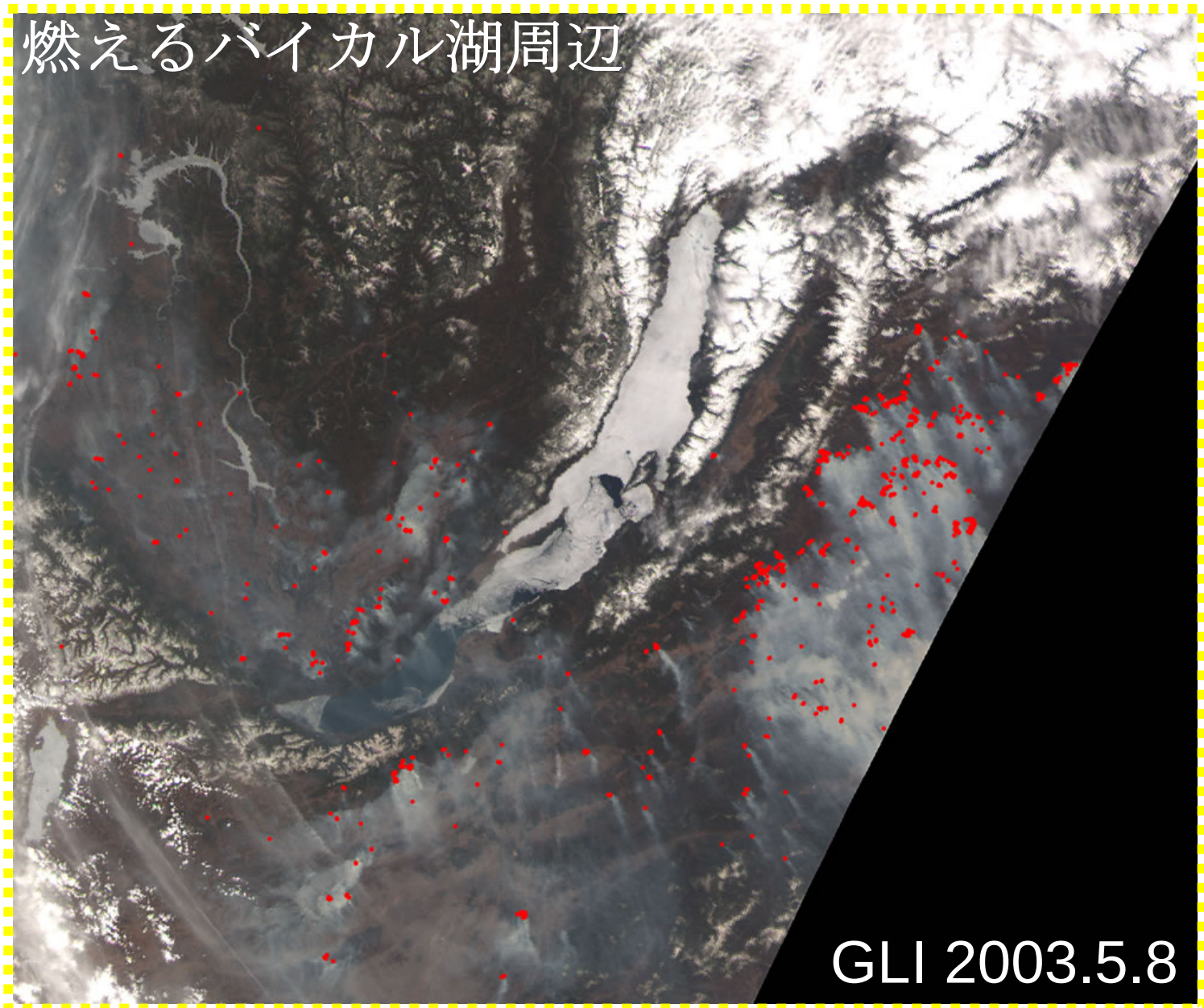
台風14号

GLI 250mチャンネル

通常画像
RGB=
0.68, 0.55, 0.46μm

本画像
RGB=
2.2, 1.6, 0.46μm

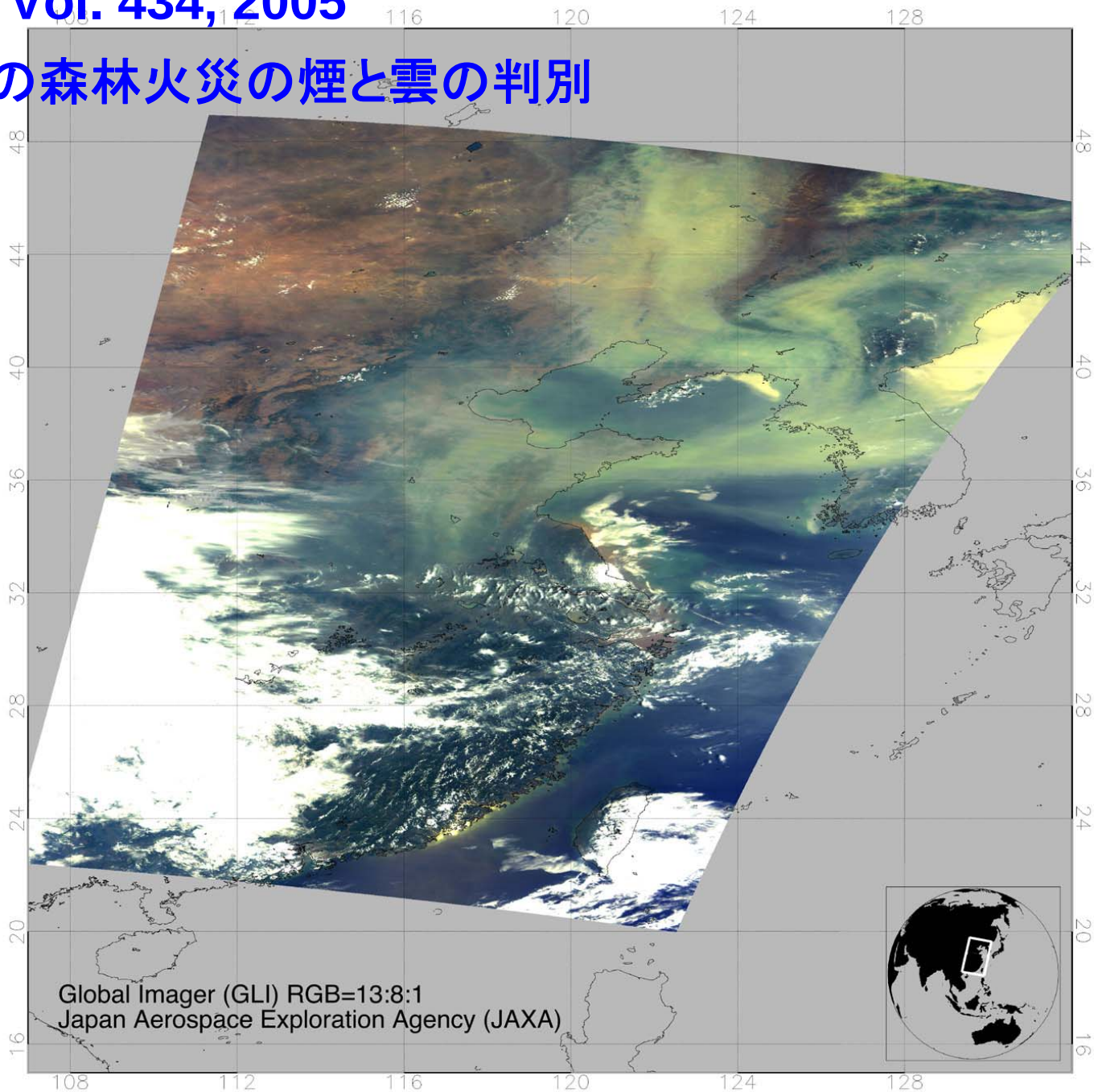
1km分解能によるグローバルモニタリング



“Nature” Vol. 434, 2005

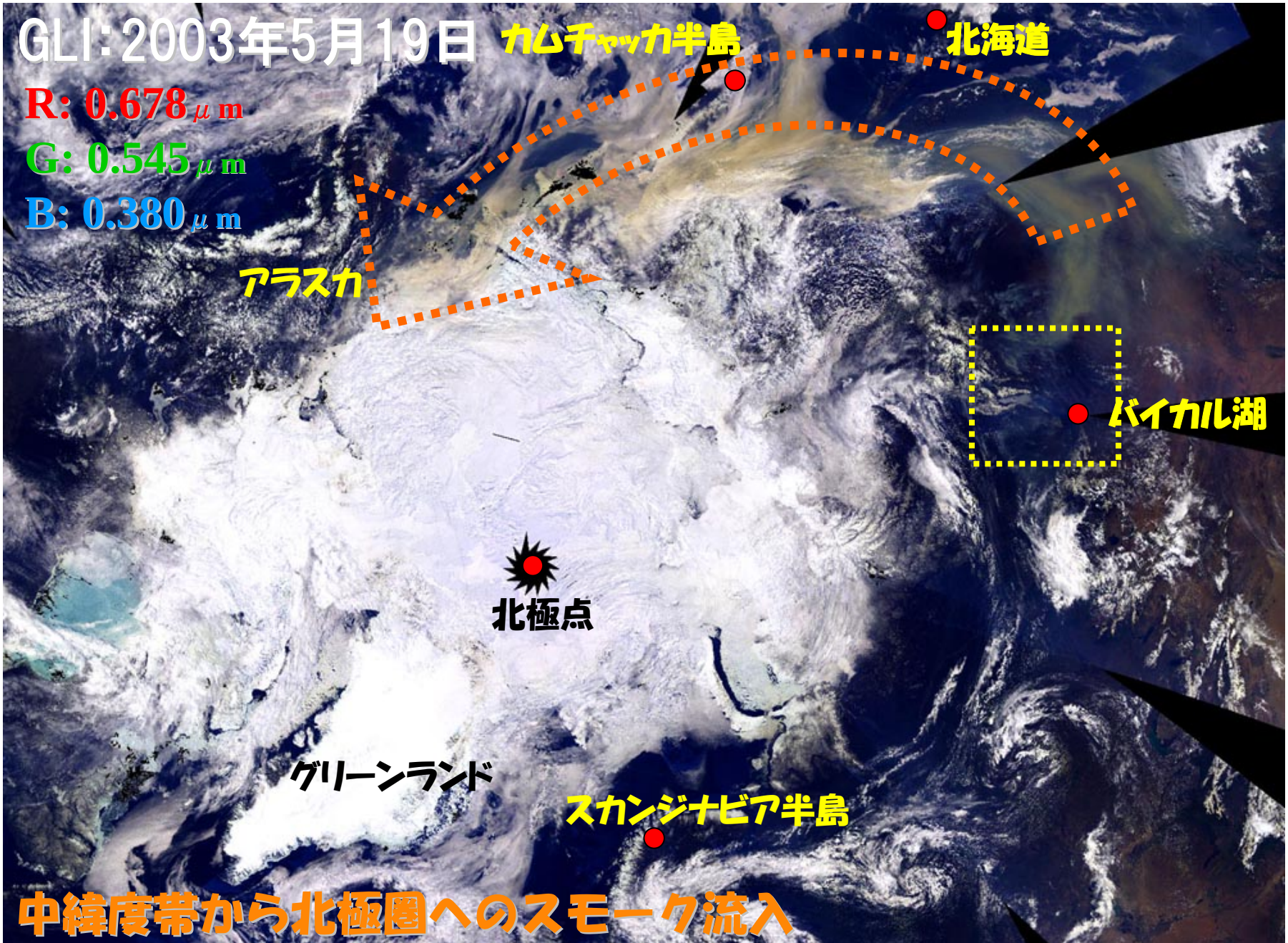
シベリアの森林火災の煙と雲の判別

R: 678nm
G: 545nm
B: 380nm



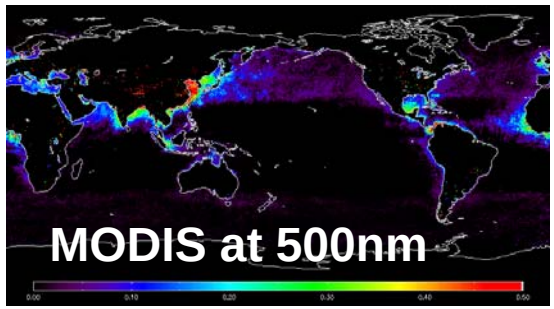
"news (Climatologists seek clear view of Asia's smog)" by D. Cyranoski and I. Fuyuno, 2005, Nature, Vol. 434, pp128

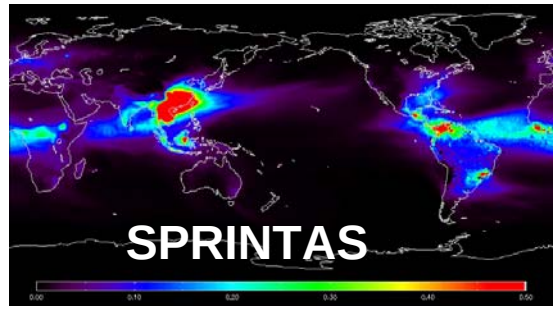
1km分解能によるグローバルモニタリング



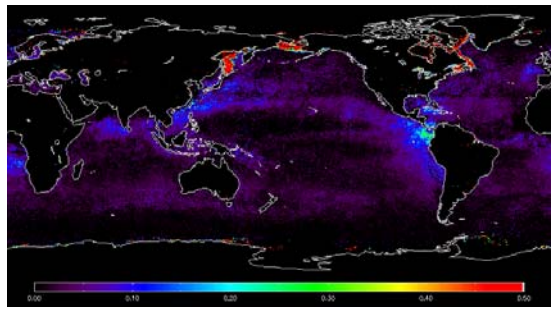
2003

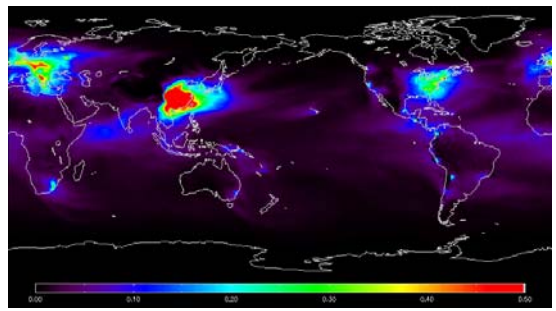
Carbon



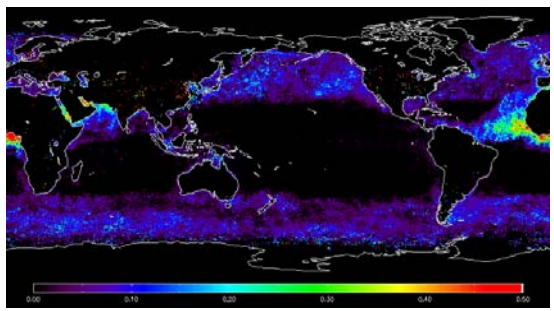


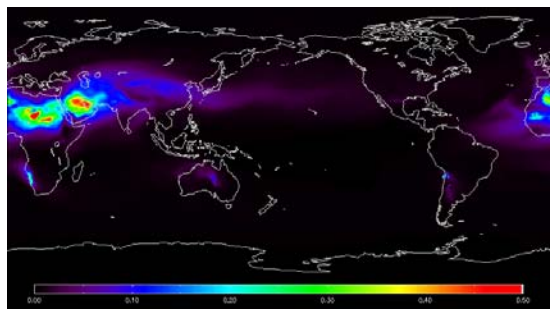
Sulfate



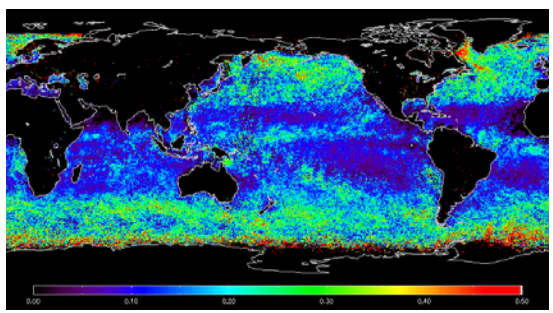


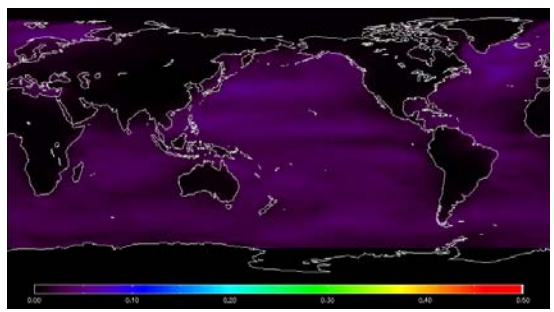
Dust





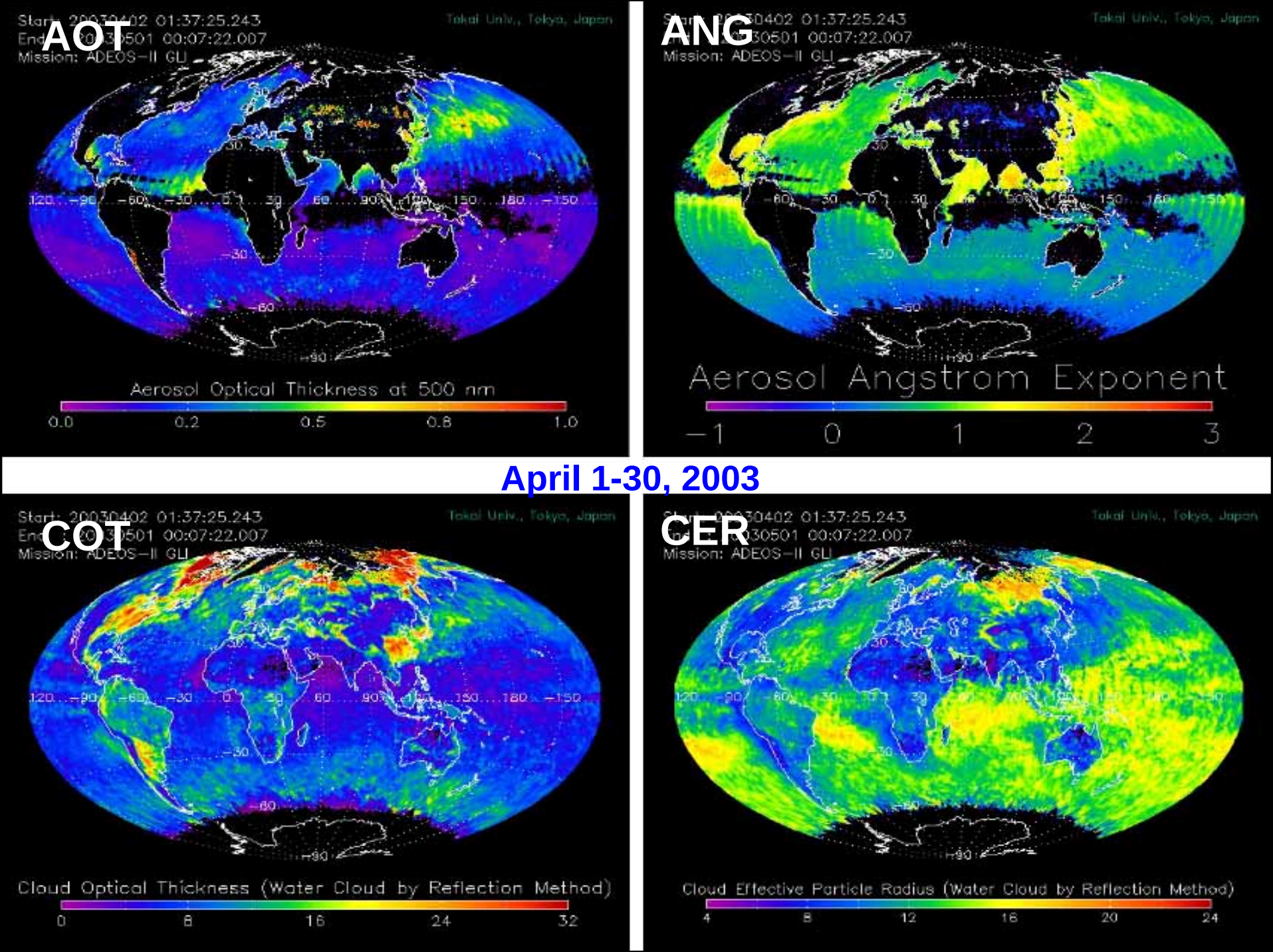
Sea Salt

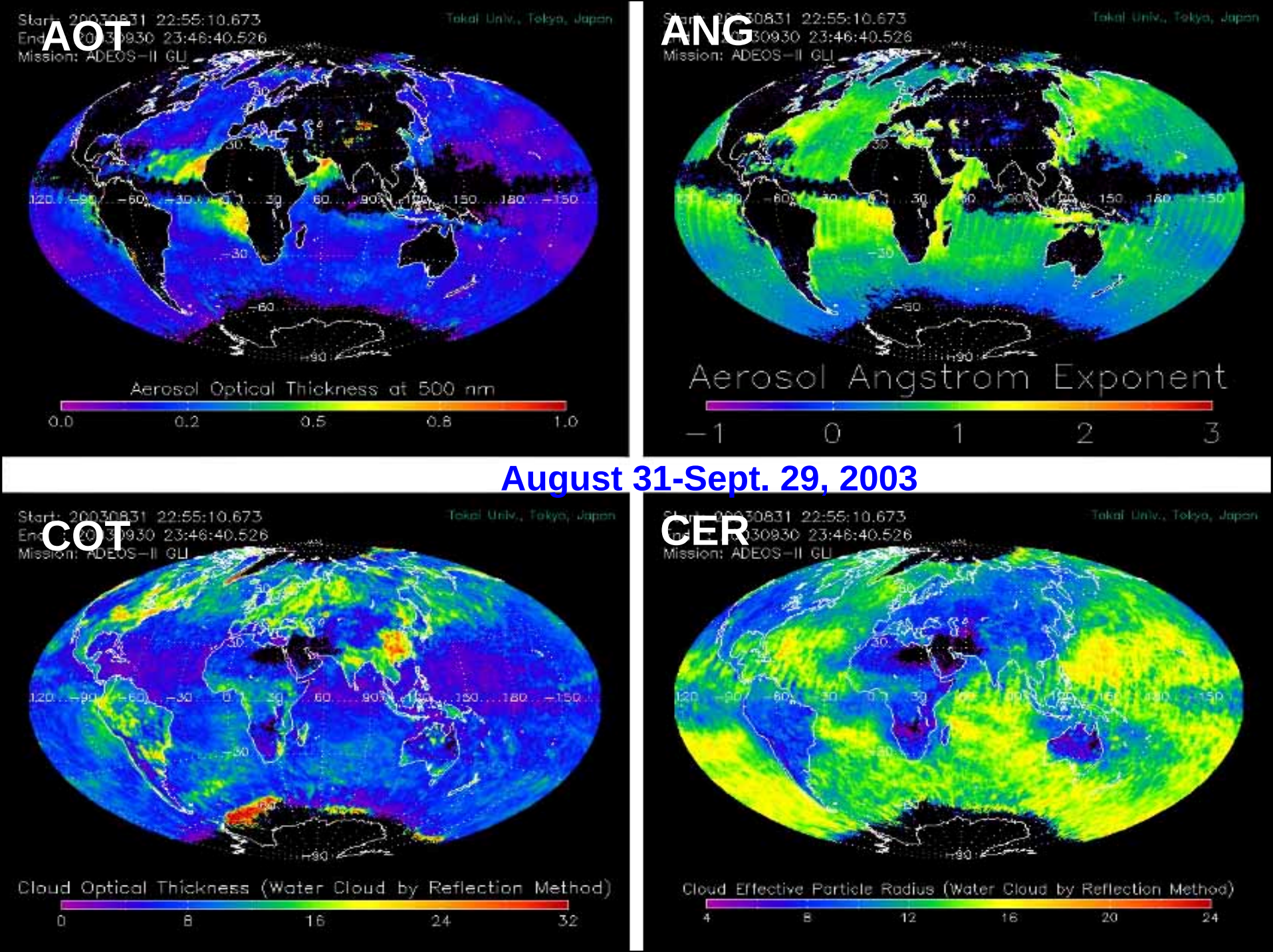




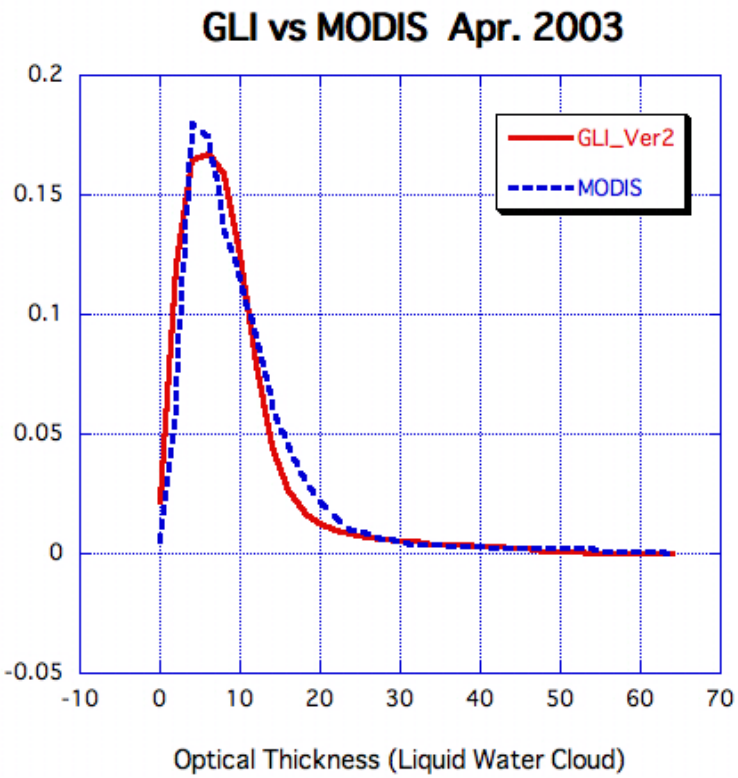
GLI product & model comparison

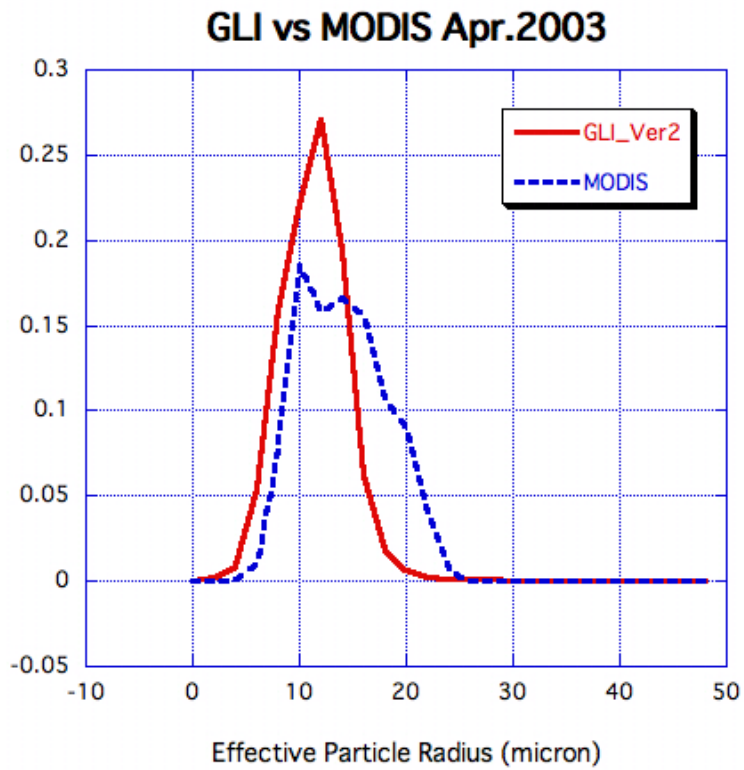
http://atm-phys.nies.go.jp/~hakiko/GLI/GLI-ATSEG_200303.html


AOT
Tokai Univ., Tokyo, Japan
Mission: ADEOS-II GLI
Aerosol Optical Thickness at 500 nm
0.0
0.2
0.5
0.8
1.0
ANG
Tokai Univ., Tokyo, Japan
Mission: ADEOS-II GLI
Aerosol Angstrom Exponent
−1
0
1
2
3
April 1-30, 2003
COT
Tokai Univ., Tokyo, Japan
Mission: ADEOS-II GLI
Cloud Optical Thickness (Water Cloud by Reflection Method)
0
8
16
24
32
CER
Tokai Univ., Tokyo, Japan
Mission: ADEOS-II GLI
Cloud Effective Particle Radius (Water Cloud by Reflection Method)
4
8
12
16
20
24


AOT
Aerosol Optical Thickness at 500 nm
0.0
0.2
0.5
0.8
1.0
ANG
Aerosol Angstrom Exponent
−1
0
1
2
3
August 31-Sept. 29, 2003
COT
Cloud Optical Thickness (Water Cloud by Reflection Method)
0
8
16
24
32
CER
Cloud Effective Particle Radius (Water Cloud by Reflection Method)
4
8
12
16
20
24

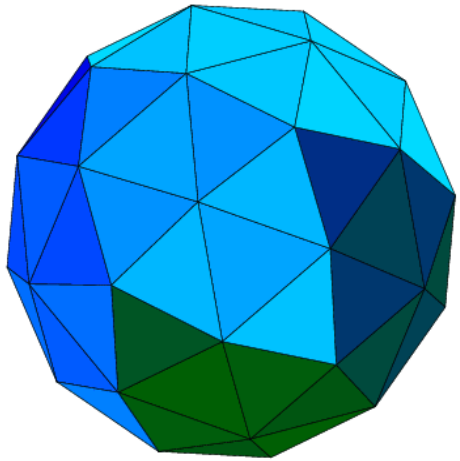
GLI vs MODIS (standard product) Water Cloud in Apr. 2003

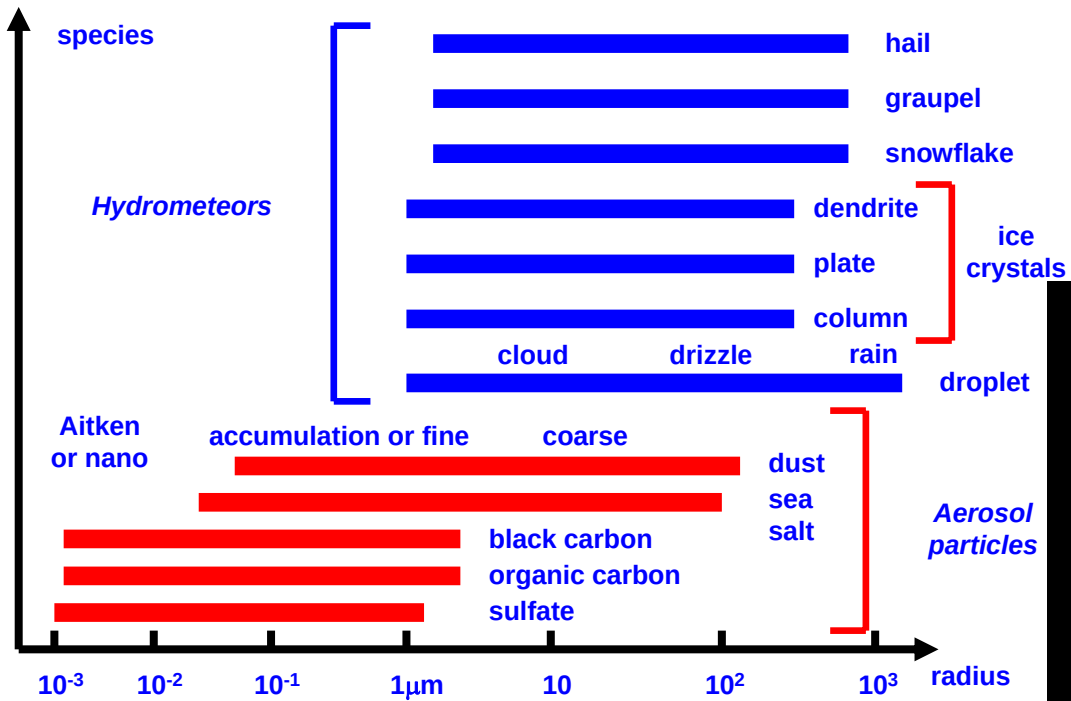




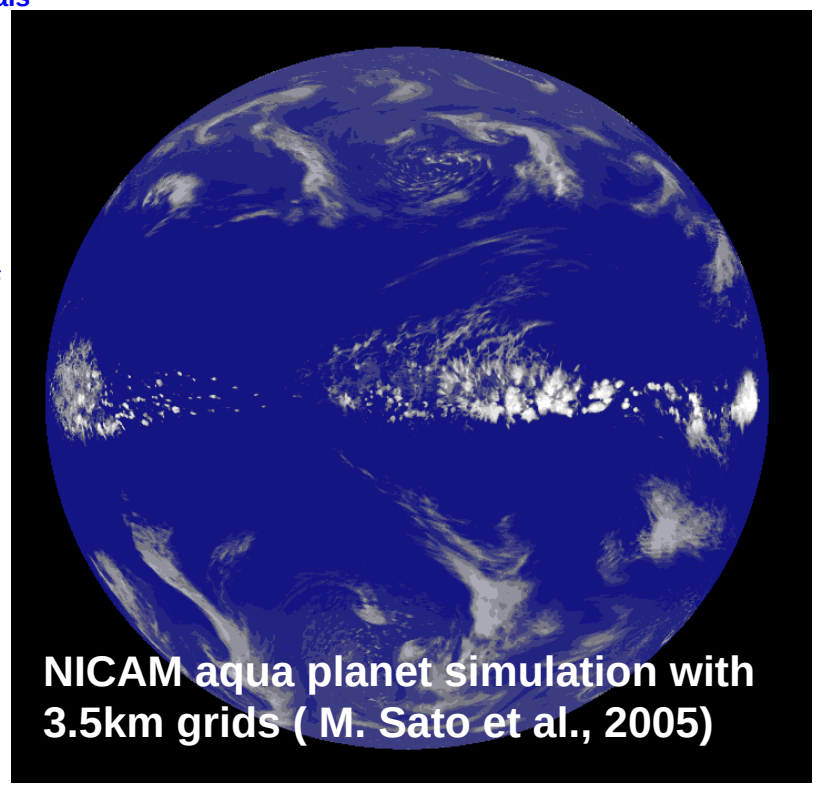
T.Y. Nakajima (2006)

JMA/NHM, FRCGC/NICAM (non-hydrostatic model) and Binned cloud model





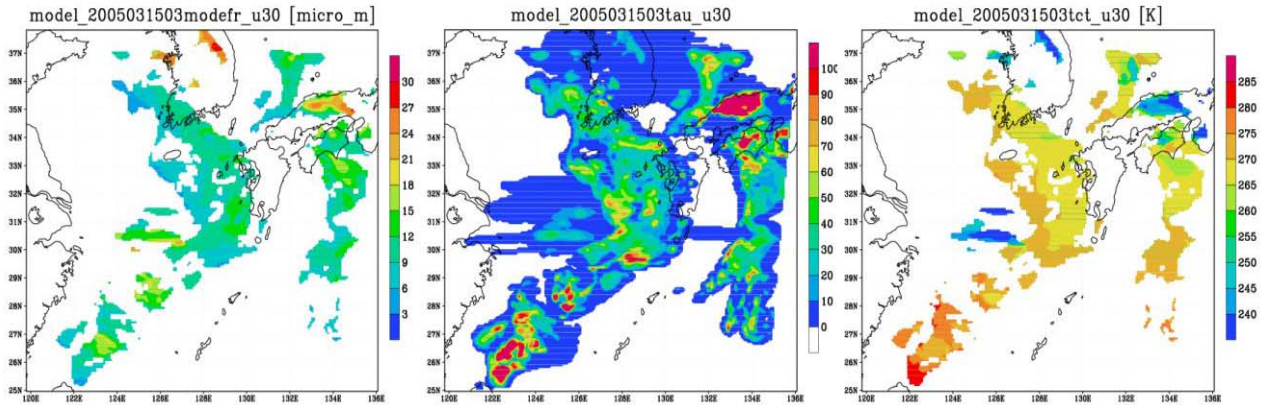
SPRINTARS+HUCM



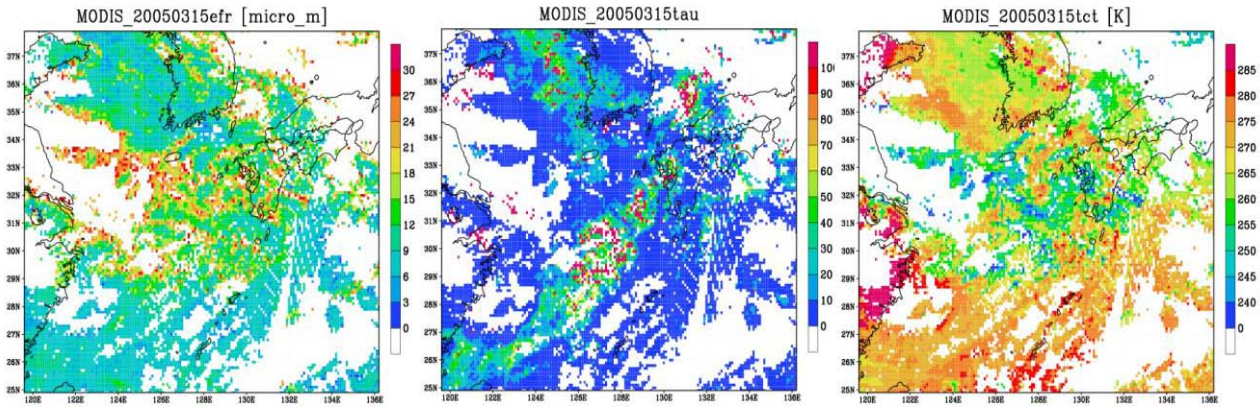
NICAM aqua planet simulation with 3.5km grids (M. Sato et al., 2005)

REF **COT** **TCT**

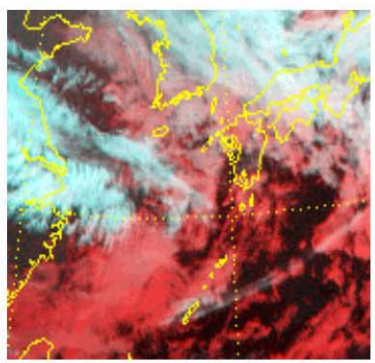
Binned NHM

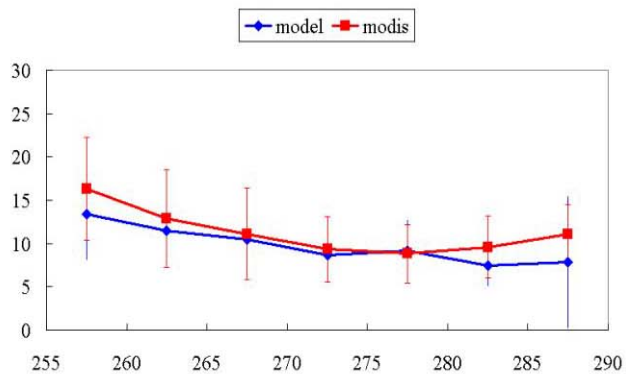


MODIS



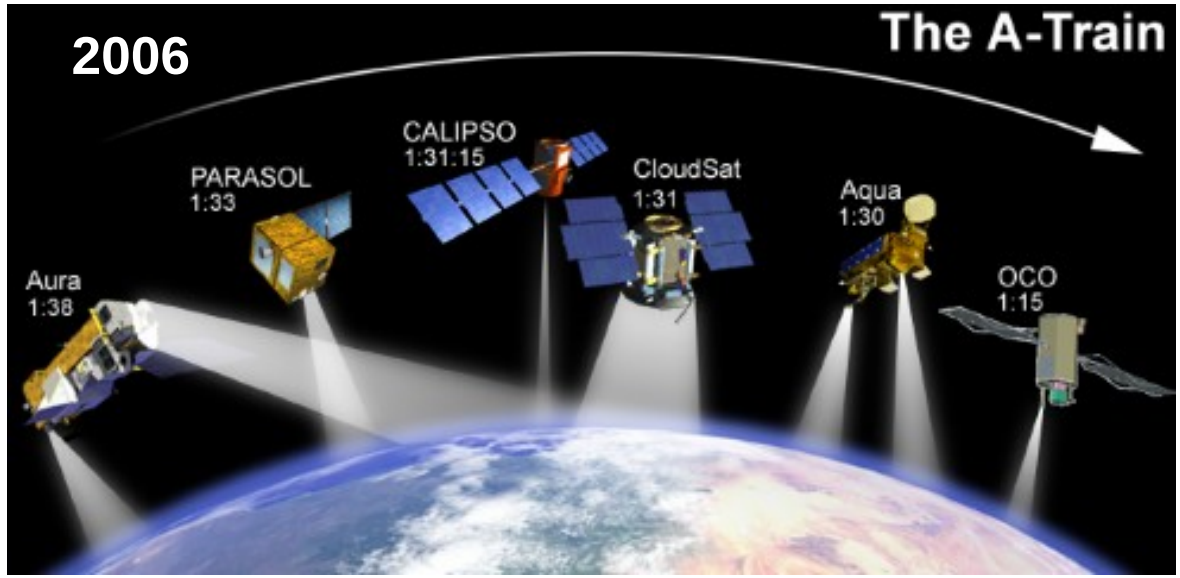
NHM+HUCM
March 15th, 2005
(ABC/EAREX05)

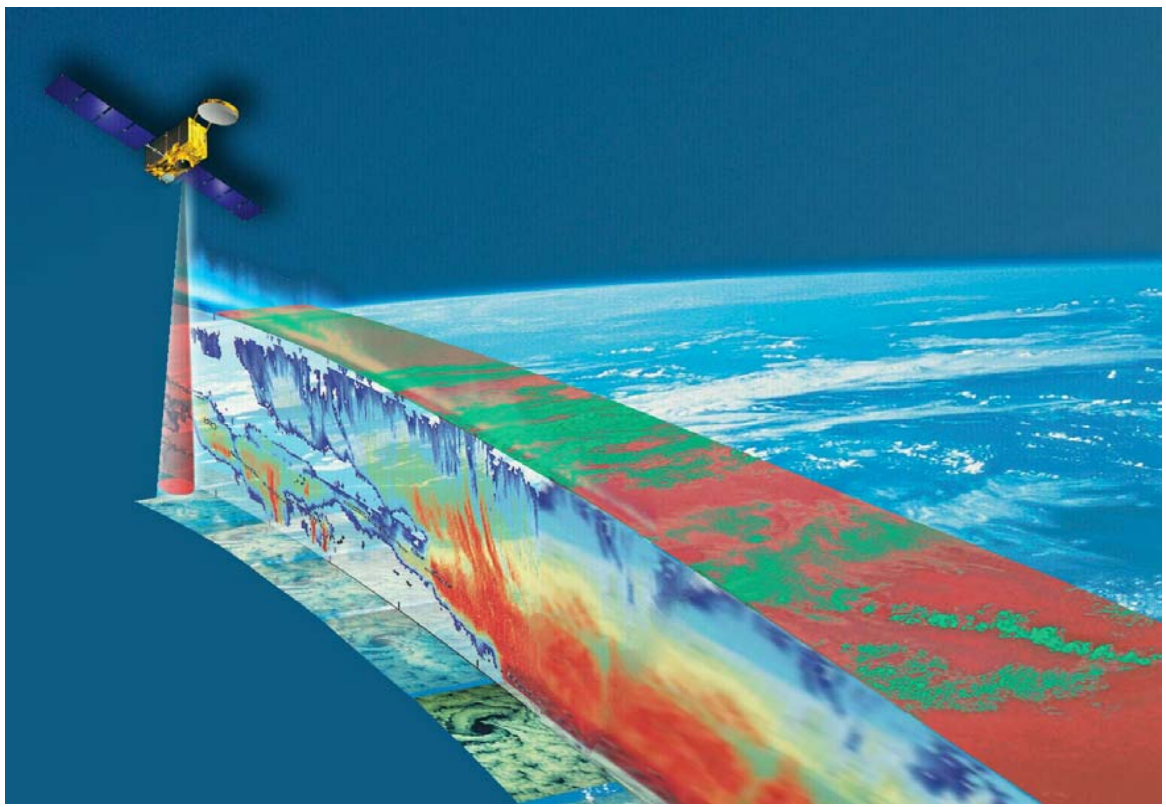




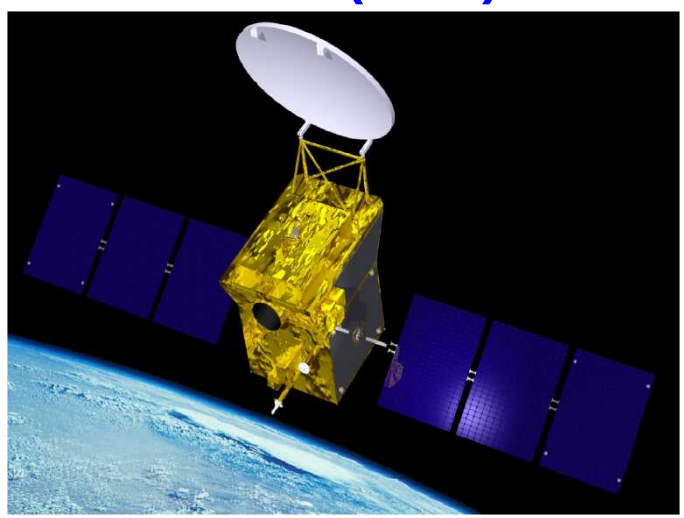
T. Iguchi (IAMAS2005)

次世代型
雲観測衛星

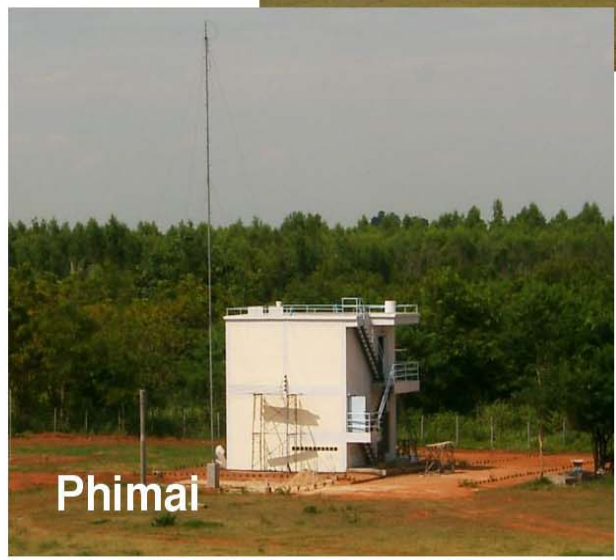




ESA-JAXA-NICT/
EarthCARE (2012)




GOSAN ABC super site


Phimai

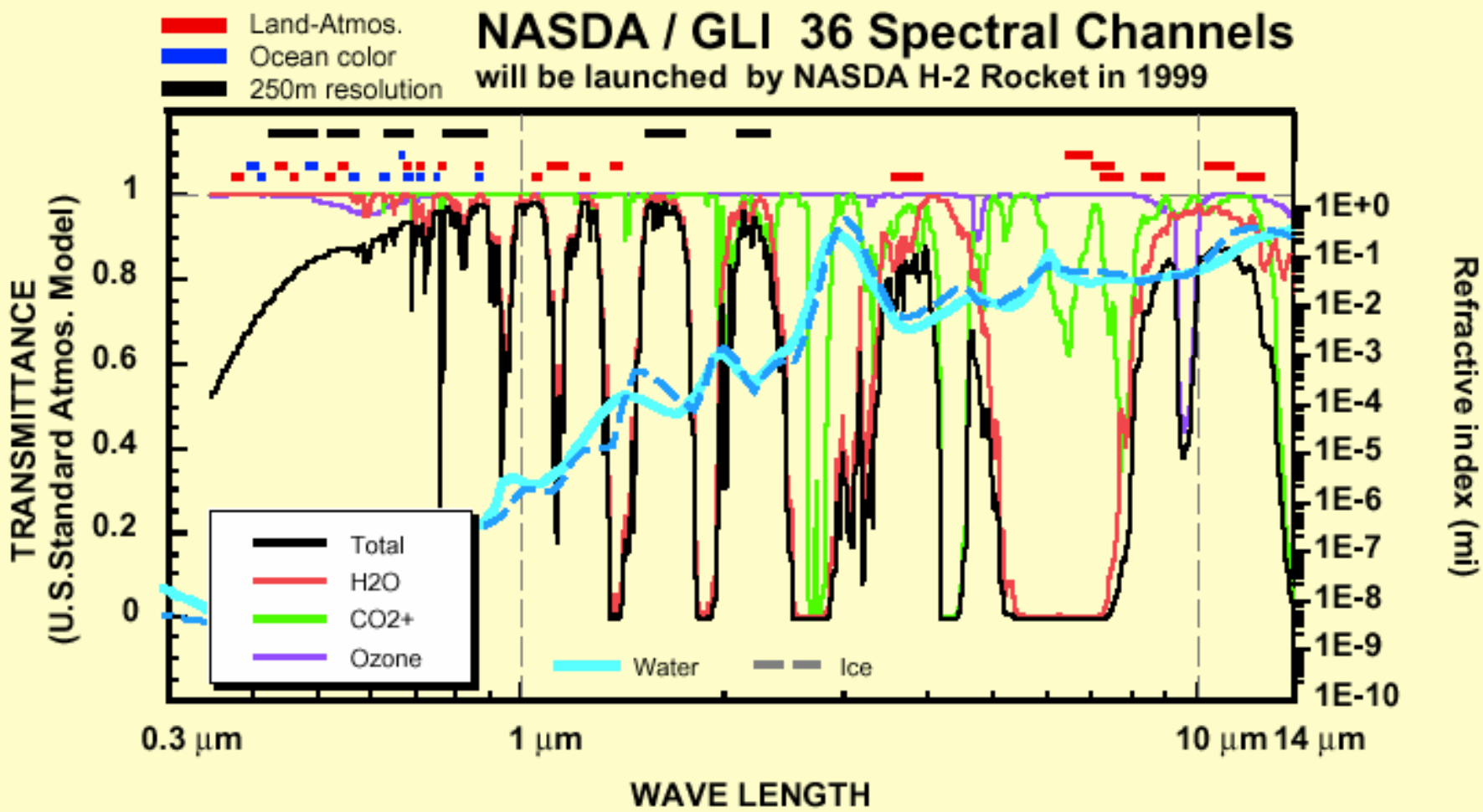

Amami/ Hedo


Hamindhoo

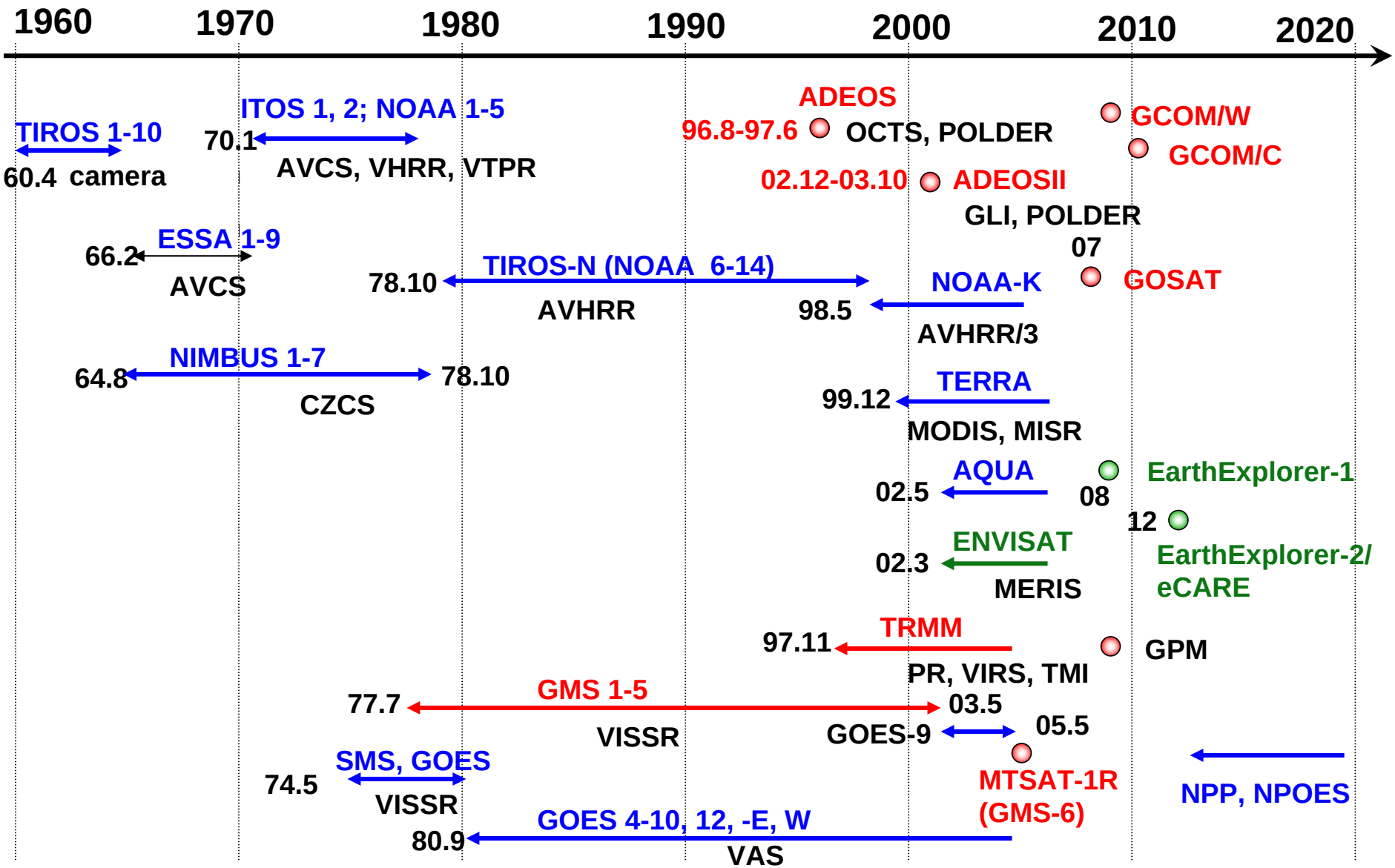
結論

- 大気リモートセンシング・コミュニティーがADEOS, ADEOS-IIを契機に作られた。
- MODISは6年以上、OCTSとGLIは7ヶ月
- 衛星観測に関する論文作成には3年ルールがあるので、ねばり強い研究支援が必要である。(NASAの例）
- 大気に関しても、多くの知見が得られた。
- モデルとの比較・同化がはじまりつつある。
- 将来には、GOSAT（炭酸ガス）、GPM（降雨）、CLOUDSAT/CALIPSOやeCARE（雲）衛星が登場する。

GLI channel allocation



気象衛星の歴史

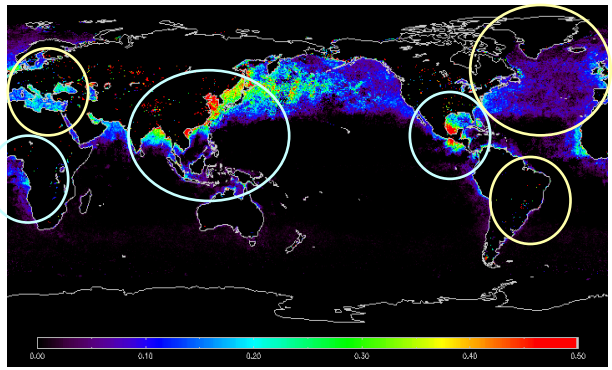

1960
1970
1980
1990
2000
2010
2020
TIROS 1-10
60.4 camera
ITOS 1, 2; NOAA 1-5
70.1
AVCS, VHRR, VTPR
ADEOS
96.8-97.6
OCTS, POLDER
GCOM/W
GCOM/C
02.12-03.10
ADEOSII
GLI, POLDER
07
GOSAT
ESSA 1-9
66.2
AVCS
TIROS-N (NOAA 6-14)
78.10
AVHRR
NOAA-K
98.5
AVHRR/3
NIMBUS 1-7
64.8
78.10
CZCS
TERRA
99.12
MODIS, MISR
AQUA
02.5
08
EarthExplorer-1
12
ENVISAT
02.3
MERIS
EarthExplorer-2/
eCARE
TRMM
97.11
PR, VIRS, TMI
GPM
GMS 1-5
77.7
03.5
VISSR
GOES-9
05.5
MTSAT-1R
(GMS-6)
SMS, GOES
74.5
VISSR
NPP, NPOES
GOES 4-10, 12, -E, W
80.9
VAS

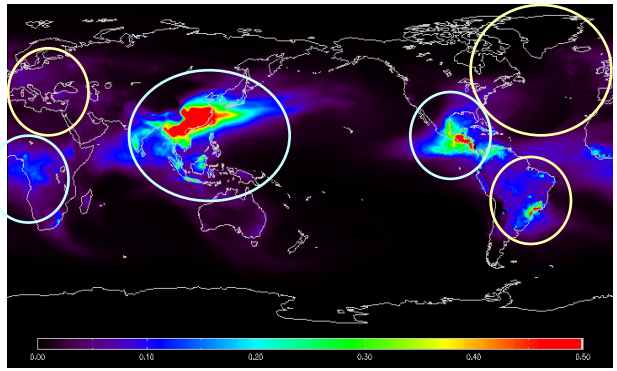
Monthly mean optical thickness
April, 2003

MODIS
Four channels (H&N GRL2002)

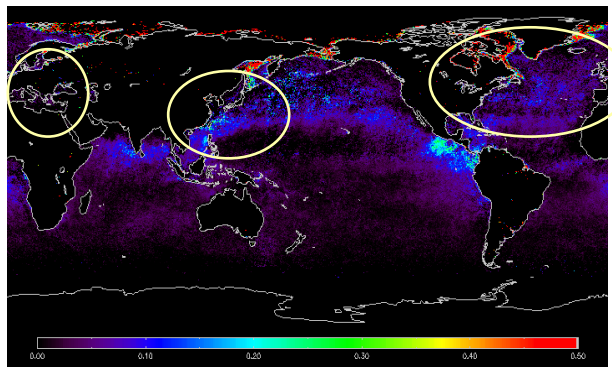
SPRINTARS
Provided by Dr. Takemura

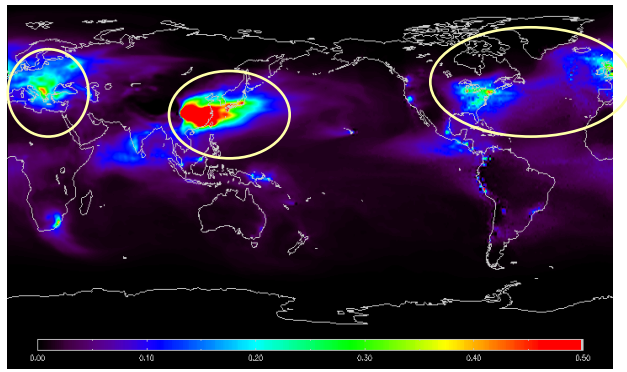
CRB



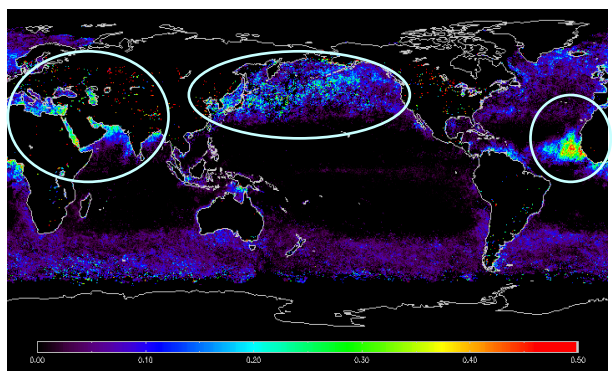


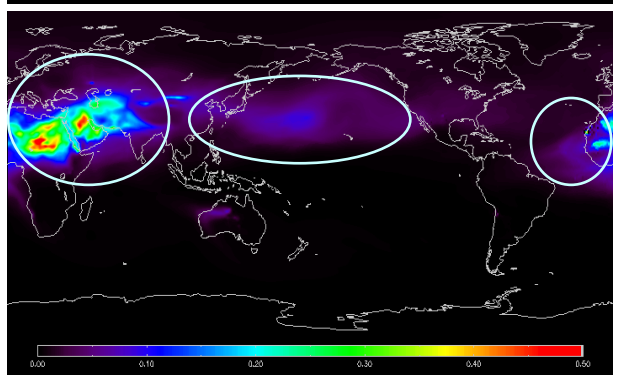
SLF





DST



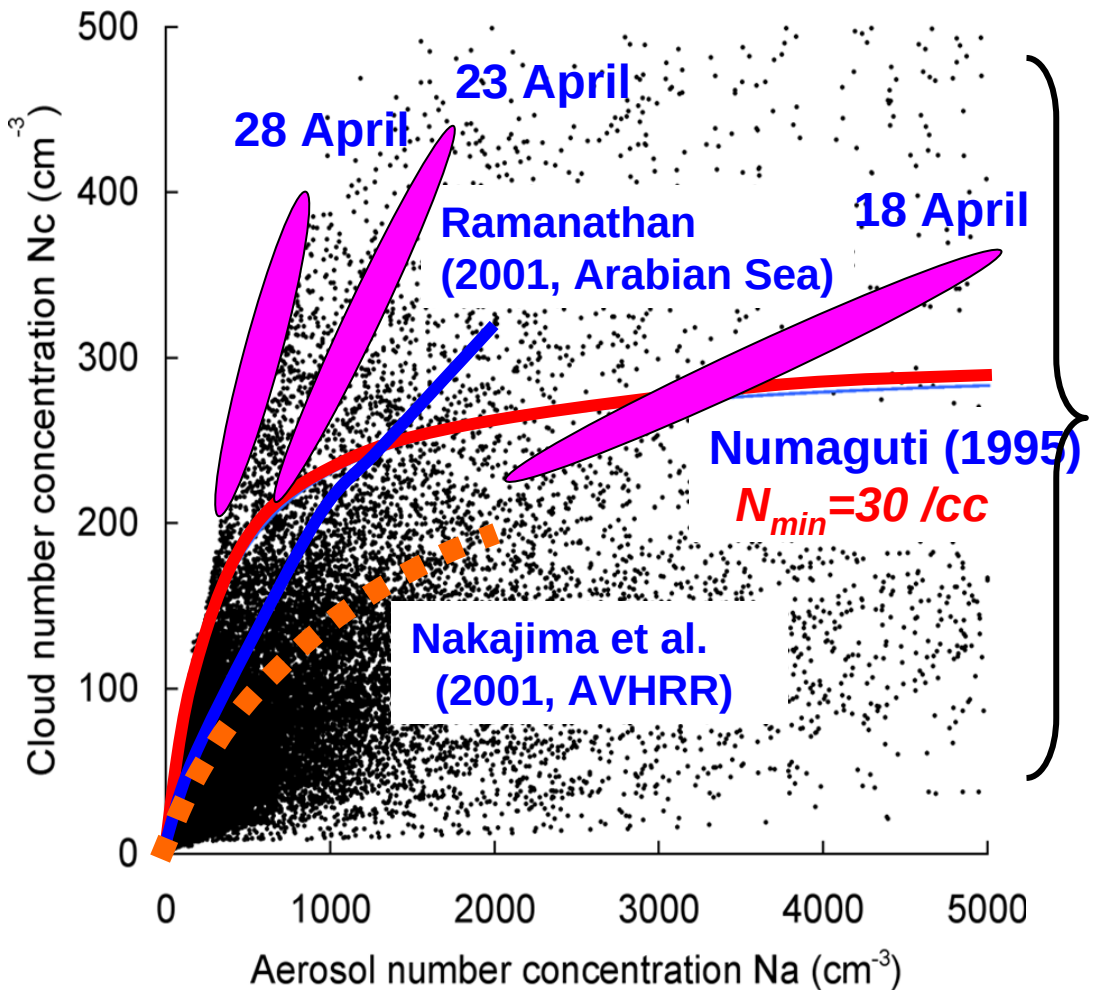


Higurashi et al. (IAMAS2005)

Optical Thickness at 500nm

Optical Thickness at 550nm

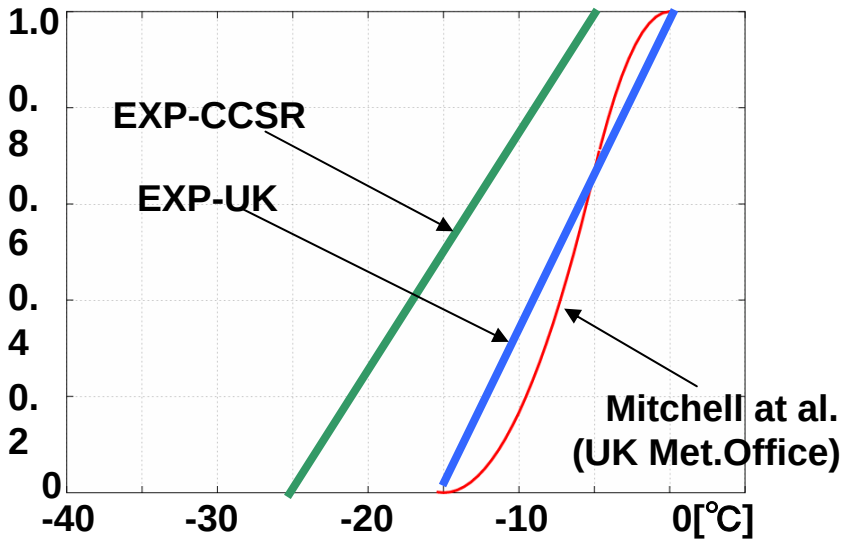
- Ghan-Takemura parameterization (2005)
- Increased minimum aerosol number over land

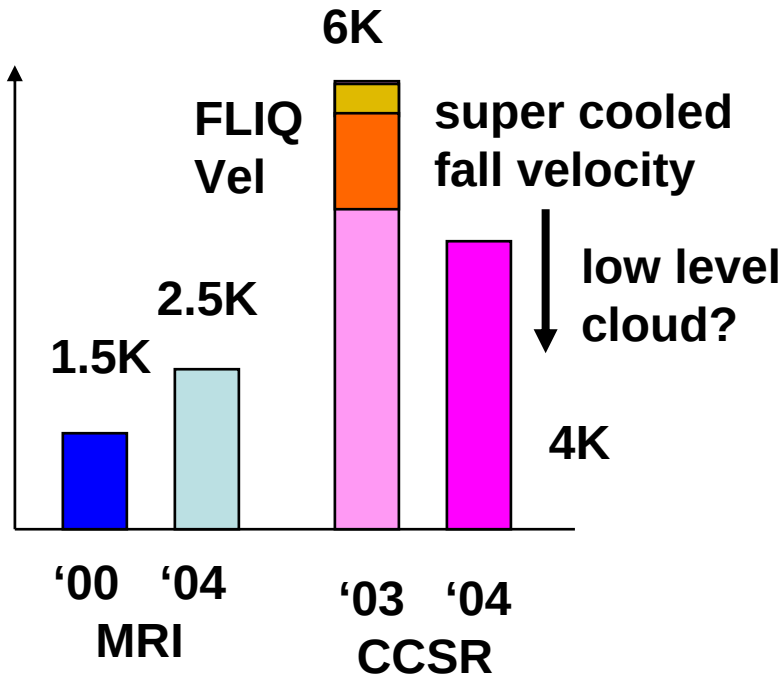


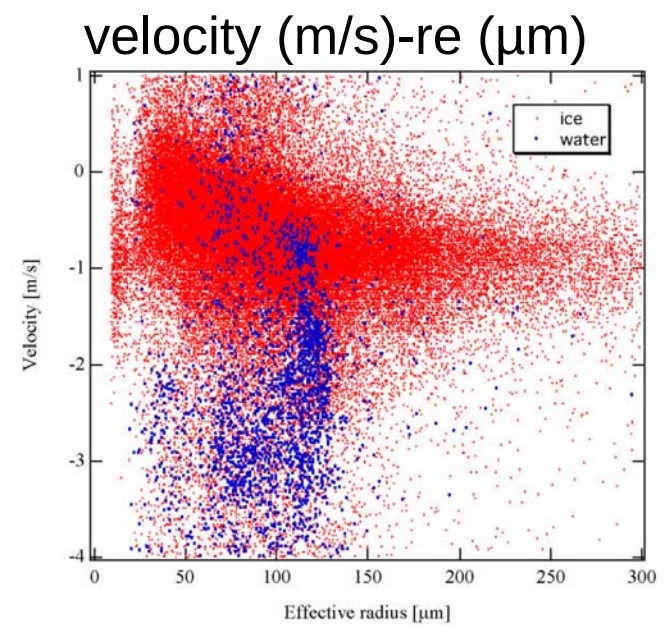
Takemura et al. (2005)

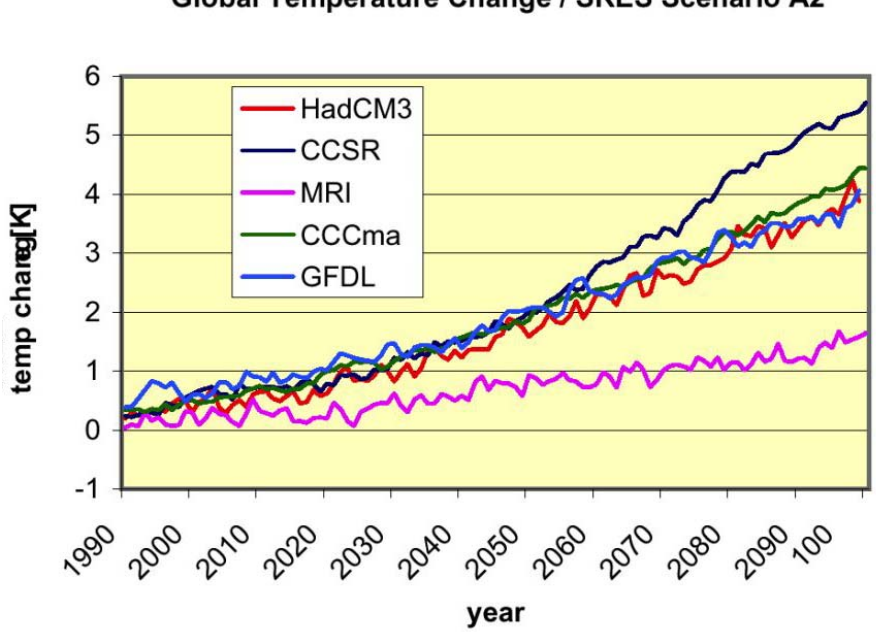
N_{min}=30 /cc ocean
=300 /cc land
Updraft velocity
Chemical species

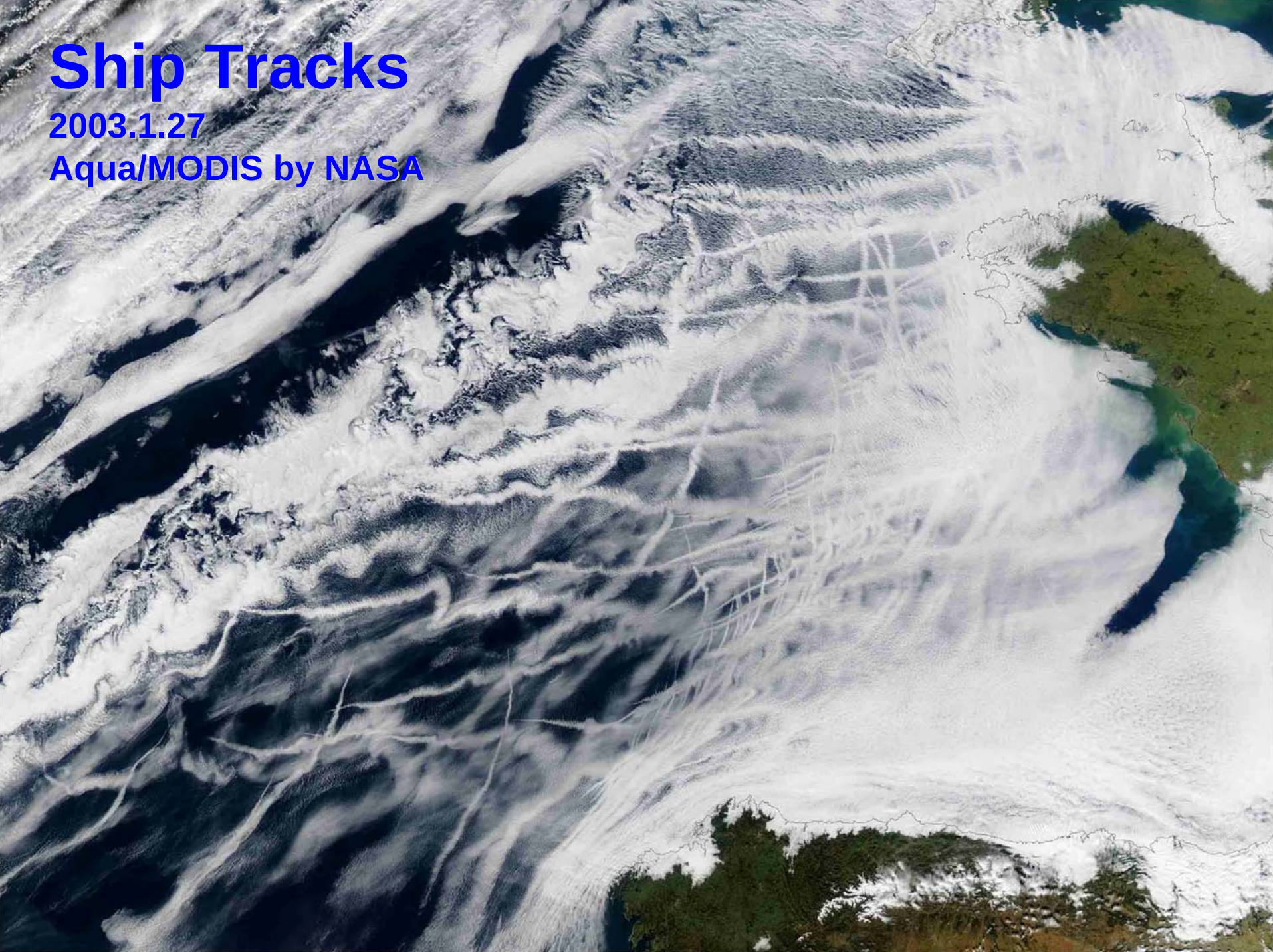
Temperature dependence of clouds










Ship Tracks
2003.1.27
Aqua/MODIS by NASA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Chiba
Xianghe
Beijing
Anmyon
Tottori
Gwangju
Aksu
Dunhuang
Yinchuan/
Shapatou
Taishang
Qira
Nepal
Nagqu
Hefei
Huanshang
Gosan
Fukuoka
Nagasaki
Fukue
Osaka
Shirahama
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Wan-Li
Minami
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Om Koi
Bac Giang
Hok Tsui
Lu-Lin
Kao-Hsiung
Pune
Sri-Samrong
Mukdahan
Phimai
Bangkok
Hanimaadhoo
ABC
SKYNET
AERONET
Others
ABC-EAREX